ARTISAN®
TECHNOLOGY GROUP

Your **definitive** source for quality pre-owned equipment.

Artisan Technology Group
(217) 352-9330 | sales@artisantg.com | artisantg.com

Full-service, independent repair center
with experienced engineers and technicians on staff.

We buy your excess, underutilized, and idle equipment
along with credit for buybacks and trade-ins.

Custom engineering
so your equipment works exactly as you specify.

- Critical and expedited services
- In stock / Ready-to-ship
- Leasing / Rentals / Demos
- ITAR-certified secure asset solutions

Expert team | Trust guarantee | 100% satisfaction

All trademarks, brand names, and brands appearing herein are the property of their respective owners.

Find the *Tolomatic Axidyne Axiom Plus PV10* at our website: *Click HERE*

Tolomatic
EXCELLENCE *IN MOTION*®

USER GUIDE

Axiom Plus (PV)
Brushless Servo Controller / Drive



NOW WITH ANALOG INPUT

LINEAR SOLUTIONS MADE EASY

Product and Safety Notice

Use of Axiom Servo Drives

Axiom Plus systems are intended to be part of a controlled system or to operate in a stand-alone configuration. Installation and operating instructions for all system components must be observed.

Unless otherwise specified, Axiom Plus systems are intended for use in a normal industrial environment. Installation is to be in a suitable electrical cabinet capable of protecting the unit from exposure to excessive moisture, corrosive agents or excessive ambient temperatures. Installation of the hardware must only be attempted by skilled personnel and with adherence to the installation instructions in this manual. This unit does not contain any user serviceable components. Should repair or replacement of a unit become necessary, please contact the place of purchase for instructions.

Safety Notes

As with any electrical equipment, there are some possible hazards associated with the installation and use of this hardware. Please observe the following precautions. Further specific Warnings and Cautions are listed throughout this manual.

Installation and Maintenance: All installation and maintenance must be carried out by qualified personnel.

Generation: A mechanically driven motor will act as a generator. Because dangerous voltage levels may be generated, motor to drive connections must be suitably guarded to protect against electrical shock hazards.

Cables: Use only Tolomatic supplied cables, or cables deemed suitable for use by a competent person familiar with the electrical and mechanical requirements of a given application.

Supply: Axiom Plus units must be connected to a permanent power source and fused according to the instructions in this manual, in accordance with all local and national electrical codes.

Safety Requirements: The safe and proper installation and operation of this unit into a machine system is the responsibility of the machine designer and should comply with all applicable local and national safety requirements. In Europe, this is likely to include the Machinery Directive, the ElectroMagnetic Compatibility Directive and the Low Voltage Directive. In the United States this will likely include the National Electrical Code.

Mechanical Installation: Units must be installed inside an appropriate electrical cabinet providing environmental controls and protection. The minimum requirements are outlined in this manual.

Information furnished is believed to be accurate and reliable. However, Tolomatic assumes no responsibility for its use or for any errors that may appear in this document.

Tolomatic reserves the right to change the design or operation of the equipment described herein and any associated motion products without notice. Information in this document is subject to change without notice.

200909231453

Contents

Contents i

List of Figures v

Introduction ix
Graphic Symbols and Warning Classifications ix
Notices ..... *x*
Axiom Plus System Overview xiii
Power Ratings ..... *xiii*
Interface Cables ..... *xiv*
Axiom Plus Features xiv
Motor/Encoder Input ..... *xv*
Encoder Follower Input ..... *xv*
Encoder Output ..... *xv*
Digital I/O ..... *xvi*
Ac Input Power ..... *xvi*
Drive and Motor Protection Circuitry ..... *xvi*
Agency Approvals ..... *xvi*
Axiom Plus Software xvii

Chapter 1: Safety
Potential Hazards 1-1
Your Responsibilities 1-2
Safety Guidelines 1-2

Chapter 2: Theory of Operation
Discussion of Drive Technologies 2-1
Three-Phase Brushless Motors 2-1
Commutation 2-2
Brushless Servo Drives 2-3
Hall Commutated Drives 2-3
Sine Commutated Drives 2-4
Vector Drives 2-5

Chapter 3: Unpacking, Inspection and Storage
Unpacking the Drive 3-1
Inspection Procedure 3-1
Storage 3-1

Chapter 4: Physical Mounting of Drive
Physical Mounting of Drive 4-2

Chapter 5: Power Connections and Fusing
General Wiring Guidelines 5-1
Axiom Plus PV10, PV20, PV30 5-2

Chapter 6: Motor Encoder and Power Connections
General Wiring Guidelines 6-1
Axiom Plus Systems 6-2
Emergency Stop Connection 6-3

Chapter 7: Software Installation
Hardware and Software Requirements 7-1
Installation.....7-1

Chapter 8: Initial Check Out
Setup/Configuration Screen 8-1
Commands, Setup and Configuration Mode.....8-3
Indexer Model Selection/Setup 8-3
Motor Model Selection/Setup.....8-4
Phasing Configuration 8-4
Gains and Limits.....8-5
Register Precision 8-5
ModBus Configuration 8-6
Check Out Procedure 8-7

Chapter 9: I/O Connections
Inputs 9-1
Analog Inputs 9-6
Outputs 9-9

Chapter 10: Regeneration Resistor Use and Sizing
Regeneration Resistor Use and Sizing 10-1

Chapter 11: Final Checkout and Tuning
Online Tuning and Diagnosis.....11-1
Command Menu, Online Tuning/Diagnosis Mode.....11-1
Indexer Status, Fault, I/O 11-2
Oscilloscope.....11-3
Encoder Feedback Section 11-4
Drive Diagnosis Screen 11-4
Drive Tuning Screen 11-5
Drive Tuning 11-7
Auto Tuning 11-7
Manual Tuning 11-8
Analog Input Gain and Offset 11-8
Adjustments and Diagnostics 11-8

Chapter 12: Programming
Programming Environment 12-2
Sequential Program Editor 12-2
PRG Menu.....12-3
Sequential Program Debugger 12-5
User Units 12-7
Sequential Program Listing.....12-8
Creating a Sequential Motion Program Instruction 12-9
Instruction Command Set 12-10
Analog Input Position Mode 12-12
Analog Input Velocity Mode.....12-13
Analog Position Conversion Factor.....12-22
PLC Program Editor 12-28
PLC Menu 12-28

Creating / Editing a PLC Rung 12-30
Operation Details Screen 12-31
Default PLC Program 12-44

Chapter 13: Communication/Protocol

ASCII Command 13-1
RS232 Serial Communications Character Framing Settings *13-1*
Read /Write Register Value Using ASCII Commands Over RS232 Serial Port *13-1*
Reading Indexer Internal Fault and Status Identification Flag Words *13-5*
Reading Process Variable/Diagnostic Registers *13-6*
Manipulation of PLC Flags Using ASCII Serial Port Commands *13-7*
Scaling and Interpretation of Values Stored in Axiom Plus Registers *13-9*
General Analog Input Functionality Analog Register *13-11*
ModBus Communication Setting 13-12
Addressing of Slave Axiom Plus Devices 13-13
Mapping 13-14
Axiom Plus Registers into Modbus Registers 13-14
Axiom Plus Discrete I/O and Flags into ModBus 0X and 1X Memory Space 13-20
Command stream Handling, Time-Separation of Commands, Etc. 13-23
ModBus Commands Supported by Axiom Plus 13-24
Registers 13-29

Chapter 14: Examples

Indexer Type Control of the Axiom Plus 14-1
PLC Program Listing *14-1*
Sequential Program Listing *14-4*

Chapter 15: Status and Fault Display

Normal Operation 15-1
Status Codes 15-1
Faults 15-1
Fault and Status Codes 15-2

Chapter 16: Maintenance & Troubleshooting

Maintenance 16-1
Periodic Maintenance 16-1
Troubleshooting Guide 16-2

Appendix A: Options and Accessories

Cables A-1
Communications Cables A-1
Buffered Encoder Output / Auxiliary Encoder Cable A-1
Motor Cables A-2

Appendix B: Specifications
Agency Approvals B-1
Power B-1
Command Sources B-2
Serial Communication Port B-2
Control Loops B-2
Inputs and Outputs B-2
Connectors B-2
Environmental B-3
Motor Protection B-3
Regeneration Ratings B-3
Power Dissipation B-4

Appendix C: Motor Performance Data
Motor Drive Performance Curves for MRV Series Motor Drives C-1

Appendix D: Motor Dimension Drawings
Motor Dimension Drawings D-1

Appendix E: Warranty Information
Defective Equipment E-1
Return Procedure E-1
Product Support E-2
Distributor & Representative Network E-2
Application Engineers & Field Service E-2

List of Figures

Figure	Description	Page
4.1	Axiom PV10 Mounting Dimensions	4-2
4.2	Axiom PV20 and Axiom PV30 Mounting Dimensions	4-3
5.1	Axiom PV10/20/30 Single-Phase Drive Power Connections	5-2
5.2	208/230 Vac Three-Phase; Axiom PV10/20/30 Three-Phase Power Connections	5-2
6.1	PV10/20/30 Motor Power Cable Connections for MRV 2X, 3X, 5X.	6-2
6.2	PV10/20/30 Motor Encoder Connections	6-2
6.3	Emergency Stop Connection	6-3
6.4	Drive Remains Powered	6-4
8.1	Axiom Plus Setup Software Opening Screen	8-1
8.2	Setup and Configuration Screen	8-2
8.3	Register Precision Configuration Screen	8-5
8.4	ModBus Configuration Window	8-6
9.1	Axiom Plus Input Circuit Diagram	9-1
9.2	Axiom Plus Sinking Input Connected to Sourcing Switches Using Internal Power Supply	9-2
9.3	Axiom Plus Sinking Input Connected to Sourcing Switches Using External Power Supply	9-2
9.4	Axiom Plus Sinking Input Connected to Sourcing Output Using Internal Power Supply	9-3
9.5	Axiom Plus Sinking Input Connected to Sourcing Output Using External Power Supply	9-3
9.6	Axiom Plus Sourcing Input Connected to Sinking Switches Using Internal Power Supply	9-4
9.7	Axiom Plus Sourcing Input Connected to Sinking Switches Using External Power Supply	9-4
9.8	Axiom Plus Sourcing Input Connected to Sinking Outputs Using Internal Power Supply	9-5
9.9	Axiom Plus Sourcing Input Connected to Sinking Outputs Using External Power Supply	9-5
9.10	Front Panel Overlay	9-6
9.11	Single Ended and Differential Analog Input Connections	9-6
9.12	Pullup/Pulldown Wiring	9-7
9.13	Axiom Plus Output Circuit	9-9
9.14	Axiom Plus Sourcing Output Connected to Sinking Input Using Internal Power Supply	9-10
9.15	Axiom Plus Sourcing Output Connected to Sinking Input Using External Power Supply	9-10
9.16	Axiom Plus Sinking Output Connected to Sourcing Input Using Internal Power Supply	9-11
9.17	Axiom Plus Sinking Output Connected to Sourcing Input Using External Power Supply	9-11

Figure	Description	Page
9.18	Axiom Plus Sinking Output Connected to Sourcing Opto22 Solid State Relays	9-12
9.19	Axiom Plus Power Off Holding Brake Connection	9-12
10.1	Brake Connection & Regeneration Resistor Connections	10-2
11.1	Tuning and Diagnosis Screen	11-2
11.2	Drive-Stage Diagnosis Screen	11-4
11.3	Drive-Stage Tuning Screen	11-5
11.4	Tuning and Diagnostic Screen with Analog Input Calibration Function Active	11-9
12.1	Sequential Program Display / Edit Screen	12-2
12.2	Register Display Screen	12-4
12.3	I/O Flag Table Screen	12-4
12.4	Sequential Program Debugger	12-5
12.5	Watched Registers & Flags	12-6
12.6	View / Edit Default Parameters Window	12-7
12.7	Sequential Program Listing Screen	12-8
12.8	Icon Menu Window	12-8
12-9	Axis Motion Window	12-8
12-10	Absolute Position Move Window	12-11
12.11	Sequential Instruction Form for Programming of Analog Absolute Position Control	12-13
12.12	Sequential Instruction Form for Programming of Analog Absolute Velocity Control	12-14
12.13	Set/Clear Multiple Flags	12-16
12.14	Program Control Window	12-17
12.15	Branch on Analog Input Compare	12-18
12.16	Branch on Register Compare	12-19
12.17	Parameter Value Change Window	12-20
12.18	Axis Homing Routines Window	12-21
12.19	Absolute Position Feedback Mode	12-24
12.20	Register Manipulation Window	12-26
12.21	Increment/Decrement Count Register	12-27
12.22	PLC Menu and Programming Form Screen	12-28
12.23	PLC Programming Form Screen	12-30
12.24	Operation Details Screen	12-31
12.25	Operation Selection Screen	12-32
12.26	One Shot Definition Screen	12-33
12.27	Register Comparison Screen	12-34
12.28	Timer Definition Screen	12-35
12.29	Counter Definition Screen	12-36
12.30	Operand Display / Selection / Comment Screen	12-37
12.31	Indexer Control Flags Screen	12-41
12.32	Default PLC Program Example	12-44
13.1	ModBus Configuration and Setup Screen	13-12

Figure	Description	Page
14.1	PLC Program Listing	14-2
14.2	PLC Program Listing	14-3
14.3	PLC Program Listing	14-4
14.4	Sequential Program Listing	14-5
14.5	Sequential Program Listing	14-6
14.6	Sequential Program Listing	14-7
14.7	Sequential Program Listing	14-8
A.1	RS-232 Communications Cable (P/N 3600-1172)	A-1
A.2	Encoder Output Cable (P/N 3604-1213)	A-2
A.3	Tolomatic MRV Motor Connector Pinouts	A-4
C.1	MRV 11Y PV10 Single-Phase, Three-Phase Drive Performance Curves	C-1
C.2	MRV 21Y PV10 Single-Phase, Three-Phase Drive Performance Curves	C-2
C.3	MRV 22Y PV10 Single-Phase, Three-Phase Drive Performance Curves	C-2
C.4	MRV 23Y PV10 Single-Phase, Three-Phase Drive Performance Curves	C-3
C.5	MRV 24Y PV10 Single-Phase, Three-Phase Drive Performance Curves	C-3
C.6	MRV 31Y PV10 Single-Phase, Three-Phase Drive Performance Curves	C-4
C.7	MRV 31Z PV20 Single-Phase, Three-Phase Drive Performance Curves	C-4
C.8	MRV 32Y, PV20 Single-Phase, Three-Phase Drive Performance Curves	C-5
C.9	MRV 32Z PV30 Single-Phase, Three-Phase Drive Performance Curves	C-5
C.10	MRV 33Y PV30 Single-Phase, Three-Phase Drive Performance Curves	C-6
C.11	MRV 33Z PV30 Single-Phase, Three-Phase Drive Performance Curves	C-6
C.12	MRV 51Z PV30 Single-Phase, Three-Phase Drive Performance Curves	C-7
D.1	MRV 11 Motor	D-1
D.2	MRV 21/22/23/24 Motors	D-1
D.3	MRV 31/32/33 Motors	D-2
D.4	MRV 51 Motor	D-2

This manual provides step-by-step instructions for installing, controlling, tuning and maintaining your Tolomatic Axiom Plus system. It details the hardware connections necessary to operate this unit in each of its operating modes.

All Axiom series drives use Axiom® setup software installed on a personal computer running Microsoft Windows® 95, 98, NT or XP operating system. The software utilizes a graphical user interface, allowing point and click setup and tuning of the drive when used with Tolomatic servo motors.

Graphic Symbols and Warning Classifications



Protective Conductor terminal (Earth ground)



Chassis terminal (Not a protective ground)



Risk of Electrical Shock symbol

The use of the following symbols and signal words is based on an estimation of the likelihood of exposure to the hazardous situation and what could happen as a result of exposure to the hazard. ***DANGER, WARNING*** or ***CAUTION*** require accompanying information notices to prevent potential personal injury and equipment damage.

Classifications include:



DANGER! Indicates a very hazardous situation which, if not avoided, could result in death or serious injury. This signal word is limited to the most extreme situations.



WARNING! Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.



Caution! Indicates a potentially hazardous situation which, if not avoided, may result in property damage or minor to moderate injury.

NOTICES

Danger Notices



DANGER! Adjustment, operation and service of this equipment should only be performed by qualified electrical personnel familiar with its operation and hazards. Read and understand this manual before attempting installation or operation of this equipment. Failure to observe this precaution could result in serious bodily injury or loss of life.



DANGER! The user of this equipment is responsible for observing all local, national and international codes. Proper grounding, wiring practice, disconnects and overcurrent protection are of particular importance. Failure to observe this precaution could result in serious bodily injury or loss of life.



DANGER! Any shielded power cables must be grounded in at least one place for safety. Failure to ground the shield of a shielded power cable could result in potentially lethal voltages being present on the shield and anything connected to it.



DANGER! The DC bus capacitors may retain a hazardous voltage level for a period of time after input power has been removed. After disconnecting power, wait for the time period listed on the front of the unit before servicing. This allows the bus capacitors time to bleed down to a safe voltage level. Failure to observe this precaution could result in serious bodily injury or loss of life.

Warning Notices



WARNING! Always perform initial motor checkout with the motor disconnected from the load. Remove keys or loose couplings from the motor shaft to prevent injury from flying metal parts. Improper wiring could result in unexpected motor movement. Be prepared to remove power if improper motor movement occurs.



WARNING! Full DC bus voltage is present at the regeneration resistor terminals. Treat them with the same respect and practice as the power and motor drive connections.



WARNING! Large leakage currents exist in AC line filters. They must be grounded properly before applying power. Filter capacitors retain high voltages after power removal. Before handling the equipment, voltages should be measured to determine safe levels prior to handling the equipment. Failure to observe this precaution could result in severe bodily injury.



WARNING! The circuits in the Axiom Plus are potential sources of severe electrical shock. Follow all safety guidelines to avoid shock.



WARNING! Rotating motor shafts can cause extensive damage and injury. Motors must be properly guarded during testing and in the final installation.



WARNING! The user must provide an external, hard-wired emergency stop circuit in addition to the controller circuitry. This circuit must remove power from the system in case of improper operation. The drive enable is not adequate for this purpose, as it does not remove supply voltage from the unit and may not disable the system in all circumstances. Uncontrolled machine operation may result if this procedure is not followed. Failure to observe this precaution could result in severe bodily injury.



WARNING! High voltage may be present on the terminals of the unit. Remove power and disconnect the power cable before making or removing any connection. Again mention wait for bus bleed-down.

Caution Notices



Caution! Do not tin (solder) the exposed leads on cables. Tinned leads will loosen in time and may come loose from their screw terminal connections.



Caution! Ensure that encoder signals are connected properly. Incorrect connection of encoder signals will result in a “run away” motor condition and/or incorrect commutation.



Caution! Electronic components are subject to damage by static electricity. Follow Electrostatic Discharge (ESD) practices while handling components.



Caution! If the cabinet is ventilated, use filtered or conditioned air to prevent the accumulation of dust and dirt on electronic components. The air should be free of oil, corrosives, or electrically conductive contaminates.

Axiom Plus System Overview

The Axiom Plus unit uses a high speed Digital Signal Processor (DSP) to perform all calculations necessary for high bandwidth, digital control of three-phase brushless servo motors. All tuning parameters are set and stored digitally using the Axiom Plus setup software. In addition, the unit includes a 1-1/2 axis controller function with user assignable I/O and an integrated PLC.

With brushless motors, the Axiom Plus incorporates state-of-the-art Space Vector Commutation to give 12.5% better bus voltage utilization than traditional sinusoidal commutation drives. This allows for improved motor speed/torque performance over older technology trapezoidal or sinusoidal motor drives.

In addition, the Axiom Plus implements a Flux Vector, or field oriented, current control algorithm. This allows for precise, high bandwidth current control in each individual motor phase and minimizes torque variations due to slight phase-to-phase differences within a motor's windings. It also minimizes non-torque producing motor current for less motor heating and better speed/ torque performance than with traditional trapezoidal and sinusoidal control algorithms.

POWER RATINGS

Three power levels of Axiom Plus are available.

- Axiom Plus PV10 with a continuous current rating of 5A and a peak rating of 10A from a single or three phase power source.
- Axiom Plus PV20 with a continuous current rating of 10A and a peak rating of 20A from a single or three phase power source.
- Axiom Plus PV30 with a continuous current rating of 15A and a peak rating of 30A from a single or three phase power source.

The Axiom Plus system, when combined with Tolomatic MRV series brushless servo motors, can provide continuous torque up to 75 lb-in (10.7 Nm), peak torque up to 150 lb-in (21.4 Nm) and speeds up to 6000 RPM.

INTERFACE CABLES

Standard motor power and encoder feedback cables, as well as communications cables, are available to complete the motion control system and provide reliable, trouble free start-up. For a description of optional equipment, refer to Appendix A: Options and Accessories.

Axiom Plus System Features

Sequential Motion Control - An easy to use sequential motion control programming environment.

PLC Programming - Provides a method to create more complex motion control programs than can be done with a sequential controller alone.

State-of-the-Art Space Vector Commutation - Provides 12.5% better bus voltage utilization than traditional sinusoidal commutation drives.

State-of-the-art Flux Vector Motor Current Control - Allows higher bandwidth control of torque producing current than traditional Sinusoidal approach. Flux Vector control also improves overall efficiency by reducing harmonic currents in motor windings. Flux Vector control is also known as field-oriented control.

High Performance Digital Signal Processor (DSP) Technology - Allows for the implementation of advanced brushless motor control algorithms.

Digital Current, Velocity and Position Calculations - Provide for high bandwidth motor control while minimizing drift and aging problems inherent in traditional analog drives.

Standard Features:

- 15 optically isolated inputs with 5-25 Vdc range (if analog is not used)
- 8 optically isolated outputs with 5-25 Vdc range
- One 14-bit analog input (±10Vac)-full differential – 12 optically isolated inputs with 5-25Vdc range
- Built-in 24Vdc 400mA power supply

- Built-in 1-1/2 axis programmable motion controller
- Built-in real-time scanned “PLC” for complex machine control tasks
- Encoder Follower input
- Designed for use with Tolomatic MRV series brushless motors.
- Pluggable terminal block connections for ease of Installation.
- Continuous output ratings of 5A, 10A and 15A.
- Peak output ratings of 10A, 20A and 30A. (3 sec. peak)
- Buffered encoder output.
- 115/208/230Vac input, 50/60Hz, single or three phase.
- Short-circuit protection.
- Overcurrent protection.
- Bus over-voltage shutdown.
- Internal bus current regeneration.
- Connection for additional external regeneration capacity.
- Motor and Drive thermal protection.
- Auto-Phasing: Requires no Hall Effect switches for phasing or commutation.
- RS-232 communications, including ASCII and Modbus RTU protocols
- Windows-based software for setup, tuning and diagnostics.
- Integral 3A brake relay.
- Front panel status and fault display indicators.

MOTOR/ENCODER INPUT

A single, motor-mounted optical encoder provides complete commutation information as well as position and velocity feedback. The input can accept a wide range of encoder line counts at quadrature rates up to 4MHz.

ENCODER FOLLOWER INPUT

This input provides power (5Vdc) for an incremental quadrature (A & B channel) differential output encoder and provides the input command for all gearing functions.

ENCODER OUTPUT

The Axiom Plus incorporates a buffered encoder output signal for connection to a motion controller. This is a 5Vdc differential signal.

I/O – INPUT OUTPUT

The Axiom Plus unit incorporates several dedicated discrete I/O connections.

- Brake Relay Output - A 3A relay contact for connection to an actuator or motor shaft-mounted “energize-to-release”-type brake.
- Motor Temp Input - Connection for a motor’s internal temperature switch. This requires a normally closed (N.C.) connection. If this connection is broken, the unit shuts down and displays the appropriate fault on the fault indicator.
- Total of 15 Assignable Inputs / 5-25 Vdc range
- Total of 8 Assignable Outputs
- I/O controlled from sequential motion program or “PLC”
- One ±10 Vac analog input range

ANALOG INPUT

- 14-bit
- ±10 volt differential
- Scale and offset adjustments
- ±2 LSB’s accuracy over full scale input range

AC INPUT POWER

Axiom Plus units are powered directly from a single-phase or three-phase ac main. The drive accepts nominal input voltages of 115Vac, 208Vac or 230Vac. The input range is switch selectable. The 115V selection is for 115Vac operation. The 230V selection is for 208Vac or 230Vac operation.



Caution! Failure to make the correct switch selection for the supplied voltage will result in the drive entering a fault condition when power is applied. The drive will not operate until powered down and switched correctly.

DRIVE AND MOTOR PROTECTION CIRCUITRY

- Seven-segment LED display provides drive status and fault codes at a glance
- Over-temperature, short circuit and over-current protection for the power output
- Peak and continuous current limits

- Bus over-voltage and under-voltage
- Motor over-speed protection
- Watchdog timers provide fail-safe operation

AGENCY APPROVALS

The Axiom Plus is UL approved and CE certified.

Axiom Plus Software

All drive/motor setup, tuning and programming is accomplished with the Axiom Plus setup software. This is a Windows-based graphical interface that communicates through the drive's RS-232 serial communications port. Windows 95, 98, NT and XP are supported.

- The software allows easy selection of any Tolomatic MRV series brushless servo motor.

- The software provides a user friendly "on-screen" oscilloscope and diagnostic screen for tuning and troubleshooting.

- The software incorporates a "point-and-click" editor for entering the user's sequential motion program and "PLC" ladder logic program.

- Digital auto-tuning allows easy setup. All tuning adjustments are made via software to immediately set servo system compensation parameters, thus eliminating time-consuming potentiometer adjustment.

This page intentionally left blank

Before you begin...

Please read this manual in its entirety before attempting to install or operate the unit. In this way, risk of injury, damage or wasted time and effort can be minimized.

Potential Hazards

The equipment described in this manual is intended for use in industrial drive systems. This equipment can endanger life through rotating machinery and high voltages, and so it is essential that guards for both electrical and mechanical parts are not removed.

Hazards which can be encountered in the use of this equipment include:

- Electric Shock
- Electric Fire
- Mechanical
- Stored Energy

These hazards must be controlled by suitable machine design, using the safety guidelines which follow. There are no chemical or ionizing radiation hazards.

VOLTAGE POTENTIALS



DANGER! DC bus capacitors may retain hazardous voltages after input power has been removed. Before working on the unit, wait the full time interval listed on the warning on the front of the unit. Failure to observe this precaution could result in severe bodily injury or loss of life.

Voltage potentials for the internal drive circuitry vary from 325 Volts above to 325 Volts below earth ground for a 230 Volt input. Voltages can reach 400 Vdc within the unit. All circuits, including the connections on the front panel, should be considered “hot” when power is connected and for the time specified in the warning on the front of the unit after power is removed.

Your Responsibilities

As the user or person installing this product, you are responsible for determining the suitability of the product for the intended application. Tolomatic is neither responsible nor liable for indirect or consequential damage resulting from the inappropriate use of this product.

A qualified person is someone who is familiar with all safety codes and established safety practices, pertaining to the installation, operation and maintenance of this equipment and the hazards involved. For more detailed definitions, refer to IEC 364.

It is recommended that anyone who operates or maintains electrical or mechanical equipment should have a basic knowledge of First Aid. As a minimum, they should know where the First Aid equipment is kept and the identity of the official First Aid personnel.

These safety notes do not represent a complete list of the steps necessary to ensure safe operation of the equipment. For further information, please contact the nearest Tolomatic distributor.

Safety Guidelines

Electrical shock and fire hazards can be avoided by using normal installation procedures for electrical power equipment in an industrial environment. Installation must be undertaken by suitably qualified personnel. Note that this amplifier must be installed in an industrial cabinet such that access is restricted to suitably qualified personnel.

Mechanical hazards are associated with potentially uncontrolled movement of the motor shaft. If this imposes a risk in the machine, appropriate precautions must be made to electrically disconnect the motor from the unit when personnel have access to moving parts of the machine. Note also that the motor must be securely mounted at all times.

Stored energy hazards are both electrical and mechanical.

1. Electrical hazards can be avoided by disconnecting the Axiom Plus from its power source and waiting for the time indicated in the warning on the front of the unit prior to removing the protective covers or touching any connections.

2. Mechanical hazards require a risk analysis on the effects of stored mechanical energy when the machine is running at speed, as well as the potential for the conversion of electrical energy stored in the unit being converted to mechanical energy. Electrical energy may be stored in the Axiom Plus for the time indicated in the warning on the front of the unit.

   The following points should be observed for the safety of personnel:

- Only qualified personnel familiar with the equipment are permitted to install, operate and maintain the device.
- System documentation must be available and observed at all times.
- All non-qualified personnel should maintain a safe distance from the equipment.
- The system must be installed in accordance with local regulations.
- The equipment is intended for permanent connection to a main power input. It is NOT intended for use with a portable power input.
- DO NOT power up the unit without all guards and covers in place.
- DO NOT operate the unit without connecting the motor conductors to the appropriate terminals.
- Always remove power before making or removing any connection on the unit. Failure to observe this condition could result in injury or damage to equipment.
- DO NOT remove cover from unit. There are no internal user serviceable parts or adjustments required.
- DO NOT make any connections to the internal circuitry. Connections on the front panel are the only points where users should make connections.
- Be careful of the line voltage input, motor output and shunt terminals. High voltage is present when power is applied to the unit.
- DO NOT use the ENABLE input as a safety shutdown. Always remove power before maintaining or repairing the unit.

This page intentionally left blank

Theory of Operation 2

Discussion of Drive Technologies

Axiom Plus units include a state-of-the-art Vector drive designed to drive three-phase brushless servo motors. This type of drive offers several performance improvements over conventional "six-step," "trapezoidal," or "sine" commutation brushless servo drives.

Three-Phase Brushless Motors

Three-phase brushless servo motors employ a three-phase, wye-connected motor winding wound on the stator, or stationary outer part of the motor. The rotor has permanent magnets installed. A two-pole motor has one North-South pole pair (two poles) and a four-pole motor has two North-South pole pairs (four poles).

There are several advantages to this configuration over a conventional DC brush commutated servo motor.

- Because the windings are wound on the stator rather than the rotor (armature), much better heat transfer occurs between the heat generating windings and the outside environment. This allows a more powerful motor to be built in a smaller package without encountering overheating problems.

- Because only the relatively small magnets are mounted on the rotor, brushless servo motors can be built with much lower rotor inertia than brush motors. This facilitates higher bandwidth response and enables motors with much higher maximum speeds to be built economically.

- As the name implies, these motors are brushless. This means there are no motor brushes to wear out. This translates into less maintenance. In fact, there is no reason why a properly sized brushless servo motor cannot provide years of maintenance-free operation.

As with most technological improvements, there are some disadvantages or difficulties inherent in brushless servo motor technology. The primary one is the need for more sophisticated drive technology to electronically commutate the motor.

Commutation

Any time electrical current flows in a wire or coil of wires, a magnetic field is created. In a motor, this magnetic field is used to generate torque at the motor shaft output. In a permanent magnet motor, this occurs when a magnetic field caused by current flowing in the motor windings attracts the permanent magnets in the motor.

Maximum torque is generated when the internal magnetic field generated by the motor windings is at a right angle (90 degrees) with respect to the permanent magnet's magnetic field. By controlling the magnitude and direction of the current flowing in the motor windings, the magnetic field generated by them can be made to rotate around the motor axis. The attraction between this rotating field and the permanent magnet's magnetic field is what causes motor shaft rotation.

The necessary switching of current between the motor windings to cause this magnet field rotation is what is referred to as commutation. This switching can be done electronically or mechanically.

In a conventional DC brush servo motor, this switching is done mechanically. By incorporating a number of motor windings with their current switched through carbon brushes riding on copper commutation bars, effective commutation is accomplished at speeds (typically) of 4000 RPM or less. The servo drive is only required to control overall current.

Brushless servo motors are a better choice when higher speed, rapid acceleration, higher bandwidth and compact size are needed. They are commutated electronically. By controlling the magnitude and direction of current in the three phase windings, high bandwidth speed and torque control can be accomplished. This means the motor drive must control both the commutation and the motor current to provide servo performance.

BRUSHLESS SERVO DRIVES

In order to provide servo performance with permanent magnet brushless servo motors, several different commutation and current control schemes have been used. These can be grouped into three main types: Hall Commutated Drives, Sine Commutation Drives, and Vector Drives. Axiom drives are vector drives.

Hall Commutated Drives

This drive type uses Hall-effect sensors in the motor to trigger one of six commutation states. These states are accomplished by alternately connecting each motor leg to bus positive, off and bus negative. By offsetting the cycle on each leg by 120¡ electrically (60¡ of shaft rotation for a four-pole motor), six switching states are generated. These switching states can also be referred to as voltage vectors.

This commutation generates the rotating magnetic field necessary for motor shaft rotation. However, since there are only six voltage vectors applied, the field rotates in steps. This means its magnetic field is not at a right angle to the rotor magnet's field at all times. This causes the torque to vary as the motor rotates. This phenomena is referred to as torque ripple.

Because the magnetic fields are not at right angles at all times, some of the motor current does not produce torque. This current still heats the motor windings, causing excess heat to be generated in the motor.

Current control in these drives is closed loop, but only for total motor current. Since current is not controlled in each motor phase, minor winding variations can lead to currents that do not distribute exactly as intended in the three motor phases. This leads to some additional torque ripple.

Also, since only overall motor current is controlled, there will always be a growing amount of "phase lag" as the motor speed increases. This is due to the fact that each motor leg acts as a series R-L circuit electrically (Resistive-Inductive). Any time voltage is changed in an R-L circuit, the current change lags due to inductive reactance. The effect of this is that, with increasing speed, the generated current

vector lags behind the commanded voltage vector by an increasing amount. This causes the torque to roll off with speed, even though the motor current remains constant.

Sine Commutation Drives

By employing more modern microcontroller technology to brushless servo drives, sine commutation can be achieved. This type of drive uses resolver or encoder feedback to determine the rotor position angle. This information is used to look up sine function values in a lookup table in the drive's microcontroller memory. By applying three 120¡ spaced sine based voltage vectors to the three motor legs, a rotating voltage vector can be applied at any angle relative to the motor's axis. Ideally, this commutation scheme produces sinusoidal current waveforms on each of the three motor phases. Since this waveform closely matches the motor's back EMF waveform, torque ripple is dramatically reduced.

In addition to better commutation, most sine commutation drives use microcontroller or DSP (Digital Signal Processor) technology to implement their control loop filters digitally. This eliminates potentiometer tuning and problems associated with analog circuit drift and aging. This same technology allows implementation of other features not possible in drives without the computing capability of these more modern drives.

Though these drives are a considerable improvement over older brushless servo drive technologies, they still suffer some limitations. The most significant are reduced bus voltage utilization and lack of individual motor phase current control.

By using the sine table lookup calculation for commutation, only 75% of the available bus voltage can be effectively used. Though no drive can achieve 100% utilization of available bus voltage, a sine commutation drive sacrifices more maximum speed at a given motor torque than other drive technologies. This is the price paid for achieving low ripple motor torque.

The other limitation of these drives is the same as the older drive types. Because the traditional sine drive commutation does not resolve individual motor leg currents, it is subject to the same tolerance-induced torque errors (ripple) and the same phase lag issues.

Since phase lag is such a major problem at higher speeds, many drives attempt to solve the phase lag problem by introducing a "phase advance" factor into their voltage vector calculation. This advances the three rotating voltage vectors by an amount equal to the expected current phase lag for a given speed.

In a perfect world, this voltage vector phase advance would accurately compensate for current phase lag. In the real world, however, factors such as motor winding resistance and inductance tolerances come into play. Also, variations in motor back EMF, cable resistance and winding resistance changes due to temperature all add variability to the actual current vector produced in any given motor at a given speed. Consequently, any phase advance factor is only a "best-guess" value. Due to these tolerance issues, there will still be some phase current error in any real motor drive combination. This will result in some loss of torque at higher speeds, additional motor heating and torque variability with current (ripple).

Some of the most modern sine commutation drives attempt to solve these problems by taking individual current phase readings and running multiple current loops. These drives attain a higher level of performance than traditional sine drives, but still do not provide the full closed loop control of TORQUE PRODUCING current possible with state-of-the-art vector drives which thereby provide higher efficiency and high bandwidth torque response over the full speed range.

Vector Drives — Field-Oriented Control

The term Vector Drive refers to a class of drives that sense motor current in each individual motor phase and resolves these readings into two current vectors. One vector is the torque producing current (I_q). The other is the waste current (I_d). The current control algorithm then works to drive the non-torque producing component (I_d) to zero. This method gives high bandwidth torque response over the full speed range without the phase lag and tolerance issues that plague older drive technologies.

The technology in these drives is made possible due to the availability of high speed DSP technology. Because the control

algorithms necessary for vector drive technology are computationally intense, it was generally not practical to implement them in an affordably priced brushless servo motor drive in the past.

The same DSP technology that makes vector drive technology a reality in all Axiom brushless servo drives, makes all digital control loop tuning and other advanced features practical in all Axiom brushless servo motor drives. These drives are designed and built to provide enhanced performance and years of dependable service.

The first performance improvement incorporated into Axiom PV and DV series drives is an enhanced commutation scheme known as Space Vector Commutation. This commutation scheme is similar to sine commutation except that it uses a more computationally intense algorithm that gains back some of the bus voltage utilization lost in sine commutation. Axiom PV and DV series drives will typically provide 12.5% more speed at a given torque than the theoretical maximum possible with sine commutation.

Furthermore, as a Vector Drive, all Axiom PV and DV series drives provide closed loop motor control of torque producing current. They accomplish this by first accurately measuring motor current in each motor phase leg 10,000 times each second. This information is used to calculate the actual torque producing current vector being produced in the motor.

Because this is a true vectored closed loop current control system, torque errors due to tolerances and R-L time constant induced phase lag are automatically compensated for in the algorithm. All Tolomatic MRV motors can be driven from zero speed to full rated speed with negligible torque ripple or loss of torque due to tolerance or current phase lag issues.

In addition to the enhanced drive features built into all Axiom series drives, the Axiom Plus PV series incorporates a 1.5 axis motion controller in the same package. This controller has a sequential program thread that executes the motion commands. It also has a scanned “PLC” ladder logic thread to allow I/O and control logic functions to run asynchronously with respect to the sequential program.

Unpacking, Inspection & Storage 3

Unpacking the Drive

Remove the Axiom Plus unit from the shipping carton. Retain the shipping materials for storage or in case the unit needs to be returned. Check contents against the packing list. Model number, part number and related information appear on a label on the side of the unit.

Inspection Procedure

To protect your investment and ensure applicable warranty rights, Tolomatic recommends the unit be carefully inspected for any signs of physical damage. If any damage is detected, contact the purchasing agent to make a claim with the shipper.

If any improper performance is detected while testing the unit, contact your Tolomatic distributor to obtain a Return Material Authorization (RMA). Do this as soon as possible after receipt of the unit.

For specific warranty information, refer to Appendix D in this manual.

Storage

Return the unit to its original shipping carton using the original packing materials. Store in a clean dry place with humidity between 5% and 95%, non-condensing. Make sure the temperature is between -20° and 70° C (-4° and 158° F).

This page intentionally left blank

Physical Mounting of the Drive 4

1. This unit must be mounted in a proper electrical enclosure providing protection to IP54 (protected against dust and splashing water), or IP65 (dust free and protected against water jets) where the environment is poor. Many NEMA (National Electrical Manufacturers Association) Type 4 cabinets provide this level of protection.

2. Size enclosure to provide the following spacing around the unit:

Above and Below	5.1 cm (2 in)
Sides:	1.25 cm (0.5 in)
Front:	7.6 cm (3 in)



Caution! If the cabinet is ventilated, use filtered or conditioned air to prevent accumulation of dust and dirt inside the drive. The air must be free of oil, corrosives or electrically conductive contaminants.

3. Position the unit vertically on a flat, solid surface capable of supporting the unit's weight.

4. Bolt the unit to the cabinet using the mounting slots on the top and bottom. Use M5 metric (1/4-20) or #10MS bolts.

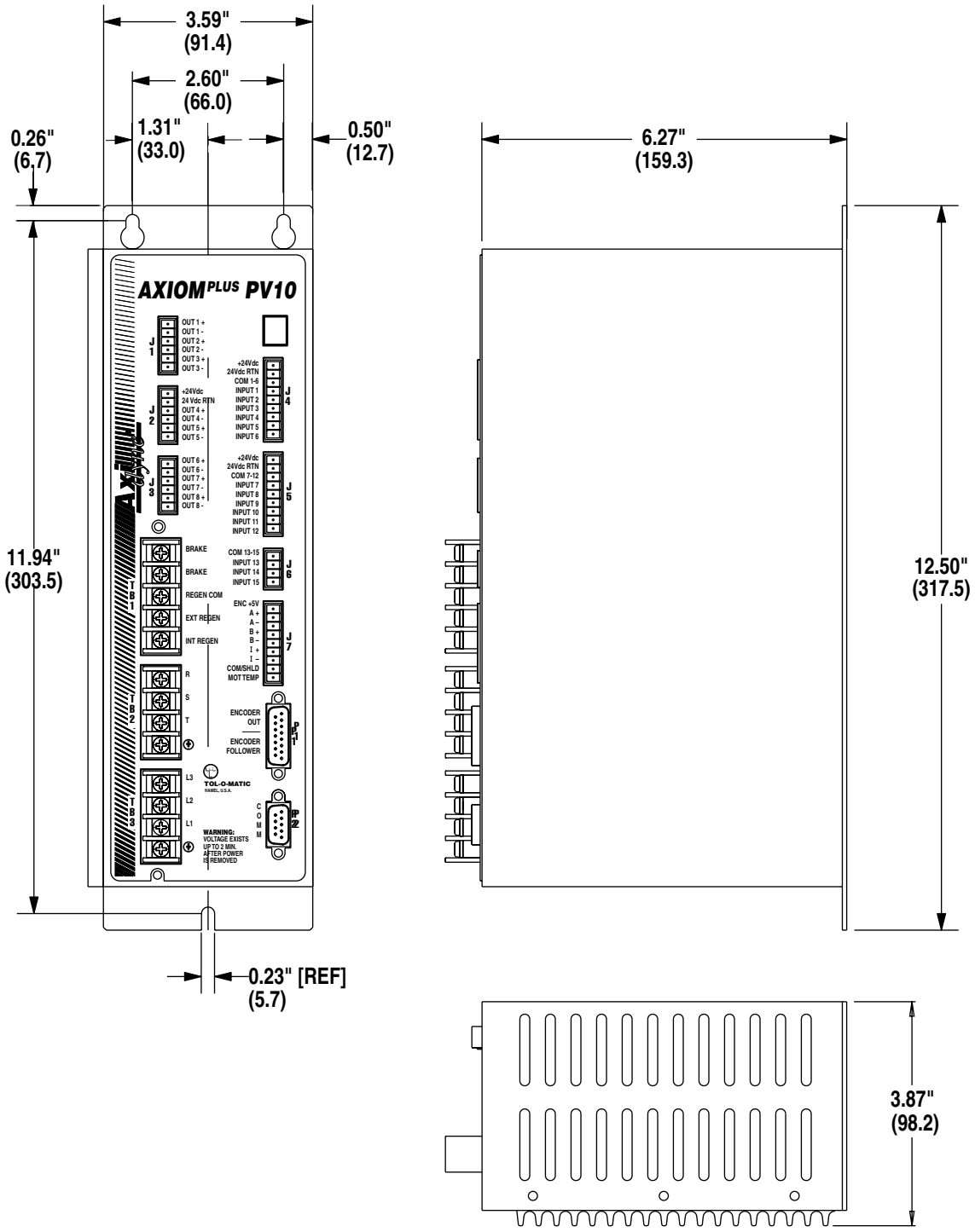


Figure 4.1 - Axiom PV10 Mounting Dimensions

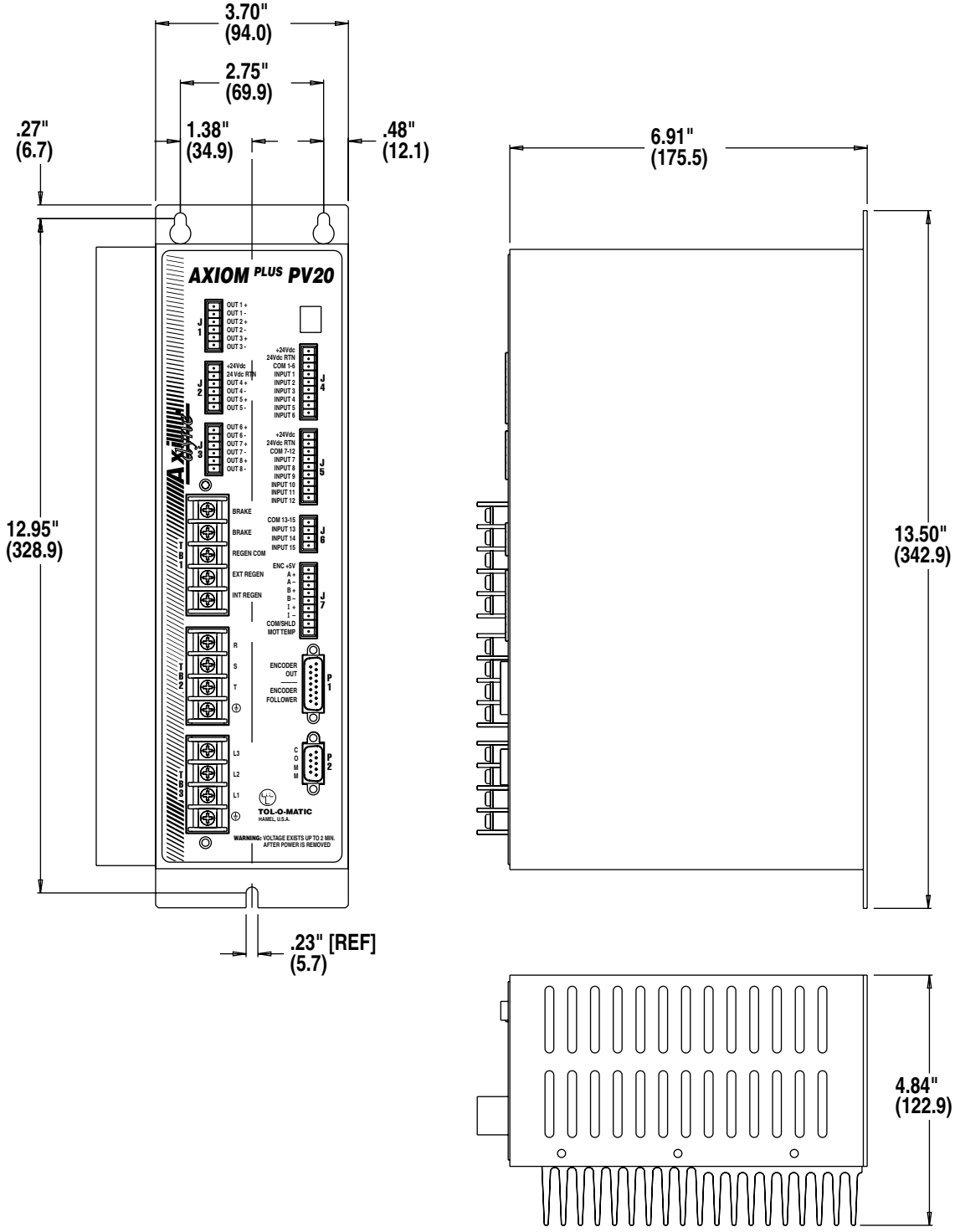


Figure 4.2 - Axiom PV20 and Axiom PV30 Mounting Dimensions

This page intentionally left blank

Power Connections & Fusing 5



DANGER! The user is responsible for conforming with all applicable local, national and international codes. Wiring practices, grounding, disconnects and overcurrent protection (fusing) are of particular importance. Failure to observe this precaution could result in severe bodily injury or loss of life.



DANGER! The user is responsible for designing an adequate Emergency Stop (E-Stop) circuit. It is not adequate to depend on the drive enable for an E-Stop. a properly designed E-Stop circuit should remove power from the drive and apply a brake to the motor or load when necessary. Failure to observe this precaution could result in severe bodily injury or loss of life.



Caution! Do not tin (solder) the exposed leads on cables. Tinned cables may loosen in screw terminal connections over time.

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.

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 devices (such as welders) found in a typical industrial environment.

All power cables should be copper conductors rated 60° C minimum and should be tightened to the terminal blocks with 9.0 in. •lbs of torque.

Axiom Plus PV10, PV20 & PV30

Axiom Plus systems operate from single or three phase power, 50/60Hz. Nominal input ranges are 115Vac or 208/230Vac. The switch on top of the unit should be set to reflect the proper range. Motor performance is dependent on input voltage. Refer to motor/drive performance curves in Appendix C for performance information. Refer to Appendix B for input power requirements and fuse accordingly. The use of properly sized time delay fuses will minimize any nuisance trips due to inrush current at power up.

Note: Although fuses are recommended, long trip delay circuit breakers may be used. Refer to Appendix B for information on drive inrush ratings and specify circuit breakers accordingly.

Axiom Plus units are designed for direct connection to an ac power main. No isolation transformer is necessary.

Note: It is always advisable to use three phase power whenever available. Three phase power will ensure a minimum of motor bus voltage ripple. This will provide for the smoothest possible motor torque and help ensure maximum life of the internal bus capacitors. It may also aid in plant power distribution.

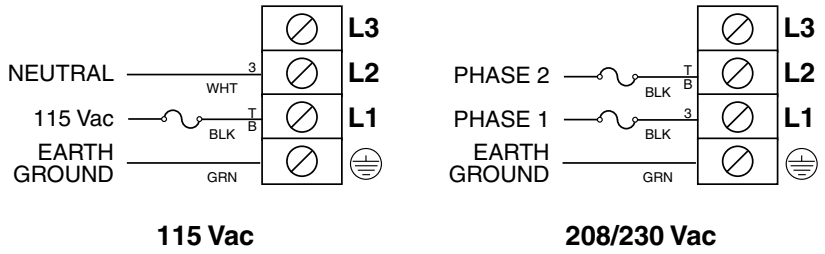


Figure 5.1 - Axiom Plus PV10/20/30 Single-Phase Power Connections

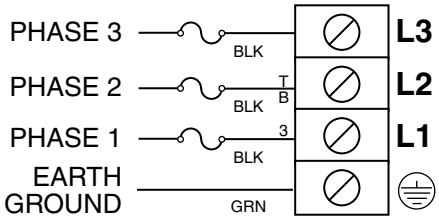


Figure 5.2 - 208/230 Vac Three-Phase; Axiom Plus PV10/20/30 Three-Phase Power Connections

Motor Encoder & Power Connections 6

This chapter contains information about proper connection of motor power and encoder wiring. For additional information on Tolomatic motor performance specifications please refer to Appendix C.

WARNING! Never connect or disconnect motor power connections when power is applied to the unit. To do so could cause electrical shock or result in severe arcing and may damage the motor or Axiom Plus.

Caution! Proper phasing of the drive outputs relative to the motor terminals is critical. Double check the connections after wiring the motor.

Caution! Do not tin (solder) the exposed leads on cables. Tinned leads will loosen in time and may come loose from their screw terminal connections.

General Wiring Guidelines

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

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

All power cables should be copper conductors rated 60° C minimum and should be tightened to the terminal blocks with 9.0 in. •lbs of torque.

Axiom Plus Systems

All Axiom brushless servo drives are designed to drive three phase brushless servo motors. For proper operation, the motor must be connected to the drive in the proper phasing sequence.

MRV 11 Motor

MOTOR CONNECTOR PINOUT	
RED	PHASE R
WHT	PHASE S
BLU	PHASE T

MRV51 Motor ONLY

MOTOR CONNECTOR PINOUT	
RED	PHASE R
WHITE	PHASE S
BLACK	PHASE T

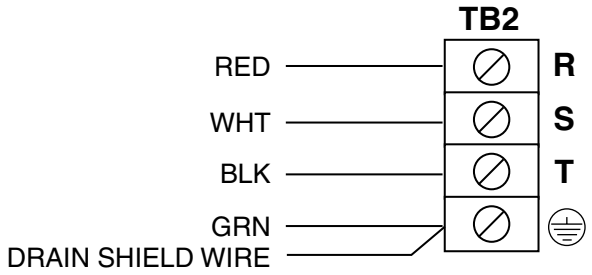


Figure 6.1 - PV10/20/30 Motor Power Cable Connections for MRV 2X, 3X

Proper encoder phasing is necessary for proper motor operation. The following color codes apply to Tolomatic cables.

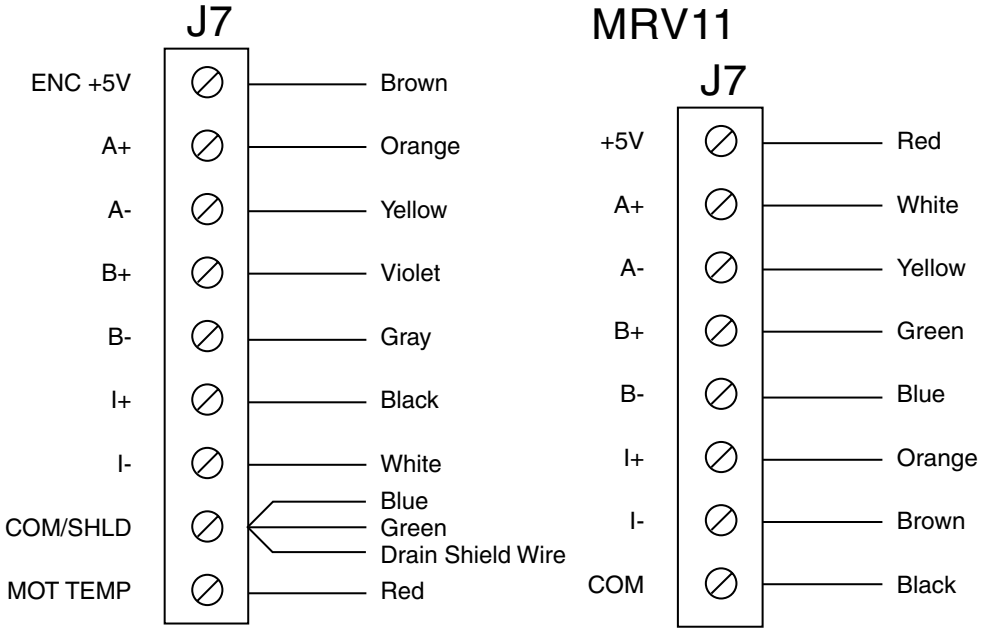


Figure 6.2 - PV10/20/30 Motor Encoder Connections

Emergency Stop Connection

Emergency stop can be implemented in a number of ways depending on the application requirements. In most cases, the best method is to simply remove power to the drive.

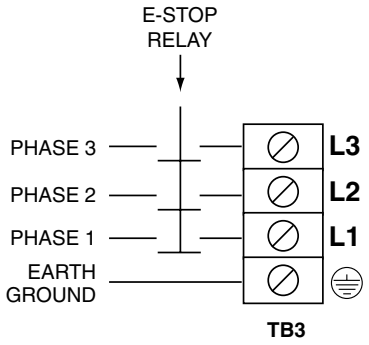


Figure 6.3 - Emergency Stop Connections

A few applications require that the controller maintain encoder feedback information after an E-stop.

In this case, the emergency stop needs to disable the drive, then break the connection from the drive to the motor. The drive remains powered so that it maintains its phasing information. Failure to disable the Axiom+ output BEFORE physically breaking the connection with the motor can cause damage to the Axiom+ unit.

When recovering from the emergency stop condition, it is important to reconnect the motor to the drive before enabling the drive. Failure to do this will result in the drive entering a fault condition.

WARNING! While in the emergency stop condition, the motor may move out of position and cause a large following error to accumulate in the controller. It is the users responsibility to ensure that this is accounted for so that a large jerk that could cause damage or injury does not occur when the drive is enabled.

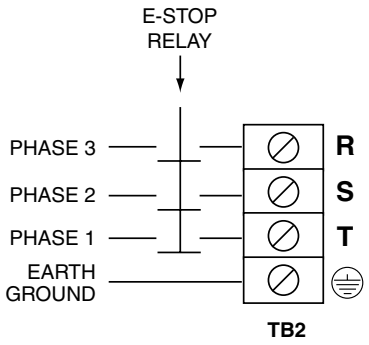


Figure 6.4 - Drive Remains Powered

Software Installation 7

This chapter provides information about installation of Axiom software on a personal computer.

Hardware and Software Requirements

- A personal computer running Microsoft Windows 95, 98, NT or XP
- A hard disk with 10 MB of free disk space
- CD ROM drive

Installation

1. Close all Windows® programs.
2. Insert the disc in the CD-ROM drive.
3. View the contents of the CD-ROM
4. Select the Programming Software directory
5. Select the Axiom Plus Directory
6. Run the Setup.exe program to start the install
7. Follow the screen prompts until installation is complete.

This page intentionally left blank

It is strongly recommended that an initial check out be performed on the motor-drive combination at this time. This should be done with the motor disconnected from the load. This procedure will verify that the correct motor is chosen and that it is connected and phased properly before proceeding further.

Setup / Configuration Screen

In order to access the Setup / Configuration screen to perform your initial checkout, please follow the steps below:

1. Recheck power, motor and encoder connections to make sure all are correct.

2. Apply power to the Axiom Plus. If the unit has NOT yet been configured, it should flash an “F-99” fault code. If it HAS been configured, it should display the letter “d” on the status indicator.

3. Open the Axiom setup software. The setup software main menu will appear (see Figure 8.1).



Figure 8.1 - Axiom Plus Setup Software Opening Screen

4. Connect the serial communications cable from a spare serial port on your computer to the COMM connection (9-pin D-sub connector) on the drive.

5. From the opening screen, select COMM1, COMM2, COMM3, or COMM4. Then choose “Axiom Plus Indexer Setup/Config”

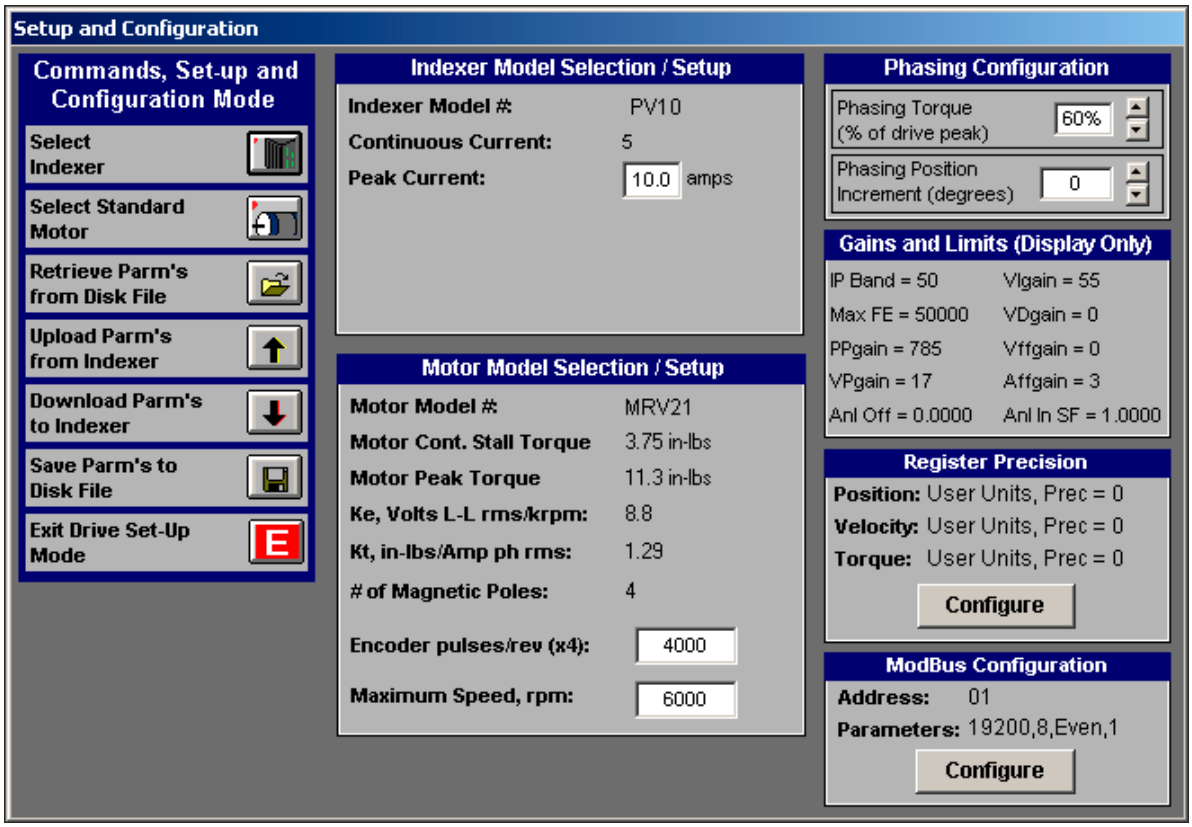


Figure 8-2 - Set-Up and Configuration Screen

The Setup and Configuration screen is divided into seven sections, which are labeled as follows:

1) Commands, Setup and Configuration Mode
2) Indexer Model Selection / Setup
3) Motor Model Selection / Setup
4) Phasing Configuration
5) Gains and Limits (Display Only)
6) Register Precision
7) ModBus Configuration

COMMANDS, SETUP AND CONFIGURATION MODE

This section is comprised of seven buttons, whose functions are described below:

- **Select Indexer** – This enables the selection of the appropriate Axiom Plus drive, as indicated on the label at the top of the unit. *Note: An incorrect setting can be selected, but cannot be downloaded to the unit. In the event that you make an incorrect selection, you will be prompted to change to match the unit to which you are connected.*
- **Select Standard Motor** – This enables the selection of a standard Tolomatic brushless servo motor. The Model number of Tolomatic motors can be found on the unit label affixed to the side of the motor. This corresponds to one of the choices in the pulldown menu that appears when the button is selected. *Note: This Axiom Plus unit is not configured for use with non-Tolomatic motors. For use of the unit with a non-Tolomatic motor, please contact the sales representative from whom this unit was purchased.*
- **Retrieve Parameters from Disk File** – This allows the user to bring a previously saved set of parameters into the active workspace, in order to download them to the connected Axiom Plus unit.
- **Upload Parameters from Indexer** – Uploads the drive parameters stored in the connected Axiom Plus unit into the active workspace.
- **Download Parameters to Indexer** – Sends the drive parameters active in the workspace down to a connected Axiom Plus. *Note: This command will overwrite any drive parameters currently stored in the unit. It will also reset the values of all non-volatile memory registers to zero.*
- **Save Parameters to Disk File** – This enables the drive parameters in the active workspace to be saved to file.
- **Exit Drive Setup Mode** – This returns the user to the Main Menu.

INDEXER MODEL SELECTION / SETUP

This section displays the selected Indexer model number and the corresponding continuous current available from this unit. It also indicates the current setting for peak current. The default setting is the maximum for the unit, but can be modified to the peak value

best suited to your application. *Note: The minimum setting is 2 amps, and the maximum is two times the continuous rating.*

MOTOR MODEL SELECTION / SETUP

When the Select Standard Motor button (above) is pressed, a dropdown menu of Tolomatic brushless servo motors appears in this section. Only those motors which are compatible with the selected drive will be displayed. Once a choice is made, the motor data associated with that choice will be displayed. The Encoder pulses/rev and Max Speed can be modified in this window to match your application.

The Encoder pulses/rev setting is related to the particular encoder you are using, as displayed in quadrature (x4), and must be set between 2000 and 100000 counts.

The Max Speed must be at least 10 rpm and no more than the maximum speed rating for the selected motor.

Note: If the model number of your motor is not displayed in the dropdown list, it is not compatible with the drive choice you have selected in the section above. Please verify that you have chosen the correct drive, and if your motor is still unavailable, please contact the sales representative from whom this unit was purchased to obtain the appropriate motor/drive combination.

PHASING CONFIGURATION

This section allows for changes to both phasing torque and phasing position, if required by your particular application. If the actuator has high friction or a large, overhung (vertical) load, the PHASING TORQUE can be increased. This will cause more motor movement when the drive "phases" after power up. If the load is not vertical or the actuator has low friction, the phasing torque should be left at the default setting.

If the load always comes to rest at one end of travel (as in a back-driving, vertical load with no brake) the PHASING POSITION control should be used to bring the load off the end of travel limit when the motor phases. The units are in degrees of motor rotation. Positive (+) corresponds to CW motor shaft rotation.

GAINS AND LIMITS

This section displays the tuning values associated with the parameters uploaded to the workspace, as well as coding input calibration parameters. On the initial startup, the values appearing are simply placeholders. These values are only displayed here, but can be modified in the Tuning and Diagnosis screen.

REGISTER PRECISION

This section allows the user to modify the decimal precision of the registers for Position, Velocity and Torque. If you plan to use the default units (encoder counts and Q15 value) for these registers you will not need to use the Configuration function. If you wish to change to user units, you can do so as follows:

Click the Configure Button to open the Register Precision Configuration screen

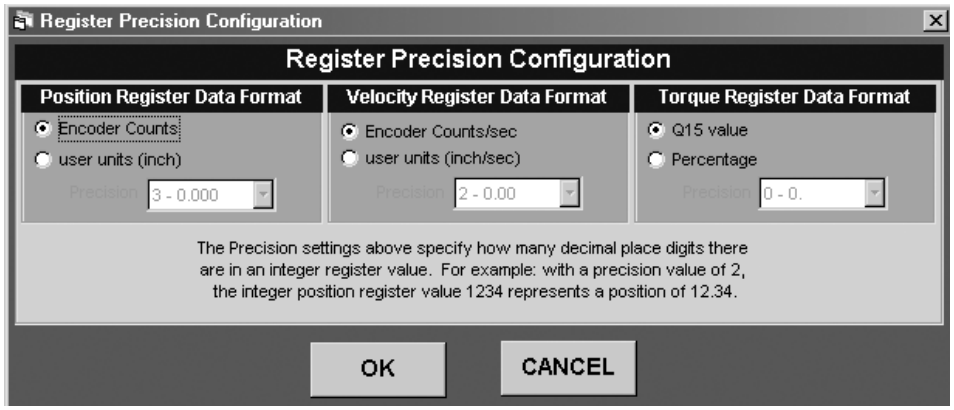


Figure 8.3 - Register Precision Configuration Window

The user units available on this screen will be those chosen in the opening screen of the Sequential Program Editor. Position Register will be in user units and Velocity Register in user units/second. The default data format for torque is the Q15 value, which can be an integer value from 0 to 32761, where 32761 equals 100% torque. The only other torque register format is percentage of full torque, allowing the user to avoid using the more complicated Q15 format. The example given on the bottom of the screen demonstrates how the precision setting affects the reading of user-defined register value.

MODBUS CONFIGURATION

This section shows the current configuration of the unit as it relates to ModBus setup and addressing. In order to use this feature, the drive must be operating in ModBus Mode.

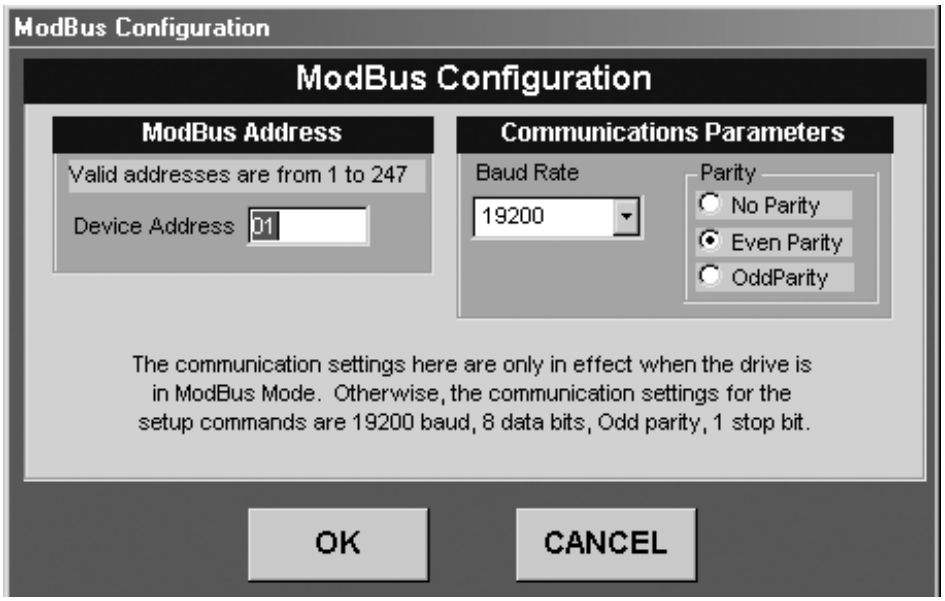


Figure 8.4 - ModBus Configuration Window

Now that you are familiar with the Setup and Configuration screen, you are ready to proceed with your initial checkout.
Note: It is strongly recommended that you perform this procedure without connecting the motor to a load.

Check Out Procedure

1. Recheck power, motor and encoder connections to make sure all are correct.

2. Select “Upload Parm’s from Indexer.” After a few seconds, the message “Upload Complete” should appear on the screen. The first time this is done, placeholder parameters will be displayed.

3. Choose the correct Tolomatic motor from the list displayed.

4. Set Phasing Torque and Phasing Degree as required by your application (see above).

5. Select “Download Parm’s to Indexer.” After a few seconds, the message “Download Complete” should appear on the screen.

6. The drive is now configured and ready to run. Continue by wiring the unit appropriately for your application as described in the next section.

This page intentionally left blank

Inputs

Caution! The maximum voltage that can be applied to an input terminal is 25 VDC

The Axiom Plus provides 15 optically isolated inputs if analog input is not used. The inputs can be configured to sink or source current (5VDC – 25VDC, 2.7mA – 15 mA) in each of the three banks of inputs. This allows connection to TTL, PLC's, relays and mechanical switches. Because the input circuits are isolated, they require a source or power. The power can be provided from the Axiom Plus built in 24VDC 400mA power supply or an external customer supplied 5VDC – 24VDC power supply.

Note that inputs 13 and 14 serve also as inputs to the 14-bit differential analog input. Because of this, these inputs have an input impedance of 40 Kohms. These inputs can tolerate 5 volts common mode with respect to Axiom Plus chassis ground. Proper operation of these inputs will require 2.2Kv pull-up/pull-down resistors when paired with single-ended outputs.

The diagrams on the following pages show how to connect the Axiom Plus inputs to various devices.

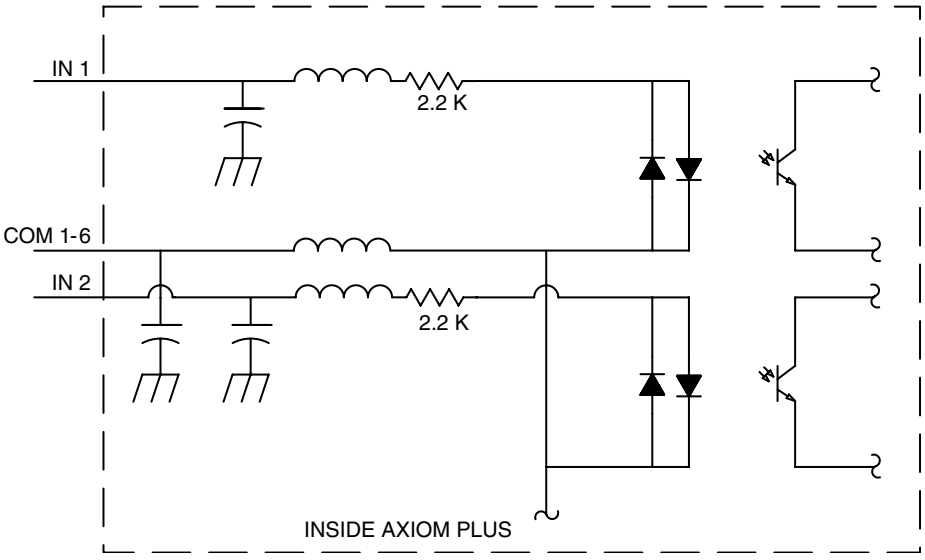


Figure 9.1 - Axiom Plus Input Circuit Diagram

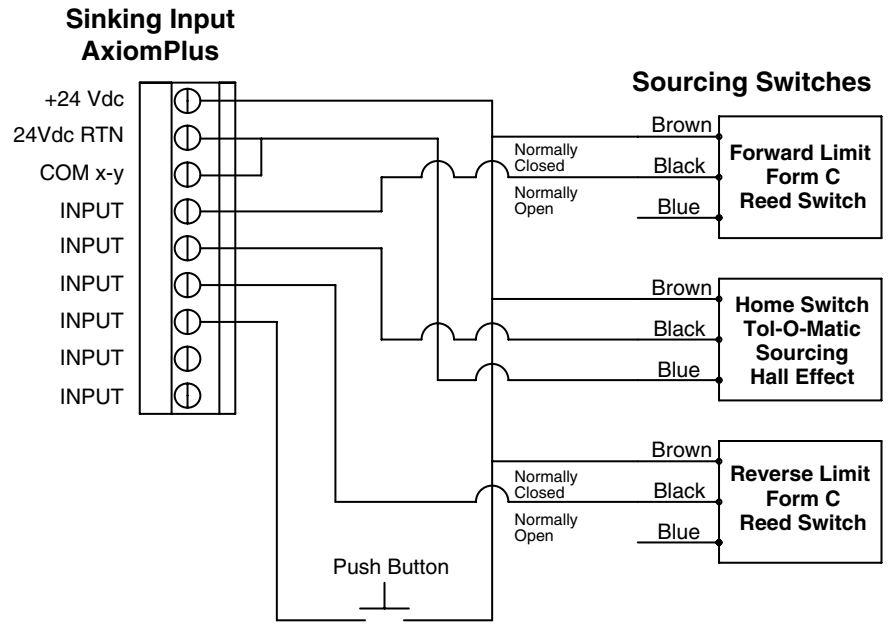


Figure 9.2 - Axiom Plus Sinking Input Connected to Sourcing Switches Using Internal Power Supply

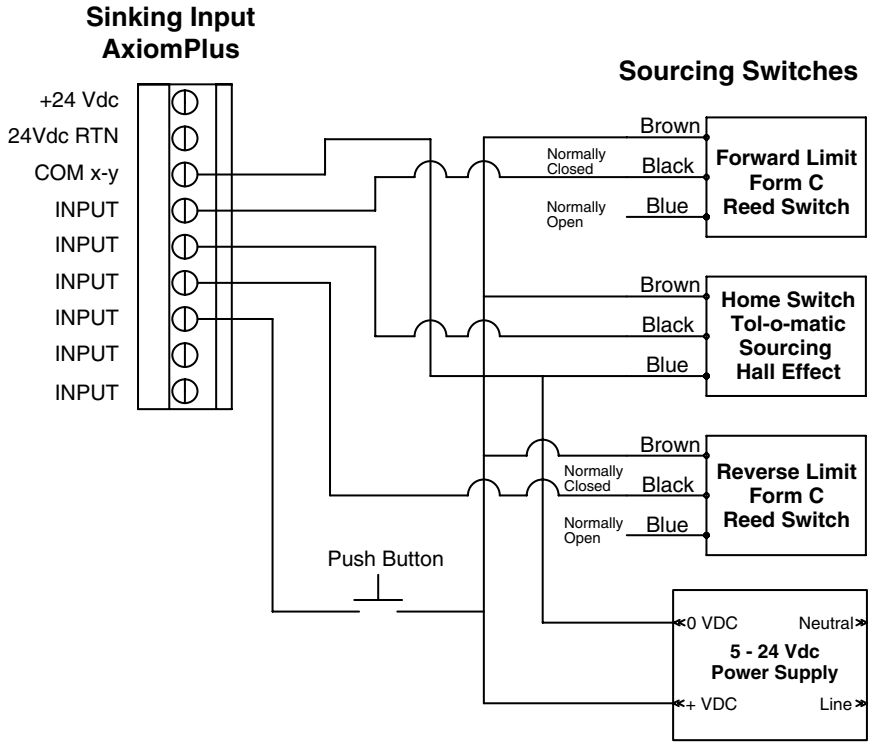


Figure 9.3 - Axiom Plus Sinking Input Connected to Sourcing Switches Using External

Power Supply

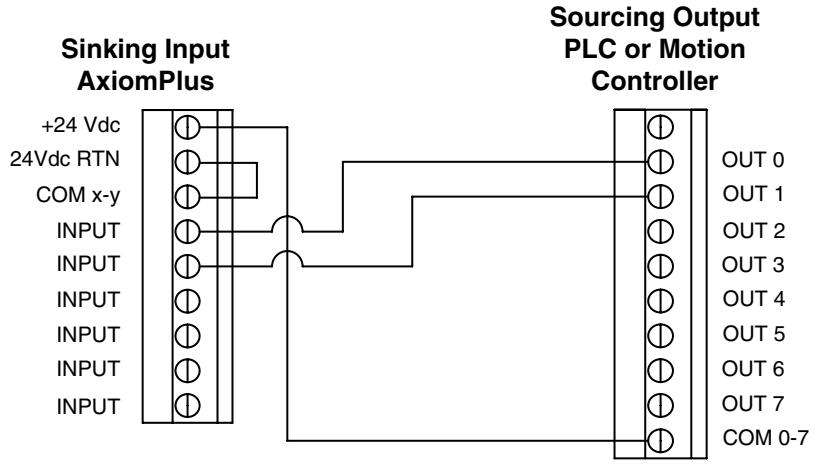


Figure 9.4 - Axiom Plus Sinking Input Connected to Sourcing Output Using Internal Power Supply

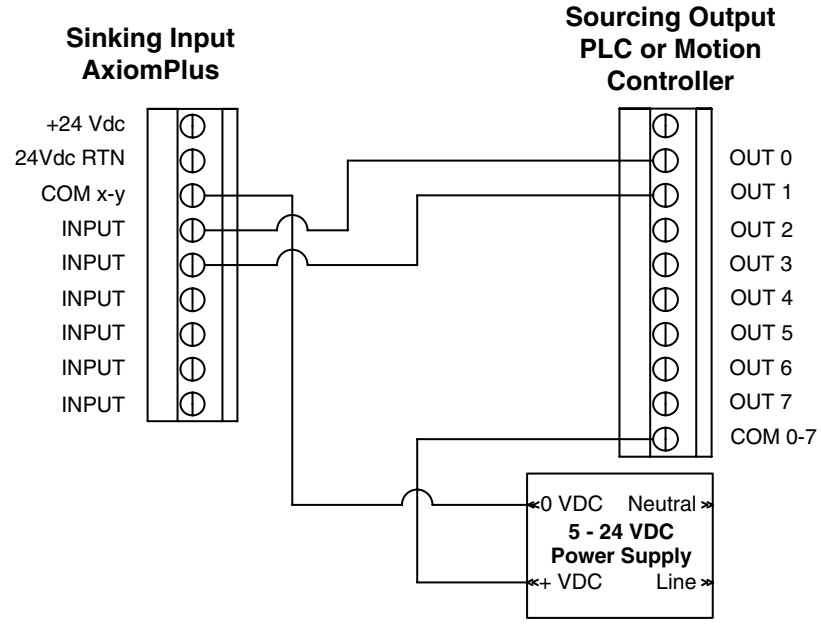


Figure 9.5 - Axiom Plus Sinking Input Connected to Sourcing Output Using External Power Supply

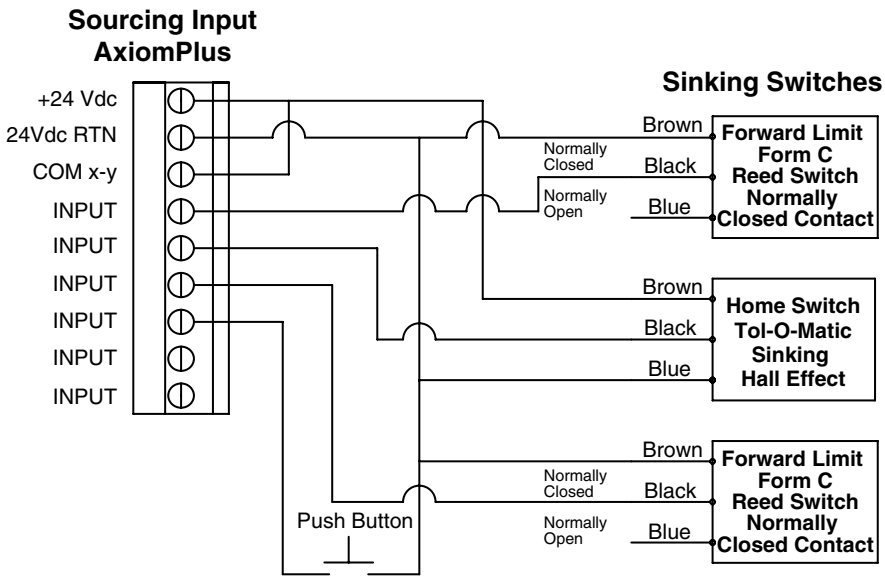


Figure 9.6 - Axiom Plus Sourcing Input Connected to Sinking Switches Using Internal Power Supply

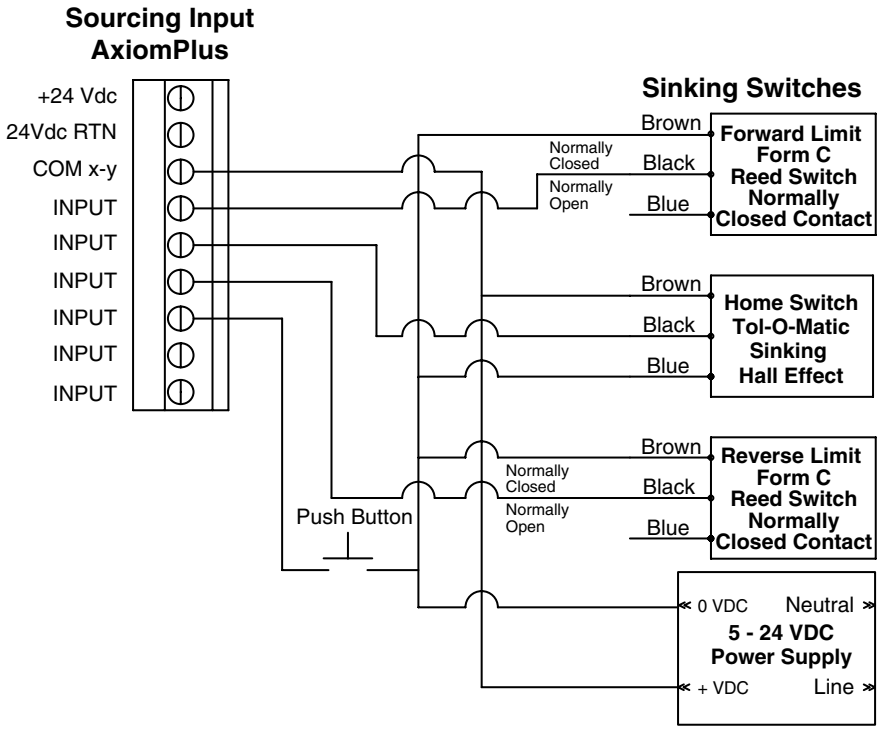


Figure 9.7 - Axiom Plus Sourcing Input Connected to Sinking Switches Using External Power Supply

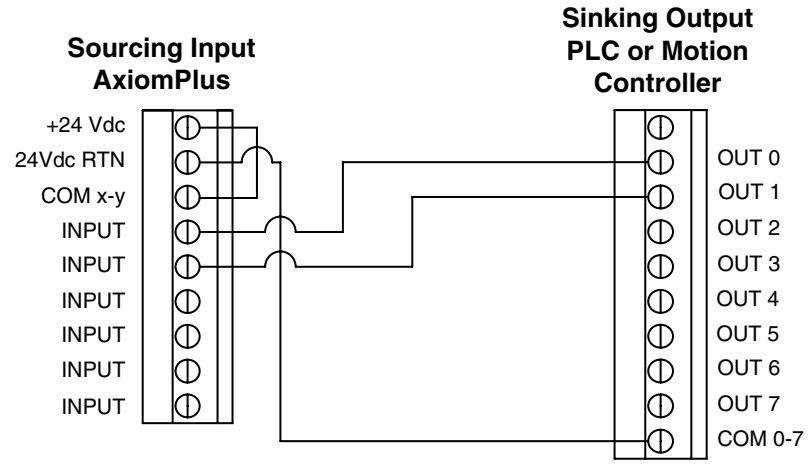


Figure 9.8 - Axiom Plus Sourcing Input Connected to Sinking Outputs Using Internal Power Supply

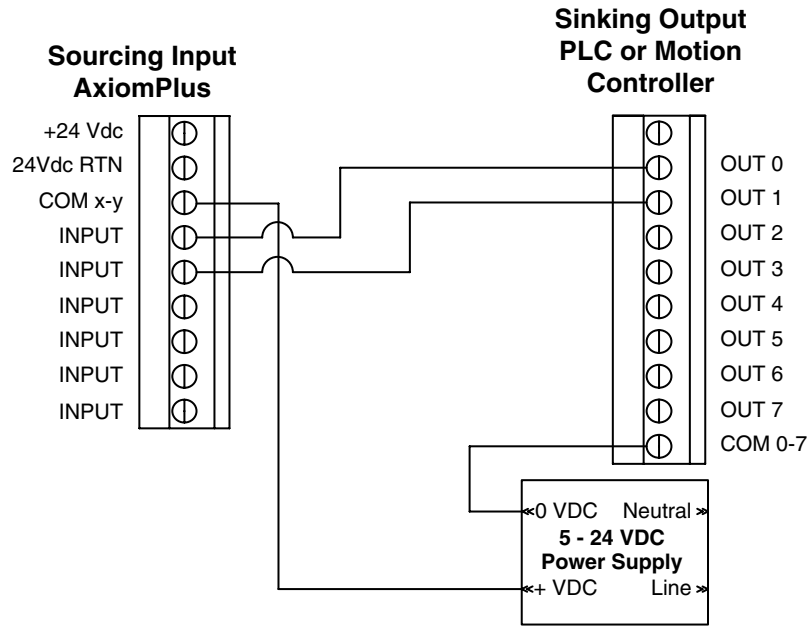


Figure 9.9 - Axiom Plus Sourcing Input Connected to Sinking Outputs Using External Power Supply

Analog Input Specifications and Hardware Connections

Analog input hardware and functionality has been added to this series of Axiom+ PV-series. This hardware allows connection of a fully differential analog source using "dual-use" terminals that were dedicated to general-purpose inputs on previous versions. The general purpose inputs can still be utilized if the analog input option is not needed. The front panel overlay of the Axiom+ products indicates which inputs are available for dual use.

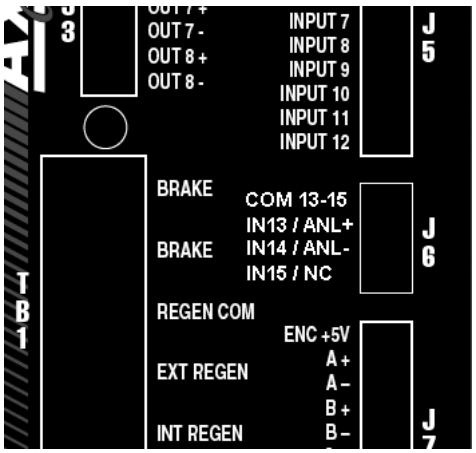


Figure 9.10 - Front Panel Overlay showing Analog Input and General Purpose Input Connection at J6

The analog input connection can be wired as single ended or differential. Please refer to the diagrams below:

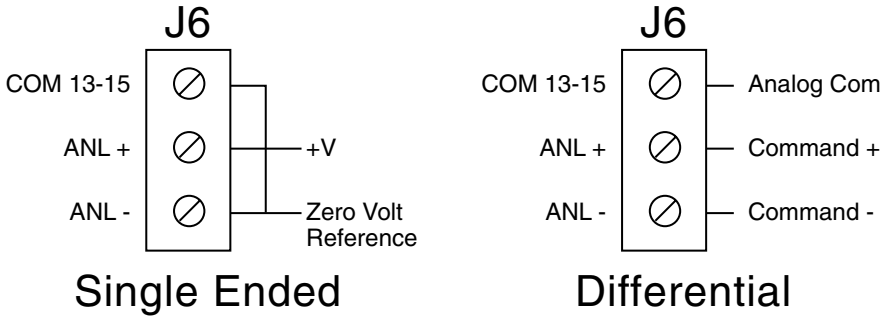


Figure 9.11 - Single Ended and Differential Analog Input Connections

- Input terminal 13 serves as the analog plus input. Input terminal 14 serves as the analog minus input. The input common terminal next

to input terminal 13 will also serve as analog common. If the analog input is used, terminal 15 is considered “no connection”.

- Input 13, 14 and 15 will still be available if the analog input function is not used. The switching levels of these inputs and voltage rating will be as for the other general purpose inputs.

Note: Because of the high input impedance, proper operation of inputs 13 and 14 will require 2.2kOhm pullup/pulldown resistors if used with outputs that are single-ended.

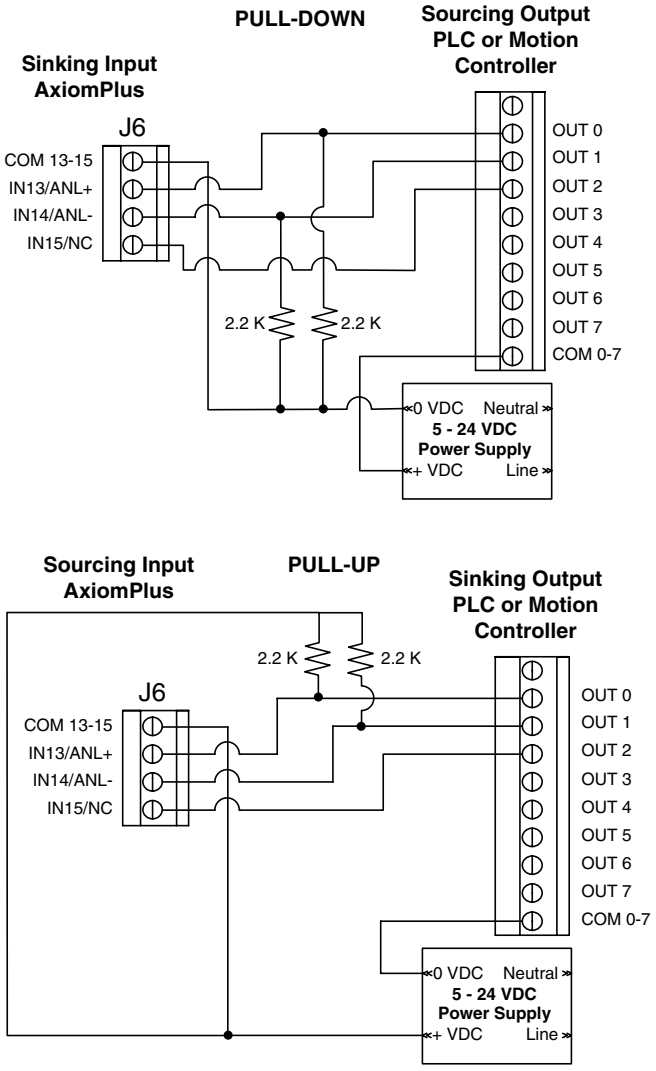


Figure 9.12 - Pullup/Pulldown Wiring

Following is a list of performance specifications and hardware connection issues related to the analog input feature.

Analog Input

Resolution	14 bit
Specified input range	+/- 10 volts
Conversion range	+/- 7782
Effective resolution	15564
Absolute accuracy	+/- 2 LSB's
Analog input impedance	
Analog + input to analog - input	40 kOhms
Either input to analog common	40 kOhms
Signal common mode range	+/- 5 volts (with respect to analog common);
Common mode rejection ratio	60 decibels typical
Input signal	
Hardware filtered	2 kHz, 2nd order
Sampled / converted	5 kHz
Firmware digital filter	200 Hz, 2nd order

Scale and offset parameters for the analog input can be adjusted using tuning and diagnostic functions.

Outputs

The Axiom Plus has 8 programmable outputs. The outputs are optically isolated, meaning there is no electrical connection between the controller and the output terminals. The signal is transmitted to the output circuit as light. This signal drives a NPN transistor that conducts current when the output is on.

Caution! The maximum voltage between and pair of + and – output terminals is 24VDC. Never connect AC voltages to the output terminals. Maximum current is 20mA per output.

Since the outputs are optically isolated power must be provided to the outputs. The power can be supplied from the Axiom Plus built in 24VDC 400mA power supply or an external customer supplied 5VDC – 24VDC power supply. The current must be limited to 20mA or less to prevent damage to the output transistor.

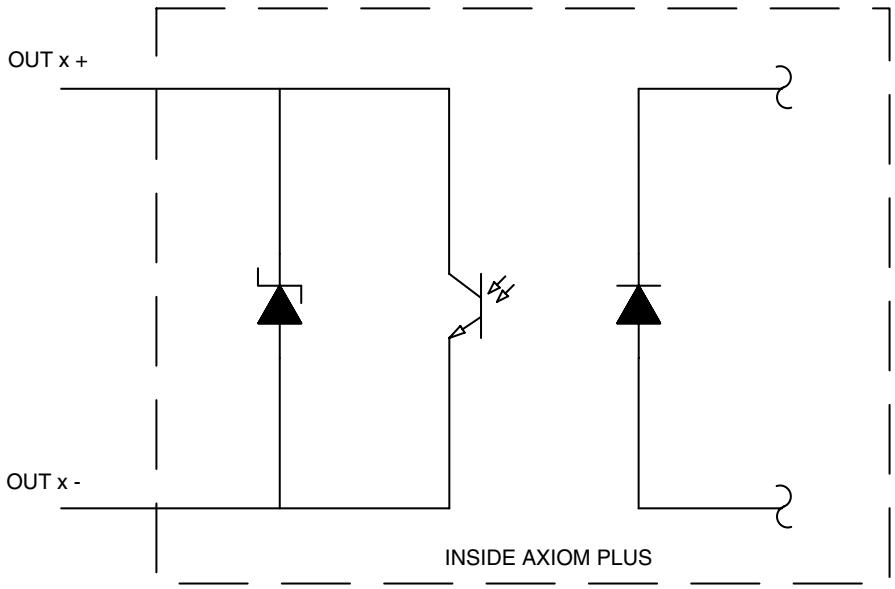


Figure 9.13 - Axiom Plus Output Circuit

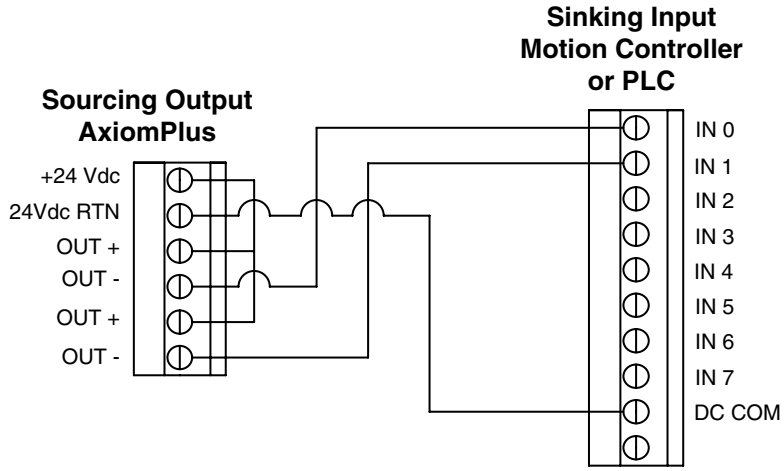


Figure 9.14 - Axiom Plus Sourcing Output Connected to Sinking Input Using Internal Power Supply

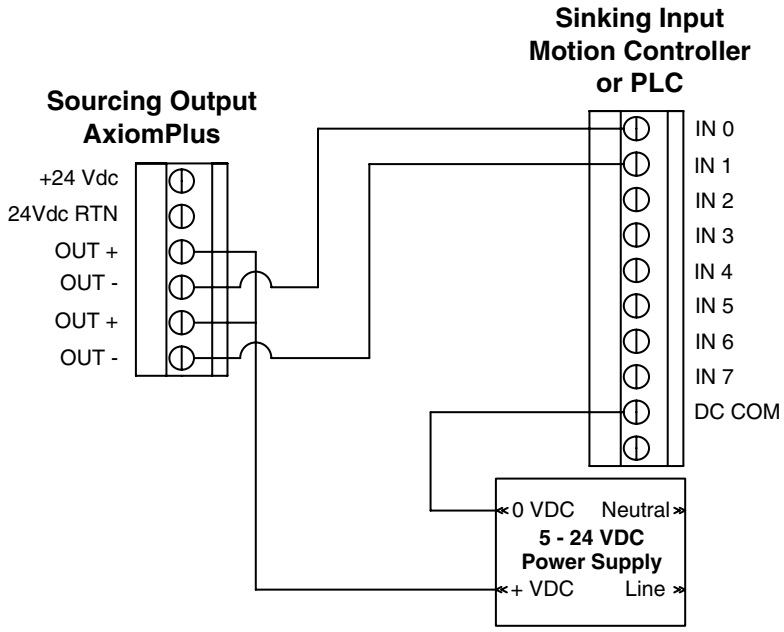


Figure 9.15 - Axiom Plus Sourcing Output Connected to Sinking Input Using External Power Supply

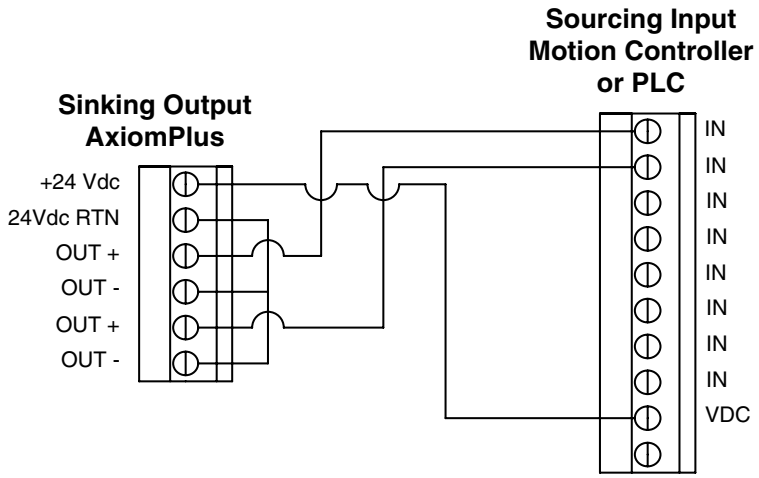


Figure 9.16 - Axiom Plus Sinking Output Connected to Sourcing Input Using Internal Power Supply

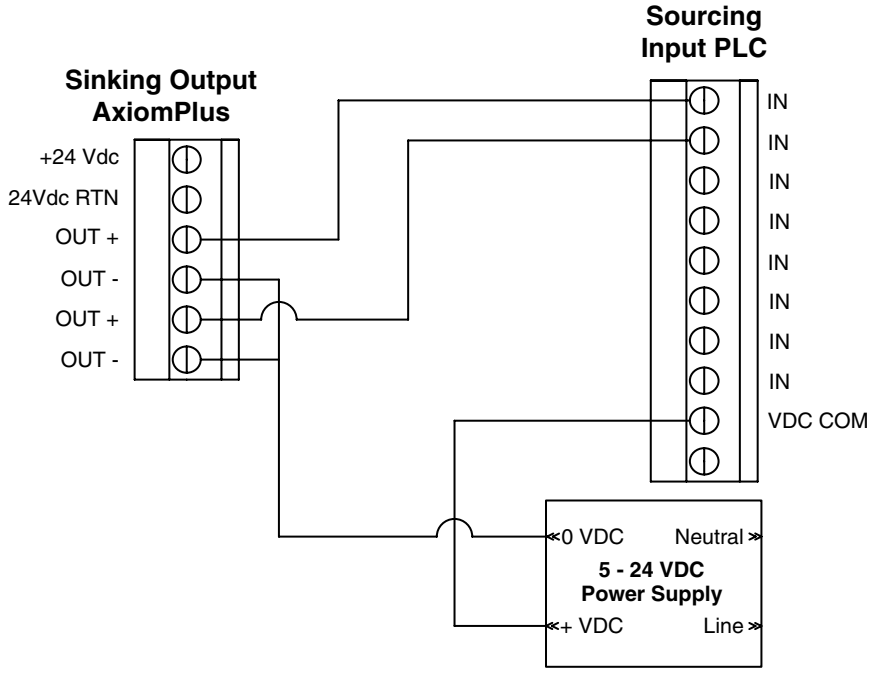


Figure 9.17 - Axiom Plus Sinking Output Connected to Sourcing Input Using External Power Supply

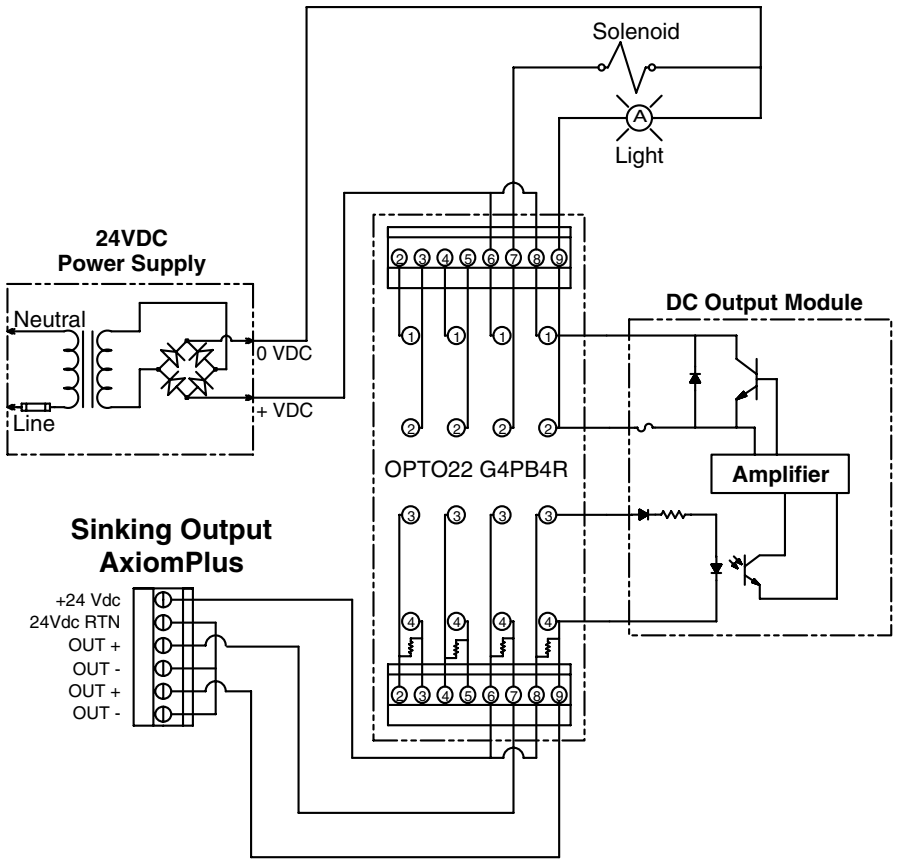


Figure 9.18 - Axiom Plus Sinking Output Connected to Sourcing Opto22 Solid State Relays

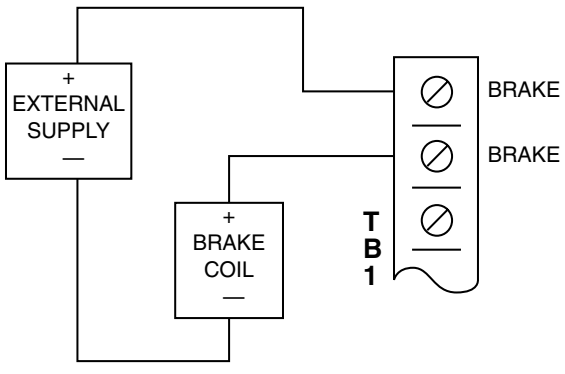


Figure 9.19- Axiom Plus Power Off Holding Brake Connection

Regeneration Resistor Use & Sizing 10

Whenever the load applied to a motor attempts to overtake the motor, the motor starts receiving power from the load instead of providing power to it. It does this by acting as a generator. When this happens it puts power back into the drive's power supply capacitors. This power is directed back into the motor as soon as it is needed.

Under many applications, some power goes back into the drive with each deceleration of the load. As long as this energy does not cause the bus voltage to exceed a safe level, no other form of regeneration is required.

In many horizontal applications where aggressive deceleration is demanded, and in most vertical load applications, the bus voltage would exceed safe levels. In these applications, switching circuitry and a high wattage resistive load are employed to dissipate this excess energy as heat.

All Tolomatic Axiom® Plus units provide an internal regeneration resistor. In addition, all Axiom Plus units provide for connection of a high wattage external resistor pack to accommodate the most severe applications.

Since the internal resistors of the Axiom Plus PV series can dissipate the full peak load, no external resistor pack is required in most applications. A simple rule of thumb is to use the internal resistor for horizontal screw-drive actuator applications. Many belt-drive and vertical screw-drive actuator applications can also use the internal resistor if the duty cycle is low. For high duty cycle or heavy vertical load applications, use an external regeneration resistor.



Caution! If bus voltage regeneration causes a drive temperature fault, an external regeneration resistor is needed.



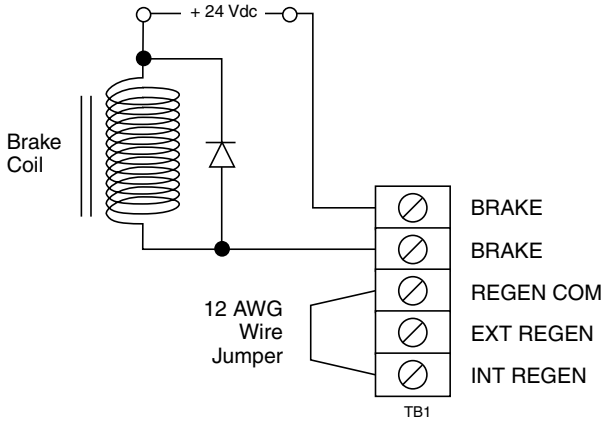
Caution! Either the internal or the external resistor pack should always be connected on any Axiom PV series application. Never connect both, as this may destroy the internal switching circuitry. All Tolomatic Axiom Plus units incorporate a brake relay. This is designed for use with an "energize-to-release" type of load brake. The brake relay contacts are rated for 3A. The relay contact is closed (brake released) only when the drive is enabled and not faulted. At any other time, the relay contacts open to apply the brake.

NOTE: Always wire a snubber circuit in parallel with the brake coil unless the coil has one internally wired. This can be a silicon switching diode for a DC coil brake. An MOV or R-C circuit may be used with an AC coil.

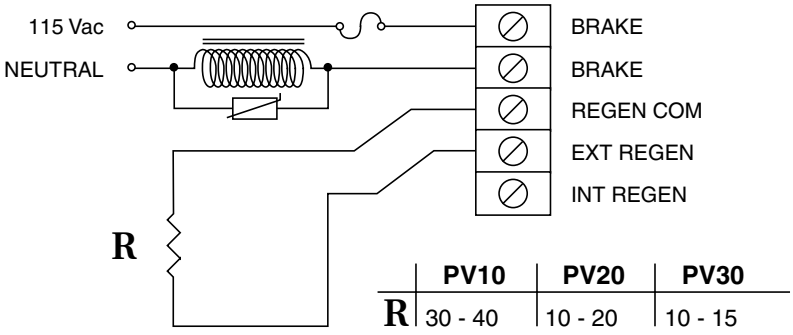
WARNING! Do not connect a jumper wire from REGEN COM to EXT REGEN. Permanent unit damage will result.

WARNING! If external regeneration resistance is necessary - use a resistor of the desired Watt rating and with a resistance value within the range specified in Figure 10.1.

24 VDC Brake with Internal Regen



115 Vac Brake with External Regen



	PV10	PV20	PV30
R	30 - 40	10 - 20	10 - 15

Figure 10.1 - Brake Connection & Regeneration Resistor Connections

Final Checkout & Tuning 11

Axiom Plus units always operate in “position” mode. The position command is generated by the internal trajectory generator and applied as a digital command to the unit’s position loop. The error position is continuously calculated and used to derive a command velocity. The position error is simply the difference between the actual motor shaft position, as determined by encoder feedback, and the commanded position. One commanded position count will be evaluated by the Axiom Plus as equivalent to a command for one quadrature encoder count of position change. Thus for a motor with a 1,000 line encoder (4,000 quadrature counts per motor revolution), 2000 step pulses should cause one half revolution of motor movement. At steady state, the unit attempts to hold the motor at exactly the position commanded, (zero position following error). With proper tuning, response and stiffness can be matched to the application’s load to achieve desired performance.

Online Tuning and Diagnosis

In order to perform final checkout and tuning of your Axiom Plus, you will need to use the Online Tuning and Diagnosis functionality in the software, which you previously used for your initial checkout. From the Main Menu, select On Line Tuning and Diagnosis to access this screen.

Note: It is highly recommended that you familiarize yourself with the operation of the functions available in the Online Tuning and Diagnosis menu, as this will greatly simplify the tuning process.

The Online Tuning and Diagnosis Page is divided into several sections, as described below:

COMMAND MENU, ONLINE TUNING/DIAGNOSIS MODE

Master Enable

This button allows the user to enable and disable the drive via software. The current state of this function will be indicated by that word appearing in color (Green for Enabled, Red for Halt). Be aware that the choice displayed on the button is NOT the active state, but rather the state that will exist when the button is depressed.
Note:This function is only usable as long as the “drive enable” logic in the PLC program is held true. If the PLC conditions required for

"drive enable" are not met, the drive will remain disabled, regardless of the state of the software enable/disable function.

Drive Stage Tuning/Diagnosis

This button allows the user to toggle the screen functionality between Tuning and Diagnosis modes. The mode displayed next to the button is the INACTIVE mode, and will be activated by selecting the button. The functionality displayed in the center of the screen will change accordingly.

Exit Tuning and Diagnosis

Returns the user to the Main Menu

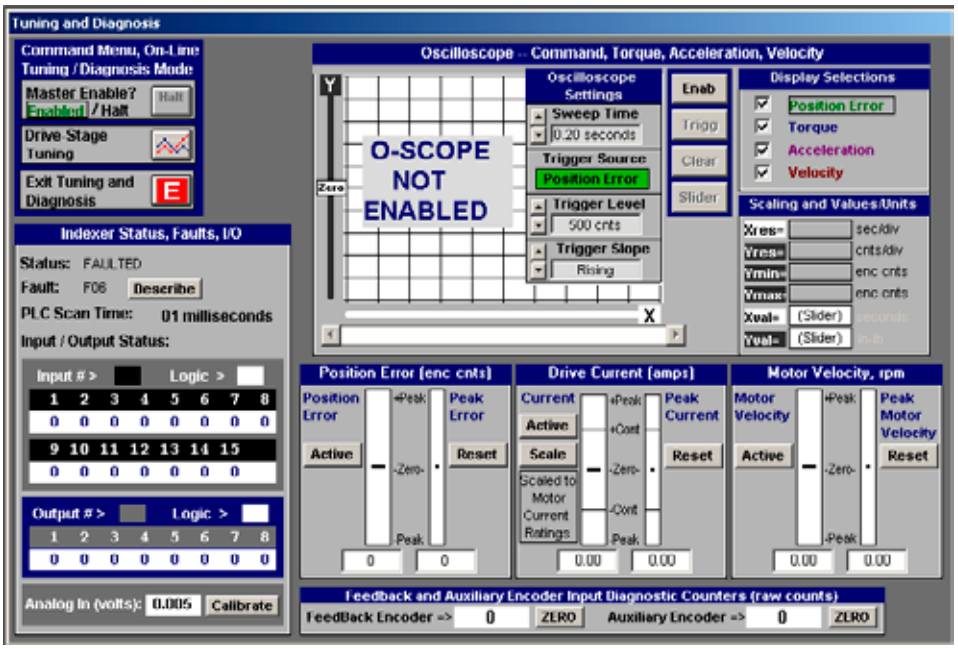


Figure 11.1 - Tuning and Diagnosis Screen

INDEXER STATUS, FAULT, I/O

This area indicates whether the drive enable logic in the PLC program is currently true (enabled) or false (disabled), if a fault condition exists, the actual scan time of the PLC program resident in the drive and also the current logic state of the fifteen inputs and eight outputs.

In the event that a fault condition does exist, the fault code will be displayed (matching the fault code flashing on the unit's LED) and a button labeled "Description" will appear. When pressed it will provide a brief description of the fault in question, whether the fault is "Fatal" (cycle power required) or "Non-fatal" and in some cases, how the fault may be cleared.

OSCILLOSCOPE

The built-in virtual oscilloscope in the Axiom setup and tuning software is designed specifically for Axiom Plus tuning.

The oscilloscope is controlled by four buttons, located on the center of the section:

Enable - Sets the scope to trigger on the next event.
Trigger - Brings up the trigger menu.
Clear - Clears the screen of the last event snapshot.
Slider - Enables/disables the slider feature. The slider allows accurate readings of the traces.

Display Selections

This area has four choices: Position Error, Torque, Acceleration and Velocity. Boxes checked will be displayed graphically on the scope. Clicking on a selection (ie. Position Error) will cause the scope window and slider to be scaled for optimal display of that particular parameter. The "scaled" parameter is indicated by a box outlining the word. You can then read that parameter's value at any point along the graph by moving the slider.

Scaling and Values/Units

All units are automatically scaled and displayed in the boxes in this section. The bottom two boxes display the X and Y coordinates that correspond to the Slider bar position.

Oscilloscope Settings

To take a reading, you must first define the Oscilloscope settings. *Note: If the Oscilloscope Settings menu is not visible, press the Clear button.*

- **Sweep Time** – This value can be set from .02 seconds to 20 seconds. This is the time period for one complete display sweep.

- **Trigger Source** – This displays the parameter whose change will trigger the sweep to begin. The user can define this by clicking on the Trigger button. The trigger setting adjustment frame is visible ALWAYS between scope sampling events. The button simply allows viewing the settings against the backdrop of already-sampled data.
  Note: The Axiom Plus unit must be enabled for the Trigger button to be active.
- **Trigger Level** - This value can be set from 0 to 100% of the Trigger parameter's value.
- **Trigger Slope** - The scope can trigger on a rising or falling slope. A rising slope would correspond to a CW step command.

ENCODER FEEDBACK SECTION

This small section at the bottom of the screen allows the user to evaluate the "raw count" change of the primary and auxiliary encoders, based on an arbitrary zero point, which is established by selecting the "Zero" button for that encoder.

The center section of the screen will change appearance, depending on whether Drive-Stage Tuning or Drive-Stage Diagnosis has been selected (see above).

DRIVE-STAGE DIAGNOSIS SCREEN

This screen is the default, and is normally active when you first enter the Tuning and Diagnosis menu.

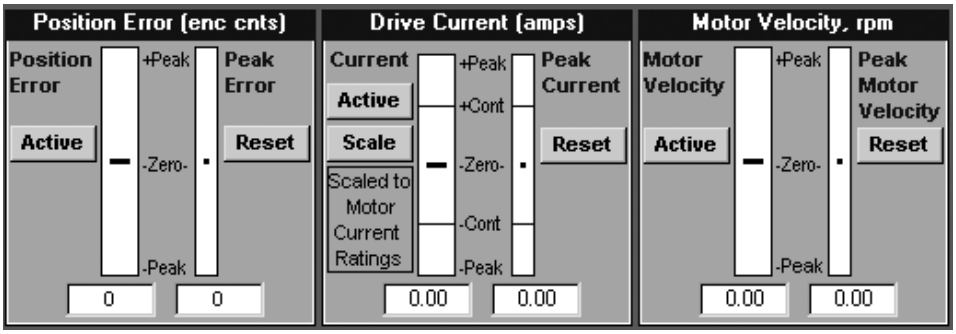


Figure 11.2 - Drive-Stage Diagnosis Screen

This section allows the user to monitor both actual and peak readings for the Position Error, Drive Current and Motor Velocity. To

engage the monitoring function, press the Active button in one of the three windows, and watch for the window header to change from white to green text. The Reset button allows the user to clear the peak value, to evaluate the impact of changes to the system. The Peak Current value in the Drive Current window can be scaled to reflect the peak value of either the Axiom Plus or the servo motor on the system.

DRIVE-STAGE TUNING SCREEN

This screen is intended for use during automatic and manual tuning of the system.

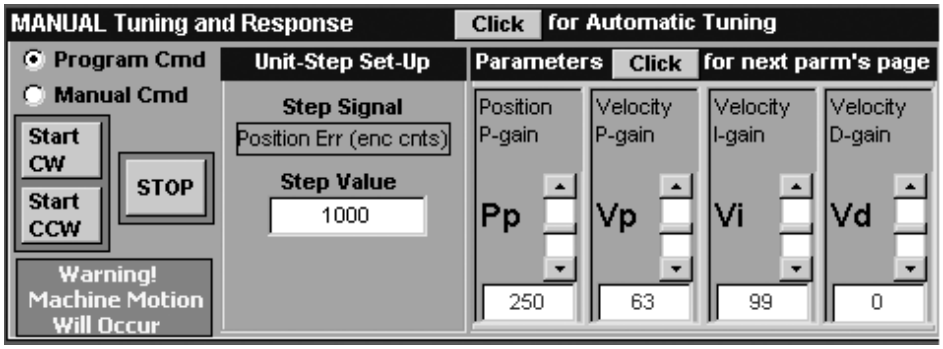


Figure 11.3 - Drive-Stage Tuning Screen

There are essentially three sections in this window, and these function as follows:

Drive Interface Section – The left-most portion of this screen allows the user to select the source for the command logic that operates the drive.

Caution! Motor motion will occur when using these functions, and appropriate safety precautions should be observed.

Program Cmd – This enables the sequential program and PLC program that are resident in the unit, allowing for tuning of the system using the "live" program.
Manual Cmd – This allows the user to disengage the "live" program, and command the drive manually using the "Start" and "STOP" buttons below. The command will now be based on the "Step" information in the Unit-Step Set-Up section of the window.
Note: The Manual Cmd function works with both Manual and

Auto tuning. The word "Manual" in this case refers to the control of the trajectory generator, and not the tuning method.

Unit-Step Set-Up – The content of this area will be determined by whether Automatic Tuning or Manual Tuning has been selected in the section header.

Manual Tuning – The area will allow the user to determine the step value (in encoder counts) to be used when the StartCW or StartCCW buttons are pressed. The motor will be commanded to move accordingly for the purposes of evaluating the tuning using the oscilloscope.
Automatic Tuning – When the Automatic Tuning button is selected, the area will show the appropriate step signal units, and will allow the user to define both the step value and the time for the auto tune function to use. In most cases, the default values are suitable for tuning.

Parameters – This section allows the user to manually adjust eight different tuning parameters, allowing for "fine tuning" of the servo control. These parameters are used as follows:

- **Pp gain** (Position proportional gain) increases stiffness by increasing magnitude of response to position error.
- **Vp gain** (Velocity proportional gain) increases system "stiffness" by increasing magnitude of response to velocity error.
- **Vi gain** (Velocity integral gain) will improve steady state following error. Excessive Vi gain will cause oscillations.
- **Vd gain** (Velocity derivative gain) improves damping and stiffness. Excessive Vd gain promotes noise sensitivity and high frequency oscillations.

To access the other four sliders, select the button on the section header labeled "Click".

Aff (Acceleration feed forward) produces a direct component of torque that is proportional to the rate of change of the velocity command.
Vff (Velocity feed forward) produces a direct component of torque feed forward that is proportional to the velocity command and thus position following error.
Mfe (Maximum following error) defines how the value for Following Error beyond which the unit will fault. When this value

is exceeded during operation, the Axiom Plus will fault out ("F55").
Ipb (In-Position Band) Any time the unit's following error is less than or equal to this number, the In Position state will be true(1). If the following error is greater than this value, the In Position bit flag (IS 006)will be (0).

Note: For most applications, the feed forward settings should be left at zero (0). Aff helps compensate for inertia and helps with system damping, while Vff helps compensate for viscous friction.

Now that you are familiar with the controls in this section, you are ready to perform the initial and final tuning of your system.

Drive Tuning

AUTO TUNING

To perform Auto Tune function:

1. Select On Line Tuning and Diagnosis from the main menu.
2. Select Drive-Stage Tuning button (see above).
3. Click command button "for Automatic Tuning".
4. Make sure the system is enabled. As discussed previously, the drive may be software disabled from this screen, but cannot be enabled unless the Enable input is active (via the PLC).
5. Use the "Start CW" and/or "Start CCW" command buttons to initiate tuning steps. Caution: Motor motion will occur in the designated direction.
6. When the auto tune function is complete, the motor will stop and the PID tuning values will be displayed. These values can be accepted or rejected. Before accepting or rejecting calculated gain parameters, the software allows the user to adjust the bandwidth of the system via a scroll bar. Lower bandwidths are appropriate for systems with high-inertia loads and/or poor coupling (compliance or bandwidth). Higher values of bandwidth give the best performance with stiffly coupled systems.

The Auto Tune function will normally provide stable tuning values. However, these will not necessarily be optimal values. It is recommended that the user proceed to the manual tuning section and use the oscilloscope functions to observe the response. The

drive may then be fine tuned for better response. Auto-tune step parameters (torque level and time duration) can be adjusted if necessary to improve auto-tuning. Default values are usually most appropriate

MANUAL TUNING

Although the auto tune mode will produce usable results for most systems, it is usually desirable to further tailor the system response to fully meet the needs of your application. After performing an auto tune as outlined above, proceed with the following steps in order to manually tune the drive.

1. Set an appropriate step size in the step value window. A value less than 500 is usually appropriate.
2. Clear and enable the oscilloscope (see above) before each step.
3. Make a CW or CCW step by clicking on the appropriate button.



Caution! Motor movement will occur.

Make adjustments to the gains until the desired response is achieved. It is usually best to start with a relatively low value of proportional (Pp) gain and adjust the velocity gains first. Then gradually increase the Pp gain as a final step.

ANALOG INPUT GAIN AND OFFSET ADJUSTMENT AND DIAGNOSTICS

The “tuning and diagnostics” mode of Axiom+ setup and configuration software allows for monitoring of the analog input value in millivolts and also for adjustment of gain and offset of the analog conversion. The user can thus calibrate the analog input against an accurate voltmeter or even make slight adjustments in gain and offset to help match the converted input value with a particular analog source.

Figure 11.3 shows the diagnostics screen with the analog calibrate function selected. As shown, the analog input value is displayed (updated in real-time) in millivolts. The two scroll bars allow the user to adjust gain (labeled "Scale Factor") and offset of the analog conversion.

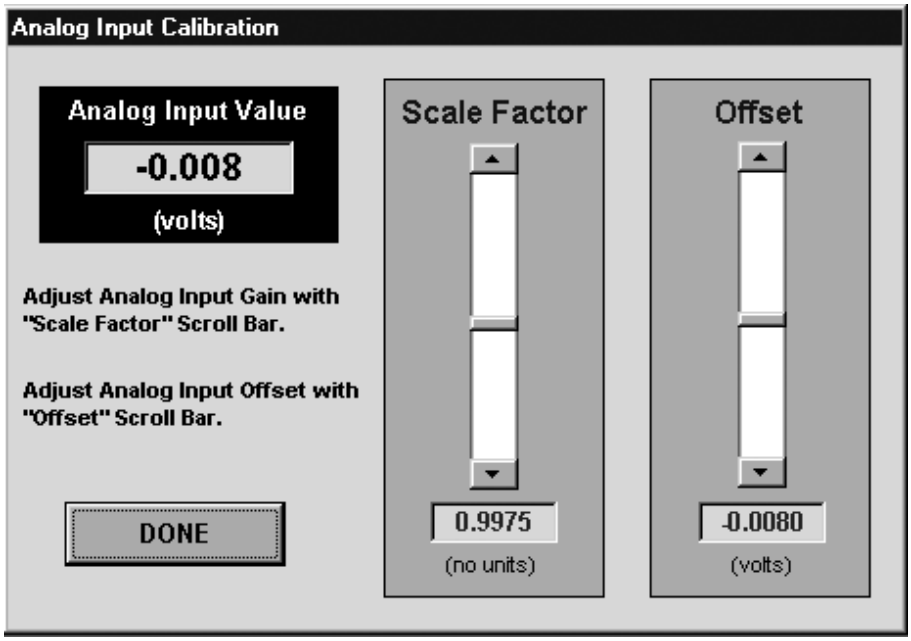


Figure 11.3 Tuning and Diagnostics Screen with Analog Input Calibration Function active

- Note: The scroll bar adjustments are "live", i.e. any change in analog input gain or offset is immediately effective, and values are stored in indexer non-volatile EEPROM memory as they are changed.

  Once the analog input is calibrated, the settings will be permanently active.

The recommended way to calibrate the analog input:

- Short the two analog input terminals together to force an input of zero volts
- Adjust the offset for a displayed reading of 0.000 volts.
- Apply a fixed voltage of 9 to 10 volts would be applied positive and adjust the gain so that the diagnostic reading accurately matches the input voltage.
- After this, switch the polarity at the input and verify the negative reading to see if any additional gain tweaking is necessary.
- Lastly, check the offset with zero volt input again.
  This approach would match the analog input most accurately with a bi-polar voltage input. In reality, the user might want to make additional fine adjustments relative to the particular voltage source or transducer being used. The voltage displayed represents the value

that is used by the indexer for all analog functionality during application run-time operation. This displayed voltage will always reflect the active scale factor and offset adjustments set by the user. These parm's are stored in indexer non-volatile memory automatically, are considered part of the indexer configuration settings and can be saved to a file along with the rest of the configuration data.

The diagnostics screen also displays the analog input reading (with gain and offset applied) when the analog input calibration function is not active. The value is then displayed "live" at the lower, left-hand part of the screen, below the I/O status display.

- **Note: The displayed value is in signed volts with a millivolt resolution, and reflects the active user-adjusted gain ("Scale Factor") and offset adjustments.**

  Once the analog input is calibrated according to the user's requirements, the analog input value can be used for PLC comparison purposes, and in a variety of sequential instructions allowing control of position, velocity, and torque / thrust according to the analog value.

Programming 12

The operating environment of the Axiom Plus consists of two separate parts or “threads”. These are the sequential program and the PLC program. The sequential program executes actual move commands and is programmed using the Sequential Program editor. The PLC program is a scanned logic program that operates like a stand alone Programmable Logic Controller (PLC). The two programs communicate with each other through internal binary logic bits, referred to in this document as “bit flags” or simply “flags”. There are a total of 64 user-definable bit flags in the Axiom Plus for communication between PLC program scan and Sequential motion program. There are 32 discrete flags which are “Read/ Write” in the sequential program and “Read Only” in the PLC, and 32 that are “Read/Write” in the PLC and “Read Only” in the sequential program. In addition to these 64, there are a number of special purpose (designated) flags that are “Read/Write” in the PLC and can be monitored (read) in the sequential program. These flags control and monitor the trajectory generator, which, in turn, commands the drive section, causing motion. By combining the functionality of these two threads, complex control programs can be written that would be difficult or impossible with a PLC or sequential motion controller alone.

As the name implies, the sequential motion program is executed sequentially. One instruction is executed to completion before the next is begun. All move commands are set up and executed by the sequential motion program. In addition, input/output commands, branch commands and time delay commands can be executed in a sequential motion program. The sequential program is most useful for efficiently executing a series of sequential program steps, often a part of machine control applications. In simple applications, the sequential motion program can be used to run the entire application. In more complex applications, it can be used in conjunction with the PLC functionality to implement a control program capable of running virtually any single axis application.

The PLC program operates as a traditional “ladder logic” controller. It allows a scanned I/O and logic program to execute asynchronously with respect to the sequential motion program. Because of the 64 communication flags between the PLC and the sequential motion program, it is possible to effectively address applications requiring

complex I/O and logical operation along with single axis motion control. The PLC is best suited for handling events that occur asynchronously with respect to the main sequential program.

Programming Environment

The Axiom Plus programming platform consists of a sequential program editor and a PLC program editor. Only one of these editors can be open at a time, but the user can move back and forth between the sequential and PLC editors without losing the work in progress in a given editor. The sequential program (.prg) and PLC program (.plc) can be saved as separate files, or saved together using the "Save Project" command. All comments within a PLC and/or sequential program are uploaded and downloaded with the program, eliminating the need to maintain a separate comment file.

Sequential Program Editor

The Sequential Program Editor is a graphical user interface designed to quickly and easily develop a sequential motion program. To create or edit the Sequential Motion Program, click on the "Sequential Motion Program" button on the Main Menu screen.

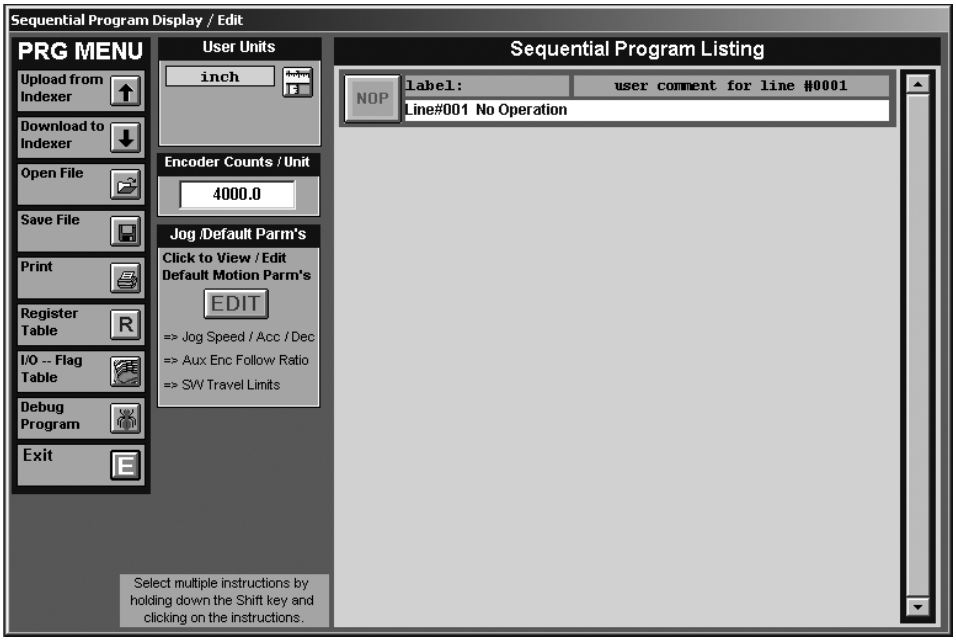


Figure 12.1 - Sequential Program Display / Edit Screen

The above screen will appear consisting of an editing window and a menu of buttons. These buttons are used to select the desired action, and their function is described below:

PRG MENU

 **UPLOAD FROM INDEXER**
This will upload the sequential program (and its associated comments) from the Axiom Plus unit. In order to perform this operation, you must be connected to the unit via the RS-232 interface, and be using software that is compatible with the firmware of the drive.
Note: This operation will overwrite any sequential program that is resident in the programming workspace. If you need to keep the program currently in the workspace for future use, you will need to utilize the Save function (see below).

 **DOWNLOAD TO INDEXER**
This will send the sequential program (and its associated comments) to the memory of the Axiom Plus.
Note: This operation will overwrite the sequential program currently stored in the unit.

 **OPEN FILE**
Allows the user to open a sequential motion program previously saved to disk or to create a new file.

 **SAVE FILE**
Saves the sequential motion program in the workspace to disk.

 **PRINT**
Prints the program currently in the workspace.

 **REGISTER TABLE**
Provides access to the full listing of available registers, and allows commenting to be performed here.

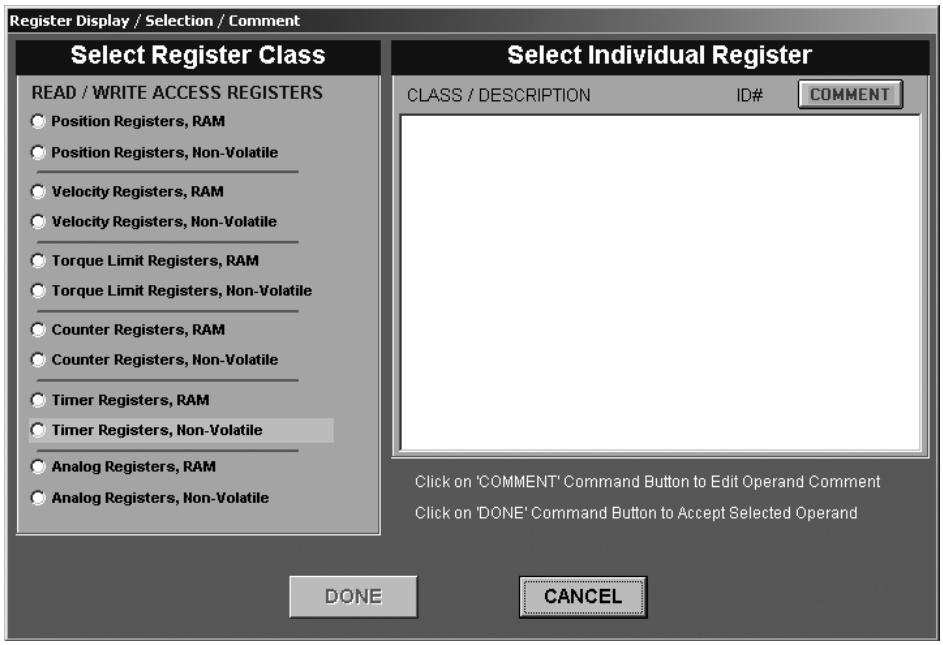


Figure 12.2 - Register Display Screen



I/O FLAG TABLE

Display a list of the I/O and PLC bit flags, and allows comments to be inserted here. The “double-star” icon in the USED? Column indicates that this I/O or flag is being used by the sequential motion program or the PLC program.

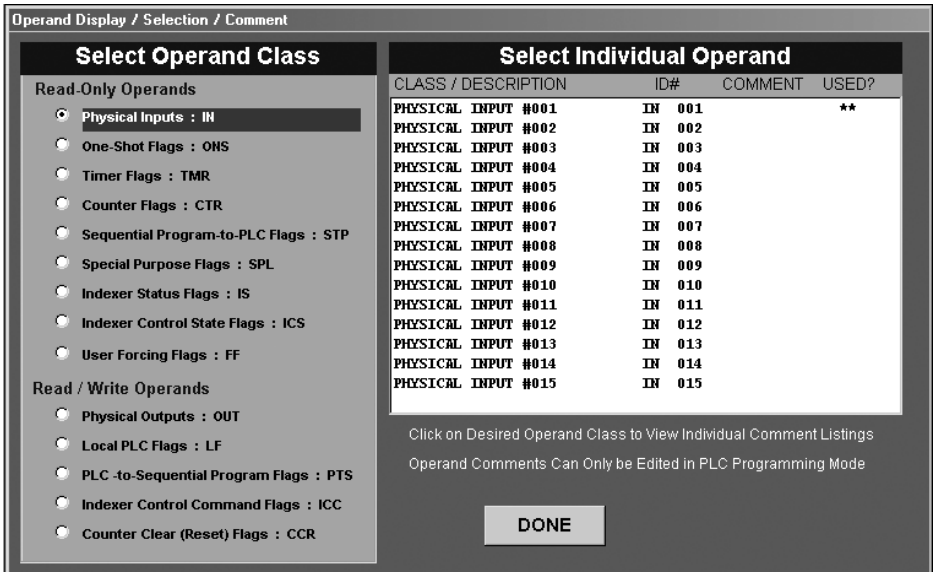


Figure 12.3 - I/O Flag Table Screen

SEQUENTIAL PROGRAM DEBUGGER

A method of debugging a sequential program is available to the user when testing a sequential program. A button labeled "Debug Program" has been added to the Sequential Program user menu. The Debugger allows the user to single step through the Sequential Program and to view and modify the values of flags and registers.

When clicked, the Sequential Program Debug menu replaces the Program Menu, "User Units", "Encoder Counts / Unit", and "Jog / Default Parms" configuration information boxes replaced with the Debug Menu and "Drive Status" and "Jog Control" boxes. The next instruction to be executed is highlighted with a red background, shown in the sample screen Figure 12.4 below.

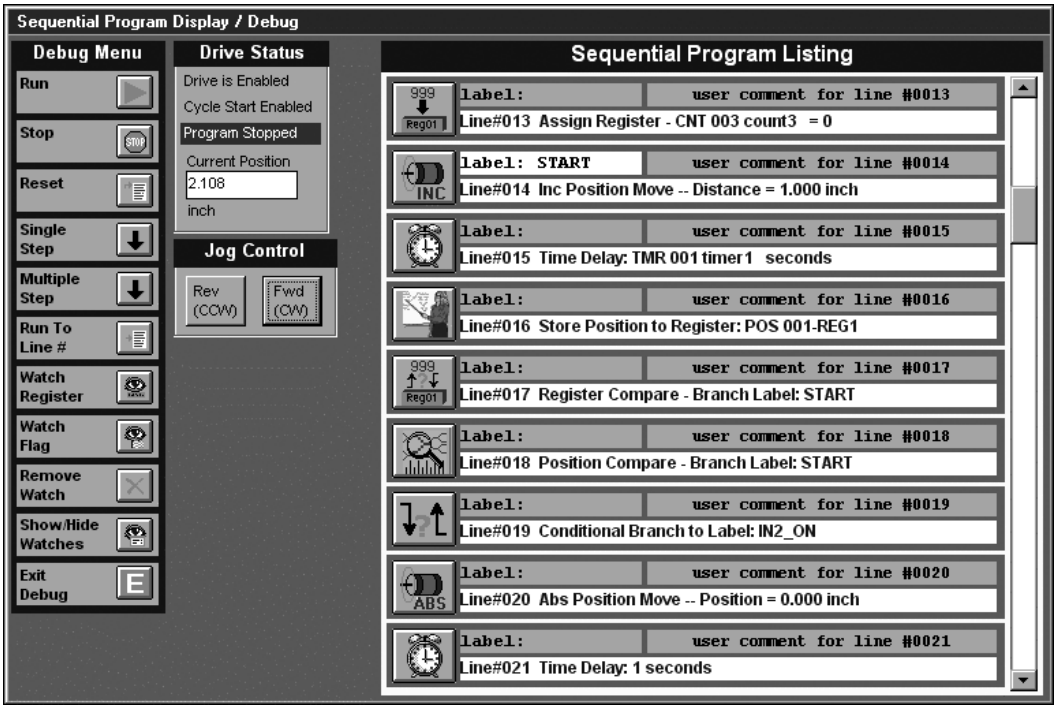


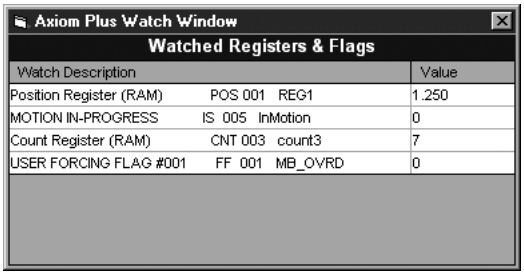
Figure 12.4 - Sequential Program Debugger

The Debug Menu allows the user to start and stop the program, and if stopped, single step one instruction at a time, step over a number of instructions, or run to a specified instruction line and stop.

Other options on the menu allow the user to view the contents of registers and the value of operand flags. Selecting either the "Watch

Register" or "Watch Flag" items brings up the Watch Window, which displays the watched register's description and its current value.

Figure 12.5 - Watched Registers & Flags



If the user double clicks on an item in the watch window, a dialog box pops up that allows the user to enter a new value for the register or flag. Only registers and forcing flags can be modified in the watch window. All others are read only. A value can only be changed when the program is stopped.

If the program is stopped, the user can use the "Jog Control" buttons to move the actuator. Click and hold on either button will cause the drive to move as long as the button is down. This jog control initiates a jog move using the settings for Jog1.

The Drive Status box, the current program line and the watch window, if present, are updated every 500ms.

Debug Menu Options:

- **Run** - Starts the sequential program running.
- **Stop** - Stops a running sequential program.
- **Single Step** - Executes one line of a sequential program.
- **Multiple Step** - Run the program until the number of lines specified has been executed.
- **Run to Line #** - Run the program until the specified line number has been reached.
- **Watch Register** - Add a register to the watch window.
- **Watch Flag** - Add a flag to the watch window.
- **Remove Watch** - Removes the selected watch item from the watch window. To select an item, simply click on it
- **Show/Hide Watches** - Brings up the watch window if not present or closes it if it is.
- **Exit Debug** - Exits debug mode and returns to the Program Edit screen.

 **EXIT**

Returns user to the Axiom Plus main menu screen.

USER UNITS

The units used when programming motion can be set up from the opening screen of the sequential programming editor. The user clicks on the ruler icon in the user unit box and selects the desired unit. If the desired unit is not in the list, “Other” can be selected and the unit label can be entered.

Encoder Counts/Unit

Once the unit label is selected above, ‘counts per unit’ needs to be entered. Standard Tolomatic brushless servo motors use a 1000 line encoder operating in quadrature, equaling 4000 counts/rev. (Example: A 2-turns-per-inch screw has 2 x 4000=8000 counts/inch). A negative value (i.e. –8000 counts / inch) would reverse the polarity for programmed motion (a positive move would be CCW and a negative move would be CW). Changing the polarity of the user units does not effect PLC jogging or encoder following.

Jog/Default Parameters

In the Jog/Default parameters window the default speeds, acceleration, deceleration and encoder following ratios are entered. Default values will be downloaded to the Axiom Plus with the sequential program. Software travel limits can also be set via this screen. These are intended as default values only, and all (except Cycle Stop Decel) can also be set and varied within a sequential program.

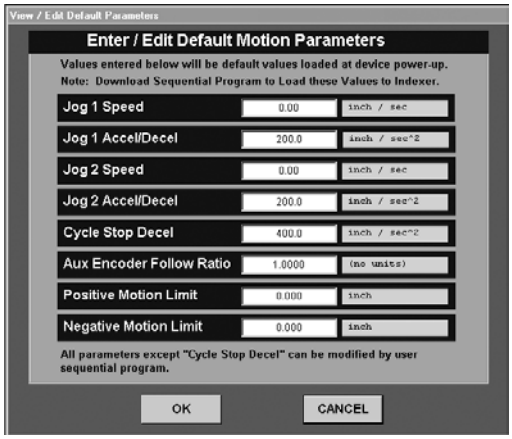


Figure 12.6 - View / Edit Default Parameters Window

SEQUENTIAL PROGRAM LISTING

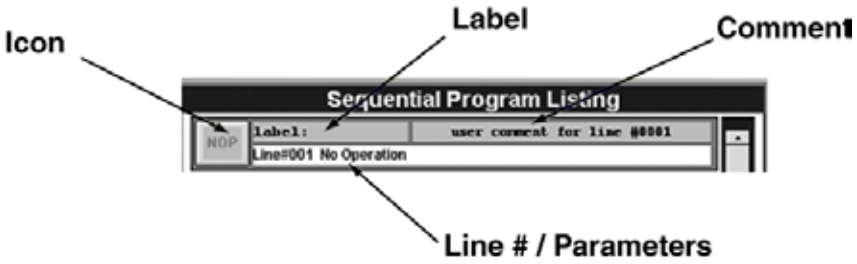


Figure 12.7- Sequential Program Listing Screen

A single program instruction consists of the following four parts:

Icon - An icon is a visual representation of the type of instruction being used. Clicking here brings up the following menu:

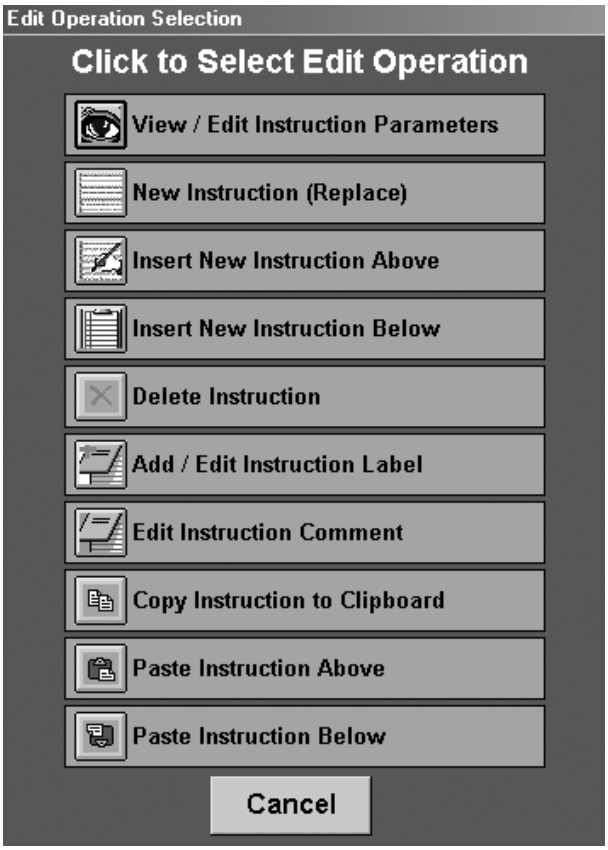


Figure 12.8 - Icon Menu Window

Label - Provides a location that the program can branch to, or indicates the beginning of a subroutine. The label acts as identification of a specific program line.
Line number / Parameters - All the instruction parameters are displayed when the mouse is placed over this portion of the program line. Clicking here allows the user to modify the parameters associated with this instruction.
Instruction comment - User-defined comment for this line.

CREATING A SEQUENTIAL MOTION PROGRAM INSTRUCTION

If the user clicks on an instruction icon, a window will appear displaying a list of edit operations. The user then may choose the desired operation and click on its button. The following is a description of those operations.

 **VIEW/EDIT INSTRUCTION PARAMETERS**
View or edit an existing instruction.

 **REPLACE INSTRUCTION**
Add a new instruction to the current line or replace the existing instruction.

 **INSERT ABOVE INSTRUCTION**
Inserts an instruction line above the currently selected one.

 **INSERT BELOW INSTRUCTION**
Adds an instruction line after the currently selected one.

 **DELETE INSTRUCTION**
Deletes the currently selected instruction line.

 **ADD/EDIT INSTRUCTION LABEL**
Add or edit the eight character instruction label assigned to each instruction. This label is the label used by the program for the destination of a jump, branch, or subroutine call instruction.

 **EDIT INSTRUCTION COMMENT**
Edit the 32 character comment assigned to each instruction.

INSTRUCTION COMMAND SET

The program instructions are divided into groups based on function. From the instruction type selection window (above), select the type of instruction needed, then select the specific instruction.

AXIS MOTION

This group of instructions sets the type of axis motion desired. The user can set up an “Absolute Position Move”, an “Incremental Position Move” or a “Velocity Move”.

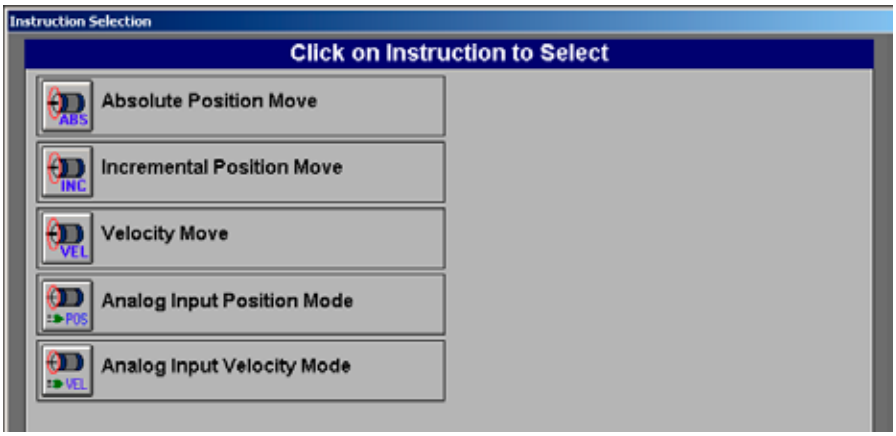


Figure 12.9 - Axis Motion Window

ABSOLUTE POSITION MOVE

Allows the user to define a move that will end at a defined distance from the “zero” point. The Axiom Plus defines motor rotating CW (facing the shaft) as the positive direction and CCW as the negative direction. This assumes a positive value of user-units conversion factor. A negative value (i.e. –8000 counts / inch) would reverse this polarity for programmed motion. This “zero” point is defined by the user as part of a homing routine. The values for Position and Speed can be either an actual number, or can be designated as a register value stored in the unit. Final position, velocity, acceleration and deceleration can all be set from this screen, along with editing the instruction labels and instruction comments.

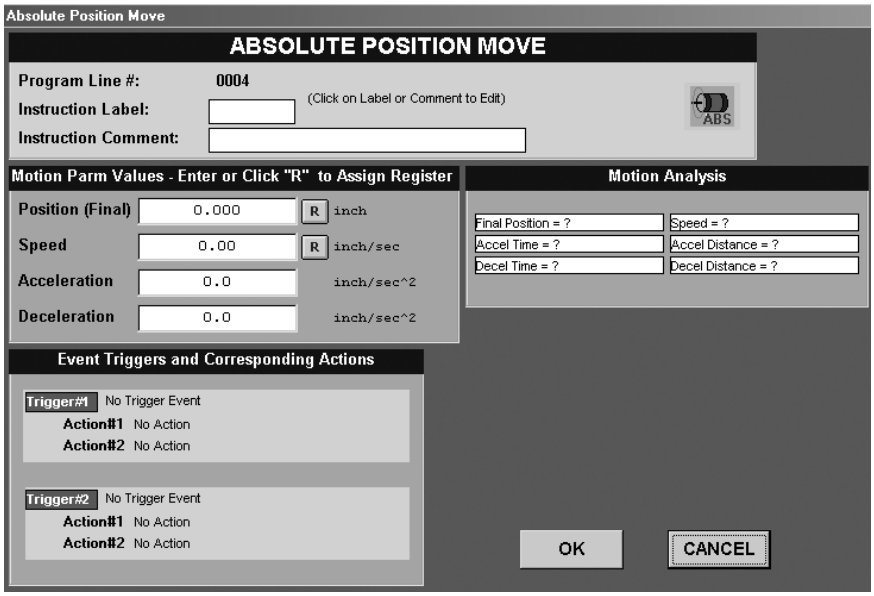


Figure 12.10 - Absolute Position Move Window

In addition, the user may embed up to two event triggers in a given move. Each one of these event triggers can cause up to two actions to take place. This allows the user to make complex moves triggered by an input, PLC flag or position reached. Bit flags and outputs can also be set from within a move.

TRIGGERS – The triggers are set up by selecting trigger #1 or trigger #2 from the Move window (Absolute, Incremental or Velocity). Selecting a trigger brings up the Motion Event Trigger Parameters window. The user then selects the source of the trigger, either an absolute position reached or a PLC flag/ physical input. The next step is to define the action to take place once the trigger is received. There can be two separate actions for each trigger. Action #1 can be one of the following: set new speed, set/clear an output (physical or flag to PLC), or terminate the current move. Action #2 can be either to define a new torque limit or set/clear an output (physical or flag to PLC).



INCREMENTAL POSITION MOVE

This instruction causes the axis to move an incremental distance from the currently commanded position. It has the same setup and event trigger parameters as those for the absolute position move instruction described above.



VELOCITY MOVE

Commands the axis to accelerate and move at a defined velocity. The motion can be modified or terminated using an event trigger, as described above.



ANALOG INPUT POSITION MODE

This sequential instruction has been provided to allow control of absolute position command via the analog input. The instruction parameters allow matching an analog input range to a commanded range of absolute system position. Thus, a servo system can "track" an analog input signal. Figure 12.11 shows the programming screen for this instruction.

MAXIMUM SPEED AND ACCEL / DECEL - These parameters are entered in similar fashion to other axiom+ motion instructions. These parameters are both unsigned and effectively limit the speed of position tracking response to rapid changes in the command analog input. Maximum speed can be assigned to a velocity register, as well.

ANALOG POSITION CONVERSION FACTOR - This allows the user to set the gain applied to analog voltage to determine absolute position command. A value of 1 for this parameter would mean that a change of 1 volt in the analog input signal would provide for a change of 1 user unit in the commanded position.

ANALOG COMMAND POSITION OFFSET - This parameter provides a means of programming an offset or shift in the range of commanded absolute position. The user should enter the position that would correspond to a zero volt analog input for this parameter.

Once Analog Input Position Control Mode is executed, absolute position will immediately begin to track the analog input based on the programmed parameters. Cycle pause and resume functions will work to pause and resume motion. The sequential program will halt at this instruction and motion will track the analog input until the "exit" condition occurs, which is a logic 1 state for the programmed exit flag.

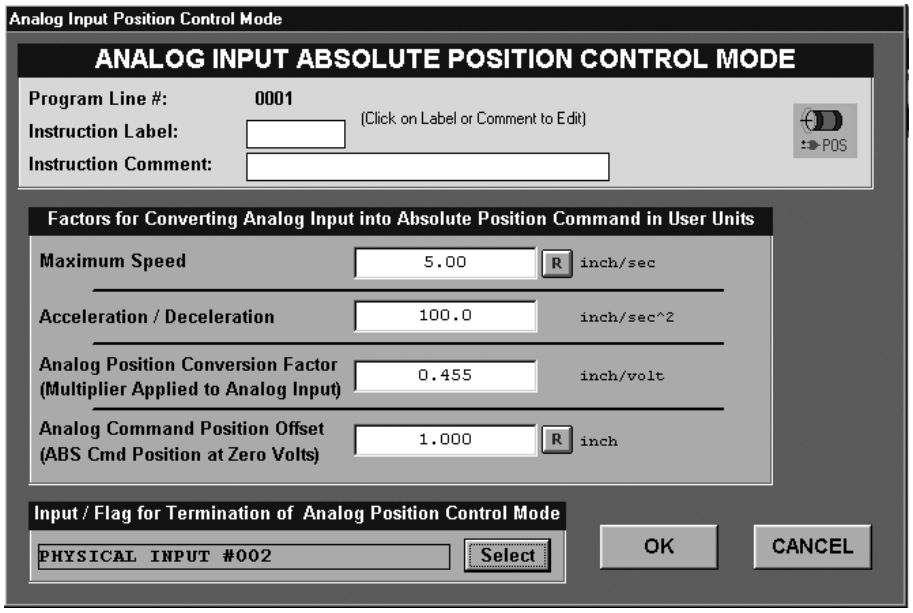


Figure 12.11 - Sequential Instruction Form for Programming of Analog Absolute Position Control

In figure 12.11 the scale factor is programmed for a value of 0.455 inches / volt and the offset for 1.0 inches at zero volts. Thus, an analog input in volts times 0.455 plus 1.0 will correspond to the absolute command position. In this example, physical input #002 is chosen as the exit flag. If and when input #002 is logic state 1, this instruction will terminate, motion tracking of the analog input will stop and the system will decelerate to a stop. Execution of the next sequential instruction will then commence.



ANALOG INPUT VELOCITY MODE

These sequential instructions allow control of motion velocity based on the value of the analog input.

This functionality could be used for jogging or "joy-stick" type operation modes with the analog input acting as the velocity command source.

Another possible use would be to control torque or thrust according to analog feedback from a force or torque transducer. This could be done by programming the instruction to produce a velocity proportional to the "error" between desired analog feedback

setpoint and the actual analog value. Analog Input Velocity Control Mode will initiate velocity tracking of the analog input and will remain active until a logic 1 condition exists for the user selected exit flag. While in analog input velocity mode, motion can be stopped and started using the cycle pause and cycle resume functionality of the PLC. In figure 12.12, physical input #002 has been selected as the exit flag. Once the exit condition is made, motion will decelerate to a stop and execution of the next sequential instruction will start.

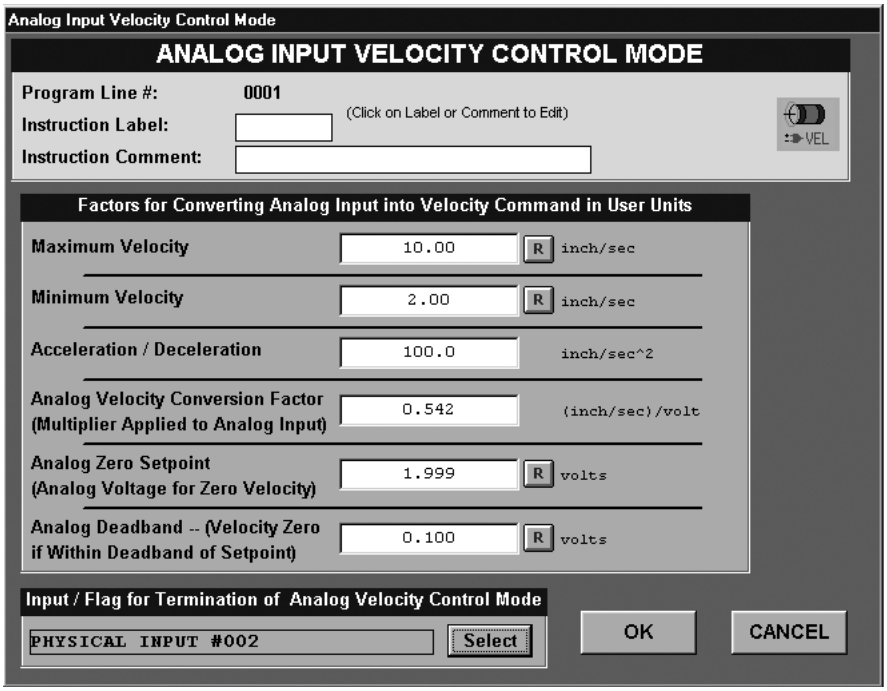


Figure 12.12 - Sequential Instruction Form for Programming of Analog Velocity Control

- The velocity parameters are entered as signed numbers to define a range of allowed velocity command.
- Once this instruction is executed and velocity command tracking of the analog input value begins, the velocity will be limited according to the maximum and minimum values programmed.
- These values can be assigned to a register instead of being hard-entered.
- The acceleration. / deceleration parameter provides a limit on the rate of change of velocity tracking and should be set to a reasonable value based on the system capabilities.

ANALOG VELOCITY CONVERSION FACTOR - This parameter allows setting a gain relating commanded velocity in user units / second to the analog input value in volts. The figure shows a value of 0.542 inches / volt. Thus, for each volt of change at the analog input, the commanded velocity would change by .542 inches / second.

Note: This parameter can be a negative value, if desired.

ANALOG ZERO SETPOINT - This parameter allows the user to enter an offset for the voltage-to-velocity conversion. The figure shows a value of 1.999 volts. Thus, an analog input signal of 1.999 volts would produce a command velocity of zero. This parameter and the conversion factor allow complete definition of a range of velocity command values corresponding to an analog input signal range.

ANALOG DEADBAND - This parameter allows the user to enter a voltage range around the setpoint which will correspond to a command of zero velocity. In the figure, a value of 0.100 volts is programmed. This means that if the analog input voltage is withing 0.100 volts of the setpoint of 1.999 volts, the commanded velocity will be zero.

THRUST CONTROL - To use Analog Input Velocity Control Mode for thrust control, do the following:

- An analog signal corresponding to actual thrust must be provided to the indexer.
- The analog offset (setpoint) should then be programmed to a value corresponding to the desired thrust.
- The conversion factor then essentially sets the "gain" of the response to errors in thrust.
- The deadband parameter can be used to prevent "hunting" around the desired thrust setpoint.
- PLC compare operations and other logic can be utilized to control the exit condition.



OUTPUT/FLAG CONTROL

This group of instructions allows control of the physical outputs or internal bit flags from within the sequential motion program.

 **SET/CLEAR OUTPUT** - Sets or clears one of 8 physical outputs. If the output is also used in the PLC the state determined by the PLC takes precedence.

 **SET/CLEAR FLAG** - Sets or clears one of the 32 Sequential to PLC flags.

 **SET / CLEAR MULTIPLE FLAGS** - Sequential Instruction. This sequential instruction allows the user to change a block of flags, of 8 or 16, in the drive. Any flags that are set or cleared in this instruction, those changes take place simultaneously. The blocks of flags available are shown in figure 12-13. To use this instruction, the user first selects the block of flags they wish to modify, then clicking on the flag entry in the table to right will cycle through the 3 options for that flag, 1 = set, 0 = clear, or X = no change.

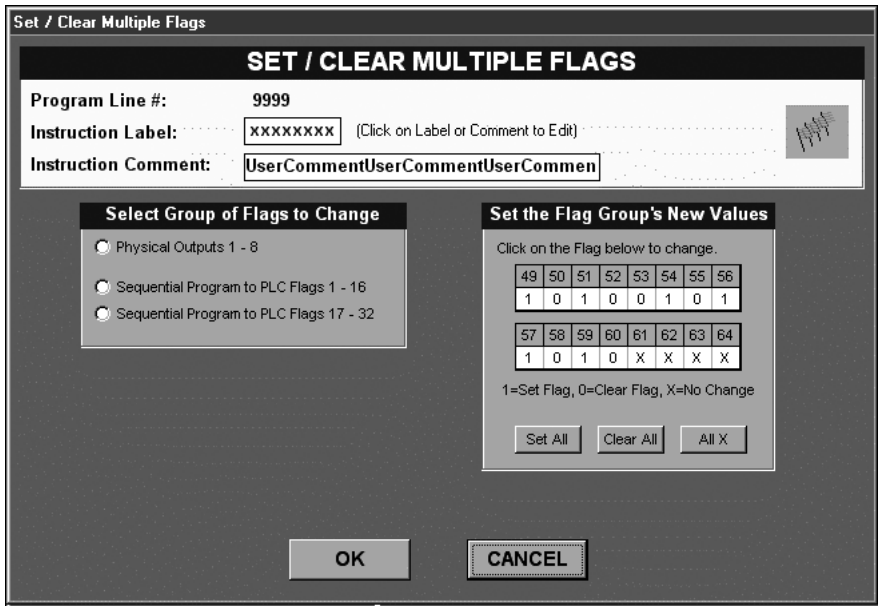


Figure 12.13 - Set / Clear Multiple Flags



PROGRAM CONTROL

This group of instructions controls the program flow of the sequential motion program. This group is divided into the following instructions:

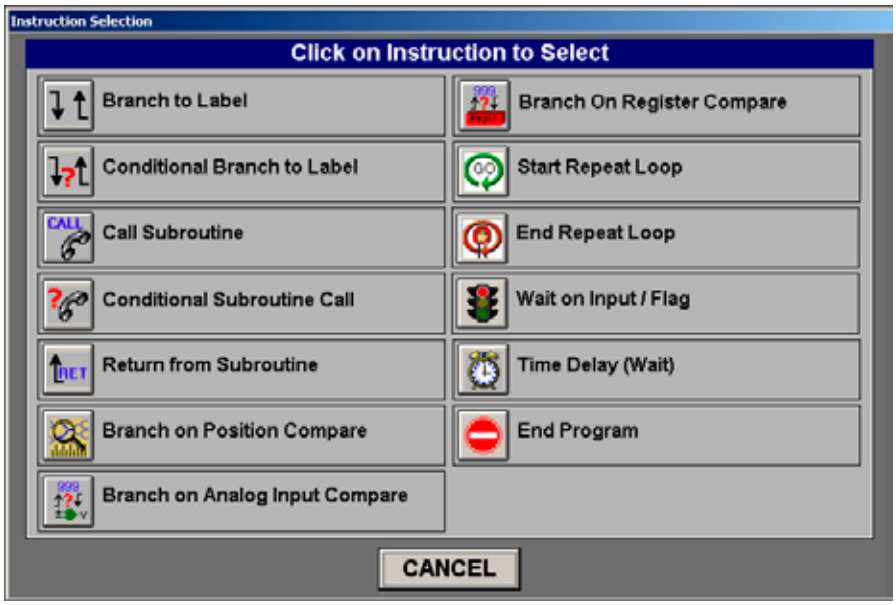


Figure 12.14 - Program Control Window

BRANCH TO LABEL - Causes the program execution to jump to the designated instruction label.

CONDITIONAL BRANCH TO LABEL - Causes program execution to jump to the designated instruction label only if the desired condition is met. If it is not met, the program jumps to the next instruction. The condition can be a physical input or PLC-to-Sequential flag. The logic state can be selected as logic 1 (true) or logic 0 (false).

CALL SUBROUTINE - Causes an unconditional subroutine call. When a subroutine is called the program executes the instructions starting with the subroutine label. The last instruction in the subroutine must be a "Return From Subroutine" instruction. This causes program control to return to the instruction following the "Call Subroutine" instruction. Subroutines calls can be nested four deep.

CONDITIONAL SUBROUTINE CALL - Causes a subroutine call to the designated instruction label only if the desired condition is met. If it is not met, the program continues with the next instruction. The last instruction in the subroutine must be a "Return From Subroutine" instruction. This causes program

control to return to the instruction following the “Call Subroutine” instruction. The condition can be a physical input or PLC-to-Sequential flag. The logic state can be selected as logic 1 (true) or logic 0 (false). Subroutines calls can be nested four deep.



RETURN FROM SUBROUTINE - Returns program execution to the instruction following the one that called the subroutine.



BRANCH ON POSITION COMPARE - This causes the sequential program to branch to another label based on the comparative value of either actual or commanded position against a user-defined value or a register value. The user can define the comparison type (<,>, <=, >=, <>, =) and if the condition is met, the sequential program will branch to the selected label.



BRANCH ON ANALOG INPUT COMPARE - This sequential program instruction compares the value of the analog input to a register or a fixed value. The instruction is shown in figure 12-15. First select the type of compare needed then enter the value of register to compare the analog reading against then enter a label to branch to if the condition is true.

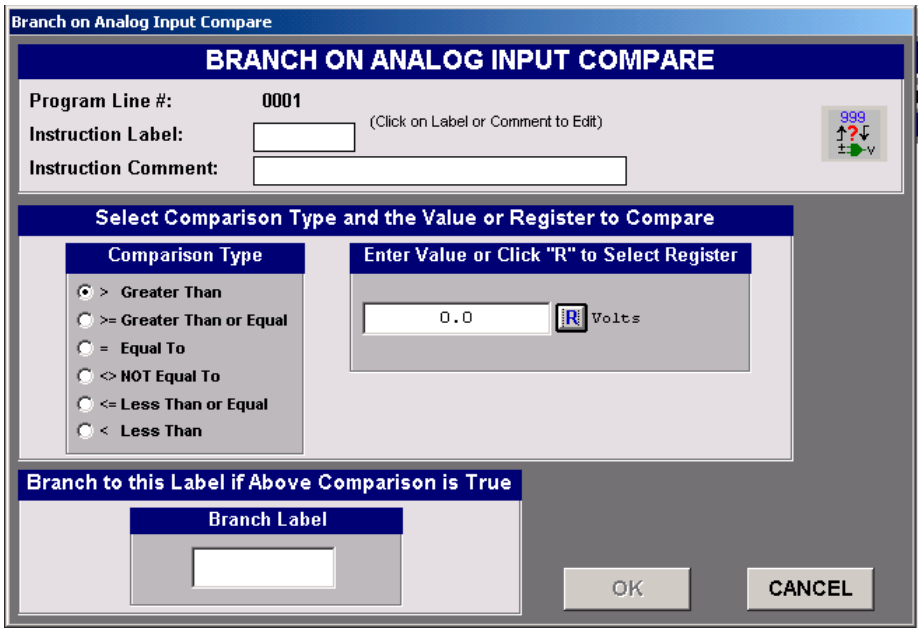


Figure 12.15 - Branch on Analog Input

BRANCH ON REGISTER COMPARE - This sequential program instruction compares the value of a register to a fixed value, or to a value in another register, then to branch to a labeled instruction. The instruction's setup dialog box is shown in figure 12.15. To make a register comparison, first select the register that you want to compare against. Then select type of comparison you wish to make, then enter the value to test against or select a register with a value, and lastly enter the branch label.

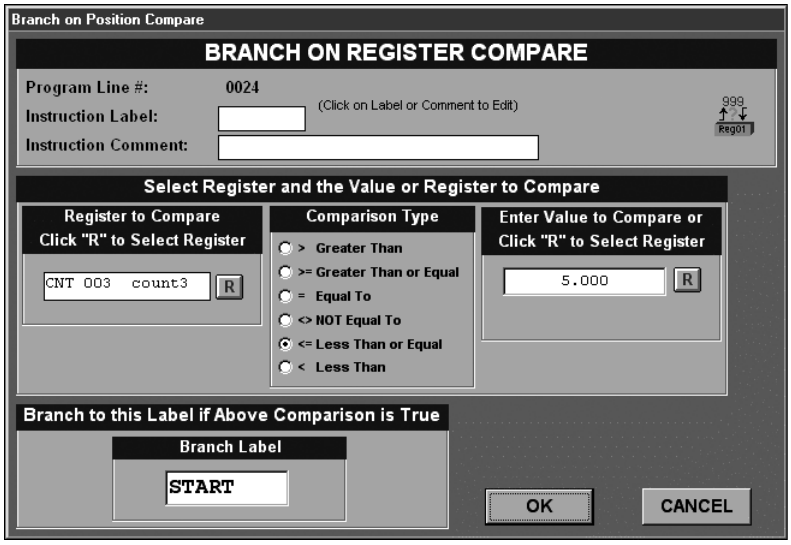


Figure 12.16 - Branch on Register Compare

START REPEAT LOOP - Placed at the beginning of a block of instructions that need to be repeated a defined number of times. The user enters the number of times that the loop is to be repeated between 1 and 10,000. Repeat loops can be nested a maximum of three deep.

END REPEAT LOOP - The last instruction in a repeat loop. The instructions between the Start Repeat Loop and the End Repeat Loop will be executed the number of times entered in the Start Repeat Loop instruction.

WAIT ON INPUT / FLAG - Causes program execution to wait for the selected state of the input or PLC-to-Sequential flag to be met. A selection can also be made that allows jogging while waiting.

TIME DELAY (WAIT) - Causes program execution to wait for the selected time period before moving to the next instruction. The allowable range is between 0.01 and 1000 seconds.

END PROGRAM - Causes the sequential program to terminate. It also sets a one-shot status bit (IS009) in the PLC program.

PARAMETER VALUE CHANGE

This group of instructions changes various internal parameters from within the sequential motion program. This type of instruction is divided into the following instructions:

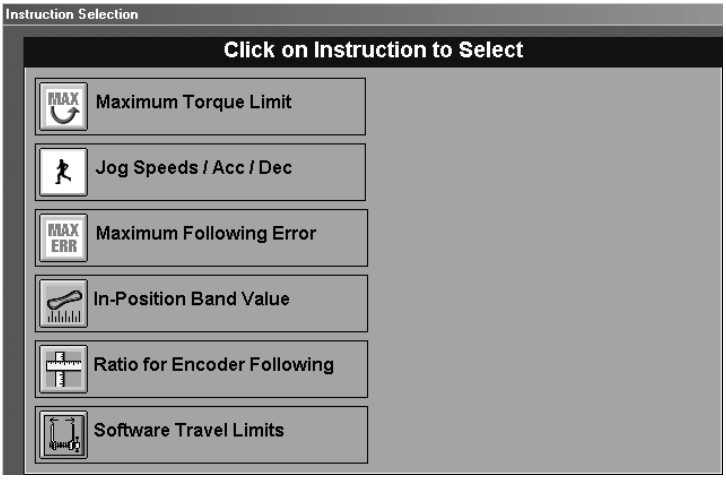


Figure 12.17 - Parameter Value Change Window

MAXIMUM TORQUE LIMIT - Changes the drives maximum torque limit. The limit is entered as a percentage of the value set in drive setup and configuration. It is also possible to use a register.

MAXIMUM FOLLOWING ERROR - Changes the maximum following error from the global setting set in the drive tuning screen.

IN POSITION BAND VALUE - Changes the "In Position Band" setting from the global setting set in the drive tuning screen.

RATIO FOR ENCODER FOLLOWING - Sets the gear ration for the encoder follower function. The encoder following has a range from 0.0001 to 99.9999. The ratio for the encoder following is calculated by dividing the desired commanded encoder counts by the auxiliary encoder counts.

SOFTWARE TRAVEL LIMITS – Sets (or re-sets) the soft travel limits for use in programming motion. These limits will be defined in current user units (inch, etc.) and will be in effect until they are re-defined elsewhere in the sequential program.

AXIS HOMING ROUTINES / ABSOLUTE POS FEEDBACK

Use this group of instructions to choose homing routines. This type is divided into the following instructions:

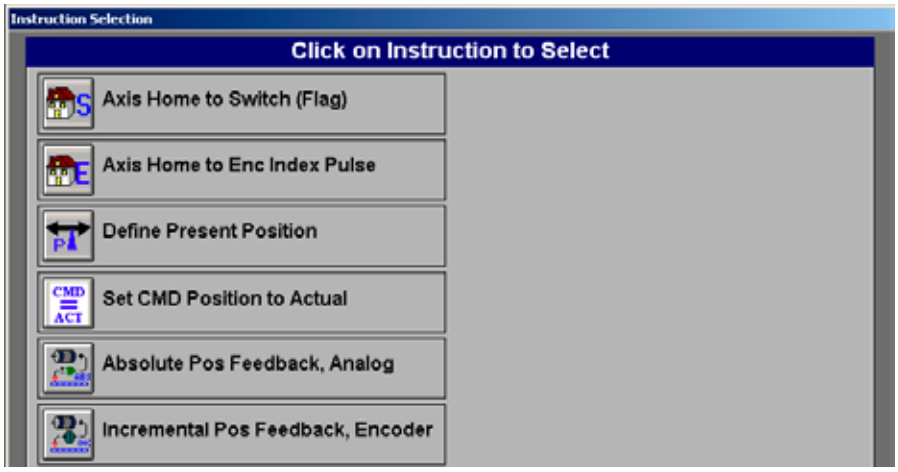


Figure 12.18 - Axis Homing Routines Window

AXIS HOME TO LIMIT SWITCH (FLAG)- Causes the actuator to move until it detects the home switch. The home to switch routine works by moving in the selected direction until it detects the home switch, it then decelerates to a stop and moves at the creep speed in the opposite direction until it detects another transition in the home switch. There is an option to allow an automatic reversal of direction if the end of travel is encountered before the home switch.

 **AXIS HOME TO INDEX PULSE** - Causes the actuator to move until it detects the home switch then an index pulse. The home to index pulse routine works by moving in the selected direction until it detects the home switch, it then decelerates to a stop and moves at the creep speed in the opposite direction unit it detects the first index pulse after a transition in the home switch. There is an option to allow an automatic reversal of direction if the end of travel is encountered before the home switch.

 **DEFINE PRESENT POSITION** – Allows either Actual or Commanded position to be arbitrarily defined as an absolute position.
Note: All future absolute positions will be referenced against this definition.

 **SET COMMAND POSITION TO ACTUAL** – This command sets the Commanded position (from the trajectory generator) to match the Actual position (as determined by encoder feedback). As a result, following error is zeroed out.

 **ABSOLUTE POSITION FEEDBACK, ANALOG –** This sequential instruction allows switching position feedback for servo control from the incremental encoder to an absolute, analog source. This "Absolute Position Feedback from Analog Input" instruction can be accessed in the sequential programming editor as a "homing" type instruction.

When this instruction is executed, the axis position is essentially referenced to an absolute position based on the analog input value and the user entered instruction parameters. Indexer status flag 004 is set upon successful execution of this instruction, as the axis is then effectively "homed". Subsequent motion commands will than servo based on the analog input value.

ANALOG POSITION CONVERSION FACTOR

The parameter "Analog Position Conversion Factor" allows the user to set a scale factor relating user units of position to volts of absolute feedback. This value can be positive or negative.

NOTE: It is important that the sequential program encoder counts / user unit parameter and the scale factor defining volts

per user unit match up. This is because, even when position feedback comes from the analog input, velocity loop closure is still based on the incremental encoder feedback.

EXAMPLE 1:

- An actuator / motor system has 10 inches of total stroke with a 2-pitch ballscrew and a 1000 line encoder.
- This system would have an encoder resolution of 1000 * 4 *2 = 8000 encoder counts per inch. This parameter would be entered on the main sequential programming screen.
- Now assume that linear, absolute analog feedback is available that provides 9 volts of output range over the 10 inch stroke.
- Also assume that voltage increases with travel in the same direction that produces positive encoder count accumulation.

The correct scale factor for analog position feedback would then be 9 / 10 = .9 volts per inch.

CAUTION!!! It is important that the sign of these parameters provides for the same polarity, i.e. if the analog feedback polarity does not match the equivalent position feedback from the incremental encoder, the system will be unstable and a run-away condition would result.

ANALOG POSITION OFFSET

Once the scale factor is properly set, the "Analog Position Offset" parameter can be set to provide a position reference point. This parameter defines the absolute position that corresponds to zero volts analog input. Some systems may not ever produce a zero volt analog signal, but this parameter is useful and valid nonetheless.

EXAMPLE 2: Using the system outlined in Example 1:

- Assume the zero position to be in the center of the 10 inch travel range, i.e. at 5 inches.
- With a defined a scale factor of .9 volts per inch and stated that the analog feedback voltage ranges from 0 to 9 volts over the 10 inches of system travel, then 5 inches of physical position would correspond to 5 * 0.9 = 4.5 volts at 5 inches.
- What is desired is an absolute position of zero corresponding to 4.5 volts. Thus, at zero volts, the position would be (0-4.5) * (1/0.9) = - 5 inches.

- If the Analog Position Offset is programmed for –5 inches at zero volts, then the analog input range of 0 to 9 volts, will correspond to absolute position of –5 to +5 inches, as desired.

  In figure 12.19, the scale factor is programmed for a value of 0.5 inches / volt. The offset is programmed for 0 inches at zero volts. In this case, the absolute position feedback value will correspond to the analog input value in volts multiplied by 0.5 with no offset added.

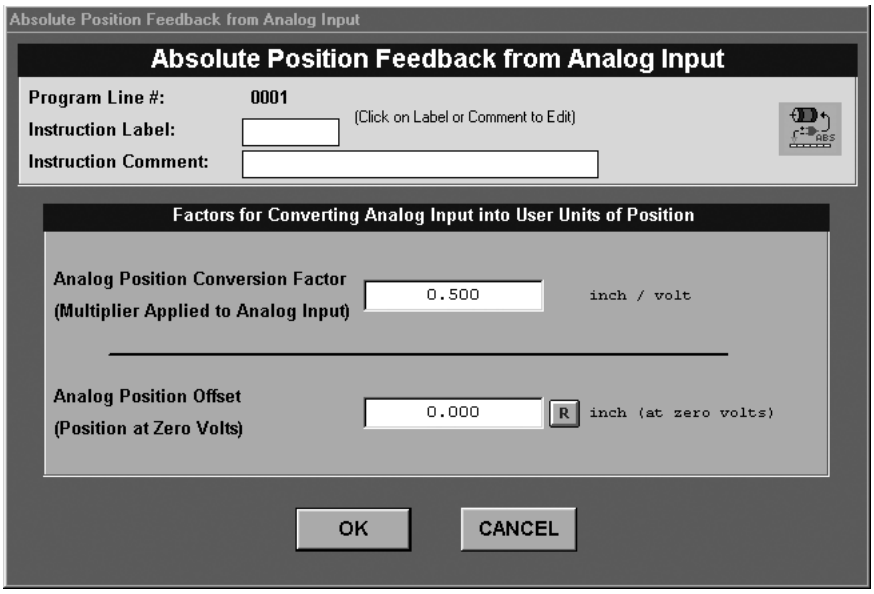


Figure 12.19 - Absolute Position Feedback Mode

The scale factor and offset parameters provide for flexibility in assigning an absolute position range to the analog range provided by any form of analog position feedback.

CAUTION!!! It is important that the analog feedback device covers the entire range of travel, as loss of feedback creates a potential run-away condition.

While the indexer is operating with absolute analog position feedback, the following error is monitored in "equivalent encoder counts". Thus, appropriate setting of maximum following error parameter can provide some level of feedback failure detection and system protection. Velocity loop closure is still accomplished by the incremental feedback device. All software diagnostics

referring to encoder counts will correspond to "equivalent" incremental encoder counts based on the analog input and programmed parameters while operating with absolute analog position feedback.

Once the “Absolute Position Feedback from Analog Input” is executed, the indexer will operate with position feedback coming from the analog input, pending the following conditions:

- **PROGRAM STOP OR NON-FATAL FAULT** - If the program is stopped or a non-fatal fault occurs, the position feedback source will remain the analog input.
- **FATAL FAULT OR RESET** - A fatal fault requiring reset, a power-down reset, or reset after download will reset the feedback mode to use the incremental encoder.
- **SEQUENTIAL PROGRAM SWITCH** - The Incremental Pos Feedback Encoder instruction is provided to force a switch back to incremental position feedback.

NOTE: If this instruction is executed, position feedback switches back to incremental per the encoder, but the absolute position reference is unchanged. When position feedback is from the analog input, then an absolute position reference has been rigorously defined and other sequential instructions that would modify this absolute reference, such as homing instructions and “Define Present Position” cannot be executed. *An attempt by the sequential program to execute any other instruction that changes the absolute position reference while the indexer is operating with analog position feedback will result in a fault.*

Also, if while operating with analog position feedback, the position feedback value ranges to full-scale (either +10 or –10 volts) and the position command is effectively outside the bounds of this equivalent range, an "F55" fault will occur.



REGISTER MANIPULATION

This set of commands enables the programmer to interface with the register values stored in the unit during execution of the sequential program.

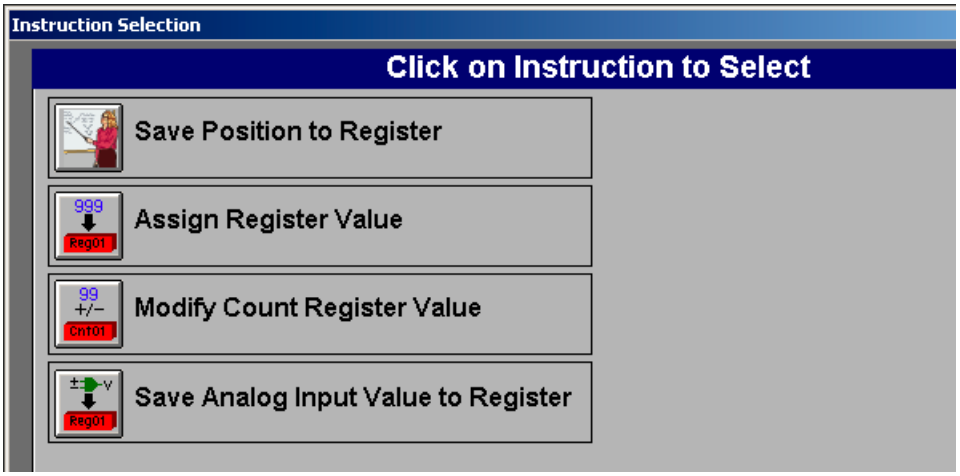


Figure 12.20 - Register Manipulation Window

SAVE POSITION TO REGISTER – This allows either the Actual position (based on encoder feedback) or the Commanded position (based on the trajectory generator) to be stored into a position register. Positions can be stored to either RAM or non-volatile registers, depending on whether the value should be maintained after power-down. Once stored to a register, the position can then be used as a reference throughout the sequential program.

ASSIGN REGISTER VALUE – This command allows the definition of a register value for either Position, Velocity or Torque. These values can be stored in RAM or non-volatile registers (see above) and can be used throughout the sequential program wherever the “Register” icon is displayed.

MODIFY COUNT REGISTER VALUE – This instruction modifies a count register in a sequential program. The "Increment/Decrement Count Register" instruction allows the user to modify the value in a count register by either adding or subtracting an integer value. Since count registers are a positive value, it will not decrement to a value less than 0.

To use this instruction, the user selects a count register, then chooses increment or decrement, then enter a value to be used.

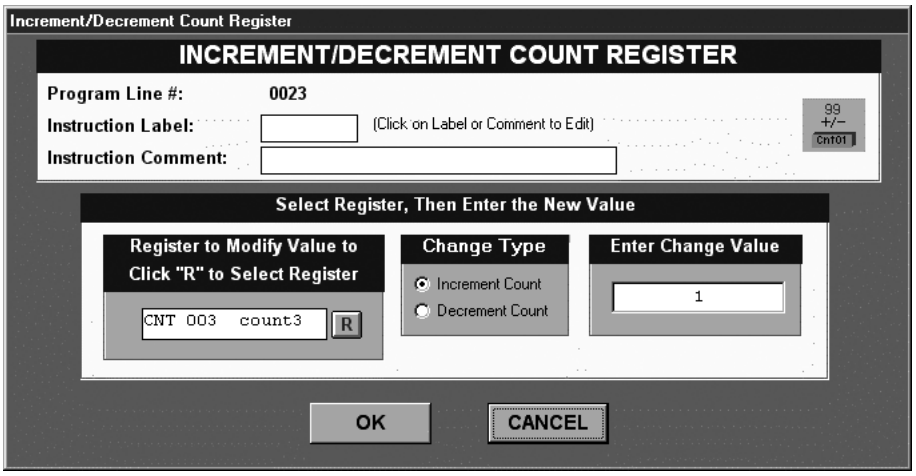


Figure 12.21 - Increment / Decrement Count Register



SAVE ANALOG INPUT VAULE TO REGISTER – This instruction saves the current value of the analog input to a register. Select the RAM or EEPROM register to save the analog value to.

PLC Program Editor

The PLC Program Editor is a graphical "point and click" application designed to quickly and easily develop a ladder logic program. To create or edit the PLC ladder logic program, click on the "PLC Scan Programming" button on the Main Menu screen.

A screen will appear consisting of an editing window with a menu of buttons on the right labeled "PLC Menu". These buttons are used to select the desired action.

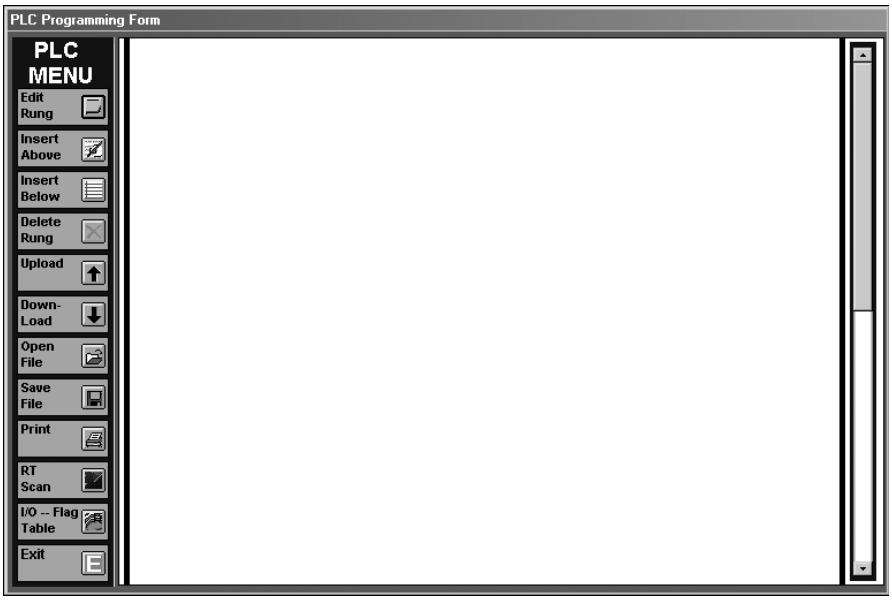


Figure 12.22 - PLC Menu and Programming Form Screen

All of the upper level functions for the PLC editor are selected from this screen. To select a rung for editing, click on the rung number (ex. RUNG 001).

PLC MENU

EDIT RUNG

Brings up the editing screen for the selected rung. The user can also double click on the rung number to invoke the rung edit function.

 **INSERT ABOVE RUNG**
Brings up the editing screen for a new rung to be placed above the currently selected rung.

 **INSERT BELOW RUNG**
Brings up the editing screen for a new rung to be placed below the currently selected rung.

 **DELETE RUNG**
Deletes the currently selected rung.

 **UPLOAD**
Uploads the PLC program stored in the Axiom Plus drive to the PC.

 **DOWNLOAD**
Downloads the currently displayed PLC program to the Axiom Plus drive.

 **OPEN FILE**
Open a PLC program file previously saved to disk.

 **SAVE FILE**
Save a PLC program to disk.

 **PRINT**
Prints the current PLC program to the default printer.

 **RT SCAN**
Opens the realtime scan window allowing viewing of the current states of the PLC rungs.

 **I/O FLAG TABLE**
Displays a list of the I/O and PLC bit flags. User may edit comments from this window.

 **EXIT**
Returns user to the Axiom Plus main menu screen.

CREATING / EDITING A PLC RUNG:

By selecting the Insert Above or Insert Below command to create a new rung or by double clicking on an existing rung, the PLC rung editor screen opens either a new rung template or the selected rung.

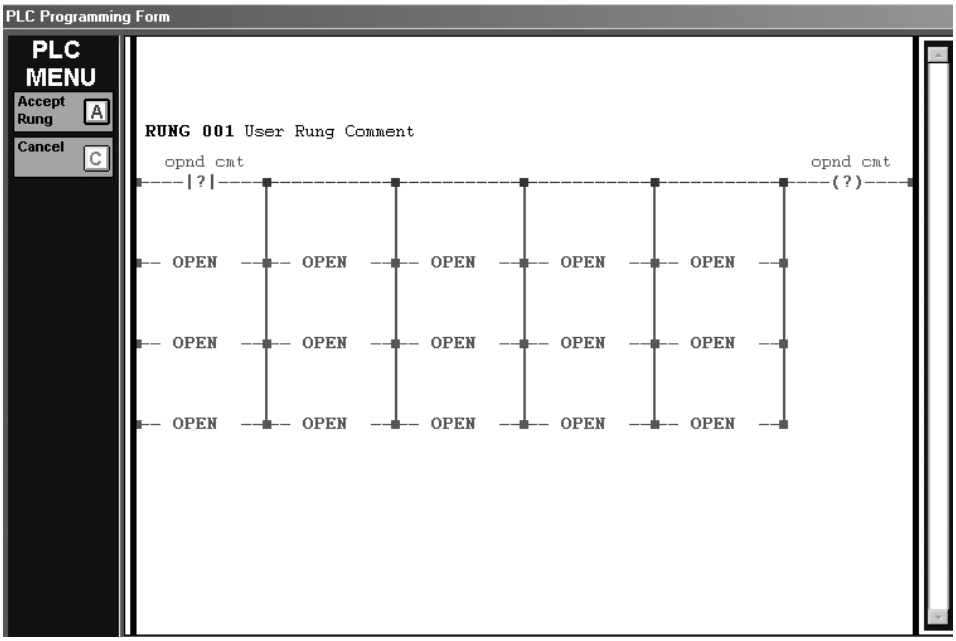


Figure 12.23 - PLC Programming Form Screen

Any rung location with a valid operation already in place is displayed in blue. The open locations are gray and display the word “OPEN”. To place an operation in a location, click on that location, and the Operation Details screen will open.

OPERATION DETAILS SCREEN

The Operation details screen allows the user to select and modify the operation, the operand and associated comments.

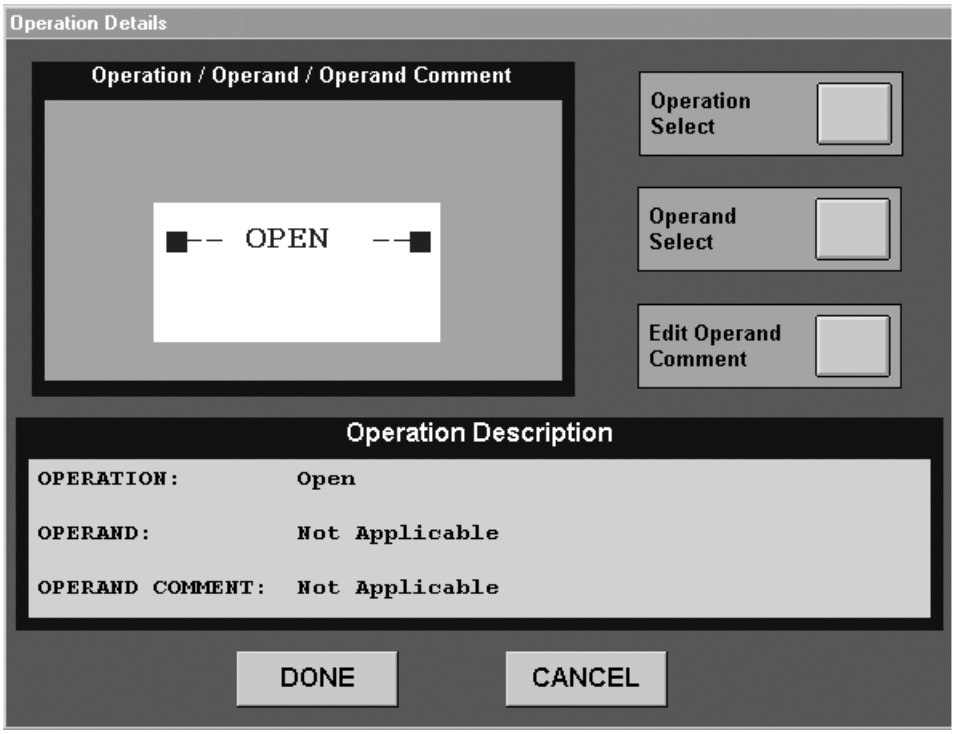


Figure 12.24 - Operation Details Screen

OPERATION SELECT

Use to select the logical function desired for the rung in question. Operations are defied as either inputs or outputs. A rung can have multiple inputs (logical operations) that it evaluates, but a rung can only have a single output. The first five vertical columns of a rung are designated for inputs, while the left-most column holds the single output. The editor only allows selection of the operation "type" that is appropriate for a given column. Clicking the Operation Select button will bring up the Contact Selection screen.

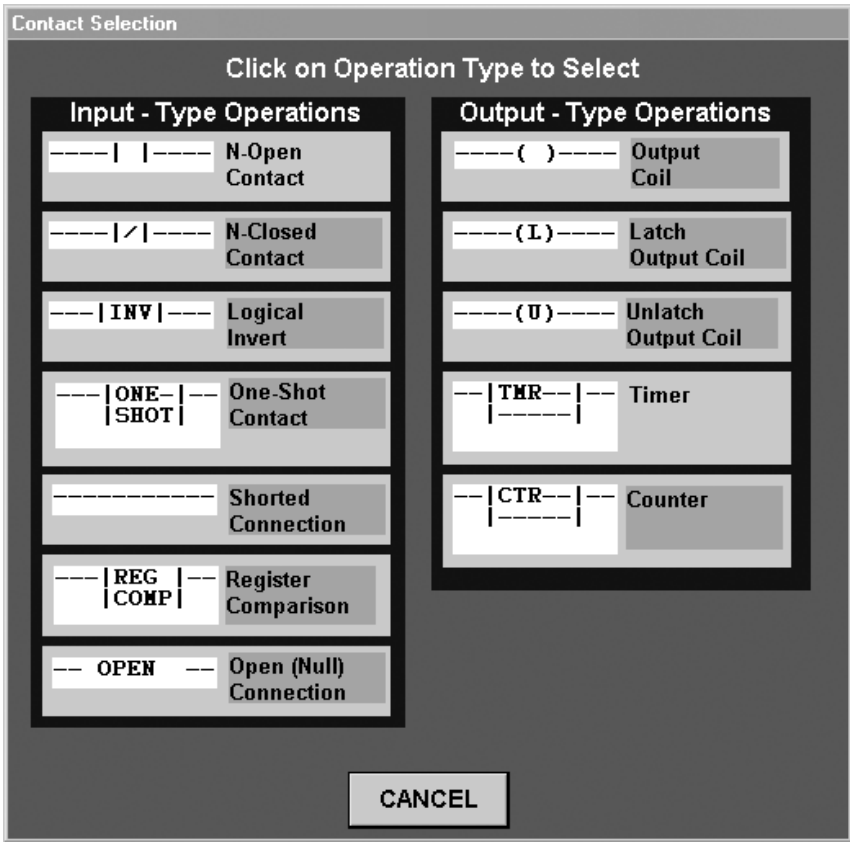


Figure 12.25 - Operation Selection Screen

The "contact types" available for use with the active rung location will turn blue as you move the mouse over them. There are twelve different operations available, depending on whether you are working on an input or an output.

The functions of these are as follows:

INPUT OPERATIONS

----| |---- **NORMALLY OPEN CONTACT** - Operation is true when the associated contact is made (ex. When the associated input or coil is active or "on").

----|/|---- **NORMALLY CLOSED CONTACT** - Operation is true when the associated contact is not made (ex. When the associated input or coil is not active or "off").

---|INV|--- **LOGICAL INVERT** - This operation inverts the logic state. If the input side logic is true, the output passed to the coil or next operation will be false. If it is false, the output will be true.

---|ONE-|-- **ONE SHOT CONTACT** - When the input side of this operation goes true, its output is true for one complete program scan. The remaining rungs in the current scan will see the output and the associated One-Shot flag bit as true and the rungs above it will see it as true in the next scan. After that, the output will remain false until the input goes false and then true again. There are 16 one-shot flags available for use in the PLC, which can be accessed from the One-Shot Definition Form below.

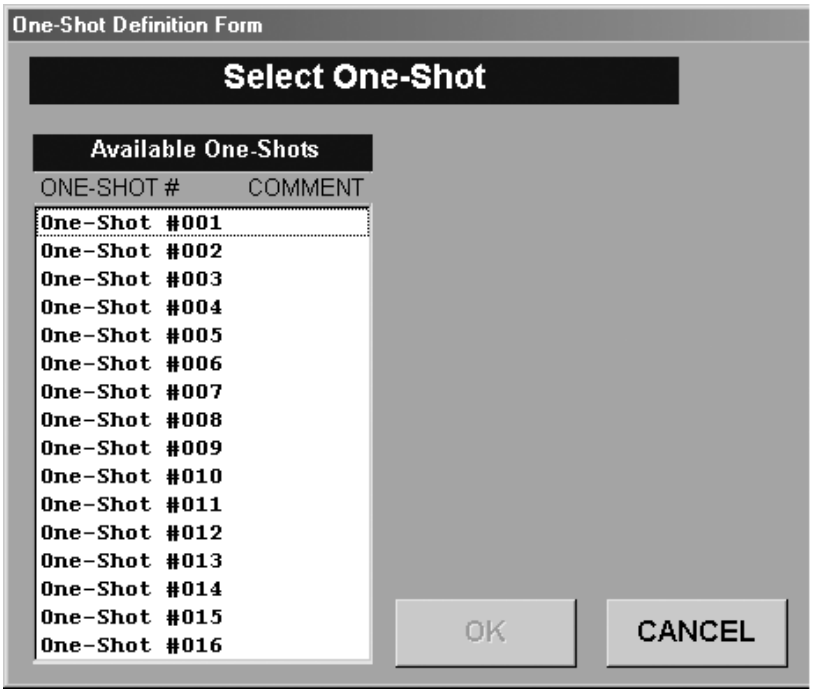


Figure 12.26 - One Shot Definition Screen

---------- **SHORTED CONNECTION** - This is simply a short circuit (always true) to the next location on the rung.

---|PVAR|--
|CMPR|

PROCESS VARIABLE COMPARISON – This allows the comparison of current Position, Velocity, Torque or analog input to a pre-defined register value, with either a “>”,“<” or “<window<” result resulting in a “logic-true” condition. If the window option is selected, the window value for the comparison will need to be entered.
Note: These are all Actual values, rather than Commanded values.

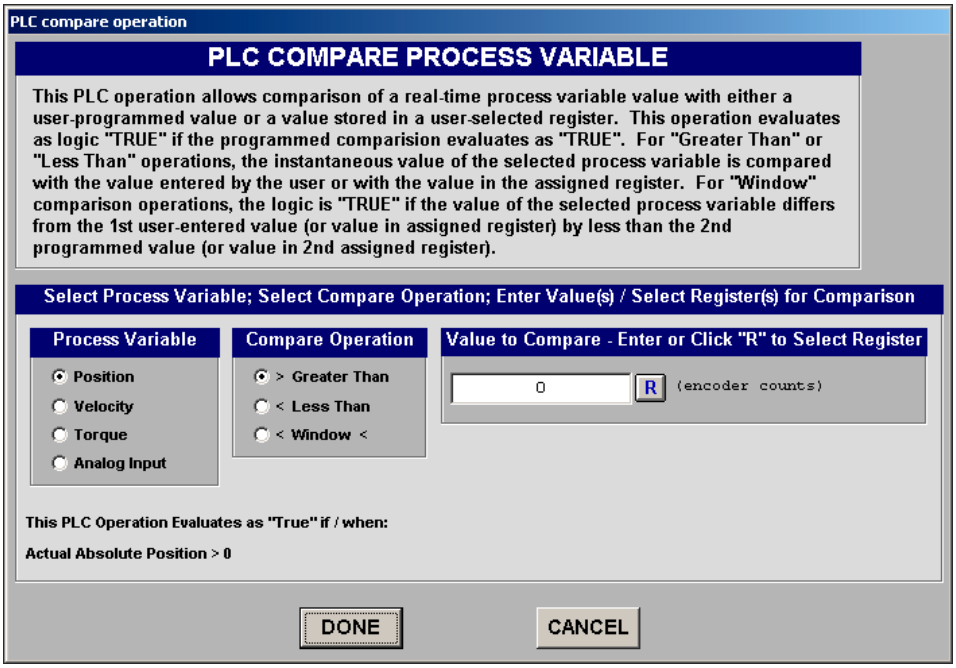


Figure 12.27 - Register Comparison Screen

-- OPEN -- **OPEN (NULL) CONNECTION** - This simply inserts an open circuit (always false) at the current rung location. This cannot be used as the only input location on a given rung, but rather must be used in conjunction with other logic conditions.

OUTPUT OPERATIONS

----( )---- **OUTPUT COIL** - This is a standard ladder logic output coil. It will go true (“on”) whenever the conditions in the rung are met to result in a true condition.

----(L)---- **LATCH OUTPUT COIL** - When the rung conditions are true at this coil, it latches the associated output (turns on and stays on) until it is unlatched with the Unlatch Output Coil operation.

----(U)---- **UNLATCH OUTPUT COIL** - When the rung conditions are true at this coil, it unlatches the associated output.

--|TMR--|-- **TIMER** - There are 16 timers, which can be programmed in .01 second increments. The time value can be entered directly or a register can be used.

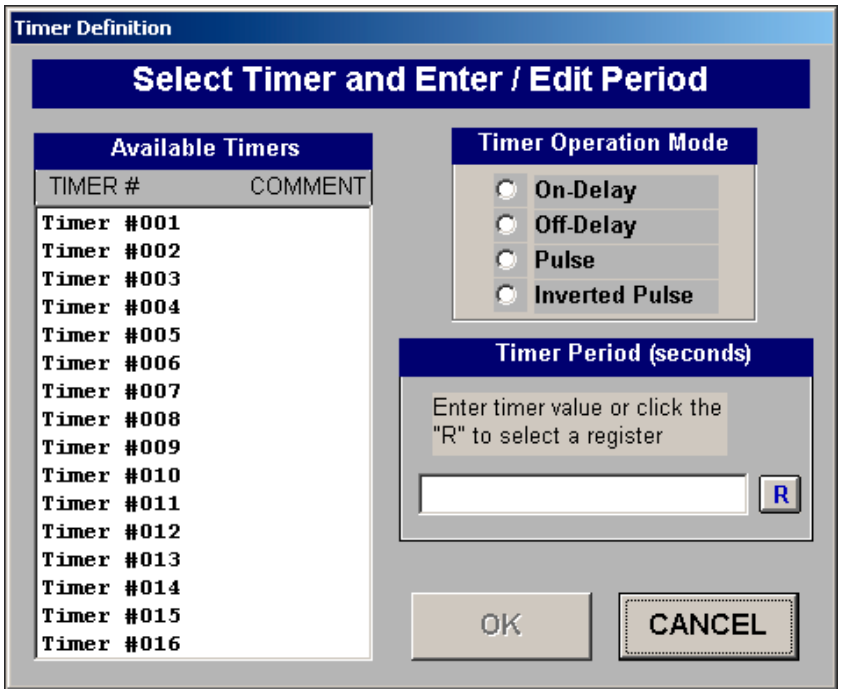


Figure 12.28 - Timer Definition Screen

Four timer types can be selected.

On-Delay - the timer output flag bit goes true the selected amount of time after the rung is true. The timer flag bit will stay true until the rung goes false.
Off-Delay - the timer output flag bit goes true the selected amount of time after the timer goes from true to false. The timer flag bit will stay true until the timer goes true.
Pulse - the timer output flag bit will be true the entered amount of time after the timer goes true.
Inverted Pulse - the timer output flag bit will be false the entered amount of time after the times goes true.

--|CTR--|--
  |-----| **COUNTER** - There are 16 counters available. The count can be entered directly or a register can be used.

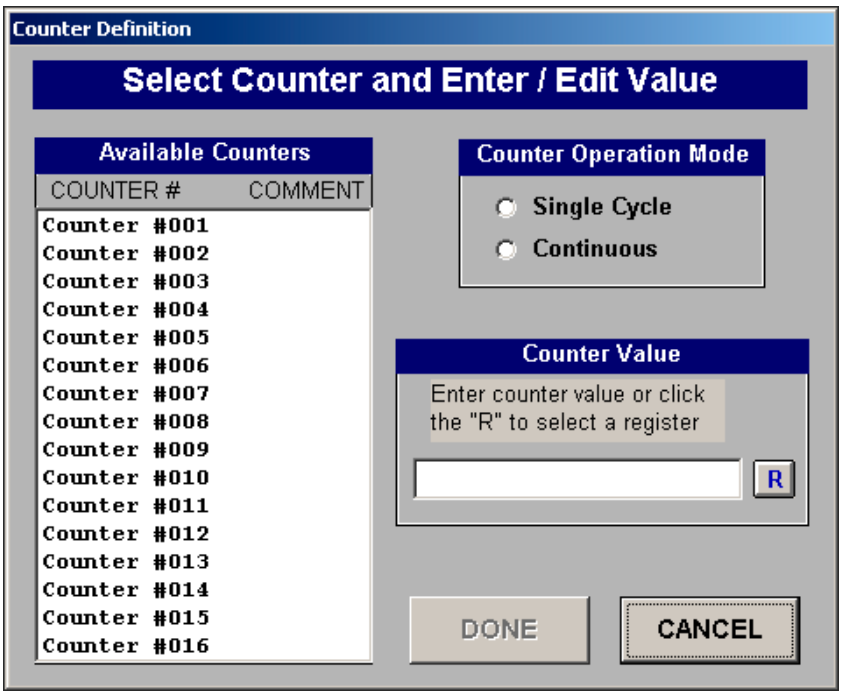


Figure 12.29 - Counter Definition Screen

Two counter types can be selected.

Single Cycle Counter - Counts each false to true transition of the counter rung as one count. When the entered number of counts is reached the counter output bit flag will be true and stay true until the counter is reset to zero by the counter reset coil going true. After the counter is reset the output bit flag will be false. The counter can also be reset to zero at any time with the counter reset coil.

Continuous Counter - Counts each false to true transition of the counter rung as one count. When the entered number of counts is reached the counter output bit flag will be true for one program scan only. The counter will then reset to zero and the start counting again with a false to true transition of the counter rung. The counter can also be reset at any time with the counter reset coil.

OPERAND SELECT

Used to select an operand to associate with the operation. The operand is the condition being evaluated by the operation, in order to determine the logic state. This can be an external variable, such as a physical inputs, or internal variables, such as bit flags. Only the operands appropriate for the chosen operation type will be displayed.

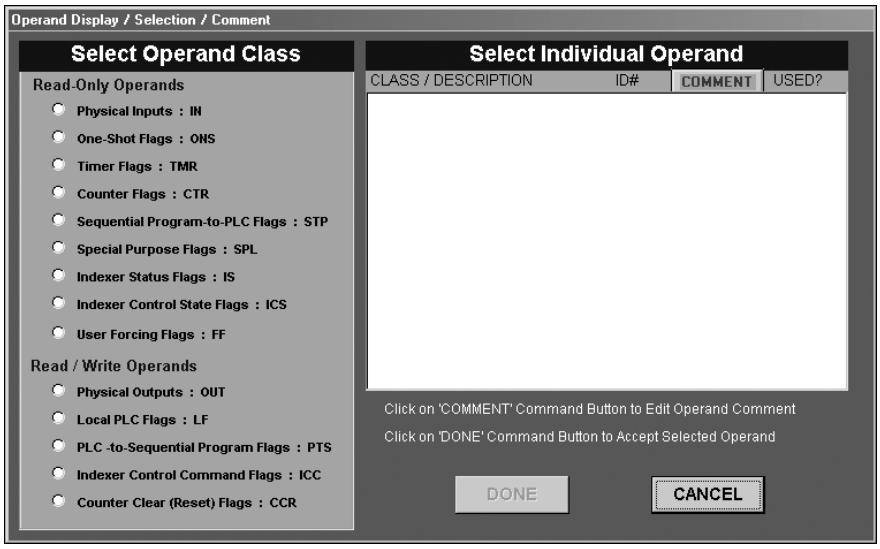


Figure 12.30 - Operand Display / Selection / Comment Screen

The functions on this screen perform as follows:



COMMENTS - Each operand may have a comment, with up to eight characters, associated with it. In addition, each rung can have up to a 64 character comment. These comments are downloaded and stored with the PLC program, so that the user will always have them available when he uploading a program from an Axiom Plus.

READ-ONLY OPERANDS

PHYSICAL INPUTS (IN) - Each of these operands corresponds directly to the sensed value of one of the 15 available physical inputs.

ONE-SHOT FLAGS (ONS) - Stores the output state of the one of the 16 associated one-shot operations available for use in the ladder-logic program.

TIMER FLAGS (TMR) - Holds the output state of one of the associated 16 timer operations available.

COUNTER FLAGS (CTR) - Holds the output state of one of the associated 16 counter operations available.

SEQUENTIAL PROGRAM TO PLC FLAGS (STP) - This set of general purpose bit flags is a series of 32 bits that are read or write in the sequential program and read only in the PLC. These bits are normally used to allow the sequential program to signal the PLC. These bits can then be used in the ladder logic program to control I/O or logic in the PLC program.

SPECIAL PURPOSE FLAGS (SPL) - These bit flags are provided with fixed logical functions

First Scan (SPL001) - This bit flag is true on the first PLC scan after power-up, it is false otherwise.

Logic One (SPL002) - This bit flag in always true

Logic Zero (SPL003) - This bit flag is always false

P2 DSUB Pin 6 <--> Pin 9 (SPL004) - This bit is true only when pins 6 and 9 of DSUB P2 are shorted

INDEXER STATUS FLAGS (IS) - Indexer status bit flags are provided to allow the PLC access to the controller operating and motion status.

Auto-phasing complete (IS001) - This bit flag is true if phasing complete, otherwise it is false.

Fault (IS002) - This bit flag is true if the drive is faulted otherwise it is false.

Fatal Fault (IS003) - This bit flag is true if the drive has a fatal fault, otherwise it is false.

Axis Home Position Defined (IS004) - This bit flag is true if the homing instruction was executed to completion in the sequential program.

Motion-in-Progress (IS005) - This bit flag is true if the axis is currently executing a move.

Axis in Position (IS006) - This bit flag is true if the encoder position is within the preset in-position band, otherwise it is false.

PC disable asserted (IS007) - This bit flag is true if the disable state is being forced by PC via serial communications.
PC step mode asserted (IS008) - This bit flag is true if the PC has set the controller in step mode for manual or auto-tuning.
Sequential End Program One Shot (IS009) - Gives a one shot when the sequential program executes an end of program instruction.
Positive Motion Limit Reached (IS010) – Bit flag is true when the positive (cw) software travel limit has been reached.
Negative Motion Limit Reached (IS011) – Bit flag is true when the negative (ccw) software travel limit has been reached.
Torque at Peak Limit (IS012)- Bit flag is true when the drive has reached the torque limit.

INDEXER CONTROL STATE FLAGS (ICS) - This set of eight read only bit flags can be read in the PLC in order to monitor the status of the controller. Following is a list and description of these bits.

Drive output enabled status (ICS001) - This bit flag is true when the controller is enabled and not faulted.
Cycle run status (ICS002) - This bit flag is true when a sequential program is executing, otherwise it is false.
Cycle pause status (ICS003) - This bit flag is true when a program cycle is in the "pause" state.
Jog 1 CW in process (ICS004) - This bit flag is true when using jog 1 in the CW direction.
Jog 1 CCW in process (ICS005) - This bit flag is true when using jog 1 in the CCW direction.
Jog 2 CW in process (ICS006) - This bit flag is true when using jog 2 in the CW direction.
Jog 2 CCW in process (ICS007) - This bit flag is true when using jog 2 in the CCW direction.
Auxiliary encoder following active (ICS008) - This bit flag is true when encoder following is true.
PC Debug PRG RUN (ICS009) - User is running sequential debug mode.
PC Debug PRG STOP (ICS010) - User is running sequential debug mode but sequential program is stopped.
PC Debug PRG JOG+ (ICS011) - User is jogging + from debug mode.

PC Debug PRG JOG - (ICS012) - User is jogging - from debug mode.

FORCING FLAGS (FF) - The 64 forcing flags are used with either ModBus or ASCII interface. The state of the forcing pages is set by the ModBus master or the computer communicating over the ASCII serial connection.

READ / WRITE OPERANDS

PHYSICAL OUTPUTS (OUT)- Allows the state of one the 8 physical outputs to be set when used as the operand of a output coil. Physical outputs can be set or cleared by both the PLC and the sequential program, with the PLC being dominant in the case of conflict. When used as the operand of a contact it is a bit flag that follows the state of the output.

LOCAL PLC FLAGS (LF) - The 64 local PLC flags are used as internal logic storage in the ladder logic program. They can be useful for carrying the logic states through multiple rungs. They can also be used as either an operand for a coil or a contact. When used as a contact if allows the state of its output coil.

PLC TO SEQUENTIAL PROGRAM FLAGS (PTS) - These 48 flags are provided as a means of signaling the sequential motion program. They can be set and cleared by the PLC, and are read-only to the sequential program. Normally used to allow the PLC to provide an asynchronous monitoring function of a condition or set of conditions, they perform some logic operation or conditioning and then pass a bit flag to the sequential program. The sequential program can conditionally branch or call subroutines according to these bit flags, or monitor them for live trigger events during motion. This simple construct makes it much easier to monitor and control events that are asynchronous with respect to the sequential program.

INDEXER CONTROL FLAGS (ICC) - This set of flags allows the PLC to control the axis motion.

Following is a list of these flags and their function.

Drive Output Enable Command (ICC001) - This output coil

operation enables the drive. The internal condition for the drive to enable are that no faults exist. This command needs to be maintained for the drive to stay enabled.

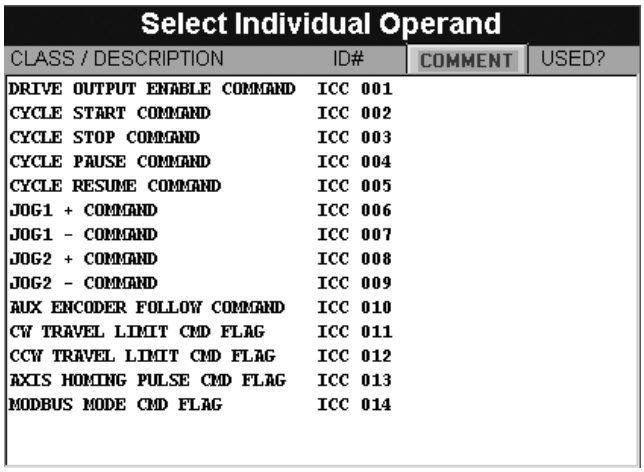


Figure 12.31 - Indexer Control Flags Screen

Cycle Start Command (ICC002) - The cycle start output coil starts the sequential program running. This command needs to be maintained for the sequential program to keep running. If the rung goes false the sequential program will stop. The internal conditions for cycle start are that the drive is enabled and cycle stop is false.

Cycle Stop Command (ICC003) - Stops the sequential program, if motion is in progress the motor decelerates to a stop using the rate entered in Jog/Default Parameters or the programmed rate whichever is higher. The cycle stop will override the cycle start command.

Cycle Pause Command (ICC004) - The cycle pause command causes the sequential program to pause. If a move is in progress, it will decelerate to a stop at the rate entered in the current move instruction and wait until the resume command is given.

Cycle Resume Command (ICC005) - The cycle resume command will restart the sequential program if in a pause condition. If a move was in progress when the sequential program was paused, the motion will complete and the

program will move on to the next command. The pause command will take precedence over the resume command. If the pause command is being held true the cycle will not resume.

Jog 1 CW (ICC006) - The jog 1 CW output coil will cause the motor to move clockwise (positive direction) at the rate defined in the Jog/Default parameters window. For the jog to operate: the drive needs to be enabled, the sequential program stopped and encoder following mode not enabled. If these conditions are not met the motor will not jog.

Jog 1 CCW (ICC007) - The jog 1 CCW output coil will cause the motor to move counter-clockwise (negative direction) at the rate defined in the Jog/Default parameters window. For the jog to operate: the drive needs to be enabled, the sequential program stopped and encoder following mode not enabled. If these conditions are not met the motor will not jog.

Jog 2 CW (ICC008) - The jog 2 CW output coil will cause the motor to move clockwise (positive direction) at the rate defined in the Jog/Default parameters window. For the jog to operate: the drive needs to be enabled, the sequential program stopped and encoder following mode not enabled. If these conditions are not met the motor will not jog.

Jog 2 CCW (ICC009) - The jog 2 CCW output coil will cause the motor to move counter-clockwise (negative direction) at the rate defined in the Jog/Default parameters window. For the jog to operate: the drive needs to be enabled, the sequential program stopped and encoder following mode not enabled. If these conditions are not met the motor will not jog.

Auxiliary Encoder Follower Command (ICC010) - The auxiliary encoder follower command will cause the Axiom Plus to start following the auxiliary encoder at the ratio defined in the Jog/Default parameters window or a value assigned in the sequential program. For the encoder following to operate: the drive needs to be enabled, the sequential program stopped and not be in the jog mode. If these conditions are not met encoder following will not be enabled.

CW Travel Limit Flag (ICC011) - This is used to define the physical input or conditions that the CW travel limit switch is connected to. When the switch is activated during normal operation, the drive will fault and display the limit switch fault L01 on the front panel LED and the motor will be commanded to stop immediately. The limit will not cause a fault during a homing move if the reverse direction option is selected.

CCW Travel Limit Flag (ICC012) - This is used to define the physical input or conditions that the CCW travel limit switch is connected to. When the switch is activated during normal operation, the drive will fault and display the limit switch fault L02 on the front panel LED and the motor will be commanded to stop immediately. The limit will not cause a fault during a homing move if the reverse direction option is selected.

Axis Homing Signal (ICC013) - This is used to define the physical input or conditions that is used for the home instruction in the sequential program.

ModBus Mode Command Flag (ICC014)- The Axiom Plus can be operated as a ModBus slave device. To do so, this command flag must be set. See Chapter 13 for additional detail.

COUNTER CLEAR (RESET) FLAGS (CTS) - The counter clear output coil, clears the current count value of the selected counter function.

DEFAULT PLC PROGRAM

The Axiom Plus ships with a default PLC program that will allow the controller to run as a simple sequential controller with little or no modifications to the PLC program. The default PLC program is also installed on the computer's hard drive along with the programming software, so it can be reloaded if necessary.

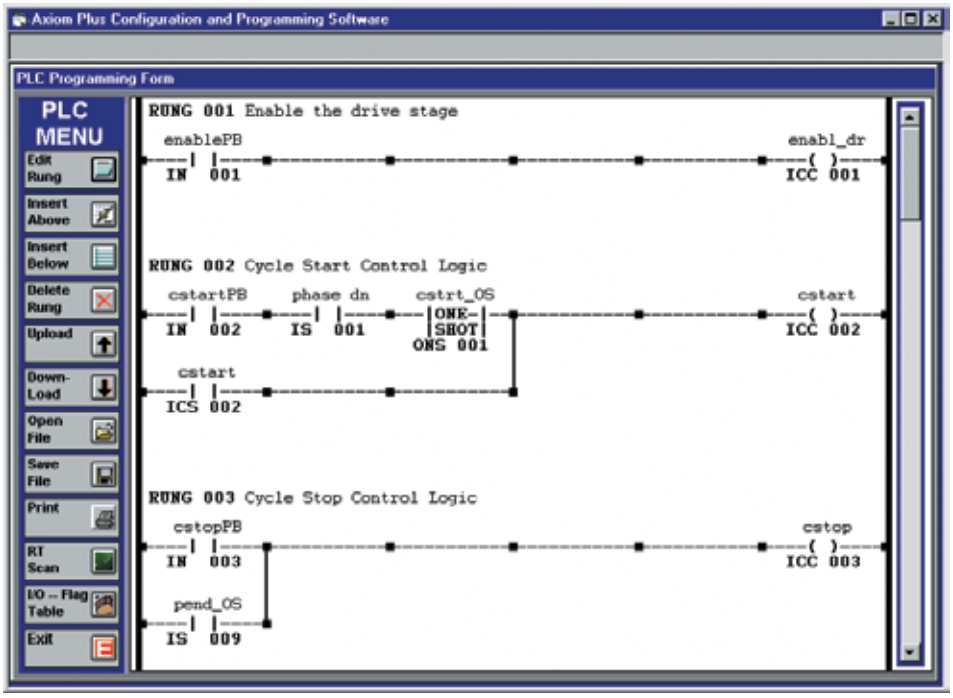


Figure 12.32 - Default PLC Program Example

The user may need to change the inputs used in the default PLC program to match the field wiring of the Axiom Plus. The Axiom Plus does not use dedicated inputs or outputs for the enable input, home switch, CW limit, CCW limit, enabled output, in position output and fault output. The user can determine the interface that is required and assign the inputs and outputs in the PLC program.

The following table is the I/O assignment and usage for the default PLC program:

Input/Output #	Comment	Usage
IN 1	enab_in	Enables the drive stage, required before motor can move.
IN 2	cstartPB	Cycle start push button, this input starts the sequential program. When the input is removed the sequential program will stop.
IN 3	cstopPB	Cycle stop push button, this input will cause the sequential program to stop.
IN 4	cpausePB	Cycle pause push button, this input will cause the sequential program execution to pause and wait for the cycle resume input.
IN 5	cresumPB	Cycle resume push button, this input will cause the sequential program to resume executing if it was in a cycle pause condition.
IN 6	Jog1+PB	This input will cause the motor to jog at the rate defined for Jog 1 in the positive direction, if the sequential program is not running.
IN 7	Jog1-PB	This input will cause the motor to jog at the rate defined for Jog 1 in the negative direction, if the sequential program is not running.
IN 8	cw lim	Defines input 7 as the clockwise limit for motor rotation. The controller will fault if this input occurs when the motor is moving clockwise, except during a home move if reverse direction is selected.
IN 9	home sw	Defines input 8 as the home switch. The home switch is in the home instruction to define the position of the motor/actuator.
IN 10	ccw lim	Defines input 9 as the counter clockwise limit for motor rotation. The controller will fault if this input occurs when the motor is moving counter clockwise, except during a home move if reverse direction is selected.

This page intentionally left blank

ASCII Command

Axiom+ products support registers and discrete flags that can be manipulated via general ASCII commands over the serial (RS232) port. Both RAM and non-volatile registers are provided. These registers can be programmed in place of hard-entered values for position, velocity, and torque-limit throughout the sequential program. PLC forcing flags, physical outputs, physical inputs, local flags, and status flags can be read and/or written as appropriate in similar fashion using serial ASCII commands.

This functionality allows any device capable of sending ASCII command strings to act as a "master" and manipulate the "slave" Axiom+ with a single serial connection.

RS232 SERIAL COMMUNICATIONS CHARACTER FRAMING SETTINGS

ASCII commands and Axiom Plus software serial communication settings are always:

Baud rate:	19200 baud fixed
Start bits:	1 start bit
Data bits:	8 data bits
Parity:	1 parity bit, odd parity
Stop Bits:	1 stop bit
Handshaking:	none, no hardware or software handshaking

The user cannot modify character framing or baud rate for ASCII command functionality or software communication.

READ / WRITE REGISTER VALUE USING ASCII COMMANDS OVER RS232 SERIAL PORT

Registers can be manipulated via ASCII serial port commands. It should be noted that communication settings should be 19200 baud, 8 data bits, 1 stop bit, odd parity. Following is a listing of command syntax:

Serial Command Syntax:

Note: All numerical data is transmitted and received in Ascii-coded hex format. All data is transmitted most-significant byte / word first.

Position Ram Registers
Read: UR81XXXX
XXXX is register id (1-32), Ascii-coded hex
Returns: A 32-bit signed integer register value is returned as Ascii-coded hex
Write: UW81XXXXYYYYYYY
XXXX is register id (1-32), Ascii-coded hex
YYYYYYYY is 32-bit signed integer to be written to register, Ascii-coded hex

Position EEPROM Registers
Read: UR83XXXX
XXXX is register id (1-32), Ascii-coded hex
Returns: A 32-bit signed integer register value is returned as Ascii-coded hex
Write: UW83XXXXYYYYYYY
XXXX is register id (1-32), Ascii-coded hex
YYYYYYYY is 32-bit signed integer to be written to register, Ascii-coded hex

Velocity Ram Registers
Read: UR85XXXX
XXXX is register id (1-16), Ascii-coded hex
Returns: A 32-bit signed integer register value is returned as Ascii-coded hex
Write: UW85XXXXYYYYYYY
XXXX is register id (1-16), Ascii-coded hex
YYYYYYYY is 32-bit signed integer to be written to register, Ascii-coded hex
Velocity EEPROM Registers
Read: UR87XXXX
XXXX is register id (1-16), Ascii-coded hex
Returns: 32-bit signed integer register value returned as Ascii-coded hex
Write: UW87XXXXYYYYYYY
XXXX is register id (1-16), Ascii-coded hex
YYYYYYYY is 32-bit signed integer to be written to register, Ascii-coded hex

Torque-Limit RAM Registers
Read: UR89XXXX
XXXX is register id (1-32), Ascii-coded hex
Returns: 16-bit integer register value is returned as low word of 32-bit integer, Ascii-coded hex
Write: UW89XXXXYYYYYYY
XXXX is register id (1-32), Ascii-coded hex
YYYYYYYY is 32-bit integer, with low word being 16-bit value to be written to register, Ascii-coded hex

Torque-Limit EEPROM Registers
Read: UR8BXXXX
XXXX is register id (1-32), Ascii-coded hex
Returns: A 16-bit integer register value is returned as low word of 32-bit integer, Ascii-coded hex
Write: UW8BXXXXYYYYYYY
XXXX is register id (1-32), Ascii-coded hex
YYYYYYYY is 32-bit integer, with low word being 16-bit value to be written to register, Ascii-coded hex

Count RAM Registers
Read: UR8DXXXX
XXXX is register id (1-4), Ascii-coded hex
Returns: 32-bit integer register value returned as Ascii-coded hex
Write: UW8DXXXXYYYYYYY
XXXX is register id (1-4), Ascii-coded hex
YYYYYYYY is 32-bit integer to be written to register, Ascii-coded hex

Count EEPROM Registers
Read: UR8FXXXX
XXXX is register id (1), Ascii-coded hex
Returns: 32-bit integer register value returned as Ascii-coded hex
Write: UW8FXXXXYYYYYYY
XXXX is register id (1), Ascii-coded hex
YYYYYYYY is 32-bit integer to be written to register, Ascii-coded hex

Timer RAM Registers
Read: UR91XXXX
XXXX is register id (1-8), Ascii-coded hex
Returns: 32-bit integer register value returned as Ascii-coded hex
Write: UW91XXXXYYYYYYY
XXXX is register id (1-8), Ascii-coded hex
YYYYYYYY is 32-bit integer to be written to register, Ascii-coded hex

Timer EEPROM Registers
Read: UR93XXXX
XXXX is register id (1), Ascii-coded hex
Returns: 32-bit integer register value returned as Ascii-coded hex
Write: UW93XXXXYYYYYYY
XXXX is register id (1), Ascii-coded hex
YYYYYYYY is 32-bit integer to be written to register, Ascii-coded hex

Analog RAM Registers
Read: UR95XXXX
XXXX is register id (1-4), Ascii-coded hex
Returns: 32-bit signed integer register value returned as Ascii-coded hex
Write: UW95XXXXYYYYYYY
XXXX is register id (1-4), Ascii-coded hex
YYYYYYYY is 32-bit signed integer to be written to register, Ascii-coded hex

Analog EEPROM Registers
Read: UR97XXXX
XXXX is register id (1-2), Ascii-coded hex
Returns: 32-bit signed integer register value returned as Ascii-coded hex
Write: UW97XXXXYYYYYYY
XXXX is register id (1-2), Ascii-coded hex
YYYYYYYY is 32-bit signed integer to be written to register, Ascii-coded hex

Absolute, incremental, and velocity moves now handle assigned registers as the source of position, velocity, and torque-limit values, both in programming motion and trigger events and actions. Register accesses in motion instructions and trigger evaluations involve a data range check, with invalid data causing a "F58" fault.

As an example of writing to a position register, assume the user has a serial master connected to an Axiom+. The user wishes to write a value of 8000 encoder counts to non-volatile position register # 17. 17 decimal equals 0011h, and 8000 decimal equals 00001F40h. Sending command string "UW83001100001F40" encoded ASCII will accomplish this register write. To verify this register operation, the user could have the master send string "UR830011" to read the value in position non-volatile register #17. "00001F40" would be the string returned by the Axiom+.

It should be noted that command strings must be sent contiguously, without time delays between characters, as the Axiom+ generates a fault if 0.2 seconds elapses between characters in any one command string. Also, carriage return and linefeed characters will be stripped and ignored. Serial communications settings must be: 19200 baud, 8 data bits, 1 stop bit, odd parity. No hardware or software handshaking is used.

READING INDEXER INTERNAL FAULT AND STATUS IDENTIFICATION FLAG WORDS

Read 1 Word: UR41XXXX

XXXX is internal fault and status flag word id (1-2), Ascii-coded hex

word1 corresponds to internal fault / status flag word 0

word2 corresponds to internal fault / status flag word 1

32-bit integer value returned as Ascii-coded hex, with bits 0-15 corresponding to bit-flag values of selected word. Bit 0 of returned word corresponds to bit 0 of internal fault and status flag word, etc.

Bit assignments of internal fault and status flag words:

Internal fault / status flag word 0

bit 0 : processor fault, display code of "F00"
bit 1 : drive not configured, display code "F99"
bit 2 : power selection switch fault, "F01"
bit 3 : bridge hardware fault, "F02"
bit 4 : current feedback fault, "F03"
bit 5 : current regulation fault, "F04"
bit 6 : drive over-temperature fault, "F05"
bit 7 : motor over-temperature fault, "F06"
bit 8 : encoder feedback / commutation fault, "F07"

bit 9 : fatal PLC fault, display code "F98"
bit 10 : fatal seq. program fault, display code "F97"
bit 11 : phasing fault (non-fatal), "F51"
bit 12 : drive over-current fault (non-fatal), "F52"
bit 13 : motor over-current fault (non-fatal), "F53"
bit 14 : bus under-voltage fault (non-fatal), "F54"
bit 15 : maximum following-error fault (non_fatal), "F55"

Internal fault / status flag word 1
bit 0 : velocity regulation fault (non-fatal), "F56"
bit 1 : serial communications fault (non-fatal), "F57"
bit 2 : positive travel limit fault (non-fatal), "FL1"
bit 3 : negative travel limit fault (non-fatal), "FL2"
bit 4 : sequential program execution fault (non-fatal), "F58"
bit 5 : drive disabled condition, "d"
bit 6 : phasing in progress, "P"
bit 7 : clockwise travel limit active (no fault), "L01"
bit 8 : counter-clockwise limit active (no fault), "L02"
bit 9 : drive enabled condition, "E"
bit 10 : reserved
bit 11 : reserved
bit 12 : reserved
bit 13 : reserved
bit 14 : reserved
bit 15 : reserved

Note: For purposes of display to Axiom Plus LED, fault/status priority is as follows:
"F00" (bit0, word 0) is highest display priority, "F99" (bit1, word 0) is next highest, and so on. "E" (bit9, word 1) is the lowest display priority.

READING PROCESS VARIABLE / DIAGNOSTIC REGISTERS

These registers exist as read-only registers, allowing an ASCII serial master to read certain process values.

Process Variable / Diagnostic Register #001
-holds command absolute position

Process Variable / Diagnostic Register #002
-holds actual absolute position

Process Diagnostic Register #003
Command velocity - user units or enc cnts / sec as configured.

Process Diagnostic Register #004
Actual velocity - user units or enc cnts / sec as configured.

Process Diagnostic Register #005
Torque - as fraction of peak available torque, user units (%) or Q15 as configured.

Process Diagnostic Register #006
Analog Input - analog input voltage in millivolts.

The syntax for an ASCII serial command to read a Process Variable / Diagnostic Register is as follows:
Command Syntax -Read 1 Register: URA1XXXX
XXXX is register ID, ASCII-coded hex
32-bit signed integer value returned as Ascii-coded hex

MANIPULATION OF PLC FLAGS USING ASCII SERIAL PORT COMMANDS

Various PLC flags can now be read and/or written using serial commands. General serial port commands are provided for reading and writing PLC I/O and flags. All data is sent and received as ASCII-coded hex. Command strings must be transmitted to the Axiom+ as a single, contiguous string. Settings are 19200 baud, 8 data bits, 1 stop bit, odd parity, no handshaking. Following is a listing of flags that can be manipulated and a description of serial command syntaxes:

Flags Available for Read and/or Write via serial port:

User Forcing Flags	64 total	read / write via serial port read-only in PLC
Physical Inputs	15 total	read-only via serial port read-only in PLC
Physical Outputs	8 total	read-only via serial port read / write in PLC
PLC Local Flags	64 total	read-only via serial port read/write in PLC

Indexer Status Flags	12 total	read-only via serial port read-only in PLC
Indexer Control State Flags	12 total	read-only via serial port read-only in PLC

Serial Command Syntax:

Note: All numerical data transmitted and received in Ascii-coded hex format. All data transmitted most-significant byte / word first.

User Forcing Flags

Read 1 Flag: UR03XXXX

XXXX is flag id (1-64), Ascii-coded hex
Returns: A 32-bit integer value is returned as Ascii-coded hex, with bit0 representing logic state of forcing flag queried

Set 1 Flag: US03XXXX

XXXX is flag id (1-64), Ascii-coded hex
The identified forcing flag will be set to 1
Returns: Nothing

Clear 1 Flag: UC03XXXX

XXXX is flag id (1-64), Ascii-coded hex
The identified forcing flag will be cleared to 0
Returns: Nothing

Read 1 Word: UR01XXXX

XXXX is word id (1 only), Ascii-coded hex
Returns: 32-bit integer value returned as Ascii-coded hex, with bits 0-15 representing logic state of forcing flags 1-16 respectively

Physical Inputs

Read 1 Word: UR05XXXX

XXXX is word id (1 only), Ascii-coded hex
Returns: A 32-bit integer value is returned as Ascii-coded hex, with bits 0-14 representing logic state of inputs 1-15 respectively

Physical Outputs

Read 1 Word: UR09XXXX

XXXX is word id (1 only), Ascii-coded hex
Returns: A 32-bit integer value is returned as Ascii-coded hex,

with bits 0-7 representing logic state of outputs 1-8 respectively

PLC Local Flags Read 1 Word: UR0DXXXX
XXXX is local flag word id (1-4), Ascii-coded hex
word1 corresponds to local flags 1-16
word2 corresponds to local flags 17-32
word3 corresponds to local flags 33-48
word4 corresponds to local flags 49-64
Returns: A 32-bit integer value is returned as Ascii-coded hex, with bits 0-15 representing logic state of local flags of selected word. Bit 0 of returned word corresponds to local flag 1 if word1 selected, local flag 17 if word2 queried, etc.

Indexer Status Flags
Read 1 Word: UR11XXXX
XXXX is word id (1 only), Ascii-coded hex
Returns: a 32-bit integer value returned as Ascii-coded hex, with bits 0-10 representing logic state of indexer status flags 1-12 respectively

Indexer Control State Flags
Read 1 Word: UR15XXXX
XXXX is word id (1 only), Ascii-coded hex
Returns: A 32-bit integer value is returned as Ascii-coded hex, with bits 0-7 representing logic state of indexer control state flags 1-12 respectively

As an example, suppose the user wants to program a master to set PLC forcing flag # 14. 14 decimal is 000E hex. Sending "US03000E" would cause forcing flag #14 to be set to logic 1, and any PLC logic incorporating this flag would be influenced accordingly.

SCALING AND INTERPRETATION OF VALUES STORED IN AXIOM PLUS REGISTERS

All registers in the Axiom Plus contain 32-bit values, stored in "raw-data" units when accessed by the sequential program. In other words, register values are assumed to be encoder counts for position,

encoder counts per second for velocity, and a Q15 value for torque (where 0-32767 is equivalent to 0-100% torque). These values are suitable for use in ASCII commands, since the necessary scaling is typically done by the ASCII master device (PC or intelligent controller).
Should the user prefer to communicate a value in user-defined units, however, the Axiom Plus is capable of performing this scaling operation.

Simply select the user units appropriately in the set-up screen, and then scale the precision of the value as indicated below.

If user units is selected, the user will choose a decimal point position from 0 to 5:

XXXX	decimal shift of 0
XXXX.0	decimal shift of 1
XXXX.00	decimal shift of 2
XXXX.000	decimal shift of 3
XXXX.0000	decimal shift of 4
XXXX.00000	decimal shift of 5

If user units and a decimal shift of 3 is selected, then a register value of 3245 will represent a distance of 3.245 user units, and the firmware will make the appropriate scaling calculations on the fly during execution whenever a position register is used as the source of a distance value.

Velocity Registers

The user will select between:

Raw units – encoder counts / second
User units – inches / second, millimeters / second, etc.
(User units are defined in sequential program)

If user units is selected, the user will choose a decimal point position from 0 to 4:

XXXX	decimal shift of 0
XXXX.0	decimal shift of 1
XXXX.00	decimal shift of 2
XXXX.000	decimal shift of 3
XXXX.0000	decimal shift of 4

If user units and a decimal shift of 2 is selected, then a register value of 754 will represent a velocity of 7.54 user units / second, and the firmware will make the appropriate scaling calculations on the fly during execution whenever a velocity register is used as the source of a speed value.

Torque-Limit Registers

The user will select between:

Raw units – Q15 ratio , 0-32767d corresponds to 0 – 100% torque
User units – 0 – 100%
(torque-limit user unit is always considered to be a %)

If user units is selected, the user will choose a decimal point position from 0 to 1:

XXX	decimal shift of 0
XXX.0	decimal shift of 1

If user units and a decimal shift of 1 is selected, then a register value of 754 will represent a torque-limit of 75.4 % (% of peak configured current / torque), and the firmware will make the appropriate scaling calculations on the fly during execution whenever a torque-limit register is used as the source of a torque-limit value.

GENERAL ANALOG INPUT FUNCTIONALITY – ANALOG REGISTERS

The analog input reading can be used in a number of general sequential instructions and in the PLC.

ANALOG INPUT REGISTERS

RAM	4
Non-Volatile	2
Register Size	16 Bit
Voltage Value	Millivolt (signed)
Read / Write	via serial port and ASCII or ModBUS

Four RAM and two non-volatile registers have been provided to store voltage values consistent with the voltage data available from the analog input. These registers are 16-bits in size and hold voltage values in millivolts (signed). Thus, a register value of –8,500 decimal

corresponds to –8.500 volts. These analog registers are available for reading and writing by the user via the serial port and ASCII or MODBUS commands. In addition, the new watch window functions in Axiom+ software will allow monitoring of these register values and also value assignment. Instructions in the sequential program that require entering of a voltage value will also allow the programmer to select an analog register. The PLC compare operation now supports comparison of the analog input reading to a register value. The sequential program also supports comparison of the analog input to a hard-entered value or register value, and general comparison of analog register values. Analog registers can be assigned values by the sequential program as per other register types. And there is a sequential instruction to store the present analog input reading to an analog register for subsequent use.

ModBus Communication Setting

The Axiom Plus can be operated as a ModBus slave device. To do so, the ModBus mode command flag (ICC 014) must be set. This can be done in the PLC portion of the Axiom Plus, as described in Chapter 12. To ensure proper communication, the ModBus RTU protocol communication framing and baud rate must be the same for both Axiom Plus and its master. These can be configured in the Axiom Plus indexer setup and configuration.

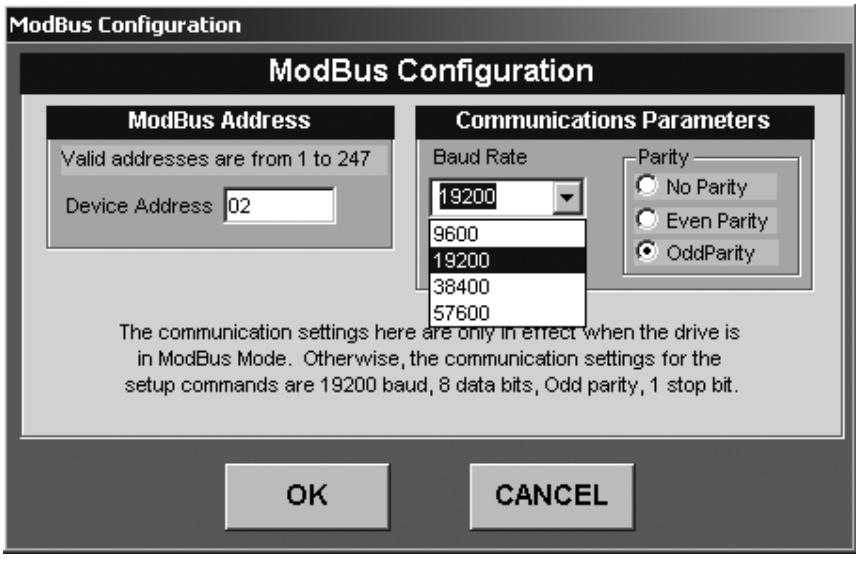


Figure 13.1 - ModBus Configuration and Setup Screen

ModBus RTU protocol communications will support the following framing and baud rate options:

Baud rate: 9600, 19200*, 38400, or 57600 baud
Start bits: 1 start bit
Data bits: 8 data bits
Parity: even*, odd, or none
Stop Bits: 1 stop bit if parity*, 2 stop bits if no parity check (character always 11 bits total)
Handshaking: none, no hardware or software handshaking
*default settings

The user can select from the above options in any combination to define the character framing for ModBus RTU communications. This selection will be made at configuration, and once a configuration is downloaded to the Axiom Plus, the chosen settings will be made active for all ModBus communications.

ADDRESSING OF SLAVE AXIOM PLUS DEVICES

Address arbitration for the Axiom Plus in ModBus mode is performed by the "master" in a multi-drop fashion. The master sends a command to set the active address, and "slave" devices activate accordingly.

ModBus addresses from 1 to 247 are supported, with 0 being the broadcast address. The address can be assigned by the user as part of initial drive configuration, in the Drive Setup and Configuration screen.

Mapping

AXIOM PLUS REGISTERS INTO MODBUS REGISTERS

At present, the following registers are provided for use in Axiom Plus programming:

Registers	Non-Volatile	RAM
Position	32	32
Velocity	16	16
Torque	32	32
Counter	4	1
Timer	8	1
Analog	4	2

For purposes of ModBus identification, all registers hold 32-bit integers, either signed or unsigned depending upon register type. (Thus, two ModBus 16-bit registers are required to store each Axiom Plus programmable register.) ModBus holding register addresses (4XXXX registers) will be assigned to Axiom Plus programmable registers.

Note: The first ModBus holding register has address 40001, but is actually addressed as 0 in ModBus query messages, with register 40002 addressed as 1, etc. The ModBus query message identifies the register type, so the 4 identifier is not used as part of the register address.

All Axiom Plus registers, are 32-bits in width. They are accessible for reading and writing ModBus commands acting on 4XXXX holding registers.

Address mapping will be done so that the high word of a programmable register will always fall on an EVEN address.

ModBus commands that access single or multiple Axiom Plus registers will be required to specify the address of the first 4XXXX register of the 4XXXX register pair containing the total register contents. This register will always have an even address, but an odd ModBus id (example: ModBus holding register 40003 represents an odd id, but its address for access purposes is 2, which is even.

A command accessing register memory that is reserved or in some cases accessing a range including more than one type (position, velocity, torque-limit) of register data will result in an error – the command will not be processed normally; an exception response will be returned to the master device.

RAM REGISTERS — Grouped for Single-Command Access

	POSITION				VELOCITY				TORQUE			
	HIGH WORD		LOW WORD		HIGH WORD		LOW WORD		HIGH WORD		LOW WORD	
NO	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS
001	40001	0	40002	1	40003	2	40004	3	40005	4	40006	5
002	40017	16	40018	17	40019	18	40020	19	40021	20	40022	21
003	40033	32	40034	33	40035	34	40036	35	40037	36	40038	37
004	40049	48	40050	49	40051	50	40052	51	40053	52	40054	53
005	40065	64	40066	65	40067	66	40068	67	40069	68	40070	69
006	40081	80	40082	81	40083	82	40084	83	40085	84	40086	85
007	40097	96	40098	97	40099	98	40100	99	40101	100	40102	101
008	40113	112	40114	113	40115	114	40116	115	40117	116	40118	117

NON-VOLATILE REGISTERS — Grouped for Single-Command Access

	POSITION				VELOCITY				TORQUE			
	HIGH WORD		LOW WORD		HIGH WORD		LOW WORD		HIGH WORD		LOW WORD	
NO	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS
001	40129	128	40130	129	40131	130	40132	131	40133	132	40134	133
002	40145	144	40146	145	40147	146	40148	147	40149	148	40150	149
003	40161	160	40162	161	40163	162	40164	163	40165	164	40166	165
004	40177	176	40178	177	40179	178	40180	179	40181	180	40182	181
005	40193	192	40194	193	40195	194	40196	195	40197	196	40198	197
006	40209	208	40210	209	40211	210	40212	211	40213	212	40214	213
007	40225	224	40226	225	40227	226	40228	227	40229	228	40230	229
008	40241	240	40242	241	40243	242	40244	243	40245	244	40246	245

POSITION REGISTERS — Grouped Sequentially

	NON-VOLATILE				RAM			
	HIGH WORD		LOW WORD		HIGH WORD		LOW WORD	
NO	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS
009	40513	512	40514	513	40257	256	40258	257
010	40515	514	40516	515	40259	258	40260	259
011	40517	516	40518	517	40261	260	40262	261
012	40519	518	40520	519	40263	262	40264	263
013	40521	520	40522	521	40265	264	40266	265
014	40523	522	40524	523	40267	266	40268	267
015	40525	524	40526	525	40269	268	40270	269
016	40527	526	40528	527	40271	270	40272	271
017	40529	528	40530	529	40273	272	40274	273
018	40531	530	40532	531	40275	274	40276	275
019	40533	532	40534	533	40277	276	40278	277
020	40535	534	40536	535	40279	278	40280	279
021	40537	536	40538	537	40281	280	40282	281
022	40539	538	40540	539	40283	282	40284	283
023	40541	540	40542	541	40285	284	40286	285
024	40543	542	40544	543	40287	286	40288	287
025	40545	544	40546	545	40289	288	40290	289
026	40547	546	40548	547	40291	290	40292	291
027	40549	548	40550	549	40293	292	40294	293
028	40551	550	40552	551	40295	294	40296	295
029	40553	552	40554	553	40297	296	40298	297
030	40555	554	40556	555	40299	298	40300	299
031	40557	556	40558	557	40301	300	40302	301
032	40559	558	40560	559	40303	302	40304	303

All ModBus 4XXXX register addresses not listed above are considered "RESERVED".

VELOCITY REGISTERS — Grouped Sequentially

	NON-VOLATILE				RAM			
	HIGH WORD		LOW WORD		HIGH WORD		LOW WORD	
NO	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS
009	41025	1024	41026	1025	40769	768	40770	769
010	41027	1026	41028	1027	40771	770	40772	771
011	41029	1028	41030	1029	40773	772	40774	773
012	41031	1030	41032	1031	40775	774	40776	775
013	41033	1032	41034	1033	40777	776	40778	777
014	41035	1034	41036	1035	40779	778	40780	779
015	41037	1036	41038	1037	40781	780	40782	781
016	41039	1038	41040	1039	40783	782	40784	783

All ModBus 4XXXX register addresses not listed above are considered "RESERVED".

TORQUE-LIMIT REGISTERS — Grouped Sequentially

	NON-VOLATILE				RAM			
	HIGH WORD		LOW WORD		HIGH WORD		LOW WORD	
NO	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS
009	41537	1536	41538	1537	41281	1280	41282	1281
010	41539	1538	41540	1539	41283	1282	41284	1283
011	41541	1540	41542	1541	41285	1284	41286	1285
012	41543	1542	41544	1543	41287	1286	41288	1287
013	41545	1544	41546	1545	41289	1288	41290	1289
014	41547	1546	41548	1547	41291	1290	41292	1291
015	41549	1548	41550	1549	41293	1292	41294	1293
016	41551	1550	41552	1551	41295	1294	41296	1295
017	41553	1552	41554	1553	41297	1296	41298	1297
018	41555	1554	41556	1555	41299	1298	41300	1299
019	41557	1556	41558	1557	41301	1300	41302	1301
020	41559	1558	41560	1559	41303	1302	41304	1303
021	41561	1560	41562	1561	41305	1304	41306	1305
022	41563	1562	41564	1563	41307	1306	41308	1307
023	41565	1564	41566	1565	41309	1308	41310	1309
024	41567	1566	41568	1567	41311	1310	41312	1311
025	41569	1568	41570	1569	41313	1312	41314	1313
026	41571	1570	41572	1571	41315	1314	41316	1315
027	41573	1572	41574	1573	41317	1316	41318	1317
028	41575	1574	41576	1575	41319	1318	41320	1319
029	41577	1576	41578	1577	41321	1320	41322	1321
030	41579	1578	41580	1579	41323	1322	41324	1323
031	41581	1580	41582	1581	41325	1324	41326	1325
032	41583	1582	41584	1583	41327	1326	41328	1327

All ModBus 4XXXX register addresses not listed above are considered "RESERVED".

COUNTER REGISTERS

	NON-VOLATILE				RAM			
	HIGH WORD		LOW WORD		HIGH WORD		LOW WORD	
NO	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS
001	40135	0134	40136	0135	40007	0006	40008	0007
002					40023	0022	40024	0023
003					40039	0038	40040	0039
004					40055	0054	40056	0055

TIMER REGISTERS

	NON-VOLATILE				RAM			
	HIGH WORD		LOW WORD		HIGH WORD		LOW WORD	
NO	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS
001	40137	0136	40138	0137	40009	0008	40010	0009
002					40025	0024	40026	0025
003					40041	0040	40042	0041
004					40057	0056	40058	0057
005					40073	0072	40074	0073
006					40089	0088	40090	0089
007					40105	0104	40106	0105
008					40121	0120	40122	0121

ANALOG REGISTERS

	NON-VOLATILE				RAM			
	HIGH WORD		LOW WORD		HIGH WORD		LOW WORD	
NO	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS	ID	ADDRESS
001	40139	0138	40140	0139	40011	0010	40012	0011
002	40155	0154	40156	0155	40027	0026	40028	0027
003					40043	0042	40044	0043
004					40059	0058	40060	0059

PROCESS VARIABLE DIAGNOSTIC REGISTERS — Grouped Sequentially

001-002 (READ ONLY)

	HIGH WORD		LOW WORD		
NO	ID	ADDRESS	ID	ADDRESS	
001	44353	4352	44354	4353	HOLDS ABSOLUTE COMMAND POSITION
002	44355	4354	44356	4355	HOLDS ABSOLUTE ACTUAL POSITION
003	44357	4356	44358	4357	HOLDS COMMAND VELOCITY
004	44359	4358	44360	4359	HOLDS ACTUAL VELOCITY
005	44361	4360	44362	4361	HOLDS TORQUE OUTPUT
006	44363	4362	44364	4363	HOLDS THE CURRENT VALUE AT ANALOG INPUT

AXIOM PLUS DISCRETE I/O AND FLAGS INTO MODBUS 0X AND 1X MEMORY SPACE

ModBus allows reading the status of and in some cases forcing the logic of discrete flags and physical I/O.

ModBus addresses for read and/or write access:

Physical Inputs	1 - 15	ModBus access read-only
Physical Outputs	1 - 8	ModBus access read-only
PLC Local Flags	1 - 64	ModBus access read-only
Indexer Status Flags	1 - 12	ModBus access read-only
Indexer Control State Flags	1 - 12	ModBus access read-only
PLC Forcing Flags	1 - 64	ModBus access read / write

Axiom Plus discrete flags that allow read-only access to a ModBus "master" will be mapped into ModBus input space (1X ModBus references), with the exception of physical outputs.

Physical outputs will be mapped into ModBus coil space (0X ModBus references).

Axiom Plus discrete flags that allow read and write (force) access to a ModBus "master" will be mapped into ModBus coil space (0X ModBus references).

Note: Even though physical outputs and PLC forcing flags are mapped into ModBus coil address space, only PLC forcing flags can be written or forced, physical outputs present read-only access.

The following table lists address mapping for Axiom Plus discrete flags into ModBus coil (0X) and input (1X) address space.

Physical Inputs mapped into ModBus input space (1X references) – ModBus access read-only

Axiom Plus Discrete	ModBus	Address
Physical Input 001	0000	
Physical Input 002	0001	
|	|	
|	|	
|	|	
Physical Input 015	0014	
RESERVED	0015	0255

PLC Local Flags mapped into ModBus input space (1X references) – ModBus access read-only

Axiom Plus Discrete	ModBus	Address
PLC Local Flag 001	0256	
PLC Local Flag 002	0257	
|	|	
|	|	
|	|	
PLC Local Flag 064	0319	
RESERVED	0320	0511

Indexer Status Flags mapped into ModBus input space (1X references) – ModBus access read-only

Axiom Plus Discrete	ModBus	Address
Indexer Status Flag 001	0512	
Indexer Status Flag 002	0513	
|	|	
|	|	
|	|	
Indexer Status Flag 012	0523	
RESERVED	0523	0767

Indexer Control State Flags mapped into ModBus input space (1X references) – ModBus access read-only

Axiom Plus Discrete	ModBus	Address
Indexer Control State Flag 001	0768	
Indexer Control State Flag 002	0769	
|	|	
|	|	
|	|	
Indexer Control State Flag 012	0779	
RESERVED	0780	1027

Physical Outputs mapped into ModBus coil space (0X references) – ModBus access read-only

Axiom Plus Discrete	ModBus	Address
Physical Output 001		0000
Physical Output 002		0001
|	|	
|	|	
|	|	
Physical Output 008	0007	
RESERVED	0008	
|	|	
|	|	reserved for Physical Outputs
|	|	
RESERVED	0255	

PLC Forcing Flags mapped into ModBus coil space (0X references) – ModBus access read / write

Axiom Plus Discrete	ModBus	Address
PLC Forcing Flag 001	0256	
PLC Forcing Flag 002	0257	
|	|	
|	|	
|	|	
PLC Forcing Flag 064	0319	
RESERVED	0320	0543

PLC Local Flags mapped into ModBus coil space (0X references) – ModBus access read-only

Axiom Plus Discrete	ModBus	Address
PLC Local Flag 001	0512	
PLC Local Flag 002	0513	
|	|	
|	|	
|	|	
PLC Local Flag 064	0575	
RESERVED	0576	0767

All ModBus 0X and 1X reference addresses not listed above are considered "RESERVED". However, reads of non-existent discretes in units of 16-bits (between word boundaries) may be allowed.

COMMAND STREAM HANDLING, TIME-SEPARATION OF COMMANDS, ETC.

ModBus RTU relies on time-spacing to separate commands. Thus, a ModBus RTU command must always be sent as a continuous stream of bytes. The required time-spacing to mark command start/end is expressed in character times at the active baud rate. Any elapsed time between received characters of more than 1.5 character times is interpreted as a potential break between messages, with a minimum of 3.5 character times necessary for a valid time-space between messages. This means that the Axiom Plus firmware monitors serial port receiving activity for time-spacing between received characters. A sequence of bytes preceded AND followed by an idle time of at least 3.5 character times will be assumed to represent a valid ModBus message. A sequence of characters broken by an idle time of greater than 1.5 character times but less than 3.5 character times will not be considered to be a valid message.

Axiom Plus firmware will tag the input serial buffer with regard to valid message spacing and use control bits to note occurrence of an illegal break. A command handler running once per PLC scan will operate on data assumed to constitute a complete ModBus message from the "master". A routine to calculate the message CRC and compare it to the CRC sent with the message will be applied to data in the buffer to check for valid message data. If data is received with

invalid time-spacing, or if the CRC check fails, no response will be returned. After CRC check, the command handler pulls message data from the buffer, decodes the command, takes the appropriate action, and formulates the correct response message (and load the response bytes into the output buffer) for transmission back to the "master". The Axiom Plus can only place one response message in the output buffer at one time, and will allow at least 3.5 character times to elapse between the transmission of the last character of a response before a new response message is loaded into the serial output buffer. The serial input buffer can hold up to 8 messages, as long as the input buffer length (2K bytes) is not exceeded.

Refer to document **"Modicon ModBus Protocol Reference Guide, PI-MBUS-300 rev. J"** for a more detailed description of ModBus message framing and command handling.

MODBUS COMMANDS SUPPORTED BY AXIOM PLUS

Refer to sections **"Mapping of Axiom Plus discrete I/O and Flags into ModBus 0X and 1X reference memory space"** and **"Mapping of Axiom Plus registers into ModBus Register Memory Space"** of this document for listing of supported registers and discretes.

A brief description of the command syntax and capabilities and the associated response message will be given for each message. All messages will begin with a 1-byte address field, followed by a 1-byte command id field. The final 2 bytes of any message will contain the CRC value for data validity check. Normal response messages from the Axiom Plus to the ModBus master device will begin with the slave address, followed by the command id of the message that prompted the response. Remaining data will be included based on the original query message. If the message from the master includes requests to read or write registers or discretes that are not supported by the Axiom Plus, an exception response will be returned to the master, informing the master of the type of error.

Note: Packet and character framing errors will cause the Axiom Plus to generate an "F57" serial communications fault.

Follow is a proposed list of ModBus commands supported by the Axiom Plus.

01 Read Coil Status

Reads the logical (1 or 0) state of discrete coils (outputs) and flags mapped to ModBus 0X reference addresses. Broadcast is not supported. This command includes 2-bytes to hold the starting address (address of the first coil to be read), and a 2-byte field containing the number of coils to be read. Keep in mind that "coils" refers to any Axiom Plus discrete output or flag mapped to ModBus 0X reference address space. The normal response to this query from the master will include a number of data bytes necessary to hold the logic status of the discretes queried, with each bit of a byte corresponding to one coil (output or flag). If any coil addresses not supported by the Axiom Plus are queried for read, an error, or exception, response will be returned. Only one class, or type, of Axiom Plus discrete can be read by a single 01 command. In other words, physical output status and PLC forcing flags status could not be read using a single command. The absolute maximum number of coils that will ever be allowed for a 01 command is 256.

02 Read Input Status

Reads the logical (1 or 0) state of discrete inputs (physical inputs or flags) mapped to ModBus 1X reference addresses. Broadcast is not supported. This command syntax is similar to that for command 01-Read Coil Status. The normal response will include data bytes as necessary to return the logic status of each input (physical input or flag) queried. If any input addresses not supported by the Axiom Plus are queried for read, it will be considered an error and an exception response will be returned. Only one class, or type, of Axiom Plus discrete input or flag can be read by a single 02 command. The absolute maximum number of inputs that will ever be allowed for a single 02 command is 256.

03 Read Holding Registers

Reads the binary data contained in ModBus 4X holding registers. The command field includes the starting address of the first register to be read and the number of registers to be read. For the Axiom Plus, all register data is considered to be 32-bit, so only multiples of two registers can be read without error. In other words, the first register to be read must have an even address, and the number of ModBus 4X registers to be read will be 2x's the number of Axiom Plus 32-bit registers. The normal response will contain data bytes,

with 2 bytes necessary for each ModBus register read; thus, 4 bytes will be required in the response data field to hold the value of each 32-bit Axiom Plus register read. The Axiom Plus will not support reads of more than 512 ModBus 4X registers (256 Axiom Plus 32-bit registers). Also, any query requesting the reading of a "reserved" register will be considered to be in error and an exception response will be returned. Register mapping to 4X reference address space is done so that it is possible to read all register types (position, velocity, and torque-limit registers) with a single 03 command for Axiom Plus registers with id's from 1 to 8. Axiom Plus registers with id's greater than 8 are grouped in contiguous blocks by type, allowing groups of Axiom Plus registers of a particular type to be read using a single 03 command.

05 Force Single Coil

This command message provides for forcing the logic state of a single ModBus 0X reference coil. This command can be broadcast, i.e. sent with the broadcast address such that the commanded forcing action occurs in multiple slave devices. The Axiom Plus will only support forcing (setting or resetting of logic state) of PLC forcing flags. Physical outputs cannot be forced. The normal response to this command is simply an echo of the query, sent once the coil logic state has been forced. If the coil addressed for forcing does not correspond to an existing PLC forcing flag address in the Axiom Plus, the message will be considered in error and an exception response will be returned. The absolute maximum number of coils to be forced that will ever be supported by this command in the Axiom Plus is 256.

15 Force Multiple Coils

This command message provides for forcing the logic state of single or multiple ModBus 0X reference coils. This command can be broadcast, i.e. sent with the broadcast address such that the commanded forcing action occurs in multiple slave devices. The Axiom Plus will only support forcing (setting or resetting of logic state) of PLC forcing flags. Physical outputs cannot be forced. A normal response contains the slave address, command function code, starting address, and number of coils forced. If coil addresses for forcing do not correspond to existing PLC forcing flag addresses in the Axiom Plus, the message will be considered in error and an exception response will be returned. The absolute maximum number of coils forced by a single 15 command that will ever be supported by the Axiom Plus is 256.

16 Preset Multiple Registers
This command allows a ModBus master to write values to multiple registers residing in Axiom Plus memory, mapped into ModBus 4X register space. This command can be broadcast. The command field includes the starting address of the first register to be written, the number of registers to be written, and the data to be written. It must be noted that all Axiom Plus registers are 32-bit registers, and each Axiom Plus register is mapped to 2 ModBus 4X register addresses. Thus, any 16 command must specify an even starting address and a number of registers to be written that is a multiple of 2. Requests for writes to odd numbers of registers, or registers not supported by the Axiom Plus will be considered in error, and an exception response will be returned. Due to the way in which Axiom Plus registers are mapped to ModBus 4X address space, it is possible to write different types (position, velocity, or torque-limit) of Axiom Plus registers or contiguous blocks of registers of the same type with a single 16 command. Again, writing to "reserved" registers is illegal.

17 Report Slave ID
This command allows a ModBus master to poll the Axiom Plus slave for 8 bytes of device ID and fault/status data. This command cannot be broadcast. The information returned in the data bytes of a normal response is as follows:

1st byte: Axiom Plus Indexer ID
0 – PV10
1 – PV20
2 – PV30

2nd byte: Enable Status
FFh – enabled
00h – not enabled

3rd, 4th bytes: Axiom Plus Firmware Version
decimal number * (1/10) corresponds to firmware version number. last decimal digit represents letter code (0 for none, 1 for a, etc.). example: 2000 corresponds to firmware version of v2.00.

5th through 8th bytes: 32-bits of Fault / Status Flags
bit 0, _fsflag0.0: processor fault, display code of "F00"

bit 1, _fsflag0.1: drive not configured, display code “F99”
bit 2, _fsflag0.2: power selection switch fault, “F01”
bit 3, _fsflag0.3: bridge hardware fault, “F02”
bit 4, _fsflag0.4: current feedback fault, “F03”
bit 5, _fsflag0.5: current regulation fault, “F04”
bit 6, _fsflag0.6: drive over-temperature fault, “F05”
bit 7, _fsflag0.7: motor over_temperature fault, “F06”
bit 8, _fsflag0.8: encoder feedback / commutation fault, “F07”
bit 9, _fsflag0.9: fatal PLC fault, display code “F98”
bit 10, _fsflag0.10: fatal seq. program fault, display code “F97”
bit 11, _fsflag0.11: phasing fault (non-fatal), “F51”
bit 12, _fsflag0.12: drive over-current fault (non-fatal), “F52”
bit 13, _fsflag0.13: motor over-current fault (non-fatal), “F53”
bit 14, _fsflag0.14: bus under-voltage fault (non-fatal), “F54”
bit 15, _fsflag0.15: maximum following-error fault (non_fatal), “F55”
bit 16, _fsflag1.0: velocity regulation fault (non-fatal), “F56”
bit 17, _fsflag1.1: serial communications fault (non-fatal), “F57”
bit 18, _fsflag1.2: positive travel limit fault (non-fatal), “FL1”
bit 19, _fsflag1.3: negative travel limit fault (non-fatal), “FL2”
bit 20, _fsflag1.4: sequential program execution fault (non-fatal), “F58”
bit 21, _fsflag1.5: drive disabled condition, “d”
bit 22, _fsflag1.6: phasing in progress, “P”
bit 23, _fsflag1.7: clockwise travel limit active (no fault), “L01”
bit 24, _fsflag1.8: counter-clockwise limit active (no fault), “L02”
bit 25, _fsflag1.9: drive enabled condition, “E”

note: above 32-bit word returned by slave as four bytes with most-significant byte first.

The preceding descriptions of supported command functionality and syntax are very general. The ModBus master and Axiom Plus slave should automatically handle the details of query and response message composition and framing. For more underlying technical details into the workings of these commands at the signal level, refer to document **“Modicon ModBus Protocol Reference Guide, PI-MBUS-300 rev. J”.**

Indexer Type Control of the Axiom Plus

Requirement:
External controller needs to command six different motion sequences in the Axiom Plus

Solution:
Since six motion sequences are required, use three outputs from the external controller connected to three inputs on the Axiom Plus (IN 10, 11 and 12) to define a binary sequence giving six possible states. The Axiom Plus will use the inputs to set six PLC to Sequential bit flags that correspond to index 1 - 6. In the Axiom Plus PLC start with the default PLC program and add the six rungs required to setup the PLC to Sequential flags. See rungs 13 through 18 in the example showing how the rungs are programmed.

See Figure 14.1 on next page

9/4/01 08.57 AM Page 1

PLC Program Listing

```
RUNG 001 Drive Output Stage Enable Logic

   enab in                                                          ENABLE
+----| |----+-----------+-----------+-----------+-----------+----( )----+
   IN  001                                                       ICC 001


RUNG 002 Cycle Start Control Logic

   cstartPB    cstrt_OS                                           cstart
+----| |----+---|ONE-|--+-----------+-----------+-----------+----( )----+
   IN  002      |SHOT|  |                                       ICC 002
               ONS 001  |
                        |
   cstrt_?              |
+----| |----+-----------+
   ICS 002


RUNG 003 Cycle Stop Control Logic

   cstartPB                                                        cstop
+----|/|----+-----------+-----------+-----------+-----------+----( )----+
   IN  002   |                                                   ICC 003
             |
   pend_OS   |
+----| |----+
   IS  009


RUNG 004 Cycle Pause Control Logic

   cpausePB                                                        cpause
+----| |----+-----------+-----------+-----------+-----------+----( )----+
   IN  003                                                       ICC 004


RUNG 005 Cycle Resume Control Logic

   cresumPB    cresm_OS                                           cresume
+----| |----+---|ONE-|--+-----------+-----------+-----------+----( )----+
   IN  004      |SHOT|                                          ICC 005
               ONS 002


RUNG 006 JOG1 SPEED POSITIVE -- Control Logic

   jog1+PB     home sw                                          JOG1_pos
+----| |----+----|/|----+-----------+-----------+-----------+----( )----+
   IN  005     IN  008                                       ICC 006
```

Figure 14.1 PLC Program Listing

```
RUNG 007 JOG1 SPEED NEGATIVE -- Control Logic

   jog1-PB      cw lim                                                JOG1_neg
+----| |----+----|/|----+-----------+-----------+-----------+----( )----+
   IN  006     IN  007                                               ICC 007



RUNG 008 CW Travel Limit Logic

    cw lim                                                            CWLIMIT
+----| |----+-----------+-----------+-----------+-----------+----( )----+
   IN  007                                                           ICC 011



RUNG 009 CCW Travel Limit Logic

   ccw lim                                                           CCWLIMIT
+----| |----+-----------+-----------+-----------+-----------+----( )----+
   IN  009                                                           ICC 012



RUNG 010 Home Switch Logic

   home sw                                                           homespls
+----| |----+-----------+-----------+-----------+-----------+----( )----+
   IN  008                                                           ICC 013



RUNG 011 User Rung Comment

    in_pos                                                            in pos
+----| |----+-----------+-----------+-----------+-----------+----( )----+
   IS  006                                                           OUT 001



RUNG 012 User Rung Comment

    fault                                                             flt out
+----| |----+-----------+-----------+-----------+-----------+----( )----+
   IS  002                                                           OUT 002



RUNG 013 User Rung Comment

   input A     input B     Input C                                   index 1
+----| |----+----|/|----+----|/|----+-----------+-----------+----( )----+
   IN  010     IN  011     IN  012                                   PTS 001
```

Figure 14.2 PLC Program Listing

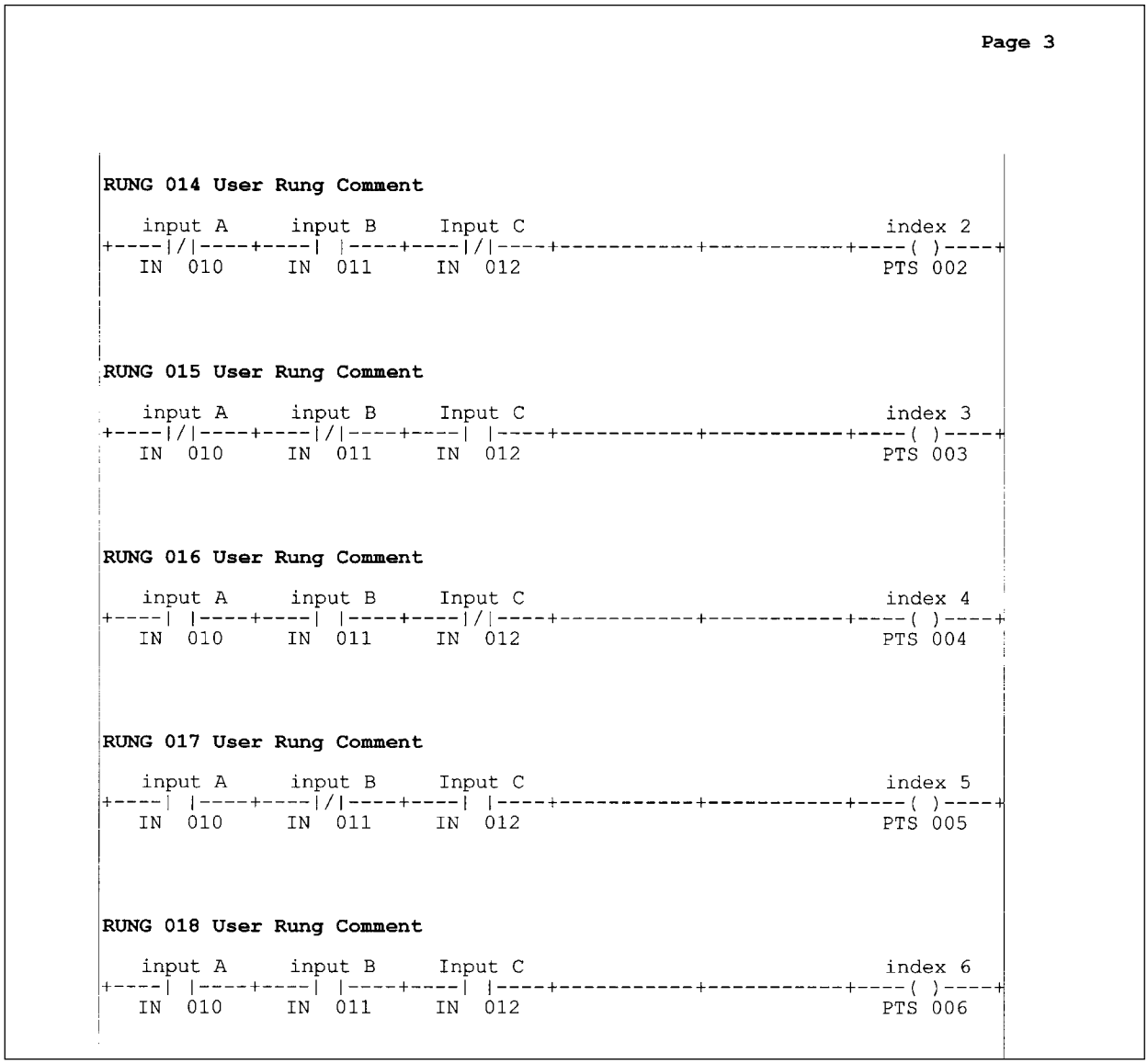


Figure 14.3 PLC Program Listing

Sequential Program Listing:

The sequential program is setup using a main loop that will call the required subroutine based on the state of the PLC to Sequential Flag. The sequential program has six conditional subroutine calls in the main loop with the six subroutines following. In each of the subroutines there can be any number of moves making this program more powerful than a standard indexer.

See Figure 14.4 on next page

9/4/01 08.57 AM Page 1

Sequential Program Listing

```
Line#001
label:
comment: Homing routine
Axis Home to Encoder Index Pulse -- CCW approach
Approach Speed = 5.0  Creep Speed = 0.25
Automatic Reversal at Travel Limit Active


Line#002
label top
comment: Provides location to jump to
No Operation


Line#003
label:
comment: Call to index 1
Conditional Subroutine Call: index 1
Conditional Operand: PLC-to-SEQ PRG FLAG #001 : PTS 001
Call Subroutine on Logic 1 (normally-open)


Line#004
label:
comment: Call to index 2
Conditional Subroutine Call: index 2
Conditional Operand: PLC-to-SEQ PRG FLAG #002 : PTS 002
Call Subroutine on Logic 1 (normally-open)


Line#005
label:
comment: Call to index 3
Conditional Subroutine Call: index 3
Conditional Operand: PLC-to-SEQ PRG FLAG #003 : PTS 003
Call Subroutine on Logic 1 (normally-open)


Line#006
label:
comment: Call to index 4
Conditional Subroutine Call: index 4
Conditional Operand: PLC-to-SEQ PRG FLAG #004 : PTS 004
Call Subroutine on Logic 1 (normally-open)


Line#007
label:
comment: Call to index 5
Conditional Subroutine Call: index 5
Conditional Operand: PLC-to-SEQ PRG FLAG #005 : PTS 005
Call Subroutine on Logic 1 (normally-open)


Line#008
label:
comment: Call to index 6
Conditional Subroutine Call: index 6
Conditional Operand: PLC-to-SEQ PRG FLAG #006 : PTS 006
Call Subroutine on Logic 1 (normally-open)
```

Figure 14.4 Sequential Program Listing

```
Line#009
label:
comment: Jump to label top and rescan
Branch to Label: top


Line#010
label index 1
comment: Start of index 1
Inc Position Move -- Move Distance = 10.000 inch
Vel = 2.00  Acc = 5.0  Dec = 10.0
Trigger #1:  No Trigger Event
Trigger #2:  No Trigger Event


Line#011
label:
comment: user comment for line #0011
Time Delay: 2 seconds


Line#012
label:
comment: user comment for line #0012
Inc Position Move -- Move Distance = -5.000 inch
Vel = 2.00  Acc = 5.0  Dec = 10.0
Trigger #1:  No Trigger Event
Trigger #2:  No Trigger Event


Line#013
label:
comment: user comment for line #0013
Time Delay: 1 seconds


Line#014
label:
comment: user comment for line #0014
Inc Position Move -- Move Distance = -5.000 inch
Vel = 2.00  Acc = 10.0  Dec = 15.0
Trigger #1:  No Trigger Event
Trigger #2:  No Trigger Event


Line#015
label:
comment: End of index 1
Return from Subroutine


Line#016
label index 2
comment: Start of index 2
Abs Position Move -- Position = 0.000 inch
Vel = 2.00  Acc = 10.0  Dec = 15.0
Trigger #1:  No Trigger Event
Trigger #2:  No Trigger Event
```

Figure 14.5 Sequential Program Listing

```
Line#017
label:
comment: End of index 2
Return from Subroutine


Line#018
label index 3
comment: Start of index 3
Inc Position Move -- Move Distance = 1.000 inch
Vel = 3.00  Acc = 25.0  Dec = 25.0
Trigger #1:  No Trigger Event
Trigger #2:  No Trigger Event


Line#019
label:
comment: End of index 3
Return from Subroutine


Line#020
label index 4
comment: Start of index 4
Inc Position Move -- Move Distance = -2.000 inch
Vel = 5.00  Acc = 25.0  Dec = 25.0
Trigger #1:  No Trigger Event
Trigger #2:  No Trigger Event


Line#021
label:
comment: user comment for line #0021
Inc Position Move -- Move Distance = 2.000 inch
Vel = 1.00  Acc = 5.0  Dec = 5.0
Trigger #1:  No Trigger Event
Trigger #2:  No Trigger Event


Line#022
label:
comment: End of index 4
Return from Subroutine


Line#023
label index 5
comment: Start of index 5
Abs Position Move -- Position = 10.000 inch
Vel = 5.00  Acc = 25.0  Dec = 25.0
Trigger #1:  No Trigger Event
Trigger #2:  No Trigger Event


Line#024
label:
comment: End of index 5
Return from Subroutine
```

Figure 14.6 Sequential Program Listing

```
Line#025
label index 6
comment: Start of index 6
Abs Position Move -- Position = 5.000 inch
Vel = 0.50  Acc = 1.0  Dec = 1.0
Trigger #1:  No Trigger Event
Trigger #2:  No Trigger Event


Line#026
label:
comment: End of index 6
Return from Subroutine
```

Figure 14.7 Sequential Program Listing

Status and Fault Display 15

The *Axiom Plus* drives support a set of status and fault conditions that can be displayed on the drive's seven-segment display. In addition, any fault will display on the diagnostic screen of the *Axiom*® setup software whenever a computer is connected to the drive.

Normal Operation

Whenever the drive is powered, and no fault or status conditions are present, it will display the letter "d" when disabled or "E" when enabled. This lets the user know the drive's status at a glance.

Status Codes

Anytime the drive detects a condition that is not a "fault", yet not a normal condition, it will display a flashing three-character code. For example, "L"— "0" — "1" indicates the drive is enabled and has reached the CW end of travel limit switch.

Faults

Faults are caused by conditions that make it necessary for the drive to shut down. When one occurs, the drive disables its power amplifier output stage and displays the appropriate fault code. A fault is displayed by flashing "F" followed by a two-digit code. For example, "F" — "5" — "5" indicates that the maximum allowable following error has been exceeded.

There are two classes of faults in Tolomatic Axiom series servo motor drives. The first class are called *Fatal Faults*. These indicate that something is seriously wrong with the system and can only be cleared by removing power from the drive.

The second class of faults are *Non-Fatal Faults*. These faults are of a less serious nature. They can be cleared by disabling the drive, correcting the condition that caused the fault, then enabling the drive again.

FAULT AND STATUS CODES (Listed in order of decreasing priority).

FATAL FAULTS (Requires line power-down, power-up and assertion of enable signal to reset.)

F00- Processor Fault
- An internal error has occurred in the DSP.

F01 - Power Selection Switch Fault
- Line-power selection switch set incorrectly.

F02 - Bridge Hardware Fault
- Short circuit or bus over-voltage.

F03 - Current Feedback Fault
- Line-to-line current discrepancy (possible open winding).
- Current feedback circuitry not functioning correctly.

F04 - Current Regulation Fault
- Drive current regulation out of tolerance.
- Current feedback in "saturation" for 1 second.

F05 - Drive Over-Temperature Fault
- Drive heat sink over 90° C.

F06 - Motor Over-Temperature Fault
- Motor thermostat protection fault.

F07 - Encoder Feedback / Commutation Fault

F98 - Fatal PLC Fault
- An internal error has occurred in the PLC scan.

F97 - Fatal Sequential Program
- An internal error has occurred in the sequential program execution.

NON-FATAL FAULTS (Requires removal, then re-assertion of the enable signal to reset.)

F51 - Phasing Fault
- Initial phase estimation routine not executed successfully.

F52 - Drive Over-Current Fault
- Inverse time trip calculated based on the drive's peak and continuous rating.

F53 - Motor Over-Current Fault
- I^2*time protection based on the motor's peak and continuous rating.

F54 - Bus Under-Voltage Fault
- Bus voltage falls below low-limit.

F55 - Maximum Following-Error Fault
- (Position modes only), maximum following error reached. This limit is set in the setup software.

F56 - velocity regulation fault
- Velocity regulation out of tolerance.

F57 - serial communication fault

F58 - Sequential Program Execution Fault
- Error has occurred in sequential program.

F99 - Drive has not yet been configured. The drive cannot be enabled until it has been configured.

FL1 - Positive Travel Limit
- Controller received End-Of-Travel Limit input.

FL2 - Negative Travel Limit
- Controller received End-Of-Travel Limit input.

STATUS CONDITIONS

d - Drive Disabled
- Drive not enabled due to state of enable input or command from PC. No faults are present.

E - Drive Enabled
- Drive is enabled and ready to respond to command.

P - Phasing in process

L01 - Drive Clockwise Travel Limit Reached
- Displayed when clockwise travel limit input is “made” and drive is enabled, with no faults.

L02 - Drive Counter-Clockwise Travel Limit Reached
- Displayed when counter-clockwise travel limit input is “made” and drive is enabled, with no faults.

This page intentionally left blank

Maintenance & Troubleshooting 16

This section provides a description of suggested maintenance activities and an in-depth troubleshooting chart.

Maintenance

The Axiom drive is designed to function with minimum maintenance.



DANGER! DC bus capacitors may retain hazardous voltages after input power has been removed. Before working on the drive, wait the full time interval listed on the warning on the front of the drive. Failure to observe this precaution could result in severe bodily injury or loss of life.

PERIODIC MAINTENANCE

Normally the only maintenance required is removal of superficial dust and dirt from the drive and a quick check of cabling insulation and connections.

Cleaning

To clean the drive, use a compressed air nozzle set for low pressure (<30 psi) to blow the exterior surface and the vents clean.

Cable Inspection

Inspect the cables, particularly the power connections, to verify the connection.

- All power connections should be securely tightened.
- D-shell connectors can be inspected for proper seating and signal continuity.
- Visually inspect all cables for abrasion.

Troubleshooting Guide

Tolomatic Axiom series drives are designed for ease of installation and years of trouble-free operation. If difficulties are encountered in the setup or in operation, this guide should prove useful in diagnosing and correcting the problem. If problems persist, please contact your Tolomatic distributor for further assistance.

Symptom/Fault Code: Status display not lit.
Possible Causes: No ac power; internal malfunction.
Possible Solutions: Verify ac power and connections; call your Tolomatic distributor.

Symptom/Fault Code: Digital I/O not working correctly.
Possible Causes: No 5-25Vdc power.
Possible Solutions: Verify correct connection.

Symptom/Fault Code: F01 - Power selection switch fault.
Possible Causes: Line-power selection switch set incorrectly.
Possible Solutions: Set to "115 V" for 115 Vac operation or "230 V" for 208 Vac or 230 Vac operation.

Symptom/Fault Code: F02 - Bridge hardware fault.
Possible Causes: Motor lead short circuit; bus over-voltage; drive's output bridge damaged.
Possible Solutions: Check motor cables and motor for shorts; connect internal or external regen resistor; call your Tolomatic distributor.

Symptom/Fault Code: F03 - Current feedback fault.
Possible Causes: Possible open winding; current feedback circuitry not functioning correctly.
Possible Solutions: Check motor cable wiring and motor windings; call your Tolomatic distributor.

Symptom/Fault Code: F04 - Current regulation fault.
Possible Causes: Drive current regulation out of tolerance; current feedback in "saturation" for 1 second.
Possible Solutions: Check motor cables and motor windings; verify that torque/speed requirement not greater than motor/drive capability.

Symptom/Fault Code: F05 - Drive over-temperature fault.
Possible Causes: Drive heat sink over 90° C.
Possible Solutions: Ambient temp above 50° C.; need external regen pack.

Symptom/Fault Code: F06 - Motor over-temperature fault.
Possible Causes: Motor thermostat tripped.
Possible Solutions: Inadequate motor cooling; motor rating exceeded.

Symptom/Fault Code: F51 - Phasing fault.
Possible Causes: Initial phase estimation routine not executed successfully.
Possible Solutions: Check encoder and motor wiring; increase phasing torque.

Symptom/Fault Code: F07- Encoder feedback/commutator fault.
Possible Causes: Encoder feedback error - missing feedback.
Possible Solutions: Check encoder cable and connections.

Symptom/Fault Code: F52 - Drive over-current fault.
Possible Causes: Inverse time trip calculated based on the drive's peak and continuous rating exceeded.
Possible Solutions: Verify sizing requirements; check tuning; check for mechanical problems in system.

Symptom/Fault Code: F53 - Motor over-current fault.
Possible Causes: I^2*time protection based on the motor's peak and continuous rating exceeded.
Possible Solutions: Verify sizing requirements; check for mechanical problems in system.

Symptom/Fault Code: F54 - Bus under-voltage fault.
Possible Causes: Bus voltage falls below low-limit.
Possible Solutions: Check line voltage under load (must be at least 90 Vac).

Symptom/Fault Code: F55 - Maximum following-error fault.
Possible Causes: Maximum position following error reached.
Possible Solutions: Verify correct maximum following error setting; check tuning; check for mechanical problems in system.

Symptom/Fault Code: F56 - Velocity regulation fault.
Possible Causes: Velocity regulation out of tolerance.
Possible Solutions: Check tuning; check for mechanical problems in system.

Symptom/Fault Code: F57 - Serial communication fault.
Possible Causes: Communication cable not connected.
Possible Solutions: Check communication cable connections.

This page intentionally left blank

Appendix

This page intentionally left blank

Cables

COMMUNICATION CABLES

Tolomatic offers a pre-wired RS-232 communication cable for connection between a computer and the drive. This cable is supplied with 9-pin D-sub connectors on both ends. Following is a connection diagram for this cable.

PIN #	COLOR	DRIVE FUNCTION	PC FUNCTION
PIN 2	WHITE	TX	RX
PIN 3	GREEN	RX	TX
PIN 5	BLACK	COMMON	COMMON
PIN 7	BLUE	NOT USED	NOT USED
PIN 8	ORANGE	NOT USED	NOT USED

Figure A.1 - RS-232 Communications Cable (P/N 3600-1172)

BUFFERED ENCODER OUTPUT / AUXILIARY ENCODER CABLE

Tolomatic offers a pre-wired cable for encoder signal connection from the drive to a motion controller. This cable is also used to connect to an auxiliary encoder for encoder follower applications. The cable connects the drive's buffered encoder output signal to a controller's encoder feedback signal connection or to the auxiliary encoder. Cable is supplied in a 3M length and has a 15-pin D-sub connector on the Axiom drive end. Following is a connection diagram.

PIN #	COLOR	FUNCTION
1	WHT/BLU STRIPE	AUX ENC +5V
2	WHT/ORG STRIPE	AUX ENC A+
3	ORG/WHT STRIPE	AUX ENC A-
4	WHT/GRN STRIPE	AUX ENC B+
5	GRN/WHT STRIPE	AUX ENC B-
6	WHT/BRN STRIPE	AUX ENC I+
7	BRN/WHT STRIPE	AUX ENC I-
8	BLU/WHT STRIPE	COMMON
9	WHT/GRA STRIPE	ENCODER OUT A +
10	GRA/WHT STRIPE	ENCODER OUT A -
11	RED/BLU STRIPE	ENCODER OUT B +
12	BLU/RED STRIPE	ENCODER OUT B -
13	RED/ORG STRIPE	ENCODER OUT I +
14	ORG/RED STRIPE	ENCODER OUT I -
15		RESERVED

Figure A.2 - Encoder Output Cable (P/N 3604-1213)

MOTOR CABLES

Tolomatic offers cables for connection of Axiom PV series brushless servo motors/drives.

MRV 1x motors are supplied with flying leads and do not require any special cable connectors.

Tolomatic motor/encoder cables have a connector pre-wired to the motor end. The other end may be cut to length by the customer and terminated directly to the screw terminal connections on the drive. No special connectors are needed on the drive end.

All MRV 2x, 3x and 5x series brushless servo motors use the same encoder cable connectors. Tolomatic encoder cables use 24AWG shielded, twisted pair cable.

Encoder cables for all MRV 2x,3x and 5x motors and all PV series drives:

6 m length	3604-1196
15 m length	3604-1197

Motor cables are offered for Tolomatic MRV 2x, 3x and 5x brushless servo motors. Cables for MRV 2x and 3x motors should be ordered according to the drive with which they will be used. All cables use shielded, four conductor cable. Wire size ranges from 16AWG to 12AWG.

MRV 5x motors have a different motor power connector and use a different cable.

Motor cables for MRV 2x and 3x motors used with PV10 drives (16AWG).

6 m length	3604-1190
15 m length	3604-1191

Motor cables for MRV 2x and 3x motors used with PV20 drives (14AWG).

6 m length	3604-1192
15 m length	3604-1193

Motor cables for MRV 2x and 3x motors used with PV30 drives (12AWG).

6 m length	3604-1194
15 m length	3604-1195

Motor cables for use with MRV 5x motors use with PV30 drives (12AWG).

7.5 m length	3604-1202
15 m length	3604-1203

MRV 1X Motor

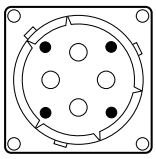
MOTOR CONNECTOR PINOUT	
RED	PHASE R
WHT	PHASE S
BLU	PHASE T

MRV 1X ENCODER

MOTOR CONNECTOR PINOUT	
RED	+ 5V
WHT	A +
YLW	A -
GRN	B +
BLU	B -
ORG	I +
BRN	I -
BLK	COM

MRV 2X/3X Motor

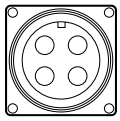
MOTOR CONNECTOR PINOUT	
PIN	FUNCTION
1	PHASE R
2	PHASE S
3	PHASE T
4	CASE GROUND



MS3112E - 14 - 8P
MOTOR CONNECTOR
MATING CONNECTOR
MS3116E - 14 - 8S
(NOT SHOWN)

MRV 5X Motor

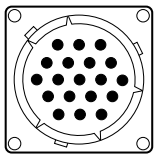
MOTOR CONNECTOR PINOUT	
PIN	FUNCTION
A	PHASE R
B	PHASE S
C	PHASE T
D	CASE GROUND



MS3102E - 20 - 4P
MOTOR CONNECTOR
MATING CONNECTOR
MS3106E - 20 - 45
(NOT SHOWN)

MRV 2X/3X/5X Encoder

		SENSOR/FEEDBACK CONNECTOR PINOUT		
	PIN	FUNCTION	PIN	FUNCTION
Red	A	THERMOSTAT	L	N.C.
Green	B	THERMOSTAT	M	N.C.
	C	N.C.	N	CHANNEL B Purple
Black	D	INDEX	P	CHANNEL $\overline{B}$ Grey
White	E	$\overline{\text{INDEX}}$	R	N.C.
Orange	F	CHANNEL A	S	N.C.
Yellow	G	CHANNEL $\overline{A}$	T	N.C.
Blue	H	ENCODER GROUND	U	N.C.
	J	N.C.	V	N.C.
Brown	K	+5 VDC ENCODER		



MS3112E - 14 - 19P
MOTOR CONNECTOR
MATING CONNECTOR
MS3116E - 14 - 19S
(NOT SHOWN)

Figure A.3 - Tolomatic MRV Motor Connector Pinouts

Agency Approvals

Refer to agency marks on drive or contact Tolomatic for latest information on agency approvals.

Power

PV10

Continuous Current Rating	5A (peak/phase)
Peak Current Rating	10A (peak/phase)
Maximum Input Current (Single Phase)	12.5 A (rms)
Maximum Input Current (Three Phase)	7.5A (rms)
Input Voltage (Single or Three Phase)	95Vac-130Vac/190Vac-250Vac; (voltage range is switch selected)
Input Frequency	47Hz-63Hz
Peak Inrush Current	65 A

PV20

Continuous Current Rating	10A (peak/phase)
Peak Current Rating	20A (peak/phase)
Maximum Input Current (Single Phase)	25A (rms)
Maximum Input Current (Three Phase)	15A (rms)
Input Voltage (Single or Three Phase)	95Vac-130Vac/ 190Vac-250Vac; (voltage range is switch selected)
Input Frequency:	47Hz-63Hz
Peak Inrush Current	160 A

PV30

Continuous Current Rating	15A (peak/phase)
Peak Current Rating	30A (peak/phase)
Maximum Input Current (Single Phase)	37.5A (rms)
Maximum Input Current (Three Phase)	22.5A (rms)
Input Voltage (Single or Three Phase)	95Vac-130Vac/190Vac-250Vac; (voltage range is switch selected)
Input Frequency	47Hz-63Hz
Peak Inrush Current	160 A

Command Sources

Serial Communication Port

Type	RS-232
Baud	19,200 Baud

Control Loops

Type	All digital
Modes	Torque, Velocity and Position control
Torque Loop Update Rate	10 kHz
Velocity Loop Update Rate	5 kHz
Position Loop Update Rate	2.5 kHz

Inputs and Outputs

Optically Isolated Inputs	5Vdc - 25Vdc, 2.7mA - 15mA. 15 general purpose inputs can be configured to source or sink current.
Optically Isolated Outputs	8 optically isolated, 25Vdc max., 20mA max. Can be configured to source or sink current.
Dedicated Relay Output	N.O. contact, 24Vdc, 115/230Vac, 3A max.
Motor Feedback	Incremental encoder, 5Vdc, differential, 4 mHz max., A/B/I channels. 500 line min. with a 4 pole motor, 250 line min. with a 2 pole motor.
Encoder Output	Differential, 5Vdc, A/B/I channels.

Connectors

Serial	9 pin D-Sub.
Encoder Output	15 pin D-Sub.
Power, Motor, Brake Relay and Regen.	Screw terminal block.
All Others	Pluggable screw terminal blocks.

Environmental

Storage Temperature	-40° to 70° C.
Operating Temperature	0° to 50° C.
Humidity	5% to 95%, non-condensing.
Weight	PV10 8lbs. (3.7kg). PV20 12lbs. (5.5kg) PV30 12lbs. (5.5kg)

Motor Protection

The drive has internal shut down circuitry to protect against motor phase to phase short circuits and phase to ground short circuits. This circuitry will shut down drive's output amplifier stage in a small fraction of a second when it detects a short circuit condition.

In addition, the drive does an I^2T calculation based on the motor's thermal time constant. A fault indication is generated if this calculation indicates that the motor windings are about to exceed a safe temperature.



DANGER! Always make sure drive has a proper earth ground before operating system. A drive with an inadequate earth ground connection can present a dangerous shock hazard to operating personnel.



WARNING! Every effort should be made to prevent motor power connection short circuits form occurring. Even though the drive will shut down when such a condition is detected, very high currents will flow and there is still danger of damage to the drive and motor. In addition, a possibility of electrical shock may be present in some circumstances.

Regeneration Ratings

PV10 25W rms at 25°C ambient. Derate linearly to 5W rms at 50°C ambient.

PV20 50W rms at 25°C ambient. Derate linearly to 15W rms at 50°C ambient.

PV30 50W rms at 25°C ambient. Derate linearly to 5W rms at 50°C ambient.

Power Dissipation

The Axiom drive dissipates power that results in cabinet heating. The following table lists power dissipation values. Calculate the cabinet cooling requirements using the power dissipation information and formulae below.

NOTE: These values do not include shunt regulator power (regenerated power).

NOTE: These values correspond to a drive operating at its full continuous current rating at 100% duty cycle. As such they can be considered as maximum or "worst case."

PV10	28W
PV20	47W
PV30	65W

Maximum power losses are shown to help size a NEMA 12 or equivalent enclosure and to ensure the required ventilation. Typical power losses are about one-half maximum power losses.

When sizing an enclosure with no active method of heat dissipation, the following equation approximates the size of the required enclosure:

$T = 4.08 * (Q/A) + 1.1$

where:
T = Temperature difference between inside air and outside ambient air (°F)
Q = Heat generated in enclosure (watts)
A = Enclosure surface area in ft^2 = (2dw + 2dh + 2wh) / 144
d = Depth in inches
h = Height in inches
w = Width in inches

Tolomatic can provide a range of brushless servo motors to cover a broad range of applications. Following are the torque/speed curves for these motors paired with *Axiom Plus* drives.

Motor Drive Performance Curves for MRV Series Motor Drives

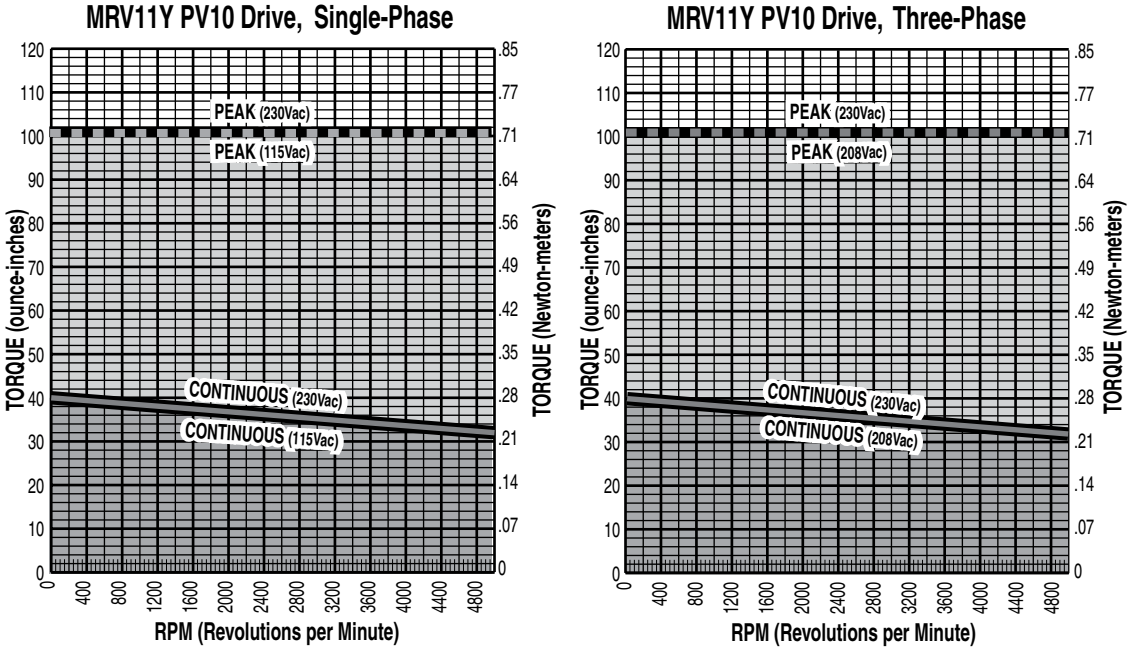


Figure C.1 - MRV 11Y PV10 Single-Phase, Three-Phase Drive

MRV Series Motor Drives (continued)

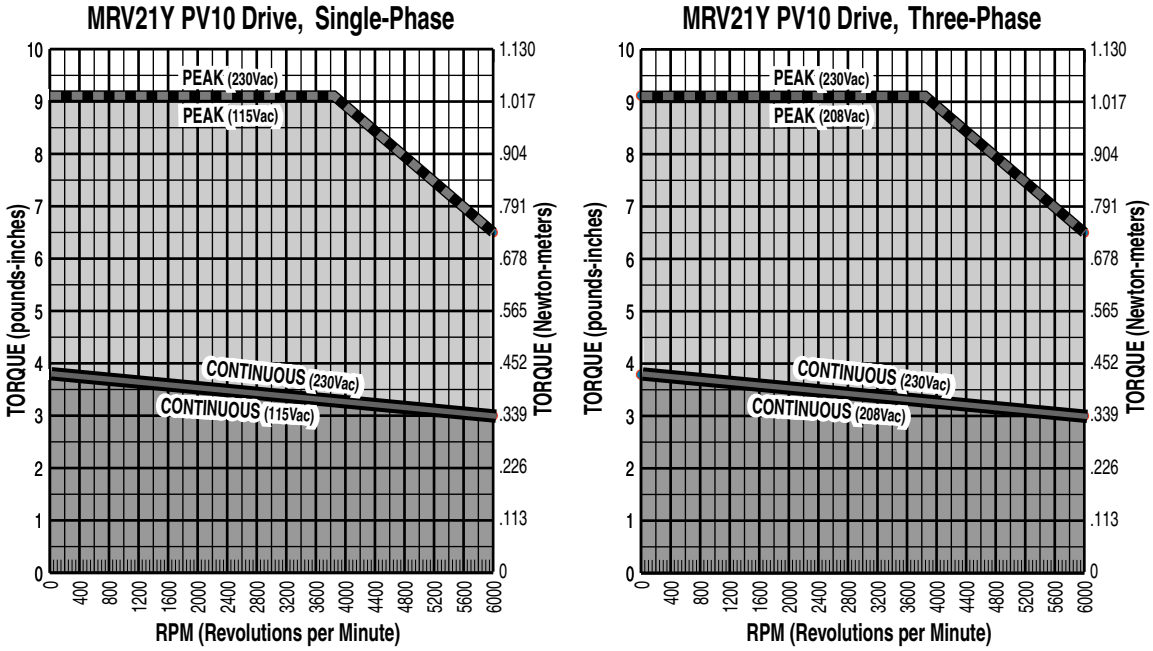


Figure C.2 - MRV 21Y PV10 Single-Phase, Three-Phase Drive

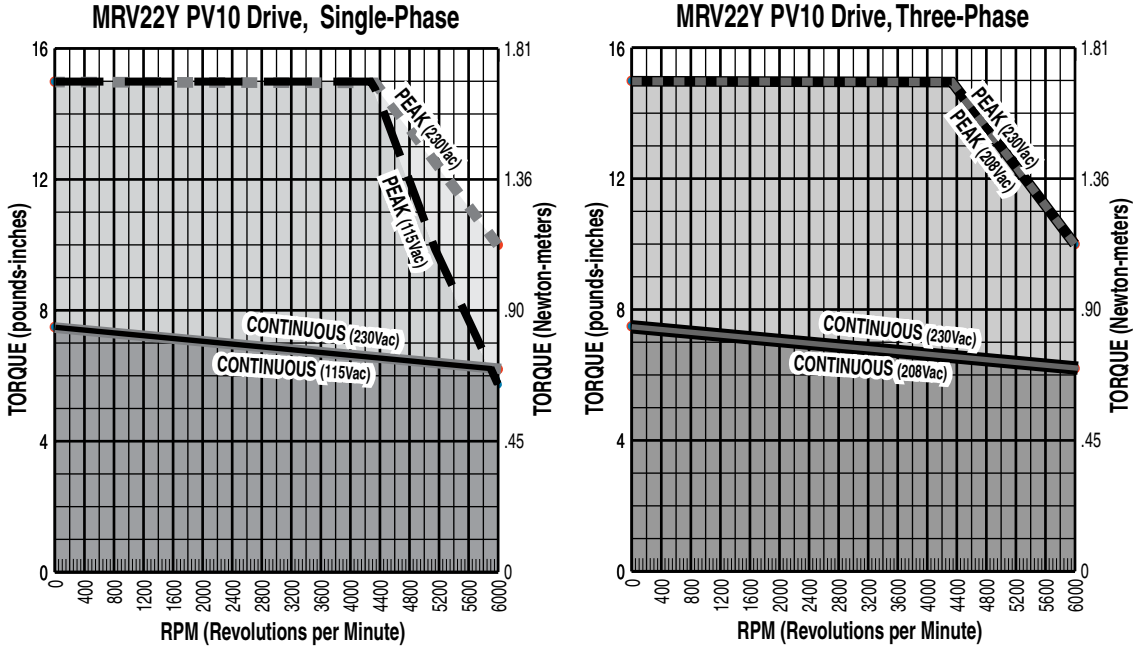


Figure C.3 - MRV 22Y PV10 Single-Phase, Three-Phase Drive

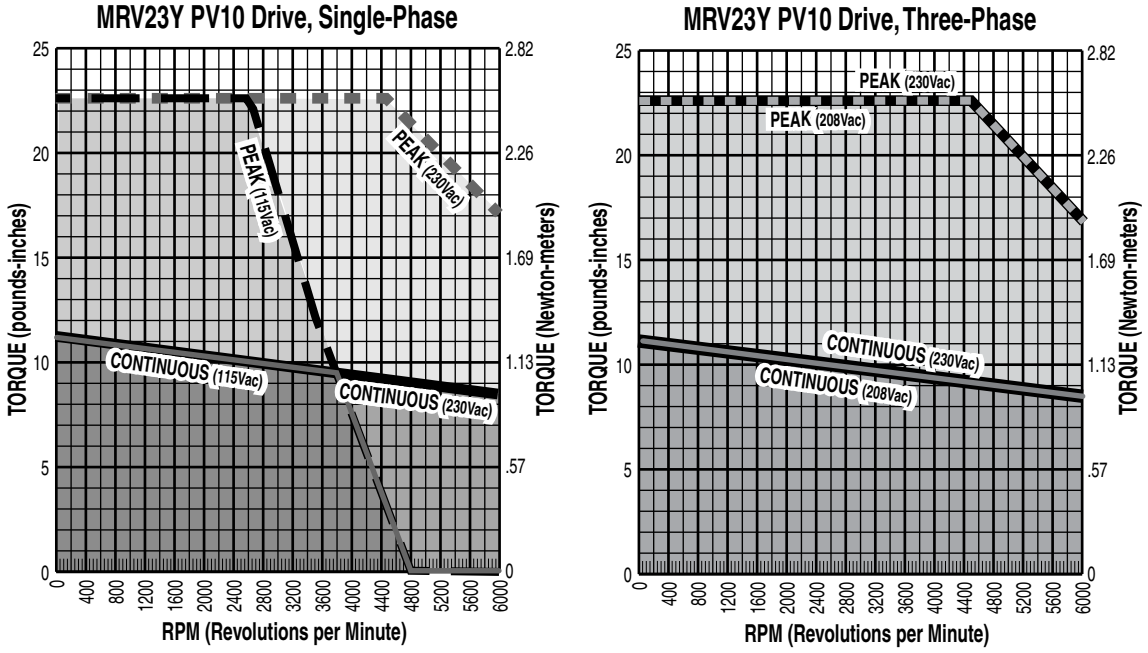


Figure C.4 - MRV 23Y PV10 Single-Phase, Three-Phase Drive

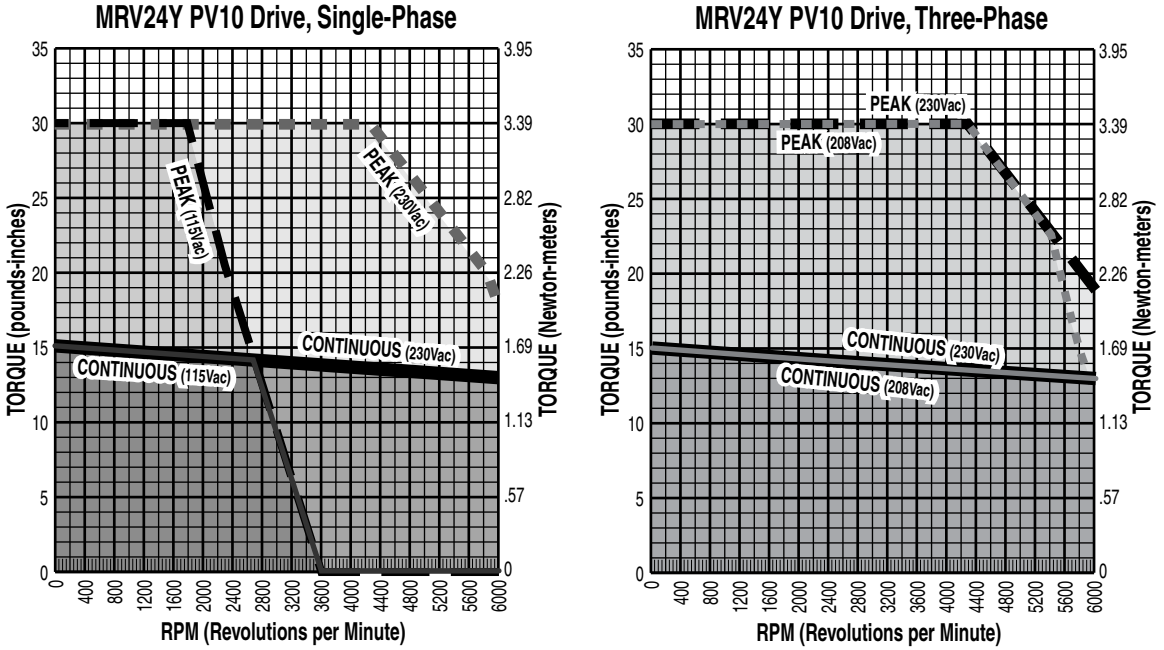


Figure C.5 - MRV 24Y PV10 Single-Phase, Three-Phase Drive

MRV Series Motor Drives (continued)

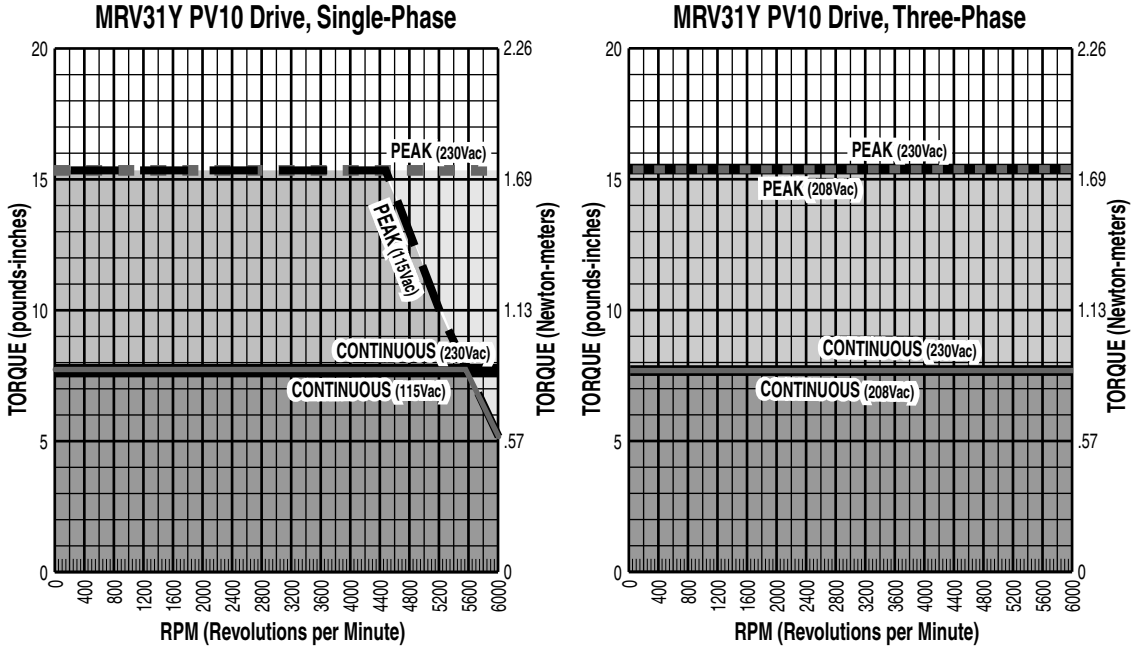


Figure C.6 - MRV 31Y PV10 Single-Phase, Three-Phase Drive

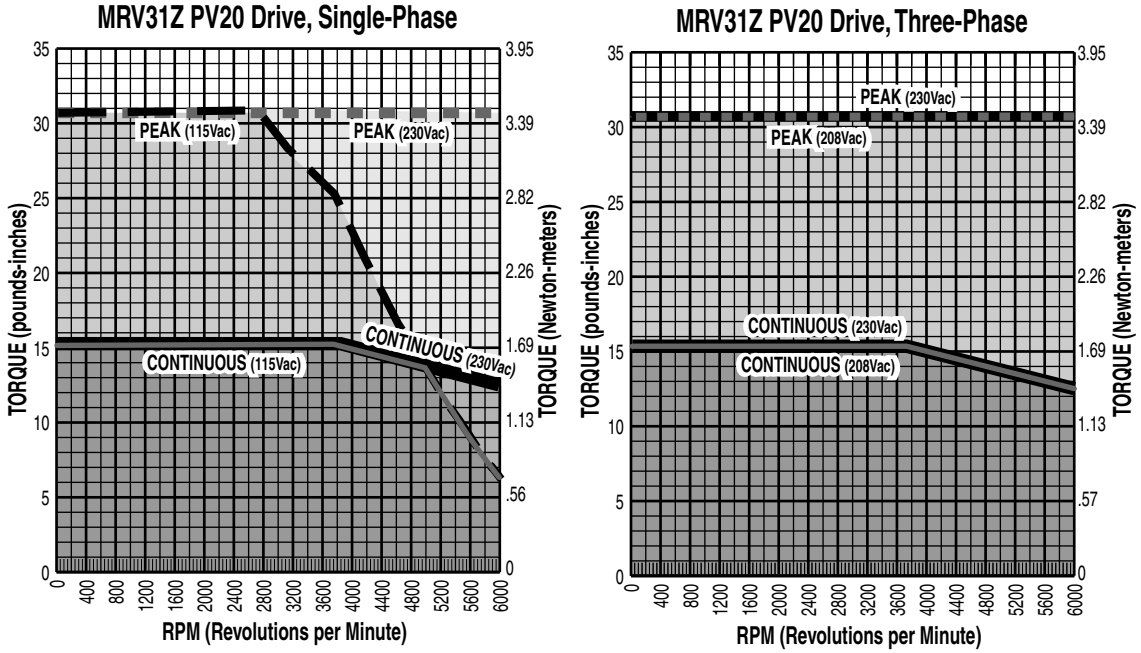


Figure C.7 - MRV 31Z PV20 Single-Phase, Three-Phase Drive

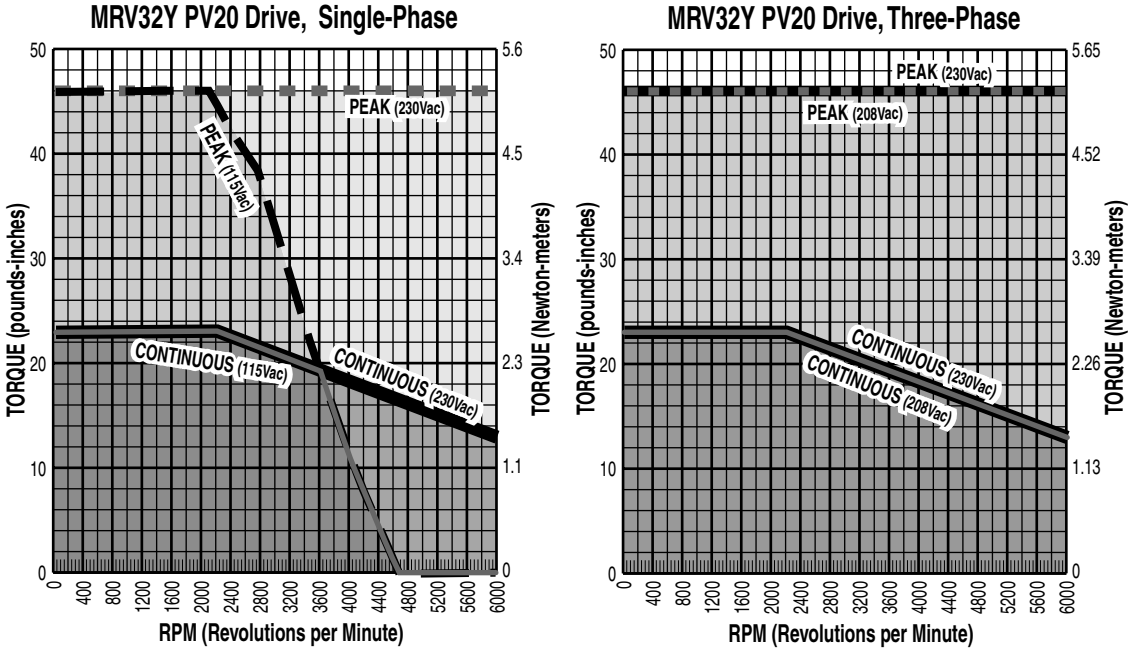


Figure C.8 - MRV 32Y, PV20 Single-Phase, Three-Phase Drive

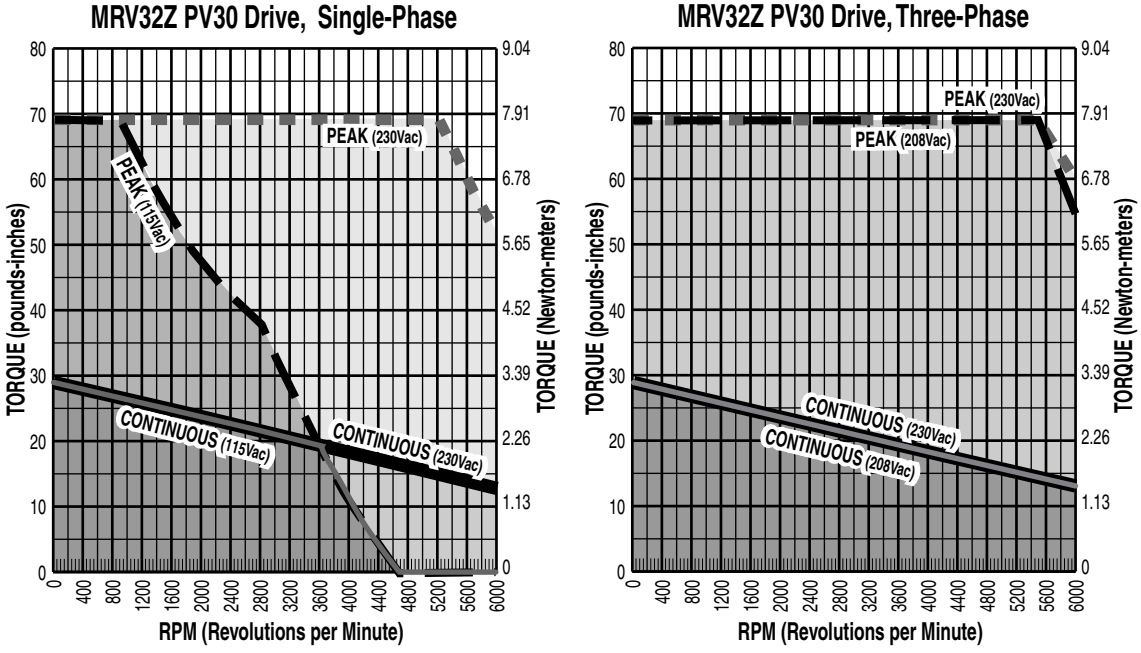


Figure C.9 - MRV 32Z PV30 Single-Phase, Three-Phase Drive

MRV Series Motor Drives (continued)

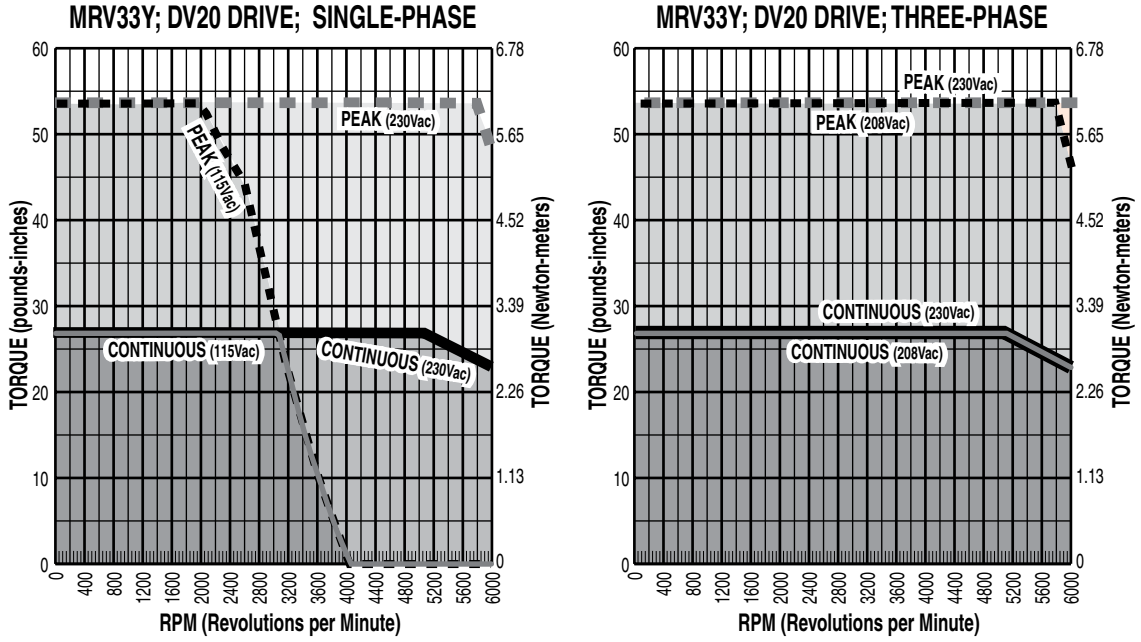


Figure C.10 - MRV 33Y PV10/20 Single-Phase, Three-Phase Drive

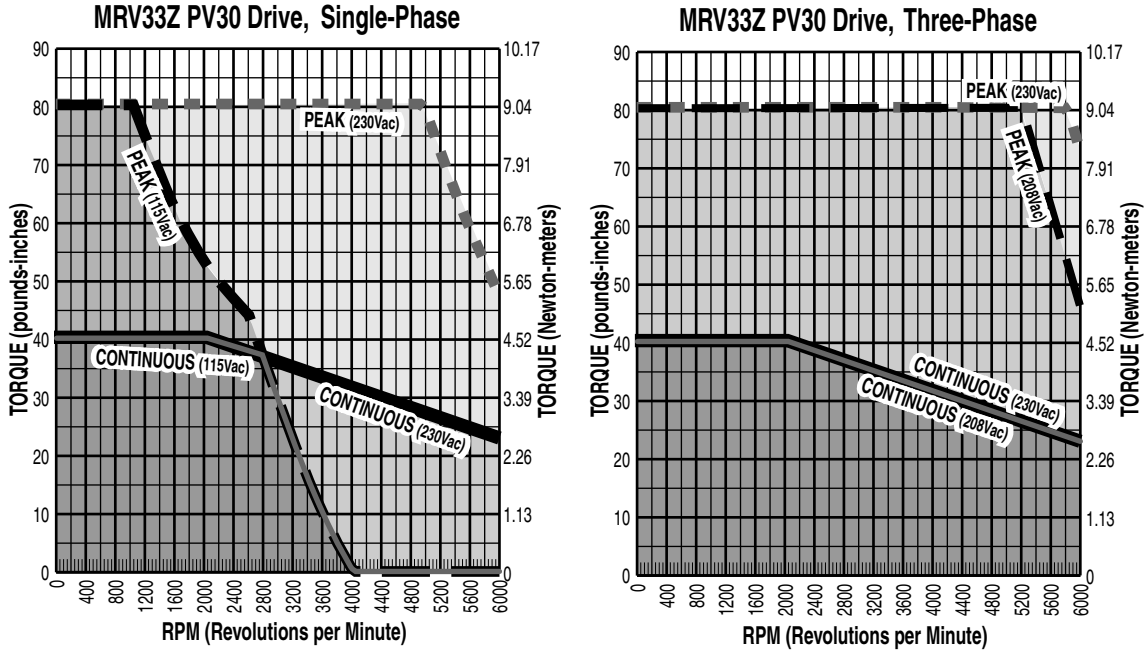


Figure C.11 - MRV 33Z PV30 Single-Phase, Three-Phase Drive

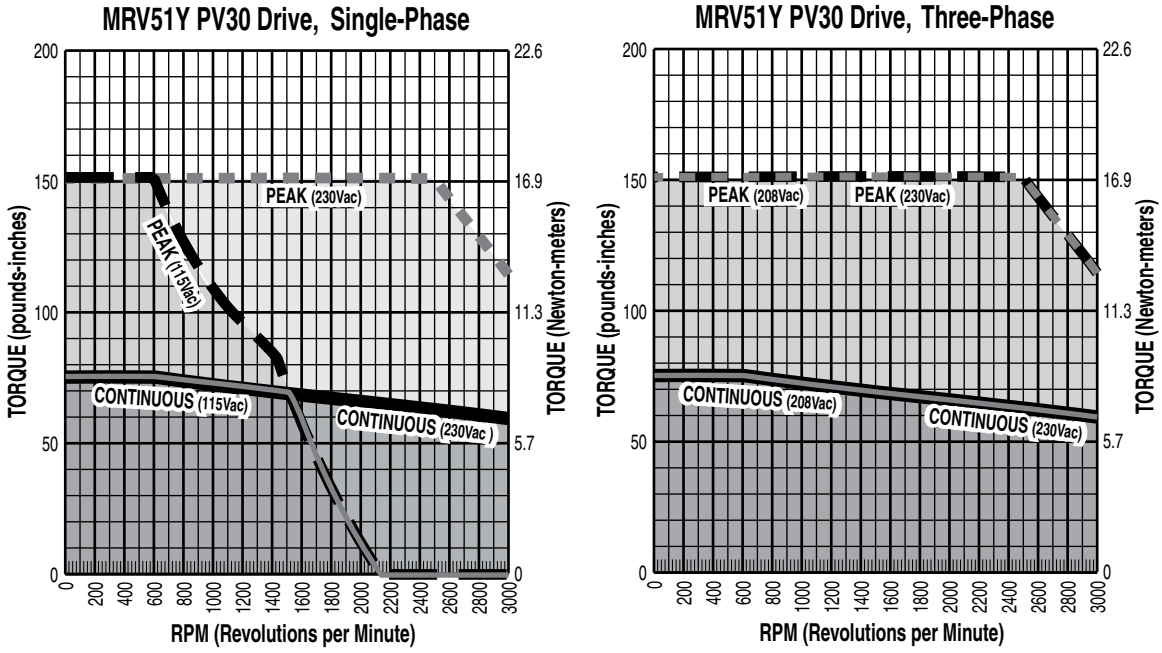


Figure C.12 - MRV 51Z PV30 Single-Phase, Three-Phase Phase Drive

This page intentionally left blank

Brushless MRV Motors

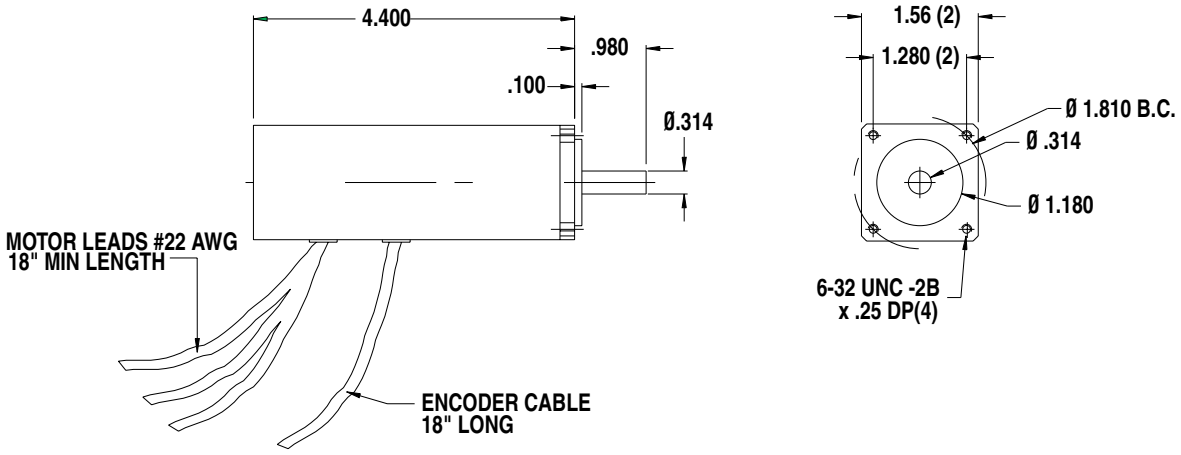


Figure D.1 - MRV 11 Motor

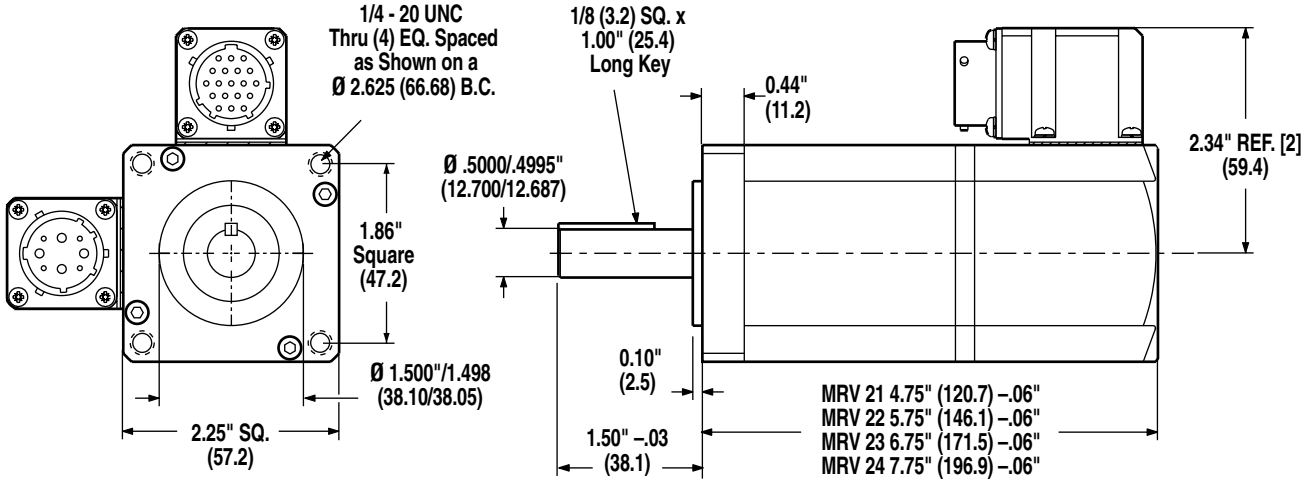


Figure D.2 - MRV 21/22/23/24 Motors

Brushless MRV Motors

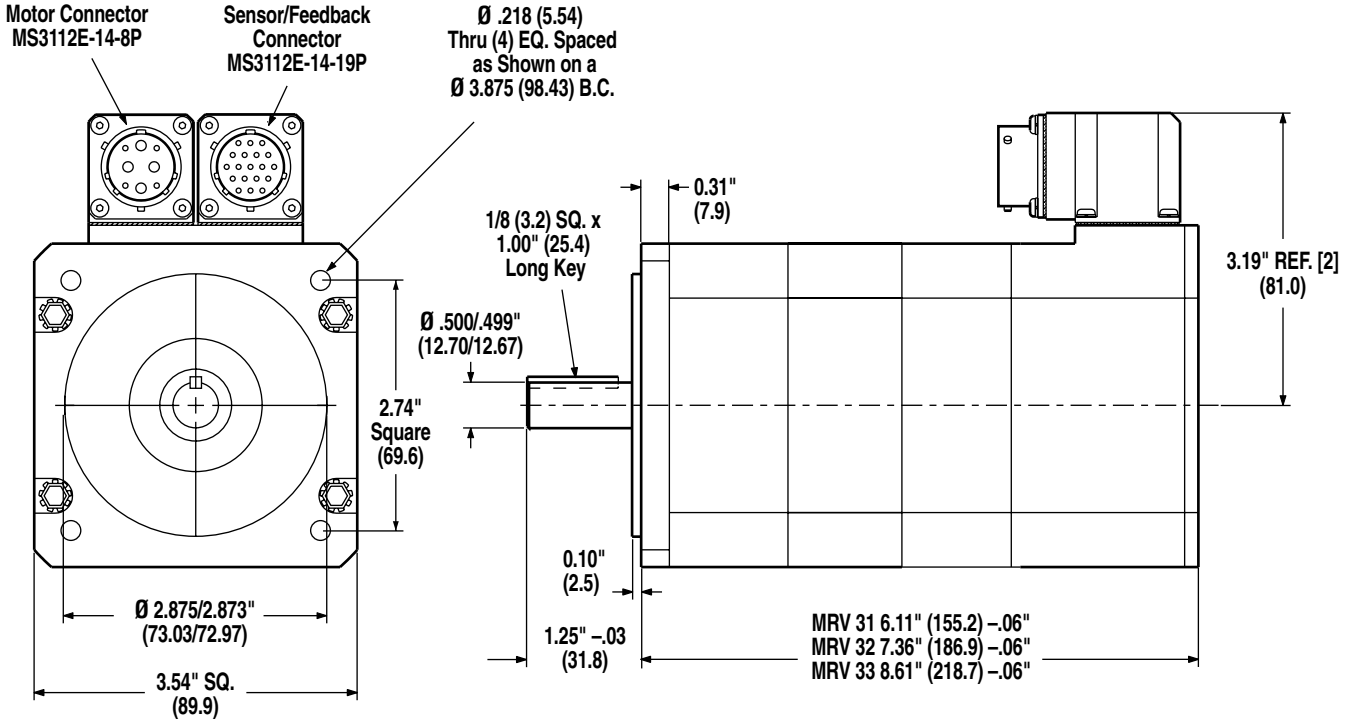


Figure D.3 - MRV 31/32/33 Motors

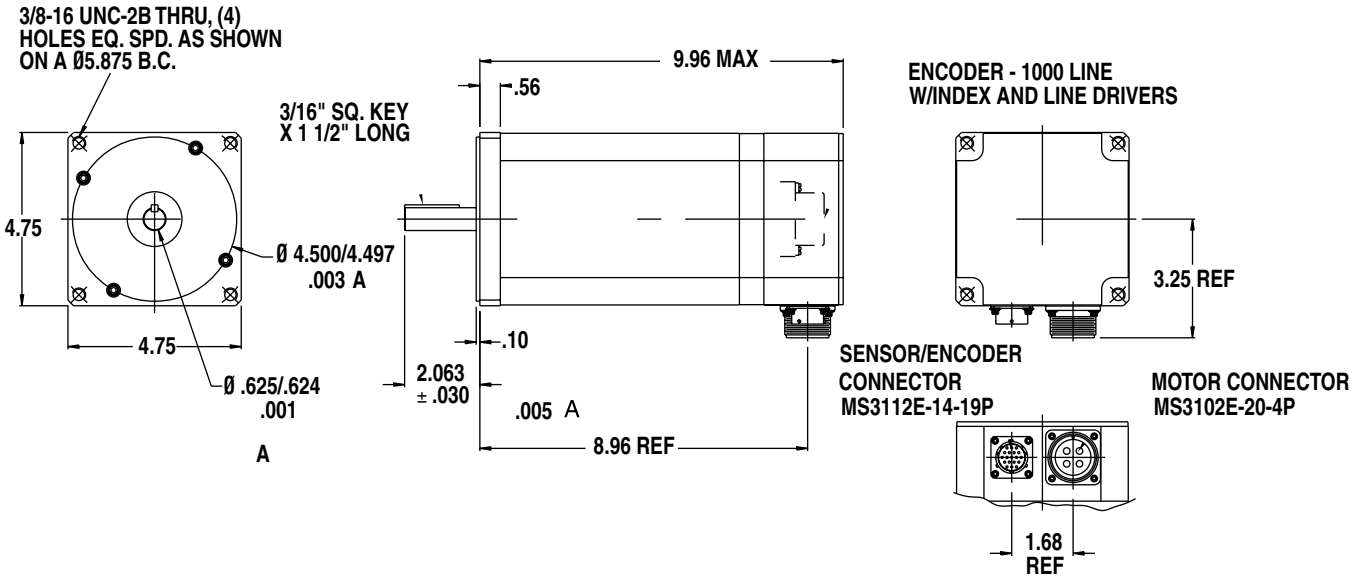


Figure D.4 - MRV 51 Motor

Warranty Information



The following product warranty and returned goods information summarizes the product warranty and return policy of Tolomatic. A copy of the formal Returned Goods and Field Service Policy is available upon request.

Defective Equipment

If the user is unable to correct a problem, and the product is defective, the unit may be returned to any distributor of Tolomatic products for repair or replacement.

There are no field serviceable parts in the drive. If the drive fails, the unit should be returned to the factory for repair or replacement. To save unnecessary work and repair charges, please verify that the drive unit is defective before returning it for repair.

Axiom drives are warranted against defects in material and assembly. Limitations to warranty coverage are detailed in Terms/Conditions of Sale: items #10 Return of Product and #11 Warranty. Products that have been modified by the customer, physically mishandled, or otherwise abused through incorrect wiring, inappropriate settings, and so on, are exempt from the warranty plan.

Return Procedure

To ensure accurate processing and prompt return of any Tolomatic product, the following procedure must be followed:

1. Call the nearest distributor of Tolomatic products to obtain a Return Material Authorization (RMA) number. Do not return the drive or any other equipment without a valid RMA number. Returns lacking a valid RMA number will not be accepted and will be returned to the sender.

2. Pack the drive in the original shipping carton. Tolomatic is not responsible or liable for damage resulting from improper packaging or shipment.

Repaired units are shipped via UPS Ground delivery. If another method of shipping is desired, please indicate this when requesting the RMA number and include this information with the returned unit.

Product Support

Tolomatic product support is available over the phone. When you call, you should be at your computer and have the hardware and software manuals at hand. Be prepared to give the following information:

- The version numbers of the hardware and software products.
- The type of hardware that you are using.
- The fault indicators and the exact wording of any messages that appears on your screen.
- How you have tried to solve the problem.

Distributor & Representative Network

Tolomatic has a wide network of distributors that are trained to support our products. If you encounter problems, call the distributor or representative where you purchased the product before contacting the factory.

Application Engineers & Field Service

In the United States, you can reach the Tolomatic factory based support staff by phone Monday through Friday at 1-800-328-2174. The applications engineers can assist you with programming difficulties as well as ideas for how to approach your automation task. Should your problem require on-site assistance, field service is available.

From outside the United States, call 763-478-8000 using the appropriate international access code.

© Copyright 2009
Tolomatic, Incorporated. All rights reserved.
Axiom, Tolomatic and Excellence In Motion are registered trademarks of Tolomatic Incorporated. All other products or brand names are trademarks of their respective holders.

200909231453

Tolomatic
EXCELLENCE IN MOTION®

3800 County Road 116
Hamel, MN 55340
763.478.8000 Telephone
763.478.8080 Fax
1.800.328.2174 Toll Free
http://www.tolomatic.com

3600-4628_06

Artisan Technology Group is an independent supplier of quality pre-owned equipment

Gold-standard solutions

Extend the life of your critical industrial, commercial, and military systems with our superior service and support.

We buy equipment

Planning to upgrade your current equipment? Have surplus equipment taking up shelf space? We'll give it a new home.

Learn more!

Visit us at **artisantg.com** for more info on price quotes, drivers, technical specifications, manuals, and documentation.

Artisan Scientific Corporation dba Artisan Technology Group is not an affiliate, representative, or authorized distributor for any manufacturer listed herein.

We're here to make your life easier. How can we help you today?

(217) 352-9330 | sales@artisantg.com | artisantg.com

ARTISAN® TECHNOLOGY GROUP