



# Errata Sheet

This Errata Sheet contains corrections or changes made after the publication of this manual.

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|                          |                            |              |                |
|--------------------------|----------------------------|--------------|----------------|
| <b>Product Family:</b>   | DL305                      | <b>Date:</b> | September 2018 |
| <b>Manual Number</b>     | D3-ANLG-M                  |              |                |
| <b>Revision and Date</b> | 3rd Edition, February 2003 |              |                |

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## Changes to Chapter 2. D3-04AD 4-Channel Analog Input

*This module is no longer available. Please consider the F3-08AD-1 or F3-04ADS as a replacement*

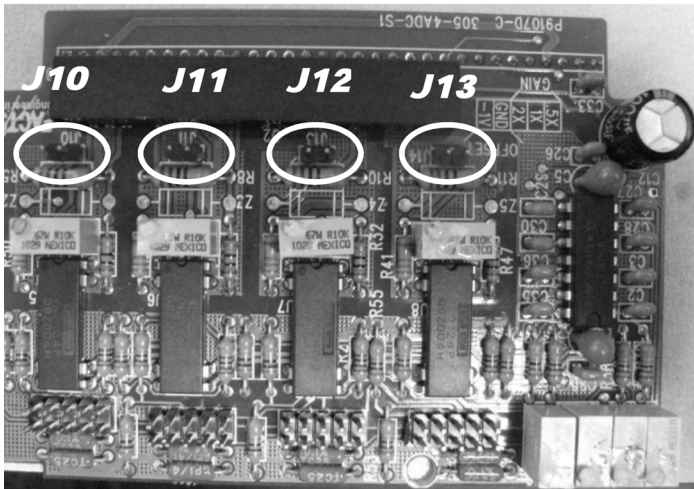
## Changes to Chapter 3. F3-04ADS 4-Channel Isolated Analog Input

Page 3-3. Setting the Module Jumpers; Jumper Locations

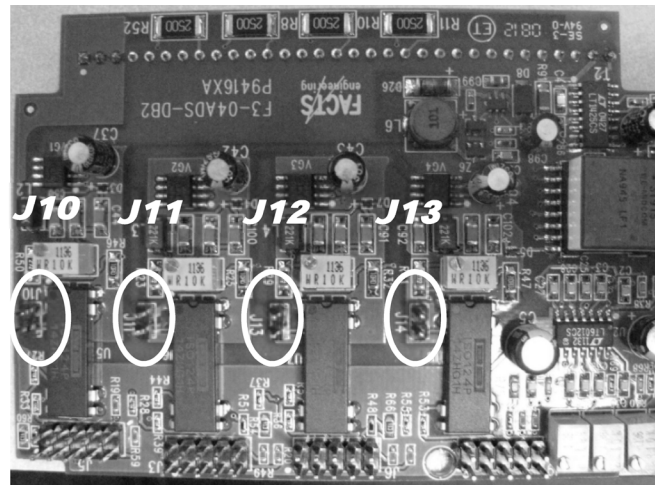
*The PC board was redesigned and the locations of jumpers J10, J11, J12, and J13 changed. The jumpers were rotated 90 degrees and are closer to the back of the module than the original layout. The functionality of the jumpers did not change. The orientation of the 5 pairs of pins for each channel is the same.*

The photo on the right shows the new design, while the one on the left shows the original PC board. The photo on the left matches the drawing shown on page 3-3. The redesigned PC boards are in modules manufactured starting in mid-2012.0

**Original PC Board Layout  
(Manufactured prior to mid-2012)**



**Redesigned PC Board Layout  
(Manufactured after mid-2012)**





# Errata Sheet

## Changes to Chapter 5. F3-16AD 16-Channel Analog Input

Page 5-9. Wiring Diagram

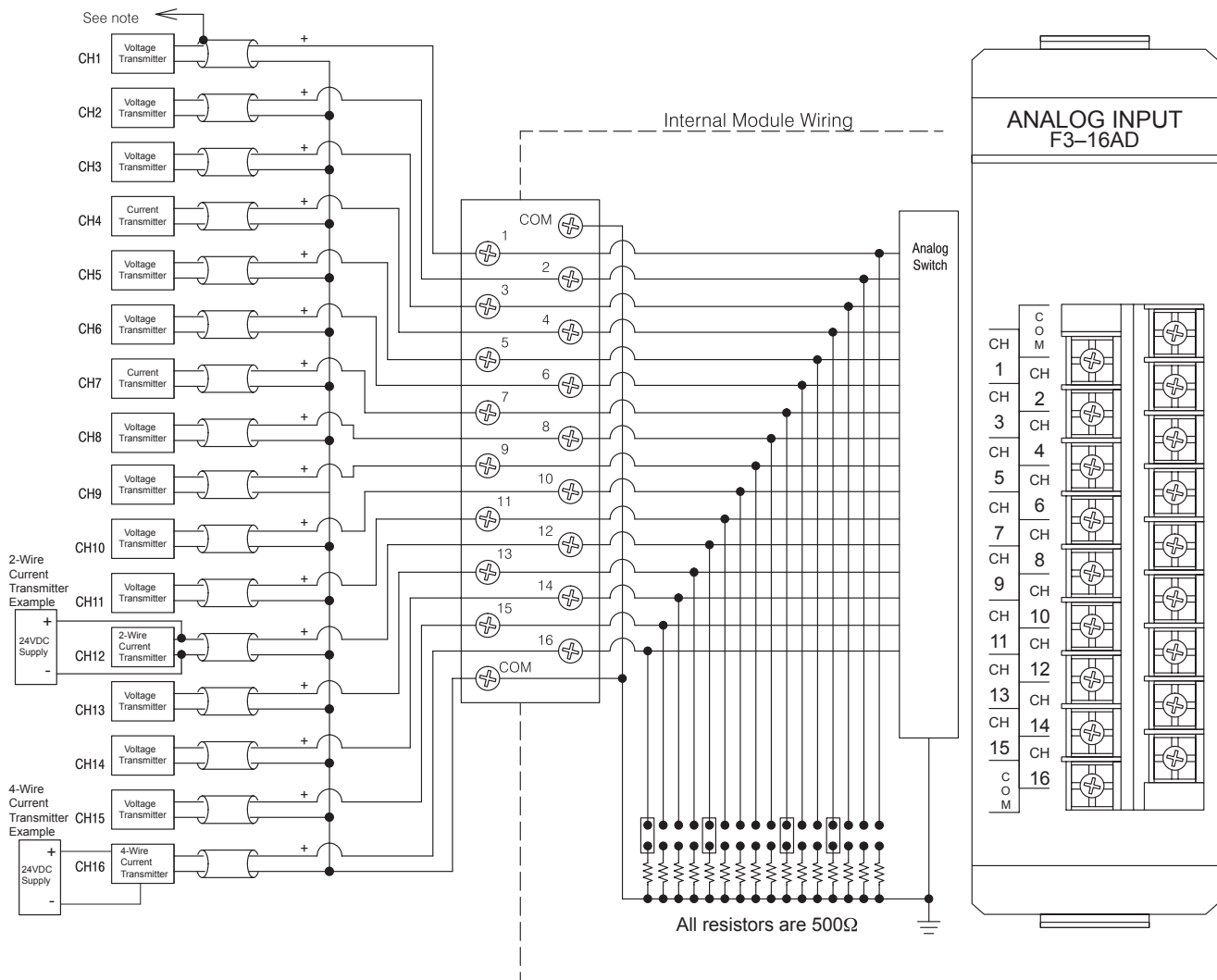
The wiring diagram shows "current transmitters" CH 4, 7, 12, and 16. The diagram should show external 24VDC power supplies for these current transmitters. A 2-wire current transmitter example of this has been added to the diagram below for CH12.

Also, CH16 has been changed to show a 4-wire current transmitter example.

### Wiring Diagram

Note 1: Terminate all shields at their respective signal source.

Note 2: Jumpers for CH4, 7, 12 and 16 are installed for current input.



DL305  
Analog I/O Modules

Manual Number D3-ANLG-M



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# Manual Revisions

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*If you contact us in reference to this manual, be sure to include the revision number.*

**Title:** DL305 Analog I/O Modules, 2nd Edition, Rev. D

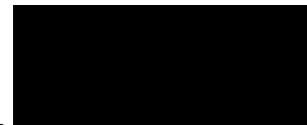
**Manual Number:** D3-ANLG-M

| Issue       | Date  | Description of Changes  |
|-------------|-------|---|
| Original    | 1/94  | Original Issue  |
| 2nd Edition | 3/96  | Corrections   |
| Rev. A      | 4/96  | Minor corrections   |
| Rev. B      | 6/98  | Downsized to spiral<br>Corrected sequencing examples            |
| Rev. C      | 11/99 | Added example programs for the D3-350 CPU.                      |
| 3rd Edition | 2/03  | Added pointer method and additional D3-350 programming examples |



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## Appendix A: DL305 Data Types and Memory Map

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# Getting Started

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In This Chapter. . . .

- Introduction
  - Physical Characteristics
  - Analog Input Terminology
  - Analog Output Module Terminology
  - Selecting the Appropriate Module
  - Analog Made Easy - Four Simple Steps
-

## Introduction

**Purpose of this manual** This manual will show you how to select and install analog input and analog output modules. It also shows several ways to use the analog data in your PLC program.

**Who should read this manual** If you understand the DL305 and DL350 instruction sets and system setup requirements, this manual will provide all the information you need to install and use the analog modules. This manual *is not* intended to be a tutorial on analog signal theory, but rather, a user reference manual for the DL305 Analog I/O modules.

**Supplemental Manuals** If you have purchased operator interfaces or **DirectSOFT™**, you will need to supplement this manual with the manuals that are written for these products.

**Technical Support** We realize that even though we strive to be the best, the information may be arranged in such a way you cannot find what you are looking for. First, check these resources for help in locating the information:

- **Table of Contents** – chapter and section listing of contents, in the front of this manual
- **Quick Guide to Contents** – chapter summary listing on the next page
- **Appendices** – reference material for key topics, near the end of this manual
- **Index** – alphabetical listing of key words, at the end of this manual

You can also check our online resources for the latest product support information:

- **Internet** – the address of our Web site is <http://www.plcdirect.com>
- **Bulletin Board Service(BBS)** – call (770)–844–4209

If you still need assistance, please call us at 800–633–0405. Our technical support group is glad to work with you in answering your questions. They are available Monday through Friday from 9:00 A.M. to 6:00 P.M. Eastern Standard Time. If you have a comment or question about any of our products, services, or manuals, please fill out and return the 'Suggestions' card that was shipped with this manual.



**Chapters**

The main contents of this manual are organized into the following nine chapters:

**1****Getting Started**

introduces the various DL305 Analog modules. Also includes tips on getting started and how to design a successful system.

**2****D3-04AD**

explains the 4 channel analog input module. Provides ladder logic examples for all bases and CPUs.

**3****F3-04ADS**

explains the 4 channel isolated analog input module. Provides ladder logic examples for all bases and CPUs.

**4****F3-08AD**

explains the 8 channel analog input module. Provides ladder logic examples for all bases and CPUs.

**5****F3-16AD**

explains the 16 channel analog input module. Provides ladder logic examples for all bases and CPUs.

**6****D3-02DA**

explains the 2 channel analog output module. Provides ladder logic examples for all bases and CPUs.

**7****F3-04DA-1**

explains the 4 channel analog output module. Provides ladder logic examples for all bases and CPUs.

**8****F3-04DAS**

explains the 4 channel isolated analog output module. Provides ladder logic examples for all bases and CPUs.

**9****F3-08THM-n**

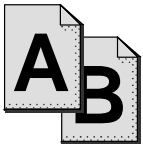
explains the 8 channel Thermocouple input module. Provides ladder logic examples for all bases and CPUs.

**10****F3-08TEMP**

explains the 8 channel temperature input module. Provides ladder logic examples for all bases and CPUs.

**Appendices**

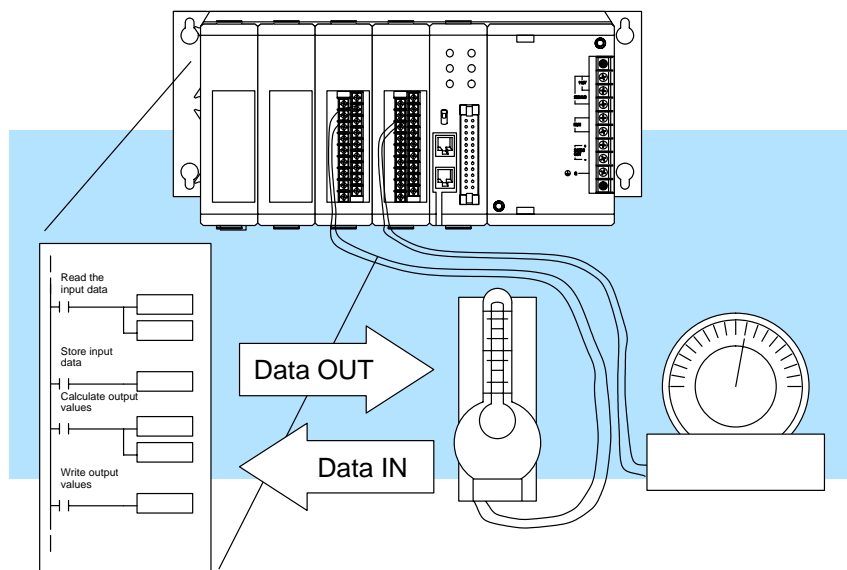
Additional reference information on the DL305 analog modules is in the following five appendices:

**Reference Appendices**

- **A** – DL305C Data Types and Memory Map
- **B** – DL350 Data Types and Memory Map

## DL305 Analog Components

There are a wide variety of Analog I/O modules available for use with the DL305 family of automation products. These modules are well suited for monitoring and controlling various types of analog signals such as pressure, temperature, etc. There are modules specifically designed for thermocouple and temperature input requirements. No complex programming or module setup software is required. Simply install the module, add a few lines to your RLL program, and you're ready!



### DL305 Analog I/O

The following is a list of the types of analog input and analog output modules that are available.

- D3-04AD — 4 channel input, 8-bit resolution
- F3-04ADS — 4 channel isolated input, 12-bit resolution
- F3-08AD — 8 channel input, 12-bit resolution
- F3-16AD — 16 channel input, 12-bit resolution
- D3-02DA — 2 channel output, 8-bit resolution
- F3-04DA-1 — 4 channel output, 12-bit resolution
- F3-04DAS — 4 channel isolated output, 12-bit resolution

### Thermocouple Input

There is also an 8 channel thermocouple input module that converts type E, J, K, R, S, or T thermocouple signals into direct temperature readings. This module can also convert other types of low-level (millivolt range) signals into digital values. The part number for this module is F3-08THM-n, where n is the type of thermocouple. If you want a millivolt input version, simply replace n with a 1 (0-50 mV) or a 2 (0-100mV). All versions offer 12-bit resolution.

### Temperature Input

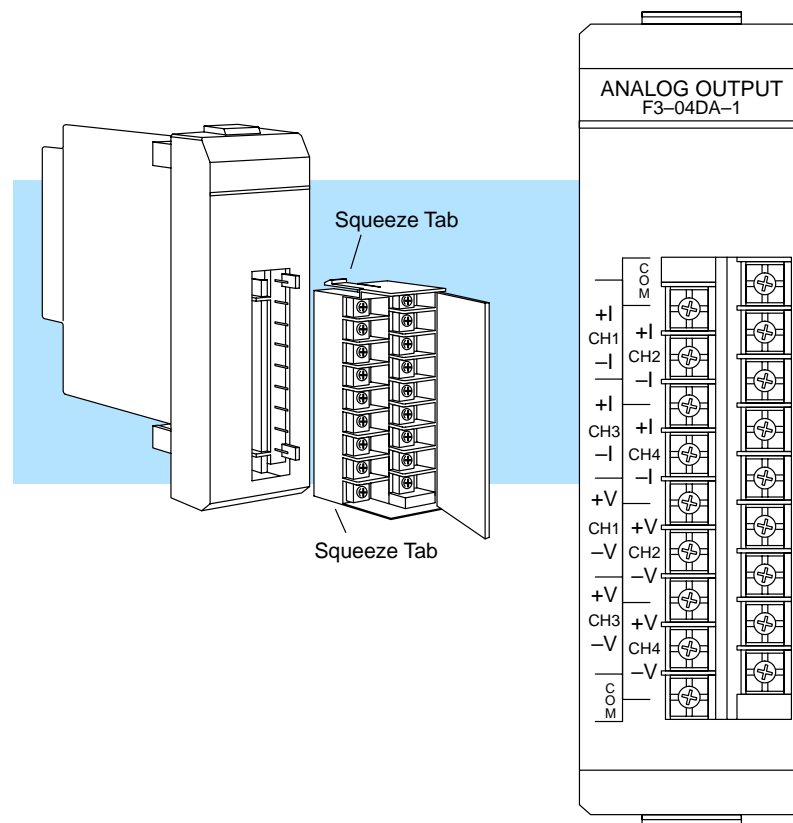
The Temperature Input module provides 8 channels for direct temperature measurement in either Celsius or Fahrenheit from  $-55^{\circ}$  to  $150^{\circ}$  C. Order part number F3-08TEMP. This module offers 12-bit resolution.

## Physical Characteristics

The DL305 Analog Modules provide many features that make the modules easier to use. For example, the terminal block can be removed making wiring a simple task. You can also use our **DIN**ector product line to organize your wiring even further (see our catalog for details).

Some of the modules provide LEDs used to determine the signal level. Since there are not enough LEDs to show all of the channels at once, there is a small switch underneath the terminal cover that allows you to select the channel for monitoring. Not all of the modules have this feature.

Most of the modules also have jumpers that can be set to select between the various types of signals. Each chapter will show how to set these jumpers for the selections you need.



## Selecting the Appropriate Module

The following tables provide a condensed version of the information you need to select the appropriate module. The most important thing is to simply determine the number of channels required and the signal ranges that must be supported. Once you've determined these parameters, look in the specific chapter for the selected module to determine the installation and operation requirements.

### Analog Input

| Specification                       | D3-04AD                   | F3-04ADS   | F3-08AD                   | F3-16AD   |
|-------------------------------------|---------------------------|--|---------------------------|---|
| Channels                            | 4                         | 4  | 8                         | 16  |
| Input Ranges                        | 1 – 5V<br>4 – 20 mA       | 0 – 5V<br>1 – 5V<br>0 – 10V<br>± 5V<br>± 10V<br>0 – 20mA<br>4 – 20mA | 4 – 20mA                  | 0 – 5V<br>1 – 5V<br>0 – 10V<br>± 5V<br>± 10V<br>0 – 20mA<br>4 – 20mA <sup>1</sup> |
| Resolution                          | 8 bit (1 in 256)          | 12 bit (1 in 4096)   | 12 bit (1 in 4096)        | 12 bit (1 in 4096)  |
| Channel Isolation                   | Non-isolated (one common) | Isolated   | Non-isolated (one common) | Non-isolated (one common)   |
| Input Type                          | Differential              | Differential   | Single ended              | Single ended  |
| Maximum Inaccuracy at 77 °F (25 °C) | 1%                        | ± 0.3%   | 0.35%                     | 0.25% voltage<br>1.25% current  |
| See Chapter . . .                   | 2                         | 3  | 4                         | 5   |

<sup>1</sup> – resolution is reduced with 4–20 mA signals. You should use the F3-08AD if the primary application requires 4–20 mA signals.

## Analog Output

| Specification                       | D3-02DA                      | FACTS F3-04DA-1                           | FACTS F3-04DAS                                 |
|-------------------------------------|------------------------------|---|--|
| Channels                            | 2                            | 4   | 4  |
| Output Ranges                       | 1 – 10VDC<br>4 – 20 mA       | 0 – 5V<br>0 – 10V<br>4 – 12mA<br>4 – 20mA | 0 – 5V<br>0 – 10V<br>± 5V<br>± 10V<br>4 – 20mA |
| Resolution                          | 8 bit (1 in 256)             | 12 bit (1 in 4096)                        | 12 bit (1 in 4096)                             |
| Channel Isolation                   | Non-isolated<br>(one common) | Non-isolated<br>(one common)              | Isolated                                       |
| Output Type                         | Single ended                 | Single ended                              | Differential                                   |
| Maximum Inaccuracy at 77 °F (25 °C) | ± 0.4%                       | ± 0.2% voltage<br>± 0.6% current          | ± 0.8%   |
| See Chapter . . . .                 | 6                            | 7   | 8  |

## Special Input

| Specification                       | F3-08TEMP                    | FACTS F4-04DA   |
|-------------------------------------|------------------------------|---|
| Channels                            | 8, Temperature Input         | 8, Thermocouple Input   |
| Input Ranges                        | 0 – 1mA<br>AD590 input types | E: –270/1000 °C, –450/1832 °F<br>J: –210/760 °C, –350/1390 °F<br>K: –270/1370 °C, –450/2500 °F<br>R: 0/1768 °C, –32/3214 °F<br>S: 0/1768 °C, –32/3214 °F<br>T: –270/400 °C, –450/752 °F<br>50mV: 0 – 50 mV<br>100mV: 0–100 mV |
| Resolution                          | 12 bit (1 in 4096)           | 12 bit (1 in 4096)  |
| Channel Isolation                   | Non-isolated                 | Non-isolated  |
| Input Type                          | Single ended                 | Differential  |
| Maximum Inaccuracy at 77 °F (25 °C) | 0.25%                        | 0.35%   |
| See Chapter . . . .                 | 10                           | 9   |

# Analog Made Easy – Four Simple Steps

Once you've selected the appropriate module, use the chapter that describes the module and complete the following steps.

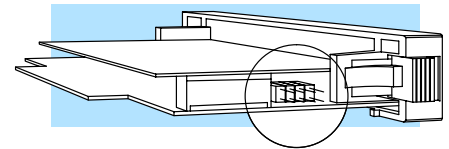
**STEP 1.** Take a minute to review the detailed specifications to make sure the module meets your application requirements.

|                      |  |                       |                                |
|----------------------|--|-----------------------|--------------------------------|
| Channels per module  | 4  | Base power required   | 9VDC @ 144mA<br>24VDC @ 108 mA |
| Output Ranges        | 0 to 5V, 0 to 10V,<br>4 to 120mA, 4 to 20 mA<br>Source | External power source | None                           |
| Resolution           | 12 bit (1/4096)  | Operating temperature | 0-60 deg. C<br>32-140 deg. F   |
| Output current       | 5mA (source)<br>2.5mA (sink)<br>(voltage output)       | Relative Humidity     | 5 to 95% noncond.              |
| Output impedance     | 0.5 ohm<br>(voltage output)                            | Weight                | 6.3 oz. (180 g)                |
| External resistance  | 1k ohm max (current)<br>2k ohm min (voltage)           | Terminal Type         | Removable                      |
| Conversion time      | 50 microseconds max                                    | LED Display           | 777777777777                   |
| Accuracy             | ???????????????  |                       |                                |
| Accuracy/temperature | ±1-50 PPM per deg. C                                   |                       |                                |
| 11C points required  | 16 Outputs   |                       |                                |

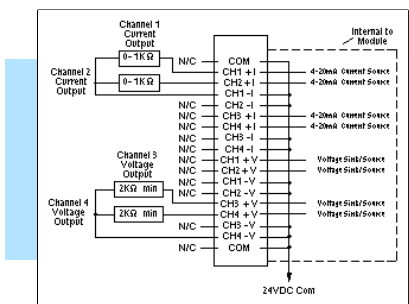
**STEP 2.** Set the module switches and/or jumpers to select:

- number of channels
- the operating ranges (voltage or current)

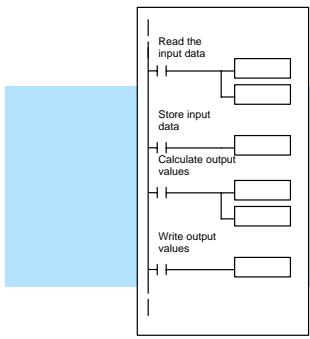
Note, some of the modules may not have switches.



**STEP 3.** Connect the field wiring to the module connector.



**STEP 4.** Review the module operating characteristics and write the control program.



## Analog Input Terminology

We use several different terms throughout the rest of this manual. You don't have to be an expert on analog terms to use the products, but it may help make it easier to select the appropriate modules if you take a few minutes to review these definitions.

|  |   |
|--|---|
| <b>Channels per Module</b>                                     | The number of analog channels or points available in the module to connect to field devices.  |
| <b>Input Ranges</b>  | The input ranges in voltage and/or current that the module will operate properly within.  |
| <b>Resolution</b>  | The number of binary weighted bits available on the digital side of the module for use in converting the analog value to a digital value.                               |
| <b>Input Type</b>  | Specifies if the module accepts single ended, bipolar or differential input signals.  |
| <b>Input Impedance</b>   | The input impedance of the module using a voltage or current input signal.  |
| <b>Conversion Method</b>                                       | The method the module uses to convert the analog signal to a digital value.   |
| <b>Conversion Time</b>   | The amount of time required to complete the analog to digital conversion.   |
| <b>Linearity Error and Total Tolerance (Relative Accuracy)</b> | The linearity and accuracy of the digital representation over the entire input range.   |
| <b>Accuracy vs. Temperature</b>                                | The effect of temperature on the accuracy of the module.  |
| <b>LED Display</b>   | LED indicators on the module  |
| <b>I/O Points Required</b>                                     | The number of I/O points the CPU must dedicate to the module.   |
| <b>External Power Source</b>                                   | Some modules require a separate 24VDC power source. The 24VDC output supply at the local or expansion base can be used as long as you do not exceed the current rating. |
| <b>Base Power Required</b>                                     | The amount of base current required by the module. Use this value in your power budget calculations.  |
| <b>Operating Temperature</b>                                   | The minimum and maximum temperatures the module will operate.   |
| <b>Relative Humidity</b>                                       | The minimum and maximum humidity the module will operate.   |
| <b>Terminal Type</b>   | Indicates whether the terminal type is a removable or non-removable connector or a terminal.  |
| <b>Weight</b>  | The weight of the module.   |

## Analog Output Module Terminology

|                                 |   |
|---------------------------------|---|
| <b>Channels per Module</b>      | The number of analog channels or points available in the module to connect to field devices.  |
| <b>Output Ranges</b>            | The output ranges in voltage and/or current modes the module will operate properly within.  |
| <b>Resolution</b>               | The number of binary weighted bits available on the digital side of the module for use in converting the digital value to an analog signal.                             |
| <b>Output Current</b>           | The maximum current the module will drive using a voltage output signal.  |
| <b>Output Impedance</b>         | The output impedance of the module using a voltage output signal.   |
| <b>Load Impedance</b>           | The minimum and maximum resistance the module can drive using a current output signal.  |
| <b>Conversion Time</b>          | The amount of time required to complete the digital to analog conversion.   |
| <b>Accuracy</b>                 | The linearity and calibrated accuracy of the digital representation over the entire output range.   |
| <b>Accuracy vs. Temperature</b> | The effect of temperature on the accuracy of the module.  |
| <b>LED Display</b>              | LED indicators on the module  |
| <b>External Power Source</b>    | Some modules require a separate 24VDC power source. The 24VDC output supply at the local or expansion base can be used as long as you do not exceed the current rating. |
| <b>Base Power Required</b>      | The amount of base current required by the module. Use this value in your power budget calculations.  |
| <b>Operating Temperature</b>    | The minimum and maximum temperatures the module will operate.   |
| <b>Relative Humidity</b>        | The minimum and maximum humidity the module will operate.   |
| <b>Terminal Type</b>            | Indicates whether the terminal type is a removable or non-removable connector or a terminal.  |
| <b>Weight</b>                   | The weight of the module.   |
| <b>I/O Points Required</b>      | The number of I/O points the CPU must dedicate to the module.   |



# D3-04AD 4-Channel Analog Input

---

*This module is no longer available. Please consider the F3-08AD-1 or F3-04ADS as a replacement.*

## In This Chapter. . . .

- Module Specifications
  - Setting the Module Jumpers
  - Connecting the Field Wiring
  - Module Operation
  - Writing the Control Program
-

## Module Specifications

The following table provides the specifications for the D3-04AD Analog Input Module. Review these specifications to make sure the module meets your application requirements.

|                          |   |
|--------------------------|---|
| Number of Channels       | 4   |
| Input Ranges             | 1 – 5V, 4 – 20 mA   |
| Resolution               | 8 bit (1 in 256)  |
| Channel Isolation        | Non-isolated (one common)   |
| Input Type               | Differential or Single ended  |
| Input Impedance          | 1 M $\Omega$ minimum, voltage<br>250 $\Omega$ current                 |
| Absolute Maximum Ratings | 0 – +10V maximum, voltage<br>0 – 30 mA maximum, current               |
| Linearity                | $\pm 0.8\%$ maximum   |
| Accuracy vs. Temperature | $\pm 70$ ppm / $^{\circ}\text{C}$ maximum                             |
| Maximum Inaccuracy       | 1% maximum at 25 $^{\circ}\text{C}$                                   |
| Conversion Method        | Sequential comparison   |
| Conversion Time          | 2 ms maximum  |
| Power Budget Requirement | 55 mA @ 9V  |
| External Power Supply    | 24 VDC, $\pm 10\%$ , 65 mA, class 2                                   |
| Operating Temperature    | 32 $^{\circ}$ to 140 $^{\circ}$ F (0 $^{\circ}$ to 60 $^{\circ}$ C)   |
| Storage Temperature      | -4 $^{\circ}$ to 158 $^{\circ}$ F (-20 $^{\circ}$ to 70 $^{\circ}$ 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   |
| Noise Rejection Ratio    | Normal mode: -6 dB/250Hz<br>Common mode: 60dB/60Hz (-5 to 10V)        |

### Analog Input Configuration Requirements

The D3-04AD Analog 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:

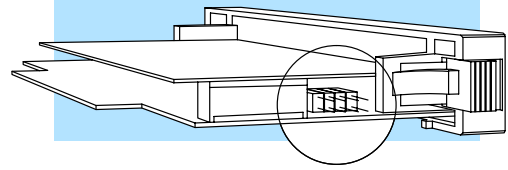
- For local and expansion systems, the available power budget and 16-point module usage are the limiting factors.

## Setting the Module Jumpers

There are four jumpers located on the module that select between 1–5V and 4–20 mA signals. The module is shipped from the factory for use with 1–5V signals.

If you want to use 4 – 20 mA signals, you have to install a jumper. No jumper is required for 1 – 5V operation. Each channel range may be selected independently of the others.

| Range     | Jumper    |
|-----------|-----------|
| 1 – 5V    | Removed   |
| 4 – 20 mA | Installed |



## Connecting the Field Wiring

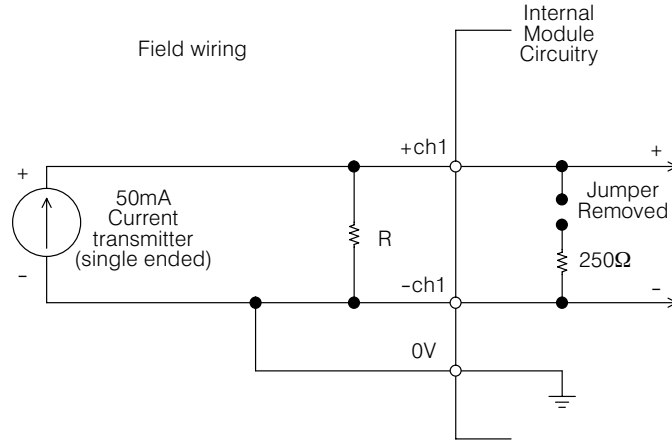
**Wiring Guidelines** Your company may have guidelines for wiring and cable installation. If so, you should check those before you begin the installation. Here are some general things to consider.

- 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 D3-04AD requires a separate power supply. The DL305 bases have built-in 24 VDC power supplies that provide up to 100 mA of current. If you only have one analog module, you can use this power source instead of a separate supply. If you have more than two analog modules, or you would rather use a separate supply, choose one that meets the following requirements: 24 VDC  $\pm$  10%, Class 2, 65mA current (or greater, depending on the number of modules being used.)

### Custom Input Ranges

Occasionally you may have the need to connect a transmitter with an unusual signal range. By changing the wiring slightly and adding an external resistor to convert the current to voltage, you can easily adapt this module to meet the specifications for a transmitter that does not adhere to one of the standard input ranges. The following diagram shows how this works.



$$R = \frac{V_{\max}}{I_{\max}}$$

R = value of external resistor

$V_{\max}$  = high limit of selected voltage range

$I_{\max}$  = maximum current supplied by the transmitter

---

Example: current transmitter capable of 50mA, 1 - 5V range selected.

$$R = \frac{5V}{50mA} \quad R = 100 \text{ ohms}$$

---

**NOTE:** Your choice of resistor can affect the accuracy of the module. A resistor that has  $\pm 0.1\%$  tolerance and a  $\pm 50\text{ppm} / ^\circ\text{C}$  temperature coefficient is recommended.

---

### Current Loop Transmitter Impedance

Standard 4 to 20 mA transmitters and transducers can operate from a wide variety of power supplies. Not all transmitters are alike and the manufacturers often specify a minimum loop or load resistance that must be used with the transmitter.

The D3-04AD provides 250 ohm resistance for each channel. If your transmitter requires a load resistance below 250 ohms, then you do not have to make any adjustments. However, if your transmitter requires a load resistance higher than 250 ohms, then you need to add a resistor in series with the module.

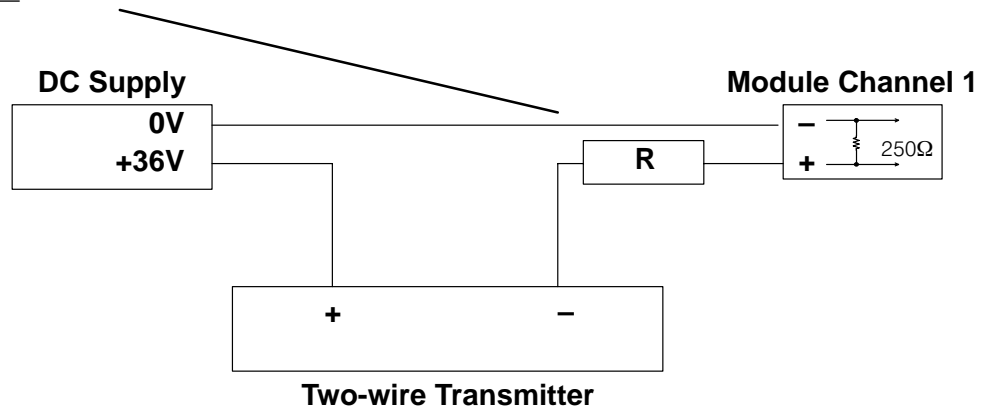
Consider the following example for a transmitter being operated from a 36 VDC supply with a recommended load resistance of 750 ohms. Since the module has a 250 ohm resistor, you need to add an additional resistor.

$$R = Tr - Mr$$

$$R = 750 - 250$$

$$R \geq 500$$

$R$  – Resistor to add  
 $Tr$  – Transmitter Requirement  
 $Mr$  – Module resistance (internal 250 ohms)



**Removable Connector**

The D3-04AD module has a removable connector to make wiring easier. Simply squeeze the tabs on the top and bottom and gently pull the connector from the module.

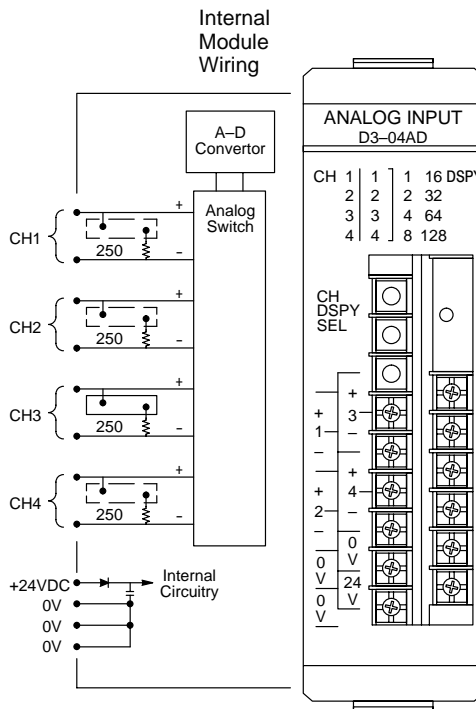
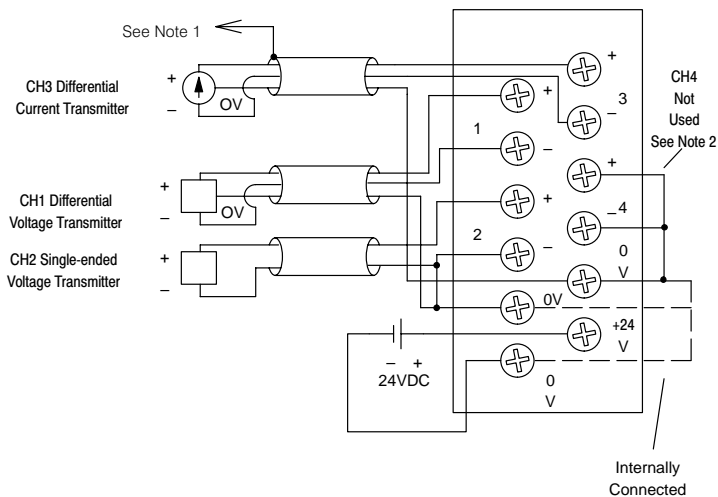
**Wiring Diagram**

Note 1: Terminate all shields of the cable at their respective signal source.

Note 2: Unused channels should be shorted to 0V or have the Jumper installed for current input for best noise immunity.

Note 3: When a differential input is is not used 0V should be connected to the - of that channel.

D3-04AD  
4-Channel Analog Input



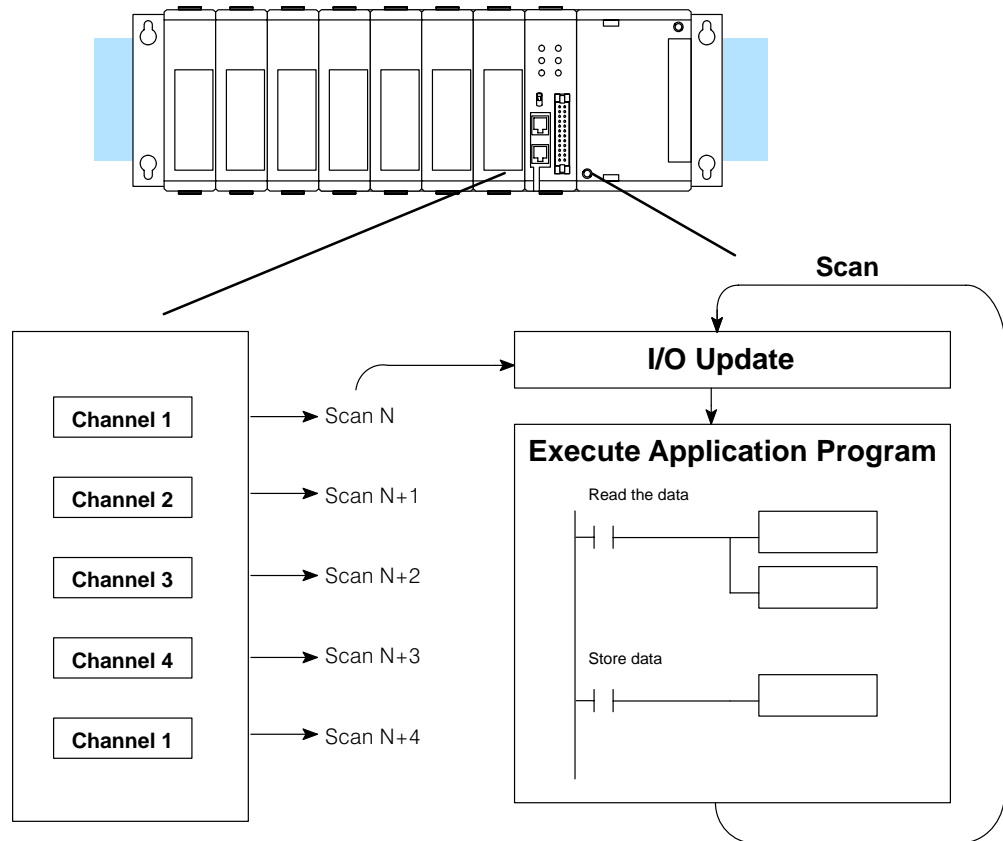
# Module Operation

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 D3-04AD module supplies 1 channel of data per each 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.

You do not have to select all of the channels. Unused channels are not processed, so if you select only two channels, then each channel will be updated every other scan.



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 8-bit binary representation. This enables the module to continuously provide accurate measurements without slowing down the discrete control logic in the RLL program.

D3-04AD  
4-Channel Analog Input

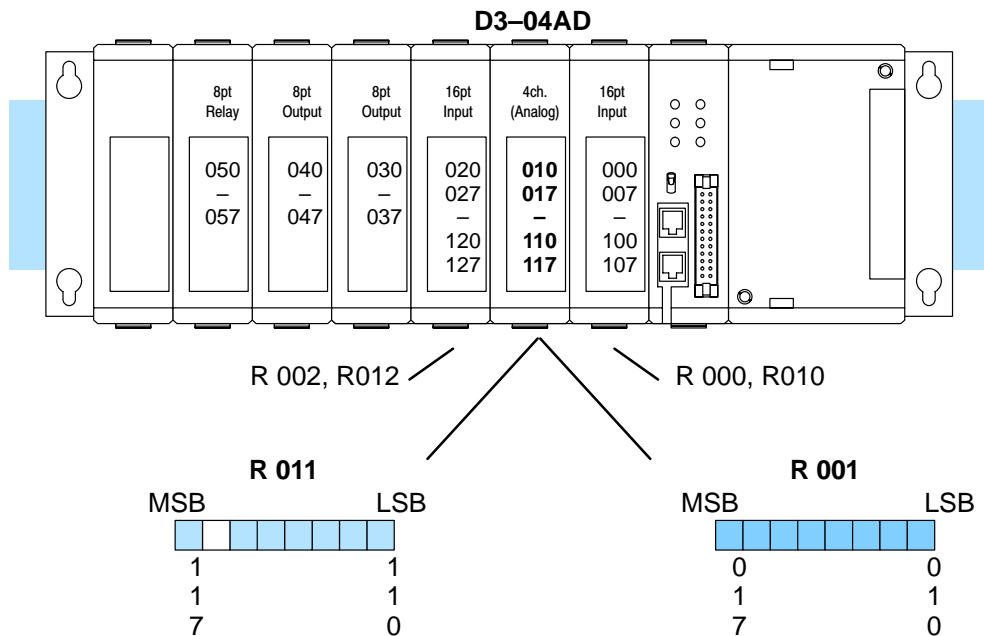
**Understanding the I/O Assignments**

You may recall the D3-04AD module appears to the CPU as a 16-point module. Some of the points are inputs to the CPU and some are outputs to the module. These 16 points provide:

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

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.

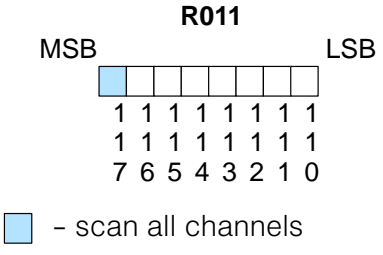
D3-04AD  
4-Channel Analog Input



□ - not used  
Within these two register locations, the individual bits represent specific information about the analog signal.

**All Channel Scan Output**

The most significant point (MSP) assigned to the module acts as an output to the module and controls the channel scanning sequence. This allows flexibility in your control program. If this output is on, all channels will be scanned sequentially. If the output is off, you can use other points to select a single channel for scanning.



| Scan | Out 117 | Channel Input |
|------|---------|---------------|
| N    | Off     | None          |
| N+1  | On      | 1             |
| N+2  | On      | 2             |
| N+3  | On      | 3             |
| N+4  | On      | 4             |
| N+5  | On      | 1             |
| N+6  | Off     | None          |
| N+7  | Off     | None          |



**Single Channel Scan Outputs**

The upper register also contains two additional outputs that can be used to choose a single channel for scanning. These outputs are *ignored* if the channel scan output is turned on.

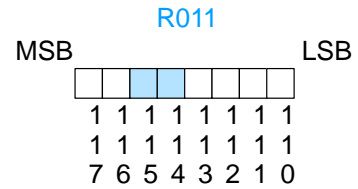
(Note, our example shows outputs 114 and 115. Your output point will depend on where you have installed the module.)

| Out 114 | Out 115 | Channel |
|---------|---------|---------|
| Off     | Off     | 1       |
| On      | Off     | 2       |
| Off     | On      | 3       |
| On      | On      | 4       |

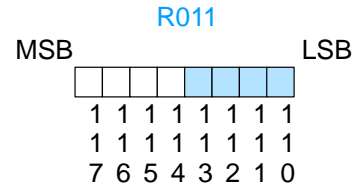
**Active Channel Selection Inputs**

The first four points of the upper register are used as inputs to tell the CPU which channel is being processed. (Remember, the previous bits only tell the module which channels to scan.) In our example, when input 110 is on the module is telling the CPU it is processing channel 1. Here's how the inputs are assigned.

| Input | Active Channel |
|-------|----------------|
| 110   | 1              |
| 111   | 2              |
| 112   | 3              |
| 113   | 4              |



- scan a single channel



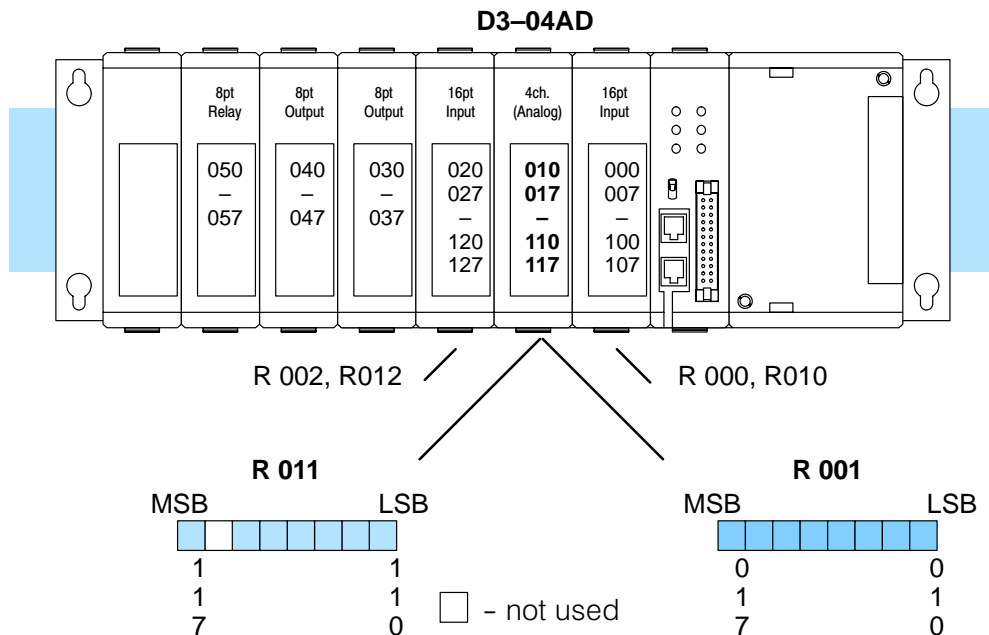
- channel selection inputs



## Writing the Control Program (DL330 / DL340)

### Identifying the Data Locations

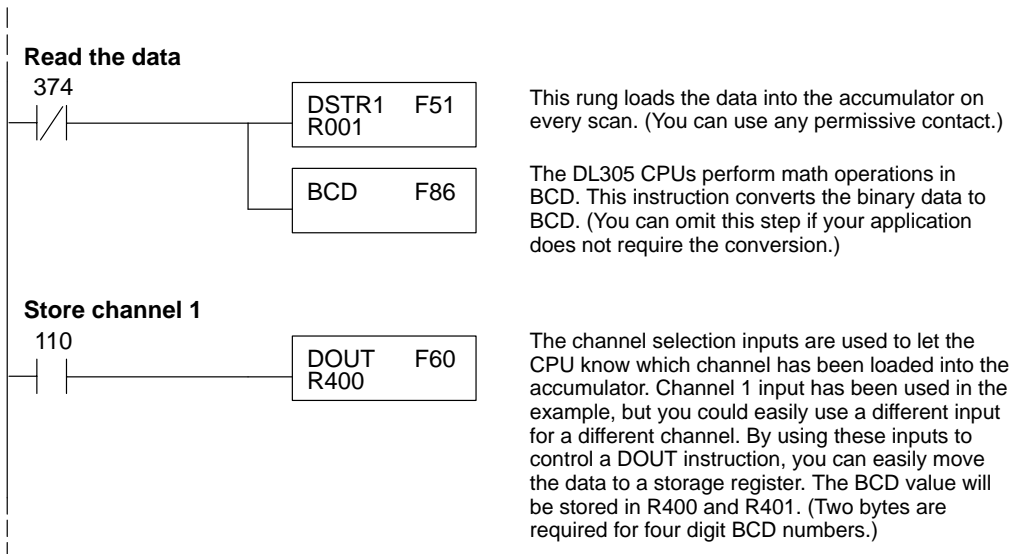
Since all channels are multiplexed into a single data word, the control program must be setup to determine which channel is being read. Since the module provides input points to the CPU, it is very easy to use the channel status bits to determine which channel is being monitored.



D3-04AD  
4-Channel Analog Input

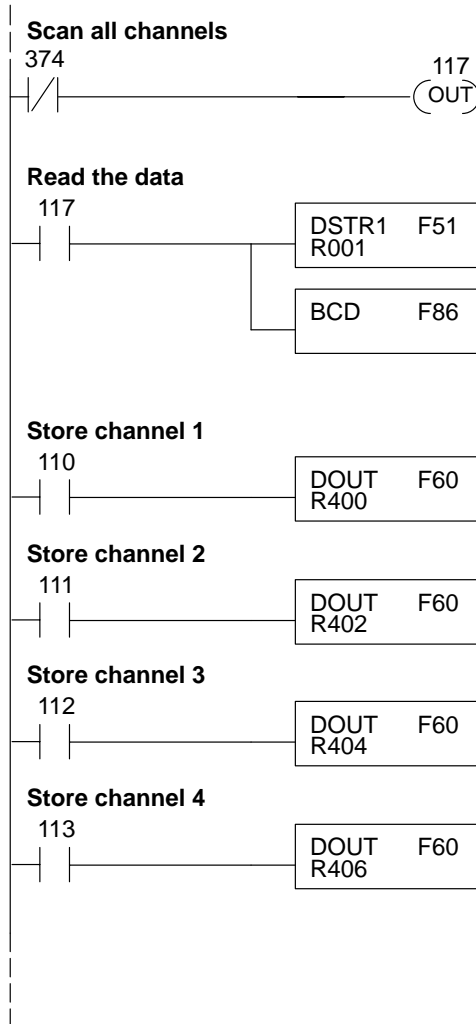
### Single Channel on Every Scan

The following example shows a program that is designed to read a single channel of analog data into a Register location on every scan. Once the data is in a Register, you can perform math on the data, compare the data against preset values, etc. This example is designed to read channel 1. If you choose another channel, you would have to add a rung (or rungs) that use the channel select bits to select the channel for scanning. You would also have to change the rung that stores the data.



### Reading Multiple Channels over Alternating Scans

The following example shows a program that is designed to read multiple channels of analog data into Register locations. This example reads one channel per scan. Once the data is in a Register, you can perform math on the data, compare the data against preset values, etc.



Turn on output 117, which instructs the module to scan all channels.

This rung loads the data into the accumulator. This rung executes for all channels.

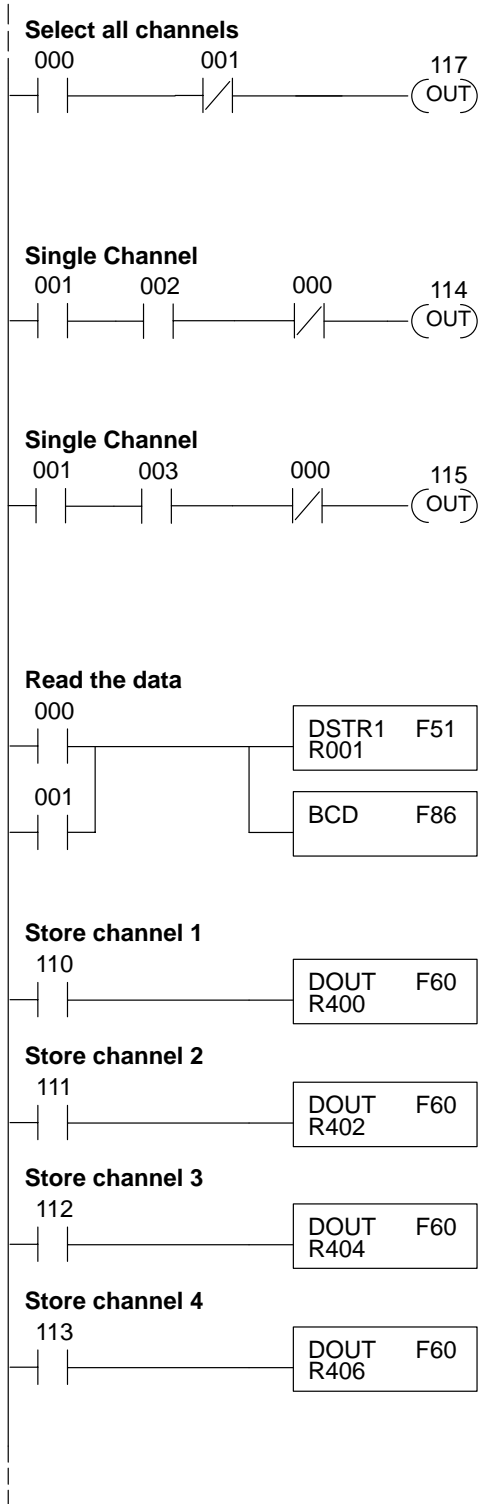
The DL305 performs math operations in BCD. This instruction converts the binary data to BCD. (You can omit this step if your application does not require the data in BCD format.)

The channel selection inputs are used to let the CPU know which channel has been loaded into the accumulator. By using these inputs to control a DOUT instruction, you can easily move the data to a storage register. Notice that the DOUT instruction stores the data in two bytes. (Two bytes are required for four digit BCD numbers.)

D3-04AD 4-Channel Analog Input

**Single or Multiple Channels**

The following example shows how you can use the same program to read either all channels or a single channel of analog data into Register locations. Once the data is in a Register, you can perform math on the data, compare the data against preset values, etc.



Inputs 000 and 001 are used to select between single channel scanning and all channel scanning. These two points were arbitrarily chosen and could be any permissive contacts. When output 117 is on, all channels will be scanned.

Input 001 selects single channel scan. Inputs 002 and 003 select which channel by turning on outputs 114 and 115 as necessary.

| 114 | 115 | Channel |
|-----|-----|---------|
| Off | Off | Ch. 1   |
| On  | Off | Ch. 2   |
| Off | On  | Ch. 3   |
| On  | On  | Ch. 4   |

This rung loads the data into the accumulator. This rung executes for all channel scan or single channel scan.

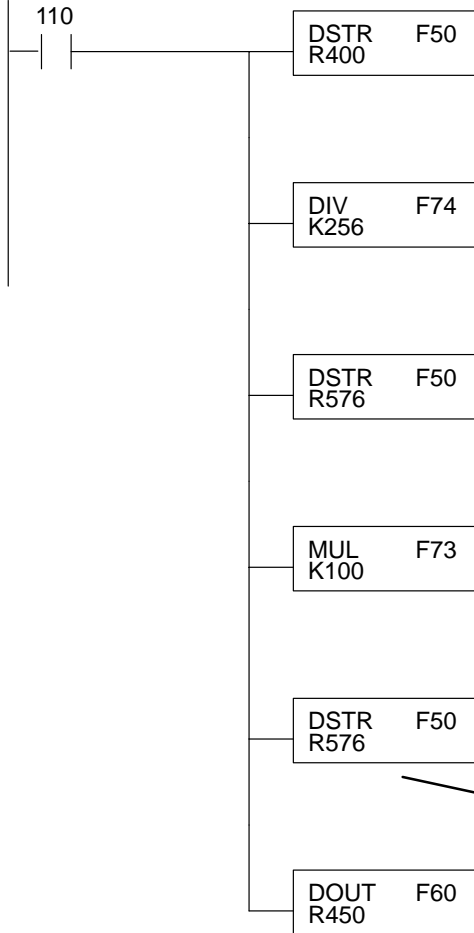
The DL305 performs math operations in BCD. This instruction converts the binary data to BCD. (You can omit this step if your application does not require the data in BCD format.)

The channel selection inputs are used to let the CPU know which channel has been loaded into the accumulator. By using these inputs to control a DOUT instruction, you can easily move the data to a storage register. Notice that the DOUT instruction stores the data in two bytes. This is because two bytes are required to store the BCD number.

The following instructions are required to scale the data. We'll continue to use the 42.9 PSI example. In this example we're using channel 1. Input 110 is the active channel indicator for channel 1. Of course, if you were using a different channel, you would use the active channel indicator point that corresponds to the channel you were using.

This example assumes you have already read the analog data and stored the BCD equivalent in R400 and R401

### Scale the data



This instruction brings the analog value (in BCD) into the accumulator.

| Accumulator |   |   |   | Aux. Accumulator |   |   |   |
|-------------|---|---|---|------------------|---|---|---|
| 0           | 1 | 1 | 0 | 0                | 0 | 0 | 0 |
| R577        |   |   |   | R576             |   |   |   |

The analog value is divided by the resolution of the module, which is 256. ( $110 / 256 = 0.4296$ )

| Accumulator |   |   |   | Aux. Accumulator |   |   |   |
|-------------|---|---|---|------------------|---|---|---|
| 0           | 0 | 0 | 0 | 4                | 2 | 9 | 6 |
| R577        |   |   |   | R576             |   |   |   |

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

| Accumulator |   |   |   | Aux. Accumulator |   |   |   |
|-------------|---|---|---|------------------|---|---|---|
| 4           | 2 | 9 | 6 | 4                | 2 | 9 | 6 |
| R577        |   |   |   | R576             |   |   |   |

The accumulator is then multiplied by the scaling factor, which is 100. ( $100 \times 4296 = 429600$ ). Notice that the most significant digits are now stored in the auxiliary accumulator. (This is different from the way the Divide instruction operates.)

| Accumulator |   |   |   | Aux. Accumulator |   |   |   |
|-------------|---|---|---|------------------|---|---|---|
| 9           | 6 | 0 | 0 | 0                | 0 | 4 | 2 |
| R577        |   |   |   | R576             |   |   |   |

This instruction moves the two-byte auxiliary accumulator for further operations.

| Accumulator |   |   |   | Aux. Accumulator |   |   |   |
|-------------|---|---|---|------------------|---|---|---|
| 0           | 0 | 4 | 2 | 0                | 0 | 4 | 2 |
| R577        |   |   |   | R576             |   |   |   |

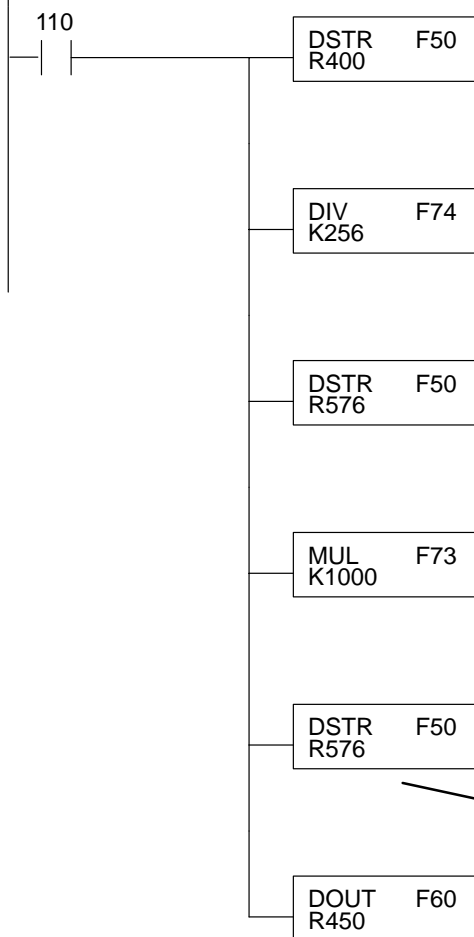
This instruction stores the accumulator to R450 and R451. R450 and R451 now contain the PSI, which is 42 PSI.

| Accumulator |   |   |   | Store in R451 & R450 |   |   |   |
|-------------|---|---|---|----------------------|---|---|---|
| 0           | 0 | 4 | 2 | 0                    | 0 | 4 | 2 |
| R577        |   |   |   | R451 R450            |   |   |   |

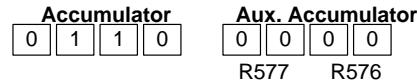
You probably noticed that the previous example yielded 42 PSI when the real value should have been 42.9 PSI. By changing the scaling value slightly, we can “imply” an extra decimal of precision. Notice in the following example we’ve added another digit to the scale. Instead of a scale of 100, we’re using 1000, which implies 100.0 for the PSI range.

This example assumes you have already read the analog data and stored the BCD equivalent in R400 and R401

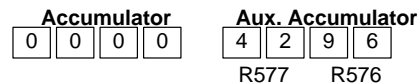
**Scale the data**



This instruction brings the analog value (in BCD) into the accumulator.



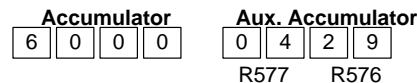
The analog value is divided by the resolution of the module, which is 256. (110 / 256 = 0.4296)



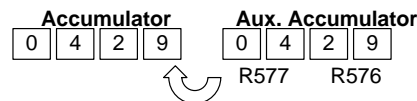
This instruction moves the two-byte decimal portion into the accumulator for further operations.



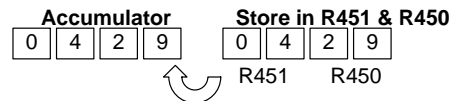
The accumulator is multiplied by the scaling factor, which is now 1000. (1000 x 4296 = 4296000). The most significant digits are now stored in the auxiliary accumulator. (This is different from the way the Divide instruction operates.)



This instruction moves the two-byte auxiliary accumulator for further operations.



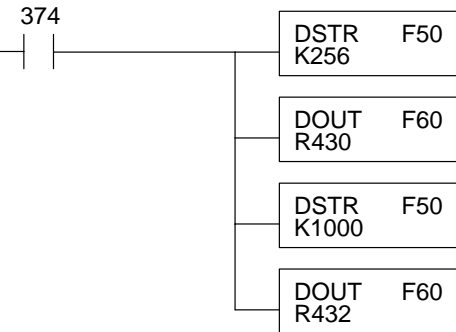
This instruction stores the accumulator to R450. R450 now contains the PSI, which implies 42.9.



This example program shows how you can use the instructions to load the equation constants into data registers. The example is written for channel 1, but you can easily use a similar approach to use different scales for all channels if required.

You may just use the appropriate constants in the instructions dedicated for each channel, but this method allows easier modifications. For example, you could easily use an operator interface or a programming device to change the constants if they are stored in Registers.

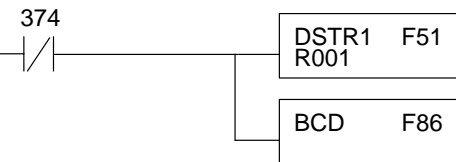
### Load the constants



On the first scan, these first two instructions load the analog resolution (constant of 256) into R430 and R431.

These two instructions load the high limit of the Engineering unit scale (constant of 1000) into R432 and R433. Note, if you have different scales for each channel, you'll also have to enter the Engineering unit high limit for those as well.

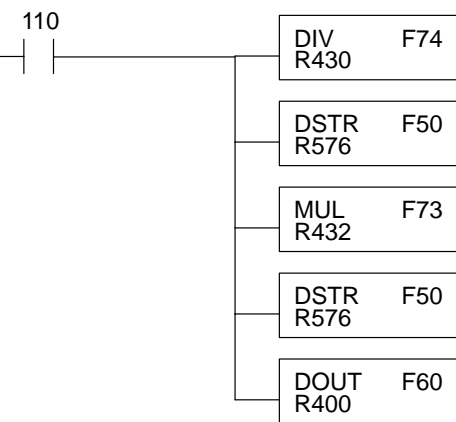
### Read the data



This rung loads the data into the accumulator on every scan. (You could use any permissive contact.)

The DL305 CPUs perform math operations in BCD. Since we will perform math on the data, the data must be converted from binary data to BCD.

### Store channel 1



The analog value is divided by the resolution of the module, stored in R430.

This instruction moves the decimal portion from the auxiliary accumulator into the regular accumulator for further operations.

The accumulator is multiplied by the scaling factor, stored in R432.

This instruction moves most significant digits (now stored in the auxiliary accumulator) into the regular accumulator for further operations.

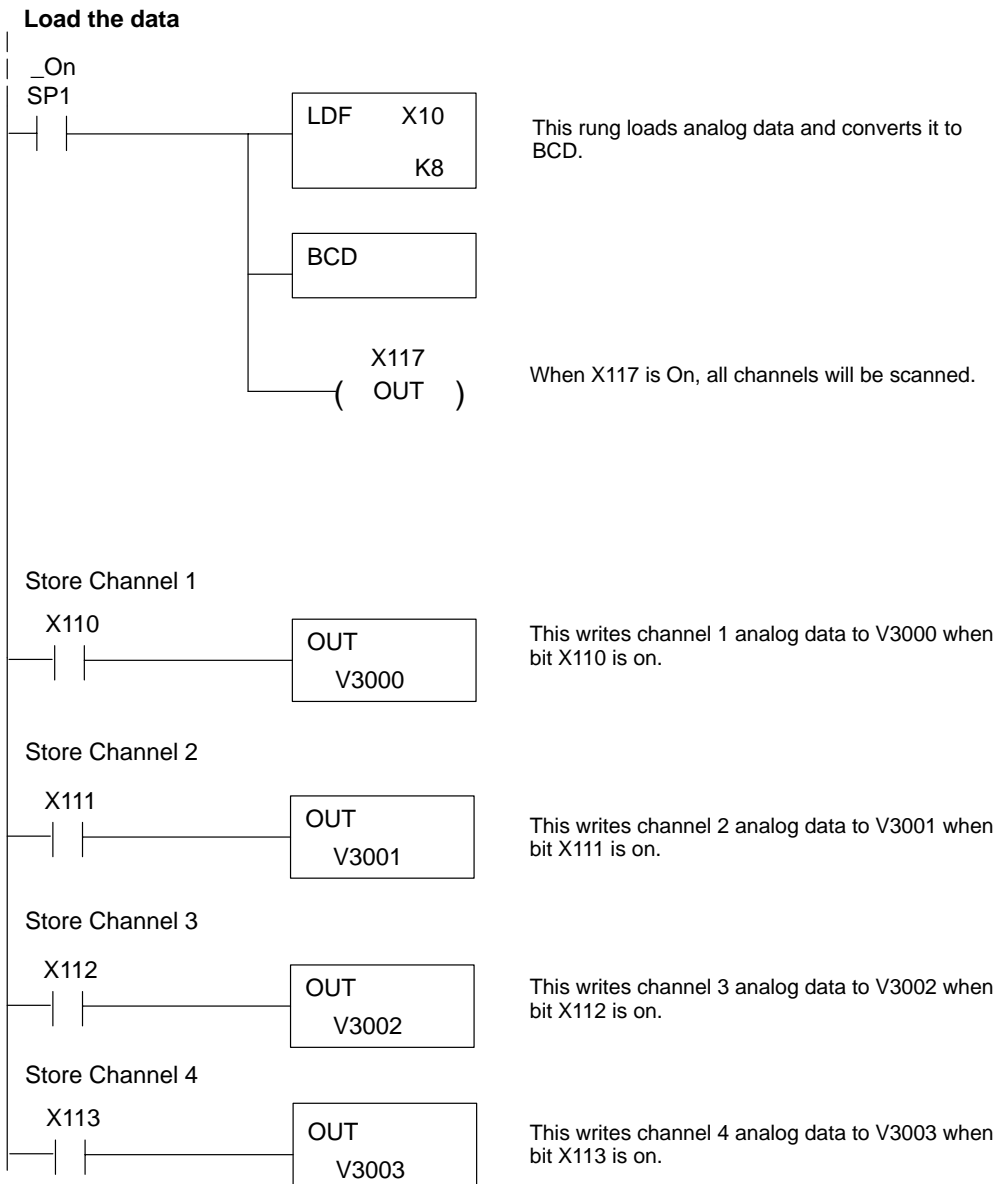
The scaled value is stored in R400 and R401 for further use.



# Writing the Control Program (DL350)

## Multiplexing: DL350 with a Conventional DL305 Base

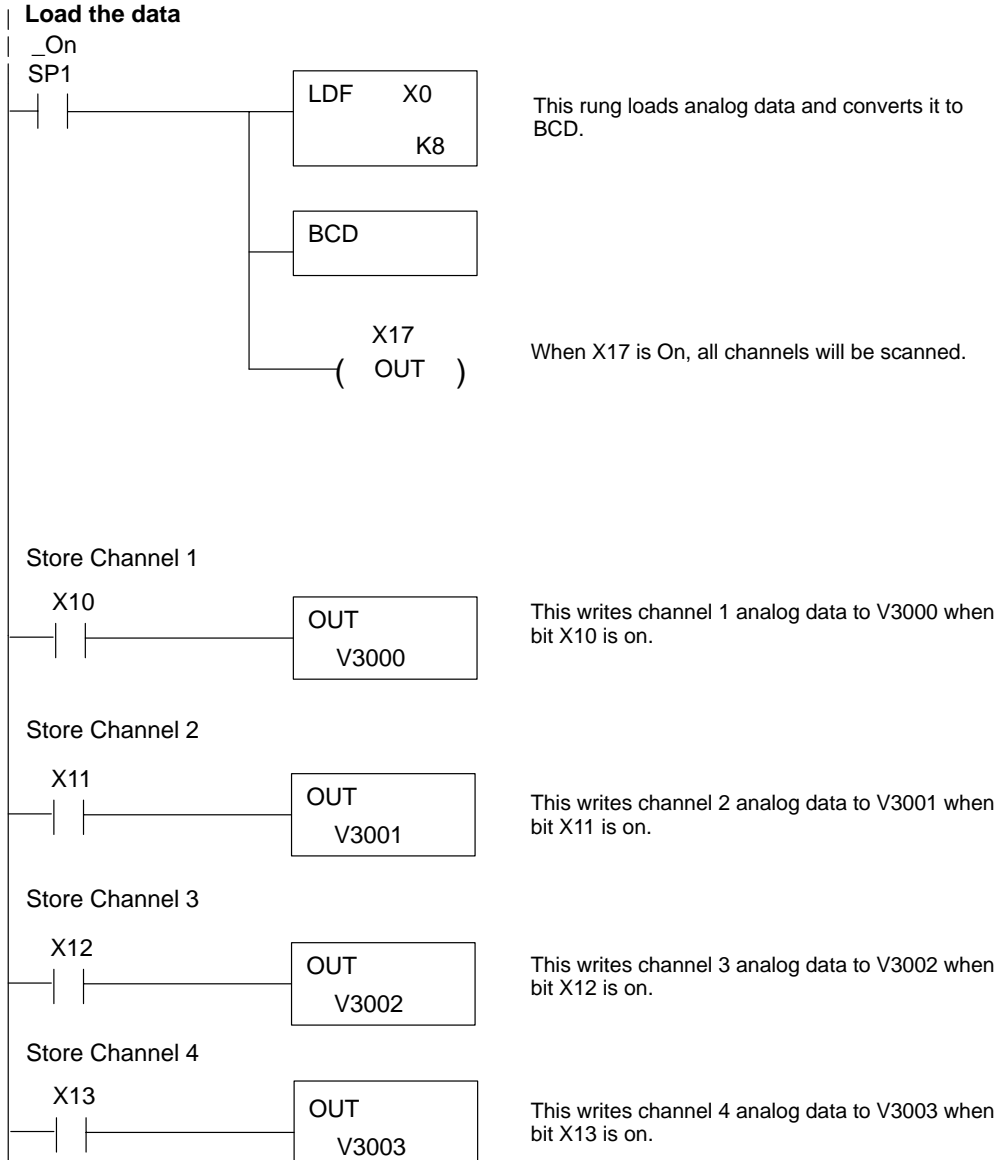
The example below shows how to read multiple channels on an D3-04AD Analog module in the 10-17/110-117 address slot. This module must be placed in a 16 bit slot in order to work.



D3-04AD  
4-Channel Analog Input

### Multiplexing: DL350 with a D3-xx-1 Base

The example below shows how to read multiple channels on an D3-04AD Analog module in the X0 address of the 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.



**Scaling the Input Data**

Most applications usually require measurements in engineering units, which provide more meaningful data. This is accomplished by using the conversion formula shown.

$$\text{Units} = (A/255)*S$$

Units = value in Engineering Units

A = Analog value (0 – 255)

S = Engineering unit range

The following example shows how you would use the analog data to represent pressure (PSI) from 0 to 100. This example assumes the analog value is 110, which is slightly less than half scale. This should yield approximately 43 PSI.

$$\text{Units} = (A/255)*S$$



$$\text{Units} = (110/255)*100$$

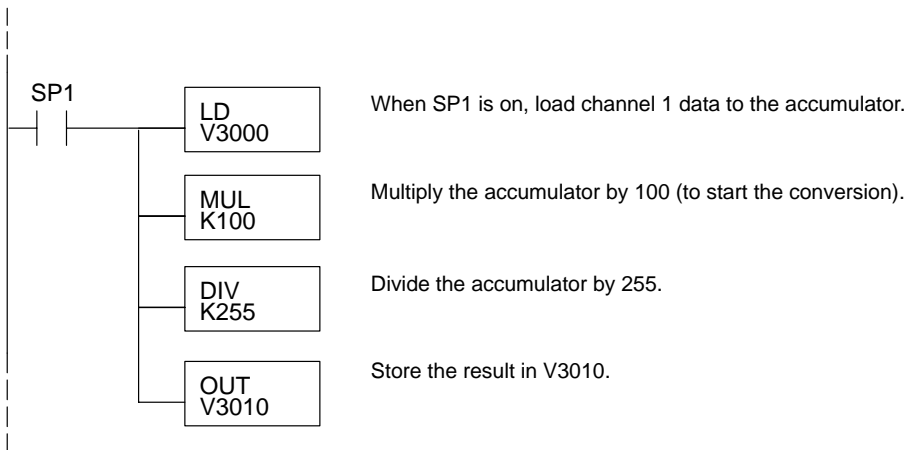


$$\text{Units} = 43$$

Here is how you would write the program to perform the engineering unit conversion. This example assumes you have the analog data in BCD format data loaded into V3000.



**NOTE:** This example uses SP1, which is always on. You could also use an X, C, etc. permissive contact.



**Analog 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 analog signal level ... |
|-----------|-----------------------------------|---|
| 1 to 5V   | $A = (4D/255) + 1$                | $D = (255/4)(A-1)$                      |
| 4 to 20mA | $A = (16D/255) + 4$               | $D = (255/16)(A-4)$                     |

For example, if you are using the 1 to 5V range and you have measured the signal at 3V, you would use the following formula to determine the digital value that should be stored in the register location that contains the data.

$$D = (255/4)(A-1)$$

$$D = (255/4)(3V-1)$$

$$D = (63.75) (2)$$

$$D = 127.5 \text{ (or 128)}$$

# **F3–04ADS**

## **4-Channel Isolated Analog Input**

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In This Chapter. . . .

- Module Specifications
  - Setting the Module Jumpers
  - Connecting the Field Wiring
  - Module Operation
  - Writing the Control Program
-

## Module Specifications

The following table provides the specifications for the F3-04ADS Analog Input Module. Make sure the module meets your application requirements.

|                              |   |
|------------------------------|---|
| Number of Channels           | 4, isolated   |
| Input Ranges                 | 0 – 5V, 0 – 10V, 1 – 5V, $\pm 5V$ , $\pm 10V$ ,<br>0 – 20 mA, 4 – 20 mA           |
| Resolution                   | 12 bit (1 in 4096)  |
| Input Type                   | Differential  |
| Max. Common mode voltage     | $\pm 750V$ peak continuous transformer isolation                                  |
| Noise Rejection Ratio        | Common mode: $-100$ dB at 60Hz  |
| Active Low-pass Filtering    | $-3$ dB at 10Hz, $-12$ dB per octave  |
| Input Impedance              | $250\Omega \pm 0.1\%$ , 1/2W current input<br>$200K\Omega$ voltage input          |
| Absolute Maximum Ratings     | $\pm 40$ mA, current input $\pm 100V$ , voltage input                             |
| Conversion Time              | 1 channel per scan, successive approximation, AD574                               |
| Linearity Error              | $\pm 1$ count (0.03% of full scale) maximum                                       |
| Full Scale Calibration Error | $\pm 9$ counts maximum  |
| Offset Calibration Error     | $\pm 4$ counts maximum, bipolar ranges<br>$\pm 2$ counts maximum, unipolar ranges |
| Accuracy vs. Temperature     | 57 ppm / $^{\circ}C$ maximum full scale   |
| Recommended Fuse             | 0.032 A, Series 217 fast-acting, current inputs                                   |
| Power Budget Requirement     | 183 mA @ 9 VDC, 50 mA @ 24 VDC  |
| External Power Supply        | None required   |
| Operating Temperature        | $32^{\circ}$ to $140^{\circ}$ F ( $0^{\circ}$ to $60^{\circ}$ C)                  |
| Storage Temperature          | $-4^{\circ}$ to $158^{\circ}$ F ( $-20^{\circ}$ to $70^{\circ}$ 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   |

### Analog Input Configuration Requirements

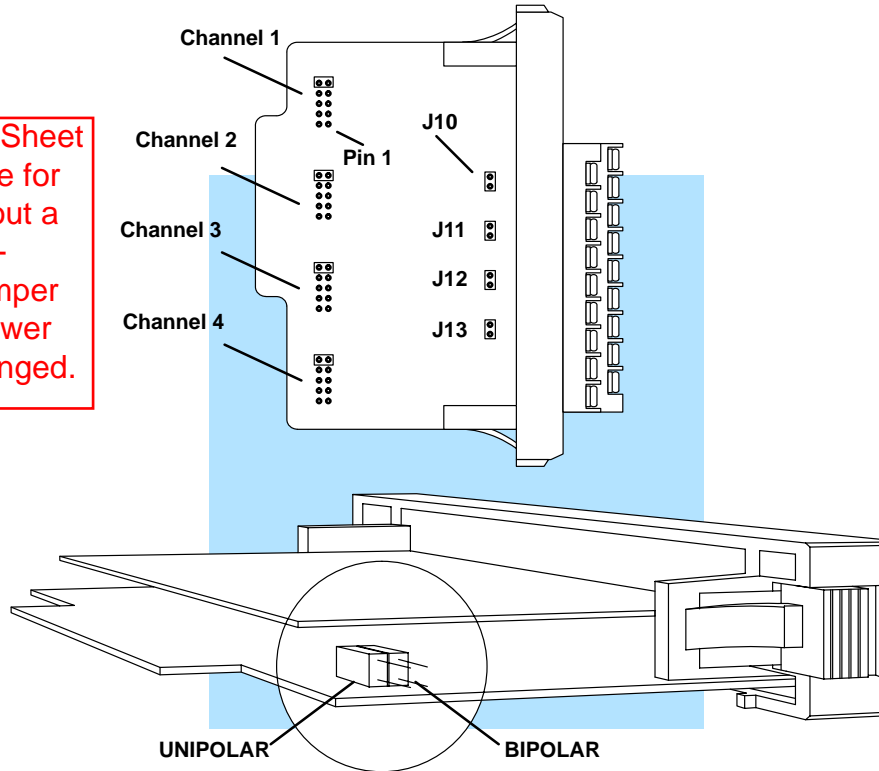
The F3-04ADS Analog Input appears as a 16-point module. The module can be installed in any slot configured for 16 points. See the DL305 User Manual for details on using 16 point modules in DL305 systems. The limitation on the number of analog modules are:

- The module should not be placed in the last slot of a rack (due to size constraints.)
- For local and expansion systems, the available power budget and 16-point module usage are the limiting factors.

# Setting the Module Jumpers

**Jumper Locations** The module is set at the factory for a 4–20 mA signal on all four channels. If this is acceptable you do not have to change any of the jumpers. The following diagram shows how the jumpers are set.

See the Errata Sheet on the first page for information about a circuit board re-design. The jumper locations on newer PC boards changed.



F3-04ADS  
4-Ch. Isolated Analog In.

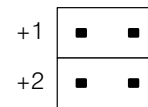
## Selecting the Number of Channels

If you examine the rear of the module, you'll notice several jumpers. The jumpers labeled +1 and +2 (located on the larger board, near the terminal block) 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 four 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.

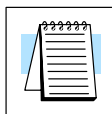
Any unused channels are not processed so if you only select channels 1, 2, and 3, channel 4 will not be active. The table shows which jumpers to install.



Jumpers installed as shown selects 4-channel operation

| Channel    | +1  | +2  |
|------------|-----|-----|
| 1          | No  | No  |
| 1, 2,      | Yes | No  |
| 1, 2, 3    | No  | Yes |
| 1, 2, 3, 4 | Yes | Yes |

### Selecting Input Signal Ranges



As you examine the jumper settings, notice there are jumpers for each individual channel. These jumpers allow you to select the type of signal (voltage or current) and the range of the signal. The following tables show the jumper selections for the various ranges. Only channel 1 is used in the example, but all channels must be set.

**NOTE:** The Polarity jumper selects Unipolar or Bipolar operation for all channels.

| Bipolar Signal Range                | Jumper Settings        |                      |                    |
|-------------------------------------|------------------------|----------------------|--------------------|
| -5 VDC to +5 VDC<br>(-20 to +20 mA) | Polarity<br>Uni Bi<br> | Channel 1 Ranges<br> | Current Jumper<br> |
| -10 VDC to +10 VDC                  | Polarity<br>Uni Bi<br> | Channel 1 Ranges<br> | Current Jumper<br> |

| Unipolar Signal Range  | Jumper Settings        |                      |                    |
|--|------------------------|----------------------|--------------------|
| 4 to 20 mA<br>(1 VDC to 5 VDC, remove the current jumper)    | Polarity<br>Uni Bi<br> | Channel 1 Ranges<br> | Current Jumper<br> |
| 0 VDC to +5 VDC<br>(0 to +20 mA, install the current jumper) | Polarity<br>Uni Bi<br> | Channel 1 Ranges<br> | Current Jumper<br> |
| 0 VDC to +10 VDC   | Polarity<br>Uni Bi<br> | Channel 1 Ranges<br> | Current Jumper<br> |



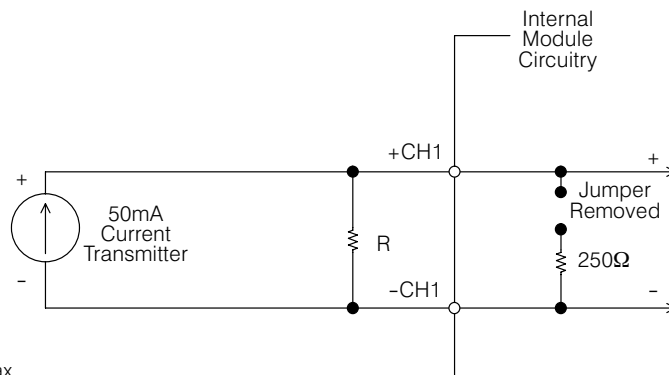
# Connecting the Field Wiring

**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.
- 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.

**User Power Supply Requirements** The F3-04ADS receives all power from the base. A separate power supply is not required.

**Custom Input Ranges** Occasionally you may have the need to connect a transmitter with an unusual signal range. By changing the wiring slightly and adding an external resistor to convert the current to voltage, you can easily adapt this module to meet the specifications for a transmitter which does not adhere to one of the standard input ranges. The following diagram shows how this works.



$$R = \frac{V_{max}}{I_{max}}$$

R = value of external resistor

$V_{max}$  = high limit of selected voltage range

$I_{max}$  = maximum current supplied by the transmitter

Example: current transmitter capable of 50mA, 0 - 10V range selected.

$$R = \frac{10V}{50mA} \quad R = 200 \text{ ohms}$$



**NOTE:** Your choice of resistor can affect the accuracy of the module. A resistor with a  $\pm 0.1\%$  tolerance and a  $\pm 50\text{ppm} / ^\circ\text{C}$  temperature coefficient is recommended.

### Current Loop Transmitter Impedance

Standard 4 to 20 mA transmitters and transducers can operate from a wide variety of power supplies. Not all transmitters are alike and the manufacturers often specify a minimum loop or load resistance that must be used with the transmitter.

The F3-04ADS provides 250 ohm resistance for each channel. If your transmitter requires a load resistance below 250 ohms, then you do not have to make any adjustments. However, if your transmitter requires a load resistance higher than 250 ohms, then you need to add a resistor in series with the module.

Consider the following example for a transmitter being operated from a 36 VDC supply with a recommended load resistance of 750 ohms. Since the module has a 250 ohm resistor, you need to add an additional resistor.

$$R = Tr - Mr$$

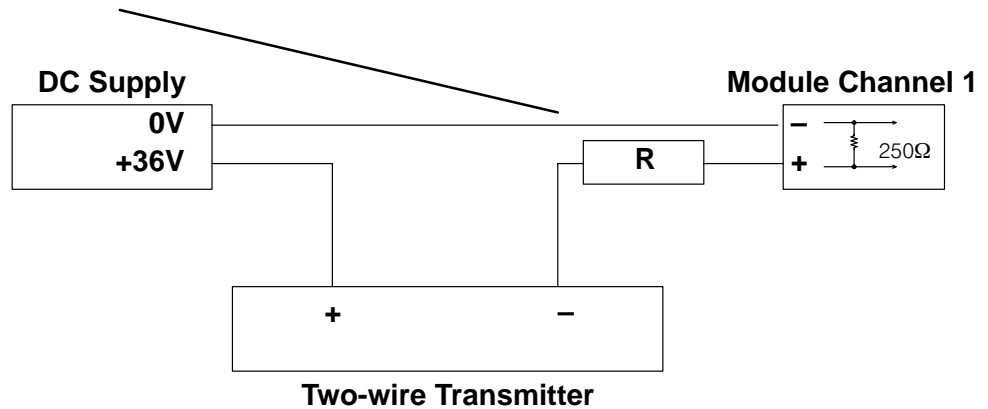
R – Resistor to add

$$R = 750 - 250$$

Tr – Transmitter Requirement

$$R \geq 500$$

Mr – Module resistance (internal 250 ohms)



**Removable Connector**

The F3-04ADS module has a removable connector to make wiring easier. Simply squeeze the top and bottom tabs and gently pull the connector from the module.

**Wiring Diagram**

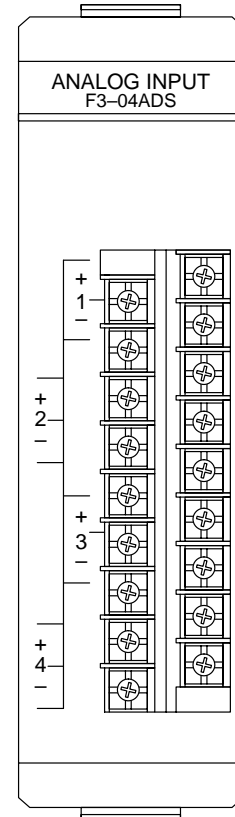
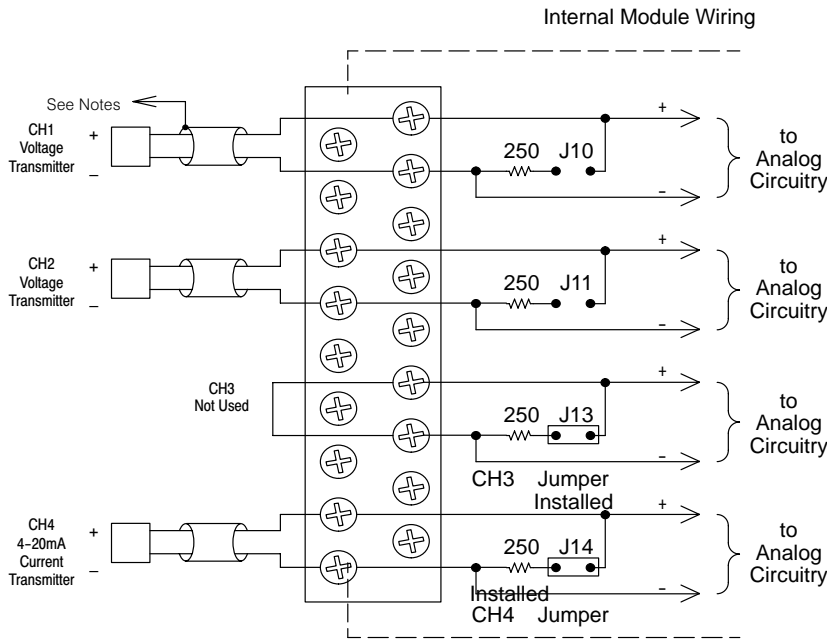
Note 1: Connect unused voltage or current inputs to 0VDC at terminal block or leave current jumper installed (see Channel 3).

Note 2: A Series 217, 0.032A, Fast-acting fuse is recommended for 4-20mA current loops.

Note 3: Transmitters may be 2, 3, or 4 wire type.

Note 4: Transmitters may be powered from separate power sources.

Note 5: Terminate all shields of the cable at their respective signal source.



F3-04ADS  
4-Ch. Isolated Analog In.

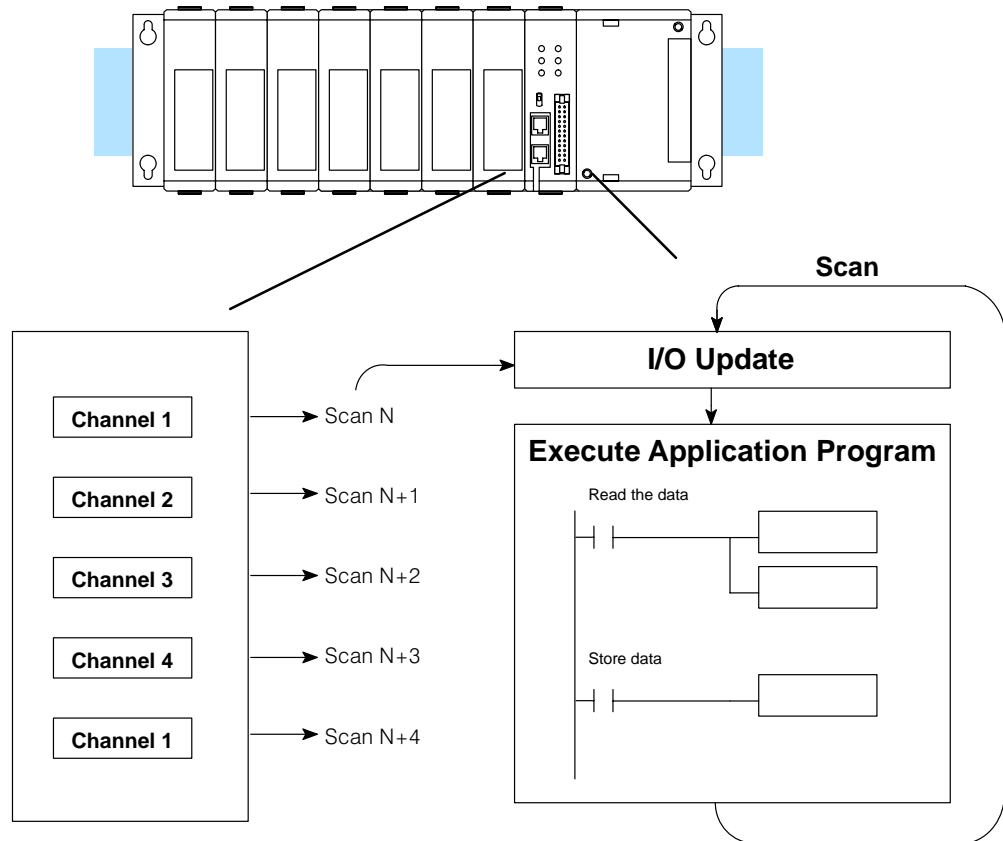
## Module Operation

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 F3-04ADS module supplies 1 channel of data per each 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.

You do not have to select all of the channels. Unused channels are not processed, so if you select only two channels, then each channel will be updated every other scan.



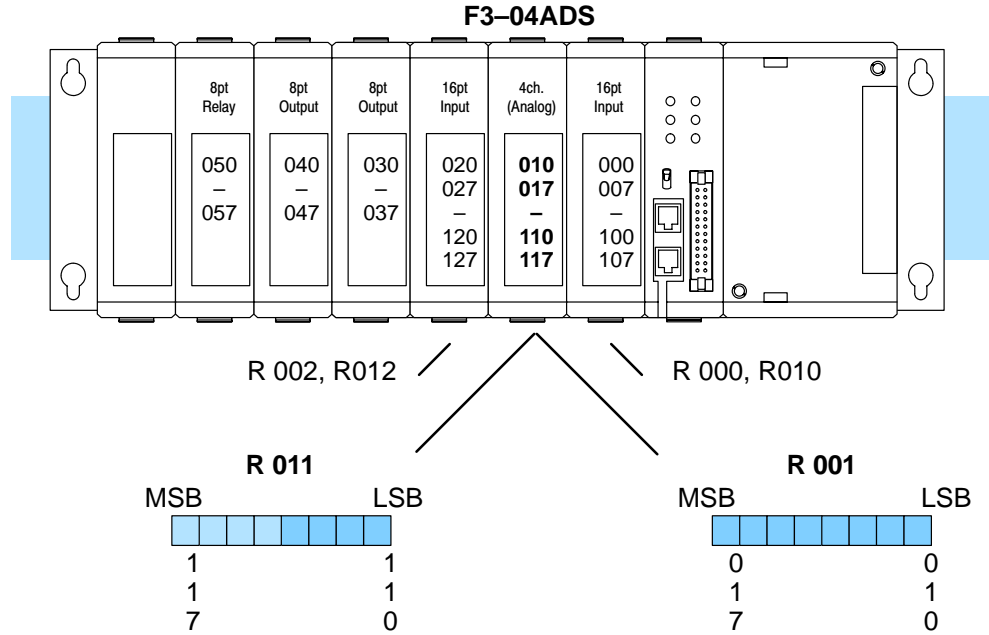
Even though the channel updates to the CPU are synchronous with the CPU scan, the module asynchronously monitors the analog transmitter signal and converts the signal to a 12-bit binary representation. This enables the module to continuously provide accurate measurements without slowing down the discrete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

**Understanding the I/O Assignments**

You may recall the F3-04ADS 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 analog signal.

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.

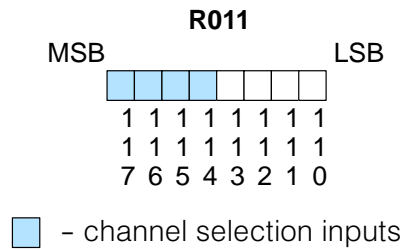


Within these two register locations, the individual bits represent specific information about the analog signal.

**Active Channel Selection Inputs**

The last four points of the upper register are used as inputs to tell the CPU which channel is being processed. In our example, when input 114 is on the module is telling the CPU it is processing channel 1. Here's how the inputs are assigned.

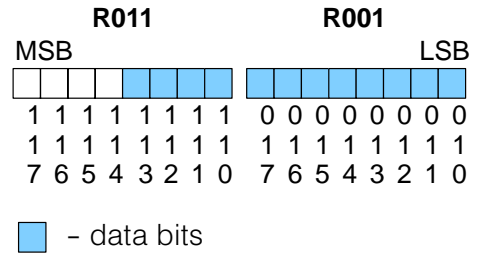
| Input | Active Channel |
|-------|----------------|
| 114   | 1              |
| 115   | 2              |
| 116   | 3              |
| 117   | 4              |



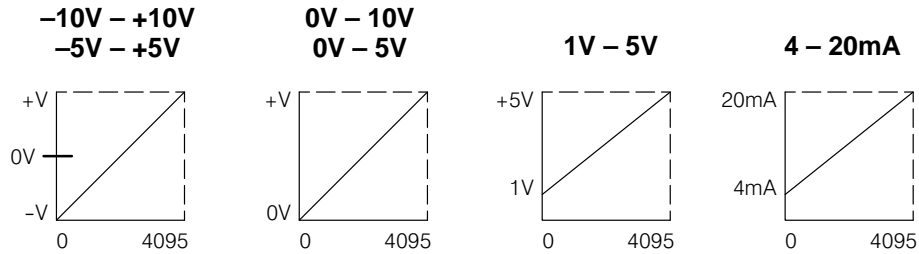
### Analog Data Bits

The remaining twelve bits represent the analog data in binary format.

| 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  |



Since the module has 12-bit resolution, the analog signal is converted into 4096 “pieces” ranging from 0 – 4095 ( $2^{12}$ ). For example, with a 0 to 10V scale, a 0V signal would be 0, and a 10V signal would be 4095. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal. The following diagram shows how this relates to each signal range.



Each “piece” can also be expressed in terms of the signal level by using the equation shown. The following table shows the smallest signal levels that will result in a change in the data value for each signal range.

$$\text{Resolution} = \frac{H - L}{4095}$$

H = high limit of the signal range

L = low limit of the signal range

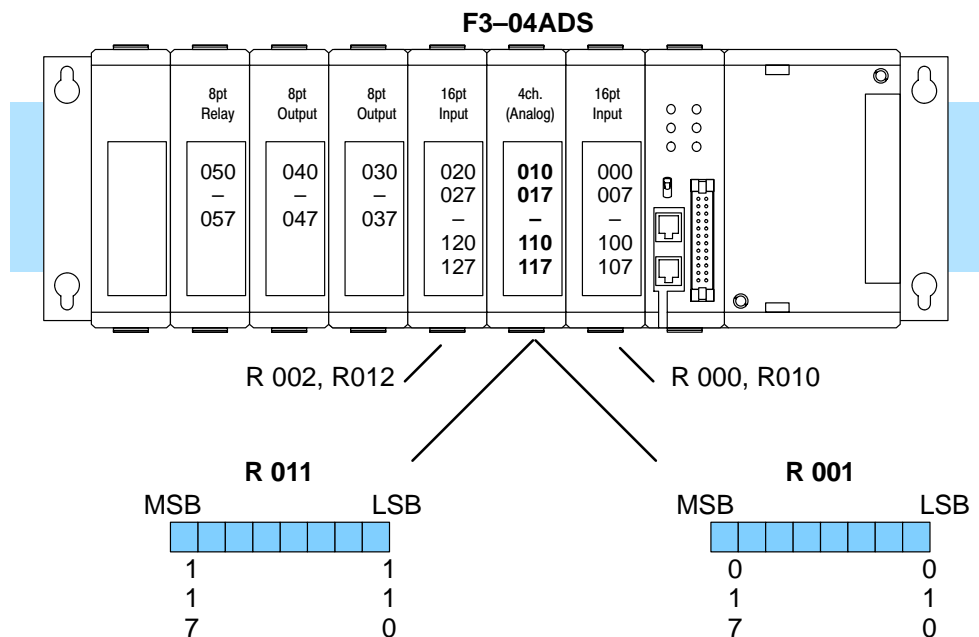
| Range       | Highest Signal | Lowest Signal | Smallest Change |
|-------------|----------------|---------------|-----------------|
| -10 to +10V | +10V           | -10V          | 4.88 mV         |
| -5 to +5V   | +5 V           | -5V           | 2.44 mV         |
| 0 to 5V     | 5V             | 0V            | 1.22 mV         |
| 0 to 10V    | 10 V           | 0V            | 2.44 mV         |
| 1 to 5V     | 5V             | 1V            | 0.98 mV         |
| 4 to 20mA   | 20mA           | 4mA           | 3.91 $\mu$ A    |

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 (DL330 / DL340)

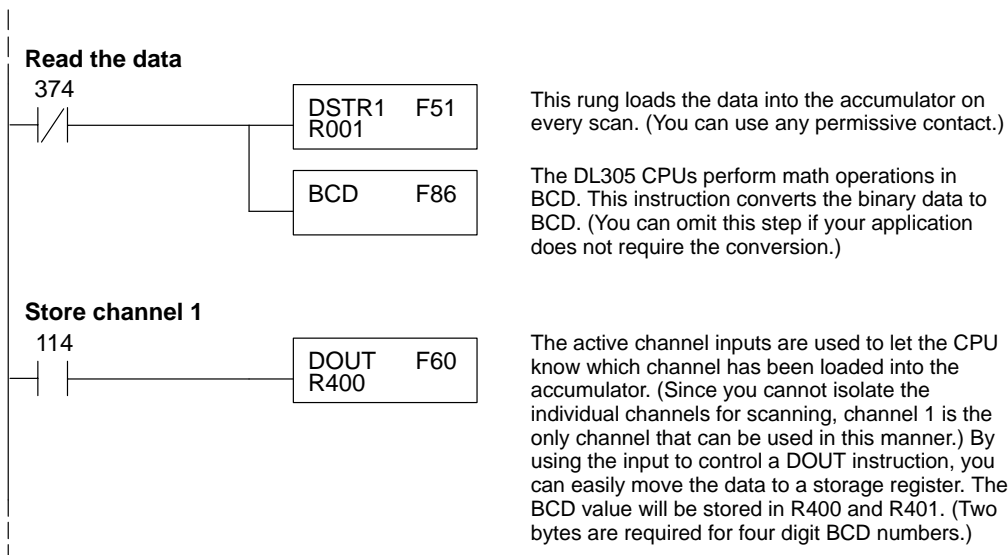
### Identifying the Data Locations

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 active channel status bits to determine which channel is being monitored.



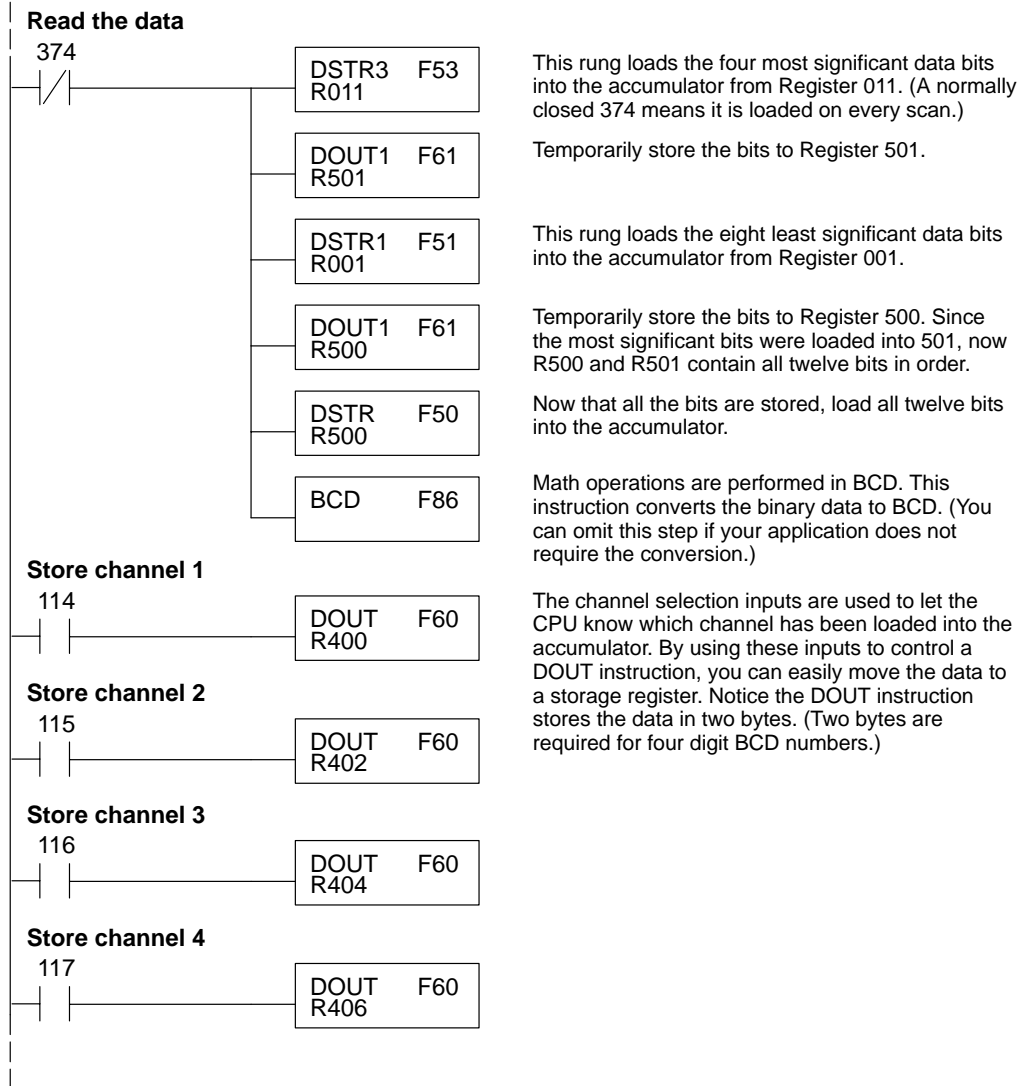
### Single Channel on Every Scan

The following example shows a program that is designed to read a single channel of analog data into a Register location on every scan. Once the data is in a Register, you can perform math on the data, compare the data against preset values, etc. This example is designed to read channel 1. Since you use jumpers to select the number of channels to scan, this is the only channel that you can use in this manner.



### Reading Multiple Channels over Alternating Scans

The following example shows a program designed to read any of the available channels of analog data into Register locations. Once the data is in a Register, you can perform math on the data, compare the data against preset values, etc. 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.



F3-04ADS  
4-Ch. Isolated Analog In.



### Scaling the Input Data

Most applications usually require measurements in engineering units, which provide more meaningful data. This is accomplished by using the conversion formula shown.

The following example shows how you would use the analog data to represent pressure (PSI) from 0 to 100. This example assumes the analog value is 1760. This should yield approximately 42.9 PSI.

$$\text{Units} = \frac{A}{4096} S$$

Units = value in Engineering Units

A = Analog value (0 – 4095)

S = high limit of the Engineering unit range

$$\text{Units} = \frac{A}{4096} S$$



$$\text{Units} = \frac{1760}{4096} 100$$

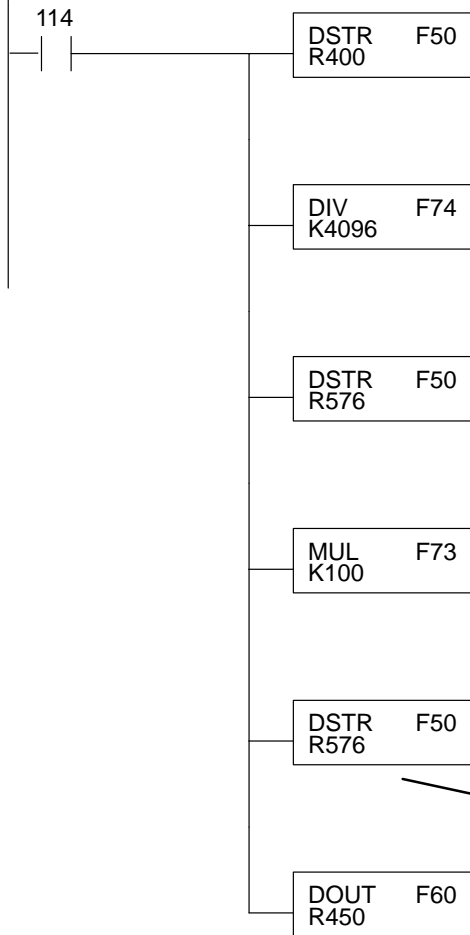


$$\text{Units} = 42.9$$

The following instructions are required to scale the data. We'll continue to use the 42.9 PSI example. In this example we're using channel 1. Input 114 is the active channel indicator for channel 1. Of course, if you were using a different channel, you would use the active channel indicator point that corresponds to the channel you were using.

This example assumes you have already read the analog data and stored the BCD equivalent in R400 and R401

### Scale the data



This instruction brings the analog value (in BCD) into the accumulator.

| Accumulator |   |   |   | Aux. Accumulator |      |   |   |
|-------------|---|---|---|------------------|------|---|---|
| 1           | 7 | 6 | 0 | 0                | 0    | 0 | 0 |
|             |   |   |   | R577             | R576 |   |   |

The analog value is divided by the resolution of the module, which is 4096. ( $1760 / 4096 = 0.4296$ )

| Accumulator |   |   |   | Aux. Accumulator |      |   |   |
|-------------|---|---|---|------------------|------|---|---|
| 0           | 0 | 0 | 0 | 4                | 2    | 9 | 6 |
|             |   |   |   | R577             | R576 |   |   |

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

| Accumulator |   |   |   | Aux. Accumulator |      |   |   |
|-------------|---|---|---|------------------|------|---|---|
| 4           | 2 | 9 | 6 | 4                | 2    | 9 | 6 |
|             |   |   |   | R577             | R576 |   |   |

The accumulator is then multiplied by the scaling factor, which is 100. ( $100 \times 4296 = 429600$ ). Notice the most significant digits are now stored in the auxiliary accumulator. (This is different from the way the Divide instruction operates.)

| Accumulator |   |   |   | Aux. Accumulator |      |   |   |
|-------------|---|---|---|------------------|------|---|---|
| 9           | 6 | 0 | 0 | 0                | 0    | 4 | 2 |
|             |   |   |   | R577             | R576 |   |   |

This instruction moves the two-byte auxiliary accumulator for further operations.

| Accumulator |   |   |   | Aux. Accumulator |      |   |   |
|-------------|---|---|---|------------------|------|---|---|
| 0           | 0 | 4 | 2 | 0                | 0    | 4 | 2 |
|             |   |   |   | R577             | R576 |   |   |

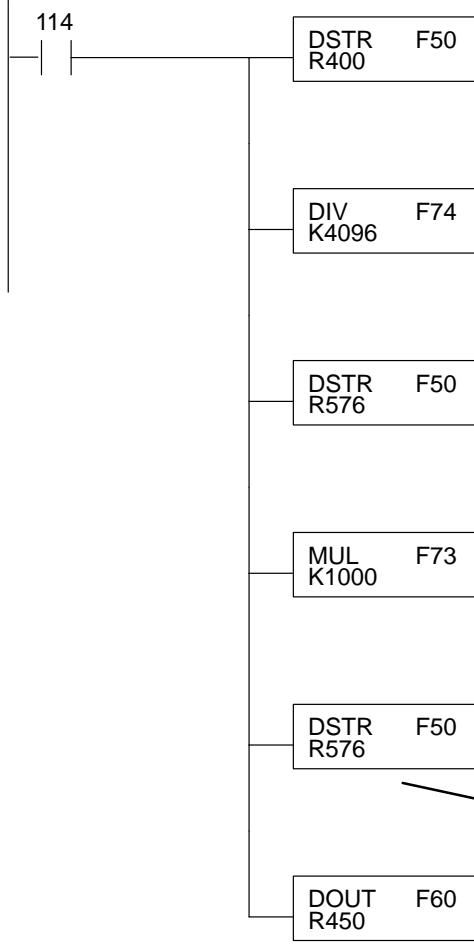
This instruction stores the accumulator to R450. R450 now contains the PSI, which is 42 PSI.

| Accumulator |   |   |   | Store in R451 & R450 |      |   |   |
|-------------|---|---|---|----------------------|------|---|---|
| 0           | 0 | 4 | 2 | 0                    | 0    | 4 | 2 |
|             |   |   |   | R451                 | R450 |   |   |

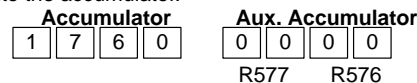
You probably noticed the previous example yielded 42 PSI when the real value should have been 42.9 PSI. By changing the scaling value slightly, we can “imply” an extra decimal of precision. Notice in the following example we’ve added another digit to the scale. Instead of a scale of 100, we’re using 1000, which implies 100.0 for the PSI range.

This example assumes you have already read the analog data and stored the BCD equivalent in R400 and R401

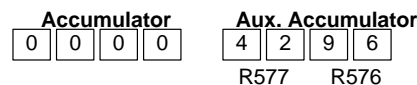
**Scale the data**



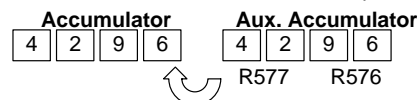
This instruction brings the analog value (in BCD) into the accumulator.



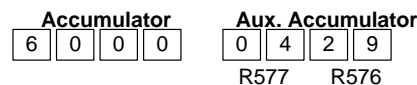
The analog value is divided by the resolution of the module, which is 4096. (1760 / 4096 = 0.4296)



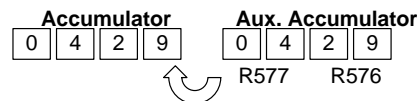
This instruction moves the two-byte decimal portion into the accumulator for further operations.



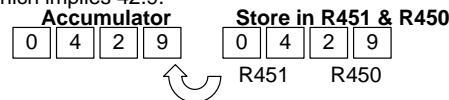
The accumulator is multiplied by the scaling factor, which is now 1000. (1000 x 4296 = 4296000). The most significant digits are now stored in the auxiliary accumulator. (This is different from the way the Divide instruction operates.)



This instruction moves the two-byte auxiliary accumulator for further operations.

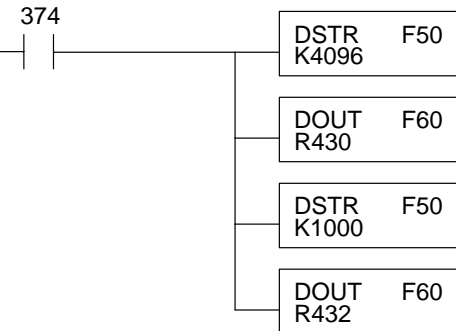


This instruction stores the accumulator to R450 and R451. R450 and R451 now contain the PSI, which implies 42.9.



This example program shows how you can use the instructions to load these equation constants into data registers. The example is written for channel 1, but you can easily use a similar approach to use different scales for all channels if required. You may just use the appropriate constants in the instructions dedicated for each channel, but this method allows easier modifications. For example, you could easily use an operator interface or a programming device to change the constants if they are stored in Registers.

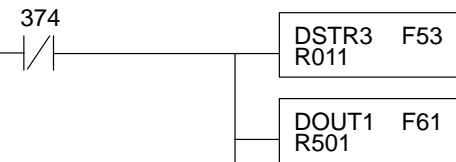
### Load the constants



On the first scan, these first two instructions load the analog resolution (constant of 4096) into R430 and R431.

These two instructions load the high limit of the Engineering unit scale (constant of 1000) into R432 and R433. Note, if you have different scales for each channel, you'll also have to enter the Engineering unit high limit for those as well.

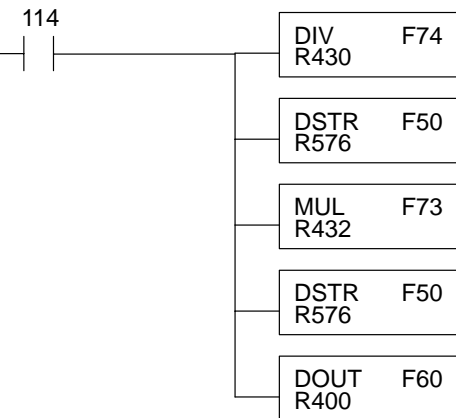
### Read the data



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

Temporarily store the bits to Register 501.

### Store channel 1



The analog value is divided by the resolution of the module, which is stored in R430.

This instruction moves the decimal portion from the auxilliary accumulator into the regular accumulator for further operations.

The accumulator is multiplied by the scaling factor, which is stored in R432.

This instruction moves most significant digits (now stored in the auxilliary accumulator) into the regular accumulator for further operations.

The scaled value is stored in R400 and R401 for further use.

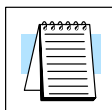
## Writing the Control Program (DL350)

### 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.



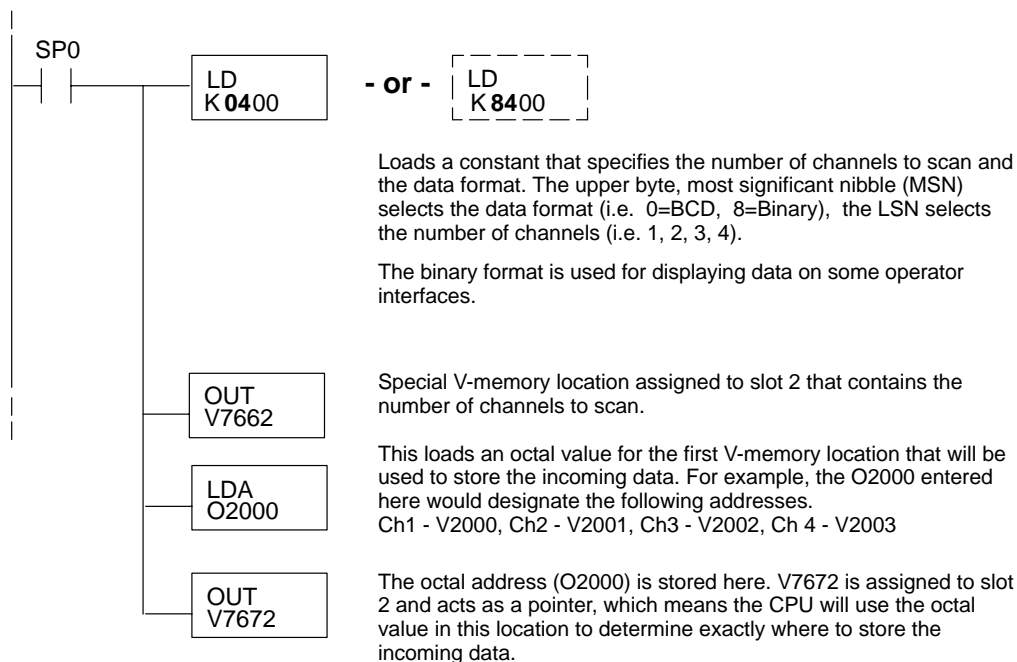
**NOTE:** Do not use the pointer method and the PID PV auto transfer from I/O module function together for the same module. If using PID loops, use the pointer method and ladder logic code to map the analog input data into the PID loop table.

### 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.

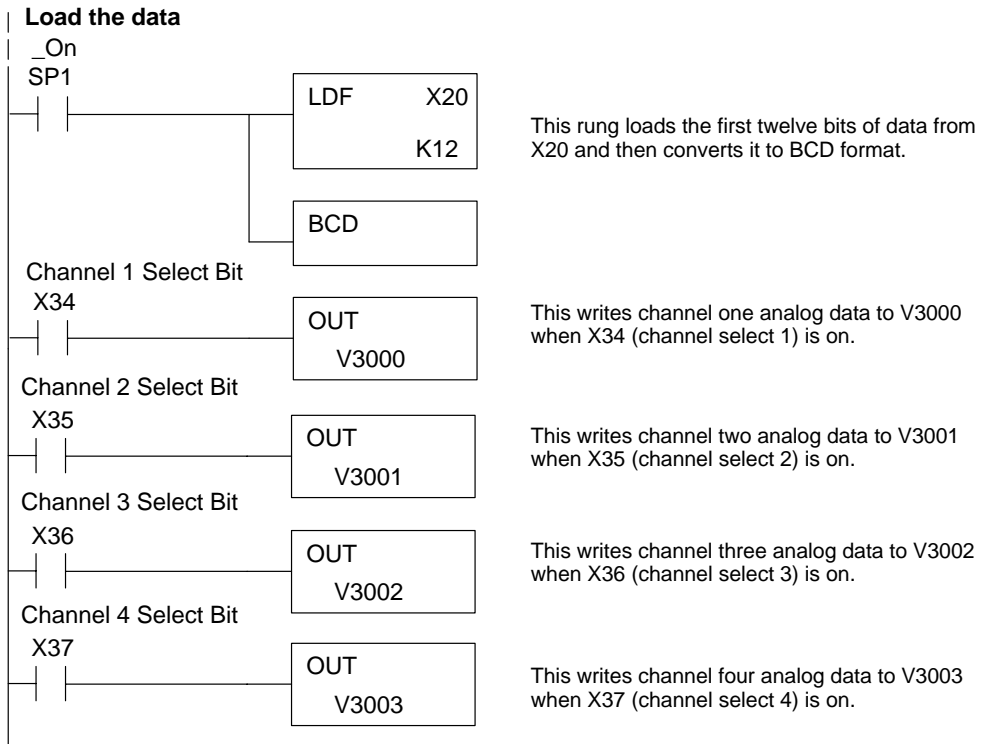


The table shows the special V-memory locations used with the DL350. Slot 0 (zero) is the module next to the CPU, slot 1 is the module two places from the CPU, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. The pointer method is supported on expansion 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 |

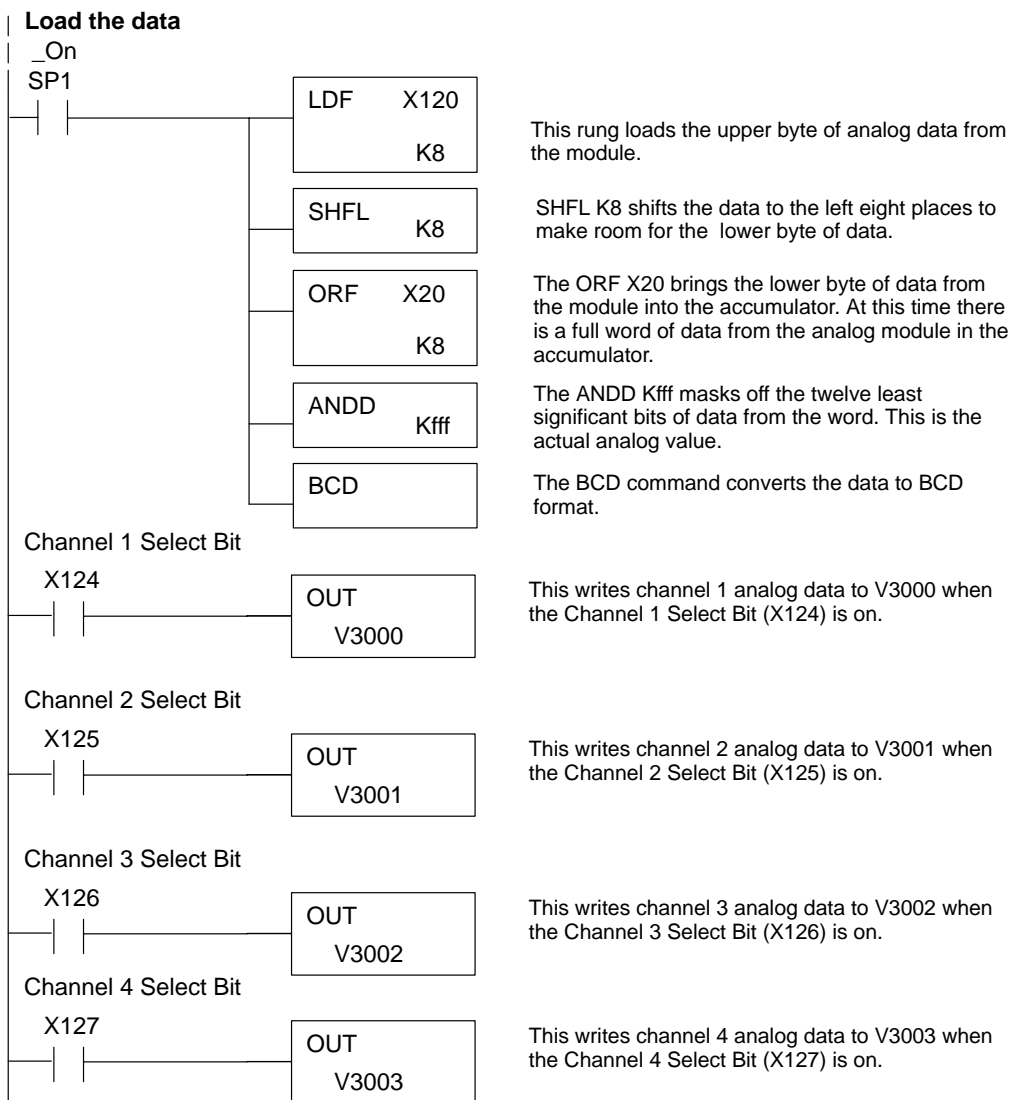
### Multiplexing: DL350 with a D3-xx-1 Base

The example below shows how to read multiple channels on a F3-04ADS Analog module in the X20 address position 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.



**Multiplexing:  
DL350 with a  
Conventional  
DL305 Base**

The example below shows how to read multiple channels on an F3-04ADS Analog module in the 20-27/120-127 address slot. This module must be placed in a 16 bit slot in order to work.



F3-04ADS  
4-Ch. Isolated Analog In.

### Scaling the Input Data

Most applications usually require measurements in engineering units, which provide more meaningful data. This is accomplished by using the conversion formula shown.

You may have to make adjustments to the formula depending on the scale you choose for the engineering units.

$$\text{Units} = A \frac{H - L}{4095}$$

H = high limit of the engineering unit range

L = low limit of the engineering unit range

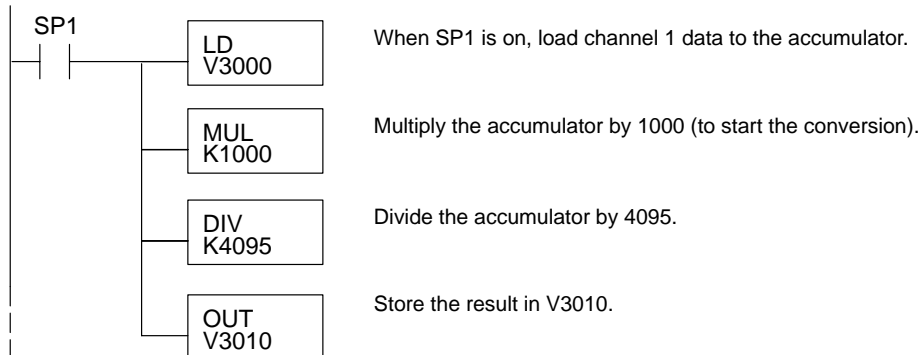
A = Analog value (0 – 4095)

For example, if you wanted to measure pressure (PSI) from 0.0 to 99.9 then you would have to multiply the analog value by 10 in order to imply a decimal place when you view the value with the programming software or a handheld programmer. Notice how the calculations differ when you use the multiplier.

Here is how you would write the program to perform the engineering unit conversion. This example assumes you have BCD data loaded into the appropriate V-memory locations using instructions that apply for the model of CPU you are using.



**NOTE:** This example uses SP1, which is always on. You could also use an X, C, etc. permissive contact.





**Analog 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 analog signal level ... |
|--------------|-----------------------------------|---|
| -10V to +10V | $A = \frac{20D}{4095} - 10$       | $D = \frac{4095}{20}(A + 10)$           |
| -5V to +5V   | $A = \frac{10D}{4095} - 5$        | $D = \frac{4095}{10}(A + 5)$            |
| 0 to 5V      | $A = \frac{5D}{4095}$             | $D = \frac{4095}{5} A$                  |
| 0 to 10V     | $A = \frac{10D}{4095}$            | $D = \frac{4095}{10} A$                 |
| 1 to 5V      | $A = \frac{4D}{4095} + 1$         | $D = \frac{4095}{4}(A - 1)$             |
| 4 to 20mA    | $A = \frac{16D}{4095} + 4$        | $D = \frac{4095}{16}(A - 4)$            |

For example, if you are using the -10 to +10V range and you have measured the signal at 6V, you would use the following formula to determine the digital value that should be stored in the register location that contains the data.

$$D = \frac{4095}{20}(A + 10)$$

$$D = \frac{4095}{20}(6V + 10)$$

$$D = (204.75)(16)$$

$$D = 3276$$



# **F3-08AD-1**

## **8-Channel**

### **Analog Input**

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In This Chapter. . . .

- Module Specifications
  - Setting the Module Jumpers
  - Connecting the Field Wiring
  - Module Operation
  - Writing the Control Program
-

## Module Specifications

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

|                          |  |
|--------------------------|--|
| Number of Channels       | 8, single ended (one common)   |
| Input Ranges             | 4 – 20 mA  |
| Resolution               | 12 bit (1 in 4096)   |
| Input Impedance          | 250 $\Omega$ $\pm$ 0.1%, 1/2W current input                                  |
| Absolute Maximum Ratings | $\pm$ 30mA   |
| Conversion Time          | 35 $\mu$ s per channel<br>1 channel per CPU scan                             |
| Converter Type           | Successive Approximation, AD574  |
| Linearity Error          | $\pm$ 1 count (0.03% of full scale) maximum                                  |
| Maximum Inaccuracy       | 0.35% of full scale at 77 °F (25 °C)   |
| Accuracy vs. Temperature | 57 ppm / °C maximum full scale (including maximum offset change of 2 counts) |
| Recommended Fuse         | 0.032 A, Series 217 fast-acting  |
| 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  |

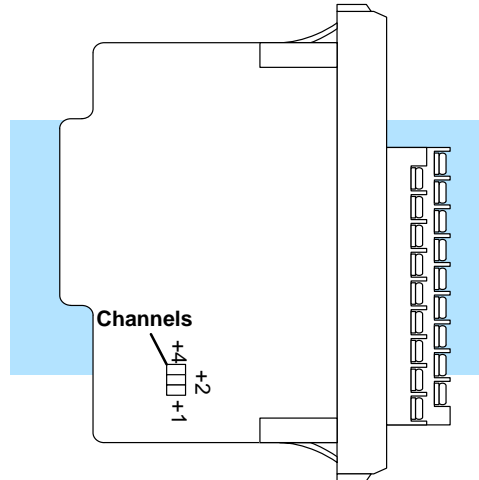
### Analog Input Configuration Requirements

The F3-08AD Analog 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

**Jumper Locations** The module is set at the factory for a 4–20 mA signal on all eight channels. If this is acceptable you do not have to change any of the jumpers. The following diagram shows how the jumpers are set.



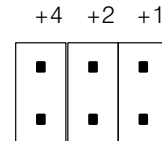
## Selecting the Number of Channels

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 (channel 1). By installing the jumpers you can add channels. The module is set from the factory for eight 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 |



Jumpers installed as shown selects 8-channel operation

## 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 F3-08AD receives all power from the base. A separate power supply is not required.

**Current Loop Transmitter Impedance** Standard 4 to 20 mA transmitters and transducers can operate from a wide variety of power supplies. Not all transmitters are alike and the manufacturers often specify a minimum loop or load resistance that must be used with the transmitter.

The F3-08AD provides 250 ohm resistance for each channel. If your transmitter requires a load resistance below 250 ohms, then you do not have to make any adjustments. However, if your transmitter requires a load resistance higher than 250 ohms, then you need to add a resistor in series with the module.

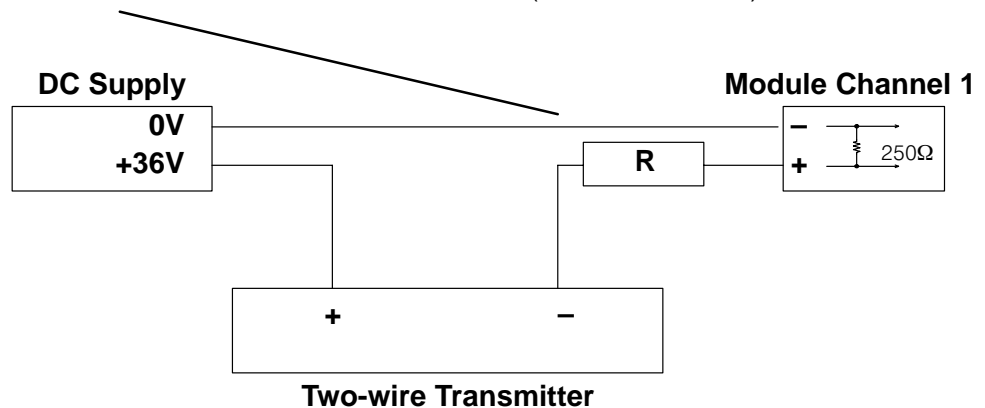
Consider the following example for a transmitter being operated from a 36 VDC supply with a recommended load resistance of 750 ohms. Since the module has a 250 ohm resistor, you need to add an additional resistor.

$$R = Tr - Mr$$

$$R = 750 - 250$$

$$R \geq 500$$

$R$  – Resistor to add  
 $Tr$  – Transmitter Requirement  
 $Mr$  – Module resistance (internal 250 ohms)



**Removable Connector**

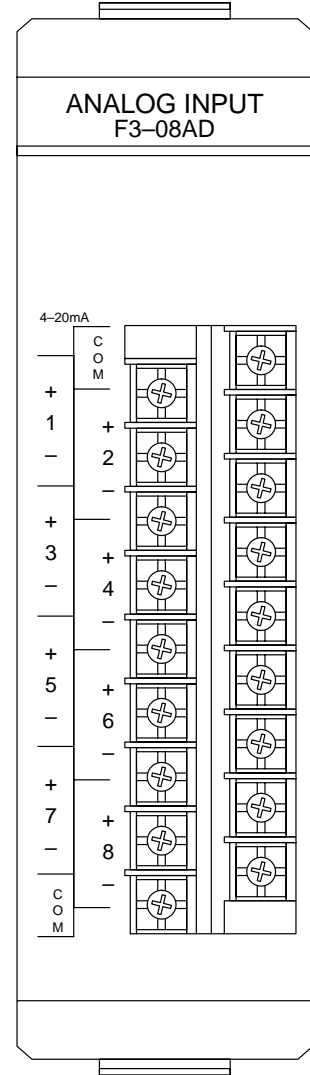
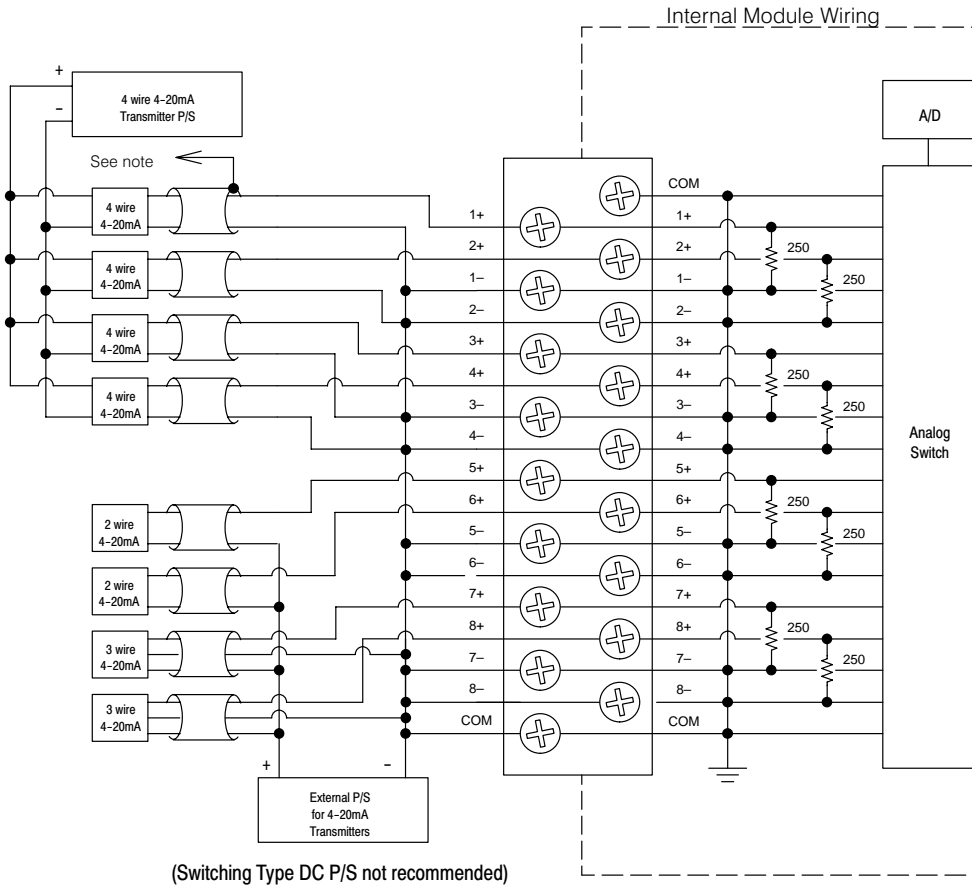
The F3-08AD module has a removable connector to make wiring easier. Simply squeeze the top and bottom tabs and gently pull the connector from the module.

**Wiring Diagram**

Note 1: Terminate all shields at their respective signal source

Note 2: To avoid "ground loop" errors, the following transmitter types are recommended:

- 2 & 3 wire: Isolation between input signal & P/S
- 4 wire: Full isolation between input signal, P/S and output signal.



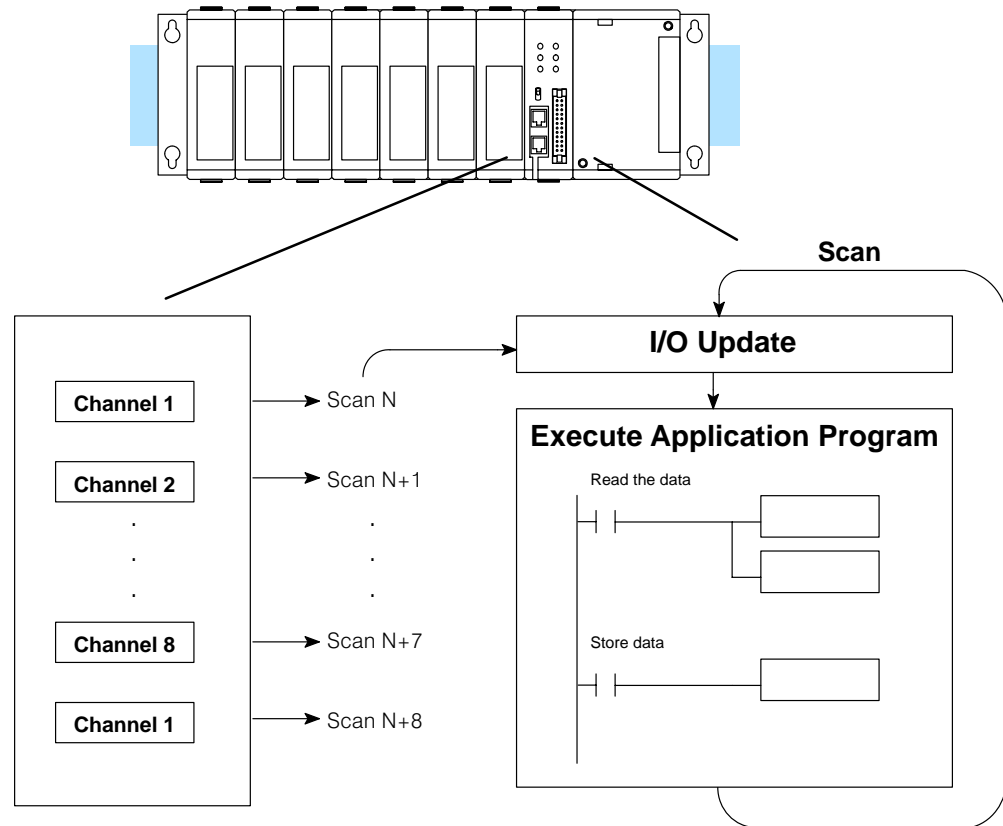
## Module Operation

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 F3-08AD module supplies 1 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 analog 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.

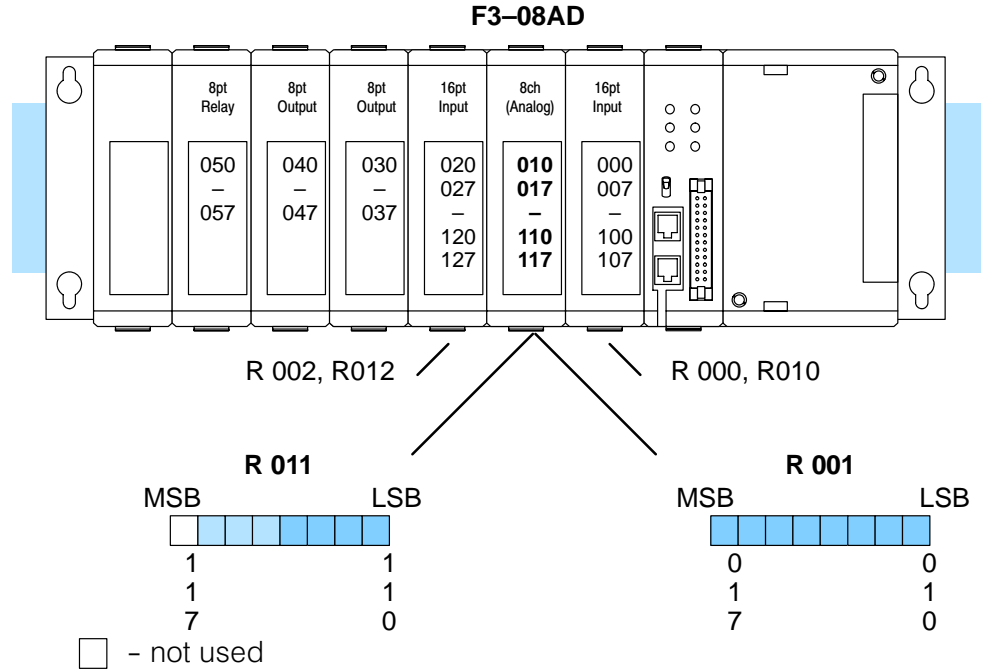


**Understanding the I/O Assignments**

You may recall the F3-08AD 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 analog signal.

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.

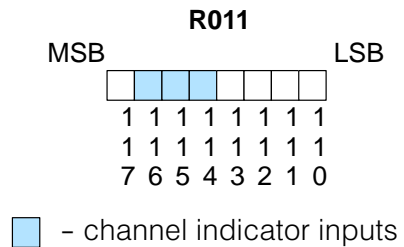


Within these two register locations, the individual bits represent specific information about the analog signal.

**Active Channel Indication Inputs**

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

| Scan | Channel Inputs | Active 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              |

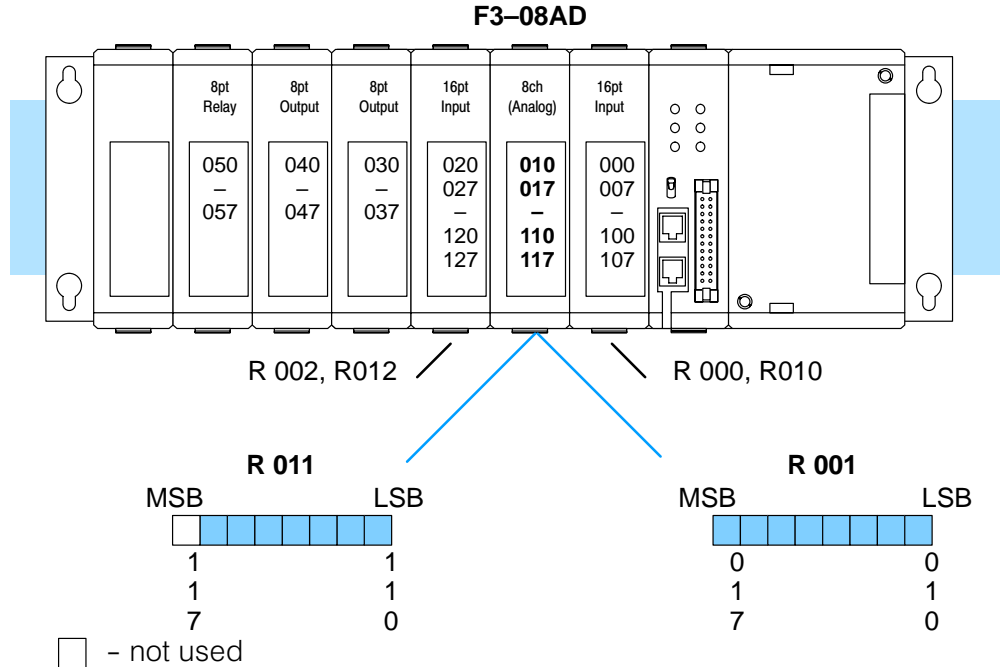




# Writing the Control Program (DL330 / DL340)

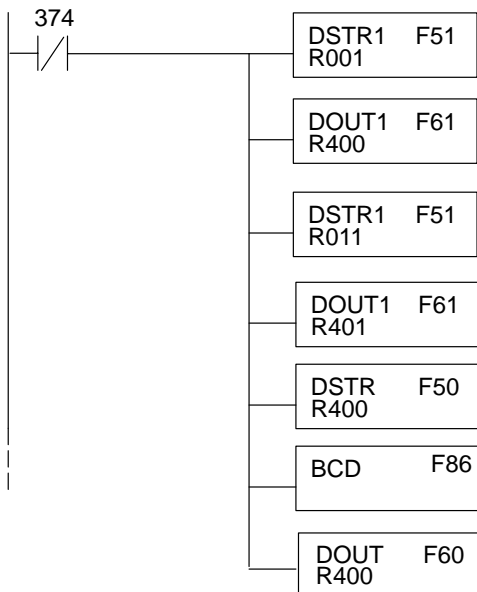
## Identifying the Data Locations

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 active channel status bits to determine which channel is being monitored.



## Single Channel on Every Scan

The following example shows a program that is designed to read a single channel of analog data into a Register location on every scan. Once the data is in a Register, you can perform math on the data, compare the data against preset values, etc. This example is designed to read channel 1. Since you use jumpers to select the number of channels to scan, this is the only channel that you can use in this manner.



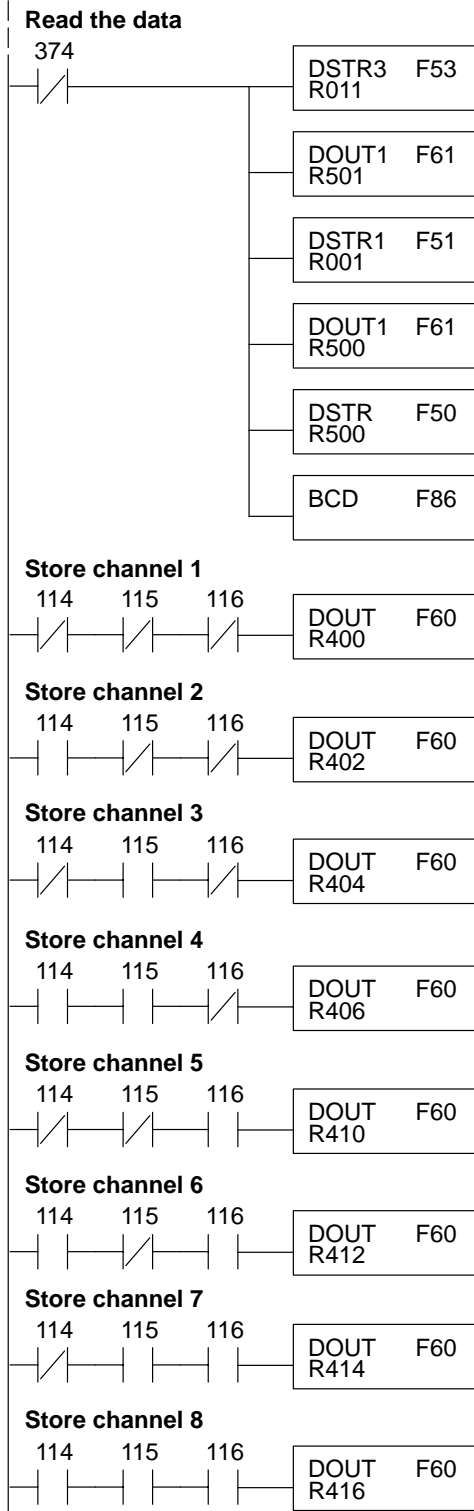
This rung loads the data into the accumulator on every scan. (You can use any permissive contact.)

Since the active channel indicators are all off when channel 1 is being read, you would not have to use them. (Since you cannot isolate the individual channels for scanning, channel 1 is the only channel that can be used in this manner.) The DOUT1 instruction moves the data to a storage register. The BCD value will be stored in R400 and R401. (Two bytes are required for four digit BCD numbers.)

The DL305 CPUs perform math operations in BCD. This instruction converts the binary data to BCD. (You can omit this step if your application does not require the conversion.)

### Reading Multiple Channels over Alternating Scans

The following example shows a program designed to read any of the available channels of analog data into Register locations. Once the data is in a Register, you can perform math on the data, compare the data against preset values, etc. 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.



This rung loads the four most significant data bits into the accumulator from Register 011 on every scan. (You could use any permissive contact.)

Temporarily store the bits to Register 501.

This rung loads the eight least significant 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. (You can omit this step if your application does not require the conversion.)

The channel indicator inputs are used to let the CPU know which channel has been loaded into the accumulator. By using these inputs to control a DOUT instruction, you can easily move the data to a storage register. Notice the DOUT instruction stores the data in two bytes. (Two bytes are required for four digit BCD numbers.)

**Scaling the  
Input Data**

Most applications usually require measurements in engineering units, which provide more meaningful data. This is accomplished by using the conversion formula shown.

The following example shows how you would use the analog data to represent pressure (PSI) from 0 to 100. This example assumes the analog value is 1760. This should yield approximately 42.9 PSI.

$$\text{Units} = \frac{A}{4096} S$$

Units = value in Engineering Units

A = Analog value (0 – 4095)

S = high limit of the Engineering unit range

$$\text{Units} = \frac{A}{4096} S$$



$$\text{Units} = \frac{1760}{4096} 100$$

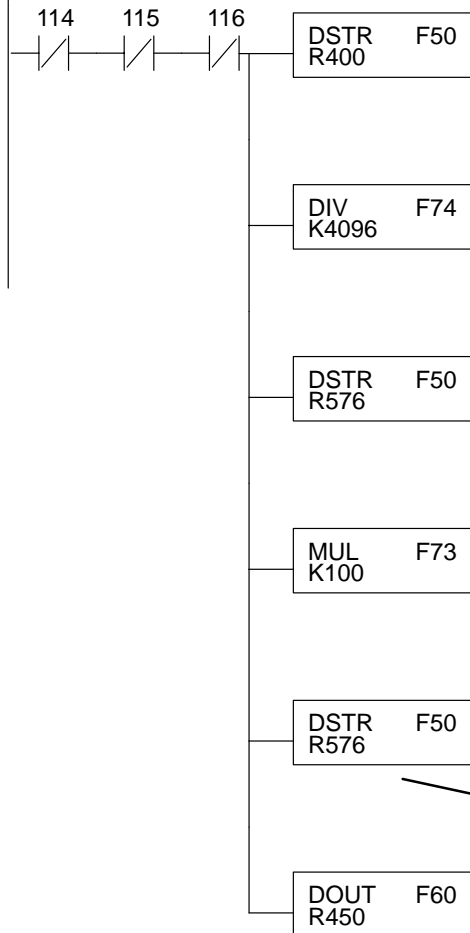


$$\text{Units} = 42.9$$

The following instructions are required to scale the data. We'll continue to use the 42.9 PSI example. In this example we're using channel 1. Input 114, input 115, and input 116 are all off when channel 1 data is being read. Of course, if you were using a different channel, you would use the active channel indicator point combination that corresponds to the channel you were using.

This example assumes you have already read the analog data and stored the BCD equivalent in R400 and R401

### Scale the data



This instruction brings the analog value (in BCD) into the accumulator.

| Accumulator |   |   |   | Aux. Accumulator |   |   |   |
|-------------|---|---|---|------------------|---|---|---|
| 1           | 7 | 6 | 0 | 0                | 0 | 0 | 0 |
| R577        |   |   |   | R576             |   |   |   |

The analog value is divided by the resolution of the module, which is 4096. ( $1760 / 4096 = 0.4296$ )

| Accumulator |   |   |   | Aux. Accumulator |   |   |   |
|-------------|---|---|---|------------------|---|---|---|
| 0           | 0 | 0 | 0 | 4                | 2 | 9 | 6 |
| R577        |   |   |   | R576             |   |   |   |

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

| Accumulator |   |   |   | Aux. Accumulator |   |   |   |
|-------------|---|---|---|------------------|---|---|---|
| 4           | 2 | 9 | 6 | 4                | 2 | 9 | 6 |
| R577        |   |   |   | R576             |   |   |   |

The accumulator is then multiplied by the scaling factor, which is 100. ( $100 \times 4296 = 429600$ ). Notice the most significant digits are now stored in the auxiliary accumulator. (This is different from the way the Divide instruction operates.)

| Accumulator |   |   |   | Aux. Accumulator |   |   |   |
|-------------|---|---|---|------------------|---|---|---|
| 9           | 6 | 0 | 0 | 0                | 0 | 4 | 2 |
| R577        |   |   |   | R576             |   |   |   |

This instruction moves the two-byte auxiliary accumulator for further operations.

| Accumulator |   |   |   | Aux. Accumulator |   |   |   |
|-------------|---|---|---|------------------|---|---|---|
| 0           | 0 | 4 | 2 | 0                | 0 | 4 | 2 |
| R577        |   |   |   | R576             |   |   |   |

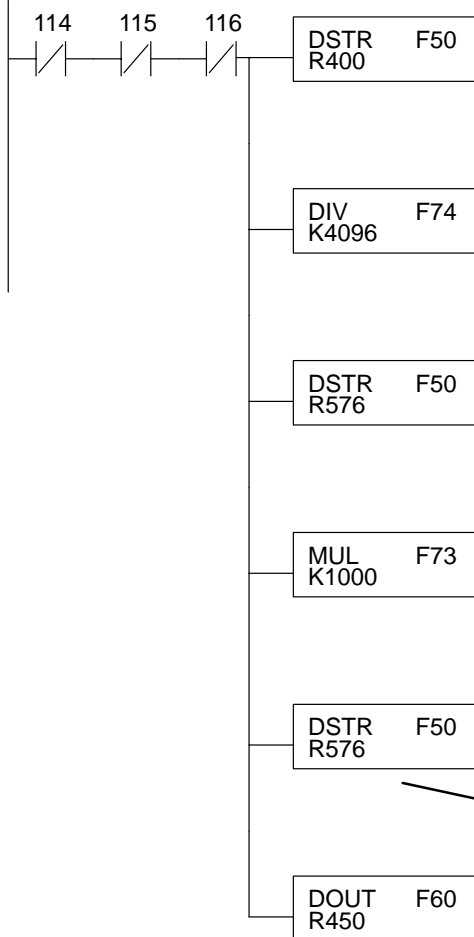
This instruction stores the accumulator to R450 and R451. R450 and R451 now contain the PSI, which is 42 PSI.

| Accumulator |   |   |   | Store in R451 & R450 |   |   |   |
|-------------|---|---|---|----------------------|---|---|---|
| 0           | 0 | 4 | 2 | 0                    | 0 | 4 | 2 |
| R577        |   |   |   | R451 R450            |   |   |   |

You probably noticed the previous example yielded 42 PSI when the real value should have been 42.9 PSI. By changing the scaling value slightly, we can “imply” an extra decimal of precision. Notice in the following example we’ve added another digit to the scale. Instead of a scale of 100, we’re using 1000, which implies 100.0 for the PSI range.

This example assumes you have already read the analog data and stored the BCD equivalent in R400 and R401

### Scale the data



This instruction brings the analog value (in BCD) into the accumulator.

| Accumulator |   |   |   | Aux. Accumulator |      |   |   |
|-------------|---|---|---|------------------|------|---|---|
| 1           | 7 | 6 | 0 | 0                | 0    | 0 | 0 |
|             |   |   |   | R577             | R576 |   |   |

The analog value is divided by the resolution of the module, which is 4096. ( $1760 / 4096 = 0.4296$ )

| Accumulator |   |   |   | Aux. Accumulator |      |   |   |
|-------------|---|---|---|------------------|------|---|---|
| 0           | 0 | 0 | 0 | 4                | 2    | 9 | 6 |
|             |   |   |   | R577             | R576 |   |   |

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

| Accumulator |   |   |   | Aux. Accumulator |      |   |   |
|-------------|---|---|---|------------------|------|---|---|
| 4           | 2 | 9 | 6 | 4                | 2    | 9 | 6 |
|             |   |   |   | R577             | R576 |   |   |

The accumulator is multiplied by the scaling factor, which is now 1000. ( $1000 \times 4296 = 4296000$ ). The most significant digits are now stored in the auxiliary accumulator. (This is different from the way the Divide instruction operates.)

| Accumulator |   |   |   | Aux. Accumulator |      |   |   |
|-------------|---|---|---|------------------|------|---|---|
| 6           | 0 | 0 | 0 | 0                | 4    | 2 | 9 |
|             |   |   |   | R577             | R576 |   |   |

This instruction moves the two-byte auxiliary accumulator for further operations.

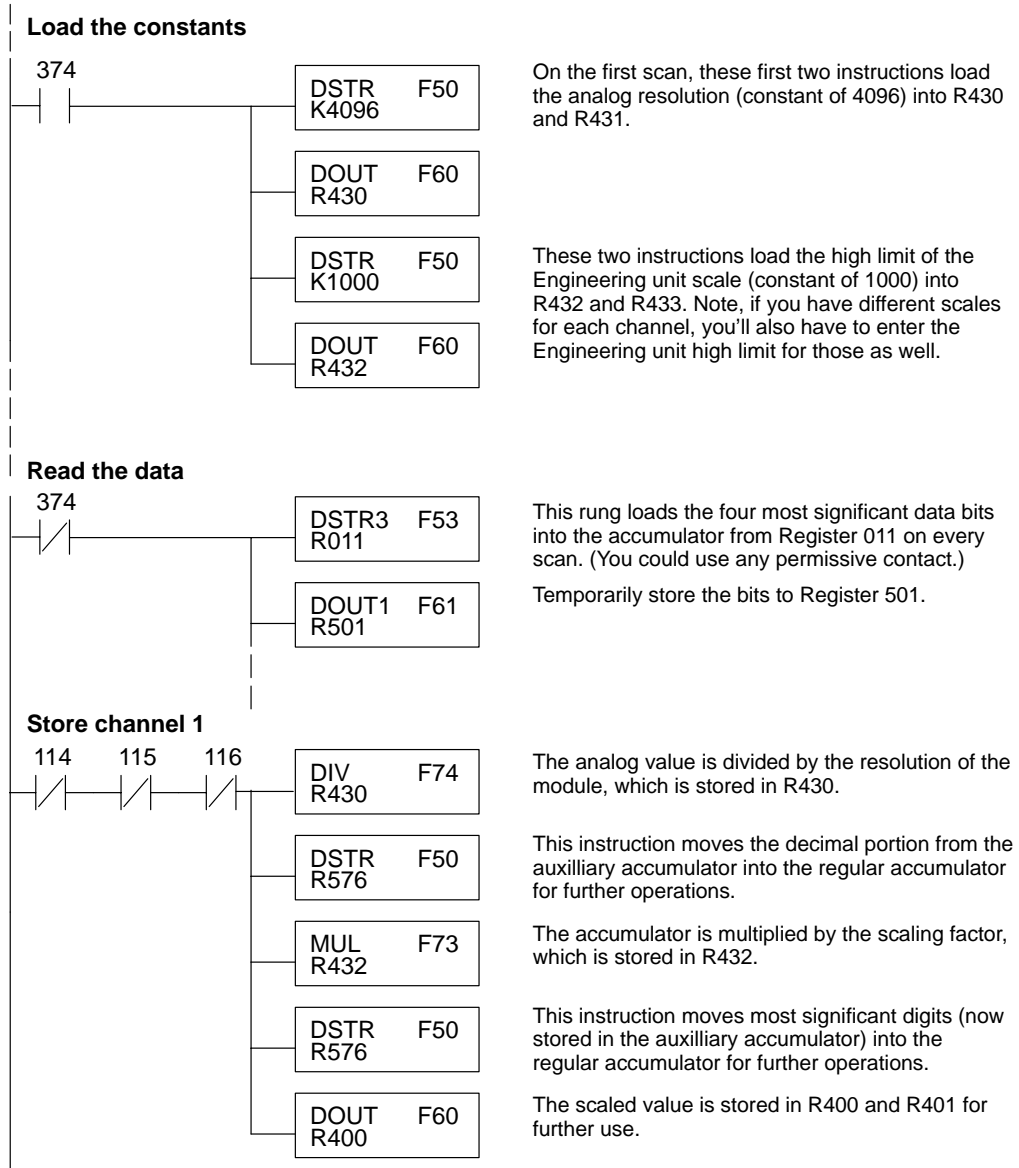
| Accumulator |   |   |   | Aux. Accumulator |      |   |   |
|-------------|---|---|---|------------------|------|---|---|
| 0           | 4 | 2 | 9 | 0                | 4    | 2 | 9 |
|             |   |   |   | R577             | R576 |   |   |

This instruction stores the accumulator to R450 and R451. R450 and R451 now contain the PSI, which implies 42.9.

| Accumulator |   |   |   | Store in R451 & R450 |      |   |   |
|-------------|---|---|---|----------------------|------|---|---|
| 0           | 4 | 2 | 9 | 0                    | 4    | 2 | 9 |
|             |   |   |   | R451                 | R450 |   |   |

This example program shows how you can use the instructions to load these equation constants into data registers. The example was written for channel 1, but you could easily use a similar approach to use different scales for all channels if required.

You could just use the appropriate constants in the instructions dedicated for each channel, but this method allows easier modifications. For example, you could easily use an operator interface or a programming device to change the constants if they are stored in Registers.





## 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.



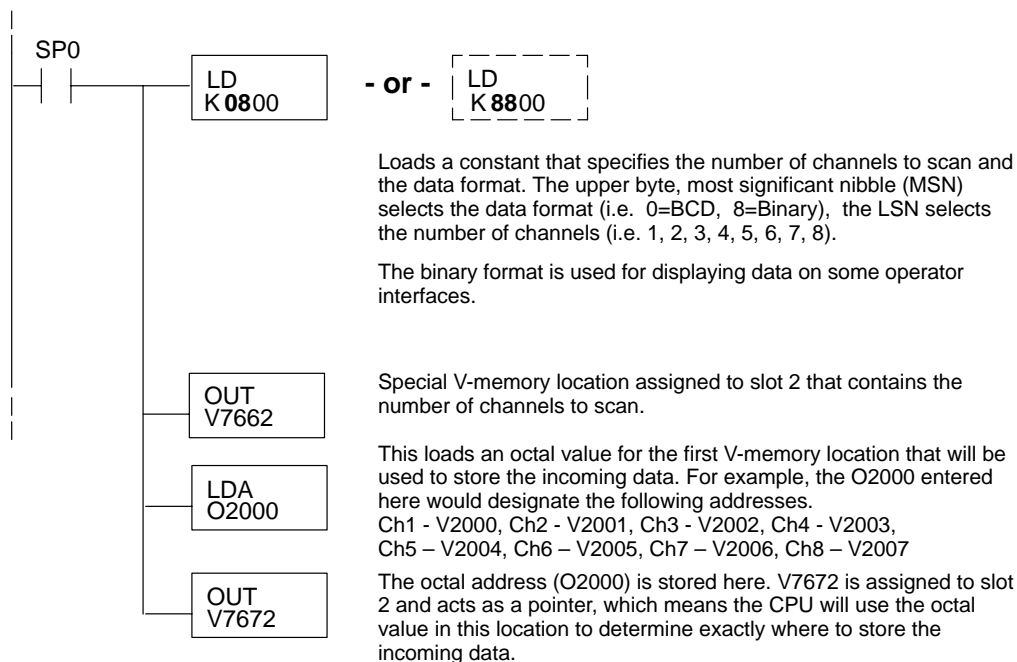
**NOTE:** Do not use the pointer method and the PID PV auto transfer from I/O module function together for the same module. If using PID loops, use the pointer method and ladder logic code to map the analog input data into the PID loop table.

### 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.



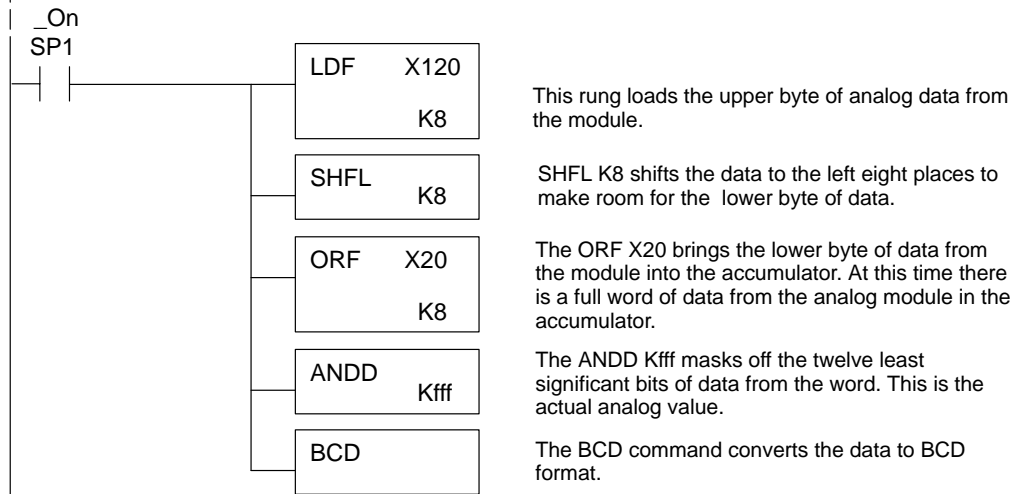
The table shows the special V-memory locations used with the DL350. Slot 0 (zero) is the module next to the CPU, slot 1 is the module two places from the CPU, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. The pointer method is supported on expansion 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 Conventional DL305 Base

The example below shows how to read multiple channels on an F3-08AD Analog module in the X20-27 / X120-127 address slot. This module must be placed in a 16 bit slot in order to work.

#### Load the data



#### Channel 1 Select Bit States



#### Channel 2 Select Bit States

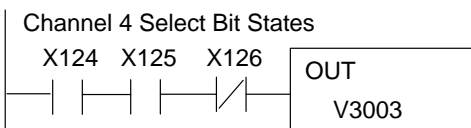


#### Channel 3 Select Bit States

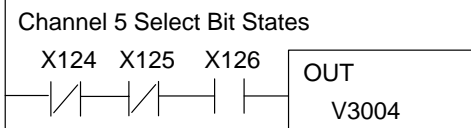


example continued on next page

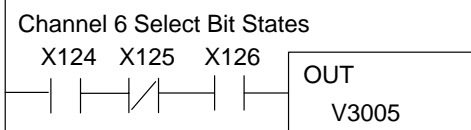
example continued from previous page



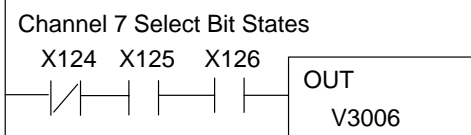
This writes channel four analog data to V3003 when bits X124, X125 and X126 are as shown.



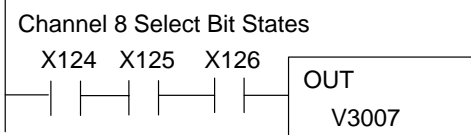
This writes channel five analog data to V3004 when bits X124, X125 and X126 are as shown.



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.

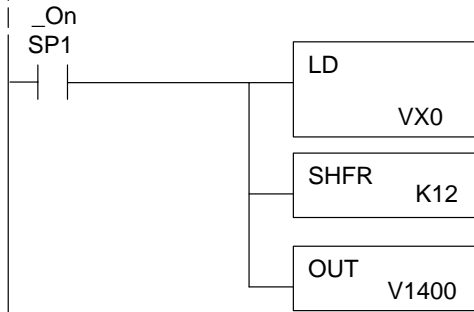


This writes channel eight analog data to V3007 when bits X124, X125 and X126 are as shown.

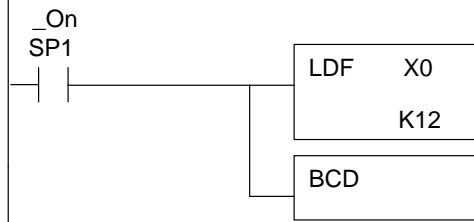
### Multiplexing: DL350 with a D3-xx-1 Base

The example below shows how to read multiple channels on an F3-08AD Analog module in the X0 address slot of a 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.

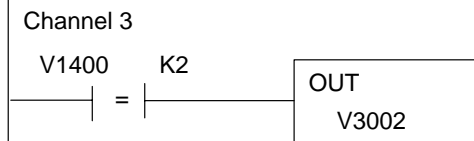
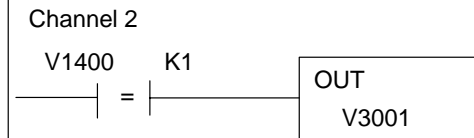
#### Load the data



This rung loads the only the channel select bits into V1400. The SHFR shifts the analog data out of the word.



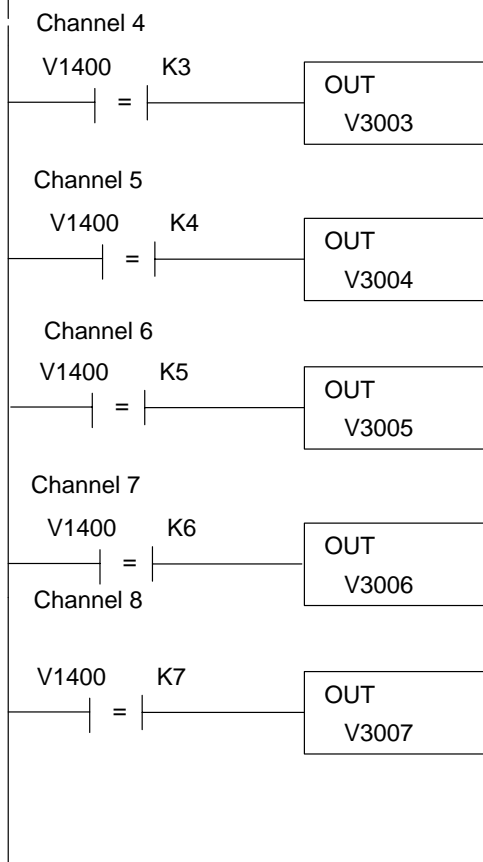
This rung loads the only the analog input data and converts it to BCD.



These rungs store the BCD analog input data into consecutive V memory registers. V1400 will increment once per scan from 0 to 7.

example continued on next page

## example continued from previous page



These rungs store the BCD analog input data into consecutive V memory registers. V1400 will increment once per scan from 0 to 7.

### Scaling the Input Data

Most applications usually require measurements in engineering units, which provide more meaningful data. This is accomplished by using the conversion formula shown.

You may have to make adjustments to the formula depending on the scale you choose for the engineering units.

$$\text{Units} = A \frac{H - L}{4095}$$

H = high limit of the engineering unit range

L = low limit of the engineering unit range

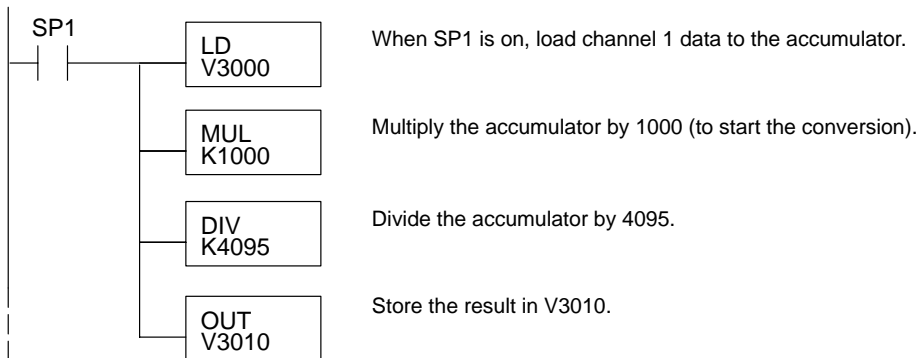
A = Analog value (0 – 4095)

For example, if you wanted to measure pressure (PSI) from 0.0 to 99.9 then you would have to multiply the analog value by 10 in order to imply a decimal place when you view the value with the programming software or a handheld programmer. Notice how the calculations differ when you use the multiplier.

Here is how you would write the program to perform the engineering unit conversion. This example assumes you have BCD data loaded into the appropriate V-memory locations using instructions that apply for the model of CPU you are using.



**NOTE:** This example uses SP1, which is always on. You could also use an X, C, etc. permissive contact.



### Analog 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 analog signal level ... |
|-----------|-----------------------------------|---|
| 4 to 20mA | $A = \frac{16D}{4095} + 4$        | $D = \frac{4095}{16}(A - 4)$            |

For example, if you have measured the signal at 10mA, you would use the following formula to determine the digital value that should be stored in the register location that contains the data.

$$D = \frac{4095}{16}(A - 4)$$

$$D = \frac{4095}{16}(10\text{mA} - 4)$$

$$D = (255.93) (6)$$

$$D = 1536$$

# F3–16AD

## 16-Channel Analog Input

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In This Chapter. . . .

- Module Specifications
  - Setting the Module Jumpers
  - Connecting the Field Wiring
  - Module Operation
  - Writing the Control Program
-

## Module Specifications

The following table provides the specifications for the F3-16AD Analog Input Module from FACTS Engineering. Review these specifications to make sure the module meets your application requirements.

|   |  |
|---|--|
| Number of Channels  | 16, single ended (one common)  |
| Input Ranges  | $\pm 5V$ , $\pm 10V$ , $0-5V^1$ , $0-10V$ ,<br>$0-20\text{ mA}$ , $4 - 20\text{ mA}^2$ |
| Resolution  | 12 bit (1 in 4096)   |
| Input Impedance   | $2M\Omega$ , voltage input<br>$500\Omega \pm 1\%$ , current input                      |
| Absolute Maximum Ratings  | $\pm 25V$ , voltage input<br>$\pm 30\text{ mA}$ , current input                        |
| Conversion Time   | $35\mu\text{s}$ per channel<br>1 channel per CPU scan                                  |
| Converter Type  | Successive Approximation, AD574  |
| Linearity Error   | $\pm 1$ count maximum  |
| Maximum Inaccuracy at 77 °F (25 °C)   | 0.25% of full scale, voltage input<br>1.25% of full scale, current input               |
| Accuracy vs. Temperature  | 57 ppm / °C maximum full scale   |
| Recommended Fuse  | 0.032 A, Series 217 fast-acting, current inputs  |
| Power Budget Requirement  | 33 mA @ 9 VDC, 47 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  |
| 1 – requires gain adjustment with potentiometer.  |  |
| 2 – resolution is 3275 counts (instead of 4096). Allows easier broken transmitter detection |  |

### Analog Input Configuration Requirements

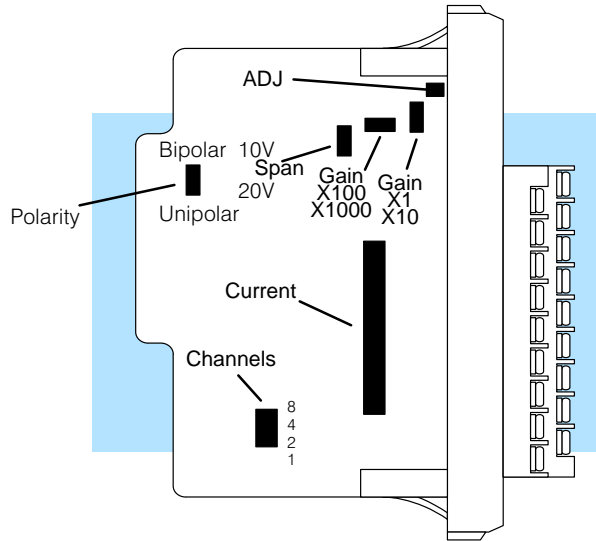
The F3-16AD Analog Input appears as a 16-point module. The module can be installed in any slot configured for 16 points. See the DL305 User Manual for details on using 16 point modules in DL305 systems. The limitation on the number of analog modules are:

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



# Setting the Module Jumpers

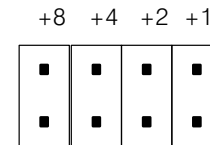
**Jumper Locations** The module is set at the factory for a 0–20 mA signal on all sixteen channels. If this is acceptable you do not have to change any of the jumpers. The following diagram shows the jumper locations.



## Selecting the Number of Channels

If you examine the rear of the module, you'll notice several jumpers. The jumpers labeled +1, +2, +4 and +8 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 sixteen channel operation.

Any unused channels are not processed so if you only select channels 1–8, then the last eight channels will not be active. The following table shows which jumpers to install.



Number of Channels

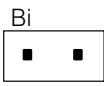
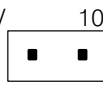


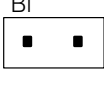
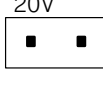


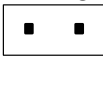
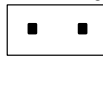


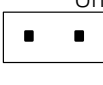
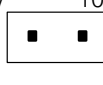


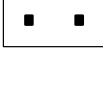
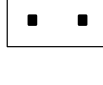






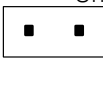
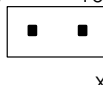


**Jumpers installed as shown selects 16-channel operation**

| Channel(s)      | Jumper |     |     |     | Channel(s)                             | Jumper |     |     |     |
|-----------------|--------|-----|-----|-----|--|--------|-----|-----|-----|
|                 | +8     | +4  | +2  | +1  |  | +8     | +4  | +2  | +1  |
| 1               | No     | No  | No  | No  | 1 2 3 4 5 6 7 8 9                      | Yes    | No  | No  | No  |
| 1 2             | No     | No  | No  | Yes | 1 2 3 4 5 6 7 8 9 10                   | Yes    | No  | No  | Yes |
| 1 2 3           | No     | No  | Yes | No  | 1 2 3 4 5 6 7 8 9 10 11                | Yes    | No  | Yes | No  |
| 1 2 3 4         | No     | No  | Yes | Yes | 1 2 3 4 5 6 7 8 9 10 11 12             | Yes    | No  | Yes | Yes |
| 1 2 3 4 5       | No     | Yes | No  | No  | 1 2 3 4 5 6 7 8 9 10 11 12 13          | Yes    | Yes | No  | No  |
| 1 2 3 4 5 6     | No     | Yes | No  | Yes | 1 2 3 4 5 6 7 8 9 10 11 12 13 14       | Yes    | Yes | No  | Yes |
| 1 2 3 4 5 6 7   | No     | Yes | Yes | No  | 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15    | Yes    | Yes | Yes | No  |
| 1 2 3 4 5 6 7 8 | No     | Yes | Yes | Yes | 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 | Yes    | Yes | Yes | Yes |

### Selecting Input Signal Ranges

As you examined the jumper settings, you may have noticed there are current jumpers for each individual channel. These jumpers allow you to select the type of signal (voltage or current).

The span and polarity jumpers are used to select the signal range. The polarity and span selection affect all the channels. For example, if you select unipolar operation and a 10V span, you can use both 0 –10V and 0–20 mA signals at the same time. Channels that will receive 0–20 mA signals should have the current jumper installed. The following table shows the jumper selections for the various ranges. (Only channel 1 is used in the example, but all channels must be set.)

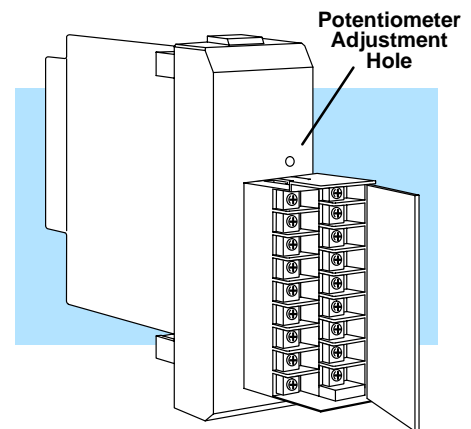
| Bipolar Signal Range  | Jumper Settings   |   |  |
|---|---|---|--|
| -5 VDC to +5 VDC  | Polarity<br>Bi      Uni<br>    | Span<br>20V    10V<br>   | Current Jumper<br><br>Gain Jumper<br>x1      x10<br>       |
| -10 VDC to +10 VDC  | Polarity<br>Bi      Uni<br>    | Span<br>20V    10V<br>   | Current Jumper<br><br>Gain Jumper<br>x1      x10<br>       |
| Unipolar Signal Range   | Jumper Settings   |   |  |
| 0 to 20 mA<br>(these settings are also used for the 4–20mA range) | Polarity<br>Bi      Uni<br> | Span<br>20V    10V<br> | Current Jumper<br><br>Gain Jumper<br>x1      x10<br>    |
| 0 VDC to +10 VDC  | Polarity<br>Bi      Uni<br> | Span<br>20V    10V<br> | Current Jumper<br><br>Gain Jumper<br>x1      x10<br>   |
| 0 VDC to +1 VDC   | Polarity<br>Bi      Uni<br> | Span<br>20V    10V<br> | Current Jumper<br><br>Gain Jumper<br>x1      x10<br>   |
| 0 VDC to +0.1 VDC   | Polarity<br>Bi      Uni<br> | Span<br>20V    10V<br> | Current Jumper<br><br>Gain Jumper<br>x100    x1000<br> |
| 0 VDC to +0.01 VDC  | Polarity<br>Bi      Uni<br> | Span<br>20V    10V<br> | Current Jumper<br><br>Gain Jumper<br>x100    x1000<br> |

| Input Signal Range   | Jumper Settings  |
|--|--|
| 0 VDC to +5 VDC<br>(requires gain adjustment<br>see instructions below)  | Polarity: Bi Uni<br>Span: 20V 10V<br>Current Jumper: x1 x10<br>Gain Jumper: x1 x10 |
| 0 VDC to +12 VDC<br>(requires gain adjustment<br>see instructions below) | Polarity: Bi Uni<br>Span: 20V 10V<br>Current Jumper: x1 x10<br>Gain Jumper: x1 x10 |

### Variable Gain Adjustment

If you look at the terminal block closely, you'll notice a small hole conceals an adjustment potentiometer. This small potentiometer is used to adjust the gain for certain situations.

For example, if you have 0–5V transmitters you have to use the 0–10V scale on the module. Since the module converts the signal to a digital value between 0 and 4095, a 5V signal would only yield a value of 2048. Fortunately, the variable gain feature provides a simple solution. Just complete the following steps.



1. Install a jumper on the gain adjustment pins. (This jumper location is labeled ADJ. This jumper will remain installed after the gain adjustment.)
2. Apply 5V to one of the channels.
3. Use a handheld programmer or **DirectSOFT** to monitor the input register that contains the analog data. (If you're not familiar with this procedure, wait until you read the section on Writing the Control Program. This will show you how to get data into a register. You can come back to this procedure later.)
4. Adjust the potentiometer until the register value reads 4094 or 4095. The potentiometer is turned clockwise to increase the gain.

Now the module has been adjusted so a 5V signal provides a digital value of 4095 instead of 2048.

## Connecting the Field Wiring

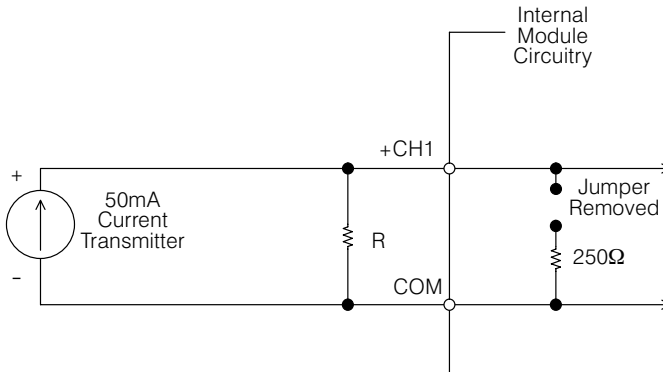
**Wiring Guidelines** Your company may have guidelines for wiring and cable installation. If so, you should check those before you begin the installation. Here are some general things to consider.

- 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 F3-16AD receives all power from the base. A separate power supply is not required.

### Custom Input Ranges

Occasionally you may have the need to connect a transmitter with an unusual signal range. By changing the wiring slightly and adding an external resistor to convert the current to voltage, you can easily adapt this module to meet the specifications for a transmitter that does not adhere to one of the standard input ranges. The following diagram shows how this works.



$$R = \frac{V_{\max}}{I_{\max}}$$

R = value of external resistor

$V_{\max}$  = high limit of selected voltage range

$I_{\max}$  = maximum current supplied by the transmitter

Example: current transmitter capable of 50mA, 0 - 10V range selected.

$$R = \frac{10V}{50mA} \quad R = 200 \text{ ohms}$$

**NOTE:** Your choice of resistor can affect the accuracy of the module. A resistor that has  $\pm 0.1\%$  tolerance and a  $\pm 50\text{ppm} / ^\circ\text{C}$  temperature coefficient is recommended.

### Current Loop Transmitter Impedance

Standard 4 to 20 mA transmitters and transducers can operate from a wide variety of power supplies. Not all transmitters are alike and the manufacturers often specify a minimum loop or load resistance that must be used with the transmitter at the various voltages.

The F3-16AD provides 500 ohm resistance for each channel. If your transmitter requires a load resistance below 500 ohms, then you do not have to make any adjustments. However, if your transmitter requires a load resistance higher than 500 ohms, then you need to add a resistor in series with the module.

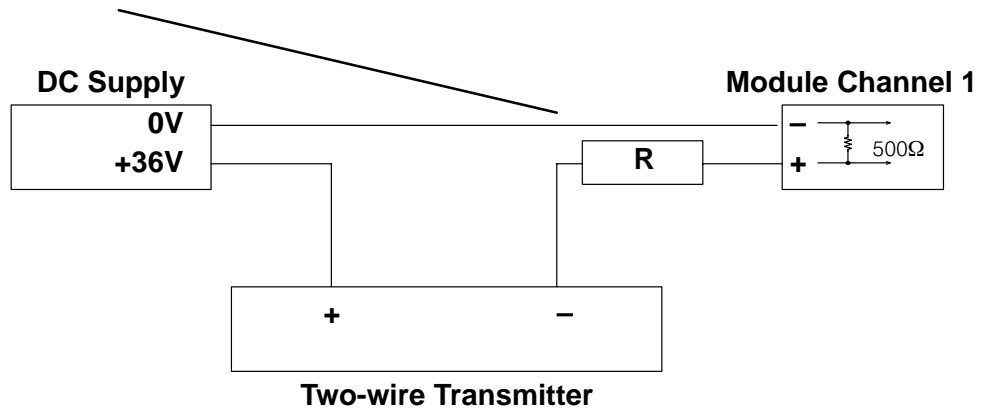
Consider the following example for a transmitter being operated from a 36 VDC supply with a recommended load resistance of 750 ohms. Since the module has a 500 ohm resistor, you need to add an additional resistor.

$$R = Tr - Mr$$

$$R = 750 - 500$$

$$R \geq 250$$

R – Resistor to add  
 Tr – Transmitter Requirement  
 Mr – Module resistance (internal 500 ohms)



**Removable Connector**

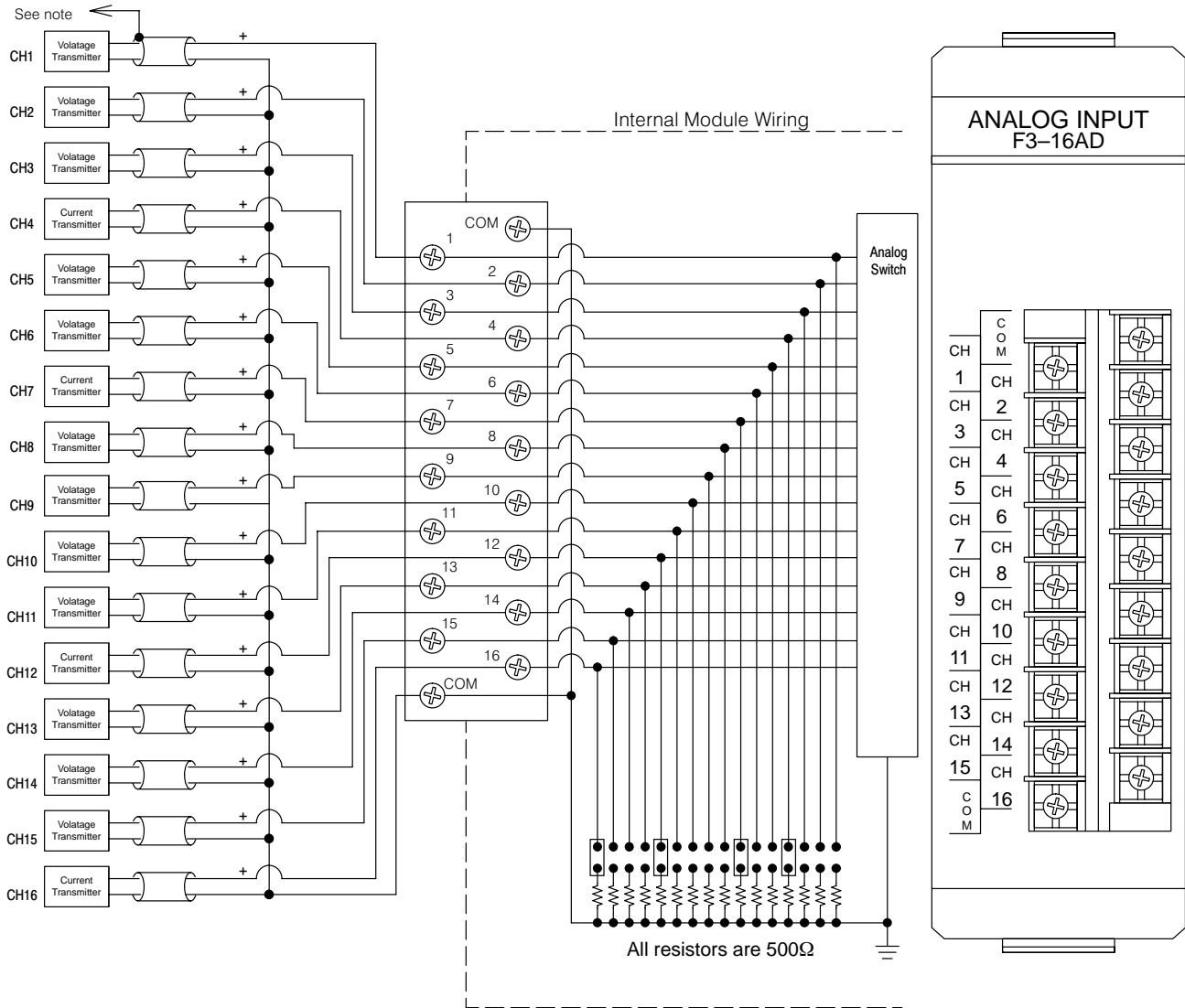
The F3-16AD module has a removable connector to make wiring easier. Simply squeeze the top and bottom tabs and gently pull the connector from the module.

**Wiring Diagram**

Note 1: Terminate all shields at their respective signal source.

Note 2: Jumpers for CH4, 7, 12 and 16 are installed for current input.

See Errata Sheet at the beginning of this file. The wiring diagram has been revised to show 2-wire and 4-wire current transmitter examples with connections to external 24 VDC power supplies.



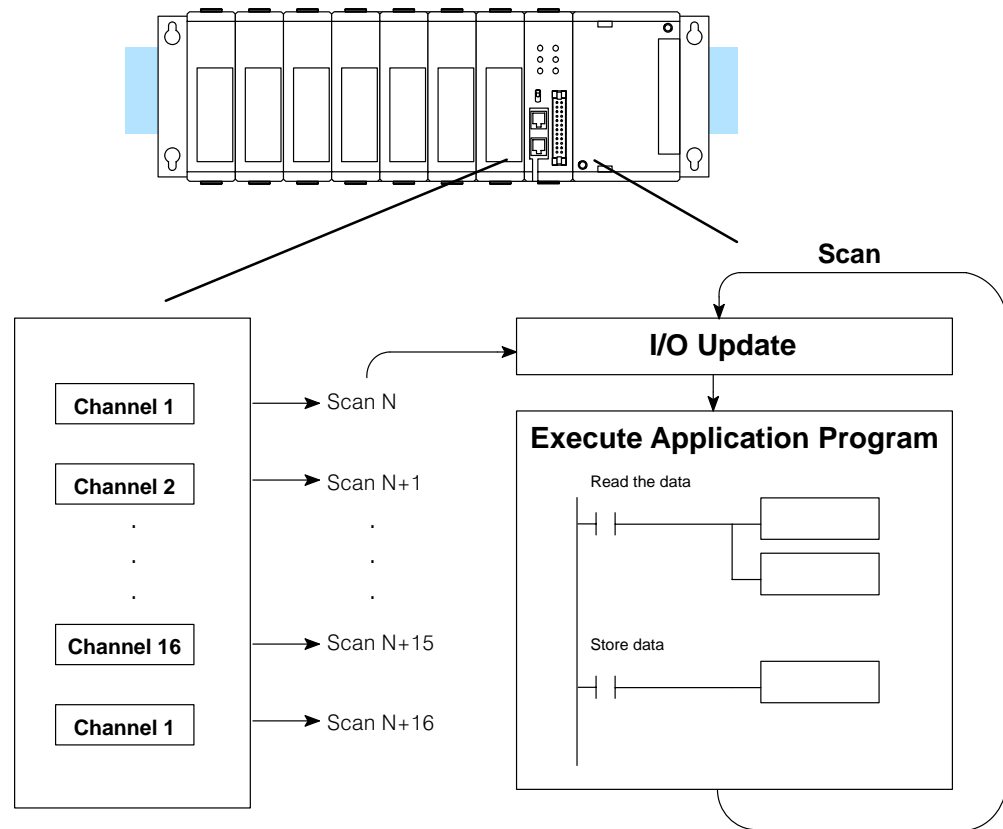
## Module Operation

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 F3-16AD module supplies 1 channel of data per each CPU scan. Since there are sixteen channels, it can take up to sixteen 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 eight channels, then the channels will be updated within eight scans.



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 12-bit binary representation. This enables the module to continuously provide accurate measurements without slowing down the discrete control logic in the RLL program.

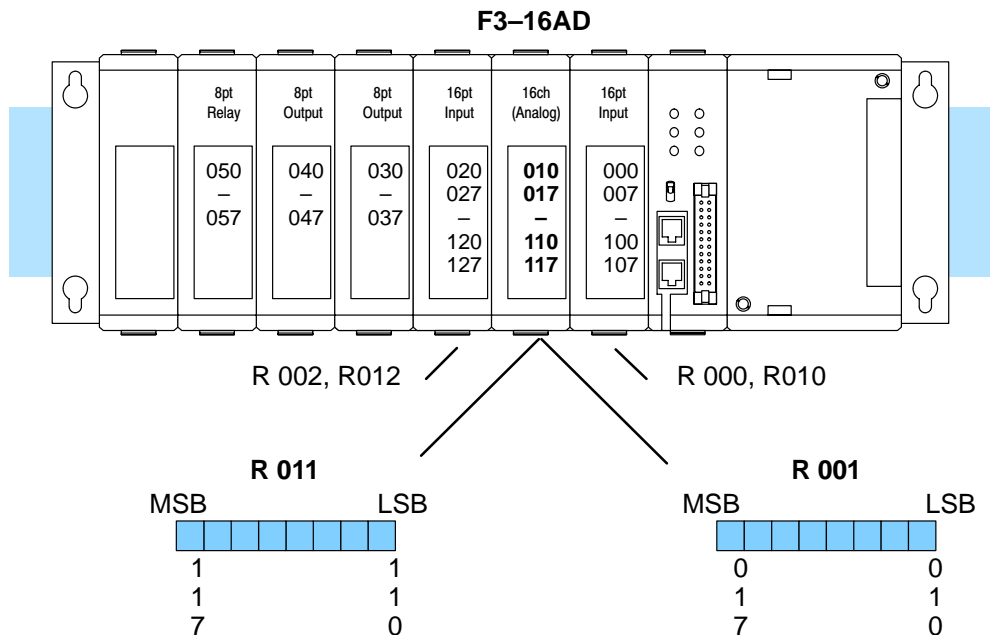


**Understanding the I/O Assignments**

You may recall the F3-16AD 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 analog signal.

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.

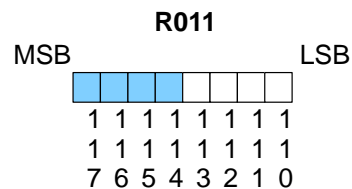


Within these two register locations, the individual bits represent specific information about the analog signal.

### Active Channel Indicator Inputs

The last four inputs of the upper Register indicate the active channel. The indicators automatically increment with each CPU scan.

| Scan | Channel Inputs | Active Channel |
|------|----------------|----------------|
| N    | 0000           | 1              |
| N+1  | 0001           | 2              |
| N+2  | 0010           | 3              |
| N+3  | 0011           | 4              |
| N+4  | 0100           | 5              |
| N+5  | 0101           | 6              |
| N+6  | 0110           | 7              |
| N+7  | 0111           | 8              |
| N+8  | 1000           | 9              |
| N+9  | 1001           | 10             |
| N+10 | 1010           | 11             |
| N+11 | 1011           | 12             |
| N+12 | 1100           | 13             |
| N+13 | 1101           | 14             |
| N+14 | 1110           | 15             |
| N+15 | 1111           | 16             |



- channel indicator inputs

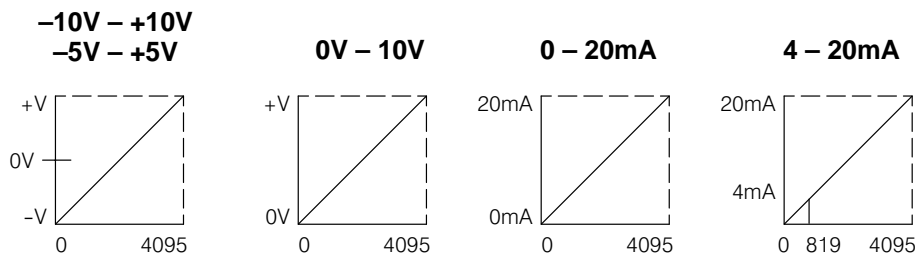
**Analog Data Bits**

The remaining twelve bits represent the analog data in binary format.

| Bit     | Value | Bit | Value | R011 |   |   |   |   |   | R001 |   |   |   |   |   |     |   |   |   |   |   |   |   |  |  |  |  |
|---------|-------|-----|-------|------|---|---|---|---|---|------|---|---|---|---|---|-----|---|---|---|---|---|---|---|--|--|--|--|
|         |       |     |       | MSB  |   |   |   |   |   |      |   |   |   |   |   | LSB |   |   |   |   |   |   |   |  |  |  |  |
| 0 (LSB) | 1     | 6   | 64    |      |   |   |   |   |   |      |   |   |   |   |   |     |   |   |   |   |   |   |   |  |  |  |  |
| 1       | 2     | 7   | 128   | 1    | 1 | 1 | 1 | 1 | 1 | 1    | 1 | 0 | 0 | 0 | 0 | 0   | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |  |  |  |
| 2       | 4     | 8   | 256   | 1    | 1 | 1 | 1 | 1 | 1 | 1    | 1 | 1 | 1 | 1 | 1 | 1   | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  |  |  |  |
| 3       | 8     | 9   | 512   | 7    | 6 | 5 | 4 | 3 | 2 | 1    | 0 | 7 | 6 | 5 | 4 | 3   | 2 | 1 | 0 | 7 | 6 | 5 | 4 |  |  |  |  |
| 4       | 16    | 10  | 1024  |      |   |   |   |   |   |      |   |   |   |   |   |     |   |   |   |   |   |   |   |  |  |  |  |
| 5       | 32    | 11  | 2048  |      |   |   |   |   |   |      |   |   |   |   |   |     |   |   |   |   |   |   |   |  |  |  |  |

■ - data bits

Since the module has 12-bit resolution, the analog signal is converted into 4096 “pieces” ranging from 0 – 4095 (2<sup>12</sup>). For example, with a 0 to 10V scale, a 0V signal would be 0, and a 10V signal would be 4095. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal. The following diagram shows how this relates to each signal range.



**NOTE:** When you use 4–20mA signals, you have to use the 0–20mA scale. You do not have resolution of 4096 if the 4–20mA signal is present. In this case, the range is 819 to 4095. This is because a 0 still represents 0mA, not 4mA.

Each “piece” can also be expressed in terms of the signal level by using the equation shown. The following table shows the smallest signal levels that will possibly result in a change in the data value for each signal range.

$$\text{Resolution} = \frac{H - L}{4095}$$

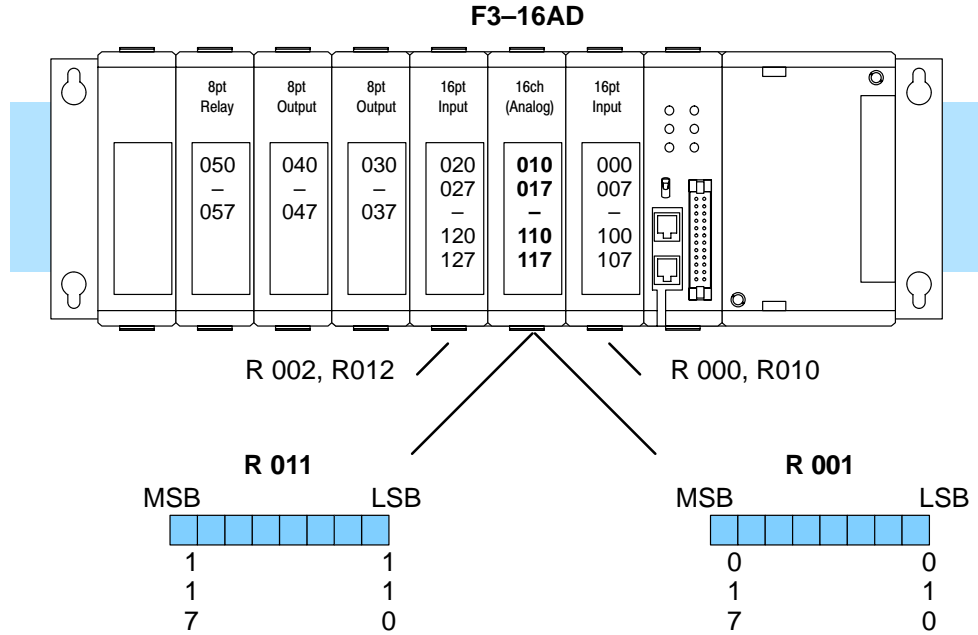
H = high limit of the signal range  
L = low limit of the signal range

| Range                         | Highest Signal | Lowest Signal | Smallest Change |
|-------------------------------|----------------|---------------|-----------------|
| -10 to +10V                   | +10V           | -10V          | 4.88 mV         |
| -5 to +5V                     | +5 V           | -5V           | 2.44 mV         |
| 0 to 5V                       | 5V             | 0V            | 1.22 mV         |
| 0 to 10V                      | 10V            | 0V            | 2.44 mV         |
| 0 to 12V                      | 12V            | 0V            | 2.90 mV         |
| 0 to 20mA<br>(4 to 20mA also) | 20mA           | 0mA           | 4.88 μA         |
| 0 to 1V                       | 1 V            | 0 V           | 0.244 mV        |
| 0 to 0.1V                     | 0.1 V          | 0 V           | 24.4 uV         |
| 0 to 0.01V                    | 0.01 V         | 0 V           | 2.44 uV         |

### Writing the Control Program (DL330 / DL340)

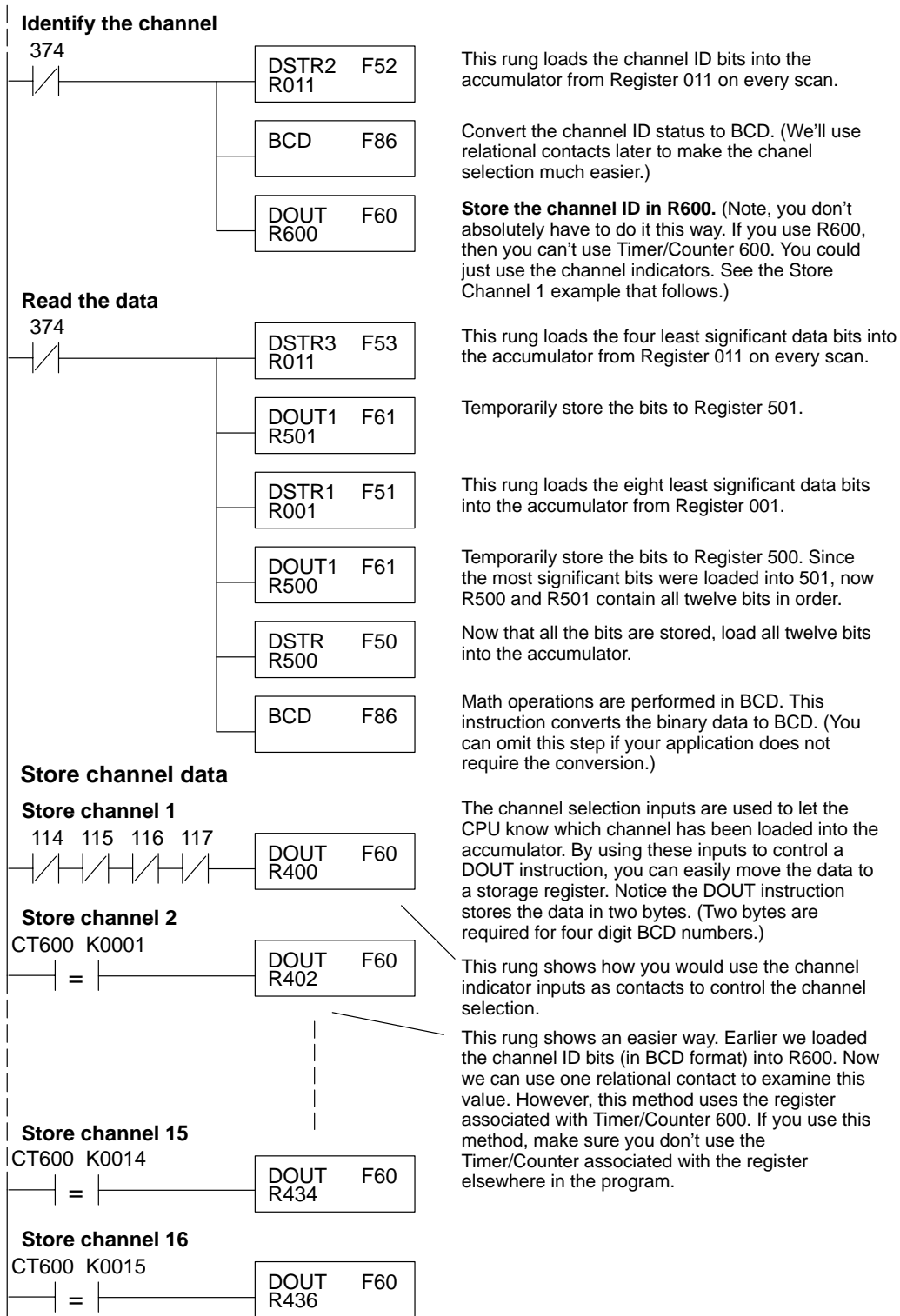
#### Identifying the Data Locations

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 active channel status bits to determine which channel is being monitored.



**Example Program**

The following example shows a program designed to read any of the available channels of analog data into Register locations. Once the data is in a Register, you can perform math on the data, compare the data against preset values, etc. Since the DL305 CPUs use 8-bit word instructions, you have to move the data in pieces. It's pretty simple if you follow the example.



**Scaling the Input Data**

Most applications usually require measurements in engineering units, which provide more meaningful data. This is accomplished by using the conversion formula shown.

The following example shows how you would use the analog data to represent pressure (PSI) from 0 to 100. This example assumes the analog value is 1760. This should yield approximately 42.9 PSI.

$$\text{Units} = \frac{A}{4096} S$$

Units = value in Engineering Units

A = Analog value (0 – 4095)

S = high limit of the Engineering unit range

$$\text{Units} = \frac{A}{4096} S$$



$$\text{Units} = \frac{1760}{4096} 100$$

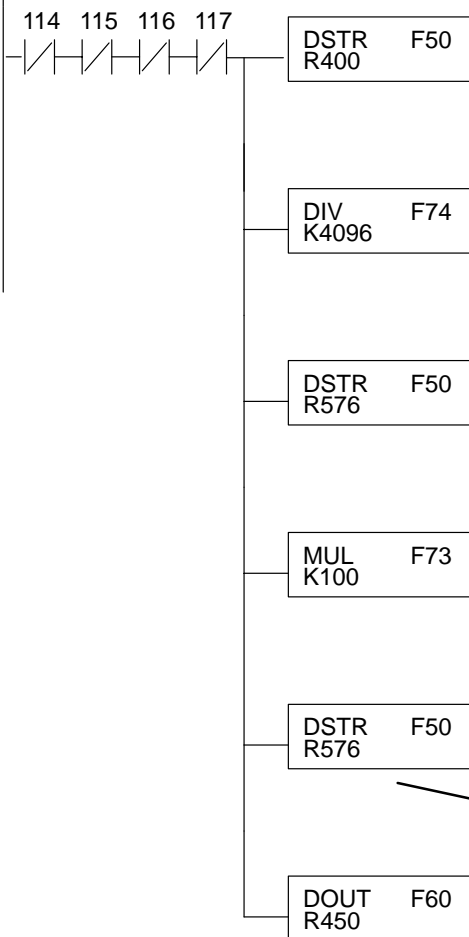


$$\text{Units} = 42.9$$

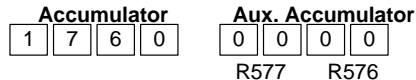
The following instructions are required to scale the data. (We'll continue to use the 42.9 PSI example.) In this example we're using channel 1. The active channel indicator inputs are all off when channel 1 data is being read. Of course, if you were using a different channel, you would use the active channel indicator point combination that corresponds to the channel you were using.

This example assumes you have already read the analog data and stored the BCD equivalent in R400 and R401

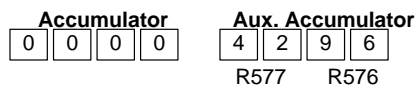
**Scale the data**



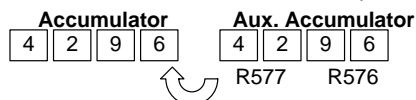
This instruction brings the analog value (in BCD) into the accumulator.



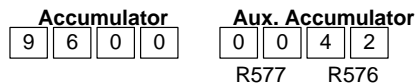
The analog value is divided by the resolution of the module, which is 4096. ( $1760 / 4096 = 0.4296$ )



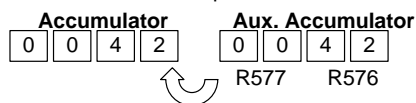
This instruction moves the two-byte decimal portion into the accumulator for further operations.



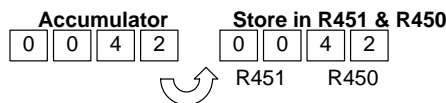
The accumulator is then multiplied by the scaling factor, which is 100. ( $100 \times 4296 = 429600$ ). Notice the most significant digits are now stored in the auxiliary accumulator. (This is different from the way the Divide instruction operates.)



This instruction moves the two-byte auxiliary accumulator for further operations.



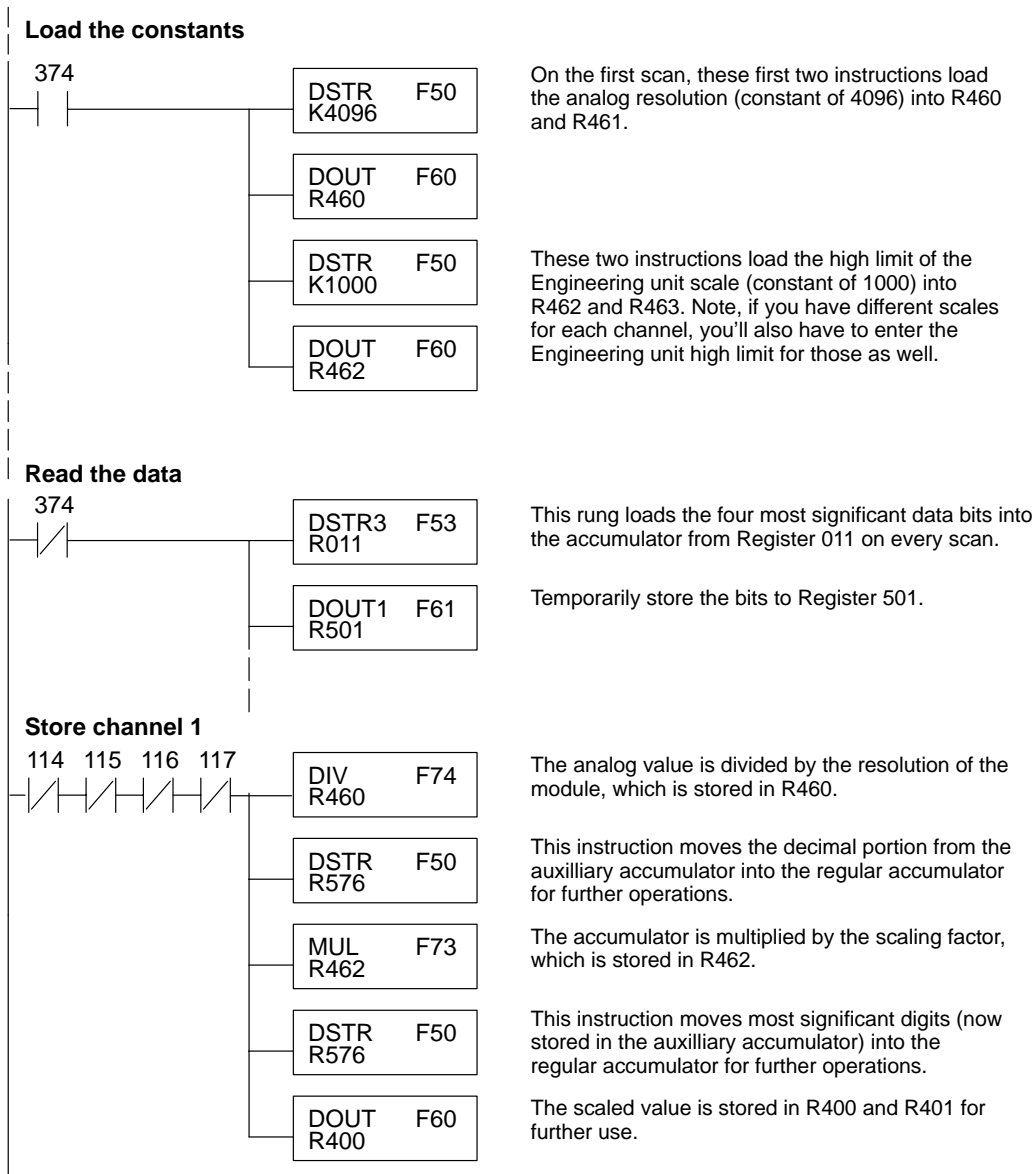
This instruction stores the accumulator to R450. R450 now contains the PSI, which is 42 PSI.







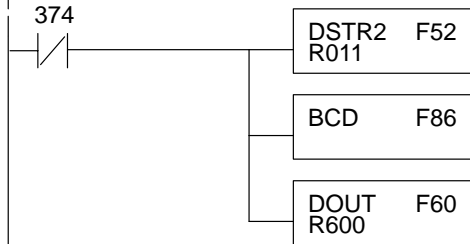
This example program shows how you can use the instructions to load these equation constants into data registers. The example is written for channel 1, but you can easily use a similar approach to use different scales for all channels if required. You may just use the appropriate constants in the instructions dedicated for each channel, but this method allows easier modifications. For example, you could easily use an operator interface or a programming device to change the constants if they are stored in Registers.



### Broken Transmitter Detection

If you use 4–20mA signals you can easily check for broken transmitter conditions. Since you have to use the 0–20mA range and the lowest signal for the 4–20mA transmitter is 4mA, the lowest digital value for the signal is not 0, but instead is 819. If the transmitter is working properly the smallest value you should ever see is 819. If you see a value of less than about 750 (allowing for tolerance), then you know the transmitter is broken.

#### Read the channel ID

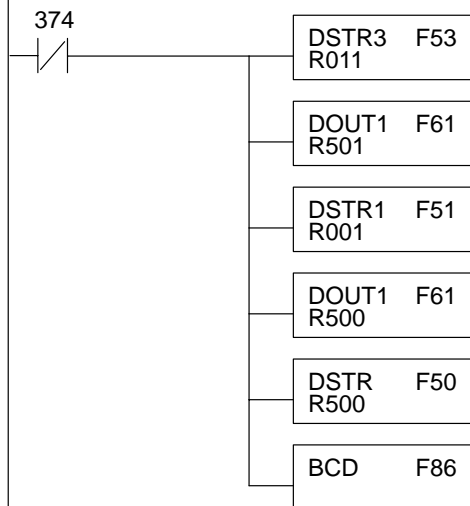


This rung loads the channel ID bits into the accumulator from Register 011 on every scan.

Convert the channel ID status to BCD. We'll use relational contacts later to make the channel selection much easier.)

Store the channel ID in R600.

#### Read the data



This rung loads the four most significant data bits into the accumulator from Register 011 on every scan.

Temporarily store the bits to Register 501.

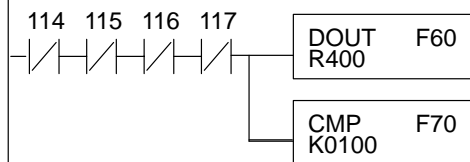
This rung loads the eight least significant data bits into the accumulator from Register 001.

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.

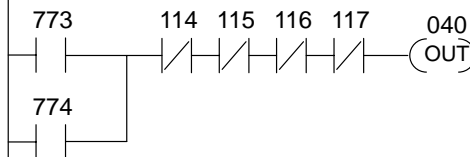
Math operations are performed in BCD. This instruction converts the binary data to BCD. (You can omit this step if your application does not require the conversion.)

#### Store channel 1



The DOUT instruction copies the accumulator data to R400 and R401. Since the data is still in the accumulator, we can compare it against a constant. Since the minimum value for a 4mA signal is 819 (minus the module tolerance), we can choose a value for the compare. We picked 100, but you could choose something else from 0 to about 750.

#### Broken transmitter indicator on channel 1



Flags 773 and 774 are used with the Compare instruction. In this example if the analog value is less than or equal to 100, then output 040 is turned on.

You may want to latch 040 to catch intermittent broken transmitters.

## 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.



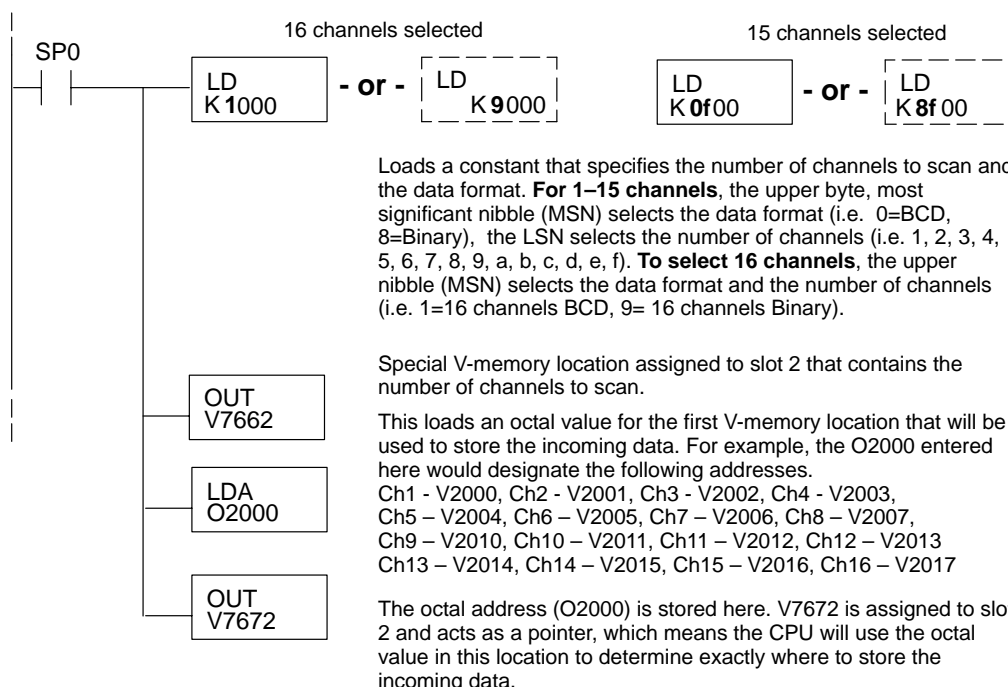
**NOTE:** Do not use the pointer method and the PID PV auto transfer from I/O module function together for the same module. If using PID loops, use the pointer method and ladder logic code to map the analog input data into the PID loop table.

### 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<sup>PLUS</sup> 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.

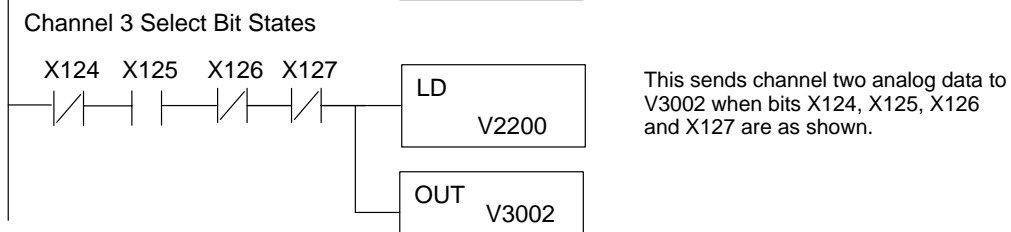
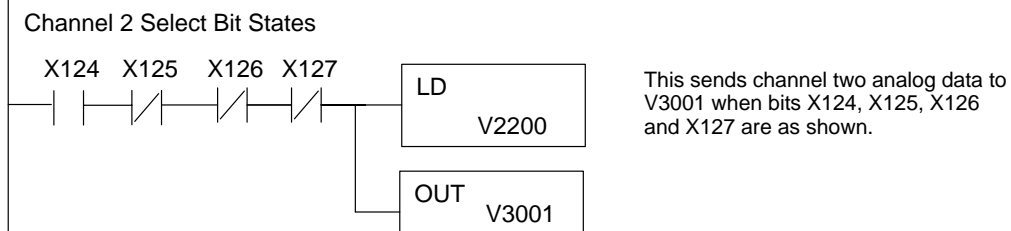
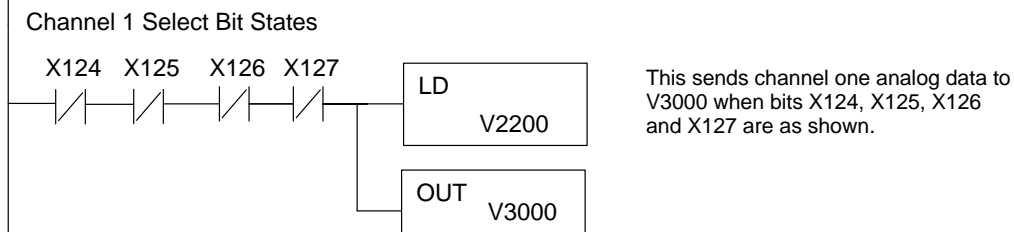
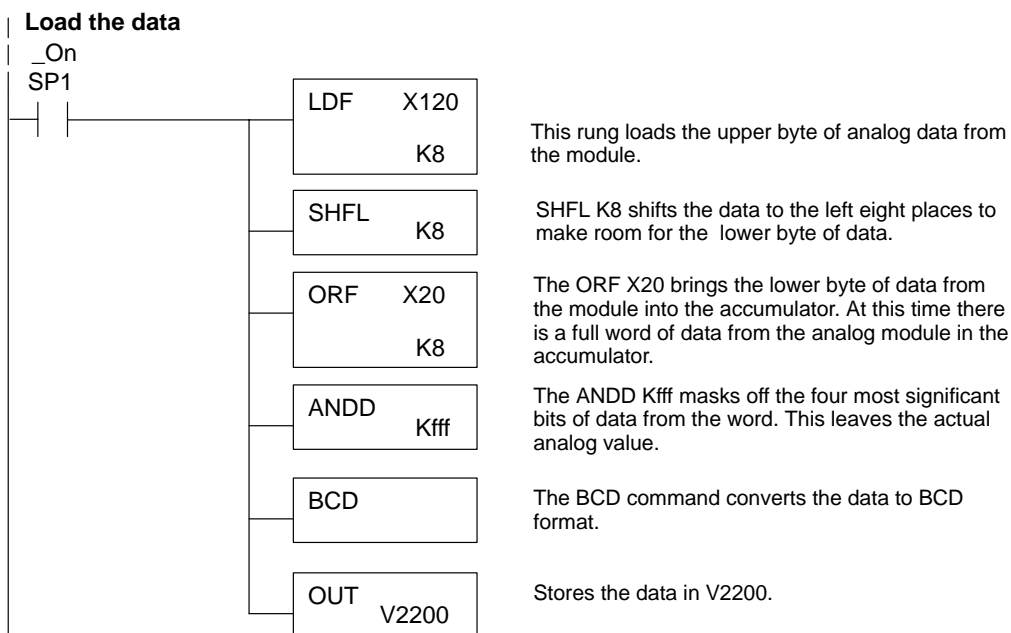


The table shows the special V-memory locations used with the DL350. Slot 0 (zero) is the module next to the CPU, slot 1 is the module two places from the CPU, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. The pointer method is supported on expansion 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 |

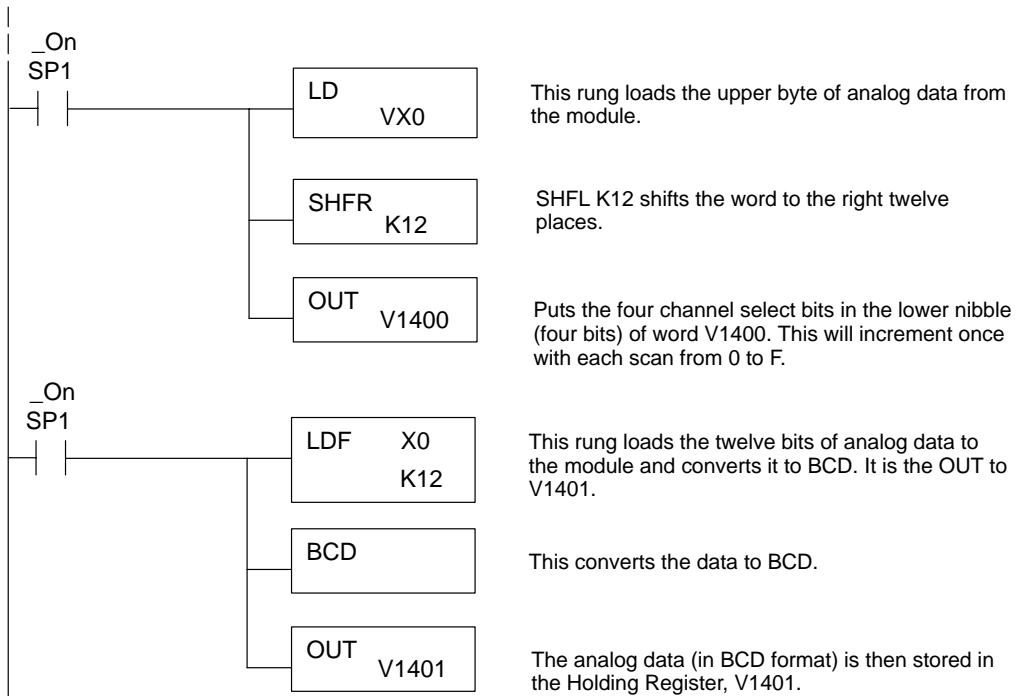
**Multiplexing:  
DL350 with a  
Conventional  
DL305 Base**

The example below shows how to read multiple channels on an F3-08AD Analog module in the 20-27/120-127 address slot. This module must be placed in a 16 bit slot in order to work.

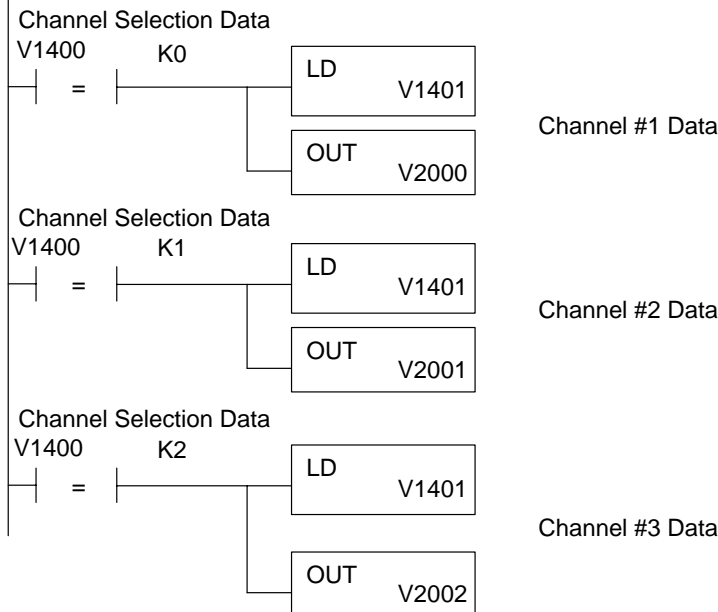


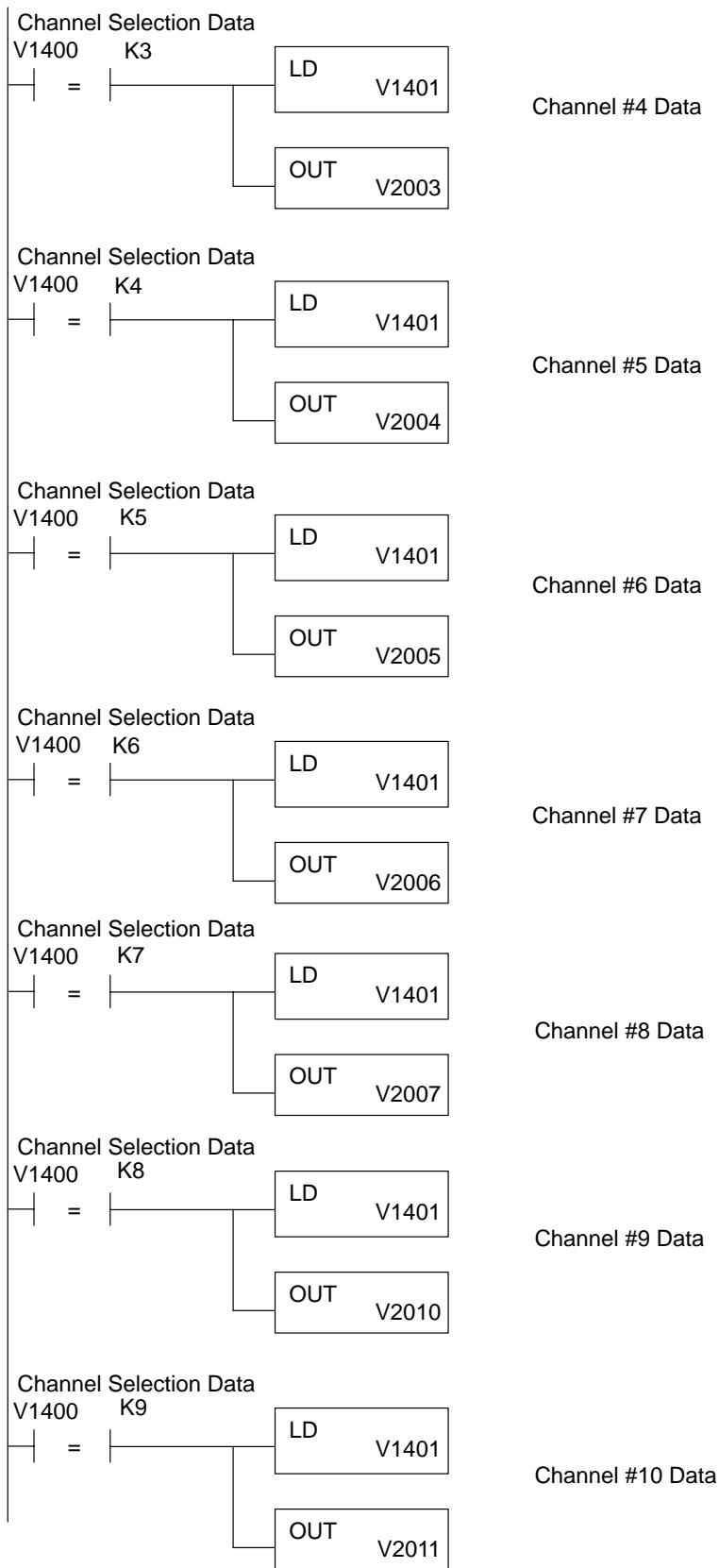
### Multiplexing: DL350 with a D3-XX-1 Base

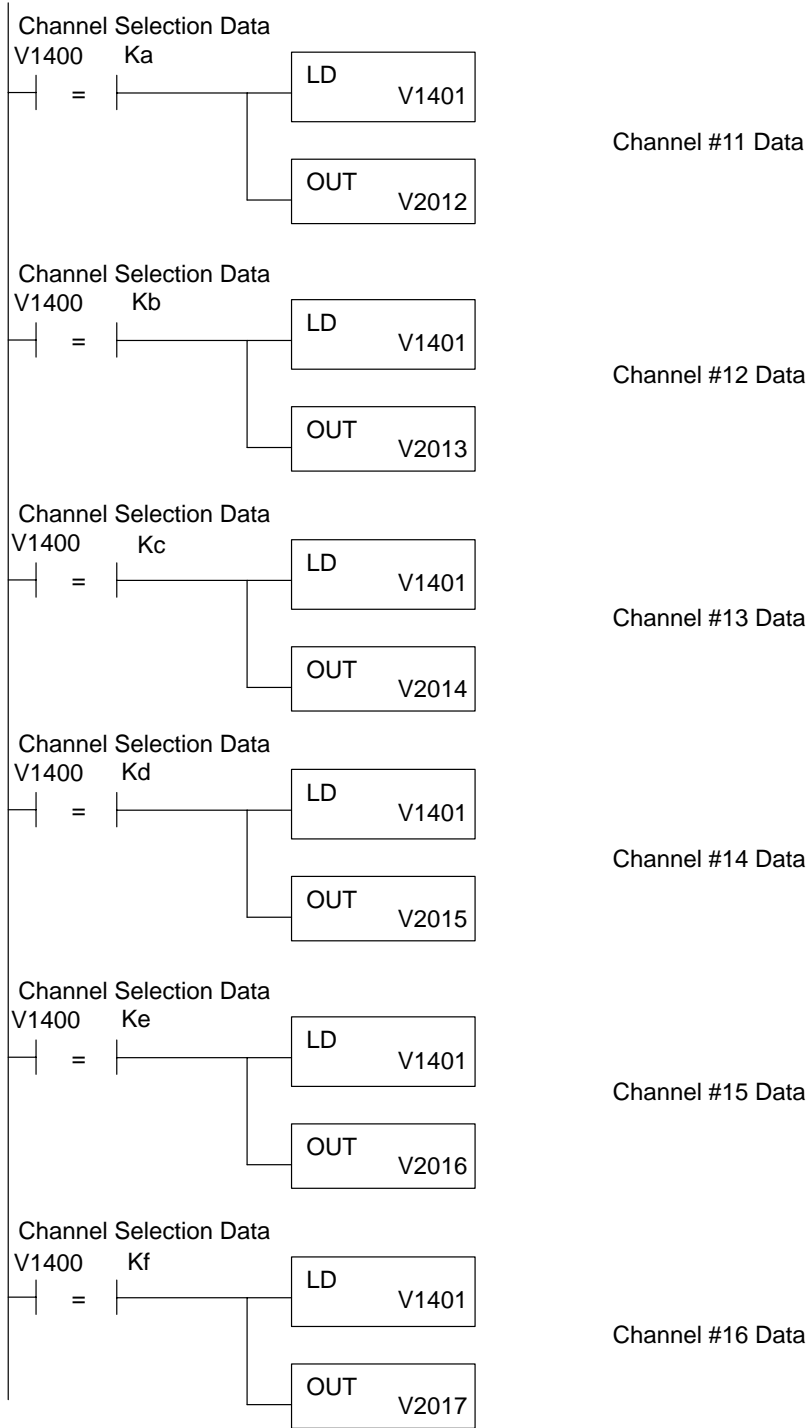
The example below shows how to read multiple channels on an F3-16AD Analog module in the X0 address slot of the D3-XX-1 base. If any expansion bases are used in the system, they must all be D3-xx-1 to be able to use this example. Otherwise, the conventional base addressing must be used.



**Rungs 3-18 compare the count of the channel select bits. When the corresponding bits are true, the channel data for that channel is stored in the proper V-memory location. For sixteen channels of analog data, the module will require sixteen scans in order to update all channels.**









## Scaling the Input Data

Most applications usually require measurements in engineering units, which provide more meaningful data. This is accomplished by using the conversion formula shown.

You may have to make adjustments to the formula depending on the scale you choose for the engineering units.

$$\text{Units} = A \frac{H - L}{4095}$$

H = high limit of the engineering unit range

L = low limit of the engineering unit range

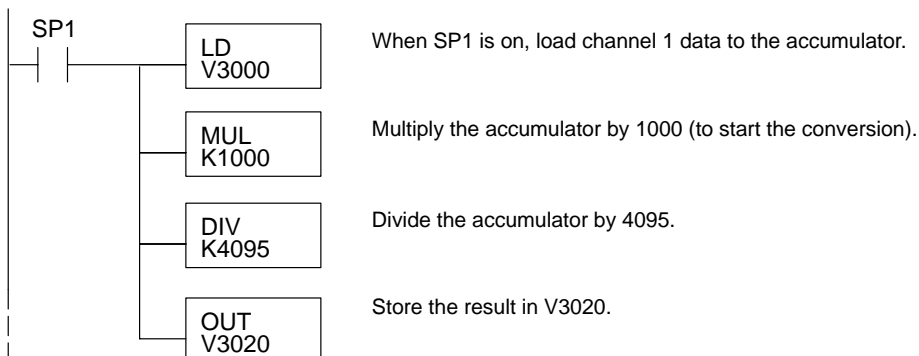
A = Analog value (0 – 4095)

For example, if you wanted to measure pressure (PSI) from 0.0 to 99.9 then you would have to multiply the analog value by 10 in order to imply a decimal place when you view the value with the programming software or a handheld programmer. Notice how the calculations differ when you use the multiplier.

Here is how you would write the program to perform the engineering unit conversion. This example assumes you have BCD data loaded into the appropriate V-memory locations using instructions that apply for the model of CPU you are using.



**NOTE:** This example uses SP1, which is always on. You could also use an X, C, etc. permissive contact.



**Analog 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 analog signal level ... |
|--------------------------|-----------------------------------|---|
| -10V to +10V             | $A = \frac{20D}{4095} - 10$       | $D = \frac{4095}{20}(A + 10)$           |
| -5V to +5V               | $A = \frac{10D}{4095} - 5$        | $D = \frac{4095}{10}(A + 5)$            |
| 0 to 5V                  | $A = \frac{5D}{4095}$             | $D = \frac{4095}{5} A$                  |
| 0 to 10V                 | $A = \frac{10D}{4095}$            | $D = \frac{4095}{10} A$                 |
| 0 to 12V                 | $A = \frac{12D}{4095}$            | $D = \frac{4095}{12} A$                 |
| 0 to 20mA<br>(or 4-20mA) | $A = \frac{20D}{4095}$            | $D = \frac{4095}{20} A$                 |
| 0 to 1V                  | $A = \frac{1D}{4095}$             | $D = \frac{4095}{1} A$                  |
| 0 to 0.1V                | $A = \frac{0.1D}{4095}$           | $D = \frac{4095}{0.1} A$                |
| 0 to 0.01V               | $\ell A = \frac{0.01D}{4095}$     | $D = \frac{4095}{0.01} A$               |

For example, if you are using the -10 to +10V range and you have measured the signal at 6V, you would use the following formula to determine the digital value that should be stored in the register location that contains the data.

$$D = \frac{4095}{20}(A + 10)$$

$$D = \frac{4095}{20}(6V + 10)$$

$$D = (204.75) (16)$$

$$D = 3276$$

# D3–02DA

## 2–Channel

# Analog Output

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In This Chapter. . . .

- Module Specifications
  - Connecting the Field Wiring
  - Module Operation
  - Writing the Control Program
-

## Module Specifications

The following table provides the specifications for the D3-02DA Analog Output Module. Review these specifications to make sure the module meets your application requirements.

|                          |  |
|--------------------------|--|
| Number of Channels       | 2 (independent)  |
| Output Ranges            | 0 – 10V, 4 – 20 mA                                       |
| Resolution               | 8 bit (1 in 256)   |
| Output Type              | Single ended   |
| Output Impedance         | .5 $\Omega$ maximum, voltage output                      |
| Output Current           | 10 mA minimum, voltage output @ 10 VDC                   |
| Load Impedance           | 550 $\Omega$ maximum, 5 $\Omega$ minimum, current output |
| Total Inaccuracy         | $\pm$ 0.4% maximum at 25° C                              |
| Accuracy vs. Temperature | $\pm$ 50 ppm / °C maximum                                |
| Conversion Time          | 100 $\mu$ s maximum (2 channels/scan)                    |
| Power Budget Requirement | 80 mA @9V  |
| External Power Supply    | 24 VDC, $\pm$ 10%, 170 mA, class 2                       |
| 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  |

### Analog Output Configuration Requirements

The D3-02DA Analog Output 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.

## 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 module or the power supply return (0V). *Do not* ground the shield at both the module and the transducer.
- 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 D3-02DA requires a separate power supply. Choose a supply that meets the following requirements: 24 VDC  $\pm 10\%$ , Class 2, 170mA current (or greater, depending on the number of modules being used.)

**Load Requirements** Each channel can be wired independently for a voltage or current transducer.

- Current transducers must have an impedance between 5 and 550 ohms
- Voltage transducers must have an impedance greater than 1K ohms.

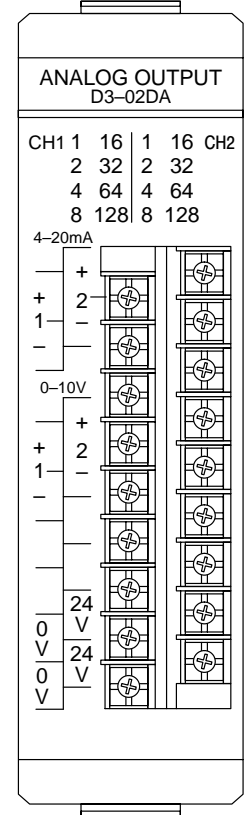
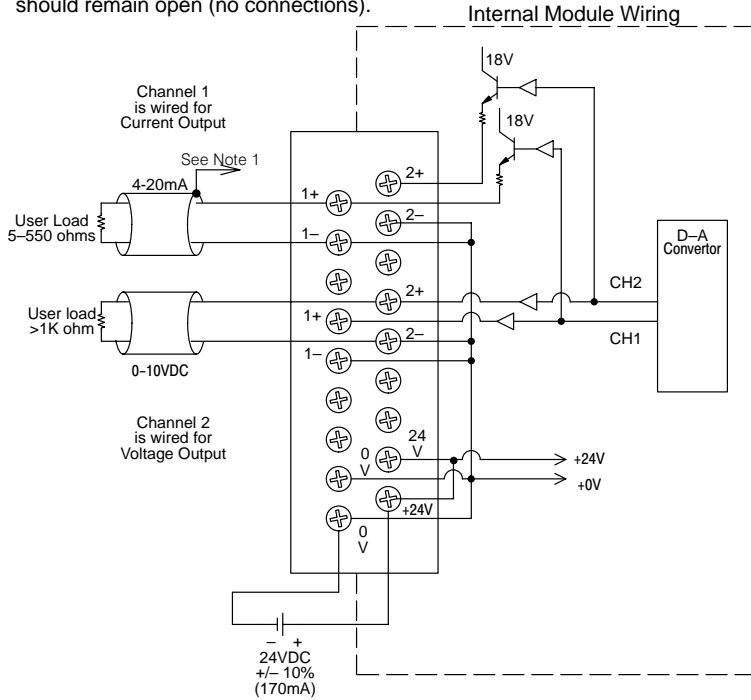
**Removable Connector**

The D3-02DA module has a removable connector to make wiring easier. Simply remove the retaining screws and gently pull the connector from the module.

**Wiring Diagram**

Note 1: Shields should be connected to the 0V of the module or to the 0V of the P/S.

Note 2: Unused voltage and current outputs should remain open (no connections).

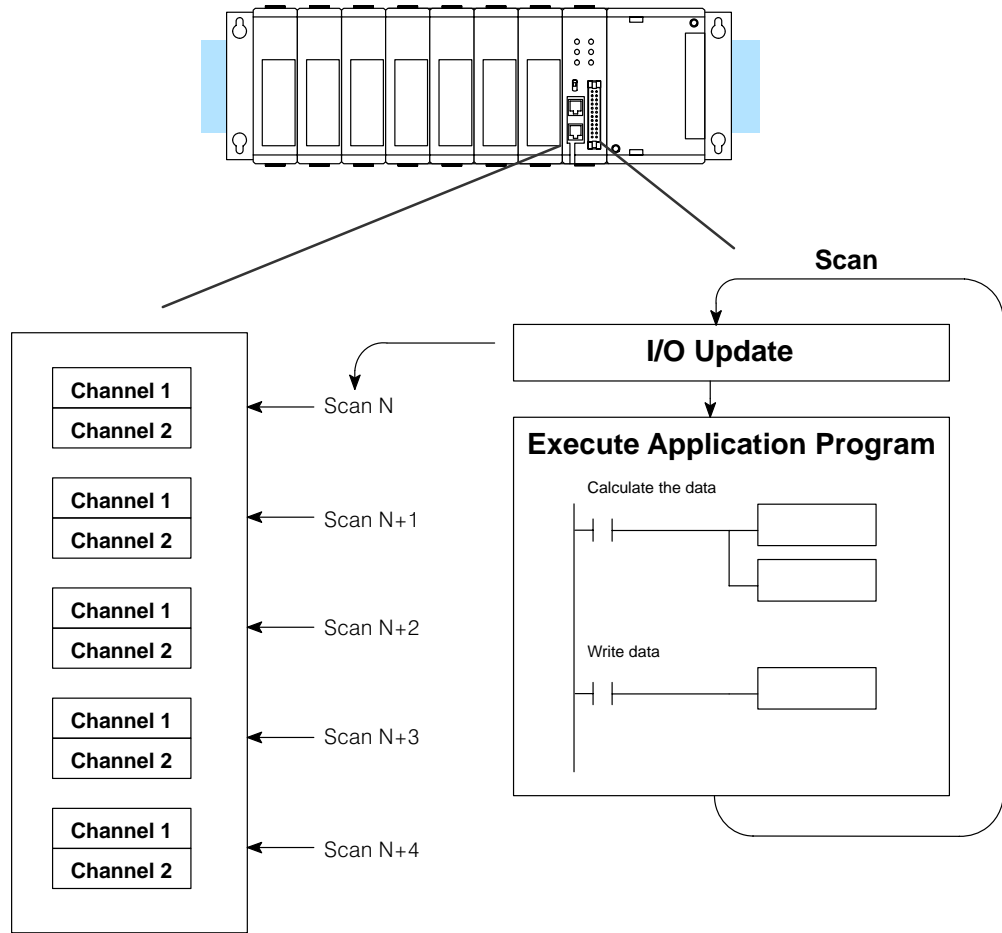


# Module Operation

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

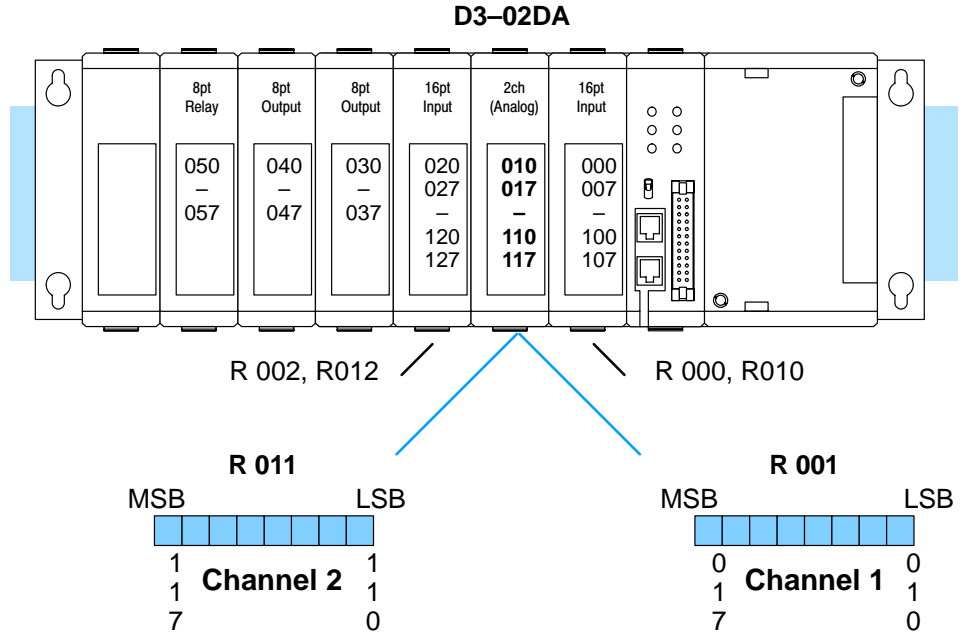
The D3-02DA module updates both channels in the same scan. The control program updates the two channels of this module independent of each other and each channel does not have to be refreshed on each scan.



**Understanding the I/O Assignments**

You may recall the D3-02DA module appears to the CPU as a 16-point module. These 16 points provide the digital representation of the analog signal.

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.



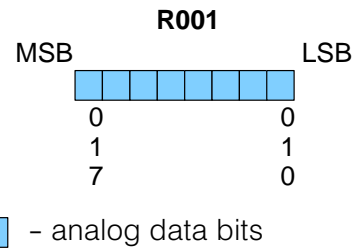
Within these two word locations, the individual bits represent specific information about the analog signal.



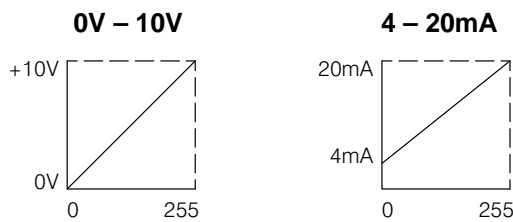
**Analog Data Bits**

The first register contains the data for channel one (R001). The second register contains the data for channel two (R011).

| Bit | Value | Bit | Value |
|-----|-------|-----|-------|
| 0   | 1     | 4   | 16    |
| 1   | 2     | 5   | 32    |
| 2   | 4     | 6   | 64    |
| 3   | 8     | 7   | 128   |



Since the module has 8-bit resolution, the analog signal is converted into 256 “pieces” ranging from 0 – 255 (2<sup>8</sup>). For example, with a 0 to 10V scale, a 0V signal would be 0, and a 10V signal would be 255. This is equivalent to a binary value of 0000 0000 to 1111 1111, or 00 to FF hexadecimal. The following diagram shows how this relates to each signal range.



Each “piece” can also be expressed in terms of the signal level by using the equation shown. The following table shows the smallest signal levels that will result in a change in the data value for each signal range.

$$\text{Resolution} = \frac{H - L}{255}$$

H = high limit of the signal range  
L = low limit of the signal range

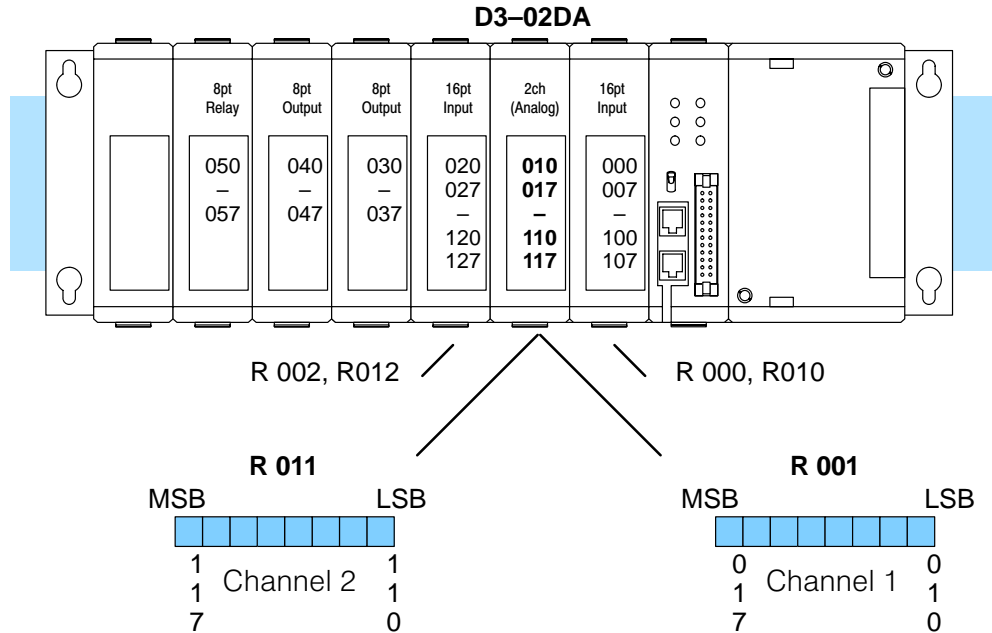
| Range     | Highest Signal | Lowest Signal | Smallest Change |
|-----------|----------------|---------------|-----------------|
| 0 to 10V  | 10V            | 0V            | 39 mV           |
| 4 to 20mA | 20mA           | 4mA           | 62.5 μA         |

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 (DL330 / DL340)

### Identifying the Data Locations

As mentioned earlier, you can update either channel or both channels during the same scan. Since the module does not have any channel select bits, you just simply determine the location of the data word and send the data word to the output module whenever you need to update the data.



### Calculating the Digital Value

Your program has to calculate the digital value to send to the analog module. There are many ways to do this, but most all applications are understood more easily if you use measurements in engineering units. This is accomplished by using the conversion formula shown. You may have to make adjustments to the formula depending on the scale you choose for the engineering units.

$$A = 256 \frac{U}{H - L}$$

- A = Analog value (0 - 255)
- U = Engineering Units
- H = high limit of the Engineering unit range
- L = low limit of the Engineering unit range

The following example shows how you would use Engineering Units to obtain the digital value to represent pressure (PSI) from 0 to 100. This example assumes you want to obtain a pressure of 42 PSI, which is slightly less than half scale.

$$A = 256 \frac{U}{H - L}$$

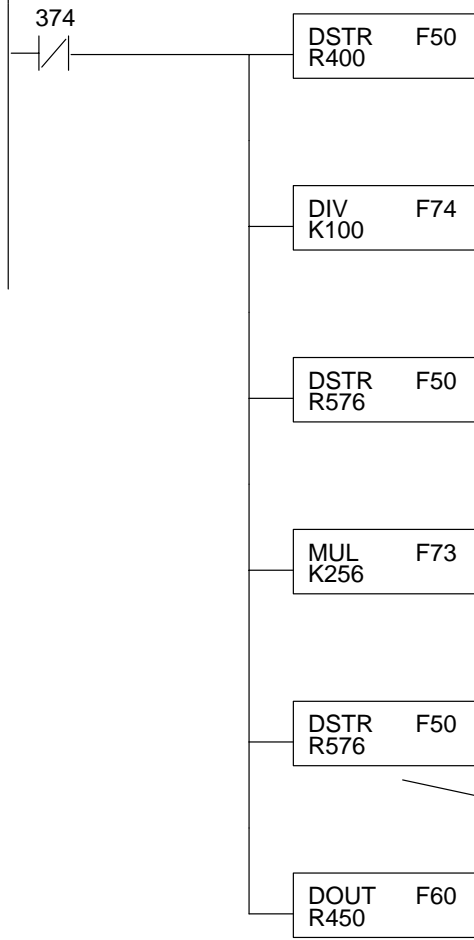
$$A = 256 \frac{42}{100 - 0}$$

$$A = 107.5 \text{ (or 108)}$$

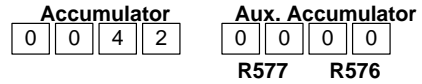
Here's how you would write the program to perform the Engineering Unit conversion. This example assumes you have calculated or loaded the engineering unit value and stored it in R400. Also, you have to perform this for both channels if you're using different data for each channel.

This example assumes you have already loaded the Engineering unit value in R400.

**Scale the data**



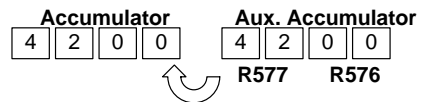
This instruction loads Engineering unit value into the accumulator.



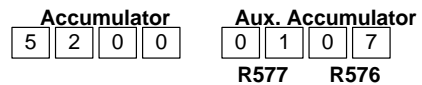
The Engineering unit value is divided by the Engineering unit range (42/100=.42). In this case the range is 100. (100 - 0 = 100)



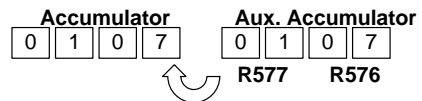
This instruction moves the two-byte decimal portion into the accumulator for further operations.



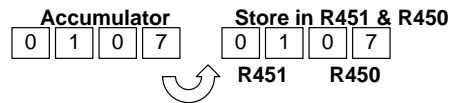
The accumulator is then multiplied by the module resolution, which is 256. (256 x 4200 = 1075200). Notice the most significant digits are now stored in the auxiliary accumulator. (This is different from the Divide instruction operation.)



This instruction moves the two-byte auxiliary accumulator for further operations.



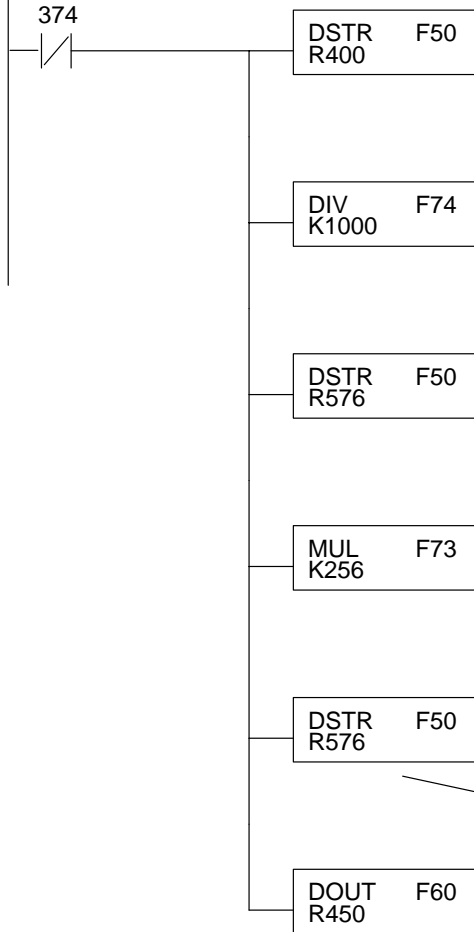
This instruction stores the accumulator to R451 and R450. R451 and R450 now contain the digital value, which is 107.



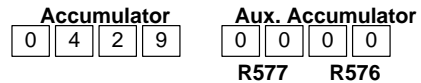
There will probably be times when you need more precise control. For example, maybe your application requires 42.9 PSI, not just 42 PSI. By changing the scaling value slightly, we can “imply” an extra decimal of precision. Notice in the following example we’ve entered 429 as the Engineering unit value and we’ve added another digit to the scale. Instead of a scale of 100, we’re using 1000, which implies 100.0 for the PSI range.

This example assumes you have already loaded the Engineering unit value in R400.

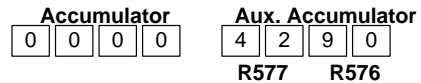
### Scale the data



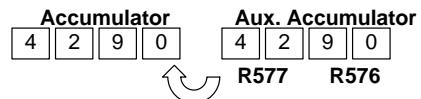
This instruction loads Engineering unit value into the accumulator.



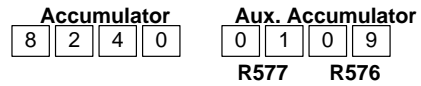
The Engineering unit value is divided by the Engineering unit range, which in this case is 1000. (100.0 implied range) (429/1000 = .429)



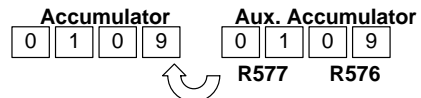
This instruction moves the two-byte decimal portion into the accumulator for further operations.



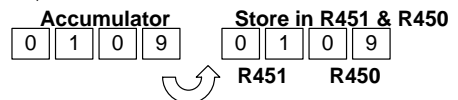
The accumulator is then multiplied by the module resolution, which is 256. (256 x 4290 = 1098240). Notice the most significant digits are now stored in the auxiliary accumulator. (This is different from the Divide instruction operation.)



This instruction moves the two-byte auxiliary accumulator for further operations.



This instruction stores the accumulator to R450 and R451. R450 and R451 now contain the digital value, which is 109.

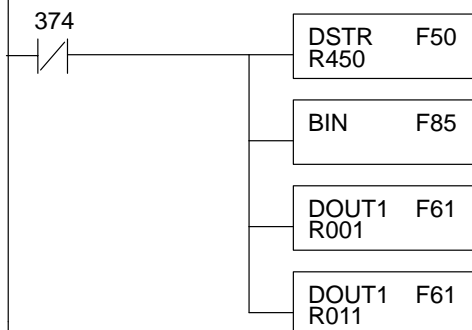


## Sending the Same Data to Both Channels

In some applications, you'll want to send the same output values to both channels. The following program example shows how to send the digital values to the module.

This example assumes you have already loaded the Engineering unit value in R450 and R451.

### Send Channel 1 & 2



This rung loads the data into the accumulator on every scan.

Since the data is in BCD format, you have to convert it to binary before you send the data to the module.

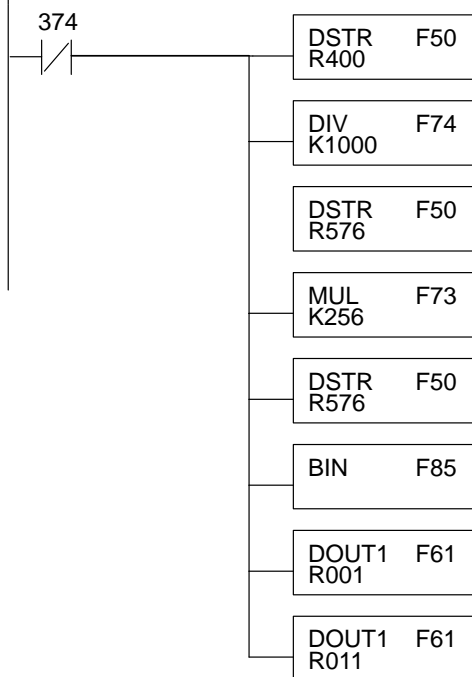
Send the accumulator data to the Register that corresponds to channel 1, which is R001.

Send the accumulator data to the Register that corresponds to channel 2, which is R011.

If you want a shorter program, just combine the data scaling and output instructions.

This example assumes you have already loaded the Engineering unit value in R400.

### Send Channel 1 & 2



This instruction loads Engineering unit value into the accumulator.

The Engineering unit value is divided by the Engineering unit range, which in this case is 1000. (100.0 implied range)

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

The accumulator is then multiplied by the module resolution, which is 256.

This instruction moves the two-byte auxiliary accumulator into the regular accumulator.

Since the data is in BCD format, you have to convert it to binary before you send the data to the module.

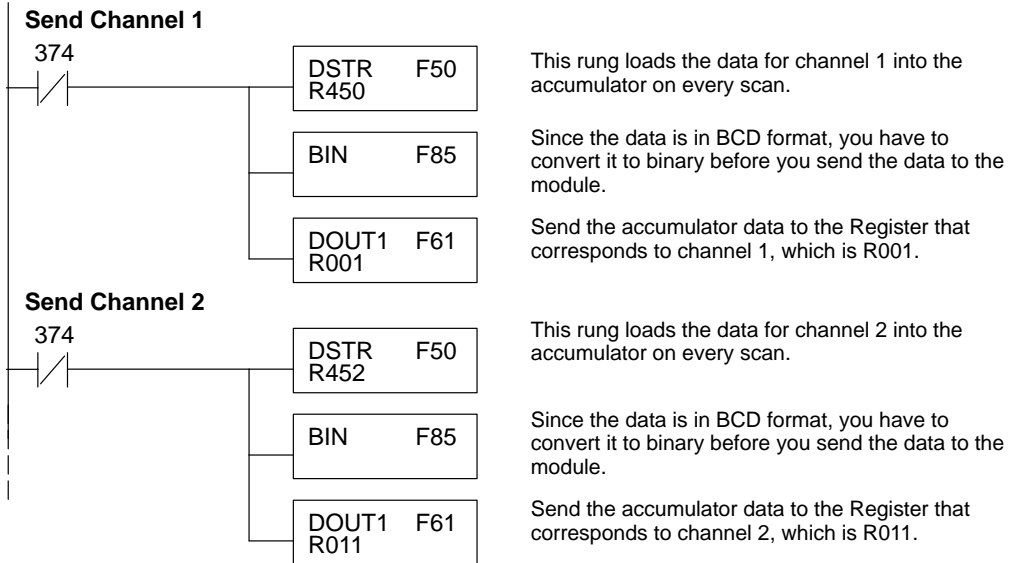
Send the accumulator data to the Register that corresponds to channel 1, which is R001.

Send the accumulator data to the Register that corresponds to channel 2, which is R011.

## Sending Specific Data to Each Channel

In this case, the example logic is setup to send different data to each channel. Of course, you would have to have separate routines to calculate the output data and you would have to store the different values in separate registers.

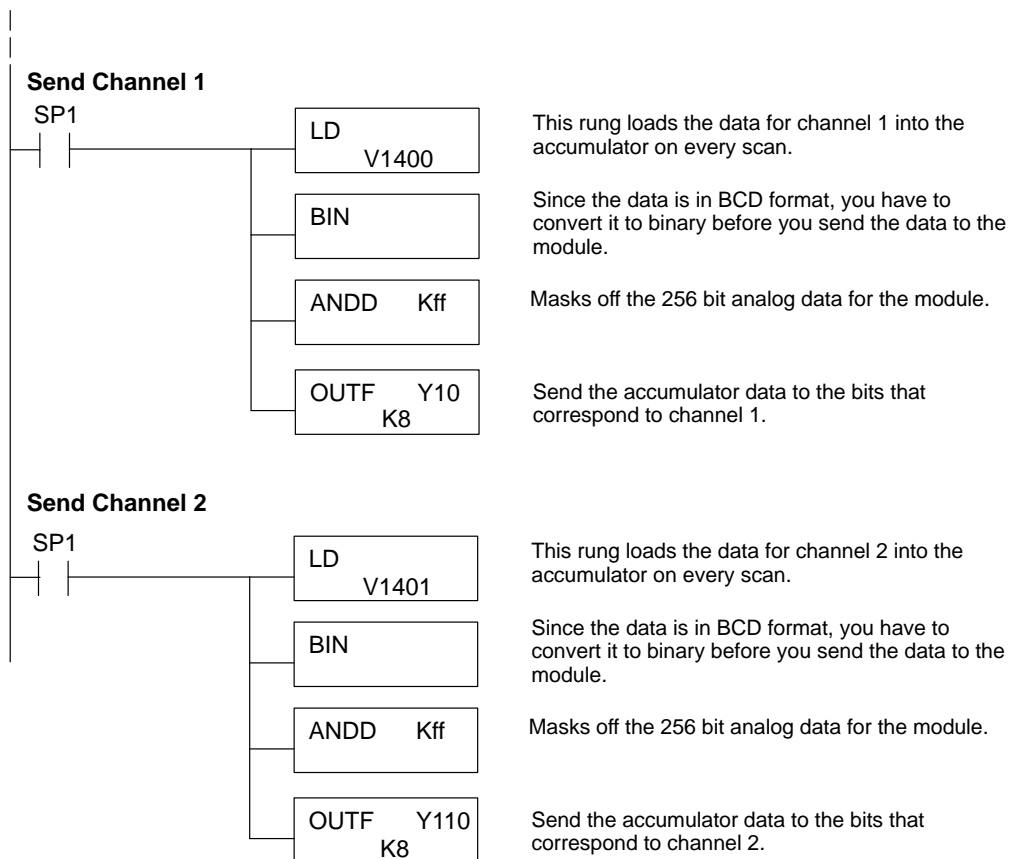
This example assumes you have already loaded the Engineering unit value for Channel 1 in R450 and R451 and the data for Channel 2 in R452 and R453.



## Writing the Control Program (DL350)

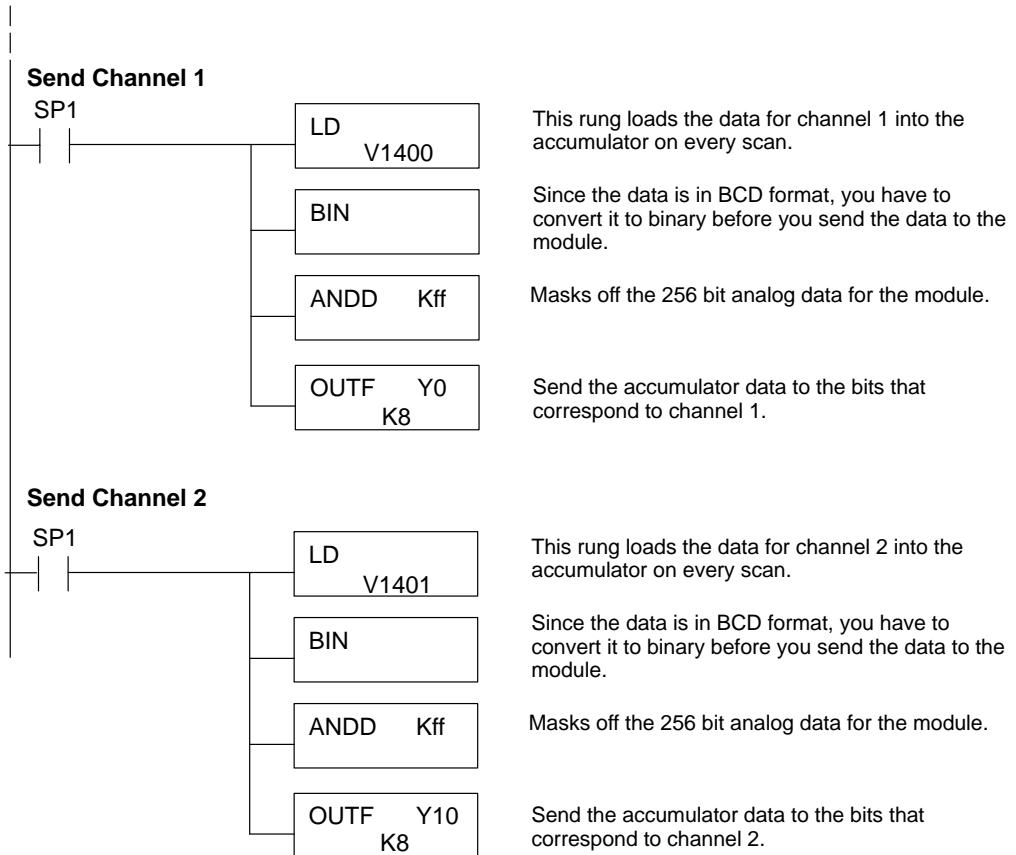
### Multiplexing: DL350 with a Conventional DL305 Base

This example assumes the module is in the Y10-17 / Y110-117 slot of a 305 conventional base. In this example V1400 contains the BCD data for channel 1 and V1401 contains the data for channel 2.



**Multiplexing:  
DL350 with a  
D3-xx-1 Base**

This example assumes the module is in Y0 address slot of a D3-xx-1 base . In this example V1400 contains the BCD data for channel 1 and V1401 contains the data for channel 2. 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.





**Analog and Digital Value Conversions**

Sometimes it is helpful to be able to quickly convert between the voltage or current 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 analog signal level ... |
|-----------|-----------------------------------|---|
| 0 to 10V  | $A = \frac{10D}{255}$             | $D = \frac{255}{10} A$                  |
| 4 to 20mA | $A = \frac{16D}{255} + 4$         | $D = \frac{255}{16} (A - 4)$            |

For example, if you are using the 4–20mA range and you know you need a 10mA signal level, you would use the following formula to determine the digital value that should be sent to the module.

$$D = \frac{255}{16} (A - 4)$$

$$D = \frac{255}{16} (10\text{mA} - 4)$$

$$D = (15.93) (6)$$

$$D = 96$$

**Calculating the Digital Value**

Your program must calculate the digital value to send to the analog module. There are many ways to do this, but most applications are understood more easily if you use measurements in engineering units. This is accomplished by using the conversion formula shown.

You may have to make adjustments to the formula depending on the scale you choose for the engineering units.

$$A = U \frac{255}{H - L}$$

A = Analog value (0 – 255)

U = Engineering Units

H = high limit of the engineering unit range

L = low limit of the engineering unit range

Consider the following example which controls pressure from 0.0 to 99.9 PSI. By using the formula, you can easily determine the digital value that should be sent to the module. The example shows the conversion required to yield 49.4 PSI. Notice the formula uses a multiplier of 10. This is because the decimal portion of 49.4 cannot be loaded, so you adjust the formula to compensate for it.

$$A = 10U \frac{255}{10(H - L)}$$

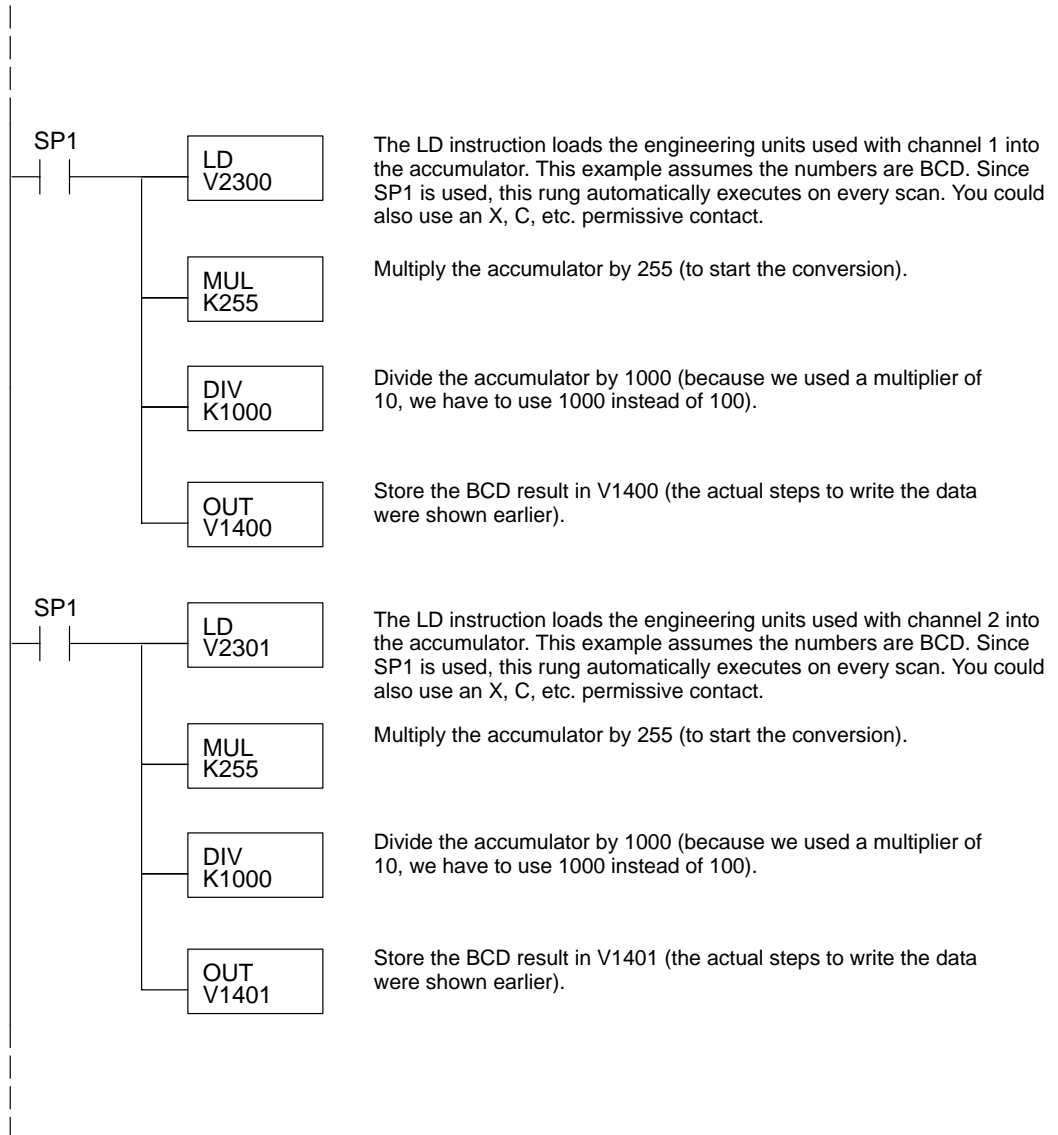
$$A = 494 \frac{255}{1000 - 0}$$

$$A = 126$$



The example program below shows how you would write the program to perform the engineering unit conversion. This example assumes you have calculated or loaded the engineering unit values in BCD and stored them in V2300 and V2301 for channels 1 and 2 respectively.

**NOTE:** The DL350 offers various instructions that allow you to perform math operations using BCD format. It is easier to perform math calculations in BCD and then convert the value to binary before sending the data to the module.



# F3-04DA-1

## 4-Channel

# Analog Output

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In This Chapter. . . .

- Module Specifications
  - Setting the Module Jumpers
  - Connecting the Field Wiring
  - Module Operation
  - Writing the Control Program (DL330 / DL340)
  - Writing the Control Program (DL350)
-

## Module Specifications

The following table provides the specifications for the F3-04DA-1 Analog Output Module. Review these specifications to make sure the module meets your application requirements.

|  |  |
|--|--|
| Number of Channels                     | 4  |
| Output Ranges                          | 0 – 5V, 0 – 10V, 4 – 12 mA,<br>4 – 20 mA (source)                          |
| Resolution                             | 12 bit (1 in 4096)   |
| Output Type                            | Single ended (one common)  |
| Output Impedance                       | 0.5 $\Omega$ typical, voltage output                                       |
| Output Current                         | 5 mA source, 2.5 mA sink (voltage)   |
| Short-circuit Current                  | 40 mA typical, voltage output  |
| Load Impedance                         | 1K $\Omega$ maximum, current output<br>2K $\Omega$ minimum, voltage output |
| Linearity Error                        | $\pm$ 1 count ( $\pm$ 0.03% maximum)                                       |
| Maximum Inaccuracy at 77 °F<br>(25 °C) | $\pm$ 0.6% of span, current output<br>$\pm$ 0.2% of span, voltage output   |
| Accuracy vs. Temperature               | $\pm$ 50 ppm / °C maximum  |
| Conversion Time                        | 30 $\mu$ S maximum   |
| Power Budget Requirement               | 144 mA @9V, 108 mA @ 24V   |
| 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  |

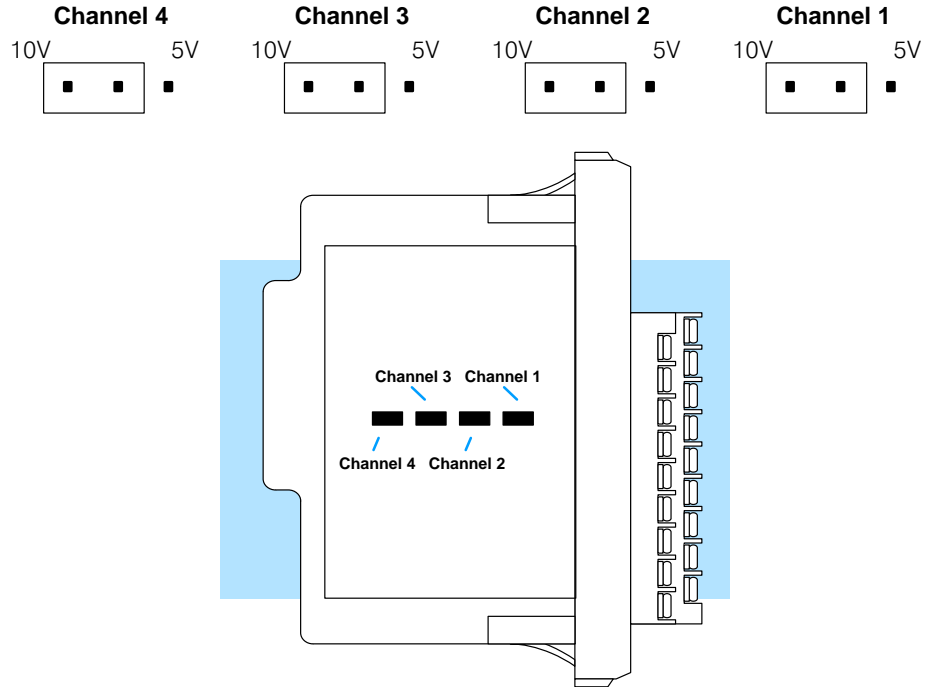
### Analog Output Configuration Requirements

The F3-04DA-1 Analog Output 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

**Jumper Locations** The module is set at the factory for a 0–10V signal on all four channels. (This range also allows 4–20 mA operation since there are separate I and V wiring terminals.) If this is acceptable you do not have to change any of the jumpers. The following diagram shows the jumper locations.



F3-04DA-1  
4-Channel Analog Output

**Selecting Output Signal Ranges** The jumper is set from the factory to allow either 0–10V or 4–20mA operation on all channels. In addition, you can select 0 – 5V or 4 – 12 mA operation by moving the jumper. (Only channel 1 is used in the example, but all channels must be set.)

| Signal Range                   | Jumper Settings              |
|--------------------------------|------------------------------|
| 0 to +5 VDC<br>4 to 12 mA      | Range<br>0-10V      0-5V<br> |
| 0 VDC to +10 VDC<br>4 to 20 mA | Range<br>0-10V      0-5V<br> |

## 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 module or the power supply return (0V). *Do not* ground the shield at both the module and the transducer.
- 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 F3-04DA-1 receives all power from the base. A separate power supply is not required.

**Load Requirements** Each channel can be wired independently for a voltage or current transducer.

- Current transducers must have an impedance less than 1K ohm.
- Voltage transducers must have an impedance greater than 2K ohms.

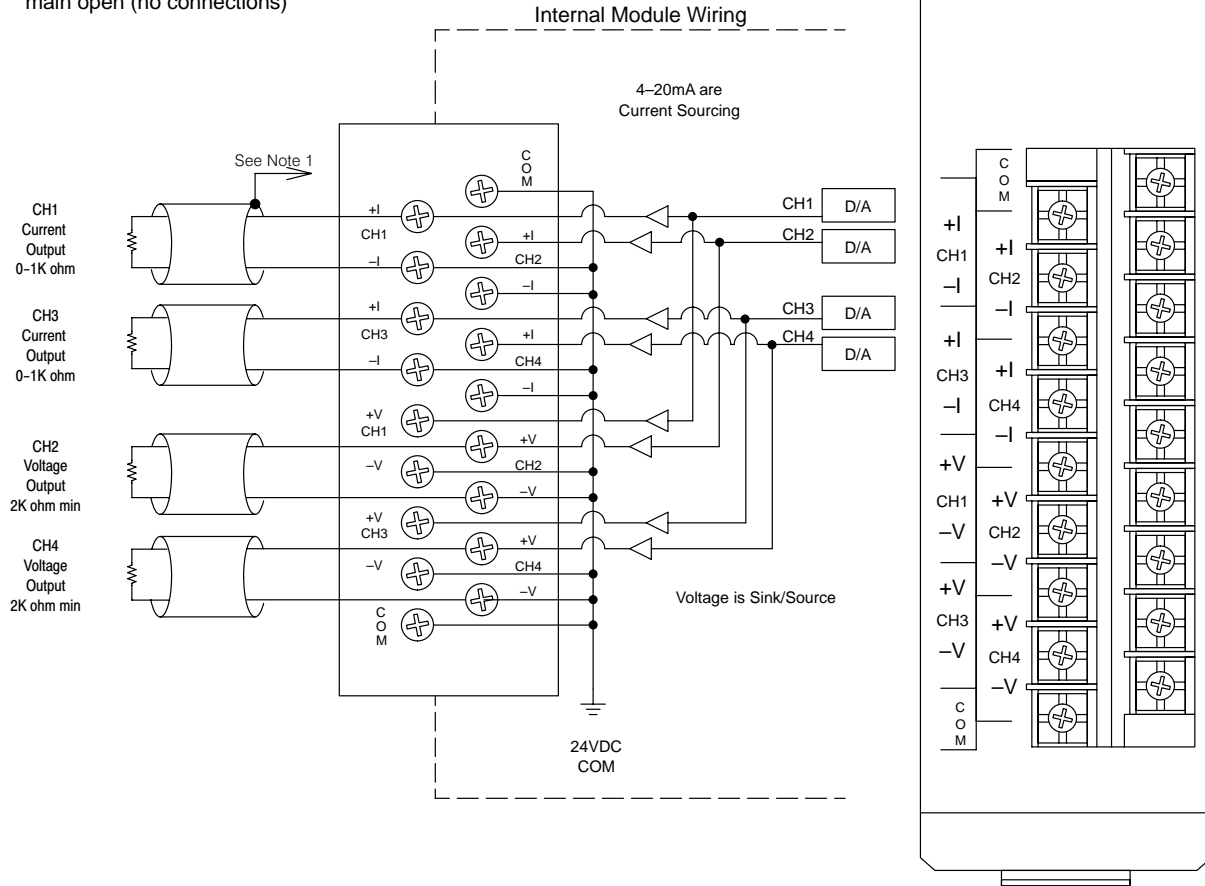
**Removable Connector**

The F3-04DA-1 module has a removable connector to make wiring easier. Simply squeeze the top and bottom tabs and gently pull the connector from the module.

**Wiring Diagram**

Note 1: Shields should be connected to the 0V (COM) of the module

Note 2: Unused voltage & current outputs should remain open (no connections)



F3-04DA-1  
4-Channel Analog Output

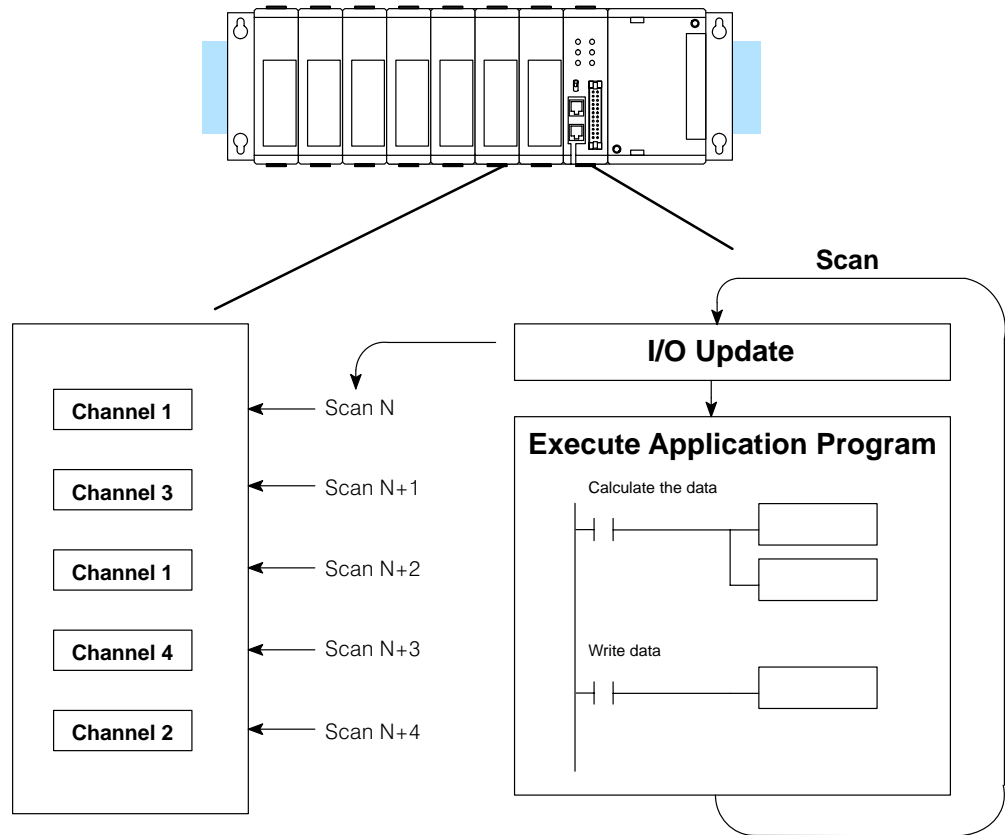
# Module Operation

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 F3-04DA-1 module can update one channel per CPU scan. Your RLL program selects which channel to update, so you have complete flexibility to solve your application requirements.

F3-04DA-1  
4-Channel Analog Output



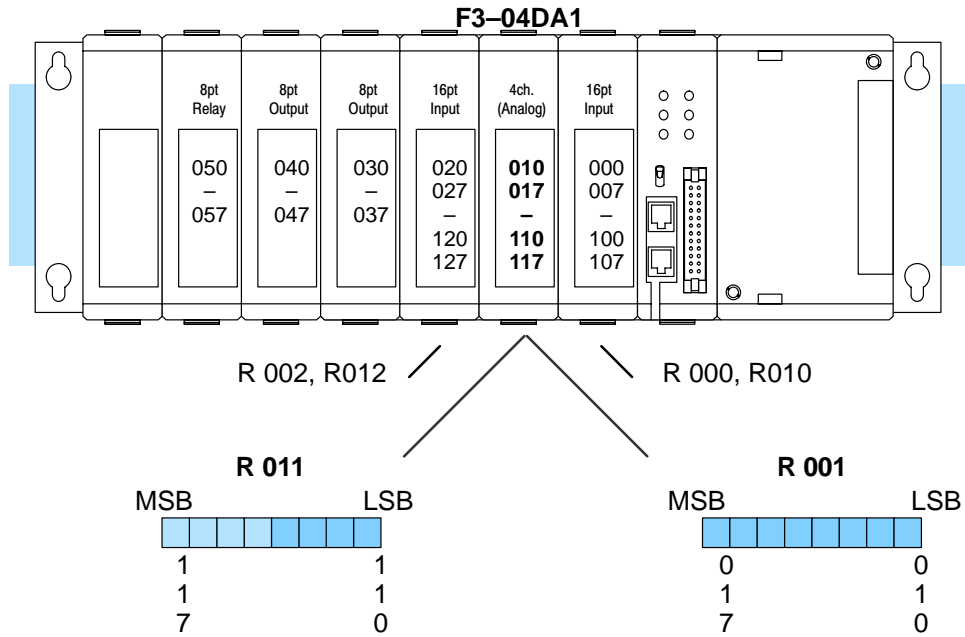


**Understanding the I/O Assignments**

You may recall the F3-04DA-1 module appears to the CPU as a 16-point module. These 16 points provide:

- the digital representation of the analog signal.
- identification of the channel to receive the data.

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.



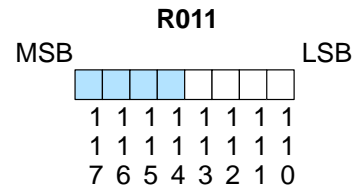
F3-04DA-1  
4-Channel Analog Output

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

**Channel Selection Inputs**

The last four points of the upper register are used as outputs to tell the module which channel to update. In our example, when output 114 is on, channel 1 will be updated. Here's how the outputs are assigned.

| Output | Channels |
|--------|----------|
| 114    | 1        |
| 115    | 2        |
| 116    | 3        |
| 117    | 4        |

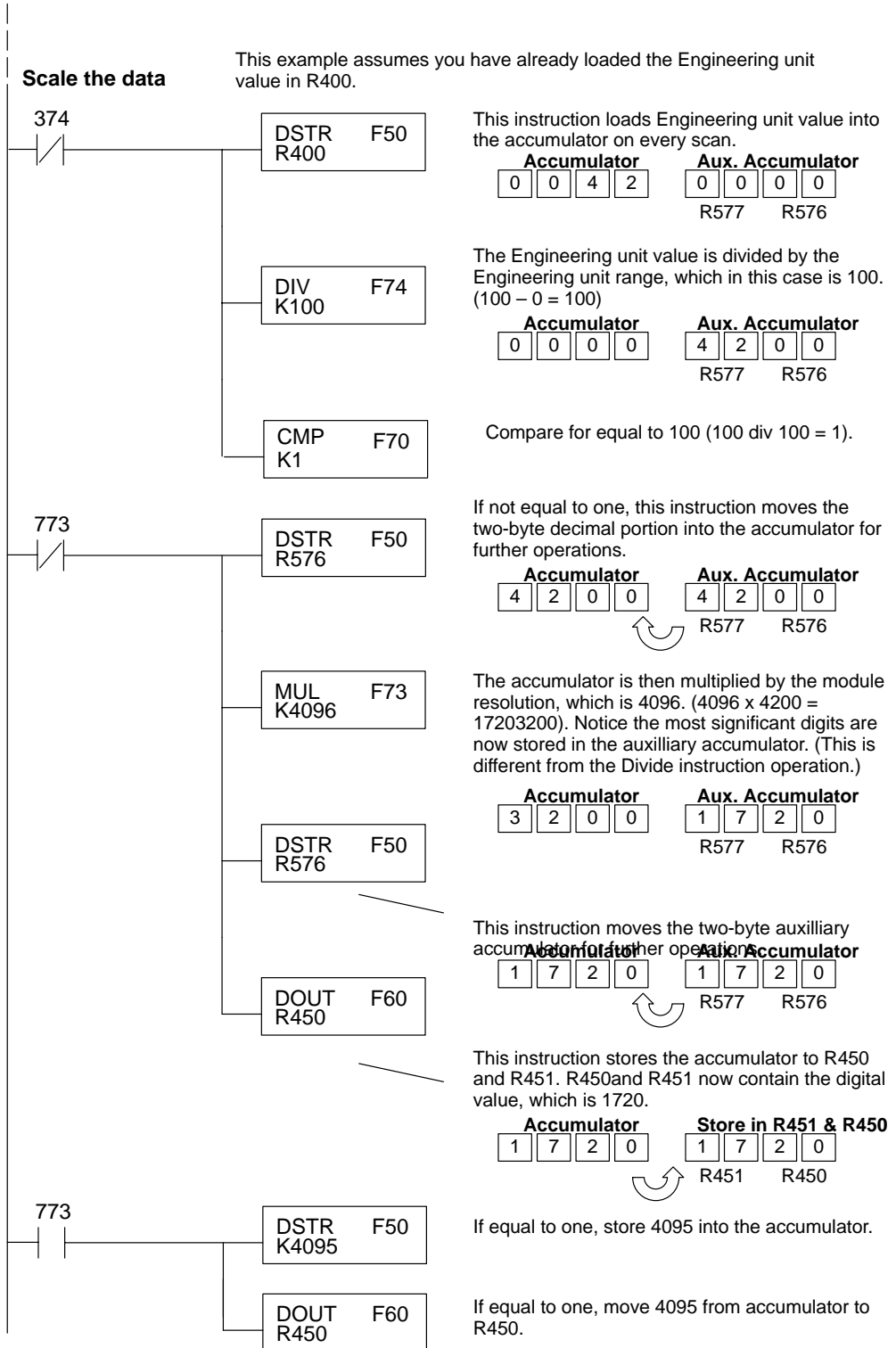


■ - channel selection outputs



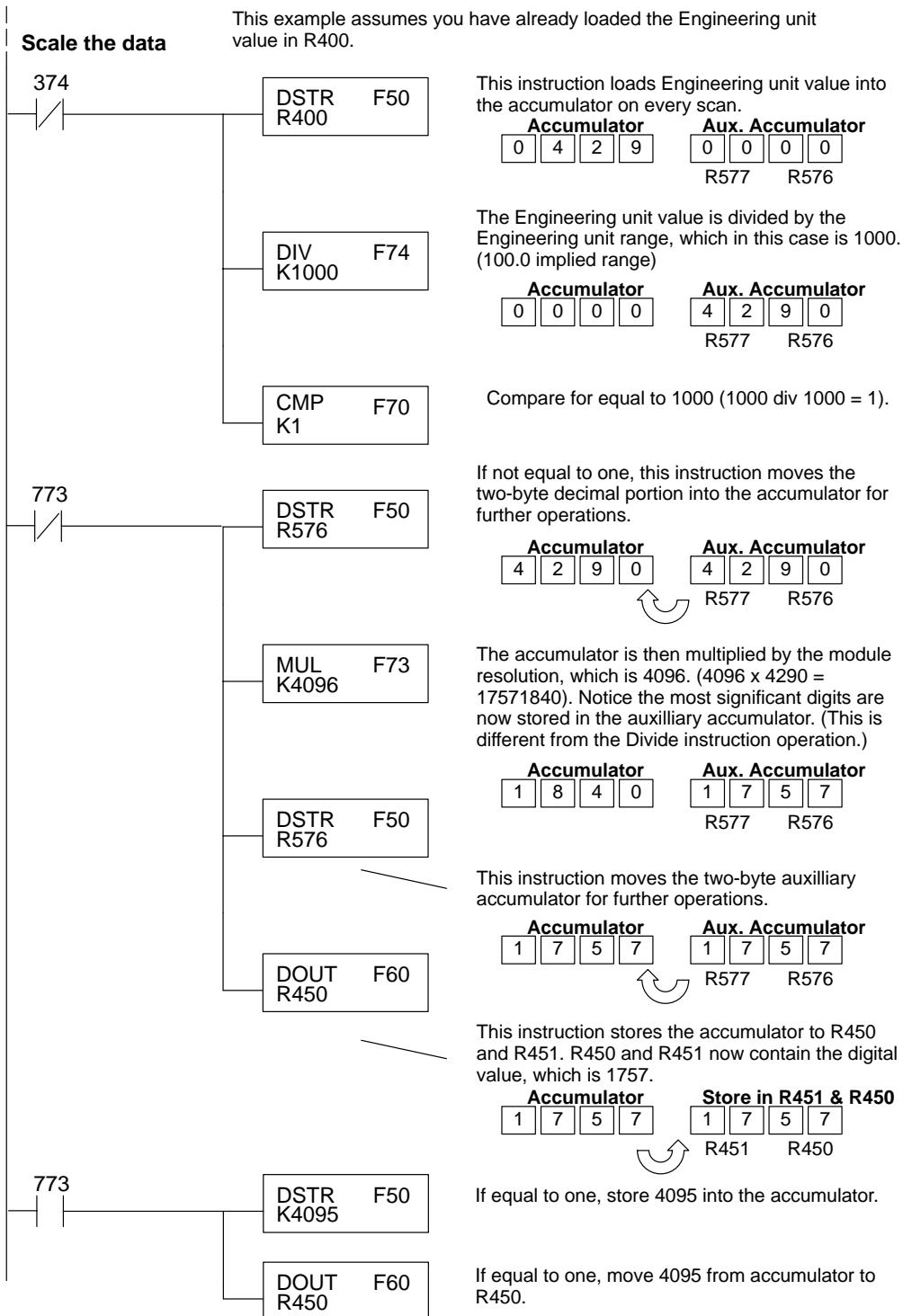


Here's how you would write the program to perform the Engineering unit conversion. This example assumes you have calculated or loaded the engineering unit value and stored it in R400. Also, you have to perform this for all channels if you're using different data for each channel.



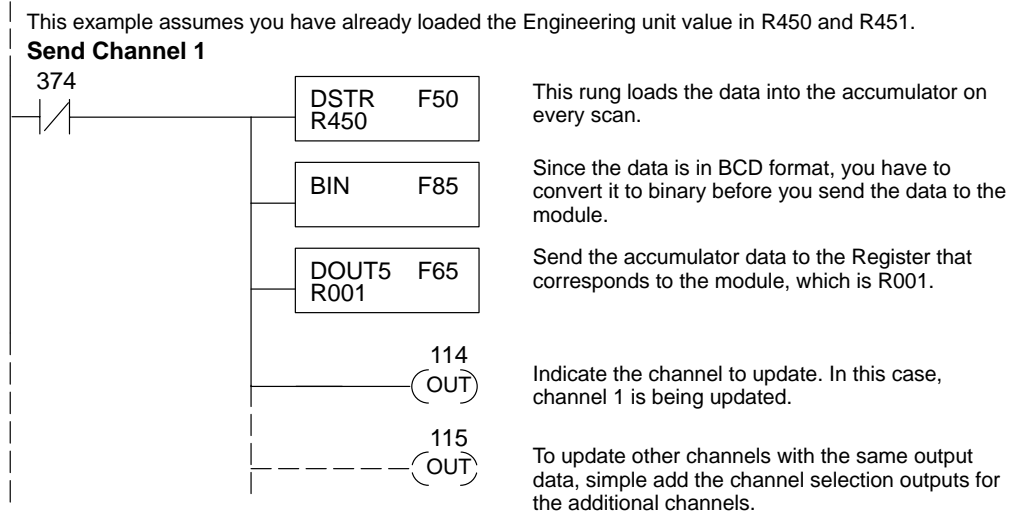
F3-04DA-1 4-Channel Analog Output

There will probably be times when you need more precise control. For example, maybe your application requires 42.9 PSI, not just 42 PSI. By changing the scaling value slightly, we can “imply” an extra decimal of precision. Notice in the following example we’ve entered 429 as the Engineering unit value and we’ve added another digit to the scale. Instead of a scale of 100, we’re using 1000, which implies 100.0 for the PSI range.

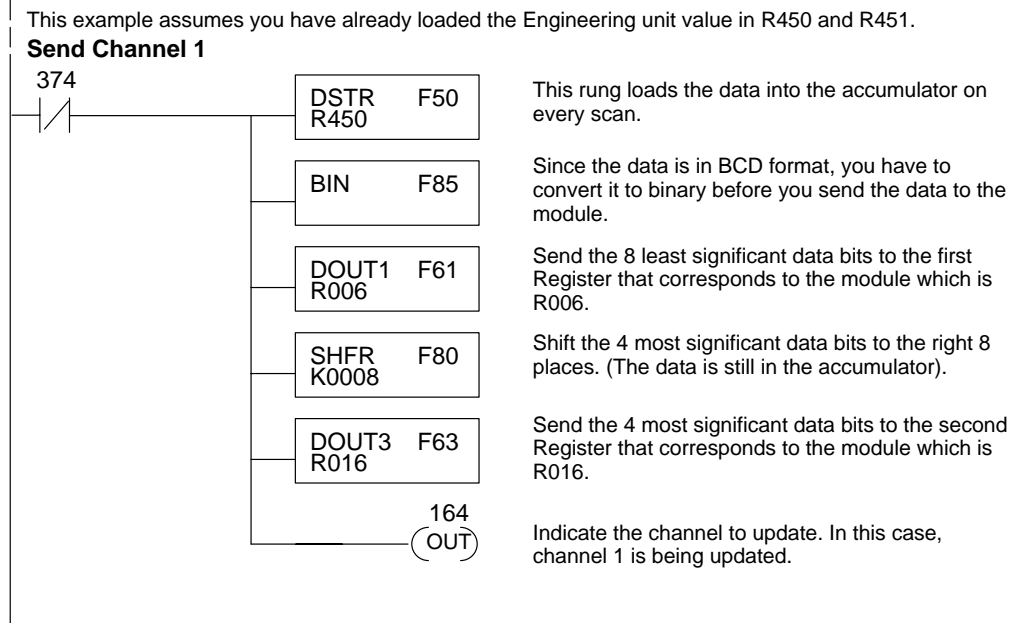


### Sending Data to a Single Channel

The following program example shows how to send the digital value to a single channel.



If you install the F3-04DA-1 in the slot corresponding to registers 6 and 16, you have to make a slight program adjustment. This is because the DOUT5 instruction is not supported for this slot.

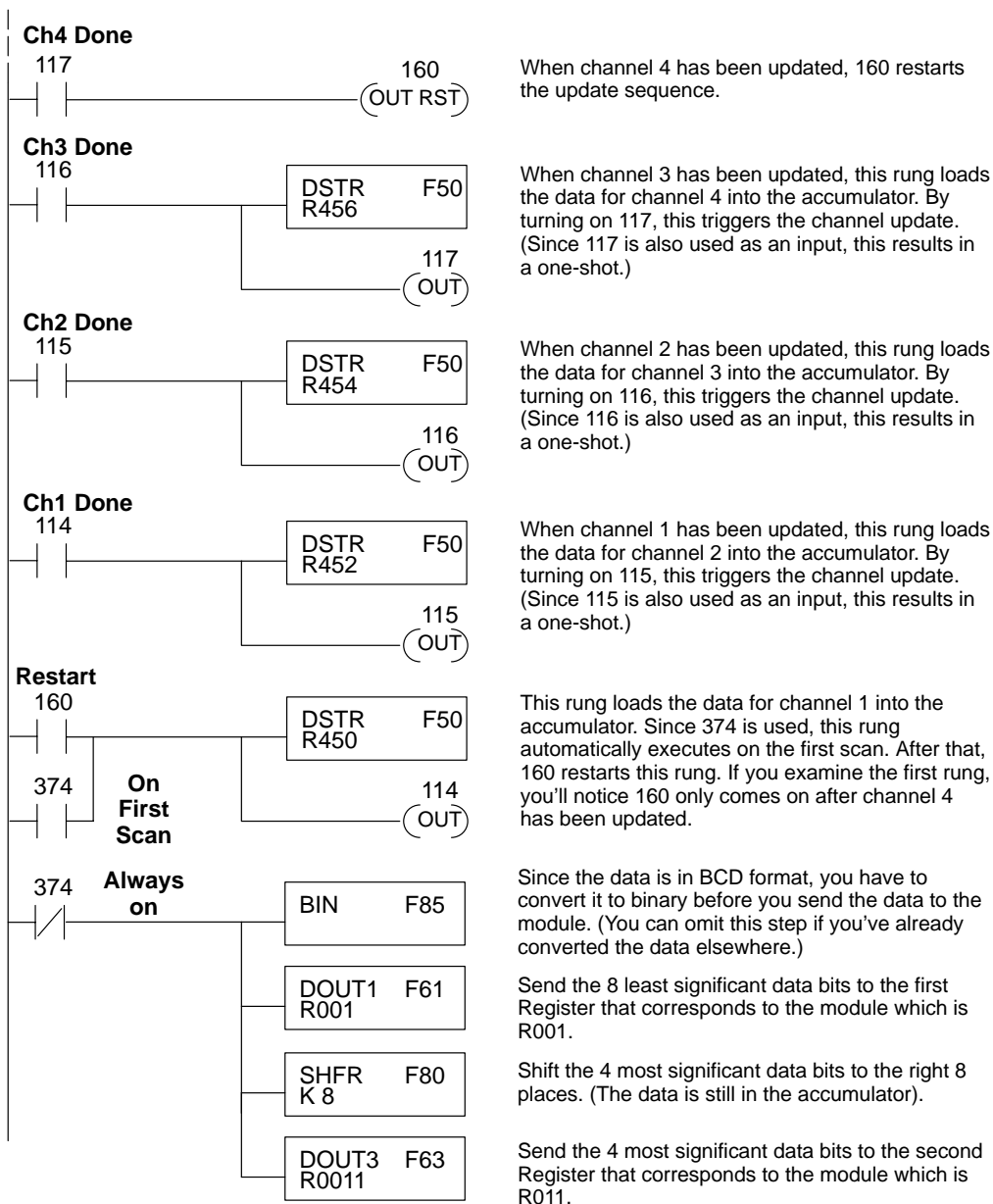


### Sequencing the Channel Updates

This example shows how to send digital values to the module when you have more than one channel. This example will automatically update all four channels over four scans. The example is fairly simple and will work in most all situations, but there are instances where problems can occur. The logic must be active on the first CPU scan and all subsequent scans. If the logic gets stopped or disabled for some reason, there is no way to restart it. If you're using an RLL<sup>PLUS</sup> (Stage) program, put this logic in an initial stage that is always active. Also, you should avoid using the this example if you require the analog output logic to be used inside a Master Control Relay field of control. Even if you do not have a need for the MCR, you can still accidentally disable the analog output logic by inadvertently writing to the multiplexing control relays with an operator interface or intelligent module, such as an ASCII BASIC module, etc.

### Sequencing Example

The following program example shows how to send the digital values to multiple channels. With this program, all channels will be updated within four scans. You must use the rungs in the order shown, but you can include them anywhere in the program.



## Writing the Control Program (DL350)

### Reading Values: Pointer Method and Multiplexing

There are two methods of reading values:

- The pointer method (**all system bases must be D3-xx-1 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 CPU, but for ease of programming it is strongly recommended that you use the pointer method.

### Pointer Method

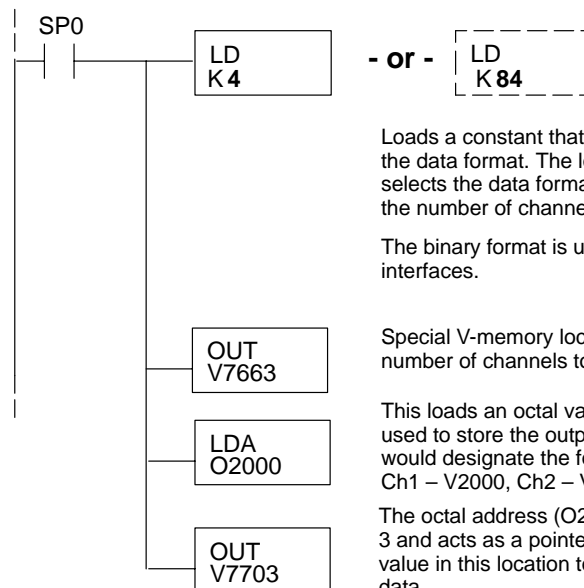
The DL350 has special V-memory locations assigned to each base slot that greatly simplifies the programming requirements. By using these V-memory locations you can:

- specify the number of channels to update.
- specify where to obtain the output data.



**NOTE:** Do not use the pointer method and the PID Control Output auto transfer to I/O module function together for the same module. If using PID loops, use the pointer method and ladder logic code to map the analog output data from the PID loop to the output module memory location(s).

The following program example shows how to set up these locations. Place this rung anywhere in the ladder program, or in the initial stage when using stage programming.



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

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

Special V-memory location assigned to slot 3 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 output data. For example, the O2000 entered here would designate the following addresses.

Ch1 - V2000, Ch2 - V2001, ch3 - V2002, ch4 - V2003

The octal address (O2000) is stored here. V7703 is assigned to slot 3 and acts as a pointer, which means the CPU will use the octal value in this location to determine exactly where to store the output data.

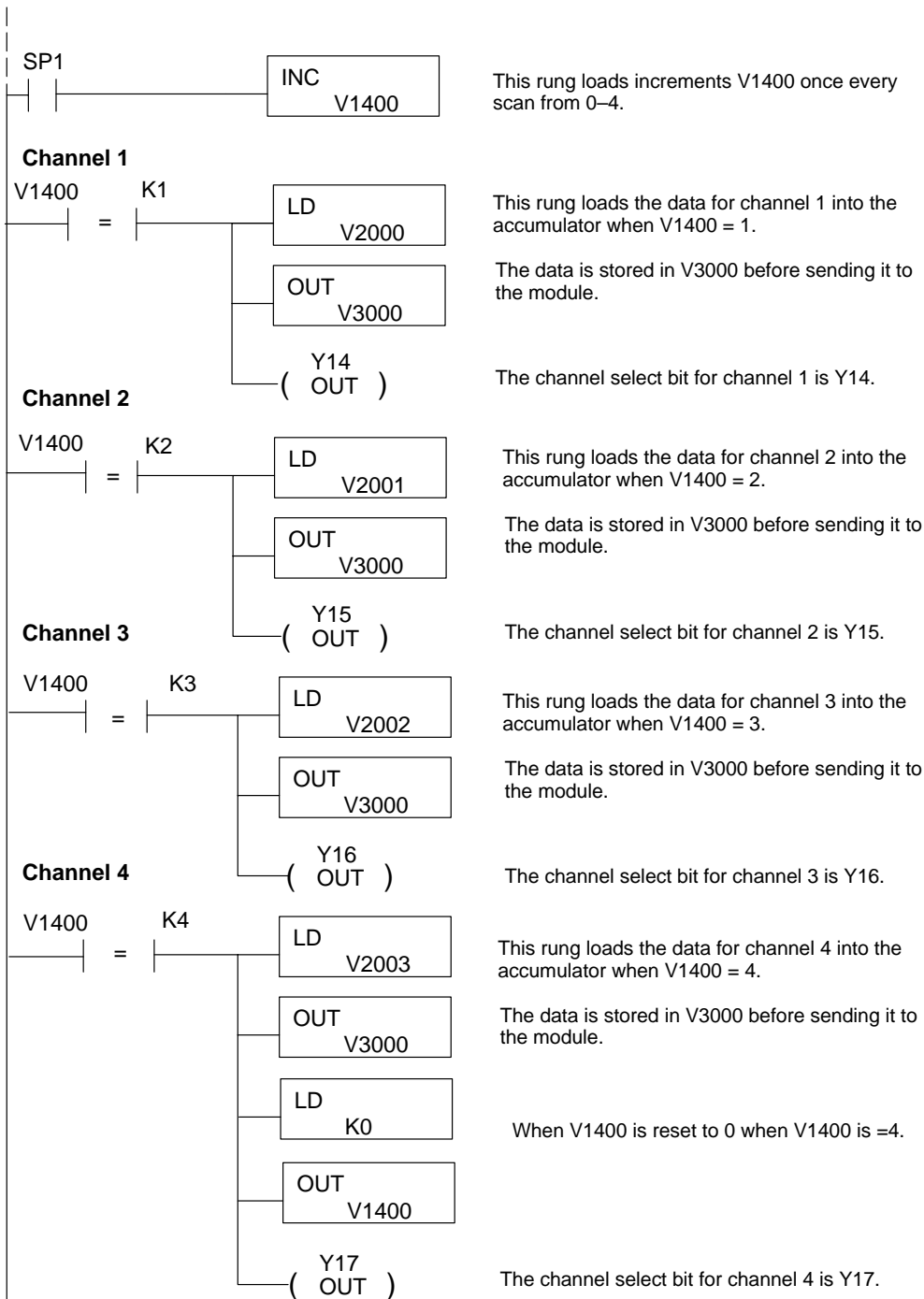
The table shows the special V-memory locations used with the DL350. Slot 0 (zero) is the module next to the CPU. Remember, the CPU only examines the pointer values at these locations after a mode transition. The pointer method is supported on expansion bases (all bases must be D3-xx-1) up to a total of 8 slots away from the DL350. The pointer method is not supported in slot 8 of a 10 slot base.

| Analog Output 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  | V7700 | V7701 | V7702 | V7703 | V7704 | V7705 | V7706 | V7707 |



**Multiplexing:  
DL350 with a  
D3-xx-01 Base**

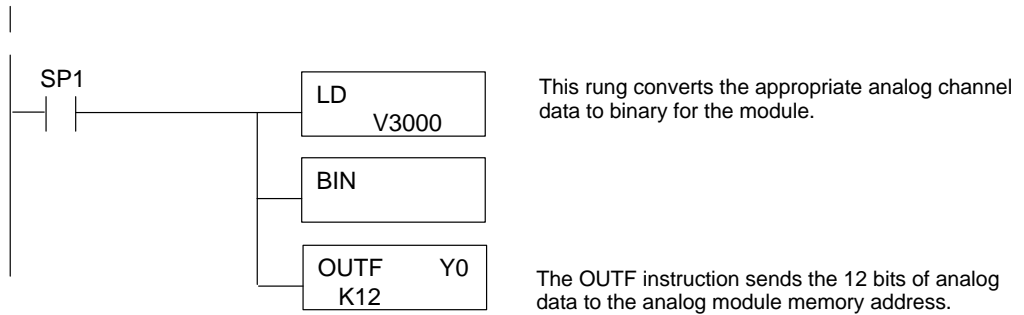
This example assumes the module is in Y0 address slot of D3-xx-1 base. In this example V2000 contains the data for channel and V2001 for channel 2, etc. If any expansion bases are used in the system, they must all be D3-xx-1 to be able to use this example. Otherwise, the conventional base addressing must be used.



example program continued on next page

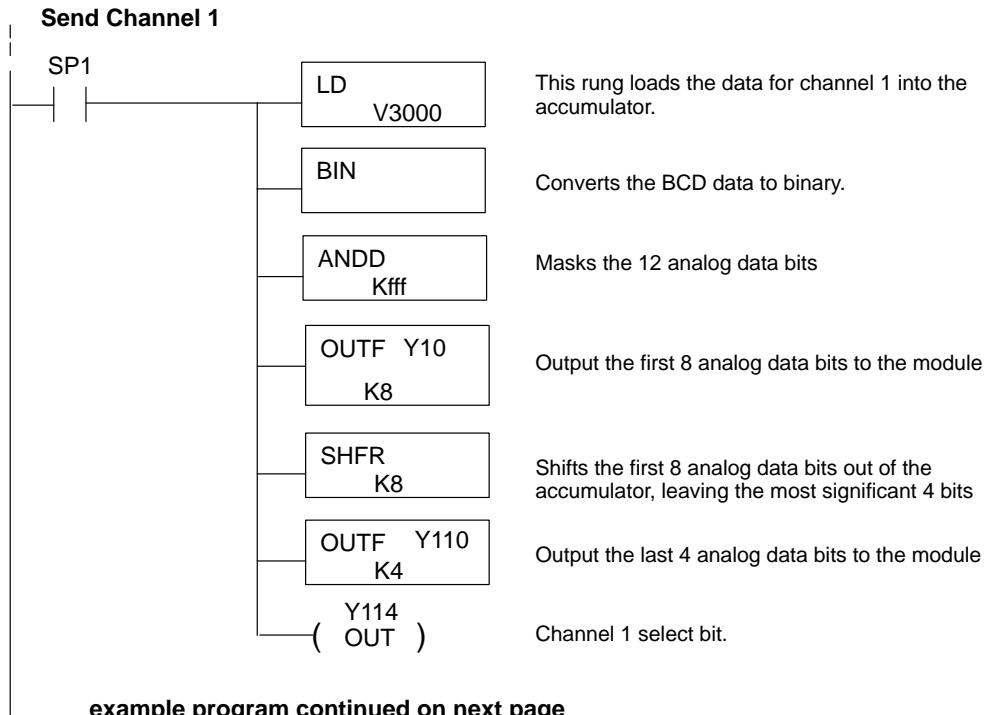
F3-04DA-1  
4-Channel Analog Output

### example program continued from previous page



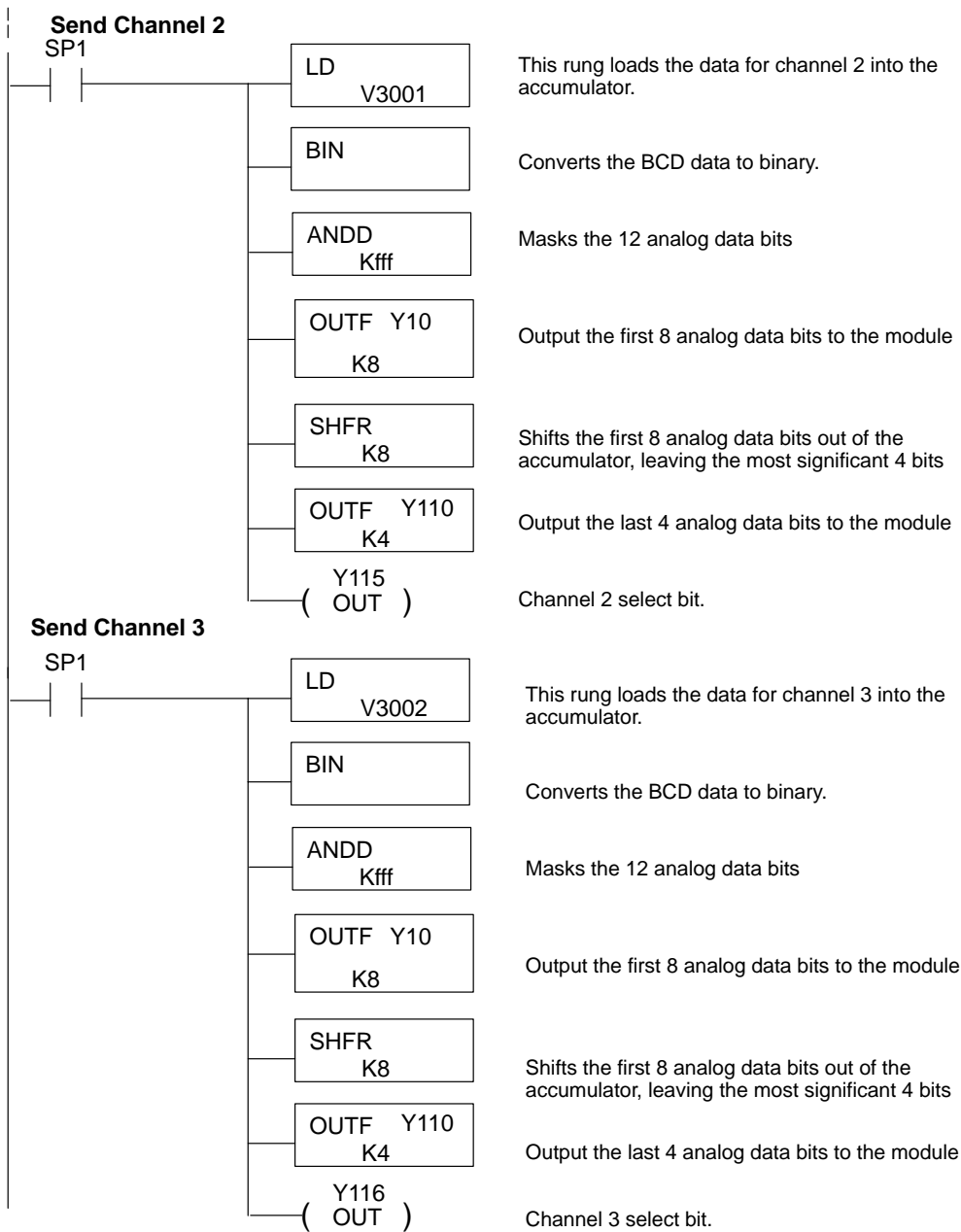
### Multiplexing: DL350 with a Conventional DL305 Base

This example assumes the module is in the 10-17 / 110-117 slot of a 305 conventional base. In this example V3000 contains the BCD data for channel 1 and V3001 contains the data for channel 2, etc. One more rung would be necessary for channel 4.



example program continued on next page

example program continued from previous page.



**Calculating the Digital Value**

Your program must calculate the digital value to send to the analog module. There are many ways to do this, but most applications are understood more easily if you use measurements in engineering units. This is accomplished by using the conversion formula shown.

You may have to make adjustments to the formula depending on the scale you choose for the engineering units.

$$A = U \frac{4095}{H - L}$$

A = Analog value (0 – 4095)

U = Engineering Units

H = high limit of the engineering unit range

L = low limit of the engineering unit range

Consider the following example which controls pressure from 0.0 to 99.9 PSI. By using the formula, you can easily determine the digital value that should be sent to the module. The example shows the conversion required to yield 49.4 PSI. Notice the formula uses a multiplier of 10. This is because the decimal portion of 49.4 cannot be loaded, so you adjust the formula to compensate for it.

$$A = 10U \frac{4095}{10(H - L)}$$

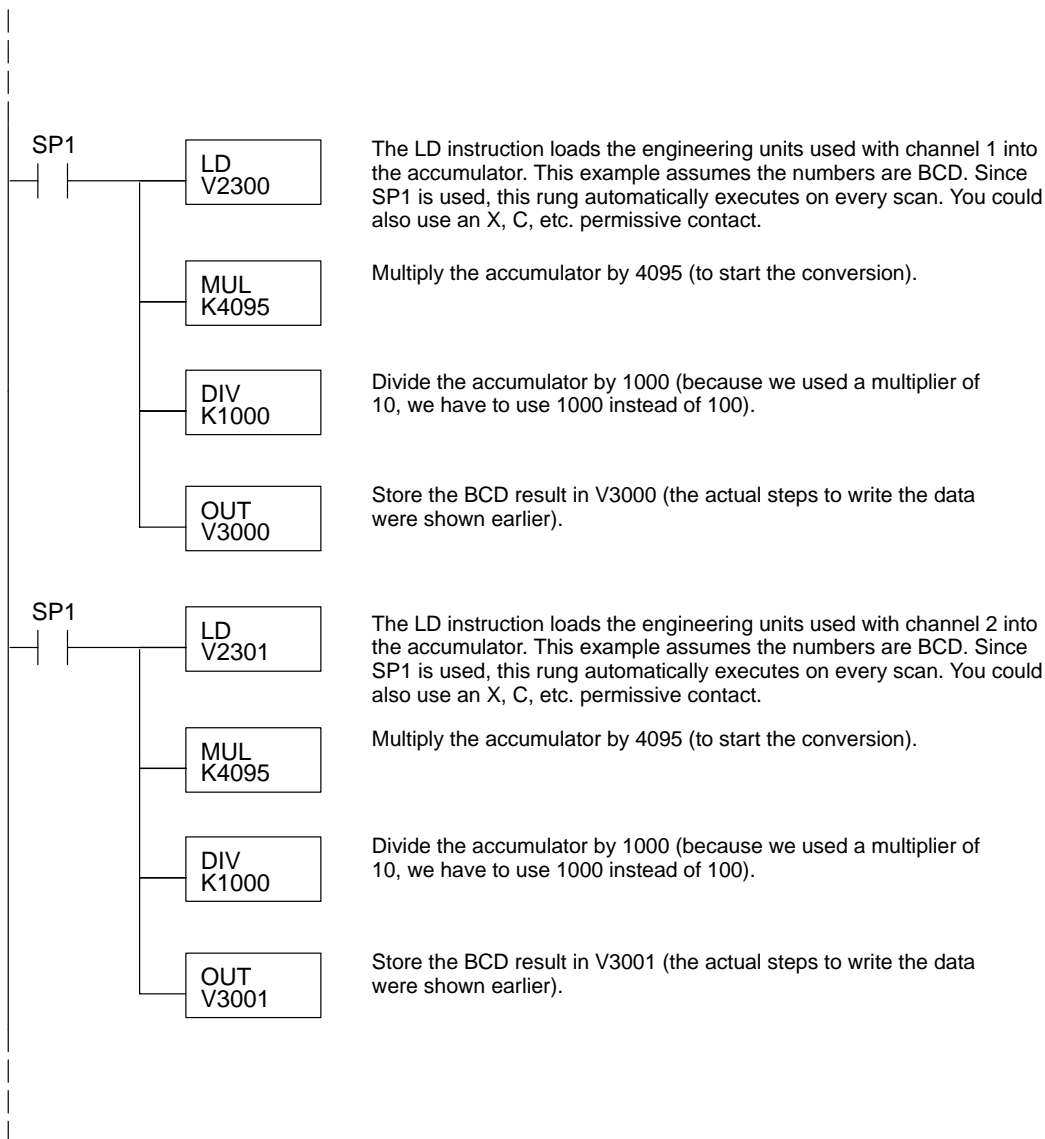
$$A = 494 \frac{4095}{1000 - 0}$$

$$A = 2023$$

The example program shows how you would write the program to perform the engineering unit conversion. This example assumes you have calculated or loaded the engineering unit values in BCD and stored them in V2300 and V2301 for channels 1 and 2 respectively.



**NOTE:** The DL350 offers various instructions that allow you to perform math operations using BCD format. It is easier to perform math calculations in BCD and then convert the value to binary before sending the data to the module.



**Analog and Digital Value Conversions**

Sometimes it is helpful to be able to quickly convert between the voltage or current 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 analog signal level ... |
|-----------|-----------------------------------|---|
| 0 to 5V   | $A = \frac{5D}{4095}$             | $D = \frac{4095}{5} A$                  |
| 0 to 10V  | $A = \frac{10D}{4095}$            | $D = \frac{4095}{10} A$                 |
| 4 to 12mA | $A = \frac{12D}{4095} + 4$        | $D = \frac{4095}{12} (A - 4)$           |
| 4 to 20mA | $A = \frac{16D}{4095} + 4$        | $D = \frac{4095}{16} (A - 4)$           |

For example, if you are using the 4–20mA range and you know you need a 10mA signal level, you would use the following formula to determine the digital value that should be sent to the module.

$$D = \frac{4095}{16} (A - 4)$$

$$D = \frac{4095}{16} (10\text{mA} - 4)$$

$$D = (255.93) (6)$$

$$D = 1536$$

# **F3–04DAS**

## **4-Channel Isolated Analog Output**

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In This Chapter. . . .

- Module Specifications
  - Setting the Module Jumpers
  - Connecting the Field Wiring
  - Module Operation
  - Writing the Control Program (DL340/DL350)
  - Writing the Control Program (DL350)
-

## Module Specifications

The following table provides the specifications for the F3-04DAS Analog Output Module. Review these specifications to make sure the module meets your application requirements.

|                          |   |
|--------------------------|---|
| Number of Channels       | 4   |
| Output Ranges            | $\pm 5\text{V}$ , $\pm 10\text{V}$ , $0-5\text{V}$ , $0-10\text{V}$ , $1-5\text{V}$ ,<br>$0-20\text{ mA}$ , $4-20\text{ mA}$                                  |
| Resolution               | 12 bit (1 in 4096)  |
| Output Type              | Isolated, 750 VDC channel-to-channel<br>750 VDC channel-to-logic  |
| Output Current           | $\pm 5\text{ mA}$ , voltage output  |
| Short-circuit Current    | $\pm 20\text{ mA}$ typical, voltage output  |
| Capacitive Load Drive    | $0.1\mu\text{F}$ typical, voltage output  |
| Load Impedance           | $470\Omega$ maximum, current output<br>$2\text{K}\Omega$ minimum, voltage output  |
| Isolation Mode Rejection | 140 dB at 60Hz  |
| Linearity Error          | $\pm 1$ count ( $\pm 0.03\%$ maximum)   |
| Calibration Error        | $\pm 0.15\%$ typical, $\pm 0.75\%$ maximum of span<br>$\pm 10\text{ ppm} / ^\circ\text{C}$ maximum of full scale  |
| Calibrated Offset Error  | $\pm 1$ count maximum, current output<br>$\pm 5\text{ mV}$ typical, $\pm 50\text{ mV}$ max., voltage output<br>$\pm 0.2\text{ mV}$ typical / $^\circ\text{C}$ |
| Conversion Time          | $30\mu\text{S}$ maximum, 1 channel/scan   |
| Power Budget Requirement | 154 mA @9V, 145 mA @ 24V (maximum)  |
| External Power Supply    | None required   |
| Operating Temperature    | $32^\circ$ to $140^\circ\text{ F}$ ( $0^\circ$ to $60^\circ\text{ C}$ )   |
| Storage Temperature      | $-4^\circ$ to $158^\circ\text{ F}$ ( $-20^\circ$ to $70^\circ\text{ C}$ )   |
| 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   |

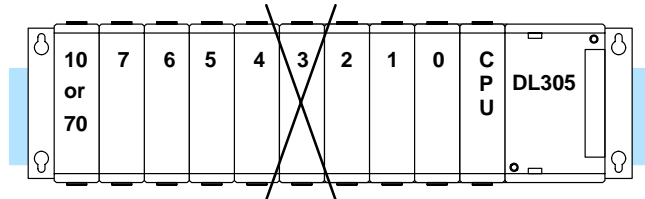
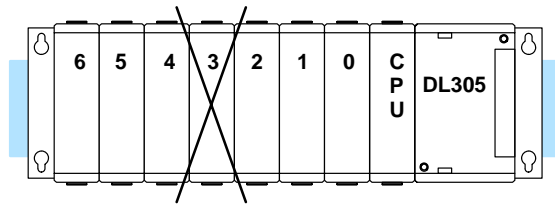
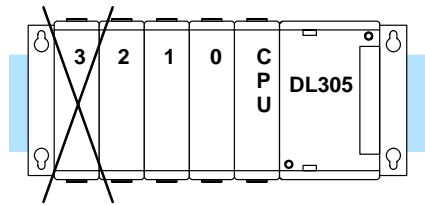


### Analog Output Configuration Requirements

The F3-04DAS Analog Output appears as a 16-point module. The module can be installed in any slot configured for 16 points, but **should not be installed in Slot 3 of any DL305 base**. 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.

**WARNING:** You should not install this module in Slot 3 of any DL305 base. The module has traces on the edge card connector that may become damaged if the module is repeatedly installed and removed. The solder mask that protects the traces may be scraped off, which may cause a short circuit on the I/O bus. The short circuit can lead to unpredictable system operation or cause damage to the CPU or power supply.



## Setting the Module Jumpers

**Jumper Locations** The module is set at the factory for a 0–10V signal on all four channels. If this is acceptable you do not have to change any of the jumpers.

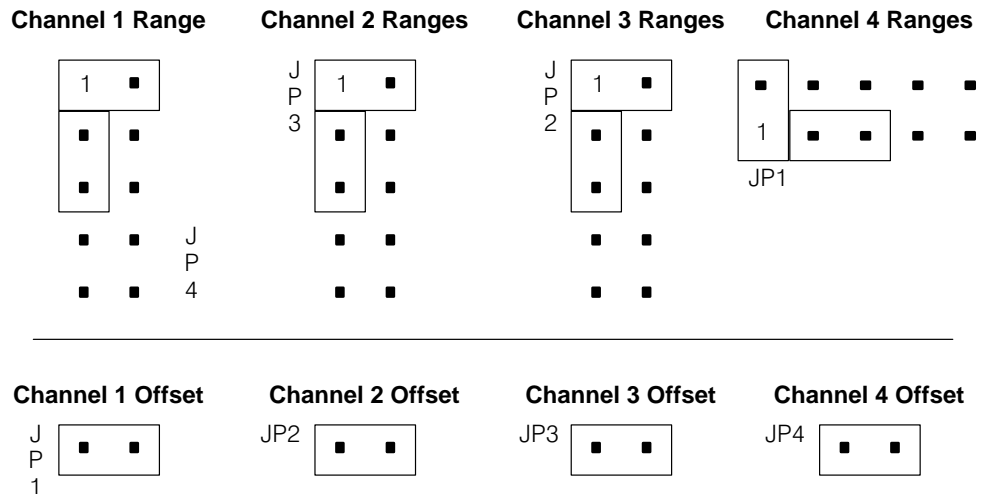
If you examine the top board on the module you will notice four sets of jumpers. The jumpers are assigned to the channels as follows.

- Channel 1 — Jumper JP4
- Channel 2 — Jumper JP3
- Channel 3 — Jumper JP2
- Channel 4 — Jumper JP1

**NOTE:** At first glance it might appear we have the channel / jumper assignments out of order. Your eyes do not deceive you. Channel 1 *is* controlled by JP4.

Each channel also has a jumper located on the bottom board of the module. These jumpers select a 1V (or 4mA) offset for each channel. Remove the jumper for any range that requires an offset. These jumpers are assigned as expected. JP1 selects an offset for channel 1, JP2 selects an offset for channel 2, etc.

The following diagram shows how the jumpers are assigned. It also shows the factory settings.



**Selecting Input Signal Ranges**

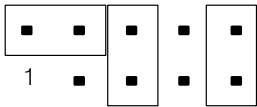
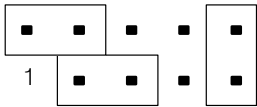
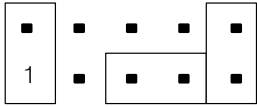
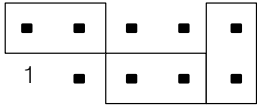
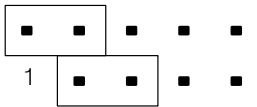
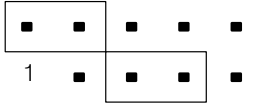
The following tables show the jumper selections for the various ranges. (Only channel 1 is used in the example, but all channels must be set.)

| Bipolar Signal Range             | Jumper Settings                                 |
|----------------------------------|---|
| -5 VDC to +5 VDC                 | <p>Channel 1 (JP4)      Offset Jumper (JP1)</p> |
| -10 VDC to +10 VDC               | <p>Channel 1 (JP4)      Offset Jumper (JP1)</p> |
| Unipolar Signal Range            | Jumper Settings                                 |
| 4 to 20 mA<br>(1 VDC to 5 VDC)   | <p>Channel 1 (JP4)      Offset Jumper (JP1)</p> |
| 0 VDC to +5 VDC<br>(0 to +20 mA) | <p>Channel 1 (JP4)      Offset Jumper (JP1)</p> |
| 0 VDC to +10 VDC                 | <p>Channel 1 (JP4)      Offset Jumper (JP1)</p> |

F3-04DAS  
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**Special Output Signal Ranges**

The following tables show the jumper selections for some additional ranges that are not normally found in many applications. Notice you can install or remove the offset jumper to change the settings. (Only channel 1 is used in the example, but all channels must be set.)

| Signal Range Offset Installed | Signal Range Offset Removed | Jumper Settings  |
|-------------------------------|-----------------------------|--|
| -10 VDC to +6 VDC             | -9 VDC to +7 VDC            | Channel 1 (JP4)<br>   |
| -5 VDC to +3 VDC              | -4 VDC to +4 VDC            | Channel 1 (JP4)<br>   |
| -2.5 VDC to +2.5 VDC          | -1.5 VDC to +3.5 VDC        | Channel 1 (JP4)<br>  |
| -2.5 VDC to +1.5 VDC          | -1.5 VDC to +2.5 VDC        | Channel 1 (JP4)<br> |
| 0 VDC to 8 VDC                | 1 VDC to 9 VDC              | Channel 1 (JP4)<br> |
| 0 VDC to 4 VDC                | 1 VDC to 5 VDC              | Channel 1 (JP4)<br> |

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## 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 module or the power supply return (0V). *Do not* ground the shield at both the module and the transducer.
- 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 F3-04DAS receives all power from the base. A separate power supply is not required.

**Load Requirements** Each channel can be wired independently for a voltage or current transducer.

- Current transducers must have an impedance less than 470 ohms.
- Voltage transducers must have an impedance greater than 2K ohms.

**Removable Connector**

The F3-04DAS module has a removable connector to make wiring easier. Simply squeeze the top and bottom tabs and gently pull the connector from the module.

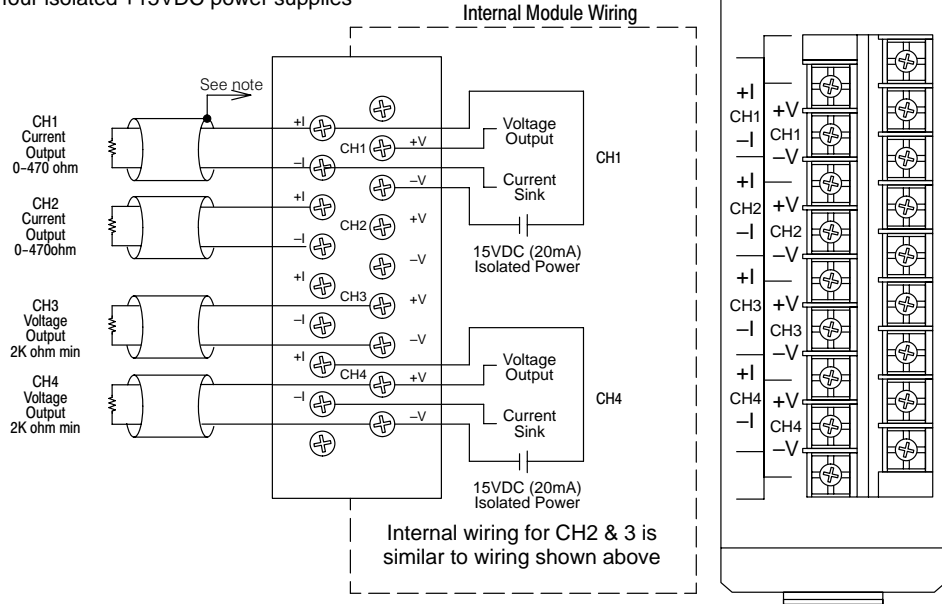
**Wiring Diagram**

Note 1: Shields should be connected to the respective channel's -V terminal of the module.

Note 2: Each isolated output channel may have either a voltage or current load, but not both

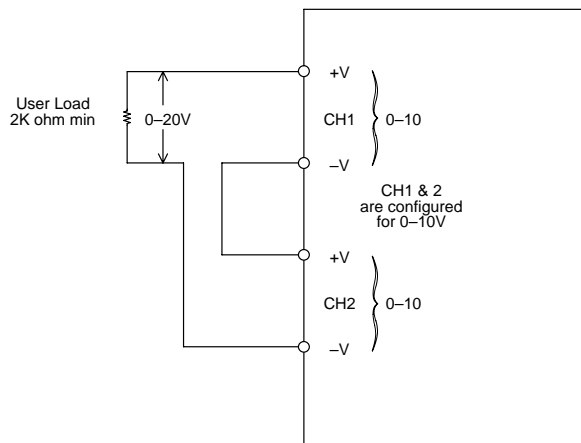
Note 3: An external 0.31 Amp fast-acting fuse in series with the isolated +I terminal (+15VDC) is recommended to protect against accidental shorts to the -V terminal (15VDC common)

Note 4: Do not attempt to source more than 20mA from any one of the four isolated +15VDC power supplies



**Combining Voltage Outputs**

You may occasionally encounter transmitters that have a very unusual signal range. Since each channel is isolated, you can “daisy chain” the channels to provide output voltage signals that are outside of the normal operating range. For example, you could connect the first two channels to provide a voltage output from 0 to 20 VDC.



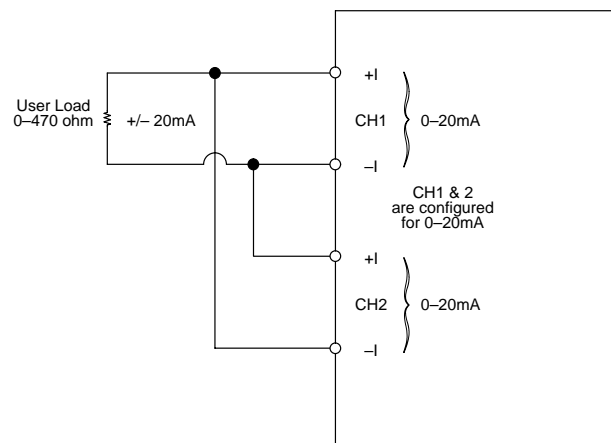
F3-04DAS  
4 Ch. Isolated Analog Out.

### Combining Current Outputs

You cannot connect the current outputs in series (like the voltage outputs) but you can achieve unusual ranges with a few wiring and programming tricks. For example, let's say an application requires a  $\pm 20$  mA range. By completing the following steps, you could easily accommodate this requirement.

1. Configure channel 1 and channel 2 for 0–20mA.
2. Connect the +I of channel 1 to the –I of channel 2.
3. Connect the –I of channel 1 to the +I of channel 2.
4. Send 0 (digital value) to channel 2 while you send 0–4095 (digital value) to channel 1. To reverse the power flow, send 0 to channel 1 while you send the 0–4095 value to channel 2. (See the section on Writing the Control Program for information on sending data values.)

**WARNING:** The isolated +15 VDC power supplies are rated at a maximum of 20 mA. Current ratings that exceed 20 mA will damage the module beyond repair. For example, if you used the 0–10 VDC range for the example, the current would approach 40 mA which would cause damage to the module.

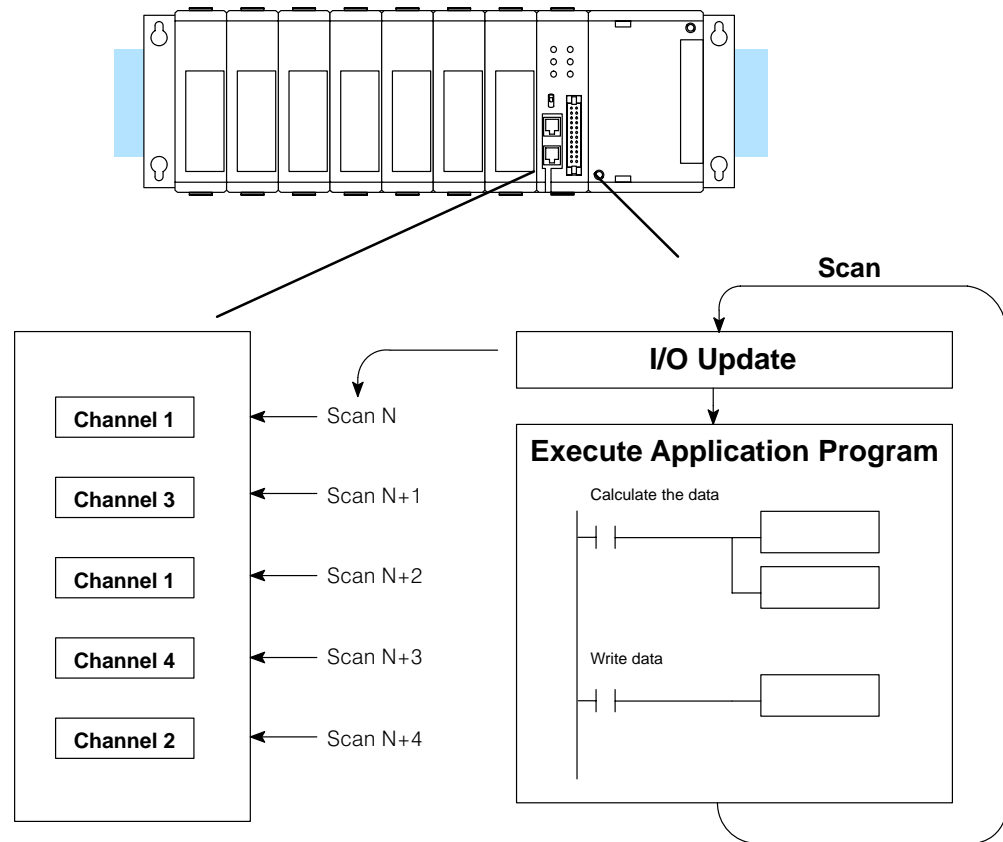


## Module Operation

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 F3-04DAS module can update one channel per CPU scan. Your RLL program selects the channel to update, so you have complete flexibility in solving your application requirements.



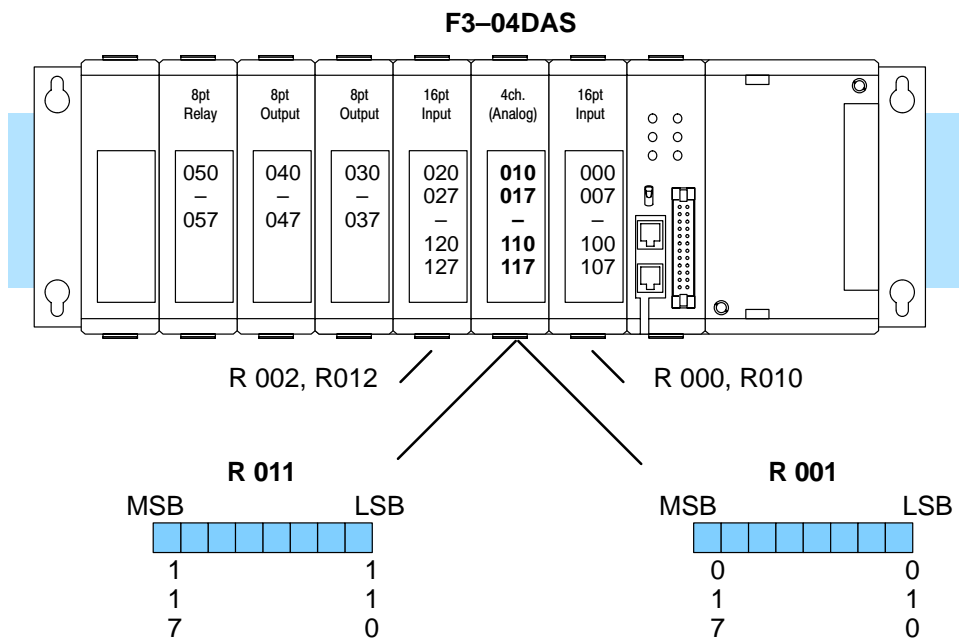


**Understanding the I/O Assignments**

You may recall the F3-04DAS module appears to the CPU as a 16-point module. These 16 points provide:

- the digital representation of the analog signal.
- identification of the channel to receive the data.

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.

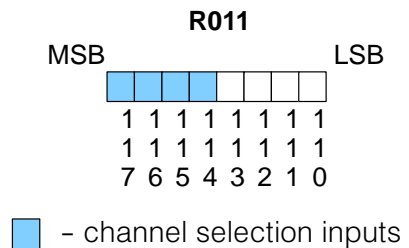


Within these two word locations, the individual bits represent specific information about the analog signal.

**Channel Selection Inputs**

The last four points of the upper register are used as outputs to tell the module which channel to update. In our example, when output 114 is on, channel 1 will be updated. Here's how the outputs are assigned.

| Output | Channels |
|--------|----------|
| 114    | 1        |
| 115    | 2        |
| 116    | 3        |
| 117    | 4        |

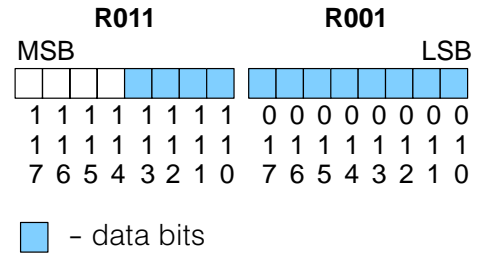


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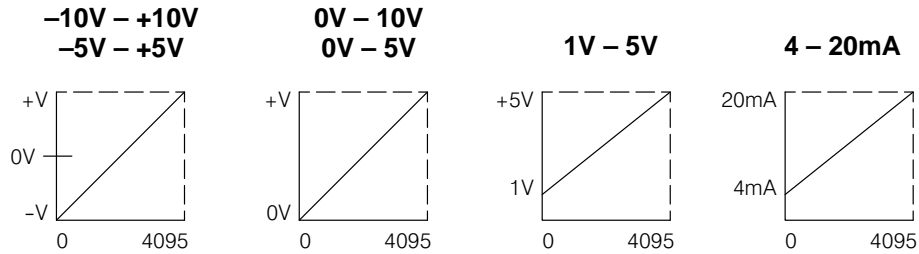
### Analog Data Bits

The remaining twelve bits represent the analog data in binary format.

| 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  |



Since the module has 12-bit resolution, the analog signal is converted into 4096 “pieces” ranging from 0 – 4095 ( $2^{12}$ ). For example, with a 0 to 10V scale, a 0V signal would be 0, and a 10V signal would be 4095. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal. The following diagram shows how this relates to each signal range.



Each “piece” can also be expressed in terms of the signal level by using the equation shown. The following table shows the smallest signal levels that will possibly result in a change in the data value for each signal range.

$$\text{Resolution} = \frac{H - L}{4095}$$

H = high limit of the signal range

L = low limit of the signal range

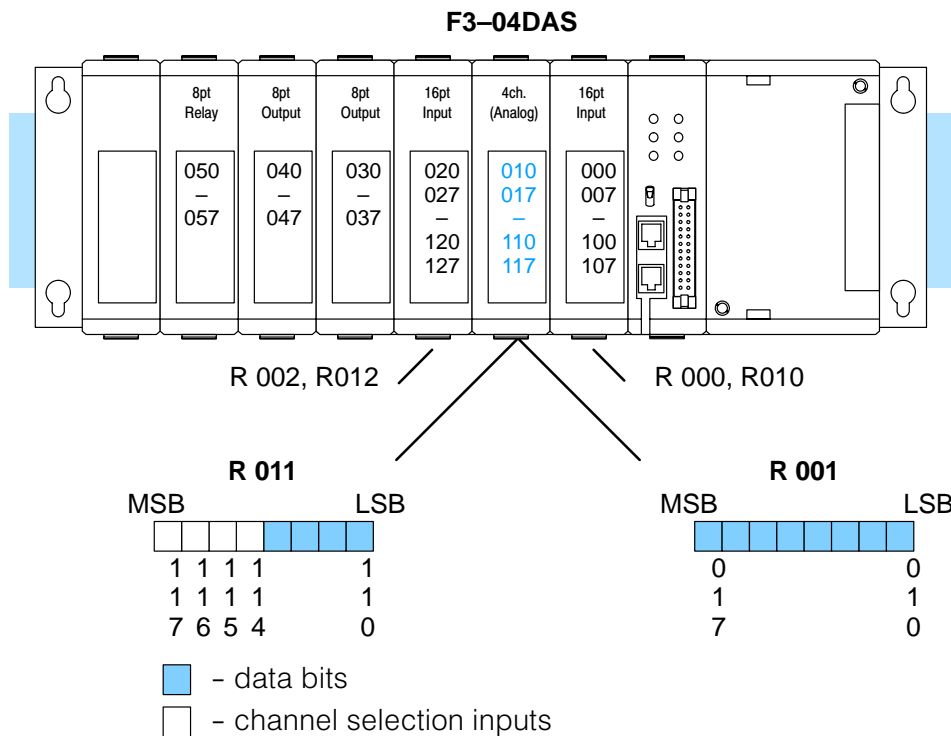
| Range       | Highest Signal | Lowest Signal | Smallest Change |
|-------------|----------------|---------------|-----------------|
| -10 to +10V | +10V           | -10V          | 4.88 mV         |
| -5 to +5V   | +5 V           | -5V           | 2.44 mV         |
| 0 to 5V     | 5V             | 0V            | 1.22 mV         |
| 0 to 10V    | 10V            | 0V            | 2.44 mV         |
| 1 to 5V     | 5V             | 1V            | 0.98 mV         |
| 4 to 20mA   | 20mA           | 4mA           | 3.91 $\mu$ A    |

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 (DL330 / DL340)

### Identifying the Data Locations

As mentioned earlier, you can use the channel selection bits to determine which channels will be updated. The following diagram shows the location for both the channel selection bits and data bits.



F3-04DAS  
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### Calculating the Digital Value

Your program has to calculate the digital value to send to the analog module. There are many ways to do this, but most all applications are understood more easily if you use measurements in engineering units. This is accomplished by using the conversion formula shown. You may have to make adjustments to the formula depending on the scale you choose for the engineering units.

$$A = 4096 \frac{U}{H - L}$$

- A = Analog value (0 – 4095)
- U = Engineering Units
- H = high limit of the Engineering unit range
- L = low limit of the Engineering unit range

The following example shows how you would use Engineering Units to obtain the digital value to represent pressure (PSI) from 0 to 100. This example assumes you want to obtain a pressure of 42 PSI, which is slightly less than half scale.

$$A = 4096 \frac{U}{H - L}$$

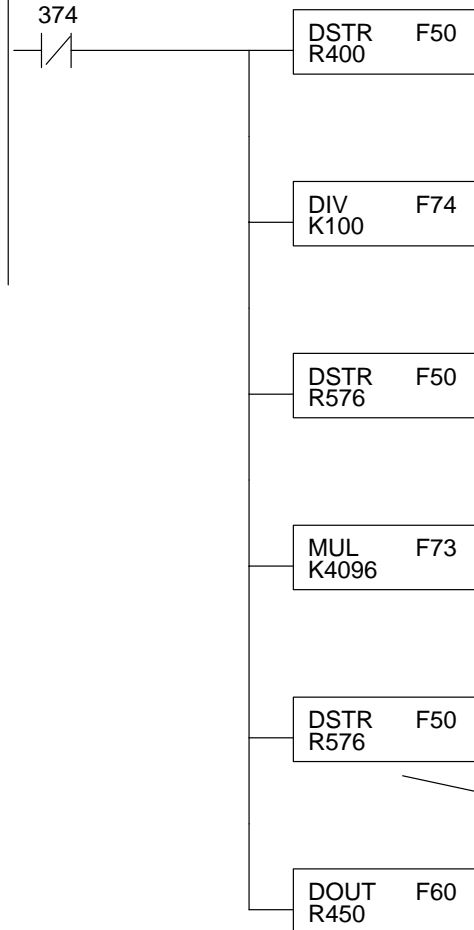
$$A = 4096 \frac{42}{100 - 0}$$

$$A = 1720$$

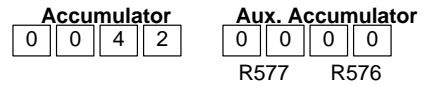
Here's how you would write the program to perform the Engineering Unit conversion. This example assumes you have calculated or loaded the engineering unit value and stored it in R400. Also, you have to perform this for all channels if you're using different data for each channel.

This example assumes you have already loaded the Engineering unit value in R400.

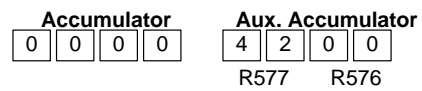
### Scale the data



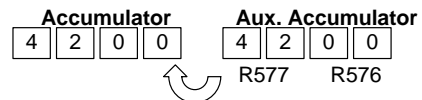
This instruction loads Engineering unit value into the accumulator on every scan.



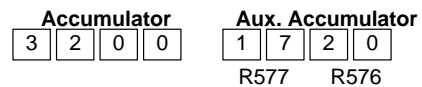
The Engineering unit value is divided by the Engineering unit range, which in this case is 100. (100 - 0 = 100)



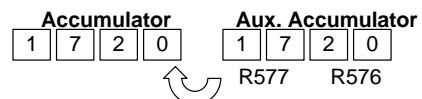
This instruction moves the two-byte decimal portion into the accumulator for further operations.



The accumulator is then multiplied by the module resolution, which is 4096. (4096 x 4200 = 17203200). Notice the most significant digits are now stored in the auxiliary accumulator. (This is different from the Divide instruction operation.)



This instruction moves the two-byte auxiliary accumulator for further operations.



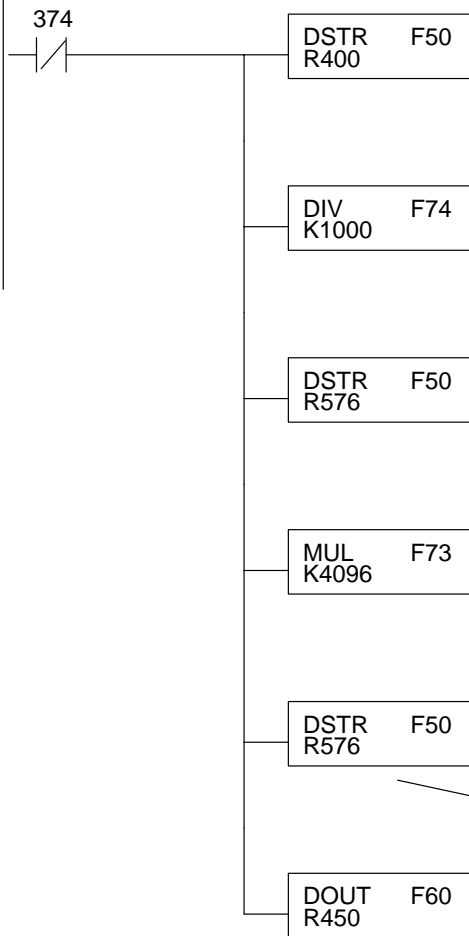
This instruction stores the accumulator to R450 and R451. R450 and R451 now contain the digital value, which is 1720.



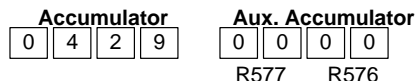
There will probably be times when you need more precise control. For example, maybe your application requires 42.9 PSI, not just 42 PSI. By changing the scaling value slightly, we can “imply” an extra decimal of precision. Notice in the following example we’ve entered 429 as the Engineering unit value and we’ve added another digit to the scale. Instead of a scale of 100, we’re using 1000, which implies 100.0 for the PSI range.

This example assumes you have already loaded the Engineering unit value in R400.

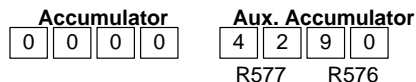
**Scale the data**



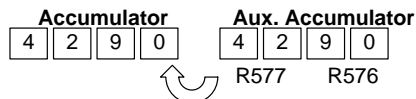
This instruction loads Engineering unit value into the accumulator on every scan.



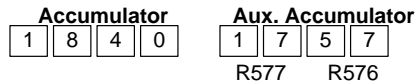
The Engineering unit value is divided by the Engineering unit range, which in this case is 1000. (100.0 implied range)



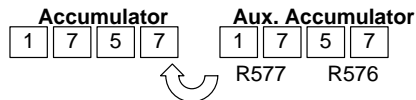
This instruction moves the two-byte decimal portion into the accumulator for further operations.



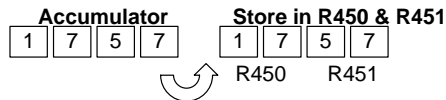
The accumulator is then multiplied by the module resolution, which is 4096. (4096 x 4290 = 17571840). Notice the most significant digits are now stored in the auxiliary accumulator. (This is different from the Divide instruction operation.)



This instruction moves the two-byte auxiliary accumulator for further operations.

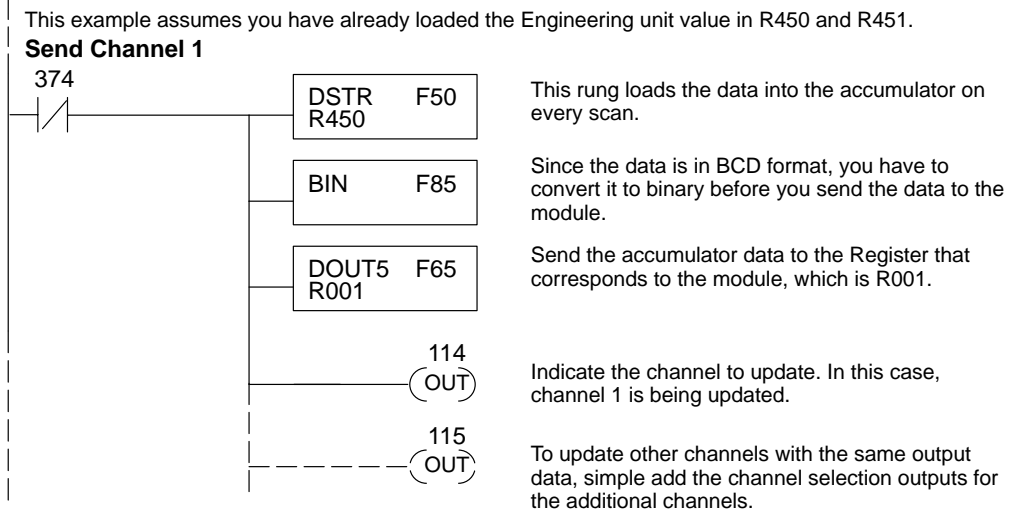


This instruction stores the accumulator to R450 and R451. R450 and R451 now contain the digital value, which is 1757.

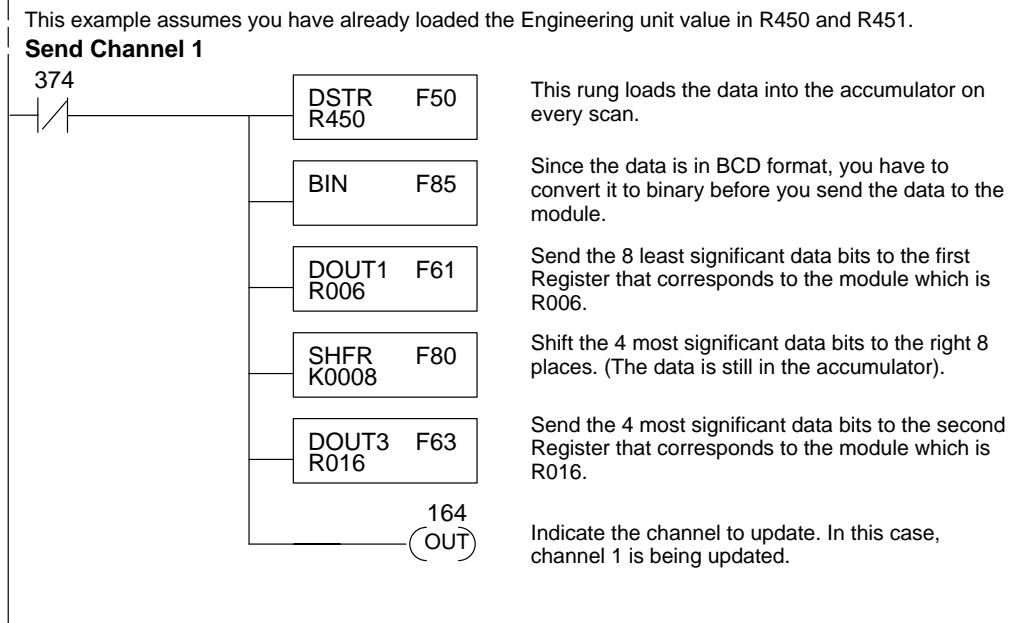


### Sending Data to a Single Channel

The following program example shows how to send the digital value to a single channel.



If you install the F3-04DA-1 in the slot corresponding to registers 6 and 16, you have to make a slight program adjustment. This is because the DOUT5 instruction is not supported for this slot.

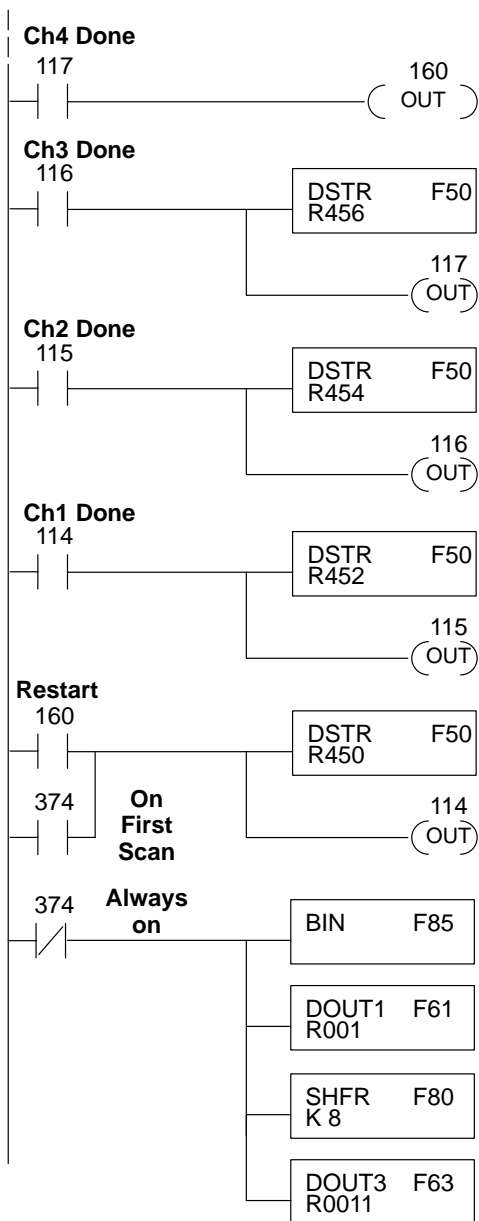


**Sequencing the Channel Updates**

This example shows how to send digital values to the module when you have more than one channel. This example will automatically update all four channels over four scans. The example is fairly simple and will work in most all situations, but there are instances where problems can occur. The logic must be active on the first CPU scan and all subsequent scans. If the logic gets stopped or disabled for some reason, there is no way to restart it. If you're using an RLL<sup>PLUS</sup> (Stage) program, put this logic in an initial stage that is always active. Also, you should avoid using the this example if you require the analog output logic to be used inside a Master Control Relay field of control. You could also accidentally disable the analog output logic by inadvertently writing to the multiplexing control relays with an operator interface or intelligent module, such as an ASCII BASIC module, etc.

**Sequencing Example**

The following program example shows how to send the digital values to multiple channels. With this program, all channels will be updated within four scans. You must use the rungs in the order shown, but you can include them anywhere in the program.



When channel 4 has been updated, 160 restarts the update sequence.

When channel 3 has been updated, this rung loads the data for channel 4 into the accumulator. By turning on 117, this triggers the channel update. (Since 117 is also used as an input, this results in a one-shot.)

When channel 2 has been updated, this rung loads the data for channel 3 into the accumulator. By turning on 116, this triggers the channel update. (Since 116 is also used as an input, this results in a one-shot.)

When channel 1 has been updated, this rung loads the data for channel 2 into the accumulator. By turning on 115, this triggers the channel update. (Since 115 is also used as an input, this results in a one-shot.)

This rung loads the data for channel 1 into the accumulator. Since 374 is used, this rung automatically executes on the first scan. After that, 160 restarts this rung. If you examine the first rung, you'll notice 160 only comes on after channel 4 has been updated.

Since the data is in BCD format, you have to convert it to binary before you send the data to the module. (You can omit this step if you've already converted the data elsewhere.)

Send the 8 least significant data bits to the first Register that corresponds to the module which is R001.

Shift the 4 most significant data bits to the right 8 places. (The data is still in the accumulator).

Send the 4 most significant data bits to the second Register that corresponds to the module which is R011.

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# Writing the Control Program (DL350)

## Reading Values: Pointer Method and Multiplexing

There are two methods of reading values:

- The pointer method (**all system bases must be D3-xx-1 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 CPU, but for ease of programming it is strongly recommended that you use the pointer method.

## Pointer Method

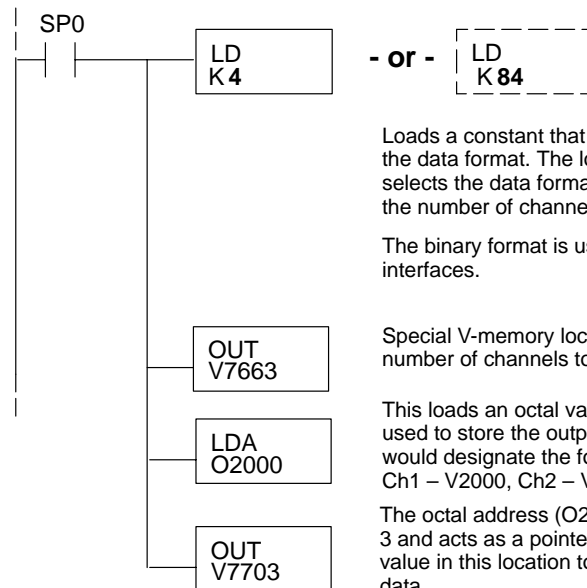
The DL350 has special V-memory locations assigned to each base slot that greatly simplifies the programming requirements. By using these V-memory locations you can:

- specify the number of channels to update.
- specify where to obtain the output data.



**NOTE:** Do not use the pointer method and the PID Control Output auto transfer to I/O module function together for the same module. If using PID loops, use the pointer method and ladder logic code to map the analog output data from the PID loop to the output module memory location(s).

The following program example shows how to set up these locations. Place this rung anywhere in the ladder program, or in the initial stage when using stage programming.



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

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

Special V-memory location assigned to slot 3 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 output data. For example, the O2000 entered here would designate the following addresses.  
Ch1 - V2000, Ch2 - V2001

The octal address (O2000) is stored here. V7703 is assigned to slot 3 and acts as a pointer, which means the CPU will use the octal value in this location to determine exactly where to store the output data.

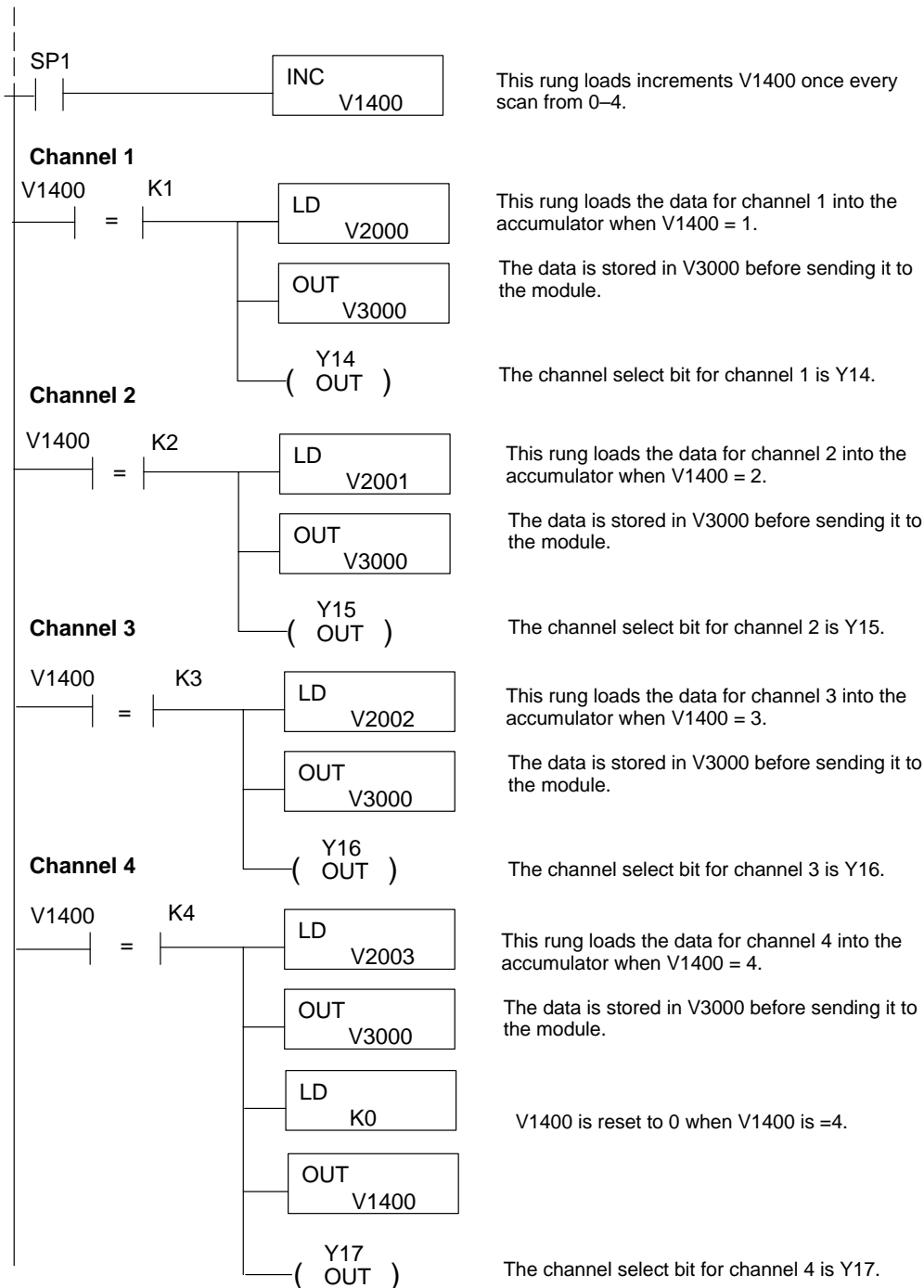
The table shows the special V-memory locations used with the DL350. Slot 0 (zero) is the module next to the CPU. Remember, the CPU only examines the pointer values at these locations after a mode transition. The pointer method is supported on expansion bases (all bases must be D3-xx-1) up to a total of 8 slots away from the DL350. The pointer method is not supported in slot 8 of a 10 slot base.

| Analog Output 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  | V7700 | V7701 | V7702 | V7703 | V7704 | V7705 | V7706 | V7707 |



**Multiplexing:  
DL350 with a  
D3-xx-1 Base**

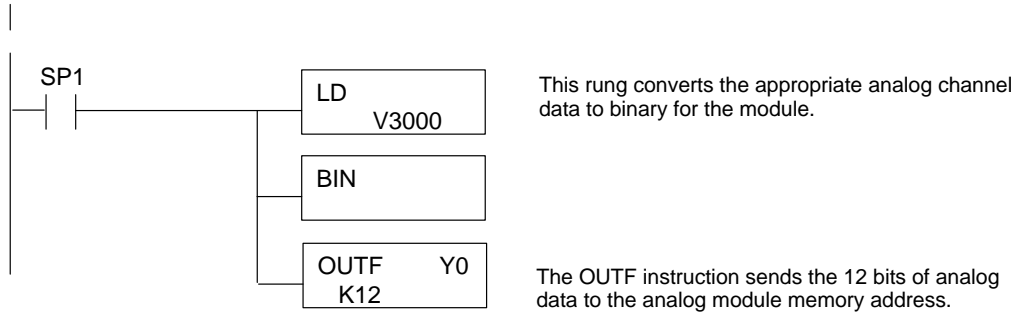
This example assumes the module is in Y0 address slot of a D3-xx-1. In this example V2000 contains the data for channel 1 and V2001 for channel 2, etc. in BCD. If any expansion bases are used in the system, they must all be D3-xx-1 to be able to use this example. Otherwise, the conventional base addressing must be used.



example program continued on next page

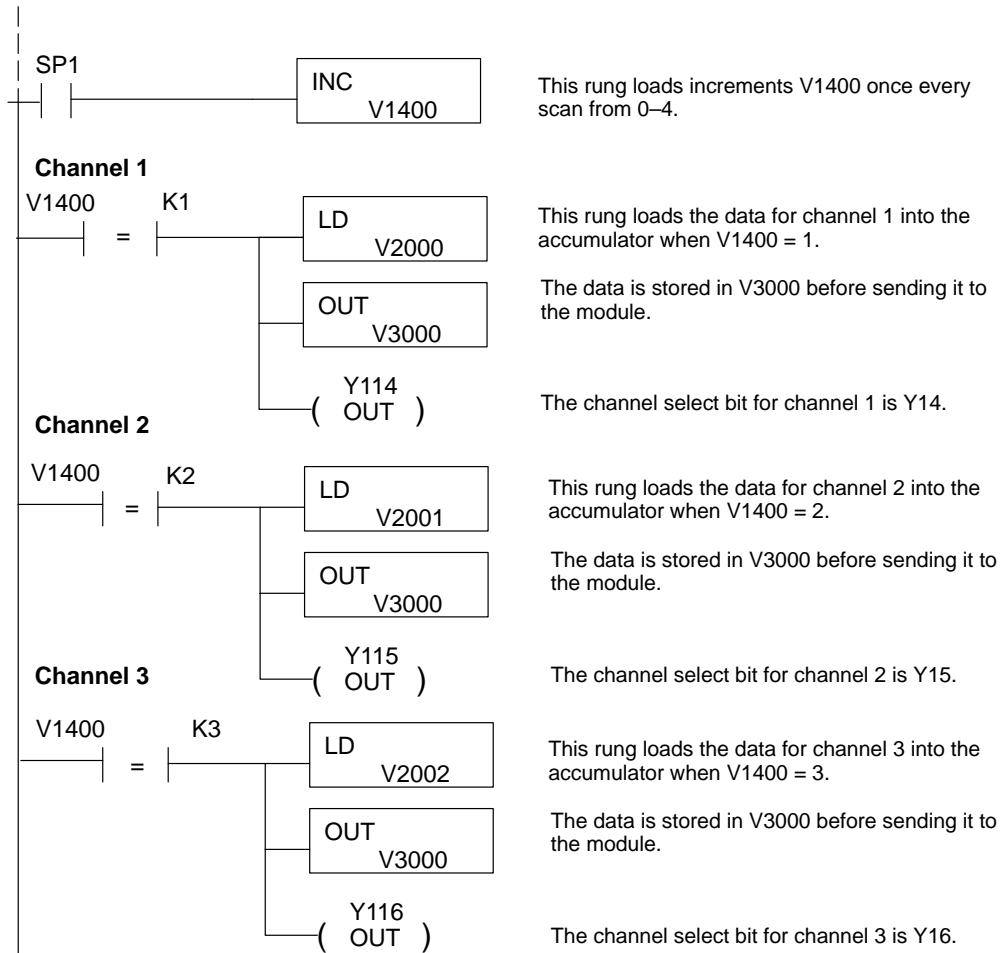
F3-04DAS  
4 Ch. Isolated Analog Out.

### example program continued from previous page



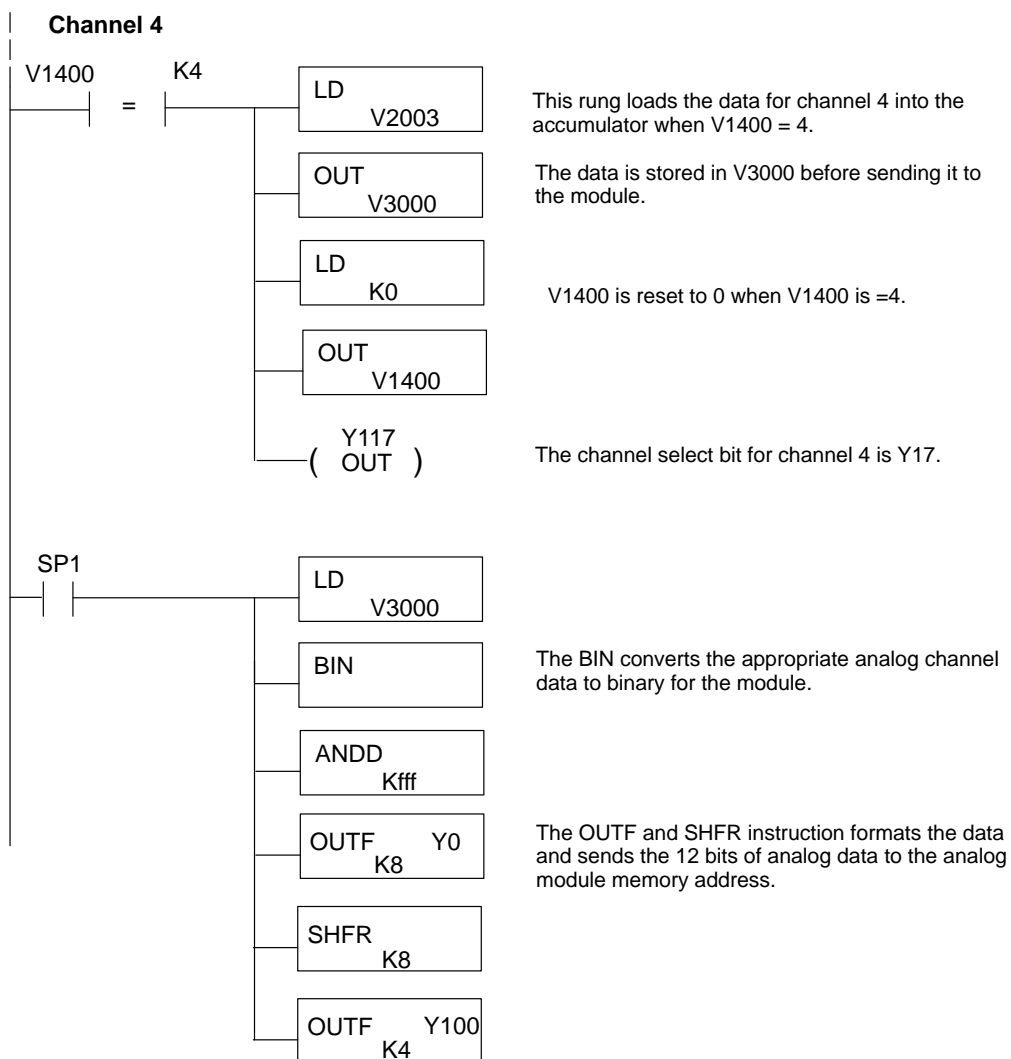
### Multiplexing: DL350 with Conventional DL305 Base

This example assumes the module is in the Y0-10 / Y100-107 slot of a 305 conventional base. In this example V2000 contains the BCD data for channel 1 and V2001 contains the data for channel 2, etc. One more rung would be necessary for channel 4.



example program continued on next page

example program continued from previous page



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**Calculating the Digital Value**

Your program must calculate the digital value to send to the analog module. There are many ways to do this, but most applications are understood more easily if you use measurements in engineering units. This is accomplished by using the conversion formula shown.

You may have to make adjustments to the formula depending on the scale you choose for the engineering units.

$$A = U \frac{4095}{H - L}$$

A = Analog value (0 – 4095)

U = Engineering Units

H = high limit of the engineering unit range

L = low limit of the engineering unit range

Consider the following example which controls pressure from 0.0 to 99.9 PSI. By using the formula, you can easily determine the digital value that should be sent to the module. The example shows the conversion required to yield 49.4 PSI. Notice the formula uses a multiplier of 10. This is because the decimal portion of 49.4 cannot be loaded, so you adjust the formula to compensate for it.

$$A = 10U \frac{4095}{10(H - L)}$$

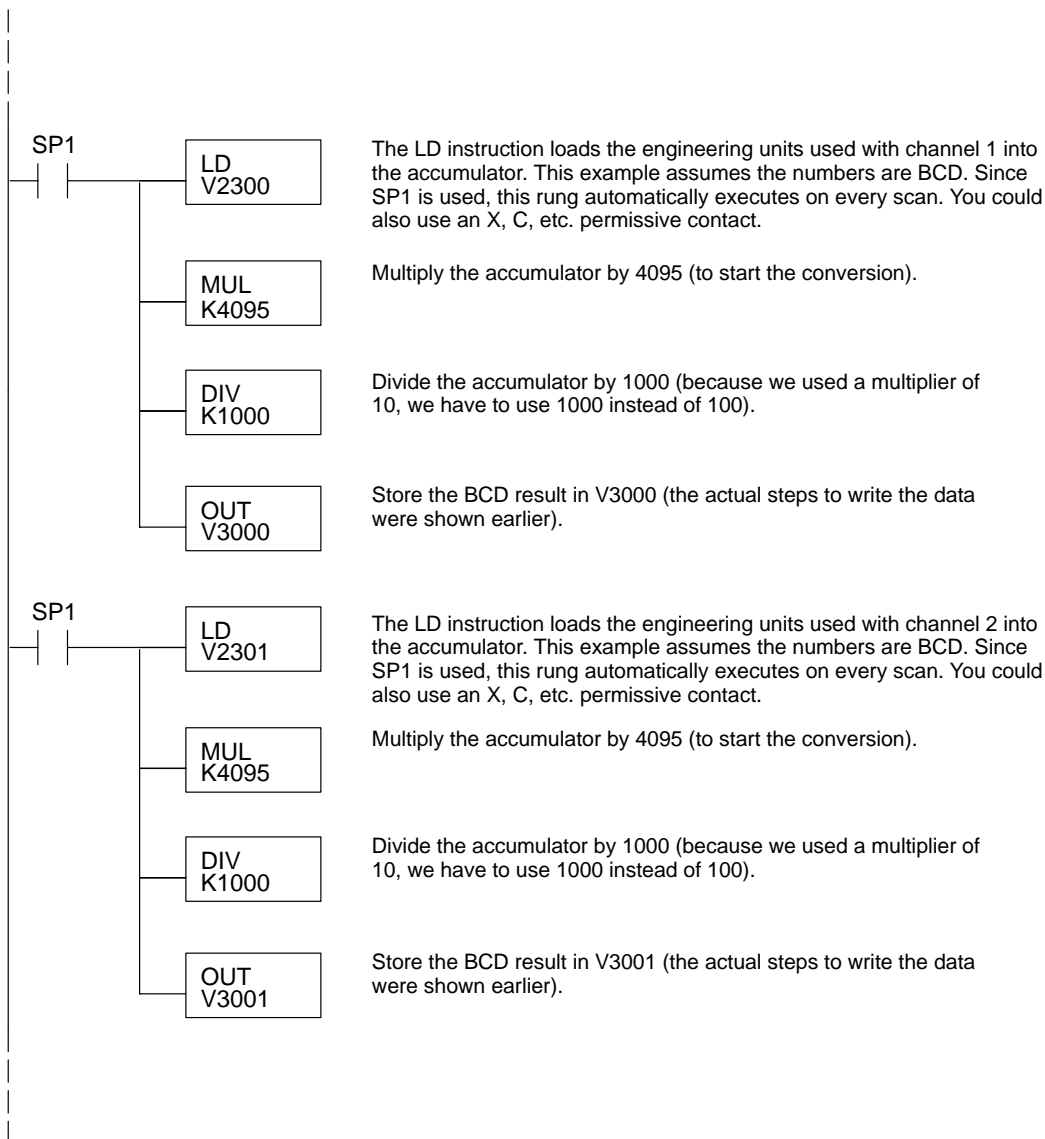
$$A = 494 \frac{4095}{1000 - 0}$$

$$A = 2023$$

The example program below shows how you would write the program to perform the engineering unit conversion. This example assumes you have calculated or loaded the engineering unit values in BCD and stored them in V2300 and V2301 for channels 1 and 2 respectively.



**NOTE:** The DL350 offers various instructions that allow you to perform math operations using BCD format. It is easier to perform math calculations in BCD and then convert the value to binary before sending the data to the module.



**Analog and Digital Value Conversions**

Sometimes it is helpful to be able to quickly convert between the voltage or current 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 signal level ... |
|--------------|-----------------------------------|----------------------------------|
| -10V to +10V | $A = \frac{20D}{4095} - 10$       | $D = \frac{4095}{20}(A + 10)$    |
| -5V to +5V   | $A = \frac{10D}{4095} - 5$        | $D = \frac{4095}{10}(A + 5)$     |
| 0 to 5V      | $A = \frac{5D}{4095}$             | $D = \frac{4095}{5} A$           |
| 0 to 10V     | $A = \frac{10D}{4095}$            | $D = \frac{4095}{10} A$          |
| 1 to 5V      | $A = \frac{4D}{4095} + 1$         | $D = \frac{4095}{4}(A - 1)$      |
| 4 to 20mA    | $A = \frac{16D}{4095} + 4$        | $D = \frac{4095}{16}(A - 4)$     |

For example, if you are using the -10 to +10V range and you have measured the signal at 6V, you would use the following formula to determine the digital value that should be stored in the register location that contains the data.

$$D = \frac{4095}{20}(A + 10)$$

$$D = \frac{4095}{20}(6V + 10)$$

$$D = (204.75)(16)$$

$$D = 3276$$

# **F3-08THM-n**

## **8-Channel**

### **Thermocouple Input**

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In This Chapter. . . .

- Introduction
  - Module Specifications
  - Setting the Module Switches
  - Connecting the Field Wiring
  - Module Operation
  - Writing the Control Program
-

## Introduction

### Automatic Conversion

The F3-08THM-n Thermocouple Input Module provides eight, differential thermocouple input channels (12-bit resolution). The module automatically converts type E, J, K, R, S or T thermocouple signals into direct temperature readings. No extra scaling or complex conversion is required. You can select between °F or °C operation.

This module is also available in versions specially designed to convert millivolt signal levels into direct digital values (0-4095). Two versions are available, one for 0-50mV and one for 0-100mV.

### Hardware Features

The F3-08THM-n also features automatic cold junction compensation, thermocouple linearization, plus analog and digital filtering. The temperature calculation and linearization are based on data provided by the National Bureau of Standards.

### Diagnostic Features

Thermocouple burnout and other errors are automatically reported to the CPU. For example, if the thermocouple becomes disconnected, then a value of 4095 is assigned to that channel.



## Module Specifications

The following table provides the specifications for the F3-08THM-n Thermocouple Input Module from FACTS Engineering. Review these specifications to make sure the module meets your application requirements.

|                                     |  |
|-------------------------------------|--|
| Number of Channels                  | 8, differential inputs   |
| Input Ranges                        | Type E: -270/1000 °C, -450/1832 °F<br>Type J: -210/760 °C, -350/1390 °F<br>Type K: -270/1370 °C, -450/2500 °F<br>Type R: 0/1768 °C, -32/3214 °F<br>Type S: 0/1768 °C, -32/3214 °F<br>Type T: -270/400 °C, -450/752 °F<br>-1: 0 – 50 mV<br>-2: 0–100 mV |
| Resolution                          | 12 bit (1 in 4096)   |
| Input Impedance                     | 27K $\Omega$ DC  |
| Absolute Maximum Ratings            | Fault protected input, 130 Vrms or 100 VDC   |
| Cold Junction Compensation          | Automatic  |
| Conversion Time                     | 15ms per channel, minimum<br>1 channel per CPU scan  |
| Converter Type                      | Successive Approximation, 574  |
| Linearity Error                     | $\pm 1$ count (0.03% of full scale) maximum  |
| Maximum Inaccuracy at 77 °F (25 °C) | 0.35% of full scale  |
| Accuracy vs. Temperature            | 57 ppm / °C maximum full scale   |
| Power Budget Requirement            | 50 mA @ 9 VDC, 34 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  |

### Analog Input Configuration Requirements

The F3-08THM-n Thermocouple 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

**Jumper Locations** The module is set at the factory for °C thermocouple readings. If this is acceptable you do not have to change any of the jumpers. The following diagram shows how the jumpers are set.

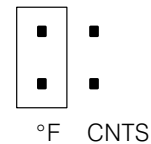
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**WARNING: DO NOT change the calibration jumper settings. If you think this jumper has been changed, make sure it is NOT in the CAL position. All calibration is performed at the factory. Any changes to this may affect the module accuracy which could result in the risk of personal injury and/or equipment damage.**

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**Selecting °F or °C Operation** There is a jumper located on the bottom of the board that selects between °C and °F temperature measurements. This jumper (labeled °F) should be removed if you require °C measurements.

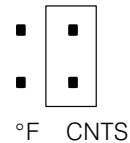
### Measurement Selection



Remove this jumper for °C operation.

**Selecting 0-4095 Operation** There is a jumper located on the bottom of the board that allows you to disable the direct temperature conversion feature. If you install a jumper on the CNTS pin, the temperature will be represented by a digital value between 0 and 4095. For example, an E type thermocouple would have a value of 0 for -450 °F and a value of 4095 for 1832 °F.

### Measurement Selection



Install this jumper to obtain digital values (0 - 4095).

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**NOTE:** If you are using the -1 (50mV) or the -2 (100mV) millivolt input versions, you should make sure this jumper is installed.

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# Connecting the Field Wiring

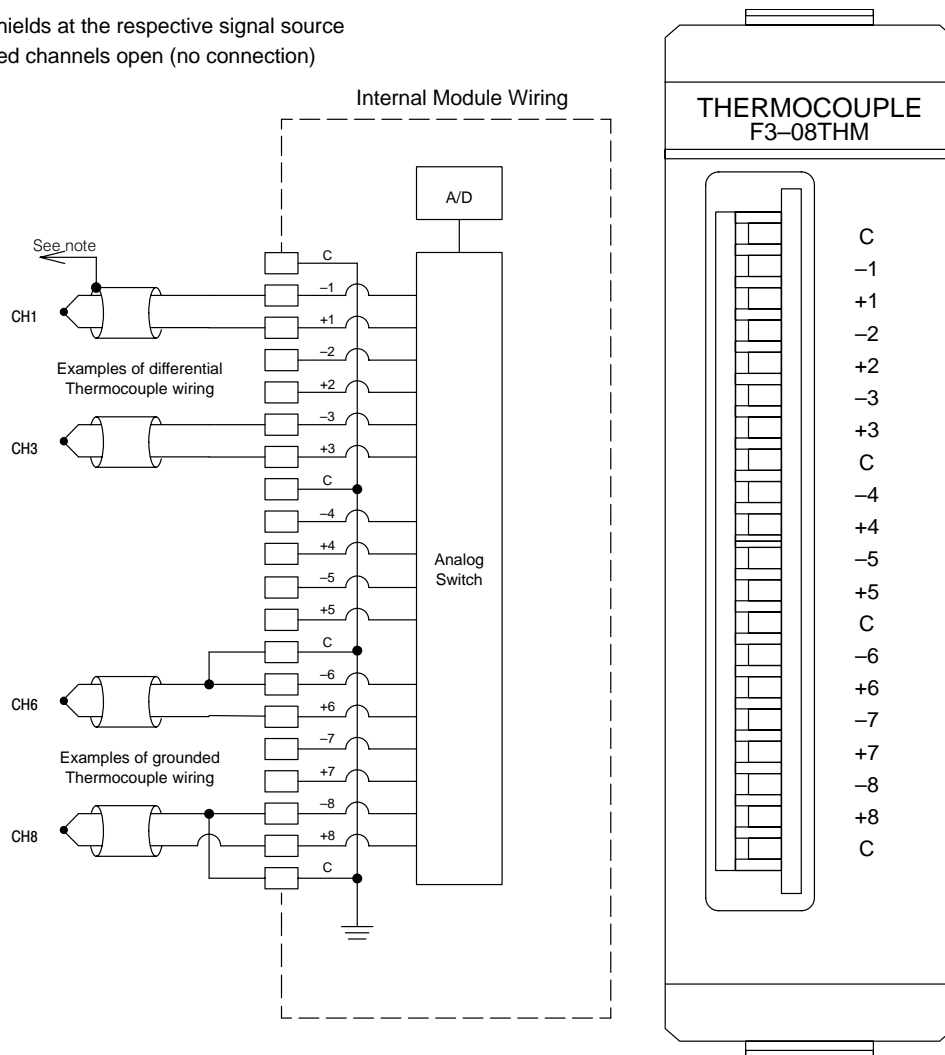
**Wiring Guidelines** Your company may have guidelines for wiring and cable installation. If so, you should check those before you begin the installation. Here are some general things to consider.

- 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 F3-08THM-n receives all power from the base. A separate power supply is not required.

## Wiring Diagram

Note 1: Terminate shields at the respective signal source  
 Note 2: Leave unused channels open (no connection)



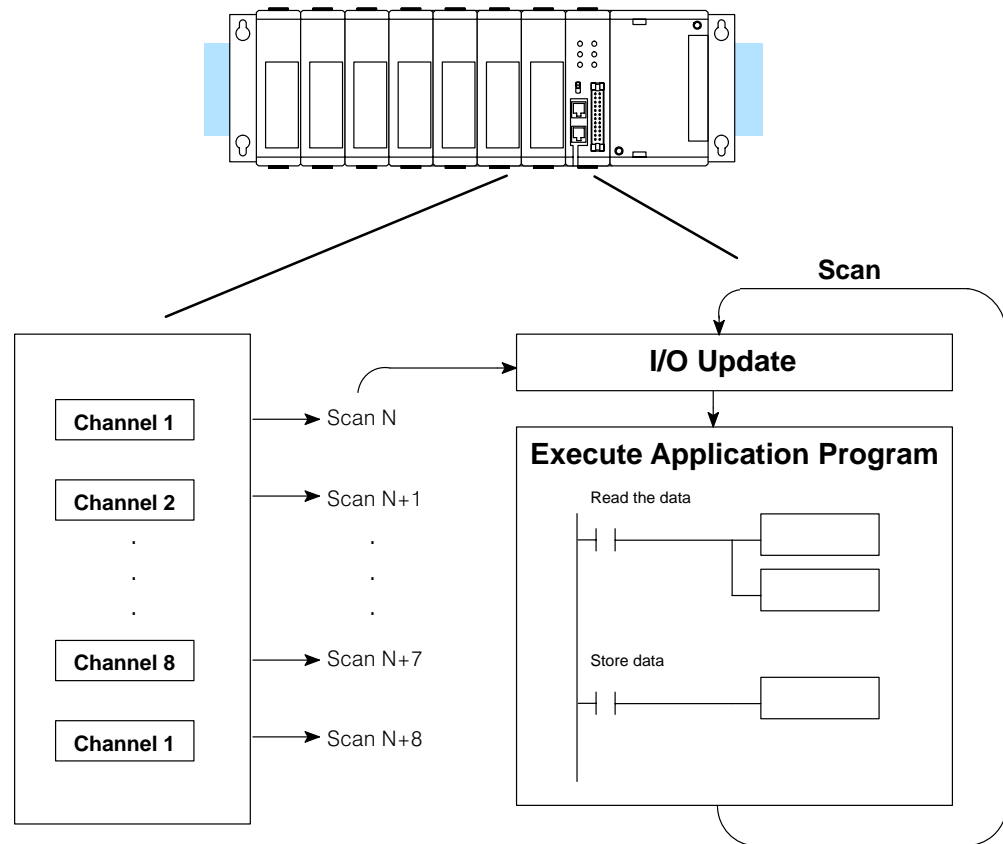
F3-08THM-n  
8Ch. Thermocouple In.

## 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 F3-08THM-n module supplies 1 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.



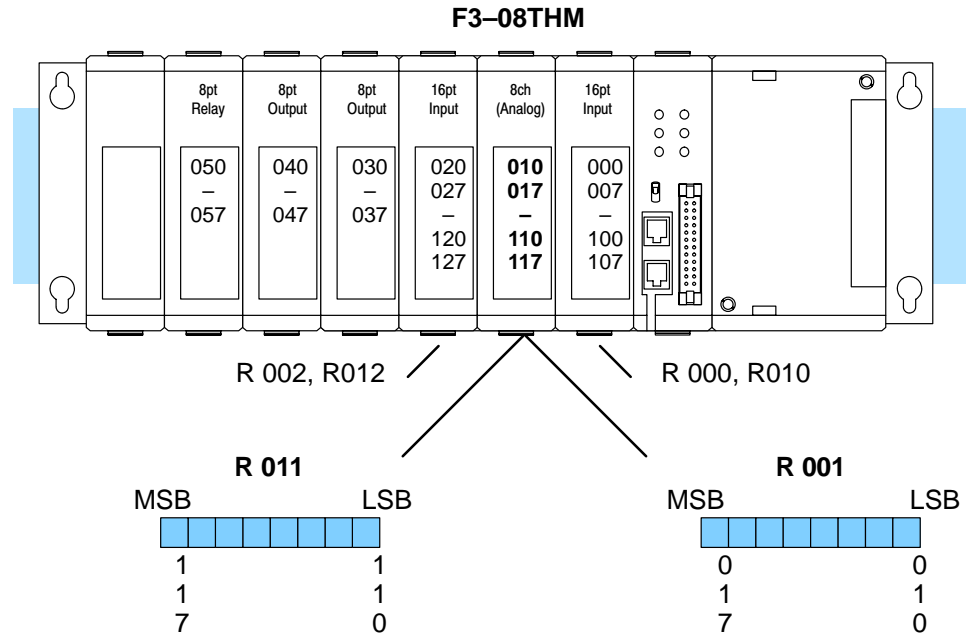
Even though the channel updates to the CPU are synchronous with the CPU scan, the module asynchronously monitors the thermocouple signal and converts the signal to a temperature (or 12-bit binary) representation. This enables the module to continuously provide accurate measurements without slowing down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

**Understanding the I/O Assignments**

You may recall the F3-08THM-n 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.

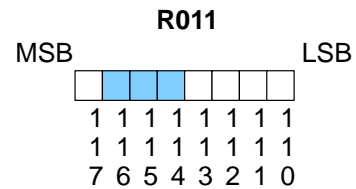


Within these two register locations, the individual bits represent specific information about the analog signal.

**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.

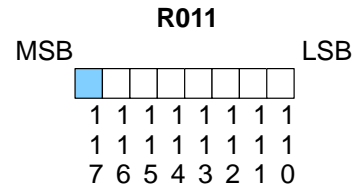
| Scan | Active Channel |         |
|------|----------------|---------|
|      | Inputs         | Channel |
| N    | 000            | 1       |
| N+1  | 001            | 2       |
| N+2  | 010            | 3       |
| N+3  | 011            | 4       |
| N+4  | 100            | 5       |
| N+5  | 101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



■ - active channel indicator inputs

**Temperature Sign Bit**

The most significant bit is used to note the sign of the temperature. If this bit is on, then the temperature is negative. If the bit is off, then the temperature is positive.

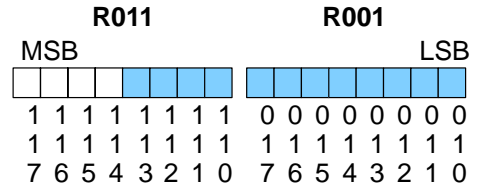


- temperature sign

**Analog Data Bits**

The first twelve bits represent the temperature. If you have selected the 0-4095 scale, 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  |



- data bits

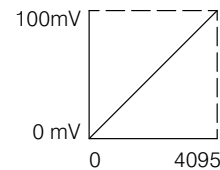
**Temperature Input Resolution**

Typically, the F3-08THM-n resolution enables you to detect a 1 °C change in temperature. The National Bureau of Standards publishes conversion tables that show how each temperature corresponds to an equivalent signal level.

**Millivolt Input Resolution**

Since the module has 12-bit resolution, the analog signal is converted into 4096 "pieces" ranging from 0 – 4095 (2<sup>12</sup>). For example, with a -2 (100mV) module a signal of 0 mV would be 0, and a signal of 100 mV would be 4095. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal. The diagram shows how this relates to the example signal range.

**0-100 mV Scale**



$$\text{Resolution} = \frac{H - L}{4095}$$

H = high limit of the signal range

L = low limit of the signal range

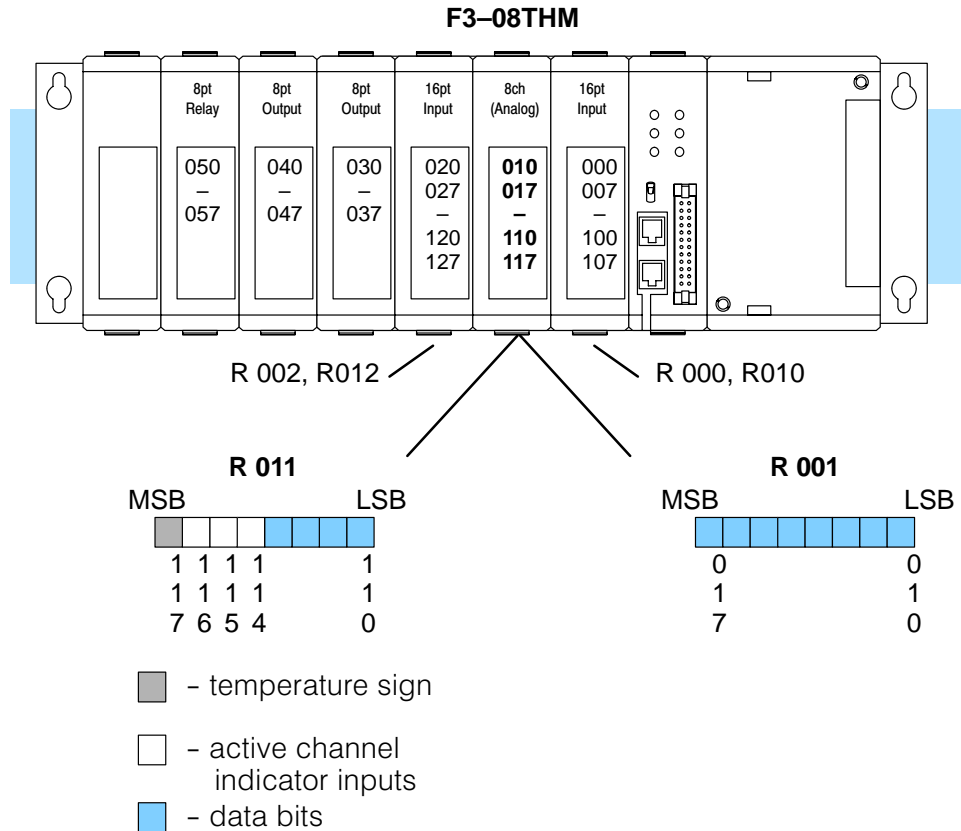
| Range      | Highest Signal | Lowest Signal | Smallest Change |
|------------|----------------|---------------|-----------------|
| 0 – 50 mV  | 50 mV          | 0 mV          | 12.2 μV         |
| 0 – 100 mV | 100mA          | 0mA           | 24.2 μV         |

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 (DL330 / DL340)

### Identifying the Data Locations

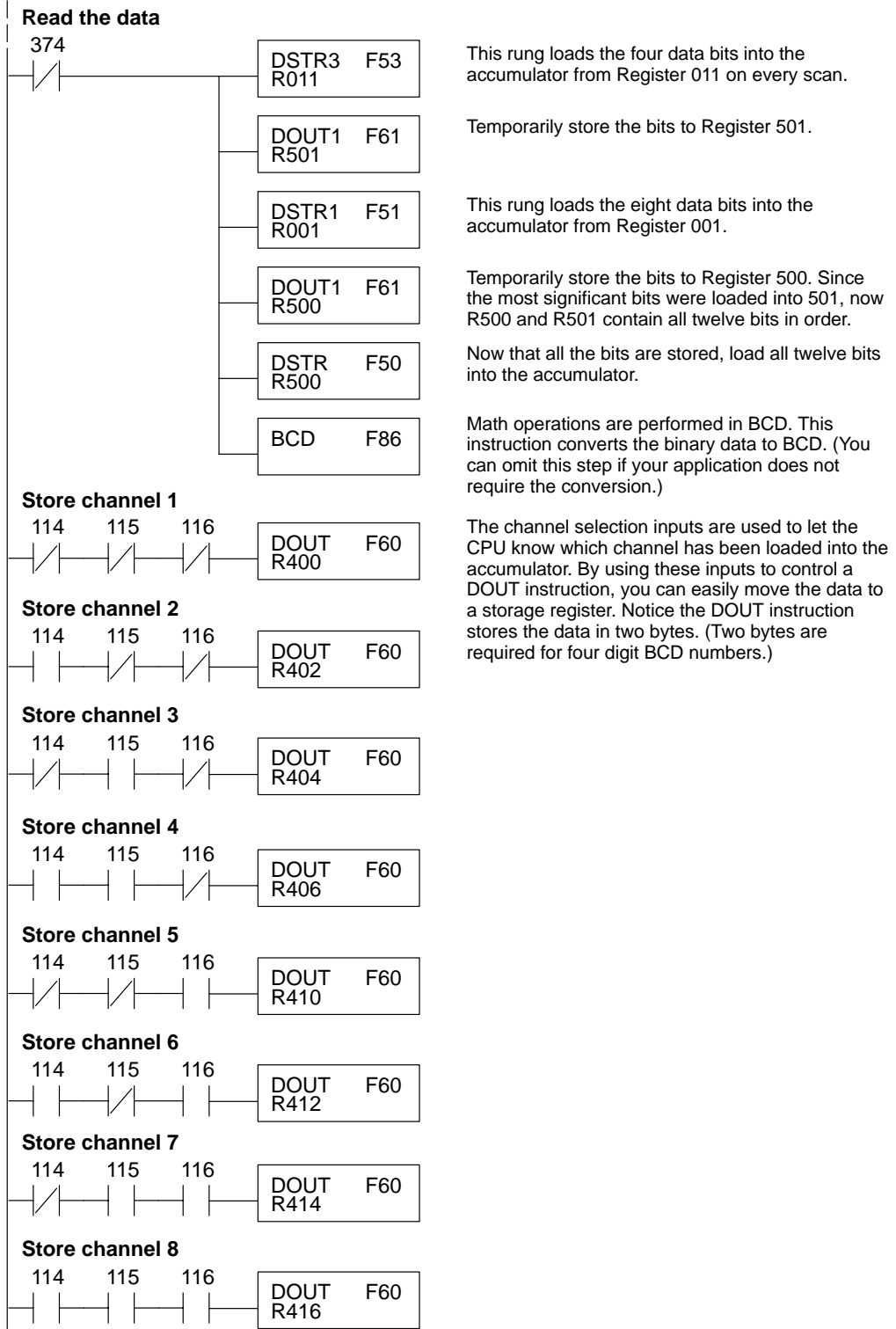
Since all channels are multiplexed into a single data word, the control program must be setup to determine which channel is being read. Since the module provides input points to the CPU, it is very easy to use the channel status bits to determine which channel is being monitored.



### Automatic Temperature Conversion

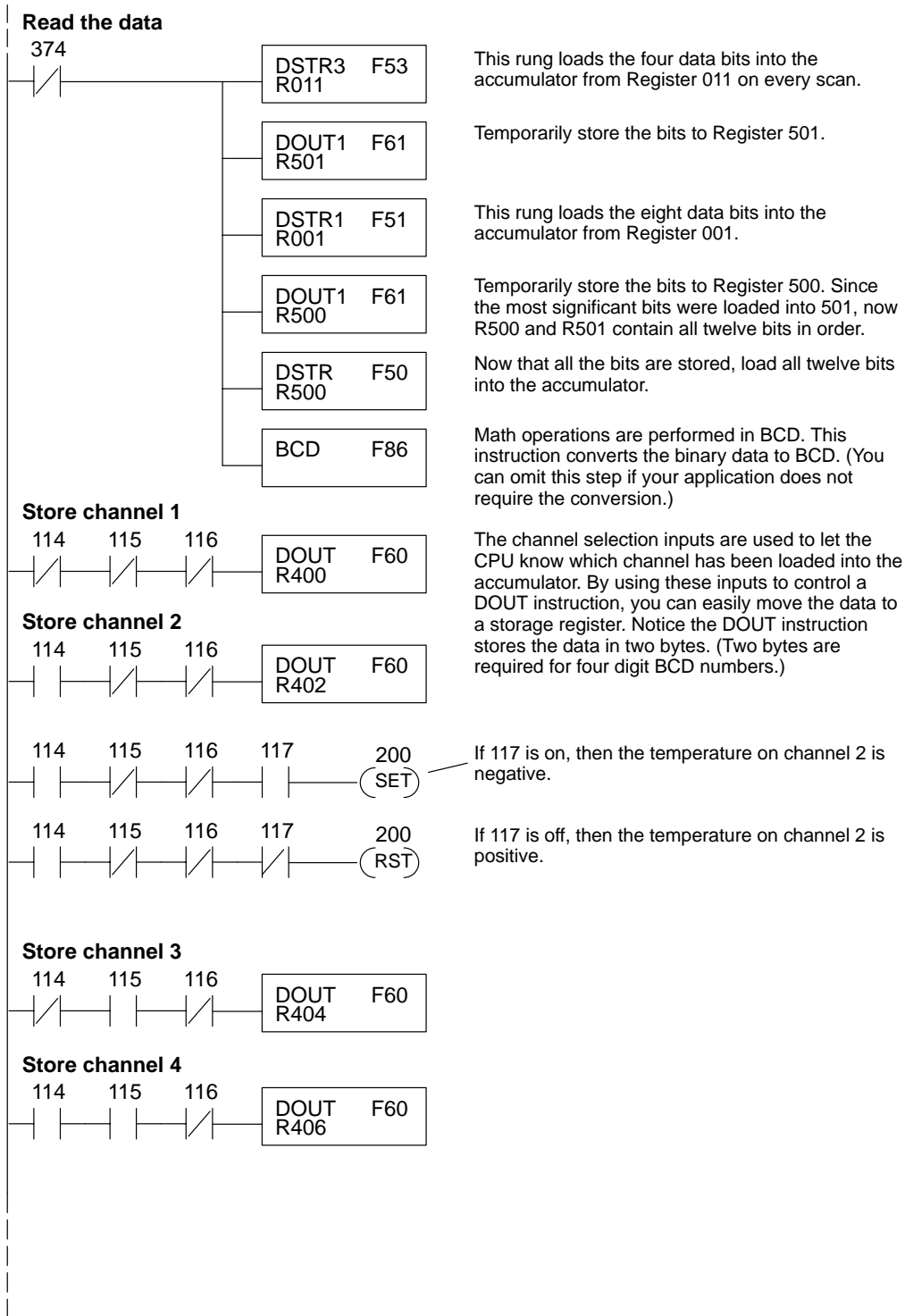
If you are using the temperature scale (°F or °C) then you do not have to perform any scaling. Once you convert the binary temperature reading to a four-digit BCD number, you have the temperature.

The following example shows a program designed to read any of the available channels of data into Register locations. Once the data is in a Register, you can perform math on the data, compare the data against preset values, etc. 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.





**Using the Sign Bit** By adding a couple of simple rungs you can easily monitor the temperature for positive vs. negative readings. (For example, you have to know whether the temperature is +100 °F or -100 °F.) Notice how we've changed Channel 2 to control an output that denotes the sign of the temperature.



**Scaling the Input Data**

If you are using the -1 (50mV) or the -2 (100mV) versions, you may want to scale the data to represent the measurements in engineering units, which provide more meaningful data. This is accomplished by using the conversion formula shown.

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**NOTE:** The thermocouple versions automatically provide the correct temperature readings. Scaling is not required.

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The following example shows how you would use the analog data to represent pressure (PSI) from 0 to 100. This example assumes the analog value is 1760. This should yield approximately 42.9 PSI.

$$\text{Units} = \frac{A}{4096} S$$

Units = value in Engineering Units

A = Analog value (0 – 4095)

S = high limit of the Engineering unit range

$$\text{Units} = \frac{A}{4096} S$$



$$\text{Units} = \frac{1760}{4096} 100$$

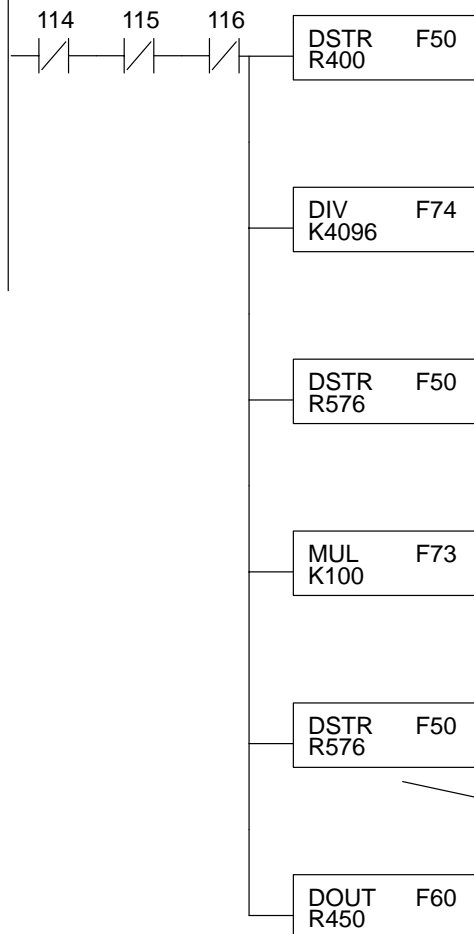


$$\text{Units} = 42.9$$

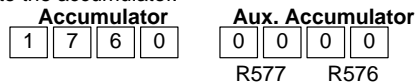
The following instructions are required to scale the data. (We'll continue to use the 42.9 PSI example.) Once we've explained how these instructions operate, we'll show an example program.

This example assumes you have already read the analog data and stored the BCD equivalent in R400 and R401

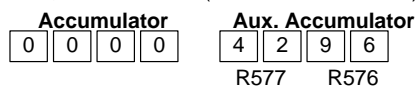
**Scale the data**



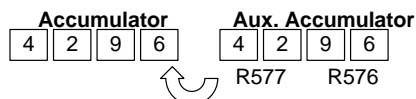
This instruction brings the analog value (in BCD) into the accumulator.



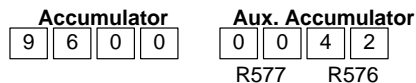
The analog value is divided by the resolution of the module, which is 4096. (1760 / 4096 = 0.4296)



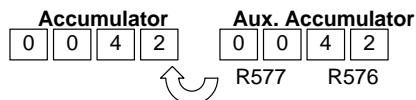
This instruction moves the two-byte decimal portion into the accumulator for further operations.



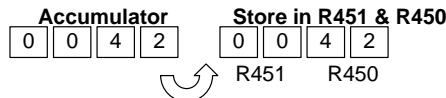
The accumulator is then multiplied by the scaling factor, which is 100. (100 x 4296 = 429600). Notice the most significant digits are now stored in the auxiliary accumulator. (This is different from the way the Divide instruction operates.)



This instruction moves the two-byte auxiliary accumulator for further operations.



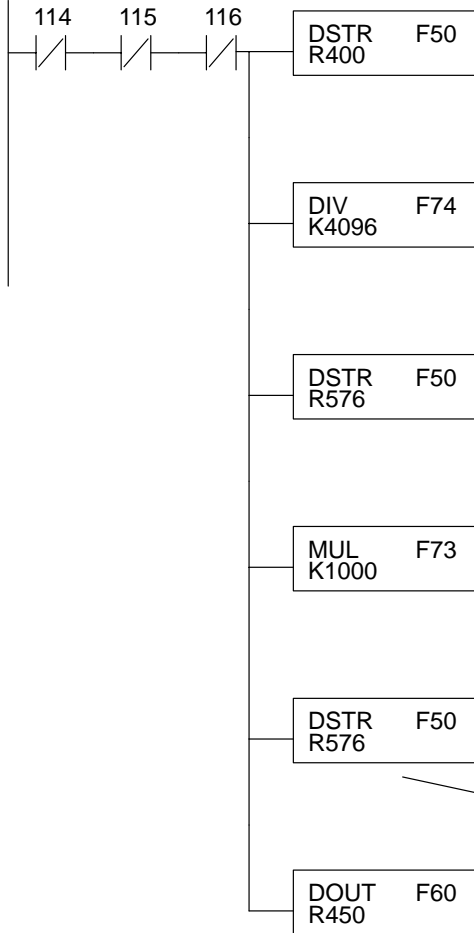
This instruction stores the accumulator to R450 and R451. R450 and R451 now contain the PSI, which is 42 PSI.



You probably noticed the previous example yielded 42 PSI when the real value should have been 42.9 PSI. By changing the scaling value slightly, we can “imply” an extra decimal of precision. Notice in the following example we’ve added another digit to the scale. Instead of a scale of 100, we’re using 1000, which implies 100.0 for the PSI range.

This example assumes you have already read the analog data and stored the BCD equivalent in R400 and R401

### Scale the data



This instruction brings the analog value (in BCD) into the accumulator.

| Accumulator |   |   |   | Aux. Accumulator |      |   |   |
|-------------|---|---|---|------------------|------|---|---|
| 1           | 7 | 6 | 0 | 0                | 0    | 0 | 0 |
|             |   |   |   | R577             | R576 |   |   |

The analog value is divided by the resolution of the module, which is 4096. ( $1760 / 4096 = 0.4296$ )

| Accumulator |   |   |   | Aux. Accumulator |      |   |   |
|-------------|---|---|---|------------------|------|---|---|
| 0           | 0 | 0 | 0 | 4                | 2    | 9 | 6 |
|             |   |   |   | R577             | R576 |   |   |

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

| Accumulator |   |   |   | Aux. Accumulator |      |   |   |
|-------------|---|---|---|------------------|------|---|---|
| 4           | 2 | 9 | 6 | 4                | 2    | 9 | 6 |
|             |   |   |   | R577             | R576 |   |   |

The accumulator is multiplied by the scaling factor, which is now 1000. ( $1000 \times 4296 = 4296000$ ). The most significant digits are now stored in the auxiliary accumulator. (This is different from the way the Divide instruction operates.)

| Accumulator |   |   |   | Aux. Accumulator |      |   |   |
|-------------|---|---|---|------------------|------|---|---|
| 6           | 0 | 0 | 0 | 0                | 4    | 2 | 9 |
|             |   |   |   | R577             | R576 |   |   |

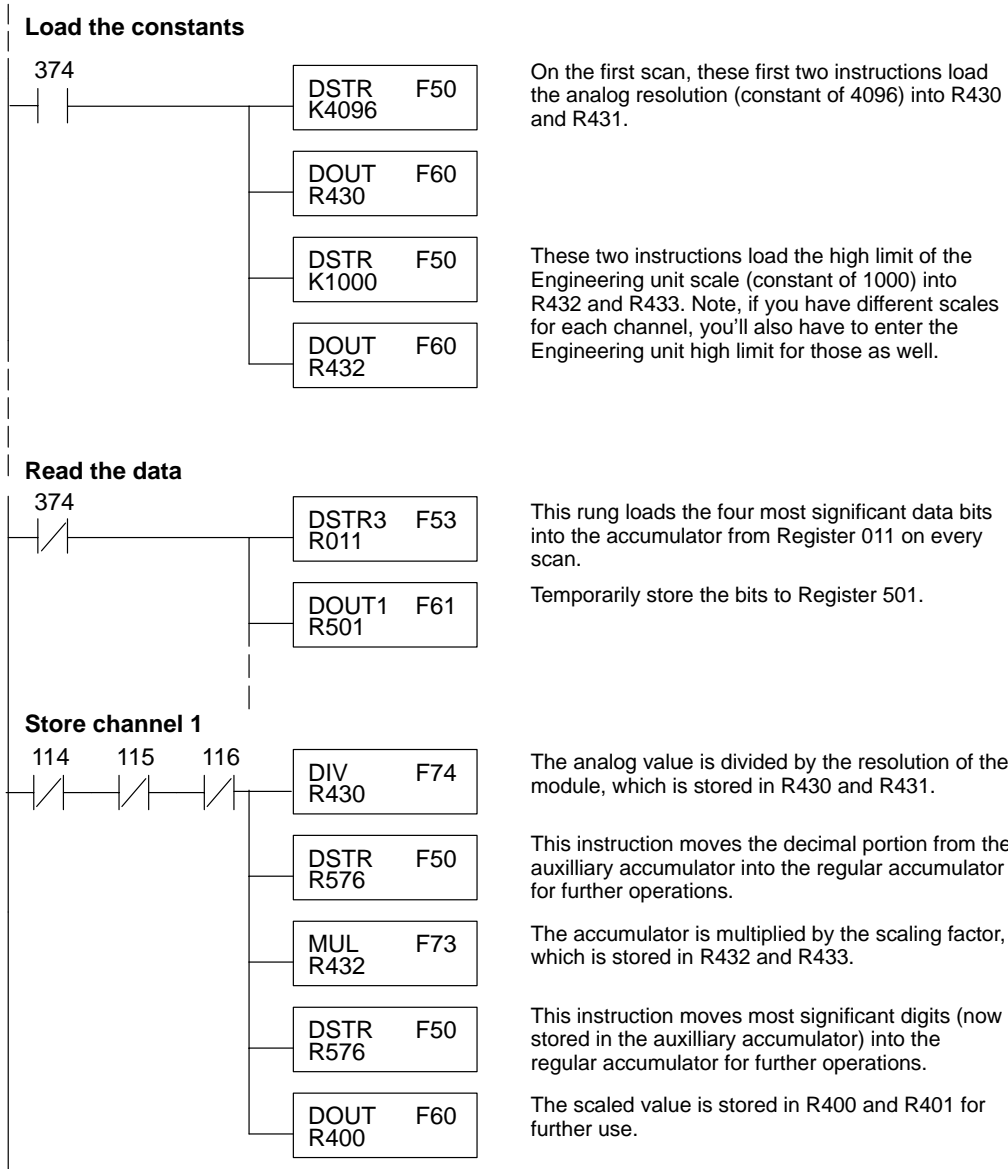
This instruction moves the two-byte auxiliary accumulator for further operations.

| Accumulator |   |   |   | Aux. Accumulator |      |   |   |
|-------------|---|---|---|------------------|------|---|---|
| 0           | 4 | 2 | 9 | 0                | 4    | 2 | 9 |
|             |   |   |   | R577             | R576 |   |   |

This instruction stores the accumulator to R450 and R451. R450 and R451 now contains the PSI, which implies 42.9.

| Accumulator |   |   |   | Store in R451 & R450 |      |   |   |
|-------------|---|---|---|----------------------|------|---|---|
| 0           | 4 | 2 | 9 | 0                    | 4    | 2 | 9 |
|             |   |   |   | R451                 | R450 |   |   |

This example program shows how you can use the instructions to load these equation constants into data registers. The example is written for channel 1, but you can easily use a similar approach to use different scales for all channels if required. You may just use the appropriate constants in the instructions dedicated for each channel, but this method allows easier modifications. For example, you could easily use an operator interface or a programming device to change the constants if they are stored in Registers.



## 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

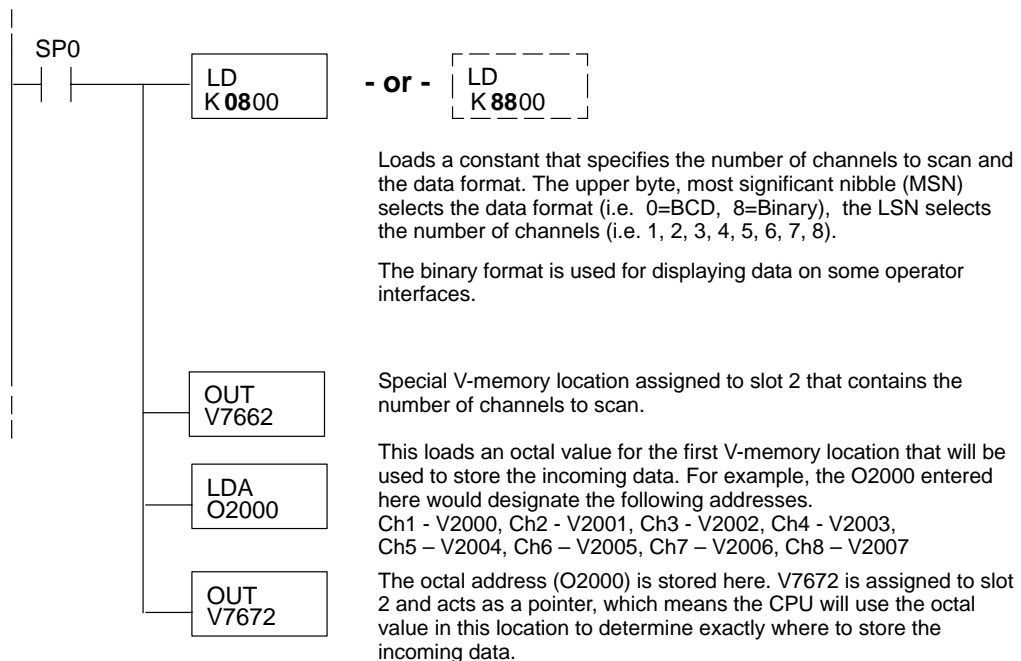
You must use the multiplexing method with remote I/O modules (the pointer method will not work). You can use either method when using DL350, but for ease of programming it is strongly recommended that you use the pointer method.

### 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<sup>PLUS</sup> 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.

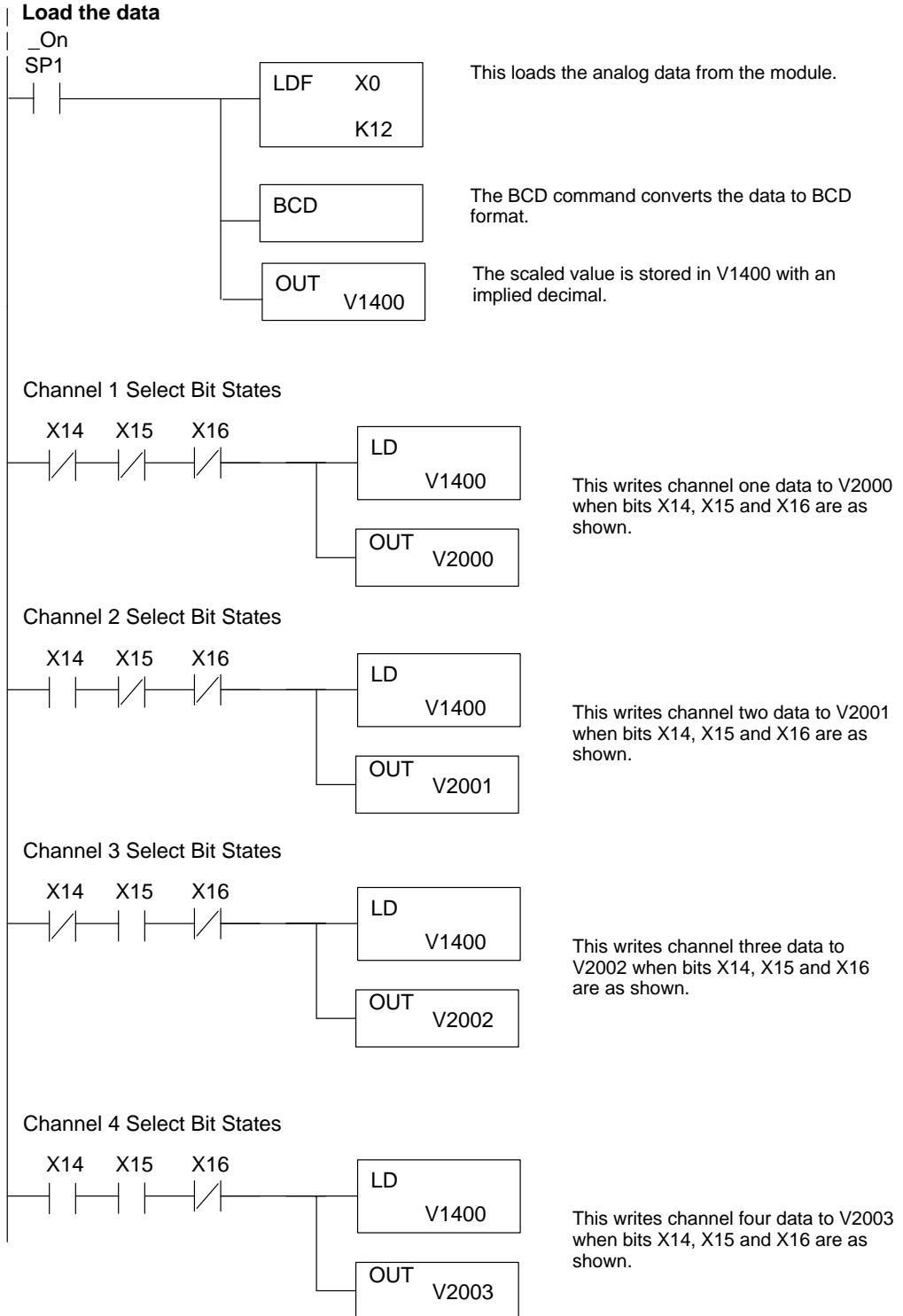


The table shows the special V-memory locations used with the DL350. Slot 0 (zero) is the module next to the CPU, slot 1 is the module two places from the CPU, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. The pointer method is supported on expansion 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.

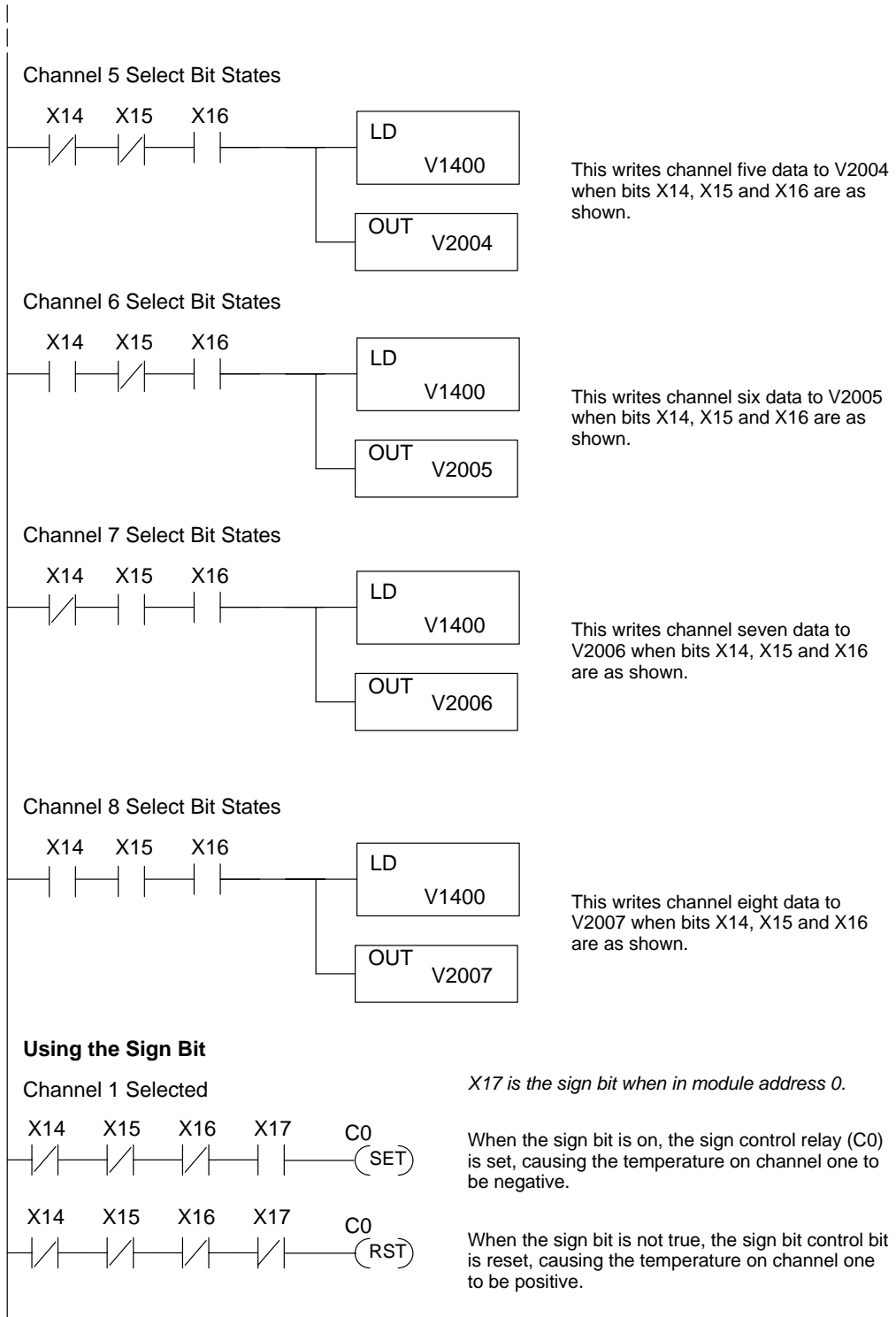
| Analog Input Module Slot-Dependent V-memory Locations |       |       |       |       |       |       |       |       |
|---|-------|-------|-------|-------|-------|-------|-------|-------|
| Slot  | 0     | 1     | 2     | 3     | 4     | 5     | 6     | 7     |
| No. of Channels                                       | 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 multiple channels on an F3-08THM Thermocouple module in the X0 address slot 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.



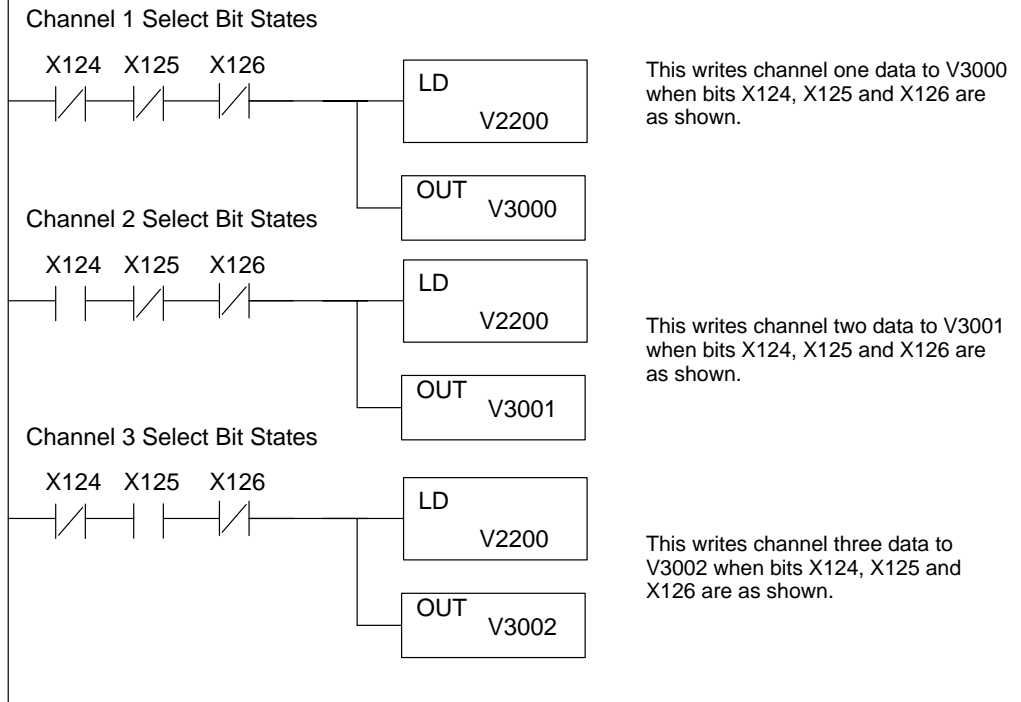
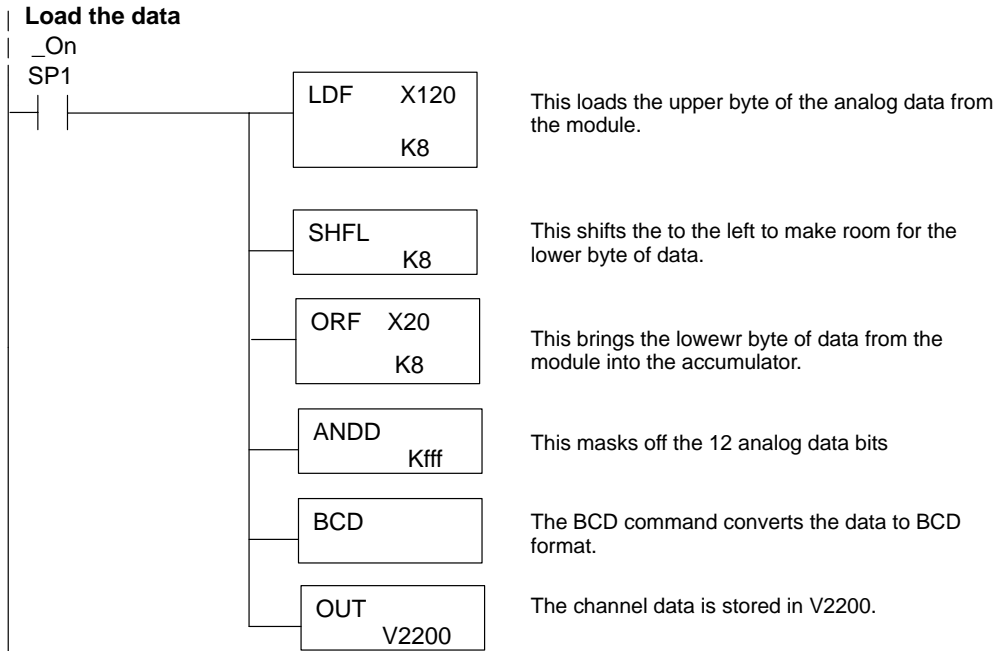


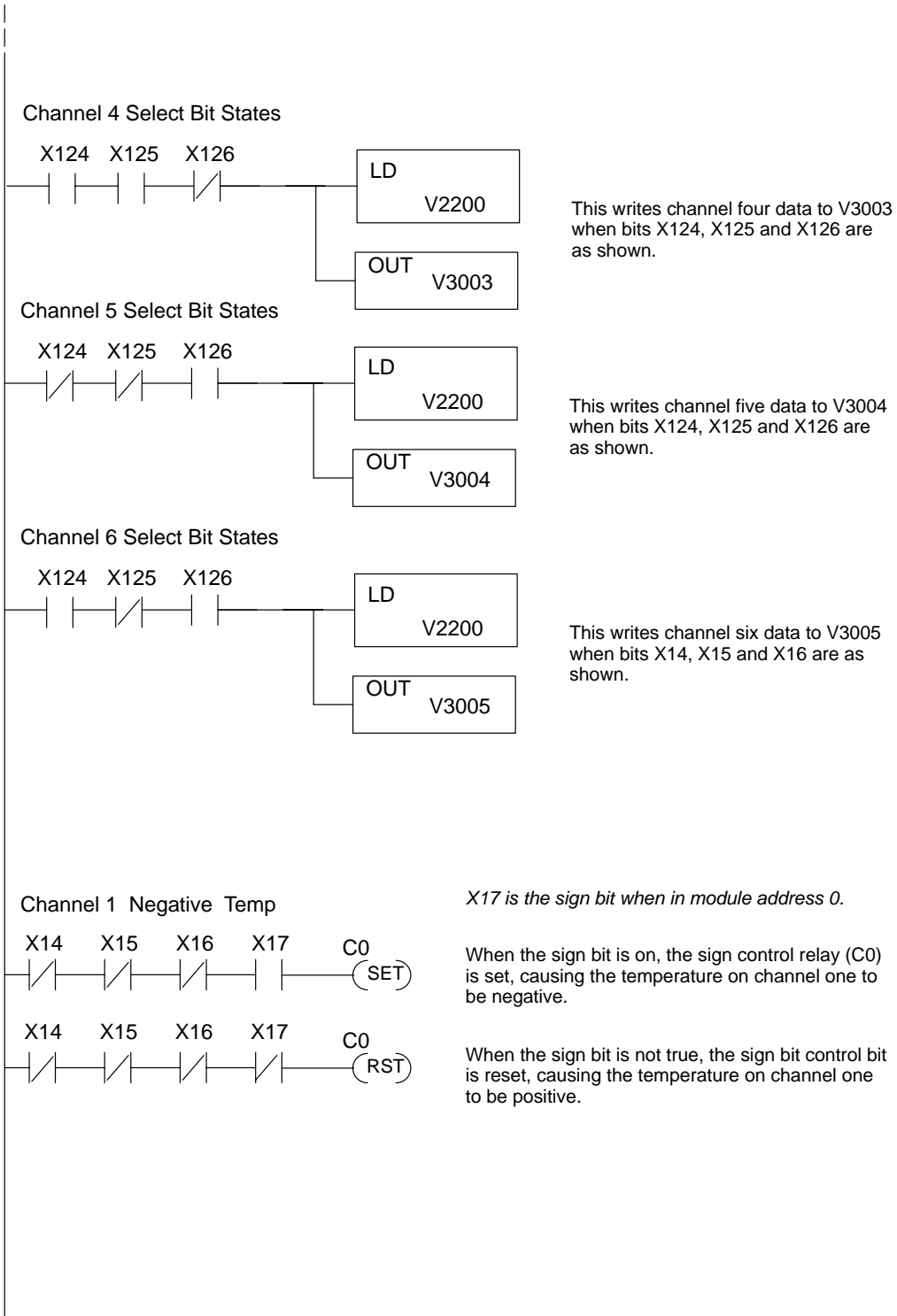


F3-08THM-n  
8Ch. Thermocouple In.

**Multiplexing:  
DL350 with a  
Conventional  
DL305 Base**

The example below shows how to read multiple channels on an F3-08THM Thermocouple module in the X20-X27 / 120 -127 address of a DL305 conventional base. The first six channels are shown.





### Scaling the Input Data

Most applications usually require measurements in engineering units, which provide more meaningful data. This is accomplished by using the conversion formula shown.

You may have to make adjustments to the formula depending on the scale you choose for the engineering units.

$$\text{Units} = A \frac{H - L}{4095}$$

H = high limit of the engineering unit range

L = low limit of the engineering unit range

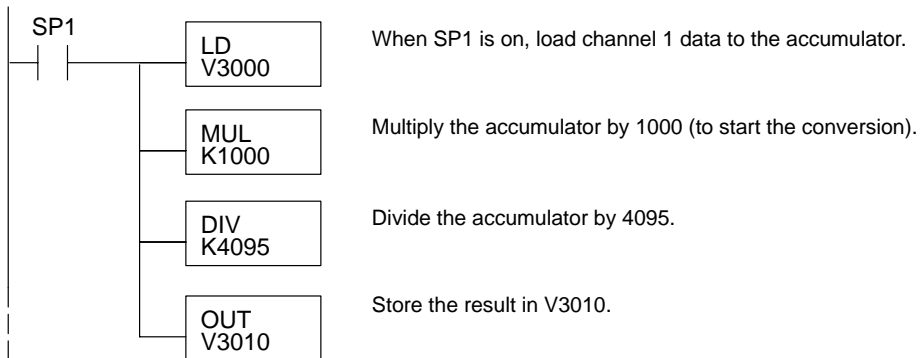
A = Analog value (0 – 4095)

For example, if you wanted to measure pressure (PSI) from 0.0 to 99.9 then you would have to multiply the analog value by 10 in order to imply a decimal place when you view the value with the programming software or a handheld programmer. Notice how the calculations differ when you use the multiplier.

Here is how you would write the program to perform the engineering unit conversion. This example assumes you have BCD data loaded into the appropriate V-memory locations using instructions that apply for the model of CPU you are using.



**NOTE:** This example uses SP1, which is always on. You could also use an X, C, etc. permissive contact.



### Temperature and Digital Value Conversions

Since the thermocouple devices are non-linear, it is much easier to rely on published standards for conversion information. The National Bureau of Standards publishes conversion tables that show how each temperature corresponds to an equivalent signal level.

### Millivolt 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.

| mV Range             | If you know the digital value ... | If you know the analog signal level ... |
|----------------------|-----------------------------------|---|
| MV50<br>0 to 50 mV   | $A = \frac{50D}{4095}$            | $D = \frac{4095}{50} A$                 |
| MV100<br>0 to 100 mV | $A = \frac{100D}{4095}$           | $D = \frac{4095}{100} A$                |

For example, if you are using a -2 (100mV) version and you have measured the signal as 30 mV, you would use the following formula to determine the digital value that should be stored in the register location that contains the data.

$$D = \frac{4095}{100} A$$

$$D = \frac{4095}{100} (30)$$

$$D = (40.95) (30)$$

$$D = 1229$$



# **F3-08TEMP**

## **8-Channel**

# **Temperature Input**

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In This Chapter. . . .

- Module Specifications
  - Setting the Module Jumpers
  - Connecting the Field Wiring
  - Module Operation
  - Writing the Control Program
-

## 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)<br>No missing codes 0.25 °C with AD590M |
| Input Impedance                     | 10K $\Omega$ $\pm$ 0.1%                                    |
| Absolute Maximum Ratings            | $\pm$ 50 mA  |
| Conversion Time                     | 35 $\mu$ s per channel, maximum<br>1 channel per CPU scan  |
| Converter Type                      | Successive Approximation, AD574                            |
| Linearity Error                     | $\pm$ 1 count (0.03% of full scale) maximum                |
| Maximum Inaccuracy at 77 °F (25 °C) | 0.25% of full scale  |
| Accuracy at 25 °C                   | $\pm$ 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) –<br>(Opto 22 PN ICTD)<br>-67° to 302° F (-55° to 150°C) –<br>(Analog Devices PN AC2626J)  |
| Transmitter Output for Opto 22 and Analog Devices | 1 $\mu\text{A} / ^\circ\text{K}$ , 298.2 $\mu\text{A}$ @ 25 $^\circ\text{C}$<br>218 $\mu\text{A}$ @ -55 $^\circ\text{C}$ , 423 $\mu\text{A}$ @ 150 $^\circ\text{C}$ |

### 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.

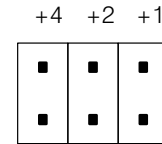
### Selecting the Number of Channels

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.

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 |



**Number of Channels**

Jumpers installed as shown selects 8-channel operation

## 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.

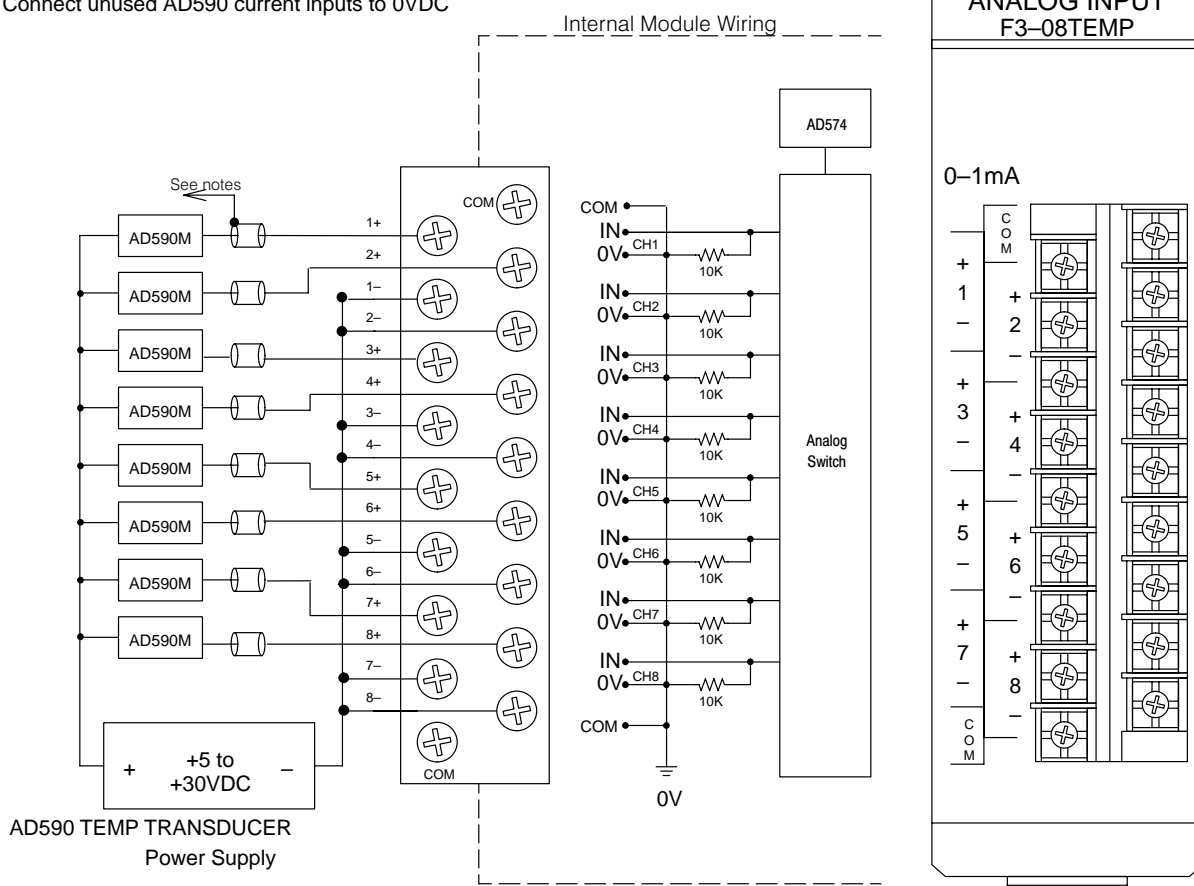
- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the signal source. *Do not* ground the shield at both the module and the source.
- Don't run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.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

Note 1: Terminate the shield at the signal source (0V reference potential)

Note 2: Connect unused AD590 current inputs to 0VDC



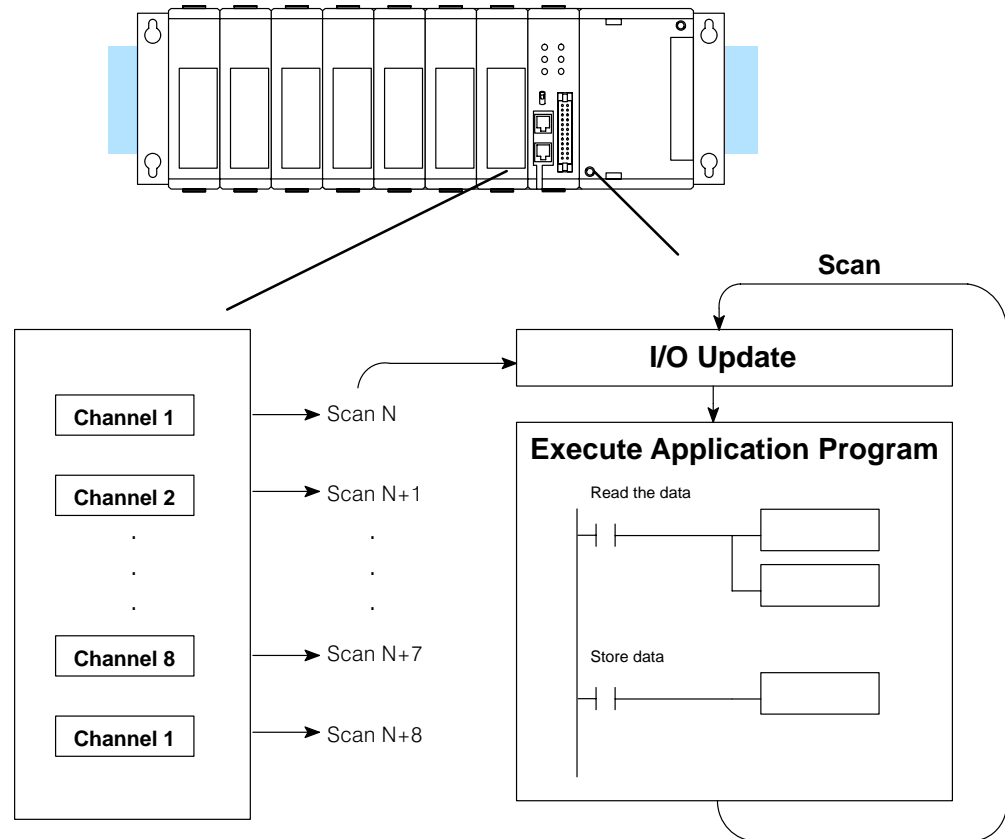
## Module Operation

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 supplies 1 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.



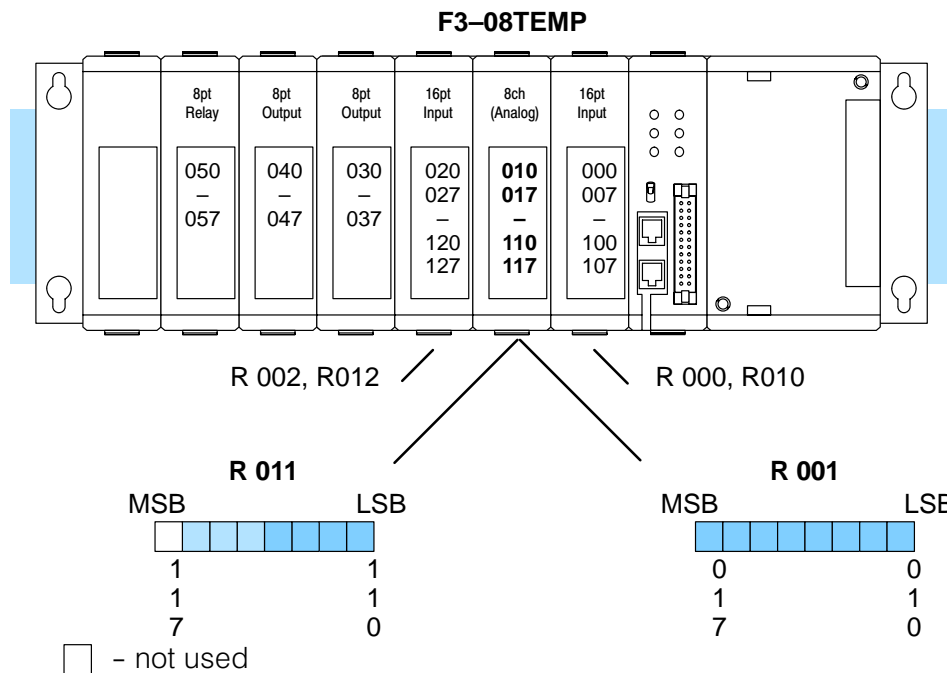
Even though the channel updates to the CPU are synchronous with the CPU scan, the module asynchronously monitors the temperature transmitter signal and converts the signal to a 12-bit binary representation. This enables the module to continuously provide accurate measurements without slowing down the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

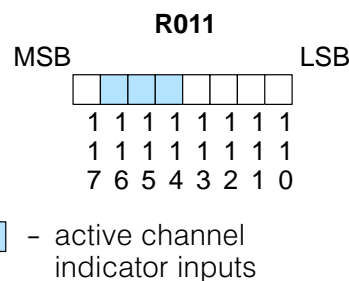


Within these two register locations, the individual bits represent specific information about the analog signal.

**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       |

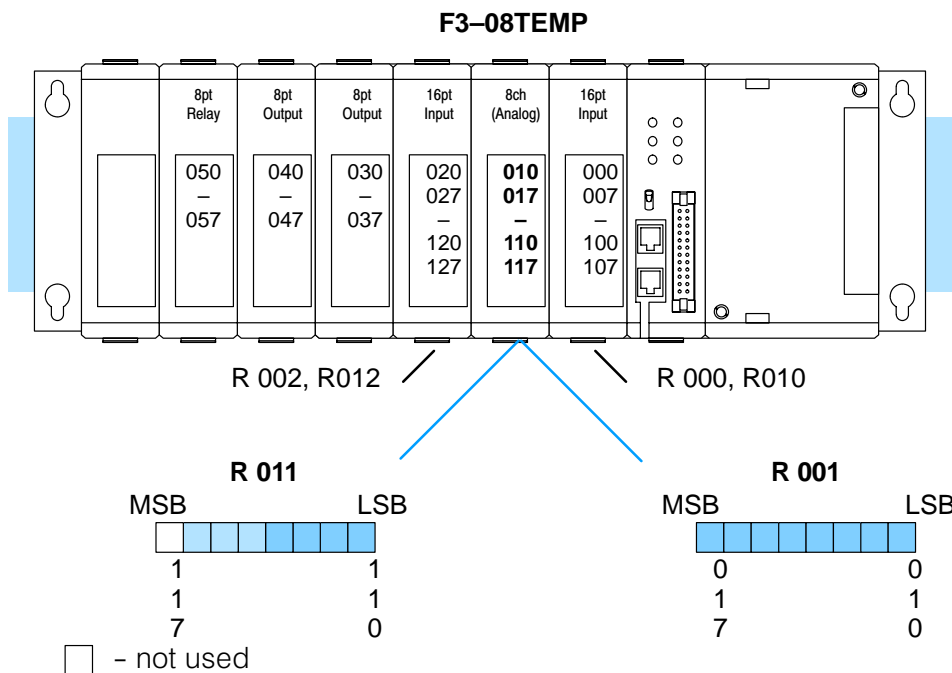




# Writing the Control Program (DL 330 / DL340)

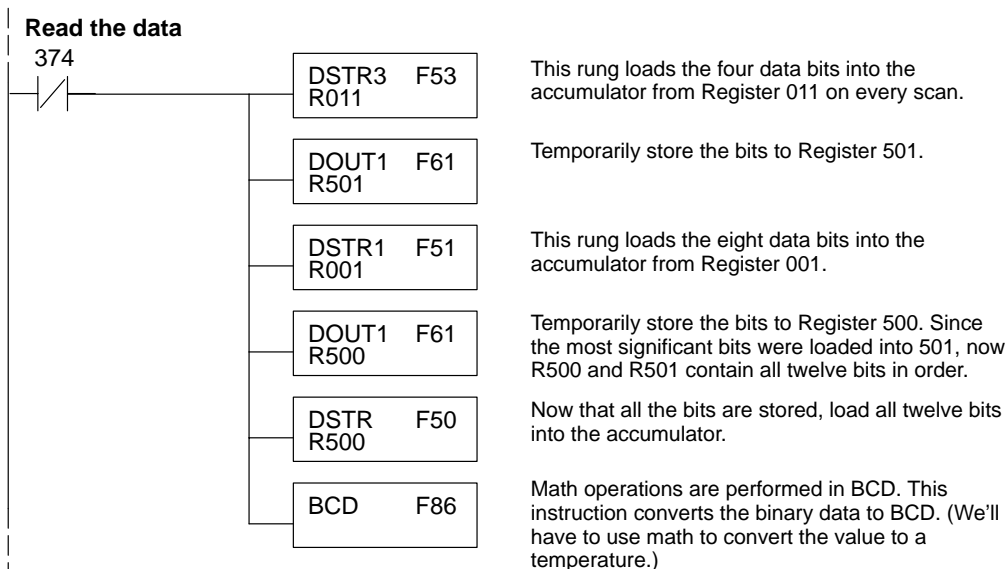
## Identifying the Data Locations

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.



## 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.

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



$$\text{Temp} = 149.9$$

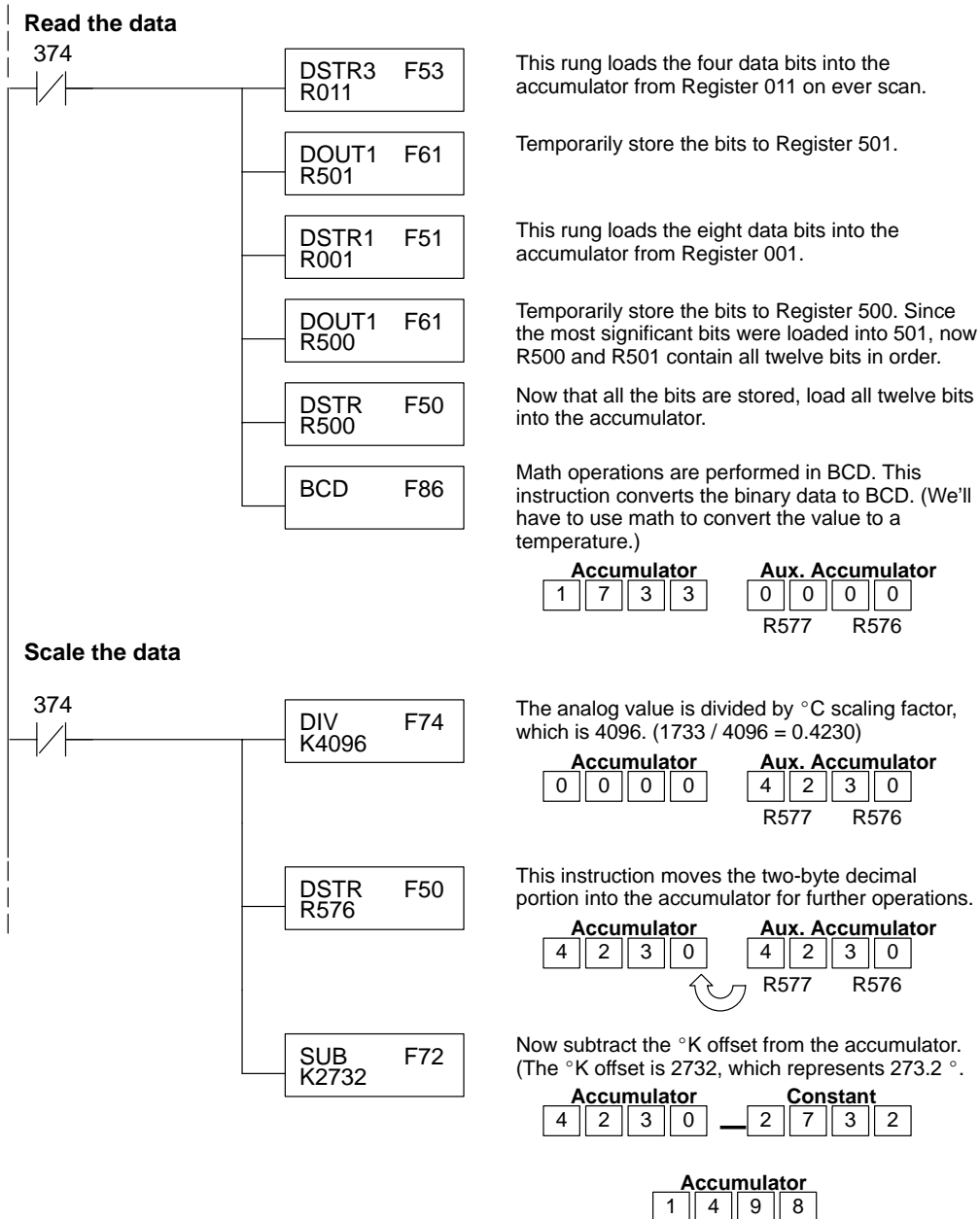
You can't quite enter the formula exactly as is with the DL305 instruction set. You have to use a value that implies the decimal point of precision. Plus, since we can move the decimal portion into the accumulator, we do not have to multiply the value by 1000.

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.



### 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.

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

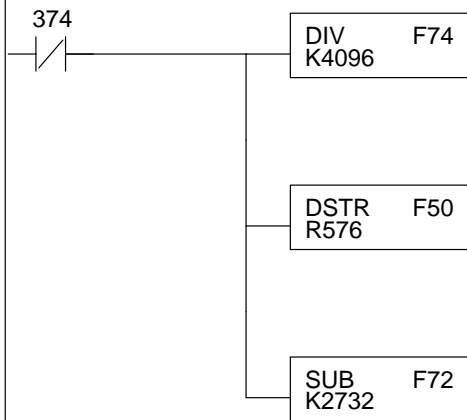


$$\text{Temp} = -30.0$$

This example assumes you have already read the analog data into the accumulator and converted the data to BCD.

**Accumulator**  
0 9 9 6

#### Scale the data



The analog value is divided by °C scaling factor, which is 4096. ( $996 / 4096 = 0.2431$ )

**Accumulator**      **Aux. Accumulator**  
0 0 0 0      2 4 3 1  
R577      R576

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

**Accumulator**      **Aux. Accumulator**  
2 4 3 1      2 4 3 1  
R577      R576

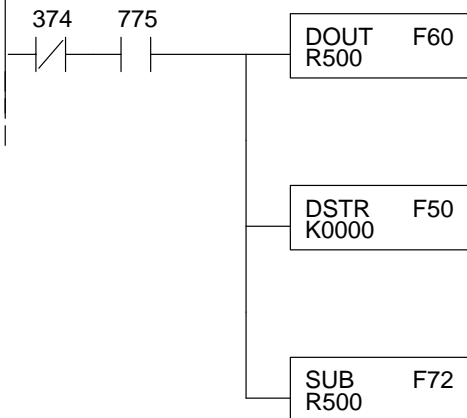
Now subtract the °K offset from the accumulator. (The °K offset is 2732, which represents 273.2 °.)

**Accumulator**      **Constant**  
2 4 3 1      - 2 7 3 2

**Accumulator**      **SP775**  
0 6 9 9      1 (on)

Since the DL305 encountered a negative number, it turns contact 775 on to indicate a borrow.

#### Below zero correction



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

**Accumulator**      **R501**      **R500**  
0 6 9 9      0 6 9 9

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

**Accumulator**  
0 0 0 0

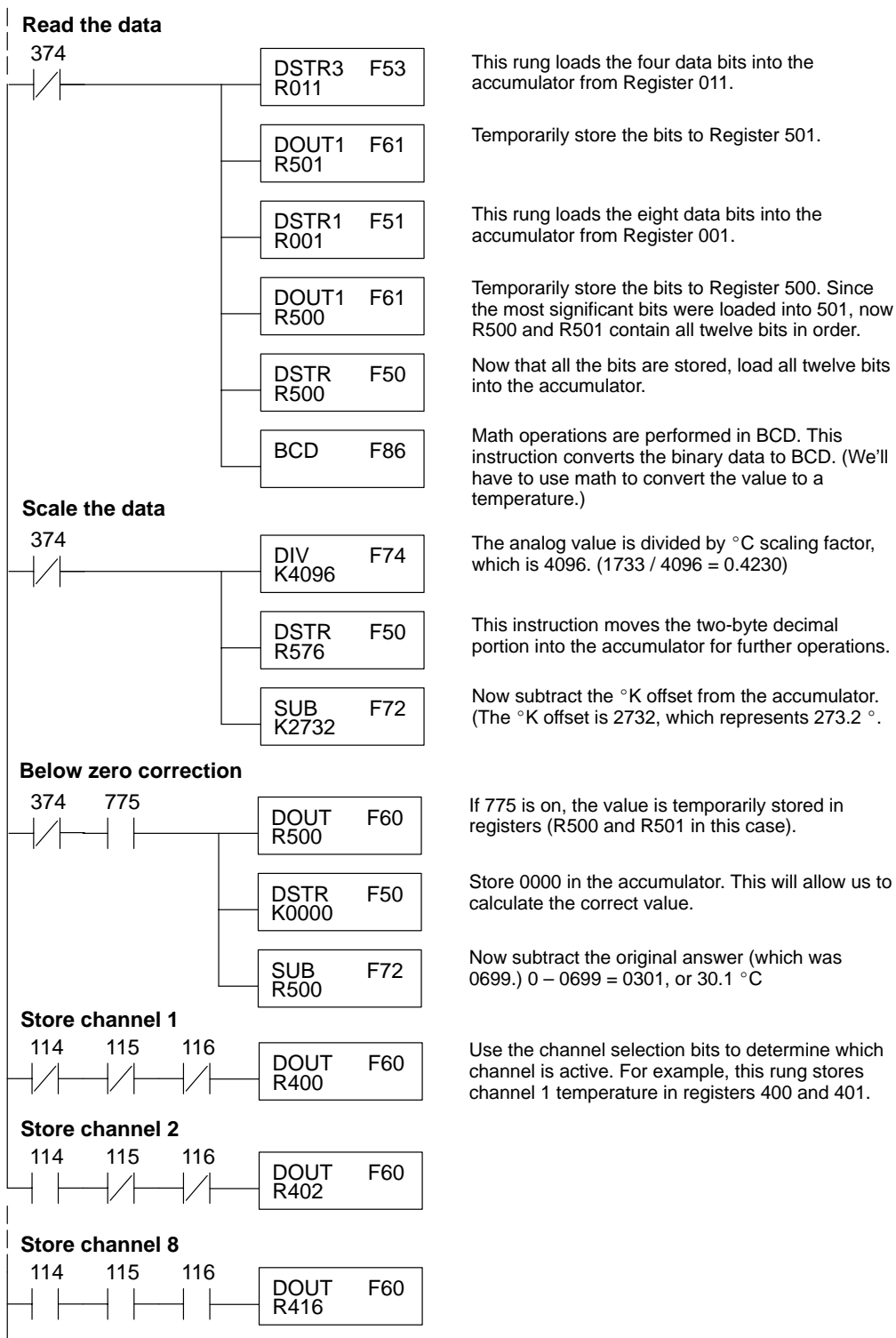
Now subtract the original answer (which was 0699.)  $0 - 0699 = 0301$ , or 30.1 °C

**Accumulator**      **Constant**  
0 0 0 0      - 0 6 9 9

**Accumulator**      **SP775**  
0 3 0 1      1 (on)

**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

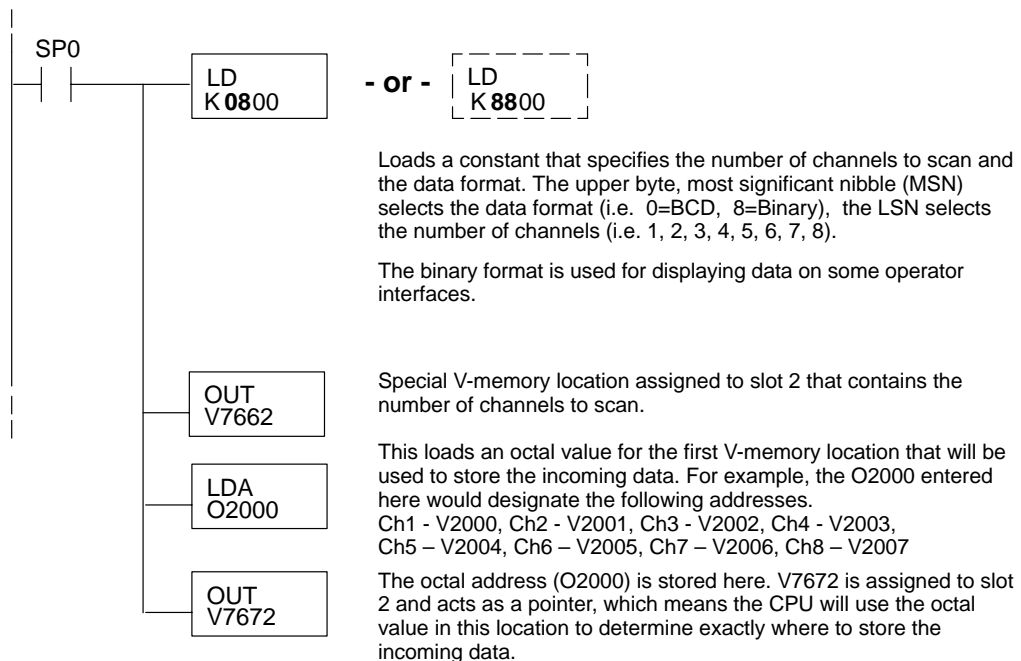
You must use the multiplexing method with remote I/O modules (the pointer method will not work). You can use either method when using DL350, but for ease of programming it is strongly recommended that you use the pointer method.

### 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 <sup>PLUS</sup> 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.

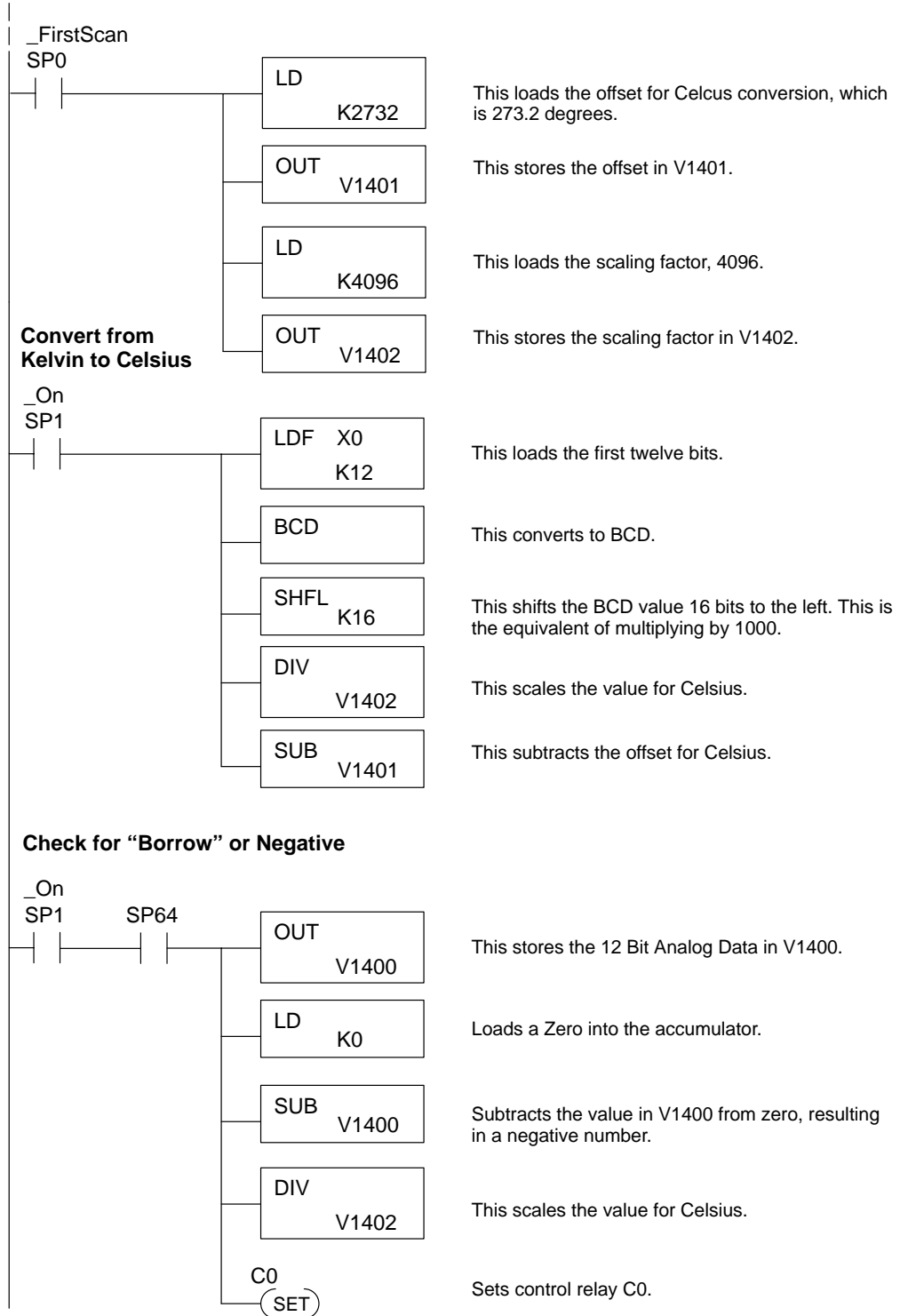


The table shows the special V-memory locations used with the DL350. Slot 0 (zero) is the module next to the CPU, slot 1 is the module two places from the CPU, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. The pointer method is supported on expansion 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 |

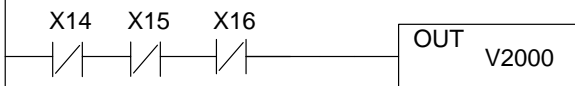
### Multiplexing: DL350 with a D3-XX-1 Base

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.



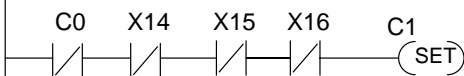
When the appropriate channel select bits are turned on, the converted analog data is then stored in V-memory locations, starting with V2000 (for channel 1).

Channel 1 Select Bit States



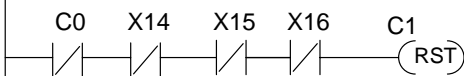
This writes channel one data to V2000 when bits X14, X15 and X16 are as shown.

The negative indicator bit



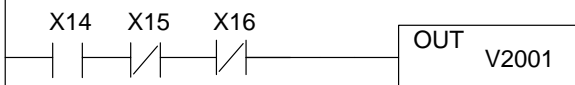
These two rungs control the negative indicator bit. When the channels select bits are true for a particular channel and C0 is on, the negative bit for that channel is set. When the temperature goes above 0 Celsius, the bit is reset.

Notice that this only applies to Channels 1.



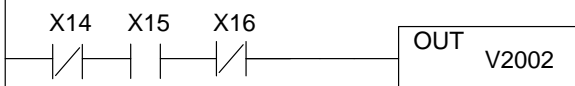
The remaining channels are shown below, without covering the negative bit logic.

Channel 2 Select Bit States

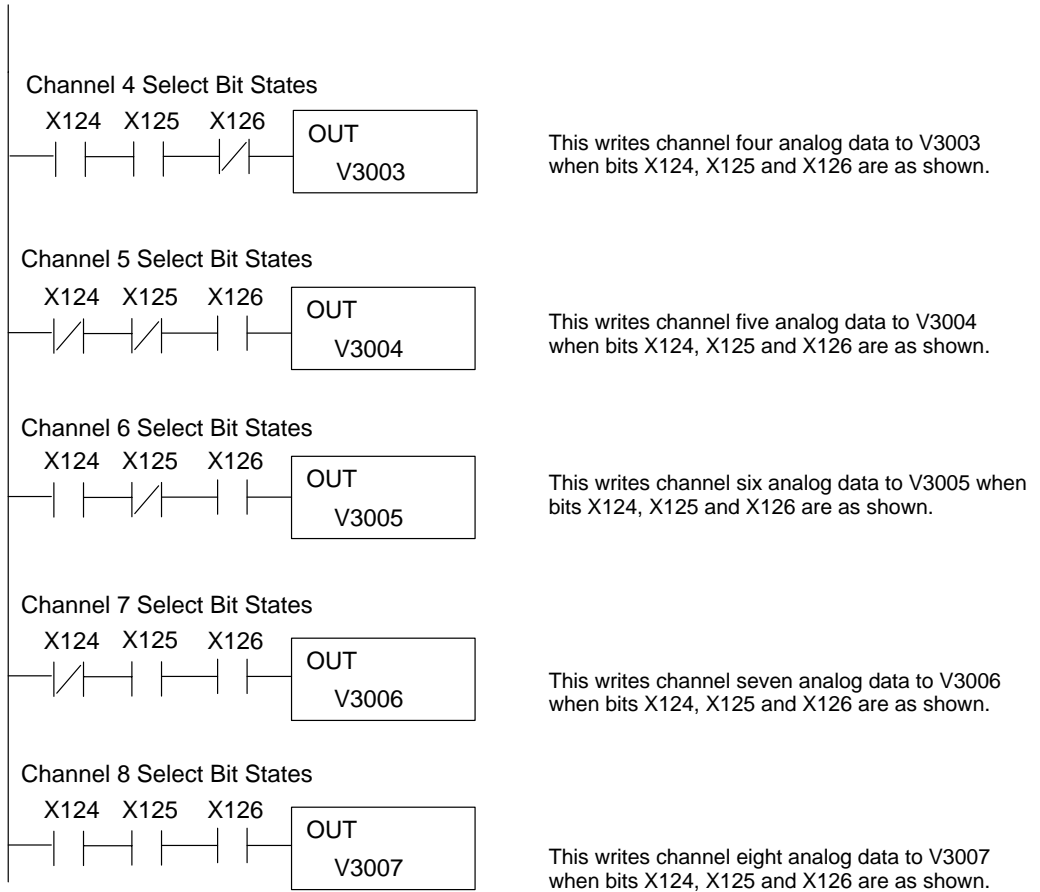


This writes channel two data to V2001 when bits X14, X15 and X16 are as shown.

Channel 3 Select Bit States



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





### 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 to 150 °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.

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

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

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

$$D = 1241$$



# DL305

## Data Types and Memory Map

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### In This Chapter. . . .

- DL330 Memory Map
  - DL330P Memory Map
  - DL340 Memory Map
  - I/O Point Bit Map
  - Control Relay Bit Map
  - Special Relays
  - Data Registers
-

### DL330 Memory Map

| Memory Type                    | Discrete Memory Reference (octal) | Register Memory Reference (octal) | Qty. Decimal | Symbol   |
|--------------------------------|-----------------------------------|-----------------------------------|--------------|--|
| Input / Output Points          | 000 – 157<br>700 – 767            | R000 – R015<br>R070 – R076        | 168 Total    |  |
| Control Relays                 | 160 – 373                         | R016 – R037                       | 140          |  |
| Special Relays                 | 374 – 377<br>770 – 777            | R037<br>R077                      | 12           |  |
| Timers / Counters              | 600 – 673<br>674 – 677*           | None                              | 64           |  |
| Timer / Counter Current Values | None                              | R600 – R673<br>R674 – R677*       | 64           |  |
| Timer / Counter Status Bits    | T600 – T673<br>T674 – T677*       | None                              | 64           |  |
| Data Words                     | None                              | R400 – R563                       | 116          | None specific, used with many instructions                       |
| Shift Registers                | 400 – 577                         | None                              | 128          |  |
| Special Registers              | None                              | R574 – R577                       | 4            | R574 – R575 used with FAULT<br>R576 – R577 Auxiliary Accumulator |

\* T/C Setpoint Unit Only. Can be used as data registers if the Timer/Counter Setpoint Unit or Thumbwheel Interface Module is not used. R564 – R573 contain the preset value used with the Timer / Counter Setpoint Unit. R674 – R677 contain the current values for these timers or counters.

## DL330P Memory Map

| Memory Type                    | Discrete Memory Reference (octal) | Register Memory Reference (octal) | Qty. Decimal | Symbol   |
|--------------------------------|-----------------------------------|-----------------------------------|--------------|--|
| Input / Output Points          | 000 – 157<br>700 – 767            | R000 – R015<br>R070 – R076        | 168 Total    |  |
| Control Relays                 | 160 – 174<br>200 – 277            | R016 – R017<br>R020 – R027        | 77           |  |
| Special Relays                 | 175 – 177<br>770 – 777            | R017<br>R077                      | 11           |  |
| Timers / Counters              | 600 – 673<br>674 – 677*           | None                              | 64           |  |
| Timer / Counter Current Values | None                              | R600 – R673<br>R674 – R677*       | 64           |  |
| Timer / Counter Status Bits    | T600 – T673<br>T674 – T677*       | None                              | 64           |  |
| Data Words                     | None                              | R400 – R563                       | 116          | None specific, used with many instructions                       |
| Stages                         | S0 – S177                         | R100 – R117                       | 128          |  |
| Special Registers              | None                              | R574 – R577                       | 4            | R574 – R575 used with FAULT<br>R576 – R577 Auxiliary Accumulator |

\* T/ C Setpoint Unit Only. Can be used as data registers if the Timer/Counter Setpoint Unit or Thumbwheel Interface Module is not used, which provides a total of 128 data registers.

R564 – R573 contain the preset value used with the Timer / Counter Setpoint Unit. R674 – R677 contain the current values for these timers or counters.

### DL340 Memory Map

| Memory Type                    | Discrete Memory Reference (octal)     | Register Memory Reference (octal) | Qty. Decimal | Symbol   |
|--------------------------------|---------------------------------------|-----------------------------------|--------------|--|
| Input / Output Points          | 000 – 157<br>700 – 767                | R000 – R015<br>R070 – R076        | 168 Total    |  |
| Control Relays                 | 160 – 373<br>1000 – 1067              | R016 – R037<br>R100 – R106        | 180          |  |
| Special Relays                 | 374 – 377<br>770 – 777<br>1070 – 1077 | R037<br>R077<br>R107              | 20           |  |
| Timers / Counters              | 600 – 673<br>674 – 677*               | None                              | 64           |  |
| Timer / Counter Current Values | None                                  | R600 – R673<br>R674 – R677*       | 64           |  |
| Timer / Counter Status Bits    | T600 – T673<br>T674 – T677*           | None                              | 64           |  |
| Data Words                     | None                                  | R400 – R563<br>R700 – R767        | 172          | None specific, used with many instructions   |
| Shift Registers                | 400 – 577                             | None                              | 128          |  |
| Special Registers              | None                                  | R574 – R577<br>R770 – R777        | 12           | R574–R575 used with FAULT<br>R576–R577 Auxiliary Accumulator<br>R770–R777 Communications Setup |

\* T/C Setpoint Unit Only. Can be used as data registers if the Timer/Counter Setpoint Unit or Thumbwheel Interface Module is not used. R564 – R573 contain the preset value used with the Timer / Counter Setpoint Unit. R674 – R677 contain the current values for these timers or counters.

## I/O Point Bit Map

These tables provide a listing of the individual Input points associated with each register location for the DL330, DL330P, and DL340 CPUs.

| MSB |     | I/O References |     |     |     |     |     | LSB | Register Number |
|-----|-----|----------------|-----|-----|-----|-----|-----|-----|-----------------|
| 007 | 006 | 005            | 004 | 003 | 002 | 001 | 000 | R0  |                 |
| 017 | 016 | 015            | 014 | 013 | 012 | 011 | 010 | R1  |                 |
| 027 | 026 | 025            | 024 | 023 | 022 | 021 | 020 | R2  |                 |
| 037 | 036 | 035            | 034 | 033 | 032 | 031 | 030 | R3  |                 |
| 047 | 046 | 045            | 044 | 043 | 042 | 041 | 040 | R4  |                 |
| 057 | 056 | 055            | 054 | 053 | 052 | 051 | 050 | R5  |                 |
| 067 | 066 | 065            | 064 | 063 | 062 | 061 | 060 | R6  |                 |
| 077 | 076 | 075            | 074 | 073 | 072 | 071 | 070 | R7  |                 |
| 107 | 106 | 105            | 104 | 103 | 102 | 101 | 100 | R10 |                 |
| 117 | 116 | 115            | 114 | 113 | 112 | 111 | 110 | R11 |                 |
| 127 | 126 | 125            | 124 | 123 | 122 | 121 | 120 | R12 |                 |
| 137 | 136 | 135            | 134 | 133 | 132 | 131 | 130 | R13 |                 |
| 147 | 146 | 145            | 144 | 143 | 142 | 141 | 140 | R14 |                 |
| 157 | 156 | 155            | 154 | 153 | 152 | 151 | 150 | R15 |                 |
| 167 | 166 | 165            | 164 | 163 | 162 | 161 | 160 | n/a |                 |
| 177 | 176 | 175            | 174 | 173 | 172 | 171 | 170 | n/a |                 |
| 707 | 706 | 705            | 704 | 703 | 702 | 701 | 700 | R70 |                 |
| 717 | 716 | 715            | 714 | 713 | 712 | 711 | 710 | R71 |                 |
| 727 | 726 | 725            | 724 | 723 | 722 | 721 | 720 | R72 |                 |
| 737 | 736 | 735            | 734 | 733 | 732 | 731 | 730 | R73 |                 |
| 747 | 746 | 745            | 744 | 743 | 742 | 741 | 740 | R74 |                 |
| 757 | 756 | 755            | 754 | 753 | 752 | 751 | 750 | R75 |                 |
| 767 | 766 | 765            | 764 | 763 | 762 | 761 | 760 | R76 |                 |

**NOTE:** 160 – 167 can be used as I/O in a DL330 or DL330P CPU under certain conditions. 160 – 177 can be used as I/O in a DL340 CPU under certain conditions. You should consult the DL305 User Manual to determine which configurations allow the use of these points.

These points are normally used as control relays. You cannot use them as both control relays and as I/O points. Also, if you use these points as I/O, you cannot access these I/O points as a Data Register reference.

## Control Relay Bit Map

The following tables provide a listing of the individual control relays associated with each register location for the DL305 CPUs.

**NOTE:** 160 – 167 can be used as I/O in a DL330 or DL330P CPU under certain conditions. 160 – 177 can be used as I/O in a DL340 CPU under certain conditions. You should consult the DL305 User Manual to determine which configurations allow the use of these points.

You cannot use them as both control relays and as I/O points. Also, if you use these points as I/O, you cannot access these I/O points as a Data Register reference.

| MSB |     | DL330<br>Control Relay References |     |     |     |     |     | LSB | Register<br>Number |
|-----|-----|-----------------------------------|-----|-----|-----|-----|-----|-----|--------------------|
| 167 | 166 | 165                               | 164 | 163 | 162 | 161 | 160 | R16 |                    |
| 177 | 176 | 175                               | 174 | 173 | 172 | 171 | 170 | R17 |                    |
| 207 | 206 | 205                               | 204 | 203 | 202 | 201 | 200 | R20 |                    |
| 217 | 216 | 215                               | 214 | 213 | 212 | 211 | 210 | R21 |                    |
| 227 | 226 | 225                               | 224 | 223 | 222 | 221 | 220 | R22 |                    |
| 237 | 236 | 235                               | 234 | 233 | 232 | 231 | 230 | R23 |                    |
| 247 | 246 | 245                               | 244 | 243 | 242 | 241 | 240 | R24 |                    |
| 257 | 256 | 255                               | 254 | 253 | 252 | 251 | 250 | R25 |                    |
| 267 | 266 | 265                               | 264 | 263 | 262 | 261 | 260 | R26 |                    |
| 277 | 276 | 275                               | 274 | 273 | 272 | 271 | 270 | R27 |                    |
| 307 | 306 | 305                               | 304 | 303 | 302 | 301 | 300 | R30 |                    |
| 317 | 316 | 315                               | 314 | 313 | 312 | 311 | 310 | R31 |                    |
| 327 | 326 | 325                               | 324 | 323 | 322 | 321 | 320 | R32 |                    |
| 337 | 336 | 335                               | 334 | 333 | 332 | 331 | 330 | R33 |                    |
| 347 | 346 | 345                               | 344 | 343 | 342 | 341 | 340 | R34 |                    |
| 357 | 356 | 355                               | 354 | 353 | 352 | 351 | 350 | R35 |                    |
| 367 | 366 | 365                               | 364 | 363 | 362 | 361 | 360 | R36 |                    |
|     |     |                                   |     | 373 | 372 | 371 | 370 | R37 |                    |

\* Control relays 340 – 373 can be made retentive by setting a CPU dipswitch. See the DL305 User Manual for details on setting CPU dipswitches.



| MSB  |     |     |     |     |     |     | DL330P                   | LSB | Register Number |
|------|-----|-----|-----|-----|-----|-----|--------------------------|-----|-----------------|
|      |     |     |     |     |     |     | Control Relay References |     |                 |
| 167  | 166 | 165 | 164 | 163 | 162 | 161 | 160                      | R16 |                 |
|      |     |     | 174 | 173 | 172 | 171 | 170                      | R17 |                 |
| 207  | 206 | 205 | 204 | 203 | 202 | 201 | 200*                     | R20 |                 |
| 217  | 216 | 215 | 214 | 213 | 212 | 211 | 210                      | R21 |                 |
| 227  | 226 | 225 | 224 | 223 | 222 | 221 | 220                      | R22 |                 |
| 237  | 236 | 235 | 234 | 233 | 232 | 231 | 230                      | R23 |                 |
| 247  | 246 | 245 | 244 | 243 | 242 | 241 | 240                      | R24 |                 |
| 257  | 256 | 255 | 254 | 253 | 252 | 251 | 250                      | R25 |                 |
| 267  | 266 | 265 | 264 | 263 | 262 | 261 | 260                      | R26 |                 |
| 277* | 276 | 275 | 274 | 273 | 272 | 271 | 270                      | R27 |                 |

\* Control relays 200 – 277 can be made retentive by setting a CPU dipswitch. See the DL305 User Manual for details on setting CPU dipswitches.

| MSB  |      |      |      |      |      |      | DL340                    | LSB  | Register Number |
|------|------|------|------|------|------|------|--------------------------|------|-----------------|
|      |      |      |      |      |      |      | Control Relay References |      |                 |
| 167  | 166  | 165  | 164  | 163  | 162  | 161  | 160                      | R16  |                 |
| 177  | 176  | 175  | 174  | 173  | 172  | 171  | 170                      | R17  |                 |
| 207  | 206  | 205  | 204  | 203  | 202  | 201  | 200                      | R20  |                 |
| 217  | 216  | 215  | 214  | 213  | 212  | 211  | 210                      | R21  |                 |
| 227  | 226  | 225  | 224  | 223  | 222  | 221  | 220                      | R22  |                 |
| 237  | 236  | 235  | 234  | 233  | 232  | 231  | 230                      | R23  |                 |
| 247  | 246  | 245  | 244  | 243  | 242  | 241  | 240                      | R24  |                 |
| 257  | 256  | 255  | 254  | 253  | 252  | 251  | 250                      | R25  |                 |
| 267  | 266  | 265  | 264  | 263  | 262  | 261  | 260                      | R26  |                 |
| 277  | 276  | 275  | 274  | 273  | 272  | 271  | 270                      | R27  |                 |
| 307  | 306  | 305  | 304  | 303  | 302  | 301  | 300                      | R30  |                 |
| 317  | 316  | 315  | 314  | 313  | 312  | 311  | 310                      | R31  |                 |
| 327  | 326  | 325  | 324  | 323  | 322  | 321  | 320                      | R32  |                 |
| 337  | 336  | 335  | 334  | 333  | 332  | 331  | 330                      | R33  |                 |
| 347  | 346  | 345  | 344  | 343  | 342  | 341  | 340*                     | R34  |                 |
| 357  | 356  | 355  | 354  | 353  | 352  | 351  | 350                      | R35  |                 |
| 367  | 366  | 365  | 364  | 363  | 362  | 361  | 360                      | R36  |                 |
|      |      |      |      | 373* | 372  | 371  | 370                      | R37  |                 |
| 1007 | 1006 | 1005 | 1004 | 1003 | 1002 | 1001 | 1000                     | R100 |                 |
| 1017 | 1016 | 1015 | 1014 | 1013 | 1012 | 1011 | 1010                     | R101 |                 |
| 1027 | 1026 | 1025 | 1024 | 1023 | 1022 | 1021 | 1020                     | R102 |                 |
| 1037 | 1036 | 1035 | 1034 | 1033 | 1032 | 1031 | 1030                     | R103 |                 |
| 1047 | 1046 | 1045 | 1044 | 1043 | 1042 | 1041 | 1040                     | R104 |                 |
| 1057 | 1056 | 1055 | 1054 | 1053 | 1052 | 1051 | 1050                     | R105 |                 |
| 1067 | 1066 | 1065 | 1064 | 1063 | 1062 | 1061 | 1060                     | R106 |                 |

\* Control relays 340 – 373 can be made retentive by setting a CPU dipswitch. See the DL305 User Manual for details on setting CPU dipswitches.

## Special Relays

The following table shows the Special Relays used with the DL305 CPUs.

| CPUs                     | Special Relay | Description of Contents   |
|--------------------------|---------------|---|
| DL330P                   | 175           | 100 ms clock, on for 50 ms and off for 50 ms.   |
|                          | 176           | Disables all outputs except for those entered with the SET OUT instruction.             |
|                          | 177           | Battery voltage is low.   |
| DL330<br>DL340           | 374           | On for the first scan cycle after the CPU is switched to Run Mode.                      |
|                          | 375           | 100 ms clock, on for 50 ms and off for 50 ms.   |
|                          | 376           | Disables all outputs except for those entered with the SET OUT instruction.             |
|                          | 377           | Battery voltage is low.   |
| DL330<br>DL330P<br>DL340 | 770           | Changes timers to 0.01 second intervals. Timers are normally 0.1 second time intervals. |
|                          | 771           | The external diagnostics FAULT instruction (F20) is in use.                             |
|                          | 772           | The data in the accumulator is greater than the comparison value.                       |
|                          | 773           | The data in the accumulator is equal to the comparison value.                           |
|                          | 774           | The data in the accumulator is less than the comparison value.                          |
|                          | 775           | An accumulator carry or borrow condition has occurred.                                  |
|                          | 776           | The accumulator value is zero.  |
|                          | 777           | The accumulator has an overflow condition.  |
| DL340                    | 1074          | The RX or WX instruction is active.   |
|                          | 1075          | An error occurred during communications with the RX or WX instructions.                 |
|                          | 1076          | Port 2 communications mode: on = ASCII mode, off = HEX mode                             |
|                          | 1077          | Port 1 communications mode: on = ASCII mode, off = HEX mode                             |

## Data Registers

The following 8-bit data registers are primarily used with data instructions to store various types of application data. For example, you could use a register to hold a timer or counter preset value.

Some data instructions call for two bytes, which will correspond to two consecutive 8-bit data registers such as R401 and R400. The LSB (Least Significant Bit) will be in register R400 as bit0 and the MSB (Most Significant Bit) will be in register R401 as bit17.

**NOTE:** Data Registers are retentive.

| DL330 / DL330P<br>8-Bit Data Registers |     |     |     |     |     |     |     |
|--|-----|-----|-----|-----|-----|-----|-----|
| 407                                    | 406 | 405 | 404 | 403 | 402 | 401 | 400 |
| 417                                    | 416 | 415 | 414 | 413 | 412 | 411 | 410 |
| 427                                    | 426 | 425 | 424 | 423 | 422 | 421 | 420 |
| 437                                    | 436 | 435 | 434 | 433 | 432 | 431 | 430 |
| 447                                    | 446 | 445 | 444 | 443 | 442 | 441 | 440 |
| 457                                    | 456 | 455 | 454 | 453 | 452 | 451 | 450 |
| 467                                    | 466 | 465 | 464 | 463 | 462 | 461 | 460 |
| 477                                    | 476 | 475 | 474 | 473 | 472 | 471 | 470 |
| 507                                    | 506 | 505 | 504 | 503 | 502 | 501 | 500 |
| 517                                    | 516 | 515 | 514 | 513 | 512 | 511 | 510 |
| 527                                    | 526 | 525 | 524 | 523 | 522 | 521 | 520 |
| 537                                    | 536 | 535 | 534 | 533 | 532 | 531 | 530 |
| 547                                    | 546 | 545 | 544 | 543 | 542 | 541 | 540 |
| 557                                    | 556 | 555 | 554 | 553 | 552 | 551 | 550 |
|  |     |     |     | 563 | 562 | 561 | 560 |

| DL340<br>8-Bit Data Registers |     |     |     |     |     |     |     |
|-------------------------------|-----|-----|-----|-----|-----|-----|-----|
| 407                           | 406 | 405 | 404 | 403 | 402 | 401 | 400 |
| 417                           | 416 | 415 | 414 | 413 | 412 | 411 | 410 |
| 427                           | 426 | 425 | 424 | 423 | 422 | 421 | 420 |
| 437                           | 436 | 435 | 434 | 433 | 432 | 431 | 430 |
| 447                           | 446 | 445 | 444 | 443 | 442 | 441 | 440 |
| 457                           | 456 | 455 | 454 | 453 | 452 | 451 | 450 |
| 467                           | 466 | 465 | 464 | 463 | 462 | 461 | 460 |
| 477                           | 476 | 475 | 474 | 473 | 472 | 471 | 470 |
| 507                           | 506 | 505 | 504 | 503 | 502 | 501 | 500 |
| 517                           | 516 | 515 | 514 | 513 | 512 | 511 | 510 |
| 527                           | 526 | 525 | 524 | 523 | 522 | 521 | 520 |
| 537                           | 536 | 535 | 534 | 533 | 532 | 531 | 530 |
| 547                           | 546 | 545 | 544 | 543 | 542 | 541 | 540 |
| 557                           | 556 | 555 | 554 | 553 | 552 | 551 | 550 |
|                               |     |     |     | 563 | 562 | 561 | 560 |
| 707                           | 706 | 705 | 704 | 703 | 702 | 701 | 700 |
| 717                           | 716 | 715 | 714 | 713 | 712 | 711 | 710 |
| 727                           | 726 | 725 | 724 | 723 | 722 | 721 | 720 |
| 737                           | 736 | 735 | 734 | 733 | 732 | 731 | 730 |
| 747                           | 746 | 745 | 744 | 743 | 742 | 741 | 740 |
| 757                           | 756 | 755 | 754 | 753 | 752 | 751 | 750 |
| 767                           | 766 | 765 | 764 | 763 | 762 | 761 | 760 |

## DL350 System V-memory

| System V-memory | Description of Contents  | Default Values / Ranges |
|-----------------|--|-------------------------|
| V7620–V7627     | Locations for DV–1000 operator interface parameters  |                         |
| V7620           | Sets the V-memory location that contains the value.  | V0 – V3777              |
| V7621           | Sets the V-memory location that contains the message.  | V0 – V3777              |
| V7622           | Sets the total number (1 – 16) of V-memory locations to be displayed.  | 1 – 16                  |
| V7623           | Sets the V-memory location that contains the numbers to be displayed.  | V0 – V3777              |
| V7624           | Sets the V-memory location that contains the character code to be displayed.   | V0 – V3777              |
| V7625           | Contains the function number that can be assigned to each key.   | V-memory for X, Y, or C |
| V7626           | Reserved   | 0,1,2,3,12              |
| V7627           | Reserved   | Default=0000            |
| V7630–V7632     | Reserved   | –                       |
| V7633           | User defined timer interrupt/operation of battery/Binary instruction sign flag*<br>Bit 0–7      40H Setting Interrupt<br>Bit 12      ON with battery sign flag. ON use sign flag –<br>OFF no sign flag<br>Bit 15      Binary instruction sign flag. ON use sign flag –<br>OFF no sign flag |                         |
| V7634           | User defined timer interrupt   |                         |
| V7640           | Loop Table Beginning address   | V1400–V7340             |
| V7641           | Number of Loops Enabled  | 1–4                     |
| V7642           | Error Code – V–memory Error Location for Loop Table  |                         |
| V7643–V7647     | Reserved   |                         |
| V7650           | Port 2 End–code setting Setting (A55A), Nonprocedure communications start.   |                         |
| V7651           | Port 2 Data format –Non–procedure communications format setting.   |                         |
| V7652           | Port 2 Format Type setting – Non–procedure communications type code setting.   |                         |
| V7653           | Port 2 Terminate–code setting – Non–procedure communications Termination code setting.   |                         |
| V7654           | Port 2 Store V–mem address – Non–procedure communication data store V–Memory address.  |                         |
| V7655           | Port 2 Setup area –0–7 Comm protocol (flag 0) 8–15 Comm time out/response delay time (flag 1)  |                         |
| V7656           | Port 2 setup area – 0–15 Communication (flag2, flag 3)   |                         |
| V7657           | Port 2 setup area – Bit to select use of parameter   |                         |
| V7660–V7707     | Set–up Information   |                         |
| V7710–V7717     | Reserved   |                         |
| V7720–V7722     | Locations for DV–1000 operator interface parameters.   |                         |
| V7720           | Titled Timer preset value pointer  |                         |
| V7721           | Title Counter preset value pointer   |                         |
| V7722           | HiByte-Titled Timer preset block size, LoByte-Titled Counter preset block size   |                         |
| V7730–V7737     | For slot 0 to 7 D3–DCM   |                         |
| V7747           | Location contains a 10ms counter. This location increments once every 10ms.  |                         |
| V7750           | Reserved   |                         |

| System V-memory | Description of Contents  |
|-----------------|--|
| V7751           | Fault Message Error Code — stores the 4-digit code used with the FAULT instruction when the instruction is executed.     |
| V7752           | Reserved   |
| V7753           | Reserved   |
| V7754           | Reserved   |
| V7755           | Error code — stores the fatal error code.  |
| V7756           | Error code — stores the major error code.  |
| V7757           | Error code — stores the minor error code.  |
| V7760–V7762     | Reserved   |
| V7763–V7764     | Location for syntax error information.   |
| V7765           | Scan — stores the total number of scan cycles that have occurred since the last Program Mode to Run Mode transition.     |
| V7766           | Contains the number of seconds on the clock. (00 to 59).   |
| V7767           | Contains the number of minutes on the clock. (00 to 59).   |
| V7770           | Contains the number of hours on the clock. (00 to 23).   |
| V7771           | Contains the day of the week. (Mon, Tue, etc.).  |
| V7772           | Contains the day of the month (1st, 2nd, etc.).  |
| V7773           | Contains the month. (01 to 12)   |
| V7774           | Contains the year. (00 to 99)  |
| V7775           | Scan — stores the current scan time (milliseconds).  |
| V7776           | Scan — stores the minimum scan time that has occurred since the last Program Mode to Run Mode transition (milliseconds). |
| V7777           | Scan — stores the maximum scan time that has occurred since the last Program Mode to Run Mode transition (milliseconds). |

## DL350 Comm Port 2 Control Relays

The following system control relays are valid only for D3–350 CPU remote I/O setup on Communications Port 2.

| System CRs   | Description of Contents   |
|--------------|---|
| C740         | Completion of setups – ladder logic must turn this relay on when it has finished writing to the Remote I/O setup table                    |
| C741         | Erase received data – turning on this flag will erase the received data during a communication error.                                     |
| C743         | Re-start – Turning on this relay will resume after a communications hang-up on an error.  |
| C750 to C757 | Setup Error – The corresponding relay will be ON if the setup table contains an error (C750 = master, C751 = slave 1... C757=slave 7      |
| C760 to C767 | Communications Ready – The corresponding relay will be ON if the setup table data is valid (C760 = master, C761 = slave 1... C767=slave 7 |

## DL350 Memory Map

| Memory Type            | Discrete Memory Reference (octal) | Word Memory Reference (octal)  | Qty. Decimal | Symbol                                     |
|------------------------|-----------------------------------|--------------------------------|--------------|--|
| Input Points           | X0 – X777                         | V40400 – V40437                | 512          | X0<br>                                     |
| Output Points          | Y0 – Y777                         | V40500 – V40537                | 512          | Y0<br>                                     |
| Control Relays         | C0 – C1777                        | V40600 – V40677                | 1024         | C0      C0<br>                             |
| Special Relays         | SP0 – SP777                       | V41200 – V41237                | 512          | SP0<br>                                    |
| Timer Current Values   | None                              | V0 – V377                      | 256          | V0    K100<br>                             |
| Timer Status Bits      | T0 – T377                         | V41100 – V41117                | 256          | T0<br>                                     |
| Counter Current Values | None                              | V1000 – V1177                  | 128          | V1000    K100<br>                          |
| Counter Status Bits    | CT0 – CT177                       | V41140 – V41147                | 128          | CT0<br>                                    |
| Data Words             | none                              | V1400 – V7377<br>V10000–V17777 | 3072<br>4096 | None specific, used with many instructions |
| Stages                 | S0 – S1777                        | V41000 – V41077                | 1024         | S0<br>                                     |
| System parameters      | None                              | V7400–V7777                    | 256          | System specific, used for various purposes |

### DL 350 X Input / Y Output Bit Map

This table provides a listing of the individual Input points associated with each V-memory address bit.

| DL350 Input (X) and Output (Y) Points |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     | X Input Address | Y Output Address |
|---------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----------------|------------------|
| MSB                                   |     |     |     |     |     |     |     |     |     |     |     |     |     |     | LSB |                 |                  |
| 17                                    | 16  | 15  | 14  | 13  | 12  | 11  | 10  | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |                 |                  |
| 017                                   | 016 | 015 | 014 | 013 | 012 | 011 | 010 | 007 | 006 | 005 | 004 | 003 | 002 | 001 | 000 | V40400          | V40500           |
| 037                                   | 036 | 035 | 034 | 033 | 032 | 031 | 030 | 027 | 026 | 025 | 024 | 023 | 022 | 021 | 020 | V40401          | V40501           |
| 057                                   | 056 | 055 | 054 | 053 | 052 | 051 | 050 | 047 | 046 | 045 | 044 | 043 | 042 | 041 | 040 | V40402          | V40502           |
| 077                                   | 076 | 075 | 074 | 073 | 072 | 071 | 070 | 067 | 066 | 065 | 064 | 063 | 062 | 061 | 060 | V40403          | V40503           |
| 117                                   | 116 | 115 | 114 | 113 | 112 | 111 | 110 | 107 | 106 | 105 | 104 | 103 | 102 | 101 | 100 | V40404          | V40504           |
| 137                                   | 136 | 135 | 134 | 133 | 132 | 131 | 130 | 127 | 126 | 125 | 124 | 123 | 122 | 121 | 120 | V40405          | V40505           |
| 157                                   | 156 | 155 | 154 | 153 | 152 | 151 | 150 | 147 | 146 | 145 | 144 | 143 | 142 | 141 | 140 | V40406          | V40506           |
| 177                                   | 176 | 175 | 174 | 173 | 172 | 171 | 170 | 167 | 166 | 165 | 164 | 163 | 162 | 161 | 160 | V40407          | V40507           |
| 217                                   | 216 | 215 | 214 | 213 | 212 | 211 | 210 | 207 | 206 | 205 | 204 | 203 | 202 | 201 | 200 | V40410          | V40510           |
| 237                                   | 236 | 235 | 234 | 233 | 232 | 231 | 230 | 227 | 226 | 225 | 224 | 223 | 222 | 221 | 220 | V40411          | V40511           |
| 257                                   | 256 | 255 | 254 | 253 | 252 | 251 | 250 | 247 | 246 | 245 | 244 | 243 | 242 | 241 | 240 | V40412          | V40512           |
| 277                                   | 276 | 275 | 274 | 273 | 272 | 271 | 270 | 267 | 266 | 265 | 264 | 263 | 262 | 261 | 260 | V40413          | V40513           |
| 317                                   | 316 | 315 | 314 | 313 | 312 | 311 | 310 | 307 | 306 | 305 | 304 | 303 | 302 | 301 | 300 | V40414          | V40514           |
| 337                                   | 336 | 335 | 334 | 333 | 332 | 331 | 330 | 327 | 326 | 325 | 324 | 323 | 322 | 321 | 320 | V40415          | V40515           |
| 357                                   | 356 | 355 | 354 | 353 | 352 | 351 | 350 | 347 | 346 | 345 | 344 | 343 | 342 | 341 | 340 | V40416          | V40516           |
| 377                                   | 376 | 375 | 374 | 373 | 372 | 371 | 370 | 367 | 366 | 365 | 364 | 363 | 362 | 361 | 360 | V40417          | V40517           |
| 417                                   | 416 | 415 | 414 | 413 | 412 | 411 | 410 | 407 | 406 | 405 | 404 | 403 | 402 | 401 | 400 | V40420          | V40520           |
| 437                                   | 436 | 435 | 434 | 433 | 432 | 431 | 430 | 427 | 426 | 425 | 424 | 423 | 422 | 421 | 420 | V40421          | V40521           |
| 457                                   | 456 | 455 | 454 | 453 | 452 | 451 | 450 | 447 | 446 | 445 | 444 | 443 | 442 | 441 | 440 | V40422          | V40522           |
| 477                                   | 476 | 475 | 474 | 473 | 472 | 471 | 470 | 467 | 466 | 465 | 464 | 463 | 462 | 461 | 460 | V40423          | V40523           |
| 517                                   | 516 | 515 | 514 | 513 | 512 | 511 | 510 | 507 | 506 | 505 | 504 | 503 | 502 | 501 | 500 | V40424          | V40524           |
| 537                                   | 536 | 535 | 534 | 533 | 532 | 531 | 530 | 527 | 526 | 525 | 524 | 523 | 522 | 521 | 520 | V40425          | V40525           |
| 557                                   | 556 | 555 | 554 | 553 | 552 | 551 | 550 | 547 | 546 | 545 | 544 | 543 | 542 | 541 | 540 | V40426          | V40526           |
| 577                                   | 576 | 575 | 574 | 573 | 572 | 571 | 570 | 567 | 566 | 565 | 564 | 563 | 562 | 561 | 560 | V40427          | V40527           |
| 617                                   | 616 | 615 | 614 | 613 | 612 | 611 | 610 | 607 | 606 | 605 | 604 | 603 | 602 | 601 | 600 | V40430          | V40530           |
| 637                                   | 636 | 635 | 634 | 633 | 632 | 631 | 630 | 627 | 626 | 625 | 624 | 623 | 622 | 621 | 620 | V40431          | V40531           |
| 657                                   | 656 | 655 | 654 | 653 | 652 | 651 | 650 | 647 | 646 | 645 | 644 | 643 | 642 | 641 | 640 | V40432          | V40532           |
| 677                                   | 676 | 675 | 674 | 673 | 672 | 671 | 670 | 667 | 666 | 665 | 664 | 663 | 662 | 661 | 660 | V40433          | V40533           |
| 717                                   | 716 | 715 | 714 | 713 | 712 | 711 | 710 | 707 | 706 | 705 | 704 | 703 | 702 | 701 | 700 | V40434          | V40534           |
| 737                                   | 736 | 735 | 734 | 733 | 732 | 731 | 730 | 727 | 726 | 725 | 724 | 723 | 722 | 721 | 720 | V40435          | V40535           |
| 757                                   | 756 | 755 | 754 | 753 | 752 | 751 | 750 | 747 | 746 | 745 | 744 | 743 | 742 | 741 | 740 | V40436          | V40536           |
| 777                                   | 776 | 775 | 774 | 773 | 772 | 771 | 770 | 767 | 766 | 765 | 764 | 763 | 762 | 761 | 760 | V40437          | V40537           |



## DL350 Control Relay Bit Map

This table provides a listing of the individual control relays associated with each V-memory address bit.

| MSB |     | DL350 Control Relays (C) |     |     |     |     |     |     |     |     |     |     |     |     |     | LSB    |  | Address |
|-----|-----|--------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|--|---------|
| 17  | 16  | 15                       | 14  | 13  | 12  | 11  | 10  | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0   |        |  |         |
| 017 | 016 | 015                      | 014 | 013 | 012 | 011 | 010 | 007 | 006 | 005 | 004 | 003 | 002 | 001 | 000 | V40600 |  |         |
| 037 | 036 | 035                      | 034 | 033 | 032 | 031 | 030 | 027 | 026 | 025 | 024 | 023 | 022 | 021 | 020 | V40601 |  |         |
| 057 | 056 | 055                      | 054 | 053 | 052 | 051 | 050 | 047 | 046 | 045 | 044 | 043 | 042 | 041 | 040 | V40602 |  |         |
| 077 | 076 | 075                      | 074 | 073 | 072 | 071 | 070 | 067 | 066 | 065 | 064 | 063 | 062 | 061 | 060 | V40603 |  |         |
| 117 | 116 | 115                      | 114 | 113 | 112 | 111 | 110 | 107 | 106 | 105 | 104 | 103 | 102 | 101 | 100 | V40604 |  |         |
| 137 | 136 | 135                      | 134 | 133 | 132 | 131 | 130 | 127 | 126 | 125 | 124 | 123 | 122 | 121 | 120 | V40605 |  |         |
| 157 | 156 | 155                      | 154 | 153 | 152 | 151 | 150 | 147 | 146 | 145 | 144 | 143 | 142 | 141 | 140 | V40606 |  |         |
| 177 | 176 | 175                      | 174 | 173 | 172 | 171 | 170 | 167 | 166 | 165 | 164 | 163 | 162 | 161 | 160 | V40607 |  |         |
| 217 | 216 | 215                      | 214 | 213 | 212 | 211 | 210 | 207 | 206 | 205 | 204 | 203 | 202 | 201 | 200 | V40610 |  |         |
| 237 | 236 | 235                      | 234 | 233 | 232 | 231 | 230 | 227 | 226 | 225 | 224 | 223 | 222 | 221 | 220 | V40611 |  |         |
| 257 | 256 | 255                      | 254 | 253 | 252 | 251 | 250 | 247 | 246 | 245 | 244 | 243 | 242 | 241 | 240 | V40612 |  |         |
| 277 | 276 | 275                      | 274 | 273 | 272 | 271 | 270 | 267 | 266 | 265 | 264 | 263 | 262 | 261 | 260 | V40613 |  |         |
| 317 | 316 | 315                      | 314 | 313 | 312 | 311 | 310 | 307 | 306 | 305 | 304 | 303 | 302 | 301 | 300 | V40614 |  |         |
| 337 | 336 | 335                      | 334 | 333 | 332 | 331 | 330 | 327 | 326 | 325 | 324 | 323 | 322 | 321 | 320 | V40615 |  |         |
| 357 | 356 | 355                      | 354 | 353 | 352 | 351 | 350 | 347 | 346 | 345 | 344 | 343 | 342 | 341 | 340 | V40616 |  |         |
| 377 | 376 | 375                      | 374 | 373 | 372 | 371 | 370 | 367 | 366 | 365 | 364 | 363 | 362 | 361 | 360 | V40617 |  |         |
| 417 | 416 | 415                      | 414 | 413 | 412 | 411 | 410 | 407 | 406 | 405 | 404 | 403 | 402 | 401 | 400 | V40620 |  |         |
| 437 | 436 | 435                      | 434 | 433 | 432 | 431 | 430 | 427 | 426 | 425 | 424 | 423 | 422 | 421 | 420 | V40621 |  |         |
| 457 | 456 | 455                      | 454 | 453 | 452 | 451 | 450 | 447 | 446 | 445 | 444 | 443 | 442 | 441 | 440 | V40622 |  |         |
| 477 | 476 | 475                      | 474 | 473 | 472 | 471 | 470 | 467 | 466 | 465 | 464 | 463 | 462 | 461 | 460 | V40623 |  |         |
| 517 | 516 | 515                      | 514 | 513 | 512 | 511 | 510 | 507 | 506 | 505 | 504 | 503 | 502 | 501 | 500 | V40624 |  |         |
| 537 | 536 | 535                      | 534 | 533 | 532 | 531 | 530 | 527 | 526 | 525 | 524 | 523 | 522 | 521 | 520 | V40625 |  |         |
| 557 | 556 | 555                      | 554 | 553 | 552 | 551 | 550 | 547 | 546 | 545 | 544 | 543 | 542 | 541 | 540 | V40626 |  |         |
| 577 | 576 | 575                      | 574 | 573 | 572 | 571 | 570 | 567 | 566 | 565 | 564 | 563 | 562 | 561 | 560 | V40627 |  |         |
| 617 | 616 | 615                      | 614 | 613 | 612 | 611 | 610 | 607 | 606 | 605 | 604 | 603 | 602 | 601 | 600 | V40630 |  |         |
| 637 | 636 | 635                      | 634 | 633 | 632 | 631 | 630 | 627 | 626 | 625 | 624 | 623 | 622 | 621 | 620 | V40631 |  |         |
| 657 | 656 | 655                      | 654 | 653 | 652 | 651 | 650 | 647 | 646 | 645 | 644 | 643 | 642 | 641 | 640 | V40632 |  |         |
| 677 | 676 | 675                      | 674 | 673 | 672 | 671 | 670 | 667 | 666 | 665 | 664 | 663 | 662 | 661 | 660 | V40633 |  |         |
| 717 | 716 | 715                      | 714 | 713 | 712 | 711 | 710 | 707 | 706 | 705 | 704 | 703 | 702 | 701 | 700 | V40634 |  |         |
| 737 | 736 | 735                      | 734 | 733 | 732 | 731 | 730 | 727 | 726 | 725 | 724 | 723 | 722 | 721 | 720 | V40635 |  |         |
| 757 | 756 | 755                      | 754 | 753 | 752 | 751 | 750 | 747 | 746 | 745 | 744 | 743 | 742 | 741 | 740 | V40636 |  |         |
| 777 | 776 | 775                      | 774 | 773 | 772 | 771 | 770 | 767 | 766 | 765 | 764 | 763 | 762 | 761 | 760 | V40637 |  |         |

| Additional DL305 Control Relays (C) |      |      |      |      |      |      |      |      |      |      |      |      |      |      | Address |        |
|-------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|---------|--------|
| MSB                                 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |         | LSB    |
| 17                                  | 16   | 15   | 14   | 13   | 12   | 11   | 10   | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0       |        |
| 1017                                | 1016 | 1015 | 1014 | 1013 | 1012 | 1011 | 1010 | 1007 | 1006 | 1005 | 1004 | 1003 | 1002 | 1001 | 1000    | V40640 |
| 1037                                | 1036 | 1035 | 1034 | 1033 | 1032 | 1031 | 1030 | 1027 | 1026 | 1025 | 1024 | 1023 | 1022 | 1021 | 1020    | V40641 |
| 1057                                | 1056 | 1055 | 1054 | 1053 | 1052 | 1051 | 1050 | 1047 | 1046 | 1045 | 1044 | 1043 | 1042 | 1041 | 1040    | V40642 |
| 1077                                | 1076 | 1075 | 1074 | 1073 | 1072 | 1071 | 1070 | 1067 | 1066 | 1065 | 1064 | 1063 | 1062 | 1061 | 1060    | V40643 |
| 1117                                | 1116 | 1115 | 1114 | 1113 | 1112 | 1111 | 1110 | 1107 | 1106 | 1105 | 1104 | 1103 | 1102 | 1101 | 1100    | V40644 |
| 1137                                | 1136 | 1135 | 1134 | 1133 | 1132 | 1131 | 1130 | 1127 | 1126 | 1125 | 1124 | 1123 | 1122 | 1121 | 1120    | V40645 |
| 1157                                | 1156 | 1155 | 1154 | 1153 | 1152 | 1151 | 1150 | 1147 | 1146 | 1145 | 1144 | 1143 | 1142 | 1141 | 1140    | V40646 |
| 1177                                | 1176 | 1175 | 1174 | 1173 | 1172 | 1171 | 1170 | 1167 | 1166 | 1165 | 1164 | 1163 | 1162 | 1161 | 1160    | V40647 |
| 1217                                | 1216 | 1215 | 1214 | 1213 | 1212 | 1211 | 1210 | 1207 | 1206 | 1205 | 1204 | 1203 | 1202 | 1201 | 1200    | V40650 |
| 1237                                | 1236 | 1235 | 1234 | 1233 | 1232 | 1231 | 1230 | 1227 | 1226 | 1225 | 1224 | 1223 | 1222 | 1221 | 1220    | V40651 |
| 1257                                | 1256 | 1255 | 1254 | 1253 | 1252 | 1251 | 1250 | 1247 | 1246 | 1245 | 1244 | 1243 | 1242 | 1241 | 1240    | V40652 |
| 1277                                | 1276 | 1275 | 1274 | 1273 | 1272 | 1271 | 1270 | 1267 | 1266 | 1265 | 1264 | 1263 | 1262 | 1261 | 1260    | V40653 |
| 1317                                | 1316 | 1315 | 1314 | 1313 | 1312 | 1311 | 1310 | 1307 | 1306 | 1305 | 1304 | 1303 | 1302 | 1301 | 1300    | V40654 |
| 1337                                | 1336 | 1335 | 1334 | 1333 | 1332 | 1331 | 1330 | 1327 | 1326 | 1325 | 1324 | 1323 | 1322 | 1321 | 1320    | V40655 |
| 1357                                | 1356 | 1355 | 1354 | 1353 | 1352 | 1351 | 1350 | 1347 | 1346 | 1345 | 1344 | 1343 | 1342 | 1341 | 1340    | V40656 |
| 1377                                | 1376 | 1375 | 1374 | 1373 | 1372 | 1371 | 1370 | 1367 | 1366 | 1365 | 1364 | 1363 | 1362 | 1361 | 1360    | V40657 |
| 1417                                | 1416 | 1415 | 1414 | 1413 | 1412 | 1411 | 1410 | 1407 | 1406 | 1405 | 1404 | 1403 | 1402 | 1401 | 1400    | V40660 |
| 1437                                | 1436 | 1435 | 1434 | 1433 | 1432 | 1431 | 1430 | 1427 | 1426 | 1425 | 1424 | 1423 | 1422 | 1421 | 1420    | V40661 |
| 1457                                | 1456 | 1455 | 1454 | 1453 | 1452 | 1451 | 1450 | 1447 | 1446 | 1445 | 1444 | 1443 | 1442 | 1441 | 1440    | V40662 |
| 1477                                | 1476 | 1475 | 1474 | 1473 | 1472 | 1471 | 1470 | 1467 | 1466 | 1465 | 1464 | 1463 | 1462 | 1461 | 1460    | V40663 |
| 1517                                | 1516 | 1515 | 1514 | 1513 | 1512 | 1511 | 1510 | 1507 | 1506 | 1505 | 1504 | 1503 | 1502 | 1501 | 1500    | V40664 |
| 1537                                | 1536 | 1535 | 1534 | 1533 | 1532 | 1531 | 1530 | 1527 | 1526 | 1525 | 1524 | 1523 | 1522 | 1521 | 1520    | V40665 |
| 1557                                | 1556 | 1555 | 1554 | 1553 | 1552 | 1551 | 1550 | 1547 | 1546 | 1545 | 1544 | 1543 | 1542 | 1541 | 1540    | V40666 |
| 1577                                | 1576 | 1575 | 1574 | 1573 | 1572 | 1571 | 1570 | 1567 | 1566 | 1565 | 1564 | 1563 | 1562 | 1561 | 1560    | V40667 |
| 1617                                | 1616 | 1615 | 1614 | 1613 | 1612 | 1611 | 1610 | 1607 | 1606 | 1605 | 1604 | 1603 | 1602 | 1601 | 1600    | V40670 |
| 1637                                | 1636 | 1635 | 1634 | 1633 | 1632 | 1631 | 1630 | 1627 | 1626 | 1625 | 1624 | 1623 | 1622 | 1621 | 1620    | V40671 |
| 1657                                | 1656 | 1655 | 1654 | 1653 | 1652 | 1651 | 1650 | 1647 | 1646 | 1645 | 1644 | 1643 | 1642 | 1641 | 1640    | V40672 |
| 1677                                | 1676 | 1675 | 1674 | 1673 | 1672 | 1671 | 1670 | 1667 | 1666 | 1665 | 1664 | 1663 | 1662 | 1661 | 1660    | V40673 |
| 1717                                | 1716 | 1715 | 1714 | 1713 | 1712 | 1711 | 1710 | 1707 | 1706 | 1705 | 1704 | 1703 | 1702 | 1701 | 1700    | V40674 |
| 1737                                | 1736 | 1735 | 1734 | 1733 | 1732 | 1731 | 1730 | 1727 | 1726 | 1725 | 1724 | 1723 | 1722 | 1721 | 1720    | V40675 |
| 1757                                | 1756 | 1755 | 1754 | 1753 | 1752 | 1751 | 1750 | 1747 | 1746 | 1745 | 1744 | 1743 | 1742 | 1741 | 1740    | V40676 |
| 1777                                | 1776 | 1775 | 1774 | 1773 | 1772 | 1771 | 1770 | 1767 | 1766 | 1765 | 1764 | 1763 | 1762 | 1761 | 1760    | V40677 |

## DL350 Stage™ Control / Status Bit Map

This table provides a listing of the individual Stage™ control bits associated with each V-memory address.

| DL350 Stage (S) Control Bits |     |     |     |     |     |     |     |     |     |     |     |     |     |     | Address |        |
|------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|---------|--------|
| MSB                          |     |     |     |     |     |     |     |     |     |     |     |     |     |     |         | LSB    |
| 17                           | 16  | 15  | 14  | 13  | 12  | 11  | 10  | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0       |        |
| 017                          | 016 | 015 | 014 | 013 | 012 | 011 | 010 | 007 | 006 | 005 | 004 | 003 | 002 | 001 | 000     | V41000 |
| 037                          | 036 | 035 | 034 | 033 | 032 | 031 | 030 | 027 | 026 | 025 | 024 | 023 | 022 | 021 | 020     | V41001 |
| 057                          | 056 | 055 | 054 | 053 | 052 | 051 | 050 | 047 | 046 | 045 | 044 | 043 | 042 | 041 | 040     | V41002 |
| 077                          | 076 | 075 | 074 | 073 | 072 | 071 | 070 | 067 | 066 | 065 | 064 | 063 | 062 | 061 | 060     | V41003 |
| 117                          | 116 | 115 | 114 | 113 | 112 | 111 | 110 | 107 | 106 | 105 | 104 | 103 | 102 | 101 | 100     | V41004 |
| 137                          | 136 | 135 | 134 | 133 | 132 | 131 | 130 | 127 | 126 | 125 | 124 | 123 | 122 | 121 | 120     | V41005 |
| 157                          | 156 | 155 | 154 | 153 | 152 | 151 | 150 | 147 | 146 | 145 | 144 | 143 | 142 | 141 | 140     | V41006 |
| 177                          | 176 | 175 | 174 | 173 | 172 | 171 | 170 | 167 | 166 | 165 | 164 | 163 | 162 | 161 | 160     | V41007 |
| 217                          | 216 | 215 | 214 | 213 | 212 | 211 | 210 | 207 | 206 | 205 | 204 | 203 | 202 | 201 | 200     | V41010 |
| 237                          | 236 | 235 | 234 | 233 | 232 | 231 | 230 | 227 | 226 | 225 | 224 | 223 | 222 | 221 | 220     | V41011 |
| 257                          | 256 | 255 | 254 | 253 | 252 | 251 | 250 | 247 | 246 | 245 | 244 | 243 | 242 | 241 | 240     | V41012 |
| 277                          | 276 | 275 | 274 | 273 | 272 | 271 | 270 | 267 | 266 | 265 | 264 | 263 | 262 | 261 | 260     | V41013 |
| 317                          | 316 | 315 | 314 | 313 | 312 | 311 | 310 | 307 | 306 | 305 | 304 | 303 | 302 | 301 | 300     | V41014 |
| 337                          | 336 | 335 | 334 | 333 | 332 | 331 | 330 | 327 | 326 | 325 | 324 | 323 | 322 | 321 | 320     | V41015 |
| 357                          | 356 | 355 | 354 | 353 | 352 | 351 | 350 | 347 | 346 | 345 | 344 | 343 | 342 | 341 | 340     | V41016 |
| 377                          | 376 | 375 | 374 | 373 | 372 | 371 | 370 | 367 | 366 | 365 | 364 | 363 | 362 | 361 | 360     | V41017 |
| 417                          | 416 | 415 | 414 | 413 | 412 | 411 | 410 | 407 | 406 | 405 | 404 | 403 | 402 | 401 | 400     | V41020 |
| 437                          | 436 | 435 | 434 | 433 | 432 | 431 | 430 | 427 | 426 | 425 | 424 | 423 | 422 | 421 | 420     | V41021 |
| 457                          | 456 | 455 | 454 | 453 | 452 | 451 | 450 | 447 | 446 | 445 | 444 | 443 | 442 | 441 | 440     | V41022 |
| 477                          | 476 | 475 | 474 | 473 | 472 | 471 | 470 | 467 | 466 | 465 | 464 | 463 | 462 | 461 | 460     | V41023 |
| 517                          | 516 | 515 | 514 | 513 | 512 | 511 | 510 | 507 | 506 | 505 | 504 | 503 | 502 | 501 | 500     | V41024 |
| 537                          | 536 | 535 | 534 | 533 | 532 | 531 | 530 | 527 | 526 | 525 | 524 | 523 | 522 | 521 | 520     | V41025 |
| 557                          | 556 | 555 | 554 | 553 | 552 | 551 | 550 | 547 | 546 | 545 | 544 | 543 | 542 | 541 | 540     | V41026 |
| 577                          | 576 | 575 | 574 | 573 | 572 | 571 | 570 | 567 | 566 | 565 | 564 | 563 | 562 | 561 | 560     | V41027 |
| 617                          | 616 | 615 | 614 | 613 | 612 | 611 | 610 | 607 | 606 | 605 | 604 | 603 | 602 | 601 | 600     | V41030 |
| 637                          | 636 | 635 | 634 | 633 | 632 | 631 | 630 | 627 | 626 | 625 | 624 | 623 | 622 | 621 | 620     | V41031 |
| 657                          | 656 | 655 | 654 | 653 | 652 | 651 | 650 | 647 | 646 | 645 | 644 | 643 | 642 | 641 | 640     | V41032 |
| 677                          | 676 | 675 | 674 | 673 | 672 | 671 | 670 | 667 | 666 | 665 | 664 | 663 | 662 | 661 | 660     | V41033 |
| 717                          | 716 | 715 | 714 | 713 | 712 | 711 | 710 | 707 | 706 | 705 | 704 | 703 | 702 | 701 | 700     | V41034 |
| 737                          | 736 | 735 | 734 | 733 | 732 | 731 | 730 | 727 | 726 | 725 | 724 | 723 | 722 | 721 | 720     | V41035 |
| 757                          | 756 | 755 | 754 | 753 | 752 | 751 | 750 | 747 | 746 | 745 | 744 | 743 | 742 | 741 | 740     | V41036 |
| 777                          | 776 | 775 | 774 | 773 | 772 | 771 | 770 | 767 | 766 | 765 | 764 | 763 | 762 | 761 | 760     | V41037 |

| DL350 Additional Stage (S) Control Bits (continued) |      |      |      |      |      |      |      |      |      |      |      |      |      |      | Address |        |
|---|------|------|------|------|------|------|------|------|------|------|------|------|------|------|---------|--------|
| MSB   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |         | LSB    |
| 17  | 16   | 15   | 14   | 13   | 12   | 11   | 10   | 7    | 6    | 5    | 4    | 3    | 2    | 1    | 0       |        |
| 1017  | 1016 | 1015 | 1014 | 1013 | 1012 | 1011 | 1010 | 1007 | 1006 | 1005 | 1004 | 1003 | 1002 | 1001 | 1000    | V41040 |
| 1037  | 1036 | 1035 | 1034 | 1033 | 1032 | 1031 | 1030 | 1027 | 1026 | 1025 | 1024 | 1023 | 1022 | 1021 | 1020    | V41041 |
| 1057  | 1056 | 1055 | 1054 | 1053 | 1052 | 1051 | 1050 | 1047 | 1046 | 1045 | 1044 | 1043 | 1042 | 1041 | 1040    | V41042 |
| 1077  | 1076 | 1075 | 1074 | 1073 | 1072 | 1071 | 1070 | 1067 | 1066 | 1065 | 1064 | 1063 | 1062 | 1061 | 1060    | V41043 |
| 1117  | 1116 | 1115 | 1114 | 1113 | 1112 | 1111 | 1110 | 1107 | 1106 | 1105 | 1104 | 1103 | 1102 | 1101 | 1100    | V41044 |
| 1137  | 1136 | 1135 | 1134 | 1133 | 1132 | 1131 | 1130 | 1127 | 1126 | 1125 | 1124 | 1123 | 1122 | 1121 | 1120    | V41045 |
| 1157  | 1156 | 1155 | 1154 | 1153 | 1152 | 1151 | 1150 | 1147 | 1146 | 1145 | 1144 | 1143 | 1142 | 1141 | 1140    | V41046 |
| 1177  | 1176 | 1175 | 1174 | 1173 | 1172 | 1171 | 1170 | 1167 | 1166 | 1165 | 1164 | 1163 | 1162 | 1161 | 1160    | V41047 |
| 1217  | 1216 | 1215 | 1214 | 1213 | 1212 | 1211 | 1210 | 1207 | 1206 | 1205 | 1204 | 1203 | 1202 | 1201 | 1200    | V41050 |
| 1237  | 1236 | 1235 | 1234 | 1233 | 1232 | 1231 | 1230 | 1227 | 1226 | 1225 | 1224 | 1223 | 1222 | 1221 | 1220    | V41051 |
| 1257  | 1256 | 1255 | 1254 | 1253 | 1252 | 1251 | 1250 | 1247 | 1246 | 1245 | 1244 | 1243 | 1242 | 1241 | 1240    | V41052 |
| 1277  | 1276 | 1275 | 1274 | 1273 | 1272 | 1271 | 1270 | 1267 | 1266 | 1265 | 1264 | 1263 | 1262 | 1261 | 1260    | V41053 |
| 1317  | 1316 | 1315 | 1314 | 1313 | 1312 | 1311 | 1310 | 1307 | 1306 | 1305 | 1304 | 1303 | 1302 | 1301 | 1300    | V41054 |
| 1337  | 1336 | 1335 | 1334 | 1333 | 1332 | 1331 | 1330 | 1327 | 1326 | 1325 | 1324 | 1323 | 1322 | 1321 | 1320    | V41055 |
| 1357  | 1356 | 1355 | 1354 | 1353 | 1352 | 1351 | 1350 | 1347 | 1346 | 1345 | 1344 | 1343 | 1342 | 1341 | 1340    | V41056 |
| 1377  | 1376 | 1375 | 1374 | 1373 | 1372 | 1371 | 1370 | 1367 | 1366 | 1365 | 1364 | 1363 | 1362 | 1361 | 1360    | V41057 |
| 1417  | 1416 | 1415 | 1414 | 1413 | 1412 | 1411 | 1410 | 1407 | 1406 | 1405 | 1404 | 1403 | 1402 | 1401 | 1400    | V41060 |
| 1437  | 1436 | 1435 | 1434 | 1433 | 1432 | 1431 | 1430 | 1427 | 1426 | 1425 | 1424 | 1423 | 1422 | 1421 | 1420    | V41061 |
| 1457  | 1456 | 1455 | 1454 | 1453 | 1452 | 1451 | 1450 | 1447 | 1446 | 1445 | 1444 | 1443 | 1442 | 1441 | 1440    | V41062 |
| 1477  | 1476 | 1475 | 1474 | 1473 | 1472 | 1471 | 1470 | 1467 | 1466 | 1465 | 1464 | 1463 | 1462 | 1461 | 1460    | V41063 |
| 1517  | 1516 | 1515 | 1514 | 1513 | 1512 | 1511 | 1510 | 1507 | 1506 | 1505 | 1504 | 1503 | 1502 | 1501 | 1500    | V41064 |
| 1537  | 1536 | 1535 | 1534 | 1533 | 1532 | 1531 | 1530 | 1527 | 1526 | 1525 | 1524 | 1523 | 1522 | 1521 | 1520    | V41065 |
| 1557  | 1556 | 1555 | 1554 | 1553 | 1552 | 1551 | 1550 | 1547 | 1546 | 1545 | 1544 | 1543 | 1542 | 1541 | 1540    | V41066 |
| 1577  | 1576 | 1575 | 1574 | 1573 | 1572 | 1571 | 1570 | 1567 | 1566 | 1565 | 1564 | 1563 | 1562 | 1561 | 1560    | V41067 |
| 1617  | 1616 | 1615 | 1614 | 1613 | 1612 | 1611 | 1610 | 1607 | 1606 | 1605 | 1604 | 1603 | 1602 | 1601 | 1600    | V41070 |
| 1637  | 1636 | 1635 | 1634 | 1633 | 1632 | 1631 | 1630 | 1627 | 1626 | 1625 | 1624 | 1623 | 1622 | 1621 | 1620    | V41071 |
| 1657  | 1656 | 1655 | 1654 | 1653 | 1652 | 1651 | 1650 | 1647 | 1646 | 1645 | 1644 | 1643 | 1642 | 1641 | 1640    | V41072 |
| 1677  | 1676 | 1675 | 1674 | 1673 | 1672 | 1671 | 1670 | 1667 | 1666 | 1665 | 1664 | 1663 | 1662 | 1661 | 1660    | V41073 |
| 1717  | 1716 | 1715 | 1714 | 1713 | 1712 | 1711 | 1710 | 1707 | 1706 | 1705 | 1704 | 1703 | 1702 | 1701 | 1700    | V41074 |
| 1737  | 1736 | 1735 | 1734 | 1733 | 1732 | 1731 | 1730 | 1727 | 1726 | 1725 | 1724 | 1723 | 1722 | 1721 | 1720    | V41075 |
| 1757  | 1756 | 1755 | 1754 | 1753 | 1752 | 1751 | 1750 | 1747 | 1746 | 1745 | 1744 | 1743 | 1742 | 1741 | 1740    | V41076 |
| 1777  | 1776 | 1775 | 1774 | 1773 | 1772 | 1771 | 1770 | 1767 | 1766 | 1765 | 1764 | 1763 | 1762 | 1761 | 1760    | V41077 |

## DL350 Timer and Counter Status Bit Maps

This table provides a listing of the individual timer and counter contacts associated with each V-memory address bit.

| DL350 Timer (T) and Counter (CT) Contacts |     |     |     |     |     |     |     |     |     |     |     |     |     |     | Timer Address | Counter Address |        |
|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|---------------|-----------------|--------|
| MSB                                       |     |     |     |     |     |     |     |     |     |     |     |     |     | LSB |               |                 |        |
| 17  | 16  | 15  | 14  | 13  | 12  | 11  | 10  | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0             |                 |        |
| 017                                       | 016 | 015 | 014 | 013 | 012 | 011 | 010 | 007 | 006 | 005 | 004 | 003 | 002 | 001 | 000           | V41100          | V41140 |
| 037                                       | 036 | 035 | 034 | 033 | 032 | 031 | 030 | 027 | 026 | 025 | 024 | 023 | 022 | 021 | 020           | V41101          | V41141 |
| 057                                       | 056 | 055 | 054 | 053 | 052 | 051 | 050 | 047 | 046 | 045 | 044 | 043 | 042 | 041 | 040           | V41102          | V41142 |
| 077                                       | 076 | 075 | 074 | 073 | 072 | 071 | 070 | 067 | 066 | 065 | 064 | 063 | 062 | 061 | 060           | V41103          | V41143 |
| 117                                       | 116 | 115 | 114 | 113 | 112 | 111 | 110 | 107 | 106 | 105 | 104 | 103 | 102 | 101 | 100           | V41104          | V41144 |
| 137                                       | 136 | 135 | 134 | 133 | 132 | 131 | 130 | 127 | 126 | 125 | 124 | 123 | 122 | 121 | 120           | V41105          | V41145 |
| 157                                       | 156 | 155 | 154 | 153 | 152 | 151 | 150 | 147 | 146 | 145 | 144 | 143 | 142 | 141 | 140           | V41106          | V41146 |
| 177                                       | 176 | 175 | 174 | 173 | 172 | 171 | 170 | 167 | 166 | 165 | 164 | 163 | 162 | 161 | 160           | V41107          | V41147 |

This portion of the table shows additional Timer contacts available with the DL350.

| DL350 Additional Timer (T) Contacts |     |     |     |     |     |     |     |     |     |     |     |     |     |     | Timer Address |        |
|-------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|---------------|--------|
| MSB                                 |     |     |     |     |     |     |     |     |     |     |     |     |     | LSB |               |        |
| 17                                  | 16  | 15  | 14  | 13  | 12  | 11  | 10  | 7   | 6   | 5   | 4   | 3   | 2   | 1   | 0             |        |
| 217                                 | 216 | 215 | 214 | 213 | 212 | 211 | 210 | 207 | 206 | 205 | 204 | 203 | 202 | 201 | 200           | V41110 |
| 237                                 | 236 | 235 | 234 | 233 | 232 | 231 | 230 | 227 | 226 | 225 | 224 | 223 | 222 | 221 | 220           | V41111 |
| 257                                 | 256 | 255 | 254 | 253 | 252 | 251 | 250 | 247 | 246 | 245 | 244 | 243 | 242 | 241 | 240           | V41112 |
| 277                                 | 276 | 275 | 274 | 273 | 272 | 271 | 270 | 267 | 266 | 265 | 264 | 263 | 262 | 261 | 260           | V41113 |
| 317                                 | 316 | 315 | 314 | 313 | 312 | 311 | 310 | 307 | 306 | 305 | 304 | 303 | 302 | 301 | 300           | V41114 |
| 337                                 | 336 | 335 | 334 | 333 | 332 | 331 | 330 | 327 | 326 | 325 | 324 | 323 | 322 | 321 | 320           | V41115 |
| 357                                 | 356 | 355 | 354 | 353 | 352 | 351 | 350 | 347 | 346 | 345 | 344 | 343 | 342 | 341 | 340           | V41116 |
| 377                                 | 376 | 375 | 374 | 373 | 372 | 371 | 370 | 367 | 366 | 365 | 364 | 363 | 362 | 361 | 360           | V41117 |

