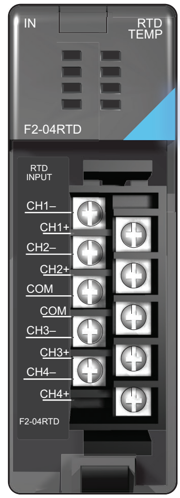
F2-04RTD 4-Channel RTD Input

Chapter 6

In This Chapter...

Module Specifications



The F2-04RTD 4-Channel Resistive Temperature Detector Input Module provides the following features and benefits:

- Provides four RTD input channels with 0.1 °F temperature resolution.
- Automatically converts type Pt100Ω, jPt100Ω, Pt1000Ω, Cu25Ω, Cu10Ω signals into direct temperature readings. No extra scaling or complex conversion is required.
- Temperature data can be expressed in °F or °C, and as magnitude plus sign or 2's complement.
- Precision lead wire resistance compensation by dual matched current sources and ratiometric measurements.
- The temperature calculation and linearization are based on data provided by the National Institute of Standards and Technology (NIST).
- Diagnostic features include detection of short circuits and input power disconnection.

Module Calibration

The module automatically re-calibrates every five seconds to remove any offset and gain errors. The F2-04RTD module requires no user calibration. However, if your process requires calibration, it is possible to correct the RTD tolerance using ladder logic. A constant can be added or subtracted to the actual reading for that particular RTD.

RTD Input Configuration Requirements

The F2-04RTD temperature input module requires 32 discrete input points. The module can be installed in any slot of a DL205 system, including remote bases. The limiting factors on the number of analog modules used are:

- For local and local expansion systems, the available power budget and number of discrete I/O points.
- For remote I/O systems, the available power budget and number of remote I/O points.

Check the user manual for the particular CPU model being used for more information regarding the available power budget and number of local, local expansion or remote I/O points.

***NOTE**: D2-230 CPUs with firmware release version 1.6 or later, D2-240 CPUs with firmware release 2.5 or later, D2-250 CPUs with firmware release version 1.06 or later are required for proper operation.*

Input Specifications

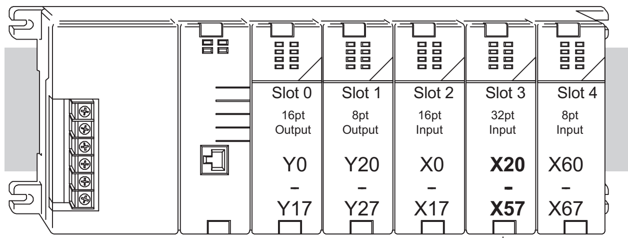
The following table provides the specifications for the F2-04RTD Input Module. Review these specifications to make sure the module meets your application requirements.

Input Specifications	
Number of Channels	4, differential inputs
Input Ranges	Pt100 -200.0°C – 850.0°C (-328°F – 1562°F) PT1000 -200.0°C – 595.0°C (-328°F – 1103°F) jPt100 -38.0°C – 450.0°C (-36°F – 842°F) Cu10Ω -200.0°C – 260.0°C (-328°F – 500°F) Cu25Ω -200.0°C – 260.0°C (-328°F – 500°F)
Resolution	±0.1°C, ±0.1°F (±3276.7)
Absolute Maximum Ratings	Fault Protected Inputs to ±50VDC
Converter Type	Charge Balancing, 24 bit
Sampling Rate	160ms per channel
Linearity Error (End to End)	±0.05°C maximum, ±0.01°C typical
PLC Update Rate	4 channels per scan max. (D2-240, D2-250–1, D2-260 or D2-262 CPU) 1 channel per scan max. (230 CPU)
Temperature Drift	5ppm per °C (maximum)
Maximum Inaccuracy	maximum inaccuracy = ±1°C
RTD Excitation Current	200µA
Common Mode Range	0–5 VDC
Notch Filter	>100dB notches @ 50/60Hz f_{-3dB} = 13.1 Hz
Digital Input Points Required	32 (X) input points 15 binary data bits, 1 sign bit, 2 channel ID bits 4 fault bits
Power Budget Requirements	90mA @ 5VDC (supplied by base)
Operating Temperature	0–60°C (32–140°F)
Storage Temperature	-20 to 70°C (-4 to 158°F)
Relative Humidity	5–95% (non-condensing)
Environmental Air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3-304

Special Placement Requirements (D2-230 and Remote I/O Bases)

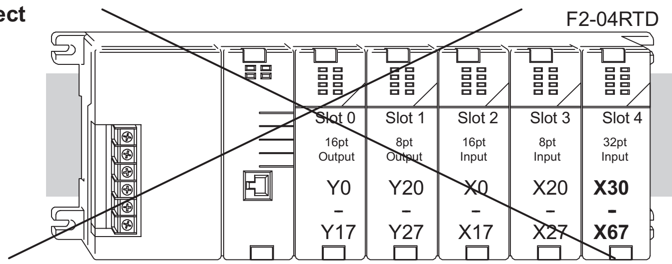
It is important to examine the configuration if a D2-230 CPU is being used. As can be seen in the section on **Writing the Control Program**, V-memory locations are used to manage the analog data. If the module is placed so that the input points do not start on a V-memory boundary, the instructions will not be able to access the data. This also applies when placing this module in a remote base using a D2-RSSS in the CPU slot. Refer to the diagrams below.

Correct!

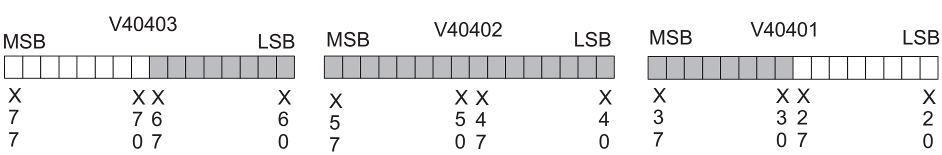


Data is correctly entered so input points start on a V-memory boundary address from the table below.

Incorrect



Data is split over three locations, so instructions cannot access data from a D2-230.



To use the V-memory references required for a D2-230 CPU, the first input address assigned to the module must be one of the following X locations. The table also shows the V-memory addresses that correspond to these X locations.

X	X0	X20	X40	X60	X100	X120	X140	X160
V	V40400	V40401	V40402	V40403	V40404	V40405	V40406	V40407

Setting the Module Jumpers

Jumper Locations

Locate the bank of seven jumpers (J8) on the PC board. Notice that the description of each jumper is on the PC board. The following options can be selected by installing or removing the jumpers:

- Number of channels: 1–4.
- The input type: 10Ω or 25Ω copper, jPt100Ω, Pt100Ω or Pt1000Ω RTDs
- Temperature conversion: 2's complement or magnitude plus sign format in Fahrenheit or Celsius.

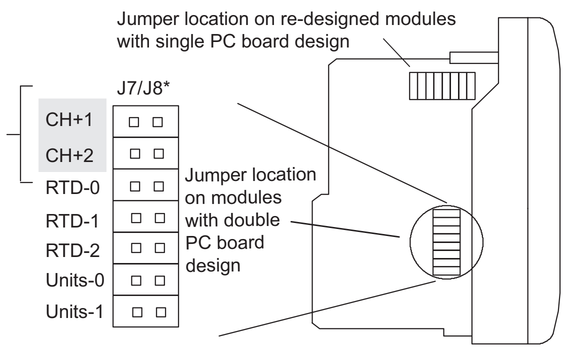
To prevent losing a jumper when it is removed, store it near its original location by sliding one of its sockets over a single pin.

Selecting the Number of Channels

The two jumpers labeled **CH+1** and **CH+2** are used to select the number of channels that will be used. The factory default setting is four-channel operation (both jumpers installed). Any unused channels are not processed. For example, if you select channels 1 – 3, channel 4 will be inactive. The table shows how to arrange the jumpers to select the number of channels.

X = jumper installed, empty space = jumper removed

Number of Channels	Jumper	
	CH+1	CH+2
1		
2	X	
3		X
4	X	X



* Jumper is designated J8 on double PC board models and J7 on single PC board models.

Setting Input Type

The jumpers labeled **RTD-0, RTD-1**, and **RTD-2** are used to select the type of RTD. The module can be used with many types of RTDs however, all channels of the module must be the same RTD type.

The default setting from the factory is Pt100Ω (RTD-2 comes with the jumper removed). This selects the DIN 43760 European type RTD. European curve type RTDs are calibrated to DIN 43760, BS1905, or IEC751 specification which is 0.00385 Ω/Ω/°C (100°C = 138.5Ω).

The jPt100Ω type is used for the American curve (0.00392 Ω/Ω/°C), platinum 100Ω RTDs. The 10Ω and 25Ω RTD settings are used with copper RTDs.

The table shows how to arrange the jumpers to set the input type.

X = jumper installed, empty space = jumper removed.

RTD Inputs	Jumper Pins		
	RTD-0	RTD-1	RTD-2
Cu 10Ω			
Cu 25Ω	X		
jPt100Ω		X	
Pt100Ω	X	X	
Pt1000Ω			X

Selecting the Conversion Units

Use the last two jumpers, **Units-0** and **Unit-1**, to set the conversion unit. The options are magnitude + sign or 2's complement in Fahrenheit or Celsius. The module comes from the factory with both jumpers installed for magnitude + sign conversion in Fahrenheit.

All RTD types are converted into a direct temperature reading in either Fahrenheit or Celsius. The data contains one implied decimal place. For example, a value in V-memory of 1002 would be 100.2°C or °F.

Negative temperatures can be represented in either 2's complement or magnitude plus sign form. If the temperature is negative, the most significant bit in the V-memory location is set (X17, if the starting address for the module is X0).

The 2's complement data format may be required to correctly display bipolar data on some operator interfaces. This data format could also be used to simplify averaging a bipolar signal. To view this data format in ***Direct***Soft, select Signed Decimal.

The table shows how to arrange the jumpers.

X = jumper installed, empty space = jumper removed.

Number of Channels	Temperature Conversion Units			
	Magnitude + Sign °F	Magnitude + Sign °C	2's Compliment °F	2's Compliment °C
Units-0	X		X	
Units-1	X	X		

Connecting the Field Wiring

Wiring Guidelines

Your company may have guidelines for wiring and cable installation. If so, check the guidelines before beginning the installation. Here are some general things to consider:

- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. Do not ground the shield at both the module and the source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- Route the wiring through an approved cable housing to minimize the risk of accidental damage. Check local and national codes to choose the correct method for your application.

RTD - Resistance Temperature Detector

Use shielded RTDs whenever possible to minimize noise on the input signal. Ground the shield wire at one end only, preferably at the RTD source.

Lead Configuration for RTD Sensors

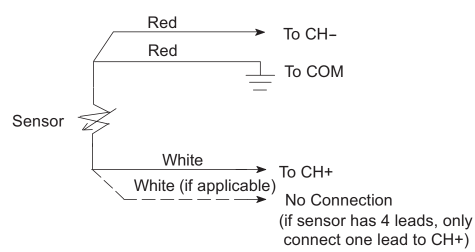
The suggested three-lead configuration shown below provides one lead to the CH+ terminal, one lead to the CH– terminal, and one lead to the common terminal. Compensation circuitry nulls out the lead length for accurate temperature measurements.

Some sensors have four leads. When making connections, do not connect the second lead to the CH+ input; leave that lead unconnected.

Do not use configurations that lack the use of the same color lead to both the CH– and COM terminals. There is no compensation so temperature readings will be inaccurate.

This module has low RTD excitation current, the worse case dissipation with 100Ω RTDs connected is only 0.016 mW.

Wiring Connections For Typical RTD Sensor



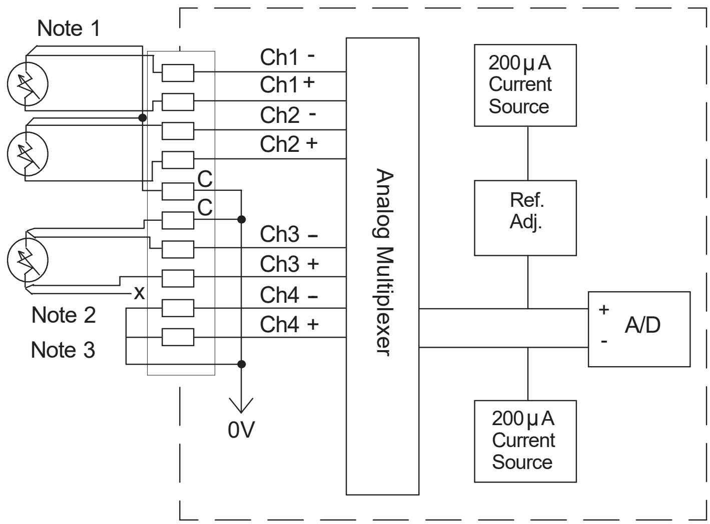
Ambient Variations in Temperature

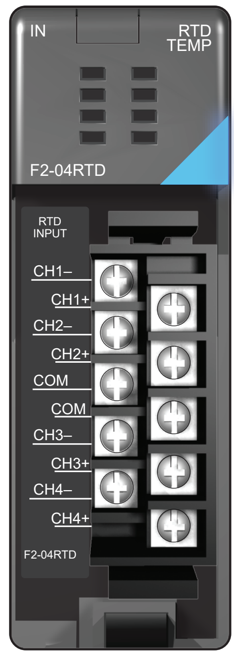
The F2-04RTD module has been designed to operate within the ambient temperature range of 0 to 60°C.

Precision analog measurement with no long term temperature drift is assured by a chopper stabilized programmable gain amplifier, ratiometric referencing, and automatic offset and gain calibration.

Wiring Diagram

The F2-04RTD module has a removable connector to make wiring easier. Simply squeeze the top and bottom retaining clips and gently pull the connector from the module.





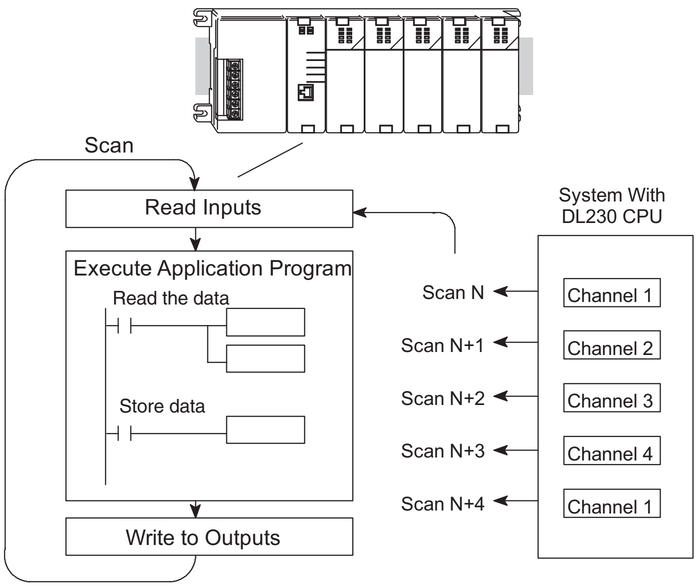
NOTE 1: *The three wires connecting an RTD to the module must be the same type and length. Do not use the shield or drain wire for the third connection.*
NOTE 2: *If an RTD sensor has four wires, the plus (+) sense wire should be left unconnected as shown.*
NOTE 3: *Short unused channels to COM terminal (C)*

Module Operation

Before beginning to write the control program, it is important to take a few minutes to understand how the module processes the analog signals.

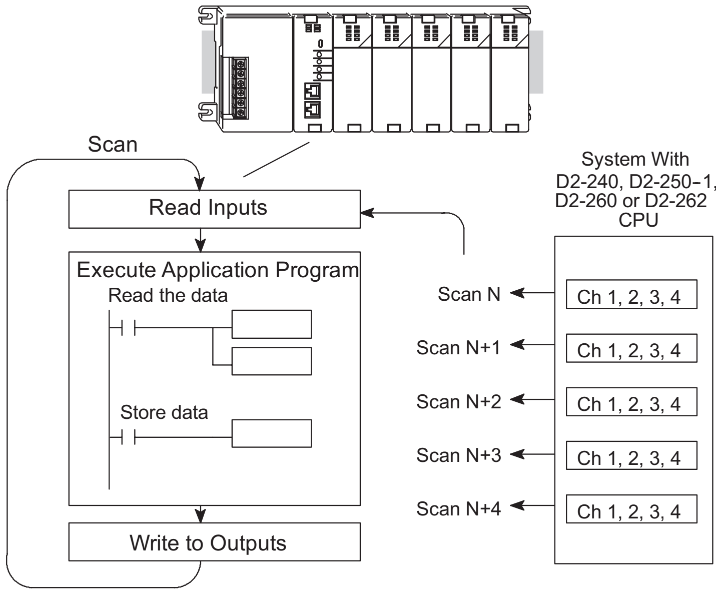
Channel Scanning Sequence (Multiplexing) for a D2-230 CPU

The F2-04RTD module can supply different amounts of data per scan, depending on the type of CPU being used. The D2-230 can obtain one channel of data per CPU scan. Since there are four channels, it can take up to four scans to get data for all channels. Once all channels have been scanned the process starts over with channel 1. Unused channels are not processed, so if only two channels are selected, each channel will be updated every other scan. The multiplexing method can also be used for the D2-240, D2-250-1, D2-260 or D2-262 CPUs.



Channel Scanning Sequence (Pointer Method) for D2-240, D2-250-1, D2-260 or D2-262 CPUs

If a D2-240, a D2-250-1, a D2-260 or a D2-262 CPU is being used, all four channels of input data can be captured in one scan. This is because the D2-240, D2-250-1, D2-260 and D2-262 CPUs support special V-memory locations that are used to manage the data transfer. This is discussed in more detail in the next section on **Writing the Control Program**.



Analog Module Updates

Even though the channel updates to the CPU are synchronous with the CPU scan, the module asynchronously monitors the analog transmitter signal and converts the signal to a 16-bit binary representation. This enables the module to continuously provide accurate measurements without slowing down the discrete control logic in the RLL program.

The time required to sense the temperature and copy the value to V-memory is 160ms minimum to 640ms plus 1 scan time maximum (number of channels x 160ms + 1 scan time).

Writing the Control Program

Reading Values: Pointer Method and Multiplexing

There are two methods of reading values:

- Pointer method
- Multiplexing

The multiplexing method must be used with a D2-230 CPU. The multiplexing method must also be used with remote I/O modules (the pointer method will not work). Either method can be used with the D2-240, D2-250-1, D2-260 or D2-262 CPUs, but for ease of programming it is highly recommended to use the pointer method.

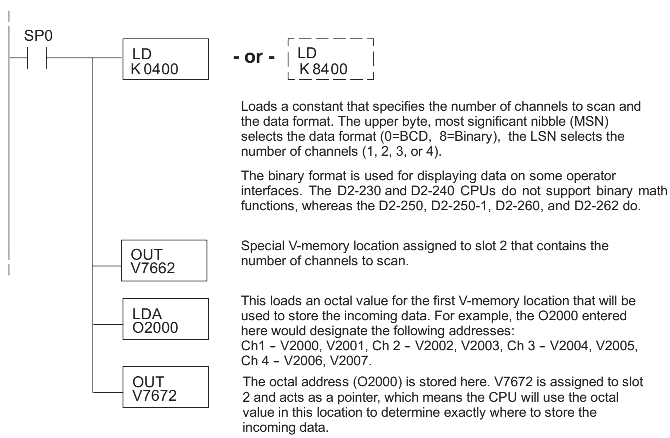
Pointer Method for the D2-240, D2-250-1, D2-260 or D2-262 CPUs

The CPU has special V-memory locations (shown in tables on the following page) assigned to each base slot that greatly simplifies the programming requirements. These V-memory locations allow you to:

- Specify the data format
- Specify the number of channels to scan.
- Specify the storage locations.

The example program shows how to setup these locations. Place this rung anywhere in the ladder program, or in the initial stage if stage programming instructions are used. This is all that is required to read the data into V-memory locations. Once the data is in V-memory, math instructions can be used on the data, compare the data against preset values, etc. V2000 is used in the example, but any user V-memory location can be used. The module is installed in slot 2 for the examples. Use the V-memory locations shown in the application. The pointer method automatically converts values to BCD.

NOTE: *D2-240 CPUs with firmware release version 2.5 or later and D2-250 CPUs with firmware release version 1.06 or later support this method. Use the D2-230 multiplexing example if the firmware revision is earlier .*



The following tables show the special V-memory locations used by the D2-240, D2-250-1, D2-260 or D2-262 for the CPU base and local expansion base I/O slots. Slot 0 (zero) is the module next to the CPU or D2-CM module. Slot 1 is the module two places from the CPU or D2-CM, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. Also, if the D2-230 (multiplexing) method is used, verify that these addresses in the CPU are 0 (zero).

The Table below applies to the D2-240, D2-250-1, D2-260 or D2-262 CPU base.

CPU Base: Analog Input Module Slot-Dependent V-memory Locations								
Slot	0	1	2	3	4	5	6	7
No. of Channels	V7660	V7661	V7662	V7663	V7664	V7665	V7666	V7667
Storage Pointer	V7670	V7671	V7672	V7673	V7674	V7675	V7676	V7677

The Table below applies to the D2-250-1, D2-260 or D2-262 CPU base 1.

Expansion Base D2-CM #1: Analog Input Module Slot-Dependent V-memory Locations								
Slot	0	1	2	3	4	5	6	7
No. of Channels	V36000	V36001	V36002	V36003	V36004	V36005	V36006	V36007
Storage Pointer	V36010	V36011	V36012	V36013	V36014	V36015	V36016	V36017

The Table below applies to the D2-250-1, D2-260 or D2-262 CPU base 2.

Expansion Base D2-CM #2: Analog Input Module Slot-Dependent V-memory Locations								
Slot	0	1	2	3	4	5	6	7
No. of Channels	V36100	V36101	V36102	V36103	V36104	V36105	V36106	V36107
Storage Pointer	V36110	V36111	V36112	V36113	V36114	V36115	V36116	V36117

The Table below applies to the D2-260 and D2-262 CPU base 3.

Expansion Base D2-CM #3: Analog Input Module Slot-Dependent V-memory Locations								
Slot	0	1	2	3	4	5	6	7
No. of Channels	V36200	V36201	V36202	V36203	V36204	V36205	V36206	V36207
Storage Pointer	V36210	V36211	V36212	V36213	V36214	V36215	V36216	V36217

The Table below applies to the D2-260 and D2-262 CPU base 4.

Expansion Base D2-CM #4: Analog Input Module Slot-Dependent V-memory Locations								
Slot	0	1	2	3	4	5	6	7
No. of Channels	V36300	V36301	V36302	V36303	V36304	V36305	V36306	V36307
Storage Pointer	V36310	V36311	V36312	V36313	V36314	V36315	V36316	V36317

Negative Temperature Readings with Magnitude Plus Sign (Pointer Method) for the D2-240, D2-250-1, D2-260 or D2-262 CPUs

With bipolar ranges, some additional logic will be needed to determine whether the value being returned represents a positive voltage or a negative voltage. For example, the direction for a motor might need to be known. There is a solution for this:

- If bipolar ranges are used and a value greater than or equal to 8000_{hex} is obtained, the value is negative.
- If a value less than or equal to $7FFF_{hex}$ is obtained, then the value is positive.

The sign bit is the most significant bit, which combines 8000_{hex} to the data value. If the value is greater than or equal to 8000_{hex}, only the most significant bit and the active channel bits need to be masked to determine the actual data value.

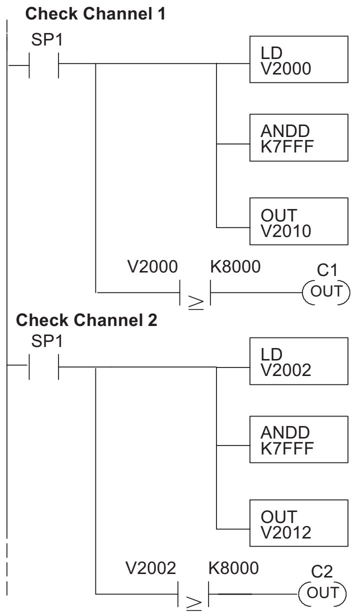
NOTE: *D2-240 CPUs with firmware release version 2.5 or later and D2-250 CPUs with firmware release version 1.06 or later support this method. Use the D2-230 multiplexing example if your firmware is an earlier version.*

The two programs on the next page show how this can be accomplished. The first example uses magnitude plus sign (binary) and the second example uses magnitude plus sign (BCD). The examples only show two channels.

It is good to know when a value is negative, so these rungs should be placed before any other operations that use the data, such as math instructions, scaling operations, etc. Also, if stage programming instructions are being used, these rungs should be in a stage that is always active.

NOTE: *This logic is only needed for each channel that is using bipolar input signals.*

Magnitude Plus Sign (Binary)



Load channel 1 data from V-memory into the accumulator. Contact SP1 is always on.

This instruction masks the sign bit of the binary data, if it is set. Without this step, negative values will not be correct so do not forget to include it.

Put the actual signal value in V2010. Now you can use the data normally.

Channel 1 data is negative when C1 is on (a value of −1.0 reads as 8010, −2.0 is 8020, etc.).

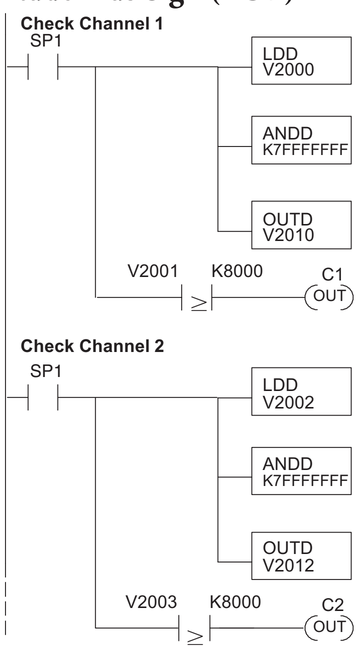
Load channel 2 from V-memory into the accumulator. Contact SP1 is always on.

This instruction masks the sign bit of the binary data, if it is set. Without this step, negative values will not be correct so do not forget to include it.

Put the actual signal value in V2012. Now you can use the data normally.

Channel 2 data is negative when C2 is on (a value of −1.0 reads as 8010, −2.0 is 8020, etc.).

Magnitude Plus Sign (BCD)



Load channel 1 data from V-memory into the accumulator. Remember, the data can be negative. Contact SP1 is always on.

This instruction masks the sign bit of the BCD data, if it is set. Without this step, negative values will not be correct so do not forget to include it.

Put the actual signal value in V2010. Now you can use the data normally.

Channel 1 data is negative when C1 is on (a value of −1.0 reads as 8000 0010, −2.0 is 8000 0020, etc.).

Load channel 2 from V-memory into the accumulator. Remember, the data can be negative. Contact SP1 is always on.

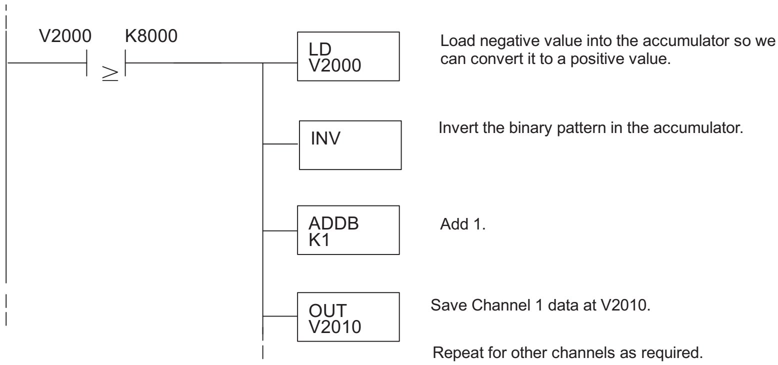
This instruction masks the sign bit of the BCD data, if it is set. Without this step, negative values will not be correct so do not forget to include it.

Put the actual signal value in V2012. Now you can use the data normally.

Channel 2 data is negative when C2 is on (a value of −1.0 reads as 8000 0010, −2.0 is 8000 0020, etc.).

Negative Temperatures 2's Complement (Binary/Pointer Method) for the D2-240, D2-250-1, D2-260 or D2-262 CPUs

The 2's complement mode is used for negative temperature display purposes, while at the same time using the magnitude plus sign of the temperature in a control program. The ***Direct***Soft element Signed Decimal is used to display negative numbers in 2's complement form. To find the absolute value of a negative number in 2's complement, invert the number and add 1 as shown in the following example.

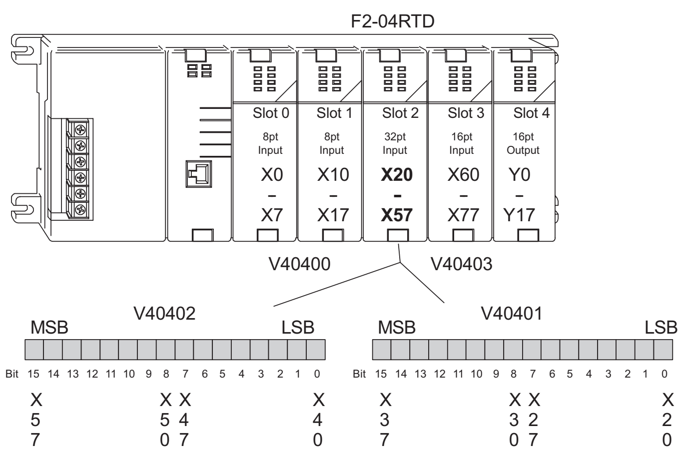


Understanding the Input Assignments (Multiplexing Ladder Only)

Remember that this module appears to the CPU as a 32-point discrete input module. Use these points to obtain:

- An indication of which channel is active
- The digital representation of the analog signal
- Module diagnostic information

Since all input points are automatically mapped into V-memory, it is easy to determine the location of the data word that will be assigned to the module.



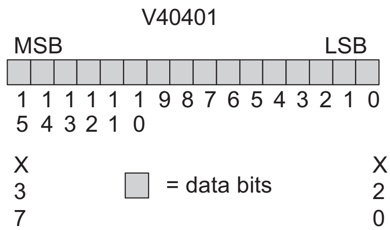
When a D2-230 CPU is used, the input points must start on a V-memory boundary. To use the V-memory references required for a D2-230 CPU, refer to the table below. The first input address assigned to a module must be one of the X inputs shown. The table also shows the V-memory addresses that correspond to these X inputs.

X	X0	X20	X40	X60	X100	X120	X140	X160
V	V40400	V40401	V40402	V40403	V40404	V40405	V40406	V40407

Analog Data Bits

The first 16 bits represent the analog data in binary format.

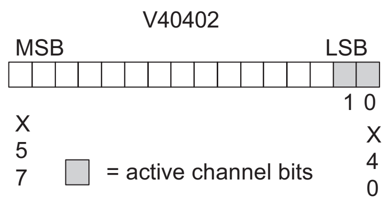
Bit	Value	Bit	Value
0	1	8	256
1	2	9	512
2	4	10	1024
3	8	11	2048
4	16	12	4096
5	32	13	8192
6	64	14	16384
7	128	15	32768



Active Channel Bits

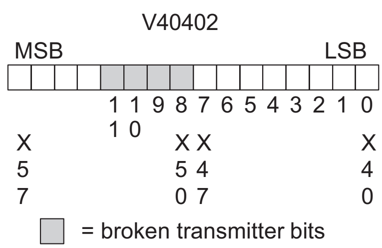
The active channel bits represent the multiplexed channel selections in binary format.

Bit 1	Bit 0	Channel
0	0	1
0	1	2
1	0	3
1	1	4



Broken Transmitter Bits (Multiplexing Ladder Methods)

The broken transmitter bits are on when the corresponding RTD is open.

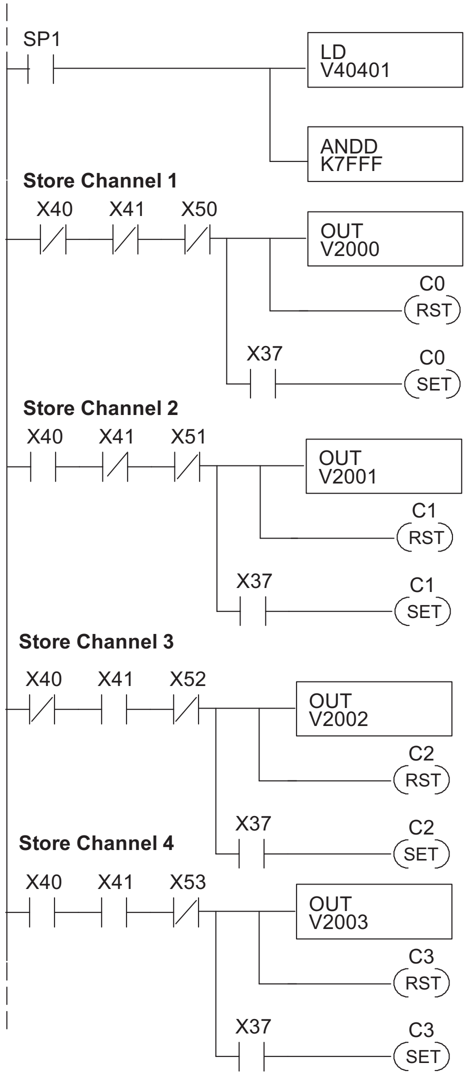


NOTE: *The broken transmitter bits only function using the Multiplexing method.*

Reading Magnitude Plus Sign Values (Multiplexing)

The D2-230 CPU does not have the special V-memory locations that allows for automatic management of the data transfer. Since all channels are multiplexed into a single data word, the control program must be set up to determine which channel is being read. Since the module appears as X input points to the CPU, it is very easy to use the active channel status bits to determine which channel is being monitored.

NOTE: *D2-230 CPUs with firmware release version 1.6 or later required for multiplexing ladder.*



Loads the complete data word into the accumulator. The V-memory location depends on the I/O configuration. See Appendix A for the memory map.

This instruction masks the sign bit. Without this, the values used will not be correct so do not forget to include it.

When X40, X41, and X50 are off, channel 1 data is stored in V2000. C0 is reset to indicate that channel 1's value is positive.

If X37 is on, the data value represents a negative temperature. C0 is set to indicate that channel 1's value is negative.

When X40 is on and X41 and X51 are off, channel 2 data is stored in V2001. C1 is reset to indicate that channel 2's value is positive.

If X37 is on, the data value represents a negative temperature. C1 is set to indicate that channel 2's value is negative.

When X40 and X52 are off and X41 is on, channel 3 data is stored in V2002. C2 is reset to indicate that channel 3's value is positive.

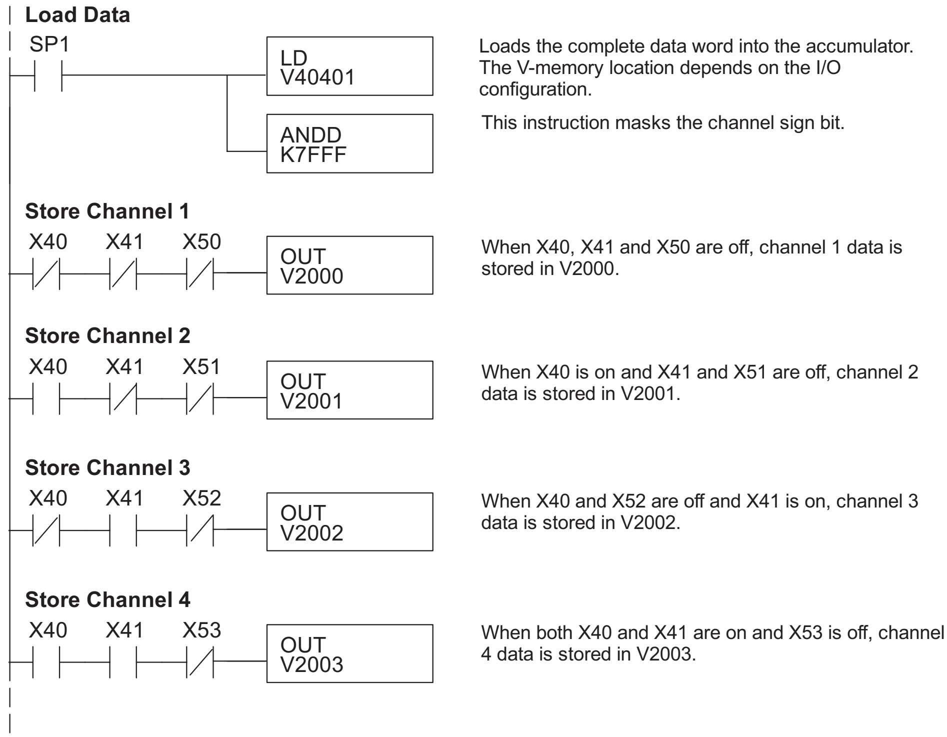
If X37 is on, then the data value represents a negative temperature. C2 is set to indicate that channel 3's value is negative.

When both X40 and X41 are on and X53 is off, channel 4 data is stored in V2003. C3 is reset to indicate that channel 4's value is positive.

If X37 is on, the data value represents a negative temperature. C3 is set to indicate that channel 4's value is negative.

Reading 2's Compliment Values (Multiplexing)

The D2-230 CPU does not have the special V-memory locations that allows for automatic management of the data transfer. Since all channels are multiplexed into a single data word, the control program must be set up to determine which channel is being read. Since the module appears as X input points to the CPU, it is very easy to use the active channel status bits to determine which channel is being monitored. The 2's complement data format may be required to correctly display bipolar data on some operator interfaces. This data format could also be used to simplify averaging a bipolar signal. To view this data format in *Direct*SOFT, select Signed Decimal.



Scaling the Input Data

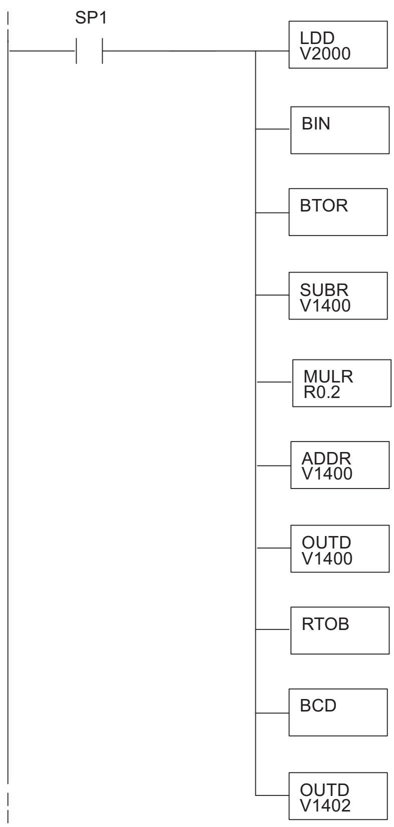
No scaling of the input temperature is required. The readings directly reflect the actual temperatures. For example: a reading of 8482 is 848.2°C, a reading of 16386 is -0.2°C (magnitude plus sign) and a reading of 32770 is -0.2° (2's complement).

Filtering Input Noise (D2-250-1, D2-260 and D2-262 CPUs Only)

Add the following logic to filter and smooth analog input noise in D2-250-1, D2-260 and D2-262 CPUs. This is especially useful when using PID loops. Noise can be generated by the field device and/or induced by field wiring.

In the following example, the analog value in BCD is first converted to a binary number. Memory location V1400 is the designated workspace in this example. The MULR instruction is the filter factor, which can be from 0.1–0.9. The example uses 0.2. Using a smaller filter factor increases filtering. A higher precision value can be used, but it is not generally needed. The filtered value is then converted back to binary and then to BCD. The filtered value is stored in location V1402 for use in the application program or a PID loop.

NOTE 1: *Please review intelligent instructions (IBox) in Chapter 5 of D2-USER-M, which simplify this and other functions. The IBox instructions are supported by the D2-250-1, D2-260 and D2-262.*
NOTE 2: *Be careful not to do a multiple number conversion on a value. For example, if the pointer method is used to get the analog value, it is in BCD and must be converted to binary. However, if the conventional method of reading analog is used and the first 15 bits are masked, the value is already in binary and no conversion is needed. Also, if the conventional method is used, change the LDD V2000 instruction to LD V2000.*



Loads the analog signal, which is a BCD value and has been loaded from V-memory location V2000, into the accumulator. Contact SP1 is always on.

Converts the BCD value in the accumulator to binary. Remember, this instruction is not needed if the analog value is originally brought in as a binary number.

Converts the binary value in the accumulator to a real number.

Subtracts the real number stored in location V1400 from the real number in the accumulator, and stores the result in the accumulator. V1400 is the designated workspace in this example.

Multiplies the real number in the accumulator by 0.2 (the filter factor), and stores the result in the accumulator. This is the filtered value.

Adds the real number stored in location V1400 to the real number filtered value in the accumulator, and stores the result in the accumulator.

Copies the value in the accumulator to location V1400.

Converts the real number in the accumulator to a binary value, and stores the result in the accumulator.

Converts the binary value in the accumulator to a BCD number.
NOTE: The BCD instruction is not needed for PID loop PV (loop PV is a binary number).

Loads the BCD number filtered value from the accumulator into location V1402 to use in your application or PID loop.