Tolomatic
EXCELLENCE *IN MOTION*®

STEPPER

HARDWARE & INSTALLATION GUIDE

ACS – Actuator Control Solutions

Stepper Drive/Controller and Motors

3604-4183_00

LINEAR SOLUTIONS MADE EASY

201503201516

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Read through the applicable sections of the manual before the equipment is unpacked, installed or operated. Pay 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 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 radii 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, high quality braided or foil with braided shielded cables are recommended. The standard motor cables provided by Tolomatic have a braided 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.

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.

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)

Fail Safe Emergency Stop Recommendations

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.

WARNING!

Incorrect wiring can feedback through the USB port and damage your computer. Use good wiring practices to prevent ground loops.

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.

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 drive power.
- 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.
- Do not plug and unplug cables while the drive is energized.

Wiring for CE Compliance

- Use a braided shield motor cable such as Igus Chainflex CF140US-07-04.
- See Section 5-2 for motor cable description.

1.1 The ACS Stepper Drive/Controller for Actuator Control Solutions

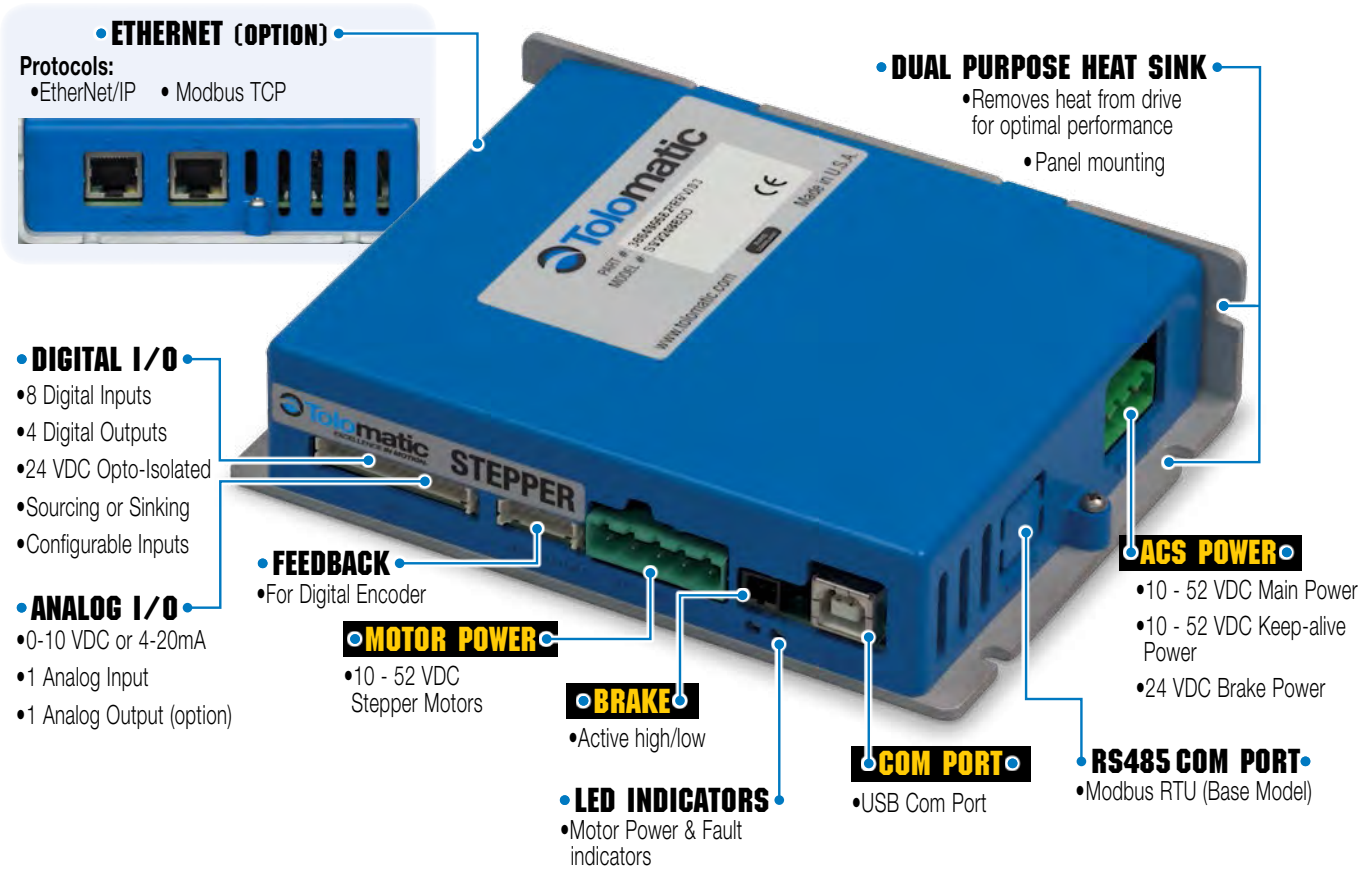
Tolomatic's ACS Drive/Controller is a stepper drive and controller intended for use with electric actuators. Tolomatic's Motion Interface software allows the user to select the compatible Tolomatic electric linear actuator of choice. The software automatically sets most of the necessary parameters to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

Currently there are three ACS Drive/Controller choices:

- #3604-9665 - ACS Stepper Drive/Controller, Modbus RTU over RS485 - firmware 36043183UD.tol
- #3604-9666 - ACS Stepper Drive/Controller, EtherNet/IP (Analog Output) - firmware 36043183UD.tol
- #3604-9667 - ACS Stepper Drive/Controller, Modbus TCP (Analog Output) -firmware 36043183UD.tol

NOTE: They will collectively be referred to as ACS Drive throughout this guide

1.1.1 ACS Stepper Drive/Controller — Overview



ACS Drive/Controller (3604-9665) Capabilities

- 4, 8, or 16 move command modes (absolute, incremental and jog or home with analog output echoing position of actuator from encoder) for infinite position capability
- Analog position mode (0-10 VDC or 4-20 mA)
- Pneumatic mode replaces pneumatic valve logic for simple motion
- ModBus RTU over RS485 provides infinite positioning
- 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 capability
- Configurable digital I/O (24 VDC Opto-Isolated) (sourcing or sinking)
- Compatible with most 24/48 VDC stepper motors

ACS Drive/Controller (3604-9666, 3604-9667) Additional Capabilities

- EtherNet mode provides infinite positioning using EtherNet/IP and Modbus TCP protocols
- Dual EtherNet port with internal switch for easy daisy chaining
- Analog output for Analog Position Mode

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 3, 5 or 10 meter lengths.

Disc and Cable

Tolomatic software is always available online at www.tolomatic.com. For your convenience a software CD and optional USB computer connections are available:

Tolomatic Motion Interface Software CD (3604-9526) and a USB Type B cable (3604-1852)

Brake Cable

Tolomatic offers a 5-meter brake power cable with drive and brake mating connectors

2.1 Operating Environment

WARNING!

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

The ACS Drive 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 water and other conductive contamination. In addition, proper ESD procedures should be observed to prevent static discharge and damage to electronic components.

ACS Drive 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 Drive Operating Conditions

2.2 ACS Drive Dimensions

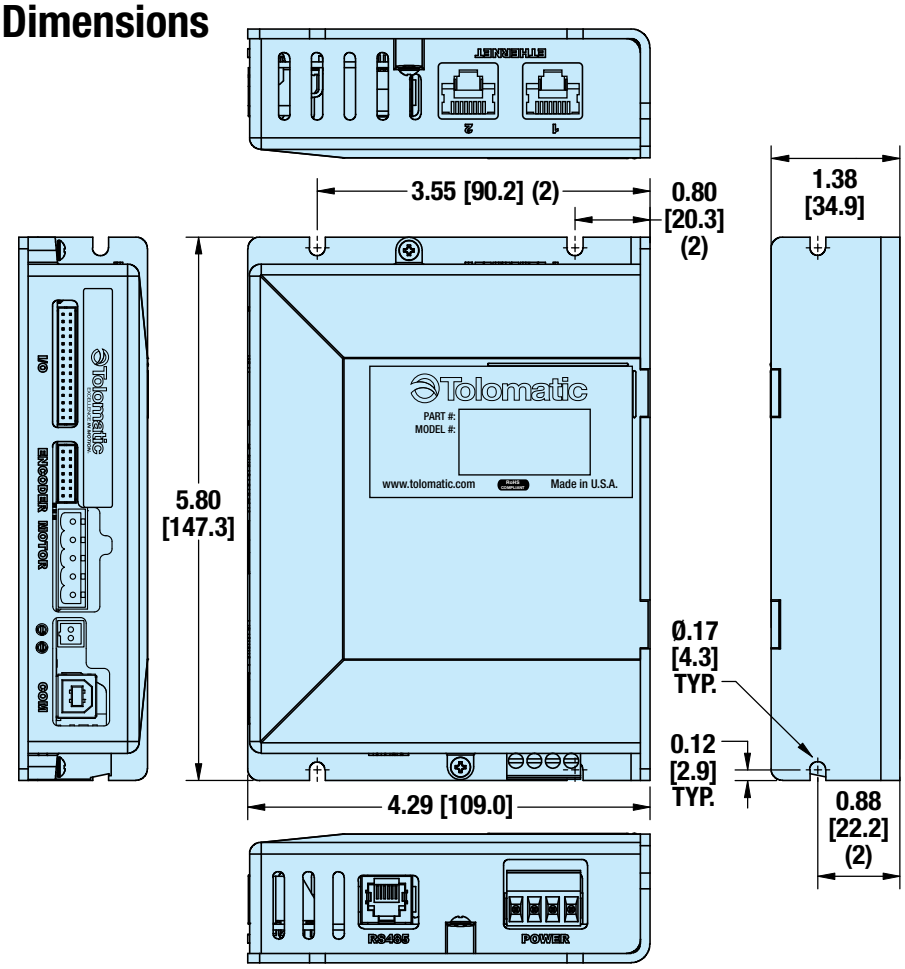


Figure 2-1: ACS Drive Dimensions

2.3 Mounting the ACS Drive

The drive/controller is intended to be mounted vertically (as shown in Figure 2-2) 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 provided the ambient temperature is kept within limits and the drive is mounted to a metal surface suitable enough to heat sink the drives.

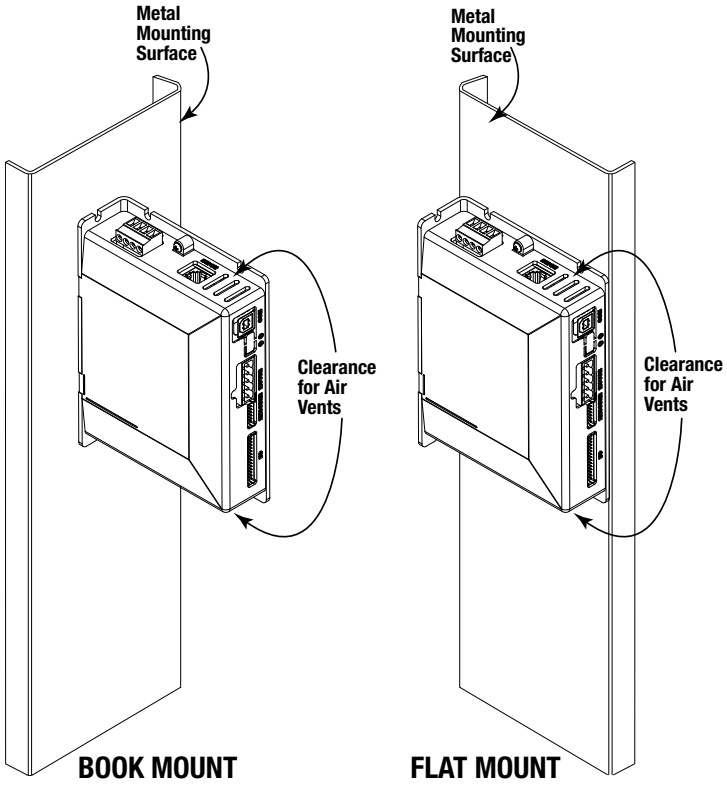


Figure 2-2 Mounting the ACS Drive

3.1 CD & USB Cable

NOTE: The most current version of software and firmware is always available at www.tolomatic.com

Tolomatic offers a CD with Tolomatic Motion Interface software, drive firmware and firmware upgrade utility. A USB type B cable is also available for connecting your computer to the ACS drive.

ACS Drive Accessories	
ITEM	**TOLOMATIC PART NUMBER**
Tolomatic Motion Interface Software CD	3604-9526
1 meter USB Cable	3604-1852

Table 3-1: CD and USB cable part numbers.

4.1 ACS Drive and Actuator Basic Setup

Figure 4-1 shows the simple setup of the ACS Drive, the Tolomatic ERD actuator and the necessary cables and power source.

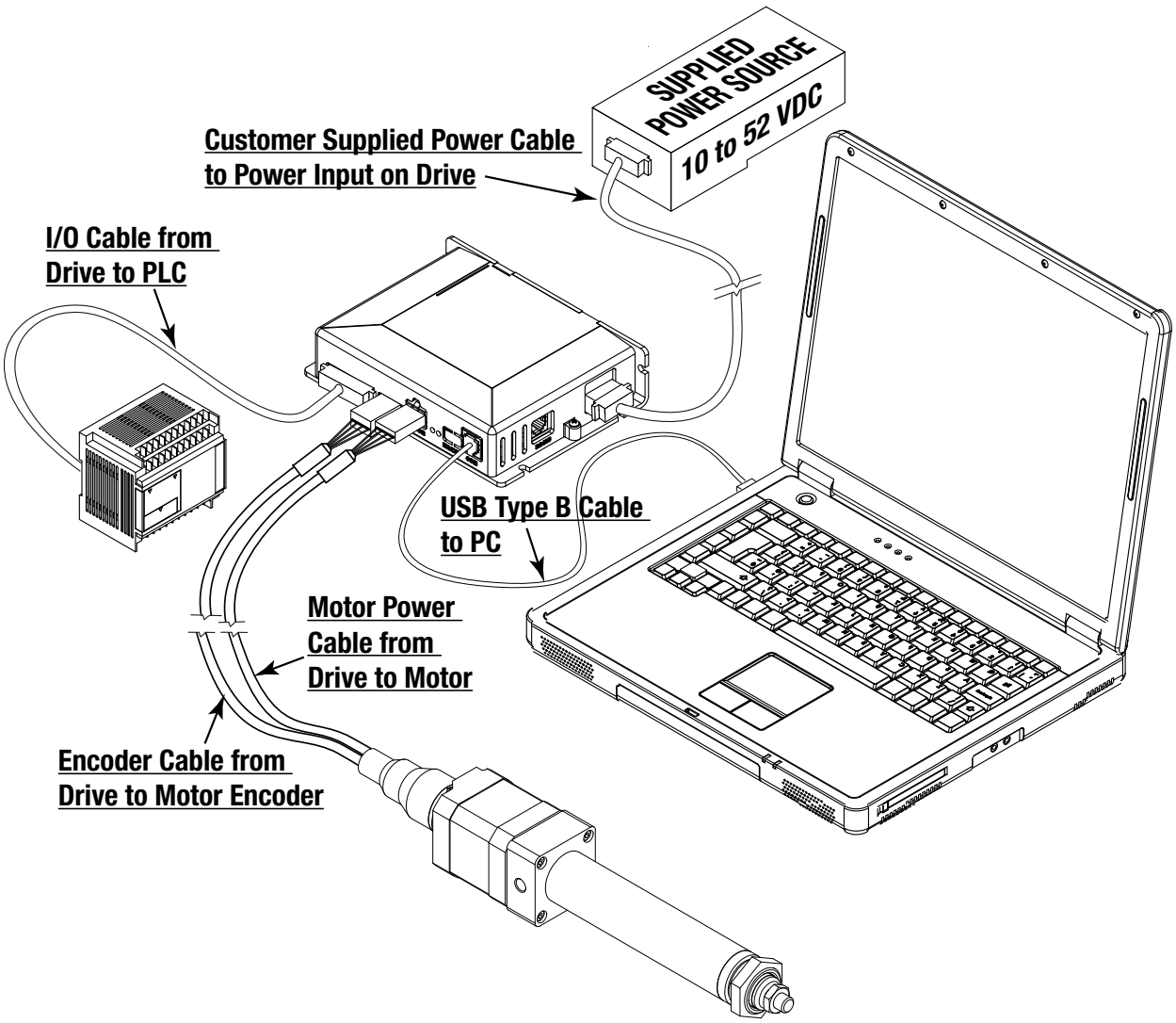


Figure 4-1: ACS Drive and ERD Actuator– Basic Setup

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

Motor Power Cable: Section 5

Encoder Cable: Section 5

I/O Cable: Section 5

USB: Section 5

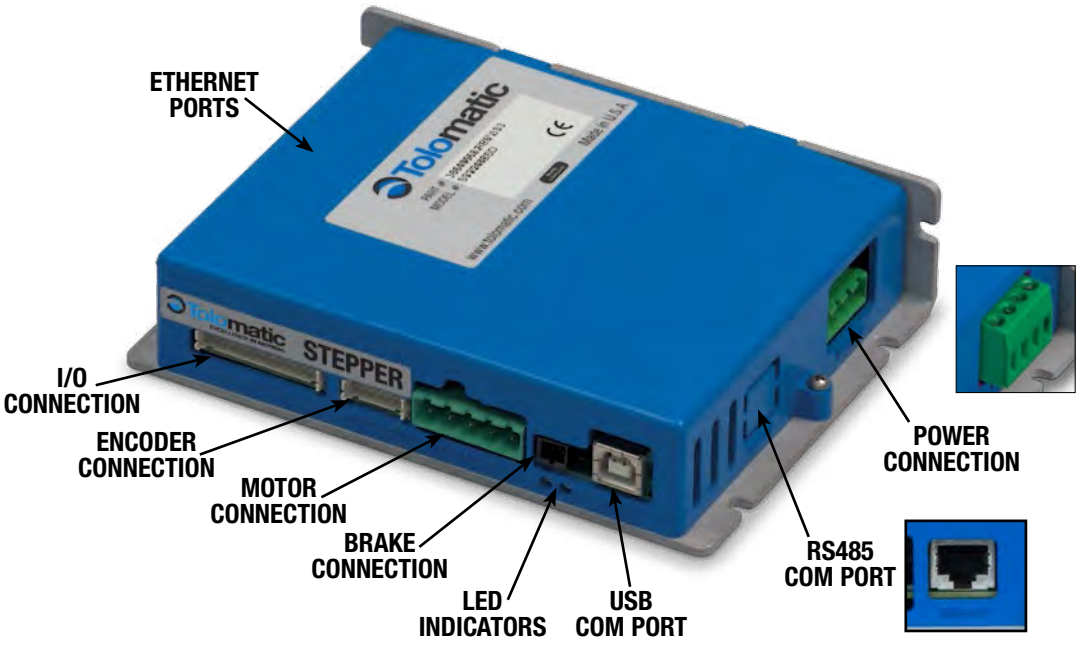
For recommended power supplies: Section 6

4.1.1 Setup Procedures

1. Install drive/controller and actuator into appropriate fixtures.
2. Wire the 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 programming cable and install the Tolomatic Motion Interface software.
6. Configure ACS Drive.
7. Program the logic device.

5.1 Connections and Cables Overview

All cables for the ACS Drive 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.

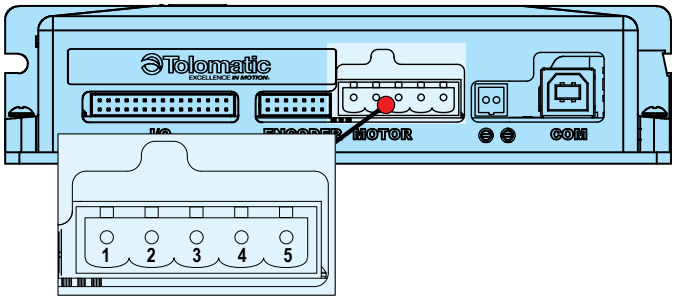


Figure 5-1: Motor Power Connection on ACS Drive

ACS CONNECTOR (ON-SHORE) PIN NUMBERS	SIGNAL	CABLE WIRE COLOR	MOTOR CONNECTOR (TYCO)
1	Motor A-	Black	6
2	Motor A+	Green	3
3	Shield	Shield	2
4	Motor B+	Red	1
5	Motor B-	White	4

Table 5-1: Motor Power Connection pinouts

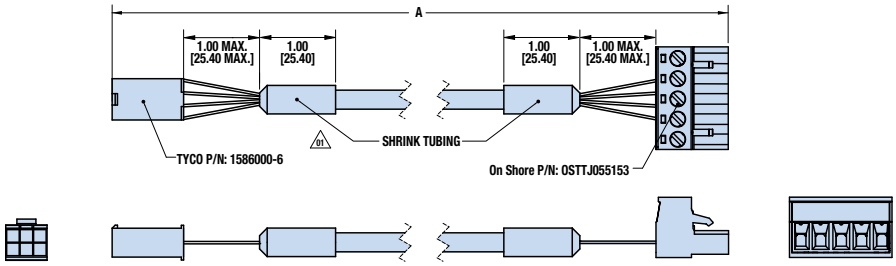


Figure 5-2: Motor Power Cable 3604-1708/1709/1710

CABLE	TOLOMATIC PART NO.	DRIVE MATING CONNECTOR	MOTOR MATING CONNECTOR	MOTOR CONTACTS	DIM. "A"
Motor Power: 3-meter	3604-1708	On Shore PN OSTTJ055153	Tyco PN: 1586000-6	Tyco PN: 1586314-3	3 m 118"
Motor Power: 5-meter	3604-1709	On Shore PN OSTTJ055153	Tyco PN: 1586000-6	Tyco PN: 1586314-3	5 m 197"
Motor Power: 10-meter	3604-1710	On Shore PN OSTTJ055153	Tyco PN: 1586000-6	Tyco PN: 1586314-3	10 m 394"

Table 5-2: Motor Power Cable and Connector Parts

NOTE: For CE compliance use a quality braided shield cable such as Igus Chainflex CF140US-07-04. See Appendix 1 for motor pinout chart.

5.3 Encoder Connection and Cable

The ACS Drive has an encoder port that supports differential signal 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 signal noise. The drive can supply +5VDC power to the feedback device up to 100mA.

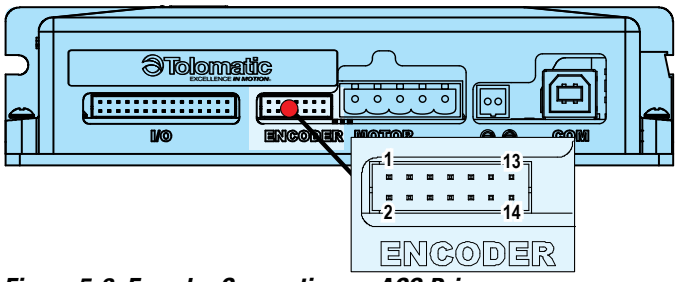


Figure 5-3: Encoder Connection on ACS Drive

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 pinouts

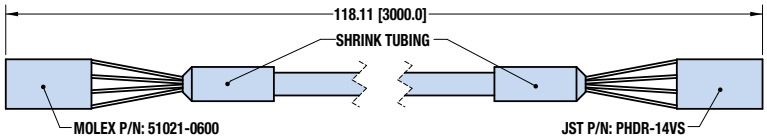


Figure 5-4: Encoder Cable 3604-1768/1769/1969

FOR NEMA 11, 17, 23 MOTORS					
CABLE	**TOLOMATIC PART NO.**	**DRIVE MATING CONNECTOR**	**DRIVE MATING CONTACTS**	**ENCODER MATING CONNECTOR**	**ENCODER MATING CONTACTS**
Encoder: 3-meter	3604-1768	JST PN: PHDR-14VS	JST PN: SPHD-001T-P0.5	Molex PN: 51021-0600	Molex PN: 50079-8100
Encoder: 5-meter	3604-1769	JST PN: PHDR-14VS	JST PN: SPHD-001T-P0.5	Molex PN: 51021-0600	Molex PN: 50079-8100
Encoder: 10-meter	3604-1969	JST PN: PHDR-14VS	JST PN: SPHD-001T-P0.5	Molex PN: 51021-0600	Molex PN: 50079-8100
FOR NEMA 34 MOTORS					
CABLE	**TOLOMATIC PART NO.**	**DRIVE MATING CONNECTOR**	**DRIVE MATING CONTACTS**	**ENCODER MATING CONNECTOR**	**ENCODER MATING CONTACTS**
Encoder: 3-meter	3604-1971	JST PN: PHDR-14VS	JST PN: SPHD-001T-P0.5	Molex PN: 15-04-5104	Molex Inserts PN: 14-60-0058
Encoder: 5-meter	3604-1972	JST PN: PHDR-14VS	JST PN: SPHD-001T-P0.5	Molex PN: 15-04-5104	Molex Inserts PN: 14-60-0058
Encoder: 10-meter	3604-1973	JST PN: PHDR-14VS	JST PN: SPHD-001T-P0.5	Molex PN: 15-04-5104	Molex Inserts PN: 14-60-0058

Table 5-4: Encoder Cable and Connector Parts

NOTE: See Appendix 1 for encoder pinout chart

5.4 I/O Connection and Cable

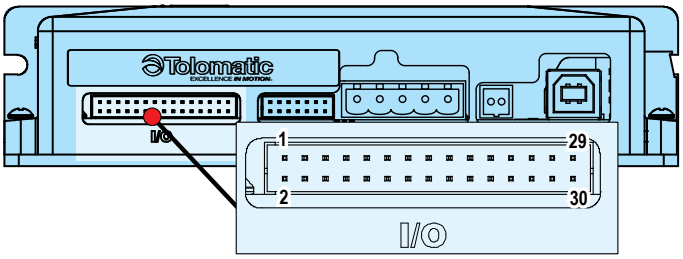


Figure 5-5: I/O Connection on ACS Drive

JST #PHDR-30VS		
PIN NUMBERS	**SIGNAL**	**CABLE WIRE COLOR**
1	Input ISO 1	Red/Black/White
2	Input ISO 2	Orange/Green
3	Input ISO 3	Red/White
4	Input ISO 4	Green/White
5	Input ISO 5	Blue/White
6	Input ISO 6	White/Black/Red
7	Input ISO 7	White/Red

8	Input ISO 8	Orange/Red	
9	Input ISO 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	
16	Output 4 -	Orange/Black	
17	Output 4 +	Red	
20	Case Ground	Shield	
23	*Step Input	Blue/Red	*Not yet supported
24	*Direction Input	Red/Green	by software
25	NA	Green	
26	NA	Black/Red	
27	Analog Out	GRN/Black/White	
28	Analog In	Black/White/Red	
29	Signal Ground	Black	
30	Signal Ground	Black/White	
28	Analog In	Black/White/Red	
29	Signal Ground	Black	
30	Analog Ground	Black/White	

Table 5-5: I/O Connection pinouts

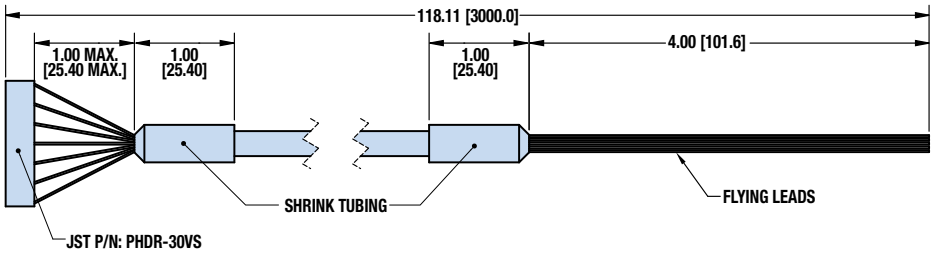


Figure 5-6: I/O Cable 3604-1770/1771

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 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.

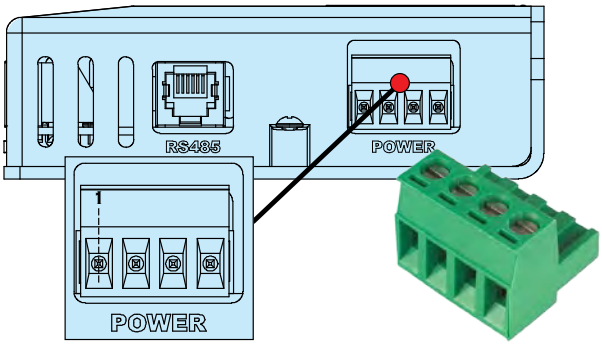
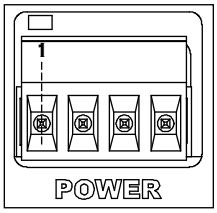


Figure 5-7: Input Power Connection



PIN NUMBERS	SIGNAL
1	Main Power 10 - 52 VDC
2	Keep-alive 10 - 52 VDC
3	Brake Power 24 VDC
4	Ground – Power

Table 5-7: Input Power pinouts

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

Table 5-8: Input Power Cable Parts

5.6 Brake Output Connection

The brake output is controlled via an onboard Circuit Brake Power is supplied via the Input Power Connection and output on the Brake Output Connection.

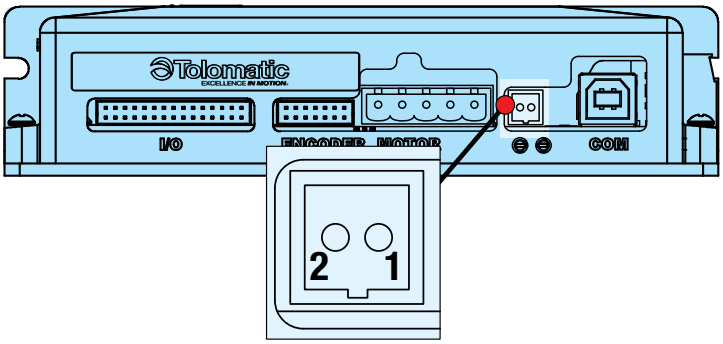
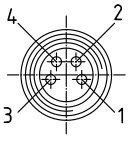


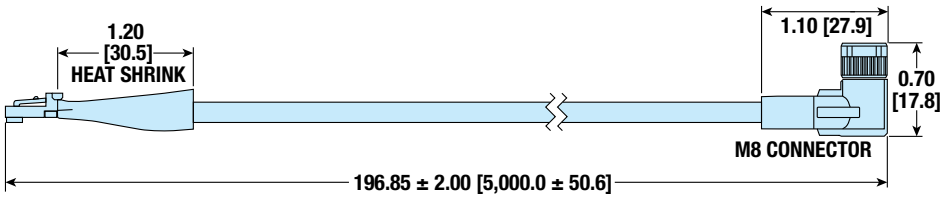
Figure 5-8: Brake Connection

MOLEX #0050579702		M8 CONNECTOR - PHOENIX CONTACT # 1406242
PIN NUMBERS	FUNCTION	PIN NUMBERS
1	Brake -	1
2	Brake +	2



Front View

Table 5-9: Brake Pinout



CABLE	DESCRIPTION
3604-1949 Brake Cable	ACS Brake Cable, 5m

Figure 5-9: Brake Cable

5.7 USB 2.0 Connection

The USB port connector is a standard B type connector.

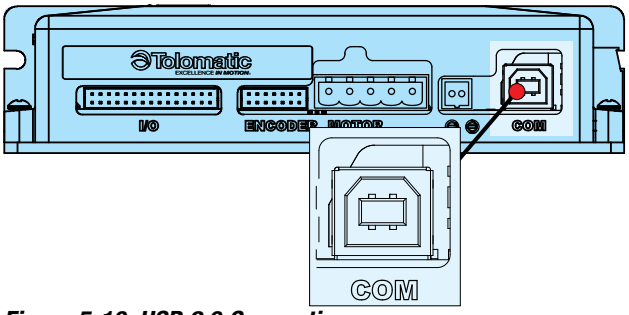


Figure 5-10: USB 2.0 Connection

5.8 RS-485 Connection

The ACS RS485 connection requires an RJ45 plug with 3 conductors. The ACS controller/drive uses a two-wire configuration for RS485 connection. This requires three signals: A, B, and Common. Signals A and B are a differential pair. Signals A and B are duplicated on pins 7 and 8. Common is used as a reference voltage. Figure 5-10 shows the pin assignment on the ACS socket.

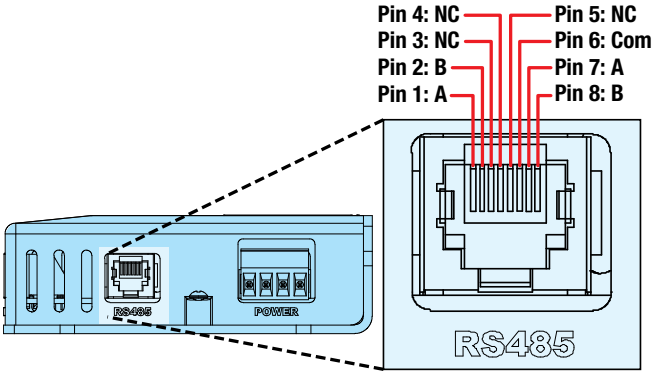


Figure 5-11: ACS 2-Wire RS485 with RJ45 Socket

5.8.1 RS-485 Cable Length

A multipoint serial line bus is made of a main cable (the trunk) which connects to a Master device, and derivation cables that tap off from the trunk to Slave devices. RS-485 transceivers have a wide (-7V to +12V) common mode range. This differential signal has good noise immunity for long distance transmission lines. The absolute maximum cable length of the trunk is 4,000 feet. If more than one

Slave device is tapped from the trunk, then terminating 150 Ohm resistors must be placed across lines A and B at both ends of the trunk. The derivation cable to the Slave device must be short with a maximum cable length of 60 feet. Some factors that may reduce cable length are: the number of devices on a multi-drop application, the quality of cabling used, and the baud rate selected.

5.8.2 RS-485 Grounding

The Common wire must be connected to protective ground. This wire should only be connected at one point on the bus, preferably at the Master device. If ground potentials are too large, resistors must be placed in the Common wire at each device to limit the current and prevent damage to the circuit. This is shown in Figure 5-12.

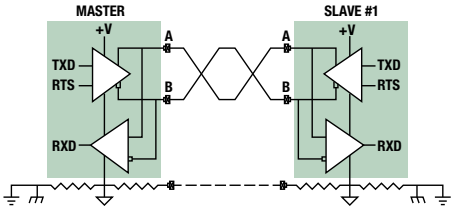


Figure 5-12: Resistors in ground wire to limit current

5.9 Ethernet Connection

The following parts have two Ethernet ports with a built-in switch to be used for daisy chaining.
3604-9666 - ACS Stepper Drive/Controller, EtherNet/IP™
3604-9667 - ACS Stepper Drive/Controller, Modbus TCP

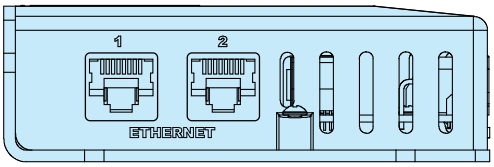
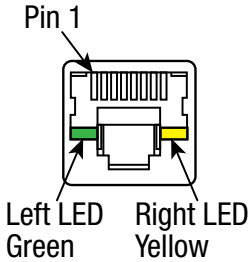


Figure 5-13 EtherNet/IP Connection for ACS Drive Programmability



PIN NUMBER	FUNCTION
1	Transmit Port (+) Data Terminal
2	Transmit Port (-) Data Terminal
3	Receive Port (+) Data Terminal
4	NA
5	NA
6	Receive Port (-) Data Terminal
7	NA
8	NA

Table 5-10 EtherNet/IP pinouts and Connections

5.10 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.

In Figure 5-14 proper cable looping is shown for connectors located on the top or side of the unit. Units mounted with connectors on the bottom surface require no cable looping.

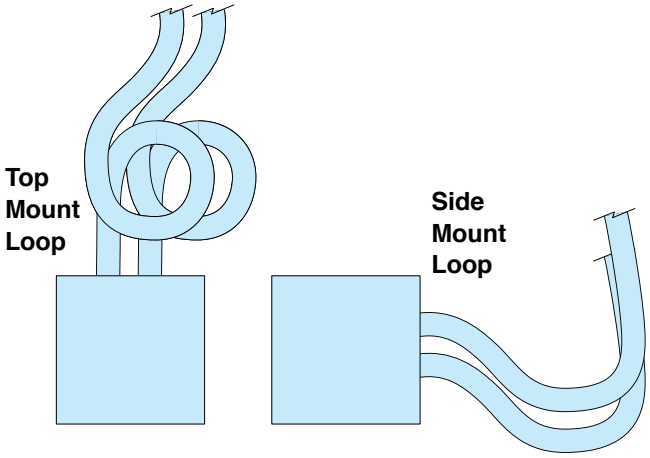


Figure 5-14 Cable Routing for Top and Side Facing Connectors

5.10.1 Ethernet Cable

The selection of cables has a profound impact on network performance and reliability. Selecting the correct cable requires an understanding of the environment where the cable is installed.

Due to high data rate and reliability considerations, at the minimum, Cat5e cables should be used with the ACS Drive. If the cables are made on site, they must be tested to meet performance criteria set according to TIA/EIA -568-B standard. This cable definition is the general cable requirements for copper and fiber cabling installations.

5.10.2 Ethernet Cable Length

The following information on cables is from the ODVA standard. Reference Section 8-9.2.3.6 of the ODVA EtherNet/IP Standard v. 1.11 for additional information.

Patch Cord Length

EtherNet/IP specifications limit the channel to 100 meters or up to 90 meters horizontal wiring with two 5-meter patch cords. Some applications will require longer patch cords. In these applications the total length of horizontal wiring must be adjusted to compensate for the added loss of each connector pair and additional patch cord length beyond 10m.

$$C = \frac{(102-H)}{(1+D)} \qquad (1)$$

Where:

C is the maximum combined length (m) of the work area cable, equipment cable, and patch cord

H is the length (m) of the horizontal cable (H + C </= 100 m)

D is a de-rating factor for the patch cord type (0.2 for 24 AWG UTP/24 AWG ScTP and 0.5 for 26 AWG ScTP). The de-rating factors are based on COMMERCIAL cables. Other constructions, such as high flex, may have different performance. Consult the manufacturer for information.

W is the maximum length (m) of the work area cable.

T is the total length of horizontal, patch and equipment cords.

The maximum stranded cable length is limited to 85mm for the channel with the standard 20% derating for standard stranded cables.

WIRE TYPE VERSUS LENGTH					
PATCH CABLE GAUGE	D	H	W	C	T
	PATCH DERATING	HORIZONTAL LENGTH (H+C<=100M)	PATCH LENGTH	TOTAL LENGTH PATCH AND EQUIPMENT	TOTAL LENGTH OF PATCH, EQUIPMENT AND HORIZONTAL
#24	0.2	100	0	0	100
#24	0.2	0	80	85	85
#24	0.2	25	59	64	89
#24	0.2	50	38	43	93
#26	0.5	0	63	68	68
#26	0.5	25	46	51	76
#26	0.5	50	30	35	85
#26	0.5	100	0	0	100

Table 5-11: Cable Wire Type versus Cable Length

6.1 Digital Inputs

6.1.1 Specifications

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

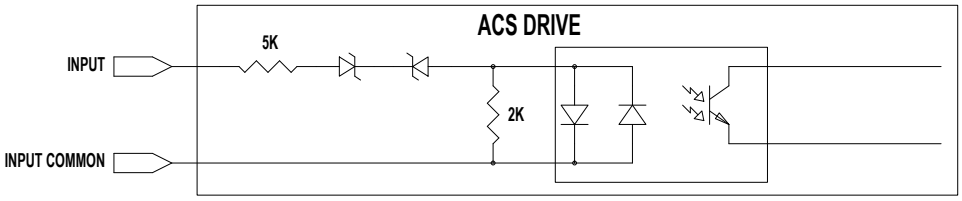


Figure 6-1: Digital Input Circuit

Opto-isolated Digital Input Specifications		
Parameter	**Value**	**Units**
Input Voltage Range	0 to 28	VDC
On State Voltage Range	16 to 28	VDC
Off State Voltage Range	0 to 5	VDC
On State Current: 16VDC (minimum) 24VDC (nominal) 28VDC (maximum)	 1.9 3.4 4.2	mA
Nominal Input Impedance (24V)	7	KΩ
Off State Current (maximum)	0.4	mA
Update Rate (maximum)	2	ms

Table 6-1: Opto-Isolated Digital Input Specifications

6.1.2 Typical Wiring Diagrams

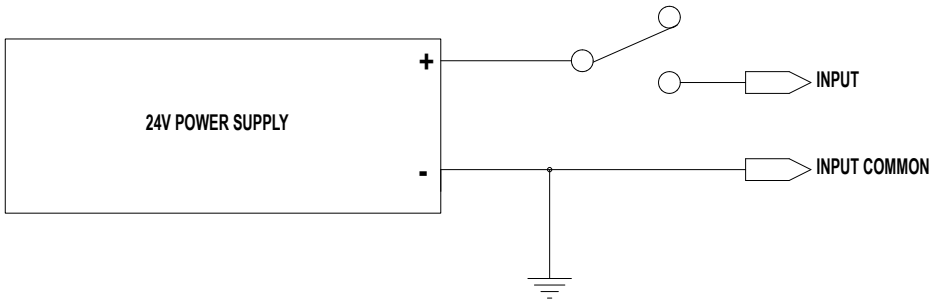


Figure 6-2: Input Source (switched) Connection

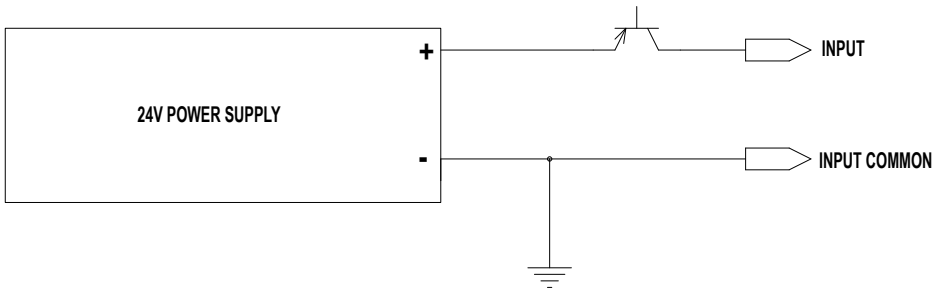


Figure 6-3: Input Source (PNP) Connection

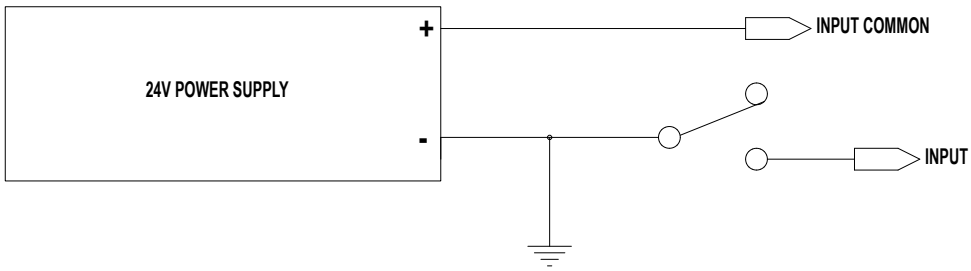


Figure 6-4: Input Sink (switched) Connection

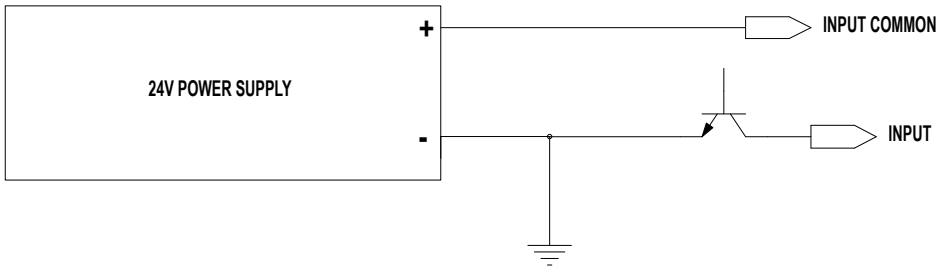


Figure 6-5: Input Sink (NPN) Connection

6.2 Digital Outputs

6.2.1 Specifications

The ACS Drive 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. If an over current condition is present, the output turns off until the load is removed.

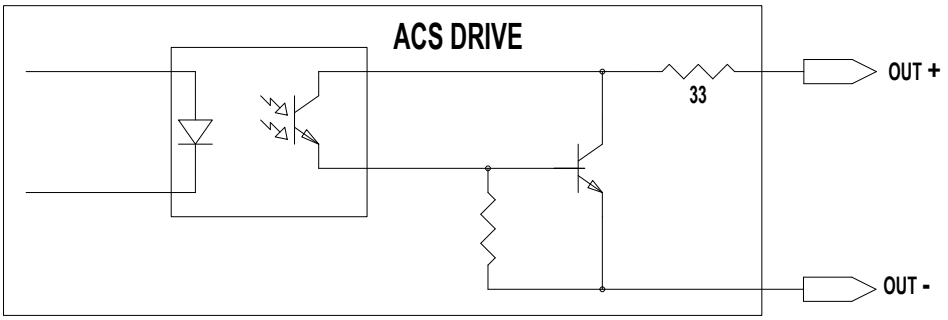


Figure 6-6: Output Circuit

Digital Output Specifications		
Parameter	**Value**	**Units**
Switched Voltage (max)	24	V
Output Voltage drop (20mA)	2	V
Continuous Current (max)	20	mA
Fold Back Current	80	mA
Update Rate (10KOhm Load)	2	ms
Output Leakage Current	30	uA

Table 6-2: Digital Output Specifications

6.2.2 Typical Wiring Diagrams

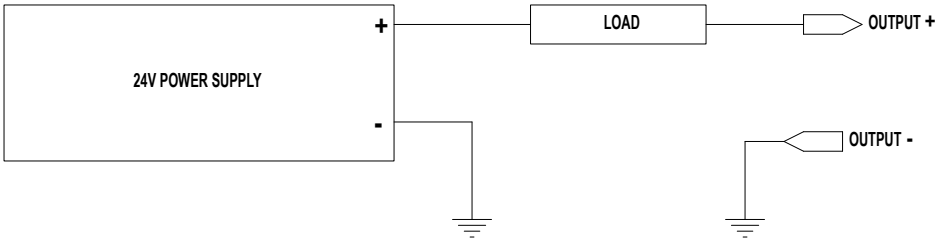


Figure 6-7: Digital Output Sinking Connection

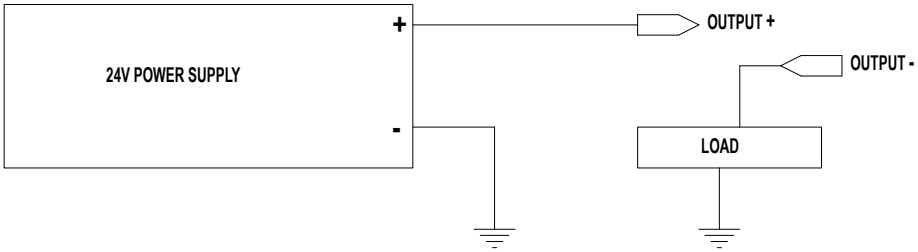


Figure 6-8: Digital Output Sourcing Connection

6.3 Analog Input

6.3.1 Specifications

The ACS Drive comes with one analog input. The input is configurable through software to be 0-10V or 4-20mA input. The analog input is referenced to the analog ground pin.

Parameter	Value	Units
Voltage Mode Input Voltage (min)	0	V
Voltage Mode Input Voltage (max)	10	V
Current Mode Input Current (min)	4	mA
Current Mode Input Current (max)	20	mA
Current Mode Input impedance (nom)	500	Ohm
Resolution	12	Bits

Table 6-3: Analog Input Specifications

6.3.2 Equivalent Circuit

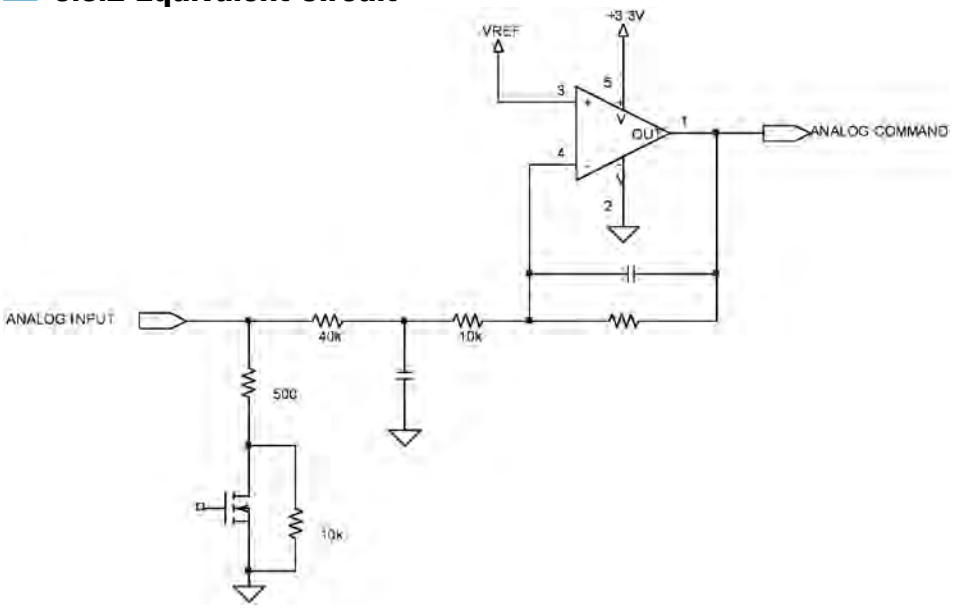


Figure 6-9: Analog Input Equivalent Circuit

IMPORTANT!

Devices sharing analog inputs and outputs must have their grounds connected together for proper and reliable operation.

6.4 Analog Output

6.4.1 Specifications

The ACS Drive can have one analog output capable of 0-10V or 4-20mA operation (on selected models). The analog output is referenced to the analog output ground pin.

Parameter	Value	Units
Output Voltage (min)	0	V
Output Voltage (max)	10	V
Output Current (min)	4	mA
Output Current (max)	20	mA
Resolution	12	Bits

Table 6-4: Analog Output Specifications

6.4.2 Equivalent Circuit

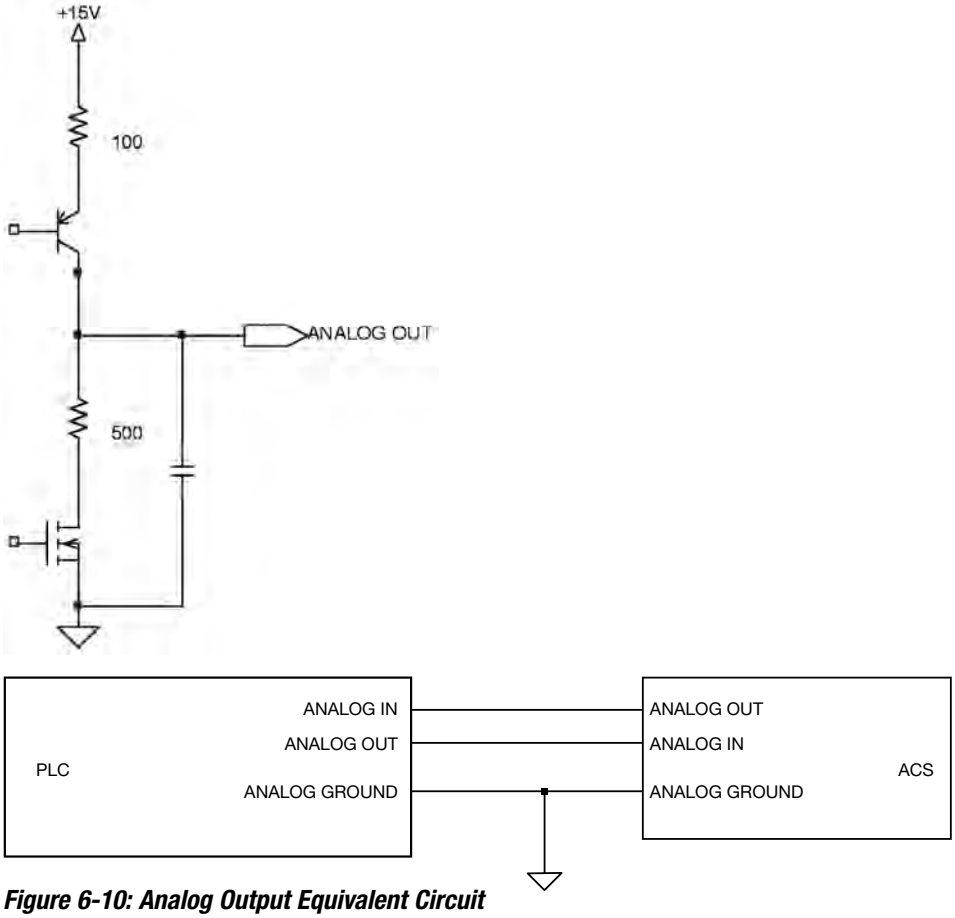


Figure 6-10: Analog Output Equivalent Circuit

IMPORTANT!

Devices sharing analog inputs and outputs must have their grounds connected together for proper and reliable operation.

6.5 Brake Output

6.5.1 Specifications

Parameter	Value	Units
Input Voltage	24	V
Absolute Maximum Voltage	70	V
Output Current	0 - 500	mA

Table 6-5: Brake Output Specifications

6.5.2 Equivalent Circuit

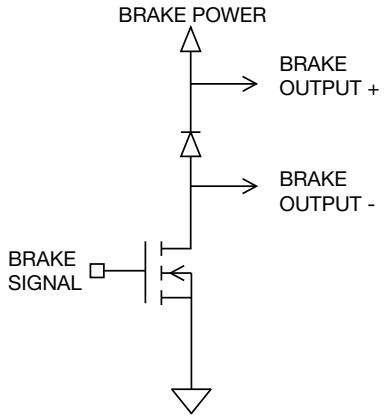


Figure 6-11: Brake Output Equivalent Circuit

6.6 Input Power

6.6.1 Drive Specifications

ACS Internal Drive Specifications		
Parameter	**Value**	**Units**
Current - Maximum	10	Arms
Voltage - Nominal	10-52	V
Over Voltage[1]	55	V
Under Voltage[2]	9	V
Absolute Maximum Voltage	60	V
Logic Current Draw Maximum (24V)	100	mA

Table 6-6: ACS Internal Drive Specifications

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.

[1] Drive will fault at 55V; any voltage above the absolute max voltage can result in permanent damage.

[2] Drive will fault below 9V.

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.

6.6.2 Typical Wiring Diagrams

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.

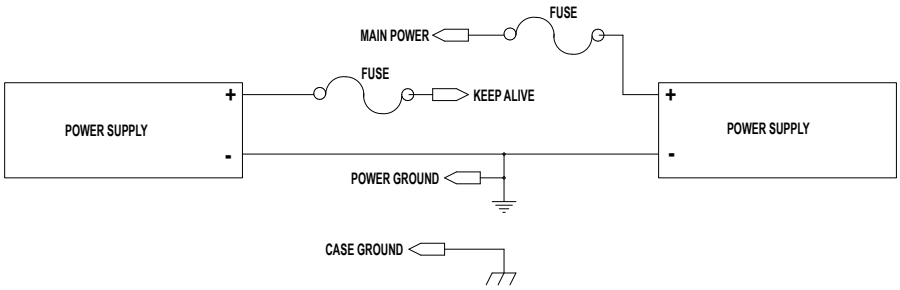


Figure 6-12: ACS Drive Logic and Main Power Supplies

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.

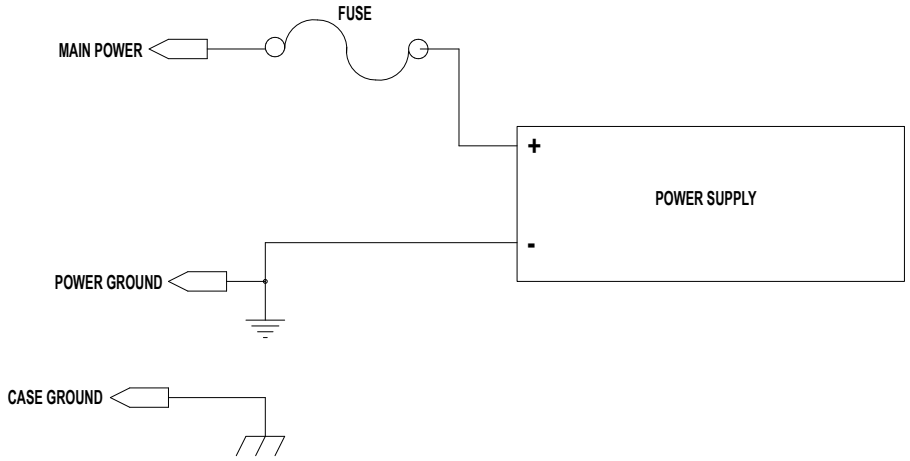


Figure 6-13: ACS Drive Single Supply – Main Power

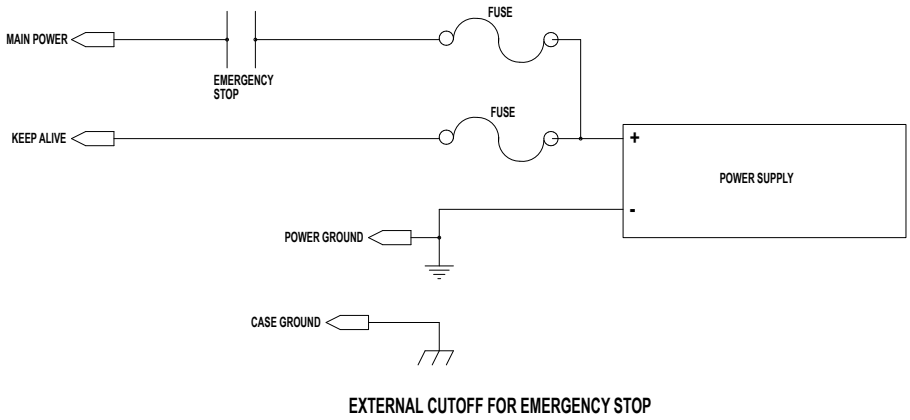


Figure 6-14: ACS Drive External Cutoff Switch for Emergency Stop

6.6.3 Power Supply Selection

Both unregulated and regulated power supply can be used to power the ACS Drive.

Unregulated supply can be a better choice depending on the application as they have a larger output capacitance. This characteristic makes an unregulated power supply a better energy absorption source. Unregulated power supply is a good choice for applications that require aggressive acceleration it can provide peak currents without faulting and will not trip on high voltage. **However, unregulated power supply does not have over voltage protection and care must be**

taken not to exceed the maximum voltage of the actuator by using a shunt regulator and proper fusing to prevent excessive loading of the supply.

Regulated supply can be used to power the ACS drive, but additional measures may need to be taken. **To prevent regenerative energy from reaching the supply, a blocking diode and capacitor, appropriately sized for the application, should be installed. In addition, a shunt regulator may be needed to dissipate excess energy or regeneration in high inertia applications.** A shunt regulator is available Part Number 2180-1163.

The ACS Drive is intended to run off of an isolated DC power source. The power supply required will depend on the application. A 48V supply will allow the actuator to operate at maximum speed. A 24V supply will result in approximately half the rated velocity. Input current will depend on the actuator power needed in the installation. If operating more than one actuator 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	MOTOR PHASE AMPS PEAK	CALCULATED MAX SUPPLY AMPS	MAX WATTS 24/48V
NEMA 11 - 1 Stack	1.0	0.6	14.4
NEMA 17 - 1 Stack	1.5	0.85	20.4
NEMA 23 - 1 Stack	2.0	1.1	26.4
NEMA 23 - 2 Stack	5.0	2.6	62.4
NEMA 34 - 1 Stack	10.0	5.1	122.4
NEMA 34 - 2 Stack	10.0	5.1	122.4

Table 6-7: Maximum Power Supply Current for Tolomatic Motors

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

Motor Current (Phase Amps Peak) * 0.5 + 0.1

For example, if the motor is rated at 10 Amps-peak, the calculation would look like:

10 * 0.5 + 0.1 = 5.1

Converting current (Arms) to power (Watts):

Supply power = current x 24V

Example: If 2.3A is needed, 2.3A x 24V = 55.2W.

6.6.4 Suggested Power Supplies:

Switching Power Supply:	Lambda SWS600-48
Unregulated Power Supply:	International Power IP500U36
Bus Fuse:	15 Amp, 125V or equivalent or sized for application
Logic Power Fuse:	2 Amp, 125V or equivalent
Shunt Regulator:	Applied Motion RC-50, PN: 1000-237

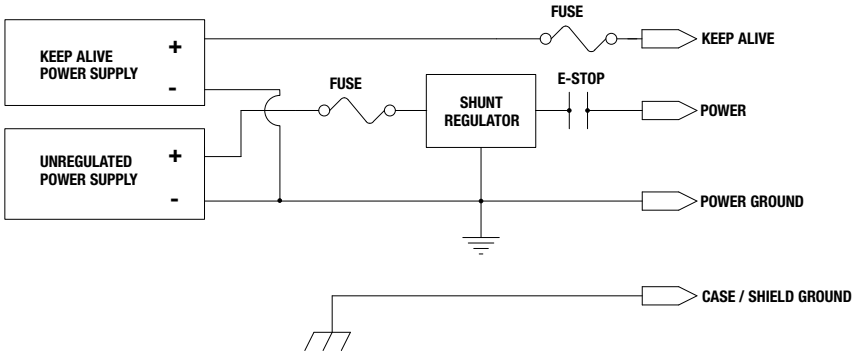


Figure 6-15: Unregulated Power Supply Configuration with Shunt Regulator

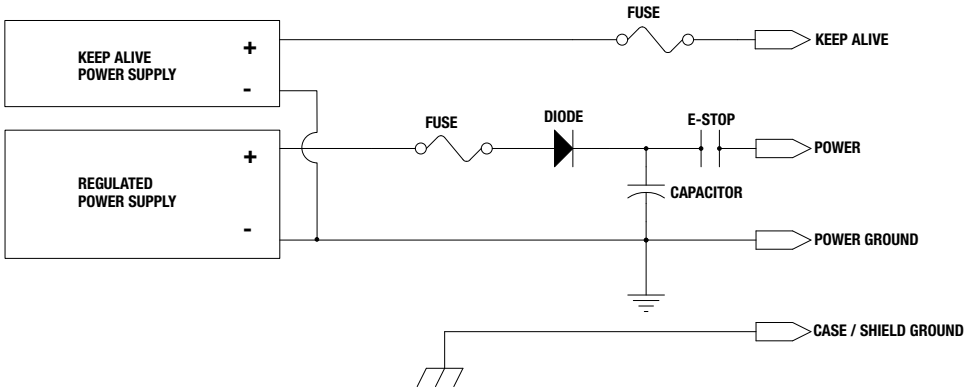


Figure 6-16: Regulated Power Supply Configuration with Blocking Diode and Added Capacitance

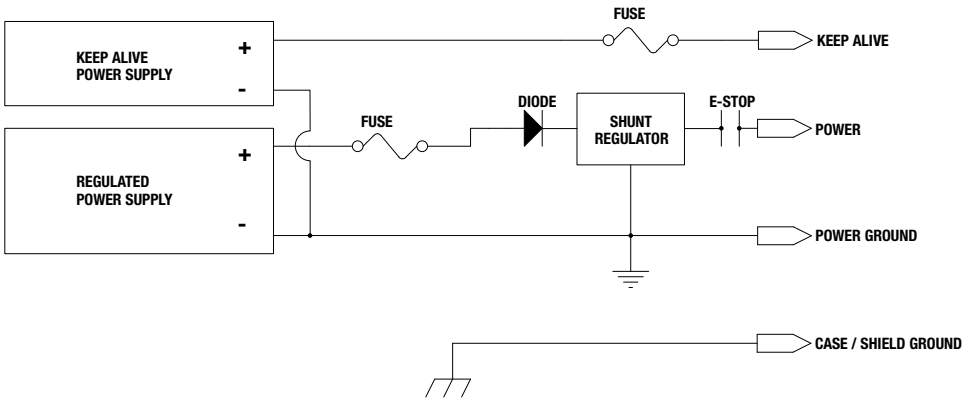


Figure 6-17: Regulated Power Supply with Blocking Diode and Shunt Regulator

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 Ω load. Additional software filtering of digital inputs by TMI will increase response time.

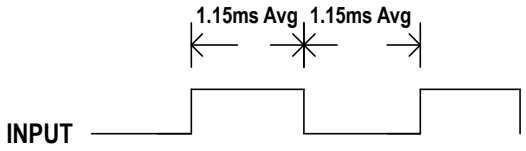


Figure 7-1 Input Requirement

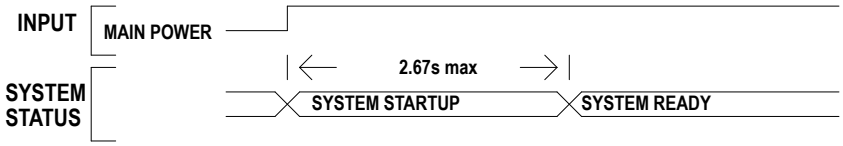


Figure 7-2 System Startup Timing

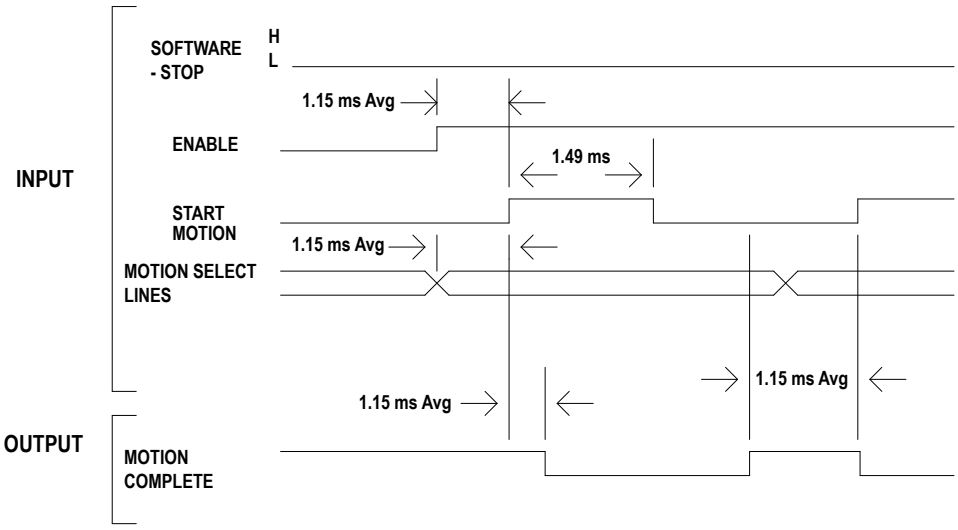


Figure 7-3 Jog Move Timing

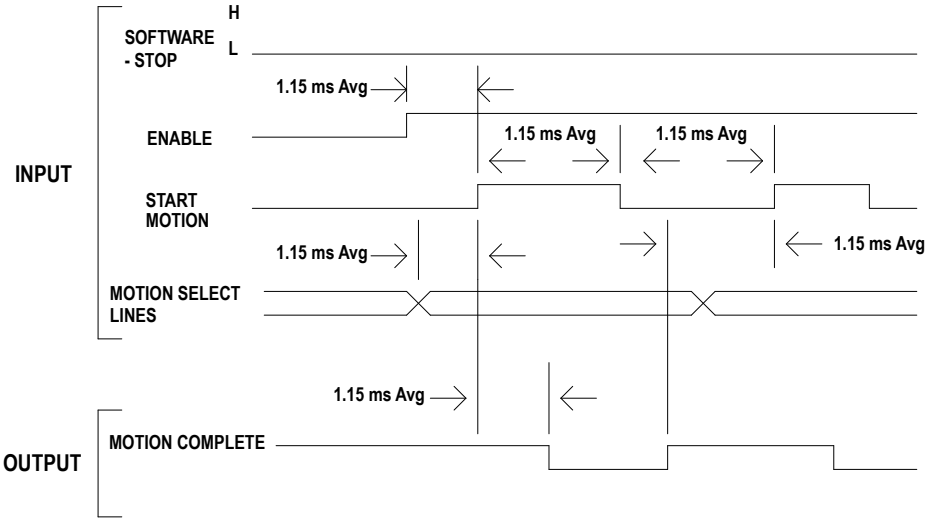


Figure 7-4 Absolute & Incremental Move Timing

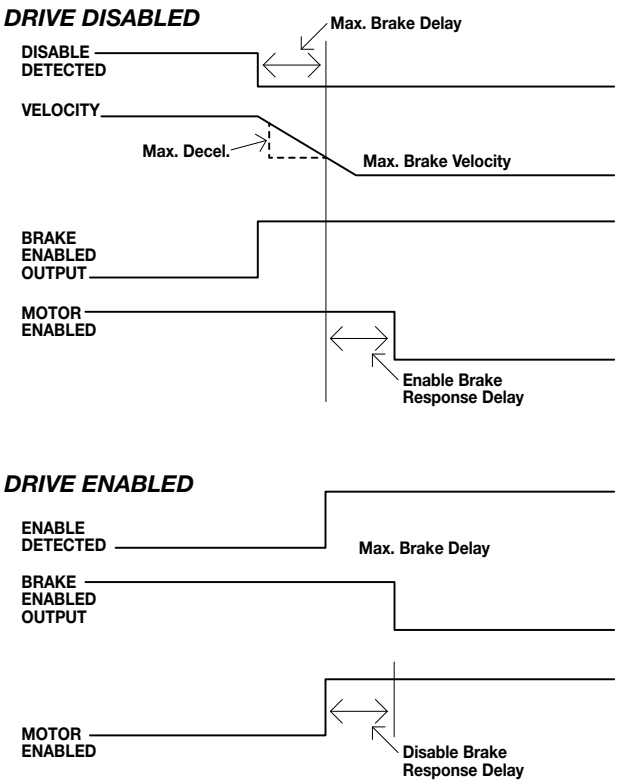


Figure 7-5 Brake Subsystem Timing

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 Software Stop signal is high, the drive will ignore start motion pulses.

8.1 Move Select Logic Table

The Index Move Mode (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

4 Move Commands Mode Logic Table		
MOVE	**MS1**	**MS2**
1	0	0
2	1	0
3	0	1
4	1	1

Table 8-1: 4 Move Commands Mode Logic

8 Move Commands Mode Logic Table			
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

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	
Green, Off	Motor is not powered (Disabled)
Green, On	Motor is powered (Enabled)
Red, On and Solid	A critical fault has occurred
Red, On and Blinking	A safety fault has occurred
Green, On and Blinking **Red, On and Blinking**	Drive is in firmware upgrade mode

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

NOTE: To clear faults; PLC needs to lower/raise the enable digital input or TMI user must press the Enable button on the motion manager

Faults are divided into Safety Faults and Critical Faults.

Safety Faults are configurable. If the fault is configured as a stop motion, the fault will be cleared automatically once the fault condition is no longer present. 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 described at left.

All Critical Faults will disable the motor when they occur. To clear these faults, the fault condition cannot be present and the enable input line must be lowered and then raised to proceed with motion.

Safety Faults Table	
Positive Limit Switch	Positive limit switch has been reached. If configured to 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 there is motion in the negative direction.
Negative Limit Switch	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 there is motion in the positive direction.

Safety Faults Table	
Position Error	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 defined 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. If fault is configured as 'Disable Motor' the enable input must be cycled. NOTE: If force is less than 100%, a position error fault will not be triggered. It will stop and hold position (push mode).
Software Stop	If an input is configured as an Software Stop and fault is enabled, this fault will be activated when the signal level on the pin is high. This fault is configured as a stop motion, it will be cleared after the Software Stop input is lowered and next move is commanded. If fault is configured as 'Disable Motor' the enable input must be cycled. Motion will not be allowed until Software Stop has been cleared.

Table 9-2: Safety Faults

Critical Faults Table	
Over Current	Current draw from motor driving circuitry is above drive's rated limit.
Drive Over Temp	Drive temperature is greater than the maximum allowed temperature (75˚C).
Drive Over Voltage	Main power voltage exceeds the maximum voltage.
Drive Under Voltage	Main power voltage below the minimum voltage.
Flash Error	Memory checksum error or firmware version mismatch. If error occurs at: Power-up – Flash memory checksum error or firmware version mismatch. During Motion – Communication failure to motor driver.
Watchdog Timeout	Firmware did not respond in time. Occasionally this fault is induced from power cycling the drive when the USB cable is connected to a PC. Disconnect USB and power cycle the drive to clear the fault. This fault can also occur if the power supply is too small for the drive, actuator & load and the supply faults and resets, typically occurring during deceleration portion of a move.

Table 9-3: Critical Faults

10.1 Troubleshooting

10.1.1 Troubleshooting the ACS Stepper Drive

SYMPTOM / TROUBLE	POSSIBLE CAUSE / RESOLUTION
No communication to drive	1. Check power connection. (See page 6_6 for wiring) 2. Try another USB cable. 3. Verify that the communication cable is plugged in securely. 4. Verify that all drivers are up-to-date. 5. Try a different computer.
Actuator cannot move load	1. The load is too large. 2. There is too much friction. 3. Side load is excessive. 4. Power supply does not have enough current capability. 5. Current limits are set too low. 6. Verify movement with no load attached. 7. Verify that the drive has been configured properly for the actuator.
Drive is overheating	1. Ambient temperature is too high. 2. Cooling is insufficient. 3. Drive spacing is too close. 4. Holding current is too high. 5. Voltage is too high.
Actuator is operating erratically	1. Motor/encoder signals disconnected, damaged or wired incorrectly. 2. Determine if power supply has enough current. 3. Check to see if any faults are being generated. 4. Verify that the drive has been configured properly for the actuator. 5. Verify the issue is not mechanical. 6. Verify that the brake is not enabled while attempting motion.

SYMPTOM / TROUBLE	POSSIBLE CAUSE / RESOLUTION
No response from drive in I/O mode	1. Verify the enable signal is on. 2. Verify that all of the I/O are configured properly. 3. Verify wiring to the actuator and drive. 4. Disconnect from software or select digital input controlled radio button on mode setup tab. 5. Verify that the move index table contains all appropriate data. 6. Verify that the drive is seeing I/O using TMI digital I/O tool. 7. Home the actuator.
Red and Green LEDs on, both blinking and no communication (See page 9_1-9_2 for Red LED faults and recovery.)	1. Cycle power to drive. 2. Verify firmware upgrade completed without interruption. 3. Restart firmware upgrade in compatibility mode.
No Ethernet Communication (Ref. EtherNet/IP User's Guide 3600-4168)	1. Check Ethernet cables. 2. Verify Ethernet cable is plugged in securely. 3. Incorrect combination of IP address, subnet mask & gateway. Check with your network administrator. 4. Verify that you can ping drive.
Red and green LEDs toggling back and forth	1. Drive is in upgrade mode. Launch Tolomatic firmware upgrade and reload firmware.

Table 10-1: Troubleshooting Descriptions

Motors

There are currently four frame sizes– NEMA 11, NEMA 17, NEMA 23 and NEMA 34 available from Tolomatic (six different motors) – available for operation with the ACS Drive. Each motor is available with an optional differential incremental encoder. All motors come with a short 150mm cable and connector on the motor body.

Tolomatic Motor Specifications						
SPEC	**NEMA 11**	**NEMA 17**	**NEMA 23 1-Stack**	**NEMA 23 2-Stack**	**NEMA 34 1-Stack**	**NEMA 34 2-Stack**
Resistance (Ohms)	3.5	2.4	1.5	0.39	0.138	0.188
Inductance (mH)	2.3	4.5	3.7	1.53	1.13	2.0
Rated Current (Amps-Peak/Phase)	1.0	1.5	2.0	5.0	10.0	10.0
Maximum Torque (in-lbs)	1.85	5.26	7.53	13.4	24.3	53.0
Maximum RPM	1800	2000	1200	2000	2000	1850
Degree per Step	1.8°	1.8°	1.8°	1.8°	1.8°	1.8°
Rotor Inertia (lb-in²)	0.006	0.028	0.075	0.133	0.324	0.546

Table A-1: Tolomatic Stepper Motor Specifications

Tolomatic Motor Part Numbers		
MOTOR	**NO ENCODER**	**WITH ENCODER**
NEMA 11	3604-1779	3604-1780
NEMA 17	3604-1775	3604-1776
NEMA 23 1-Stack	3604-1777	3604-1778
NEMA 23 2-Stack	3604-1954	3604-1955
NEMA 34 1-Stack	3604-1956	3604-1957
NEMA 34 2-Stack	3604-1961	3604-1962

Table A-2: Tolomatic Stepper Motor Part Numbers

Encoder Specifications				
MOTOR TYPE	**FRAME SIZE**	**ENCODER**	**CABLE CONNECTOR PART NUMBER**	**CABLE TERMINAL PART NUMBER**
Bipolar Stepper, 1.8˚ per Step	NEMA 23	Differential; 500 line (2000 count post quad)	794954-6	50212-8000
Bipolar Stepper, 1.8˚ per Step	NEMA 34	Differential; 500 line (2000 count post quad)	Molex 15-04-5104 (x1)	inserts: Molex 14-60-0058 (x2)

Table A-3: Encoder Specifications

MOTOR CONNECTIONS							
3m / 5m / 10m Cable		Motor Connector or Leads					
Wire Color	Tyco Pin	NEMA11 Molex Pin	NEMA17 Molex Pin	NEMA23 1-Stack Molex Pin	NEMA23 2-Stack Leads	NEMA34 1-Stack Leads	NEMA34 2-Stack Leads
Tolomatic Order Code		AMS1A1C1	AMS1B1C1	AMS1C1C1	AMS1C2C1	AMS1D1C1	AMS1D2C1
Black	6	6	1	1	Black	Black	Black
Green	3	4	3	3	Green	Green	Green
Red	1	3	4	4	Red	Red	Red
White	4	1	6	6	White	White	White

Table A-4: NEMA11, 17, 23, 34 Motor Connection pinouts

ENCODER Connections: US Digital PN E8P-500-197-D-D-M-B Molex Mating Connector: 510221-0600; Molex Contacts: 50079-8100		
WIRE COLOR	MOLEX PIN	SIGNAL
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-5: NEMA11, 17, 23 Encoder Connections and Connector pinouts

ENCODER Connections: US Digital PN E5-500-394-NE-D-G-D-B Connector: Molex 15-04-5104; Contacts: Molex inserts 14-60-0058 (x2)		
WIRE COLOR	MOLEX PIN	SIGNAL
Blue	6	ENC A+
Orange	5	ENC A-
Yellow	10	ENC B+
Gray	9	ENC B-
Black	2	Signal Ground
Red	7	+5VDC

Table A-6: NEMA 34 - Encoder Connections and Connector pinouts

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.

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Tolomatic
EXCELLENCE IN MOTION®

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

www.tolomatic.com