



## Model 5100 Analog Modules Application Guide

The information in this document is current as of the following hardware and firmware revision levels. Some features may not be supported in earlier revisions. See **Error! Hyperlink reference not valid.** for the availability of firmware updates or contact CTC Technical Support.

Model Number	Hardware Revision	Firmware Revision
5101/5102/5103/5104	B, C and E	4.05
5100 A, K, Q, R	0	1.07
5100 F, G, H, J	C	1.01
5100 D, E	A	1.01



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## 1.0 Introduction

This document provides details about programming Quickstep programs for 5100 series controllers containing Analog Inputs and Outputs. The following table lists the available analog modules for 5100 series controllers and their configurations:

Module	+/- 10 V Output	+/- 10 V Input	+/- 20 mV Input	4-20 mA Input	+/- 100 mV Input/ Thermocouple
<b>A</b>	2	2			
<b>D</b>	6				
<b>E</b>	8				
<b>F</b>		4			
<b>G</b>			4		
<b>H</b>				4	
<b>J</b>					4
<b>K</b>	2				2
<b>Q</b>	2		2		
<b>R</b>	2			2	

## 2.0 Using Analog Outputs

Analog Outputs provide a -10 V to +10 V range. The analog voltage is set by using a Quickstep store instruction on an Analog Output symbol or on the special purpose registers assigned to analog outputs (Analog Outputs 1 – 256 use special purpose registers 8001 – 8256). The actual voltage is specified in millivolts.

```
store 100 to Analog_Output_1  ;;; puts 0.1 V on Analog Output 1
store -9823 to Analog_Output_2 ;;; puts -9.823 V on Analog Output 2
store 2500 to Reg_8003  ;;; puts 2.5 V on Analog Output 3
```

Analog outputs can be used as data sources for “store” and “if” instructions by referencing the appropriate special purpose registers:

```
store Reg_8003 * 1 to Analog_Ouput_2 ;;; Output 2 based on Output 1
if Reg_8009 > 2500 goto Next ;;; Checks Analog Output 9
```

## 2.1 Configuring Analog Outputs

Analog Outputs are by default referenced in millivolts. Register 13022 can be used to change the reference to analog outputs to units of microvolts, providing greater resolution on output modules where it is available. By default, register 13022 has a value of 1, indicating output values will be in millivolts. Writing a 0 to register 13022 will change output values to microvolts:

```
store 0 to Reg_13022 ;;; Sets Analog Outputs to Microvolt resolution
store 2000000 to Analog_Output_1 ;;; puts 2.0 V on Analog Output 1
```

Register 13022 needs only to be set once at the beginning of the Quickstep program and will affect all subsequent read and write operations to analog output values.

## 3.0 Using Analog Inputs

Analog inputs in the 5100 Series controllers come in several configurations to support the wide range of analog input sensors available. Different applications require different amounts of precision of the analog signal. Higher resolutions will allow for more precise control algorithms, while lower resolutions will result in data that is easier to read and manipulate in applications where higher precision is not required. The desired resolution can be set for individual analog inputs providing higher resolution data when needed or lower resolution data when preferred. Also, the J and K modules (with +/- 100 mV inputs) support conversion functions needed to read Thermocouple inputs.

### 3.1 Configuring Analog Inputs

In order to configure the various options for collecting and presenting data, two sets of special purpose registers have been designated for use. One sets up the type of data conversion function to run which is used in temperature applications where the thermocouple is read directly by a J or K temperature module. By default, no conversion will be run.

Registers 9001-9256 – Conversion Type:

<i><b>Value</b></i>	<i><b>Conversion Type</b></i>
<i><b>0</b></i>	No Conversion
<i><b>1</b></i>	Cold Junction Compensation Device
<i><b>2</b></i>	B1-50A RTD
<i><b>10</b></i>	Type K Thermocouple
<i><b>11</b></i>	Type J Thermocouple
<i><b>12</b></i>	Type T Thermocouple
<i><b>13</b></i>	Type E Thermocouple
<i><b>14</b></i>	Type R Thermocouple
<i><b>15</b></i>	Type S Thermocouple

The second register is desired range for the analog input. By default, all 5100 analog modules return data on a +/- 10,000 = +/- Full Scale. Higher resolution can be obtained

by selection a +/- 10,000,000 scale. Or more readable forms may be selected for other inputs, such as 20 mV inputs, 4-20 mA inputs, or 100 mV inputs. Thermocouple and CJC inputs must be set to one of the available temperature ranges. Non-Thermocouple inputs must be set to a voltage or current range.

*Registers 9501-9756 – Range Select:*

Value	Range Selection
0	+/- 10,000 (All modules, Also See Register 13010)
1	+/- 10,000,000 (All modules, Also See Register 13010)
2	+/- 20,000 (alternate setting for +/- 20 mV, Modules G & Q)
3	+/- 100,000 (alternate setting for +/- 100 mV, Modules J & K)
4	4,000 – 20,000 (alternate setting for 4-20 mA, Modules H & R)
11	Celsius (for CJC, RTD, Thermocouple Conversions Only)
12	Fahrenheit (for CJC, RTD, Thermocouple Conversions Only)
13	Kelvin (for CJC, RTD, and Thermocouple Conversions Only)

By default, the controller represents the full range of the input as +/- 10,000. For higher resolution modules, more accuracy can be obtained by selecting a range of +/- 10,000,000. There are also special ranges for +/- 100 mV, +/- 20 mV, and 4-20 mA which provide readings in microvolt/microamp resolution.

Input Type	+/- 10V	+/- 100 mV	+/- 20 mV	+/- 20 mA
Available Range Settings	0, 1	0, 1, 3* 10, 11, 12**	0, 1, 2	0, 1, 4

\*When no Thermocouple or CJC conversion is selected for the input.

\*\*When Thermocouple or CJC conversion is selected for the input.

**Settings for +/- 10 Volt Inputs:**

0: 1 count = 1 millivolt

1: 1 count = 1 microvolt

**Settings for +/- 20 mV Inputs:**

0: 1 count = 2 microvolts

1: 1 count = 2 nanovolts

2: 1 count = 1 microvolt

**Settings for +/- 100 mV Inputs**

0: 1 count = 10 microvolts

1: 1 count = 10 nanovolts

3: 1 count = 1 microvolt

Settings for CJC and Thermocouple Conversions for +/- 100 mV Inputs

10: 1 count = 0.1 C

11: 1 count = 0.1 F

12: 1 count = 0.1 K

Settings for 4-20 mA Inputs

0: 1 count = 2 microamps

1: 1 count = 2 nanoamps

4: 1 count = 1 microamp

NOTE: All inputs will read only as accurately as their specified resolution for regardless of setting. For example, a +/- 10V input will read in increments of 305 microvolts when set to a range of 1.

The appropriate conversion type must be selected before the range is selected or you may cause a controller fault or override the range settings when the conversion is changed. Setting an invalid range will result in invalid data from the input or possibly a controller software fault.

## 3.2 Using Voltage and Current Inputs

All voltage and current inputs have a default range of +/- 10,000 over the full range of the analog signal. This default range can be changed to +/- 10,000,000 by using register 13,010. It defaults to a value of 1, but changing its value to 0 results in increased resolution on certain analog modules.

Other ranges are available for specific analog modules. For modules G and Q, with +/- 20mV inputs designed for load cell applications, a range of 2 will report the mV value over the full range of the input. For modules J and K with a +/- 100 mV range, a range selection of 3 will result in mV reading. For modules H and R, with inputs designed to read 4-20 mA signals, a range selection of 4 will result in a milliamp reading.

## 3.3 Using Thermocouple Inputs

The J and K modules support a wide range of Thermocouple type connections. The thermocouple type must be set by changing the conversion type register for each input or using the global change registers discussed below. When a J or K type thermocouple type is specified, the input range for that channel automatically changes to the Celsius \* 10 scale. Once a thermocouple type is selected, the scale can be changed to C, F, or K units as desired. For example:

```
store 11 to Reg_9009      ;;; sets input 9 to J Thermocouple
store 11 to Reg_9010      ;;; sets input 10 to J Thermocouple
store 10 to Reg_9011      ;;; sets input 11 to K Thermocouple
store 1 to Reg_9012       ;;; sets input 12 to CJC
store 11 to Reg_9509      ;;; sets input 9 to Celsius (x10)
store 11 to Reg_9510      ;;; sets input 10 to Celsius (x10)
store 12 to Reg_9511      ;;; sets input 11 to Fahrenheit (x10)
store 13 to Reg_9512      ;;; sets input 12 to Kelvin (x10)
```



All temperature scale readings are made to 0.1 (tenths) resolution. So 25.0 degrees (regardless of units being Celsius, Fahrenheit, or Kelvin) would be read as 250 and 212.0 degrees would be read as 2120.

The Thermocouple types that are supported are controlled by a file called "Thermocouples.tbl". This file must reside on the flash disk within the /\_system/Datatables subdirectory. Without this file conversions can not be made. To determine the type of thermocouples supported the "get thermocouples" or "get versions" telnet administration command may be issued. Descriptive information and revisions will then be available. Currently the file contains support for J, K, E, R, S and T type thermocouples. The "code" displayed when retrieving information is the same value that would be written into the 9001-9256 register block during initialization.

The thermocouple table information is not read into memory until it is needed. Therefore the very first write to 9001-9256 for a particular type will cause it to be loaded and cached in memory, causing a slight delay. It is recommended that this be done at program initialization or with the 5100.ini startup file (*Model 5100 Script Language Guide, Document #951-510003*).

Analog inputs can be used in Quickstep **store** instructions or **if** instructions as follows:

```
store Analog_In_10 - Setpoint_R1 to Error_R11    ;;; calculate error
if Analog_In_11 > 2000 goto OverTempLimit        ;;; over 200.0 F limit!
```

The first three inputs on a J analog input module are differential. The last (fourth) input is single ended. It is recommended only the differential inputs be used as Thermocouple inputs. The last single ended input may be used for the CJC input. If the last single ended input is used as a Thermocouple input the T/C must be an isolated tip device.

Accuracy – Optimal accuracy is obtained when the controller has stabilized under power for 30 minutes. This is not a requirement, however, may be desirable for high accuracy applications.

### 3.4 Using the CJC Input

Each 5100 series controller with a J or K module is shipped with a CJC device, designed to measure a reference temperature at the 5100 controller required to calculate the thermocouple temperature. This device should be connected to the last J or K input channel on the 5100. This input must be configured by the programmer to be a CJC channel:

```
store 1 to Reg_9012                ;;; sets input 12 to CJC
```

Only 1 CJC channel can exist in a single controller.

It is also possible to not use a physical CJC input and use a programmed or alternate temperature source. In this case, the CJC temperature must be stored to register 9997.

```
Store 250 to Default_CJC_Temp_R9997 ;;; sets CJC temp to 25.0 C
```

Note that the temperature required in register 9997 is the temperature of the terminal block connectors on the 5100 series controller where the thermocouples are connected. Any error will directly affect the accuracy of the thermocouple inputs.

### 3.5 Analog Input Digital Filters

Registers 18501 – 18756 allow you to specify digital filter length for the analog inputs for 5100 series analog modules. The value entered in the register specifies the total number of samples taken. The samples are continuously averaged for use in your program. The default value is one, meaning unfiltered. A single sample period for an analog conversion is 2.0833 ms. Control Technology Corp.'s recommended filter value is eight ( $2.0833 * 8 = 16.67$  ms or a 60 Hz rate). A digital filter value of 8 or a multiple of 8 helps reject any 60 Hz noise that may be present on your system.

For example, the following Quickstep instruction sets a digital filter value of 8 for analog input #5:

```
Store 8 to Reg_18505 ;;; Set filter length of 8 for Analog Input 5
```

NOTE: The analog inputs perform their operations asynchronously. Larger filter lengths will not affect controller response to other activities.

### 4.0 Configuring Remote Analog I/O

Remote Analog I/O are configured the same way as local analog I/O using the mapped I/O addresses on the local unit. The only exception is when using CJC channels with thermocouple inputs. When using thermocouple inputs on remote units, you must set a CJC channel for each unit using thermocouple inputs. Use Register 9996 to select the unit, 0 for the local unit, 1 for the remote unit before setting each CJC channel. For example, to set Analog Input 1 as the CJC channel for the local thermocouples, and Analog Input 15 as the CJC channel for the remote thermocouples, the following configuration would be used:

```
Store 0 to Reg_9996 ;;; Set local unit CJC
Store 1 to Reg_9001 ;;; Set Analog Input 1 - CJC for local TC's
Store 1 to Reg_9996 ;;; Set remote unit CJC
Store 1 to Reg_9015 ;;; Set Analog Input 15 - CJC for remote TC's
```

### 5.0 Special Purpose Registers

The following special purpose registers are supported with analog modules on the 5100 controller:

8001 – 8256: Alternate Access to Analog Outputs

8501 – 8756: Alternate Access to Analog Inputs

9001 – 9256: Conversion Type Selection

9501 – 9576: Analog Input Range Selection

9996: Remote 5100 CJC Channel Selection (0 = Local Unit, 1 = Remote Unit)

9997: Default Cold Junction Temperature (Degrees C \* 10, Default 250 = 25.0 C)

13010: Legacy Analog Input Global Range Selection. 0 = Normal. 1 = All Inputs set for +/- 10,000,000 will instead read +/- 10,000. (Not recommended in new applications.)

13022: Analog Output Range Selection. 0 = microvolt. 1 = millivolt (Default)

18501 – 18256: Digital Filter Length