F3–08TEMP 8-Channel Temperature Input

In This Chapter. . . .

Module Specifications

The F3–08TEMP Temperature Input Module provides eight, single-ended temperature inputs for use with AD590 type temperature transmitters (range of 0–1mA.) The module provides 12-bit resolution. You can use the RLL control program to select between °F or °C operation.

The following table provides the specifications for the F3–08TEMP Temperature Input Module from FACTS Engineering. Review these specifications to make sure the module meets your application requirements.

Number of Channels	8, single-ended inputs
Input Ranges	0 – 1 mA
Resolution	12 bit (1 in 4096) No missing codes 0.25 °C with AD590M
Input Impedance	10KΩ ±0.1%
Absolute Maximum Ratings	±50 mA
Conversion Time	35μs per channel, maximum 1 channel per CPU scan
Converter Type	Successive Approximation, AD574
Linearity Error	±1 count (0.03% of full scale) maximum
Maximum Inaccuracy at 77 °F (25 °C)	0.25% of full scale
Accuracy at 25 °C	±1 °C with AD590M transmitter
Accuracy vs. Temperature	57 ppm / °C maximum full scale
Power Budget Requirement	25 mA @ 9 VDC, 37 mA @ 24 VDC
External Power Supply	None required
Operating Temperature	32° to 140° F (0° to 60° C)
Storage Temperature	–4° to 158° F (–20° to 70° C)
Relative Humidity	5 to 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

Compatible Temperature Probe Specifications

The following table provides the specifications for input temperature probes compatible with this module.

Compatible Temperature Probe Specifications	
Transmitter Type	AD590
Input Temperature Range	–40° to 212° F (–40° to 100°C) – (Opto 22 PN ICTD) –67° to 302° F (–55° to 150°C) – (Analog Devices PN AC2626J)
Transmitter Output for Opto 22 and Analog Devices	1 μA / °K, 298.2 μA @ 25 °C 218 μA @ –55 °C, 423 μA @ 150 °C

Analog Input Configuration Requirements

The F3–08TEMP Temperature Input appears as a 16-point module. The module can be installed in any slot configured for 16 points. See the DL305 User Manual for details on using 16 point modules in DL305 systems. The limitation on the number of analog modules are:

- For local and expansion systems, the available power budget and 16-point module usage are the limiting factors.

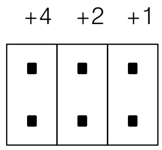
Setting the Module Jumpers

Factory Settings

The module is set at the factory for eight-channel operation. If this is acceptable you do not have to change any of the jumpers. The following diagram shows how the jumpers are set.

Selecting the Number of Channels

If you examine the rear of the module, you'll notice several jumpers. The jumpers labeled +1, +2 and +4 are used to select the number of channels that will be used. Without any jumpers the module processes one channel. By installing the jumpers you can add channels. The module is set from the factory for eight channel operation.



Number of Channels

Jumpers installed as shown selects 8-channel operation

For example, if you install the +1 jumper, you add one channel for a total of two. Now if you install the +2 jumper you add two more channels for a total of four.

Any unused channels are not processed so if you only select channels 1–4, then the last four channels will not be active. The following table shows which jumpers to install.

Channel(s)	+4	+2	+1
1	No	No	No
1 2	No	No	Yes
1 2 3	No	Yes	No
1 2 3 4	No	Yes	Yes
1 2 3 4 5	Yes	No	No
1 2 3 4 5 6	Yes	No	Yes
1 2 3 4 5 6 7	Yes	Yes	No
1 2 3 4 5 6 7 8	Yes	Yes	Yes

Connecting the Field Wiring

Wiring Guidelines

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

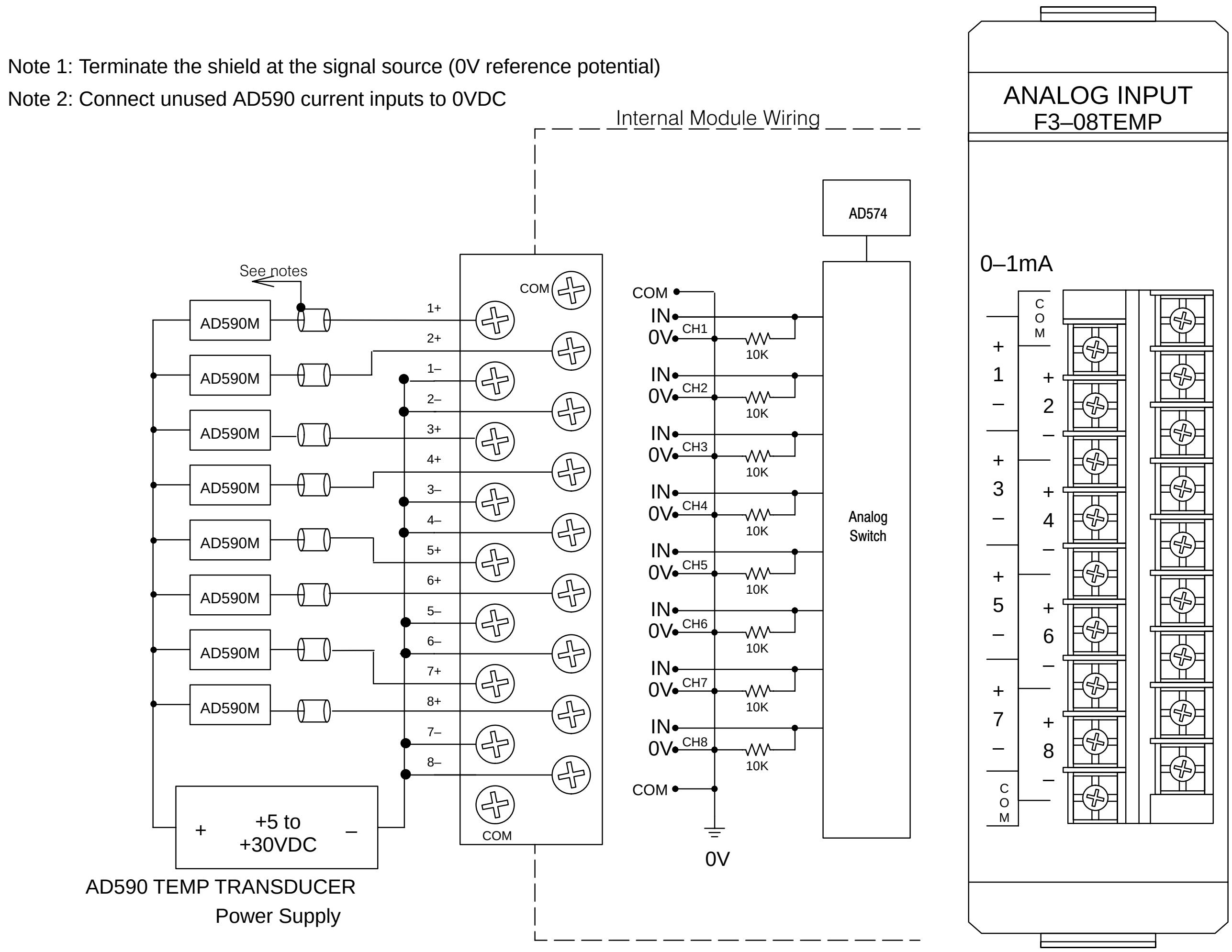
- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the signal source. *Do not* ground the shield at both the module and the source.
- Don't run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- 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.

User Power Supply Requirements

The F3–08TEMP receives all power from the base. A separate power supply is not required.

Removable Connector

The F3–08TEMP module has a removable connector to make wiring easier. Simply remove the retaining screws and gently pull the connector from the module.



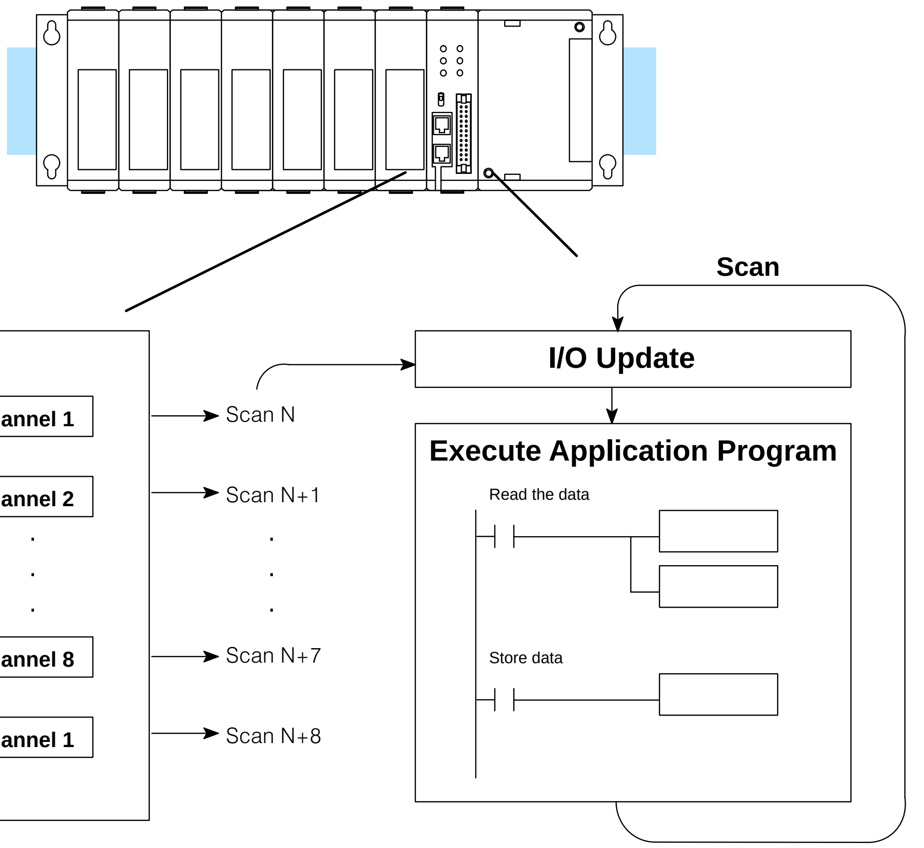
Module Operation

Before you begin writing the control program, it is important to take a few minutes to understand how the module processes and represents the analog signals.

Channel Scanning Sequence

The F3–08TEMP module supplies1 channel of data per each CPU scan. Since there are eight channels, it can take up to eight scans to get data for all channels. Once all channels have been scanned the process starts over with channel 1.

You do not have to select all of the channels. Unused channels are not processed, so if you select only four channels, then the channels will be updated within four scans.



Even though the channel updates to the CPU are synchronous with the CPU scan, the module asynchronously monitors the temperature transmitter signal and converts the signal to a 12-bit binary representation. This enables the module to continuously provide accurate measurements without slowing down the discrete control logic in the RLL program.

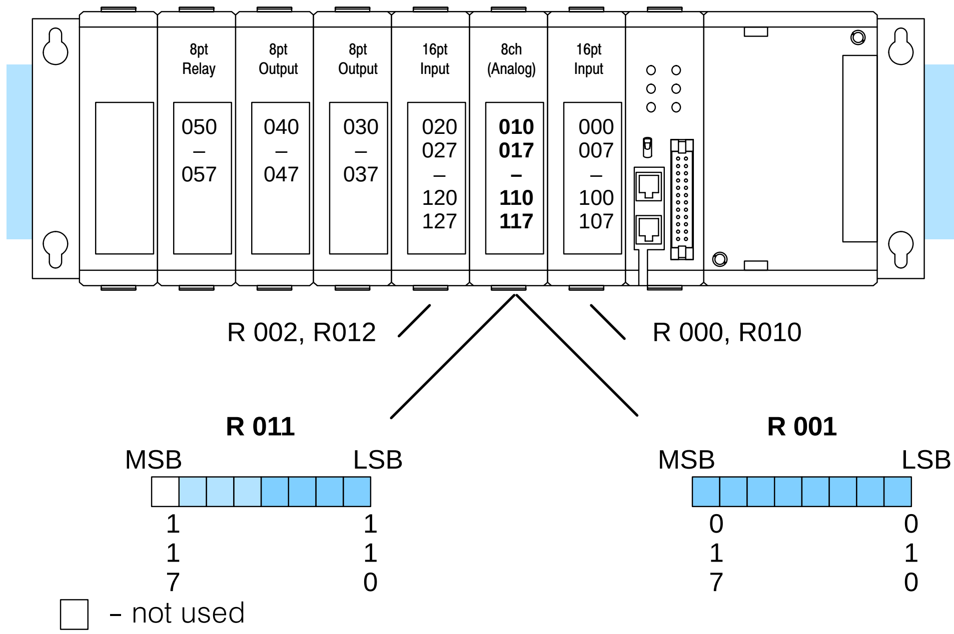
Understanding the I/O Assignments

You may recall the F3–08TEMP module appears to the CPU as a 16-point module. These 16 points provide:

- an indication of which channel is active.
- the digital representation of the temperature.

Since all I/O points are automatically mapped into Register (R) memory, it is very easy to determine the location of the data word that will be assigned to the module.

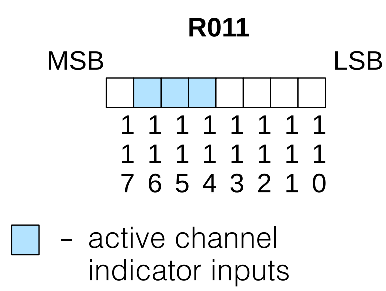
F3–08TEMP



Within these two register locations, the individual bits represent specific information about the analog signal.

Active Channel Indicator Inputs

The next to last three bits of the upper Register indicate the active channel. The indicators automatically increment with each CPU scan.

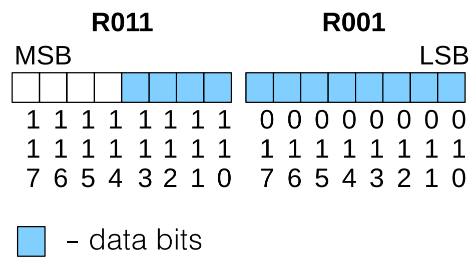


Scan	Active Channel Inputs	Channel
N	000	1
N+1	001	2
N+2	010	3
N+3	011	4
N+4	100	5
N+5	101	6
N+6	110	7
N+7	111	8
N+8	000	1

Analog Data Bits

The first twelve bits represent the temperature. The following format is used.

Bit	Value	Bit	Value
0 (LSB)	1	6	64
1	2	7	128
2	4	8	256
3	8	9	512
4	16	10	1024
5	32	11	2048



Temperature Input Resolution

Typically, the F3–08TEMP resolution enables you to detect a 0.1 °F change in temperature.

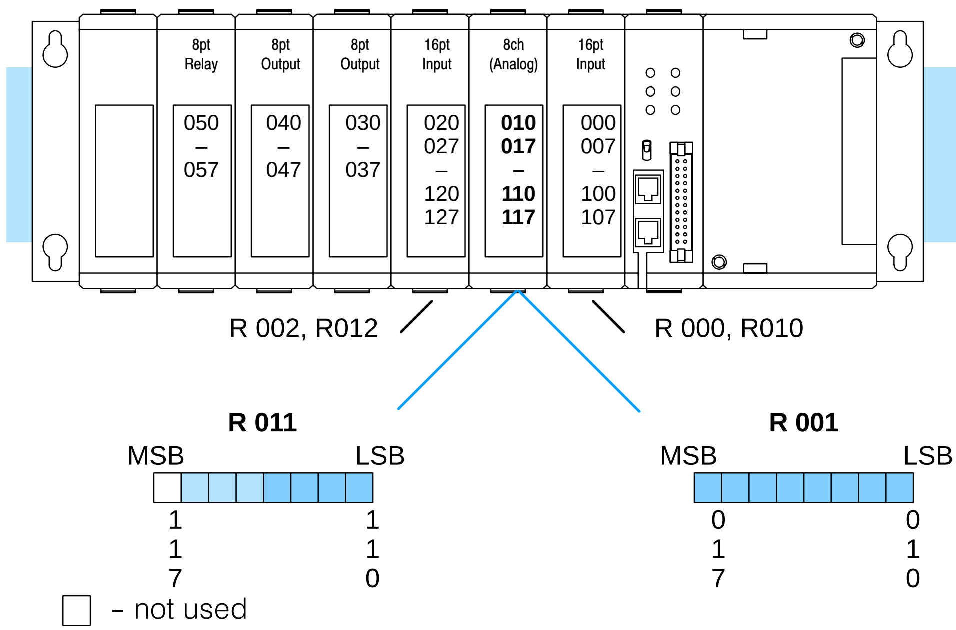
Now that you understand how the module and CPU work together to gather and store the information, you're ready to write the control program.

Writing the Control Program (DL 330 / DL340)

Identifying the Data Locations

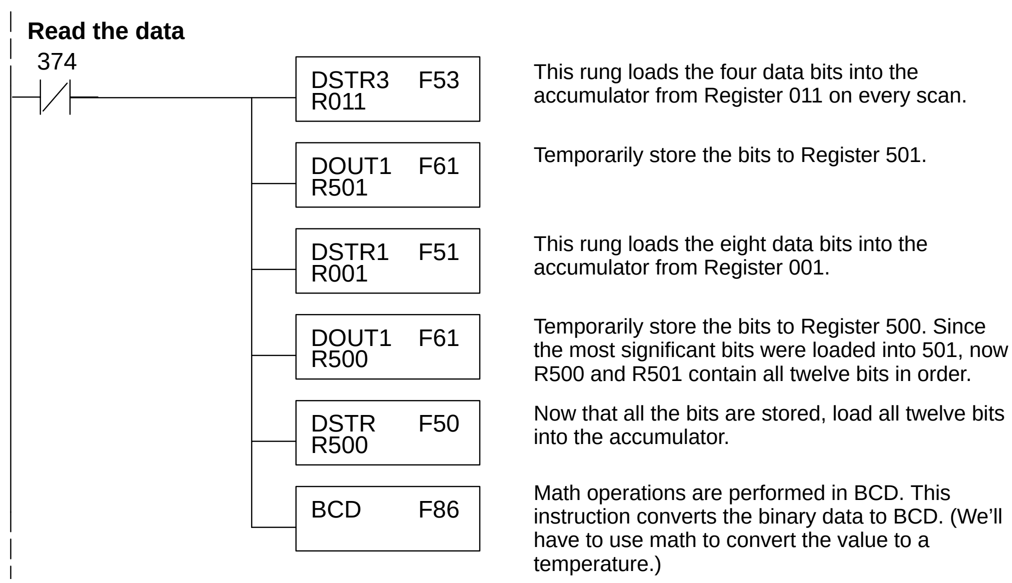
Since all channels are multiplexed into a single data word, the control program must be setup to determine which channel is being read. Since the module provides input points to the CPU, it is very easy to use the channel status bits to determine which channel is being monitored.

F3–08TEMP



Reading the Digital Value

The following example program is designed to read any of the available channels of data . Once the data is read, you'll have to add some logic to convert the data into a °C or °F temperature. (More on the conversion in a minute. For now, let's just read the value into the accumulator.) Since the DL305 CPUs use 8-bit word instructions, you have to move the data in pieces. It's simple if you follow the example.



Converting the Data to Temperature

Once the input data is stored in a register location, you will need to convert it to represent the temperature you are measuring. Use the formulas shown to convert the data to show the temperature in °C and °F.

For °C Readings

$$\text{Temp} = 1000\frac{A}{4096} - 273.2$$

Temp = temperature in °C

A = Analog value (0 – 4095)

273.2 = °K offset
(0 °K = –273.2 °C)

For °F Readings

$$\text{Temp} = 1000\frac{A}{2276} - 459.6$$

Temp = temperature in °F

A = Analog value (0 – 4095)

459.6 = °K offset
(0 °K = –459.6 °F)

The following example shows how you would use the analog data to represent the temperature. This example assumes the analog value is 1733. This should yield approximately 150 °C.

$$\text{Temp} = 1000\frac{1733}{4096} - 273.2$$

$$\text{Temp} = 149.9$$

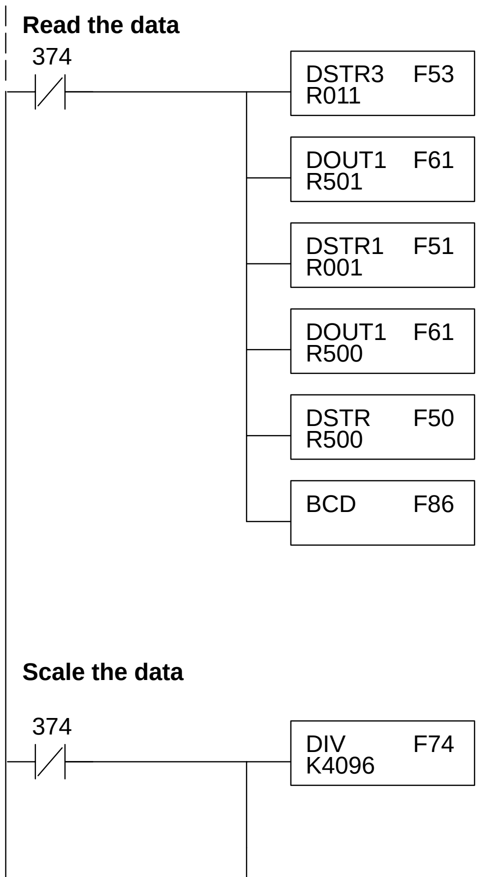
You can't quite enter the formula exactly as is with the DL305 instruction set. You have to use a value that implies the decimal point of precision. Plus, since we can move the decimal portion into the accumulator, we do not have to multiply the value by 1000.

The following instructions show you how to solve the conversion problem. (We'll continue to use the 150 °C example.)

NOTE: This example uses °C. To use °F, simply change the scaling factor and offset instructions to use the F formula.

- °**F scale** — Constant of 2276 for scaling factor, constant of 4596 for offset.
- °**C scale** — constant of 4096 for scaling factor, constant of 2732 for offset.

Read the data



This rung loads the four data bits into the accumulator from Register 011 on ever scan.

Temporarily store the bits to Register 501.

This rung loads the eight data bits into the accumulator from Register 001.

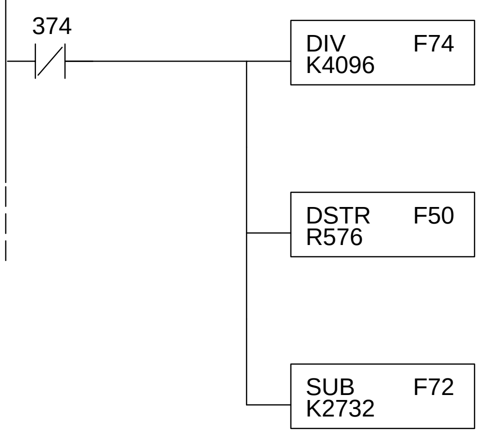
Temporarily store the bits to Register 500. Since the most significant bits were loaded into 501, now R500 and R501 contain all twelve bits in order.

Now that all the bits are stored, load all twelve bits into the accumulator.

Math operations are performed in BCD. This instruction converts the binary data to BCD. (We'll have to use math to convert the value to a temperature.)

Accumulator				Aux. Accumulator			
1	7	3	3	0	0	0	0
				R577		R576	

Scale the data



The analog value is divided by °C scaling factor, which is 4096. (1733 / 4096 = 0.4230)

Accumulator				Aux. Accumulator			
0	0	0	0	4	2	3	0
				R577		R576	

This instruction moves the two-byte decimal portion into the accumulator for further operations.

Accumulator				Aux. Accumulator			
4	2	3	0	4	2	3	0
				R577		R576	

Now subtract the °K offset from the accumulator. (The °K offset is 2732, which represents 273.2 °.

Accumulator					Constant			
4	2	3	0	—	2	7	3	2

Accumulator			
1	4	9	8

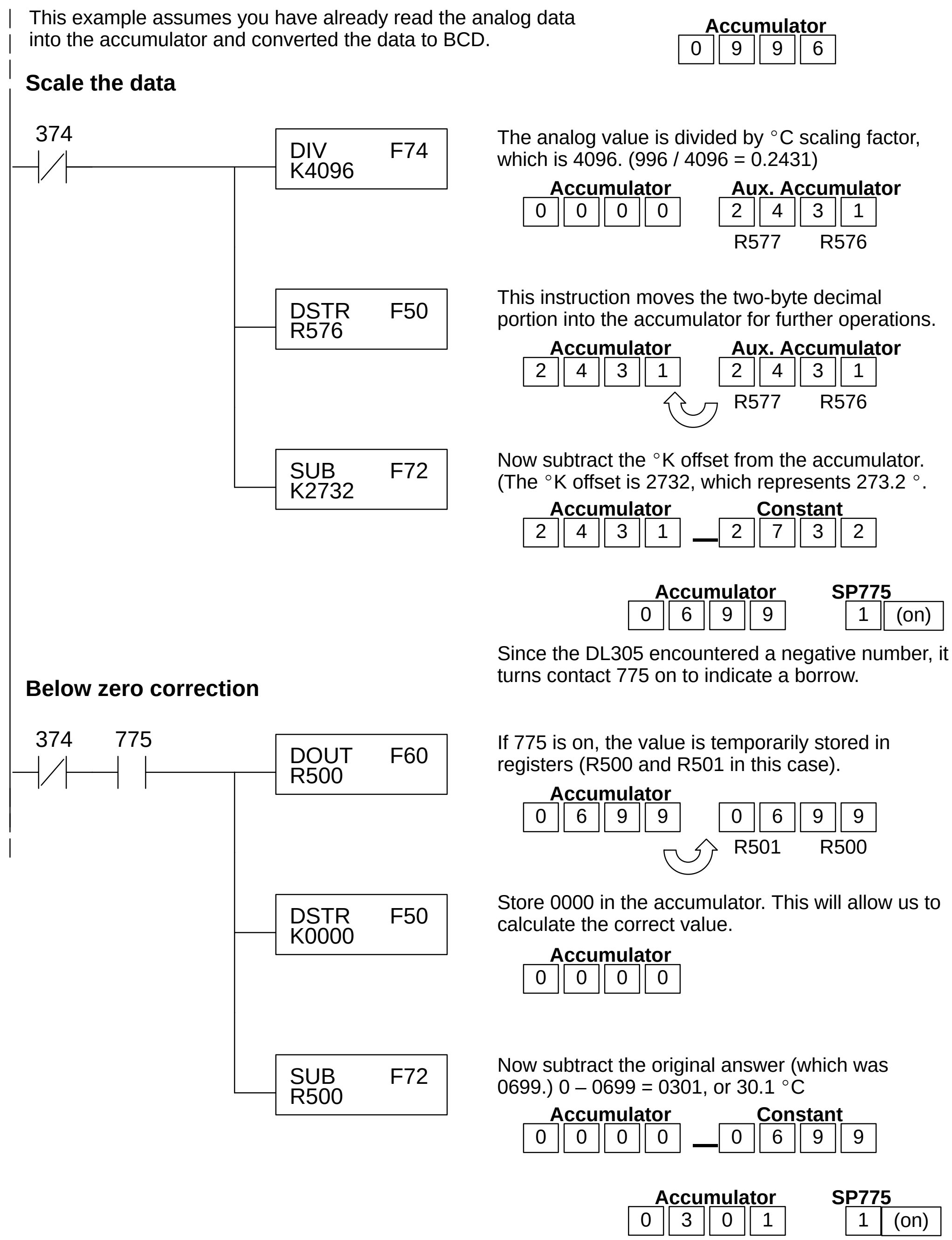
Reading Temperatures Below Zero

You have to perform some additional calculations if the temperature is below zero. Since the DL305 sets a special contact 775 if the subtraction results in a value below zero, you can use this to indicate further calculations are required. The following example shows the scaling and zero indication for a temperature of –30 C.

$$\text{Temp} = 1000\frac{996}{4096} - 273.2$$

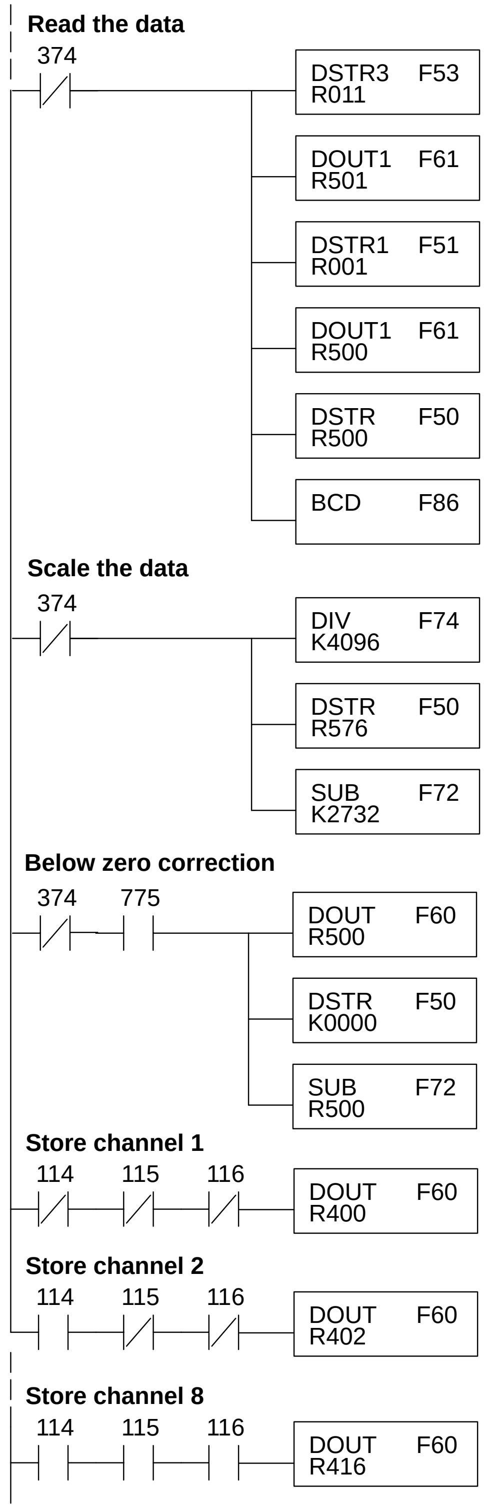
$$\downarrow$$

$$\text{Temp} = -30.0$$



Storing the Temperature

Once you've read the data and converted it to a temperature, you can use the channel selection inputs to store each of the eight channels. Once you've stored the data you can perform data comparisons, additional math, etc.



This rung loads the four data bits into the accumulator from Register 011.

Temporarily store the bits to Register 501.

This rung loads the eight data bits into the accumulator from Register 001.

Temporarily store the bits to Register 500. Since the most significant bits were loaded into 501, now R500 and R501 contain all twelve bits in order.

Now that all the bits are stored, load all twelve bits into the accumulator.

Math operations are performed in BCD. This instruction converts the binary data to BCD. (We'll have to use math to convert the value to a temperature.)

The analog value is divided by °C scaling factor, which is 4096. (1733 / 4096 = 0.4230)

This instruction moves the two-byte decimal portion into the accumulator for further operations.

Now subtract the °K offset from the accumulator. (The °K offset is 2732, which represents 273.2 °.

If 775 is on, the value is temporarily stored in registers (R500 and R501 in this case).

Store 0000 in the accumulator. This will allow us to calculate the correct value.

Now subtract the original answer (which was 0699.) 0 – 0699 = 0301, or 30.1 °C

Use the channel selection bits to determine which channel is active. For example, this rung stores channel 1 temperature in registers 400 and 401.

Writing the Control Program (DL350)

Reading Values: Pointer Method and Multiplexing

There are two methods of reading values for the DL350:

- The pointer method **(all system bases must be D3–xx–1 bases to support the pointer method)**
- Multiplexing

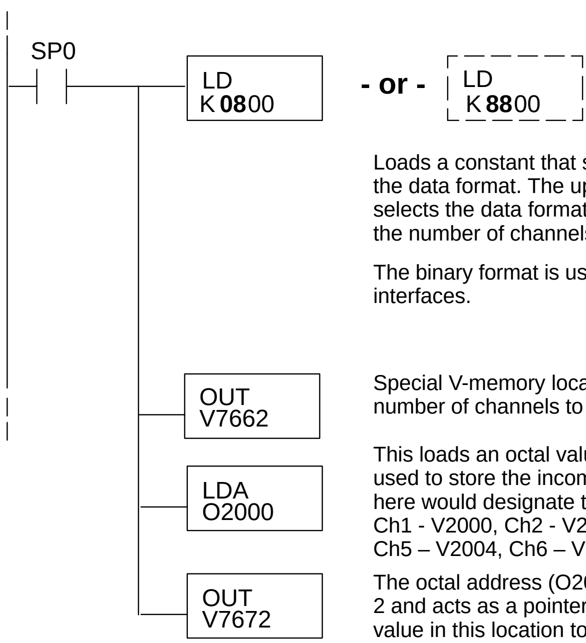
You must use the multiplexing method with remote I/O modules (the pointer method will not work). You can use either method when using DL350, but for ease of programming it is strongly recommended that you use the pointer method.

Pointer Method

The DL350 has special V-memory locations 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 you are using RLL*PLUS* instructions. This is all that is required to read the data into V-memory locations. Once the data is in V-memory, you can perform math on the data, compare the data against preset values, and so forth. V2000 is used in the example, but you can use any user V-memory location. In this example the module is installed in slot 2. You should use the V-memory locations for your module placement.



Loads a constant that specifies the number of channels to scan and the data format. The upper byte, most significant nibble (MSN) selects the data format (i.e. 0=BCD, 8=Binary), the LSN selects the number of channels (i.e. 1, 2, 3, 4, 5, 6, 7, 8).

The binary format is used for displaying data on some operator interfaces.

Special V-memory location assigned to slot 2 that contains the number of channels to scan.

This loads an octal value for the first V-memory location that will be used to store the incoming data. For example, the O2000 entered here would designate the following addresses.
Ch1 - V2000, Ch2 - V2001, Ch3 - V2002, Ch4 - V2003,
Ch5 – V2004, Ch6 – V2005, Ch7 – V2006, Ch8 – V2007

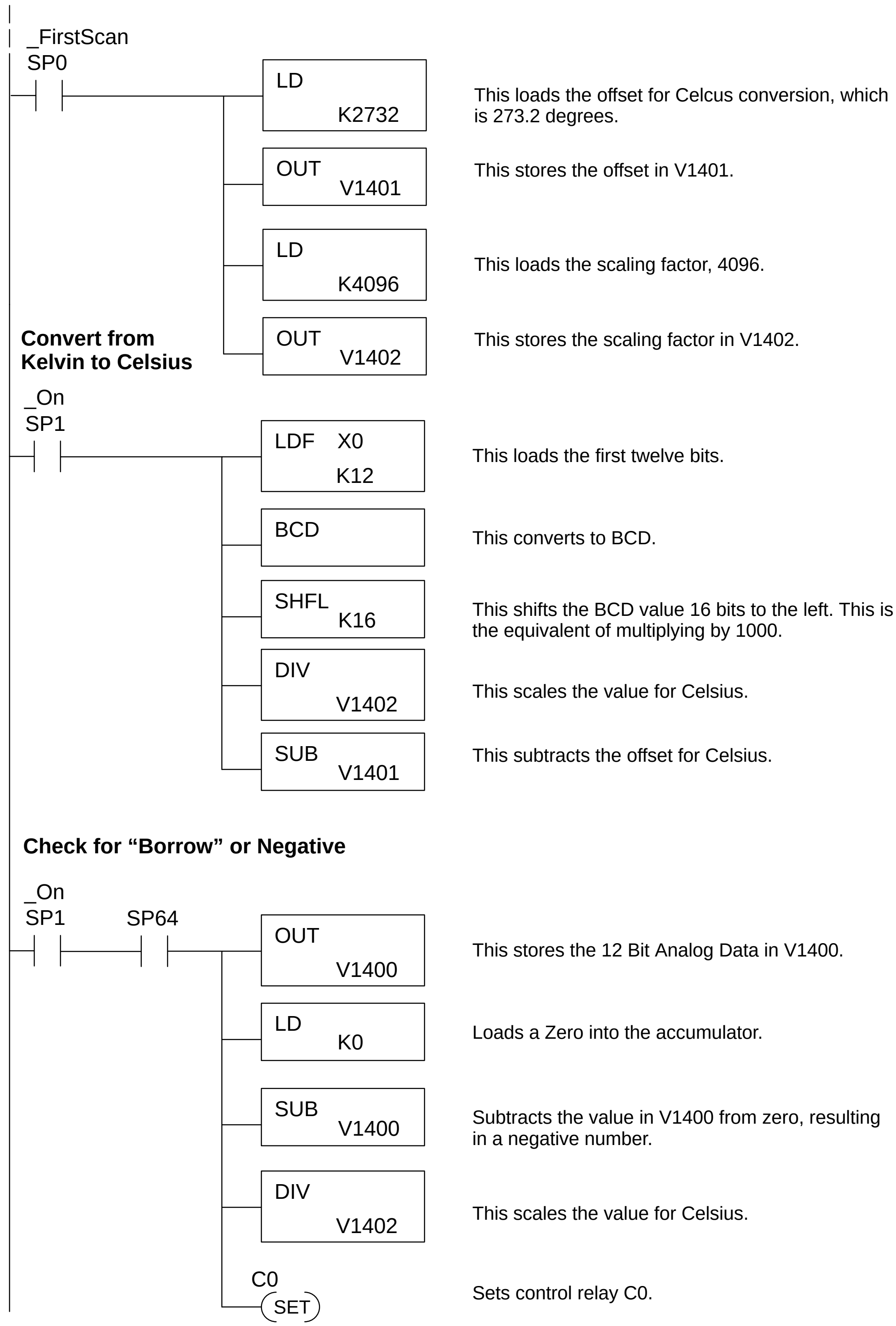
The octal address (O2000) is stored here. V7672 is assigned to slot 2 and acts as a pointer, which means the CPU will use the octal value in this location to determine exactly where to store the incoming data.

The table shows the special V-memory locations used with the DL350. Slot 0 (zero) is the module next to the CPU, slot 1 is the module two places from the CPU, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. The pointer method is supported on expansion bases up to a total of 8 slots away from the DL350 CPU. The pointer method is not supported in slot 8 of a 10 slot 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

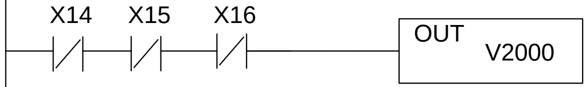
Multiplexing: DL350 with a D3–XX–1 Base

The example below shows how to read an Analog Devices AD590 temperature transducer on an F3–08TEMP Temperature Input module in the X0 address of the D3–xx–1 Base. If any expansion bases are used in the system, they must all be D3–xx–1 to be able to use this example. Otherwise, the conventional base addressing must be used.



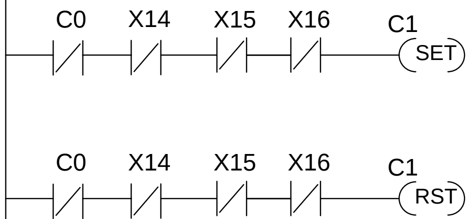
When the appropriate channel select bits are turned on, the converted analog data is then stored in V-memory locations, starting with V2000 (for channel 1).

Channel 1 Select Bit States



This writes channel one data to V2000 when bits X14, X15 and X16 are as shown.

The negative indicator bit

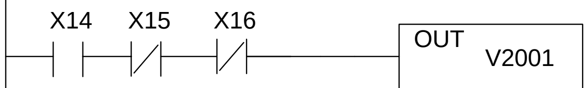


These two rungs control the negative indicator bit. When the channels select bits are true for a particular channel and C0 is on, the negative bit for that channel is set. When the temperature goes above 0 Celsius, the bit is reset.

Notice that this only applies to Channels 1.

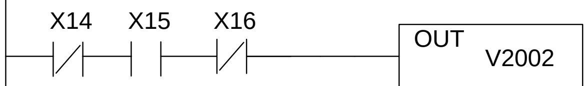
The remaining channels are shown below, without covering the negative bit logic.

Channel 2 Select Bit States

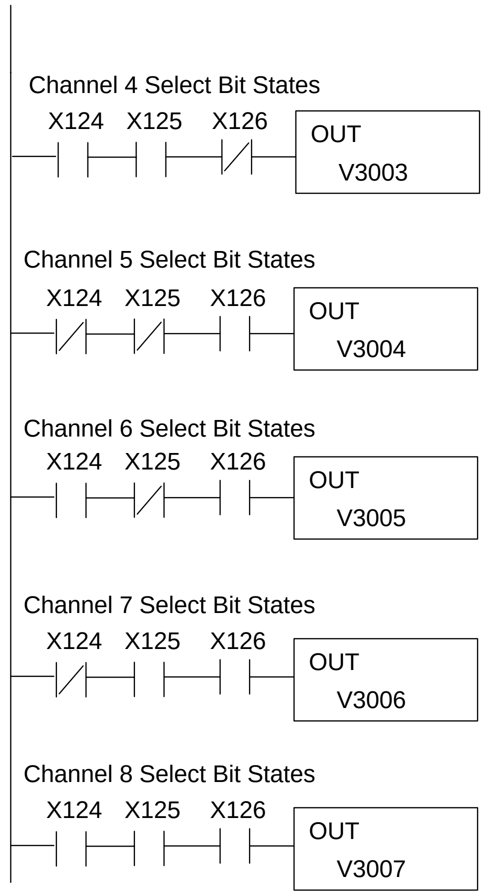


This writes channel two data to V2001 when bits X14, X15 and X16 are as shown.

Channel 3 Select Bit States



This writes channel three data to V2002 when bits X14, X15 and X16 are as shown.



This writes channel four analog data to V3003 when bits X124, X125 and X126 are as shown.

This writes channel five analog data to V3004 when bits X124, X125 and X126 are as shown.

This writes channel six analog data to V3005 when bits X124, X125 and X126 are as shown.

This writes channel seven analog data to V3006 when bits X124, X125 and X126 are as shown.

This writes channel eight analog data to V3007 when bits X124, X125 and X126 are as shown.

Temperature and Digital Value Conversions

Sometimes it is helpful to be able to quickly convert between the signal levels and the digital values. This is especially helpful during machine startup or troubleshooting. The following table provides formulas to make this conversion easier.

Range	If you know the digital value ...	If you know the temperature ...
–55 to150 °C	$T = \frac{1000D}{4095} - 273.2$	$D = \frac{4095}{1000}(T + 273.2)$
–67 to 302 °F	$T = \frac{1000D}{2276} - 459.6$	$D = \frac{2276}{1000}(T + 459.6)$

For example, if you have measured the temperature at 30 °C, you would use the following formula to determine the digital value that should be stored in the register location that contains the temperature.

$$D = \frac{4095}{1000}(T + 273.2)$$

$$D = \frac{4095}{1000}(30 + 273.2)$$

$$D = (4.095)\ (303.2)$$

$$D = 1241$$