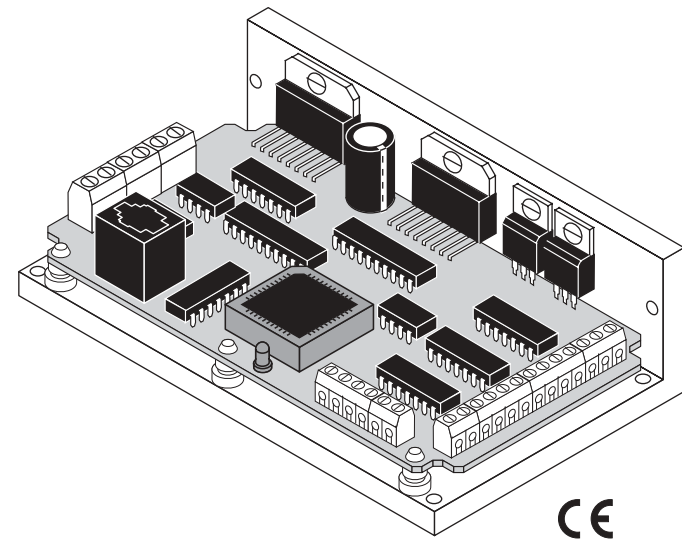


# **Hardware Manual**

## **3540i**

### **Programmable Step Motor Driver**



CE

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**Applied Motion Products, Inc.**

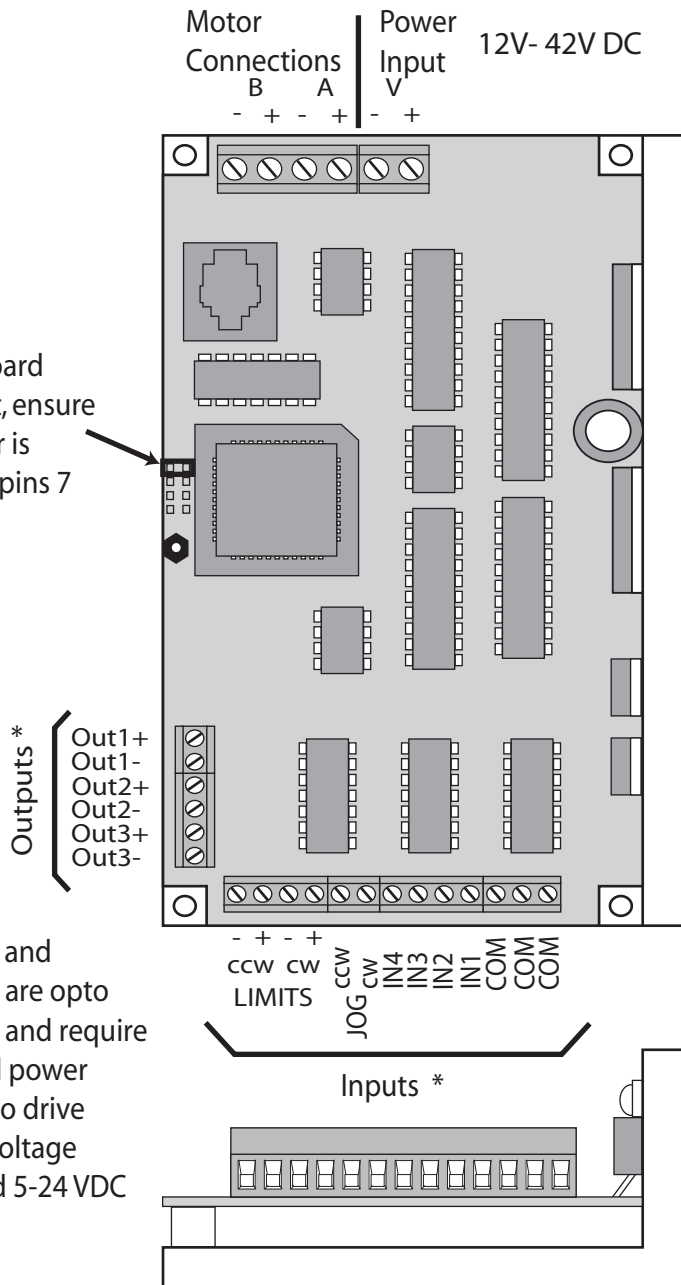
404 Westridge Drive Watsonville, CA 95076

Tel (831) 761-6555 (800) 525-1609 Fax (831) 761-6544



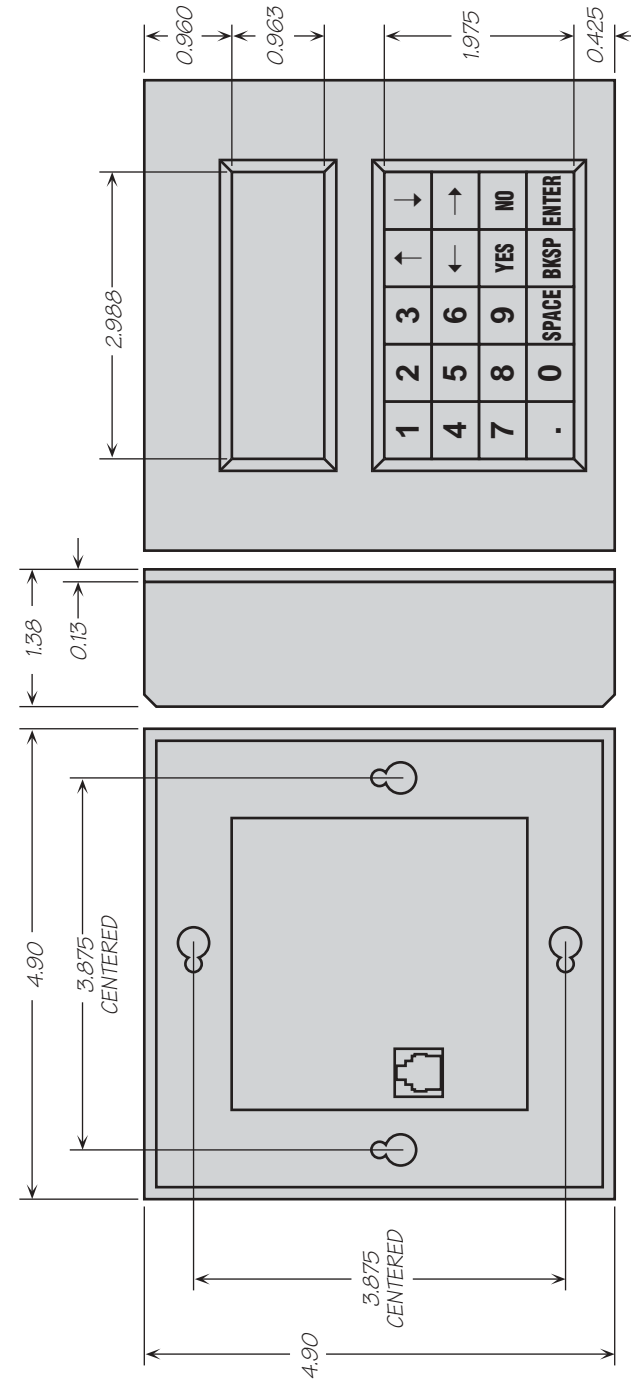
## Connections

NOTE  
If option board not present, ensure that jumper is present on pins 7 & 8.



\* inputs and outputs are opto isolated and require external power supply to drive them. Voltage required 5-24 VDC

## Mechanical Outline - Optional MMI



## Technical Specifications

<b>Amplifiers</b>	Dual, MOSFET H-bridge, 3 state, pulse width modulated switching at 20 kHz. 0.2 - 3.5 amps/phase output current, software selectable. 147 watts maximum output power. Automatic idle current reduction (software programmable), reduces current to motor when idle. Minimum motor inductance is 0.8 mH.
<b>Power Supply</b>	Accepts 12 - 42 VDC power supply. 3.5 amps typical max load. 7A maximum power on surge.
<b>Inputs</b>	5 - 24V, optically isolated. 2200 ohms internal resistance. Can be configured for sinking (NPN) or sourcing (PNP) signals.
<b>Outputs</b>	Optically isolated. 24V, 100 mA max.
<b>Microstepping</b>	13 software selectable resolutions. Steps per revolution with 1.8° motor: 2000, 5000, 10000, 12800, 18000, 20000, 21600, 25000, 25400, 25600, 36000, 50000, 50800. Waveform: pure sine.
<b>Motion Update</b>	12800 Hz.
<b>Physical</b>	Constructed on black anodized aluminum chassis/heat sink. 1.5 x 3 x 5 inches overall. 12 oz. 0-70°C ambient temp range. Power LED. See page 17 for detailed drawing .
<b>Connectors</b>	Power, motor: screw terminal block. Wire size: AWG 12 - 28. I/O Signals: screw terminal block. Wire size: AWG 16 - 28.



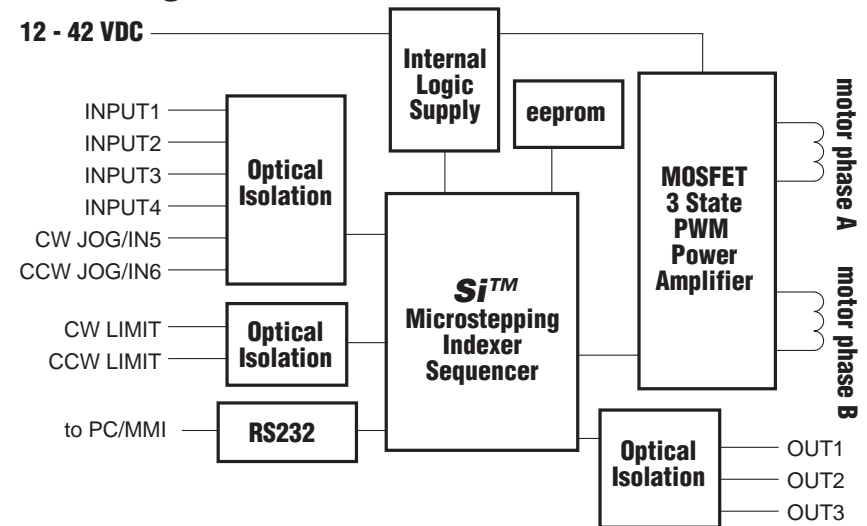
## Introduction

Thank you for selecting an Applied Motion Products motor control. We hope our dedication to performance, quality and economy will make your motion control project successful. If there's anything we can do to improve our products or help you use them better, please call or fax. We'd like to hear from you. Our phone number is (800) 525-1609 or you can reach us by fax at (831) 761-6544.

## Features

- Powerful, precise and efficient mosfet driver providing up to 3.5 amps per phase and microstepping to 50,800 steps per revolution.
- Accepts 12 - 42 VDC power supply.
- Powerful, flexible, easy to use indexer.
- Connects by a simple cable to your PC for programming (cable included).
- Microsoft Windows-based software for easy set up and programming.
- Eight inputs for interacting with the user and other equipment.
- Three outputs for coordinating external equipment.
- All I/O is optically isolated, 5 - 24 V, sinking or sourcing signals. (Except PC/MMI port which is  $\pm 12V$  RS-232.)
- Sturdy 1.5 x 3 x 5 inch metal chassis.
- Screw terminal connectors for motor, DC power and I/O signals
- Optional man machine interface (MMI) allows operator to enter distances, speeds, loop counts and more.

## Block Diagram

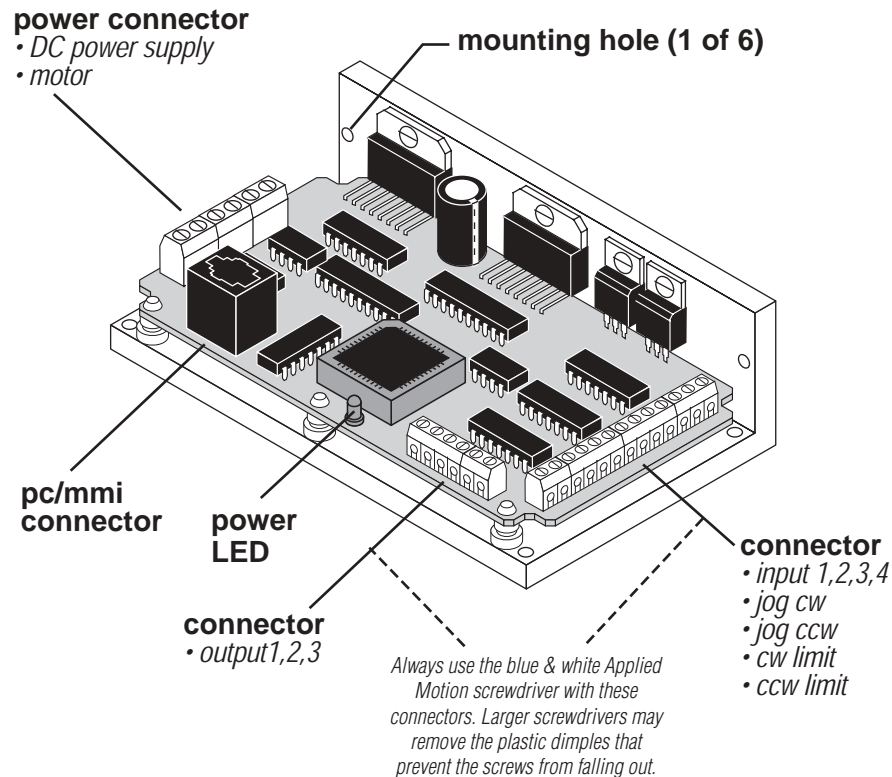


## Getting Started

To use your 3540i motor control, you will need the following:

- ✓ a power supply (see page 5 for help in choosing one).
- ✓ a compatible step motor (see page 17 for recommended motors)
- ✓ a small flat blade screwdriver for tightening the connectors - an Applied Motion Products screwdriver suitable for this purpose is included with your drive.
- ✓ a personal computer running Windows 3.1, 95 or NT with a 9 pin serial port (486 or better with 8 MB ram recommended)
- ✓ the Si Programmer™ software that came with your 3540i
- ✓ the programming cable that came with your 3540i
- ✓ Si Programmer™ manual

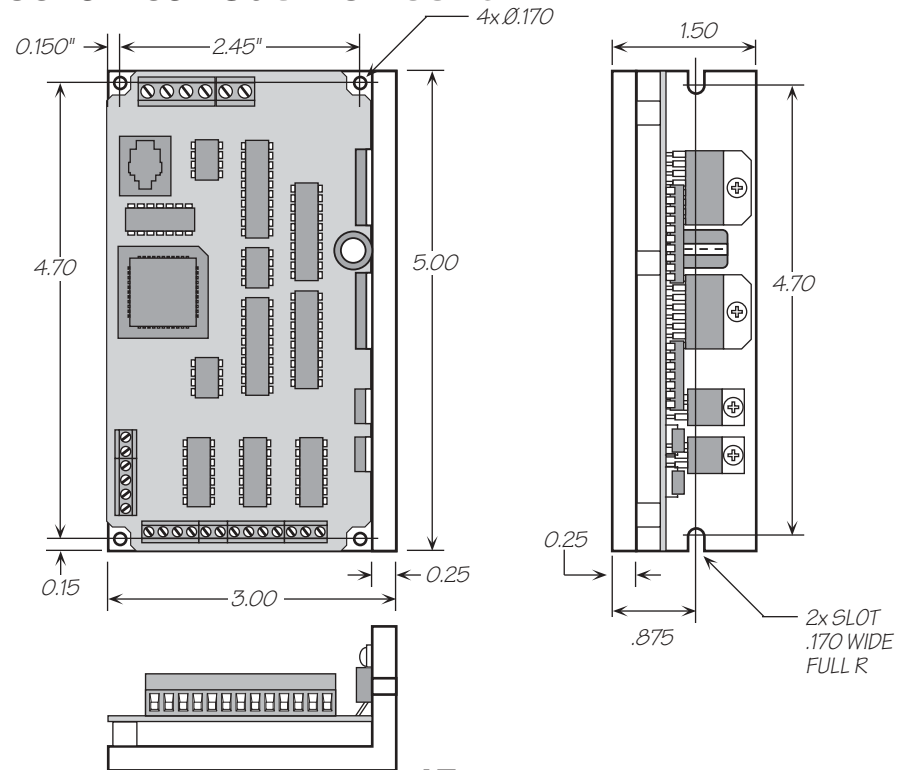
The sketch below shows where to find the important connection and adjustment points. Please examine it now.



## Recommended Motors

Motor Number	Size inches	Winding Connection	Max Torque oz-in	Current Amps
5014-842	1.38 x 1.38 x 1.57	4 lead	19	1.0
HT17-068	1.65 x 1.65 x 1.30	parallel	23	1.0
HT17-071	1.65 x 1.65 x 1.54	parallel	30	1.25
HT17-075	1.65 x 1.65 x 1.85	parallel	40	1.7
5023-122	2.22 x 2.22 x 2.0	parallel	60	2.0
5023-123	2.22 x 2.22 x 3.0	parallel	100	2.5
5023-124	2.22 x 2.22 x 4.0	parallel	150	3.5
HT23-394	2.22 x 2.22 x 1.54	parallel	60	2.8
HT23-397	2.22 x 2.22 x 2.13	parallel	140	2.8
HT23-400	2.22 x 2.22 x 2.99	parallel	180	2.0
5034-348	3.38 x 3.38 x 2.50	parallel	130	3.5

## Mechanical Outline - 3540i

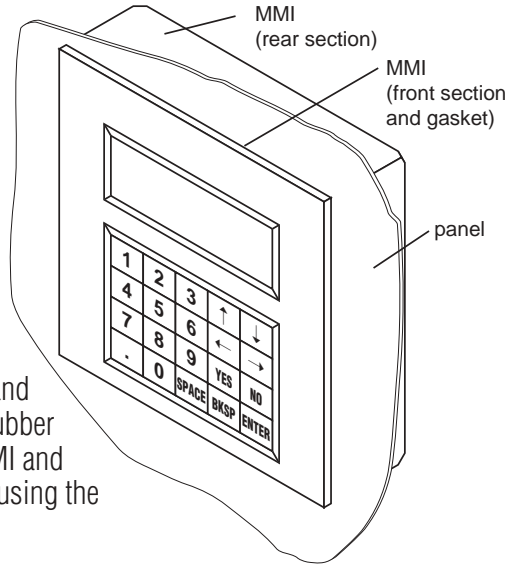


## Flush Mounting

When you remove the MMI from the shipping carton, you will notice that it has two parts. The first is a fairly thin section that contains the keypad, display and some circuit boards. The other part is thicker and contains the telephone jack and a cable that connects to the keypad assembly.

When you flush mount the MMI in a panel, only the thin section will stick out from your panel - the large portion mounts behind your panel. You'll need to cut a precise section from your panel. There is a cardboard template in your box for this purpose.

If you want the MMI to be dust proof and watertight, you must place the black rubber gasket between the thin part of the MMI and your panel. Assemble the two halves using the eight small screws.

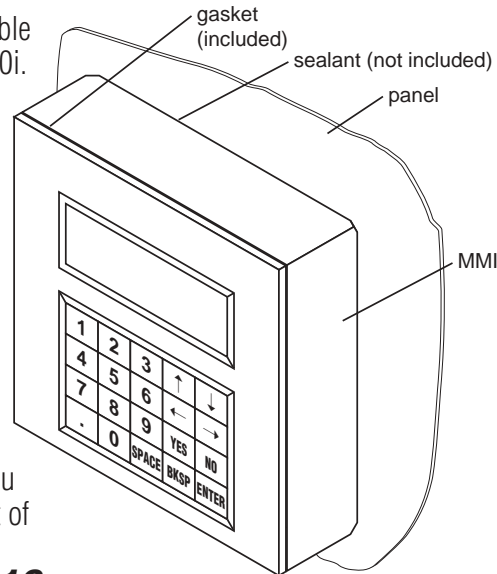


## Surface Mounting

An easier way to mount the MMI is to bolt the two halves together ahead of time, using the eight small screws. If you want the MMI to be dust proof and watertight, put the black rubber gasket between the two halves before screwing them together.

Then cut a hole in your panel for the cable that runs between the MMI and the 3540i. The hole must be at least 5/8" in diameter for the connector to fit through. You will also need two holes that line up with the big mounting holes in the MMI. The mechanical outline on page 19 shows the location of the big mounting holes.

When you mount the MMI to your panel, you will need to use some kind of sealant to keep dust and liquid out. Silicone or latex caulking is okay, or you can make your own gasket from a sheet of compliant material like rubber or RTV.

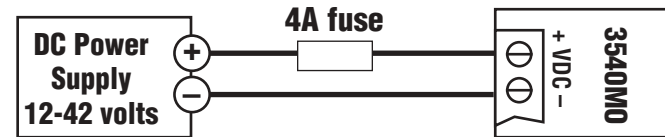


## Connecting the Power Supply

If you need information about choosing a power supply, please read *Choosing a Power Supply* below. The PS430 from Applied Motion Products is a good supply for this drive.

If your power supply does not have a fuse on the output or some kind of short circuit current limiting feature you need to put a 4 amp fast acting fuse between the drive and power supply. Install the fuse on the + power supply lead.

Connect the motor power supply as shown below. Use no smaller than 20 gauge wire. **Be careful not to reverse the wires.** Reverse connection will destroy your driver, void your warranty and generally wreck your day.



## Choosing a Power Supply

We recommend using an Applied Motion Products PS430 power supply with this drive. The PS430 provides 30 volts DC at 4 amps, as well as 500 mA of well regulated 5 volt power for your logic circuits. It also has built-in fuses. If you do not choose an A.M.P. supply, please follow the recommendations below.

## Voltage

Chopper drives like the 3540i work by switching the voltage to the motor terminals on and off while monitoring current to achieve a precise level of phase current. To do this efficiently and silently, you'll want to have a power supply with a *voltage rating at least five times that of the motor*. Depending on how fast you want to run the motor, you may need even more voltage than that. If you choose an unregulated power supply, do not exceed 28 volts. This is because unregulated supplies are rated at full load current. At lesser loads, like when the motor's not moving, the actual voltage can be up to 1.4 times the rated voltage. For smooth, quiet operation, a lower voltage is better.

## Current

The maximum supply current you could ever need is the sum of the two phase currents. However, you will generally need a lot less than that, depending on the motor type, voltage speed and load conditions. That's because the 3540i uses switching amplifiers, converting a high voltage and low current into lower voltage and higher current. The more the power supply voltage exceeds the motor voltage, the less current you'll need from the power supply. A motor running from a 24 volt supply can be expected to draw only half the supply current that it would with a 12 volt supply.

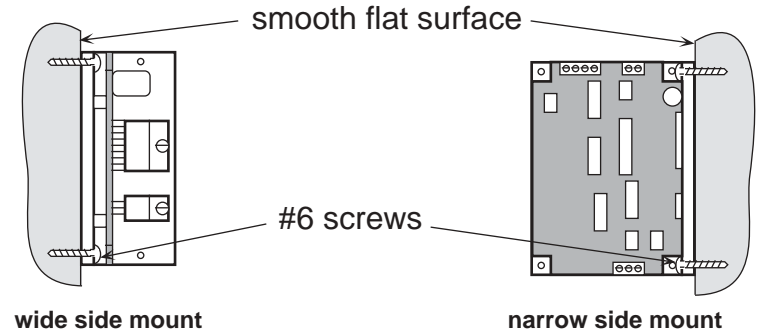
We recommend the following selection procedure:

1. If you plan to use only a few drives, get a power supply with at least twice the rated phase current of the motor.
2. If you are designing for mass production and must minimize cost, get one power supply with more than twice the rated current of the motor. Install the motor in the application and monitor the current coming out of the power supply and into the drive at various motor loads. This will tell you how much current you really need so you can design in a lower cost power supply. If you plan to use a regulated power supply you may encounter a problem with current fold back. When you first power up your drive, the full current of both motor phases will be drawn for a few milliseconds while the stator field is being established. After that the amplifiers start chopping and much less current is drawn from the power supply. If your power supply thinks this initial surge is a short circuit it may "fold back" to a lower voltage. Because of that, unregulated power supplies are better. They are also less expensive.

## Mounting the Drive

You can mount your drive on the wide or the narrow side of the chassis. If you mount the drive on the wide side, use #6 screws through the four corner holes. For narrow side mounting applications, you can use #6 screws in the two side holes.

***The 3540i drive will dissipate heat better if you mount it on the narrow side. Please use narrow side mounting whenever possible.***



The amplifiers in the 3540i generate heat. To operate the drive continuously at maximum power you may need additional heat sinking or forced air cooling.

***Never use your drive in a space where there is no air flow or where other devices cause the surrounding air to be more than 50° C. Don't put the drive where it can get wet or where metal particles can get on it.***

## Mounting the Optional MMI

There are two ways to mount the MMI in your application. No matter which method you choose, you'll need to connect the MMI to your 3540i with the programming cable. You will not, however, need the adapter plug. The MMI has the same telephone style connector as the 3540i.

Depending on how you mount the MMI and cable in your application, you may find that it is difficult to remove the cable from the back of the MMI. If this is the case, and you need to reprogram the 3540i, you can use any telephone line cord as a programming cable. They are available at most supermarkets and discount stores. Please be careful not to lose the adapter plug that connects the telephone cord to the COM port of your PC. The adapter is a custom made part and is only available from Applied Motion.

## Microstepping

Most step motor drives offer a choice between full step and half step resolutions. In full step mode, both motor phases are used all the time. Half stepping divides each step into two smaller steps by alternating between both phases on and one phase on.

Microstepping drives like the 3540i precisely control the amount of current in each phase at each step position as a means of electronically subdividing the steps even further. The 3540i offers a choice of 13 step resolutions. The highest setting divides each full step into 254 microsteps, providing 50,800 steps per revolution when using a 1.8° motor.

In addition to providing precise positioning and smooth motion, microstep drives can be used for motion conversion between different units. The 25,400 step/rev setting is provided as a means of converting motion from metric to english. (There are 25.4 mm in an inch.) Other settings provide step angles that are decimal degrees (36,000 steps/rev makes the motor take 0.01° steps.) Some settings are used with lead screws. When the drive is set to 2000 steps/rev and used with a 5 pitch lead screw, you get .0001 inches/step.

The microstep resolution of the 3540i is set by the Si Programmer™ software.

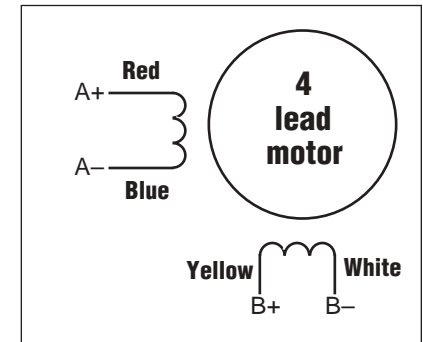
## Connecting the Motor



**Never connect the motor to the driver when the power is on.**  
**Secure any unused motor leads.**  
**Never disconnect the motor while the power is on.**  
**Never connect motor leads to ground or to a power supply.**

You must now decide how to connect your motor to the drive.

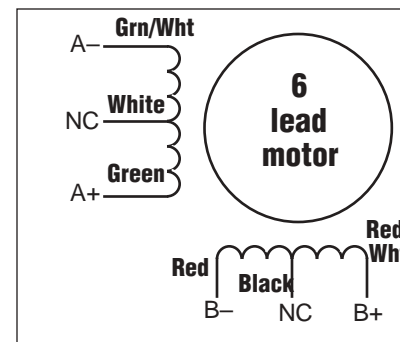
**Four lead motors** can only be connected one way. Please follow the sketch at the right.



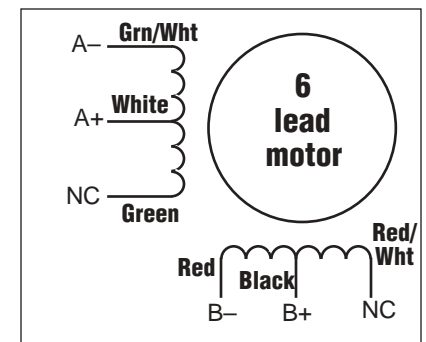
4 Leads

**Six lead motors** can be connected in series or center tap. In series mode, motors produce more torque at low speeds, but cannot run as fast as in the center tap configuration. In series operation, the motor should be operated at 30% less than the rated current to prevent overheating. Winding diagrams for both connection methods are shown below.

*Note: NC means not connected to anything.*

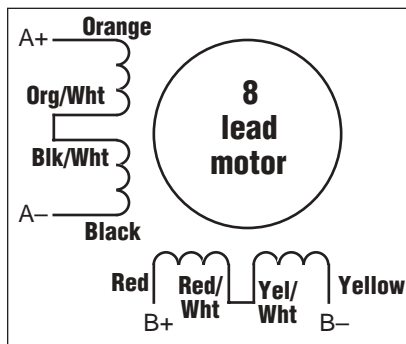


6 Leads Series Connected

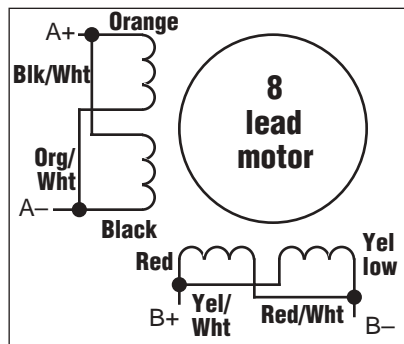


6 Leads Center Tap Connected

**Eight lead motors** can also be connected in two ways: series and parallel. As with six lead motors, series operation gives you more torque at low speeds and less torque at high speeds. In series operation, the motor should be operated at 30% less than the rated current to prevent overheating. The wiring diagrams for eight lead motors are shown below.



8 Leads Series Connected



8 Leads Parallel Connected

## Connecting to the PC

- Locate your computer within 6 feet of the 3540i.
- Your 3540i was shipped with a black adapter plug. It has a telephone style jack at one end and a larger 9 pin connector at the other. Plug the large end into the COM1 serial port of your PC. Secure the adapter with the screws on the sides. If the COM1 port on your PC is already used by something else, you may use the COM2 port for the 3540i. On some PCs, COM2 will have a 25 pin connector that does not fit the black adapter plug. If this is the case, and you must use COM2, you may have to purchase a 25 to 9 pin serial adapter at your local computer store.
- Your 3540i was also shipped with a 7 foot telephone line cord. Plug one end into the adapter we just attached to your PC, and the other end into the RS232 jack on your 3540i.

**Never connect the 3540i to a telephone circuit. It uses the same connectors and cords as telephones and modems, but the voltages are not compatible.**

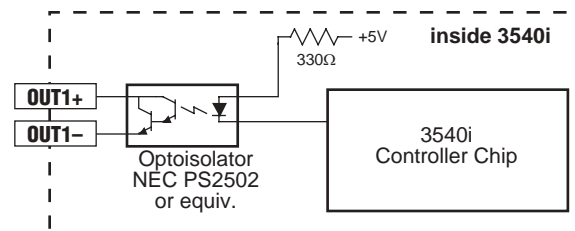
**Programming Note: Always apply power to 3540i after the Si™ Programmer software is running on your PC.**

## Wiring Outputs

Before we discuss the output conditions, we need to talk about the circuitry. All three 3540i outputs are optically isolated. That means that there is no electrical connection between the indexer-drive and the output terminals. The signal is transmitted to the output as light. What you "see" is a transistor (NPN type) that closes, or conducts current, when the output is "low". When the output is high, the transistor is open.

*At power-up, the 3540i sets all three programmable outputs high (open circuit).*

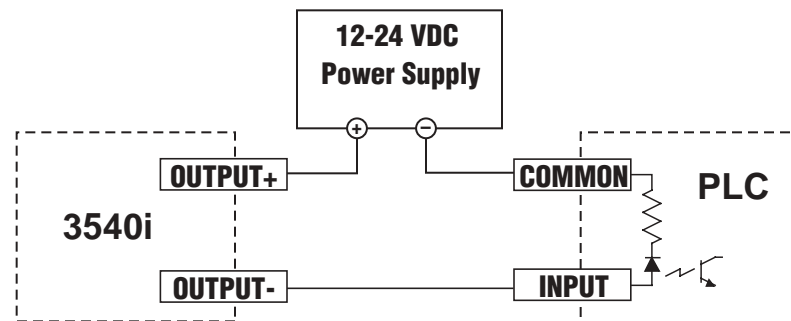
**The maximum voltage between any pair of + and - output terminals is 24 volts DC. Never connect AC voltages to the 3540i output terminals. Maximum current is 100 mA per output.**

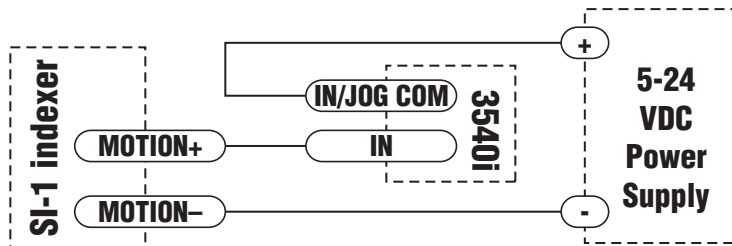


Schematic Diagram of 3540i Output Circuit

Since there is no electrical connection to the 3540i, you must provide the source of current and voltage, typically from a power supply. You must also limit the current to less than 100 mA so that the output transistor is not damaged. You would normally use a resistor for this, but some loads (such as PLC inputs) limit the current automatically.

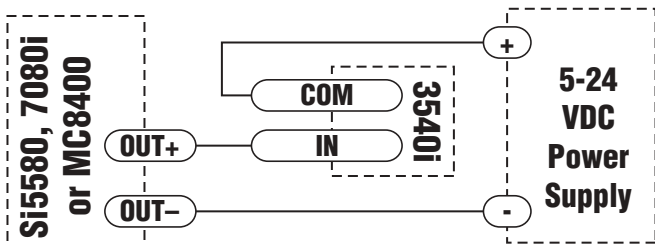
The diagram below shows how to connect an 3540i output to an optically isolated PLC input.





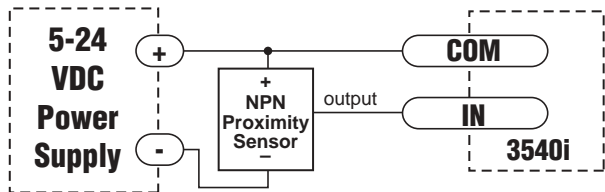
**Connecting an Input to the SI-1 Motion Output**

(Set SI-1 motion signal to "in position". SI-1 will trigger 3540i at end of each move.)



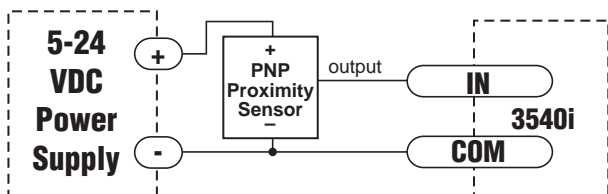
**Connecting an Si5580, 7080i or MC8400**

(When output closes, 3540i input goes low.)



**Connecting an NPN Type Proximity Sensor to an 3540i Input**

(When prox sensor activates, 3540i input goes low.)



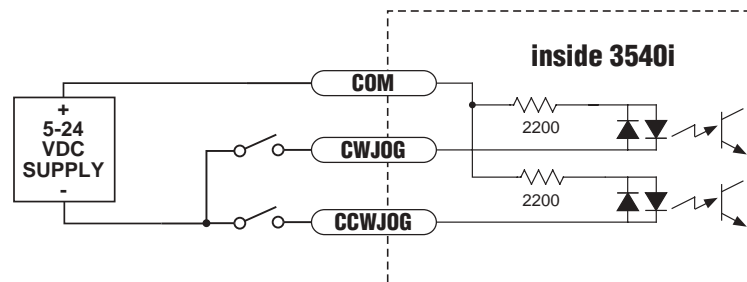
**Connecting a PNP Type Proximity Sensor to an 3540i input**

(When prox sensor activates, 3540i input goes low.)

**Jogging**

Two of the 3540i input terminals are provided for jogging the motor. The inputs are labeled "JOG CW" and "JOG CCW". Activating one of the inputs commands the drive to move the motor at a pre-designated speed until the contact is opened. A relay or mechanical switch can be used to activate the jog inputs. 5-24 volt circuitry can also be used. The schematic diagram of the input circuit is shown below.

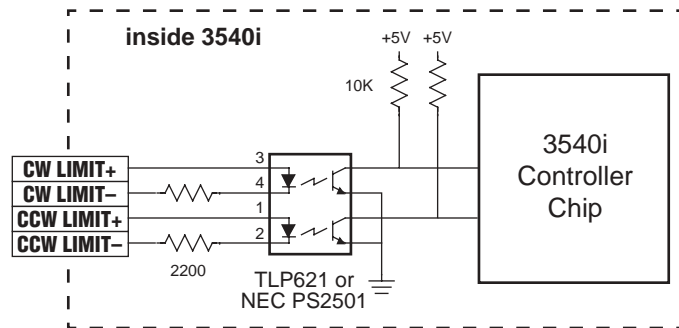
If you're using a switch or relay, wire one end to the JOG input and the other to the power supply - terminal. Then connect the COM and power supply + terminals.



**Limit Switches**

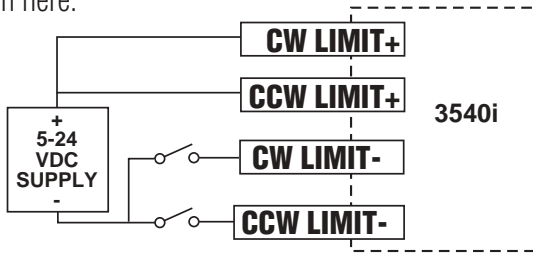
The 3540i has two limit switch inputs, LIMIT CW and LIMIT CCW. By connecting switches or sensors that are triggered by the motion of the motor or load, you can force the 3540i to operate within certain limits. This is useful if a program error could cause damage to your system by traveling too far.

The limit inputs are optically isolated. This allows you to choose a voltage for your limit circuits of 5 to 24 volts DC. It also allows you to have long wires on limit sensors that may be far from the 3540i with less risk of introducing noise to the 3540i. The schematic diagram of the limit input circuit is shown below.



## Wiring a Limit Switch

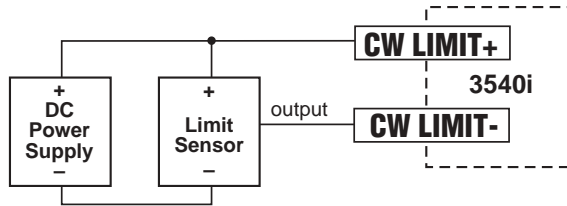
You can use normally open or normally closed limit switches. Either way, wire them as shown here.



## Limit Sensors

Some systems use active limit sensors that produce a voltage output rather than a switch or relay closure. These devices must be wired differently than switches.

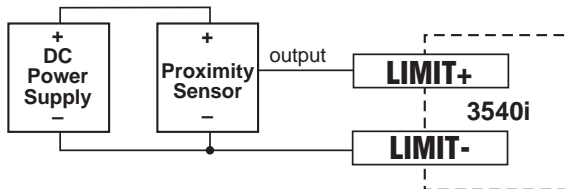
If your sensor has an open collector output or a sinking output, wire it like this:



Wiring for Sinking or Open Collector Output

If the sensor output goes low at the limit, select the option "closed." If the output is open, or high voltage, choose "open."

Other sensors have sourcing outputs. That means that current can flow out of the sensor output, but not into it. In that case, wire the sensor this way:

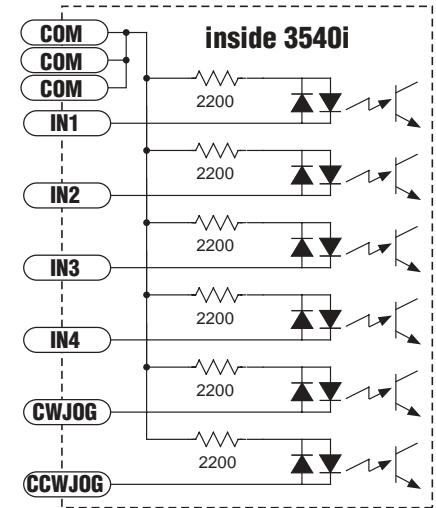


Wiring for Sourcing Output

If the sensor output goes high at the limit, choose the program option "closed." If the output is low at the limit, select "open."

## Wiring Inputs

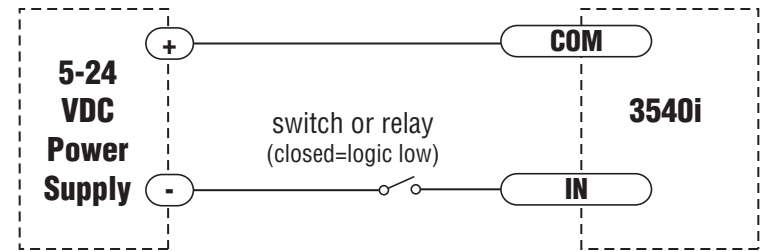
The 3540i input circuits can be used with sourcing or sinking signals, 5 to 24 volts. This allows connection to TTL circuits, PLCs, relays and mechanical switches. Because the input circuits are isolated, they require a source of power. If you are connecting to a TTL circuit or to a PLC, you should be able to get power from the PLC or TTL power supply. If you are using relays or mechanical switches, you will need a 5 - 24 volt power supply. This also applies if you are connecting the 3540i inputs to another Si product from Applied Motion, like the SI-1 and Si-100 indexers or the Si5580, 7080i and MC8400 indexer-drives.



*Note: if current is flowing into or out of an 3540i input, the logic state of that input is low. If no current is flowing, or the input is not connected, the logic state is high.*

The diagrams on the following pages show how to connect 3540i inputs to various devices.

**The maximum voltage that can be applied to an input terminal is 24 volts DC. Never apply AC voltage to an input terminal.**



Connecting an Input to a Switch or Relay

Use normally open momentary switch to trigger 3540i using Wait Input instruction.

Use single throw switch for parameter selection using If Input instruction.

Use normally open momentary switch for jogging.

# **Instructions**

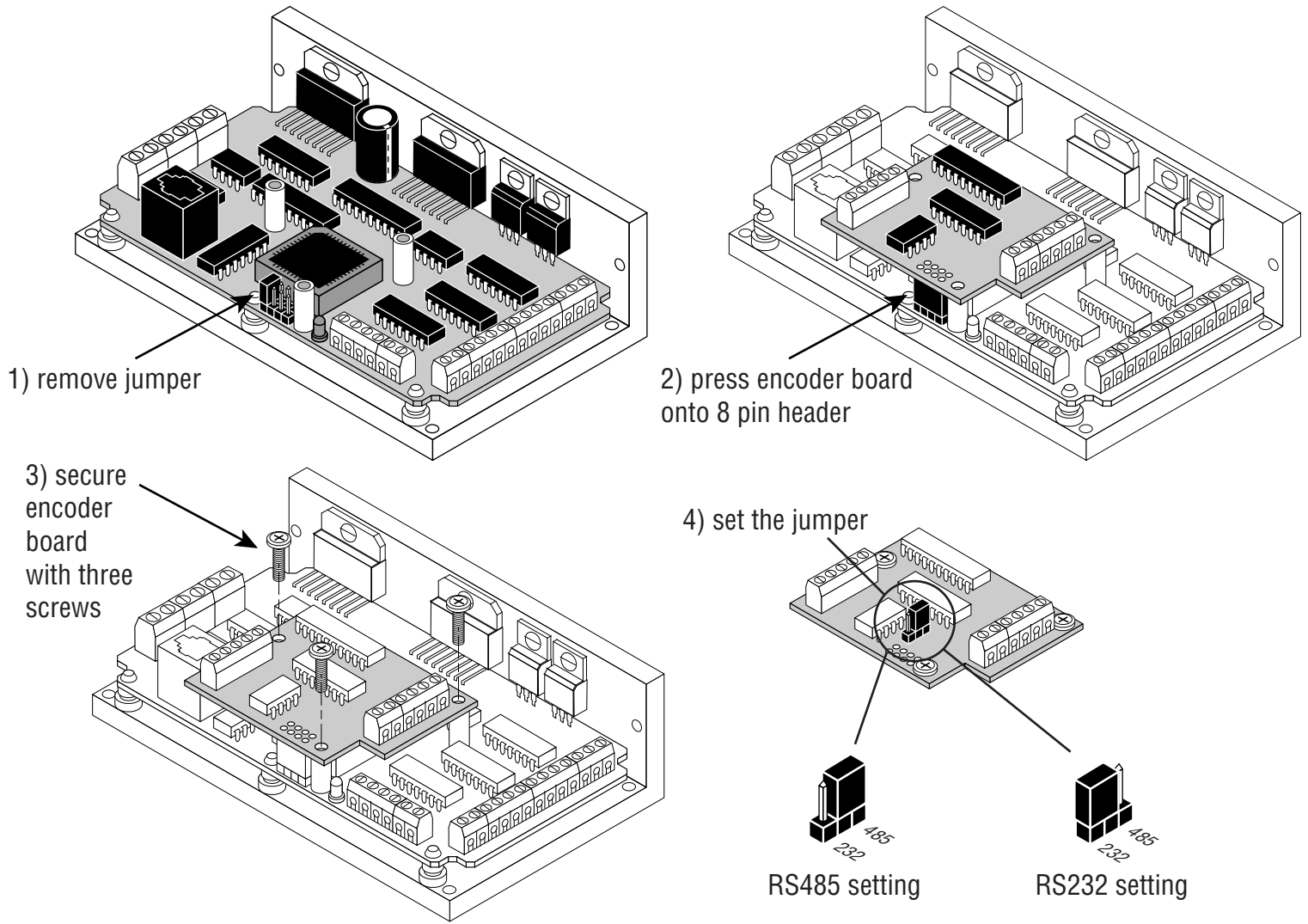
**P/N 1000-175**

## **Encoder & RS485 Option Board**

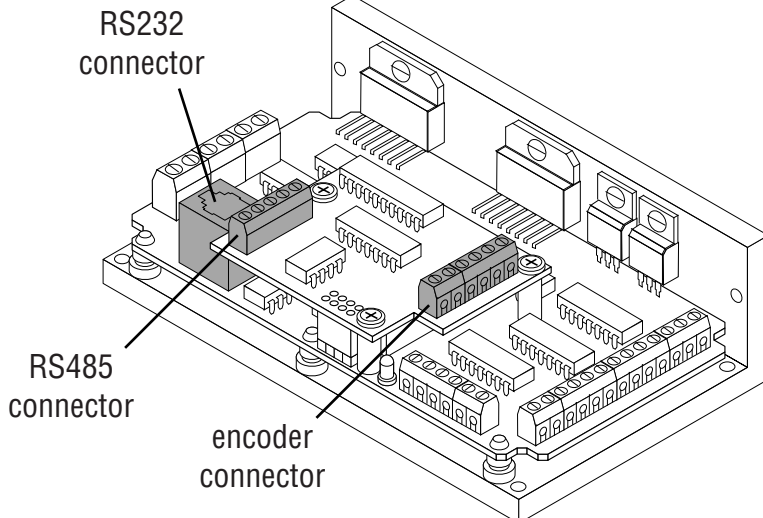
**for 3540i Programmable Step Motor Drive**



404 Westridge Drive  
Watsonville, CA 95076  
(831) 761-6555 • fax (831) 761-6544  
[www.applied-motion.com](http://www.applied-motion.com)



## Connectors



### RS232

To use the RS232 interface, connect your drive using the RS232 cable & adaptor provided with your 3540i drive.

Set the jumper as shown above.

Set the jumper as shown on page 2 of these instructions.

Our RS485 implementation is a multi-drop network with separate transmit and receive wires. One pair of wires must connect the host computer's transmit signals to each drive's RX+ and RX- terminals. Another pair connects the TX+ and TX- drive terminals to the host computer's receive signals. A logic ground terminal is provided on each drive and can be used to keep all drives at the same ground potential. This terminal connects internally to the DC power supply return (V-), so if all the drives on the RS485 network are powered from the same supply it is not necessary to connect the logic grounds. You should still connect one drive's GND terminal to the host computer ground. **Before wiring the entire system, you'll need to connect each drive individually to the host computer so that a unique address can be assigned to each drive.** Proceed as follows:

1. Connect the drive TX+ to the PC's RX+ terminal.
2. Connect the drive TX- to PC RX-.
3. Connect RX+ to TX+.
4. Connect RX- to TX-.
5. Connect GND to GND.

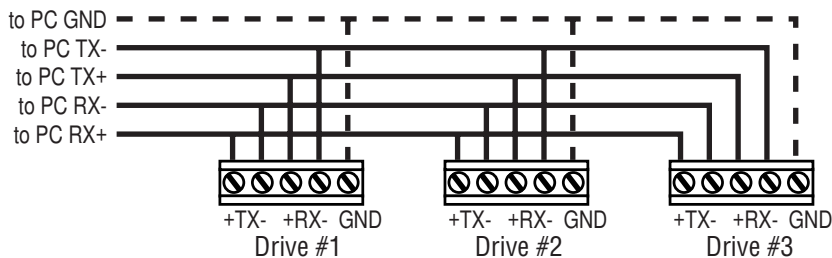
Apply power to the PC and start the *SiNet™ Setup* software. Select the proper comm port (1,2,3 or 4) then apply power to the drive. Press the Caps Lock key. **The drives only accept commands in uppercase.** Type RV then press ENTER. If the drive has power and is properly wired, it will respond with "RV=x". Where x is the firmware version of your drive. If the drive responds, you're home free: the RS485 network is functioning.

Next, you must choose an address for this drive. Any of the "low ascii" characters (many of which appear above the number keys on a PC keyboard) is acceptable: ! " # \$ % & ' ( ) \* + , - . / 0 1 2 3 4 5 6 7 8 9 : ; < > ? @

To find out what address is in the drive now, type DA then press enter. The drive will respond with DA=x, where x is the address that was last stored. (For example, the response might be DA=@ or DA=!). To change the address, type DAY, where y is the new address character, then press ENTER.

To test the new address, type yRV, then press ENTER. For example, if you set the address to % and want to test that, type %RV. The drive should respond just as it does to RV, the global revision level request.

Once all the drives have been assigned unique addresses, you can proceed to wire the whole system together as shown below.



### Getting an RS485 adaptor for your PC

Model 117701 from Jameco Electronics (800-831-4242) works well. This adaptor is for a 25 pin serial port. If you are like most people and have a 9 pin serial port on your PC, you will also need to purchase Jameco cable 31721. Connect as follows:

adaptor	drive	
1	RX+	<i>Set the switches for DCE and TxON,RxON</i>
2	RX-	
3	TX-	<i>Don't forget to plug in the DC power adaptor that comes with the unit.</i>
4	TX+	

## Wiring the Encoder

The 1000-175 option board is designed for use with single ended or differential output quadrature encoders. Differential encoders are recommended because they provide better noise immunity.

There is one restriction on your choice of encoder. The motor resolution must be a multiple of the encoder resolution. Keep in mind that the drive uses "X4" decoding of the encoder signals, so a 1000 line encoder produces 4000 counts per revolution.

An excellent choice of encoders is the U.S. Digital E2-1000 series. That unit has a 1000 line code wheel, which produces 4000 counts/rev at the drive. That will work well with a motor resolution of 20000 step/rev, which is the default setting. Simply set the encoder ratio (ER software command) at 5.

The U.S. Digital E2-500 series is also popular and provides 2000 counts/rev. For the E2-500, set ER at 10.

The sketches on the right show proper wiring for single ended and differential encoders. Built-in "pull up" resistors are provided for "open collector" encoder outputs. A +5VDC output is provided for powering the encoder. 100 mA is available.

The schematic diagram of the encoder input circuitry is shown at the right.

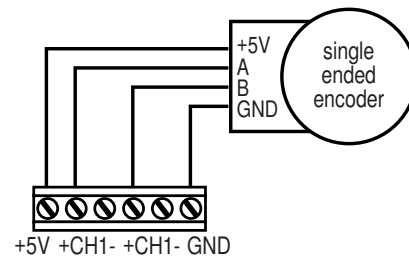
## Testing the Encoder

In the diagram above, we suggested that you connect the encoder A channel to the drive's CH1 input, and the encoder B channel to CH2. However, depending on how your motor is wired, this might cause the encoder to count in the opposite direction as the motor. That's bad, because encoder position tracking depends on the encoder counting up when the motor does.

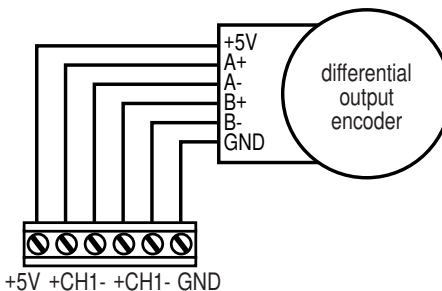
The best way to test the encoder is:

1. Wire the motor, encoder, power supply, and PC. Connect only one drive for this test. (It makes no sense to wire the others now, as we aren't certain about the encoder connections yet.)
2. Power up the computer and the drive.
3. Launch the SiNet™ Setup software.
4. Type "EP" then press enter. The drive will respond with "EP=" and some number, near 0. That's your power on encoder position, in encoder counts.
5. If EP is not 0, type EP0 to make it so.
6. Type "SP" then press enter. The drive will send "SP=0". The motor position is 0 steps.
7. Type FL. The motor will move one revolution in the positive direction.
8. Type SP. The new motor position should be "SP=20000". You've moved 20000 steps, the power on default distance.
9. Type EP. The drive will tell you the new encoder position. If that position is negative, you must power down the drive and switch the encoder A and B wires. (On a differential output encoder, swap A+ for B+ and A- for B-.)
10. Power up and try again.
11. Once you've gotten the encoder counting in the right direction, you'll need to set the encoder ratio (ER). ER is the ratio of encoder counts to motor counts. If, after step 9, you got SP=20000 and EP=4000, the ratio is 5. Type ER5.

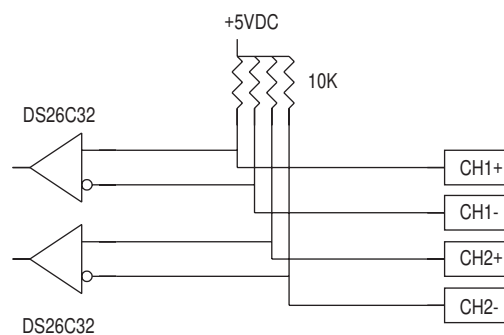
Note: the drive does not "remember" the ER setting when power is removed. You'll need to reset this parameter each time power is applied to the drive. This is true of nearly all SiNet™ Command Language parameters. The only parameters that can be committed to nonvolatile memory are power on current (PC), power up mode (PM) and RS485 address (DA).



Connecting a Single Ended Encoder



Connecting a Differential Encoder



Encoder Board Schematic