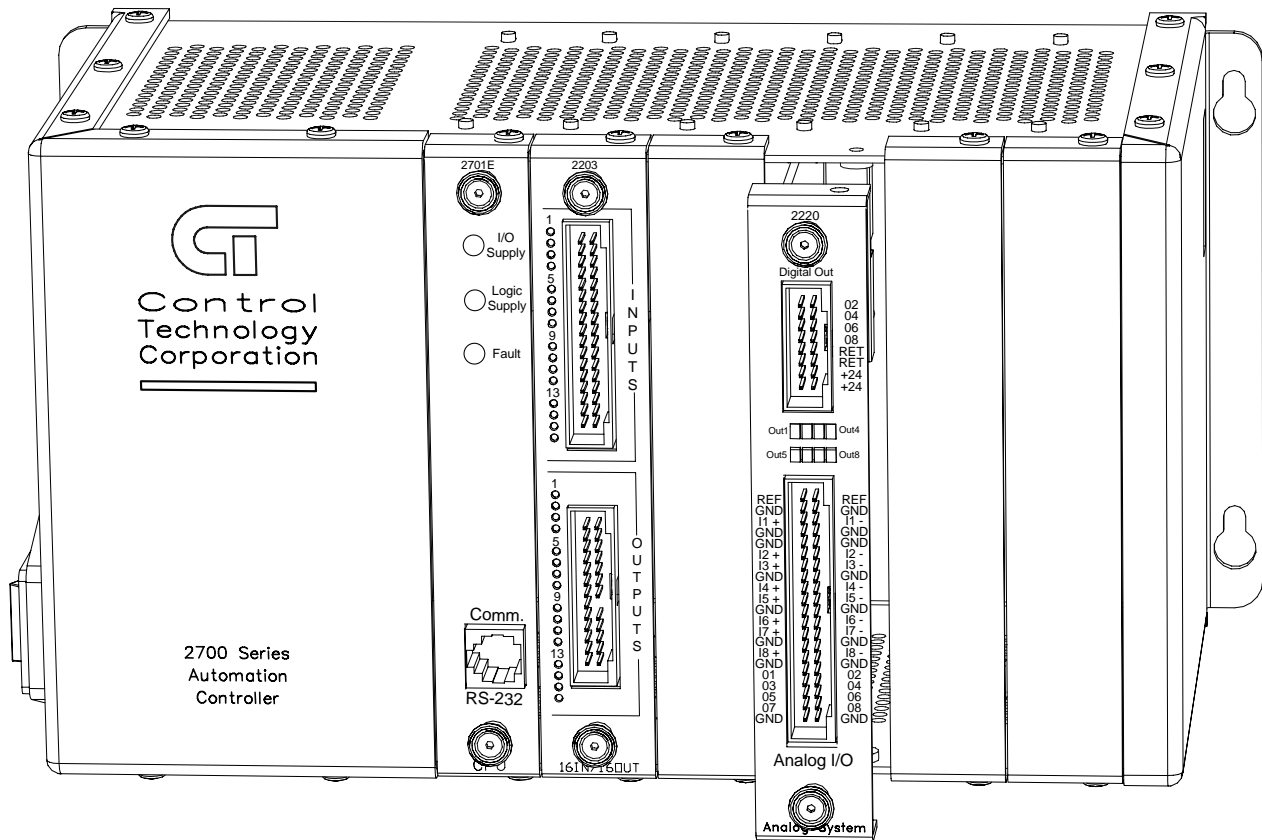




# Model 2220 Analog Input / Output Module Installation Guide



Doc. No. 2220IG  
Rev. A 02/01

---

The information in this document is subject to change without notice. The software described in this document is provided under license agreement and may be used or copied only in accordance with the terms of the license agreement.

The information, drawings, and illustrations contained herein are the property of Control Technology Corporation. No part of this manual may be reproduced or distributed by any means, electronic or mechanical, for any purpose other than the purchaser's personal use, without the express written consent of Control Technology Corporation.

The following are trademarks of Control Technology Corporation:

- Quickstep
- CTC Monitor
- CTC Utilities

MS-DOS and Windows are trademarks of Microsoft Corporation.

---

# Contents

---

<b>Notes to Readers</b> .....	<b>v</b>
<b>System Overview</b> .....	<b>7</b>
Features .....	7
Local CPU for Increased Performance .....	7
Isolation .....	7
Input Threshold Triggering .....	7
Minimum and Maximum Capture .....	7
<b>Description</b> .....	<b>8</b>
<b>Connection Diagrams</b> .....	<b>9</b>
<b>Specifications</b> .....	<b>10</b>
<b>Hardware / Firmware Revision Levels</b> .....	<b>11</b>
<b>Board Handling Precautions</b> .....	<b>12</b>
<b>Installing the 2220 Module</b> .....	<b>13</b>
<b>Connecting Digital Outputs</b> .....	<b>14</b>
Using Open-Collector Outputs .....	14
Connecting Multiple Devices .....	15
Connecting to a Second External Power Supply .....	15
Accessing Digital Outputs on a 2220 I/O Module .....	17
<b>Connecting and Programming Analog Inputs</b> .....	<b>18</b>
Connecting Analog Inputs .....	18
Connecting a Differential Signal .....	18
Connecting a Single-Ended Signal .....	18
Connecting to a Potentiometer .....	18
Specifying Digital Filter Length .....	19
Setting Up Input Thresholds .....	19
Disabling the Thresholding Feature .....	21
Alternate Access to Analog Inputs .....	21
Setting Analog Input Range .....	21
Minimum / Maximum Capture .....	22
<b>Connecting and Programming Analog Outputs</b> .....	<b>23</b>
Connecting Analog Outputs .....	23
Access to Analog Outputs .....	23

---

**This page is intentionally left blank.**

---

# Notes to Readers

---

The *Model 2220 Analog Input / Output Installation Guide* provides the following information:

- System Overview -- describes the special features of this module.
- Description and Connection Diagrams -- an overview of the 2220's basic functions; pinout diagrams for all connectors.
- Specifications -- general, analog I/O, and digital output specifications.
- Hardware/Firmware Revision Levels -- lists the hardware and firmware revisions for various 2220 modules and several CTC controllers.
- Board Handling Precautions-- contains general guidelines on handling printed circuit boards with ESD devices.
- Installing the Module-- describes how to install the module in a CTC controller.
- Connecting Digital Outputs -- provides information on open-collector outputs, connecting to multiple devices, connecting to a second external power supply, and accessing the digital outputs with registers 18001-18128.
- Connecting/Programming Analog Inputs -- describes how to connect to various types of analog devices; discusses input threshold setup and digital filter lengths; provides information on the minimum/maximum capture function.
- Connecting/Programming Analog Outputs -- describes how to connect to analog outputs and how to access the analog outputs with registers 8001-8128.

---

## 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](http://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:

---

<b>ALL CAPS BOLDFACE</b>	Identifies DOS, Windows, installation program file names.
<b>Boldface</b>	Indicates information you must enter, an action you must perform, or a selection you can make on a dialog box or menu.
<i>Italics</i>	Indicates a word requiring an appropriate substitution. For example, replace <i>filename</i> 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 names of Quickstep instructions in text.
Courier font	Identifies step names, comments, output changes, and Quickstep instructions appearing in the Quickstep editor.
Art Code 	Identifies the file name of a particular graphic image.

---

## How to Contact Control Technology Corporation

Control Technology Corporation is located in Massachusetts, and we are open from 8:30 a.m. to 5:00 p.m. eastern time. Contact us at 1-508-435-9595 and 1-800-282-5008 or FAX 1-508-435-2373.

See us on the World Wide Web at [www.ctc-control.com](http://www.ctc-control.com).

## Your Comments

We welcome your suggestions and comments about this or any other Control Tech document. Comment forms are in the file called **BUGRPT.WRI**, which was installed in the **QSWIN21** directory during your Quickstep installation. You can also email comments to [techpubs@control.com](mailto:techpubs@control.com).

# System Overview

---

## Features

The Model 2220 Analog I/O Module has 8 differential analog inputs, 8 analog outputs, and 8 digital outputs. The analog inputs are bipolar ( $\pm 10$  V) and offer 15-bit resolution. You can program each input to digitally filter the incoming signal, which provides increased stability. In addition, a maximum of 256 analog samples can be continuously averaged at an update rate of 2.083 milliseconds.

The eight bipolar analog outputs have 13-bit resolution, an output range of  $\pm 10$  V, and the ability to perform closed-loop operations for various types of control. Eight open-collector outputs are also available for driving DC loads. Each output can handle a maximum load of 0.5A and provides overcurrent and short-circuit protection.

Additional options are listed in the table below.

Model Number	Features
2220-100	0-20 mV inputs, 1 Hz filtering
2220-101	10 Hz input filtering
2220-102*	1 Hz input filtering, PID interface
2220-103*	PID interface

\*Note: These options are used with the Model 2334 and Model 2335 Analog Interface Modules.

## Local CPU for Increased Performance

The 2220 has a 16-bit processor that performs all on-board functions. This results in fast, asynchronous update times without degrading the performance of the controller's main CPU. Each I/O point is refreshed every 2.083 milliseconds and is made available to the main CPU through dual-port RAM technology. Your Quickstep program is free to interrogate analog inputs and write to the outputs at any time without injecting lengthy conversion delays into the execution time.

## Isolation

The 2220's inputs and outputs are opto-isolated from the controller's CPU logic to reduce error-inducing ground-loops and increase noise immunity. The 2220's analog ground is transformer-isolated locally, which further reduces the potential for ground interaction in a complex system.

## Input Threshold Triggering (Models 2220, 2220-100, 2220-101 only)

Analog inputs can be locally configured to control an associated digital output. This action is based on reaching a pre-defined setpoint. You can dynamically adjust these setpoints from your Quickstep program or with an operator interface. Two setpoints per channel are used to configure a hysteresis boundary that prevents undesired crossover switching of the digital output. Since the threshold sensing is handled locally on the 2220 module, it is not subject to controller response times and is repeatable to within 2.25 milliseconds per channel.

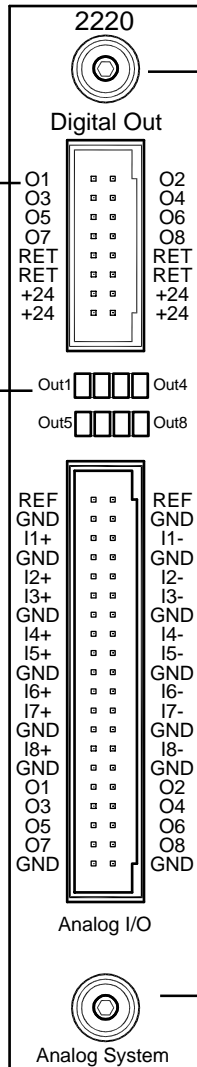
## Minimum and Maximum Capture (Models 2220-102, 2220-103 only)

This feature automatically captures maximum and minimum analog input values and makes this information available to a Quickstep program or communications connection.

# 2220 Description

**Digital Output Connector** - Provides access to digital outputs 1-8. You can connect to these outputs with a Model 2260 connector kit or a Model 2273 pigtail cable.

**NOTE:** Some 2220 modules contain the original LEDs, which are no longer available. Although the new LEDs are in a new location, the module functions exactly as it did before.



Module Extraction Handle - Do not detach!

**Analog I/O Connector** - Provides access to 8 analog inputs and outputs. The 2220 has 8 differential inputs and a 10 V reference. The inputs accept  $\pm 10$  VDC signals. The 2220 also has 8 analog outputs that can range from  $\pm 10$  VDC. Connect to the analog inputs and outputs with a Model 2260 connector kit. This kit includes mating connectors and pins for the digital outputs as well as the analog inputs and outputs. You can also use a Model 2280 6-foot pigtail cable.

Module Extraction Handle - Do not detach!

2220F1

# 2220 Connection Diagrams

<b>Dedicated Digital Output Connector</b>		<b>Pin #</b>	<b>Signal</b>
		1	D Output 1
		2	D Output 2
		3	D Output 3
		4	D Output 4
		5	D Output 5
		6	D Output 6
		7	D Output 7
		8	D Output 8
		9	Return
		10	Return
		11	Return
		12	Return
		13	+24 VDC
		14	+24 VDC
		15	+24 VDC
		16	+24 VDC

<b>Analog I/O Connector</b>		<b>Pin #</b>	<b>Signal</b>	<b>Pin #</b>	<b>Signal</b>
		1	10 V Ref.	2	10 V Ref.
		3	Return	4	Return
		5	A Input 1+	6	A Input 1-
		7	Return	8	Return
		9	A Input 2+	10	A Input 2-
		11	A Input 3+	12	A Input 3-
		13	Return	14	Return
		15	A Input 4+	16	A Input 4-
		17	A Input 5+	18	A Input 5-
		19	Return	20	Return
		21	A Input 6+	22	A Input 6-
		23	A Input 7+	24	A Input 7-
		25	Return	26	Return
		27	A Input 8+	28	A Input 8-
		29	Return	30	Return
		31	A Output 1	32	A Output 2
		33	A Output 3	34	A Output 4
		35	A Output 5	36	A Output 6
		37	A Output 7	38	A Output 8
		39	Return	40	Return

# Specifications

Description	Min.	Typical	Max.	Units
<b>Power Supply Requirements</b>				
Logic Supply (5 V)		190.0	230.0	mA
Auxiliary Supply (24 V)		41.0	190.0	mA
<b>Absolute Maximum Ratings</b>				
Ambient Temperature				
Operating	0		+50	°C
Storage	-20		+80	°C
Maximum Analog Input Voltage			±15	VDC
Minimum Analog Output Load Resistance	2.0		+5.0	kΩ
Maximum Output Current (2 kΩ @ 10 VDC)				
Precision 10 V Reference Output			25	mA
Digital Outputs (Per Output)			500	mA
Analog Isolation – Voltage Withstand (one minute duration maximum)			1500	V
<b>Analog Output Specifications</b>				
Output Voltage Range	-10.000		+10.000	VDC
Output Resolution		2.44		mV
Output Settling Time				
-10.000 to +10.000 V		0.2		ms
0 to 5.000 V		0.1		ms
<b>Analog Input Specifications</b>				
Differential Input Range	-10.000000		10.000000	VDC
Common Mode Voltage Range	-10		+10	VDC
Input Resistance		10		MΩ
Input Resolution (15-Bit)		.00305		%FS
Input Accuracy (25°C, 8-Sample Filtering)		.00305		%FS
Input Conversion Time (Asynchronous)		2.083		ms
Input Filter Settings (Default = 1 Sample)	2.083		533.248	ms
Threshold Triggering Response (Analog Input to Digital Output Response)		2.25		ms
<b>Dedicated Digital Output Specifications</b>				
On Voltage (I <sub>o</sub> = 500 mA)		.6	1.2	VDC
Off Leakage (Applied Voltage = 24 VDC)		1	100	μA DC
Maximum Output Current <sup>1</sup>			500	mA DC

**Notes:**

1. All digital outputs have short-circuit and overcurrent protection.
2. The specifications listed above are at 25°C, unless otherwise specified.

# Hardware / Firmware Revision Levels

---

<b>Model Numbers</b>	<b>Hardware Revision Level</b>	<b>Firmware Revision Level<sup>2</sup></b>
2220-100, -101	F or greater	2.0
2220 -102, -103	F or greater	3.2
2600 Series	C or greater	2.10 or greater
2700 Series	C or greater	2.10 or greater

**NOTES:**

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 2600/2700 series 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)

# Board Handling Precautions

---



The module's printed circuit board contains electrostatic discharge sensitive (ESD) devices. Improper handling could result in damage to the board. The following precautions are recommended when handling the board or before inserting it into the controller:

- Make sure you are grounded electrically by either using a wrist strap connected to an electrically grounded workstation or by physically touching the controller case or something electrically connected to the controller case.
- Avoid touching the leads or contacts of the circuit board and handle the board by its edges only.
- Transport circuit boards in protective, anti-static bags, bins or totes. Do not insert boards into materials such as plastic, polystyrene foam, clear plastic bags, bubble wrap, or plastic trays.

# Installing the 2220 Module

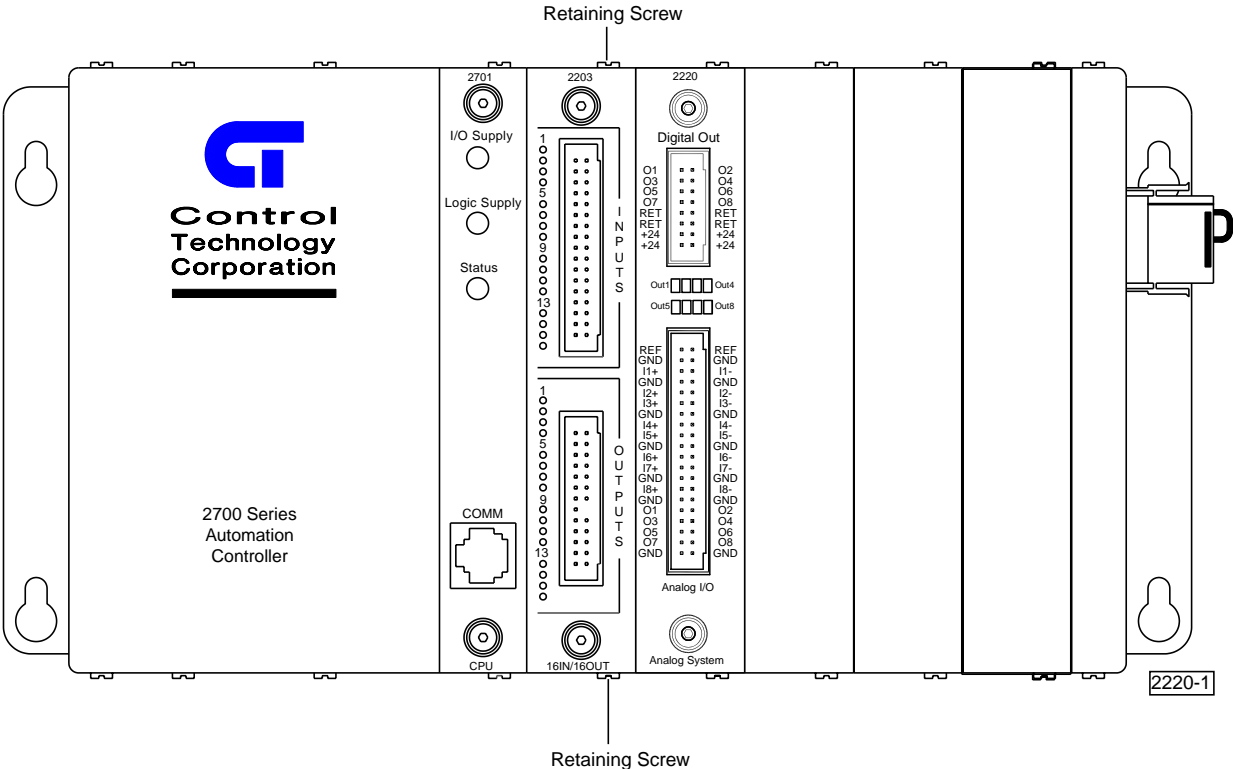
The module fits into one of the slots of your automation controller. You can insert any combination of modules into the controller (subject to system limits) and can install them in any order. This is possible because the controller’s CPU dynamically assigns such items as motor numbers, input numbers, and output numbers each time power is re-applied to the controller. These numbers are assigned from left-to-right across the controller.

To install a module into the automation controller:

**NOTE:** Retain all hardware removed during this procedure.

1. Remove all AC and DC power, including any external supplies connected to the controller.
2. Locate an unused slot and remove two retaining screws from the top and bottom of its cover plate.
3. Slide the module into the slot and make sure that the circuit board slides into the nylon guides at the top and bottom of the controller case. Make sure that the card is oriented properly so that its labels are right-side-up.
4. Press the module firmly into the controller. Make sure that the module’s faceplate is flush with the adjacent sheet metal surface.
5. Re-install two retaining screws in the top and bottom of the new module.

**NOTE:** The illustration below shows the original 2220 faceplate. The new faceplate has different LEDs that are in a new location. Refer to the *2220 Description* section for a view of the new faceplate.

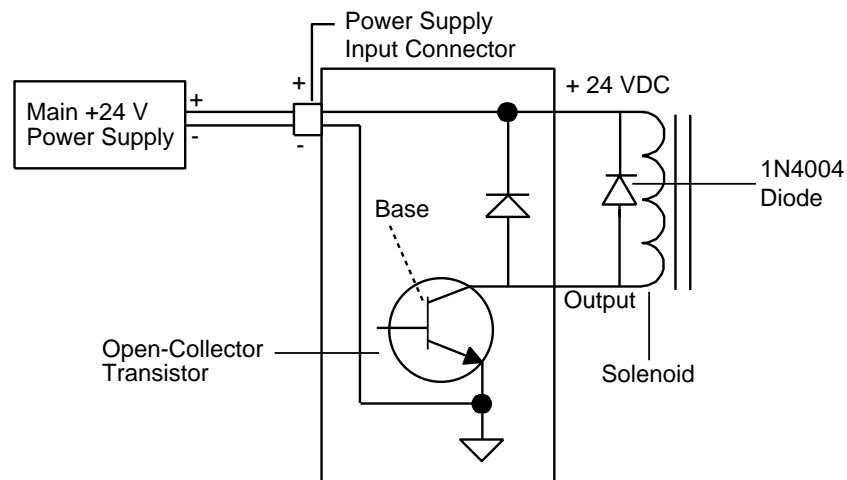


# Connecting Digital Outputs

## Using Open-Collector Outputs

The Model 2220 has 8 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 the schematic below, 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.



DI3

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 the illustration on the previous page 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.

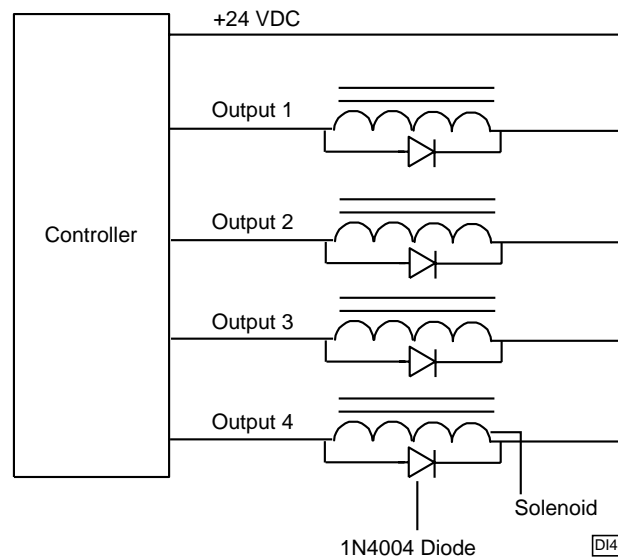


---

## 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. The illustration below shows four solenoid valves that are controlled by Outputs 1-4. Power is supplied to each output from the controller's power supply.

---



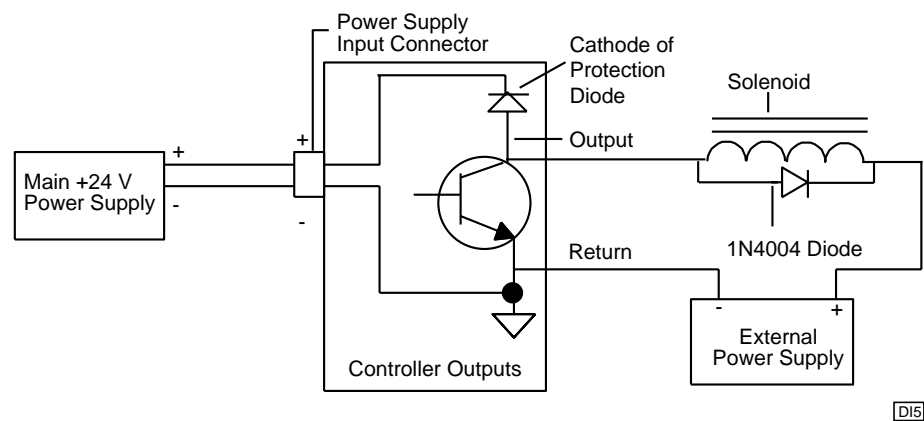
---

## Connecting to a Second External Power 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. The diagram below 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.

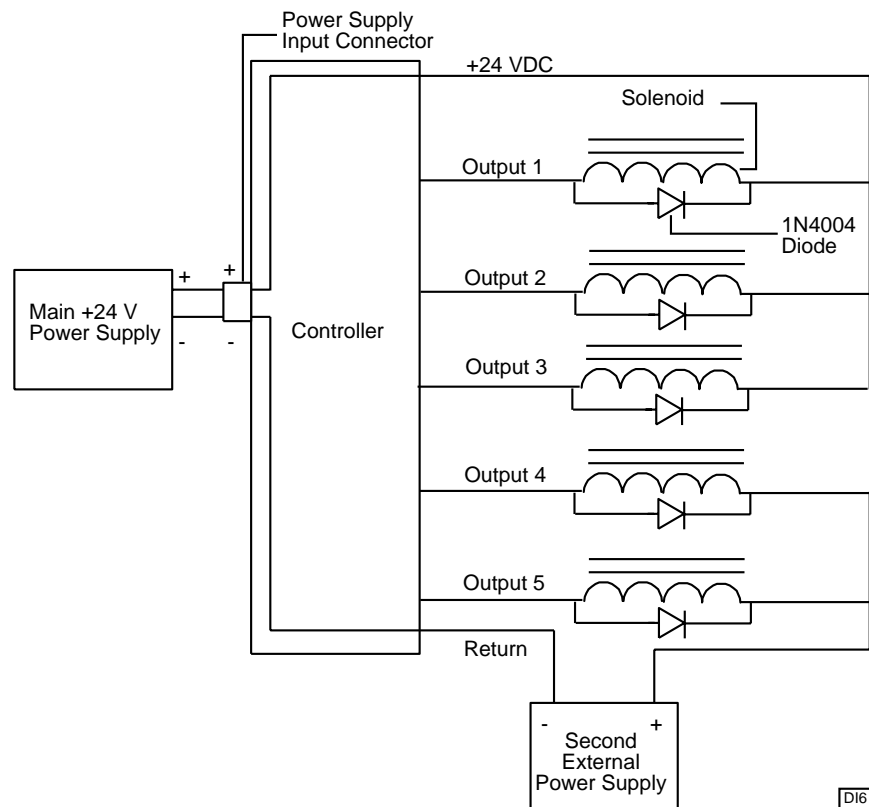
---



**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 the previous illustration, 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 the illustration above, 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.



**NOTE:**

Do not use an external power supply with an output voltage that exceeds the voltage rating of the Model 2220's outputs.

**CAUTION:**



Do not connect the positive [+] terminals of the power supplies together! Damage to one of the supplies may result. The illustration above 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.

---

## Accessing Digital Outputs on a 2220 I/O Module

You can access the 2220's digital outputs through registers 18001-18128. These outputs are mapped one-for-one with analog inputs. The following examples show how to use these registers.

This instruction turns on the fourth output:

```
store 1 to reg_18004
```

This instruction turns off the eighth output:

```
store 0 to reg_18008
```

In the following instruction, the controller continues to the next step if 2220 output 26 (of a series of 2220 modules) is on.

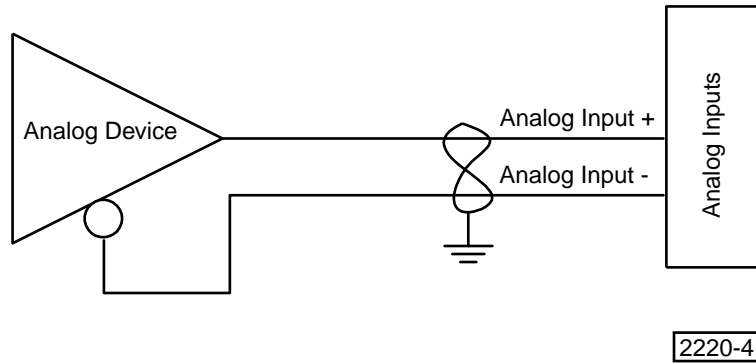
```
if reg_18026 = 1 goto next
```

# Connecting and Programming Analog Inputs

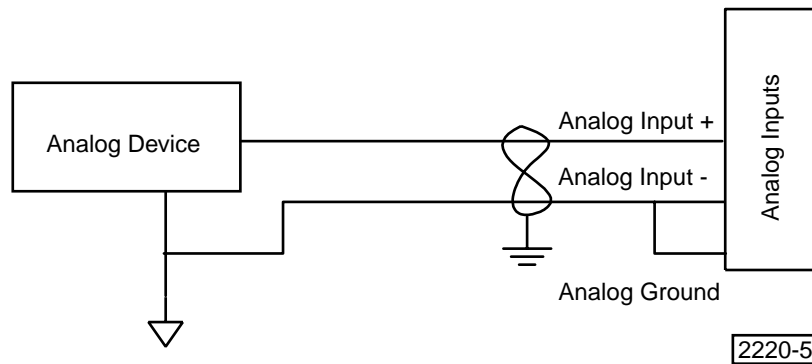
## Connecting Analog Inputs

The 2220's analog inputs are opto-isolated from the controller's CPU logic circuitry. This reduces ground-looping and increases noise immunity. The illustrations below show wiring configurations for a differential signal, a single-ended signal, and a potentiometer.

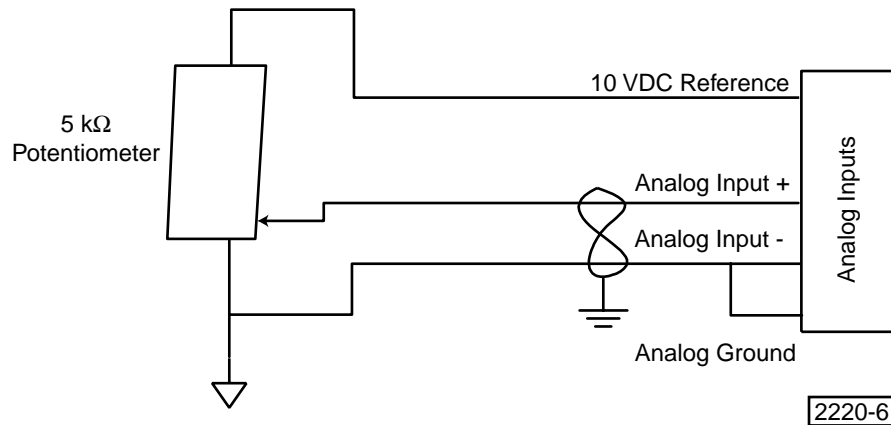
### Connecting a Differential Signal



### Connecting a Single-Ended Signal



### Connecting to a Potentiometer



---

## Specifying Digital Filter Length

Use registers 18501-18628 to specify the digital filter length for the 2220's analog inputs. Enter a value in one of these registers to specify the total number of samples processed by the 2220. These samples are continuously averaged for use in your Quickstep program. The default value is 1, or unfiltered. A single sample period for an analog conversion is 2.0833 ms. CTC recommends that you set the filter length value to 8 (2.0833 \* 8 = 16.67 ms, or a 60 Hz rate). If the value is set to 8 or a multiple of 8, it helps reject any 60 Hz noise that may be present on your system.

---

**NOTE:** The analog inputs are designed to operate asynchronously. This allows you to specify larger filter lengths without affecting the controller's performance.

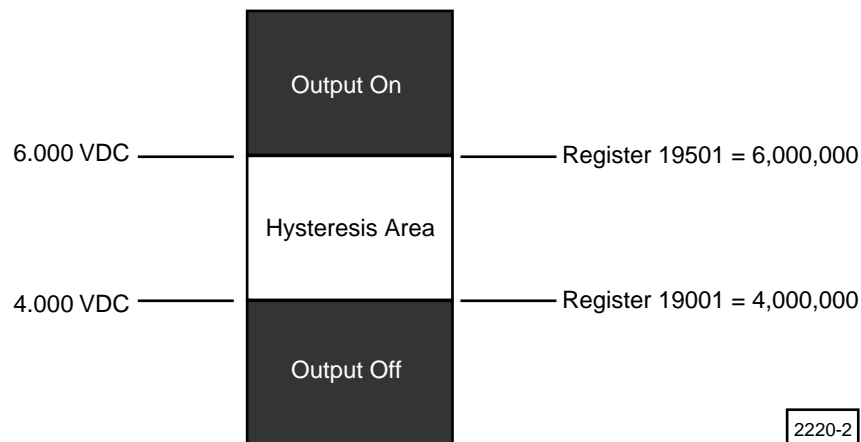
---

## Setting Up Input Thresholds (Models 2220, 2220-100, 2220-101 only)

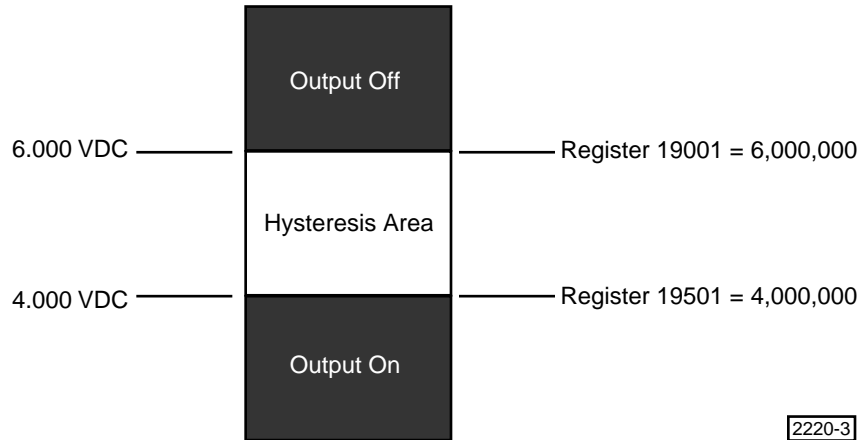
You can configure each analog input to control an associated digital output that is based on reaching pre-defined setpoints. The digital outputs are mapped one-to-one with the analog inputs. When an analog input reaches a pre-defined setpoint value, the controller turns the associated digital output ON or OFF.

You can dynamically adjust the setpoints from your Quickstep program by using CTCMON or with an operator interface. The dedicated digital outputs are configured as open-collector transistors that are available for driving DC loads. Each output can handle up to 0.5 A and provides overcurrent and short-circuit protection.

Registers 19001-19128 and 19501-19628 set the threshold setpoints for the dedicated digital outputs. The way they are used depends on how you want to control the output. For example, the illustration below shows that the first output remains OFF until the voltage level on analog input 1 meets or exceeds 6 VDC. If the voltage falls below 4 VDC, the output turns back OFF. In this example, the hysteresis area ranges between 4-6 VDC to prevent the output from toggling ON or OFF when the voltage reaches the edge of the setpoint.



The next example shows that the first output remains ON until the voltage level on analog input 1 meets or exceeds 6 VDC. If the voltage falls below 4 VDC, the output turns back ON. In this example, the hysteresis area ranges between 4-6 VDC to prevent the output from toggling ON or OFF when the voltage reaches the edge of the setpoint.



The program sample below configures analog input 1. When the value exceeds 3 VDC, digital output 1 turns ON. When the value falls below 2.5 VDC, the output turns OFF. This process is handled locally by the 2220's CPU and does not affect the Quickstep program's execution time.

```
[10] DIGITAL_OUTPUT_THRESHOLDS
    ;;
    ;; Register 19001 sets the minimum threshold for analog
    ;; input 1 as 2.500000. Register 19501 sets the maximum
    ;; threshold for analog input 1 as 3.000000.
    ;;
-----
<NO CHANGE IN DIGITAL OUTPUTS>
-----
store 2500000 to Reg_19001
store 3000000 to Reg_19501
goto next
```

Your Quickstep program can check the status of an output at any time. The dedicated outputs are accessed through registers 18001-18128, which have read/write capability. A value of 0 indicates that the output is OFF and a 1 means it is ON. You can use an IF instruction to determine the output's ON/OFF state. You can also toggle the output ON or OFF by storing a 0 or 1 to the appropriate register.

In the following example, the program jumps to the next step when dedicated output 1 is ON.

```
[56] CHECK_DEDICATED_OUTPUT
    ;;
-----
<NO CHANGE IN DIGITAL OUTPUTS>
-----
if Reg_18001=1 goto next
```

---

### **Disabling the Thresholding Feature**

You can disable the thresholding feature in one of the following ways:

1. Store a number greater than 10,000,000 to register 19501 (for analog input 1) or to register 19628 (for analog input 128).
2. Store a number less than -10,000,000 to register 19001 (for analog input 1) or to register 19128 (for analog input 128).

### **Alternate Access to Analog Inputs**

Registers 8501-8628 provide alternate access to the analog inputs. All values are expressed in millivolts and can range from -10,000,000 to +10,000,000 (-10 to +10 VDC). The following example checks the value on an analog input and proceeds to the next step if the value is greater than 9.150000 VDC:

```
if Reg_8504>9150000 goto next
```

### **Setting Analog Input Range**

Register 13010 sets the range of all analog inputs as 0 to 10,000 (normal range on the inputs is 0 to  $\pm$  10,000,000). Store 1 to this register at the beginning of your program to automatically set the range of all analog inputs as 0 to 10,000.

## Minimum / Maximum Capture (Models 2220-102, 2220-103 only)

Registers 19001-19128 (minimum) and 19501-19628 (maximum) capture the minimum and maximum analog input values measured on channels 1-128. These registers all have read / write capability. You can reset a capture value by writing the desired value to the register with a Quickstep STORE instruction. This minimum/maximum value is retained until it is exceeded by the analog input value. The following example illustrates how this works:

```
[1] Start
    ;;; Sample Task for Shut Down of a system when an analog
    ;;; input exceeds a threshold value.
    ;;;
    ;;; Only valid for 2220-102 and 2220-103 modules with
    ;;; firmware v3.2 or later (PID functionality)
    ;;;
    ;;; Look to see if the analog input 1 capture value exceeds
    ;;; 1,000,000 (1 Volt)
    -----
    <NO CHANGE IN DIGITAL OUTPUTS>
    -----
    if Analog_Max_Capture_R19501 > 1000000 goto Shut_Down

[2] Shut_Down
    ;;; We exceeded the maximum value on analog input 1,
    ;;; Set a flag to shut down the system and wait for
    ;;; a reset command
    -----
    <NO CHANGE IN DIGITAL OUTPUTS>
    -----
    set Temp_Fault_F1
    monitor Reset_Switch_I1 goto Next

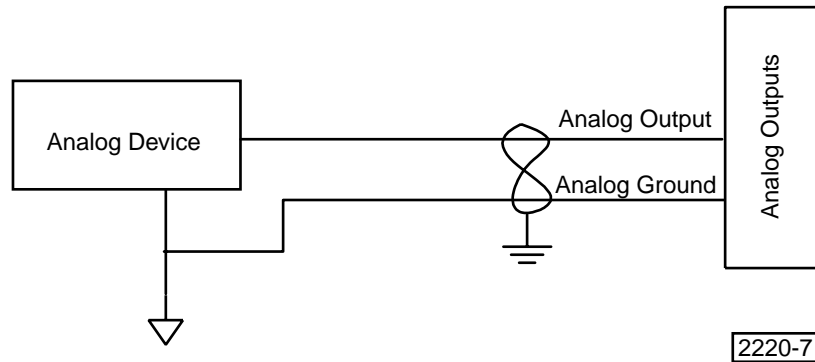
[3] Reset
    ;;; Clear the Temperature Fault Flag
    ;;;
    ;;; Reset the Max Capture value below the threshold value
    ;;; for system shutdown and go back up to the step to check
    ;;; the analog input max capture value
    -----
    <NO CHANGE IN DIGITAL OUTPUTS>
    -----
    clear Temp_Fault_F1
    store 900000 to Analog_Max_Capture_R19501
    goto Start
```

# Connecting and Programming Analog Outputs

---

## Connecting Analog Outputs

The 2220 has 8 bipolar ( $\pm 10$  volts) analog outputs with 13-bit resolution. The following illustration shows an analog output's wiring configuration:



---

**NOTE:** All shields, which are part of a cable, are connected to ground on the controller end (side) of the cable.

---

## Access to Analog Outputs

Registers 8001-8128 provide alternate access to the analog outputs. The following examples check the value on an analog output and change the value of an output. All values are expressed in millivolts.

The following example checks the value of analog output 1 and proceeds to the next step when the value is reached:

```
if Reg_8001 > 1259 goto TURN_OFF_VALVE
```

This example instructs the controller to send 4.500 VDC out on analog output 6.

```
store 4500 to Reg_8006
```

You may also use a STORE instruction to directly change an analog output's value.

```
store 4500 to AOUT_6
```

---

**This page is intentionally left blank.**