ELECTRIC LINEAR MOTION PRODUCTS

SSC 1-4 Multi-Axis / Multi-Function Servo / Stepper Controller

User's Manual

TOL-O-MATIC, INC

Excellence in Motion®

8/00

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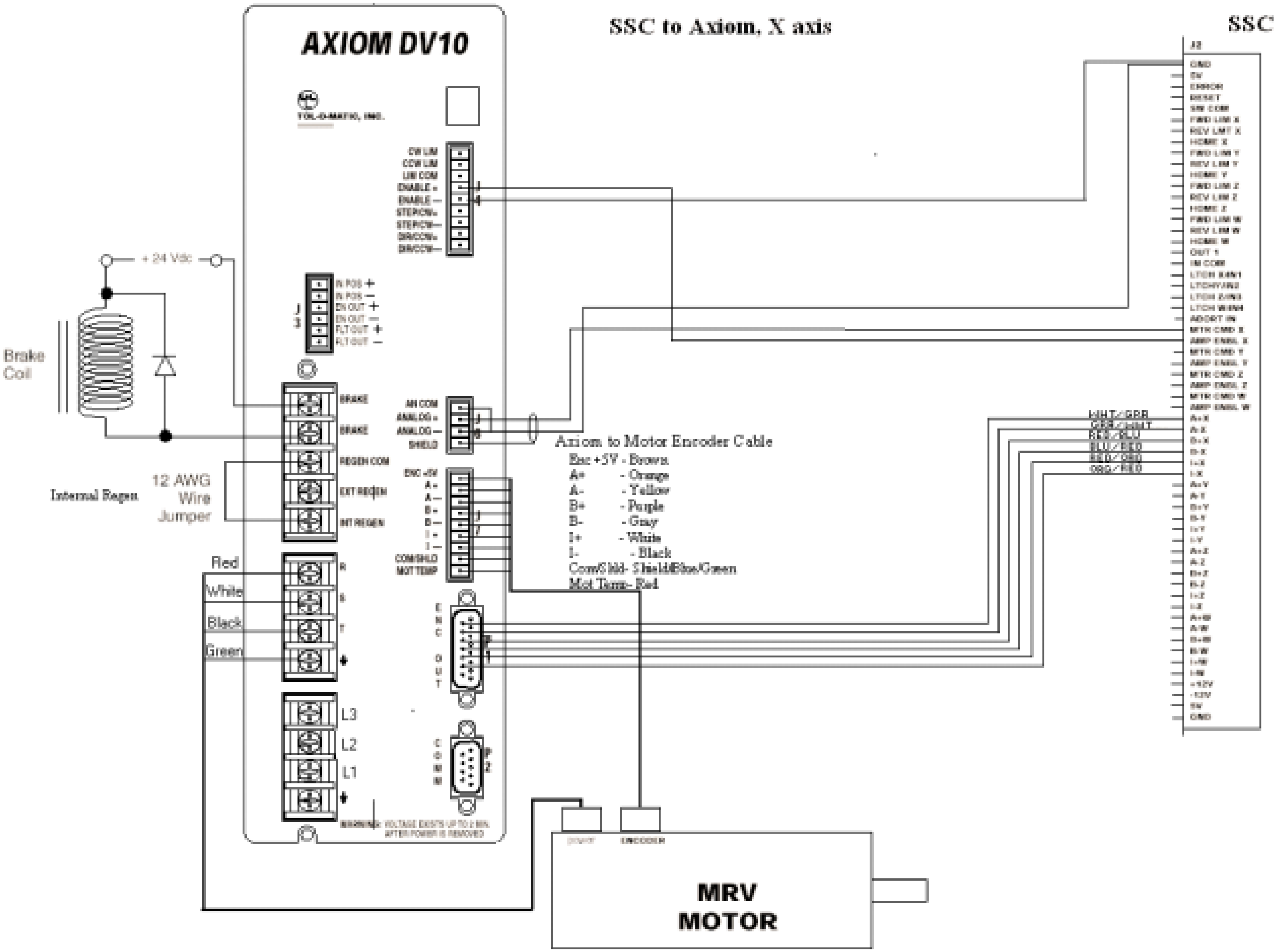
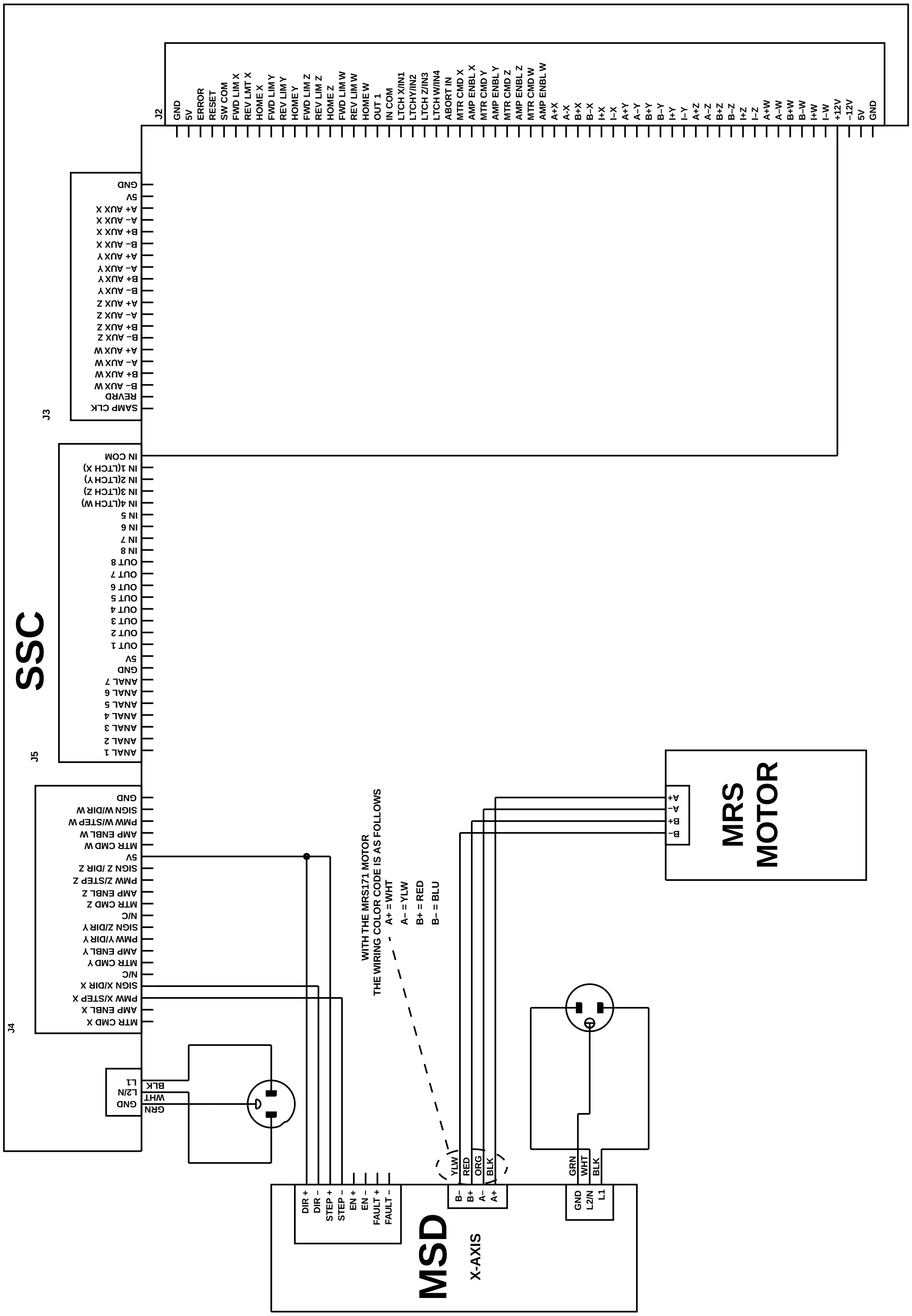

SSC to Axiom, X axis
AXIOM DV10
TOL-O-MATIC, INC.
CW LIM
CCW LIM
LIM COM
ENABLE +
ENABLE –
STEP/CW+
STEP/CW–
DIR/CCW+
DIR/CCW–
J
3
IN POS +
IN POS –
EN OUT +
EN OUT –
FLT OUT +
FLT OUT –
BRAKE
BRAKE
REGEN COM
EXT REGEN
INT REGEN
R
S
T
L3
L2
L1
WARNING: VOLTAGE EXISTS UP TO 2 MIN AFTER POWER IS REMOVED
AN COM
ANALOG +
ANALOG –
SHIELD
ENC +5V
A +
A –
B +
B –
I +
I –
COM/SHLD
MOT TEMP
ENC
OUT
COMM
P2
+ 24 Vdc
Brake Coil
Internal Regen
12 AWG Wire Jumper
Red
White
Black
Green
Axiom to Motor Encoder Cable
Enc +5V - Brown
A+ - Orange
A- - Yellow
B+ - Purple
B- - Gray
I+ - White
I- - Black
Com/Shld- Shield/Blue/Green
Mot Temp- Red
POWER
ENCODER
MRV MOTOR
SSC
J2
GND
5V
ERROR
RESET
SW COM
FWD LIM X
REV LMT X
HOME X
FWD LIM Y
REV LIM Y
HOME Y
FWD LIM Z
REV LIM Z
HOME Z
FWD LIM W
REV LIM W
HOME W
OUT 1
IN COM
LTCH X/IN1
LTCH Y/IN2
LTCH Z/IN3
LTCH W/IN4
ABORT IN
MTR CMD X
AMP ENBL X
MTR CMD Y
AMP ENBL Y
MTR CMD Z
AMP ENBL Z
MTR CMD W
AMP ENBL W
A+X
A-X
B+X
B-X
I+X
I-X
A+Y
A-Y
B+Y
B-Y
I+Y
I-Y
A+Z
A-Z
B+Z
B-Z
I+Z
I-Z
A+W
A-W
B+W
B-W
I+W
I-W
+12V
-12V
5V
GND
WHT/GRR
GRR/WHT
RED/BLU
BLU/RED
RED/ORG
ORG/RED



WITH THE MRS171 MOTOR
THE WIRING COLOR CODE IS AS FOLLOWS
A+ = WHT
A– = YLW
B+ = RED
B– = BLU

Electrical Specifications

SERVO CONTROL	
ANALOG Amplifier Command:	+/-10 Volts analog signal. Resolution 16-bit DAC or .0003 Volts. 3 mA maximum.
A+, A-, B+, B-, IDX+, IDX- Encoder and Auxiliary	TTL compatible, but can accept up to +/- 12 Volts. Quadrature phase on CHA, CHB. Can accept single-ended (A+, B+ only) or differential (A+, A-, B+, B-). Maximum A, B edge rate: 8 MHz. Minimum IDX pulse width: 120nsec.
STEPPER CONTROL	
Pulse	TTL (0-5 Volts) level at 50% duty cycle. 2,000,000 pulses/sec maximum frequency.
Direction	TTL (0-5 Volts)
INPUT/OUTPUT	
Uncommitted Inputs, Limits, Home Abort Inputs:	2.2K ohm in series with optoisolator. Requires at least 1 mA to activate. Can accept up to 28 Volts without additional series resistor. Above 28 Volts requires additional resistor.
AN[1] through AN[7] Analog Inputs:	Standard configuration is +/-10 Volt. 12-Bit Analog-to-Digital convertor, 15 mAmp, 0.005 resolution.
OUT[1] through OUT[8] Outputs:	TTL (0-5vdc, 24mAmp)
IN[1] through IN[8] Inputs:	Optoisolated, 5-28 vdc
AC Power Input, 110 or 220 Vac, 50 or 60 Hz:	2 Amp (Inrush) 200 VA
POWER OUTPUTS	
+5V	1 a
+12V	600 ma
-12V	20 ma

Performance Specifications

Minimum Servo Loop Update Time:	SSC1 — 250 µsec. SSC2 — 375 µsec. SSC3 — 500 µsec. SSC4 — 500 µsec.
Position Accuracy:	+/- 1 quadrature count
Velocity Accuracy:	
Long Term	Phase-locked, better than .005%
Short Term	System dependent
Position Range:	+/-2147483647 counts per move
Velocity Range:	up to 8,000,000 cts/sec
Motor Command Resolution:	16 Bits or 0.0003 V
Variable Range:	+/-2 billion
Variable Resolution:	1 * 10-4
Array Size:	8000 elements
Program Size:	1000 lines x 80 characters

Pin-Out Description for SSC

OUTPUTS

Analog Motor Command

+/- 10 Volt range signal for driving amplifier. In servo mode, motor command output is updated at the controller sample rate. In the motor off mode, this output is held at the OF command level.

Amp Enable

Signal to disable and enable an amplifier. Amp enable goes low on Abort and OE1.

PWM/STEP OUT

PWM/STEP OUT is used for directly driving power bridges for DC servo motors or for driving step motor amplifiers. For servo motors: If you are using a conventional amplifier that accepts a +/- 10 Volt analog signal, this pin is not used and should be left open. The switching frequency is 16.7 KHZ. The PWM output is available in two formats: Inverter and Sign magnitude. In the Inverter Mode, the PWM signal is .2% duty cycle for full negative voltage, 50% for 0 Voltage and 99.8% for full positive charge. In the Sign Magnitude Mode (Jumper SM), the PWM signal is 0% for 0 Voltage, 99.6% for full voltage and the sign of the Motor Command is available at the sign output.

Pin-Out Description for SSC

PWM/STEP OUT

For step motors: The STEP OUT pin produces a series of pulses for input to a step motor driver. The pulses may either be low or high. The pulse width is 50%. Upon Reset, the output will be low if the SM jumper is on. If the SM jumper is not on, the output will be Tri-state.

Sign/Direction

Used with PWM signal to give the sign of the motor command for servo amplifiers or direction for step motors.

Error

The signal goes low when the position error on any axis exceeds the value specified by the error limit command, ER.

Output 1–Output 8

These 8 TTL outputs are uncommitted and may be designated by the user to toggle relays and trigger external events. The output lines are toggled by Set Bit, SB and Clear Bit, CB instructions.

INPUTS

Encoder, A+, B+

Position feedback from incremental encoder with two channels in quadrature, CHA and CHB. The encoder may be analog or TTL. Any resolution encoder may be used as long as the maximum frequency does not exceed 8,000,000 quadrature states/sec. The controller performs quadrature decoding of the encoder signals resulting in a resolution of quadrature counts (4 x encoder cycles). Note: Encoders that produce outputs in the format of pulses and direction may also be used by inputting the pulses into CHA and direction into Channel B and configuring this mode.

Encoder Index, I+

Once-Per-Revolution encoder pulse. Used in Homing sequence or Find Index command to define home on an encoder index.

Encoder, A-, B-, I-

Differential inputs from encoder. May be input along with CHA, CHB for noise immunity of encoder signals. The CHA- and CHB- inputs are optional.

Auxiliary Encoder, Aux A+, Aux B+, Aux I+, Aux A-, Aux B-, Aux I-

Inputs for additional encoder. Used when an encoder on both the motor and the load is required.

Abort

A low input stops commanded motion instantly without a controlled deceleration. Also aborts motion program.

Reset

A low input resets the state of the processor to its power-on condition. The previously saved state of the controller, along with parameter values, and saved sequences are restored.

Forward Limit Switch

When active, inhibits motion in forward direction. Also causes execution of limit switch subroutine, #LIMSWI. The polarity of the limit switch may be set with the CN command.

Reverse Limit Switch

When active, inhibits motion in reverse direction. Also causes execution of limit switch subroutine, #LIMSWI. The polarity of the limit switch may be set with the CN command.

Home Switch

Input for Homing(HM) and Find Edge (FE) instructions. Upon BG following HM or FE, the motor accelerates to slew speed. A transition on this input will cause the motor to decelerate to a stop. The polarity of the Home Switch may be set with the CN command.

Input 1 – Input 8 – Isolated

Uncommitted inputs. May be defined by the user to trigger events. Inputs are checked with the Conditional Jump instruction and After Input instruction or Input Interrupt. Input 1 is latch X, Input 2 is latch Y, Input 3 is latch Z and Input 4 is latch W if the high speed position latch function is enabled.

Latch

High speed position latch to capture axis position within 20 nano seconds on occurrence of latch signal. AL command arms latch. Input 1 is latch X, Input 2 is latch Y, Input 3 is latch Z and Input 4 is latch W.

Using This Manual

Your SSC motion controller has been designed to work with both servo and stepper type motors. Installation and system setup will vary depending upon whether the controller will be used with stepper motors, or servo motors, To make finding the appropriate instructions faster and easier, icons will be next to any information that applies exclusively to one type of system. Otherwise, assume that the instructions apply to all types of systems. The icon legend is shown below.

⬭

Attention: Pertains to servo motor use, such as the Tol-O-Matic Axiom Drive.

⎍

Attention: Discussion under this icon typically refer to stepper motors, but also include other drivers that accept step and direction signals, such as Tol-O-Matic's MSD Microstepping drive.

Please note that many examples are written for the SSC 4 four-axis controller. Users of the SSC 3 three-axis controller, SSC 2 two-axis controller or SSC one-axis controller should note that the SSC 3 uses the axes denoted as XYZ, the SSC 2 uses the axes denoted as XY, and the SSC uses the X-axis only.

WARNING: Machinery in motion can be dangerous! It is the responsibility of the user to design effective error handling and safety protection as part of the machine. Tol-O-Matic shall not be liable or responsible for any incidental or consequential damages.

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Overview 1

Introduction

The SSC Series are packaged motion controllers designed for stand-alone operation. Features include coordinated motion profiling, uncommitted inputs and outputs, non-volatile memory for stand-alone operation and RS232/RS422 communication. Extended performance capabilities include: fast 8 MHz encoder input frequency, precise 16-bit motor command output DAC, +/-2 billion counts total travel per move, faster sample rate, and multitasking of up to four programs.

Designed for maximum system flexibility, the SSC is available for one to four axes and can be interfaced to a variety of motors and drives including step motors, servo motors and hydraulics.

Each axis accepts feedback from a quadrature linear or rotary encoder with input frequencies up to 8 million quadrature counts per second. For dual-loop applications that require one encoder on both the motor and the load, auxiliary encoder inputs are included for each axis.

The powerful controller provides many modes of motion including jogging, point-to-point positioning, linear and circular interpolation with infinite vector feed, electronic gearing and user-defined path following. Several motion parameters can be specified including acceleration and deceleration rates, and slew speed. The SSC also provides S-curve acceleration for motion smoothing.

For synchronizing motion with external events, the SSC includes 8 optoisolated inputs, 8 programmable outputs and 7 analog inputs.

Despite its full range of sophisticated features, the SSC is easy to program. Programming is performed using the Tol-O-Motion SSC Software which allows programming to be done in a visual environment that generates two letter commands to be downloaded to the controller. Experienced users are able to program the controller directly by using two letter commands in the terminal mode. To prevent system damage during machine operation, the SSC provides several error handling features. These include software and hardware limits, automatic shut-off on excessive error, abort input, and user-definable error and limit routines.

SSC Functional Elements

The SSC circuitry can be divided into the following functional groups as shown in Figure 1.1 and discussed below.

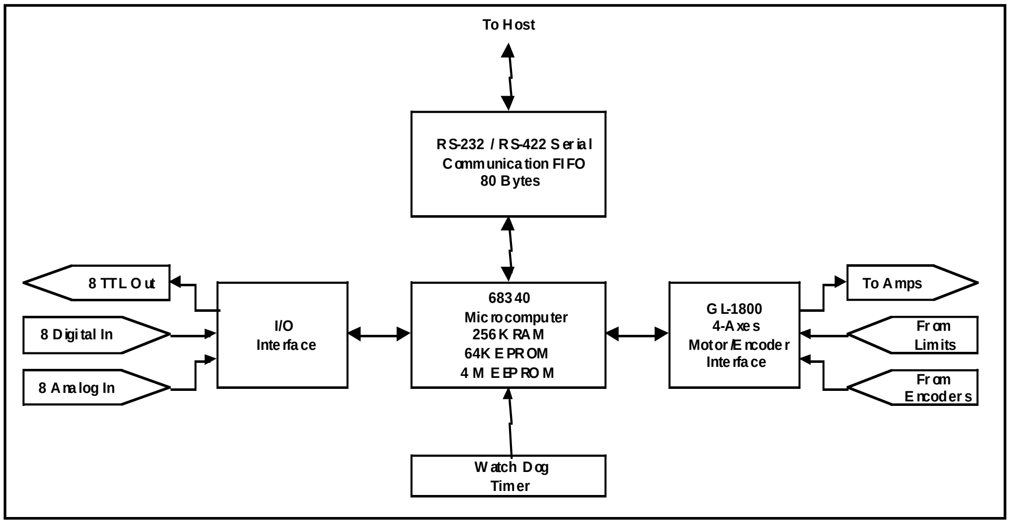


Figure 1.1 - SSC Functional Elements

MICROCOMPUTER SECTION

The main processing unit of the SSC is a specialized 32-bit Motorola 68340 Series Microcomputer with 256K RAM, 64 K EPROM and 4 M bytes EEPROM. The RAM provides memory for variables, array elements and application programs. The EPROM stores the firmware of the SSC. The EEPROM allows parameters and programs to be saved in non-volatile memory upon power down.

MOTOR INTERFACE

For each axis, a GL-1800 gate array performs quadrature decoding of the encoders at up to 8 MHz, generates the +/-10 Volt analog signal (16 Bit DAC) for input to a servo amplifier, and generates step and direction signal for step motor drivers.

COMMUNICATION

Communication to the SSC is via two separately addressable RS232 ports. The ports may also be configured by the factory for RS422. The serial ports may be daisy-chained to other SSC controllers.

SYSTEM ELEMENTS

As shown in Fig. 1.2, the SSC is part of a motion control system which includes amplifiers, motors and encoders. These elements are described below

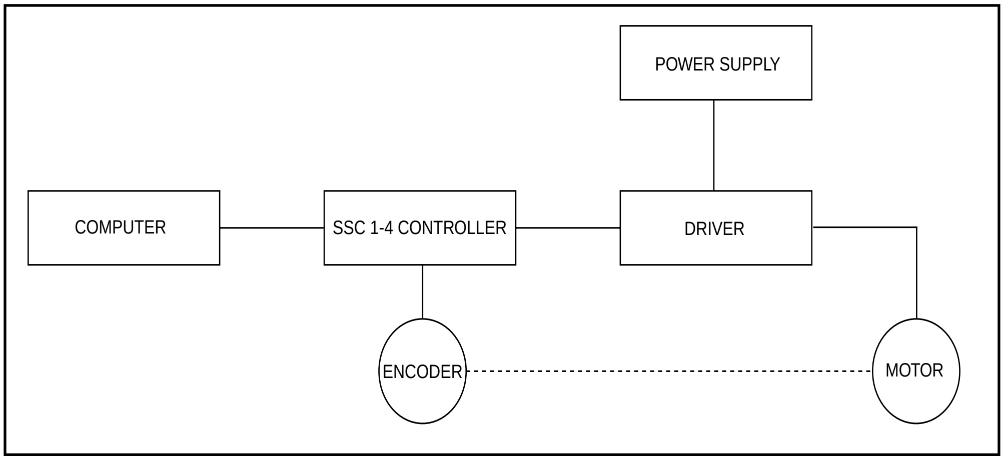


Figure 1.2 - Elements of Servo systems

Motor

A motor converts current into torque which produces motion. Each axis of motion requires a motor sized properly to move the load at the desired speed and acceleration. Tol-O-Matic's sizing and selection software can help you calculate motor size and drive size requirements.

The motor may be a step or servo motor and can be brush-type or brushless, rotary or linear. For step motors, the controller can be configured to control full-step, half-step, or microstep drives.

SSC FUNCTIONAL ELEMENTS

Amplifier (Drive)

For each axis, the power amplifier converts a +/-10 Volt signal from the controller into current to drive the motor. The amplifier should be sized properly to meet the power requirements of the motor. For brushless motors, an amplifier that provides electronic commutation is required. The amplifiers may be either pulse-width-modulated (PWM) or linear. They may also be configured for operation with or without a tachometer. For current amplifiers, the amplifier gain should be set such that a 10 Volt command generates the maximum required current. For example, if the motor peak current is 10A, the amplifier gain should be 1 A/V. For velocity mode amplifiers, 10 Volts should run the motor at the maximum speed.

For stepper motors, the amplifier converts step and direction signals into current.

Encoder

An encoder translates motion into electrical pulses which are fed back into the controller. The SSC accepts feedback from either a rotary or linear encoder. Typical encoders provide two channels in quadrature, known as CHA and CHB. This type of encoder is known as a quadrature encoder. Quadrature encoders may be either single-ended (CHA and CHB) or differential (CHA,CHA-,CHB,CHB-). The SSC decodes either type into quadrature states or four times the number of cycles. Encoders may also have a third channel (or index) for synchronization.

The SSC can also interface to encoders with pulse and direction signals.

There is no limit on encoder line density, however, the input frequency to the controller must not exceed 2,000,000 full encoder cycles/second or 8,000,000 quadrature counts/sec. For example, if the encoder line density is 10,000 cycles per inch, the maximum speed is 200 inches/second.

The standard voltage level is TTL (zero to five volts), however, voltage levels up to 12 Volts are acceptable. If using differential signals, 12 Volts can be input directly to the SSC. Single-ended 12 Volt signals require a bias voltage input to the complementary inputs.

Set Up 2

Elements You Need

Before you start, you will need the following system elements:

1. SSC Motion Controller and included cables, RS232, 60 pin ribbon cable and 26-pin ribbon cable.
2. Breakout terminals - (Optional) for screw terminal accessibility a 60 pin, 26-pin din rail breakout terminal block from Tol-O-Matic is recommended.
3. Servo motors with Encoder (one per axis) or step motors
4. Motor Driver (Amplifier) e.g. Tol-O-Matic Axiom Servo or Micro Stepper Drive
5. PC (Personal Computer with RS232 port)
6. Tol-O-Motion SSC Software

For servo motors, the amplifiers should accept an analog signal in the +/-10 Volt range as a command. The amplifier gain should be set so that a +10V command will generate the maximum required current. For example, if the motor peak current is 10A, the amplifier gain should be 1 A/V. For velocity mode amplifiers, a command signal of 10 Volts should run the motor at the maximum required speed.

For step motors, the amplifiers should accept step and direction signals.

8. For stepper motor operation, you will need an additional 20-pin ribbon cable, J4, to connect step and direction signals.

Installing the SSC

EIGHT STEPS TO SETTING UP YOUR SSC CONTROLLER

1. Setting jumpers
2. Configuring dip switches
3. Connecting Power
4. Installing software
5. Establishing communication
6. Connections to drive (amplifiers) and encoder
7. Connecting standard servo motors
8. Connecting step motors

1. Setting Jumpers on the SSC

These switches have been pre configured at Tol-O-Matic based on the configuration used to order the system, and therefore step one is not required unless you choose to change the axis type.

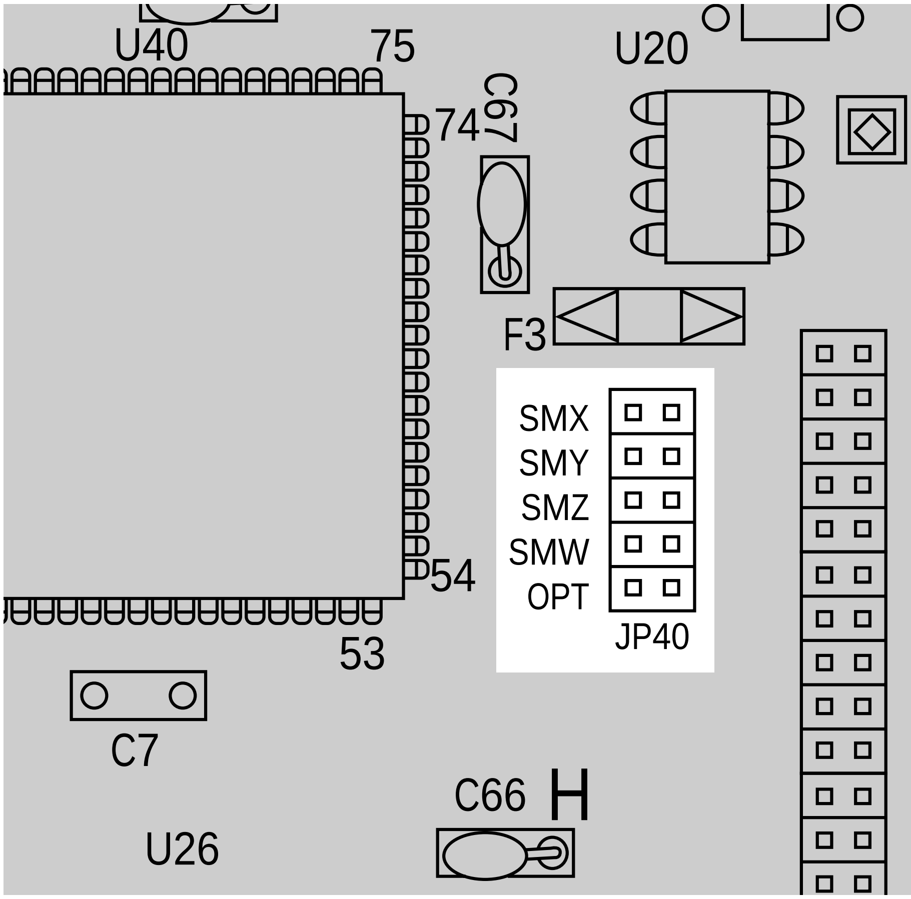
Configuration code	X - AXIS	Y - AXIS	Z - AXIS	W - AXIS		PART NO.
SSC10	ST	-	-	-		3600-0110
SSC10	SV	-	-	-		3600-0210
SSC21	ST	ST	-	-		3600-0121
SSC21	SV	ST	-	-		3600-0221
SSC22	ST	SV	-	-		3600-0122
SSC22	SV	SV	-	-		3600-0222
SSC31	ST	ST	ST	-		3600-0131
SSC31	SV	ST	ST	-		3600-0231
SSC32	ST	ST	SV	-		3600-0132
SSC32	SV	ST	SV	-		3600-0232
SSC33	ST	SV	ST	-		3600-0133
SSC33	SV	SV	ST	-		3600-0233
SSC34	ST	SV	SV	-		3600-0134
SSC34	SV	SV	SV	-		3600-0234
SSC41	ST	ST	ST	ST		3600-0141
SSC41	SV	ST	ST	ST		3600-0241
SSC42	ST	ST	ST	SV		3600-0142
SSC42	SV	ST	ST	SV		3600-0242
SSC43	ST	ST	SV	ST		3600-0143
SSC43	SV	ST	SV	ST		3600-0243
SSC44	ST	ST	SV	SV		3600-0144
SSC44	SV	ST	SV	SV		3600-0244
SSC45	ST	SV	ST	ST		3600-0145
SSC45	SV	SV	ST	ST		3600-0245
SSC46	ST	SV	ST	SV		3600-0146
SSC46	SV	SV	ST	SV		3600-0147
SSC47	ST	SV	SV	ST		3600-0147
SSC47	SV	SV	SV	ST		3600-0247
SSC48	ST	SV	SV	SV		3600-0148
SSC48	SV	SV	SV	SV		3600-0248

ST = STEP AND DIRECTION SV = +- 10 V OUTPUT

The SSC has jumpers inside the controller box which may need to be installed. To access these jumpers, the cover of the controller box must be removed. The following describes each of the jumpers.

WARNING: Never open the controller box when AC power is applied to it.

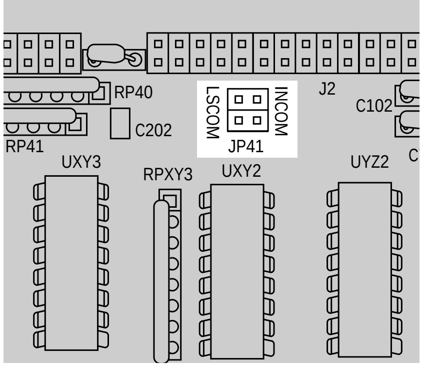
For each axis that will be driving a stepper motor, a stepper mode (SM) jumper must be connected.



JP40

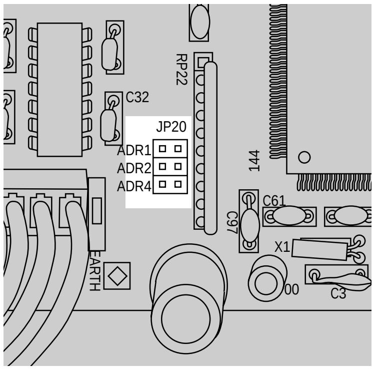
The stepper mode jumpers are located next to the GL-1800 which is the largest IC on the board. The jumper set is labeled JP40 and the individual stepper mode jumpers are labeled SMX, SMY, SMZ, SMW. The fifth jumper of the set, OPT, is for use by Tol-O-Matic technicians only.

INSTALLING THE SSC

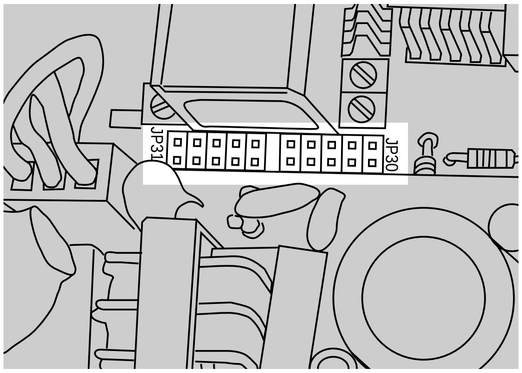


JP41

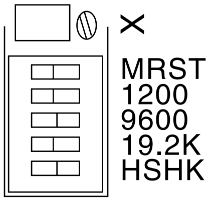
JP41, can be used to connect the controllers internal 5Vdc power supply to the optoisolation inputs. This may be desirable if your system will be using limit switches, home inputs digital inputs, or hardware abort and optoisolation is not necessary for your system. For a further explanation, see section Bypassing the Opto-Isolation in Chapter 4.



JP 20 sets addressing for daisy-chain operation. See Daisy-Chaining in communication section.



JP 30, 31are used to select RS232 or RS422. These are factory preset.



2. Configuring DIP Switches on the SSC

Located on the outside of the controller box is a set of 5 DIP switches.

Switch 1 is the Master Reset switch. When this switch is on, the controller will perform a master reset upon PC power up. Whenever the controller has a master reset, all programs and motion control parameters stored in EEPROM will be ERASED. During normal operation, this switch should be off.

Switch 2,3 and 4 are used to configure the baud rate of the main RS232 serial port. See section Configuration in Chapter 3.

Switch 5 is used to configure both serial ports for hardware handshake mode. Set this switch on for handshake mode. Please note that the Tol-O-Matic communication software requires that hardware handshake mode be enabled.

3. Connecting AC Power to the Controller

Before applying power, connect the 60-pin and 26-pin ribbons between the controller and the breakout terminals. The SSC requires a single AC supply voltage, single phase, 50 Hz or 60 Hz. from 90 volts to 260 volts.

WARNING: Dangerous voltages, current, temperatures and energy levels exist in this product and in its associated amplifiers and servo motor(s). Extreme caution should be exercised in the application of this equipment. Only qualified individuals should attempt to install, set up and operate this equipment.

WARNING: Never open the controller when AC power is applied to it. Applying power will turn on the green light power indicator.

4. Installing the Tol-O-Motion SSC Software

After you have installed the SSC controller and powered up your computer, install the Tol-O-Motion SSC Software, available for Windows 3.1, 95 and NT, by running “setup.exe” on disc number 1.

5. Establishing Communication

Use the supplied RS232 cable to connect the MAIN serial port to your computer or terminal. The SSC main serial port is configured as DATASET. Your computer or terminal must be configured as a DATATERM for full duplex, no parity, 8 bits data, one start bit and one stop bit. This can be accomplished by using the Tol-O-Motion SSC software serial communication setup see Chapter 3 Communication setup in this manual.
Select the baud rate switches on the controller to match the default setting of 9600. Settings of The PC (19.2 kb, 9600 or1200b). For Additional information on auxiliary ports and daisy chaining, see Chapter 3 Communication.

6. Connections to Drive and Encoder

Once you have established communications between the Tol-O-Motion software and the SSC, you are ready to connect the rest of the motion control system. The motion control system typically consists of a drive for each axis of motion, and a motor to transform the current from the drive into torque for motion.

If using a Tol-O-Matic motor/drive, see pages 2-12 thru 2-14 for wiring.

Perform Online setup to set motor and encoder type and initial PID gain. (See Chapter 5)

System connection procedures will depend on system components and motor types. Any combination of motor types can be used with the SSC.

Here are the first steps for connecting the drives and encoders:

Step A: Connect the motor to the drive with no connection to the controller.

Consult the drive documentation for instructions regarding proper connections and startup.

Step B: Connect the drive enable signal.

Before making any connections from the drive to the controller, you need to verify that the ground level of the drive is either floating or at the same potential as earth.

WARNING: When the amplifier ground is not isolated from the power line or when it has a different potential than that of the SSC ground, serious damage may result to the SSC controller and amplifier.

If you are not sure about the potential of the ground levels, connect the two ground signals (drive ground and earth) by a 10 KΩ resistor and measure the voltage across the resistor. Only if the voltage is zero, connect the two ground signals directly.

The AEN (amplifier/drive enable) signal can be used by the controller to disable the motor. It will disable the motor when the watchdog timer activates, the motor-off command, is given, or the position error exceeds the error limit with the “Off-On-Error” function enabled.

The standard configuration of the AEN signal is TTL active high. In other words, the AEN signal will be high when the controller expects the amplifier to be enabled. See Chapter 4 Input/Output connections.

Step C: Connect the encoders

For stepper motor operation, an encoder is optional.

For servo motor operation, if you have a preferred definition of the forward and reverse directions, make sure that the encoder wiring is consistent with that definition.

The SSC accepts single-ended or differential encoder feedback with or without an index pulse. For encoder connection, simply match the leads from the encoder you are using to the encoder feedback inputs on the breakout terminals. The signal leads are labeled XA+ (channel A), XB+ (channel B), and XI+ (index). For differential encoders, the complement signals are labeled XA-, XB-, and XI-.

Note: When using pulse and direction encoders, the pulse signal is connected to CHA and the direction signal is connected to CHB. The controller must be configured for pulse and direction.

Step D: Verify proper encoder operation.

Start with the X encoder first. Once it is connected, turn the motor shaft and monitor the position in the display window. The controller response will vary as the motor is turned.

At this point, if display does not vary with encoder rotation, there are three possibilities:

1. The encoder connections are incorrect - check the wiring as necessary.

2. The encoder has failed - using an oscilloscope, observe the encoder signals. Verify that both channels A and B have a peak magnitude between 5 and 12 volts. Note that if only one encoder channel fails, the position reporting varies by one count only. If the encoder failed, replace the encoder. If you cannot observe the encoder signals, try a different encoder.

3. There is a hardware failure in the controller- connect the same encoder to a different axis. If the problem disappears, you probably have a hardware failure. Consult the factory for help.

7. Connecting Standard Servo Motors

The following discussion applies to connecting the SSC controller to standard servo motor drives:

The motor and the drive may be configured in the torque or the velocity mode. In the torque mode, the amplifier gain should be such that a 10 Volt signal generates the maximum required current. In the velocity mode, a command signal of 10 Volts should run the motor at the maximum required speed.

Step A. Check the Polarity of the Feedback Loop

It is assumed that the motor and drive are connected together and that the encoder is operating correctly. Before connecting the motor drive to the controller, read the following discussion on setting Error Limits and Torque Limits. Note that this discussion uses the X axis as an example.

Step B. Set the Error Limit as a Safety Precaution

Usually, there is uncertainty about the correct polarity of the feedback. The wrong polarity causes the motor to run away from the starting position. Using the programming terminal, the following parameters can be given to avoid system damage:

Input the commands:

ER 2000 <CR>	Sets error limit on the X axis to be 2000 encoder counts
OE 1 <CR>	Disables X axis amplifier when excess position error exists

If the motor runs away and creates a position error of 2000 counts, the motor amplifier will be disabled. Note: This function requires the

Amplifier Enable (AEN) signal to be connected from the controller to the amplifier.

Step C. Set Torque Limit as a Safety Precaution

To limit the maximum voltage signal to your amplifier, the SSC controller has a torque limit command, TL. This command sets the maximum voltage output of the controller and can be used to avoid excessive torque or speed when initially setting up a servo system.

When operating a drive in torque mode, the voltage output of the controller will be directly related to the torque output of the motor. The user is responsible for determining this relationship using the documentation of the motor and drive. The "torque" limit can be set to a value that will limit the motor's output torque.

When operating a drive in velocity or voltage mode, the voltage output of the controller will be directly related to the velocity of the motor. The user is responsible for determining this relationship using the documentation of the motor and drive. The "torque" limit can be set to a value that will limit the speed of the motor.

For example, the following command will limit the output of the controller to 1 volt on the X axis:

```
TL 1 <CR>
```

Note: Once the correct polarity of the feedback loop has been determined, the torque limit should, in general, be increased to the default value of 9.99. The servo will not operate properly if the torque limit is below the normal operating range.

Step D: Connect the Motor

Once the parameters have been set, connect the analog motor command signal (ACMD) to the drive input.

To test the polarity of the feedback, use the jog by position function. (See Chapter 5)

When the polarity of the feedback is wrong, the motor will attempt to run away. The controller should disable the motor when the position error exceeds 2000 counts. If the motor runs away, the polarity of the loop must be inverted.

Note: Inverting the Loop Polarity
When the polarity of the feedback is incorrect, the user must invert the loop polarity and this may be accomplished by several methods. If you are driving a brush-type DC motor, the simplest way is to invert the two motor wires (typically red and black). When driving a brushless motor, the polarity reversal may be done with the encoder. If you are using a single-ended encoder, interchange the signal CHA and CHB. If, on the other hand, you are using a differential encoder, interchange only CHA+ and CHA-.

Note: Reversing the Direction of Motion
If the feedback polarity is correct but the direction of motion is opposite to the desired direction of motion on a brush DC motor, reverse the motor leads AND the encoder signals. For a brushless motor, see documentation for drive on reversing direction of rotation.

Note: Tuning
When the position loop has been closed with the correct polarity, the next step is to adjust the PID filter parameters, KP, KD and KI. It is necessary to accurately tune your servo system to ensure fidelity of position and minimize motion oscillation as described in the tuning section of this chapter.

8. Connecting Step Motors

In Stepper Motor operation, the pulse output signal of the SSC has a 50% duty cycle. Step motors operate open loop and do not require encoder feedback. When a stepper is used, the auxiliary encoder for the corresponding axis is unavailable for an external connection. If an encoder is used for position feedback, connect the encoder to the main encoder input corresponding to that axis. The commanded position of the stepper can be interrogated with RP or DE. The encoder position can be interrogated with TP.

The frequency of the step motor pulses can be smoothed with the filter parameter. The filter parameter has a range between 0.5 and 8, where 8 implies the largest amount of smoothing.

See Command Reference regarding KS, RP, DE, TP and other two letter commands.

The SSC profiler commands the step motor amplifier. All SSC motion commands apply in stepper mode. Since step motors run open-loop, the PID filter does not function and the position error is not generated.

To connect step motors with the SSC you must follow this procedure:

Step A. Install Step Mode jumpers

Each axis of the SSC that will operate a stepper motor must have the corresponding stepper motor jumper installed. The jumpers are preset at Tol-O-Matic to match system ordered.

Step B. Connect step and direction signals.

Make connections from controller to motor amplifiers. (These signals are found on 20 pin breakout connected to J4). Consult the documentation for your step motor drive. See p2.14 for Tol-O-Matic MSD connection.

SSC J2 Main; 60 Pin IDC

1. Zero Volt Ref.	2. 5V
3. Error	4. Reset
5. Limit Switch Common	6. Forward Limit - X
7. Reverse Limit - X	8. Home - X
9. Forward Limit - Y	10. Reverse Limit - Y
11. Home - Y	12. Forward Limit - Z
13. Reverse Limit - Z	14. Home - Z
15. Forward Limit - W	16. Reverse Limit - W
17. Home - W	18. Output 1
19. Input Common	20. Latch X or Input 1
21. Latch Y or Input 2	22. Latch Z or Input 3
23. Latch W or Input 4	24. Abort Input
25. Motor Command X	26. Amp Enable X
27. Motor Command Y	28. Amp Enable Y
29. Motor Command Z	30. Amp Enable Z
31. Motor Command W	32. Ampo Enable W
33. A+X	34. A-X
35. B+X	36. B-X
37. I+X	38. I-X
39. A+Y	40. A-Y
41. B+Y	42. B-Y
43. I+Y	44. I-Y
45.A+Z	46. A-Z
47. B+Z	48. B-Z
49. I+Z	50. I-Z
51. A+W	52. A-W
53. B+W	54. B-W
55. I+W	56. I-W
57. +12V	58. -12 V
59. 5V	60. Zero Volt Ref.

SSC J3 Auxiliary Encoder; 20- Pin IDC:

1. Sample Clock	2. Reserved
3. B- Aux W	4. B+ Aux W
5. A- Aux W	6. A+ Aux W
7. B- Aux Z	8. B+ Aux Z
9. A- Aux Z	10. A+ Aux Z
11. B- Aux Y	12. B+ Aux Y
13. A- Aux Y	14. A+ Aux Y
15. B- Aux X	16. B+ Aux X
17. A- Aux X	18. A+ Aux X
19. 5V	20. Zero Volt Ref.

SSC J4 Driver ; 20- Pin IDC:

1. Motor Command X	2. Amp Enable X
3. PMW X/ StepX	4. Sign X/ Dir X
5.	6. Motor Command Y
7. Amp Enable Y	8. PMW Y/ Step Y
9. Sign Y/ Dir Y	10.
11. Motor Command Z	12. Amp Enable Z
13. PMW Z / Step Z	14. Sign Z/ Dir Z
15. 5V	16. Motor Command W
17. Amp Enable W	18. PMW W/ Step W
19. Sign W/ Dir W	20. Zero Volt Ref.

SSC J5 General I/O; 26- Pin IDC

1. Analog 1	2. Analog 2
3. Analog 3	4. Analog 4
5. Analog 5	6. Analog 6
7. analog 7	8. Zero Volt Ref.
9. 5v	10. Output 1
11. Output 2	12. Output 3
13. Output 4	14. Output 5
15. Output 6	16. Output 7
17. Output 8	18. Input 8
19. Input 7	20. Input 6
21. Input 5	22. Input 4 (Latch W)
23. Input 3 (Latch Z)	24. Input 2 (Latch Y)
25. Input 1 (Latch X)	26. Input Common

AC Power Inputs:

Hot	Connects to 110 or 220 AC
Neutral	Return for AC
Earth	Chassis input

SSC Main Port; 9- Pin:

1. CTS - output	2. Transmit data - output
3. Receive data - input	4. RTS - input
5. Zero Volt Ref.	6. CTS - output
7. RTS - Input	8. CTS - output
9. 5V	

SSC - Auxiliary Port; 9- Pin:

1. CTS - input	2. Receive data - input
3. Transmit data - output	4. RTS - output
5. Zero Volt Ref.	6. CTS - input
7. RTS - output	8. CTS - input
9. 5V	

Figure 2.1 - SSC Connector Pinout

AXIS	SSC TERMINAL J2	BREAKOUT PIN #	WIRE COLOR	AXIOM TERMINAL
X	ZERO VOLT REF.	1		ANALOG CMND-
	MOTOR COMMAND X	25		ANALOG CMND+
	A+X	33	WHT/GRAY	ENCODER OUT A+
	A-X	34	GRAY/WHT	ENCODER OUT A-
	B+X	35	RED/BLUE	ENCODER OUT B+
	B-X	36	BLUE/RED	ENCODER OUT B-
	I+X	37	RED/ORG	ENCODER OUT I+
	I-X	38	ORG/RED	ENCODER OUT I-
	ZERO VOLT REF.	1	BLUE/WHT	COMMON
Y	ZERO VOLT REF.	1		ANALOG CMND-
	MOTOR COMMAND Y	27		ANALOG CMND+
	A+Y	39	WHT/GRAY	ENCODER OUT A+
	A-Y	40	GRAY/WHT	ENCODER OUT A-
	B+Y	41	RED/BLUE	ENCODER OUT B+
	B-Y	42	BLUE/RED	ENCODER OUT B-
	F+Y	43	RED/ORG	ENCODER OUT I+
	F-Y	44	ORG/RED	ENCODER OUT I-
	ZERO VOLT REF.	1	BLUE/WHT	COMMON
Z	ZERO VOLT REF.	1		ANALOG CMND-
	MOTOR COMMAND Z	29		ANALOG CMND+
	A+Z	45	WHT/GRAY	ENCODER OUT A+
	A-Z	46	GRAY/WHT	ENCODER OUT A-
	B+Z	47	RED/BLUE	ENCODER OUT B+
	B-Z	48	BLUE/RED	ENCODER OUT B-
	I+Z	49	RED/ORG	ENCODER OUT I+
	I-Z	50	ORG/RED	ENCODER OUT I-
	ZERO VOLT REF.	1	BLUE/WHT	COMMON
W	ZERO VOLT REF.	1		ANALOG CMND-
	MOTOR COMMAND W	31		ANALOG CMND+
	A+W	51	WHT/GRAY	ENCODER OUT A+
	A-W	52	GRAY/WHT	ENCODER OUT A-
	B+W	53	RED/BLUE	ENCODER OUT B+
	B-W	54	BLUE/RED	ENCODER OUT B-
	I+W	55	RED/ORG	ENCODER OUT I+
	I-W	56	ORG/RED	ENCODER OUT I-
	ZERO VOLT REF.	1	BLUE/WHT	COMMOM

Figure 2.2 - Connecting to the AXIOM Servo Drives

CONNECTING STEP MOTORS

AXIS	SSC TERMINAL J4	BREAKOUT PIN #	MSD TERMINAL
X	STEP X	3	STEP -
	DIR X	4	DIR -
	5V	15	STEP+, DIR+
Y	STEP Y	8	STEP -
	DIR Y	9	DIR -
	5V	15	STEP+, DIR+
Z	STEP Z	13	STEP -
	DIR Z	14	DIR -
	5V	15	STEP+, DIR+
W	STEP W	18	STEP -
	DIR W	19	DIR -
	5V	15	STEP+, DIR+

Figure 2.3 - Connecting to the MSD Microstepper Drive

SSC TERMINAL J5	BREAKOUT PIN #	WIRE	FUNCTION
ANALOG 1	1	BROWN	X AXIS
ANALOG 2	2	BLACK	Y AXIS
INPUT 7	19	ORANGE	RECORD (LEFT BUTTON)
INPUT 8	18	WHITE	DONE (RIGHT BUTTON)
5V	9	BLUE	
ZERO VOLT REF.	8	GREEN	
5V	26	Jumper wire between Pin 9 and 26	

Figure 2.5 - Connecting to the JS Joystick

Tune the Servo System

The intent of this section is to give the user a basic familiarity with the operating modes of the Axiom series of servo-motor drives and how they affect tuning. The Axiom drive product line, manufactured by Tol-O-Matic, Inc., consists of three brushless servo-motor drives and one drive for brushed motors. For specific instructions on tuning the Axiom see your drive's user manual.

For specific instructions on tuning the SSC see the tuning section of chapter 5.

The brushless motor drives (DV10, DV20, and DV30) are designed to give optimum performance with modern, permanent magnet brushless AC servo-motors. The DB20 is for use with traditional brush-commutated DC servo-motors. All of these drives support two primary modes of operation when used with the SSC.

TORQUE MODE

The drive produces motor torque proportional to an analog voltage command signal. For operation in torque mode, the fundamental current control functions are accomplished automatically by the drive. When the drive is operating in torque mode, the command source is the analog input from the SSC, which can be adjusted for offset and scaled by the drive. The user need only configure the drive to select the correct motor and make sure the analog input command signal is appropriately supplied. No tuning of the PID (proportional, integral, derivative) is required in the drive. The tuning is done in the SSC by adjusting its PID values to achieve the desired response. The SSC creates a motion profile based on the distance, speed, acceleration and deceleration of the programmed motion, that determines the desired motor position at every sampling period. The closing of the position loop forces the motor to follow the desired position.

VELOCITY MODE

The drive controls motor speed in proportion to an analog voltage command signal from the controller. The fundamental control function of a servo drive operating in velocity mode is to control the rotational velocity of the connected motor with precision. This means that the control response must have a high bandwidth and enough “stiffness” to prevent external disturbances (load changes) from significantly affecting velocity regulation. Tight control of velocity allows positioning moves to be accomplished with smooth, accurate trajectories. When operated in velocity mode, Axiom

TUNE THE SERVO SYSTEM

series drives receive their command signal via an external, analog signal from the SSC. The SSC needs only to handle the position loop calculations to derive a velocity command by tuning the proportional gain. The drives require tuning of the velocity PID control algorithm, whereby velocity control bandwidth and stiffness can be tailored for maximum performance with a given application. The Axiom software provides a very powerful tuning and diagnostic interface to aid the user in achieving optimum velocity control. Tuning of the PID values in the SSC is also required.

Communication 3

Introduction

The SSC has two RS232 ports. The main port is the data set and the auxiliary port is the data terminal. The main port can be configured through the switches on the front panel, and the auxiliary port can be configured with the software. The auxiliary port can either be configured as a general port or for daisy-chain communications. The auxiliary port configuration can be saved using the Burn (BN) instruction to write controller parameters to EEPROM. The RS232 ports also have a clock synchronizing line that allows synchronization of motion on more than one controller.

RS232 Ports

The RS232 pin-out description for the main and auxiliary port is given below. Note, the auxiliary port is essentially the same as the main port except transmit and receive are reversed. The SSC may also be configured by the factory for RS422. These pin-outs are also listed below.

Note: If you are connecting the RS232 auxiliary port to a terminal or any device which is a DATATERM, it is necessary to use a connector adapter, which changes a dataterm to a dataset. This cable is also known as a 'null' modem cable.

RS232 - MAIN PORT {P1}

1	DTR - output
2	Transmit Data - output
3	Receive Data - input
4	Carrier Detect - input
5	Zero Volt Ref.
6	Not Used
7	Not Used
8	Not Used
9	Can be connected to +5V or sample clock with jumpers

RS232 - AUXILIARY PORT {P2}

1	Carrier Detect - input
2	Receive Data - input
3	Transmit Data - output
4	Data Terminal Ready
5	Zero Volt Ref.
6	Not Used
7	Not Used
8	Not Used
9	5V (Can be disconnected or connected to sample clock with jumpers)

*RS422 - MAIN PORT {P1}

1	Data Terminal Ready- output
2	Transmit Data- output
3	Receive Data- input
4	Carrier Detect- input
5	Zero Volt Ref.
6	Data Terminal Ready+ output
7	Transmit+ output
8	Receive+ input
9	Carrier Detect+ input

RS232 PORTS

*RS422 - AUXILIARY PORT {P2}

1 Carrier Detect- input	6 Carrier Detect+ input
2 Receive Data- input	7 Receive+ input
3 Transmit Data- output	8 Transmit+ output
4 Data Terminal Ready- output	9 Data Terminal Ready+ output
5 Zero Volt Ref.	

Default configuration is RS232. RS422 configuration available by factory.

Configuration

Configure your PC for 8-bit data, one start-bit, one stop-bit, full duplex and no parity. The baud rate for the RS232 communication can be selected by setting the proper switch configuration on the front panel according to the table below.

BAUD RATE SELECTION

SWITCH SETTING			INTERPRETATION
1200	9600	19.2K	
ON	ON	OFF	300 Baud rate
ON	OFF	OFF	1200 Baud rate
ON	OFF	ON	4800 Baud rate
OFF	ON	OFF	9600 Baud rate
OFF	OFF	ON	19200 Baud rate – (Default Setting)
OFF	ON	ON	38400 Baud
ON	ON	ON	SELF TEST

The RS232 main port can be configured for handshake or non-handshake mode. Set the HSHK switch to ON to select the handshake mode. In this mode, the RTS and CTS lines are used. The CTS line will go high whenever the SSC is not ready to receive additional characters. The RTS line will inhibit the SSC from sending additional characters. Note, the RTS line goes high for inhibit. The handshake should be turned on to ensure proper communication especially at higher baud rates.

The auxiliary port of the SSC can be configured either as a general port or for the daisy-chain. When configured as a general port, the port can be commanded to send ASCII messages to another SSC controller or to a display terminal or panel.

To configure Port 2 in visual program see communication instruction under configuration group in Chapter 5.

To configure Port 2 in terminal mode the command is in the format of:
CC m,n,r,p where m sets the baud rate, n sets for either handshake or non-handshake mode, r sets for general port or the auxiliary port, and p turns echo on or off.
m - Baud Rate - 300,1200,4800,9600,19200,38400
n - Handshake - 0=No; 1=Yes
r - Mode - 0=General Port; 1=Daisy-chain
p - Echo - 0=Off; 1=On; Valid only if r=0

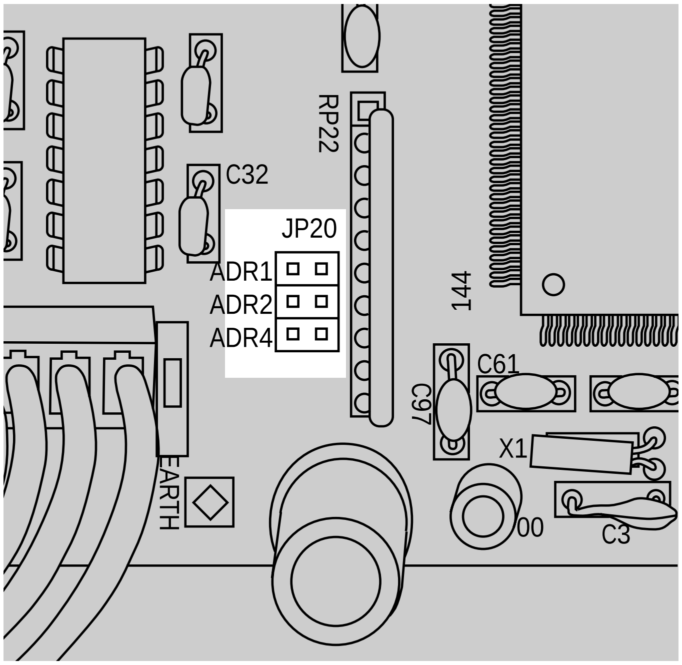
Note, for the handshake of the auxiliary port, the roles for the RTS and CTS lines are reversed.

Example:

INSTRUCTION	INTERPRETATION
CC 1200,0,0,1	Configure auxiliary communication port for 1200 baud, no handshake, general port mode and echo turned on.

DAISY-CHAINING

Up to eight SSC controllers may be connected in a daisy-chain allowing for multiple controllers to be commanded from a single serial port. One SSC is connected to the host terminal via the RS232 at port 1 or the main port. Port 2 or the auxiliary port of that SSC is then brought into port 1 of the next SSC, and so on. The address of each of the SSC is configured by setting the three address jumpers JP20 (ADR4,ADR2,ADR1) located inside the box near the main processor IC.



JP20

CONFIGURATION

ADR1 represents the 2^0 bit, ADR2 represents 2^1 bit, and ADR4 represents 2^2 bit of the address. The eight possible addresses, 0 through 7, are set as follows:

ADR4	ADR2	ADR1	ADDRESS
OFF	OFF	OFF	0
OFF	OFF	ON	1
OFF	ON	OFF	2
OFF	ON	ON	3
ON	OFF	OFF	4
ON	OFF	ON	5
ON	ON	OFF	6
ON	ON	ON	7

Programming of the controllers in daisy-chain mode must be done in the two letter terminal mode.

To communicate with any one of the SSC units, give the command “%A”, where A is the address of the board. All instructions following this command will be sent only to the board with that address. Only when a new %A command is given will the instruction be sent to another board. The only exception is “!” command. To talk to all the SSC boards in the daisy-chain at one time, insert the character “!” before the software command. All boards receive the command, but only address 0 will echo.

Note: The CC command must be specified to configure the port P2 of each unit.

Daisy Chain Example:

Objective: Control a 7-axis motion system using two controllers, an SSC 4 axis controller and a SSC 3 axis controller. Address 0 is the SSC 4 and address 1 is the SSC 3.

DESIRED MOTION PROFILE:

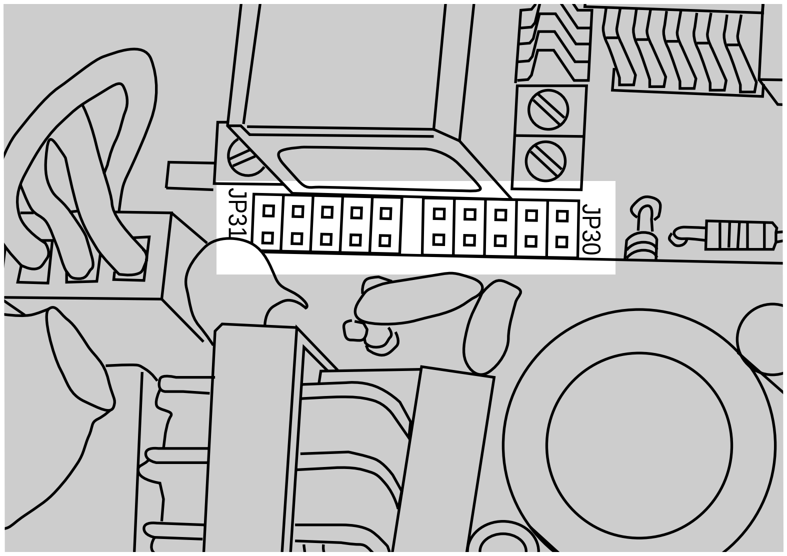
Address 0 (SSC 4)	X Axis is 500 counts
	Y Axis is 1000 counts
	Z Axis is 2000 counts
	W Axis is 1500 counts

Address 1 (SSC 3)	X Axis is 700 counts Y Axis is 1500 counts Z Axis is 2500 counts

INSTRUCTION	**INTERPRETATION**
%0	Talk only to controller 0 (SSC 4)
PR 500,1000,2000,1500	Specify X,Y,Z,W distances
%1	Talk only to controller board 1 (SSC 3)
PR 700,1500,2500	Specify X,Y,Z distances
!BG	Begin motion on both controllers

SYNCHRONIZING SAMPLE CLOCKS

It is possible to synchronize the sample clocks of all SSC's in the daisy-chain. This involves burning in the command, TM-1, in all SSC's except for one SSC which will be the source. It is also necessary to put a jumper on pins 7 and 9 of the JP30 and JP31 jumper blocks.



JP30 & JP31

Controller Response to DATA

Most SSC terminal mode instructions are represented by two characters followed by the appropriate parameters. Each instruction must be terminated by a carriage return or semicolon.

Instructions are sent in ASCII, and the SSC decodes each ASCII character (one byte) one at a time. It takes approximately .5 msec for the controller to decode each command. However, the PC can send data to the controller at a much faster rate because of the FIFO buffer.

After the instruction is decoded, the SSC returns a colon (:) if the instruction was valid or a question mark (?) if the instruction was not valid.

For instructions that return data, such as Tell Position (TP), the SSC will return the data followed by a carriage return, line feed and : .

It is good practice to check for ":" after each command is sent to prevent errors. An echo function is provided to enable associating the SSC response with the data sent. The echo is enabled by sending the command EO 1 to the computer.

Notes:

Input / Output Connections 4

Overview

The SSC provides optoisolated digital inputs for forward limit, reverse limit, home, and abort signals. The controller also has 8 optoisolated, uncommitted inputs (for general use) as well as 8 TTL outputs and 7 analog inputs configured for voltages between +/- 10 volts.

This chapter describes the inputs and outputs and their proper connection. Inputs 1-4 and Output 1 are available on both J2 and J5.

Connection to the analog inputs or general inputs 5-8 or all outputs except Output 1 is accomplished through 26-pin J5 connector on the SSC.

If you plan to use the auxiliary encoder feature of the SSC, you must also connect to the 20-pin J3 connector.

General Wiring Guidelines

It is always best to keep power wiring separate from control wiring. Properly terminated shielded cables for control wiring will help ensure minimal interference problems, but should be combined with good wire routing practice to ensure optimum results.

Power and control wiring should be run in separate conduit or wiring trays with as much separation as is practical to achieve. When power and control cabling needs to cross, it should be done at right angles.

Analog torque or velocity command signals are the most susceptible to interference from 50/60Hz power wiring. However, encoder and other control wiring can pick up interference from the 50/60Hz power itself or transient energy present on the power lines. This transient energy is most often caused by relays and contactors, other motors and their drives and welders in a typical industrial environment.

Where a great deal of interference is present on the power lines, a line filter may be necessary. Choose one with the appropriate voltage and current rating for the controller. (The drive may also require a line filter.) Also, follow the manufacturer’s recommendations for installations. This must include a proper ground.

Using Optoisolated Inputs

LIMIT SWITCH INPUT

The forward limit switch (FLSx) inhibits motion in the forward direction immediately upon activation of the switch. The reverse limit switch (RLSx) inhibits motion in the reverse direction immediately upon activation of the switch. If a limit switch is activated during motion, the controller will make a decelerated stop using the deceleration rate previously set with the DC command. The motor will remain in a servo state after the limit switch has been activated and will hold motor position.

When a forward or reverse limit switch is activated, the current application program that is running will be interrupted and the controller will automatically jump to the #LIMSWI subroutine if one exists. This is a subroutine which the user can include in any motion control program and is useful for executing specific instructions upon activation of a limit switch.

After a limit switch has been activated, further motion in the direction of the limit switch will not be possible until the logic state of the switch returns back to an inactive state. Be careful that the deceleration does not take the motion past the limit switch, without a #LIMSWI routine to ensure no further motion in the limit direction. Any attempt at further motion before the logic state has been reset will result in the following error: “022 - Begin not possible due to limit switch” error.

The operands, _LFx and _LRx, return the state of the forward and reverse limit switches, respectively (x represents the axis, X,Y,Z,W etc.). The value of the operand is either a ‘0’ or ‘1’ corresponding to the logic state of the limit switch. Using a terminal program, the state of a limit switch can be printed to the screen with the command, MG _LFx or MG _LRx. This prints the value of the limit switch operands for the ‘x’ axis. The logic state of the limit switches can also be interrogated with the TS command. For more details on TS see the Two-Letter Command Reference (chapter 13).

HOME SWITCH INPUT

The Home inputs are designed to provide reference points for a motion control application. A transition in the state of a Home input alerts the controller that a particular reference point has been reached by a moving part in the motion control system. A reference point can be a switch or an encoder index pulse.

The Home input detects any transition in the state of the switch and toggles between logic states 0 and 1 at every transition.

HOMING ROUTINES

There are three homing routines supported by the SSC: *Find Edge, Find Index, and Standard Home.* To add Homing to Visual Program use the Home Instruction in the motion group.

Find Edge

The x-axis Find Edge routine is initiated by the command sequence: FEX <return>, BGX <return>. The Find Edge routine will cause the motor to accelerate, then slew at constant speed until a transition is detected in the logic state of the Home input. The motor will then decelerate to a stop. The acceleration rate, deceleration rate and slew speed are specified by the user, prior to the movement, using the commands AC, DC, and SP. It is recommended that a high deceleration value be used so the motor will decelerate rapidly after sensing the Home switch. The position is <u>not</u> set to zero

Find Index

The x-axis Find Index routine is initiated by the command sequence: FIX <return>, BGX <return>. Find Index will cause the motor to accelerate to the user-defined slew speed (SP) at a rate specified by the user with the AC command and slew until the controller senses a change in the index pulse signal from low to high. The motor then decelerates to a stop at the rate previously specified by the user with the DC command. Although Find Index is an option for homing, it is not dependent upon a transition in the logic state of the Home input, but instead is dependent upon a transition in the level of the index pulse signal. The position is set to zero

Standard Homing

The x-axis Standard Homing routine is initiated by the sequence of commands HMX <return>, BGX <return>. Standard Homing is a combination of Find Edge and Find Index homing. Initiating the standard homing routine will cause the motor to slew until a transition is detected in the logic state of the Home input. The motor will accelerate at the rate specified by the command, AC, up to the slew speed. After detecting the transition in the logic state on the Home Input, the motor will decelerate to a stop at the rate specified by the command, DC. After the motor has decelerated to a stop, it switches direction and approaches the switch transition point at the speed of 256 counts/sec. When the logic state changes again, the motor moves forward at the same speed, until the controller senses the index pulse. After detection, it decelerates to a stop and defines this position as 0.

USING OPTOISOLATED INPUTS

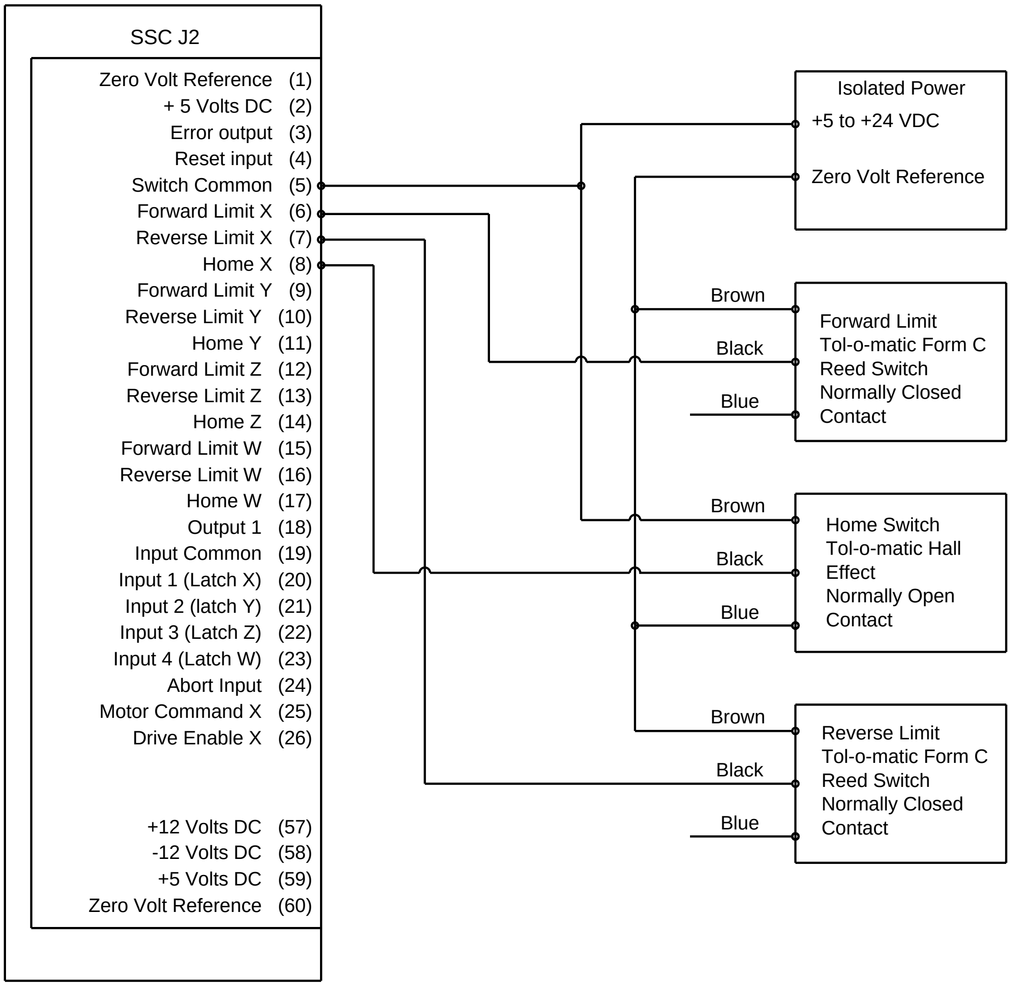


Figure 4.1 - Recommended Limit Wiring

NOTE: When wiring limits, normally closed limits must be configured as active high. This is done using I/O group, dedicated inputs or the CN command.

> The logic state of the Home input can be interrogated with the command MG _HMX. This command returns a 0 or 1 if the logic state is low or high, respectively. The state of the Home input can also be interrogated indirectly with the TS command.

For examples and further information about Homing, see command HM, FI, FE of the Command Reference and the section entitled 'Homing' in the Programming Motion Section of this manual. See Figure 4.1 for recommended limit switch and home switch wiring.

ABORT INPUT

The function of the Abort input is to immediately stop the controller upon transition of the logic state.

NOTE: The response of the abort input is significantly different from the response of an activated limit switch. When the abort input is activated, the controller stops generating motion commands immediately, whereas the limit switch response causes the controller to make a decelerated stop.

ALSO NOTE: The effect of an Abort input is dependent on the state of the off-on-error function for each axis. If the Off-On-Error function is enabled for any given axis, the motor for that axis will be turned off when the abort signal is generated. This could cause the motor to 'coast' to a stop since it is no longer under servo control. If the Off-On-Error function is disabled, the motor will decelerate to a stop as fast as mechanically possible and the motor will remain in a servo state.

All motion programs that are currently running are terminated when a transition in the Abort input is detected. For information on setting the Off-On-Error function, see the Command Reference, OE.

NOTE: The error LED does not light up when the Abort Input is active.

UNCOMMITTED DIGITAL INPUTS

The SSC has 8 uncommitted opto-isolated inputs. These inputs are specified as INx where x specifies the input number, 1 through 8. These inputs allow the user to monitor events external to the controller. For example, the user may wish to have the x-axis motor move 3 inches in the positive direction when the logic state of IN1 goes low.

USING OPTOISOLATED INPUTS

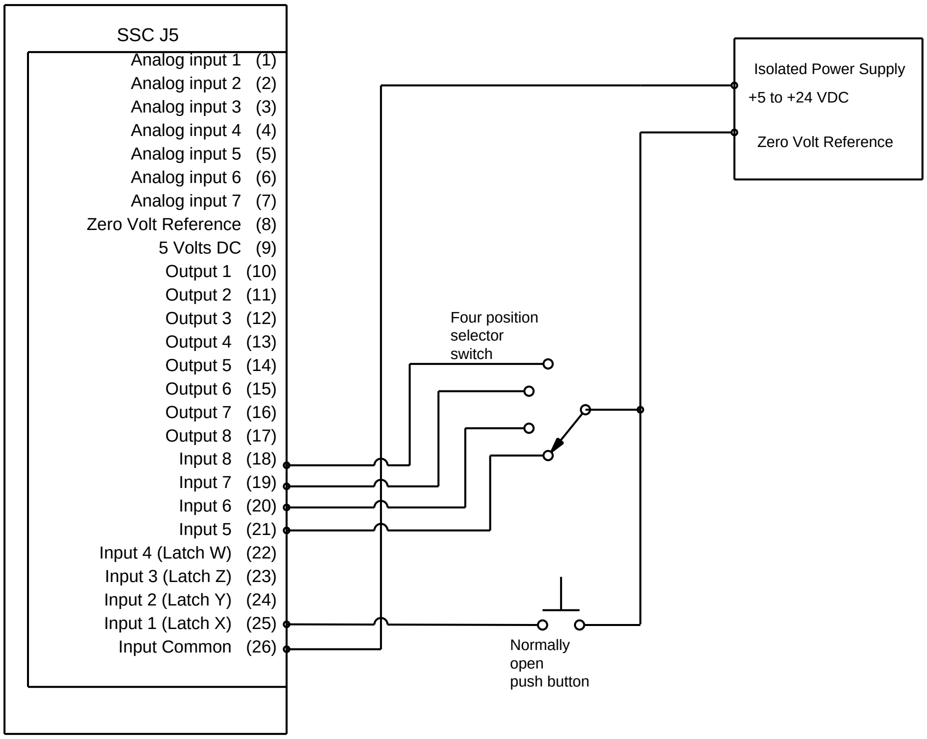


Figure 4.2 - Input Wiring

Wiring the Optoisolated Inputs

The default state of the controller configures all inputs to be interpreted as a logic one without any connection. (high) **The inputs must be brought low to be interpreted as a zero.** With regard to limit switches, a limit switch is considered to be activated when the input is brought low (or a switch is closed to zero volt ref.). Some inputs can be configured to be active when the input is high - see section Changing Optoisolated Inputs from Active High to Active Low.

The optoisolated inputs are organized into groups. For example, the general inputs, IN1-IN8, and the ABORT input are one group. **Each group has a common signal which supplies current for the inputs in the group. In order to use an input, the associated common signal must be connected to voltage between +5 and +28 volts, see discussion below.**

The optoisolated inputs are connected in the following groups:

GROUP	COMMON SIGNAL
IN1-IN8, ABORT	INCOM (Input Common)
FLX,RLX,HOMEX	LSCOM (Limit Switch Common)
FLY,RLY,HOMEY	
FLZ,RLZ,HOMEZ	
FLW,RLW,HOMEW	

A logic zero (low) is generated when at least 1mA of current flows from the common signal to the input. **A positive voltage (with respect to the input) must be supplied at the common signal.** This can be accomplished by connecting a voltage in the range of +5V to +28V into Common Signal of the input circuitry from a separate power supply.

WIRING THE OPTOISOLATED INPUTS

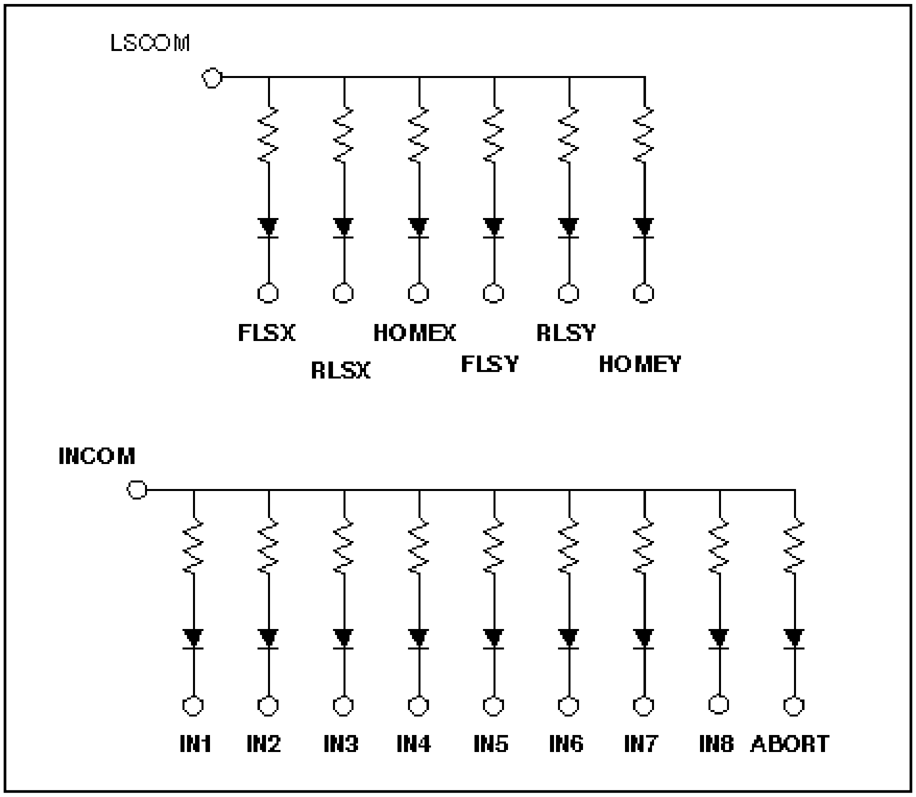


Figure 4.3 - The Optoisolated Inputs

USING AN ISOLATED POWER SUPPLY

To take full advantage of opto-isolation, an isolated power supply should be used to provide the voltage at the common signal connection. **When using an isolated power supply, do not connect the zero volt reference of the isolated power to the zero volt reference of the controller.** A power supply in the voltage range between 5 to 28 Volts may be applied directly (see Figure 4-4). For voltages greater than 28 Volts, a resistor, R, is needed in series with the input such that

$$1 \text{ mA} < V \text{ supply}/(R + 2.2K\Omega) < 15 \text{ mA}$$

BYPASSING THE OPTO-ISOLATION:

If no isolation is needed, the internal 5 or 12 Volt supply may be used to power the switches, as shown in Figure 4-5. This can be done by connecting a jumper between the pins LSCOM or INCOM and internal +5V or +12V. To close the circuit, wire the desired input to any zero volt reference terminal.

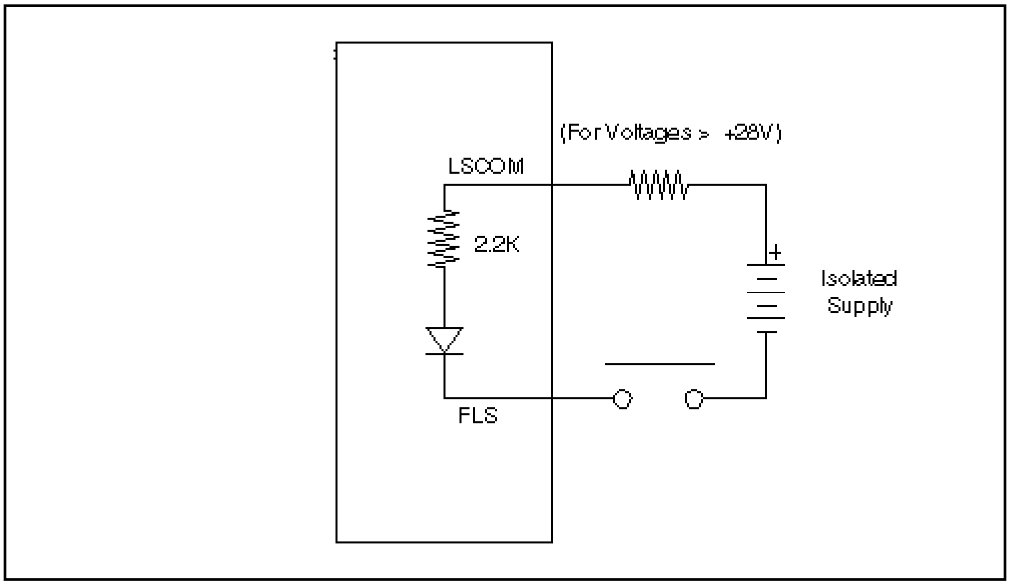


Figure 4.4 - Connecting a single Limit or Home Switch to an Isolated Supply

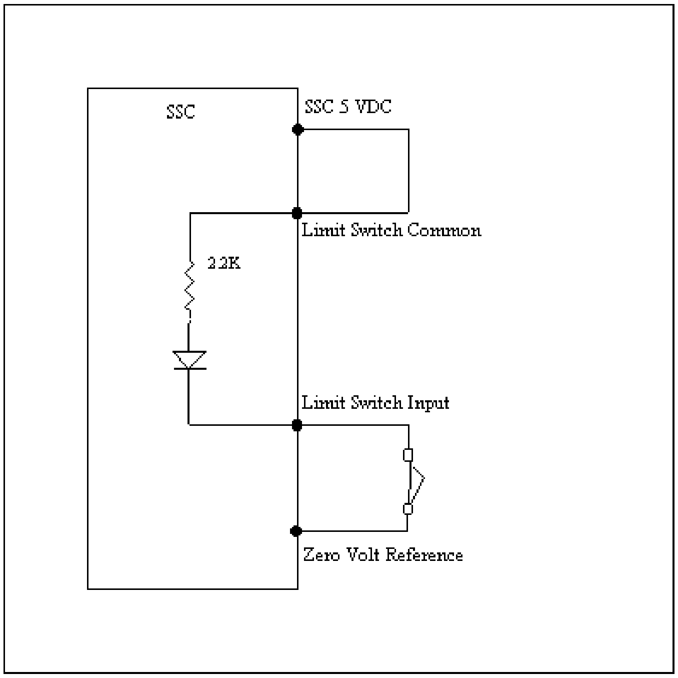


Figure 4.5 - Connecting Limit switches to the internal 5V supply

WIRING THE OPTOISOLATED INPUTS

CHANGING OPTOISOLATED INPUTS FROM ACTIVE LOW TO ACTIVE HIGH

Some users may prefer that the optoisolated inputs be active high. For example, the user may wish to have the inputs be activated with a logic one signal. The limit, home and latch inputs can be configured through software to be active high or low with the CN command. For more details on the CN command see Chapter 12 of the Two-Letter Command Reference section. The Abort input cannot be configured in this manner.

RESET INPUT

The reset input is a TTL level, non-isolated signal and is used to locally reset the SSC without resetting the PC.

Analog Inputs

The SSC has seven analog inputs configured for the range between -10V and 10V. The inputs are decoded by a 12-bit A/D converter giving a voltage resolution of approximately .005V. The impedance of these inputs is 10 KW. The analog inputs are specified as AN[x] where x is a number 1 thru 7.

Using the Outputs

The SSC provides several output signals including eight general outputs, an error signal, ER, and four amplifier enable signals AEN. All the output signals are TTL. See figures 4.7 and 4.8 for how to wire outputs.

ANALOG COMMAND OUTPUT & ENABLE OUTPUT

The SSC analog command voltage, ACMD, ranges between +/-10V. This signal, along with Zero Volt Ref., provides the input to the servo power amplifiers. The power amplifiers must be sized to drive the motors and load. The gain should be set such that a 10 Volt input results in the maximum required current.

The SSC also provides an amplifier enable signal (AEN). This signal changes under the following conditions: the watchdog timer activates, the motor-off command (MO) is given, or the Enable Off-On-Error command (OE1) is given and the position error exceeds the error limit. As shown in Figure 4.6, AEN can be used to disable the amplifier for these conditions.

The standard configuration of the AEN signal is TTL active high. (5 volts = enable, 0 volt = disable) In other words, the AEN signal will be high when the controller expects the amplifier to be enabled.

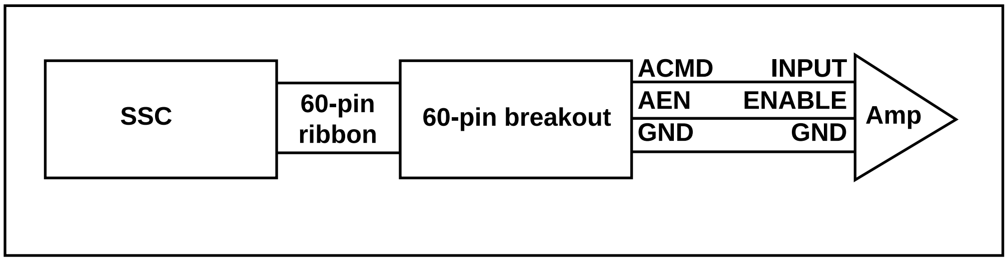


Figure 4.6 - Connecting AEN to an amplifier

USING THE OUTPUTS

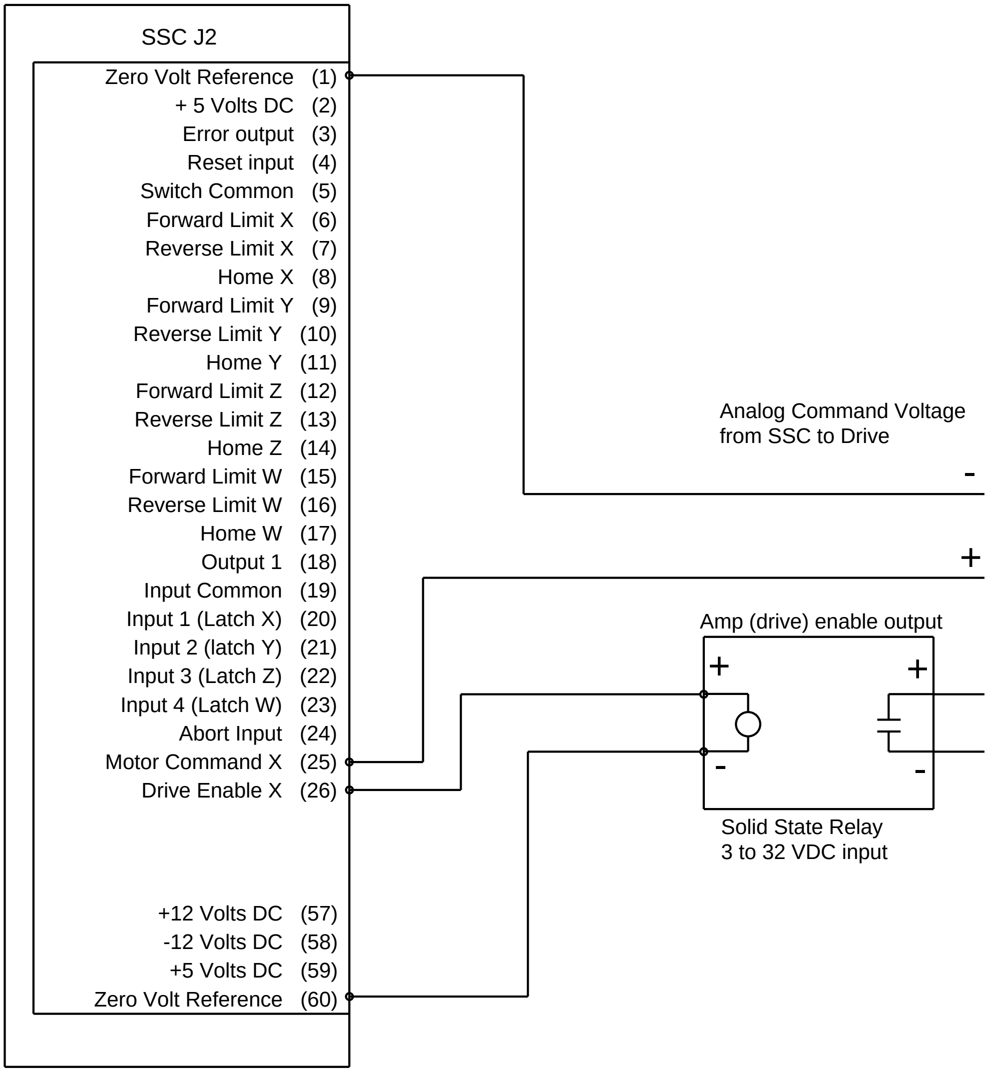


Figure 4.7 - Enable Output

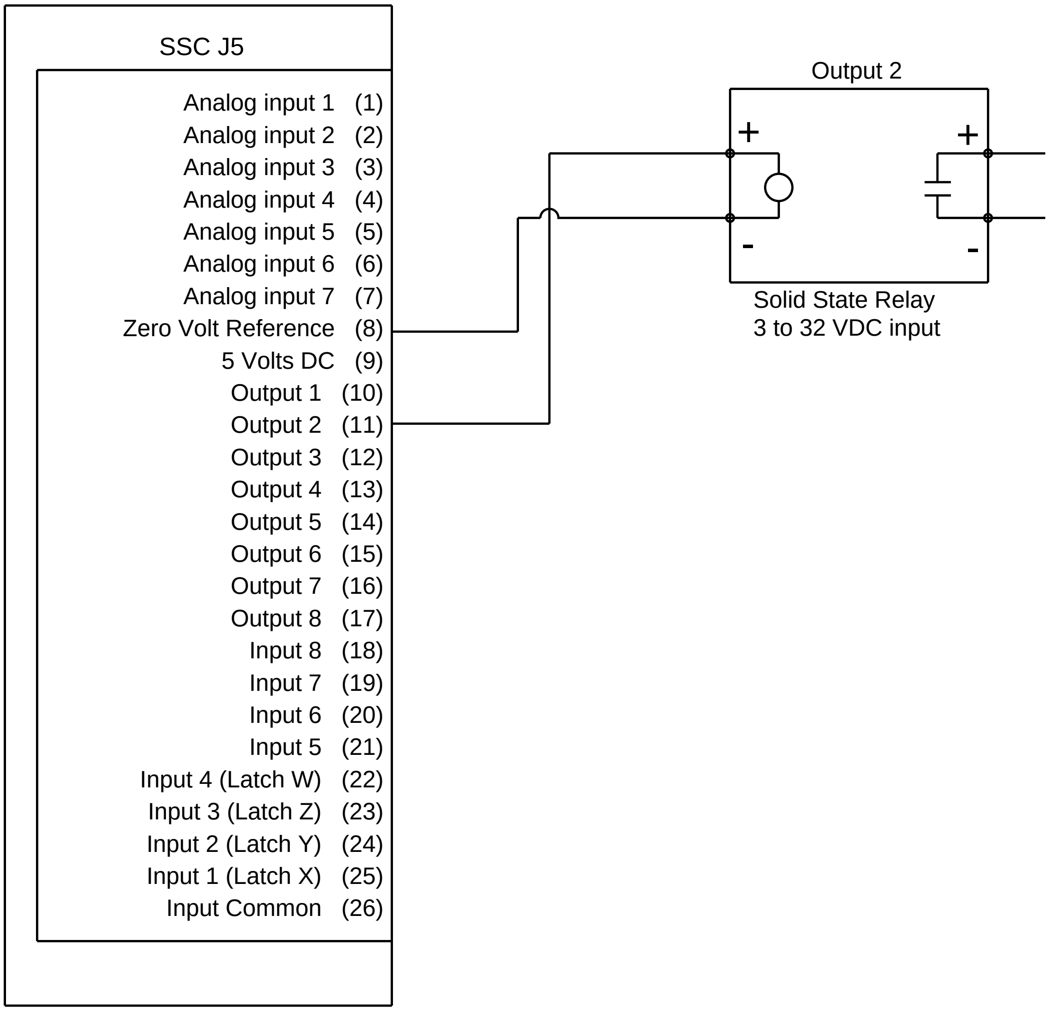


Figure 4.8 - Output wiring

Offset Adjustment

For each axis, the SSC provides offset correction potentiometers to compensate for any offset in the analog output. These potentiometers have been adjusted at the factory to produce 0 Volts output for a zero digital motor command. Before making any adjustment to the offset, send the motor off command, MO, to the SSC. This causes a zero digital motor command. Connect an oscilloscope or voltmeter to the motor command pin. You should measure zero volts. If not, adjust the offset potentiometer on the SSC until zero volts is observed.

Tol-O-Motion SSC Visual Programming 5

Introduction

Tol-O-Motion SSC motion control software has been developed to provide a windows-based and user friendly interface between the Tol-O-Matic multi-axis motion controller and your computer through RS-232 cable. When no serial communication is established, the Tol-O-Motion SSC allows you to setup the controller and program. You can setup the controller and save the controller's setup parameters to a disk file. The controller's setup settings can be loaded from a disk file when the controller is on line. The programming window can help you to create motion programs in plain English style (visual code) and generate source code (assembly-like motion commands) for the controller.

When the controller is online the following features are available:

Display

The display window shows the statues of the controller including I/O and limit switches.

Terminal

Terminal window is used to edit the two letter source code.

Joystick Teach

Joystick Teach window is used online to create a series of 2 axis linear moves that can be loaded into a program.

Scope

A data acquisition panel for collecting system data from position, position error, 2nd encoder position, commanded position, latch, stop code, switches and torque.

Tune

Used to set PID gains in automatic or manual modes.

Jog

Jogs the axis by position or speed.

INTRODUCTION

Hit F1 key on your keyboard or use the “help” button in the window to get help anytime.

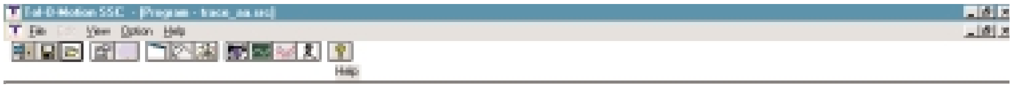


Figure 5.1 - Menu Bar

WINDOWS 95/98/NT INSTALLATION INSTRUCTION

1. Insert the Tol-O-Motion SSC software installation disk 1 in your computer’s floppy drive

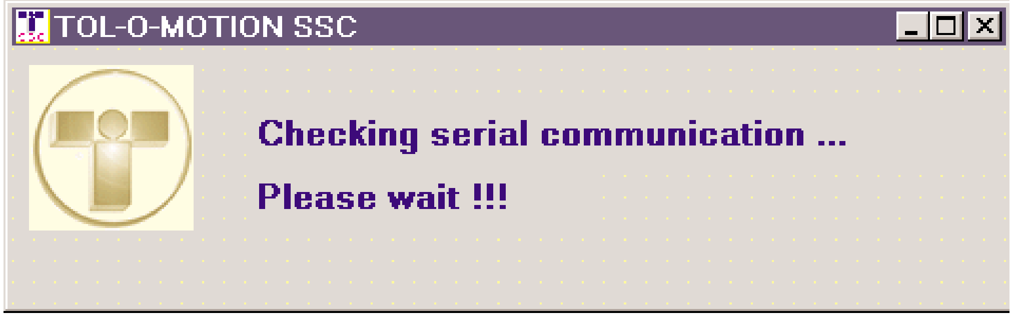
2. From the start menu, choose run

3. In the Run window, click in the Command Line box

4. Type A:\SETUP.EXE

5. Follow the on –screen instructions that appear

After installing the software, run SSC software to start the motion control program. The following screen will first show up to communicate with the controller. Please refer to Controller Offline section if the controller is offline or refer to Controller Online section when the serial communication is established.



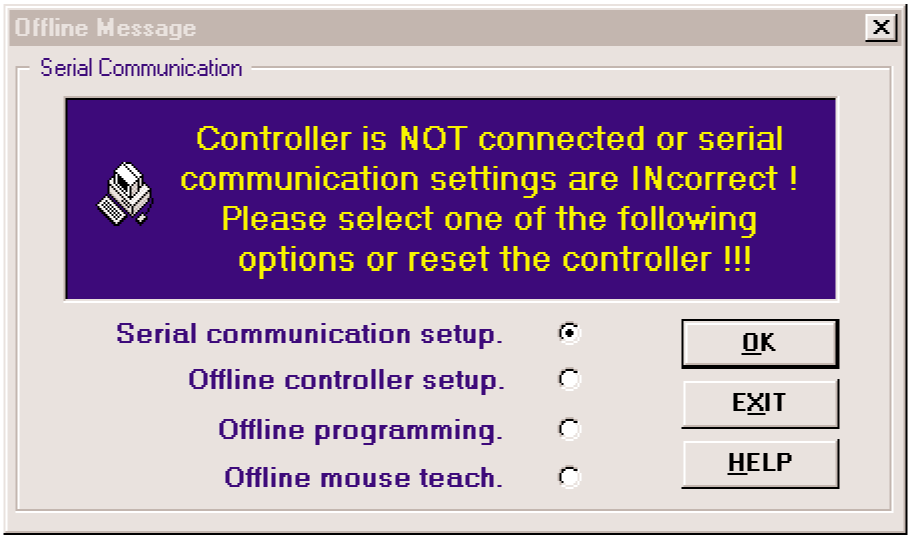
Checking serial communication ...

Please wait !!!

Figure 5.2 - Startup Message

Controller Offline

If no serial communication is established, the software will display a message, as shown in Fig. 5.3, which responds no controller is connected or serial communication settings are incorrect. There are four options available without the controller connected.



Offline Message

Serial Communication

Controller is NOT connected or serial communication settings are INcorrect ! Please select one of the following options or reset the controller !!!

Serial communication setup. ●

Offline controller setup. ○

Offline programming. ○

Offline mouse teach. ○

Figure 5.3 - Controller Offline Message

SERIAL COMMUNICATION SETUP

To set serial communication parameters, click the “SERIAL COMMUNICATION SETUP” option in Fig. 5.3 and hit “OK”, which will bring up the serial communication window as shown in Fig. 5.4.

The serial communication setting window allows you to select the baud rate, data bit, stop bit, controller echo, parity, flow control and the communication port on your computer. You can simply click on appropriate option for each setting and click “DONE” to resume serial communication.

The default settings of the serial communication parameters are:

Baud rate: 9600
Data bit: 8
Stop bit: 1
Parity: None
Echo: Off
Flow Control: XOn/RTS, Both request-to-send and XOn/XOff
handshaking.
Port: COM1

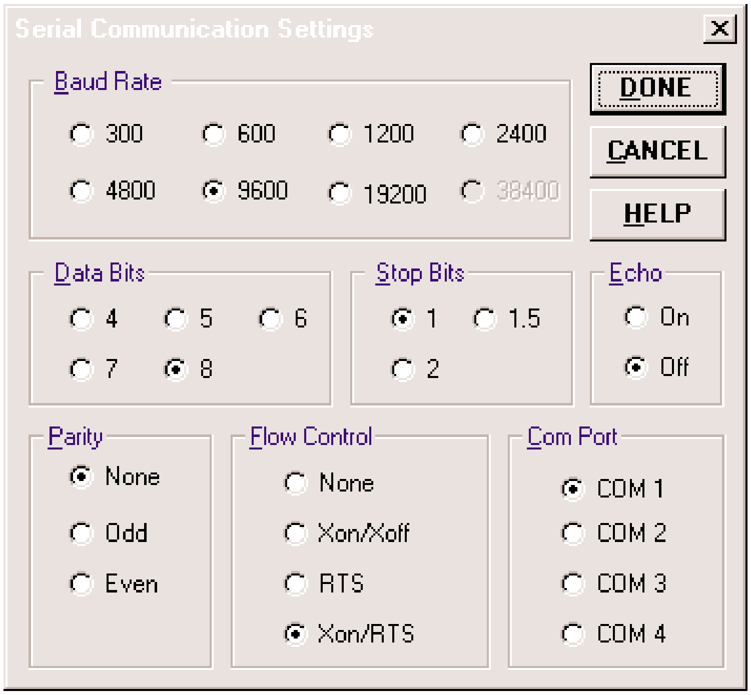
CONTROLLER OFFLINE
Serial Communication Setup

Be sure to set the communication settings in the controller the same as those set in the software. The dip switch settings on the controller front panel corresponding to different baud rate are listed as follows.

Dip Switch Settings			Interpretation
1200(2)	9600(3)	19.2K(4)	
ON	ON	OFF	300 Baud Rate
ON	OFF	OFF	1200 Baud Rate
ON	OFF	ON	4800 Baud Rate
OFF	**ON**	**OFF**	***9600 Baud Rate**
OFF	OFF	ON	19200 Baud Rate
OFF	ON	ON	38400 Baud Rate
ON	ON	ON	Self Test

* default setting

The RS232 main port can be configured for handshake or non-handshake mode. Set the HSHK switch(5) to ON to select the handshake mode (default setting). In this mode, the RTS and CTS lines are used. The CTS line will go high whenever the controller is not ready to receive additional characters. The RTS line will inhibit the controller from sending additional characters. Note: the RTS line goes high for inhibit. The handshake should be turned on to ensure proper communication especially at higher baud rates.



Serial Communication Settings

Baud Rate: ○ 300 ○ 600 ○ 1200 ○ 2400 ○ 4800 ● 9600 ○ 19200 ○ 38400

Data Bits: ○ 4 ○ 5 ○ 6 ○ 7 ● 8

Stop Bits: ● 1 ○ 1.5 ○ 2

Echo: ○ On ● Off

Parity: ● None ○ Odd ○ Even

Flow Control: ○ None ○ Xon/Xoff ○ RTS ● Xon/RTS

Com Port: ● COM 1 ○ COM 2 ○ COM 3 ○ COM 4

Figure 5.4 - Serial Communication Setup

OFFLINE CONTROLLER SETUP

To perform offline controller setup, click the “Offline controller setup” option in Fig. 5.3 or click setup toolbar button from main window and hit “OK”, which will pop up the setup window as shown in Fig. 5.5. Click on the number of axes of your system, which will pop up the window shown in Fig. 5.6.

When configure offline controller window is loaded, the set up default value is automatically loaded from C:\windows\win.ini to configure offline controller window.

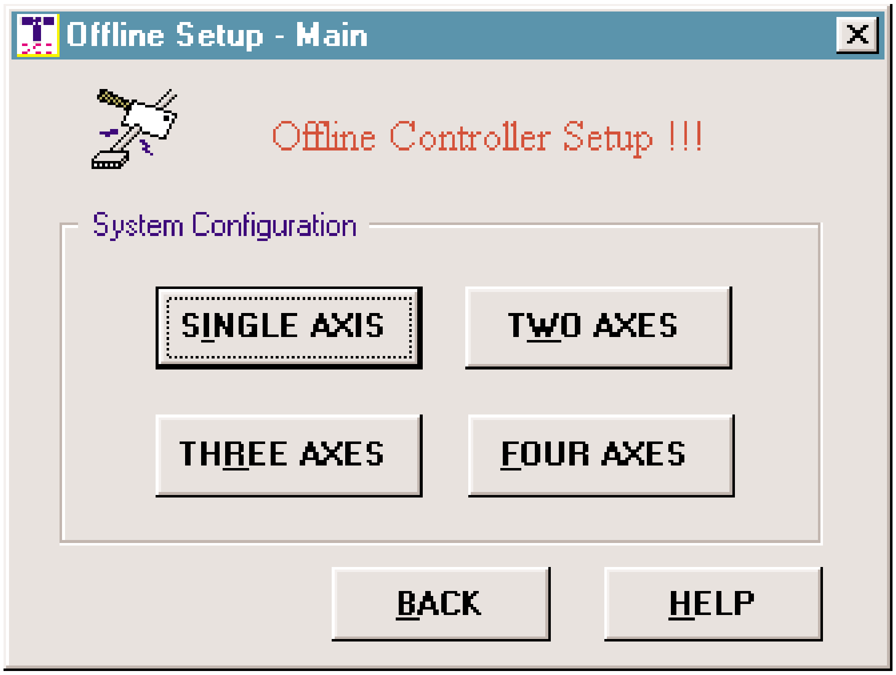


Figure 5.5 - Offline Controller Setup

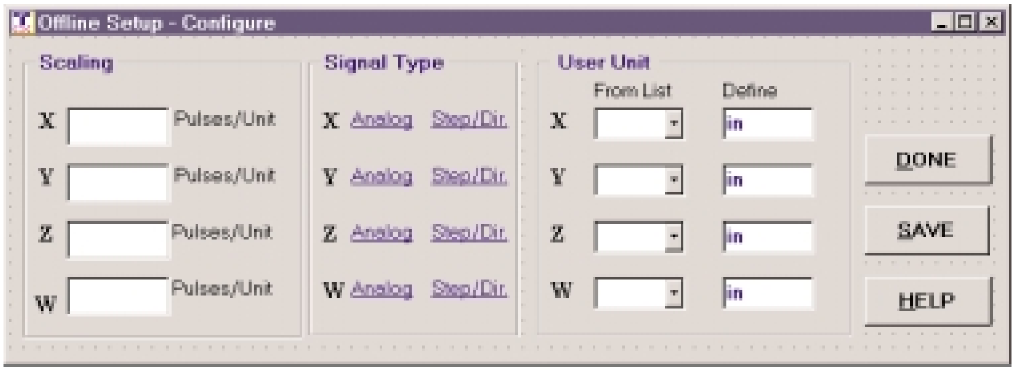


Figure 5.6 - Configure Offline Controller

Save/Done

After finishing the offline controller setup, click “SAVE” to save settings to a disk file. Click “DONE” to go to offline message window and automatically save setup value to file C:\windows\win.ini as a default value.

User Unit

Select user units (available from inch, foot, centimeter, meter, and count) for each axis in your application or define your own unit (e.g. cc). The user unit selected here will be used throughout the program.

Scaling

Configure scaling from counts(pulses) to user’s selected unit (default inch) For example: pitch of leadscrew (turns per inch, TPI) * encoder resolution (counts per revolution) = total counts per inch.

Configure signal type:

A. Analog: If an analog signal is selected, a servo setup window, as shown in Fig. 5.7, will show up for you to configure the servo settings.

1. Configure main and/or auxiliary encoders type:

Normal quadrature
Normal pulse and direction
Reversed quadrature
Reverse pulse and direction

Note: For each axis of motion, the controller accepts inputs from incremental encoders with two channels in quadrature, or 90 electrical degrees out of phase. The controller performs quadrature decoding of the two signals (encoder signal A and B), resulting in bi-directional position information with a resolution of four times the number of full encoder cycles. For example, a 1000 lines encoder is decoded into 4000 quadrature counts per revolution. An optional third channel or index pulse (encoder signal I) may be used for homing or synchronization.

Several types of incremental encoders may be used: linear or rotary, analog or digital, single-ended or differential. Any line resolution may be used, the only limitation being that the encoder input frequency must not exceed 2,000,000 full cycles/sec (or 8,000,000 quadrature counts/sec). The controller also accepts inputs from an additional encoder for each axis. These are called auxiliary encoders and can be used for dual-loop applications. The encoder inputs are not isolated.

2. Set PID gains, feedforward gains and compensation gains:

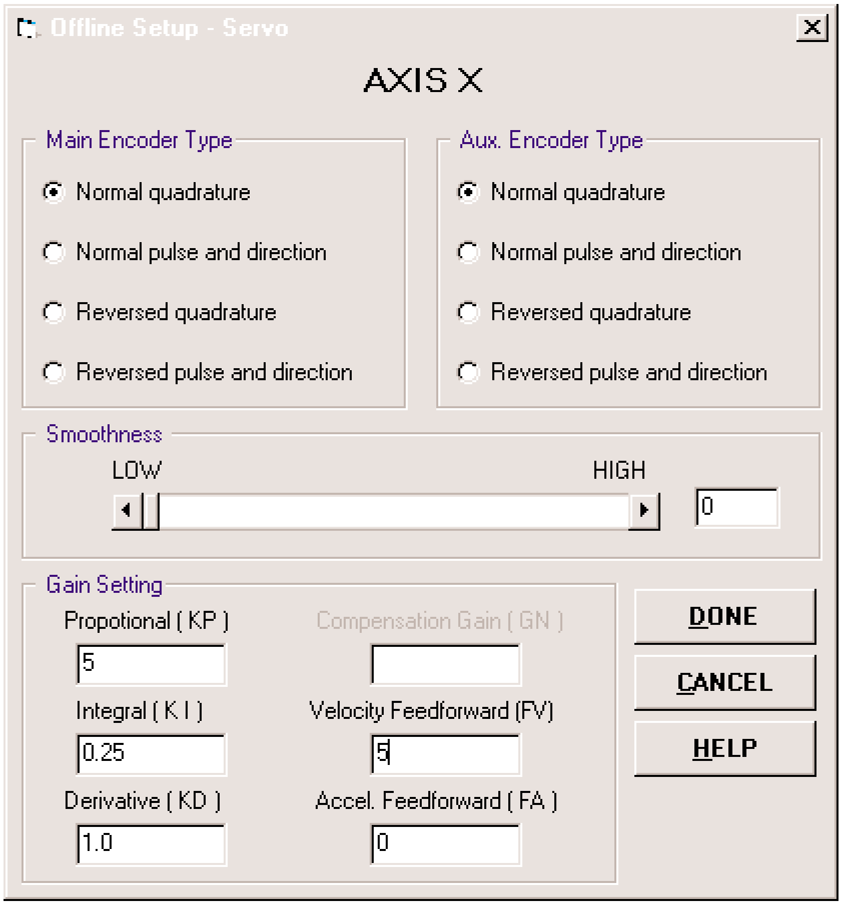
Proportional gain (KP)
Integral gain (KI)
Derivative gain (KD)
Velocity feedforward gain (FV)
Acceleration feedforward gain (FA)
Compensation gain (GN) -
not used for current version of controller

3. Set servo smoothness time constant (S-curve):

The smoothing function filters the acceleration and deceleration in independent moves to produce a smooth velocity profile. The resulting profile, known as S-curve, has continuous acceleration and results in reduced mechanical vibrations. The smoothness sets the bandwidth of the filter where 0 (lowest) means no filtering and 255 (highest) means maximum filtering. Note that the filtering results in longer motion time.

Hit “DONE” to exit motor setup or “CANCEL” to cancel setup.

CONTROLLER OFFLINE
Offline Controller Setup



Offline Setup - Servo

AXIS X

Main Encoder Type

- ● Normal quadrature
- ○ Normal pulse and direction
- ○ Reversed quadrature
- ○ Reversed pulse and direction

Aux. Encoder Type

- ● Normal quadrature
- ○ Normal pulse and direction
- ○ Reversed quadrature
- ○ Reversed pulse and direction

Smoothness

LOW HIGH 0

Gain Setting

Propotional (KP) 5

Compensation Gain (GN)

Integral (K I) 0.25

Velocity Feedforward (FV) 5

Derivative (KD) 1.0

Accel. Feedforward (FA) 0

Figure 5.7 - Servo axis setup

B. Step/Dir: If a step or direction signal is selected, a stepper motor setup window, as shown in Fig. 5.8, will display for setting stepper smoothness. The parameter smooths the frequency of the step motor pulses. Larger values of smoothness constant provide greater smoothness. The default value is 2. Note that the smoothness results in a longer motion time.

Hit “DONE” to finish stepper motor setup or “CANCEL” to cancel setup.

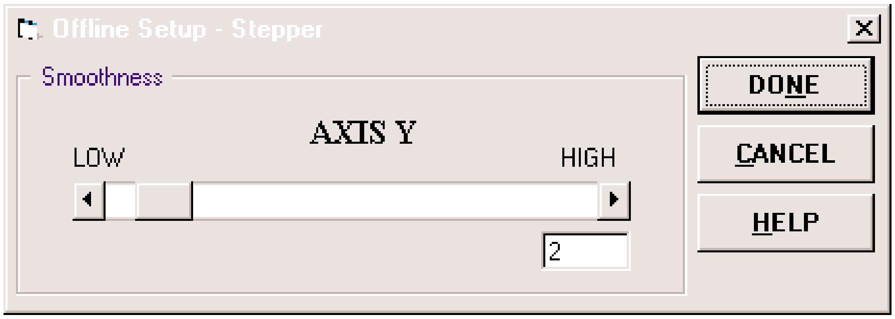


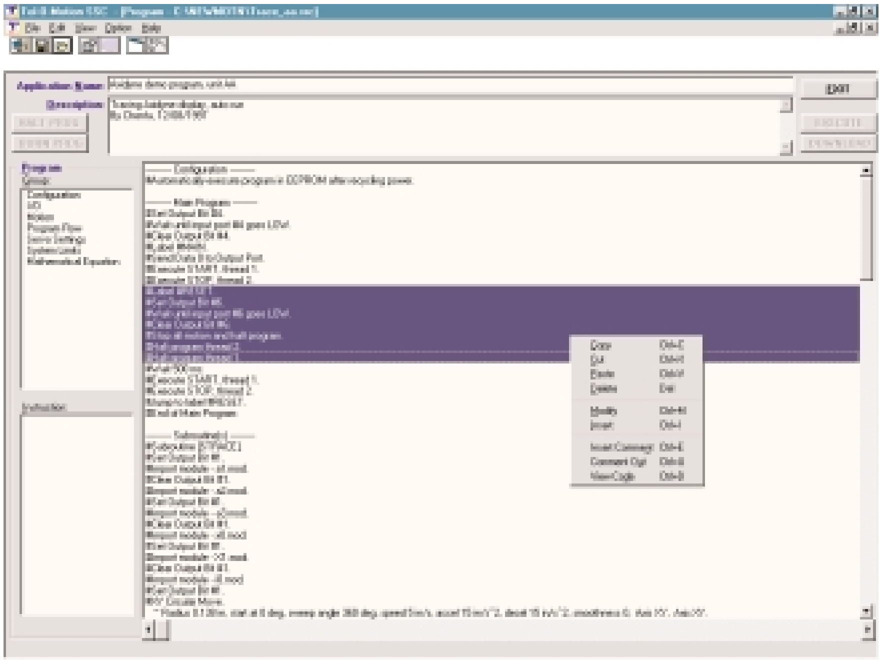
Figure 5.8 - Stepper Axis Setup

Save / Exit

After finishing the offline controller setup, as shown in Fig. 5.5, click "SAVE" to save settings to a disk file, "DONE" to go back to offline message window and automatically save setup value to file C:\windows\win.ini as a default value.

OFFLINE PROGRAMMING

Offline programming, as shown in Fig. 5.9, provides as much functionality as the online programming with the exception of "execute", "halt motion", "burn program", and "download" code to the controller. The program code created in offline programming can be saved in a disk file and be loaded when the controller is connected afterwards.



```
——— Configuration ———
#Automatically execute program in EEPROM after recycling power.

——— Main Program ———
#Set Output Bit #4.
#Wait until input port #4 goes LOW.
#Clear Output Bit #4.
#Label #MAIN1
#Send Data 0 to Output Port.
#Execute START, thread 1.
#Execute STOP, thread 2.
#Label #RESET1
#Set Output Bit #6.
#Wait until input port #6 goes LOW.
#Clear Output Bit #6.
#Stop all motion and halt program.
#Halt program thread 2.
#Halt program thread 1.
#Wait 500ms.
#Execute START, thread 1.
#Execute STOP, thread 2.
#Jump to label #RESET1.
#End of Main Program

——— Subroutine(s) ———
#Subroutine [STRACE]
#Set Output Bit #1.
#Import module - [illegible].mod.
#Clear Output Bit #1.
#Import module - [illegible].mod.
#Set Output Bit #1.
#Import module - [illegible].mod.
#Clear Output Bit #1.
#Import module - [illegible].mod.
#Set Output Bit #1.
#Import module - [illegible].mod.
#Clear Output Bit #1.
#Import module - [illegible].mod.
#Set Output Bit #1.
#XY Circular Move.
  * Radius [illegible], start at 0 deg, sweep angle 360 deg, speed [illegible], accel [illegible], decel [illegible], smoothness [illegible], Axis [illegible], Axis [illegible].
```

Figure 5.9 - Offline Programming

Controller Online

When the serial communication is established, the Axidyne Tol-O-Motion SSC logo and controller type will be displayed. There are thirteen toolbar buttons under the Tol-O-Motion SSC main window. Clicking on any of the buttons will take you to the corresponding stage of operation.

The toolbar buttons are:

Exit	Quit the SSC programming software
Save	Save the current program to a disk file
Open	Open an existing program file from disk drive
Setup	Used to setup the number of axes, motors, encoders, and PID gain.
Terminal	Terminal window is used to edit the two letter source code
Program	Program window is used to create motion programs
Joystick Teach	Joystick Teach window is used online to create a series of linear moves that can be loaded into a program
Display	The display window shows the states of the I/O and limit switches
Scope	Data acquisition panel
Tune	Tune the system PID gains
Jog	Manual positioning of system
Help	Programming help

SETUP

To setup the controller, click the SETUP toolbar button in the main panel as shown in Fig. 5.10. An Online Controller Setup Window Fig. 5.11 will show up, the default setup value will be loaded from controller’s EEPROM to setup window. Use the following functions to save or load the setup parameters and finish the controller setup.

“Load Setup Parameters From File”: load setting parameters from disk file which could be created in your offline controller setup.

“Save Setup Parameters to File”: Save setup parameters to a disk file.

“WRITE Setup Parameters to EEPROM”: burn current settings to EEPROM in the controller. (Save settings and overwrite existing settings in the controller’s EEPROM)

“DONE”: finish setup and go back to the previous window. Changes are not saved to EEPROM.

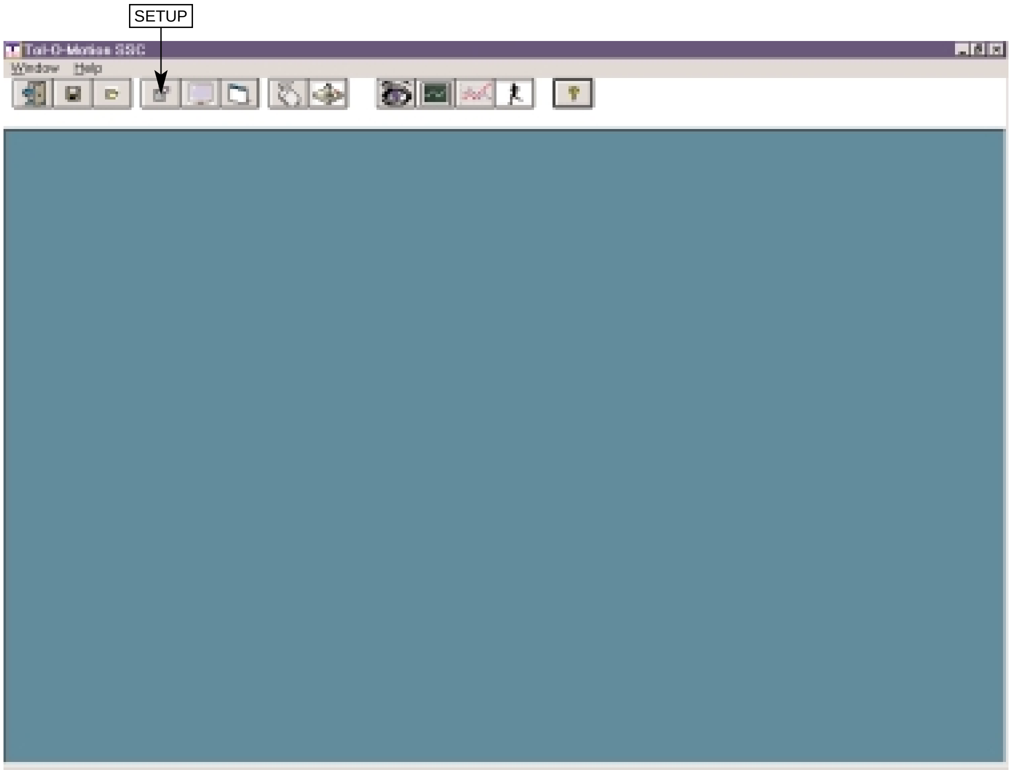
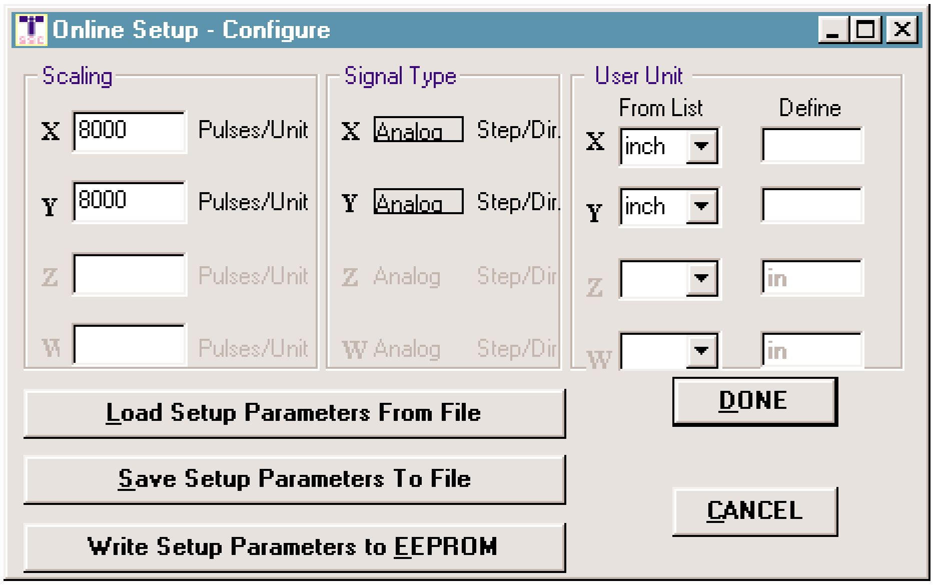


Figure 5.10 - Controller Online - Main Panel

CONTROLLER ONLINE Setup


Online Setup - Configure
Scaling
Signal Type
User Unit
From List
Define
Load Setup Parameters From File
Save Setup Parameters To File
Write Setup Parameters to EEPROM
DONE
CANCEL

Scaling: X 8000 Pulses/Unit; Y 8000 Pulses/Unit; Z Pulses/Unit; W Pulses/Unit

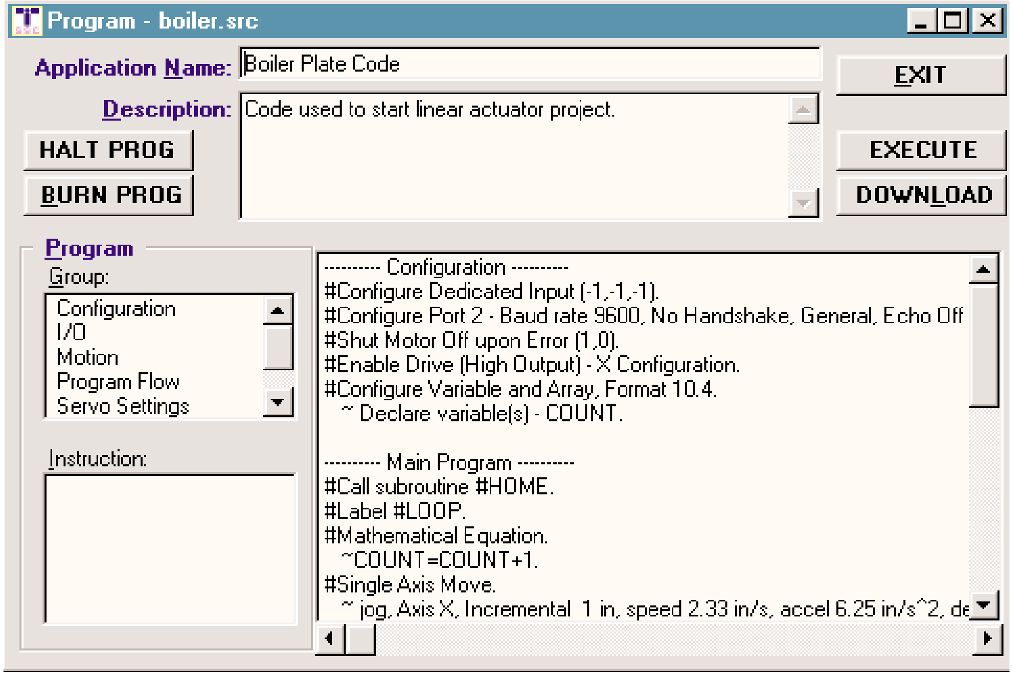
Signal Type: X Analog Step/Dir.; Y Analog Step/Dir.; Z Analog Step/Dir; W Analog Step/Dir

User Unit: X inch; Y inch; Z in; W in

Figure 5.11 - Online Controller Setup

PROGRAM WINDOW

The program window, as shown in Fig. 5.12, provides an easy-to-use interface for users who are not familiar with controller's language. Executable code and plain English pseudo-code are generated after defining the application.



Application Name: Boiler Plate Code

Description: Code used to start linear actuator project.

```
--------- Configuration ---------
#Configure Dedicated Input (-1,-1,-1).
#Configure Port 2 - Baud rate 9600, No Handshake, General, Echo Off
#Shut Motor Off upon Error (1,0).
#Enable Drive (High Output) - X Configuration.
#Configure Variable and Array, Format 10.4.
  ~ Declare variable(s) - COUNT.

--------- Main Program ---------
#Call subroutine #HOME.
#Label #LOOP.
#Mathematical Equation.
  ~COUNT=COUNT+1.
#Single Axis Move.
  ~ jog, Axis X, Incremental  1 in, speed 2.33 in/s, accel 6.25 in/s^2, de
```

Figure 5.12 - Tol-O-Motion Programmer

Application name:

Specify name of the application.

Description:

Brief description of the program for reference.

Menus and Buttons

“DOWNLOAD”

Download the executable code to the controller.

“EXECUTE”

Execute the program currently residing in the controller.

“HALT”

Halt the program and the motion.

“BURN”

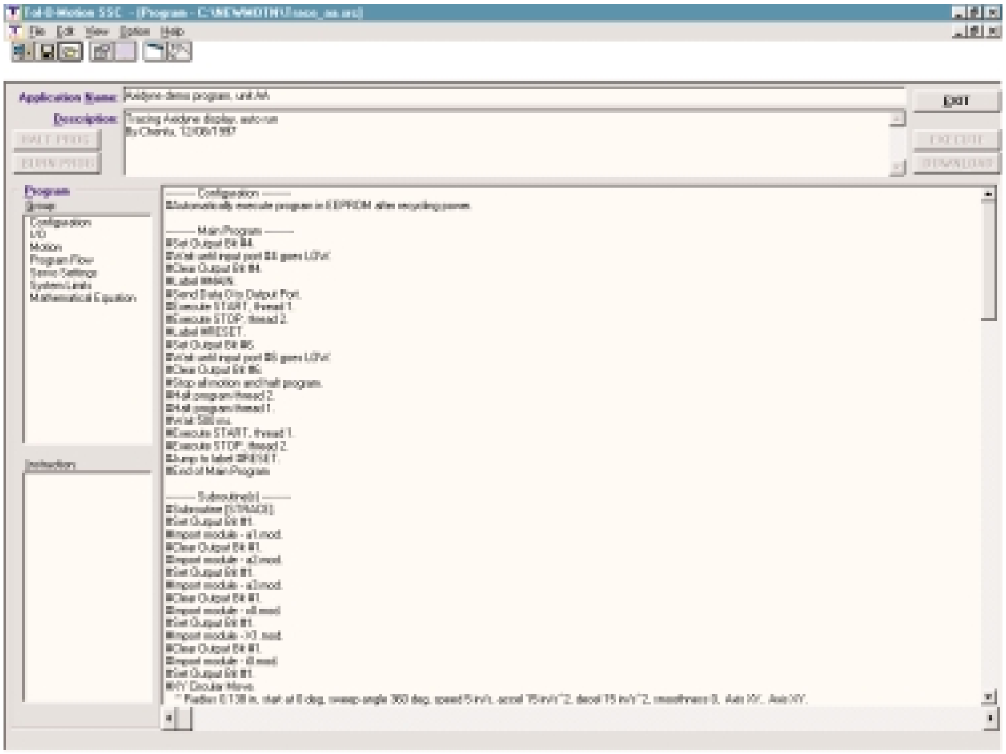
Burns program to EEPROM memory.

Program:

The program instructions are arranged in seven groups relating to the function of each instruction. To select a program instruction first select the relevent group and then the specific instruction required. In the program, each instruction is treated as an independent module. For example, a 2D circular motion is a module which might include several motion segments (several arc moves with different speeds, accelerations or decelerations).

There are three general sections to a program. First is the “Configuration”, second is the “Main Program” and third is the “Subroutines”. (See Figure 5.13)

CONTROLLER ONLINE
Program Window



Application Name: Aeldyne demo program, unit AA

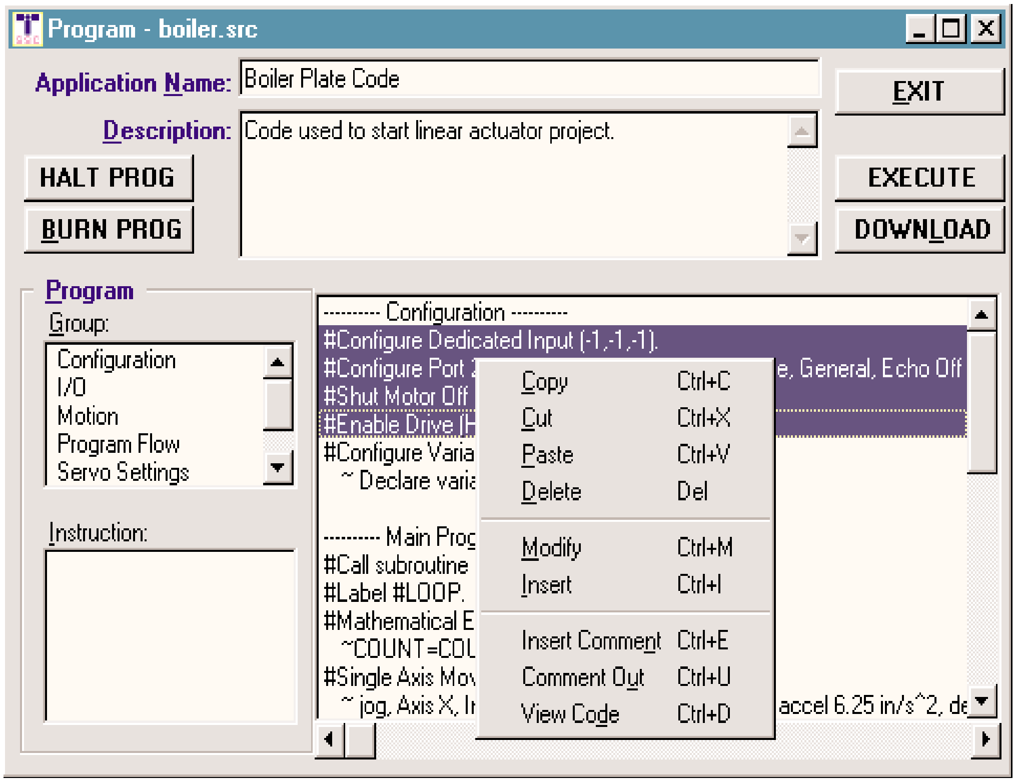
Description: Tracing Aeldyne display, auto-run
By Chents, 12/08/1997

```
——— Configuration ———
#Automatically execute program in EEPROM after recycling power.

——— Main Program ———
#Set Output Bit #4.
#Wait until input port #4 goes LOW.
#Clear Output Bit #4.
#Label #MAIN.
#Send Data Qty Output Port.
#Execute START, thread 1.
#Execute STOP, thread 2.
#Label #RESET.
#Set Output Bit #6.
#Wait until input port #6 goes LOW.
#Clear Output Bit #6.
#Stop all motion and halt program.
#Halt program thread 2.
#Halt program thread 1.
#Wait 500 ms.
#Execute START, thread 1.
#Execute STOP, thread 2.
#Jump to label #RESET.
#End of Main Program

——— Subroutine(s) ———
#Subroutine [STRACE].
#Set Output Bit #1.
#Import module - a1.mod.
#Clear Output Bit #1.
#Import module - a2.mod.
#Set Output Bit #1.
#Import module - a3.mod.
#Clear Output Bit #1.
#Import module - a4.mod.
#Set Output Bit #1.
#Import module - X3 .mod.
#Clear Output Bit #1.
#Import module - t0.mod.
#Set Output Bit #1.
#XY Circular Move.
  ** Radius 0.138 in, start at 0 deg, sweep-angle 360 deg, speed 5 in/s, accel 15 in/s^2, decel 15 in/s^2, smoothness 0, Axis XY, Axis XY.
```

Figure 5.13 - Three Sections of Program

A program is started by selecting the relevant group then the desired instruction. The new instructions are placed after the last instruction added in the proper section. Subroutines are created by choosing the subroutine instruction in the Program Flow group, all of the following instructions are placed in the subroutine until an end of subroutine instruction is added. Once an end of subroutine is selected the following instructions will revert back to the end of the main section.

Editing of a program is done by selecting the line or lines that are to be acted upon and choosing the desired command from the edit menu or by right clicking the mouse.



Application Name: Boiler Plate Code

Description: Code used to start linear actuator project.

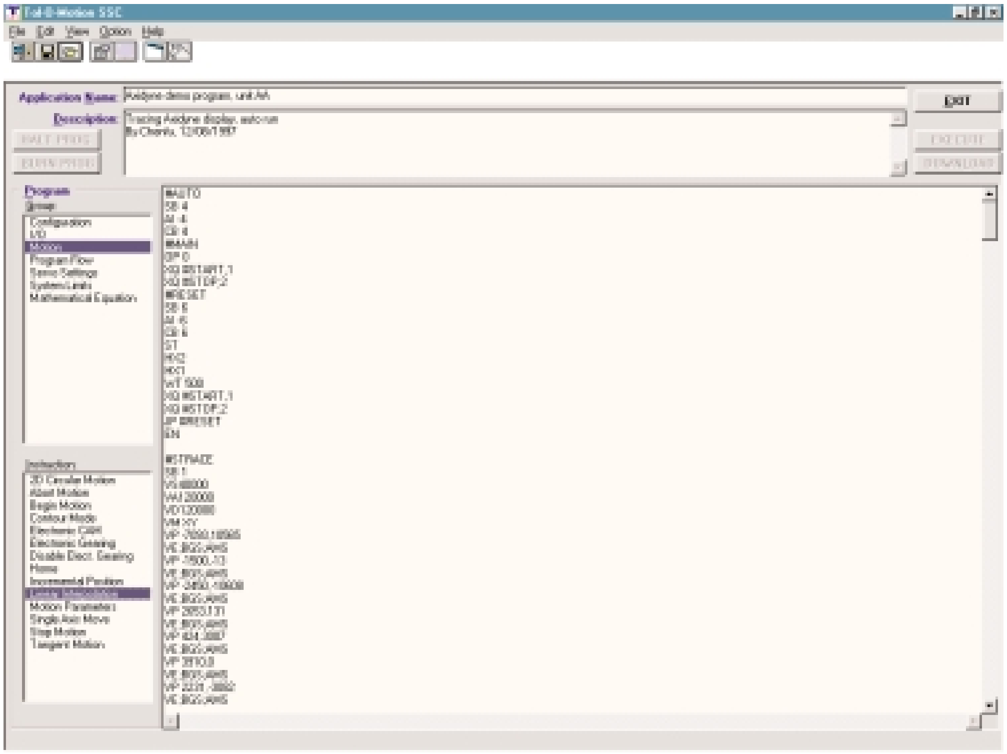
```
--------- Configuration ---------
#Configure Dedicated Input (-1,-1,-1).
#Configure Port 2                  e, General, Echo Off
#Shut Motor Off
#Enable Drive (H
#Configure Varia
  ~ Declare varia

--------- Main Prog
#Call subroutine
#Label #LOOP.
#Mathematical E
  ~COUNT=COU
#Single Axis Mov
  ~ jog, Axis X, In                accel 6.25 in/s^2, de
```

Figure 5.14 - Program Editing

Other Windows-standard editing functions are available by selecting the line(s) to be edited and clicking the right mouse button. (See menu in Figure 5.14) Note that multiple or single lines can be selected, copied, cut, pasted, deleted, or commented out.

Program instructions can be inserted into the program by selecting the line that the command will be inserted before, clicking the right mouse button, and choosing Insert from the edit menu, then selecting the desired program statement from the instruction list.

CONTROLLER ONLINE
Program Window



Application Name: Aeldyne demo program, unit AA

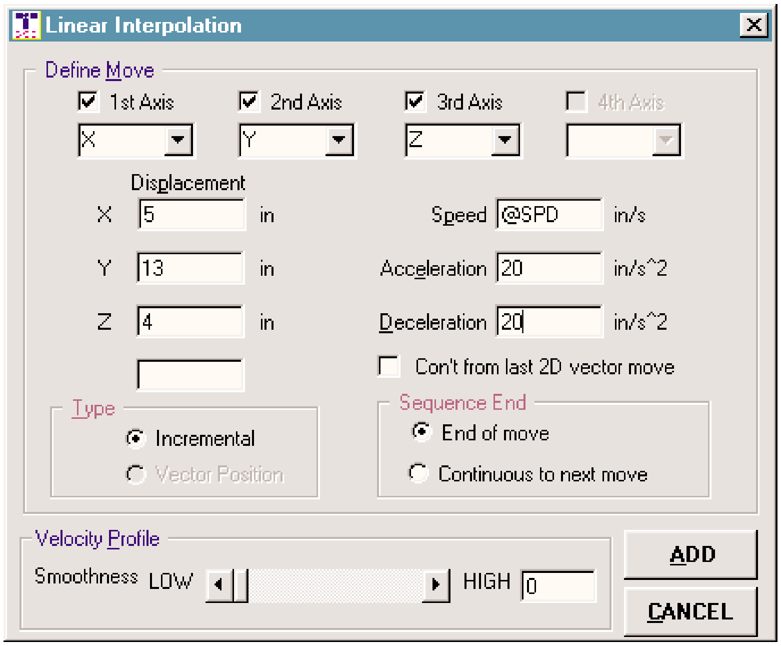
Description: Tracing Aeldyne display, auto-run
By Chorris, 12/08/1997

```
#AUTO
SB 4
AI -4
CB 4
#MAIN
OP 0
XQ #START,1
XQ #STOP,2
#RESET
SB 6
AI -6
CB 6
ST
HX2
HX1
WT 500
XQ #START,1
XQ #STOP,2
JP #RESET
EN

#STRACE
SB 1
VS 80000
VA 200000
VD 120000
VM XY
VP -7000,10565
VE 8020,4415
VP -1800,-13
VE 8020,4415
VP -3450,-10608
VE 8020,4415
VP 2853,131
VE 8020,4415
VP 424,3087
VE 8020,4415
VP 3910,0
VE 8020,4415
VP 3231,-3852
VE 8020,4415
```

Figure 5.15 - View Code

Using variables in visual program modules instead of fixed values

In the program module, first use "@" followed by the variable name.



☑ 1st Axis: X
☑ 2nd Axis: Y
☑ 3rd Axis: Z
□ 4th Axis

Displacement
X: 5 in
Y: 13 in
Z: 4 in

Speed: @SPD in/s
Acceleration: 20 in/s^2
Deceleration: 20 in/s^2

□ Con't from last 2D vector move

Type
● Incremental
○ Vector Position

Sequence End
● End of move
○ Continuous to next move

HIGH: 0

Figure 5.16 - Using Variables

Overview of Menu Options

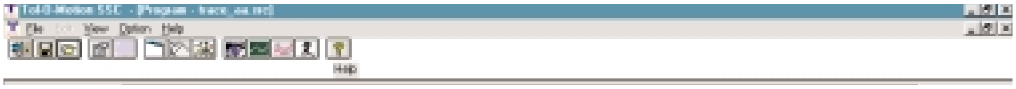


Figure 5.17 - Menu Bar

MENU/OPTIONS	RESULT
FILE MENU	
New	Open a new program file
Open	Open an existing program file from disk drive
Save	Save the current program to a disk file
Save As	Save the current program with a different file name.
Print Program	Print the program
Print Code	Print the two letter code generated by the program
Import Module	Import a code module created by the teach or terminal mode
Back to Main Window	Go back to main program window
Exit	Quit the SSC programming software
EDIT MENU	
Copy	Use the Copy command any time you wish to send a copy of program instruction to the clipboard for later use without disturbing the text as it appears currently in the program window. NOTE: Copy is also available by clicking the right mouse button. Clicking the button and select the “Copy” has the same effect as selecting Edit|Copy. Keyboard Shortcut: Ctrl + C
Cut	Use the Cut command any time you wish to cut or delete selected program instruction temporarily and hold it in the clipboard for later use. NOTE: Cut is also available by clicking the right mouse button. Clicking the button and select the “Cut” has the same effect as selecting Edit|Cut. Keyboard Shortcut: Ctrl + X
Paste	Use the Paste command any time you want to past (insert) program instruction from the clipboard into your program. You can use the Paste command with the Cut command to move program instruction, or with the Copy command to complete the copying process. NOTE: Paste is also available by clicking the right mouse button. Clicking the button and select the “Paste” has the same effect as selecting Edit|Paste. Keyboard Shortcut: Ctrl + V
Delete	Delete the current selected program instruction. NOTE: Delete is also available by clicking the right mouse button. Clicking the button and select the “Delete” has the same effect as selecting Edit|Delete. Keyboard Shortcut: Del
Modify	Individual program instruction can be modified by selecting Edit|Modify or double clicking on the line to be modified.

CONTROLLER ONLINE
Program Window

NOTE: Modify is also available by clicking the right mouse button. Clicking the button and select the “Modify” has the same effect as selecting Edit|Modify.
Keyboard Shortcut: Ctrl + M

Insert

Program instruction can be insert into the program by selecting line that the command will be insert before, selecting Edit|Insert, then select desired program instruction.
NOTE: Insert is also available by clicking the right mouse button. Clicking the button and select the “Insert” has the same effect as selecting Edit|Insert.
Keyboard Shortcut: Ctrl + I

Insert Comment

Insert Comment used to include explanatory remarks in program
Syntax: 'Comment
The comment argument is the text of any comment you want to include and comment argument is not an executable program instruction.
NOTE: Insert Comment is also available by clicking the right mouse button. Clicking the button and select the “Insert Comment” has the same effect as selecting Edit|Insert Comment.
Keyboard Shortcut: Ctrl + E

Comment Out

Individual program instruction can be Comment Out by selecting Edit|Comment Out. When you select “Comment Out”, the single quotation mark will be added to the head of program instruction. Once the program instruction is comment out, it is no longer an executable program statement.
NOTE: Comment Out is also available by clicking the right mouse button. Clicking the button and select the “Comment Out” has the same effect as selecting Edit|Comment Out.
Keyboard Shortcut: Ctrl + U

View Code

Individual program instruction’s code can be viewed by selecting Edit|View Code.
NOTE: View Code is also available by clicking the right mouse button. Clicking the button and select the “View Code” has the same effect as selecting Edit|View Code.
Keyboard Shortcut: Ctrl + D

VIEW MENU

Program	Work with the visual program
Source Code	View the two letter source code created by visual code

OPTION MENU

Program Status	Indicated if the thread is running or not
Trace Program	Choose the thread for trace to run on

HELP MENU

Help on Programming	Access the built in help text
About	Display the version of SSC programming software

SSC Programming Tree

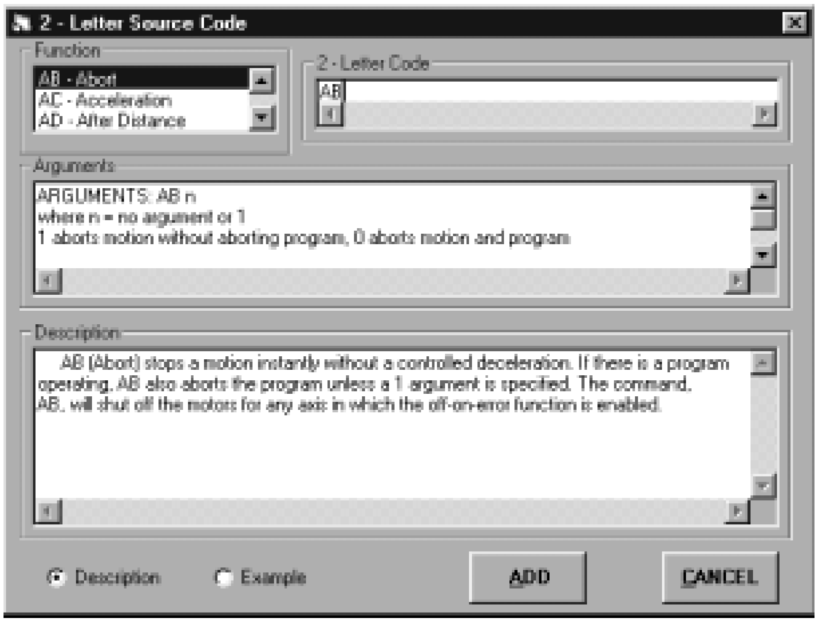
PROGRAM GROUP	GROUP INSTRUCTION
2 Letter Code:	2-Letter Code *Pop-up window*
Configuration:	
	Acccel and Decel
	Analog Feedback
	Arm Latch
	Communication
	Define Position
	Drive
	Encoder
	Extended I/O
	Motor
	Position Format
	Record Data
	User Setup Settings
	Variable and Array
	Write to EEPROM
I/O:	
	Output
	Dedicated Inputs
Motion:	
	2D Circular Interpolation
	Abort Motion
	Begin Motion
	Contour Mode
	Electronic Cam
	Electronic Gearing
	Disable Electronic Gearing
	Home
	Incremental Position
	Linear Interpolation
	Motion Parameters
	Single Axis Move
	Stop Motion
	Tangent Motion
Program Flow:	
	Auto Execution
	Clear Screen
	End
	Execute
	Halt Task
	Interrupt
	Jump
	Label
	Print
	Repeat
	Subroutine
	User Interface
	Wait
	Wait For Condition
	Zero Subroutine Stack
Servo Settings:	Dual Loop
	Feed Forward
	Loop Rate
	Offset
	PID Gains
System Limits:	Following Error
	Integrator
	Motor Disable Upon Error
	Poition
	Torque
Mathmatical Equation:	
	Mathmatical Equation *Pop-up window*

Program Instructions

GROUP = TWO LETTER SOURCE CODE

Allows the user to add a two letter command to the visual programming environmnet.

The 2-Letter Source Code window provides discriptions of the arguments used with each command as well as an example of its usage.



Function:
AB - Abort
AC - Acceleration
AD - After Distance

2 - Letter Code: AB

ARGUMENTS: AB n
where n = no argument or 1
1 aborts motion without aborting program, 0 aborts motion and program

AB (Abort) stops a motion instantly without a controlled deceleration. If there is a program operating, AB also aborts the program unless a 1 argument is specified. The command, AB, will shut off the motors for any axis in which the off-on-error function is enabled.

● Description ○ Example

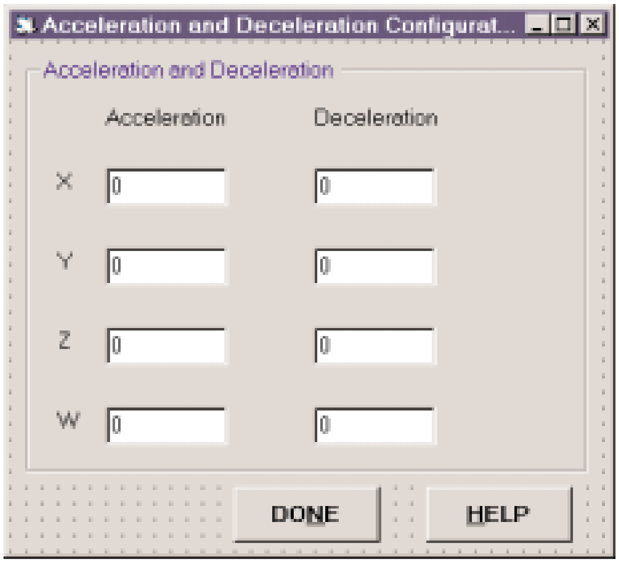
GROUP = CONFIGURATION

Contains thirteen instructions for users to configure the controller settings.

Accel and Decel:

Allows the user to set initial acceleration and deceleration rates for each axis in the units specified in Setup. The acceleration and deceleration rates are specfied from this window will be used throughout the program.

Note: Specify realistic acceleration rates based on your physical system such as motor torque rating, loads, and amplifier current rating. Specifying an excessive acceleration will cause large following error during acceleration and the motor will not follow the commanded profile.


Acceleration and Deceleration Configurat...
Acceleration and Deceleration
DONE
HELP

	Acceleration	Deceleration
X	0	0
Y	0	0
Z	0	0
W	0	0

Figure 5.18 - Accel and Decel

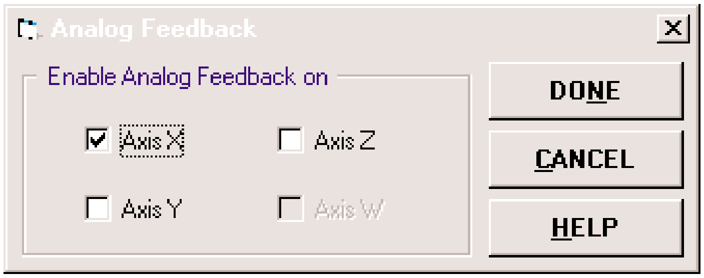
Analog Feedback:

Enable analog feedback for selected axis, Fig. 5.19.

The Analog Feedback command is used to set an axis with analog feedback instead of digital feedback (quadrature/pulse direction). As the analog feedback is decoded by a 12-bit A/D converter, an input voltage of 10 volts is decoded as a position of 2047 counts and a voltage of -10 volts corresponds to a position of -2048 counts.

PROGRAM INSTRUCTIONS
Group = Configuration

When using Analog Feedback use analog input 1 for x axis and analog input 2 for 4 axis, etc.



Analog Feedback

Enable Analog Feedback on

☑ Axis X   □ Axis Z

□ Axis Y   □ Axis W

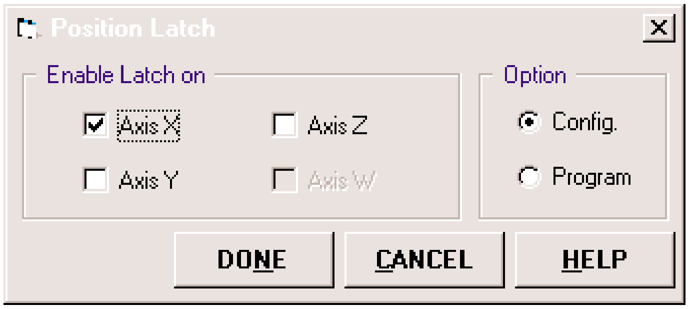
Figure 5.19 - Analog Feedback

Arm Latch:

Enable latch on selected axis.

Often it is desirable to capture the position precisely for registration applications. The controller provides a position latch feature. This feature allows the position of X,Y,Z or W to be captured within 25 microseconds of an external signal.

The arm latch command enables the latching function (high speed position capture) of the controller. When the command is used to arm the position latches, the encoder position will be captured upon a low going signal on input 1 (X axis), input 2 (Y axis), input 3 (Z axis), and input 4 (W axis). Note: The latch must be re-armed after each latching event. To read the latch position, use controller parameters in the math equation window.



Position Latch

Enable Latch on

☑ Axis X   □ Axis Z

□ Axis Y   □ Axis W

Option

● Config.

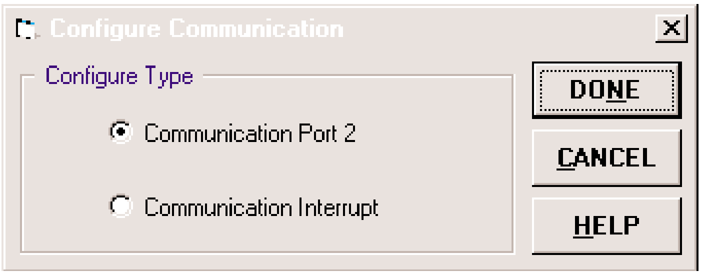
○ Program

Figure 5.20 - Arm Latch

Communication:

Configure serial communication port 2 or communication interrupt.

The communication port option, as shown in Fig. 5.21, allows the user to configure the RS232 port number 2. Port 2 must be configured before use. The interrupt option configures the communication interrupt for Port 1 and Port 2. It also enables live communication for Port 1. A communication interrupt causes a jump to the #COMINT subroutine.



Configure Communication

Configure Type

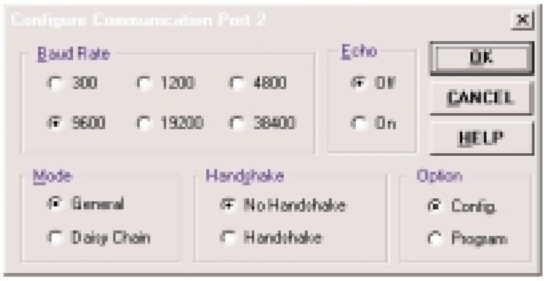
● Communication Port 2

○ Communication Interrupt

Figure 5.21 - Configure Communication

Port 2 communication:

By selecting the communication port 2 option in Fig. 5.21 and clicking “OK”, a port 2 communication window will pop up as shown in Fig. 5.22, which allows you to set baud rate, echo, mode(general or daisy chain), and handshaking.



Configure Communication Port 2

Baud Rate: ○ 300 ○ 1200 ○ 4800 ● 9600 ○ 19200 ○ 38400

Echo: ● Off ○ On

Mode: ● General ○ Daisy Chain

Handshake: ● No Handshake ○ Handshake

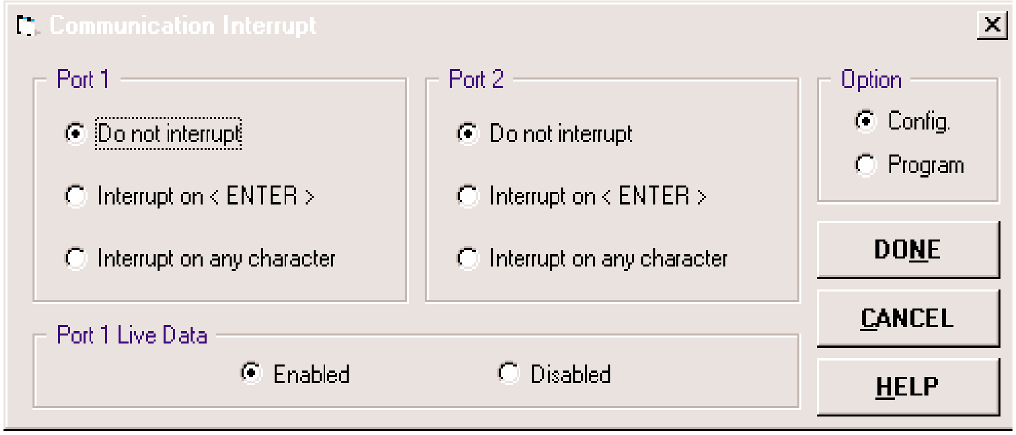
Option: ● Config. ○ Program

Figure 5.22 - Port 2 Communication

Communication interrupt:

By selecting the interrupt option in Fig. 5.21 and clicking “OK”, a communication interrupt window will pop up as shown in Fig. 5.23, which provides interrupt control for port 1 and 2. This also enables live data communication control on port 1. If live data is enabled on Port 1, it will not respond to commands sent from terminal.

PROGRAM INSTRUCTIONS
Group = Configuration


Communication Interrupt

Port 1
● Do not interrupt
○ Interrupt on < ENTER >
○ Interrupt on any character

Port 2
● Do not interrupt
○ Interrupt on < ENTER >
○ Interrupt on any character

Option
● Config.
○ Program

Port 1 Live Data
● Enabled ○ Disabled

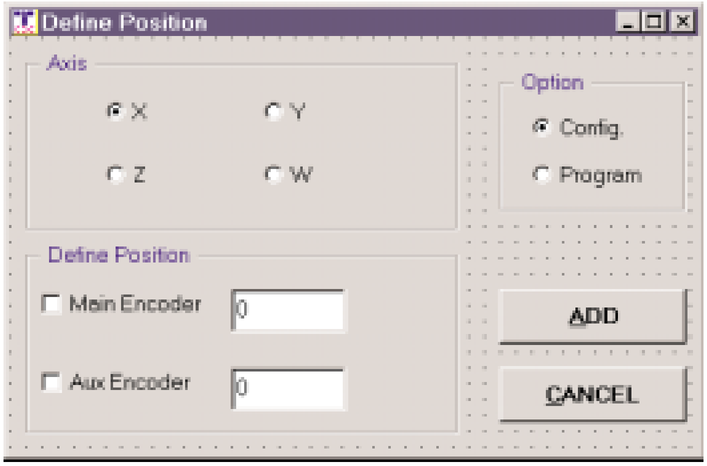
Figure 5.23 - Communication Interrupt

Define Position:

The “define position – Main Encoder” sets the current motor position and current command position to a user specified value.

The “define position – Aux Encoder” defines the position of the auxiliary encoders. The auxiliary encoders may be used for dual-loop applications. It is useful when you need an encoder on the motor and on the load. The encoder on the load is typically the auxiliary encoder and is used to verify the true load position. Any error in load position is used to correct the position.

Click : “ADD” to move encoder position definition for selected axis, and “EXIT” when finished.


Define Position

Axis

● X ○ Y

○ Z ○ W

Option

● Config.

○ Program

Define Position

□ Main Encoder 0

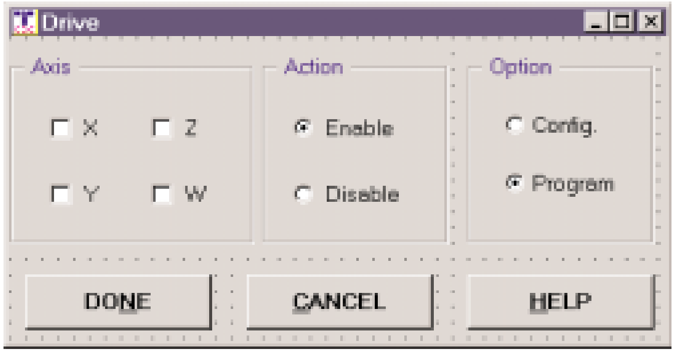
□ Aux Encoder 0

Figure 5.24 - Define Position

Drive:

This window allows users to enable/disable the motor drive. Selecting the “Disable” option will shut off the servo control and dedicated amplifier enable signal. The controller will continue to monitor the motor position. Selecting the “Enable” will cause the controller to <u>set the commanded position to be the current motor position</u> and to enable the motor drive for the specified axes.

Use the “Config” or “Program” option to place the code in configuration or program selection. Select the axis/axes of motor drive to enable or disable. Click “DONE” when finished.


Drive

Axis

□ X □ Z

□ Y □ W

Action

● Enable

○ Disable

Option

○ Config.

● Program

Figure 5.25 - Drive

PROGRAM INSTRUCTIONS
Group = Configuration

Encoder:

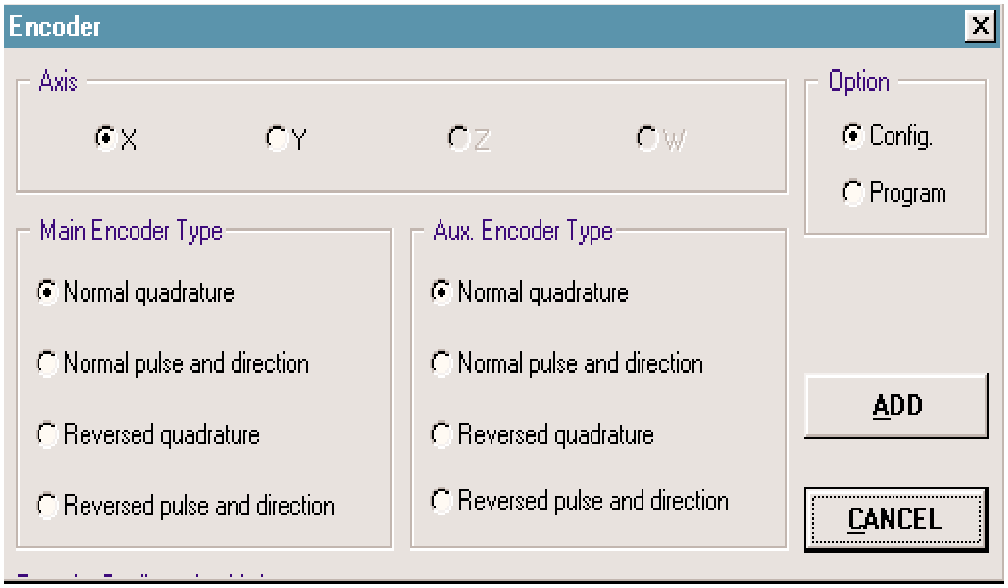
Define encoder type.

The encoder setup window, as shown in Fig. 5.26, configures the encoder to the quadrature type or the pulse and direction type. It also allows inverting the polarity of the encoders. The configuration applies independently to the four main axes encoders and the four auxiliary encoders. The auxiliary encoder may be mounted on the motor, the load, or in any position. The auxiliary encoder may be of the standard quadrature type, or it may be of the pulse and direction type. The controller also offers the provision for inverting the direction of the encoder rotation.

Click

"ADD" to add encoder configuration for each axis selected

"DONE" when finished.



Encoder

Axis
● X ○ Y ○ Z ○ W

Option
● Config.
○ Program

Main Encoder Type
● Normal quadrature
○ Normal pulse and direction
○ Reversed quadrature
○ Reversed pulse and direction

Aux. Encoder Type
● Normal quadrature
○ Normal pulse and direction
○ Reversed quadrature
○ Reversed pulse and direction

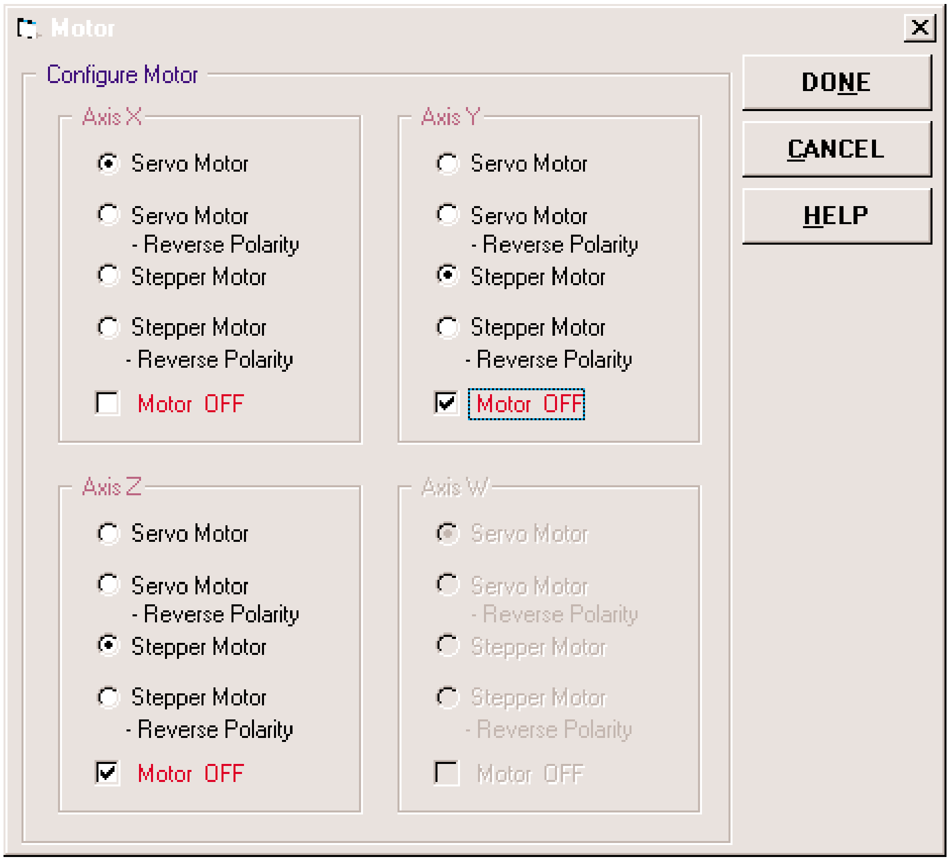
Figure 5.26 - Define Encoder Type

Motor:

Define motor type and its initial status for each axis.

The motor configuration window, as shown in Fig. 5.27, selects the type of the motor and the polarity of the drive signal. Motor types include standard servo motors which require a voltage in the range of +/- 10 Volts, and step motors which require pulse and direction signals. The polarity reversal inverts the analog signals for servo motors, and inverts logic level of the pulse train, for step motors.

The “Motor OFF” option will shut off the control algorithm when configured, however, the controller will continue to monitor the motor position.



Configure Motor

Axis X
● Servo Motor
○ Servo Motor - Reverse Polarity
○ Stepper Motor
○ Stepper Motor - Reverse Polarity
□ Motor OFF

Axis Y
○ Servo Motor
○ Servo Motor - Reverse Polarity
● Stepper Motor
○ Stepper Motor - Reverse Polarity
☑ Motor OFF

Axis Z
○ Servo Motor
○ Servo Motor - Reverse Polarity
● Stepper Motor
○ Stepper Motor - Reverse Polarity
☑ Motor OFF

Axis W
● Servo Motor
○ Servo Motor - Reverse Polarity
○ Stepper Motor
○ Stepper Motor - Reverse Polarity
□ Motor OFF

Figure 5.27 - Define Motor Type

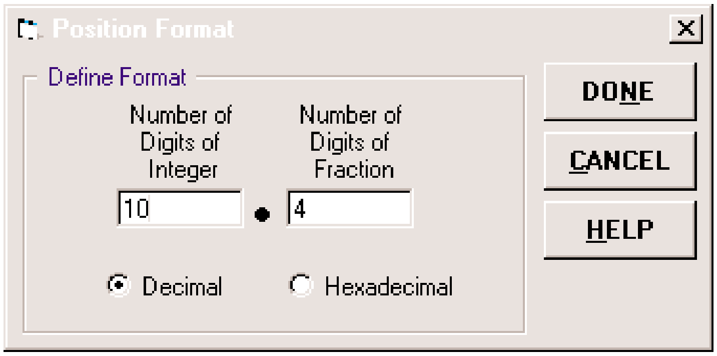
PROGRAM INSTRUCTIONS
Group = Configuration

Position Format:

Define position format.

The position format window, as shown in Fig. 5.28, allows the user to format the position numbers such as those returned in the display. The number of digits of integers and the number of digits of decimals can be selected with this command. An extra digit for sign and a digit for decimal point will be added to the total number of digits. Hexadecimal format is available with a dollar sign preceding the characters. Hex numbers are displayed as 2s complement with the first bit used to signify the sign.

If a number exceeds the format, the number will be displayed as the maximum possible positive or negative number (i.e. 999.99, -999, $8000 or $7FF).



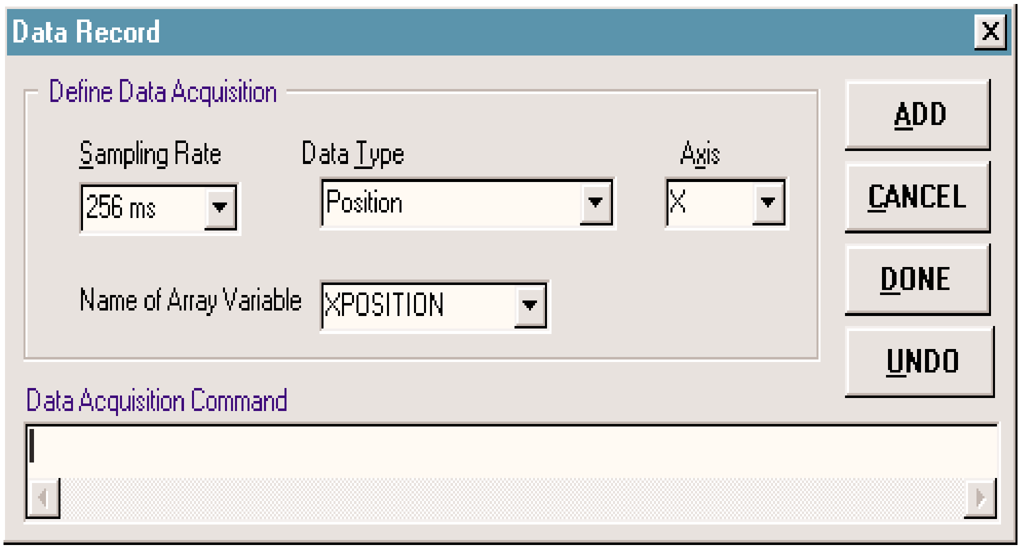
Number of Digits of Integer 10 • Number of Digits of Fraction 4

● Decimal ○ Hexadecimal

Figure 5.28 - Position Format

Record Data:

The data acquisition window, as shown in Fig. 5.29, selects one through four arrays for automatic data capture. The selected arrays must be dimensioned in the “Variable and Array” instruction. The data to be captured is specified by selecting the data type and sampling rate. The record mode is useful for recording the real-time motor position during motion. The data is automatically captured in the background and does not interrupt the program sequence.



Data Record

Define Data Acquisition

Sampling Rate: 256 ms

Data Type: Position

Axis: X

Name of Array Variable: XPOSITION

Data Acquisition Command

Figure 5.29 - Record Data

User Setup Settings:

Allows the user to save the PID and motor type settings in the program. Useful if multiple programs are run that require different setup values. The system setup does not need to be changed when switching programs.

Variable and Array:

Declare/deallocate variable and array names and define their formats.

Many motion applications include parameters that are variable. For example, a cut-to-length application often requires that the cut length be variable. The motion process is the same, however, the length is changing. To accommodate these applications, the controller provides for the use of both numeric and string variables. A program can be written in which certain parameters, such as position or speed, are defined as variables. The variables can later be assigned by the operator or determined by the program calculations.

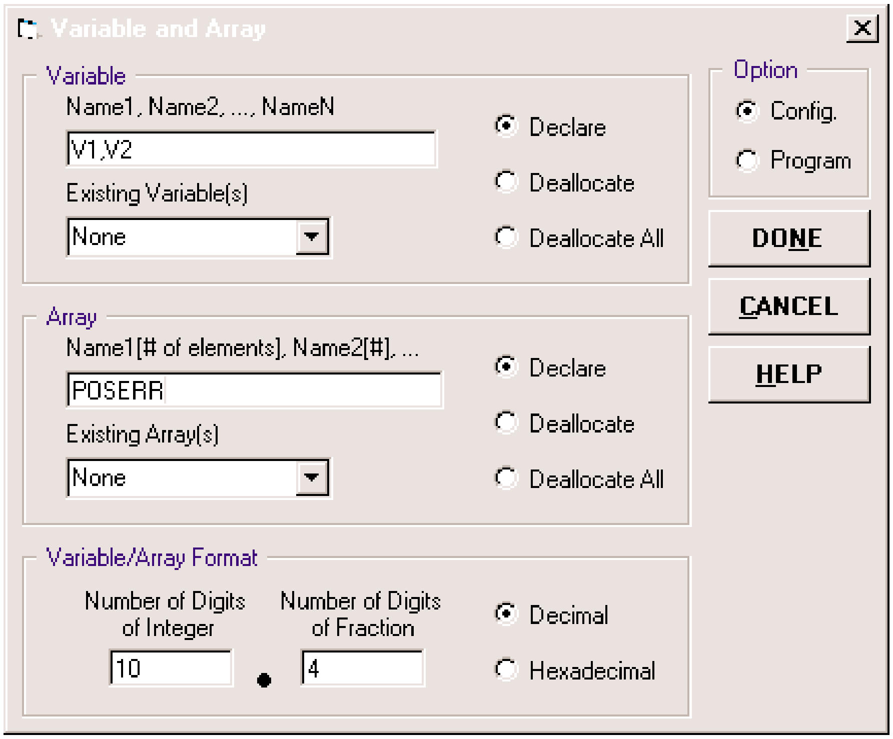
For storing and collecting numerical data, the controller provides array space for 8000 elements in up to 30 arrays. Arrays can be used to capture real-time data, such as position, torque and analog input values. In the contouring mode, arrays are convenient for learning a position trajectory and later playing it back.

The variable and array window, as shown in Fig. 5.30, defines a single dimensional array with a name and number (n) of total elements. The

PROGRAM INSTRUCTIONS
Group = Configuration

maximum number of arrays that the user can define is limited to 30. With the thirty arrays, the maximum number of elements is limited to 8000. If the user needs only one array, then the limitation to maximum number of elements is still 8000. The first element of the defined array starts with element number 0 and the last element is at n-1. It also allows the variables and arrays to be formatted for the number of digits before and after the decimal point. When displayed, the integer portion represents the number of digits before the decimal point, and the fraction portion represents the number of digits after the decimal point. When in hexadecimal, the string will be preceded by a $. Hex numbers are displayed as 2s complement with the first bit used to signify the sign.

If a number exceeds the format, the number will be displayed as the maximum possible positive or negative number (i.e. 999.99, -999, $8000 or $7FF).



Variable and Array

Variable

Name1, Name2, ..., NameN: V1,V2

Existing Variable(s): None

● Declare
○ Deallocate
○ Deallocate All

Option

● Config.
○ Program

Array

Name1[# of elements], Name2[#], ...: POSERR

Existing Array(s): None

● Declare
○ Deallocate
○ Deallocate All

Variable/Array Format

Number of Digits of Integer: 10 ● Number of Digits of Fraction: 4

● Decimal
○ Hexadecimal

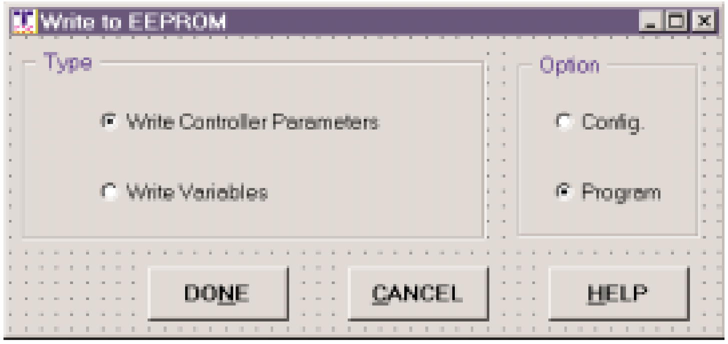
Figure 5.30 - Variable And Array

Write to EEPROM:

Write controller parameters or variables from RAM to EEPROM in the controller.

The write controller parameters option, as shown in Fig. 5.31, saves certain controller parameters in non-volatile EEPROM memory. Programs are not saved and must be downloaded from the host computer upon power-up. This command typically takes 250 msec to execute and must not be interrupted. See the BN command for a list of parameters.

The write variables option saves the controller variables in non-volatile EEPROM memory. This command typically takes up to 2 seconds to execute and must not be interrupted.



Write to EEPROM

Type

● Write Controller Parameters

○ Write Variables

Option

○ Config.

● Program

Figure 5.31 - Burn EEPROM

Use the “Config” or “Program” option to place the code in configuration or program selection.

GROUP = I/O

Contains two instructions for input / output control.

Output:

The “Control output channel”

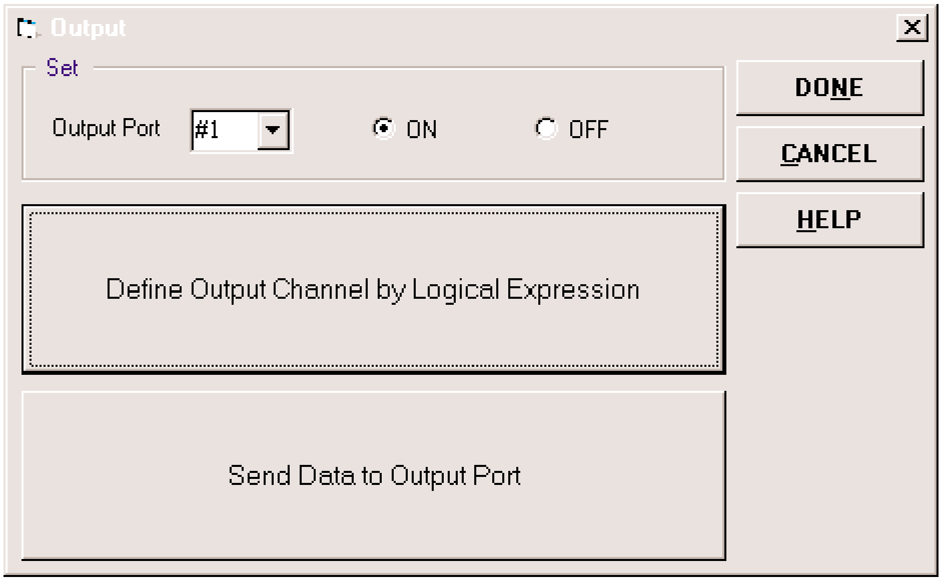
The control output channel option sets or clears one of the eight programmable outputs. See Fig. 5.32.

Define output bit by logical expression: see Fig. 5.33.

The “Define output bit by logical expression” option defines output 1 through 8 as either 0 (off) or 1 (on) depending on the result from the logical expression. Any non-zero value of the expression results in a one on the output.

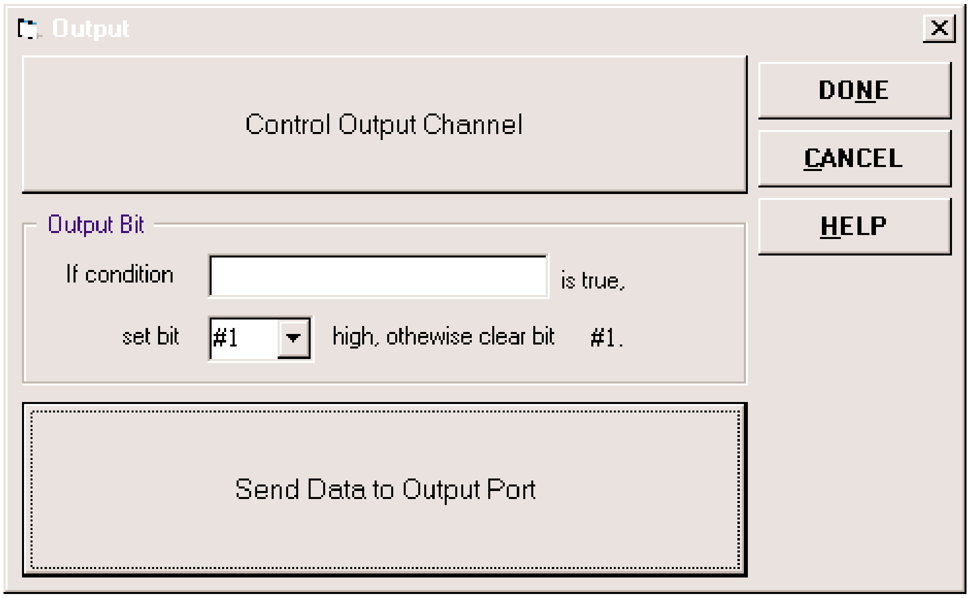
PROGRAM INSTRUCTIONS
Group = I/O

Send data (0-255) to output port: see Fig. 5.34.
The “Send data” option sends data to the output port of the controller. This option turns on the outputs based on the binary sequence of the decimal value (“0” is off, “1” is on).



Output Port #1 ● ON ○ OFF

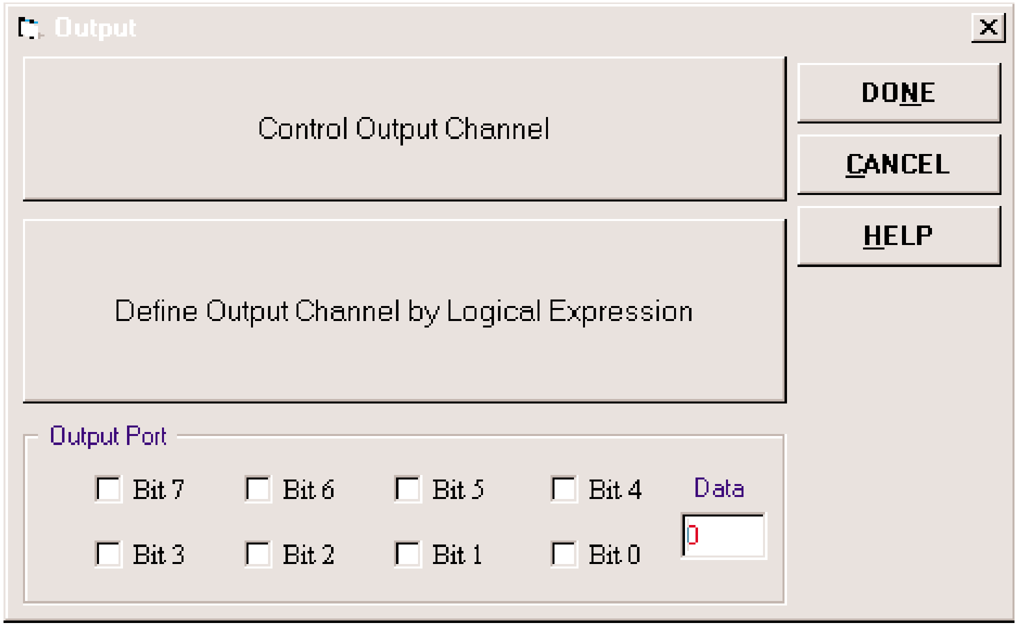
Figure 5.32 - Control Output Channel



If condition [ ] is true,

set bit #1 high, othewise clear bit #1.

Figure 5.33 - Define Output Bit by Logical Expression



Output Port

□ Bit 7 □ Bit 6 □ Bit 5 □ Bit 4

□ Bit 3 □ Bit 2 □ Bit 1 □ Bit 0

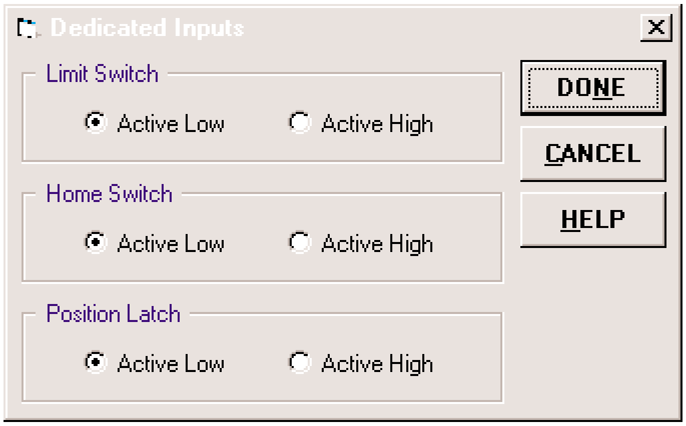
Data: 0

Figure 5.34 - Send Data to Output Port

Dedicated Inputs:

Configure the polarity of dedicated home, limit, and latch switches.

See chapter 4 input/output connections. Changing the home switch from active low to active high also changes the direction of initial home move.



Limit Switch: ● Active Low ○ Active High

Home Switch: ● Active Low ○ Active High

Position Latch: ● Active Low ○ Active High

Figure 5.35 - Dedicated Input Switches

PROGRAM INSTRUCTIONS
Group = Motion

GROUP = MOTION

Contains 14 motion instructions.

2D Circular Motion:

The controller allows a 2-D path consisting of linear and arc segments to be prescribed. Motion along the path is continuous at the prescribed vector speed even at transitions between linear and circular segments. The controller performs all the complex computations of linear and circular interpolation, freeing the host computer from this time intensive task.

The smoothing is accomplished by filtering the acceleration profile. Trapezoidal velocity profiles have acceleration rates which change abruptly from zero to maximum value. The discontinuous acceleration results in infinite jerk that causes vibration. The smoothing of the acceleration profile leads to a continuous acceleration profile and a finite jerk, which reduces the mechanical shock and vibration.

First, select the proper positive and negative direction for the X and Y axis on the display by clicking on the axis labels in upper right corner to change the display to match your system.

As shown in Fig. 5.37, the circular motion programming shows all necessary parameters for performing an arc move. Select the axes for circular motion and specify radius, start and sweep angle of the arc and its direction. Define the motion parameters which are speed, acceleration, deceleration and smoothness for the move. The sequence end option is selected to stop at the end of the move or continue to the next move. Continue from last 2D vector move is used when the previous move is also a vector move.

The start angle is defined as the angle formed between zero degrees on the coordinate system and the start of the arc measuring in the direction of positive rotation. The sweep angle defines the motion of the arc starting at the start angle through the desired distance in the selected direction of motion. The direction of the arc can be either CW or CCW from the start angle. See Fig. 5.36 for a graphical representation.

Immediately prior to the execution of the first coordinated movement, the controller defines the current position to be zero for all movements in a sequence. NOTE: This “local” definition of zero

does not effect the absolute coordinate system or subsequent coordinated motion sequences. A motion sequence is completed when the "end of move" is selected.

2D circular motion can be combined with linear interpolation to create continuous motion.

"ADD" to add current arc segment to 2D this module, or

"CANCEL" to return to the main program.

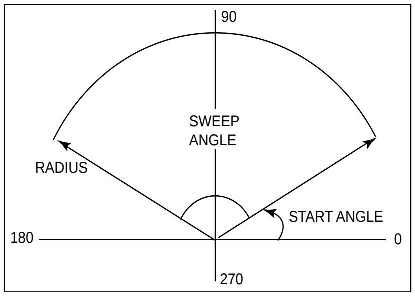
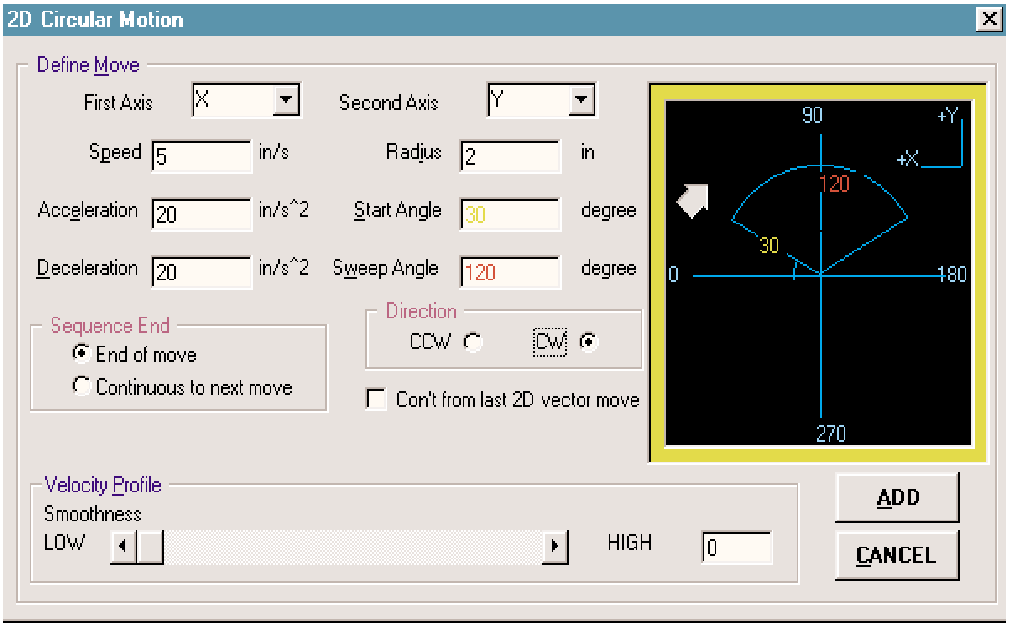


Figure 5.36 - Definition of Start, Sweep Angle, And Radius



2D Circular Motion

Define Move

First Axis: X

Second Axis: Y

Speed: 5 in/s

Radius: 2 in

Acceleration: 20 in/s^2

Start Angle: 30 degree

Deceleration: 20 in/s^2

Sweep Angle: 120 degree

Sequence End
- ● End of move
- ○ Continuous to next move

Direction: CCW ○ CW ●

□ Con't from last 2D vector move

Velocity Profile

Smoothness: LOW HIGH 0

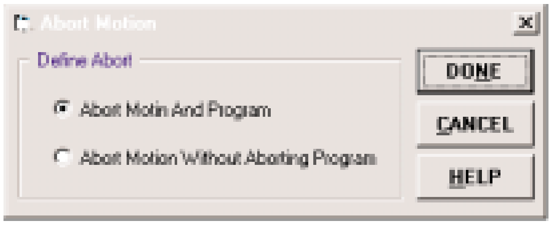
Figure 5.37 - 2D Circular Motion

PROGRAM INSTRUCTIONS
Group = Motion

Abort Motion:

Abort motion and program or abort motion only.

Stops a motion instantly without a controlled deceleration. Will shut off the motors for any axis in which the off-on-error function is enabled.

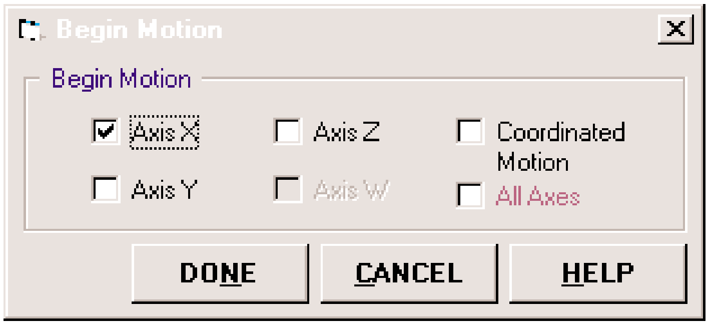


● Abort Motin And Program
○ Abort Motion Without Aborting Program

Figure 5.38 - Abort Motion

Begin Motion:

Specify independent or coordinated motion to begin.
Multiple axis may be selected.



☑ Axis X
☐ Axis Y
☐ Axis Z
☐ Axis W
☐ Coordinated Motion
☐ All Axes

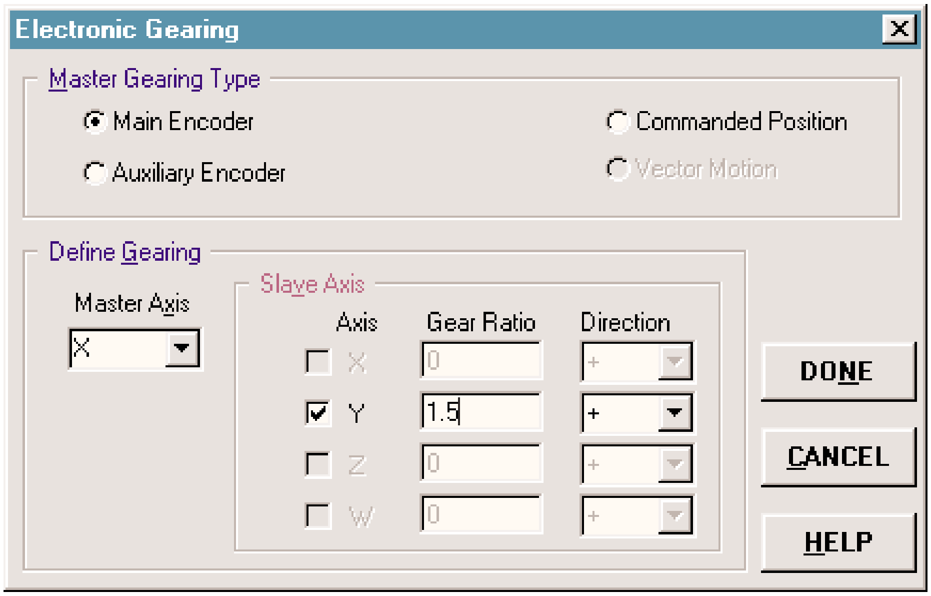
Figure 5.39 - Begin Motion

Electronic Gearing:

Electronic gearing mode allows 1, 2 or 3 axes to be electronically geared to one master axis. The master may rotate in both directions and the geared axes will follow at the specified gear ratio. The gear ratio may be different for each axis and changed during motion.

The electronic gearing window, as shown in Fig. 5.40, specifies the master axis and gear ratio for electronic gearing. Only one master may be specified. The master may be the main encoder input, auxiliary encoder input, or the commanded position of any axis. The master may also be the commanded vector move in a coordinated motion of linear or circular interpolation type.

When the master is a simple axis, it may move in any direction and the slave follows. When the master is a commanded vector move, the vector move is considered positive and the slave will move forward if the gear ratio is positive, and backward if the gear ratio is negative. The slave axes and ratios are specified in the gear ratio field. The gear ratio may be different for each geared axis and range between +/-127.9999. The slave axis will be geared to the actual position of the master. The master can go in both directions. Specifying zero gear ratio disables gearing mode. A limit switch also disables the gearing.



Electronic Gearing

Master Gearing Type

● Main Encoder ○ Commanded Position

○ Auxiliary Encoder ○ Vector Motion

Define Gearing

Master Axis: X

Slave Axis

	Axis	Gear Ratio	Direction
□	X	0	+
☑	Y	1.5	+
□	Z	0	+
□	W	0	+

Figure 5.40 - Electronic Gearing

Home:

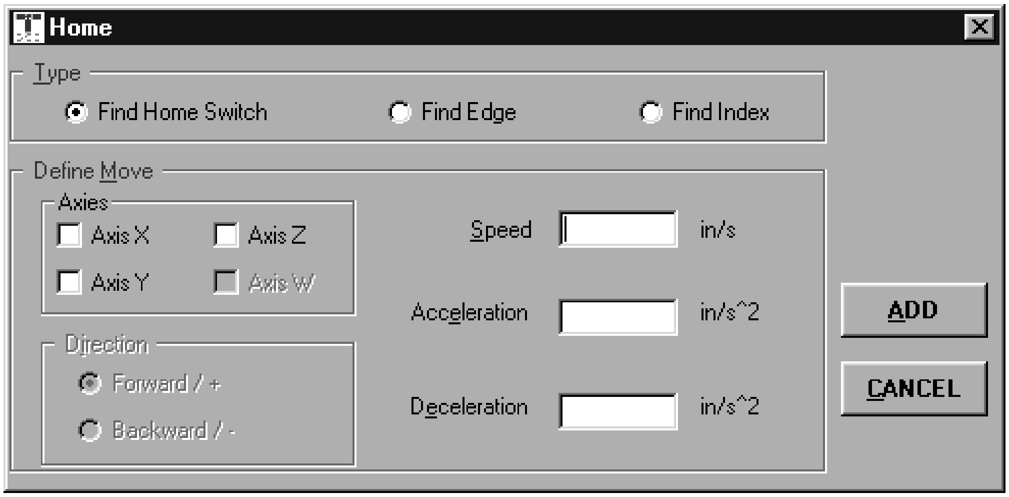
The home instructions may be used to home the motor to a mechanical reference. This reference is connected to the home input line. There are three options, find home switch, find edge, and find index, in the home programming window as shown in Fig. 5.41. Individual axes may be chosen or all axes may be selected.

Option 1: Find Home Switch

The find home switch potion performs a three-stage homing sequence. The first stage consists of the motor moving at the user programmed speed until it sees a transition on the homing input for that axis. The direction for this first stage is determined by the initial state of the Homing Input. Once the homing input changes state, the motor decelerates to a stop. The state of the homing input can be configured using the “I/O, Dedicated Inputs” instruction.

PROGRAM INSTRUCTIONS
Group = Motion

The second state consists of the motor changing directions and slowly approaching the transition again. When it detects the transition, it stops.



Home

Type

● Find Home Switch ○ Find Edge ○ Find Index

Define Move

Axies

□ Axis X □ Axis Z
□ Axis Y □ Axis W

Direction

● Forward / +
○ Backward / -

Speed [ ] in/s
Acceleration [ ] in/s^2
Deceleration [ ] in/s^2

Figure 5.41 - Home

The third stage consists of the motor slowly moving forward until it detects an index pulse from the encoder. It stops at this point and defines it as position 0. **When a step motor is used, the homing function consists of the first two stages.**

j

Option 2: Find Index

The find index option allows the motor to move until an encoder index pulse is detected. The controller looks for a transition from low to high. **When the transition is detected, motion stops and the position is defined as zero.** To improve accuracy, the speed during the search should be specified as 500 counts/s or less. The find index function is useful in custom homing sequences. The direction of motion is specified by the sign of the jog speed function.

Option 3: Find Edge

The find edge option moves a motor until a transition is seen on the homing input for that axis. The direction of motion depends on the initial state of the homing input. Once the transition is detected, the motor decelerates to a stop. This function is useful for creating your own homing sequences. **Note: the find edge function does not define position as zero after transition is detected.**

Click
“ADD” to include the homing procedure for a selected axis, or
“CANCEL” to return to the main program.

Single Axis Move:

The single axis move window, as shown in Fig. 5.42, includes move by displacement or speed. Select the move type and motion parameters for any available axis. Then click

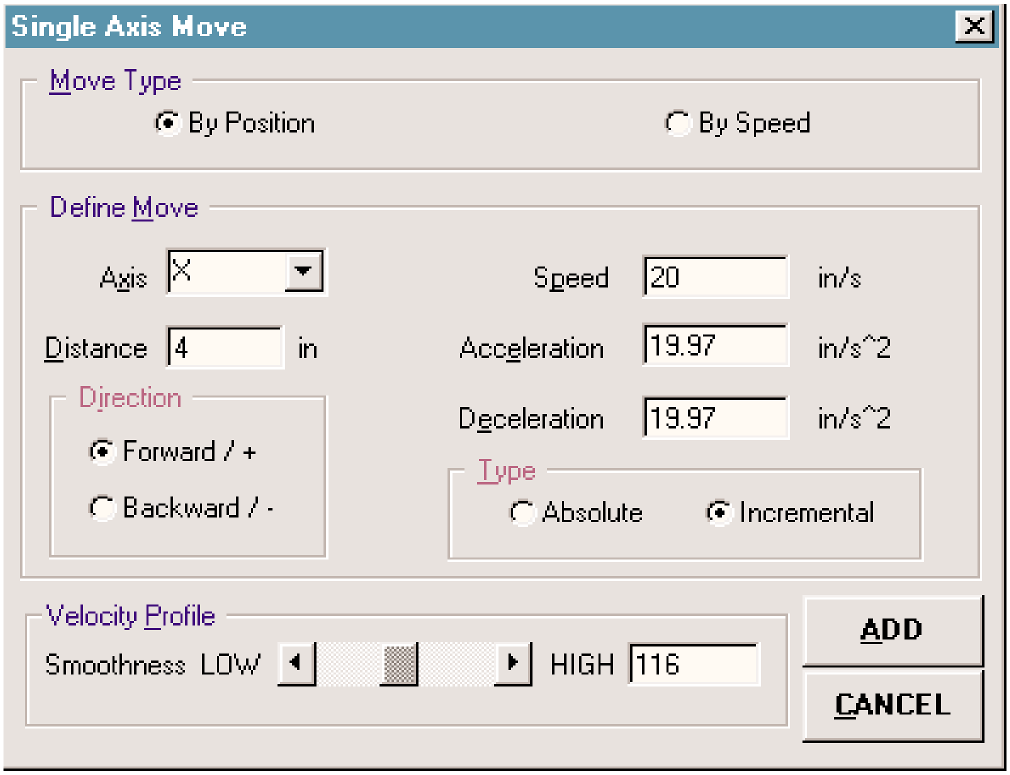
“ADD” to include the motion for a selected axis, or
“CANCEL” to return to the main program.

In the position mode, motion between the specified axes is independent, and each axis follows its own profile. The user specifies the desired absolute or relative position, slew speed, acceleration ramp, and deceleration ramp, for each axis. On execution, the controller profiler generates the corresponding trapezoidal or triangular velocity profile and position trajectory. A new command position along the trajectory is generated every sample period. Motion is complete when the last position command or target position is generated by the profiler.

The speed mode of Single Axis Move is very flexible because the speed, direction and acceleration can be changed during motion. It should be noted that the controller operates as a closed-loop position controller even while in the motion. The controller converts the velocity profile into a position trajectory where a new position target is generated every sample period. This method of control results in precise speed regulation with phase lock accuracy.

The smoothing function is accomplished by filtering the acceleration profile. Trapezoidal velocity profiles have acceleration rates which change abruptly from zero to maximum value. The discontinuous acceleration results in infinite jerk that causes vibration. The smoothing of the acceleration profile leads to a continuous acceleration profile and a finite jerk, which reduces the mechanical shock and vibration.

PROGRAM INSTRUCTIONS
Group = Motion



Single Axis Move

Move Type

● By Position ○ By Speed

Define Move

Axis: X

Distance: 4 in

Direction

● Forward / +

○ Backward / -

Speed: 20 in/s

Acceleration: 19.97 in/s^2

Deceleration: 19.97 in/s^2

Type

○ Absolute ● Incremental

Velocity Profile

Smoothness LOW HIGH 116

Figure 5.42 - Single Axis Move

Linear Interpolation:

In linear interpolation, motion between the axes is coordinated to maintain the prescribed vector speed, acceleration, and deceleration along the specified path.

When three or more axis are selected, several incremental segments may be given in a continuous move sequence, making the linear interpolation mode ideal for following a piece-wise linear path. There is no limit to the total move length.

When two axis are selected, immediately prior to the execution of the first coordinated movement, the controller defines the current position to be zero for all movements in a sequence. NOTE: This “local” definition of zero does not effect the absolute coordinate system or subsequent coordinated motion sequences. A motion sequence is completed when the “end of move” is selected.

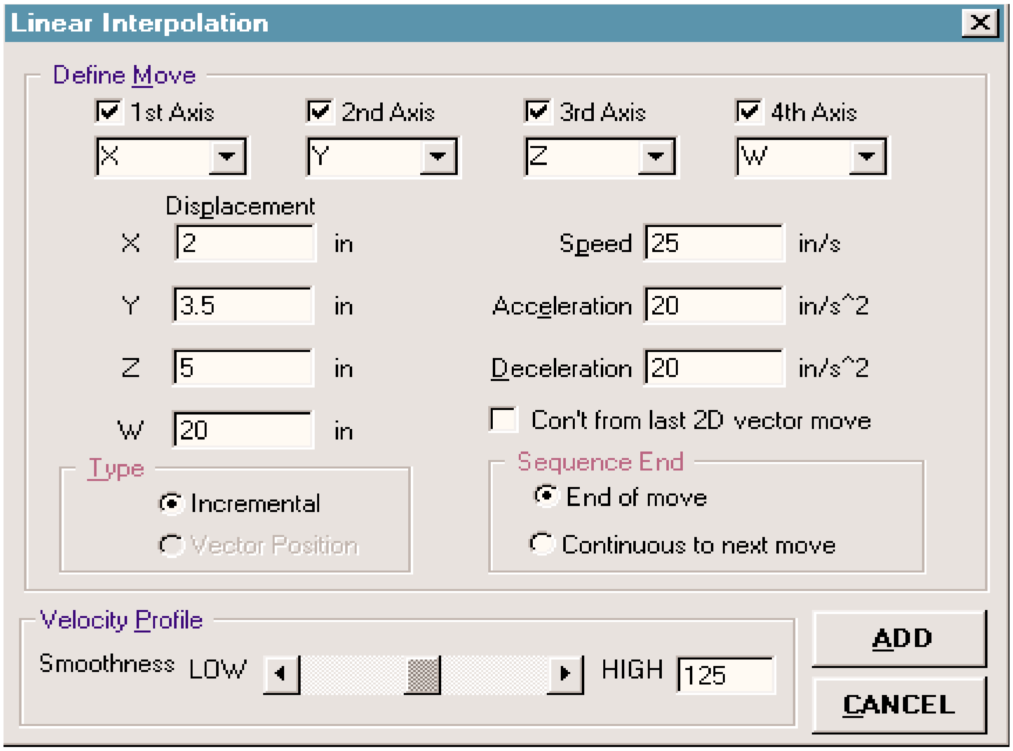
2D circular motion can be combined with linear interpolation to create continuous motion.

The linear interpolation window, as shown in Fig. 5.43, specifies the linear interpolation mode where selected axis denote the axes for linear interpolation. Any set of 1,2,3 or 4 axes may be used for linear interpolation. The displacement field is used to specify the distances or positions for linear interpolation. The sequence end sub-window specifies the end of the linear interpolation sequence. Several linear interpolation segments may be given as long as the controller sequence buffer has room for additional segments.

The smoothing is accomplished by filtering the acceleration profile. Trapezoidal velocity profiles have acceleration rates which change abruptly from zero to maximum value. The discontinuous acceleration results in infinite jerk that causes vibration. The smoothing of the acceleration profile leads to a continuous acceleration profile and a finite jerk, which reduces the mechanical shock and vibration.

It should be noted that the controller computes the vector speed based on the axes specified in the linear interpolation mode. For example, select linear interpolation for the X,Y and Z axes. The speed of these axes will be computed from VS2=XS2+YS2+ZS2, where XS, YS and ZS are the speed of the X,Y and Z axes. If the incremental displacement specifies only X and Y, the speed of Z will still be used in the vector calculations.

PROGRAM INSTRUCTIONS
Group = Motion



☑ 1st Axis: X ☑ 2nd Axis: Y ☑ 3rd Axis: Z ☑ 4th Axis: W

Displacement
X 2 in
Y 3.5 in
Z 5 in
W 20 in

Speed 25 in/s
Acceleration 20 in/s^2
Deceleration 20 in/s^2
☐ Con't from last 2D vector move

Type
● Incremental
○ Vector Position

Sequence End
● End of move
○ Continuous to next move

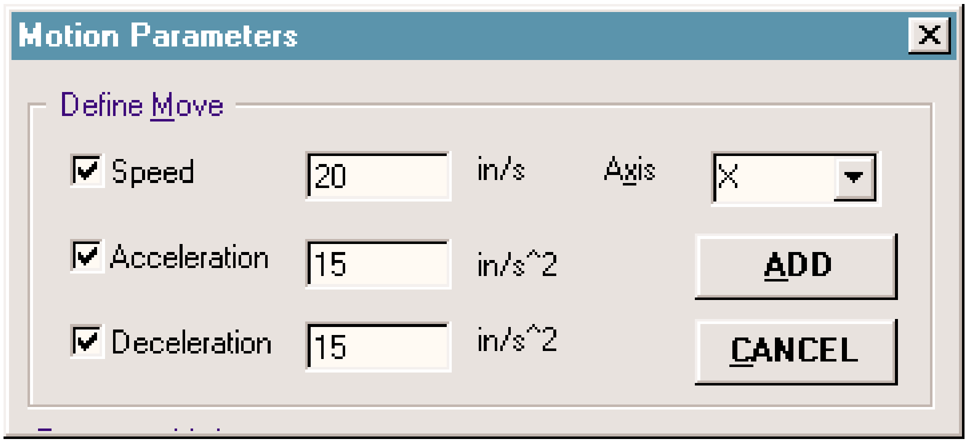
Velocity Profile
Smoothness LOW – HIGH 125

Figure 5.43 - Linear Interpolation

Click
"ADD" to add interpolation segment to procedure, or
"CANCEL" to return to the main program.

Motion Parameters:

Specify speed, acceleration, and deceleration for selected axes.

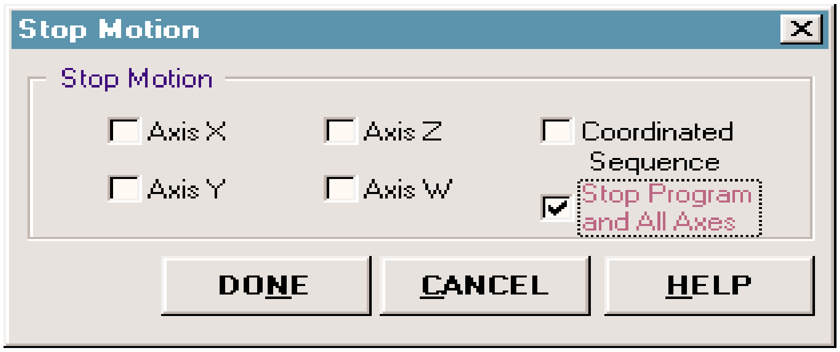


☑ Speed 20 in/s Axis X
☑ Acceleration 15 in/s^2
☑ Deceleration 15 in/s^2

Figure 5.44 - Define Motion Parameters

Stop Motion:

Stop independent, coordinated motion, all motion or all motion and program. Motors will come to a decelerated stop.


Stop Motion

Stop Motion

□ Axis X
□ Axis Z
□ Coordinated Sequence
□ Axis Y
□ Axis W
☑ Stop Program and All Axes

Figure 5.45 - Stop Motion

Increment Position:

The increment position allows for a change in the command position while the actuator is moving. The command has three effects depending on the motion being executed.

Case One: Motor is standing still:

An increment position command is equivalent to a relative move command. The actuator will move to the specified position at the requested slew speed and acceleration.

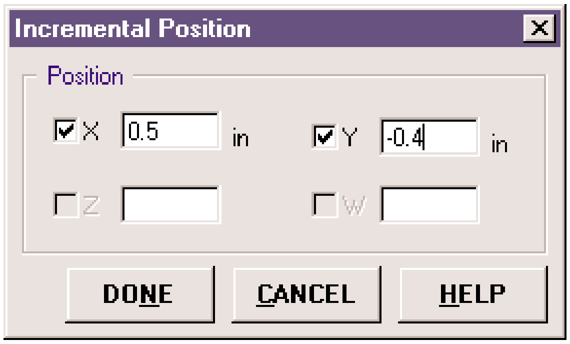
Case Two: Motor is moving toward specified position:

An increment position command will cause the actuator to move to a new position target, which is the old target plus the incremental position user specified. The incremental position must be in the same direction as the existing motion.

Case Three: Motor is in the jog-by-speed mode:

The increment position command will cause the actuator to instantly try to servo an incremental position from the present instantaneous position. The speed and acceleration parameters have no effect. This command is useful when two axes in which one of the axis' speed is indeterminant due to a variable diameter pulley.

PROGRAM INSTRUCTIONS
Group = Motion



Incremental Position

Position

☑ X 0.5 in ☑ Y -0.4 in

□ Z □ W

Figure 5.46 - Incremental Position

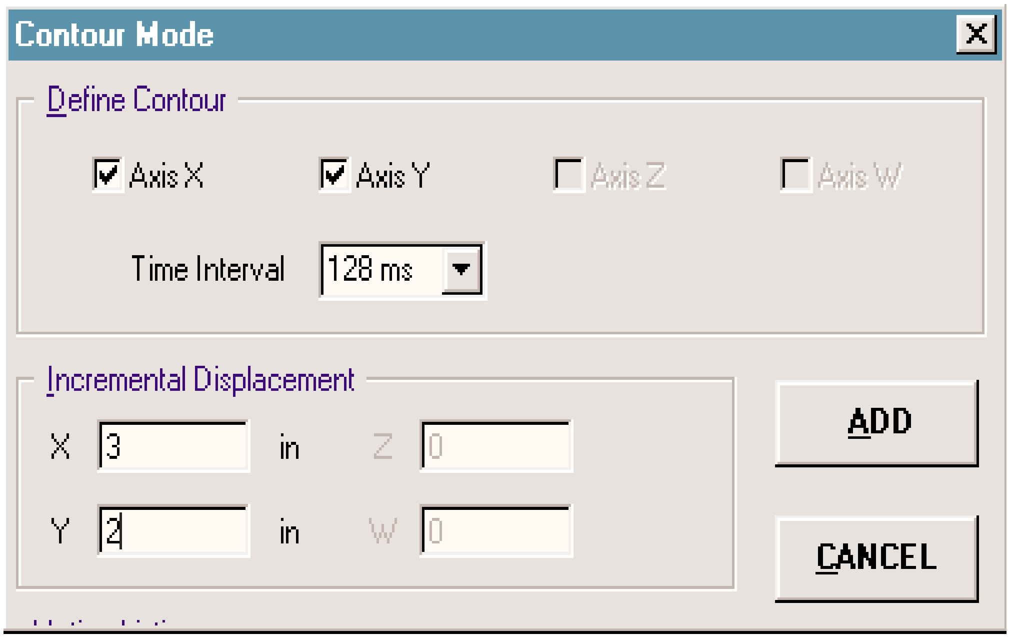
Contour Mode:

Define contour axis/axes, time interval and incremental displacement.

The contour mode programming window is shown in Fig. 5.47. This mode allows any arbitrary position curve for 1,2,3 or 4 axes to be prescribed which is ideal for following computer generated paths such as parabolic, spherical or user-defined profiles. Here, the path is not limited to straight line and arc segments. Also, the path length may be infinite.

The incremental displacement sub-window specifies the position increment, and the time interval list specifies the time for the incremental displacement on X,Y,Z and W axes. The units of the command are in user selected unit. The time interval list sets the time interval for contouring mode. Setting the time interval once will set the time interval for all following contour data until a new time interval command is selected.

Use:
“ADD” to add the contour data to the program, or
“CANCEL” to return to the main program window.



Define Contour

☑ Axis X ☑ Axis Y □ Axis Z □ Axis W

Time Interval 128 ms

Incremental Displacement

X 3 in Z 0

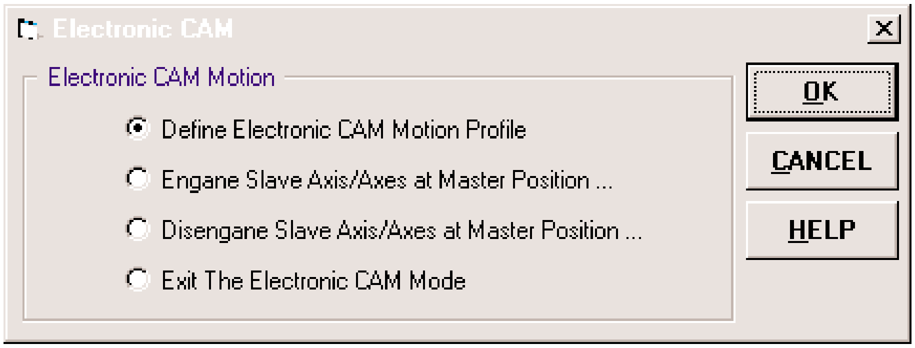
Y 2 in W 0

Figure 5.47 - Contour Mode

Electronic CAM:

The electronic cam is a motion control mode which enables the periodic synchronization of several axes of motion when one of the axes is independent and is not necessarily driven by the controller. The electronic cam is a more general type of electronic gearing which allows a table-based relationship between the axes. It allows synchronizing all the controller axes.

The electronic CAM (ECAM) window, as shown in Fig. 5.46, defines the CAM profile, position for master/slave axis engagement and disengagement. Each portion of ECAM is described as follows.



Electronic CAM Motion

● Define Electronic CAM Motion Profile

○ Engane Slave Axis/Axes at Master Position ...

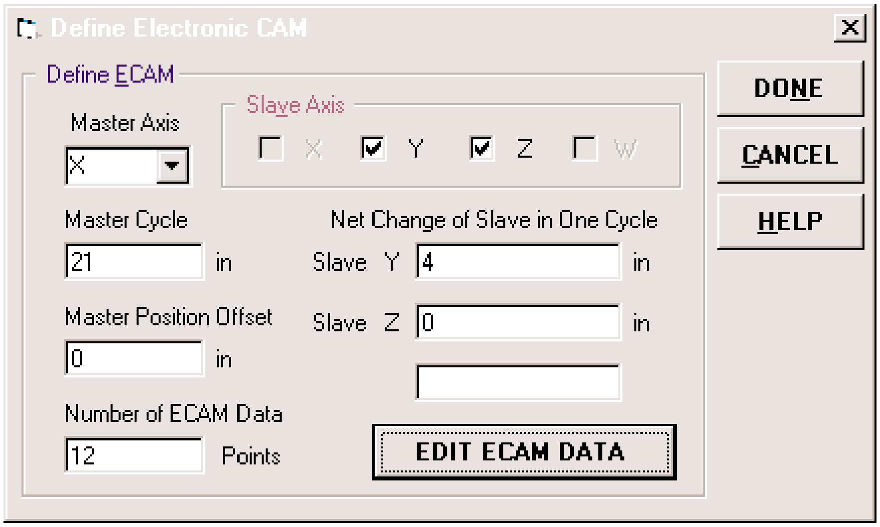
○ Disengane Slave Axis/Axes at Master Position ...

○ Exit The Electronic CAM Mode

Figure 5.48 - Electronic CAM

PROGRAM INSTRUCTIONS
Group = Motion

First: Define electronic CAM motion profile
Start by selecting the master axis and slave axis/axes for the electronic cam mode. Any available axis may be chosen. Second, specify the master cycle (M1-M0, see Fig. 5.50) and the net change of slave in one cycle (S1-S0, see Fig. 5.50). If there is a position offset for the master, then enter the offset for the master axis. Third, determine number of data points of the electronic CAM table. Lastly, click the "EDIT ECAM DATA" button to enter/edit the ECAM data.



Define Electronic CAM

Define ECAM

Master Axis: X

Slave Axis: □ X ☑ Y ☑ Z □ W

Master Cycle: 21 in

Net Change of Slave in One Cycle
Slave Y: 4 in
Slave Z: 0 in

Master Position Offset: 0 in

Number of ECAM Data: 12 Points

Figure 5.49 - ECAM Motion Profile

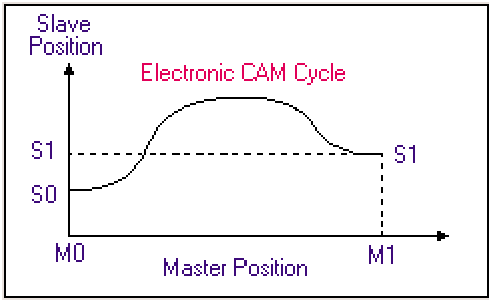
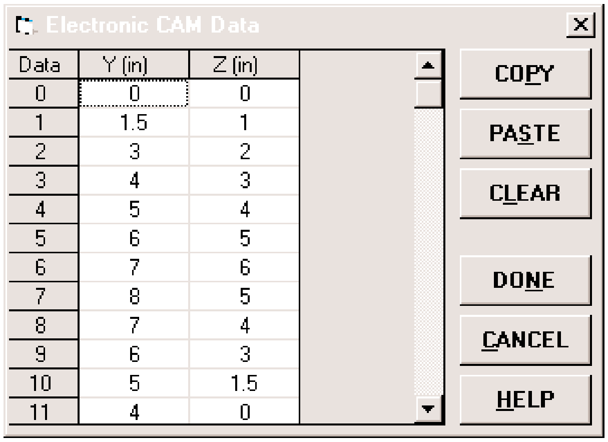


Figure 5.50 - Define ECAM Motion Profile

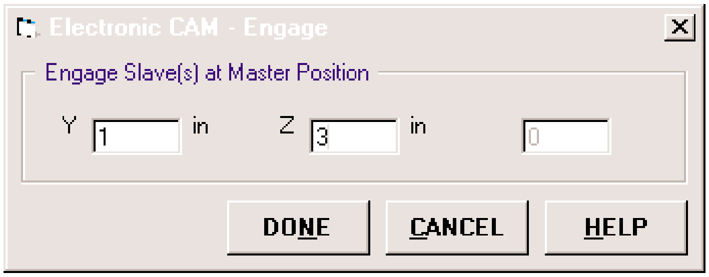
A grid table, as shown in Fig. 5.51, is available for entering the CAM data. Use "COPY" to copy selected data, "PASTE" to paste copied data to selected field(s), or "CLEAR" to clear highlighted fields.



Data	Y (in)	Z (in)
0	0	0
1	1.5	1
2	3	2
3	4	3
4	5	4
5	6	5
6	7	6
7	8	5
8	7	4
9	6	3
10	5	1.5
11	4	0

Figure 5.51 - Edit ECAM Profile Data

Second: Engage slave axis/axes at particular master position
The engage window, as shown in Fig. 5.52, engages an ECAM slave axis at a specified position of the master. If a value is specified outside of the master's range, the slave will engage immediately. Once a slave motor is engaged, its position is redefined to fit within the cycle.



Engage Slave(s) at Master Position

Y 1 in Z 3 in 0

Figure 5.52 - Engage ECAM

Third: Disengage slave axis/axes at specific master position
The disengage window, as shown in Fig. 5.53, disengages an electronic cam slave axis at the specified master position. Separate points can be specified for each axis. If a value is specified outside of the master's range, the slave will disengage immediately.

PROGRAM INSTRUCTIONS
Group = Motion

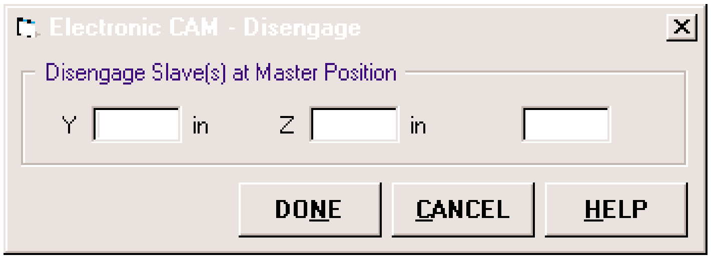

Electronic CAM - Disengage
Disengage Slave(s) at Master Position
Y
in
Z
in
DONE
CANCEL
HELP

Figure 5.53 - Disengage ECAM

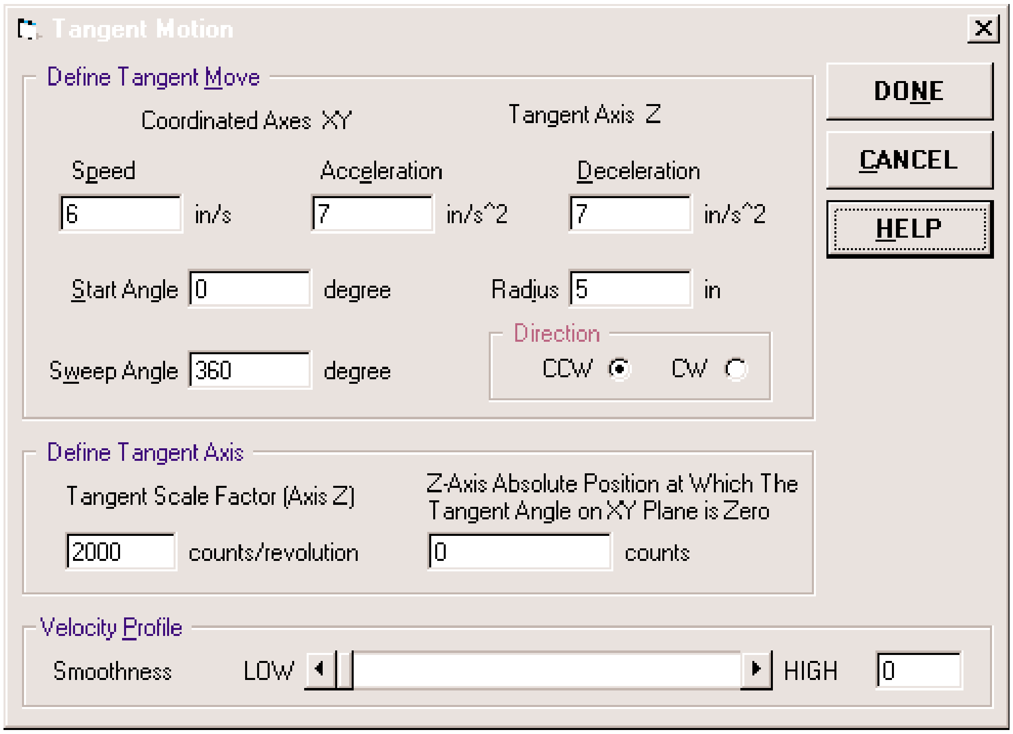
Fourth: Exit electronic CAM mode

Tangent Motion:

Tangent motion instruction, as shown in Fig. 5.54, is used to continuously position the Z axis tangent to the arc being created by the X and Y axis in 2D circular or linear motion. Define the scale factor for the Z axis in counts per revolution and the absolute position of the Z axis, at which the resulting angle of the Z axis equals zero in the X and Y coordinated motion plane. Tangent is useful for cutting applications where a cutting tool must remain tangent to the part.

The start angle is defined as the angle formed between zero degrees on the coordinate system and the start of the arc measuring in the direction of positive rotation. The sweep angle defines the motion of the arc starting at the start angle through the desired distance in the selected direction of motion. The direction of the arc can be either CW or CCW from the start angle. See Fig. 5.36 for a graphical representation.

The smoothing is accomplished by filtering the acceleration profile. Trapezoidal velocity profiles have acceleration rates which change abruptly from zero to maximum value. The discontinuous acceleration results in infinite jerk that causes vibration. The smoothing of the acceleration profile leads to a continuous acceleration profile and a finite jerk, which reduces the mechanical shock and vibration.



Define Tangent Move

Coordinated Axes XY   Tangent Axis Z

Speed: 6 in/s   Acceleration: 7 in/s^2   Deceleration: 7 in/s^2

Start Angle: 0 degree   Radius: 5 in

Sweep Angle: 360 degree

Direction: CCW ● CW ○

Define Tangent Axis

Tangent Scale Factor (Axis Z): 2000 counts/revolution

Z-Axis Absolute Position at Which The Tangent Angle on XY Plane is Zero: 0 counts

Velocity Profile

Smoothness LOW ◂ ▸ HIGH 0

Figure 5.54 - Tangent Motion

GROUP = PROGRAM FLOW

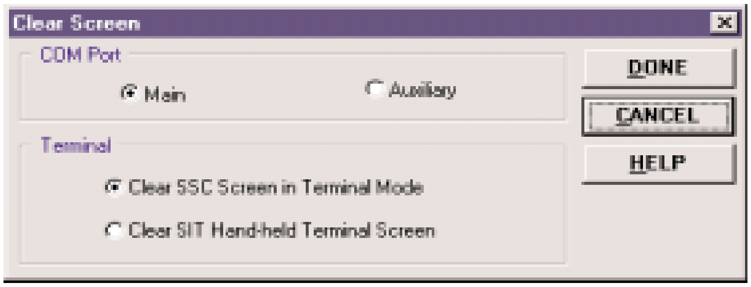
Contains 15 instructions for program flow controls.

Auto Execution:

Insert the label “#AUTO” at the beginning of program to execute the program automatically when the controller is power on.

Clear Screen:

The clear screen instruction sends clear screen to Tol-O-Matic SIT or to SSC terminal mode. Choose the COM port and specify the SIT or the SSC terminal mode screen.



COM Port: ● Main ○ Auxiliary

Terminal:

● Clear SSC Screen in Terminal Mode

○ Clear SIT Hand-held Terminal Screen

Figure 5.55 - Clear Screen

PROGRAM INSTRUCTIONS
Group = Program Flow

End:

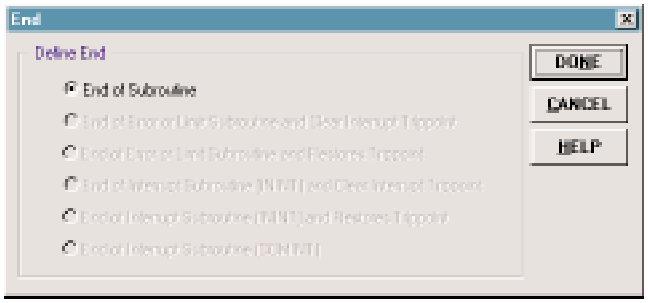
The end instruction, as shown in Fig. 5.56, includes: end of regular subroutine, end of error or limit subroutine or end of interrupt subroutine.

The “End of Subroutine” option is used to designate the end of a subroutine. If a subroutine has been called by the “Jump to Subroutine” instruction, the end command will return execution to the instruction after the “Jump to subroutine” instruction.

The “End of Error or Limit Subroutine” is used to end a position error handling subroutine or limit switch handling subroutine. The error handling subroutine begins with the #POSERR label. The limit switch handling subroutine begins with the #LIMSWI. If the program was waiting for a trippoint to occur, prior to the interrupt, the trippoint can either be preserved on return to the main program or the trippoint can be cleared.

The “End of Input Interrupt” (INIT) subroutine is used to end the interrupt subroutine beginning with the label #INIT. The end of interrupt subroutine causes a return to the main program and re-enables input interrupts. If the program was waiting for a trippoint to occur, prior to the interrupt, the trippoint can either be preserved on return to the main program or the trippoint can be cleared.

The “End of Communication Interrupt Subroutine” (COMINT) is used to end a communication interrupt subroutine beginning with the label #COMINT. The end of interrupt causes a return to main program. The interrupt can either be restored or cleared on return to the main program. If the program was waiting for a trippoint to occur, prior to the interrupt, the trippoint can either be preserved on return to the main program or the trippoint can be cleared



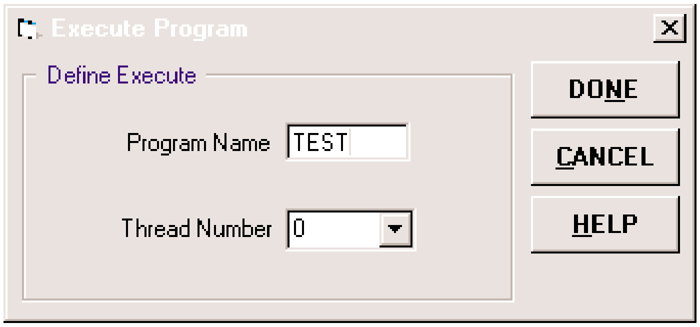
Define End

● End of Subroutine
○ End of Error or Limit Subroutine and Clear Interrupt Trippoint
○ End of Error or Limit Subroutine and Restores Trippoint
○ End of Interrupt Subroutine [ININT] and Clear Interrupt Trippoint
○ End of Interrupt Subroutine [ININT] and Restores Trippoint
○ End of Interrupt Subroutine [COMINT]

Figure 5.56 - End

Execute:

The execute instruction, as shown in Fig. 5.57, starts a program module running. Execution will start at the label/name specified. Up to four programs may be executed simultaneously to perform multitasking. To run a program, specify the program name and thread number (0-3).



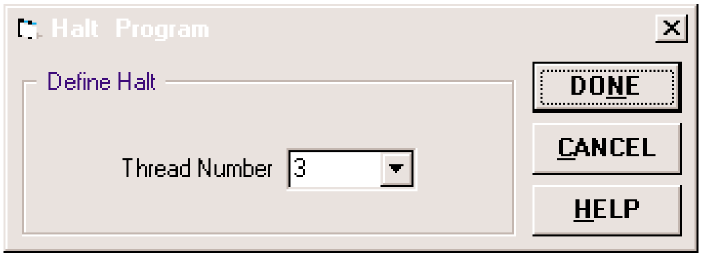
Program Name TEST

Thread Number 0

Figure 5.57 - Execute

Halt Task:

The halt instruction, as shown in Fig. 5.56, halts the execution of any of the four programs that may be running independently in multitasking. The thread number specifies the program to be halted.



Thread Number 3

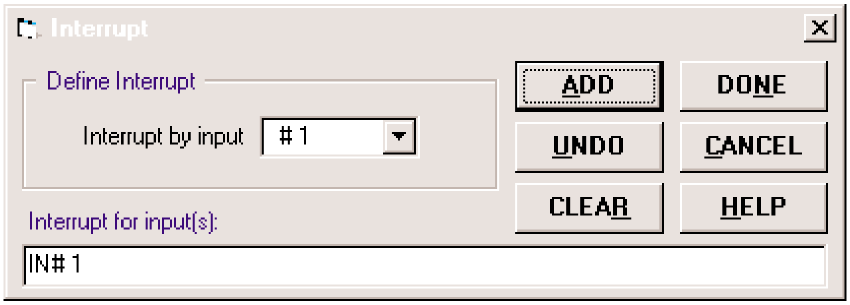
Figure 5.58 - Halt Task

Interrupt:

Specify input interrupt.

The interrupt instruction, as shown in Fig. 5.57, enables the input interrupt function for the specified inputs. Use “ADD” to add as many inputs as necessary to the function call, “UNDO” to delete last added input interrupt or “CLEAR” to clear the input interrupt command string. If any of the specified inputs go low during program execution, the program will jump to the subroutine with label #INIT. Any trippoints set by the program will be cleared. The “end of interrupt” instruction is used to return from the #INIT routine. The “end of interrupt” command also re-enables input interrupts.

PROGRAM INSTRUCTIONS
Group = Program Flow



Define Interrupt

Interrupt by input: #1

Interrupt for input(s): IN#1

Figure 5.59 - Interrupt

Jump:

The jump instruction, as shown in Fig. 5.60 and 5.61, includes jump to a label and jump to subroutine.

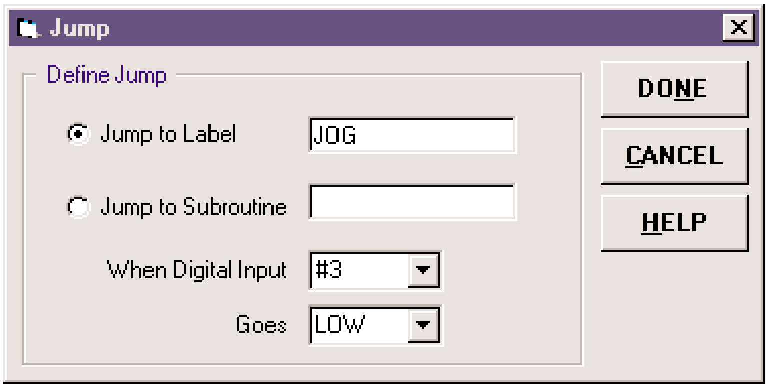
The "jump to label" causes a jump to a program location on an optional condition. The program location may be any label. The condition is a conditional statement which uses a logical operator such as equal to or less than. A jump is taken if the specified condition is true.

The "jump to subroutine" will change the sequential order of execution of commands in a program. If the jump is taken, program execution will continue at the line specified by the destination parameter, which can be a label name. After the next "end of subroutine" is encountered, program execution will continue with the instruction following the "jump to subroutine" instruction. There can be a "jump to subroutine" command within a subroutine. These can be nested 8 deep in the controller.

By clicking "Select digital input as condition", the user can select jump to a program location or subroutine based on input status.

The alternative is a jump taken if the specified condition is true. click the "Use Math Func" button to specify the condition using the mathematical functions. Conditions are tested with logical operators. The available logical operators are:

<	less than
>	greater than
=	equal to
<=	less than or equal to
>=	greater than or equal to
<>	not equal



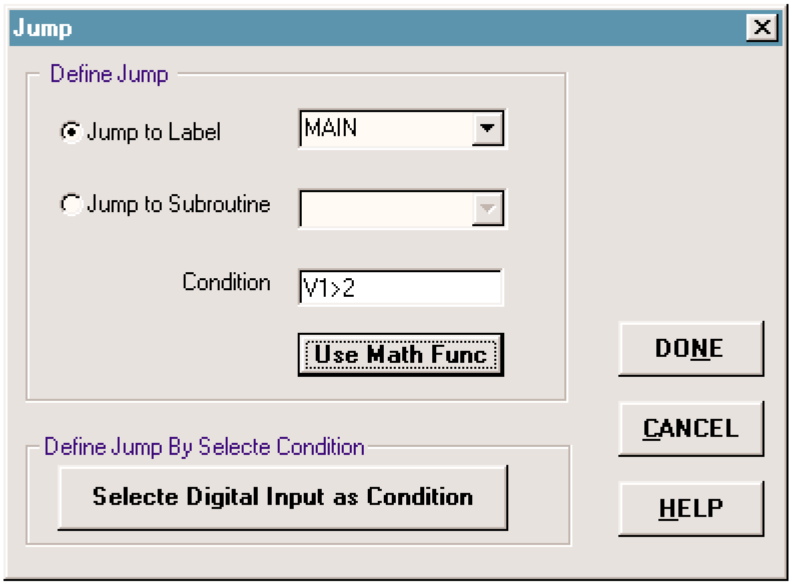
● Jump to Label JOG

○ Jump to Subroutine

When Digital Input #3

Goes LOW

Figure 5.60 - Jump (Digital Input as condition)


Jump
Define Jump
Use Math Func
Define Jump By Selecte Condition
Selecte Digital Input as Condition
DONE
CANCEL
HELP

● Jump to Label MAIN

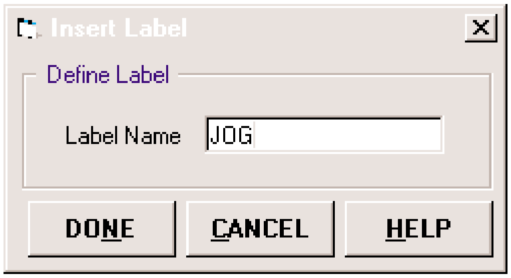
○ Jump to Subroutine

Condition V1>2

Figure 5.61 - Jump (by specified condition)

Label:

Enter desired label name in the text field, as shown in Fig. 5.62, to insert a label to the program.



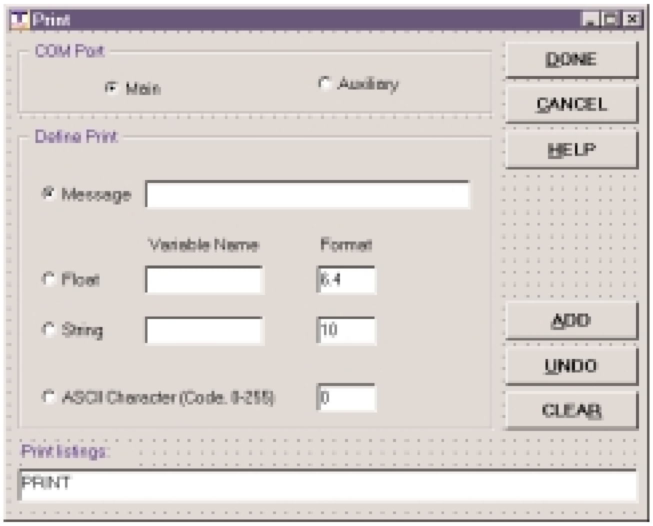
Label Name JOG

Figure 5.62 - Label

PROGRAM INSTRUCTIONS
Group = Program Flow

Print:

The print instruction, as shown in Fig. 5.63, sends data out of the controller to an external display device (Hand held terminal or monitor). This can be used to alert an operator, send instructions or return a variable value. Select main or auxiliary to specify which serial port to send the message. Main = main port, Auxiliary = auxiliary port. Use "ADD" to add output data and its format (if necessary) to the print command line, "UNDO" to delete last added data, or "CLEAR" to clear the print command string.



COM Port
● Main ○ Auxiliary

Define Print
● Message

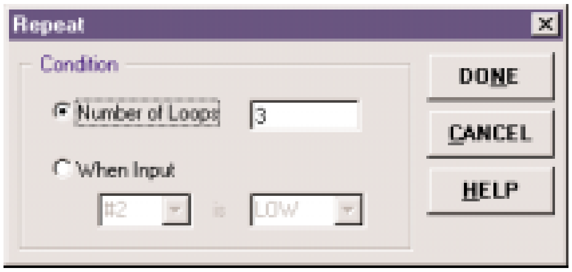
	Variable Name	Format
○ Float		6.4
○ String		10
○ ASCII Character (Code. 0-255)		0

Print listings:
PRINT

Figure 5.63 - Print

Repeat:

Repeat instruction allows user to either specify number of cycles to iterate or trigger condition to repeat. Two lines of code will be created — begin and end of the repeat loop. Any commands added after the repeat ask the user if they are to be inside the loop until the first time "NO" is selected. The user can also cut and paste the begin or end statement anywhere in the program.



Condition
● Number of Loops 3
○ When Input #2 is LOW

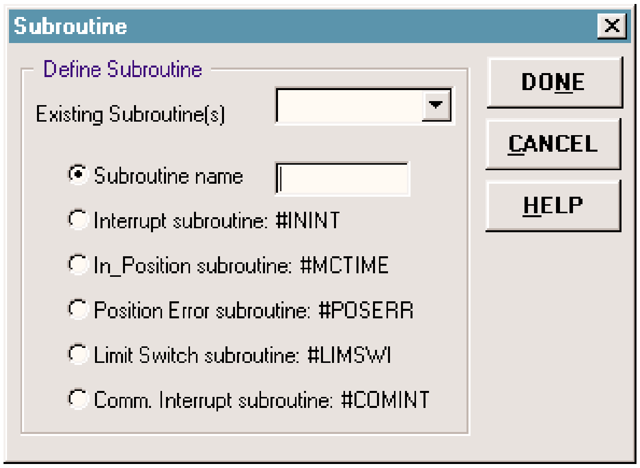
Figure 5.64 - Repeat

Subroutine:

The subroutine instruction, as shown in Fig. 5.65, starts a user defined or system subroutine. A subroutine is a group of instructions beginning with a subroutine label and ending with an end command. Subroutines are called from the main program with the jump subroutine instruction, followed a conditional statement. Up to 8 subroutines can be nested. After the subroutine is executed, the program sequencer returns to the program location where the subroutine was called unless the subroutine stack is manipulated with the zero subroutine stack instruction.

The system subroutines are:

Input Interrupt subroutine - #INIT
IN_Position subroutine - #MCTIME
Position error subroutine - #POSERR
Limit switch subroutine - #LIMSWI
Communication interrupt subroutine - #COMINT



Existing Subroutine(s)

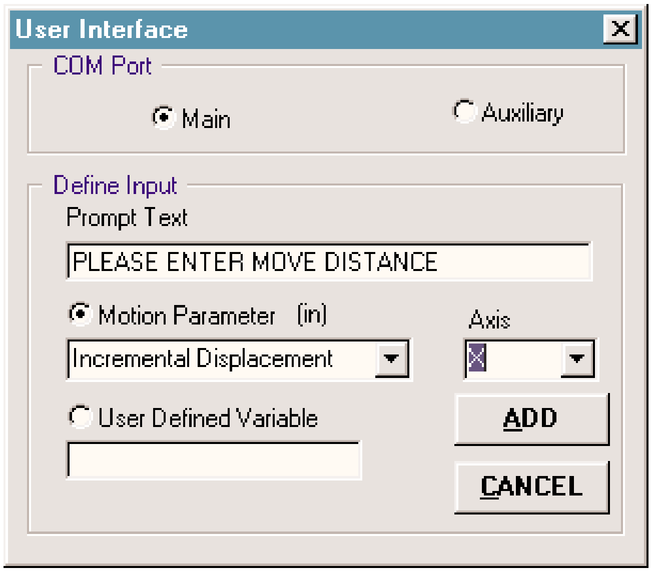
● Subroutine name
○ Interrupt subroutine: #ININT
○ In_Position subroutine: #MCTIME
○ Position Error subroutine: #POSERR
○ Limit Switch subroutine: #LIMSWI
○ Comm. Interrupt subroutine: #COMINT

Figure 5.65 - Subroutine

User Interface:

The user interface instruction, as shown in Fig. 5.66, allows a variable to be input from a keyboard on either the main or auxiliary serial port. When the variable input command is executed in a program, the prompt message is displayed. The operator then enters the variable value followed by a carriage return. The entered value is assigned to the specified variable name. The variable input command holds up execution of following commands in a program until a carriage return or semicolon is detected. If no value is given prior to a semicolon or carriage return, the previous variable value is kept. Input Interrupts, Error Interrupts and Limit Switch Interrupts will still be active.

PROGRAM INSTRUCTIONS
Group = Program Flow



User Interface

COM Port

● Main ○ Auxiliary

Define Input

Prompt Text: PLEASE ENTER MOVE DISTANCE

● Motion Parameter (in): Incremental Displacement

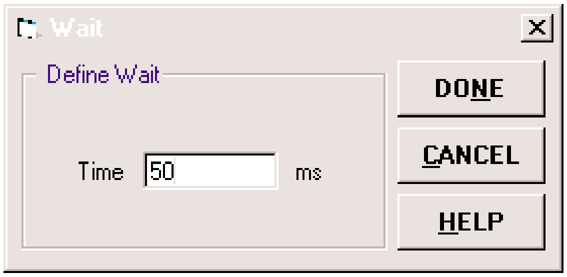
Axis: X

○ User Defined Variable

Figure 5.66 - User Interface

Wait:

The wait instruction, as shown in Fig. 5.67, is a trippoint used to time events. After this command is executed, the controller will wait for the number of samples specified before executing the next command. If the loop rate instruction has not been used to change the sample rate from 1 msec, then the units of the wait command are milliseconds.



Wait

Define Wait

Time 50 ms

Figure 5.67 - Wait

Wait For Condition:

There are five trippoint types, position, speed, clock, motion, and input, available in the controller.

Trippoint: Position
Wait until absolute or relative position is achieved, Fig. 5.68.

The “after absolute position”, “after distance”, “after relative distance”, and “after vector distance” options are trippoints used to control the timing of events.

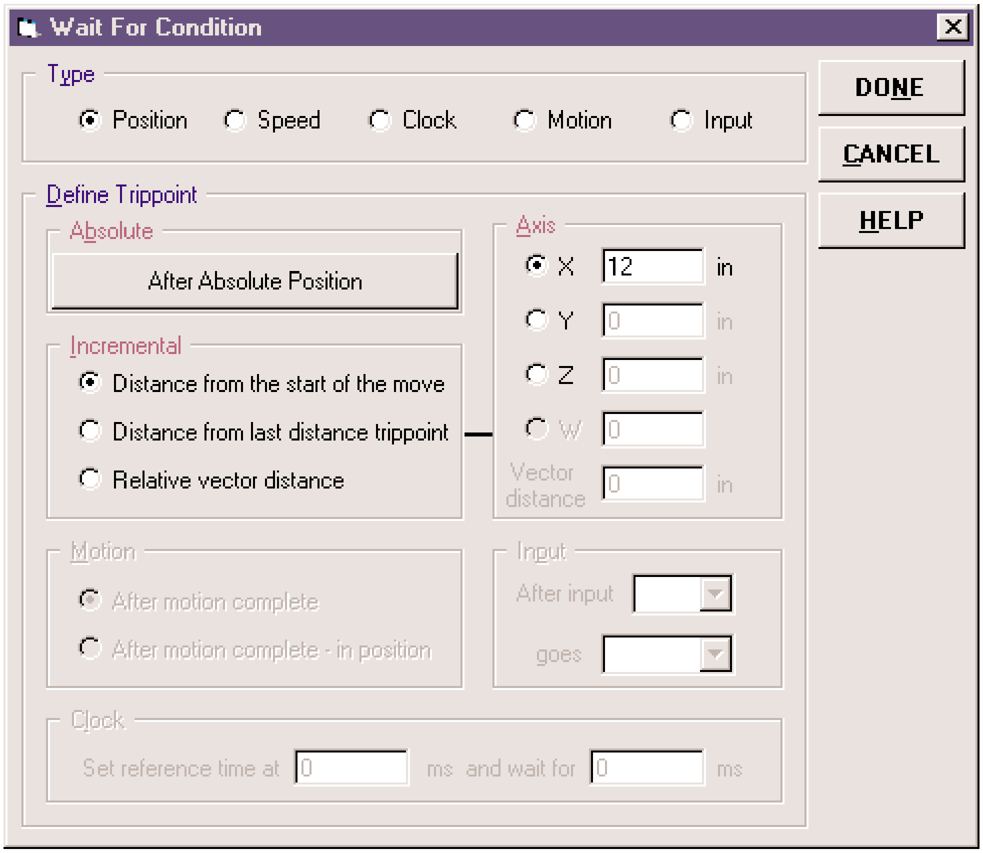
The *“after absolute position”* trippoint will hold up the execution of the following command until the absolute actual position of the motor crosses the position specified. Only one axis may be specified at a time. The trippoint will also be cleared by the completion of the move.

The *“after distance”* trippoint will hold up the execution of the following command until the position command has reached the specified relative distance from the start of the move.

The *“after relative”* trippoint will hold up execution of the following command until the specified relative distance has reached from either last “after relative distance” or “after distance” trippoint, or from the start of the move. Only one axis may be specified at a time.

The *“after vector distance”* trippoint is used to hold up execution of the next command during coordinated moves such as circular or linear interpolation. This trippoint occurs when the path distance of a sequence reaches the specified value. The distance is measured from the start of a coordinated move sequence or from the last “after vector distance” command.

PROGRAM INSTRUCTIONS
Group = Program Flow



Type: ● Position ○ Speed ○ Clock ○ Motion ○ Input

Incremental: ● Distance from the start of the move ○ Distance from last distance trippoint ○ Relative vector distance

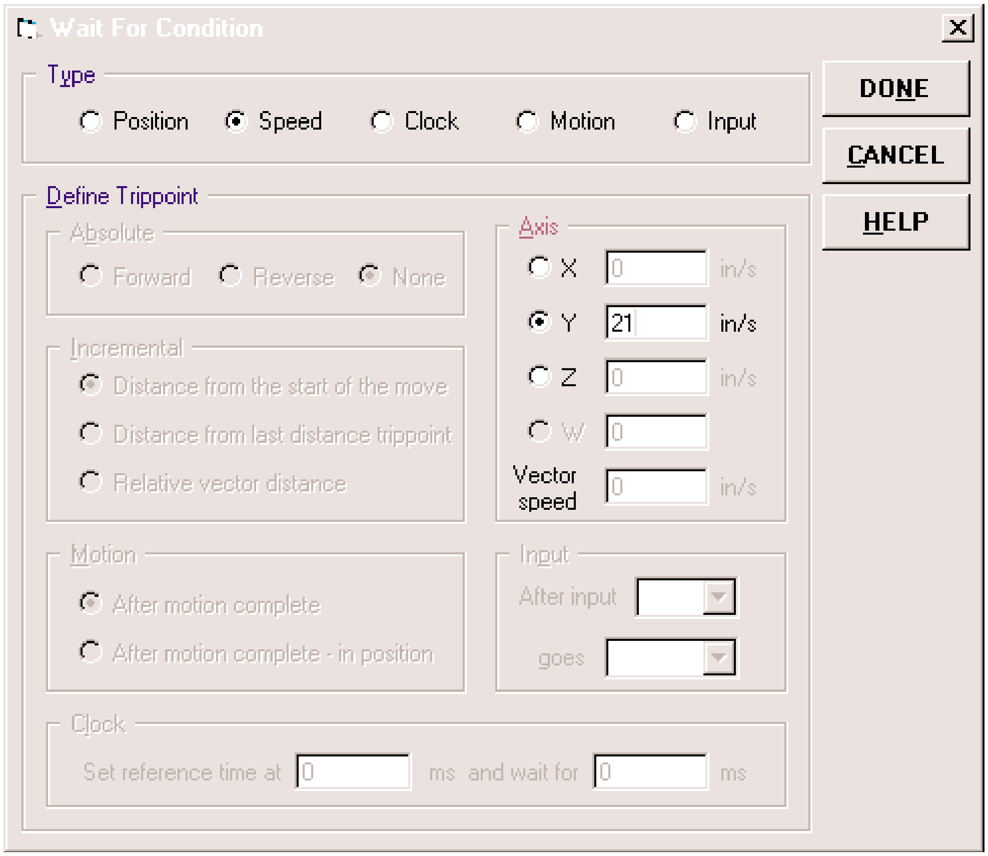
Axis: ● X 12 in ○ Y 0 in ○ Z 0 in ○ W 0 Vector distance 0 in

Set reference time at 0 ms and wait for 0 ms

Figure 5.68 - Wait For Position

Trippoint: Speed
Wait until speed is achieved.

The "at speed" trippoint, as shown in Fig. 5.69, occurs when the generated motion profile has reached the specified speed. This command will hold up execution of the following command until the speed is reached. The "at speed" trippoint will operate after either accelerating or decelerating. If the speed is not reached, the trippoint will be triggered after the motion is stopped (after deceleration).



Wait For Condition

Type

○ Position ● Speed ○ Clock ○ Motion ○ Input

Define Trippoint

Absolute

○ Forward ○ Reverse ● None

Incremental

● Distance from the start of the move

○ Distance from last distance trippoint

○ Relative vector distance

Motion

● After motion complete

○ After motion complete - in position

Axis

○ X 0 in/s

● Y 21 in/s

○ Z 0 in/s

○ W 0

Vector speed 0 in/s

Input

After input

goes

Clock

Set reference time at 0 ms and wait for 0 ms

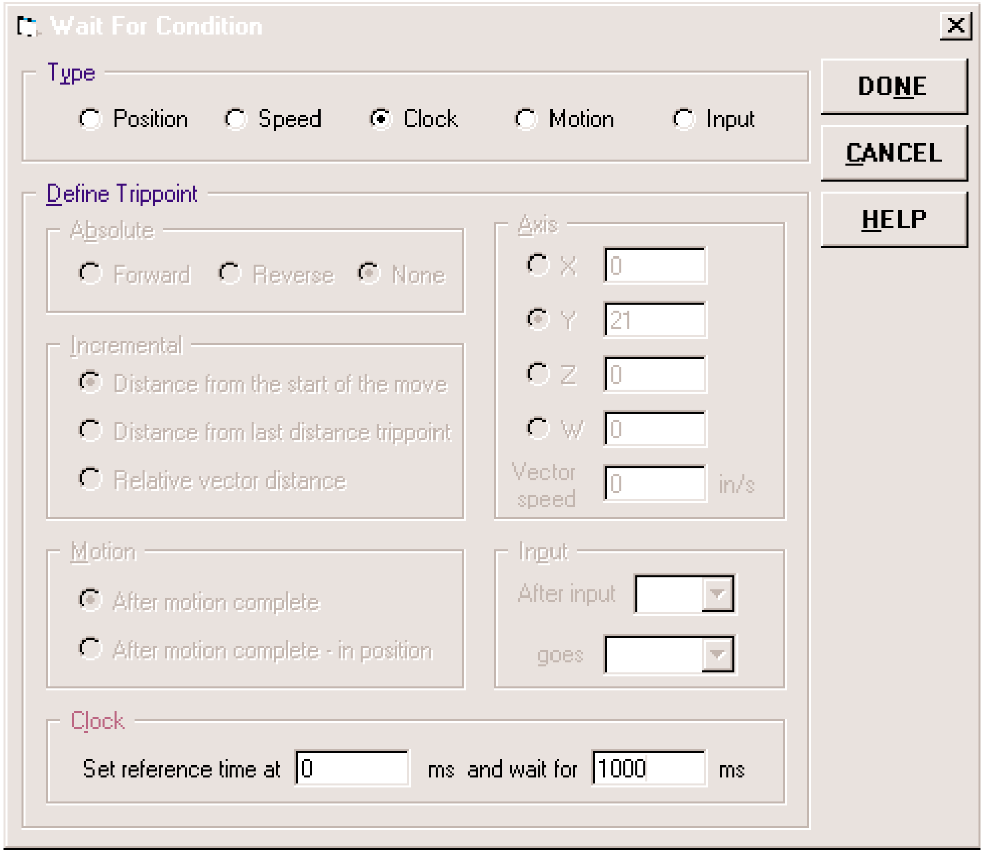
Figure 5.69 - Speed Trippoint

Trippoint: Clock

Set reference time and wait for a period of time.

The “clock” trippoint, as shown in Fig. 5.70, is used to hold up execution of the next command until after the specified time has elapsed. The time is measured with respect to a defined reference time. Positive reference value, n, specifies n msec from the reference. Negative reference value, -n, specifies n msec from the reference and establishes a new reference after the elapsed time period.

PROGRAM INSTRUCTIONS
Group = Program Flow



Type: ○ Position ○ Speed ● Clock ○ Motion ○ Input

Define Trippoint

Absolute: ○ Forward ○ Reverse ● None

Incremental: ● Distance from the start of the move ○ Distance from last distance trippoint ○ Relative vector distance

Axis: ○ X 0 ● Y 21 ○ Z 0 ○ W 0 Vector speed 0 in/s

Motion: ● After motion complete ○ After motion complete - in position

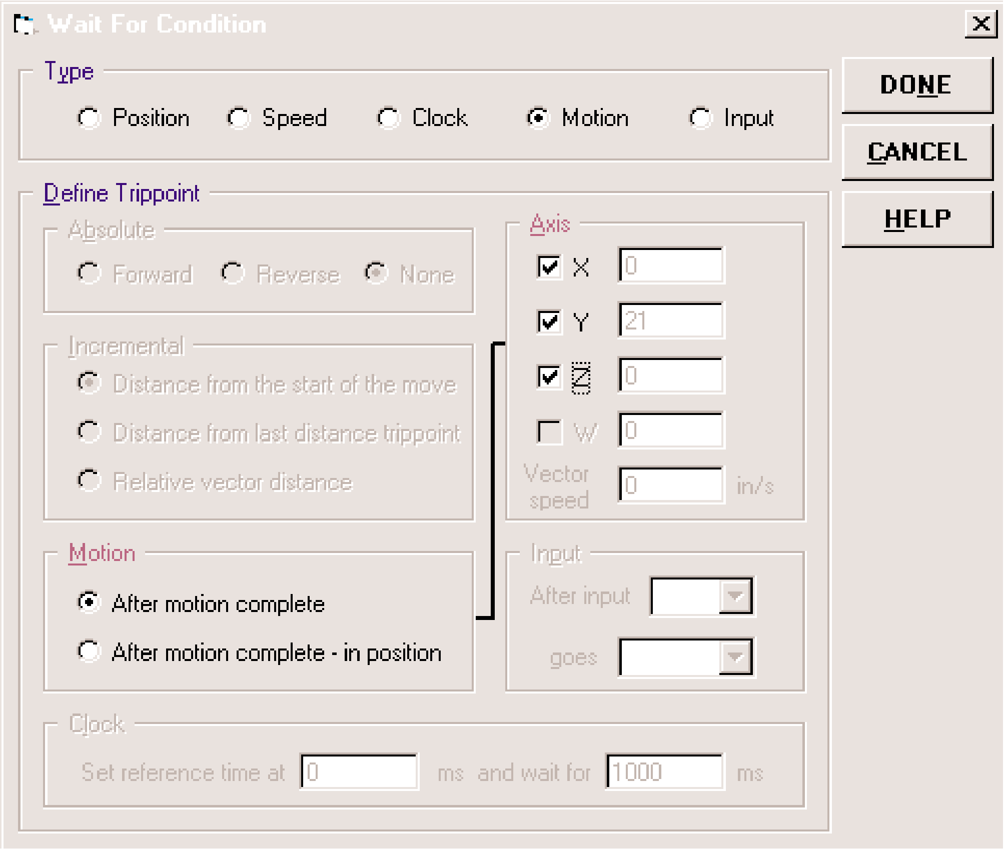
Input: After input goes

Clock: Set reference time at 0 ms and wait for 1000 ms

Figure 5.70 - Clock Trippoint

Trippoint Motion
Wait until motion is completed.

The “after motion” trippoint, as shown in Fig. 5.71, is used to control the timing of events. This command will hold up execution of the following commands until the current move on the specified axis or axes is completed. Any combination of axes or a motion sequence may be specified with the “after motion” trippoint. For example, Select axis XY waits for motion on both the X and Y axis to be complete. Use “after motion” trippoint with no parameter specified will wait when motion on all axes is complete.



Type
○ Position ○ Speed ○ Clock ● Motion ○ Input

Define Trippoint

Absolute
○ Forward ○ Reverse ● None

Incremental
● Distance from the start of the move
○ Distance from last distance trippoint
○ Relative vector distance

Motion
● After motion complete
○ After motion complete - in position

Axis
☑ X 0
☑ Y 21
☑ Z 0
☐ W 0
Vector speed 0 in/s

Input
After input
goes

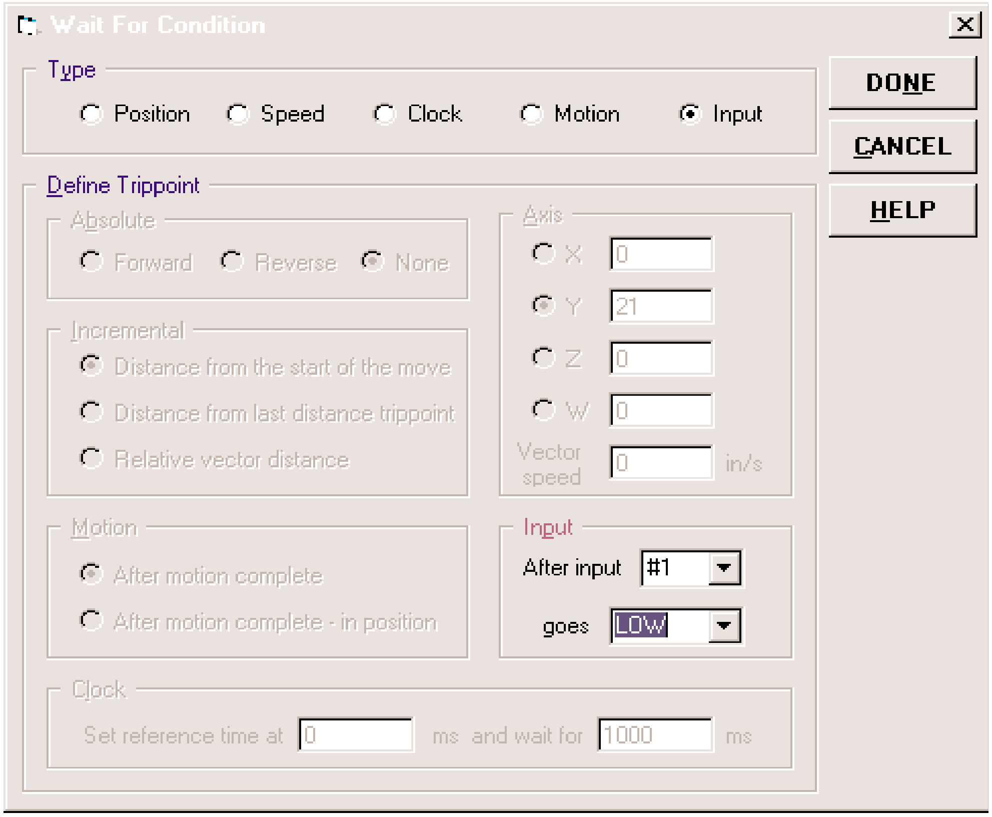
Clock
Set reference time at 0 ms and wait for 1000 ms

Figure 5.71 - Motion Trippoint

Trippoint: Input
Wait until input goes high or low.

The “after input” trippoint, as shown in Fig. 5.72, is used in motion programs to wait until after the specified input has occurred. Select the status to wait for the input to go high or low.

PROGRAM INSTRUCTIONS
Group = Program Flow



Wait For Condition

Type

○ Position ○ Speed ○ Clock ○ Motion ● Input

Define Trippoint

Absolute

○ Forward ○ Reverse ● None

Incremental

● Distance from the start of the move

○ Distance from last distance trippoint

○ Relative vector distance

Axis

○ X 0

● Y 21

○ Z 0

○ W 0

Vector speed 0 in/s

Motion

● After motion complete

○ After motion complete - in position

Input

After input #1

goes LOW

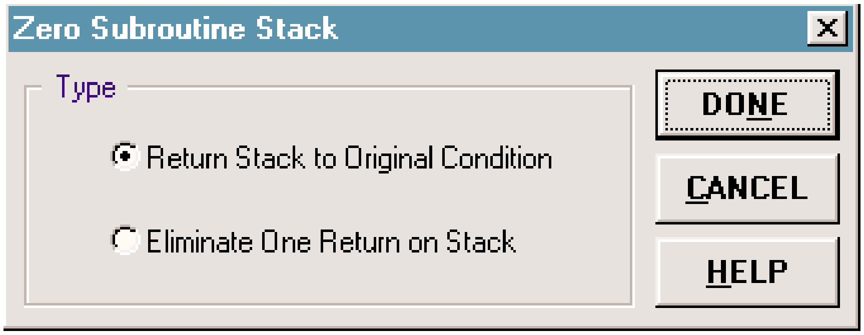
Clock

Set reference time at 0 ms and wait for 1000 ms

Figure 5.72 - Input Trippoint

Zero Subroutine Stack:

It is possible to manipulate the subroutine stack by using the “zero subroutine stack” instruction. Every time a jump to subroutine instruction, interrupt or automatic routine (such as #POSERR or #LIMSWI) is executed, the subroutine stack is incremented by 1. Normally the stack is restored with an End instruction. Occasionally it is desirable not to return back to the program line where the subroutine or interrupt was called. The “zero subroutine stack” instruction clears one return of the stack. This allows the program sequencer to continue to the next line. The “return stack to original condition” resets the stack to its initial value. For example, if a limit occurs and the #LIMSWI routine is executed, it is often desirable to restart the program sequence instead of returning to the location where the limit occurred.



Zero Subroutine Stack

Type

● Return Stack to Original Condition

○ Eliminate One Return on Stack

Figure 5.73 - Zero Subroutine Stack

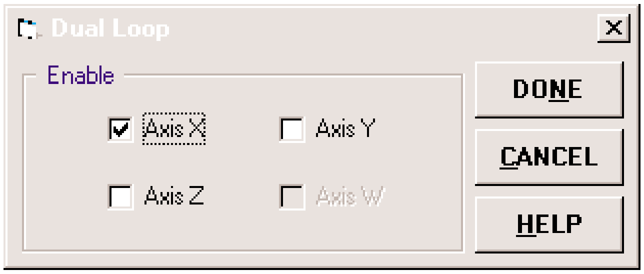
GROUP = SERVO SETTINGS

Includes five instructions for servo control settings.

Dual Loop:

Enable dual loop control.

The dual loop function, as shown in Fig. 5.74, changes the operation of the PID filter. It causes the derivative term to operate on the dual encoder instead of the main encoder. This results in improved stability in the cases where there is a backlash between the motor and the main encoder, and where the dual encoder is mounted on the motor.



Dual Loop

Enable

☑ Axis X □ Axis Y

□ Axis Z □ Axis W

Figure 5.74 - Dual Loop Control

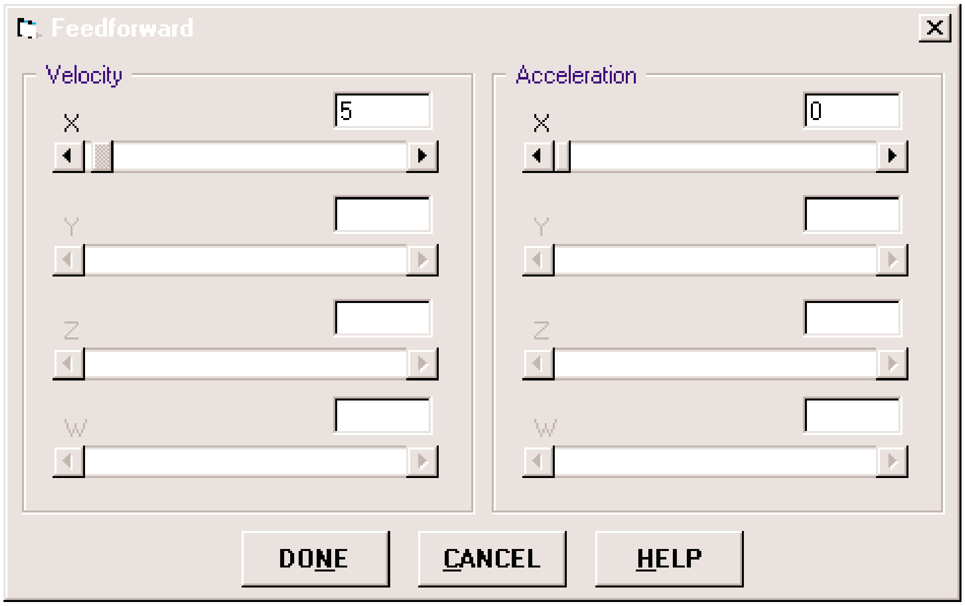
Feedforward:

Specify feedforward velocity and acceleration gains for servo axis.

The feedforward instruction, as shown in Fig. 5.75, sets the velocity and acceleration feedforward coefficients. The velocity coefficient, generates an output bias signal in proportions to the commanded velocity.

The acceleration coefficient, when scaled by the acceleration, adds a torque bias voltage during the acceleration phase and subtracts the bias during the deceleration phase of a motion.

PROGRAM INSTRUCTIONS
Group = Servo Settings



Feedforward

Velocity

X 5

Acceleration

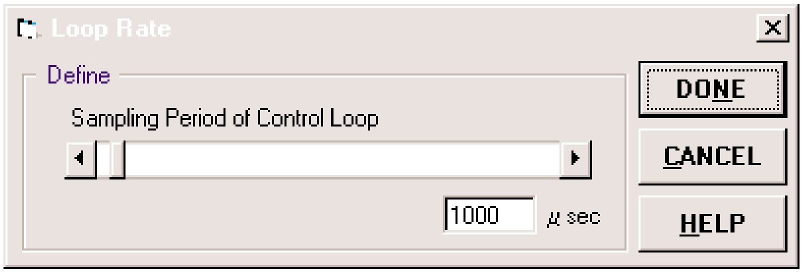
X 0

Figure 5.75 - Feedforward Gains

Loop Rate:

Change servo control loop rate, default 1 ms.

The loop rate instruction, as shown in Fig. 5.76, sets the sampling period of the control loop. Changing the sampling period will uncalibrate the speed and acceleration parameters. A negative number turns off the internal clock allowing for an external source to be used as the time base. The units of loop rate is microsecond.



Loop Rate

Define

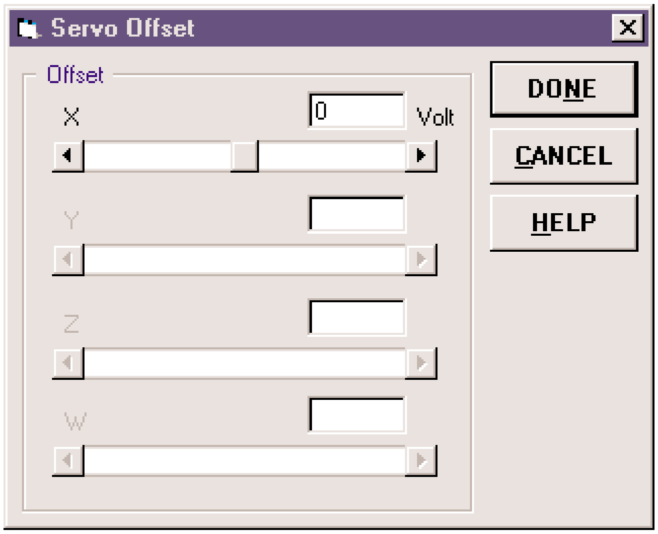
Sampling Period of Control Loop 1000 μ sec

Figure 5.76 - Loop Rate

Offset:

Servo command offset (volt).

The servo offset instruction, as shown in Fig. 5.77, sets a bias voltage in the motor command output. This can be used to counteract gravity or an offset in an amplifier.



X 0 Volt

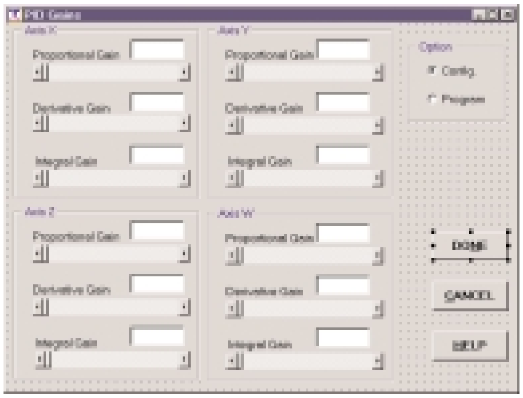
Figure 5.77 - Servo Offset

PID Gains:

Specify PID gains for servo axis.

This command can be used to add the PID setting to the program. This is desirable when running multiple programs on the same controller that require different PID gains or the load varies enough during motion that it requires changes in the PID setting. Proportional Gain designates the proportional constant in the controller filter. Derivative Gain designates the Derivative constant in the controller filter. Integral Gain sets the integral gain of the control loop.

Select the “Config” or “Program” option to place the code in configuration or program selection.



Option
● Config
○ Program

Figure 5.78 - PID Gains

PROGRAM INSTRUCTIONS
Group = System Limits

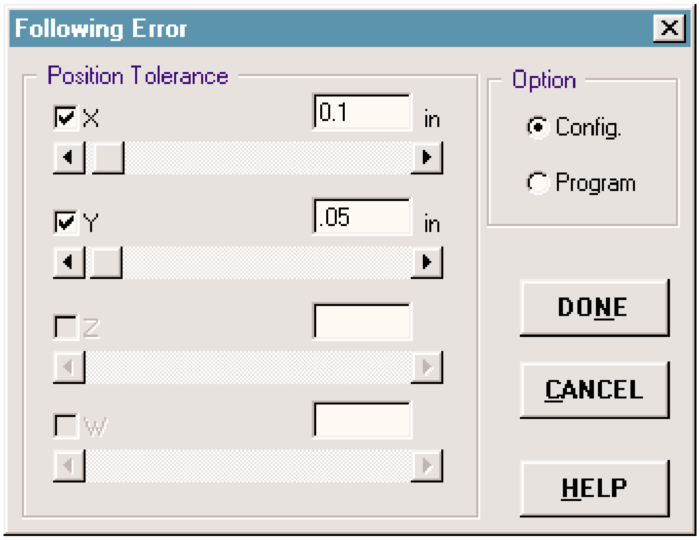
GROUP = SYSTEM LIMITS

Includes five instructions for configuring system limits.

Following Error:

Define position error tolerance for each axis.

The error tolerance window, as shown in Fig. 5.79, sets the magnitude of the X,Y,Z and W-axis position errors that will trigger an error condition. When the limit is exceeded, the error output (J2, pin 3) will go low (true). If the Off On Error command is active, the motors will be disabled. The error limit specified by the error tolerance should be high enough as not to be reached during normal operation. Examples of exceeding the error limit would be a mechanical jam, or a fault in a system component such as encoder or amplifier.



Position Tolerance

☑ X 0.1 in

☑ Y .05 in

□ Z

□ W

Option

● Config.

○ Program

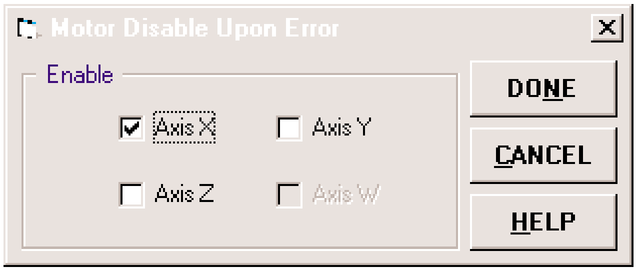
Figure 5.79 - Following Error

Motor Disable Upon Error:

Enable/disable motor when error occurred.

The motor off on error window, as shown in Fig. 5.80, sets the controller to shut off the motor command if a position error in excess of the limit specified by the error tolerance occurs. When the function is enabled, an abort either from the abort input or the abort command will shut off the motor.

If a position error is detected on an axis, and the motion was under an independent move, only that axis will be shut off. However, if the motion is a coordinated mode of the types (linear or circular interpolation), all the participating axes will be stopped.


Motor Disable Upon Error

Enable

☑ Axis X □ Axis Y

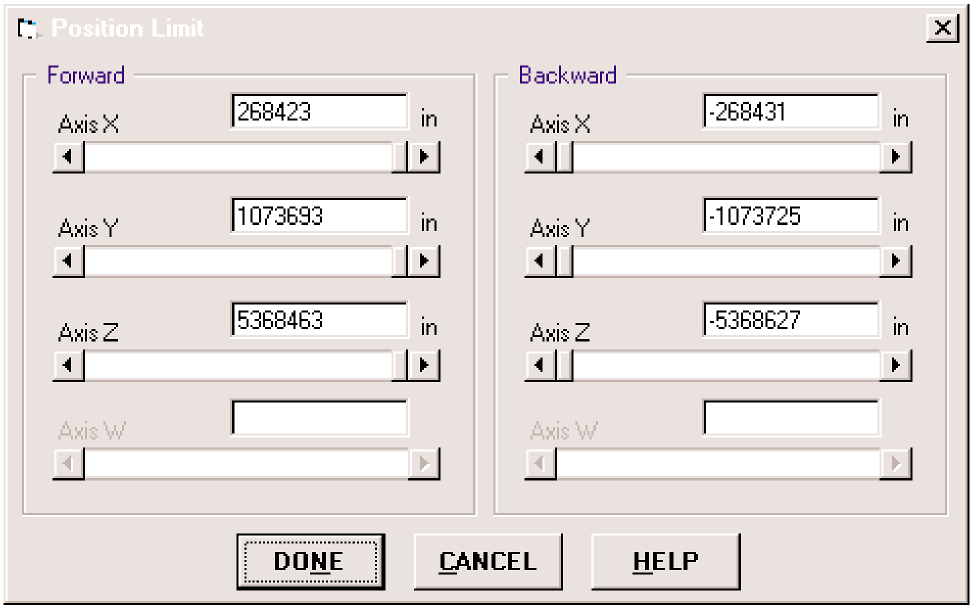
□ Axis Z □ Axis W

Figure 5.80 - Motor Disable Upon Error

Position:

Set position limits for each axis.

The position limit window, as shown in Fig. 5.81, sets the forward and reverse software limits. If the limit is exceeded during motion, motion on that axis will decelerate to a stop. Reverse motion beyond this limit is not permitted. The reverse limit is activated at X-1, Y-1, Z-1, W-1. Forward motion beyond this limit is not permitted. The forward limit is activated at X+1, Y+1, Z+1, W+1. To disable the reverse limit, scroll X,Y,Z,W to minimum (left). The forward limit is disabled by setting its value to maximum.


Position Limit

Forward

Axis X 268423 in

Axis Y 1073693 in

Axis Z 5368463 in

Axis W

Backward

Axis X -268431 in

Axis Y -1073725 in

Axis Z -5368627 in

Axis W

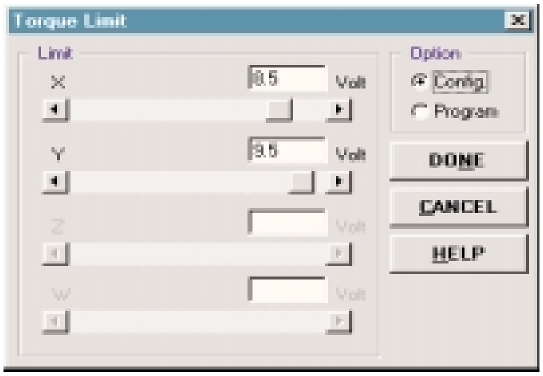
Figure 5.81 - Position Limit

PROGRAM INSTRUCTIONS
Group = System Limits

Torque:

Set torque limits for each axis. (unit in volt)

The torque limit window, as shown in Fig. 5.82, sets the limit on the motor command output. For example, a value of 5 limits the motor command output to 5 volts. Maximum output of the motor command is 9.996 volts.



Option: ● Config ○ Program

X 8.5 Volt

Y 9.5 Volt

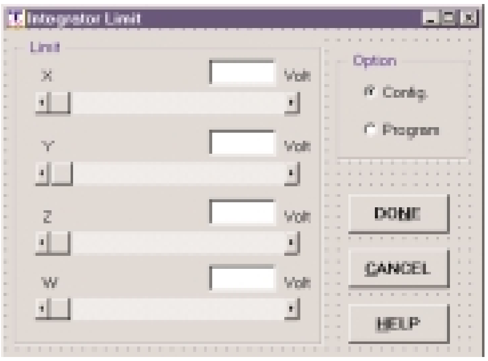
Figure 5.82 - Torque Limit

Integrator:

Set integrator limit for each axis. Select the “Config” or “Program” option to place the code in configuration or program selection.

The integrator window, as shown in Fig. 5.83, limits the effect of the integrator function in the filter to a certain voltage. For example, 2 volt limits the output of the integrator of the X-axis to the +/-2 Volt range.

A negative parameter also freezes the effect of the integrator during the move. For example, -3 limits the integrator output to +/-3V. If, at the start of the motion, the integrator output is 1.6 Volts, that level will be maintained through the move.



Option: ● Config ○ Program

Figure 5.83 - Integrator Limit

GROUP = MATHEMATICAL EQUATION

The instruction window of the mathematical function is shown in Fig. 5.84. The numeric range for addition, subtraction and multiplication operations is +/-2,147,483,647.9999. The precision for division is 1/65,000. Mathematical operations are executed from left to right. Parentheses can be used and nested four deep. Calculations within a parentheses have precedence. Functions may be combined with mathematical expressions. The order of execution is from left to right. The units of the SIN and COS functions are in degrees with resolution of 1/128 degrees. The values can be up to +/-4 billion degrees. The following is the listing of available arithmetic functions in the motion controller.

1. SIN: sine
2. COS: cosine
3. SQR: square root; accuracy is +/-.0004
4. ABS: absolute
5. INT: integer portion
6. FRAC: fraction portion
7. RND: rounds number .5 and up to next integer
8. +: addition
9. -: subtraction
10. *: multiplication
11. /: division
12. &: logical AND (bit-wise)
13. |: logical OR (On some computers, a solid vertical line appears as a broken line)
14. ( ): parentheses
15. IN: read digital input
16. AN: read analog input

Example:

V1=@ABS[V7]

Variable, V1, is equal to the absolute value of variable V7.

V2=5@SIN[P1]*

Variable, V2, is equal to 5 times the sine of the variable, P1.

V3=@IN[1]

Variable, V3, is equal to the digital value of input 1.

V4=@AN[5]

Variable, V4, is equal to the digital value of analog input 5.

*S1=7.5*V1/2*

Variable, S1, is equal to 7.5 multiplied by V1 and divided by 2

PROGRAM INSTRUCTIONS
Group = Mathematical Equation

COUNT=COUNT+2

The variable, COUNT, is equal to the current value plus 2.

*RX=_TPX-(@COS[45]*40)*

Puts the position of X minus 28.28 in RX.

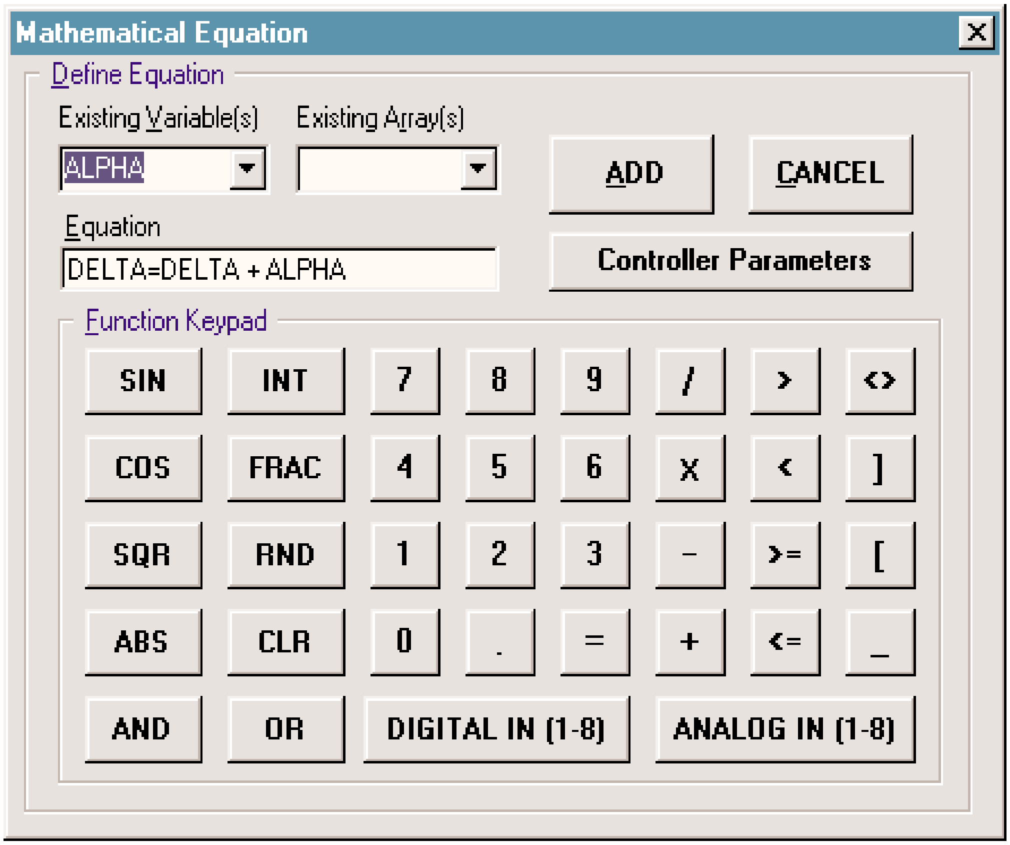
*Note: 40 * cosine of 45° is 28.28*

TEMP=@IN[1]&@IN[2]

TEMP is equal to 1 only if Input 1 and Input 2 are high

Click the "Controller Parameter(s)" button to display lists of parameters, motion, position or velocity, system configuration, status, and input/output, that are available to be included in the math function. Select the desired parameter to return its value from the controller. For example, X3 = _RPX will assign commanded position of axis X to variable X3.

Click "ADD" to add an equation to the listing.


Mathematical Equation

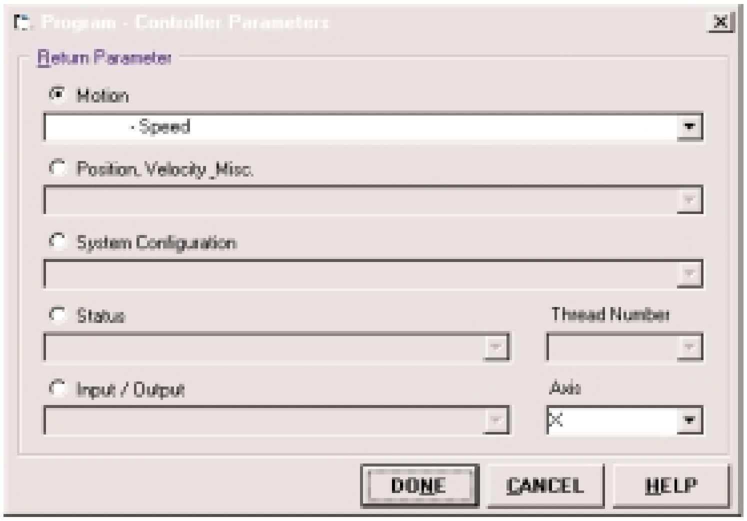
Define Equation

Existing Variable(s): ALPHA

Existing Array(s):

Equation: DELTA=DELTA + ALPHA

Figure 5.84 - Mathematical Functions



Program - Controller Parameters

Return Parameter

● Motion

Speed

○ Position, Velocity, Misc.

○ System Configuration

○ Status

Thread Number

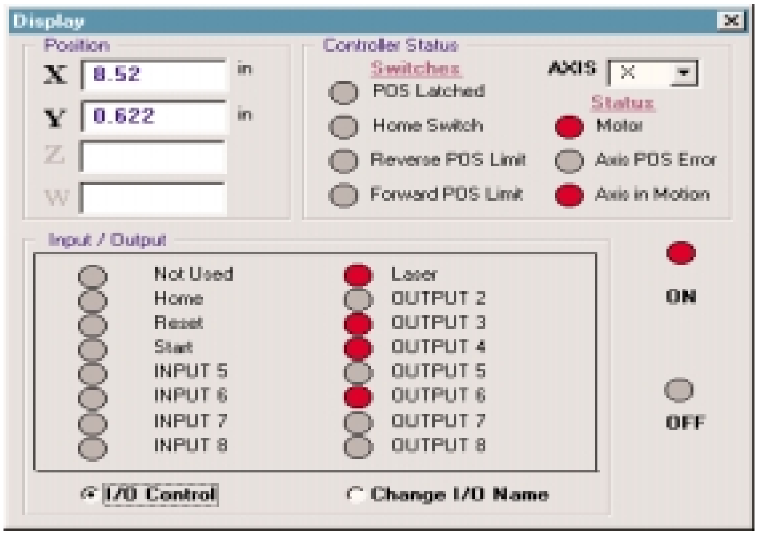
○ Input / Output

Axis: X

Figure 5.85 - Controller Parameters

Display

As shown in Fig. 5.86, the display window shows the position of each axis, input/output status, status of dedicated input switches and system status. Position is displayed in the unit that was selected in controller setup. The digital I/O status is shown as red for ON and gray for OFF state. The I/O name can be modified by clicking the "change I/O name" option and then selecting the I/O channel. When choosing the "I/O control" option, you can toggle the controller outputs by clicking the output status indicators on the screen. Position latch, home, reverse and forward position limit switches, and controller status of the selected axis are displayed for troubleshooting.



Display

Position

X 8.52 in

Y 0.622 in

Z

W

Controller Status

AXIS: X

Switches		Status	
○	POS Latched		
○	Home Switch	●	Motor
○	Reverse POS Limit	○	Axis POS Error
○	Forward POS Limit	●	Axis in Motion

Input / Output

○	Not Used	●	Laser
○	Home	○	OUTPUT 2
○	Reset	●	OUTPUT 3
○	Start	●	OUTPUT 4
○	INPUT 5	○	OUTPUT 5
○	INPUT 6	●	OUTPUT 6
○	INPUT 7	○	OUTPUT 7
○	INPUT 8	○	OUTPUT 8

● ON

○ OFF

● I/O Control ○ Change I/O Name

Figure 5.86 - Display Panel

Jog

A jog window, as shown in Fig. 5.87, is displayed after clicking the “JOG” toolbar button on the Main Window. The “JOG” panel includes independent axis move and two dimensional coordinated motion.

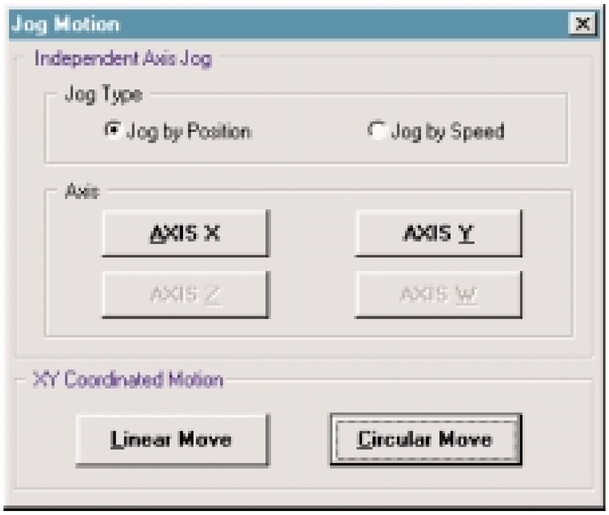


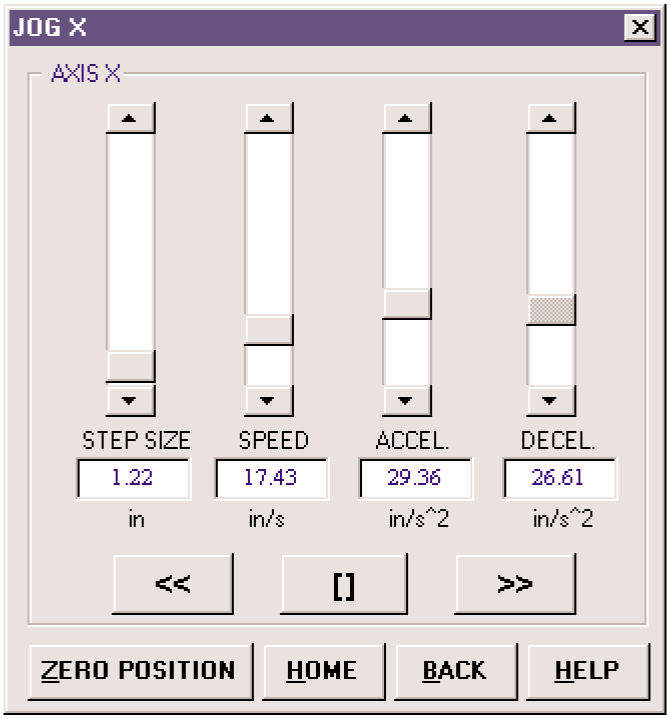
Figure 5.87 - Jog Motion Main Window

JOG BY POSITION

Clicking “axis X” for independent “jog by position motion” will bring up the window, as shown in Fig. 5.88, to configure jog motion parameters. Use the scroll bar or enter values in the text field and hit ENTER to specify incremental displacement, speed, acceleration, and deceleration in the user’s unit for an independent jog. Then

click “>>” button to move forward,
click “<<” button to jog backward, or
click “[]” button to stop.

Hit “BACK” button to go back to previous window. The “ZERO POSITION” button to set current position to zero or “HOME” button to perform homing routine.



STEP SIZE 1.22 in

SPEED 17.43 in/s

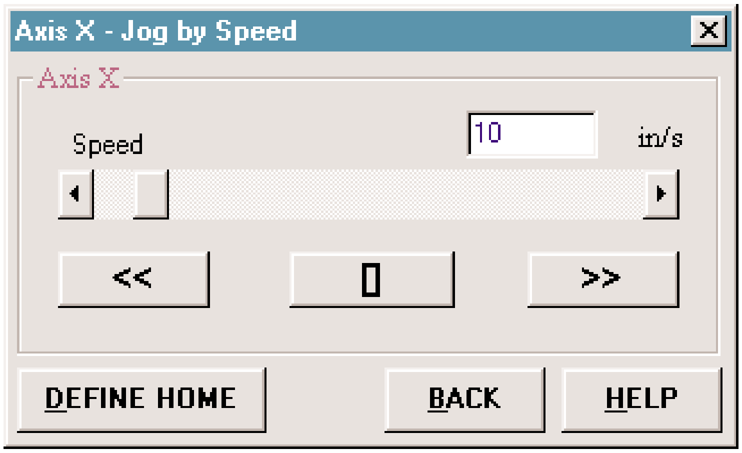
ACCEL. 29.36 in/s^2

DECEL. 26.61 in/s^2

Figure 5.88 - Independent Jog by Incremental Position

JOG BY SPEED

Clicking “axis Z” for independent “jog by speed” motion will pop up the window, as shown in Fig. 5.89. Specify the jog speed by using the scroll bar or enter the desired value in the text field. Then click “>>” button to jog forward, “<<” button to jog backward, or “[]” button to stop.



Speed 10 in/s

Figure 5.89 - Independent Jog by Speed

JOG

TWO-AXIS (XY) JOG: LINEAR INTERPOLATION:

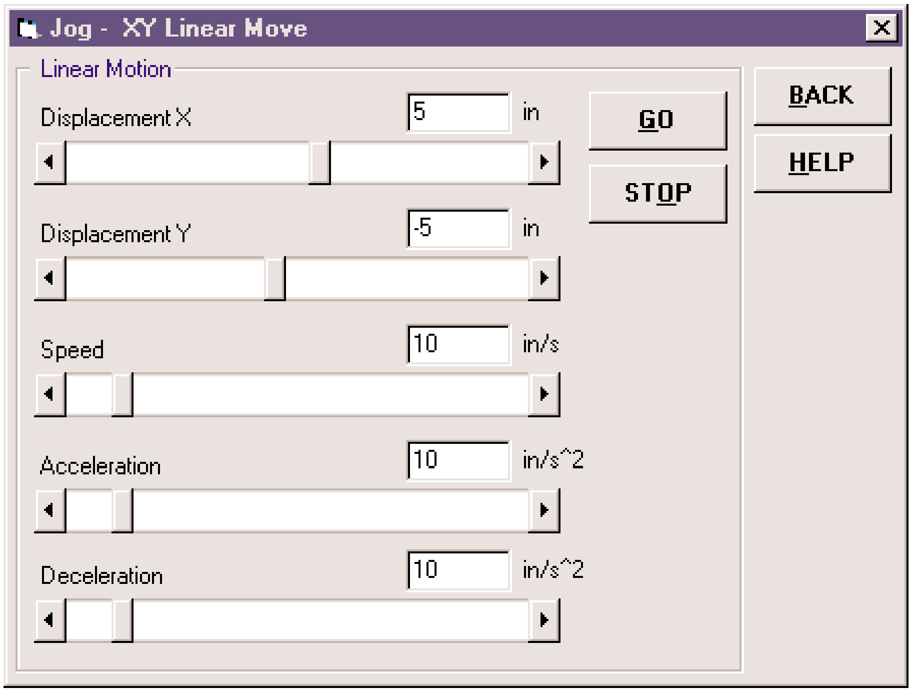
Click the “Linear Move” in the jog motion panel as shown in Fig. 5.87. A linear interpolation panel will show up as in Fig. 5.90. Use scroll bar or enter desired values in text field and hit ENTER to specify incremental displacement, vector speed, acceleration, and deceleration. Then
click “GO” button to begin the jog motion, or
click “STOP” button to terminate motion.

Click “BACK” button to go back to the previous window.

CIRCULAR INTERPOLATION:

To perform two-dimensional circular motion, click the “Circular Move” in the jog motion panel as shown in Fig. 5.87. An XY circular move panel will display as shown in Fig. 5.91. Use the scroll bar or enter values in the text field and hit enter to specify arc radius, start angle (in degree), sweep angle (in degree), vector speed, acceleration, and deceleration. Then
click “GO” button to start arc move, or
click “STOP” button to stop motion.

Click “BACK” button to go back to previous window.



Jog - XY Linear Move

Linear Motion

Displacement X 5 in

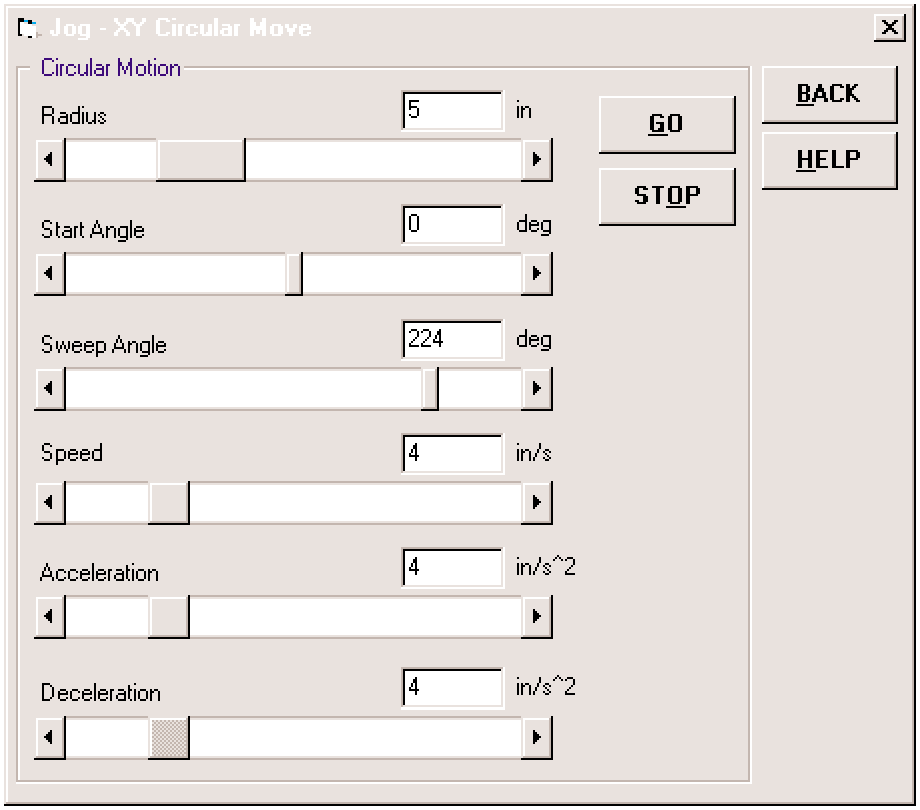
Displacement Y -5 in

Speed 10 in/s

Acceleration 10 in/s^2

Deceleration 10 in/s^2

Figure 5.90 - Linear Interpolation Panel



Jog - XY Circular Move

Circular Motion

Radius 5 in

Start Angle 0 deg

Sweep Angle 224 deg

Speed 4 in/s

Acceleration 4 in/s^2

Deceleration 4 in/s^2

Figure 5.91 - Circular Interpolation Panel

Teach By Joystick

The teach by joystick window, as shown in Fig. 5.92, has been designed for two axes (XY) applications. Enable the joystick function by clicking the “Enable” option. Use the joystick to move the actuators to a desired position. Specify motion parameters (speed, acceleration, and deceleration) and click the left button (RECORD) on the joystick to record data. You can also use the “WAIT” button to place a wait statement in the teaching sequence. After finishing a series of data acquisitions, click the right button (DONE) on the joystick to terminate the teach mode. Use “OUTPUT” button to trigger single/multiple output(s) between moves. (See Figures 5.92, 5.94 and 5.95.)

“Step by step” or “continuous” play back options are available under the play back sub window. Use the “Edit” menu to edit the speed, acceleration and deceleration associated with each move. (See Figure 5.93) Collected data can be saved into a disk file by choosing the “Save Teach Data” option under the “File” menu. Also, the program code to perform the teach operation can be saved as a module that can be imported into programs.

TEACH BY JOYSTICK

Use “Save Code As Module” to save teach motion code. To import the teach motion module,use the import module command under the file menu when creating program.

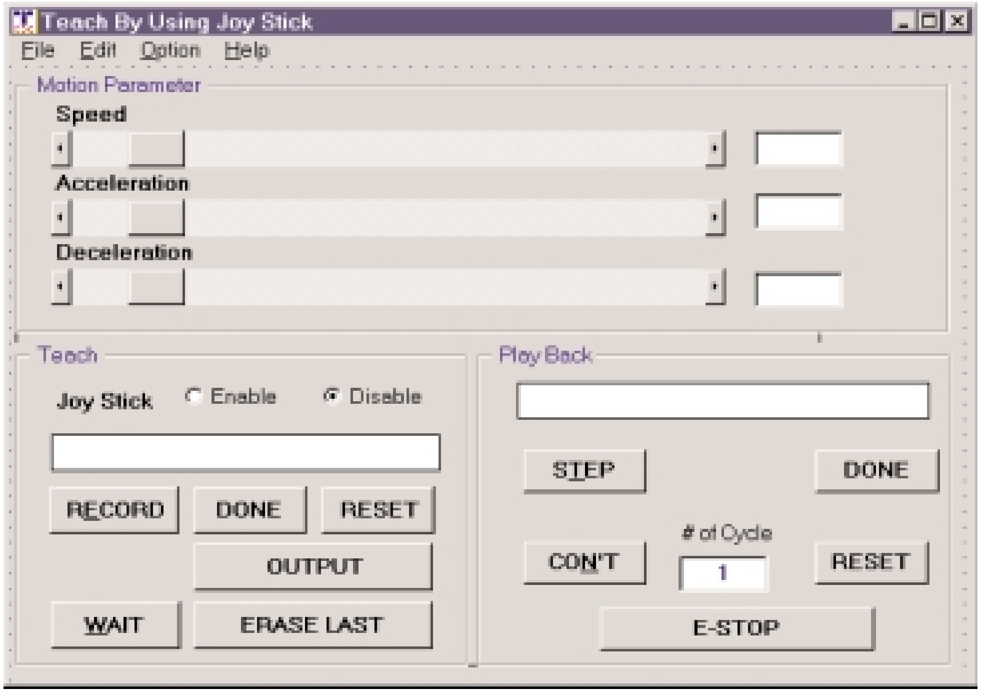
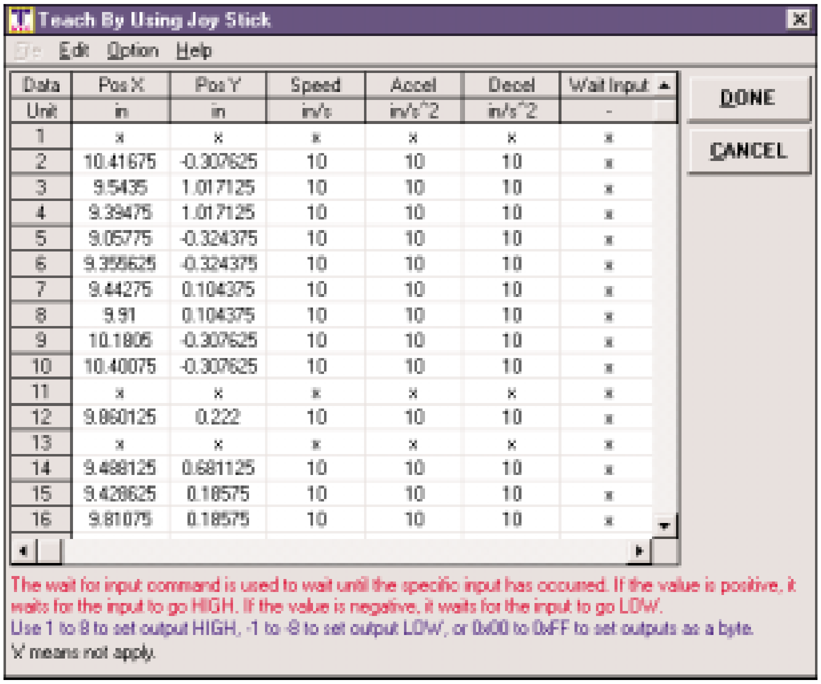


Figure 5.92 - Teach By Joystick



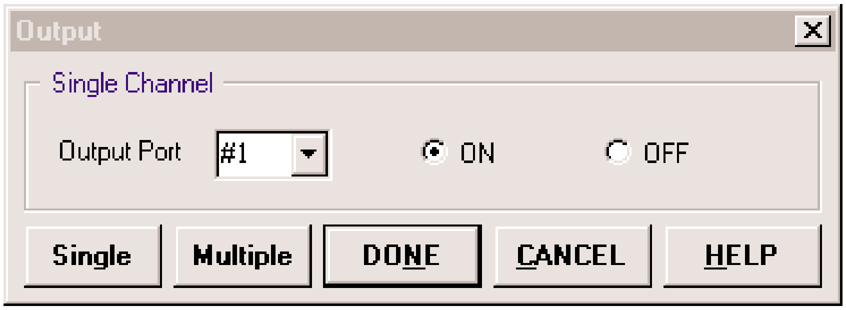
Data	Pos X	Pos Y	Speed	Accel	Decel	Wait Input
Unit	in	in	in/s	in/s^2	in/s^2	-
1	x	x	x	x	x	x
2	10.41675	-0.307625	10	10	10	x
3	9.5435	1.017125	10	10	10	x
4	9.39475	1.017125	10	10	10	x
5	9.05775	-0.324375	10	10	10	x
6	9.355625	-0.324375	10	10	10	x
7	9.44275	0.104375	10	10	10	x
8	9.91	0.104375	10	10	10	x
9	10.1805	-0.307625	10	10	10	x
10	10.40075	-0.307625	10	10	10	x
11	x	x	x	x	x	x
12	9.860125	0.222	10	10	10	x
13	x	x	x	x	x	x
14	9.488125	0.681125	10	10	10	x
15	9.428625	0.18575	10	10	10	x
16	9.81075	0.18575	10	10	10	x

The wait for input command is used to wait until the specific input has occured. If the value is positive, it waits for the input to go HIGH. If the value is negative, it waits for the input to go LOW.

Use 1 to 8 to set output HIGH, -1 to -8 to set output LOW, or 0x00 to 0xFF to set outputs as a byte.

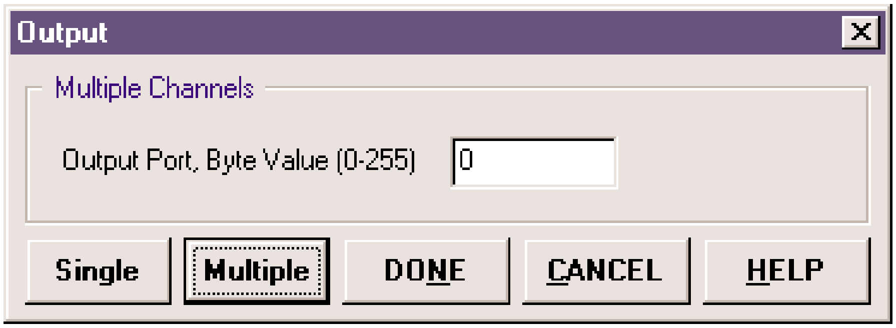
'X' means not apply.

Figure 5.93 - Edit Teach Data



Output Port #1 ● ON ○ OFF

Figure 5.94 - Single Output

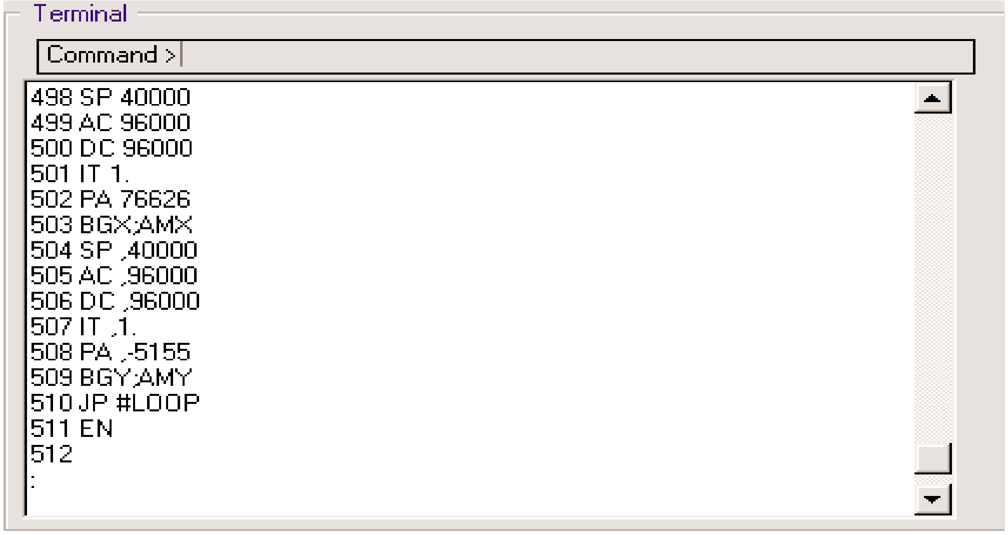


Output Port, Byte Value (0-255) 0

Figure 5.95 - Multiple Outputs

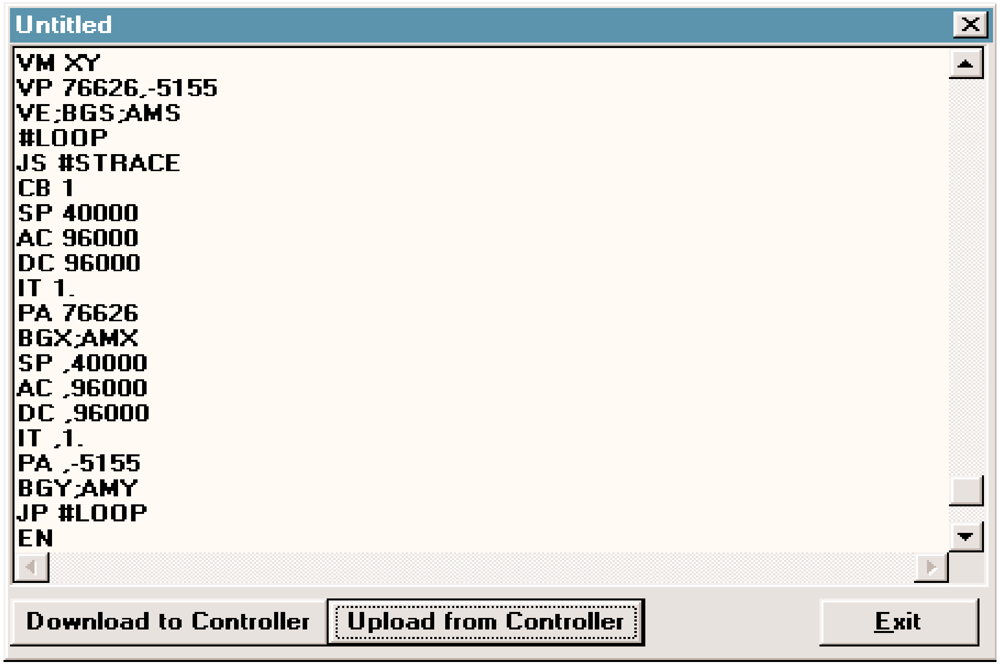
Terminal

A terminal window, as shown in Fig. 5.100, is available for the user to directly communicate with the controller using the controller's two-letter motion language. Access Terminal from the Online Main Panel toolbar button. Within Terminal an "EDITOR" is available for programming using the two-letter motion control language. The program code can be downloaded or uploaded using the editor, as shown in Fig. 5.101. However, the program function, provides English commands to allow the user to learn and become efficient in programming with very little practice.



```
498 SP 40000
499 AC 96000
500 DC 96000
501 IT 1.
502 PA 76626
503 BGX;AMX
504 SP ,40000
505 AC ,96000
506 DC ,96000
507 IT ,1.
508 PA ,-5155
509 BGY;AMY
510 JP #LOOP
511 EN
512
:
```

Figure 5.100 - Terminal Panel



```
VM XY
VP 76626,-5155
VE;BGS;AMS
#LOOP
JS #STRACE
CB 1
SP 40000
AC 96000
DC 96000
IT 1.
PA 76626
BGX;AMX
SP ,40000
AC ,96000
DC ,96000
IT ,1.
PA ,-5155
BGY;AMY
JP #LOOP
EN
```

Figure 5.101 - Program Editor

Scope

A data acquisition panel, as shown in Fig. 5.102, is available for collecting system data from position, position error, 2nd encoder position, commanded position, latch, stop code, switches and torque. Collected data can be saved to a disk file for post analysis.

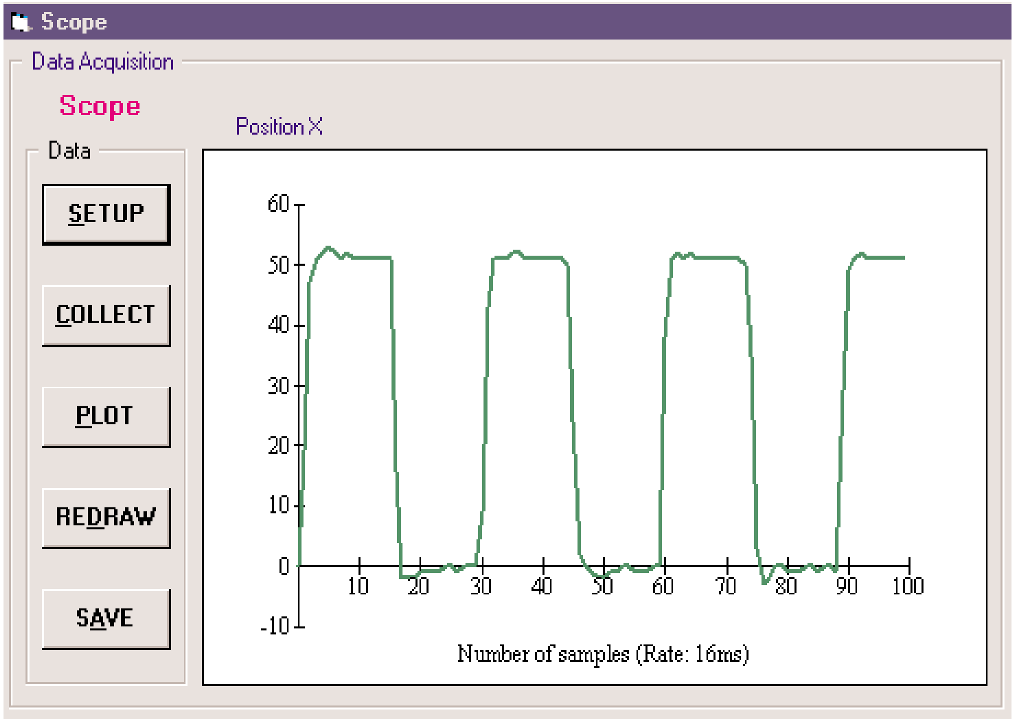
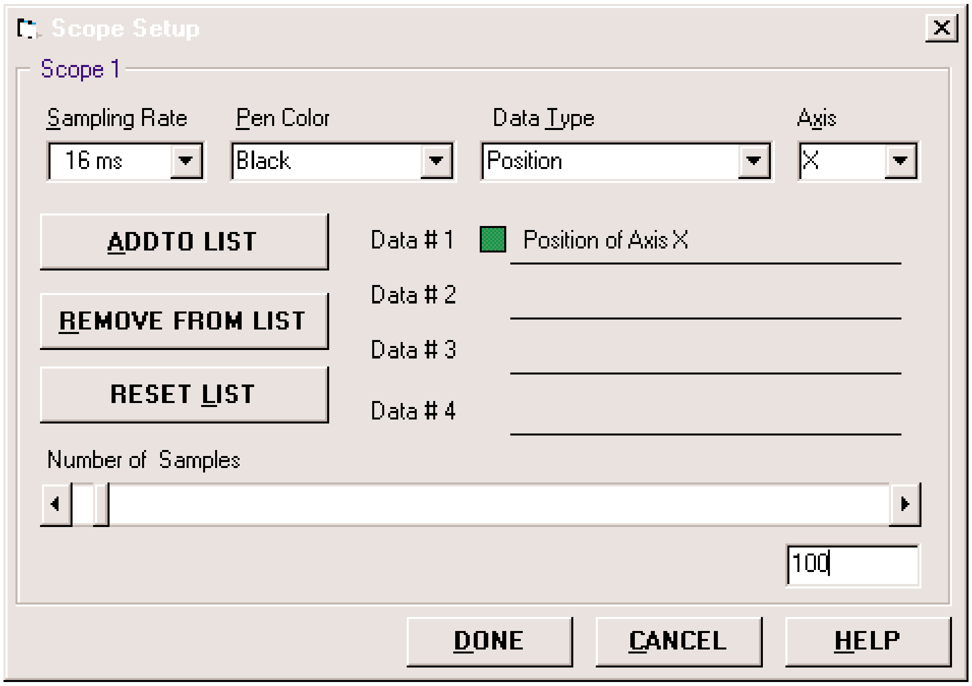


Figure 5.102 - Data Acquisition

Clicking “SETUP”, will pop up a setup window as shown in Fig. 5.103, to configure data type, sampling rate, number and samples and pen color for acquisition. Up to four data can be collected simultaneously by the motion controller.

After setup, click the “COLLECT” button to select the start time for data collection. (See Figure 5.104.) The “START” button starts data collection after the selected condition.

Time required for data acquisition depends on the sampling rate and number of samples specified in the setup window. When the controller is done with the data collection, click the “PLOT” button to display the data. Use “REDRAW” to redraw the data curves and “SAVE” to save acquired data into a disk file.



Scope Setup

Scope 1

Sampling Rate: 16 ms

Pen Color: Black

Data Type: Position

Axis: X

Data # 1 🟩 Position of Axis X

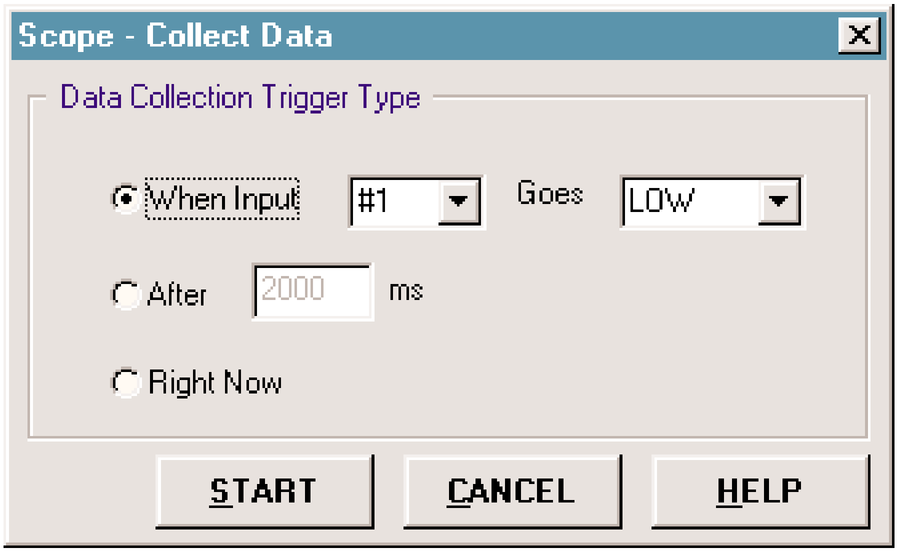
Data # 2

Data # 3

Data # 4

Number of Samples: 100

Figure 5.103 - Scope Setup



Scope - Collect Data

Data Collection Trigger Type

● When Input #1 Goes LOW

○ After 2000 ms

○ Right Now

Figure 5.104 - Collect Data

Tune

Auto tuning and manual tuning methods are available to adjust the PID gains of the controller. After clicking the “TUNE” button, the tuning method window will show up as in Fig. 5.104. Select the desired tuning method either automatic tuning or manual tuning.

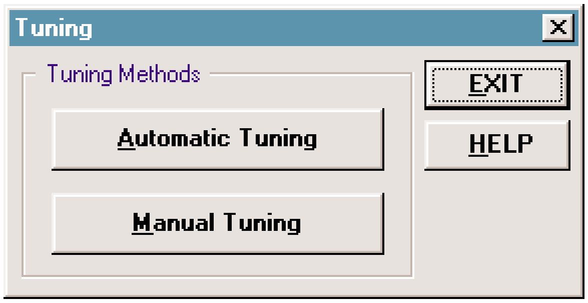
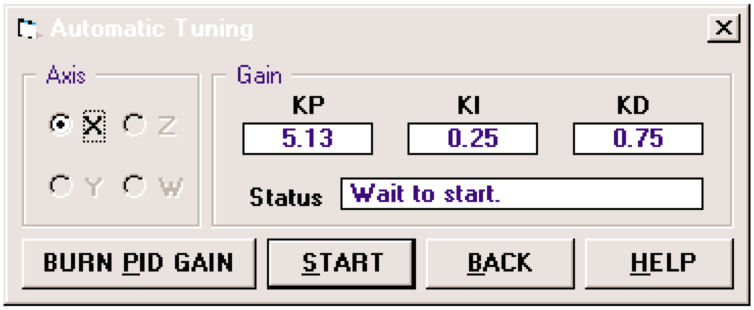


Figure 5.105 - Tuning Methods

AUTOMATIC TUNING:

In automatic tuning mode, see Fig. 3.106, specify the axis to tune and the current PID gains for that selected axis will be displayed. Confirm that drive is connected properly and enabled. Automatic tuning will move the actuator back and forth while increasing the KD and KP. When KP and KD have been determined, KI is increased until desired response is achieved. Click “START” to begin auto tuning. When tuning is complete, the recommended PID gains are shown. Use the “SAVE PID GAIN” button to save PID settings in the controller’s memory permanently.



● X ○ Z
○ Y ○ W

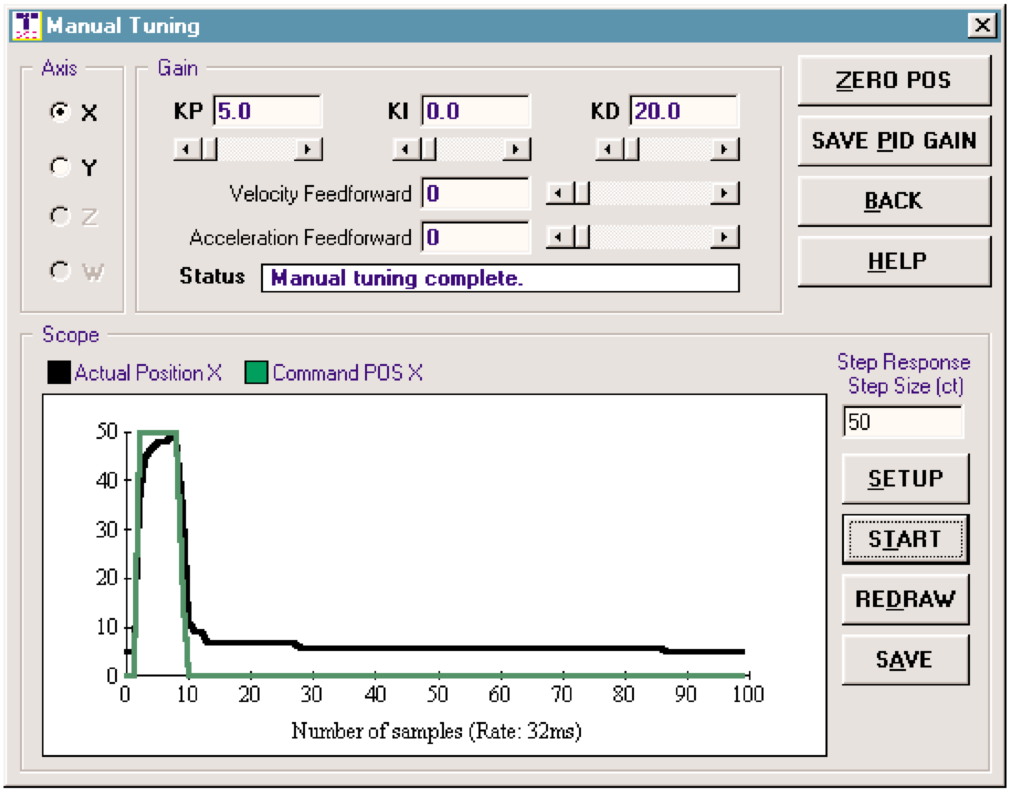
KP	KI	KD
5.13	0.25	0.75

Status: Wait to start.

Figure 5.106 - Auto Tuning

MANUAL TUNING:

In manual tuning mode, see Fig. 107, specify the axis to tune and the current PID gains and feedforward velocity and acceleration for that selected axis will be displayed. Adjust the PID gain settings and the feedforward coefficients by using the scroll bar (or arrows) under of next to the display.



Axis: ● X ○ Y ○ Z ○ W

KP 5.0 KI 0.0 KD 20.0

Velocity Feedforward 0

Acceleration Feedforward 0

Status Manual tuning complete.

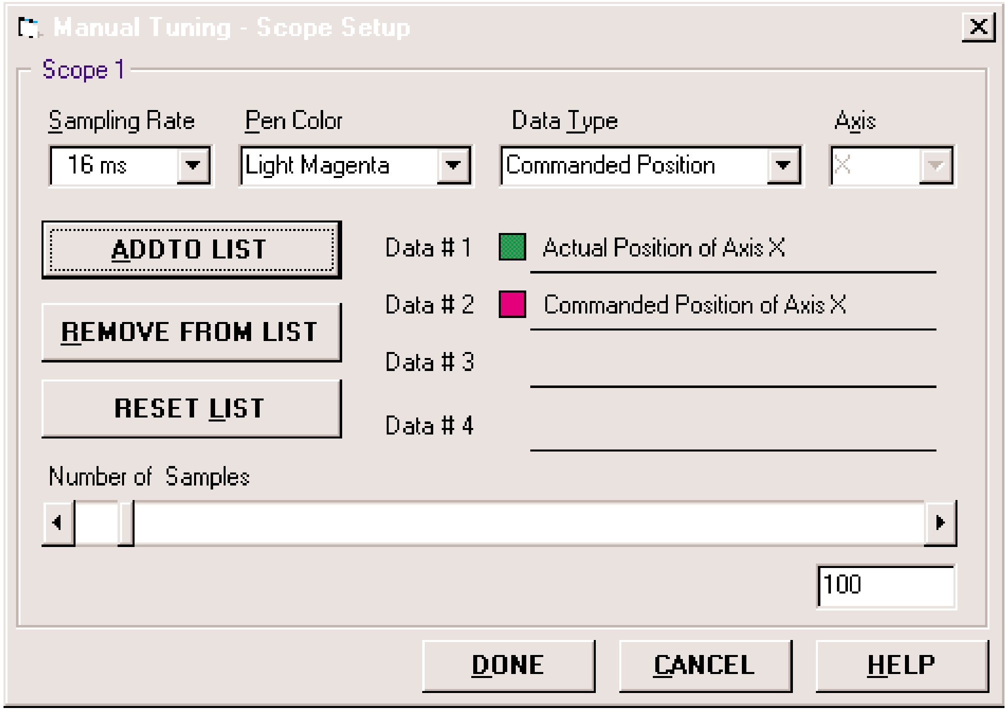
Step Response Step Size (ct) 50

Figure 5.107 - Manual Tuning

Use the “SETUP” button (see figure 5.108) to setup the scope to collect the “Actual Position” and the “Commanded Position” of the axis that is being tuned. Configure the data type, sampling rate, number of samples and pen color. Up to four channels of data can be collected simultaneously by the motion controller. The “Step Response Step Size (ct)” is based on encoder counts, a step size should be entered to give the desired amount of actuator movement. The “Zero position” button should be clicked before the tuning cycle is started to zero out the graph. The “Start” button starts a manual

TUNE

tune cycle using the values entered for the PID gains. When the cycle is complete a graph is displayed showing the response of the system. The tuning data can be saved by clicking "SAVE" button. Use the "SAVE PID GAIN" button to save PID settings in the controllers non-volatile memory.



Sampling Rate: 16 ms
Pen Color: Light Magenta
Data Type: Commanded Position
Axis: X

Data # 1 🟩 Actual Position of Axis X
Data # 2 🟥 Commanded Position of Axis X
Data # 3
Data # 4

Number of Samples: 100

Figure 5.108 - Scope Setup for Manual Tuning

Tune the Servo System

The intent of this section is to give the user a basic familiarity with the operating modes of the Axiom series of servo-motor drives and how they affect tuning. The Axiom drive product line, manufactured by Tol-O-Matic, Inc., consists of three brushless servo-motor drives and one drive for brushed motors. For specific instructions on tuning the Axiom see your drive's user manual.

The brushless motor drives (DV10, DV20, and DV30) are designed to give optimum performance with modern, permanent magnet brushless AC servo-motors. The DB20 is for use with traditional brush-commutated DC servo-motors. All of these drives support two primary modes of operation when used with the SSC.

TORQUE MODE

The drive produces motor torque proportional to an analog voltage command signal. For operation in torque mode, the fundamental current control functions are accomplished automatically by the drive. When the drive is operating in torque mode, the command source is the analog input from the SSC, which can be adjusted for offset and scaled by the drive. The user need only configure the drive to select the correct motor and make sure the analog input command signal is appropriately supplied. No tuning of the PID (proportional, integral, derivative) is required in the drive. The tuning is done in the SSC by adjusting its PID values to achieve the desired response. The SSC creates a motion profile based on the distance, speed, acceleration and deceleration of the programmed motion, that determines the desired motor position at every sampling period. The closing of the position loop forces the motor to follow the desired position.

VELOCITY MODE

The drive controls motor speed in proportion to an analog voltage command signal from the controller. The fundamental control function of a servo drive operating in velocity mode is to control the rotational velocity of the connected motor with precision. This means that the control response must have a high bandwidth and enough "stiffness" to prevent external disturbances (load changes) from significantly affecting velocity regulation. Tight control of velocity allows positioning moves to be accomplished with smooth, accurate trajectories. When operated in velocity mode, Axiom series drives receive their command signal via an external, analog signal from the SSC. The SSC needs only to handle the position loop calculations to derive a velocity command by tuning the proportional gain. The drives

TUNE THE SERVO SYSTEM

require tuning of the velocity PID control algorithm, whereby velocity control bandwidth and stiffness can be tailored for maximum performance with a given application. The Axiom software provides a very powerful tuning and diagnostic interface to aid the user in achieving optimum velocity control. Tuning of the PID values in the SSC is also required.

Tuning the Controller PID filter

DESCRIPTION ON THE PID FILTER

Proportional Gain, Kp

Proportional gain is the most common form of control loop compensation. The proportional gain produces a motor command proportional to the difference between the commanded motor position and actual motor position.. The proportional gain factor defines the ratio by which a control error is multiplied to provide a value for the driving output. The effect of this action is to force the actual velocity to track the command. Increasing proportional gain generally increases bandwidth, however, system stability margins will limit the allowable gain value. Inertial loading is present, to a greater or lessor degree, in all motor control systems. The inertia seen by the motor causes velocity to lag torque. Increasing proportional gain can reduce this lag by generating relatively large driving torque levels for small position errors. Since a proportional gain term requires some finite amount of error to produce an output, proportional gain alone will not drive steady-state error completely to zero.

Integral Gain, Ki

Integral gain is applied to control loops to eliminate steady-state error and to offset changing load conditions. Integral gain in a position loop produces a component of torque command that is proportional to the integration over time of the position error. In other words, the magnitude of the torque component due to an integral term increases with both the magnitude of the position error and the length of time the error has existed. In this way, an integral term can theoretically eliminate steady-state error. Excessive integral gain will tend to produce oscillatory behavior in the control loop.

Derivative Gain, Kd

Derivative control effectively adds phase lead to a control system. The derivative term produces a torque component that is proportional to the rate of change of the position error. For example, if the actual position began to quickly decrease while the position command did not change, this would produce a positive rate of change in the position error. The derivative term would produce a proportional positive torque component. Derivative gain in the position loop can be increased to improve position smoothness and damping. Excessive derivative gain will make the control loop very “noisy”, wasting current.

Acceleration Feedforward Gain, FA

Acceleration feedforward produces a torque component proportional to the rate of change of the velocity command. This term is not part of the closed-loop velocity transfer function. As acceleration feedforward gain is increased, more torque is produced to boost command changes. One use for acceleration feedforward gain is to help compensate for large load inertias. A value of acceleration feedforward gain that is too high for the corresponding system will likely cause current noise (oscillation).

Velocity Feedforward Gain, FV

The velocity feedforward term will produce a torque component directly proportional to the command velocity. As with acceleration feedforward, velocity feedforward is not part of the closed-loop velocity control scheme. Increasing velocity feedforward gain will increase the magnitude of the torque component produced for a given velocity command. This gain can be adjusted to help compensate for viscous friction in a system. Viscous friction is friction that increases as motor speed increases. Judicious use of velocity feedforward gain can reduce velocity following error. Excessive values of velocity feedforward gain may increase “hunting” when the motor tries to remain at rest at a given position.

OPERATING A DRIVE IN TORQUE MODE

A drive may be set in torque mode for vertical applications, or for tension or force control applications. When controlling a drive in torque mode, the SSC proportional (Kp) and integral (Ki) and derivative (Kd) gains are most useful with typical systems. Acceleration feedforward gain (FA) should be applied only as necessary to help offset large load inertias. Velocity feedforward gain (FV) can probably be left at zero for most systems. If friction is causing excessive velocity following errors at high speeds, some FV gain may be helpful.

OPERATING A DRIVE IN VELOCITY MODE

When a drive is set in velocity mode, it will be tuned first for its Kp, Ki, Kd values. When controlling a drive in velocity mode the SSC proportional (Kp) is most useful with typical systems. Small amounts of derivative (Kd) and integral (Ki) gains may improve performance, but may not be needed. Acceleration feedforward gain (FA) should be applied only as necessary to help offset large load inertias. Velocity feedforward gain (FV) can probably be left at zero for most systems. If friction is causing excessive velocity following errors at high speeds, some FV gain may be helpful.

PERFORM AN AUTOMATIC TUNE

Automatic tuning should be performed when controlling a drive operating in torque mode. When controlling a drive operating in velocity mode do not perform an auto tune; instead proceed to manual tuning. An auto tune should be done to get an initial starting point for the PID filter. The auto tune routine starts by increasing the Kd then slowly incrementing the Kp and testing the response of each increment. The routine continues increasing Kd and incrementing Kp until the desired response is achieved. The routine then increased Ki and tests the position error. The auto tune may not work for all systems, if the auto tune fails to produce a PID filter with smooth motion proceed to the manual tune and restore the default values of Kp=6, Ki=0, Kd=64.

FINE TUNE RESPONSE WITH A MANUAL TUNE

Setup the scope to monitor the actual and commanded position. Set the step count (encoder counts) to a value that will create enough motor movement to get a usable response (usually about one inch). Click start to begin the motion and plot the response on the screen (remember to first click zero position before starting). The goal is for the actual position to exactly follow the commanded position. Once the actual closely follows the desired position. Change the setup of the graph to monitor the position error. The position error graph will show the error in counts during and after the motion.

SAVE THE PID VALUES

When the final values for Kd, Kp and Ki have been determined they should be burned into the EEprom memory of the SSC by clicking on “SAVE PID GAINS” button.

Notes: