THE UNIDEX® 511 MOTION CONTROLLER

USER'S MANUAL

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If you should have any questions about the UNIDEX 511 Motion Controller or comments regarding the documentation, please refer to Aerotech online at:
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For your convenience, a product registration form is available at our web site.

Our web site is continually updated with new product information, free downloadable software and special pricing on selected products.

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PREFACE

The Preface provides an overview of topics covered in each chapter and conventions used in this manual. This manual contains information on the following topics:

CHAPTER 1: INTRODUCTION

Chapter 1 contains an overview of the UNIDEX 511 motion control system, as well as a sample system diagram. This chapter also contains precautionary notes about installing and using the UNIDEX 511 motion control system.

CHAPTER 2: GETTING STARTED

This chapter contains information about the components comprising the UNIDEX 511 system, unpacking and inspecting the equipment, and contains a quick, to the point, installation and setup of the U511 control system. This includes connecting cables and wiring, verifying feedback and limits, and jogging an axis.

CHAPTER 3: USER'S INTERFACE

Information regarding the front panel controls of the U511 and the liquid crystal display (LCD) screens appearing on the front panel is found in Chapter 3. Also provided is a complete list of menu items displayed through the UNIDEX 511 front panel interface. Sample screens are illustrated for all functions.

CHAPTER 4: PARAMETERS

This chapter provides information that helps the operator to understand and configure the parameters within the UNIDEX 511 system. Appropriate parameter configuration optimizes the UNIDEX 511 for an application. Chapter 4 includes discussions of all software parameters, motor and feedback configurations, and other topics related to the operation and configuration of the UNIDEX 511 system.

CHAPTER 5: PROGRAMMING COMMANDS

Chapter 5 supplies information required to understand the UNIDEX 511 programming environment. Included is an in-depth discussion of individual programming commands.

CHAPTER 6: REMOTE MODE OPERATION

Information about controlling the U511 remotely through one of the RS-232 ports or the IEEE-488 parallel port is found in Chapter 6.

CHAPTER 7: WINDOWS INTERFACE AND UTILITIES

This chapter contains information about the Windows™ Utilities. These utilities include a parameter editor, an axis scope screen, a diagnostic screen, and a file transfer utility. The utilities run on any PC and operate remotely from the U511 using the RS-232 standard.

CHAPTER 8: TUNING SERVO LOOPS

Chapter 8 provides information about servo loops and proper tuning techniques.

CHAPTER 9: PROGRAMMING EXAMPLES

This chapter contains sample applications highlighting UNIDEX 511 features, parameter settings, and sample programs.

CHAPTER 10: HARDWARE DETAILS

Chapter 10 supplies a variety of technical specifications for the UNIDEX 511. These specifications include test points, jumper configurations, encoder signal specifications, pinouts, outputs, bus specifications, and others.

CHAPTER 11: TROUBLESHOOTING

This chapter provides a reference tool if problems with the UNIDEX 511 arise.

APPENDIX A: GLOSSARY OF TERMS

Appendix A contains a list of definitions of terms used in this manual.

APPENDIX B: WARRANTY AND FIELD SERVICE

Appendix B contains the warranty and field service policy for Aerotech products.

APPENDIX C: SETTING UP AN AC BRUSHLESS MOTOR WITH THE UNIDEX 511

Appendix C contains a procedure for setting up AC brushless motors with the U511.

APPENDIX D: iSBX-IO48 BOARDS

This Appendix explains how to set up and program optional iSBX-I048 boards.

APPENDIX E: U511 BACKUP UTILITY

Appendix E contains information on the DOS utility for backing up or restoring parameter files, configuration files, and user program files.

APPENDIX F: UNIDEX 11 EMULATION SOFTWARE

Appendix F contains information about the optional software that allows the UNIDEX 511 to emulate the UNIDEX 11.

APPENDIX G: THE RDP-PC RESOLVER-TO-DIGITAL BOARD

Information explaining how to set up and install optional RDP-PC resolver-to-digital boards, is given in Appendix G.

INDEX

The index contains a page number reference of topics discussed in this manual. Locator page references in the index contain the chapter number (or appendix letter) followed by the page number and the reference.

MANUAL CONVENTIONS

Throughout this manual the following conventions are used:

- Use of "n" within a program block signifies that any axis (X, Y, Z or U) or drive (1, 2, 3, or 4) may be inserted.
- When mixed with small letters, capitalized letters within a command indicate the minimum entry for that command (e.g., DIsable). Most commands are given in capital letters.
- The terms UNIDEX 511 and U511 are used interchangeably throughout this manual.
- *Italic font* is used to illustrate syntax and arguments for programming commands.
- Double quotation marks (" ") are used to indicate U511 parameter names.
- Underlined letters refer to an <ALT> - letter keystroke.
- Hexadecimal numbers are listed using a preceding "0x" (for example, 0x300, 0x12F, 0x01EA, etc.,) to distinguish them from decimal numbers.
- An "x" preceding a parameter number represents the axis number (1, 2, 3 or 4) for the corresponding axis (X, Y, Z, or U), respectively. Therefore, parameter x38 (the "Position channel"), for example, actually corresponds to four distinct parameters:

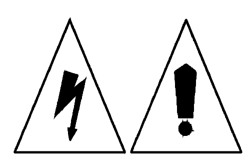
  138 for the "Position channel" of axis X

  238 for the "Position channel" of axis Y

  338 for the "Position channel" of axis Z, and

  438 for the "Position channel" of axis U

- The terms ENTER and <Return> are used interchangeably throughout this document when referring to the keyboard.
- Within the index, a bold locator page number (e.g., Components, **1-1**) indicates that the reference is part of an illustration. An italic locator page number (e.g., OP500 Cable Pinouts, *5-7*) indicates that the reference is part of a table. Text references are shown in a standard serif font (e.g., Software Setup, 3-1).
- Graphic icons or keywords may appear in the outer margins to provide visual references of key features, components, operations, or notes.
- Danger and/or Warning symbols (see right) appear in the outer margins next to important precautions. Failure to observe these precautions could result in serious injury and/or damage to the equipment.



DANGER WARNING

- The following statements apply wherever a Warning or Danger symbol appears within this manual. Failure to observe these precautions could result in serious injury to those performing the procedures and/or damage to the equipment.

WARNING

If the equipment is used in a manner not specified by the manufacturer, the protection of the equipment may be impaired.

WARNING

To minimize the possibility of electrical shock and bodily injury, make certain that the mains power supply is disconnected before opening the chassis.

WARNING

To minimize the possibility of electrical shock and bodily injury, make certain that all of the electrical power switches are in the off position prior to making any electrical connections.

DANGER

To minimize the possibility of electrical shock and bodily injury when any electrical circuit is in use, ensure that no person comes in contact with the circuitry.

DANGER

When this controller is installed within a system, mechanical motion may occur. Care must be exercised that all personnel remain clear of any moving parts.

DANGER

To minimize the possibility of bodily injury, disconnect mains power supply. Make certain that all electrical power switches are in the off position prior to making any mechanical adjustments.

WARNING

Protection ground connection symbol "⏚"

- This manual uses the symbol "∇ ∇ ∇" to indicate the end of a chapter.

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CHAPTER 1: INTRODUCTION

In This Section:

1.1. Overview of the UNIDEX 511 System

The UNIDEX 511 (or U511) system is a stand-alone multiaxis motion controller (refer to Figure 1-1). The U511 controller contains up to four integral amplifiers and all the circuitry necessary to interface with up to four positioning stages. The UNIDEX 511 contains 48 digital I/O lines, two serial ports, an IEEE-488 parallel port, joystick interface, and the ability to support ISA expansion boards. A Windows™-compatible utility program is shipped with each UNIDEX 511 system. It communicates with the U511 through one of the RS-232 ports and allows the user to perform software updates, run diagnostics, edit parameters, transfer files, and graphically tune and observe motion performance. The U511 also contains a flash memory-based, read/write hard drive. All parameters and user programs are stored here. A typical system is illustrated in Figure 1-2.

Figure 1-1. UNIDEX 511

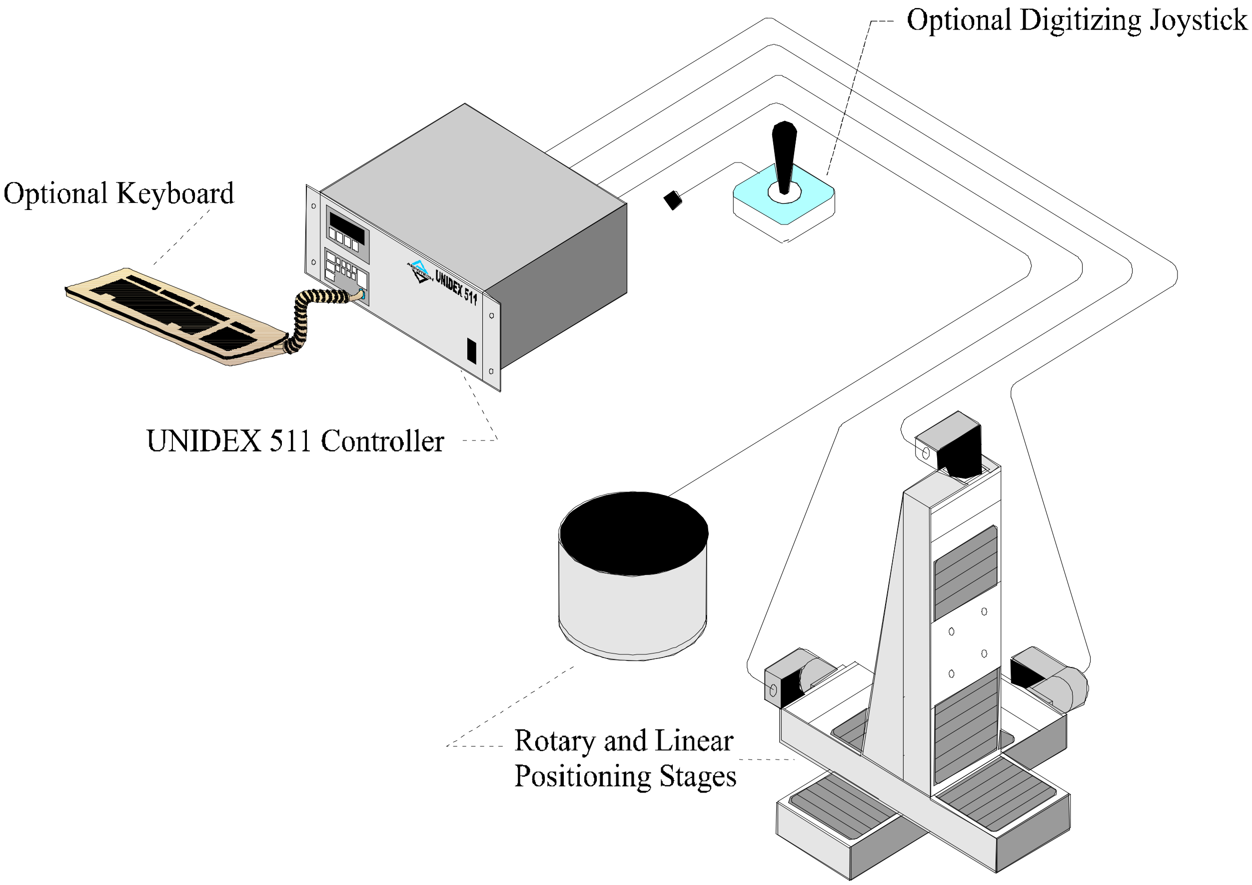

Figure 1-2. The UNIDEX 511 System Diagram

1.2. Ordering Information

Table 1-1 lists U511 series options that are available from Aerotech, Inc. For complete ordering information, refer to the Aerotech Motion Control Catalog.

Table 1-1. Basic Motion Controllers

Controller	Description
U511x-y-v1-0	One-to-two axis UNIDEX 511 with integral power supply and interconnection panel for all signals
U511x-y-v1-v2	Three-to-four axis UNIDEX 511 with integral power supply and interconnection panel for all signals

* Specify package style "x" as follows:

S = Desktop

R = Rack mount

Specify AC power "y" as follows:

A = 115 VAC

B = 230 VAC

C = 100 VAC

D = 208 VAC

Specify DC bus voltage "v1" and "v2" as follows:

30 = ±30 VDC

40 = 40 VDC

80 = 80 VDC

160 = 160 VDC

Table 1-2 lists the Aerotech motor drivers that can be used with the UNIDEX 511.

Table 1-2. Available Motor Drivers compatible with UNIDEX 511

Motor Driver	Description
AM8007C (Microstepping)	Microstepping motor driver, 7 A cont., 7 A peak, 20 kHz PWM, 40-80 V bus
DS16020C (DC Brush)	DC Brush:, 10 A cont. 20 A peak, 20 kHz PWM, 40-160 V bus
DS16030C (DC Brush)	DC Brush:, 15 A cont. 30 A peak, 20 kHz PWM, 40-160 V bus
AS32020C-Fn	AC brushless servo motor driver, 10 A cont., 20 A peak, 20 kHz PWM, 40-160 V bus
AS3005LC-Fn	AC brushless servo motor driver, 3 A cont., 5 A peak, linear DC 30 V bus

1.3. Options and Accessories

A variety of options and accessories may be purchased with the UNIDEX 511 to enhance its standard operation. Table 1-3 lists the Aerotech options and accessories that can be used with the UNIDEX 511 Series motion controllers. Brief descriptions of each option follow.

Table 1-3. Options and Accessories Available for the UNIDEX 511

Accessories	Description
HW500	3.6 inch handwheel assembly and cable (25-pin male "D")
JBV	Joystick with digitizing capability
JI	Industrial joystick with digitizing capability
PSO-PC	Programmable, position synchronized, laser firing control card used to provide output signals based on the positions of up to three axes
RDP-PC-n	Four-channel resolver-to-digital converter card to receive inductosyn or resolver feedback
BRKBPS-x	Fail-safe brake control logic
PB8	Opto 22 interface board that provides 8 inputs or 8 outputs
PB16	Opto 22 interface board that provides 8 inputs and 8 outputs
PB24	Opto 22 interface board that provides 16 inputs and 8 outputs

1.4. Safety Procedures and Warnings

The following statements apply wherever the Warning or Danger symbol appears within this manual. Failure to observe these precautions could result in serious injury to those performing the procedures and/or damage to the equipment.

To minimize the possibility of electrical shock and bodily injury, make certain that the mains power supply is disconnected before opening the chassis.

To minimize the possibility of electrical shock and bodily injury, make certain that all of the electrical power switches are in the off position prior to making any electrical connections.

To minimize the possibility of electrical shock and bodily injury when any electrical circuit is in use, ensure that no person comes in contact with the circuitry.

When this controller is installed within a system, mechanical motion will occur. Care must be exercised that all personnel remain clear of any moving parts.

To minimize the possibility of bodily injury, make certain that all electrical power switches are in the off position prior to making any mechanical adjustments.

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CHAPTER 2: GETTING STARTED

In This Section:

2.1. Introduction

This chapter steps the operator through unpacking the U511, connecting cables, and verifying basic functionality.

2.2. Unpacking the UNIDEX 511 Unit

Before unpacking any components, visually inspect the containers of the U511 system for any evidence of shipping damage. If any such damage exists, notify the shipping carrier immediately.

Remove the packing list from the UNIDEX 511 container. Make certain that the items listed on the packing slip are contained within the package. The following items should be found in every UNIDEX 511 system:

- The UNIDEX 511 Motion Controller User's Manual
- Windows™ -compatible, 32 bit U511 utility software
- UNIDEX 511 packing slip (listing products shipped with the order)

The following list of additional items may be included with the UNIDEX 511 system, depending on the options and accessories that have been specified:

- Motor connector cables
- JBV or JI joystick and cable
- Handwheel assembly and cable
- I/O cables or Opto 22 boards
- RS-232 cable

2.3. UNIDEX 511 Setup Flowchart

Figure 2-1 illustrates a flowchart providing an overview of the installation process from connecting the cables to jogging an axis.

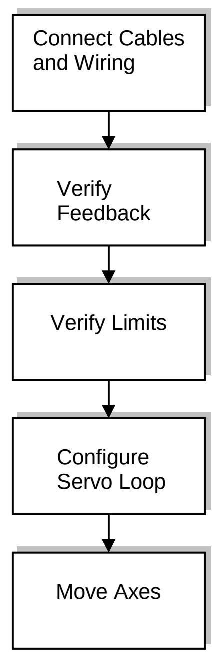

Figure 2-1. Flowchart Overviewing the Installation/Configuration Process

2.4. Installing Cables and Wiring

System installation varies with the number and types of components that have been purchased from Aerotech, Inc. to complement the UNIDEX 511 PC bus controller. The following descriptions may not be applicable to all systems. Figure 2-2 is an illustration of the rear panel connectors.

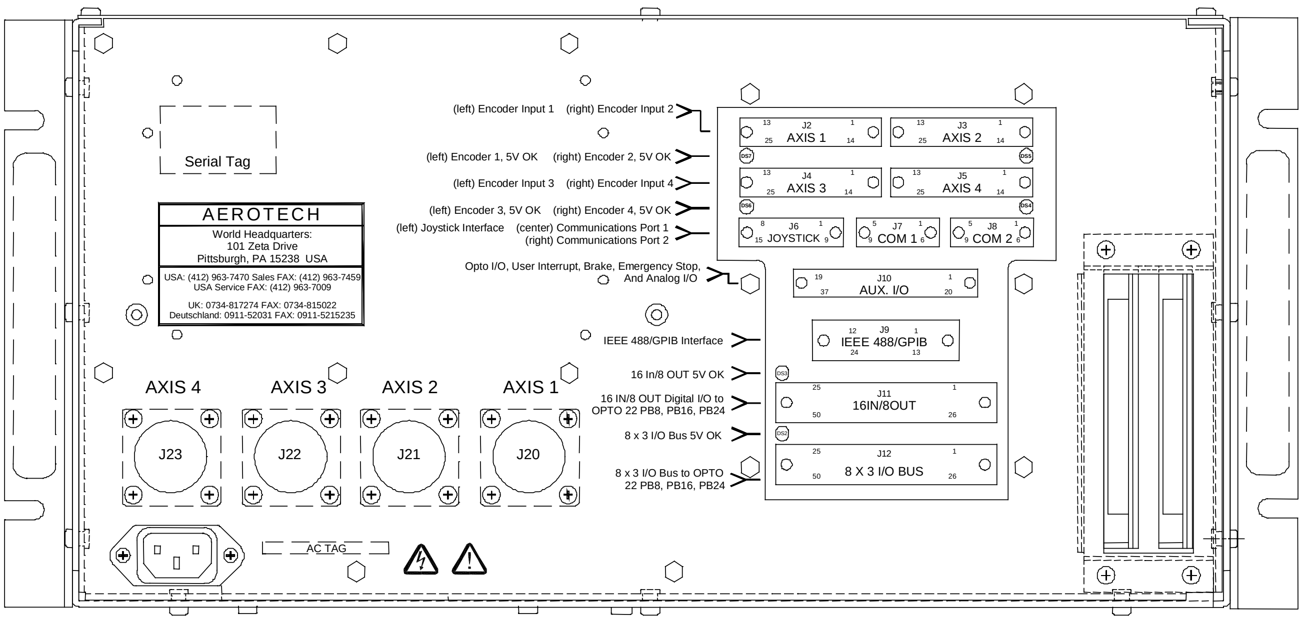

Figure 2-2. Rear Panel Connectors of the U511

- The round 14-pin plastic connectors are for connecting to the motors
- The 25-pin "D" type connectors are for connecting to the encoder and limits

Aerotech positioning systems have two cables, one for the motor and one for the encoder. The encoder cable and motor cable must be connected to corresponding channels.

Note: 1. Protective earthing is through mains power connection
2. Supply connection is mains power cord (mains power disconnect)
3. Protective earthing connection is indicated by the symbol "⏚".

Cables must not be connected or disconnected from the U511 while power is applied. Doing so may cause damage to the system or its components.

Before connecting the U511 to its power source, compare the desired input power to the required input power indicated by the AC power tag (rear of the U511).

2.5. Software Configuration Considerations

The UNIDEX 511 can be configured for a variety of motor and feedback devices. Modification of this configuration can be accomplished from the Setup menu screen. The configuration information is saved internally as a parameter file "*.PRM."

If a complete system was purchased from Aerotech, including positioning stages and cables, the UNIDEX 511 already contains a functional parameter file named "xxxxxx.PRM"; where "xxxxxx" refers to the sales order number and serial number.

For a detailed discussion of the parameters listed in this section (and others) refer to the individual parameter listings found in Chapter 4: Parameters.

2.6. Special Startup Considerations

It is recommended that several functions be verified prior to enabling an axis for motion. To facilitate this verification process, a Diagnostics window is provided in the U511 software package. This Diagnostics screen displays hardware (limits, I/O, etc.) and servo-related information (traps, machine position, etc.) dynamically (in real time). It is useful for system setup and debug purposes. The Diagnostics window is accessed from the DIAG key on the main screen.

The UNIDEX 511 software also contains a tracking display window that shows position data in real time. The position is displayed in programmable units that the operator may define (e.g., mm, in, etc.). The axis positions can be viewed from the MDI mode or the program screens.

IMPORTANT

> Make certain that all system traps and faults are enabled prior to initiating any axis movement. For more information, refer to the faults, traps, and mask parameters in Chapter 4: Parameters.

2.6.1. Feedback Verification

Before enabling any axis, is it important to verify the feedback from the motors. This is done using the axis position display. The tracking display should be stable while the axis is stationary (that is, the values in the axis position display windows should not change), although slight movement with high resolution systems is normal.

Feedback phasing may be verified by manually turning the motor. Clockwise/counter-clockwise rotation should produce an increasing/decreasing display. If not, feedback phasing is incorrect. The Diagnostics window will always display CW rotation as increasing feedback.

Motor direction for rotary motors (clockwise or counter-clockwise), is always referenced by "looking into" the shaft end of the motor. For linear motors, the positive direction is defined as movement away from the motor forcer's integral wiring.

Make certain that the UNIDEX 511 is appropriately configured for the type of motor being driven.

IMPORTANT

2.6.2. Limit Verification

Limit verification is extremely important in the startup of the UNIDEX 511 system. Improperly configured limits can cause damage to system components and can pose safety hazards to operators and others. Limit verification requires the operator to disable each axis, manually engage each limit, and then check the state of that limit input using the Diagnostics window. The Diagnostics window will display the state of limit inputs as either an "H" (for "high") or an "L" (for "low"). Depending on their polarity, the limits should change from high to low or from low to high when activated. Normally closed limit switches go from low to high when activated. Normally open limit switches go from high to low when activated. If no change is observed, the limit system is faulty. Refer to Chapter 4 of this manual for more information about limit parameters.

To prevent the possibility of personal injury or possible damage to the equipment, do not enable the axes until the limits are working properly.

WARNING

2.6.3. Preliminary Servo Loop Setup

In the most general sense, control loops are systems that create output signals based on (1) input signals and (2) a series of servo gains that define the output over a variety of input criteria. These gains must be individually tailored to every unique application. The process of manipulating these servo gains to provide the most desirable response is called *servo tuning*. In UNIDEX 511 systems, servo loops are tuned using the servo gain parameters.

In the UNIDEX 511 system, there are five tuning parameters associated with each axis. Each set of servo tuning parameters must be properly configured before the associated axis can be enabled. The five servo loop tuning parameters are listed in Table 2-1.

Table 2-1. Servo Loop Tuning Parameters

Abbr.	Description/Function
"Kpos"	Position Loop Gain
"Ki"	Velocity Loop Integrator
"Kp"	Velocity Loop Proportional Gain
"Vff"	Velocity Feed Forward
"Aff"	Acceleration Feed Forward

Servo loop tuning should be done with the motors fully loaded. Inertia, momentum, gravity, friction, and other forces effect the response of the system.

Preliminary servo loop setup consists of enabling the axis and tuning the servo loop for the desired performance. Information on UNIDEX 511 parameters can be found in Chapter 4: Parameters. Information on servo loop tuning can be obtained from Chapter 8: Servo Loop Tuning.

If Aerotech stages are ordered with your UNIDEX 511 controller, the servo loop gain parameters will already be set from the factory.

2.7. Enabling and Moving an Axis

After performing the initial configurations, it is important to verify everything functions properly. Enable and jog the axis from the Jog screen under the MDI screen. It is recommended to initiate movement of the axis in "Freerun-low speed" mode. Also, check the home cycle by pressing the home button.

2.8. Internal System Wiring

The U511 wiring varies depending on the AC input voltage, number of axes, DC bus voltage, and drive modules. A system wiring drawing is provided with the documentation package for the U511. The system drawing contains information concerning fuse values and some jumper settings.

Additional information about the U511 is located on the system serial label and AC power tag (located on the rear of the U511). The serial label contains the customer order number (required when calling customer service), system drawing number, and system part number. The AC power tag includes AC power requirements, line voltage, and current requirements.

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CHAPTER 3: THE USER INTERFACE

In This Section:

3.1. Introduction

The user interface consists of a front control panel and a software program that produces a series of text screens in the viewing area. To operate the controller, the user uses the keypad of the front control panel to manipulate information on the text screens. This section discusses the control panel and the text screens.

3.2. Control Panel

The standard control panel consists of a power switch, a 28-item sealed membrane keypad, and an eight by 40 character liquid crystal display (LCD). Refer to Figure 3-1. The LCD displays a series of screens holding information that can be viewed, selected, or altered by operating certain keys on the keypad. The keypad allows users to access all the utilities of the U511.

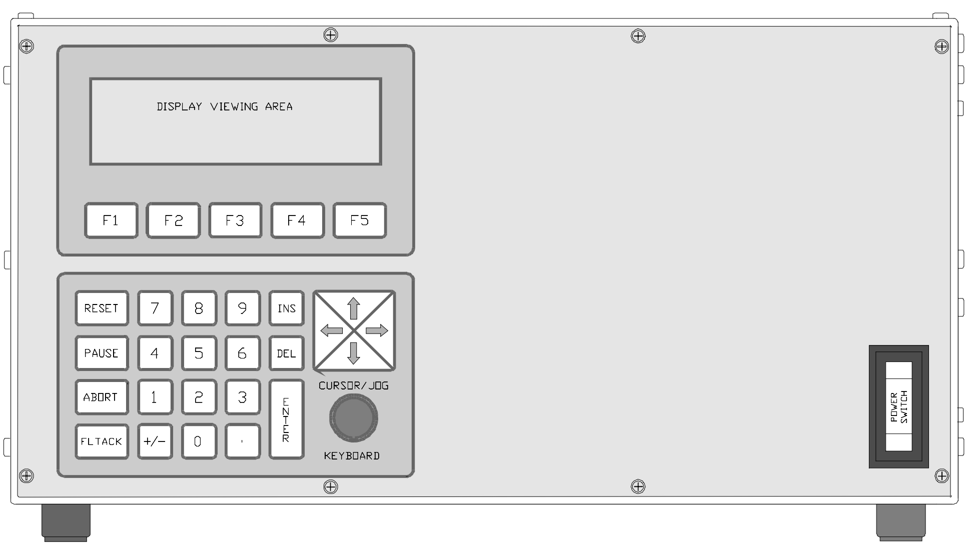


Figure 3-1. Control Panel

A description of the keys and their functions follows.

- **Function Keys (F1 - F5).** Located directly beneath the LCD, these keys allow the user to activate corresponding functions that appear above them in the viewing area. Such choices include functions that allow the user to quit the screen, go to the next screen, go back a screen, and a host of other commands that are specific to the screen display. The screens and the corresponding commands are discussed later in this chapter. These keys are also programmable. See the SKEY command in Chapter 5.
- **RESET Key.** This key performs a hardware reset function equivalent to turning the power switch off and on.
- **PAUSE Key.** This key toggles the pause/feedhold state. The current state of the function can be determined from the MDI window or the Diagnostics screen. Global subroutine calls ":Pauseon"/":Pauseoff" are executed.
- **ABORT Key.** This key causes all axes to ramp to a stop under servo control. Global subroutine ":Abort" is executed.
- **FLTACK Key.** This key causes the same action as the abort key, but in addition, it clears any fault conditions. Any axis in a limit will be moved out. Global subroutine ":Faultack" is executed.
- **Number Pad.** Including a "+/-" key and a decimal key, the numerical keypad allows users to enter positive and negative integers and decimal numbers into designated locations in the viewing area.
- **INS and DEL keys.** Insert and delete keys are used during text editing. When insert is active, the cursor will appear as a full block. The DEL key will remove the character pointed to by the cursor. The INS key also changes the "Copy" function to the "Paste" function.
- **Cursor/Jog Keys (arrows).** The cursor/jog keys have a two-fold purpose. In normal mode, they move the cursor up and down, left and right through the information on the viewing area so users can access the appropriate item on the screen. When in jog mode, the cursor keys are used to move the axes.

In addition to the keypad, there is a QWERTY compatible keyboard port on the front panel so an optional keyboard can be used to type commands in directly.

3.3. Power-up Screen

When the U511 is first powered-up, the screen provides information on the U511 software version and amount of free memory. It also reveals whether remote mode is enabled. In addition, this screen lists a Main menu of five major U511 functions, any of which can be activated by pressing one of the function keys (F1-F5) below the screen. The Power-up screen is shown in Figure 3-2.

```
   Unidex 511 - Software Version 1.01

Free Memory 48226 (bytes)




Program  Setup    Diag    Tune     MDI
   F1      F2      F3      F4      F5
```

Figure 3-2. Power-Up Screen

The following is a description of the five selectable functions (F1-F5) on the Power-up screen:

F1 Program	The Program function allows the user to run programs, edit files, copy and delete files, and digitize programs.
F2 Setup	The Setup function provides the user the ability to check, change, and save parameters.
F3 Diag	The Diagnostics function allows the user to check status, fault conditions, and communication operations.
F4 Tune	The Tune function allows the user to tune, check or change tuning parameters, and save tuning parameters.
F5 MDI	The MDI function allows the user to operate the joystick, enter individual program commands, and perform jog operations.

Activating one of these functions opens other screens with additional function choices on them. These function submenus either carry out some related operation or lead, in turn, to more screens. This series of menus and submenus is illustrated in Figure 3-3. Each submenu is related somehow to the function that activated it. For example, the File function under the Program menu leads to a screen called File Operations where users can copy or delete files. The menus under Setup and Diagnostics shown in Figure 3-3 are not selectable functions but "pages" of information that can be accessed with the "Next" function.

In the sections that follow, screens are discussed in a top down fashion with the first Main menu function discussed under a major section heading, and all the submenus beneath it discussed in subsections under the major heading. In each section, the screen is described first and then the actions of the corresponding functions are listed.

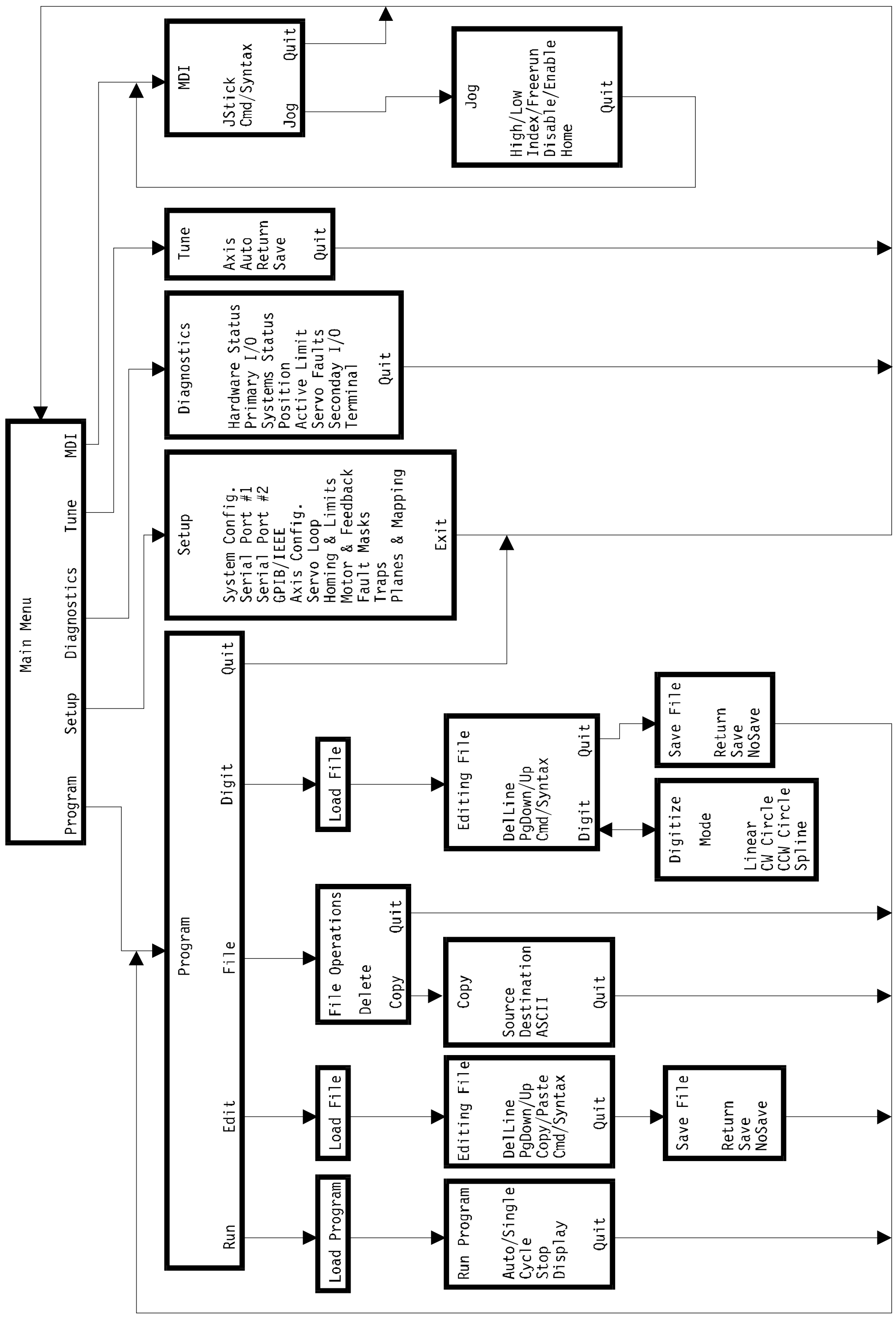


Figure 3-3. U511 Menus Activated by the Function Keys

3.4. Program Menu

Upon hitting the F1 key in the Power-up screen, the Program screen appears. Refer to Figure 3-4. The Program screen allows the user to select program-related operations such as running programs, editing, copying files, deleting files, and digitizing programs. This screen also reveals U511 status information. The first line shows whether the U511 is in incremental or absolute mode, the manual feed override (MFO) percentage, and the feedrate. The next four lines display axis position and status information.

```
    Program   Inc Mfo 100 F960.0/min
X            0.000  mm  Enabled
Y            0.000  mm  Enabled
Z            0.000  mm  Enabled
U            0.000  mm  Enabled


  Run    Edit    File    Digit    Quit
```

F1	F2	F3	F4	F5

Figure 3-4. Program Screen

There are five functions or commands on this screen, four of which lead to other screens. The following is a description of the selectable functions under the Program screen (F1-F5):

F1 Run	The Run function loads and runs programs.
F2 Edit	The Edit function edits files and programs.
F3 File	The File function copies or deletes U511 files.
F4 Digit	The Digit function digitizes a program using a joystick.
F5 Quit	The Quit function exits or quits the Program screen and returns to the Main menu.

The functions leading to other screens are discussed below.

3.4.1. Program Menu: the Run Submenu

Choosing F1 under the Program screen leads to the Running Program screen. First, however, the Load Program screen is displayed. The Load Program screen is used to select the program to be loaded and run. Refer to Figure 3-5. To select a program, use the cursor keys to move the cursor to the desired program. The selected program will be shown in reverse video and also listed in the first line of the screen. Press the ENTER key to load the selected program. If the U511 is currently running a program, this screen will not be displayed–the Running Program screen is displayed instead.

```
    Load Program:  TEST1.PRG
TEST1.PRG          11 10/10/97 09:46PM
TEST5.PRG          31 08/21/97 09:50PM
TEST2.PRG          13 10/10/97 09:45PM




PgDown    *.*                     Quit
   F1        F2       F3       F4       F5
```

Figure 3-5. Load Program Screen

There are three selectable functions under the Load Program screen. These are described below:

F1 PgDown/PgUp	This function moves one screen down or up through the list of displayed files. Toggle between PgDown and PgUp by reversing the direction with the cursor keys.
F2 *.*/*.prg	This function toggles between displaying all files (*.*) or just program files (*.prg). The function key label shows the extension that will be selected when F2 is pressed.
F5 Quit	The Quit function exits or quits this operation and returns to the Program screen.

After a program has been selected and loaded (when ENTER is pressed), the Running Program screen is displayed. Refer to Figure 3-6. This screen is used to start, control, and monitor programs. The program and line being executed are listed in the first line of the screen. Axis position and status information appears in the center of the screen. The axis position information is automatically updated as the program runs.

```
  Running Program: TEST1.PRG  Line:1
 X           0.000 mm  Enabled
 Y           0.000 mm  Enabled
 Z           0.000 mm  Enabled
 U           0.000 mm  Enabled


 Auto    Cycle    Stop   Display   Quit
   F1      F2       F3       F4       F5
```

Figure 3-6. Running Program Screen

This screen has five selectable functions that are described below:

F1 Auto/Single	The Auto/Single key determines if the program is to run automatically (Auto) or by executing one block at a time (Single).
F2 Cycle	Cycle is used to start and step through programs.
F3 Stop	Stop is used to stop a running program. All axis motion will terminate and the program will be unloaded from memory.
F4 Display	Display allows the user to monitor the running program. Executing program lines can be displayed on the screen by pushing this key. This slows down block processing time of the U511 and is only recommended for program debugging.
F5 Quit	Quit will exit the Run Program screen and will prompt the user if a program is running. A program is allowed to run in the background after pressing this key.

3.4.2. Program Menu: the Edit Submenu

Pressing the F2 key in the Program screen brings up the Edit submenu. The Edit submenu is a series of screens. First, the Edit File screen, which is used to select the file to be edited, appears. Refer to Figure 3-7. To select a file, use the up and down arrow keys or the PgDown/PgUp function to move the cursor. The selected file is shown in reverse video. The selected file name or "untitled" in the case of a new file, appears in the first line. Press ENTER to begin editing.

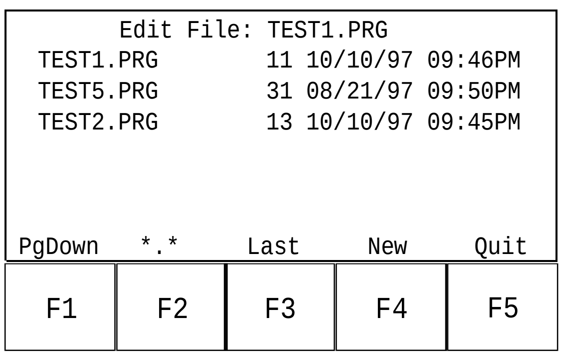


Figure 3-7. Edit File Screen, Edit File Submenu

There are five selectable functions on the Edit File screen:

F1 PgDown/PgUp	This function moves one screen down or up through the list of displayed files. Toggle between PgDown and PgUp by reversing the direction with the cursor keys.
F2 *.*/*.prg	This function toggles between displaying all files (*.*) or just program files (*.prg). The function key label shows the extension that will be selected when F2 is pressed.
F3 Last	This function recalls the last selected file or program.
F4 New	New generates a new program.
F5 Quit	The Quit function exits or quits this operation.

The Program Editor screen (refer to Figure 3-8) is displayed after a program has been selected and loaded. A program may be edited using an external keyboard. If there is no keyboard, menu-assisted editing can be entered by pushing the Commands key (F4). If F4 is pushed when the cursor is on a line that contains a command, the syntax for that command will appear in a special screen. The command can then be modified using the submenus specific to that command. If F4 is pushed on a blank program line, the Edit Command screen appears where the user can choose the desired command from the displayed list. When editing the program in menu-assisted mode, the up and down arrow keys may be used to scroll through the program.

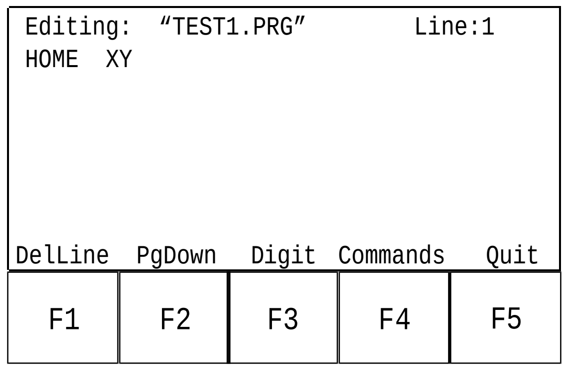


Figure 3-8. Program Editor Screen

There are five selectable commands on the Program Editor screen, one of which leads to other screens. Below is a description of the functions (F1-F5) on the Program Editor screen:

F1 DelLine	The DelLine function deletes the selected line of a file.
F2 PgDown/PgUp	This function moves one screen down or up through the command lines. Toggle between PgDown and PgUp by reversing the direction with the cursor keys.
F3 Copy/Paste	This function is used to copy one line of a file. To paste, press the INS key (F3 becomes Paste) and position the cursor to where the line is to be inserted and press F3.
F4 Commands	This function summons the Edit Command screen where users can build a command without using the keyboard. It also helps the user with program command syntax.
F5 Quit	The Quit function is used to exit or quit this operation. It summons the "Save As:" screen so the program can be saved.

The following screen (Figure 3-9) is an example of an Edit Command screen. Pressing the Commands key (F4) while the cursor is on a blank line accesses the Edit Command screen. The Edit Command screen is used to enter commands without using a keyboard and to help with program command syntax. The most commonly used commands are displayed in the first screen. Other commands follow alphabetically. A command can be selected by using the PgUp, PgDown, and arrow keys to locate the cursor on the desired command then pressing ENTER. After pressing ENTER, a specialized command screen, which will help the user with the program command syntax, will be displayed.

> Use of the Edit Command screen is only necessary when a keyboard is unavailable.

```
              Index
ENABLE    DISABLE   HOME      SLEW
FREERUN   DWELL     INDEX     LINEAR
CC        CW        Fa        OUT
IO        IOSET     Loop      NEXT
IF        GOTO      :label    ;comment
Press ENTER for syntax
 PgUp   PgDown                   Quit
```

F1	F2	F3	F4	F5

Figure 3-9. Edit Command Screen

This screen has three selectable functions that are described below:

F1 PgUp	This function is used to page up through the commands.
F2 PgDown	This function is used to page down through the commands.
F5 Quit	The Quit function is used to exit or quit this operation.

The specialized command screens that appear after pressing ENTER on the Edit Command screen (or by pressing Commands [F4] while the cursor is on a command in the Program Editor screen) differ depending on the command that was selected. An example of one of these specialized command screens is shown in Figure 3-10. This screen is for the INDEX command. The first line of the screen shows the file name and the line of the program that the command is being added to. The next line shows the name of the command. The third line shows the syntax for the command. In this case, the syntax structure means that the axis to be moved (X, Y, Z, or U) must be followed by a distance (a, b, c, or d), followed by the feedrate of the move for each axis (XFe, XFf, etc.). The fourth line is where the user builds the command to be inserted into the program using the functions at the bottom of the screen. To insert a modified command into the Program Editor, the user must press ENTER after the command has been built. When this is done, the program returns to the Program Editor screen with the new command displayed in it.

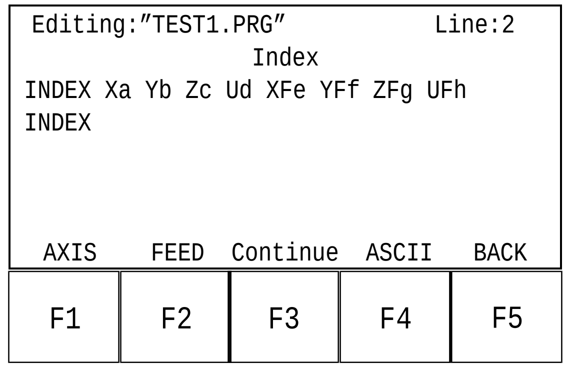


Figure 3-10. Specialized Command Edit Screen

The functions at the bottom of the specialized command screens differ depending on the command selected. The AXIS (F1) and FEED (F2) functions are specific to the INDEX command. These functions open screens where the user can select and insert axis and feedrate characters into the command. The following general commands are found on most specialized command edit screens.

F3 Continue	Returns the user to the Edit Command screen and appends the next command to the present command.
F4 ASCII	Opens the ASCII utility so users can enter characters without using a keyboard.
F5 Back	Returns the user to the Program Editor screen without inserting the modified command into the program.

Leave the Program Editor by pressing the Quit key. Upon leaving the Program Editor, the "Save File As:" screen (Figure 3-11) is displayed. This screen allows the user to change or assign a file name, return to the edit session, save and exit, or just exit.

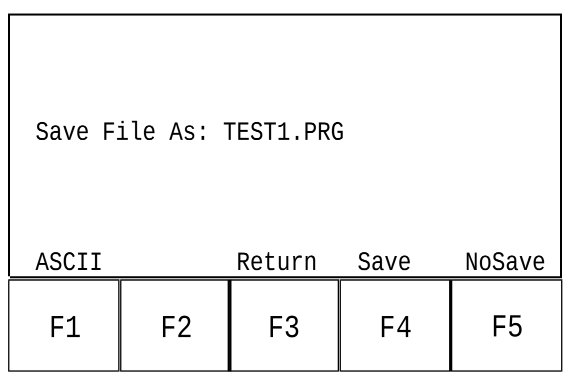


Figure 3-11. "Save File As:" Screen

This screen has four selectable functions, one of which leads to other screens. These functions are described below:

F1 ASCII	Opens the ASCII utility so users can enter or change the name of the file.
F3 Return	Return will return the user to the program being edited.
F4 Save	Save will store the file being edited and exit edit mode.
F5 NoSave	NoSave will exit edit mode without saving the file.

3.4.3. The ASCII Utility

This screen enables users to build commands or file names, including non-numerical characters, using only the keys on the front panel. If the user has a keyboard, the commands or file names can be typed in directly.

Use of the ASCII utility is only necessary when a keyboard is unavailable.

The ASCII utility appears in many forms. An example screen is shown in Figure 3-12. This screen is for editing a file name and would appear after the user pressed "ASCII" (F1) in the "Save File As:" screen. The important features on this page are the two lines of ASCII characters and the functions at the bottom of the page.

The data entry point is automatically placed to the right of "Save File As:" The cursor is situated on the first line of the ASCII characters. To insert an ASCII character, use the function keys at the bottom of the screen or the arrow keys on the front panel to move the cursor to the desired character, then press ENTER. The selected character will appear at the entry point. This can be repeated until the command or filename is built.

```
Save File As: TEST1.PRG

  !"#$%&'()*+,-./0123456789:;<=>?
@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_
TabLeft TabRight  HOME     END     QUIT

  F1      F2      F3      F4      F5
```

Figure 3-12. The ASCII Utility

The five function keys on the ASCII utility are described below:

F1 TabLeft	Moves the cursor to the left five characters in the ASCII list.
F2 TabRight	Moves the cursor to the right five characters in the ASCII list.
F3 Home	Moves the cursor to the beginning of the ASCII character list.
F4 End	Moves the cursor to the end of the ASCII character list.
F5 Quit (or Back)	Registers the changes and returns to the original screen with the command or file name inserted.

3.4.4. Program Menu: the File Submenu

Upon choosing the F3 key in the Program screen, the user enters the file operations mode. The File Operations screen (Figure 3-13) is used to copy and delete files. Move the cursor to the desired file (it will appear in reverse video), then select Copy (F4) to make a copy of a file, or Del (F3) to erase the file. The F2 function toggles between displaying all files (*.*) or just program files (*.prg). The function key label shows the extension that will be selected when F2 is pressed.

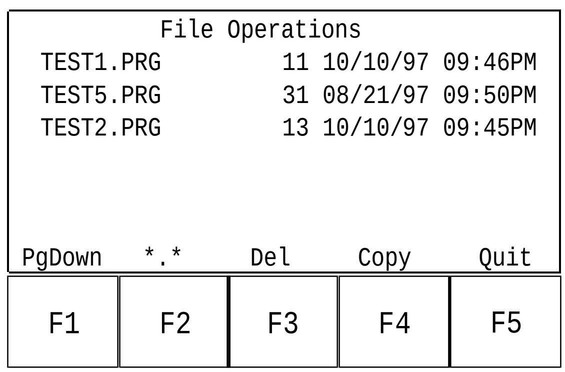


Figure 3-13. File Operations Screen

3.4.5. Program Menu: The Digitize Submenu

The Digitize function allows the user to edit a file and use the joystick to generate positioning commands in the program. This function may be used to generate linear, circular (clockwise or counterclockwise), or spline move commands.

When Digitize is selected from the Program submenu, an Edit File screen, similar to the one in the Edit submenu is displayed. Refer back to Figure 3-7. The user is required to input the file to be digitized. Once the file is selected or new file is chosen, the Program Editor screen for the Digitize submenu will be displayed. See Figure 3-14. This screen functions identically to the Program Editor screen of the Edit submenu except that the Copy/Paste function is replaced with a “Digit” function. This function enables the joystick and allows the user to select the type of command generated.

Pressing the joystick "C" button generates program lines. Refer to Figure 3-15. Move commands are generated in absolute or incremental mode depending on the current state of the U511 (see the Programming command in the Chapter 5).

```
Editing:  "TEST1.PRG"        Line:1
HOME  XY




DelLine  PgDown   Digit  Commands   Quit
  F1       F2      F3       F4       F5
```

Figure 3-14. Program Editor Screen, Digitize Menu

Following is a description of the selectable functions (F1-F5):

F1 DelLine	The DelLine function deletes the selected line of a file.
F2 PgDown/PgUp	This function moves one screen down or up through the command lines. Toggle between PgDown and PgUp by reversing the direction with the cursor keys.
F3 Digit	This function summons the Digitizing screen where users can select the digitize mode and insert commands with the joystick.
F4 Commands	This function summons the Edit Command screen where users can build a command without using the keyboard. It also helps the user with program command syntax. The Edit Command screen in the Digitize submenu is the same routine as in the Edit submenu.
F5 Quit	The Quit function is used to exit or quit this operation.

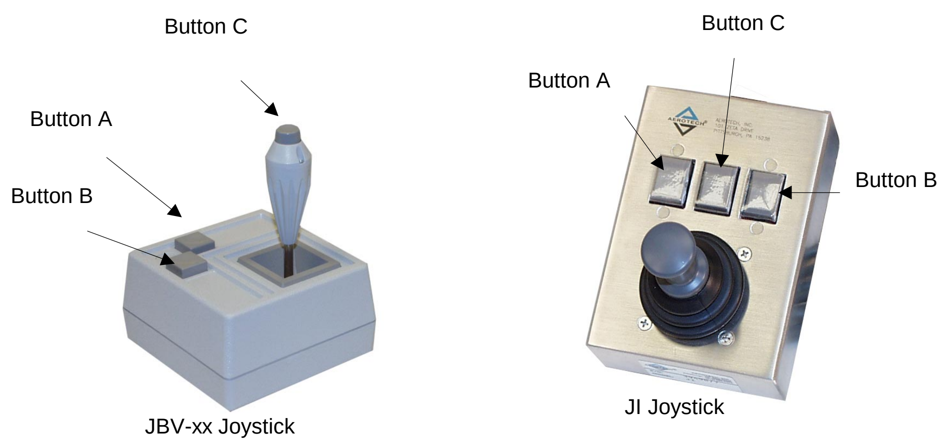


Figure 3-15. Joysticks Showing the "C" Button

In the digitizing screens that follow, the Mode (F1) key is used to select the digitizing mode. The screens differ depending on the mode. All screens, however, show the same information at the top of the screen. First the program name is displayed, followed by an abbreviation that shows whether the U511 is in incremental or absolute mode. Next, the mode of joystick slew operation is displayed. The joystick can be in linear, circular, or spline mode and it can be in low speed (l), high-speed (h), or position (p) mode. The "B" button on the joystick selects the latter mode. The axes that are under joystick control are also displayed at the top of the screen. These are shown in axis pairs because the joystick can, at most, control two axes of motion at once. The "A" button toggles between axis pairs. When digitizing mode is entered, all enabled axes are available for joystick control.

Linear Digitizing

The Linear Digitizing screen is shown in Figure 3-16. The linear digitizing mode uses the joystick to generate linear move commands in a program. This mode is selected by pressing the Mode (F1) key until "Linear" is displayed at the top of the screen. Use the joystick to slew the axes to the desired point and then press the "C" button on the joystick to incorporate the move. Only axis positions that have changed will be entered into the program. Any number of moves may be incorporated before quitting the screen. To see the commands, press Quit (F5), which returns the user to the Program Editor screen with the commands inserted.

```
UNTITLED.PRG      Inc Linear Slew l X,Y
X         0.000  mm  Enabled
Y         0.000  mm  Enabled
Z         0.000  mm  Enabled
U         0.000  mm  Disabled

Move to linear point
  Mode                             Quit
```

F1	F2	F3	F4	F5

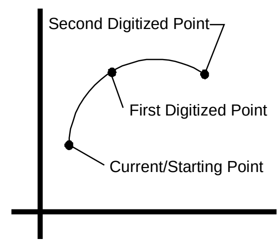
Figure 3-16. Linear Digitizing Screen

The following is a description of the selectable functions (F1-F5):

F1 Mode — Mode selects type of digitizing command.

F5 Quit — Quit inserts the linear moves and returns the user to the Program Editor.

Circular Digitizing



The Circular Digitizing screen is shown in Figure 3-17. Circular digitizing uses the joystick to generate clockwise (CW) or counterclockwise (CCW) move commands in a program. This mode is selected by pressing the Mode (F1) key until "Cir" is displayed at the top of the screen. The circle is calculated based on three points on the arc (see margin). The starting point is the current position. Move the axes to the first point, press the joystick "C" button, and then repeat for the second point. The U511 automatically calculates the circle direction. After the first point on the circle is entered, the user may reenter it by pressing the F2 key. This will overwrite the previously recorded position while preserving the starting point.

```
 UNTITLED.PRG   Inc Cir(XY) Slew l X,0
X       0.000  mm  Enabled
Y       0.000  mm  Enabled
Z       0.000  mm  Enabled
U       0.000  mm  Disabled

Move to first circle point
 Mode           Haxis    Vaxis    Quit
```

F1	F2	F3	F4	F5

Figure 3-17. Circular Digitizing Screen

There are four selectable functions in the menu at the bottom of the page. These functions (F1-F5) are described below.

F1 Mode	Mode selects type of digitizing command.
F3 Haxis	Haxis selects the circle horizontal axis displayed at the top of the screen.
F4 Vaxis	Vaxis selects the circle vertical axis displayed at the top of the screen.
F5 Quit	Quit inserts the circular move and returns the user to the Program Editor

Spline Digitizing

The Spline Digitizing screen is shown in Figure 3-18. Pushing the Mode key (F1) until "Spline" appears at the top of the screen enters the spline mode. This mode is very similar to linear digitizing except that the commands generated do not contain the "LI" instruction. Use the joystick to slew the axes to the desired points and press the joystick "C" button. Any number of points may be entered. The user must place a "SPLINE ON" command at the beginning of a block of points and a "SPLINE OFF" command at the end of the block. These commands can be added in the previous Program Editor screen using the keyboard or the Commands function.

```
  UNTITLED.PRG  Inc Spline Slew l X,0
X       0.000 mm Enabled
Y       0.000 mm Enabled
Z       0.000 mm Enabled
U       0.000 mm Disabled

Move to spline point
 Mode                            Quit
```

F1	F2	F3	F4	F5

Figure 3-18. Spline Command Screen

The functions (F1-F5) at the bottom of the screen are described below:

F1 Mode	Mode selects type of digitizing command.
F5 Quit	Quit returns the program to the Program Editor.

3.5. Setup Menu: Parameters

Upon hitting the F2 key in the Power-up screen, the Setup menu appears. The Setup screens are used to check and change the U511 parameters. Setup consists of 11 screens or "pages" with groups of related parameters on each. The pages are as follows:

Page Number	Page Title
1	System Configuration
2	Serial Port #1 Setup
3	Serial Port #2 Setup
4	GPIB/IEEE-488 Setup
5	Axis Configuration
6	Servo Loop
7	Homing and Limits
8	Motor and Feedback
9	Fault Masks
10	Traps
11	Planes and Mapping

Parameters are classified as axis parameters if they are used for all four axes. All other parameters are considered general parameters. Axis parameters are numbered 100 to 199, 200 to 299, 300 to 399, and 400 to 499 for axes one through four respectively. General parameters are numbered 0 to 99 and 500 and up. Parameter type and number are displayed in the upper right corner of all Setup screens. A general parameter page is shown in Figure 3-19 and an axis parameter page is shown in Figure 3-20.

The page number is displayed at the top left of the page. The page title is displayed at the top of the page. Scroll through parameters on a page by pressing the up and down arrows. The Back (F1) and Next (F2) keys move through the parameter pages. F3 is a special purpose key that selects the next axis or plane, depending on the parameter. It is also used to toggle through a list of predefined choices in some cases.

To change a parameter value, there are several options. The line above the function keys usually lists instructions for changing a parameter value. In most cases were the parameter has a numerical value, simply scroll the cursor to the value to be changed and enter the appropriate value through the keypad. Pressing the left/right arrow keys changes yes/no parameter values. Any 0/1 fault mask bits are also toggled in this way. The Default (F4) key sets the parameter to the factory default value.

> Starting with software version 5.02, the default key will return a system-specific "default" value. Otherwise, a general default value will be returned (see Appendix E: Backup Utility).

Additional information concerning the setup parameters can be found in Chapter 4: Parameters.

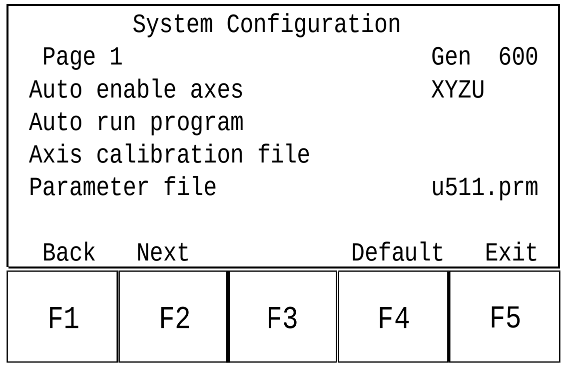


Figure 3-19. System Configuration Page (General Parameters)

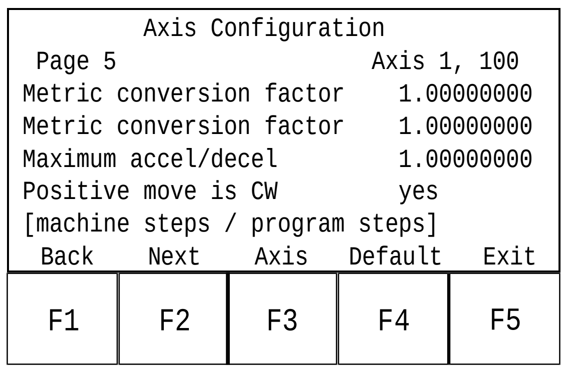


Figure 3-20. Axis Configuration Page (Axis Parameters)

There are from four to five functions on the general and axis pages. The following describes typical functions (F1-F5) on these pages:

F1 Back	Back selects the previous setup page.
F2 Next	Next selects the following setup page.
F3 Axis	Axis selects the axis (1-4). This information is displayed at the top of the page along with the parameter number.
F4 Default	Starting with software version 5.02, the Default key will return a system-specific "default" value. Otherwise, a general default value will be returned (see Appendix E: Backup Utility).
F5 Exit	Exits this operation and returns to the "Save Changes?" screen. This screen gives the user the opportunity to save the parameter changes to the current file, save the changes as another file name, or quit and return to the Main menu without recording the changes.

3.5.1. Setup Menu: The Fault Masks Page

The Fault Masks page (Page 9) is used to setup the fault mask parameters. The Fault Masks page is shown in Figure 3-21. This page differs from the other Setup pages, as it is the only page that requires another page to change parameter values. The user need not enter the hexadecimal numbers in any fault mask. As shown in the figures, the page instructs the user to press ENTER to expand the mask. The expanded Fault Masks page breaks down the selected fault mask into its individual bits so the user can edit them one at a time. An example of an expanded Fault Masks page is shown in Figure 3-22.

```
               Fault Masks
  Page 9                     Axis 1, 161
 AUX output                 FFFFFFF00100
 Halt queue                 FFFFFFF00000
 Abort motion               FFFFFFFF717F
 Enable brake               FFFFFFF00000
 Press ENTER to expand mask!
  Back    Next    Axis   Default   Exit
   F1      F2      F3      F4       F5
```

Figure 3-21. Fault Masks Page

The functions at the bottom of the page are the same as for any axis parameter.

```
           Global fault masks
  Page 9                 Axis  1, 155
Position error           0
RMS current error        0
Integral error           0
CW  Hardware             1

                                  Back
   F1      F2      F3      F4       F5
```

Figure 3-22. Expanded Fault Masks Page

The complete fault mask spans several pages. Use the up and down arrow keys to scroll through the list of faults. The Back key (F5) returns the user to the original Fault Masks page. To toggle between a 0 and a 1, press the left and right arrow keys.

3.6. Diagnostics Menu

Upon hitting the F3 key in the Main menu, the Diagnostics menu appears. Like the parameters, the diagnostic items are arranged into groups or pages. The Diagnostics pages provide information concerning the hardware and system status of the U511. These pages are as follows:

Page Number	Page Title
1	Hardware Status
2	Primary I/O
3	System Status
4	Position
5	Active Limits
6	Servo Faults
7	Secondary I/O
8	Terminal

The user changes nothing on these pages. They are for information only. The page number is at the top left of the page and the title is at the top center. On most pages, the top right of the page lists the axis numbers (1, 2, 3, and 4) for the column of status information below. Diagnostics menu pages all have the same function keys at the bottom of the page. Toggle through the pages by hitting the Back (F1) or Next (F2) function keys. The Quit key returns the user to the Main menu screen. The pages in the Diagnostics menu are described below.

3.6.1. Diagnostics Menu: Hardware Status Page

The Hardware Status page displays status information concerning limits, amplifier faults, and encoder faults. The Hardware Status page is shown in Figure 3-23. Table 3-1 describes the components of the Hardware Status page.

```
Page 1     Hardware Status     1 2 3 4
   CW hardware limit           H H H H
   CCW hardware limit          H H H H
   Home hardware limit         H H H H
   Amplifier fault             H H H H
   Encoder sine fault          Y Y Y Y
   Encoder cosine fault        Y Y Y Y
 Back    Next                     Quit
   F1      F2      F3      F4      F5
```

Figure 3-23. The Hardware Status Page

Table 3-1. Hardware Status Diagnostics

Field	Status Description
CW hardware limit	Indicates the current hardware input level of the CW limit input (H = +5 V level, L = GND level).
CCW hardware limit	Indicates the current hardware input level of the CCW limit input (H = +5 V level, L = GND level).
Home hardware limit	Indicates the current hardware input level of the Home input (H = +5 V level, L = GND level).
Amplifier fault	Shows whether an amplifier is in a fault condition (H = +5 V level, L = GND level).
Encoder sine fault	Records whether there is an invalid differential sine signal on the encoder (Y = fault, N = no fault). A broken wire, loss of encoder power, or low signal amplitude can cause this.
Encoder cosine fault	Records whether there is an invalid differential cosine signal on the encoder (Y = fault, N = no fault). A broken wire, loss of encoder power, or low signal amplitude can cause this.

3.6.2. Diagnostics Menu: Primary I/O Page

The Primary I/O page (refer to Figure 3-24) displays status information concerning digital I/O and the A/D inputs. Table 3-2 describes the components of the Primary I/O page.

```
Page 2       Primary I/O
 Inputs             1111111111111111
 Outputs                    00000000
 A/D input 1                    0.00
 A/D input 2                    0.00
 A/D input 3                    0.00
 A/D input 4                    0.00
 Back    Next                    Quit

  F1      F2      F3      F4      F5
```

Figure 3-24. Primary I/O Page

Table 3-2. Primary I/O Status Diagnostics

Field	Status Description
Inputs	Shows inputs on the 16 IN/8 OUT bus (0 = GND level, 1 = +5 V level).
Outputs	Shows outputs on the 16 IN/8 OUT bus. A 0/1 on the output corresponds to the programmed output level.
A/D inputs 1-4	Shows the direct analog/digital converter voltage (0-5 V) for the corresponding input.

3.6.3. Diagnostics Menu: System Status Page

The System Status page (Page 3) displays the manual feed override (MFO) value, Emergency Stop status, Brake status, Pause status, Joystick status, and the Status Word. The System Status page is shown in Figure 3-25. Table 3-3 describes the components of the System Status page.

```
Page 3        System Status
  MFO                           100.0%
  Emergency Stop                     N
  Brake                              Y
  Pause                              N
  Joystick ABC                     HHH
  Status Word                   00000F
 Back    Next                     Quit
   F1      F2      F3      F4      F5
```

Figure 3-25. System Status Page

Table 3-3. System Status Diagnostics

Field	Status Description
MFO	Shows the current manual feed override percentage from 0% to 199%. Also displayed in the MDI window if not equal to 100%.
Emergency Stop	Indicates current E-Stop status (Y = on, N = off) if E-Stop bit in any fault mask is enabled and E-Stop input is true. Also shown in the MDI window.
Brake	Indicates brake status (Y = on, N = off). The brake is a U511 option requiring additional hardware and is enabled in the fault mask.
Pause	Indicates pause status (Y = pause, N = no pause). Pressing the PAUSE button on the front panel toggles the pause state.
Joystick ABC	Indicates current functionality of the joystick buttons. A, B, and C do not physically correspond to the joystick buttons. The C on the screen is the interlock signal that must be low (L) for the joystick to operate. A and B correspond to the joystick "A" and "B" buttons. Pressing joystick "A" or "B" buttons causes the display to go from H to L. The joystick "C" button activates both "A" and "B" buttons/status bits.
Status Word	Indicates the internal "read status (5)" value.

3.6.4. Diagnostics Menu: Position Page

The Position page (refer to Figure 3-26) displays In Position status, Marker status, and the individual Axis Positions. Table 3-4 shows components of the Position page.

```
Page 4         Position        1 2 3 4
  In Position                  * * * *
  Marker                       * - * -
  Axis 1 Position [0000]             0
  Axis 2 Position [2000]             0
  Axis 3 Position [0000]             0
  Axis 4 Position [0000]             0
 Back    Next                     Quit

  F1      F2      F3      F4      F5
```

Figure 3-26. The Position Page

Table 3-4. Position Diagnostics

Field	Status Description
In Position	Indicates whether or not the axis is in its commanded position ("*" = in position, "-" = not in position).
Marker	Indicates when the encoder marker has been found ("*" = found, "-" = not found).
Axis 1-4 Position [ ]	Shows current axis position in machine steps. The positions shown in brackets are useful for resolver setup. For resolvers, they represent the resolver-to-digital converter 16-bit value.

3.6.5. Diagnostics Menu: Active Limits Page

The Active Limits page (refer to Figure 3-27) displays limit status information. This page differs from the Hardware Status page because the polarity is programmable and the axis must be enabled to have an active limit. Components of the Active Limits page are shown in Table 3-5.

```
Page 5     Active Limits       1 2 3 4
  CW  hardware limit           - - - -
  CCW hardware limit           - - - -
  Home hardware limit          - - - -
  CW  software limit           - - - -
  CCW software limit           - - - -

Back    Next                      Quit
```

F1	F2	F3	F4	F5

Figure 3-27. Active Limit Page

Table 3-5. Active Limit Diagnostics

Field	Status Description
CW hardware limit	Indicates whether the CW hardware travel limit is active ("*" = active, "-" = inactive).
CCW hardware limit	Indicates whether the CCW hardware travel limit is active ("*" = active, "-" = inactive).
Home hardware limit	Indicates whether the Home limit is active ("*" = active, "-" = inactive).
CW software limit	Indicates if the software CW travel limit is active ("*" = active, "-" = inactive").
CCW software limit	Indicates if the software CCW travel limit is active ("*" = active, "-" = inactive").

3.6.6. Diagnostics Menu: Servo Faults Page

The Servo Faults page (refer to Figure 3-28) displays servo fault and trap information. The axis must be enabled to show a fault. Table 3-6 shows components of the Servo Faults page.

```
Page 6      Servo Faults       1 2 3 4
  Feedback fault               - - - -
  Amplifier fault              - - - -
  Position trap                - - - -
  Velocity trap                - - - -
  Integral trap                - - - -
  RMS torque                   - - - -
 Back    Next                     Quit

  F1      F2      F3      F4      F5
```

Figure 3-28. Servo Faults Page

Table 3-6. Servo Fault Diagnostics

Field	Status Description
Feedback fault	Indicates whether there is a feedback fault ("*" = active fault, "-" = no fault).
Amplifier fault	Indicates whether an amplifier is in a fault ("*" = active fault, "-" = no fault).
Position trap	Indicates whether the position error exceeds value in parameter x19 ("*" = position error > x19, "-" = no position trap).
Velocity trap	Indicates whether the velocity error exceeds value in parameter x18 ("*" = velocity error > x18, "-" = no velocity trap).
Integral trap	Indicates whether integral error exceeds the parameter x20 value ("*" = integral error > x20, "-" = no integral error trap).
RMS torque	Indicates whether RMS torque (drive current command) exceeds the parameter x48 value ("*" = RMS torque > x48, "-" = no RMS torque fault).

3.6.7. Diagnostics Menu: Secondary I/O Page

The Secondary I/O page (refer to Figure 3-29) displays the status of the 8 X 3 I/O bus and the Hall inputs. Components of the Secondary I/O page are shown Table 3-7.

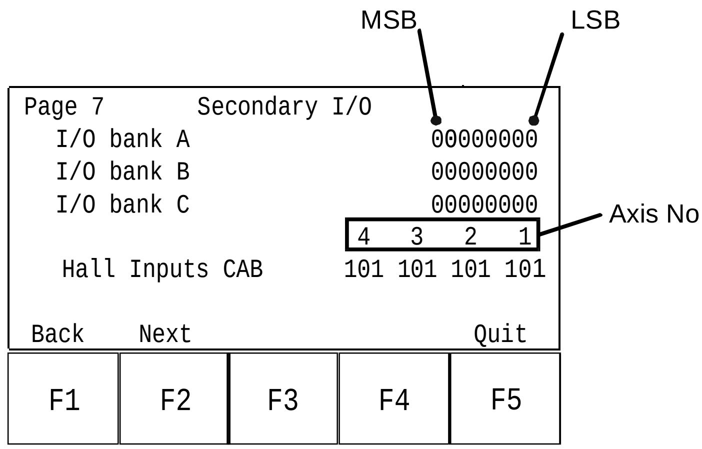


Figure 3-29. Secondary I/O Page

Table 3-7. Secondary I/O Diagnostics

Field	Status Description
I/O banks A-C	Shows the current input status of the 8 X 3 I/O bus if programmed as inputs. When configured as outputs, shows the programmed output value. See the IOSET and IO commands in Chapter 5: Programming Commands.
Hall Inputs CAB	Applicable only with AC brushless motors. Indicates the state of the Hall sensors. See Motor Setup (MSET) command in Chapter 5: Programming Commands.

3.6.8. Diagnostics Menu: Terminal Page

The Terminal page (refer to Figure 3-30) monitors serial and GPIB communications between the U511 and a host system. This page may also be used to send characters. To select the port to transmit to, press the up or down arrows. The selected port will have an underline cursor (_). Other ports will have a solid block cursor. Type from the keyboard or input from the front panel. These characters will be transmitted to the host system. An "*" beside the port indicates that remote communications are active on that port. The active components of the Terminal page are shown in Table 3-8.

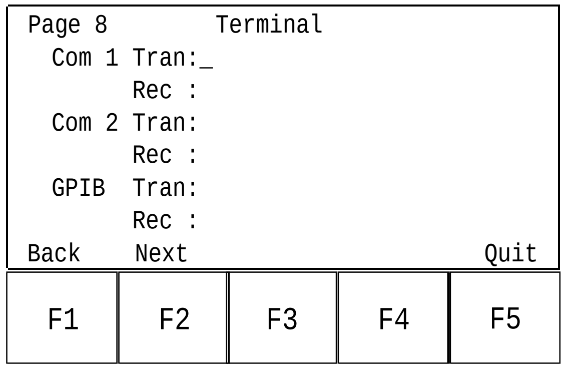


Figure 3-30. Terminal Page

Table 3-8. Active Components of the Terminal Page

Field	Status Description
Tran:	Sends and displays characters transmitted to the host system from the selected port. Pressing ENTER will send the EOS (end of string) character.
Rec:	Displays characters received from any/all ports. Nonprintable characters will be displayed in hexadecimal format and in brackets.

3.7. Tune Menu

Upon pressing the F4 key in the Power-up screen, the Tune screen appears (refer to Figure 3-31). The Tune screen is used for axis tuning. This screen can be used to manually enter Kpos, Ki, Kp, Vff, and Aff gains. Use the up and down arrows to select the field to be modified. Move the cursor to the desired field and enter the numerical value. Press ENTER to activate the gain in the servo loop. Press Save (F4) to save the new gain values to the parameter file.

```
Axis 1
Kpos  100
Ki    10000     Distance (mm)  80.0000
Kp    600000    Bandwidth (Hz) 35
Vff   256       Frequency (Hz) 1
Aff   0         Damping        .7

 Axis    Auto   Restore   Save    Quit
  F1      F2      F3       F4      F5
```

Figure 3-31. Tune Screen

There are five functions on this screen, which are described below:

F1 Axis	Axis selects the axis displayed on the screen (1-4).
F2 Auto	Performs autotuning. See below.
F3 Restore	Restore sets the tuning values back to stored values.
F4 Save	Save stores tuning values/gains to the parameter file.
F5 Quit	Quit is used to exit the tuning screen.

This screen can also be used to automatically calculate gains. The process is called autotuning. The UNIDEX 511 does this by moving the motor in a progressively faster back and forth motion and recording the current required for the move. This data is used along with the user-specified Bandwidth and Damping parameters to calculate servo loop gains.

Setting Distance and Frequency

The first step in autotuning is to set the Distance and Frequency parameters. The Distance parameter determines how much the motor moves, and Frequency determines the speed of movement during autotuning. Typical values are 25-100 mm for Distance and 1 Hz for Frequency. If a RMS error occurs during autotuning, the Distance or Frequency may be set too high. If the Distance is too low, the U511 responds with "Could not calculate gains!"

Setting Bandwidth and Damping

The Bandwidth and Damping parameters specify the desired response of the motor. The higher the Bandwidth, the better the stage performance will be. This means minimizing velocity error, position error, and settling time. Higher Bandwidth numbers will result in higher servo loop gains. A typical value of Bandwidth is 35 Hz.

The Damping parameter determines how the motor comes into position. A low Damping value (.3) may allow the axis to come into position more quickly, but take longer to completely settle. There may also be some overshoot at the end of the move. A value of .7 will ensure that there is minimal overshoot. A typical value of Damping is .5.

Procedure for Autotuning

1. Defeat Position and Velocity Error traps. This is done by modifying the "Global fault mask" on Page 9 of the Setup Menu (see axis parameter x55).
2. Set starting gains. If the user does not have "working" gains, set Kpos = 1, Ki = 1000, Kp = 10,000, and Vff = 256.
3. Set excitation Distance and Frequency. Distance is in current units (mm or in).

   Typical Distance = 25 mm or 1 in (see text)

   Typical Frequency = 1 Hz
4. Set desired bandwidth and damping. A Bandwidth of 10 Hz and Damping of .5 are good starting points.
5. Run autotune by pressing the Auto key (F2).
6. Increase bandwidth by 5 Hz increments until system becomes loud or unstable. Return to next lower bandwidth and retune.
7. Save gains to parameter file by pressing F4.
8. Re-enable Position and Velocity Error traps (see axis parameter x55).

> Autotuning cannot be run on stepper motors, motors with tachometer feedback, or dual loop systems.

> See the autotuning portion of the Chapter 8 for additional information on autotuning.

3.7.1. Troubleshooting Autotuning

Some tips for troubleshooting autotuning are given in Table 3-9.

Table 3-9. Troubleshooting the Autotune Process

Problem	Possible Causes / Solutions
System responds with "Could not calculate gains!"	An axis fault has occurred. Ki and Kp must be set > 0. Vff must be set to 256. Current is too high, lower Distance or Frequency. Tracking rate of feedback device has been exceeded, lower Distance or Frequency. Top feedrate trap occurs. Lower Distance or Frequency, or defeat trap if allowed.
Motor makes a loud noise and shuts off immediately	Gains are set too high, decrease Ki and Kp. Motor commutation parameters are incorrect (AC motors only). Encoder signals are missing, verify in Diagnostics. Encoder is damaged, verify on Diagnostics.
Motor does not move at all	Motor is not enabled. Motor is disconnected. Amplifier has faulted. Shut system off for 30 seconds and retry.

3.8. MDI Menu

Upon hitting the F5 key in the Power-up screen, the Machine Direct Input (MDI) screen appears (refer to Figure 3-32). The MDI screen provides joystick control, jog operations, and the ability to enter individual commands. This screen also shows U511 status information. The first line relates whether the U511 is in incremental or absolute mode. It also shows MFO percentage and the feedrate. The next four lines display axis position and status information. Commands may be typed in using an external keyboard or menu-assisted commands may be entered using the Commands (F4) function. The up and down arrows scroll through a list of previously entered commands.

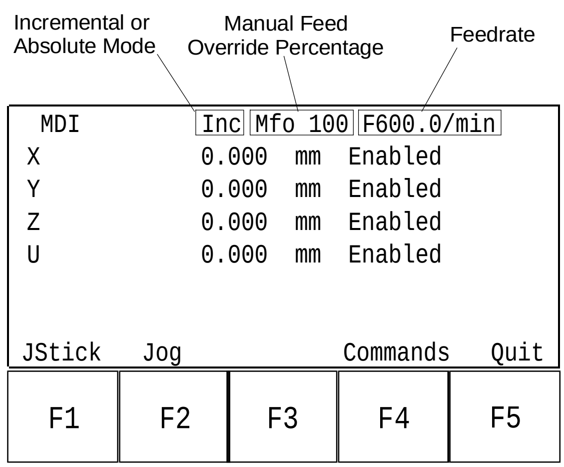


Figure 3-32. MDI Screen

There are four functions at the bottom of the screen, three of which lead to other screens. They are described below.

F1 JStick	Opens the Joystick screen where axes can be positioned using the joystick.
F2 Jog	Opens the Jog screen where axes can be positioned using the left and right arrow keys.
F4 Commands	This function summons the Command screen where users can build a command without using the keyboard. It also helps the user with program command syntax. This is the same routine as in the Program: Edit submenu.
F5 Quit	Quit exits the MDI screen and returns to the Main menu.

3.8.1. MDI Menu: Joystick Submenu

The joystick function screen is shown in Figure 3-33 This screen allows the operator to move the axes to a desired point using the joystick. Axis position information will be automatically updated on the screen. It will only activate if a joystick is connected to the U511. Any pair of enabled axes will be selectable with the joystick "B" button. Pressing the joystick "C" button or the Quit (F5) key terminates this screen.

```
  MDI          Inc Mfo 100 Slew  h x, 0
X              0.000 mm  Enabled
Y              0.000 mm  Disabled
Z              0.000 mm  Disabled
U              0.000 mm  Disabled



                                 Quit
   F1      F2      F3      F4      F5
```

Figure 3-33. JStick Screen

3.8.2. MDI Menu: Jog Submenu

The jog screen (refer to Figure 3-34) allows the user to move an axis under manual control. Pressing the left or right arrow key does this. Axis motion will stop when the key is released. The jog axis is shown in reverse video and is selected by pressing the up and down arrow keys. Axis motion can be continuous (freerun) or of a fixed distance (index). Refer to the Setup section for jog speed and distance parameters. This screen can also be used to enable/disable or Home an axis. The currently selected axis is shown in reverse video.

```
        Jog:  Freerun - High Speed
X              3.725 mm  Enabled
Y            -33.608 mm  Enabled
Z              4.900 mm  Enabled
U              4.275 mm  Enabled

Arrows: UP/DN Select Axis, LF/RT Jog
 High   Index   Disable   Home   Quit
   F1      F2      F3      F4      F5
```

Figure 3-34. Jog Screen

There are five functions at the bottom of the screen. These are described below.

F1 High/Low	This function selects high or low speed.
F2 Index/Freerun	This function selects index or freerun mode.
F3 Enable/Disable	This function will enable or disable the axis.
F4 Home	This function will Home the selected axis.
F5 Quit	Quit exits the Jog screen.

3.8.3. MDI Menu: Commands Submenu

This screen is for menu-assisted command entry. Essentially it is the same screen as the Command Edit screen under the Program: Edit submenu. Refer to Section 3.4.2: Program: Menu: the Edit Submenu to receive instructions on using the Commands screen.

∇ ∇ ∇

CHAPTER 4: PARAMETERS

In This Section:

4.1. Introduction

This chapter describes all of the parameters of the UNIDEX 511 system. Parameters are assembled into 11 groups based on their appearance on "pages" in the Setup menu (F2). Each page of the menu represents a group of related parameters. The sections in this chapter are arranged according to these groups under a subtitle that has the name of the page to which the parameters belong. Within these sections, parameters are presented in the order in which they appear in the software. Additional sections are included to explain topics that are closely related to the parameters. Table 4-1 shows a listing of the parameters and their default values grouped by page.

For easy reference the parameter number is displayed in the margin beside the parameter explanation. An example is illustrated in the margin to the right. **009**

Table 4-1. U511 Parameters Grouped by Page

Parameter Number	Description	Default Value	Found on Page #
Page 1: System Configuration			4-7
600	"Auto enable axes"	No axis enabled	4-7
601	"Auto run program"	None	4-7
602	"Axis calibration file"	None	4-7
603	"Parameter file"	U511.PRM	4-7
604	"Firmware file"	A:\U511.JWP	4-7
605	"M-code file"	None	4-7

Table 4-1. U511 Parameters Grouped by Page (continued)

Parameter Number	Description	Default Value	Found on Page #
606	"Global subroutine file"	GLBSUB.PRG	4-8
607	"PSO-PC firmware file"	None	4-8
15	"PSO-PC DPRAM address" (hex address 0xnnnn)	0xD800	4-8
16	"PSO-PC I/O address" (hex address 0xnnn)	0	4-9
98	"Safe zone output bit 0,1-8"	0	4-9
99	"Option board setup code"	0	4-9
500	"User interrupt setup code"	0	4-10
90, 92, 94, 96	"A/D *channel n* joystick deadband"	0	4-10
91, 93, 95, 97	"A/D *channel n* center"	0	4-11
647	"Enable speaker" (y/n)	No	4-11
648	"Password"	None	4-12
501	"Abort on input high 0, 1-16"	0	4-12
Pages 2 and 3: Serial Port #n Setup			4-13
608, 617	"Baud rate" (bits per second)	9600	4-13
609, 618	"Data bits" (bits)	8	4-13
610, 619	"Stop bits" (bits)	1	4-13
611, 620	"Parity" (N, O, E)	N	4-13
612, 621	"End of string character"	10	4-13
613, 622	"Fast output?" (y/n)	Yes	4-13
614, 623	"Command ACK character"	6	4-14
615, 624	"Command NAK character"	21	4-14
616, 625	"Default configuration"	0	4-14
Page 4: GPIB/IEEE - 488 Setup			4-15
626	"GPIB address" (0-30)	2	4-15
627	"EOS character"	10	4-15
628	"Parallel Pol Response bit" (0-NONE or 1-8)	0	4-15
629	"Time out" (seconds)	30	4-15
630	"Default configuration"	0	4-15
Page 5: Axis Configuration			4-16
x00	"Metric conversion factor" (mach. steps/program step)	1.0	4-16
x01	"English conversion factor" (mach. steps/program step)	1.0	4-16

Table 4-1. U511 Parameters Grouped by Page (continued)

Parameter Number	Description	Default Value	Found on Page #
x16	"Max accel/decel" (machine steps/ms/ms)	1.00000000	4-19
x11	"Positive (+) move is CW" (y/n)	Yes	4-19
x12	"Positive (+) jog same as + move" (y/n)	Yes	4-20
x13	"Enable pause in freerun" (y/n)	Yes	4-20
x14	"Enable MFO in freerun" (y/n)	Yes	4-21
x15	"Enable axis calibration" (y/n)	No	4-21
x35	"In position deadband" (machine steps)	10	4-25
x37	"Backlash correction amount" (machine steps)	0	4-26
x50	"Joystick high speed" (machine steps/sec)	40960	4-27
x51	"Joystick low speed" (machine steps/sec)	2560	4-27
x52	"Joystick absolute scale" (machine steps)	10	4-28
x71	"Enable orthogonality table" (y/n)	No	4-29
x72	"Enable 2-D error mapping" (y/n)	No	4-29
11, 12, 13, 14	"Modulo rollover" (machine steps)	0	4-29
x83	"Filter time constant" (ms)	0	4-31
x84	"AUX output active high" (y/n)	Yes	4-31
x85	"Reverse Joystick Directions"	No	4-31
631, 632,633, 634	"Jog low speed" (machine steps/ms)	10	4-31
635, 636, 637, 648	"Jog high speed" (machine steps/ms)	25	4-31
639, 640, 641, 642	"Jog distance" (machine steps)	4000	4-31
Page 6: Servo Loop			4-32
x25	"Kpos" (0-8,388,607)	50	4-32
x26	"Ki" (0-8,388,607)	5000	4-32
x27	"Kp" (0-8,388,607)	100000	4-32
x28	"Vff" (0-8,388,607)	256	4-33
x29	"Aff" (0-8,388,607)	0	4-33
x62	"Loop update rate (* .25 ms)" (1-100)	1	4-34
x24	"Enable Notch filter?" (y/n)	No	4-34
x30	"Notch filter N0"	0.00000000	4-35
x31	"Notch filter N1"	0.00000000	4-35
x32	"Notch filter N2"	0.00000000	4-35
x33	"Notch filter D1"	0.00000000	4-35
x34	"Notch filter D2"	0.00000000	4-35
x78	"Servo loop type"	0	4-35

Table 4-1. U511 Parameters Grouped by Page (continued)

Parameter Number	Description	Default Value	Found on Page #
Page 7: Homing and Limits			4-41
x02	"Home direction CCW" (y/n)	Yes	4-42
x03	"Home switch normally open" (y/n)	Yes	4-43
x04	"Home feedrate" (machine steps/ms)	25.00000000	4-44
x06	"Home offset" (machine steps)	0	4-44
x09	"Limit switch normally open" (y/n)	Yes	4-45
x10	"Limit to mechanical stop" (machine steps)	2000	4-45
x22	"CCW software limit" (machine steps)	-140,737,488,355,327	4-46
x23	"CW software limit" (machine steps)	140,737,488,355,327	4-46
x74	"Use home limit during home" (y/n)	No	4-47
x75	"Safe zone - limit" (machine steps)	0	4-47
x76	"Safe zone + limit" (machine steps)	0	4-47
x77	"Limit debounce distance" (machine steps)	750	4-48
Page 8: Motor and Feedback			4-49
x38	"Position channel"	Axis # = Channel #	4-56
x39	"Velocity channel"	0	4-57
x40	"Position setup code"	3	4-58
x41	"Velocity setup code"	3	4-59
x42	"Amplifier type" (0-DC Brush, 1-AC Brushless, 2-Step, 3-recirc)	0	4-60
x43	"Commutation cycles/rev"	4	4-61
x44	"Feedback steps/rev"	4000	4-62
x45	"Commutation phase offset" (0-359 degrees)	0	4-62
x46	"Stepper high current %" (0-100%)	70.0000	4-62
x47	"Stepper low current %" (0-100%)	35.0000	4-63
x63	"Microstepping resolution" (machine steps)	4000	4-63
x64	"Stepper correction" (y/n)	Yes	4-63
x65	"Stepper correction speed" (microstep/ms)	1.00000000	4-64
x66	"Base speed" (machine steps/ms)	0	4-64
x67	"Base speed advance" (0-359 degrees)	0	4-65

Table 4-1. U511 Parameters Grouped by Page (continued)

Parameter Number	Description	Default Value	Found on Page #
x68	"Phase speed" (machine steps/ms)	0	4-65
x69	"Phase speed advance" (0-359 degrees)	0	4-65
x79	"Primary DAC offset" (mV)	0	4-65
x80	"Secondary DAC offset" (mV)	0	4-65
x82	"Encoder factor"	0	4-66
Page 9: Fault Masks			4-67
x55	"Global fault mask"	FFFFFFFF319F	4-69
x56	"Disable"	FFFFFFF0EF87	4-69
x57	"Interrupt"	FFFFFFF00000	4-69
x58	"AUX output"	FFFFFFF00000	4-69
x59	"Halt queue"	FFFFFFF08E00	4-70
x60	"Abort motion"	FFFFFFFF9E78	4-70
x61	"Enable brake"	FFFFFFF00000	4-70
Page 10: Traps			4-71
x17	"Top feedrate" (machine steps/ms)	440.000000	4-71
x18	"Max velocity error" (0-8,388,607)	1000	4-72
x19	"Max position error" (0-8,388,607)	4000	4-73
x20	"Max integral error" (0-8,388,607)	655360	4-74
x48	"RMS current trap" (0-100%)	30.0000	4-75
x49	"RMS current sample time" (1-16,383 ms)	10000	4-77
x53	"Clamp current output" (0-100%)	100.0000	4-78
x54	"AUX fault output bit"	Axis # = Bit #	4-79
x70	"Amplifier fault active low" (y/n)	Yes	4-80
Page 11: Planes and Mapping			4-81
0	"Number of contour planes" (1,2,4)	1	4-84
1	"Keep position after reset?" (y/n)	No	4-86
2	"MFO pot offset" (0-255)	0	4-87
3	"Axis 1 plane 1-4 as XYZU"	1,X	4-88
4	"Axis 2 plane 1-4 as XYZU"	1,Y	4-88
5	"Axis 3 plane 1-4 as XYZU"	1,Z	4-88

Table 4-1. U511 Parameters Grouped by Page (continued)

Parameter Number	Description	Default Value	Found on Page #
6	"Axis 4 plane 1-4 as XYZU"	1,U	4-88
7	"Axis 1 gantry y/n slave 2,3,4"	None	4-90
8	"Axis 2 gantry y/n slave 1,3,4"	None	4-90
9	"Axis 3 gantry y/n slave 1,2,4"	None	4-90
10	"Axis 4 gantry y/n slave 1,2,3"	None	4-90
18, 36, 54, 72	"Segment time" (1-20 ms)	10	4-93
19, 37, 55, 73	"Ramp time" (ms)	150	4-94
20, 38, 56, 74	"Default to metric" (y/n)	Yes	4-95
21, 39, 57, 75	"Linear accel/decel" (y/n)	No	4-96
22, 40, 58, 76	"Contour feedrate" (program steps/ms)	16.00000000	4-97
23, 41, 59, 77	"X axis index feedrate" (program steps/ms)	16.00000000	4-97
24, 42, 60, 78	"Y axis index feedrate" (program steps/ms)	16.00000000	4-97
25, 43, 61, 79	"Z axis index feedrate" (program steps/ms)	16.00000000	4-97
26, 44, 62, 80	"U axis index feedrate" (program steps/ms)	16.00000000	4-97
27, 45, 63, 81	"Clamp feedrate" (program steps/ms)	256.00000000	4-98
28, 46, 64, 82	"Corner rounding time" (1-32000 ms)	150	4-98
29, 47, 65, 83	"Metric digits" (1-8)	3	4-101
30, 48, 66, 84	"English digits" (1-8)	4	4-102
31, 49, 67, 85	"Contouring mode"	0	4-103

4.2. Page 1: System Configuration

Page 1 parameters primarily allow the user to indicate which files will be run after reset. Configuration parameters for the optional PSO-PC board are also included, as are parameters for setting the joystick deadband and center position. These and other parameters are explained in detail in this section.

4.2.1. "Auto enable axes"

Parameter 600 selects the axes that are automatically enabled on power up. Axes X, Y, Z, and/or U can be selected. To deselect an axis, simply delete the entry leaving the field blank. No axes enabled is the default setting. **600**

4.2.2. "Auto run program"

Parameter 601 selects a program to be loaded and executed in auto mode after power up. The default setting is a blank, meaning no program is to be executed. To deselect a file, simply delete it, leaving the field blank. **601**

4.2.3. "Axis calibration file"

Parameter 602 is the "Axis calibration file" loaded to the DSP during reset. The default setting is blank; meaning no calibration file is to be used. To deselect a file, simply delete it, leaving the field blank. **602**

4.2.4. "Parameter file"

Parameter 603 specifies the file containing parameters 0-99 and axis parameters 100-199, 200-299, 300-399, and 400-499. The default file is U511.PRM. If the UNIDEX 511 is factory configured by Aerotech, this field will contain a file name of the form 123456.PRM. The six-digit number is the Aerotech reference number for the system. **603**

4.2.5. "Firmware file"

Parameter 604 is the file loaded to the DSP during reset. The default file is A:\U511.JWP. **604**

4.2.6. "M-code file"

Parameter 605 is a file containing "M"-code definitions that can be accessed from any program. The default setting is a blank; meaning no program is available. To deselect a file, simply delete it, leaving the field blank. **605**

4.2.7. "Global subroutine file"

606

Parameter 606 is a file containing global subroutines that can be called from any program. The default setting is GLBSUB.PRG. To deselect a file, simply delete it, leaving the field blank. The GLBSUB.PRG file contains skeleton subroutines that are automatically executed when the PAUSE, ABORT, or FLTACK keys are pressed or when the system is first powered up.

4.2.8. "PSO-PC firmware file"

607

The UNIDEX 511 has several optional accessories that can be used to augment the operation of the system. One such option is the PSO-PC card. Parameter 607 is the file that is loaded to the PSO card after reset. If a PSO-PC card is installed, this field should be set to "A:\PCPSO.FRM." The default setting is blank; meaning no program is available. To deselect a file, simply delete it, leaving the field blank. For more information about the PSO-PC card, refer to the PSO-PC Operation and Technical Manual (P/N: EDO105).

4.2.9. "PSO-PC DPRAM address" (hex address 0xnnnn)

015

The UNIDEX 511 has several optional accessories that can be used to augment the operation of the system. One such option is the PSO-PC card. If the PSO option is used with the UNIDEX 511 system, then parameters 015 and 016 must be configured to permit proper communications between the PSO-PC board and the U511. System parameter 015 specifies (in hexadecimal) the base address of the dual-ported RAM. System parameter 016 specifies the I/O port address.

By default, the PSO-PC is configured to use DPRAM base address 0x0D800 and I/O address 310. For more information about the PSO-PC card, refer to the PSO-PC Operation and Technical Manual (P/N: EDO105).

> The dual PSO-PC hardware decodes 4K (4096) byte blocks of system memory. The dual-ported RAM size is 2K (2048) bytes. Therefore, the dual-ported RAM appears twice within the 4 K byte memory block. The default jumper settings of the PSO-PC board map the dual-ported RAM to memory locations D800:0000 and D800:0800. The first 2 K byte block should be used for programming consistency.

> This parameter must agree with the hardware address setting specified by jumpers JP16-JP23 of the PSO-PC board. Refer to the PSO-PC manual (EDO105) for more information.

4.2.10. "PSO-PC I/O address" (hex address 0xnnn)

If the PSO option is used with the U511 system, then parameters 015 and 016 must be configured to permit proper communications. Parameter number 016 specifies (in hexadecimal) the host base address for use with the U511 motion controller. Set this parameter to 0 to disable the board and to 310 to enable it. For more information about the PSO-PC card, refer to the PSO-PC Operation and Technical Manual (P/N: EDO105). 016

> This parameter must agree with the hardware address setting specified by jumpers JP2-JP7 on the PSO-PC board. For additional information, refer to the PSO-PC manual (EDO105).

4.2.11. "Safe zone output bit 0,1-8"

Parameter 098 specifies which UNIDEX 511 output to turn on (low) when all axes are in their specified Safe Zones. See parameters x75 and x76 under Homing and Limits for an explanation of Safe Zone. 098

This parameter can have a value of zero or 1 through 8. A parameter value of zero, which is the default value, defeats the safe zone function.

4.2.12. "Option board setup code"

Parameter 099 indicates which option board is being used. The option board is determined by the status of the first two bits of parameter 099. The configuration can be changed by entering an appropriate decimal value for Parameter 099. The settings for parameter 099 are given in Table 4-2. 099

bit #0:	Setting bit #0 causes the U511 to enable access to the 4EN Option board. Inputs are read using the IN2 and IN3 commands. Outputs are written using the OU1, OU3, and OU4 commands.
bit #1	Setting bit #1 enables scanning of an optional iSBX encoder card. The encoder position can be read from the U511's memory at L:1BC3.
bits #2-#23	Reserved.

Table 4-2. Settings for Parameter 099

Parameter #	Range	Default Value
099	0 - 8388607	0

4.2.13. "User interrupt setup code"

500

Parameter 500 sets the usage of the user interrupt input. The usage is determined by the status of the first two bits of parameter 500. The configuration can be changed by entering an appropriate decimal value for the parameter. This input is active low. Settings for parameter 500 are given in Table 4-3.

bit #0	Set to 1 to abort all axis motion on user interrupt.
bit #1	If set to 0, the UINT_N input will disable itself after the first occurrence. If this bit is set to 1, the UINT_N input will remain active.
bit #2-#23	Reserved.

Table 4-3. Settings for Parameter 500

Parameter #	Range	Default Value
500	0 - 8388607	0

4.2.14. "A/D *channel n* joystick deadband" Parameters

090 092 094 096

These parameters define the deadbands associated with the center position of the joystick. There is no resulting motion when the joystick is within this band. The parameter value is the number of A/D counts in the deadband. The default value is zero, which is internally interpreted as 16 A/D counts for backward compatibility.

The parameter definitions are listed in Table 4-4. Parameters 090 and 092 are currently not used because the joystick is connected to channel numbers 3 and 4. A/D channel number 1 is normally the MFO input. A/D channel 2 is normally the user analog input.

Table 4-4. Joystick Deadband Parameters

Parameter #	A/D Channel	Default Value
090	A/D Channel No. 1	0
092	A/D Channel No. 2	0
094	A/D Channel No. 3 (joystick vertical axis)	0
096	A/D Channel No. 4 (joystick horizontal axis)	0

The A/D converter is 8 bits scaled so that 0 V gives an output of 0 and +5 V gives an output of 255. An A/D output of 128 corresponds to an input of +2.5 V.

4.2.15. "A/D *channel n* center" Position Parameters

These parameters specify the center position of the A/D inputs used for joystick mode. 091
This allows the joystick pot to be digitally centered or calibrated. The parameter value is
the number of A/D counts assigned to the center position. The default value is zero, which
is internally interpreted as 128 A/D counts (2.5 V) for backward compatibility. 093

The parameter definitions are listed in Table 4-5. Parameters 091 and 093 are currently
not used because the joystick is connected to channel numbers 3 and 4. A/D channel no. 1 095
is normally the MFO input. A/D channel 2 is normally the user analog input.

097

Table 4-5. Joystick Center Position Parameters

Parameter #	A/D Channel	Default Value
091	A/D Channel No. 1	0
093	A/D Channel No. 2	0
095	A/D Channel No. 3 (joystick vertical axis)	0
097	A/D Channel No. 4 (joystick horizontal axis)	0

The A/D converter is 8 bits scaled so that 0 V gives an output of 0 and +5 V gives an output of 255. An A/D output of 128 corresponds to an input of +2.5 V.

4.2.16. "Enable speaker"

Parameter 647 turns the audible feedback system on or off. With the parameter set to 647
"yes" the U511 will make an audible beep every time a key on the front panel or keyboard
is pressed. With this parameter set to "no," no beeps will be heard. However, even with
the speaker disabled, the U511 will beep once upon power up. The default condition is
"no."

648

4.2.17. "Password"

If a password is entered in parameter number 648, the UNIDEX 511 will prompt the user for a password when turned on. An incorrect password will prohibit the user from modifying system parameters and programs. A blank entry in parameter 648 will defeat the password function. The settings for the password parameter are shown in Table 4-6.

Table 4-6. Settings for Parameter 648

Parameter #	Range	Default Value
648	0 -20 characters	Blank

501

4.2.18. "Abort on input high 0, 1-16"

Parameter 501 allows the user to define an input bit on the 16 IN/8 OUT I/O connector as a global abort input. All enabled axes will ramp to a stop and "Abort Active" will be displayed in the MDI window. This will occur when the input bit is in the logic "1" (+5 V or high impedance) state. A parameter setting of 0 (the default) defeats the Abort input. Parameter settings are given in Table 4-7.

Table 4-7. Settings for Parameter 501

Parameter #	Range	Default Value
501	0, 1-16	0

4.3. Pages 2 and 3: Serial Port *#n* Setup

Parameters on pages 2 and 3 of the U511 are identical. Each set of parameters is related to one of the two RS-232 serial data ports. In this section, the parameters for configuring these serial ports for data transmission are discussed. Each discussion covers the parameter for data port 1 and the corresponding parameter for data port 2.

4.3.1. "Baud rate" (bits per second)

Parameters 608 and 617 specify the data transmission rate of serial ports 1 and 2, respectively, in bits per second. Allowable baud rates are 1200, 2400, 4800, 9600, 19,200, 38,400, 57,600, and 115,200 bits per second. The default value is 9600.

608, 617

4.3.2. "Data bits" (7-8)

Parameters 609 and 618 specify the number of data bits used to represent one character of data. The options are 7 or 8 bits. The default is 8 bits.

609, 618

4.3.3. "Stop bits" (1-2)

In asynchronous transmission, stop bit(s) are the last bits used to indicate the end of a character. Parameters 610 and 619 represent the number of bits used to indicate the end of a character. The choices are 1 or 2 bits. The default is 1 bit.

610, 619

4.3.4. "Parity" (N, O, E)

Parity is an error detection scheme that uses and extra checking bit, called the parity bit, to allow the receiver to determine whether there has been an error in the received data. The value of the bit is set so that the sum of the data bits and the parity bit is always either even (for even parity) or odd (for odd parity). Parameters 611 and 620 are the RS-232 parity setting. The choices are N for none, O for odd, and E for even. The default is N.

611, 620

4.3.5. "End of string character"

Parameters 612 and 621 specify a value that should be used to terminate remote commands to the U511. This character will terminate strings returned by the U511. The character may range from 0 to 255. The default has a decimal value of 10 and a hexadecimal value of 0x0A (line feed [LF] character).

612, 621

4.3.6. "Fast output?" (y/n)

The UNIDEX 511 will output characters as fast as possible if parameter 613 or 622 is set to yes. If set to no, a slight delay will be inserted between characters transmitted. The default value is yes.

613, 622

4.3.7. "Command ACK character"

614, 623

The U511 will return the character specified in parameter 614/623 after it has successfully received and decoded a remote command. The host computer should wait for this character (or NAK) to be returned from the U511. If a time out occurs, the communications port should be cleared (send ##). The parameter can range from 0 to 255. The default has a decimal value of 6 and a hexadecimal value of 0x06.

4.3.8. "Command NAK character"

615, 624

The U511 will return the character specified by parameter 615/624 if it receives an unknown remote command or if a syntax error exists with an immediate command. The host computer should wait for this character (or ACK) to be returned from the U511. If a time out occurs, the communications port should be cleared (send ##). The value of this parameter may range from 0 to 255. The default value has a decimal value of 21 and a hexadecimal value of 0x15.

4.3.9. "Default configuration"

616, 625

The number of parameter 616/625 specifies the operation of the remote interface after a power up condition. See Chapter 6: Remote Mode Operations for more information. This parameter can range from 0 to 8,388,607 and the default value is 0.

Any communication parameter can be entered in hexadecimal format, as in 0x123, or decimal format, as in 163.

4.4. Page 4: GPIB/IEEE-488 Setup

Parameters in this section address the setup of the GPIB/IEEE-488 port.

4.4.1. "GPIB address" (0-30)

U511 controllers can be linked through the GPIB bus. Each controller would then be given an address of its own. Parameter 626 is the communications address of the U511 GPIB port. The value may range from 0 to 30. The default value is 2. **626**

4.4.2. "EOS character"

The character represented by parameter 627 should terminate all strings received by the U511. All strings returned by the U511 are terminated by this character and EOI. The default has a decimal value of 10 and a hexadecimal value of 0x0A (line feed [LF] character). **627**

4.4.3. "Parallel Pol Response bit" (0-NONE or 1-8)

Parameter 628 determines how the U511 responds to a parallel poll. If a service request is pending, the specified bit, either 1 through 8 will be read as logic 1. If this parameter is set to 0, the U511 does not respond to the parallel poll. The default value is 0. **628**

4.4.4. "Time out" (seconds)

Parameter 629 is the time out setting for the bus. The default setting is 0. **629**

4.4.5. "Default configuration"

The number of parameter 630 specifies the operation of the remote interface after a power up condition. See Chapter 6: Remote Mode Operations for more information. This parameter can range from 0 to 8,388,607 and the default value is 0. **630**

> Any communication parameter can be entered in hexadecimal format as in 0x123 or in decimal format as in 163.

4.5. Page 5: Axis Configuration

The Axis Configuration page contains miscellaneous parameters used to configure the UNIDEX 511 system. These parameters are explained in detail in this section. Parameters with and "x" in front of them actually represent 4 different parameters where x can equal 1, 2, 3, or 4 for axes 1, 2, 3, or 4, respectively.

4.5.1. "Metric (x00) and English (x01) conversion factors"

x00

x01

A *conversion factor* is a number that determines system scaling (i.e., the number of machine steps in relation to program steps). These parameters give the operator the flexibility to define arbitrary program units (inches, tenths of inches, millimeters, centimeters, etc.) on a per axis basis for either Metric or English measuring systems. The following terms are used in the explanation of the system conversion (scale) factor:

Program Unit — User units such as inches, millimeters, degrees, etc. These are the units that are used within the application program.

Machine Step — Smallest feedback device step. This is the smallest possible increment of movement as measured by the feedback device.

Machine Steps/Unit — The number of machine steps per programming unit.

Program Steps — The smallest programmable increment of motion. Program steps = programming units * 10 ^{ndec} where "ndec" is the number of decimal digits set by the "Metric digits" and "English digits" parameters (parameter numbers 29, 47, 65, 83 and 30, 48, 66, 84, respectively).

If the number of decimal digits is specified as 3, then the programming step size is .001 (there are 1000 programming steps per programming unit).

The UNIDEX 511 uses one of two system conversion factors to convert programming units into machine steps. The default conversion factor used for each axis is specified as either English or Metric by the Metric system (yes/no) parameter (020, 038, 056, and 074). The scaling mode set by these parameters may be overridden by use of the G70 (English) or G71 (Metric) commands.

Conversion Factor Formula

The UNIDEX 511 uses an internal formula to derive conversion factors. This formula is shown below.

$$\text{Conversion Factor} = \frac{\text{Machine Steps}/\text{Programming Unit}}{\text{Program Steps}/\text{Programming Unit}} \qquad \text{or}$$

$$\text{Conversion Factor} = \frac{\left(\text{Machine Steps}/\text{Programming Unit}\right)}{10^{\text{ndec}}}$$

Conversion factors (i.e., parameters x00 and x01) are represented using a standard floating point number (e.g., 1.0) in the software package.

To calculate the conversion factor, the user will need:

1. The number of machine steps per programming unit.

   This is the number of encoder counts in 1 inch, 1 mm, or 1 degree, etc.

2. The number of program steps per program unit.

   This value is related to the number of decimal digits (ndec) parameter. Refer to Table 4-8.

Table 4-8. Relationship Between Number of Decimal Digits Parameters and the Number of Programming Steps per Programming Unit

Smallest Programming Unit	Number of Decimal Digits (ndec) Parameter	Program Steps per Programming Unit
0.1	1	10
0.01	2	100
0.001	3	1,000
0.0001	4	10,000
0.00001	5	100,000
0.000001	6	1,000,000
0.0000001	7	10,000,000
0.00000001	8	100,000,000

> The "Number of Decimal Place Digits" parameter needs to be entered separately in the axis plane. This should be done for both English and Metric scale factors.

Example 1

A rotary axis has a 5000-line encoder with a "times 10" external multiplier box. Calculate the conversion factor so that the programmed unit is in degrees with a resolution of 0.001 degrees.

The total machine step count is 5000 x 10 x 4 (= 200,000 counts per revolution) every 360 degrees. The number of machine steps per programming unit is 200000/360 = 555.55555555. The value $10^{ndec} = 10^3 = 1000$. The calculated conversion factor is 555.55555555/1000 = 0.55555555. Enter 0.55555555 in the value box.

Example 2

Consider the example of a system that has a 4 mm pitch ball screw (i.e., 4 mm/rev) and a 1,000 (x 4) line encoder. From this information, the English and Metric conversions are accomplished as follows:

Metric Scale Factor

In Metric mode, we know that the programming unit is 1 millimeter (1 mm). If 1 revolution of the ball screw motor produces 4,000 machine steps and 4 mm of motion, then the number of machine steps per programming unit is

$$\frac{\text{Machine Steps}}{\text{Prog Unit}} = \frac{\text{4,000 Machine Steps}}{\text{4 mm}} = \text{1000 Machine Steps / mm.}$$

The number of decimal places is usually selected so that programming steps and machine steps are of similar size. ndec = 3.

$$\text{Conversion factor} = \frac{\text{1,000 Machine Steps / mm}}{10^{3}} = 1.0$$

machine steps/programming unit = 1000

programming steps/programming units = 1000

1 Programming Step = 1 mm.

English Scale Factor

In English mode, one programming unit = 1 inch. One motor revolution is 1000 * 4 = 4,000 machine steps. Since 1 inch = 25.4 mm and one motor revolution = 4 mm, there are 6.35 motor revolutions per inch or 6.35 * 4,000 = 25,400 machine steps/programming unit. Four decimal places should be selected so that the programming resolution is not sacrificed.

$$\text{Conversion factor} = \frac{\text{25,400 Machine Steps / inch}}{10^{4}} = 2.54$$

This conversion factor is entered as 2.54.

Machine Steps / Programming Unit = 25,400

programming steps/programming unit = 1,000

Default

The conversion factor parameters each default to the value 1.0. Set the scale factor to 1.0 and the number of decimal places to 0 if you want to program in machine steps.

4.5.2. "Max accel/decel" (machine steps/ms/ms)

x16

Parameter x16 is the "Maximum accel/decel" parameter. The value of this parameter specifies the acceleration/deceleration rate of axis motion for all freerun (FReerun), home (HOme), and point-to-point (G0/INDEX) acceleration profiles. The same value is used for both acceleration and deceleration.

This parameter value can range from 0.004 to 255 machine steps/ms^2. The default value is 1.00000000 machine steps/ms^2. Refer to Table 4-9.

Table 4-9. Settings for Parameter x16

Param #	Axis #	Range (in machine steps/ms^2)	Default (in machine steps/ms^2)
116	1	0.004 to 255	1.00000000
216	2	0.004 to 255	1.00000000
316	3	0.004 to 255	1.00000000
416	4	0.004 to 255	1.00000000

The value of parameter x16 should be reduced if abrupt motion or servo traps occur during acceleration or deceleration during the home cycle (HOme), freerun (FReerun), or G0(INdex) programming commands.

This parameter does not apply to linear and circular contour motion. Contour motion uses the "Contour Ramp Time" parameter.

4.5.3. "Positive (+) move is CW" (y/n)

x11

Each axis of the UNIDEX 511 may be configured so that either a positive or negative command results in clockwise motor rotation. The direction of motor rotation is specified relative to "looking into" the shaft end of the motor.

This parameter can be set to either yes or no. Descriptions are given in Table 4-10.

Table 4-10. Settings for Parameter x11

Param #	Axis #	Description
x11	1, 2, 3, 4	Yes - A positive command results in CW motor rotation (default) No - A positive command results in CCW motor rotation

x12

4.5.4. "Positive (+) jog same as + move" (y/n)

Each axis of the UNIDEX 511 may be configured such that either a positive or negative jog command results in motion in the same or opposite direction as the "Positive (+) move is CW" (x11) parameter.

This parameter can be set to either yes or no. Descriptions are given in Table 4-11.

Table 4-11. Settings for Parameter x12

Param #	Axis #	Description
x12	1, 2, 3, 4	Yes - A positive jog results in motion that is in the same direction as specified by the "Positive (+) move is CW" parameter No - A positive jog results in motion that is in the opposite direction as specified by the "Positive (+) move is CW" parameter

x13

4.5.5. "Enable pause in freerun" (y/n)

This parameter is used to enable or disable the pause function when the associated axis is in freerun.

This parameter can be set to either yes or no. Descriptions are given in Table 4-12.

Table 4-12. Settings for Parameter x13

Param #	Axis #	Description
x13	1, 2, 3, 4	Yes - Pause function is enabled during freerun of the associated axis (default) No - Pause function is disabled during freerun of the associated axis

4.5.6. "Enable MFO in freerun" (y/n)

The UNIDEX 511 may be equipped with an external Manual Feedrate Override (MFO) potentiometer. This parameter is used to enable or disable this potentiometer's effect when the associated axis is in freerun. x14

This parameter value can be set to either yes or no. Descriptions are given in Table 4-13.

Table 4-13. Settings for Parameter x14

Param #	Axis #	Description
x14	1, 2, 3, 4	Yes - MFO potentiometer is enabled when the associated axis is in freerun (default) No - MFO potentiometer is disabled when the associated axis is in freerun

4.5.7. "Enable axis calibration" (y/n)

Axis calibration is an option available to the UNIDEX 511 user. A maximum of 2,047 points of correction data is available. These points are loaded to the DSP during initialization from a calibration (.CAL) file. Subsequent axis positioning is then adjusted based on the .CAL file data. x15

The table format is the number of absolute machine steps needed to correct the current position. Feedback polarity is always increasing for CW rotation and decreasing for CCW rotation. Correction numbers should be entered accordingly, regardless of home direction and programmed polarity. Correction can be positive or negative.

Axis calibration is repeating. A move outside the calibration window will be mapped back into the table. If this operation is undesirable, the end of the calibration file should be "padded" with the last error. In the case of circular calibration, the calibration table should equal one revolution.

Axis calibration will be active when:

- The "Enable axis calibration" parameter (x15) is set to "yes"
- The ASCII calibration file (.CAL) is present and specified in parameter number 602
- The axis has been homed

A sample of the ASCII file format for the calibration file is shown in Figure 4-1.

Axis calibration is enabled by axis parameter x15. Refer to Table 4-14. Sample calibration data are listed in Table 4-15.

Table 4-14. Settings for Parameter x15

Param #	Axis #	Description
115	1	Yes - Axis calibration is enabled for axis 1 No - Axis calibration is not enabled for axis 1 (default)
215	2	Yes - Axis calibration is enabled for axis 2 No - Axis calibration is not enabled for axis 2 (default)
315	3	Yes - Axis calibration is enabled for axis 3 No - Axis calibration is not enabled for axis 3 (default)
415	4	Yes - Axis calibration is enabled for axis 4 No - Axis calibration is not enabled for axis 4 (default)

```
;***** Comments *******************************************
;  The :START and :END statements surround the calibration information.
;  First non-comment line is axis number (1-4).  Second non-comment line
;  is the sample distance (in machine steps) that the axis must travel before
;  the next sequential correction datum is added to the current position to
;  correct it.  Correction data is space-separated and may be entered on
;  multiple lines.
;*****************  SAMPLE.CAL  ************************
:START                                  ;start axis call block
1                                       ;axis number  (1,2,3, or 4)
1000                                    ;sample distance in machine steps
                                        ;(>256)
1 2 3 5 7 9 12 14 16 14 10 8 5 2 1 0    ;absolute machine step correction
                                        ;data
:END                                    ;end axis call block
:START                                  ;next axis to be calibrated
2                                       ;axis number (1, 2, 3, or 4)
1000                                    ;sample distance in machine steps
1 1 1 2 4 2 5 10 8 8 7 6 6 2 1 1        ;absolute machine step correction
                                        ;data
:END                                    ;end axis call block
          :                                        :
          :                                        :
```

Figure 4-1. Sample ASCII Calibration File

Table 4-15. Sample Calibration Table

Displayed Distance	Actual Distance	Correction Data
1000	1001	+1
2000	2002	+2
3000	3003	+3
4000	4005	+5
5000	5007	+7
6000	6009	+9
7000	7012	+12
8000	8014	+14
9000	9016	+16
10000	10014	+14
11000	11010	+10
12000	12008	+8
13000	13005	+5
14000	14002	+2
15000	15001	+1
16000	16000	0

The calibration (.CAL) file can also contain axis orthogonality correction data. This is similar to axis calibration. Refer to Figure 4-2.

For orthogonality correction, axis correction will not begin until the position dependent axis completes a home cycle and axis parameter x71 of the position dependent axis ("Enable orthogonality table" parameter[x71]) is set to "yes."

IMPORTANT

It is conceivable that a single calibration (.CAL) file might contain eight sections: four axis calibration sections and four orthogonality correction sections. Axis calibration and orthogonality correction may be enable/disabled independently using parameters x15 and x71 as appropriate.

The corrected axis position (in machine steps) can be observed in the Diagnostics window.

```
;***** Comments ****************************************************
;  Standard calibration correction data ... (Only one axis is shown)
;*****************************************************************
:START                                   ; start axis call block
1                                        ; axis number  1,2,3,4
1000                                     ; sample distance in machine steps
1 2 3 5 7 9 12 14 16 14 10 8 5 2 1 0     ; abs mach step correction data
:END                                     ; end axis call block

;*****************************************************************
;  Axis orthogonality correction data can also be entered in the .CAL table.
;  The format is the same as above, except for the axis number component.
;  The axis number can be a two digit number AB, where A represents the
;  axis number to be corrected, and B represents the position dependent axis
;  number.  Correction does not begin until the B axis is homed.  The A axis
;  does not need to be homed.  A maximum of 256 points are allowed for
;  orthogonality correction.  The sample distance must be greater than
;  256 encoder counts.   An example follows.
;*****************************************************************
:START                                   ;start axis call block
21                                       ;ortho correction of axis 2 based on
                                         ;position of axis 1
1000                                     ;sample distance in machine steps
                                         ;(>256)
1 2 3 5 7 9 12 14 16 14 10 8 5 2 1 0     ; absolute machine step corr. data
:END                                     ;end axis call block
```

Figure 4-2. Sample Calibration File with Orthogonality Data

4.5.8. "In position deadband" (machine steps)

x35

The "In position deadband" parameter (x35) specifies a window (given in machine steps) into which the axis position error must fall in order for the "in position" status bit to be set. The UNIDEX 511 continually compares the axis position error (the difference between the commanded position of an axis and its feedback position) with the in-position dead-band value. If the position error is less than or equal to the value specified in parameter x35, then the "in position" status bit of the Diagnostics screen is set (a "*" appears). The in position status bit will not be set if axis motion is commanded.

The in-position dead-band parameter value is given in machine steps and can range from 0 to 65,536. The default value is 10 machine steps. Refer to Table 4-16.

> The UNIDEX 511 continues to drive the position error to zero even after it is within the established dead-band.

Table 4-16. Settings for Parameter x35

Param #	Axis #	Range	Default Values
135	1	0-65,536 machine steps	10 machine steps
235	2	0-65,536 machine steps	10 machine steps
335	3	0-65,536 machine steps	10 machine steps
435	4	0-65,536 machine steps	10 machine steps

x37

4.5.9. "Backlash correction amount" (machine steps)

The "Backlash correction amount" parameter (x37) specifies the number of machine steps required to compensate for any backlash present in the mechanical system after a direction change. Positioning accuracy is increased when this value is added to the new direction.

This parameter value can range from 0 to 65,536 machine steps. The default setting for this parameter is 0 (no backlash compensation for the specified axis). See Table 4-17.

Table 4-17. Settings for Parameter x37

Param #	Axis #	Range	Default Values
137	1	0-65,536 machine steps	0 (no backlash compensation)
237	2	0-65,536 machine steps	0 (no backlash compensation)
337	3	0-65,536 machine steps	0 (no backlash compensation)
437	4	0-65,536 machine steps	0 (no backlash compensation)

IMPORTANT

Large amounts of mechanical backlash will limit the usable band width of the servo system. This function will not satisfactorily compensate for a poor mechanical system.

4.5.10. "Joystick high speed" (machine steps/sec)

x50

The "Joystick high speed" (x50) parameter defines the speed of the associated axis when a joystick (SLEW) command is issued. Because resolution ratios vary between axes, the operator must ensure that the speed/distance ratio for each affected axis is compatible prior to requesting a joystick move.

The range of and default values for this parameter are given in Table 4-18.

Table 4-18. Settings for Parameter x50

Param #	Axis #	Range	Default Values
150	1	0-8,388,607 machine steps/sec	40,960 machine steps/sec
250	2	0-8,388,607 machine steps/sec	40,960 machine steps/sec
350	3	0-8,388,607 machine steps/sec	40,960 machine steps/sec
450	4	0-8,388,607 machine steps/sec	40,960 machine steps/sec

4.5.11. "Joystick low speed" (machine steps/sec)

x51

The "Joystick low speed" (x51) parameter defines the speed of the associated axis when a joystick (SLEW) command is issued. Because resolution ratios vary between axes, the operator must ensure that the speed/distance ratio for each affected axis is compatible prior to requesting a joystick move.

The range of and default values for this parameter are given in Table 4-19.

Table 4-19. Settings for Parameter x51

Param #	Axis #	Range	Default Values
151	1	0-8,388,607 machine steps/sec	2,560 machine steps/ sec
251	2	0-8,388,607 machine steps/ sec	2,560 machine steps/ sec
351	3	0-8,388,607 machine steps/ sec	2,560 machine steps/ sec
451	4	0-8,388,607 machine steps/ sec	2,560 machine steps/ sec

x52

4.5.12. "Joystick absolute scale" (machine steps)

The absolute mode scale parameter is a scaling value (from 0 to 255) that is multiplied by the 8-bit, analog-to-digital converter output value. It creates a window of axis movement that is used for fine positioning when the system is in joystick absolute mode.

This parameter value can range from 0 to 255 which corresponds to axis movement windows from ±100 machine steps up to ±25,500 machine steps. The default setting for this parameter is 10, which corresponds to a movement window of approximately -1,000 machine steps to 1,000 machine steps. Refer to Table 4-20.

Table 4-20. Settings for Parameter x52

Param #	Axis #	Param Range	Axis Movement Window (Range)	Default
152	1	0-255	0-25,500 machine steps	10 (1,000 machine steps)
252	2	0-255	0-25,500 machine steps	10 (1,000 machine steps)
352	3	0-255	0-25,500 machine steps	10 (1,000 machine steps)
452	4	0-255	0-25,500 machine steps	10 (1,000 machine steps)

The output from the 8-bit A/D converter is from 0-255. Some of these "counts" are used internally by the UNIDEX 511. As a result, the *usable* portion of the A/D output is approximately 200 counts. This provides a ±100 count (approximate) axis movement window prior to multiplication by parameter x52.

4.5.13. "Enable orthogonality table" (y/n)

x71

Parameter x71 is used to enable and disable the use of orthogonality data in a calibration (.CAL) file. When this parameter is enabled (set to "yes"), the corresponding axis is enabled for orthogonality correction. The orthogonality entries in the specified calibration (.CAL) file are used for this correction. Refer to Table 4-21.

Table 4-21. Settings for Parameter x71

Param #	Axis #	Description
171	1	Yes - Axis orthogonality correction is enabled for axis 1 No - Axis orthogonality correction is not enabled for axis 1 (default)
271	2	*same as axis 1*
371	3	*same as axis 1*
471	4	*same as axis 1*

For additional information, refer to Section 4.5.7: "Enable axis calibration" (on page 4-21).

4.5.14. "Enable 2-D error mapping" (y/n)

x72

Parameter x72 is used to enable and disable 2-dimensional error mapping of a pair of axes. When this parameter is enabled (set to "yes"), the UNIDEX 511 uses the contents of a .MAP file (usually provided by Aerotech) to perform 2-dimensional calibration of selected axes.

For additional information, contact the technical support department at Aerotech.

4.5.15. "Modulo rollover" (machine steps) for axes 1-4

011

012

013

014

The modulo rollover parameters (011, 012, 013, and 014) are used in rotary-type applications to define the number of machine steps associated with each *cycle*. Applications such as a rotary tables, for example, may require that you set a rollover point or a *modulo* distance. This allows the axis position to be read in units such as degrees. The sizes of the UNIDEX 511's absolute, relative and machine position registers are 47 bits plus one sign bit. This gives the position registers a range of 0 to 2^{47}-1. Parameters 011, 012, 013, and 014 correspond to axes 1 through 4, respectively.

For example, the position of a rotating machine part repeats every 360°. The actual servo position is of less importance than the machine's angular position. To provide the angular position, the position registers could be configured to rollover every 360° (see Figure 4-3). To do that, the following calculations must be made:

1. Determine the number of position counts that are in 360° of motion for the selected axis.
2. Set the appropriate rollover parameter to this value.

The range for these parameters is from a minimum of 0 (counter rollover feature is disabled) to a maximum value of 2^{47}-1. Counter rollover is applied to individual axes using parameters 011-014 (corresponding to axes 1-4, respectively). Counter rollover parameter settings are listed in Table 4-22.

Table 4-22. Settings for Parameters 011, 012, 013, and 014

Value	Function
0	Modulo rollover is disabled for the associated axis (default)
1 to (2^{47} - 1)	Modulo rollover specified in machine steps

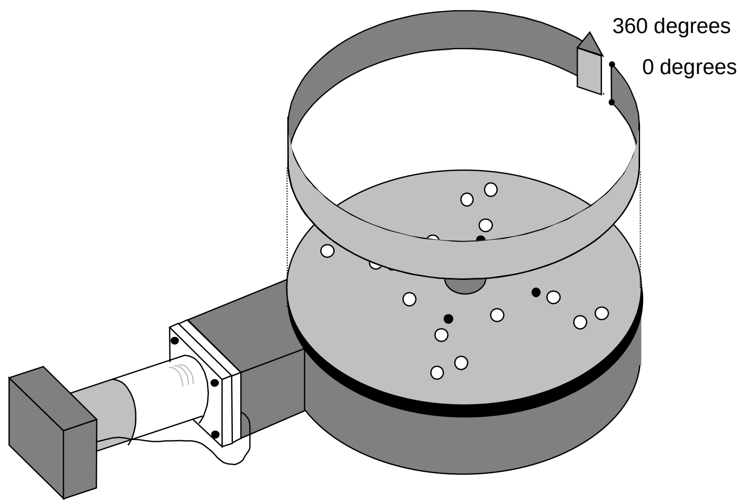


Figure 4-3. Modulo Rollover in Rotary Stage Application

4.5.16. "Filter time constant" (ms)

x83

Parameter x83 is used in conjunction with the alternate contouring mode. A non-zero value activates an exponential filter on the specified axis. The time constant of the filter is given in milliseconds. The primary use of the filter is to smooth a trajectory that consists of non-tangential moves in G8 (velocity profiling) mode. The filter should also be used in the new contouring mode if feedhold or MFO is desired. A low filter value (10 ms) is sufficient in these cases. A "Filter time constant" of 0 turns the filter completely off. A parameter setting of 1 dissipates the filter contents with no filter affect. If you do not plan to use the filter, the parameter should be set to 0. See related parameters 031, 049, 067, and 085, "Contouring mode," for more information. Settings for parameter x83 are given in Table 4-23

Table 4-23. Settings for parameter x83

Parameter #	Range	Default Value
x83	0 - 8388607	0

4.5.17. "AUX output active high" (y/n)

x84

Parameter x84 sets the active state of the auxiliary output bit. If this parameter is set to "yes," the auxiliary output bit will be set high if a fault condition is set to activate the auxiliary output bit. The settings for this parameter are shown in Table 4-24.

Table 4-24. Settings for Parameter x84

Parameter #	Value	Description
x84	Yes (default)	AUX Output bit active high
	No	AUX Output bit active low

4.5.18. Reverse Joystick Direction

x85

Parameter x85 is used to affect the joystick direction with respect to motor direction.. Setting this parameter to "yes" will cause a positive joystick direction to command the motor in the negative machine direction. The default setting of this parameter is "no".

4.5.19. "Jog low speed" (machine steps / ms)

631-634

Parameters 631, 632, 633, and 634 are for axes 1-4 respectively. They specify the low speed jog feedrate when the U511 is in the jog freerun mode. The default value is 10.

4.5.20. "Jog high speed" (machine steps / ms)

635-638

Parameters 635, 636, 637, and 638 are for axes 1-4 respectively. They specify the high speed jog feedrate when the U511 is in the jog freerun mode. The default value is 25.

4.5.21. "Jog distance" (machine steps)

639-642

Parameters 639, 640, 641, and 642 are for axes 1-4 respectively. They specify the distance the axis will move when in jog index mode. The default is 4000 machine steps.

4.6. Page 6: Servo Loop

The servo loops parameters are used to configure and tune the servo control loops of the UNIDEX 511 system. These parameters are explained in detail in this section.

4.6.1. "Kpos" (position loop gain, 0-8,388,607)

x25

The "Kpos" value represents the position loop gain segment of the servo loop. This gain setting produces an output directly proportional to the position error, thus producing a constant counteracting force to the error.

Parameter x25 can have a value ranging from 0 to 8,388,607 and defaults to 50.

A "Kpos" value that is too large may cause oscillation.

4.6.2. "Ki" (velocity loop integrator, 0-8,388,607)

x26

The "Ki" value represents the integral gain portion of the servo loop. The integral gain value produces an output, which is a summation of the velocity errors, producing an increasing counteracting force for a constant or increasing position error.

This parameter can range from 0 to 8,388,607. The system default setting is 5,000.

A "Ki" value that is too large may cause oscillation.

4.6.3. "Kp" (velocity loop proportional gain, 0-8,388,607)

x27

Parameter x27, "Kp" value, represents the proportional gain of the velocity loop, which is the inner loop portion of the dual control loop. This setting serves to dampen system response by producing a dampening force as long as the system is progressing toward error reduction.

This parameter can have a range from 0 to 8,388,607. The system default setting for this parameter is 100,000.

A "Kp" value that is too large may cause oscillation.

4.6.4. “Vff” (velocity feed forward, 0-8,388,607)

x28

The “Vff” value (parameter x28) represents velocity feed forward. The velocity feed forward bypasses the position portion of the control loop. Velocity commands are sent directly to the velocity loop, resulting in a reduction of position errors.

Resolution differences between position and velocity feedback transducers may be compensated for by the proper configuration of this parameter. The actual scaling of the feed forward command is “Vff”/256, where “Vff” is the value of axis parameter x28.

This parameter's value can range from 0 to 8,388,607. The system default setting for x28 is 256. This gives an actual scale factor of 1 (i.e., 256/256=1).

> If no secondary feedback channel is specified, this parameter should be set to 256.

4.6.5. “Aff” (acceleration feed forward, 0-8,388,607)

x29

The “Aff” value represents acceleration feed forward. The acceleration feed forward value attempts to eliminate servo loop errors during acceleration and deceleration. It accomplishes this by sending a portion of the commanded acceleration/deceleration to the motor directly.

Parameter x29 has a range from 0 to 8,388,607. The default setting is 0.

> This parameter helps to eliminate errors during acceleration/deceleration only.

4.6.6. "Loop update rate (* 0.25 ms)"

x62

Parameter x62 is the servo loop update rate parameter. This parameter specifies how often the servo control loop is to be updated by the UNIDEX 511. This parameter specifies a multiplier (1-32,000) that corresponds to update rates of 0.25 ms (1 * 0.25 ms) and 8 sec (32,000 * 0.25 ms = 8000 ms = 8 sec). Refer to Table 4-25.

Table 4-25. Settings for Parameter x62

Param #	Axis #	Range of Values (Update Rates Shown in Parentheses)	Defaults
162	1	1 to 32000 (corresponding to 0.25 ms to 8 sec)	1 (=0.25 ms)
262	2	1 to 32000 (corresponding to 0.25 ms to 8 sec)	1 (=0.25 ms)
362	3	1 to 32000 (corresponding to 0.25 ms to 8 sec)	1 (=0.25 ms)
462	4	1 to 32000 (corresponding to 0.25 ms to 8 sec)	1 (=0.25 ms)

4.6.7. "Enable Notch Filter?" (y/n)

x24

The "Enable Notch Filter?" parameter (x24) specifies whether or not notch or low pass filtering is enabled for each axis of the system. This parameter can have one of two possible settings: yes or no. Setting parameter x24 to "yes" enables notch or low pass filtering. Setting parameter x24 to "no" (the default setting) disables notch/low pass filtering. Refer to Table 4-26.

Table 4-26. Settings for Parameter x24

Param #	Axis #	Value	Meaning
x24	1, 2,	Yes	Notch/low pass filtering is active
	3, 4	No	Filtering is disabled (default)

4.6.8. "Notch filter N0, N1, N2, D1, and D2"

Parameters x30 through x34 represent filter coefficients N0, N1, N2, D1 and D2 of a second order difference equation. Filter coefficients N0, N1, N2, D1, and D2 can be used to implement a notch filter or a second order, low pass filter. These are described in the following sections.

x30

x31

x32

x33

x34

These parameters have a range from -2.0 to 2.0. The system default setting is 0 for no notch filtering.

4.6.8.1. The Notch Filter

The UNIDEX 511 implements a *second order discrete time filter*. The filter has a sample time specified by axis parameter no. x62. The general format of this equation is shown below.

$$H(z) = \frac{N_0 + N_1 z^{-1} + N_2 z^{-2}}{1 + D_1 z^{-1} + D_2 z^{-2}}$$

The filter coefficients N0, N1, N2, D1, and D2 (parameters x30, x31, x32, x33, and x34) are derived through calculations that are based on the *continuous time transfer function* equation shown below.

$$H(s) = \frac{s^2 + K(\frac{\omega_0}{Q})s + \omega_0^2}{s^2 + (\frac{\omega_0}{Q})s + \omega_0^2}$$

Two functions define a *notch filter*: the center frequency (ω_0), and the "quality factor" (Q). The resonant (center) frequency must be measured from the system. The quality factor is a characterization of the width of the notch. For example, a large "Q" value (e.g., 5) results in a narrow stop band, while a small "Q" value (e.g., 0.1) results in a wide stop band.

The backwards difference transformation:

$$s = \frac{z-1}{zTs}$$

is used to convert the continuous time equations into discrete time.

To determine appropriate notch filter coefficient values, it is convenient to make the following definitions:

$$A \equiv KT_s \frac{\omega_0}{Q} \qquad B \equiv T_s \frac{\omega_0}{Q} \qquad C \equiv (\omega_0 T_s)^2$$

where:

ω_0 = center frequency in radians/sec ($\omega = 2\pi f$)

K = desired gain at center frequency

T_s = servo loop sample time (in sec) (normally $0.25\text{x}10^{-3}$ sec or 0.25 ms) (see parameter x62 for more information)

Q = quality factor (characterizes the width of the notch).

With these definitions in place, the simplified calculation of notch filter coefficients is listed below.

$$N_0 = \frac{1 + A + C}{1 + B + C} \qquad D_1 = \frac{-(2 + B)}{1 + B + C}$$

$$N_1 = \frac{-(2 + A)}{1 + B + C} \qquad D_2 = \frac{1}{1 + B + C}$$

$$N_2 = \frac{1}{1 + B + C}$$

4.6.8.2. Notch Filter Example

A system resonance has been identified at 70 Hz. Calculate the notch filter coefficient to provide 6 dB of attenuation at this frequency with a "Q" value of 5.

First, convert the center frequency in hertz (*fo*) to radians/sec (ω_0).

$$\omega_0 = 2\pi * 70 = 440 \text{ radians / sec}$$

Next, calculate the gain constant (K) at the center notch frequency (ω_0).

$$K = 10^{\frac{dB}{20}} = 10^{\frac{-6}{20}} = 0.5$$

The servo sample time (from axis parameter x62) is $0.25\text{x}10^{-3}$ sec (4 kHz update rate). We assume that this parameter is set to 0 or 1, which gives a 0.25 ms update time.

Although not required, the width of the notch can be calculated using the following equation:

$$BW = \frac{f_0}{Q} = \frac{70}{5} = 14 \ Hz$$

Next, the intermediate values A, B, and C must be calculated:

$$A = KT_s \frac{\omega_0}{Q} = (0.5)(0.00025)\left(\frac{440}{5}\right) = 0.011$$

$$B = T_s \frac{\omega_0}{Q} = (0.00025)\left(\frac{440}{5}\right) = 0.022$$

$$C = (\omega_0 T_s)^2 = (440 * 0.00025)^2 = 0.0121$$

Using the values for A, B, and C, and the formulas discussed earlier, the notch filter coefficients N0, N1, N2, D1, and D2 can be calculated and entered in parameters x30, x31, x32, x33, and x34, respectively.

$$N_0 = \frac{1 + A + C}{1 + B + C} = \frac{1.0231}{1.0341} = 0.989363$$

$$N_1 = \frac{-(2 + A)}{1 + B + C} = \frac{-2.011}{1.0341} = -1.944686$$

$$N_2 = \frac{1}{1 + B + C} = \frac{1}{1.0341} = 0.96704$$

$$D_1 = \frac{-(2 + B)}{1 + B + C} = \frac{-2.022}{1.0341} = -1.955323$$

$$D_2 = \frac{1}{1 + B + C} = \frac{1}{1.034} = 0.967024$$

Notch filter calculations are done in radians (not degrees).

4.6.8.3. The Second Order, Low Pass Filter

The UNIDEX 511 may also implement a *second order, low pass filter*. The coefficients for a low pass filter are defined below.

$$H(s) = \frac{\omega_0^2}{s^2 + (\frac{\omega_0}{Q})^2 s + \omega_0^2} \qquad Q = .707$$

$$E = 2\tan^{-1}(\pi f_0 Ts)$$

$$F = \frac{1 - \frac{d}{2}\sin(E)}{1 + \frac{d}{2}\sin(E)} \;.$$

where:

f_0 = roll off frequency

d = damping factor (a value of 1.414 is recommended)

T*s* = servo loop sample time (in sec) (normally $0.25\text{x}10^{-3}$ sec or 0.25 ms) (see parameter x62 for more information)

$$N_0 = (1 + D_1 + D_2)/4$$
$$N_1 = (1 + D_1 + D_2)/2$$
$$N_2 = (1 + D_1 + D_2)/4$$
$$D_1 = -(1 + F)\cos(E)$$
$$D_2 = F$$

4.6.9. "Servo loop type"

x78

The UNIDEX 511 PID loop configuration can be changed. The configuration is determined by the status of the first 3 bits of parameter x78. See Table 4-27. Entering an appropriate decimal value for Parameter x78 can change the configuration. See Table 4-28. A parallel control loop block diagram is illustrated in Figure 4-4. The dual loop diagram is found elsewhere in this manual.

Table 4-27. Bits of Parameter x78 and PID Loop Configuration

Bit No.	Bit Status	PID Loop Configuration
0	0	Position+velocity loop
	1	Parallel loop
1	0	"Kpos" always on
	1	"Kpos" on when velocity command = 0
2	0	"Vff" scaling is 256
	1	"Vff" scaling is 65536
3–23	Reserved	

Parallel loop does not support dual loop mode.

Table 4-28. Decimal Settings for Parameter x78

"Servo loop type" Parameter	Servo Loop Type	Integrator/Position Loop Control	"Vff" scaling
0 (default)	Position+velocity	None	x256
1	Parallel	None	x1
2	Position+velocity	"Kpos" on only when velocity command = 0	x256
3	Parallel	"Kpos" on only when velocity command = 0	x1
4	Position+velocity	None	x65536
5	Parallel	None	x1
6	Position+velocity	"Kpos" on only when velocity command = 0	x65536
7	Parallel	"Kpos" on only when velocity command = 0	x1

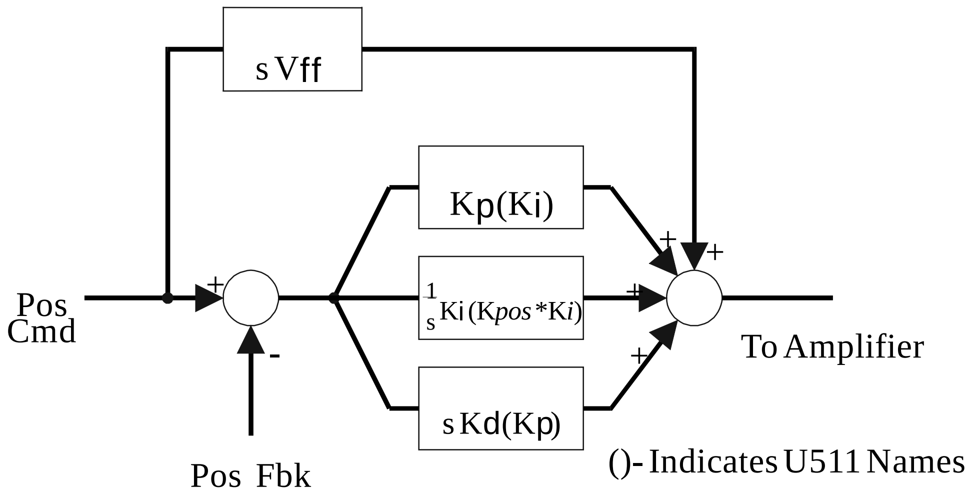


Figure 4-4. Parallel Control Loop Block Diagram

4.7. Page 7: Homing and Limits

The homing and limits parameters are used to configure the UNIDEX 511's *home cycle* and the accompanying limit switches. The *home cycle* is the process in which an axis is commanded to a known reference position (e.g., a zero position).

The parameters in homing and limits group have a unique setting for each of the four axes (i.e., parameter x02 is actually four parameters [102, 202, 302, and 402], each of which corresponds to axes 1-4, respectively). The homing and limits parameters are explained in detail in the following sections. A brief description of the home cycle precedes the parameter descriptions.

4.7.1. The Home Cycle

Home Cycle

The home cycle is used to move a specified axis to a hardware referenced position. The home cycle is illustrated in Figure 4-5. The cycle is comprised of the following moves.

1. The axis will move from its current position (❶) at the rate set by the "Home feedrate" parameter (x04) in the direction set by the "Home direction CCW" (y/n) parameter (x02) until the home limit input is activated (❷). The polarity of the home limit switch is set by the "Home switch normally open" parameter (x03). During a home cycle, the end of travel limit in the home direction will be ignored while the home limit input is active. However, the axis can also use the end of travel limit as a home limit by setting axis parameter x74 to "no."
2. The axis reverses direction and moves out of the limit, (❸), a distance specified by axis parameter x77 ("Limit debounce distance"). The axis will move at the home feed rate until the marker is found, then it decelerates to a stop (❹). It will then move the distance specified by the "Home offset" parameter (x06) minus the distance from the marker (❺). If the "Home offset" is set to 0, the axis will move in the reverse direction back to the marker. The axis will end up at a position that is the "Home offset" number of machine steps away from the marker. When the move is complete, the UNIDEX 511 will reset its position counters to zero.

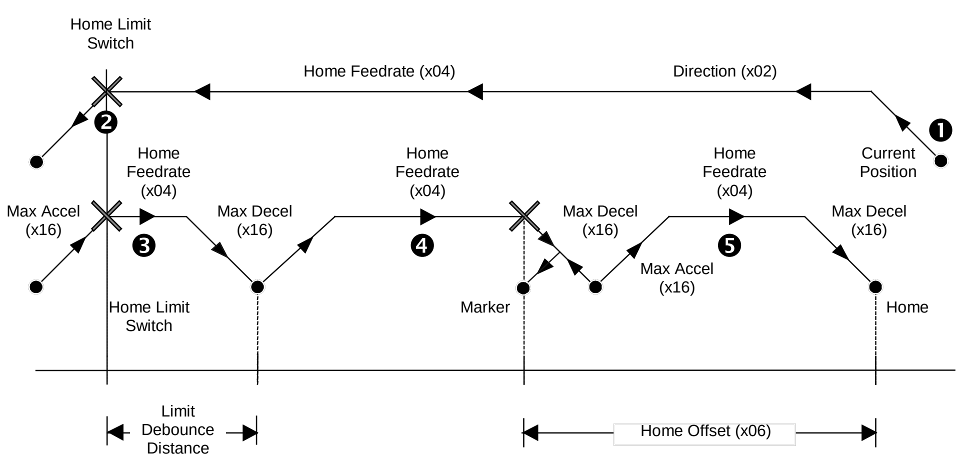


Figure 4-5. Home Cycle

If the feedback device type is a resolver, the axis will move to the null position of the marker.

4.7.2. "Home direction CCW" (y/n)

x02

Each axis of the UNIDEX 511 needs to be configured for the direction that the axis motor will turn when going to the home position (refer to Figure 4-5 on page 4-41). This parameter must be configured to reflect the motor direction that causes the axis to move toward the home limit switch. Motor direction (clockwise [CW] or counter-clockwise [CCW]) is specified "looking into" the shaft end of the motor. Refer to Figure 4-6.

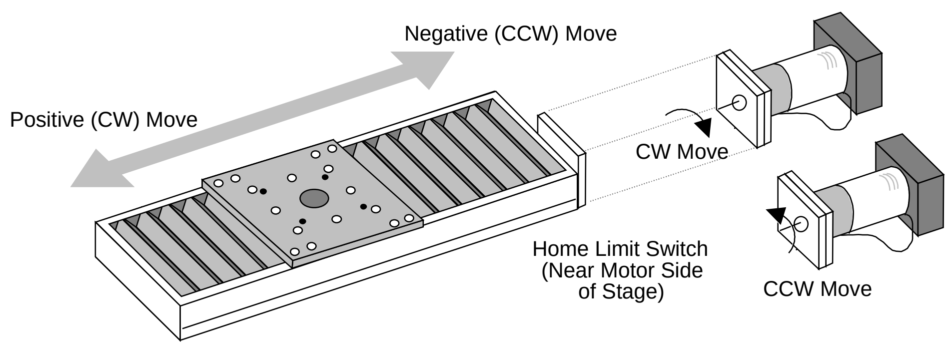


Figure 4-6. Typical Stage Showing CW and CCW Motor Rotation

This parameter can be set to one of two possible values that are explained in Table 4-29.

Table 4-29. Settings for Parameter x02

Param #	Axis #	Values	Description (* Indicates Default Setting)
102	1	Yes (**Y**)	CCW motor rotation moves axis to home position *
		No (N)	CW motor rotation moves axis to home position
202	2	Yes (**Y**)	CCW motor rotation moves axis to home position *
		No (N)	CW motor rotation moves axis to home position
302	3	Yes (**Y**)	CCW motor rotation moves axis to home position *
		No (N)	CW motor rotation moves axis to home position
402	4	Yes (**Y**)	CCW motor rotation moves axis to home position *
		No (N)	CW motor rotation moves axis to home position

Although most stages are typically configured as shown in Figure 4-6 (i.e., CW motor rotation is a positive move), stages using fold-back motors and/or gearheads may have positive and negative moves reversed.

4.7.3. "Home switch normally open" (y/n)

x03

Parameter x03 must be configured to correspond to the polarity of the home limit switch in its inactive state. Typically, Aerotech stages are configured with normally open home limit switches.

As the stage moves toward the home limit, a projection on the underside of the stage table comes in contact with the home limit switch assembly. In a normally open configuration (x03=yes), the stage table projection moves into the limit switch thereby closing the contacts and causing a home limit fault. Conversely, in a normally closed configuration (x03=no), the stage table projection moves into the limit switch thereby opening the contacts and causing a home limit fault.

The settings for parameters 103, 203, 303, and 403 are summarized in Table 4-30.

Table 4-30. Settings for Parameter x03

Param #	Axis #	Values	Description
103	1	Yes (**Y**)	Home limit switch is normally open (default)
		No (N)	Home limit switch is normally closed
203	2	Yes (**Y**)	Home limit switch is normally open (default)
		No (N)	Home limit switch is normally closed
303	3	Yes (**Y**)	Home limit switch is normally open (default)
		No (N)	Home limit switch is normally closed
403	4	Yes (**Y**)	Home limit switch is normally open (default)
		No (N)	Home limit switch is normally closed

The limit inputs are pulled to logic high on the UNIDEX 511 control board.

x04

4.7.4. "Home feedrate" (machine steps/ms)

Parameter x04 specifies the home feedrate for each axis. The axis will move toward the home limit at the feedrate set by parameter x04 (given in machine steps per ms) until that home limit input becomes active. Next, the travel direction is reversed, the encoder marker is found, and then the home position is achieved. Refer to the home cycle discussion at the beginning of this section.

This parameter can range in value from 0.004 to 32,767 machine steps per ms. The default value for this parameter is 25 machine steps per ms. Refer to Table 4-31.

Table 4-31. Settings for Parameter x05

Param #	Axis #	Range	Default
105	1	0.004 to 32,767 machine steps/ms	25 machine steps/ms
205	2	0.004 to 32,767 machine steps/ms	25 machine steps/ms
305	3	0.004 to 32,767 machine steps/ms	25 machine steps/ms
405	4	0.004 to 32,767 machine steps/ms	25 machine steps/ms

x06

4.7.5. "Home offset" (machine steps)

If the desired home position is not at the marker location, parameter x06 may be used to set the offset value. The distance from the encoder marker (or resolver null) to the desired home position must be measured, converted into machine steps, and entered into parameter x06. After the axis has moved the offset distance, the position counters will reset to zero.

Parameter x06 can have values that range from -8,388,607 to +8,388,607. A value of 0 (the default) indicates that the encoder marker (or resolver null) is located at the home position. Refer to Table 4-32.

Table 4-32. Settings for Parameter x06

Param #	Axis #	Range (in Machine Steps)	Default
106	1	- 8,388,607 to +8,388,607	0 (no home offset)
206	2	- 8,388,607 to +8,388,607	0 (no home offset)
306	3	- 8,388,607 to +8,388,607	0 (no home offset)
406	4	- 8,388,607 to +8,388,607	0 (no home offset)

The polarity of the "Home offset" is not affected by axis parameter x11 "Positive (+) move is CW" (y/n).

4.7.6. "Limit switch normally open" (y/n)

x09

This parameter must be configured to correspond to the polarity of the axis limit switch in its inactive state. This parameter can have one of two possible values: "yes" for a normally open limit switch (default) and "no" for a normally closed limit switch. Refer to Table 4-33.

Table 4-33. Settings for Parameter x09

Param #	Axis #	Values
109	1	Yes - Normally open limit switch (default)
		No - Normally closed limit switch
209	2	Yes - Normally open limit switch (default)
		No - Normally closed limit switch
309	3	Yes - Normally open limit switch (default)
		No - Normally closed limit switch
409	4	Yes - Normally open limit switch (default)
		No - Normally closed limit switch

> It is recommended that the limit switch be manually checked before connecting the motor to the system.

4.7.7. "Limit to mechanical stop" (machine steps)

x10

This parameter specifies the stopping distance, in machine steps, when an axis hits a limit switch. When this value is specified, a deceleration rate is calculated so that deceleration occurs within the specified distance regardless of the current speed. This prevents the stage from hitting a mechanical stop. If axis parameter x16 ("Max accel/decel") specifies a greater deceleration rate, then the value of parameter x16 rather than the calculated rate, is used.

The default value for parameter x10 is 2000 machine steps. Setting this parameter to zero forces the deceleration rate to take on the value specified in axis parameter x16.

4.7.8. "CCW software limit" (machine steps)

x22

This parameter is used to establish a software limit (in machine steps) when the motor is rotating in the CCW direction. This limit is referenced from the hardware home position and is not active until the axis is sent home.

This parameter value can range from $(-2)^{47}$ to $(+2)^{47}$ machine steps. The default and minimum value is $(-2)^{47}$ (which equals -140,737,488,355,328 steps). See Table 4-34.

Table 4-34. Settings for Parameter x22

Param #	Axis #	Range (in machine steps)	Default
122	1	$(-2)^{47}$ to $(+2)^{47}$	$(-2)^{47}$ machine steps
222	2	$(-2)^{47}$ to $(+2)^{47}$	$(-2)^{47}$ machine steps
322	3	$(-2)^{47}$ to $(+2)^{47}$	$(-2)^{47}$ machine steps
422	4	$(-2)^{47}$ to $(+2)^{47}$	$(-2)^{47}$ machine steps

The "Fault Mask" default setting enables the software limits. Refer to Section 4.10: Traps for more information.

4.7.9. "CW software limit" (machine steps)

x23

This parameter is used to establish a software limit (in machine steps) when the motor is rotating in the CW direction. This limit is referenced from the hardware home position and is not active until the axis has completed a home cycle.

This parameter value ranges form $(-2)^{47}$ to $(+2)^{47}$ machine steps. The default and maximum value is $(+2)^{47}$ (which equals 140,737,488,355,328 steps). See Table 4-35.

Table 4-35. Settings for Parameter x23

Param #	Axis #	Range (in machine steps)	Default
123	1	$(-2)^{47}$ to $(+2)^{47}$	$(+2)^{47}$ machine steps
223	2	$(-2)^{47}$ to $(+2)^{47}$	$(+2)^{47}$ machine steps
323	3	$(-2)^{47}$ to $(+2)^{47}$	$(+2)^{47}$ machine steps
423	4	$(-2)^{47}$ to $(+2)^{47}$	$(+2)^{47}$ machine steps

The "Fault Mask" default setting enables the software limits. Refer to Section 4.10: Traps for more information.

4.7.10. "Use home limit during home" (y/n)

x74

The UNIDEX 511 has three limit inputs, "CW," "CCW," and "HOME." If parameter x74 is set to "yes," the home cycle will move in the specified direction until the home limit is activated. If set to "no," the home cycle will ignore the home limit input. Instead, it will reference the limit switch that is in the home direction. In this case, the limit switch will not generate a fault condition.

The default for this parameter is "no." Refer to Table 4-36.

Table 4-36. Settings for Parameter x74

Param #	Axis #	Values
174	1	Yes - Uses home limit input
		No - Ignores home limit input (default)
274	2	Yes - Uses home limit input
		No - Ignores home limit input (default)
374	3	Yes - Uses home limit input
		No - Ignores home limit input (default)
474	4	Yes - Uses home limit input
		No - Ignores home limit input (default)

4.7.11. "Safe zone limits" (machine steps)

x75

x76

A safe zone is a region defined by a range of specified positions on 1, 2, 3, or 4 axes. For each axis, one range within its travel may be defined for this function with the "Safe zone + limit and – limit" parameters. This range is in machine steps and is referenced to the hardware home position. Refer to Table 4-37.

Each axis with a specified range must be enabled, homed, and within the specified limits to be considered within the safe zone. The output bit specified by general parameter number 098 will be driven to its active state (low impedance to ground) when all axes are in their safe zone ranges. Setting parameters x75 and x76 to zero (the default value) defeats the safe zone function for that axis. Also, see general parameter number 098 for more information.

Table 4-37. Safe Zone Limit Parameters

Param #	Definition	Default Value
x75	"Safe zone –limit" (machine steps)	0
x76	"Safe zone +limit" (machine steps)	0

x77

4.7.12. "Limit debounce distance" (machine steps)

This parameter specifies the distance that the axis takes to decelerate when moving out of the home or limit switch during a home cycle. The value is a distance in machine steps. A zero value defeats the function. The range and default values for this parameter are shown in Table 4-38.

Table 4-38. Settings for Parameter x77

Param #	Axis #	Range	Default Value
177	1	0 - 8388607 mach. steps	750 mach. steps
277	2	0 - 8388607 mach. steps	750 mach. steps
377	3	0 - 8388607 mach. steps	750 mach. steps
477	4	0 - 8388607 mach. steps	750 mach. steps

4.8. Page 8: Motors and Feedback

The UNIDEX 511 utilizes several parameter settings for configuration based on the motor and drive type being used. This section provides an introduction to motor and feedback configuration. The motor and feedback configuration parameters are explained in detail in the sections that follow.

The parameters that are used to configure motor and feedback functions of the U511 depend on the type of motor that is being used. A list of motor types (Stepper, AC Brushless, and DC Servo), their related parameters, and default values are shown in Table 4-39.

Table 4-39. Motor Feedback Parameters

Param #	Description	Step	AC Brushless	DC Servo	Default Value(s)
x38	"Position channel"	✓	✓	✓	1, 2, 3, 4
x39	"Velocity channel"	N/A	✓	✓	0
x40	"Position setup code"	✓	✓	✓	3
x41	"Velocity setup code"	N/A	✓	✓	3
x42	"Amplifier type"	✓	✓	✓	0
x43	"Commutation cycles/rev"	N/A	✓	N/A	4
x44	"Feedback steps/rev"	✓	✓	✓	4000
x45	"Commutation phase offset" (degrees)	N/A	✓	N/A	0
x46	"Stepper high current %" (0-100%)	✓	N/A	N/A	70
x47	"Stepper low current %" (0-100%)	✓	N/A	N/A	35
x63	"Microstepping resolution" (machine steps)	✓	N/A	N/A	4000
x64	"Stepper correction" (y/n)	✓	N/A	N/A	Yes
x65	"Stepper correction speed"	✓	N/A	N/A	1.0
x66	"Base speed" (machine steps/ms)	N/A	✓	N/A	0
x67	"Base speed advance" (0-359 degrees)	N/A	✓	N/A	0
x68	"Phase speed" (machine steps/ms)	N/A	✓	N/A	0
x69	"Phase speed advance" (0-359 degrees)	N/A	✓	N/A	0
x79	"Primary DAC offset" (mV)	✓	✓	✓	0
x80	"Secondary DAC offset" (mV)	✓	✓	✓	0
x82	"Encoder factor"	N/A	✓	✓	0

4.8.1. Introduction to Motor and Feedback Configurations

Parameters in the Motor Feedback page are used to configure the motors that control the system's axes. There are three types of motors that are typically used for control. Some of the parameters in this page apply to all motor configurations, while some are valid only for certain types of motors. The three most common types of motors are stepper motors, AC brushless motors (including linear motors), and DC brush servo motors.

Motors may or may not be used in conjunction with a feedback device. In open-loop configurations, a feedback device is not used. Such configurations make the assumption that the axis will attain its commanded position without any feedback or verification. This is only used in stepper motor applications. Conversely, a closed-loop system uses a feedback device to verify the position of the axis. Such configurations compare the desired axis position with the actual position from the feedback device. Two common feedback devices are encoders and resolvers. An encoder is a rotary device that transmits a pulsed signal based on the number of revolutions of the device. A resolver is a two-phase, rotary, electromagnetic transducer in which inductive coupling (between the rotor and stator windings) and trigonometric principles are used to provide absolute position information over one electrical cycle.

In rotary motors and feedback devices, it is important to determine the rotation direction for proper orientation and configuration. A motor is said to be rotating in the positive (+) direction if the shaft is turning in the clockwise (CW) direction while looking "into" the motor from the shaft end. In this case, the feedback device should be counting in the positive direction. Refer to Figure 4-7.

> ☞ The encoder direction may be changed by reversing the SIN+ and SIN- encoder signals. Similarly, the direction of a resolver may be changed by reversing the SIN+ and SIN- feedback signals. Use this to correct a feedback-phasing problem.

Each axis may be connected to two feedback devices: one for position (the primary feedback device) and the other for velocity (the secondary feedback device). Each of the feedback devices also has setup parameters that specify the transducer type, location, resolution, and mode of operation.

> ☞ The secondary feedback channel and setup code parameters need to be configured only for dual loop applications. For all other applications, these parameters should be set to zero.

> ☞ Multiple axes must not be configured for feedback from the same channel, otherwise improper operation will result.

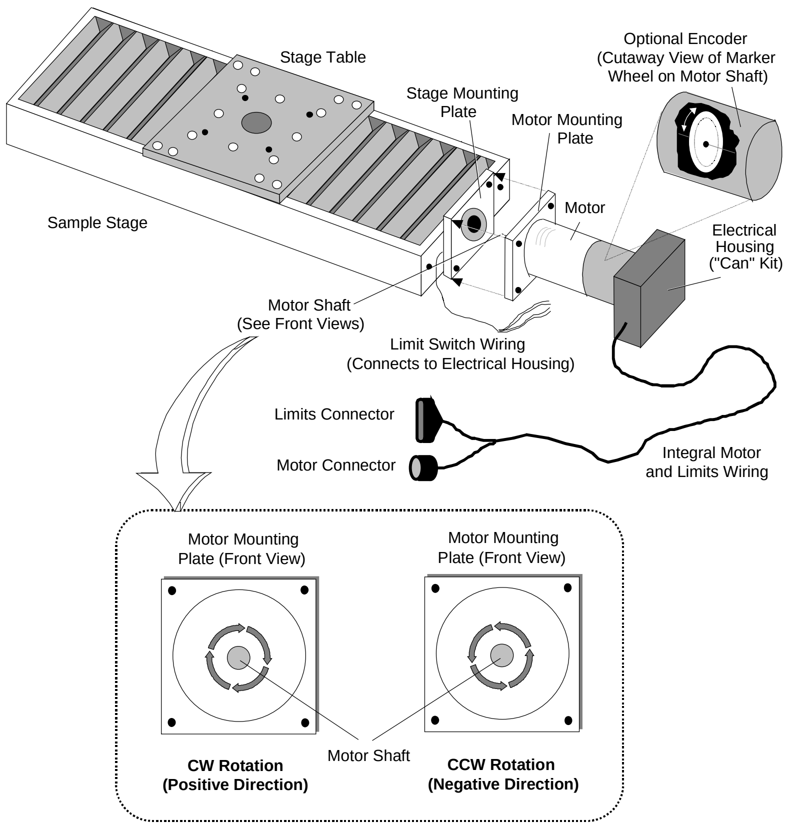


Figure 4-7. Motor and Encoder Rotation

Encoder feedback channels are RS-422 differential quadrature signals. Channels 1-4 are located on the UNIDEX 511 main board. The U511 automatically multiplies the fundamental encoder line count by four. Conversion to user units is done using axis parameters x00 ("Metric conversion factor") and x01 ("English conversion factor").

A U511 resolver-to-digital converter board (U511 RDP) must be installed and configured for applications requiring resolver feedback. The U511 can accept two RDP boards. The first contains feedback channels 9-12, while the second contains feedback channels 13-16.

Normally, one feedback device is used per axis, however in some applications, a dual-loop setup may provide greater control. In this case, one transducer provides the position feedback and a separate transducer provides velocity feedback. The user must specify the channel of both transducers in the setup parameters. The channel inherently specifies the feedback device type. The setup code specifies the resolution and mode of operation of the feedback device.

Commutation information in the case of AC brushless servo motors comes from the velocity feedback transducer. The "Feedback steps/rev" parameter (x44) should be entered based on the velocity feedback transducer.

> English and Metric conversion factors are calculated with respect to the position feedback resolution.

As mentioned earlier, the three most common types of motors are stepper motors, AC brushless motors, and DC brush servo motors. For stepper motor applications, parameter x42 (drive type) must be configured to either 2 or 3. Most stepper motor applications are open loop applications (that is, they have no feedback). As such, the commanded position is the assumed motor position.

Stepping Motors

The UNIDEX 511 can drive up to four stepping motors. To drive the motors, two current command phases are output, separated by 90 electrical degrees. For typical open-loop operation, the UNIDEX 511 generates 2048 micro-machine steps per pole of the motor. This equates to 102,400 machine steps per revolution (2048 x 50 = 102,400). The maximum commutation frequency for stepper motors is 2,500 Hz yielding 3000 rpm maximum. In open-loop applications, the stepper motor uses the home limit switch as a reference point during home cycles. A marker wheel or encoder may be used to provide a more repeatable home cycle reference.

> If parameter x38 ("Position channel") is configured for an encoder (i.e., x38=1 to 4), then the UNIDEX 511 will stop on the marker pulse during home cycles.

The UNIDEX 511 checks for encoder feedback if parameter x38 ("Position channel") is set for an encoder (i.e., x38=1 to 4), and parameter x44 ("Feedback steps/rev") is non-zero. If x38 is set for an encoder, but parameter x44=0, then the UNIDEX 511 assumes that a marker wheel is attached. In this case, the marker wheel is referenced during the home cycle.

> For encoder verification applications, the UNIDEX 511 scales the micro steps to encoder counts. The U511 uses parameter x44 ("Feedback steps/rev") to determine the number of micro steps per revolution. This value must be evenly divisible by 50 (poles per revolution). The UNIDEX 511 automatically multiplies the SIN/COS signals by four.

When using stepper motors, the motor torque must be high enough to prevent motor stall or drop out. This can be detected by attaching an encoder to the stepping motor and entering a value into parameter x19 ("Max position error"). This value specifies the maximum allowable encoder count error between the commanded motor position and the actual position. If the difference between these two positions exceeds the value set in parameter x19, the axis generates a fault condition.

The UNIDEX 511 provides a feature called dynamic current scaling in applications using stepper motors. The UNIDEX 511 changes the stepper motor current level based on the commanded velocity. If the commanded velocity is zero for a duration of 500 ms, the current level goes to a programmable low value (axis parameter x46 - the "Stepper low current %" parameter). Once a move is commanded, the current level immediately goes to the high value (axis parameter x47 - the "Stepper high current %" parameter).

AC Brushless Motor with Encoder

Another common type of motor is an AC brushless motor. For AC brushless motor applications, parameter x42 ("Amplifier type") must be set to 1 (AC brushless). The UNIDEX 511 can drive up to four AC brushless servo motors. Two DAC current command channels are output, separated by 120 electrical degrees and updated at a rate of 4 kHz.

For closed-loop operation using an encoder for feedback, parameter x38 ("Position channel") must be set for an encoder (x38=1 to 4). Hall effect signals are assumed to be present and are used for six-step and sinusoidal commutation.

To configure the UNIDEX 511 with an AC brushless servo motor for commutation exclusively from the six step Hall sensors, set parameter x43 ("Commutation cycles/rev") to zero.

An invalid Hall state ("000" or "111") generates a feedback fault.

If the commutation factor is non-zero, the UNIDEX 511 will switch to sinusoidal commutation on the first Hall state transition encountered after the axis is enabled. The number of encoder counts per revolution (parameter x44) is used to generate the proper sinusoidal commutation signals.

AC Brushless Motor with Resolver

The UNIDEX 511 uses the resolver to determine the initial rotor position and all subsequent commutation. Parameters x43 (Commutation cycle/rev) and parameter x44 ("Feedback steps/rev" [x 4]) parameters must be configured appropriately.

The commutation factor is the number of electrical cycles per motor revolution. Commutation factors for 4, 6, and 8 poles are shown in Table 4-40.

Table 4-40. Commutation Factors for 4, 6, and 8 Poles

Number of Poles	Commutation Factor
4 pole	2 cycles
6 pole	3 cycles
8 pole	4 cycles

Parameter x38 ("Position channel") must be set for a resolver channel (9-16). Parameter x40 ("Position setup code") must specify the proper resolution of the RDP. The UNIDEX 511 RDP board must be factory configured for the proper system resolution. Use Table 4-41 to ensure proper configuration.

Table 4-41. Factory Configuration for UNIDEX 511 RDP

RDP Resolution (bits)	Counts per Revolution	Setup Code
10	1,024	1
12	4,096	2
14	16,384	3
16	65,536	4
16/14 Dynamic	65,536	5

The UNIDEX 511 uses the resolver to determine the initial rotor position and all subsequent commutation. Parameters x43 ("Commutation cycle/rev") and x44 ("Feedback steps/rev" [x 4]) must be configured appropriately.

The phase currents may be offset from the reference position by setting parameter x45 ("Commutation phase offset" [degrees]).

The UNIDEX 511 will reference to the resolver null during a home cycle.

Improper phasing of AC brushless servo motors may cause the system to fault when the axis is enabled or when motion is attempted. A fixed relationship exists between the feedback device and the generated phase currents.

DC Motor

Another common type of motor is a DC brush motor. Prior to using a DC brush motor, parameter x42 ("Amplifier type") must be configured to "0-DC Brush." The UNIDEX 511 supplies the DC brush motor one current (torque) command voltage.

The DC brush motor can use any feedback channel. Parameter x39 ("Velocity channel") and parameter x41 ("Velocity setup code") need only to be set for "dual-loop" type applications.

Parameter x38 ("Position channel") must be set for an encoder (1-4). Encoder channels 5-8 are used with the 4EN option board for velocity feedback.

For encoder operation, parameter x40 ("Position setup code") is ignored. The UNIDEX 511 will reference to the marker during the home cycle.

For resolver operation, parameter x38 ("Position channel") must be set for a resolver channel (9-16). Parameter x40 ("Position setup code") must specify the proper resolution of the RDP (The UNIDEX 511 RDP must be installed).

The UNIDEX 511 RDP board must be factory configured for the proper system resolution. Configuration information is shown in the following table.

Table 4-42. RDP Resolution and Setup Codes

RDP Resolution (bits)	Counts per Revolution	Setup Code
10	1,024	1
12	4,096	2
14	16,384	3
16	65,536	4
16/14 Dynamic	65,536	5

See axis parameters x38 through x41 for more information.

4.8.2. "Position channel"

x38

This parameter is used to configure the channel of the primary feedback device being used. The parameter value is a code that corresponds to a particular feedback device for each axis (1-4). This parameter has a range from 0-24. Feedback channels, their respective feedback types, and additional hardware requirements are summarized in Table 4-43.

Table 4-43. Settings for Parameter x38

Feedback Channel	Feedback Type	Additional Hardware Required
0	Open Loop	None (for stepper motors only)
1 - 4	Encoder	None (UNIDEX 511 main board only) (defaults for axes 1-4)
5 - 8	*Reserved*	*Reserved*
9 - 12	Resolver	Requires RDP-PC board #1
13 - 16	Resolver	Requires RDP-PC board #2
17 - 18	Laser	Requires RMX-PC board #1 (x 512 [λ/1024] resolution)
19 - 20	Laser	Requires RMX-PC board #2 (x 512 [λ/1024] resolution)
21 - 22	Laser	Requires RMX-PC board #1 (x 4 [λ/32] resolution)
23 - 24	Laser	Requires RMX-PC board #2 (x 4 [λ/32] resolution)

Feedback should always be verified before enabling the axis.

4.8.3. "Velocity channel"

x39

This parameter is used to configure the secondary feedback channel of UNIDEX 511. The parameter value is a code that corresponds to a particular feedback device for each axis (1-4). This parameter has a range from 0-24. Feedback channels, their respective feedback types, and additional hardware requirements are summarized in Table 4-44.

Table 4-44. Settings for Parameter x39

Feedback Channel	Feedback Type	Additional Hardware Required
0	Open Loop	None (for stepper motors only)
1 - 4	Encoder	None (UNIDEX 511 main board only) (defaults for axes 1-4)
5 - 8	Encoder	4EN Option Board
9 - 12	Resolver	Requires RDP-PC board #1
13 - 16	Resolver	Requires RDP-PC board #2
17 - 18	Laser	Requires RMX-PC board #1 (x 512 [λ/1024] resolution)
19 - 20	Laser	Requires RMX-PC board #2 (x 512 [λ/1024] resolution)
21 - 22	Laser	Requires RMX-PC board #1 (x 4 [λ/32] resolution)
23 - 24	Laser	Requires RMX-PC board #2 (x 4 [λ/32] resolution)

If this parameter is configured incorrectly, sporadic operation may occur.

4.8.4. "Position setup code"

x40

Parameter x40 specifies a code that corresponds to the bit resolution mode whenever a resolver is being used as the primary feedback device. This parameter has a range from 0-5. The meanings for these setup codes are listed in Table 4-45.

Table 4-45. Settings for Parameter x40

Feedback Setup Code	Action	RDP Resolution (bits)	Counts per Revolution
0	None	N/A	N/A
1	Resolver 10-bit mode	10 bits	1,024
2	Resolver 12-bit mode	12 bits	4,096
3	Resolver 14-bit mode	14 bits (default)	16,384
4	Resolver 16-bit mode	16 bits	65,536
5	Resolver dynamic resolution mode	16/14 bits dynamic	65,536/ 16,384

The UNIDEX 511's RDP hardware must be configured for the same resolution.

4.8.5. "Velocity setup code"

x41

Parameter x41 specifies a code that corresponds to the bit resolution mode whenever a resolver is being used as the secondary feedback device. This parameter has a range from 0-5. The meanings for these setup codes are listed in Table 4-46.

Table 4-46. Settings for Parameter x41

Feedback Setup Code	Action	RDP Resolution (bits)	Counts per Revolution
0	None	N/A	N/A
1	Resolver 10-bit mode	10 bits	1,024
2	Resolver 12-bit mode	12 bits	4,096
3	Resolver 14-bit mode	14 bits (default)	16,384
4	Resolver 16-bit mode	16 bits	65,536
5	Resolver dynamic resolution mode	16/14 bits dynamic	65,536/ 16,384

The UNIDEX 511's RDP hardware must be configured for the same resolution.

x42

4.8.6. "Amplifier type" (0-DC Brush, 1-AC Brushless, 2-Step, 3-Recirc)

This parameter is used to configure the UNIDEX 511 for the type of motor being used. The amplifier is commanded to the recirculation mode (mode 3) when in position and when in low current mode. When configured for the recirculation mode of operation (x42 = 3), the ripple current is reduced to almost zero, thereby causing the motor to run cooler.

This parameter has a range from 0-3 with the drive types listed in Table 4-47.

Table 4-47. Settings for Parameter x42

Drive Type Code	Drive Type
0	DC brush (default)
1	AC brushless (including linear drives)
2	Stepper amplifier - no recirculation
3	Stepper amplifier - recirculation mode

IMPORTANT

Improper configuration of this parameter will cause the motor to "trap" when it is enabled or when motion is commanded.

4.8.7. "Commutation cycles/rev" (AC brushless motors only)

x43

Parameter x43 is used to configure the UNIDEX 511 for the number of electrical cycles per motor revolution of the feedback device. The value of this parameter, in conjunction with the value of axis parameter x44 ("Feedback steps/rev" [x 4]), is used to generate the proper sinusoidal phase currents. Refer to Table 4-48.

Table 4-48. Sample Commutation Factors for AC Brushless Motors

Commutation Factor	# of Poles	Cycles per Revolution
1	2 pole	1 cycle/rev
2	4 pole	2 cycles/rev
3	6 pole	3 cycles/rev
4 (default)	8 pole	4 cycles/rev

Setting this value to 0 for an AC brushless servo motor with encoder feedback will result in six step commutation.

This parameter has a range from 0 to 65,536 with a default value of 4. Sample commutation factors are shown above in Table 4-48.

Improper configuration will cause a "trap" when a move is commanded.

This parameter should be set to 1 for linear motors.

4.8.8. "Feedback steps/rev" (AC brushless motors only)

x44

The value of this parameter, in conjunction with the value of axis parameter x43 ("Commutation cycles/rev"), is used to generate the proper sinusoidal phase currents. This parameter applies to all servo motors and stepper motors with encoder verification. It does not apply to DC brush motors.

This parameter has a range from 0 to 2^{48}. The system default value is 4000 for a 1000 line encoder.

IMPORTANT

> Improper configuration will cause a "trap" when a move is commanded. Also, the value of this parameter should be evenly divisible by 50 (poles per revolution) for stepping motors.

4.8.9. "Commutation phase offset" (0-359 degrees)

x45

Some AC brushless motors may require a phasing relationship that is different than the one provided by the UNIDEX 511. The default phasing may be adjusted by the configuration of this parameter.

This parameter has a range from 0-359°. The system default is 0 for no phase offset.

Refer to the previous section for additional phasing information.

All Aerotech amplifiers require a 0° offset except for the AS3005, which requires a 300° offset.

4.8.10. "Stepper high current %" (0-100%) (stepper drives only)

x46

The UNIDEX 511 utilizes dynamic current scaling based on the motor's commanded velocity. If an axis is setup as a stepper and a motion is commanded, the UNIDEX 511 will output the percentage (set by this parameter) of the maximum output voltage (+/- 10 volts). For example, a value of 100% corresponds to 10 volts. This value is the peak of the sinusoidal current command during motion.

This parameter has a range from 0% to 100%. The system default is 70 %.

> Actual motor current depends on the amplifier's scaling.

4.8.11. "Stepper low current %" (0-100%) (stepper drives only)

x47

The UNIDEX 511 utilizes dynamic current scaling based on the motor's commanded velocity. If the commanded velocity is zero for 500 ms, the current level will go to the value set by this parameter, reducing motor heating.

This parameter sets the percentage of the maximum output voltage that the UNIDEX 511 can generate (+/-10 volts). This value is taken from the peak of the sinusoidal current command while in position.

This parameter has a range from 0% to 100 %. The system default is 35%.

Actual motor current depends on the amplifier's scaling.

4.8.12. "Microstepping resolution" (machine steps) (stepper drives only)

x63

Parameter x63 sets the microstepping resolution of an open loop stepper. This value is specified in microsteps per revolution.

This parameter has a range from 200 to 102,400 microsteps per revolution. The system default is 4000 microsteps per revolution.

4.8.13. "Stepper correction" (y/n) (stepper drives only)

x64

Parameter x64 specifies whether or not encoder verification is enabled for each axis that is configured as an open loop stepper.

This parameter can have the values listed in Table 4-49.

Table 4-49. Settings for Parameter x64

Param #	Axis #	Settings
164	1	Yes - Encoder verification enabled for axis 1 (default) No - No encoder verification for axis 1
264	2	Yes - Encoder verification enabled for axis 2 (default) No - No encoder verification for axis 2
364	3	Yes - Encoder verification enabled for axis 3 (default) No - No encoder verification for axis 3
464	4	Yes - Encoder verification enabled for axis 4 (default) No - No encoder verification for axis 4

x65

4.8.14. "Stepper correction speed" (microsteps/ms)

Parameter x65 specifies a correction speed in microsteps per millisecond for each axis that is configured as an open loop stepper. The range for this parameter value is from 1 to 8,388,607. The system default is 1 microstep/ms.

x66

4.8.15. "Base speed" (machine steps/ms) (AC brushless only)

At top speeds, the motor's back EMF (Kb) limits the amount of current that can be driven into the motor. This occurs when the generated back EMF is near the bus voltage of the amplifier.

Phase advance is used to increase the usable speed of an AC brushless motor. It does this by a technique called "field weaking." The effective torque angle of the motor is advanced from 90 degrees at high speeds, thus reducing the motors back EMF. This allows more current to be driven into the motor for a given bus voltage. The phase advance characteristics curve is specified by four parameters. The first two parameters (x66 and x67) specify the slope of the first section (the base speed). Parameters x68 and x69 specify the slope of the second section (the phase speed). The example in Figure 4-8 illustrates the phase advance slope for an application where a phase advance of 10° at 1200 rpm and 30° at 3000 rpm is needed.

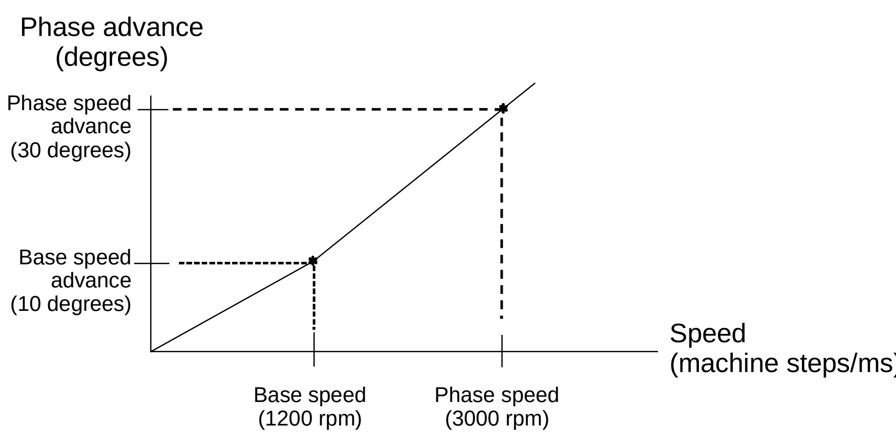


Figure 4-8. Phase Advance Slope

Parameter x66 is the "Base speed" specified by the user in machine steps/ms. The range is a value from 0 to 8,388,608. The system default is zero (0).

☞ The phase advance does not work with DC or stepping motors. Also, the function will not increase torque at low speeds.

The UNIDEX 511 clamps the maximum allowed phase advance at 40°.

4.8.16. "Base speed advance" (0-359 degrees) (AC brushless only)

x67

Parameter x67 is the phase advance in degrees at the specified base speed. Working in conjunction with parameter x66, this parameter is the number of degrees that the torque angle is increased beyond 90° at the speed set in parameter x66.

The range for this parameter value is from 0 to 359 degrees. The system default is zero (0).

4.8.17. "Phase speed" (machine steps/ms) (AC brushless only)

x68

Parameter x68 is the phase speed specified by the user in machine steps/ms. The range for parameter x68 is a value from 0 to 8,388,608. The system default is zero (0).

4.8.18. "Phase speed advance" (0-359 degrees) (AC brushless only)

x69

Parameter x69 is the phase advance in degrees at the specified phase speed. Working in conjunction with parameter x68, this parameter is the number of degrees that the torque angle is increased beyond 90° at the speed set in parameter x68.

The range for this parameter value is from 0 to 359 degrees. The system default is zero (0).

4.8.19. "DAC offset parameters" (mV)

x79

x80

Parameters x79 and x80 provide a DC offset to the generated primary and secondary current command. They may be used in tachometer applications to null-out the digital/analog (D/A) converters. The values for these parameters are specified in mV and can range from -10,000 to +10,000 mV. The default value is zero. Refer to Table 4-50 for a definition of these parameters.

Table 4-50. Settings for Parameters x79 and x80

Param #	Definition	Range (mV)	Default Value
x79	Primary current command offset	-10,000 to 10,000	0 mV
x80	Secondary current command offset	-10,000 to 10,000	0 mV

4.8.20. "Encoder factor"

x82

Parameter x82 can be used to change the position feedback resolution. This number multiplies encoder counts from the position loop encoder. This should be used only in dual loop applications in which the position loop resolution is less than the velocity loop resolution. Setting the parameter to -1 can reverse the polarity of the encoder. The default value of 0 will not change the resolution. Settings for parameter x82 are given in Table 4-51.

Table 4-51. Settings for Parameter x82

Parameter #	Range	Default Value
x82	-8388607 - 8388607	0

4.9. Page 9: Fault Masks

The fault parameters are part of the UNIDEX 511's error checking and safety system. They are used to define the level at which error conditions are recognized and the resultant actions that will occur. These parameters are explained in detail in this section.

4.9.1. Introduction to Fault Masks

Fault masks are used to define how an axis responds to a given error condition. Each axis can respond to an error condition by performing one or more of the following tasks:

- "Disable" Disables axis amplifier and servo loop
- "Interrupt" Generates an internal hardware interrupt
- "AUX output" Sets/clears an output bit
- "Halt queue" Immediately stops trajectory generation
- "Abort motion" Decelerates axis to a stop
- "Enable brake" Activates the U511's brake circuitry
- "Global fault mask" Enables/Disables detection of error conditions for all tasks

Each task has an associated mask (number) displayed in hexadecimal format. Each bit of this mask corresponds to a possible error condition. Refer to Table 4-52. If the mask bit is set to 1 and the error condition occurs, the task will execute. If the mask bit is set to 0, the task will not execute.

The "Global fault mask" determines which error conditions will be detected. Setting a bit to 0 disables detection of the error condition for all tasks.

The UNIDEX 511 allows bitwise manipulation of these masks. It is not necessary to enter these numbers in hexadecimal format. On the Fault Masks page, simply move the cursor to the parameter you want to modify and hit RETURN. The screen will be replaced by an expanded representation of the fault mask that will let the user enter a 1 or a 0 for the indicated error condition.

The UNIDEX 511 also contains a global emergency stop (E-Stop) task, which is linked to an external opto-isolated input. Setting the emergency stop bit in any fault mask on any axis to 1 enables this input. When E-Stop input occurs, all axes will disable and the "emergency stop" message will be displayed. Driving the opto isolation on and pressing the FLTACK key clears the condition.

Table 4-52. Fault Mask Bit Descriptions

Bit #	Description of Condition	Description
0	Position error	"Max position error" (x19) exceeded
1	RMS current level exceeded	"RMS current trap" (x48) and "RMS current sample time" (x49) exceeded
2	Integral error	"Max integral error" (x20) exceeded
3	CW hardware limit	CW limit input in active state
4	CCW hardware limit	CCW limit input in active state
5	CW software limit	"CW software limit" (x23) position exceeded
6	CCW software limit	"CCW software limit" (x22) position exceeded
7	Amplifier fault	Amplifier fault signal in active state
8	Feedback fault	Encoder line broken or resolver tracking error
9-11	*Reserved*	
12	Feedrate error	"Top feedrate" (x17) exceeded
13	Velocity error	"Max velocity error" (x18) exceeded
14	Emergency stop	Emergency stop input active
15	*Reserved*	
16	Axis 1 any fault	Linkage to other axis
17	Axis 2 any fault	Linkage to other axis
18	Axis 3 any fault	Linkage to other axis
19	Axis 4 any fault	Linkage to other axis
20-23	*Reserved*	
24-27	*Reserved*	
28-31	*Reserved*	
32-35 36-39 40-43 44-47	*Reserved* *Reserved* *Reserved* *Reserved*	

4.9.2. "Global fault mask"

x55

Parameter x55 is the "Global fault mask" parameter. This parameter defines a "global" 48-bit pattern (mask) that either enables (1) or disables (0) detection of fault conditions associated with the corresponding bits for all tasks. The appropriate fault bit (see Table 4-52 on page 4-68) must be set to a "1" for the associated faults to be detected and reported. The default bit pattern for this parameter is FFFF FFFF 319F.

4.9.3. "Disable"

x56

Parameter x56 defines a 48-bit pattern mask (corresponding to the faults listed in Table 4-52 on page 4-68) that specifies which fault conditions (if any) are used to disabled the associated axis. A "1" in a bit position indicates that the corresponding fault condition will disable the associated axis. A "0" in a bit position indicates that the corresponding fault condition is ignored. For example, if bit # 0 (position error bit) of parameter **3**56 is set to 1, then a position error fault on axis **3** will cause that axis to be disabled. The default bit pattern for the "Disable" axis fault mask is FFFF FFF0 EF87.

4.9.4. "Interrupt"

x57

Parameter x57 defines a 48-bit pattern mask (corresponding to the faults listed in Table 4-52 on page 4-68) that specifies which fault conditions (if any) are used to generate a hardware interrupt (when any of the selected fault conditions are true). A "1" in a bit position indicates that the corresponding fault condition will generate a hardware interrupt if the fault occurs. A "0" in a bit position indicates that the corresponding fault condition is not used to generate a hardware interrupt. For example, if bit # 14 (emergency stop bit) of parameter **2**57 is set to 1, then an emergency stop error fault on axis **2** will cause the UNIDEX 511 to generate a hardware bus interrupt. If multiple bits are set to 1 in parameter x57, then a hardware bus interrupt is generated if *any* of the faults associated with those bits occur.

The default bit pattern for the "Interrupt" fault mask is FFFF FFF0 0000 (all assigned bits are set to 0).

4.9.5. "AUX output"

x58

A fault (see Table 4-52 on page 4-68) is considered to be an AUX output fault if the corresponding bit in this "AUX output" fault mask is set to 1. If any of the selected faults occurs, then the UNIDEX 511 will set an output low. This output number is selected in parameter x54 (Output for "AUX output"). The default setting for this parameter is FFFF FFF0 0000 (no faults are selected, therefore "AUX output" faults are effectively disabled).

4.9.6. "Halt queue"

x59

This parameter specifies a fault mask pattern (corresponding to the faults in Table 4-52 on page 4-68) that causes the UNIDEX 511 to stop reading information from the internal queue (that is, stop program execution) if any of the selected conditions are true (i.e., if any of the selected faults occur). The default setting for this parameter is FFFF FFF0 8E00.

> When this condition goes into effect, the commanded velocity will be immediately forced to zero. No ramping will occur and the contouring of the motion will be stopped.

4.9.7. "Abort motion"

x60

Parameter x60 specifies a fault mask pattern (corresponding to the faults in Table 4-52 on page 4-68) that causes the corresponding axis of the UNIDEX 511 to ramp to a stop and wait for an acknowledgment if any of the selected conditions are true (i.e., if any of the selected faults occur). All active axes will decelerate linearly using their individual acceleration/deceleration rates. The default setting for parameter x60 is FFFF FFFF 9E78.

> The ABORT cycle does not preserve the contour of the motion.

4.9.8. "Enable brake"

x61

Parameter x61 specifies a fault mask pattern (corresponding to the faults in Table 4-52 on page 4-68) that causes the brake output to be activated immediately if any of the selected conditions are true (i.e., if any of the selected faults occur). For more information about the brake output, refer to the Chapter 10: Technical Details. The default setting for this parameter is FFFF FFF0 0000.

> Only one axis should specify a non-zero mask for the brake. The brake will be automatically disengaged when the axis is enabled and engaged when the axis is disabled.

> The brake fault mask is usually configured to turn the brake on when a "disable" error occurs.

4.10. Page 10: Traps

Trap parameters are a part of the UNIDEX 511's error checking and safety system. They are used to define the limits for fault conditions. These parameters are explained in the sections that follow. For additional information, refer to Section 4.9: Faults page.

4.10.1. "Top feedrate" (machine steps/ms)

x17

Parameter x17 sets the highest speed (in machine steps/ms) for which the axis is mechanically configured. If a feedrate is requested that is higher than the value specified in x17, then the message "Feedrate Error" is displayed in the Program mode screen of the software. In addition, the feedrate error status can be viewed from the Diagnostics screens in the software. See Chapter 3: The User Interface for more information.

This parameter value can range from 0.004 to 131,071 machine steps/ms. The default value is 440 machine steps/ms. Refer to Table 4-53.

Table 4-53. Settings for Parameter x17

Param #	Axis #	Range (in machine steps/ms)	Default (in machine steps/ms)
117	1	0.004 to 131,071	440
217	2	0.004 to 131,071	440
317	3	0.004 to 131,071	440
417	4	0.004 to 131,071	440

This parameter is provided as a system safety feature. The system will "trap" if a feedrate is inadvertently requested that is higher than this setting.

4.10.2. "Maximum velocity error" (0-8,388,607)

x18

This parameter sets the maximum amount of velocity error (the difference between the actual velocity and the programmed velocity) that is acceptable in the application. For most applications it is advisable to set the maximum velocity error to the same value as the commanded velocity. The units of this parameter are machine steps per servo cycle.

If the velocity of an axis exceeds the value set in x18, then the message "Velocity Error" is displayed in the Program mode screen of the software. In addition, the velocity error state can be viewed from the Diagnostics screens in the software. See Chapter 3: The User Interface for more information.

This parameter value can range from 0 to 8,388,607 machine steps/quarter millisecond (qms). The default value is 1,000 machine steps/qms. Refer to Table 4-54.

Table 4-54. Settings for Parameter x18

Param #	Axis #	Range (in machine steps/qms)	Default (in machine steps/qms)
118	1	0 to 8,388,607	1000
218	2	0 to 8,388,607	1000
318	3	0 to 8,388,607	1000
418	4	0 to 8,388,607	1000

4.10.3. "Maximum position error" (0-8,388,607)

x19

Parameter x19 sets the maximum amount of position error (the difference between the actual position and the programmed position) allowed before a fault is generated. If the position error of an axis exceeds the value set in x19, then the message "Position Error" is displayed in the Program mode screen of the software. In addition, the position error state can be viewed from the Diagnostics screens in the software. See Chapter 3: The User Interface for more information.

This feature can be used to detect abnormal runtime conditions such as mechanical degradation of the system, motor failure, amplifier failure, etc. The U511's graphical tuning software should be used to evaluate the position error dynamically under typical operations.

This parameter value can range from 0 to 8,388,607 machine steps. The default value is 4000 machine steps. Refer to Table 4-55.

Table 4-55. Settings for Parameter x19

Param #	Axis #	Range (in machine steps)	Default (in machine steps)
119	1	0 to 8,388,607	4000
219	2	0 to 8,388,607	4000
319	3	0 to 8,388,607	4000
419	4	0 to 8,388,607	4000

This value may need to be significantly higher when tuning the servo loop for the first time.

4.10.4. "Maximum integral error" (0-8,388,607)

x20

Parameter x20 sets the maximum amount of integral error allowable before an error condition is generated.

If the integral error exceeds the value set in x20, then the message "Integral Error" is displayed in the Program mode screen of the software. In addition, the integral error state can be viewed from the Diagnostics screens in the software. See Chapter 3: The User Interface for more information.

This parameter value can range from 0 to 8,388,607. The default value is 655,360. Refer to Table 4-56.

Table 4-56. Settings for Parameter x20

Param #	Axis #	Range	Default
120	1	0 to 8,388,607	655,360
220	2	0 to 8,388,607	655,360
320	3	0 to 8,388,607	655,360
420	4	0 to 8,388,607	655,360

This type of error generally indicates and amplifier or motor failure.

4.10.5. "RMS current trap" (0-100%)

x48

The "RMS current trap" parameter specifies a percentage (0% to 100%) of the maximum output voltage (+/- 10 volts nominal) commanded by the UNIDEX 511 that corresponds to the desired RMS current limit. An "RMS Current Level Exceeded" fault condition occurs if the RMS current exceeds the RMS limit for the specified "RMS current sample time" (x49). Likewise, a fault occurs if twice the RMS current limit is exceeded for half of the "RMS current sample time" (x49) (and so on, for any fractional portion of the "RMS current sample time"). An RMS fault may occur before the "RMS current sample time" expires if the accumulated RMS current level for the present sample period exceeds the product of the RMS level and the sample time. Refer to Figure 4-9.

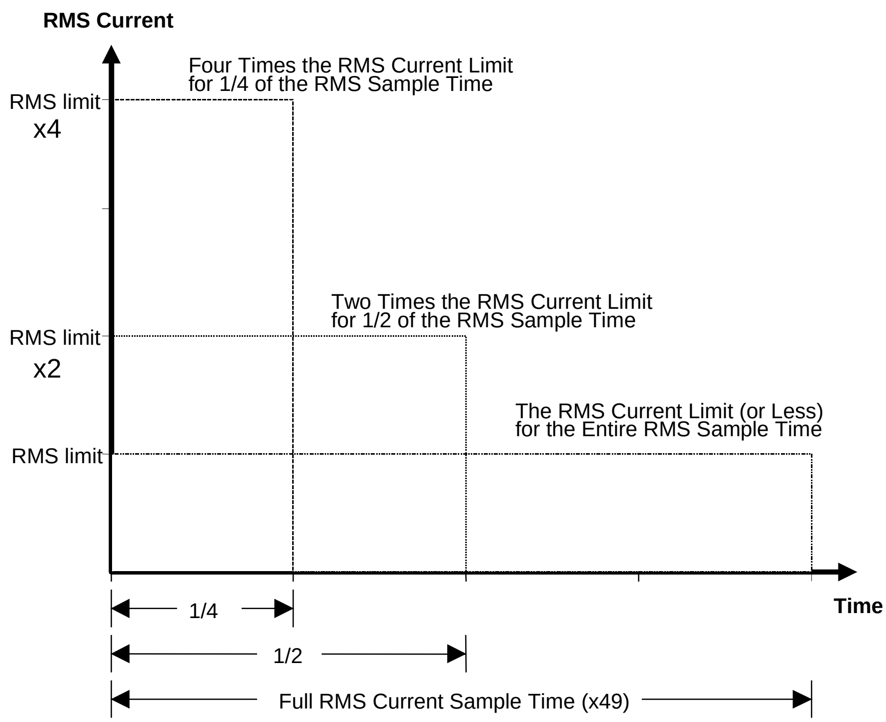


Figure 4-9. Sample RMS Current Maximums

When an RMS current trap occurs, the message "RMS current level exceeded" is displayed in the Program mode screen of the software. In addition, the RMS current limit error can be viewed from the Diagnostics screens in the software. See Chapter 3: The User Interface for more information.

This parameter value can range from 0% to 100%. The default value is 30%. Refer to Table 4-57.

Table 4-57. Settings for Parameter x48

Param #	Axis #	Range	Default
148	1	0% to 100%	30.0000 %
248	2	0% to 100%	30.0000 %
348	3	0% to 100%	30.0000 %
448	4	0% to 100%	30.0000 %

If the value of parameter x48 is set to 100%, an RMS current trap will never be generated for the associated axis.

This parameter is used in conjunction with parameter x49 to determine RMS current level faults.

4.10.6. "RMS current sample time" (1-16,383 ms)

x49

Parameter x49 sets the RMS current sample time. This time represents the span over which the RMS current must remain below the RMS current limit (calculated using parameter x48), otherwise an "RMS Current Level Exceeded" fault will occur. A fault may occur before the sample time expires. This occurs if the accumulated RMS current level for the present sample period exceeds the corresponding RMS level for the fractional portion of the sample time (e.g., twice the level for half the time, three times the level for one third the time, etc.). Refer to Figure 4-9.

The "RMS current sample time" parameter may be referred to as the *thermal time constant*. This name reflects the function of the parameter because the RMS current drawn by a motor over a period of time will tend to heat up the motor. Therefore, the operator should choose a parameter value that will cause a fault *before* the motor overheats and fails.

This parameter value can range from 1 to 16,383 ms. The default value is 10,000 ms (or 10 seconds). Refer to Table 4-58.

Table 4-58. Settings for Parameter x49

Param #	Axis #	Range	Default
149	1	1 to 16,383 ms	10,000 ms
249	2	1 to 16,383 ms	10,000 ms
349	3	1 to 16,383 ms	10,000 ms
449	4	1 to 16,383 ms	10,000 ms

This parameter is used in conjunction with parameter x48 to determine RMS current level faults.

4.10.7. "Clamp current output" (0-100%)

x53

Parameter x53 is the "Clamp current output" parameter. The maximum output voltage of the control loop may be clamped in order to limit the amplifier current and motor torque. This parameter is expressed as a percentage of the maximum output voltage.

The actual motor current depends on amplifier scaling. This parameter should be set such that the maximum peak current of the motor is not exceeded. A fault condition is not generated if the UNIDEX 511 tries to exceed the maximum current output level, however, position errors or integral error faults may occur.

This parameter value can range from 0 % to 100 %. The default value for this parameter is 100 %. Refer to Table 4-59.

Table 4-59. Settings for Parameter x53

Param #	Axis #	Range	Default
153	1	0 % to 100 %	100 %
253	2	0 % to 100 %	100 %
353	3	0 % to 100 %	100 %
453	4	0 % to 100 %	100 %

This parameter provides a safety feature to prevent the peak currents from damaging the amplifiers and or motors. Proper configuration of this parameter can help to avoid equipment damage.

4.10.8. "AUX fault output bit" (0, 1-8)

x54

Parameter x54 is used to specify an output bit (1-8) that is activated (set low) if a programmable "AUX output" fault condition (see x58) is met. Deactivate this feature by entering 0. Refer to Hardware Details chapter for technical details about the eight TTL outputs of the UNIDEX 511 including output lines, pin numbers, and electrical characteristics.

Parameter x54 can have a value that ranges from 0 to 8. These values are explained in Table 4-60.

Table 4-60. Settings for Parameter x54

Param #	Axis #	Values and Descriptions
x54	1, 2, 3, 4	0 disabled 1 - output bit 0 is activated on associated AUX output faults (default for axis 1) 2 - output bit 1 is activated on associated AUX output faults 3 - output bit 2 is activated on associated AUX output faults 4 - output bit 3 is activated on associated AUX output faults 5 - output bit 4 is activated on associated AUX output faults 6 - output bit 5 is activated on associated AUX output faults 7 - output bit 6 is activated on associated AUX output faults 8 - output bit 7 is activated on associated AUX output faults

A reset of the UNIDEX 511 sets all output bits high (deactivated).

4.10.9. "Amplifier fault active low" (y/n)

x70

Parameter x70 specifies the polarity of the drive amplifier fault signal input to the UNIDEX 511. This parameter must be configured to correspond to the input signal in its inactive state.

In a normally open (active low) configuration (x70 = yes), a 5 volt signal represents a normal (non-fault) condition and a 0 volt signal indicates a drive fault condition. Conversely, in a normally closed (active high) configuration (x70 = no), a 0 volt signal represents a normal (non-fault) condition and a 5 volt signal indicates a drive fault condition. The settings for parameter x70 are shown in Table 4-61.

Table 4-61. Settings for Parameter x70

Param #	Axis #	Values	Description
170	1	Yes (**Y**)	Drive fault signal is active low (default)
		No (N)	Drive fault signal is active high
270	2	Yes (**Y**)	Drive fault signal is active low (default)
		No (N)	Drive fault signal is active high
370	3	Yes (**Y**)	Drive fault signal is active low (default)
		No (N)	Drive fault signal is active high
470	4	Yes (**Y**)	Drive fault signal is active low (default)
		No (N)	Drive fault signal is active high

4.11. Page 11: Planes and Mapping

The Planes and Mapping page contains parameters that are used to configure contour planes and gantry (master/slave) motion. These parameters are explained in detail in this section. An overview of planes is presented in the next section, followed by descriptions of the planes and mapping parameters.

4.11.1. Overview of Planes

The UNIDEX 511 system can control up to four axes of motion as well as miscellaneous inputs and outputs. Typically, these inputs, outputs, and/or axes are controlled from a program that is written for the particular application. A UNIDEX 511 program consists of a series of instructions that are executed sequentially to perform the desired functions.

The programming/control process starts when a program is written using a set of UNIDEX 511 programming commands. When the operator starts the program, the first chunk is loaded from RAM on the U511 into a program buffer (8 Kbytes on the U511) for execution. Execution of the program starts with the first command in the buffer. After the first command is finished executing (e.g., commanding an axis, checking an input, etc.), the command is removed from the buffer . This process continues until the entire program has been queued into the program buffer and has finished executing. This programming scheme is ideal for controlling a single multi-axis system through a series of discrete steps. Refer to Figure 4-10.

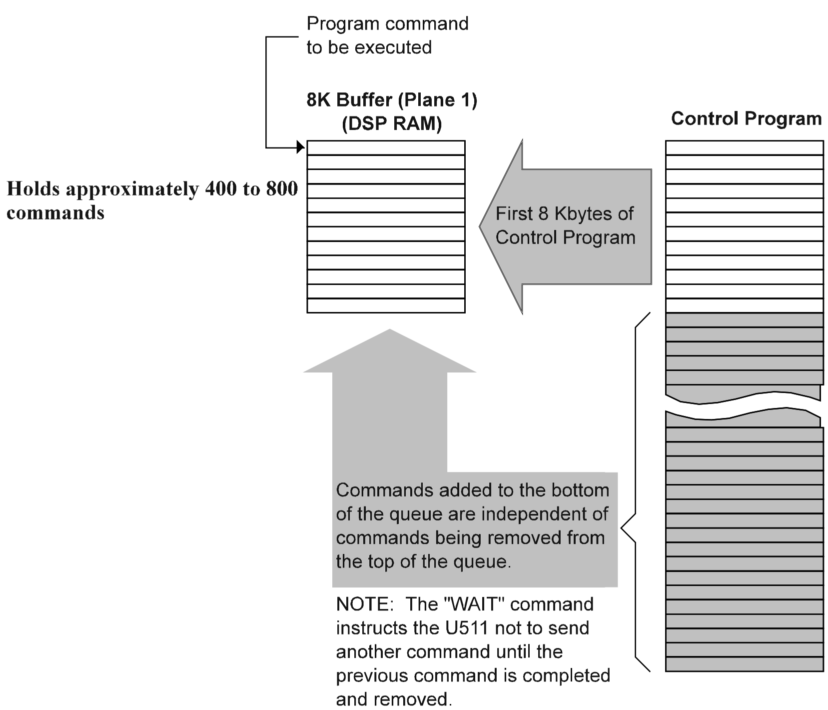


Figure 4-10. Programming Control Using a Single Plane

The versatility of the UNIDEX 511 system provides a second, more powerful programming scheme that allows multiple "programs" (two or four) to perform independent control functions (e.g., commanding an axis, checking an input, etc.) asynchronously and "simultaneously." This programming scheme multitasks between a user-defined number of sections (1, 2, or 4) of the original 8 Kbyte program buffer. Each of these sections is called a *plane*.

A plane is a program buffer (of fixed size) that contains programming statements. One, two, or four planes may be defined, each containing programming statements unique to that plane. The UNIDEX 511 executes the first (and then subsequent) lines in each plane in a round-robin fashion called multitasking. The multitasking is performed so quickly that the planes appear to be executing simultaneously. Refer to Figure 4-11.

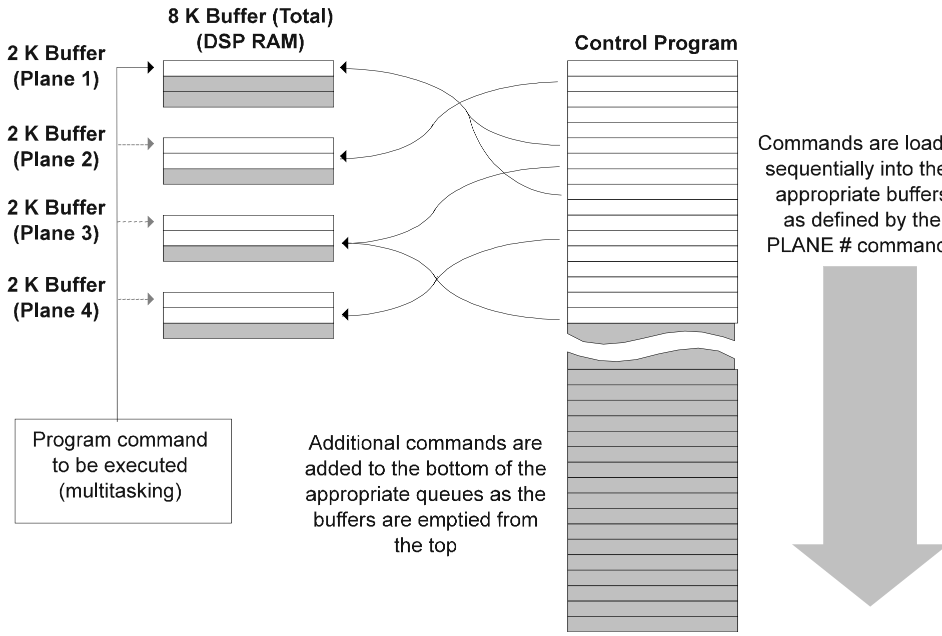


Figure 4-11. Programming Control Using Four Planes

Below are important issues to remember when using planes.

- The programming buffer is 8 Kbytes in size
- The U511 system can be configured to use 1, 2, or 4 planes
- The 8 Kbyte program buffer is divided equally among the planes being used (i.e., there will be one 8 Kbyte buffer, two 4 Kbyte buffers, or four 2 Kbyte buffers)
- One or more axes can be mapped to (i.e., associated with) a single plane
- An axis cannot be mapped to more than one plane
- Axis commands, for a particular axis, can be included within a particular plane only if the axis has been mapped to that plane

- A plane can be used for non-axis control such as monitoring inputs and/or setting outputs
- Special programming commands are used to route individual program statements to their appropriate planes (buffers)
- When a plane buffer is filled with commands, no additional commands to that plane can be queued until a slot in the queue is freed (i.e., the oldest command is completed and removed from the buffer). If this occurs, and the next sequential command to be loaded into the program buffer is directed to that plane, then the other planes must wait

A sample UNIDEX 511 program segment is listed in Figure 4-12. Although programming has not yet been explained, the program segment shown below is relatively simplistic and offers an example of the use of planes. Comments are preceded by semicolons and are listed to the right of programming commands for clarity.

```
; This program segment illustrates the use of planes in programming. This program
;segment assumes the following parameter settings have been established:
;       000 =   2              ;"Number of contour planes" is set to 2
;       003 =   1,X            ;Axis 1 [param 003] is mapped to plane 1 as "X"
;       004 =   2,Y            ;Axis 2 [param 004] is mapped to plane 2 as "Y"
;       005 =   2,Z            ;Axis 3 [param 005] is mapped to plane 2 as "Z"
;       006 =   1,U            ;Axis 4 [param 006] is mapped to plane 1 as "U"
;-----------------------------------------------------------------------------------------------
            :                                          :
        PLANE 1                ;Select plane 1
        EN  X    U             ;Enable axes X and U (of plane 1) for motion
        PLANE 2                ;Select plane 2
        EN  Y    Z             ;Enable axes Y and Z (of plane 2) for motion
        G1  Y50000             ;Linear move Y axis (in plane 2) 50000 machine steps
        PLANE 1                ;Select plane 2 (Y axis is still moving...)
        G1  X10000             ;Linear move X axis (in plane 1) 10000 machine steps
        G1  U500               ;Linear move U axis (in plane 1) 500 machine steps
            :                                          :
```

Figure 4-12. Sample Programming Segment Showing the Use of Planes

Using the parameter settings shown above, the UNIDEX 511 assigns two internal buffers for plane commands. The 8 Kbyte program buffer is therefore divided into two equal buffers of 4 Kbytes each. Next, the operator loads the program into hardware memory. When the operator starts the program, the software begins sending the program (one line at a time) to the appropriate program buffer in the DSP's memory using a special software command. The software continues to send commands to the appropriate buffers until either a target buffer is filled, or until the program finishes.

On the UNIDEX 511 side, the multitasking program is checking each of the buffers (in a round-robin fashion) and executing the next appropriate instruction in each. When an instruction in a buffer is completed, the instruction is removed from the buffer, remaining instructions are shifted up, and a slot in the buffer is freed for additional programming statements from the software.

Notice that axis Y (in Figure 4-12) is given a linear move (G1) command of 50000 units (in plane 2). This is followed by a linear X axis move of 10000 units (in plane 1). By using planes and multitasking, the UNIDEX 511 is able to carry out the request in plane 1 before the request in plane 2 is finished (i.e., before the Y axis completes its 50000-unit linear move).

For more information about programming using planes, refer to Chapter 5: Programming Commands.

4.11.2. "Number of contour planes" (1, 2, or 4)

000

This function defines the number of contour planes through which the UNIDEX 511 will multitask. Each contour plane is assigned its own memory area that holds program commands that are exclusively targeted for that plane.

The program buffer of the UNIDEX 511 is fixed at 8 Kbytes regardless of the number of contour planes selected. One, two, or four planes may be used for maximum flexibility and efficiency. If one plane is specified, the size of the program buffer is fixed at 8 Kbytes. If two planes are selected, the size of each program buffer is fixed at 4 Kbytes. Finally, if four planes are selected, the size of each program buffer is fixed at 2 Kbytes.

In a single plane configuration (parameter 000=1), the UNIDEX 511 will wait for one command to finish before beginning to execute the next command. For example, if an axis is commanded to move 300 mm, the UNIDEX 511 will wait until that position is reached before the next command is interpreted and executed. In this configuration, the entire 8 Kbyte program buffer is available to the control program. If the control program is larger than 8 Kbytes, portions are queued into the buffer as preceding commands are executed and removed from buffer.

In a multiple plane configuration (parameter 000=2 or 4), commands are queued to particular program buffers (i.e., planes). The first program statement in each of these buffers is executed in a multitasking environment so that the tasks appear to run concurrently. In these configurations, the 8 Kbyte program buffer is divided equally among the planes. As commands are read from the control program, they are sent to the appropriate buffers.

> If a program buffer (i.e., a plane) becomes filled, and additional program commands for that plane are forthcoming, the plane is marked as "busy" until a command is completed and removed from the queue.

For additional information about planes, refer to the previous section (Overview of Planes). For additional information on mapping axes to planes, refer to parameters 003, 004, 005, and 006.

Analyzing the application and the best programming style for that application is vital to optimizing the number of programming planes required. For non-multitasking applications, one contour plane is suitable. This is the typical operating mode for most controllers and is the default setting for this parameter. In addition, all axes are assigned to contour plane one by default. However, many applications require independent, asynchronous motions with real time responses. In these cases, it is better to define multiple contour planes.

This parameter can have the value 1, 2, or 4. This corresponds to either 1 (the default), 2, or 4 contour planes. Settings for parameter 000 are shown in Table 4-62.

Table 4-62. Settings for Parameter 000

Value	Number of Program Buffers	Size of Each Program Buffer
1	1 (default)	8 Kbytes
2	2	4 Kbytes
4	4	2 Kbytes

It is suggested that the number of contour planes set by this parameter be as small as possible for the application. Doing this will provide the maximum buffer size and the fastest processing time.

Following configuration of this parameter, the system must be reinitialized so that the new number of planes is recognized.

IMPORTANT

4.11.3. "Keep position after reset?" (y/n)

001

This parameter configures the UNIDEX 511 to either clear (that is, set to 0) all absolute, relative and machine positions following a reset (no) or to retain the current axis values (yes).

Axis positions are often programmed to a known location following a home cycle. A home cycle is often commanded as a normal startup function, in which case the setting of this parameter is immaterial. It is suggested, however, that this parameter be set to yes, as it may aid in recovering information and diagnosing problems.

This parameter can have one of two possible settings that are listed in Table 4-63.

Table 4-63. Settings for Parameter 001

Value	Function
Yes	Maintains position information following a reset
No	Clears position information following a reset (default)

This parameter defaults to "no." This means that the position counter will clear the position information following a reset.

IMPORTANT

If the axis moves during the reset more than 16,384 counts for an encoder or 1/2 revolution for a resolver, the UNIDEX 511's position tracking registers (and the axis position display of the Program mode software window) will not be accurate after the reset.

4.11.4. "MFO pot offset" (0-255)

002

This parameter is used to enable or disable an optional manual feed override (MFO) potentiometer (pot). The MFO pot, if used, is attached to the auxiliary I/O connector on the rear of the chassis of the UNIDEX 511.

The "MFO pot offset" parameter has a range from 0 to 255. A value of 0 should be used if the MFO option is not used. A 0 value can also be used to disable an existing MFO pot. If an MFO pot is enabled (that is, parameter 002>0), then the value set by this parameter represents an offset that becomes the new 0% MFO position. Refer to Table 4-64.

Table 4-64. Settings for Parameter 002

Value	Description
0	Used when the MFO potentiometer option is not being used or to disable an existing MFO pot. (default)
1-255	Specifies the "MFO pot offset" for 0% MFO.

If the pot is enabled (i.e., parameter 002>0), the U511 reads the current pot position (as a value from 0 to 255 counts) through an 8 bit A/D converter. The value of parameter 002 *shifts* the 0% MFO mark, thereby creating a user-definable low-end deadband over which the MFO is 0%. The new MFO percentage is then defined as a function of the MFO offset from parameter 002 (a value from 1-255) and the actual A/D converter value (0-255) read by the U511. Setting parameter 002>0, effectively creates a low-end pot deadband and automatically rescales the remainder of the pot range over the remaining number of converter counts. This is accomplished using the following equation.

MFO % = ((1 + Converter Value - Value of Parameter 002) / 255) * 100%

For example, setting parameter 002 = 55 will create a 55-count deadband at the low end of the pot range. The A/D converter data from 0 to 55 counts will be treated as a 0% MFO. Any data greater than 55 can be calculated by substituting the current A/D converter value (56-255) in the above equation and solving for MFO %. See Figure 4-13. The typical value for this parameter when connecting to a pot is 10.

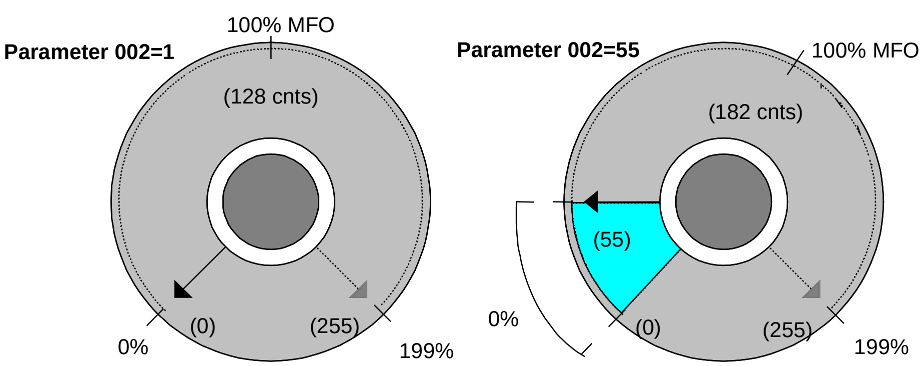


Figure 4-13. MFO Potentiometer With and Without Offsets

4.11.5. "Axis {1, 2, 3, 4} plane 1-4 as X, Y, Z, U"

003

004

005

006

The UNIDEX 511 is capable of multitasking at such high speeds, that it appears as though tasks are being performed simultaneously. The execution of these tasks, as well as how the tasks relate to each other is programmable by the operator. Four memory areas are available to receive motion commands. These memory areas are referred to as contour planes.

These parameters also are used to map one or more axes to a contour plane and assign the axes a programming name (i.e., X, Y, Z, or U). Assigning an axis to plane zero, blocks that axis from any motion.

The syntax of parameters 003-006 can have one of two possible formats:

0 which means that all motion is blocked on the associated axis

(003=0 blocks all motion on axis 1, 004=0 blocks all motion on axis 2, etc.), or

a,*b* where:

a = the plane number {1, 2, 3, or 4} to which the respective axis is mapped

b = the axis designator {X, Y, Z, or, U} (e.g., 003=4, X maps axis 1 to plane 4 as "X")

The defaults settings for these parameters are (1,X), (1,Y), (1,Z), and (1,U) (i.e., axes 1,2,3, and 4 are all mapped to plane 1 as X, Y, Z, and U, respectively). This is summarized in Table 4-65.

Table 4-65. Settings for Parameters 003, 004, 005, and 006

Param #	Axis #	Value	Description	Examples
003	1	0	Blocks motion on axis 1	0
		a,*b*	Map axis 1 to plane *a* as *b*, where *a* = {1, 2, 3, or 4}, and *b* = {X, Y, Z, or U}.	**1,X** (default) 2,U 3,Z
004	2	0	Blocks motion on axis 2	0
		a,*b*	Map axis 2 to plane *a* as *b*, where *a* = {1, 2, 3, or 4}, and *b* = {X, Y, Z, or U}.	**1,Y** (default) 1,Z 2,X
005	3	0	Blocks motion on axis 3	0
		a,*b*	Map axis 3 to plane *a* as *b*, where *a* = {1, 2, 3, or 4}, and *b* = {X, Y, Z, or U}.	**1,Z** (default) 4,X 3,Y
006	4	0	Blocks motion on axis 4	0
		a,*b*	Map axis 4 to plane *a* as *b*, where *a* = {1, 2, 3, or 4}, and *b* = {X, Y, Z, or U}.	**1,U** (default) 4,Y 1,Z

Axis one is always assigned to amplifier/drive channel one, axis two to amplifier/ drive channel two, etc.

An axis must not be assigned to more than one contour plane. If the UNIDEX 511 system is inadvertently configured this way, a feedback error is generated.

For additional information on the use of planes, refer to Section 4.11.1: Overview of Planes (on page 4-81) as well as the PLane command in Chapter 5: Programming.

4.11.6. "Axis {1,2,3,4} gantry yes/none slave {1,2,3,4}"

007 008 009 010

When performing contour type moves, it may be desirable to pair axes in a master/slave relationship. In such configurations, motions commanded to the master axis are automatically sent to the slave axis.

These parameters must be configured relative to each other. In addition, an axis may be designated as a master or a slave, but not both (i.e., parameter 007 cannot designate axis 2 as a slave and parameter 008 designate axis 2 as a master).

The syntax of parameters 007-010 can have one of two possible formats:

n which means the associated axis is not a gantry master, or

y,*b* which means the associated axis is a gantry master having axis *b* (one of the remaining 3 axes) as the slave axis (e.g., 007=y,2 sets axis 1 as the gantry master with slave axis 2). The *b* can also be preceded by a negative sign (-). This will invert the direction of motion of the slave with respect to the master.

The defaults setting for these parameters is "n" (i.e., axes 1,2,3, and 4 are not gantry masters). Other settings for these parameters are summarized in Table 4-66.

Table 4-66. Settings for Parameters 007, 008, 009, and 010

Param #	Axis #	Value	Description	Examples
007	1	none	Axis 1 is not a gantry master	**none** (default)
		y,*b*	Axis 1 is a gantry master having axis *b* as the slave axis, where: *b* = {2, 3, or 4}.	y,2 y,-2 y,3 y,-3 y,4 y,-4
008	2	none	Axis 2 is not a gantry master	**none** (default)
		y,*b*	Axis 2 is a gantry master having axis *b* as the slave axis, where: *b* = {1, 3, or 4}.	y,1 y,-1 y,3 y,-3 y,4 y,-4
009	3	none	Axis 3 is not a gantry master	**none** (default)
		y,*b*	Axis 3 is a gantry master having axis *b* as the slave axis, where: *b* = {1, 2, or 4}.	y,1 y,-1 y,2 y,-2 y,4 y,-4
010	4	none	Axis 4 is not a gantry master	**none** (default)
		y,*b*	Axis 4 is a gantry master having axis *b* as the slave axis, where: *b* = {1, 2, or 3}.	y,1 y,-1 y,2 y,-2 y,3 y,-3

Once the master is enabled, the slave is automatically enabled.

Gantry axes are linked together at all times except for home cycles. The home cycles are done independently except during the marker search. Each axis does an independent search for its marker (for encoders) or null (for resolvers). When one axis finds its marker, it will wait for the other to complete its marker search. The home cycle is not complete until both the master and the slave axes finish their move.

The home cycle parameters for the gantry axes should be set the same. Gantry alignment can be adjusted by changing the limit to marker and "Home offset" parameters. If individual adjustment is not desired, the master axis' limits and marker signals should be connected to the slave's channel.

It is desirable to have identical stages oriented in the same direction. The limit switches and markers should also be aligned as close as possible.

For resolver gantry systems, each axis determines the distance it must move to go to the resolver's absolute zero position. The setting of parameter x06 ("Home offset") is added to this distance. The move is then executed at the feedrate specified by parameter x04 ("Home feedrate"). The home cycle is not complete until both the master and slave axes finish their move.

For example, consider a gantry system in which the slave axis marker is "d" machine steps from the master axis' marker. (In the case of a resolver, the marker position is replaced by the zero or "null" position.) The alignment of the axes can be adjusted by changing the master's "Home offset" parameter value to reflect the distance "d." The slave axis should have an offset setting of "0." Refer to Figure 4-14.

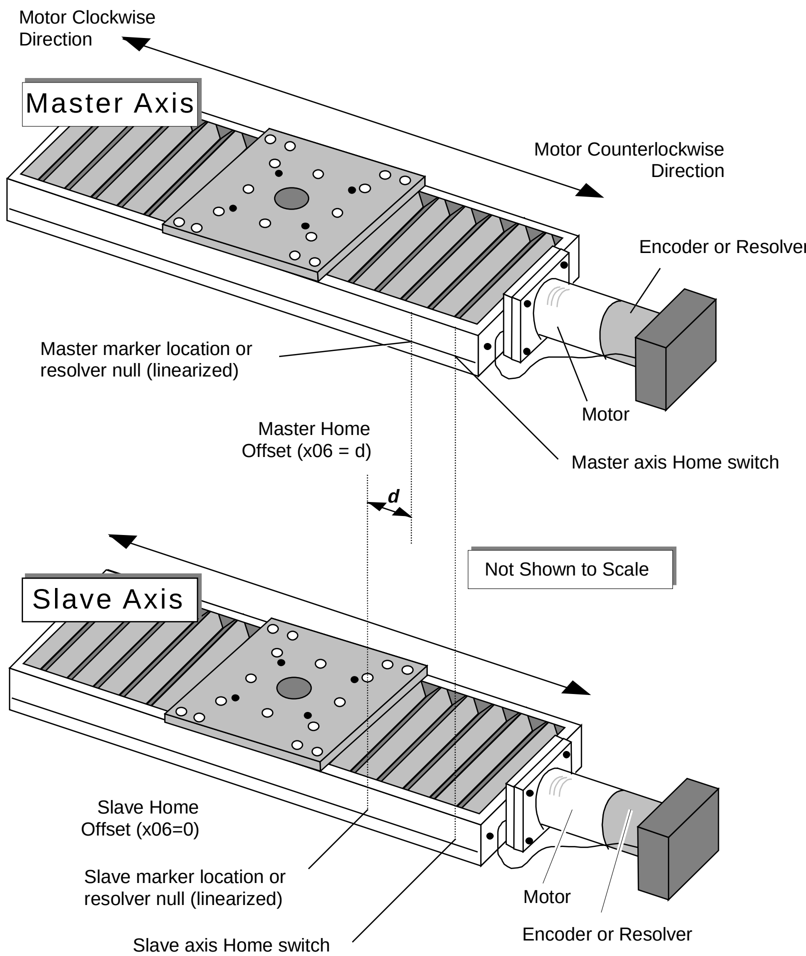
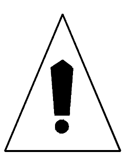


Figure 4-14. Using "Home offset" Parameter to Keep Gantry Aligned After Homing



The following servo-related parameters should be set to the same values for both axes involved in the gantry:

x02 - "Home direction is CCW" (y/n)
x04 - "Home feedrate" (machine steps/ms)
x16 - "Max accel/decel" (machine steps/ms/ms).

4.11.7. "Segment time" (1-20 ms)

018 036 054 072

During trajectory generation, the UNIDEX 511 divides the motion into segments. These parameters represent the motion time for each segment (in milliseconds [ms]). The default setting of 10 ms is sufficient for most applications. If the application requires many short moves with short ramp times, you may wish to reduce the value of this setting. The minimum value is one millisecond.

These parameter values can range from 1 to 20 ms for each of the planes under command. The system default is 10 ms. Refer to Table 4-67.

Table 4-67. Settings for Parameters 018, 036, 054, and 072

Param #	Plane #	Range	Examples
018	1	1-20 ms	1 = Provides the slowest calculation time and yields the maximum number of indexing segments 10 = Provides a moderate calculation time and yields a moderate number of indexing segments (default) 20 = Provides the fastest calculation time and yields the minimum number of indexing segments
036	2	1-20 ms	*see examples shown above*
054	3	1-20 ms	*see examples shown above*
072	4	1-20 ms	*see examples shown above*

This parameter will not increase servo velocities in any way. It may be used to improve the processing efficiency of the calculation effort during trajectory generation.

4.11.8. "Ramp time" (1-32,000 ms)

019

037

055

073

The acceleration and deceleration time of linear and circular motion is set using parameters 019, 037, 055, and 073 (refer to Figure 4-15). These parameters also specify the time it takes to change velocities in velocity profiling mode. "Ramp time" applies to linear or sinusoidal accel/decel profiles.

These parameters can range from 1 to 32,000 milliseconds. The system default for these parameters is 150 ms. Settings for these parameters are listed in Table 4-68.

Table 4-68. Settings for Parameters 019, 037, 055, and 073

Parameter #	Plane #	Range	Default
019	1	1-32,000 ms	150 ms
037	2	1-32,000 ms	150 ms
055	3	1-32,000 ms	150 ms
073	4	1-32,000 ms	150 ms

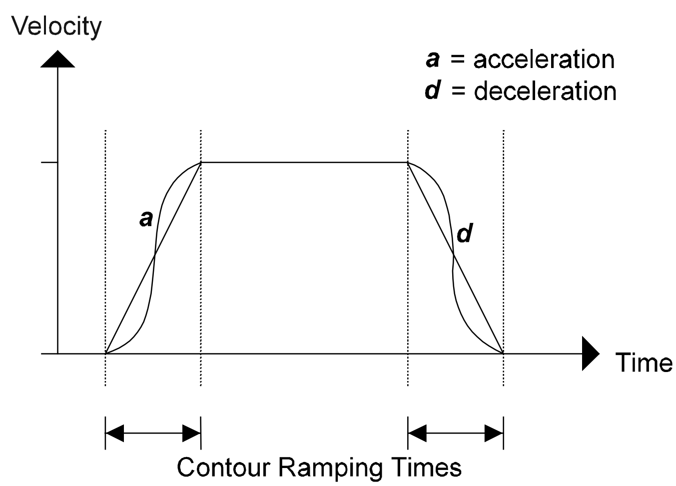


Figure 4-15. Contour Ramping (Acceleration/Deceleration) Time

Systems with high mass or inertia will require longer ramping times.

Contour Ramping Time does not apply to Index, Home, and Freerun moves.

4.11.9. "Default to metric" (yes/no)

020 038 056 074

Parameters 20, 38, 56, and 74 specify the default use of the Metric or English measurement system when programming the conversion factor for contour planes 1-4, respectively. The conversion factor is used to determine system scaling. The actual values for the conversion factors are programmed in parameters x00 (Metric) and x01 (English). Parameters 020, 038, 056, and 074 only specify the measurement system.

This parameter can have one of two possible values (yes or no) and is programmed on a per plane basis. Settings for parameters 020, 038, 056, and 074 are listed and described in Table 4-69.

Table 4-69. Settings for Parameters 020, 038, 056, and 074

Value	Function
Yes	Metric system *is* used for the associated contour plane (default)
No	Metric system *is not* used (i.e., English System is used) for the associated contour plane

Be sure to set parameters 029, 047, 065, and 083 ("Metric digits") or parameters 030, 048, 066, and 084 ("English digits") as appropriate, for each of the active contour planes. Refer to Table 4-70 for a reference of these associations.

IMPORTANT

Table 4-70. Parameter Associations between Planes, Measurement Units, and the Number of Decimal Digits

Plane #	English/Metric Units	Number of Decimal Digits
1	English (parameter 020 = no)	Use parameter 030
	Metric (parameter 020 = yes)	Use parameter 029
2	English (parameter 038 = no)	Use parameter 048
	Metric (parameter 038 = yes)	Use parameter 047
3	English (parameter 056 = no)	Use parameter 066
	Metric (parameter 056 = yes)	Use parameter 065
4	English (parameter 074 = no)	Use parameter 084
	Metric (parameter 074 = yes)	Use parameter 083

For information on determining an appropriate conversion factor, refer to parameter x00 (the "Metric conversion factor") or parameter x01 (the "English conversion factor").

021

039

057

075

4.11.10. "Linear accel/decel" (y/n)

The UNIDEX 511 supports two types of acceleration/deceleration ramping trajectories: linear and inverse sine. Each contour plane must be delineated as either linear or inverse sine for this ramping. The strict form of linear ramping may be replaced by the smoother sine ramping option to reduce "jerky" motion during axis acceleration/deceleration. Refer to Figure 4-16.

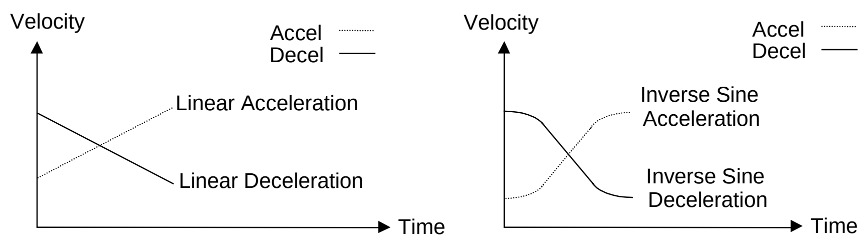


Figure 4-16. Graphs of Linear and Inverse Sine Ramping Trajectories

Each of these parameters can have either a "yes" or "no" value, where "yes" indicates that linear acceleration/deceleration is defined for the associated plane, and "no" (the default value) indicates that inverse sine acceleration/deceleration is defined for the associated plane. These values are summarized in Table 4-71.

Table 4-71. Settings for Parameters 021, 039, 057, and 075

Param #	Plane #	Descriptions
021	1	Yes = Accel/decel is linear for plane 1 No = Accel/decel is inverse sine type for axis 1 (default)
039	2	Yes = Accel/decel is linear for plane 2 No = Accel/decel is inverse sine type for axis 2 (default)
057	3	Yes = Accel/decel is linear for plane 3 No = Accel/decel is inverse sine type for axis 3 (default)
075	4	Yes = Accel/decel is linear for plane 4 No = Accel/decel is inverse sine type for axis 4 (default)

☞ As a recommendation, the operator should set this parameter to "no" (inverse sine ramping) for systems having high inertia and/or mass.

4.11.11. "Contour feedrate" (program steps/ms)

Parameters 022, 040, 058, and 076 specify a default feedrate (in program steps/ms) to be used by axes in each contour plane if a feedrate is not explicitly stated (in the program) for that plane. Typically, most programs that request contour type motion specify a feedrate. A feedrate that is explicitly stated in a program (for a particular plane) will override the value of parameter 022, 040, 058, or 076, as appropriate. A default feedrate must be set for each active contour plane.

These parameters can have values from 1 to 32,767 program steps/ms. The system default is 16 program steps/ms. Refer to Table 4-72.

022

040

058

076

Table 4-72. Settings for Parameters 022, 040, 058, and 076

Param #	Plane #	Range	Default
022	1	1-32,767 program steps/ms	16 program steps/ms
040	2	1-32,767 program steps/ms	16 program steps/ms
058	3	1-32,767 program steps/ms	16 program steps/ms
076	4	1-32,767 program steps/ms	16 program steps/ms

4.11.12. "X, Y, Z, and U axes index feedrates" (program steps/ms)

These parameters set the default axis feedrates (in program steps/ms) of axes 1, 2, 3, and 4 for each active contour plane (1-4) when performing point-to-point (indexed) moves. A command line feed rate (if specified) will override the settings of these parameters. See the INDEX command for more details.

These parameters can have values from 0.004 to 32,767 program steps/ms. The system default is 16.0 program steps/ms. Refer to Table 4-73 for plane assignments and settings.

023 - 026

041 - 044

059 - 062

077 - 080

Table 4-73. Point-to-point Feedrate Parameter Assignments and Settings

Plane	Axes				Ranges in	Defaults in
#	1	2	3	4	prog steps/ms	prog steps/ms
1	023	024	025	026	0.004 to 32,767	16.0 prog steps/ms
2	041	042	043	044	0.004 to 32,767	16.0 prog steps/ms
3	059	060	061	062	0.004 to 32,767	16.0 prog steps/ms
4	077	078	079	080	0.004 to 32,767	16.0 prog steps/ms

4.11.13. "Clamp feedrate" (program steps/ms)

027 045 063 081

This parameter specifies the maximum feedrate allowed on the corresponding plane for all *contour type* motion (linear or circular) in that plane. The value specified in this parameter is given in program steps/ms and can range from 0.004 to 32,767 program steps/ms. The system default is 256.0 program steps/ms for each of the contour planes. A maximum feedrate must be specified for each of the active contour planes. Settings for this parameter are listed in Table 4-74.

Table 4-74. Settings for Parameters 027, 045, 063, and 081

Param #	Plane #	Range
027	1	0.0004 to 32,767 program steps/ms (default = 256.0)
045	2	0.0004 to 32,767 program steps/ms (default = 256.0)
063	3	0.0004 to 32,767 program steps/ms (default = 256.0)
081	4	0.0004 to 32,767 program steps/ms (default = 256.0)

If a contour feedrate (programmed or derived after MFO adjustment) is larger than the setting of this parameter, then the UNIDEX 511 will automatically clamp it to the appropriate "Clamp feedrate" value.

4.11.14. "Corner rounding time" (1-32,000 ms)

028 046 064 082

When corner rounding is being used with contour type motion (i.e., after a ROUNDING ON or G23, "activate corner rounding" programming command has been issued), it may be desirable to blend step velocities to provide for smooth motor operation (see Figure 4-17). During deceleration, when there is time remaining for motion (as established by this parameter), the next block of motion will begin. A corner rounding non-ramp time must be specified for each of the active contour planes.

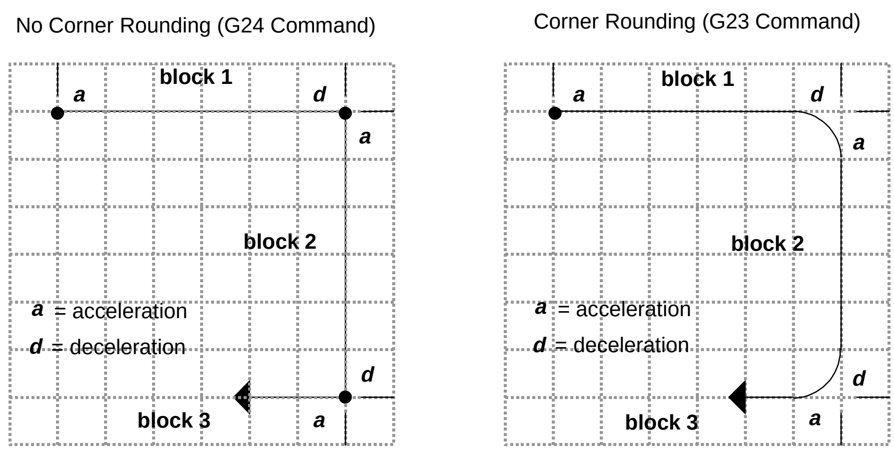


Figure 4-17. Sample Motion Path Shown with and without Corner Rounding

The non-ramp time specifies a time in milliseconds (from 1 to 32,000) during which the deceleration of one motion overlaps the acceleration of the next motion. This overlap causes one motion control block to begin its acceleration ramp before the preceding motion block finishes its deceleration. The result is a rounded corner, the size of which is determined by the acceleration/deceleration times and the setting of the corner rounding non-ramp time parameter. A sample non-ramp time overlap for corner rounding is illustrated in Figure 4-18.

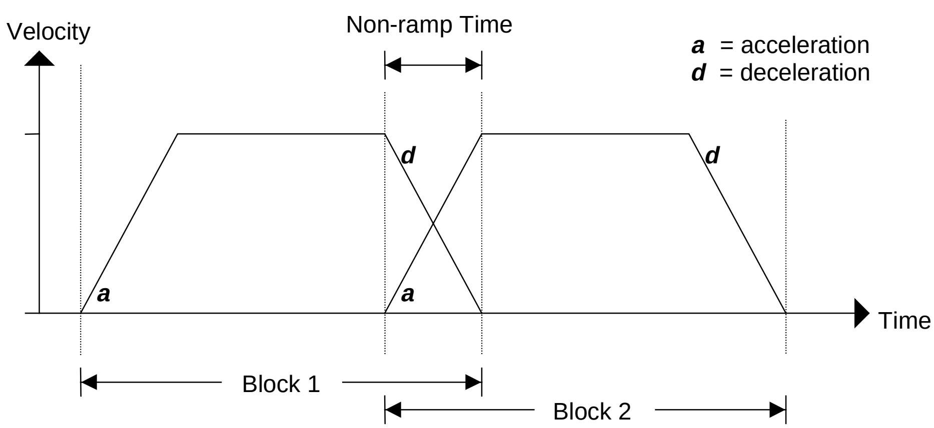


Figure 4-18. Velocity Diagram of Corner Rounding (G23)

When corner rounding is not used (e.g., G24 or ROUNDING OFF programming command), each contour path decelerates to its target position before the next block of motion begins. Refer to Figure 4-19.

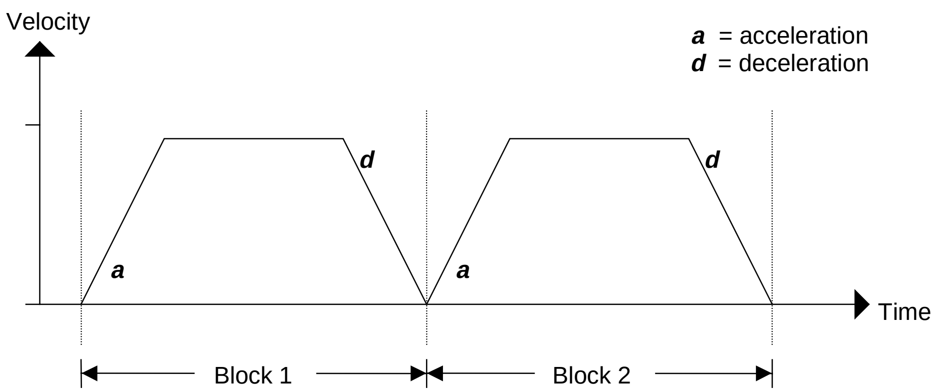


Figure 4-19. Velocity Diagram of Non-corner Rounding (G24)

Non-ramp time is defined as the time between the path stop and the start of the next block. Non-ramp time parameter values can range from 1 to 32,000 milliseconds and have defaults settings of 150 ms. Refer to Table 4-75.

Table 4-75. Settings for Parameters 028, 046, 064, and 082

Param #	Plane #	Range	Default Value
028	1	1-32000 ms	150 ms
046	2	1-32000 ms	150 ms
064	3	1-32000 ms	150 ms
082	4	1-32000 ms	150 ms

When performing a contour motion, this command effects the behavior of deceleration.

Programming a non-ramp time (using the ROUNDING *time* command) overrides (but does not change) the settings of parameters 028, 046, 064, or 082.

Make certain the non-ramp time is less than or equal to the ramp time.

4.11.15. "Metric digits" (1-8)

029 047 065 083

This parameter sets the number of zeros that are added after the decimal place in Metric mode displays. It is used in conjunction with parameter x00 (the "Metric conversion factor") to determine system scaling (i.e., the number of machine steps in relation to program steps). Parameters 029, 047, 065, and 083 correspond to contour planes 1 through 4, respectively. This parameter must be configured for each of the active contour planes.

These parameters can have values that range from 1-8 decimal places. Examples are shown in Table 4-76.

Table 4-76. Settings for Parameters 029, 047, 065, and 083

Value	Example	Function
1	123.1	Allots 1 decimal place after the decimal point
2	123.12	Allots 2 decimal places after the decimal point
3	123.123	Allots 3 decimal places after the decimal point (default)
4	123.1234	Allots 4 decimal places after the decimal point
5	123.12345	Allots 5 decimal places after the decimal point
6	123.123456	Allots 6 decimal places after the decimal point
7	123.1234567	Allots 7 decimal places after the decimal point
8	123.12345678	Allots 8 decimal places after the decimal point

For information on determining an appropriate Metric conversion factor, refer to parameter x00 (the "Metric conversion factor").

4.11.16. "English digits" (1-8)

030

048

066

084

This parameter sets the number of zeros that are added after the decimal place in English mode displays. It is used in conjunction with parameter x01 (the "English conversion factor") to determine system scaling (i.e., the number of machine steps in relation to program steps). Parameters 030, 048, 066, and 084 correspond to contour planes 1 through 4, respectively. This parameter must be configured for each of the active contour planes.

These parameters can have values that range from 1-8 decimal places. Examples are shown in Table 4-77.

Table 4-77. Settings for Parameters 030, 048, 066, and 084

Value	Example	Function
1	123.1	Allots 1 decimal place after the decimal point
2	123.12	Allots 2 decimal places after the decimal point
3	123.123	Allots 3 decimal places after the decimal point
4	123.1234	Allots 4 decimal places after the decimal point (default)
5	123.12345	Allots 5 decimal places after the decimal point
6	123.123456	Allots 6 decimal places after the decimal point
7	123.1234567	Allots 7 decimal places after the decimal point
8	123.12345678	Allots 8 decimal places after the decimal point

For information on determining an appropriate "English conversion factor," refer to parameter x01 (the "English conversion factor").

4.11.17. "Contouring mode"

These parameters select the contouring mode. The default is 0, which uses the normal contouring mode (CM0), and 1 selects the alternate contour mode (CM1). This parameter is used to turn on enhanced G8 mode. CM0 mode blends moves together by combining deceleration of one move with the acceleration of the next move. CM1 mode does not. It requires that the last move be preceded by a G9 (velocity profiling off) if in G8 mode. See the related parameter x83, "Filter time constant," for more information. The settings for parameters 031, 049, 067, and 085 are given in Table 4-78.

031

049

067

085

Table 4-78. Settings for Parameters 31,49,67, and 85

Parameter #	Plane #	Range	Default Value
031	1	0 - 100	0
049	2	0 - 100	0
067	3	0 - 100	0
085	4	0 - 100	0

∇ ∇ ∇

CHAPTER 5: PROGRAMMING COMMANDS

In This Section:

5.1. Introduction

The UNIDEX 511 decodes most programming commands by the first two characters, although the user may include more as desired for clarification. Other commands require a specific subset of letters or the entire command to be specified. The commands are not case sensitive. Throughout this chapter the commands appear in uppercase letters for easy recognition. Certain RS-274 codes may also be used to input certain commands. These are discussed later in this chapter.

This chapter uses the typographical conventions listed in Table 5-1.

Table 5-1. Programming Conventions Used in This Manual

Example	Description
INDEX	Uppercase bold letters are used to indicate terms used at the operating system command level.
distance	Words in italic indicate information that you **must** supply to validate the command.
[[option]]	Items between double brackets are optional.
BRAKE {*on*|*off*}	Braces and a vertical bar indicate a choice among two or more items. You must choose one of the items unless double square brackets [[{ }]] surround the braces.
MAP *plane,drive,axis...*	Three dots following an item indicate that more items having the same form may be included.
⋮	A column of dots indicates that part of an example program has been omitted.
ENTER	Small capital letters signify names of keyboard keys.

Several command arguments are entered using a single character. These argument designators are listed in Table 5-2.

Table 5-2. Single Character Arguments for Programming

Argument	Meaning
X Y Z U	Each of the four axes names
C	Designates the center point for circular motions
F	"Contour feedrate"
V	User's variable, V0 through V255

5.2. Mathematical Function Commands

The following section describes the variables, operators and functions available through the U511 programming.

5.2.1. Direct Variables (V0 through V255)

The UNIDEX 511 permits the use of direct variables throughout a program and within functions. The format for these variables is:

V*n*, where $0 \le n \le 255$

There are 256 general purpose double precision direct variables available, labeled V0 through V255. These variables are global and may be used between multiple programs run by the U511.

> These variables are initialized to zero after system initialization.

Numeric constants may be specified in *floating point*, *exponential*, or *hexadecimal* formats. Variables are automatically formatted in either floating point, exponential, or hexadecimal formats. For example:

```
V12 = 34.395        ;Floating point number
V200 = 0x3F         ;Hexadecimal integer format
V106 = 1.257e-7     ;Exponential format
```

5.2.2. Indirect Variables (VV0 through VV255)

Variables may be addressed indirectly. That is, the actual variable number is itself a variable. This is a very powerful feature, permitting treatment of variables as though they were a single dimensional array. The format for an indirect variable is:

VV*n*, where $0 \le n \le 255$

For example, assume that V12=56, then VV12 actually refers to V56. V56 may equal some other unrelated value. For example:

```
V35 = 10.237    ;Assigns 10.237 to variable V35
V0 = 35         ;Assigns 35 to variable V0
V1 = VV0        ;Assigns value of V35 to V1
```

In this case, the value of the variable number specified by V0 (e.g., V35, which equals 10.237) is assigned to variable V1.

5.2.3. Functions

Table 5-3 summarizes the functions that are executed by the U511, as well as a description of each function and examples.

Table 5-3. Supported Functions

Function	Description	Examples
DEG(*radians)*	Converts radians into degrees	V0=DEG(0.25) ;V0=14.3293 degrees
RAD*(degrees)*	Converts degrees into radians	V2=RAD(35) ;V2=0.6108 radians
TAN*(angle)*	Calculates the tangent of *angle* (where *angle* is given in radians)	V17=TAN(0.785) ;V17=0.9992
ATN*(arg)*	Calculates the arctangent (inverse tangent) of argument (where *arg* is dimensionless, and the result is in radians)	V68=ATN(1) ;V68=0.7853981 V32=DEG(ATN(1)) ;V32=45 degrees
SIN*(angle)*	Calculates the sine of the term *angle* (where *angle* is in radians and the result is dimensionless)	V56=SIN(5) ;V56= -0.958924 V71=SIN(RAD(30)) ;V71=0.5

Table 5-3 Supported Functions (Continued)

Function	Description	Examples
ASIN(*arg*)	Calculates the arcsine (inverse sine) of the argument (where *arg* is dimensionless, and the result is in radians)	V90=ASIN(-0.958924) ;V90=5 radians
COS(*angle*)	Calculates the cosine of the term *angle* (where *angle* is in radians and the result is dimensionless)	V22=COS(4) ;V22= -0.653643 V71=COS(RAD(30)) ;V71=0.8660254
ACOS(*arg*)	Calculates the arccosine (inverse cosine) of the argument (where *arg* is dimensionless and the result is in radians)	V38=ACOS(0.5) ;V38=1.0471975
SQR(*pos_num*)	Calculates the square root of *pos_num*	V34=SQR(36) ;V34=6
ABS(*number*)	Returns the absolute value of *number*	V84=ABS(-12.876) ;V84=12.876

5.2.4. Operators and Evaluation Hierarchy

Constants, functions, and variables may be combined using the mathematical operators listed in Table 5-4.

Table 5-4. Mathematical Operators and Their Evaluation Hierarchy

<table>
<tr><th>Operator</th><th>Function</th><th>Priority</th></tr>
<tr><td>( )</td><td>Grouping</td><td>Highest</td></tr>
<tr><td>* , / , ^ , | , &</td><td>Respectively-Multiplication, Division, Exponentiation, Bitwise OR, Bitwise AND</td><td>↓</td></tr>
<tr><td>+ , - , || , &&</td><td>Respectively-Addition, Subtraction, Logic OR, Logic AND</td><td>↓</td></tr>
<tr><td>= , < , > , <> , <= , >=</td><td>Respectively-Equate or Assignment, Less than, Greater than, Not equal to, Less than or equal to, Greater than or equal to</td><td>Lowest</td></tr>
</table>

Below are some examples of using operators.

V0=SQR(V11)+ABS(COS(V23))-SIN(RAD(V23-12*V32))

V1=V1+1.5

V2=V3+V4+VV10*3

V0=0xf&0x2 ;V0=2, the bitwise AND of hex F and 2

V0=2|1 ;V0=3, the bitwise OR of 2 and 1

5.3. System Registers

The interpreter uses predefined registers to designate axis positions. The various registers are discussed in the section that follows.

5.3.1. Relative Position Registers

Relative position registers represent the commanded axis position with respect to the software home position. These registers can be set to any value using the SOFTWARE HOME or G92 command. This allows the user to define an offset for programming convenience.

The SOFTWARE POSITION command should be used to update the registers after an unsynchronized move such as SLEW or FREERUN is completed. Pressing the Abort key or executing the ABORT command will also update these registers. The return value is in program steps. See the PROGRAM command for more information on "program steps." Refer to Table 5-5.

Table 5-5. Relative Position Registers

Register	Meaning
$XRP	X axis relative position, in program steps
$YRP	Y axis relative position, in program steps
$ZRP	Z axis relative position, in program steps
$URP	U axis relative position, in program steps

5.3.2. Absolute Position Registers

Absolute position registers represent the commanded axis position with respect to the hardware home position. These registers are cleared only after successfully executing a HOME command. The SOFTWARE POSITION command should be used to update the registers after an unsynchronized move such as SLEW or FREERUN is completed. Pressing the Abort key or executing the ABORT command will also update these registers. The return value is in program steps. See the PROGRAM command for more information on "program steps." Refer to Table 5-6.

Table 5-6. Absolute Position Registers

Register	Meaning
$XAP	X axis commanded position referenced from the HOME position
$YAP	Y axis commanded position referenced from the HOME position
$ZAP	Z axis commanded position referenced from the HOME position
$UAP	U axis commanded position referenced from the HOME position

5.3.3. Real Time Feedback Position Registers

Real time feedback position registers represent the axis position from the feedback device (encoder, resolver, etc.) with respect to the software home position. This is the feedback position input to the servo loop. The difference between the Real Time Feedback Position and Real Time Commanded Position is position error. The value returned from the register is in program steps. See the PROGRAM command for more information on "program steps." Refer to Table 5-7.

Table 5-7. Real Time Feedback Position Registers

Registers	Meaning
$XFP	X axis real time feedback position referenced from the SOFTWARE HOME
$YFP	Y axis real time feedback position referenced from the SOFTWARE HOME
$ZFP	Z axis real time feedback position referenced from the SOFTWARE HOME
$UFP	U axis real time feedback position referenced from the SOFTWARE HOME

5.3.4. Real Time Command Position Registers

Real time commanded position registers represent the axis position that is commanded by the UNIDEX 511 with respect to the software home position. This is the real time position command input to the servo loop. The difference between the Real Time Feedback Position and Real Time Commanded Position is position error. The value returned from the register is in program steps. See the PROGRAM command for more information on "program steps." Refer to Table 5-8 for the real time commanded position registers.

Table 5-8. Real Time Commanded Position Registers

Registers	Meaning
$XCP	X axis real time commanded position referenced from the SOFTWARE HOME
$YCP	Y axis real time commanded position referenced from the SOFTWARE HOME
$ZCP	Z axis real time commanded position referenced from the SOFTWARE HOME
$UCP	U axis real time commanded position referenced from the SOFTWARE HOME

5.3.5. Understanding the Concept of Program Steps

The measuring unit called "Program Steps" is based upon the number of decimal digits that is displayed in the program mode screen. For example, if the number of decimal digits displayed is 4, then the smallest move displayed in the position display is 0.0001. The number 0.0001 is considered 1 "Program Step" since it is the smallest unit that can be programmed. Knowing this, a 1.0 in the position display is equivalent to 10000 "Program Steps." Also, if the user displays 3 decimal digits, the smallest step is 0.001 and is equivalent to 1 "Program Step." The following formula below applies:

$$Program\ Units = \frac{Value\ from\ Position\ Register}{10^{Number\ of\ Decimal\ Digits}}$$

5.3.6. A/D Channel Registers

The A/D Channel registers are used to read the values of the 4 A/D Channels. They are eight-bit and can read a voltage between 0 and +5 VDC. The values in the A/D registers range from 0 to 255, which represent analog voltage levels. To convert these values to voltages, divide the registers by 51.2. They are engaged using the ENABLE AD command and disengaged using the DISABLE AD command. Refer to Table 5-9.

Table 5-9. A/D Channel Registers

Register	Signal Name	Description
$AD0	AIN 1–(AIN1)	MFO input
$AD1	AIN 2–(AIN0)	Spare
$AD2	AIN 3	Joystick–Vertical
$AD3	AIN 4	Joystick–Horizontal

5.4. System Inputs $INP and $IN0-$INF

System input commands may be used to return a 16 bit word having a value that corresponds to the state of all inputs or specified inputs. The command syntax for system inputs is:

$INP Returns a 16 bit word, each bit corresponding to the state (0 or 1) of an input

$IN*n* Returns an individual bit value (0 or 1) that corresponds to the state of a particular input.

The UNIDEX 511 normally has 16 input lines. The state of the inputs may be read using the $INP command. The value returned by $INP will be between 0 (all inputs low) and 65,535 (all inputs high). The value of $INP is the decimal equivalent of the 16 bit binary number denoted by the state of the 16 inputs.

Unused inputs are pulled high, so they contribute to the values of the $INP value. Individual bits can be tested with the bitwise AND operator (&). For example:

```
IF ($INP & 0x3) THEN
:
:
```

When an input is high, that input line contributes the following amount to the $INP value:

$x = 2^n$ where *n* = the input number (0 to 15).

Individual bits can be read by the $IN*n* command. The term *n* is the hexadecimal number (0 through F) which represents the respective input number (0 through 15). The value of the input may be determined with the following logic:

If $IN*n* = 2^n	then that input is high
If $IN*n* = 0	then that input is low
$IN5	gives the binary state of input number 5
$INF	gives the binary state of input number 15

Multiple inputs may be checked using an additive process. For example,

V0 = $IN5 + $IN8 + $INA, or V0 = $INP & 0x520.

The status of the inputs may be ascertained from the Primary I/O screen under the Diagnostics menu. Refer to Chapter 3: The User Interface.

5.5. Programming Commands

The UNIDEX 511 supports many programming commands. These commands are listed in Table 5-10 and explained in detail in the sections that follow. Table 5-10 also lists command abbreviations and supported RS-274 ("G" and "M") codes.

Table 5-10. UNIDEX 511 Programming Commands

Command	Abbreviation	RS-274 Code
ABORT	AB	
ACCELERATION	AC	
AC PL (ACcel PLane)	AC PL	
AFCO (AUTO FOCUS)	AFCO	
AGAIN	AG	M47
AT (Autotune)*	AT	
BEEP	BE	
BOARD	BO	
BRAKE	BR	
CAL (Load Calibration File)*	CAL	
CCW_CIRCLE	CC	G3
CLRSCR (Clear Screen)*	CLRSCR	
CI (Command Interrupt)*	CI	
CM (Contouring Mode)*	CM	
COMREC (Strings in Port)*	COMREC	
COMVAR (String to Variable)*	COMVAR	
CS (Command Scope)*	CS	
CW_CIRCLE	CW	G2
CUTTER COMPENSATION COMMANDS *		G40, G41, G42, G43, G44
CVI (Convert to Integer)*	CVI	
CYCLE	CY	
DAC (D/A Output)*	DA	
DISABLE	DI	
DS (Display Servo)*	DS	
DWELL	DW	G4
DY (Dynamic Gain)	DY	
ENABLE	EN	
ERROR	ER	
EXIT	EX	M2
FAULT ACKNOWLEDGE	FA	
FL (Filter Time Constant)*	FL	

Table 5-10. UNIDEX 511 Programming Commands (Continued)

Command	Abbreviation	RS-274 Code
FREERUN	FR	
GAIN	GA	
GEAR	GE	
GOTO	GO	
HALT	HA	
HOME	HO	
IF	IF	
INDEX	IN	G0
INn (Read Inputs)*	INn	
INTERRUPT	INT	
IO (Set/Read 8 X 3 I/O)*	IO	
IOSET (Setup 8 X 3 I/O Port)*	IOSET	
JOG	JO	
: (label marker)*	:	
LINEAR	LI	G1
LOOP	LO	
LVDT	LV	
M0 ("M Zero")	M0	M0
MAP	MA	
MCOMM (Motor Commutation)	MC	
MESSAGE	ME	
MR (Memory Read)*	MR	
MSET (Motor Setup)*	MS	
MW (Memory Write)*	MW	
NEXT	NE	
OEn (Extended Output)*	OEn	
OUTPUT	OU	
PARALLEL	PAR	
PRM (Parameter Read)	PRM	
PAUSE	PA	
PLANE	PL	
PROGRAM	PR	
(English Mode)		G70
(Metric Mode)		G71
(Absolute Mode)		G90
(Incremental Mode)		G91

Table 5-10. UNIDEX 511 Programming Commands (Continued)

Command	Abbreviation	RS-274 Code
QUEUE AGAIN QUEUE CANCEL QUEUE INPUT	QU AG QU CA QU IN	
RAMP	RA	
REFERENCE	REF	
RETURN	RE	
ROTATE (Part Rotation)	ROT	
ROUNDING (On/Off)	RO	G23/G24
SCF (Scale Factor)*	SCF	
SEGMENT	SE	
SKEY (Soft Keys)*	SK	
SLEW	SL	
SOFTWARE HOME SOFTWARE LIMIT SOFTWARE POSITION	SO HO SO LI SO PO	G92
SPLINE	SP	
START	ST	
SUBROUTINE	SU	
SYNC	SYNC	
TARGET TRACKING* TE (Tracking Enable) TD (Tracking Disable) TP (Target Position)	 TE TD TP	
TRAJECTORY	TR	
TRIGGER	TRI	
UMFO (Manual Feed Override)*	UM	
VAR (Read/Write Variable)*	VAR	
VELOCITY	VE	G8/G9
WAIT	WA	
WHILE/ENDWHILE	WH/ENDW	

Table Notes:

* No English language command. Use the command abbreviation or G code to implement.

5.5.1. ABORT

The AB command aborts motion of the axes and clears the queue buffer. All enabled axes will ramp to a stop using the "Max accel/decel" parameter (x16). The software position registers will then be updated with the new position.

The abort command is similar to pressing the front panel abort key.

SYNTAX:

AB

There are no arguments needed with AB command.

5.5.2. ACCELERATION

The AC command is used to specify the acceleration/deceleration rate for each axis. This command overrides, but does not change the setting of parameter x16 ("Max accel/decel" [machine steps/ms/ms]). The rate established by this command remains in effect until updated by a subsequent AC entry or a system reset.

SYNTAX:

ACCELERATION *axis_rate*

AC *axis_rate*

axis_rate	The *axis_rate* argument defines an axis (X, Y, Z, or U) as well as an associated acceleration/deceleration rate for that axis (given in machine steps/msec^2).

The INDEX and FREERUN commands use this command's data for ramp up and ramp down functions.

The acceleration rate that can be used with the AC command is a maximum of 2^{15} machine steps/msec^2. The use of the decimal point is optional (e.g., AC Z25 is the same as AC Z25.).

EXAMPLES:

AC X1	;The acceleration rate for axis X is 1 steps/msec^2
AC Z25	;The acceleration rate for axis Z is 25 steps/msec^2

Related commands

INDEX, FREERUN

AC PL

5.5.3. AC PL (ACCEL PLANE)

The ACCEL PLANE command will limit the acceleration during linear and circular moves by lowering the feedrate and adjusting the ramp time. One block look ahead is used to slow down before a circle or final move in a Velocity Profiling (G8) sequence. Look ahead is done only in the MMI or with the "::" command in a custom program.

Note: This command works for contour mode 1 (CM 1) only.

Note: Setting the acceleration value to 0 will turn this function off.

SYNTAX:

ACcel PLane = a

a = maximum acceleration in units/sec/sec or steps/sec/sec, depending on the current programming mode.

EXAMPLE:

```
PR UN          ; assume units are millimeters
AC PL=1000     ; set acceleration at 1000 millimeters/sec/sec for current plane
```

Related Commands:

G25/G26/G27/Rounding

5.5.4. AFCO (Auto Focus)

AFCO

The AFCO command enables a secondary position loop in the U511 much like the primary position loop (using Kpos). Unlike the primary position loop that uses the encoder for feedback, this loop uses the analog input for feedback. The analog input is converted to a digital signal by the 12 bit A/D converter. The U511 commands the motor to move so that the analog input is at the user specified voltage.

The analog input number is specified by the "channel" argument. This should be between 1 and 4. A zero value tells the U511 to stop the tracking mode and return to normal operation.

The "pos" argument is the desired position (set point) of the analog input in units of volts.

The "gain" argument is a number which multiplies the A/D error to give a correction speed. This gain number is like the Kpos argument in the normal servo loop. If the scaling of the analog input and encoder is 1:1, the "gain" value can be the same as the Kpos. This is assuming that the analog transducer is properly mounted.

The "speed" parameter is the maximum speed that the motor will move when the analog input is not at the desired position. The motor may not actually move at this speed if the gain of the loop is low. The units of the speed parameter are the same as the feedrate units of F,XF,YF,ZF,UF. The units can be English / metric, units / minute, units/second, program steps / minute, or program steps / second.

SYNTAX:

"**AFCO** *axis, channel, pos, gain, speed*, [*deadband, max, min, flags*]"

Arguments ([] indicates optional parameters)**:**

where:		units
axis	XYZU	
channel	A/D converter channel 1-4, or 0 = off	
pos	target A/D position (set point)	volts
gain	sets responsiveness of loop (Like KPOS)	
speed	maximum correction speed of motor	same as feedrate "F"
[dead-band]	dead band	A/D counts
[max]	maximum motor movement in positive direction	units
[min]	minimum motor movement in negative direction	units
[flags]	see text	

Optional arguments: (default to 0)
All optional parameters default to 0.

The "dead band" argument allows the user to specify a region about the target A/D position for which there will be no motor movement. A zero value here indicates no dead band.

The "max" argument is the maximum motor movement in units that will be allowed. This number can be interpreted as absolute or incremental depending on the setting of bit #3 of the flags argument.

The "min" argument is the minimum motor movement in units, that will be allowed. This number can be interpreted as absolute or incremental depending on the setting of bit #3 of the flags argument. Absolute values are with respect to the hardware home position ; ie. the position displayed in the diagnostic window. Incremental values are with respect to the position of the motor when the command was given. Bit #2 of the flags argument, when set, enables this feature. The units of the max and min argument are the current programming unit, ie. mm, Inches, or program steps.

The "flags" argument allows the user to change certain characteristics of the auto focus loop. The bits in the following table can be OR-ed together. Reserved bits should be programmed as zero. See Table 5-11 for a list of optional arguments.

Table 5-11. Optional Arguments

Bit #	Value	Description	Hex
0	0	Command is queued, will be affected by wait mode. Considered done when the error is within the dead-band. bit #8-11 of status word 5 will be set until finished.	0x000000
	1	command will not be queued, not affected by wait mode. bit #8-11 of status word 5 will be not be affected by command is finished.	0x000001
1	0	command will continue to track when null position is found	
	1	function will automatically turn off after null position is found	0x000002
2	0	motor travel is not limited	
	1	enable motor travel limits (max/min arguments)	0x000004
3	0	max / min arguments are with respect to home (absolute)	
	1	max / min arguments are incremental	0x000008
2..22		reserved (program as 0)	
23	0	polarity of loop is not reversed.	
	1	reverse polarity of loop.	0x800000

Motion command such as G0,G1,etc cannot be issued to the U511 when in the focus mode. The focus mode will be exited by sending an AFCO command with the channel set to 0. The software position should be updated using the SOFTWARE POSITION command when the auto focus mode is stopped. The abort function will also terminate the focus mode and automatically update the software position registers.

The range of this input is –10V to +10V that gives a digital value of –2048 to +2047 respectively for the 12 bit A/D converter.

EXAMPLE #1:

"AFCO X,1,0,100,1000,1,10,-10,0x80000F"

Description: track on analog input #1, zero position with a gain of 100. Maximum correction speed is 1000 mm / min. There is one A/D count of dead-band. The encoder will move +/- 10 mm (assuming metric mode) relative to the point where to command was given. The polarity of the tracking loop is reversed. The U511 will not wait for command execution to complete. Auto focus will shut off when the axis is within 1 count of the 0 position.

EXAMPLE #2:

```
AFCO Y,1,-5,100,1000,1        ; tracking to -5V analog input level
DWELL 10                      ; wait for system to settle
AFCO Y,0                      ; turn focus off
WAIT ON                       ; wait for above commands to finish
SOFTWARE  POSITION  Y         ; update encoder positions
```

Programming Notes:

An unused channel on the U511 can be setup to display the analog input value. This is done by setting the axis parameter 38 to 45-48 for analog channel 1-4 respectively. This is useful for initial setup of the analog sensor and for polarity verification. If the polarity of the sensor is incorrect, the motor will run in wrong direction. This may result in damage to the system. On initial setup of the tracking loop, it is recommended that the max correction speed be set low and the max / min encoder movement parameters be utilized.

General parameter #99 should have bit #2 set (i.e. set it to 4) to signal that the U511 should read the 12 bit A/D converter. This software feature requires V5.11 or higher. The joystick and MFO analog inputs are not available when using the 12 bit A/D converter.

The ABORT function / button will stop the auto focus mode. The axis cannot be homed when in auto focus mode.

The A/D target position can be changed by sending a new AFCO command with a different target voltage. This can be done even if a AFCO command is currently active.

It is highly recommended that a dead-band of at least one A/D count is used for applications where the user is monitoring the completion of the cycle.

AG

5.5.5. AGAIN

The AG command is used to send the program flow to the first line of the program.

SYNTAX:

AGAIN

AG

M47

EXAMPLE:

```
OUTPUT 2,1          ;Set output bit 1
G1 X10 Y10 F100     ;Linear move of X and Y at the designated feed rate
OUTPUT 2,0          ;Clear output bit 2
AGAIN               ;Rerun program
```

Related commands

QUEUE, LOOP, NEXT

5.5.6. AT (Autotune)

AT

The AT command is usually called automatically by the U511 software as an excitation signal for the autotuning function. This command, however can be also be invoked like any other command to generate a sinusoidal excitation to a specified axis. This can be used for simple frequency response calculations.

Note that this command also specifies the data collection parameters for the automatic autotuning function. The U511 software contains the algorithms that analyze this data and fits gains to the servo system. When the command is invoked alone, these data collection parameters are ignored. This command WILL NOT directly calculate servo loop gains.

SYNTAX

AT *axis*,*startfreq*,*amplitude*,*cycles*,[[numfreq]],[[samptime]],[[numsamp]]

startfreq	Frequency of oscillation (.1-100).
amplitude	Peak-peak position displacement in units.
cycles	Number of cycles to generate.
[[numfreq]]*	Number of multiples of "startfreq" to generate (the frequency is doubled and the position displacement is halved).
[[samptime]]*	Sample time in ms.
[[numsamp]]*	Number of samples to collect (reserved for U511 software use only).

* = parameter not required

EXAMPLE:

AT 1,1.2,100,10 ; This command generates 10 cycles of a sinusoidal
; velocity command to axis 1 with a maximum
; displacement of 100 mm and a frequency of 1.2 Hz

BE

5.5.7. BEEP

This command will turn on the UNIDEX 511 beeper a designated number of times. It can be used to signify the end of a program or important points in a program. The default is one beep.

SYNTAX:

BEEP [*count*]

BE [*count*]

count	The number of times to turn on the beeper. Count = 0 will turn off the beeper. Leaving the count blank will cause the beeper to beep once.

EXAMPLE:

```
BE 5            ;The beeper will sound five times at the designate point
                ;in the program
```

BO

5.5.8. BOARD

The U511 can come equipped with an optional U500 board. The BO command is used to select which board is to receive the forthcoming commands. Board 1 is the U511 and board 2 is the optional U500. The board selection remains in effect until the next board command is issued. Only one board may be selected at a time.

SYNTAX:

BOARD *number*

BO *number*

number	Designates the UNIDEX 511 board number (1 or 2) to receive the commands.

EXAMPLE:

```
BOARD 1         ;or
BO 1            ;Selects board number 1 to receive commands
```

IMPORTANT

> The UNIDEX 511 cannot generate a precise contour type move between separate boards.

5.5.9. BRAKE

The BR command manually engages or disengages the UNIDEX 511 brake output. The additional circuitry for the brake is a factory wired option on the UNIDEX 511.

This command can be used to manually turn the brake on for an axis just before disabling it. This may be useful in vertical axis applications when axis movement cannot be tolerated. The U511 does not immediately release the brake on a *linked* axis when enabled. There are approximately 100 milliseconds before the brake is released.

SYNTAX:

BRAKE *state*

BR *state*

state	The *state* argument can be set to one of two options: ON .... Engages the brake OFF... Disengages the brake.

EXAMPLE:

BRAKE ON	;Optional brake is now engaged
BR ON	;Same result using the abbreviated syntax
BRAKE OFF	;Optional brake is now disengaged
BR OFF	;Same result using the abbreviated syntax

Related commands

ENABLE AXIS, DISABLE AXIS, Fault Mask Parameters, "Enable brake" Mask Parameter

The brake output must be *linked* to only one axis with parameter x61 ("Enable brake"). The brake output is deactivated (unclamped) when the axis is enabled, and activated (clamped) when the axis is disabled. This command only works when the axis is enabled.

IMPORTANT

CAL

5.5.10. CAL (Load Calibration File)

The CAL command downloads axis calibration data from a file. This can be used to dynamically down load calibration files during a user program. The calibration data does not become active until the axis completes a home cycle.

SYNTAX:

CAL *"filename"*

"filename"	The file containing the axis calibration data.

EXAMPLE:

CAL "B:\SCAN1.CAL"

Related commands (none)

CC
CW

5.5.11. CLOCKWISE and COUNTERCLOCKWISE CIRCULAR INTERPOLATION

The clockwise (CW) or counterclockwise (CCW) circle commands initiate circular contour-type motion (i.e., circles or arcs). The axis pair assigned to the circular motion automatically adjusts its path and feed rate to maintain a circular contour path.

The UNIDEX 511 uses the contour plane's ramp time to ramp both of the axes up to steady speed and then down to the target distance (the ramp can be linear or inverse_sine type).

> If the contour path is insufficient for ramping, the UNIDEX 511 automatically converts it into linear motion.

SYNTAX:

For clockwise rotation:

CW_CIRCLE *end1 end2* **C***c1,c2* {**F***feedrate* | **FT***feedrate_time*}

CW *end1 end2* **C***c1,c2* {**F***feedrate* | **FT***feedrate_time*}

G2 *end1 end2* **C***c1*,c2 {**F***feedrate* | **FT***feedrate_time*}

CW_CIRCLE *end1 end2* **I***c1* **J***c2*

G2 *end1 end2* **I***c1* **J***c2*{**F***feedrate*|**FT***feedrate_time*}

For counterclockwise rotation:

CCW_CIRCLE *end1 end2* **C***c1,c2* {**F***feedrate* | **FT***feedrate_time*}

CC *end1 end2* **C***c1*,c2 {**F***feedrate* | **FT***feedrate_time*}

G3 *end1 end2* **C***c1,c2* {**F***feedrate* | **FT***feedrate_time*}

G3 *end1 end2* **I***c1* **J***c2*{**F***feedrate* | **FT***feedrate_time*}

end1	Defines the first axis (X, Y, U, or Z) that is involved in motion, and the first end point (or present point).
end2	Defines the second axis (X, Y, Z, or U) involved in motion and the second end point (or present point).
c1,c2	Defines the center point of each arc. The maximum end/center point is 2^{31} machine steps.

The center point is always specified incrementally from the starting point of the circle, regardless of the programmed mode.

feedrate	Upon initializing the U511, the default units for feedrate are in units/min. The units are defined by the "English and Metric conversion factors." The units for feedrate can be changed by the PROGRAM command. The maximum feedrate that can be used for a contour type move is 2^{15} machine steps/msec.

If a feedrate subcommand is missing, the UNIDEX 511 will use a previously programmed feedrate or the feedrate established by general parameter numbers 022, 040, 058, and 076.

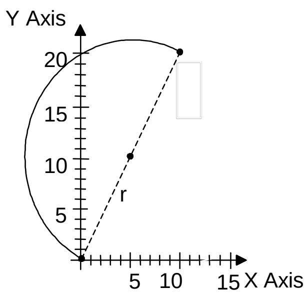
feedrate_time	Defines the time (in seconds) that is allocated to complete the contour move. The UNIDEX 511 calculates the contour feedrate based on the contour path. The feedrate time is valid for the current block only.

The contour feedrate is clamped at the feedrate established by general parameters 027, 045, 063, 081 – "Clamp feedrate."

The corner-rounding, noncorner-rounding, and velocity profile programming options may be used in conjunction with these circular moves. See the ROUNDING (G23 and G24), and VELOCITY (G8 and G9) command descriptions in this chapter.

Circles and Arcs

EXAMPLES:
The following commands can be used to create a CW arc ending at point (10,20) with a center point of (5,10) incrementally away from the starting point. The previously set feedrate is assumed by its absence.



CW_CIRCLE X10 Y20 C5,10 ;or

CW X10 Y20 C5,10 ;or

G2 X10 Y20 C5,10

Each of the following commands can be used to create one full CCW circle with a radius of 1.

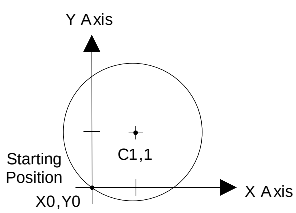
CCW_CIRCLE X0 Y0 C1,1 F100 ;or

CCW X0 Y0 **I**1 **J**1 F100; ;or

G3 X0 Y0 **I**1 **J**1 F100

The following command can be used to create one full CW circle with a radius of $\sqrt{2}$ and a center point of (1,1), assuming incremental mode.

CW X0 Y0 C1,1 F100



Any one of the following commands can be used to create CW circular motion with end points and center points defined in variables. The previously set feedrate applies.

CW_CIRCLE X=V1 Y=V2 C=V3,V4 ;or

CW X=V1 Y=V2 C=V3,V4 ;or

G2 X=V1 Y=V2 I=V3 J=V4

Helix Motions (Circular plus Linear)

Helix motion incorporates linear motion and circular motion. The syntax for clockwise and counterclockwise helix motion is similar to regular circular motion, with the addition of the **LINEAR** term and its associated arguments. Variations of the command syntax for helix motions are shown below.

SYNTAX:

CW_CIRCLE *end1 end2* **C***c1,c2* {**F***feedrate* | **FT***feedrate_time*}
  LINEAR *d3* {**F***feedrate* | **FT***feedrate_time*}

CW *end1 end2* **C***c*1,c2 {**F***feedrate* | **FT***feedrate_time*}
  LINEAR *d3* {**F***feedrate* | **FT***feedrate_time*}

CW *end1 end2* **C***c1,c2* {**F***feedrate* | **FT***feedrate_time*}
  LI *d3* {**F***feedrate* | **FT***feedrate_time*}

G2 *end1 end2* **C***c1,c2* {**F***feedrate* | **FT***feedrate_time*}
  G1 *d3* {**F***feedrate* | **FT***feedrate_time*}

EXAMPLES:
In the following example, axes Z and U do clockwise circular motion. A new contour feedrate of 100 is specified. Axes X and Y do linear motion.

CW_CIRCLE Z20 U20 C10,10 F100 **LINEAR** X10 Y20

CW Z20 U20 C10,10 F100 **LI** X10 Y20

CW Z20 U20 C10,10 F100 **G1** X10 Y20

This example shows a helical path beginning with linear move of the X axis, CCW circular move of the Y and Z axes to endpoint of 5,5. Entire move to take 10.5 seconds.

G3 Y10 Z10 C5,5 FT10.5 **G1** X10

Dual Circular Motions (spherical motion)

Dual circular motion commands use the combined syntax of two circular motion commands. Variations are shown below.

SYNTAX:

CW_CIRCLE *end1end2* **C***c1,c2* {**F***feedrate* | **FT***feedrate_time*}
    CW_CIRCLE *end1end2* **C***c1,c2* {**F***feedrate* | **FT***feedrate_time*}

CW *end1end2* **C***c1,c2* {**F***feedrate* | **FT***feedrate_time*}
    CW *end1end2* **C***c1,c2* {**F***feedrate* | **FT***feedrate_time*}

G2 *end1end2* **C***c1,c2* {**F***feedrate* | **FT***feedrate_time*}
    G2*end1end2* **C***c1,c2* {**F***feedrate* | **FT***feedrate_time*}

Related commands

LINEAR, RAMP, ROUNDING, VELOCITY, TRAJECTORY, PROGRAM, G70/G71, G90/G91

5.5.12. CLRSCR (Clear Screen)

CLRSCR

The CLRSCR command clears the message display line. There is no English language equivalent for this command. Use CLRSCR to implement it.

SYNTAX:

CLRSCR

There are no arguments needed with the CLRSCR command.

5.5.13. CI (Command Interrupt)

CI

The CI command is used to generate a hardware bus interrupt after the command finishes. There is no English language equivalent for this command. Use CI to implement it.

SYNTAX:

CI {ON|OFF}, *master_in, slave_out*

{ON|OFF}	Enables/disables this feature.
master_in	Specifies the input number (0-16) of the hardware bus interrupt line that is to be set low after the command finishes: 0 = disable the command 1-16 = inputs 0-15
slave_out	Specifies the output bit (0-8) that is set low along with the hardware interrupt: 0 = disable the command 1-8 = output bits 0-7

IMPORTANT

This command should only be used in custom software applications that require the use of hardware bus interrupts.

5.5.14. CM (Contouring Mode)

CM

The Contouring Mode command (CM) is used to set normal contouring mode (CM 0) or enhanced contouring mode (CM1). Normal contouring mode blends moves together by combining the deceleration of one move with the acceleration of the next move. The enhanced mode does not and requires that the last move be preceded by a G9 command (velocity profiling off) if in G8 mode.

For profiles with velocity profiling off (G9 mode), CM0 and CM1 function identically.

The Filter Time Constant command (FL) can be used with enhanced contouring mode to produce corner-rounding effects or to smooth transitions between non-tangential moves.

The default contouring mode can also be set by general parameters 31, 49, 67, and 85. The CM command is modal and will remain in effect until reset.

CM 1 mode is recommended for profiles that consist of many short moves or moves with non-tangential vectors. The maximum allowed MFO value in CM1 is 100%.

There is no English language equivalent to this command. Use CM to implement it.

SYNTAX:

CM #

#	0 for normal contouring mode. 1 for enhanced contouring mode.

EXAMPLE:

CM 1	;Set new contouring mode

Related commands

FL

COMREC

5.5.15. COMREC (Strings In Port)

This is one of two commands for retrieving variable input from the COM port. COMREC returns the number of strings in the COM port buffer. There is no English language equivalent to this command.

SYNTAX:

COMREC (*port #*)

V*n***=COMREC** (*port #*)

n	Variable number.
port #	The number of the port to check.

EXAMPLE:

```
:LOOP
IF ( COMREC (1) > 0 ) THEN  ;Check COM 1 receive buffer
V0 = COMVAR (1)             ;Store result in variable
ME DI "Received %fV0"       ;Display value received
ENDIF
GOTO :LOOP                  ;Continue
```

Related commands:

COMVAR

5.5.16. COMVAR (String to Variable)

COMVAR

This is one of two commands for retrieving variable input from the COM port. COMVAR converts a string in the COM port buffer to a variable. There is no English language equivalent to this command.

SYNTAX:

V*n* **= COMVAR** (*port #*)

n	Variable number.
port #	Number of port to convert from.

EXAMPLE:

```
:LOOP
IF ( COMREC (1) > 0 ) THEN  ;Check COM 1 receive buffer
V0 = COMVAR (1)             ;Store result in variable
ME DI "Received %fV0"       ;Display value received
ENDIF
GOTO :LOOP                  ;Continue
```

Related commands:

COMREC

CS

5.5.17. CS (Command Scope)

The CS command is used for data acquisition on the U511 and is used internally by the scope and autotune functions. Up to 7500 points of actual position or feedback position can be acquired for all four axes. The sample time base is programmable in increments of 1 ms.

Function	Command	Lower 16 bits
Set sample rate	0x40000	Sample Rate (1-65,535)
Number of samples to take	0xB0000	1-7500
Start Sampling Data	0xC0000	0-feedback pos 1-command pos
read current sample no.	0xD0000	X

Collected data is written to internal memory locations L:4000-B52F. Axis 1-4 positions are written sequentially to memory for each sampling interval. The first sample point would be organized in memory as follows:

1st Sample	L:4000	Axis 1 Position
	L:4001	Axis 2 Position
	L:4002	Axis 3 Position
	L:4003	Axis 4 Position
2nd Sample	L:4004	Axis 1 Position
	.	.
	.	.

This data can be read from the internal memory using the "MR" command. This command has no English language equivalent. Use CS to implement it.

SYNTAX:

V*n*=**CS** ####

n	Variable number.
####	Defines the cmd argument to the aer_scope_command. It returns the return code of the aer_scope_command into the specified variable.

EXAMPLES:

```
V0=CS 0x40000+1        ;Sets time base to 1 ms
V0=CS 0xb0000+7500     ;Sets "long" number of samples
V0=CS 0xc0000          ;Collect data
:here
V0=CS 0xd0000          ;Return number of points collected, returns zero when all
                       ;points collected
if v0>0 :here
```

Related commands (none)

5.5.18. Cutter Compensation Commands

G40-G44

Cutter compensation offsets programmed moves to compensate for the size of the cutting tool. The UNIDEX 511 implements cutter compensation with the following G code commands:

G40 - cutter comp. off
G41 - cutter comp. on, LEFT
G42 - cutter comp. on, RIGHT
G43 - define cutter radius
G44 - define compensated axes.

Cutter compensation operates only on contoured motions, G1, G2, and G3. It modifies the endpoint of a move based on the next move. Therefore, a move will not begin executing until the next move has been commanded. Commands that occur between contours are stored until the next contoured motion is sent. No more than 5 commands should be placed between contours.

Contoured moves are modified either by making the move shorter or by adding a circle with the same radius as the cutter, between the moves.

The first move is assumed to be a move on to the part. This move is the first move after a G41 or G42 command and can be linear or circular. The end point of this move is adjusted so that it is normal to the second move's starting point, offset by the tool radius. Refer to Figure 5-1.

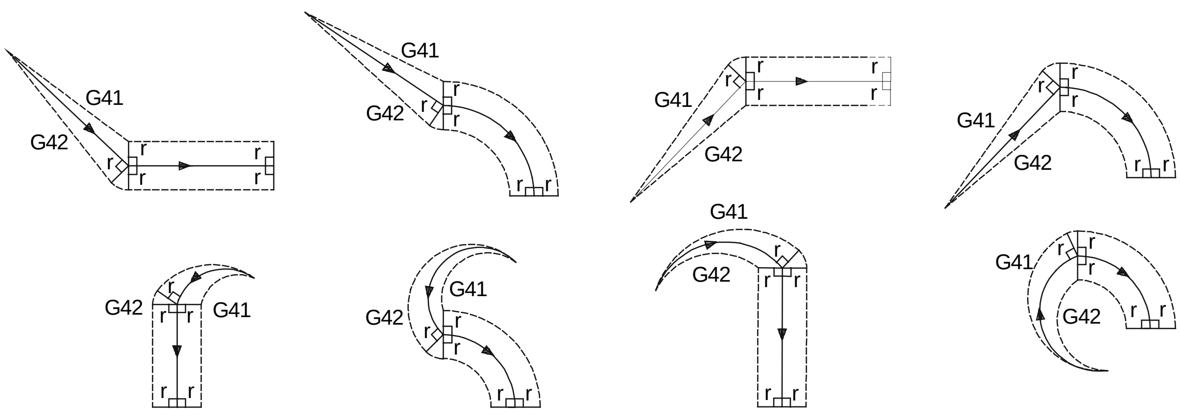


Figure 5-1. Startup Moves

The last move is assumed to be a move off of the part. This contour occurs after the G40 command. The end point of the move preceding the G40 command (last move on work piece) is adjusted to be normal to the move's programmed endpoint. Refer to Figure 5-2.

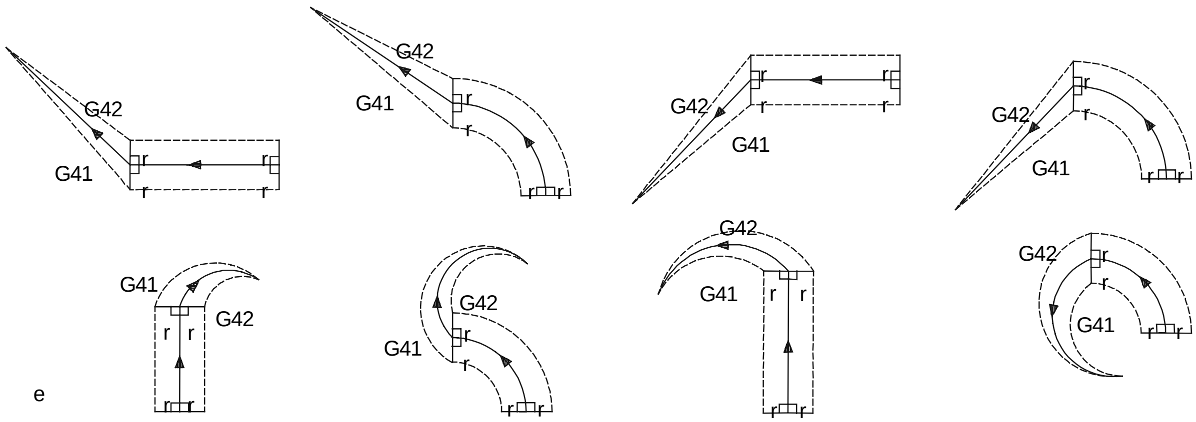


Figure 5-2. Ending Moves

In the case of a circular move on to the work piece, the programmed end angle is preserved. For a move off of the part, the circle's start angle is preserved.

> Abort and reset clears cutter compensation. Any buffered commands are lost.

SYNTAX:

G40	Turns off cutter radius compensation. The contour following this command moves off of the work piece.
G41	Turns on cutter radius compensation LEFT. A tool radius and the axes to be compensated must first be specified.
G42	Turns on cutter radius compensation RIGHT. A tool radius and the axes to be compensated must first be specified (default).
G43 R*units*	Set cutter radius.
G44 *axis axis*	Defines axes for compensation: X, Y, Z, or U.

units	Cutter radius. Units are the same as current programming mode: English units, metric units, or steps.
axis	Defines axes for compensation: X, Y, Z, or U.

EXAMPLE:

The following example program demonstrates the cutter compensation commands. See Figure 5-3.

```
; ##### CUTCOMP1.PRG #####
;
; - demonstrates cutter compensation while doing a square
```

```
;
ENABLE X Y                ; Enable axes
HOME X Y                  ; Home axes
PROGRAM UNITS UNITS/MIN
                          ; Set to units (default)
G91                       ; Set Incremental mode
G70                       ; Set English mode
Ramp 100

; ##### 1st, do square with no cutter comp ####
G1 X1 Y1 F10              ; Move on to part
G1 Y1                     ; Side
G1 X1                     ; Side
G1 Y-1                    ; Side
G1 X-1                    ; Side
G1 X-1 Y-1                ; Move off
G4 500                    ; Dwell 1/2 sec

; ##### 2nd, do square with cutter comp ####
G43 R.25                  ; Set tool radius to .25"
G44 X Y                   ; Define cutter comp axes
G41                       ; Cutter comp left
G1 X1 Y1 F10              ; Move on to part
G8 G1 Y1                  ; Side
G1 X1                     ; Side
G1 Y-1                    ; Side
G9 G1 X-1                 ; Side
G40                       ; Cutter comp off
G1 X-1 Y-1                ; Move off
```

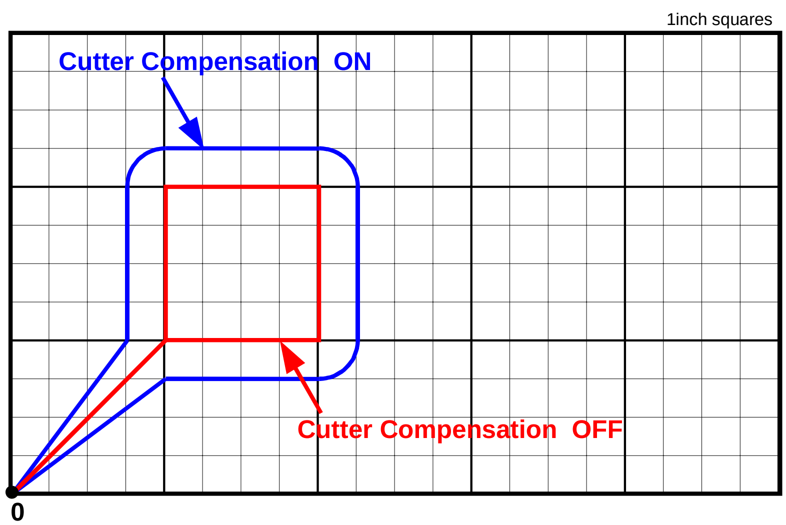


Figure 5-3. Cutter Compensation Example

CVI

5.5.19. CVI (Convert to Integer)

The CVI command is used to convert a given value to an integer.

SYNTAX:

v#=**CVI**(*expression*)

v#	Any user variable (v0 - v255).
expression	Any mathematical expression.

EXAMPLE:

v10=**CVI***(3.97)*	;Result v10 = 3
v15=**CVI***(v15*3.24)*	;Result v15 = int value of v15*3.24

CY

5.5.20. CYCLE

The CYCLE ON command is used to map an input bit to the cycle start function. While a program is running, the interface scans the input bit. If the input bit value equals the bitstate specified in the command, the cycle start function is called. This command is identical to the cycle function button in the program screen. Refer to the example in Figure 5-4. CYCLE OFF stops the scanning of the input bit. This command also can be used with the iSBX-IO48 board.

SYNTAX:

CYCLE ON, *inputbit,bitstate*

CYCLE OFF

CY ON, *inputbit,bitstate*

CY OFF

inputbit	Input bit number (0 to 15) 16 IN/8 OUT I/O bus input bit. Valid iSBX-IO48 input bit ($000 to $127). Input bit number (16 to 39) 8 X 3 I/O bus input bit.
bitstate	Bit value to send cycle start, either 1 or 0.

EXAMPLE:

CYCLE ON, 4,1	;Checks input bit 4 for a logical 1. If the value is present, ;calls cycle start

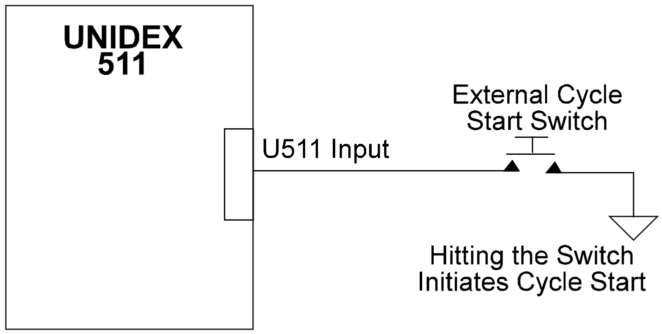


Figure 5-4. CYCLE START Function

5.5.21. DAC (D/A Output)

DA

Digital to analog conversion (D/A) channels are normally used for axis servo loop current commands. D/A channels 5-8 are normally used by the servo processor as the second current command phase when using AC brushless or stepper motors. Unused D/A channels may be used as analog outputs and have ranges of +10 VDC to -10 VDC.

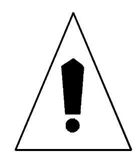
SYNTAX:

DAC *number, volts*

DA *number, volts*

number	Output number (1, 2, 3, 4, 5, 6 ,7, or 8).
volts	Voltage output (-10 to +10 volts).

The DAC command should not be issued to a channel that is being used for servo or stepping motor operation.



IMPORTANT

The following channel-signal relationship exists:

DA Channel	Signal	Test Point
1	ICMD1B	TP10
5	ICMD1A	TP14
2	ICMD2B	TP11
6	ICMD2A	TP15
3	ICMD3B	TP12
7	ICMD3A	TP16
4	ICMD4B	TP13
8	ICMD4A	TP17

EXAMPLE:

```
DA 1,2.5          ;Sets D/A #1 to 2.5 volts
```

DI

5.5.22. DISABLE

The DISABLE command is used to disable one or more axes. When axes are disabled, the servo loop continues to track the position, but the current command output remains at zero, so motion is stopped. The command is also used to disengage the reading of the A/D registers.

SYNTAX:

DISABLE *axis*

DI *axis*

DI AD

axis Defines the axes (X, Y, Z, or U) to be disabled.

EXAMPLE:

```
DISABLE Y Z        ;or
DI Y Z             ;Motors for axes Y and Z are disabled
V10=5/256          ;8 bit A/D, measuring from 0 to +5 VDC
                   ;Calc voltage resolution of 1 bit.
ENABLE X Y AD      ;Engage the reading of the A/D registers,
                   ;enable X, Y axes as well
V0=$AD0*V10        ;Read the value at A/D channel #0, convert to volts
V1=$AD1*V10        ;Read the value at A/D channel #1, convert to volts
V2=$AD2*V10        ;Read the value at A/D channel #2, convert to volts
V3=$AD3*V10        ;Read the value at A/D channel #3, convert to volts
DISABLE AD         ;Disengage the reading of the A/D channels
```

Related commands

ENABLE

5.5.23. DS (Display Servo Loop Data)

Digital-to-analog conversion (D/A) channels are normally used for axis servo loop current commands. D/A channels 5-8 are normally used by the servo processor as the second current command phase when using AC brushless or stepper motors. The DS command provides real-time servo loop display through unused D/A channels (using, for example, a scope connected to the appropriate pins on the AUX I/O connector). This command has no English language equivalent. Use DS to implement it.

SYNTAX:

DS *axis, variable, scale, D/A_chan*

axis	Axis number, where: 0 = no display 1-4 = Axes 1-4
variable	Data to be displayed, where: PC = Position Command - mach steps VA = Actual Velocity - mach steps/0.25 ms PA = Actual Positions - mach steps VE = Velocity Error - mach steps/0.25 ms PE = Position Error - mach steps TQ = Torque Output - ± 10 V (scale does not apply here) VC = Velocity Command - mach steps
scale	Voltage per bit (0 to 10 volts/bit).
D/A_chan	D/A channel number (1-8).

The DS command should not be issued to a channel that is being used for servo or stepping motor operation.

IMPORTANT

The following channel-signal relationship exists:

A Channel	Signal	Test Point
1	ICMD1B	TP10
5	ICMD1A	TP14
2	ICMD2B	TP11
6	ICMD2A	TP15
3	ICMD3B	TP12
7	ICMD3A	TP16
4	ICMD4B	TP13
8	ICMD4A	TP17

EXAMPLE:

```
DS 1,TQ,10,5        ;Displays torque output information of axis 1's servo loop,
                    ;to D/A 5 (ICMD1A) within the range of 0-10 volts
```

DW

5.5.24. DWELL

The DWELL command establishes a time delay (in milliseconds) of a programmed duration. The DWELL command must occupy it's own block within a program.

SYNTAX:

DWELL *time*

DW *time*

G4 *time*

time Duration of dwell in msec.

The dwell time may be set at zero to 2^{23} msec.

EXAMPLE:

DWELL 100	;Program execution delayed for 100 msec
G4 V10	;Program execution delayed for the time stored in variable ;10

Related commands

GAIN, WAIT

DY

5.5.25. DY (Dynamic Gain)

The DY command is used to control the position loop gain, Kpos . When the axis has a non-zero velocity command, Kpos will be set to the gain specified in the argument. When there is no commanded velocity and the timeout (specified in milliseconds) has been exceeded, Kpos will return to its previous value.

SYNTAX:

DY axis time Kpos

axis:	X,Y,Z,U
time:	the amount of time after the velocity command is 0, that Kpos is set to the value of axis parameter 25
Kpos:	the position loop gain

EXAMPLE:

DY X 20 1	; set Kpos for the X axis to 20 when moving, return to ; previous value after 1 msec.

Related Commands:

GAIN

5.5.26. ENABLE

The ENABLE command is used to enable one or more axes. It is also needed to enable scanning of the A/D channel registers.

EN

SYNTAX:

ENABLE *axis* [[**AD**]]	Enable axes and optionally enable A/D registers.
EN *axis*	Enable axes.
EN AD	Engage the reading of the A/D registers and put the values in the A/D registers.
axis	Defines the axes (X, Y, Z, or U) to be enabled.

EXAMPLE:

```
ENABLE X Y Z        ;Or
EN X Y Z            ;Motors for axes X, Y, and Z are enabled
V10=5/256           ;8 bit A/D, measuring from 0 to +5 VDC
                    ;Calc voltage resolution of 1 bit.
ENABLE X Y AD       ;Engage the reading of the A/D registers
                    ;Enable X, Y axes as well
V0=$AD0*V10         ;Read the value at A/D channel #0, convert to volts
V1=$AD1*V10         ;Read the value at A/D channel #1, convert to volts
V2=$AD2*V10         ;Read the value at A/D channel #2, convert to volts
V3=$AD3*V10         ;Read the value at A/D channel #3, convert to volts
DISABLE AD          ;Disengage the reading of the A/D channels
```

An axis should not be enabled until the initial system checks (described in Chapter 2), have been completed.

IMPORTANT

5.5.27. ERROR

The ERROR command is used to change the current fault mask. This overrides but does not change the fault mask parameter defined in the parameter file.

SYNTAX:

ERROR *axis_number*, *reaction_mask*, *fault_stimulus_bit*

axis_number	0, 1, 2, or 3.	
reaction_mask	0-6, where:	
	0 = "Global fault mask"	4 = "Halt queue"
	1 = "Disable"	5 = "Abort motion"
	2 = "Interrupt"	6 = "Enable brake"
	3 = "AUX.output"	
fault_stimulus_bit	0-19, where:	
	0 = Position Error	
	1 = RMS Current Error	
	2 = Integral Error	
	3 = Hardware Limit +	
	4 = Hardware Limit -	
	5 = Software Limit +	
	6 = Software Limit -	
	7 = Amplifier Fault	
	8 = Feedback Device Error	
	9-11 = Reserved (Cannot be changed)	
	12 = Feedrate greater than Max Error	
	13 = Velocity Error	
	14 = Emergency Stop	
	15 = Reserved (Cannot be changed)	
	16 = Drive # 1 Fault	
	17 = Drive # 2 Fault	
	18 = Drive # 3 Fault	
	19 = Drive # 4 Fault	

Bits 9, 10, 11, and 15 are reserved and cannot be changed.

EXAMPLE:

```
ER 0,0,071FF          ;Set drive #1 error mask as hex data 071FF
```

An axis should not be enabled until the initial system checks (described in Chapter 2), have been completed.

IMPORTANT

5.5.28. EXIT

The EXIT command is used to terminate program flow. If this command is not used in a program, program flow will continue to the end of the program file.

SYNTAX:

EXIT

EX

M2

EXAMPLE:

```
;*****************************
;Main Program
;*****************************
    :                      ;Body of main program
    :                      ;Additional commands
SUB  :SUB1                 ;Go to subroutine SUB1 then return
SUB  :SUB2                 ;Go to subroutine SUB2 then return
    :                      ;Additional commands
    :                      ;Additional commands
EXIT                       ;End of Main Program (Don't fall through to subroutines)

:SUB1                      ;Subroutine SUB1
    :                      ;Additional commands
RETURN                     ;Return to main program

:SUB2                      ;Subroutine SUB2
    :                      ;Additional commands
RETURN                     ;Return to main program
```

FA

5.5.29. FAULT ACKNOWLEDGE

The FAULT ACKNOWLEDGE command performs the same function as pushing the "FLTACK" front panel key. This will clear any axis faults such as position error, RMS current error, and similar errors. If an axis is in a limit, the FA command will cause the UNIDEX 511 to move out of the limit. This command is designed for remote mode use in immediate mode (e.g., "IFA") (see Chapter 6: Remote Mode Operations).

SYNTAX:

FA

There are no arguments with the FA command.

EXAMPLE:

FA

Related commands:

ABORT

FL

5.5.30. FL (Filter Time Constant)

The Filter Time Constant (FL) command is used in conjunction with the alternate contouring mode (CM1). This command activates an exponential filter on the specified axis. The time constant of the filter is given in milliseconds. The primary use of the filter is to smooth a trajectory that consists of non-tangential moves in G8 (velocity profiling) mode. The filter should also be used in the alternate contouring mode (CM1) if feedhold or MFO is desired. A low filter value (10 ms) is sufficient in these cases. A filter time constant of 0, turns the filter completely off. A parameter setting of 1 dissipates the filter contents with no filter affect. If you are not planning to use the filter, the time / parameter should be set to 0.

This command has no English language equivalent. Use FL to implement it.

SYNTAX:

FL X#, **Y**#, **Z**#, **U**#

#	Defines the filter time constant in ms.

EXAMPLE:

FL X10	;10 ms filter

Related commands

CM

5.5.31. FREERUN

The FREERUN command is used to produce background motion of designated axes. Freerun motion is completely unsynchronized to contoured motion.

SYNTAX:

FREERUN *axis±feedrate,distance*

FR *axis±feedrate,distance*

axis	Defines the axes (X, Y, Z, or U) under Freerun control.
± feedrate	Defines direction and velocity of the axes under freerun. If the feedrate equals zero, freerun will stop. Upon initializing the U511, the default units for feedrate are in units/min. The units are defined by the "English and Metric conversion factors." The units for feedrate can be changed by the PROGRAM command.
distance	Defines the distance of the freerun. If the distance is not included, the axis will run until commanded to stop.

The FREERUN command must be used with one axis at a time.

Following freerun of an axis, it is advisable that the SOFTWARE POSITION command be executed to update the position registers with the current position of the axes. See the section on System Registers.

Trajectory for freerun motion is linear only. Ramping is based on maximum acceleration. The corner-rounding and velocity profiling options are not available to axes under freerun control.

EXAMPLES:

FR X100	;The X axis will run continuously in the positive direction ;at a feedrate of 100
FR Y-100,2000	;Enables the Y axis for freerun in the negative direction ;with a feedrate of 100. Freerun will stop at 2000
FR X0	;Stops X axis freerun

Related commands

INDEX, LINEAR, CW_CIRCLE, CCW_CIRCLE, ACCELERATION, SOFTWARE POSITION, PROGRAM, G70, G71, G91, G92

GA

5.5.32. GAIN

The GAIN command is used to set servo loop related values. These values override, but do not change the corresponding axis parameter values. Refer to Chapter 4 of this manual for a detailed explanation of all of the gain values.

SYNTAX:

GAIN *axis param_name&val*

GA *axis param_name&val...*

axis	Defines the axis (X, Y, Z, or U) that receives the gain value change.
param_name&val	Specifies a servo loop parameter name followed by an associated value. Valid options for *param_name&val* are:

[[**KPOS***val*]] [[**KI***val*]] [[**KP***val*]] [[**VFF***val*]] [[**AFF***val*]]
Used to enter new values for the servo loop gain values (x25, x26, x27, x28, and x29). One or more of these parameters may be used in succession.

[[**N0***val*]] [[**N1***val*]] [[**N2***val*]] [[**D1***val*]] [[**D2***val*]]
Defines new notch filter coefficient values (x30, x31, x32, x33, x34).

NOTCH{0|1}	Used to enable (1) or disable (0) the notch filter function (x24). NOTCH can be abbreviated NO.
DEADBAND*val*	Used to enter a new value (in machine steps) to be used as a positional deadband (x35). DEADBAND can be abbreviated DE.
CLAMP*val*	Used to enter a new percentage at which the integrator output will be clamped (x36). CLAMP can be abbreviated CL.

EXAMPLES:

GAIN X KPOS1500 **KI**500 **KP**600000 **VFF**256 **AFF**0
;Sets all servo loop gains

GAIN Y N110 **N2**20 **D1**5 **D2**6
;Sets notch filter coefficients for the Y axis

GAIN Y NOTCH1	;Turns the notch filter ON for the Y axis
GAIN Z DEADBAND10	;Sets the Deadband for 10 machine steps
GAIN U CLAMP100	;Sets the integrator clamp to 100%
GAIN X KPOS1000	;Sets "Kpos" servo loop gain for the X axis to 1000
GAIN Y VFF0	;Sets Velocity feedforward of Y axis to zero

5.5.33. GEAR

GE

The GEAR command moves an axis (the slave) based on the feedback of another axis (the master). The slave axis follows the motion of the master axis from the time the command is given until the gearing is released. The master axis can be a handwheel or other feedback device. The master axis is not required to be a closed loop servo.

SYNTAX:

GEAR *slave_number,master_number,slave_ratio,master_ratio*

GE *slave_number,master_number,slave_ratio,master_ratio*

slave_number Defines the slave axis (1,2,3, or 4).

master_number 0 = disengage gear
1,2,3,4 = axis
S1 = use iSBX encoder board

slave_ratio and master_ratio

Positive or negative integer value. Maximum value is 8,388,608.

These optional parameters specify the scaling to be used. If they are not used, a one-to-one linkage is generated.

The ratio of these two arguments (slave_ratio/ master_ratio) represents the scaling of slave counts to master counts. A negative number may be specified to provide a reverse direction of motion to the slave axis.

EXAMPLES:

GE 2,1	;Link axis 2 to the motion of axis 1 with a 1:1 ratio
GE 2,1,-3,10	;Link axis 2 to axis 1. The axes will move with the ;following ratio: ;-3 slave steps : 10 master steps (= -3). The slave will ;move -3 machine steps for every 10 machine steps of ;the master
GE 1,S1,1,4	;Link axis 1 to the iSBX encoder input with handwheel ;scaling (1:4)
GE 2,0	;Disengages the gear

Related commands

SOFTWARE POSITION

To engage and disengage a handwheel, the GEAR command must be used because the handwheel uses a feedback channel (1, 2, 3, 4, S1).

After using the GEAR command, the position registers need updated with the SOFTWARE POSITION command. See the section on System Registers.

5.5.34. GOTO

GO

The GOTO command is used to direct program flow to a previously defined label or another program. Variable labels are accepted for branching using the "**:%v**###" syntax. The RETURN command is not used in conjunction with the GOTO command. Refer to Figure 5-5.

SYNTAX:

GOTO *:label*

GO *:label*

GOTO *program*

GO *program*

GO :%v###

GO LINE ##

:*label*	Specifies a label name within a program (program flow will go to the specified label and then continue from there).
program	Specifies a program name (program flow will go to another program). The called program must be identified using the format *Filename.ext*. When the called program is finished, control is returned to the original program. A RETURN command is not used in conjunction with the GOTO statement.
###	A U511 variable 0 through 255.
##	Sets program to line number ##.

EXAMPLES:

```
GO :Sec1           ;Program flow goes to label :SEC1 and begins execution
   :               ;⎫
   :               ;⎬These lines are skipped
   :               ;⎭
:SEC1              ;Program execution continues here...

GOTO Prog1.prg     ;Program flow goes to the "Prog1.prg" file and begins
                   ;processing
   :               ;When finished, program control returns here and
                   ;continues
v25 = 700
GO :%v25           ;Program execution will jump to label :700
...
:700
ME DI "program jumped to here"
```

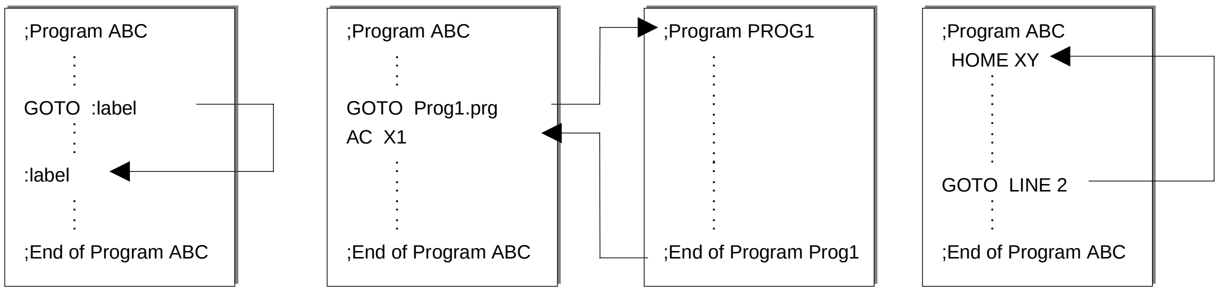


Figure 5-5. Sample Uses of the GOTO Command

Related commands

SUBROUTINE, LOOP, IF

5.5.35. HALT

HA

The HALT command is used to stop all activity on the current contour plane. When a HALT command is initiated, the UNIDEX 511 retains all commands in an internal queue buffer. These commands are not processed until the other plane removes the halt.

The HALT command affects the current plane only. The UNIDEX 511 ensures that all planes do not process the HALT command simultaneously.

SYNTAX:

HALT

HA

EXAMPLE:

HALT	;Stops processing all commands in the current contour ;plane

Related commands

WAIT, MAP, START

5.5.36. HOME

HO

The HOME command is used to move specified axes to the hardware home position. The home sequence is described in Chapter 4 of this manual.

SYNTAX:

HOME *axis*

HO *axis*

axis	Defines the axis (X, Y, Z, or U) to send to the home position.

EXAMPLES:

HOME X	;*or*
HO X	;X axis sent home
HOME X Y Z U	;*or*
HO X Y Z U	;All axes sent home

Related commands

SOFTWARE HOME, G92

5.5.37. IF

IF

The IF command is used to signal a conditional GOTO. First, two values are compared. If the result of the comparison is true, then the program flow will go to a designated label or program. Otherwise, the next sequential command is decoded. The available comparison operators are shown in Table 5-12 below.

SYNTAX:

IF *val1operatorval2 destination*

IF(expression)**THEN**
...
ELSE
...
ENDIF

IF(expression)**THEN**
...
ENDIF

val1	First value of comparison. The value may be in the form of an integer or variable.
val2	Second value of comparison. The value may be in the form of an integer or variable.
operator	Comparison operator. Refer to Table 5-12.

destination	Label to go to when condition is true, or subroutine to go to when condition is true. Destination can either be a label or a subroutine. A label is specified by a ":" symbol. A subroutine is specified by "SU" followed by the label of the subroutine. When the subroutine is finished, the U511 executes the next command after the IF statement.

Table 5-12. Comparison Operators

Operator	Function
=	equal to
<	less than
>	greater than
<>	not equal to
>=	greater than or equal to
<=	less than or equal to

EXAMPLE:

```
:LOOP                 ;Label
IF $IN1=2 :LOOP       ;Waits for input bit 1 to go low before continuing
IF $IN4 = 0 SU :CUTHOLE
                      ;If input #4 is low, then execute subroutine called
                      ;CUTHOLE
```

Related commands

SUBROUTINE, GOTO, LABEL MARKER ":"

5.5.38. INDEX

The INDEX command specifies point-to-point non-synchronized motion of any or all axes. The motion of each axis is based on its individual maximum acceleration rate. An inverse sine ramp achieves the axis feedrate where a steady speed is maintained until the inverse-sine is applied again to ramp down to the axis target distance.

SYNTAX:

INDEX *axis distance axis feedrate ...*

G0 *axis distance axis feedrate ...*

axis	Defines the axis involved in the motion (X, Y, Z, or U).
distance	Defines the length of the movement.
feedrate	Defines the INDEX feedrate for the specified axis (XF, YF, ZF, or UF). Upon initializing the U511, the default units for feedrate are in units/min. The units are defined by the "English and Metric conversion factors." The units for feedrate can be changed by the PROGRAM command.

If the target distance is insufficient for ramping, the UNIDEX 511 automatically calculates and implements the shortest path to the target.

All axes specified with this command start motion at the same time but stop relative to their individual axis' target distance and feedrate. When the target distance is reached for the specified axes, the UNIDEX 511 executes the next command block. Since each axis motion is done independently, the corner-rounding or velocity profiling motion options are not available for use with this command. The maximum distance that can be specified by the INDEX command is 2^{31} machine steps. The maximum feedrate that can be specified by the INDEX command is 2^{15}.

If an indexing feedrate subcommand is missing for an axis, the UNIDEX 511 will use a previously programmed feedrate or the feedrate established by general parameters 023-026, 041-044, 059-062, and 077-080 ("X, Y, Z, and U axis index feedrate").

EXAMPLES:

INDEX X10 XF100 Y20	;Index move axis X 10 using the specified feed rate for axis ;X. Index move axis Y 20 using the default or previous ;index feed rate
G0 X10 Y-20 Z-30 U40	;Index move X 10, Y -20, Z -30, and U 40 using the ;previously set feed rate used by each of these axes

Related commands

LINEAR, CW_CIRCLE, CCW_CIRCLE, FREERUN, ACCELERATION, PROGRAM, G70/G71, G90/G91

5.5.39. INn (Read Inputs)

INn

This command reads the inputs of the U511 card or the 4EN encoder card. IN0 is similar to $INP command, however, the IN0 command reads the inputs directly. The "n" in the INn command must be filled by a number from 0 to 4 in order for it to be distinguished from the INdex command.

> General parameter number 99 bit number 0 should be set to 1 when using the 4EN option board's I/O.

SYNTAX:

INn	Where "n" is a number from 0 to 4.
INn, *bit*, *bit*	
n	0 for U511 card 16 inputs 1: 4EN option board - read back OU1 bits 2: 4EN option board (24 inputs) 3: 4EN option board (16 in, 8 out) 4: 4EN option board (12 in, 8 out)
bit	0-23 for bit number to read

EXAMPLES:

V0=IN0	;Read UNIDEX 511 input bits
V0=IN2,0,1	;Read bits 0 and 1 of 4EN option board P8 connector

Related commands

OU, OUn, $INP, OEn

INT

5.5.40. INTERRUPT

The INT command is used to "Interrupt" program execution. In addition to U511 inputs, this programming command also can be used to program the iSBX-IO48 board.

SYNTAX:

INT *board, nLevel, nInputBit, nOnOff, Label*

board	Board = 1.
nLevel	Level of interrupt where: 0 = turn off 1 = jump to label (abort all motion) 2 = jump to label (don't abort motion) 3 = jump to label, turn off interrupt, (no abort) 4 = jump to label, turn off interrupt, (abort motion)
nInputBit	Input bit number (0 to 15) 16 IN/8 OUT I/O bus input bit. Valid iSBX-IO48 Input Bit ($000 to $127). Input bit number (16 to 39) 8 X 3 I/O bus input bit.
nOnOff	0 = int when *nInputBit* low 1 = int when *nInputBit* high
Label	Label to jump to on interrupt.

EXAMPLES:

INT *1,1,0,0,:turnoff*	;Interrupt on board 1, input 0. Jump to :turnoff when input ;bit 0 goes from high to low. Abort all motion
INT *1,4,8,1,:exit*	;Interrupt on board 1, input 8. Jump to :exit when input bit ;8 goes from low to high
INT *1,0,10*	;turn off int for board 1, input 10

IO

5.5.41. IO (Set/Read 8 X 3 I/O)

This command is used to set or clear bits on the 8 X 3 I/O connector. It is also used to read an input byte (8 bits). The status of the I/O banks can be ascertained with the Secondary I/O screen under the Diagnostics menu. Refer to Chapter 3: User Interface.

SYNTAX:

IO*port value*

IO*port bit#*, 0/1,...

port	Bank of 8 X 3 I/O connector, 0-2.
value	Specifies the 8 bit output data 0-255 or 0xFF.
bit#	Specifies the bit number that is affected.

EXAMPLE:

IO0 0,1,1,1,2,0	;Set bits 0 and 1 to 1, bit 2 to 0 of port 0
V0=IO1	;Read 8 bit inputs

5.5.42. IOSET (Setup 8 X 3 I/O)

IOSET

The IOSET command configures the 8 X 3 I/O bus as inputs or outputs. This bus is configurable in groups of 8 bits as inputs or outputs. All ports are set as input after a hardware reset. Output data can be written to this port (using the IO command) before the direction is configured. See Chapter 10: Technical Details for more information. The status of the I/O banks can be ascertained with the Secondary I/O screen under the Diagnostics menu. Refer to Chapter 3: User Interface.

SYNTAX:

IOSET *port,dir,port,dir,port,dir*

port Port 0 through 2.

dir 0 for input, 1 for output.

The port to connector relationship is shown in Table 5-13.

Table 5-13. The Port to 8 X 3 I/O Connector Relationship

Port	Port Bit Number	8 X 3 I/O Connector
0	Bit #7-0	24-17
1	Bit #7-0	16-9
2	Bit #7-0	8-1

EXAMPLE:

```
IOSET 0,1,1,0,2,0          ;Set 8 out and 16 in
```

JO

5.5.43. JOG

The JOG command calls the Jog screen from a program. When this occurs, the program execution pauses and the Jog screen appears so the operator can jog the axes. The user presses the Quit button in the Jog screen to return to the program.

SYNTAX:

JOG

JO

There are no arguments needed with the JOG command.

EXAMPLE:

```
ENABLE XY
HOME XY
   :
JOG
   :
```

Related commands

FREERUN

5.5.44. Label Marker (:)

:

A label is an ASCII string that may be used to define an entry point within a program. The label command must occupy it's own program block.

SYNTAX:

:*label*

label	Specifies an ASCII string, up to 8 characters in length.

EXAMPLE:

:SECT1	;Inserts the label "SECT1" into the program. Label names ;are arbitrary. Label markers may be used as an entry ;point for a GOTO or SUBROUTINE command

Related commands

GOTO, SUBROUTINE, IF

5.5.45. LINEAR

The LINEAR motion command initiates contour motion in which each axes adjusts its own feedrate to maintain a contour path. All specified axes start and stop at the same time. The UNIDEX 511 uses this contour plane's ramp time to produce either a linear or inverse-sine type ramp to get all axes to steady speed.

The contour feedrate is clamped at the rate set by general parameter 027, 045, 063, or 081 ("Clamp feedrate").

SYNTAX:

LINEAR *axis distance...* {**F***feedrate*|**FT***feedrate_time*}

G1 *axis distance...* {**F***feedrate*|**FT***feedrate_time*}

axis	Defines one or more axes (X, Y, Z, U) for motion.
distance	Defines the distance of the move.
feedrate	Defines a new contour feedrate. Upon initializing the UNIDEX 511, the default units for feedrate are in units/min. The units are defined by the "English and Metric conversion factors." The units for feedrate can be changed by the PROGRAM command.
feedrate_time	Defines the time (in seconds) that is allocated to complete the contour move. The UNIDEX 511 calculates the contour feedrate based on the contour path. The *feedrate_time* value is valid for the current block only.

> If the target distance is insufficient for ramping, the UNIDEX 511 automatically calculates and implements the shortest path to the target for each axis.

The corner-rounding or velocity profiling motion options may be used in conjunction with this command. The maximum feedrate that can be used for a contour type move is 2^{15}.

> If a feedrate subcommand is missing, the UNIDEX 511 will use a previously programmed feedrate or the feedrate established by general parameter # 022, 040, 058, 076 ("Contour feedrate").

EXAMPLE:

LINEAR X10 Y20 F100	;Contour move of X and Y axes at contour feedrate
G1 X10 Y-20 Z-30 U40	;Contour move of all four axes at a previously set feedrate
LINEAR X=V10 F=V11	;Contour move of X axis with the distance and feedrate ;contained in variables 10 and 11

Related commands

INDEX, CW_CIRCLE, CCW_CIRCLE, FREERUN, RAMP, ACCELERATION, ROUNDING, VELOCITY, TRAJECTORY, PROGRAM, G70/G71, G90/G91

LO

5.5.46. LOOP

The LOOP command signals the beginning of a group of program statements to be repeated, and specifies the number of repeats.

SYNTAX:

LOOP *number*

LO *number*

number	Specifies the number of times to repeat the statements in the "command block." The command block consists of the program statements contained between the LOOP and NEXT commands.

EXAMPLE:

```
LOOP 5          ;Signifies the start of the command block
X10             ;⎫
  :             ;⎬ Command block
X-10            ;⎭
NEXT            ;End of command block.  Repeat 5 times
```

Related commands

NEXT

5.5.47. LVDT

The LVDT command links an axis number (1-4) with an R/D channel number (9-16) of an RDP-PC board for very accurate positioning. When the LVDT command is executed, the specified axis moves in the specified direction (CW or CCW) until the RDP-PC board determines that the LVDT sensor is at its null position (i.e., a point that is halfway between the minimum and maximum position). The axis moves in the search direction at the rate set by the "Home feedrate" (axis parameter x04). When the LVDT reaches a specified point, the axis will ramp down and begin searching for the null position. The axis stops on the null position of the LVDT sensor, completing the cycle.

SYNTAX:

LVDT *axisnumber*,*channelnumber*,*direction* [[*speed1*, *speed2*]]

axis number	Specifies the axis number (1, 2, 3, or 4) for the LVDT reference.
channel number	Specifies the RDP channel number to be referenced by this command. The default for unused RDP channels is 16 bit mode. The LVDT command must specify an RDP channel (9-16). No other axis should reference this channel through axis parameters x38, x39, x40, or x41.
direction	Direction of search (CW or CCW).
speed1	Speed axis moves in machine steps/ms until the ramp down point.
speed2	Speed axis moves in machine steps/ms until the null is found.

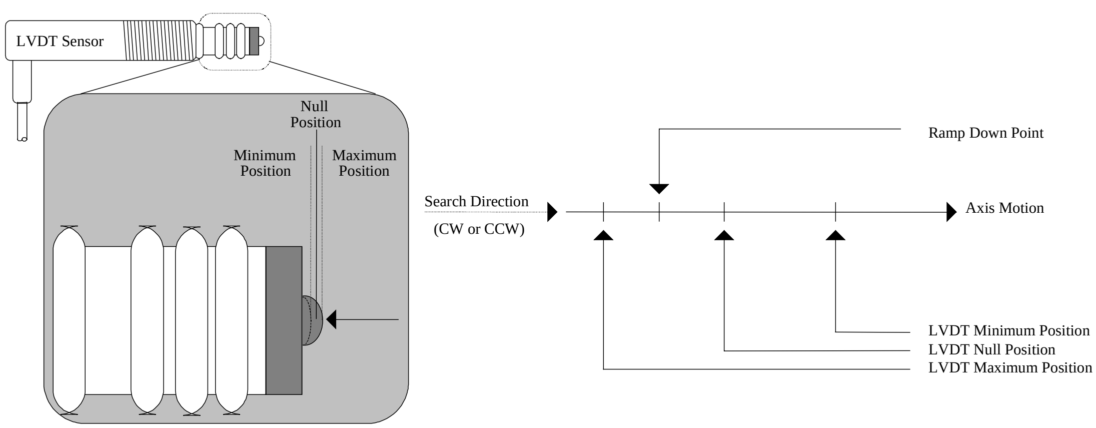


Figure 5-6. LVDT Sensor

EXAMPLE:

LVDT 1,9,CW	;Axis #1 uses R/D channel #9 for feedback. Direction of ;motion is CW

The U511 RDP board is required to provide the feedback channel. Also, no other axes should reference the argument channel through axis parameters x38, x39, x40, or x41.

5.5.48. M0 (M Zero)

The M0 ("M zero") command is used to initiate a pause in the program flow. Program execution continues when the cycle button is pushed.

SYNTAX:

M0

There are no arguments needed with the M0 command.

EXAMPLE:

M0	;Wait until cycle button is pushed.

5.5.49. MAP

The MAP command (1) assigns one or more drives (1, 2, 3, or 4) to any of four contour planes, and (2) assigns an axis name (X, Y, Z, or U) to each drive.

SYNTAX:

MAP *drive,plane,axis...*

MA *drive,plane,axis...*

drive	Defines the drive number to be assigned.
plane	Defines the plane number that the drive is to be assigned.
axis	Assigns an axis name to the defined drive and plane.

The MAP command must define all four drive combinations, even if the system does not contain four drives. The U511 does not recognize a partially defined command.

Each time the map is redefined, the U511 will wait to complete all previous commands.

EXAMPLES:

MAP 1,1,X,2,1,Y,3,1,Z,4,1,U	;All drives assigned to plane 1, drive 1 as X, drive 2 ;as Y, drive 3 as Z, drive 4 as U

MAP 1,1,X,2,2,Y,3,3,Z,4,4,U	;Drive 1 assigned to plane 1 as X, drive 2 assigned to ;plane 2 as Y, drive 3 assigned to plane 3 as Z, drive ;4 assigned to plane 4 as U
MAP 1,1,X,2,2,X,3,3,X,4,4,X	;Drive 1 assigned to plane 1 as X, drive 2 assigned to ;plane 2 as X, drive 3 assigned to plane 3 as X, drive ;4 assigned to plane 4 as X

Related commands

WAIT, HALT, START

5.5.50. MCOMM (Motor Commutation)

MC

The MCOMM (motor commutation) command is used to setup AC brushless or brush motors for commutation with the UNIDEX 511. This command automatically disables position, velocity, and integral traps and outputs a current (torque) vector that is 90 degrees advanced from the rotor vector. The command can also be used to output a constant torque. The motor should spin freely and smoothly in the direction specified. Refer to Chapter 3 of this manual for additional motor configuration information.

SYNTAX:

MCOMM *drive, volts*

MC *drive, volts*

drive	Drive number (1-4).
volts	-10 to +10 volts of commutation where: < 0 = CCW rotation = 0 = Cancels the function > 0 = CW rotation

EXAMPLES:

MC 1,2.5	;Set drive #1 to 2.5 volts for commutation
MC 1,0	;Cancel previous command, disable axis
ENABLE Z	;Enable third axis (Z)
MC 3,1	;One volt peak output to axis 3
MC 3,0	;Stop rotation and disable axis

Related commands

MSET, parameters x38-x44

> To avoid damage to the motor and related equipment, the motor must be disconnected from the load.
>
> Refer to Chapter 4: Parameters for more information about motor commutation and setup.

IMPORTANT

ME

ME CO

ME DI

ME FI

5.5.51. MESSAGE

The MESSAGE command is used to send a message to the display, serial port, or a file. Variable values may also be entered. The message may be text or the value of user or system variables.

SYNTAX:

MESSAGE *dest*1+*dest*2+*dest*3+*dest*4 +*var_input "message"*

ME *dest1+dest*2+*dest3+dest4 +var_input "message"*

dest# A message may be sent to one or more of the following destinations using the syntax shown below:

MESSAGE CO (*port***)** Send a message to serial port

MESSAGE DISPLAY A message is sent to the CRT display.

MESSAGE FILE(*path\name.ext, w|a*)

A message is sent to the file *path\name.ext* where:
w = write to a new file (any existing file is overwritten)
a = append to the end of an existing file.
Use the "w" argument to create and write the first line of a new file. Then use the "a" argument to append messages to the new file.

var_input V0-255 data input.
VV0-255 data input (array).

Formats for displaying variable values are:

%	Real number with 6 digits after the decimal point
%e	Displays number in exponential format (i.e., 1.257e-7)
%.nf	Real number with n digits after the decimal point
%s	Patch string in hex format
%x	Hex format
%%	Display the % symbol

"message" Comprised of text or variable. Must be enclosed in double quotes (" ") or single quotes (' ').

port 1 to 3 for COM1, COM2, or GPIB

EXAMPLES:

ME FILE(TEST.TXT,w) "This is a test"
;Creates a new file and writes "This is a test" to the file

ME DI+V0 "V0 = %V0, ENTER NEW VALUE "
;Displays current value of V0 in a dialog window, and
;prompts for a new value

ME DI+CO(1) "Starting Loop"
;Send message terminated with end of string character to
;COM1 port

ME DI+FI(ERR.LOG,A) "Program Error Status %V0"
;Display and append to file called ERR.LOG the value of
;program variable V0 (the program error status)

5.5.52. MR (Memory Read)

MR

The MR command reads the value of a DSP memory location. This command is for special applications and is not intended for general use.

SYNTAX:

MR *mtype, addr*

mtype	X, Y, or L for X, Y, or L memory space.
addr	Address to read within memory space.

EXAMPLE:

V0=MR X,0xb ;This reads the data at address 0xb from X memory space
;and places the value in v0 (this is the location of the 16
;inputs)

This command is for special applications and is not intended for general use.

Related commands

MW

MS

5.5.53. MSET (Motor Setup)

The motor setup (MSET) command is used to set a fixed vector when setting up an AC brushless motor. This function outputs a fixed vector current command. The rotor will lock into the commanded position. This function can be used to setup motor phasing by checking the Hall effect states at each point.

SYNTAX:

MSET *axis,volts,phase*

MS *axis,volts,phase*

axis	Defines the axis channel number (1=X, 2=Y, 3=Z, and 4=U). Only one drive at a time may be configured. Entering a 0 after the drive number cancels this command.
volts	Output voltage (0 to +10 volts) (A value of 0 stops motion and disables the axis).
phase	Electrical phase (0 to 360 degrees). Specifies a 0 to 360 degree electrical offset for the torque vector.

IMPORTANT

To avoid damage to the motor and related equipment, the motor must be disconnected from the load. Also, make sure parameters x53–"Clamp current output," x48–"RMS current trap," and x49–"RMS current sample time" are properly set.

When using this command with a configured system, servo loop traps will occur. To eliminate this, temporarily set the following axis parameters to zero.
(x19) "Max position error"
(x20) "Max integral error"

Do not proceed unless you are sure of maximum motor current and amplifier scaling.

Make certain the "Max position error" and the "Max integral error" parameters are returned to their original values following phasing of the AC brushless motor.

For resolver feedback, the resolver position should be "0000" when the "Commutation phase offset" parameter is set to 0.

EXAMPLES:

MS 1,2.5	;Sets drive #1 to 2.5 volts to line up the resolver
MS 1,0	;Cancels previous command, disables drive

To verify phasing, a small user program may also be written which steps through all states. The motor should rotate in the clockwise direction. If the motor steps in the opposite direction, the motor phasing is incorrect. Refer to Table 5-14.

```
EN U                  ;Fourth (U) axis
:loop_label           ;Loop back here
MS 4,.5,0             ;1/2 volt output - phase 0
DW 500                ;1/2 second pause
MS 4,.5,60            ;Phase 60
DW 500                ;
MS 4,.5,120           ;Phase 120
DW 500                ;
MS 4,.5,180           ;Phase 180
DW 500                ;
MS 4,.5,240           ;Phase 240
DW 500                ;
MS 4,.5,300           ;Phase 300
DW 500                ;
GOTO :loop_label      ;Continue
```

Table 5-14. Motor Phase Labels and Hall States

	Desired Hall State		
Phase Labels on the Motor	**C**	**A**	**B**
Commanded Vector	*MSB*		*LSB*
330-30 degrees	1	0	0
30-90 degrees	1	0	1
90-150 degrees	0	0	1
150-210 degrees	0	1	1
210-270 degrees	0	1	0
270-330 degrees	1	1	0

Related commands

MC (Motor Commutation)

MW

5.5.54. MW (Memory Write)

The MW command writes a data value to a DSP memory location. The mode argument indicates whether to overwrite the existing memory data, AND the new data with the previous data, or OR the new data with the previous data. This command is not queued in the U511 memory. It is executed immediately by the host processor and the U511. This command is for special applications and is not intended for general use.

SYNTAX:

MW *mtype, addr, data* [,*mode*]

mtype	X or Y for X or Y memory space.
addr	Address to write within memory space.
data	Data to be written.
mode	AND if ANDING data; OR if ORING data; otherwise overwrite data.

EXAMPLES:

MW Y, 0x1a,6	;Writes a 6 to memory location 0x1a in Y memory space ;(this is the location of the 8 outputs)
MW Y, 0x1a, 1 ,OR	;Set bit 0 of the outputs and does not affect the other bits

This command is for special applications and is not intended for general use.

Related commands

MR

5.5.55. NEXT

The NEXT command is used to specify the endpoint of the group of program blocks comprising the loop.

SYNTAX:

NEXT

EXAMPLE:

```
LOOP 10
X10
DWELL 100
X-10
NEXT                        ;Signals the end of the Repeat Loop.
```

Related commands

LOOP

5.5.56. OEn (Extended Output)

This command sets output bits on either the U511 card or the 4EN encoder card. The OEn command is executed immediately by the U511. This differs from the "OU" command that is loaded into the U511's queue buffer and executed synchronously with other programmed commands. It is useful for real time control of the output bus. The "n" in the OEn command must be filled with a number from 0 to 4 in order for the command to work.

> General parameter number 099, bit number 0, should be set to 1 when using the 4EN option board's I/O.

SYNTAX:

OEn *val* Where "n" is a number from 0 to 4.

OEn *bit, highlow, bit, highlow...*

n	0: U511 card (same as OU command except not queued) 1: 4EN option board - P7 (24 out) 3: 4EN option board - P9 (16 in, 8 out) 4: 4EN option board - P10 (12 in, 8 out)
val	Value of output.
bit	Bit number to set.
highlow	0 sets bit low, 1 sets bit high.

EXAMPLES:

OE0 0X55	; Send real time output to U511
OE1 0,1,1,1,2,1	; Send real-time output to 4EN option board P7 connector

Related commands

INn, $IN, OU

5.5.57. OUTPUT

OU

The OUTPUT (or OU) command is used to set or clear individual output bits or write an 8 bit value to the bus. The output value may be specified as either a decimal or hexadecimal number. The actual output polarity is the opposite of the programmed polarity. Programming an output bit as a "1" causes the output to be pulled low. Programming an output bit as a "0" causes the output to be in the high impedance state. The power-on default state of all outputs is "0" (high impedance). Refer to the digital I/O bus specifications in Chapter 10: Technical Details for additional information. The status of the outputs may be ascertained from the Primary I\O screen under the Diagnostics menu. See Chapter 3: User Interface.

SYNTAX:

OUTPUT *Out_value*

OUTPUT *bitnumber, value*

Out_value	Output value from 0-255 decimal (0-0xFF for hex).
bitnumber	Specifies the bit number that is affected.
value	Specifies the bit polarity.

EXAMPLES:

OUTPUT 127	;Output value specified in decimal
OUTPUT 0x55	;Output value specified in hexadecimal
OUTPUT 0,1,3,0	;Individual output bits (e.g., 0 and 3) affected. All others ;remain unchanged
OUTPUT V0	;Output condition is specified using a variable

Related commands:

OEn, $INP, $IN, INn, IO

5.5.58. PARALLEL

The PARallel command should be used when in a Velocity Profiling (G8) sequence with Contour Mode 1 . If the angle between contour moves (G1,G2,G3) is greater than the angle specified with this command, the U511 will temporarily switch to G9 mode (i.e., decelerate to a stop).

SYNTAX:

PARallel = angle
angle = max. angle between contour moves before switching to G9 mode, specified in degrees

EXAMPLE:

PAR=1 ; set stop condition to 1° between vectors

Related Commands:

Velocity, Contour Mode

5.5.59. PRM (PARAMETER READ)

This command is used to read the value of a parameter from the current parameter file. This command will only work for numeric parameters and yes/no parameters. If a parameter value = yes, the variable will = 1, for no, the variable = 0.

SYNTAX:

v## = **PRM** (xxx)

= a variable number

xxx = parameter number

EXAMPLE:

v0=PRM(100) ; reads parameter #100 value into v0

PA

5.5.60. PAUSE

The PAUSE ON command is used to map an input bit to the pause function. While a program is running, the interface scans the input bit. If the input bit value equals the bitstate specified in the command, the pause function is called. This command is identical to the "PAUSE" button on the UNIDEX 511 front panel. See Figure 5-7 for an example. PAUSE OFF stops the scanning of the input bit. This command also can be used with the iSBX-IO48 board.

SYNTAX:

PAUSE ON, *inputbit,bitstate*

PAUSE OFF

PA ON, *inputbit,bitstate*

PA OFF

inputbit	Input bit number (0 to 15) 16 IN/8 OUT I/O bus input bit. Valid iSBX-IO48 input bit ($000 to $127). Input bit number (16 to 39) 8 X 3 I/O bus input bit.
bitstate	Bit value to send pause, either 1 or 0.

EXAMPLE:

PAUSE ON, 3,1 ;Checks input bit 3 for a logical 1. If the value is present, ;calls pause function

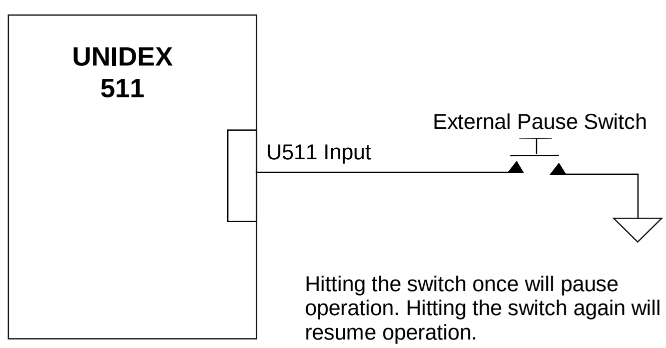


Figure 5-7. PAUSE Function

5.5.61. PLANE

PL

The PLANE command is used to select the contour plane to receive a command.

The UNIDEX 511 is able to execute one to four axes of motion control. Normally the user programs axes with:

Synchronous motion	Multiple axes doing contour motion all starting and stopping at the same time, or
Block-by-block execution	Each command block must completely finish motion before the next command block is executed.

If, however, the application requires multiple axes of contour motion being done independent of each other, the user may group those axes into different contour planes. Axes within a contour plane continue to be capable of synchronous and block-by block motion. Axes assigned to different contour planes move independently.

There are 1, 2, or 4 contour planes available for use (established by general parameter 000 ["Number of contour planes"]).

Each contour plane can have zero to four axes assigned to it. The same axis cannot be assigned to more than one plane. If a contour plane does not have any axes assigned to it, the UNIDEX 511 internally blocks the plane so that no commands can be sent to it.

SYNTAX:

PLANE *number*

PL *number*

number	Selects one plane at a time, selection remains in effect until the next plane command is issued.

EXAMPLES:

PL 1 G1 X100	;Move in plane 1, linear move of the X axis
PL 2 G1 Y100	;Move in plane 2, linear move of the Y axis. Because the X ;and Y axes are in different planes, Y will begin motion at ;the same time as the X axis

Related commands

MAP, WAIT, START and HALT.

5.5.62. PROGRAM

PR

The PROGRAM (or PR) statement establishes the current programming environment. The default programming environment is incremental units and units/minute. The default programming system (English/Metric) may be specified per plane by using general parameters 20, 38, 56, and 74.

SYNTAX:

PROGRAM *eng_or_met*
abs_or_incr
unit_or_step
unit/min_or_unit/sec_or_step/min_or_step/sec

PR *eng_or_met*
abs_or_incr
unit_or_step
unit/min_or_unit/sec_or_step/min_or_step/sec

eng_or_met	EN (English)	Motion distance units are specified in English units (e.g., inches, feet, yards, etc.).
	ME (Metric)	Motion distance units are specified in metric units (millimeters, centimeters, meters, etc.).

> The above subcommands override, but do not change the setting of general parameters 020, 038, 056, or 074 ("Default to metric" [y/n]).

The following arguments may be specified in any order. If one of each of the groups is not specified, the one in bold print will be in effect.

abs_or_incr	ABsolute	Motion distance is referenced to the software home position.
	INcremental	Motion distance is an offset referenced from the current position.
unit_or_step	**UNit**	Motion distance is in user units (e.g., inches/millimeters, etc.).
	STep	Motion distance is in program steps.

unit/min_or_unit/sec_ or_step/min_ or_step/sec

UNit/MInute	Motion feedrate is in (inch or mm) per minute.
UNit/SEcond	Motion feedrate is in (inch or mm) per second.
STep/MInute	Motion feedrate is in program steps per minute.
STep/SEcond	Motion feedrate is in program steps per second.

EXAMPLE:

```
PROGRAM ME Incremental Unit Unit/Minute
        ;The program motion is in the metric mode, each move
        ;distance is an offset from the current position, the value is
        ;in millimeters, and feedrate is in millimeters per minute
```

Related commands

PLANE

A "programming step" is the simplest programming increment. Programming units and steps are related by the parameters 029, 030, 047, 048, 065, 066, 083, and 084.

QU

5.5.63. QUEUE

The UNIDEX 511 reserves an 8,000 word internal memory space for storage of command sets, referred to as the queue buffer. Each time a new command set is received, it is stored in the queue buffer until ready for processing. When the command has been processed, the buffer space it occupied is freed for reuse.

If one plane has been specified for use by general parameter 000 ("Number of contour planes"), all of the 8,000 word space is available for storage. If two planes have been specified for use by general parameter 000, each plane may use 4,000 words of storage. If four planes have been specified for use by general parameter 000, each plane may use 2,000 words of storage.

When the queue buffer is full, any new command that is input will not be stored in the queue buffer until a free space is available.

SYNTAX:

QUEUE AGAIN

QUEUE CANCEL

QUEUE INPUT *num,val...*

QU IN,*$nn,value*

QU IN, *$nnb,value,$nnb,value,...*

QUEUE AGAIN	Directs program flow back to the top of the queue buffer, and repeats the entire command set.
QUEUE CANCEL	Cancels the AGAIN case, decodes the next command.
QUEUE INPUT *num,val*	Causes the system to wait for a specific signal on an input line before processing the next command.
num	Designates the input number (0-F).
val	Specifies the input value (0/1).
QU IN,*$nn,value*	Accesses I/O on iSBX expansion card and evaluates value of entire port.
$nn	Address of iSBX-IO48.
value	Value of bit pattern to wait until.

QU IN *$nnb,value,$nnb,value,...*

Accesses I/O on iSBX expansion card and evaluates individual bits of iSBX port.

$nn	Address of iSBX-IO48. Must be the same for all arguments within command.
b	Bit number to check.
value	Value of bit number (0 or 1).

The Abort function is used to clear the queue buffer.

IMPORTANT

EXAMPLES:

X100 F1000	
DW 1000	
X-100	
DW 1000	
QU AG	;Proceed to the top of the queue buffer, then repeat the ;entire process
QU IN,0,1,1,1	;Waits until input bits 0 and 1 are "1" before control ;continues with the next command in the queue

Related commands

ABORT, HALT, PLANE

RA

5.5.64. RAMP

The RAMP time command is the time that it takes each axis to change from the current velocity to the new velocity. RAMP time is used only for contour motion. This command establishes the ramp time for the current contour plane only.

This command overrides, but does not change general parameters 019, 037, 055, and 073 ("Ramp time").

SYNTAX:

RAMP *time*

RA *time*

time	Time in milliseconds, ranging from 1 to 32,000 ms.

EXAMPLES:

RAMP 300	;Sets ramp time to 300 msec
RAMP V10	;Sets ramp time to value of variable 10

Related commands

TRAJECTORY, LINEAR, CW_CIRCLE, CCW_CIRCLE, G2, G3

IMPORTANT

To ensure smooth motion make certain that (steady velocity)/(ramp time) <= ("Max accel/decel" rate).

5.5.65. REFERENCE

REF

This command moves the specified axes from the current postion to the marker position. It is similar to a home cycle, except, a limit/home switch is not used. Once the marker (or resolver null) is found, the home offset move is executed and the hardware/software positions are cleared.

SYNTAX:

REF *axis…*

axis =X[YZU].

EXAMPLE:

REF XYZU

Related Commands:

HOME, SOFTWARE HOME, G92

5.5.66. RETURN

RE

The RETURN command is used to signal the end of a subroutine and to direct the program flow back to the program block that follows the block calling the subroutine.

SYNTAX:

RETURN

RE

EXAMPLE:

```
:SUB1
  :
  :
RETURN                  ;Program flow will return to the caller.
```

Related commands

SUBROUTINE

5.5.67. ROTATE (Part Rotation)

ROT

Part rotation reproduces a parts program at a specified angle. The command can be used to create a circular array. Part rotation begins when the "ROT" command is given with a non-zero rotation angle. All moves are rotated with respect to the point when rotation was turned on. Rotation continues until the ROT command is given with a zero rotation angle.

SYNTAX:

ROT *axis1,axis2,angle*

axis1	First axis to rotate.
axis2	Second axis to rotate.
angle	Angle in degrees.

EXAMPLES:

ROT X,Y,45	; Start part rotation - rotate XY plane by 45 degrees
ROT X,Y,0	; Turn off part rotation

5.5.68. ROUNDING

RO

When performing a contour motion, this command affects the behavior of deceleration. Under normal conditions, when this command option is OFF-G24 (default state), each contour path decelerates to its target position before the next block of motion begins. Refer to Figure 5-8.

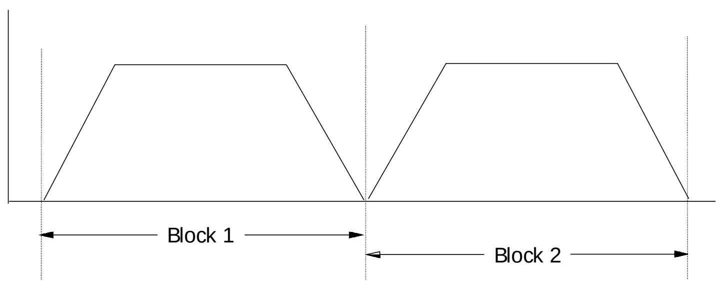


Figure 5-8. Illustration of No Corner Rounding (G24)

When this command option is ON-G23, the next block of motion will begin before the previous path is complete, creating a "rounded corner" at the end of the path. Refer to Figure 5-9.

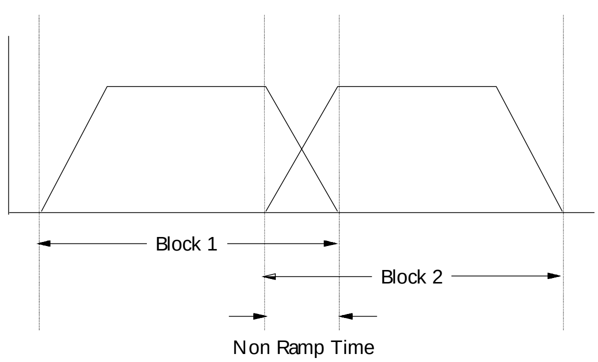


Figure 5-9. Illustration of Corner Rounding (G23)

The time between the path stop and the start of the next block is defined as "non-ramp time" and may also be programmed through this command option. Programming a non-ramp time overrides but does not change the setting of General Parameters 028, 046, 064, or 082 ("Corner rounding time").

SYNTAX:

ROUNDING {*on*|*off*}

ROUNDING *time*

G23

G24

on	G23, activates corner rounding for the specified plane.
off	G24, deactivates corner rounding for the specified plane.
time	Designates the non-ramp time in milliseconds.

Make certain the non-ramp time is less than or equal to the ramp time.

EXAMPLES:

ROUNDING 100	;Sets non-ramp time to 100 msec
ROUNDING ON	;Or
G23	;Activates rounding option
ROUNDING OFF	;Or
G24	;Deactivates rounding option

Related commands

LINEAR, CW_CIRCLE, CCW_CIRCLE, RAMP

5.5.69. SCF (Overriding Scale Factor)

SCF

The SCF command can enlarge or reduce a part by scaling motions/moves without a rewrite of the user's program. The programmed distance is essentially multiplied by the overriding scale factor.

The scale factor affects G0, G1, G2, and G3 commands. The commanded positions for all motion commands will be enlarged or reduced by the scale factor. Setting scaling to 1 will effectively disable the scaling command. This command will work in both absolute and incremental moves. The relative and absolute position registers will contain positions as though scaling is turned off. Only the feedback register will be changed to reflect the true position of the motor. When using the G2 or G3 commands, the scale value for each of the two axes must be identical, however, the signs may differ.

SYNTAX:

SCF X*xScaleFactor* **Y***yScaleFactor* **Z***zScaleFacto*r **U***uScaleFactor*

xScaleFactor yScaleFactor...
Overriding scale factor for the X axis, Y axis etc.

EXAMPLES:

SCF X2 Y.5	;Sets scaling of X to twice programmed distance, and Y to ;half of programmed distance
SCF X1 Y1	;Turns off scaling for X and Y axes
SCF Z-1 U1	;Produces mirror image

5.5.70. SEGMENT

SE

The UNIDEX 511 divides each motion into "segments" then cubic splines those segments into 1/4 millisecond velocity commands to the servo loop. The larger the segment size, the fewer number of steps are required for internal calculation.

The segment_time established for the designated contour plane is used for INDEX, and/or CONTOUR motion calculation. The default *segment_time* is 10 ms. The value established through this command is used to optimize an application that requires consecutive short distance motion from block to block.

SYNTAX:

SEGMENT *segment_time*

SE *segment_time*

segment_time Time in milliseconds, 1 to 20 ms range.

This command overrides but does not change the value of general parameters 018, 036, 054, or 072 ("Segment time").

EXAMPLES:

SE 10	;Sets *segment_time* to 10 ms
SE V10	;Sets *segment_time* to the value contained in variable 10

SK

5.5.71. SKEY (Soft Keys)

The SKey command is used to reprogram the function keys located on the front panel.

SYNTAX:

SKey SEt *fKey, type, label, text*

fKey	Function key to reassign (1 - 5).
type	1 = Goto label, no abort 2 = Subroutine label, no abort 3 = Parts program, no abort 4 = Goto label, abort motion 5 = Subroutine label, abort motion 6 = Parts program, abort motion
label	Label to jump to when function key hit.
text	Text to place on function key (≤ 8 characters)

SKey GEt Waits for a valid function key to be pressed.

SKey ENable *fKeyA(,fKeyB,fKeyC,...)*
Enables a function key.

fKeyA	Function key to enable (1 - 5).
fKeyB,...	Optional function keys to enable.

SKey DIsable *fKeyA(,fKeyB,fKeyC,...)*
Disables a function key.

Arguments same as SKey ENable.

SKey UNdef *fKeyA(,fKeyB, fKeyC,...)*
Returns the function key to the original function as set in the MMI software.

Arguments same as SKey ENable.

EXAMPLES:

SKey SEt *3,1,:cut, Cut Part*	;Set key F3 to jump to :cut when hit, button text = ;"Cut Part"
SKey UN *3*	;Undefined F3, returns F3 back to original function

5.5.72. SLEW

SL

The SLEW command is used in conjunction with the joystick option to provide immediate axis control. While in the joystick slew mode, the following functions are available:

Joystick A Button	Toggles pairs of axes/drives between *h1 v1* and *h2 v2* as specified.
Joystick B Button	Selects between high velocity, low velocity, and absolute positioning mode. Refer to axis parameters x50 ("Joystick high speed"), x51 ("Joystick low speed"), and x52 ("Joystick absolute scale").
Joystick C Button	Cancels previous joystick command. Same as the SLEW C command.

If more than one contour plane is enabled when the SLEW command is issued, the UNIDEX 511 processes them one at a time. Refer to PLANE for information concerning contour planes.

When SLEW mode is canceled, the absolute and relative position registers will not reflect the axis positions. They can be updated with the "Software Position" command. Refer to the SOFTWARE command description for additional information.

Following use of the joystick to slew the axes to the desired position, the slew mode may be terminated by depressing the joystick's C button. (Refer to Figure 5-10.) The UNIDEX 511 will resume processing with the next command in the queue buffer.

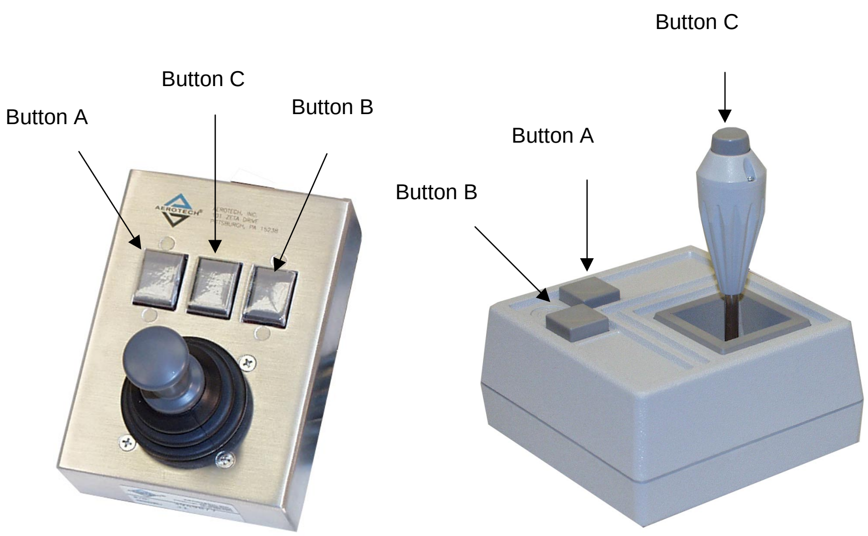


Figure 5-10. Optional UNIDEX 511 Joystick, JI Model Left, JBV Model Right

SYNTAX:

SLEW *h1 v1 h2 v2*

SLEW C

h1 v1 h2 v2	Defines 2 horizontal and vertical axis/plane pairs (X, Y, Z, and U) for the joystick.
C	Cancels slew type motion (same as pressing the C button on the joystick).

EXAMPLES:

```
SLEW                    ;No arguments.  Slews all axes as defined below:

                        ;X and Y axes are assigned to plane 1 which is enabled
                        ;Z and U axes assigned to plane 2 that also is enabled
                        ;X = joystick plane 1, horizontal joystick movement
                        ;Y = joystick plane 1, vertical joystick movement
                        ;Z = joystick plane 2, horizontal joystick movement
                        ;U = joystick plane 2, vertical joystick movement
SLEW X Y Z 0            ;Slew the selected axes of the enabled contour plane

                        ;The sequence of the axes (X, Y, Z, U, or 0 for blank)
                        ;determines the joystick's directional relationship:

                          ;X = joystick plane 1, horizontal joystick movement
                          ;Y = joystick plane 1, vertical joystick movement
                          ;Z = joystick plane 2, horizontal joystick movement
                          ;U = joystick plane 2, axis not affected
SLEW 1 2 3 4            ;Slew the selected drives (not axes). The selected drives do
                        ;not need to be within the enabled contour plane.  The
                        ;sequence of the drives (1, 2, 3, 4, or blank) determines the
                        ;joystick's directional relationship

      :
SLEW X Y                ;Enable axis joystick
WAIT ON                 ;Wait for previous command to finish
SOFTWARE POSITION X Y
      :                 ;Update absolute and relative position registers with
      :                 ;adjusted machine position, then resume normal operation
```

Make certain a drive assigned to joystick slew motion has no other motion assigned to it.

Related commands

WAIT, SOFTWARE POSITION X Y Z U

5.5.73. SOFTWARE

The SOFTWARE command is used to set software home, limit, and position locations.

SYNTAX:

SOFTWARE HOME *axis_positio*n

G92 *axis_positio*n

SOFTWARE LIMIT *axis_CCWdistance,CWdistance*

SOFTWARE POSITION *axis*

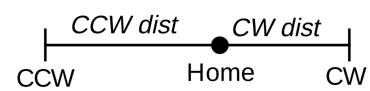
The functions available with this command are as follows:

SOFTWARE HOME *axis_positio*n or

G92 *axis_positio*n — The command with no axis designation, sets the position register of all active axes to zero. The command, with an axis designation, sets the position registers of the designated axis to the specified value.

SOFTWARE LIMIT *axis_CCWdistance,CWdistance*

Sets the counterclockwise (CCW) and clockwise (CW) travel limit distance (in program units such as inches, mm, etc.) for the specified axis as referenced from the hardware home position. Must HOME axes before software limits take effect.



SOFTWARE POSITION *axis*

Establishes a software position for each of the specified axes that is referenced from the current hardware position. This position is useful after a freerun or when using either a joystick or handwheel option, so that the new software position is updated to match the current hardware position.

EXAMPLES:

```
G92                             ;Sets position register of all of the axes in the current plane
                                ;to 0
G92 X0                          ;Sets the position register of the X axis to 0.  All other axes
                                ;are unaffected
SOFTWARE HOME X1.2 Y3.4 Z5.6 U7.8
                                ;Sets the position registers to the specified values
SOFTWARE LIMIT X-10,5
                                ;Sets the X axis counterclockwise limit at -10 program
                                ;units from the hardware home
                                ;Sets the X axis clockwise limit at 5 program units from
                                ;the hardware home
```

```
SOFTWARE POSITION X Y Z
                          ;Updates the X, Y, and Z axes software position from the
                          ;current hardware position
```

> Before using the SOFTWARE HOME command, the SOFTWARE POSITION command must be used first.

5.5.74. SPLINE

SP

The UNIDEX 511's SPLINE function refers to the controller's ability to perform cubic spline fitting of multiple successive target positions. The result is a smoother path, with minimal positional disturbances and jerking between points. The command is well suited for non-Cartesian geometric motion.

The cubic splining function is in terms of position versus time for up to four axes at once. The target positions are specified in command lines that follow the SPLINE ON command. These target position specifications look very much like INDEX commands. The UNIDEX 511 looks ahead two positions to assure path smoothing, so at minimum, two target position specifications are needed to begin proper splining motion.

The target positions contain the axis designators intended to spline X, Y, Z, and/or U, and their position values attached to each axis designator. The path time (T), or the feedrate (F), is the last argument of the target position command. T in seconds, is specified where a constant time, but variable feedrate is needed between target positions. F is specified as a constant feedrate, but variable time is needed between target positions. T and F arguments are contradictory in function and are not used in the same target position command. Using both time and feedrate in a single target position command will cause a programming fault.

When splining motions are enabled, the controller will not process any other types of motion commands such as INDEX, CONTOURED, or FREERUN commands.

SYNTAX:

SPLINE {*ON*|*OFF*}

SP {*ON*|*OFF*}

ON	Enables the splining function. Subsequent motions will curve fit.
OFF	Disables the splining function.

EXAMPLE:

The following example illustrates a three point spline. Incremental mode is assumed.

```
SPLINE ON               ;Spline is turned ON
X3.32 Y4.321 T0.123     ;Incremental motion in 123 ms
X0.332 Y0.555           ;Incremental motion in 123 ms
```

X1.099 Y0.987 OU0x55	;Incremental motion in 123 ms. At the end of the motion, ;the output command of 0x55 is executed, turning ON ;output bits 0,2,4, and 6
SPLINE OFF	;Splining is turned OFF

Related commands

INDEX, CW_CIRCLE, CCW_CIRCLE, FREERUN, G90, G91, G70, G71, PROGRAM

5.5.75. START

ST

The START command is used to activate planes that are currently under the HALT command.

SYNTAX:

START *plane*

START *wait,plane, ...*

plane	Identifies the planes (1, 2, 3, and 4) that require a start.
wait	Wait until designated planes go into the halt state, then starts all of them.

The START command can be used only to activate planes other than its own.

EXAMPLE:

START 1,2	;Activates planes 1 and 2 if they are on HALT
START WAIT,1,2	;Wait until planes 1 and 2 go into halt state, then start both ;of them. If either or both planes 1 and 2 are not yet in the ;HALT state, WAIT will continue indefinitely

Related commands:

WAIT, HALT, MAP

SU

5.5.76. SUBROUTINE

The SUBROUTINE (or SU) command is used to direct program flow to a previously defined label or another program. Variable labels are accepted for branching using the “**:%v**###” syntax. The designated program will be processed and then program flow will return to the program block that follows the SUBROUTINE command. The RETURN command must be included at the end of the subroutine.

SYNTAX:

SUBROUTINE *:label* Jump to label

SUBROUTINE *program* Jump to program

SU :%v### Jump to label specified by variable ###.

:label	Program flow will go to the specified label.
program	Program flow will go to another program. The called program must be identified by using the *filename.ext* format.
###	Is a U511 variable 0 through 255.

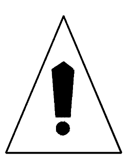
EXAMPLE:

```
SU :SUB1            ;Program flow will go to the location of the label :SUB1
                    ;and begin processing the command blocks until a
                    ;RETURN command is encountered
SU PROG1.PRG
                    ;Program flow will go to file PROG1.PRG and begin
                    ;processing the command blocks until a RETURN is
                    ;encountered

v25 = 700
SU :%v25            ;Program execution will jump to label :700
...
:700
ME DI “program jumped to here”
RETURN
```

Related commands

RETURN



IMPORTANT

The command blocks making up the subroutine must be located after the main program's EXIT command.

5.5.77. SYNC

SYNC

The SYNC command causes queue execution to pause until all corner rounding/velocity profile moves have completed.

5.5.78. Target Tracking Commands (TE, TD, TP)

TE

TD

TP

Target tracking is a real time form of motion profile generation. Real time target positions are sent to the DSP from the user program. The axes then attempt to move to the desired position at the velocity specified. At any time, a new target position can be sent to the DSP. The filter parameter is used to implement a first order exponential digital filter. This smoothes starts, stops, and transitions in velocity and direction. The functions are as follows:

SYNTAX:

TE *axis*	Tracking Enable–enable target tracking on single axis (1, 2, 3, or-4). Functions will not enable if axis is in fault condition. Repeating the command can enable multiple axes.
TD *axis*	Tracking Disable–disable target tracking mode on single axis 1-4 and return to normal.
TP *axis,pos,vel,filter*	Target Position–set tracking position for single axis.
axis	Axis number (1, 2, 3, or 4).
pos (machine steps)	Target position for the specified axis. This position is with respect to the hardware home position and is in machine steps.
vel (machine steps/sec)	Maximum speed at which the axis will move to get to the target position.
filter (0-1)	The exponential ramping filter. A value of 1 will produce no ramping effect. Values close to 0 will produce long ramp times. Typical values are .01 to .001.

EXAMPLE:

This example program enables target tracking for the X axis and moves to target position. The program assumes the X axis is mapped to drive 1.

```
ENABLE X              ;
HOME X                ;
WAIT ON               ; Wait for home to finish
TE 1                  ; Enable target tracking drive 1
TP 1,1000,1000,.01    ; Set target position–axis will move here
   :                  ;
   :                  ; Add real time desired position commands here
   :                  ;
TD 1                  ; Disable target tracking for drive 1
```

TR

5.5.79. TRAJECTORY

The TRAJECTORY command is used when doing contour type motion, to specify whether the acceleration and deceleration ramp type will be linear or inverse-sine.

SYNTAX:

TRAJECTORY *type*

TR *type*

type	Where:
LINEAR	Identifies the acceleration/deceleration ramp as linear type for the current plane and
SINE	Identifies the acceleration/deceleration ramp as inverse-sine type for the current plane.

EXAMPLE:

```
TRAJECTORY LINEAR  ; Accel/decel ramp trajectory type is linear
TRAJECTORY SINE    ; Accel/decel ramp trajectory type is inverse-sine
```

Related commands

RAMP

5.5.80. TRIGGER

This command starts planes 1, 2, 3, or 4 (or any combination of planes) that are currently halted. This is a real time, now queued command.

SYNTAX:

TRIGGER *plane, plane,…*

plane	Plane 1-4.

EXAMPLE:

This example loads commands into planes 1 and 2 of the U511's queue, then triggers them simultaneously.

```
PLANE 1
HALT
G1 X1 F1000
G1 X.2 Y.2
…                     ; More commands for plane 1
PLANE 2
HALT
G1 Z1 F1000
G1 Z.3
G1 Z.1 U.2
…                     ; More commands for plane 2
TRIGGER 1,2           ; Start planes 1 and 2
```

Related Commands:

WAIT, HALT

5.5.81. UMFO (Manual Feed Override)

The UMFO command option is used to override the MFO potentiometer setting.

UM

SYNTAX:

UMFO {*OFF*|*ON,feed_rate*}

OFF	Enables the MFO potentiometer.
ON,0-199	Disables the MFO potentiometer and specifies a feedrate from 0-199% of the programmed feedrate.

EXAMPLES:

UMFO ON,100	;Disables the MFO potentiometer and sets feedrate at ;100% of programmed value
UMFO OF	;Enables the MFO potentiometer

5.5.82. VAR (Read/Write Variables)

The VAR command is used to read and write user variables to files.

VAR

SYNTAX:

VAR OPEN *filename*	Opens file for storing and retrieving variables.
VAR READ *#,#,#,...*	Read a variable from the open file.
VAR READ ALL	Reads all 256 variables.
VAR WRITE *#,#,...*	Writes current value of the variable to the open file.
VAR WRITE ALL	Writes the values of all 256 variables to file.
VAR CLOSE	Closes open variable file.
filename	Name of file for storing or retrieving variables.
#	Name of variable where # = 0 to 255.

EXAMPLE:

VAR OPEN *var.txt*	
	;Opens file c:\u511\var.txt
VAR WRITE *23,45*	;Writes values of *v23* and *v45* to var.txt
VAR READ *45*	;Reads value of *v45* from var.txt
	;and sets *v45* to this value on the card
VAR CLOSE	;Closes var.txt

5.5.83. VELOCITY

VE

The VELOCITY command is used when performing contour type motion to blend consecutive motions into one continuous path. It is a modal command and as such will remain in effect until turned OFF.

The UNIDEX 511 has two methods of blending moves together (contour modes). Contour mode 0 (CM0) blends the deceleration of one move with the acceleration of the next move. This mode is best for long moves if total move time is greater than twice the ramp time. Contour mode 1 (CM1) ramps on the first G8 move and the last. It should be used for short moves if the move time is less than twice the ramp time.

SYNTAX:

VELOCITY *on|off*

G8

G9

on (G8)	Enables Velocity Profiling.
off (G9)	Disables Velocity Profiling.

EXAMPLES:

G8 G1 X100 F100	;Enables velocity profiling
G2 X0 Y20 C0,10 F200	;Blends linear motion to produce this circular motion at ;specified feedrate
G9 G1 X-100 F100	;Blends linear motion, disables velocity profiling at the end ;of this move

VELOCITY ON	;Does same thing as above
G1 X100 F100	;
G2 X0 Y20 C0,10 F200	;
VELOCITY OFF	;
G1 X-100 F100	;

IMPORTANT

The last contour move in velocity profiling must include a VELOCITY OFF (G9) command.

Related commands

INDEX, LINEAR, CW_CIRCLE, CCW_CIRCLE

5.5.83.1. Correct Usage and Limitations of the Velocity Profiling Algorithm

The following two plots show the results of running a program first without velocity profiling, then with profiling in CM0 mode. The three moves of this program are: G1 X10 F960, G1 X5, and G1 X10.

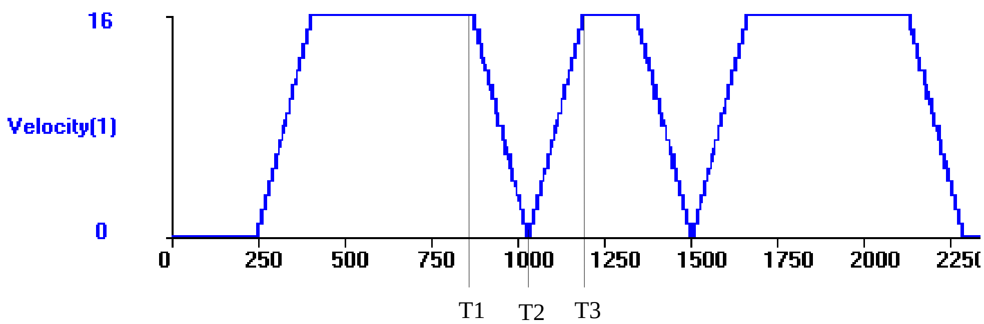


Figure 5-11. Plot of Velocity Without Velocity Profiling

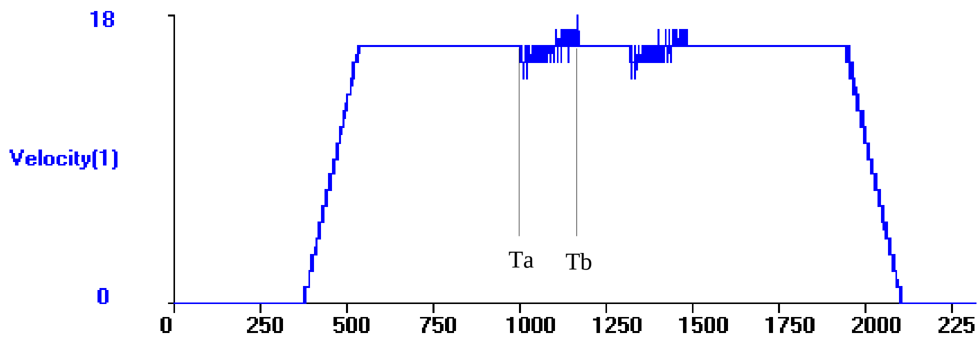


Figure 5-12. Plot of Velocity With Velocity Profiling

The second plot shows how the three moves are blended into one smooth motion. This velocity is generated by overlapping the two motion commands by beginning the next move when the current move begins to decelerate. The velocity during this transition between moves (time Ta to Tb) is achieved by adding the velocity of the deceleration of the current move (time T1 to T2) to the acceleration of the next move (time T2 to T3). With ramp times staying constant and distances long enough so that the motion will ramp up to the desired velocity, velocity profiling will produce the desired results.

The following mathematical analysis shows how to determine the shortest move that will still allow for proper velocity profiling. The time of this shortest move is twice the ramp time, and doing the calculations assuming linear acceleration, the acceleration equals the feedrate divided by the ramp time:

$$a = v_F / t_R$$

The distance is the sum of the distances traveled during acceleration and deceleration.

$$x_t = \frac{1}{2} a t_{Ra}^2 + \frac{1}{2} a t_{Rd}^2$$

Substituting in for acceleration yields the simple formula,

$$x_t = v_F t_R$$

For the above example, where v = 960 mm/min = 16 mm/s and with ramp time set at 160 ms, the shortest programmable move for proper velocity profiling is 2.56 mm.

Changing the second move in the above example from `G1 X5` to `G1 X1`, demonstrates the problem that can occur. See the following plots. The first plot shows the motion without profiling, the second plot shows what happens when the moves are blended together.

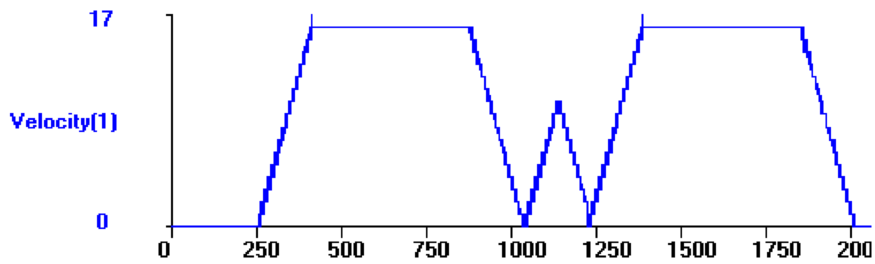


Figure 5-13. Short Middle Move With No Velocity Profiling

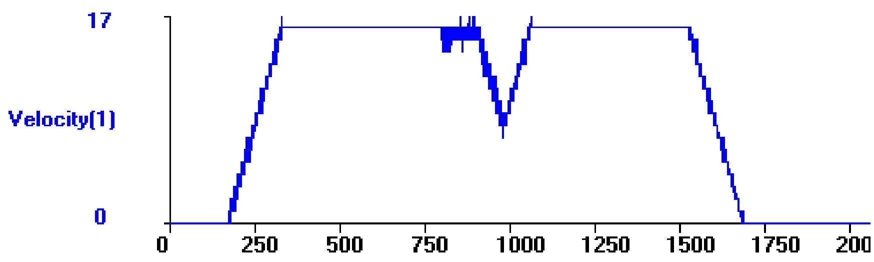


Figure 5-14. Short Middle Move With Velocity Profiling

Because the second move is not able to ramp up to full speed, the profiled velocity is not smooth. Lowering the ramp time or using contour mode 1 (CM1) can reduce the dip in the velocity profile. This 1 mm move would take about 60 ms to ramp up to the desired velocity. The next plot shows the same motion with the ramping time set to 50 ms.

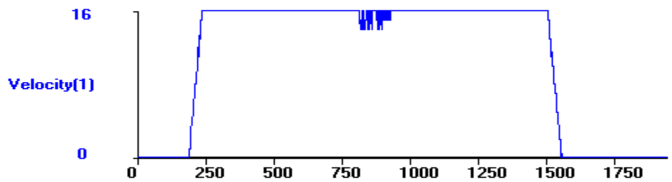


Figure 5-15. Same Motion With Ramping Time Reduced

With two axes in motion, the same effects are present. The next example is velocity profiling a circle using linear moves. The circle has a 5 mm radius and is divided into 500 linear moves. The ramp time is again the parameter to change in order to get the appropriate response. The following two plots show the velocity of the axes, the first plot has a 150 ms ramp time, the second plot has a 5 ms ramp time. Notice that the profiles are similar, but the shorter ramp time allows the axes to achieve higher speeds.

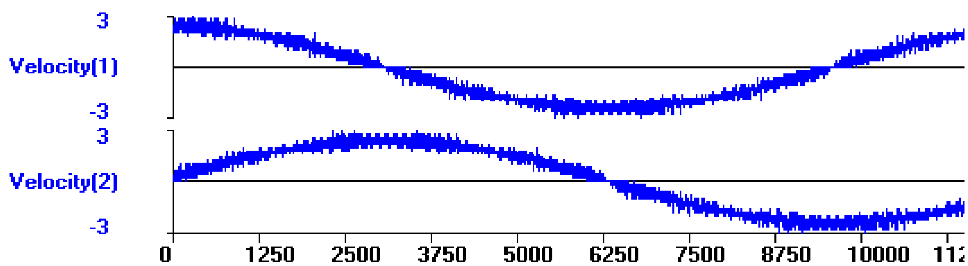


Figure 5-16. Circular Profiling With Long Ramp Time

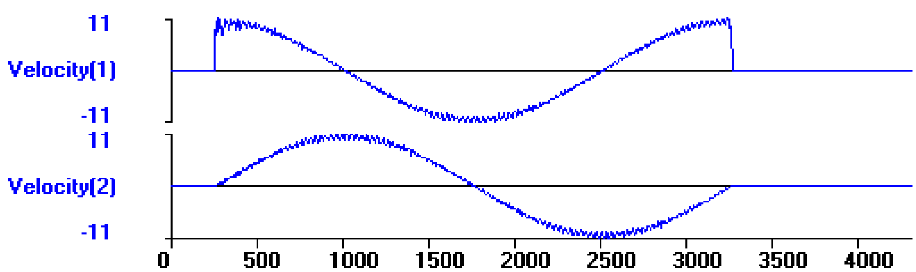


Figure 5-17. Circular Profiling With Short Ramp Time

There are advantages to generating the profile by adding the velocity of the deceleration of the current move to the acceleration of the next move. In some controllers, velocity profiling only works with smooth curves. The UNIDEX 511 allows for profiling of "corners" within the move. Consider the following three moves in G8 mode, `G1 X10, G1 X5 Y5, G1 X10`. The following plot shows the plot of the two axis velocities. The motion is completed with the surface speed staying constant.

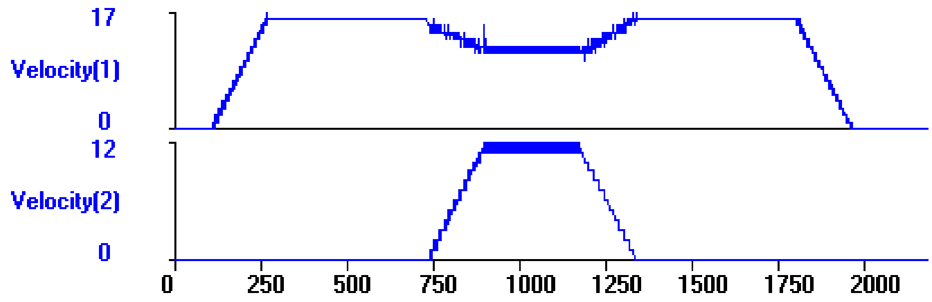


Figure 5-18. Two Axis Linear Move With Velocity Profiling

The constant surface speed is 16 mm/sec. The speed of each individual axis during the X5 Y5 move is determined by breaking the surface speed into its component vector speeds. The equation relating the three velocities together is determine by the Pythagorean Theorem:

$$v_s^2 = v_x^2 + v_y^2$$

In this example, because the moves are the same distance, $vx = vy$ = 11.3 mm/sec.

5.5.83.2. CM1 Contouring Mode

The contouring mode can be changed by executing the CM command. The normal mode (CM0) blends moves together by combining deceleration of one move with the acceleration of the next move. The alternate mode (CM1) does not. It requires that the last move be preceded by a G9 (velocity profiling off) command if in G8 mode. The default contouring mode can also be set by general parameters 31, 49, 67, and 85. The previous profile examples assumed CM0 mode. In the following examples, CM1 is assumed. Also shown are the program codes for the motion generating the profiles.

Consider the following program:

```
ENABLE X Y
WAIT  ON
SC
CM 1                    ; SET CONTOUR MODE 1
G8                      ; VELOCITY PROFILING ON
G1 X10 Y1 F10000
X9 Y2
X8 Y3
X7 Y4
X6 Y5
X5 Y6
X4 Y7
X3 Y8
X2 Y9
G9 X1 Y10
```

Velocity Command plots for each axis of this program are shown in Figure 5-19. The plots in Figure 5-19 show how the U511 generates the velocity profile for nontangential vectors. Note that there is no ramping of individual axis velocities between vectors.

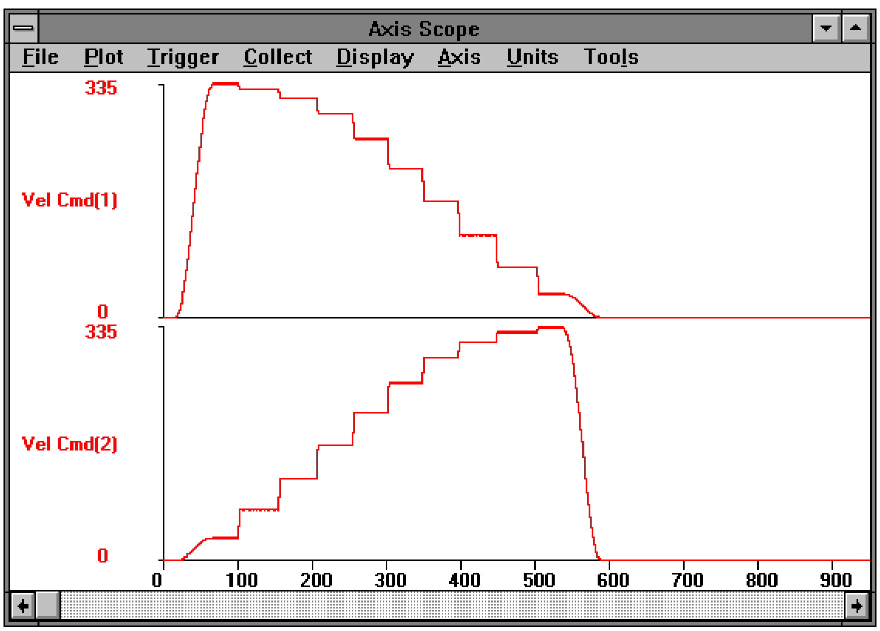


Figure 5-19. Velocity Profile for Nontangential Vectors

Consider the same program but with a digital filter added through the FL command. A plot for this situation is shown in Figure 5-20.

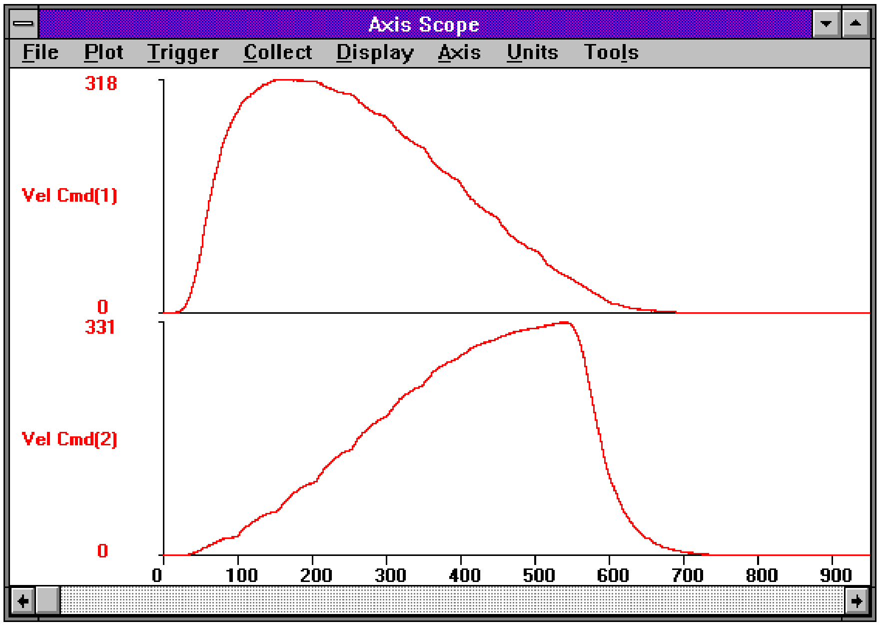


Figure 5-20. Velocity Profile With Digital Filter

This plot shows the same move profile as the preceding plot except that a digital filter has been added with a time constant of 100 ms (see the FL command for more details). This filter smoothes the edges between nontangential vectors. Although the smoothing occurs it results in some skewing or distortion of the part.

The next program has the G9 command commented out to show what will happen if the last move in a sequence of G8 moves is not a G9 move.

```
ENABLE X Y
WAIT  ON
SC
CM 1                 ; Set contour mode 1
G8                   ; Velocity profiling on
G1 X50 F10000        ; Last move
;; G9 X10            ; Commented-out to show effects of CM1 velocity
                     ; profiling
```

A plot of the velocity command is shown in Figure 5-21.

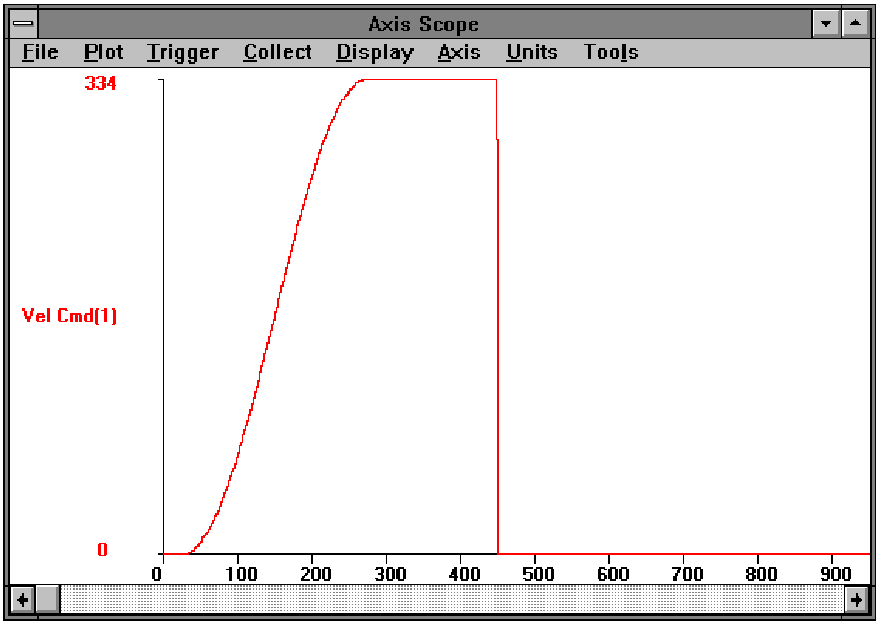


Figure 5-21. Velocity Profile Without a G9 Command at the End of the Sequence

The plot shows that the Velocity Command will immediately ramp to a stop. This will almost always cause an axis fault of some sort and is not considered proper use of velocity profiling mode.

> This type of transition can be smoothed by the use of the Filter command (see FL) but the best way is to terminate a sequence of G8 moves with a G9 move.

5.5.84. WAIT

WA

The WAIT command is used to instruct the UNIDEX 511 to wait until all previous commands in the current contour plane's queue buffer are completed before executing the next line of the program.

SYNTAX:

WA

WAIT

ON	Enables the WAIT command. All previous commands are processed before taking next command.
OFF	Disables the WAIT command.
ALL	Automatically inserts a WAIT ON command at the end of each command block.

EXAMPLES:

WA ON	;Waits until completion of all previous commands
WA OF	;Disables the WAIT command
WA AL	;Waits at the completion of every command block

Related commands

MAP, HALT, START

5.5.85. WHILE/ENDWHILE

WH/ENDW

The WHILE command evaluates the expression and if true, executes to the ENDWHILE statement. The ENDWHILE statement returns to the WHILE statement and the loop is executed until the expression becomes false.

SYNTAX:

WHILE (*expression*)

WH (*expression*)

ENDWHILE

ENDW

expression Any valid U511 expression.

EXAMPLE:

```
V0=0              ;Assign zero to variable
WHILE (V0<10)     ;Do while variable less than 10
G1 X10 F1000      ;Move axis
V0=V0+1           ;Increment variable by 1
ENDWHILE          ;Return to WHILE as long as V0 less than 10. Otherwise
                  ;quit
```

Related commands:

LOOP, NEXT, IF, GOTO

∇ ∇ ∇

CHAPTER 6: REMOTE MODE OPERATIONS

In This Section:

6.1. Introduction

The UNIDEX 511 can be completely controlled remotely from a PC. The U511 has three communications ports, COM1, COM2 and an optional General Purpose Interface Bus (GPIB) interface. Remote commands can be sent from both serial ports and the GPIB port at the same time. Remote commands are sent in ASCII format to the U511 followed by an end of string (EOS) character. Some commands cause the U511 to return data. This data is in ASCII format terminated by the EOS character set by the port parameter (parameters 612, 621, and 627).

6.1.1. GPIB IEEE-488 Interface

The GPIB is the IEEE-488 standard parallel interface used for attaching sensors and programmable instruments to a computer. The U511's GPIB interface is activated when the GPIB system controller addresses the U511 to become a talker or listener. Only the EOS character is required to terminate commands to the U511. The Interface Clear (IFC) and Device Clear (DCL) GPIB functions reset the U511's interface. These commands can be used to recover if a communications time out occurs.

The GPIB interface does not use the software handshake ACK/NAK characters except during file transfers.

In U11 emulation mode, the DCL function causes a hardware reset.

6.1.2. RS-232 (COM1 and COM2) Interface

There are two RS-232 interfaces (COM1 or COM2). The U511 can be controlled through either RS-232 interface. It can be connected to a PC with a one-to-one 9 pin D to 9 pin D cable. These interfaces do not use hardware handshake signals.

6.2. Troubleshooting Remote Communications

The U511 Diagnostics screen contains a simple terminal emulator to display received and transmitted characters. Characters between 0x0 and 0x1f are displayed in brackets. Characters typed from the front panel or keyboard are transmitted to the selected remote port. This screen should be used to verify the connection with the host controller. If you are not able to transmit and receive characters in this screen, the following remote commands will not work!

6.3. Command Handshake Mode (RS-232 Only)

Acknowledge handshake mode is enabled by default. If a valid command is sent to the U511, it will return the "Command ACK character" immediately. The NAK character will be returned immediately if the U511 receives an illegal remote command.

If the U511 does not respond with an ACK or NAK character within a maximum of 1 sec, an incorrect or incompatible communication parameter ("Baud rate," "Parity," etc.) may have been selected. Make sure that the host computer is capable of running at the desired baud rate and that a shielded cable is used. The "SP" (Save Parameter File) command may take longer to respond with the ACK character because it involves writing to flash memory. Time out checking by the host computer should not be used with this command. The "AR" and "BR" commands may also take longer to respond with an ACK/NAK. This is because programs are preprocessed and syntax-checked before execution.

The "##" command can be sent after a time out to clear the communications port. See parameters numbered 614, 615, 623, and 624.

The handshake mode can be turned off by setting bit number 9 of register 0. This is the same as the "Default configuration" parameter for COM1 and COM2 (parameter numbers 616 and number 625). See the RRn and WRn remote commands for more details.

The GPIB interface does not use the software handshake ACK/NAK characters except during file transfers. In this case they are encoded as ASCII characters.

6.4. Remote Commands

The following section describes commands needed to communicate with the UNIDEX 511. In the commands that follow, the syntax is given to the left of the "**:**" whereas the name or description of the command is given to the right. Most parameters like the EOS, ACK/NAK, etc., are programmable. In the tables that follow, the default values of these parameters are given in parentheses.

6.4.1. ##: Enable RS-232 Remote Communications

This command configures the serial port for remote mode. It will then accept and respond to remote commands. The "##" command does not require an end of string terminator. This command should also be used to resynchronize the serial communications buffer in the event of a time out. Table 6-1 shows the communications sequence for the enable RS-232 remote mode command.

Table 6-1. Enable RS-232 Remote Mode Sequence

Direction of Transfer	Command	Description
Host→U511	##	Enable RS-232 remote mode

Example: ##

This command only applies to RS-232 operation.

6.4.2. Program Execution

ARprog: Auto Run a Program

BRprog: Block Run a Program

These commands load the program, “prog,” into memory. The program name can be any valid U511 program in DOS “8.3” format.

In AUTO run mode, the program will begin execution immediately. A service request (SRQ) will be sent immediately if there is a syntax error in the program (See section 6.4.4 Service Request Mode). A SRQ can be sent if a run-time error occurs, otherwise the SRQ will be sent when the program completes. If in HOLD mode, the U511 will not begin execution of the program until the “TR” command is received. Table 6-2 shows the communication sequence for the auto run program command.

In BLOCK run mode, the program will not begin execution immediately. SRQ will be sent immediately if there is a syntax error. The program can be executed block by block by sending “TR” commands. The U511 will generate SRQ’s (if enabled) after each block. Table 6-3 shows the communication sequence for the block run program command.

Table 6-2. Auto Run a Program Communication Sequence

Direction of Transfer	Command	Description
Host→U511	AR	Auto Run command
Host→U511	Program name	Name of program to be run
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06) and program will begin. If hold mode is enabled then trigger will be needed
U511→Host Note: SRQ will only be sent if SRQ mode is active	SRQ character See SRQ section	Service request character (%) at completion of program if service request mode is active Perform service request procedure

Example: ARtest1.prg <EOS character>

Table 6-3. Block Run a Program Communication Sequence

Direction of Transfer	Command	Description
Host→U511	BR	Block Run command
Host→U511	Program name	Name of program to be run
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)
Host→U511	Trigger command See Trigger command (TR)	Trigger command is required to initiate each program step. This command must be repeated until program completes
U511 →Host Note: SRQ will only be sent if SRQ mode is active	SRQ character See SRQ section	Service request character (%) at completion of each step if service request mode is active Perform service request procedure

Example: BRtest1.prg <EOS character>

6.4.3. PA: Program Abort

This command causes a currently executing program to abort. All axes will stop and the program will unload. Table 6-4 shows the communication sequence for the Program Abort command.

Table 6-4. Program Abort Communication Sequence

Direction of Transfer	Command	Description
Host→U511	PA	Program Abort command
Host→U511	EOS character	End of string character (LF) Program or command will terminate.
U511→Host	ACK/NAK character	Acknowledge character (0x06)

Example: PA <EOS character>

6.4.4. Service Request Mode (SRQ)

SR1: Turn ON

SR0: Turn OFF

SRc: Set Service Request Character to "c"

UNIDEX 511 can be put into service request mode (SRQ). SRQ mode sends a character to the host when an event has occurred. The host should then pol the U511 to determine its status.

In GPIB mode, "SRQ" is an intrinsic function. The controller should Serial Pol the U511 to clear SRQ. In RS-232 mode, the SRQ is generated with a programmable character.

These commands turn service request mode on or off. They are also used to set the SRQ character for RS-232 mode to "c." Table 6-5 shows the communication sequence for the Service Request On command. The communication sequence for the Service Request Off command is shown in Table 6-6. Table 6-7 shows the communication sequence for the Set Service Request Character command. Table 6-8 shows the communication sequence for a service request response operation.

The U511 will generate a SRQ under the following conditions:

1. Program is finished executing in AUTO mode.
2. Block has finished executing in BLOCK mode.
3. Immediate command has finished execution.
4. Runtime error in the program.
5. Syntax error in the program. This will occur immediately after the 'AR' or 'BR' command since the program is syntax-checked before execution.
6. An axis error such as a limit or position error occurs.
7. An illegal remote command is sent. The normal response to a service request is to Serial Pol the U511 ("Q" or GPIB Serial Pol function). The user can then determine the source of the error from the status byte.
8. When the U511 has finished saving parameters to flash memory using the SP command.

Table 6-5. Service Request On Sequence

Direction of Transfer	Command	Description
Host→U511	SR1	Service Request On code
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)

Example: SR1 <EOS character>

Table 6-6. Service Request Off Sequence

Direction of Transfer	Command	Description
Host→U511	SR0	Service Request Disable code
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)

Example: SR0 <EOS character>

Table 6-7. Set Service Request Character Sequence

Direction of Transfer	Command	Description
Host→U511	SR	Service Request code
Host→U511	SRQ character	Service request character (%)
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)

Example: SR% <EOS character>

Table 6-8. Service Request Response Sequence

Direction of Transfer	Command	Description
U511→ Host	SRQ character	Initiate service request (%)
U511→Host	EOS character	End of string character (LF)
Host→U511	Q	Query character
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)
U511→Host	Serial Pol reply	Serial Pol reply code characters
U511→Host	EOS character	End of string character (LF)

Example: Q <EOS character>

6.4.5. Hold/Trigger/Cancel

HD1: Enable Hold Mode

HD0: Cancel Hold Mode

TR: Trigger

The Enable Hold Mode command (HD1) is used to activate hold mode. When hold mode is active, commands and programs will require a Trigger command to initiate the operation. Table 6-9 shows the communication sequence for the enable hold mode command.

Table 6-9. Enable Hold Mode Sequence

Direction of Transfer	Command	Description
Host→U511	HD1	Enable Hold Mode code
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)

Example: HD1 <EOS character>

The Cancel Hold Mode command (HD0) is used to turn off hold mode. When hold mode is off (default), commands and programs will not require a Trigger command to start them unless otherwise noted (example: program block run). Table 6-10 shows the communication sequence for the disable hold mode command.

Table 6-10. Disable Hold Mode Sequence

Direction of Transfer	Command	Description
Host→U511	HD0	Disable Hold Mode code
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)

Example: HD0 <EOS character>

The communication sequence for the Trigger command is shown in Table 6-11. The "TR" command is used to control the start of commands and programs for the following conditions:

1. Execute a command string issued with the "I" command when in hold mode.
2. Start execution of a program loaded in AUTO mode (AR) when in hold mode.
3. Single step a program loaded in the BLOCK mode (BR).
4. Repeat the last Immediate command sent to the controller.

Table 6-11. Trigger Command Sequence

Direction of Transfer	Command	Description
Host→U511	TR	Trigger command code
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)

Example: TR <EOS character>

The DET or "TR" command can be used in GPIB mode.

Example:

HD1<EOS>
IXF1000D1000<EOS>
TR<EOS>

6.4.6. PE: Print Error Message String

This command returns the last error message in the system. Table 6-12 shows the communication sequence for the Print Error Message command. These error messages occur:

1. When a syntax error occurs with an immediate command or program.
2. When a runtime error, such as an axis limit, occurs while executing a program.

The error message is cleared when a successful command is sent. The U511 will return a space followed by <EOS> (i.e., " <EOS>").

Example: "Error: Axis in limit"

Table 6-12. Print Error Message Sequence

Direction of Transfer	Command	Description
Host→U511	PE	Print Error Message command
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)
U511→Host	Error message string	Error message character string
U511→Host	EOS character	End of string character (LF)

Example: PE <EOS character>

6.4.7. I: Execute Immediate Command

The "I" command executes valid U511 program commands. Any program command can be sent in the form "Icmdstring." A syntax error or execution error will be indicated by bit #2 of the status byte. A service request will be sent if enabled. The "PE" command can be given to retrieve an error message. Bit #5 of the status byte indicates that the command is executing. When the command is finished, a service request will be sent if enabled.

If the U511 is in HOLD mode, execution is delayed until the Trigger command is sent.

Example:

IEN X Y

IHO X Y

IG1 X10 Y10

IABORT

IFAULTACK

Etc.

Table 6-13 shows the communication sequence for the Execute Immediate command.

Table 6-13. Immediate Command Sequence

Direction of Transfer	Command	Description
Host→U511	I	I command character
Host→U511	Immediate command	Immediate command string
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06) and command will begin. If hold mode is enabled then trigger will be needed
U511→Host Note: SRQ will only be sent if SRQ mode is active	SRQ character See SRQ section	Service request character (%) at completion of command if service request mode is active Perform service request procedure

Example: IX100. <EOS character>

6.4.8. FMn: Format of Returned Data

This command specifies the format of returned data where n = :

0 = decimal ASCII format:

> The UNIDEX 511 prints data as a decimal number followed by the <EOS> character. Data should be converted to binary format by the C conversion function "atol()" or equivalent.

1 = hex ASCII format:

> Leading zeros will be appended to the string displayed in hexadecimal format. This mode is useful for debugging.

2 = binary format:

> Binary output data is always a fixed number of bytes. There is no EOS character in RS-232 mode. In GPIB mode, the EOI signal is used to end the transmission.

The least significant byte (LSB) is always sent first in binary mode. The PS and PX commands return 4 bytes in binary mode. The Q command returns one byte.

Binary mode overrides the ASCII modes.

Example: Status word 0x01234567 printed in:

HEXASCII:	"01234567"<EOS>
DECIMAL:	"19088743"<EOS>
BINARY:	67 45 23 01

Table 6-14 shows the communication sequence for the Format of Returned Data command.

Table 6-14. Format of Return Data Command Sequence

Direction of Transfer	Command	Description
Host→U511	FM	Format command
Host→U511	Format code	Format code character (0, 1, or 2)
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)

Example: FM0 <EOS character>

> See the "RR," "WR," and "FM" commands for more information.

6.4.9. PXn, PYn, PZn, PUn: Axis Positions

These commands return axis positions of the specified axis. All positions are scaled to user units. The "n" is the position type. If "n" is omitted, U511 will feedback case 8, the encoder position. Refer to Table 6-15. Table 6-16 shows the communication sequence for the print axis position command.

Table 6-15. Values of "n" and Feedback Type for the Axis Positions Commands

n	Feedback Type
0	Relative command position
4	Absolute command position
8	Encoder position
12	Servo command position

Table 6-16. Print Axis Position Sequence

Direction of Transfer	Command	Description
Host→U511	P	Print command character
Host→U511	Axis code	Axis character (X, Y, Z, or U)
Host→U511	Feedback code	Feedback code character (0, 4, 8, or 12)
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)
U511→Host	Position string	Position character string
U511→Host	EOS character	End of string character (LF)

Example: PX8 <EOS character>

In binary mode, this command will return 4 bytes LSB (first)...MSB.

6.4.10. Q: Serial Pol command

This is the Serial Pol status byte initiated by a "Q" command in RS-232 mode or a Serial Pol GPIB function. UNIDEX 511 is requesting service if bit number 6 is set. Reading the Serial Pol byte clears this bit. Bit assignments are as shown in Table 6-17.

Table 6-17. Status Byte Bit Assignments

Bit	Function
bit 0:	1 = communications port error: break, frame, parity, or overrun error This bit indicates that a communications error has occurred and the communications port is unreliable at the selected baud rate. Try decreasing the baud rate. A shielded cable should always be used. Cleared after read.
bit 1:	1 = program is currently running
bit 2:	1 = program execution error / Immediate command error (I...). Set when: 1. program runtime error 2. Immediate command syntax error (I...) This bit is cleared when a new program is loaded or a new Immediate (I...) command is sent to the controller. Use the "PE" command to get an ASCII error message.
bit 3:	1 = illegal remote command An illegal remote command was sent to the U511 or a syntax error occurred with that command. The Serial Pol command (Q) in RS-232 mode or the Serial Pol function in GPIB mode clears this bit. Use the "PE" command to get an ASCII error message.
bit 4:	1 = axis fault An axis fault occurred (i.e., position error, RMS current error, limit, etc.). This bit is cleared by the Fault Acknowledge command (IFA). Use the "PE" command to get an ASCII error message.
bit 5:	1 = command is executing
bit 6:	1 = service request pending
bit 7:	1 = any error

Table 6-18 shows the communication sequence for the Serial Pol command.

Table 6-18. Serial Pol Sequence

Direction of Transfer	Command	Description
Host→U511	Q	Serial Pol command
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)
U511→Host	Serial Pol status	Serial Pol status string
U511→Host	EOS character	End of string character (LF)

Example: Q <EOS character>

In binary mode, this command will return 1 byte.

6.4.11. PSn: Print Status

The PSn command returns a 32 bit number. The "n" is the status word requested. The value and corresponding status of "n" is shown in Table 6-19.

Table 6-19. Values of "n" and Corresponding Status for the PSn Command

n	Status
0	16 IN/8 OUT inputs
1	Axis 1 status
2	Axis 2 status
3	Axis 3 status
4	Axis 4 status
5	Axis enable / in position / comm / queue not empty / halted
6	Current MFO
7	Joystick status
8	Current board number
9	Commands in queue for plane 1
10	Commands in queue for plane 2
11	Commands in queue for plane 3
12	Commands in queue for plane 4

Returned values for this function follow.

n = 0	returns 16 input line condition
n = 1-4	returns fault/trap/limit information for axes 1-4, respectively, (with the following bit assignments):

bit 0	1 = position error, 0 = no fault
bit 1	1 = RMS current error, 0 = no fault
bit 2	1 = integral error, 0 = no fault
bit 3	1 = hardware limit +, 0 = no fault
bit 4	1 = hardware limit -, 0 = no fault
bit 5	1 = software limit +, 0 = no fault
bit 6	1 = software limit -, 0 = no fault
bit 7	1 = driver fault, 0 = no fault
bit 8	1 = feedback device error, 0 = no fault
bits 9-11	*unused*
bit 12	1 = feedrate > max setting error, 0 = no fault
bit 13	1 = velocity error, 0 = no fault
bit 14	1 = emergency stop, 0 = no fault
bits 15-30	*unused*

n = 5	returns axis active/in position/plane information (with the following bit assignments):

bit 0	1 = axis 1 enabled, 0 = disabled
bit 1	1 = axis 2 enabled, 0 = disabled
bit 2	1 = axis 3 enabled, 0 = disabled
bit 3	1 = axis 4 enabled, 0 = disabled
bit 4	1 = axis 1 not in position, 0 = in position
bit 5	1 = axis 2 not in position, 0 = in position
bit 6	1 = axis 3 not in position, 0 = in position
bit 7	1 = axis 4 not in position, 0 = in position
bit 8	1 = plane 1 comm. busy, 0 = comm. OK
bit 9	1 = plane 2 comm. busy, 0 = comm. OK
bit 10	1 = plane 3 comm. busy, 0 = comm. OK
bit 11	1 = plane 4 comm. busy, 0 = comm. OK
bit 12	1 = queue 1 buffer is not empty, 0 = empty *
bit 13	1 = queue 2 buffer is not empty, 0 = empty *
bit 14	1 = queue 3 buffer is not empty, 0 = empty *
bit 15	1 = queue 4 buffer is not empty, 0 = empty *
bit 16	1 = plane 1 halted, 0 = plane 1 "running"
bit 17	1 = plane 2 halted, 0 = plane 2 "running"
bit 18	1 = plane 3 halted, 0 = plane 3 "running"
bit 19	1 = plane 4 halted, 0 = plane 4 "running"
bit 20	*unused*
bit 21	1 = feedhold active
bit 22	1 = DSP interrupt generated
bit 23	1 = command in DSP buffer

* - An empty queue means that there are no unprocessed commands. If a plane's queue buffer is marked "not empty," it is processing commands.

n = 6 returns the current manual feedrate override % (MFO)

n = 7 returns the joystick status (with the following bit assignments):

bit 0-1	00 = high velocity mode
	01 = low velocity mode
	1x = absolute positioning mode
bit 2-3	00 = plane 1 active
	01 = plane 2 active
	1x = block delete active (digitizing mode)
bit 4	1 = joystick interlock open (error)
	0 = joystick interlock closed (normal)
bit 5-7	000 = no current horizontal axis defined
	001 = axis 1 active
	010 = axis 2 active
	011 = axis 3 active
	100 = axis 4 active
bit 8-10	current vertical axis (0-4)
	000 = no current vertical axis defined
	001 = axis 1 is the active vertical axis
	010 = axis 2 is the active vertical axis
	011 = axis 3 is the active vertical axis
	100 = axis 4 is the active vertical axis
bit 11	1 = received joystick cancel command
bit 12-13	unused
bit 14	0 = joystick is deactivated
	1 = joystick is now active

n = 8 returns the currently active board number (1-6)

n = 9-12 returns the number of actions remaining in queue for planes 1-4. This data is meaningless when used with the PLC or QUEUE commands.

Table 6-20 shows the communication sequence for the print status command.

Table 6-20. Print Status Sequence

Direction of Transfer	Command	Description
Host→U511	PS	Print Status command
Host→U511	Word code	Status word code (0-12)
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)
U511→Host	Status string	Status word character string
U511→Host	EOS character	End of string character (LF)

Example: PS0 <EOS character>

6.4.12. RRn/WRn,val: Read / Write Register

UNIDEX 511 registers contain remote configuration and status information. Each register is a 32 bit number, which can be read using the RR command, and written to using the WR command. Table 6-21 shows the communication sequence for the Read Register command. The communication sequence for the Write Register command is shown in Table 6-22.

The value to be written to the register (val) is an ASCII string in either decimal or hexadecimal format. The "n" is the register to write to. Only register 0 is defined for use; others are reserved for future use.

R**EGISTER 0:** *Communications Status.* The "Default configuration" parameter under the setup screens for COM1, COM2, and GPIB, set the default value for this register (See parameter numbers 616, 625, and 630). The bit definitions for register 0 are shown in Table 6-23.

Table 6-21. Read Register Sequence

Direction of Transfer	Command	Description
Host→U511	RR	Read Register command
Host→U511	Register n	Register n to be read
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)
U511→Host	Register value	Register value string
U511→Host	EOS character	End of string character (LF)

Example: RR0 <EOS character>

Table 6-22. Write Register Sequence

Direction of Transfer	Command	Description
Host→U511	WR	Write Register command
Host→U511	Register n	Register n to be read
Host→U511	,	Separate register n from value
Host→U511	Register value	Value to be loaded into register
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)

Example: WR0,0 <EOS character>

Table 6-23. Bit Definitions for Register 0

Bit	Meaning	Hex Value
0:	In command HOLD mode	0x001
1:	In SRQ mode	0x002
2:	Binary status mode	0x004
3:	Add block numbers when printing program	0x008
4:	Status in HEX-ASCII mode (if not binary)	0x010
5:	Send SRQ on powerup	0x020
6:	Remote mode automatically enabled on power up	0x040
7:	Send CR+LF as EOS	0x080
8:	COM port never used for remote (will ignore "##" sequence)	0x100
9:	DO NOT send command ACK/NAK handshake character	0x200
10-31:	Reserved	

In binary mode, the RR commands returns 4 bytes, LSB first.

6.4.13. Parameter Editing

WPn,val: Set Parameter "n" as "val"

RPn: Return Parameter "n"

SP: Saves Parameter Data to Disk

The WP command changes parameter "n" to a specified value (val). The first time this command is given, the parameter file is opened and read to memory from the flash disk. This memory copy is edited using the RP and WP commands. Parameter values range from 0 to 699 (see Parameters chapter). Table 6-24 shows the communication sequence for the write parameter command.

Table 6-24. Write Parameter Sequence

Direction of Transfer	Command	Description
Host→U511	WP	Write Parameter command
Host→U511	Parameter n	Parameter n to be read
Host→U511	,	Separate parameter n from value
Host→U511	Parameter value	Value to be loaded into parameter
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)

Example: WP0,0 <EOS character>

The RP command returns the ASCII value of the parameter specified. Table 6-25 shows the communication sequence for the Read Parameter command.

Table 6-25. Read Parameter Sequence

Direction of Transfer	Command	Description
Host→U511	RP	Read Parameter command
Host→U511	Parameter n	Parameter n to be read
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)
U511→Host	Parameter value	Parameter value string
U511→Host	EOS character	End of string character (LF)

Example: RP0 <EOS character>

The SP command saves the file back to the flash disk. The save process can take several seconds. During this time, serial communications are blocked. It is recommended that service request mode be enabled and used with this command to detect the completion of this action. The UNIDEX 511 will send a service request when finished. Table 6-26 shows the communications sequence for the Save Parameters command.

Table 6-26. Save Parameters Sequence

Direction of Transfer	Command	Description
Host→U511	SP	Save Parameter command
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)
U511→Host Note: SRQ will only be sent if SRQ mode is active	SRQ character See SRQ section	Service request character (%) at completion of save if service request mode is active. Perform service request procedure

Example: SP <EOS character>

6.4.14. RE: Hardware Reset

The U511 does a hardware reset when the RE command is issued. This is the same as cycling the power or pressing the reset button. Table 6-27 shows the communications sequence for the Hardware Reset command.

Table 6-27. Hardware Reset Sequence

Direction of Transfer	Command	Description
Host→U511	RE	Hardware Reset command
Host→U511	EOS character	End of string character (LF)

Example: RE <EOS character>

6.4.15. File Transfers

ULfilename: Upload File

This command sends a file from the host PC to the U511. The sequence of events in this process is described below and also in Table 6-28.

1. Host sends Upload File command and file name (followed by <EOS>) to U511. The "filename" is the file to transfer.
2. U511 responds with one character. If ready to accept data, the U511 will send the ACK character. If there is a problem, U511 will send the NAK character and file transfer will be aborted. The ACK and NAK characters are programmable. See Parameters chapter.
3. Host sends number of bytes to upload to the U511. This is an ASCII string terminated by <EOS>.
4. The U511 responds with one character. If ready to accept data, the U511 will send the ACK character. If there is a problem, U511 will send the NAK character and file transfer will be aborted. The U511 will return an ASCII formatted ACK or NAK character if running from the GPIB interface. The ACK and NAK characters are programmable. See Parameters chapter.

This step may take several seconds because the U511 is preparing to write to flash memory.

5. Host sends file data to U511.
6. U511 will return an ASCII string with the 16 bit checksum.

   The checksum is calculated by accumulating each byte of the file data to a 16 bit signed integer (short data type). UNIDEX 511 will return either a checksum of 0 or 1 if a file write error has occurred.

It may take several seconds for the U511 to write to flash memory before it responds with the checksum.

A summary of the sequence of commands for uploading a file is shown in Table 6-28.

Table 6-28. Upload File Sequence

Direction of Transfer	Command	Description
Host→U511	UL	Upload File command
Host→U511	File name	Name of file to send
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)
Host→U511	Number of bytes	Number of bytes in file
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)
Host→U511	File string	File character string
U511→Host	Checksum	Checksum value
U511→Host	EOS character	End of string character (LF)

Example: ULTEST1.PRG <EOS character>

DLfilename: Download File

This command sends a file from the U511 to the host PC. The sequence of events in this process is described below.

1. Host sends Download File command and file name (followed by <EOS>) to U511. The "filename" is the file to transfer.
2. The U511 will then send the ACK character to acknowledge a valid file name. A NAK character will be sent by the U511 to notify the host that the file transfer can not take place.
3. The U511 responds with the number of bytes that it is going to transmit. This is an ASCII string terminated by the EOS character.
4. The host should then send the ACK character when it is ready to accept data. If the host does not want to download this data, it should send the NAK character. If the file does not exist, the U511 will return a file size of "0" bytes. The host should send a NAK to abort transmission. The ACK/NAK characters are formatted as ASCII characters if the GPIB interface is used.

The ACK and NAK characters are programmable. See Chapter 4:Parameters.

5. The U511 will transmit the file data to the host.

6. U511 will transmit the checksum as an ASCII string terminated by the EOS character. The checksum is calculated by accumulating each byte of the file data to a 16 bit signed integer (short data type).

A summary of the sequence of commands for downloading a file is shown in Table 6-29.

Table 6-29. Sequence of Commands when Downloading Files

Direction of Transfer	Command	Description
Host→U511	DL	Download File command
Host→U511	File name	Name of file to send
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)
U511→Host	Number of bytes	Number of bytes in file
U511→Host	EOS character	End of string character (LF)
Host→U511	ACK/NAK character	Acknowledge character (0x06)
U511→Host	File string	File character string
U511→Host	Checksum	Checksum value
U511→Host	EOS character	End of string character (LF)

Example: DLTEST1.PRG <EOS character>

6.4.16. PD: Print Directory

This command prints a list of all files currently on the U511's flash disk. Table 6-30 shows the communication sequence for the print directory command.

Table 6-30. Print Directory Sequence

Direction of Transfer	Command	Description
Host→U511	PD	Print Directory command
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)
U511→Host	Directory string	Directory character string
U511→Host	EOS character	End of string character (LF)

Example: PD <EOS character>

6.4.17. PPfile: Print Program "File" to Port

This command returns an ASCII output of the specified file. The file name is output first. Line numbers are also added at the beginning of each line. This command is useful when using a terminal emulator, to check a file's content. The U511 utility program uses the "DL" and "UL" commands. Table 6-31 shows the communication sequence for the Print Program "File" command.

Table 6-31. Print Program "File" Sequence

Direction of Transfer	Command	Description
Host→U511	PP	Print Program command
Host→U511	File name	Name of file to print
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)
U511→Host	File string	File character string
U511→Host	EOS character	End of string character (LF)

Example: PPTEST1.PRG <EOS character>

6.4.18. RVn: Read Variable

This command returns the value of variable "n" in ACSII format. Table 6-32 shows the communication sequence for the read variable command.

Table 6-32. Read Variable Sequence

Direction of Transfer	Command	Description
Host→U511	RV	Read Variable command
Host→U511	Variable n	Variable n to be read (ASCII)
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)
U511→Host	Variable value	Variable value string (ASCII)
U511→Host	EOS character	End of string character (LF)

Example: RV0 <EOS character>

6.4.19. DFfilename: Delete File

This command deletes a file from the U511's memory. The file name can be any valid U511 nomenclature. Table 6-33 shows the communications sequence for the Delete File command.

Table 6-33. Delete File Sequence

Direction of Transfer	Command	Description
Host→U511	DL	Delete File command
Host→U511	File name	Name of file to delete
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)

Example: DFtest1.prg <EOS character>

6.4.20. HE [cmd]: Help Menu

The HE command returns all of the U511 commands or the syntax of the specified command. The brackets signify that the command name is optional. If a command is typed in, its syntax is returned. If the command is left off, a list of all of the commands is returned. The sequence of communications for the HE command is shown in Table 6-34.

Table 6-34. Help Menu Command Sequence

Direction of Transfer	Command	Description
Host→U511	HE	Help Menu command
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)

Example: HE<EOS character>; HE LI<EOS character>

6.4.21. GV: Software Version

The GV remote command returns the current software version as an ASCII string. This is the same version number that is displayed on the U511's Startup screen. The version consists of a major version and a minor version separated by a decimal point. The sequence of communications for the GV command is shown in Table 6-35.

Table 6-35. Software Version Command Sequence

Direction of Transfer	Command	Description
Host→U511	GV	Software Version command
Host→U511	EOS character	End of string character (LF)
U511→Host	ACK/NAK character	Acknowledge character (0x06)

Example: GV<EOS character>; U511 returns 5.00<EOS character>

6.5. UNIDEX 511 Remote Timing

The oscilloscope output plot shown in Figure 6-1, shows the timing of the U511 for a GPIB command. The command, "PX8<CR><LF>," was sent to read the real-time position of the X-axis encoder. The top waveform is the interrupt on the U511 generated by the GPIB chip. The second waveform is the ATN (attention) signal. The third waveform is the NRFD (not ready for data) signal.

Four interrupts are visible on the first wave form. The first interrupt occurs 200 µs after the command is sent and tells the U511 to be a listener. The second interrupt, occurring 1.5 ms after the command is sent, is the PX command being received. The third interrupt occurs at 2.8 ms. This interrupt is the Read command. The final interrupt, occurring around 4 ms, is when the position data is returned by the U511.

The cycle time for this sequence averages around 3.5 ms and ranges between 2.8 and 4.5 ms. This cycle time is when the U511 is displaying the Startup screen. Different screens, depending on the updates required, will slow the transfer cycle. For example, if the U511 is displaying a Diagnostics screen, the cycle time increases to an average of 6.5 ms.

The host PC for this test was a 486 running at 66 MHz using a National Instruments AT-GPIB board in an ISA slot.

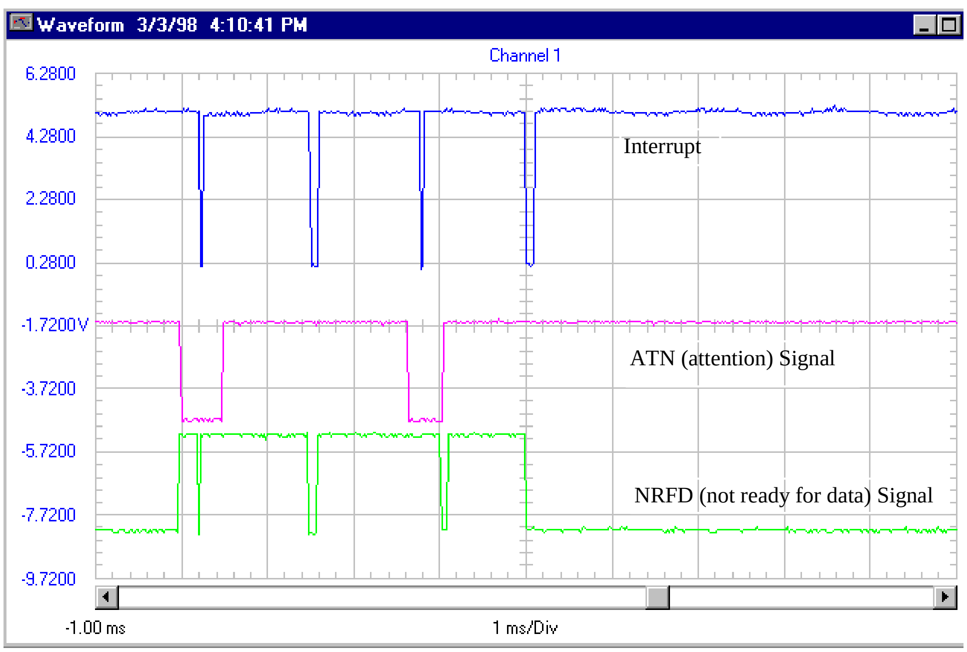


Figure 6-1. Plot Showing Signals Generated by a GPIB Command

The same sequence of commands was also run on the U511 using the RS-232 interface at 9600 baud. The "PX8" command was sent and the resulting position was read back serially. This sequence took 13.0 ms to complete, the delay between receiving the command and outputting the position data was 0.75 ms. This sequence at 57,600 baud required an average of 2.0 ms to complete. Figure 6-2 shows the receive and transmit lines during the transfer at 9600 baud. The top waveform is the receive line.

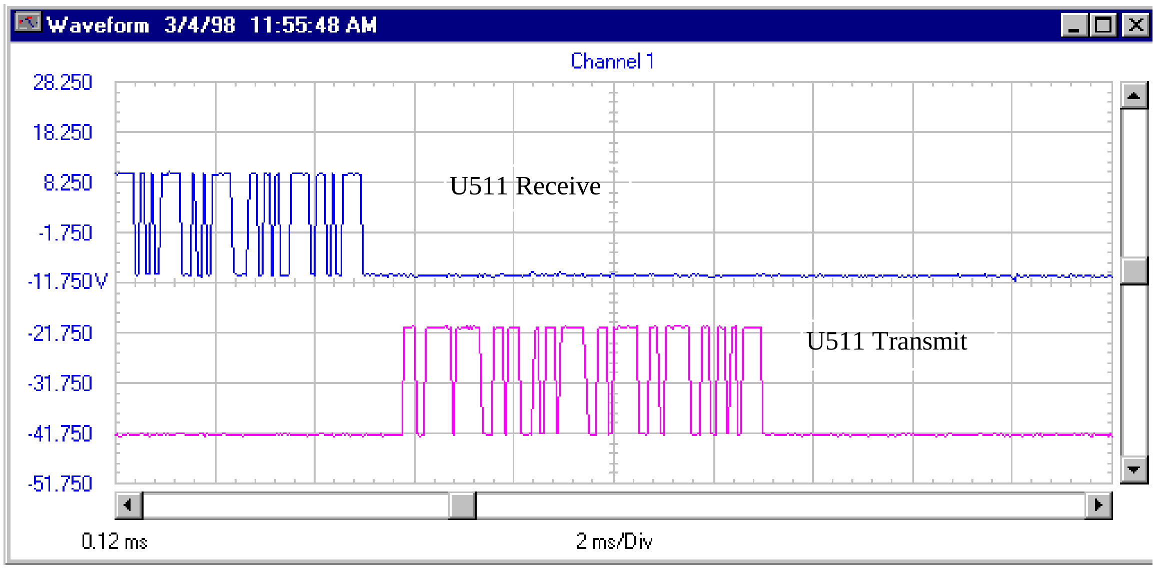


Figure 6-2. Receive and Transmit Lines During Transfer at 9600 Baud

6.6. C Program Example

The following example was written in C language and demonstrates the command sequence for an Immediate command. This program will send a character string to the U511 and read back the ACK character. If the ACK character is wrong, or a character is not received within the time out period, a status error code will be set. In order to simplify and minimize the length of this example, only portions relating directly to the U511 operation will be shown.

Immediate Command C Program Example

/* Following routine performs an Immediate Command operation. */

/* Routine calls the U511_sendcmd(command pointer) function. */

```
{
        int cmd_stat;                              /* error status variable/

        char  *char_buf = "IX1000.";               /* I cmd. string */
        cmd_stat = U511_sendcmd(char_buf);  /* send Immediate cmd string*/

        if(cmd_stat == 0)                          /* Check for no error */
           {
               printf(" Command transmitted and ACK character received. \n");
           }

        if(cmd_stat == 1)                          /* Check for not ACK char. */
            {
              printf(" Received Code other than ACK character . \n");
            }

        if(cmd_stat == 2)                          /* Check for time out error */
             {
               printf(" ACK character Time out error. \n");
             }

        printf(" Press any key to continue");
          chrb = getch();                        /* Wait for key */
}
```

```
/* Function to send command string     U511_sendcmd(command pointer)  */
/*  This routine will send a command string to the U511 and check        */
/*  for an acknowledge ACK character. Function will return status value       */

U511_sendcmd(cmdptr)

char *cmdptr;

  {
    int  j;                                   /* Misc. use variable */
    int stat = 0;                             /* Status Code, initialized */
   char inchr;                                /* Read Charcter */

   for(j=0; cmdptr[j] != 0; j++)              /* check for end of cmd string */
      {
          com_write(comdptr[j]);              /* Send character to U511 */
       }
```

```
    com_write(0x0A);            /* Send EOS char. to U511 */

    stat = 0;                   /* Clear status code ( no error) */
    wait_DATA(.2);              /* Wait for ACK or .2 sec Time Out */
    if( com_ready() )           /* Check for serial port character */
      {
        inchr = com_read();     /* Read character */
        if(inchr != 6)          /* check for ACK character */
          {
            stat = 1;           /* Not ACK char., set status code */
          }
      }
    else                        /* No character */
      {
        stat = 3;               /* Time out error, set status code */
      }

    return(stat);               /* return status value */
  }
```

NOTE: The following functions (contained in this program) are not standard C functions.

com_write();	This function outputs a character to the serial port.
wait_DATA();	This function is a wait loop that is set in seconds and is terminated if the serial port receives a character. This function is used to prevent program lockups through time outs.
com_ready();	This function is checks if a character has been received by the serial port. If a character is present, the function will return a true condition. This function is also used in the "wait_DATA();" function to check for a received character.
com_read();	This function will read and return one character from the serial port.

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CHAPTER 7: WINDOWS INTERFACE AND UTILITIES

In This Section:

7.1. Introduction

The Windows™-compatible interface software was created for Windows NT 4.0 and Windows 95. To install the software, insert disk 1 of the installation and run "setup.exe." During installation, the operator can select either U511 standard software or U11 emulation software. If the user is using the UNIDEX 511 controller to replace a UNIDEX 11 controller, select U11 emulation. Otherwise, for normal operation select U511 standard software.

Four different utilities are installed. These include:

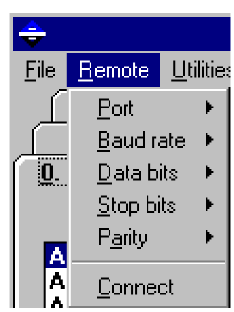
- a parameter editor
- an axis scope window
- a diagnostics program
- a file transfer utility

A UNIDEX 511 folder is created in the Program folder of the Start menu. This folder contains icons for each of the four utility packages. To start a utility, left-click on the corresponding icon.

Each of these programs will communicate to the UNIDEX 511 using an RS-232 connection. The RS-232 cable should be a one-to-one cable connecting a serial port of the PC to one of the COM ports on the U511. A standard RS-232 cable should be supplied with the system. Only one of the utility programs can be running at a time.

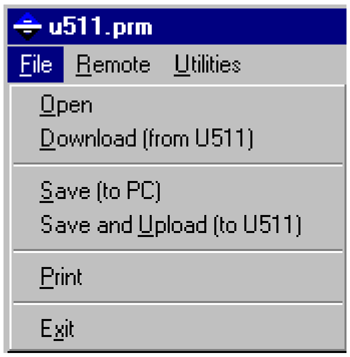
7.2. COM Port Settings: Common to all Software Utilities

Each utility has a "Remote" menu selection. The options below this selection set up the communication parameters: port number, baud rate, data bits, stop bits, and parity. The port number is the COM port of the PC communicating to the U511. The baud rate, data bits, stop bits, and parity must be set the same for both the utility software running on the PC and for the U511. Pressing the Setup (F2) key on the front panel of the U511 changes the U511 COM port parameters. The COM port settings for the U511 are on Pages 2 and 3 of the Setup screen. The default settings on the U511 and the Windows software are 9600 baud, 8 data bits, 1 stop bit, and no parity. The "Connect" menu option is used to establish connection to the U511 if any of the settings are changed or if the COM port was closed for any reason.



7.3. UNIDEX 511 Parameter Editor

On startup of the Parameter Editor, the U511 will send the current parameter file to the Edit Parameter screen. The parameters are organized in the same manner as the parameters displayed by the U511 when entering the Setup menu from the U511 front panel. Each tab on the software corresponds to a page on the U511 software. Refer to Figure 7-1. A description of each parameter is listed in Chapter 4: Parameters. To change a value of a parameter, select the parameter on the tab, then change the value in the text box and hit ENTER.



To save the changes after all changes have been made, select "Save and Upload (to U511)" from the File menu option. This selection will bring up a file dialog box. Type or select the file name the parameters will be saved as. Note that the parameter file currently being used by the U511 is listed on Tab 0: System Config. If renaming the file on the U511, make sure that parameter 603 ("Parameter file") is set to this new parameter file name. To make the parameter changes take effect, cycle the power or press the RESET button on the front panel of the U511. To save a backup file of the parameters, select "Save (to PC)" and enter a name for the parameter file.

The other menu items under File are "Open" and "Download (from U511)." Open is used to open a parameter file that exists on the PC. The Download selection opens and sends a parameter file that exists on the U511.

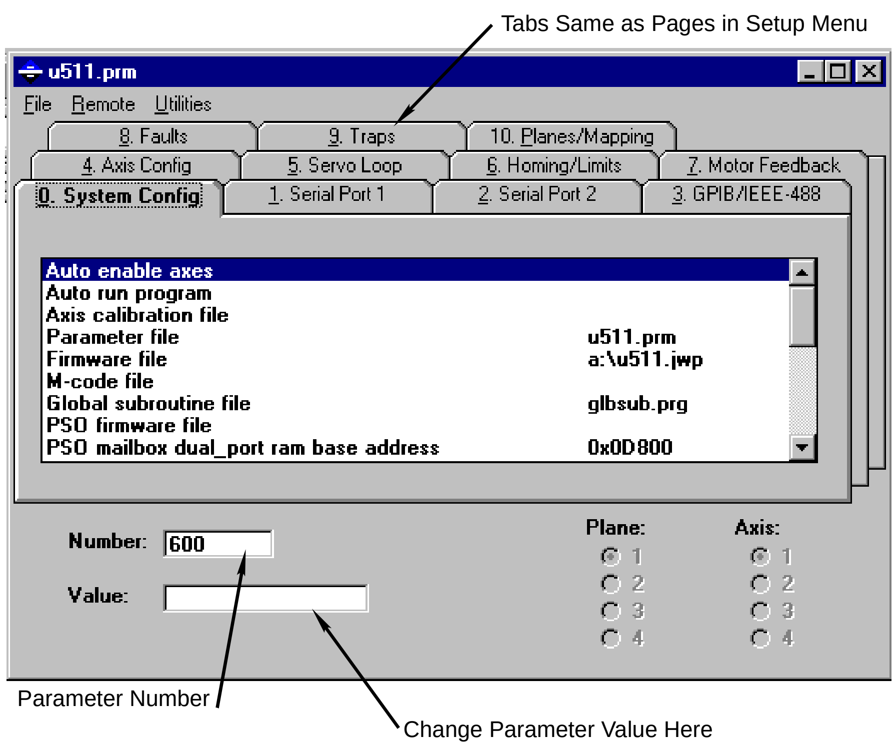


Figure 7-1. The Edit Parameter Screen

The Utilities submenu of the Parameter Editor contains options to transfer parameter values between axes and/or planes. The Utilities submenu of the Parameter Editor is illustrated in Figure 7-2.

Figure 7-2. The Cascaded Transfer Menu

The "Transfer Parameters Between... ➢" menu provides two types of transfer options: transfer between axes and transfer between planes. The cascaded Transfer Parameters Between... ➢ option submenu is displayed in Figure 7-2.

When the "Axes" option is selected, an axis transfer popup window is displayed (see Figure 7-3). This window allows the operator to specify source and target axes for selected parameter values. The "Transfer from:" radio buttons select the desired source axis (1-4). Only one of these radio buttons may be selected at a time. The "Transfer to:" check boxes specify the destination of the axis parameter values. Multiple axes may be selected in the "Transfer to:" check boxes if desired. The operator can choose to transfer all or a subset of axis parameters. This is accomplished through the "Parameters to Transfer:" check boxes (refer to Figure 7-3). When a check box is selected, the associated parameters are transferred.

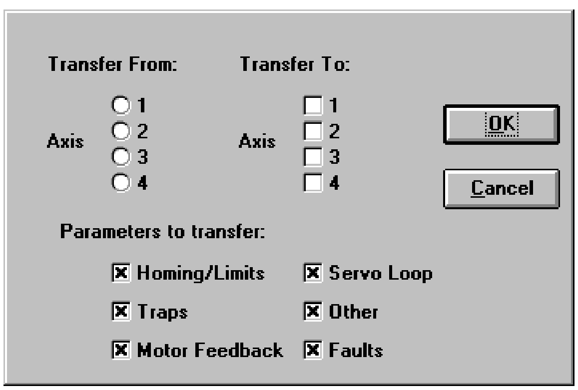


Figure 7-3. Transfer Parameter Values Between Axes Popup

Clicking on the OK button performs the transfer of axis parameter values as defined by the transfer settings. The transfer popup is closed after the selected transfer is completed. The CANCEL button can be used to close the transfer popup without performing any transfer functions.

Parameter values can also be transferred between planes. When the "Planes" option is selected, a plane transfer popup window is displayed (refer to Figure 7-4). This window allows the operator to specify source and target planes for selected parameter values.

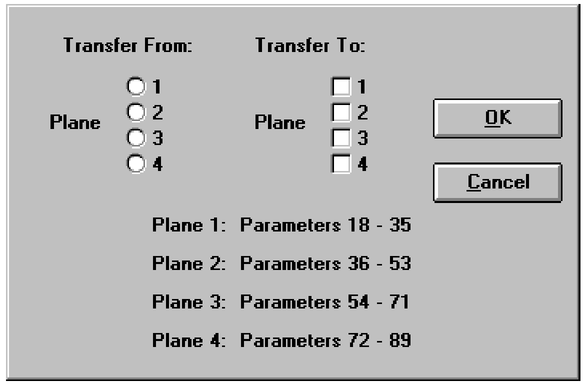


Figure 7-4. Transfer Parameter Values Between Planes Popup

7.3.1. Edit Parameters: The Number, Value, and Axis Fields

The "Number:," "Value:," "Select Axis:," and "Select Plane:" fields of the Edit Parameters screen are used to locate parameter names (based on parameter numbers), select axes and planes, and view or change parameter values. The Number: field displays the number of the parameter that is currently highlighted in the parameter tab. When a new parameter is selected from a parameter tab, its parameter number is displayed in this field. This field can also be used to display the parameter name when only a parameter number is known. This is accomplished by typing the parameter number in the Number: field and pressing ENTER. If a valid parameter number is entered, the associated tab will become the focus, and the corresponding parameter name will be highlighted.

The Value: field contains the value of the selected parameter. To change the value of a selected parameter, type in the desired value and press ENTER. The default value of the parameter can be produced by entering "d" in value field box and hitting ENTER. The Select Axis and Plane radio buttons are used to specify the desired axis and plane to be viewed or edited.

7.4. UNIDEX 511 Axis Scope Utility

The Axis Scope window is a data display and axis tuning feature. The window contains a menu bar with loop tuning and display options. Information about the Axis Scope window and servo loop tuning is discussed in the Chapter 8: Tuning Servo Loops.

7.5. UNIDEX 511 Diagnostics Screen

The Diagnostics screen displays a dynamic window of software and hardware status fields for each of the four axes (X, Y, Z, and U). The Diagnostics window displays axis positions, analog-to-digital (A/D) input values, manual feed override, hardware/software faults, limits, traps, etc. The Diagnostics window is illustrated in Figure 7-5.

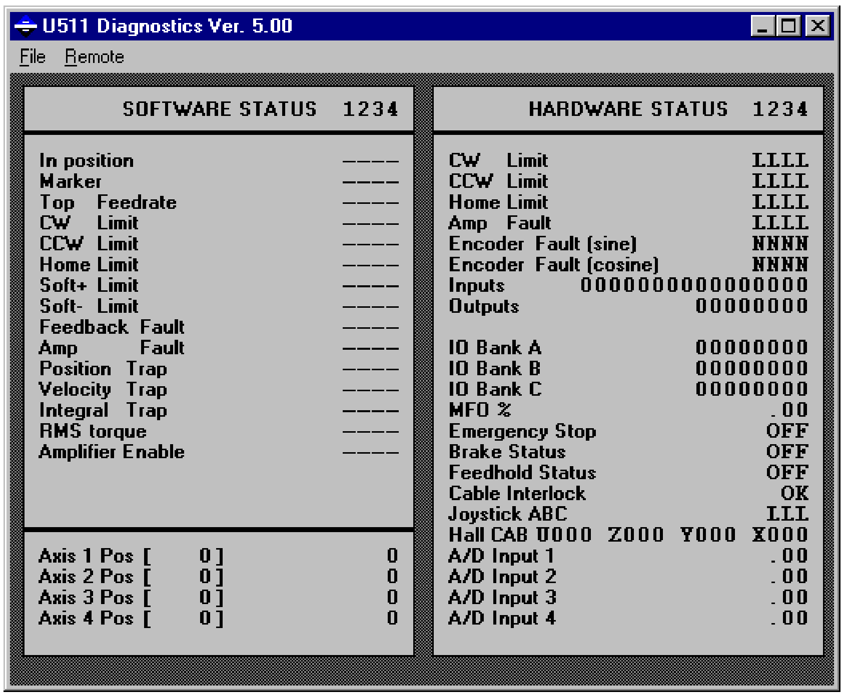


Figure 7-5. The Diagnostics Window

Other than the Remote item, which has already been discussed, the Diagnostics window has a menu bar that contains a single menu - the File menu. The File menu contains the Exit option that is used to close the Diagnostics window. Hitting ENTER also closes the Diagnostics window.

The Software Status portion of the Diagnostics screen contains 15 sets of status flags for each of the four axes. Normal conditions are displayed as a dash (-), and fault/trap/limit conditions are displayed as an asterisk (*). Each set of status flags contains four individual indicators, each corresponding to an axis from left to right (for example, **In position** - * - - indicates that axes 1, 3, and 4 have not reached their respective commanded positions and axis 2 has reached its commanded position.)

The axis position portion of the Diagnostics screen contains the current positions (in machine steps) for each axis. This display will contain the corrections made by axis calibration, orthogonality correction, and backlash compensation. The corresponding value of the encoder counter or resolver-to-digital converter is shown in square brackets to the left.

The Hardware status portion of the Diagnostics screen displays the status of hardware related attributes such as the current CW and CCW limit status for each axis (L=low limit, H=high limit), the encoder fault status (Y=yes, N=no) for SIN and COS signals for each of the four encoders, input status, output status, etc. The hardware status portion also contains analog-to-digital input values for inputs 1-4.

The components of the Diagnostics screen are described in Table 7-1, Table 7-2, and Table 7-3.

Table 7-1. Software Status Diagnostics

Field	Description
In position	Indicates whether or not the axis has reached its commanded position (* = in position)
Marker	Indicates when the encoder marker has been found (* = found)
Top Feedrate	Indicates if the current feedrate exceeds the "Top feedrate" parameter, x17 (* = feedrate exceeded x17)
CW Limit	Indicates if the CW hardware travel limit has been exceeded (* = CW limit switch was made and axis is enabled)
CCW Limit	Indicates if the CCW hardware travel limit has been exceeded (* = CCW limit switch was made and axis is enabled)
Home Limit	Indicates if the Home limit switch has been made (* = limit)
Soft CW Limit	Indicates if the software "CW software limit" (x23) has been exceeded (* = x23 has been exceeded)
Soft CCW Limit	Indicates if the software "CCW software limit" (x22) has been exceeded (* = x22 has been exceeded)
Feedback Trap	Indicates that the feedback signal from the feedback device has been lost (* = signal has been lost)
Amplifier Trap	Indicates that the amplifier is in a fault condition (* = amplifier in fault)
Position Trap	Indicates that the position error exceeds the maximum allowable position error (* = current position is > value in x19)

Table 7-1. Software Status Diagnostics (continued)

Field	Description
Velocity Trap	Indicates that the velocity error exceeds the maximum allowable velocity error (* = current velocity is > value in x18)
Integral Trap	Indicates that the integral error exceeds the maximum allowable integral error (* = current integral error > value in x20)
RMS Torque	Current Trap. Indicates that the present output current exceeds the current defined by parameter x48 ("RMS current trap").
Amplifier Enable	Indicates the current status of the axis (* = axis is enabled, - = axis is disabled)

Table 7-2. Axis Position Diagnostics

Field	Description
Axis 1 Pos	Current position of axis 1 in machine steps
Axis 2 Pos	Current position of axis 2 in machine steps
Axis 3 Pos	Current position of axis 3 in machine steps
Axis 4 Pos	Current position of axis 4 in machine steps

The axis position fields contain an additional value that is enclosed in brackets. This value is a hexadecimal number that shows the absolute position of the feedback device. In the case of encoders, the number displayed in brackets is not very useful and should be ignored. However, for resolvers, this number represents the absolute position of the resolver from the R/D hardware. The absolute position can range from 0x00 to 0xFFFF.

Table 7-3. Hardware Status Diagnostics

Field	Description
CW Limit	Indicates the current hardware input level of the CW limit input (H = "high" signal, L = "low" signal)
CCW Limit	Indicates the current hardware input level of the CCW limit input (H = "high" signal, L = "low" signal)
Home Limit	Indicates the current hardware input level of the Home input (H = "high" signal, L = "low" signal)

Table 7-3. Hardware Status Diagnostics (continued)

Field	Description
Amplifier Fault	Indicates that an amplifier is in a fault condition (H = "high" fault signal; L = "low" fault signal)
Encoder Fault (Sine)	Indicates that the encoder read head detected that the SIN and $\overline{\text{SIN}}$ signals are in the same state
Encoder Fault (Cosine)	Indicates that the encoder read head detected that the COS and $\overline{\text{COS}}$ signals are in the same state
Inputs (BIN)	Indicates the states of the 16 digital inputs in binary format from 0000 0000 0000 0000 to 1111 1111 1111 1111
Outputs (BIN)	Indicates the states of the 8 digital outputs in binary format from 0000 0000 to 1111 1111
I/O Bank A	Indicates the states of the 8 I/O lines of bank A
I/O Bank B	Indicates the states of the 8 I/O lines of bank B
I/O Bank C	Indicates the states of the 8 I/O lines of bank C
MFO %	Indicates the current manual feedrate override percentage from 0% to 199%
Emergency Stop	Indicates the current emergency stop status (On or Off)
Brake Status	Indicates the current brake status (On or Off)
Feedhold Status	Indicates the current feedhold status (On or Off) ("On" means that a pause condition has occurred)
Joystick ABC	Indicates the current input status of joystick buttons A, B and C. The format is ABC, where A is status of A button (L = press, H = no press), and B is status of B button (L = press, H = no press). If C is pressed, both position A and B go low (e.g., LLH)
Hall BCA	Applicable only with AC brushless motors. Indicates the state of Hall sensors. See Motor Setup (MSET) command
A/D Input 1	Indicates the direct analog/digital converter voltage (0-5 V) for input 1
A/D Input 2	Indicates the direct analog/digital converter voltage (0-5 V) for input 2
A/D Input 3	Indicates the direct analog/digital converter voltage (0-5 V) for input 3
A/D Input 4	Indicates the direct analog/digital converter voltage (0-5 V) for input 4

7.6. UNIDEX 511 File Transfer Utility

The UNIDEX 511 File Transfer Utility is a software utility that transfers files between the U511 and a host PC using an RS-232 connection. This utility can be used to upload the UNIDEX 511 system software, in the case of software upgrades. To run the software, select "U511 File Transfer Utility" from the "UNIDEX 511" menu item under "Programs" from the Start menu.

7.6.1. Manufacturing Mode

Manufacturing mode loads system software, loads DOS, loads BIOS, or erases B drive. To place the U511 in Manufacturing mode, turn power off and remove the top cover from the unit. On the control board on the bottom of the U511, there is a JP12 jumper connecting pins 5 and 6. Remove this jumper to place the U511 in Manufacturing mode. When power is reapplied to the unit, the LCD display will show:

```
0123456789abcdefghijklmnopqrstuvwxyzABC
DEFGHIJKLMNOPQRSTUVWXYZabc
```

> To minimize the possibility of electrical shock and bodily injury, make certain that the mains power supply is disconnected before opening the chassis.

To put the U511 back into normal operating mode, replace the JP12 jumper connecting pins 5 to 6. Once power is turned back on, the U511 should be back in the normal mode of operation.

7.6.2. Loading System Software

To load system software, first the U511 must be put in Manufacturing mode (see Section 7.6.1). A one-to-one RS-232 cable should be connected between the host PC and COM2 of the UNIDEX 511. Note that updating the system software will work properly only when COM2 of the U511 is used. From the File Transfer Utility software, select the correct COM port settings from the "Remote" menu item. The only setting necessary to select, is the COM port of the PC. The other settings are ignored by the software, as loading the system software will always be done at 57.6 k baud, with 8 data bits, 1 stop bit, and no parity. Once the COM port is selected, select "Load System Software" from the "File" menu item. This will bring up a file dialog box. There are two different options of U511 system software. These are the files: U511.ABS and U11.ABS. The file U511.ABS is the standard U511 software. The U11.ABS is the U511 software using the UNIDEX 11 command set, to allow for backward compatibility to previous users of the UNIDEX 11 controller. After selecting the appropriate file, the transfer will begin and will take at least 2 minutes to complete. Once the status bar reaches 100% and the display shows "Transfer Complete," the software has been loaded properly. Turn power off and replace the JP12 jumper connecting pins 5 to 6 to put the U511 back into the normal operation mode.

7.6.3. Loading DOS or BIOS

Reloading DOS or BIOS to the U511 should only be necessary in the case of a crash or error in the operating system. This procedure is similar to loading system software (see Section 7.6.2). Follow the same procedure for loading system software: set the U511 in Manufacturing mode, connect the RS-232 cable from COM2 of the U511 to the host PC, and select the PC's COM port from the software. From the "File" menu item, select either "Load DOS" or "Load BIOS." This will bring up a file dialog box. Select the DOS file: DOS.ABS or select the BIOS file: BIOS.ABS.

7.6.4. Erasing B Drive

This procedure requires that a PC keyboard be connected to the U511. Set up Manufacturing mode by following the procedure for loading system software (Section 7.6.2). This selection will erase the B drive which contains the parameters and all user program files. Following this procedure, the B drive will need to be reformatted. From the a> prompt on the U511, type "format b:."

WARNING

> This procedure should only be performed in the event of a catastrophic failure of the B drive.

7.6.5. Uploading a File (to UNIDEX 511)

To upload a file, the U511 must be in normal operating mode with the U511 software running. Connect a one-to-one RS-232 cable between the U511 and the host PC. The COM port settings must be selected for both the U511 and the host PC. To change the U511 COM port settings, from the main screen of the U511 software, select the Setup menu (F2) to enter the parameter screen. The COM port settings are on Pages 2 and 3. Enter the desired settings. The Windows software will run up to and including the 57.6 k baud setting. Select the COM port settings of the host PC from the File Transfer Utility software's "Remote" menu item. Once the COM port settings are correct, select "Upload File" from the "File" menu item. A file dialog box will be displayed. Select the file from the host PC to be uploaded. After this file is selected, another dialog box will be displayed showing the files stored on the U511, enter the file name to save the file as on the U511. The status bar will show the progress of the file transfer, when the status bar shows 100% and the display shows "Transfer complete," the file has been uploaded properly.

7.6.6. Downloading a file (from UNIDEX 511)

To download a file, follow the instructions on uploading a file (see section 7.6.4): put the U511 in normal operating mode, connect an RS-232 cable, and choose the COM port settings for both the U511 and the host PC. Select "Download file" from the "File" menu item of the File Transfer Utility software. A file dialog box showing the files stored on the U511 will be displayed, choose the file to download. Another dialog box will be displayed, select the location and file name to store the file as on the host PC. The file transfer will then begin. The status bar will show the progress of the file transfer, when the status bar shows 100% and the display shows "Transfer complete," the file has been downloaded properly.

∇ ∇ ∇

CHAPTER 8: TUNING SERVO LOOPS

In This Section:

8.1. Introduction

This chapter explains the procedures for tuning U511 servo loops with and without tachometer feedback using the U511 Axis Scope Utility. This utility can be used to display the effects of the servo loop gain settings.

Included in this chapter are step-by-step procedures for tuning motors connected to the U511 to yield optimal performance. Optimal performance is usually characterized by a minimized position error. The U511 uses a dual control loop having an inner velocity loop and an outer position loop. The loop is updated according to the "Loop update rate (*.25 ms)" parameter. Refer to Figure 8-1 for an illustration of the servo loop.

Before tuning can be performed, the motor and encoder must be properly connected and setup. For additional information, see the following sections:

Chapter 4 – Parameters
Chapter 10 – Technical Details
Appendix C – Setting Up an AC Brushless Motor with the UNIDEX 511

The host PC must be connected to the UNIDEX 511 through an RS-232 port.

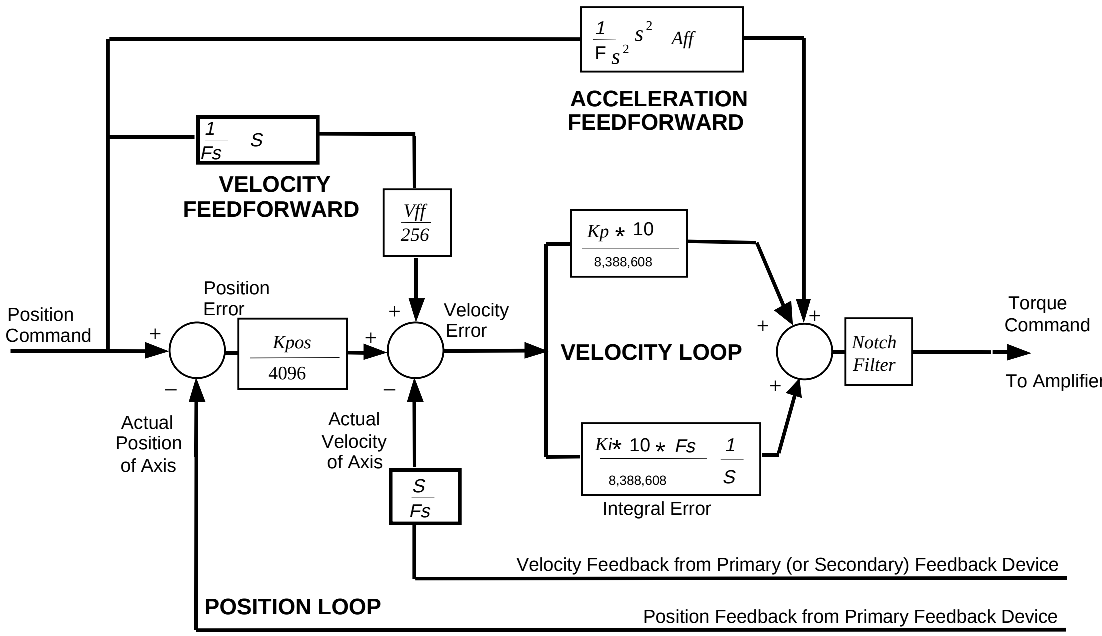


Figure 8-1. UNIDEX 511 Servo Loop

8.2. Axis Scope Tuning Window

The Axis Scope window is a tool that aids the user in improving the performance of the control-system servo loop. When tuning an axis, Axis Scope is used to move the axis in a forward direction and then in a reverse direction. As the axis moves, servo data such as position error, velocity error, velocity command, etc., is collected. The Axis Scope window allows the user to analyze these signals and adjust the servo gains appropriately, thus improving an axis to its realistic optimal performance. Refer to Figure 8-2 for an illustration of the Axis Scope window.

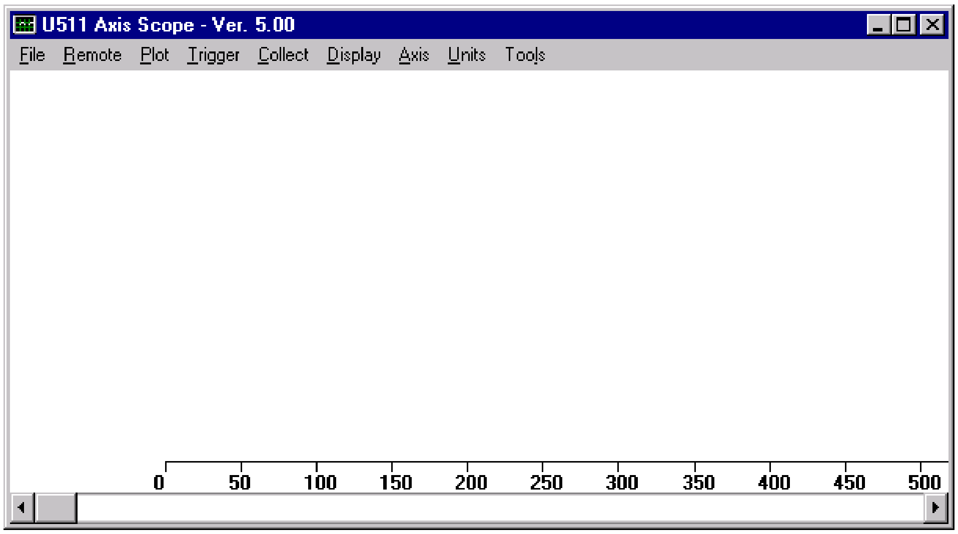


Figure 8-2. Axis Scope Window

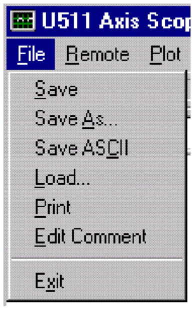
There are nine menu options available to the user on the Axis Scope window. The options are shown in Table 8-1.

Table 8-1. Menu Items on the Axis Scope Window

Command	Description
File	Save/load plot (.PLT) files, save ASCII files, exit
Remote	Sets PC's COM port parameters
Plot	Specifies plot options and which functions to plot
Trigger	Data collection method, motion, and control options
Collect	Defines the number of points to be collected
Display	Defines the number of points to be displayed
Axis	Specifies the axis (1, 2, 3, or 4) to be displayed
Units	Specifies distance and time units for the display
Tools	Enables/disables the cursor, status, control, and gains tools (menu bars with handy features)

The underscored letters in the Table are "short cut keys." Typing one of these keys with the Axis Tuning pull-down menu activated will activate the command.

Each of these menu options is discussed briefly below.

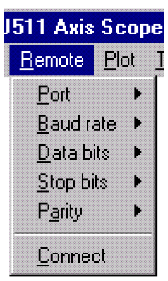


8.2.1. The File Menu

The File menu contains options that allow the operator to perform file operations with plot data. The Save and Save As... menu items save the current data sample to the PC's hard drive. The file format is binary. This file can be loaded in at a later time with the Load... menu item. The Save ASCII selection is used to generate a text listing of the currently displayed data. This can be useful when importing the data into other software packages. The Print item will send the graphical plot image to the printer. The Edit Comment item allows the user to add text to a plot. The File menu options are listed in Table 8-2.

Table 8-2. File Menu Options in Axis Scope

Command	Description
Save	Saves plot results to current binary plot (.PLT) file
Save As...	Saves plot results to a new binary plot (.PLT) file
Save ASCII	Saves plot results as an ASCII text (.TXT) file
Load...	Loads (from disk into memory) a previously saved binary plot (.PLT) file and displays it on the Axis Scope window
Print	Sends screen plots to the printer
Exit	Closes the Axis Scope window



8.2.2. The Remote Menu

The Remote pull-down menu allows the user to setup the serial communications parameters. These setting must agree with the settings loaded into the UNIDEX 511 from the front panel. A baud rate of 57,600 is recommended when using the Axis Scope utility.

8.2.3. The Plot Menu

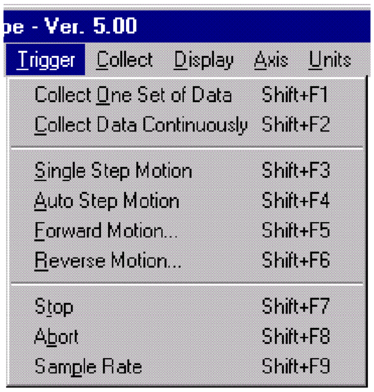
The Plot menu allows the operator to specify plot options and which signals to plot. The first nine options in the Plot menu allow the operator to specify one or more functions to be plotted over time. The nine options are Velocity Feedback, Velocity Command, Velocity Error, Position Feedback, Position Command, Position Error, Torque, Analog Input, and Integrator. One or more of these functions can be selected as the vertical axis (or axes) of the plots in the display window. Normally, for tuning, the operator will look at Velocity Command, Velocity Error, and the Position Error options.

The Torque, Analog Input, and Integrator options cannot be displayed simultaneously. The desired signal must be selected (checked) before sampling the data.

The Zero Line option, the Refresh option, and the Overlap option, allow the operator to customize the look of the plot display. The Zero Line option aligns the plot to the vertical zero line. The Refresh option clears the display and replots the data.

The Two Axis XY Plot option shows the Position Feedback or Position Command of two axes – one with respect to the other. Two axes must be selected and only the Position Feedback or Position Command can be displayed.

8.2.4. The Trigger Menu

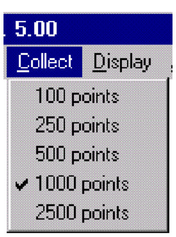


The Trigger menu of the Axis Scope window contains options that allow the operator to specify a data collection method (Collect One Set of Data or Collect Data Continuously), motion options (Single Step Motion, Auto Step Motion, Forward Motion, Reverse Motion), and control options (Stop, Abort, and Sample Rate). The Trigger menu options are listed in Table 8-3. When selected, the Forward Motion... and Reverse Motion... options display popups that allow the user to define the motion command to be used for forward and reverse axis motions, respectively

When the Sample Rate option is selected, the software displays the Scope Sample Timebase popup window. From this popup the operator enters the frequency at which samples are to be taken. This value is given in milliseconds (ms) and defaults to a value of 1 ms.

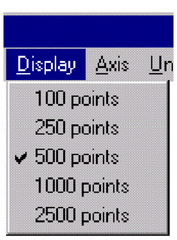
Table 8-3. Trigger Menu Options in Axis Scope

Command	Description
Collect One Set of Data	Collects one set of data (as specified in Collect submenu), plots the results, and stops. No motion is commanded
Collect Data Continuously	Collects one set of data (as specified in Collect submenu), plots the results, and starts over again. No motion is commanded
Single Step Motion	Performs commanded motion one step at a time (alternately sends the forward motion and the reverse motion and collects data during each cycle)
Auto Step Motion	Performs motion continuously (automatically, same as single step only continuous)
Forward Motion...	Prompts operator to specify a desired forward step motion command (e.g., G1 X1 F1000)
Reverse Motion...	Prompts operator to specify a desired reverse step motion command (e.g., G1 X-1 F1000)
Stop	Stops axis motion after the current data set has been collected and then updates the plot
Abort	Stops axis motion immediately (aborts motion) and then updates the plot
Sample Rate	Prompts the operator to specify how often a sample is read (given in milliseconds [ms])



8.2.5. The Collect Menu

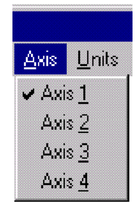
The Collect menu of the Axis Scope window specifies the number of data points to be collected in a single set. Once these points are collected, they are displayed on the Axis Scope window according to the settings of other menu items. The Collect menu contains five data set sizes: 100, 250, 500, 1000, and 2500. Normally, the operator starts out with this set at 2500 points.



8.2.6. The Display Menu

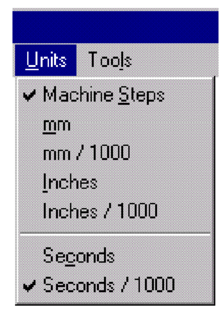
The Display menu of the Axis Scope window is similar to the Collect submenu. Display specifies the number of data points that are displayed or plotted. Like the Collect menu, the Display menu contains five data set sizes: 100, 250, 500, 1000 and 2500 points. Only one data set can be selected at a given time.

8.2.7. The Axis Menu



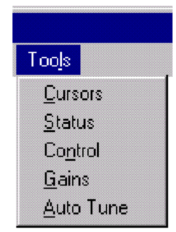
The Axis menu of the Axis Scope window specifies which axis to display. The functions shown in the Plot menu refer to the current axes as selected by this menu. This menu supports axes 1, 2, 3, and 4. Multiple axes may be selected. When selected, the axis name has a check mark to its left.

8.2.8. The Units Menu



The Units menu of the Axis Scope window specifies the distance and time measurement units for the plot display. The data can be displayed in any one of the following units: Machine Steps, millimeters (mm, based on "Metric conversion factor"), microns (mm/1000), Inches (based on "English conversion factor"), and thousandths of inches (Inches/1000). Time units can be displayed in either Seconds or milliseconds (Seconds/1000).

8.2.9. The Tools Menu



The Tools menu enables or disables the display of five toolbars on the Axis Scope window. The options of this menu are: Cursors, Status, Control, Gains, and Auto Tune. Selecting an option from this menu toggles the display of the associated toolbar. When a toolbar is being displayed, a check mark appears to the left of the associated option in the Tools menu.

8.3. The Axis Scope Toolbars

This section discusses the Axis Scope toolbars and the servo gains used to tune the axes.

The Cursors option is used to display/hide the Cursors toolbar. This toolbar contains features that assist the operator in determining time differences between points on the plot as well as frequency information. The Cursors toolbar is illustrated in Figure 8-3

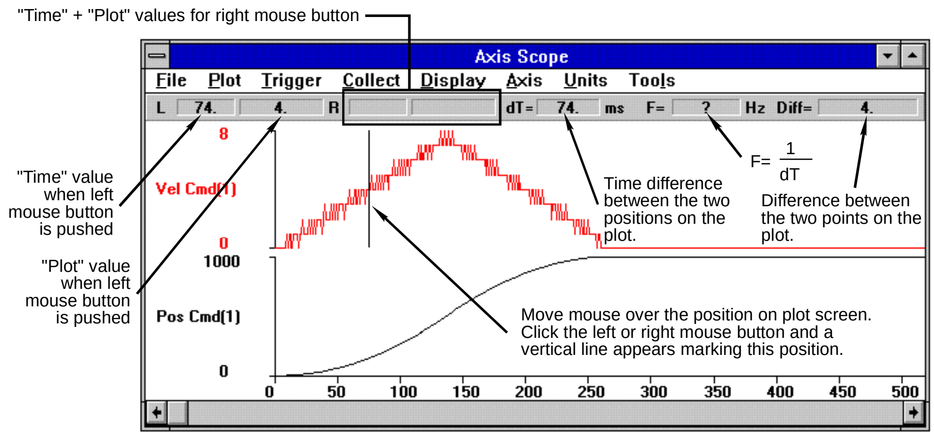


Figure 8-3. Cursors Toolbar of the Axis Scope Window

The Gains, Status, and Control toolbars are illustrated in Figure 8-4. These toolbars are frequently used together in the tuning process.

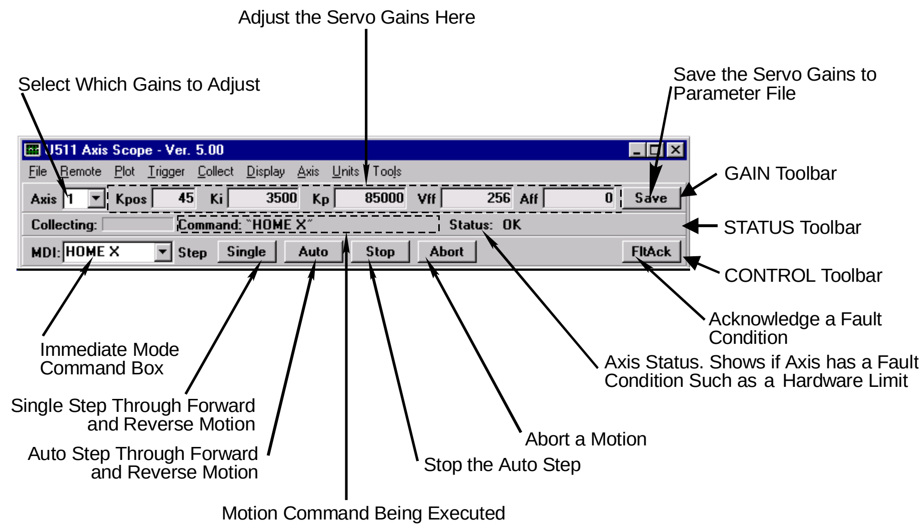


Figure 8-4. Gains, Status, and Control Toolbars

The Gains option is used to display/hide the Gains toolbar. This toolbar contains an axis selection button as well as loop tuning gains fields for easy parameter access.

The Status option is used to display/hide the Status toolbar. This toolbar contains fields that display the current status of the data collection process and axis fault information.

The Control option is used to display/hide the Control toolbar. This toolbar contains features such as an MDI command box, program step buttons, and control buttons.

The Auto Tune option is used to display/hide the autotune toolbar. Autotuning is a procedure that automatically identifies motor parameters and determines the motor gains. The autotune toolbar and the autotune process are discussed later in this chapter.

8.3.1. "Kp" Proportional Gain

This is the Proportional Gain. It is part of the Velocity Loop in the UNIDEX 511's Servo Loop. This gain reduces the amount of velocity error. Also, this gain has a dampening effect in the servo loop. This is the first gain to adjust.

8.3.2. "Ki" Integral Gain

This is the Integral Gain. It is part of the Velocity Loop in the UNIDEX 511's Servo Loop. This gain reduces the amount of velocity error. Moreover, this gain helps remove steady-state position errors at the end of a move. This is the second gain to adjust.

8.3.3. "Kpos" Position Gain

This is the Position Gain. It is the only gain in the Position Loop in the UNIDEX 511's Servo Loop. This gain reduces the amount of position error and decreases the settling time. This is the third gain to adjust.

8.3.4. "Vff" Velocity Feedforward Gain

This is the Velocity Feedforward Gain. It is the only gain in the velocity feedforward loop in the UNIDEX 511's servo loop. For motors without a secondary feedback device it is always 256. Otherwise, the user must calculate a value for "Vff." To calculate "Vff," use the following formula:

$$Vff = \left(\text{Velocity loop resolution} / \text{Position loop resolution} \right) \times 256$$

8.3.5. "Aff" Acceleration Feedforward Gain

This is the Acceleration Feedforward Gain. It is the only gain in the acceleration feedforward loop in the UNIDEX 511's servo loop. This gain is used to remove position error during the acceleration and deceleration of a move.

8.4. Autotuning

Autotuning is used to automatically calculate gains. The UNIDEX 511 does this by moving the motor in a progressively faster back and forth motion and recording the current required for the move. This data is used along with the user specified "BW" (Bandwidth) and Damping to calculate servo loop gains.

8.4.1. Setting up an Excitation

First, in order to determine the characteristics of the stage, the U511 must excite the system. It does this with a sinusoidal motion. The user must input the amplitude and frequency of this motion. This is done in the autotune screen. The amplitude is entered in mm or in. The frequency of excitation is entered in the Freq. (Hz) box (this is similar to running a signal generator into the controller).

In order for the software to successfully identify system parameters, the torque and velocity signals must be of reasonable amplitude. This means the torque signal should be greater than 1V PK when viewed in the tuning window. If the software responds with an error message, it may be because the amplitude or frequency is set too low.

Typical amplitude is 25-50mm (1-2in) and a frequency of 1Hz. Once the software responds with gain values, you can move on to the next step.

> The U511 only displays velocity feedback and torque (for one axis) when in autotune mode.

8.4.2. Specifying Desired Performance

The second step is to specify how well you want the system to perform. This is done in terms of bandwidth and damping. The damping is usually set to .7. You should start with a low value of bandwidth (10Hz) and work up until the system becomes unstable. Then return to the next lower gain values.

8.4.3. Bandwidth and Damping

Bandwidth is the responsiveness of the system expressed in terms of frequency. Higher bandwidth systems are more desirable than lower bandwidth systems. They have less position error, can track better with lower times, contour better, have smaller settling times, etc. Systems with high bandwidth have high gains.

Damping is how oscillatory the system is. This is evident in how stable the system is when it comes into position at the end of a move. Air bearing systems should use a damping of .7, mechanical bearing systems should use .3.

8.4.4. Autotuning Procedure

The following information and procedure can be used during the auotuning process.

The Autotuning Toolbar

In order to perform autotuning, the Axis Scope window must display the autotune toolbar. From the Tools menu of the Axis Scope window, select the Gains option and the Auto Tune option. The gains and autotune toolbars will be displayed on the screen. Refer to Figure 8-5. The autotune toolbar allows the user to enter the parameters Distance (Dist), Frequency (Freq), Bandwidth (BW), and Damping into the autotuning program.

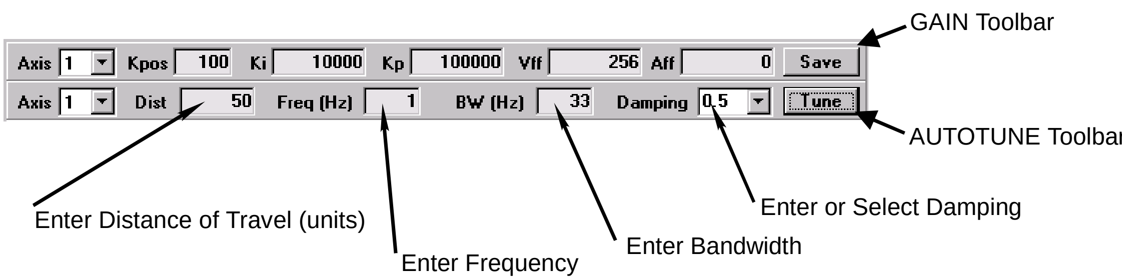


Figure 8-5. The Gain and Auto Tune Toolbars

Setting Distance and Frequency

The first step is to set the "Dist" (Distance) and "Freq" (Frequency) parameters. The Distance parameter determines how much the motor moves and Frequency determines the speed of movement during autotuning. Typical values are 25-100 mm for distance and 1 Hz for frequency. If an RMS error occurs during autotuning, the distance or frequency may be set to high. If the distance is too low, the U511 responds with "Could not identify system parameters!"

Setting Bandwidth and Damping

The Bandwidth and Damping parameters specify the desired response of the motor. The higher the Bandwidth, the better the stage performance will be. This means minimizing velocity error, position error, and settling time. Higher bandwidth numbers will result in higher servo loop gains. A typical value of Bandwidth is 35 Hz.

The Damping parameter determines how the motor comes into position. A low Damping value (.3) may allow the axis to come into position more quickly, but take longer to completely settle. There may also be some overshoot at the end of the move. A value of .7 will ensure that there is minimal overshoot. A typical value of Damping is .5.

> An RS-232 cable must be connected between the host PC and the U511.

Autotuning Procedure

The following procedure may be used to autotune the system.

1. Defeat position and velocity error traps by modifying the "Global fault mask" parameter using the front panel "Setup" menu or the "U511 Parameter Editor" RS-232 windows utility software (see axis parameter x55).
2. Run the "U511 Axis Scope" utility software. Select Gains and Auto Tune from the Tools pull down menu.
3. Set starting gains. If you do not have "working" gains, set "Kpos"=1, "Ki"=1000, "Kp"=10000, and "Vff"=256.
4. Set excitation distance and frequency in the "Dist" and "Freq" text boxes. "Dist" is in current units (mm or in).

   Typical Dist = 25 mm or 1 in (see text)

   Typical Freq = 1 Hz
5. Set desired Bandwidth (BW) and Damping. A Bandwidth of 10 Hz and Damping of .5 are good starting points.
6. Run autotune by pressing the TUNE button. Answer YES to save gains to the servo loop.
7. Increase bandwidth by 5 Hz increments until system becomes loud or unstable. Return to next lower bandwidth and retune.
8. Save gains to parameter file by pressing the SAVE button.
9. Re-enable position and velocity error traps (see axis parameter #55).

> Autotuning cannot be run on stepper motors, motors with tachometer feedback or on dual loop systems

Three autotuning plots are shown in the following Figures. Figure 8-6 shows results of an autotune where "Dist" was set too low. The torque output is generally less than a volt and the commanded velocity plot is not sinusoidal. This stage should be retuned with the "Dist" increased.

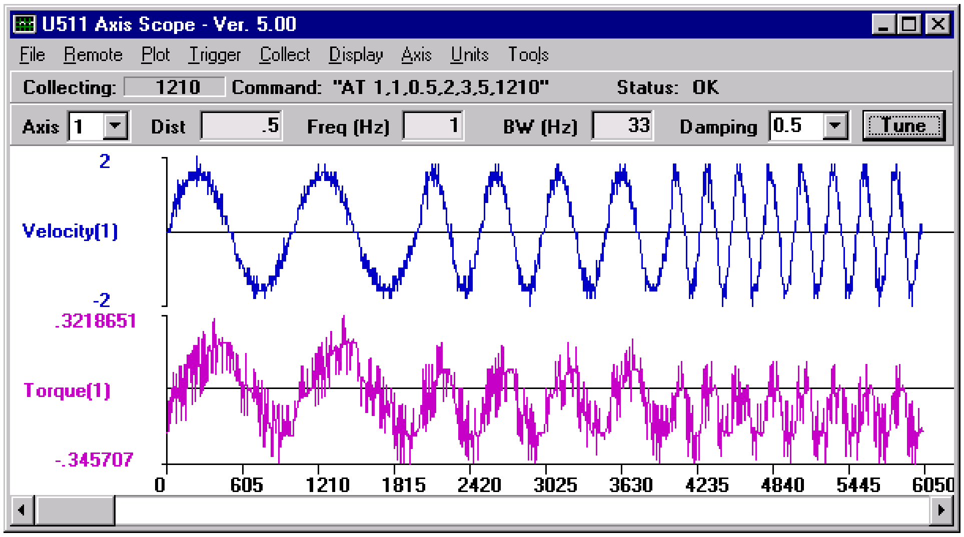


Figure 8-6. Autotune Plot Where "Dist" Has Been Set Too Low

Figure 8-7 shows an autotune plot where the distance is too large. The plot shows that the torque output becomes clipped at 10V. This stage should be re-tuned with the Dist decreased, so that the torque output is no longer clipped.

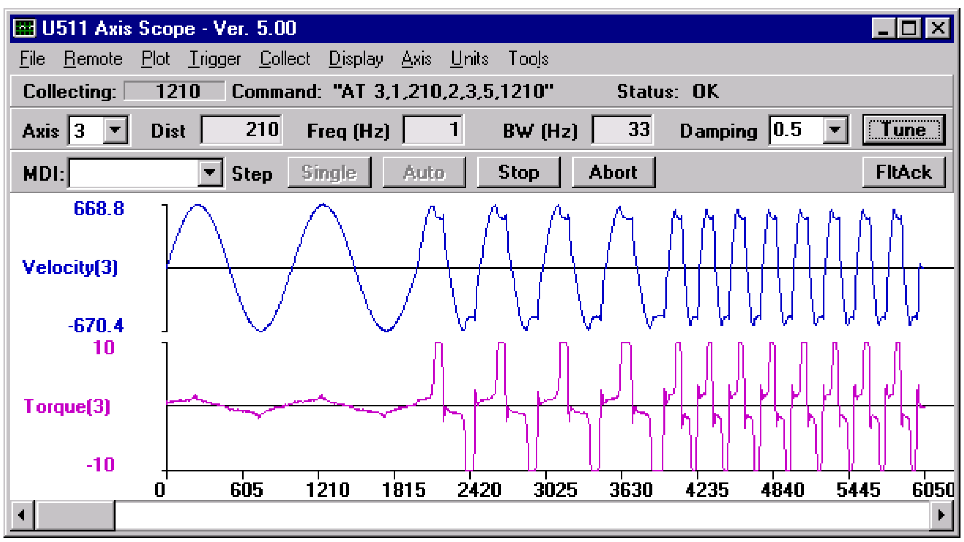


Figure 8-7. Autotune Plot Where "Dist" Has Been Set Too High

Figure 8-8 shows a proper autotuning procedure. Both the torque and velocity commands are sinusoidal and the torque output peak is greater than one volt. A resulting plot similar to this should identify the parameters of the motor/stage and produce gains that will allow the stage to be run adequately.

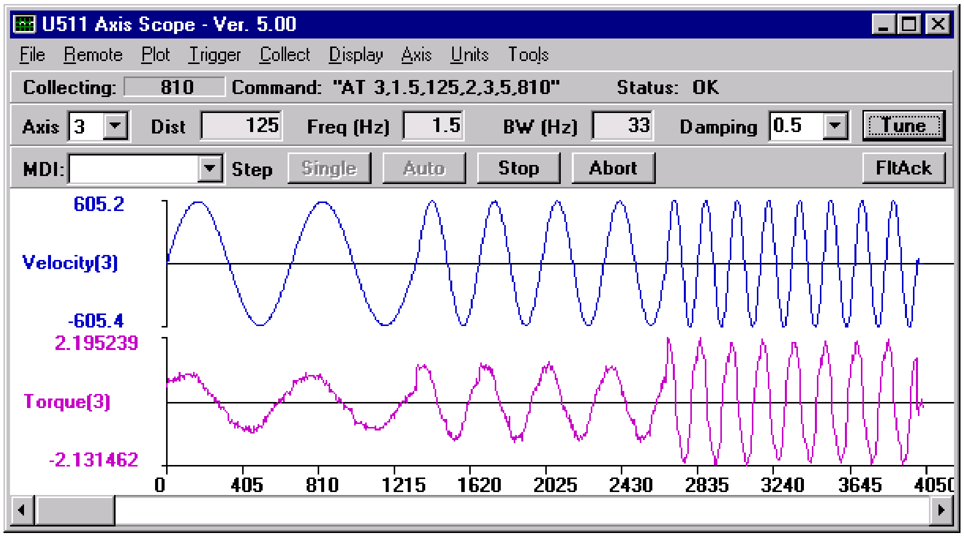


Figure 8-8. Autotune Plot Showing Proper Calibration

8.4.5. Dual Loop Systems

Autotuning may be performed on dual loop systems by temporarily configuring the U511 to run in single loop mode, i.e. from the velocity feedback transducer only. This is accomplished by setting the primary feedback channel parameter (axis parameter x38) to the velocity feedback device's channel and setting the secondary feedback channel (axis parameter x39) to 0. Autotuning will yield the correct values for Ki and Kp. The Kpos term will need to be manually adjusted when the U511 configuration is returned to dual loop mode.

8.4.6. Guidelines and Limitations

- It is usually necessary to defeat the velocity error and position error traps before tuning.
- If you do not have ballpark gains for a system, start out with low values, Kpos=10, Ki=1000, Kp=10,000.
- Most systems should be able to achieve a bandwidth of at least 30Hz.
- Care must be taken not to exceed the maximum tracking rate of the feedback device, especially resolvers/inductosyns. Large gimbals with inductosyns cannot use autotuning.
- Autotuning *will* work with vertical axis configurations.
- For systems with large mass or high inertia, it may be necessary to reduce the excitation frequency to .25 - .5Hz. For small systems, it may be necessary to increase the frequency to 2Hz.
- Autotuning can be run on unconnected motors and linear motors.

- When changing the servo loop update rate from 4KHz to 1KHz, Kp should be reduced by a factor of 4, Ki should stay the same, and Kpos should increase by a factor of 4.
- When changing resolution from 1000 lines to 2000 lines, Ki and Kp should be reduced by a factor of 2, Kpos stays the same.

8.4.7. Troubleshooting Autotuning

Some tips for troubleshooting autotuning are given in Table 8-4.

Table 8-4. Troubleshooting the Autotune Process

Problem	Possible Causes / Solutions
System responds with "Could not calculate gains"	An axis fault has occurred. "Ki" and "Kp" must be set > 0. "Vff" must be set to 256. Current is too high, lower Distance or Frequency. Tracking rate of feedback device has been exceeded. "Top feedrate" trap occurs. Lower Distance or Frequency, or defeat trap if allowed.
Motor makes a loud noise and shuts off immediately	Gains are set too high, decrease "Ki" and "Kp". Motor commutation parameters are incorrect (AC brushless motors only). Encoder signals are missing, verify in Diagnostics. Encoder is damaged, verify in Diagnostics.
Motor does not move at all	Motor is not enabled. Motor is disconnected. Amplifier has faulted. Shut system off for 30 seconds and retry.

8.5. Tuning Procedure for Servo Loops

The following procedure can be used as a guide when tuning the UNIDEX 511 servo loop. This procedure does not apply to motors with tachometers. Figure 8-9 shows the overall tuning process with the Axis Scope window. The tuning process discussed in this section was performed using the "X" axis (axis 1) of an X-Y stage. The user's system may behave differently and have different values for servo gains. However, the overall process is the same and the same process can be repeated for the other axes in the system. When adjusting each of the servo gains, the user will essentially be following the procedure below:

1. Press the SINGLE button on the Control toolbar to step through a forward or reverse motion.
2. Observe the signal plots on the Axis Scope window.
3. Make a decision on whether to increase or decrease the value of the servo gain and if the observed signal is acceptable to move on to the next servo gain.
4. Repeat.

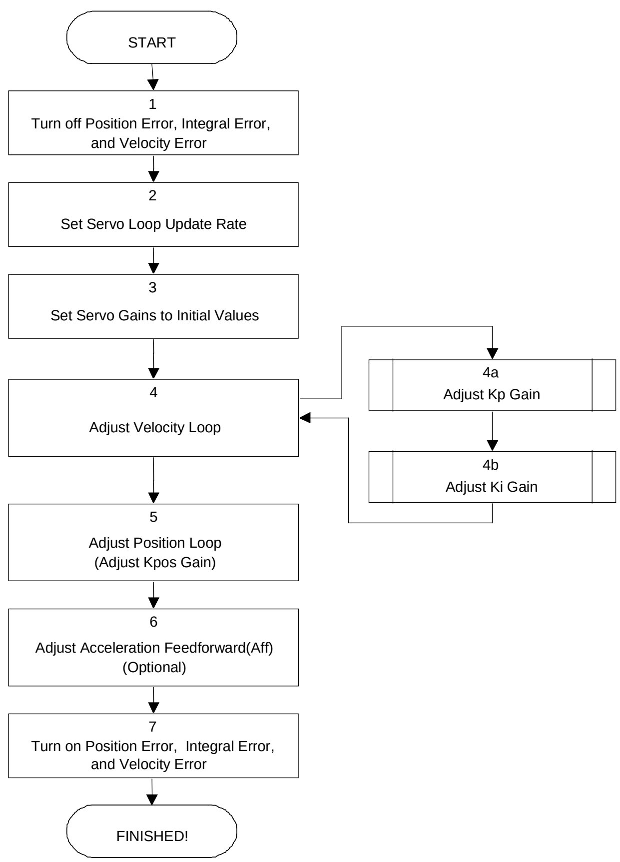
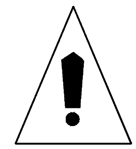


Figure 8-9. Flowchart of Overall Tuning Process

The following is a step-by-step procedure for tuning motors without tachometers.

Please read each step thoroughly before performing the task.


IMPORTANT

1. Turn off the "Position Error," "Integral Error," and "Velocity Error" traps. In the UNIDEX 511 Parameter Editor, deselect the Position Error, Integral Error and Velocity Error in the "Faults" parameter tab. Refer to Figure 8-10.

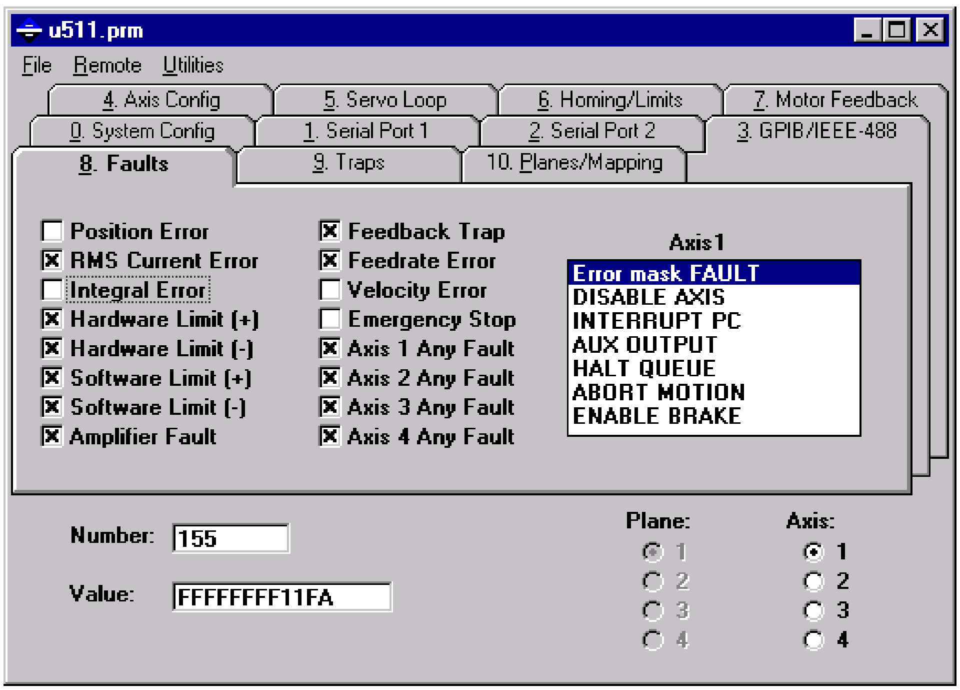


Figure 8-10. The Faults Tab of the Parameter Editor

2. The "Loop update rate (*.25 ms)" parameter from the Servo Loop tab, shown in Figure 8-11, must be set appropriately in order to get optimal performance from the system. The default update rate is 0.25 ms (4 kHz) and the user would put a 1 as that parameter's value. Another common choice is 1 ms (1 kHz) and the user would put a 4 as that parameter's value. Some low resolution systems (500 line encoders, etc.), high inertia systems, or low velocity systems perform better at a lower update rate such as 1 kHz. If the user doesn't know what to use for this parameter then an update rate of 4 kHz should be used. However, an update rate of 1 kHz can be used. If the update rate is changed, the tuning process must be repeated.

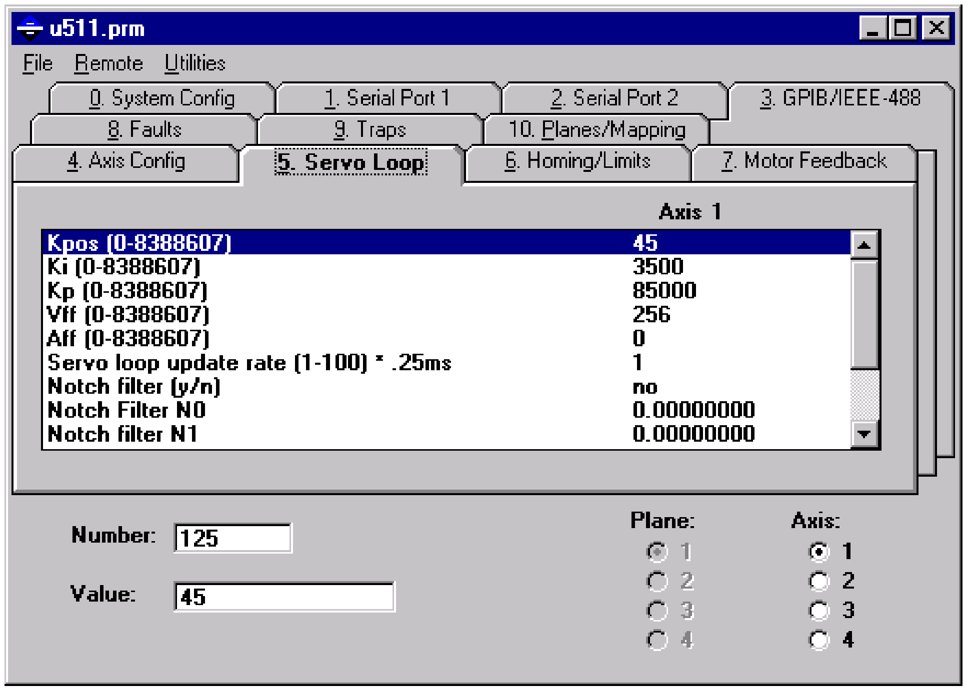


Figure 8-11. Servo Loop Tab of the Parameter Editor

3. Set servo parameters to initial values. While still in the U511 Parameter Editor window (refer to Figure 8-11), enter in the initial values for the servo gains. Table 8-5 has the initial values for these servo gains.

Table 8-5. Initial Servo Parameter Values

"Kpos"	"Ki"	"Kp"	"Vff"	"Aff"
0	0	≤10000	256	0

Save the parameters to the U511 by selecting "Save and Upload (to U511)" from the File menu. The U511 will need to be reset for the parameters to take effect.

4. Prepare the Axis Scope window for tuning by performing the following functions:

   a. Press the MAXIMIZE button on the Axis Scope window, shown in Figure 8-12 so the Axis Scope window fills the entire screen.

Figure 8-12. MAXIMIZE Button on the Axis Scope Window

b. In the Collect menu select "2500 points."

c. In the Display menu select "2500 points."

d. In the Axis menu select axis number 1 (X axis) or the axis that will be tuned.

e. In the Plot menu, select Velocity Command, Velocity Error, and Position Error.

f. In the Trigger menu, set the Forward Motion... and Reverse Motion... to a typical move. For metric mode, a move such as *LINEAR X10 F2000* for Forward Motion... and *LINEAR X-10 F2000* for Reverse Motion... is appropriate. For English mode, moves such as LINEAR X1 F180 and LINEAR X-1 F180 for Forward Motion... and Reverse Motion..., respectively, are appropriate. Also set the Sample Rate to 1.

g. In the Tools menu select Status, Control, and Gains.

When the SINGLE button is pressed, axis number 1 will first move as specified by Forward Motion... When the SINGLE button is pressed again, axis number 1 will move as specified by Reverse Motion...

5. Adjust the Velocity Loop using "Kp" and "Ki." The "Kpos" and "Ki" have been set to zero (0) to eliminate the Position Loop and half of the Velocity Loop. Thus, the only gain that is having an effect is "Kp" which is the other half of the Velocity Loop.

Even though the user may only be concerned with how well the stage positions, the Velocity Loop cannot be overlooked as it is interrelated to positioning. The better a stage tracks velocity, the closer it will be to its correct position.

The objective in adjusting "Kp" is to reduce the velocity error to 5-10 steps. In between pressing the SINGLE button, the operator should observe no screeching and howling from the motor. Noise means "Kp" is set too high causing it to oscillate. It may screech a little during the move, but not when at a standstill.

If the motor doesn't move, "Kp" is too low. Increase the value of "Kp" and try again by pressing the SINGLE button.

If you are adjusting the gains that Aerotech has setup for your system, use the existing "Kp" as your starting point.

Once the motor is moving back and forth, the user should see a graph similar to Figure 8-13. From this graph, it is seen that there are 20 to 30 steps of velocity error. "Kp" must be increased to reduce the amount of velocity error. After repeating this process a few times, the velocity error will look similar to Figure 8-14. From this graph the user can observe that the average velocity error during the move is about 6 units. Moreover the motor does not oscillate when it is stopped.

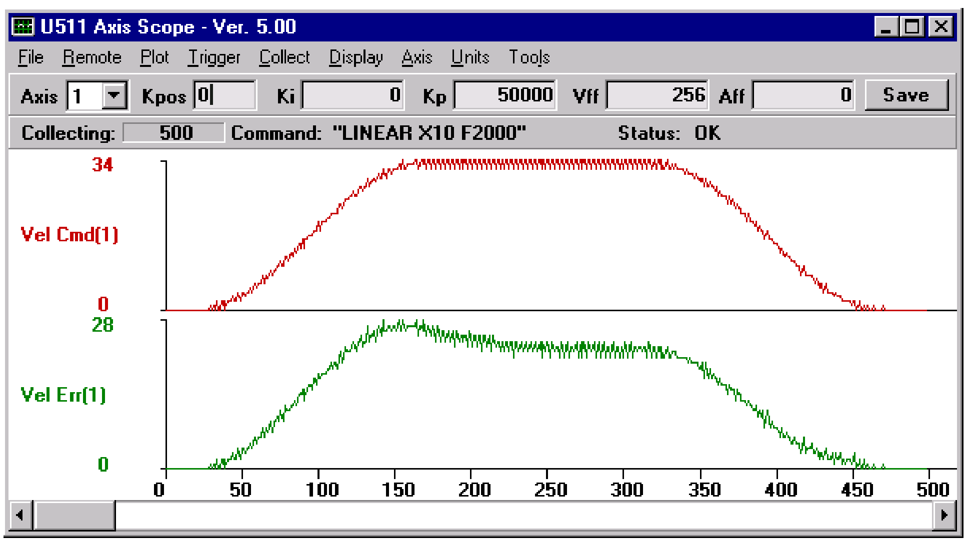


Figure 8-13. Unacceptable Velocity Error

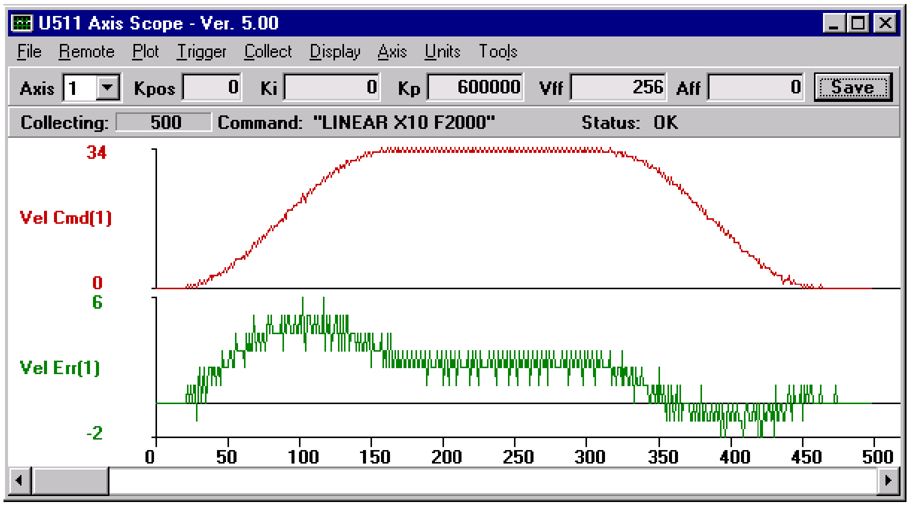


Figure 8-14. Acceptable Velocity Error (When Adjusting "Kp")

The user can stop adjusting "Kp" and start adjusting "Ki."

Use a starting value of 100 for "Ki." The main objective in adjusting "Ki" is to reduce velocity error and position error (Refer to Figure 8-15). As "Ki" is increased, the error is reduced. However, a very large "Ki" will introduce a high frequency oscillation (Refer to Figure 8-16).

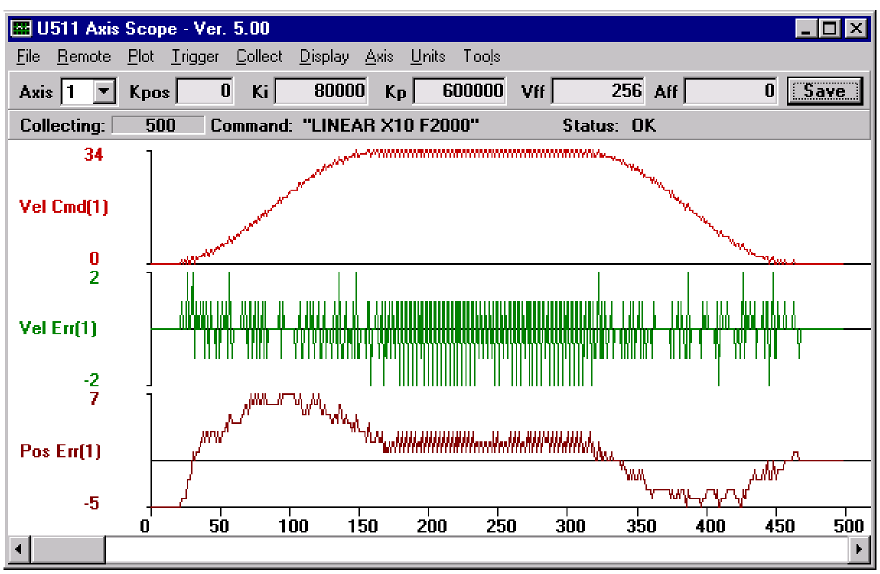


Figure 8-15. Proper Adjustment of "KI"

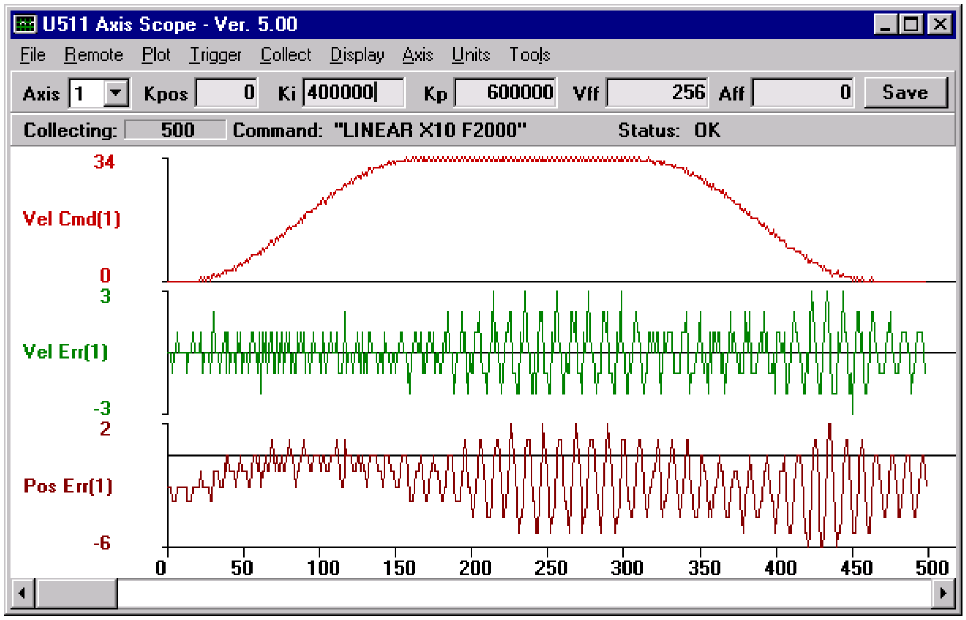


Figure 8-16. Oscillation in Position Error When "Ki" is too High

> The user can stop adjusting "Ki" and start adjusting "Kpos."

6. Adjust the Position Loop using "Kpos." Use a starting value of 1-10 for "Kpos." As the user increases "Kpos," it will be observed that the position error is reduced. The main objective is to adjust "Kpos" until the position error is within user's tolerance or starts to oscillate; whatever comes first.

   As previously mentioned, if "Kpos" is too high, the user will encounter a low frequency oscillation (stage vibrates strongly). This will cause the UNIDEX 511 to generate a *RMS current trap*, which essentially means that too much current is being sent to the motor (the "RMS current trap" acts the same way as a fuse).

   Shown in Figure 8-17 is a plot of a good "Kpos." From this graph it can be seen that there is little settling time. In other words, the position error ends near the same time the Velocity Command ends; so the move is "in position" at the end of the commanded move. For comparison, Figure 8-18 illustrates a plot where "Kpos" is too high.

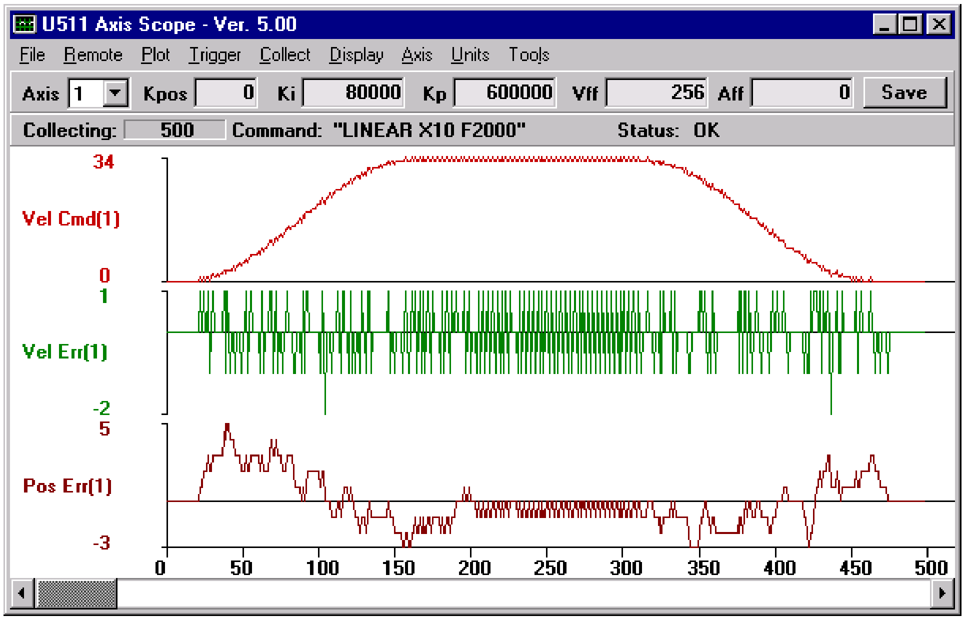


Figure 8-17. Plot Showing an Appropriate Value for "Kpos"

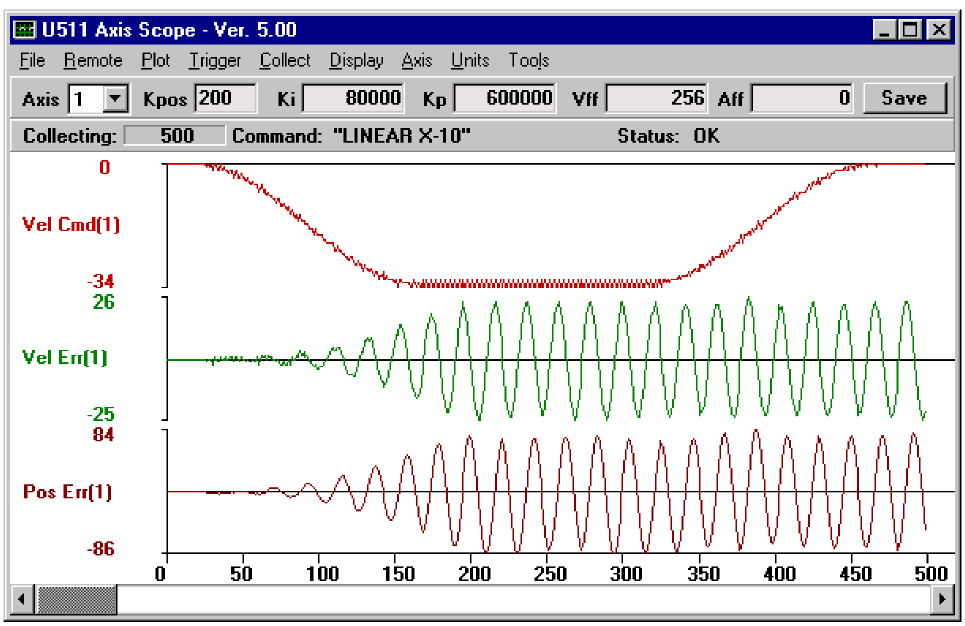


Figure 8-18. Plot Showing Overall Effects When "Kpos" is High

7. Adjust Acceleration Feedforward Loop using "Aff." The Acceleration Feedforward gain ("Aff") attempts to remove position error during the acceleration and deceleration of a move.

Adjusting "Aff" is optional. The user's application may not need it.

8. Turn the Position Error, Integral Error, and Velocity Error traps on by returning to the U511 Parameters Editor window and selecting the Parameter tab called "Faults." Turn the "Position Error," the "Integral Error," and the "Velocity Error" back on by checking the boxes. This will reactivate these traps.

   Save and exit the Parameter Editor window.

   Reinitialize the UNIDEX 511.

8.6. Tuning Tips

Some tips for tuning AC brushless motors and low resolution encoders are given below.

- AC brushless motors usually have cyclic position error. Most Aerotech AC brushless rotary motor systems will have a disturbance of 4 cycles per motor revolution (8 pole motor). Aerotech linear motors have a pitch of 2.4 in and will generate a cyclic error with a period of 2.4 in. These errors are due to gain or offset differences in the amplifier phases.
- A low resolution encoder (1000 lines/rev) and a high servo loop sampling rate (4 kHz) may cause high frequency noise or squealing sounds. These systems will usually perform quieter by changing the "Loop update rate (*.25 ms)" (axis parameter x62) from zero to four. The "Kp" gain should be decreased by a factor of four and "Kpos" increased by a factor of four when doing this. The "Ki" should remain unchanged.
- The position loop bandwidth can be calculated from the "Kpos" and servo loop update frequency. The calculation is as follows:

$$F_{BW}(Hz) = \frac{K_{pos} \cdot F_{servo}}{4096 \cdot 2 \cdot \pi}$$

where:

F_{servo} = servo loop update frequency (Hz) (typically 1000 or 4000)

8.7. Tuning With Tachometer Feedback

The UNIDEX 511 servo is easily configured for compatibility with external tachometers providing negative velocity feedback. To adapt to an external tachometer based Velocity Loop, the inherent digital Velocity Loop operation within the controller needs to be disabled. This is done by setting the digital servo loop proportional gain ("Kp") to zero. The servo system's Velocity Loop then needs compensated by the tachometer/amplifier combination.

When configured this way, the analog outputs of the UNIDEX 511, which normally deliver current commands to amplifiers, will now deliver velocity commands to amplifiers accepting tachometer feedback.

In this configuration, the servo system has the following characteristics:

- The amplifier is configured to accept tachometer based (negative) velocity feedback
- The amplifier controls the Velocity Loop of the servo system. Tuning for the Velocity Loop is accomplished in the pre-amp section of the amplifier
- The proportional gain parameter ("Kp") in the UNIDEX 511 controller's servo loop parameter set has been set to zero (0) for that axis, disabling its digital Velocity Loop functionality
- The controller is now commanding velocity to the amplifier instead of commanding torque to the amplifier

8.7.1. In-Position Integrator

Setting "Ki"≠0 can enable an in-position integrator. After "Ki" is set to a nonzero value, the UNIDEX 511 will attempt to remove steady-state position errors. This function also helps to reduce the effects of tachometer loop drift. In-position integration is accomplished at a rate that is directly proportional to the integral gain value that is set in "Ki."

> If a value for "Ki" is too large, it will induce oscillation into the position error and increase the settling time.

8.7.2. Velocity Feed Forward

The following error (position error) that occurs while the axis is moving may be reduced significantly by setting the "Vff" to a non-zero value. When the velocity feed forward function is enabled (i.e., "Vff"≠0), an added voltage is sent to the tachometer loop. This signal is proportional to the Velocity Command and the value of "Vff." "Vff" is adjusted to minimize position error of the servo system.

8.7.3. Servo Parameter Setup for Tachometer Feedback

When configuring a servo loop containing external negative velocity feedback from a tachometer, the servo gain values shown in Table 8-6 are adjusted.

Table 8-6. Servo Gain Values

Parameter	Name	Value	Comments
Position Gain	"Kpos"	Adjust per application	Should be maximized for servo stability and acceptable position error (following error) levels
Integral Gain	"Ki"	Optional	In-position integrator that helps reduce steady state position errors and the effects of tachometer loop drift
Proportional Gain	"Kp"	Always Zero	The digital Velocity Loop must be disabled so it does not conflict with an external tachometer providing velocity feedback
Velocity Feed Forward	"Vff"	Optional	Minimizes following error (position error) of the servo system
Acceleration Feed Forward	"Aff"	Always Zero	Use of this parameter also conflicts within external tachometer providing velocity feedback

8.7.4. The Axis Scope Toolbars

The user will employ the same Axis Scope toolbars shown in Figure 8-4 on page 8-8 when tuning with tachometer feedback. However, the gains on the Gains toolbar have slightly different meanings with tachometer feedback. The gain definitions are as shown below.

8.7.4.1. "Kpos" Position Gain

The Position Gain is the only gain in the Position Loop in the UNIDEX 511's Servo Loop. This gain reduces the amount of position error and decreases the settling time. It is the first gain to adjust.

8.7.4.2. "Ki" In-Position Integrator

This is the In-Position Integrator. Setting "Ki" to a non-zero value causes the UNIDEX 511 to attempt to remove steady-state position errors. This function also helps reduce the effects of tachometer loop drift. "Ki" is the second gain to adjust.

If the value for "Ki" is too large it will induce oscillation into the position error and increase the settling time.

8.7.4.3. "Vff" Velocity Feedforward Gain

The Velocity Feedforward Gain is the only gain in the Velocity Feedforward Loop in the UNIDEX 511's Servo Loop. This gain reduces the amount of position error for systems with a tachometer. It is the third gain to adjust.

8.7.4.4. "Kp" Proportional Gain

"Kp" is the proportional gain used in systems with tachometers. It is always set to zero (0).

8.7.4.5. "Aff" Acceleration Feedforward Gain

The Acceleration Feedforward Gain is the only gain in the Acceleration Feedforward Loop in the UNIDEX 511's Servo Loop. For systems with tachometers, it is always zero (0).

8.8. Tuning Tachometer Loops

The following procedure is a guide for tuning motors with tachometers. Figure 8-19 shows the overall tuning process with the Axis Scope window. The tuning process discussed here was performed using the "X" axis (axis 1) of an X-Y stage. The user's system may behave differently and have different values for servo gains. However, the overall process is the same and the process can be repeated for the other axes. When adjusting the servo gains, the user will essentially be following the procedure below:

1. Press the SINGLE button on the Control toolbar to step through a forward or reverse motion.
2. Observe the signal plots on the Axis Scope window.
3. Make a decision on whether to increase or decrease the value of the servo gain and if the observed signal is acceptable, move on to the next servo gain.
4. Repeat.

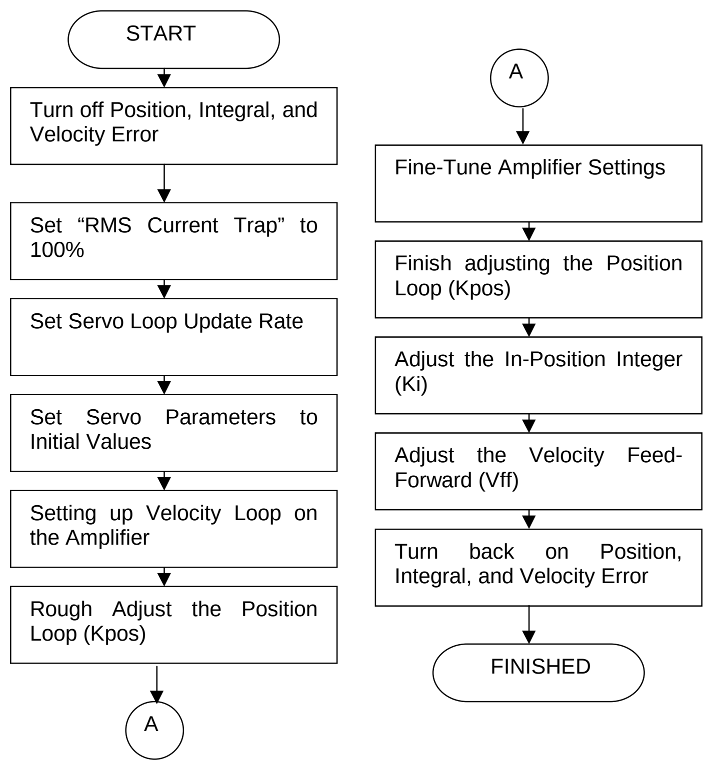
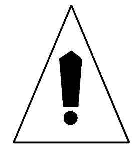


Figure 8-19. Flowchart of Overall Tach Tuning Process

The following is a step-by-step procedure for tuning motors with tachometers.

Please read each step thoroughly before performing the task.


IMPORTANT

1. Turn off the "Position Error," "Integral Error" and "Velocity Error" traps. In the UNIDEX 511 Parameter Editor, deselect the Position Error, Integral Error and Velocity Error in the "Faults" parameter tab. Refer to Figure 8-20

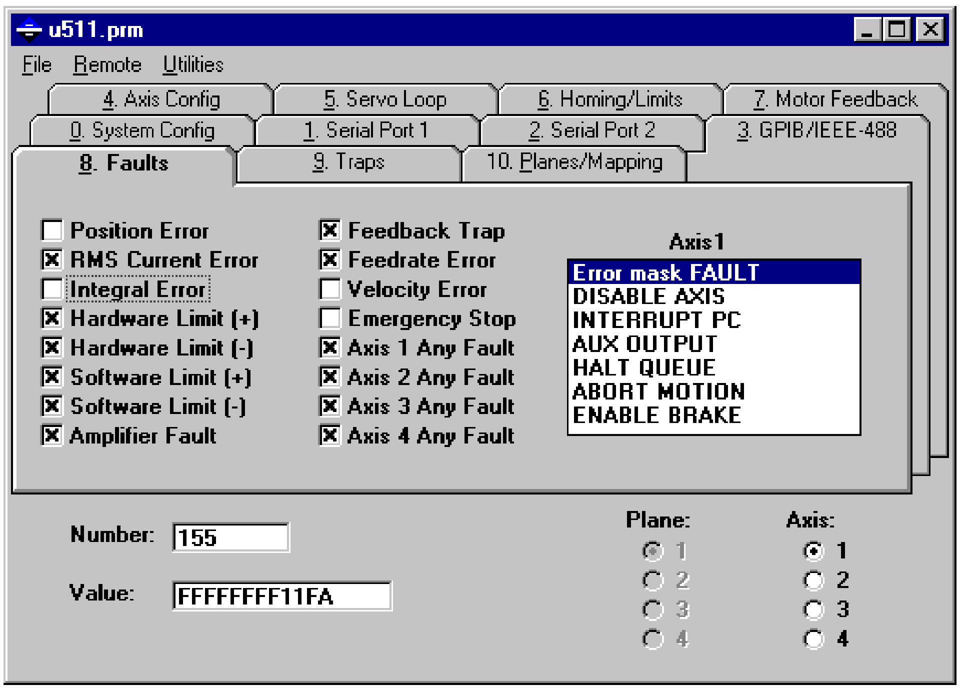


Figure 8-20. Faults Tab of the Parameter Editor

2. Set the "RMS current trap" parameter to 100%. While still in the Parameter Editor window, select the parameter tab called "Traps." Set the parameter, "RMS current trap," to 100%.

3. The "Loop update rate (*.25 ms)" parameter from the Servo Loop tab, shown in Figure 8-21 must be set appropriately in order to get optimal performance from the system. The default update rate is 0.25 ms (4 kHz) and the user would put a 1 as that parameter's value. Another common choice is 1 ms (1 kHz) and the user would put a 4 as that parameter's value. Some low resolution systems (500 line encoders, etc.), high inertia systems, or low velocity systems perform better at lower update rates such as 1 kHz. If the user doesn't know what to use for this parameter then an update rate of 4 kHz should be used. However, an update rate of 1 kHz can be used. If the update rate is changed, the tuning process must be repeated.

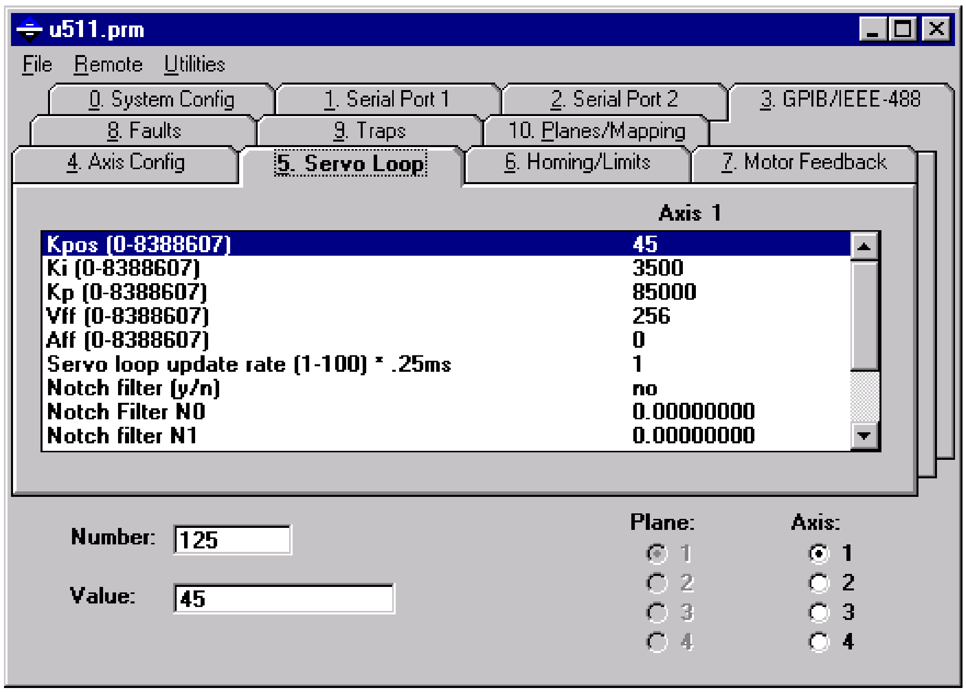


Figure 8-21. Servo Loop Tab of the Parameter Editor

4. Set servo parameters to initial value. While still in the Parameter Editor window (refer to Figure 8-21) enter in the initial values for the servo gains. Table 8-7 has the initial values for these servo gains.

Table 8-7. Initial Servo Parameter Values - Tach Tuning

"Kpos"	"Ki"	"Kp"	"Vff"	"Aff"
0	0	0	0	Always 0

Save the values set in the Parameter Editor window and then exit this window. Reinitialize the UNIDEX 511 by pressing the RESET button.

5. Set up the Velocity Loop on the amplifier.

> If the user has a non-Aerotech amplifier, the manufacturer should provide information for setting the amplifier to Velocity Command and explain how to optimize the Velocity Loop.

If the user has a DS16020/DS16030 Aerotech amplifier, the Velocity Loop is adjusted the following way:

a. Select a fuse to protect the motor for the continuous current rating of the motor and insert it in the appropriate fuse holder of the amplifier. Refer to Figure 8-22 for location of the fuse holder.

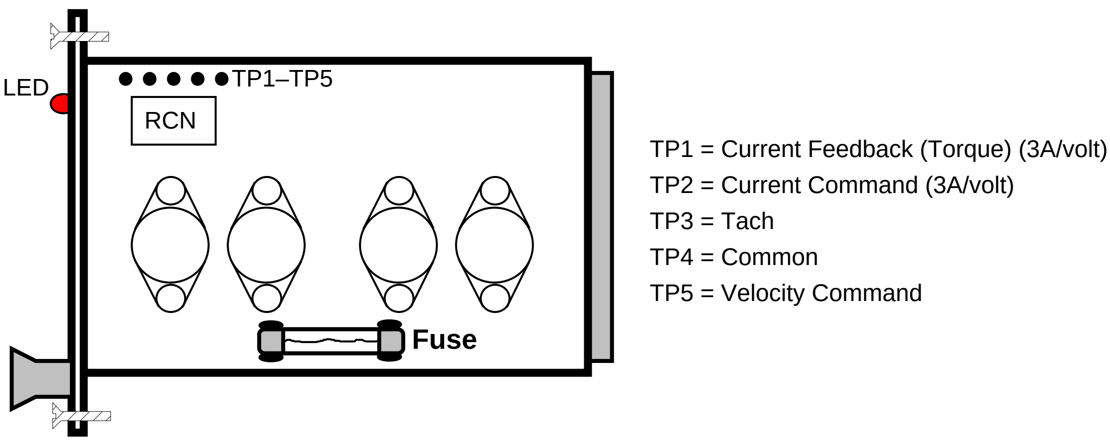


Figure 8-22. Cross-section of the DS16020/16030 Amplifier

b. Make ballpark adjustments to the potentiometers on the Aerotech DS16020/16030 amplifier as shown in Figure 8-23.

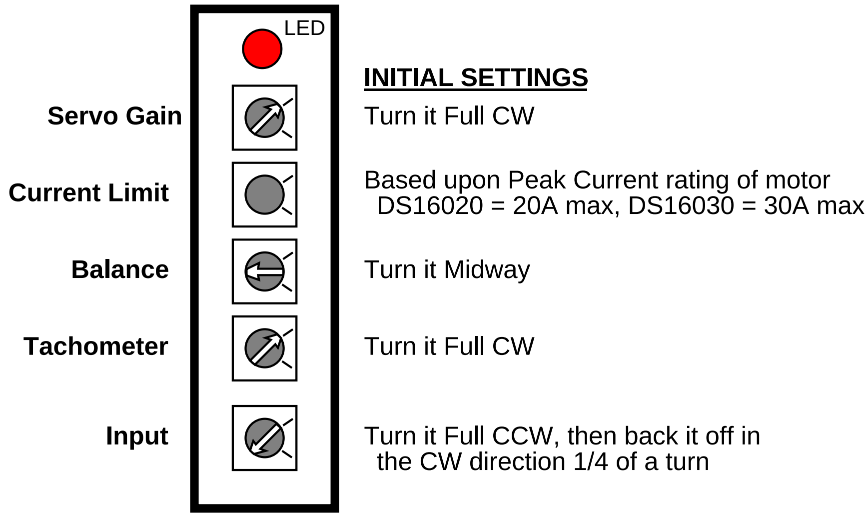


Figure 8-23. Amplifier Potentiometer Layout

> The initial setting of the Current Limit potentiometer is based upon the peak current rating of the motor. If the user has a motor with a 10 A peak current rating and a DS16020, which has a maximum current output of 20 A, set the Current Limit potentiometer to midway for a representation of 10 A. Then back it off 1/8 turn in the CW direction. Full CW allows the minimum amount of current through and full CCW allows the maximum.

c. Adjust the Servo Gain potentiometer on the amplifier by first enabling the axis and then turning the potentiometer counterclockwise (CCW) until the motor oscillates (i.e., the stage vibrates). The motor will produce a screeching sound when it oscillates. Back the gain off by turning it clockwise (CW) until the oscillation stops. Make another 1/8 turn CW from that position so it's not on the borderline of having the motor oscillate.

6. Prepare the Axis Scope window for tuning by performing the following functions:

a. Press the MAXIMIZE button on the Axis Scope window so the Axis Scope window fills the entire screen.

b. In the Collect menu select "2500 points."

c. In the Display menu select "2500 points."

d. In the Axis menu select axis number 1 (X axis) or the axis that will be tuned.

e. In the Plot menu select Velocity Command and Position Error.

f. In the Trigger menu, set the Forward Motion... and Reverse Motion... to a typical move. For metric mode, a move such as *LINEAR X10 F2000* for Forward Motion... and *LINEAR X-10 F2000* for Reverse Motion... is appropriate. For English mode, moves such as LINEAR X1 F180 and LINEAR X-1 F180 for Forward Motion... and Reverse Motion..., respectively, are appropriate. Also set the Sample Rate to 1.

g. In the Tools menu select Status, Control, and Gains.

When the SINGLE button is pressed, axis number 1 will first move as specified by the Forward Motion.... When the SINGLE button is pressed again, axis number 1 will move as specified by the Reverse Motion....

7. Adjust the "Kpos" position gain in order to get the position error to end at or near the same time the Velocity Command ends. Entering a value in the "Kpos" box on the Axis Scope window makes the adjustment to "Kpos." Refer to Figure 8-4. If "Kpos" is set too high, the position error will visibly oscillate and the motor will vibrate. The user is not striving to reduce the position error, though that will happen. However, the axis needs to be rough tuned because the following step will be to fine tune the potentiometers on the amplifier.

Since all Servo Gains are set to zero, the user must set the "Kpos" to a starting value, otherwise the stage won't move. Normal starting values are 10, 100, 1000, etc.

Once the stage is moving, the user should see a graph similar to the one in Figure 8-24. This graph illustrates that "Kpos" is too low. The stage moves slowly in the positive direction and then in the negative direction.

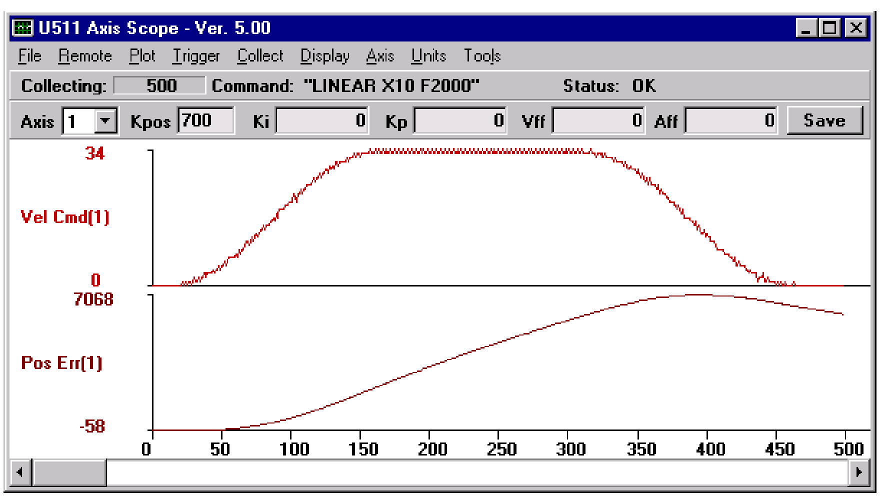


Figure 8-24. Axis Scope Window Showing "Kpos" Too Low

If the motor doesn't move then "Kpos" is too low. Increase the value of "Kpos" and try again by pressing the SINGLE button.

The stage may want to drift away on its own when it is enabled. Increasing "Kpos" will stop this.

If the user is adjusting the gains that Aerotech has provided for the system, use the existing "Kpos" as the starting point.

When "Kpos" is increased, the position error is beginning to end at or near the end of the commanded move as illustrated in Figure 8-25. The axis is roughly tuned, so continue with the following step.

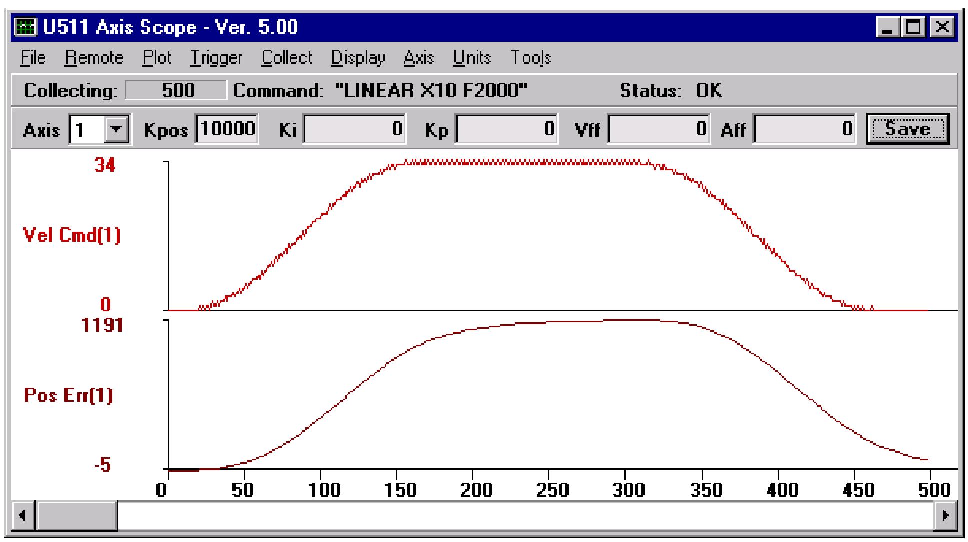


Figure 8-25. Plot Showing a Roughly Tuned Axis (When Adjusting "Kpos")

8. This step requires fine tuning the amplifier settings. First, adjust the Balance pot on the amplifier in order to remove any DC offset in the position error. Press the AUTO button to repetitively move the stage in the forward motion and reverse motion. While the stage is moving, adjust the Balance pot and remove any DC offset in the position error. Press the STOP button when the task is done. This is shown in Figure 8-26.

Second, the user will fine tune the Current Limit pot on the Aerotech DS16020/16030 amplifiers after commanding the motor to move short, fast moves and observing the current feedback from TP1 on the amplifier with an oscilloscope (O-scope). In order to do this, perform the following steps.

a. Connect the O-scope leads to TP1 (current feedback) and TP4 (common) on the amplifier.

b. Select the Trigger menu on the Axis Scope window and set up the Forward Motion... and Reverse Motion... to represent a short fast move.

c. Press the AUTO button and allow the stage to repetitively move in the forward and reverse motion.

d. While the stage is moving, adjust the Current Limit pot to clamp the current to either 4 times the continuous current rating of the motor or the peak current rating of the motor, whichever is less.

The current feedback on TP1 is 3 amps per volt, so a 2 volt signal on the O-scope would represent 6 amps. Press the STOP button when complete. Figure 8-27 illustrates what the user will see after one move.

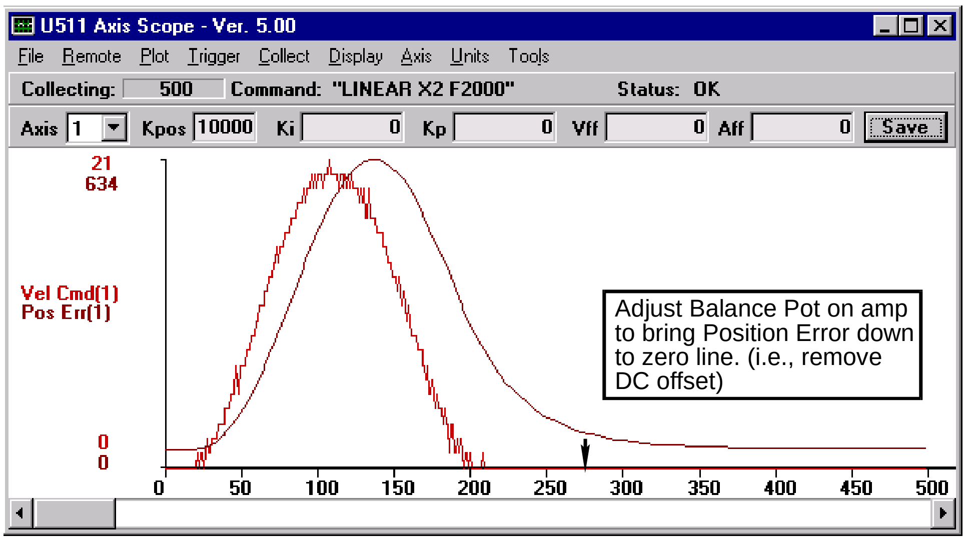


Figure 8-26. Plot Showing the Removal of DC Offsets in the Position Error

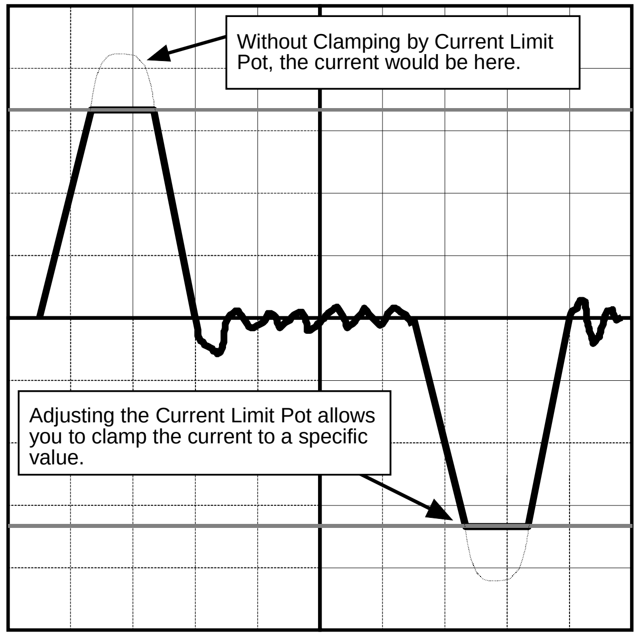


Figure 8-27. O-scope Showing Current Feedback for One Move

Third, if necessary, the user may have to fine tune the Input pot if unable to achieve maximum speed for the motor. To fine tune the Input pot, perform the following procedure.

a. Connect the O-scope to TP5 (Velocity Command) and TP4 (common) on the amplifier.

b. Select the Trigger menu on the Axis Scope window and set up Forward Motion... and Reverse Motion... to represent a move at 1/2 of the maximum speed.

c. Press the AUTO button and allow the stage to repetitively move in the forward and reverse motion.

d. While the stage is moving, adjust the Input pot so that when the motor is moving at 1/2 speed the Velocity Command on TP5 is 4 volts.

e. Press the STOP button when completed.

9. Finish adjusting the Position Loop ("Kpos") where the main concern is to strive for smoothness in the position error and to have the position error end at or near the same time the Velocity Command ends. After repeating the process of starting and stopping the axis and adjusting "Kpos" the graph should look like Figure 8-28.

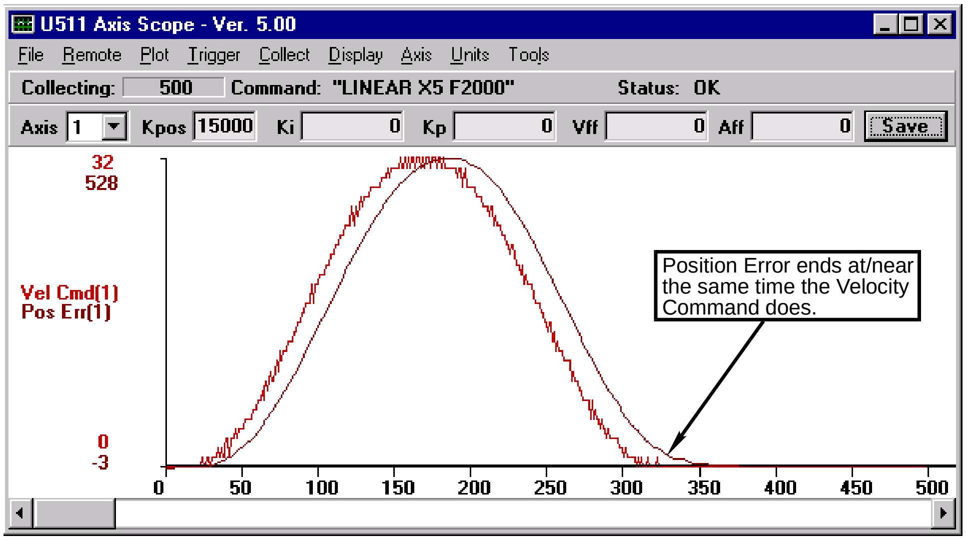


Figure 8-28. Plot Illustrating Smoothness in the Position Error

Referring to Figure 8-28, the position error ends at or near the end of the Velocity Command. The point where the user stops adjusting the "Kpos" depends upon how much settling time is allowed in the system.

If "Kpos" is too high, the motor will oscillate.

10. Adjust the In-Position Integrator ("Ki") to remove any drift (DC offset) in the position error that might not have been removed with the Balance pot. Increasing "Ki" may help the position error to end closer to the end of the Velocity Command.

If "Ki" is too high, the settling time will increase as the position error begins to oscillate after the end of the Velocity Command.

Figure 8-29 is a plot that displays a case where "Ki" is too high and Figure 8-30 shows a plot of the position error with the appropriate "Ki" value.

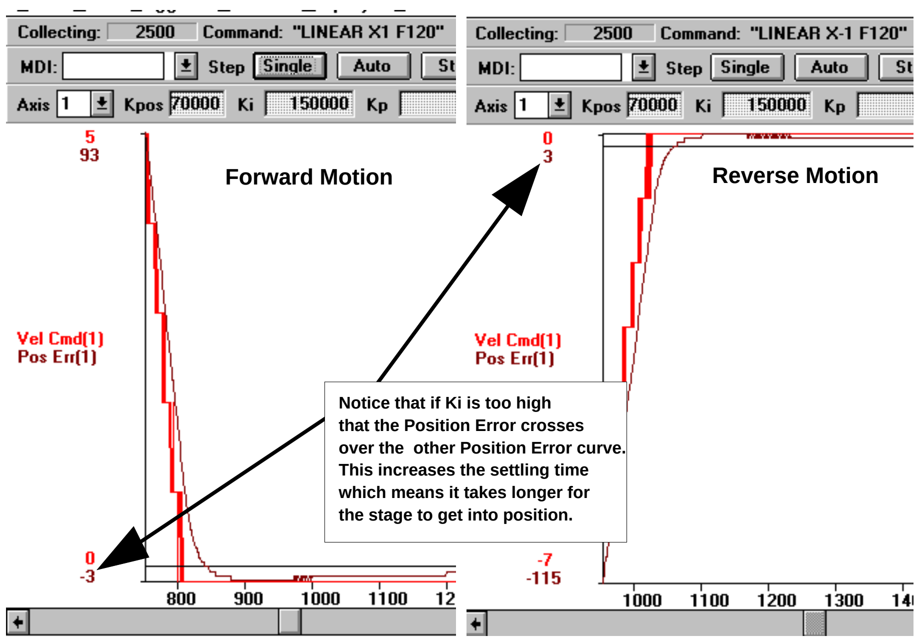


Figure 8-29. Plot Showing Effects on Position Error (When "Ki" is too High)

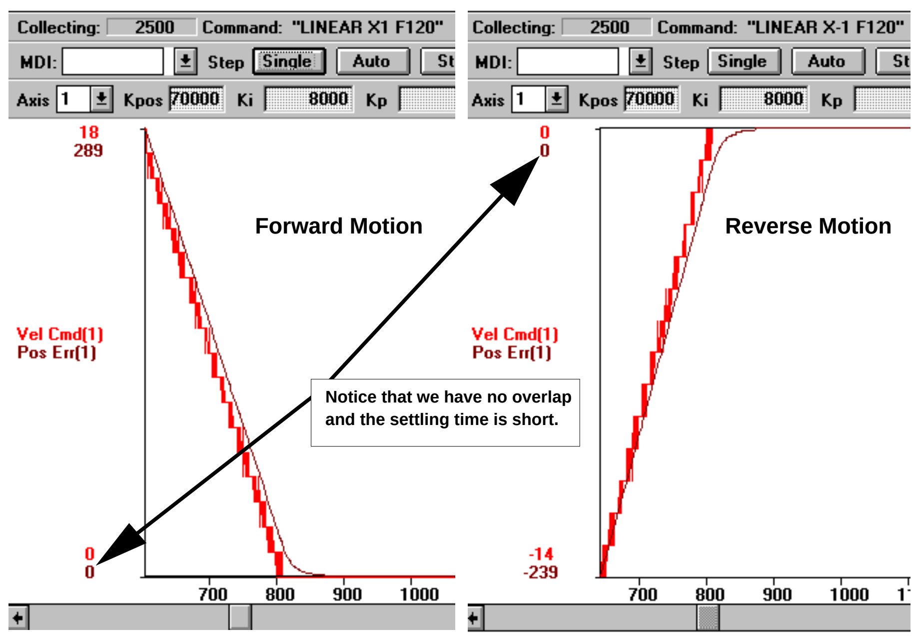


Figure 8-30. Plot of the Position Error With Appropriate "Ki" Value

11. Adjust the Velocity feedforward value to reduce the position error (if desired). When doing this, attempt to get the position error within 10 to 20 machine steps of error. The objective is to obtain smoothness in the Position Error and to get within 10 to 20 counts of error. Figure 8-31 illustrates that "Vff" has reduced the amount of position error. However, "Vff" still needs to be increased so the position error can be reduced some more. This is shown in Figure 8-32 where the position error has been reduced to within 10 counts of error. It is OK to allow some following error in the system.

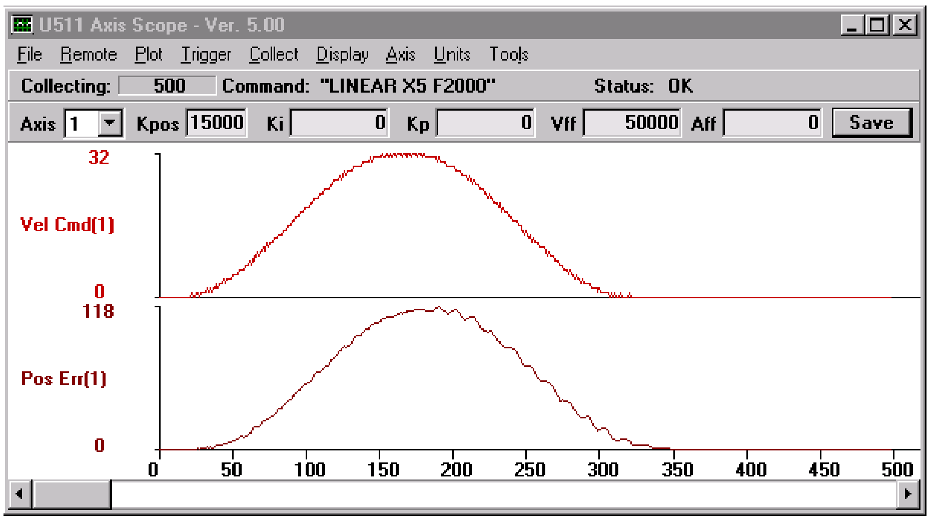


Figure 8-31. Position Error After Increasing "Vff"

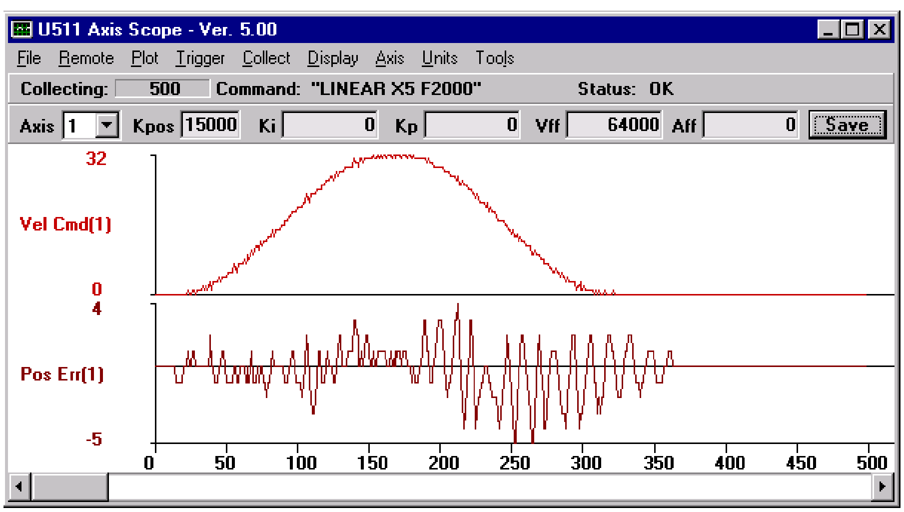


Figure 8-32. Position Error Reduced to Within 10 Counts of Error Using "Vff"

Shown in Figure 8-33 is plot of what happens when "Vff" is set too high and the position error reverses direction. Notice that the "Vff" was not increased much and that the position error increased.

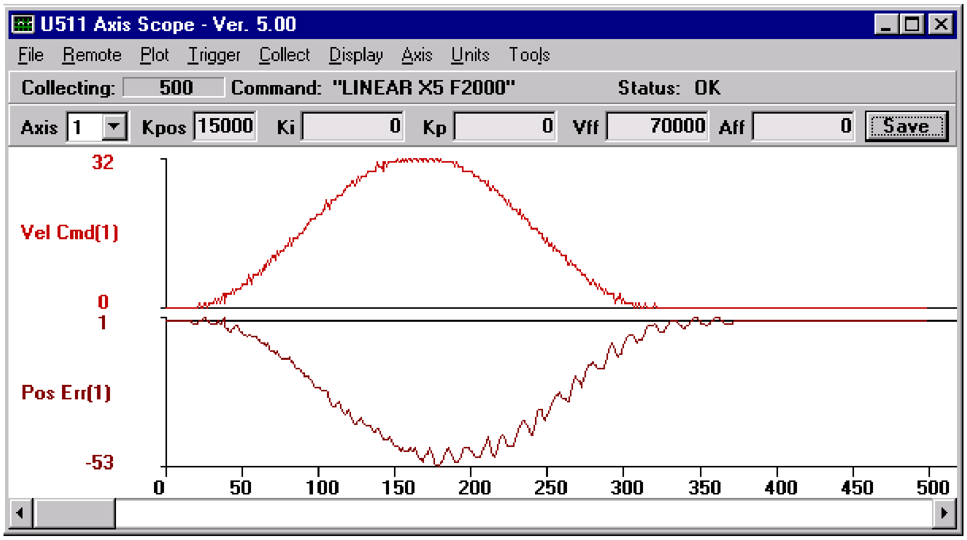


Figure 8-33. Plot of Position Error When "Vff" is too High

12. Turn the Position Error, Integral Error, and Velocity Error traps on by returning to the U511 Parameters Editor window and selecting the Parameter tab called "Faults." Turn the "Position Error," the "Integral Error," and the "Velocity Error" back on by checking the boxes. This will reactivate these traps.

    Save and exit the Parameter Editor window.

    Reinitialize the UNIDEX 511.

∇ ∇ ∇

CHAPTER 9: PROGRAMMING EXAMPLES

In This Section:

9.1. Introduction

This chapter is intended to provide an overview of several UNIDEX 511 applications. It is assumed that you have unpacked and checked the U511 system, configured the hardware and software, installed the necessary components, and are otherwise ready to begin using the UNIDEX 511 system in a *real* application.

The application examples and associated programs in this section are intended to give the reader only a general overview of just some of the capabilities of the UNIDEX 511 system. These samples provide some basic fundamentals on which more advanced (and virtually unlimited) applications may be realized.

The program examples shown in this Chapter use comments (descriptive text that follows a semicolon ";" character) to explain the program statements. While thorough (and relevant) commenting in a program is very useful (and is encouraged), it may be necessary to limit the amount of comments in your program if the program size (including comments, commands, etc.) becomes larger than 64K. Another way to reduce program size is to use the abbreviated forms of commands (usually the first two letters in the command name) or G-codes whenever possible.

9.2. Incremental (Relative) Motion with Velocity Profiling

In this application, the UNIDEX 511 is used to *outline* (that is, etch or cut the shape of) a part using two axes (X and Y). The part is outlined using a program consisting of some setup statements and 15 individual movements. The outline shape and the individual movements are illustrated in Figure 9-1. In addition, incremental (relative) coordinates (ΔX,ΔY) are given for the beginning and end points of each movement as well as the home position (0,0). The center points for circular motions are shown as **X**'s with their relative center point coordinates given as well.

Velocity profiling is a programming feature that, when enabled, ensures that the path velocity for the entire shape remains constant. Without velocity profiling, acceleration and deceleration would occur between the paths of individual movements (producing a very *segmented* motion). Velocity profiling is not recommended for motions that make extreme direction changes (for example, 90° turns). Such changes will often cause faults to occur. For this reason, velocity profiling can be temporarily enabled or disabled throughout a program. This is illustrated in the example that follows.

In Figure 9-1, notice that velocity profiling is disabled prior to starting move number 12, and then reenabled at the end of this movement. This movement begins and ends with sharp (90°) angles (which could cause faults if velocity profiling is used), therefore velocity profiling is disabled during this portion of the part outline. Because velocity profiling is off during motion 12, the path decelerates as motion 11 is completed, and then accelerates at the beginning of motion 13.

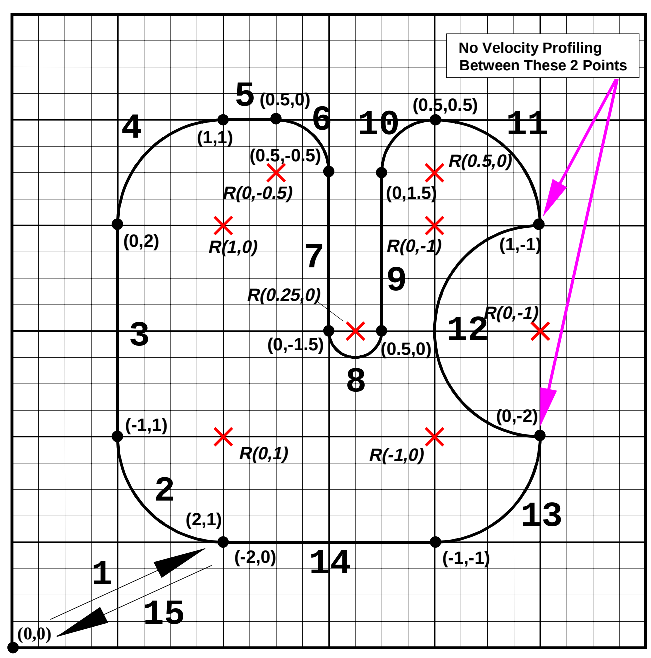


Figure 9-1. Sample Path for Incremental (Relative) Motion Demonstration Using Velocity Profiling

The program used to trace the path in Figure 9-1 (VELOCTY1.PRG), is listed below. Comments have been added for clarity. The program has been rewritten as VELOCTYG.PRG using G codes where possible.

```
;****************************************************************************************
;       Title:          VELOCTY1.PRG
;       Description:    This program traces a part in incremental mode and
;                       shows velocity profiling.
;****************************************************************************************
PROGRAM  EN  IN                   ;Use English and incremental modes
HOME X Y                          ;Send axes home
WAIT OFF                          ;Disable the WAIT command
ROUNDING OFF                      ;Disable corner rounding feature
VELOCITY ON                       ;Turn on velocity profiling
INDEX  X2 Y1                      ;1st move - Move from home

MESSAGE DISPLAY "WAITING 5 SECONDS!!!!"      ;Let operator know
DWELL 5000                                   ;we're pausing...

CW_CIRCLE X-1 Y1 C0,1 F100        ;2nd move - CW arc (circle)
LINEAR X0 Y2                      ;3rd move - Vertical (linear) move
CW_CIRCLE X1 Y1 C1,0              ;4th move - CW arc (circle)
LINEAR X.5 Y0                     ;5th move - Horizontal (linear) move
CW_CIRCLE X.5 Y-0.5 C0,-.5        ;6th move - CW arc (circle)
LINEAR X0 Y-1.5                   ;7th move - Vertical (linear) move
CCW_CIRCLE X.5 Y0 C0.25,0         ;8th move - CCW semicircle
LINEAR X0 Y1.5                    ;9th move - Vertical (linear) move
CW_CIRCLE X.5 Y.5 C.5,0           ;10th move - CW arc (circle)
VELOCITY OFF                      ;11th move - Shut off velocity profiling at
CW_CIRCLE X1 Y-1 C0,-1            ;            end of this move (CW arc)
CCW_CIRCLE X0 Y-2 C0,-1           ;12th move - CCW semicircle
VELOCITY ON                       ;13th move - Restore velocity profiling
CW_CIRCLE  X-1 Y-1 C-1,0          ;            then do CW arc (circle)
LINEAR X-2 Y0                     ;14th move - Horizontal (linear) move

MESSAGE DISPLAY "WAITING 5 SECONDS!!!!!!"    ;Let operator know
DWELL 5000                                   ;we're pausing again...
HOME X Y                          ;15th move - Return to home position.
EXIT                              ;End of program
;****************************************************************************************
;       End of Program VELOCTY1.PRG
;****************************************************************************************
```

```
;*****************************************************************************************
;          Title:             VELOCTYG.PRG
;          Description:       This program traces a part in incremental mode and
;                             shows velocity profiling using G codes.
;*****************************************************************************************
G70                                      ;Use English mode
G91                                      ;Use incremental mode
HOME X Y                                 ;Send axes home
G8                                       ;Turn on velocity profiling
G0  X2  Y1                               ;1st move - Move from home

MESSAGE DISPLAY "WAITING 5 SECONDS!!!!"           ;Let operator know
G4  5000                                          ;we're pausing...

G2  X-1 Y1 C0,1  F100                    ;2nd move - CW arc (circle)
G1  X0  Y2                               ;3rd move - Vertical (linear) move
G2  X1 Y1 C1,0                           ;4th move - CW arc (circle)
G1  X.5 Y0                               ;5th move - Horizontal (linear) move
G2  X.5 Y-0.5 C0,-.5                     ;6th move - CW arc (circle)
G1  X0 Y-1.5                             ;7th move - Vertical (linear) move
G3  X.5 Y0 C0.25,0                       ;8th move - CCW semicircle
G1  X0 Y1.5                              ;9th move - Vertical (linear) move
G2  X.5 Y.5 C.5,0                        ;10th move - CW arc (circle)
G9                                       ;11th move - Shut off velocity profiling at
G2  X1 Y-1 C0,-1                         ;               end of this move (CW arc)
G3  X0 Y-2 C0,-1                         ;12th move - CCW semicircle
G8                                       ;13th move - Restore velocity profiling
G2  X-1 Y-1 C-1,0                        ;               then do CW arc (circle)
G1  X-2 Y0                               ;14th move - Horizontal (linear) move

MESSAGE DISPLAY "WAITING 5 SECONDS!!!!!!"         ;Let operator know
G4  5000                                          ;we're pausing again...

HOME X Y                                 ;15th move - Return to home position.
M2                                       ;End of program
;*****************************************************************************************
;          End of Program VELOCTYG.PRG
;*****************************************************************************************
```

9.3. Absolute Motion with Velocity Profiling

In this application, the UNIDEX 511 is used to *outline* (that is, etch or cut the shape of) a part using two axes (X and Y). The part is outlined using a program consisting of some setup statements and 15 individual movements. The outline shape and the individual movements are illustrated in Figure 9-2. In addition, absolute coordinates (X, Y) are given for the beginning and end points of each movement as well as the home position (0,0). The center points for circular motions are shown as **X**'s with their absolute center point coordinates given as well (Centers of circles are always incremental). This application is the same as the previous application except that absolute motion is used instead of relative motion.

In Figure 9-2, notice that velocity profiling is disabled prior to starting move number 12, and then re-enabled at the end of this movement. This movement begins and ends with sharp (90°) angles (which could cause faults if velocity profiling is used), therefore velocity profiling is disabled during this portion of the part outline. Because velocity profiling is off during motion 12, the path decelerates as motion 11 is completed, and then accelerates at the beginning of motion 13.

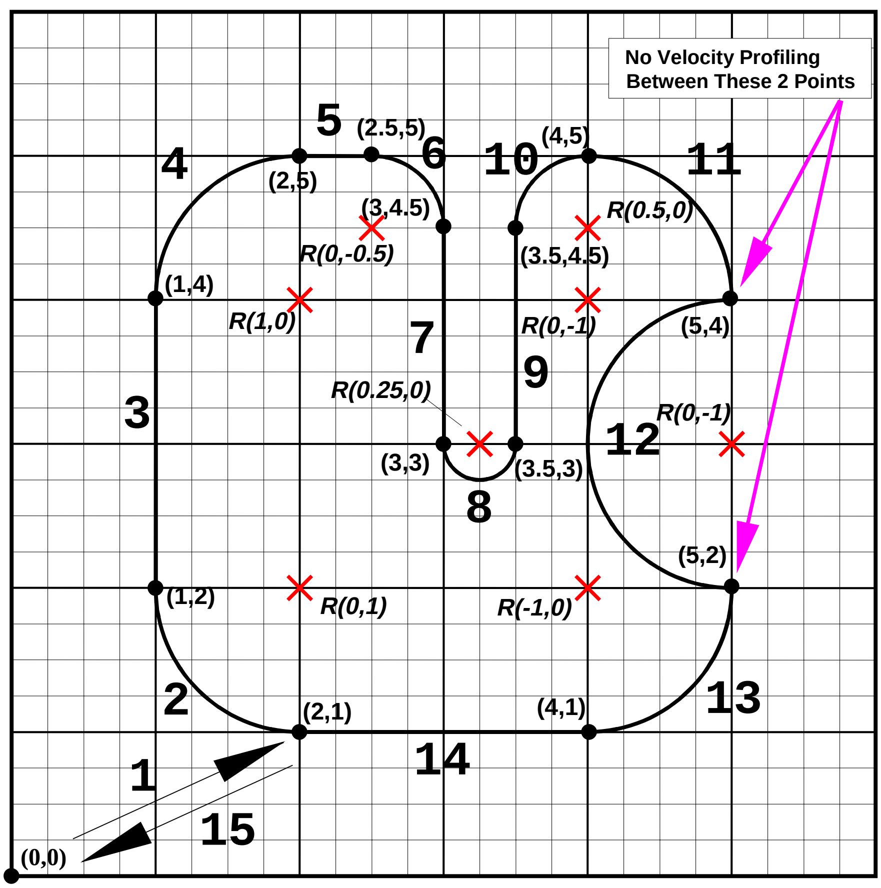


Figure 9-2. Sample Path for Absolute Motion Example Using Velocity Profiling

```
;****************************************************************************************
;           Title:                  VELOCTY2.PRG
;           Description:            This program traces a part in absolute mode and
;                                   shows velocity profiling.
;****************************************************************************************
HOME X Y                                ;Send axes home
WAIT OFF                                ;Disable the WAIT command
ROUNDING OFF                            ;Disable corner rounding feature
VELOCITY ON                             ;Turn on velocity profiling
INDEX  X2 Y1                            ;1st move - Move from home

MESSAGE DISPLAY "WAITING 5 SECONDS!!!!"          ;Let operator know
DWELL 5000                                       ;we're pausing...

CW_CIRCLE X1  Y2  C0,1  F50             ;2nd move - CW arc (circle)
LINEAR X1  Y4                           ;3rd move - Vertical (linear) move
CW_CIRCLE X2  Y5  C1,0                  ;4th move - CW arc (circle)
LINEAR X2.5  Y5                         ;5th move - Horizontal (linear) move
CW_CIRCLE X3  Y4.5  C0,-0.5             ;6th move - CW arc (circle)
LINEAR X3  Y3                           ;7th move - Vertical (linear) move
CCW_CIRCLE X3.5  Y3  C0.5,0             ;8th move - CCW semicircle
LINEAR X3.5  Y4.5                       ;9th move - Vertical (linear) move
CW_CIRCLE X4  Y5  C0.5,0                ;10th move - CW arc (circle)
VELOCITY OFF                            ;11th move - Shut off velocity profiling at
CW_CIRCLE X5  Y4  C0,-1                 ;              end of this move (CW arc)
CCW_CIRCLE X5  Y2  C0,-1                ;12th move - CCW semicircle
VELOCITY ON                             ;13th move - Restore velocity profiling
CW_CIRCLE  X4  Y1  C-1,0                ;              then do CW arc (circle)
LINEAR X2  Y1                           ;14th move - Horizontal (linear) move

MESSAGE DISPLAY "WAITING 5 SECONDS!!!!!!"        ;Let operator know
DWELL 5000                                       ;we're pausing again...

HOME X Y                                ;15th move - Return to home position.
EXIT                                    ;End of program
;****************************************************************************************
;           End of Program VELOCTY2.PRG
;****************************************************************************************
```

9.4. CNC Demonstration Using Velocity Profiling, Linear, and Circular Interpolation

```
;*******************************************************************************************
;This program is a CNC demonstration.  It uses velocity profiling
;along with linear and circular interpolation.  The part is first cut
;using velocity profiling, then without velocity profiling.
;*******************************************************************************************
PROGRAM ENGLISH INCREMENTAL   ;Program in English, incremental mode
ENABLE X Y                    ;Enable the axes
G0 X5                         :Shape is created using
G8 G1 X10 Y10 F100            ;velocity profiling
G2 X0 Y-10 I0 J-5 F200        ;Clockwise semicircle
G1 X-10 Y10 F100              ;Linear move
G9 G3 X0 Y-10 C0,-5 F300      ;Velocity profiling turned off
                              ;at the end of this move
DW 3000                       ;Dwell (wait) for 3 seconds

G1 X10 Y10 F100               ;Create same shape again
                              ;without velocity profiling
G2 X0 Y-10 I0 J-5 F200
G1 X-10 Y10 F100
G3 X0 Y-10 C0,-5 F300
M0                          ;Wait until cycle key is hit
AGAIN                         ;Repeat program
EXIT
```

9.5. Corner Rounding

In this application, the UNIDEX 511 is used to *outline* a square using two axes (X and Y). The part is outlined using a program consisting of some setup statements and 4 linear absolute movements. The outline shape and the individual movements are illustrated in Figure 9-3. In addition, absolute coordinates (X, Y) are given for the beginning and end points of each linear movement. Rather than incorporating circular motions at the corners of the square, the corner rounding function is enabled. This feature provides an easy way to smooth *sharp edges* or to create *fillets* without having to incorporate circular motions into the program.

For rounded edges that require precise circular contouring, it is recommended that the programmer use the circle commands (CW and CCW) rather than the corner rounding feature.

An illustration of the square outline using corner rounding is shown in Figure 9-3. The associated program listing follows.

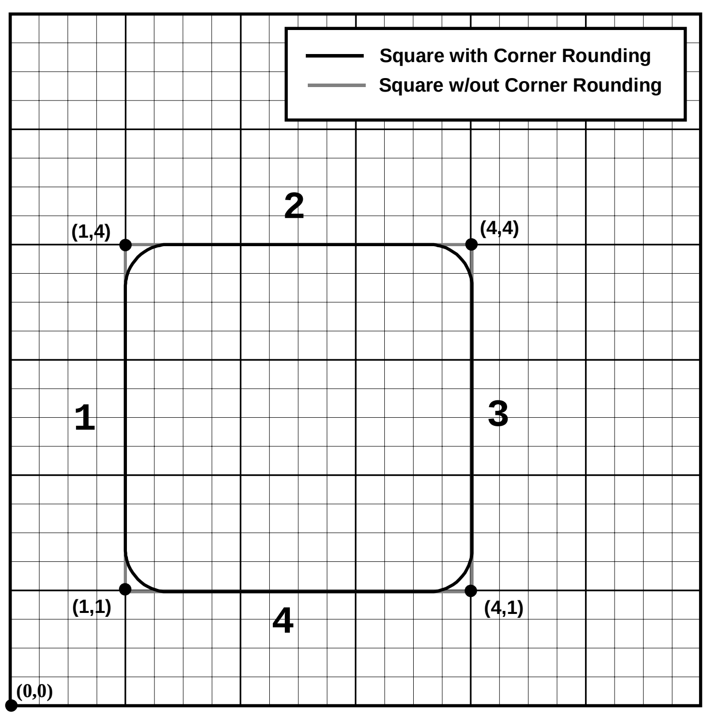


Figure 9-3. Sample Path of Square With and Without the Rounding Feature

```
;****************************************************************************************
;          Title:              CORNER.PRG
;          Description:        This program demonstrates the effects of using the
;                              corner rounding feature.
;****************************************************************************************

PROGRAM EN  AB                  ;Use English and absolute modes
HOME X Y                        ;Send axes home
WAIT OFF                        ;Disable the WAIT command
INDEX  X1 Y1                    ;Move into position, then prompt the
                                ;operator for a rounding time (msec).

MESSAGE DISPLAY+V0  "Enter Rounding Time (msec): "

IF  V0<>0  :DOROUND             ;Do rounding for any non-zero time
ROUNDING OFF                    ;Else, shut off rounding
GOTO :CONT                      ;Continue (merge)

:DOROUND                        ;Perform the rounding
ROUNDING ON                     ;First turn rounding ON
ROUNDING V0                     ;Set the rounding time

:CONT                           ;Do the square
LINEAR  X4  Y1                  ;1st move
LINEAR  X4  Y4                  ;2nd move
LINEAR  X1  Y4                  ;3rd move
LINEAR  X1  Y1                  ;4th move

ROUNDING OFF                    ;Done.  Turn off the rounding feature.
DWELL 2000                      ;Pause
HOME  X  Y                      ;Return to home position.

EXIT                            ;End of program
;****************************************************************************************
;          End of Program CORNER.PRG
;****************************************************************************************
```

The non-ramp time may be included as part of the ROUNDING command or may be set through general parameters 028, 046, 064, and 082 (the "Corner rounding time" parameters). Programming a non-ramp time through the ROUNDING command overrides, but does not change the settings of general parameters 028, 046, 064, and 082.

The non-ramp time value that you specify (either in the program or through the appropriate general parameters) is proportional to the amount of corner rounding that will take place. For example, a small rounding time will yield parts with very slightly rounded corners. A large rounding time will yield parts with a more pronounced amount of rounding. Since other factors such as acceleration/deceleration times, feedrate, etc. determine the extent of rounding, it may be necessary to experiment several times before the desired amount of rounding is achieved.

9.6. GEAR Demonstration of a Master Axis with Two Slave Axes

This demonstration shows how the GEAR command is used. In this example, two slave axes are controlled from a single master axis. Gear ratios for the slave axes and the master axis are entered as variables (in machine counts). The machine count values for each axis can have a maximum value of 8,388,608 and can be either positive or negative. If the machine counts for a master/slave axis pair have different signs (for example, the master has a positive number of machine counts and the slave has a negative number of machine counts), then that master/slave pair will move in opposite directions (that is, a CW move of the master axis will produce a CCW move of the slave axis).

Next, the master axis is disabled, allowing it to be turned manually. As the master axis is moved, the slave axes respond based on the master's movement and the respective master to slave gear ratios. The master axis can be enabled and moved automatically through program control if desired. The gear program, GEAR.PRG, follows.

```
;*******************************************************************************************
;       Title:          GEAR.PRG
;       Description:    This program demonstrates the use of the GEAR
;                       programming statement to create a single master
;                       axis that is followed by two slaves axes at user-
;                       definable rates (gear ratios).
;*******************************************************************************************
PROGRAM  ME  IN                          ;Use Metric and incremental modes
MESSAGE DISPLAY "The X & Y axes will be slaves to the Z axis."
MESSAGE DISPLAY "You must supply the ratio of Z counts to the other axes."
MESSAGE DISPLAY " "
MESSAGE DISPLAY "Requesting Z to X ratio:  (Z counts to X counts)"
MESSAGE DISPLAY+V0 " # of Z counts"
MESSAGE DISPLAY+V1 " # of X counts"
MESSAGE DISPLAY " "
MESSAGE DISPLAY "Requesting Z to Y ratio:  (Z counts to Y counts)"
MESSAGE DISPLAY+V2 " # of  counts"
MESSAGE DISPLAY+V3 " # of Y counts"
MESSAGE DISPLAY " "
MESSAGE DISPLAY "The X to Z ratio is %.0FV0 to %.0FV1"
MESSAGE DISPLAY "The Z to Y ratio is %.0FV2 to %.0FV3"
MESSAGE DISPLAY " "
GEAR 1,3,V1,V0                           ;Link slave axis 1 (X) with master 3 (Z)
                                         ;using the specified gear ratios
GEAR 2,3,V3,V2                           ;Link slave axis 2 (Y) with master 3 (Z)
                                         ;using the specified gear ratios
ENABLE X Y                               ;Enable slave axes X and Y
DISABLE Z                                ;Disable master axis Z so it can be turned
                                         ;manually
MESSAGE DISPLAY "Z axis is disabled, so you can move it by hand."
MESSAGE DISPLAY " "
MESSAGE DISPLAY "  - Type 'GEAR 1,0,0' to disable X axis"
MESSAGE DISPLAY "  - Type 'GEAR 2,0,0' to disable Y axis"
MESSAGE DISPLAY " "
```

```
;*******************************************************************************************
;          End of Program GEAR.PRG
;*******************************************************************************************
```

9.7. Interlocking Contour Planes

```
;*******************************************************************************************
;This program is an interlocking contour plane example.  The program will make a
;move in plane 1, at the end of that move it will trigger plane 2 to start.  Plane 1
;will then make a CW circle and be halted.  Plane 2 will make a move and trigger
;plane 1 to begin again.
;
;Note:  Set parameter 000 equal to 2 to allow for 2 contour planes
;*******************************************************************************************

MAP 1,1,X,2,1,Y,3,2,X,4,2,Z
PLANE 2 ENABLE X                ;Drive 3 in plane 2 (X)
                                ;Drive 4 in plane 2 (Z)
HALT                            ;Stop motion of plane 2
G0 X50 F100                     ;Move 2, plane 2 motion put into buffer
PLANE 1 ENABLE X Y
G0 X50 Y50 F100                 ;Move 1, plane 1 motion
WAIT ON                         ;Wait until move 1 is done
                                ;to begin 3 axis move 2
START 2                         ;Start plane 2 after motion in plane 1
G2 X0 Y0 C0,20 F500             ;Move 2, CW circle in plane 1
WAIT ON                         ;Wait until move 2 is finished
                                ;to begin move 3
START 2
HALT                            ;Stop motion in plane 1
G0 X50 Y50 F100                 ;Move 4, plane 1 motion put into buffer
PLANE 2
G0 X-25                         ;Move 3, plane 2 motion
WAIT ON                         ;Wait until move 3 is finished
                                ;to begin 3 axis move 4
START 1                         ;Start motion of plane 1
G0 X-25                         ;Move 4, plane 2 motion
EXIT
```

9.8. Splining

This program is an example of splining. Refer to Figure 9-4 for the output of the program.

```
;*******************************************************************************************
;This is an example of splining.  The part will be cut at a constant velocity.
;*******************************************************************************************
        PROGRAM ENGLISH INCREMENTAL
        ENABLE X Y
        OUTPUT 0X00                 ;Sets all outputs low, high z impedance
        SPLINE ON                   ;Turn on spline
        X1  Y3  L  F100             ;L denotes a linear motion, no splining for
                                    ;Motion to this position
        X0.06  Y0.1                 ;Position 2
        X0.14  Y0.2                 ;Position 3
        X0.2   Y0.07                ;Position 4
        X0.2   Y0.03                ;Position 5
        X5     Y-0.2    L           ;Linear move to this position
        X0.1   Y-0.02               ;Position 7
        X0.08  Y-0.08               ;Position 8
        X0.02  Y-0.1                ;Position 9
               Y-3.2    L           ;Linear move to this position
        X-0.02 Y-0.1                ;Position 11
        X-0.08 Y-0.08               ;Position 12
        X-0.1  Y-0.02               ;Position 13
        X-6.2           L           ;Linear move to this position
        X-0.1  Y0.01                ;Position 15
        X-0.13 Y0.04                ;Position 16
        X-0.1  Y0.05                ;Position 17
        X-0.09 Y0.2                 ;Position 18
        X0.02  Y0.1                 ;Position 19
        SPLINE OFF                  ;Turn off spline
        EXIT
```

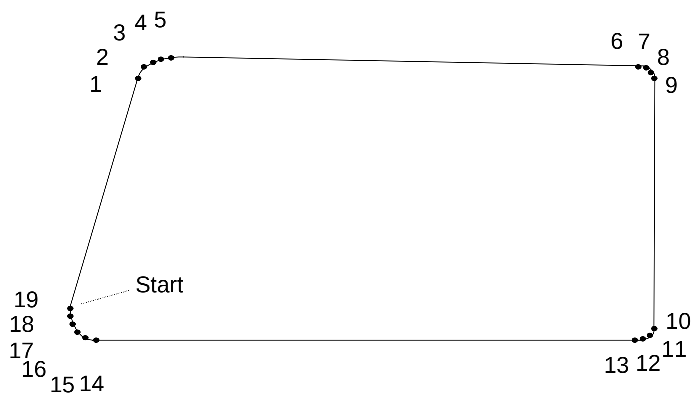


Figure 9-4. Output from Splining Example

9.9. Programming Using Inputs

```
;*******************************************************************************************
;This program is a CNC example.  Motion depends on input bit 0.  The program
;stays in a wait loop until input bit 0 is a 0.  When the input goes low, motion is
;completed and the program loops back and checks the input bit again.  The
;"start button" is assumed to pull input bit 0 low when the button is pressed.
;*******************************************************************************************
WAIT ALL                    ;Wait for each command to finish before
                            ;processing next
ENABLE X Y                  ;Enable the axes
HOME X Y                    ;Send x and y home
G0 X5 Y3 XF500 YF500        ;Move x and y to starting point
G92                         ;Set software home, reset axes to 0

:start
MESSAGE DISPLAY "Press start button to begin"

:wait
IF $IN0 = 1 :wait           ;Loops until bit 0=0
G2 X-2 Y-2 C0,-2 F100       ;If bit 0=0, complete motion
G0 X2
G0 Y2
MESSAGE DISPLAY "Motion is finished"
DWELL 3000                  ;Wait 3 seconds
GOTO :start                 ;Loop back, wait until bit 0=0 to run again
```

9.10. Part Rotation

This program demonstrates the proper use of the ROTATE or "ROT" command. Refer to Figure 9-5 for the output of the program.

```
;*****************************************************************************************
;          Title:          BOAT2.PRG
;          Description     Demonstrates parts rotation by drawing a
;                          boat every 30 degrees.
;                          Program in Millimeters.
;*****************************************************************************************
PROGRAM ABSOLUTE METRIC UNITS UNITS/MIN
ROT X,Y,0                         ; ROTATION CMD (0 for rotation off)
ENABLE X Y
HOME X Y                          ; Home X, Y
G0 X70 Y70 XF1500 YF1000          ; Move to center
G92                               ; Set all positions to 0
V0=0
LOOP 12

; ############ Boat ################
ROT X,Y,V0                        ; ROTATION CMD (0 for rotation off)
G91                               ; Incremental mode
G1 X50 F750                       ; Move away from center
G92                               ; Set all positions to 0

G90                               ; Absolute mode
G1 X25 F750                       ; Boat deck, default feedrate
                                  ;(1500mm/min)
G1 X20 Y-7.5                      ; Boat end
G3 X17.5 Y-7.5 C-1.25,0           ; Wave
G2 X15 Y-7.5 C-1.25,0             ; Wave
G3 X12.5 Y-7.5 C-1.25,0           ; Wave
G2 X10 Y-7.5 C-1.25,0             ; Wave
G3 X7.5 Y-7.5 C-1.25,0            ; Wave
G1 X0 Y0                          ; Boat front
G2 X12.5 Y22.5 C26.5,0            ; Sail
G3 X12.5 Y0 C25,-11.25            ; Sail
G3 X0 Y0 C-6.25,-17.5             ; Sail
G91                               ; Incremental mode
G1 X12.5                          ; GOTO mast location
G1 Y25                            ; Mast
G1 X5 Y-1.25                      ; Flag
G1 X-5 Y-1.25                     ; Flag
G90                               ; Absolute mode
G2 X25 Y0 C-14,-22.5              ; Sail
G3 X12.5 Y0 C-6.25,-17.5          ; Sail
G3 X12.5 Y22.5 C-25,11.25         ; Sail
```

```
G1 X0 Y0                                ; Return to 0,0
G91                                     ; Incremental mode
G1 X-50 F750                            ; Move back to center
G92                                     ; Set all positions to 0
; ############ Done Boat ################

V0=V0+30
NEXT
EXIT                                    ; End of program
;*******************************************************************************************
;                        End of BOAT2.PRG
;*******************************************************************************************
```

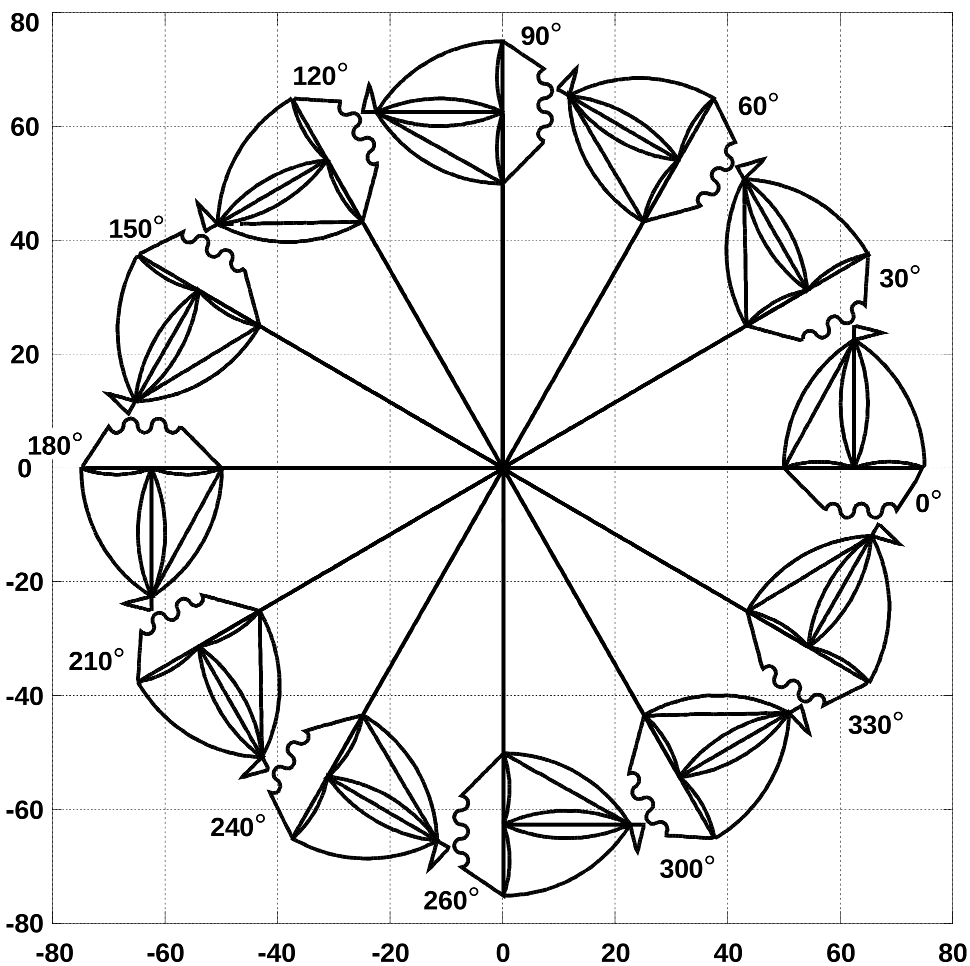


Figure 9-5. Output from Parts Rotation Example Program

9.11. Overriding Scale Factor

This program is an example of the proper use of the SCALE FACTOR or "SCF" command. Refer to Figure 9-6 for a representation of program output.

```
;*******************************************************************************************
;         Title:            BOAT_SCF.PRG
;         Description:      This program demonstrates use of the overriding scale
;                           factor (SCF) command.
;                           Units are Millimeters (Metric).
;*******************************************************************************************
;
PROGRAM METRIC INCREMENTAL UNITS UNITS/MIN
ENABLE X Y
HOME X Y                            ; Home X, Y
G0 X70 Y10 XF1500 YF1000            ; Move to center
G92                                 ; Set all positions to 0

; ######## Make a boat at 1/3 the size ###########
SCF X1/3 Y1/3                       ; Scale Factor Override to 1/3 for X & Y
SUBROUTINE :BOAT

; ######## Make a boat at 64.5% of original size ###########
SCF X0.645 Y0.645                   ; Scale Factor Override to 0.64 for X & Y
SUBROUTINE :BOAT

; ######## Make a boat at original size ###########
SCF X1 Y1                           ; Scale Factor Override to 1 for X & Y
SUBROUTINE :BOAT

; ######## Make a boat at 132.5% of original size ###########
SCF X1.325 Y1.325                   ; Scale Factor Override to 1.3 for X & Y
SUBROUTINE :BOAT

; ######## Traverse to new position ###########
SCF X1 Y1                           ; Turn Scale Factor Override OFF
V0=(1+1.325)*40
G1 Y-V0
G92

; ######## Make a boat at 215.3% of original size ###########
; ######## Boat is a MIRROR Image folded across Y Axis ###########
SCF X-2.153 Y2.153                  ; Scale Factor Override to 2.153 for X & Y
                                    ; (Mirror Image)
SUBROUTINE :BOAT

SCF X1 Y1                           ; Turn Scale Factor Override OFF for x & y
                                    ; axes
DISABLE X Y
EXIT
```

```
; ############ Boat Subroutine ################
:BOAT
G90                             ; Absolute mode
G1 X25 F500                     ; Boat deck, default feedrate (500mm/min)
G1 X20 Y-7.5                    ; Boat end
G3 X17.5 Y-7.5 C-1.25,0         ; Wave
G2 X15 Y-7.5 C-1.25,0           ; Wave
G3 X12.5 Y-7.5 C-1.25,0         ; Wave
G2 X10 Y-7.5 C-1.25,0           ; Wave
G3 X7.5 Y-7.5 C-1.25,0          ; Wave
G1 X0 Y0                        ; Boat front
G2 X12.5 Y22.5 C26.5,0          ; Sail
G3 X12.5 Y0 C25,-11.25          ; Sail
G3 X0 Y0 C-6.25,-17.5           ; Sail
G91                             ; Incremental mode
G1 X12.5                        ; GOTO mast location
G1 Y25                          ; Mast
G1 X5 Y-1.25                    ; Flag
G1 X-5 Y-1.25                   ; Flag
G90                             ; Absolute mode
G2 X25 Y0 C-14,-22.5            ; Sail
G3 X12.5 Y0 C-6.25,-17.5        ; Sail
G3 X12.5 Y22.5 C-25,11.25       ; Sail
G1 X0 Y0                        ;Return to 0,0
G1 Y40                          ; Get ready for next boat
G92
RETURN
;*************************************************************************************************
;                    End of program BOAT_SCF.PRG
;*************************************************************************************************
```

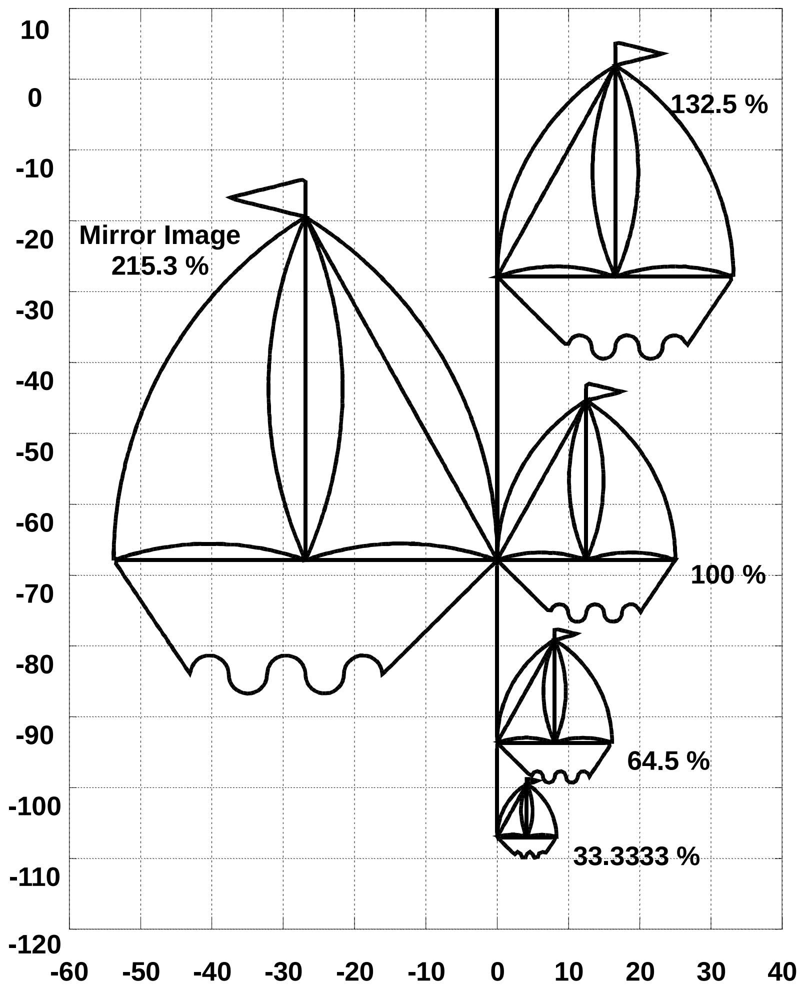


Figure 9-6. Output from Overriding Scale Factor Example Program

9.12. Softkey Use

This program demonstrates the use of the SKEY command and soft key programming.

```
;*******************************************************************
;	Simple program to demonstrate U511 softkey use.
;*******************************************************************

	EN X
	SKEY SET 1,1,:X1,"X1"
	SKEY SET 2,1,:X2,"X2"
	SKEY SET 3,1,:X3,"X3"
	SKEY SET 4,1,:X4,"X4"
	SKEY SET 5,1,:QUIT,"QUIT"

	:START
	SKEY GET		;; WAIT FOR F1-F5 HIT

	:X1
	G1 X1
	SKEY DISABLE 1
	GOTO :START

	:X2
	G1 X2
	SKEY DISABLE 2
	GOTO :START

	:X3
	G1 X3
	SKEY DISABLE 3
	GOTO :START

	:X4
	G1 X4
	SKEY DISABLE 4
	GOTO :START


	:QUIT			;;EXIT PROGRAM
	SKEY UNDEF 1
	SKEY UNDEF 2
	SKEY UNDEF 3
	SKEY UNDEF 4
	SKEY UNDEF 5

	M2			;;EXIT
```

9.13. 8 X 3 I/O Bus Program

This is a test program for the U511 8 X 3 I/O bus.

```
;;*********************************************************************************
;; Test program for U511 8 X 3 I/O bus
;;*********************************************************************************

        ABORT
        IOSET 0,1,1,0,2,0           ;SET 8OUT, 16IN
        WAIT ALL
        V2=100                      ;SET DWELL TIME

        :START
        V1=1
        LOOP 8
        IO0 V1                      ;SET OUTPUT DATA
        V1=V1*2
        DWELL V2
        SUB :DISPLAYINPUTS
        NEXT
        GOTO :START

        :DISPLAYINPUTS
        V10=IO1
        V11=IO2
        ME DI"%0.FV10 %0.FV11"
        RETURN
```

9.14. Power on Subroutine/Global Subroutine File

A global subroutine file can be used to implement functions common to multiple programs. The file name (usually called "glbsub.prg"), is specifed in the setupscreen of the U511. Several entries are defined and are hard coded by the U511. These are:

:poweron Used to execute a sequence of commands when the U511 is first powered up. These can include unit setup, enabling of axes, homing of axes, etc.

(The following entry points can only execute non-synchronized commands such as MW and OE:)

:abort This subroutine is executed when the ABORT front panel key is pushed.

:pauseon This subroutine is executed when the pause key is pushed and the U511 enters the PAUSED state.

:pauseoff executed when the pause key is pushed and the U511 exits the PAUSED state.

:faultack executed when the FLTACK (fault acknowledge) front panel key is pushed.

The U511 is factory shipped with a global subroutine file called "glbsub.prg." It has several example commands in it which are commented. Global subroutines can be executed from the MDI command window or from remote mode. From the MDI window, enter "SUB :xxxx" to execute the subroutine. From remote mode, send "ISUB :xxxx". "xxxx" refers to the label entry point in the subroutine file.

```
;***********************************************************************************************
;****** EXAMPLE GOLBAL SUBROUTINE FILE SHOWING HARD**********
;******************************** CODED ENTRY POINTS ******************************
;***********************************************************************************************

        ;; Executed on power-up
        :POWERON
        ;EN X Y Z U
        ;WA ON
        ;DW 10
        ;FA
        ;PR IN
        RETURN

        ;; Executed when ABORT key is pressed
        :ABORT
        ;OE0 0
        RETURN

        ;; Executed when PAUSE state activated
        :PAUSEON
        ;OE0 0
        RETURN
```

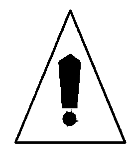
```
;; Executed when PAUSE state deactivated
:PAUSEOFF
;OE0 255
RETURN

;; executed when abort FLTACK is pressed
:FAULTACK
;OE0 0
RETURN
```

∇ ∇ ∇

CHAPTER 10: TECHNICAL DETAILS

In This Section:

Never disconnect any of the U511 cables when power is applied. Doing so may damage the system or its components.



WARNING

10.1. UNIDEX 511 Rear Panel Connectors

There are 15 connectors on the rear panel of the U511 Chassis. The following sections describe the pinouts for each connector. Figure 10-2 shows the location of the various connectors. Most connectors have a red LED next to them. These LEDs, when lit, indicate that +5 V is present on the connector.

10.1.1. Axis Connectors (Encoder Input)

These connectors are used to connect encoders, limits, and Hall effects to the U511. The connectors are labeled Encoder Input on the chassis and AXIS1, AXIS2, AXIS3, and AXIS4 on the interface board. They are designed to interface directly to standard Aerotech cables. The mating connector is a Cinch #DB-25P (Aerotech # ECK00101).

Table 10-1 shows the pinouts for the encoder input connectors. Specifications for the encoder can be found in Section 10.4: Encoder Specifications. A typical input for the limit and Hall effect inputs is shown in Figure 10-1.

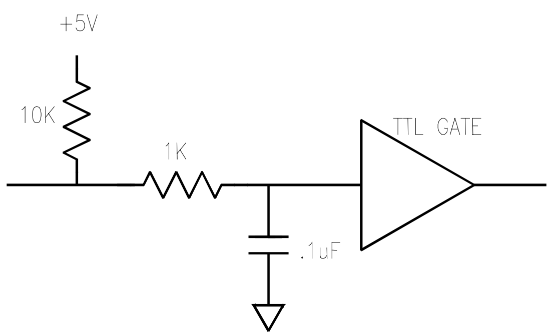


Figure 10-1. Typical Input for CW Limit, CCW Limit, Home Limit, and Hall Effect Inputs HA, HB, HC

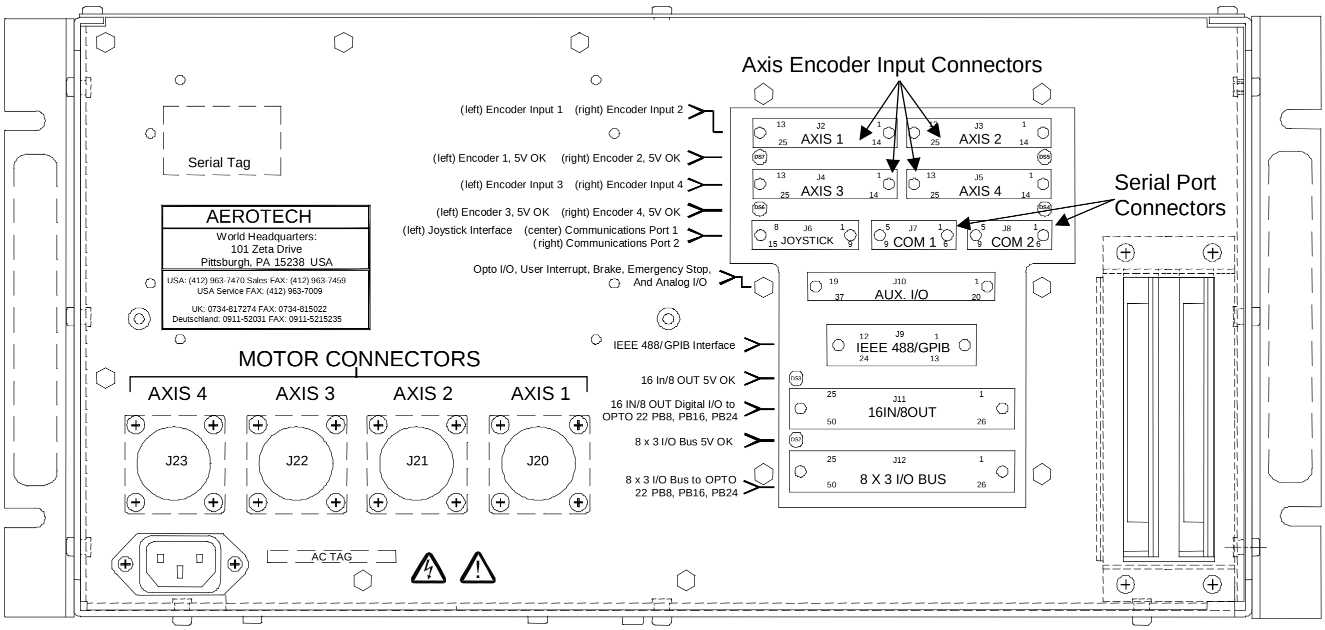


Figure 10-2. Rear View Showing Various Connectors

Table 10-1. Encoder Connector Pinouts for Axis 1 Through 4 (J2 - J5)

Pin #	Description	Pin #	Description
1	Shield (Chassis Frame)	14	Cosine Input
2	Auxiliary Shutdown Input (Remove JPx4 to Enable)	15	Cosine-N Input
3	+5 Volts	16	Limit Switch Power (+5 V or optional voltage using JPx6)
4	Common	17	Sine Input
5	Hall Effect Sensor B Input	18	Sine-N Input
6	Marker-N Input	19	Tachometer + Input (opt.)
7	Marker Input	20	Common
8	Tachometer - Input (opt)	21	Common
9		22	Home Limit Input
10	Hall Effect Sensor A Input	23	
11	Hall Effect Sensor C Input	24	Counter-clockwise Limit Input
12	Clockwise Limit Input	25	Brake + Output (opt.)
13	Brake - Output (opt)		

10.1.2. Serial Port Connections

The UNIDEX 511 has two serial ports labeled COM1 and COM2 on the interface board. Either or both ports can be used for remote communications. Refer to Table 10-2 and Table 10-3. See the Setup page of the Parameters chapter for related parameters. The mating connector is a Cinch # DE-9P (Aerotech # ECK00137).

Table 10-2. COM1 Interface Connector Pinouts

Pin #	Description	Notes
2	RS-232 data output (TXD)	Swap pins 2 and 3 by moving jumpers JP1/JP2 to the 2-3 position
3	RS-232 data input (RXD)	
7,8	Connect together by installing JP3 on interface board (default)	NOTE: U511 does not implement the hardware handshake signals CTS/RTS
5	GND	

Table 10-3. COM2 Interface Connector Pin Connections

Pin #	Description	Notes
2	RS-232 data output (TXD)	Swap pins 2 and 3 by moving jumpers JP4/JP5 to the 2-3 position
3	RS-232 data input (RXD)	
7,8	Connect together by installing JP6 on interface board (default)	NOTE: U511 does not implement the hardware handshake signals CTS/RTS
5	GND	

The U511 is factory configured for 1 to 1 connection to a PC on both serial ports.

10.1.3. Interfacing to the U511 Digital I/O

The UNIDEX 511 has two digital I/O ports. The first port consists of 16 inputs and 8 outputs and is labeled "16 IN/8 OUT" on the interface board. The second port consist of three 8 bit banks. Each bank is configurable as inputs or outputs. This port is labeled "8 X 3 I/O BUS" on the interface board. Both ports are designed for direct connection to Opto 22-style interface boards PB8, PB16, PB24, and are not opto-isolated.

All outputs default to the high impedance state on reset. A programmed logic level of "0" results in a high impedance output. A programmed logic level of "1" results in a low impedance output to GND.

The lower 4 inputs and 4 outputs from the 16 IN/8 OUT connector appear on the AUX I/O connector and are opto-isolated.

10.1.3.1. 16 IN/8 OUT I/O Bus

This bus consists of 16 inputs and 8 outputs. The inputs are pulled to +5 V on the U511 control board through 10K Ohm resistors. An unconnected input is read as a logic "1." An input pulled to ground is read as a logic "0." These inputs should not be connected to voltages in excess of 5 V.

The outputs are open collector type 74LS642 drivers capable of sinking 24 mA each. A programmed logic level of "0" results in a high impedance output. A programmed level of "1" results in a low impedance to ground. The reset/default state of this bus is all outputs to high impedance.

This interface bus is designed for direct connection to an Opto 22-style interface board.

Table 10-4 shows the pinouts for the 16 IN/8 OUT connector. The mating connector is a 3M #3564-1001 (Aerotech # ECK00353).

16 IN/8 OUT Specifications:	
Signal format	TTL
Input voltage range	0 to +5 V
Input current	.5 mA
Output voltage logic "1"	.35 V @ 24 mA
Output voltage logic "0"	High impedance

Table 10-4. 16 IN/8 OUT Connector

Pin #	Description	Pin #	Description
1	IN15 (Input 15)	14	IN2 (Input 2)
2	IN14 (Input 14)	15	IN1 (Input 1)
3	IN13 (Input 13)	16	IN0 (Input 0)
4	IN12 (Input 12)	17	OUT7 (Output 7)
5	IN11 (Input 11)	18	OUT6 (Output 6)
6	IN10 (Input 10)	19	OUT5 (Output 5)
7	IN9 (Input 9)	20	OUT4 (Output 4)
8	IN8 (Input 8)	21	OUT3 (Output 3)
9	IN7 (Input 7)	22	OUT2 (Output 2)
10	IN6 (Input 6)	23	OUT1 (Output 1)
11	IN5 (Input 5)	24	OUT0 (Output 0)
12	IN4 (Input 4)	25	+5 Volts
13	IN3 (Input 3)	26-50	Common

10.1.3.2. Opto 22 Connection Information

Table 10-5 and Figure 10-3 show Opto 22-style connections.

Table 10-5. UNIDEX 511/Opto 22 Connection Information

Interface Cable Assembly (model OPC)	PB8, PB16A, PB16C and PB24 Board					
Opto Interface (P5)	**Control Connection (edge connector on Opto board)**	**Module Position**	**Connection Description**	**Type of Module**	**Field Connection (barrier strip)**	
49	49		+5 V int supply			
47	47	0	Out 0	output	1 and 2	
45	45	1	Out 1	output	3 and 4	
43	43	2	Out 2	output	5 and 6	PB8
41	41	3	Out 3	output	7 and 8	
39	39	4	Out 4	output	9 and 10	
37	37	5	Out 5	output	11 and 12	
35	35	6	Out 6	output	13 and 14	
33	33	7	Out 7	output	15 and 16	
31	31	8	In 0	input	17 and 18	
29	29	9	In 1	input	19 and 20	PB
27	27	10	In 2	input	21 and 22	16A
25	25	11	In 3	input	23 and 24	and
23	23	12	In 4	input	25 and 26	16C
21	21	13	In 5	input	27 and 28	
19	19	14	In 6	input	29 and 30	
17	17	15	In 7	input	31 and 32	
15	15	16	In 8	input	33 and 34	
13	13	17	In 9	input	35 and 36	
11	11	18	In 10	input	37 and 38	PB24
9	9	19	In 11	input	39 and 40	

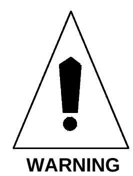
Table 10-5. UNIDEX 511/Opto 22 Connection Information (continued)

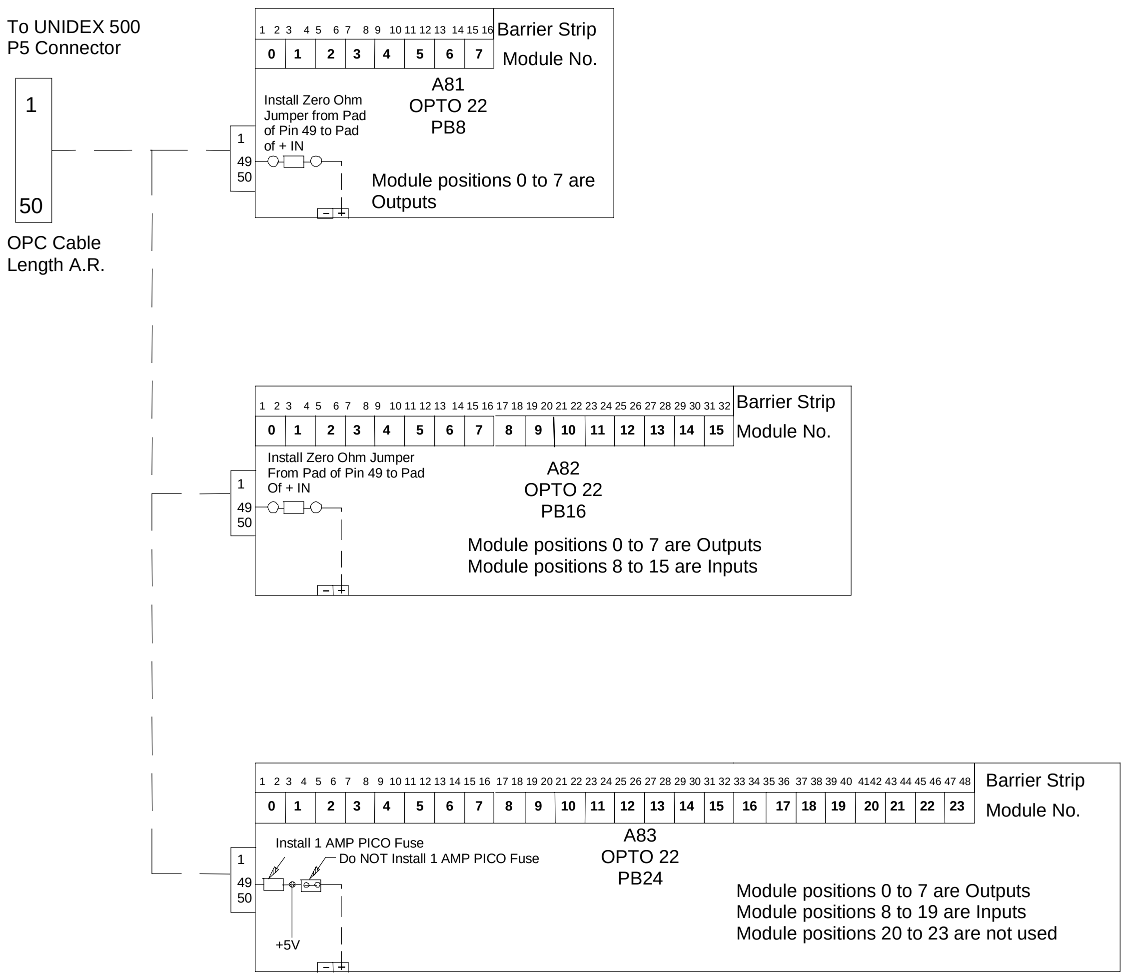
Opto Interface (P5)	Control Connection (edge connector on Opto board)	Module Position	Connection Description	Type of Module	Field Connection (barrier strip)	
7	7	20	In 12	input	41 and 42	|
5	5	21	In 13	input	43 and 44	|
3	3	22	In 14	input	45 and 46	PB24
1	1	23	In 15	input	47 and 48	↓

Note: All even pins (2-50) are signal common

Typical Modules: IDC5, IDC5B, IAC5, IAC5A, ODC5, ODC5A, OAC5, and OAC5A

WARNING! Type of module (input or output) cannot be interchanged. To do so may damage the UNIDEX 511.





Notes:

50 Pin Ribbon Cable terminated at Opto 22 Board with 50 Pin Card Edge Connector (3M P/N 3415-0001, Aerotech P/N ECK 310)

Ribbon Cable terminated at UNIDEX 500 with a 50 Pin Header (3M P/N 3425-6050, Aerotech P/N ECK 332)

Figure 10-3. Electrical Characteristics of the UNIDEX 511 Opto 22 Connections

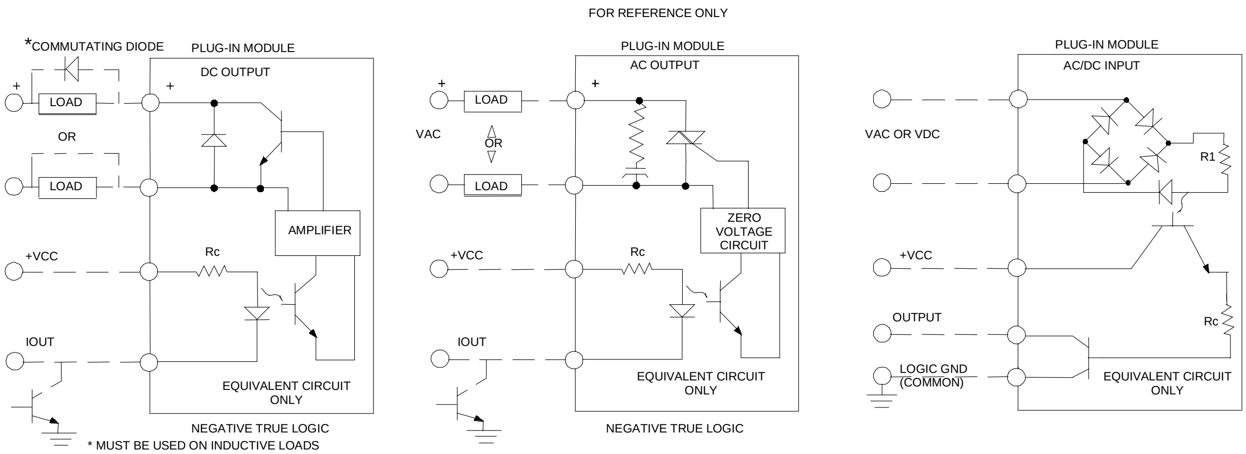


Figure 10-3. Electrical Characteristics of the UNIDEX 511 Opto 22 Connections (continued)

10.1.3.3. 8 X 3 I/O Bus

The 8 X 3 I/O bus consists of three banks of 8 bit ports, bank A, B, and C. Each port can be configured as outputs or inputs. Each I/O bit is pulled to +5 V through a 10K Ohm resistor. The ports are buffered through 74ACT652 type buffers and can source/sink 24 mA per bit. A programmed logic "1" level results in an output voltage of 0 (GND). A programmed logic level of "0" results in an output voltage of +5 V.

Table 10-6 shows the pinouts for the 8 X 3 I/O Bus connector. The mating connector is a 3M #3564-1001 (Aerotech # ECK00353). Specifications are shown below.

Specifications:

Input voltage range	0 to +5 V
Input current	.5 mA
Output voltage logic "1"	.35 V @ 24 mA
Output voltage logic "0"	4 V @ 24 mA

This interface bus is designed for direct connection to an Opto 22-style interface board.

Table 10-6. 8 X 3 I/O Bus Connector Pinouts (J12)

Pin #	Description	Pin #	Description
1	IOC7 (I/O C-7)	14	IOB2 (I/O B-2)
2	IOC6 (I/O C-6)	15	IOB1 (I/O B-1)
3	IOC5 (I/O C-5)	16	IOB0 (I/O B-0)
4	IOC4 (I/O C-4)	17	IOA7 (I/O A-7)
5	IOC3 (I/O C-3)	18	IOA6 (I/O A-6)
6	IOC2 (I/O C-2)	19	IOA5 (I/O A-5)
7	IOC1 (I/O C-1)	20	IOA4 (I/O A-4)
8	IOC0 (I/O C-0)	21	IOA3 (I/O A-3)
9	IOB7 (I/O B-7)	22	IOA2 (I/O A-2)
10	IOB6 (I/O B-6)	23	IOA1 (I/O A-1)
11	IOB5 (I/O B-5)	24	IOA0 (I/O A-0)
12	IOB4 (I/O B-4)	25	+5 Volts
13	IOB3 (I/O B-3)	26-50	Common

10.1.3.4. On-board Opto-isolated I/O

The lower 4 in/4 out of the 16 IN/8 OUT connector are duplicated on the AUX I/O connector and are opto-isolated. The opto-isolator used is a NEC PS2501 type or equivalent. The 4 in/4 out on the 16 IN/8 OUT connector are not opto-isolated.

Inputs

The U511 has four resistors to limit current through the input diodes of the opto-isolators. The default value is for a 5 V power supply. The user must connect a +5 V supply to the IINSUP pin. The input is pulled low when connection is completed to the power supply through the input (IINx). The U511 will read a logic "0" when this occurs. When the connection is removed, the U511 will read a logic "1."

Table 10-7 lists the locations of the current limiting resistors and AUX I/O pin numbers for the opto-isolated inputs. Figure 10-4 shows the opto-isolated inputs.

Input diode specifications:	Isolation voltage	5000 V rms
	Diode forward current	10 mA
	Diode forward voltage	1.1 V at 10 mA

Table 10-7. Control Board Current Limiting Resistor Locations for Opto-isolated Inputs

Name	RN# - pin #	Standard (+5 Volts)	Description	AUX I/O pin#
IIN0	RN7-1,2	390 Ohms	Isolated input 0	5
IIN1	RN7-3,4	390 Ohms	Isolated input 1	6
IIN2	RN7-5,6	390 Ohms	Isolated input 2	7
IIN3	RN7-7,8	390 Ohms	Isolated input 3	8
IINSUP	n/a	n/a	Anode of opto-isolator diode(+5 V)	9

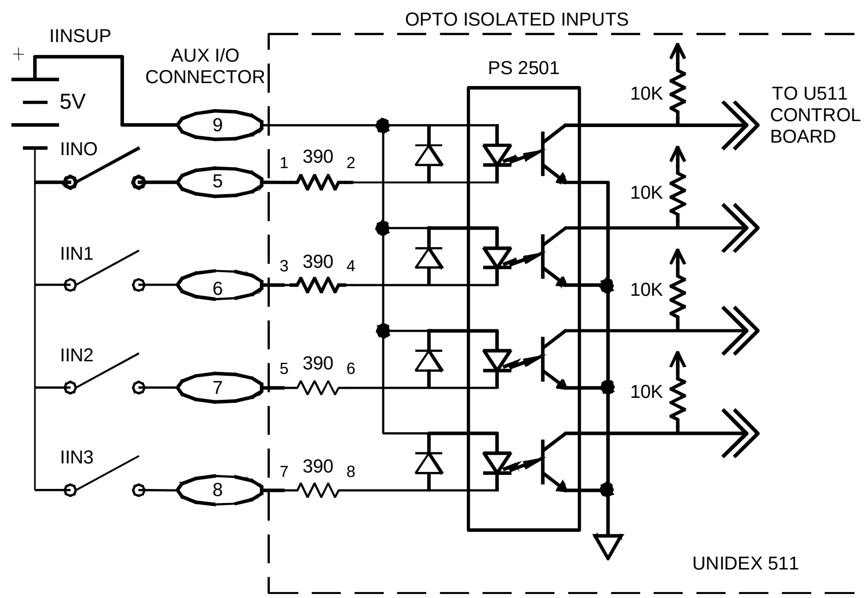


Figure 10-4. Opto-isolated Inputs

Outputs

The U511 also contains 4 opto-isolated outputs. These are open collector outputs without pull-up resistors capable of sinking 10 mA. When an output is programmed as logic "0," the IOUTx pin goes to a high impedance state. This is also the reset state. When an output is programmed as a logic "1," the output is pulled to "IOUTCOM" state, (typically GND). The user should connect the external power supply's return (V-) to the IOUTCOM for proper operation. Table 10-8 shows the opto-isolated pin locations. Figure 10-5 shows a diagram of the opto-isolated outputs.

Output transistor specifications:	collector - emitter voltage	1 V @ 10 mA 5 V @ 30 mA
	max collector - emitter voltage	30 V
	power dissipation per output	100 mW

Table 10-8. Opto-isolated Output Pin Locations

Name	Description	AUX I/O pin#
IOUT0	Isolated output 0	19
IOUT1	Isolated output 1	20
IOUT2	Isolated output 2	21
IOUT3	Isolated output 3	22
IOUTCOM	Common point of emitters	23

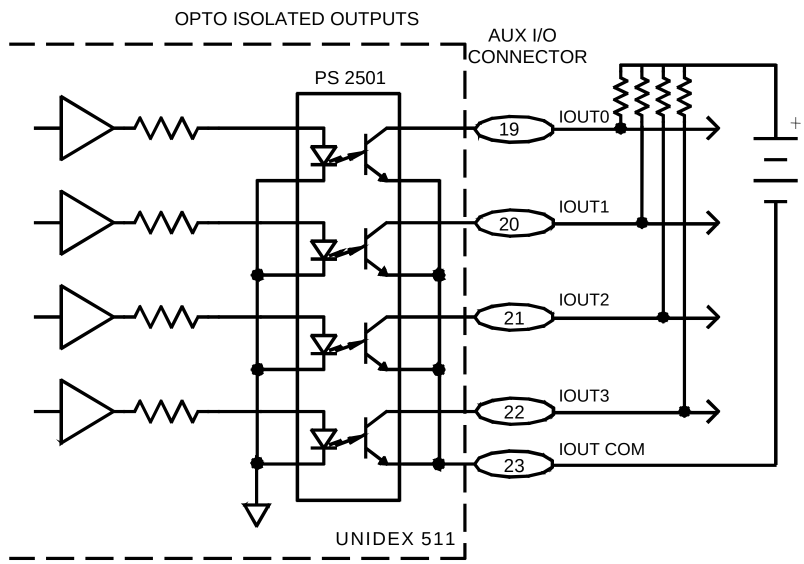
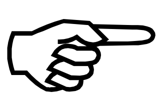


Figure 10-5. Opto-Isolated Outputs

10.1.4. AUX I/O Connector

The AUX I/O connector contains miscellaneous I/O signals for the U511. These include the hardware interrupt, (UINT), emergency stop input (E-Stop), 4 in/4 out opto isolated I/O and associated power supply connections, D/A outputs (shared by amplifiers), and analog inputs.

Table 10-9 shows the pinouts for the AUX I/O connector. The mating connector is a Cinch # DC-37P (Aerotech # ECK00119).



DAC channels are used as current commands to the internal amplifiers. Unused DAC channels are available for general purpose use. AC brushless and Stepper motors require two DAC channels; DC motors require only 1.

Table 10-9. AUX I/O Connector Pinouts (J10)

Pin #	Description	Pin #	Description
1	UINT+ (User Interrupt +)	20	IOUT1 (Output 1)
2	UINT- (User Interrupt -)	21	IOUT2 (Output 2)
3	E-Stop+ (Emergency Stop +)	22	IOUT3 (Output 3)
4	E-Stop- (Emergency Stop -)	23	IOUTCOM (Opto-Isolator COM for IOUT1-3)
5	IIN0 (Input 0)	24	AIN0 (Analog Input #0)
6	IIN1 (Input 1)	25	AIN1 (Analog Input #1)
7	IIN2 (Input 2)	26	DAC1 (+/- 10 V @1 mA)
8	IIN3 (Input 3)	27	DAC2 (+/- 10 V @1 mA)
9	IINSUP (Opto-Isolator +V Supply for IIN0-3)	28	DAC3 (+/- 10 V @1 mA)
10	Brake + Output (See Brake Option for Requirements)	29	DAC4 (+/- 10 V @1 mA)
11	Brake - Output (See Brake Option for Requirements)	30	Reserved
12	AIN2 (Analog Input #2, also connected to Joystick 2 Potentiometer)	31	ADC12-1 (A/D Input #1) (optional)
13	AIN3 (Analog Input #3, also connected to Joystick 1 Potentiometer)	32	ADC12-2 (A/D Input #2) (optional)
14	DAC5 (+/- 10 V @1 mA)	33	ADC12-3 (A/D Input #3) (optional)
15	DAC6 (+/- 10 V @1 mA)	34	ADC12-4 (A/D Input #4) (optional)
16	DAC7 (+/- 10 V @1 mA)	35	Reserved
17	DAC8 (+/- 10 V @1 mA)	36	DSPTX (Serial Output) Reserved
18	Common	37	DSPRX (Serial Input) Reserved
19	IOUT0 (Output 0)		

10.1.4.1. UINT User Interrupt Input

The UINT is an opto-isolated input used for real time position latching of the encoder inputs and other special functions. A diagram of this input is shown in Figure 10-6.

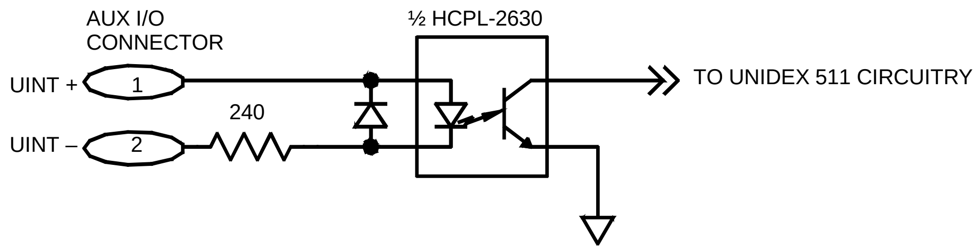


Figure 10-6. The UINT Opto-Isolated Input

10.1.4.2. E-Stop Emergency Stop Input

The UNIDEX 500 has an optically isolated emergency stop input (refer to Figure 10-7). The user must provide an external power supply to drive the on-board opto-isolator. External voltages and resistances are enumerated in Table 10-10.

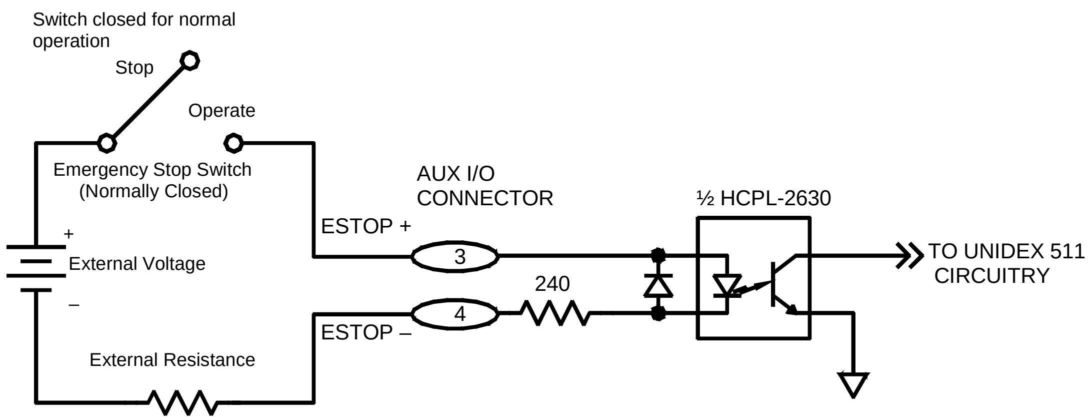


Figure 10-7. Electrical Characteristics of the UNIDEX 511 Emergency Stop Interface

Once the emergency stop input is connected, the software must be set to look for an emergency stop condition. This is set by system parameter x55–"Global fault mask." For any axis, select the Emergency Stop bit for this parameter. This will force an emergency stop if the external circuitry is opened.

Table 10-10. External Voltages and Resistances for the Emergency Stop Input

External Voltage	External Resistance (in Ohms)
5 VDC	0 Ohm
12 VDC	290 Ohms, 1/4 watt
24 VDC	1 KOhms, 1/2 watt

10.1.5. Joystick Connector

The following table shows the pin connections for the Joystick connector. The mating connector is a Cinch # DA-15P (Aerotech # ECK00100). This connector is designed to connect directly to an Aerotech joystick PN JBV or JI.

Table 10-11. Joystick Interface Connector Pinouts (J6)

Pin #	Description	Pin #	Description
1	+5 Volts	9	N/C
2	Joystick Button A Input	10	N/C
3	Pot 1 Input (JSW1/AIN3)	11	N/C
4	GND	12	N/C
5	N/C	13	Interlock
6	Pot 2 Input (JSW2/AIN2)	14	N/C
7	Joystick Button B Input	15	N/C
8	N/C		

10.1.6. IEEE-488 / GPIB Bus Connector

The following table shows the pin connections for the IEEE-488/GPIB Bus connector. The mating connector is a male IEEE-488 connector. This is a standard connection to the IEEE-488/GPIB bus.

Table 10-12. IEEE-488 / GPIB Interface Connector Pinouts (J8)

Pin #	Description	Pin #	Description
1	DIO1 (Data Line 1)	13	DIO5 (Data Line 5)
2	DIO2 (Data Line 2)	14	DIO6 (Data Line 6)
3	DIO3 (Data Line 3)	15	DIO7 (Data Line 7)
4	DIO4 (Data Line 4)	16	DIO8 (Data Line 8)
5	EOI (End or Identify)	17	REN (Remote Enable)
6	DAV (Data Valid)	18	Common
7	NRFD (Not Ready for Data)	19	Common
8	NDAC (Not Data Accepted)	20	Common
9	IFC (Interface Clear)	21	Common
10	SRQ (Service Request)	22	Common
11	ATN (Attention)	23	Common
12	Shield	24	Common

10.1.7. Axis 1-4 Motor Connectors

The standard motor interface connector is a 14 pin AMP circular plastic connector. The mating connector is an AMP # 206044-1 (Aerotech # ECK00131). The back shell is an AMP # 206070-1 (Aerotech # ECK00134). The pins for the connector are AMP #66098-7 (Aerotech # EIK00194). The following table lists the motor connector pin assignments for stepper, DC Brush, and AC motor applications.

Table 10-13. Motor Connector Pinouts (J20-J23)

Pin #	Stepper motor	DC brush motor	AC motor
1	Motor Frame	Motor Frame	Motor Frame
2	Phase A		
3	Phase B/		Phase A
4	Phase B	Motor -	Phase B
5		Motor +	Phase C
6		Motor -	Phase B
7	Phase A/	Motor +	Phase C
8	Motor Shield	Motor Shield	Motor Shield
9			Phase A
10-14			

> Always disconnect the main power connection before opening the U511.

WARNING

10.2. Control Board Jumpers

There are several jumpers located on the U511 Control Board that can be changed by the user. These are listed in the table below. Also refer to Figure 10-8. The jumpers marked reserved are factory configured and should not be changed by the user.

Table 10-14. Control Board Jumper "JP" Description (JP1-JP15)

JP #	Setting	Description
1-4		Reserved
5	1-2*	COM2: RS-232 +/- 12 volt format
	2-3	COM2: RS-422 5 V differential
6	1-2*	COM2: RS-232 +/- 12 volt format
	2-3	COM2: RS-422 5 V differential
7	1-2*	COM2: RS-232 +/- 12 volt format
	2-3	COM2: RS-422 5 V differential
8	Removed*	COM2: RS-232 +/- 12 volt format
	Installed	COM2: RS-422 5 V differential
9	Removed*	COM2: RS-232 +/- 12 volt format
	Installed	COM2: RS-422 5 V differential
10-11		Reserved
12	5-6 installed*	Normal boot mode
	5-6 removed	Boot to MFG mode
	3-4 installed*	Display/front panel enabled
	3-4 removed	Display/front panel disabled
	1-2 installed*	No operation
	1-2 removed	Reset COM1, COM2 parameters to default
13-15		Reserved

* Default Setting

To minimize the possibility of electrical shock and bodily injury, make certain that the mains power supply is disconnected before opening the chassis.

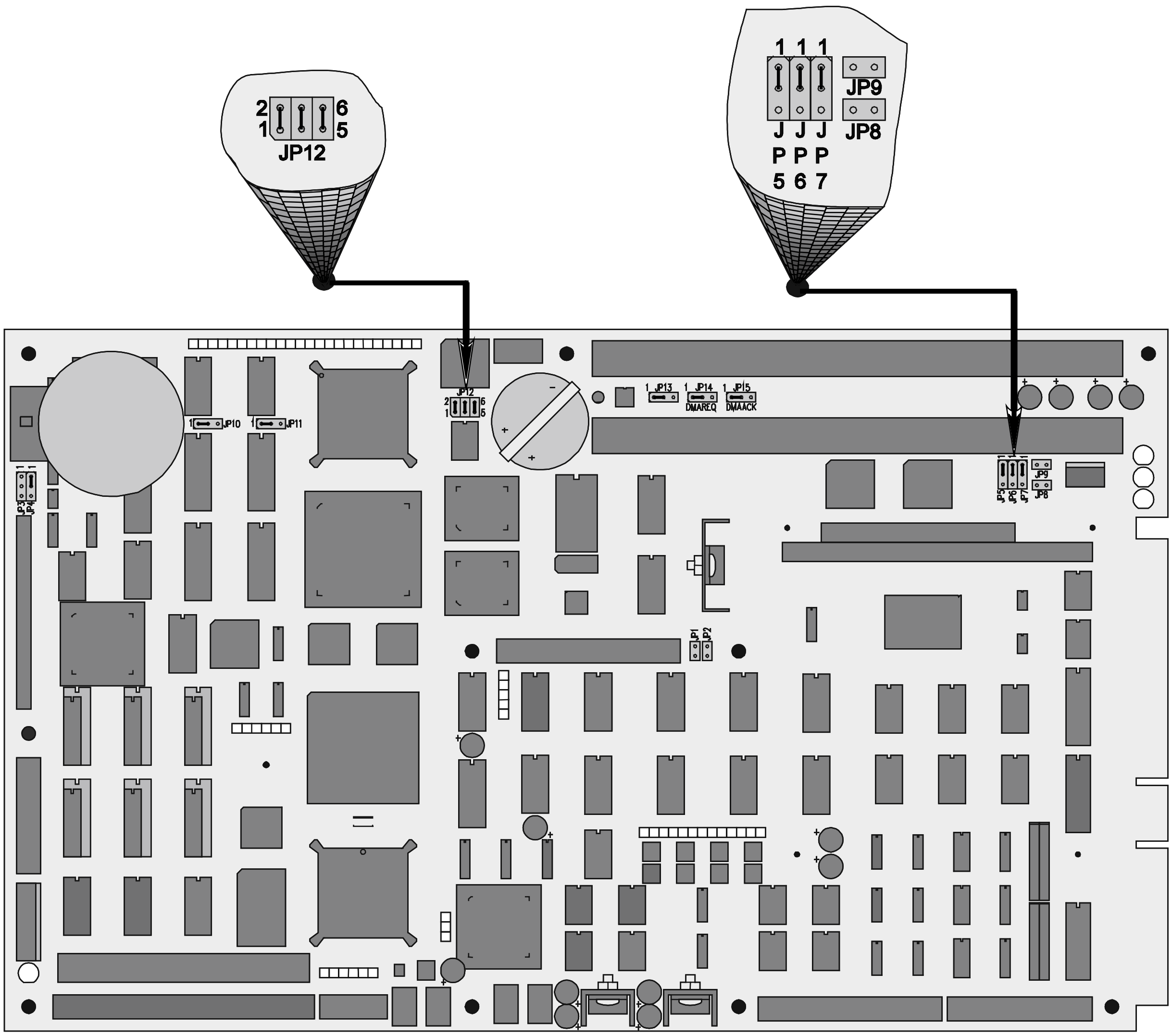


Figure 10-8. Control Board Showing Locations of User Configurable Jumpers

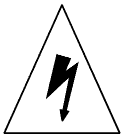
10.3. Interface Board Jumpers

Table 10-15 describes the U511 Interface Board "JP" jumpers. The user can change jumpers 1-6. Refer to Figure 10-9. The other jumpers are factory configured and should not be changed by the user.

Table 10-15. Interface Board jumper "JP" description (JP1-JP46)

JP #	Setting	Description
1	1-2*	COM 1: J7-2 data out (for direct connection to PC)
	2-3	COM 1: J7-2 data in
2	1-2*	COM 1: J7-3 data in (for direct connection to PC)
	2-3	COM 1: J7-3 data out
3	IN*	COM 1: RTS (J7-7) connected to CTS (J7-8)
	OUT	COM 1: RTS (J7-7) not connected to CTS (J7-8)
4	1-2*	COM 2: J8-3 data in (for direct connection to PC)
	2-3	COM 2: J8-3 data out
5	1-2*	COM 2: J8-2 data out (for direct connection to PC)
	2-3	COM 2: J8-2 data in
6	IN*	COM 2: RTS (J8-7) connected to CTS (J8-8)
	OUT	COM 2: RTS (J8-7) not connected to CTS (J8-8)
7-46		Reserved - factory configured
		(refer to Engineering Specification)

* Default Setting



To minimize the possibility of electrical shock and bodily injury, make certain that the mains power supply is disconnected before opening the chassis.

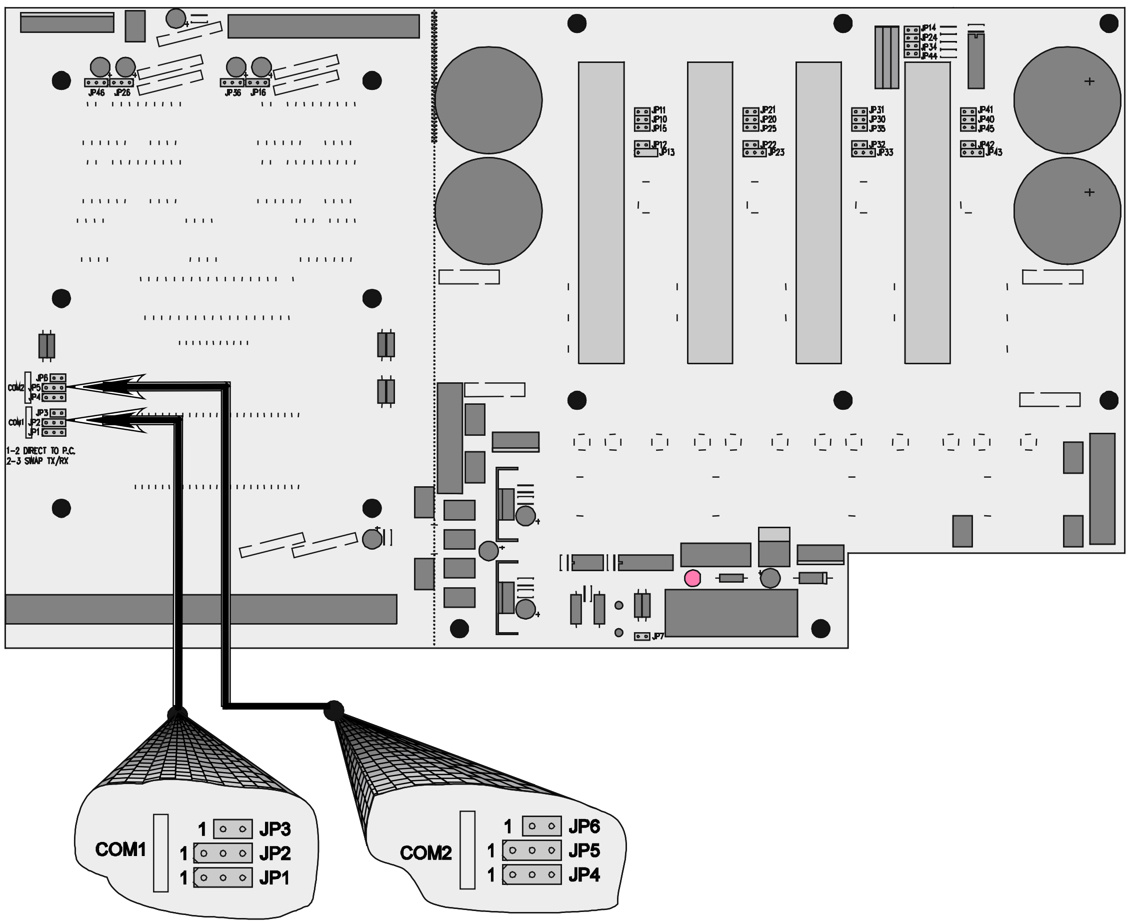


Figure 10-9. Interface Board Showing Locations of User Configurable Jumpers

10.4. Encoder Specifications

The U511 encoder inputs are differential RS-422 type inputs. They are normally terminated by 180 ohm resistors. If single ended encoders are desired, the terminator must be removed and a 4.7 KOhm, 1/4 W resistor should be placed from the unused input to ground. Encoder fault detection should be defeated in the parameter section if this is done. Encoder terminating resistor locations and values are shown in Table 10-16. The electrical characteristics of a single ended encoder interface are shown in Figure 10-10.

Table 10-16. Encoder Terminating Resistor Locations and Values

Signal Name	AXIS 1 RN#-pin#	AXIS 2 RN#-pin#	AXIS 3 RN#-pin#	AXIS 4 RN#-pin#	Standard	Optional
SIN+	RN6-1	RN6-5	RN4-1	RN4-5	180 Ohms	
SIN-	RN6-2	RN6-6	RN4-2	RN4-6		
COS+	RN6-3	RN6-7	RN4-3	RN4-7	180 Ohms	
COS-	RN6-4	RN6-8	RN4-4	RN4-8		
MRK+	RN5-1	RN5-3	RN5-5	RN5-7	180 Ohms	.1 uF Capacitor *
MRK-	RN5-2	RN5-4	RN5-6	RN5-8		

* Use a 180 ohm termination resistor for standard differential encoders. When using Aerotech stepper motors with the home marker wheel option, you must replace the termination resistor with a .01 µF capacitor.

Encoder input specifications:

Data format	RS-422, 5 V differential
Maximum tracking rate	16 MHz data rate, 4 MHz sine/cosine frequency

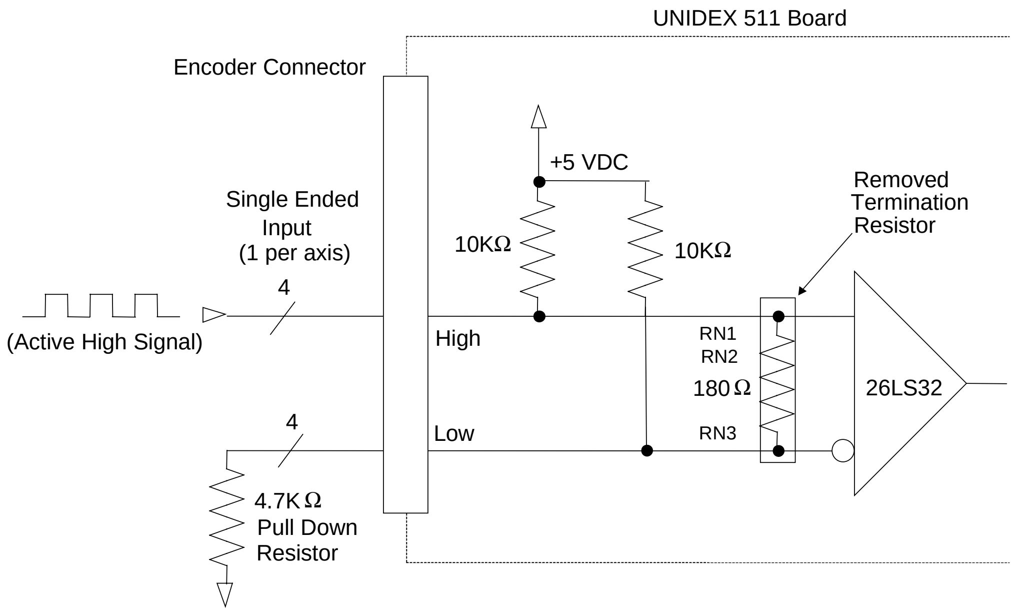


Figure 10-10. Electrical Characteristics of a Single Ended Encoder Interface

10.5. UNIDEX 511 Control Board Test Points (TP1-TP25)

Table 10-17 describes the U511 Control Board test points (TP). These are generally not needed by the user and are included here for reference.

Table 10-17. Control Board Test Points

TP	Description	TP	Description
4	GND	18	MRK1 (Marker 1)
6	E-Stop	19	MRK2 (Marker 2)
10	ICMD1B (DAC1)	20	MRK3 (Marker 3)
11	ICMD2B (DAC2)	21	MRK4 (Marker 4)
12	ICMD3B (DAC3)	22	BRAKE-N
13	ICMD4B (DAC4)	26	UINT-N
14	ICMD1A (DAC5)	30	AIN0 (Analog input 0)
15	ICMD2A (DAC6)	31	AIN1 (Analog Input 1)
16	ICMD3A (DAC7)	32	JSW2 (Analog Input 2 / Joystick Wiper 2)
17	ICMD4A (DAC8)	33	JSW1 (Analog Input 3 / Joystick Wiper 1)

10.6. "PSO Encoder Bus" Connector (P6)

The Control Board "PSO Encoder Bus" connector (P6) is a 26 pin header connector. This connector provides a one-to-one interface to the PSO-PC card. When the PSO-PC is used, the P6 connector is connected to the PSO-PC P6 connector. This links the encoder signals from the U511 Control board to the PSO-PC card. The signals are sent in single ended format to the PSO-PC card. The pinouts for this connector are listed in Table 10-18.

For more information about the PSO-PC option, refer to the PSO-PC Operation and Technical Manual (P/N: EDO105).

Table 10-18. U511 Control Board 'PSO Encoder Bus' Connector Pinouts (P6)

Pin #	Description	Pin #	Description
1	Axis 1 Sine	2	Axis 1 Cosine
3	GND	4	GND
5	Axis 2 Sine	6	Axis 2 Cosine
7	GND	8	GND
9	Axis 3 Sine	10	Axis 3 Cosine
11	GND	12	GND
13	Axis 4 Sine	14	Axis 4 Cosine
15	INTBUS	16	GND
17		18	GND
19		20	GND
21		22	GND
23		24	GND
25		26	

10.7. UNIDEX 511 Mechanical Specifications

The U511 is available in a Desktop or a Rack mount package. The following sections will describe each of these packages.

10.7.1. UNIDEX 511 Desktop Specifications

The U511 Desktop package is a standard U511 Chassis with tiltable feet mounted on bottom of chassis. The U511 air ventilation is through the chassis bottom, back, and sides, which must not be blocked. Sufficient room must also be provided in the rear of the U511 for making connections (6" min.). This distance will be dependent on the connectors and cables being used.

The U511 overall dimensions (Nominal):

Width 17.0 in (432 mm)

Height 9.4 in (239 mm)(with tiltable feet)

Depth 15.0 in (381 mm)

Weight 21 to 37 lbs (depending on options)

Note: Tiltable Feet height are approximately 0.6 in

10.7.2. UNIDEX 511 Rack mount Specifications

The U511 Rack mount package is a standard U511 Chassis with rack mounting brackets mounted on each side of chassis. The U511 air ventilation is through the chassis bottom, back, and sides, which must not be blocked. Sufficient room must also be provided in the rear of the U511 for making connections (6 in minimum). This distance will be dependent on the connectors and cables being used.

The U511 overall dimensions:(Nominal):

Width 19.0 in (483 mm)

Height 8.8 in (224 mm)

Depth 15.0 in (381 mm)(with rack mounting brackets)

Weight 21 to 37 lbs (depending on options)

Note: Each rack mounting bracket is approx. 1.0 in (25 mm) wide

10.8. UNIDEX 511 Electrical Specifications

Aerotech configures each U511 to fit your particular power requirements. The Possible input voltages are 115 VAC, 230 VAC, 100 VAC, and 208 VAC. The system also has the capability of 50 or 60 hertz operation. Refer to Table 10-19.

Table 10-19. Electrical Specifications

VAC IN	# of Axis	Max. AC Line Input	Bus Voltage	Max. Watts Out
115 VAC	2	5 A	30	200
	2	5 A	(40, 80)	350
	2	10 A	160	1000
	4	10 A	(30, 40, 80, 160)	400-2000 *
230 VAC	2	5 A	30	200
	2	5 A	(40, 80, 160)	350
	4	5 A	(30, 40, 80, 160)	400-700 *
100 VAC	2	5 A	30	200
	2	5 A	(40, 80, 160)	350
	4	10 A	(30, 40, 80, 160)	400-700 *
208 VAC	2	5 A	30	200
	2	5 A	(40, 80, 160)	350
	4	5 A	(30, 40, 80, 160)	400-700 *

* Maximum Watts Out is dependent on drive and bus voltage combination. Some configurations will result in a lower maximum power.

- Protective grounding is through the main power connection.
- The supply connection is the main power cord (the main power disconnect).
- Protective grounding connection is indicated by the symbol "⏚".

Before connecting the U511 to its power source, compare the input power source to the required input power indicated by the system part number.

10.9. UNIDEX 511 Environmental Specifications

- Temperature: Ambient
- Operating: 0-35°C (32-95°F)
- Storage: -20-70°C (4-158°F)
- Humidity: Maximum operating humidity is 80% for temperatures up to 31°C, non-condensing (decreasing linearly to 50% relative humidity at 40°C).
- Altitude: Up to 2000m.
- Pollution: Pollution degree 2 (normally only non-conductive pollution).
- Use: Indoor use only.

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CHAPTER 11: TROUBLESHOOTING

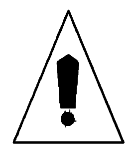
In This Section:

If you have technical support questions, please have the following information available before calling:

1. The current version of the software. The version is displayed after power-up or reset. The GV remote command also returns the version number.
2. Your customer order number.
3. If possible, be located at the system and have it ready, in case additional checks, diagnoses, or support is needed.

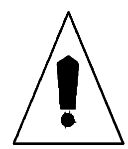
Warnings and Cautions:

No User Serviceable Parts.



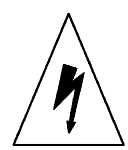
WARNING

Mains power cord is the disconnect device when servicing.



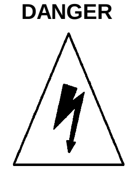
WARNING

Hazardous voltages may be present at the Mains inlet and motor connectors.



DANGER

Voltages up to 24 Volts may be present at I/O and Brake connectors.



DANGER

DANGER

Motors must be mechanically secured before applying power.

DANGER

Motor Temperatures may exceed 50°C.

DANGER

Danger, risk of electric shock.

11.1. Stepper Motors and Related Problems

Some common problems that relate to the use of stepper motors are listed and diagnosed in Table 11-1.

Table 11-1. Troubleshooting for Stepper Motors (and Related) Problems

Problem	Possible Causes / Solutions	See Also ...
The stepper motor overheats...	The "Stepper high current %" parameter (x46) is set too high. The "Stepper low current %" parameter (x47) is set too high.	4.8
The stepper motor drops out...	The "Ramp time" parameter is set too low. The "Max accel/decel" parameter is set too low. Load on motor is too great.	4.5, 4.11
The motor rotates in the wrong direction ...	The motor phasing is incorrect.	4.8
The motor has no torque ...	The appropriate axis is not enabled. The motor wiring is faulty. The amplifier fuse is blown.	3.0 Motor or Amp Documents
The amplifier LED is on, but the motor will not move (even though it did previously)...	Check for a blown amplifier fuse.	

WARNING

Always disconnect main power connection before opening the U511 chassis.

The system drawing and amplifier documentation contains information regarding the fuses.

10, 12, and 15 amp fuses are not user replaceable. An open fuse usually indicates that the unit should be returned for service.

11.2. Servo Related Problems

Some common problems that relate to the use of servo motors are listed and diagnosed in Table 11-2.

Table 11-2. Troubleshooting for Servo Related Problems

Problem	Possible Causes / Solutions	See Also ...
The motor has no torque ...	The appropriate axis is not enabled. The motor wiring is faulty. The amplifier fuse is blown. The amplifier is faulty.	3.0 Appendix B Motor or Amp Documents
The motor buzzes or makes an unusual noise ...	The PID loop gains are not adjusted properly.	2.6, 8.0
The motor runs away when it is enabled ...	The feedback device is not connected. The wrong feedback channel has been specified. Verify feedback. The wrong feedback setup code has been specified. Verify feedback.	2.6 4.8 Appendix B Motor or Amp Documents
A position or integral trap error occurs when the motor is enabled ...	The feedback device is not connected. The wrong feedback channel has been specified. Verify feedback. The motor has no torque. (See above)	2.6, 4.8 Appendix B Motor or Amp Documents
A position or integral trap error occurs when motion is commanded ...	The feedback device is not connected. The wrong feedback channel has been specified. Verify feedback. The wrong feedback setup code has been specified. Verify feedback. The motor has no torque. (See above)	2.6, 4.8 Appendix B Motor or Amp Documents
The amplifier does not enable ...	An amplifier fault has occurred. This could be due to an improperly wired or shorted motor. The amplifier is faulty.	Motor or Amp Documents Appendix B

WARNING

Always disconnect main power connection before opening the U511 chassis.

11.3. Problems Involving Fault Conditions

Some common problems relating to fault conditions are listed and diagnosed in Table 11-3.

Table 11-3. Troubleshooting for Problems Involving Fault Conditions

Problem	Possible Causes / Solutions	See Also ...
A position or integral trap error occurs when the axis is enabled ...	The feedback device is not connected. The wrong feedback channel has been specified. Verify the feedback. The wrong feedback setup code has been specified. Verify the feedback. Feedback device is phased wrong. Make sure feedback counts positive when motor is turned clockwise (CW).	2.6, 4.8 Motor or Amp Documents Appendix B
A position or integral trap error occurs when motion is commanded ...	The feedback device is not connected. The wrong feedback channel has been specified. Verify the feedback. The wrong feedback setup code has been specified. Verify the feedback.	2.6, 4.8 Motor or Amp Documents Appendix B
An emergency stop condition occurs ...	The emergency stop input is in the active state. Set the fault mask parameter if an emergency stop is not desired.	4.9
A clockwise (CW) or counter-clockwise (CCW) limit condition always exists ...	Limits are not connected to the UNIDEX 511. Run diagnostics. The active polarity parameters of the limits are set wrong.	2.5, 2.6, 4.7
An axis is in a CW or CCW limit condition ...	The commanded motion extended past the limit. Acknowledge the fault to move out of the limit range. The system has been powered up in the limit condition. Acknowledge the fault to move out of the limit range. The active limit polarity setup parameter is set wrong. Software limits are improperly set.	3.0, 4.7

Always disconnect main power connection before opening the U511 chassis.

WARNING

Table 11-3. Troubleshooting for Problems Involving Fault Conditions (Cont.)

Problem	Possible Causes / Solutions	See Also ...
An over current trap (RMS over current fault) error has occurred ...	If the motor makes unusual noises or oscillates, the gain parameters may need to be adjusted. The "RMS current trap" parameter is set too low. The "RMS current sample time" is set too short. The mechanical system is damaged or jammed. The motor/amplifier may be undersized for the load.	2.5, 2.6, 4.10, 8.0 Appendix B Motor or Amp Documents
A feedback trap has occurred ...	The incorrect feedback channel has been specified. The incorrect feedback setup code has been specified. The encoder is not connected. Run diagnostics and check tracking display. Single ended encoders are connected. Set the fault mask to ignore encoder faults. A sinusoidal encoder is connected. The UNIDEX 511 accepts square wave encoders only. One or more encoder connections are broken. The encoder is faulty. The resolver is not connected. A resolver-to-digital tracking loop error has occurred. One or more resolver connections are broken. Incorrect setup code for the resolver has been used. The resolver reference has not been adjusted properly.	4.3, 4.8, 4.10, Appendix B
A feedrate trap has occurred ...	The commanded feedrate may have exceeded the "Top feedrate" parameter (x17).	4.10

WARNING

Always disconnect main power connection before opening the U511 chassis.

11.4. Homing Related Problems

Some common problems relating to the homing process are listed and diagnosed in Table 11-4.

Table 11-4. Troubleshooting for Homing Related Problems

Problem	Possible Causes / Solutions	See Also ...
The axis takes a long time to home ...	The "Home feedrate" parameter (x04) is set too low. The "Max accel/decel" parameter (x16) is set too low.	4.7
The axis runs into a limit during the home cycle ...	The homing direction parameter is wrong. The home switch is not connected.	4.7
Software limits are not working ...	The home cycle may not have completed yet.	4.7

11.5. RS-232 Communications Related Problems

Some things to check when commands through the RS-232 serial ports do not work are listed and diagnosed in Table 11-5

Table 11-5. Troubleshooting for RS-232 Related Problems

Problem	Possible Causes / Solutions	See Also ...
Remote commands do not work ...	Check Diagnostics terminal screen (page 8). Run terminal emulation software on PC to check communications. Check serial port configuration under Setup (pages 2 and 3) Check cabling. U511 requires a one to one connection to a PC.	3.0, 4.3, 6.0

Always disconnect main power connection before opening the U511 chassis.

WARNING

11.6. IEEE-488/GPIB Related Problems

Some things to check when commands through the IEEE-488/GPIB do not work are listed and diagnosed in Table 11-6.

Table 11-6. Troubleshooting for IEEE-488/GPIB Related Problems

Problem	Possible Causes / Solutions	See Also
Remote commands do not work ...	Check Diagnostics terminal screen (page 8). Check address and EOS parameters under Setup (page 4).	3.0, 4.4, 6.0

WARNING

Always disconnect main power connection before opening the U511 chassis.

11.7. Fuse Replacement

The following table lists the manufacturer and Aerotech's part number for typical replacement fuses. Additional fuse information can be found on the System Drawing supplied with the unit.

Table 11-7. Fuse Replacement Part Numbers

Fuse	Manufacturer PN	Aerotech PN
15 amp, 3 AG, Bus	PN. BK/MDA-15	PN. EIF116
12 amp, 3 AG, Bus	PN. BK/MDA-12	PN. EIF173
10 amp, 3 AG, Bus	PN. BK/MDA-10	PN. EIF117
4 amp, 3 AG, Bus	PN. BK/MDA-4	PN. EIF104
2 amp, 5x20 mm fuse	Littlefuse 235002	PN. EIF195
1 amp, 5x20 mm fuse	Littlefuse 218001	PN. EIF189

Note:

- Fuses are located on the U511 interface board and in an internal mounted fuse block.
- Information concerning fuse values and fuses on power amps can be obtained from the system drawing and amplifier documentation.
- Always disconnect the mains power disconnect before opening the U511 chassis.
- 10, 12, and 15 amp fuses are not user replaceable. An open fuse usually indicates that the unit should be returned for service.

11.8. Preventative Maintenance

The U511 and external wiring should be inspected monthly. Inspections may be required at more frequent intervals, depending on the environment and use of the system. The table below lists the recommended checks that should be made during these inspections.

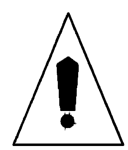
Table 11-8. Preventative Maintenance

Check	Action to Take
Visually inspect chassis for loose or damaged parts and hardware. Note: Internal inspection not required.	Parts should be repaired as required. If internal damage is suspected, those parts must then be inspected and repaired as necessary.
Inspect cooling vents.	Remove any accumulated material from vents.
Check for fluids and electrically conductive material exposure.	Fluids and electrically conductive material must be removed and not allowed to enter the U511 chassis. Note: Disconnect main power to avoid shock hazard.
Visually inspect all cables and connections.	Tighten or resecure any loose connections. Replace worn or frayed cables. Replace broken connectors.

11.9. Cleaning

The U511 should be wiped clean with a clean, dry (or slightly damp with water), soft cloth. Fluids and sprays are not recommended because internal contamination may result in electrical shorts and/or corrosion. The electrical power must be disconnected from the U511 while cleaning. Do not allow cleaning substance on to any of the connectors. Avoid cleaning the U511 labels on the rear panel to prevent erasing label information.

Always disconnect main power connection before cleaning the U511 chassis.



WARNING

11.10. Battery

The U511 contains a lithium battery used to supply power to program RAM. The battery is located on the U511 control board (labeled B1).

Battery Type: BCX723B50

Manufacturer: Electrochem

Aerotech Part #: ECZ00126

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APPENDIX A: GLOSSARY OF TERMS

In This Section:

- Terms Used In This Manual
- Definitions

This appendix contains definitions of terms that are used throughout this manual.

absolute positioning - Absolute positioning is positioning that is done with respect to an initial starting position (typically referred to as the home position) and typically uses a standard coordinate system (using [X, Y] coordinates is an example of absolute positioning). In contrast, incremental (or relative) positioning is done using a series of relative moves. These moves are relative to the previous location rather than a single reference point (for example, relative changes in position [ΔX,ΔY] are examples of incremental positioning).

acceleration feed forward - Acceleration feed forward is a control strategy (represented as a dimensionless gain value that is sometimes used during the motor tuning process) in which acceleration commands are sent directly to the amplifier.

accuracy - Accuracy is the difference between an expected value and an actual value expressed as a percentage.

ACK (acknowledgment) - The communications code sent from a receiving station to a transmitting station to acknowledge the error-free receipt of transmitted data or the state of readiness to receive more data.

amplifier - An amplifier is a hardware device having an output that is a function of the input signal.

axis - An axis is a direction along which movement occurs.

axis calibration - Axis calibration is the process by which the current position of an axis is adjusted to match the actual position (as determined by a laser for example) of the axis.

backlash - Backlash is a movement that occurs between two or more interacting mechanical parts as a result of looseness.

ballscrew - A ballscrew is a precision motion component of mechanical stages and consists of a precisely threaded shaft (or channel) and a housing that rides along the shaft as the shaft is rotated. The housing of a ballscrew contains ball bearings that ride in the channel of the shaft as the shaft rotates. A small tube on the housing recycles the bearings as the shaft rotates. The conversion factor parameter calculation is different for ballscrew systems compared to other systems. (Compare with leadscrew.)

batch file - A batch file is a file that contains a series of commands (e.g., the AUTOEXEC.BAT file is a batch file).

bit - The term bit is an acronym for "Binary digIT" and represents a single binary number (i.e., a "1" or a "0"). In digital computers, a bit's two states can represent an off state and an on state, a high voltage and a low voltage, the numbers 0 and 1, etc.

brushless motor - Aerotech brushless motors are three-phase, rare earth permanent magnet servo motors which generate a sinusoidal back EMF voltage and are usually referred to as AC brushless motors. Another type, usually referred to as the DC brushless motors, generate a trapezoidal back EMF and produce more torque ripple.

byte - A byte is a common unit of information storage made up of eight binary digits (bits). A byte can be used to represent a single ASCII character (e.g., "A"= 01000001 [binary]) or binary numbers from 00000000 to 11111111 (from 0 to 255 decimal), depending on how it is used.

circular interpolation - Circular interpolation refers to the UNIDEX 511's ability to coordinate two axes to produce accurate circular motion using minimal reference information (e.g., the center point and a radius).

closed loop system - A closed loop system is a drive system that uses sensors for direct feedback of position and/or velocity. Contrast with open loop system

commutation - Commutation refers to the process by which every other cycle of an alternating current is reversed so that a single unidirectional current is supplied. In the case of motors, commutation refers to the switching of current to motor windings which causes the motor to rotate. In a DC servo motor, this is done mechanically using brushes and a commutator. A brushless motor is electronically commutated using a position feedback device such as an encoder that is mounted to the rotor. Stepping motors are electronically commutated without feedback (in an open loop fashion).

constant velocity motion - Constant velocity motion refers to the U511's ability to perform motion while maintaining a constant velocity during the motion. For an application example, consider an irregularly shaped pattern that requires a series of *perforations* (made using a series of on/off laser pulses, for example). Constant velocity motion ensures that the length of each perforation is the same.

cubic spline interpolation - Cubic spline interpolation is a mathematical process used by the U511 in which a smooth curve (path) is based on two sets of coordinates ([X1,Y1] and [X2,Y2]) on the curve. Unlike linear interpolation, however, a previous coordinate ([X0,Y0]) and following coordinate ([X3,Y3]) are used to determine the curve's slope entering the path and exiting the path.

derivative gain - Derivative gain is a dimensionless motor tuning parameter that serves to dampen the system response by producing a dampening force as long as the system is progressing toward error reduction.

double word - A word is a number of bytes that are processed as a single unit by a computer. In the U511, a word consists of two bytes or 16 bits. A double word is twice that amount (i.e., four bytes or 32 bits).

electronic gearing - Electronic gearing is the process of moving one or more slave axes in coordination with a master axis without continuously sending commands from the host program. By establishing a series of relationships between axes, the servo processor will continuously update the positions and velocities of the slave axes based on the commanded motion of the master axis. The master can be a physical axis in the system or a virtual axis used for synchronization purposes only.

encoder - An encoder is a rotary device that transmits a pulsed signal based on the number of revolutions of the device.

faults - A fault is an error condition that occurs when a component of the UNIDEX 511 system operates outside certain parameters. Fault masks are used to allow the U511 system to detect and act on any fault condition of the system. Examples of major fault conditions include position faults, velocity faults, integral faults, RMS over current faults, amplifier faults, and feedback faults.

feedrate error - A feedrate error is a type of fault that is generated by the UNIDEX 511 if the current speed of an axis exceeds a programmable maximum speed (called the Top Feedrate parameter [x17]). Feedrate errors are necessary because certain stages or motors have a maximum operating speed above which components may be damaged.

fillet - A fillet is a concave junction where two surfaces meet. When machining a part using the U511, a fillet can be created using corner rounding (rather than specifying dimensions for circular motions). This gives a smooth *curved* junction rather than a sharp 90° angle for example.

floating point number format - Floating point number format is a method of representing numbers without defining a fixed number of decimal places. Two common forms of floating point number format are fixed-style format (e.g., 12.345, 0.000001, -2, etc.) and scientific notation (e.g., 12.3E4, -1.2E-3, etc.). The UNIDEX 511 uses fixed-style format for floating point numbers.

G codes - see RS-274 commands.

Hall effect switch - A Hall effect switch is a solid state switch that is activated by a magnetic field. Some AC brushless motors use Hall effect switches.

handwheel - A handwheel is an encoder-based manual control input device that can be used to simplify machine setup or testing.

helical interpolation - Helical interpolation refers to the UNIDEX 511's ability to coordinate three axes to produce accurate helix motion (e.g., an upward circular spiral) using minimal reference information (e.g., the center point and a radius of the circle portion of the spiral and a feedrate).

hexadecimal number format - Hexadecimal number format is a method of representing large numbers using base 16 rather than the standard base 10. In base 16 or hexadecimal number format (often abbreviated "hex"), the number positions represent powers of 16 (rather than powers of 10 in decimal). The decimal number positions (1's, 10's, 100's, 1,000's, 10,000's, etc.) are replaced with hexadecimal number positions (1's, 16's, 256's, 4096's, etc.). Also, while the individual numerals for the decimal system are 0-9, the numerals for the hexadecimal number system (which requires 16 unique "numerals") are 0-9 then A-F (where $A_{16}=10_{10}$, $B_{16}=11_{10}$, $C_{16}=12_{10}$, $D_{16}=13_{10}$, $E_{16}=14_{10}$, and $F_{16}=15_{10}$). For simplicity in this manual, hexadecimal numbers are written with a preceding "0x" rather than using the subscript 16. For example, the hexadecimal number 12A5 is written 0x12A5. Numbers without the preceding "0x" are assumed to be decimal unless otherwise indicated.

home cycle - The home cycle is series of motions that are used to move the specified axes to a hardware referenced position. The Home feedrate parameter sets the feedrate associated with the home cycle.

home marker option - The home marker option is a type of encoder that can be used with stepper motors. This option provides an inexpensive way of establishing a very accurate home reference (usually within 0.1 microns, in most Aerotech equipment). The home marker is protected in a rugged housing that also provides terminal connections for the encoder, the motor and the limit switch.

in-position integrator - An in-position integrator is a motor tuning adjustment that can be used to help remove steady-state position errors as well as reduce the effects of tachometer loop drift. In-position integration is accomplished at a rate that is directly proportional to the velocity loop integrator (Ki).

incremental positioning - Incremental (or relative) positioning is done using a series of relative moves. These moves are relative to the previous location rather than a single reference point (for example, relative changes in position [ΔX,ΔY] are examples of incremental positioning). In contrast, absolute positioning is positioning that is done with respect to an initial starting position (typically referred to as the home position) and typically uses a standard coordinate system (using [X,Y] coordinates is an example of absolute positioning).

Inductosyn - An Inductosyn is a rugged, very accurate, multipole electromagnetic transducer with an operating principle similar to that of a resolver.

integral error - Integral error is the summation of position errors over time. An integral error fault is generated if the integral error for an axis exceeds a programmable maximum integral error value (parameter x20). Integral error is reset every time the axis is reset.

integral gain - Integral gain is a dimensionless motor tuning parameter that serves to help remove steady-state position errors as well as reduce the effects of tachometer loop drift.

iSBX expansion port - The iSBX expansion port is a standard Intel interface that uses either an 8 or 16 bit data bus and is used primarily for communications-oriented additions to the system. The iSBX expansion port has a communications data rate of approximately 1 MB/sec (1,048,576 bytes per second).

jog move - A jog move is a momentary movement of a servo drive to provide manual control of axis motion.

joystick - A joystick is manual input control device that digitizes a path using two axes. A joystick offers direct motion control for easy machine setup and testing.

jumpers - Jumpers are hardware *ties* that you manually position onto different posts to configure the hardware platform. Jumpers on the UNIDEX 511 board are used to configure the COM2 format, the front panel display, the operating mode, and other features.

leadscrew - A leadscrew is a motion component of stages and consists of a threaded shaft and a housing that rides along the shaft as the shaft is rotated. The housing of a leadscrew contains a similar thread that rides along the shaft thread as the shaft rotates. Leadscrews are more economical, but less accurate than ballscrews.

LED - LED is an acronym for light-emitting diode. An LED is a semiconductor diode that converts electrical energy into visible electromagnetic radiation. The UNIDEX 511 board has several LEDs visible from the back of the unit that are used for diagnostic purposes.

linear interpolation - Linear interpolation is a mathematical process used by the U511 in which a straight line (path) is based on two sets of coordinates ([X1,Y1] and [X2,Y2]) on the line. Unlike cubic spline interpolation (which uses two additional coordinates to determine the slope of the smoothed curve), linear interpolation only uses two sets of coordinates and generates a straight (not smoothed) path.

linear motor driver - A linear motor driver is a non-switching type of DC servo amplifier that drives the motor with direct current. Linear amplifiers do not generate electrical noise or switching losses in the motor. They do, however, have a higher rate of power dissipation than a pulse-width modulated (PWM) amplifier.

LSB - Least significant bit.

M codes - see RS-274 commands.

machine step - A machine step is the smallest feedback device step that can be taken. This is the smallest possible increment of movement as measured by the feedback device.

microstepping - Microstepping is a technique for driving stepping motors more smoothly and with higher resolution than full step control. Current is divided in a sine-cosine fashion between motor phases to provide intermediate positions between full step positions.

multitasking - Multitasking is software technique that gives several functions (or tasks) the appearance of individually having sole access to the resources of the system (for example, the microprocessor). In its simplest form, a multitasking system assigns a small time slice to each task in a round robin fashion. Only one task at a time has access to the multitasking system's resources. When each successive task has had the opportunity to use the system resources (for a brief period), the cycle repeats.

MSB - Most significant bit.

NAK (negative acknowledgment) a negative response to the reception for data, or the response to an inquiry of transmission status.

notch filter - A notch filter is a software filter that is used to remove a section of frequencies in order to stabilize a system with a known mechanical resonance.

open loop system - An open loop system is a drive system that does not employ feedback sensors to monitor position or velocity. Most stepper motor applications are open loop (that is, they have no feedback). The commanded position is the assumed motor position.

Contrast with closed loop system.

operator - (1) An operator is one who uses the UNIDEX 511 system.

operator - (2) An operator is a programming element that is used to link terms in an expression. Programming operators include the standard arithmetic operators (e.g., +, -, * and /), comparison operators (e.g., < and >) and Boolean operators (e.g., AND, OR and NOT) and others.

orthogonality - Orthogonality is a state of two axes in which one is perpendicular to the other. The UNIDEX 511 provides orthogonality correction capabilities that allow an axis to be corrected (using absolute machine step correction data) based on a position-dependent axis. Orthogonality correction, if used, is incorporated into the axis calibration (.CAL) file.

plane - A plane is an axis or group of axes that can be coordinated (for example, a particular action of one plane can trigger an action on another plane) or independent (for example, one plane can be milling a part while another plane is etching circles). Planes can also be virtual planes, which are not linked to any particular axis, but act as queues or buffers.

point-to-point motion - Point-to-point motion simply involves specifying a target position. After the target position is commanded, the controller strives to attain that position with no time or path constraints.

position error - Position error is the difference between the commanded position of an axis and the feedback position (i.e., the difference between the desired position and the actual position). A position error fault occurs if the current position error exceeds a programmable maximum position error (parameter x19). Position error is measured in machine steps.

position synchronized output card (PSO-PC) - The position synchronized output card is an optional PC-bus based card that can be used in conjunction with the U511 to provide programmable laser-firing control.

program - A program is a set of instructions that are carried out in some predefined logical order. A UNIDEX 511 program is a sequential list of UNIDEX 511 programming commands (see Chapter 5) which tell the U511 control board how to perform specific motions for a particular application. UNIDEX 511 programs may be created/edited on-line (from within the Program menu) or off-line (using any standard ASCII text editor). U511 program files use .PRG as their extension.

program step - A program step is the smallest programmable increment of motion that can be commanded. A program step equals the programming units * 10 ^{ndec} where "ndec" is the number of decimal digits set by parameters 029, 030, 047 and 048 for Metric mode, and parameters 065, 066, 083 and 084 for English mode.

program unit - A program unit is a user-defined measurement unit such as inches, millimeters, degrees, etc. Program units are used within the application program and provide the operator with flexibility and ease of use. For example, it is more meaningful for an operator to command a "100 mm" move than it is to command a "752 machine step" move.

proportional gain - Proportional gain is a dimensionless motor tuning parameter that produces an output that is related to the Velocity Error in the servo loop.

qms - QMS is an abbreviation for quarter millisecond - a unit of time that is used when determining values such as velocity error, for example, that is measured in machine units per quarter millisecond (i.e., machine units/qms). One qms is equivalent to 0.25 milliseconds.

quadrature - Quadrature is the state of two signals that are displaced 90 degrees with respect to each other. In most rotary incremental optical encoders, light (from an LED, for example) is measured after it is passed through slits in a grating disk (which is attached to the axis being measured). Typically, two tracks on the disk have their gratings displaced 90 degrees with respect to each other (that is, the tracks are said to be in quadrature).

registers - In the U511, registers are used by the software to designate axis positions. Relative position registers ($XRP, $YRP, $ZRP and $URP) represent the commanded axis positions (in machine steps) with respect to the software home position. Absolute position registers ($XAP, $YAP, $ZAP and $UAP) represent the commanded axis positions (in machine steps) with respect to the hardware home position.

reset - *see initialization*.

resolver - A resolver is a two-phase, rotary, electromagnetic transducer in which inductive coupling (between the rotor and stator windings) and trigonometric principles are employed to provide absolute position information over one electrical cycle (which is one revolution for "single-step" resolvers)

resolver-to-digital card (RDP-PC) - The RDP-PC card is an optional ISA bus-based R/D card that is used to receive resolver or Inductosyn feedback. Resolution is selectable among 10-bit, 12-bit, 14-bit, or 16-bit.

RMS current trap - RMS current trap is an error that occurs if the current being commanded to a motor exceeds a programmable limit (see parameters x48 and x49). RMS current trap is analogous to a software "fuse". Essentially, this fault functions the same as a physical fuse, but is done through software. One obvious advantage is that a "software fuse" does not have to be replaced like a physical fuse.

RS-274 - The term RS-274 refers to a set of standardized motion control programming commands. These commands consist of the letter "G" or "M" followed by a one- or two-digit number (e.g., M47, G3, M2, G70, etc.). A subset of the RS-274 command set is available for certain UNIDEX 511 program commands for programmers who may be more familiar with the G/M codes rather than the corresponding UNIDEX 511 programming commands. Not all U511 programming commands have an RS-274 G code or M code counterpart. Refer to Chapter 5: Programming for more information.

servo control system - A servo control system (servo loop) is a motion control system which continuously compares desired position/velocity to actual position/velocity and produces an error correction command. Servo systems use sensors to feedback actual position/velocity.

shaft runout - Shaft runout is an expression of the total indicated reading of wobble or nonconcentricity as measured at the end of a motor shaft when the shaft is rotated one complete revolution.

soft keys - Soft keys are software "buttons" that are analogous to function keys on a standard PC keyboard. In the U511 software, five soft keys are located across the bottom of the display.

software - The term software refers to a computer program. Contrast software with hardware, the physical machinery, components and support peripherals through which the software runs.

spherical interpolation - Spherical interpolation refers to the UNIDEX 511's ability to coordinate multiple axes to produce accurate spherical motion using minimal reference information (e.g., the center point and a radius of the sphere).

task - A UNIDEX 511 task is one of four sets of instructions that are executed sequentially at such a high speed that each task has the impression that it alone has full access to all of the microprocessor's time.

time-based motion - A time-based motion is a motion that arrives at a specified location in a desired amount of time. After the target position of a move is programmed, the controller chooses any speed to achieve that position on time.

traps -*See* faults.

tuning - Tuning is the process of optimizing the operation of a servo system.

variables - Variables are programming terms that are used as temporary storage locations for calculations. Direct variables (V0 through V255) are general purpose, double precision storage locations. Indirect variables (VV0 through VV255) are used to indirectly address other variables. For example, if V35=999 and V1=35, then you can indirectly address the contents of V35 using the statement V0=VV1. In this case, the contents of V1 (35) is used as an index to V35. The value of V35 (999) is placed in V0.

velocity error - Velocity error is the difference between the commanded velocity and the velocity derived from the feedback position (i.e., the difference between the desired velocity and the actual velocity). Velocity error is measured in machine steps per quarter millisecond (machine steps/qms). A velocity error fault occurs if, at any time, the velocity error of the system exceeds a programmable velocity error (specified by parameter x18).

velocity feed forward - Velocity feed forward is a control strategy (represented as a dimensionless gain value that is sometimes used during the motor tuning process) in which current velocity disturbances are converted into corrective actions now in order to minimize the future effects of the disturbances.

velocity profiled motion - Velocity profiled motion is a move of a programmed distance and speed from the current position. Velocity profiled motions are executed only after the previous motion has reached its deceleration point.

word - A word is a number of bytes that are processed as a single unit by a computer. In the U511, a word consists of two bytes or 16 bits.

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APPENDIX B: WARRANTY AND FIELD SERVICE

In This Section:
- Laser Product Warranty
- Return Products Procedure
- Returned Product Warranty Determination
- Returned Product Non-warranty Determination
- Rush Service
- On-site Warranty Repair
- On-site Non-warranty Repair

Aerotech, Inc. warrants its products to be free from defects caused by faulty materials or poor workmanship for a minimum period of one year from date of shipment from Aerotech. Aerotech's liability is limited to replacing, repairing or issuing credit, at its option, for any products which are returned by the original purchaser during the warranty period. Aerotech makes no warranty that its products are fit for the use or purpose to which they may be put by the buyer, whether or not such use or purpose has been disclosed to Aerotech in specifications or drawings previously or subsequently provided, or whether or not Aerotech's products are specifically designed and/or manufactured for buyer's use or purpose. Aerotech's liability or any claim for loss or damage arising out of the sale, resale or use of any of its products shall in no event exceed the selling price of the unit.

Laser Products

Aerotech, Inc. warrants its laser products to the original purchaser for a minimum period of one year from date of shipment. This warranty covers defects in workmanship and material and is voided for all laser power supplies, plasma tubes and laser systems subject to electrical or physical abuse, tampering (such as opening the housing or removal of the serial tag) or improper operation as determined by Aerotech. This warranty is also voided for failure to comply with Aerotech's return procedures.

Return Procedure

Claims for shipment damage (evident or concealed) must be filed with the carrier by the buyer. Aerotech must be notified within (30) days of shipment of incorrect materials. No product may be returned, whether in warranty or out of warranty, without first obtaining approval from Aerotech. No credit will be given nor repairs made for products returned without such approval. Any returned product(s) must be accompanied by a return authorization number. The return authorization number may be obtained by calling an Aerotech service center. Products must be returned, prepaid, to an Aerotech service center (no C.O.D. or Collect Freight accepted). The status of any product returned later than (30) days after the issuance of a return authorization number will be subject to review.

Returned Product Warranty Determination

After Aerotech's examination, warranty or out-of-warranty status will be determined. If upon Aerotech's examination a warranted defect exists, then the product(s) will be repaired at no charge and shipped, prepaid, back to the buyer. If the buyer desires an air freight return, the product(s) will be shipped collect. Warranty repairs do not extend the original warranty period.

Returned Product Non-warranty Determination

After Aerotech's examination, the buyer shall be notified of the repair cost. At such time the buyer must issue a valid purchase order to cover the cost of the repair and freight, or authorize the product(s) to be shipped back as is, at the buyer's expense. Failure to obtain a purchase order number or approval within (30) days of notification will result in the product(s) being returned as is, at the buyer's expense. Repair work is warranted for (90) days from date of shipment. Replacement components are warranted for one year from date of shipment.

Rush Service

At times, the buyer may desire to expedite a repair. Regardless of warranty or out-of-warranty status, the buyer must issue a valid purchase order to cover the added rush service cost. Rush service is subject to Aerotech's approval.

On-site Warranty Repair

If an Aerotech product cannot be made functional by telephone assistance or by sending and having the customer install replacement parts, and cannot be returned to the Aerotech service center for repair, and if Aerotech determines the problem could be warranty-related, then the following policy applies:

Aerotech will provide an on-site field service representative in a reasonable amount of time, provided that the customer issues a valid purchase order to Aerotech covering all transportation and subsistence costs. For warranty field repairs, the customer will not be charged for the cost of labor and material. If service is rendered at times other than normal work periods, then special service rates apply.

If during the on-site repair it is determined the problem is not warranty related, then the terms and conditions stated in the following "On-Site Non-Warranty Repair" section apply.

On-site Non-warranty Repair

If any Aerotech product cannot be made functional by telephone assistance or purchased replacement parts, and cannot be returned to the Aerotech service center for repair, then the following field service policy applies:

Aerotech will provide an on-site field service representative in a reasonable amount of time, provided that the customer issues a valid purchase order to Aerotech covering all transportation and subsistence costs and the prevailing labor cost, including travel time, necessary to complete the repair.

Company Address

Aerotech, Inc.
101 Zeta Drive
Pittsburgh, PA 15238-2897
USA

Phone: (412) 963-7470
Fax: (412) 963-7459
TWX: (710) 795-3125

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APPENDIX C: SETTING UP AN AC BRUSHLESS MOTOR WITH THE UNIDEX 511

In This Section:

C.1. Introduction

AC brushless motor commutation differs from that of a DC brush motor. The servo loop output for a DC brush motor is a signal between -10 and +10 volts. This signal is connected to an amplifier that converts the voltage into motor current. The current produces torque in the motor. The servo loop output is sometimes called a current command even though it is a voltage.

The DC brush motor has a pair of fixed magnets mounted in the motor's shell and a rotor which has a series of windings called the armature. When current passes through the armature windings, it produces a magnetic field that interacts with the fixed magnets to produce a force. In order to maximize this force, the fields should be separated by 90 degrees. In a DC brush motor, this is done by the brushes and commutator. The brushes carry the current to the commutator and as the motor rotates, a new set of armature windings are energized. This keeps the armature magnetic field perpendicular to the magnets.

AC brushless motor construction is the reverse of a DC brush motor–the permanent magnets are on the rotor and the windings are mounted to the motor housing. Because the windings are stationary, there is no need for brushes. However, the current in the windings must change so that the generated magnetic field is perpendicular to the field produced by the rotor magnets. A feedback device is used to keep track of the rotor position.

C.2. Setup Procedure

The UNIDEX 500 generates two phases of current commands separated by 120 degrees. The servo loop output is multiplied by these phases and sent to the amplifier. A third phase may be generated by adding the first two and inverting its polarity. Aerotech amplifiers do this automatically on the amplifier. The phases are as follows:

Phase A = sin(ang)

Phase B = sin(ang + 120)

Phase C = - (Phase A + Phase B)

The UNIDEX 511 has two test functions for setting up AC brushless motors–"MSET" and "MCOMM." The MSET function sends a "two phase" vector at a specified angle and voltage. The MCOMM function sends a (commutated) torque command at a specified voltage level. The syntax of these commands is as follows:

MSET *axis,voltage,angle*

where:

axis = axis number (1-4)

voltage = amplitude of vector output (0-10 V)

angle = angle of output vector (0-359 °)

MCOMM *axis,voltage*

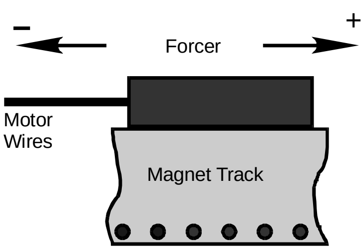
where:

axis = axis number (1-4)

voltage = peak magnitude of torque output.

To use these commands in setting up an AC brushless motor, the following procedure is recommended.

1. Disconnect motor from load.
2. Connect motor leads A, B, and C to amplifier A, B, and C, respectively.
3. Set axis parameter x42, "Amplifier type(0-DC brush, 1-AC brushless, 2-step 3 recirc)," to 1 for AC brushless servo.
4. Set servo loop gains "Kpos," "Ki," and "Kp" to 0.
5. Defeat Position Error and Integral Error faults.
6. Enable the axis.
7. Check motor direction by sending a series of MSET commands with increasing angles. See the example program below. As the angle increases, the motor should move in the positive or CW direction. If it does not, reverse two of the motor leads (see margin for linear motor directions).



Linear Motor Phasing

Example Program

This program increments the vector by 10 degrees each time through the loop. It is written for the X axis. To change to a different axis, change line #1 and V0. The motor should not be connected to the load during this test.

```
ENABLE X          ; enable axis to check (X, Y, Z, or U)
V0=1              ; axis number (1,2,3, or 4)
V1=.5             ; peak amplifier output voltage
V2=0              ; starting angle (0 degrees)
V3=1000           ; time in milliseconds between vectors (step speed)
WAIT ON           ; wait for previous commands to finish
ABORT             ; abort internal queue buffer
LOOP 36           ; loop for one electrical cycle
MSET V0,V1,V2     ; send vector
DWELL V3          ; delay between vectors
V2=V2+10          ; angle of next vector
NEXT
QUEUE AGAIN       ; run program continuously
```

The feedback device's position display should also be increasing (See page 4 of the Diagnostics window in the interface program.

8. Check the Hall signals. The Hall signals can be viewed on Page 7 of the U511 Diagnostics window. See Figure C-1. As the motor is moved in the positive direction, the Hall signals should cycle through the proper states. Swap Hall signals until the proper sequence is obtained. See Table C-1. Aerotech linear and rotary AC brushless motors require Hall effect feedback except for rotary AC brushless motors with resolvers. Resolvers provide absolute position information for one revolution of the motor.

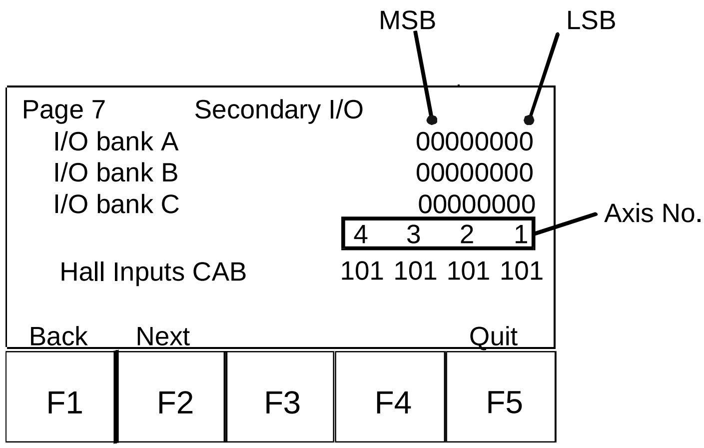


Figure C-1. Page 7-U511 Diagnostics Window

Table C-1. Hall State Table

MSET angle (degrees)	HC (msb)	HA	HB (lsb)
330-30	1	0	0
30-90	1	0	1
90-150	0	0	1
150-210	0	1	1
210-270	0	1	0
270-330	1	1	0

9. Set commutation offset. Record the Hall states using the MSET command every 10 degrees. Compare with the desired Hall states. Calculate the needed shift in degrees to make the recorded Hall states align with the desired Hall states. Enter this number (in degrees) for axis parameter x45, "Commutation phase offset." Re-check Hall signals.

10. Verify motor commutation:

    a. Set axis parameter x43, "Commutation cycles," to 0. This will force the controller to commutate from the Hall signals only (six step mode).

    b. Linear motor:

       Send the MCOMM command and verify the motor output force. Since the motor will move open loop, make sure the positioning stage is secured before sending the command. The motor force output should be smooth and in the same direction over the length of travel. Motor force can be measured with a spring scale. Test the other direction by specifying a negative voltage in the MCOMM command.

    c. Rotary motor:

       If the motor is disconnected from the load, the open loop speed of the motor can be checked using the MCOMM command. A properly phased motor will go the same speed in each direction. Use the axis tuning scope to observe the velocity.

    d. Set axis parameter x43 back to its original value. It should be 1 for linear motors and 2, 3, or 4 for rotary motors. Also make sure that axis parameter x44, "Feedback," is set properly. For linear motors, enter the number of steps per electrical cycle. UNIDEX 511 will now commutate in sinusoidal mode. The above commutation checks can be repeated if desired. The motor torque output should feel "smoother" in sinusoidal mode than in six step mode. If the motor is commutating properly in six step mode but not sinusoidal mode, check axis parameter x44. Also verify encoder operation. The encoder should count in the positive direction when a positive torque is commanded.

11. Re-enable axis position and integral faults in the fault mask and tune servo loop.

> See related Aerotech Engineering Specification ES12731-n for signal definitions, color coding, and motor revision information.

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APPENDIX D: iSBX-IO48 BOARDS

In This Section:

D.1. Introduction

The iSBX-IO48 board allows the user to connect user-configurable I/O to the UNIDEX 511 via its iSBX port.

The iSBX-IO48 can drive up to two I/O boards (such as two PB24A Opto 22 boards) as shown in Figure D-1. Because each I/O board can have up to 24 I/O bits apiece; the iSBX-IO48 board can drive a total of 48 I/O bits. Also, each I/O board is termed a "bank" of 24 I/O bits, thus the iSBX-IO48 board has two banks. They are labeled Bank #0 and Bank #1 as shown in Figure D-2.

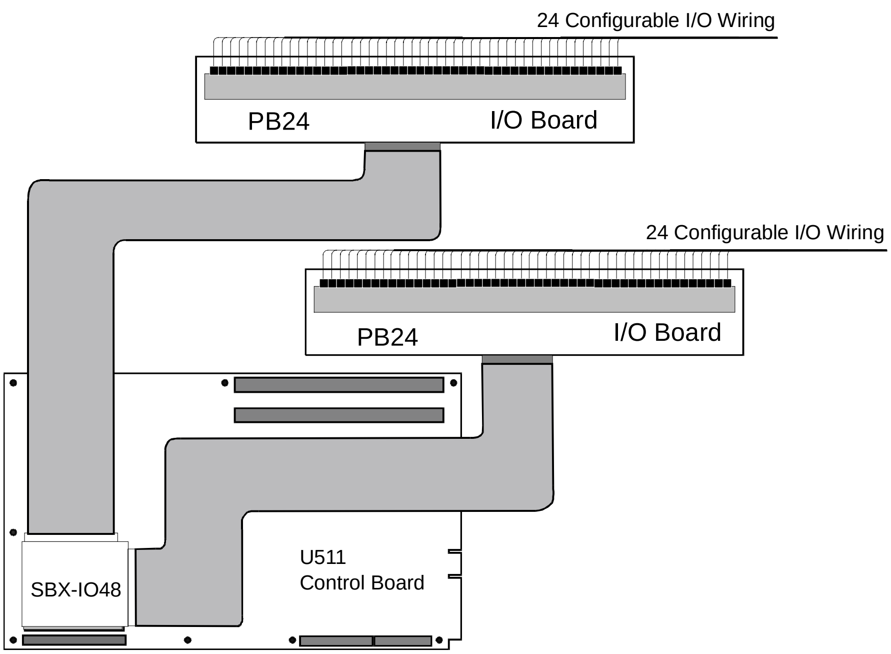
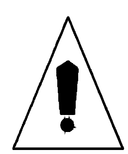


Figure D-1. An iSBX-IO48 Card Connected to Two I/O Cards

Always disconnect main power connection before opening the U511 chassis.



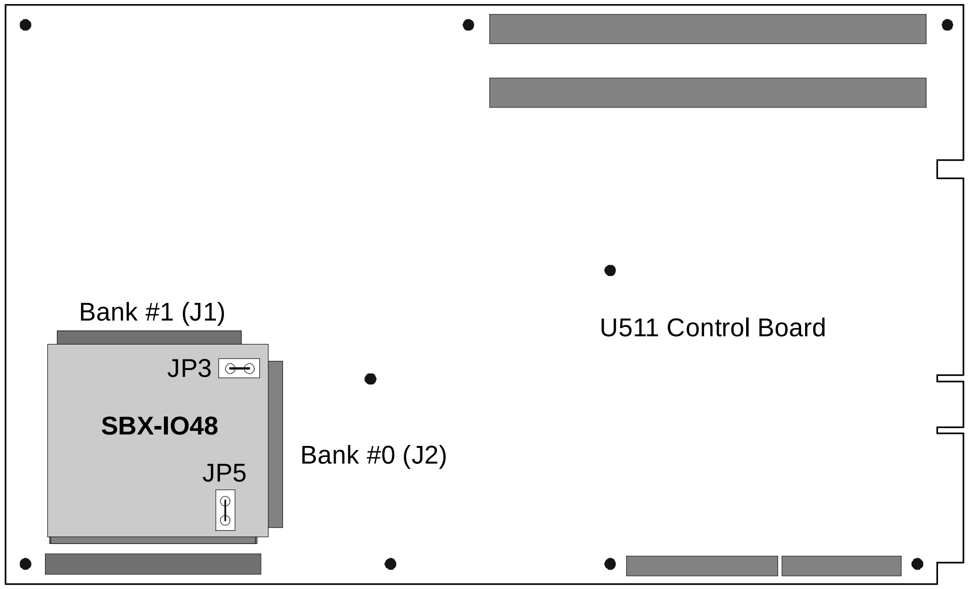


Figure D-2. The iSBX-IO48 Card

Each bank is divided into four ports termed A, B, Cl, and Ch. Port A and port B are 8 bits in size. Port Cl and port Ch are 4 bits in size. The pinout for each bank showing their corresponding ports is shown in Table D-1. The pinouts on the I/O board are shown in Figure D-3.

Table D-1. iSBX-IO48 Pinouts

Port	Address (1)	Slot on PB24A	Pinout on J1 & J2
A	$x00	23	1
	$x01	22	3
	$x02	21	5
	$x03	20	7
	$x04	19	9
	$x05	18	11
	$x06	17	13
	$x07	16	15
B	$x10	15	17
	$x11	14	19
	$x12	13	21
	$x13	12	23

Table D-1. iSBX-IO48 Pinouts (continued)

Port	Address [1]	Slot on PB24A	Pinout on J1 & J2
B	$x14	11	25
	$x15	10	27
	$x16	9	29
	$x17	8	31
Cl	$x20	7	33
	$x21	6	35
	$x22	5	37
	$x23	4	39
Ch	$x24	3	41
	$x25	2	43
	$x26	1	45
	$x27	0	47

1. x = 0 for bank #0 (J2 on iSBX-IO48) or x = 1 for bank #1 (J1 on iSBX-IO48)

All even pins on J1 and J2 are common. Also, pin 49 on both J1 and J2 is jumper selectable (J3 and J5) to provide +5 volts.

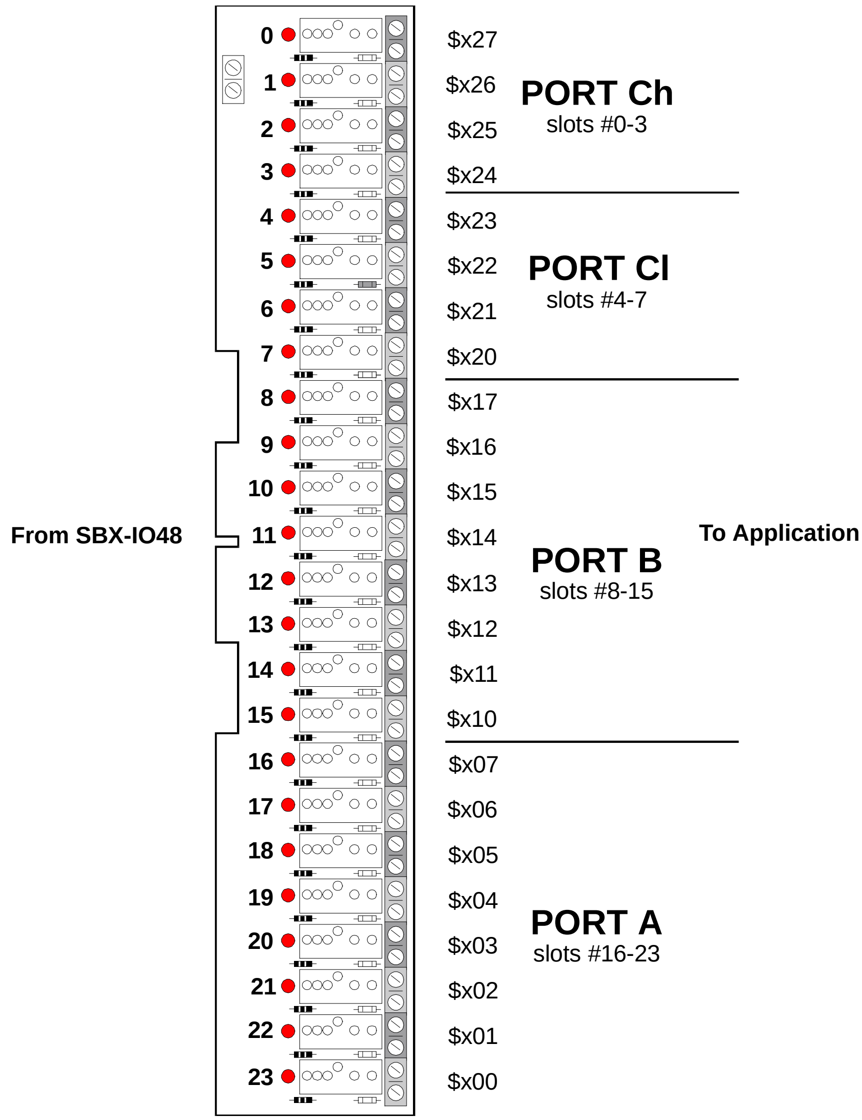


Figure D-3. iSBX-IO48 Pinouts on the PB24 I/O Card

D.2. iSBX-IO48 Jumper Settings

There are two jumpers on the iSBX-IO48 called JP3 and JP5. These jumpers select whether the iSBX-IO48 provides +5 volts on pin #49. The JP3 jumper sets pin 49 on bank #0 (J2), and jumper JP5 sets pin 49 on bank #1 (J1). When the jumper is inserted, it provides +5 volts to pin 49. When the jumper is removed, pin 49 is not connected.

D.3. Configuring the iSBX-IO48

The iSBX-IO48 is configured as input or output by setting a control port with a control word. The hexadecimal number $03, is the address for the control port on bank #0 and $13 is the address for the control port on bank #1. By setting the control port to specific control word (e.g., $03=144), the iSBX-IO48 configures the ports as inputs or outputs. The 16 possible control words are shown in Table D-2.

Table D-2. iSBX-IO48 Control Words

Control Word (decimal)	Inputs				Outputs			
128					A	B	Cl	Ch
129			Cl		A	B		Ch
130		B			A		Cl	Ch
131		B	Cl		A			Ch
136				Ch	A	B	Cl	
137			Cl	Ch	A	B		
138		B		Ch	A		Cl	
139		B	Cl	Ch	A			
144	A					B	Cl	Ch
145	A		Cl			B		Ch
146	A	B					Cl	Ch
147	A	B	Cl					Ch
152	A			Ch		B	Cl	
153	A		Cl	Ch		B		
154	A	B		Ch			Cl	
155	A	B	Cl	Ch				

After writing the control word, inputs can be read to UNIDEX 511 variables and outputs can be set. On reset of the U511, the ports are set to input state and the bits are set to high impedance state. Once a control word is written and a port is set as an output, the bits are pulled low. To avoid undesired output states, after writing a control word, immediately follow it by setting the output ports properly.

D.4. Programming the iSBX-IO48

Once the iSBX-IO48 is configured, the status of the inputs can be read and the states of the outputs can be set. Ports can be set as a whole or individually. Each port has a unique address as shown below:

Port A	$x0,
Port B	$x1,
Port Cl/Ch	$x2,

where x is 0 for Bank #0 and 1 for Bank #1. To address an individual bit, the bit is specified after the port address. For example, to address bit 4 of port B on bank #0, use a $014 address.

The status of an input is either the bit value (i.e., 1 for bit 0, 2 for bit 1, 4 for bit 2, etc.) for high impedance or 0 for low impedance. Inputs are read by assigning them to the UNIDEX 511's variables. For example, if bit 4 of port B on bank #0 is configured as input, its status can be read by the statement V4=$014. The contents of variable V4 can then be examined to see if it is the bit value or 0.

The status of an output can be set to either a 1 for high impedance or 0 for low impedance. Outputs are set by assigning value to them. For example, if bit 4 of port B on bank #0 is configured as an output, its state can be set to a high impedance by the statement $014=1. This output can be set to a low impedance by the statement $014=0.

The following sample program sets outputs and reads inputs of the iSBX-IO48 card:

```
$03=144                 ;configure for port A as input, B and C as outputs for
                        ;Bank #0. Control word = 144
$01=255                 ;set outputs of port B high
$02=85                  ;turn on even outputs of port C
v0=$000                 ;read bit 0 of port A
me di "bit 0 = %v0"     ; v0 = 0 or 1
v0=$001                 ;read bit 1 of port A
me di "bit 1 = %v0"     ; v0 = 0 or 2
v0=$002
me di "bit 2 = %v0"     ; v0 = 0 or 4
v0=$003
me di "bit 3 = %v0"     ; v0 = 0 or 8
v0=$004
me di "bit 4 = %v0"
v0=$005
me di "bit 5 = %v0"
v0=$006
```

```
me di "bit 6 = %v0"
v0=$007                  ; read bit 7 of port A
me di "bit 7 = %v0"      ; v0 = 0 or 128
```

Other UNIDEX 511 programming commands use the iSBX-IO48. These include the INT, PLC, CYCLE, PAUSE, and QUEUE INPUT commands. See Chapter 5, Programming Commands for more information on these commands that can use iSBX-IO48 I/O.

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APPENDIX E: BACKUP UTILITY

In This Section:

E.1. Introduction

The UNIDEX 511 backup utility is a DOS utility used to store and retrieve parameter files, configuration files, and user programs. This utility is used before system release to store a copy of the U511 parameter file and configuration file. The user may also use this utility to backup programs or modified files.

E.2. Memory Banks

There are 10 backup memory banks allowing each bank to store one file from the "B" drive. The maximum size of a file that can be placed in one backup memory bank is 2000 bytes.

The first two backup memory banks are reserved for the default parameter file and the default configuration file, respectively. These are the backup files used to obtain default parameter values and to restore copies of these files when they are not located on the "B" drive. The files used in these memory banks are specific to the system and are placed in the appropriate backup memory banks before delivery.

E.3. Backing-up Files

To back-up files, use the syntax shown below.

SYNTAX:

BACKUP *option filename*

option This argument is a single character and is used to specify the desired action:

(b)ackup:	Copy a file from the 'B' drive to backup memory
(r)estore:	Copy a file from backup memory to a file on the 'B' drive
(v)iew:	View the backup memory status. Each bank is shown to be free, or gives the file name and the file size in bytes. No filename is to be specified

filename	This is the filename to be stored in backup memory (option "b") or restored from backup memory (option "r"). The filename should be in standard DOS format using a maximum of 8 characters for the file name and a three character file extension (i.e., filename.nam).

EXAMPLE

backup b 12345.prm	;this will backup the parameter file 12345.prm
backup r 12345.prm	;this will restore the parameter file 12345.prm to the ;"B" drive

To modify the system default parameter values, use the restore option to place a custom *.prm file into memory bank number 1, and/or to place a custom *.cfg file into bank number 2. The values from these custom files will then be used for system defaults and will be used to replace missing parameter files from the "B" drive. Other files, such as user programs may be stored in banks 3 through 10.

> The backup memory is allocated in the flash memory sector containing DOS. Reloading DOS on the UNIDEX 511, will overwrite all files in backup memory. It may be necessary to restore all important files to the "B" drive before reloading DOS.

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APPENDIX F: UNIDEX 11 EMULATION SOFTWARE

In This Section:

F.1. Introduction

The UNIDEX 511 can emulate the UNIDEX 11's remote interface and motion commands. However, the user interface, front panel keys, and rear panels are not the same. This special emulation software is identified by "U11 EMULATION" displayed on the power up screen. It is intended for replacement of the UNIDEX 11 only and is not recommended for new designs.

F.2. Supported Commands

Table F-1 and Table F-2 list U11 commands that the U511 supports. Please refer to the "U11 Motion Controller Programming Manual" (PN# EDU103) for more information. System commands in Table F-1 are RS-232/GPIB IEEE 488 remote interface commands. Table F-2 shows motion and program flow commands.

Table F-1. System Commands Supported by the U511

Command	Notes
Ann	Auto Run program #01-99
Bnn	Block Run program #01-99
C	Hardware reset
D	Cancel S or R
Enn*	Begin downloading program #nn
E$nn*	Delete program #nn
E$00*	Erase all programs 01-99
F	Insert block numbers when printing program
G	Cancel block number printing
H	Put controller in hold mode
I(string) *	Send Immediate command
Jc	Set service request mode or define service request character "c" (optional)
K	Service request mode off
L	Not implemented on U511

Table F-1. System Commands Supported by the U511 (continued)

Command	Notes
M	Transmit status in binary format (default)
N	Transmit status in Hex-ASCII mode
O	Cancel hold mode (default)
PX,PY, PU,PV	Return axis position
PD	Print directory listing
Pnn	Print program #nn
P00	Print all programs
PS	Print status bytes
Q	Return serial poll byte (RS-232 only)
R	Not supported on U511 (no hardware)
S	Enable joystick
T	Trigger to start program execution

Note: All commands are followed by <CR><LF> except the "E" command.

Table F-2. Motion/Flow Commands Supported by the U511

Command	Description
AB	Absolute mode
AD	Set ramp time (ms)
BF	Beeper off
BN	Beeper on
CLRSCR	Clear display message area (*enhanced command*)
CO	Corner rounding on
CS nn I????	Conditional gosub
CT nn I????	Conditional goto
DB	Output BCD
DD	Output decimal
DI XYUV	Disable axes (*enhanced command*)
DW n or a.b	Dwell n .1 msec or a.b seconds

Table F-2. Motion/Flow Commands Supported by the U511 (continued)

Command	Description
EN XYUV	Enable axes (*enhanced command*)
GS nn	Goto subroutine nn
GT nn	Goto label nn
H XYUV	Home axes
IN	Incremental mode
IT ????	Wait for input state true
LB nn	Define label
LXaYbUcVd	Set position registers to abcd
ME+DI "…"	Display message to front panel (*enhanced command*)
NC	Corner rounding off
OR ????	Output on run
OS ????	Output on stop
OT ????	Set output bits
PS	Program stop
RC ????	Conditional repeat
RE	Repeat loop end
RP	Repeat program
RS n	Repeat loop start, n times
R XYUV	Restart freerun with previous feedrate
SR	Subroutine return
WA ON/OFF/ALL	Wait mode (*enhanced command*)
X Fa De Y Fb Df U Fc Dg V Fd Dh	Index move at feedrate (F) a, b, c, d; distance (D) e, f, g, h. One or more axes at a time.
X Fa R+/-	Freerun axis at feedrate a steps/sec in +/- direction

Notes: 1) ???? refers to the four input/output bits, LSB to MSB. The inputs may be specified as "1" (+5V), "0" (0V), or "X" don't care. See Chapter 10: Technical Details for more information.

2) Feedrates are in steps/second. Distances are in steps.

F.3. Differences Between the U511 and the U11

Some differences in the operation of the U511 and the U11 are indicated below:

1) Corner rounding is not implemented on the U511 in U11 compatible mode.
2) The DD and DB commands output data to the 8 X 3 I/O connector, lower 12 bits.
3) The U511 does not use internal CLK/DIR signals. Therefore the auxiliary control inputs are not available.
4) On the UNIDEX 11, J25 is the DIO/HSB option. The HSB option is not implemented on the U511. The DIO input mode, which allows the user to strobe program numbers or connect to the Thumb Wheel option, is not implemented.
5) The U511 has 16 inputs and 8 output that are available on the 16 IN/8 OUT connector. The lower four inputs and outputs are available on the AUX I/O connector and are opto-isolated on this connector only. The lower four inputs and outputs are program compatible with the U11 and are accessed with the OT, IT, etc. commands. See the "Technical Details" chapter for more information.
6) The U511 does not require an "*" to terminate commands (except for the "E" commands). The EOS character, which is typically <LF>, is the only terminator necessary for remote communication. The <CR> character is ignored if present.
7) The UNIDEX 511 has the ability to program in user defined units. These units are specified by two parameters, an axis scale factor, and number of decimal places. For compatibility with the U11, the axis scale factor should be set to 1.0, and the number of decimal places should be set to 0. The U511 will then program in machine steps.

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APPENDIX G: THE RDP-PC RESOLVER-TO-DIGITAL BOARD

In This Section:

G.1. Introduction

The RDP-PC option is a resolver-to-digital board that receives resolver or Inductosyn® feedback. A resolver is a two-phase, AC-excited, rotary, variable transformer that outputs sinusoidally related signals. These signals (when processed by the RDP-PC board) yield very accurate shaft position information. Single-speed resolvers provide absolute position information over one shaft revolution. Inductosyns are essentially multipole resolvers and are available in both rotary and linear varieties. Rotary and linear Inductosyns typically have pole spacings of 0.5 degrees and 2 mm, respectively, providing positioning resolutions as fine as 0.05 arc seconds and 30.5 nanometers when combined with the RDP-PC converter. Standard R/D converter accuracy is ±8 arc min/electrical cycle. The RDP-PC board is software-selectable to 10, 12, 14, or 16-bit resolution.

G.2. RDP Board Hardware Setup

The RDP board connects between the UNIDEX 511 and a feedback device, such as an Inductosyn or resolver. Before the RDP board can be installed into the UNIDEX 511, it must be properly configured. The following steps will configure the board for installation into the UNIDEX 511. Refer to Figure G-1 for jumper, resistor network (RCN), and test point locations.

Always disconnect main power connection before opening the U511 chassis.

WARNING

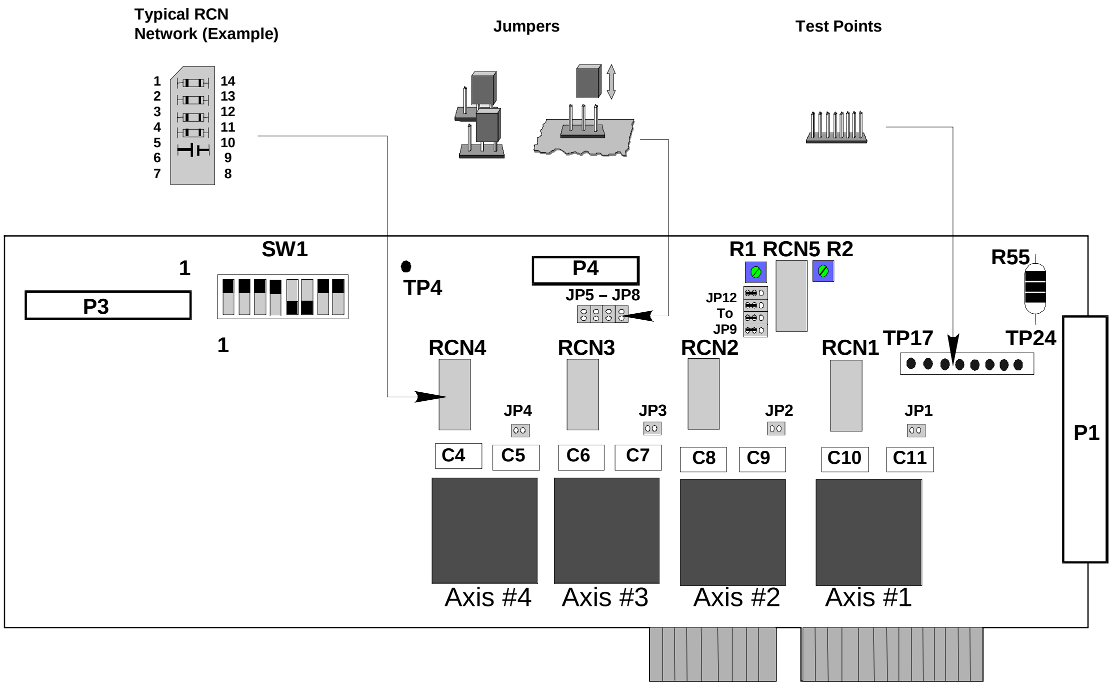


Figure G-1. RDP-PC Board

1. Configure jumpers JP1 through JP4 for the appropriate converter demodulator adjust mode. Refer to Table G-1 for the correct settings.

Table G-1. Jumper Settings for Converter Demodulator Adjust Mode

Axis	Enable	Disable
1	Install JP1	Remove JP1 (default)
2	Install JP2	Remove JP2 (default)
3	Install JP3	Remove JP3 (default)
4	Install JP4	Remove JP4 (default)

These jumpers should only be enabled when adjusting the phase offset pot (R1) for a rotary Inductosyn.

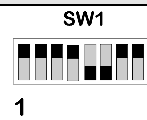
2. Enable or disable the over-temperature thermistor by setting jumpers JP5 through JP8. Refer to Table G-2.

Table G-2. Jumper Settings for Over-temperature Thermistor Input

Axis	Disable	Enable
1	Install JP5 (default)	Remove JP5
2	Install JP6 (default)	Remove JP6
3	Install JP7 (default)	Remove JP7
4	Install JP8 (default)	Remove JP8

3. Set switch SW1 for the correct extension bus address. Refer to Table G-3.

Table G-3. RDP Board Extension Bus Address Settings

Extension Bus Address	Switch Settings
RDP board # 1 - use if one board installed (default)	
RDP board # 2	

RDP board #1 is accessed by feedback channels 9 through 12 and RDP board #2 if accessed by feedback channels 13 through 16. If only one board is installed, use the default switch setting.

4. Select whether the device to be used is a resolver or an Inductosyn by configuring jumpers JP9 through JP12. Refer to Table G-4.

Table G-4. Inductosyn or Resolver Jumper Settings

Axis	Resolver	Inductosyn
#1	Set JP9 to 1-2 (default)	Set JP9 to 2-3
#2	Set JP10 to 1-2 (default)	Set JP10 to 2-3
#3	Set JP11 to 1-2 (default)	Set JP11 to 2-3
#4	Set JP12 to 1-2 (default)	Set JP12 to 2-3

5. Configure resistor network RCN5 (see Figure G-1) for the oscillator frequency that will be used. Refer to Table G-5.

Table G-5. Oscillator Frequency Configuration for RCN5

RCN5							
Description	**Pins 1-14**	**Pins 2-13**	**Pins 3-12**	**Pins 4-11**	**Pins 5-10**	**Pins 6-9**	**Pins 7-8**
Standard 10 kHz (default)	1.96 kΩ 1%	1.96 kΩ 1%	6.2 kΩ	3.9 kΩ	1500 pF	OPEN	OPEN
7.5 kHz	1.1 kΩ 1%	1.1 kΩ 1%	6.2 kΩ	3.9 kΩ	1500 pF	OPEN	OPEN
5 kHz	560 Ω 1%	560 Ω 1%	6.2 kΩ	3.9 kΩ	1500 pF	OPEN	OPEN
Linear Inductosyn 10 kHz	1.96 kΩ 1%	1.96 kΩ 1%	6.2 kΩ	3.9 kΩ	OPEN	OPEN	OPEN

6. Capacitors 4 through 11 must be configured for the oscillator frequency that will be used. Refer to Table G-6.

Table G-6. Oscillator Frequency Configuration for Capacitors

Axis/Capacitor	10 kHz	7.5 kHz	5 kHz
Axis #1: C10, C11	Install a 270 pF capacitor (default)	Install a 390 pF capacitor	Install a 560 pF capacitor
Axis #2: C8, C9	Install a 270 pF capacitor (default)	Install a 390 pF capacitor	Install a 560 pF capacitor
Axis #3: C6, C7	Install a 270 pF capacitor (default)	Install a 390 pF capacitor	Install a 560 pF capacitor
Axis #4: C4, C5	Install a 270 pF capacitor (default)	Install a 390 pF capacitor	Install a 560 pF capacitor

7. The bit resolution that will be used is determined by the configuration of resistor networks RCN1 through RCN4. Refer to Table G-7.

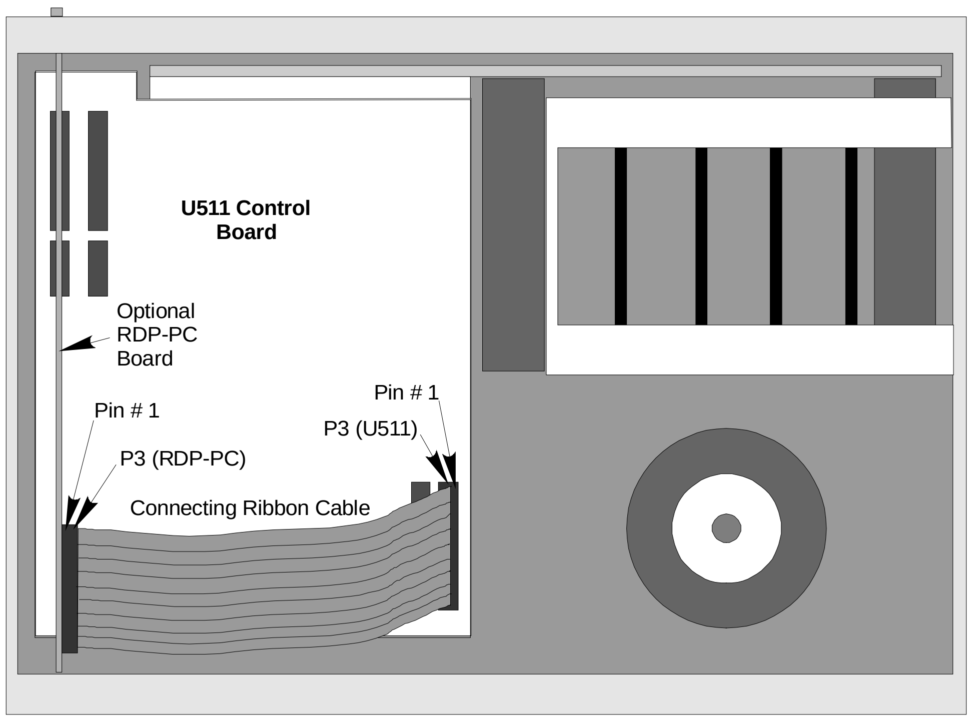
Table G-7. Bit Resolution Configuration; RCN1 Through RCN4 on RDP Board

RCN1 Through RCN4 (where RCN1 = Axis #1)								
Description	**U511 Setup Code**	**Pins 1-14**	**Pins 2-13**	**Pins 3-12**	**Pins 4-11**	**Pins 5-10**	**Pins 6-9**	**Pins 7-8**
16-14 Bit Dynamic Resolution 1K BW (default)	5	8.2 kΩ	1500 pF	8200 pF	91.0 kΩ	64.9 kΩ 1%	21.5 kΩ 1%	OPEN
16 Bit Resolution 1K BW	4	8.2 kΩ	390 pF	1800 pF	360 kΩ	62 kΩ	OPEN	OPEN
16 Bit Resolution 750 BW	4	8.2 kΩ	680 pF	3300 pF	270 kΩ	62 kΩ	OPEN	OPEN
16 Bit Resolution 500 BW	4	8.2 kΩ	1500 pF	8200 pF	180 kΩ	62 kΩ	OPEN	OPEN
12 Bit Resolution 1K BW	2	130 kΩ	390 pF	1800 pF	360 kΩ	62 kΩ	OPEN	OPEN
12 Bit Resolution 750 BW	2	130 kΩ	680 pF	3300 pF	270 kΩ	62 kΩ	OPEN	OPEN

G.3. Installing the RDP Board into the UNIDEX 511

To connect the RDP board to the UNIDEX 511 board, connect the 50-pin ribbon cable from P3 of the RDP board to P3 of the UNIDEX 511 board. Refer to Figure G-2.

Make sure pin #1 of the ribbon cable mates with pin #1 of the P3 connectors.



UNIDEX 511 - Top View

Figure G-2. RDP Board Connection to UNIDEX 511 Board

WARNING

Always disconnect main power connection before opening the U511 chassis.

G.4. UNIDEX 511 Software Setup

The U511 software needs to be configured for the RDP board. Parameters from the Motor and Feedback page (Page 8) in the Setup menu, need to be updated to reflect the hardware settings of the RDP board as shown in the following tables.

1. Set the "Position channel" parameter (x38) as shown in Table G-8.

Table G-8. Setting "Position channel" (x38) for the RDP Board

Axis	"Position channel" for RDP Board #1	"Position channel" for RDP Board #2
1	9 (default)	13
2	10 (default)	14
3	11 (default)	15
4	12 (default)	16

If using an RDP board to incorporate a secondary feedback device, the same settings would apply, but the parameter called "Velocity channel" (x39) would be changed. Otherwise, the "Velocity channel" parameter should be zero.

2. Set the "Position setup code" parameter (x40) for the hardware resolution as configured by RCN 1 through RCN 4. Refer to Table G-9.

Table G-9. Setting "Primary feedback setup code" (x40) for the RDP Board

Resolution	Counts/Revolution	"Primary feedback setup code"
16-14 bit dynamic resolution	65,536	5
16 bit	65,536	4
14 bit	16,384	3
12 bit	4096	2
10 bit	1024	1
Not used	—	0

If using an RDP board to incorporate a secondary feedback device, the same settings would apply, but the parameter called "Velocity setup code" (x41) would be changed. Otherwise, the "Velocity setup code" parameter should be zero.

3. Save the parameter changes and reinitialize the UNIDEX 511 to make them take effect.

G.5. Connecting the Device to the RDP Board

Resolvers or Inductosyns connect to the RDP-PC through P1 on the back of the RDP-PC board. The pinouts for the connector are listed in Table G-10. Figure G-3 shows the mating DB37 connector while Figure G-4 shows the suggested cabling between the RDP board and a resolver or Inductosyn.

Table G-10. RDP Board Pinouts

Pin #	Axis #	Signal	Pin #	Axis #	Signal
1	4	Shield	20	4	COS -
2	4	COS +	21	4	SIN -
3	4	SIN +	22	—	Ground
4	4	Ground	23	4	Over-temp thermistor input
5	4	REF +	24	—	Ground
6	3	REF +	25	3	Over-temp thermistor input
7	3	Shield	26	3	Ground
8	3	COS +	27	3	COS -
9	3	SIN +	28	3	SIN -
10	2	Over-temp thermistor input	29	—	Ground
11	2	REF +	30	2	Ground
12	2	Shield	31	—	Ground
13	2	COS +	32	2	COS -
14	2	SIN +	33	2	SIN -
15	1	Over-temp thermistor input	34	—	Ground
16	1	REF +	35	1	Ground
17	1	Shield	36	1	COS -
18	1	COS +	37	1	SIN -
19	1	SIN +			

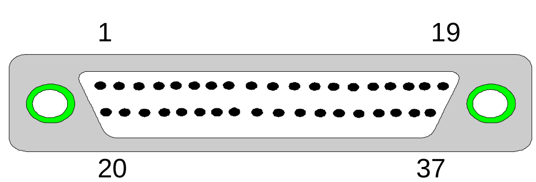


Figure G-3. Mating DB37 Connector

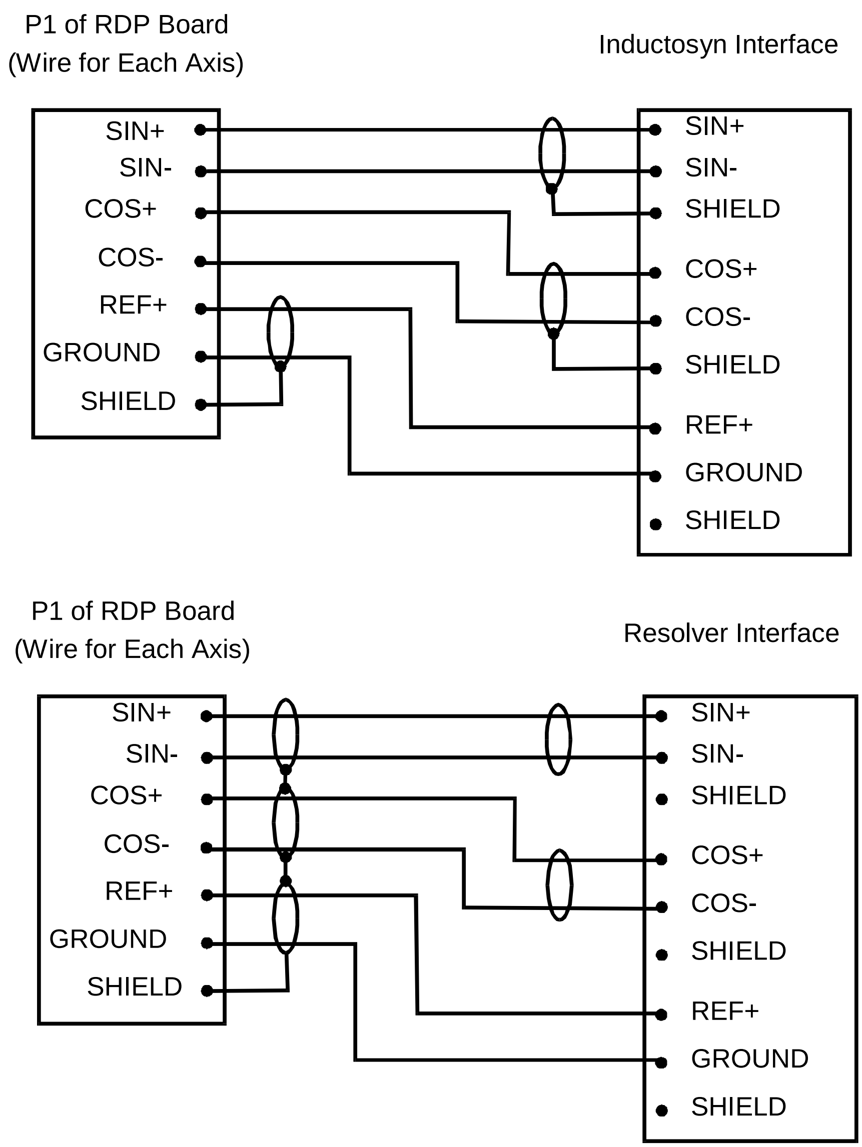
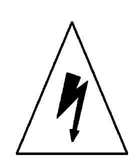


Figure G-4. Suggested Cabling from RDP Board to Resolver or Inductosyn

Hazardous voltages are present inside open chassis when main power is connected.



G.6. Adjusting the Gain on the RDP Board

Once a resolver or Inductosyn is connected to the RDP board, the user must verify that a sinusoidal signal is being sent from the feedback device and adjust the amplitude, if necessary. The signals can be monitored from the test points listed in Table G-11.

Table G-11. RDP Board Test Points

Test Points	Axis #	Sine/Cosine Signal
TP17	4	COS
TP18	3	COS
TP19	2	COS
TP20	1	COS
TP21	1	SIN
TP22	2	SIN
TP23	3	SIN
TP24	4	SIN
TP4	-	Ground

To verify that a sinusoid signal is being received from the axis with a resolver or Inductosyn, perform the following steps.

1. Connect an oscilloscope (O-scope) to the COS signal of the axis being tested and connect the ground of the O-scope to TP4. Move the resolver or Inductosyn; a COS signal (sinusoid) should be observed on the O-scope.
2. Connect the O-scope to the SIN signal of the axis being tested. Move the resolver or Inductosyn again verifying that a SIN signal (sinusoid) is seen on the O-scope.
3. Verify that the amplitude of the sinusoidal signal of the axis being tested is within specifications. Connect an O-scope to either the SIN or COS signal and connect the ground lead to TP4. Move the resolver or Inductosyn and observe the amplitude increase and decrease.
4. Notice that when the COS signal's amplitude is at maximum, the SIN signal's amplitude is at minimum and vice-versa.
5. Stop moving the resolver or Inductosyn when the amplitude of the sinusoid is at its maximum.
6. The maximum should be 2 V RMS, which is ≈2.8284 V peak or ≈5.6568 V peak to peak.
7. If it is not 2 volts RMS, then adjust the R2 potentiometer until it is.

G.7. Nulling the Phase Offset (Rotary Inductosyns Only)

To null the phase offset of rotary Inductosyns, perform the following.

1. Disable the axis being tested.
2. Set the appropriate converter demodulator adjust mode jumper (JP1 through JP4) for the axis being tested to the "enabled" configuration.
3. Connect an O-scope to pin #1 of the appropriate RCN# (where RCN1 = Axis #1, RCN2 = Axis #2, etc.). For example, if checking Axis #1, then connect the O-scope to pin #1 of RCN1. Connect the ground lead to TP4.
4. Adjust the phase offset pot (R1) until the ideal rectified signal is present. Refer to Figure G-5. Get as close as possible.
    - A different capacitor may be needed for pins 5 and 10 of RCN5
    - The R1 pot adjusts the phase offsets for all 4 axes (only applies if they are rotary Inductosyns), so if more than one rotary Inductosyn is being used, they have to be of the same type
5. Return the previously set jumper (JP1 through JP4) to the "disabled" configuration.

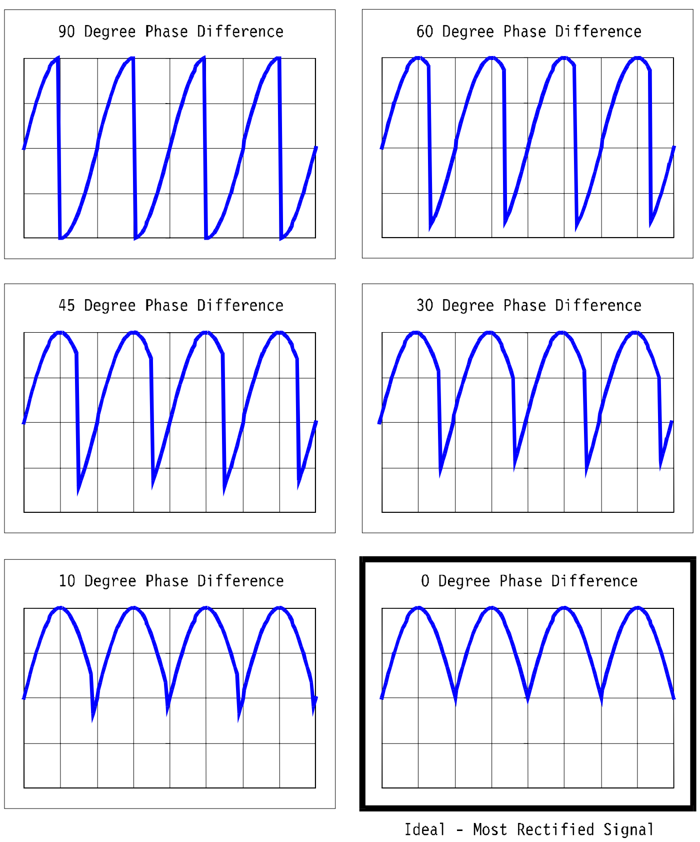
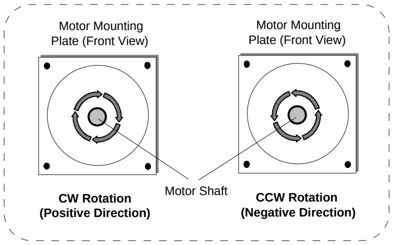


Figure G-5. Rectified Signals with the Most Ideal Signal

G.8. Verifying Resolver or Inductosyn Operation



To verify that the resolver or Inductosyn works after properly adjusting the gain, perform the following.

1. From the UNIDEX 511 Diagnostics Display (Page 4), with the axis disabled, turn the motor shaft clockwise. The Position Display should count positively. Turning the motor shaft counterclockwise should make the Position Display count negatively. Otherwise, the SIN+ and SIN- lines must be swapped.

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SYMBOLS

NUMBERS

A

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June, 2000

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