Axidyne®

ELECTRIC LINEAR MOTION PRODUCTS

SSD Servo Drives and Motors

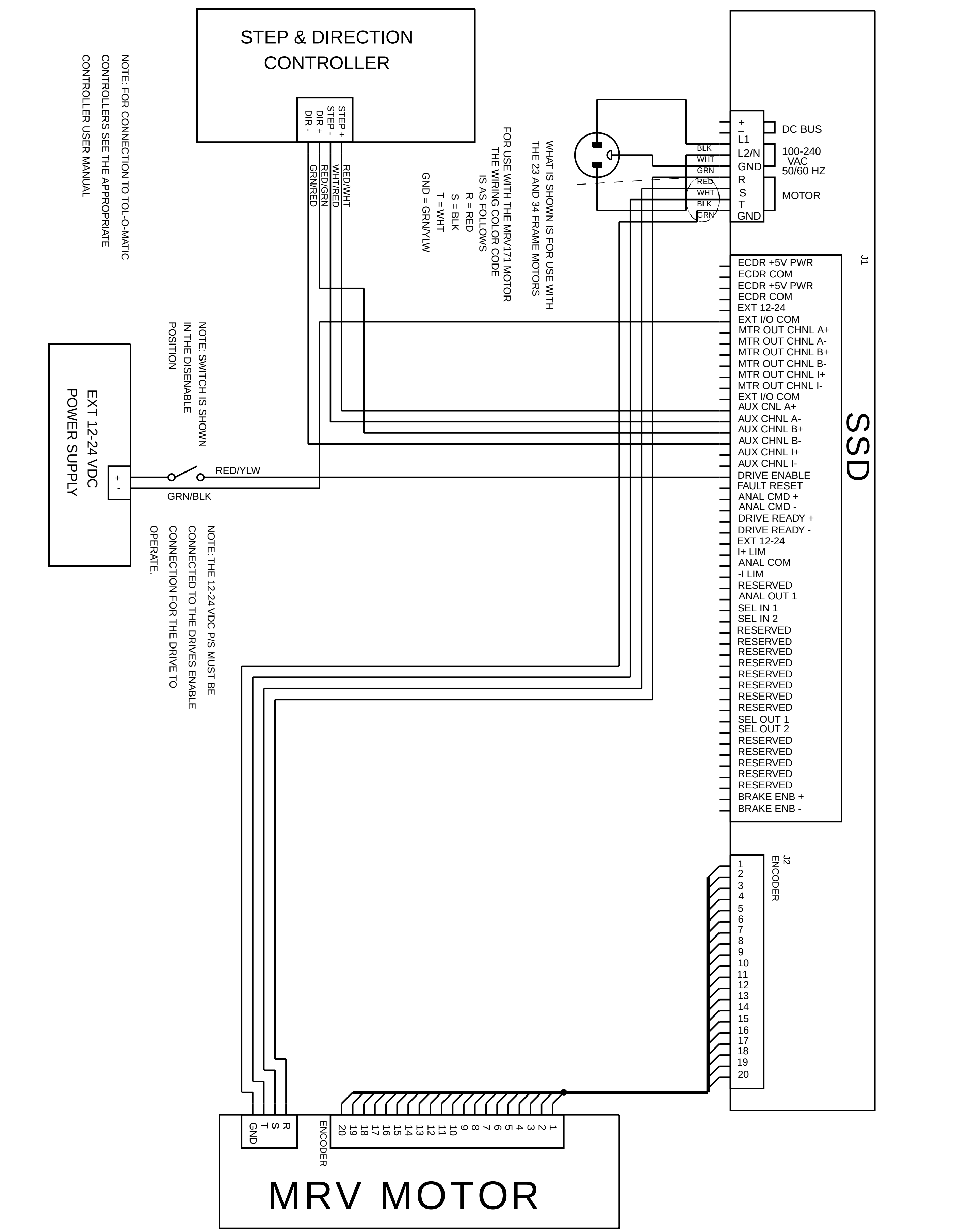
Installation Manual

TOL-O-MATIC, INC

Excellence in Motion®

3600-4062B

BASIC WIRING SCHEMATIC
CONNECTION FOR THE SSD



Product Notice

Use of Axidyne SSD Servo Line Drives

SSD drives are intended for use as transistorized electronic amplifiers powering brushless servo motors in machinery. As such, they must be part of a controlled system that includes a controlling device. They are not intended to independently control a motor. Instructions in the motor and control system manuals must be observed; this document does not replace those instructions.

Unless specified otherwise, SSD Line drives are intended for use in a normal industrial environment, installed in a suitable electrical cabinet without exposure to excessive or corrosive moisture or abnormal ambient temperatures. The exact operating conditions may be established by referring to the data for the drive. The connection and control of drives in machinery is a skilled operation, disassembly or repair must not be attempted. In the event that a drive fails to operate correctly, contact the place of purchase for return instructions.

Safety Notes

There are some possible hazards associated with the use of drives. The following precautions should be observed. Specific Warnings and Cautions are listed in the Preface to the manual.

Installation and Maintenance: Installation and maintenance or replacement must be carried out by suitably qualified service personnel, paying particular attention to possible electrical and mechanical hazards.

Weight: Large drives are heavy, the center of gravity may be offset and removable covers shield internal components. When handling, take appropriate precautions and lift the equipment using permanent, fixed surfaces, such as the base; avoid lifting the device using protective cover shields that may be loose. Beware of sharp edges; use protective gloves when handling such assemblies.

Flying Leads and Loose Cables: Ensure that flying leads or loose cables are suitably restrained, to prevent snagging or entanglement, or are disconnected before carrying drives with such leads or cables.

Generation: If a motor is driven mechanically, it may generate hazardous voltages which are conducted from its power input terminals to the drive. The power connector must be suitably guarded to prevent a possible shock hazard.

Loose Drives: When running an unmounted drive, ensure that the cooling fan is adequately guarded and sufficient airflow is provided around the drive to ensure adequate cooling. The mounting surface of the drive is a heat sink and its surface temperature may increase when the drive is operating. If a motor is connected to the drive, remove the key which otherwise could fly out and restrain the motor before applying power to the drive.

Damaged Cables: Damage to cables or connectors may cause an electrical hazard. Ensure there is no damage before energizing the system.

Supply: Drives connect to a permanent main power source; not a portable power source. Suitable fusing and circuit protection devices are required. Consult the instructions and adhere to local and national regulations before connecting and energizing the drive.

Safety Logic Signals: Logic signals from the drive are interruptible signals; they are removed when power is removed from the drive. Consult the manual for information on auxiliary power connections that may be employed when these signals are used for safety purposes.

Safety Requirements: The safe incorporation of Tol-O-Matic SSD products into a machine system is the responsibility of the machine designer, who should comply with the local safety requirements at the place where the machine is to be used. In Europe this is likely to be the Machinery Directive, the ElectroMagnetic Compatibility Directive and the Low Voltage Directive. In the United States this is likely to be the National Electrical Code.

Mechanical Connection: Drives must be installed inside an electrical cabinet that provides environmental controls and protection. Installation information for the drive is provided in the manual and list the minimum installation requirements for the drive are provided in the manual. Motors and controlling devices that connect to the drive should have specifications that complement the capabilities of the drive.

Motors: Motors controlled by the drive should only connect to the drive; they should not connect directly to the AC line. Use of custom motors requires the entering of a valid thermal time constant, otherwise the motor overload protection will not function properly.

WARNING! A SEVERE MOTOR JUMP WILL OCCUR IF THE DRIVE IS ENABLED WITH A LARGE ERROR BETWEEN THE POSITION COMMANDED BY THE CONTROLLER AND THE ACTUAL MOTOR POSITION.
To prevent this from occurring, make sure the SSD drive and controller are energized with the drive in the disabled position. Before sending any commands from the controller to the SSD drive, make sure the SSD drive is enabled. When powering units down, disable the SSD drive prior to powering down the controller and the drive. If the actuator is to be moved while the drive and controller are powered up manual position correction, disable the SSD drive, manually position the actuator, and then reset or re-zero the controller prior to re-enabling the SSD drive.

Preface

This manual provides a step-by-step approach to building a servo system using an SSD drive. The manual is divided into chapters that cover specific phases of the system design process; from ordering components that will complement the performance of the SSD drive, to receiving, installing and verifying the drive's functionality.

Chapters in the manual include:

- ***Safety***
- ***Selecting Other System Components***
- ***Tol-O-Motion SSD Installation***
- ***Unpacking, Inspecting and Storing***
- ***Installation***
- ***Interfaces***
- ***Application and Configuration Examples***
- ***Tuning***
- ***Status Display***
- ***Maintenance and Troubleshooting***
- ***Options and Accessories***
- ***Cable Diagrams, Schematics, and Examples***
- ***Electromagnetic Compatibility Guidelines for Machine Design***
- ***Specifications***
- ***Warranty***

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About this Manual

Introduction

This manual provides instructions on how to setup and connect the SSD drive to a controlling device and a motor. An SSD drive may operate in one of several different functional modes. The hardware connections necessary to run the drive are detailed in this manual and basic software instructions are provided for common set up procedures. For detailed explanation of software instructions, refer to the comprehensive on-line instructions available in the *Tol-O-Motion SSD Software.*

The instructions in this manual detail how to install your SSD drive using *Tol-O-Motion SSD* software with a personal computer. If using the serial Host Command Language to control the drive, comprehensive instructions are accessible through the Host Mode icon, ?, displayed in the *Tol-O-Motion SSD* window.

This manual is organized into numbered chapters and alphabetical appendices. The topics covered in each chapter and section are briefly described. Typographical conventions, warnings and cautions specific to the drive, and complementary manuals are also described.

Overview
Briefly reviews major features of the SSD5, SSD10 and SSD20 drives.

Features
Lists specific features of the SSD drives and provides a complete list of the pin-outs and signals associated with each pin.

Safety
Lists general safety requirements that must be followed when installing or servicing the drive.

Selecting Other System Components
Identifies motors and signal types that are compatible with SSD drives.

Tol-O-Motion SSD Software Installation
Provides snapshot instructions for installing, accessing and exiting SSD software.

Unpacking, Inspecting and Storing
Lists what should be included with the SSD drive and provides

instructions on how to perform a basic functional test before installing or storing the drive.

Installation

Provides instructions on how to physically install the SSD drive.

Interfaces

Each signal or set of signals is identified by:
- Power requirements for driving the signal.
- Functions performed by the signal.
- Specifications, including ON and OFF states.
- Schematic depictions of the circuit design for each signal type.

The signals are grouped by the connector on which they are present.

- *J1 - Controller* Diagrams depict the cable connections necessary for common interfaces.
- *J2 - Encoder* Provides comprehensive information about the encoder signals, Hall Effect switches and thermostat connections available through this connector.
- *J3 - Serial Port* Diagrams and instructions detail how to communicate with a drive using RS-232 communications.
- *Power Connections* Provides information on making motor power, DC bus and AC power connections.

Application and Configuration Examples

Describes the hardware and software setup necessary to install the drive as one of the following types operating in a specific mode:

Command Type	*Mode*
• Analog Control	Velocity or torque mode
• Preset Controller	Velocity or torque mode
• Position Follower (Master Encoder)	Velocity mode
• Position Follower (Step/Direction)	Velocity mode
• Position Follower (Step Up/Step Down)	Velocity mode

Tuning

Provides instructions on how to tune a drive and motor combination using the autotuning or manual tuning features in *Tol-O-Motion SSD* Software.

Status Display

Discusses the Status LED indicator on the front panel. Operating or Error Messages accessible through a PC are explained.

Maintenance and Troubleshooting

Describes the minimal maintenance necessary with the SSD drives and provides a comprehensive troubleshooting chart of potential problems and their solutions.

Options and Accessories

Lists the optional equipment available for the SSD drives. Schematics and cabling examples are provided.

Specifications

Details the design and operational specifications for the SSD drives in a tabular format.

Warranty

Provides a synopsis of the warranty coverage and how to obtain warranty assistance.

Product Support

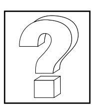
Describes the product assistance available, and lists telephone numbers for product assistance and additional on-line information.

Additional Instructions and Manuals

HOST COMMANDS AND TOL-O-MOTION SSD SOFTWARE

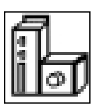
All SSD drives are setup through serial ***Host Commands.*** The drives may be configured directly through the Host Command language or indirectly through the *Tol-O-Motion SSD* software. *Tol-O-Motion SSD* is a graphical user interface that provides a visual method of accessing the Host Command language through the Microsoft Windows® operating system.

All documentation for both the Host Commands and *Tol-O-Motion SSD* software is on-line. Host Command information is available through a comprehensive on-line reference manual. *Tol-O-Motion SSD* information is available through ***Help*** menus. The on-line documents provide in-depth explanations of the Host Command language as well as the menus, windows and dialog boxes that make *Tol-O-Motion SSD* a convenient method for programming SSD drives.



To access the Host Command Reference:

- Click on the Host Command Reference icon (see left) in the *Tol-O-Motion SSD* program group.



To access Tol-O-Motion SSD Help

- Open *Tol-O-Motion SSD* by clicking on the Tol-O-Motion SSD icon, (see left), in the *Tol-O-Motion SSD* group, then press the **F1** key.

Symbols and Conventions

TYPOGRAPHICAL AND WORDING CONVENTIONS:

Drive Set Up — Text shown in this font and underlined indicates a ***Hot Key*** (keystroke combination) to quickly access a command.
Example: Choose Drive Set Up, indicates typing ALT+D followed by **ENTER** accesses this command.

Tol-O-Motion SSD Software — Text shown in this font is information to enter in a window or dialog box.

Example: Choose the icon SSD Software.

win Text in lower case bold is information to enter at a keyboard. To start Windows from the DOS prompt, type **win** and then press **ENTER.**

ALT+F4[a] Keys that should be pressed simultaneously are shown with a plus sign (+) between the key names. This example closes the active window.

ALT, F, N Keys that should be pressed in sequence are shown with a comma (,) between the key names. This example opens the FILE menu and then opens a new file.

Choose Indicates that an icon or a command is to be selected from a window or a command box. The instruction for accessing the command icon Drive Set Up states: Choose Drive Set Up.

Select Indicates that options are to be selected from a list. The instruction for accessing or entering information states: Select Drive Type and Motor Model from the respective list box.

Type Indicates that commands to enter in a command box. The instruction for loading *Tol-O-Motion SSD* software states: Type **a:setup** and then press **ENTER.**

NOTE: or **TIP:** Notes provide auxiliary information that is important to know. Tips provide hints or shortcuts that are useful.

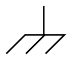
Examples: **NOTE:** This step assumes *Tol-O-Motion SSD* was installed in the *Tol-O-Motion SSD* directory during setup.

TIP: To disable the automatic Help display, choose the menu item Show Quick Start from the Help menu.

a.Microsoft® Windows™ reserves certain keystroke combinations to activate Windows commands.

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 an imminently hazardous situation which, if not avoided, will 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 minor or moderate injury. It may be used for situations that cause property damage only. It may also be used to alert against unsafe practices.

NOTICES

The following product safety notices appear where appropriate within this manual .

Danger Notices

DANGER! Only qualified electrical personnel familiar with the construction and operation of this equipment and the hazards involved should install, adjust, operate, or service this equipment. Read and understand this manual and other applicable manuals in their entirety before proceeding. Failure to observe this precaution could result in severe bodily injury or loss of life.

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

DANGER! Shielded power cables must be grounded at a minimum of one point for safety. Failure to ground a shielded power cable will result in potentially lethal voltages on the shield and anything connected to it.

DANGER! DC bus capacitors may retain hazardous voltages after input power has been removed, but will normally discharge in several seconds. Before working on the drive, measure the DC bus voltage to verify it has reached a safe level or 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.

Warning Notices

WARNING! Perform the initial power-up with the motor shaft disconnected from a load and the shaft key removed. Improper wiring or undiscovered shipping damage could result in undesired motor motion. Be prepared to remove power if excessive motion occurs.

WARNING! External shunt resistors connect directly to the power bus. For safety reasons, external shunt resistors must be enclosed.

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! A severe motor jump will occur if the drive is enabled with a large error between the position commanded by the controller and the actual motor position.

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

WARNING! When using a motor without a thermal sensor, a valid thermal time constant must be used. Otherwise the motor overload protection will not function properly.

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 disable the system in case of improper operation. Uncontrolled machine operation may result if this procedure is not followed. Failure to observe this precaution could result in severe bodily injury.

WARNING! The user must provide an external circuit to delay output of the analog signal when the signal is used to perform an operation. After reset both analog outputs may be in an indeterminate state for a short period before they stabilize at the setting stored in the Personality Module and selected in the Tol-O-Motion SSD I/O Configuration window. Failure to observe this precaution could result in severe bodily injury.

WARNING! High voltage may be present on the terminals of the drive. Remove power and disconnect the power cable before making or removing any connection.

WARNING! Motor power connectors are for assembly purposes only. They should not be connected or disconnected while the drive is powered.

Caution Notices

Caution! Do not tin (solder) the exposed leads on cables. Solder contracts over time and may loosen the connection.

Caution! Ensure that encoder signals are connected properly. Incorrect connection of encoder signals will result in improper rotor position 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.

Overview

The SSD drives use microcontrollers to digitally manage the current, velocity, and position. All system and application parameters are set in software, which ensures repeatability of all functions and prevents element drift.

A single unit fully encloses all electronics. An external transformer is not required on the power line. All connectors and indicators are accessible and clearly marked on the front panel.

SSD Microdrive Overview

DRIVE POWER RATINGS

Three power levels of SSD microdrives are available. All models have integral power supplies and are functionally equivalent. They differ only in output power and physical size:

- SSD5 with continuous output power of 500 Watts using a single phase power source.
- SSD10 with continuous output power of 1000 Watts using a single phase power source.
- SSD20 with continuous output power of 2000 Watts using a single phase power source.

The SSD drives, when combined with brushless servo motors, provide continuous torque up to 44 lb-in (5 Nm) and peak torque up to 140 lb-in (25 Nm).

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. Refer to *Options and Accessories* on page A-137 for optional equipment.

SSD Features

High Performance Microcontroller Technology

All digital current, velocity and position loop calculations as well as the motor commutation calculation are performed by a microcontroller.

IPM Technology

IPM (Intelligent Power Module) technology in the output stage provides a high frequency, digital **PWM** (Pulse Width Modulation) sine wave that controls the current loop, including overcurrent, short circuit and overtemperature protection.

Analog and Digital Interfaces

All SSD drives allow the user to select one of the following analog or digital command interfaces:

- **±10 Volt analog interface** - velocity or torque control
- **Presets (from one to eight binary inputs)** - torque or velocity control
- **Quadrature encoder digital interface** - electronic gearing position follower
- **Step/Direction digital interface** - position control
- **CW/CCW (step up/step down) interface** - position control

Encoder Control

A single, motor mounted encoder provides complete commutation information and velocity feedback. .

Encoder Output

A selectable output allows the encoder resolution to be specified for maximum performance without adding circuitry. Outputs are differential line drivers capable of dividing the motor encoder signal by a factor of 1, 2, 4 or 8.

Digital I/O

Digital I/O channels allow the user to program the drive to fit the specific application. Power for the I/O must be supplied by an external 12- 24 VDC power source. Selections include:

- Three selectable, optically isolated, active high inputs.
- Two dedicated, control (ENABLE and FAULT RESET), optically isolated, active high inputs.
- Two selectable, optically isolated and short circuit protected, active high outputs.
- Two dedicated (BRAKE and DRIVE READY), normally open relay outputs.

Analog I/O

A dedicated analog input provides current limiting capabilities, while the analog output can be customized to fit the application:

- One dedicated 0 - 10 Volt, analog input (EXTERNAL CURRENT LIMIT)
- One selectable, ±10 Volt analog output.

AC Input Power

SSD microdrives are powered directly from a main 100-240 VAC single phase line.

Personality Module

EEPROM (electrically erasable programmable read only memory) stores both motor and application specific settings and parameters for the drive.

Command Sources

SSD drives accept commands from a variety of sources through a serial port using either RS-232 or four-wire RS-485 communications. Command sources include:

- Personal computers
- Host computers
- Programmable Logic Controllers
- Motion controllers

Multiple Protection Circuits

Device and circuit protection, and diagnostic information is provided by:

- Bi-color single point LED
- Overtemperature, short circuit and overcurrent protection for the power output
- I^2T (power-time) protection for the motor and the power drive
- Bus Overvoltage
- Bus Undervoltage
- Overspeed
- Fault diagnostics
- Watchdog timers provide fail-safe operation.

Tol-O-Motion SSD Software

A Windows based software interface provides start-up selections. Tasks are organized for efficient set up, control and maintenance. Context sensitive, on-line help provides immediate assistance.

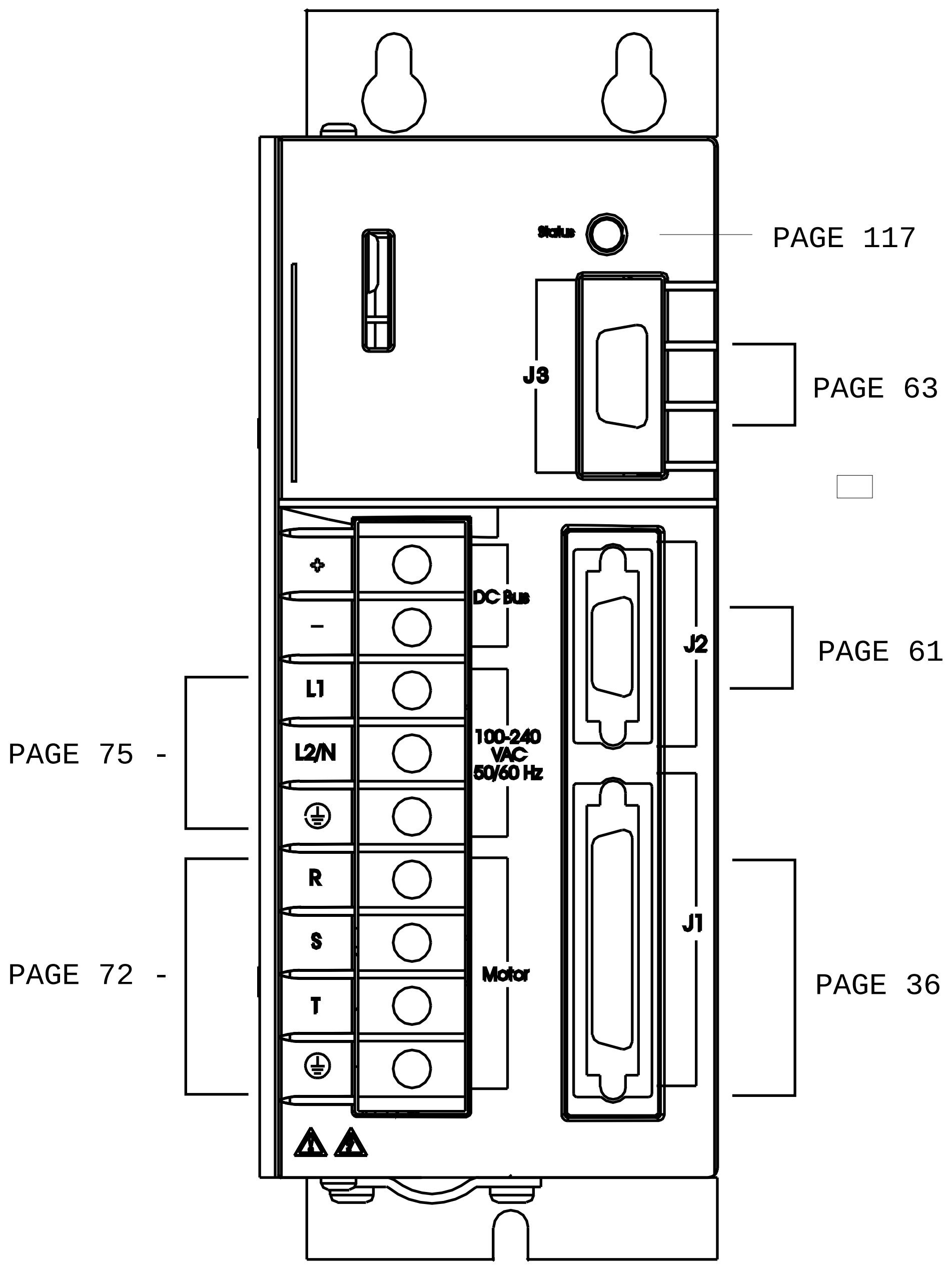
- Set up is simplified by a series of logically arranged set up screens.
- Files can be stored and printed for on-line or off-line modification, and on-site or off-site back-up.
- Diagnostic and set up tools make system integration easy.
- Critical information is available with complete on-line help.
- User defined velocity, acceleration, position and torque parameters.
- Tuning and diagnostics are aided with an on-screen dual channel digital oscilloscope.
- On-screen meters and software tools provide rapid debugging and measurement.

Communications

A serial port provides communications to the connected drive using either RS-232 or four-wire RS-485 communications. The serial interface allows the user to configure a drive using any PC or host computer that permits RS-232 or four-wire RS-485 communications.

Autotuning

Digital auto tuning allows easy setup. All adjustments are made in software, which immediately sets the servo system compensation parameters. This eliminates the time-consuming adjustments required by potentiometers.


Status
PAGE 117
J3
PAGE 63
DC Bus
J2
PAGE 61
L1
L2/N
100-240
VAC
50/60 Hz
PAGE 75 -
R
S
T
Motor
J1
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PAGE 36

	J3 - Serial Port	
1	RCV+	RS-485
2	RCV	RS-232
3	XMT	RS-232
4	XMT+	RS-485
5	COM	
6	reserved	
7	RCV-	RS-485
8	XMT-	RS-485
9	reserved	

	J2 - Encoder
1	Encoder + 5V PWR
2	Encoder VCOM
3	Encoder + 5V PWR
4	Encoder VCOM
5	reserved
6	reserved
7	Mtr. Encdr Input Chnl A+
8	Mtr. Encdr Input Chnl A-
9	Mtr. Encdr Input Chnl B+
10	Mtr. Encdr Input Chnl B-
11	Mtr. Encdr Input Chnl I+
12	Mtr. Encdr Input Chnl I-
13	Hall A
14	Hall B
15	Hall C
16	Absolute Position
17	reserved
18	reserved
19	Thermal Switch +
20	Thermal Switch -

	J1 - Controller
1	Encoder + 5VDC PWR
2	Encoder COM
3	Encoder + 5VDC PWR
4	Encoder COM
5	External 12-24
6	External I/O COM
7	Mtr. Output Chnl A+
8	Mtr. Output Chnl A-
9	Mtr. Output Chnl B+
10	Mtr. Output Chnl B-
11	Mtr. Output Chnl I+
12	Mtr. Output Chnl I-
13	External I/O COM
14	Auxiliary Chnl A+
15	Auxiliary Chnl A-
16	Auxiliary Chnl B+
17	Auxiliary Chnl B-
18	Auxiliary Chnl I+
19	Auxiliary Chnl I-
20	Drive Enable
21	Fault Reset
22	Analog Cmnd+
23	Analog Cmnd-
24	Drive Ready+
25	Drive Ready-
26	External 12-24
27	I+ limit
28	Analog COM
29	-I Limit
30	reserved
31	Analog Output 1
32	Selectable Input 1
33	Selectable Input 2
34	Selectable Input 3
35	reserved
36	reserved
37	reserved
38	reserved
39	reserved
40	reserved
41	reserved
42	Selectable Output 1
43	Selectable Output 2
44	reserved
45	reserved
46	reserved
47	reserved
48	reserved
49	Brake Enable +
50	Brake Enable -

Safety 1

Installing and Using the SSD Drive

Read the complete manual before attempting to install or operate the drive. By reading the manual you will become familiar with practices and procedures that allow you to operate the drive safely and effectively.

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, therefore 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 are:

- 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, but will normally discharge in several seconds. Before working on the drive, measure the DC bus voltage to verify it has reached a safe level or 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.

Voltage potentials for the internal drive circuitry vary from 325 Volts above to 325 Volts below earth ground for a 240 Volt input. Voltages can reach 450 VDC within the drive. 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 drive after power is removed.

Your Responsibilities

As the user or person installing this drive, you are responsible for determining the suitability of the product for the intended application. Tol-O-Matic 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 notes and established safety practices, with 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 Aiders.

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 distributor of Tol-O-Matic products.

Safety Guidelines

Electrical shock and fire hazards are 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 suitable qualified personnel.

Mechanical hazards are associated with potentially uncontrolled movement of the motor shaft. If this imposes a risk in the machine, then appropriate precautions must be made to electrically disconnect the motor from the drive 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 drive from its power source and measuring the DC bus voltage to verify it has reached a safe level or by waiting for the time indicated in the warning on the front of the drive 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 drive being converted to mechanical energy. Electrical energy may be stored in drive for the time indicated in the warning on the front of the drive.

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 the covers in place and the protective conductor connected.
- Do not operate the unit without connecting the motor conductor to the appropriate terminal on the drive.
- Always remove power before making or removing any connection on the unit.
- Before removing the cover of the unit, shut off the main power and measure the DC bus voltage to verify it has reached a safe level or wait for the time as indicated on the front of the drive.
- 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 DC bus and shunt terminals. High voltage is present when power is applied to the drive.

- Never connect the DC- (negative) terminal to earth ground, the drive requires a floating DC bus.
- Do not use the ENABLE input as a safety shutdown. Always remove power to a drive before maintaining or repairing the unit.
- Motors without thermal protection devices require a valid thermal time constant. Otherwise the motor overload protection will not function properly.

Unpacking, Inspecting & Storing 2

This chapter describes the steps which ensure that the drive will function as specified. The steps include:

- Unpacking the SSD drive
- Inspecting the drive for shipping damage
- Testing the basic functionality of the drive
- Guidelines for storing the drive.

Unpacking the Drive

1. Remove the SSD drive from the shipping carton and remove all packing materials from the unit. The materials and carton may be retained for storage or shipment of the drive.

2. Check all items against the packing list. A label located on the side of the unit identifies:
    - model number
    - part number
    - serial number
    - manufacturing date code.

Inspection Procedure

To protect the investment and ensure applicable warranty rights, Tol-O-Matic recommends the following steps be performed upon receipt of the unit:

- Inspect the unit for any physical damage that may have been sustained during shipment.
- Perform the *Inspections Test* to verify the functionality of the unit.

If damage is detected, either concealed or obvious, contact the purchasing agent to make a claim with the shipper. If degraded performance is detected when testing the unit, contact the nearest distributor of Tol-O-Matic products to obtain a Return Material Authorization (RMA). Do this as soon as possible after receipt of the unit.

The *Warranty* section on page F-161 summarizes the period and conditions under which SSD drives are warranted against defects.

Testing the Unit

Drives are burned-in and individually tested before they leave the factory. However, damage may occur during shipping. Perform the procedures below to ensure the SSD drive is operational and undamaged.

Abbreviated directions for connecting the drive to a motor and a PC are provided. The test requires:

- Approximately 20 minutes to complete
- A motor with appropriate power and encoder cables
- A PC with the *Tol-O-Motion SSD* software package installed
- An RS-232 communications cable
- An external 24 VDC power supply
- A single phase 100-240 VAC, 50/60 Hz power source. Standard wall outlet power is suitable for verification testing of SSD drives.
- A test cable constructed from two normally open switches, several pieces of 1.5 mm2 (16 AWG) wire and a mating connector. Connectors are listed in *Mating Connectors* on page A-138. The Appendix *Options and Accessories* on page A-137 lists the cables.

During the test, power is removed several times. Always measure the DC Bus voltage to verify the bus capacitors are fully discharged, or wait for the time indicated in the warning on the front of the drive. The bus capacitors must be fully discharged for the subsequent steps to be valid.

If problems are encountered during this procedure, refer to *Troubleshooting* on page 11-121 of this manual, review other appropriate sections in this manual, or call the local distributor of Tol-O-Matic products.

WARNING! Perform the initial power-up with the motor shaft disconnected from a load and the shaft key removed. Improper wiring or undiscovered shipping damage could result in undesired motor motion. Be prepared to remove power if excessive motion occurs.

Hardware setup

Make the connections described below and shown in Figure 2.1.

1. Connect an RS-232 cable between the serial port on the PC and the J3 connector on the SSD drive (see *Options and Accessories*, page A-137.)

2. Connect a Motor/Feedback cable from the motor to the J2 connector on the SSD.

3. Connect a jumper wire with a toggle switch between J1-20 (ENABLE) and J1-26 (12-24VDC). This cable provides manual control for enabling or disabling the SSD drive. Figure 2.1 shows the jumper, including its normally open toggle switch.

4. Connect an external 12-24 VDC power supply to J1-5 and J1-6, or J1-26 and J1-13.

5. Connect a Power Cable between an external 100/240 VAC, 50/60 Hz power source and the L1, L2/N and (GND) connections.

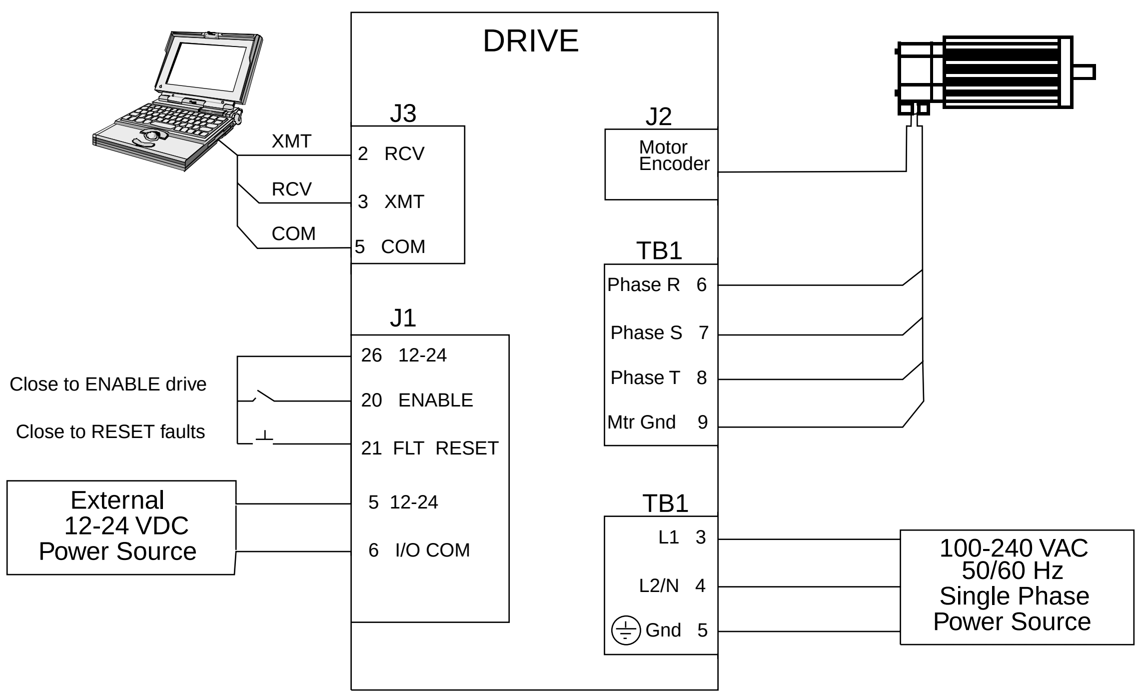


Figure 2.1 Host Mode Connection Diagram

Drive Checkout Test

WARNING! Be prepared to disable the drive or remove input power if excessive motor motion occurs while performing the following steps.

This test sequentially verifies that:
- Drive power wiring is correct and start-up logic is functioning.
- The drive and motor are correctly wired
- Drive serial communications are operational

Before beginning the *Initial Power-up*, please check the following:
- All wiring and mounting to verify correct installation
- Input voltages to ensure they do not exceed specifications for the drive or motor.

INITIAL POWER-UP

1. Verify the AC power is within specifications at the terminal strip.
2. Switch the AC Power to ON and verify the Status LED is green.
3. Switch the power to OFF and wait until the DC Bus Voltage is below 30 Volts.
4. Connect the motor windings to:
   - R (TB1-6)for the Phase R winding
   - S (TB1-7) for the Phase S winding
   - T (TB1-8) for the Phase T winding
   - ⏚ for the Ground connection.
5. If a brake motor is being used for the test, connect the brake relay:
   - Refer to page 6-43
6. Switch AC Power ON again and verify the STATUS LED is green.
7. Switch the power OFF and wait until the DC Bus Voltage is below 30 Volts.

COMMUNICATIONS VERIFICATION

8. Start *Tol-O-Motion SSD* on the PC.

9. Close any windows that are open in *Tol-O-Motion SSD*.

10. Select **P**C setup from the **C**ommunications menu in *Tol-O-Motion SSD*.

11. Verify the communication port settings match those of the drive, then select OK. Factory default drive settings are:
    - Baud Rate: 9600
    - Data Bits: 8
    - Parity: None
    - Stop Bits: 1
    - Serial Port: COM1

    Assignment of communications ports on PCs varies between manufacturers. The COM port setting for the drive and PC must match. Refer to *Troubleshooting* on page 11-121 if communication problems are encountered.

12. Switch AC power ON.

13. Select **R**ead Drive Parameters from the **C**ommunications menu in *Tol-O-Motion SSD*.

14. Select OK in the Drive Select dialog box. A dialog box indicating that the PC is reading drive parameters should appear.

    If this dialog box does not appear, a message appears advising the user to check the COM settings and the communication cable. If necessary, refer to *Troubleshooting* on page 11-121 for instructions on how to perform these checks.

INITIAL DRIVE OPERATION

15. When the message appears that a motor must be selected, choose OK. The Drive Select dialog box is selected with Motor Selection active.

16. Select the appropriate motor from the drop-down Motor Selection box.

17. Choose OK when the message appears advising that the drive must reset. A change in motor parameters requires reselection of the firmware based drive/motor tables. The software reset prevents improper sequencing of these table parameters.

18. Choose Close from the Drive Setup window.

19. Select the Control **P**anel icon from the Drive Window.

20. Close the connection between J1-26 and J1-20 to enable the drive.

21. Holding torque should be sufficient so that the shaft is either immovable or very resistant to rotation.

22. Move the ***slide bar*** in the Control Panel window to the right and then to the left. Verify that the motor rotates:
    - CW as the slide bar is moved right of center, and
    - CCW as the *Slide Bar* is moved left of center.

    If the motor rotates in the wrong direction (CCW when the slide bar is set to the right of center) or jumps and locks-up, motor phasing and encoder feedback phasing may be incorrect. If necessary, refer to *Troubleshooting*, page 11-121 for instructions on how to correct the motor power connections at TB1 or the encoder feedback connections at J2.

23. Choose Set to **Z**ero. The motor will stop rotating.

24. Choose Drive **D**isable and verify the motor shaft can be rotated by hand.

25. Choose Drive **E**nable and verify the motor shaft has holding torque

(i.e. the shaft cannot be moved or moves with resistance.)

26. Open the connection between J1-26 and J1-20 to disable the drive.

27. Choose Close from the Control Panel window.

    A drive completing these steps is functional. If the SSD drive did *not* pass the steps above, refer to *Troubleshooting* on page 11-121.

    NOTE: For information on testing the digital and analog signals refer to *Testing Digital Outputs* on page 11-128, *Testing Digital Inputs* on page 11-130, *Testing Analog Output* on page 130 and *Testing Analog Input* on page 11-131.

Storing the Unit

Return the drive to its shipping carton using the original packing materials to enclose the unit.

Store the drive in a clean, dry place that will not exceed the following ranges:

- Humidity: 5% to 95%, non-condensing
- Storage temperature: -40° to 158° F. (-40° to 70° C.).

Selecting Other System Components

This chapter briefly reviews the motors, command sources and interfaces for SSD5, SSD10 and SSD20 drives. Selection of complementary servo components allows the operator to efficiently connect other devices to the microdrive. Pertinent information about each is provided to assist in planning the required servo system.

Motors

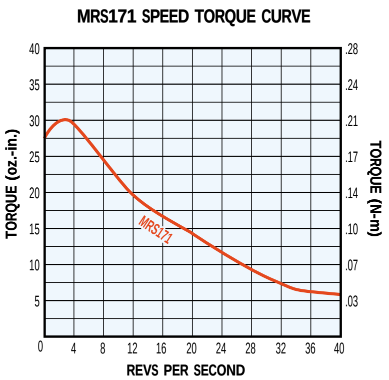
The SSD is compatible with many motors, both Tol-O-Matic motors and motors from other manufacturers. Drive and motor parameters for all compatible Tol-O-Matic motors are programmed into each SSD drive at the factory. Tol-O-Matic motors that are compatible with the SSD drives include:

- MRV171
- MRV231
- MRV232
- MRV233
- MRV234
- MRV341
- MRV342
- MRV343

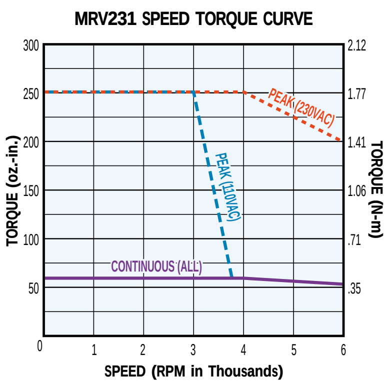
Tol-O-Motion SSD software simplifies drive and motor setup with predefined parameters for each drive and motor combination.

Custom motors or motors not supplied by Tol-O-Matic may be interfaced, please contact Tol-O-Matic for assistance.

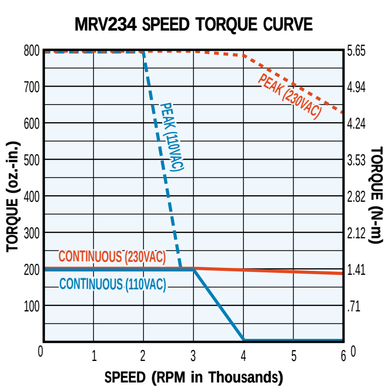
Command Source



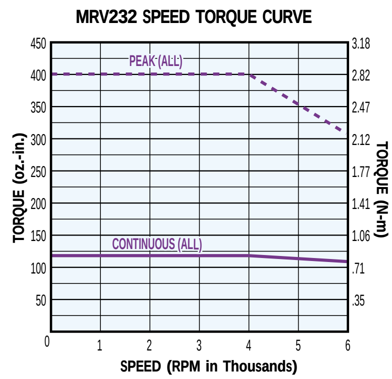
MRV171



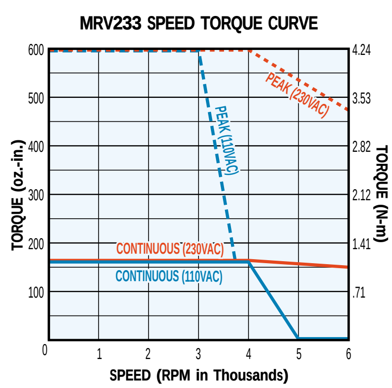
MRV231



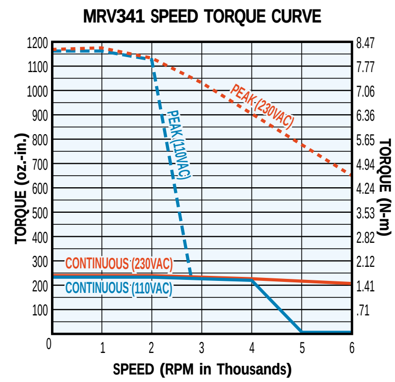
MRV234



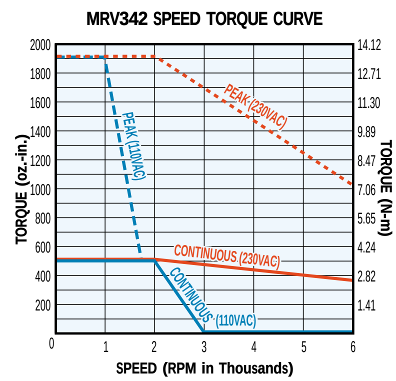
MRV232



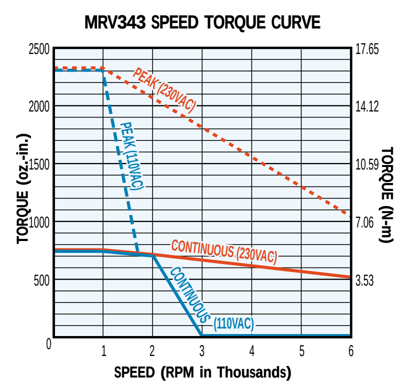
MRV233



MRV341



MRV342



MRV343

In the analog mode of operation, the SSD drive requires a variable ±10 Volt DC external analog signal capable of driving the servo regulator's command input at an input impedance of 13.3 kOhms. Choose a source such as a PLC (programmable logic controller), the DAC (digital-to-analog converter) of a computer, or a motion controller that meets this requirement.

Differential or single-ended line drivers may supply the signals for the encoder inputs, step and direction inputs, and step up/down inputs. The differential signal must be capable of supplying at least 5 mA with 2.0 Volts across the + and - inputs. A differential signal source provides the best noise margin of all the interface circuit options. Single-ended signals from TTL drivers must be capable of sourcing or sinking 5 mA.

In the preset mode, the controlling device should be capable of sourcing 4.5 mA into the digital inputs.

Serial Communications Interface

SSD drives are configured and controlled via a serial communication link. The serial port allows the SSD to interface with other user-supplied equipment such as:

- Host computers
- PLCs
- PCs
- Motion controllers.

The serial communication interface for the SSD supports:

- RS-232 and the four wire RS-485 communications standards
- NRZ (non-return to zero) asynchronous serial format
- Baud rates: 1200, 2400, 4800, 9600 and 19200
- Parity generation and checking: Even, Odd or None.

Connection of communication cables between the drive and user-supplied equipment is described in the following sections:

- One SSD drive - *Single Axis RS-232 setup* on page 6-66.
- Multiple SSD drives - *Multiple Axes Four-Wire RS-485* on page 6-67.

I/O Interface

ANALOG INPUT

One analog input channel is accessible to the user. The analog input limits the peak current available from the drive.

LIMIT (current limit). The analog signal must be within 0-10 Volt range and single-ended.

If this signal is not provided, the peak current of the drive may be set in software through the Drive Parameter window.

ANALOG OUTPUT

One analog output channel may be defined by the user through software:

ANALOG is a ±10 Volt signal. The allowable current draw of the load is ±2 mA

This analog output is designed for monitoring purposes only. Tol-O-Matic recommends this signal not be used for control purposes due to the relatively high ripple voltage (1%).

DIGITAL INPUTS

Control Inputs

Two, optically isolated, single ended, active high, dedicated control inputs provide controller ENABLE, and FAULT RESET functions. These inputs operate with switch closure or sourcing type transistor outputs.

The current rating of each input is 10 mA nominal.

Selectable Inputs

Three, optically isolated, single ended, active high inputs support logic type interfaces. The input circuits operate with switch closure or sourcing type transistor circuits. Selectable inputs are:

- Drive Mode Select
- Integrator Inhibit
- Follower Enable
- Forward Enable
- Reverse Enable
- Preset Selects (3 presets provide up to 8 digital preset combinations)
- Analog Override.

The current rating of each input is 10 mA nominal.

DIGITAL OUTPUTS

Control Outputs

Two normally open relays are dedicated control outputs to the following signals:

- BRAKE/DRIVE ENABLED
- DRIVE READY

The current ratings of each relay is 1 Amp at 30 VDC.

If using a motor with the 90VAC brake option, a user-provided relay may be driven by these outputs up to the specified levels. Refer to *I/O Configuration* in the on-line *Tol-O-Motion SSD* help for additional information about the software parameters.

Selectable Outputs

Two, optically isolated, single ended, active high, current sourcing, discrete output channels provide logic outputs under software control. Selectable outputs are:

- In Position
- Position Window
- Zero Speed
- Speed Window
- Peak Current Limit
- At Speed
- Drive Enabled
- Bus Charged

Each selectable output channel is capable of sourcing 50 mA maximum and is optically isolated and short circuit protected.

AUXILIARY ENCODER INTERFACE

The external encoder I/O port permits quadrature-type encoder signals for applications, such as electronic gearing.

Encoder Inputs

Software automatically selects the appropriate input based on the command source:

- Master Encoder
- Step/Direction
- Step Up/Step Down.

Encoder Output

The resolution of the encoder output channel is under software control. The motor encoder signal is divided by 1, 2, 4 or 8 to provide an output from a differential line driver measured in PPR (pulses per revolution). The maximum encoder frequency output is 1 MHz (4 MHz quadrature).

European Union Requirements

SSD drives conform to the following European Union Directives:

- Low Voltage Directive (72/23/EEC, 93/68/EEC)
- Electromagnetic Compatibility Directive (89/336/EEC, 92/31/EEC, 93/68/EEC)

Compliance with the EEC Directives is contingent on:

A. Installation of AC line filters between the power source and the drive.
B. The use of certified cables.

Installing Tol-O-Motion SSD Software 4

This chapter provides information about:

- minimum PC hardware and software necessary to run *Tol-O-Motion SSD;*
- step-by-step instructions on how to load *Tol-O-Motion SSD;*
- how to start and quit *Tol-O-Motion SSD* and introduces the Drive Window, the main command window for *Tol-O-Motion SSD;*
- how to access on-line help.

Instructions for using the features available in *Tol-O-Motion SSD* are detailed in on-line help. To access the *Help* menu, press the **F1** key.

Hardware and Software Requirements

The minimum PC configuration required to run the software includes:

- A DOS-based computer with a minimum 286 microprocessor
- A hard disk with 2.0 MB of free disk space
- 3½ inch, 1.44MB floppy disk drive
- 2 MB of RAM
- A Video Graphics Array (VGA) monitor
- Microsoft Windows version 3.1, 95, or NT
- Mouse (recommended)

Windows must be installed on the PC. If Windows is not already installed, refer to the appropriate Microsoft manual to install Windows on the computer.

Installation

To install Tol-O-Motion SSD software on a hard drive:

1. Make a backup copy of the *Tol-O-Motion SSD* disk in one of two ways:

   - Copy the *Tol-O-Motion SSD* disk using the Disk menu in the Windows File Manager.
   - If the computer has only one floppy disk drive: at the DOS command line prompt, type **diskcopy a: b:** (be sure to include spaces), then press **ENTER.** The software will prompt the user when to insert the ***source disk*** (*Tol-O-Motion SSD*) and when to insert the ***target disk*** (blank).

2. If Windows is not running, type **win** at the DOS prompt (C:>). If Windows is already running, close any open applications.

3. Insert the *Tol-O-Motion SSD* disk into a 1.44MB floppy disk drive, (typically drive A:), then close the drive door.

4. Choose Run, from the File menu in Windows Program Manager.

5. Type **a:setup** and then press **ENTER.** A message box will appear indicating that Setup is initializing. The message box may be present for up to 40 seconds, depending on the speed of the PC.

6. A dialog box prompts the user to confirm whether or not Tol-O-Motion SSD should be installed on the hard drive (C: drive) of the PC.

   To install *Tol-O-Motion SSD:*
   Choose Continue, or press **ENTER,** and continue with the next step.

   To stop the installation:
   Choose Exit. The program returns to Windows.

7. Setup then asks where *Tol-O-Motion SSD* should be installed.

   To accept the path Setup proposes in the Path: box (c:\tolomotn\...):
   Choose Continue.

   To choose another directory:
   Type a new path in the Path: box, then choose Continue. **NOTE:** There is no confirmation of the entry so be sure to type carefully.

   To return to the initial Setup window:
   Choose Back.

   To stop the installation:
   Choose Exit. The program returns to Windows.

   To obtain on-line help with the installation:
   Choose Help.

8. A status bar informs the user of installation progress. When Setup is complete, choose OK or press **ENTER** to return to Windows.

Starting and Quitting Tol-O-Motion SSD

Setup automatically creates the *Tol-O-Motion SSD* program group and then returns the user to Windows. The *Tol-O-Motion SSD* program group provides access to the *Tol-O-Motion SSD* application icon from the C:> prompt or Windows.

To access *Tol-O-Motion SSD* from the C:> Prompt
Type **win c:\tolomotn\tolomotn.exe**. **NOTE:** This step assumes *Tol-O-Motion SSD* was loaded into the c:**tolomotn** directory during setup.

The *Tol-O-Motion SSD* start-up screen will open.

To access *Tol-O-Motion SSD* from Windows

1. Choose the *Tol-O-Motion SSD* program group from the Program Manager in Windows.

   TIP: If the *Tol-O-Motion SSD* window is not active, hold down **CTRL** and press **TAB** (CTRL+TAB) until the *Tol-O-Motion SSD* title bar and icon are highlighted, or select Tol-O-Motion SSD from the list in the **W**indow menu.

2. Choose the *Tol-O-Motion SSD* icon from the *Tol-O-Motion SSD* program group. The *Tol-O-Motion SSD* start-up screen will open.

TOL-O-MOTION SSD START-UP SCREEN

When *Tol-O-Motion SSD* starts for the first time, its default instructions are:

- Display the Help menu - Quick Start.
- Present the Drive Select window. The Drive Select window offers Drive 0, which is the default drive address assigned at the factory.

The default *Tol-O-Motion SSD* Start-Up Screen is shown in Figure 4.1. The comments point-out many of the Windows controls that are available in *Tol-O-Motion SSD*.

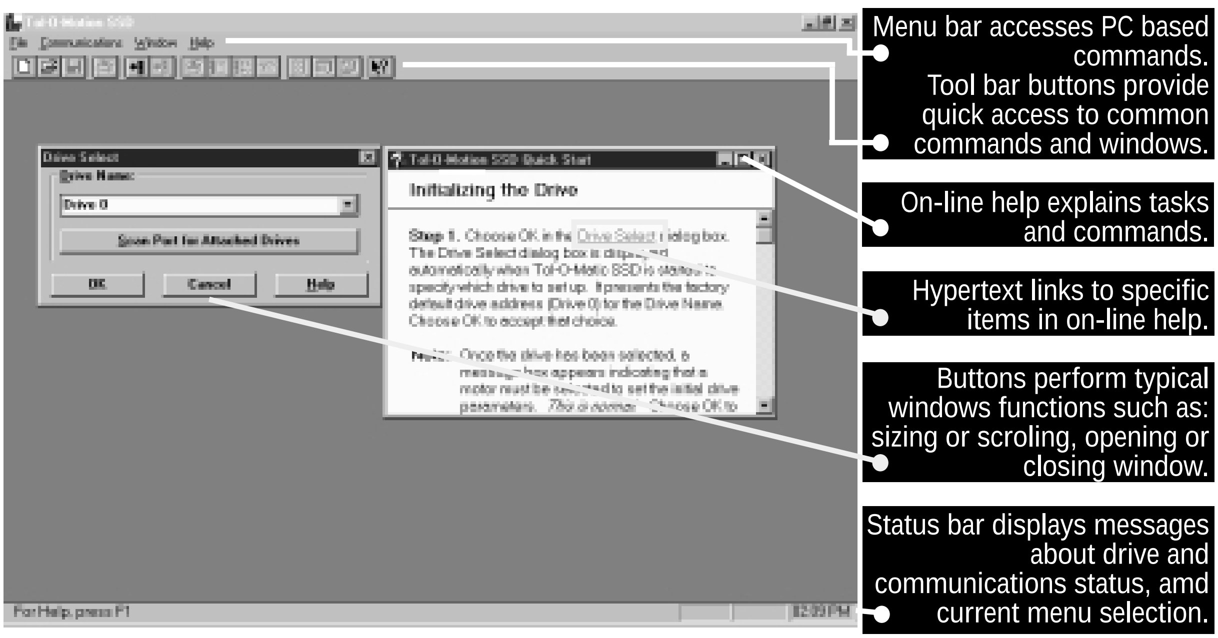


Figure 4.1 - Master Start-Up Screen Default

TIP: *Tol-O-Motion SSD* displays the Help menu - Quick Start - when it is first accessed. To disable this automatic display, deselect the menu item Show Quick Start from the Help menu.

THE README FILE

A file titled README, may be included in the *Tol-O-Motion SSD* directory. This file contains installation instructions, change notes from previous revisions, and information that became available after this manual was printed. After *Tol-O-Motion SSD* is installed, it is possible to access this file by:

1. choosing the Read Me icon (shown at left) in the *Tol-O-Motion SSD* window; or

2. using *Microsoft Write* or an equivalent application program to view the file "readme.wri" in the directory path where *Tol-O-Motion SSD* is installed.

MISCELLANEOUS FILES

Firmware Files

Four hexadecimal files are supplied in the Miscellaneous directory on the *Tol-O-Motion SSD* diskette. The current revision level of drive firmware is displayed in the Drive Information window of *Tol-O-Motion SSD*.

The hexadecimal files and their functions are:

- **Firmware** - Main Operating firmware for the drive
- **Boot Block** - Drive Initialization firmware for the drive
- **Motor Table Block** - Motor Parameter firmware for the drive.

Mechanical Installation Requirements

1. Mount the unit in an enclosure providing protection to IP54 (protected against dust and splashing water), or IP65 (dust free and protected against water jets) if the work environment is poor. Many NEMA (National Electrical Manufacturers Association) Type 4 cabinets provide this level of protection. Minimum cabinet requirements are:

   - Depth: 243.8 cm (9.6 inches).
   - Adequate sizing and/or ventilation to dissipate the heat generated by the SSD drives. Refer to *Power Dissipation* on page E-159 for the amount of heat generated by SSD drives and enclosure sizing equations.

2. Minimum unobstructed surrounding space for cooling air intake (and fan exhaust from the SSD20:)

   - Above: 50.8 cm (2 inches)
   - Below: 50.8 cm (2 inches)
   - Sides: 1.25 cm (0.5 inches)
   - Front: 76.2 cm (3.0 inches) for cable clearance.

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.

3. Position the drive in a vertical position on a flat, solid surface that meets the following weight, vibration and shock, altitude and humidity, airflow clearance, and temperature requirements.

   Unit weights are:
   - SSD5: 1.7 Kg (3.7 Lbs)
   - SSD10: 2.05 Kg (4.5 Lbs)
   - SSD20: 2.0 Kg (4.4 Lbs)

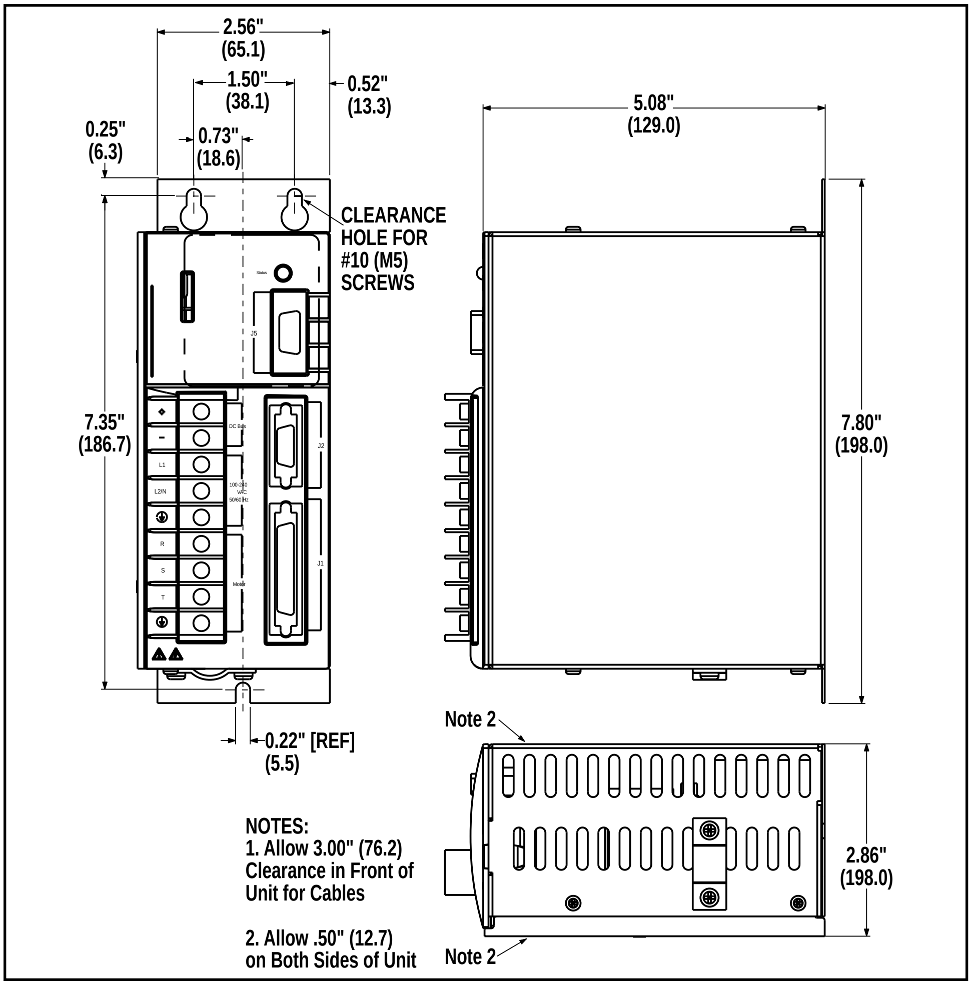


Figure 5.1 SSD5 Mounting Dimensions

Table 5.A SSD5 Mounting Dimensions

	Dimention	
	mm	inches
A	198.12	7.80
A1	165.10	6.50
A2	6.35	0.25
A3	21.08	0.83
A4	6.07	2.39
A5	94.49	3.72
A6	5.00	0.20
A7	22.10	0.87
A8	31.75	1.25
A9	8.64	0.34
A10	31.75	1.25
A11	57.15	2.25

	Dimention	
	mm	inches
B	72.60	2.86
B1	65.02	2.56
B2	38.10	1.50
B3	18.54	0.73
B4	13.21	0.52
B5	5.58	0.22
C	146.05	5.75
C1	129.03	5.08

a. Power Cable bracket extends up to 20mm (0.80 inches)

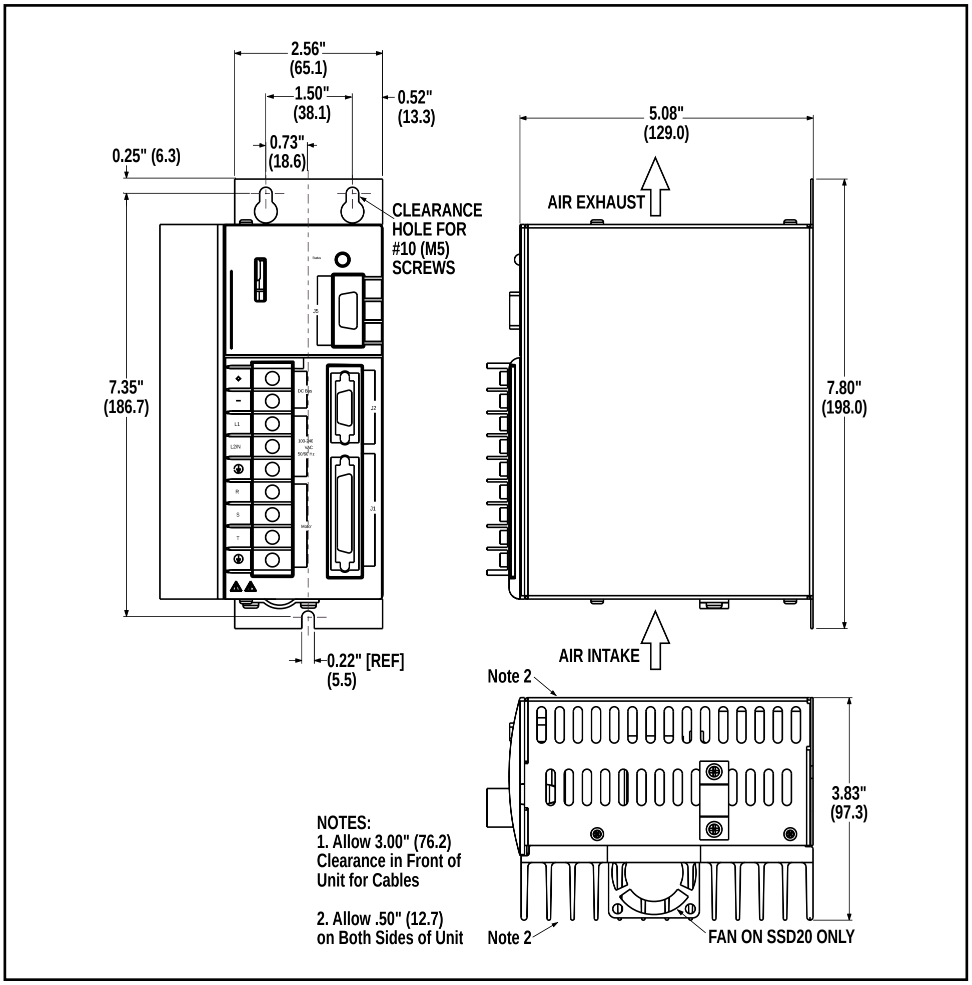


Figure 5.2 SSD 10 and SSD 20 Mounting Dimensions

Table 5.B SSD5/SSD10/SSD20 Mounting Dimensions

	Dimention	
	mm	inches
A	198.12	7.80
A1	165.10	6.50
A2	6.35	0.25
A3	21.08	0.83
A4	6.07	2.39
A5	94.49	3.72
A6	5.00	0.20
A7	22.10	0.87
A8	31.75	1.25
A9	8.64	0.34
A10	31.75	1.25
A11	57.15	2.25

	Dimention	
	mm	inches
B	97.30	3.38
B1	65.02	2.56
B2	38.10	1.50
B3	18.54	0.73
B4	13.21	0.52
B5	5.58	0.22
C	146.05	5.75
C1	129.03	5.08

a. Power Cable bracket extends up to 20mm (0.80 inches)

Vibration and shock, altitude and humidity limits are:

- Vibration: 2g at 10 to 2000 Hz
- Shock: 15g 11 msec half sine
- Altitude: 1500 meters (5000 feet), Derate power performance 3% for ea. 300 m above 1500 m (1000 ft above 5000 ft).
- Humidity: 5% to 95% non-condensing

Ambient operating temperature range and airflow clearances are:

- 0° to 55° C. (32° to 131° F.).
- 50.8 mm (2 inches) above and below unit for airflow.

4. Bolt the unit to the cabinet using the mounting slots in the drive. Mounting dimensions are shown in Figure 5.2. The recommended size of mounting hardware is:

   - M5 Metric (1/4-20 equivalent), or
   - #10 MS bolts.

Interface Connections

Input/Output and power cables connect to the front panel of a SSD drive, no internal connections are necessary.

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

I/O Connections are fully described in the following sections:

- *J1 - Controller* on page 6-36 defines the controller connections.
- *J2 - Encoder* on page 6-61 defines the motor encoder connections.
- *J3 - Serial Port* on page 6-63 defines the RS-232/RS-485 serial port connections.

Power Connections are fully described in the following sections:

- *Power Connections* on page 7-71. defines the power connections.

Specific operational setups are depicted in Figures 8.1 through Figure 8.5 (pages 8-78 through 8-99). These figures cover velocity and torque mode controls for:

- Analog Controllers,
- Preset Controllers,
- Position Followers using a Master Encoder,
- Position Followers using a Step/Direction signal, or
- Position Followers using Step Up/Down signals.

Wiring

Wiring sizes and practices, as well as grounding and shielding techniques are described in the sections listed below. Refer to *Power Connections* on page 7-71.

The descriptions represent common wiring practices and should prove satisfactory in the majority of applications.

Note: Cables, listed in *Options and Accessories* on page A-137, are not rated for continuous flexing.

Minimum wire gages for power cables are listed in:

- *Motor Power Contact and Wire Size Recommendations* on page 7-76,
- *AC Input Power Sizing Requirements* on page 7-76.

Electromagnetic Compatibility

GENERAL GUIDELINES

Refer to the appendix *Electromagnetic Compatibility Guidelines for Machine Design* on page C-141 for an in-depth discussion of electromagnetic compatibility (EMC) and ***electromagnetic interference*** (EMI).

EUROPEAN UNION EMC DIRECTIVES

The SSD drives are designed and tested to meet the European EMC Directive. A declaration of conformity, which enumerates the standards used, is included in the manual.

Two installation requirements are necessary to meet this directive:

- Use of an external AC line filter, and
- Use of certified cables

DANGER! 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. Failure to observe this precaution could result in severe bodily injury.

Refer to the appendix *Options and Accessories* on page A-137 for part numbers. The following diagrams show the mounting dimensions for single phase AC Line Filters available from Tol-O-Matic.

Table 5.C shows a typical filter selection matrix for SSD drives. All the filters identified below are manufactured by Schaffner or Roxburgh and are widely available. There are many AC line filter manufacturers whose filters can be successfully integrated. Tol-O-Matic recommends Schaffner or Roxburgh filters based on lab test results, but the machine builder is responsible for the suitability of the filter selection in a specific application. These filters can be used for distributing power to multiple drives, rather than using an individual filter for each drive. Further information is available from Schaffner (1-800-367-5566) or Roxburgh (01724.281770 [011.44.1724.281770 from the USA]).

AC line filters for use with SSD drives are listed below:

Table 5.C AC Line Filters for SSD Drives

	Part Number	
Drive	**Roxburgh**	**Schaffner**
SSD5	MIF 06, MDF 06	FN 350-8
SSD10	MIF 10, MDF 16	FN 350-12
SSD20	MIF 23, MDF 18	FN 350-20

Basic guidelines for reducing electrical noise and increasing electromagnetic compatibility (EMC) are listed in *Electromagnetic Compatibility Guidelines for Machine Design* on page C-141.

Interfaces 6

This chapter provides information about:

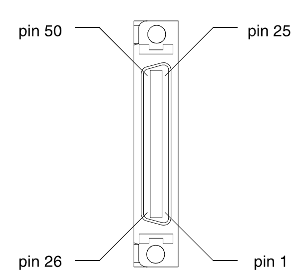
- Interface signals available on the SSD drive
  - J1 - The Controller interface for commanding and reporting motion
  - J2 - The Encoder interface for reporting movement by the motor
  - J3 - The Serial interface for communicating with the drive.
- Commonly encountered interface cabling methods
- Optional signal extension kits and standard cables.

J1 - Controller

J1 is a 50 pin female mini-D connector (AMP 2-178238-7) for connecting a host computer or controller to the drive. Contact between the connector's shell and the grounded chassis provides shield termination. This section lists the connector pin-outs and provides signal specifications.

Table 0.A J1 Controller Pin-Outs

Pin & Signal		Description	Pin & Signal		Description	Pin & Signal		Description
1	+5VDC	Encoder +5V DC	20	ENABLE	Drive Enable	39		Reserved
2	ECOM	Encoder Common	21	RESET	Fault Reset	40		Reserved
3	+5VDC	Encoder +5V DC	22	CMND+	Analog Command+	41		Reserved
4	ECOM	Encoder Common	23	CMND-	Analog Command-	42	OUTPUT 1	Selectable Output 1
5	I/O PWR	12-24	24	READY+	Drive Ready+	43	OUTPUT 2	Selectable Output 2
6	I/O COM	I/O	25	READY-	Drive Ready-	44		Reserved
7	AOUT+	Motor Encoder Output Channel A+	26	I/O PWR	12-24	45		Reserved
8	AOUT-	Motor Encoder Output Channel A-	27	+I LIMIT	Positive Current Limit	46		Reserved
9	BOUT+	Motor Encoder Output Channel B+	28	ACOM	Analog Common	47		Reserved
10	BOUT-	Motor Encoder Output Channel B-	29		Reserved	48		Reserved
11	IOUT+	Motor Encoder Output Channel I+	30		Reserved	49	BRAKE+	Brake Enable+
12	IOUT-	Motor Encoder Output Channel I-	31	ANALOG1	Analog Output 1	50	BRAKE-	Brake Enable-
13	I/O COM	I/O	32	INPUT1	Selectable Input 1			
14	AX+/CW+/ STEP+	Auxiliary Encoder Channel A+	33	INPUT2	Selectable Input 2			
15	AX-/CW-/ STEP-	Auxiliary Encoder Channel A-	34	INPUT3	Selectable Input 3			
16	BX+/ CCW+/ DIR+	Auxiliary Encoder Channel B+	35		Reserved			
17	BX-/CCW-/ DIR-	Auxiliary Encoder Channel B-	36		Reserved			
18	IX+	Auxiliary Encoder Channel I+	37		Reserved			
19	IX-	Auxiliary Encoder Channel I-	38		Reserved			



Options & Accessories *on page A-137 lists the available cables.*

Digital I/O Power

SSD drives require an external +24VDC power source for the inputs and outputs.

EXTERNAL 12-24 VOLT I/O POWER

The external 12-24 VDC power supply must be capable of supplying at least 250 mA. The current rating of each 12-24VDC output relay is 90 mA nominal.

The pin-outs are:

I/O PWR	J1-5	J1-26
I/O COM	J1-6	J1-13

(See page 6-40)

The I/O VCOM must be grounded to meet the European Low Voltage Directive (LVD).

DIGITAL INPUTS

SSD drives have active high inputs, which prevent disconnects and ground faults from activating a drive.

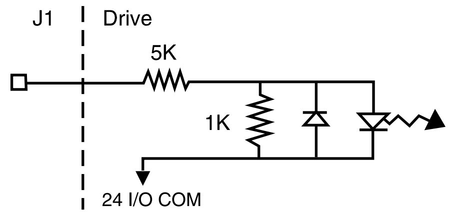


Figure 6.1 Digital Input Circuit

Two discrete input circuits types are available on the J1 connector. Both circuits support logic type interfaces with optically isolated, single ended and active high characteristics.

Dedicated Control Circuits

The ENABLE and FAULT RESET inputs interface with switch closures or sourcing type outputs. The current rating of each input channel is 4.5 mA nominal.

Selectable Circuits

INPUT 1, INPUT 2 and INPUT 3 operate with switch closures or sourcing type circuitry. The current rating of each input channel is 4.5 mA nominal. Selectable inputs are:

Drive Mode Select	Reverse Enable	Analog Override
Integrator Inhibit	Preset Select A	
Follower Enable	Preset Select B	
Forward Enable	Preset Select C	

Refer to the *I/O Configuration* section of the on-line *Tol-O-Motion SSD* Help for information on choosing the input type for each channel. Refer to the Preset Control Application example for detailed use of the presets.

DIGITAL INPUT	PIN NUMBER	FUNCTION/DESCRIPTION
ENABLE	J1-20	Enables and disables the drive. Motor torque cannot be applied unless the ENABLE input is active.
FAULT RESET	J1-21	Resets the drive after a fault. The controller is enabled (if the ENABLE switch is active) after the FAULT RESET is applied. If the drive is not faulted when the RESET is made, the servo controller ignores the RESET signal. The reset occurs on the transit.
INPUT 1	J1-32	General purpose input selectable to one of several drive functions. Refer to Tol-O-Motion on-line Help and the table below for I/O configuration.
INPUT 2	J1-33	General purpose input selectable to one of several drive functions. Refer to Tol-O-Motion on-line Help and the table below for I/O configuration.
INPUT 3	J1-34	General purpose input selectable to one of several drive functions. Refer to Tol-O-Motion on-line Help and the table below for I/O configuration.

Table 6.B General and Dedicated Inputs

Inputs 1, 2 and 3 each may be software configured as Preset Select A, B or C.

<table>
<tr><th>Function</th><th colspan="5">Description</th></tr>
<tr><td rowspan="2">Drive Mode Select</td><td colspan="5">Active[1] state configures the drive for Torque Mode.</td></tr>
<tr><td colspan="5">Inactive[2] state selects the personality EEPROM setting as the command source.</td></tr>
<tr><td>Integrator Inhibit</td><td colspan="5">Active[1] state zeros the Velocity Loop Error Integrator.</td></tr>
<tr><td>Follower Enable</td><td colspan="5">Active[1] state allows the position loop to track the AUXILIARY POSITION LOOP signal when in the Follower mode.</td></tr>
<tr><td>Forward Enable</td><td colspan="5">Active[1] state allows forward commands in velocity mode only. If this input is inactive or not connected, no velocity command will be allowed in the forward direction. If motion is in progress when the input is pulled low or disconnected, the drive halts immediately without deceleration control. The COMMAND signal is clamped internally to 0 Volts.</td></tr>
<tr><td>Reverse Enable</td><td colspan="5">Active[1] state allows reverse commands in velocity mode only. If this input is inactive or not connected, no velocity command will be allowed in the reverse direction. If motion is in progress when the input is pulled low or disconnected, the drive halts immediately without deceleration control. The COMMAND signal is clamped internally to 0 Volts.</td></tr>
<tr><td></td><td colspan="5">Active[1] or Inactive[2] states select one of the eight presets shown in the following binary table:</td></tr>
<tr><td></td><td></td><td colspan="3">BINARY CODE</td><td></td></tr>
<tr><td></td><td></td><td>C</td><td>B</td><td>A</td><td>Description</td></tr>
<tr><td></td><td>Preset 0</td><td>0</td><td>0</td><td>0</td><td>Preset 0 is the programmed input.</td></tr>
<tr><td rowspan="7">Preset Speeds or Torques</td><td>Preset 1</td><td>0</td><td>0</td><td>1</td><td>Preset 1 is the programmed input.</td></tr>
<tr><td>Preset 2</td><td>0</td><td>1</td><td>0</td><td>Preset 2 is the programmed input.</td></tr>
<tr><td>Preset 3</td><td>0</td><td>1</td><td>1</td><td>Preset 3 is the programmed input.</td></tr>
<tr><td>Preset 4</td><td>1</td><td>0</td><td>0</td><td>Preset 4 is the programmed input.</td></tr>
<tr><td>Preset 5</td><td>1</td><td>0</td><td>1</td><td>Preset 5 is the programmed input.</td></tr>
<tr><td>Preset 6</td><td>1</td><td>1</td><td>0</td><td>Preset 6 is the programmed input.</td></tr>
<tr><td>Preset 7</td><td>1</td><td>1</td><td>1</td><td>Preset 7 is the programmed input.</td></tr>
<tr><td>Analog Override</td><td colspan="5">Active[1] state selects the COMMAND input to be the command source. The default setting is Velocity mode.
Inactive[2] state selects the personality EEPROM setting as the command source. Analog Override is typically inactive, which selects the EEPROM setting in Tol-O-Motion SSD (Torque, Follower, etc.).</td></tr>
<tr><td colspan="6">1 - Active state indicates current flow through the input optocoupler.
2 - Inactive state indicates no current flow.</td></tr>
</table>

Table 6.C INPUT1 and INPUT2 Functions

The specifications for these inputs are as follows:

Parameter	Description	Minimum	Maximum
ON state Voltage	Voltage applied to the input to guarantee an ON state	20 VDC	28 VDC
ON state Current	Current flow into the input to guarantee an ON state.	3.5 mA	5.5 mA
OFF state Voltage	Voltage applied to the input to guarantee an OFF state.	10.8 VDC	3 VDC
OFF state Current	External leakage current into the input to guarantee an OFF state.	3.0 mA	10.0 mA

2 VDC

Table 6.D Digital Input Specifications

Input Interface Circuit Examples

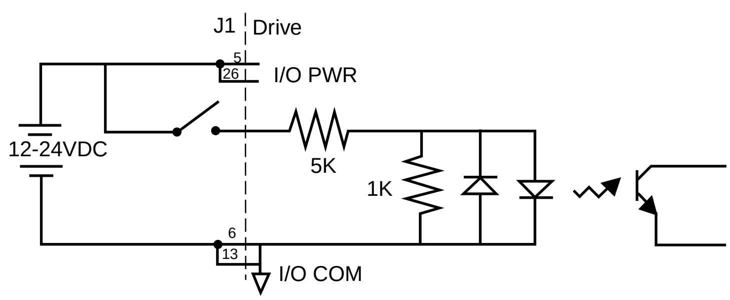


Figure 6.2 Drive Input Connected to a Switch/Relay Contact

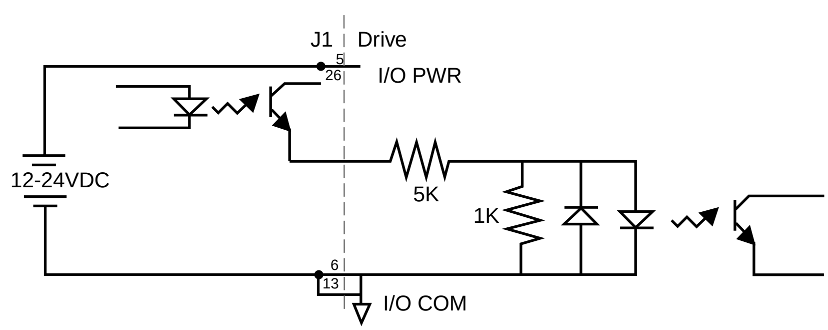


Figure 6.3 Drive Input Connected to an Opto-Isolator

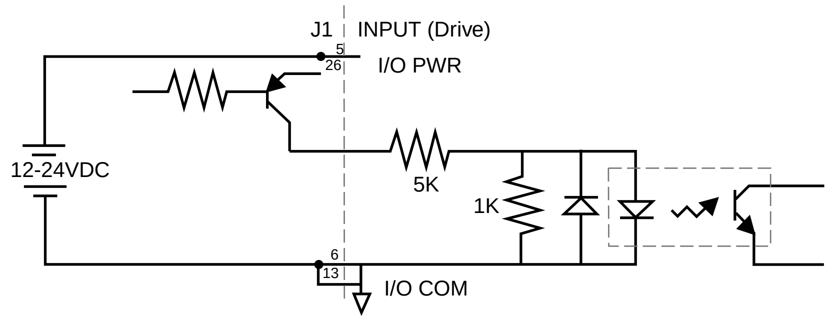


Figure 6.4 Drive Input Connected to an Active High Sourcing Transistor

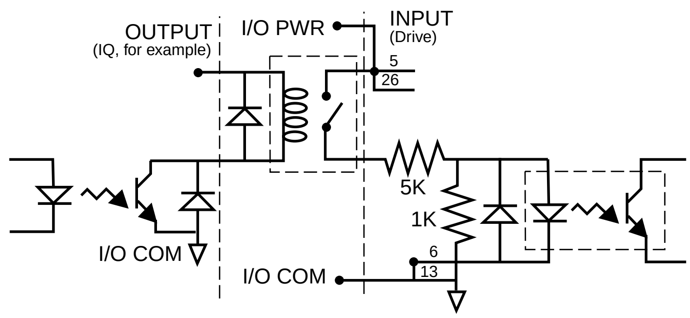


Figure 6.5 Drive Input Connected to Active Low Output using a Switch/Relay

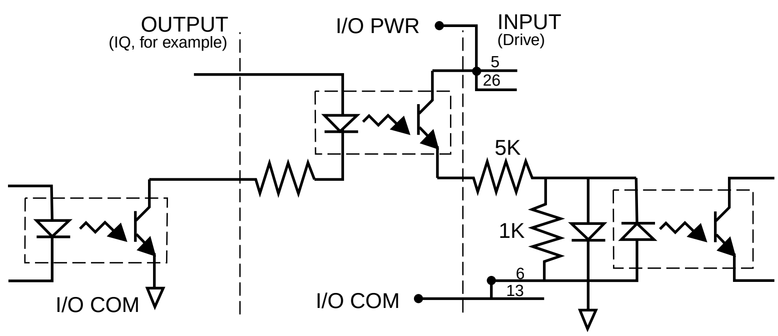


Figure 6.6 Drive Input Connected to Active Low Output using an Opto-Isolator

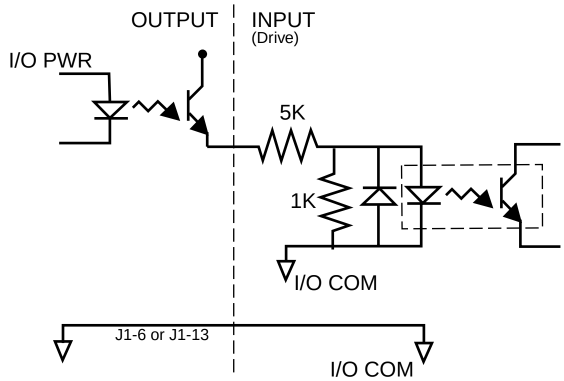


Figure 6.7 Drive Input Connected to Sourcing Output

DIGITAL OUTPUTS

Two types of discrete output circuits are available on the J1 connector:

- Dedicated relay outputs
- Selectable transistor based outputs

Both types support 12-24 VDC logic interfaces:

Dedicated Relay Outputs

BRAKE/DRIVE ENABLED and DRIVE READY. Each output is a normally open relay. The brake relays are rated for 1 Amp at 30 VDC and 0.5 Amp at 125 VAC. The Drive Ready contacts are rated for 1 A at 30 VDC.

NOTE: The Brake contacts may be used to control brakes on Tol-O-Matic motors with a 34” frame or smaller. A user provided relay may be driven by these outputs if higher power levels are required.

Selectable Transistor Outputs

OUTPUT 1 and OUTPUT 2 are 12-24 VDC, optically isolated and short circuit protected, active high, single ended transistor output channels. Each channel sources a maximum of 50 mA.

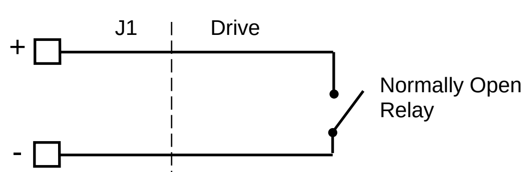


Figure 6.8 READY and BRAKE/DRIVE ENABLED Circuits

READY AND BRAKE/DRIVE ENABLED CIRCUITS

The specifications for these outputs are as follows:

Parameter	Description	Maximum
ON state resistance	Internal resistance between J1-24 (+) and J1-25 (-) or J1-49 (+) and J1-50 (-) when the contacts are closed.	1 Ohm
ON state current	Current flow through the relay when contacts are closed.	1 Amp
OFF state current	Leakage current from either output when the relay contacts are open.	0.01 mA
OFF state Voltage	Voltage difference between the outputs with open relay contacts.	30 Volts

Table 6.E READY and BRAKE/DRIVE ENABLED Output Specifications

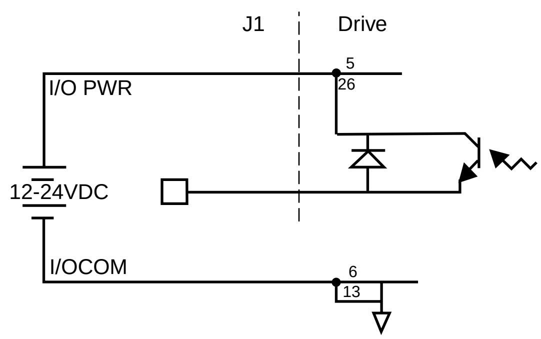


Figure 6.9 Digital Output Circuit.

Digital Output	Pin Number	Function/Description
READY	J1-24 (+)	Relay closure indicates the drive is operational and J1-25 (-)does not have a fault. Refer to “READY and BRAKE/DRIVE ENABLED Output Specifications” on page 43
		Relay closure releases the brake. Delay time is selectable (Refer to Tol-O-Motion - I/O configuration) and may be used as a drive enabled output.
BRAKE	J1-49 (+) J1-50 (-)	This signal is the inverse of the ENABLE output, although a time delay may be selected.
		Refer to “READY and BRAKE/DRIVE ENABLED Output Specifications” on page 43
OUTPUT 1	J1-42	General purpose output. Selectable from one of several drive functions. (Refer to Tol-O-Motion - I/O configuration on-line Help and Table 6.G.)
OUTPUT 2	J1-43	General purpose output. Selectable from one of several drive functions. (Refer to Tol-O-Motion - I/O configuration on-line Help and Table 6.G.)

Table 6.F Selectable Output Circuits

Function	Description
In-position	An active state indicates the position window condition is satisfied, and the zero speed condition is satisfied. The position window and zero speed range are selectable settings.
Within Window	An active state indicates the position window condition is satisfied. The position window range is a selectable setting.
Zero Speed	An active state indicates the velocity loop zero speed signal is active. The zero speed limit is a selectable setting.
Speed Window	An active state indicates the velocity loop speed window is active. The speed window range is a selectable setting.
Current Limit	An active state indicates the torque current is limited.
At Speed	An active state indicates the velocity loop AT SPEED signal is active. The at speed level is a selectable setting.
Drive Enabled	An active state indicates the ENABLE signal is active and no fault is detected.
Bus Charged	An active state indicates the DC bus is energized.
NOTE: Refer to the I/O Configuration section of the Tol-O-Motion on-line Help for further explanation of these output signals.	

Table 6.G OUTPUT1 and OUTPUT2 Functions

Parameter	Description	Minimum	Maximum
ON state Voltage	Voltage difference between the I/O PWR supply and the output when the transistor is ON.	0 VDC	1.5 VDC
ON state current	Current flow when the transistor is ON.	0 mA	50 mA
OFF state Voltage	Voltage difference between the I/O PWR supply and the output when the transistor is OFF.	0 Volts	50 Volts
OFF state current	Leakage current from the output when the transistor is OFF	.-0.1 mA	0.1 mA

Table 6.H Transistor Output Specifications

Output Interface Circuit Examples

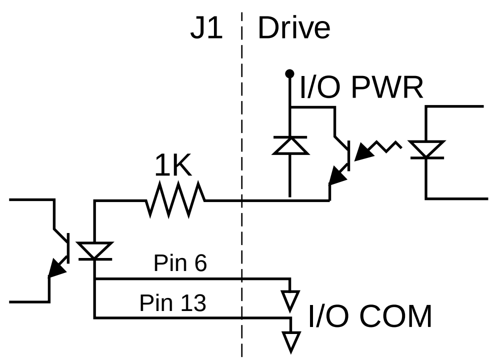


Figure 6.10 Drive Output Connected to an Opto-Isolator

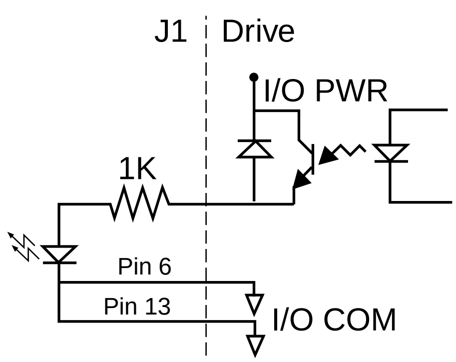


Figure 6.11 Drive Output Connected to an LED Indicator

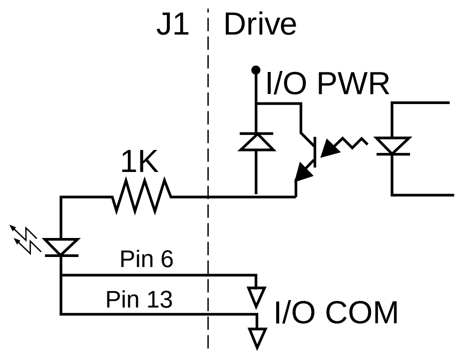


Figure 6.12 Drive Output Connected to a Resistive Load

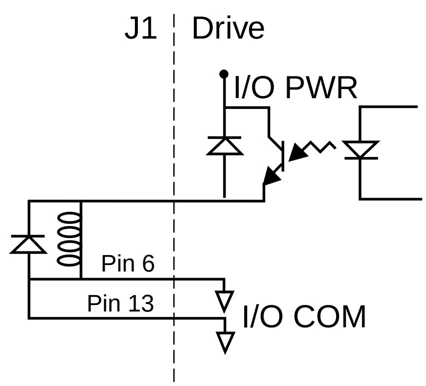


Figure 6.13 Drive Output Connected to a Switch/Relay

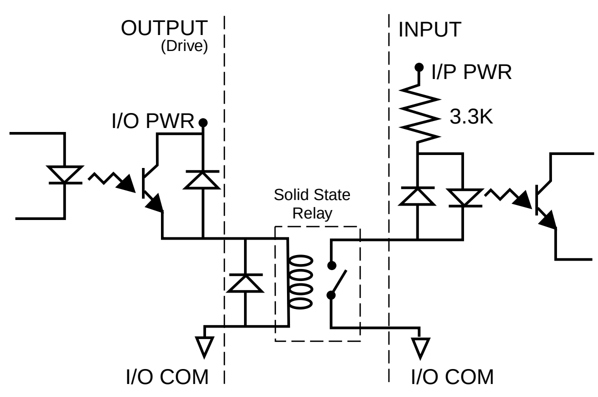


Figure 6.14 Drive Output Connected to Active Low Input using a Switch/Relay

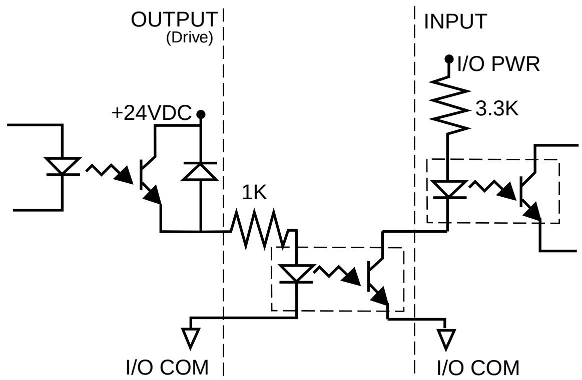


Figure 6.15 Drive Output Connected to Active Low Input using an Opto-Isolator

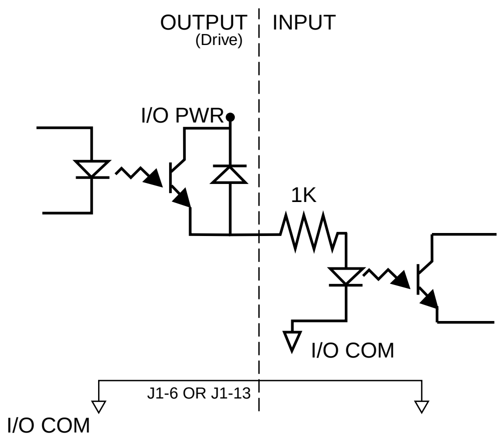


Figure 6.16 Drive Output Connected to Active High (Sinking) Input

ANALOG INPUTS

Two types of analog input circuits are available on the J1 connector:

- The current limiting input supports 0 to +10 Volt signals
- The command input supports 0 to ±10 Volt signals.

External Current Limit (I LIMIT)

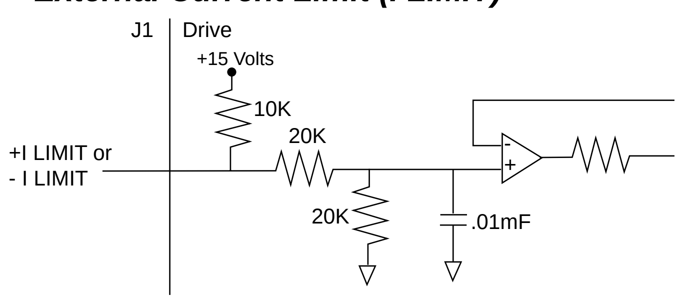


Figure 6.17 External Current Limit Circuit

ILIMIT limits the current, which provides torque, to the motor. The range is 0 to +10 Volts (where 10 Volts corresponds to maximum drive current).The analog I LIMIT signal is converted into a digital word by a 10-bit ADC (analog to digital converter). If the I LIMIT input is not connected, current is not limited.

Analog Input	**Pin Number**	**Function/Description**
Current Limit (I LIMIT)	J1-27	Limits the peak current command, which produces torque.

Table 6.I Analog Inputs (I LIMIT)

Parameter	**Description**	**Minimum**	**Maximum**
Maximum Current	Short circuit between the input and ground.		-1.5 mA
Input Signal Range	Allowable voltage applied to the input	0 Volts	+10 Volts

Table 6.J External Current Limit Input Specification

Command Input

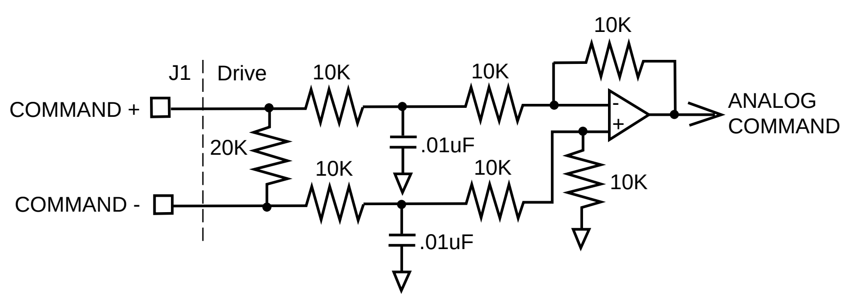


Figure 6.18 Analog COMMAND Input Circuit

The analog command signal to the drive has a range of ±10 Volts. The signal is either a torque or a velocity command, depending on the software configuration of the drive. The differential input is processed by a 16 bit analog to digital converter (ADC) to produce a digital value.

ANALOG INPUT	PIN NUMBER	DESCRIPTION
COMMAND	J1-22(+) J1-23 (-)	The SSD drive can be operated by an analog J1-23 (-) command signal, such as that generated by the Tol-O-Matic SSC series controller. If an SSC series controller is to be used, the drive will already be configured for analog command. Additional adjustments should not be necessary. (please refer to the Tol-O-Matic SSC controller manual). If the drive is in Velocity Mode configuration, the differential COMMAND signal is the velocity or motor speed command. Separate scale and offset parameters are used for the input, depending whether the signal is a velocity command or torque current command (refer to the Tol-O-Motion - Drive Parameters section).

Table 6.K Analog Command Input

Parameter	Description	Minimum	Maximum
Input Impedance	Open circuit impedance measured between (+) and (-).	13.3 kOhms	
Input Signal Range	Allowable voltage applied between (+) and (-) inputs.	0 Volts	±10 Volts

Table 6.L Analog Command Input Specifications

ANALOG OUTPUT

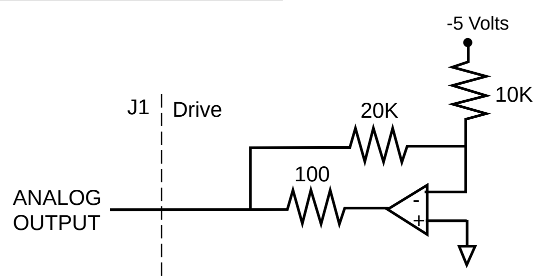


Figure 6.19 ANALOG 1 Output Circuit

A selectable output is available for monitoring by the user: ANALOG 1 (J1-30).

WARNING! The user must provide an external circuit to delay analog signal output when the signal is used to perform an operation. After reset the analog output may be in an indeterminate state for a short period before stabilizing at the software controlled setting. Failure to observe this precaution could result in severe bodily injury.

Analog Output	Pin Number	Description
ANALOG 1	J1-31	Selectable analog output. Displays the selected firmware variable along with selectable scale and offset (refer to the Tol-O-Motion - I/O configuration section
ACOM	J1-28	Analog Common (return)

Table 6.M Analog Outputs: ANALOG 1

Parameter	Description	Minimum	Maximum
Output Current	Allowable current draw of the load	-2 mA	+2 mA
Output Signal Range	Voltage range of the signal	-10 Volts	+10 Volts

Table 6.N Analog Output Specifications

MOTOR ENCODER OUTPUT SIGNAL

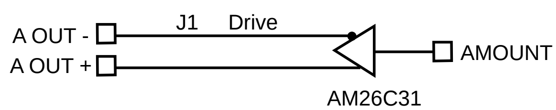


Figure 6.20 Output Encoder Interface Circuits

The motor quadrature encoder signals are supplied to an external position controller. The signals are differential, quadrature, and TTL level. The output resolution is selectable and can be divided by 1, 2, 4 or 8.

The signal frequency ((out) of the motor encoder output in Hertz (Hz) can be calculated with the equation:

$$f_{out} = \frac{V_m \cdot linecount}{60 \cdot N}$$

where:

V_m is the motor encoder velocity in rpm
Line count is the number of encoder lines/revolution of the motor mounted encoder, and N is the output divider from the software selected parameter (1, 2, 4 or 8).

If the device connected to the motor encoder output counts all edges, the count frequency is four times f_{out}.

For example, a motor with a 2000 line encoder is rotating at 3000 rpm, and the Motor Encoder Output signal is set to Divide by 1, the encoder signal frequency is:

$$f_{out} = \frac{3000 \cdot 2000}{60 \cdot 1} = 100kHz$$

A counter counting all edges registers 400 kHz for this example.

Analog Outputs: ANALOG1

ANALOG OUTPUT	PIN NUMBER	DESCRIPTION
AOUT (+) AOUT(-)	J1-7 (+) J1-8 (-)	Motor output channels A(+) and A(-). Differential TTL levels from line driver. Signal resolution is selectable.
BOUT(+) BOUT(-)	J1-9 (+) J1-10 (-)	Motor output channels B(+) and B(-). Differential TTL levels from line driver. Signal resolution is selectable.
IOUT (+) IOUT(-)	J1-11(+) J1-12 (-)	Motor output channels I(+) and I(-). Differential TTL levels from line driver. Output pulse occurs once per motor shaft revolution.

Table 6.O Motor Encoder Output Signal

Parameter	Description	Minimum	Maximum
Differential Output Voltage	Voltage measured between the (+) and (-) pins with RL = 100 Ohm.	2.0 Volts	
Output Current	Current flowing out of the (+) or (-) pin.	-20 mA	+20 mA

Table 6.P Motor Encoder Output Specifications

IOUT SIGNAL GENERATION

The Index Output Signal (IOUT) is not synchronized to a particular state of the A and B output signals (AOUT and BOUT). Some controllers, such as those used in the CNC industry, use the condition I=1, A=1, B=1 to indicate a home position. In such applications the encoder outputs from the drive cannot be used, since it cannot be guaranteed that the IOUT signal will be active during the state AOUT=1, BOUT=1. Instead, the unbuffered motor encoder signals can be used as shown below.

Auxiliary Encoder Input Types

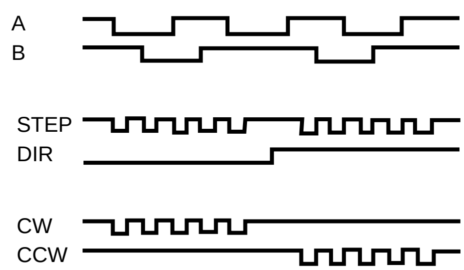


Figure 6.21 Auxiliary Encoder Inputs

The drive may be electronically geared by a remote signal. Electronic gearing may be driven by any of the following three signals:

- A master incremental encoder that generates quadrature encoder signals
- Step and direction signals, such as those created by the Tol-O-Matic MSC Stepper Controller (please refer to MSC instruction manual). If an MSC Controller is to be used, the drive will be configured for step and direction command at the factory. Further adjustments should not be necessary.
- CW (Step Up)/CCW (Step Down) signals, typically used with stepper indexers.

NOTE: The use of differential signals is strongly recommended. Single-ended signals are susceptible to noise, which may cause intermittent or continuous errors.

NOTE: To improve noise immunity, terminate cable shields at both ends of the cable. Connect shields to the back shell of the connector with a complete circumferential (360°) termination. The cable connector should then connect to chassis ground (not signal ground).

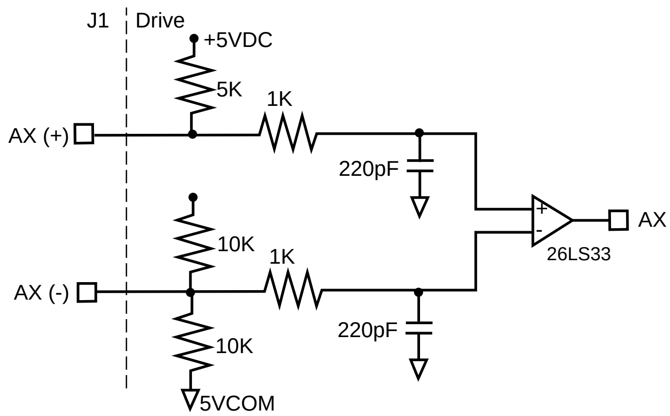


Figure 6.22 Auxiliary Encoder Input Circuit

AUXILIARY ENCODER INPUT	PIN NUMBER	DESCRIPTION
AX + AND AX-, OR STEP + AND STEP-, OR CW + (STEP UP+) AND CW- (STEP UP-)	J1-14 (+) J1-15 (-)	Auxiliary channels A(+) and A(-). Differential, quadrature, or a TTL level encoder input. The signal input and resolution are selectable.
BX (+) AND BX (-), OR DIR (+) AND DIR (-), OR CCW- (STEP DOWN-)	J1-16 (+) J1-17 (-)	Auxiliary channels B(+) and B(-). Differential, quadrature, or a TTL level encoder input. The signal input and resolution are selectable
IX (+) AND IX (-)	J1-18(+) J1-19 (-)	Auxiliary channels I(+) and I(-). Differential, quadrature, or a TTL level encoder inputs.

Table 6.Q Motor Encoder Output Signal

The input circuits shown in the following diagrams support connections to differential TTL line drivers, single-ended TTL line drivers and open collector devices. These inputs are under software control (refer to Drive Setup).

Specification	Description	Minimum	Maximum
ON State Voltage	Voltage difference between the + and - inputs that indicate an ON state.	1.0 Volts	+15 Volts
OFF State Voltage	Voltage difference between the + and - inputs that indicates an OFF state.	-1.0 Volts	-15 Volts
Common Mode Voltage	Voltagedifference between an encoder signal input and the reference ground of the drive.	-15 Volts	+15 Volts
Current Draw	Current draw into the + input or - input	-5 mA	+5 mA
A or B Signal Frequency	Frequencyof the A or B line inputs. Count frequency is 4 times this frequency, since the circuitry counts each of the four transitions in a single line.		1 MHz
Index Pulse Width	Pulse width of the index signal. The index signal is active for a percentage of the revolution, therefore the speed of the encoder dictates the pulse width.	500 nsec	

Table 6.R Quadrature Interface Specifications

INTERFACE CABLE EXAMPLES

The use of differential signals is highly recommended. This is due to the immunity of differential signals to common mode interference. Single-ended encoder interface circuits are not recommended, and may result in system malfunction.

To improve noise immunity, a cable shield should terminate at both ends of the cable. Shields should connect to the back shell of the connectors with termination around the full circumference (360°). The connectors should attach to chassis ground (not signal common).

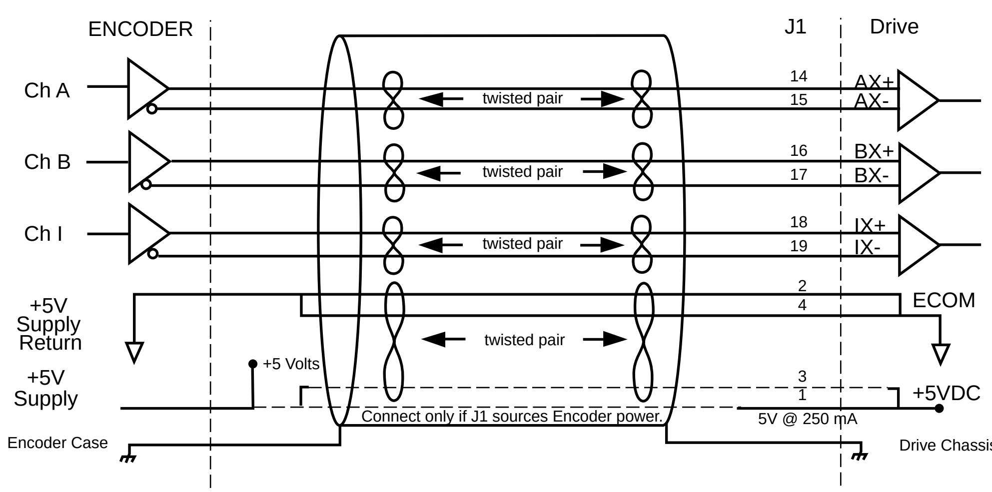


Figure 6.23 External Encoder Interface via TTL Differential Line Drivers

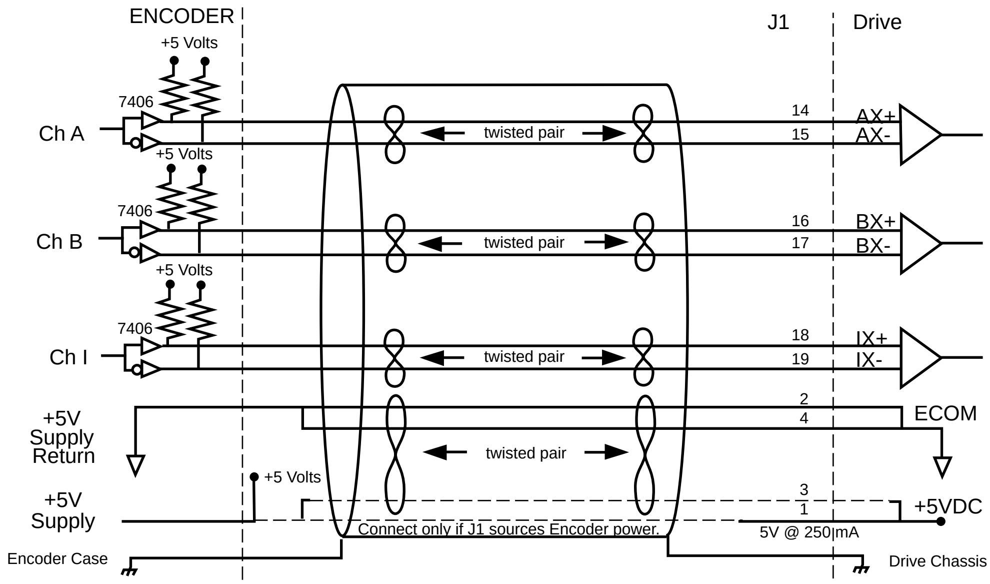


Figure 6.24 Complementary Encoder Interface via 7406 Line Drivers with Pull-up Resistors

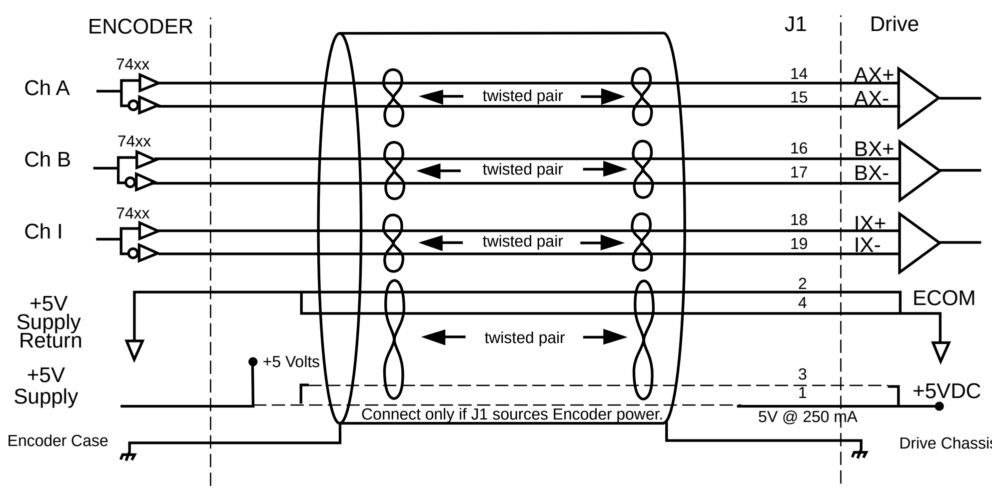


Figure 6.25 Complementary Encoder Interface via Standard TTL Logic

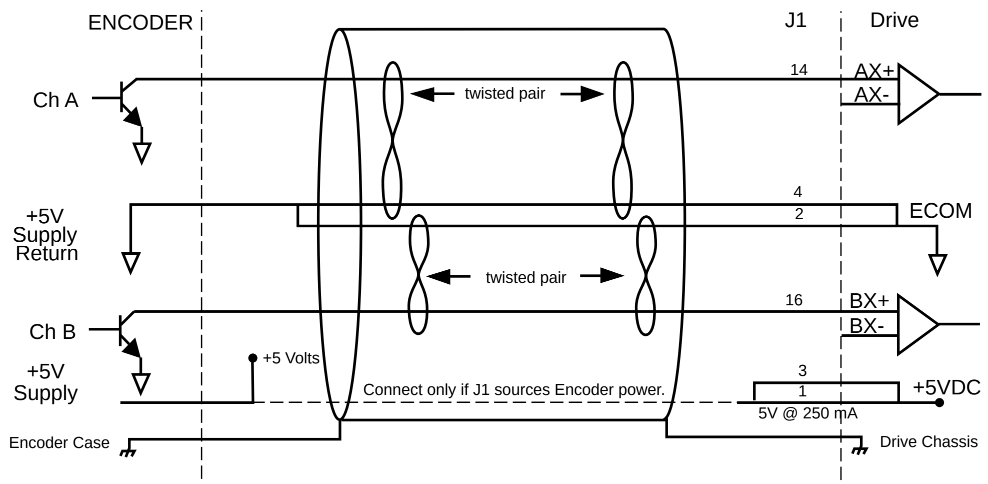


Figure 6.26 Single-Ended Encoder Interface via Open Collector Transistor without Pull-up

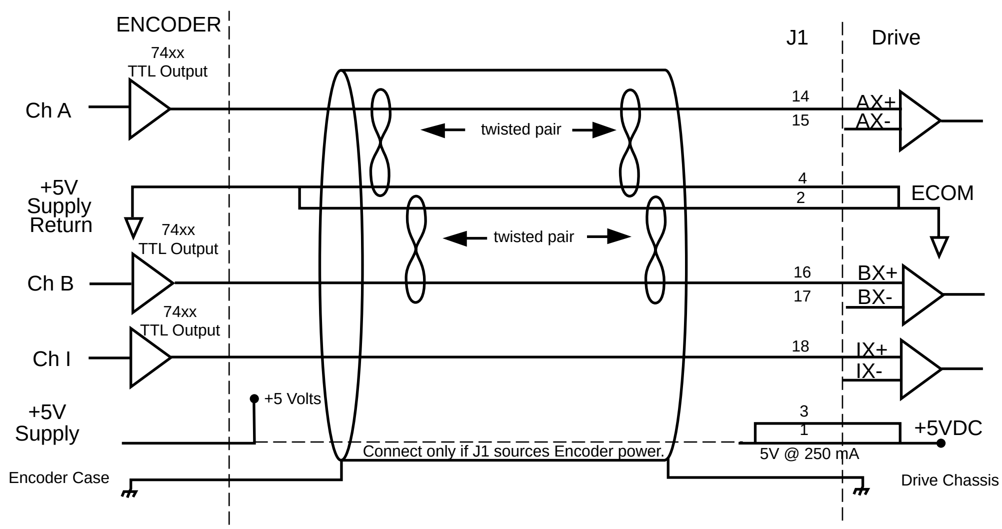


Figure 6.27 Single-Ended Encoder Interface via Standard TTL Signals

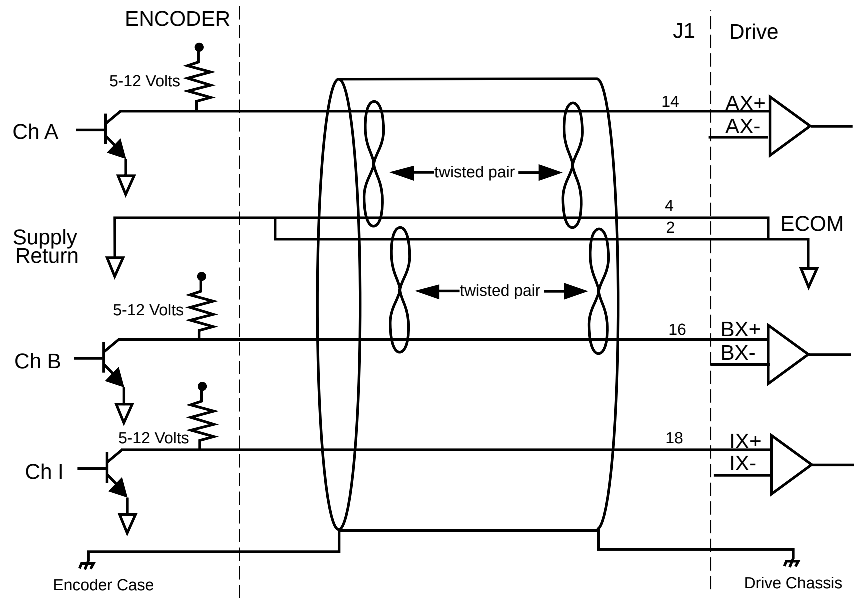


Figure 6.28 Single-Ended Encoder Interface via Open Collector Transistor with 5 VDC to 12 VDC Pull-up

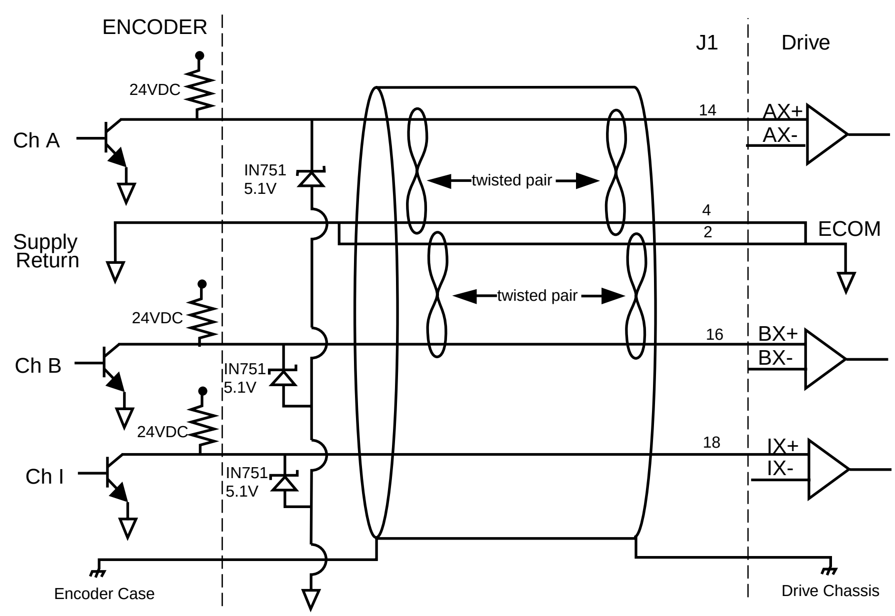


Figure 6.29 Single-Ended Encoder Interface via Open Collector Transistor with 24 VDC Pull-up

Specification	Description	Minimum	Maximum
Signal frequency	Frequency of the input signal		1 Mhz
Pulse Width	Time interval the step (CW/CCW) signal must remain in a single state for detection.	500 nsec	
Setup Time	Time interval the direction (CW/CCW) signal must be stable before the corresponding step (CCW/CW) signal changes state.	500 nsec.	
The following diagram shows the relationship between STEP and DIRECTION inputs.			

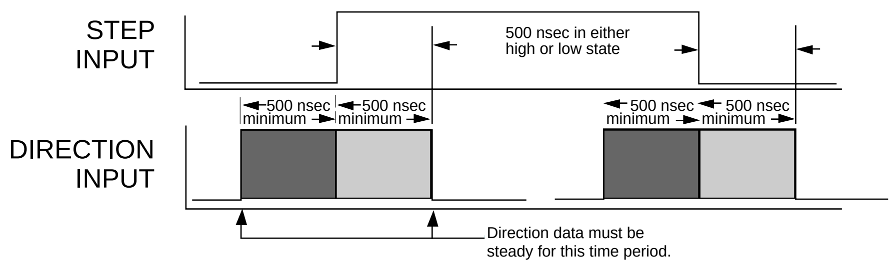


Table 6.S Step/Direction and CW/CCW (Step Up/Step Down) Interface Specifications

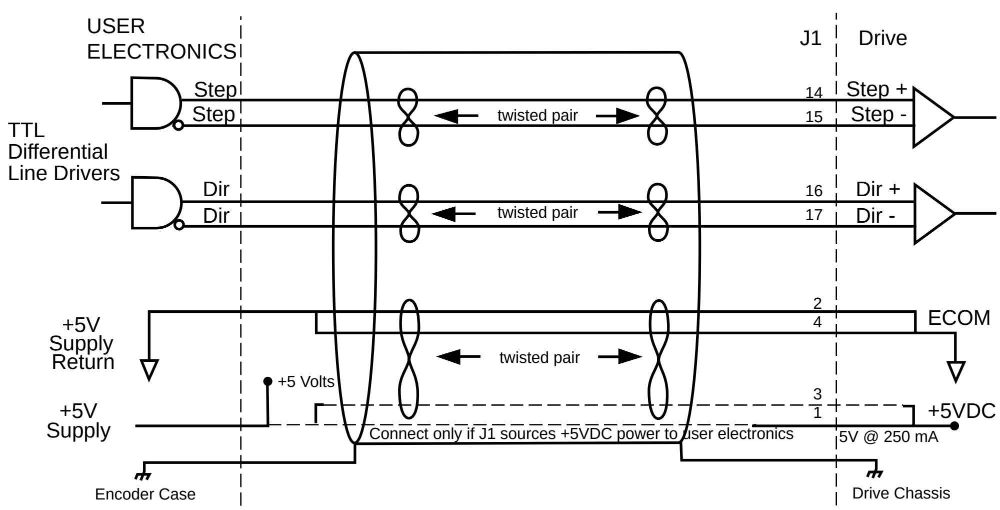


Figure 6.30 External Step/Direction Interface via TTL Differential Line Drivers

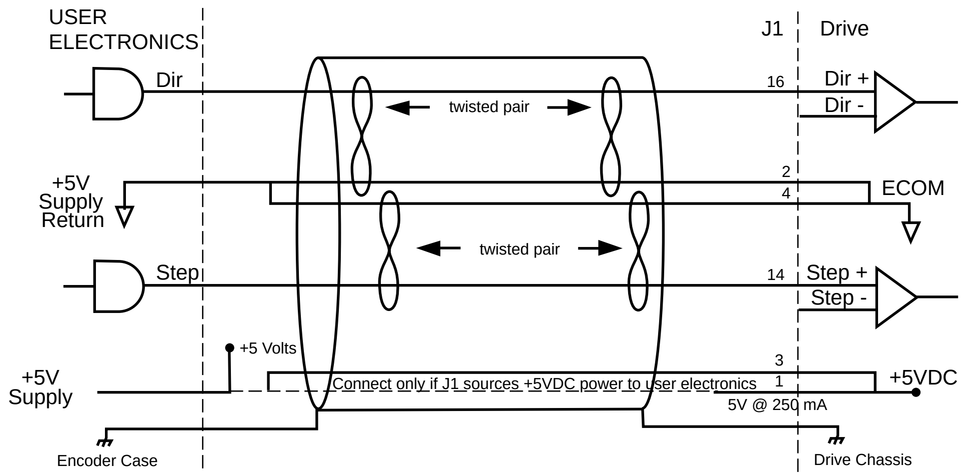


Figure 6.31 External Step/Direction Interface via Single-Ended TTL Line Drivers

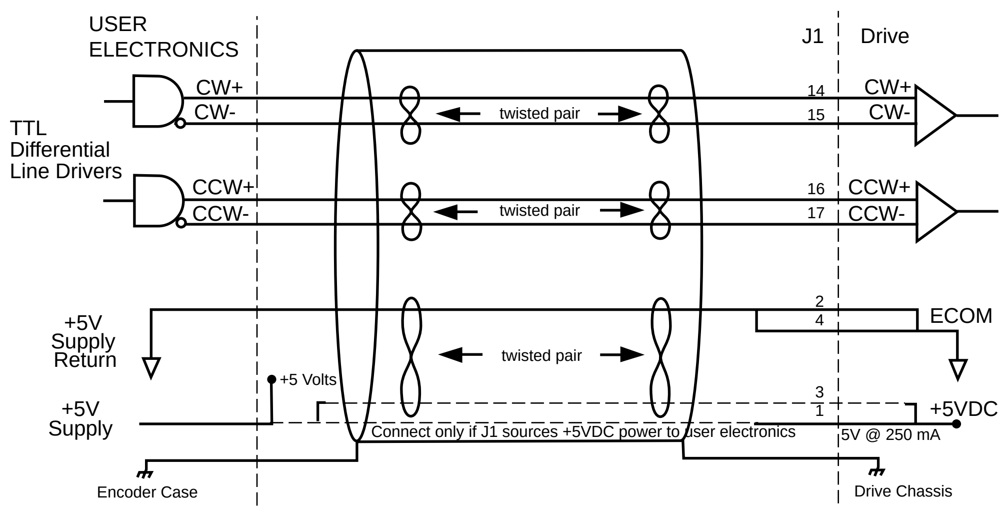


Figure 6.32 External CW/CCW (Step Up/Step Down) Interface via TTL Differential Line Drivers

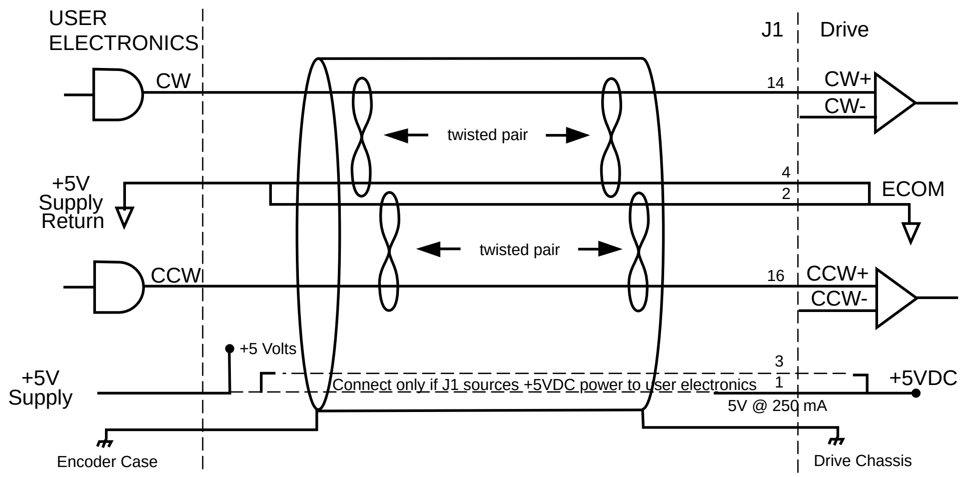
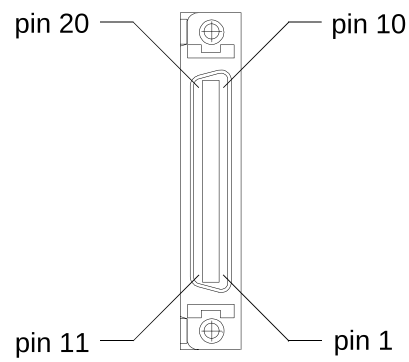


Figure 6.33 External CW/CCW (Step Up/Step Down) Interface via Single-Ended Line Drivers

J2 - ENCODER

Pin & Signal		Description	Pin & Signal		Description
1	EPWR	Encoder Power	11	I (+)	Motor Encoder Input Channel I (+)
2	ECOM	Encoder Common	12	I (-)	Motor Encoder Input Channel I (-)
3	EPWR	Encoder Power	13	A	Hall Effect A
4	ECOM	Encoder Common	14	B	Hall Effect B
5	EPWR	Encoder Power Sense +	15	C	Hall Effect C
6	ECOM	Encoder Power Sense -	16	ABS	Absolute Position
7	A (+)	Motor Encoder Input Channel A (+)	17		Reserved
8	A (-)	Motor Encoder Input Channel A (-)	18		Reserved
9	B (+)	Motor Encoder Input Channel B (+)	19	TS (+)	Thermal Switch (+)
10	B (-)	Motor Encoder Input Channel B (-)	20	TS (+)	Thermal Switch (+)



Cables are available in various lengths for connecting between J2 and the motor encoder. Options & Accessories *on page A-137 lists the cables.*

Caution! Ensure that encoder signals are connected properly. Incorrect connection of encoder signals will result in improper rotor position and/or incorrect commutation.

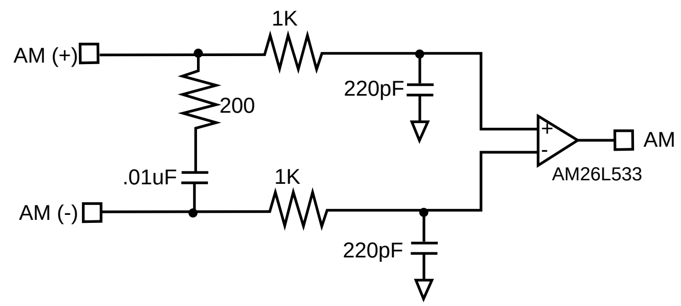


Figure 6.34 Motor Encoder Interface Circuit

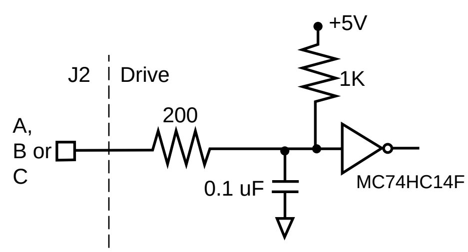
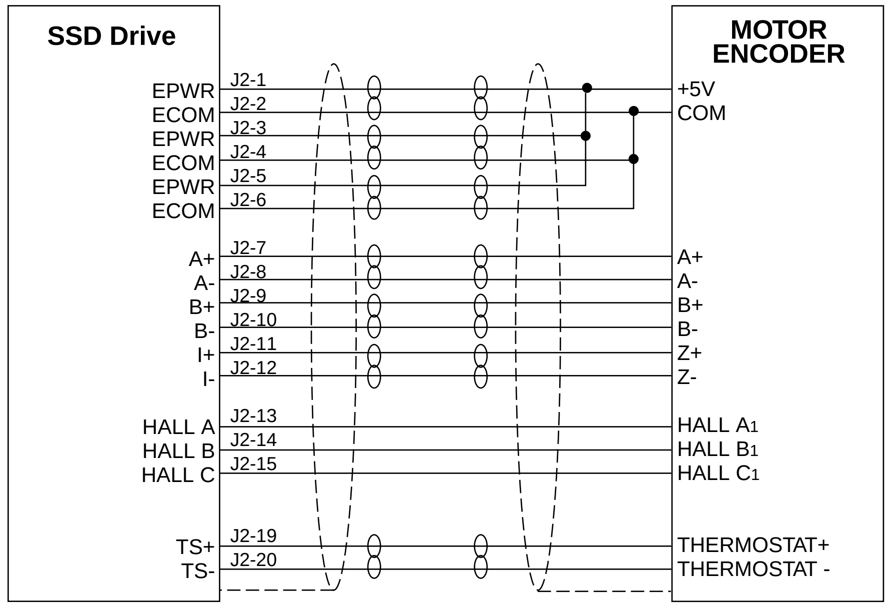


Figure 6.35 Hall Effect Sensor Circuit

Motor Encoder	Motor Encoder	Motor Encoder
EPWR	J2-1 J2-3	Encoder power
ECOM	J2-2 J2-4	Encoder common
A+ A-	J2-7 (+) J2-8 (-)	Motor Encoder Input Channel A+ and Channel A-. Accepts TTL level signals from a line driver.
B+ B-	J2-9 (+) J2-10 (-)	Motor Encoder Input Channel B+ and Channel B-. Accepts TTL level signals from a line driver.
I+ I-	J2-11 (+) JS-12 (-)	Motor Encoder Input Channel I+ and Channel I-. Accepts TTL level signals from a line driver. Output pulse occurs once per motor revolution.
HALL A	J2-13	Hall Effect A sensor logic level input. Internally pulled up to +5VDC through kOhm resistor.
HALL B	J2-14	Hall Effect B sensor logic level input. Internally pulled up to +5VDC through kOhm resistor.
	J2-17 J2-18	Reserved.
TS+ TS-	J2-19 J2-20	Thermal Switch + and Thermal Switch - are a motor overtemperature signal.

a Tol-O-Motion SSD software automatically determines the presence or absence of a motor thermal switch signal based on the motor selected in the Drive Select window. All Tol-O-Matic MRV motors have thermal overheat switches and continuity is provided on these motors.

Table 6.T J2- Motor Encoder Connector Pin-Outs



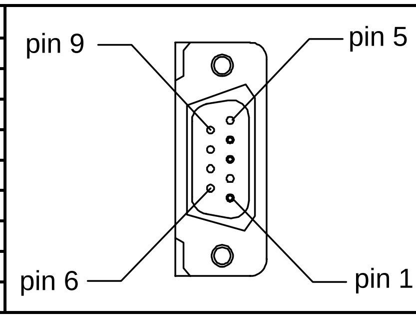
NOTES:

1. For encoders with differential Hall outputs (A+, A-, B+,B-, C+. C-) connect only the + outputs to the drive.

Figure 6.36 Tol-O-Matic SSD Motor Encoder Connections

J3 - SERIAL PORT

Pin & Signal		Description	Description
1	RCV(+)	Receive (+)	RS-485 (four wire)
2	RCV	Receive	RS-232
3	XMT	Transmit	RS-232
4	XMT(+)	Transmit (+)	RS-485 (four wire)
5	COM	+5 VDC Common	
6		Reserved[a]	
7	RCV(-)	Receive (-)	RS-485 (four wire)
8	XMT(-)	Transmit (-)	RS-485 (four wire)
9	Reserved[a]		



(a). J3 is a 9 pin female D-shell (AMP 205204-4, pins AMP 66506-3) connectors. Each connector is a serial interface that allows communication with another SSD drive, a PC, a terminal, a host computer, a controller . The shell of the connector is grounded to the chassis for the shield termination.

Table 6.U J3 Controller Pin-Outs

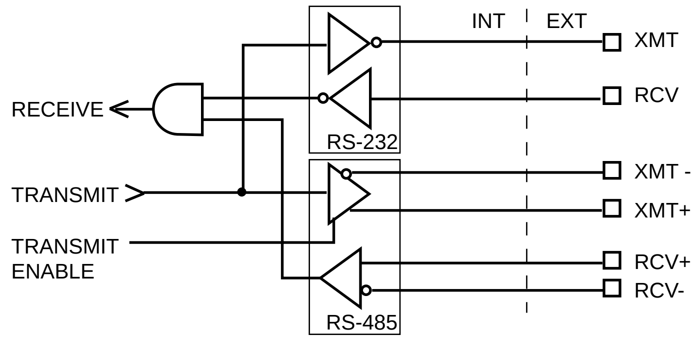


Figure 6.37 RS-232/485 Interface Circuit

The serial interface uses the standard NRZ asynchronous serial format, and supports both the RS-232 and the four wire RS-485 communications standards.

- Standard baud rates include 1200, 2400, 4800, 9600 and 19200 baud. 9600 is the factory default setting.
- Even, odd, and no parity generation/checking are supported.
- No parity is the factory default setting.
- The maximum number of SSD drives allowable on an RS-485 bus is 32.
- The maximum length of an RS-232 cable is 15 meters (50 feet).
- The maximum length of an RS-485 cable is 1220 meters (4000 feet) with 0.20 mm2 (24 AWG) wire.

Options and Accessories on page A-137 lists the cables, and the male and female connectors for the cables.

NOTE: The shell of the connector is grounded to the chassis for shield termination.

Table 6V lists the pin-outs for J3.

Auxiliary Encoder Input	Pin Number	Description
RCV (+) RCV (-)	J3 - 1 (+) J3 - 7 (-)	RS-485 differential receiver input (to drive)
XMT (+) XMT (-)	J3 - 4 (+) J3 - 8 (-)	RS-485 differential transmitter output (from drive)
COM	J3 - 5	common serial port interface
	J3 - 6	Reserved [a]
RCV	J3 - 2	RS-232 reviever input (to drive)
XMT	J3 - 3	RS-232 transmitter output (from drive)
	J3 - 9	Reserved [a]

[a] . Do not connect any deviceto J3 - 6 or J3 - 9

Table 6.V J3 - Serial Port Connector Pin-Outs

Serial Communications Overview

SSD drives communicate via a standard NRZ (non-return to zero) asynchronous serial format, which supports either RS-232 or four-wire RS-485. The pin-out arrangement on the drive serial ports provides self-sensing of the communication standard. To change from RS-232 to four-wire RS-485 requires a simple change of the cable.

In multiple drive installations, a unique address must be assigned to each drive through software. The factory default drive address is setting is Address 0. All addresses changes are made through *Tol-O-Motion SSD* software selection. Up to 32 (1 through 32) are supported.

NOTE: Address and communications settings changes are not immediate; they are logged but do not become active until after the drive is RESET.

Each drive may be assigned a unique name of up to 32 characters in length; a name is often easier to remember than the address of a drive. *Tol-O-Motion SSD* software automatically associates a drive name with the correct drive address.

RS-232 CONNECTIONS

The address of each drive is set using *Tol-O-Motion SSD* software. Refer to the *Tol-O-Motion SSD* on-line Help.

Single Axis RS-232 setup

A single SSD drive may be selected using RS-232 communications. After cabling is attached to the unit and the drive address is assigned, configuration of (i.e., communications with) the unit may proceed.

Factory default settings for a SSD drive are:

- Address 0
- 9600 Baud
- 8 Data, No Parity, 1 Stop bit

To select the communications options:

1. Connect an RS-232 cable between the computer and a serial connector on the drive (J3).

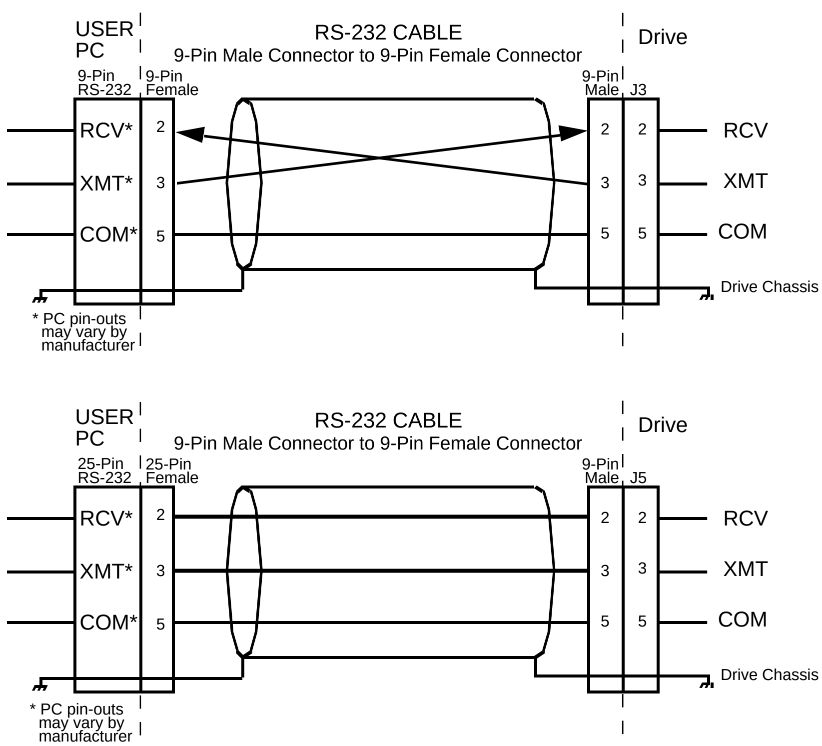


Figure 6.38 RS-232 Connection Diagrams

2. Verify the computer can communicate with the drive by performing the following:
   A. Switch drive power to ON.
   B. Start *Tol-O-Motion SSD* on the attached PC.
   C. Choose CANCEL from the Drive Select window.
   D. Select Communications from the menu.
   E. Select PC setup from the pull-down menu.
   F. Verify the port settings, and if necessary, change them, then choose OK.
   G. Select Communications from the menu.
   H. Select Read Drive Parameters from the pull-down menu.
   I. Choose OK in the Drive Select window.

3. Verify that Tol-O-Motion SSD reads the drive parameters. If not, refer to *Troubleshooting* on page 11-123.

NOTE: The Scan Port for Attached Drives option in the Drive Select window of *Tol-O-Motion SSD* will identify any attached drives. If a drive is identified, but cannot be communicated with, the Baud Rate selection must be modified.

The cable diagrams provide wiring examples for both 9 pin and 25 pin serial ports from an IBM compatible personal computer to the drive. RS-232 pin-outs vary between computer manufacturers. Check the hardware reference manual of your machine to ensure correct signal connections between the computer and the drive.

Four-Wire RS-485 Connections

The SSD drives use a variation of the RS-485 standard, known as four-wire RS-485. Four wire RS-485 uses one differential signal for host to drive transmissions, and another differential signal for drive to host transmissions. (The RS-485 standard specifies a single differential signal for transmissions in both directions.)

The four-wire RS-485 configuration also allows the host to use a RS-422 type interface.

Because the host is driving multiple receivers and receiving from multiple transmitters, RS-422 is limited to multiple axes connections with 10 or less drives. The figure below summarizes the four wire RS-485, RS-422, and RS-485 standards.

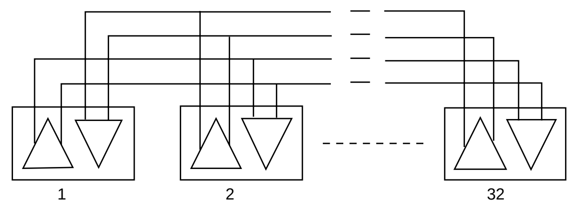
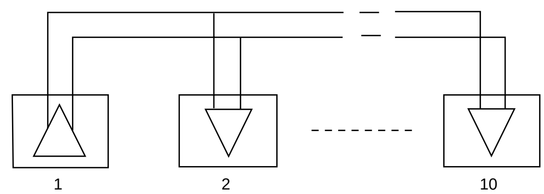
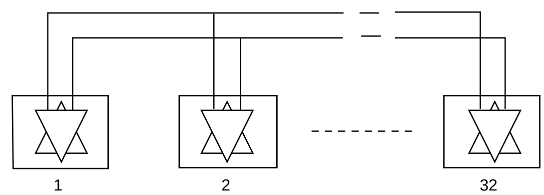
Four Wire RS-485 Differential 4 Wires 2 Signal Pairs 1 to 32 Transmitters 1 to 32 Receivers	
RS-422 Differential 4 Wires 2 Signal Pairs 1 Transmitter 1 to 10 Receivers	
RS-485 Standard Differential 2 Wires 1 Signal Pair 1 to 32 Transmitters 1 to 32 Receivers NOTE: Not applicable to SSD drives	

Figure 6.39 RS-485/RS-422 Communication Comparison

Multiple Axes Four-Wire RS-485 Communications

1. Select a previously unused address (1 - 32) from *Tol-O-Motion SSD* - Drive setup.

2. Connect cables between:
   A. The host computer and the serial port on the initial drive (J3) in the multiple drive configuration.
   B. The other serial port on the initial drive (J3) and the serial port on the next drive (J3) in the multiple drive configuration

NOTE: Flat ribbon cabling is not recommended for RS-485 connections.

3. Verify the communication settings on the computer are correct:
   A. Start *Tol-O-Motion SSD* on the attached PC
   B. Choose CANCEL from the Drive Select window
   C. Select **C**ommunications from the menu
   D. Select **P**C setup from the pull down menu.
   E. Verify the port settings, and if necessary, change them, then choose OK.

NOTE: Address 0 is the preferred address for the initial configuration of a drive. It forces the drive to the default communications parameters.

4. Verify the ability to communicate between the computer and the connected drives by:
   A. Switch drive power to ON.
   B. Select **C**ommunications from the menu.
   C. Select **R**ead Drive Parameters from the pull down menu.
   D. Select the drive to communicate with from Drive Select window (the drive must have an address that matches one of the drive addresses in the chain).
   E. Choose OK in the Drive Select window.

5. Verify that *Tol-O-Motion SSD* loads the drive parameters. If not, refer to the troubleshooting section.

6. Repeat the preceding two steps for each additional drive.

Four-wire RS-485 connections are shown below. The cable diagram provides a wiring example of a daisy chain connection in a typical installation A multi-drop cable, as shown in Figure 6.40 may also be used.

Multiple Axes RS-232 Communications

Multiple axes systems may be controlled by a computer with an RS-232 serial port. An RS-232 serial communication port may be converted to four-wire RS-485 communication by attaching an RS-232 to four-wire RS-485 converter. Figure 6.40 depicts the use of such a device.

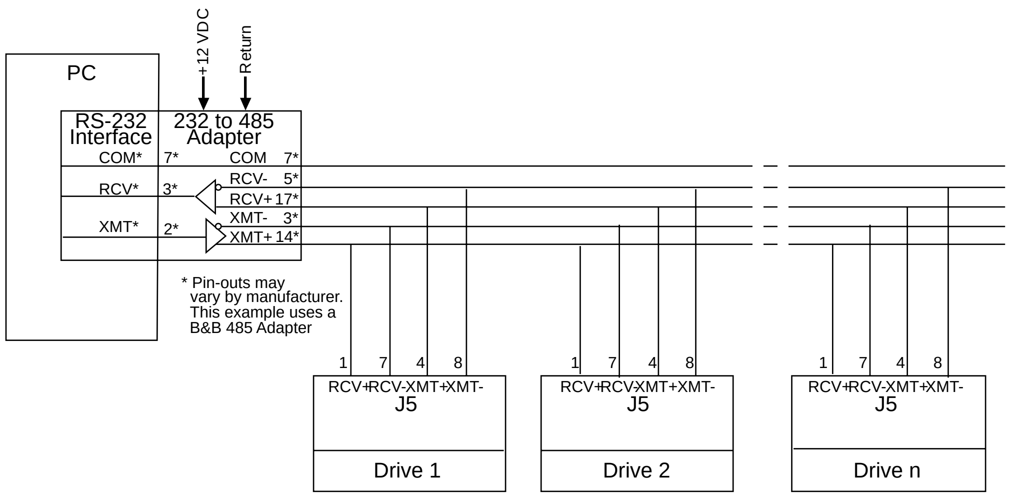


Figure 6.40 RS-232 to RS-485 Multi-Drop Connection Diagram

7 Power Connections

DC bus, single phase AC power and motor connections are provided on the Terminal Block (TB-1).

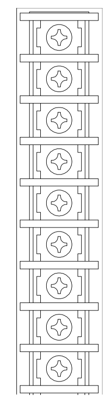
Description	Identifier	Terminal	SSD-005 SSD-010 SSD-020
DC Bus + voltage	DC BUS +	1	
DC Bus - voltage	DC BUS -	2	
100/240 VAC input power	L1 (Line 1)	3	
100/240 VAC input power	L2 (Line 2)/ N (Neutral)	4	
Safety (earth) ground	⏚	5	
R phase power to motor	R	6	
S phase power to motor	S	7	
T phase power to motor	T	8	
Motor case ground	⏚	9	

Table 7.A TB1 - DC Bus and AC Power Terminal Block Connections

***DANGER!* DC bus capacitors may retain hazardous voltages after input power has been removed, but will normally discharge in several seconds. Before working on the drive, measure the DC bus voltage to verify it has reached a safe level or 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.**

WARNING! Motor power connectors are for assembly purposes only. They should not be connected or disconnected while the drive is powered.

Motor Power Cabling

Terminals 6 through 9 connect the drive to the windings of the motor.

NOTE: Proper phasing of these outputs relative to the motor terminals is critical. Double check the connections after wiring the motor.

Table 7.B lists the drive terminals and typical motor connections. Table 7.C on page 7-76 lists the minimum wire size for making

Motor Phase Signal	Description	Terminal
R	R phase from drive	TB1-6
S	S phase from drive	TB1-7
T	T phase from drive	TB1-8
⏚	Ground for the motor case	TB1-9
NOTE: Torque all terminal connections to 1.25 Nm (11.0 lb-in).		

Table 7.B Drive Terminals and Motor Connections

Refer to *Options and Accessories* on page A-137 for a list of available Tol-O-Matic cables.

MOTOR OVERLOAD PROTECTION

The drive utilizes solid state motor overload protection which operates:

- within 8 minutes at 200% overload
- within 20 seconds at 600% overload.

EMERGENCY STOP WIRING

An overlapping contactor may be inserted between the motor and the drive for emergency stop purposes. The contactor must not simply break the motor current, it also must switch a three phase resistive load in parallel with the motor windings.

The three resistors provide dynamic braking. In addition, they prevent continuous arcing at the main contacts when breaking DC currents, such as when the motor stalls. Simply breaking the motor current can result in high voltages due to motor inductance, which will cause prolonged arcing in the contactor. In extreme cases, the prolonged arcing could result in the contactor catching fire. An overlapping contactor provides the required timing by engaging the braking contactors before the drive contactors disengage.

Figure 7.1 depicts a contactor installation with resistive loads.

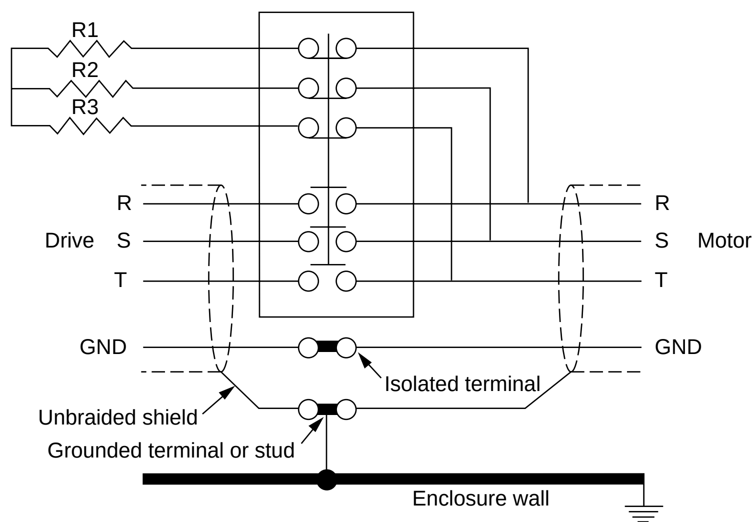


Figure 7.1 Emergency Stop Contractor Wiring

Guidelines for the installation include:

- Resistor values should be one to four times the winding resistance for good braking performance. Refer to the appendix *Dynamic Braking Resistor Selection* beginning on page D-149 for resistor sizing equations.
- Screen and ground cables should be connected as shown.
- Shields should be unbraided (not a drain wire soldered to the shield).
- Connection lengths should be minimized.
- Safety ground (GND) and shield connections are permanently connected. This is essential for electrical safety.
- EMC guidelines require connection of the shield at the point where the contactor is inserted.

AC POWER CABLING

The SSD5, SSD10 and SSD20 drives require single phase, 100 to 240 VAC rms power with an input frequency of 47 - 63 Hz. *Power* on page E-158 lists the output power characteristics of the drives. The AC input supplies power to the motor. Alternatively, the drive may be powered by an external DC power source. In either case, an external power source must provide input power to the I/O.

Terminals 3, 4 and 5 are the single phase AC input power connections for the SSD5, SSD10, SSD20.

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

WARNING! High voltage may be present on the terminals of the drive. Remove power and disconnect the power cable before making or removing any connection.

Caution! Do not tin (solder) the exposed leads on cables. Solder contracts over time and may loosen the connection.

Signal	Description	Terminal
L1	100/240 Volts AC Line 1 input power.	TB1-3
L2/N	100/240 Volts AC Neutral.	TB1-4
⏚	Safety (earth) ground	TB1-5
NOTE: Torque all terminal connections to 1.25 Nm (11.0 lb-in).		

Table 7.C TB1 - AC Power Terminals

Drive Model	Input Current	Inrush Current	Fuse Size[1]	Wire Size mm (AWG)	Transformer Size	
SSD5	5 A ACrms	75 A peak	5 A	1.5 (16)	1 kVA min	100 kVA max
SSD10	9 A. ACms	100 A peak	19 A	2.5 (14)	2 kVA min	100 kVA max
SSD20	18 A. ACrms	100 A peak	20 A	4.0 (12)	4 kVA min	100 kVA max

1. In the United States, the National Electrical Code (NEC), specifies that fuses must be selected based on the motor full load amperage (FLA), which is not to be confused with the drive input current. The largest fuse allowed under any circumstances is four times the motor FLA. Therefore the largest fuse permissible for use with the SSD is four times the motor rated continuous current (converted to an RMS value). The SSD has been evaluated and listed by Underwriters Laboratories Inc. with fuses sized as four times the continuous output current of the drives (FLA), according to UL 508C.

In almost all cases fuses selected to match the drive input current rating will meet the NEC requirements and provide the full drive capabilities. Dual element, time delay (slow acting) fuses should be used to avoid nuisance trips during the inrush current of power initialization. The fuse sizes listed are recommended values, but local regulations must be determined and adhered to.

The SSD utilizes solid state motor short circuit protection rated as follows:

Short Circuit Current Rating with No Fuse Restrictions:

Suitable for use on a circuit capable of delivering not more than 5000 RMS symmetrical Amperes, 240 Volts maximum.

Short Circuit Current Rating with Fuse Restrictions:

Suitable for use on a circuit capable of delivering not more than 200,000 RMS symmetrical Amperes, 240 Volts maximum, when protected by high interrupting capacity, current limiting fuses (Class CC, G, J, L, R, T).

Table 7.D AC Input Power Sizing Requirements

Applications and Configuration Examples 8

This chapter provides information on how to install and verify the SSD drive for various modes of operation. The procedures verify the installation by:

- Showing how the power and logic wiring is connected.
- Selecting the operational mode (Velocity or Torque) for the drive using a specified analog input signal type.
- Tuning the drive for a particular motor type and size.
- Verifying the basic functionality of the drive and motor combination.

Analog Control

If a Tol-O-Matic SSC Controller is being used, the drive will be pre-configured to run using Analog Control at the factory. No additional adjustments should be necessary. (Please consult the *SSC Controller* manual.)

To setup the unit as an Analog drive in either the Velocity or Torque mode, make the connections described below. Figure 8.1 depicts the minimum hardware necessary. Interfacing the drive to a controller requires similar output circuitry from the controller to J1. Instructions are provided to configure the drive with *Tol-O-Motion SSD* software.

HARDWARE SETUP

Make the connections described below and shown in Figure 8.1.

1. Connect a ±10VDC power source as shown to provide the analog speed or torque command.

2. Connect an RS-232 cable between the serial port on the PC and the J3 connector on the drive, or connect a TouchPad to the J3 connector.

3. Connect a Motor/Feedback cable from the motor to the J2 connector on the drive.

4. Connect a Power cable from the motor to TB1 (terminals R, S, T and ⏚) on the drive.

5. Connect a jumper wire with switches between the following pins:
   - J1-20 (ENABLE) and J1-26 (I/O PWR)
   - J1-21 (FAULT RESET) and J1-26 (I/O PWR)

   These connections provide manual control for enabling or disabling the drive and resetting faults. Figure 8.1 shows the jumper, including normally open toggle switches.

6. Connect an external 12-24 VDC power source for powering I/O to J1-5 (I/O PWR) and J1-6 (I/O COM).

7. Connect the drive to a single phase 100/240 VAC, 50/60 Hz power source.

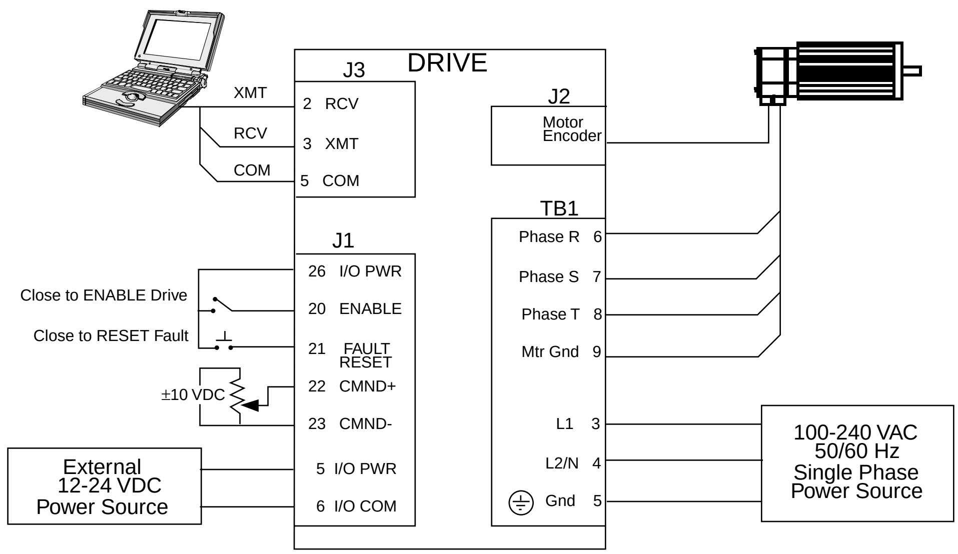


Figure 8.1 Analog Controller Connection Diagram

CONFIGURATION

Carefully check all connections before entering these parameters.

1. Switch the AC Power to ON and verify:
   - Status LED is green. Refer to *Status Indicator* on page 10-117 for an explanation of the display codes.

2. Start *Tol-O-Motion SSD* on the PC.

3. Choose Cancel from the Drive Select dialog box.

4. Select PC setup from the Communications menu in *Tol-O-Motion SSD* to display the personal computer's communication settings.

5. Verify the communication port settings of the PC match those of the drive. Factory default drive settings are:
   - Baud Rate: 9600
   - Data Bits: 8
   - Parity: None
   - Stop Bits: 1
   - Serial Port: COM1

   Select OK in the Port - Settings dialog box when the settings are correct.

6. Select Read Drive Parameters from the Communications menu.

7. Verify the *Drive Name* and *Address* are correct for the drive that is being addressed.

8. Choose OK to load the drive parameters.

   NOTE: A motor must be selected for the parameters to load.

9. If the message box appears that a motor must be selected, select OK. The Drive Setup window is displayed with Motor Model selection parameter active. The motor may be selected from the drop down box. If this message box does not appear, the motor displayed in the Motor Model box was previously selected.

10. Select or verify the correct motor model number from the drop down Motor Model list.

11. Choose OK, if a message advises that the drive must be reset. A change in motor parameters requires reselection of the firmware based drive/motor tables. The software reset is required to prevent improper sequencing of these table parameters.

12. Select the Operator Mode parameters for the drive:

Velocity Mode Settings	Torque Mode Settings
Analog Velocity Input as the operator mode	Torque Velocity Input as the operator mode

13. Choose Close from the Drive Setup window.

14. Choose the Drive **P**arameters command icon from the Drive window.

15. Select the appropriate parameters from the Drive Parameters window for the command mode in which the drive will operate:

Velocity Mode Settings	Torque Mode Settings
Analog as the Command Source Enter appropriate Scale and Offset values for the Analog Input.	Analog as the Command Source Enter appropriate Scale and Offset values for the Analog Input.

16. Choose Close to exit the window.

17. Verify the Status LED is green.

18. Select the I/O **C**onfiguration command icon from the Drive window.

19. Select or verify that all I/O Input Assignments are Not Assigned.

20. Choose Close to exit the window.

21. If Torque mode was selected in Step 12, disregard Steps 21 to 28. Tuning is not available for drives operating in Torque mode. If Velocity mode was selected in Step 12, continue with Step 21 to tune the drive.

22. Choose the Tuning command icon from the Drive window.

    NOTE: Do *not* attempt to Auto Tune systems that have gravitational effects. The drive will not hold initial position.

    NOTE: Do *not* attempt to Tune a drive with the Command Source set for Torque.

23. Select **A**uto Tune from the Tuning Mode group.

24. Select the appropriate values for the following Auto Tune commands.
    - Distan**c**e
    - S**t**ep Current
    - Motor Direction (**B**iDirectional, For**w**ard Only or R**e**verse Only)

25. Close the toggle switch between J1-26 and J1-20 to enable the drive.

26. Choose **S**tart from the Tuning window. The drive powers the motor shaft for a short period and then motion will cease. Then *Tol-O-Motion SSD* displays the calculated gains and disables the drive.

27. Open the switch between J1-26 and J1-20 to disable the drive.

28. Choose **N**ormal Drive Operation from the Tuning window.

29. Choose Close to exit the Tuning windows.

    The drive is now configured as an analog controller in either the Velocity or Torque mode.
    - The current loop is compensated properly for the selected motor.
    - The servo parameters have been setup with the unloaded motor.
    - The encoder output resolution is set to the default of divide by 1.

    The motor speed or current is commanded through the analog input. The fully digital design saves these parameters in EEPROM memory. The drive can be power cycled and, after power-up, run the parameters selected in the steps above.

START-UP

When motion is required.

1. Close the switch between J1-26 and J1-20 to enable the drive.

Preset Controller

To setup the unit as a Preset drive in the Velocity or Torque mode, make the connections described below. The following table shows the three discrete digital inputs A, B, C that select the programmable speed or torque control. Up to eight different preset speed or torque settings can be selected by using the three digital inputs in various binary combinations. Figure 8.2 depicts the minimum hardware necessary. Interfacing the drive to a controller requires similar output circuitry from the controller to J1. Instructions are provided to configure the drive with Tol-O-Matic software. Wired inputs 1,2,3 can be software configured as A, B or C.

	Inputs			
	C	**B**	**A**	**Description**
Preset 0	0	0	0	Preset 0 is a preprogrammed speed or current. All inputs are OFF[1].
Preset 1	0	0	1	Preset 1 is a preprogrammed speed or current. Only Preset Select A input is ON.
Preset 2	0	1	0	Preset 2 is a preprogrammed speed or current. Only Preset Select B input is ON.
Preset 3	0	1	1	Preset 3 is a preprogrammed speed or current. Preset Select A and Preset Select B are ON [2].
Preset 4	1	0	0	Preset 4 is a preprogrammed speed or current. Only Preset Select C input is ON[2].
Preset 5	1	0	1	Preset 5 is a preprogrammed speed or current. Preset Select A and Preset Select C are active ON [2].
Preset 6	1	1	0	Preset 6 is a preprogrammed speed or current. Preset Select B and Preset Select C are active ON [2].
Preset 7	1	1	1	Preset 7 is a preprogrammed speed or current. All Preset Select inputs are ON[2].
[1]A preset input signal that is OFF is inactive, which means no current flows through the optocoupler.				
[2]A preset input signal that is ON is active, which means current flows through the optocoupler.				

Table 8.A Preset Binary Velocity or Torque Inputs

HARDWARE SETUP

Make the connections described below and shown in Figure 8.2.

1. Connect an RS-232 cable between the serial port on the PC and the J3 connector on the drive.
   - *Options and Accessories* on page A-137 lists cables available from Tol-O-Matic. *Cable Diagrams, Schematics and Examples* on page B-139 show cable schematics.

2. Connect a Motor/Feedback cable from the motor to the J2 connector on the drive.

3. Connect a Power cable from the motor to TB1 (terminals R, S, T and) on the drive.

4. Connect a jumper wire with a toggle switch between the following pins:
   - J1-20 (ENABLE) and J1-26 (I/O PWR)
   - J1-32 (INPUT1) and J1-26 (I/O PWR)
   - J1-33 (INPUT2) and J1-26 (I/O PWR)
   - J1-34 (INPUT3) and J1-26 (I/O PWR)
   - Connect a switch between J1-21 (FAULT RESET) and J1-26 (I/O PWR).

   These connections provide manual control for enabling or disabling the drive and resetting faults.Figure 8.2 shows the jumper, including normally open toggle switches.

5. Connect an external 12-24 VDC power source for powering I/O to J1-5 (I/O PWR) and J-6 (I/O COM).

6. Connect the drive to a single phase 100/240 VAC, 50/60 Hz power source.

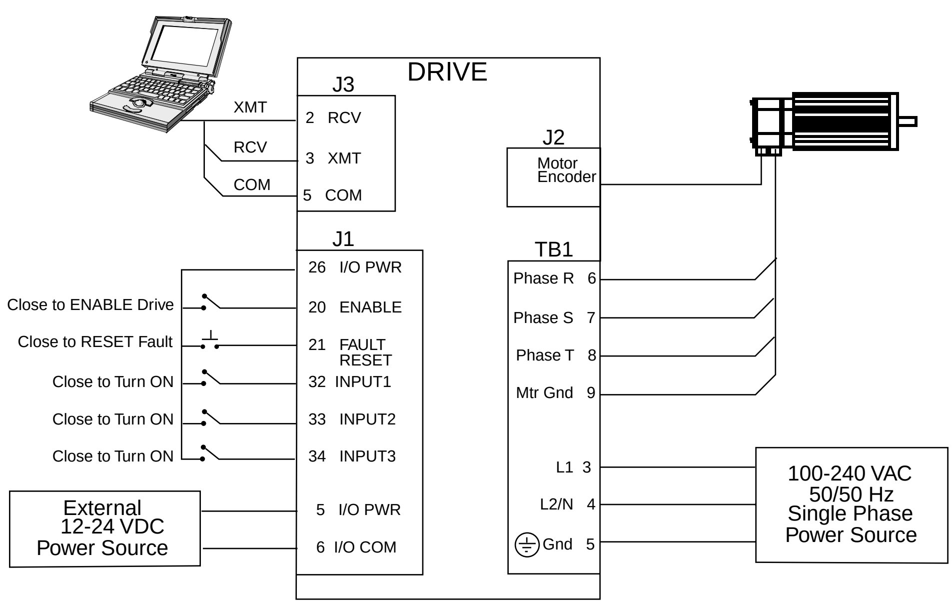


Figure 8.2 Preset Controller Connection Diagram

CONFIGURATION

Carefully check all connections before entering these parameters.

1. Switch the AC Power to ON and verify:

   - Status LED is green. Refer to *Status Indicator* on page 10-117 for an explanation of the display codes.

2. Start *Tol-O-Motion SSD* on the PC.

3. Choose Cancel from the Drive Select dialog box.

4. Select PC setup from the Communications menu in *Tol-O-Motion SSD* to display the personal computer's communication settings.

5. Verify the communication port settings of the PC match those of the drive. Factory default drive settings are:
   - Baud Rate: 9600
   - Data Bits: 8
   - Parity: None
   - Stop Bits: 1
   - Serial Port: COM1

   Select OK in the Port - Settings dialog box when the settings are correct.

6. Select Read Drive Parameters from the Communications menu.

7. Verify the Drive Name and Address are correct for the drive that is being addressed.

8. Choose OK to load the drive parameters. **NOTE:** A motor must be selected for the parameters to load.

9. If the message box appears that a motor must be selected, select OK. The Drive Setup window is displayed with Motor Model selection parameter active. The motor may be selected from the drop down box. If this message box does not appear, the motor displayed in the Motor Model box was previously selected.

10. Select or verify the correct motor model number from the drop down Motor Model list.

11. Choose OK, if a message advises that the drive must be reset. A change in motor parameters requires reselection of the firmware based drive/motor tables. The software reset is required to prevent improper sequencing of these table parameters.

12. Select the Operator Mode parameters for the drive:

Velocity Mode Settings	Torque Mode Settings
Preset Velocities as the operator mode	Preset Torques as the operator mode

13. Choose Close from the Drive Setup window.

14. Choose the Drive Parameters command icon from the Drive window.

15. Select the appropriate parameters from the Drive Parameters window for the command mode in which the drive will operate:

Velocity Mode Settings	Torque Mode Settings
Presets as the Command Source	Presets as the Command Source
Enter appropriate speed(s) for the application	Enter appropriate torque(s) for the application

16. Choose Close to exit the window.

17. Verify the Status LED is green.

18. Select Close to exit the dialog box.

19. Select the I/O Configuration command icon from the Drive window.

    Assign a digital input to each of the three Preset Selects (A, B and C): For example, the following selects three presets:
    - Input 1 to Preset Select A
    - Input 2 to Preset Select B
    - Input 3 to Preset Select C

The three presets provide up to eight binary combinations of speed or current. Not assigned preset inputs are forced to an OFF state. Refer to Table 8.A.

20. Choose Close to exit the window.

21. If Torque mode was selected in Step 14, disregard Steps 21 to 28. Tuning is not available for drives operating in Torque mode. If Velocity mode was selected in Step 14, continue with Step 21 to tune the drive.

22. Choose the Tuning command icon from the Drive window.

    NOTE: Do *not* attempt to Auto Tune systems that have gravitational effects. The drive will not hold initial position.

    NOTE: Do *not* attempt to Tune a drive with the Command Source set for Torque.

23. Verify the Status LED is green.

24. Select Auto Tune from the Tuning Mode group.

25. Select the appropriate values for the following Auto Tune commands.
    - Distance
    - Step Current
    - Motor Direction (BiDirectional, Forward Only or Reverse Only)

26. Close the toggle switch between J1-26 and J1-20 to enable the drive.

27. Choose Start from the Tuning window. The drive powers the motor shaft for a short period and then motion will cease. Then *Tol-O-Motion SSD* displays the calculated gains and disables the drive.

28. Choose Normal Drive Operation from the Tuning window.

29. Open the switch between J1-26 and J1-20 to disable the drive.

30. Choose Close to exit the Tuning window.

31. Verify the Status LED is green.

32. Close any open windows or dialog boxes.

    The drive is now configured as either a preset controller in the Velocity or Torque mode.

    - The current loop is compensated properly for the selected motor.
    - The servo parameters have been setup with the unloaded motor.
    - The encoder output resolution is set to the default of divide by 1.

    The motor speed or current is controlled through the digital inputs. The fully digital design saves the parameters in EEPROM memory. Thus the drive can be power cycled and, after power-up, run the parameters set in the steps above.

START-UP

When motion is required:

1. Close the switch between J1-26 and J1-20 to enable the drive.

2. Close any of the switches for INPUT1, INPUT2 or INPUT3 to run the drive at the programmed preset speed or torque.

Position Follower (Master Encoder)

The drive can be electronically geared to a master incremental encoder generating quadrature encoder signals. Make the connections below to setup the drive as a position follower. Figure 8.3 depicts the minimum hardware necessary. Interfacing the drive to a controller requires similar output circuitry from the controller to J1. Instructions are provided to configure the drive with *Tol-O-Motion SSD* software.

NOTE: If the SSD is enabled without defining one of the Digital Inputs as Follower Enable, *Tol-O-Motion SSD* automatically configures the SSD as the follower.

HARDWARE SETUP

Make the connections described below and shown in Figure 8.3.

1. Connect an RS-232 cable between the serial port on the PC and the J3 connector on the drive.

   - *Options and Accessories* on page E-137 lists cables available from Tol-O-Matic. *Cable Diagrams, Schematics and Examples* on page B-139 shows cable schematics.

2. Connect a Motor/Feedback cable from the motor to the J2 connector on the drive.

3. Connect a Power cable from the motor to TB1 (terminals R, S, T and GND) on the drive.

4. Connect the Master Encoder to the drive as shown in the diagram.

5. Connect a jumper wire with a switch between each of the following pins:
   - J1-20 (ENABLE) and J1-26 (I/O PWR)
   - J1-32 (INPUT1) and J1-26 (I/O PWR)
   - J1-21 (FAULT RESET) and J1-26 (I/O PWR).

   These connections provide manual control for enabling or disabling the drive and resetting faults. Figure 8.3 shows the jumper, including normally open toggle switches.

6. Connect an external 12-24 VDC power source for powering I/O to J1-5 (I/O PWR) and J-6 (I/O COM).

7. Connect the drive to a single phase 100/240 VAC, 50/60 Hz power source.

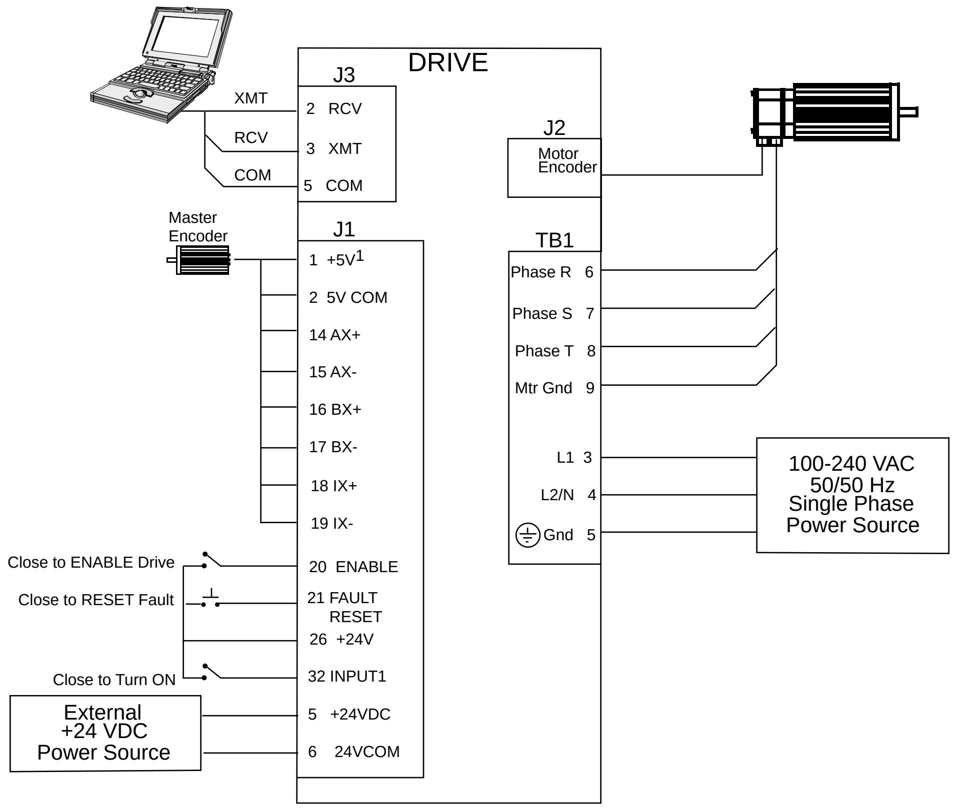


Figure 8.3 Position Follower (Master Encoder) Connection Diagram

CONFIGURATION

Carefully check all connections before entering these parameters.

1. Switch the AC power to ON and verify:
   - Status LED is green. Refer to *Status Indicator* on page 10-117 for an explanation of the display codes.

2. Start *Tol-O-Motion SSD* on the PC.

3. Choose Cancel from the Drive Select dialog box.

4. Select PC setup from the Communications menu in *Tol-O-Motion SSD* to display the personal computer's communication settings.

5. Verify the communication port settings of the PC match those of the drive. Factory default drive settings are:
   - Baud Rate: 9600
   - Data Bits: 8
   - Parity: None
   - Stop Bits: 1
   - Serial Port: COM1
   - Select OK in the Port - Settings dialog box when the settings are correct.

6. Select Read Drive Parameters from the Communications menu.

7. Verify the Drive Name and Address are correct for the drive that is being addressed.

8. Choose OK to load the drive parameters.

   NOTE: A motor must be selected for the parameters to load.

9. If the message box appears that a motor must be selected, select OK. The Drive Setup window is displayed with Motor Model selection parameter active. The motor may be selected from the drop down box. If this message box does not appear, the motor displayed in the Motor Model box was previously selected.

10. Select or verify the correct motor model number from the drop down Motor Model list.

11. Choose OK, if a message advises that the drive must be reset. A change in motor parameters requires reselection of the firmware based drive/motor tables. The software reset is required to prevent improper sequencing of these table parameters.

12. Choose Close from the Drive Setup window.

13. Choose the Drive Parameters command icon from the Drive window.

14. Select the appropriate parameters from the Drive Parameters window for the command mode in which the drive will operate:

    Master Encoder as the Command Source

    Velocity as the Mode

    Enter an appropriate Gear Ratio as the Follower Input.

15. Choose Close to exit the window.

16. Verify the Status LED is green.

17. Select the I/O Configuration command icon from the Drive Window.

18. Select an appropriate digital input from the pull-down lists available as *Digital Input Assignments* in the *I/O Configuration* window.

    For example:
    - Follower Enable as Input 1
    - Not Assigned as Inputs 2 through 3.

19. Choose Close to exit the window.

20. Choose the Tuning command icon from the Drive window.

    NOTE: Do *not* attempt to Auto Tune systems that have gravitational effects. The drive will not hold initial position.

    NOTE: Do *not* attempt to Tune a drive with the Command Source set for Torque.

21. Verify the Status LED is green.

22. Select AutoTune from the Tuning Mode group.

23. Select the appropriate values for the following Auto Tune commands.
    - Distance
    - Step Current
    - Motor Direction (BiDirectional, Forward Only or Reverse Only)

24. Close the toggle switch between J1-26 and J1-20 to enable the drive.

25. Choose Start from the Tuning window. The drive powers the motor shaft for a short period and then motion will cease. Then *Tol-O-Motion SSD* displays the calculated gains and disables the drive.

26. Choose Normal Drive Operation from the Tuning window.

27. Open the switch between J1-26 and J1-20 to disable the drive.

28. Choose Close to exit the Tuning window.

29. Verify the Status LED is green.

30. Close any open windows or dialog boxes.

The drive is now configured as a Position Follower.

- The current loop is compensated properly for the selected motor.
- The servo parameters have been setup with the unloaded motor.
- The encoder output resolution is set to the default of divide by 1.

The motor speed and position is controlled by the master encoder input. The fully digital design saves the parameters in EEPROM memory. Thus the controller can be power cycled and, after power-up, run the parameters set in the steps above.

START-UP

When motion is required:

1. Close the switch between J1-26 and J1-20 to enable the drive.

2. Close the switch between J1-26 and J1-32 to enable the follower mode.

Position Follower (Step/Direction)

If a Tol-O-Matic MSC Controller is to be used, the SSD drive will be pre-configured for step/direction control at the factory. No additional adjustments should be necessary. (Please consult the Tol-O-Matic MSC manual.)

The drive can be electronically geared or driven by *Step and Direction* signals typically used to control stepper drives. Make the connections below to setup the drive as a Position Follower in Velocity mode. Figure 8.4 depicts the minimum hardware necessary. Interfacing the drive to a controller requires similar output circuitry from the controller to J1. Instructions are provided to configure the drive with *Tol-O-Motion SSD* software.

NOTE: If the SSD is enabled without defining one of the Digital Inputs as Follower Enable, *Tol-O-Motion SSD* automatically configures the SSD as the follower.

HARDWARE SETUP

Make the connections described below and shown in Figure 8.4.

1. Connect an RS-232 cable between the serial port on the PC and the J3 connector on the drive.
2. Connect a Motor/Feedback cable from the motor to the J2 connector on the drive.
3. Connect a Power cable from the motor to TB1 (terminals R, S, T and ⏚) on the drive.
4. Connect the Stepper Indexer to the drive as shown in Figure 8.4.The motor is controlled by the indexer commands.
5. Connect a jumper wire with switches between the following pins:
   - J1-20 (ENABLE) and J1-26 (I/O PWR)
   - J1-32 (INPUT 1) and J1-26 (I/O PWR)
   - J1-21 (FAULT RESET) and J1-26 (I/O PWR).

These connections provide manual control for enabling or disabling the drive and resetting faults. Figure 8.4 shows the jumper, including normally open toggle switches.

6. Connect an external 12-24 VDC power source for powering I/O to J1-5 (I/O PWR) and J-6 (I/O COM).

7. Connect the drive to a single phase 100/240 VAC, 50/60 Hz power source.

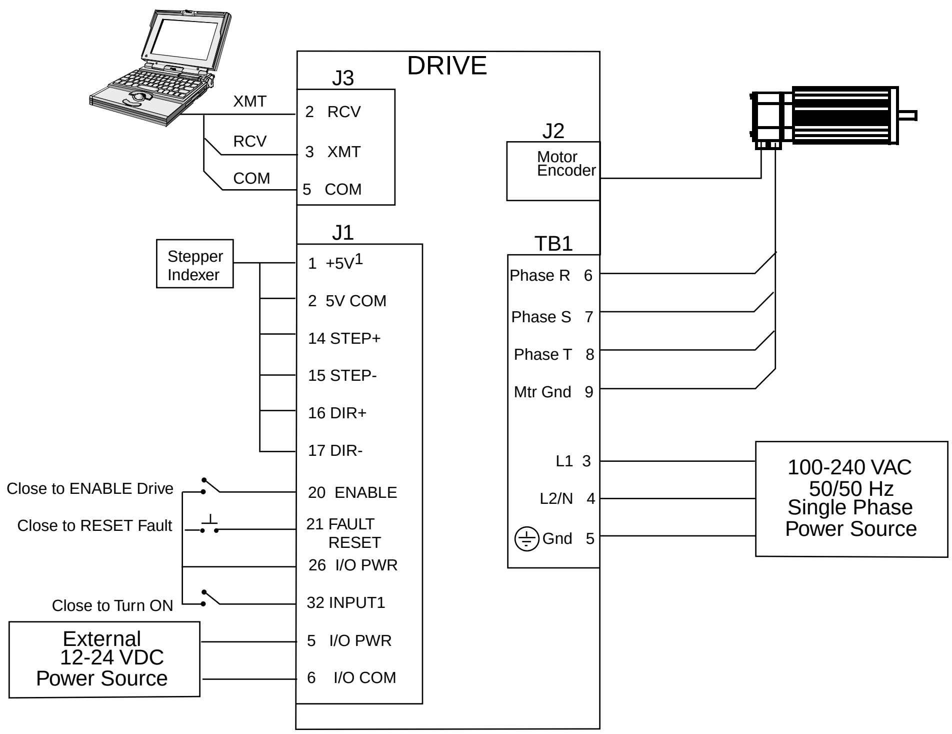


Figure 8.4 Position Follower (Step/Direction Controller) Connection Diagram

SYSTEM CONFIGURATION

Carefully check all connections before entering these parameters.

1. Switch the AC power to ON and verify:
   - Status LED is green. Refer to *Status Indicator* on page 10-117 for an explanation of the display codes.

2. Start *Tol-O-Motion SSD* on the PC.

3. Choose Cancel from the Drive Select dialog box.

4. Select PC setup from the Communications menu in *Tol-O-Motion SSD* to display the personal computer's communication settings.

5. Verify the communication port settings of the PC match those of the drive. Factory default drive settings are:
    - Baud Rate: 9600
    - Data Bits: 8
    - Parity: None
    - Stop Bits: 1
    - Serial Port: COM1

6. Select OK in the Port - Settings dialog box when the settings are correct.

7. Select Read Drive Parameters from the Communications menu.

8. Verify the Drive Name and Address are correct for the drive that is being addressed.

9. Choose OK to load the drive parameters. **NOTE:** A motor must be selected for the parameters to load.

10. If the message box appears that a motor must be selected, select OK. The Drive Setup window is displayed with Motor Model selection parameter active. The motor may be selected from the drop down box. If this message box does not appear, the motor displayed in the Motor Model box was previously selected.

11. Select or verify the correct motor model number from the drop down Motor Model list.

12. Choose OK, if a message advises that the drive must be reset. A change in motor parameters requires reselection of the firmware based drive/motor tables. The software reset is required to prevent improper sequencing of these table parameters.

13. Choose Close from the Drive Setup window.

14. Choose the Drive Parameters command icon from the Drive window.

15. Select the appropriate parameters from the Drive Parameters window for the drive:
    Step/Direction as the Command Source
    Velocity as the Mode
    Enter the appropriate Gear Ratio as the Follower Input.

16. Choose Close to exit the window.

17. Verify the Status LED is green.

18. Choose the I/O Configuration command icon from the Drive window.

19. Select an appropriate digital input from the pull-down lists available as Digital Input Assignments in the I/O Configuration window.

    For example:
    - Follower Enable as Input 1.
    - Not Assigned as Inputs 2 through 3.

20. Choose Close to exit the window.

21. Choose the Tuning command icon from the Drive window.

    NOTE: Do *not* attempt to AutoTune systems that have gravitational effects. The drive will not hold initial position.

    NOTE: Do *not* attempt to Tune a drive with the Command Source set for Torque.

22. Select Auto Tune from the Tuning Mode group.

23. Select the appropriate values for the following Auto Tune commands.
    - Distance
    - Step Current
    - Motor Direction (BiDirectional, Forward Only or Reverse Only)

24. Close the toggle switch between J1-26 and J1-20 to enable the drive.

25. Choose Start from the Tuning window. The drive powers the motor shaft for a short period and then motion will cease. Then the calculated gains are displayed and the drive is disabled.

26. Choose Normal Drive Operation from the Tuning window.

27. Open the switch between J1-26 and J1-20 to disable the drive.

28. Choose Close to exit the Tuning window.

29. Verify the Status LED is green.

30. Close any open windows or dialog boxes.

    The drive is now configured as a position follower (step/direction).
    - The current loop is compensated properly for the selected motor.
    - The servo parameters have been setup with the unloaded motor.
    - The encoder output resolution is set to the default of divide by 1.

    The motor position is commanded by the stepper indexer. The fully digital design saves the parameters in EEPROM memory. Thus the drive can be power cycled and, after power-up, run the parameters set in the steps above.

START-UP

When motion is required:

1. Close the switch between J1-26 and J1-20 to enable the drive.

2. Close the toggle switch between J1-26 and J1-32 to enable the follower mode.

Position Follower (Step Up/Step Down)

The drive can be electronically geared or driven by Step Up and Step Down signals typically used to control stepper drives. Make the connections below to setup the drive as a position follower. Figure 8.5 depicts the minimum hardware necessary. Interfacing the drive to a controller requires similar output circuitry from the controller to J1. Instructions are provided to configure the drive with *Tol-O-Motion SSD* software.

NOTE: If the SSD is enabled without defining one of the Digital Inputs as Follower Enable, *Tol-O-Motion SSD* automatically configures the SSD as the follower.

HARDWARE SETUP

Make the connections described below and shown in Figure 8.5.

1. Connect an RS-232 cable between the serial port on the PC and the J4 connector on the drive, or connect a TouchPad to the J3 connector.

2. Connect a Motor/Feedback cable from the motor to the J2 connector on the drive.

3. Connect a Power cable from the motor to TB1 (terminals R, S, T and ⏚) on the drive.

4. Connect the Stepper Indexer to the drive as shown in Figure 8.5. The motor is controlled by the indexer commands.

5. Connect a jumper wire with switches between the following pins:
   - J1-20 (ENABLE) and J1-26 (I/O PWR)
   - J1-32 (INPUT1) and J1-26 (I/O PWR)
   - J1-21 (FAULT RESET) and J1-26 (I/O PWR).

These connections provide manual control for enabling or disabling the drive and resetting faults. Figure 8.5 shows the jumper, including normally open toggle switches.

6. Connect an external 12-24 VDC power source for powering I/O to J1-5 (I/O PWR) and J-6 (I/O COM).

7. Connect the drive to a single phase 100/240 VAC, 50/60 Hz power source.

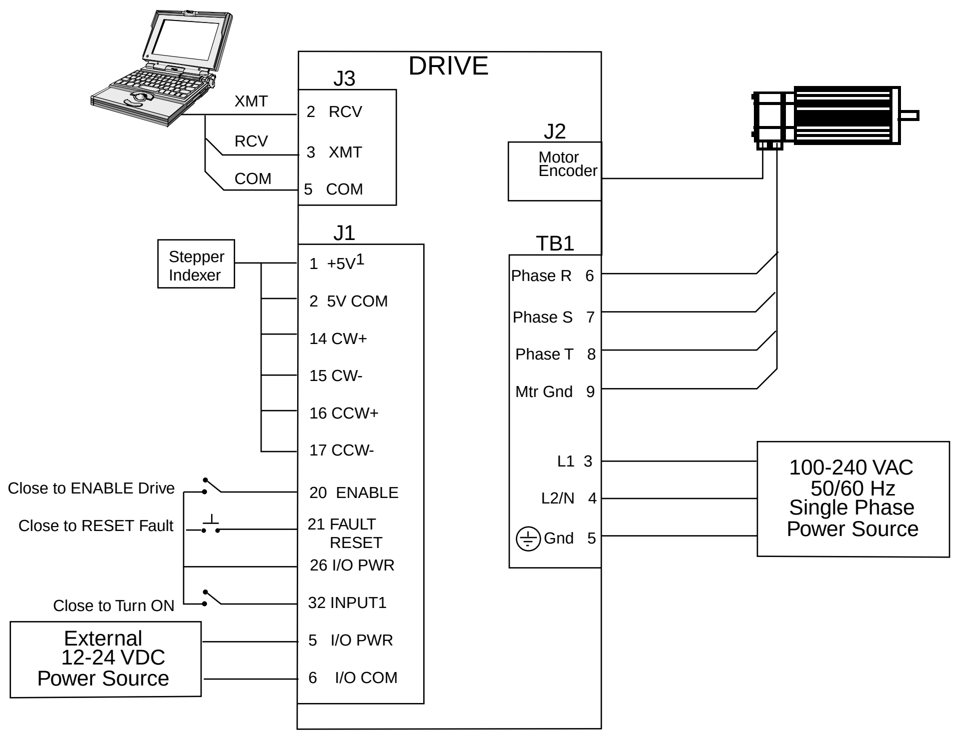


Figure 8.5 Position Follower (Step Up/Down Controller) Connection Diagram

CONFIGURATION

Carefully check all connections before entering these parameters.

1. Switch the AC Power to ON and verify:
   - Status LED is green. Refer to *Status Indicator* on page 10-117 for an explanation of the display codes.

2. Start *Tol-O-Motion SSD* on the PC.

3. Choose Cancel from the Drive Select dialog box.

4. Select PC setup from the Communications menu in *Tol-O-Motion SSD* to display the personal computer's communication settings.

5. Verify the communication port settings of the PC match those of the drive. Factory default drive settings are:
   - Baud Rate: 9600
   - Data Bits: 8
   - Parity: None
   - Stop Bits: 1
   - Serial Port: COM1

6. Select OK in the Port - Settings dialog box when the settings are correct.

7. Select Read Drive Parameters from the Communications menu.

8. Verify the Drive Name and Address are correct for the drive that is being addressed.

9. Choose OK to load the drive parameters. **NOTE:** A motor must be selected for the parameters to load.

10. If the message box appears that a motor must be selected, select OK. The Drive Setup window is displayed with Motor Model selection parameter active. The motor may be selected from the drop down box. If this message box does not appear, the motor displayed in the Motor Model box was previously selected.

11. Select or verify the correct motor model number from the drop down Motor Model list.

12. Choose OK, if a message advises that the drive must be reset. A change in motor parameters requires reselection of the firmware based drive/motor tables. The software reset is required to prevent improper sequencing of these table parameters.

13. Choose Close from the Drive Setup window.

14. Choose the Drive Parameters command icon from the Drive window.

15. Select the appropriate parameters from the Drive Parameters window for the drive:

    Step Up/Step Down as the Command Source
    Velocity as the Mode
    Enter the appropriate Gear Ratio as the Follower Input.

16. Choose Close to exit the window.

17. Verify the Status LED is green.

18. Select the I/O Configuration command icon from the Drive window.

19. Select an appropriate digital input from the pull-down lists available as Digital Input Assignments in the I/O Configuration window.

    For example:
    - Follower Enable as Input 1.
    - Not Assigned as Inputs 2 through 3.

20. Choose Close to exit the window.

21. Choose the Tuning command icon from the Drive window.

    NOTE: Do *not* attempt to Auto Tune systems that have gravitational effects. The drive will not hold initial position.

22. Verify the Status LED is green.

23. Select Auto Tune from the Tuning Mode group.

24. Select the appropriate values for the following Auto Tune commands.
    - Distance
    - Step Current
    - Motor Direction (BiDirectional, Forward Only or Reverse Only)

25. Close the toggle switch between J1-26 and J1-20 to enable the drive.

26. Choose Start from the Tuning window. The drive powers the motor shaft for a short period and then motion will cease. Then *Tol-O-Motion SSD* displays the calculated gains and disables the drive.

27. Choose Normal Drive Operation from the Tuning window.

28. Open the switch between J1-26 and J1-20 to disable the drive.

29. Choose Close to exit the Tuning window.

30. Verify the Status LED is green.

31. Close any open windows or dialog boxes.

32. The drive is now configured as a position follower in the Velocity mode.
    - The current loop is compensated properly for the selected motor.
    - The servo parameters have been setup with the unloaded motor.
    - The encoder output resolution is set to the default of divide by 1.

    The motor speed or current is controlled by the master encoder input. The fully digital design saves the parameters in EEPROM memory. Thus the drive can be power cycled and, after power-up, run the parameters set in the steps above.

START-UP

When motion is required:

1. Close the switch between J1-26 and J1-20 to enable the drive.

2. Close the switch between J1-26 and J1-32 to enable the follower mode.

Tuning 9

The SSD drives are pre-tuned at the factory to provide general performance. If tighter performance is desired, the drives can be tuned quickly and easily for a wide variety of applications. Two tuning modes are available through the software:

- Auto Tune
- Manual Tune

Tuning Guidelines

The following tuning guidelines briefly describe the tuning adjustments. These guidelines provide the user with a basic reference point should the application require additional adjustments.

GENERAL TUNING RULES

- Tune the velocity loop first and then, if the drive uses following or step/direction commands, tune the position loop.
- To widen the velocity loop bandwidth, increase the P-gain setting, decrease the I-gain setting or increase the low-pass filter bandwidth. This provides a faster rise time and increases drive response.
- To increase stiffness, increase the I-gain setting. It rejects load disturbance and compensates for system friction.
- To reduce velocity loop overshoot, increase P-gain or D-gain, or decrease I-gain.
- To reduce mechanical resonance, use a stiffer mechanical coupling or select a negative (-) D-gain value. Alternatively, decrease the low-pass filter value and the velocity loop update rate.
- If the motor oscillates, decrease either individually or together the:
    - P-gain
    - I-gain
    - low-pass filter bandwidth.

HIGH INERTIA LOADS

Proper compensation of load inertia may not be simply a matter of increasing the P-gain and I-gain settings. Problems are often encountered when tuning systems with a high load to motor inertia ratio.

Mechanical Resonance

Mechanical resonance between the motor and the load occurs when the motor and load are oscillating with the same frequency but opposite phase: when the motor is moving clockwise the load is moving counter clockwise. The amplitude of the motor and load oscillations is such that the total momentum of the oscillating system is zero. In the case of a high load to motor inertia ratio this means that the motor may be moving quite a lot while the load is not moving nearly as much. Mechanical resonance occurs as a result of compliance (springiness) between the motor inertia and load inertia. It may result from belts, flexible couplings or the finite torsional stiffness of shafts. In general, the stiffer the couplings, the higher the resonant frequency and lower the amplitude. If the motor shaft is directly coupled to the load, a mechanically resonating system usually emits a buzz or squeal at the motor.

There are several ways of dealing with this problem but they fall into two groups: change the mechanical system or change the servo-motor response. Changing the **mechanical system** might involve reducing the inertia ratio via gearboxes or pulleys, or by increasing the stiffness of the couplings. For very high performance systems and systems with low resonance frequencies, the mechanics may require changing to effectively deal with the resonance.

The second way of dealing with mechanical resonance is by changing the **servo-motor response**. This may be done by using a negative D-gain value and by reducing the P-gain, I-gain, velocity loop update rate or low-pass filter value. The D-term of the PID velocity regulator (see the velocity and torque current conditioning structure) subtracts (or adds) a proportion of the motor acceleration from the velocity error. The D-gain has the effect of increasing the acceleration current if the motor is accelerating in the wrong direction, but reducing the acceleration current if the motor is already accelerating in the right direction. When used in this way, the D-gain dampens an oscillating or ringing system. In the case of motor-load mechanical resonance, a positive D-gain actually worsens the situation. When a negative D-gain value is used in a mechanically resonating system it may be thought of as subtracting the load acceleration (the opposite sign of the motor acceleration since the system is resonating). This tends to bring the motor and load back into phase with each other and therefore reduces or eliminates mechanical resonance.

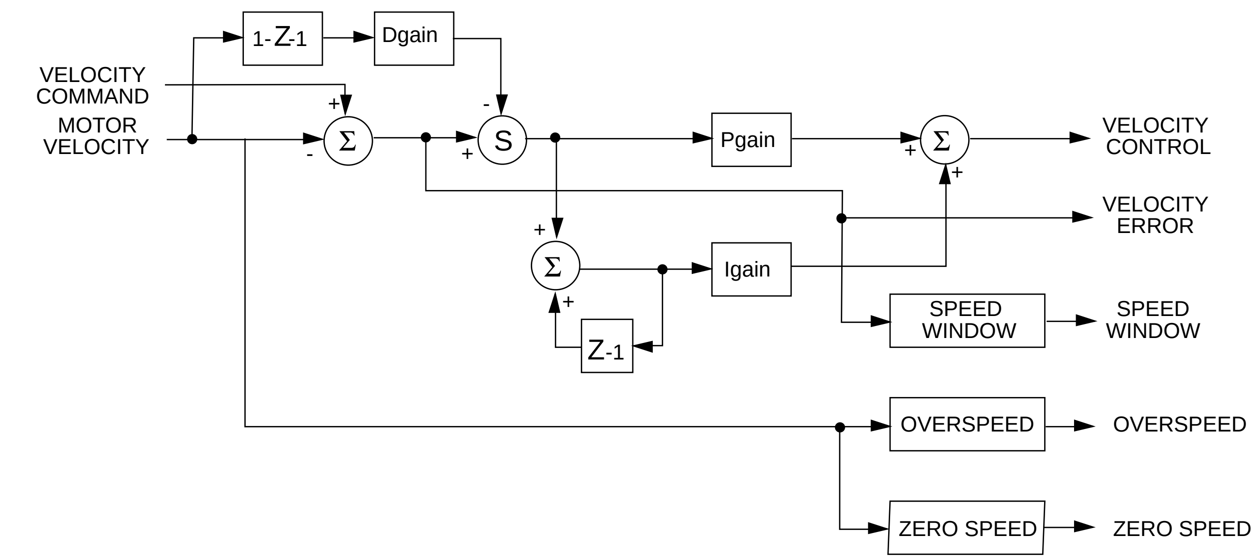


Figure 9.1 Velocity Loop Structure

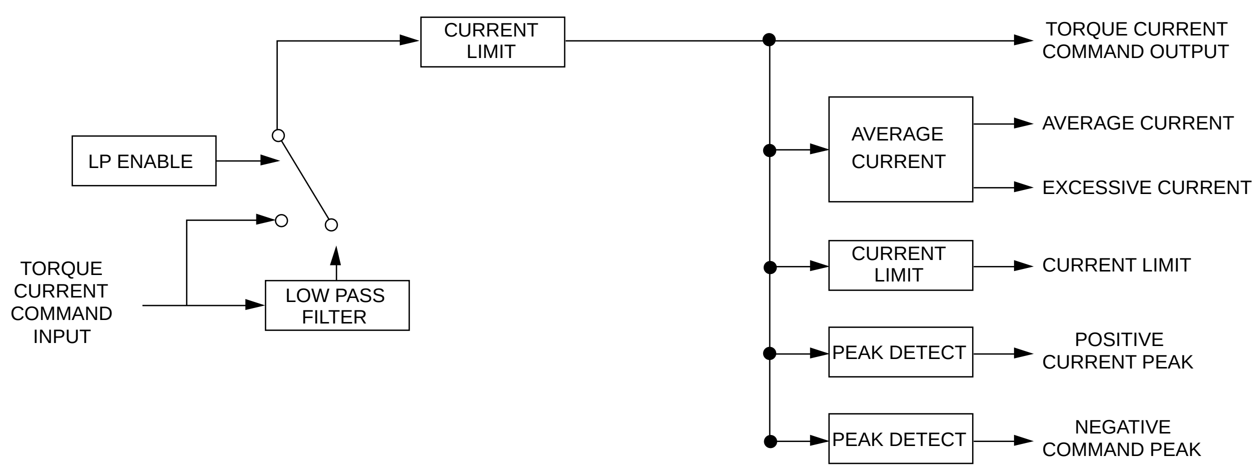


Figure 9.2 Torque Current Conditioning Structure

Reducing the value of the P-gain, low-pass filter frequency and the update frequency all have the effect of reducing the servo-motor bandwidth. As long as the resonating frequency is fairly high this will likely be acceptable, but if the resonating frequency is low it may be necessary to modify the mechanics of the system.

BACKLASH

Backlash between the motor and load effectively unloads the motor over a small angle. Within this small angle, the increased bandwidth can result in oscillations. Some backlash may be unavoidable, especially with gear reduction. If backlash is present, the inertia match between the load and motor must be properly sized for good servo performance (load inertia should roughly equal motor inertia). Gearing reduces the inertia reflected to the motor by the square of the gear reduction from motor to load. Therefore, the gear ratio must provide the required match.

Auto Tune Mode

The Auto Tune mode uses a “self-tuning” algorithm that automatically adjusts the drive’s velocity loop gain parameters. Adjustments do not require special equipment. This mode will tune a drive for constant velocity loop response across different applications. The results often provide acceptable response, but in general should be considered a starting point.

Tuning parameters adjustments are set to achieve a reasonable bandwidth and servo response based on the system inertia and friction. Auto Tune may be used when a significant amount of compliance or backlash exists (for example, belt systems) in the mechanical load, but precise tuning requires the load be fully coupled to the motor. Instability problems occur when the load is not fully coupled to the motor.

NOTE: The Auto Tune algorithm will not provide satisfactory results in systems with significant gravitational effects.

AUTO TUNING

A PC running *Tol-O-Motion SSD* is required to perform tuning on the drive.

Before using Auto Tune, three autotuning parameters must be set:

- **Distance** sets the rotation limit of the motor. This is the maximum distance the motor is allowed to move during any one test. **(NOTE:** A test in the bi-directional mode includes two different tests.)
- **Step Current** sets the amount of current given to the motor during the test. If this is set too low, a system may not move enough to gather sufficient data, if it is set too high the test will be too short and very jerky.
- **Motor Direction** (Forward Only/Reverse Only/Bi-directional) sets the rotational direction for the test. The bi-directional test does the same test in both directions, with the forward rotation first.

Auto Tune procedures are explained for each drive configuration in *Application and Configuration Examples* starting on page 8-78. The following steps generalize the *Tol-O-Motion SSD* tuning procedures.

When Auto Tune is selected, the drive rotates the motor shaft for a short time interval, typically a few seconds. Motor movement should not exceed 30 seconds.

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

1. Choose the Tuning command icon from the Drive window.

2. Choose Auto Tune from the Tuning window. This activates the Auto Tune command and Motor Direction boxes within the Tuning window. Then enter or select:

   - appropriate values for Distance in the Auto Tune command box,
   - appropriate values for Step Current in the Auto Tune command box, and
   - an appropriate motor rotation in the Motor Direction box on a PC, either:
     - BiDirectional, if the motor will be powered in both the forward and reverse directions.
     - Forward Only, if the machinery is designed to operate only in the forward direction.
     - Reverse Only, if the motor will be powered only in the reverse direction.

   Use the default settings if uncertain about what values to enter. The default settings are set to values appropriate to the drive and motor combination selected during drive initialization.

3. Enable the drive.

4. Choose Start from the Tuning window. The drive rotates the motor shaft and then motion will cease. The calculated gains are displayed and the drive is disabled.

5. Disable the drive manually.

6. Choose Normal Drive Operation from the Tuning window.

7. Enable the drive.

8. Choose Close to exit the Tuning window.

NOTE: Auto tuning does not have a velocity limit, but it does adhere to the motor **Overspeed** setting in the Drive Parameters window.

Manual Tune Mode

Manual tuning may be used to adjust the gain settings and filter frequency of the velocity regulator. The following sections briefly explain these settings. An understanding of the function for each type of gain and filtering will allow the user to effectively tune the system.

Two types of manual tuning are available:

- Velocity tuning
- Position tuning.

Before manual tuning is invoked, the Velocity, Distance and Motor Direction parameters must be set. Refer to *Auto Tune Mode* on page 9-107 for information on setting these parameters.

The velocity loop should always be tuned *before* the position loop, as velocity loop tuning affects the position loop response.

Gain settings and signal filtering are the primary methods to electrically tune a system. A understanding of the types of gain and their purposes, as well as a general understanding of filtering, are essential background knowledge to properly tune a servo system.

GAINS

Parameter	Description
P- gain	Proportional gain of the velocity regulator. P- gain controls the bandwidth of the velocity regulator by adjusting
I - gain	the control response proportional to the error. The P term of the velocity regulator commands an acceleration current that is proportional; to the velocity error.
D - gain	Integral gain of the velocity regulator. Integration in the velocity regulator forces the motor velocity to precisely follow the commanded velocity. This assumes operation under steady state conditions (velocity command or load doesn't change). I - gain controls: The stiffness or ability to reject load torque disturbances. The mount of velocity overshoot, which may cause the system to become unstable or oscillate. The I term of the velocity regulator commands an acceleration current proportional to the integral of the velocity error.
	Differential gain of the velocity regulator. Positive D - gain decreases the torsional resonance between the motor and the load.

Table 9.A Velocity Loop Gains

Parameter	Description
Kp-gain	Proportional gain of the position loop. Kp-gain changes: • The position loop bandwidth. • The settling time of the position loop. In general, the higher the value of Kp-gain the faster the settling time. However, a high value of Kp-gain with inadequate velocity loop bandwidth results in overshoot and ringing.
Kd-gain	Differential gain of the position loop. Provides position loop damping and reduces overshoot caused by Kp or Ki gain.
Kff-gain	Feedforward gain of the position loop. Kff-gain reduces following error. However, a high value of Kff-gain can result in position overshoot. A reduction in following error allows the system to more closely approximate gear driven systems.
Ki-gain	Integral gain of the position loop. Ki-gain decreases the time period for the error to decay. A non-zero value of Ki allows integration in the position loop which eliminates the steady state following error. However, a non-zero value for Ki may introduce overshoot and ringing, which cause system instability (oscillation). Note: Ki-gain is used in conjunction with the Ki Zone-value. Ki Zone - is the area around the commanded position where Ki - gain is active.
NOTE: Position Loop Gains are used in the Position Following mode only.	

Table 9.B Position Loop Gains

FILTERS

The velocity regulator has one low pass filter. The filter bandwidth range is from 1 Hz to 992 Hz.

The filter serves two purposes:

- Adjust the frequency range to remove or filter the noise produced by encoder resolution.
- Reduce the amount of the mechanical resonance in the mechanical system (e.g., belt systems).

Similar results may often be achieved by reducing the update rate of the velocity loop.

MANUAL TUNING

Manual tuning may be used to adjust the gain control parameters P, I, D and the filters. A square wave is generated by the drive to assist in the adjustment. Manual velocity tuning requires the following:

- Step Period value to be specified
- Step Velocity value to be specified.

NOTE: Always tune the velocity loop before the position loop, as Velocity loop tuning affects the position loop response.

TUNING THE VELOCITY LOOP

The Auto Tune procedure provides a starting point for velocity loop tuning. Manual tuning is desirable when very precise adjustments are required.

The following steps describe how to manually tune the velocity loop. These steps precede the manual position loop tuning procedure, which should follow velocity loop tuning.

1. Disable the drive.
2. Choose Manual Tune (Velocity Step) from the Tuning window.
3. Enter the desired step Velocity (rpm) of the internal square wave generator.
4. Enter the desired Time to complete one cycle of the square wave of the internal step velocity.
5. Select the desired Motor Direction (Forward Only, Reverse Only, or Bi-Directional).
6. Select the Oscilloscope.
7. Enable the drive.
8. Choose Start. The motor should start moving and the oscilloscope will display the commanded velocity and the motor velocity.
9. While monitoring the motor velocity waveform, increase P-gain until the desired rise time is achieved.
10. While monitoring the motor velocity waveform, increase I-gain until an acceptable amount of overshoot is reached.
11. Apply filtering by selecting Filters, and then select Filter Enable.
12. While monitoring the motor velocity waveform, decrease the filter Bandwidth until the overshoot begins to increase (in many applications the filter is not necessary).

13. Choose Stop.

14. Disable the drive.

15. Choose Normal Drive Operation.

16. Choose Close.

17. Enable the drive.

The drive's velocity loop is tuned.

TUNING THE POSITION LOOP

Specify the step period and step position values, and then input a square wave to the position loop. Adjust the gain controls parameters Kp, Kd, Kff, Ki, and Ki Zone Filters to tune the system.

NOTE: Tune the velocity loop before attempting to tune the position loop. The bandwidth of the velocity loop must be set before position loop tuning is attempted.

1. Disable the drive.

2. Choose Manual Tune (Position Step) from the Tuning window.

3. Enter an appropriate Distance Count (Step Position) for the internal square wave.

4. Enter an appropriate time to complete one cycle of the square wave for the internal step position.

5. Select the desired Motor Direction (Bi-Directional, Forward Only or Reverse Only).

6. Select the Oscilloscope.

7. Enable the drive.

8. Choose Start. The motor will move and the oscilloscope will display the Position Motor Feedback signal.

9. Increase the Kp gain while monitoring the signal on the scope. The Kp gain should be adjusted until the desired rise time is achieved, with no overshoot. Refer to Figure 9.3.

10. Increase Ki very slowly until the signal begins to overshoot.

11. Increase Kd very slowly to remove the overshoot caused by Ki.

12. In general Kff gain may continue to be set to 100.

13. Choose Stop.

14. Disable the drive.

15. Choose Normal Drive Operation.

16. Choose Close.

17. Enable the drive.

    The position loop has been tuned. The drive may be operated as a master encoder, step/direction or step up/down configuration.

Velocity Loop Tuning Examples

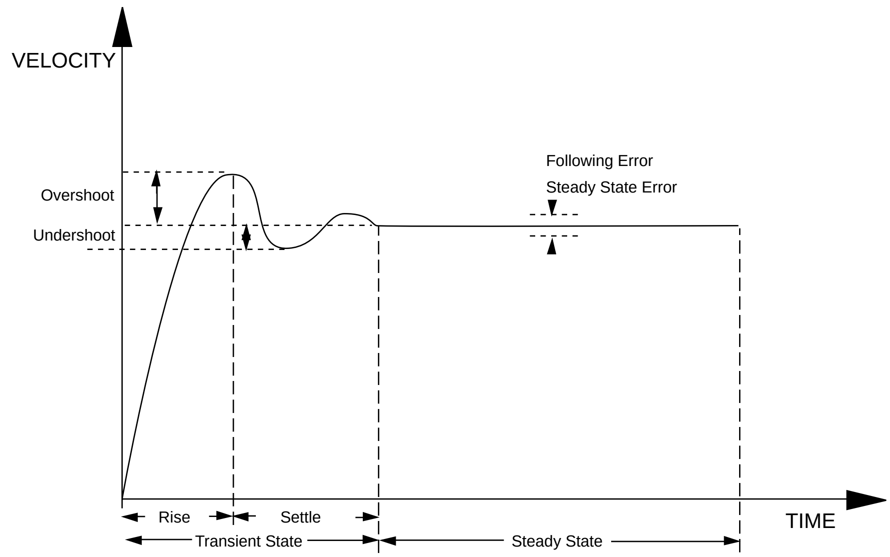


Figure 9.3 Signal Nomenclature

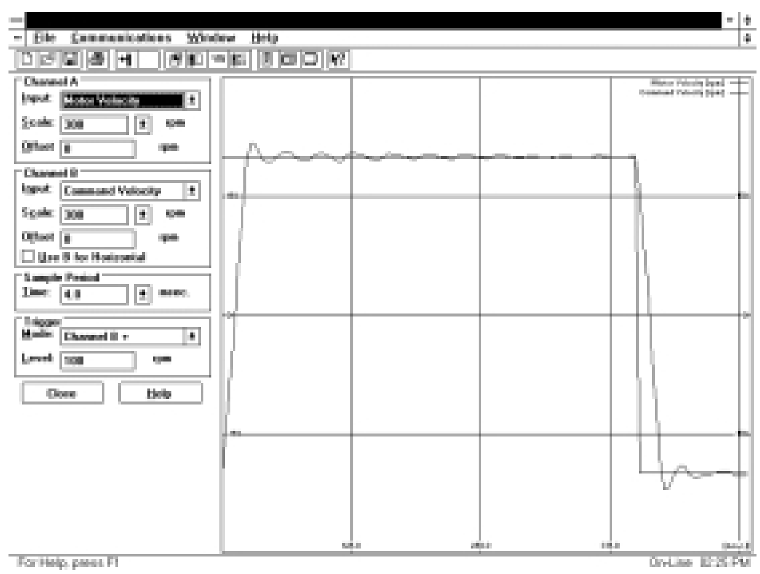


Figure 9.4 Underdamped Signal

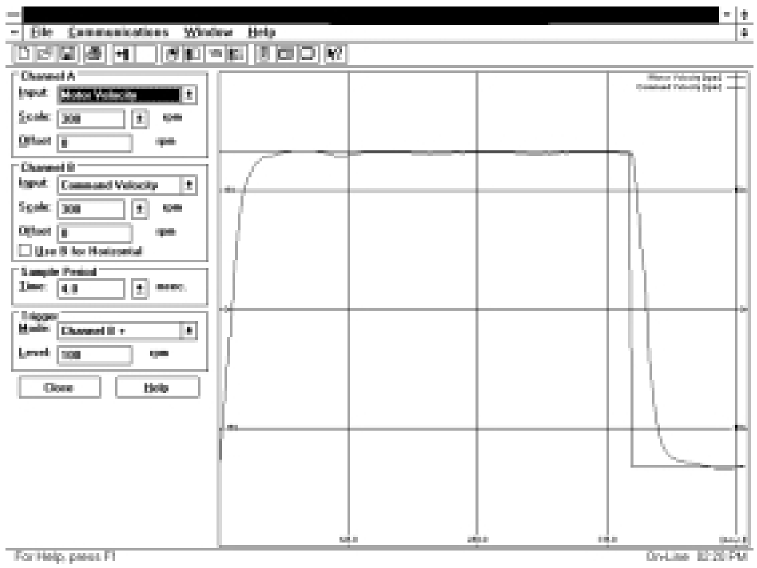


Figure 9.5 Overdamped Signal

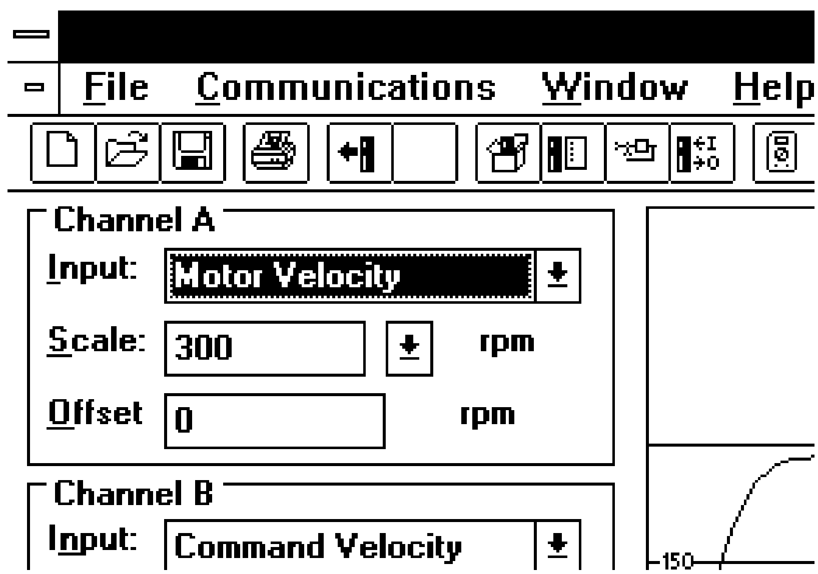


Figure 9.6 Critically Damped Signal (Ideal Tuning)

Status Display 10

A single front panel indicator displays the status of the drive on a continuous basis:

- The Status LED lights whenever the bus is energized.

Status Indicator

The **Status Indicator** is a three-level LED which indicates the current operational state of the drive. The status level is indicated by the color of the LED.

- Green = Normal operation
- Blinking Green/Orange = Drive Fault
- Orange = Hardware malfunction
- Blank = Power not supplied or hardware malfunction

Refer to *Troubleshooting* beginning on page 11-123 for trouble-shooting tables.

Error Messages

If there is a fault, the specific error messages may be accessed by attaching a PC to the SSD drive. Faults are detected by the drive in two ways: **power-up hardware** and **time-run** faults. A power-up fault usually requires servicing of the hardware, while a run-time fault can be cleared by resetting the drive.

Run Time fault handling executes every 1 millisecond (1 kHz rate). Thus the maximum time interval between an error occurring and display of the fault action is 1 millisecond.

Maintaining and Troubleshooting the SSD Line lists error codes and possible actions or solutions to take when resolving the error condition.

RUN TIME ERROR CODES

Error Code	Fault Description
01 - 03	Reserved
04	Motor Overtemperature, Thermostat
05	IPM Fault (Overtemperature/Overcurrent/Short Circuit)
06 - 08	Reserved
09	Bus Undervoltage
10	Bus Overvoltage
11	Illegal Hall State
12 - 16	Reserved
17	Excessive Average Current
18	Motor Overspeed
19	Excessive Following Error
20	Motor Encoder State Error
21	Auxiliary Encoder State Error
22	Motor Thermal Protection
23	IPM Thermal Protection
24	Excess Velocity Error
25	Communication Angle Error
26-27	Reserved
28	No Motor Selected
29	Motor Selection not in Table
30	EEPROM Write Error
31-50	Reserved

Table 10.A Run Time Error Codes

POWER-UP ERROR CODES

A power-up error indicated in almost all cases that the drive should be returned to the factory for service. In general, any occurrence of a Power-up error should be treated with extreme caution. It may indicate the hardware is marginal.

Situations that may cause drive hardware errors, and which can be remedied outside the factory include:

- A watchdog time-out error may result from electrical “noise” (electromagnetic interference - EMI), a firmware error, or a hardware malfunction. The context of the watchdog error needs to be investigated to determine the source of the problem.

Error Code	Fault Description
51	Masked ROM Block Error
52	Reserved
53	Uninitialized Personality EEPROM Error
54	Personality EEPROM Read Error
55	Personality EEPROM Data Corruption
56	Processor Watchdog Error
57	Reserved
58	Processor RAM Error
59	Reserved
60	Uninitialized Service EEPROM Error
61	Service EEPROM Read Error
62	Service EEPROM Data Corruption Error
63-73	Reserved
74	Personality EEPROM Write Error
75-78	Reserved
79-n	Data Out of Range where n = suberror parameter 1 - Serial baud rate selection 2 - Serial stop bits/parity selection 3 - Position Loop Kp 4 - Position Loop Ki 5 - Position Loop Kff 6 - Position Loop Kd 7 - Gear ratio 8 - Encoder Output Divider 9 - Velocity Loop Update Period 10 - Velocity Loop P Gain 11 - Velocity Loop I Gain 12 - Velocity Loop D Gain 13 - Reserved 14 - Analog Command Torque Offset 15 - Analog Command Torque Offset 16 - User D/A Variable Selection 17 - Command Service 18 - Drive Mode (Torque/Velocity) 19 - Tuning Direction 20 - Motor/Encoder User Alignment Offset 21 - Encoder Size 22 - Motor Torque Constant 23 - Motor Inertia 24 - Motor Back EMF 25 - Motor Resistance per Phase 26 - Motor Inductance per Phase 27 - Motor Communication Type 28 - Motor Encoder Hall Offset 29 - Motor Encoder Index Offset 30 - Motor Pole Count
80-1	Service Data Out of Range (Drive Type)
81-99	Reserved

Table 10.B Power-Up Error Codes

Maintenance & Troubleshooting 11

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

Maintenance

The SSD drive is designed to function with minimum maintenance.

DANGER!   DC bus capacitors may retain hazardous voltages after input power has been removed, but will normally discharge in several seconds. Before working on the drive, measure the DC bus voltage to verify it has reached a safe level or 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 an OSHA-approved nozzle that provides compressed air under low pressure <20 kPa (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 torqued to 1.2 Nm (11 lb-in).
- D-shell connectors can be inspected for proper seating and signal continuity.
- Visually inspect all cables for abrasion.

Data Transfer

After the drive has been configured and tuned, the data stored in the EEPROM personality module should be saved off-line. Saving the parameters off line will allow several machines to be cloned with the same mechanics and provides an emergency backup of the drive data.

To transfer the data from the drive to a PC:

1. While on-line with a drive, click on **File** in the toolbar menu
2. Select Save As..., the Save As window will appear
3. Enter the file name and press **ENTER** or choose OK to save.

To transfer the data from a PC to a drive:

1. Close all windows in *Tol-O-Motion SSD*.
2. Choose File in the toolbar menu.
3. Choose Open.
4. Select the desired file name or enter the file name to be loaded and press **ENTER** or choose OK.

   If the name of the file to be loaded is unknown, select the correct directory from the Directories box and select the file name from the displayed list of file names. The Tol-O-Motion SSD Off-Line Drive window will appear along with the selected file name.
5. Select Communications from the toolbar menu
6. Select Overwrite Drive Parameters. The Drive Select window will appear.
7. Select the drive to be configured, and then press **ENTER** or choose OK to load the parameters into the personality module.

Troubleshooting

A single LED on the front panel indicates the status of the drive on a continuous basis:

- Green = Normal operation
- Blinking Green/Orange = Drive Fault
- Orange = Hardware malfunction
- Blank = Power not supplied or hardware malfunction

A table of problems, potential causes, and appropriate actions to take to resolve the problem is included below.

If problems persist after attempting to carefully troubleshoot the system, please contact the nearest distributor of Tol-O-Matic products for further assistance.

ERROR CODES

Error codes may be accessed by attaching a PC with *Tol-O-Motion SSD* software to the serial port (J3):

- *Tol-O-Motion SSD* displays errors in two windows: Fault History and Display Fault Status;

Table 11.A Troubleshooting Guide

Problem or Symptom	Error Code	Possible Cause(s)	Action/Solution
STATUS LED not lit		No AC power	Verify power (115/230VAC single phase) is applied to the drive.
		Internal power supply malfunction.	Call factory.
Motor jumps when first enabled		Motor encoder wiring error.	Check motor encoder wiring error wiring. See Figure 6.37.
		No Absolute signal at J2-16.	Monitor Absolute signal at J2-16.
		Incorrect motor chosen in personality module.	Select the proper motor in Tol-O-Motion.
Digital I/O not working correctly.		12-24 V power supply disconnected.	Verify connections and 24V power source.
Motor Overtemperature	04	Motor TS+ (J2-19) and TS- (J2-20) pins open.	Verify TS+ (J2-19) and TS- (J2-20) connections for continuity.
		Motor thermostat trips due to: High ambient temperature, and/or Excessive RMS torque.	Operate within (not above) the continuous torque rating for the ambient temperature (40°C maximum). Lower ambient temperature.
NOTE: Tol-O-Motion software automatically determines the presence or absence of a motor thermal switch signal based on the motor selected in the Drive Select window. Tol-O-Matic motors have thermal switches and signal continuity is required on these motors.			
IPM Fault	05	Motor cables shorted.	Verify continuity of motor power cable and connector.
		Motor winding shorted internally.	Check for short on R,S,T and Gnd.
		Drive temperature too high.	Check for clogged or defective fan. Ensure cooling is not restricted by insufficient space around the unit.
		Operation above continuous power rating.	Verify ambient temperature is not too high (above 60° C). Operate within the continuous power rating.
		Output short circuit or overcurrent.	Drive has a bad IPM, replace drive.
Bus Undervoltage	09	Low AC line/AC power input (100 V AC minimum for safe drive operation.	Verify voltage level of the incoming VAC power. Check AC power source for glitches or line drop (below 90 VAC). Install an uninterruptible power supply (UPS) on the VAC input.

Problem or Symptom	Error Code	Possible Cause(s)	Action/Solution
Bus Overvoltage	10	Excessive regeneration of power. When the drive is driven by an external mechanical power source, it may regenerate too much peak energy through the drive's power supply. The system faults to save itself from an overload.	Change the deceleration or motion profile and/or reduce the reflected inertia of the system. User a larger system (motor and drive).
		Excessive AC input voltage.	Verify input is below 264 VAC.
		Output short circuit.	Check for shorts.
		Motor cabling wires shorted together.	Check for shorts.
		Internal motor winding short circuit	Check for shorts.
Illegal Hall State	11	Incorrect phasing.	Check the Hall phasing.
		Bad connections.	Verify the Hall wiring.
RESERVED	12		
RESERVED	13		
RESERVED	14		
RESERVED	15		
RESERVED	16		
Excessive Average Current	17	Excessive time at peak current.	Reduce acceleration rates. Reduce duty cycle (ON/OFF) of commanded motion. increase time permitted for motion. mechanical jam or excessive frictional load. Use larger drive and motor
		Software parameter set too low.	Increase Average Current parameter to a less restrictive setting.
		Insufficient bus voltage.	Correct the under voltage voltage condition or intermittent AC power or install a larger sizes transformer.
		Motor Phasing is incorrect.	Check motor phasing.
Motor Overspeed	18	OVERSPEED paramete in the drive set too low for the application.	Using Tol-O-Motion (refer to Drive Parameters section), set Overspeed parameter to an acceptable range for the application.
		Motor commanded to run abover Overspeed setting.	Reduce command from position controller or change velocity parameter in the position controller.
		Motor encoder is incorrect.	Check encoder phasing.

Problem or Symptom	Error Code	Possible Cause(s)	Action/Solution
Excess Following Error	19	The software position error limit was exceeded.	Increase the feed forward gain to 100%. Increase the following error window (refer to Tol-O-Motion Drive Parameters section). Retune the drive to reduce the following error. Increase the slew limit window (refer to Tol-O-Motion Drive Parameters).
Motor Encoder State	20	The motor encoder encountered an illegal transition.	Replace the motor/encoder. Use shielded cables with twisted pair wires. Route the feedback away from potential noise sources. Check the system grounds.
		Bad encoder.	Replace motor/encoder.
Auxiliary Encoder state	21	The auxiliary encoder encountered an illegal transition.	Use shielded cables with twisted pair wires. Route the encoder cable away from potential noise sources. Bad encoder - replace encoder. Check the ground connections.
Motor Thermal Protection Fault	22	The internal filter protecting the motor from overheating has tripped	Reduce acceleration rates. Reduce duty cycle (ON/OFF) of commanded motion. Increase time permitted for motion. User larger drive and motor.
IPM ThermalProtection Fault	23	The internal filter protecting the IPM at slow speed has tripped.	Reduce acceleration rates. Reduce duty cycle (ON/OFF) of commanded motion. Increase time permitted for motion. User larger drive and motor.
Excess Velocity Error	24	Velocity exceeded allowable range.	Increase time or size of allowable error. Reduce acceleration
Commutation Angle Error	25	Bad encoder	Replace encoder or motor/encoder.
RESERVED	26		
RESERVED	27		
No Motor Selected	28	No motor was selected when the drive was enabled.	Select a motor before enabling the drive.
Motor Information Missing	29	The motor number is referencing a motor that is not currently in the drive.	Select a motor that is in the drive. Update the motor tables in the drive (contact the factory).
RESERVED	30-99		Call factory.

RS-232 COMMUNICATION TEST

This test verifies communications between a SSD drive and an MS-DOS® based personal computer.

Test equipment requirements are:

- A PC running Tol-O-Motion SSD
- The Terminal mode available in Microsoft® Windows®.

1. Close all *Tol-O-Motion SSD* windows.

2. Select Communication from *Tol-O-Motion SSD* and verify communication settings.

3. Verify the communication cable pin out and check cable continuity. Refer to *RS-232 Connection Diagrams* on page 6-66.

4. If the communication cable is OK, do the following:
   A. Disconnect the communication cable from the drive (but leave the cable connected to the PC).
   B. Jumper pins 2 and 3 on the D connector of the communication cable.
   C. Close and exit from *Tol-O-Motion SSD.*
   D. Select the Terminal from the Program Manager (Terminal is usually in the Accessories group).
   E. Select Settings from the Main menu:
      - Select Terminal Emulation from the drop down menu,
      - Choose DEC VT-100,
      - Choose OK to close the dialog box.
   F. Select Settings from the Main menu
      - Select Communications from the drop down menu.
      - Choose COM1 (or the number of the communication port the drive is connected to) from the Connections sliding list.
      - Set Baud Rate to 9600.
      - Set Data Bits to 8.
      - Set Stop Bits to 1.
      - Set Parity to NONE.
      - Set Flow Control to XON/XOFF.
      - Choose OK to close the dialog box.

5. Type any character on the keyboard. The character should echo back on the screen.

   If you see the character on the screen swap pins 2 and 3, close the Windows terminal and restart *Tol-O-Motion SSD*.

   If the character does not echo back on the screen, do the following:
   - Disconnect the cable from the PC.
   - Jumper Pins 2 and 3 on the communication port of the PC.
   - Type any character on the keyboard.
     - If the character echoes back, the communication port is OK and the cable or the connectors are defective. Replace the communication cable assembly
     - If the character did *not* echo back, the communication port is defective. Replace the communication port.

TESTING DIGITAL OUTPUTS

This test verifies the functionality of the selectable outputs.

Test equipment requirements are:
- A PC running *Tol-O-Motion SSD*
- A multimeter.

This test assumes there are no error codes displayed, and a 2X VDC power supply for the I/O is connected.

NOTE: Disconnect the outputs from any external hardware while performing this test

1. Disable the drive by opening the switch connecting J1-26 and J1-20

2. From the Drive window, select the Output Diagnostics command icon.

3. Verify each of the Digital Outputs in the Output Diagnostics window registers the appropriate readings on a multimeter when the following values are set:

   A. Drive Ready box, then measure the resistance between J1-24 and J1-25.
      - If the box is checked, the resistance should read approximately 1 Ohm.
      - If the box is not checked, the resistance should read very high (> 1 MOhm).

   B. Brake Enable box, then measure the resistance between J1-49 and J1-50
      - If the box is checked, the resistance should read approximately 1Ohm.
      - If the box is not checked, the resistance should be very high (> 1 MOhm).

   A load is necessary to test the transistor outputs listed below. A 1 kOhm resistor may be connected from the transistor output (J1-42, J1-43, J1-44 or J1-45) to the I/O COM (J1-6).

   C. Digital Output 1, then measure the voltage between J1-42 and J1-13.
      - If the box is checked, the voltmeter should read approximately +24 VDC
      - If the box is not checked, the voltmeter should read approximately 0 VDC

   D. Digital Output 2, then measure the voltage between J1-43 and J1-13.
      - If the box is checked, the voltmeter should read approximately +24 VDC.
      - If the box is not checked, the voltmeter should read approximately 0 VDC.

4. After the test has been completed, select Close to exit Output Diagnostics window

   If it is determined that a digital output is defective, refer to *Return Procedure* on page F-161 to return the unit.

TESTING DIGITAL INPUTS

This test verifies the functionality of the selectable inputs.

Test equipment requirements are:

- A PC running *Tol-O-Motion SSD*
- A jumper wire.

The test assumes there are no error codes displayed, and the a 24VDC power supply is connected to the I/O.

1. Enable the drive by closing the switch connecting J1-26 and J1-20.

2. Choose the I/O Display command icon from the *Drive* Window
   A. Connect J1-20 to J1-26. The Enable indicator activates.
   B. Connect J1-21 to J1- 26. The Reset Faults indicator activates.
   C. Connect J1-31 to J1-26. The Input 1 indicator activates.
   D. Connect J1-32 to J1-26. The Input 2 indicator activates.
   E. Connect J1-33 to J1-26. The Input 3 indicator activates.

3. Choose Close to exit the I/O Display window.

If it is determined that a digital input is defective, please refer to *Return Procedure* on page F-161 to return the unit for repair.

TESTING ANALOG OUTPUT

The following tests verify the functionality of the analog outputs.

Test equipment requirements are:

- A PC running *Tol-O-Motion SSD*.
- A voltmeter.

Testing Analog Output 1

1. Disable the drive, by opening the connections between the ENABLE input and the I/O PWR.

2. Disconnect the connections to J1-30.

3. Select Output Diagnostics icon from the Drive window.

4. Select Analog Output 1 from the Output Diagnostics window.

5. Enter 1000 in the D/A Level box.

6. Connect a DC voltmeter across analog test points A1 and COM. The meter should read approximately 1 VDC.

7. Repeat Step 5 using different positive or negative values for the D/A Level. Verify the meter reads the values entered.

   If it is determined that the output is defective, refer to *Return Procedure* on page F-161 to return the unit.

TESTING ANALOG INPUT

The following test verifies the functionality of the analog input.

The tests require:

- a PC running *Tol-O-Motion SSD,* and
- a 10 kOhm potentiometer.

Testing the Current Limit Input

1. Verify the accuracy of the potentiometer with an ohmmeter before installing.

2. Disable the drive by opening the connections between the ENABLE input and I/O PWR.

3. Disconnect the connections to J1-27 and J1-28.

4. Connect the 10K potentiometer between J1-27 and J1-28. Refer to *J1 - Controller* on page 6-35 for a diagram showing the location of the pins.

5. Choose the Drive Signals command icon from *Tol-O-Motion SSD.*

6. Choose setup, if the Drive Signals setup window is not already active.

7. Choose Current - Input Limit + as the analog signal.

8. Choose OK to close the setup window and activate the Drive Signals window.

9. Slowly adjust the potentiometer while viewing the Drive Signals window. The Current - Input Limit + value should update as the potentiometer is adjusted.

   If it is determined that the analog input is defective, refer to *Return Procedure* on page F-161 to return the unit.

TESTING ENCODER INPUTS

The following test verifies both reception and transmission of the line count from an encoder by the drive.

The tests require:

- a PC running *Tol-O-Motion SSD*, and
- a motor encoder.

Testing Encoder Inputs

1. Disable the drive by opening the connections between the ENABLE input and I/O PWR.

2. Choose the Drive Parameters command icon from *Tol-O-Motion SSD*.

3. Choose Master Encoder as the Command Source.

4. Choose the Drive setup command icon from *Tol-O-Motion SSD*.

5. Choose Divide by 1 as the Master Encoder Command Input.

6. Make the following hardware connections:
   - Connect the motor encoder to J2.
   - Jumper the Encoder Inputs to the Encoder Outputs by connecting the following pins:

     J1-7 to J1-14
     J1-8 to J1-15
     J1-9 to J1-16
     J1-10 to J1-17
     J1-11 to J1-18
     J1-12 to J1-19

7. Choose the Encoder Diagnostics command icon from *Tol-O-Motion SSD*.

8. Choose Zero Count for both the Motor Encoder and Master Position Input.

9. Slowly rotate the encoder shaft by hand while observing the counts for both the Motor Encoder and Master Position Input. The Motor Encoder and Master Position Input line counts should be equal.

Appendix

Options & Accessories

SSD drives conformance to the European Union Directives is contingent on:

1. Installation of AC line filters between the power source and the drive, and

2. Use of certified cables.

SSD Drives

	Description	Part #
SSD5	500 Watt Universal Drive, single phase 100-240 VAC @ 50/60 Hz	3600-9600
SSD10	1000 Watt Universal Drive, single phase 100-240 VAC @ 50/60 Hz	3600-9601
SSD20	2000 Watt Universal Drive, single phase 100-240 VAC @ 50/60 Hz	3600-9602

Cables

Controller	Part #
J1 to flying lead (4M)	3600-5064

Encoder	Part #
J2 to MRV (2M)	3600-1162
J2 to MRV (4M)	3600-1163
J2 to MRV (6M)	3600-1164

Motor	Part #
MRV to flying lead (6M)	3600-1165

Communication	Part #
RS232	3600-1173

Mating Connectors

The following connectors are listed solely to provide a cross-reference of mating connectors for the J1, J2 or J3 connectors on the SSD drives. SSD drive conformance to the European EMC Directive is contingent on the use of certified cables.

These connectors are not available from Tol-O-Matic. (Contact the manufacturer or the nearest distributor of Tol-O-Matic products for additional information. Manufacturer phone numbers are:
3M 1-800-225-5373, AMP 1-800-522-6752.)

DDM	MATING CONNECTOR	MATING BACK SHELL	DESCRIPTION
J1	AMP 2-175677-7	AMP 176793-7	50-pin Mini D Ribbon, 28-30 AWG, Insulation Displacement, Plastic Back shell, Squeeze Latch
J1	3M 10150-6000EC1	3M 10350-A200-00	50-pin Mini D Ribbon, 28-30 AWG, Insulation Displacement, Metal Back shell, Squeeze Latch
J1	3M 10150-3000VE	3M 10350-52F0-008	50-pin Mini D Ribbon, 24-30 AWG, Solder Cup, Plastic Back shell, Squeeze Latch
J2	AMP 2-175677-2	AMP 176793-2	20-pin Mini D Ribbon, 28-30 AWG, Insulation Displacement, Plastic Back shell, Squeeze Latch
J2	3M 10120-6000EC1	3M 10320-A200-00	20-pin Mini D Ribbon, 28-30 AWG, Insulation Displacement, Metal Back shell, Squeeze Latch
J2	3M 10120-3000VE	3M 10320-52F0-008	20-pin Mini D Ribbon, 24-30 AWG, Solder Cup, Plastic Back shell, Squeeze Latch
J3	AMP 2-175677-4	AMP 176793-4	26-pin Mini D Ribbon, 28-30 AWG, Insulation Displacement, Plastic Back shell, Squeeze Latch
J3	3M 10126-6000EC1	3M 10326-A200-00	26-pin Mini D Ribbon, 28-30 AWG, Insulation Displacement, Metal Back shell, Squeeze Latch
J3	3M 10126-3000VE	3M 10326-52F0-008	26-pin Mini D Ribbon, 24-30 AWG, Solder Cup, Plastic Back shell, Squeeze Latch

1. For use with MDR Hand Press Tool Kit, 3M part number 3829

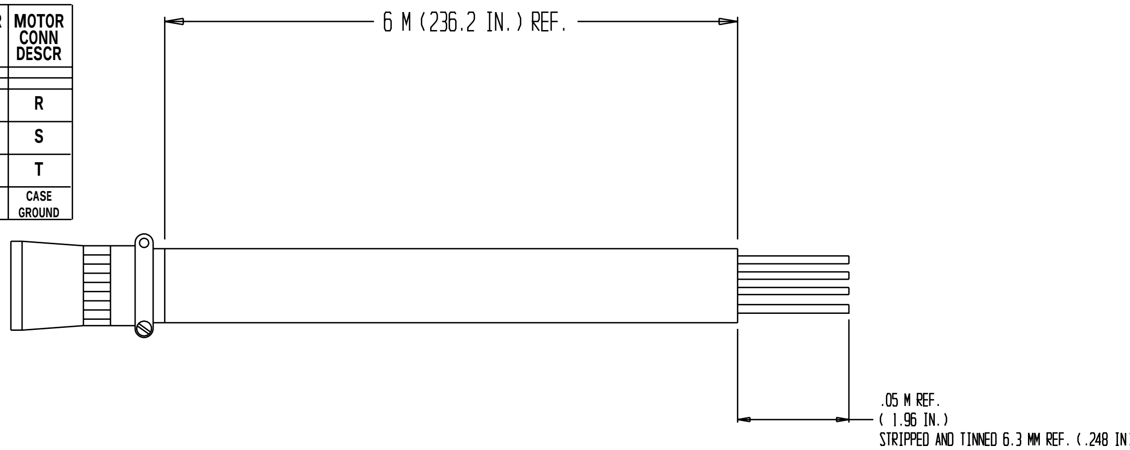
Cable Diagrams, Schematics & Examples B

Refer to Section A for *Mating Connector* cross-reference.

Motor Power Connections

MRV23_ and MRV34_

SSD CONN DESCR	WIRE COLOR	MOTOR CONN PIN #	MOTOR CONN DESCR
R	RED	1	R
S	WHT	2	S
T	BLK	3	T
GROUND	GRN	4	CASE GROUND



MRV171

Motor supplied with 1 meter flying lead power cable.

SSD CONN DESCR	MRV171 WIRE COLOR
R	RED
S	BLK
T	WHT
GROUND	GRN/YEL

Figure B.1 SSD Drive to Motor Power Connector

SSD Drive to Controller Connections

CONN. PIN	PIN & SIGNAL	WIRE COLOR	CONN. PIN	PIN & SIGNAL	WIRE COLOR	CONN. PIN	PIN & SIGNAL	WIRE COLOR
1	+5VDC	BLK/RED	24	READY+	RED/ORG	47		BLU/BRN
2	ECOM	RED/BLK	25	READY-	ORG/RED	48		BRN/BLU
3	+5VDC	BLK/WHT	26	I/O PWR	ORG/BLK	49		BLU/ORG
4	ECOM	WHT/BLK	27	+I LIMIT	GRN/WHT	50		ORG/BLU
5	I/O PWR	BLK/GRN	28	ACOM	WHT/GRN	X	BRAKE+	XXXXXXX
6	I/O COM	GRN/BLK	29		GRN/BLU	X	BRAKE-	XXXXXXX
7	AOUT+	BLK/BLU	30		BLU/GRN	X		XXXXXXX
8	AOUT-	BLU/BLK	31	ANALOG1	GRN/YLW			
9	BOUT+	BLK/YLW	32	INPUT1	YLW/GRN			
10	BOUT-	YLW/BLK	33	INPUT2	GRN/BRN			
11	IOUT+	BLK/BRN	34	INPUT3	BRN/GRN			
12	IOUT-	BRN/BLK	35		GRN/ORG			
13	I/O COM	BLK/ORG	36		ORG/GRN			
14	AX+/CW+/ STEP+	RED/WHT	37		WHT/BLU			
15	AX-/CW-/ STEP-	WHT/RED	38		BLU/WHT			
16	BX+/ CCW+/ DIR+	RED/GRN	39		WHT/YLW			
17	BX-/CCW-/ DIR-	GRN/RED	40		YLW/WHT			
18	IX+	RED/BLU	41		WHT/BRN			
19	IX	BLU/RED	42	OUTPUT 1	BRN/WHT			
20	ENABLE	RED/YLW	43	OUTPUT 2	WHT/ORG			
21	RESET	YLW/RED	44		ORG/WHT			
22	CMND+	RED/BRN	45		BLU/YLW			
23	CMND-	BRN/RED	46		YLW/BLU			

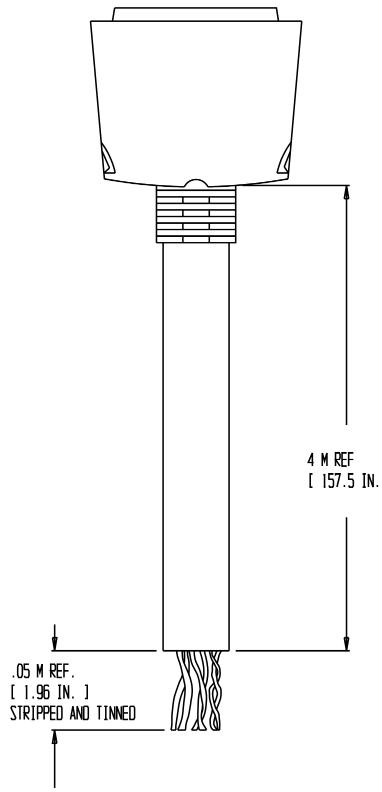


Figure B.2 J1 Connector to Flying Leads

Motor Power Connections

MRV23_ and MRV34_

DRV/CONN J2 PIN	Description	WIRE COLOR	MOTOR ENCODER CONN PIN	DRV/CONN J2 PIN	Description	WIRE COLOR	MOTOR ENCODER CONN PIN
1	Encoder Power	BLK/RED	K	11	Motor Encoder Input Channel I (+)	BLK/BRN	D
2	Encoder Common	RED/BLK	H	12	Motor Encoder Input Channel I (-)	BRN/BLK	E
3	Encoder Power	BLK/WHT	K	13	Hall Effect A	BLK/ORG	M
4	Encoder Common	WHT/BLK	H	14	Hall Effect B	ORG/BLK	C
5	Encoder Power Sense +	BLK/GRN	L	15	Hall Effect C	RED/WHT	R
6	Encoder Power Sense -	GRN/BLK	J	16	Reserved	WHT/RED	-----
7	Motor Encoder Input Channel A (+)	BLK/BLU	F	17	Reserved	RED/GRN	-----
8	Motor Encoder Input Channel A (-)	BLU/BLK	G	18	Reserved	GRN/RED	------
9	Motor Encoder Input Channel B (+)	BLK/YLW	N	19	Thermal Switch (+)	RED/BLU	A
10	Motor Encoder Input Channel B (-)	YLW/BLK	P	20	Thermal Switch (-)	BLU/RED	B

	P/N	" A "	REV
1	CR2	2 M CABLE LENGTH (78.74 IN.)	00
2	CR4	4 M CABLE LENGTH (157.48 IN.)	00
3	CR6	6 M CABLE LENGTH (236.22 IN.)	00

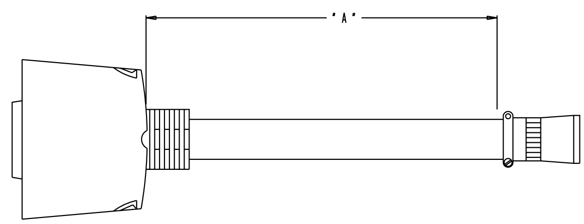


Figure B.3 J2 Connector to Motor Encoder

MRV171

Motor supplied with 1 meter encoder cable to 28 pin connector. When ordering the MRV171, a 3 meter extension cable is also supplied.

DRV/CONN J2 PIN	Description	WIRE COLOR	MOTOR ENCODER CONN PIN	DRV/CONN J2 PIN	Description	WIRE COLOR	MOTOR ENCODER CONN PIN
1	Encoder Power	GRAY	22	11	Motor Encoder Input Channel I (+)	GRN	13
2	Encoder Common	WHITE/ GRAY	23	12	Motor Encoder Input Channel I (-)	WHITE/ GRN	14
3	Encoder Power	GRAY	22	13	Hall Effect A	ORG	15
4	Encoder Common	WHITE/GRAY	23	14	Hall Effect B	WHITE/ORG	17
5	Encoder Power Sense +	BROWN	22	15	Hall Effect C	BLUE	19
6	Encoder Power Sense -	WHITE/ BROWN	23	16	Absolute Position		N/C
7	Motor Encoder Input Channel A (+)	BLACK	9	17	Reserved		N/C
8	Motor Encoder Input Channel A (-)	WHITE/ BLACK	10	18	Reserved		N/C
9	Motor Encoder Input Channel B (+)	RED	11	19	Thermal Switch (+)		N/C
10	Motor Encoder Input Channel B (-)	WHITE/ RED	12	20	Thermal Switch (+)		N/C

Figure B.4 J2 Connector to Motor Encoder

Electromagnetic Compatibility Guidelines for Machine Design

C

This appendix provides background information about Electromagnetic Interference (EMI) and machine design guidelines for Electromagnetic Compatibility (EMC). Installation requirements for compliance to the European Electromagnetic Compatibility Directive are specified in *European Union Requirements* on page 5-30. AC Line Filters necessary for European EMC compliance are listed in *AC Line Filters* on page 5-30.

Introduction

Perhaps no other subject related to the installation of industrial electronic equipment is so misunderstood as electrical noise. The subject is complex and the theory easily fills a book. This section provides guidelines that can minimize noise problems.

The majority of installations do not exhibit noise problems. However, the filtering and shielding guidelines are provided as counter measures. The grounding guidelines provided below are simply good grounding practices. They should be followed in all installations.

Electrical noise has two characteristics: the generation or emission of electromagnetic interference (EMI), and response or immunity to EMI. The degree to which a device does not emit EMI, and is immune to EMI is called the device's Electromagnetic Compatibility (EMC).

Equipment which is to be brought into the European Union legally requires a specific level of EMC. Since this applies when the equipment is brought into use, it is of considerable importance that a drive system, as a component of a machine, be correctly installed.

Figure C.1 shows the commonly used EMI model. The model consists of an EMI source, a coupling mechanism and an EMI victim. Devices such as servo drives and computers, which contain switching power supplies and microprocessors, are EMI sources. The mechanisms for the coupling of energy between the source and victim are conduction and radiation. Victim equipment can be any electromagnetic device that is adversely affected by the EMI coupled to it.

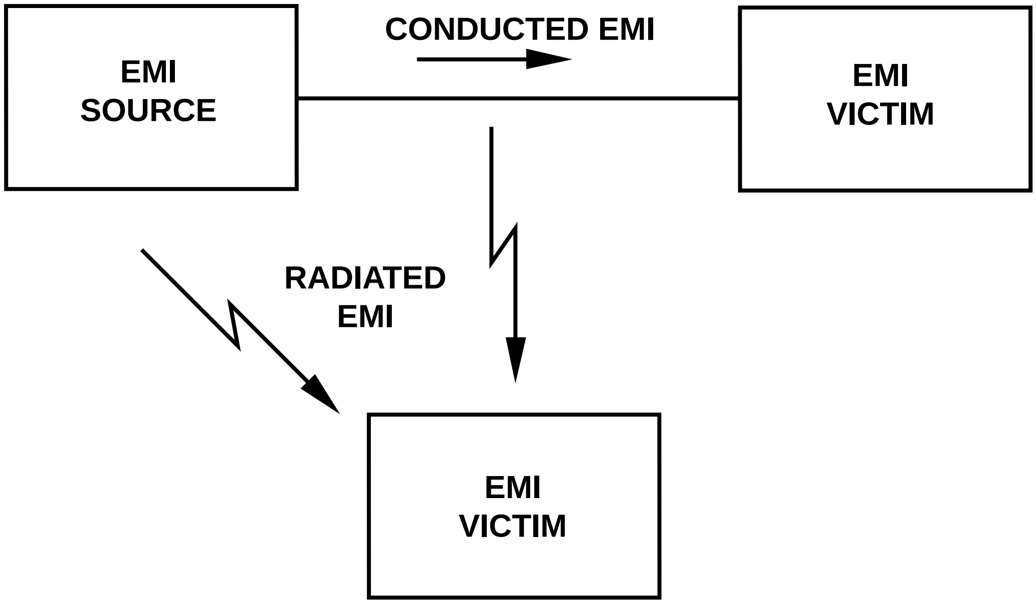


Figure C.1 EMI Source-Victim Model

Immunity to EMI is primarily determined by equipment design, but how the device is wired and grounded is also critical to achieving EMI immunity. Therefore, it is important to select equipment that has been designed and tested for industrial environments. The EMI standards for industrial equipment include the EN61000-4-X series (IEC 1000-4-X and IEC801-X), EN55011 (CISPR11), ANSI C62 and C63 and MIL-STD-461. Also, in industrial environments, encoders with differential driver outputs should be used rather than single ended outputs, and digital inputs/outputs with electrical isolation, such as those provided with optocouplers.

The EMI model provides only three options for eliminating the EMC problem:

- reduce the EMI at the source,
- increase the victim's immunity to EMI (harden the victim), or
- reduce or eliminate the coupling mechanism.

In the case of servo drives, reducing the EMI source requires slowing power semiconductor switching speeds. However, this adversely affects drive performance with respect to heat dissipation and speed/ torque regulation. Hardening the victim equipment may not be possible, or practical. The final, and often the most realistic solution is to reduce the coupling mechanism between the source and victim. This can be achieved by filtering, shielding and grounding.

Filtering

As mentioned above, high frequency energy can be coupled between circuits via radiation or conduction. The AC power wiring is one of the most important paths for both types of coupling mechanisms. The AC line can conduct noise into the drive from other devices, or it can conduct noise directly from the drive into other devices. It can also act as an antenna and transmit or receive radiated noise between the drive and other devices.

One method to improve the EMC characteristics of a drive is to use an isolation AC power transformer to feed the amplifier its input power. This minimizes inrush currents on power-up and provides electrical isolation. In addition, it provides common mode filtering, although the effect is limited in frequency by the interwinding capacitance. Use of a Faraday shield between the windings can increase the common mode rejection bandwidth, (shield terminated to ground) or provide differential mode shielding (shield terminated to the winding).

NOTE: ***Common mode*** noise is present on all conductors referenced to ground. ***Differential mode*** noise is present on one conductor referenced to another conductor.

One alternative is AC line filters to reduce the conducted EMI emitting from the drive. This allows nearby equipment to operate undisturbed. In many cases an AC line filter will not be required unless other sensitive circuits are powered off the same AC branch circuit. The basic operating principle is to minimize the high frequency power transfer through the filter. An effective filter achieves this by using capacitors and inductors to mismatch the source impedance (AC line) and the load impedance (drive) at high frequencies.

For drives brought into use in Europe, use of the correct filter is essential to meet emission requirements. Detailed information on filters is included in the manual and transformers should be used where specified in the manual.

AC LINE FILTER SELECTION

Selection of the proper filter is only the first step in reducing conducted emissions. Correct filter installation is crucial to achieving both EMI attenuation and to ensure safety. All of the following guidelines should be met for effective filter use.

1. The filter should be mounted to a grounded conductive surface.

2. The filter must be mounted close to the drive input terminals, particularly with higher frequency emissions (5-30 MHz). If the distance exceeds 600mm (2 feet), a strap should be used to connect the drive and filter, rather than a wire.

3. The wires connecting the AC source to the filter should be shielded from, or at least separated from the wires (or strap) connecting the drive to the filter. If the connections are not segregated from each other, then the EMI on the drive side of the filter can couple over to the source side of the filter, thereby reducing, or eliminating the filter effectiveness. The coupling mechanism can be radiation, or stray capacitance between the wires. The best method of achieving this is to mount the filter where the AC power enters the enclosure. Figure C.2 shows a good installation and a poor installation.

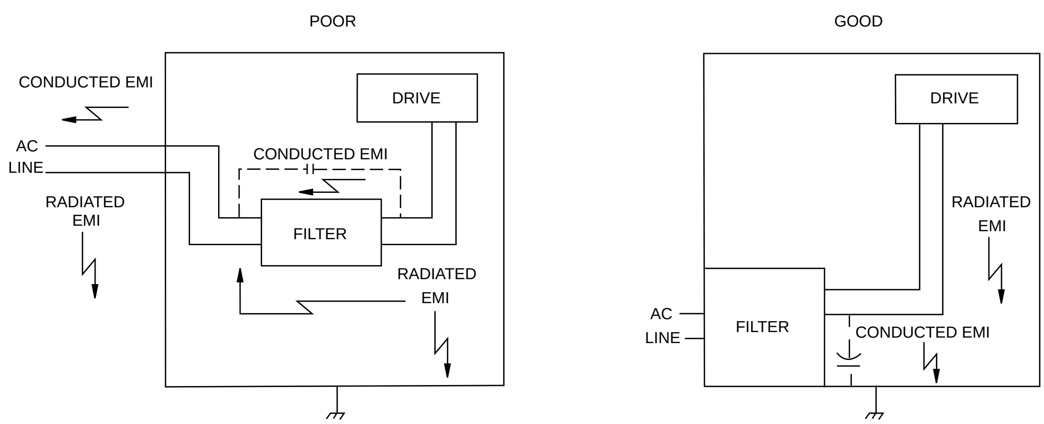


Figure C.2 AC Line Filter Installation

When multiple power cables enter an enclosure, an unfiltered line can contaminate a filtered line external to the enclosure. Therefore, all lines must be filtered to be effective. The situation is similar to a leaky boat. All the holes must be plugged to prevent sinking.

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.

If the filter is mounted excessively far from the drive, it may be necessary to mount it to a grounded conductive surface, such as the enclosure, to establish a high frequency (HF) connection to that surface. To achieve the HF ground, direct contact between the mounting surface and the filter must be achieved. This may require removal of paint or other insulating material from the cabinet or panel.

The only reasonable filtering at the drive output terminals is the use of inductance. Capacitors would slow the output switching and deteriorate the drive performance. A common mode choke can be used to reduce the HF voltage at the drive output. This will reduce emission coupling through the drive back to the AC line. However, the motor cable still carries a large HF voltage and current. Therefore, it is very important to segregate the motor cable from the AC power cable. More information on cable shielding and segregation is contained in the section on shielding. Further information is available from Schaffner (1-800-367-5566) or Roxburgh (01724.281770 [011.44.1724.281770 from the USA]).

Grounding

High frequency (HF) grounding is different from safety grounding. A long wire is sufficient for a safety ground, but is completely ineffective as an HF ground due to the wire inductance. As a rule of thumb, a wire has an inductance of 8 nH/in regardless of diameter. At low frequencies it acts as a constant impedance, at intermediate frequencies as an inductor, and at high frequencies as an antenna. The use of ground straps is a better alternative to wires. However the length to width ratio must be 5:1, or better yet 3:1, to remain a good high frequency connection.

The ground system's primary purpose is to function as a return current path. It is commonly thought of as an equipotential circuit reference point, but different locations in a ground system may be at different potentials. This is due to the return current flowing through the ground systems finite impedance. In a sense, ground systems are the sewer systems of electronics and as such are sometimes neglected.

The primary objective of a high frequency ground system is to provide a well defined path for HF currents and to minimize the loop area of the HF current paths. It is also important to separate HF grounds from sensitive circuit grounds. Figure C3 shows single point grounds for both series (daisy chain) and parallel (separate) connections. A single point, parallel connected ground system is recommended.

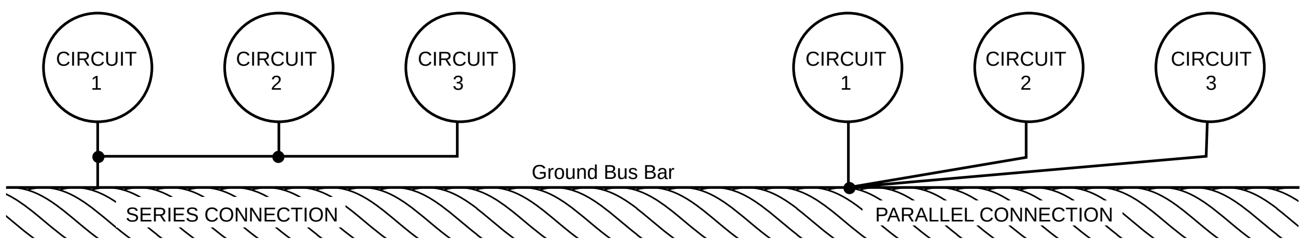


Figure C.3 Single Point Ground Types

A ground bus bar or plane should be used as the "single point" where circuits are grounded. This will minimize common (ground) impedance noise coupling. The ground bus bar (GBB) should be connected to the AC ground, and if necessary, to the enclosure. All circuits or subsystems should be connected to the GBB by separate connections. These connections should be as short as possible, and straps should be used when possible. The motor ground conductor must return to the ground terminal on the drive, not the GBB.

Shielding and Segregation

The EMI radiating from the drive enclosure drops off very quickly over distance. Mounting the drive in an enclosure, such as an industrial cabinet, further reduces the radiated emissions. The cabinet should have a high frequency ground and the size of the openings should be minimized. In addition, the drive is considered an "open" device which does not provide the proper IP rating for the environment in which it is installed. For this reason the enclosure must provide the necessary degree of protection. An IP rating or NEMA rating (which is similar to IP) specifies the degree of protection that an enclosure provides.

The primary propagation route for EMI emissions from a drive is through cabling. The cables conduct the EMI to other devices, and can also radiate the EMI. For this reason, cable segregation and shielding are important factors in reducing emissions. Cable shielding can also increase the level of immunity for a drive. For example:

- Shield termination at both ends is extremely important. The common misconception that shields should be terminated at only one end originates from audio applications with frequencies <20 kHz. RF applications must be terminate the shield at both ends, and possibly at intermediate points for exceptionally long cables.
- When shielded cables are not terminated at the cable connection and pass through the wall of a cabinet, the shield must be bonded to the cabinet wall to prevent noise acquired inside the cabinet from radiating outside the cabinet, and vice versa.
- When shielded cables are terminated to connectors, the shield must provide complete 360° coverage and terminate through the connector back shell. The shield must not be grounded inside the connector through a drain wire. Grounding the shield inside the connector couples the noise on the shield to the signal conductors sharing the connector and virtually guarantees failure to meet European EMC requirements.
- The shield must be continuous. Each intermediate connector must continue the shield connection through the back shell.
- All cables, both power and signal, should use twisted wire pairing.

The shield termination described above provides a coaxial type of configuration which provides magnetic shielding, and the shield provides a return path for HF currents that are capacitively coupled from the motor windings to the frame. If power frequency circulating currents are an issue, a 250 VAC capacitor should be used at one of the connections to block 50/60 Hz current while passing HF currents. Use of a properly shielded motor cable is essential to meet European EMC requirements.

The following suggestions are recommended for all installations.

1. Motor cables must have a continuous shield and be terminated at both ends. The shield must connect to the ground bus bar or drive chassis at the drive end, and the motor frame at the motor end. Use of a properly shielded motor cable is essential to meet European EMC requirements.
2. Signal cables (encoder, serial, analog) should be routed away from the motor cable and power wiring. Separate steel conduit can be used to provide shielding between the signal and power wiring. Do not route signal and power wiring through common junctions or raceways.
3. Signal cables from other circuits should not pass within 300 mm (1 ft.) of the drive.
4. The length or parallel runs between other circuit cables and the motor or power cable should be minimized. A rule of thumb is 300 mm (1 ft.) of separation for each 10 m (30 ft.) of parallel run. The 30 mm (1 ft.) separation can be reduced if the parallel run is less than 1 m (3 ft.).
5. Cable intersections should always occur at right angles to minimize magnetic coupling.
6. The encoder mounted on the brushless servo motor should be connected to the amplifier with a cable using multiple twisted wire pairs and an overall cable shield. Encoder cables are offered in various lengths that have correct terminations.

Persistent EMI problems may require additional counter measures. The following suggestions for system modification may be attempted.

1. A ferrite toroid, or “doughnut,” around a signal cable may attenuate common mode noise, particularly RS-232 communication problems. However, a ferrite toroid will not help differential mode noise. Differential mode noise requires twisted wire pairs.
2. Suppress each switched inductive device near the servo amplifier. Switch inductive devices include solenoids, relay coils, starter coils and AC motors (such as motor driven mechanical timers).
3. DC coils should be suppressed with a “free-wheeling” diode connected across the coil.
4. AC coils should be suppressed with RC filters (a 200 Ohm 1/2 Watt resistor in series with a 0.5 uF, 600 Volt capacitor is common).

Following these guidelines can minimize noise problems. However, equipment EMC performance must meet regulatory requirements in various parts of the world, specifically the European Union. Ultimately, it is the responsibility of the machine builder to ensure that the machine meets the appropriate requirements as installed.

Dynamic Braking Resistor Selection D

This appendix provides equations to assist in sizing resistors for dynamic braking.

Introduction

A properly sized resistive load may be required to dynamically brake the system by dissipating the energy stored in a motor. The section *Emergency Stop Wiring* on page 7-73 depicts the necessary circuitry.

Winding inductance is ignored in this analysis, which allows the load on the motor winding to be considered as purely resistive when dynamic braking occurs. This simplifies the evaluation to a scalar analysis, instead of a vector analysis. For simplicity, friction, damping and load torque also are ignored in the equations.

Dynamic Braking Equations

Equations for the magnitude of instantiates velocity, and per phase current, energy and power are derived by solving the differential equation governing the motor velocity. The equations are shown below.

Parameter	Description	Parameter	Description
i(t)	Phase Current	RL	Line-Neutral Dynamic Braking Resistance
E(t)	Per Phase Energy	KE	Peak Line-to-Line Back EMF
Jm	Motor Inertia	KT	Peak Line-to-Line Torque Constant
JL	Load Inertia	wo	Initial Angular Velocity
P(t)	Per Phase Power	w	Angular Velocity
R	Motor Line-to-Line Resistance	t	Time

Table D.A Dynamic Braking Resistor Parameters

(Equation 1) $\omega(t) = \omega_0 e^{-t/\tau}$

where

$$\tau = 0.866\left[\frac{(R + 2R_L)(J_M + J_L)}{K_E K_T}\right]$$

$$i(t) = \frac{K_E w_0 e^{-t/t}}{0.866(R + 2R_L)}$$

$$E(t) = \frac{1}{2}(J_M + J_L)\omega_0^2 e^{-t/\tau}$$

(Equation 2) $$P(t) = \left[\frac{(J_L + J_M)\omega_o^2}{2\tau}\right]e^{-2t/\tau} = 1.154\left[\frac{K_E K_T w_0^2}{(R + 2R_L)}\right]e^{-2t/t}$$

For this type of response, 98% of the energy will be dissipated in four time constants. Therefore the average power for each dynamic braking event can be calculated as:

(Equation 2) $$P_{AVE} = \frac{1}{2}(J_L + J_M)\omega_o^2\left(\frac{1}{4\tau}\right) = 0.144\,\frac{K_E K_T w_0^2}{(R + 2R_L)}$$

Figure D.1 Dynamic Braking Equations

Equation 1 is used in equation 2 and 3 to put the power in terms of the motor parameters and the dynamic braking resistance (i.e., independent of the load inertia).

Sample Calculations

The following example uses a motor with a 10 times inertia mismatch and dynamic braking resistors sized at four times the motor winding resistance. The average power of the motor is 1116 Watts for the selected parameters, but it is unlikely that a resistor with this Wattage is required. Pulse type currents, such as this example, require sufficient thermal mass to absorb the energy and to dissipate or accommodate the peak Voltage. Adequate information for intermittent duty cycle and surge current applications is seldom provided by resistor manufacturers. However, often they will assist in resistor selection when supplied with the current profile.

NOTE: The equations using the symbol ":=" are "assigned" in Mathcad®.

$$K_T := 0.74 \qquad R := 0.9 \qquad J_m := 0.00068$$

$$K_E := 90 \qquad \mathrm{K_E} := \frac{\mathrm{K_E} \cdot 60}{2 \cdot \pi \cdot 1000} \qquad K_E := 0.859$$

Figure D.2 H4075 Motor Parameters in MKS Units

$$R_L := 4 \cdot R \qquad J_L := 10 \cdot J_m \qquad \omega_0 := \frac{3000 \cdot 2 \cdot \pi}{60} \qquad \omega_0 := 314.159$$

Figure D.3 Load Inertia, Dynamic Braking Resistance and Velocity in MKS Units

$$t := 0, 0.01, ...0.5$$

Figure D.4 Time Vector

$$\tau := \frac{0.866(R + 2 \cdot R_L) \cdot (J_m + J_L)}{K_E \cdot K_T} \qquad \tau = 0.083$$

Figure D.5 Time Constant (seconds)

$$i(t) := \frac{K_E \cdot \omega_0 \cdot e^{-t/t}}{0.866(R + 2 \cdot R_L)}$$

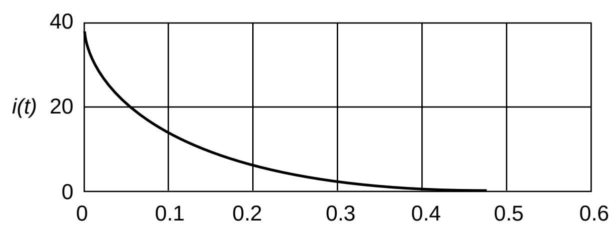


Figure D.6 Current Calculation (Amps)

$$P(t) := \left[\frac{1.154 \cdot K_E \cdot K_T \cdot \omega_0^2}{(R + 2 \cdot R_L)}\right] \cdot e^{\frac{-2 \cdot t}{\tau}}$$

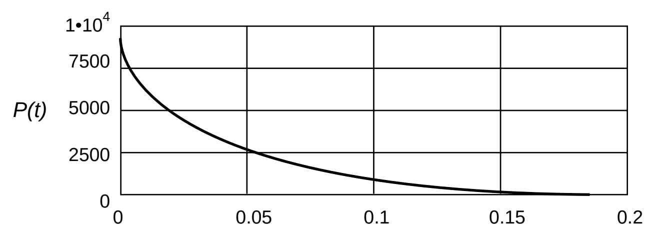


Figure D.7 Instantaneous Power Calculation (Watts)

$$P_{AVE} := 0.144\left[\frac{K_E \cdot K_T \cdot \omega_0^2}{R + 2 \cdot R}\right]$$

$$P_{AVE} = 1116$$

Figure D.8 Average Power (Watts)

Specifications

AGENCY APPROVALS

UL and cUL	UL 508C File E178547
CE mark	Low Voltage Directive and Electromagnetic Compatibility Directive; Certificate of Conformity from TUV Product Service

ENVIRONMENTAL

Operating Temperature	0(C to 55(C (32(F to 131(F)
Storage Temperature	-40(C to 70(C (-40(F to 158(F)
Humidity	5% to 95% non-condensing
Altitude	1500 meters (5000 feet); Derate 3% for each 300 m above 1500 m (1000 ft. above 5000 ft.)
Vibration	10 to 2000 Hz @ 2g
Shock	15g 11 millisecond half sine

DIELECTRIC WITHSTANDING (HI-POT)

Main AC	1414 (1500) VDC for 1 minute, <5mA leakage current

NOTE: Metal Oxide Varistors (MOVs) between line and earth ground must be removed when testing. Internal EMI filter capacitors require testing with DC Voltage.

WEIGHT

SSD5	1.7 Kg (3.7 Lbs)
SSD10	2.05 Kg (4.5 Lbs)
SSD20	2.0 Kg (4.4 Lbs)

MOTOR ENCODER INTERFACE

Power Output	5 Volts DC
Encoder Inputs	A/B, Differential, 26LS33 input, 1 MHz (4 MHz Quadrature) Maximum Signal Frequency, Line Break Detection, 1/T Low Speed Measurement
Encoder Outputs	A/B, Differential, AM26C31 output, 1 MHz (4 MHz Quadrature) Maximum Signal Frequency, Output divisible by 1, 2, 4 or 8.
Thermostat Inputs	Normally closed
Hall Inputs	Single-ended, 5 Volt Logic
ABS Input	0 to 5 Volt, 10-bit

USER INTERFACE

Serial Port	RS-232 or four wire RS-485, 1200 to 19200 baud
Status Display	3 Level LED
Addressing	Software selected

DIGITAL INPUTS

Selectable (3)	12-24 Volt, Optically Isolated, Single ended, Active High, 4.5 mA nominal
FAULT RESET	12-24 Volt, Optically Isolated, Single ended, Active High, 4.5 mA nominal
ENABLE	12-24 Volt, Optically Isolated, Single ended, Active High, 4.5 mA nominal

DIGITAL OUTPUTS

Selectable (2)	12-24 Volt, Short Circuit Protected, Optically Isolated, Single-ended, Active High, 50 mA maximum
BRAKE	12-24 Volt, Normally Open Relay, 1 A
READY	12-24 Volt, Normally Open Relay, 100 mA
Digital I/O Power Supply	User supplied 24VDC

ANALOG INPUTS

Current Limit (I LIMIT)	0 to 10 Volt, single-ended, 5 kOhm input Impedance
COMMAND	±10 Volt, Differential, 13 kOhm input Impedance, offset software adjustable

ANALOG OUTPUTS

ANALOG1	0 to 10 Volt, 2 mA maximum
	26LS33 Input, 4 MHz Count Frequency
	Differential/Single-ended
Auxiliary Encoder Signal Input	A/B
	Step/Direction
	CW/CCW
Motor Encoder Output	AM26C31 Differential Driver, Divide by 1, 2, 4, or 8
	Differential output is 2.0 Vdc across a 100 Ohm load

MEMORY

Parameter Data Retention	20 years

MOTOR PROTECTION

Motor Overload Protection	The drive utilizes solid state motor overload protection which operates: • within 8 minutes at 200% overload • within 20 seconds at 600% overload

SPEED REGULATION

Type	Digital, PID
-3dB Bandwidth	300 Hz
-45° Bandwidth	50 Hz
Ripple	±0.44 rpm with 5000 PPR encoder
Speed Range	1:8000 rpm

POSITION REGULATION

Type	Digital, PID with Feedforward

FILTERS

Low Pass	Digital, 0 - 1000 Hz, -3 dB Bandwidth, Selectable

continued

SOFTWARE CONTROLS

Data Collection (2)	128 samples @ 5 kHz Sample Rate
Firmware	Factory installed EEPROM
Operating Modes	Torque or Velocity
Command Sources	Analog
	Auxiliary Encoder
	Presets
	Step/Direction
	CW/CCW
Autotuning	Position and
	Velocity Loop
Manual Tuning	Position or
	Velocity Loop
User Set-up	*Tol-O-Motion SSD*
Diagnostics	Motor or Auxiliary Encoder Checks
	Digital Output Override
	Analog Output Override
Serial Protocol	7-bit ASCII, Checksum, Active Response

POWER-UP FAULTS

	EPROM Checksum
	EEPROM Checksum
	SRAM Write/Read
	Watchdog Reset
	A/D ConversionD/A Conversion
Run-Time Faults	Motor Overtemperature
	Bus Overvoltage
	IPM Fault
	Overspeed
	Excess Error
	Encoder State Change
	Illegal Hall State
Selectable Digital Inputs	Mode Select
	Integrator Inhibit
	Follower Enable
	Forward Enable
	Reverse Enable
	Preset Selects
	Analog Override

Selectable Digital Outputs	In-Position Within Position Window Zero Speed Within Speed Window ± Current Limit Up To Speed Enabled Charged

SPEED CONTROL COMMAND

Range	0 to ±32,767 RPM (actual maximum speed depends on the motor/drive combination)

Power

	SSD5	SSD10	SSD20
AC Input Voltage and Frequency	100-240 VAC_{rms} nominal Single Phase 47 - 63 Hz	100 to 240 VAC_{rms} nominal Single Phase 47 - 63 Hz	100 to 240 VAC_{rms} nominal Single Phase 47 - 63 Hz
AC Input Current	5 Arms	9 Arms	18 Arms
Bus Voltage	141-339 VDC	141-339 VDC	141-339 VDC
Output Peak Current	7.5 Amps	15 Amps	30 Amps
Continuous Output Current (peak)	2.5 Amps	5 Amps	10 Amps
Bus Capacitance Energy Absorption *(from 325-400 Vdc Bus)*[a]	38 Joules C=1410uF	51 Joules C=1880uF	51 Joules C=1880uF
Peak Power Output[b]	120 Vac 0.9 kWatts 240 Vac1.8 kWatts	120 Vac 1.3 kWatts 240 Vac 2.7 kWatts	120 Vac 2.7 kWatts 240 Vac 5.5 kWatts
Continuous Power Output2	120 Vac 0.3 kWatts 240 Vac 0.6 kWatts	120 Vac 0.6 kWatts 240 Vac 1.2 kWatts	120 Vac 1.2 kWatts 240 Vac 2.5 kWatts

a. Bus capacitance energy absorption is based on the following equations:

$$\varepsilon = \frac{1}{2}C\left(V^2{}_f\right) - \frac{1}{2}C\left(V^2{}_i\right)$$

$$\varepsilon = \frac{1}{2}C(420)^2 - \frac{1}{2}C(325)^2$$

$$\frac{1}{2}C \cdot \left(420^2 - 325^2\right) = C(35387)$$

$$ifC = 17 \times 470\mu F,\ E = 282$$

b. Power outputs are based on the following equation:

$$kWatts = \left(VAC \times \frac{I_{Rmax}}{\sqrt{2} \times}\sqrt{3}\right) \times 0.85$$

POWER DISSIPATION

The SSD 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.

Current as % of Rated Continuous Current	SSD5	SSD10	SSD20
100	48 W	48 W	50 W
NOTE: These values *do not* include external shunt regulator power (regenerated power)			

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

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 enclosure necessary:

T = 4.08 * (Q/A) + 1.1

where:
T = Temperature difference between inside air and outside ambient (°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

The following product warranty and returned goods information summarizes the product warranty and return policy of Tol-O-Matic. 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 Tol-O-Matic products for repair or replacement.

There are no field serviceable parts in the drive, other than fuses and jumpers. 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.

SSD drives are warranted against defects in material and assembly. Limitations to warranty coverage are detailed in *Returned Goods and Field Service Policy*. 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 Tol-O-Matic product, the following procedure must be followed:

1. Call the nearest distributor of Tol-O-Matic 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. Tol-O-Matic 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

Axidyne 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

Tol-O-Matic 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.

Applications Engineers and Field Service

In the United States you can reach the Tol-O-Matic 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.

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Axidyne®