2

Installation, Wiring, and Specifications

In This Chapter. . . .

Safety Guidelines

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. Sufficient emergency circuits should be provided to stop either partially or totally the operation of the PLC or the controlled machine or process. These circuits should be routed outside the PLC in the event of controller failure, so that independent and rapid shutdown are available. Devices, such as "mushroom" switches or end of travel limit switches, should operate motor starter, solenoids, or other devices without being processed by the PLC. These emergency circuits should be designed using simple logic with a minimum number of highly reliable electromechanical components. 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.

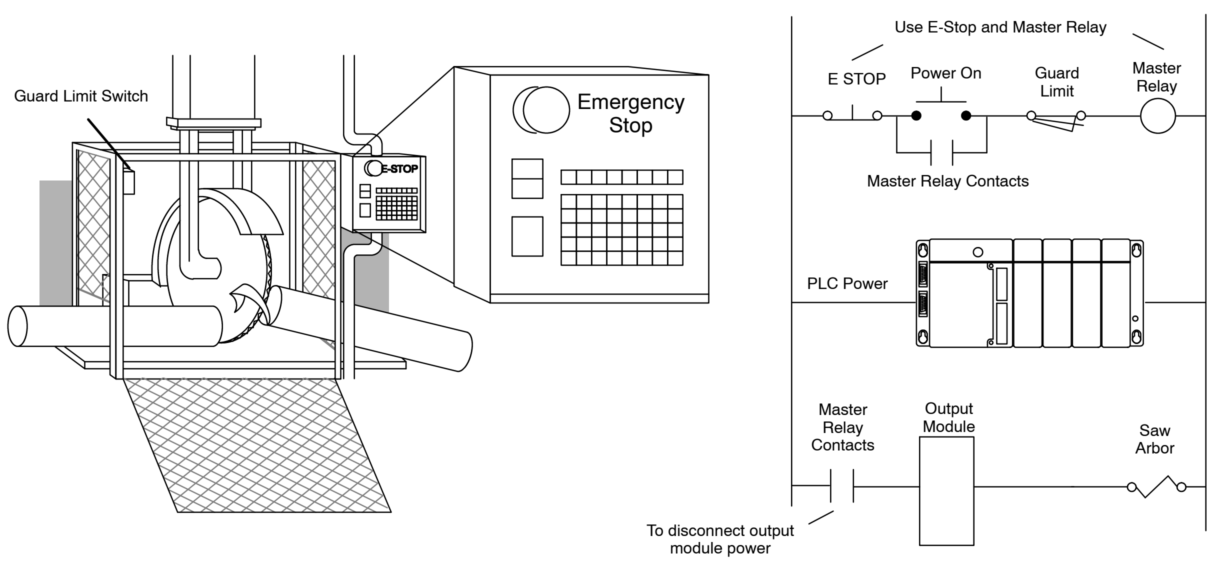
- Emergency stop switch for disconnecting system power
- Mechanical disconnect for output module power
- Orderly system shutdown sequence in the PLC control program

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.).



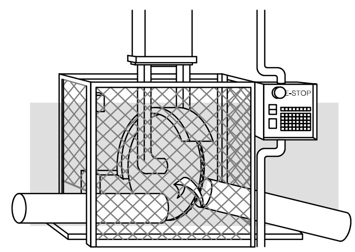
Emergency Power Disconnect

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.

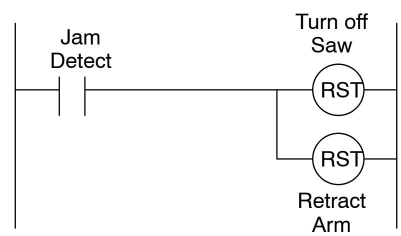
After an emergency shutdown or any other type of power interruption, there may be requirements that must be met before the PLC control program can be restarted. For example, there may be specific register values that must be established (or maintained from the state prior to the shutdown) before operations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

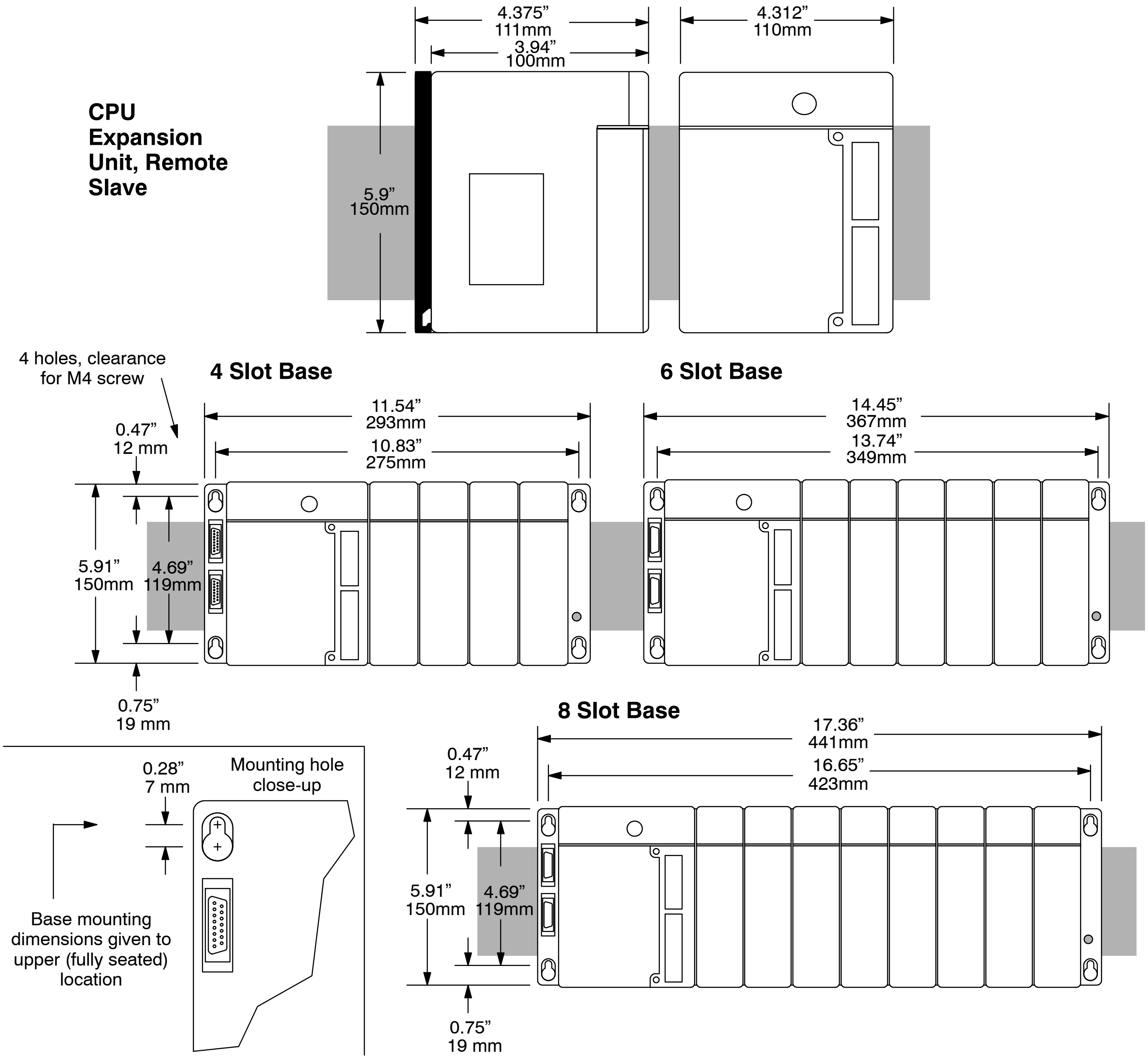
WARNING: Explosion Hazard! – Do not disconnect equipment unless power has been switched off or area is known to be non–hazardous.

Mounting Guidelines

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

- Environmental specifications
- Power supply specifications
- Regulatory Agency Approvals
- Enclosure Selection and Component Dimensions

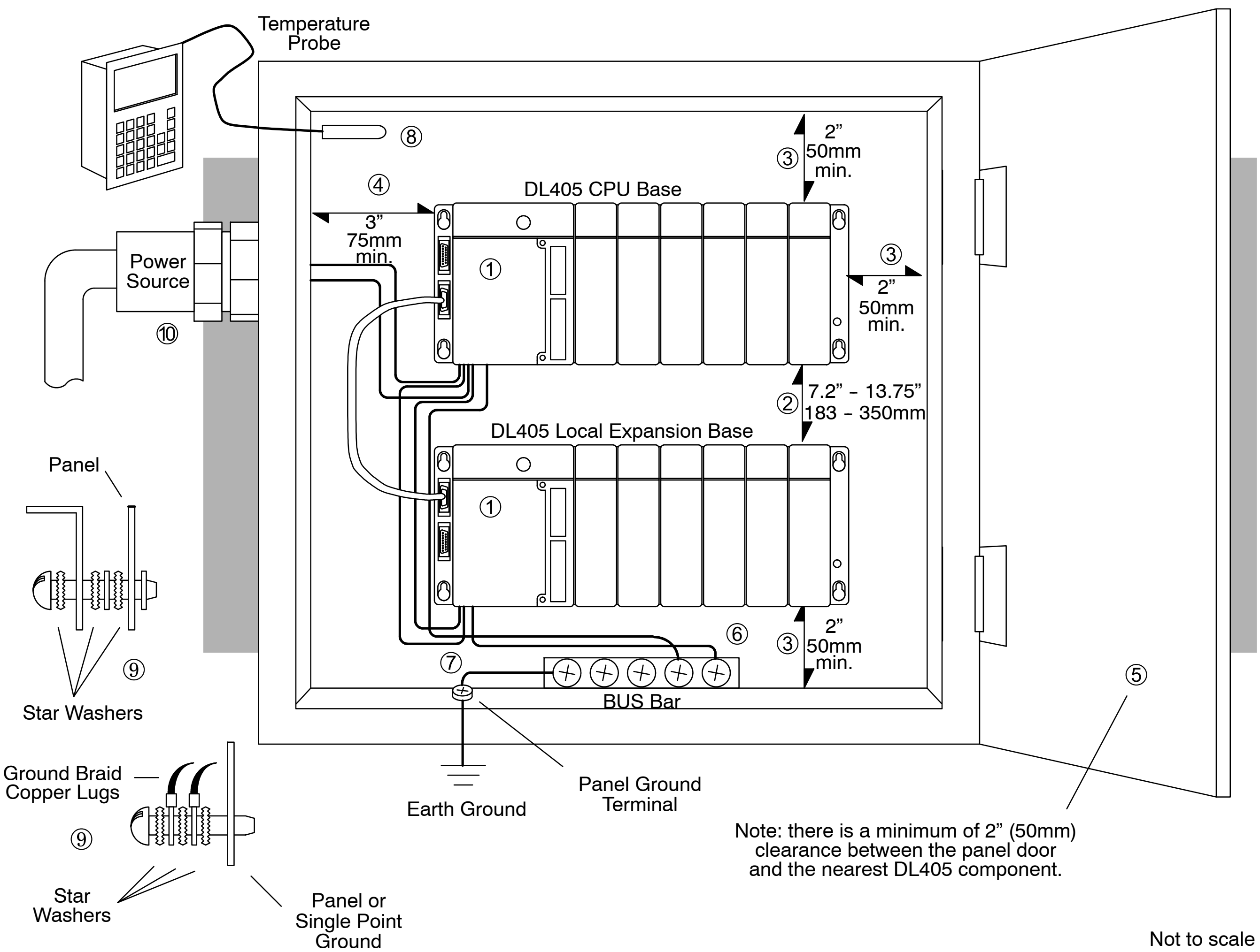
Base Dimensions The following diagram shows the outside dimensions and mounting hole locations for the 4-slot, 6-slot, and 8-slot bases. Make sure you follow the installation guidelines to allow proper spacing from other components.



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. The bases must be mounted horizontally to provide proper ventilation.
2. There should be a minimum of 7.2” (183mm) and a maximum of 13.75” (350mm) between bases.
3. A minimum clearance of 2” (50mm) between the base and the top, bottom and right side of the cabinet should be provided.
4. A minimum clearance of 3” (75mm) between the base and the left side of the cabinet should be provided.
5. There must be a minimum of 2” clearance between the panel door and the nearest DL405 component.



6. Connect the ground terminal on the DL405 base 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. A rule of thumb is to achieve 0.1 ohm of DC resistance between the DL405 base and the single point ground.

7. 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. For this connection you should use #12 AWG stranded copper wire as a minimum. Minimum wire sizes, color coding, and general safety practices should comply with appropriate electrical codes and standards for your area.

   A good common ground reference (Earth ground) is essential for proper operation of the DL405, which include:

   a) Installing a ground rod as close to the panel as possible.
   b) Connection to incoming power system ground.
8. Installations where the ambient temperature may approach the lower or upper limits of the specifications should be evaluated properly. To do this place a temperature probe in the panel, close the door and operate the system until the ambient temperature has stabilized. If the ambient temperature is not within the operating specification for the DL405 system, measures such as installing a cooling/heating source must be taken to get the ambient temperature within the DL405 operating specifications.
9. Device mounting bolts and ground braid termination bolts should be #10 copper bolts or equivalent. Tapped holes instead of nut–bolt arrangements should be used whenever possible. To assure good contact on termination areas impediments such as paint, coating or corrosion should be removed in the area of contact.
10. The DL405 system is designed to be powered by 110 VAC, 220 VAC, or 24 VDC normally available throughout an industrial environment. Isolation transformers and noise suppression devices are not normally necessary, but may be helpful in eliminating/reducing suspect power problems.

Enclosures

Your selection of a proper enclosure is important to ensure safe and proper operation of your DL405 system. Applications of DL405 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, cooling, and maintenance

Agency Approvals

Some applications require agency approvals. The DL405 agency approvals for which DL405 products are submitted are;

- UL (Underwriters' Laboratories, Inc.)
- CE EMC (Electromagnetic Compatibility)
- CUL (Canadian Underwriters' Laboratories)

A complete listing of agency approvals for each product in the DL405 family is available in the sales catalog, or you may call 1–800–633–0405 (U.S.).

Environmental Specifications

The following table lists the environmental specifications that generally apply to the DL405 system (CPU, Expansion Unit, Bases, I/O Modules). The ranges that vary for the Handheld Programmer are noted at the bottom of this chart. I/O module operation may fluctuate depending on the ambient temperature and your application. Please refer to the appropriate I/O module chapters for the temperature derating curves applying to specific modules.

Specification	Rating
Storage temperature	–4° F to 158° F (–20° C to 70° C)*
Ambient operating temperature	32° F to 140° F (0° C to 60° 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

*Storage temperature for the Handheld Programmer is 14° to 149°F (–10° to 65° C)
**Ambient humidity for the Handheld Programmer is 20% to 90% non-condensing.

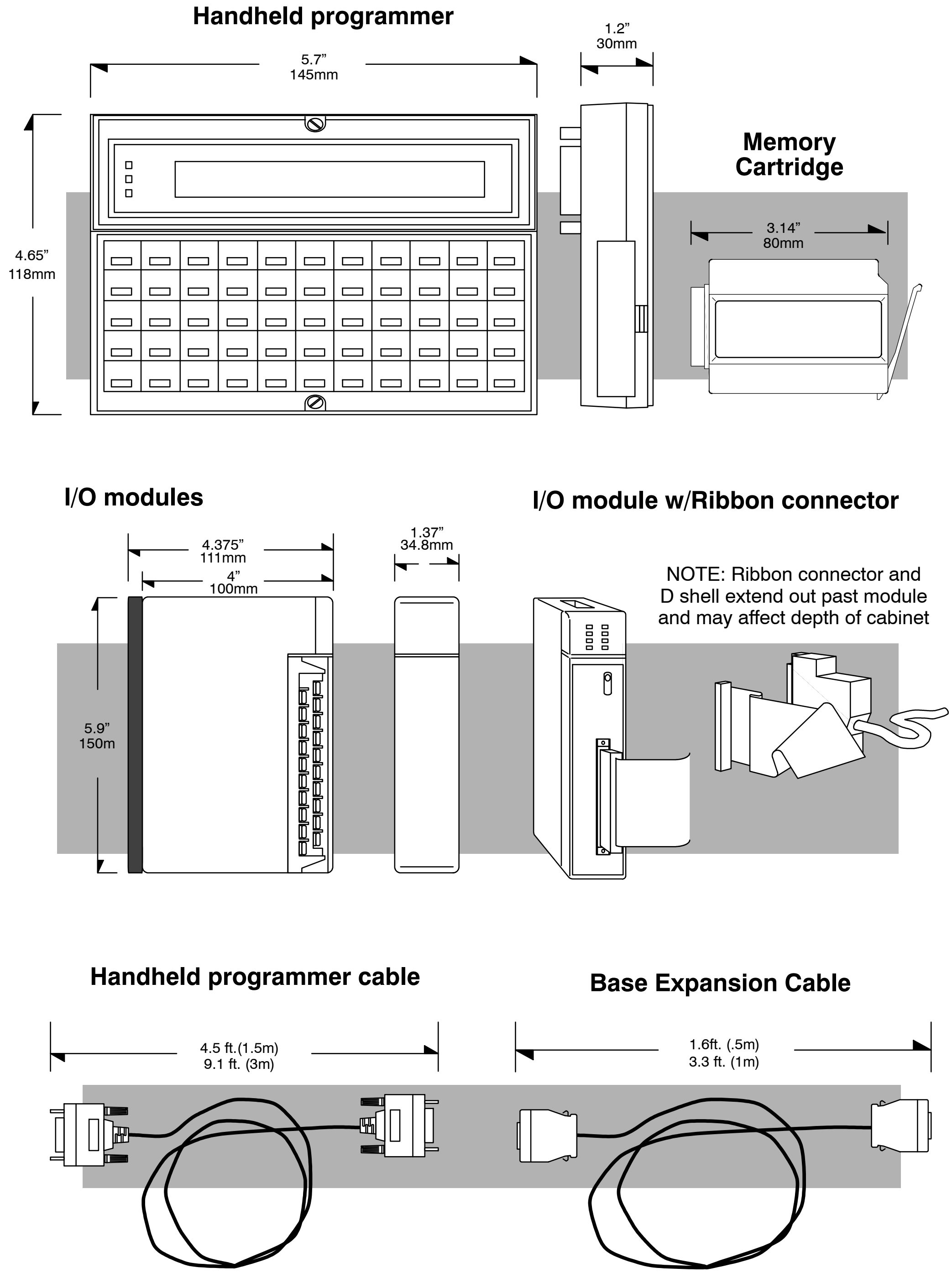
Power

The external power source must be capable of suppling voltage and current complying with the PLC power supply specifications.

Specifications	DL405 Series CPUs
Voltage withstand (dielectric strength)	1 min. @ 1500 VAC between primary, secondary, field ground and run relay
Insulation resistance	> 10MΩ at 500 VDC
Input voltage range D4–430 / D4–440 / D4–450 / D4–EX	85–132 VAC (110 range) / 170–264 VAC (220 range)
Input voltage range D4–440DC–1 / D4–EXDC	20–29 VDC (24VDC) less than 10% ripple
Input voltage range D4–440DC–2 / D4–EXDC–2	90–146 VDC (125 VDC) less than 10% ripple
Maximum inrush current D4–430 / D4–440 / D4–EX	20A
Maximum inrush current D440DC–1 / D4–EXDC	10A
Maximum inrush current DL440DC–2 / D4–EXDC–2	20A
Maximum power DL430/DL440/DL450, D4–EX	50VA
Maximum power DL440DC–1, D4–EXDC	38W
Maximum power DL440DC–2, D4–EXDC–2	30W
24VDC Auxiliary Power Supply (D4–EX only)	20–28 VDC @ 0.4A maximum, ripple > 1V p-p

Component Dimensions

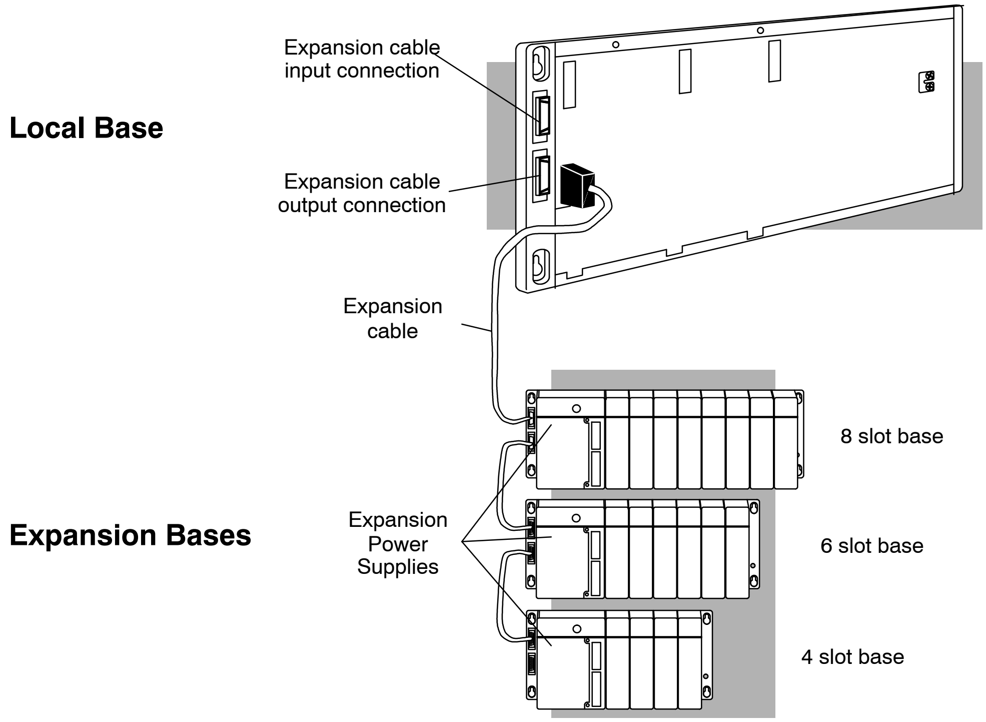
Before installing your PLC system you will need to know the dimensions for the components in your system. The diagram on this page provide the component dimensions and should be used to define your enclosure specifications. Remember to leave room for potential expansion. Appendix E provides the weights for each component.



Installing DL405 Bases

Three Sizes of Bases

All I/O configurations of the DL405 (except for Slice I/O) will use a selection of either 4, 6 or 8 slot base(s). Local and expansion bases can be 4, 6, or 8-slot in size. Local and expansion bases differ only in how they are wired in a system.

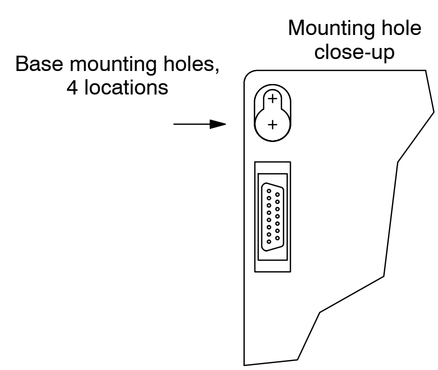


WARNING: To minimize the risk of electrical shock, personal injury, or equipment damage, always disconnect the system power before installing or removing any system component.

Mounting the Base

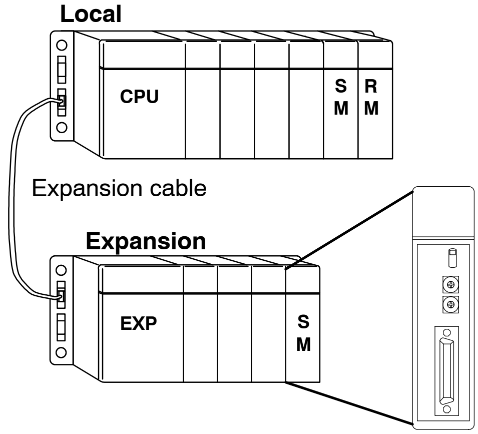
The CPU/Expansion Unit/Remote Slave must always be installed in the left-most slot in a base. This slot is marked on the base as P/S, CPU. The I/O modules can be installed in any remaining slots. It is not necessary for all slots to be filled for your system to work correctly. You may use filler modules to fill the empty slots in the base.

The base is secured to the equipment panel or machine using four M4 screws in the corner locations shown to the right. The mounting cut-outs allow removal of the base after installation, without completely removing the mounting screws. Full mounting template dimensions are given in the previous section on Mounting Guidelines.



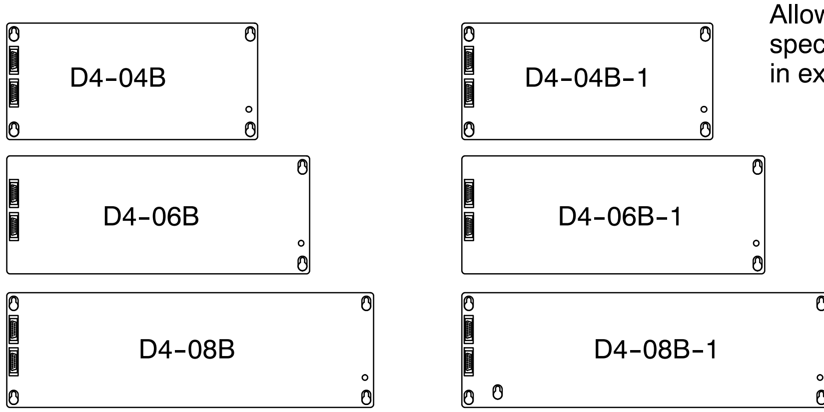
Choosing the Base Type

There are two types of bases to choose from. The standard base type restricts the placement of specialty modules (or intelligent modules) to the local base with the CPU. By using the DL450 CPU and the new "expanded bus" base type, you can also use specialty modules in expansion bases as shown to the right. When all bases in the local/expansion system are of the new type, the DL450 can communicate with specialty modules in any base. In all other respects, the new base is an exact replacement for the standard bases.



The part numbers for standard bases and the new bases are listed below.

Standard Bases **Expanded Bus Bases**



Allows selected specialty modules in expansion bases

The base expansion connectors on the new bases have new data signals used in communicating with specialty I/O across bases. Accordingly, you must observe the following restrictions and guidelines with the new bases:

- Only the DL450 type CPU (in the local base) can communicate with a specialty module in an expansion base.
- In the above case, both local and expansion bases must be the new (–1) type.
- Of course, you can still have specialty modules in the local base.
- The new bases can also be used with DL430 and DL440 CPUs (however, these CPUs cannot communicate with specialty I/O in expansion bases).
- You can mix standard bases with new bases in a system, but no specialty I/O modules may be used in expansion bases in this case (the standard bases do not pass through the specialty I/O signals on their expansion connectors).

NOTE: If you are designing a new DL450 CPU–based application, we recommend using the new bases (–1 type) so you can add specialty modules in any base later.

Installing Components in the Base

Setting the CPU DIP Switches (DL430/440 Only)

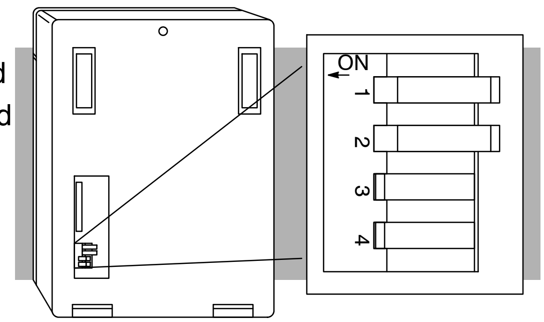
There is one bank of four configuration switches located on the back of DL430 and DL440 CPUs. These switches affect battery low detection, station address override and baud rate of the secondary port (25-pin D connector). The figure below indicates the location of these DIP switches. Equivalent configuration of the DL450 CPU requires selecting AUX functions on a programming device.

Switch 1

- ON = Battery low indicator disabled
- OFF= Battery low indicator enabled

Switch 2

- ON = Station address override is enabled (address 1)
- OFF= Station address is set by AUX function with programming device

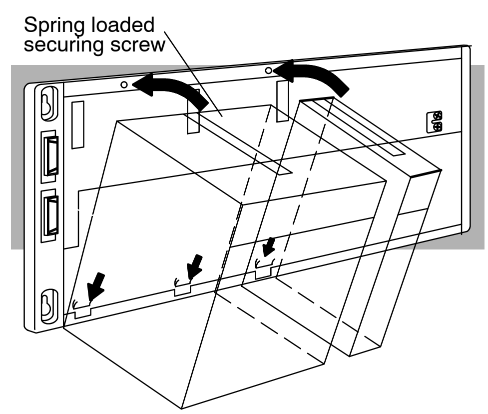


NOTE: Setting Switch 2 on forces the station address to 1. It does not change the address set by the programming device. When Switch 2 is turned off again the address will revert back to the address stored in memory via the AUX function.

Port 1 Baud Rate	Switch 3	Switch 4
300	Off	Off
1200	Off	On
9600	On	Off
19200	On	On

NOTE: Parity, Mode and Station address for port 2 is selected by AUX functions using a programming device.

1. Note the components have plastic tabs at the bottom and a screw at the top.
2. With the device tilted slightly forward, hook the plastic tabs into the notch on the base.
3. Then gently push the top of the component back toward the base until it is firmly installed into the base.
4. Now tighten the screw at the top of the device to secure it to the base.



WARNING: To minimize the risk of electrical shock, personal injury, or equipment damage, always disconnect the system power before installing or removing any system component.

CPU and Expansion Unit Wiring Guidelines

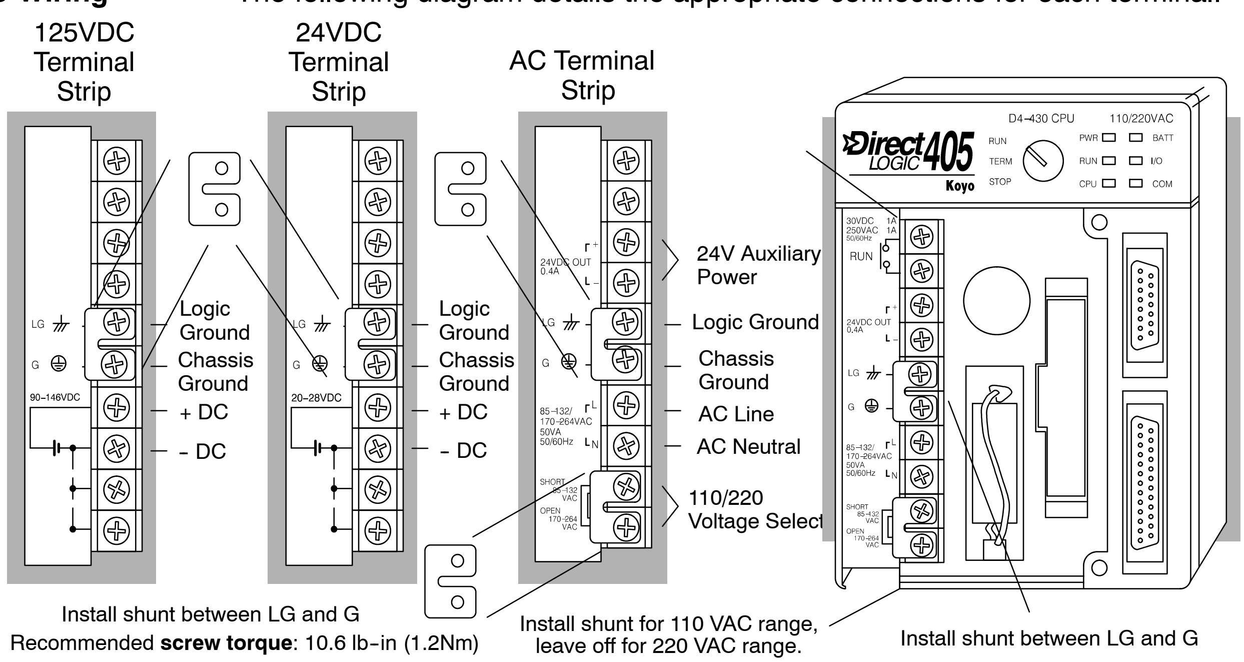
The main power terminal connections are under the front covers of the DL405 CPUs and Expansion Units. The list below describes the function of each of the terminal screws. Most of the terminal screws are identical between the CPU and the Expansion Unit. If the terminal screw only applies to one of the units it will be noted.

- **Run Relay** – (CPU only) indicates to an external device when the CPU is in Run Mode by contact closure. Its normally-open contacts can also remove power from critical I/O points if CPU comes out of Run mode.
- **24VDC Auxiliary Power** – can be used to power field devices or I/O modules requiring external power. It supplies up to 400 mA of current at 20–28VDC, ripple less than 1 V P-P. (Not available on DC CPUs.)
- **Logic Ground** – internal ground to the system which can be tied to field devices/communication ports to unite ground signals.
- **Chassis Ground** – where earth ground is connected to the unit.
- **AC Power** –where the line (hot) and the neutral (common) connections are made to the CPU/Expansion Unit. (This is also where the DC power source is connected for the 24/125 VDC CPU. The positive connection is tied to line and the negative connection is tied to ground.)
- **110/220 Voltage Select** – a shunt across two of the terminals determines the voltage selection. Install the shunt to select 110VAC input power, and remove the shunt to select 220VAC power input (the shunt is not required for DC-powered CPUs or Expansion Units.)

WARNING: Damage will occur to the power supply if 220 VAC is connected to the terminal connections with the 115 VAC shunt installed. Once the power wiring is connected, install the protective cover to avoid risk of accidental shock.

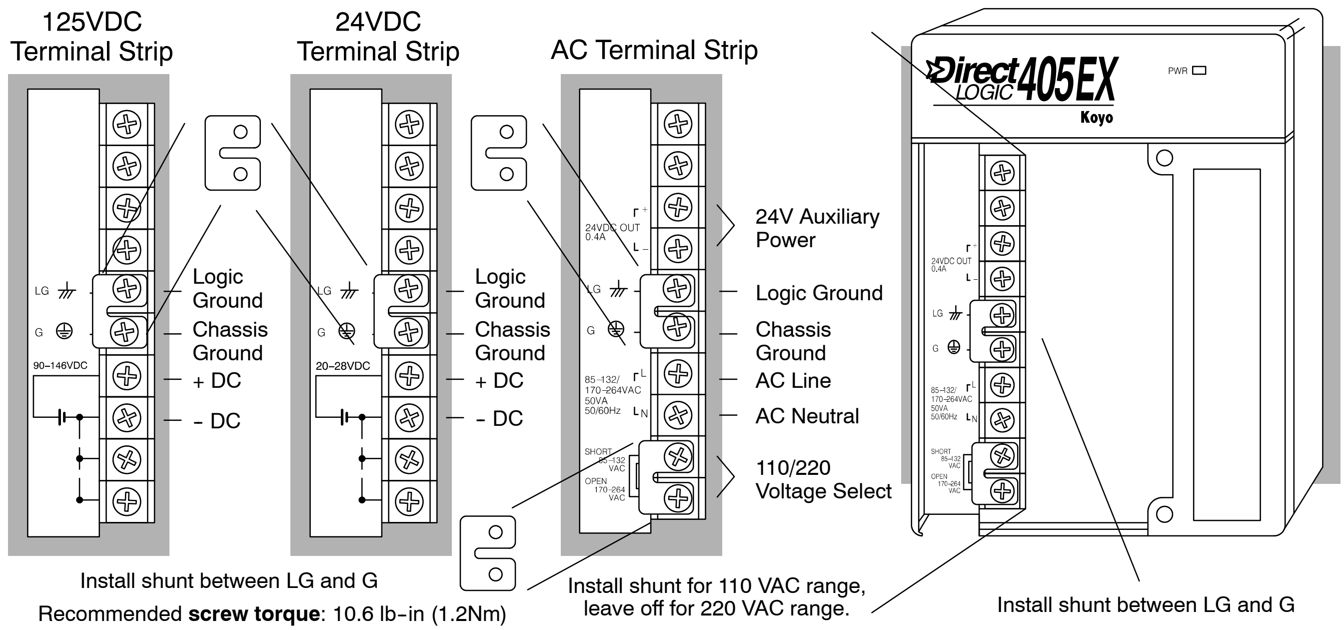
CPU Wiring

The following diagram details the appropriate connections for each terminal.



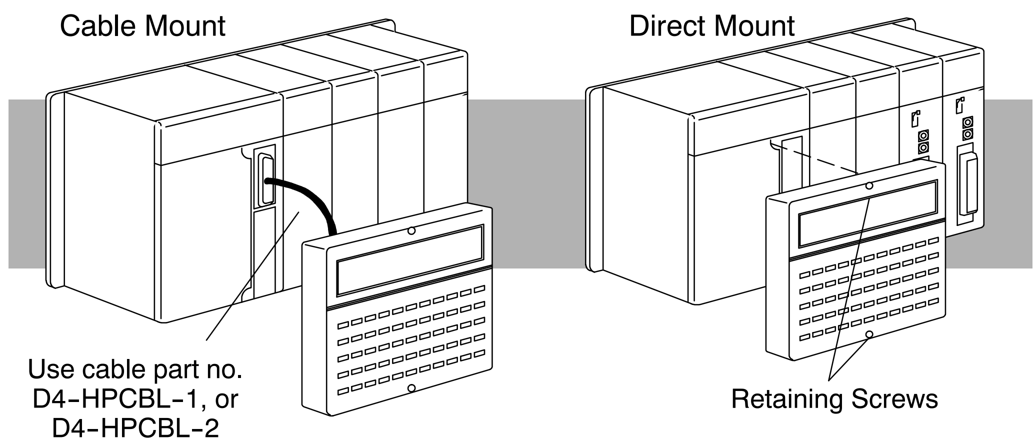
Expansion Unit Wiring

The following diagram details the appropriate connections for each terminal.

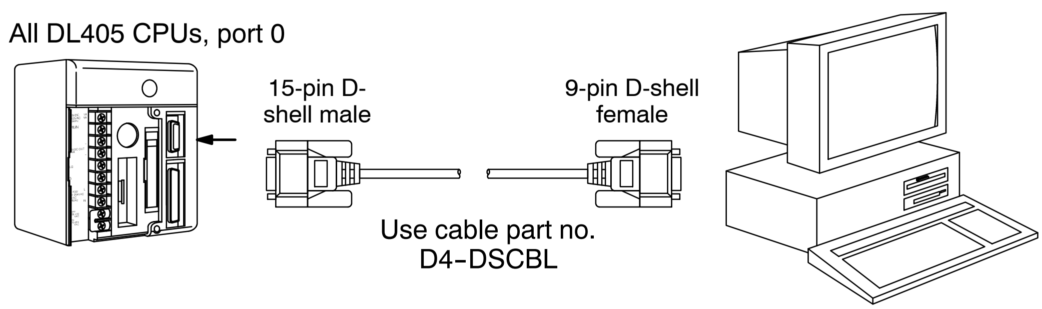


Connecting Programming Devices

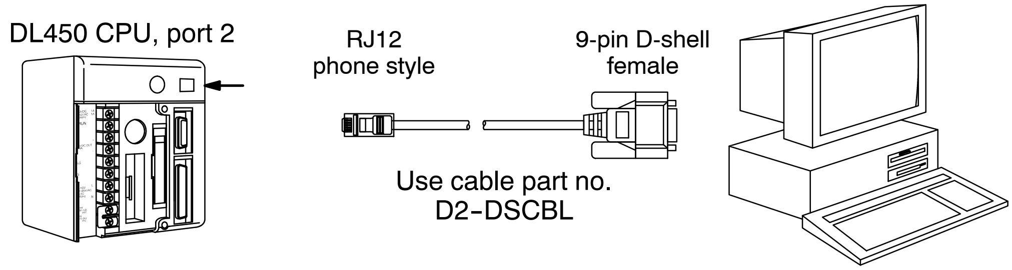
You can mount the Handheld directly to Port 0 of any DL405 CPU (15-pin D-shell connector), or you can use a 9 foot (3m) or 4.6 ft (1.5m) cable as shown below.



The standard port for use in ***Direct***SOFT programming is the 15-pin port 0 on all DL405 CPUs. The cable shown below is approximately 12 feet (3.66m) long.

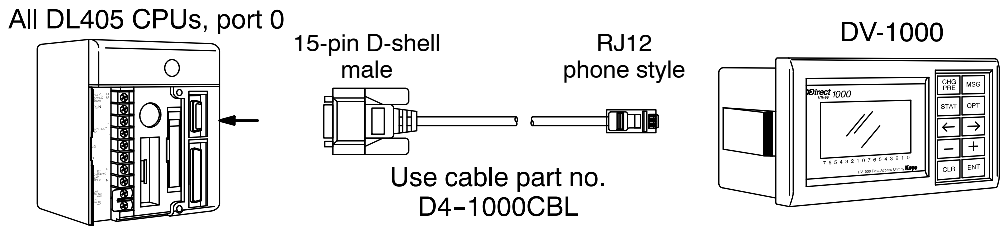


On the DL450, you may use port 2 instead for ***Direct***SOFT programming. The cable shown below is approximately 12 feet (3.66m) long.

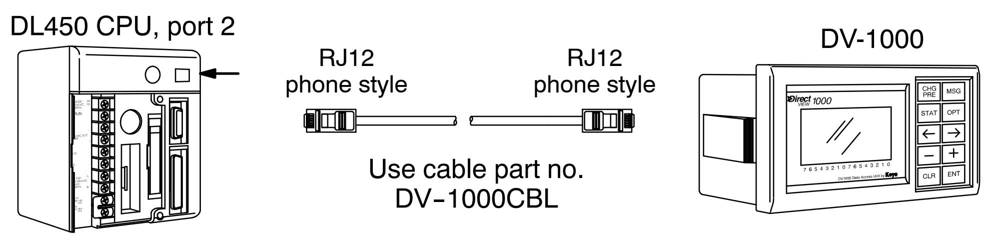


Connecting Operator Interface Devices

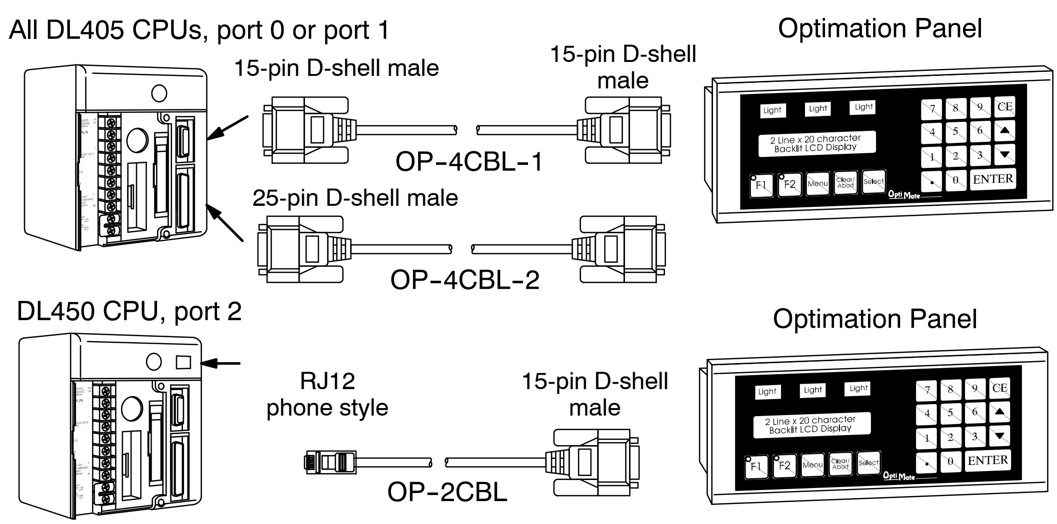
Operator interfaces usually require data and power connections. However, the popular DV-1000 Data Access Unit may receive data and power directly from any DL405 CPU, using the 2 meter (6.56 ft.) long cable shown below.



The DL450 can connect to a DV-1000 from port 2, using the 2 meter (6.56 ft.) long cable shown below.



Optimation operator interface panels require separate power and data connections. Connect the CPU port 0, port 1, or port 2 (DL450) to an Optimation panel choosing the appropriate 2 meter (6.56 ft.) long cable from the three shown below.

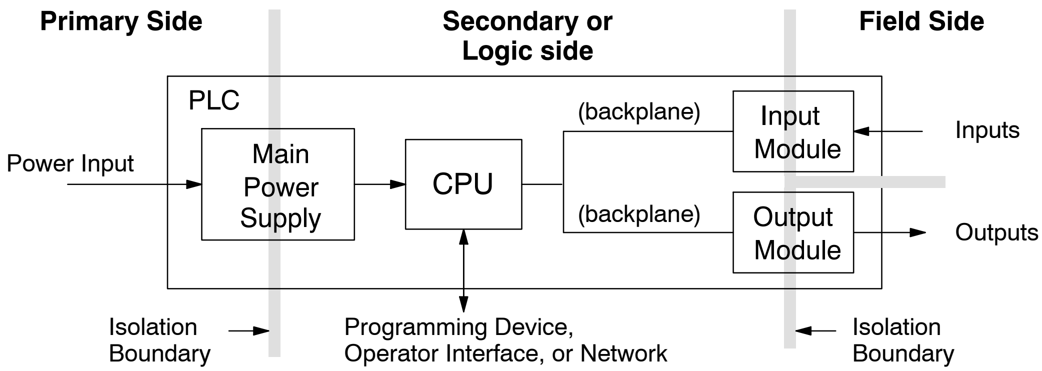


I/O Wiring Strategies

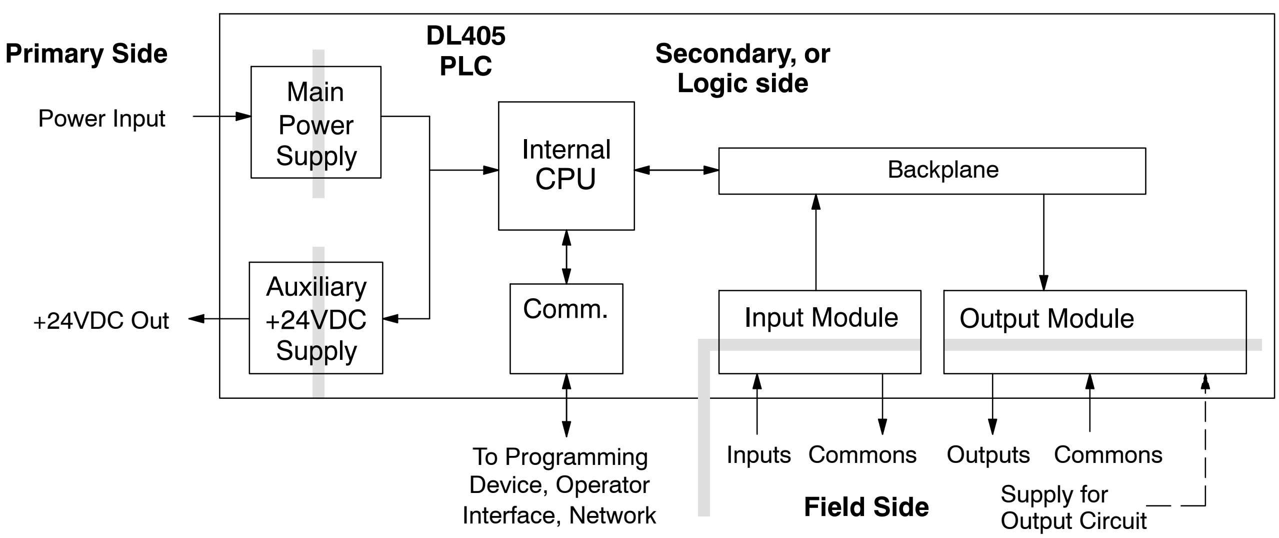
The DL405 PLC system is very flexible and will work in many different wiring configurations. By studying this section before actual installation, you can probably find the best wiring strategy for your application . This will help to lower system cost, wiring errors, and avoid safety problems.

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 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.*



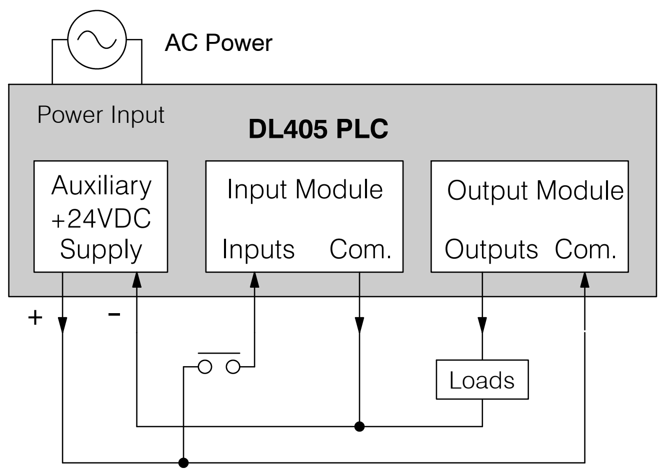
The next figure shows the physical layout of a DL405 PLC system, as viewed from the front. In addition to the basic circuits covered above, AC-powered CPUs include an auxiliary +24VDC power supply with its own isolation boundary. Since the supply output is isolated from the other three circuits, it can power input and/or output circuits!



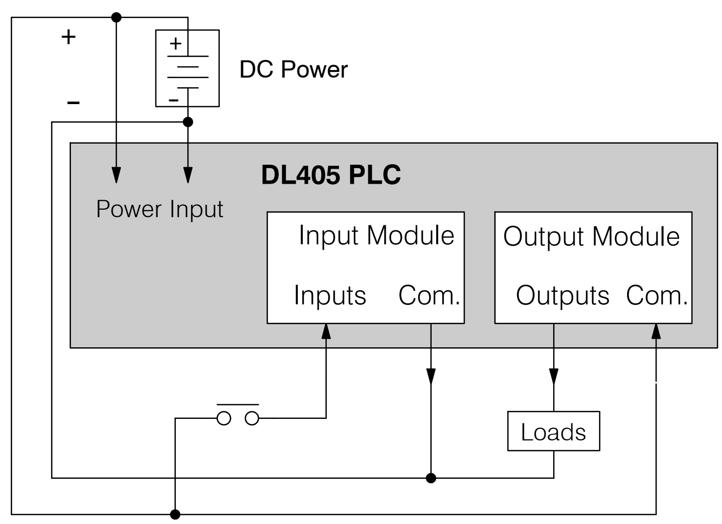
In some cases, using the built-in auxiliary +24VDC supply can result in a cost savings for your control system. It can power combined loads up to 400 mA. Be careful not to exceed the current rating of the supply. If you are the system designer for your application, you may be able to select and design in field devices which can use the +24VDC auxiliary supply.

Powering I/O Circuits with the Auxiliary Supply

All DL405 CPUs feature the internal auxiliary supply. If input devices AND output loads need +24VDC power, the auxiliary supply may be able to power both circuits as shown in the following diagram (400 mA limit).



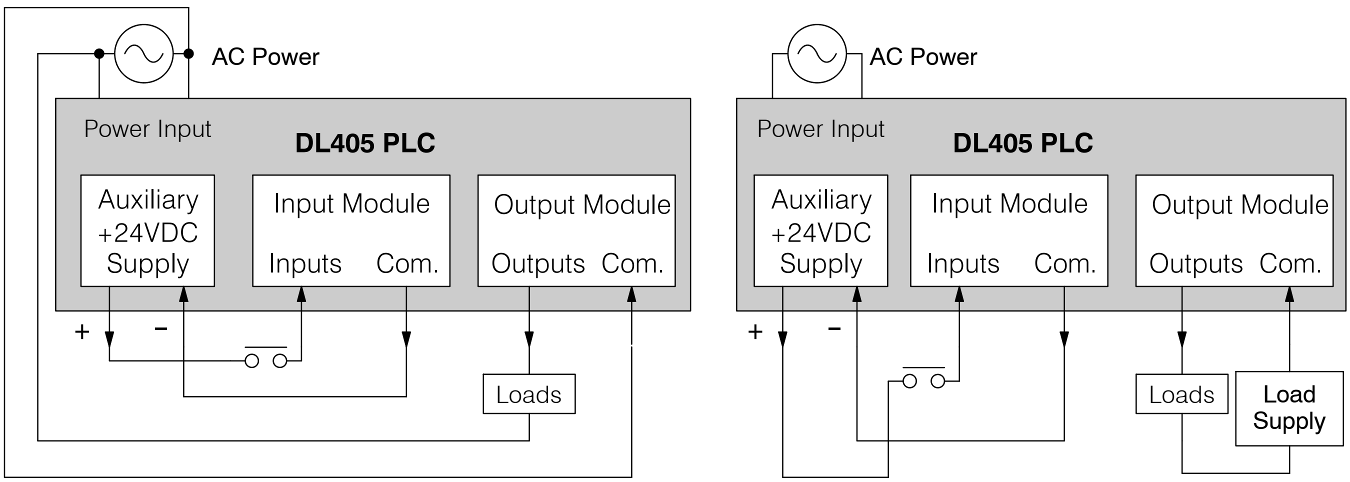
DC-powered DL405 CPUs are designed for application environments in which low-voltage DC power is more readily available than AC. These include a wide range of battery–powered applications, such as remotely-located control, in vehicles, portable machines, etc. For this application type, all input devices and output loads typically use the same DC power source. Typical wiring for DC-powered applications is shown in the following diagram.



Powering I/O Circuits Using Separate Supplies

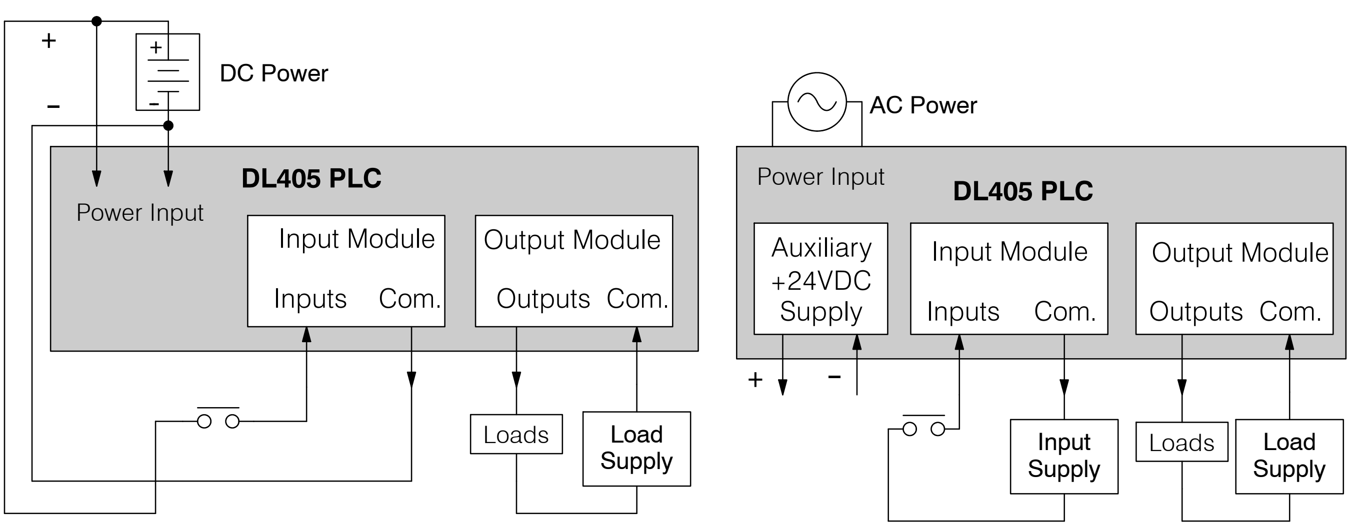
In most applications it will be necessary to power the input devices from one power source, and to power output loads from another source. Loads often require high-energy AC power, while input sensors use low-energy DC. If a machine operator is likely to come in close contact with input wiring, then safety reasons also require isolation from high-energy output circuits. It is most convenient if the loads can use the same power source as the PLC, and the input sensors can use the auxiliary supply, as shown to the left in the figure below.

If the loads cannot be powered from the PLC supply, then a separate supply must be used as shown to the right in the figure below.



Some applications will use the PLC external power source to also power the input circuit. This typically occurs on DC-powered PLCs, as shown in the drawing below to the left. The inputs share the PLC power source supply, while the outputs have their own separate supply.

A worst-case scenario, from a cost and complexity view-point, is an application which requires separate power sources for the PLC, input devices, and output loads. The example wiring diagram below on the right shows how this can work, but also that the auxiliary supply output is an unused resource. For these reasons, you'll probably want to avoid this situation if possible.



Sinking/Sourcing Concepts

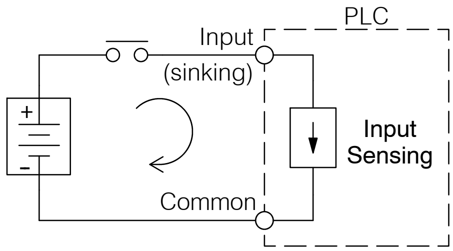
Before going further in our study of wiring strategies, we must have a solid understanding of "*sinking*" and "*sourcing*" concepts. Use of these terms occurs frequently in input or output circuit discussions. It is the goal of this section to make these concepts easy to understand, further ensuring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

Sinking = provides a path to supply **ground (–)**

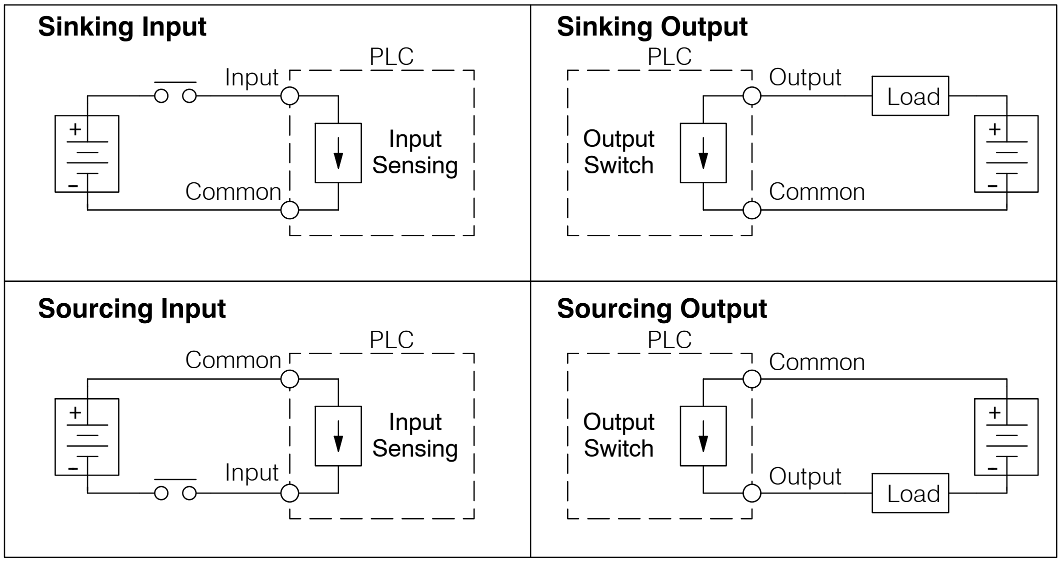
Sourcing = provides a path to supply **source (+)**

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 sinking or sourcing *only* 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.

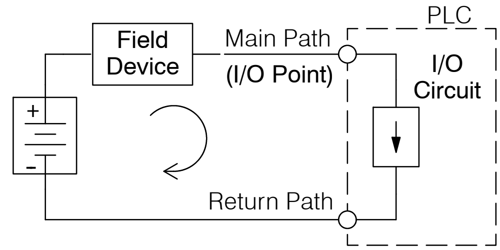


By applying the circuit principle above to the four possible combinations of input/output sinking/sourcing types, we have the four circuits as shown below. The I/O module specifications at the end of this chapter list the input or output type.

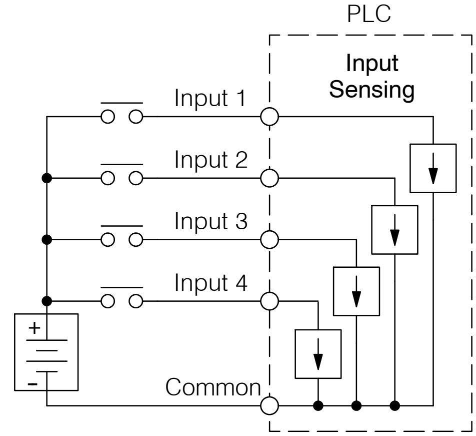


I/O "Common" Terminal Concepts

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.



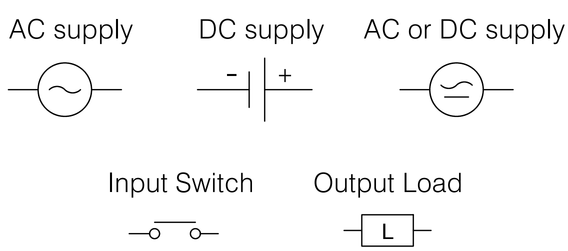
If we had unlimited space and budget for I/O terminals, then every I/O point could have two dedicated terminals just as the figure above shows. However, providing this level of flexibility is not practical or even necessary for most applications. So, most Input or Output points on PLCs are in groups which share the return path (called *commons*). 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.

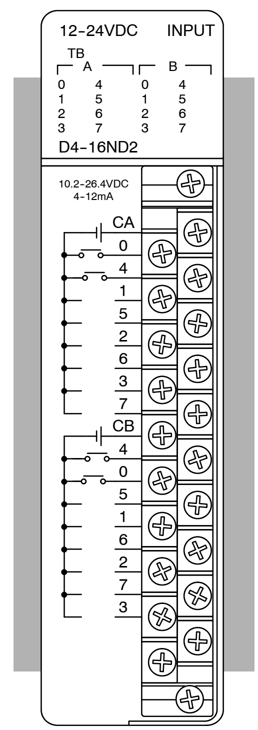


NOTE: In the circuit above, the current in the common path is 4 times any channel's input current when all inputs are energized. This is especially important in output circuits, where heavier gauge wire is sometimes necessary on commons.

Most DL405 input and output modules group their I/O points into banks that share a common return path. The best indication of I/O common grouping is on the wiring label, such as the one shown to the right. The miniature schematic shows two circuit banks with eight input points in each. The common terminal for each is labeled "CA" and "CB", respectively.

In the wiring label example, the positive terminal of a DC supply connects to the common terminals. Some symbols you will see on the wiring labels, and their meanings are:



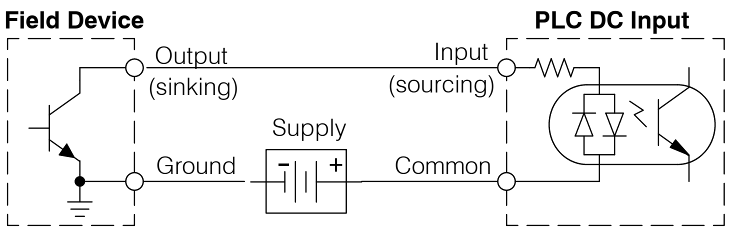


Connecting DC I/O to "Solid State" Field Devices

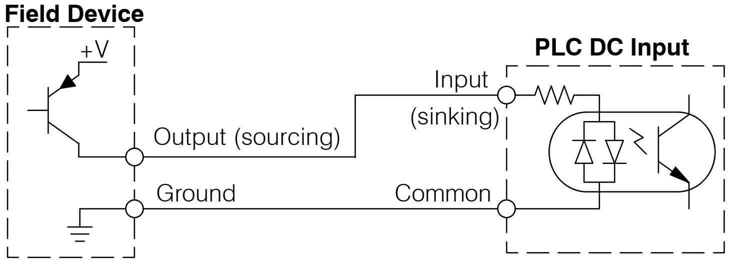
In the previous section on Sourcing and Sinking concepts, we explained that DC I/O circuits sometimes will only allow current to flow one way. This is also true for many of the field devices which have solid-state (transistor) interfaces. In other words, field devices can also be sourcing or sinking.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

Solid State Input Sensors

Several DL405 DC input modules 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 +24 auxiliary supply or another supply (+12 VDC or +24VDC), as long as the input specifications are met.



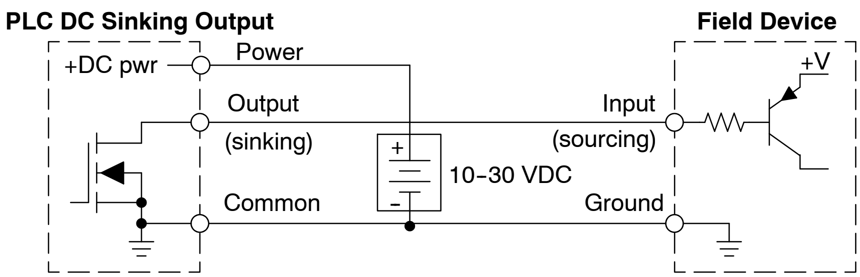
In the next circuit, a field device has an open-emitter PNP transistor output. It sources current to the PLC input point, which sinks the current back to ground. Since the field device is sourcing current, no additional power supply is required.



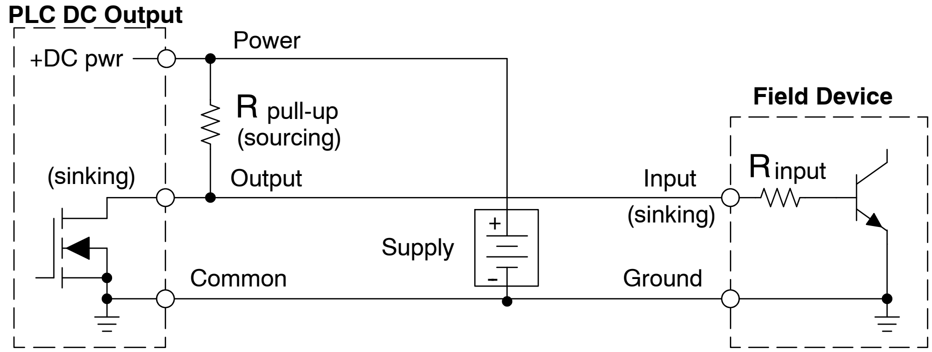
Solid State Output Loads

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 control signal, not to send DC power to an actuator.

Several of the DL405 DC output modules are the sinking type. This means that each DC output provides a path to ground when it is energized. 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 sinking 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 $R_{pull\text{-}up}$ from the output to the DC output circuit power input.



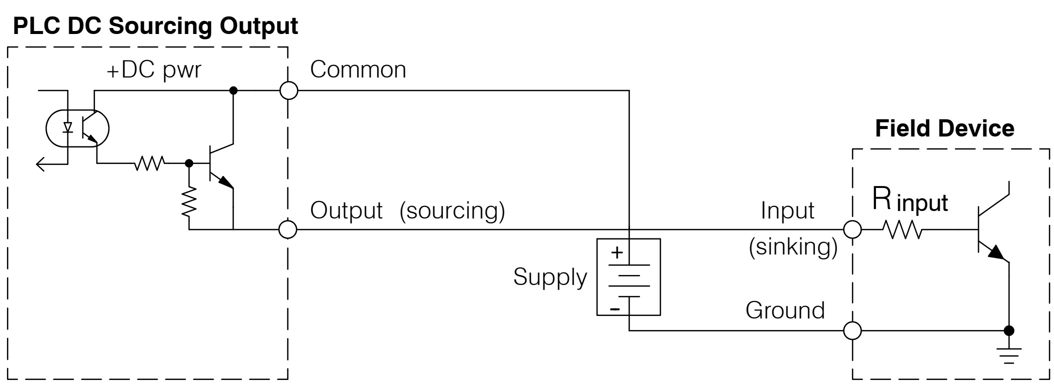
NOTE 1: DO NOT attempt to drive a heavy load (>25 mA) with this pull-up method
NOTE 2: Using the pull-up resistor to implement a sourcing output has the effect of inverting the output point logic. In other words, the field device input is energized when the PLC output is OFF, from a ladder logic point-of-view. 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 $R_{pull\text{-}up}$. 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 $R_{pull\text{-}up}$. Then calculate the power $P_{pull\text{-}up}$ (in watts), in order to size $R_{pull\text{-}up}$ properly.

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

$$R_{pull\text{-}up} = \frac{V_{supply} - 0.7}{I_{input}} - R_{input} \qquad P_{pull\text{-}up} = \frac{V_{supply}^{2}}{R_{pullup}}$$

Of 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

Four output modules in the DL405 I/O family feature relay outputs: D4-08TR, F4-08TRS-1, F4-08TRS-2, D4-16TR. 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)

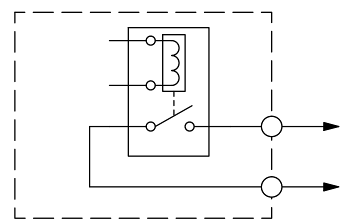
Some applications in which NOT to use relays:

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

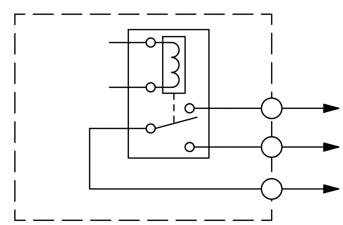
Relay outputs in the DL405 output modules are available in two contact arrangements, shown to the right. The Form A type, or SPST (single pole, single throw) type is normally open and is the simplest to use. The Form C type, or SPDT (single pole, double throw) type has a center contact which moves and a stationary contact on either side. This provides a normally closed contact and a normally open contact.

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.

Relay with Form A contacts



Relay with Form C contacts



Transient Suppression for Inductive Loads in a Control System

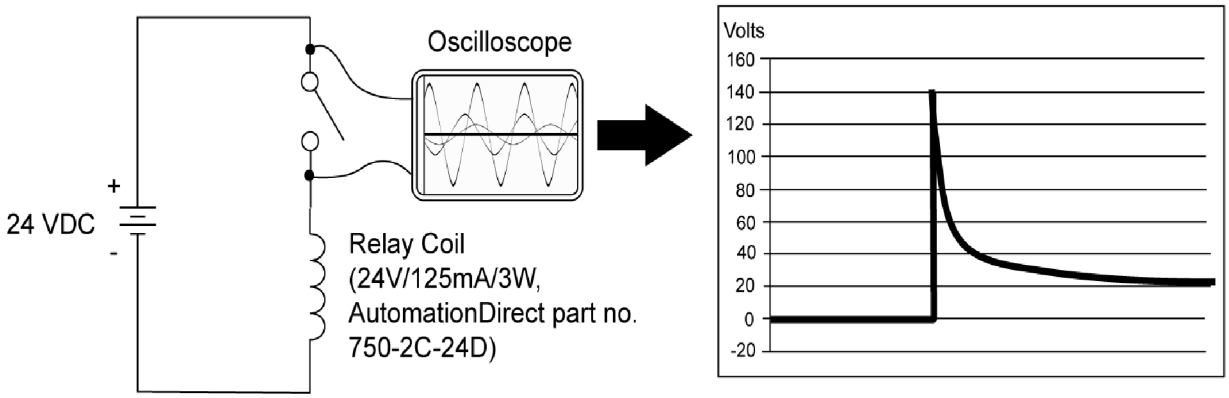
The following pages are intended to give a quick overview of the negative effects of transient voltages on a control system and provide some simple advice on how to effectively minimize them. The need for transient suppression is often not apparent to the newcomers in the automation world. Many mysterious 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 24V/125mA/3W 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 140V.

Example: Circuit with no Suppression



In the same circuit, replacing the relay with a larger 24V/290mA/7W relay will generate a transient voltage exceeding 800V (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.

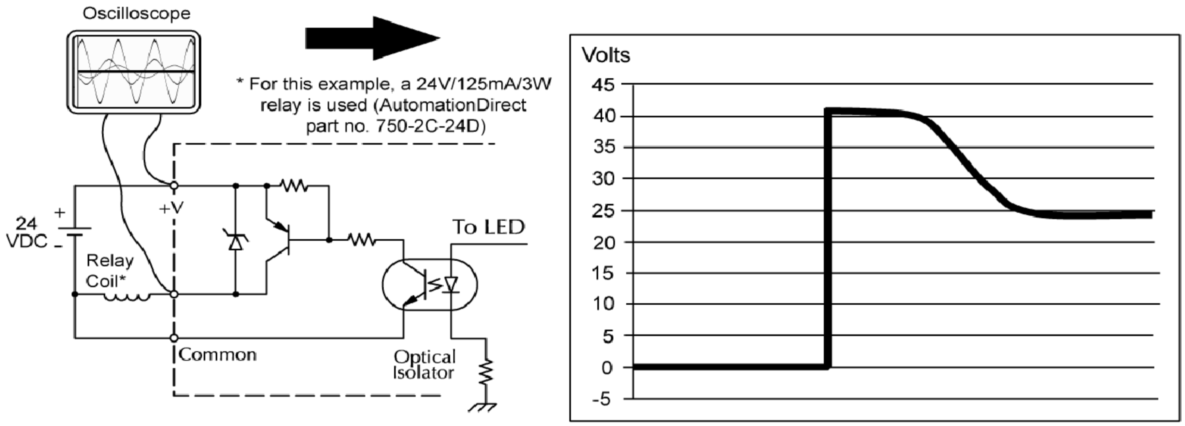
A very destructive side-effect of the arcing across relay contacts is the electromagnetic interference (EMI) it can cause. This occurs because the arcing causes a current surge, which releases RF energy. The entire length of wire between the relay contacts, the coil, and the power source carries the 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.

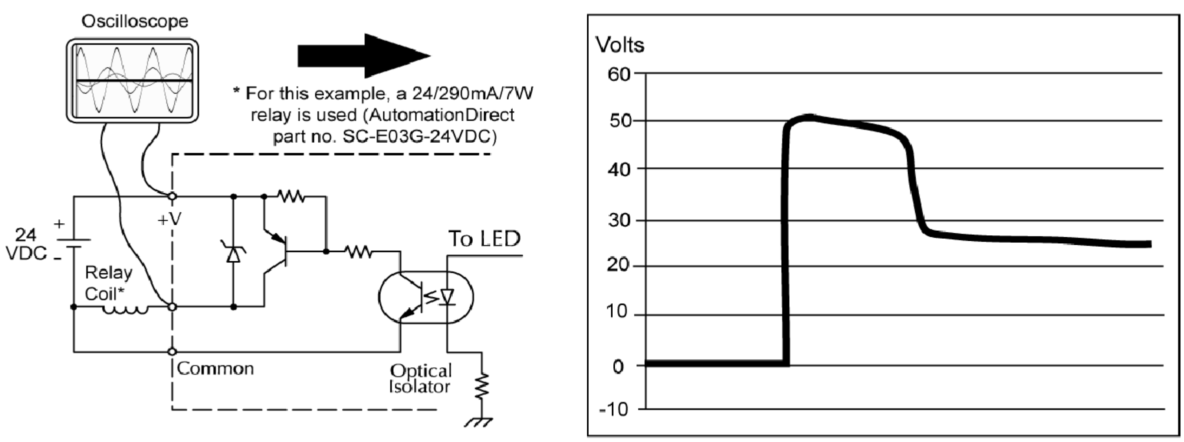
Here is another example using the same 24V/125mA/3W relay used earlier. This example measures the PNP transistor output of a D0–06DD2 PLC, which incorporates an integrated Zener diode for transient suppression. Instead of the 140V peak in the first example, the transient voltage here is limited to about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

Example: Small Inductive Load with Only Integrated Suppression



The next example uses the same circuit as above, but with a larger 24V/290mA/7W relay, thereby creating a larger inductive load. As you can see, the transient voltage generated is much worse, peaking at over 50V. 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



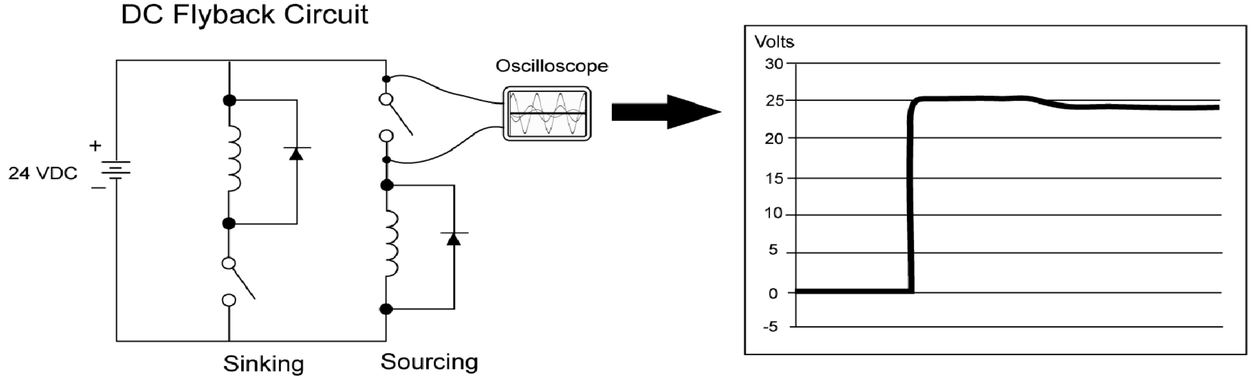
Additional transient suppression should be used in both of the preceding examples. If you are unable to measure the transients generated by the connected loads of your control system, using additional transient suppression on all inductive loads would be the safest practice.

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.

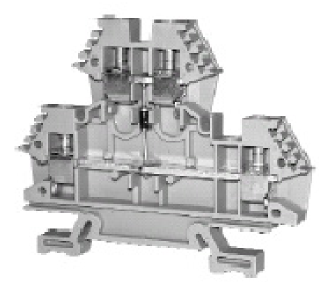
DC Flyback Circuit



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 600 VDC 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

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.

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

ZL-TSD8-120
Transorb Module

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.

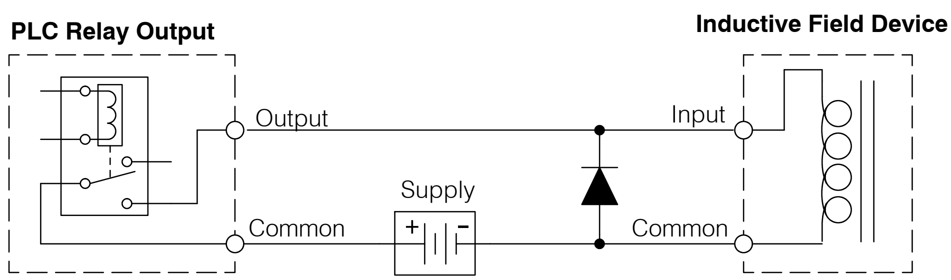
For example, a MOV or TVS diode rated for use on 24-48 VDC coils would need to have a high enough voltage rating to NOT conduct at 48V. That suppressor might typically start conducting at roughly 60VDC. If it were mounted across a 24V coil, transients of roughly 84V (if sinking output) or -60V (if sourcing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

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.



Another method of surge suppression is to use a resistor and capacitor (RC) snubber network. The RC network must be located 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 we are ready to calculate values for R and C, according to the formulas:

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

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, we first, we calculate the peak values:

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

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

Now, finding the values of R and C, we have:

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

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

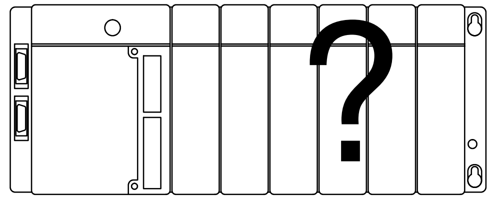
$$x = 1 + \frac{50}{169.7} = 1.29 \qquad R\ (\Omega) = \frac{169.7}{10 \times 0.707^{1.29}} = 16\ \Omega,\ 1/2\ W,\ \pm\ 5\%$$

Installation, Wiring, and Specifications

I/O Module Wiring and Specifications

Module Placement

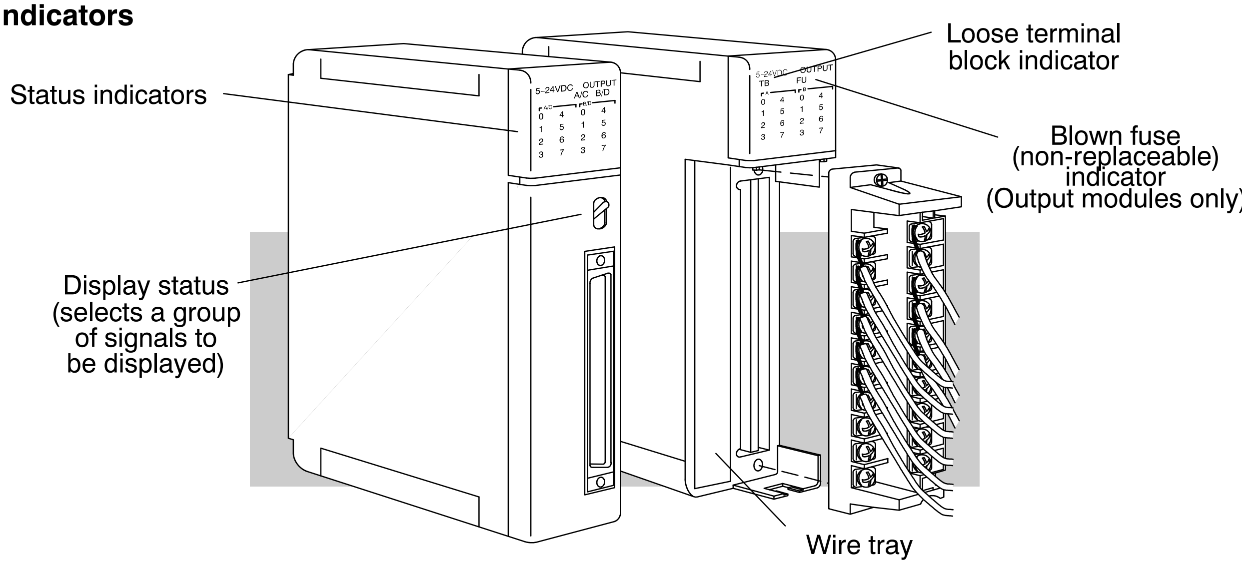
Before wiring the I/O modules in your system to field devices, it's very important to make sure each I/O module is in the right slot and base in the system. Costly wiring errors may be avoided by doing the following:



- Do the power budget calculations for each base to verify the base power supply can power all the modules in the base. Information on how to do this is in Chapter 4, System Design and Configuration.
- Some specialty I/O modules may only be installed in particular slots (will not function properly, otherwise). Check the corresponding manuals before installation and wiring.
- Whenever possible, keep modules with high voltage and current wiring away from sensitive analog modules.

I/O Module Status Indicators

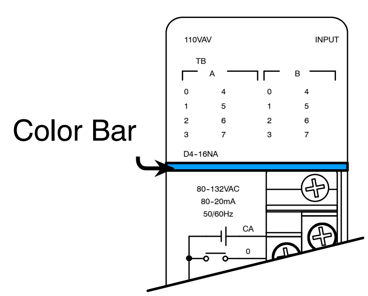
The diagram below shows the status indicator location for common I/O modules.



Color Coding of I/O Modules

The DL405 family of I/O modules have a color-coded stripe on the front bezel to help identify whether the module type is input, output, or special module. The color code meaning is listed below:

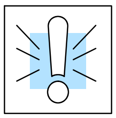
Module Type	Color Code
Discrete/Analog Output	Red
Discrete/Analog Input	Blue
Other	White



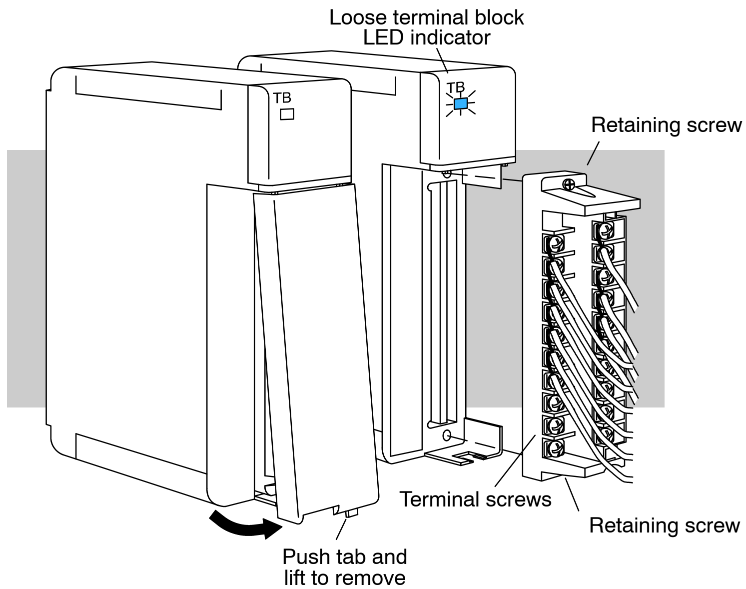
Wiring a Module with a Terminal Block

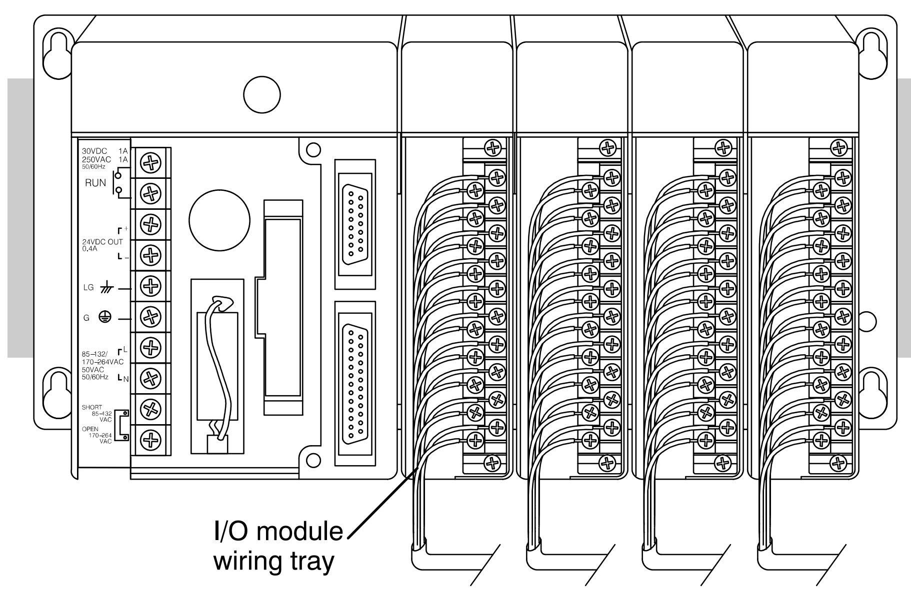
You must first remove the front cover of the module prior to wiring. To remove the cover depress the bottom tab of the cover and tilt the cover up to loosen from the module.

All DL405 I/O module terminal blocks are removable for your convenience. To remove the terminal block loosen the retaining screws and and lift the terminal block away from the module. When you return the terminal block to the module make sure the terminal block is tightly seated. Be sure to tighten the retaining screws. You should also verify the loose terminal block LED is off when system power is applied.



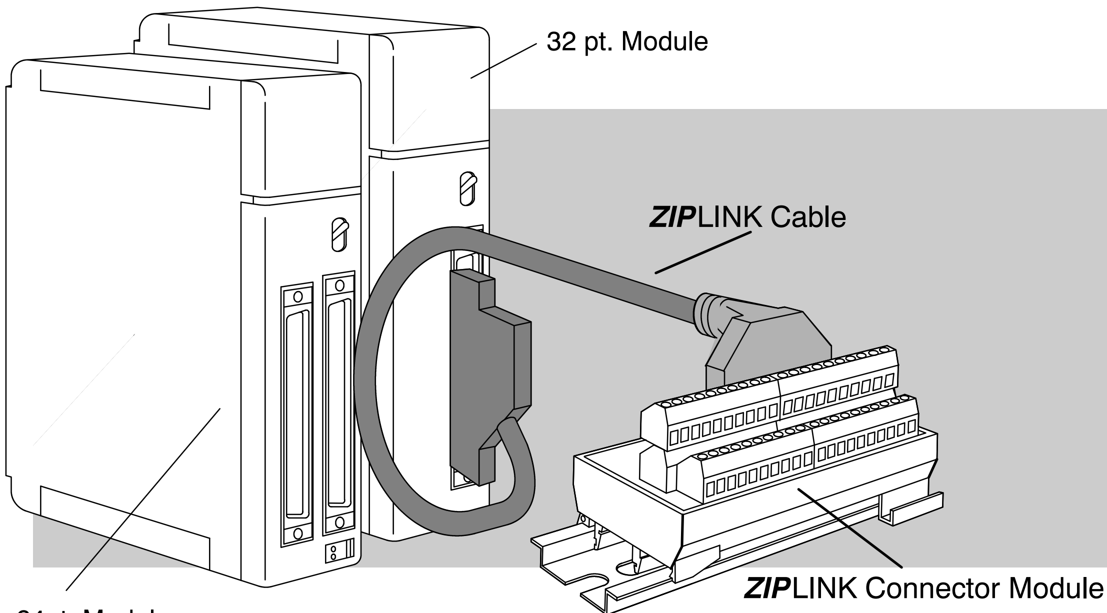
WARNING: For some modules, field device power may still be present on the terminal block even though the PLC system is turned off. To minimize the risk of electrical shock, disconnect all field device power *before* you remove the connector.





Wiring 32 and 64 Point I/O Modules

The 32 point and 64 point I/O modules use a different style of connector due to the increased number of I/O points. There are several types of connection methods available to choose from. A ***ZIP***Link connection system is shown in the figure below. Refer to the next section for complete information on ribbon and solder type connectors and accessories. Another option is to use the D4-IOCBL-1, a 3m prewired solder connector and cable with pigtail.



The ***ZIP***Link system offers "plug and play" capability, eliminating the need for traditional wiring. Simply plug one end of the ***ZIP***Link cable into a 32 or 64 point I/O module and the other end into a ***ZIP***link Connector Module. Refer to the Connection Systems section in the catalog for a complete list of cable and connector part numbers.

Part Numbers for Module Connectors

Both types of connectors are available from AutomationDirect.

AutomationDirect Part Numbers

- D4-IO3264R — Ribbon cable connectors, 2 in a pack. Can be used on either 32 point or 64 point modules.
- D4-IO3264S — Solder type connector, 2 in a pack. Can be used on either 32 point or 64 point modules.

Ribbon Cable

The chart below lists cables which can be used to connect the terminal block with a 32 I/O module. They have 40 conductors and .050" pitch PVC stranded ribbon cable.

Description/Type	Vendor	Part Number
Gray / 26 AWG	3M	3801 / 40
Gray / 26 AWG	Belden	9L260 40
Gray / 28 AWG	Belden	9L280 40
Gray / 28 AWG	DuPont	76825–040
Gray / 28 AWG	AMP	499116–5
Color coded / 26 AWG	3M	3811 / 40
Color coded / 28 AWG	Belden	9R280 40
Color coded / 28 AWG	DuPont	76177–040

Ribbon Cable Connectors

These ribbon cable connectors are for attaching the ribbon cable to the terminal block. They are all .100" x .100" 2 x20 female ribbon connectors with a center bump.

Description/Type	Vendor	Part Number
Connector Strain Relief	3M 3M	3417–7640 3448–3040
Connector Strain Relief	3M 3M	3417–7640 3448–3040
Connector (pre-assembled) Strain Relief	3M 3M	89140–0103–T0 3448–89140
Connector (with strain relief)	Thomas & Betts	622–4041
Connector (pre-assembled) Strain Relief	AMP AMP	746286–9 499252–1
Connector (with strain relief)	DuPont	66902–240
Connector (with strain relief)	Molex	15–29–9940

Interface Terminal Block

Below are terminal blocks which can be used to transition a 40 conductor ribbon cable to 40 discrete field wires. The terminal block features are: 2 x 20 .100" x .100" pin center (male) connector head terminals (.2" centers) accepting 22–12 AWG, no fuses.

Description/Type	Vendor	Part Number
Panel Mount Rail Mount	Weidmuller	RI–40A /914897 RI–40A /914908
Rail Mount	Phoenix Contacts	FLKM 40 / 2281076
Special Mount (DIN rail compatible) includes ribbon connector	Augat/RDI	2M40FC

I/O Wiring Checklist

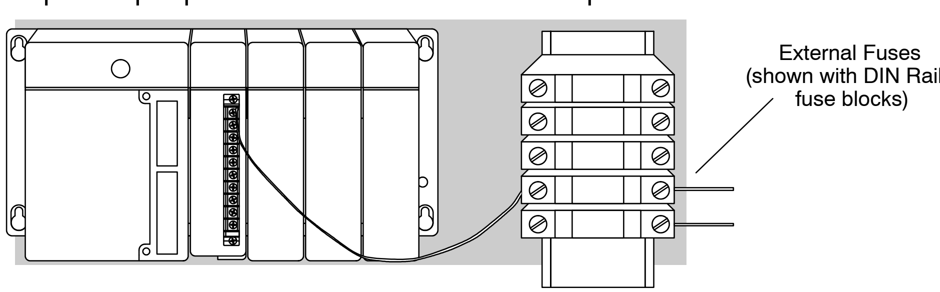
Use the following guidelines when wiring the I/O modules in your system.

1. Note the limits to the size of wire the modules can accept. The table below lists the maximum AWG for each module type. Smaller AWG is acceptable to use for each of the modules.

Module type	Suggested AWG Range	Suggested Torque
CPU	12 AWG	10.63 lb-inch (1.2 N•m)
8 point	12 AWG	7.97 lb-inch (0.9 N•m)
16 point	14 AWG	7.97 lb-inch (0.9 N•m)
32 point 64 point (connectors sold separately)	***Zip***Link: ZL-4CBL4# cable / ZL-CM40 connector block D4-IOCBL-1 (3m pigtail cable with D4-IO3264S) D4-IO3264R (ribbon type connector) D4-IO3264S (solder type connector)	

Note: 12 AWG Type TFFN or Type MTW can be used on 8pt. modules. 14 AWG Type TFFN or Type MTW can be used on 16pt. modules. Other types of wire may be acceptable, but it really depends on the thickness of the wire insulation. If the insulation is too thick and you use all the I/O points, then the plastic terminal cover may not close properly.

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. Where possible use wire trays for routing .
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 lines.
8. Where possible avoid running DC wiring in close proximity to AC wiring.
9. Avoid creating sharp bends in the wires.
10. **IMPORTANT!** To help avoid having a module with a blown fuse, we suggest you add external fuses to your I/O wiring. A fast blow fuse, with a lower current rating than the I/O module fuse can be added 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.



DL405 Input Module Chart

The following table lists the available DL405 input modules. Specifications begin on the following page.

DL405 Input Module Type	Number of Input Points	DC Current Sink Input	DC Current Source Input	AC Input
D4-16ND2	16		✓	
D4-16ND2F	16		✓	
D4-32ND3-1	32	✓	✓	
D4-32ND3-2	32	✓	✓	
D4-64ND2	64		✓	
D4-08NA	8			✓
D4-16NA	16			✓
D4-16NE3	16	✓	✓	✓
F4-08NE3S	8	✓	✓	✓
D4-08ND3S	8	✓	✓	

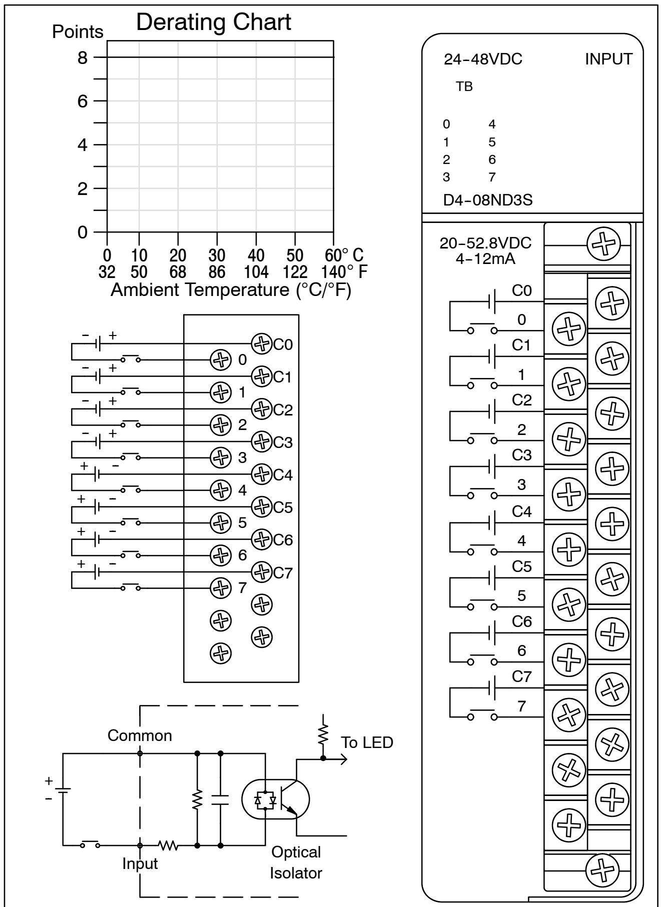
DL405 Output Module Chart

The following table lists the available DL405 output modules. Specifications begin after the input modules' specifications.

DL405 Output Module Type	Number of Output Points	DC Current Sink Output	DC Current Source Output	AC Output
D4-08TD1	8	✓		
F4-08TD1S	8	✓		
D4-16TD1	16	✓		
D4-16TD2	16		✓	
D4-32TD1	32	✓		
D4-32TD1-1	32	✓		
D4-32TD2	32		✓	
D4-64TD1	64	✓		
D4-08TA	8			✓
D4-16TA	16			✓
D4-08TR	8	✓	✓	✓
F4-08TRS-1	8	✓	✓	✓
F4-08TRS-2	8	✓	✓	✓
D4-16TR	16	✓	✓	✓

D4-08ND3S DC Input

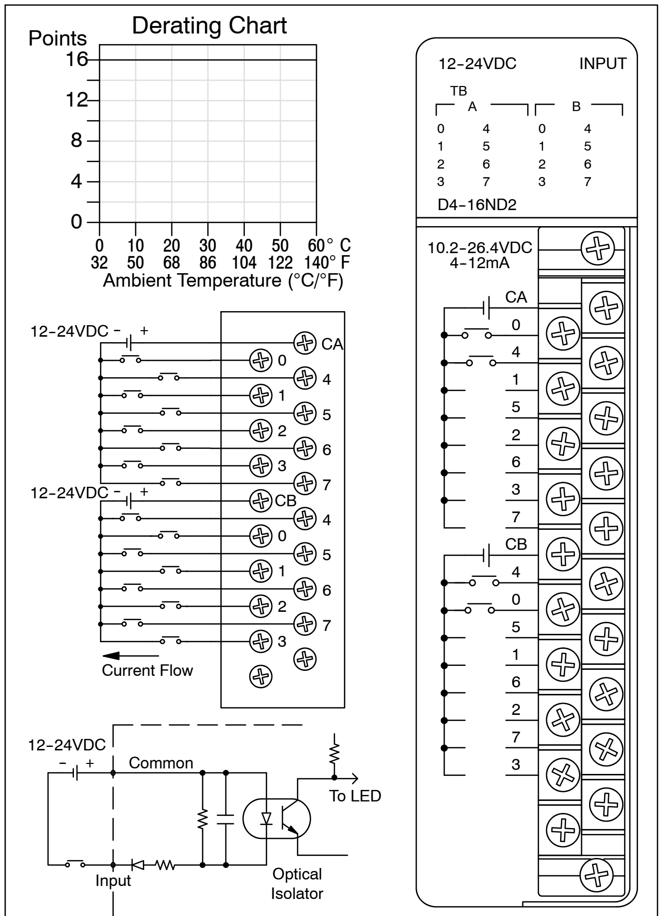
Inputs per module	8 (sink/source)
Commons per module	8 (isolated)
Input voltage range	20-52.8VDC
Peak voltage	52.8VDC
ON voltage level	>18 V
OFF voltage level	< 7V
Input impedance	4.8 K Ω
Input current @ 24 / 48 VDC	5 mA / 10 mA
Minimum ON current	3.5 mA
Maximum OFF current	1.5 mA
Base power required 5V	100 mA max
OFF to ON response	3-10 ms
ON to OFF response	3-12 ms
Terminal type	Removable
Status indicators	Logic Side
Weight	8.8 oz. (250 g)



Current sourcing configuration shown

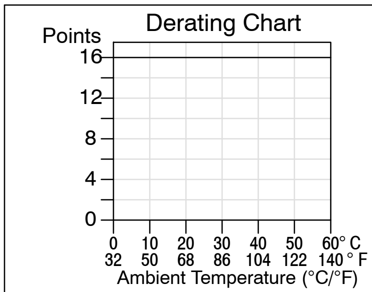
D4-16ND2 DC Input

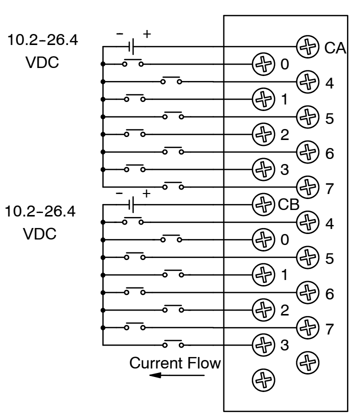
Inputs per module	16 (current sourcing)
Commons per module	2 (isolated)
Input voltage range	10.2-26.4VDC
Peak voltage	26.4VDC
ON voltage level	> 9.5VDC
OFF voltage level	< 4.0 VDC
Input impedance	3.2 KΩ @ 12VDC 2.9 KΩ @24VDC
Input current @ 12 / 24VDC	3.8 mA / 8.3 mA
Minimum ON current	3.5 mA
Maximum OFF current	1.5 mA
Base power required 5V	150 mA max
OFF to ON response	1-7 ms (2.3 typical)
ON to OFF response	2-12 ms (4.6 typical)
Terminal type	Removable
Status indicators	Logic Side
Weight	8.8 oz. (250 g)

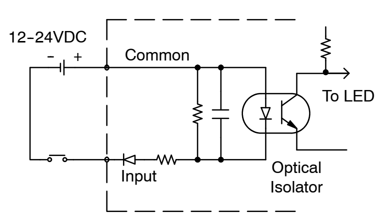


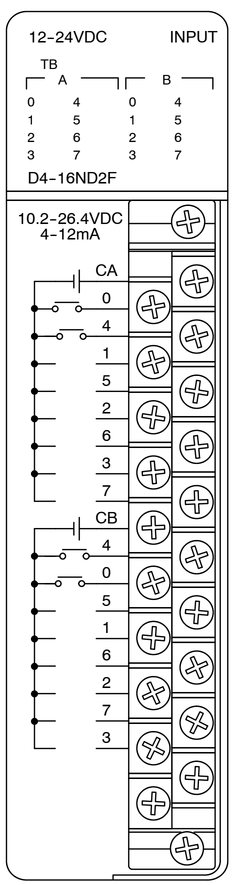
D4-16ND2F DC Input

Inputs per module	16 (current sourcing)
Commons per module	2 (isolated)
Input voltage range	10.2-26.4VDC
Peak voltage	26.4VDC
ON voltage level	> 9.5VDC
OFF voltage level	< 4.0VDC
Input impedance	3.2 K Ω @ 12VDC 2.9 K Ω @ 24VDC
Input current @ 12 / 24 VDC	3.8 mA / 8.3 mA
Minimum ON current	3.5 mA
Maximum OFF current	1.5 mA
Base power required 5V	150 mA max
OFF to ON response	1 ms
ON to OFF response	1 ms
Terminal type	Removable
Status indicators	Logic Side
Weight	8.8 oz. (250 g)







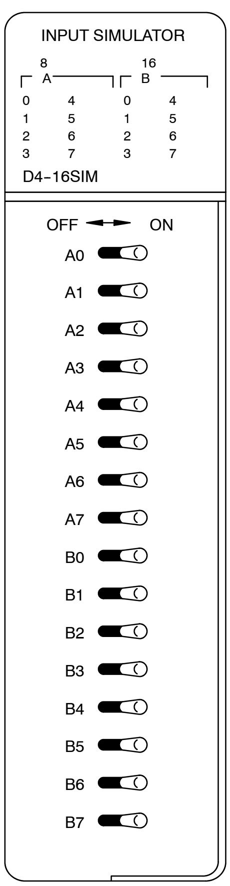


D4-16SIM Input Simulator

Inputs per module	8 or 16, selectable
Base power required 5V	150 mA Max
Terminal type	None
Status indicators	Logic Side
Weight	8.8 oz. (250 g)

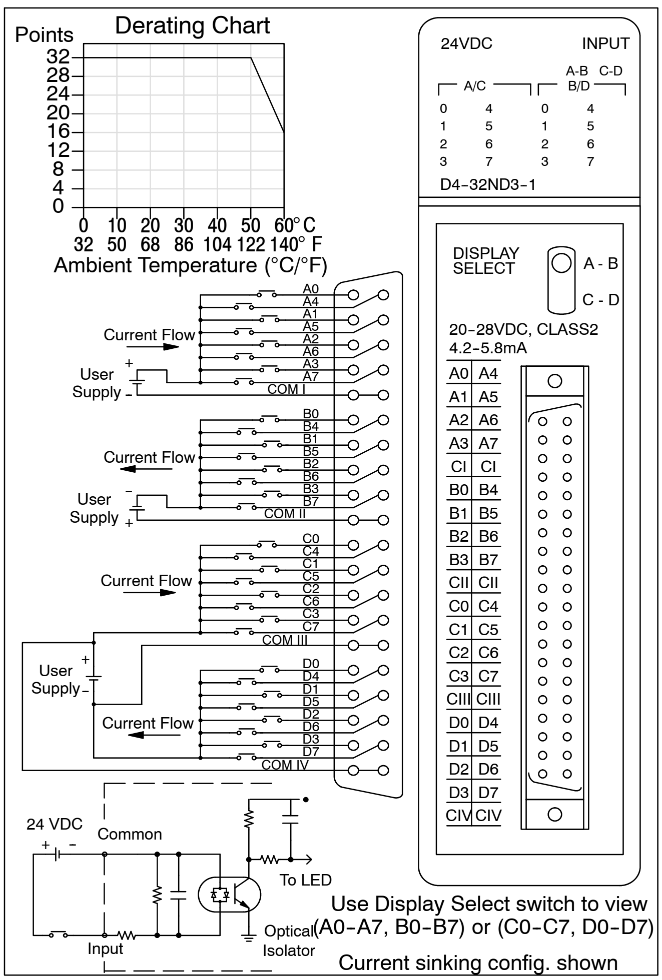
8 or 16 input point selection switch is located on the back of the module

Switch position is indicated by the LEDs above the input switches



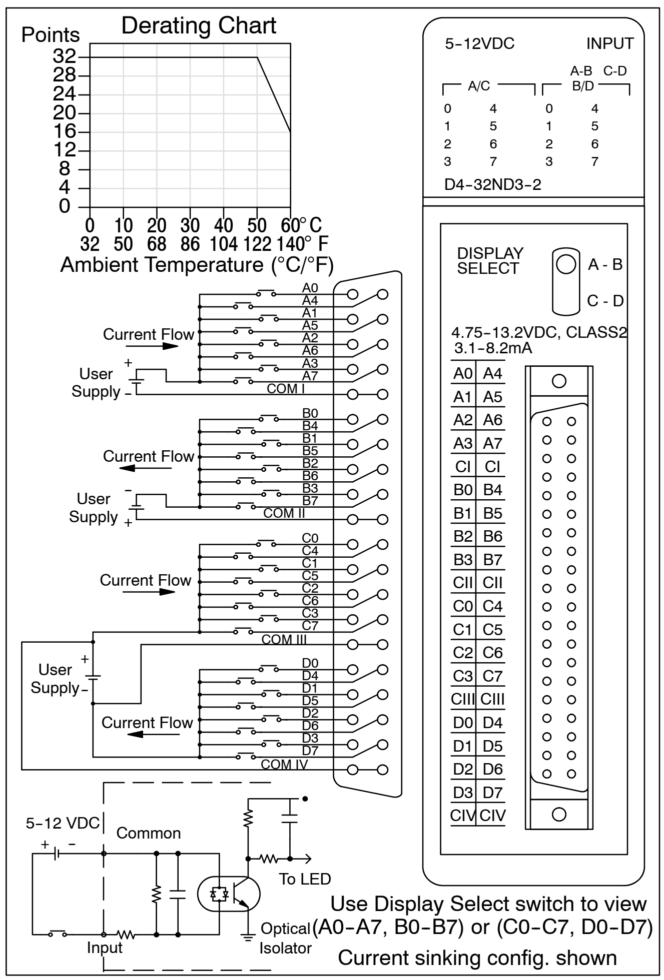
D4-32ND3-1, 24VDC Input

Inputs per module	32 (sink/source)
Commons per module	4 (isolated)
Input voltage range	20-28VDC
Peak voltage	30VDC
ON voltage level	> 19V
OFF voltage level	< 10 V
Input impedance	4.8 K Ω
Input current	5 mA
Minimum ON current	3.5 mA
Maximum OFF current	1.6 mA
Base power required 5V	150 mA max
OFF to ON response	2-10 ms
ON to OFF response	2-10 ms
Terminal type	Removable, 40 pin conn.
Status indicators	Logic Side
Weight	6.6 oz. (190 g)



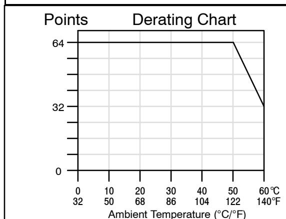
D4-32ND3-2 5-12VDC Input

Inputs per module	32 (sink/source)
Commons per module	4 (isolated)
Input voltage range	4.75-13.2VDC (TTL, CMOS)
Peak voltage	15VDC
ON voltage level	> 4 V (use pullup R for TTL in)
OFF voltage level	< 2 V
Input impedance	2 KΩ @ 5V,1.6 KΩ @ 12V
Input current	3.1 mA @ 5V, 7.5 mA @ 12V
Minimum ON current	1.8 mA
Maximum OFF current	0.8 mA
Base power required 5V	150 mA max
OFF to ON response	1-4 ms
ON to OFF response	1-4 ms
Terminal type	Removable, 40 pin conn.
Status indicators	Logic Side
Weight	6.6 oz. (190 g)

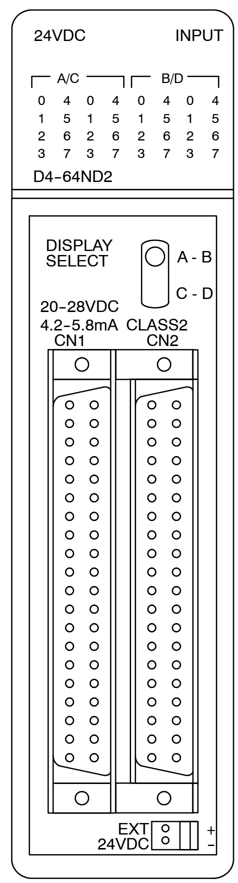


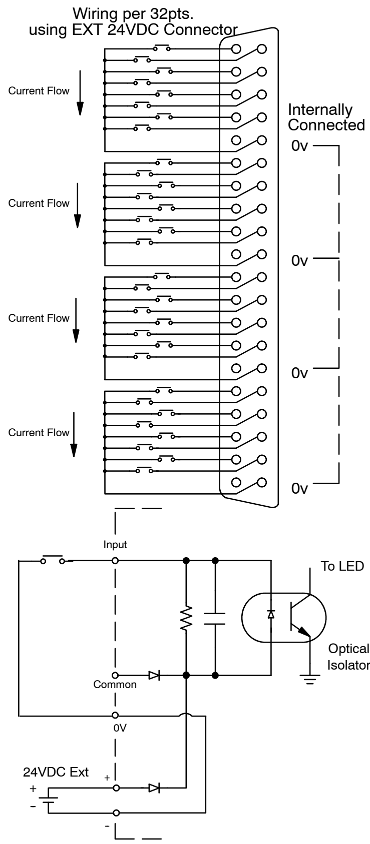
D4-64ND2, 24 VDC Input Module

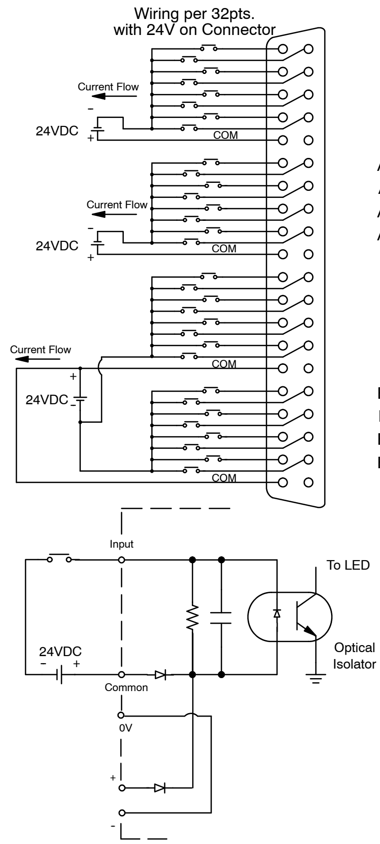
Module Location	CPU base only *	Base power required 5V	300 mA max
Inputs per module	64 (current sourcing)	External power required (optional)	24VDC ±10%, 320mA max
Commons per module	8 (isolated)	OFF to ON response	2.5 ms (typical)
Input voltage range	20 – 28 VDC	ON to OFF response	5.0 ms (typical)
Peak voltage	30 VDC	Terminal type	2, Removable 40 pin connectors (sold separately)
ON voltage level	> 20 V		
OFF voltage level	< 13 V	Status indicators	Logic Side
Input impedance	4.8 K Ω	Weight	7.8 oz. (220 g)
Input current	5.0 mA @ 24 VDC		
Minimum ON current	3.6 mA		
Maximum OFF current	2.6 mA		

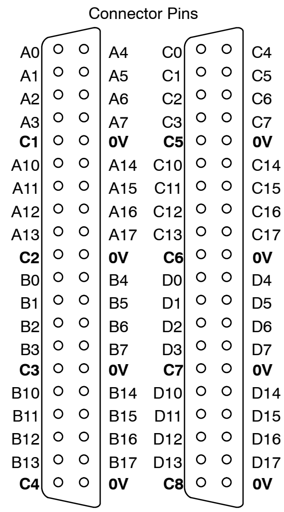


Since there are only 32 LEDs on the module, you can only display the status for 32 points at one time. In the A - B position the status of the first group of 32 input points (A0-A17, B0-B17) are displayed (connector 1). In the C - D position the status of the second group of 32 input points (C0-C17, D0-D17) are displayed (connector 2).





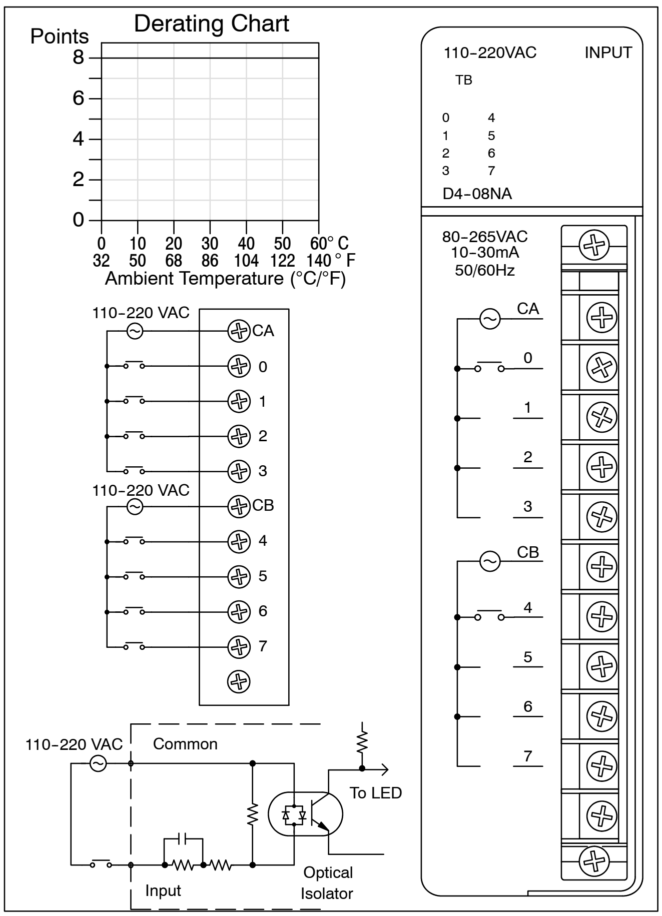




* Module location – this module placement is restricted to the local base on DL430/DL440 systems. It may also be placed in expansion bases in DL450 systems that are using the new (-1) bases.

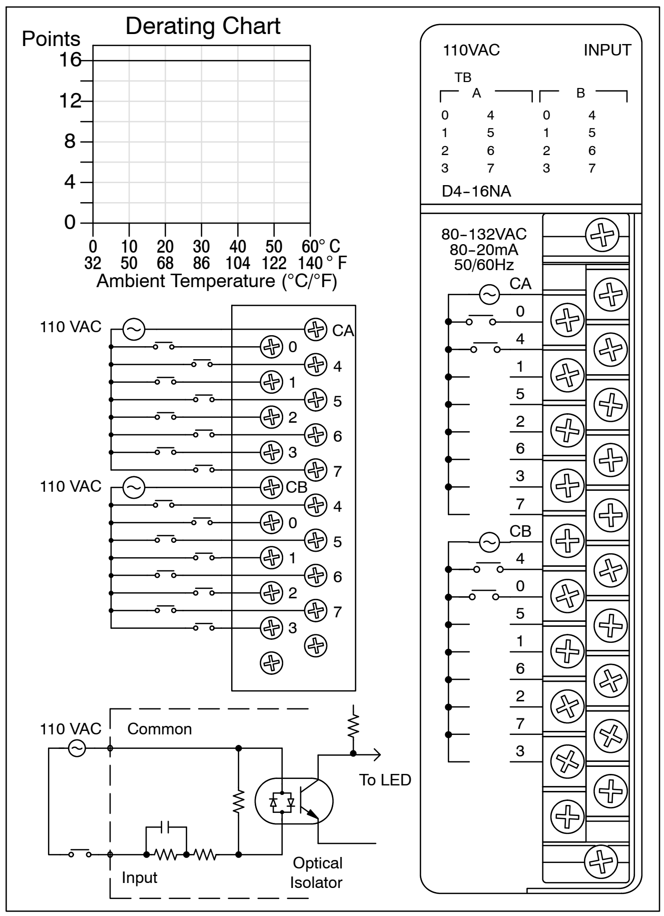
D4-08NA 110-220VAC Input

Inputs per module	8
Commons per module	2 (isolated)
Input voltage range	80-265VAC
Peak voltage	265VAC
AC frequency	47-63 Hz
ON voltage level	> 70V
OFF voltage level	< 30 V
Input impedance	12 K Ω
Input current	8.5 mA @100VAC 20 mA @ 230VAC
Minimum ON current	5 mA
Maximum OFF current	2 mA
Base power required 5V	100 mA max
OFF to ON response	5-30 ms
ON to OFF response	10-50 ms
Terminal type	Removable
Status indicators	Logic Side
Weight	8.4 oz. (240 g)



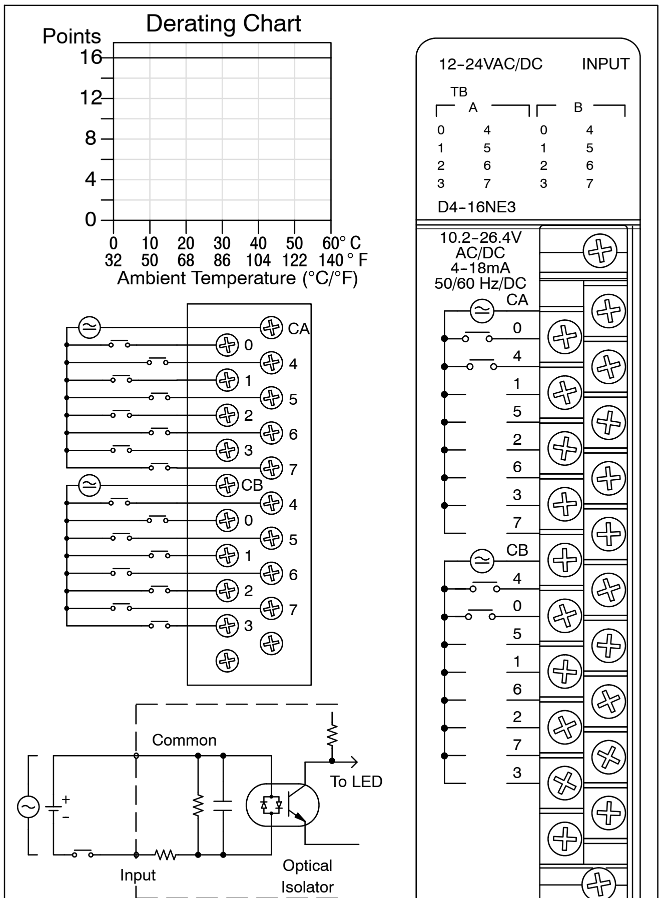
D4-16NA 110VAC Input

Inputs per module	16
Commons per module	2 (isolated)
Input voltage range	80-132VAC
Peak voltage	132VAC
AC frequency	47-63 Hz
ON voltage level	> 70V
OFF voltage level	< 20 V
Input impedance	8 K Ω
Input current	14.5 mA @120VAC
Minimum ON current	7 mA
Maximum OFF current	2 mA
Base power required 5V	150 mA max
OFF to ON response	5-30 ms
ON to OFF response	10-50 ms
Terminal type	Removable
Status indicators	Logic Side
Weight	9.5 oz. (270 g)



D4-16NE3 12–24VAC/DC Input

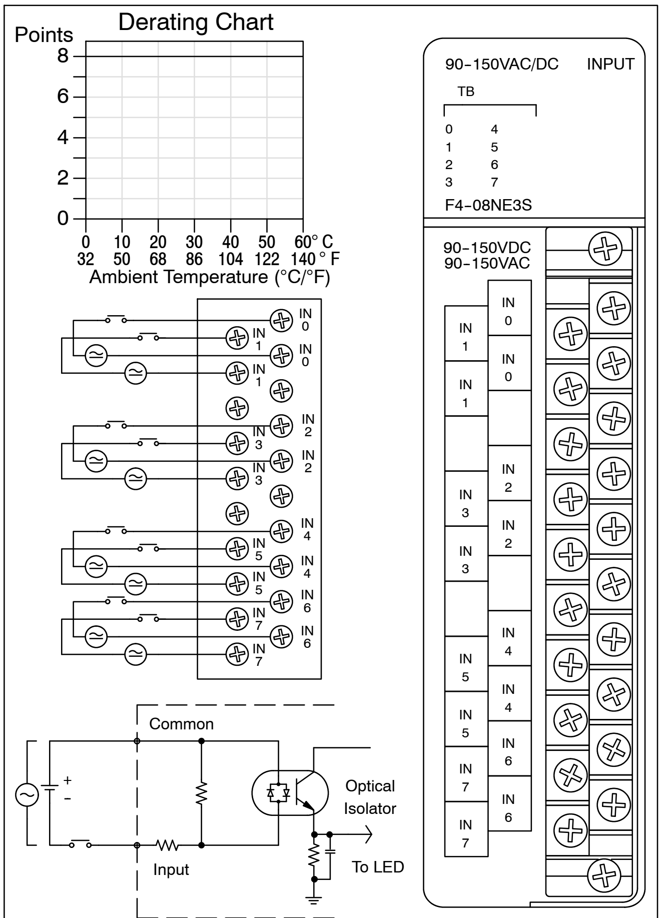
Inputs per module	16 (sink/source)
Commons per module	2 (isolated)
Input voltage range	10.2–26.4VAC/VDC
Peak voltage	37.5VAC/VDC
AC frequency	47–63 Hz
ON voltage level	> 9.5V
OFF voltage level	< 3.0V
Input impedance @ 12V/24V	3.2 K Ω / 2.9 K Ω
Input current @ 12V / 24V	3.8 mA / 8.3 mA
Minimum ON current	4 mA
Maximum OFF current	1.5 mA
Base power required 5V	150 mA max
OFF to ON response	5–40 ms
ON to OFF response	10–50 ms
Terminal type	Removable
Status indicators	Logic Side
Weight	8.8 oz. (250 g)



Current sourcing configuration shown

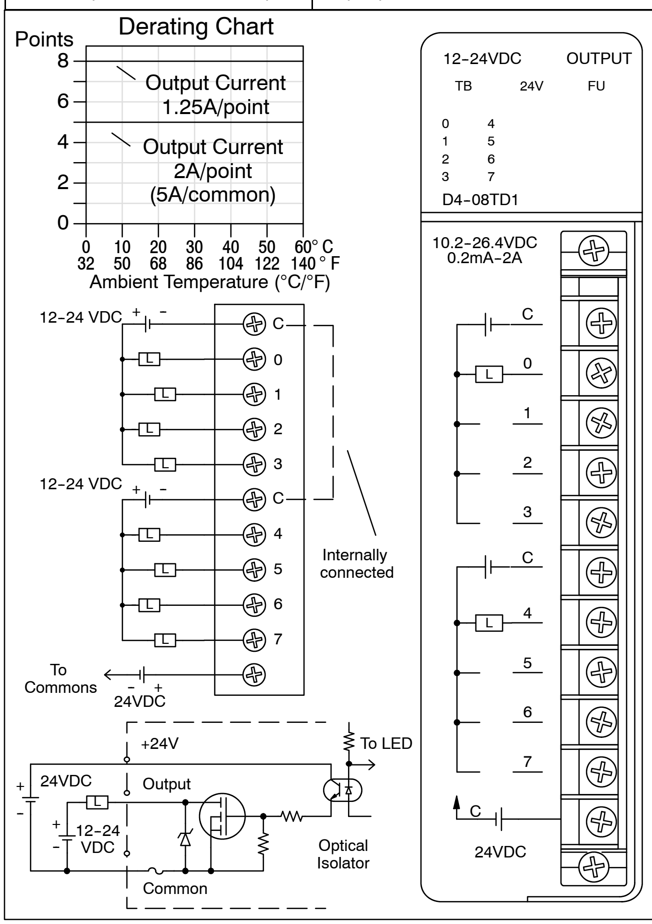
F4-08NE3S 90–150VAC/DC In

Inputs per module	8 (sink/source)
Commons per module	8 (isolated)
Input voltage range	90–150 VAC/VDC
Peak voltage	350 peak < 1ms
AC frequency	47–63 Hz
ON voltage level	> 90 VDC / 75VAC
OFF voltage level	< 60 VDC / 45VAC
Input impedance	22 K Ω
Input current	5.5 mA @ 120V
Minimum ON current	4 mA
Maximum OFF current	2 mA
Base power required 5V	90 mA max
OFF to ON response	8 ms
ON to OFF response	15 ms
Terminal type	Removable
Status indicators	Logic Side
Weight	9 oz. (256 g)



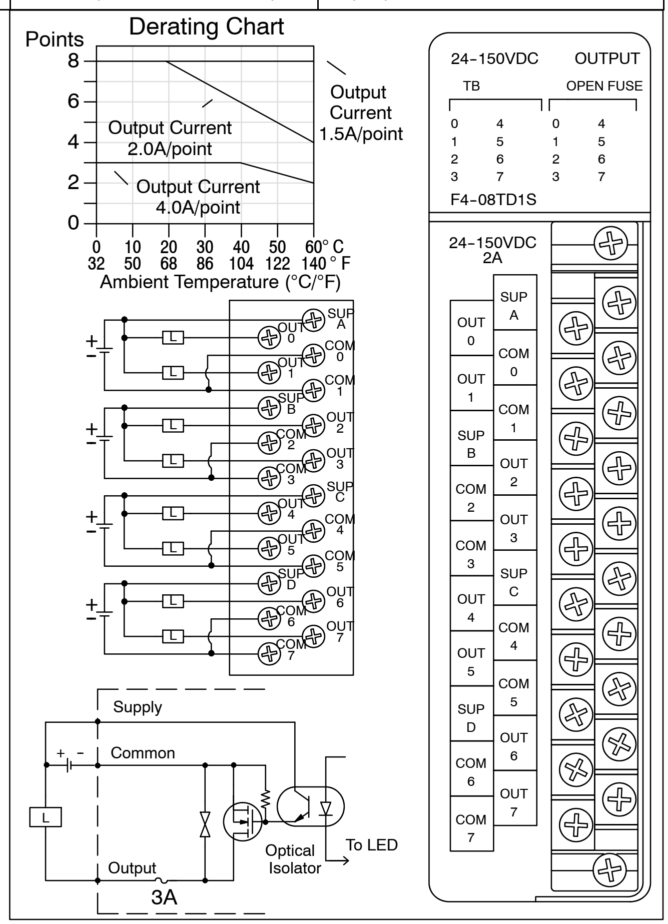
D4-08TD1 12-24 VDC Output

Outputs per module	8 (current sinking)
Commons per module	2 internally connected
Operating voltage	10.2-26.4VDC
Output type	NMOS FET (open drain)
Peak voltage	40VDC
ON voltage drop	0.5VDC @ 2A, 0.2 VDC @1A
Max current (resistive)	2A / point, 5A / common
Max leakage current	0.1mA @ 40VDC
Max inrush current	12A for 10 ms, 6A for 100 ms
Minimum load	0.2mA
Base power required 5V	150mA max
External DC required	24VDC ±10%@35 mA
OFF to ON response	1 ms
ON to OFF response	1 ms
Terminal type	Removable
Status indicators	Logic Side
Weight	8.4 oz. (240 g)
Fuses (non-replaceable)	1 (7A) per common



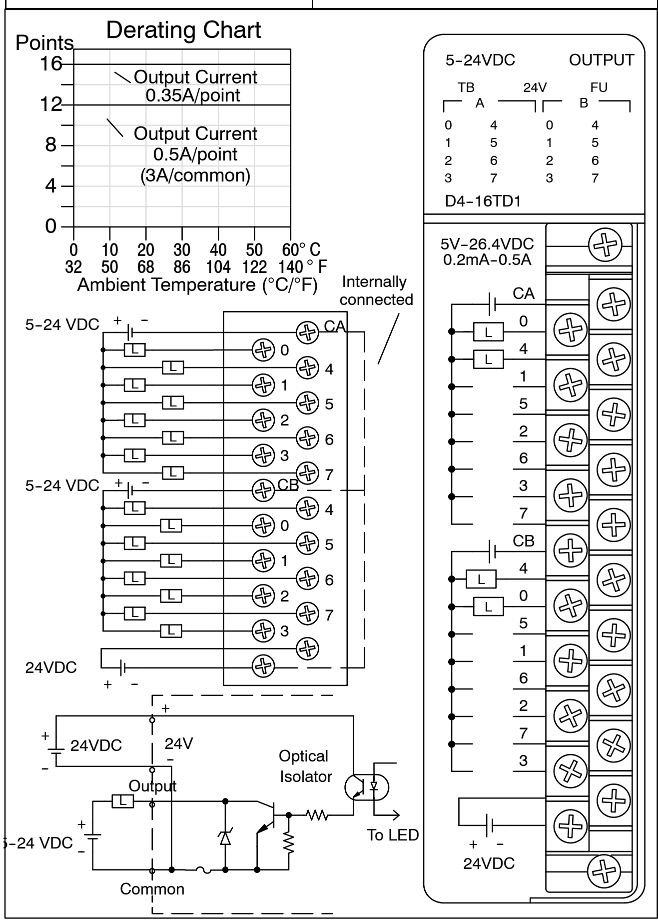
F4-08TD1S 24-150 VDC Isolated Out

Outputs per module	8 (current sinking)
Commons per module	4 (isolated)
Operating voltage	24-150VDC
Output type	MOS FET
Peak voltage	200 VDC, <1mS
ON voltage drop	1VDC @ 2A
Max current	2A / point, 4A / common
Max leakage current	5 µA
Max inrush current	30A /1ms, 6A / 10ms, 3A / 100ms
Minimum load	N/A
Base power required 5V	295 mA max
External DC required	None
OFF to ON response	25 µs
ON to OFF response	25 µs
Terminal type	Removable
Status indicators	Logic Side
Weight	10 oz. (282 g)
Fuses (non-replaceable)	1 (3A) per output



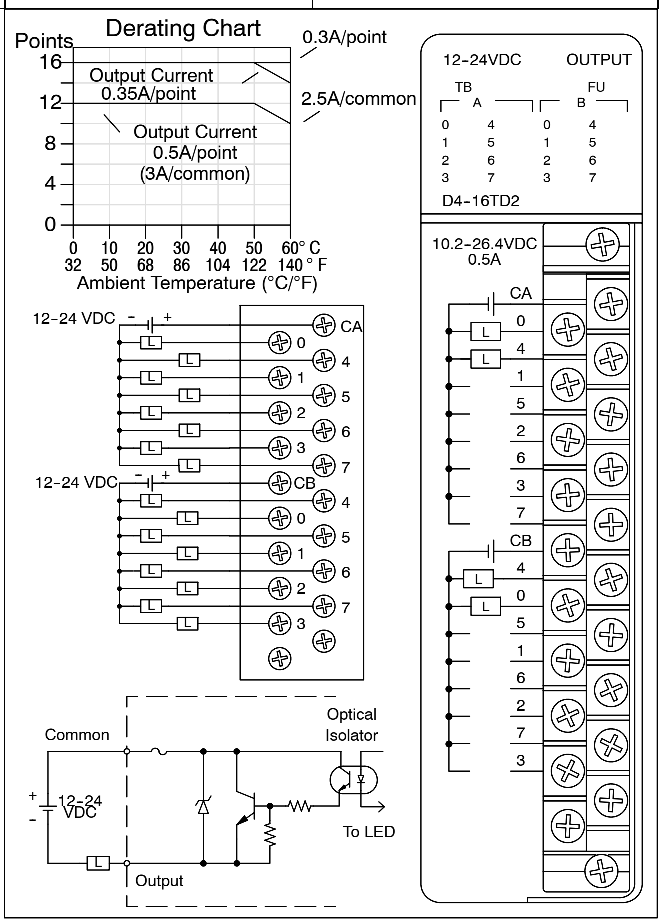
D4-16TD1 5-24 VDC Output

Outputs per module	16 (current sinking)
Commons per module	2 internally connected
Operating voltage / peak	4.5–26.4VDC, 40 VDC Peak
Output type	NPN Open collector
ON voltage drop	0.5V @ 0.5A, 0.2V @ 0.1A
Max current (resistive)	0.5A / point, 3A / common
Max leakage current	0.1mA @ 40VDC
Max inrush current	2A for 10 ms, 1A for 100 ms
Minimum load	0.2mA
Base power required 5V	200mA max
External DC required	24VDC ±10% @125mA
OFF to ON response	0.5 ms
ON to OFF response	0.5 ms
Terminal type	Removable
Status indicators	Logic Side
Weight	9.5 oz. (270 g)
Fuses (non-replaceable)	1 (5A) per common



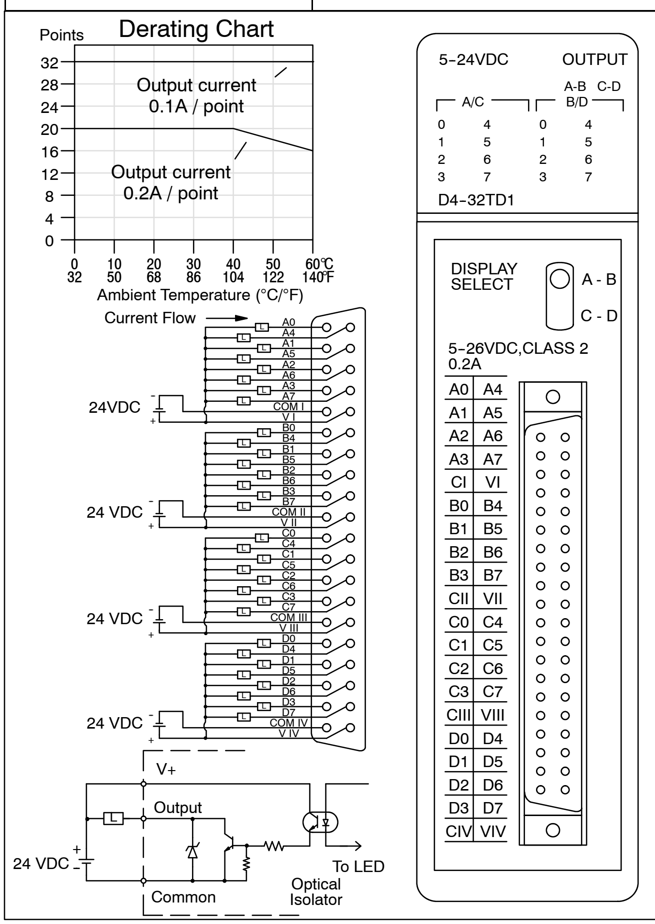
D4-16TD2, 12–24 VDC Output

Outputs per module	16 (current sourcing)
Commons per module	2 (isolated)
Operating voltage / peak	10.2–26.4 VDC, 40 VDC Peak
Output type	NPN Emitter Follower
ON voltage drop	1.5 VDC @ 0.5A
Max current (resistive)	0.5A / point, 3A / common @ 50° C, 2.5A /common @ 60°C
Max leakage current	0.1mA @ 40 VDC
Max inrush current	2A for 10 ms, 1A for 100 ms
Minimum load	0.2mA
Base power required 5V	400mA max
External DC required	None
OFF to ON response	1 ms
ON to OFF response	1 ms
Terminal type	Removable
Status indicators	Logic Side
Weight	9.8 oz. (280 g)
Fuses (non-replaceable)	1 (5A) per common



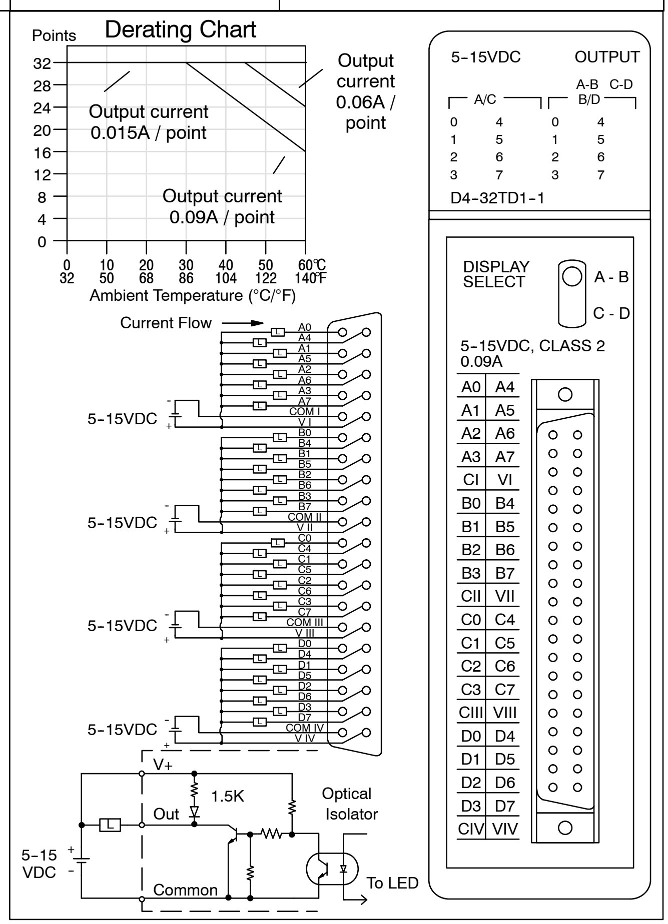
D4-32TD1, 5-24VDC Output

Outputs per module	32 (current sinking)
Commons per module	4 (isolated)
Operating voltage	4.75-26.4 VDC
Output type	NPN Open Collector
Peak voltage	36 VDC
ON voltage drop	0.6 VDC @ 0.2A
Max current (resistive)	0.2A / point, 1.6A / common
Max leakage current	0.1mA @ 36 VDC
Max inrush current	1A for 10 ms, 0.5A for 100 ms
Minimum load	0.1mA
Base power required 5V	250mA max
External DC required	24VDC ±10%, 140mA max
OFF to ON response	0.1 ms
ON to OFF response	0.1 ms
Terminal type	Removable
Status indicators	Logic Side
Weight	6.7 oz. (190 g)
Fuses	None



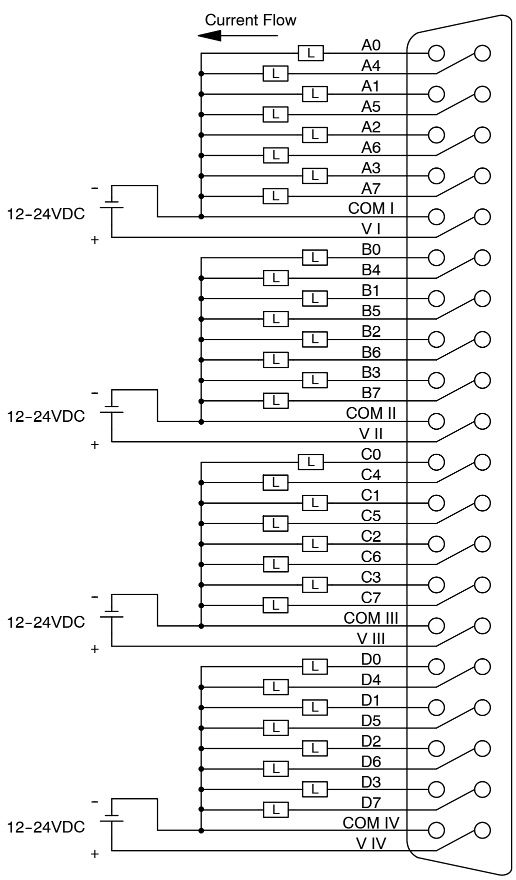
D4-32TD1-1, 5-15VDC Output

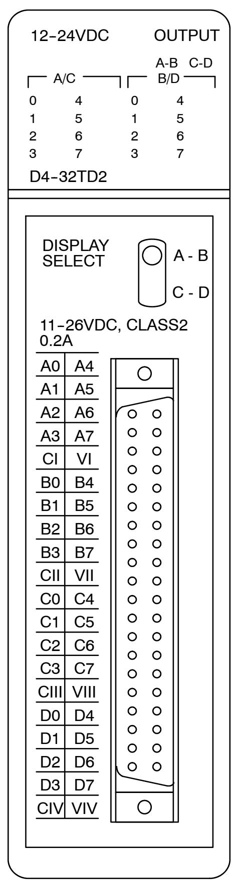
Outputs per module	32 (current sinking)
Commons per module	4 (isolated)
Operating voltage	5-15 VDC
Output type	NPN Open Collector (w / pullup)
Peak voltage	16.5 VDC
ON voltage drop	0.4 VDC @ 0.1A
Max current (resistive)	0.09A/pt, 0.72A/com, 2.88A/ mod.
Max leakage current	0.01mA @ 16.5 VDC
Max inrush current	0.5A for 10ms, 0.2A for 100ms
Minimum load	0.15mA
Base power req., 5V	250mA max
External DC required	5-15VDC ±10%, 150mA max
OFF to ON response	0.1 ms
ON to OFF response	0.1 ms
Terminal type	Removable
Status indicators	Logic Side
Weight	6.7 oz. (190 g)
Fuses	None

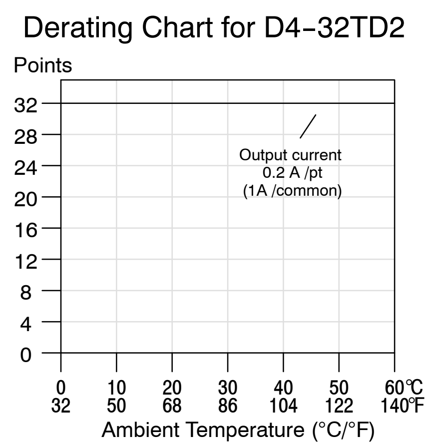


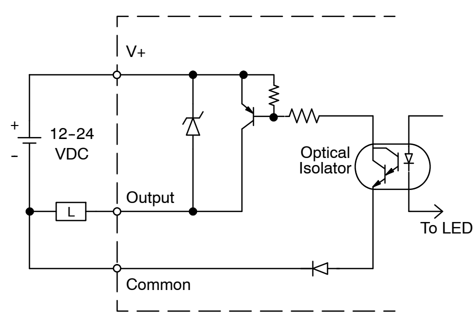
D4-32TD2, 12-24 VDC Output Module

Outputs per module	32 (current sourcing)	External DC required	10.8-26.4VDC 1A / common including load
Commons per module	4 (isolated)		
Operating voltage	10.8-26.4 VDC		
Output type	PNP Open Collector	OFF to ON response	< 0.2 ms
Peak voltage	30 VDC	ON to OFF response	< 0.2 ms
ON voltage drop	0.6 VDC @ 0.2A	Terminal type	Removable
Max current (resistive)	0.2A / point 1.0A / common 4.0A / module	Status indicators	Logic Side
		Weight	6.7 oz. (190 g)
Max leakage current	0.01mA @ 26.4 VDC	Fuses	None
Max inrush current	500 mA for 10 ms		
Minimum load	0.2mA		
Base power required 5V	350mA max		







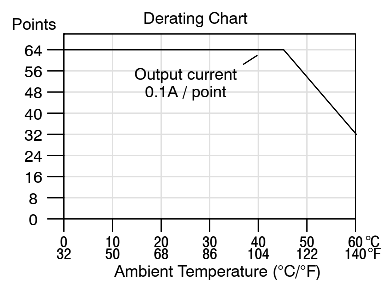


Only 16 status points can be displayed at one time on the front of the module.
In the A - B position the status of the first group of 16 output points (A0-A7, B0-B7) is displayed.
In the C - D position the status of the second group of 16 output points (C0-C7, D0-D7) is displayed.

D4-64TD1, TTL/CMOS/5-24 VDC Output Module

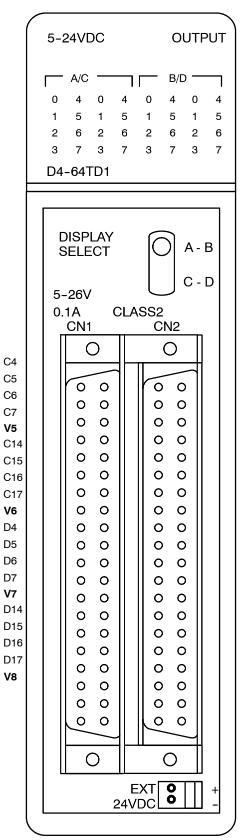
Module Location	CPU base only *
Outputs per module	64 (current sinking)
Commons per module	8 (non-isolated)
Operating voltage	4.75-26.5 VDC
Output type	NPN Open Collector
Peak voltage	36 VDC
ON voltage drop	0.6 VDC @ 0.1A
Max current (resistive)	0.1A / point 1.0A / common 8.0A / module
Max leakage current	0.01mA @ 36 VDC
Max inrush current	1A for 1 ms 700mA for 100 ms

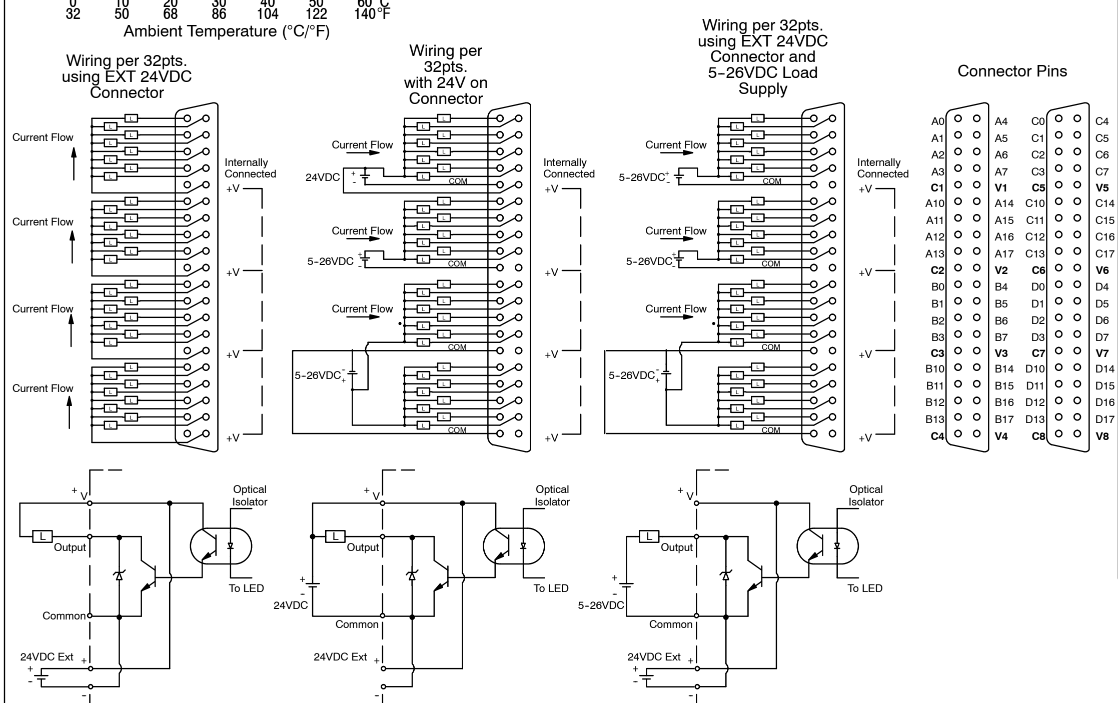
Minimum load	0.1mA
Base power required 5V	800mA max
External DC required	24VDC ±10%, (800mA + 50mA per common) 7.0A total max
OFF to ON response	< 0.1 ms
ON to OFF response	< 0.2 ms
Terminal type	2, Removable 40-pin connectors (sold sep.)
Status indicators	Logic Side
Weight	7.4 oz. (210 g)
Fuses	None



Only 32 status points can be displayed at one time on the front of the module. In the A - B position the status of the first group of 32 output points (A0-A17, B0-B17) are displayed (connector 1). In the C - D position the status of the second group of 32 output points (C0-C17, D0-D17) are displayed (connector 2).

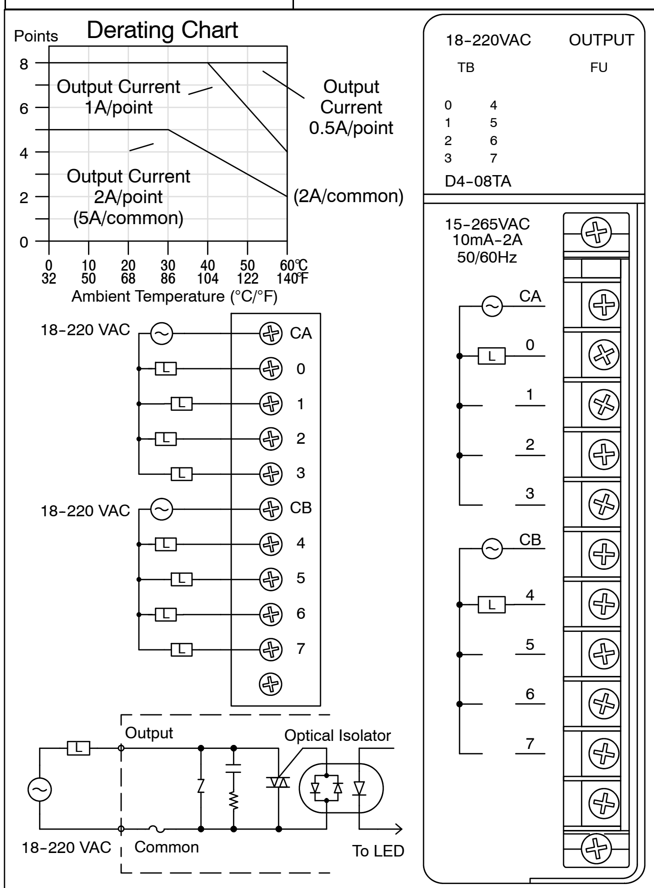
* Module location - this module placement is restricted to the local base on DL430/DL440 systems. It may also be placed in expansion bases in DL450 systems that are using the new (-1) bases.





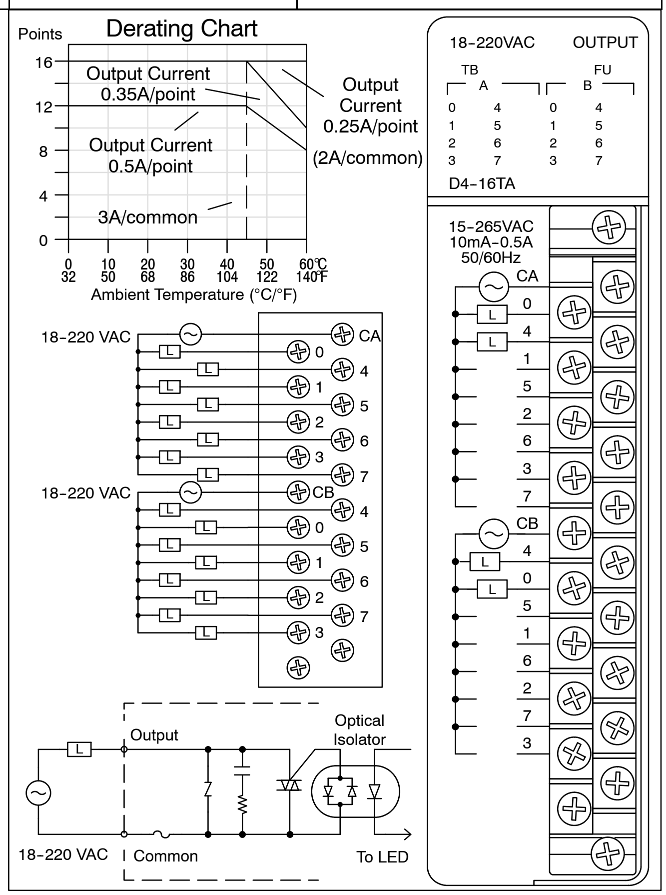
D4-08TA, 18-220VAC Output

Outputs per module	8
Commons per module	2 (isolated)
Operating voltage	15-265VAC
Output type	SSR (triac)
Peak voltage	265VAC
AC frequency	47-63 Hz
ON voltage drop	1.5VAC @ 2A
Max current	2A / point, 5A / com. @ 30°C 2A / common @ 60 °C
Max leakage current	5mA @ 265VAC
Max inrush current	30A for 10 ms, 10A for 100 ms
Minimum load	10 mA
Base power required 5V	250 mA max
OFF to ON response	1 ms
ON to OFF response	1 ms +1/2 AC cycle
Terminal type	Removable
Status indicators	Logic Side
Weight	11.6 oz. (330 g)
Fuses (non-replaceable)	1 (8A) per common



D4-16TA, 18-220VAC Output

Outputs per module	16
Commons per module	2 (isolated)
Operating voltage	15-265VAC
Output type	SSR (triac)
Peak voltage	265VAC
AC frequency	47-63 Hz
ON voltage drop	1.5 VAC @ 0.5A
Max current	0.5A / pt, 3A / common @ 45 °C 2A / common @ 60 °C
Max leakage current	4mA @ 265VAC
Max inrush current	15A for 10 ms, 10A for 100 ms
Minimum load	10 mA
Base power required 5V	450 mA max
OFF to ON response	1 ms
ON to OFF response	1 ms +1/2 AC cycle
Terminal type	Removable
Status indicators	Logic Side
Weight	12.2 oz. (350 g)
Fuses (non-replaceable)	1 (5A) per common

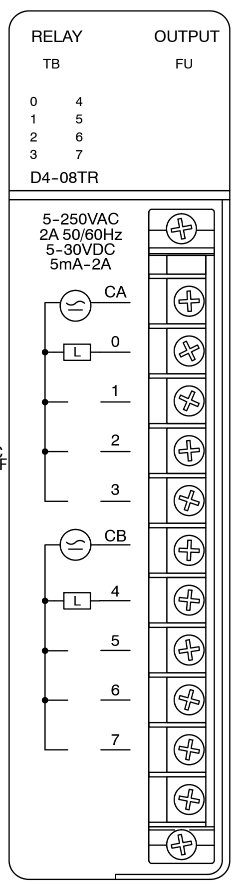


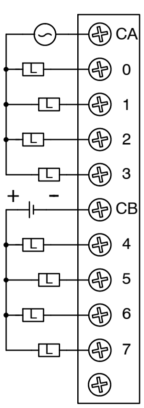
D4-08TR, Relay Output

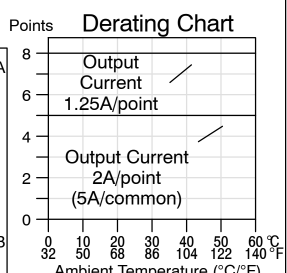
Outputs per module	8 relays
Commons per module	2 (isolated)
Operating voltage	5-30VDC / 5-250VAC
Output type	Form A (SPST-NO)
Peak voltage	30VDC / 256VAC
AC frequency	47-63 Hz
Max current (resistive)	2A / point, 5A / common
Max leakage current	0.1mA @ 265VAC
Max inrush current	2A
Minimum load	5mA
Base power required 5V	550mA max
External DC required	None
OFF to ON response	12 ms
ON to OFF response	12 ms
Terminal type	Removable
Status indicators	Logic Side
Weight	9.1 oz. (260 g)
Fuses (non-replaceable)	1 (8A) per common

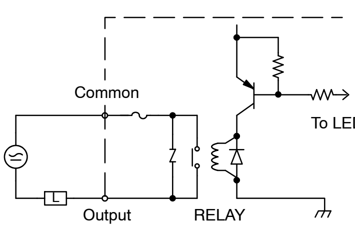
Typical Relay Life (Operations)

Maximum Resistive or Inductive Inrush Load Current	Operating Voltage		
	30VDC	125VAC	250VAC
2A resistive	100K	300K	200K
2A inductive	100K	80K	60K
0.5A resistive	800K	1M	800K
0.5A inductive	300K	300K	200K







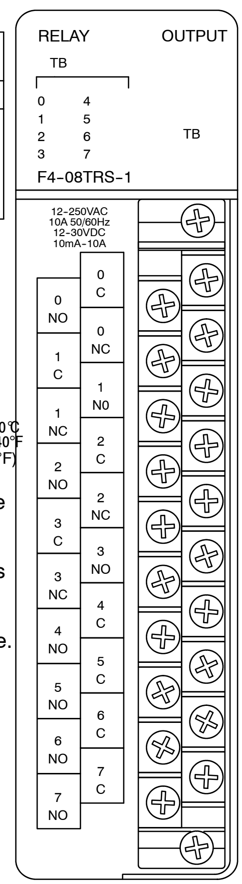


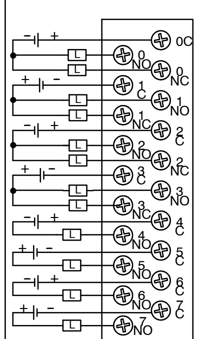
F4-08TRS-1, Relay Output

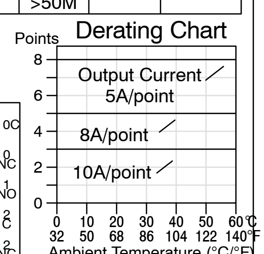
Outputs per module	8 relays
Commons per module	8 (isolated)
Operating voltage:12-30VDC, 12-125VAC, 125-250VAC*	
Output type: 4, Form C (SPDT), 4, Form A (SPST-NO)	
Peak voltage	30VDC / 250VAC @10A
AC frequency	47-63 Hz
Max current (resistive)	10A / point, 40A / module
Max leakage current	0.1mA @ 265VAC
Max inrush current	10A
Minimum load	100mA @12 VDC
Base power required 5V	575mA max
External DC required	None
OFF to ON response	7 ms
ON to OFF response	9 ms
Terminal type	Removable
Status indicators	Logic Side
Weight	13.2 oz. (374 g)
Fuses (non-replaceable)	1 (10A/125V) per common

Typical Relay Life (Operations)

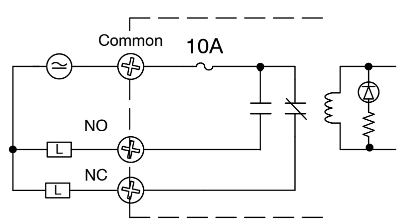
Maximum Resistive or Inductive Inrush Load Current	Operating Voltage		
	30VDC	125VAC	250VAC
1/4 HP		25K	
10.0A	50K	50K	
5.0A	200K	100K	
3.0A	325K	125K	50K
0.5A	>50M		







Maximum DC voltage rating is 120 VDC @ 0.5A, 30,000 cycles typical. Motor starters up to and including NEMA size 3 can be used with this module.

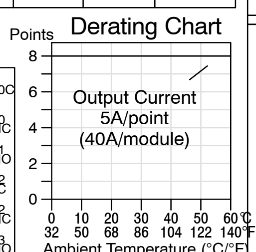


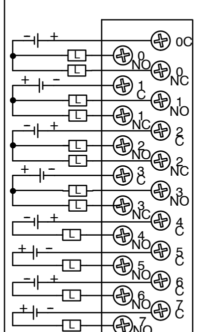
F4–08TRS–2, Relay Output

Outputs per module	8 relays
Commons per module	8 (isolated)
Operating voltage	12–30VDC, 12–250VAC
Output type: 4 Form C (SPDT), 4 Form A (SPST–NO)	
Peak voltage	30VDC / 250VAC @5A
AC frequency	47–63 Hz
Max current (resistive)	5A / point, 40A / module
Max inrush current	10A
Minimum load	100mA @12 VDC
Base power required 5V	575mA max
External DC required	None
OFF to ON response	7 ms
ON to OFF response	9 ms
Terminal type	Removable
Status indicators	Logic Side
Weight	13.8 oz. (390 g)
Fuses, (user replaceable)	1 (10A, 250V) per common 19379–K–10A Wickman

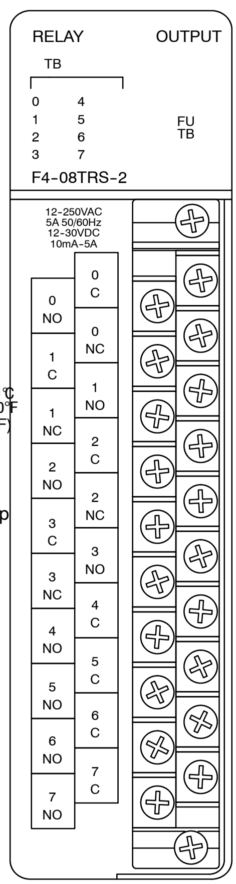
Typical Relay Life (Operations)

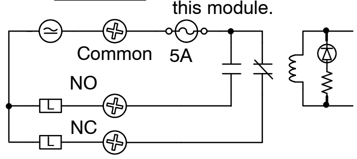
Maximum Resistive or Inductive Inrush Load Current	Operating Voltage		
	28VDC	120VAC	240VAC
5.0A 3.0A .05A	200K 325K >50M	100K 125K	50K



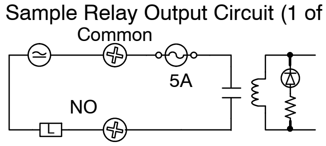


Maximum DC voltage rating is 120 VDC @ 0.5A, 30,000 cycles typical. Motor starters up to and including NEMA size 3 can be used with this module.





Sample Relay Output Circuit (1 of 4)



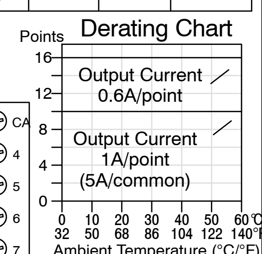
Sample Relay Output Circuit (1 of 4)

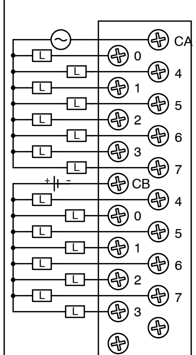
D4–16TR, Relay Output

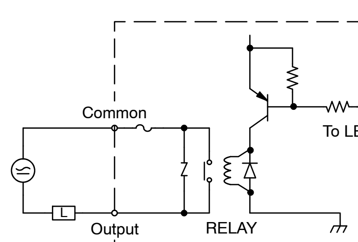
Outputs per module	16 relays
Commons per module	2 (isolated)
Operating voltage	5–30VDC / 5–250VAC
Output type	Form A (SPST–NO)
Peak voltage	30VDC / 256VAC
AC frequency	47–63 Hz
Max current (resistive)	1A / point, 5A / common
Max leakage current	0.1mA @ 265VAC
Max inrush current	4A
Minimum load	5mA
Base power required 5V	1000mA max
External DC required	None
OFF to ON response	10 ms
ON to OFF response	10 ms
Terminal type	Removable
Status indicators	Logic Side
Weight	10.9 oz. (310 g)
Fuses (non-replaceable)	1 (8A) per common

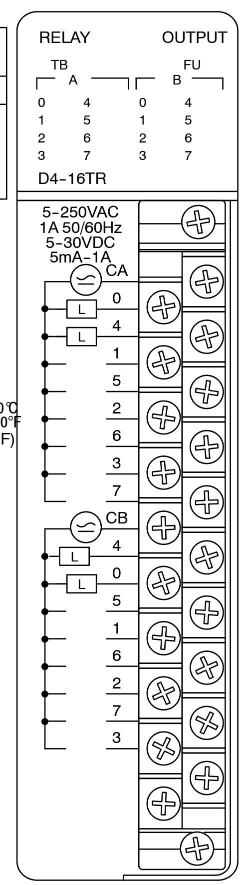
Typical Relay Life (Operations)

Maximum Resistive or Inductive Inrush Load Current	Operating Voltage		
	30VDC	125VAC	250VAC
1A resistive 1A inductive 0.5A resistive 0.5A inductive	>1M 400K >2M >1M	500K 200K 800K 300K	300K 100K 500K 200K









Glossary of Specification Terms

Inputs or Outputs Per Module	Indicates number of electrical input or output points per module and designates current sinking, current sourcing, or either.
Commons Per Module	Number of electrical commons per module. A common is a connection to an input or output module which is shared by multiple I/O circuits. It is ususally in the return path to the power supply of the I/O circuit.
Input Voltage Range	The operating voltage range of an input circuit, measured from an input point to its common terminal, when the input is ON.
Output Voltage Range	The output voltage range of an output circuit, measured from an output point to its common terminal, when the output is OFF.
Peak Voltage	Maximum voltage allowed for an input or output circuit for a short duration.
AC Frequency	AC modules are designed to operate within a specific frequency range.
ON Voltage Level	The minimum voltage level at which an input point will turn ON.
OFF Voltage Level	The maximum voltage level at which an input point will turn OFF.
Input Impedance	The electrical resistance measured between an input point and its common point. Since this resistance is non-linear, it may be listed for various input currents.
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.
Minimum Load	The minimum load current required for an output circuit to operate properly.
External DC Required	Some output modules require external power for the output circuitry.
On Voltage Drop	Sometimes called “saturation voltage”, it is the voltage measured from an output point to its common terminal when the output is ON, at max. load.
Maximum Leakage Current	The maximum current a connected maximum load will receive when the output point is OFF.
Maximum Inrush Current	The maximum current used by a load for a short duration upon an OFF to ON transition of a output point. It is greater than the normal ON state current and is characteristic of inductive loads in AC circuits.
Base Power Required	The +5VDC power from the base required to operate the module. Be sure to observe the base power budget calculations.
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. These LEDs are electrically located on the logic (CPU) side of the I/O interface circuit.
Terminal Type	Indicates whether the module’s connector is removable or non-removable.
Weight	Indicates the weight of the module. See Appendix E for a list of the weights for the various DL405 components.
Fuses	Protective device for an output circuit, which stops current flow when current exceeds the fuse rating current. It may be replaceable or non-replaceable, or located externally or internally.