

INSTALLATION, WIRING, AND SPECIFICATIONS



CHAPTER 2

In this Chapter

Safety Guidelines.....	2-2
Orientation to DL05 Front Panel.....	2-5
Mounting Guidelines.....	2-7
Wiring Guidelines.....	2-11
System Wiring Strategies.....	2-14
Wiring Diagrams and Specifications.....	2-32
Glossary of Specification Terms.....	2-48

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.

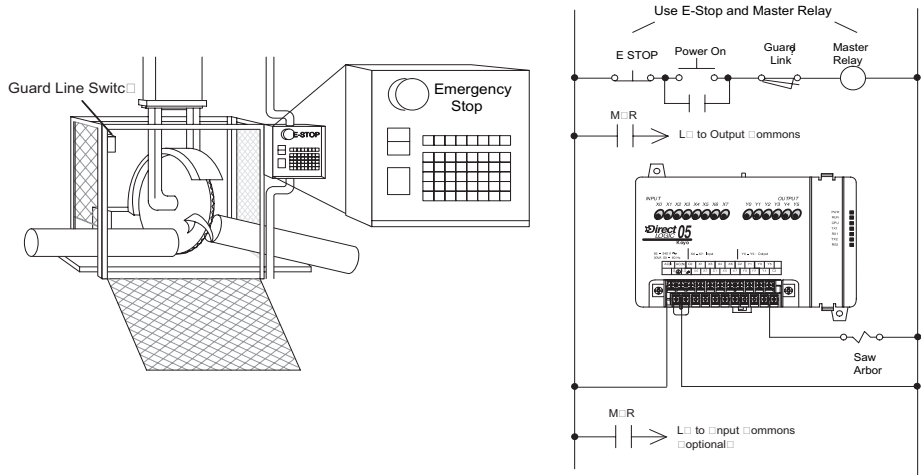
- Emergency stop switch for disconnecting system power
- Mechanical disconnect for output module power
- Orderly system shutdown sequence in the PLC control program

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.).



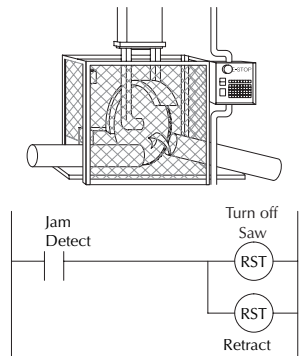
Emergency Power Disconnect

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

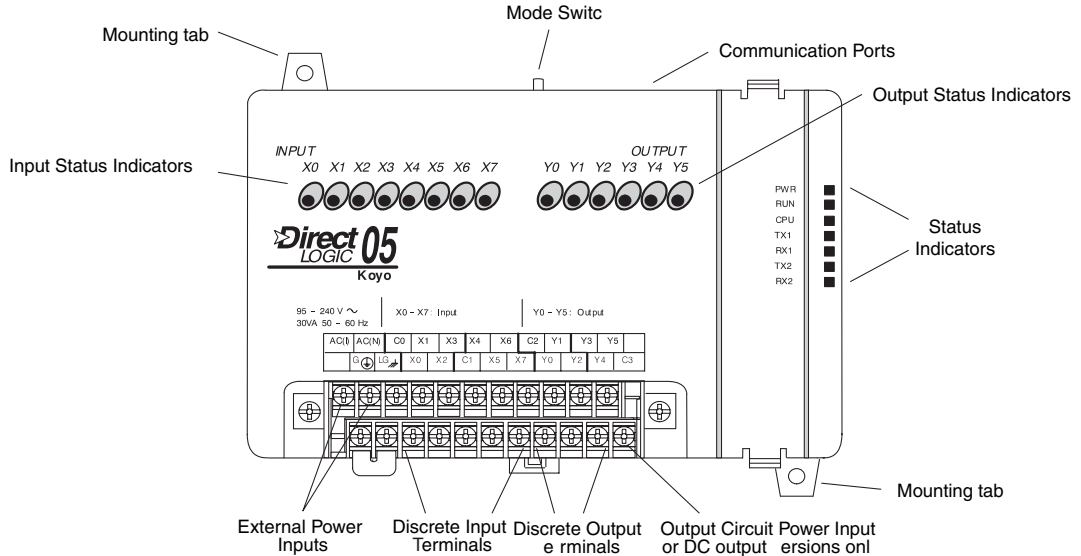
Ideally, the first level of fault detection is the PLC control program, which can identify machine problems. Certain shutdown sequences should be performed. The types of problems are usually things such as jammed parts, etc. that do not pose a risk of personal injury or equipment damage.



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.

Orientation to DL05 Front Panel

Most connections, indicators, and labels on the DL05 Micro PLCs are located on its front panel. The communication ports are located on the top side of the PLC. Please refer to the drawing below.



The upper section of the connector accepts external power connections on the two left-most terminals. From left to right, the next five terminals are one of the input commons (C0) and input connections X1, X3, X4, and X6. The remaining four connections are an output common (C2) and output terminals Y1, Y3, and Y5.

The lower section of the connector has the chassis ground (G) and the logic ground (LG) on the two left-most terminals. The next two terminals are for the inputs X0 and X2. Next is the other input common (C1) followed by inputs X5 and X7. The last four terminals are for outputs Y0, Y2, Y4, and the second output common (C3). On DC output units, the end terminal on the right accepts power for the output stage.

An option slot is located on the right end of the PLC. This is where the simulator module can be installed for testing. Option module descriptions available for the DL05 can be found either in the DL05/DL06 Options Modules User Manual, D0-OPTIONS-M, in our catalog or on our website.



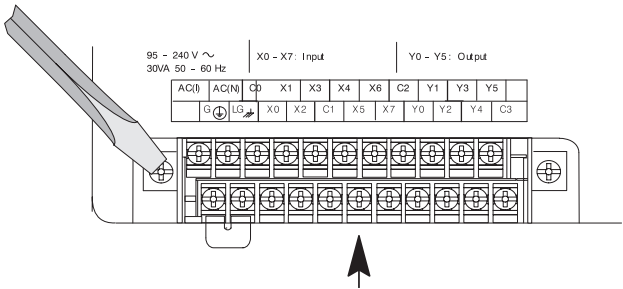
WARNING: For some applications, field device power may still be present on the terminal block even though the Micro PLC is turned off. To minimize the risk of electrical shock, check all field device power before you expose or remove either connector wire from under a terminal block, or two 18 AWG wires (one on each side of the screw).

Connector Removal

All of the terminals for the DL05 are contained on one connector block. In some instances, it may be desirable to remove the connector block for easy wiring. The connector is designed for easy removal with just a small screwdriver. The drawing below shows the procedure for removal at one end.

Connector Removal

1. Loosen the retention screws on each end of the connector block.



2. From the center of the connector block, pry upward with the screwdriver until the connector is loose.

The terminal block connector on DL05 PLCs has regular screw terminals, which will accept either standard blade-type or #1 Philips screwdriver tips. Use No. 16 to 18 AWG solid/stranded wire. The maximum torque is 0.343Nm (3.036 inch-lbs).

Spare terminal block connectors and connector covers may be ordered by individual part numbers:

Spare Parts -Terminal Block and Cover		
Part Number	Qty Per Package	Description
F0-IOCON	2	DL05 I/O Terminal Block
D0-AAC-1	1 each	DL05 I/O Terminal Block, I/O Terminal Block Cover, and Option Slot Cover

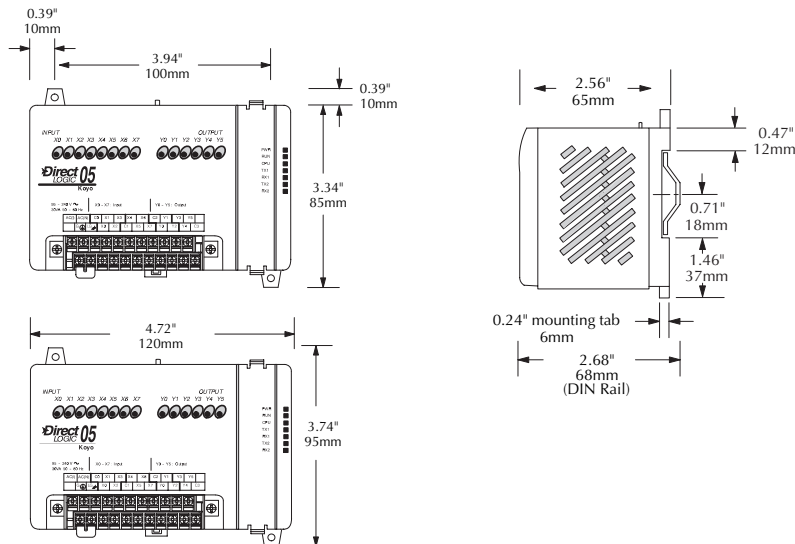
Mounting Guidelines

In addition to the panel layout guidelines, other specifications can affect the definition and installation of a PLC system. Always consider the following:

- Environmental Specifications
- Power Requirements
- Agency Approvals
- Enclosure Selection and Component Dimensions

Unit Dimensions

The following diagram shows the outside dimensions and mounting hole locations for all versions of the DL05. Make sure you follow the installation guidelines to allow proper spacing from other components.



Enclosures

Your selection of a proper enclosure is important to ensure safe and proper operation of your DL05 system. Applications of DL05 systems vary and may require additional features. The minimum considerations for enclosures include:

- Conformance to electrical standards
- Protection from the elements in an industrial environment
- Common ground reference
- Maintenance of specified ambient temperature
- Access to equipment
- Security or restricted access
- Sufficient space for proper installation and maintenance of equipment

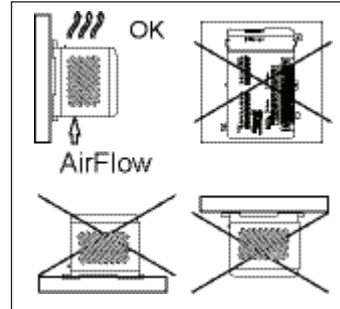
Panel Layout & Clearances

There are many things to consider when designing the panel layout. The following items correspond to the diagram shown. Note: there may be additional requirements, depending on your application and use of other components in the cabinet.

1. Mount the PLCs horizontally as shown below to provide proper ventilation. You *cannot* mount the DL05 units vertically, upside down, or on a flat horizontal surface. If you place more than one unit in a cabinet, there must be a minimum of 7.2" (183mm) between the units.

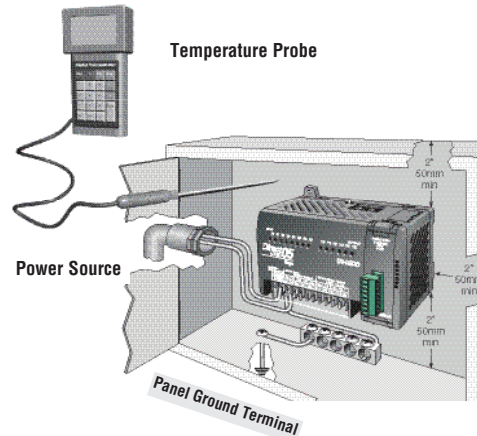
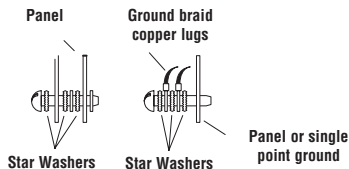
2. Provide a minimum clearance of 2" (50mm) between the unit and all sides of the cabinet. Note, remember to allow for any operator panels or other items mounted in the door.

3. There should also be at least 3" (78mm) of clearance between the unit and any wiring ducts that run parallel to the terminals.



4. The ground terminal on the DL05 base must be connected to a single point ground. Use copper stranded wire to achieve a low impedance. Copper eye lugs should be crimped and soldered to the ends of the stranded wire to ensure good surface contact. Remove anodized finishes and use copper lugs and star washers at termination points.

NOTE: There is a minimum clearance requirement of 2" (51cm) between the panel door (or any devices mounted in the panel door) and the nearest DL05 component.



5. There must be a single point ground (i.e. copper bus bar) for all devices in the panel requiring an earth ground return. The single point of ground must be connected to the panel ground termination. The panel ground termination must be connected to earth ground. Minimum wire sizes, color coding, and general safety practices should comply with appropriate electrical codes and standards for your area.

6. A good common ground reference (Earth ground) is essential for proper operation of the DL05. One side of all control and power circuits and the ground lead on flexible shielded cable must be properly connected to common ground reference. Methods which provide a good common ground reference, include:

- Installing a ground rod as close to the panel as possible.
- Connection to incoming power system ground.

7. Evaluate any installations where the ambient temperature may approach the lower or upper limits of the specifications. If you suspect the ambient temperature will not be within the operating specification for the DL05 system, measures such as installing a cooling/heating source must be taken to get the ambient temperature within the range of specifications.

8. The DL05 systems are designed to be powered by 95–240 VAC or 12–24 VDC normally available throughout an industrial environment. Electrical power in some areas where the PLCs are installed is not always stable and storms can cause power surges. Due to this, powerline filters are recommended for protecting the DL05 PLCs from power surges and EMI/RFI noise. The Automation Powerline Filter, for use with 120 VAC and 240 VAC, 1–5 Amps (part number APF120N05), is an excellent choice, however, you can use a filter of your choice. These units install easily between the power source and the PLC.

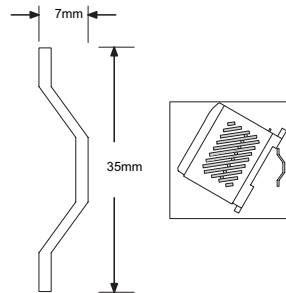


NOTE: If you are using other components in your system, make sure you refer to the appropriate manual to determine how those units can affect mounting dimensions.

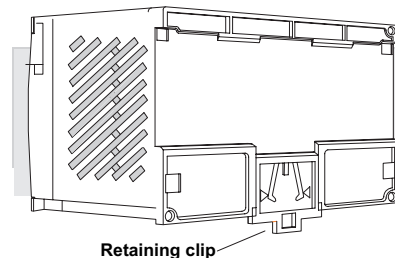
Using DIN Rail Mounting Rails

DL05 Micro PLCs can be secured to a panel by using mounting rails. We recommend rails that conform to DIN EN standard 50 022. They are approximately 35mm high, with a depth of 7mm. If you mount the Micro PLC on a rail, do consider using end brackets on each side of the PLC. The end bracket helps keep the PLC from sliding horizontally along the rail, reducing the possibility of accidentally pulling the wiring loose. On the bottom of the PLC is a small retaining clip. To secure the PLC to a DIN rail, place it onto the rail and gently push up on the clip to lock it onto the rail. To remove the PLC, pull down on the retaining clip, lift up on the PLC slightly, then pulling it away from the rail.

Din Rail Dimensions



Din Rail Slot
Use 35mm x 7mm rail
conforming to DIN EN 50022



NOTE: Refer to our catalog for a complete listing of **DINnector** connection systems.

Environmental Specifications

The following table lists the environmental specifications that generally apply to DL05 Micro PLCs. The ranges that vary for the Handheld Programmer are noted at the bottom of this chart. Certain output circuit types may have derating curves, depending on the ambient temperature and the number of outputs ON. Please refer to the appropriate section in this chapter pertaining to your particular DL05 PLC.

- * Operating temperature for the Handheld Programmer and the DV-1000 is 32° to 122° F (0° to 50° C) Storage temperature for the Handheld Programmer and the DV-1000 is -4° to 158° F (-20° to 70° C).
- ** Equipment will operate down to 5% relative humidity. However, static electricity problems occur much more frequently at low humidity levels (below 30%). Make sure you take adequate precautions when you touch the equipment. Consider using ground straps, anti-static floor coverings, etc. if you use the equipment in low-humidity environments.

Environmental Specifications	
Specification	Rating
Storage temperature	-4° F to 158° F (-20° C to 70° C)
Ambient operating temperature*	32° F to 131° F (0° C to 55° C)
Ambient humidity**	5% – 95% relative humidity (non-condensing)
Vibration resistance	MIL STD 810C, Method 514.2
Shock resistance	MIL STD 810C, Method 516.2
Noise immunity	NEMA (ICS3-304)
Atmosphere	No corrosive gases
Agency approvals	UL, CE, FCC class A

Agency Approvals

Some applications require agency approvals for particular components. The DL05 Micro PLC agency approvals are listed below:

- UL (Underwriters' Laboratories, Inc.)
- CUL (Canadian Underwriters' Laboratories, Inc.)
- CE (European Economic Union)

Marine Use

American Bureau of Shipping (ABS) certification requires flame-retarding insulation as per 4-8-3/5.3.6(a). ABS will accept Navy low smoke cables, cable qualified to NEC "Plenum rated" (fire resistant level 4), or other similar flammability resistant rated cables. Use cable specifications for your system that meet a recognized flame retardant standard (i.e. UL, IEEE, etc.), including evidence of cable test certification (i.e. tests certificate, UL file number, etc.).

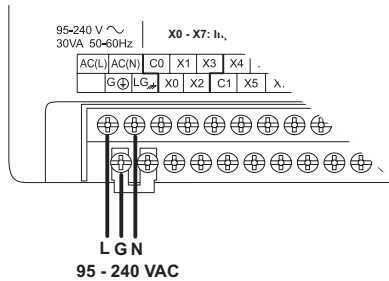


NOTE: Wiring needs to be "low smoke" per the above paragraph. Teflon coated wire is also recommended.

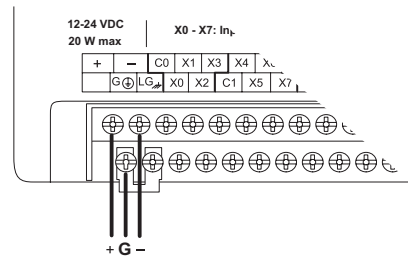
Wiring Guidelines

Connect the power input wiring for the DL05. Observe all precautions stated earlier in this manual. Follow the guidelines in this chapter. When the wiring is complete, close the connector covers. Do not apply power at this time.

110/220 VAC Power Input



12/24 VDC Power Input



WARNING: Once the power wiring is connected, secure the terminal block cover in the closed position. When the cover is open there is a risk of electrical shock if you accidentally touch the connection terminals or power wiring.

Fuse Protection for Input Power

There are no internal fuses for the input power circuits, so external circuit protection is needed to ensure the safety of service personnel and the safe operation of the equipment itself. To meet UL/CUL specifications, the input power must be fused. Depending on the type of input power being used, follow these fuse protection recommendations:

208/240 VAC Operation

When operating the unit from 208/240 VAC, whether the voltage source is a step-down transformer or from two phases, fuse both the line (L) and neutral (N) leads. The recommended fuse size is 1A, such as AutomationDirect's AGC1, fast-acting fuse.

110/125 VAC Operation

When operating the unit from 110/125 VAC, it is only necessary to fuse the line (L) lead; it is not necessary to fuse the neutral (N) lead. The recommended fuse size is 1.0A.

12/24 VDC Operation

When operating at these lower DC voltages, wire gauge size is just as important as proper fusing techniques. Using large conductors minimizes the voltage drop in the conductor. Each DL05 input power terminal can accommodate one 16 AWG wire or two 18 AWG wires. A DC failure can maintain an arc for much longer time and distance than AC failures. Typically, the main bus is fused at a higher level than the branch device, which in this case is the DL05. The recommended fuse size for the branch circuit to the DL05 is 1A, such as AutomationDirect's AGC1, fast-acting fuse.

External Power Source

The power source must be capable of supplying voltage and current complying with individual Micro PLC specifications, according to the following specifications:

Power Source Specifications		
Item	DL05 VAC Powered Units	DL05 VDC Powered Units
Input Voltage Range	110/220 VAC (95–240 VAC)	12–24 VDC (10.8–26.4 VDC)
Maximum Inrush Current	13 A, 1ms (95–240 VAC) 15 A, 1ms (240–264 VAC)	10A < 1ms
Maximum Power	30 VA	20 W
Voltage Withstand (dielectric)	1 minute @ 1500 VAC between primary, secondary, field ground	
Insulation Resistance	> 10 MΩ at 500 VDC	



NOTE 1: The rating between all internal circuits is BASIC INSULATION ONLY.

NOTE 2: It is possible to use an uninterruptible power supply (UPS); however, the output must be a sinusoidal waveform for the PLC to perform properly.

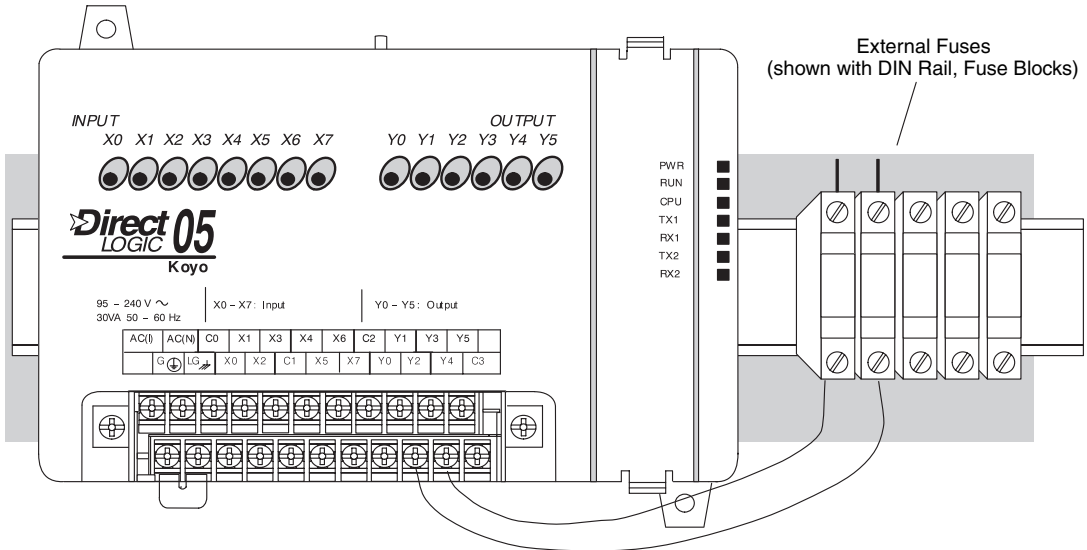
Planning the Wiring Routes

The following guidelines provide general information on how to wire the I/O connections to DL05 Micro PLCs. For specific information on wiring a particular PLC refer to the corresponding specification sheet further in this chapter.

1. Each terminal connection of the DL05 PLC can accept one 16 AWG wire or two 18 AWG size wires. Do not exceed this recommended capacity.
2. Always use a continuous length of wire. Do not splice wires to attain a needed length.
3. Use the shortest possible wire length.
4. Use wire trays for routing where possible.
5. Avoid running wires near high energy wiring.
6. Avoid running input wiring close to output wiring where possible.
7. To minimize voltage drops when wires must run a long distance, consider using multiple wires for the return line.
8. Avoid running DC wiring in close proximity to AC wiring where possible.
9. Avoid creating sharp bends in the wires.
10. Install the recommended powerline filter to reduce power surges and EMI/RFI noise.

Fuse Protection for Input and Output Circuits

Input and Output circuits on DL05 Micro PLCs do not have internal fuses. In order to protect your Micro PLC, we suggest you add external fuses to your I/O wiring. A fast-blow fuse, with a lower current rating than the I/O bank's common current rating can be wired to each common. Or, a fuse with a rating of slightly less than the maximum current per output point can be added to each output. Refer to the Micro PLC specification tables further in this chapter to find the maximum current per output point or per output common. Adding the external fuse does not guarantee the prevention of Micro PLC damage, but it will provide added protection.



I/O Point Numbering

All DL05 Micro PLCs have a fixed I/O configuration. It follows the same octal numbering system used on other *DirectLogic* family PLCs, starting at X0 and Y0. The letter X is always used to indicate inputs and the letter Y is always used for outputs.

The I/O numbering always starts at zero and does not include the digits 8 or 9. The reference addresses are typically assigned in groups of 8 or 16, depending on the number of points in an I/O group. For the DL05 the eight inputs use reference numbers X0 – X7. The six output points use references Y0 – Y5.

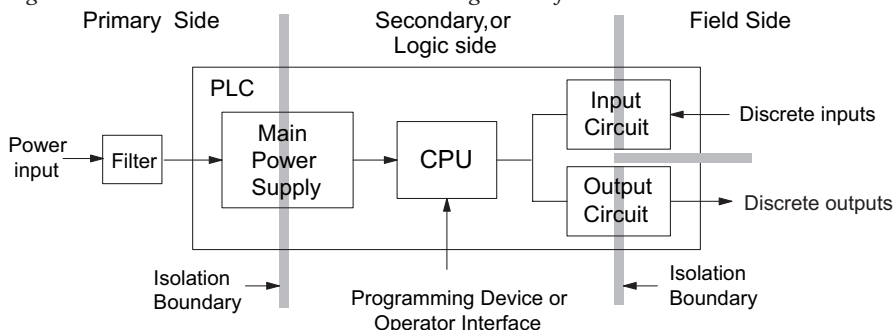
If an optional input module is installed in the option slot, the reference numbers are X100 – X107. A typical output module installed in the option slot will have references Y100 – Y107. See the DL05/06 Options Modules User Manual (D0-OPTIONS-M) for addressing other optional modules.

System Wiring Strategies

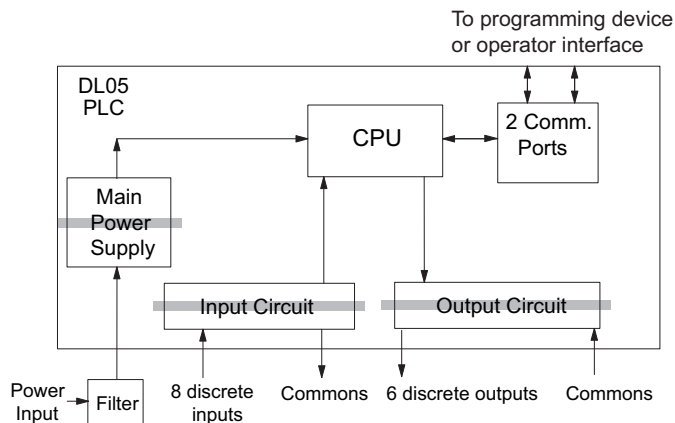
The DL05 Micro PLC is very flexible and will work in many different wiring configurations. By studying this section before actual installation, you can probably find the best wiring strategy for your application. This will help to lower system cost, wiring errors, and avoid safety problems.

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 which connect to the logic side of the PLC circuits.*



The next figure shows the internal layout of DL05 PLCs, as viewed from the front panel.

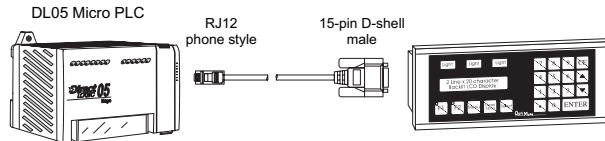


Connecting Operator Interface Devices

Operator interfaces require data and power connections. Operator interfaces with a large CRT usually require separate AC power. However, some small operator interface devices, such as the DV-1000 Data Access Unit, may be powered directly from the DL05 Micro PLC. Connect the DV-1000 to communication port 1 on the DL05 Micro PLC with a DV-1000CBL. A single cable contains transmit/receive data wires and +5V power.

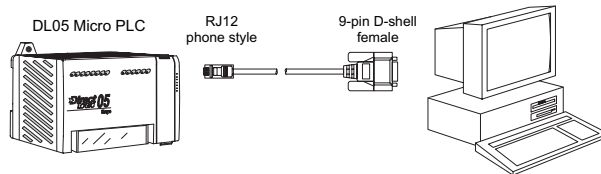


Operator interface panels require separate power and communications connections. Connect the DL05 with the proper cable and power supply for your application.

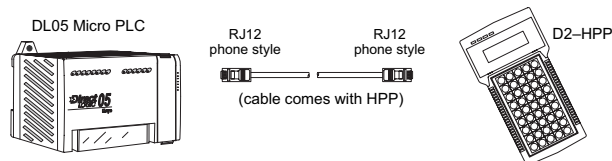


Connecting Programming Devices

DL05 Micro PLCs are programmed using *DirectSOFT 5* programming software on a PC. Limited programming can be accomplished with a handheld programmer. The DL05 can be interfaced to the PC with either a serial cable shown below or a Ethernet cable (Ethernet requires either an H0-ECOM or H0-ECOM100 module installed in the option slot).



The D2-HPP Handheld Programmer comes with a communications cable. For a replacement cable, order a DV-1000CBL.



Sinking/Sourcing Concepts

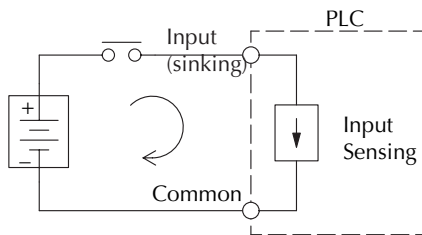
Before going further in our study of wiring strategies, we must have a solid understanding of “sinking” and “sourcing” concepts. Use of these terms occurs frequently in input or output circuit discussions. It is the goal of this section to make these concepts easy to understand, further ensuring your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

Sinking = Path to supply ground (–)

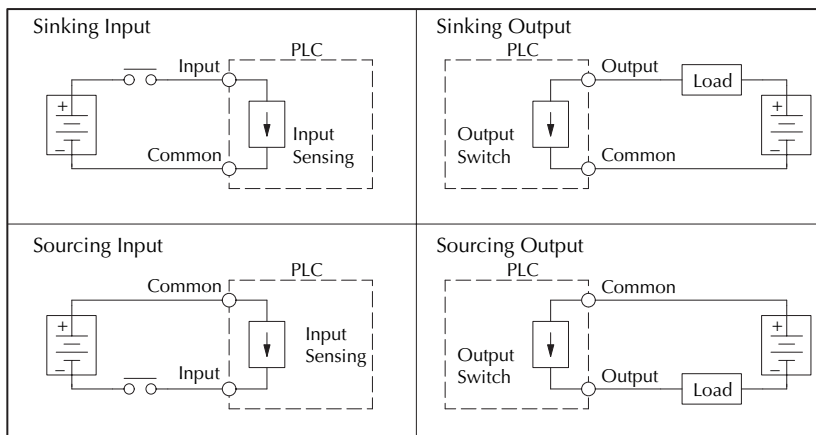
Sourcing = Path to supply source (+)

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 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.

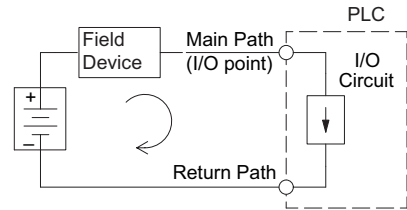


By applying the circuit principle above to the four possible combinations of input/output sinking/sourcing types, we have the four circuits as shown below. DL05 Micro PLCs provide all except the sourcing output I/O circuit types.

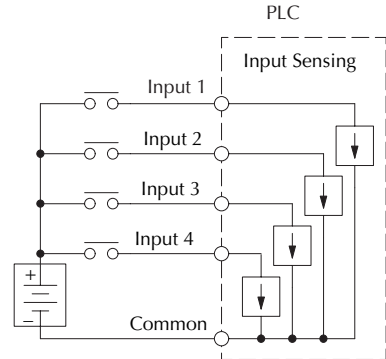


I/O “Common” Terminal Concepts

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.

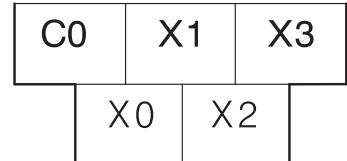


If we had unlimited space and budget for I/O terminals, then every I/O point could have two dedicated terminals just as the figure above shows. However, providing this level of flexibility is not practical or even necessary for most applications. So, most Input or Output point groups on PLCs share the 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 4 times any channel’s input current when all inputs are energized. This is especially important in output circuits, where heavier gauge wire is sometimes necessary on commons.

Most DL05 input and output circuits are grouped into banks that share a common return path. The best indication of I/O The I/O common grouping bar, labeled at the right, occurs in the section of wiring label below it. It indicates X0, X1, X2, and X3 share the common terminal located to the left of X1.



The following complete label shows two banks of four inputs and two banks of three outputs. One common is provided for each bank.

AC(L)	AC(N)	C0	X1	X3	X4	X6	C2	Y1	Y3	Y5	
	G	LG	X0	X2	C1	X5	X7	Y0	Y2	Y4	C3

The following label is for DC output versions. One common is provided for all of the outputs and the terminal on the bottom right accepts power for the output stage.

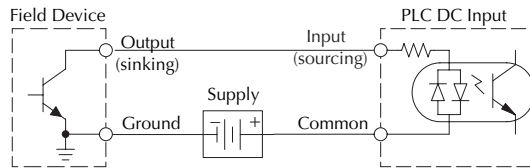
AC(L)	AC(N)	C0	X1	X3	X4	X6	C2	Y1	Y3	Y5	
	G	LG	X0	X2	C1	X5	X7	Y0	Y2	Y4	+V

Connecting DC I/O to Solid State Field Devices

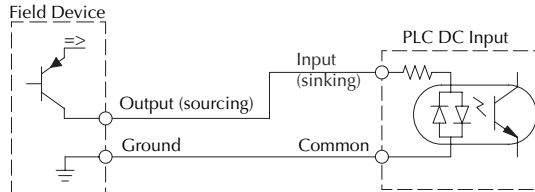
In the previous section on Sourcing and Sinking concepts, we explained that DC I/O circuits sometimes will only allow current to flow one way. This is also true for many of the field devices which have solid-state (transistor) interfaces. In other words, field devices can also be sourcing or sinking. *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 DL05's 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 power supply can be the FA-24PS +24 VDC power supply or another supply (+12 VDC or +24VDC), 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.

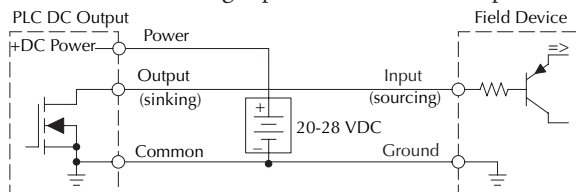


Solid State Output Loads

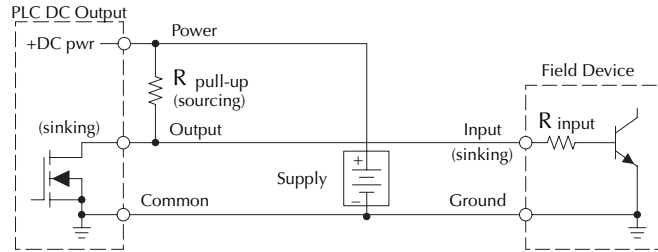
Sometimes an application requires connecting a PLC output point to a solid state input on a device. This type of connection is usually made to carry a low-level signal, not to send DC power to an actuator.

The DL05's DC outputs are sinking-only. This means that each DC output provides a path to ground when it is energized. Also, remember that all six outputs have the same electrical common, even though there are two common terminal screws. 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 $R_{\text{pull-up}}$ from the output to the DC output circuit power input.



NOTE 1: 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 $R_{\text{pull-up}}$. 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 $R_{\text{pull-up}}$. Then calculate the power

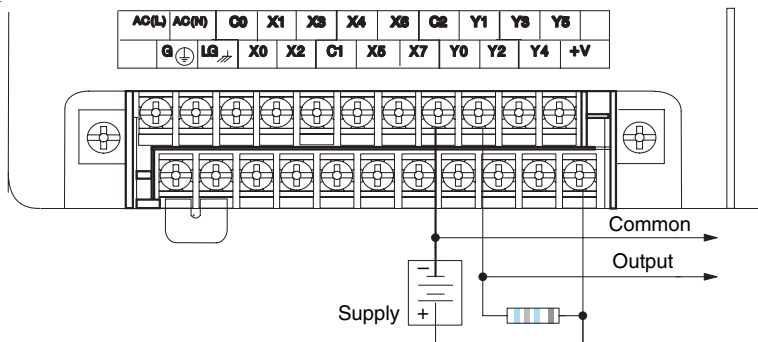
$$I_{\text{input}} = \frac{V_{\text{input (turn-on)}}}{R_{\text{input}}}$$

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

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

$P_{\text{pull-up}}$ (in watts), in order to size $R_{\text{pull-up}}$ properly.

The drawing below shows the actual wiring of the DL05 Micro PLC to the supply and pull-up resistor.



Relay Output Wiring Methods

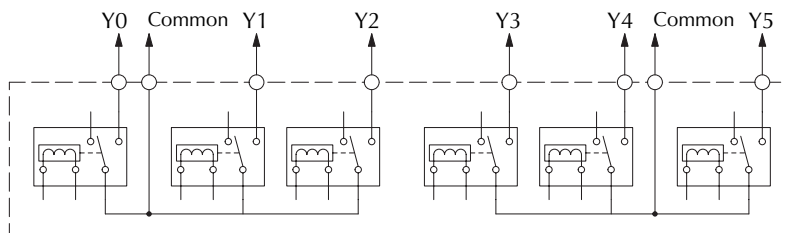
The D0-05AR and the D0-05DR models feature relay outputs. Relays are best for the following applications:

- Loads that require higher currents than the solid-state DL05 outputs can deliver
- Cost-sensitive applications
- Some output channels need isolation from other outputs (such as when some loads require AC while others require DC)

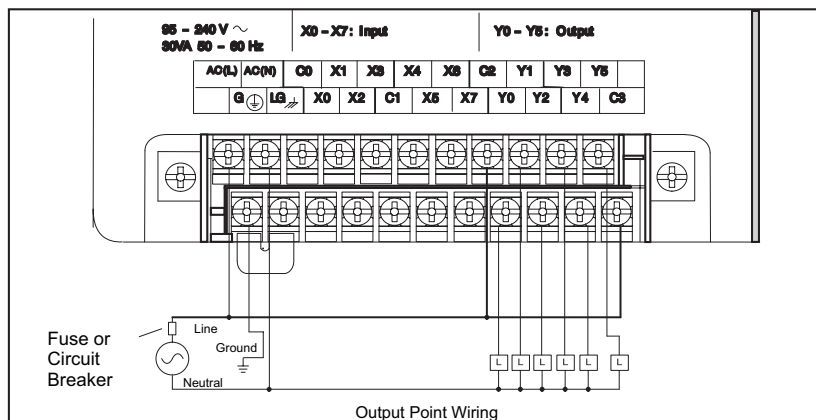
Some applications in which NOT to use relays:

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

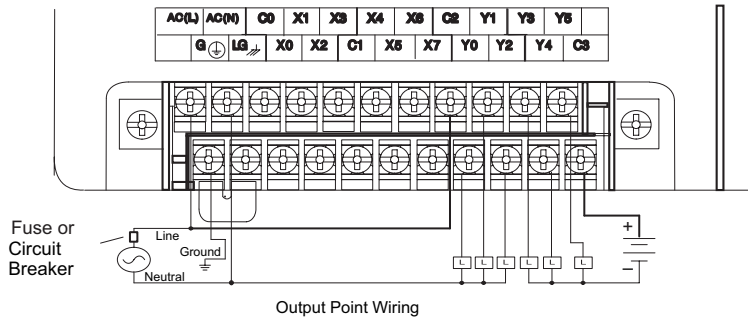
Assuming relays are right for your application, we're now ready to explore various ways to wire relay outputs to the loads. Note that there are six normally-open SPST relays available. They are organized with three relays per common. The figure below shows the relays and the internal wiring of the PLC. Note that each group is isolated from the other group of outputs.



In the circuit below, all loads use the same AC power supply which powers the DL05 PLC. In this example, all commons are connected together.



In the circuit on the following page, loads for Y0 – Y2 use the same AC power supply which powers the DL05 PLC. Loads for Y3 – Y5 use a separate DC supply. In this example, the commons are separated according to which supply powers the associated load.



Relay Outputs – Transient Suppression for Inductive Loads in a Control System

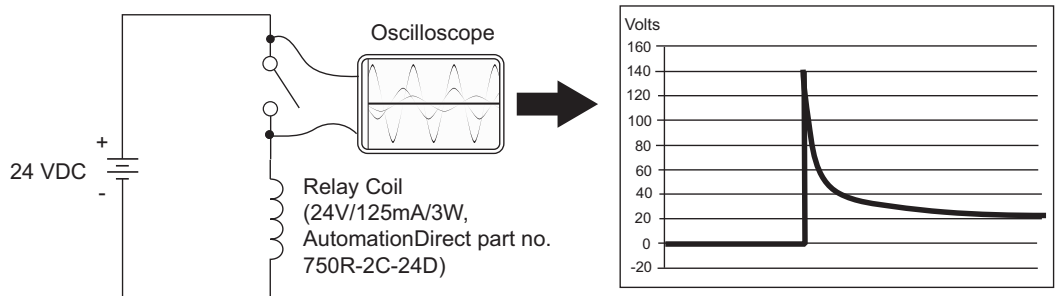
The following pages are intended to give a quick overview of the negative effects of transient voltages on a control system and provide some simple advice on how to effectively minimize them. The need for transient suppression is often not apparent to the newcomers in the automation world. Many mysterious errors that can afflict an installation can be traced back to a lack of transient suppression.

What is a Transient Voltage and Why is it Bad?

Inductive loads (devices with a coil) generate transient voltages as they transition from being energized to being de-energized. If not suppressed, the transient can be many times greater than the voltage applied to the coil. These transient voltages can damage PLC outputs or other electronic devices connected to the circuit, and cause unreliable operation of other electronics in the general area. Transients must be managed with suppressors for long component life and reliable operation of the control system.

This example shows a simple circuit with a small 24 V/125 mA/3 W relay. As you can see, when the switch is opened, thereby de-energizing the coil, the transient voltage generated across the switch contacts peaks at 140 V.

Example: Circuit with no Suppression



In the same circuit, replacing the relay with a larger 24 V/290 mA/7 W relay will generate a transient voltage exceeding 800 V (not shown). Transient voltages like this can cause many problems, including:

- Relay contacts driving the coil may experience arcing, which can pit the contacts and reduce the relay's lifespan.
- Solid state (transistor) outputs driving the coil can be damaged if the transient voltage exceeds the transistor's ratings. In extreme cases, complete failure of the output can occur the very first time a coil is de-energized.
- Input circuits, which might be connected to monitor the coil or the output driver, can also be damaged by the transient voltage.

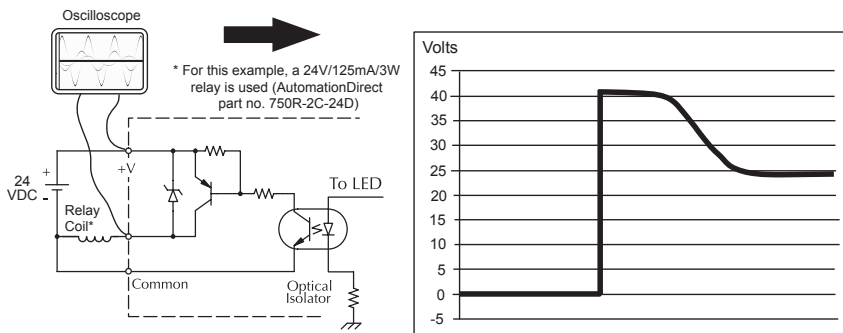
A very destructive side-effect of the arcing across relay contacts is the electromagnetic interference (EMI) it can cause. This occurs because the arcing causes a current surge, which releases RF energy. The entire length of wire between the relay contacts, the coil, and the power source carries the current surge and becomes an antenna that radiates the RF energy. It will readily couple into parallel wiring and may disrupt the PLC and other electronics in the area. This EMI can make an otherwise stable control system behave unpredictably at times.

PLC's Integrated Transient Suppressors

Although the PLC's outputs typically have integrated suppressors to protect against transients, they are not capable of handling them all. It is usually necessary to have some additional transient suppression for an inductive load.

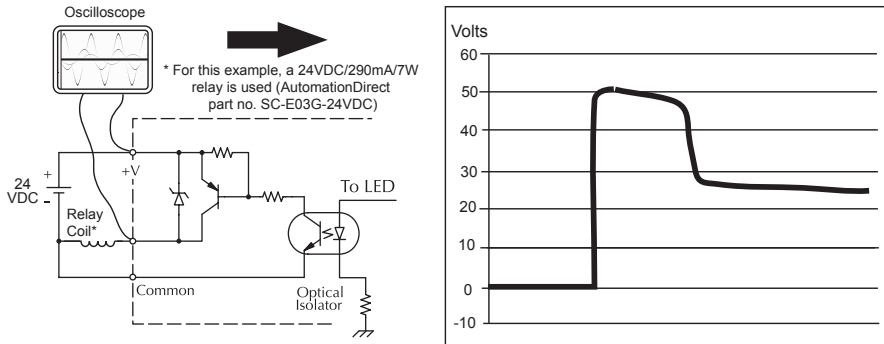
Here is another example using the same 24 V/125 mA/3 W relay used earlier. This example measures the PNP transistor output of a D0-06DD2 PLC, which incorporates an integrated Zener diode for transient suppression. Instead of the 140 V peak in the first example, the transient voltage here is limited to about 40 V by the Zener diode. While the PLC will probably tolerate repeated transients in this range for some time, the 40 V is still beyond the module's peak output voltage rating of 30 V.

Example: Small Inductive Load with Only Integrated Suppression



The next example uses the same circuit as above, but with a larger 24 V/290 mA/7 W relay, thereby creating a larger inductive load. As you can see, the transient voltage generated is much worse, peaking at over 50 V. Driving an inductive load of this size without additional transient suppression is very likely to permanently damage the PLC output.

Example: Larger Inductive Load with Only Integrated Suppression

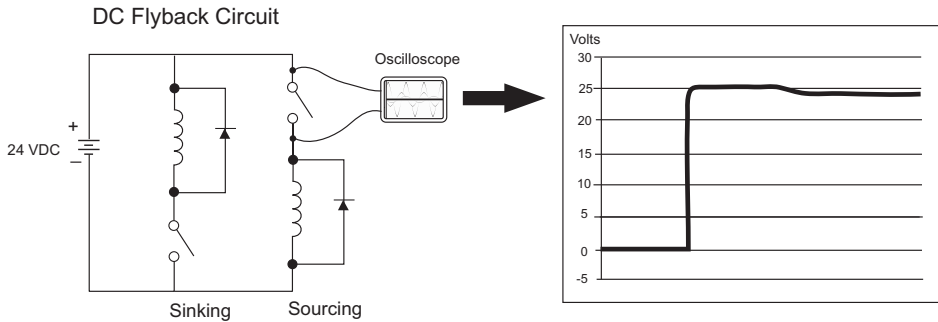


Additional transient suppression should be used in both these examples. If you are unable to measure the transients generated by the connected loads of your control system, using additional transient suppression on all inductive loads would be the safest practice.

Types of Additional Transient Protection

DC Coils:

The most effective protection against transients from a DC coil is a flyback diode. A flyback diode can reduce the transient to roughly 1V over the supply voltage, as shown in this example.



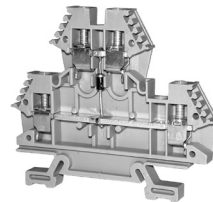
Many AutomationDirect socketed relays and motor starters have add-on flyback diodes that plug or screw into the base, such as the AD-ASMD-250 protection diode module and 784-4C-SKT-1 socket module shown below. If an add-on flyback diode is not available for your inductive load, an easy way to add one is to use AutomationDirect's DN-D10DR-A diode terminal block, a 600VDC power diode mounted in a slim DIN rail housing.



AD-ASMD-250
Protection Diode Module



784-4C-SKT-1
Relay Socket



DN-D10DR-A
Diode Terminal Block

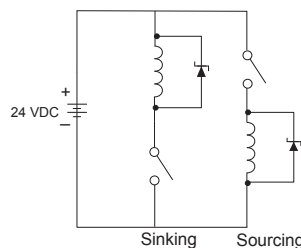
Two more common options for DC coils are Metal Oxide Varistors (MOV) or TVS diodes. These devices should be connected across the driver (PLC output) for best protection as shown below. The optimum voltage rating for the suppressor is the lowest rated voltage available that will NOT conduct at the supply voltage, while allowing a safe margin.

AutomationDirect's ZL-TSD8-24 transorb module is a good choice for 24 VDC circuits. It is a bank of 8 uni-directional 30 V TVS diodes. Since they are uni-directional, be sure to observe the polarity during installation. MOVs or bi-directional TVS diodes would install at the same location, but have no polarity concerns.



ZL-TSD8-24
Transorb Module

DC MOV or TVS Diode Circuit



AC Coils:

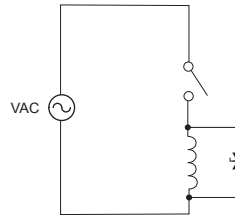
Two options for AC coils are MOVs or bi-directional TVS diodes. These devices are most effective at protecting the driver from a transient voltage when connected across the driver (PLC output) but are also commonly connected across the coil. The optimum voltage rating for the suppressor is the lowest rated voltage available that will NOT conduct at the supply voltage, while allowing a safe margin.

AutomationDirect's ZL-TSD8-120 transorb module is a good choice for 120 VAC circuits. It is a bank of eight bi-directional 180V TVS diodes.



ZL-TSD8-120
Transorb Module

AC MOV or Bi-Directional Diode Circuit

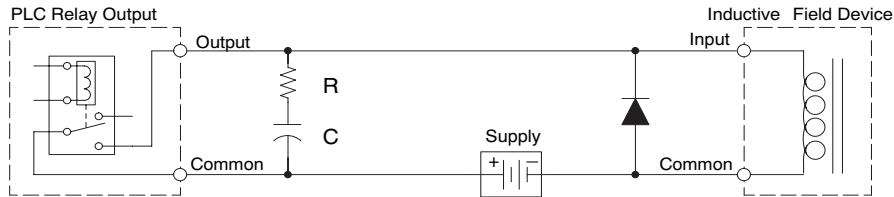


NOTE: Manufacturers of devices with coils frequently offer MOV or TVS diode suppressors as an add-on option which mount conveniently across the coil. Before using them, carefully check the suppressor's ratings. Just because the suppressor is made specifically for that part does not mean it will reduce the transient voltages to an acceptable level.

For example, a MOV or TVS diode rated for use on 24-48 VDC coils would need to have a high enough voltage rating to NOT conduct at 48 V. That suppressor might typically start conducting at roughly 60 VDC. If it were mounted across a 24 V coil, transients of roughly 84 V (if sinking output) or -60 V (if sourcing output) could reach the PLC output. Many semiconductor PLC outputs cannot tolerate such levels.

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.



Adding external contact protection may extend relay life beyond the number of contact cycles listed in the specification tables for relay modules. High current inductive loads such as clutches, brakes, motors, direct-acting solenoid valves and motor starters will benefit the most from external contact protection.

When using an RC network, locate it close to the relay module output connector. To find the values for the RC snubber network, first determine the voltage across the contacts when open, and the current through them when closed. If the load supply is AC, then convert the current and voltage values to peak values.

Now you are ready to calculate values for R and C, according to the formulas:

$$C (\mu F) = \frac{I^2}{10} \quad R (\Omega) = \frac{V}{10 \times I^x} \quad , \text{ where } x = 1 + \frac{50}{V}$$

C minimum = 0.001 μF , the voltage rating of C must be $\geq V$, non-polarized

R minimum = 0.5 Ω , 1/2 W, tolerance is $\pm 5\%$

For example, suppose a relay contact drives a load at 120VAC, 1/2 A. Since this example has an AC power source, first calculate the peak values:

$$I_{\text{peak}} = I_{\text{rms}} \times 1.414, = 0.5 \times 1.414 = 0.707 \text{ Amperes}$$

$$V_{\text{peak}} = V_{\text{rms}} \times 1.414 = 120 \times 1.414 = 169.7 \text{ Volts}$$

Now, finding the values of R and C,:

$$C (\mu F) = \frac{I^2}{10} = \frac{0.707^2}{10} = 0.05 \mu F, \text{ voltage rating} \geq 170 \text{ Volts}$$

$$R (\Omega) = \frac{V}{10 \times I^x}, \text{ where } x = 1 + \frac{50}{V}$$

$$x = 1 + \frac{50}{169.7} = 1.29 \quad R (\Omega) = \frac{169.7}{10 \times 0.707^{1.29}} = 26 \Omega, 1/2 \text{ W}, \pm 5\%$$

For inductive loads in DC circuits we recommend using a suppression diode as shown in the diagram. 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.



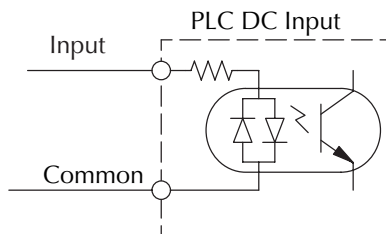
WARNING: DO NOT use this circuit with an AC power supply.

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, 3 A 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 will short-circuit the supply when the relay energizes.

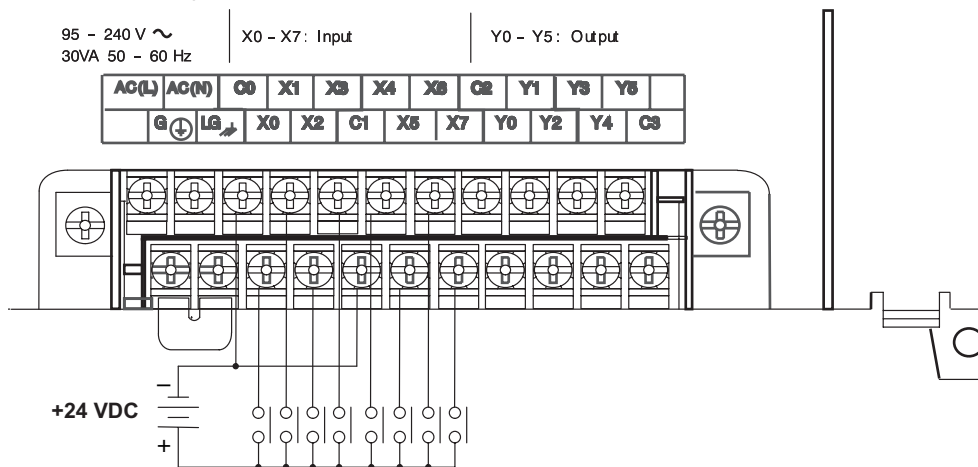
DO NOT use this circuit with an AC power supply.

DC Input Wiring Methods

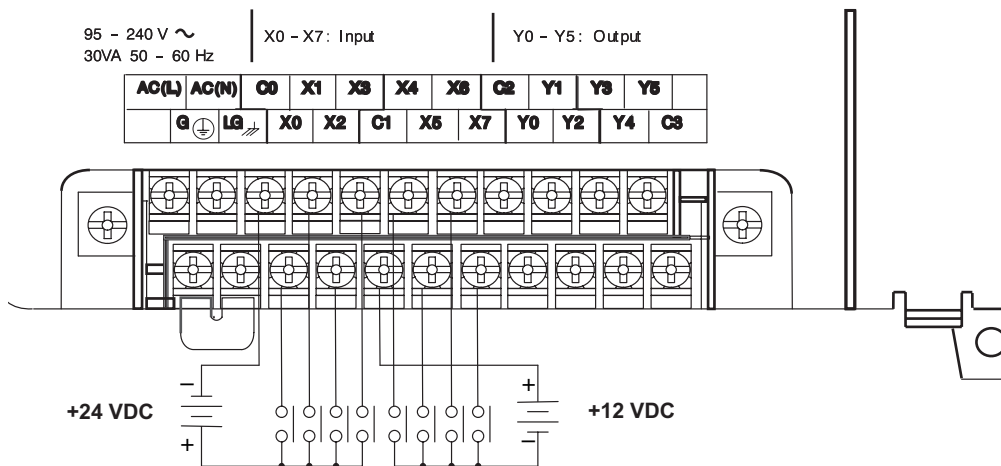
DL05 Micro PLCs with DC inputs are particularly flexible because they can be either sinking or sourcing. The dual diodes (shown to the right) allow 10.8 – 26.4 VDC. The target applications are +12 VDC and +24 VDC. You can actually wire half of the inputs as DC sinking and the other half as DC sourcing. Inputs grouped by a common must be all sinking or all sourcing.



In the first and simplest example below, all commons are connected together and all inputs are sinking.



In the next example, the first four inputs are sinking, and the last four are sourcing.

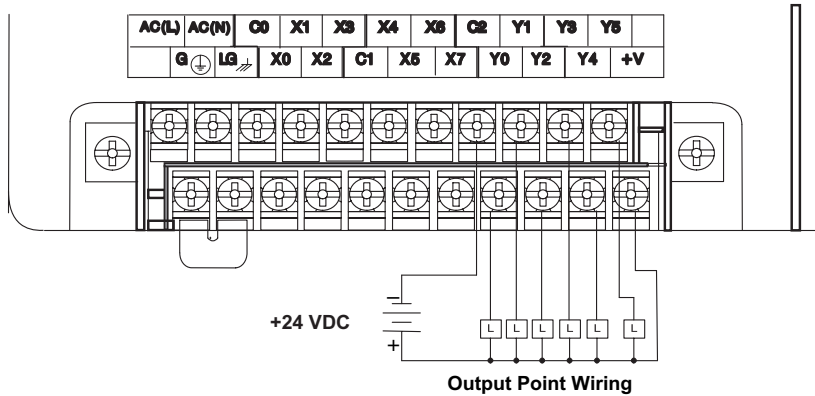


DC Output Wiring Methods

DL05 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:

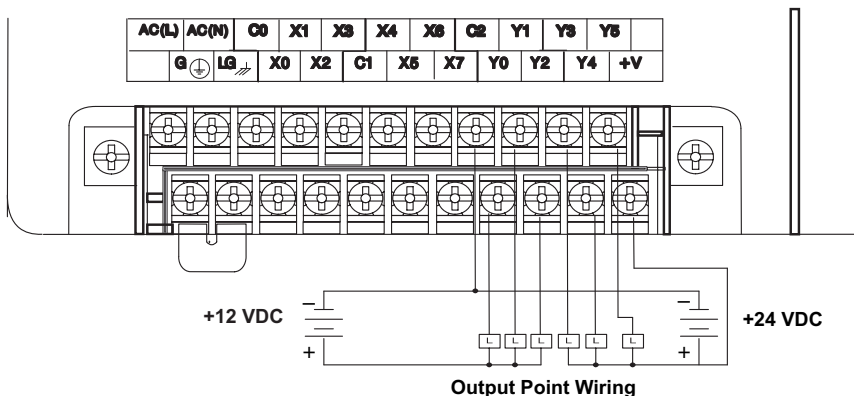
- There is only one electrical common for all six outputs. All six outputs belong to one bank.
- The output switches are current-sinking only. However, you can still use different DC voltages from one load to another.
- The output circuit inside the PLC requires external power. The supply (–) must be connected to a common terminal, and the supply (+) connects the right-most terminal on the upper connector.

In the example below, all six outputs share a common supply.



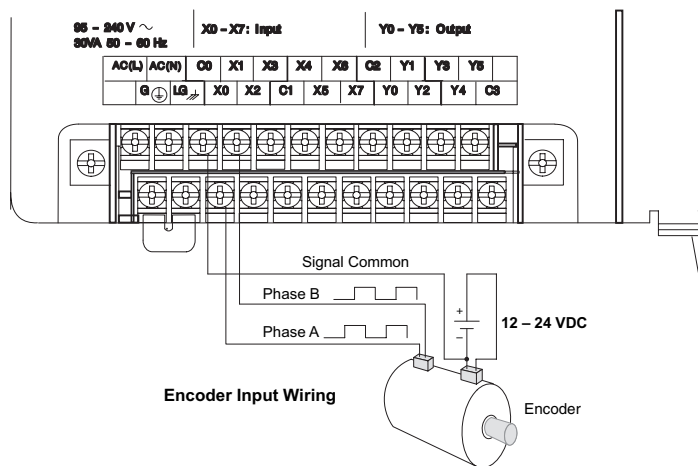
In the next example below, the outputs have “split” supplies. The first three outputs are using a +12 VDC supply, and the last three are using a +24 VDC supply. However, you can split the outputs among any number of supplies, as long as:

- all supply voltages are within the specified range
- all output points are wired as sinking
- all source (–) terminals are connected together

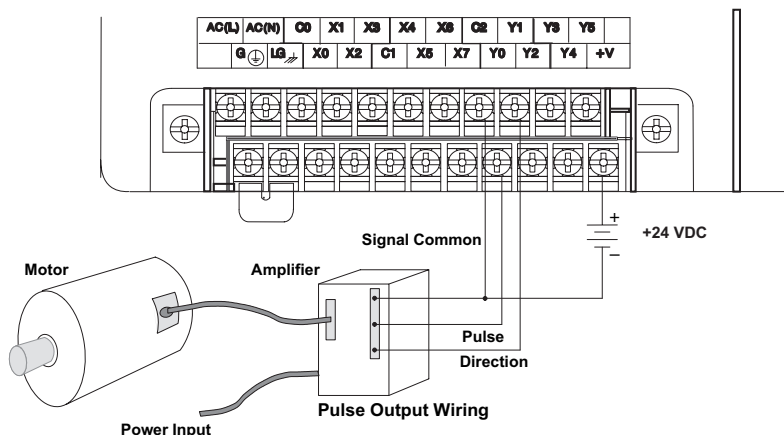


High Speed I/O Wiring Methods

DL05 versions with DC type input or output points contain a dedicated High-Speed I/O circuit (HSIO). The circuit configuration is programmable, and it processes select I/O points independently from the CPU scan. Chapter 3 discusses the programming options for HSIO. While the HSIO circuit has six modes, we show wiring diagrams for two of the most popular modes in this chapter. The high-speed input interfaces to points X0 – X2. Properly configured, the DL05 can count quadrature pulses at up to 5 kHz.



DL05 versions with DC type output points can use the High Speed I/O Pulse Output feature. It can generate high-speed pulses up to 7 KHz for specialized control such as stepper motor / intelligent drive systems. Output Y0 and Y1 can generate pulse and direction signals, or it can generate CCW and CW pulse signals respectively. See Appendix E on high-speed input and pulse output options.



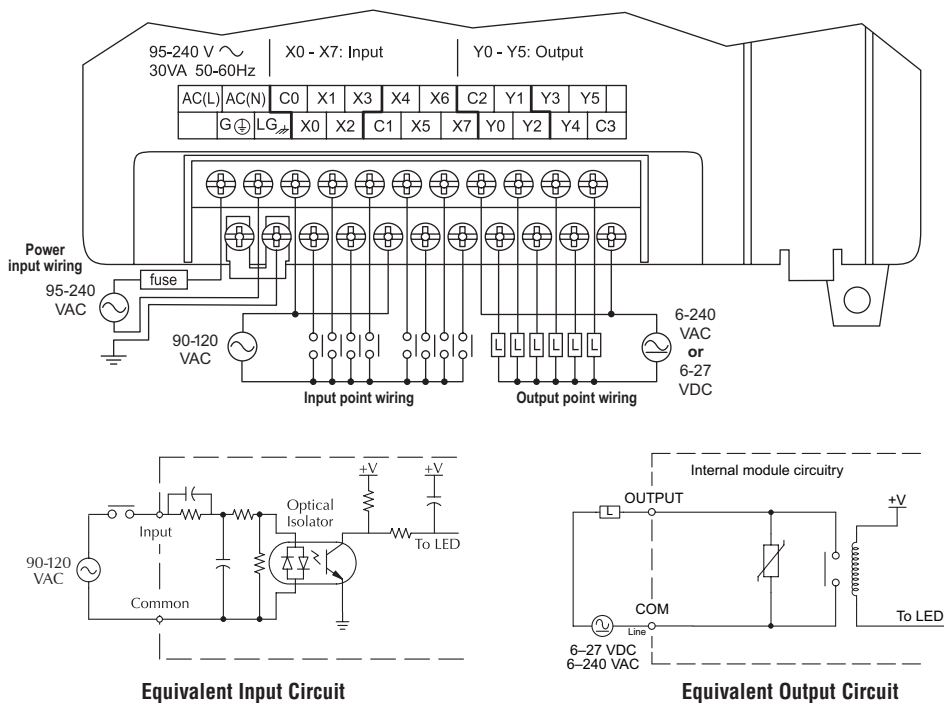
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Wiring Diagrams and Specifications

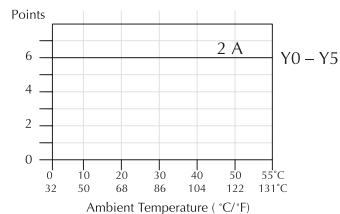
The remainder of this chapter dedicates two pages to each of the eight versions of DL05 Micro PLCs. Each section contains a basic wiring diagram, equivalent I/O circuits, and specification tables. Please refer to the section which describes the particular DL05 version used in your application.

D0-05AR I/O Wiring Diagram

The D0-05AR Micro PLC features eight AC inputs and six relay contact outputs. The following diagram shows a typical field wiring example. The AC external power connection uses four terminals at the left as shown.



The eight AC input channels use terminals in the middle of the connector. Inputs are organized into two banks of four. Each bank has a common terminal. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent input circuit shows one channel of a typical bank.



Derating Chart for Relay Outputs

The six relay output channels use terminals on the right side of the connector. Outputs are organized into two banks of three normally-open relay contacts. Each bank has a common terminal. The wiring example on the last page shows all commons connected together, but separate supplies and common circuits may be used. The equivalent output circuit shows one channel of a typical bank. The relay contacts can switch AC or DC voltages.

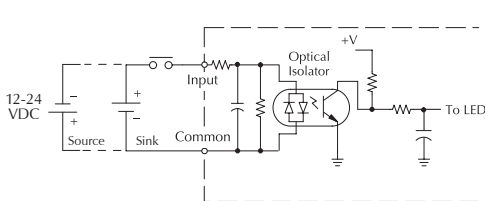
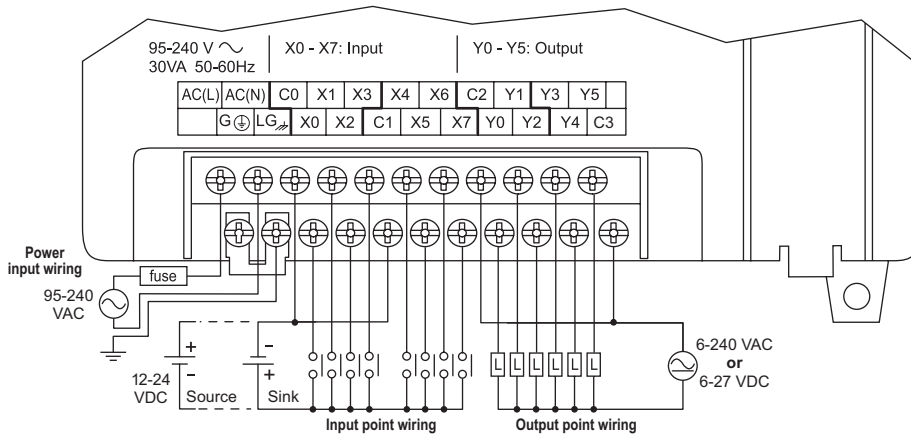
D0-05AR General Specifications	
External Power Requirements	95 – 240 VAC, 30 VA maximum,
Communication Port 1, 9600 baud (Fixed), 8 data bits, 1 stop bit, odd parity	K-Sequence (Slave), DirectNET (Slave), Modbus (Slave)
Communication Port 2, 9600 baud (default), 8 data bits, 1 stop bit, odd parity	K-Sequence (Slave), DirectNET (Master/Slave), Modbus (Master/Slave) Non-sequence/print
Programming cable type	D2-DSCBL
Operating Temperature	32 to 131° F (0 to 55 C)
Storage Temperature	–4 to 158° F (–20 to 70 C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One 16AWG or two 18AWG, 24AWG minimum

AC Input Specifications X0-X7	
Input Voltage Range (Min. - Max.)	80 – 132 VAC, 47 - 63 Hz
Operating Voltage Range	90 – 120 VAC, 47 -63 Hz
Input Current	8 mA @ 100 VAC at 50 Hz, 10 mA @ 100 VAC at 60 Hz
Max. Input Current	12 mA @ 132 VAC at 50 Hz, 15 mA @ 132 VAC at 60 Hz
Input Impedance	14KΩ @50 Hz, 12KΩ @60 Hz
ON Current/Voltage	>6 mA @ 75 VAC
OFF Current/Voltage	<2 mA @ 20 VAC
OFF to ON Response	< 40 ms
ON to OFF Response	< 40 ms
Status Indicators	Logic Side
Commons	4 channels/common x 2 banks

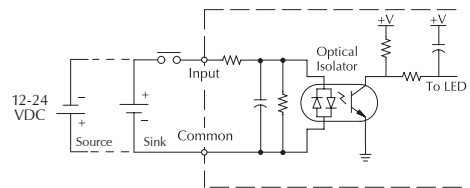
Relay Output Specifications Y0-Y5	
Output Voltage Range	(Min. – Max.) 5 – 264 VAC (47 -63 Hz), 5 – 30 VDC
Operating Voltage Range	6 – 240 VAC (47 -63 Hz), 6 – 27 VDC
Output Current	2A/point, 6A/ common
Max. leakage current	0.1 mA @264VAC
Smallest Recommended Load	5 mA @5 VDC
OFF to ON Response	< 15 ms
ON to OFF Response	< 10 ms
Status Indicators	Logic Side
Commons	3 channels/common x 2 banks
Fuses	None (external recommended)

D0-05DR I/O Wiring Diagram

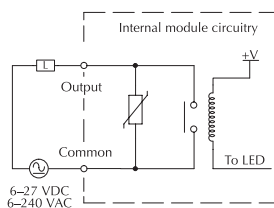
These micro PLCs feature eight DC inputs and six relay contact outputs. The following diagram shows a typical field wiring example. The AC external power connection uses four terminals at the left as shown.



Equivalent Circuit, High-speed Inputs (X0-X2)



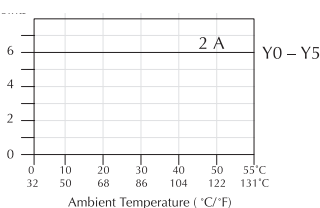
Equivalent Circuit, Standard Inputs (X3-X7)



Equivalent Output Circuit

The eight DC input channels use terminals in the middle of the connector. Inputs are organized into two banks of four. Each bank has an isolated common terminal, and may be wired as either sinking or sourcing inputs. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent circuit for standard inputs and the high-speed input circuit are shown above.

The six output channels use terminals on the right side of the connector. Outputs are organized into two banks of three normally-open relay contacts. Each bank has a common terminal. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent output circuit shows one channel of a typical bank. The relay contacts can switch AC or DC voltages.



Derating Chart for Relay Outputs

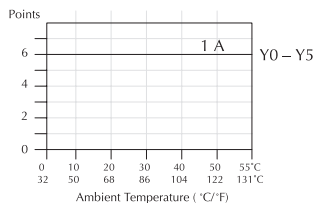
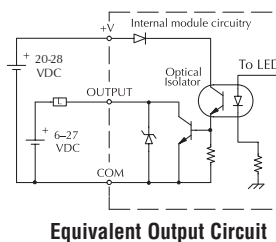
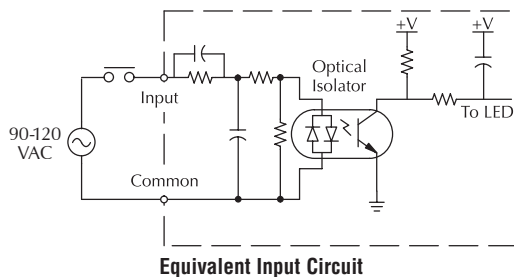
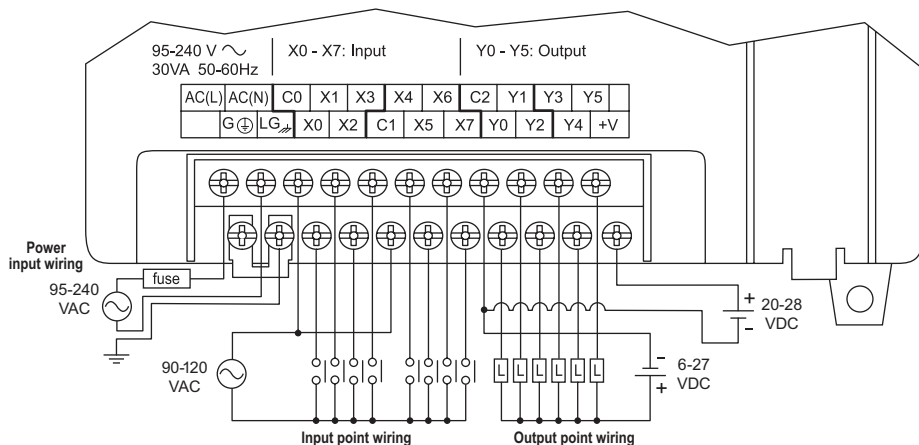
D0-05DR General Specifications	
External Power Requirements	95 – 240 VAC, 30 VA maximum,
Communication Port 1, 9600 baud (Fixed), 8 data bits, 1 stop bit, odd parity	K-Sequence (Slave), DirectNET (Slave), Modbus (Slave)
Communication Port 2, 9600 baud (default), 8 data bits, 1 stop bit, odd parity	K-Sequence (Slave), DirectNET (Master/Slave), Modbus (Master/Slave) Non-sequence / print
Programming cable type	D2-DSCBL
Operating Temperature	32 to 131° F (0 to 55 C)
Storage Temperature	–4 to 158° F (–20 to 70 C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One 16AWG or two 18AWG, 24AWG minimum

DC Input Specifications		
Parameter	High-Speed Inputs, X0 – X2	Standard DC Inputs X3 – X7
Min. - Max. Voltage Range	10.8 – 26.4 VDC	10.8 – 26.4 VDC
Operating Voltage Range	12 -24 VDC	12 -24 VDC
Peak Voltage	30 VDC (5 kHz maximum frequency)	30 VDC
Minimum Pulse Width	100 μ s	N/A
ON Voltage Level	> 10 VDC	> 10 VDC
OFF Voltage Level	< 2.0 VDC	< 2.0 VDC
Input Impedance	1.8 k Ω @ 12 – 24 VDC	2.8 k Ω @ 12 – 24 VDC
Max. Input Current	6mA @12VDC, 13mA @24VDC	4mA @12VDC, 8.5mA @24VDC
Minimum ON Current	>5 mA	>4 mA
Maximum OFF Current	< 0.5 mA	<0.5 mA
OFF to ON Response	<100 μ s	2 – 8 ms, 4 ms typical
ON to OFF Response	< 100 μ s	2 – 8 ms, 4 ms typical
Status Indicators	Logic side	Logic side
Commons	4 channels/common x 2 bank	

Relay Output Specifications	
Output Voltage Range (Min. - Max.)	5 -264 VAC (47 -63 Hz), 5 - 30 VDC
Operating Voltage	6 -240 VAC (47 -63 Hz), 6 - 27 VDC
Output Current	2A / point, 6A/ common
Maximum Voltage	264 VAC, 30 VDC
Max leakage current	0.1 mA @264 VAC
Smallest Recommended Load	5 mA
OFF to ON Response	< 15 ms
ON to OFF Response	< 10 ms
Status Indicators	Logic Side
Commons	3 channels/common x 2 banks
Fuses	None (external recommended)

D0-05AD I/O Wiring Diagram

The D0-05AD Micro PLC features eight AC inputs and six DC outputs. The following diagram shows a typical field wiring example. The AC external power connection uses four terminals at the left as shown.



Derating Chart for DC Outputs

The eight AC input channels use terminals in the middle of the connector. Inputs are organized into two banks of four. Each bank has an isolated common terminal. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent input circuit shows one channel of a typical bank.

The six current sinking DC output channels use terminals on the right side of the connector. All outputs actually share the same electrical common. Note the requirement for external power on the end (right-most) terminal. The equivalent output circuit shows one channel of the bank of six.

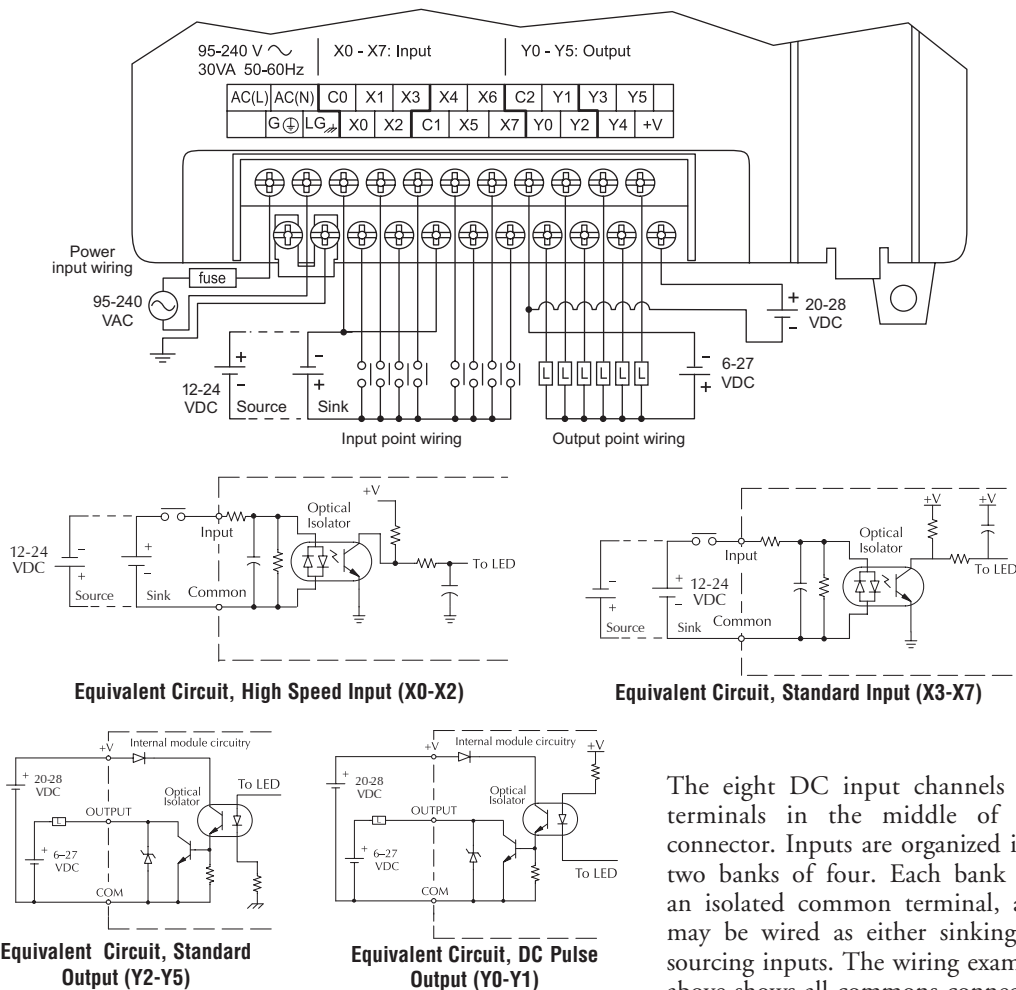
D0-05AD General Specifications	
External Power Requirements	95 – 240 VAC, 30 VA maximum,
Communication Port 1, 9600 baud (Fixed), 8 data bits, 1 stop bit, odd parity	K-Sequence (Slave), DirectNET (Slave), Modbus (Slave)
Communication Port 2, 9600 baud (default), 8 data bits, 1 stop bit, odd parity	K-Sequence (Slave), DirectNET (Master/Slave), Modbus (Master/Slave) Non-sequence/print
Programming cable type	D2-DSCBL
Operating Temperature	32 to 131° F (0 to 55 C)
Storage Temperature	–4 to 158° F (–20 to 70 C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One 16AWG or two 18AWG, 24AWG minimum

AC Input Specifications	
Input Voltage Range (Min. - Max.)	80 – 132 VAC, 47 - 63 Hz
Operating Voltage Range	90 – 120 VAC, 47 - 63 Hz
Input Current	8 mA @ 100 VAC (50Hz), 10 mA @ 100 VAC (60Hz)
Max. Input Current	12 mA @ 132 VAC (50Hz), 15 mA @ 132 VAC (60Hz)
Input Impedance	14K Ω @50 Hz, 12K Ω @60 Hz
ON Current/Voltage	>6 mA @ 75 VAC
OFF Current/Voltage	<2 mA @ 20 VAC
OFF to ON Response	< 40 ms
ON to OFF Response	< 40 ms
Status Indicators	Logic Side
Commons	4 channels/common x 2 banks

DC Output Specifications		
Parameter	Pulse Outputs, Y0 – Y1	Standard Outputs, Y2 – Y5
Min. - Max. Voltage Range	5 – 30 VDC	5 – 30 VDC
Operating Voltage	6 – 27 VDC	6 – 27 VDC
Peak Voltage	< 50 VDC (7 kHz max. frequency)	< 50 VDC
On Voltage Drop	0.3 VDC @ 1A	0.3 VDC @ 1A
Max Current (resistive)	0.5 A/pt. (1A/point for standard pt.)	1.0 A/point
Max leakage current	15 μ A @ 30 VDC	15 μ A @ 30 VDC
Max inrush current	2 A for 100 mS	2 A for 100 mS
External DC power required	20 - 28 VDC max 150mA	20 - 28 VDC max 150mA
OFF to ON Response	<10 μ s	< 10 μ s
ON to OFF Response	<30 μ s	< 60 μ s
Status Indicators	Logic Side	Logic Side
Commons	6 channels/common x 1 bank	
Fuses	None	None

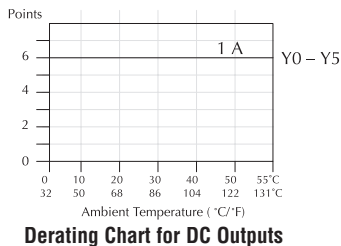
D0-05DD I/O Wiring Diagram

These micro PLCs feature eight DC inputs and six DC outputs. The following diagram shows a typical field wiring example. The AC external power connection uses four terminals at the left as shown.



The eight DC input channels use terminals in the middle of the connector. Inputs are organized into two banks of four. Each bank has an isolated common terminal, and may be wired as either sinking or sourcing inputs. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent circuits for standard inputs and the high-speed inputs are shown above.

The six current sinking DC output channels use terminals on the right side of the connector. All outputs actually share the same electrical common. Note the requirement for external power on the end (right-most) terminal. The equivalent output circuit shows one channel of the bank of six.



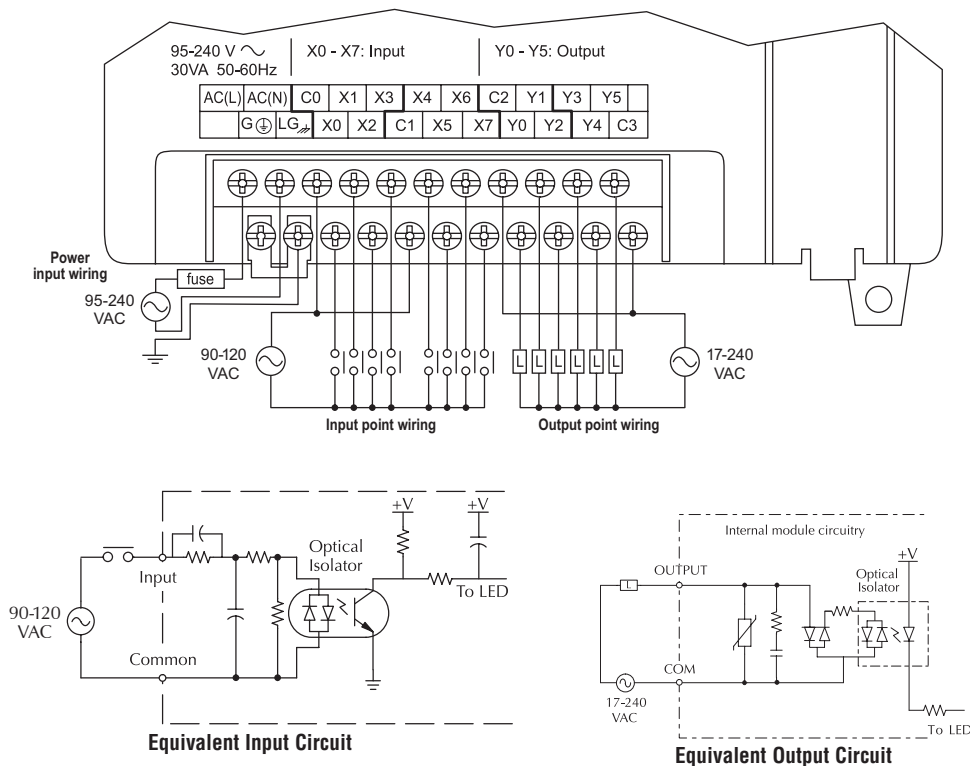
D0-05DD General Specifications	
External Power Requirements	95 – 240 VAC, 30 VA maximum,
Communication Port 1, 9600 baud (Fixed), 8 data bits, 1 stop bit, odd parity	K-Sequence (Slave), DirectNET (Slave), Modbus (Slave)
Communication Port 2, 9600 baud (default), 8 data bits, 1 stop bit, odd parity	K-Sequence (Slave), DirectNET (Master/Slave), Modbus (Master/Slave) Non-sequence/print
Programming cable type	D2-DSCBL
Operating Temperature	32 to 131° F (0 to 55 C)
Storage Temperature	–4 to 158° F (–20 to 70 C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One16 AWG or two 18 AWG, 24 AWG minimum

DC Input Specifications		
Parameter	High-Speed Inputs, X0 – X2	Standard DC Inputs X3 – X7
Min. - Max. Voltage Range	10.8 – 26.4 VDC	10.8 – 26.4 VDC
Operating Voltage Range	12 – 24 VDC	12 – 24 VDC
Peak Voltage	30 VDC (5 kHz maximum frequency)	30 VDC
Minimum Pulse Width	100 µs	N/A
ON Voltage Level	> 9.0 VDC	> 9.0 VDC
OFF Voltage Level	< 2.0 VDC	< 2.0 VDC
Max. Input Current	6mA @12VDC, 13mA @24VDC	4mA @12VDC, 8.5mA @24VDC
Input Impedance	1.8 KΩ @ 12 – 24 VDC	2.8 KΩ @ 12 – 24 VDC
Minimum ON Current	>5 mA	>4 mA
Maximum OFF Current	< 0.5 mA	<0.5 mA
OFF to ON Response	<100 µs 2 – 8 ms	4 ms typical
ON to OFF Response	< 100 µs 2 – 8 ms	4 ms typical
Status Indicators	Logic side	Logic side
Commons	4 channels/common x 2 banks	

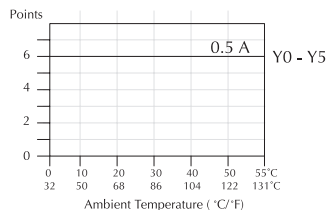
DC Output Specifications		
Parameter	Pulse Outputs Y0 – Y1	Standard Outputs Y3 – Y5
Min. - Max. Voltage Range	5 – 30 VDC	5 – 30 VDC
Operating Voltage	6 – 27 VDC	6 – 27 VDC
Peak Voltage	< 50 VDC (7 kHz max. frequency)	< 50 VDC
On Voltage Drop	0.3 VDC @ 1 A	0.3 VDC @ 1 A
Max Current (resistive)	0.5 A/pt., 1A/pt. as standard pt.	1.0 A/point
Max leakage current	15 A @ 30 VDC	15 A @ 30 VDC
Max inrush current	2 A for 100 ms	2 A for 100 ms
External DC power required	20 - 28 VDC Max 150mA	20 - 28 VDC Max 150mA
OFF to ON Response	< 10µ s	< 10 µs
ON to OFF Response	< 30 µs	< 60 µs
Status Indicators	Logic Side	Logic Side
Commons	6 channels/common x 1 bank	
Fuses	None (external recommended)	

D0-05AA I/O Wiring Diagram

The D0-05AA Micro PLC features eight AC inputs and six AC outputs. The following diagram shows a typical field wiring example. The AC external power connection uses four terminals at the left as shown.



The eight AC input channels use terminals in the middle of the connector. Inputs are organized into two banks of four. Each bank has an isolated common terminal. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent input circuit shows one channel of a typical bank.



Derating Chart for AC Outputs

The six output channels use terminals on the right side of the connector. Outputs are organized into two banks of three triac switches. Each bank has a common terminal. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent output circuit shows one channel of a typical bank.

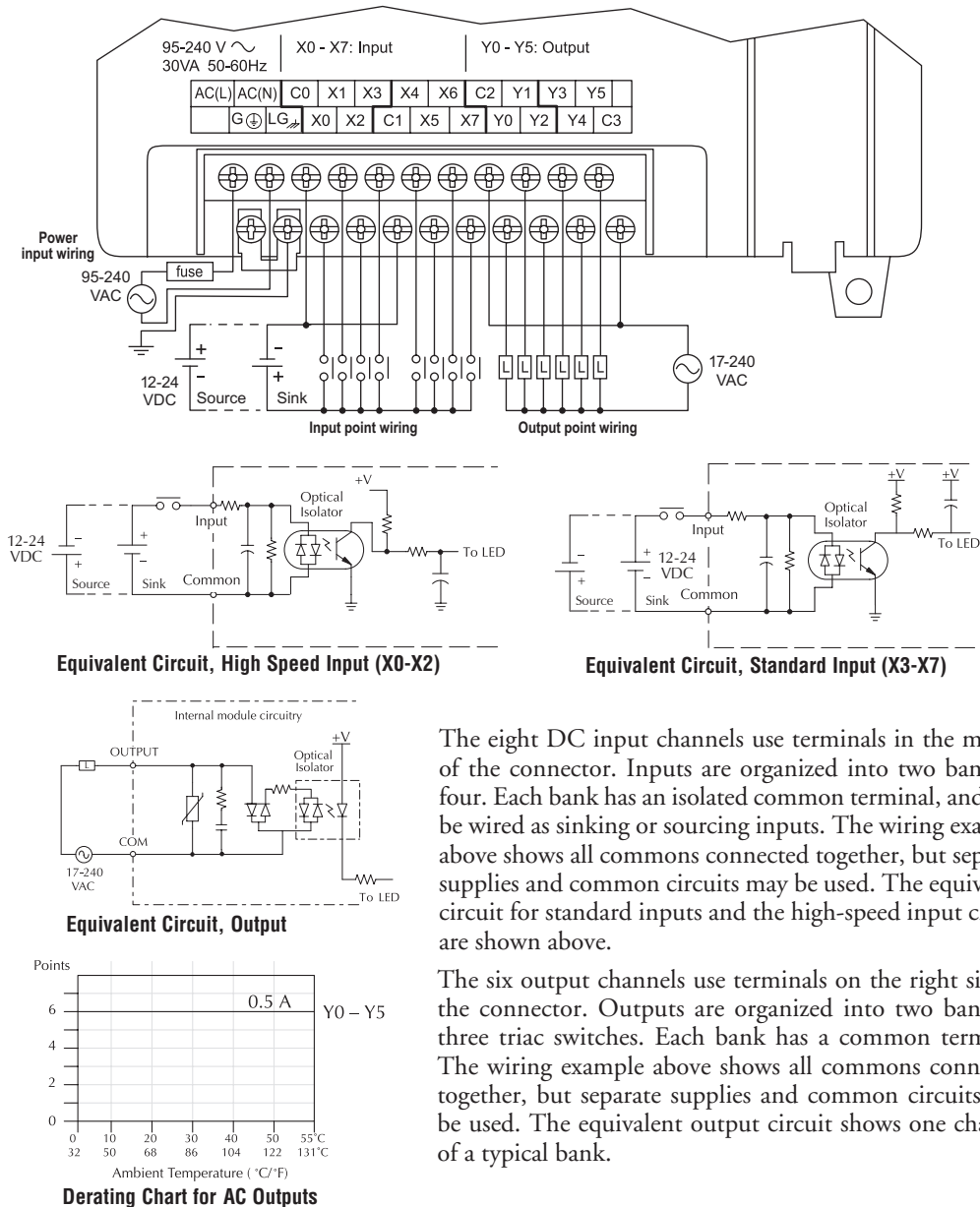
D0-05AA General Specifications	
External Power Requirements	95 – 240 VAC, 30 VA maximum,
Communication Port 1, 9600 baud (Fixed), 8 data bits, 1 stop bit odd parity	K-Sequence (Slave), Direct NET (Slave), Modbus (Slave)
Communication Port 2, 9600 baud (default) 8 data bits, 1 stop bit odd parity	K-Sequence (Slave), Direct NET (Master/Slave), Modbus (Master/Slave) Non-sequence/print
Programming cable type	D2-DSCBL
Operating Temperature	32 to 131° F (0 to 55 C)
Storage Temperature	–4 to 158° F (–20 to 70 C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One 16AWG or two 18AWG, 24AWG minimum

AC Input Specifications	
Input Voltage Range (Min. - Max.)	80 – 132 VAC, 47 - 63 Hz
Operating Voltage Range	90 – 120 VAC, 47 - 63 Hz
Input Current	8 mA @100 VAC at 50 Hz 10 mA @100 VAC at 60 Hz
Max. Input Current	12 mA @132 VAC at 50 Hz 15 mA @132 VAC at 60 Hz
Input Impedance	14 K Ω @ 50 Hz, 12 K Ω @ 60Hz
ON Current/Voltage	> 6 mA @ 75 VAC
OFF Current/Voltage	< 2 mA @ 20 VAC
OFF to ON Response	< 40 ms
ON to OFF Response	< 40 ms
Status Indicators	Logic Side
Commons	4 channels/common x 2 banks

AC Output Specifications	
Output Voltage Range (Min. - Max.)	15 – 264 VAC, 47 – 63 Hz
Operating Voltage	17 – 240 VAC, 47 – 63 Hz
On Voltage Drop	1.5 VAC (>50mA) 4.0 VAC (<50mA)
Max Current	0.5 A/point, 1.5 A/common
Max leakage current	<4 mA @ 264 VAC
Max inrush current	10 A for 10 ms
Minimum Load	10 mA
OFF to ON Response	1 ms
ON to OFF Response	1 ms +1/2 cycle
Status Indicators	Logic Side
Commons	3 channels/common x 2 banks
Fuses	None (external recommended)

D0-05DA I/O Wiring Diagram

The D0-05DA Micro PLC features eight DC inputs and six AC outputs. The following diagram shows a typical field wiring example. The AC external power connection uses four terminals at the left as shown.



The eight DC input channels use terminals in the middle of the connector. Inputs are organized into two banks of four. Each bank has an isolated common terminal, and may be wired as sinking or sourcing inputs. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent circuit for standard inputs and the high-speed input circuit are shown above.

The six output channels use terminals on the right side of the connector. Outputs are organized into two banks of three triac switches. Each bank has a common terminal. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent output circuit shows one channel of a typical bank.

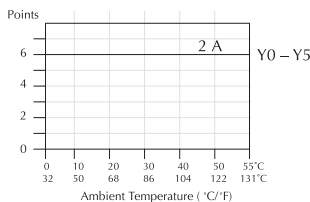
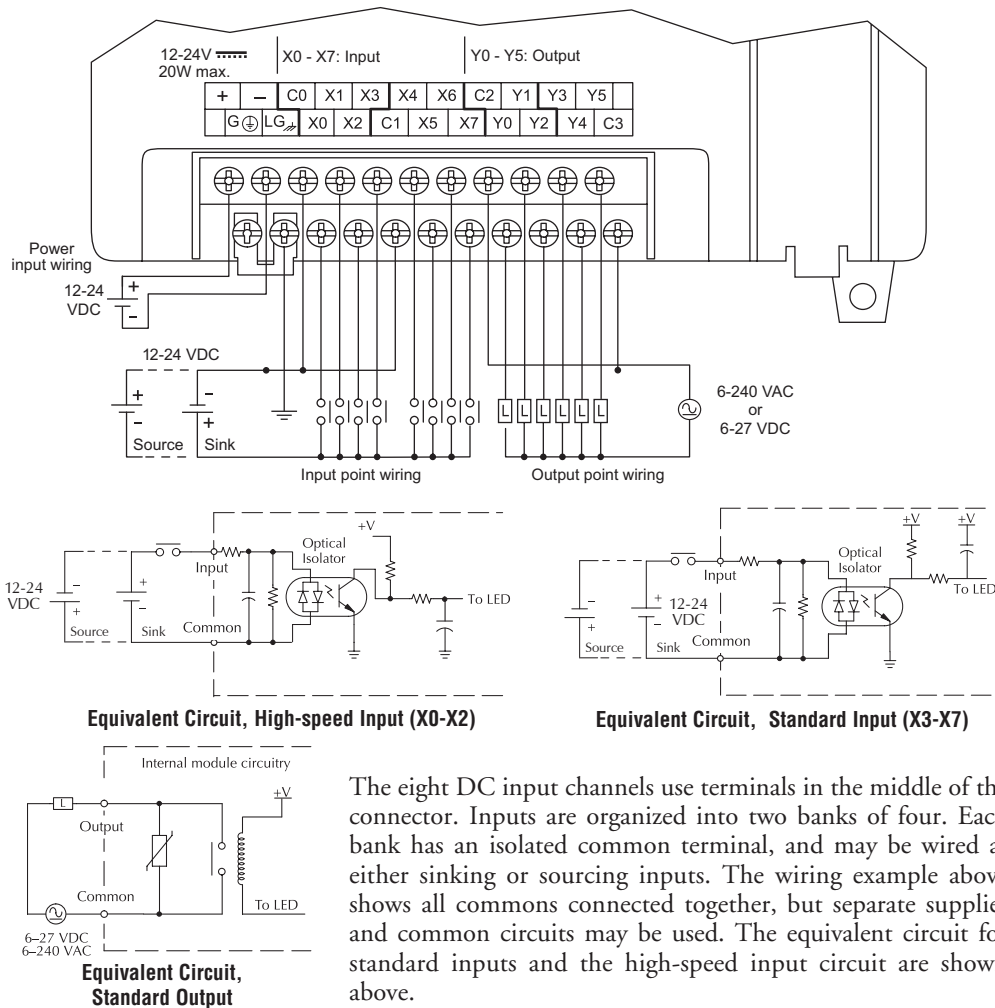
D0-05DA General Specifications	
External Power Requirements	95 – 240 VAC, 30 VA maximum,
Communication Port 1, 9600 baud (Fixed), 8 data bits, 1 stop bit, odd parity	K-Sequence (Slave), Direct NET (Slave), Modbus (Slave)
Communication Port 2, 9600 baud (default), 8 data bits, 1 stop bit, odd parity	K-Sequence (Slave), Direct NET (Master/Slave), Modbus (Master/Slave) Non-sequence/print
Programming cable type	D2-DSCBL
Operating Temperature	32 to 131° F (0 to 55 C)
Storage Temperature	-4 to 158° F (-20 to 70 C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3-304
Terminal Type	Removable
Wire Gauge	One 16 AWG or two 18 AWG, 24AWG minimum

DC Input Specifications		
Parameter	High-Speed Inputs, X0 – X2	Standard DC Inputs X3 – X7
Input Voltage Range	10.8 – 26.4 VDC	10.8 – 26.4 VDC
Operating Voltage Range	12 – 24 VDC	12 – 24 VDC
Maximum Voltage	30 VDC (5 kHz maximum frequency)	30 VDC
Minimum Pulse Width	100 µs	N/A
ON Voltage Level	> 10 VDC	> 10 VDC
OFF Voltage Level	< 2.0 VDC	< 2.0 VDC
Input Impedance	1.8 kΩ @ 12 – 24 VDC	2.8 kΩ @ 12 – 24 VDC
Minimum ON Current	>5 mA	>4 mA
Maximum OFF Current	< 0.5 mA	<0.5 mA
OFF to ON Response	<100 µs	2 – 8 ms, 4 ms typical
ON to OFF Response	< 100 µs	2 – 8 ms, 4 ms typical
Status Indicators	Logic side	Logic side
Commons	4 channels / common x 2 banks	

AC Output Specifications	
Output Voltage Range (Min. - Max.)	15 – 264 VAC, 47 – 63 Hz
Operating Voltage	17 – 240 VAC, 47 – 63 Hz
On Voltage Drop	1.5 VAC @ > 50mA, 4 VAC @ < 50mA
Max Current	0.5 A/point, 1.5 A/common
Max leakage current	< 4 mA @ 264 VAC, 60Hz
Max inrush current	10 A for 10 ms
Minimum Load	10 mA
OFF to ON Response	1 ms
ON to OFF Response	1 ms +1/2 cycle
Status Indicators	Logic Side
Commons	3 channels / common x 2 banks
Fuses	None (external recommended)

D0-05DR-D I/O Wiring Diagram

These micro PLCs feature eight DC inputs and six relay contact outputs. The following diagram shows a typical field wiring example. The DC external power connection uses three terminals at the left as shown.



Derating Chart for Relay Outputs

The eight DC input channels use terminals in the middle of the connector. Inputs are organized into two banks of four. Each bank has an isolated common terminal, and may be wired as either sinking or sourcing inputs. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent circuit for standard inputs and the high-speed input circuit are shown above.

The six output channels use terminals on the right side of the connector. Outputs are organized into two banks of three normally-open relay contacts. Each bank has a common terminal. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used. The equivalent output circuit shows one channel of a typical bank. The relay contacts can switch AC or DC voltages.

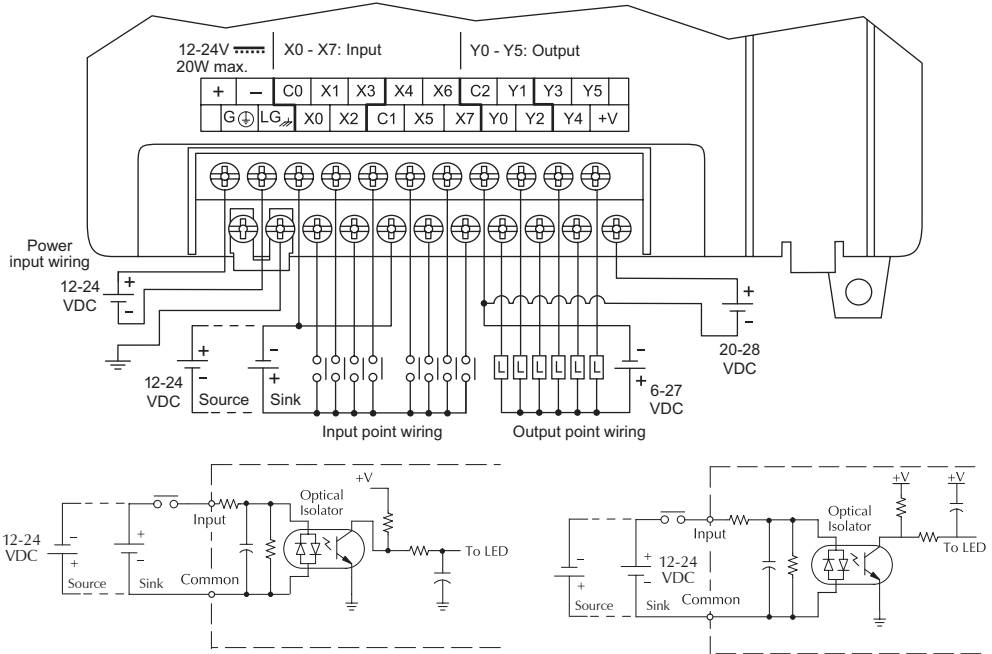
D0-05DR-D General Specifications	
External Power Requirements	12 – 24 VDC, 20 W maximum,
Communication Port 1, 9600 baud (Fixed), 8 data bits, 1 stop bit, odd parity	K-Sequence (Slave), Direct NET (Slave), Modbus (Slave)
Communication Port 2, 9600 baud (default), 8 data bits, 1 stop bit, odd parity	K-Sequence (Slave), Direct NET (Master/Slave), Modbus (Master/Slave) Non-sequence/print
Programming cable type	D2-DSCBL
Operating Temperature	32 to 131° F (0 to 55 C)
Storage Temperature	-4 to 158° F (-20 to 70 C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3-304
Terminal Type	Removable
Wire Gauge	One 16AWG or two 18AWG, 24AWG minimum

DC Input Specifications		
Parameter	High-Speed Inputs, X0 – X2	Standard DC Inputs X3 – X7
Min. - Max. Voltage Range	10.8 – 26.4 VDC	10.8 – 26.4 VDC
Operating Voltage Range	12 -24 VDC	12 -24 VDC
Peak Voltage	30 VDC (5 kHz maximum frequency)	30 VDC
Minimum Pulse Width	100 µs	N/A
ON Voltage Level	> 10 VDC	> 10 VDC
OFF Voltage Level	< 2.0 VDC	< 2.0 VDC
Input Impedance	1.8 kΩ @ 12 – 24 VDC	2.8 kΩ @ 12 – 24 VDC
Max. Input Current	6mA @12VDC ,13mA @24VDC	4mA @12VDC, 8.5mA @24VDC
Minimum ON Current	>5 mA	>4 mA
Maximum OFF Current	< 0.5 mA	<0.5 mA
OFF to ON Response	<100 µs	2 – 8 ms, 4 ms typical
ON to OFF Response	< 100 µs	2 – 8 ms, 4 ms typical
Status Indicators	Logic side	Logic side
Commons	4 channels / common x 2 banks	

Relay Output Specifications	
Output Voltage Range (Min. - Max.)	5 -264 VAC (47 -63 Hz), 5 - 30 VDC
Operating Voltage	6 -240 VAC (47 -63 Hz), 6 - 27 VDC
Output Current	2A/point 6A/common
Maximum Voltage	264 VAC, 30 VDC
Max leakage current	0.1 mA @264 VAC
Smallest Recommended Load	5 mA
OFF to ON Response	< 15 ms
ON to OFF Response	< 10 ms
Status Indicators	Logic Side
Commons	3 channels/common x 2 banks
Fuses	None (external recommended)

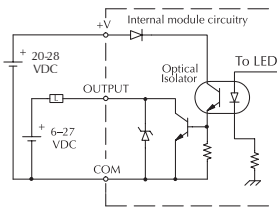
D0-05DD-D I/O Wiring Diagram

These micro PLCs feature eight DC inputs and six DC outputs. The following diagram shows a typical field wiring example. The DC external power connection uses four terminals at the left as shown.

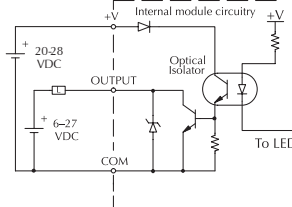


Equivalent Circuit, High Speed Input (X0-X2)

Equivalent Circuit, Standard Input (X3-X7)



Equivalent Circuit, Standard Output (Y2-Y5)

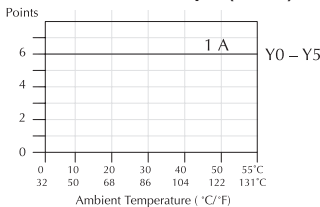


Equivalent Circuit, Pulse Output (Y0-Y1)

The eight DC input channels use terminals in the middle of the connector. Inputs are organized into two banks of four. Each bank has an isolated common terminal, and may be wired as either sinking or sourcing inputs. The wiring example above shows all commons connected together, but separate supplies and common circuits may be used.

The equivalent circuit for standard inputs and the high-speed input circuit are shown above.

The six current sinking DC output channels use terminals on the right side of the connector. All outputs actually share the same electrical common. Note the requirement for external power on the end (right-most) terminal. The equivalent output circuit shows one channel of the bank of six.



Derating Chart for DC Outputs

D0-05DD-D General Specifications	
External Power Requirements	12 – 24 VDC, 20 W maximum,
Communication Port 1, 9600 baud (Fixed), 8 data bits, 1 stop bit, odd parity	K-Sequence (Slave), DirectNET (Slave), Modbus RTU (Slave)
Communication Port 2, 9600 baud (default), 8 data bits, 1 stop bit, odd parity	K-Sequence (Slave), DirectNET (Master/Slave), Modbus RTU (Master/Slave) Non-sequence/print
Programming cable type	D2-DSCBL
Operating Temperature	32 to 131° F (0 to 55 C)
Storage Temperature	–4 to 158° F (–20 to 70 C)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3–304
Terminal Type	Removable
Wire Gauge	One 16AWG or two 18AWG, 24AWG minimum

DC Input Specifications		
Parameter	High-Speed Inputs, X0 – X2	Standard DC Inputs X3 – X7
Min. - Max. Voltage Range	10.8 – 26.4 VDC	10.8 – 26.4 VDC
Operating Voltage Range	12 – 24 VDC	12 – 24 VDC
Peak Voltage	30 VDC (5 kHz maximum frequency)	30 VDC
Minimum Pulse Width	100 μ s	N/A
ON Voltage Level	>9.0 VDC	> 9.0 VDC
OFF Voltage Level	< 2.0 VDC	< 2.0 VDC
Max. Input Current	6mA @12VDC, 13mA @24VDC	4mA @12VDC, 8.5mA @24VDC
Input Impedance	1.8 k Ω @ 12 – 24 VDC	2.8 k Ω @ 12 – 24 VDC
Minimum ON Current	>5 mA	>4 mA
Maximum OFF Current	< 0.5 mA	<0.5 mA
OFF to ON Response	<100 μ s	2 – 8 ms, 4 ms typical
ON to OFF Response	< 100 μ s	2 – 8 ms, 4 ms typical
Status Indicators	Logic side	Logic side
Commons	4 channels / common x 2 banks	

DC Output Specifications		
Parameter	Pulse Outputs, Y0 – Y1	Standard Outputs, Y3 – Y5
Min. - Max. Voltage Range	5 – 30 VDC	5 – 30 VDC
Operating Voltage	6 – 27 VDC	6 – 27 VDC
Peak Voltage	< 50 VDC (7 kHz max. frequency)	< 50 VDC
On Voltage Drop	0.3 VDC @ 1 A	0.3 VDC @ 1 A
Max Current (resistive)	0.5 A/pt., 1A/pt. as standard pt.	1.0 A/point
Max leakage current	15 μ A @ 30 VDC	15 μ A @ 30 VDC
Max inrush current	2 A for 100 ms	2 A for 100 ms
External DC power required	20 - 28 VDC Max 150mA	20 - 28 VDC Max 150mA
OFF to ON Response	< 10 μ s	< 10 μ s
ON to OFF Response	< 30 μ s	< 60 μ s
Status Indicators	Logic Side	Logic Side
Commons	6 channels / common x 1 bank	
Fuses	None (external recommended)	

Glossary of Specification Terms

Discrete Input

One of eight 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 six 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 DL05 Micro PLCs are electrically located on the logic side of the input or output circuit.