

# HARDWARE & INSTALLATION GUIDE

## ACS – Actuator Control Solutions Stepper Drive/Controller and Motors



3604-4173\_00

Air-Oil Systems, Inc. [www.airoil.com](http://www.airoil.com)

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

201102031042

|  |      |
|--|------|
| <b>List of Figures</b> .....   | iii  |
| <b>List of Tables</b> .....  | iv   |
| <b>Health and Safety Regulations</b> .....                             | vi   |
| Safety Symbols.....  | v    |
| EMC Wiring Guidelines.....   | vii  |
| Proper and Safe Use of Product.....                                    | vii  |
| Handling and Unpacking.....  | viii |
| Product Warnings.....  | viii |
| <b>1. Product Overview</b> .....                                       | 1-1  |
| 1.1 The ACS Stepper Drive/Controller for Actual Control Solutions..... | 1-1  |
| 1.1.1 The ACS Stepper Drive/Controller Basic Overview.....             | 1-1  |
| 1.1.2 Optional Accessories.....  | 1-1  |
| <b>2. Environment, Dimensions &amp; Mounting</b> .....                 | 2-1  |
| 2.1 Operating Environment.....   | 2-1  |
| 2.2 Dimensions.....  | 2-1  |
| 2.3 Mounting the ACS Drive/Controller.....                             | 2-2  |
| <b>3. Starter Kit</b> .....  | 3-1  |
| <b>4. ACS Drive/Controller Setup</b> .....                             | 4-1  |
| 4.1 ACS Drive/Controller and Actuator Basic Setup.....                 | 4-1  |
| 4.1.1 Setup Procedures.....  | 4-2  |
| <b>5. Connections &amp; Cables</b> .....                               | 5-1  |
| 5.1 Connections & Cables Overview.....                                 | 5-1  |
| 5.2 Motor Power Connection and Cable.....                              | 5-1  |
| 5.3 Encoder Connection and Cable.....                                  | 5-2  |
| 5.4 I/O Connection and Cable.....                                      | 5-3  |
| 5.5 Input Power Connection.....  | 5-4  |
| 5.6 RS-232 Connection.....   | 5-5  |
| 5.7 RS-485 Connection.....   | 5-6  |
| 5.8 Ethernet Connection.....   | 5-6  |
| 5.9 Cable Routing.....   | 5-7  |
| <b>6. Specifications and Wiring</b> .....                              | 6-1  |
| 6.1 Digital Inputs.....  | 6-1  |
| 6.1.1 Specifications.....  | 6-1  |
| 6.1.2 Typical Wiring Diagrams.....                                     | 6-2  |
| 6.2 Digital Outputs.....   | 6-2  |

# CONTENTS

---

|  |             |
|--|-------------|
| 6.2.1 Specifications .....                           | 6-2         |
| 6.2.2 Typical Wiring Diagrams .....                  | 6-3         |
| 6.3 Input Power .....                                | 6-3         |
| 6.3.1 Drive Specifications .....                     | 6-4         |
| 6.3.2 Typical Input Power Wiring .....               | 6-4         |
| 6.3.3 Power Supply Selection.....                    | 6-5         |
| 6.3.4 Suggested Power Supplies.....                  | 6-5         |
| <b>7. I/O Timing Diagrams.....</b>                   | <b>7-1</b>  |
| 7.1 I/O Timing Diagrams.....                         | 7-1         |
| 7.1.1 Move Timing Rules .....                        | 7-2         |
| <b>8. Move Select Logic.....</b>                     | <b>8-1</b>  |
| 8.1 Move Select Logic Tables .....                   | 8-1         |
| <b>9. LED Codes and Faults.....</b>                  | <b>9-1</b>  |
| 9.1 LED Codes.....                                   | 9-1         |
| 9.2 Fault Descriptions and Recovery .....            | 9-1         |
| <b>10. Troubleshooting.....</b>                      | <b>10-1</b> |
| 10.1.1 Troubleshooting the ACS Drive/Controller..... | 10-1        |
| <b>Appendix 1.....</b>                               | <b>A1-1</b> |
| Motors.....  | A1-1        |
| <b>Appendix 2.....</b>                               | <b>A2-1</b> |
| Product Warranty .....                               | A2-1        |

# List of Figures

|             |   |     |
|-------------|---|-----|
| Figure 2-1  | Mounting the ACS Drive/Controller .....                                   | 2-1 |
| Figure 3-1  | ACS Drive/Controller and ERD Actuator Basic Setup.....                    | 3-1 |
| Figure 5-1  | Motor Power Connection on ACS Drive/Controller.....                       | 5-1 |
| Figure 5-2  | Motor Power Cable 3604-1767/1766.....                                     | 5-2 |
| Figure 5-3  | Encoder Connection on ACS Drive/Controller .....                          | 5-2 |
| Figure 5-4  | Encoder Cable 3604-1768.....  | 5-3 |
| Figure 5-5  | I/O Connection on ACS Drive/Controller .....                              | 5-3 |
| Figure 5-6  | I/O Cable 3604-1770.....  | 5-4 |
| Figure 5-7  | Input Power Connection.....   | 5-4 |
| Figure 5-8  | RS-232 Connection.....  | 5-5 |
| Figure 5-9  | RS-232 Pin Connection .....   | 5-5 |
| Figure 5-10 | RS-485 Connection for Future ACS Drive/Controller Programmability .....   | 5-6 |
| Figure 5-11 | Ethernet Connection for Future ACS Drive/Controller Programmability ..... | 5-6 |
| Figure 5-12 | Cable Routing for Top and Side Mounted Connectors .....                   | 5-7 |
| Figure 6-1  | Digital Input Circuit.....  | 6-1 |
| Figure 6-2  | Input Source (switched) Connection.....                                   | 6-1 |
| Figure 6-3  | Input Source (PNP) Connection .....                                       | 6-2 |
| Figure 6-4  | Input Sink (switched) Connection .....                                    | 6-2 |
| Figure 6-5  | Input Sink (NPN) Connection .....   | 6-2 |
| Figure 6-6  | Output Circuit .....  | 6-3 |
| Figure 6-7  | Digital Output Sinking Connection .....                                   | 6-3 |
| Figure 6-8  | Digital Output Sourcing Connection .....                                  | 6-3 |
| Figure 6-9  | ACS Drive/Controller Logic and Main Power Supplies.....                   | 6-4 |
| Figure 6-10 | ACS Drive/Controller Single Supply – Main Power.....                      | 6-4 |
| Figure 6-11 | ACS Drive/Controller External Cutoff Switch for Emergency Stop.....       | 6-5 |
| Figure 7-1  | Input Requirement.....  | 7-1 |
| Figure 7-2  | System Startup Timing .....   | 7-1 |
| Figure 7-3  | Jog Move Timing.....  | 7-1 |
| Figure 7-4  | Absolute & Incremental Move Timing.....                                   | 7-2 |

# List of Tables

---

|            |  |      |
|------------|--|------|
| Table 3-1  | ACS Starter Kit Contents.....                          | 3-1  |
| Table 3-2  | D-sub to RJ12 Converter Wiring .....                   | 3-1  |
| Table 5-1  | Motor Power Connection PIN Outs .....                  | 5-1  |
| Table 5-2  | Motor Power Cable and Connector Parts .....            | 5-2  |
| Table 5-3  | Encoder Connection PIN Outs .....                      | 5-2  |
| Table 5-4  | Encoder Cable and Connector Parts .....                | 5-3  |
| Table 5-5  | I/O Connection PIN Outs .....                          | 5-4  |
| Table 5-6  | I/O Cable and Connector Parts.....                     | 5-4  |
| Table 5-7  | Input Power PIN Outs .....                             | 5-5  |
| Table 5-8  | Input Power Cable Parts .....                          | 5-5  |
| Table 5-9  | RS-232 PIN Outs and Connection .....                   | 5-5  |
| Table 5-10 | RS-232 Cable Parts .....                               | 5-5  |
| Table 6-1  | Opto-isolated Digital Input Specifications .....       | 6-1  |
| Table 6-2  | Digital Output Specifications .....                    | 6-3  |
| Table 6-3  | Drive Specifications .....                             | 6-4  |
| Table 6-4  | Maximum Power Supply Current for Tolomatic Motors..... | 6-5  |
| Table 6-5  | Recommended Switching Power Supplies .....             | 6-6  |
| Table 6-6  | Recommended Linear Regulated Power Supplies.....       | 6-6  |
| Table 6-7  | Recommended Linear Unregulated Power Supplies.....     | 6-6  |
| Table 6-8  | Fuses .....  | 6-6  |
| Table 8-1  | 4 Move Commands Mode Logic.....                        | 8-1  |
| Table 8-2  | 8 Move Commands Mode Logic.....                        | 8-1  |
| Table 8-3  | 16 Move Commands Mode Logic.....                       | 8-2  |
| Table 9-1  | LED Indicators.....                                    | 9-1  |
| Table 9-2  | Safety Faults.....                                     | 9-1  |
| Table 9-3  | Critical Faults.....                                   | 9-2  |
| Table 10-1 | Troubleshooting Descriptions .....                     | 10-1 |
| Table A-1  | Tolomatic Motor Specifications.....                    | A1-1 |
| Table A-2  | Tolomatic Motor Part Numbers.....                      | A1-1 |
| Table A-3  | Encoder Specifications .....                           | A1-1 |
| Table A-4  | NEMA 11 Motor Connection PIN Outs .....                | A1-2 |
| Table A-5  | NEMA 17 Motor Connection PIN Outs .....                | A1-2 |
| Table A-6  | NEMA 23 Motor Connection PIN Outs .....                | A1-2 |
| Table A-7  | Encoder Connections and Connector PIN Outs.....        | A1-2 |

# Health and Safety Regulations

---

Read completely through the applicable sections of the manual before the equipment is unpacked, installed or operated. Pay careful attention to all of the dangers, warnings, cautions and notes stated in the manual.

Serious injury to persons or damage to the equipment may result if the information in the manual is not followed.

## ■ Safety Symbols

Items that are specifically marked DANGER!, WARNING!, CAUTION! or NOTE! are arranged in a hierarchical system and have the following meaning:



**DANGER!**

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



**WARNING!**

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



**CAUTION!**

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



**CAUTION!**

Indicates hot surfaces. Avoid contact.

**NOTE!**

Information that requires special attention is stated here.

## ■ EMC Wiring Guidelines

### Cable routing

It is recommended that the power and signal cables for the ACS drive/controller be routed as far apart as possible to minimize system noise.

**NOTE!** The standard cables from Tolomatic are not flex rated and have a minimum bend radius of 3.75 inches. Any repeated flexing or excessive bending can result in broken conductors and intermittent faults.

### Shielding and grounding

When cabling the system, shielded cables are recommended. The standard cables provided by Tolomatic have an overall shield with drain wires. The metal angle bracket on the drive/controller is also a case ground and should be tied to earth ground. To minimize EMI and ensure system reliability, all shield drain wires from all cables should be tied to a common earth ground.

## ■ Proper and Safe Use of Product

### Protection circuits and external fuses

A fuse should be added to the input power line to protect the drive/controller and power supply from any potential over current conditions that may occur. (See Section 6: Specifications & Wiring, page 6-6)

### Fail Safe Emergency Stop Recommendations

A means for a fail safe e-stop is highly recommended to ensure equipment and personal safety. The e-stop should provide a means to remove main power from the actuator to cease and prevent any unwanted motion.

### Device Damage Prevention

To prevent permanent damage to the device, proper care should be taken not to exceed published voltage, current, temperature, and load ratings. In addition, proper wiring should be verified and safety measures checked before applying power.

### Personal Safety

During normal operation the motor can become hot. It is highly recommended to display proper safety notices and implement proper safety measures to prevent contact with hot surfaces.



### **WARNING!**

***The manufacturer takes no responsibility whatsoever if the equipment is modified or if the equipment is used in any way beyond performance specifications.***

***Unauthorized modifications or changes to the equipment are strictly forbidden and void all warranties.***

**CAUTION!**

***Proper ESD measures should be taken to avoid static electricity from contacting the signal and power lines of the drive, motor and encoder.***

**■ Handling and Unpacking**

When unpacking and handling, care should be taken not to drop the drive/controller as this can damage the connectors and internal electronics.

**■ Product Warnings**

The following precautions should be observed to prevent erratic behavior or damage:

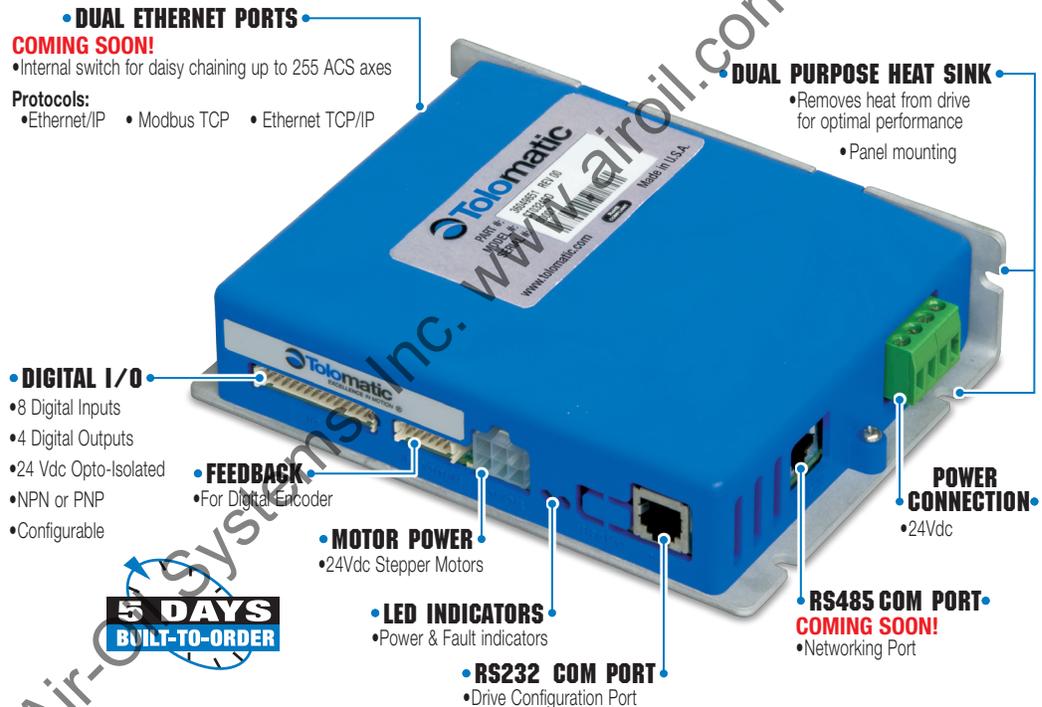
- Do not short circuit the motor power at the power connector. Doing so may damage the drive power electronics. The motor/cable is part of the current regulation circuitry. For a short occurring in a motor, the motor leads should provide enough resistance and inductance to prevent dangerous peak currents from occurring.
- Do not reverse bias the power unit.
- Do not apply voltages above the maximum rated voltage.
- Do not expose drive to conductive contaminants, moisture, or excessive temperature.
- Do not disassemble or modify the drive/controller.

Air-Oil Systems, Inc. [www.airoil.com](http://www.airoil.com)

## 1.1 The ACS Stepper Drive/Controller for Actuator Control Solutions

Tolomatic's ACS drive/controller is a stepper drive and controller intended for use with electric actuators. Tolomatic's Motion Interface software allows the user to select the compatible Tolomatic electric linear actuator of choice. The software automatically sets most of the necessary parameters to create the desired motion of the selected actuator reducing setup and programming time. (See Tolomatic Motion Interface Software Manual 3600-4167 for more information).

### 1.1.1 ACS Stepper Drive/Controller— Basic Overview



### ACS Basic Drive/Controller (3604-9651) Capabilities

- 4, 8, or 16 move command modes (absolute, incremental or jog) for infinite position capability
- Adjustable motion profile parameters (velocity, accel/decel, force). Parameters are independently configurable for each move
- Ability to reduce holding current for energy savings
- End point correction
- Zone output based on position
- Force limiting capacity
- Configurable digital I/O (24 Vdc Opto-Isolated)(NPN or PNP)
- Compatible with most 24 Vdc stepper motors

**Future Capabilities Currently in Development**

OPERATING MODES:

- Stepper mode (pulse/direction)
- Analog position mode (0-10Vdc or 4-20mA)
- Pneumatic modes

NETWORKING CAPABILITIES

- Ethernet protocols:
  - Ethernet I/P for integration with Allen Bradley PLCs
  - Modbus TCP/RTU for integration with most other PLCs & HMIs
  - Ethernet TCP/IP
- Dual ethernet ports with internal switch for daisy chaining
- Modbus RTU over RS-485

**1.1.2 Optional Accessories**

**Cable Options**



Tolomatic offers a motor power cable with drive and motor mating connectors, an encoder cable with drive and encoder connectors, and an I/O cable with drive mating connector to flying leads. Cables are available in either 3-meter or 5-meter lengths.

**Starter Kit**



Tolomatic offers a Starter Kit (Part No. 3604-9044) for use with optional USB computer connections. The kit includes:

- USB to RS-232 converter
- Adapter cable for RJ12 to D-sub
- Tolomatic Motion Interface Software CD

## 2.1 Operating Environment



### WARNING!

**Do not expose the drive to conductive contaminants, moisture, or exceed temperature settings.**

The ACS drive/controller is designed to be operated in ambient conditions from 0° – 40°C (32° – 104°F), and humidity from 0 – 90% non-condensing. There is no ingress protection (IP) for the drive, so it is important to protect the drive from coming in contact with water or other conductive contamination. In addition, proper ESD procedures should be observed to prevent static discharge and damage to electronic components.

| ACS Stepper Drive/Controller Operating Conditions |                                   |
|---|-----------------------------------|
| Ambient Temperature                               | 77° F, 25° C Nominal              |
| Operating Temperature                             | 32°-104° F, 0°-40° C Non Freezing |
| Storage Temperature                               | 32°-158° F, 0°-70° C              |
| Humidity  | 0-90% non-condensing              |

Table 2-1: ACS Operating Conditions

## 2.2 ACS Drive/Controller Dimensions

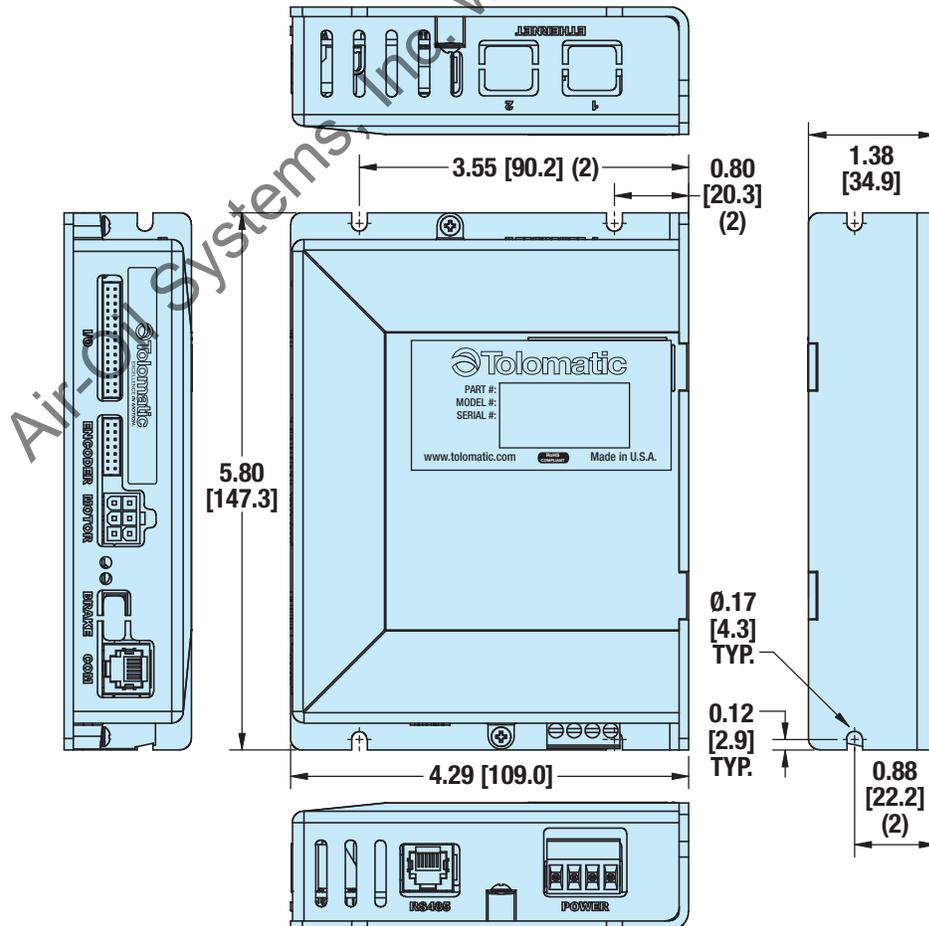
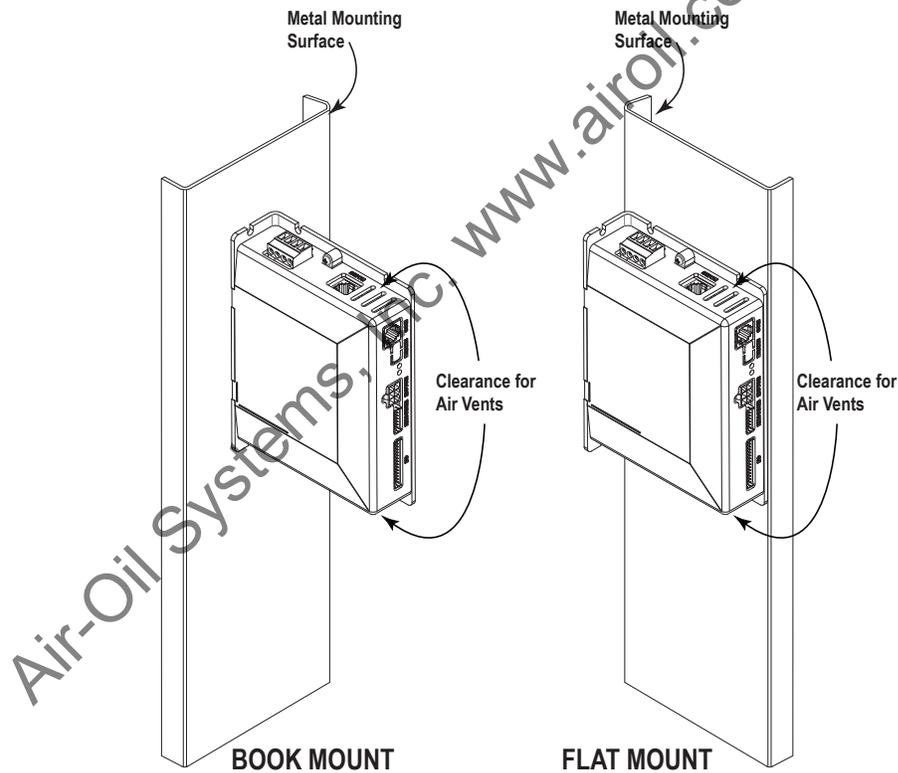


Figure 2-1: ACS Drive/Controller Dimensions

## 2.3 Mounting the ACS Drive/Controller

The drive/controller is intended to be mounted vertically to provide the vents with enough clearance on the top and bottom of the drive to allow for air flow. The metal bracket should also be mounted to a metal surface for best thermal dissipation. A 2-inch head space is recommended from the drive vents to another surface to ensure the proper Ambient temperature ratings are maintained.

It is recommended to have a minimum of 1-inch spacing between drives. This spacing may be relaxed providing the ambient temperature is kept within limits and the drive is mounted to a metal surface suitable enough to heat sink the drives.



*Figure 2-1 Mounting the ACS Drive/Controller*

## 3.1 Starter Kit

Tolomatic offers a basic Starter Kit for the ACS stepper drive/controller that can be used to convert a USB connection to a serial port.

The kit includes an RJ12 cable, a D-sub to RJ converter, a USB to RS232 converter and a CD with the Tolomatic Motion Interface software.



| ACS Drive/Controller Starter kit: PN 3604-9044 |                       |                                    |
|--|-----------------------|------------------------------------|
| ITEM   | TOLOMATIC PART NUMBER | MFR PART NUMBER                    |
| RJ12 Cable                                     | 3604-1783             | Assmann PN:<br>AT-S-26-6/6/B-7/R-R |
| D-sub to RJ Converter                          | 3604-1782             | Assmann PN:<br>AT-23065-R          |
| USB to RS232 Converter                         | 3604-1795             | Keyspan PN:<br>USA19-HS            |
| Tolomatic Motion Interface Software CD         | 3604-9526             | —                                  |

**Table 3-1: ACS Starter Kit Contents**

Tolomatic also offers a Programming Cable Kit (3604-9043) which includes the RJ12 cable and D-sub to RJ12 Converter.

The D-sub to RJ12 converter should to be wired as follows:

| WIRE COLOR | D-SUB |
|------------|-------|
| Yellow     | 2     |
| Green      | 3     |
| Red        | 4     |
| Black      | 5     |
| White      | 7     |

*Table 3-2: D-Sub to RJ12 Converter Wiring*

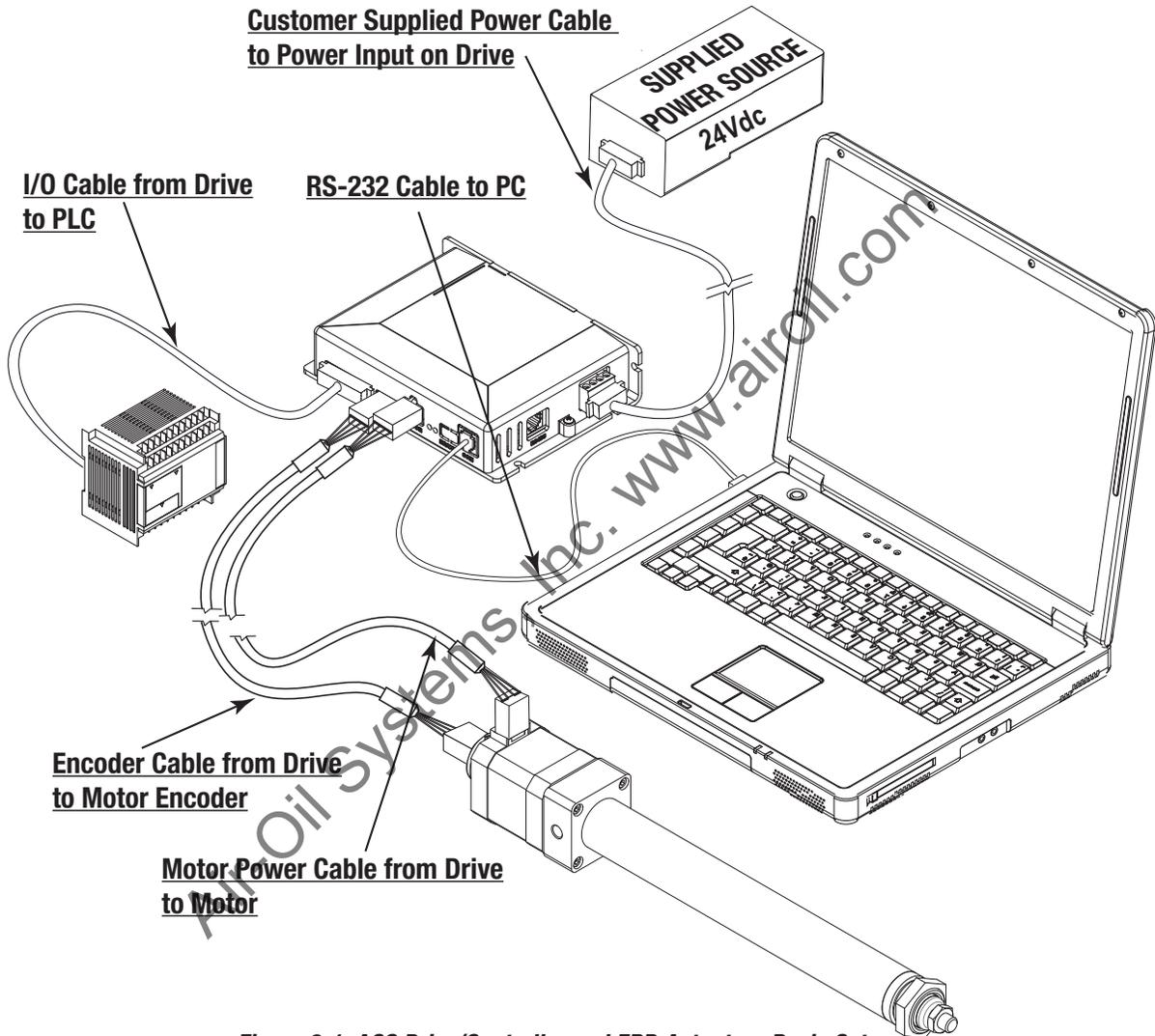
**NOTE:** The brown wire is not used.

**NOTE:** Pinout assumes RJ12 cable is reversed.

Air-Oil Systems, Inc. [www.airoil.com](http://www.airoil.com)

## 4.1 ACS Drive/Controller and Actuator Basic Setup

Figure 3-1 shows the simple setup of the ACS Drive/Controller, the Tolomatic ERD actuator and the necessary cables and power source.



**Figure 3-1: ACS Drive/Controller and ERD Actuator– Basic Setup**

Please refer to the following sections and page numbers for cable part numbers and wiring specifications:

Motor Power Cable: Section 5– pages 5-1 to 5-2

Encoder Cable: Section 5– pages 5-2 to 5-3

I/O Cable: Section 5– pages 5-3 to 5-4

RS-232 Cable: Section 5– page 5-5

For recommended power supplies: Section 6– pages 6-5 to 6-6

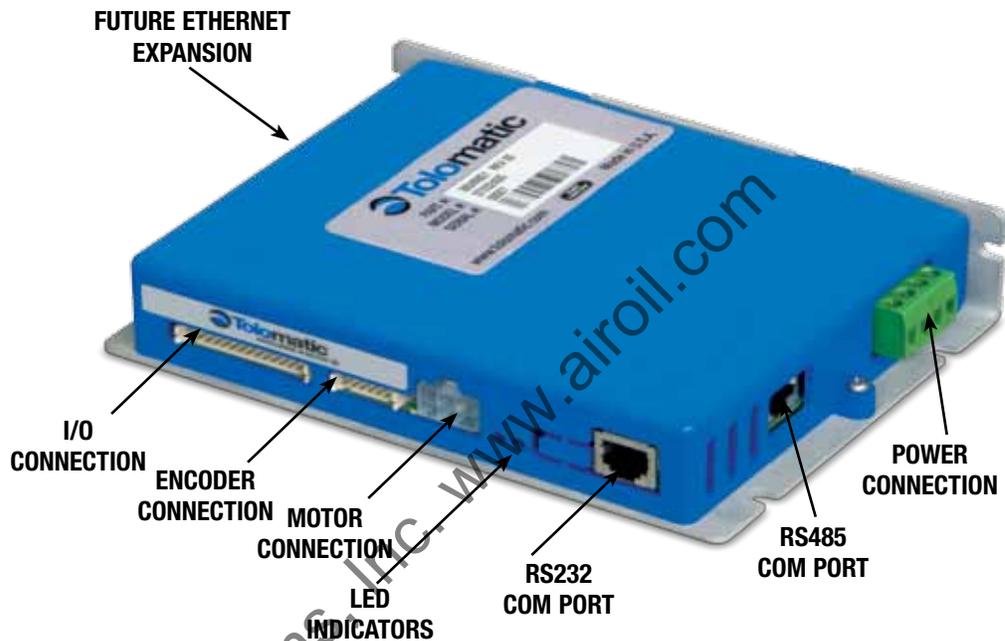
### ■ 4.1.1 Setup Procedures

1. Install drive/controller and actuator into appropriate fixtures.
2. Wire the 24Vdc power supply to the drive. See Section 6: Power Supply Selection.
3. Wire input and output signals to the desired logic device. See Section 5: Connections and Cables.
4. Attach motor and encoder cables.
5. Attach serial programming cable and install the Tolomatic Motion Interface software.
6. Configure ACS Drive/Controller.
7. Program the logic device.

Air-Oil Systems, Inc. [www.airoil.com](http://www.airoil.com)

## 5.1 Connections and Cables Overview

All cables for the ACS Drive/Controller can be ordered through Tolomatic with the exception of the power supply. When using cables other than those provided by Tolomatic, reference the cable mating connector style to ensure the proper cabling is supplied.



## 5.2 Motor Power Connection and Cables



### WARNING!

Do not connect or disconnect motor cables while the drive is powered.

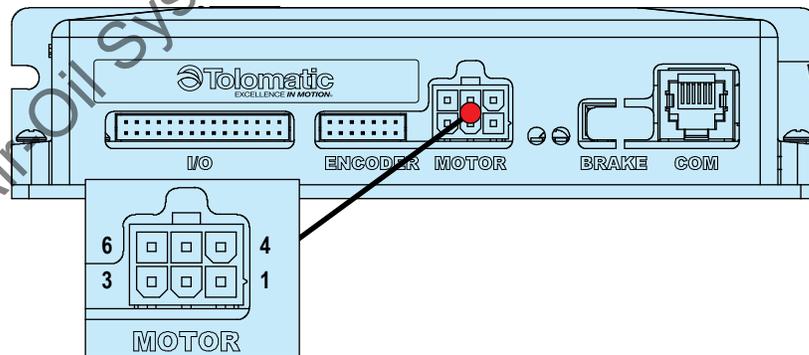


Figure 5-1: Motor Power Connection on ACS Drive/Controller

| PIN NUMBERS | SIGNAL   | CABLE WIRE COLOR |
|-------------|----------|------------------|
| 1           | Motor A+ | Red              |
| 2           | Shield   | Shield           |
| 3           | Motor B+ | Green            |
| 4           | Motor A- | White            |
| 6           | Motor B- | Black            |

Table 5-1: Motor Power Connection PIN Outs

The ACS Drive/Controller has a maximum output of 2.5A peak.

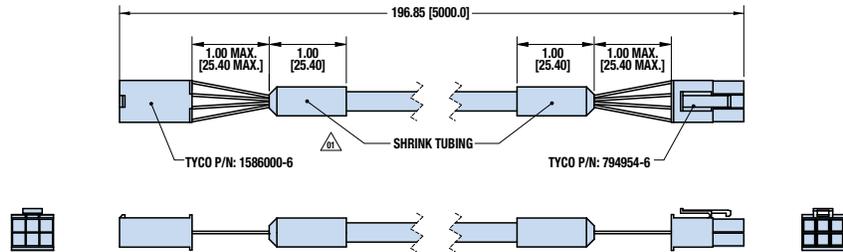


Figure 5-2: Motor Power Cable 3604-1767/1766

| CABLE                | TOLOMATIC PART NO. | DRIVE MATING CONNECTOR | DRIVE CONTACTS     | MOTOR MATING CONNECTOR | MOTOR CONTACTS     |
|----------------------|--------------------|------------------------|--------------------|------------------------|--------------------|
| Motor Power: 3-meter | 3604-1766          | Tyco PN: 794954-6      | Tyco PN: 1586315-3 | Tyco PN: 1586000-6     | Tyco PN: 1586314-3 |
| Motor Power: 5-meter | 3604-1767          | Tyco PN: 794954-6      | Tyco PN: 1586315-3 | Tyco PN: 1586000-6     | Tyco PN: 1586314-3 |

Table 5-2: Motor Power Cable and Connector Parts

### 5.3 Encoder Connection and Cable

The ACS Drive/Controller has an encoder port that supports differential quadrature encoders. Single ended encoders may be used with additional external circuitry. It is highly recommended to use differential encoders as they are more resistant to noise issues. The drive can supply +5Vdc power to the feedback device up to 100mA.

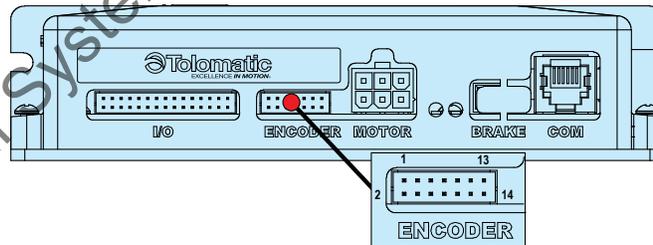
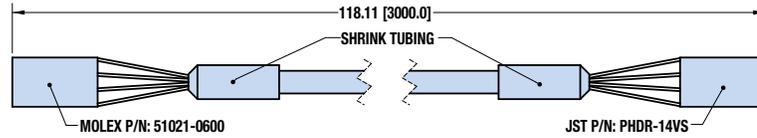


Figure 5-3: Encoder Connection on ACS Drive/Controller

| PIN NUMBERS | SIGNAL        | CABLE WIRE COLOR |
|-------------|---------------|------------------|
| 1           | ENC A+        | Blue             |
| 2           | ENC A-        | Orange           |
| 3           | ENC B+        | Yellow           |
| 4           | ENC B-        | Gray             |
| 5           | NA            | NA               |
| 6           | NA            | NA               |
| 9           | Signal Ground | Black            |
| 12          | +5Vdc         | Red              |
| 13          | Case Ground   | NA               |

Table 5-3: Encoder Connection PIN Outs

## 5: CONNECTIONS & CABLES

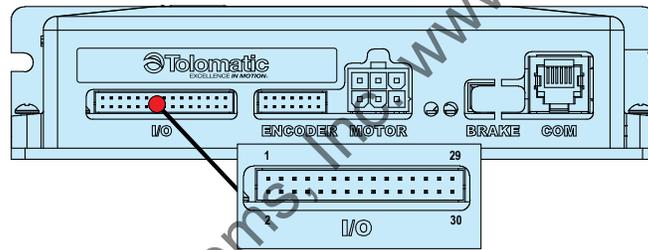


**Figure 5-4: Encoder Cable 3604-1768**

| CABLE            | TOLOMATIC PART NO. | DRIVE MATING CONNECTOR | DRIVE MATING CONTACTS     | ENCODER MATING CONNECTOR | ENCODER MATING CONTACTS |
|------------------|--------------------|------------------------|---------------------------|--------------------------|-------------------------|
| Encoder: 3-meter | 3604-1768          | JST PN:<br>PHDR-14VS   | JST PN:<br>SPHD-001T-P0.5 | Molex PN:<br>51021-0600  | Molex PN:<br>50079-8100 |
| Encoder: 5-meter | 3604-1769          | JST PN:<br>PHDR-14VS   | JST PN:<br>SPHD-001T-P0.5 | Molex PN:<br>51021-0600  | Molex PN:<br>50079-8100 |

**Table 5-4: Encoder Cable and Connector Parts**

### 5.4 I/O Connection and Cable



**Figure 5-5: I/O Connection on ACS Drive/Controller**

| PIN NUMBERS | SIGNAL     | CABLE WIRE COLOR |
|-------------|------------|------------------|
| 1           | Input 1    | Red/Black/White  |
| 2           | Input 2    | Orange/Green     |
| 3           | Input 3    | Red/White        |
| 4           | Input 4    | Green/White      |
| 5           | Input 5    | Blue/White       |
| 6           | Input 6    | White/Black/Red  |
| 7           | Input 7    | White/Red        |
| 8           | Input 8    | Orange/Red       |
| 9           | Input COM  | Green/Black      |
| 10          | Output 1 - | Red/Black        |
| 11          | Output 1 + | White            |
| 12          | Output 2 - | White/Black      |
| 13          | Output 2 + | Blue             |
| 14          | Output 3 - | Blue/Black       |
| 15          | Output 3 + | Orange           |

| PIN NUMBERS | SIGNAL        | CABLE WIRE COLOR  |
|-------------|---------------|-------------------|
| 16          | Output 4 -    | Orange/Black      |
| 17          | Output 4 +    | Red               |
| 20          | Case Ground   | Shield            |
| 23          | NA            | Blue/Red          |
| 24          | NA            | Red/Green         |
| 25          | NA            | Green             |
| 26          | NA            | Black/Red         |
| 27          | NA            | Green/Black/White |
| 28          | NA            | Black/White/Red   |
| 29          | Signal Ground | Black             |
| 30          | Analog Ground | Black/White       |

Table 5-5: I/O Connection PIN Outs

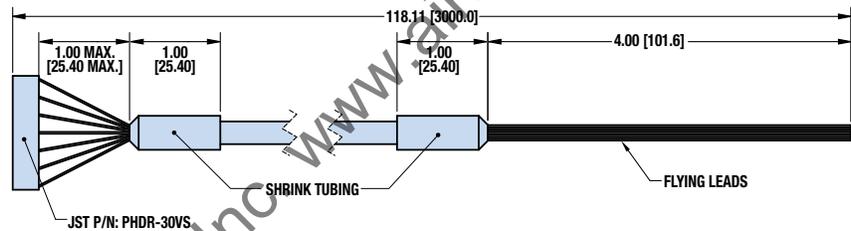


Figure 5-6: I/O Cable 3604-1770

| CABLE        | TOLOMATIC PART NO. | DRIVE MATING CONNECTOR | DRIVE MATING CONTACTS  |
|--------------|--------------------|------------------------|------------------------|
| I/O: 3-meter | 3604-1770          | JST PN: PHDR-30VS      | JST PN: SPHD-001T-P0.5 |
| I/O: 5-meter | 3604-1771          | JST PN: PHDR-30VS      | JST PN: SPHD-001T-P0.5 |

Table 5-6: I/O Cable and Connector Parts

## 5.5 Input Power Connection



### CAUTION!

Reversing polarity of the input power will damage the actuator drive electronics.

The input power is connected via pins on the drive with customer supplied cabling. The input power mating connector is supplied by Tolomatic.

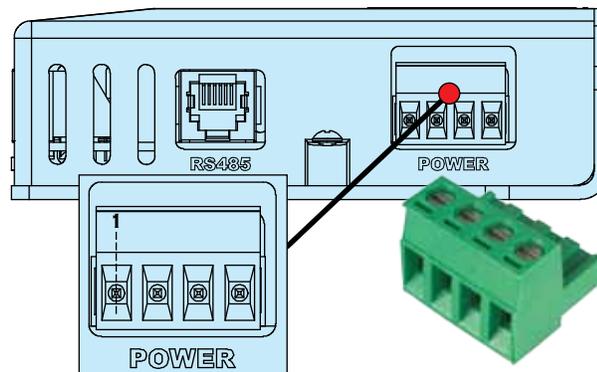


Figure 5-7: Input Power Connection

| PIN NUMBERS | SIGNAL            |
|-------------|-------------------|
| 1           | Main Power +24Vdc |
| 2           | Keep Alive +24Vdc |
| 3           | NA                |
| 4           | Ground – Power    |

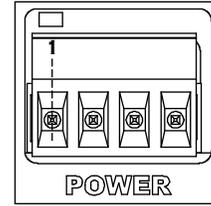


Table 5-7: Input Power PIN Outs

| CABLE             | INPUT POWER MATING CONNECTOR |
|-------------------|------------------------------|
| Customer Supplied | OnShore PN: ED950/4          |

Table 5-8: Input Power Cable Parts

## 5.6 RS-232 Connection

The RS-232 port connector is a standard RJ12 type connector and will mate with standard RJ12 connectors and cables.

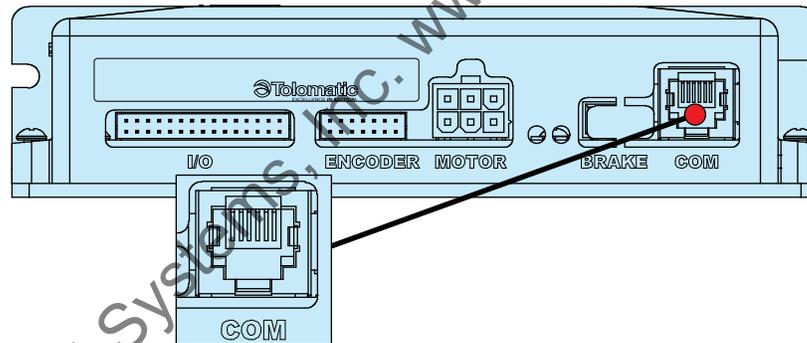
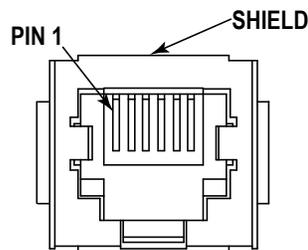


Figure 5-8: RS-232 Connection

The ACS Stepper Drive/Controller uses five signals from the RS-232 port and will need to be properly wired to the PIN diagram shown below. RS-232 baud rate is set at 38400 bps, 1-stop bit, no parity and no flow control. The RS-232 cable itself is a straight through cable.



| PIN NUMBERS | DESCRIPTION |
|-------------|-------------|
| 2           | TX          |
| 3           | RX          |
| 4           | Programming |
| 5           | Ground      |
| 6           | Reset       |

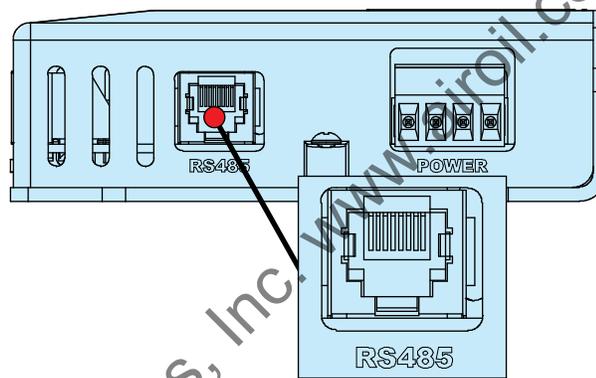
Table 5-9: RS-232 PIN Outs and Connection

| CABLE         | TOLOMATIC PART NO.             |
|---------------|--------------------------------|
| RJ12          | Customer Supplied or 3604-1787 |
| D-sub to RJ12 | 3604-1782                      |

**Table 5-10: RS-232 Cable Parts**

## 5.7 RS-485 Connection

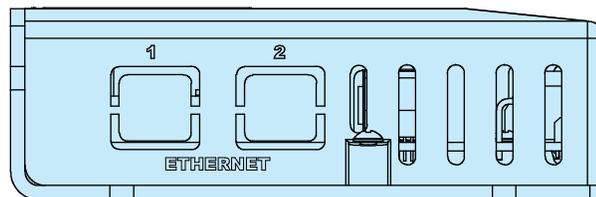
At the time of publication of this User Guide, the RS-485 port is available for future networking capability with the ACS Drive/Controller.



**Figure 5-10: RS-485 Connection for Future ACS Drive/Controller Networking Capability**

## 5.8 Ethernet Connection

At the time of publication of this user guide, the ACS Stepper Drive accommodates two Ethernet ports for future networking capability.

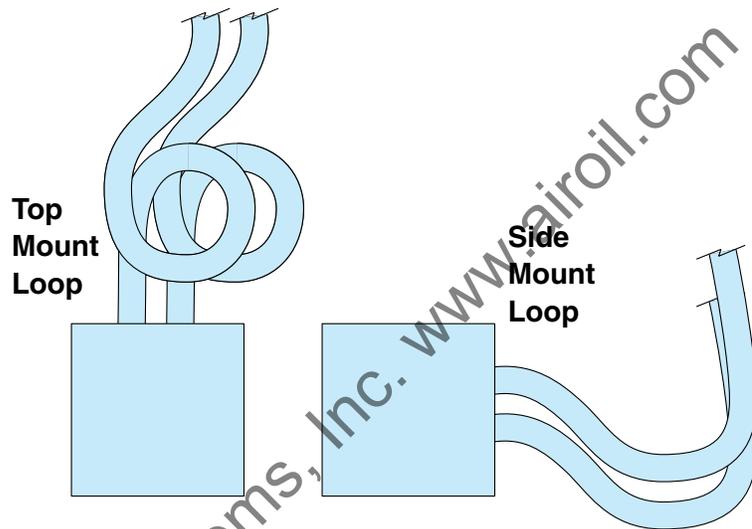


**Figure 5-11: Ethernet Connection for Future ACS Drive/Controller Programmability**

### 5.9 Cable Routing

Over time, liquid contaminants such as oil and cleaning solutions may accumulate on the cables and in the connectors if they are an exposed type. To minimize the introduction of contaminants into the connector, route the cables so that there is a loop in the cable just prior to its attachment to the connector.

Two examples are shown below depending on the orientation of the connectors. Units mounted in such a way that the connectors are on the bottom surface of the actuator require no looping.



*Figure 5-12 Cable Routing for Top and Side Facing Connectors*

## 6.1 Digital Inputs

### 6.1.1 Specifications

The ACS Drive/Controller has a total of 8 opto-isolated digital inputs. These digital inputs are optoisolated from the controller's drive circuitry and can be wired either as sinking or sourcing. All of the digital inputs have a common return.

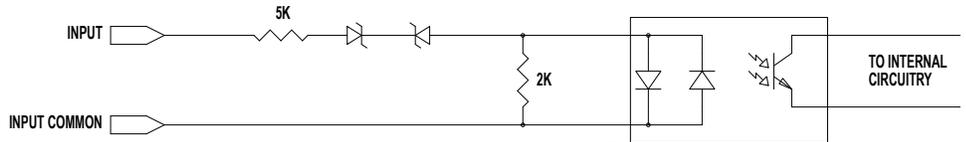


Figure 6-1: Digital Input Circuit

| Opto-isolated Digital Input Specifications |             |
|--|-------------|
| Input Voltage Range                        | 0 to 28Vdc  |
| On State Voltage Range                     | 16 to 28Vdc |
| Off State Voltage Range                    | 0 to 5Vdc   |
| On State Current:                          |             |
| 16Vdc (minimum)                            | 1.9mA       |
| 24Vdc (nominal)                            | 3.4mA       |
| 28Vdc (maximum)                            | 4.2mA       |
| Nominal Input Impedance (24V)              | 7K $\Omega$ |
| Off State Current (maximum)                | 0.4mA       |
| Update Rate (maximum)                      | 2ms         |

Table 6-1: Opto-Isolated Digital Input Specifications

### 6.1.2 Typical Wiring Diagrams

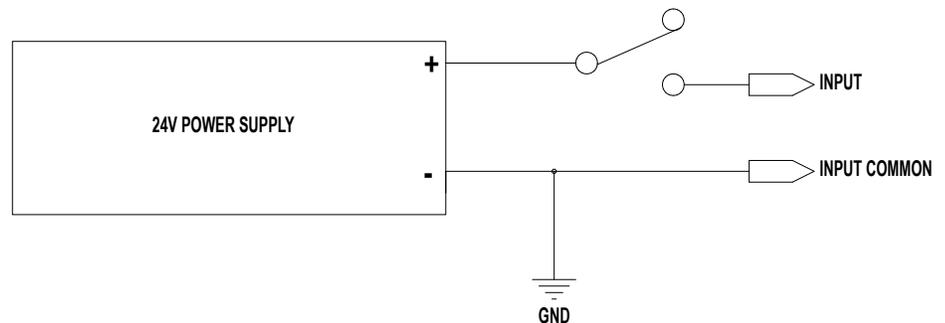
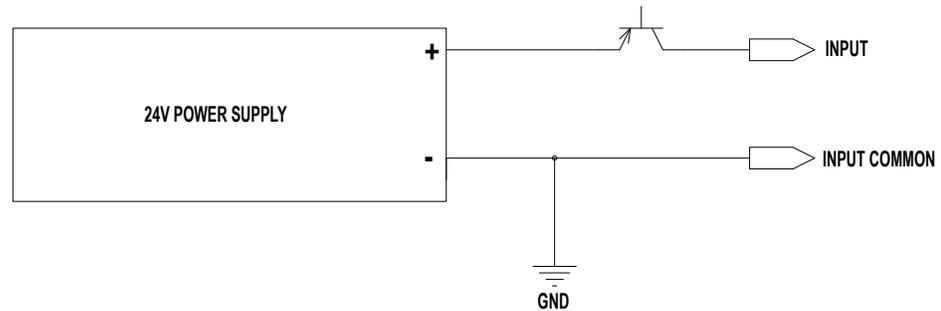
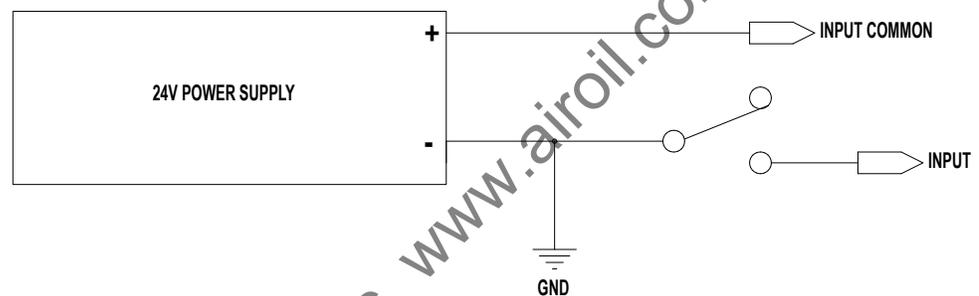


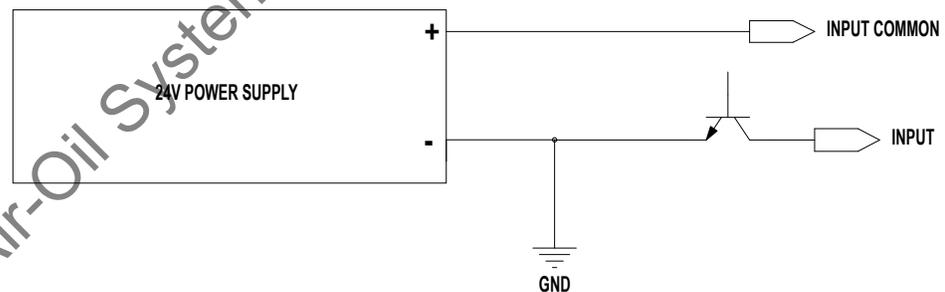
Figure 6-2: Input Source (switched) Connection



**Figure 6-3: Input Source (PNP) Connection**



**Figure 6-4: Input Sink (switched) Connection**



**Figure 6-5: Input Sink (NPN) Connection**

## 6.2 Digital Outputs

### 6.2.1 Specifications

The ACS Drive/Controller has four digital outputs. These digital outputs are opto-isolated from the drive circuitry and can be configured for sinking or sourcing. The outputs are protected against over current and short circuit conditions. Once an over current condition is present, the output turns off until the load is removed.

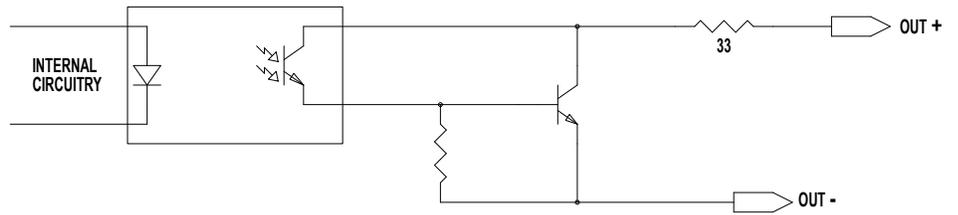


Figure 6-6: Output Circuit

| Digital Output Specifications |      |
|-------------------------------|------|
| Maximum Switched Voltage      | 24V  |
| Output Voltage drop (20mA)    | 2V   |
| Maximum Continuous Current    | 20mA |
| Fold Back Current             | 80mA |
| Update Rate (10KOhm Load)     | 2ms  |
| Output Leakage Current        | 30uA |

Table 6-2: Digital Output Specifications

### 6.2.2 Typical Wiring Diagrams

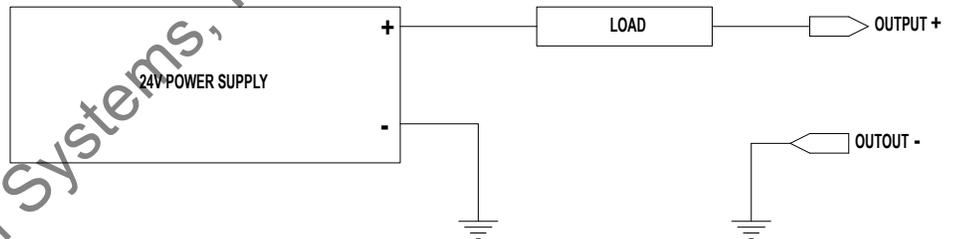


Figure 6-7: Digital Output Sinking Connection

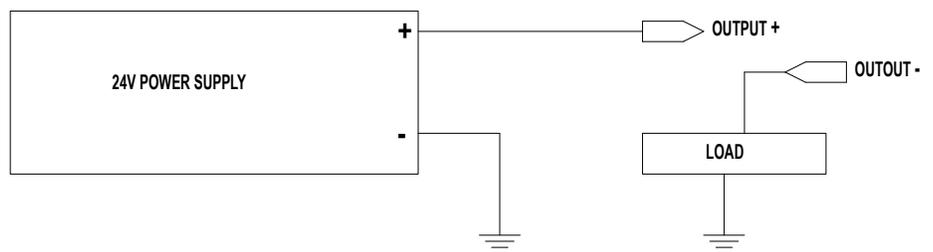


Figure 6-8: Digital Output Sourcing Connection

## 6.3 Input Power



### CAUTION!

**Voltage above the absolute maximum can result in permanent damage to the ACS internal drive components.**



### WARNING!

**Do not reverse bias the power inputs. Doing so will result in permanent damage to the drive.**



### WARNING!

**Do not short circuit the motor power at the power connector. Doing so may damage the drive power electronics. The motor/cable is part of the current regulation circuitry. For a short occurring in a motor, the motor leads should provide enough resistance and inductance to prevent dangerous peak currents from occurring.**

### 6.3.1 Drive Specifications

| ACS Internal Drive Specifications |         |
|-----------------------------------|---------|
| Current - Maximum                 | 4 A     |
| Voltage - Nominal                 | 20-28 V |
| Over Voltage <sup>1</sup>         | 30 V    |
| Under Voltage <sup>2</sup>        | 18 V    |
| Absolute Maximum Voltage          | 35 V    |
| Logic Current Draw Maximum (24V)  | 100mA   |

Table 6-3: ACS Internal Drive Specifications

<sup>1</sup> Drive will shut down at 30V; any voltage above the absolute max voltage can result in permanent damage.

<sup>2</sup> Drive will turn off below 18V.

The drive and logic (keep alive) power share the same ground. Drive logic circuitry can be powered from the keep alive input or the main drive power.

### 6.3.2 Typical Wiring Diagrams

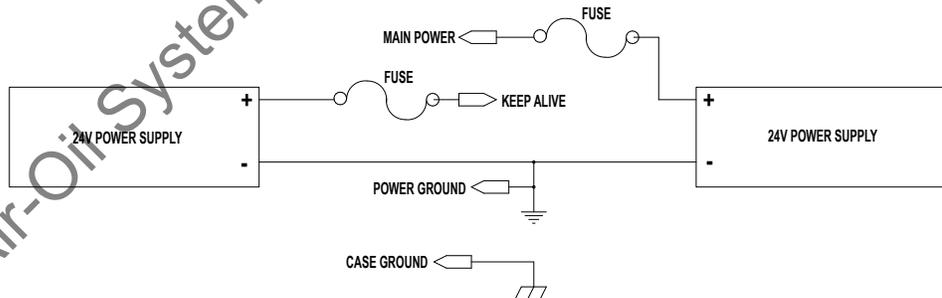


Figure 6-9: ACS Drive/Controller Logic and Main Power Supplies

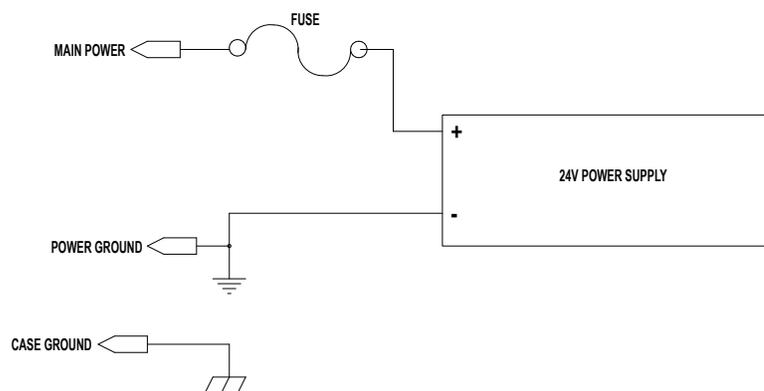


Figure 6-10: ACS Drive/Controller Single Supply – Main Power

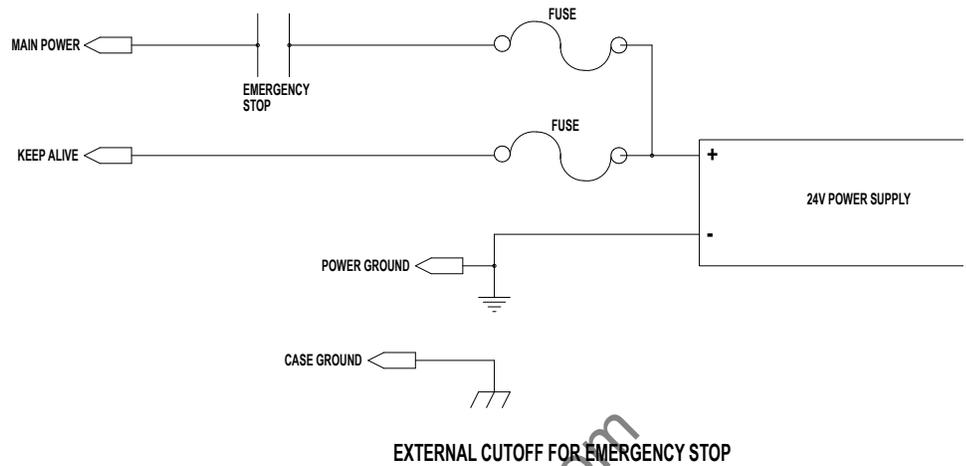


Figure 6-11: ACS Drive/Controller External Cutoff Switch for Emergency Stop



**WARNING!**

**All installations should provide a means for a hardware emergency stop that removes power from the drive in an emergency condition. The drive emergency stop function should not be relied on when safety is required. It is recommended to disconnect only the + bus power and keep the power ground line connected.**

**6.3.3 Power Supply Selection**

Both unregulated and regulated power supplies can be used to power the ACS Drive/Controller. Unregulated supplies can be a better choice depending on the application as they have a larger output capacitance, which can make them better at supplying peak current without faulting out.

The ACS Drive/Controller is intended to run off of an isolated DC power source. The power supply current that will be required will depend on the motor power needed in the installation. If operating more than one drive on the same power supply, add the required power supply rating for each actuator. Maximum power supply current for Tolomatic motors are shown below.

| Maximum Power Supply Requirements for Tolomatic Motors |                  |                        |
|--|------------------|------------------------|
| MOTOR  | MAXIMUM AMPERAGE | MAXIMUM WATTS @ 24 VDC |
| NEMA 11  | 2.3 A            | 55.2                   |
| NEMA 17  | 3.4 A            | 81.6                   |
| NEMA 23  | 4 A              | 96                     |

Table 6-4: Maximum Power Supply Current for Tolomatic Motors

To size the power supply, the following formula can also be used to estimate maximum current required:

$$\text{Motor Current (amps rms)} * 2.2 + 0.1$$

For example, if the motor is rated at 1 Arms, the calculation would look like:

$$1 \text{ Arms} * 2.2 + 0.1 = 2.3A$$

## 6: SPECIFICATIONS & WIRING

The drive can supply a maximum of 2.5A peak (1.77 Arms), so the drive will not use more than 4 Amps.

**Supply power = current x 24V**

Example: If 2.3A is needed,  $2.3A \times 24V = 55.2W$ .

### 6.3.4 Suggested Power Supplies

| Switching Power Supplies | Power Output |
|--------------------------|--------------|
| CUI PN: VGS-25-24        | 25W          |
| CUI PN: VGS-50-24        | 50W          |
| CUI PN: VGS-75-24        | 75W          |
| TDK-Lambda PN: LS150-24  | 150W         |

**Table 6-5: Recommended Switching Power Supplies**

| Linear Regulated Power Supplies | Power Output |
|---------------------------------|--------------|
| Power One PN: HB24-1.2-AG       | 28W          |
| Power One PN: HN24-3.6-AG       | 80W          |
| Power One PN: HD24-4.8-AG       | 115W         |

**Table 6-6: Recommended Linear Regulated Power Supplies**

| Linear Unregulated Power Supplies | Power Output |
|-----------------------------------|--------------|
| Acopian PN: U24Y500               | 120W         |
| Acopian PN: U24Y350               | 84W          |

**Table 6-7: Recommended Linear Unregulated Power Supplies**

| Fuses (Slow Blow Type) |
|------------------------|
| Bus Fuse: 4A           |
| Logic Power Fuse: 1A   |

**Table 6-8: Fuses**

## 7.1 I/O Timing Diagrams

The opto-isolated digital inputs require a minimum of 2ms of time to guarantee that the input signal is registered by the drive. This is an important consideration to take into account, especially if limit switches are used. If limit switches are used, careful consideration should be used to prevent missed triggering due to high velocities. Output timing assumes 10K  $\Omega$  load.

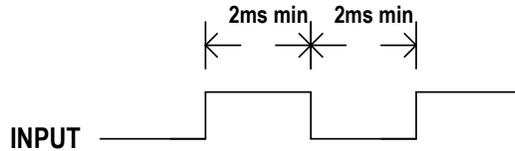


Figure 7-1 Input Requirement

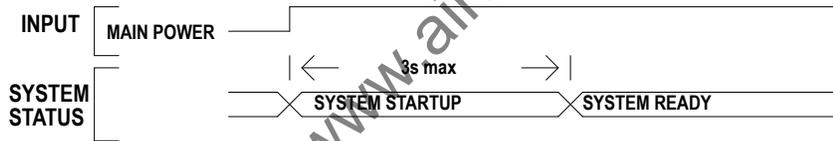


Figure 7-2 System Startup Timing

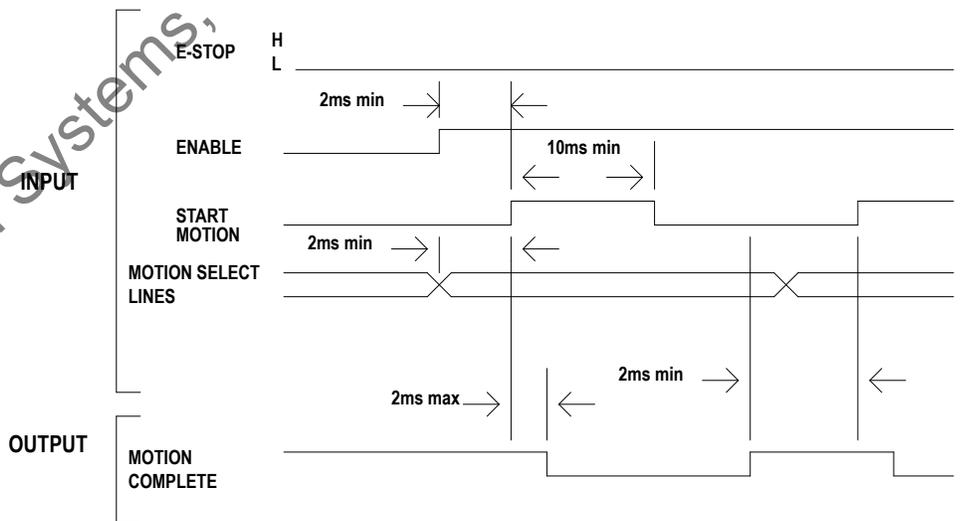


Figure 7-3 Jog Move Timing

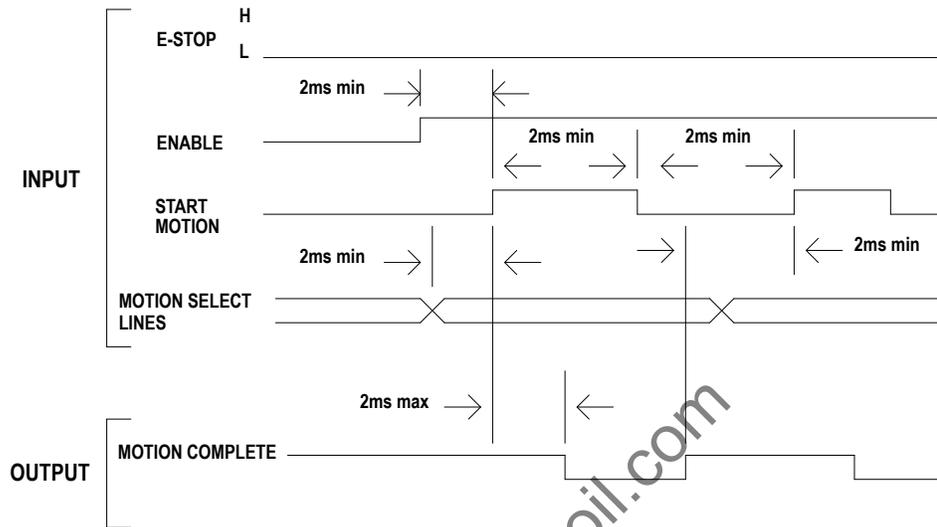


Figure 7-4 Absolute & Incremental Move Timing

### 7.1.1 Move Timing Rules

1. While the Motion Complete signal is low, the drive will ignore Start Motion pulses and Motion Selection lines.
2. If the enable signal is low or E-stop signal is high, the drive will ignore start motion pulses.

## 8.1 Move Select Logic Table

The three operating modes, 4/8/16 move commands, require digital inputs to select the desired move for execution. The digital inputs are called Move Select 1 through 4 (MS1-MS4) in the digital input map. To select the desired move command refer to the three logic tables below.

**NOTE 1:** MS# stands for Move Select #

**NOTE 2:** 1 = On; 0 = Off

| MOVE | MS1 | MS2 |
|------|-----|-----|
| 1    | 0   | 0   |
| 2    | 1   | 0   |
| 3    | 0   | 1   |
| 4    | 1   | 1   |

Table 8-1: 4 Move Commands Mode Logic

| MOVE | MS1 | MS2 | MS3 |
|------|-----|-----|-----|
| 1    | 0   | 0   | 0   |
| 2    | 1   | 0   | 0   |
| 3    | 0   | 1   | 0   |
| 4    | 1   | 1   | 0   |
| 5    | 0   | 0   | 1   |
| 6    | 1   | 0   | 1   |
| 7    | 0   | 1   | 1   |
| 8    | 1   | 1   | 1   |

Table 8-2: 8 Move Commands Mode Logic

## 8: MOVE SELECT LOGIC

---

| 16 Move Commands Mode Logic Table |     |     |     |     |
|-----------------------------------|-----|-----|-----|-----|
| MOVE                              | MS1 | MS2 | MS3 | MS4 |
| 1                                 | 0   | 0   | 0   | 0   |
| 2                                 | 1   | 0   | 0   | 0   |
| 3                                 | 0   | 1   | 0   | 0   |
| 4                                 | 1   | 1   | 0   | 0   |
| 5                                 | 0   | 0   | 1   | 0   |
| 6                                 | 1   | 0   | 1   | 0   |
| 7                                 | 0   | 1   | 1   | 0   |
| 8                                 | 1   | 1   | 1   | 0   |
| 9                                 | 0   | 0   | 0   | 1   |
| 10                                | 1   | 0   | 0   | 1   |
| 11                                | 0   | 1   | 0   | 1   |
| 12                                | 1   | 1   | 0   | 1   |
| 13                                | 0   | 0   | 1   | 1   |
| 14                                | 1   | 0   | 1   | 1   |
| 15                                | 0   | 1   | 1   | 1   |
| 16                                | 1   | 1   | 1   | 1   |

Table 8-3: 16 Move Commands Mode Logic

## 9.1 LED Codes

| LED Indicators              |                               |
|-----------------------------|-------------------------------|
| <b>Green, Off</b>           | Motor is not powered          |
| <b>Green, On</b>            | Motor is powered              |
| <b>Red, On and Solid</b>    | A critical fault has occurred |
| <b>Red, On and Blinking</b> | A safety fault has occurred   |

*Table 9-1: LED Indicators*

To clear a fault, the enable input needs to be lowered, and then raised. Faults can also be cleared by the PC software. Faults that result in a blinking red LED indicator, are cleared automatically once the fault condition is no longer present.

## 9.2 Fault Descriptions and Recovery

Faults are broken up into safety faults and critical faults. Safety faults are configurable. If a safety fault is enabled and configured for disable motor, the fault will be latched until it is cleared in the same manner as the critical faults. If the fault is configured as a stop motion, the fault will be cleared automatically once the fault condition is no longer present. All critical faults will disable the motor when they occur. To clear these faults, the fault condition cannot be present. The enable input must be lowered, then raised.

| Safety Faults Table          |   |
|------------------------------|---|
| <b>Positive Limit Switch</b> | Positive limit switch has been reached. If configured as a stop motion, motion will be allowed in the reverse direction. The fault will be cleared once the positive limit switch input is no longer active and a move in the negative direction is in progress.    |
| <b>Negative Limit Switch</b> | The negative limit switch has been reached. If configured as stop motion, motion will be allowed in the positive direction. The fault will be cleared once the negative limit switch input is no longer active and a move in the positive direction is in progress. |

| <b>Safety Faults Table</b> |   |
|----------------------------|---|
| <b>Position Error</b>      | <p>If an encoder is present, the position error fault can be enabled. If encoder position and commanded position differ by a larger magnitude than the position error, the position error fault will be activated. If fault is configured as a stop motion, fault will be cleared on next move command.</p> <p>NOTE: If force is less than 100%, a position will not be triggered. Instead, it will stop and hold position (push mode).</p> |
| <b>E-Stop</b>              | <p>If an input is configured as an E-stop and fault is enabled, the fault will be activated when the signal level on the pin is high. If fault is configured as a stop motion, it will be cleared once the E-stop input is lowered. Motion will not be allowed until E-stop has been cleared.</p>   |

**Table 9-2: Safety Faults**

| <b>Critical Faults Table</b> |  |
|------------------------------|--|
| <b>Feedback Error</b>        | Feedback device is malfunctioning.   |
| <b>Over Current</b>          | If a short circuit occurs from output to ground, this fault will be triggered. |
| <b>Motor Over Temp</b>       | Not implemented in this release.   |
| <b>Drive Over Temp</b>       | Drive temperature is greater than the maximum allowed temperature (75°C).      |
| <b>Drive Over Voltage</b>    | Main power voltage exceeds the maximum voltage (30V).                          |
| <b>Drive Under Voltage</b>   | Main power voltage below the minimum voltage (18V).                            |

**Table 9-3: Critical Faults**

## 10.1 Troubleshooting

### 10.1.1 Troubleshooting the ACS Drive/Controller

| Troubleshooting Table                                  |  |
|--|--|
| SYMPTOM / TROUBLE                                      | POSSIBLE CAUSE / RESOLUTION  |
| No communication to drive                              | <ol style="list-style-type: none"> <li>1. Check power connection.</li> <li>2. Verify the wiring of the communication cable.</li> <li>3. Verify baud rate and serial port number.</li> <li>4. Verify that the communication cable is plugged in securely.</li> <li>5. Verify that all drivers are up-to-date.</li> </ol>        |
| Actuator cannot move load                              | <ol style="list-style-type: none"> <li>1. The load is too large.</li> <li>2. There is too much friction.</li> <li>3. Side load is excessive.</li> <li>4. Power supply does not have enough current capability.</li> <li>5. Current limits are set too low.</li> </ol>  |
| Drive is overheating                                   | <ol style="list-style-type: none"> <li>1. Ambient temperature is too high.</li> <li>2. Cooling is insufficient.</li> </ol>   |
| Actuator is operating erratically                      | <ol style="list-style-type: none"> <li>1. Current is set to low.</li> <li>2. Following error is set too low.</li> <li>3. Determine if power supply has enough current.</li> <li>4. Check to see if any faults are being generated.</li> <li>5. Verify that the drive has been configured properly for the actuator.</li> </ol> |
| No response from drive in I/O mode                     | <ol style="list-style-type: none"> <li>1. Verify the enable signal is on.</li> <li>2. Verify that all of the I/O are configured properly.</li> <li>3. Verify wiring to the actuator and drive.</li> </ol>  |
| Red and Green LEDs on, both solid and no communication | <ol style="list-style-type: none"> <li>1. Verify serial programming cable and cycle power to drive.</li> <li>2. Verify that the RJ12 cable is a reversed type.</li> <li>3. Verify all connections are plugged in securely.</li> </ol>  |

**Table 10-1: Troubleshooting Descriptions**

# Appendix 1

## Motors

There are currently three different motor selections available from Tolomatic—a NEMA 11, NEMA 17 and NEMA 23—available for operation with the ACS Drive/Controller. Each motor is available with an optional differential incremental encoder. All motors come with a short 150mm cable and connector on the motor body.

| <b>Tolomatic Motor Specifications</b> |                          |                          |                          |
|---------------------------------------|--------------------------|--------------------------|--------------------------|
| <b>SPEC</b>                           | <b>NEMA 11</b>           | <b>NEMA 17</b>           | <b>NEMA 23</b>           |
| <b>Resistance</b>                     | 3.5 $\Omega$             | 2.4 $\Omega$             | 1.5 $\Omega$             |
| <b>Inductance</b>                     | 2.3 mH                   | 4.5 mH                   | 3.7 mH                   |
| <b>Rated Current</b>                  | 1 Arms                   | 1.5 Arms                 | 2 Arms                   |
| <b>Maximum Torque</b>                 | 0.813 in-lbs             | 4.4 in-lbs               | 6.25 in-lbs              |
| <b>Maximum RPM</b>                    | 1500 RPM                 | 900 RPM                  | 1050 RPM                 |
| <b>Degree per Step</b>                | 1.8°                     | 1.8°                     | 1.8°                     |
| <b>Rotor Inertia</b>                  | 0.006 lb-in <sup>2</sup> | 0.028 lb-in <sup>2</sup> | 0.075 lb-in <sup>2</sup> |

**Table A-1: Tolomatic Motor Specifications**

| <b>Tolomatic Motor Part Numbers</b> |                              |
|-------------------------------------|------------------------------|
| <b>MOTOR</b>                        | <b>TOLOMATIC PART NUMBER</b> |
| NEMA 11 with Encoder                | 3604-1780                    |
| NEMA 11 without Encoder             | 3604-1779                    |
| NEMA 17 with Encoder                | 3604-1776                    |
| NEMA 17 without Encoder             | 3604-1775                    |
| NEMA 23 with Encoder                | 3604-1778                    |
| NEMA 23 without Encoder             | 3604-1777                    |

**Table A-2: Tolomatic Motor Part Numbers**

| <b>Encoder Specifications</b>  |   |                                    |                                   |
|--------------------------------|---|------------------------------------|-----------------------------------|
| <b>MOTOR TYPE</b>              | <b>ENCODER</b>                                | <b>CABLE CONNECTOR PART NUMBER</b> | <b>CABLE TERMINAL PART NUMBER</b> |
| Bipolar Stepper, 1.8° per Step | Differential; 500 line (2000 count post quad) | 794954-6                           | 50212-8000                        |

**Table A-3: Encoder Specifications**

| <b>NEMA11 Motor Connections</b>                                       |                 |                  |               |
|---|-----------------|------------------|---------------|
| <b>TYCO Mating Connector: 51065-0600; Molex Terminals: 50212-8000</b> |                 |                  |               |
| <b>WIRE COLOR</b>   | <b>TYCO PIN</b> | <b>MOLEX PIN</b> | <b>SIGNAL</b> |
| Black   | 6               | 6                | B -           |
| Green   | 3               | 4                | B +           |
| Red   | 1               | 3                | A +           |
| Blue  | 4               | 1                | A -           |

**Table A-4: NEMA11 Motor Connection PIN Outs**

| <b>NEMA17 Motor Connections</b>                                    |                 |                |               |
|--|-----------------|----------------|---------------|
| <b>TYCO Mating Connector: PHR-6; JST Terminals: SPH-002T-P0.5S</b> |                 |                |               |
| <b>WIRE COLOR</b>  | <b>TYCO PIN</b> | <b>JST PIN</b> | <b>SIGNAL</b> |
| Black  | 6               | 1              | B -           |
| Green  | 3               | 3              | B +           |
| Red  |                 | 4              | A +           |
| Blue   | 4               | 6              | A -           |

**Table A-5: NEMA17 Motor Connection PIN Outs**

| <b>NEMA23 Motor Connections</b>                                   |                 |                |               |
|---|-----------------|----------------|---------------|
| <b>TYCO Mating Connector: XHP-6; JST Terminals: SXH-001T-P0.5</b> |                 |                |               |
| <b>WIRE COLOR</b>   | <b>TYCO PIN</b> | <b>JST PIN</b> | <b>SIGNAL</b> |
| Black   | 6               | 1              | B -           |
| Green   | 3               | 3              | B +           |
| Red   | 1               | 4              | A +           |
| Blue  | 4               | 6              | A -           |

**Table A-6: NEMA23 Motor Connection PIN Outs**

| <b>ENCODER Connections: US Digital PN E8P-500-197-D-D-M-B</b>          |                  |               |
|--|------------------|---------------|
| <b>Molex Mating Connector: 510221-0600; Molex Contacts: 50079-8100</b> |                  |               |
| <b>WIRE COLOR</b>  | <b>MOLEX PIN</b> | <b>SIGNAL</b> |
| Blue   | 2                | ENC A+        |
| Orange   | 3                | ENC A-        |
| Yellow   | 5                | ENC B+        |
| Gray   | 6                | ENC B-        |
| Black  | 1                | Signal Ground |
| Red  | 4                | +5VDC         |

**Table A-7: Encoder Connections and Connector PIN Outs**

## Appendix 2

---

### Product Warranty

Tolomatic, Inc. warrants all products manufactured by it to be free from defects in material and workmanship for a period of one year from date of shipment by Tolomatic. If, within this period, any product is proven to be defective by Tolomatic, the product will either be repaired or replaced at Tolomatic's option.

This warranty shall not apply to:

1. Products not manufactured by Tolomatic. Warranty of these products will conform and be limited to the warranty actually extended to Tolomatic by its supplier.
2. Damage to the product caused by circumstances beyond the control of Tolomatic, such as negligence, improper maintenance, or storage.
3. This warranty shall be void in the case of: any repairs or alterations made to the product by parties other than Tolomatic.

The foregoing warranties are exclusive and in lieu of all other express and implied warranties. Tolomatic is not subject to any other obligations or liabilities for consequential damages.

Air-Oil Systems, Inc. [www.airoil.com](http://www.airoil.com)

Air-Oil Systems, Inc. [www.airoil.com](http://www.airoil.com)

Copyright © 2011 Tolomatic, Inc. All rights Reserved.

All brand and product names are trademarks of their respective owners. Information in this document is believed to be accurate at time of publication.

201102031630

Air-Oil Systems, Inc. [www.airoil.com](http://www.airoil.com)



3800 County Road 116, Hamel, MN 55340

Phone: 763.478.8000

Toll Free: 1.800.328.2174

Fax: 763.478.8080

Email: [help@tolomatic.com](mailto:help@tolomatic.com)

**[www.tolomatic.com](http://www.tolomatic.com)**