![Control Technology Corporation logo]

Model 2654 MultiPro™ 32 I/O Quad Stepper Installation Guide
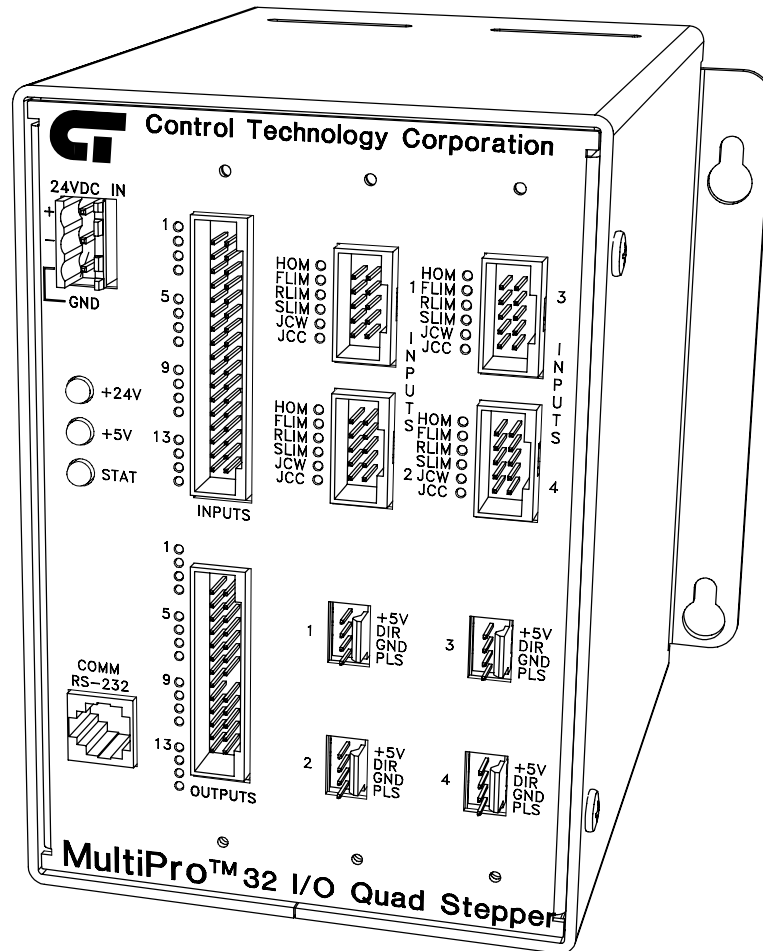
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Contents

2 Stepper Application Notes

3 Special Registers

Notes to Readers

The *Model 2654 Installation Guide* provides the following information:

- Dimensions and Mounting Considerations -- mounting dimensions and precautions on mounting the MultiPro.

- Description and Connection Diagrams -- an overview of the MultiPro's basic functions; pinout diagrams for all connectors.

- Specifications -- general, stepper, and digital I/O specifications; hardware and firmware revisions for the 2654 controller.

- Power Connections -- connecting power to the MultiPro.

- Status Lights -- how the status light functions.

- I/O Connections -- connecting digital inputs and outputs; connecting dedicated inputs.

- Controller Communications -- describes the controller's RS-232 port and its function.

- Stepper Application Notes -- programming a stepper, hardware considerations, and sample Quickstep programs.

- Special Purpose Registers -- how to use the special purpose registers.

Related Documents

The following documents contain additional information:

- For information on Quickstep, refer to the *Quickstep™ Language and Programming Guide* or the *Quickstep™ User Guide.*

- For information on the registers in your controller, refer to the *Register Reference Guide* (available at www.ctc-control.com).

- For information on Microsoft Windows or your PC, refer to the manuals provided by the vendor.

Formatting Conventions

The following conventions are used in this book:

ALL CAPS BOLDFACE	Identifies DOS, Windows, and installation program names.
Boldface	Indicates information you must enter, an action you must perform, or a selection you can make on a dialog box or menu.
Italics	Indicates a word requiring an appropriate substitution. For example, replace *filename* with an actual file name.
Text_Connected_With_Underlines	Indicates symbolic names used in Quickstep programs. Step Names are ALL_CAPITALS. Other symbolic names can be Initial_Capitals or lower_case.
SMALL CAPS	Identifies the name of Quickstep instructions in text.
Courier font	Identifies step names, comments, output changes, and Quickstep instructions appearing in the Quickstep editor.
Art Code 2217F1	Identifies the file name of a particular graphic image.

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Getting Started

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Dimensions and Mounting Considerations

All MultiPro controllers have mounting ears that allow easy mounting to flat surfaces such as a NEMA-rated electrical enclosure. Figure 1–1 provides mounting ear details and MultiPro dimensions.

Select a mounting location that protects against the environmental hazards listed below:

- Avoid flying metal chips that may result from installation or subsequent machine construction. You should also avoid conductive dusts, liquids, or condensing humidity. If any of these conditions exist, mount the MultiPro in a NEMA 4 or NEMA 12 rated enclosure.

- Do not mount the MultiPro in an environment that requires explosion proof practices.

- Avoid mounting locations that are in close proximity to devices that produce electro-magnetic interference (EMI) or radio frequency interference (RFI). Devices such as motor starters, relays, large power transformers, and ultrasonic welding apparatus fall into this category.

Figure 1–1. MultiPro Dimensions and Mounting Ear Details
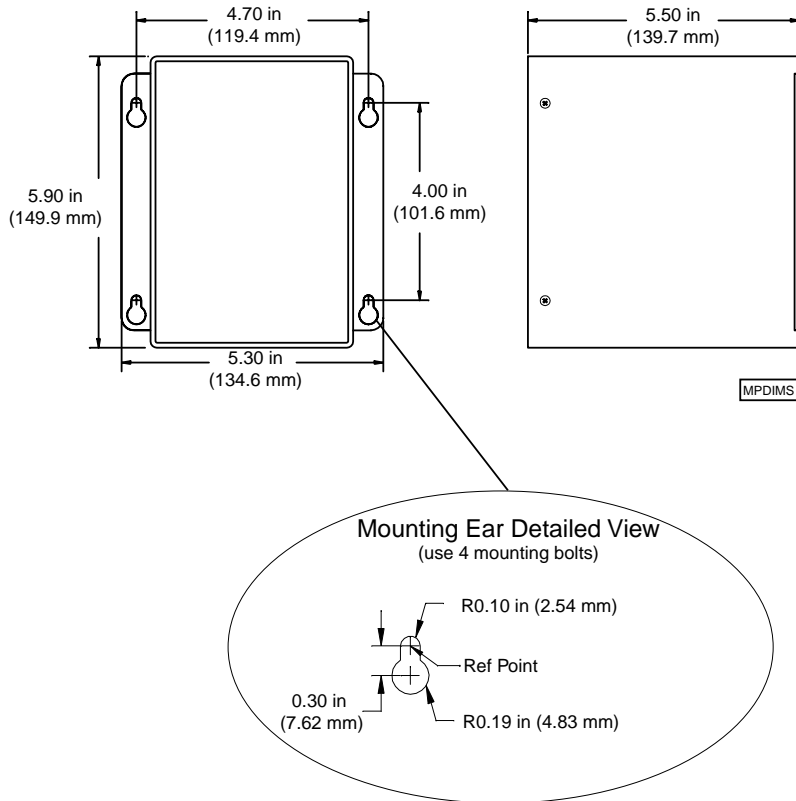
2654 Description

Figure 1–1 shows the 2654's faceplate and describes its different features.

Figure 1–1. 2654 Faceplate and Features

Power Connector - Provides 24 VDC to the controller.

Digital Input Connector - Provides access to inputs 1 - 16.

Power Indicators - Light when the power is on and indicate that the logic supply is present.

Status Light - Indicates software or hardware faults. Refer to **Status Light Description** for more information.

LED Indicators - Each digital input and output has an LED indicator. An LED indicator lights up when its associated input or output is active.

Dual RS-232 Port - Provides both programming and data communications with a PC using Quickstep and CTCMON. You can convert the port into a dual RS-232 port with the Model 2886 duplex adapter. Refer to **Computer - Controller Connections** for more information.

Dedicated Input Connector - Provides access to the stepper dedicated inputs.

External Drive Connector - Provides pulse and direction signals to the stepping motor drive.

Digital Output Connector - Provides access to outputs 1 - 16

2654F1

Connectors and Pinout Diagrams

Table 1–1. Connection Diagram - Digital Input Connector
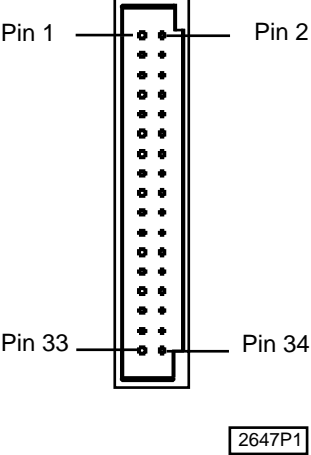
Digital Input Connector	Pin #	Signal	Pin #	Signal
Pin 1 ... Pin 2 Pin 33 ... Pin 34 2647P1	1	Input 1	2	Return
	3	Input 2	4	Return
	5	Input 3	6	Return
	7	Input 4	8	Return
	9	Input 5	10	Return
	11	Input 6	12	Return
	13	Input 7	14	Return
	15	Input 8	16	Return
	17	Input 9	18	Return
	19	Input 10	20	Return
	21	Input 11	22	Return
	23	Input 12	24	Return
	25	Input 13	26	Return
	27	Input 14	28	Return
	29	Input 15	30	Return
	31	Input 16	32	Return
	33	+24 VDC	34	Return

Table 1–2. Connection Diagram - Digital Output Connector
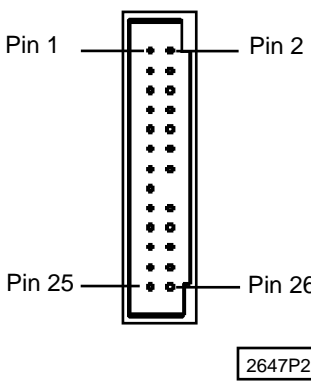
Digital Output Connector	Pin #	Signal	Pin #	Signal
Pin 1 ... Pin 2 Pin 25 ... Pin 26 2647P2	1	Output 1	2	Output 14
	3	Output 2	4	Output 15
	5	Output 3	6	Output 16
	7	Output 4	8	Return
	9	Output 5	10	Return
	11	Output 6	12	Return
	13	Output 7	14	Return
	15	Output 8	16	No pin
	17	Output 9	18	+24 VDC
	19	Output 10	20	+24 VDC
	21	Output 11	22	+24 VDC
	23	Output 12	24	+24 VDC
	25	Output 13	26	NC

Table 1–3. Connection Diagram - External Drive Connector
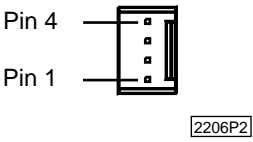
External Drive Connector	Pin #	Signal
	4	+5 VDC
	3	Direction
	2	Return
	1	Pulse

Pin 4, Pin 1, 2206P2

Table 1–4. Connection Diagram - Dedicated Input Connector
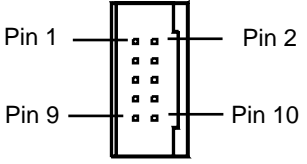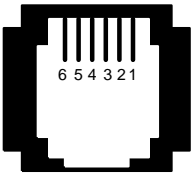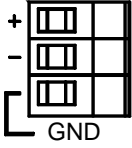
Dedicated Input Connector	Pin #	Signal
	1	Home
	2	Forward Limit
	3	Reverse Limit
	4	Soft Limit
	5	Jog CW
	6	Jog CCW
	7	+24 V Return
	8	+24 V Return
	9	+24 VDC
	10	+24 VDC

Pin 1, Pin 2, Pin 9, Pin 10, 2206P1

Table 1–5. Connection Diagram - RS-232 Connector

RS-232 Connector [1]	Pin #	Signal
	1	TxD Outbound 2
	2	TxD Outbound 1
6 5 4 3 2 1	3	Common
	4	Common
RS232	5	RxD Inbound 1
	6	RxD Inbound 2

1. The Model 2886 duplex adapter provides convenient access to both RS-232 ports. Refer to the *RS-232 Connections (Dual Ports)* section for more information.

Table 1–6. Connection Diagram - Power Connector

Power Connector	Pin #	Signal
	1	+24 VDC
+	2	+24 V Return
–	3	Ground
GND		
2647P3		

Specifications

Table 1–7. General Specifications

Description	Min.	Typical	Max.	Units
Absolute Maximum Ratings				
Ambient Temperature				
Operating	0		+50	°C
Storage	-20		+80	°C
Controller Characteristics				
Voltage range	22.0	24.0	27.0	VDC
Current requirements at 24 VDC		.4	.6	A
User memory capacity (11 year lithium-cell RAM)		32K		Bytes
The main CPU is an Hitachi SH2 processor running at 24.576 MHz.				
Controller Performance Specifications [1]				
Controller CPU clock speed		24.576		MHz
Stepper CPU clock speed		12		MHz
Sense input, jump to new step, change output		0.5		ms
Perform multiplication (between volatile registers)		0.3		ms
Time delay duration, 10 ms programmed		10.08		ms
Time delay duration, 1 s programmed		1.001		s
Internal count rate		750		Hz
Communications Characteristics				
RS-232 transmitters		± 9	± 12	VDC
RS-232 receivers	± 3		± 12	VDC
Controller Resource Summary				
Multi-tasking (tasks)			56	
Volatile registers (32-bit)			490	
Non-volatile registers (32-bit)			500	
Data table elements (16-bit, non-volatile)			8000	
Input-linkable counters			16	
Flags			32	
Program steps			1280	

1. Performance specifications shown are with one task running. RS-232 communications may degrade the count by up to 10%.
2. Specifications are at 25°C unless otherwise specified.

Table 1–8. Stepper Specifications

Description	Min.	Typical	Max.	Units
Absolute Maximum Ratings				
Current draw from +5 VDC power supply on stepper command connector [1]			96	mA DC
Electrical Specifications				
Pulse and directional output				
Low V_{OL} (I_{OL} = 24 mA)	.36		.44	VDC
High V_{OH} (I_{OH} = 24 mA)	4.44		5.25	VDC
Pulse width (jumper-configurable)				
for microstepping motor drives		1.3		ms
for half-step and full-step motor drives		34		ms
Axis control inputs				
Off voltage (I_i = 0 mA) [2]		24.0	26.4	VDC
On current (V_i = 0 V)		2.1	2.5	mA
Threshold				
Low-to-high		8.5		VDC
High-to-low		7.5		VDC
Performance Specifications				
Maximum velocity setting	1		250,000	steps/s
Resolution of maximum velocity setting		3.9		steps/s
Acceleration and deceleration settings	1		130,000,000	steps/s^2
Resolution of acceleration and deceleration settings		15.3		steps/s^2
Position range	-2,147,483,648		2,147,483,647	steps
Relative motion command range	-2,147,483,648		2,147,483,647	steps

1. This is powered by the controller's 24 V supply.
2. This value is dependent on the controller's auxiliary supply voltage (24 V is typical).
3. Specifications are at 25°C unless otherwise specified.

Table 1–9. Digital I/O Specifications

Description	Min.	Typical	Max.	Units
Absolute Maximum Ratings				
Applied input voltage [1]	0		27.0	VDC
Applied output voltage [2]	0		24.0	VDC
Output current				
Single output			500	mA DC
Total limit			5	A
Operating Characteristics				
Output on voltage (I_o = 500 mA)		0.8	1.8	VDC
Output off leakage (applied voltage = 24V) [3]		0.01	0.75	µA
Input off voltage (I_i = 0 mA)		24.0	26.4	VDC
Input on current (V_i = 0 V)		-2.10	-2.85	mA
Input on current threshold (V_i = 8 V typical)		-1.0	-1.85	mA
Input off current (typical leakage current allowable)			-250	µA

1. Under normal operation, no external input voltage is applied. Inputs should be externally switched to the input common.
2. An on-board protection diode returns to +24 V from each output.
3. In the off state, unconnected outputs are internally pulled to +5 V through a diode and an LED indicator.
4. Specifications are at 25°C unless otherwise specified.

Table 1–10. Hardware / Firmware Revision Levels

Model Numbers	Hardware Revision Level	Firmware Revision Level [1,2]
All	0	2.18

1. You can confirm firmware revision levels by doing a register read in Quickstep's monitor program. Use register 13003 to confirm the firmware revision in a MultiPro controller.
2. Firmware revision levels are not equivalent to standard decimal numbers. For example, firmware revision level 2.10 translates to:

    Major Revision Level 2
    Minor Revision Level 10

    If this value changes to 2.20, it translates to:

    Major Revision Level 2
   Minor Revision Level 20 (not revision level 2)

Power Connections

This section describes how to connect power to the MultiPro.

Connecting DC Power

The MultiPro requires an externally supplied voltage of +24 VDC for proper operation (Figure 1–2). Power is connected through the connector located on top of the MultiPro.

+24 VDC supplies power to all the I/O circuitry and also to a DC/DC converter. This conversion circuit creates an isolated +5 VDC supply that provides power to the MultiPro's logic circuitry.

Figure 1–2. 24 Volt Power Supply
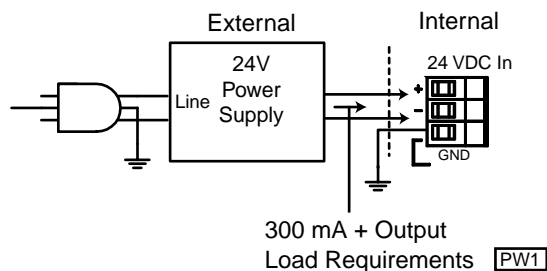
The Importance of Proper Grounding

The MultiPro's ground should follow a direct, low-impedance path to the plant's power source that is not shared by any machinery that injects a large amount of electrical noise onto the line.

◆ **Note**

For more information on noise protection, refer to CTC Technical Note No. 26, *Reducing Noise Susceptibility.* This document is available in the Customer Support area of our Web site at www.ctc-control.com.

Status Light Description

The status light (STAT) is located on the MultiPro's front left panel and is used to indicate a software or hardware fault. These faults are described below.

◆ **Note**

After the MultiPro is turned ON, the light is steady and red during the first second of operation.

Software Fault

Quickstep programs may produce software faults that are indicated by a periodic flashing light. These faults occur when the MultiPro is unable to execute because an application problem exists within the Quickstep program. You can view the fault type by viewing the program status in Quickstep's monitoring utility, CTCMon. Once a software fault occurs, the MultiPro is idle and all resources that can be set (outputs, etc.) remain in the state they were in before the fault occurred.

◆ **Note**

You can program register 13009 to turn off a specific output when a software fault occurs. Refer to the *Quick Reference Register Guide* at www.ctc-control.com for more information.

Hardware Fault

Hardware faults are displayed as a steady red light and indicate that the internal watchdog timer has disabled the MultiPro's CPU. When this occurs, the MultiPro's outputs are also disabled.

Try clearing a hardware fault by cycling the power and/or downloading the same Quickstep program. If the fault doesn't clear, your MultiPro controller may require repair. Contact our Technical Support representative for assistance.

Connecting Digital Inputs

This section describes the digital inputs and how to connect devices to these inputs.

Activating a Digital Input

The Model 2654 has 16 digital inputs that you can activate with a switch closure (Figure 1–3) to **Return**, which is the common for the controller's 24 V supply. Each input is opto-isolated from the MultiPro's logic circuitry and is internally self-powered by the 24 V supply through a current-limiting resistor.

Figure 1–3. Digital Input Activation
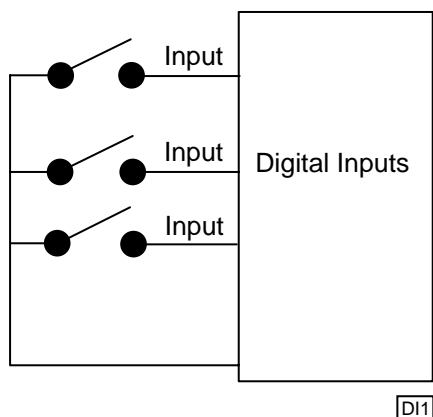
The MultiPro senses when an input is pulled down to **Return** by a switch closure. A MONITOR instruction or any other programmed instruction referring to a general purpose input can use this information.

Using Solid-State Sensors

You can connect many types of electronic sensors such as three-wire Hall-effect sensors, proximity sensors, and phototransistors to the inputs without any additional circuitry. These devices must have sinking type open-collector outputs (NPN) and must be able to withstand at least +24 V on their output terminals when they are in the OFF state. The sensor must also be able to sink the required input current (i.e.- 2.1 mA) when ON.
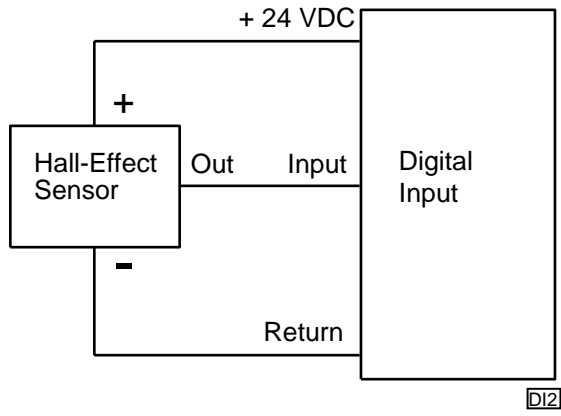
◆ **Note**

Do not use two-wire, solid-state sensors.

Electronic sensors have internal circuitry that generally requires an external power source. Figure 1–4 shows how to connect a solid-state sensor.

Figure 1–4. Connecting a Solid-State Sensor to a Digital Input

Connecting Digital Outputs

This section describes the digital outputs and how to connect devices to these inputs.

Using Open-Collector Outputs

The Model 2654 has 16 outputs for driving external loads such as solenoid valves, indicators, solid-state relays and other low-power DC loads. These outputs are configured as open-collector transistors that can switch loads up to 0.5 Amps DC. Open-collector outputs are transistors whose collector terminal is left unconnected to allow greater flexibility in its use.

An open-collector output, which is shown in Figure 1–5, performs roughly the same function as a switch contact with one side of the switch connected to ground. When the output is turned OFF, no current can flow through the transistor. This is equivalent to an open switch contact because the device being controlled is turned OFF.

Figure 1–5. Open-Collector Output
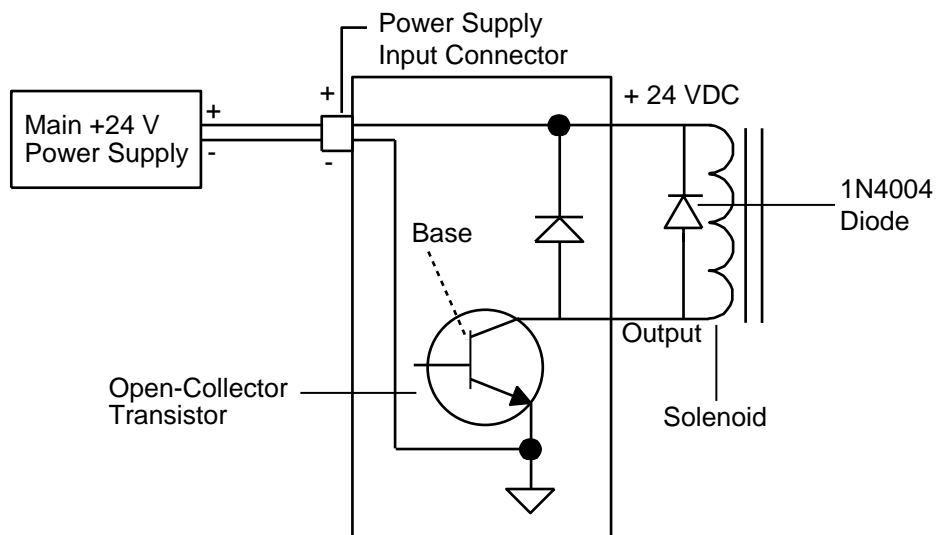
When the output is turned on, current flows through the transistor, which is equivalent to a closed switch contact. The controlled device turns on in response to the flow of current.

Connect a device to an open-collector output by connecting one of the device's terminals to the output and the other terminal to the positive side of the power supply. If the device is polarized, connect its negative [-] terminal to the output.

◆ **Note**

Control Tech recommends that you place a suppression diode across inductive loads. Use a 1N4004 diode or its equivalent. Locate the diode as close to the load as possible. Refer to Figure 1–5 for more information.

⚠️ **Caution**

Do not exceed the rated current of the power supply in use. When you calculate your system's current requirements, you need to consider the maximum number of output devices that will be turned on simultaneously. Include 0.45 A for the MultiPro in your calculation.

Connecting Multiple Devices

It is possible to supply power to multiple devices from the same power source. One lead of each device is attached to an independent output and the other lead is connected to the positive [+] terminal of the power source. Figure 1–6 shows four solenoid valves that are controlled by Outputs 1-4. Power is supplied to each output from the MultiPro's power supply.

Figure 1–6. Multiple Device Connection Diagram
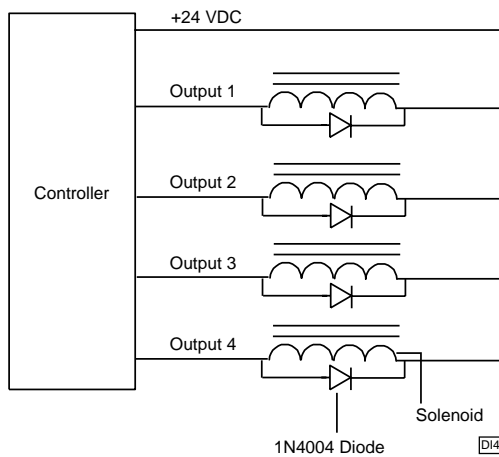
Connecting to a Second External Supply

Multiple devices can also derive their power source from a secondary external power supply. Some devices use this external supply while others use the controller's power supply. If you use this option, connect each device to the positive [+] terminal of the appropriate power supply. Figure 1–7 illustrates this setup.

◆ **Note**

If you decide to use an external power supply, do not tie the positive terminals of the two supplies together by direct means or indirect means.

Figure 1–7. External Power Supply Connection Diagram
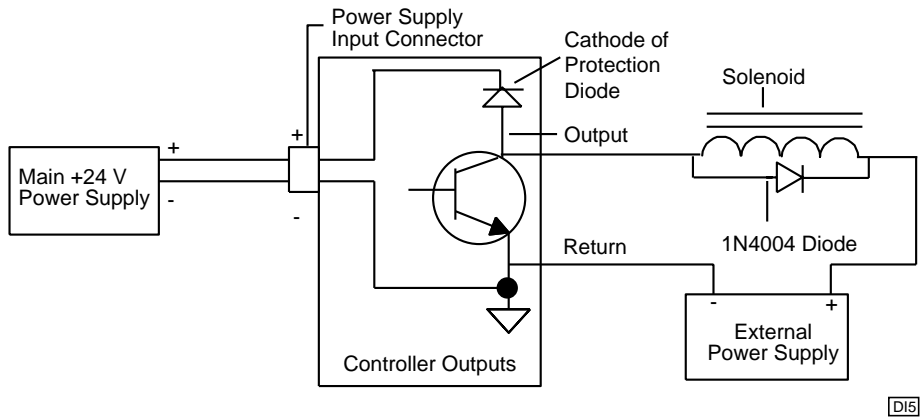
⚠ Caution

Each output has a protection diode with its cathode connected to the +24 VDC power supply through the input connector. This diode prevents damage to the output when it is connected to an inductive load. If you use an external supply as shown in Figure 1–7, a current path exists between the two supplies through the devices being controlled. Under normal circumstances, this practice is acceptable. However, some power supplies offer low impedance with respect to the power supply return when you turn them OFF. For example, in Figure 1–7, the main supply is turned OFF and the external supply is ON. Current from the external supply can energize the device connected to the output and turn it ON. To prevent this situation, make sure that both supplies are turned ON and OFF at the same time. Refer to Figure 1–8 for an alternative way to connect an external power supply.

Figure 1–8. Alternative Wiring Diagram for an External Power Supply

21
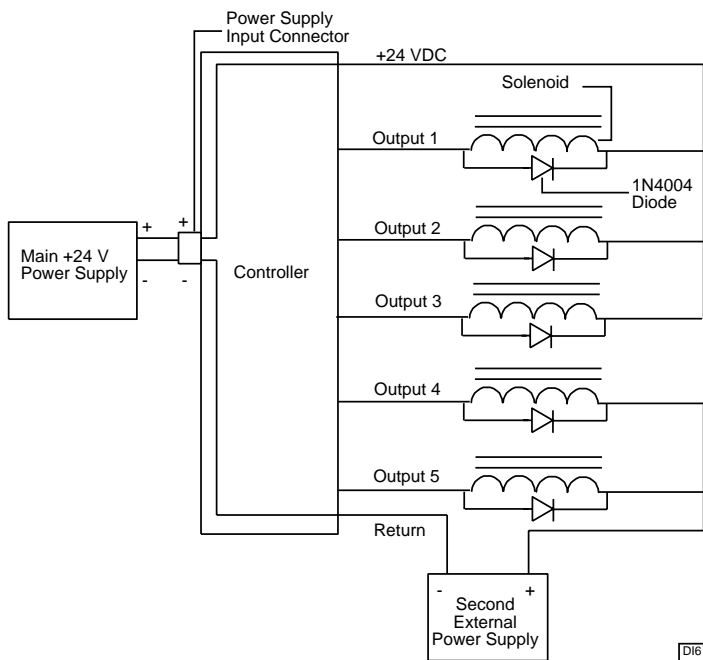
Note

Do not use an external power supply with an output voltage that exceeds the voltage rating of the MultiPro's outputs.

Caution

Do not connect the positive [+] terminals of the power supplies together! Damage to one of the supplies may result. Figure 1–8 shows the connection between the external supply's negative terminal and the output connector's return terminal. This provides a complete path for the current traveling through the device being controlled.

Connecting Dedicated Inputs

The MultiPro has six dedicated inputs that you can activate with a switch closure to **Return**, which is the common for the MultiPro's 24 V supply. Each input is opto-isolated from the MultiPro's logic circuitry and is internally self-powered by the 24 V supply through a current-limiting resistor. Figure 1–9 shows the switch closure for the dedicated inputs.

Figure 1–9. Dedicated Input Switch Closure
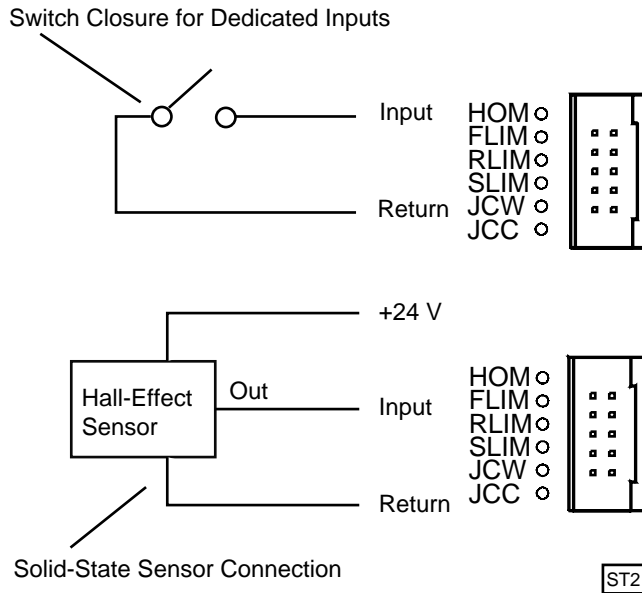
Using Solid-State Sensors

You can connect many types of electronic sensors such as three-wire Hall-effect sensors, proximity sensors, and phototransistors to the inputs without any additional circuitry. These devices must have sinking type open-collector outputs (NPN) and must be able to withstand at least +24 V on their output terminals when they are in the OFF state. The sensor must also be able to sink the required input current (i.e.- 2.1 mA) when ON.

Note

Do not use two-wire, solid-state sensors.

If the sensor requires a voltage that equals the MultiPro's built-in auxiliary voltage (24 V), the MultiPro can supply this voltage directly without requiring an additional external power supply.

Computer - Controller Connections

The MultiPro's RS-232 port provides a way to download Quickstep programs and also supports data communications. You can add a second RS-232 port with an optional duplex adapter. Refer to *RS-232 Connections (Dual Ports)* for more information.

RS-232 Protocols

Built-in protocols allow the following activities:

- **Direct communications between a PC and the MultiPro's RS-232 port** - This feature enables you to directly interact with all the MultiPro's resources such as registers, inputs, outputs, and flags without modifying the MultiPro's program.

- **Monitoring** - You can monitor a controller's activity through an RS-232 port with CTCMON.

◆ Note

The protocols mentioned above are described in the *CTC 32-Bit Data Communications Functions Reference Guide,* which is available in the Customer Support area of our web site at www.ctc-control.com.

RS-232 Connections (Single Port)

Connect to the RS-232 port through the modular jack (labeled COMM) on the MultiPro's front panel. This jack carries the receive and transmit signals and two commons (ground). Refer to Table 1–5 on page 11 for connection information on this jack.

Standard Control Technology cables are available for connecting to this jack (Figure 1–10). As an alternative, many commonly available telephone cables may be substituted.

Figure 1–10. Communication Cables and Connectors

Personal Computer with RS-232 Asynchronous Communications Board

Communications Cables:

Model 2881 - 7 feet
Model 2882 - 15 feet
Model 2883 - 25 feet

RS-232 Port

D-Connector to Modular Jack Adapter:

Model 2880A for DB25 connectors
Model 2880B for DB9 connectors

2654COM
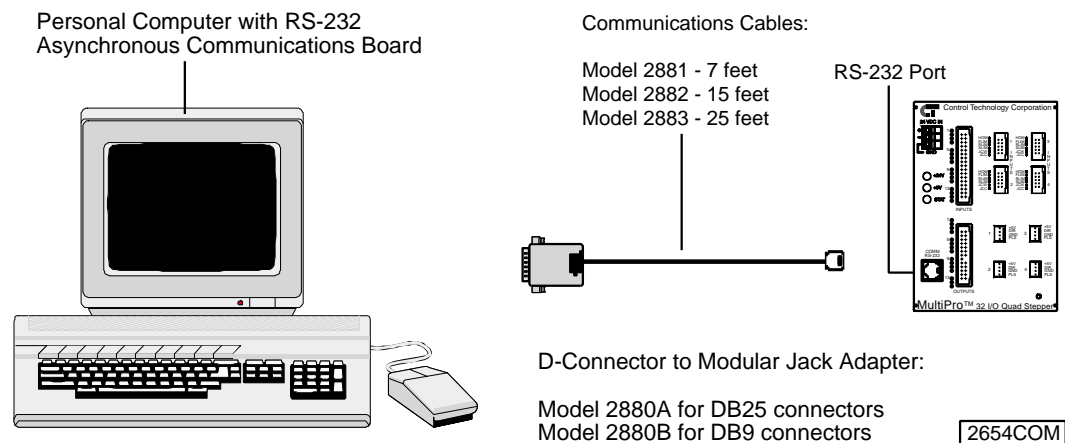
RS-232 Connections (Dual Ports)

The MultiPro can operate with dual RS-232 ports by adding the Model 2886 duplex adapter. Connect through one of the adapter's modular jacks (labeled COMM1 and COMM0). These jacks carry receive and transmit signals for both ports as well as two commons (ground). Refer to Table 1–5 on page 11 for connection information on these jacks. Figure 1–11 shows the adapter's dimensions, its wiring diagram, and how it interfaces with the MultiPro.

Figure 1–11. Model 2886 Adapter
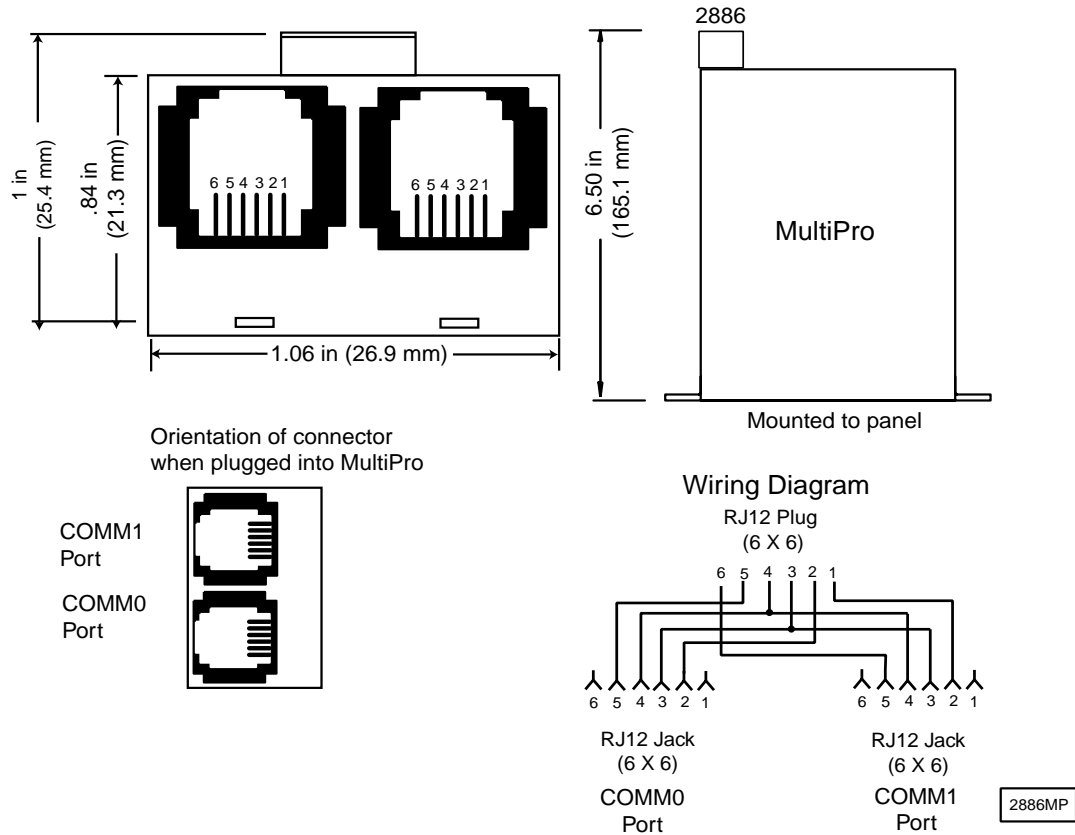
Connecting to a D Connector

RS-232 ports on computers are usually configured through 25-pin (DB25) or 9-pin (DB9) D-type connectors. Most PC manufacturers use standard wiring on these connector types. Control Technology has adapters available that connect directly to a male DB25 (Model 2880A) or DB9 (Model 2880B) connector. These adapters have a modular jack that is wired for compatibility with the COMM port. To ensure full compatibility with these adapters, you should wire the computer's communications port as a DTE (Data Terminating Equipment) device.

◆ Note

Do not connect the MultiPro to a telephone line.

Figures 1–12 and 1–13 show computer-controller connections using an RS-232 connection and DB25 and DB9 connectors.

Figure 1–12. DB9 Connections
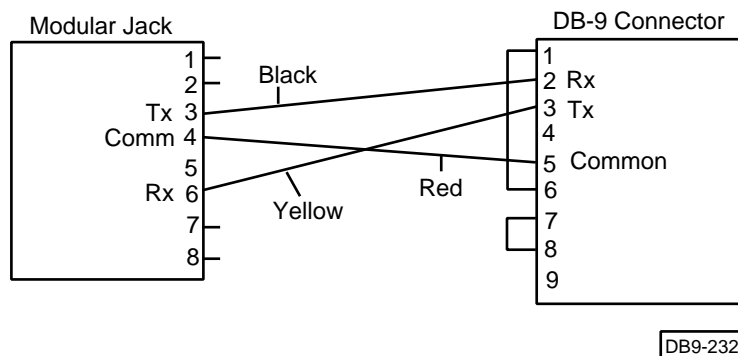
Figure 1–13. DB25 Connections

Stepper Application Notes
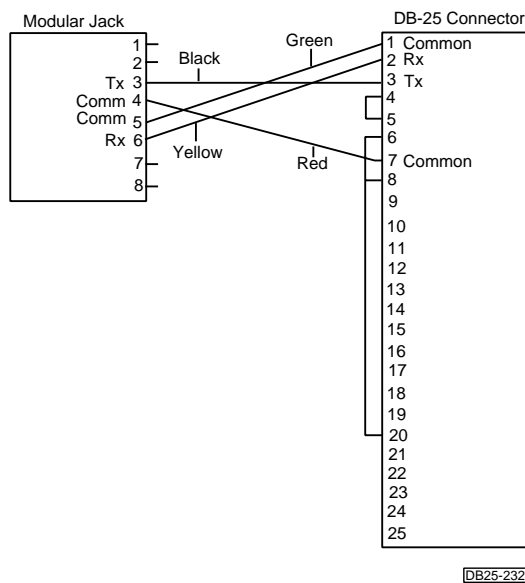
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Programming a Stepping Motor

This section describes how to program your MultiPro. When you program a stepping motor, use the following Quickstep servo instructions:

- Profile Servo

- Turn Servo

- Monitor Servo

- Zero Servo

- Search and Zero Servo

- Stop Servo

- If Servo

- Store Servo

Note

The registers mentioned in this chapter only apply to Axis 1. Refer to *Chapter 3, Special Registers*, for more information on other special registers.

Setting Up Stepping Motor Operating Parameters

The MultiPro must have a set of operating parameters before it can turn a stepping motor. You must specify these parameters with the PROFILE SERVO instruction. The stepping motor operating parameters are as follows:

- **Max Speed** — Establishes the maximum speed of the motor.

- **Accel** — Specifies the acceleration rate of the motor. The deceleration rate is the same as the acceleration rate. Refer to *Setting Acceleration and Deceleration Values* for information on setting a different deceleration rate.

◆ **Notes**

1. The **Max Speed** and **Accel** parameters are the only PROFILE SERVO parameters that work with your MultiPro. The controller ignores the other parameters.

2. The maximum speed is expressed in units of steps-per-second (steps/s). The programmed maximum speed has a resolution of 1 step/s. Acceleration and deceleration are expressed in units of steps-per-second-per-second (steps/s^2) with a granularity of 1 step/s^2.

3. The PROFILE SERVO instruction must appear before the first TURN SERVO instruction in your Quickstep program. If it is not executed before the first TURN SERVO instruction, a software fault stating, "Servo not ready," results. Additional PROFILE SERVO instructions are only necessary when you want to change the motor's operating parameters.

4. Re-profiling on-the-fly, which allows the stepping motor to take on new settings during a motor motion, is possible. To re-profile the motor, program another PROFILE SERVO instruction with a new maximum speed or acceleration value. You do not have to re-specify a value that does not change.

5. Adjustments to the ramping (acceleration and deceleration) parameters while the motor is accelerating or decelerating causes an instantaneous change in the ramp that may be undesirable. To avoid this, make changes to the ramping parameters when the motor is stopped or is turning at maximum speed. You can view the status of the motor by checking the appropriate special registers. For example, check register number 14301 for the current status of the first motor. Refer to *Chapter 3, Special Registers*, for more information.

Setting Acceleration and Deceleration Values

The PROFILE SERVO instruction acceleration parameter sets both the acceleration and deceleration values. If you want the acceleration and deceleration values to be different, use one of the group or individual access special purpose registers to set a different deceleration value. For example:

```
profile axis_1 max=50000 accel=100000
store 20000 to reg_15006 (axis No. 1 deceleration register)
```

sets the acceleration equal to 100,000 steps/s^2 and the deceleration equal to 20,000 steps/s^2. Refer to *Chapter 3, Special Registers*, for the appropriate register number for each axis.

◆ **Note**

If you specify a new acceleration rate, it overwrites the existing deceleration rate stored in Register 15006. Therefore, you must specify a new deceleration rate.

Searching for Home

Each stepping motor axis has a dedicated home input. This input is used in conjunction with the SEARCH AND ZERO instruction to set a zero or home position for the axis. This instruction starts the motor turning at the speed and acceleration specified in the PROFILE SERVO instruction. The motor turns counterclockwise if the home input's contacts are open and continues to turn in this direction until the contacts close (change state). Conversely, the motor turns clockwise if the home input's contacts are closed and continues to turn in this direction until the contacts open (change state). In either case, the home input is checked every millisecond, which offers very good repeatability. Once the MultiPro senses a contact transition on its home limit switch input (dedicated input), the motor then stops and the current position is set to zero.

Notes

1. Make sure the motor's maximum speed is low enough to stop the motor instantly. If the speed is set too high, the motor may overrun its intended position.

2. SEARCH AND ZERO SERVO the motor once at a relatively high speed to consistently put the motor in the home position. Then, SEARCH AND ZERO SERVO the motor again at a slow speed.

The following example shows how to SEARCH AND ZERO SERVO a motor:

```
[1]  COARSE_HOME
     ;;;Commence initial home sequence for motor axis 1.
     _____
          <NO CHANGE IN DIGITAL OUTPUTS>
     _____
     profile axis_1 maxspeed=2000 accel=2000
     search and zero axis_1
     monitor axis_1 stopped goto next

[2]   MOVE_OFF_HOME
    ;;;Move motor off home switch
     _____
          <NO CHANGE IN DIGITAL OUTPUTS>
     _____
     turn axis_1 cw 500 steps
     monitor axis_1 stopped goto next

[3]  FIND_HOME
    ;;;Re-profile for slower homing speed, then
    ;;;re-home motor
     _____
          <NO CHANGE IN DIGITAL OUTPUTS>
     _____
     profile axis_1 maxspeed=500 accel=500
     search and zero axis_1
     monitor axis_1 stopped goto next
```

Turning a Motor

There are three modes of turning the motor:

1. **Absolute Positioning** – In this mode, the MultiPro's stepper board always references the home (or zero) position in a turn instruction and moves a specified distance from the home position. For example, the following instruction

   ```
   turn axis_2 to 50000
   ```

   causes the motor to position itself 50,000 steps from home. The motor automatically turns in the correct direction to reach the new position.

2. **Relative Positioning** – In this mode, the direction of the turn (clockwise or counter-clockwise) is specified in the turn instruction along with a defined number of steps to turn. For example, the following instruction

   ```
   turn axis_1 cw 12340 steps
   ```

   turns the motor 12,340 steps clockwise from its current position.

3. **Velocity Control** – In this mode, you establish a direction and begin continuous operation. The maximum speed and acceleration are based on the current profile instruction and can be changed. For example, the following instruction

   ```
   turn axis_1 cw
   ```

   starts the motor turning clockwise at its current maximum speed and acceleration. The motor continues to turn until the MultiPro issues a STOP SERVO instruction or until a Limit or Stop input is activated.

Once a motor is in motion, do not initiate another turn or zero instruction until the motion is complete or the "servo not ready" software fault occurs. Use the MONITOR SERVO instruction to check the current status (running/stopped) of the motor.

The MultiPro's stepper board tracks the position of the motor with all three modes and allows you to use all three types of positioning and control in the same program.

◆ **Note**

Quickstep instructions specifying clockwise or counterclockwise operation assume that the motor is wired according to the manufacturer's recommendations and that the logical sense of the direction output of the MultiPro's stepper board agrees with the logical sense expected by the motor's drive.

Stopping the Motor

There are two instructions that terminate the motion of a motor already in motion:

- `STOP (SOFT) SERVO` causes the motor to stop at the deceleration rate specified in the last profile instruction.

- `STOP (HARD) SERVO` causes the MultiPro's stepper board to try to stop the motor instantly. However, because of momentum, the motor may not stop instantly.

In either case, you should use a `MONITOR SERVO STOPPED` instruction before issuing another turn instruction.

Monitoring and Changing Other Motor Parameters

There are various special purpose registers that allow you to monitor and change the motor parameters. For more information, refer to *Chapter 3, Special Registers*.

Using Dedicated Inputs

This section describes how to monitor and connect to dedicated inputs on the MultiPro.

Monitoring Dedicated Inputs

Registers 15007 and 15017 can return a bit pattern that indicates if any of the dedicated inputs are active. A binary representation of the dedicated input number is stored in the register. Each input has a unique binary value.

Figure 2–1 shows that the home, reverse limit, and soft stop inputs are active. Register 15007 (for axis 1) returns a value of 26 because the respective weights of the inputs are 2, 8, and 16. To test any individual input, use the bitwise AND instruction to apply a mask to the register.

Figure 2–1. Register 15007 Bit Pattern
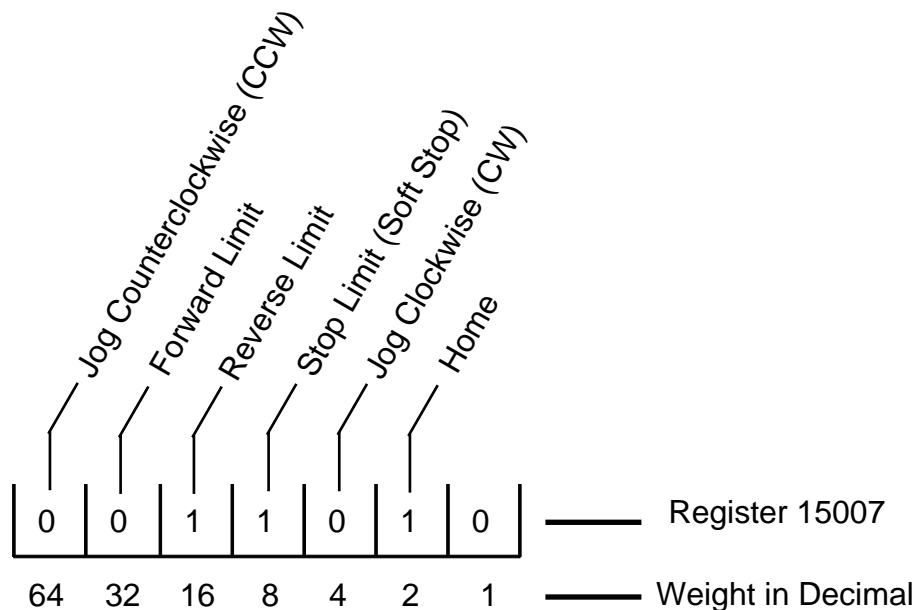
The following instruction applies a bit mask that tests to see if the Home input is active:

```
[1]   TEST_FOR_HOME_AXIS1
      ;;; Home = 2
      ───────────────────────────────────────

          <NO CHANGE IN DIGITAL OUTPUTS>

      ───────────────────────────────────────

      store reg_15007 and 2 to reg_10
      if reg_10 = 2 goto FOUND_HOME
      goto TEST_FOR_HOME_AXIS1
```

Stepper Hardware Considerations

This section discusses the MultiPro's dedicated inputs.

Dedicated Inputs

The dedicated inputs are internally pulled up to 24 VDC and are actuated by a contact closure to the 24 V Return. You can supply this closure with a mechanical switch or with certain types of solid-state, open-collector outputs. The dedicated inputs are:

- **Forward Limit –** If the motor is moving clockwise, this input disables all clockwise movement and attempts to stop the motor instantaneously. This may cause the motor to lose its home position. If this occurs, you need to re-home the motor.

- **Reverse Limit –** If the motor is moving counterclockwise, this input disables all counterclockwise movement and attempts to stop the motor instantaneously. This may cause the motor to lose its home position. If this occurs, you need to re-home the motor.

- **Soft Limit –** This input stops the motor with the deceleration rate programmed in the PROFILE SERVO instruction.

- **Jog Clockwise –** This input starts the motor turning clockwise at the acceleration rate programmed in the PROFILE SERVO instruction. The motor reaches velocity and continues to turn until this input is turned OFF. It then decelerates to a stop at the programmed deceleration rate.

- **Jog Counterclockwise –** This input starts the motor turning counterclockwise at the acceleration rate programmed in the PROFILE SERVO instruction. The motor reaches velocity and continues to turn until this input is turned OFF. The motor then decelerates to a stop at the programmed deceleration rate.

- **Home –** Refer to *Searching for Home* for more information on this input.

◆ **Notes**

1. **Start Input** *(Optional)*: If you choose the Start input option in your Quickstep program, it replaces the **Jog Clockwise** dedicated input. To use the Start dedicated input, you must program your TURN SERVO instruction with the ON START parameter. The MultiPro checks the On Start input every millisecond, which improves the repeatability of the start motion. The motion does not begin until the Start switch is activated. To choose this option, store the number 1 in register 13801 for the first axis and 13802 for the second axis. Once you store the number 1 to these registers, you do not have to store it again in your program.

2. If a motor has been stopped by any of the stop inputs listed above, the programmed instruction MONITOR SERVO STOPPED becomes true and your program proceeds to the specified step.

The dedicated inputs are not all active at the same time. The following list describes when the dedicated inputs are active and inactive.

- **Forward Limit Input** – This input is active only when the motor is moving in the clockwise direction. This allows the motor to back off of a limit switch because you can still move counterclockwise. For example, if the Forward Limit input is connected to a limit switch for a linear table and the table hits the limit switch, the table is able to move counterclockwise and return to the home position.

- **Reverse Limit Input** – This input is active only when the motor is moving in the counterclockwise direction.

- **Soft Stop Input** – This input is inactive when the motor is searching for home or when it is jogging under control of the jog inputs. It can also access the position where the input signal occurred through a special purpose register such as 13701. You can take advantage of this feature in applications where soft stop is used to synchronize a repetitive motor motion with some external event such as sensing a registration mark on a continuous web of material.

◆ Note

The soft stop input does not always stop the motor. Do not use this input with any limit switch that is designed to prevent damage to a machine.

- **Jog CW/CCW Inputs** – These inputs are only active when the motor is stopped. Once a PROFILE SERVO instruction has occurred, the motor starts turning in either a clockwise or counterclockwise direction (depending on the input).

  If both these inputs are applied simultaneously, the first one sensed by the MultiPro prevails and the other is ignored. When the jog input signal is removed, the motor decelerates to a stop at the profiled deceleration rate.

  Jog inputs are inactive in the following situations:

  – Once motion is triggered by another source, applying and/or removing a jog input has no effect.

  – Jog CW is inactive when the Forward Limit input is active. However, Jog CCW remains active.

  – Jog CCW is inactive when the Reverse Limit input is active. However, Jog CW remains active.

  – Both jog inputs are inactive when the Soft Stop input is active.

- **Home Input** – This input is only active when the MultiPro is searching for home. Otherwise, it remains inactive.

Connecting Stepper Motor Drives

Figures 2–2 through 2–5 illustrate how to connect to the following stepping motor drives:

- **Applied Motion Products (AMP)** – 235 drive series, 335 drive series, and 556 drive series stepping motors.

- **Compumotor** – OEM 350 and OEM 650 stepping motors.

- **Centent** – CNO 142 and CNO 143 stepping motors.

- **Intelligent Motion Systems (IMS)** – IM483 stepping motors.

Figure 2–2. Connecting to an Applied Motion Products Stepping Motor Drive
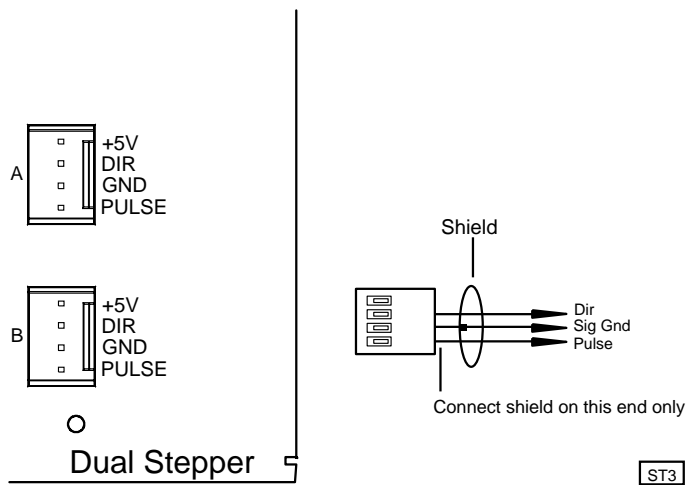
Note: The Model 2654 is a quad stepper.

Figure 2–3. Connecting to a Compumotor Stepping Motor Drive
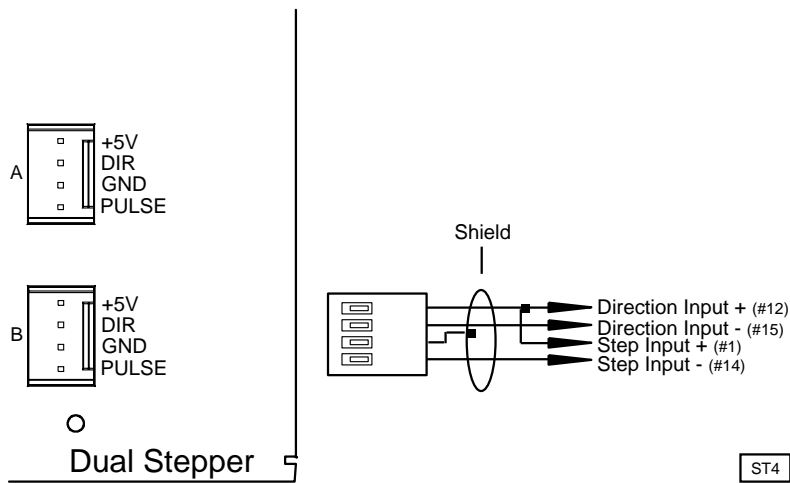
Note: The Model 2654 is a quad stepper.

Figure 2–4. Connecting to a Content Stepping Motor Drive

A +5V
   DIR
   GND
   PULSE

B +5V
   DIR
   GND
   PULSE

Shield

+ 5 V (#10)
Direction (#8)
Step Pulse (#9)

Dual Stepper

ST5
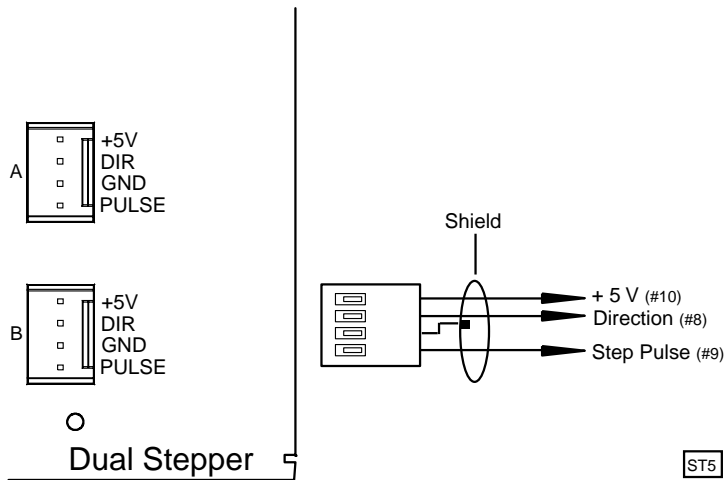
Note: The Model 2654 is a quad stepper.

Figure 2–5. Connecting to an Intelligent Motion Systems (IMS) Stepping Motor Drive

A +5V
   DIR
   GND
   PULSE

B +5V
   DIR
   GND
   PULSE

Shield

+ 5 V (#4)
Direction (#3)
Step Pulse (#2)

Dual Stepper

ST6
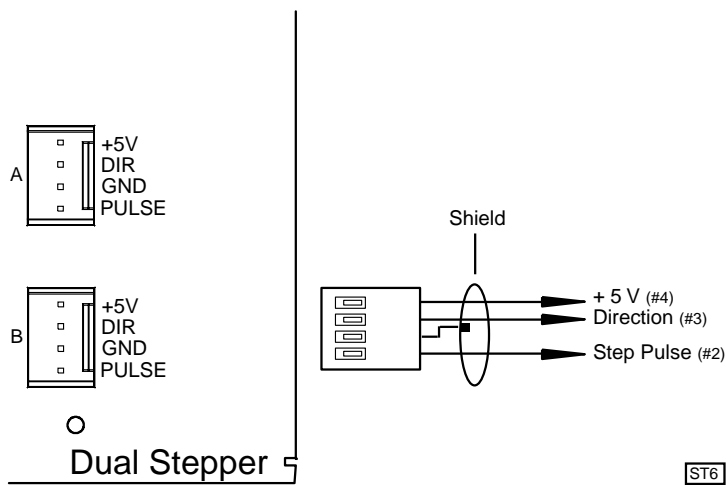
Note: The Model 2654 is a quad stepper.

Sample Quickstep Programs

This section contains sample Quickstep programs for different stepper applications.

◆ Note

Maxspeed units are in steps/s. Acceleration units are in steps/s^2.

Example 1 — Absolute Move of One Stepping Motor

This example shows a stepping motor moving 100,000 steps from its home position. The `monitor Axis_1:stopped` instruction causes the MultiPro's program to remain in this step until the motor completes the move.

```
[1] ONE_AXIS_ABSOLUTE_MOVE
    ;;; This program will commence an absolute move on axis
    ;;; one based on the parameters in the profile
    ;;; instruction.
    _____
    <NO CHANGE IN DIGITAL OUTPUTS>
    _____
    profile Axis_1 maxspeed=50000 accel=100000
    turn Axis_1 to 100000
    monitor Axis_1:stopped goto next
```

Example 2 — Relative Move of One Stepping Motor

This example shows a stepping motor moving clockwise 100,000 steps from its current position. The `monitor Axis_1:stopped` instruction causes the MultiPro's program to remain in this step until the motor completes the move.

```
[1] ONE_AXIS_RELATIVE_MOVE
    ;;; This program will commence an relative move on axis
    ;;; one based on the parameters in the profile
    ;;; instruction.
    _____
    <NO CHANGE IN DIGITAL OUTPUTS>
    _____
    profile Axis_1 maxspeed=50000 accel=100000
    turn Axis_1 cw 100000 steps
    monitor Axis_1:stopped goto next
```

Example 3 — Velocity Move of One Stepping Motor

This example shows a stepping motor moving clockwise from its current position. The motor turns until it receives a STOP SERVO instruction or until a stop input is activated. The `monitor Axis_1:stopped` instruction causes the MultiPro's program to remain in this step until the motor completes the move.

```
[1] ONE_AXIS_VELOCITY_MOVE
    ;;; This program will commence a velocity move on axis one
    ;;; based on the parameters in the profile instruction.
    _____
    <NO CHANGE IN DIGITAL OUTPUTS
    _____
    profile Axis_1 maxspeed=50000 accel=100000
    turn Axis_1 cw
    monitor Axis_1:stopped goto next
```

Example 4 — Absolute Move of Two Stepping Motors

This example shows two stepping motors. The motor connected to the first axis moves 100,000 steps from its home position and the motor connected to the second axis moves 50,000 steps from its home position. The
`monitor (and Axis_1:stopped Axis_2:stopped)`

instruction causes the MultiPro's program to remain in this step until both motors complete their moves.

Any ratio between multiple axes can be achieved by applying the following formula:

- Velocity = Acceleration * Time

- Acceleration = Velocity / Time

In this example, we are running a 2:1 ratio between the two axes. The motion on each axis will ramp up and down simultaneously.

You can re-profile either motor at any time to establish a new velocity.

If you want to start two axes simultaneously, you can program the TURN SERVO instructions using the ON START parameter. The motion of each motor will begin once the start input located on each axis is triggered. This will start all motion within one millisecond. Refer to *Dedicated Inputs* for information on using the ON START parameter and the start dedicated input.

```
[1]    TWO_AXIS_ABSOLUTE_MOVE
    ;;; This program will commence an absolute move
    ;;; on two motor axes based on the parameters in
    ;;; the profile instructions.
    _____
        <NO CHANGE IN DIGITAL OUTPUTS>
    _____
    profile Axis_1 maxspeed=50000 accel=100000
    profile Axis_2 maxspeed=25000 accel=50000
    turn Axis_1 to 100000
    turn Axis_2 to 50000
    monitor (and Axis_1:stopped Axis_2:stopped) goto next
```

Example 5 — Staggering the Motion of Two Stepping Motors

This example shows two stepping motors. The motor connected to the first axis moves 100,000 steps from its home position and the motor connected to the second axis moves 25,000 steps from its home position.

The first motor starts turning. When its position reaches half the travel distance, the program moves on to the next step and the second motor starts turning. The

```
monitor (and Axis_1:stopped Axis_2:stopped)
```

instruction causes the MultiPro's program to remain in the second step until both motors complete their moves.

Any ratio between multiple axes can be achieved by applying the following formula:

- Velocity = Acceleration * Time

- Acceleration = Velocity / Time

In this example, we are running a 2:1 ratio between the two axes. The motion on each axis will ramp up and down simultaneously.

```
[1]     TWO_AXIS_STAGGERED_MOVE
   ;;; This program will commence an absolute move
   ;;; on two motor axes based on the parameters in
   ;;; the profile instructions.
   ——————————————————————————————————
        <NO CHANGE IN DIGITAL OUTPUTS>
   ——————————————————————————————————
   profile Axis_1 maxspeed=50000 accel=100000
   profile Axis_2 maxspeed=25000 accel=50000
   turn Axis_1 to 100000
   if Axis_1:position >= 50000 goto next

[2]     TRIGGER_SECOND_AXIS
   ;;; Turn the second axis and wait for both axes
   ;;; to be complete before moving on to the next part
   ;;; of the program.
   ——————————————————————————————————
        <NO CHANGE IN DIGITAL OUTPUTS>
   ——————————————————————————————————
   turn Axis_2 to 25000
   monitor (and Axis_1:stopped Axis_2:stopped) goto next
```

Example 6 — Velocity Move of Two Stepping Motors

This example shows two stepping motors moving clockwise from their current positions. The motors will turn until they receive a STOP SERVO instruction or until a stop input is activated. The monitor (and Axis_1:stopped Axis_2:stopped) instruction causes the MultiPro's program to remain in this step until both motors complete their moves.

Any ratio between multiple axes can be achieved by applying the following formula:

- Velocity = Acceleration * Time

- Acceleration = Velocity / Time

In this example, we are running a 2:1 ratio between the two axes. The motion on each axis will ramp up and down simultaneously.

You can re-profile either motor at any time to establish a new velocity.

If you want to start two axes simultaneously, you can program the TURN SERVO instructions using the ON START parameter. The motion of each motor will begin once the start input located on each axis is triggered. This will start all motion within one millisecond. Refer to *Dedicated Inputs* for information on using the ON START parameter and the start dedicated input.

```
[1] TWO_AXIS_VELOCITY_MOVE
    ;;; This program will commence a velocity move on two motor
    ;;; axes based on the parameters in the profile instructions.
    ──────────────────────────────────────────
    <NO CHANGE IN DIGITAL OUTPUTS>
    ──────────────────────────────────────────
    profile Axis_1 maxspeed=50000 accel=100000
    profile Axis_2 maxspeed=25000 accel=50000
    turn Axis_1 cw
    turn Axis_2 cw
    monitor (and Axis_1:stopped Axis_2:stopped)
    goto next
```

Example 7 — Changing the Velocity of a Stepping Motor During Motion

This sample program positions a stepping motor and generates various velocity profiles throughout the move. After the initial parameters are set, the motor motion is started. When the position reaches 50,000 steps, the program continues to the next step. Each subsequent step changes the velocity and specifies the stepper position where the program moves to the next step.

```
[1] COMPLEX_PROFILE
    _____
    <NO CHANGE IN DIGITAL OUTPUTS>
    _____
    profile Axis_1 maxspeed=10000 accel=200000
    turn Axis_1 to 500000
    if Axis_1:position >= 50000 goto next

[2] SECOND_PROFILE
    ;;; Re-profile the motor for the a new velocity.
    _____
    <NO CHANGE IN DIGITAL OUTPUTS>
    _____
    profile Axis_1 maxspeed=20000
    if Axis_1:position >= 70000 goto next

[3] THIRD_PROFILE
     ;;; Re-profile the stepper for a new velocity.
    _____
    <NO CHANGE IN DIGITAL OUTPUTS>
    _____
    profile Axis_1 maxspeed=50000
    if Axis_1:position >= 110000 goto next

[4] FOURTH_PROFILE
    ;;; Re-profile the stepper for a new velocity.
    _____
    <NO CHANGE IN DIGITAL OUTPUTS>
    _____
    profile Axis_1 maxspeed=100000
    if Axis_1:position >= 300000 goto next

[5] FIFTH_PROFILE
    ;;; Re-profile the stepper for the next velocity.
    _____
    <NO CHANGE IN DIGITAL OUTPUTS>
    _____
    profile Axis_1 maxspeed=80000
    if Axis_1:position >= 420000 goto next

[6] SIXTH_PROFILE
    ;;; Re-profile the stepper for the final velocity and wait
    ;;; for the move to complete.
    _____
    <NO CHANGE IN DIGITAL OUTPUTS>
    _____
    profile Axis_1 maxspeed=30000
    monitor Axis_1:stopped goto PROFILE_COMPLETE
```

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Special Registers

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Special Purpose Registers for Steppers

The special registers are the same as the ones in the 2600/2700 series controllers and are set up for 4 axes of motion. For the MultiPro, use the first four registers. For example, register 14001 contains the current position of stepper axis 1, register 14002 contains the current position of stepper axis 2, and so forth.

Group access special purpose registers display the same parameters for both axes in sequence. Individual access special purpose registers display all the parameters for a single axis.

Note

R/W indicates that the MultiPro can read and write to the register.

Group Access Registers

Registers 13701 – 13704	Read-only	Soft stop position; stores the position where a soft stop input occurred.
Registers 13801 – 13804	R/W	Activates soft stop registration option.
Registers 14001 – 14004	R/W	Current position of stepping motors.
Registers 14201 – 14204	Read-only	Current velocity in steps/s.
Registers 14301 – 14304	Read-only	Status of stepping motors.

0 =	Unitialized
1 =	Stopped
2 =	Waiting for Start
3 =	Accelerating
4 =	At maximum speed
5 =	Decelerating to a new maximum speed
6 =	Decelerating to a stop
7 =	Soft stop (transition mode to initiate deceleration)

Registers 14601 – 14604	R/W	Deceleration rate in steps/s^2.

Individual Access Registers

Register 15000	R/W	Current position of stepping motors.
Register 15002	Read-only	Current velocity in steps/s.
Register 15003	Read-only	Status of stepping motors

$0 =$ Unitialized
$1 =$ Stopped
$2 =$ Waiting for Start
$3 =$ Accelerating
$4 =$ At maximum speed
$5 =$ Decelerating to a new maximum speed
$6 =$ Decelerating to a stop
$7 =$ Soft stop (transition mode to initiate deceleration)

Register 15006	R/W	Deceleration value in steps/s^2.
Register 15007	Read-only	Monitors dedicated inputs using a bit map.

Home   = 2
Jog CCW   = 4
Soft limit   = 8 (for soft stop)
Reverse limit   = 16
Forward limit   = 32
Jog CW   = 64

Note

Axis #2 functions the same as Axis #1. Registers 15010 – 15017 are used for Axis #2, Registers 15020 – 15027 are used for Axis #3, and Registers 15030 – 15037 are used for Axis #4.