

DL05/06 Option Modules USER MANUAL

Manual Number: D0-OPTIONS-M

This user manual covers the following DL05/06 option modules:

F0-08SIM - 8-Point Simulator Input Module	Chapter 2
D0-10ND3 - 10-Point DC Input Module	Chapter 2
D0-10ND3F - 10-Point DC Fast Input Module	Chapter 2
D0-16ND3 - 16-Point DC Input Module	Chapter 2
F0-08NA-1 - 8-Point AC Input Module	Chapter 2
D0-10TD1 - 10-Point DC Output Module	Chapter 2
D0-16TD1 - 16-Point DC Output Module	Chapter 2
D0-10TD2 - 10-Point DC Output Module	Chapter 2
D0-16TD2 - 16-Point DC Output Module	Chapter 2
D0-07CDR - 4-Point DC Input and 3-Point Relay Output Module	Chapter 2
D0-08TR - 8-Point Relay Output Module	Chapter 2
D0-08CDD1 - 4-Point DC Input and 4-Point DC Output Module	Chapter 2
F0-04TRS - 4-Point Relay Output Module	Chapter 2
F0-04AD-1 - 4-Ch. Analog Current Input	Chapter 3
F0-04AD-2 - 4-Ch. Analog Voltage Input	Chapter 4
F0-4AD2DA-1 - 4-Ch. In/2-Ch. Out Analog Current Combination	Chapter 5
F0-2AD2DA-2 - 2-Ch. In/2-Ch. Out Analog Voltage Combination	Chapter 6
F0-4AD2DA-2 - 4-Ch. In/2-Ch. Out Analog Voltage Combination	Chapter 7
F0-04RTD - 4-Channel RTD Input	Chapter 8
F0-04THM - 4-Channel Thermocouple Input	Chapter 9

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DL05/06 OPTION MODULES USER MANUAL



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3rd edition	05/02	added wiring guidelines and new discrete module
4th edition	07/02	added DL06 micro PLC information
4th edition Rev. A	02/03	minor changes and corrections
5th edition	05/03	added new chapter
6th edition	08/03	added one new chapter and reference new discrete module
6th edition Rev. A	01/04	added one new chapter
6th edition Rev. B	03/04	added two new discrete modules, moved D0-01MC Memory Cartridge/Real Time Clock module to DL05 user manual
6th edition Rev. C	05/05	added F0-08SIM module; minor corrections

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GETTING STARTED



CHAPTER 1

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Introduction

1

The Purpose of this Manual

This manual will describe the option modules that are available for the DL05 and DL06 micro PLC families. It will show you how to select and install an option module for your PLC.

Supplemental Manuals

You will either need a copy of the **DL05 User Manual** (D0–USER–M) or the **DL06 User Manual** (D0–06USER–M) at hand when incorporating any one of the option modules in your PLC.

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Key Topics for Each Chapter

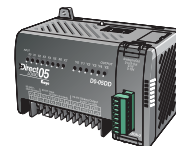
The beginning of each chapter will list the key topics that can be found in that chapter.

Getting Started	
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Selecting the Proper Module

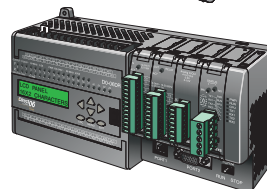
DL05

The DL05 Micro PLC only has one option slot to install an option module. The proper selection of a module is dependent on the control application.



DL06

The DL06 Micro PLC has four option slots. The option modules can also be added according to the control application.



Module Choices

There are twenty-five option modules available. The specifications and wiring diagrams for the twelve discrete I/O modules can be found in the next chapter. A full description of seven analog modules can be found in their respective chapters in this manual. The memory cartridge module, D0-01MC, can be found in the DL05 Micro PLC User Manual. The D0-DEVNETS, H0-ECOM(100), H0-PSCM & H0-CTRIO modules are described in their respective user manuals, see user manual p/n reference below. The following table lists the modules available.

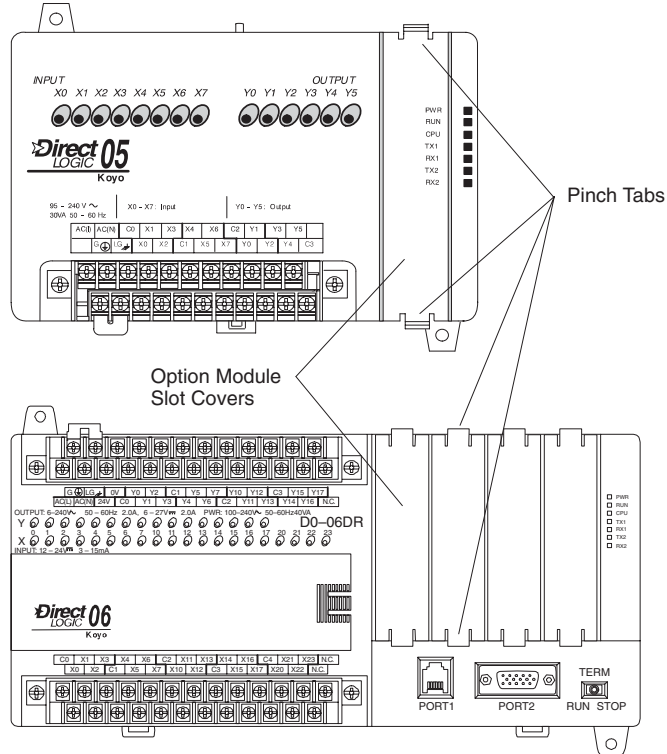
Part Number	Description
F0-08SIM	8 point Simulator Input
D0-10ND3	10 point DC Input
D0-10ND3F	10 point fast DC Input
D0-16ND3	16 point DC Input
F0-08NA-1	8 point AC Input
D0-10TD1	10 point DC Output (sinking)
D0-16TD1	16 point DC Output (sinking)
D0-10TD2	10 point DC Output (sourcing)
D0-16TD2	16 point DC Output (sourcing)
D0-07CDR	4 point DC Input, 3 point Relay Output
D0-08TR	8 point Relay Output
D0-08CDD1	4 point DC Input, 4 point DC Output (sinking)
F0-04TRS	4 point High Current Relay Output
F0-04AD-1	4-Channel Analog Input, Current
F0-04AD-2	4-Channel Analog Input, Voltage
F0-4AD2DA-1	4-Channel Input/2-Channel Output Analog Combination, Current
F0-2AD2DA-2	2-Channel Input/2-Channel Output Analog Combination, Voltage
F0-4AD2DA-2	4-Channel Input/2-Channel Output Analog Combination, Voltage
F0-04RTD	4-Channel RTD Input
F0-04THM	4-Channel Thermocouple Input
D0-01MC	Memory Cartridge/Real Time Clock (DL05 only) (see User Manual p/n D0-USER-M)
D0-DEVNETS	DeviceNet Slave (User Manual p/n D0-DEVNETS-M)
H0-ECOM(100)	10Base-T (10/100Base-T) Ethernet Network (User Manual p/n HX-ECOM-M)
H0-PSCM	Profibus Slave Communications (User Manual p/n HX-PSCM-M)
H0-CTRIO	High Speed Counter Interface (User Manual p/n HX-CTRIO-M)

Installing the Option Modules

Before installing the option module in the DL05 option slot or the DL06 option slots set the necessary jumpers and/or dip switches on the module. Refer to the chapter(s) that pertains to the module(s) being installed.

Remove the Slot Cover

The first step in installing the option module is to remove the protective option slot cover. Remove the cover by squeezing the pinch tabs and lifting the cover off.



Insert the Module

Now, insert the module into the open slot. Locate the module so the printed information is oriented in the same direction as the markings on the PLC. Be careful to align the female connector on the printed circuit board of the module with the male connector on the PLC mother board. Press the module into the slot until the front of the module is flush with the front of the PLC. Install the remaining modules in the DL06. Once the modules are in place the PLC is ready to be programmed.



WARNING: Power to the PLCs must be disconnected before inserting or removing a module. Failure to disconnect power could result in serious damage to a module, the PLC or both.

Power Budgeting

The DL06 has four option card slots. To determine whether the combination of cards you select will have sufficient power, you will need to perform a power budget calculation.

Power supplied

Power is supplied from two sources, the internal base unit power supply and, if required, an external supply (customer furnished). The D0-06xx (AC powered) PLCs supply a limited amount of 24VDC power. The 24VDC output can be used to power external devices. For power budgeting, start by considering the power supplied by the base unit. All DL06 PLCs supply the same amount of 5VDC power. Only the AC units offer 24VDC auxiliary power. Be aware of the trade-off between 5VDC power and 24VDC power. The amount of 5VDC power available depends on the amount of 24VDC power being used, and the amount of 24VDC power available depends on the amount of 5VDC power consumed. Determine the amount of internally supplied power from the table on the following page.

Power required by base unit

Because of the different I/O configurations available in the DL06 family, the power consumed by the base unit itself varies from model to model. Subtract the amount of power required by the base unit from the amount of power supplied by the base unit. Be sure to subtract 5VDC and 24VDC amounts.

Power required by option cards

Next, subtract the amount of power required by the option cards you are planning to use. Again, remember to subtract both 5VDC and 24VDC. If your power budget analysis shows surplus power available, you should have a workable configuration.

DL06 Power Supplied by Base Units		
Part Number	5 VDC (mA)	24 VDC (mA)
D0-06xx	<1500mA	300mA
	<2000mA	200mA
D0-06xx-D	1500mA	none

If the 5VDC loading is less than 2000mA, but more than 1500mA, then available 24VDC supply current is 200mA.

If the 5VDC loading is less than 1500mA, then the available 24VDC current is 300mA.

DL05/06 Power Consumed by Option Cards		
Part Number	5 VDC (mA)	24 VDC (mA)
D0-07CDR	130mA	none
D0-08CDD1	100mA	none
D0-08TR	280mA	none
D0-10ND3	35mA	none
D0-10ND3F	35mA	none
D0-10TD1	150mA	none
D0-10TD2	150mA	none
D0-16ND3	35mA	none
D0-16TD1	200mA	none
D0-16TD2	200mA	none
F0-04TRS	250mA	none
F0-08NA-1	5mA	none
F0-04AD-1	50mA	none
F0-04AD-2	75mA	none
F0-2AD2DA-2	50mA	30mA
F0-4AD2DA-1	100mA	40mA
F0-4AD2DA-2	100mA	none
F0-04RTD	70mA	none
F0-04THM	30mA	none
F0-08SIM	1mA	none
D0-DEVNETS	45mA	none
H0-PSCM	530mA	none
H0-ECOM	250mA	none
H0-ECOM100	300mA	none
H0-CTRIO	250mA	none

DL06 Base Unit Power Required		
Part Number	5 VDC (mA)	24 VDC (mA)
D0-06AA	800mA	none
D0-06AR	900mA	none
D0-06DA	800mA	none
D0-06DD1	600mA	280mA*
D0-06DD2	600mA	none
D0-06DR	950mA	none
D0-06DD1-D	600mA	280mA*
D0-06DD2-D	600mA	none
D0-06DR-D	950mA	none

DL06 Power Consumed by Other Devices		
Part Number	5 VDC (mA)	24 VDC (mA)
D0-06LCD	50mA	none
D2-HPP	200mA	none
DV1000	150mA	none


Power Budgeting Example			
Power Source		5VDC power (mA)	24VDC power (mA)
D0-06DD1 (select row A or row B)	A	1500mA	300mA
	B	2000mA	200mA
Current Required		5VDC power (mA)	24VDC power (mA)
D0-06DD1		600mA	280mA*
D0-16ND3		35mA	0
D0-10TD1		150mA	0
D0-08TR		280mA	0
F0-4AD2DA-2		100mA	0
D0-06LCD		50mA	0
Total Used		1215mA	280mA
Remaining	A	285mA	20mA
	B	785mA	note 1

* Auxiliary 24VDC used to power V+ terminal of D0-06DD1/-D sinking outputs.



Note 1: If the PLC's auxiliary 24VDC power source is used to power the sinking outputs, use power choice A, above.

DISCRETE I/O GUIDELINES



CHAPTER 2

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Safety Guidelines

2



NOTE: Products with CE marks perform their required functions safely and adhere to relevant standards as specified by CE directives provided they are used according to their intended purpose and that the instructions in this manual are adhered to. The protection provided by the equipment may be impaired if this equipment is used in a manner not specified in this manual. A listing of our international affiliates is available on our Web site: <http://www.automationdirect.com>



WARNING: Providing a safe operating environment for personnel and equipment is your responsibility and should be your primary goal during system planning and installation. Automation systems can fail and may result in situations that can cause serious injury to personnel or damage to equipment. Do not rely on the automation system alone to provide a safe operating environment. You should use external electromechanical devices, such as relays or limit switches, that are independent of the PLC application to provide protection for any part of the system that may cause personal injury or damage. Every automation application is different, so there may be special requirements for your particular application. Make sure you follow all national, state, and local government requirements for the proper installation and use of your equipment.

Plan for Safety

The best way to provide a safe operating environment is to make personnel and equipment safety part of the planning process. You should examine *every* aspect of the system to determine which areas are critical to operator or machine safety. If you are not familiar with PLC system installation practices, or your company does not have established installation guidelines, you should obtain additional information from the following sources.

- NEMA — The National Electrical Manufacturers Association, located in Washington, D.C. publishes many different documents that discuss standards for industrial control systems. You can order these publications directly from NEMA. Some of these include:

ICS 1, General Standards for Industrial Control and Systems

ICS 3, Industrial Systems

ICS 6, Enclosures for Industrial Control Systems

- NEC — The National Electrical Code provides regulations concerning the installation and use of various types of electrical equipment. Copies of the NEC Handbook can often be obtained from your local electrical equipment distributor or your local library.
- Local and State Agencies — many local governments and state governments have additional requirements above and beyond those described in the NEC Handbook. Check with your local Electrical Inspector or Fire Marshall office for information.

Three Levels of Protection

The publications mentioned provide many ideas and requirements for system safety. At a minimum, you should follow these regulations. Also, you should use the following techniques, which provide three levels of system control.

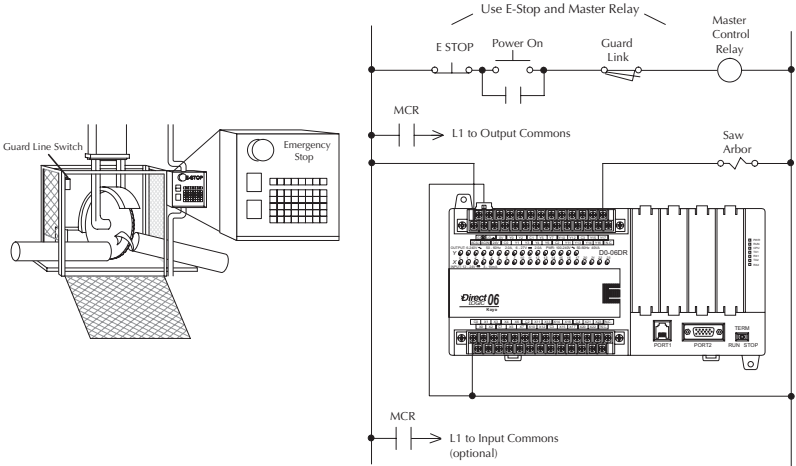
- Emergency stop switch for disconnecting system power
- Mechanical disconnect for output module power
- Orderly system shutdown sequence in the PLC control program

Emergency Stops

It is recommended that emergency stop circuits be incorporated into the system for every machine controlled by a PLC. For maximum safety in a PLC system, these circuits must not be wired into the controller, but should be hardwired external to the PLC. The emergency stop switches should be easily accessed by the operator and are generally wired into a master control relay (MCR) or a safety control relay (SCR) that will remove power from the PLC I/O system in an emergency.

MCRs and SCRs provide a convenient means for removing power from the I/O system during an emergency situation. By de-energizing an MCR (or SCR) coil, power to the input (optional) and output devices is removed. This event occurs when any emergency stop switch opens. However, the PLC continues to receive power and operate even though all its inputs and outputs are disabled.

The MCR circuit could be extended by placing a PLC fault relay (closed during normal PLC operation) in series with any other emergency stop conditions. This would cause the MCR circuit to drop the PLC I/O power in case of a PLC failure (memory error, I/O communications error, etc.).



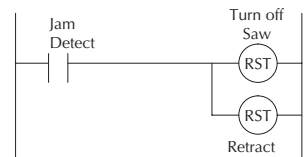
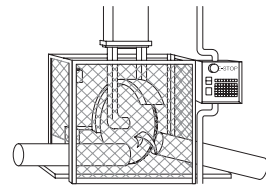
Emergency Power Disconnect

A properly rated emergency power disconnect should be used to power the PLC controlled system as a means of removing the power from the entire control system. It may be necessary to install a capacitor across the disconnect to protect against a condition known as “outrush”. This condition occurs when the output Triacs are turned off by powering off the disconnect, thus causing the energy stored in the inductive loads to seek the shortest distance to ground, which is often through the Triacs.

After an emergency shutdown or any other type of power interruption, there may be requirements that must be met before the PLC control program can be restarted. For example, there may be specific register values that must be established (or maintained from the state prior to the shutdown) before operations can resume. In this case, you may want to use retentive memory locations, or include constants in the control program to insure a known starting point.

Orderly System Shutdown

Ideally, the first level of fault detection is the PLC control program, which can identify machine problems. Certain shutdown sequences should be performed. The types of problems are usually things such as jammed parts, etc. that do not pose a risk of personal injury or equipment damage.



WARNING: The control program must not be the only form of protection for any problems that may result in a risk of personal injury or equipment damage.

Class 1, Division 2 Approval

This equipment is suitable for use in Class 1, Division 2, groups A, B, C and D or non-hazardous locations only.



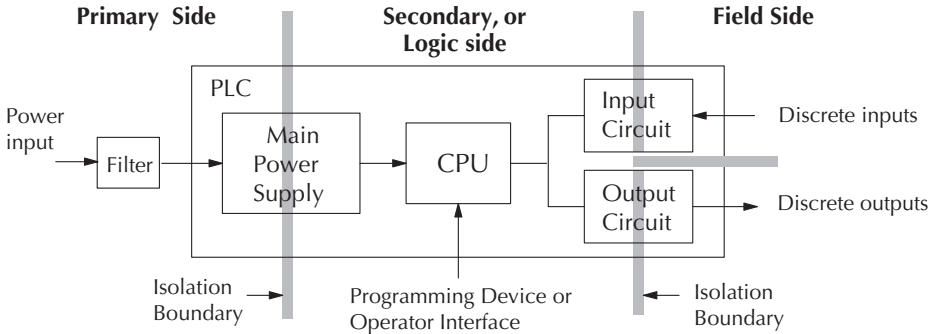
WARNING: Explosion Hazard! Substitution of components may impair suitability for Class 1, Division 2. Do not disconnect equipment unless power has been switched off or area is known to be non-hazardous.

System Wiring Strategies

The *DirectLOGIC* Micro PLCs are very flexible and will work in many different wiring configurations. By studying this section before actual installation, you can probably find the best wiring strategy for your application . This will help to lower system cost, wiring errors, and avoid safety problems.

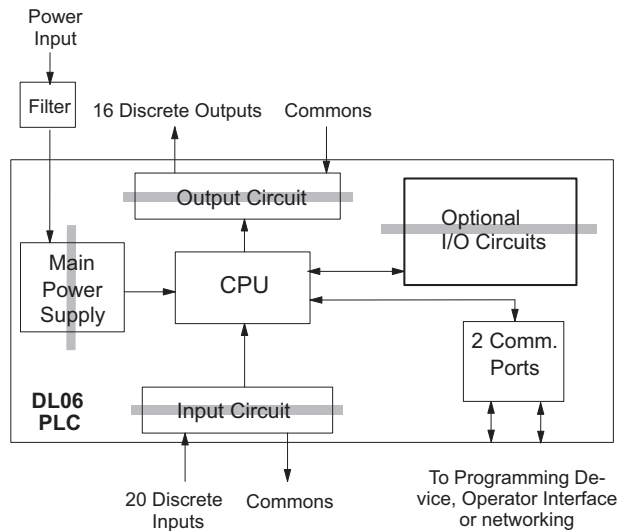
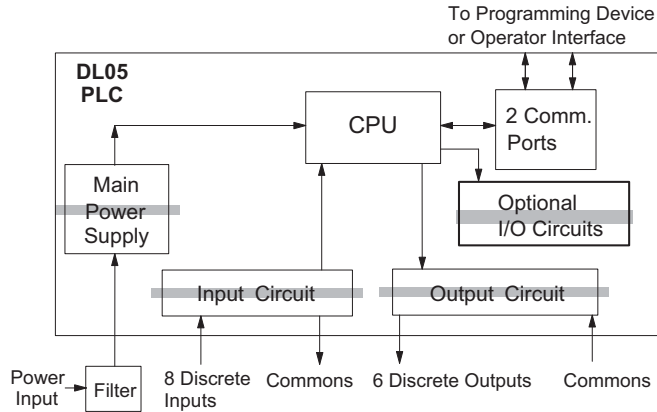
PLC Isolation Boundaries

PLC circuitry is divided into three main regions separated by isolation boundaries, shown in the drawing below. Electrical isolation provides safety, so that a fault in one area does not damage another. A powerline filter will provide isolation between the power source and the power supply. A transformer in the power supply provides magnetic isolation between the primary and secondary sides. Opto-couplers provide optical isolation in Input and Output circuits. This isolates logic circuitry from the field side, where factory machinery connects. Note that the discrete inputs are isolated from the discrete outputs, because each is isolated from the logic side. Isolation boundaries protect the operator interface (and the operator) from power input faults or field wiring faults. *When wiring a PLC, it is extremely important to avoid making external connections that connect logic side circuits to any other.*



The following figures show the internal layout of the DL05 and DL06 PLCs, as viewed from the front panels.

2



Sinking/Sourcing Concepts

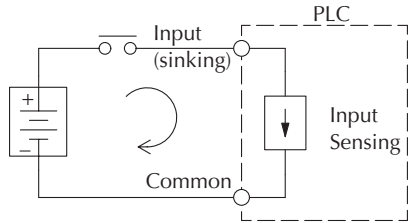
Before going further in our study of wiring strategies, we must have a solid understanding of “sinking” and “sourcing” concepts. Use of these terms occurs frequently in input or output circuit discussions. It is the goal of this section to make these concepts easy to understand, further ensuring your success in installation. First we give the following short definitions, followed by practical applications.

Sinking = Path to supply ground (-)

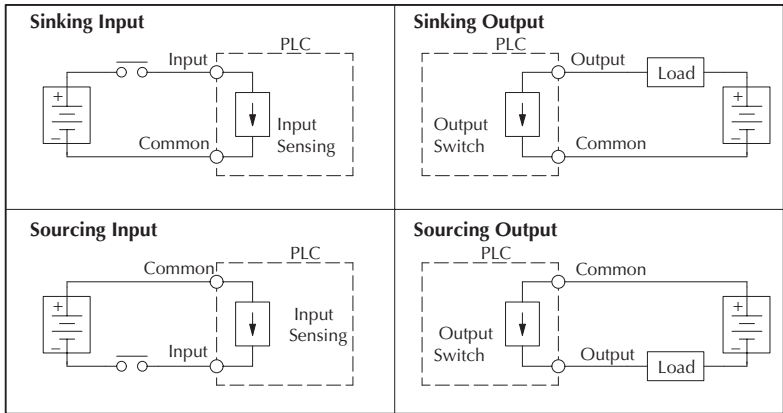
Sourcing = Path to supply source (+)

First you will notice that these are only associated with DC circuits and not AC, because of the reference to (+) and (-) polarities. Therefore, *sinking and sourcing terminology only applies to DC input and output circuits*. Input and output points that are either sinking or sourcing can conduct current in only one direction. This means it is possible to connect the external supply and field device to the I/O point with current trying to flow in the wrong direction, and the circuit will not operate. However, we can successfully connect the supply and field device every time by understanding “sourcing” and “sinking”.

For example, the figure to the right depicts a “sinking” input. To properly connect the external supply, we just have to connect it so the the input provides a path to ground (-). So, we start at the PLC input terminal, follow through the input sensing circuit, exit at the common terminal, and connect the supply (-) to the common terminal. By adding the switch, between the supply (+) and the input, we have completed the circuit. Current flows in the direction of the arrow when the switch is closed.

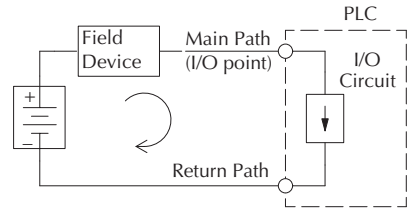


By applying the circuit principle above to the four possible combinations of input/output sinking/sourcing types, we have the four circuits as shown below. **DirectLOGIC** Micro PLCs provide all except the sourcing output I/O circuit types.

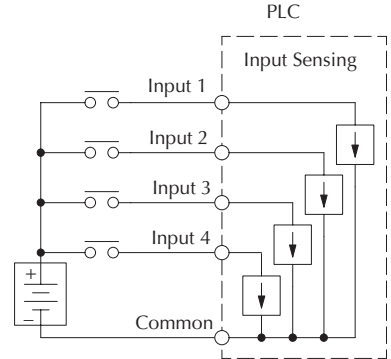


I/O “Common” Terminal Concepts

In order for a PLC I/O circuit to operate, current must enter at one terminal and exit at another. This means at least two terminals are associated with every I/O point. In the figure to the right, the Input or Output terminal is the *main path* for the current. One additional terminal must provide the *return path* to the power supply.

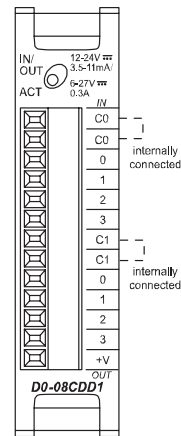


If we had unlimited space and budget for I/O terminals, then every I/O point could have two dedicated terminals just as the figure above shows. However, providing this level of flexibility is not practical or even necessary for most applications. So, most Input or Output point groups on PLCs share the return path among two or more I/O points. The figure to the right shows a group (or *bank*) of 4 input points which share a common return path. In this way, the four inputs require only five terminals instead of eight.



NOTE: In the circuit above, the current in the common path is equal to the sum of the energized channels. This is especially important in output circuits, where larger gauge wire is sometimes needed for the common.

Some of the input and output modules often share a common return path. The best indication of I/O common grouping is on the wiring label. The combination I/O module to the right is an exception. The inputs and the outputs have separate commons.

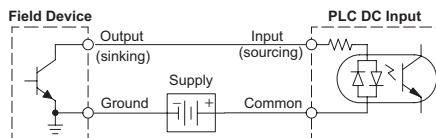


Connecting DC I/O to Solid State Field Devices

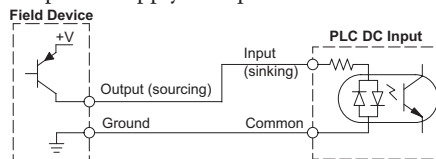
In the previous section on Sourcing/Sinking concepts, we explained that DC I/O circuits sometimes will only allow current to flow one way. This is also true for many of the field devices which have solid-state (transistor) interfaces. In other words, field devices can also be sourcing or sinking. *When connecting two devices in a series DC circuit, one must be wired as sourcing and the other as sinking.*

Solid State Input Sensors

The PLC DC inputs are flexible in that they detect current flow in either direction, so they can be wired as either sourcing or sinking. In the following circuit, a field device has an open-collector NPN transistor output. It sinks current from the PLC input point, which sources current. The source can be a FA-24PS, +24 VDC, power supply or another supply (+12 VDC or +24VDC) of your choice, as long as the input specifications are met.



In the next circuit, a field device has an open-emitter PNP transistor output. It sources current to the PLC input point, which sinks the current back to ground. Since the field device is sourcing current, no additional power supply is required.

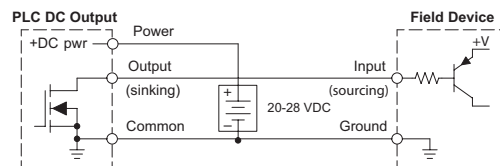


Solid State Output Loads

Sometimes an application requires connecting a PLC output point to a solid state input on a device. This type of connection is usually made to carry a low-level signal, not to send DC power to an actuator.

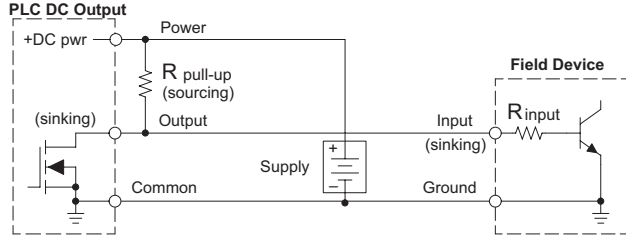
Some of the optional DC output modules are sinking-only. This means that each DC output provides a path to ground when it is energized. The six outputs of the DL05 have the same electrical common, even though there are two common terminal screws. Not so with the DL06 which has four isolated commons. Finally, recall that the DC output circuit requires power (20–28 VDC) from an external power source.

In the following circuit, the PLC output point sinks current to the output common when energized. It is connected to a sourcing input of a field device input.



In the next example we connect a PLC DC output point to the sinking input of a field device. This is a bit tricky, because both the PLC output and field device input are sinking type. Since the circuit must have one sourcing and one sinking device, we add sourcing capability to the PLC output by using a pull-up resistor. In the circuit below, we connect R_{pull-up} from the output to the DC output circuit power input.

2



NOTE: DO NOT attempt to drive a heavy load (>25 mA) with this pull-up method.



NOTE 2: Using the pull-up resistor to implement a sourcing output has the effect of inverting the output point logic. In other words, the field device input is energized when the PLC output is OFF, from a ladder logic point-of-view. Your ladder program must comprehend this and generate an inverted output. Or, you may choose to cancel the effect of the inversion elsewhere, such as in the field device.

It is important to choose the correct value of R_{pull-up}. In order to do so, we need to know the nominal input current to the field device (I_{input}) when the input is energized. If this value is not known, it can be calculated as shown (a typical value is 15 mA). Then use I_{input} and the voltage of the external supply to compute R_{pull-up}. Then calculate the power P_{pull-up} (in watts), in order to size R_{pull-up} properly.

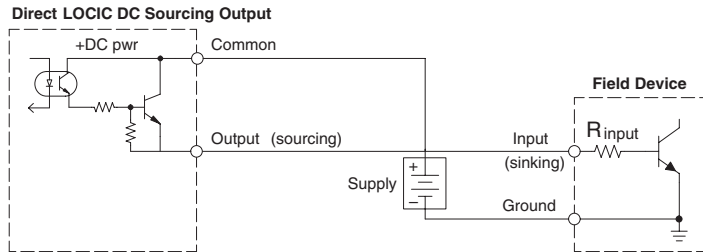
Of

$$I_{\text{input}} = \frac{V_{\text{input (turn-on)}}}{R_{\text{input}}}$$

$$R_{\text{pull-up}} = \frac{V_{\text{supply}} - 0.7}{I_{\text{input}}} - R_{\text{input}}$$

$$P_{\text{pull-up}} = \frac{V_{\text{supply}}^2}{R_{\text{pull-up}}}$$

course, the easiest way to drive a sinking input field device as shown below is to use a DC sourcing output module. The Darlington NPN stage will have about 1.5 V ON-state saturation, but this is not a problem with low-current solid-state loads.



Relay Output Guidelines

Relay outputs are available for the **DirectLOGIC** PLCs. Relays are best for the following applications:

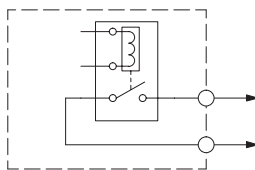
- Loads that require higher currents than the solid-state outputs can deliver
- Cost-sensitive applications
- Some output channels need isolation from other outputs (such as when some loads require different voltages than other loads)

Some applications in which NOT to use relays:

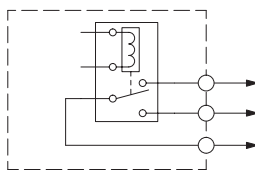
- Loads that require currents under 10 mA
- Loads which must be switched at high speed or heavy duty cycle

Relay outputs in the **DirectLOGIC** PLCs and modules are available in two contact arrangements, shown to the right. The Form A type, or SPST (single pole, single throw) type is normally open and is the simplest to use. The Form C type, or SPDT (single pole, double throw) type has a center contact which moves and a stationary contact on either side. This provides a normally closed contact and a normally open contact.

Relay with Form A contacts



Relay with Form C contacts

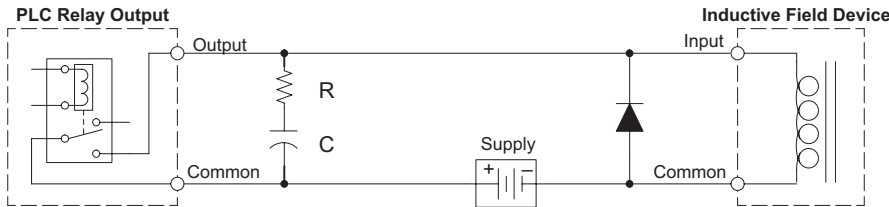


Some relay output module's relays share common terminals, which connect to the wiper contact in each relay of the bank. Other relay modules have relays which are completely isolated from each other. In all cases, the module drives the relay coil when the corresponding output point is on.

Prolonging Relay Contact Life

Relay contacts wear according to the amount of relay switching, amount of spark created at the time of open or closure, and presence of airborne contaminants. However, there are some steps you can take to help prolong the life of relay contacts:

- Switch the relay on or off only when the application requires it.
- If you have the option, switch the load on or off at a time when it will draw the least current.



Surge Suppression For Inductive Loads

Inductive load devices (devices with a coil) generate transient voltages when de-energized with a relay contact. When a relay contact is closed it “bounces”, which energizes and de-energizes the coil until the “bouncing” stops. The transient voltages generated are much larger in amplitude than the supply voltage, especially with a DC supply voltage.

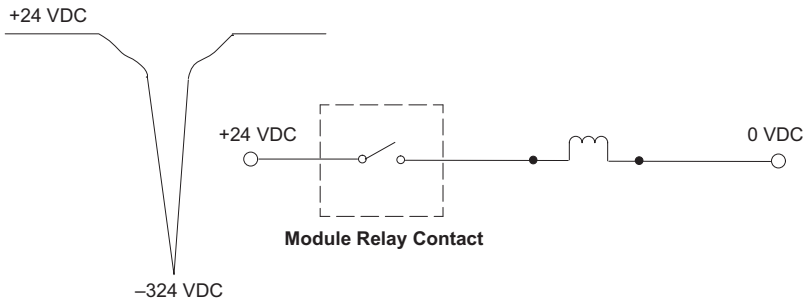
When switching a DC-supplied inductive load the full supply voltage is always present when the relay contact opens (or “bounces”). When switching an AC-supplied inductive load there is one chance in 60 (60 Hz) or 50 (50 Hz) that the relay contact will open (or “bounce”) when the AC sine wave is zero crossing. If the voltage is not zero when the relay contact opens there is energy stored in the inductor that is released when the voltage to the inductor is suddenly removed. This release of energy is the cause of the transient voltages.

When inductive load devices (motors, motor starters, interposing relays, solenoids, valves, etc.) are controlled with relay contacts, it is recommended that a surge suppression device be connected directly across the coil of the field device. If the inductive device has plug-type connectors, the suppression device can be installed on the terminal block of the relay output.

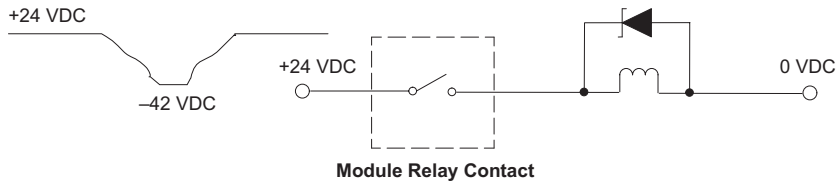
Transient Voltage Suppressors (TVS or transorb) provide the best surge and transient suppression of AC and DC powered coils, providing the fastest response with the smallest overshoot.

Metal Oxide Varistors (MOV) provide the next best surge and transient suppression of AC and DC powered coils.

For example, the waveform in the figure below shows the energy released when opening a contact switching a 24 VDC solenoid. Notice the large voltage spike.



This figure shows the same circuit with a transorb (TVS) across the coil. Notice that the voltage spike is significantly reduced.



Use the following table to help select a TVS or MOV suppressor for your application based on the inductive load voltage.

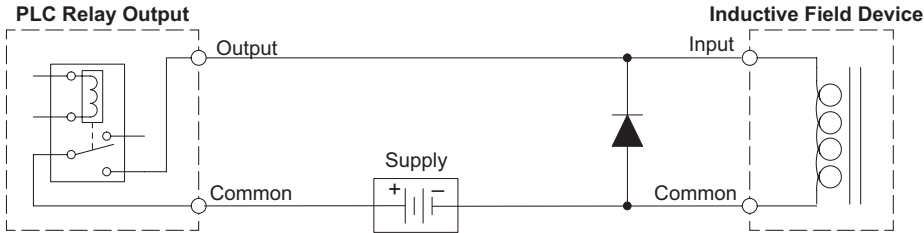
Surge Suppressors			
Vendor / Catalog	Type	Inductive Load Voltage	Part Number
AutomationDirect	TVS	110/120 VAC	ZL-TD8-120
Transient Voltage Suppressors, LiteOn Diodes; from Digi-Key Catalog: Phone: 1-800-344-4539	TVS	24 VDC	ZL-TD8-24
	TVS	220/240 VAC	P6KE350CA
	TVS	12/24 VDC	P6K30CAGICT-ND
	Diode	12/24 VDC	1N4004CT-ND
Digi-key www.digikey.com	MOV MOV	110/120 VAC 220/240 VAC	Contact Digi-Key, Corp.

Prolonging Relay Contact Life

Relay contacts wear according to the amount of relay switching, amount of spark created at the time of open or closure, and presence of airborne contaminants. There are some steps you can take to help prolong the life of relay contacts, such as switching the relay on or off only when it is necessary, and if possible, switching the load on or off at a time when it will draw the least current. Also, take measures to suppress inductive voltage spikes from inductive DC loads such as contactors and solenoids.

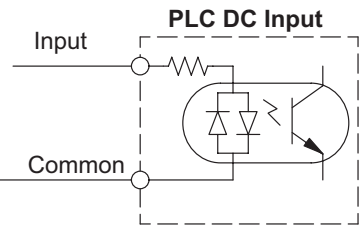
For inductive loads in DC circuits we recommend using a suppression diode as shown in the following diagram (DO NOT use this circuit with an AC power supply). When the load is energized the diode is reverse-biased (high impedance). When the load is turned off, energy stored in its coil is released in the form of a negative-going voltage spike. At this moment the diode is forward-biased (low impedance) and shunts the energy to ground. This protects the relay contacts from the high voltage arc that would occur just as the contacts are opening.

Place the diode as close to the inductive field device as possible. Use a diode with a peak inverse voltage rating (PIV) at least 100 PIV, 3A forward current or larger. Use a fast-recovery type (such as Schottky type). DO NOT use a small-signal diode such as 1N914, 1N941, etc. Be sure the diode is in the circuit correctly before operation. If installed backwards, it short-circuits the supply when the relay energizes.



DC Input Wiring Methods

DirectLOGIC Micro PLCs with DC inputs are particularly flexible because they can be either sinking or sourcing. The dual diodes (shown to the right) allow current to flow in either direction. The inputs accept 10.8–26.4 VDC. The target applications are +12 VDC and +24 VDC. You can actually wire half of the inputs as DC sinking and the other half as DC sourcing. Inputs grouped by a common must be all sinking or all sourcing.



DC Output Wiring Methods

The PLC DC output circuits are high-performance transistor switches with low on-resistance and fast switching times. Please note the following characteristics which are unique to the DC output type:

- The DL05 has only one electrical common for all six outputs. All six outputs belong to one bank.
- The DL05 output switches are current-sinking only. However, you can still use different DC voltages from one load to another.
- The DL06 has isolated commons for each group of four outputs. There are two DL06 models with output switches that are current-sinking only, and one that has sourcing output switches.
- The output circuit inside the PLC requires external power. The supply (–) must be connected to a common terminal, and the supply (+) connects the the right-most terminal on the upper connector.

Firmware and Software

The discrete option modules will only function properly in a DL05 with firmware version V4.10 (or later). If you have a DL05 with an earlier firmware version, the latest version can be downloaded from our website, www.automationdirect.com. If you are unable to download the latest firmware version along with the upgrade support tool software, call our technical support group to arrange to have your PLC upgraded.

The DL05 PLCs need to have *DirectSOFT32* Version 3.0c (or later) in order for the analog feature to perform properly. The DL06 must use *DirectSOFT32* Version 4.0 in order to use the option modules.

I/O Addressing

Module I/O Points and Addressing for the DL05 and DL06

Each discrete option module has a set number of I/O points. (This does not hold true for the analog modules). The following table shows the number of I/O points per module when used in the DL05 PLC or the first slot of a DL06 PLC that has a discrete module installed. Discrete I/O addressing for a DL06 is automatic from slot 1 to slot 4 by default.

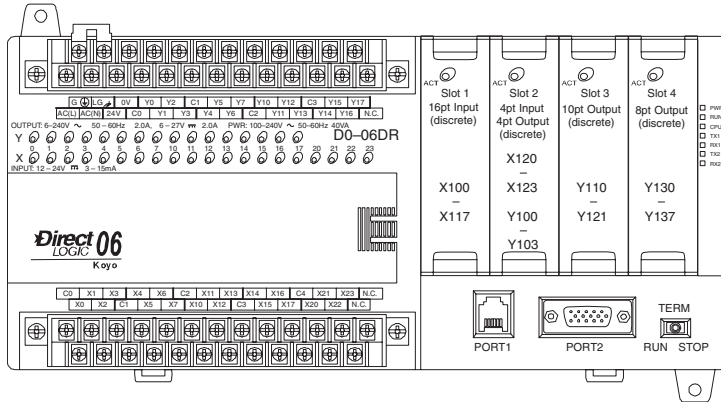
DC Input Modules	Physical I/O Points	Total I/O Points Consumed	Slot 1 I/O Address
F0-08SIM	8 Input	8 Input	X100 - X107
D0-10ND3	10 Input	16 Input (6 unused)	X100 - X107 and X110 - X111
D0-10ND3F	10 Input (fast)	16 Input (6 unused)	X100 - X107 and X110 - X111
D0-16ND3	16 Input	16 Input	X100 - X107 and X110 - X117
AC Input Modules	Physical I/O Points	Total I/O Points Consumed	Slot 1 I/O Address
F0-08NA-1	8 Input	8 Input*	X100 - X107
DC Output Modules	Physical I/O Points	Total I/O Points Consumed	Slot 1 I/O Address
D0-10TD1	10 Output	16 Output (6 unused)	Y100 - Y107 and Y110 - Y111
D0-16TD1	16 Output	16 Output	Y100 - Y107 and Y110 - Y117
D0-10TD2	10 Output	16 Output (6 unused)	Y100 - Y107 and Y110 - Y111
D0-16TD2	16 Output	16 Output	Y100 - Y107 and Y110 - Y117
Relay Output Modules	Physical I/O Points	Total I/O Points Consumed	Slot 1 I/O Address
D0-08TR	8 Output	8 Output*	Y100 - Y107
F0-04TRS	4 Output	8 Output (4 unused)*	Y100 - Y103
Combination Modules	Physical I/O Points	Total I/O Points Consumed	Slot 1 I/O Address
D0-07CDR	4 Input, 3 Output	8 Input (4 unused)*, 8 Output (5 unused)*	X100 - X103 and Y100 - Y102
D0-08CDD1	4 Input, 4 Output	8 Input (4 unused)*, 8 Output (4 unused)*	X100 - X103 and Y100 - Y103



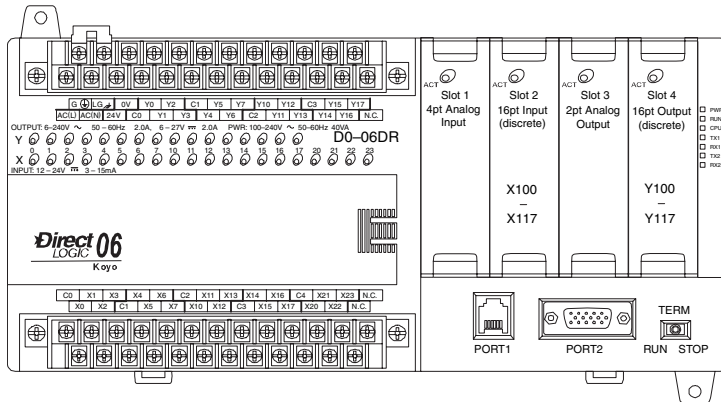
* The information shown above is for Automatic I/O Configuration, which can assign addresses in groups as small as 8 I/O points. If manual I/O Configuration is used, the smallest allowable address group size is 16 I/O points. Therefore, each manually configured I/O module will consume at least 16 X (input) and/or 16 Y (output) addresses.

The diagrams on the next page show examples of the DL06 I/O addressing with various option modules installed.

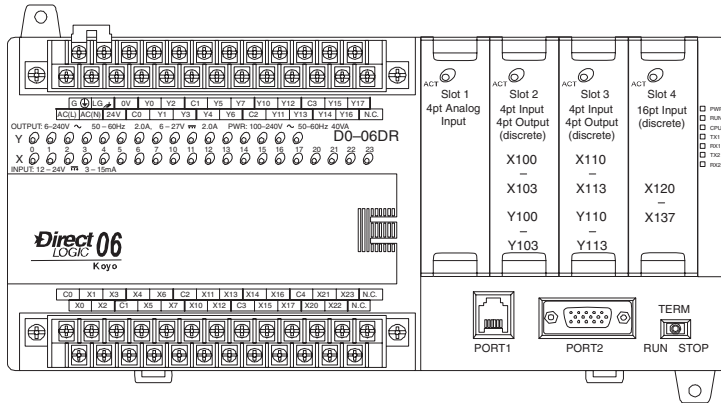
All Discrete Modules Installed I/O Addressing Example:



Discrete and Analog Modules Installed I/O Addressing Example:



Discrete and Analog Modules Installed I/O Addressing Example:



Discrete I/O General Specifications

The following is a list of general specifications for the discrete I/O option modules that are available for both the DL05 and DL06 PLCs. Also shown is information on the various removable connectors that are used for field wiring on the discrete I/O option modules along with reference to the *ZIPLink* connection system products that are available for the 16-point I/O modules.

General Specifications			
Operating Temperature	0 to 55 °C (32 to 131 °F)	Shock	MIL STD 810C 516.2
Storage Temperature	-20 to 70 °C (-4 to 158 °F)	Hi-pot	1500 VAC, 1 min.
Humidity	5 to 95% (non-condensing)	Insulation Resistance	More than 10M ohms at 500VDC
Environmental Air	No Corrosive gasses permitted	Noise Immunity	NEMA ICS3-304
Vibration	MIL STD 810C 514.2		

Discrete I/O Connector Specifications				
I/O Module	Connector	Wire Size	Screw Torque	Screwdriver Size
D0-10ND3	AutomationDirect replacement terminal kit p/n D0-ACC-4 or use Dinkle: EC350, 13-pin. *	22 - 16 AWG	0.39 Nm	DN-SS1 (recommended)
D0-10ND3F	AutomationDirect replacement terminal kit p/n D0-ACC-4 or use Dinkle: EC350, 13-pin. *	22 - 16 AWG	0.39 Nm	DN-SS1 (recommended)
D0-16ND3	ZIPLink ZL-CBL056 cable & ZL-CM056 conn. mod. or ZL-CBL056L cable & ZL-CM16L24 LED conn. mod. or build your own using a 24-pin Molex Micro Fit 3.0 receptacle, p/n 43025, or compatible.	(see ZIPLink specifications in AutomationDirect catalog under "Connection" tab.)		
F0-08NA-1	AutomationDirect replacement terminal kit p/n D0-ACC-4 or use Dinkle: EC350, 10-pin. *	22 - 16 AWG	0.39 Nm	DN-SS1 (recommended)
D0-10TD1	AutomationDirect replacement terminal kit p/n D0-ACC-4 or use Dinkle: EC350, 13-pin. *	22 - 16 AWG	0.39 Nm	DN-SS1 (recommended)
D0-16TD1	ZIPLink ZL-CBL056 cable & ZL-CM056 conn. mod. or ZL-CBL056FR cable & ZL-CM16RL24B relay mod. or ZL-CM16TF2 fuse mod. or build your own using a 24-pin Molex Micro Fit 3.0 receptacle, p/n 43025, or compatible.	(see ZIPLink specifications in AutomationDirect catalog under "Connection" tab.)		
D0-10TD2	AutomationDirect replacement terminal kit p/n D0-ACC-4 or use Dinkle: EC350, 13-pin. *	22 - 16 AWG	0.39 Nm	DN-SS1 (recommended)
D0-16TD2	ZIPLink ZL-CBL056 cable & ZL-CM056 conn. mod. or ZL-CBL056FR cable & ZL-CM16RL24B relay mod. or ZL-CM16TF2 fuse mod. or build your own using a 24-pin Molex Micro Fit 3.0 receptacle, p/n 43025, or compatible.	(see ZIPLink specifications in AutomationDirect catalog under "Connection" tab.)		
D0-07CDR	AutomationDirect replacement terminal kit p/n D0-ACC-4 or use Dinkle: EC350, 10-pin. *	22 - 16 AWG	0.39 Nm	DN-SS1 (recommended)
D0-08TR	AutomationDirect replacement terminal kit p/n D0-ACC-4 or use Dinkle: EC350, 10-pin. *	22 - 16 AWG	0.39 Nm	DN-SS1 (recommended)
D0-08CDD1	AutomationDirect replacement terminal kit p/n D0-ACC-4 or use Dinkle: EC350, 13-pin. *	22 - 16 AWG	0.39 Nm	DN-SS1 (recommended)
F0-04TRS	AutomationDirect replacement terminal kit p/n D0-ACC-4 or use Dinkle: EC350, 13-pin. *	22 - 16 AWG	0.39 Nm	DN-SS1 (recommended)

* I/O modules are supplied with connector; replacement terminal kit includes (2) 13-position & (2) 10-position terminal blocks.

Glossary of Specification Terms

2

Discrete Input

One of the input connections to the PLC which converts an electrical signal from a field device to a binary status (OFF or ON), which is read by the internal CPU each PLC scan.

Discrete Output

One of the output connections from the PLC which converts an internal ladder program result (0 or 1) to turn ON or OFF an output switching device. This enables the program to turn ON and OFF large field loads.

I/O Common

A connection in the input or output terminals which is shared by multiple I/O circuits. It usually is in the return path to the power supply of the I/O circuit.

Input Voltage Range

The operating voltage range of the input circuit.

Maximum Voltage

Maximum voltage allowed for the input circuit.

ON Voltage Level

The minimum voltage level at which the input point will turn ON.

OFF Voltage Level

The maximum voltage level at which the input point will turn OFF

Input Impedance

Input impedance can be used to calculate input current for a particular operating voltage.

Input Current

Typical operating current for an active (ON) input.

Minimum ON Current

The minimum current for the input circuit to operate reliably in the ON state.

Maximum OFF Current

The maximum current for the input circuit to operate reliably in the OFF state.

OFF to ON Response

The time the module requires to process an OFF to ON state transition.

ON to OFF Response

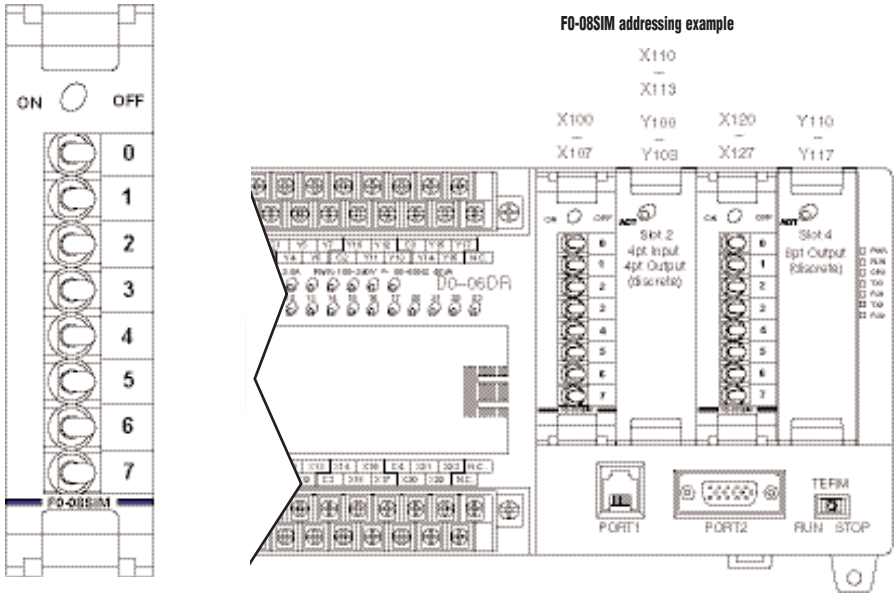
The time the module requires to process an ON to OFF state transition.

Status Indicators

The LEDs that indicate the ON/OFF status of an input or output point. All LEDs on the Micro PLCs are electrically located on the logic side of the input or output circuit.

F0-08SIM
8-Point Simulator Input Module

Input Specifications	
Number of Inputs	8
Status Indicators	None
Power Budget Requirements	1 mA @ 5 VDC (supplied by base)
Weight	45.36 g (1.6 oz.)

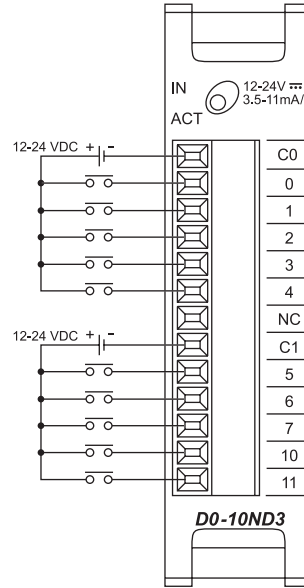


NOTE: The DL05 CPU's discrete feature for the F0-08SIM module requires **DirectSOFT32** Version 3.0c (or later) and firmware version 4.90 (or later). The DL06 requires **DirectSOFT32** version V4.0, build 16 (or later) and firmware version 1.80 (or later). See our website for more information: www.automationdirect.com.

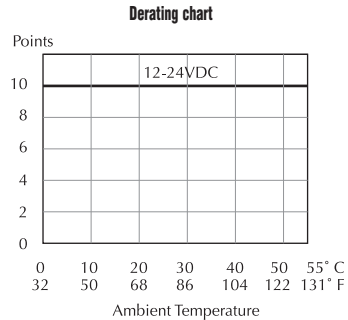
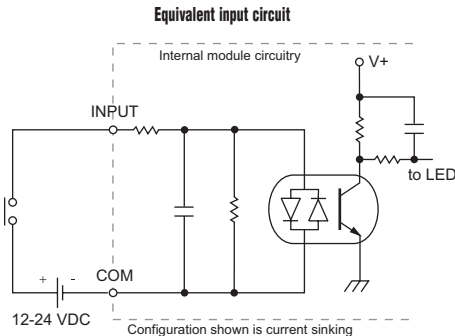
D0-10ND3 10-Point DC Input Module

2

Input Specifications	
Number of Inputs	10 (sink/source)
Input Voltage Range	10.8-26.4 VDC
Operating Voltage Range	12-24 VDC
Peak Voltage	30.0 VDC
Input Current	Typical: 4.0 mA @ 12 VDC 8.5 mA @ 24 VDC
Maximum Input Current	11 mA @ 26.4 VDC
Input Impedance	2.8 K Ω @ 12-24 VDC
On Voltage Level	> 10.0 VDC
Off Voltage Level	< 2.0 VDC
Minimum ON Current	3.5 mA
Minimum OFF Current	0.5 mA
Off to On Response	2-8 ms, Typ. 4 ms
On to Off Response	2-8 ms, Typ. 4 ms
Status Indicators	Module activity: one green LED
Commons	2 (5 pts/common) Isolated
Fuse	No fuse
Power Budget Requirements	35 mA @ 5 VDC (supplied by base), (all pts ON)
Dimensions (mm)	19.8(W) x 76.8(H) x 53.9(D)
Weight	32 g (1.13 oz.)

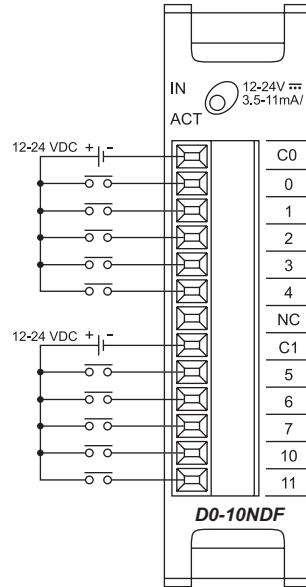


NOTE: The DL05 CPU's discrete feature for this module requires **DirectSOFT32** Version 3.0c (or later) and firmware version 4.10 (or later). The DL06 requires **DirectSOFT32** version V4.0, build 16 (or later) and firmware version 1.00 (or later). See our website for more information: www.automationdirect.com.

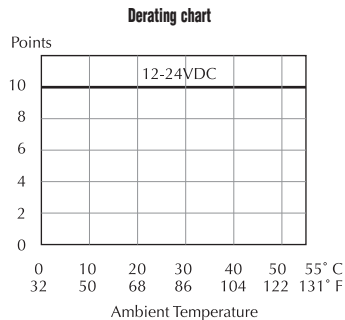
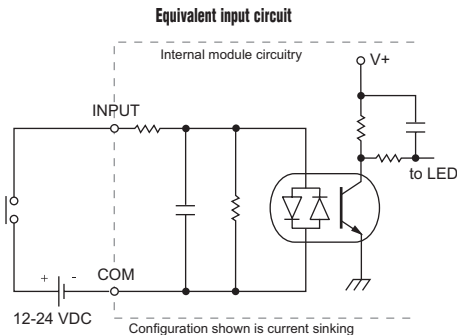


D0-10ND3F 10-Point DC Fast Input Module

Input Specifications	
Number of Inputs	10 (sink/source)
Input Voltage Range	10.8-26.4 VDC
Operating Voltage Range	12-24 VDC
Peak Voltage	30.0 VDC
Input Current	Typical: 4.0 mA @ 12 VDC 8.5 mA @ 24 VDC
Maximum Input Current	11 mA @ 26.4 VDC
Input Impedance	2.8 KΩ @ 12-24 VDC
On Voltage Level	> 10.0 VDC
Off Voltage Level	< 2.0 VDC
Minimum ON Current	3.5 mA
Minimum OFF Current	0.5 mA
Off to On Response	2 ms, Typ. 1 ms
On to Off Response	2 ms, Typ. 1 ms
Status Indicators	Module activity: one green LED
Commons	2 (5 pts/common) Isolated
Fuse	No fuse
Power Budget Requirements	35 mA @ 5 VDC (supplied by base), (all pts ON)
Dimensions (mm)	19.8(W) x 76.8(H) x 53.9(D)
Weight	32 g (1.13 oz.)



NOTE: The DL05 CPU's discrete feature for this module requires **DirectSOFT32** Version 3.0c (or later) and firmware version 4.70 (or later). The DL06 requires **DirectSOFT32** version V4.0, build 16 (or later) and firmware version 1.50 (or later). See our website for more information: www.automationdirect.com.

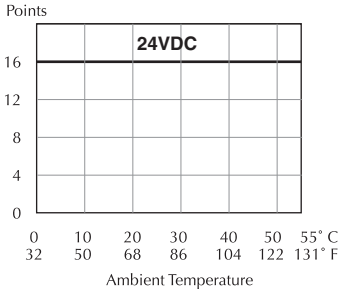


D0-16ND3 16-Point DC Input Module

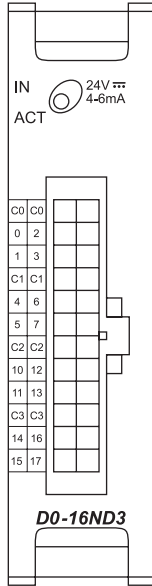
Input Specifications

Number of Inputs	16 (sink/source)
Input Voltage Range	20-28 VDC
Operating Voltage Range	24 VDC
Peak Voltage	30.0 VDC
Input Current	Typical: 4.0 mA @ 24 VDC
Maximum Input Current	6 mA @ 28 VDC
Input Impedance	4.7 K Ω @ 24 VDC
On Voltage Level	> 19.0 VDC
Off Voltage Level	< 7.0 VDC
Minimum ON Current	3.5 mA
Minimum OFF Current	1.5 mA
Off to on Response	2-8 ms, Typ. 4 ms
On to off Response	2-8 ms, Typ. 4 ms
Status Indicators	Module activity: one green LED
Commons	4 (4 pts/common) Isolated
Fuse	No fuse
Power Budget Requirements	35 mA @ 5 VDC (supplied by base), (all pts ON)
Dimensions (mm)	19.8(W) x 76.8(H) x 53.9(D)
Weight	20 g (0.71 oz.)

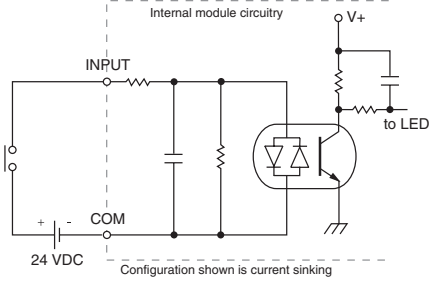
Derating chart



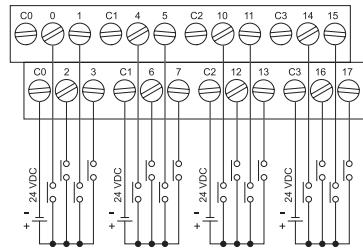
Use ZipLink ZL-CBL056 cable and ZL-CM056 connector module, or ZL-CBL056L cable and ZL-CM16L24 LED connector module. You can also build your own cables using 24-pin Molex Micro Fit 3.0 receptacle, part number 43025, or compatible.



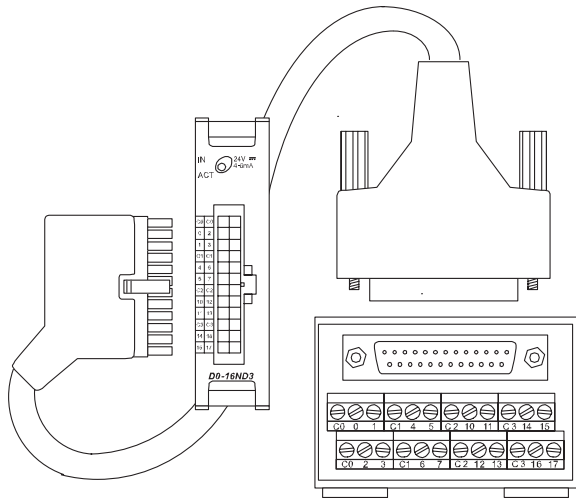
Equivalent input circuit



Wiring for ZL-CM056

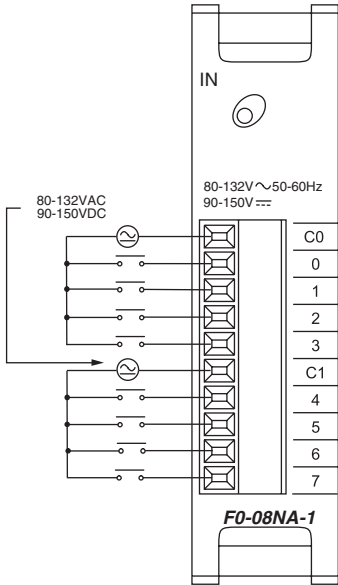


NOTE: The DL05 CPU's discrete feature for this module requires **DirectSOFT32** Version 3.0c (or later) and firmware version 4.10 (or later). The DL06 requires **DirectSOFT32** version V4.0, build 16 (or later) and firmware version 1.00 (or later). See our website for more information: www.automationdirect.com.



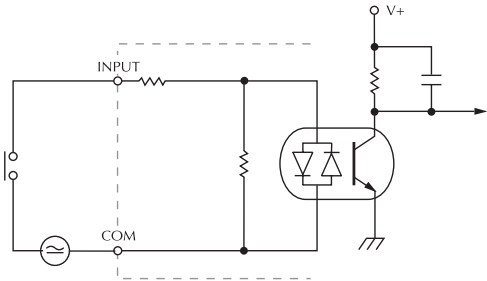
F0-08NA-1
8-Point AC Input Module

Input Specifications	
Number of Inputs	8
Input Voltage Range	80-132 VAC (90-150 VDC)
AC Frequency	47-63 Hz
Input Current	4.0 mA @ 132 VAC
Input Impedance	33 KΩ
On Voltage Level	80 VAC minimum
Off Voltage Level	20 VAC maximum
Minimum On Current	2.4 mA
Maximum Off Current	1.6 mA
Off to On Response	< 20 ms
On to Off Response	< 10 ms
Status Indicators	None
Commons	2 (4 pts/common) Isolated
Fuse	No fuse
Power Budget Requirements	5 mA @ 5 VDC (supplied by base), (all pts ON)
Dimensions (mm)	19.8(W) x 76.8(H) x 53.9(D)
Weight	31.2 g (1.1 oz.)

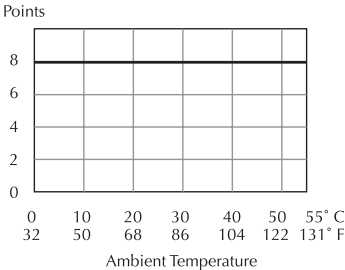


NOTE: The DL05 CPU's discrete feature for this module requires **DirectSOFT32 Version 3.0c** (or later) and firmware version 4.70 (or later). The DL06 requires **DirectSOFT32 version V4.0, build 16** (or later) and firmware version 1.50 (or later). See our website for more information: www.automationdirect.com.

Equivalent input circuit



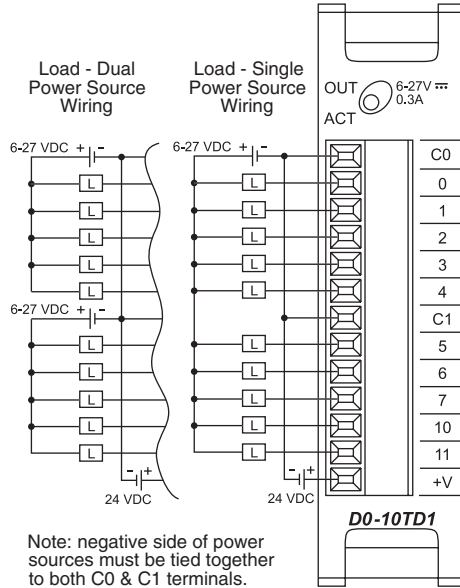
Derating chart



D0-10TD1 10-Point DC Output Module

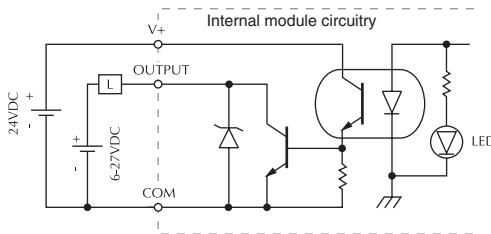
Output Specifications

Number of Outputs	10 (sinking)
Operating Voltage Range	6-27 VDC
Output Voltage Range	5-30 VDC
Peak Voltage	50.0 VDC
Maximum Output Current	0.3 A/point 1.5 A/common
Minimum Output Current	0.5 mA
ON Voltage Drop	0.5 VDC @ 0.3 A
Maximum Leakage Current	15 μ A @ 30.0 VDC
Maximum Inrush Current	1 A for 10 ms
OFF to ON Response	< 10 μ s
ON to OFF Response	< 60 μ s
Status Indicators	Module activity: one green LED
Commons	2 (5 points/common) Non-isolated
Fuse	No fuse
Power Budget Requirements	Max. 150 mA @ 5 VDC (supplied by base), (all pts. ON)
External DC Power Required	20-28 VDC max. 200 mA (all pts. ON)
Dimensions (mm)	19.8(W) x 76.8(H) x 53.9(D)
Weight	34 g (1.20 oz.)

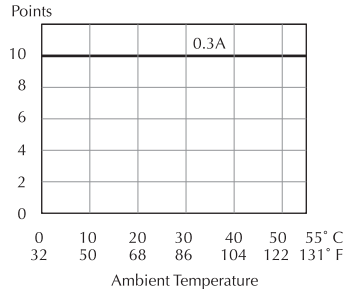


NOTE: The DL05 CPU's discrete feature for this module requires **DirectSOFT32** Version 3.0c (or later) and firmware version 4.10 (or later). The DL06 requires **DirectSOFT32** version V4.0, build 16 (or later) and firmware version 1.00 (or later). See our website for more information: www.automationdirect.com.

Equivalent output circuit

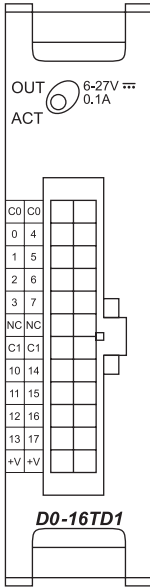


Derating chart

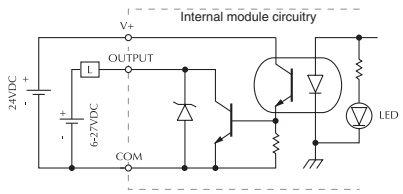


D0-16TD1 16-Point DC Output Module

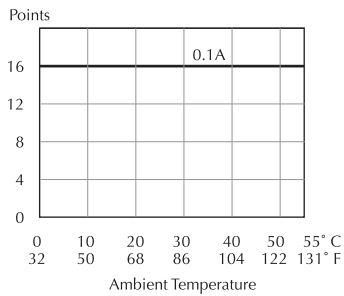
Output Specifications	
Number of Outputs	16 (sinking)
Operating Voltage Range	6-27 VDC
Output Voltage Range	5-30 VDC
Peak Voltage	50.0 VDC
Maximum Output Current	0.1 A/point 0.8 A/common
Minimum Output Current	0.5 mA
ON Voltage Drop	0.5VDC @ 0.1 A
Maximum Leakage Current	15 µA @ 30.0 VDC
Maximum Inrush Current	1 A for 10 ms
OFF to ON Response	< 0.5 ms
ON to OFF Response	< 0.5 ms
Status Indicators	Module activity: one green LED
Commons	2 (8 points/common) Non-isolated
Fuse	No fuse
Power Budget Requirements	Max. 200 mA @ 5 VDC (supplied by base), (all pts. ON)
External DC Power Required	20-28 VDC max 70 mA (all pts. ON)
Dimensions (mm)	19.8(W) x 76.8(H) x 53.9(D)
Weight	22 g (0.78 oz.)



Equivalent input circuit

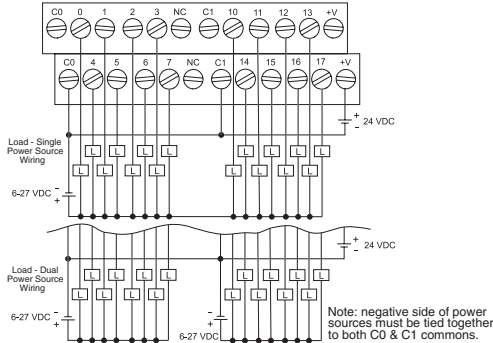


Derating chart

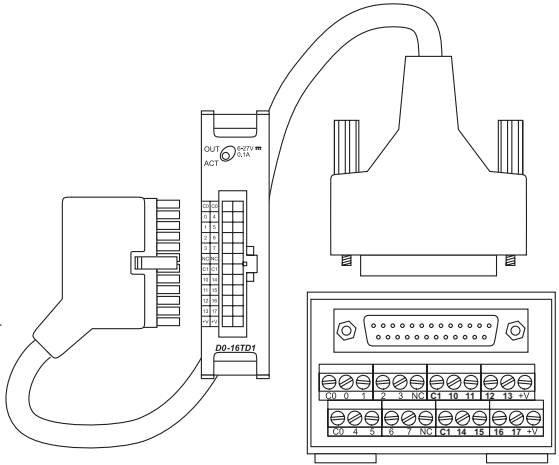


NOTE: The DL05 CPU's discrete feature for this module requires **DirectSOFT32** Version 3.0c (or later) and firmware version 4.10 (or later). The DL06 requires **DirectSOFT32** version V4.0, build 16 (or later) and firmware version 1.00 (or later). See our website for more information: www.automationdirect.com.

Wiring for ZL-CM056



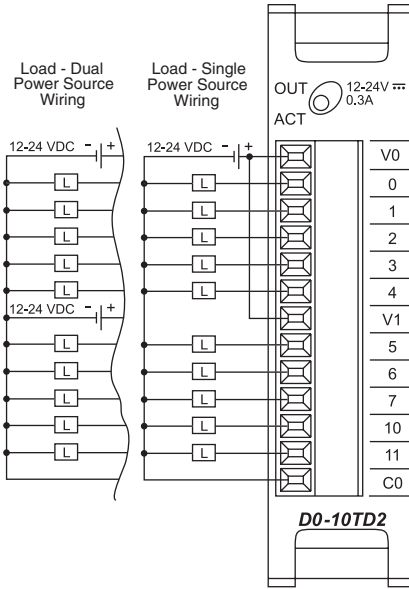
Use ZipLink ZL-CBL056 cable and ZL-CM056 connector module, or ZL-CBL056FR cable and ZL-CM16RL24B relay module or ZL-CM16TF2 fuse module. You can also build your own cables using 24-pin Molex Micro Fit 3.0 receptacle, part number 43025, or compatible.



D0-10TD2 10-Point DC Output Module

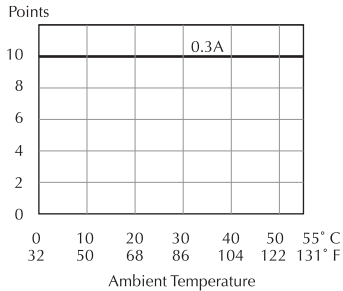
Output Specifications

Number of Outputs	10 (sourcing)
Operating Voltage Range	12-24 VDC
Output Voltage Range	10.8-26.4 VDC
Peak Voltage	50.0 VDC
Maximum Output Current	0.3 A/point 1.5 A/common
Minimum Output Current	0.5 mA
ON Voltage Drop	1.0 VDC @ 0.3 A
Maximum Leakage Current	1.5 μ A @ 30.0 VDC
Maximum Inrush Current	1 A for 10 ms
OFF to ON Response	< 10 μ s
ON to OFF Response	< 60 μ s
Status Indicators	Module activity: one green LED
+V Terminals & Common	2 (5 points/+V Terminal) Isolated, 1 Common
Fuse	No fuse
Power Budget Requirements	Max. 150 mA @ 5 VDC (supplied by base), (all pts. ON)
Dimensions (mm)	19.8(W) x 76.8(H) x 53.9(D)
Weight	38 g (1.34 oz.)

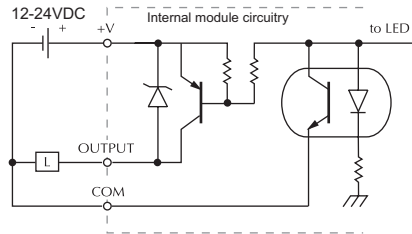


NOTE: The DL05 CPU's discrete feature for this module requires **DirectSOFT32** Version 3.0c (or later) and firmware version 4.10 (or later). The DL06 requires **DirectSOFT32** version V4.0, build 16 (or later) and firmware version 1.00 (or later). See our website for more information: www.automationdirect.com.

Derating chart

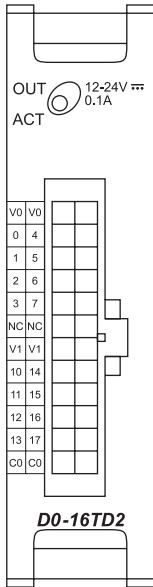


Equivalent output circuit

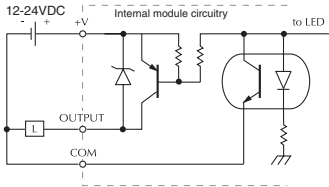


D0-16TD2 16-Point DC Output Module

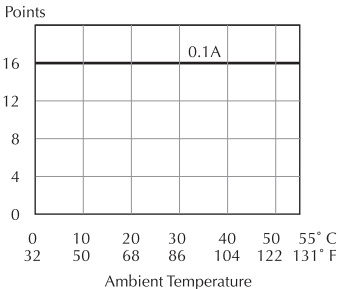
Output Specifications	
Number of Outputs	16 (sourcing)
Operating Voltage Range	12-24 VDC
Output Voltage Range	10.8-26.4 VDC
Peak Voltage	50.0 VDC
Maximum Output Current	0.1 A/point, 0.8 A/common
Minimum Output Current	0.5 mA
ON Voltage Drop	1.0VDC @ 0.1 A
Maximum Leakage Current	1.5 µA @ 26.4 VDC
Maximum Inrush Current	1 A for 10 ms
OFF to ON Response	< 0.5 ms
ON to OFF Response	< 0.5 ms
Status Indicators	Module activity: one green LED
+V Terminals & Common	2 (8 points/+V Terminal) Isolated, 1 Common
Fuse	No fuse
Power Budget Requirements	Max. 200 mA @ 5 VDC (supplied by base), (all pts. ON)
Dimensions (mm)	19.8(W) x 76.8(H) x 53.9(D)
Weight	22 g (0.78 oz.)



Equivalent output circuit

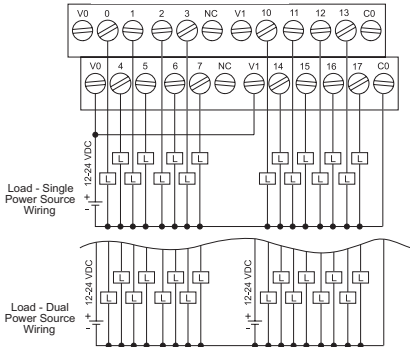


Derating chart

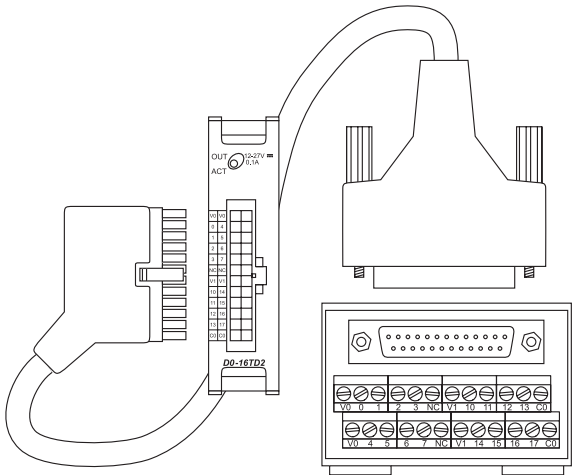


NOTE: The DL05 CPU's discrete feature for this module requires **DirectSOFT32** Version 3.0c (or later) and firmware version 4.10 (or later). The DL06 requires **DirectSOFT32** version V4.0, build 16 (or later) and firmware version 1.00 (or later). See our website for more information: www.automationdirect.com.

Wiring for ZL-CM056



Use ZipLink ZL-CBL056 cable and ZL-CM056 connector module, or ZL-CBL056FR cable and ZL-CM16RL24B relay module or ZL-CM16TF2 fuse module. You can also build your own cables using 24-pin Molex Micro Fit 3.0 receptacle, part number 43025, or compatible.



D0-07CDR 4-Point DC Input and 3-Point Relay Output Module

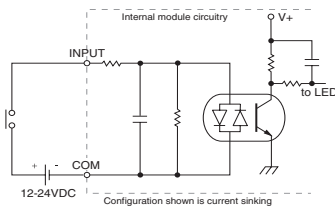
2

Input Specifications		Output Specifications	
Number of Inputs	4 (sink/source)	Number of Outputs	3
Operating Voltage Range	12-24 VDC	Operating Voltage Range	6-27 VDC/6-240 VAC
Input Voltage Range	10.8-26.4 VDC	Output Type	Relay, form A, SPST
Peak Voltage	30.0 VDC	Peak Voltage	30.0 VDC/264 VAC
Maximum Input Current	11 mA @ 26.4 VDC	Maximum Current (Resistive)	1 A/point, 4 A/common
Input Current	Typical: 4 mA @ 12 VDC 8.5 mA @ 24 VDC	Minimum Load Current	5 mA @ 5 VDC
Input Impedance	2.8 K Ω @ 12-24 VDC	Maximum Leakage Current	0.1 mA @ 264 VAC
ON Voltage Level	> 10.0 VDC	ON Voltage Drop	N/A
OFF Voltage Level	< 2.0 VDC	Maximum Inrush Current	Output 3 A for 10 ms, Comm: 10 A for 10 ms
Minimum ON Current	3.5 mA	OFF to ON Response	< 15 ms
Maximum OFF Current	0.5 mA	ON to OFF Response	< 10 ms
OFF to ON Response	2-8 ms, typical 4 ms	Status Indicators	Module activity: one green LED
ON to OFF Response	2-8 ms, typical 4 ms	Commons	1 (3 points/common)
Commons	1 (4 points/common)	Fuse	No fuse
Power Budget Requirements	Max. 200 mA @ 5 VDC (supplied by base), (all pts. ON)	Dimensions (mm)	19.8(W) x 76.8(H) x 53.9(D)
		Weight	38 g (1.34 oz.)

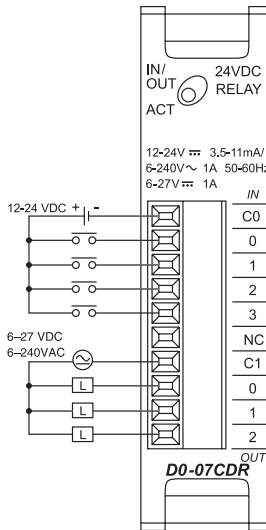
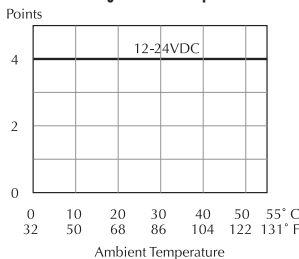


NOTE: The DL05 CPU's discrete feature for this module requires **DirectSOFT32 Version 3.0c** (or later) and firmware version 4.10 (or later). The DL06 requires **DirectSOFT32 version V4.0, build 16** (or later) and firmware version 1.00 (or later). See our website for more information: www.automatindirect.com.

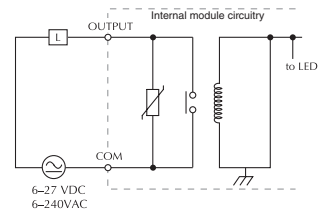
Equivalent input circuit



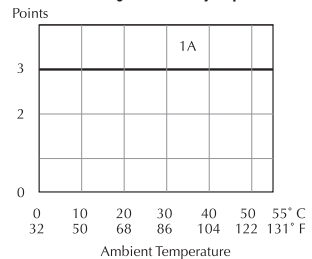
Derating chart for DC inputs



Equivalent output circuit

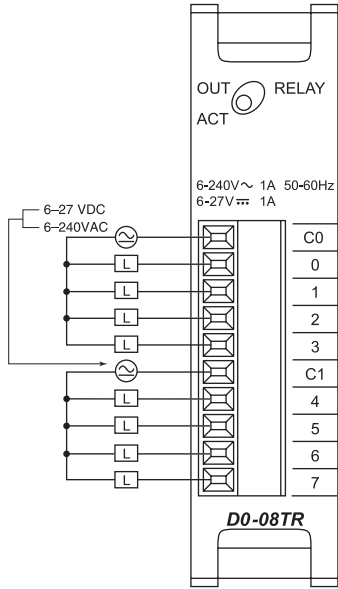


Derating chart for relay outputs

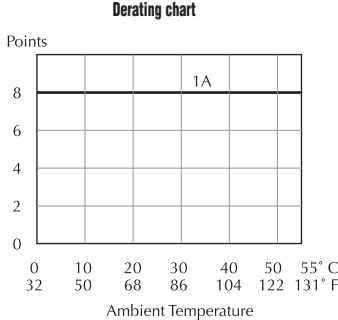
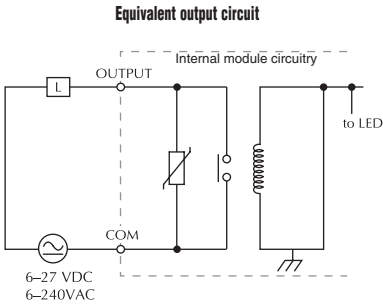


D0-08TR
8-Point Relay Output Module

Output Specifications	
Number of Outputs	8
Operating Voltage Range	6-27 VDC/6-240 VAC
Output Type	Relay, form A, SPST
Peak Voltage	30.0 VDC/264 VAC
Maximum Current (Resistive)	1 A/point, 4 A/common
Minimum Load Current	0.5mA
Maximum Leakage Current	0.1 mA @ 264 VAC
ON Voltage Drop	N/A
Maximum Inrush Current	Output: 3A for 10 ms, Common: 10A for 10 ms
OFF to ON Response	< 15 ms
ON to OFF Response	< 10 ms
Status Indicators	Module activity: one green LED
Commons	2 Isolated. (4 points/common)
Fuse	No fuse
Power Budget Requirements	Max. 280 mA @ 5 VDC (supplied by base), (all pts. ON)
Dimensions (mm)	19.8(W) x 76.8(H) x 53.9(D)
Weight	55 g (1.94 oz.)



NOTE: The DL05 CPU's discrete feature for this module requires **DirectSOFT32** Version 3.0c (or later) and firmware version 4.10 (or later). The DL06 requires **DirectSOFT32** version V4.0, build 16 (or later) and firmware version 1.00 (or later). See our website for more information: www.automationdirect.com.



D0-08CDD1 4-Point DC Input and 4-Point DC Output Module

2

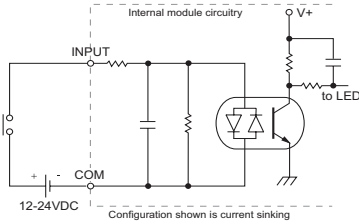
Input Specifications	
Number of Inputs	4 (sink/source)
Operating Voltage Range	10.8-26.4 VDC
Input Voltage Range	12-24 VDC
Peak Voltage	30.0 VDC
Maximum Input Current	11 mA @ 26.4 VDC
Input Current	Typical: 4 mA @ 12 VDC 8.5 mA @ 24 VDC
Input Impedance	2.8 K Ω @ 12-24 VDC
ON Voltage Level	> 10.0 VDC
OFF Voltage Level	< 2.0 VDC
Minimum ON Current	3.5 mA
Maximum OFF Current	0.5 mA
OFF to ON Response	2-8 ms, typical 4 ms
ON to OFF Response	2-8 ms, typical 4 ms
Commons	2 Non-isolated
External DC Power Required	20-28 VDC, max. 80 mA (all pts. ON)
Power Budget Requirements	Max. 200 mA @ 5 VDC (supplied by base), (all pts. ON)

Output Specifications	
Number of Outputs	4 (sinking)
Operating Voltage Range	6-27 VDC
Output Voltage Range	5-30 VDC
Peak Voltage	50.0 VDC
Maximum Output Current	0.3 A/point, 1.2 A/common
Minimum Output Current	0.5 mA
Maximum Leakage Current	1.5 μ A @ 30.0 VDC
ON Voltage Drop	0.5 VDC @ 0.3 A
Maximum Inrush Current	1 A for 10 ms
OFF to ON Response	< 10 μ s
ON to OFF Response	< 60 μ s
Status indicators	Module activity: one green LED
Commons	2 Non-isolated
Fuse	No fuse
Dimensions (mm)	19.8(W) x 76.8(H) x 53.9(D)
Weight	34 g (1.20 oz.)

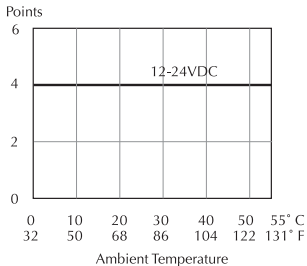


NOTE: The DL05 CPU's discrete feature for this module requires **DirectSOFT32** Version 3.0c (or later) and firmware version 4.10 (or later). The DL06 requires **DirectSOFT32** version V4.0, build 16 (or later) and firmware version 1.00 (or later). See our website for more information: www.automationdirect.com.

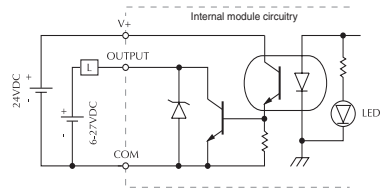
Equivalent input circuit



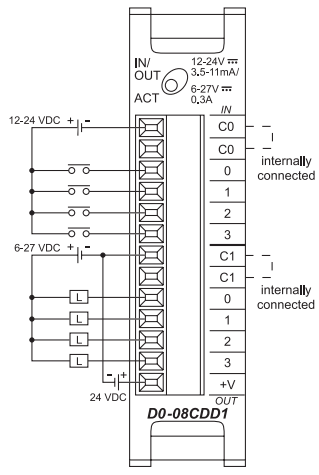
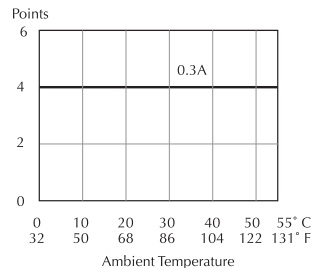
Input Derating Chart



Equivalent output circuit

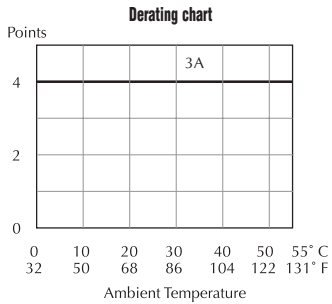
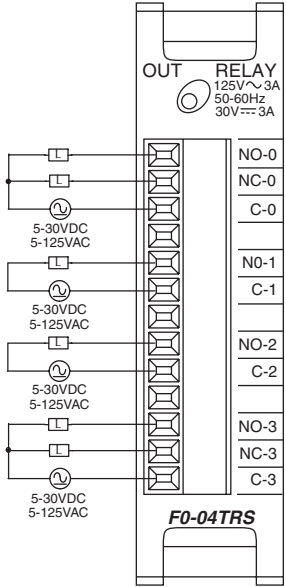


Output Derating chart



F0-04TRS
4-Point Relay Output Module

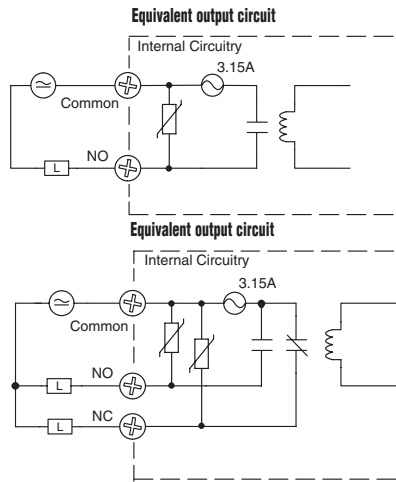
Output Specifications	
Number of Outputs	4
Operating Voltage Range	5-30 VDC/5-125 VAC
Output Type	2 - form C (SPDT) 2 - form A (SPST normally open)
Peak Voltage	60 VDC/220 VAC
AC Frequency	47-63 Hz
Maximum Current (Resistive)	3 A/point with no derating
Minimum Load Current	10 mA @ 5 VDC
Maximum Leakage Current	N/A
ON Voltage Drop	N/A
Maximum Inrush Current	5 A
OFF to ON Response	≤ 5 ms (typical)
ON to OFF Response	≤ 5 ms (typical)
Status Indicators	None
Commons	4 Isolated
Fuse	4, IEC 3.15 A, replaceable, D2-FUSE-1
Power Budget Requirements	Max. 250 mA @ 5 VDC (supplied by base), (all pts. ON)
Dimensions (mm)	19.8(W) x 76.8(H) x 53.9(D)
Weight	51 g (1.8 oz.)



NOTE: The DL05 CPU's discrete feature for this module requires **DirectSOFT32 Version 3.0c (or later)** and firmware version 4.70 (or later). The DL06 requires **DirectSOFT32 version V4.0, build 16 (or later)** and firmware version 1.50 (or later). See our website for more information: www.automationdirect.com.

F0-04TRS Typical Relay Life at 30 Operations per Minute			
Load Type	Rated Voltage	Rated Current	Number of Operations
Resistive	120VAC	3A	120,000
Resistive	120VAC	1A	550,000
Resistive	24VDC	1A	>2M
Inductive: SC-E5 Motor Starter	24VDC	0.2A	>2M (see Note)
Inductive: SC-E5 Motor Starter	120VAC	0.1A operating 1.7A fault	>2M (see Note)

Note: Transient suppression must be installed with inductive loads.



F0-04AD-1 4-Ch. ANALOG CURRENT INPUT



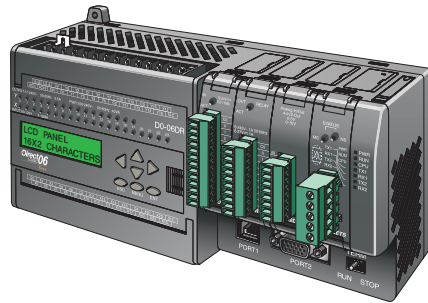
In This Chapter...

Module Specifications	3-2
Setting the Module Jumper	3-4
Connecting and Disconnecting the Field Wiring	3-4
Wiring Diagram	3-5
Module Operation	3-6
Special V-memory Locations	3-7
Using the Pointer in Your Control Program	3-9
Detecting Input Signal Loss	3-11
Scale Conversions	3-11
Special Relays	3-13
Module Resolution	3-15
Analog Input Ladder Logic Filter	3-16

Module Specifications

The F0-04AD-1 Analog Input module offers the following features:

- The DL05 and DL06 will read all four channels in one scan.
- The removable terminal block makes it possible to remove the module without disconnecting the field wiring.
- Analog inputs can be used as process variables for the four (4) PID loops in the DL05 and the eight (8) PID loops in the DL06 CPUs.
- Field device burn-out is detected on all four channels when 4–20mA range is selected.
- On-board active analog filtering and RISC-like microcontroller provide digital signal processing to maintain precise analog measurements in noisy environments.



NOTE: The DL05 CPU's analog feature for this module requires **DirectSOFT32** Version 3.0c (or later) and firmware version 2.10 (or later). The DL06 requires **DirectSOFT32** version V4.0, build 16 (or later) and firmware version 1.00 (or later). See our website for more information: www.automationdirect.com.

The following tables provide the specifications for the F0-04AD-1 Analog Input Module. Review these specifications to make sure the module meets your application requirements.

Input Specifications	
Number of Channels	4, single ended (one common)
Input Range	0 to 20 mA or 4 to 20 mA current (jumper selectable)
Resolution	12 bit (1 in 4096) for 0-20mA, scaled for 4-20mA
Step Response	25.0 mS (typ) to 95% of full step change
Crosstalk	-80 dB, 1/2 count maximum *
Active Low-pass Filtering	-3 dB at 40Hz (-12 dB per octave)
Input Impedance	125 Ohm \pm 0.1%, 1/8 W current input
Absolute Maximum Ratings	-30 mA to +30 mA current input
Converter type	Successive approximation
Linearity Error (End to End)	\pm 2 counts maximum *
Input Stability	\pm 1 count *
Full Scale Calibration Error (Offset error not included)	\pm 10 counts maximum, @ 20mA current input*
Offset Calibration Error	\pm 5 counts maximum @ 4mA current input *
Maximum Inaccuracy	\pm 0.4% @ 25°C (77°F) \pm 0.85% 0 to 60°C (32 to 140°F)
Accuracy vs. Temperature	\pm 100 ppm/ °C maximum full scale calibration (including maximum offset change)
Recommended Fuse (external)	0.032 A Series 217 fast-acting current inputs

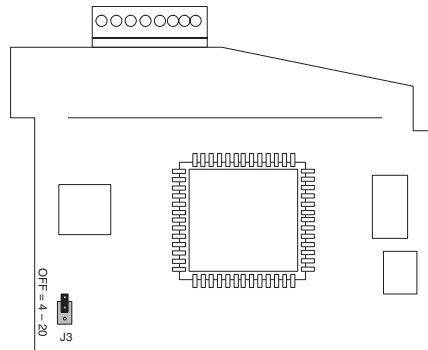
* One count in the specification table is equal to one least significant bit of the analog data value (1 in 4096).

General Specifications	
PLC Update Rate	4 channels per scan
16-bit Data Word	12 binary data bits 2 channel ID bits 2 diagnostic bits
Operating Temperature	0 to 60° C (32 to 140°F)
Storage Temperature	-20 to 70°C (-4 to 158°F)
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
Power Budget Requirement	50 mA @ 5VDC (supplied by base)
Connector	Phoenix Mecano, Inc. Part No. AK1550/8-3.5 - green
Connector Wire Size	28 - 16 AWG
Connector Screw Torque	0.4 Nm
Connector Screwdriver Size	DN-SS1 (recommended)

Setting the Module Jumper

The position of jumper J3 determines the input signal level. You can choose between 4–20mA and 0–20mA. The module ships with the jumper not connecting the two pins. In this position, the expected input signal is 4–20mA. To select 0–20mA signals, use the jumper to cover both pins.

The default jumper setting selects a 4–20mA signal source. The default jumper setting does not connect the two pins.



WARNING: Before removing the analog module or the terminal block on the face of the module, disconnect power to the PLC and all field devices. Failure to disconnect power can result in damage to the PLC and/or field devices.

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

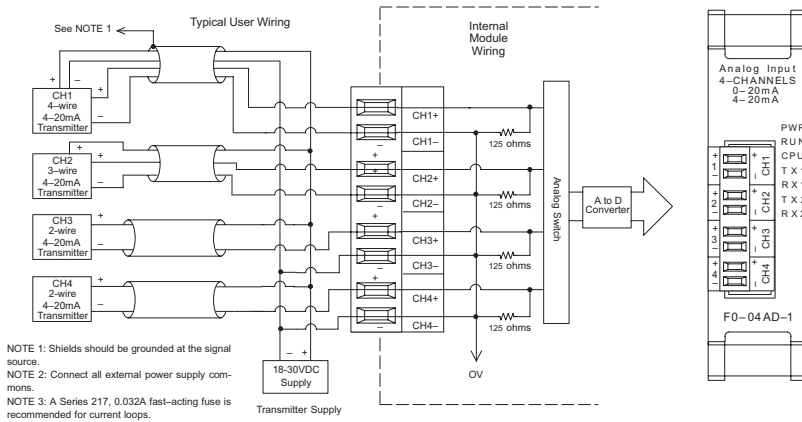
The F0–04AD–1 does not supply power to field devices. You will need to power transmitters separately from the PLC.

To remove the terminal block, disconnect power to the PLC and the field devices. Pull the terminal block firmly until the connector separates from the module.

You can remove the analog module from the PLC by folding out the retaining tabs at the top and bottom of the module. As the retaining tabs pivot upward and outward, the module's connector is lifted out of the PLC socket. Once the connector is free, you can lift the module out of its slot.

Wiring Diagram

Use the following diagram to connect the field wiring. If necessary, the F0-04AD-1 terminal block can be removed to make removal of the module possible without disturbing field wiring.



Current Loop Transmitter Impedance

Manufacturers of transmitters and transducers specify a wide variety of power sources for their products. Follow the manufacturer's recommendations.

In some cases, manufacturers specify a minimum loop or load resistance that must be used with the transmitter. The F0-04AD-1 provides 125 ohm resistance for each channel. If your transmitter requires a load resistance below 125 ohms, you do not have to make any changes. However, if your transmitter requires a load resistance higher than 125 ohms, you need to add a resistor in series with the module.

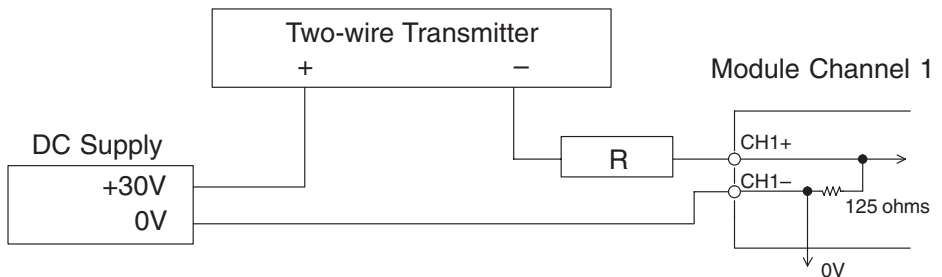
Consider the following example for a transmitter being operated from a 30 VDC supply with a recommended load resistance of 750 ohms. Since the module has a 125 ohm resistor, you need to add an additional resistor.

$$R = Tr - Mr$$

$$R = 750 - 125$$

$$R \geq 625$$

$R =$ resistor to add
 $Tr =$ Transmitter Requirement
 $Mr =$ Module resistance (internal 125 ohms)

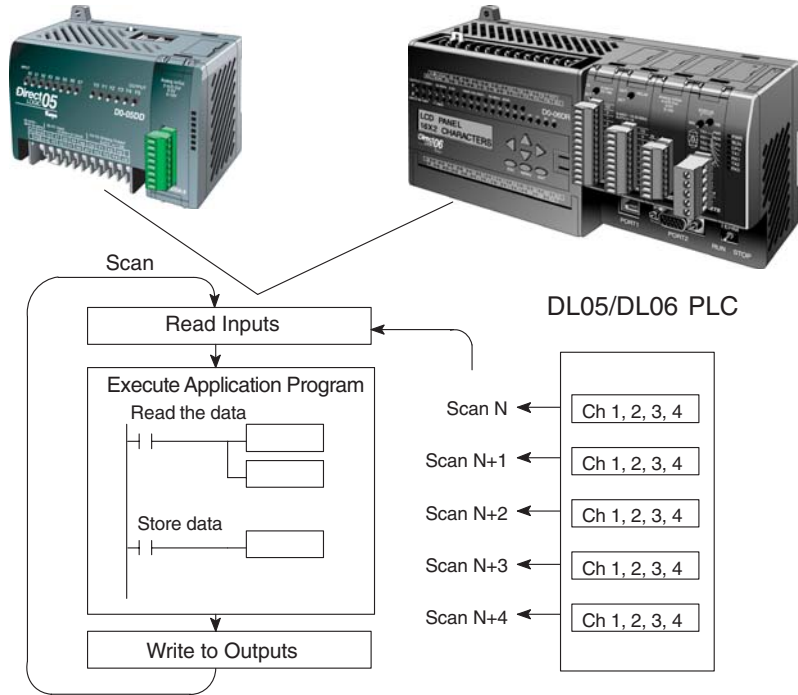


Module Operation

Channel Scanning Sequence

The DL05 and DL06 will read all four channels of input data during each scan. Each CPU supports special V-memory locations that are used to manage the data transfer. This is discussed in more detail beginning in the section on “Special V-memory Locations”.

3



Analog Module Updates

Even though the channel updates to the CPUs are synchronous with the CPU scan, the module asynchronously monitors the analog transmitter signals and converts each signal into 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.

The module takes approximately 25 milliseconds to sense 95% of the change in the analog signal. For the vast majority of applications, the process changes are much slower than these updates.



NOTE: If you are comparing other manufacturers' update times (step responses) with ours, please be aware that some manufacturers refer to the time it takes to convert the analog signal to a digital value. Our analog to digital conversion takes only a few microseconds. It is the settling time of the filter that is critical in determining the full update time. Our update time specification includes the filter settling time.

Special V-memory Locations

Formatting the Module Data

The DL05 and DL06 PLCs have special V-memory locations assigned to their respective option slots. These V-memory locations allow you to:

- specify the data format (binary or BCD)
- specify the number of channels to scan (4 channels for the F0-04AD-1)
- specify the V-memory locations to store the input data

DL05 Data Formatting

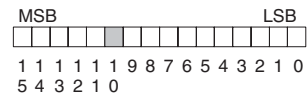
The table below shows the special V-memory locations used by the DL05 PLC for the F0-04AD-1.

Analog Input Module DL05 Special V-memory Locations	
Data Type and Number of Channels	V7700
Storage Pointer	V7701

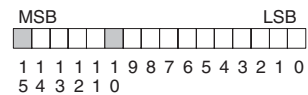
Structure of V7700

Special V-memory location 7700 identifies that a F0-04AD-1 module is installed in the DL05 option slot and the data type to be either binary or BCD.

Loading a constant of 400 into V7700 identifies a 4 channel analog input module is installed in the DL05 option slot, and reads the input data values as BCD numbers.



Loading a constant of 8400 into V7700 identifies a 4 channel analog input module is installed in the DL05 option slot, and reads the input data values as binary numbers.



Structure of V7701

V7701 is a system V-memory location used as a pointer to a user V-memory location where the analog input data is stored. The V-memory location loaded into V7701 is an octal number identifying the first user V-memory location for reading the analog input data. This V-memory location is user selectable. For example, loading O2000 causes the pointer to write Ch 1's data value to V2000, Ch 2's data value to V2001, Ch 3's data value to V2002, and Ch 4's data value to V2003.

You will find an example program that loads appropriate values to V7700 and V7701 on page 3-9.

DL06 Data Formatting

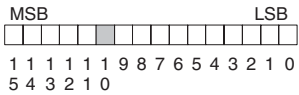
Special V-memory locations are assigned to the four option slots of the DL06 PLC. The table below shows these V-memory locations which can be used to setup the F0-04AD-1.

Analog Input Module DL06 Special V-memory Locations				
Slot No.	1	2	3	4
Data Type and Number of Channels	V700	V710	V720	V730
Storage Pointer	V701	V711	V721	V731

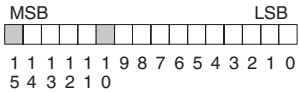
Setup Data Type and Number of Channels

V-memory locations 700, 710, 720 and 730 are used to set the data format to be read in either binary or BCD, and to set the number of channels that will be active.

For example, the F0-04AD-1 is installed in slot 1. Loading a constant of 400 into V700 sets 4 channels active, and the input data value is read as a BCD number.



With the F0-4AD-1 in slot 1, loading a constant of 8400 into V700 sets 4 channels active, and the input data value is read as a binary number.



Storage Pointer Setup

V-memory locations 701, 711, 721 and 731 are special locations used as storage pointers. A V-memory address is loaded into this location as an octal number identifying the first user V-memory location for the analog input data. This V-memory location is user selectable. For example, loading O2000 causes the pointer to write Ch 1's data value to V2000, Ch 2's data value to V2001, Ch 3's data value to V2002, and Ch 4's data value to V2003.

You will find an example program that loads appropriate values to V700 and V701 beginning on page 3-10.

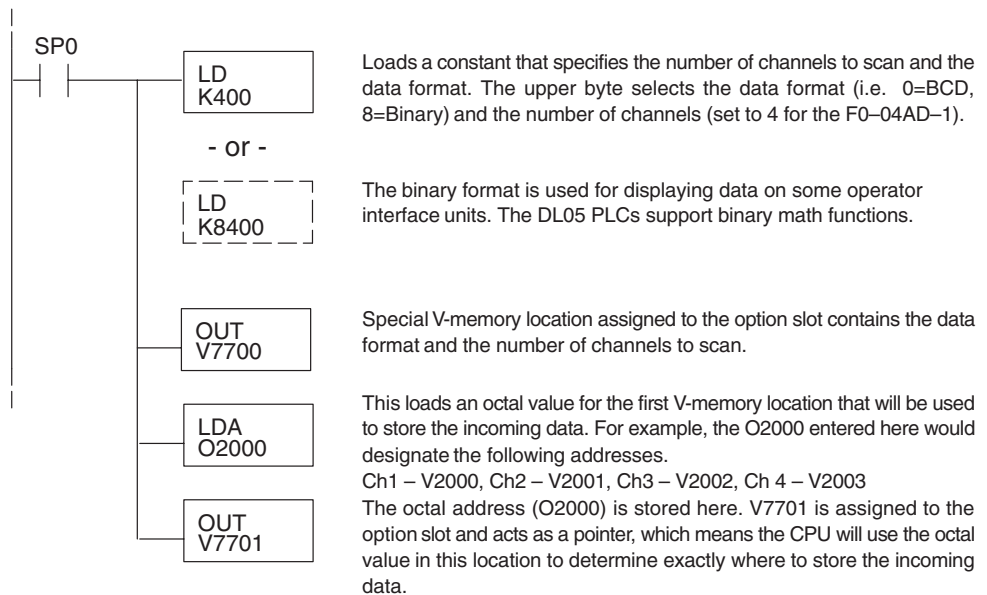
Using the Pointer in Your Control Program

DL05 Pointer Method

The DL05 CPU examines the pointer values (the memory locations identified in V7700 and V7701) on the first scan only.

The example program below shows how to setup these locations. This rung can be placed anywhere in the ladder program or in the initial stage if you are using stage programming instructions.

This is all that is required to read the analog input 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.



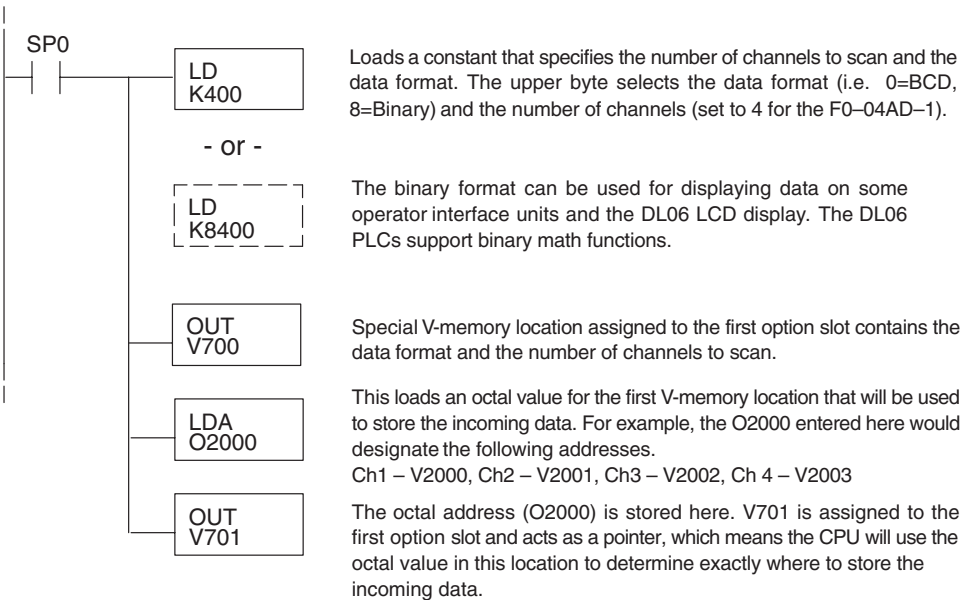
DL06 Pointer Method

Use the special V-memory table below as a guide to setup the storage pointer in the following example for the DL06. Slot 1 is the left most option slot. The CPU will examine the pointer values at these locations only after a mode transition.

Analog Input Module DL06 Special V-memory Locations				
Slot No.	1	2	3	4
No. of Channels	V700	V710	V720	V730
Input Pointer	V701	V711	V721	V731

The F0-04AD-1 can be installed in any available DL06 option slot. Using the example program from the previous page, but changing the V-memory addresses, the ladder diagram below shows how to setup these locations with the module installed in slot 1 of the DL06. Use the above table to determine the pointer values if locating the module in any of the other slot locations. Place this rung anywhere in the ladder program or in the initial stage if you are using stage programming instructions.

Like the DL05 example, this logic is all that is required to read the analog input data into V-memory locations. Once the data is in V-memory you can perform mathematical calculations with 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.



Detecting Input Signal Loss

Analog Signal Loss

The F0-04AD-1 analog module can sense the loss of analog input signals in 4-20mA loops. The Special Relays described on page 3-14 allow you to use this feature in your ladder program. For example, in the rung below SP610 is used to pull-in coil Y1, which would be used to open or close an external circuit.



The Special Relay SP610 detects a loss of input signal to channel 1. Use SP610 to trigger an alarm or shut down a machine.



NOTE: The F0-04AD-1 analog module cannot sense the loss of analog input signals in 0-20mA loops. See page 3-4 for information about setting the jumper to select your input type.

Scale Conversions

Scaling the Input Data

Many applications call for measurements in engineering units, which can be more meaningful than raw data. Convert to engineering units using the formula shown to the right.

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

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.

Analog Value of 2024, slightly less than half scale, should yield 49.4 PSI

Example without multiplier

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

$$\text{Units} = 2024 \frac{100-0}{4095} + 0$$

$$\text{Units} = 49$$

Handheld Display

V 2001	V 2000
0000	0049

Example with multiplier

$$\text{Units} = 10 A \frac{H-L}{4095} + L$$

$$\text{Units} = 20240 \frac{100-0}{4095} + 0$$

$$\text{Units} = 494$$

Handheld Display

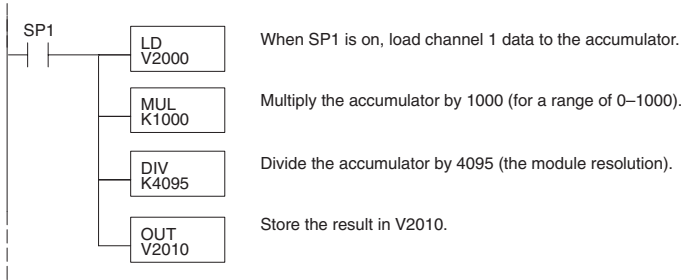
V 2001	V 2000
0000	0494

This value is more accurate

The Conversion Program

The following example shows 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 useful to 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	$A = \frac{16D}{4095} + 4$	$D = \frac{4095}{16} (A - 4)$
0 to 20mA	$A = \frac{20D}{4095}$	$D = \frac{4095}{16}$

For example, if you have measured the signal as 10mA, you can use the formula to determine the digital value that will be stored in the V-memory location that contains the data.

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

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

$$D = (255.93) (6) \quad D = 1536$$

Special Relays

The list of other Special Relays associated with the DL05 and DL06 PLCs are contained in the DL05 User Manual and the DL06 User Manual. The following special relays are new and relate to the status of the F0-04AD-1 module or one of its input channels.

DL05 Special Relays

DL05 Special Relays			
SP600	Chan 1 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP601	Chan 2 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP602	Chan 3 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP603	Chan 4 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP610	Chan 1 input open	1 = xmitter signal open	0 = xmitter signal good
SP611	Chan 2 input open	1 = xmitter signal open	0 = xmitter signal good
SP612	Chan 3 input open	1 = xmitter signal open	0 = xmitter signal good
SP613	Chan 4 input open	1 = xmitter signal open	0 = xmitter signal good

DL06 SpecialRelays

DL06 Special Relays			
Slot 1			
SP140	Chan 1 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP141	Chan 2 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP142	Chan 3 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP143	Chan 4 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP150	Chan 1 input open	1 = xmitter signal open	0 = xmitter signal good
SP151	Chan 2 input open	1 = xmitter signal open	0 = xmitter signal good
SP152	Chan 3 input open	1 = xmitter signal open	0 = xmitter signal good
SP153	Chan 4 input open	1 = xmitter signal open	0 = xmitter signal good

Slot 2			
SP240	Chan 1 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP241	Chan 2 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP242	Chan 3 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP243	Chan 4 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP250	Chan 1 input open	1 = xmitter signal open	0 = xmitter signal good
SP251	Chan 2 input open	1 = xmitter signal open	0 = xmitter signal good
SP252	Chan 3 input open	1 = xmitter signal open	0 = xmitter signal good
SP253	Chan 4 input open	1 = xmitter signal open	0 = xmitter signal good

DL06 Special Relays (cont'd)			
Slot 3			
SP340	Chan 1 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP341	Chan 2 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP342	Chan 3 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP343	Chan 4 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP350	Chan 1 input open	1 = xmitter signal open	0 = xmitter signal good
SP351	Chan 2 input open	1 = xmitter signal open	0 = xmitter signal good
SP352	Chan 3 input open	1 = xmitter signal open	0 = xmitter signal good
SP353	Chan 4 input open	1 = xmitter signal open	0 = xmitter signal good

Slot 4			
SP440	Chan 1 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP441	Chan 2 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP442	Chan 3 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP443	Chan 4 input type	0 = 0 - 20mA	1 = 4 - 20mA
SP450	Chan 1 input open	1 = xmitter signal open	0 = xmitter signal good
SP451	Chan 2 input open	1 = xmitter signal open	0 = xmitter signal good
SP452	Chan 3 input open	1 = xmitter signal open	0 = xmitter signal good
SP453	Chan 4 input open	1 = xmitter signal open	0 = xmitter signal good

Module Resolution

Analog Data Bits

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

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

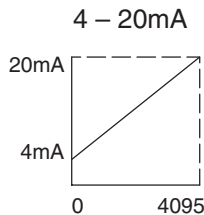
MSB												LSB											
[] [] [] [] [] [] [] [] [] [] [] []												[] [] [] [] [] [] [] [] [] [] [] []											
												1 1 9 8 7 6 5 4 3 2 1 0											
												1 0											

□ = data bits

Resolution Details

Since the module has 12-bit resolution, the analog signal is converted into 4096 counts ranging from 0 - 4095 (2^{12}). For example, a 4mA signal would be 0 and a 20mA signal would be 4095. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal.

Each count can also be expressed in terms of the signal level by using the following equation:



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

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

The following table shows the smallest detectable signal change that will result in one LSB change in the data value for each increment of the signal change.

mA Range	Signal Span (H - L)	Divide By	Smallest Detectable Change
4 to 20mA	16mA	4095	3.907µA
0 to 20mA	10mA	4095	4.884µA

Analog Input Ladder Logic Filter

PID Loops / Filtering:

Please refer to the “PID Loop Operation” chapter in the DL06 or DL05 User Manual for information on the built-in PV filter (DL05/06) and the ladder logic filter (DL06 only) shown below. A filter must be used to smooth the analog input value when auto tuning PID loops to prevent giving a false indication of loop characteristics.

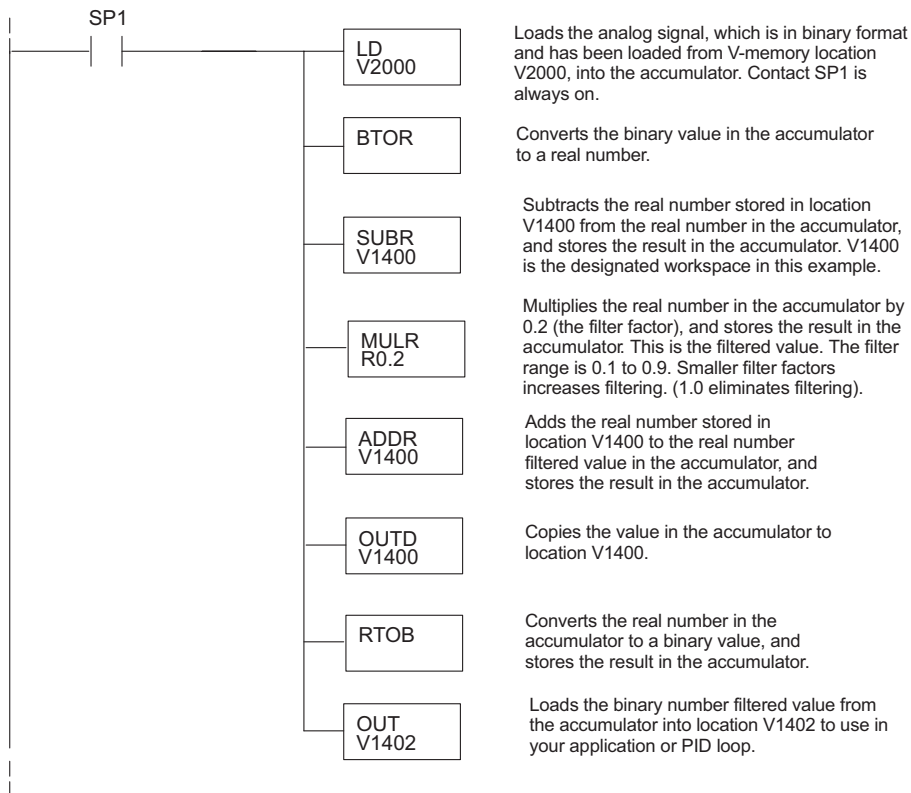
Smoothing the Input Signal (DL06 only):

The filter logic can also be used in the same way to smooth the analog input signal to help stabilize PID loop operation or to stabilize the analog input signal value for use with an operator interface display, etc.



Warning: The built-in and logic filters are not intended to smooth or filter noise generated by improper field device wiring or grounding. Small amounts of electrical noise can cause the input signal to bounce considerably. Proper field device wiring and grounding must be done before attempting to use the filters to smooth the analog input signal.

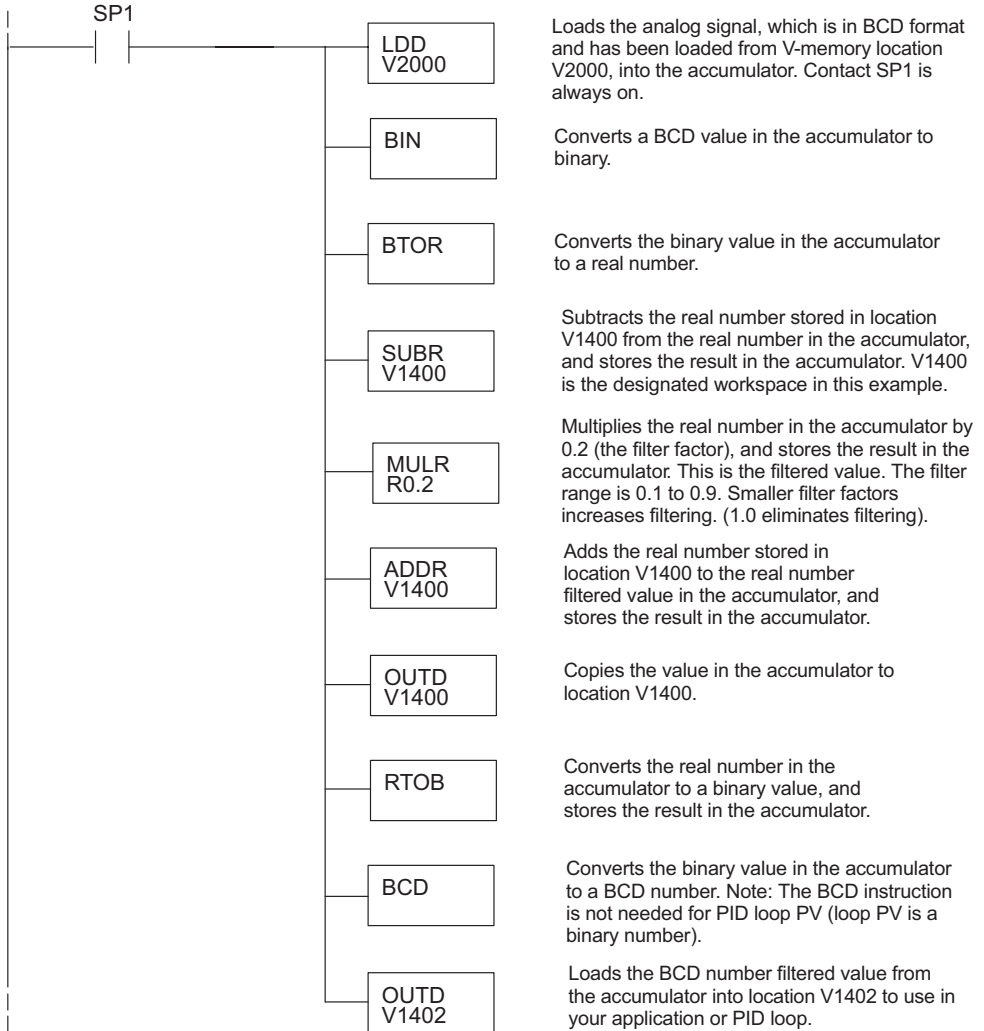
Using Binary Data Format





NOTE: Be careful not to do a multiple number conversion on a value. For example, if you are using the pointer method in BCD format to get the analog value, it must be converted to binary (BIN) as shown below. If you are using the pointer method in Binary format, the conversion to binary (BIN) instruction is not needed.

Using BCD Data Format



F0-04AD-2 4-Ch. ANALOG VOLTAGE INPUT



In This Chapter...

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Connecting and Disconnecting the Field Wiring	4-5
Wiring Diagram	4-5
Module Operation	4-6
Special V-memory Locations	4-7
Using the Pointer in Your Control Program	4-9
Scale Conversions	4-11
Module Resolution	4-14
Analog Input Ladder Logic Filter	4-15

Module Specifications

The F0-04AD-2 Analog input module offers the following features:

- The DL05 and DL06 will read all four channels in one scan.
- The removable terminal block makes it possible to remove the module without disconnecting the field wiring.
- Analog inputs can be used as process variables for the four (4) PID loops in the DL05 CPU and the eight (8) PID loops in the DL06 CPUs.
- On-board active analog filtering and RISC-like microcontroller provide digital signal processing to maintain precise analog measurements in noisy environments.



NOTE: The DL05 CPU's analog feature for this module requires **DirectSOFT32 Version 3.0c (or later)** and firmware version 2.10 (or later). The DL06 requires **DirectSOFT32 version V4.0, build 16 (or later)** and firmware version 1.00 (or later). See our website for more information: www.automationdirect.com.

The following tables provide the specifications for the F0-04AD-2 Analog Input Module. Review these specifications to make sure the module meets your application requirements.

Input Specifications	
Number of Channels	4, single ended (one common)
Input Range	0 to 5 VDC or 0 to 10 VDC (jumper selectable)
Resolution	12 bit (1 in 4096)
Step Response	10.0 mS to 95% of full step change
Crosstalk	-80 dB, 1/2 count maximum*
Active Low-pass Filtering	-3 dB at 300Hz (-12 dB per octave)
Input Impedance	Greater than 20K Ω
Absolute Maximum Ratings	$\pm 15V$
Linearity Error (End to End)	± 2 counts maximum*
Input Stability	± 1 count *
Gain Error	± 6 counts maximum *
Offset Error	± 2 counts maximum*
Maximum Inaccuracy	$\pm 0.3\%$ @ 25°C (77°F) $\pm 0.6\%$ 0 to 60°C (32 to 140°F)
Accuracy vs. Temperature	± 100 ppm/°C typical

* One count in the specification tables is equal to one least significant bit of the analog data value (1 in 4096).

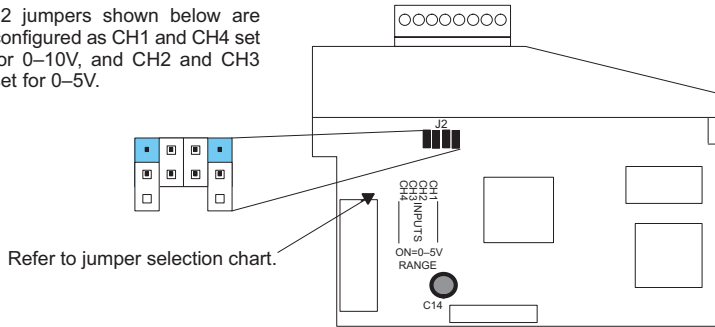
General Specifications	
PLC Update Rate	4 input channels per scan
16-bit Data Word	12 binary data bits
Operating Temperature	0 to 60° C (32 to 140° F)
Storage Temperature	-20 to 70° C (-4 to 158° F)
Relative Humidity	5 to 95% (non-condensing)
Environmental Air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3-304
Power Budget Requirement	75 mA @ 5 VDC (supplied by base)
Connector	Phoenix Mecano, Inc. Part No. AK1550/8-3.5 - green
Connector Wire Size	28 - 16 AWG
Connector Screw Torque	0.4 Nm
Connector Screwdriver Size	DN-SS1 (recommended)

Setting the Module Jumpers

The position of the J2 jumpers determines the input signal levels. You can choose between 0–5VDC or 0–10VDC. The module ships with the jumpers installed connecting the pins. In this position, the input signal level is 0–5VDC. To select 0–10VDC signals, use the jumper selection chart located on the module. One or more channels can be selected for 0–10 VDC input signal level by removing the jumper from the connecting pin of the appropriate channel. This allows you to have some channels selected for 0–5 VDC signals and other channels selected for 0–10 VDC signals.

4

J2 jumpers shown below are configured as CH1 and CH4 set for 0–10V, and CH2 and CH3 set for 0–5V.



WARNING: Before removing the analog module or the terminal block on the face of the module, disconnect power to the PLC and all field devices. Failure to disconnect power can result in damage to the PLC and/or field devices.



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

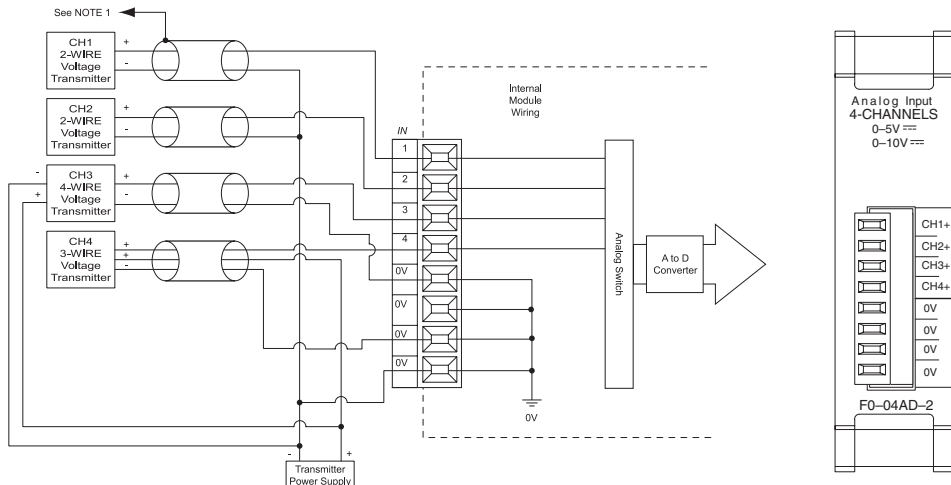
A separate transmitter power supply may be required, depending on the type of transmitter being used.

This module has a removable connector to make wiring and module removal easier. To remove the terminal block, disconnect power to the PLC and the field devices. Pull the terminal block firmly until the connector separates from the module.

The analog module can be removed from the PLC by folding out the retaining tabs at the top and bottom of the module. As the retaining tabs pivot upward and outward, the module's connector is lifted out of the PLC socket. Once the connector is free, you can lift the module out of its slot.

Wiring Diagram

Use the following diagram to connect the field wiring. If necessary, the terminal block can be be removed to make removal of the module possible without disturbing field wiring.



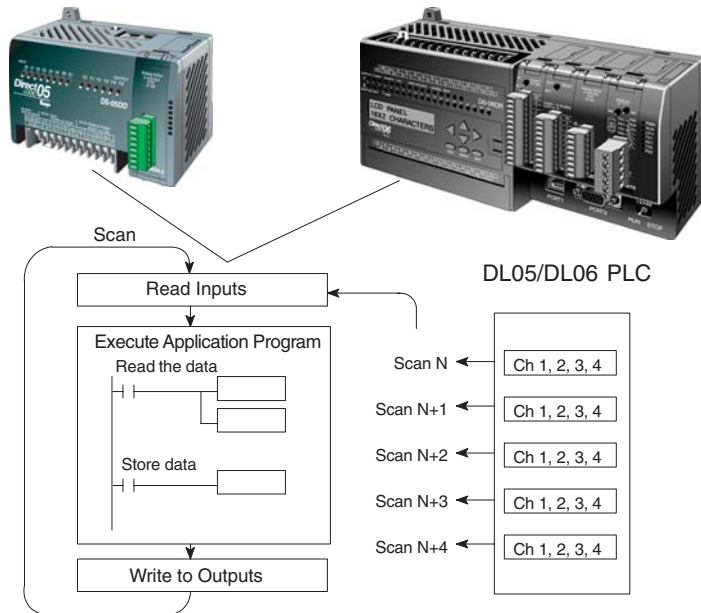
NOTE 1: Ground shields at the signal source.
NOTE 2: Connect all external power supply commons.

Module Operation

Input Channel Update Sequence

The DL05 and DL06 read four channels of input data data during each scan. The CPU supports special V-memory locations that are used to manage the data transfer. This is discussed in more detail on the next page, “Special V-memory Locations”.

4



Analog Module Updates

Even though the channel updates to the CPU are synchronous with the CPU scan, the module asynchronously monitors the analog transmitter signals and converts each signal into 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.

The module takes approximately 10 milliseconds to sense 95% of the change in the analog signal. For the vast majority of applications, the process changes are much slower than these updates.



NOTE: If you are comparing other manufacturers' update times (step responses) with ours, please be aware that some manufacturers refer to the time it takes to convert the analog signal to a digital value. Our analog to digital conversion takes only a few microseconds. It is the settling time of the filter that is critical in determining the full update time. Our update time specification includes the filter settling time.

Special V-memory Locations

Formatting the Module Data

The DL05 and DL06 PLCs have special V-memory locations assigned to their respective option slots. These V-memory locations allow you to:

- specify the data format (binary or BCD)
- specify the number of channels to scan (4 channels for the F0-04AD-2)
- specify the V-memory locations to store the input data

DL05 Data Formatting

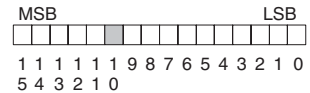
The table below shows the special V-memory locations which are used by the DL05 PLC for the F0-04AD-2.

Analog Input Module DL05 Special V-memory Locations	
Data Type and Number of I/O Channels	V7700
Input Storage Pointer	V7701

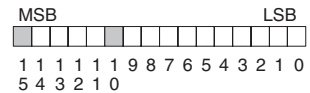
Structure of V7700

Special V-memory location 7700 identifies that a F0-04AD-2 module is installed in the DL05 option slot and the data type to be either binary or BCD.

Loading a constant of 400 into V7700 identifies a 4 channel analog input module is installed in the DL05 option slot, and reads the input data values as BCD numbers.



Loading a constant of 8400 into V7700 identifies a 4 channel analog input module is installed in the DL05 option slot, and reads the input data values as binary numbers.



Structure of V7701

V7701 is a system V-memory location used as a pointer to a user V-memory location where the analog input data is stored. The V-memory location loaded into V7701 is an octal number identifying the first user V-memory location for reading the analog input data. This V-memory location is user selectable. For example, loading O2000 causes the pointer to write Ch 1's data value to V2000, Ch 2's data value to V2001, Ch 3's data value to V2002, and Ch 4's data value to V2003.

You will find an example program that loads appropriate values to V7700 and V7701 on page 4-9.

DL06 Data Formatting

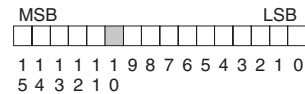
Special V-memory locations are assigned to the four option module slots of the DL06 PLC. The table below shows these V-memory locations which can be used for the F0-04AD-2.

Analog Input Module DL06 Special V-memory Locations				
Slot No.	1	2	3	4
Number of Channels	V700	V710	V720	V730
Input Pointer	V701	V711	V721	V731

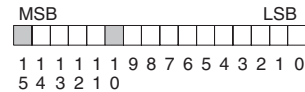
Setup Data Type and Number of Channels

V-memory locations 700, 710, 720 and 730 are used to set the data format to be read in either binary or BCD, and to set the number of channels that will be active.

For example, the F0-04AD-2 is installed in slot 1. Loading a constant of 400 into V700 sets 4 channels active, and the input data value is read as a BCD number.



With the F0-4AD-2 in slot 1, loading a constant of 8400 into V700 sets 4 channels active, and the input data value is read as a binary number.



Storage Pointer Setup

V-memory locations 701, 711, 721 and 731 are special locations used as storage pointers for the analog input data. With the analog module installed in slot 4, the V-memory location loaded in V731, for instance, is an octal number identifying the first user V-memory location to read the analog input data. This V-memory location is user selectable. For example, loading O2000 using the LDA instruction causes the pointer to write Ch 1's data value to V2000, Ch 2's data value to V2001, CH 3's data value to V2002 and Ch 4's data value to V2003.

You will find an example program that loads appropriate values to V700 and V701 on page 4-10.

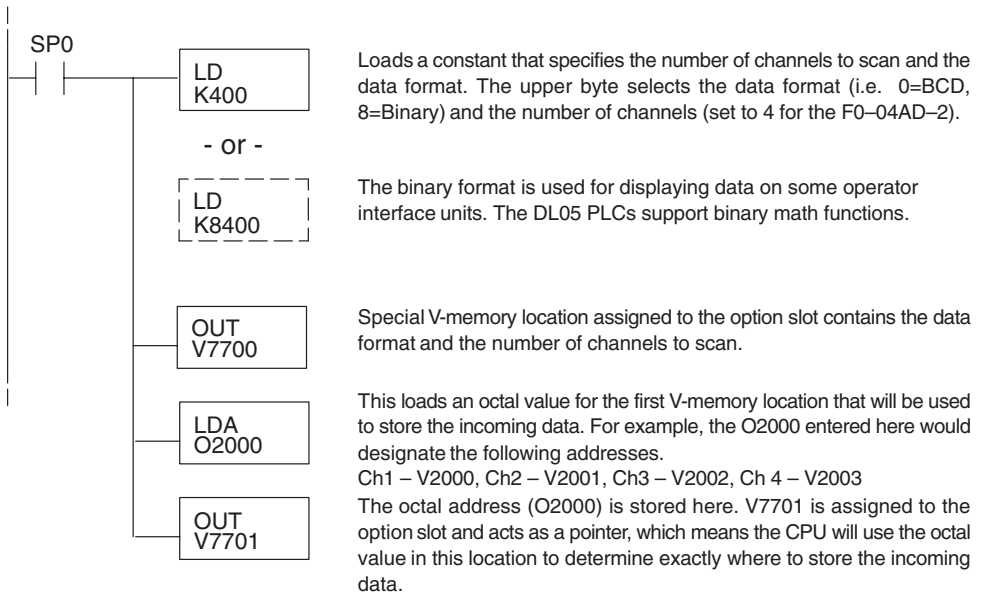
Using the Pointer in Your Control Program

DL05 Pointer Method

The DL05 CPU examines the pointer values (the memory locations identified in V7700 and V7701) on the first scan only.

The example program below shows how to setup these locations. This rung can be placed anywhere in the ladder program or in the initial stage if you are using stage programming instructions.

This is all that is required to read the analog input 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.



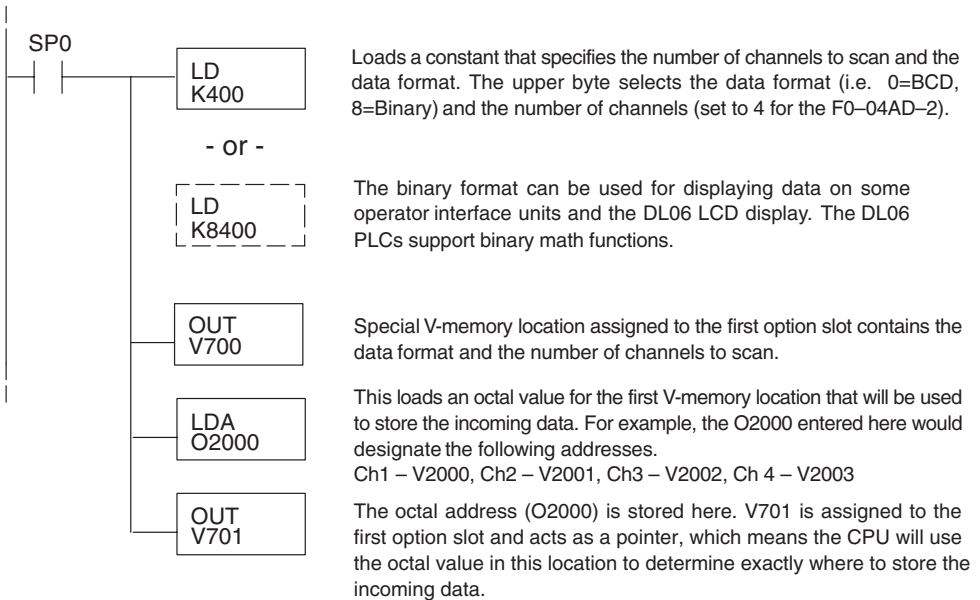
DL06 Pointer Method

Use the special V-memory table below as a guide to setup the pointer values in the following example for the DL06. Slot 1 is the left most option slot. The CPU will examine the pointer values at these locations only after a mode transition, first scan only.

Analog Input Module DL06 Special V-memory Locations				
Slot No.	1	2	3	4
Number of Channels	V700	V710	V720	V730
Input Pointer	V701	V711	V721	V731

The F0-04AD-2 can be installed in any available DL06 option slot. Using the example program from the previous page, but changing the V-memory addresses, the ladder diagram below shows how to setup these locations with the module installed in slot 1 of the DL06. Use the above table to determine the pointer values if locating the module in any of the other slot locations. Place this rung anywhere in the ladder program or in the initial stage if you are using stage programming instructions.

Like the DL05 example, this logic is all that is required to read the analog input data into V-memory locations. Once the data is in V-memory you can perform mathematical calculations with 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.



Scale Conversions

Scaling the Input Data

Many applications call for measurements in engineering units, which can be more meaningful than raw data. Convert to engineering units using the formula shown to the right.

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

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

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 100.0 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.

Analog Value of 2024, slightly less than half scale, should yield 49.4 PSI

Example without multiplier

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

$$\text{Units} = 2024 \frac{100-0}{4095} + 0$$

$$\text{Units} = 49$$

Handheld Display

V 2001	V 2000
0000	0049

Example with multiplier

$$\text{Units} = 10 A \frac{H-L}{4095} + L$$

$$\text{Units} = 20240 \frac{100-0}{4095} + 0$$

$$\text{Units} = 494$$

Handheld Display

V 2001	V 2000
0000	0494

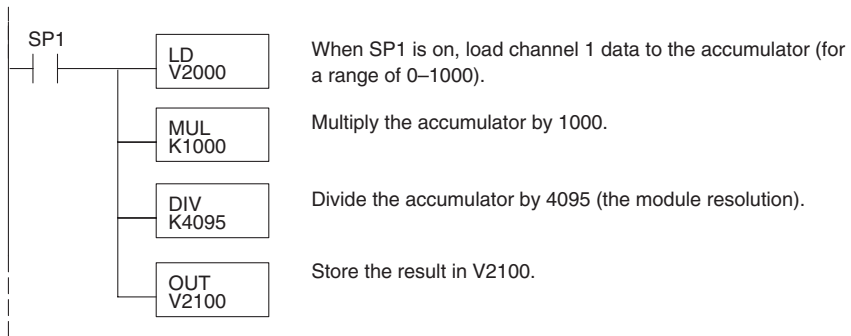
This value is more accurate

The Conversion Program

The following example shows how you would write the program to perform the engineering unit conversion from input data formats 0–4095. This example assumes the raw input data read at V2000 is in BCD format.

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

4



Analog and Digital Value Conversions

Sometimes it is useful to 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
0 to 5V	$A = \frac{5D}{4095}$	$D = \frac{4095}{5} (A)$
0 to 10V	$A = \frac{10D}{4095}$	$D = \frac{4095}{10} (A)$

For example, if you are using the 0–10V range and you need a 6V signal level, use this formula to determine the digital value (D) that will be stored in the V-memory location that contains the data.

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

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

$$D = (409.5) (6)$$

$$D = 2457$$

Module Resolution

Analog Data Bits

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

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

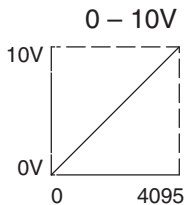
MSB												LSB											
[] [] [] [] [] [] [] [] [] [] [] []												[] [] [] [] [] [] [] [] [] [] [] []											
												1 1 9 8 7 6 5 4 3 2 1 0											
												1 0											

[] = data bits

Resolution Details

Since the module has 12-bit resolution, the analog voltage signal is converted into 4096 counts ranging from 0–4095 (2^{12}). For example, with a 0 to 10V range, a 0V signal would be a count value of 0, and a 10V signal would produce a count value of 4095. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal.

Each count can also be expressed in terms of the signal level by using the following equation:



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

H = high limit of the signal range

L = low limit of the signal range

The following table shows the smallest detectable signal change that will result in one LSB change in the data value for each increment of the signal change.

Voltage Range	Signal Span (H - L)	Divide By	Smallest Detectable Change
0 to 5V	5 volts	4095	1.22 mV
0 to 10V	10 volts	4095	2.44 mV

Analog Input Ladder Logic Filter

PID Loops / Filtering:

Please refer to the “PID Loop Operation” chapter in the DL06 or DL05 User Manual for information on the built-in PV filter (DL05/06) and the ladder logic filter (DL06 only) shown below. A filter must be used to smooth the analog input value when auto tuning PID loops to prevent giving a false indication of loop characteristics.

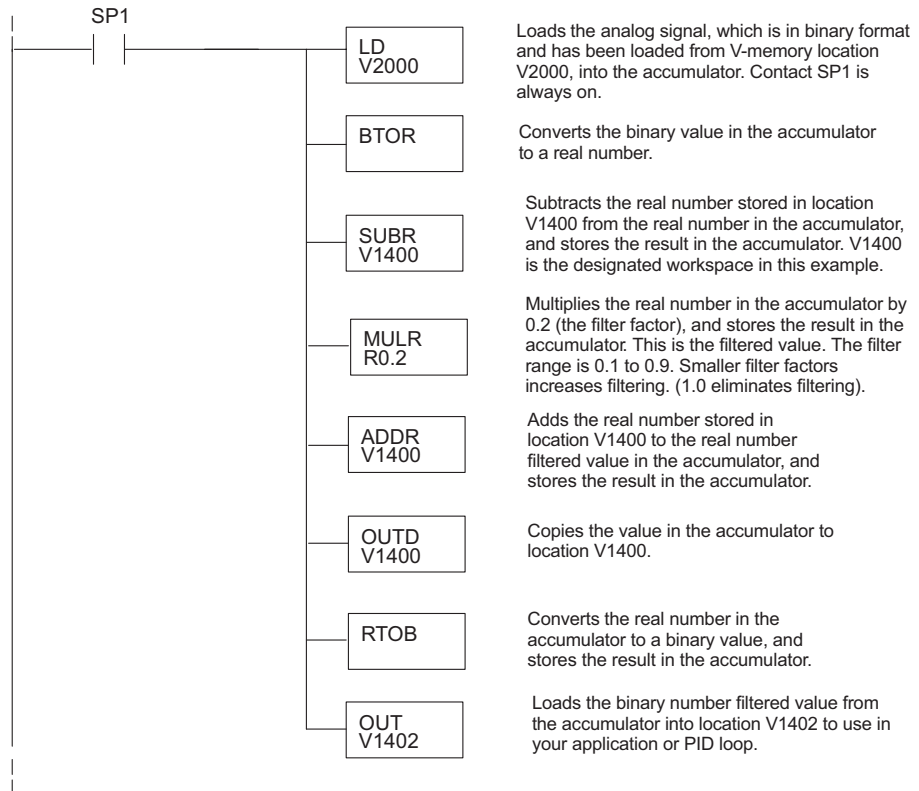
Smoothing the Input Signal (DL06 only):

The filter logic can also be used in the same way to smooth the analog input signal to help stabilize PID loop operation or to stabilize the analog input signal value for use with an operator interface display, etc.



Warning: The built-in and logic filters are not intended to smooth or filter noise generated by improper field device wiring or grounding. Small amounts of electrical noise can cause the input signal to bounce considerably. Proper field device wiring and grounding must be done before attempting to use the filters to smooth the analog input signal.

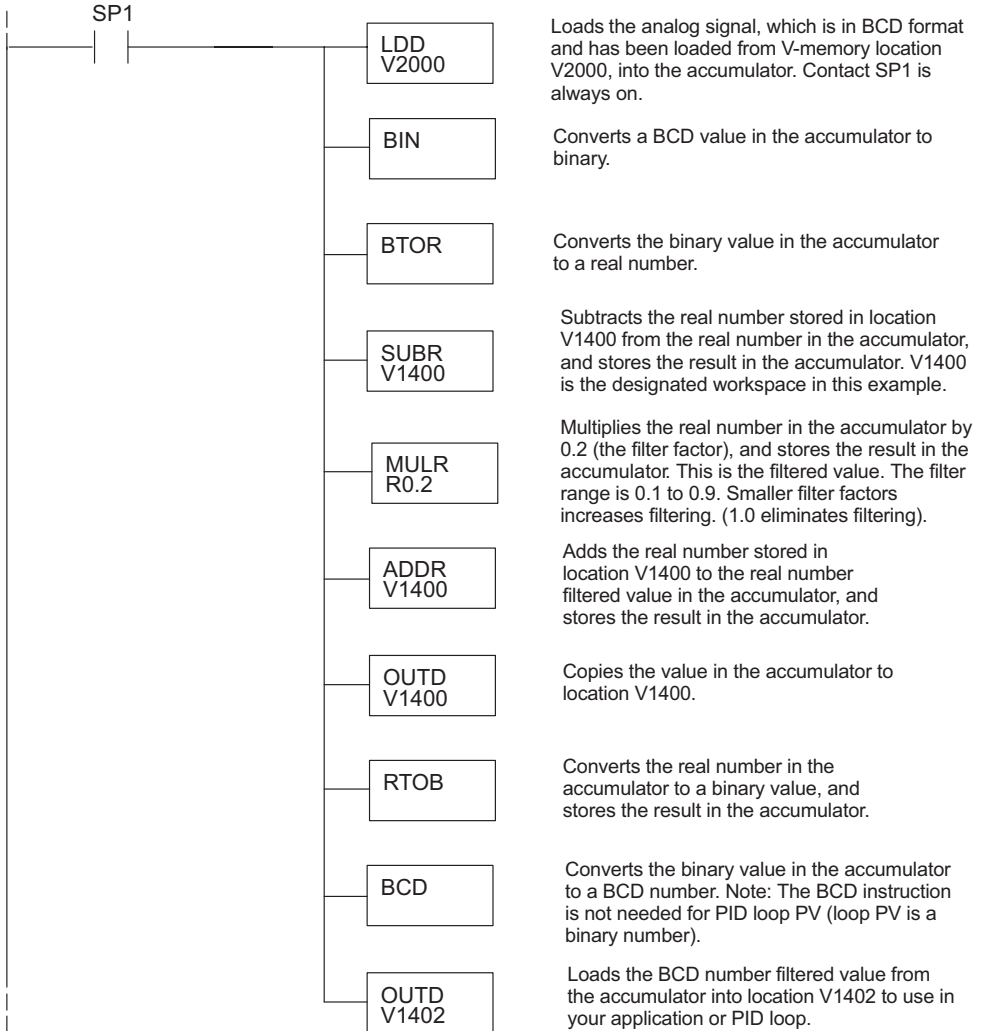
Using Binary Data Format





NOTE: Be careful not to do a multiple number conversion on a value. For example, if you are using the pointer method in BCD format to get the analog value, it must be converted to binary (BIN) as shown below. If you are using the pointer method in Binary format, the conversion to binary (BIN) instruction is not needed.

Using BCD Data Format



F0-4AD2DA-1 4-Ch. IN/2-Ch. OUT ANALOG CURRENT COMBINATION



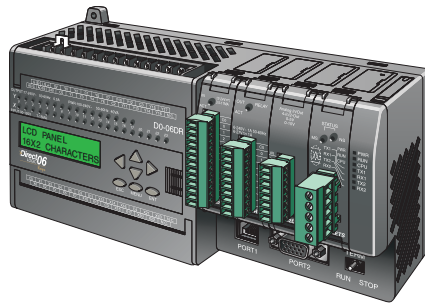
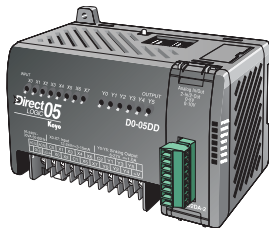
In This Chapter...

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Module Specifications

The F0-4AD2DA-1 Analog Combination module offers the following features:

- The analog input and output channels are updated in one scan.
- The removable terminal block makes it possible to remove the module without disconnecting the field wiring.
- Analog inputs can be used as process variables for the four (4) PID loops in the DL05 and the eight (8) PID loops in the DL06 CPUs.
- On-board active analog filtering and RISC-like microcontroller provide digital signal processing to maintain precise analog measurements in noisy environments.



NOTE: The DL05 CPU's analog feature for this module requires **DirectSOFT32** Version 3.0c (or later) and firmware version 3.30 (or later). The DL06 requires **DirectSOFT32** version V4.0, build 16 (or later) and firmware version 1.00 (or later). See our website for more information: www.automationdirect.com.

The following tables provide the specifications for the F0-4AD2DA-1 Analog Combination Module. Review these specifications to make sure the module meets your application requirements.

Input Specifications	
Number of Channels	4, single ended (one common)
Input Range	0 to 20 mA or 4 to 20 mA (jumper selectable)
Resolution	12 bit (1 in 4096) for 0-20mA, scaled for 4-20mA
Step Response	25.0 mS (typ) to 95% of full step change
Crosstalk	-80 dB, 1/2 count maximum *
Active Low-pass Filtering	-3 dB at 40Hz (-12 dB per octave)
Input Impedance	125 Ohm \pm 0.1%, 1/8 W current input
Absolute Maximum Ratings	-30 mA to +30 mA current input
Converter type	Successive approximation
Linearity Error (End to End)	\pm 2 counts
Input Stability	\pm 1 count *
Full Scale Calibration Error (Offset error not included)	\pm 10 counts maximum @ 20mA current input*
Offset Calibration Error	\pm 5 counts maximum @ 0mA current input *
Maximum Inaccuracy	\pm .4% @ 25°C (77°F) \pm .85% 0 to 60°C (32 to 140°F)
Accuracy vs. Temperature	\pm 100 ppm typical full scale calibration (including maximum offset change)
Recommended Fuse (external)	0.032 A Series 217 fast-acting, current inputs

*One count in the specification table is equal to one least significant bit of the analog data value (1 in 4096).

Output Specifications	
Number of Channels	2, single ended (one common)
Output Range	4 to 20 mA or 0 to 20 mA (jumper selectable)
Output Type	Current sourcing
Resolution	12 bit (1 in 4096) for 0 to 20 mA, scaled for 4 to 20 mA
Maximum Loop Voltage	30 VDC
Load (ohms)/Loop Power Supply	0-300/18-30V
Linearity Error (end to end)	\pm 2 counts (\pm 0.050% of full scale) maximum *
Conversion Settling Time	400 μ S max. full scale change
Full Scale Calibration Error Note: Error depends on the load from source terminal to ground.	\pm 26 counts max. @ 300 Ω load \pm 18 counts max. @ 250 Ω load \pm 12 counts max. @ 125 Ω load
Offset Calibration Error	\pm 10 counts max. @ 300 Ω load \pm 8 counts max @ 250 Ω load \pm 6 counts max. @ 125 Ω load
Max. Full Scale Inaccuracy (% of full scale) all errors included	300 Ω load 0.4% @ 60°C 250 Ω load 0.3% @ 60°C 125 Ω load 0.2% @ 60°C

* One count in the specification tables is equal to one least significant bit of the analog data value (1 in 4096).

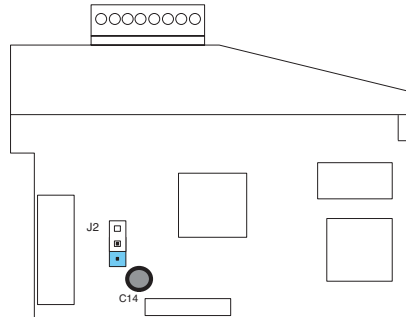
General Specifications	
PLC Update Rate	4 input channels per scan, 2 output channels per scan
16-bit Data Word	12 binary data bits
Operating Temperature	0 to 60°C (32 to 140°F)
Storage Temperature	-20 to 70°C (-4 to 158°F)
Relative Humidity	5 to 95% (non-condensing)
Environmental Air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3-304
Power Budget Requirement	100 mA @ 5VDC (supplied by base)
Connector	Phoenix Mecano, Inc., Part No. AK1550/8-3.5 - green
Connector Wire Size	28 - 16 AWG
Connector Screw Torque	0.4 Nm
Connector Screwdriver Size	DN-SS1 (recommended)

5

Setting the Module Jumper

The position of the J2 jumper determines the input and output signal level. You can choose between 0–20mA and 4–20mA signal levels. The module ships without the jumper connecting the pins (pins not jumpered). In this position, the input and output signal level is 4–20mA. To select 0–20mA signal level, install the jumper, connecting the pins.

The J2 jumper is shown in the 4–20mA position (not installed). Install the jumper for the 0–20mA position.



WARNING: Before removing the analog module or the terminal block on the face of the module, disconnect power to the PLC and all field devices. Failure to disconnect power can result in damage to the PLC and/or field devices.

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

A separate transmitter power supply may be required, depending on the type of transmitter being used.

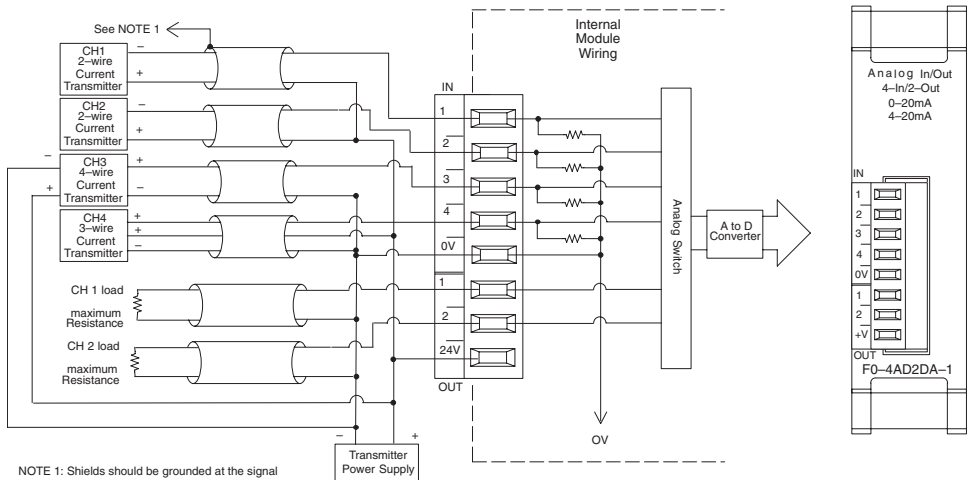
This module has a removable connector to make wiring and module removal easier. To remove the terminal block, disconnect power to the PLC and the field devices. Pull the terminal block firmly until the connector separates from the module.

The analog module can be removed from the PLC by folding out the retaining tabs at the top and bottom of the module. As the retaining tabs pivot upward and outward, the module's connector is lifted out of the PLC socket. Once the connector is free, you can lift the module out of its slot.

Wiring Diagram

Use the following diagram to connect the field wiring. If necessary, the terminal block can be removed to make removal of the module possible without disturbing field wiring.

Typical User Wiring

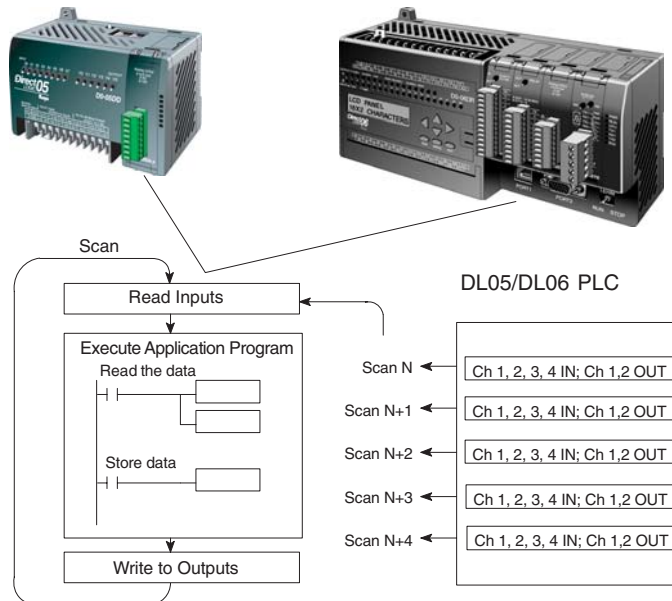


NOTE 1: Shields should be grounded at the signal source.
NOTE 2: Connect all external power supply commons.

Module Operation

Input/Output Channel Update Sequence

The DL05 and DL06 will read four channels of input data and two channels of output data during each scan. Each CPU supports special V-memory locations that are used to manage the data transfer. This is discussed in more detail beginning on the next page, “Special V-memory Locations”.



Analog Module Updates

Even though the channel updates to the CPU are synchronous with the CPU scan, the module asynchronously monitors the analog transmitter signals and converts each signal into 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.

The module takes approximately 25 milliseconds to sense 95% of the change in the analog signal. For the vast majority of applications, the process changes are much slower than these updates.



NOTE: If you are comparing other manufacturers' update times (step responses) with ours, please be aware that some manufacturers refer to the time it takes to convert the analog signal to a digital value. Our analog to digital conversion takes only a few microseconds. It is the settling time of the filter that is critical in determining the full update time. Our update time specification includes the filter settling time.

Special V-memory Locations

Formatting the Module Data

The DL05 and DL06 PLCs have three special V-memory locations assigned to their respective option slots. These V-memory locations allow you to:

- specify the data format (binary or BCD)
- specify the number of input and output channels to scan.
- specify the V-memory locations to store the input data
- specify the V-memory locations to store the output data

DL05 Data Formatting

The table below shows the special V-memory locations used by the DL05 PLC for the analog combination module.

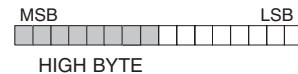
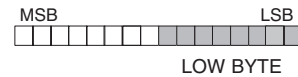
Analog Combination Module DL05 Special V-memory Locations	
Data Type and Number of I/O Channels	V7700
Input Storage Pointer	V7701
Output Storage Pointer	V7702

Structure of V7700

V-memory location 7700 is used for identifying the number of output channels, the number of input channels and the data type (binary or BCD). The low byte equals the number of output channels and the high byte equals the number of input channels. Enter a 1 through 4 to select the number of input channels and a 1 through 2 to select the number of output channels to be used. A zero (0) entered for channel selection will cause the channel, either input or output, to be inoperative.

Loading a constant of 402 into V7700 identifies four input and two output analog channels, and sets the I/O data type to BCD.

Loading a constant of 8482 into V7700 identifies four input and two output analog channels, and sets the I/O data type to binary.



Structure of V7701

V7701 is a system parameter that points to a V-memory location used for storing analog input data. The V-memory location loaded in V7701 is an octal number identifying the first V-memory location for the analog input data. This V-memory location is user selectable. For example, loading O2000 causes the pointer to write Ch 1's data value to V2000, Ch 2's data value to V2001, CH 3's data value to V2002 and Ch 4's data value to V2003.

Structure of V7702

V7702 is a system parameter that points to a V-memory location used for storing analog output data. The V-memory location loaded in V7702 is an octal number identifying the first V-memory location for the analog output data. This V-memory location is user selectable. For example, loading O2010 causes the pointer to read Ch 1's data value at V2010 and Ch 2's data value at V2011.

You will find an example program that loads appropriate values to V7700, V7701 and V7702 on page 5-11.

DL06 Data Formatting

Special V-memory locations are assigned to the four option module slots of the DL06 PLC. The table below shows these V-memory locations which can be used by the F0-4AD2DA-1.

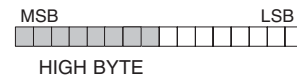
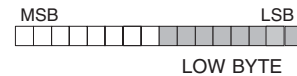
Analog Combination Module DL06 Special V-memory Locations				
Slot No.	1	2	3	4
Data Type and Number of Channels	V700	V710	V720	V730
Input Storage Pointer	V701	V711	V721	V731
Output Storage Pointer	V702	V712	V722	V732

Setup Data Type and Number of Channels

V-memory locations 700, 710, 720 and 730 are used to set the number of output channels, the number of input channels and the data type (binary or BCD). The low byte equals the number of output channels and the high byte equals the number of input channels. Enter a 1 through 4 to select the number of input channels and a 1 through 2 to select the number of output channels to be used. A zero (0) entered for channel selection will cause the channel, either input or output, to be inoperative.

Consider the F0-4AD2DA-1 to be installed in slot 2. Loading a constant of 402 into V710 identifies four input and two output analog channels, and sets the I/O data type to BCD.

Loading a constant of 8482 into V710 identifies four input and two output analog channels, and sets the I/O data type to binary.



Input Storage Pointer Setup

V-memory locations 701, 711, 721 and 731 are special locations used as a storage pointer for the analog input data. With the analog module installed in slot 2, the V-memory location loaded in V711 is an octal number identifying the first user V-memory location to write the analog input data to. This V-memory location is userselectable. For example, loading O2000 causes the pointer to write Ch 1's data value to V2000, Ch 2's data value to V2001, CH 3's data value to V2002 and Ch 4's data value to V2003.

Output Storage Pointer Setup

V-memory locations 702, 712, 722 and 732 are special locations used as a storage pointer for the analog output data. With the analog module installed in slot 2, the V-memory location loaded in V712 is an octal number identifying the first user V-memory location to read the analog output data from. This V-memory location is user selectable. For example, loading O2010 causes the pointer to read Ch 1's data value at V2010 and Ch 2's data value at V2011.

You will find an example program that loads appropriate values to V710, V711 and V712 on page 5-12.

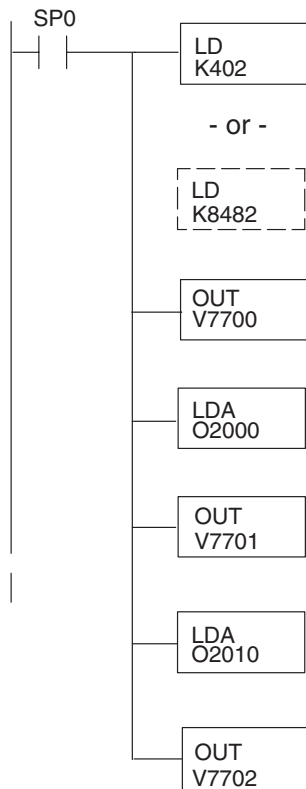
Using the Pointer in Your Control Program

DL05 Pointer Method

The DL05 CPU examines the pointer values (the memory locations identified in V7700, V7701 and V7702) on the first scan only.

The example program below shows how to setup these locations for 4 input channels and 2 output channels. This rung can be placed anywhere in the ladder program or in the initial stage if you are using stage programming instructions.

This is all that is required to read the analog input and output 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 and V2010 are used in the example, the V-memory locations are user selectable.



Loads a constant that specifies the number of channels to scan and the data format. The upper byte selects the input data format (i.e. 0=BCD, 8=Binary) and the number of input channels (set to 4). The lower byte selects the output data format (i.e. 0=BCD, 8=Binary) and the number of output channels (set to 2).

The binary format is used for displaying data on some operator interface units. The DL05 PLCs support binary math functions.

Special V-memory location assigned to the option slot contains the data format and the number of channels to scan.

This loads an octal value for the first V-memory location that will be used to store the incoming data. For example, the O2000 entered here would designate the following addresses:

Ch1 – V2000, Ch2 – V2001, Ch3 – V2002, Ch4 – V2003

The octal address (O2000) is stored here. V7701 is assigned to the option slot and acts as a pointer, which means the CPU will use the octal value in this location to determine exactly where to store the incoming data.

This loads an octal value for the first V-memory location that will be used to store the output data. For example, the O2010 entered here would designate the following addresses:

Ch1 – V2010, Ch2 – V2011

The octal address (O2010) is stored here. V7702 is assigned to the option slot and acts as a pointer, which means the CPU will use the octal value in this location to determine exactly where to get the output data.

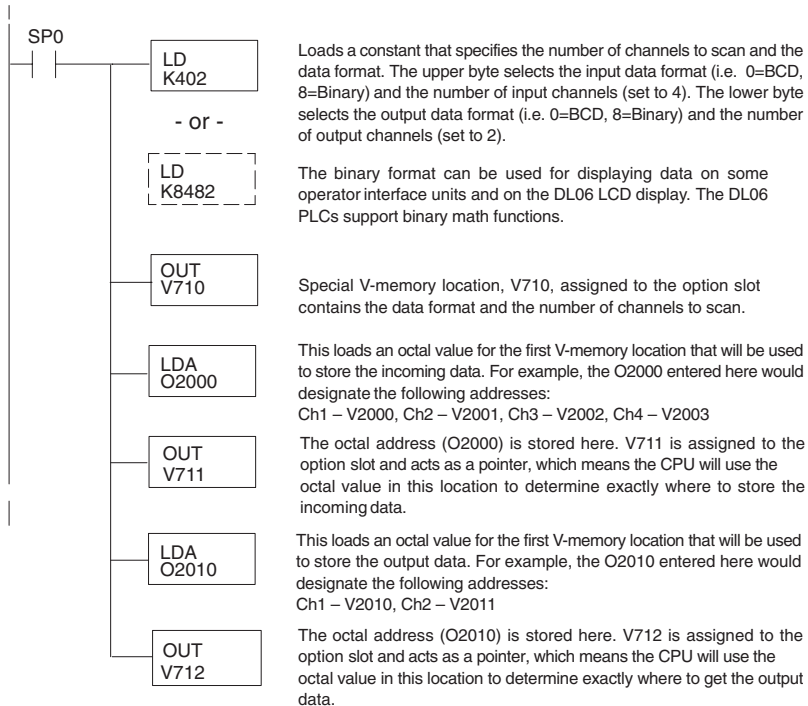
DL06 Pointer Method

Use the special V-memory table as a guide to setup the pointer values in the following example for the DL06. Slot 1 is the left most option slot. The CPU will examine the pointer values at these locations only after a mode transition, first scan only.

Analog Combination Module DL06 Special V-memory Locations				
Slot No.	1	2	3	4
No. of Channels	V700	V710	V720	V730
Input Pointer	V701	V711	V721	V731
Output Pointer	V702	V712	V722	V732

The F0-4AD2DA-1 can be installed in any available DL06 option slot. Using the example program from the previous page, but changing the V-memory addresses, the ladder diagram below shows how to setup these locations for 4 input channels and 2 output channels with the module installed in slot1 of the DL06. Use the above table to determine the pointer values if locating the module in any of the other slot locations. Place this rung anywhere in the ladder program or in the initial stage if you are using stage programming instructions.

Like the DL05 example, this logic is all that is required to read the analog input data into V-memory locations. Once the data is in V-memory you can perform mathematical calculations with the data, compare the data against preset values, and so forth. V2000 and V2010 is used in the example but you can use any user V-memory location.



Scale Conversions

Scaling the Input Data

Many applications call for measurements in engineering units, which can be more meaningful than raw data. Convert to engineering units using the formula shown to the right.

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

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

H = High limit of the engineering unit range

L = Low limit of the engineering unit range

A = Analog value (0 – 4095)

5

For example, if you wanted to measure pressure (PSI) from 0.0 to 100.0 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.

Analog Value of 2024, slightly less than half scale, should yield 49.4 PSI

Example without multiplier

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

$$\text{Units} = 2024 \frac{100-0}{4095} + 0$$

$$\text{Units} = 49$$

Handheld Display

V 2001	V 2000
0000	0049

Example with multiplier

$$\text{Units} = 10 A \frac{H-L}{4095} + L$$

$$\text{Units} = 20240 \frac{100-0}{4095} + 0$$

$$\text{Units} = 494$$

Handheld Display

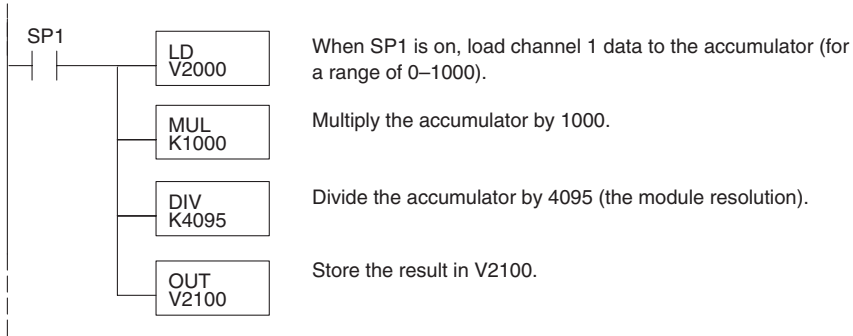
V 2001	V 2000
0000	0494

This value is more accurate

The Conversion Program

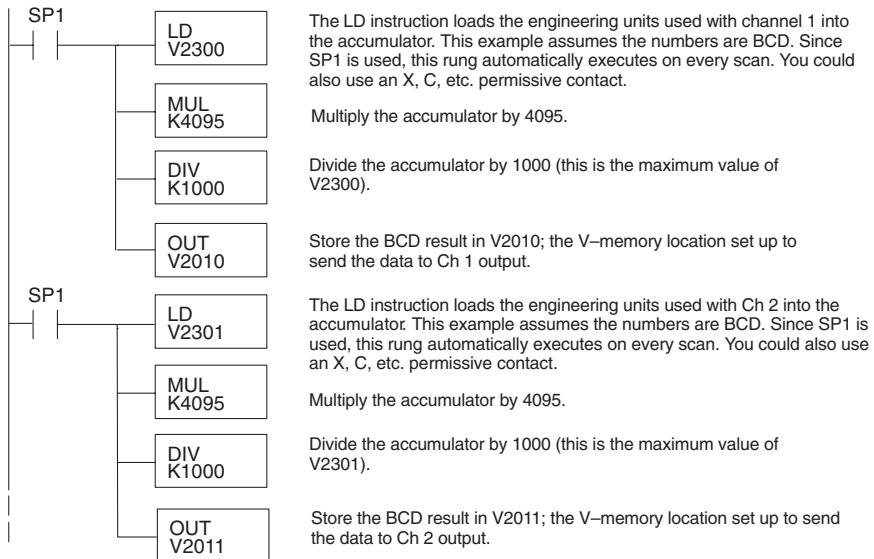
The following example shows how you would write the program to perform the engineering unit conversion from input data formats 0–4095. This example assumes the raw input data read at V2000 is in BCD format.

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



Output Conversion Program

The following example program shows how you would write the program to perform the engineering unit conversion to output data formats 0–4095. This example assumes you have calculated or loaded the engineering unit values between 0–1000 in BCD format and stored them in V2300 and V2301 for channels 1 and 2 respectively. Both the DL05 and DL06 offer instructions that allow you to perform math operations using BCD format. It is usually easier to perform any math calculations in BCD and then convert the value to binary before you send the data to the module.



Analog and Digital Value Conversions

Sometimes it is useful to convert between the signal levels and the digital values. This is especially helpful during machine startup or troubleshooting. The following tables provide 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 as 10mA, you can use the formula to determine the digital value (D) that will be stored in the V-memory location that contains the data.

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

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

$$D = (255.93) (6) \quad D = 1536$$

5

Range	If you know the digital value	If you know the analog signal level
0 to 20mA	$A = \frac{20D}{4095}$	$D = \frac{4095}{20} (A)$

This example shows the result for the 0 to 20mA range.

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

$$D = \frac{4095}{20} (10\text{mA})$$

$$D = (204.75) (10) \quad D = 2047.5$$

Module Resolution

Analog Data Bits

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

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

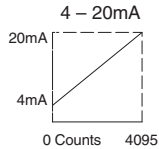
MSB												LSB											
						1 1 9 8 7 6 5 4 3 2 1 0																	
						1 0																	

□ = data bits

5

Resolution Details

Since the module has 12-bit resolution, the analog signal is converted from 4096 counts ranging from 0–4095 (212). For example, a 4mA signal would be 0 and 20mA 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 diagrams below show how this relates to the two signal ranges.

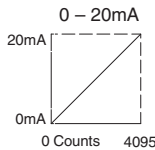


$$\text{Resolution} = \frac{H - L}{4095}$$

H = high limit of the signal range

L = low limit of the signal range

$$16\text{mA} / 4095 = 3.907\mu\text{A per count}$$



$$20\text{mA} / 4095 = 4.884\mu\text{A per count}$$

Analog Input Ladder Logic Filter

PID Loops / Filtering:

Please refer to the “PID Loop Operation” chapter in the DL06 or DL05 User Manual for information on the built-in PV filter (DL05/06) and the ladder logic filter (DL06 only) shown below. A filter must be used to smooth the analog input value when auto tuning PID loops to prevent giving a false indication of loop characteristics.

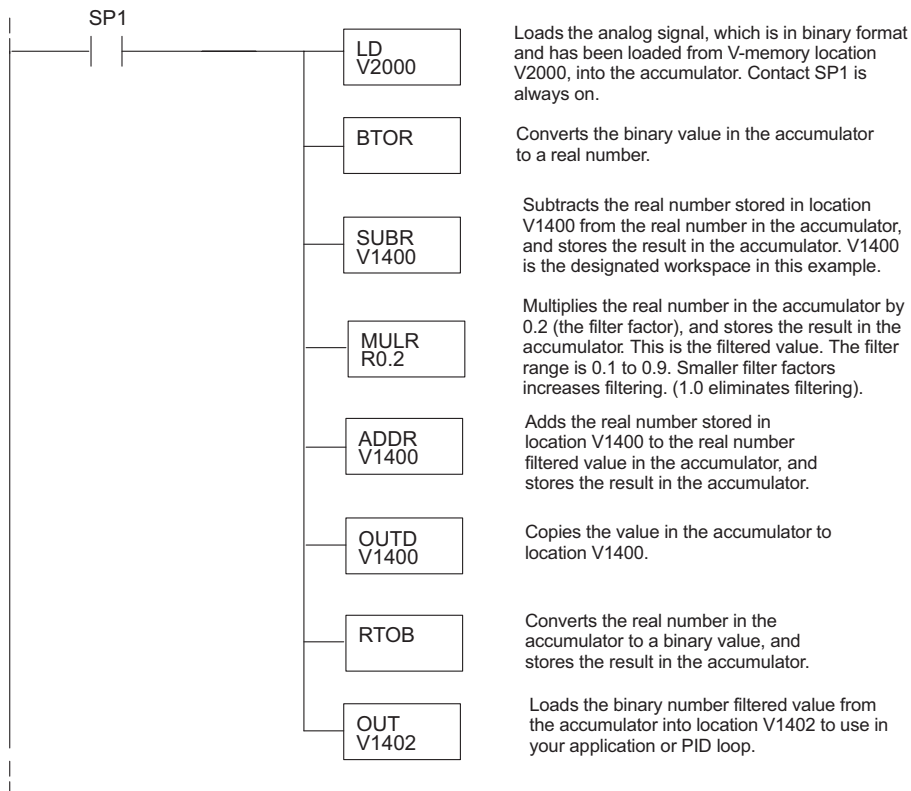
Smoothing the Input Signal (DL06 only):

The filter logic can also be used in the same way to smooth the analog input signal to help stabilize PID loop operation or to stabilize the analog input signal value for use with an operator interface display, etc.



Warning: The built-in and logic filters are not intended to smooth or filter noise generated by improper field device wiring or grounding. Small amounts of electrical noise can cause the input signal to bounce considerably. Proper field device wiring and grounding must be done before attempting to use the filters to smooth the analog input signal.

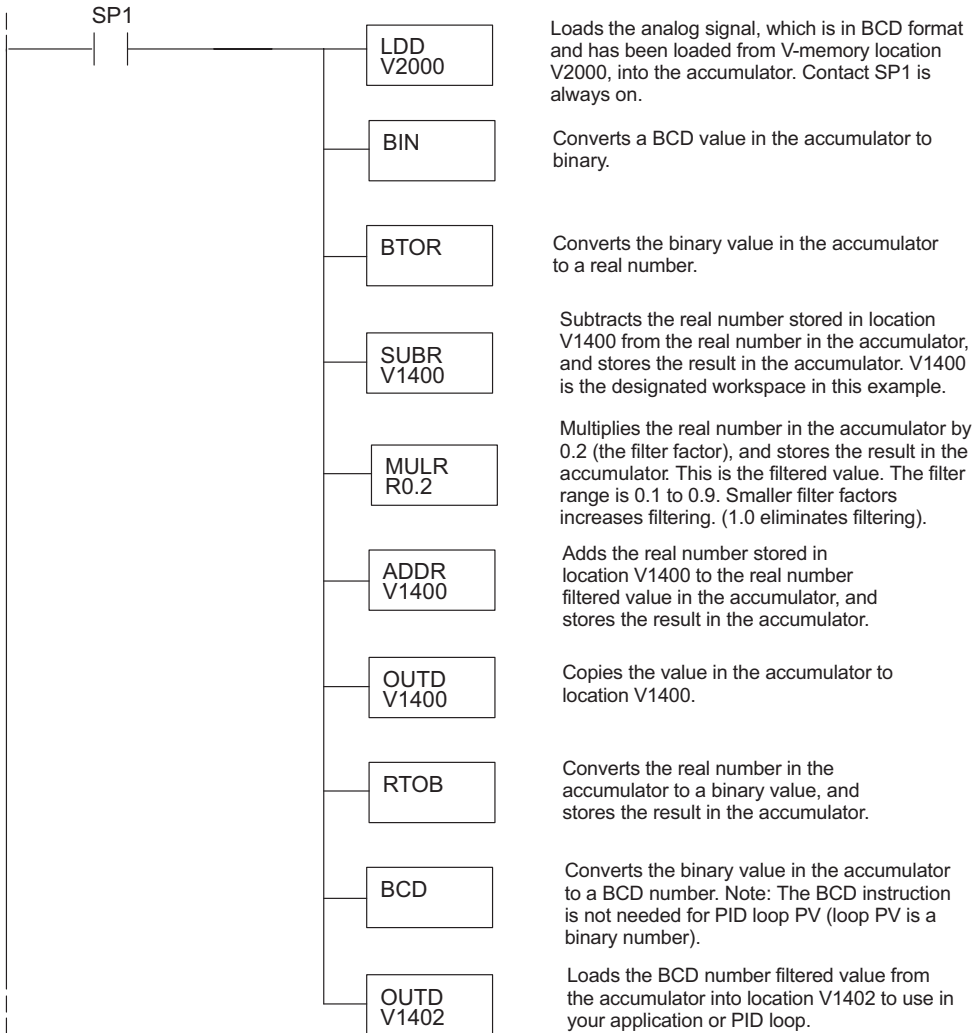
Using Binary Data Format





NOTE: Be careful not to do a multiple number conversion on a value. For example, if you are using the pointer method in BCD format to get the analog value, it must be converted to binary (BIN) as shown below. If you are using the pointer method in Binary format, the conversion to binary (BIN) instruction is not needed.

Using BCD Data Format



F0-2AD2DA-2 2-Ch. IN/2-Ch. OUT ANALOG VOLTAGE COMBINATION



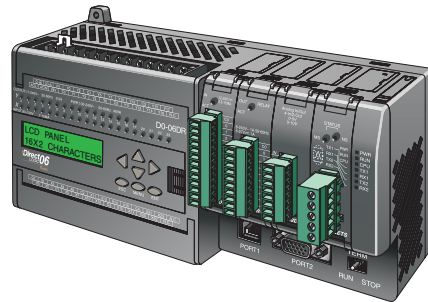
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Module Specifications6-2
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Module Specifications

The F0-2AD2DA-2 Analog Combination module offers the following features: The analog input and output channels are updated in one scan.

- The module has a removable terminal block which makes it possible to remove the module without disconnecting the field wiring.
- Analog inputs can be used as process variables for the four (4) PID loops in the DL05 and the eight (8) PID loops in the DL06 CPUs.
- On-board active analog filtering and RISC-like microcontroller provide digital signal processing to maintain precise analog measurements in noisy environments.



NOTE: The DL05 CPU's analog feature for this module requires **DirectSOFT32** Version 3.0c (or later) and firmware version 3.30 (or later). The DL06 requires **DirectSOFT32** version V4.0, build 16 (or later) and firmware version 1.00 (or later). See our website for more information: www.automationdirect.com.

The following tables provide the specifications for the F0-2AD2DA-2 Analog Voltage Combination Module. Review these specifications to make sure the module meets your application requirements.

Input Specifications	
Number of Channels	2, single ended (one common)
Input Range	0 to 5 VDC or 0 to 10 VDC (jumper selectable)
Resolution	12 bit (1 in 4096)
Step Response	10.0 mS to 95% of full step change
Crosstalk	1/2 count maximum (-80db)*
Active Low-pass Filtering	-3 dB at 300Hz (-12 dB per octave)
Input Impedance	Greater than 20K Ω
Absolute Maximum Ratings	$\pm 15V$
Linearity Error (End to End)	± 2 counts (0.025% of full scale) maximum*
Input Stability	± 1 count *
Gain Error	± 6 counts *
Offset Error	± 2 counts *
Maximum Inaccuracy	0.3% @ 25°C (77°F) 0.6% 0 to 60°C (32 to 140°F)
Accuracy vs. Temperature	± 100 ppm/°C typical

Output Specifications	
Number of Channels	2, single ended (one common)
Output Range	0 to 5 VDC or 0 to 10 VDC (jumper selectable)
Resolution	12 bit (1 in 4096)
Conversion Settling Time	50 μ S for full scale change
Crosstalk	1/2 count maximum (-80db) *
Peak Output Voltage	± 15 VDC (power supply limited)
Offset Error	0.1% of range
Gain Error	0.4% of range
Linearity Error (end to end)	± 1 count (0.075% of full scale) maximum*
Output Stability	± 2 counts*
Load Impedance	2K Ω minimum
Load Capacitance	0.01 μ F maximum
Accuracy vs. Temperature	± 50 ppm/°C typical

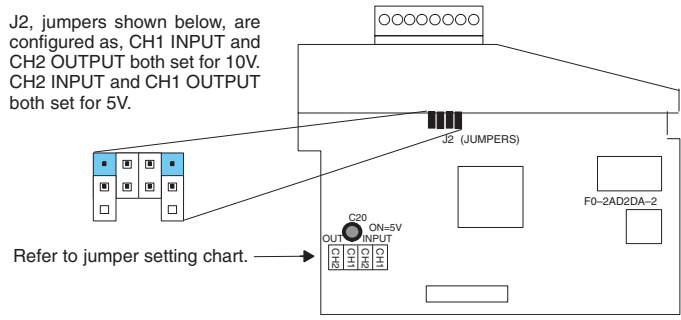
* One count in the specification table is equal to one least significant bit of the analog data value (1 in 4096).

General Specifications	
PLC Update Rate	2 input channels per scan 2 output channels per scan
16-bit Data Word	12 binary data bits
Operating Temperature	0 to 60° C (32 to 140° F)
Storage Temperature	-20 to 70° C (-4 to 158° F)
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
Power Budget Requirement	50 mA @ 5 VDC (supplied by base)
External Power Supply	30 mA, 24 VDC ±10%
Connector	Phoenix Mecano, Inc. Part No. AK1550/8-3.5 - green
Connector Wire Size	28 - 16 AWG
Connector Screw Torque	0.4 Nm
Connector Screwdriver Size	DN-SS1 (recommended)

6

Setting the Module Jumpers

The position of the J2 jumpers determines the input and output signal levels. You can choose between 0–5 VDC or 0–10 VDC. The module ships with the jumpers connecting the pins. In this position, the input and output signal level is 0–5 VDC. To select 0–10 VDC signals, use the jumper setting chart located on the module. One or more channels can be selected for 0–10 VDC input and output signal level by removing the jumper from the connecting pins of the appropriate channel. This will allow you to have one channel selected for a 0–5 VDC signal and another channel selected for a 0–10 VDC signal.



WARNING: Before removing the analog module or the terminal block on the face of the module, disconnect power to the PLC and all field devices. Failure to disconnect power can result in damage to the PLC and/or field devices.

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

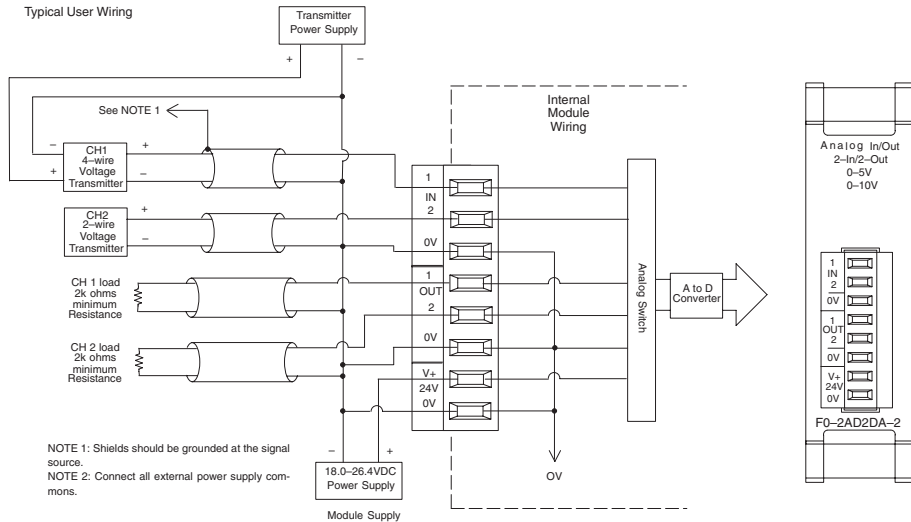
The F0-2AD2DA-2 will require an external power supply with a rating of 18.0–26.4VDC at 30 mA.

To remove the terminal block, disconnect power to the PLC and the field devices. Pull the terminal block firmly until the connector separates from the module.

You can remove the analog module from the PLC by folding out the retaining tabs at the top and bottom of the module. As the retaining tabs pivot upward and outward, the module's connector is lifted out of the PLC socket. Once the connector is free, you can lift the module out of its slot.

Wiring Diagram

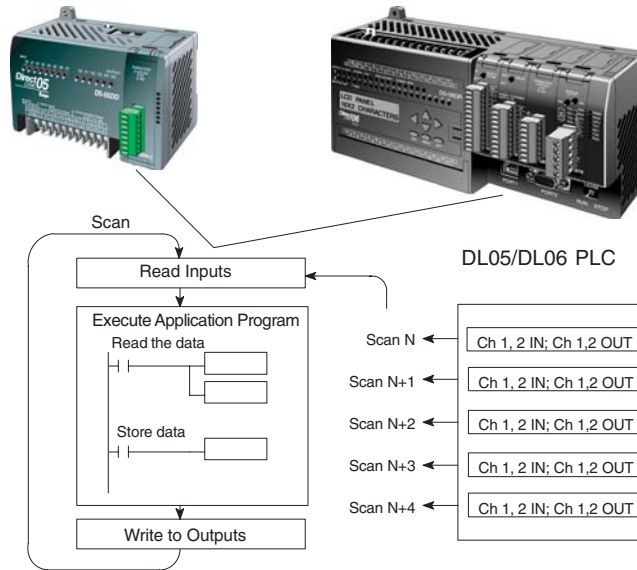
Use the following diagram to connect the field wiring. If necessary, the F0-2AD2DA-2 terminal block can be removed to make removal of the module possible without disturbing field wiring.



Module Operation

Input/Output Channel Scanning Sequence

The DL05 and DL06 read two channels of input and two channels of output data during each scan. The CPU supports special V-memory locations that are used to manage the data transfer. This is discussed in more detail on the following page, “Special V-memory Locations”.



Analog Module Updates

Even though the channel updates to the CPU are synchronous with the CPU scan, the module asynchronously monitors the analog transmitter signals and converts each signal into 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.

The module takes approximately 10 milliseconds to sense 95% of the change in the analog signal. For the vast majority of applications, the process changes are much slower than these updates.



NOTE: If you are comparing other manufacturers' update times (step responses) with ours, please be aware that some manufacturers refer to the time it takes to convert the analog signal to a digital value. Our analog to digital conversion takes only a few microseconds. It is the settling time of the filter that is critical in determining the full update time. Our update time specification includes the filter settling time.

Special V-memory Locations

Formatting the Module Data

The DL05 and DL06 PLCs have three special V-memory locations assigned to their respective option slots. These V-memory locations allow you to:

- specify the data format (binary or BCD)
- specify the number of I/O channels to scan (2 input and 2 output channels for the F0-2AD2DA-2)
- specify the V-memory locations to store the input data
- specify the V-memory locations to store the output data

DL05 Data Formatting

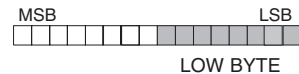
The table below shows the special V-memory locations used by the DL05 PLC for the analog combination modules.

Analog Combination Module DL05 Special V-memory Locations	
Data Type and Number of I/O Channels	V7700
Input Storage Pointer	V7701
Output Storage Pointer	V7702

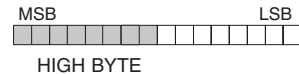
Structure of V7700

V-memory location 7700 is used for identifying the number of output channels, the number of input channels and the data type (binary or BCD). The low byte equals the number of output channels and the high byte equals the number of input channels. Either a 1 or a 2 will be entered to select the number of input and output channels to be used. A zero (0) entered for channel selection will cause the channel, either input or output, to be inoperative.

Loading a constant of 202 into V7700 identifies two input and two output analog channels, and sets the I/O data type to BCD.



Loading a constant of 8282 into V7700 identifies two input and two output analog channels, and sets the I/O data type to binary.



Structure of V7701

V7701 is a system parameter that points to a V-memory location used for storing analog input data. The V-memory location loaded in V7701 is an octal number identifying the first V-memory location for the analog input data. This V-memory location is user selectable. For example, loading O2000, using the LDA instruction, causes the pointer to write Ch 1's data value to V2000 and Ch 2's data value to V2001.

Structure of V7702

V7702 is a system parameter that points to a V-memory location used for storing analog output data. The V-memory location loaded in V7702 is an octal number identifying the first V-memory location for the analog output data. This V-memory location is user selectable. For example, loading O2010, using the LDA instruction, causes the pointer to write Ch 1's data value from V2010 and Ch 2's data value from V2011.

You will find an example program that loads appropriate values to V7700, V7701 and V7702 on page 6-10.

DL06 Data Formatting

Special V-memory locations are assigned to the four option module slots of the DL06 PLC. The table below shows these V-memory locations which can be used by the F0-2AD2DA-2.

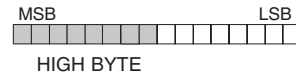
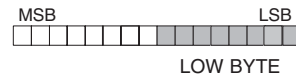
Analog Combination Module DL06 Special V-memory Locations				
Slot No.	1	2	3	4
Number of Channels	V700	V710	V720	V730
Input Pointer	V701	V711	V721	V731
Output Pointer	V702	V712	V722	V732

Setup Data Type and Number of Channels

V-memory locations 700, 710, 720 and 730 are used for identifying the number of output channels, the number of input channels and the data type (binary or BCD). The low byte equals the number of output channels and the high byte equals the number of input channels. Enter a 1 or 2 to select the number of input and output channels to be used. A zero (0) entered for channel selection will cause the channel, either input or output, to be inoperative.

For example, with a module installed in slot 1 by loading a constant of 202 into V700 identifies two input and two output analog channels, and sets the I/O data type to BCD.

And, loading a constant of 8282 into V700 identifies two input and two output analog channels, and sets the I/O data type to binary.



Input Storage Pointer

V-memory locations 701, 711, 721 and 731 are special locations used as a storage pointers for the analog input data. With the analog module installed in slot 1, the V-memory location loaded in V701 is an octal number identifying the first user V-memory location to read the analog input data. This V-memory location is user selectable. For example, loading O2000, using the LDA instruction, causes the pointer to write Ch 1's data value to V2000 and Ch 2's data value to V2001.

Output Storage Pointer

V-memory locations 702, 712, 722 and 732 are special locations used as storage pointer for the analog output data. With the analog module installed in slot 1, the V-memory location loaded in V702 is an octal number identifying the first user V-memory location to write the analog output data to. This V-memory location is user selectable. For example, loading O2010, using the LDA instruction, causes the pointer to write Ch 1's data value from V2010 and Ch 2's data value from V2011.

You will find an example program that loads appropriate values to V700, V701 and V702 on page 6-11.

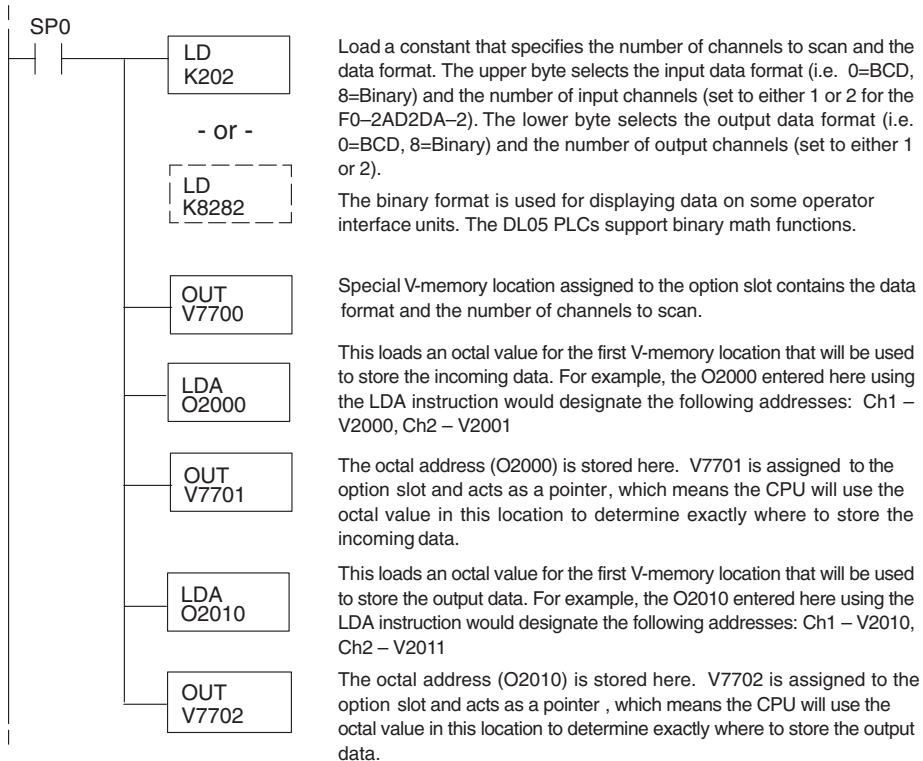
Using the Pointer in Your Control Program

DL05 Pointer Method

The DL05 CPU examines the pointer values (the memory locations identified in V7700, V7701 and V7702) on the first scan only.

The example program below shows how to setup these locations for 2 input channels and 2 output channels. This rung can be placed anywhere in the ladder program or in the initial stage if you are using stage programming instructions.

This is all that is required to read the analog input data into V-memory locations. Once the data is in V-memory you can perform mathematical calculations with the data, compare the data against preset values, and so forth. V2000 and V2010 is used in the example but you can use any user V-memory location.



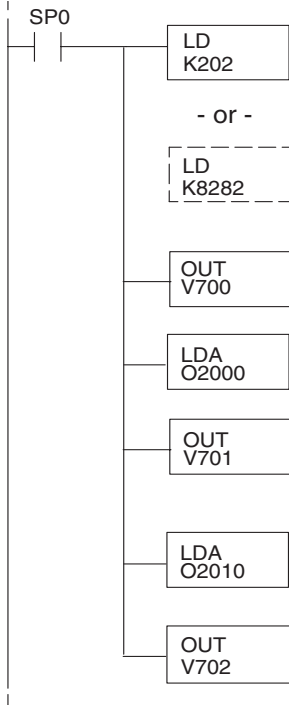
DL06 Pointer Method

Use the special V-memory table as a guide to setup the pointer values in the following example for the DL06. Slot 1 is the left most option slot. The CPU will examine the pointer values at these locations only after a mode transition, first scan only.

Analog Combination Module DL06 Special V-memory Locations				
Slot No.	1	2	3	4
Number of Channels	V700	V710	V720	V730
Input Pointer	V701	V711	V721	V731
Output Pointer	V702	V712	V722	V732

The F0-2AD2DA-2 can be installed in any available DL06 option slot. Using the example program from the previous page, but changing the V-memory addresses, the ladder diagram below shows how to setup these locations for 2 input channels and 2 output channels with the module installed in slot1 of the DL06. Use the above table to determine the pointer values if locating the module in any of the other slot locations. Place this rung anywhere in the ladder program or in the initial stage if you are using stage programming instructions.

Like the DL05 example, this logic is all that is required to read the analog input data into V-memory locations. Once the data is in V-memory you can perform mathematical calculations with the data, compare the data against preset values, and so forth. V2000 and V2010 is used in the example but you can use any user V-memory location.



Loads a constant that specifies the number of channels to scan and the data format. The upper byte selects the input data format (i.e. 0=BCD, 8=Binary) and the number of input channels (set to either 1 or 2 for the F0-2AD2DA-2). The lower byte selects the output data format (i.e. 0=BCD, 8=Binary) and the number of output channels (set to either 1 or 2).

The binary format can be used for displaying data on some operator interface units and on the DL06 LCD display. The DL06 PLCs support binary math functions.

Special V-memory location assigned to the first option slot contains the data format and the number of channels to scan.

This loads an octal value for the first V-memory location that will be used to store the incoming data. For example, O2000 entered here using the LDA instruction would designate the following addresses: Ch1 - V2000, Ch2 - V2001

The octal address (O2000) is stored here. V701 is assigned to the first option slot and acts as a pointer, which means the CPU will use the octal value in this location to determine exactly where to store the incoming data.

This loads an octal value for the first V-memory location that will be used to store the output data. For example, O2010 entered here using the LDA instruction would designate the following addresses: Ch1 - V2010, Ch2 - V2011

The octal address (O2010) is stored here. V702 is assigned to the first slot 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.

Scale Conversions

Scaling the Input Data

Many applications call for measurements in engineering units, which can be more meaningful than raw data. Convert to engineering units using the formula shown to the right.

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

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

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 100.0 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.

Analog Value of 2024, slightly less than half scale, should yield 49.4 PSI.

Example without multiplier

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

$$\text{Units} = 2024 \frac{100-0}{4095} + 0$$

$$\text{Units} = 49$$

Handheld Display

V 2001	V 2000
0000	0049

Example with multiplier

$$\text{Units} = 10 A \frac{H-L}{4095} + L$$

$$\text{Units} = 20240 \frac{100-0}{4095} + 0$$

$$\text{Units} = 494$$

Handheld Display

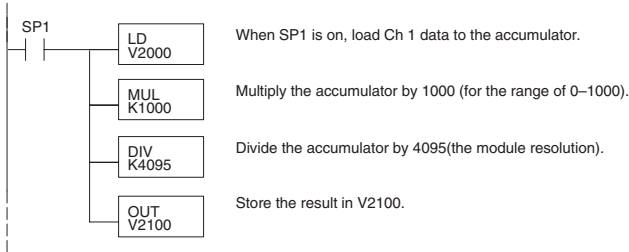
V 2001	V 2000
0000	0494

This value is more accurate

The Conversion Program

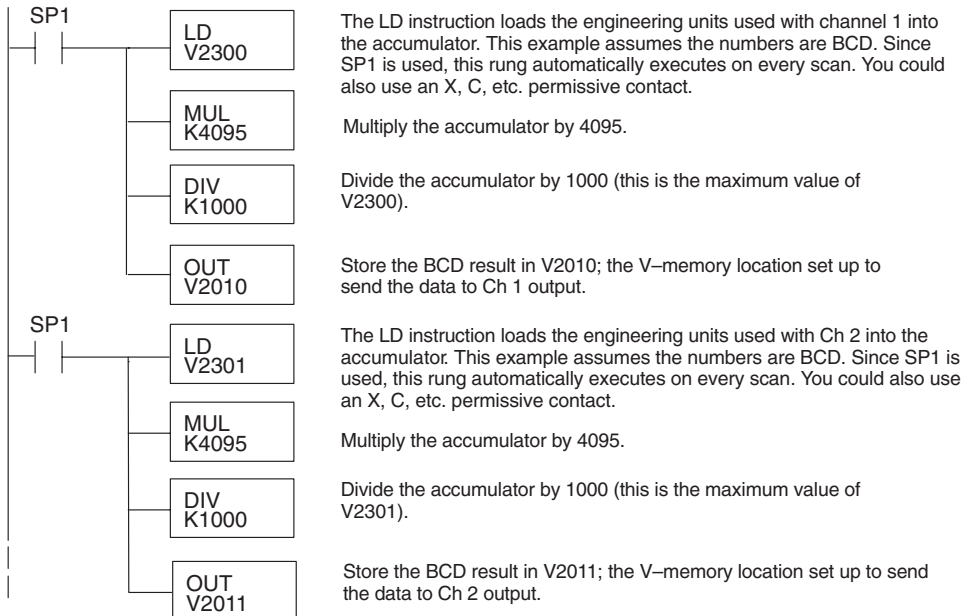
The following example shows how you would write the program to perform the engineering unit conversion from the input data format 0–4095. This example assumes the raw input data read at V2000 is in BCD format.

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



Output Conversion Program

The following example program shows how you would write the program to convert the engineering unit to the output data format 0–4095. This example assumes you have calculated or loaded the engineering unit values between 0–1000 in BCD format and stored them in V2300 and V2301 for channels 1 and 2 respectively. Both the DL05 and DL06 offer instructions that allow you to perform math operations using BCD format. It is usually easier to perform any math calculations in BCD and then convert the value to binary before you send the data to the module.



Analog and Digital Value Conversions

Sometimes it is useful to 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
0 to 5V	$A = \frac{5D}{4095}$	$D = \frac{4095}{5} (A)$
0 to 10V	$A = \frac{10D}{4095}$	$D = \frac{4095}{10} (A)$

For example, if you are using the 0–10V range and you need a 6V signal level, use this formula to determine the digital value (D) that will be stored in the V-memory location that contains the data.

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

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

$$D = (409.5) (6)$$

$$D = 2457$$

Module Resolution

Analog Data Bits

The first twelve bits represent the analog data for both inputs and outputs in binary format.

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

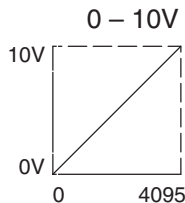
MSB												LSB											
[] [] [] [] [] [] [] [] [] [] [] []												[] [] [] [] [] [] [] [] [] [] [] []											
												1 1 9 8 7 6 5 4 3 2 1 0											
												1 0											

[] = data bits

Resolution Details

Since the module has 12-bit resolution for both inputs and outputs, the analog signal is either converted into 4096 counts or a count value will produce a proportional analog output. In either situation the count range will be from 0–4095 (2¹²). For example, with an output range of 0 to 10V, send a 0 to get a 0V signal, and send 4095 to get a 10V signal. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal.

Each count can also be expressed in terms of the signal level by using the following equation:



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

H = high limit of the signal range

L = low limit of the signal range

The following table shows the smallest detectable signal change that will result in one LSB change in the data or the amount of change in the output signal that each increment of the count value will produce.

Voltage Range	Signal Span	Divide By	Smallest detectable or Produced Change
0 to 5V	5 volts	4095	1.22 mV
0 to 10V	10 volts	4095	2.44 mV

Analog Input Ladder Logic Filter

PID Loops / Filtering:

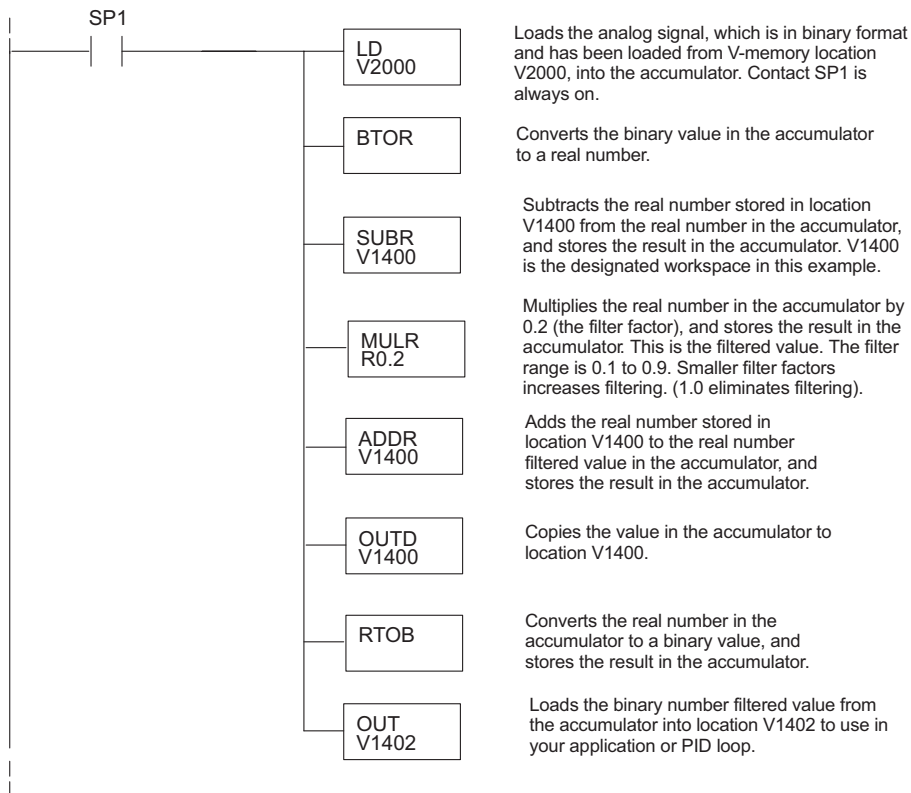
Please refer to the “PID Loop Operation” chapter in the DL06 or DL05 User Manual for information on the built-in PV filter (DL05/06) and the ladder logic filter (DL06 only) shown below. A filter must be used to smooth the analog input value when auto tuning PID loops to prevent giving a false indication of loop characteristics.

Smoothing the Input Signal (DL06 only):

The filter logic can also be used in the same way to smooth the analog input signal to help stabilize PID loop operation or to stabilize the analog input signal value for use with an operator interface display, etc.

Warning: The built-in and logic filters are not intended to smooth or filter noise generated by improper field device wiring or grounding. Small amounts of electrical noise can cause the input signal to bounce considerably. Proper field device wiring and grounding must be done before attempting to use the filters to smooth the analog input signal.

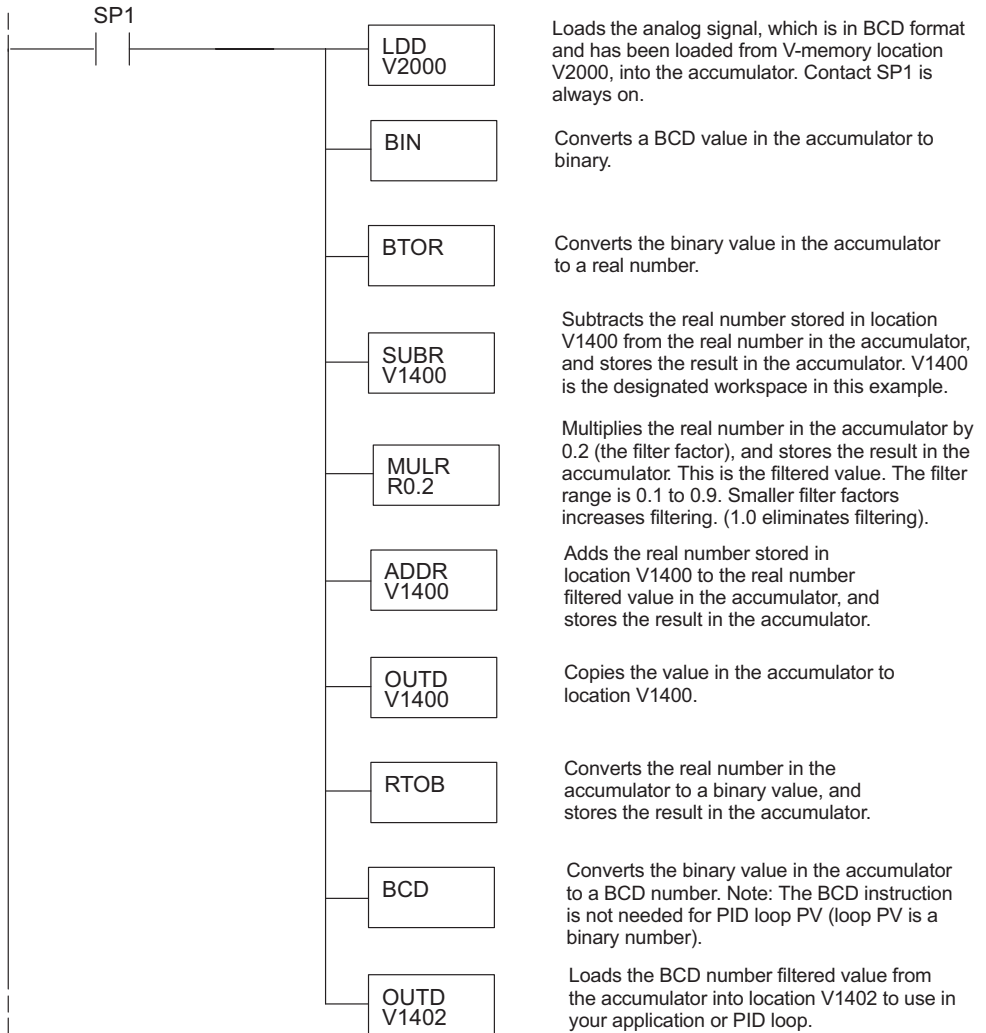
Using Binary Data Format





NOTE: Be careful not to do a multiple number conversion on a value. For example, if you are using the pointer method in BCD format to get the analog value, it must be converted to binary (BIN) as shown below. If you are using the pointer method in Binary format, the conversion to binary (BIN) instruction is not needed.

Using BCD Data Format



F0-4AD2DA-2 4-Ch. IN/2-Ch. OUT ANALOG VOLTAGE COMBINATION



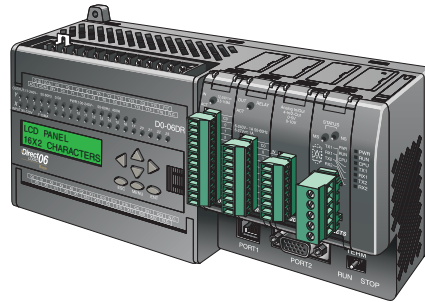
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Module Specifications

The F0-4AD2DA-2 Analog Combination module offers the following features:

- The analog input and output channels are updated in one scan.
- The removable terminal block makes it possible to remove the module without disconnecting the field wiring.
- Analog inputs can be used as process variables for the four (4) PID loops in the DL05 CPU and the eight (8) PID loops in the DL06 CPUs.
- On-board active analog filtering and RISC-like microcontroller provide digital signal processing to maintain precise analog measurements in noisy environments.



NOTE: The DL05 CPU's analog feature for this module requires **DirectSOFT32** Version 3.0c (or later) and firmware version 3.30 (or later). The DL06 requires **DirectSOFT32** version V4.0, build 16 (or later) and firmware version 1.00 (or later). See our website for more information: www.automationdirect.com.

The following tables provide the specifications for the F0-4AD2DA-2 Analog Combination Module. Review these specifications to make sure the module meets your application requirements.

Input Specifications	
Number of Channels	4, single ended (one common)
Input Range	0 to 5 VDC or 0 to 10 VDC (jumper selectable)
Resolution	12 bit (1 in 4096)
Step Response	10.0 mS to 95% of full step change
Crosstalk	-80 dB, 1/2 count maximum*
Active Low-pass Filtering	-3 dB at 300Hz (-12 dB per octave)
Input Impedance	Greater than 20K Ω
Absolute Maximum Ratings	± 15 V
Linearity Error (End to End)	± 2 counts maximum*
Input Stability	± 1 count *
Gain Error	± 6 counts maximum *
Offset Error	± 2 counts maximum*
Maximum Inaccuracy	$\pm 0.3\%$ @ 25°C (77°F) $\pm 0.6\%$ 0 to 60°C (32 to 140°F)
Accuracy vs. Temperature	± 100 ppm/°C typical

Output Specifications	
Number of Channels	2, single ended (one common)
Output Range	0 to 5 VDC or 0 to 10 VDC (jumper selectable)
Resolution	12 bit (1 in 4096)
Conversion Settling Time	50 μ S for full scale change
Crosstalk	-80 db, 1/2 count maximum*
Peak Output Voltage	± 15 VDC (power supply limited)
Offset Error	0.1% of range
Gain Error	0.4% of range
Linearity Error (end to end)	± 1 count (0.075% of full scale) maximum*
Output Stability	± 2 counts*
Load Impedance	2K Ω maximum
Load Capacitance	0.01 μ F maximum
Accuracy vs. Temperature	± 50 ppm/°C typical

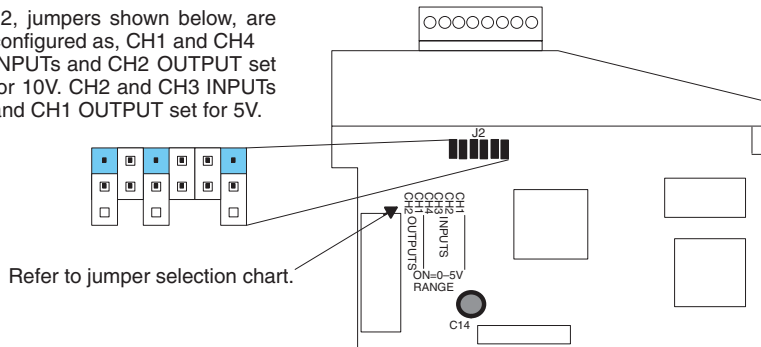
* One count in the specification table is equal to one least significant bit of the analog data value (1 in 4096).

General Specifications	
PLC Update Rate	4 input channels per scan 2 output channels per scan
16-bit Data Word	12 binary data bits
Operating Temperature	0 to 60° C (32 to 140° F)
Storage Temperature	-20 to 70° C (-4 to 158° F)
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
Power Budget Requirement	100 mA @ 5 VDC (supplied by base)
Connector	Phoenix Mecano, Inc. Part No. AK1550/8-3.5 - green
Connector Wire Size	28 - 16 AWG
Connector Screw Torque	0.4 Nm
Connector Screwdriver Size	DN-SS1 (recommended)

7 Setting the Module Jumpers

The position of the J2 jumpers determines the input and output signal levels. You can choose between 0–5VDC or 0–10VDC. The module ships with the jumpers installed connecting the pins. In this position, the input and output signal level is 0–5VDC. To select 0–10VDC signals, use the jumper selection chart located on the module. One or more channels can be selected for 0–10 VDC input and output signal level by removing the jumper from the connecting pin of the appropriate channel. This will allow you to have one channel selected for a 0–5 VDC signal and another channel selected for a 0–10 VDC signal.

J2, jumpers shown below, are configured as, CH1 and CH4 INPUTs and CH2 OUTPUT set for 10V. CH2 and CH3 INPUTs and CH1 OUTPUT set for 5V.



WARNING: Before removing the analog module or the terminal block on the face of the module, disconnect power to the PLC and all field devices. Failure to disconnect power can result in damage to the PLC and/or field devices.

Connecting and Disconnecting 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:

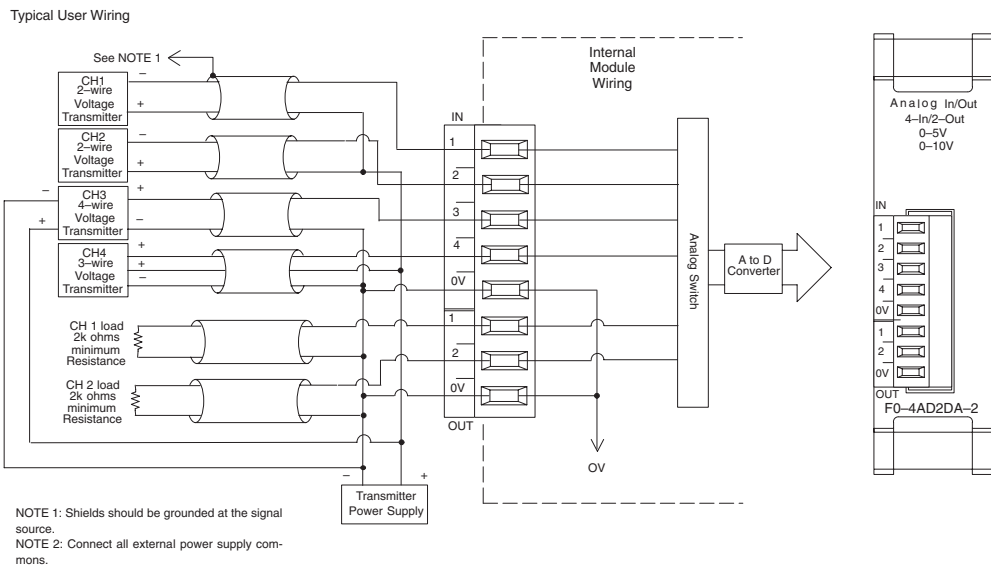
- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. *Do not* ground the shield at both the module and the source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.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

A separate transmitter power supply may be required, depending on the type of transmitter being used. This module has a removable connector to make wiring and module removal easier. To remove the terminal block, disconnect power to the PLC and the field devices. Pull the terminal block firmly until the connector separates from the module.

The analog module can be removed from the PLC by folding out the retaining tabs at the top and bottom of the module. As the retaining tabs pivot upward and outward, the module's connector is lifted out of the PLC socket. Once the connector is free, you can lift the module out of its slot.

Wiring Diagram

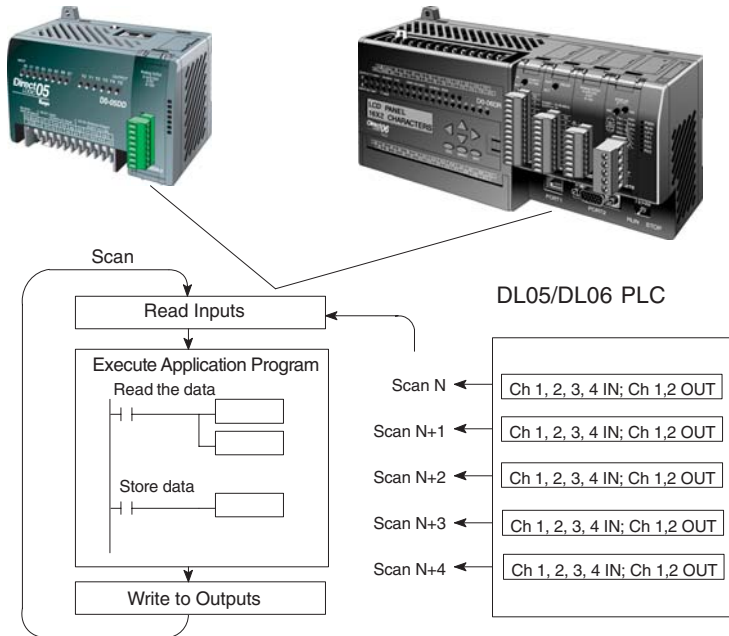
Use the following diagram to connect the field wiring. If necessary, the terminal block can be removed to make removal of the module possible without disturbing field wiring.



Module Operation

Input/Output Channel Update Sequence

The DL05 and DL06 read four channels of input data and two channels of output data during each scan. The CPU supports special V-memory locations that are used to manage the data transfer. This is discussed in more detail on the next page, “Special V-memory Locations”.



Analog Module Updates

Even though the channel updates to the CPU are synchronous with the CPU scan, the module asynchronously monitors the analog transmitter signals and converts each signal into 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.

The module takes approximately 10 milliseconds to sense 95% of the change in the analog signal. For the vast majority of applications, the process changes are much slower than these updates.



NOTE: If you are comparing other manufacturers' update times (step responses) with ours, please be aware that some manufacturers refer to the time it takes to convert the analog signal to a digital value. Our analog to digital conversion takes only a few microseconds. It is the settling time of the filter that is critical in determining the full update time. Our update time specification includes the filter settling time.

Special V-memory Locations

Formatting the Module Data

The DL05 and DL06 PLCs have three special V-memory locations assigned to their respective option slots. These V-memory locations allow you to:

- specify the data format (binary or BCD)
- specify the number of input and output channels to scan.
- specify the V-memory locations to store the input data
- specify the V-memory locations to store the output data

DL05 Data Formatting

The table below shows the special V-memory locations which are used by the DL05 PLC for the F0-4AD2DA-2.

Analog Combination Module DL05 Special V-memory Locations	
Data Type and Number of I/O Channels	V7700
Input Storage Pointer	V7701
Output Storage Pointer	V7702

Structure of V7700

V-memory location 7700 is used for identifying the number of output channels, the number of input channels and the data type (binary or BCD). The low byte equals the number of output channels and the high byte equals the number of input channels. Enter a 1 through 4 to select the number of input channels and a 1 through 2 to select the number of output channels to be used. A zero (0) entered for channel selection will cause the channel, either input or output, to be inoperative.

Loading a constant of 402 into V7700 identifies four input and two output analog channels, and sets the I/O data type to BCD.

Loading a constant of 8482 into V7700 identifies four input and two output analog channels, and sets the I/O data type to binary.



Structure of V7701

V7701 is a system parameter that points to a V-memory location used for storing analog input data. The V-memory location loaded in V7701 is an octal number identifying the first V-memory location for the analog input data. This V-memory location is user selectable. For example, loading O2000 using the LDA instruction causes the pointer to write Ch 1's data value to V2000, Ch 2's data value to V2001, CH 3's data value to V2002 and Ch 4's data value to V2003.

Structure of V7702

V7702 is a system parameter that points to a V-memory location used for storing analog output data. The V-memory location loaded in V7702 is an octal number identifying the first V-memory location for the analog output data. This V-memory location is user selectable. For example, loading O2010 using the LDA instruction causes the pointer to read Ch 1's data value at V2010 and Ch 2's data value at V2011.

You will find an example program that loads appropriate values to V7700, V7701 and V7702 on page 7-10.

DL06 Data Formatting

Special V-memory locations are assigned to the four option module slots of the DL06 PLC. The table below shows these V-memory locations which can be used for the F0-4AD2DA-2.

Analog Combination Module DL06 Special V-memory Locations				
Slot No.	1	2	3	4
Number of Channels	V700	V710	V720	V730
Input Pointer	V701	V711	V721	V731
Output Pointer	V702	V712	V722	V732

Setup Data Type and Number of Channels

V-memory location 700, 710, 720 and 730 are used for identifying the number of output channels, the number of input channels and the data type (binary or BCD). The low byte equals the number of output channels and the high byte equals the number of input channels. Enter a 1 through 4 to select the number of input channels and a 1 or 2 to select the number of output channels to be used. A zero (0) entered for channel selection will cause the channel, either input or output, to be inoperative.

For example, with a module installed in slot 4 by loading a constant of 402 into V730 identifies four input and two output analog channels, and sets the I/O data type to BCD.

Or, loading a constant of 8482 into V730 identifies four input and two output analog channels, and sets the I/O data type to binary.



Input Storage Pointer Setup

V-memory locations 701, 711, 721 and 731 are special locations used as storage pointers for the analog input data. With the analog module installed in slot 4, the V-memory location loaded in V731, for instance, is an octal number identifying the first user V-memory location to read the analog input data. This V-memory location is user selectable. For example, loading O2000 using the LDA instruction causes the pointer to write Ch 1's data value to V2000, Ch 2's data value to V2001, CH 3's data value to V2002 and Ch 4's data value to V2003.

Output Storage Pointer Setup

V-memory locations 702, 712, 722 and 732 are special locations used as storage pointers for the analog output data. With the analog module installed in slot 4, the V-memory location loaded in V732 is an octal number identifying the first user V-memory location to write the analog output data to. This V-memory location is user selectable. For example, loading O2010 using the LDA instruction causes the pointer to read Ch 1's data value at V2010 and Ch 2's data value at V2011.

You will find an example program that loads appropriate values to V700, V701 and V702 on page 7-11.

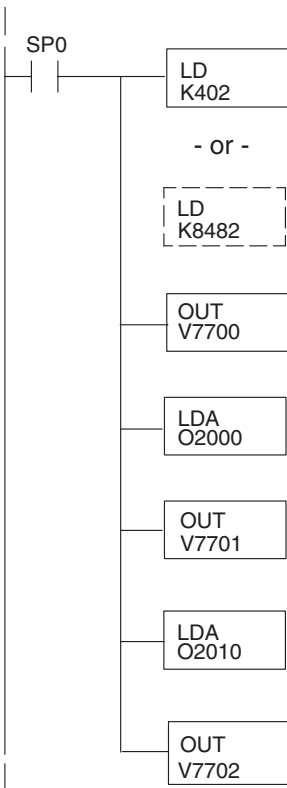
Using the Pointer in Your Control Program

DL05 Pointer Method

The DL05 CPU examines the pointer values (the memory locations identified in V7700, V7701 and V7702) on the first scan only.

The example program below shows how to setup these locations for 4 input channels and 2 output channels. This rung can be placed anywhere in the ladder program or in the initial stage if you are using stage programming instructions.

This is all that is required to read the analog input 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 and V2010 is used in the example but you can use any user V-memory location.



Loads a constant that specifies the number of channels to scan and the data format. The upper byte selects the input data format (i.e. 0=BCD, 8=Binary) and the number of input channels (set to 4). The lower byte selects the output data format (i.e. 0=BCD, 8=Binary) and the number of output channels (set to 2).

The binary format is used for displaying data on some operator interface units. The DL05 PLCs support binary math functions.

Special V-memory location assigned to the option slot contains the data format and the number of channels to scan.

This loads an octal value for the first V-memory location that will be used to store the incoming data. For example, the O2000 entered here would designate the following addresses:

Ch1 – V2000, Ch2 – V2001, Ch3 – V2002, Ch4 – V2003

The octal address (O2000) is stored here. V7701 is assigned to the option slot and acts as a pointer, which means the CPU will use the octal value in this location to determine exactly where to store the incoming data.

This loads an octal value for the first V-memory location that will be used to store the output data. For example, the O2010 entered here would designate the following addresses:

Ch1 – V2010, Ch2 – V2011

The octal address (O2010) is stored here. V7702 is assigned to the option slot and acts as a pointer, which means the CPU will use the octal value in this location to determine exactly where to get the output data.

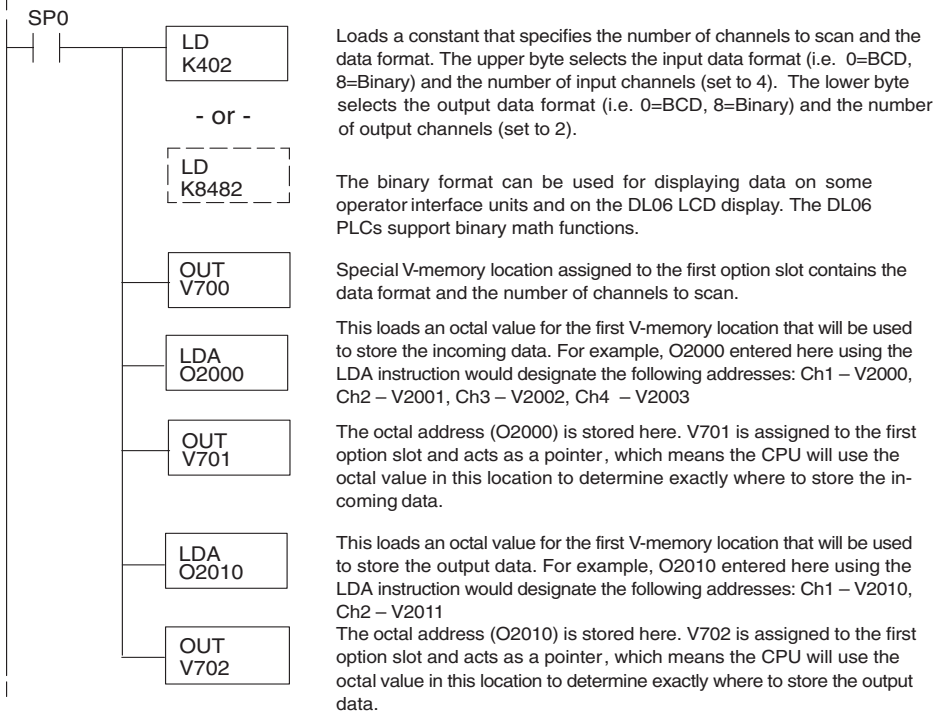
DL06 Pointer Method

Use the special V-memory table as a guide to setup the pointer values in the following example for the DL06. Slot 1 is the left most option slot. The CPU will examine the pointer values at these locations only after a mode transition, first scan only.

Analog Combination Module DL06 Special V-memory Locations				
Slot No.	1	2	3	4
Number of Channels	V700	V710	V720	V730
Input Pointer	V701	V711	V721	V731
Output Pointer	V702	V712	V722	V732

The F0-4AD2DA-2 can be installed in any available DL06 option slot. Using the example program from the previous page, but changing the V-memory addresses, the ladder diagram below shows how to setup these locations for 4 input channels and 2 output channels with the module installed in slot1 of the DL06. Use the above table to determine the pointer values if locating the module in any of the other slot locations. Place this rung anywhere in the ladder program or in the initial stage if you are using stage programming instructions.

Like the DL05 example, this logic is all that is required to read the analog input data into V-memory locations. Once the data is in V-memory you can perform mathematical calculations with the data, compare the data against preset values, and so forth. V2000 and V2010 is used in the example but you can use any user V-memory location.



Scale Conversions

Scaling the Input Data

Many applications call for measurements in engineering units, which can be more meaningful than raw data. Convert to engineering units using the formula shown to the right.

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

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

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 100.0 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.

Analog Value of 2024, slightly less than half scale, should yield 49.4 PSI

Example without multiplier

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

$$\text{Units} = 2024 \frac{100-0}{4095} + 0$$

$$\text{Units} = 49$$

Handheld Display

V 2001	V 2000
0000	0049

Example with multiplier

$$\text{Units} = 10 A \frac{H-L}{4095} + L$$

$$\text{Units} = 20240 \frac{100-0}{4095} + 0$$

$$\text{Units} = 494$$

Handheld Display

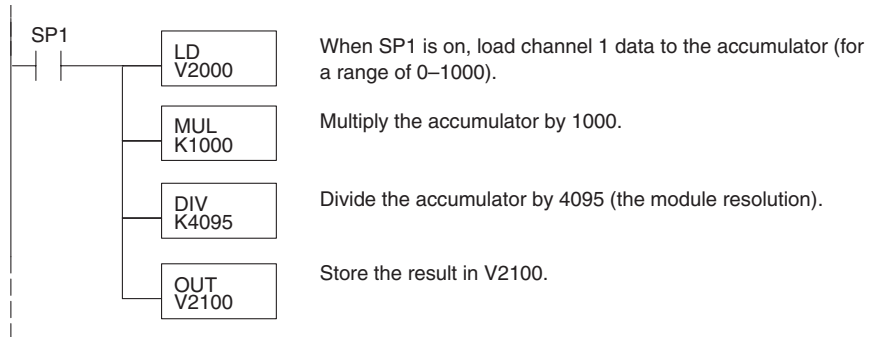
V 2001	V 2000
0000	0494

This value is more accurate

The Conversion Program

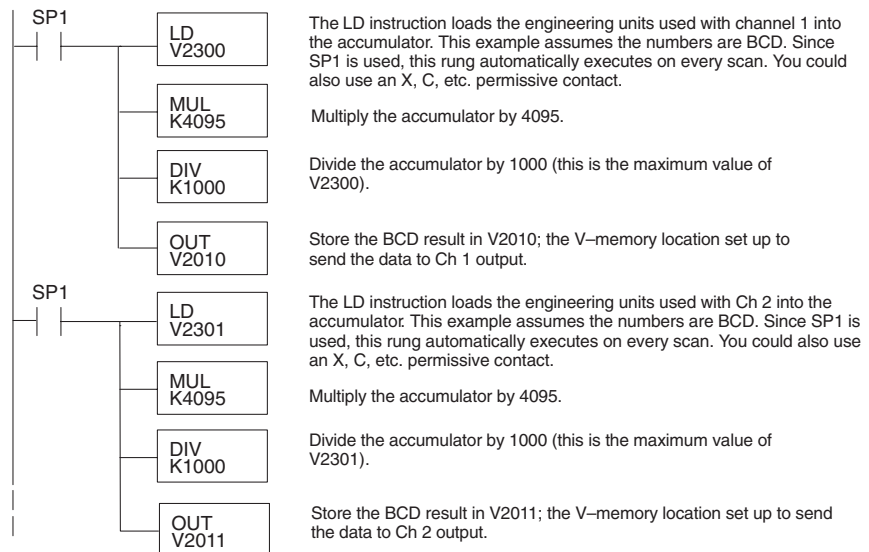
The following example shows how you would write the program to perform the engineering unit conversion from input data formats 0–4095. This example assumes the raw input data read at V2000 is in BCD format.

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



Output Conversion Program

The following example program shows how you would write the program to perform the engineering unit conversion to output data formats 0–4095. This example assumes you have calculated or loaded the engineering unit values between 0–1000 in BCD format and stored them in V2300 and V2301 for channels 1 and 2 respectively. The DL05 and DL06 offer instructions that allow you to perform math operations using BCD format. It is usually easier to perform any math calculations in BCD and then convert the value to binary before you send the data to the module.



Analog and Digital Value Conversions

Sometimes it is useful to 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
0 to 5V	$A = \frac{5D}{4095}$	$D = \frac{4095}{5} (A)$
0 to 10V	$A = \frac{10D}{4095}$	$D = \frac{4095}{10} (A)$

For example, if you are using the 0–10V range and you need a 6V signal level, use this formula to determine the digital value (D) that will be stored in the V-memory location that contains the data.

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

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

$$D = (409.5) (6)$$

$$D = 2457$$

Module Resolution

Analog Data Bits

The first twelve bits represent the analog data for both inputs and outputs in binary format.

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

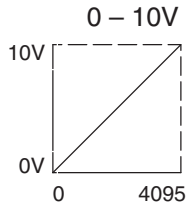
MSB												LSB											
[] [] [] [] [] [] [] [] [] [] [] []												[] [] [] [] [] [] [] [] [] [] [] []											
												1 1 9 8 7 6 5 4 3 2 1 0											
												1 0											

[] = data bits

Resolution Details

Since the module has 12-bit resolution for both inputs and outputs, the analog signal is either converted into 4096 counts or a count value will produce a proportional analog output. In either situation the count range will be from 0–4095 (2¹²). For example, with an output range of 0 to 10V, send a 0 to get a 0V signal, and send 4095 to get a 10V signal. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal.

Each count can also be expressed in terms of the signal level by using the following equation:



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

H = high limit of the signal range

L = low limit of the signal range

The following table shows the smallest detectable signal change that will result in one LSB change in the data or the amount of change in the output signal that each increment of the count value will produce.

Voltage Range	Signal Span	Divide By	Smallest Detectable or Produced Change
0 to 5V	5 volts	4095	1.22 mV
0 to 10V	10 volts	4095	2.44 mV

Analog Input Ladder Logic Filter

PID Loops / Filtering:

Please refer to the “PID Loop Operation” chapter in the DL06 or DL05 User Manual for information on the built-in PV filter (DL05/06) and the ladder logic filter (DL06 only) shown below. A filter must be used to smooth the analog input value when auto tuning PID loops to prevent giving a false indication of loop characteristics.

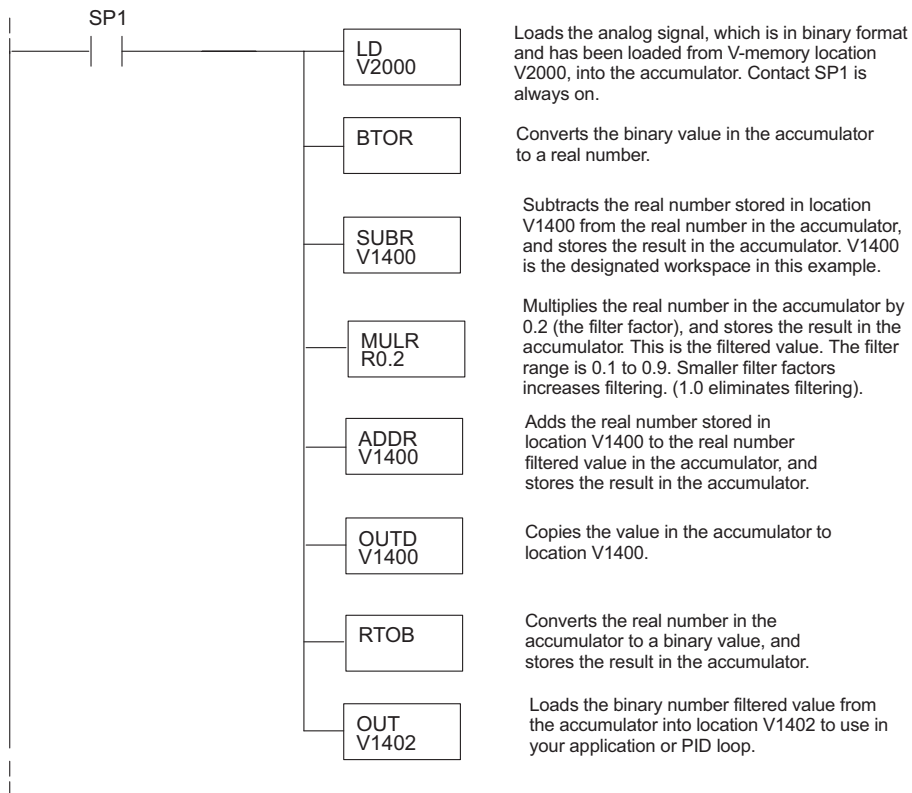
Smoothing the Input Signal (DL06 only):

The filter logic can also be used in the same way to smooth the analog input signal to help stabilize PID loop operation or to stabilize the analog input signal value for use with an operator interface display, etc.



Warning: The built-in and logic filters are not intended to smooth or filter noise generated by improper field device wiring or grounding. Small amounts of electrical noise can cause the input signal to bounce considerably. Proper field device wiring and grounding must be done before attempting to use the filters to smooth the analog input signal.

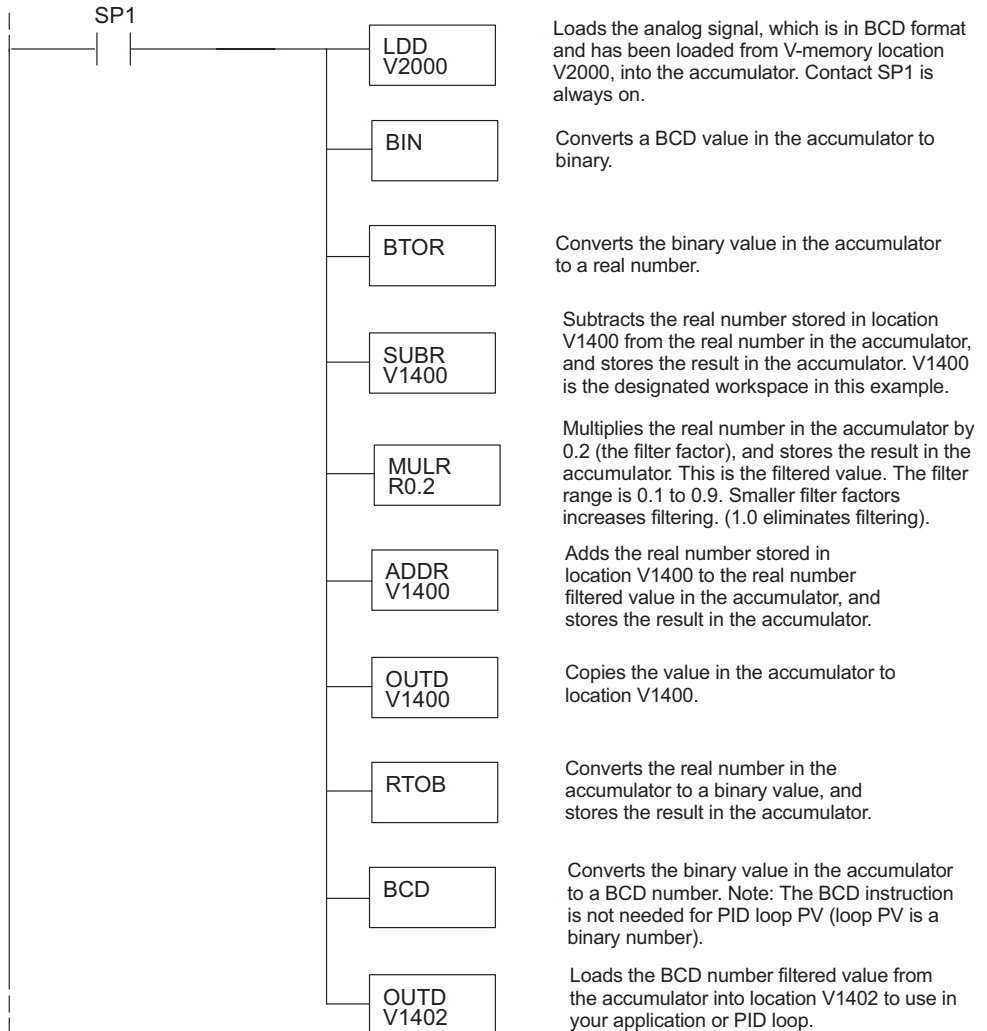
Using Binary Data Format





NOTE: Be careful not to do a multiple number conversion on a value. For example, if you are using the pointer method in BCD format to get the analog value, it must be converted to binary (BIN) as shown below. If you are using the pointer method in Binary format, the conversion to binary (BIN) instruction is not needed.

Using BCD Data Format



F0-04RTD 4-CHANNEL RTD INPUT



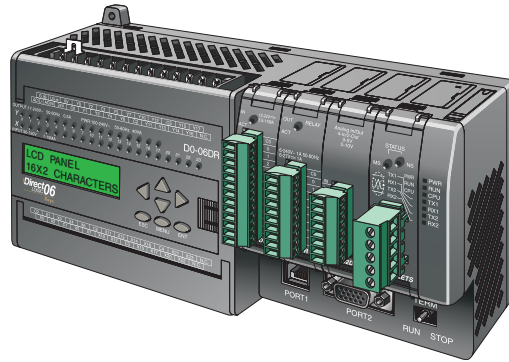
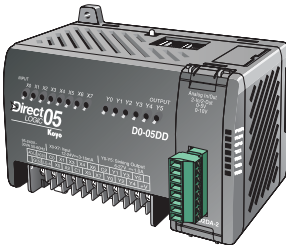
In This Chapter...

Module Specifications	8-2
Connecting and Disconnecting the Field Wiring	8-4
Module Operation	8-6
Special V-memory Locations	8-7
Configuring the Module in Your Control Program	8-11
Negative Temperature Readings with Magnitude Plus Sign	8-15
Analog Input Ladder Logic Filter	8-18
RTD Burnout Detection Bits	8-20

Module Specifications

The F0-04RTD 4-Channel Resistive Temperature Detector Input Module provides the following features and benefits:

- Provides four RTD input channels with 0.1 °C/°F temperature resolution.
- Automatically converts type Pt100Ω, jPt100Ω, Pt1000Ω, 10Ω Cu, 25Ω Cu, 120Ω Ni RTD signals into direct temperature readings. No extra scaling or complex conversion is required.
- Temperature data can be expressed in °F or °C, and as magnitude plus sign or 2's complement.
- Precision lead wire resistance compensation by dual matched current sources and ratiometric measurements. Works with three wire and four wire RTDs.
- The temperature calculation and linearization are based on data provided by the National Institute of Standards and Technology (NIST).
- Diagnostic features include detection of short circuits and input disconnection.



NOTE: The DL05 CPU's analog feature for this module requires **DirectSOFT32** Version 3.0c (or later) and firmware version 4.70 (or later). The DL06 requires **DirectSOFT32** version V4.0, build 16 (or later) and firmware version 1.50 (or later). See our website for more information: www.automationdirect.com.

Module Calibration

The module automatically re-calibrates every five seconds to remove any offset and gain errors. The F0-04RTD module requires no user calibration. However, if your process requires calibration, it is possible to correct the RTD tolerance using ladder logic. You can subtract or add a constant to the actual reading for that particular RTD. The actual reading can also be scaled to obtain the desired value using ladder logic.

Input Specifications

The following table provide the specifications for the F0-04RTD Input Module. Review these specifications to make sure the module meets your application requirements.

Input Specifications	
Number of Channels	4
Input Ranges	PT100: -200.0 °C to 850.0 °C (-328 °F to 1562 °F) PT1000: -200.0 °C to 595.0 °C (-328 °F to 1103 °F) jPt100: -38.0 °C to 450.0 °C (-36 °F to 842 °F) 10Ω Cu: -200.0 °C to 260.0 °C (-328 °F to 500 °F) 25Ω Cu: -200.0 °C to 260.0 °C (-328 °F to 500 °F) 120Ω Ni: -80.0 °C to 260.0 °C (-112 °F to 500 °F)
Resolution	16 bit (1 in 65535)
Display Resolution	±0.1 °C, ±0.1 °F (±3276.7)
Absolute Maximum Ratings	Fault Protected Inputs to ±50VDC
Converter Type	Charge Balancing, 24 bit
Sampling Rate	140ms per channel
Linearity Error (End to End)	±0.05 °C maximum, ±0.01 °C typical
PLC Update Rate	4 channels/scan
Temperature Drift	15 ppm / °C maximum
Maximum Inaccuracy	±1 °C
RTD Excitation Current	200µA
Common Mode Range	0-5VDC
Notch Filter (Common Mode Rejection)	>50 db notches at 50/60Hz
Digital Input Points Required	None; uses special V-memory locations based on slot
Power Budget Requirements	70 mA @ 5VDC (supplied by base)
Operating Temperature	0 to 60° C (32 to 140° F)
Storage Temperature	-20 to 70° C (-4 to 158° F)
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
Replacement Terminal Block	D0-ACC-4
Wire Size Range & Connector Screw Torque	28 - 16 AWG; 0.4Nm; DN-SS1 Screwdriver Recommended

Connecting and Disconnecting 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 transmitter source. *Do not* ground the shield at both the module and the source.
- Unused channels require shorting wires (jumpers) installed from terminals CH+ to CH– to COM.
- 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.

To remove the terminal block, disconnect power to the PLC and the field devices. Pull the terminal block firmly until the connector separates from the module.

You can remove the RTD module from the PLC by folding out the retaining tabs at the top and bottom of the module. As the retaining tabs pivot upward and outward, the module's connector is lifted out of the PLC socket. Once the connector is free, you can lift the module out of its slot.

Use the following diagram to connect the field wiring. If necessary, the F0-04RTD terminal block can be removed to make removal of the module possible without disturbing field wiring.

RTD - Resistance Temperature Detector

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

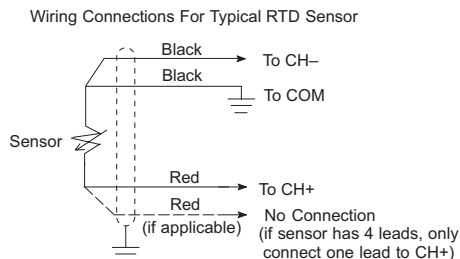
Lead Configuration for RTD Sensors

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

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

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

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



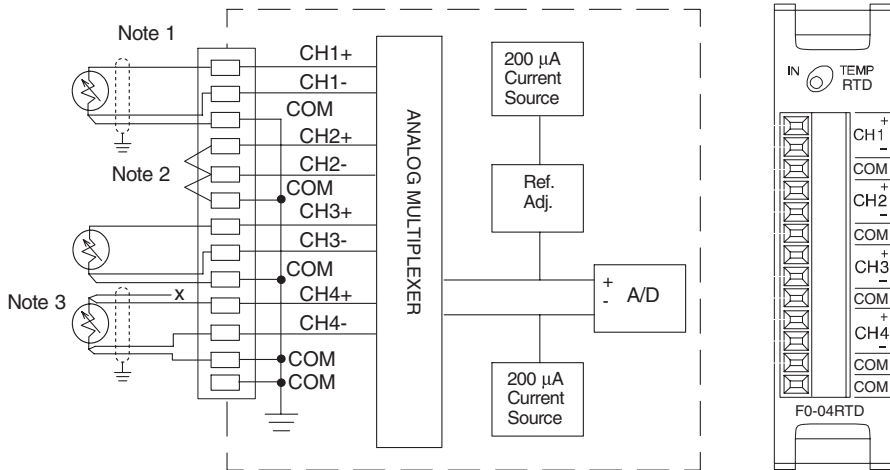
Ambient Variations in Temperature

The F0-04RTD module has been designed to operate within the ambient temperature range of 0 °C to 60 °C.

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

Wiring Diagram

Use the following diagram to connect the field wiring. If necessary, the F0-04RTD terminal block can be removed to make removal of the module possible without disturbing field wiring.



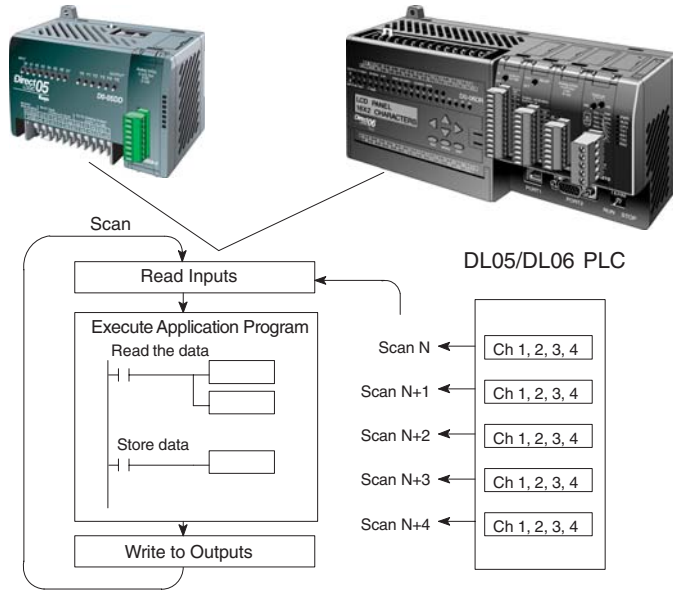
Notes:

1. The three wires connecting the RTD to the module must be the same type and length. Do not use the shield or drain wire for the third connection.
2. Unused channels require shorting wires (jumpers) installed from terminals CH+ to CH- to COM to prevent possible noise from influencing active channels. This should be done even if the unused channel is not enabled in the V-memory configuration.
3. If a RTD sensor has four wires, the plus sense wire should be left unconnected as shown.

Module Operation

Channel Scanning Sequence

The DL05 and DL06 read all four input channels data during each scan. The CPUs support special V-memory locations that are used to manage the data transfer. This is discussed in more detail on the following page, “Special V-memory Locations”.



Analog Module Update

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

The time required to sense the temperature and copy the value to V-memory is 140 milliseconds minimum to 560 milliseconds plus 1 scan time maximum (number of channels x 140 milliseconds + 1 scan time).

Special V-memory Locations

The DL05 and DL06 PLCs have special V-memory locations assigned to their respective option slots. These V-memory locations allow you to:

- specify the number of input channels enabled and BCD/Binary data format
- specify the input pointer address
- specify the RTD input type
- specify the units code – temperature scale and data format
- specify burnout data value at burnout
- read module setup diagnostics

Module Configuration Registers

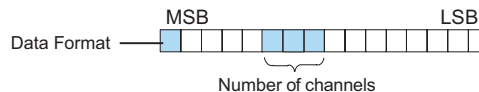
The table below shows the special V-memory locations used by the DL05 and DL06 PLCs for the F0-04RTD module.

Module Configuration Parameters	DL05 and DL06 Option Slot				
	DL05 Slot	DL06 Slot 1	DL06 Slot 2	DL06 Slot 3	DL06 Slot 4
A: Number of Channels Enabled / Data Format	V7700	V700	V710	V720	V730
B: Input Pointer	V7701	V701	V711	V721	V731
C: RTD Type	V7703	V703	V713	V723	V733
D: Units Code	V7704	V704	V714	V724	V734
E: RTD Burnout Data Value	V7706	V706	V716	V726	V736
F: Diagnostic Error	V7707	V707	V717	V727	V737

A: Number of Channels Enabled/Data Format Register

This V-memory location is used to define the number of input channels to be enabled and to set the channel data to BCD or binary format.

Number of Channels Enabled	Channel Data in BCD Format	Channel Data in Binary Format
1 Channel	K100	K8100
2 Channels	K200	K8200
3 Channels	K300	K8300
4 Channels	K400	K8400



B: Input Pointer Register

This is a system parameter that points to a V-memory location used for storing module channel input data. The V-memory location loaded in the input pointer V-memory location is an octal number identifying the first V-memory location for the input data. This V-memory location is user defined, but must use available consecutive V-memory locations. For example, loading O2000 causes the pointer to write Ch 1's data value to V2000/2001, Ch 2's data value to V2002/2003, CH 3's data value to V2004/2005 and Ch 4's data value to V2006/2007.



Note: Each channel's data value occupies two (2) consecutive V-memory locations. This allows for more than four (4) digits to be displayed if a BCD format for channel data is selected. For example: 1234.5 °F. A binary format for either a 15-bit magnitude plus sign or 16-bit 2's complement value will occupy the first V-memory location of the two V-memory locations assigned for the selected channel. Refer to the specific PLC's user manual being used for available user V-memory locations.

C: RTD Type Selection Register

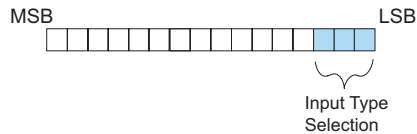
This V-memory register must be set to match the type of RTD being used. Use the table to determine your settings.

The module can be used with many types of RTDs. All channels of the module must be the same RTD type.

The default setting from the factory is Pt100Ω. This selects the DIN 43760 European type RTD. European curve type RTDs are calibrated to DIN 43760, BS1905, or IEC751 specifications which is .00385 Ω/Ω/°C (100 °C = 138.5Ω).

The jPt100Ω type is used for the American curve (.00392 Ω/Ω/°C), platinum 100Ω RTDs. The 10Ω and 25Ω RTD settings are used with copper RTDs.

RTD Type	Input Selection
Pt100 (European curve w/TCR = .00385)	K0
Cu10	K1
Cu25	K2
jPt100 (American curve w/TCR = .00392)	K3
Pt1000	K4
Ni120	K5



D: Units Code Register

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

All RTD ranges can include negative temperatures, therefore the display resolution is from -3276.7 to +3276.7.

Negative temperatures can be represented in either 2's complement or magnitude plus sign form. If the temperature is negative, the most significant bit in the V-memory location is set.

The 2's complement data format may be required to correctly display bipolar data on some operator interfaces. This data format could also be used to simplify averaging a bipolar signal. To view this data format in *DirectSoft32*, select Signed Decimal.

The bipolar input ranges may be converted to a 15-bit magnitude plus sign or a 16-bit 2's complement value.

Bit 0 = Temperature Scale

0 = Temp in degrees F

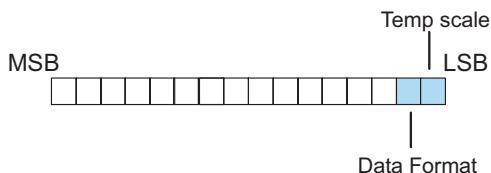
1 = Temp in degrees C

Bit 1 = Data Format

0 = Magnitude plus sign bit format

1 = 2's Complement format

Unit Code Register - Truth Table				
Temperature Scale	Data Format	Bit 1	Bit 0	Value
° F	Magnitude + sign bit	0	0	K0
° C	Magnitude + sign bit	0	1	K1
° F	2's Complement	1	0	K2
° C	2's Complement	1	1	K3



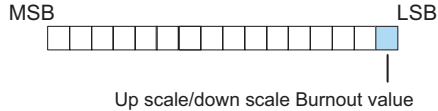
E: RTD Burnout Data Value Register

This register is used to define either up scale or down scale channel values when a channel RTD burnout occurs.

Bit 0 = Up scale/down scale value at Burnout

0 = Up scale value at Burnout, 7FFF_H (BCD/HEX) or 32767 (Binary)
written to CH register

1 = Down scale value at Burnout: 0000_H (BCD/HEX) or 0 (Binary)
written to CH register



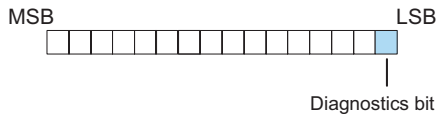
F: Diagnostics Error Register

This register is used to determine whether the configuration of the module is valid or not.

Bit 0 = Diagnostic bit:

0 = Module setup is valid

1 = Module setup is not valid

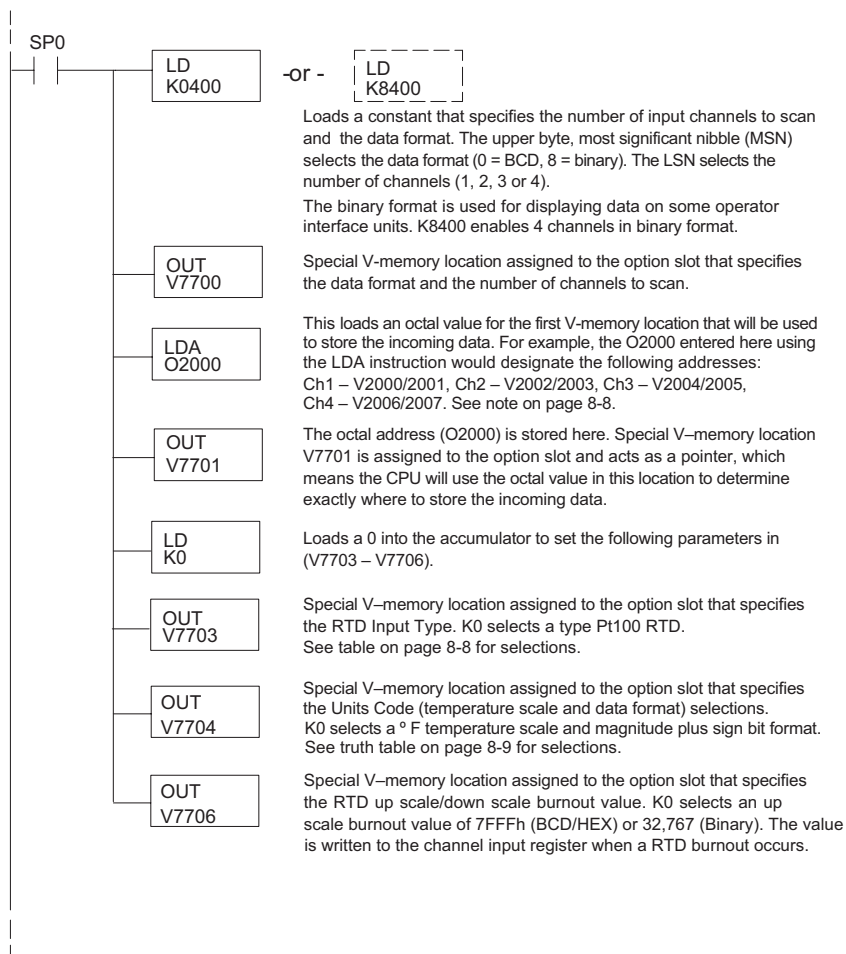


Configuring the Module in Your Control Program

DL05 Example 1

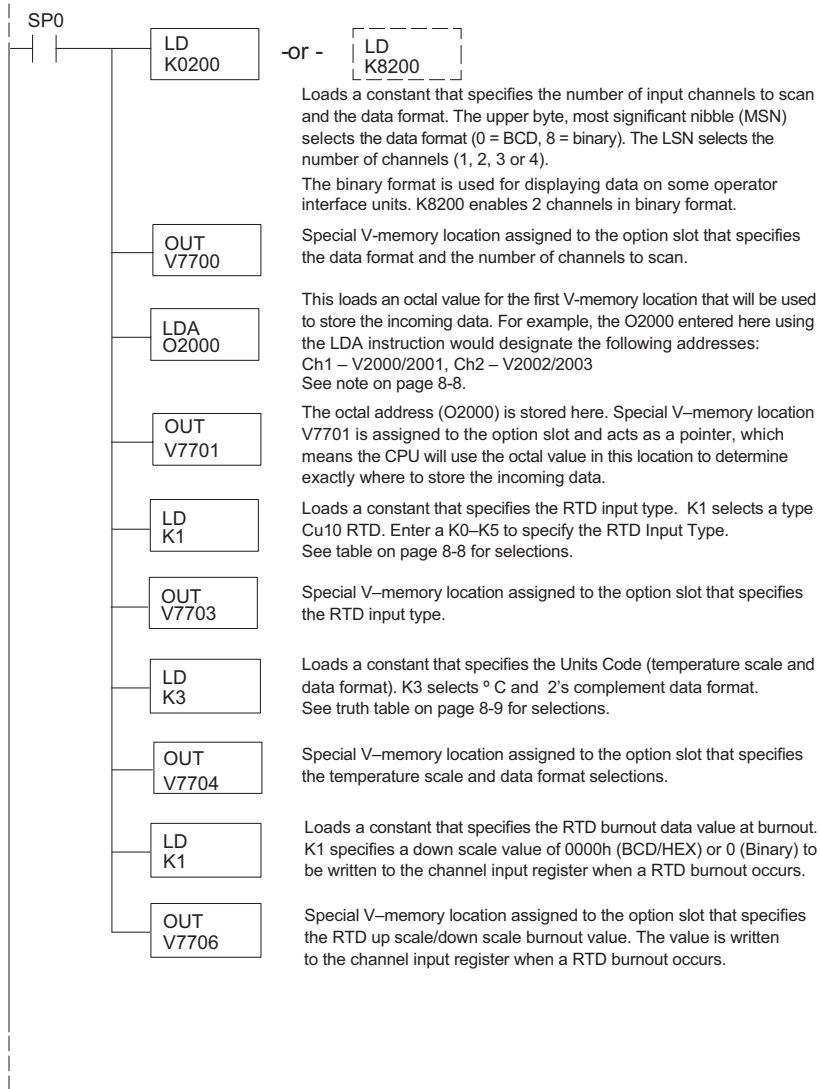
The example program below shows how to setup the F0-04RTD for 4 input channels enabled, use of a type Pt100 RTD on all 4 input channels, BCD channel data format, °F temperature scale, magnitude plus sign bit format, and with an up scale burnout value specified. Place this rung anywhere in the ladder program or in the initial stage if you are using stage programming instructions.

This is all that is required to read the temperature or voltage input data into V-memory locations. Once the data is in V-memory you can perform mathematical calculations with the data, compare the data against preset values, etc. V2000 is used in the example but you can use any user V-memory location.



DL05 Example 2

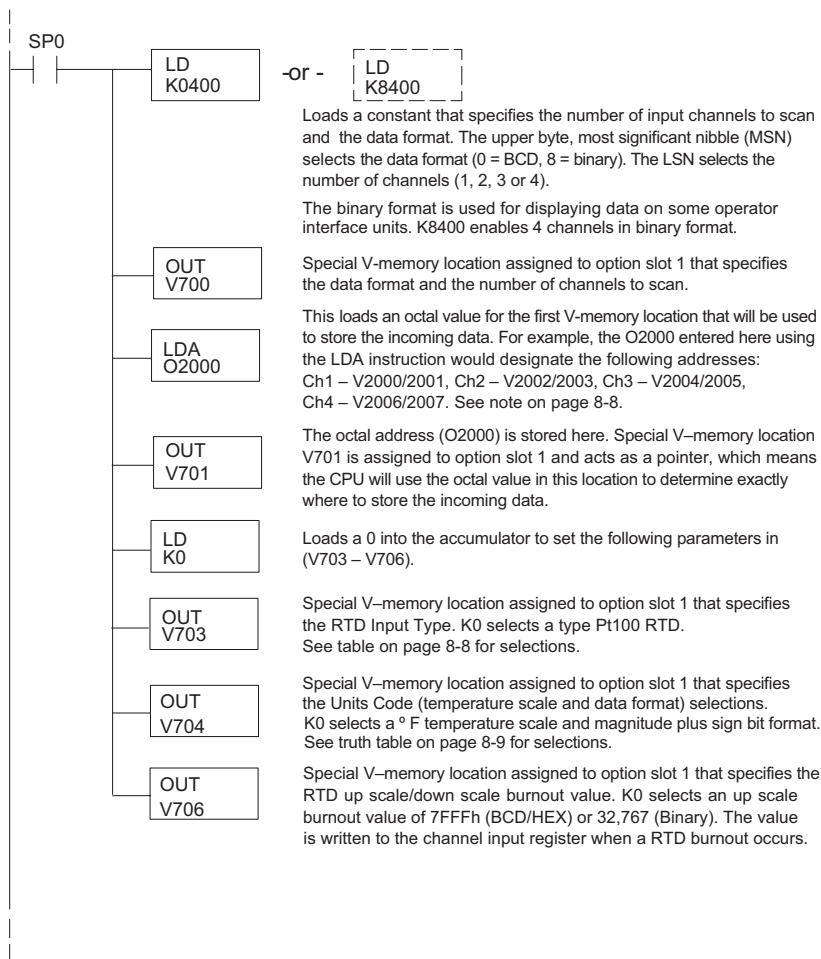
The example program below shows how to setup the F0-04RTD for 2 input channels enabled, use of a type Cu10 RTD on the first 2 input channels, BCD channel data format, °C temperature scale, 2's complement format, and with a down scale burnout value specified. Again, place this rung in the ladder program or in the initial stage if you are using stage programming instructions.



DL06 Example 1

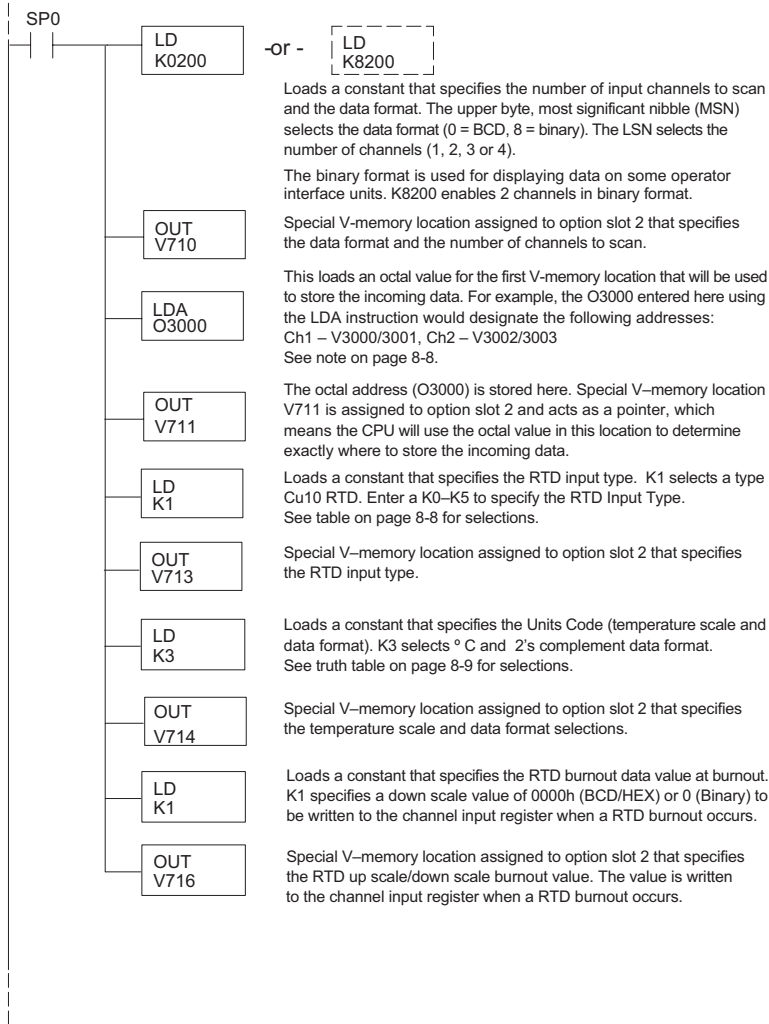
The example program below shows how to setup the F0-04RTD in option slot 1 for 4 input channels enabled, use of a type Pt100 RTD on all 4 input channels, BCD channel data format, °F temperature scale, magnitude plus sign bit format, and with an up scale burnout value specified. Use the table shown on page 8-7 to determine the pointer values if locating the module in any of the other slots. Place this rung anywhere in the ladder program or in the initial stage if you are using stage programming instructions.

This is all that is required to read the temperature or voltage input data into V-memory locations. Once the data is in V-memory you can perform mathematical calculations with the data, compare the data against preset values, etc. V2000 is used in the example but you can use any user V-memory location.



DL06 Example 2

The example program below shows how to setup the F0-04RTD in option slot 2 for 2 input channels enabled, use of a type Cu10 RTD on the first 2 input channels, BCD channel data format, °C temperature scale, 2's complement format, and with a down scale burnout value specified. Use the table shown on page 8-7 to determine the pointer values if locating the module in any of the other slots. V-memory location V3000 is shown in the example, but you can use any available user V-memory location. Again, place this rung anywhere in the ladder program or in the initial stage if you are using stage programming instructions.



Negative Temperature Readings with Magnitude Plus Sign

With bipolar ranges, you need some additional logic to determine whether the value being returned represents a positive temperature or a negative temperature. There is a simple solution:

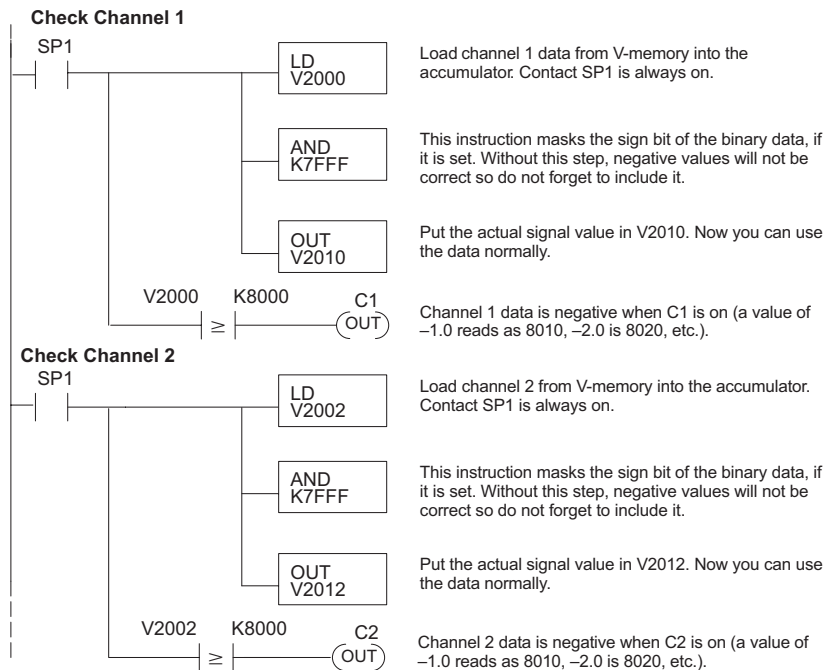
- If you are using bipolar ranges and you get a value greater than or equal to 8000_H, the value is negative.
- If you get a value less than or equal to 7FFF_H, the value is positive.

The sign bit is the most significant bit, which combines 8000_H to the data value. If the value is greater than or equal to 8000_H, you only have to mask the most significant bit and the active channel bits to determine the actual data value.

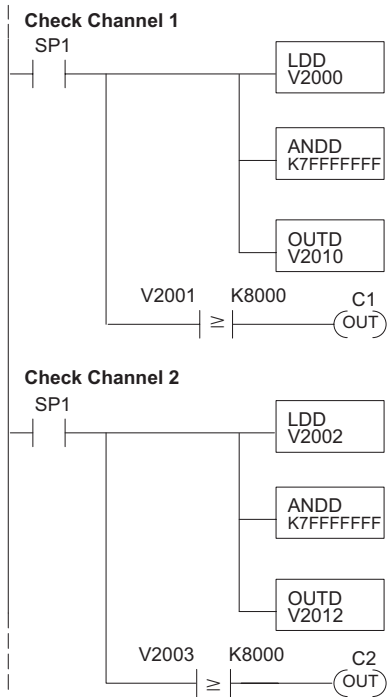
The following two programs show how you can accomplish this. The first example uses magnitude plus sign (binary) and the second example uses magnitude plus sign (BCD).

Since you always want to know when a value is negative, these rungs should be placed before any other operations that use the data, such as math instructions, scaling operations, and so forth. Also, if you are using stage programming instructions, these rungs should be in a stage that is always active. Note: you only need this logic for each channel that is using bipolar input signals. The examples only show two channels.

Magnitude Plus Sign (Binary)



Magnitude Plus Sign (BCD)



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

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

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

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

Check Channel 2

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

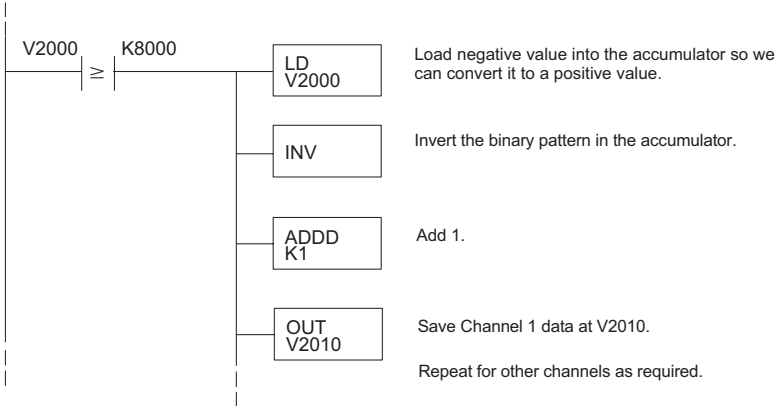
This instruction masks the sign bit of the BCD data, if it is set. Without this step, negative values will not be correct so do not forget to include it.

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

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

Negative Temperatures 2's Complement (Binary/Pointer Method)

You can use the 2's complement mode for negative temperature display purposes, while at the same time using the magnitude plus sign of the temperature in your control program. The *DirectSOFT*32 element Signed Decimal is used to display negative numbers in 2's complement form. To find the absolute value of a negative number in 2's complement, invert the number and add 1 as shown in the following example:



Analog Input Ladder Logic Filter

PID Loops / Filtering:

Please refer to the “PID Loop Operation” chapter in the DL06 or DL05 User Manual for information on the built-in PV filter (DL05/06) and the ladder logic filter (DL06 only) shown below. A filter must be used to smooth the analog input value when auto tuning PID loops to prevent giving a false indication of loop characteristics.

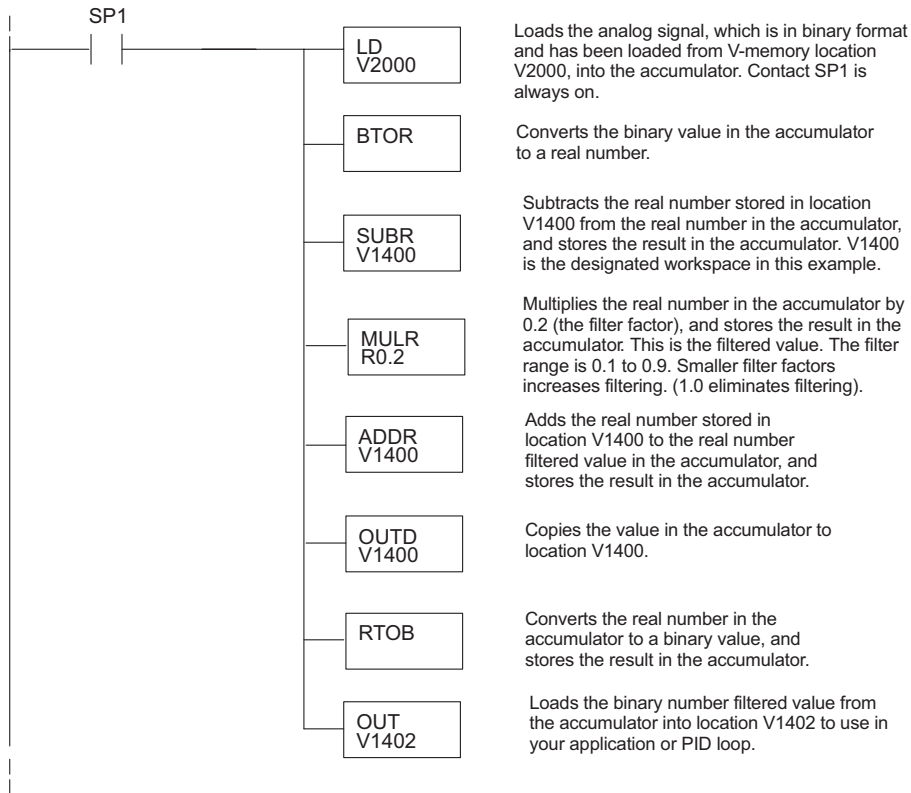
Smoothing the Input Signal (DL06 only):

The filter logic can also be used in the same way to smooth the analog input signal to help stabilize PID loop operation or to stabilize the analog input signal value for use with an operator interface display, etc.



Warning: The built-in and logic filters are not intended to smooth or filter noise generated by improper field device wiring or grounding. Small amounts of electrical noise can cause the input signal to bounce considerably. Proper field device wiring and grounding must be done before attempting to use the filters to smooth the analog input signal.

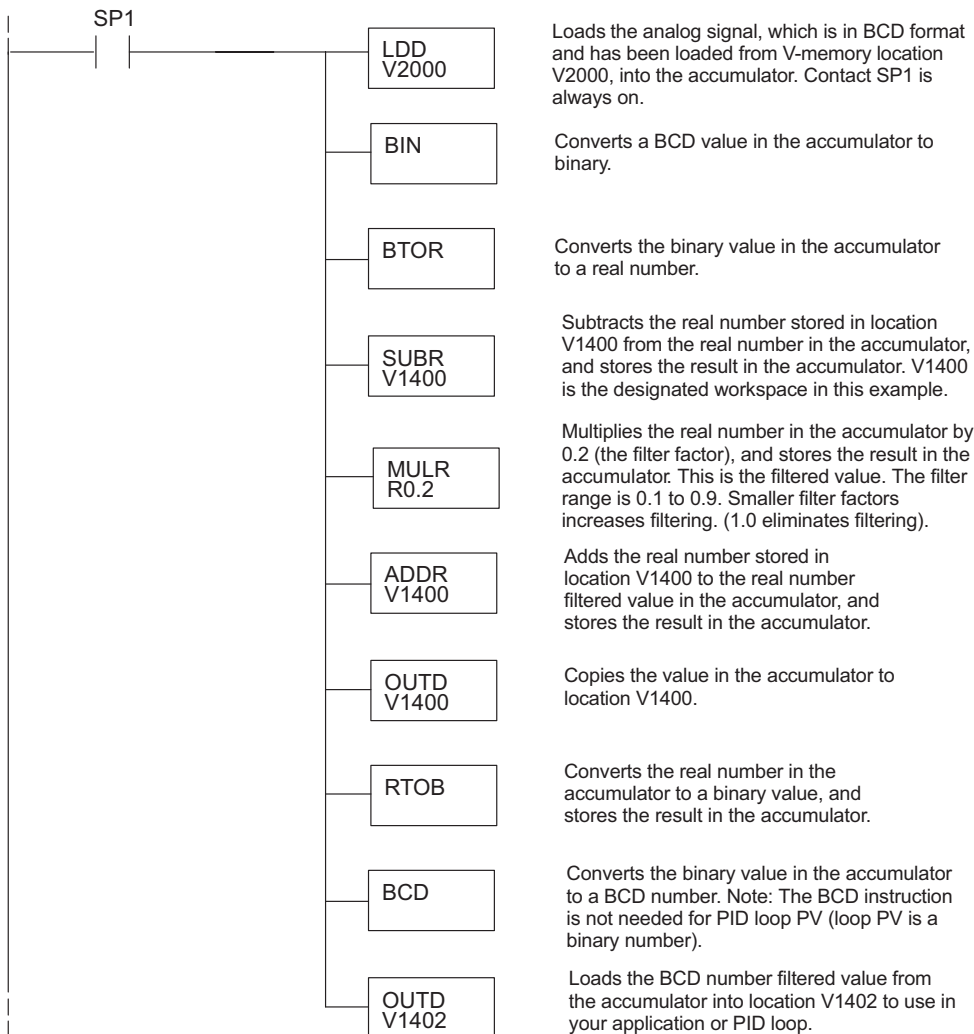
Using Binary Data Format





NOTE: Be careful not to do a multiple number conversion on a value. For example, if you are using the pointer method in BCD format to get the analog value, it must be converted to binary (BIN) as shown below. If you are using the pointer method in Binary format, the conversion to binary (BIN) instruction is not needed.

Using BCD Data Format



RTD Burnout Detection Bits

Special Relays Corresponding to RTD Burnouts

The following Special Relay (SP) bits can be used in your program to monitor for RTD burnout.

SP bit :

0 = RTD OK

1 = RTD burnout

Module Channel	DL05 and DL06 Option Slot				
	DL05 Slot	DL06 Slot 1	DL06 Slot 2	DL06 Slot 3	DL06 Slot 4
Channel 1	SP600	SP140	SP240	SP340	SP440
Channel 2	SP601	SP141	SP241	SP341	SP441
Channel 3	SP602	SP142	SP242	SP342	SP442
Channel 4	SP603	SP143	SP243	SP343	SP443

F0-04THM 4-CHANNEL THERMOCOUPLE INPUT



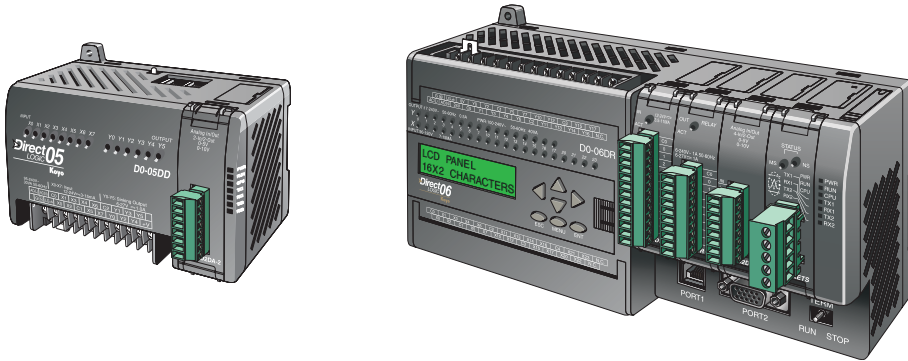
In This Chapter...

Module Specifications	9-2
Connecting and Disconnecting the Field Wiring	9-4
Module Operation	9-7
Special V-memory Locations	9-8
Configuring the Module in Your Control Program	9-12
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Thermocouple Burnout Detection Bits	9-21

Module Specifications

The F0-04THM 4-Channel Thermocouple Input Module provides the following features and benefits:

- Four thermocouple input channels with 16-bit voltage resolution or 0.1 °C/°F temperature resolution.
- Automatically converts type E, J, K, R, S, T, B, N, or C thermocouple signals into direct temperature readings. No extra scaling or complex conversion is required.
- Temperature data can be expressed in °F or °C.
- Module can be configured as 0–39.0625mVDC, ±39.0625mVDC, ±78.125mVDC, 0–156.25mV, ±156.25mVDC and 0–1.25VDC input and will convert volts and millivolt signal levels into 16-bit digital (0–65535) values.
- Signal processing features include automatic cold junction compensation (CJC), thermocouple linearization, and digital filtering.
- The temperature calculation and linearization are based on data provided by the National Institute of Standards and Technology (NIST).
- Diagnostic features include detection of thermocouple burnout or disconnection.



NOTE: The DL05 CPU's analog feature for this module requires **DirectSOFT32** Version 3.0c (or later) and firmware version 4.60 (or later). The DL06 requires **DirectSOFT32** version V4.0, build 16 (or later) and firmware version 1.40 (or later). See our website for more information: www.automationdirect.com.

The following tables provide the specifications for the F0-04THM Analog Input Module. Review these specifications to make sure the module meets your application requirements.

General Specifications	
Number of Channels	4, differential inputs, voltage or thermocouple
Common Mode Range	-1.3VDC to +3.8VDC
Conversion Time	270ms / channel
Common Mode Rejection	> 100dB @ 50/60Hz.
Input Impedance	5M Ω min.
Absolute Maximum Ratings	Fault-protected inputs to ± 50 VDC
Accuracy vs. Temperature	± 15 ppm / $^{\circ}\text{C}$ maximum;
Max. full scale error (including offset)	0 - 1.25V ± 35 ppm / $^{\circ}\text{C}$ maximum
PLC Update Rate	4 channels per scan
Power Budget Requirement	30mA @ 5VDC (supplied by base)
Operating Temperature	0 to 60 $^{\circ}\text{C}$ (32 to 140 $^{\circ}\text{F}$)
Storage Temperature	-20 to 70 $^{\circ}\text{C}$ (-4 to 158 $^{\circ}\text{F}$)
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
Replacement Terminal Block	F0-IOCON-THM (comes with CJC)
Wire Size Range & Connector Screw Torque	22 - 16 AWG; 0.192Nm; DN-SS1 Screwdriver Recommended

Thermocouple Specifications	
Input Ranges	Type J -190 to 760 $^{\circ}\text{C}$ (-310 to 1400 $^{\circ}\text{F}$) Type K -150 to 1372 $^{\circ}\text{C}$ (-238 to 2502 $^{\circ}\text{F}$) Type E -210 to 1000 $^{\circ}\text{C}$ (-346 to 1832 $^{\circ}\text{F}$) Type R 65 to 1768 $^{\circ}\text{C}$ (149 to 3214 $^{\circ}\text{F}$) Type S 65 to 1768 $^{\circ}\text{C}$ (149 to 3214 $^{\circ}\text{F}$) Type T -230 to 400 $^{\circ}\text{C}$ (-382 to 752 $^{\circ}\text{F}$) Type B 529 to 1820 $^{\circ}\text{C}$ (984 to 3308 $^{\circ}\text{F}$) Type N -70 to 1300 $^{\circ}\text{C}$ (-94 to 2372 $^{\circ}\text{F}$) Type C 65 to 2320 $^{\circ}\text{C}$ (149 to 4208 $^{\circ}\text{F}$)
Display Resolution	± 0.1 $^{\circ}\text{C}$ or ± 0.1 $^{\circ}\text{F}$
Cold Junction Compensation	Automatic
Warm-Up Time	30 minutes typically ± 1 $^{\circ}\text{C}$ repeatability
Linearity Error (End to End)	± 1 $^{\circ}\text{C}$ maximum, ± 0.5 $^{\circ}\text{C}$ typical
Maximum Inaccuracy	± 3 $^{\circ}\text{C}$ (excluding thermocouple error)

Voltage Input Specifications	
Voltage Ranges	0-39.0625mVDC, ± 39.0625 mVDC, ± 78.125 mVDC, 0-156.25mVDC, ± 156.25 mVDC, 0-1.25VDC
Resolution	16 bit (1 in 65535)
Max. Offset Error (All Input Ranges)	0.05% @ 0-60 $^{\circ}\text{C}$; Typical: 0.04% @ 25 $^{\circ}\text{C}$
Linearity Error (All Input Ranges)	0.05% @ 0-60 $^{\circ}\text{C}$; Typical: 0.03% @ 25 $^{\circ}\text{C}$
Maximum Inaccuracy	0-39.0625mVDC, ± 39.0625 mVDC, ± 78.125 mVDC ranges: 0.1% @ 0-60 $^{\circ}\text{C}$; Typical: 0.04% @ 25 $^{\circ}\text{C}$ 0-156.25mVDC, ± 156.25 mVDC, 0-1.25VDC ranges: 0.05% @ 0-60 $^{\circ}\text{C}$; Typical: 0.04% @ 25 $^{\circ}\text{C}$
All percentages are calculated as a percent of 2^{16} (65536) counts. (0.025% max error => $0.025 \times 65536/100 = 16$ counts max error)	

Connecting and Disconnecting 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 PLC power source. *Do not* ground the shield at both the transmitter and the PLC power source.
- Use thermocouple extension wire that is the same as the thermocouple type when extending the length.
- 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.

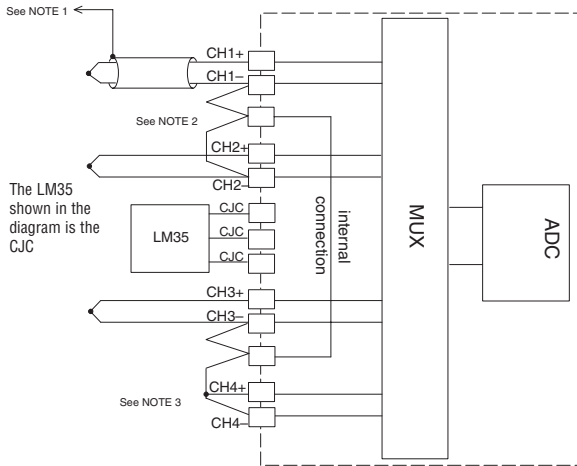
To remove the terminal block, disconnect power to the PLC and the field devices. Pull the terminal block firmly until the connector separates from the module.

You can remove the thermocouple module from the PLC by folding out the retaining tabs at the top and bottom of the module. As the retaining tabs pivot upward and outward, the module's connector is lifted out of the PLC socket. Once the connector is free, you can lift the module out of its slot.

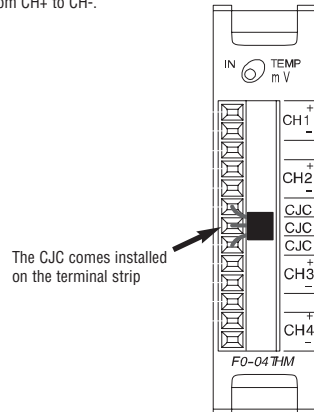
Use the following diagram to connect the field wiring. If necessary, the F0-04THM terminal block can be removed to make removal of the module possible without disturbing field wiring.

Thermocouple Input Wiring Diagram

All of the module's CH- terminals **must** be connected together. This will help eliminate ground potential differences between the input channels that could cause damage to the module. The two unlabeled terminals are internally connected and may be used for convenience to connect the CH- terminals together as shown below.



- Notes:**
1. Shields should be grounded at the PLC power source only.
 2. All CH- terminals must be connected together.
 3. Unused channels should have a shorting wire (jumper) installed from CH+ to CH-.



Thermocouples

Use shielded thermocouples whenever possible to minimize the presence of noise on the thermocouple wire. Ground the shield wire at one end only. For both grounded and ungrounded thermocouples, connect the shield to the 0V (common) terminal of the PLC power supply.

Grounded Thermocouple Assembly

A grounded thermocouple provides better response time than an ungrounded thermocouple because the tip of the thermocouple junction is in direct contact with the protective case.

Ungrounded Thermocouple Assembly

An ungrounded thermocouple is electrically isolated from the protective case. If the case is electrically grounded it provides a low-impedance path for electrical noise to travel. The ungrounded thermocouple provides a more stable and accurate measurement in a noisy environment. To avoid exceeding the common mode specifications, be sure that the machine assembly is properly bonded together.

Exposed Grounded Thermocouple

The thermocouple does not have a protective case and is directly connected to a device with a higher potential. Grounding the thermocouple assures that the thermocouple remains within the common mode specifications. Because a thermocouple is essentially a wire, it provides a low-impedance path for electrical noise. The noise filter has a response of $>100\text{dB}$ @ 50/60 Hz.



WARNING: A thermocouple can become shorted to a high voltage potential. Because common terminals are internally connected together, whatever voltage potential exists on one thermocouple will exist on the other channels.

9

Ambient Variations in Temperature

The F0-04THM module has been designed to operate within the ambient temperature range of 0 °C to 60 °C.

The cold junction compensation is calibrated to operate in a still-air environment. If the module is used in an application that has forced convection cooling, an error of 2–3 °C may be introduced. To compensate for this you can use ladder logic to correct the values.

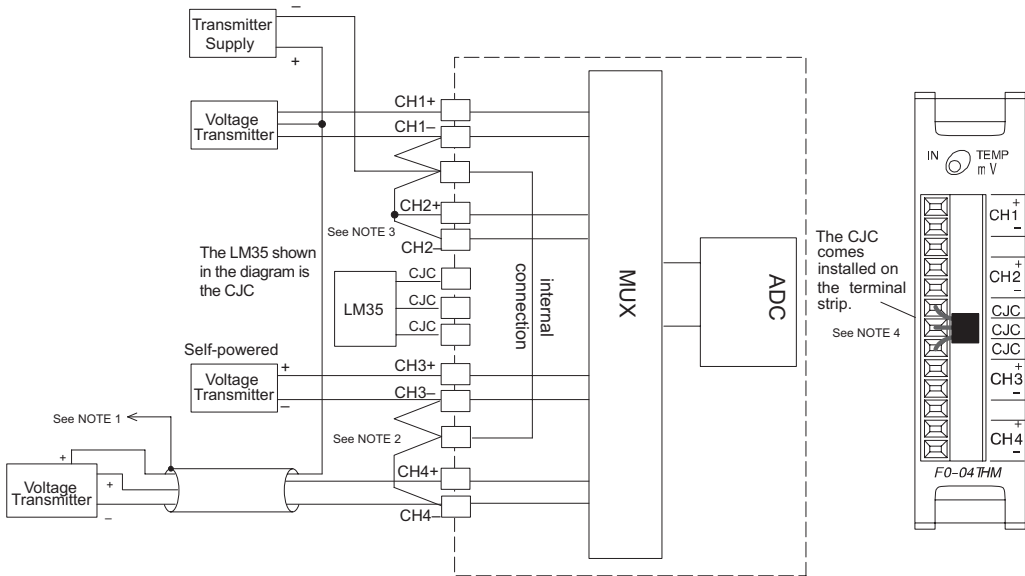
When configuring the system design it is best to locate any heat-producing devices above and away from the PLC chassis because the heat will affect the temperature readings. For example, heat introduced at one end of the terminal block can cause a channel-to-channel variation.

When exposing the F0-04THM module to abrupt ambient temperature changes it will take several minutes for the cold junction compensation and terminal block to stabilize. Errors introduced by abrupt ambient temperature changes will be less than 4 °C.

Voltage Input Wiring Diagram

All of the module's CH- terminals must be connected together as shown below. This will help eliminate ground potential differences between the input channels that could cause damage to the module. The two unlabeled terminals are internally connected and may be used for convenience to connect the CH- terminals together as shown below.

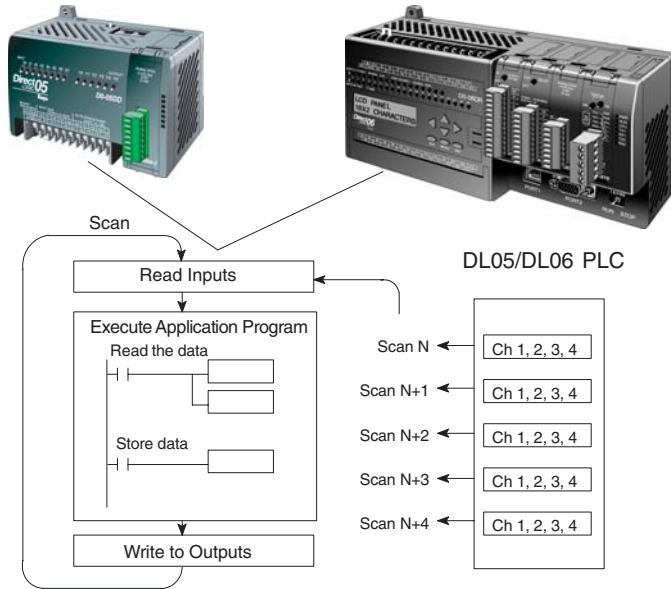
- Notes: 1. Shields should be grounded at the PLC power source.
- 2. All CH- terminals must be connected together.
- 3. Unused channels should have a shorting wire (jumper) installed from CH+ to CH-.
- 4. CJC functionality is automatically disabled when a Voltage input is selected.



Module Operation

Channel Scanning Sequence

The DL05 and DL06 read the data from all four input channels during each scan. The CPUs support special V-memory locations that are used to manage the data transfer. This is discussed in more detail on the following page, “Special V-memory Locations”.



Analog Module Update

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

The time required to sense the temperature and copy the value to V-memory is 270 milliseconds minimum to 1080 milliseconds plus 1 scan time maximum (number of channels x 270 milliseconds + 1 scan time).

Special V-memory Locations

The DL05 and DL06 PLCs have special V-memory locations assigned to their respective option slots. These V-memory locations allow you to:

- specify the number of input channels enabled and BCD/Binary data format
- specify the input pointer address
- specify the thermocouple or voltage input type
- specify the units code – temperature scale and data format
- enable/disable thermocouple burnout detection
- specify burnout data value at burnout
- read module setup diagnostics

Module Configuration Registers

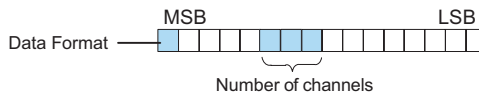
The table below shows the special V-memory locations used by the DL05 and DL06 PLCs for the F0-04THM module.

Module Configuration Parameters	DL05 and DL06 Option Slot				
	DL05 Slot	DL06 Slot 1	DL06 Slot 2	DL06 Slot 3	DL06 Slot 4
A: Number of Channels Enabled / Data Format	V7700	V700	V710	V720	V730
B: Input Pointer	V7701	V701	V711	V721	V731
C: Input Type	V7703	V703	V713	V723	V733
D: Units Code	V7704	V704	V714	V724	V734
E: Thermocouple Burnout Detection Enable	V7705	V705	V715	V725	V735
F: Thermocouple Burnout Data Value	V7706	V706	V716	V726	V736
G: Diagnostic Error	V7707	V707	V717	V727	V737

A: Number of Channels Enabled/Data Format Register

This V-memory location is used to define the number of input channels to be enabled and to set the channel data to BCD or binary format.

Number of Channels Enabled	Channel Data in BCD Format	Channel Data in Binary Format
1 Channel	K100	K8100
2 Channels	K200	K8200
3 Channels	K300	K8300
4 Channels	K400	K8400



B: Input Pointer Register

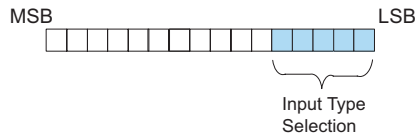
This is a system parameter that points to a V-memory location used for storing module channel input data. The V-memory location loaded in the input pointer V-memory location is an octal number identifying the first V-memory location for the input data. This V-memory location is user defined, but must use available consecutive V-memory locations. For example, loading O2000 causes the pointer to write Ch 1's data value to V2000/2001, Ch 2's data value to V2002/2003, CH 3's data value to V2004/2005 and Ch 4's data value to V2006/2007.

Note: Each channel's data value occupies two (2) consecutive V-memory locations. This allows for more than four (4) digits to be displayed if a BCD format for channel data is selected. For example: 1234.5 °F. A binary format for either a 15-bit magnitude plus sign or 16-bit 2's complement value will occupy the first V-memory location of the two V-memory locations assigned for the selected channel. Refer to the specific PLC's user manual being used for available user V-memory locations.

C: Input Type Selection Register

This V-memory register must be set to match the type of thermocouple being used or the input voltage level. Use the table to determine your settings.

Thermocouple/ Voltage Input Type	Input Selection	Temperature Range °C	Temperature Range °F
J	K0	-190 to 760	-310 to 1400
K	K1	-150 to 1372	-238 to 2502
E	K2	-210 to 1000	-346 to 1832
R	K3	65 to 1768	149 to 3214
S	K4	65 to 1768	149 to 3214
T	K5	-230 to 400	-382 to 752
B	K6	529 to 1820	984 to 3308
N	K7	-70 to 1300	-94 to 2372
C	K8	65 to 2320	149 to 4208
0-39.0625mVDC	K9	N/A	N/A
±39.0625mVDC	KA	N/A	N/A
±78.125mVDC	KB	N/A	N/A
0-156.25mVDC	KC	N/A	N/A
±156.25mVDC	KD	N/A	N/A
0-1.25VDC	KE	N/A	N/A



NOTE: The **CJC** functionality is automatically disabled when a Voltage input is selected.

D: Units Code Register

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

For thermocouple ranges which include negative temperatures (J,E,K,T,N), the display resolution is from -3276.7 to +3276.7. For positive-only thermocouple ranges (R,S,B,C), the display resolution is 0 to 6553.5.

Negative temperatures can be represented in either 2's complement or magnitude plus sign form. If the temperature is negative, the most significant bit in the V-memory location is set.

The 2's complement data format may be required to correctly display bipolar data on some operator interfaces. This data format could also be used to simplify averaging a bipolar signal. To view this data format in *DirectSoft32*, select Signed Decimal.

For unipolar thermocouple ranges (R,S,B,C), it does not matter if magnitude plus sign or 2's complement is selected.

The bipolar voltage input ranges may be converted to a 15-bit magnitude plus sign or a 16-bit 2's complement value.

Bit 0 = Temperature Scale

(ignored if Voltage input is selected)

0 = Temp in degrees F

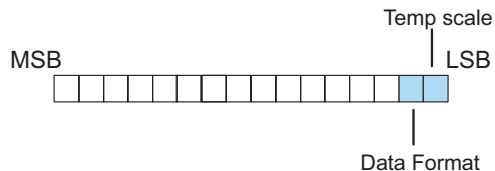
1 = Temp in degrees C

Bit 1 = Data Format

0 = Magnitude plus sign bit format

1 = 2's Complement format

Unit Code Register - Truth Table				
Temperature Scale	Data Format	Bit 1	Bit 0	Value
° F	Magnitude + sign bit	0	0	K0
° C	Magnitude + sign bit	0	1	K1
° F	2's Complement	1	0	K2
° C	2's Complement	1	1	K3



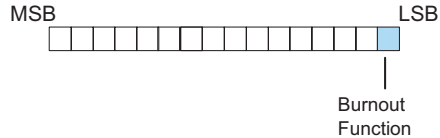
E: Thermocouple Burnout Detection Enable Register

This register is used to enable/disable the thermocouple burnout function. Be sure to disable the burnout detection function when checking the module calibration.

Bit 0 = Thermocouple Burnout Detection Enable/Disable

0 = Burnout detection is enabled

1 = Burnout detection is disabled



F: Thermocouple Burnout Data Value Register

This register is used to define either up scale or down scale channel values when a channel thermocouple burnout occurs.

Bit 0 = Up scale/down scale value at Burnout

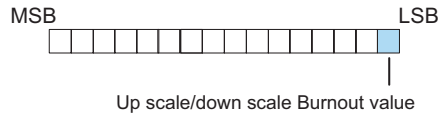
0 = Up scale value at Burnout:

Unipolar input type: $FFFF_H$ (BCD/HEX) or 65535 (Binary)
written to CH register

Bipolar input type: $7FFF_H$ (BCD/HEX) or 32767 (Binary)
written to CH register

1 = Down scale value at Burnout:

0000_H (BCD/HEX) or 0 (Binary) written to CH register



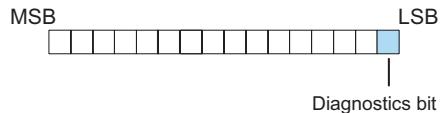
G: Diagnostics Error Register

This register is used to determine whether the configuration of the module is valid or not. It is controlled by the PLC and is read only.

Bit 0 = Diagnostic bit:

0 = Module setup is valid

1 = Module setup is not valid

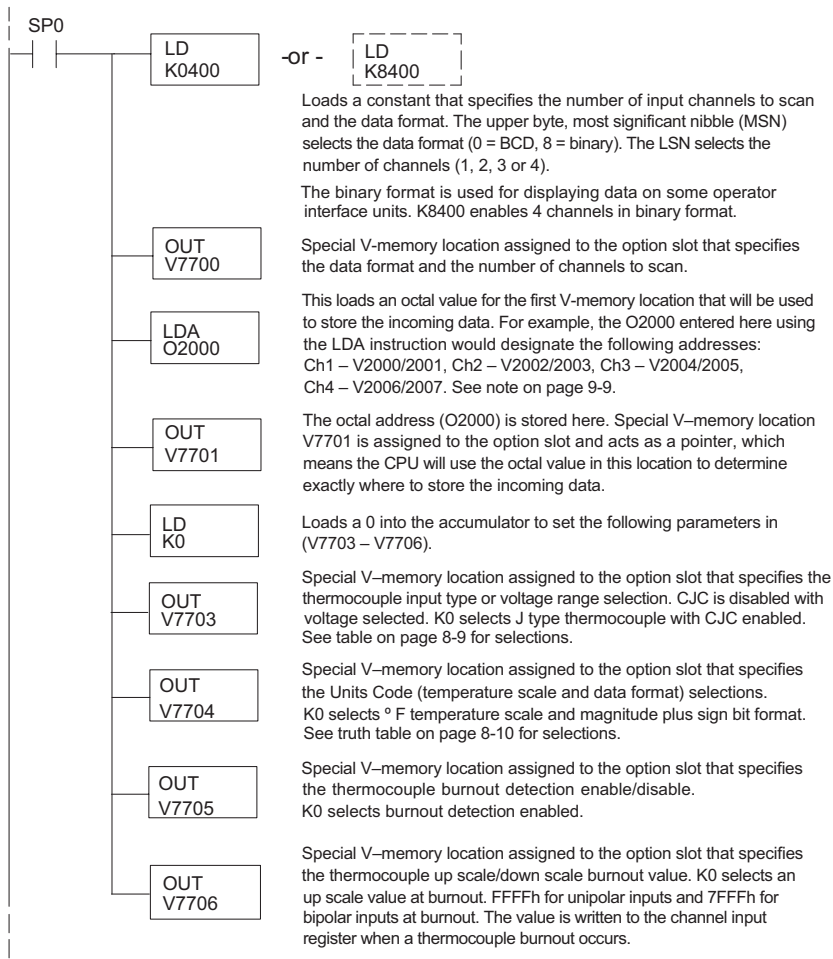


Configuring the Module in Your Control Program

DL05 Example 1

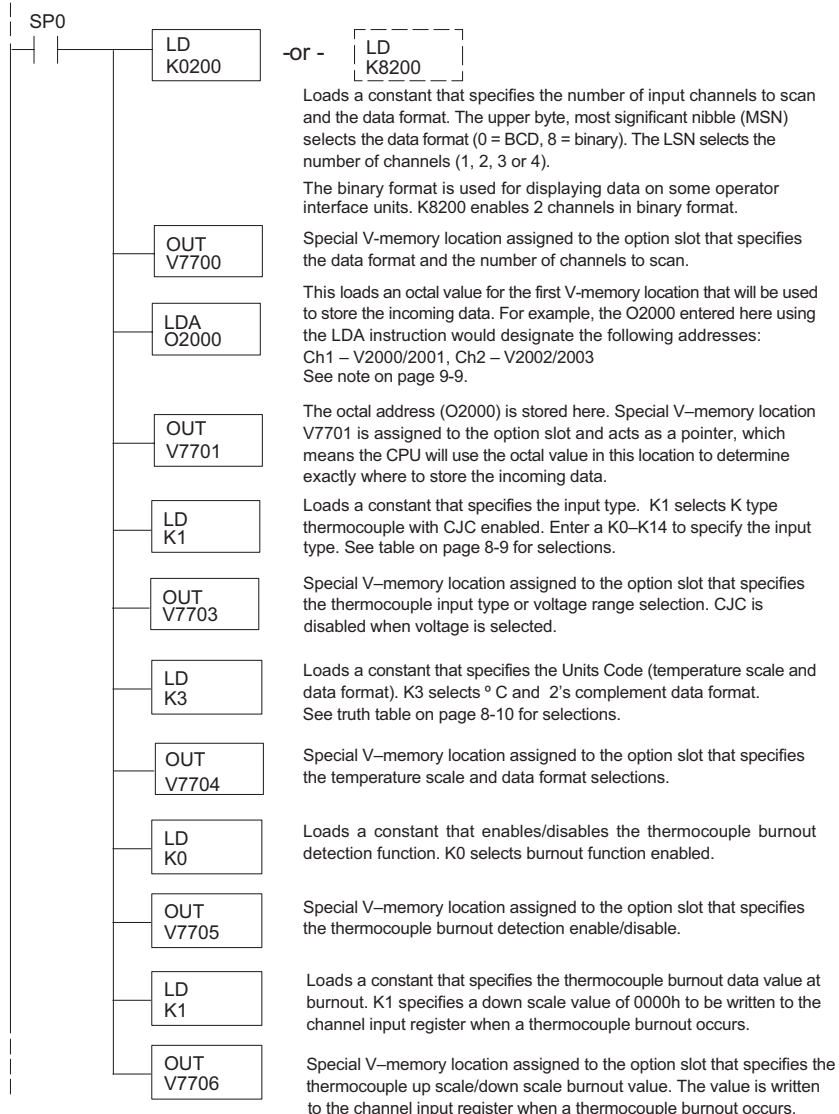
The example program below shows how to setup the F0-04THM for 4 input channels enabled, J type thermocouple on all 4 input channels, BCD channel data format, °F temperature scale, magnitude plus sign bit format, and burnout detection enabled with an up scale burnout specified. Place this rung anywhere in the ladder program or in the initial stage if you are using stage programming instructions.

This is all that is required to read the temperature or voltage input data into V-memory locations. Once the data is in V-memory you can perform mathematical calculations with the data, compare the data against preset values, etc. V2000 is used in the example but you can use any user V-memory location.



DL05 Example 2

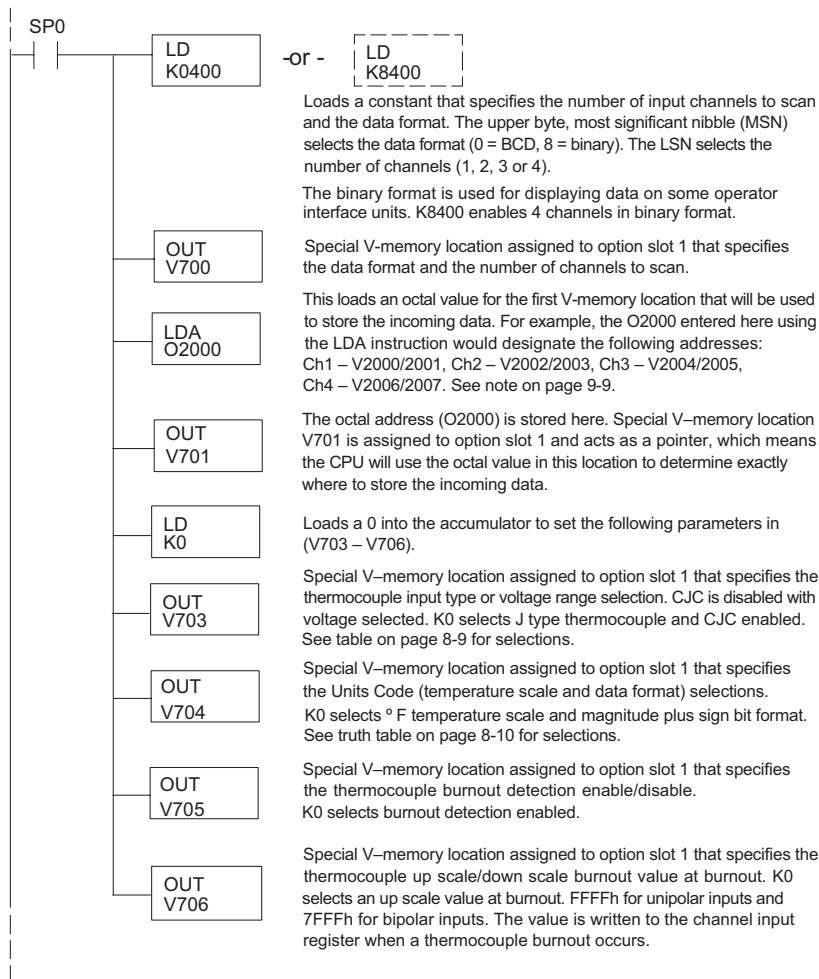
The example program below shows how to setup the F0-04THM for 2 input channels enabled, use of a K type thermocouple on the first 2 input channels, BCD channel data format, °C temperature scale, 2's complement format, and burnout detection enabled with a down scale burnout specified. Again, place this rung in the ladder program or in the initial stage if you are using stage programming instructions.



DL06 Example 1

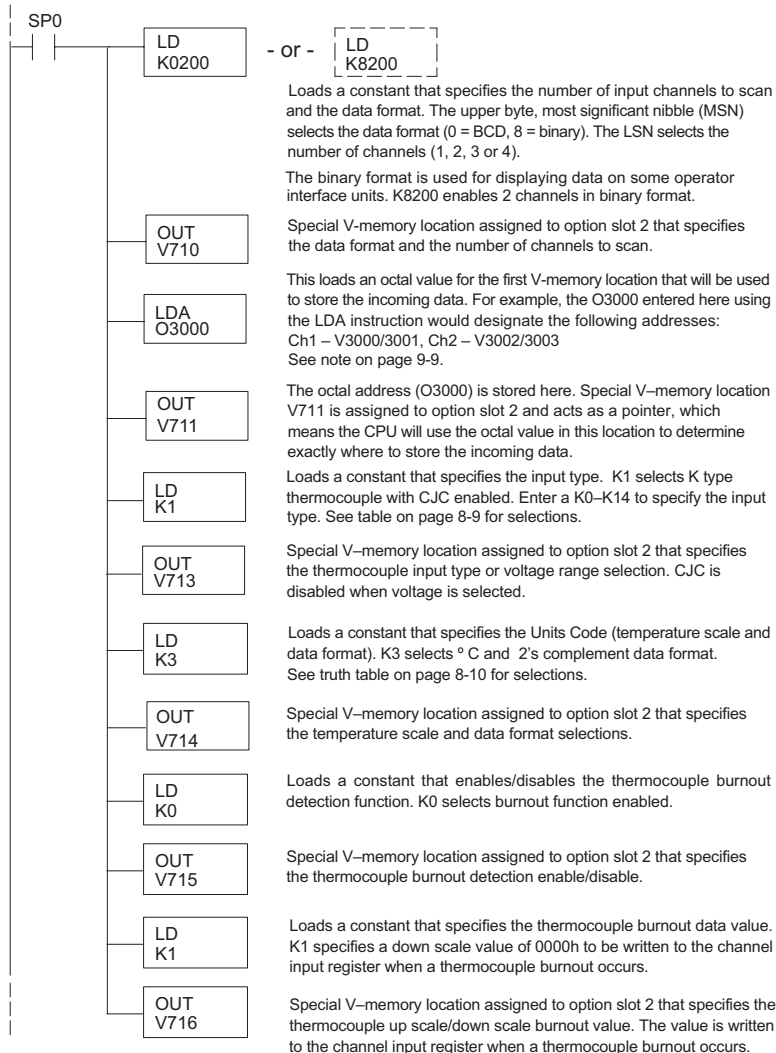
The example program below shows how to setup the F0-04THM in option slot 1 for 4 input channels enabled, use of a J type thermocouple on all 4 input channels, BCD channel data format, °F temperature scale and magnitude plus sign bit format, and burnout detection enabled with an up scale burnout specified. Use the table shown on page 9-8 to determine the pointer values if locating the module in any of the other slots. Place this rung anywhere in the ladder program or in the initial stage if you are using stage programming instructions.

This is all that is required to read the temperature or voltage input data into V-memory locations. Once the data is in V-memory you can perform mathematical calculations with the data, compare the data against preset values, etc. V2000 is used in the example but you can use any user V-memory location.



DL06 Example 2

The example program below shows how to setup the F0-04THM in option slot 2 for 2 input channels enabled, use of a K type thermocouple on the first 2 input channels, BCD channel data format, °C temperature scale, 2's complement format, and burnout detection enabled with a down scale burnout specified. Use the table shown on page 9-8 to determine the pointer values if locating the module in any of the other slots. V-memory location V3000 is shown in the example, but you can use any available user V-memory location. Again, place this rung anywhere in the ladder program or in the initial stage if you are using stage programming instructions.



Negative Temperature Readings with Magnitude Plus Sign

With bipolar ranges, you need some additional logic to determine whether the value being returned represents a positive temperature/voltage or a negative temperature/voltage. There is a simple solution:

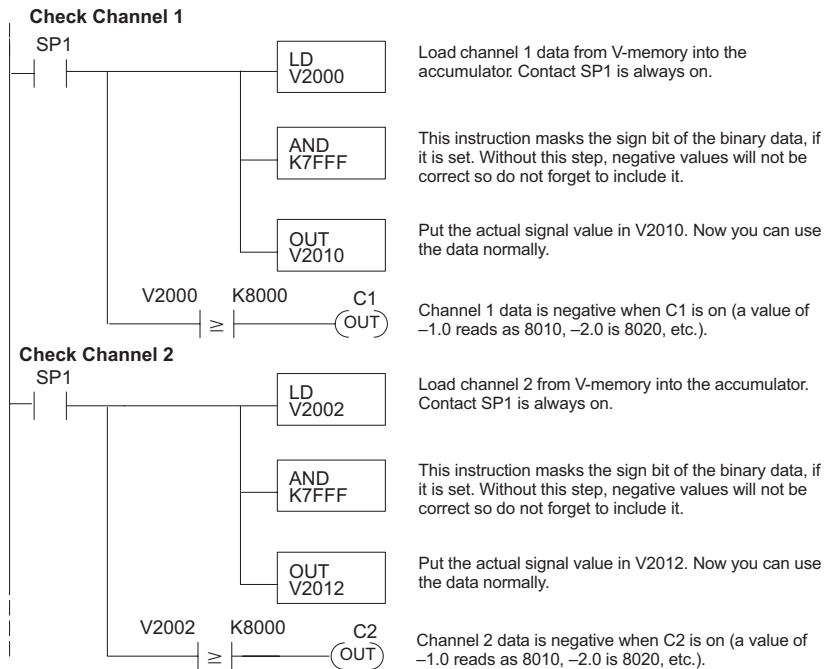
- If you are using bipolar ranges and you get a value greater than or equal to 8000_H, the value is negative.
- If you get a value less than or equal to 7FFF_H, the value is positive.

The sign bit is the most significant bit, which combines 8000_H to the data value. If the value is greater than or equal to 8000_H, you only have to mask the most significant bit and the active channel bits to determine the actual data value.

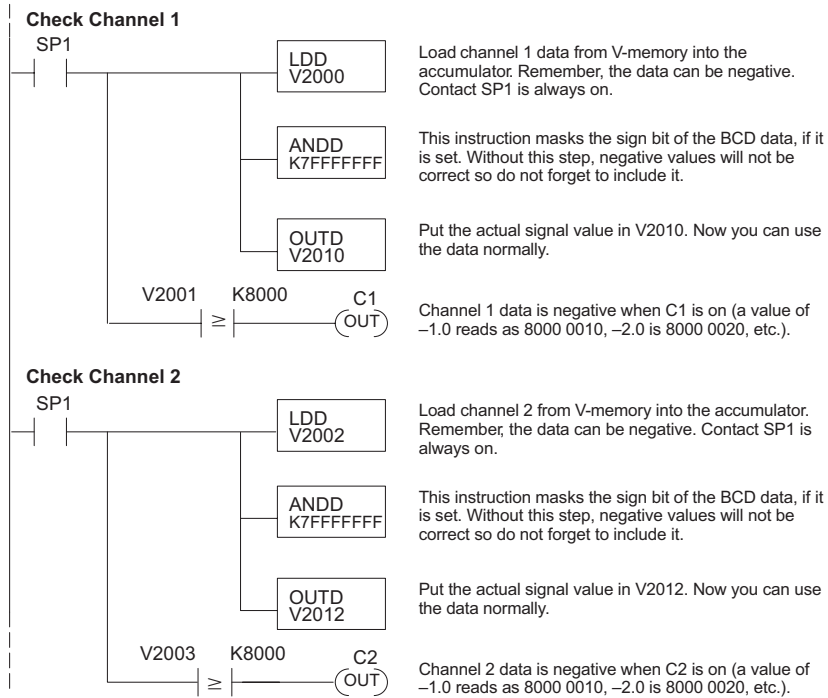
The following two programs show how you can accomplish this. The first example uses magnitude plus sign (binary) and the second example uses magnitude plus sign (BCD).

Since you always want to know when a value is negative, these rungs should be placed before any other operations that use the data, such as math instructions, scaling operations, and so forth. Also, if you are using stage programming instructions, these rungs should be in a stage that is always active. Note: you only need this logic for each channel that is using bipolar input signals. The examples only show two channels.

Magnitude Plus Sign (Binary)



Magnitude Plus Sign (BCD)



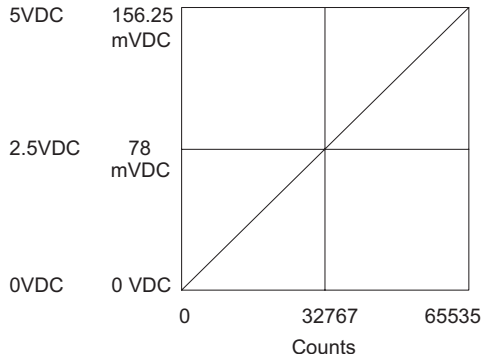
Module Resolution

Module Resolution 16-Bit (Unipolar Voltage Input)

Unipolar analog signals are converted into 65536 (2^{16}) counts ranging from 0 to 65535. For example, with a 0 to 156.25mVDC signal range, 78mVDC would be 32767. A value of 65535 represents the upper limit of the range.

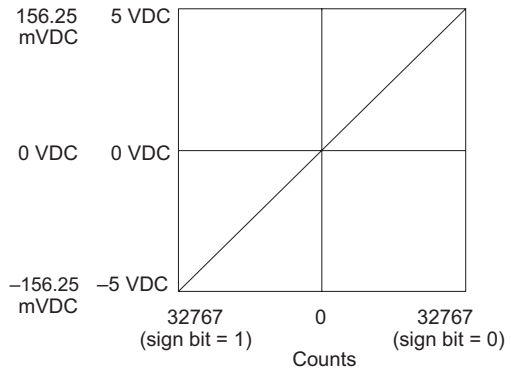
$$\text{Unipolar Resolution} = \frac{H - L}{65535}$$

H or L = high or low limit of the range



Module Resolution 15-Bit Plus Sign (Bipolar Voltage Input)

The module has 16-bit unipolar or 15-bit + sign bipolar resolution. Bipolar analog signals are converted into 32768 (2^{15}) counts ranging from 0 to 32767. For example, with a -156.25mVDC to 156.25mVDC input signal range, 156.25mVDC would be 32767. The bipolar ranges utilize a sign bit to provide 16-bit resolution. A value of 32767 can represent the upper limit of either side of the range. Use the sign bit to determine negative values.



$$\text{Bipolar Resolution} = \frac{H - L}{32767}$$

H or L = high or low limit of the range

Analog Input Ladder Logic Filter

PID Loops / Filtering:

Please refer to the “PID Loop Operation” chapter in the DL06 or DL05 User Manual for information on the built-in PV filter (DL05/06) and the ladder logic filter (DL06 only) shown below. A filter must be used to smooth the analog input value when auto tuning PID loops to prevent giving a false indication of loop characteristics.

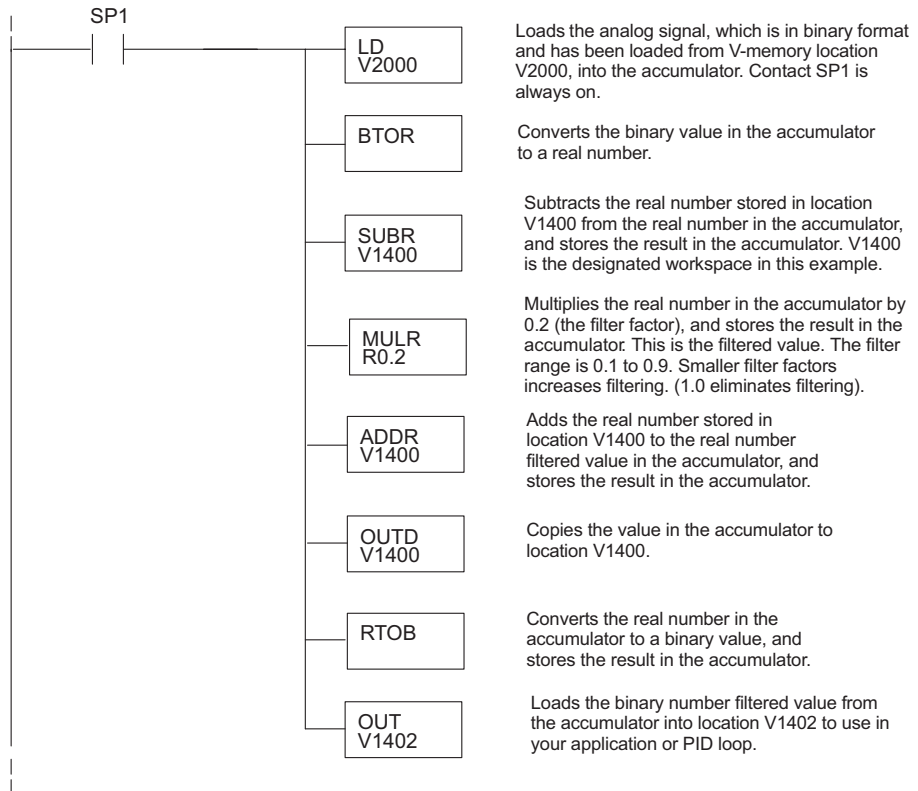
Smoothing the Input Signal (DL06 only):

The filter logic can also be used in the same way to smooth the analog input signal to help stabilize PID loop operation or to stabilize the analog input signal value for use with an operator interface display, etc.



Warning: The built-in and logic filters are not intended to smooth or filter noise generated by improper field device wiring or grounding. Small amounts of electrical noise can cause the input signal to bounce considerably. Proper field device wiring and grounding must be done before attempting to use the filters to smooth the analog input signal.

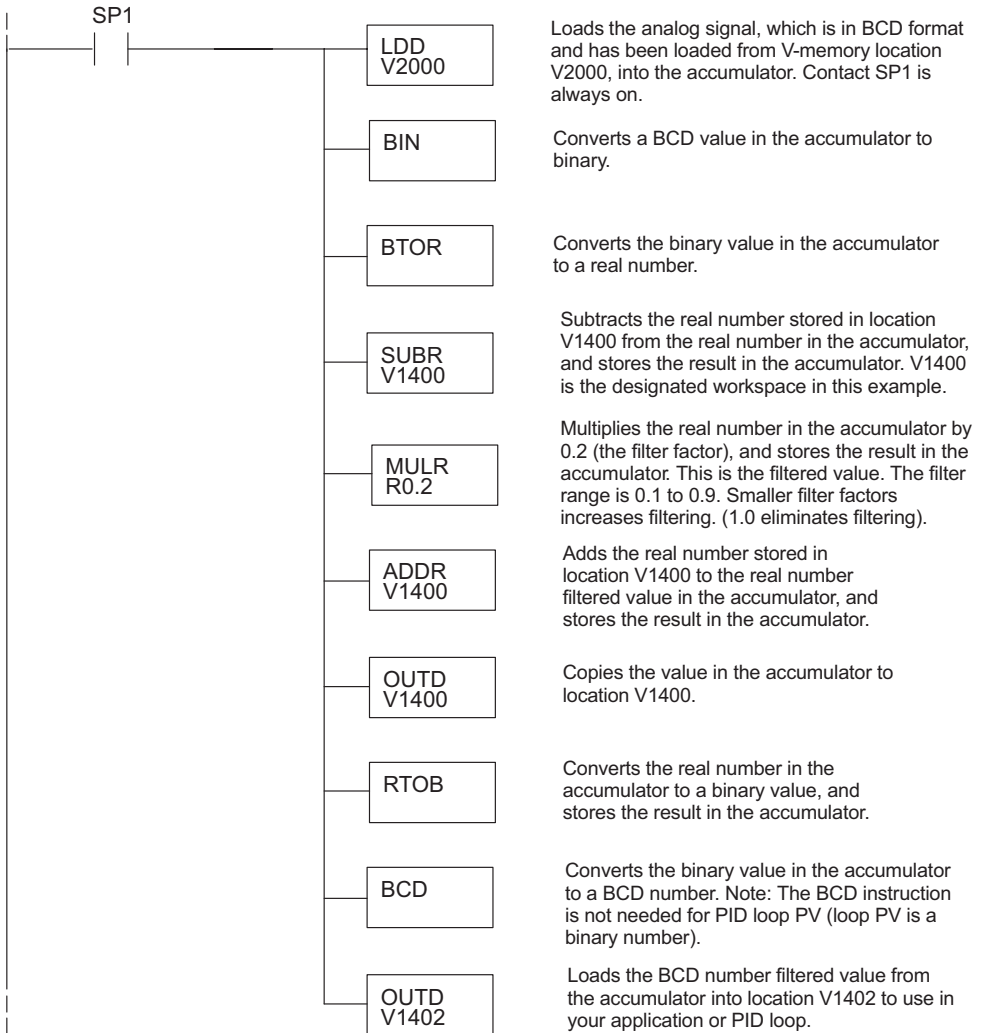
Using Binary Data Format





NOTE: Be careful not to do a multiple number conversion on a value. For example, if you are using the pointer method in BCD format to get the analog value, it must be converted to binary (BIN) as shown below. If you are using the pointer method in Binary format, the conversion to binary (BIN) instruction is not needed.

Using BCD Data Format



Thermocouple Burnout Detection Bits

Special Relays Corresponding to Thermocouple Burnouts

The following Special Relay (SP) bits can be used in your program to monitor for thermocouple burnout.

SP bit :

0 = Thermocouple OK

1 = Thermocouple burnout

Module Channel	DL05 and DL06 Option Slot				
	DL05 Slot	DL06 Slot 1	DL06 Slot 2	DL06 Slot 3	DL06 Slot 4
Channel 1	SP600	SP140	SP240	SP340	SP440
Channel 2	SP601	SP141	SP241	SP341	SP441
Channel 3	SP602	SP142	SP242	SP342	SP442
Channel 4	SP603	SP143	SP243	SP343	SP443