INSTALLATION AND WIRING

CHAPTER
8

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. 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. These publications can be ordered 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.

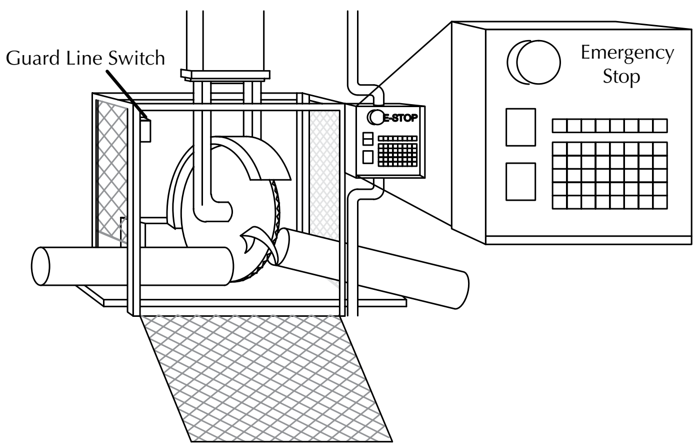
- Emergency stop switch for disconnecting system power
- Mechanical disconnect for output module power
- Orderly system shutdown sequence in the PLC control program

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.).



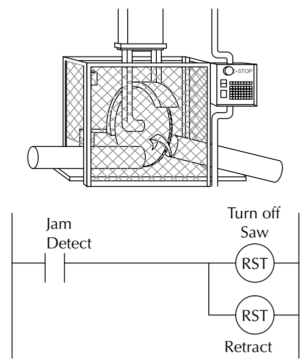
Emergency Power Disconnect

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 usually found are 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, Zone 2 Approval

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

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

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

WARNING: All models used with connector accessories must use R/C (ECBT2) mating plug for all applicable models. All mating plugs shall have suitable ratings for device.

WARNING: This equipment is designed for use in Pollution Degree 2 environments (installed within an enclosure rated at least IP54).

WARNING: Transient suppression must be provided to prevent the rated voltage from being exceeded by 140%.

Mounting Guidelines

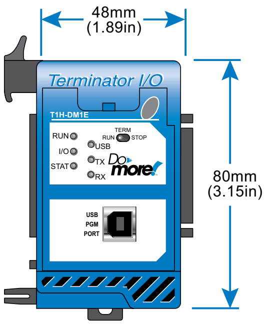
Before installing the Terminator system you will need to know the dimensions of the components. The diagrams on the following pages provide the component dimensions to use in defining your enclosure specifications. Remember to leave room for potential expansion.

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

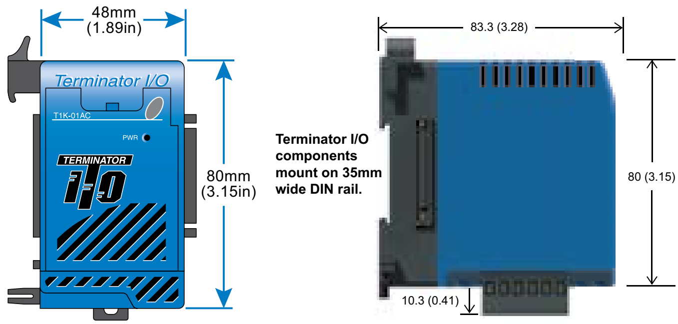
Dimensions

The following diagrams show the, CPU, base controller, power supply and I/O module dimensions. Terminator components mount on 35mm wide DIN rail.

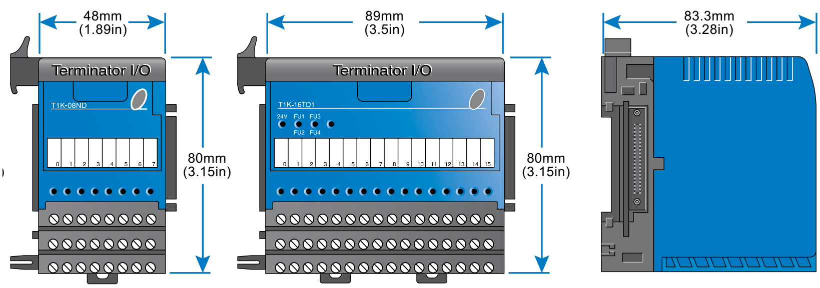
CPU



Base Controller/Power Supply



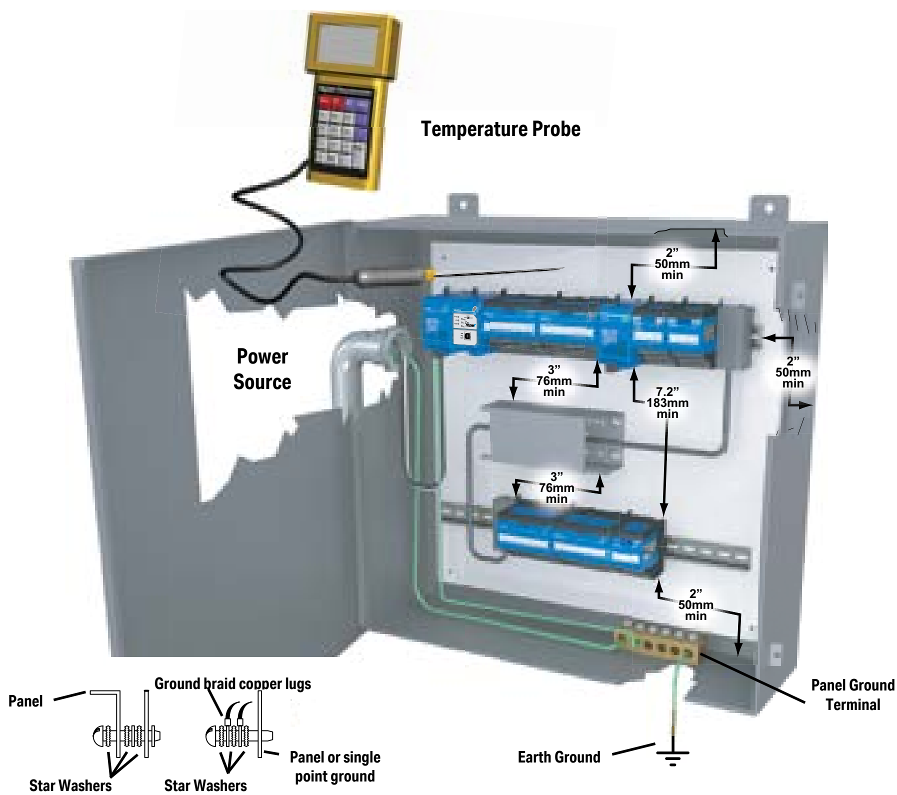
I/O Modules



Panel Mounting and Layout

It is important to design your panel properly to help ensure that the Terminator products operate within their environmental and electrical limits. The system installation should comply with all appropriate electrical codes and standards. It is important that the system also conforms to the operating standards for the application to insure proper performance.

1. Only mount the unit horizontally as shown to provide proper ventilation.
2. If you place more than one unit in a cabinet, there should be a minimum of 7.2" (183 mm) between them.
3. Provide a minimum clearance of 2" (50mm) between the units and all sides of the cabinet. There should also be at least 1.2" (30mm) of clearance between the base and any wiring ducts.



4. There must be a minimum of 2″ (50mm) clearance between the panel door and the nearest Terminator component.
5. The ground terminal on the Terminator power supply 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. A general rule is to achieve a 0.1 ohm of DC resistance between the Terminator I/O slave and the single point ground.
6. 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 12AWG 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 region. A good common ground reference (earth ground) is essential for proper operation of the Terminator system. There are several methods of providing an adequate common ground reference, including: a) Installing a ground rod as close to the panel as possible. b) Connection to incoming power system ground.
7. Properly evaluate any installation where the ambient temperature may approach the lower or upper limits of the specifications. 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 Terminator system, measure points in the panel in consideration for installing a cooling/heating source to provide the ambient temperature to meet the Terminator I/O operating specifications.
8. 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, other coating or corrosion should be removed in the area of contact.
9. The system is designed to be powered by 110/220 VAC or 24VDC 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 Terminator system. Applications of Terminator 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

Environmental Specifications

The following table lists the environmental specifications that apply to the Terminator modules. Be sure to check the specifications of the controller you are using. Also refer to the appropriate I/O module specifications, mentioned in earlier chapters, for the temperature derating curves for the specific module.

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) Impulse noise 1μs, 1000V FCC class A RFI (144MHz, 430MHz 10W, 10cm)
Atmosphere	No corrosive gases. The level for the environmental pollution = 2. (UL840)

***Equipment will operate at low humidity. However, static electricity problems occur much more frequently at lower humidity levels. 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.**

Power

The power source must be capable of supplying voltage and current complying with the base power supply specifications.

Specification	AC Power Supply	DC Power Supply
Part Number	T1K-01AC	T1K-01DC
Input Voltage Range	110/220 VAC (85–264 VAC) 50/60 Hz (47–63 Hz)	12/24 VDC (10.8–26.4 VDC) with less than 10% ripple
Maximum Inrush Current	20A	10A
Maximum Power	50VA	20W
Voltage Withstand (dielectric)	1 minute @ 1500VAC between primary, secondary, field ground	
Insulation Resistance	>10MΩ at 500VDC	
Auxiliary 24 VDC Output	20–28 VDC, 10% ripple max. 300mA. A max. of 500mA @ 24VDC can be achieved if the 5VDC power budget rating of 2000mA is reduced to 1500mA. See power budget section.	None

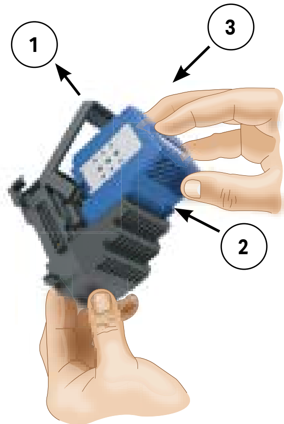
Agency Approvals

Some applications require agency approvals. Typical agency approvals which your application may require are:

- UL (Underwriters' Laboratories, Inc.)
- CSA (Canadian Standards Association)
- FM (Factory Mutual Research Corporation)
- CUL (Canadian Underwriters' Laboratories, Inc.)

Assembling the Components

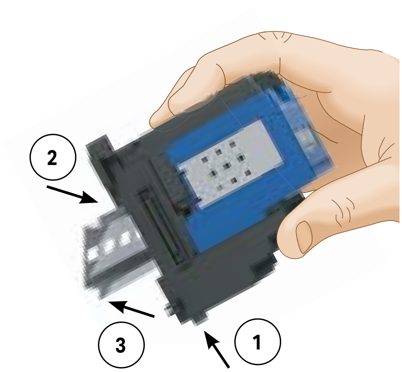
Assembling the I/O Modules and Bases

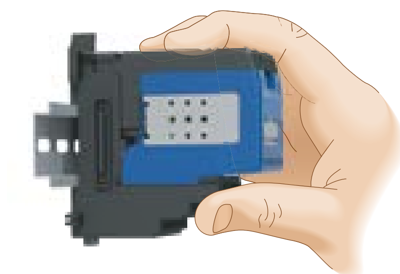


INSERT MODULE INTO BASE

1. Pull base arm back to allow space for module to enter base.
2. Align module slides with base track.
3. Press module firmly into base.

Mounting the Components on DIN Rail





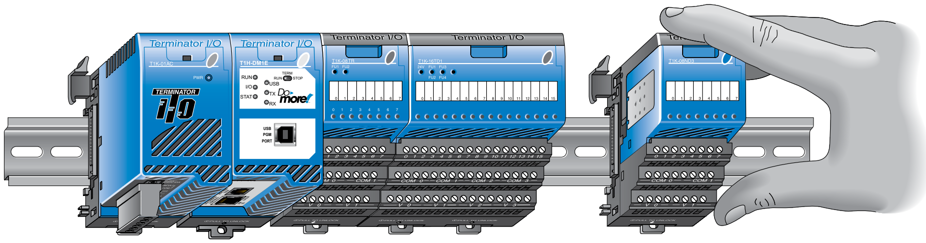
NOTE: *Do not force the module on the DIN rail. Due to slight size variations in different manufacturers' DIN rail, it may be necessary to first unlatch the locking tab, rotate the module into place, then latch the locking tab.*

INSTALL ON DIN RAIL

1. Make sure the locking tab is in the latched position (pushed in).
2. Hook upper tab over upper flange of DIN rail.
3. Tilt the unit toward DIN rail until it snaps securely to DIN rail.

Connecting the Components on the DIN Rail

SLIDE ASSEMBLY INTO POSITION ON THE DIN RAIL

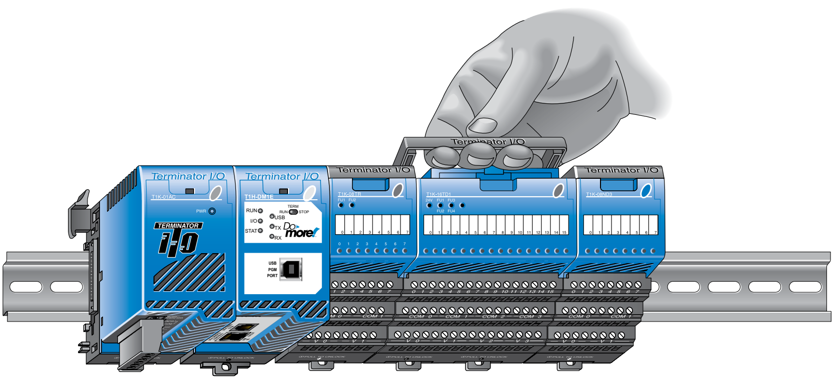


Slide the module assembly on the DIN rail until the clip arm attaches securely to the adjacent module.

NOTE: *One power supply is required in the leftmost component position followed by the CPU. Additional power supplies should be added between I/O modules as necessary to meet power budget requirements. Each power supply powers the modules to its right, but is interrupted by the next power supply.*

Removing I/O Modules from the Base

To remove a module from the base, grip the center of the base arm and rotate outward



releasing the module. Lift the module from the base.

To remove a module assembly from the DIN rail, lift the clip arm up and slide the module assembly away from the adjacent module. Pull the locking tab down (out) and lift the assembly off the DIN rail.

WARNING: The T1H Series PLC does not support any Hot-Swap features.

Multiple Power Supplies / Local Expansion Configurations

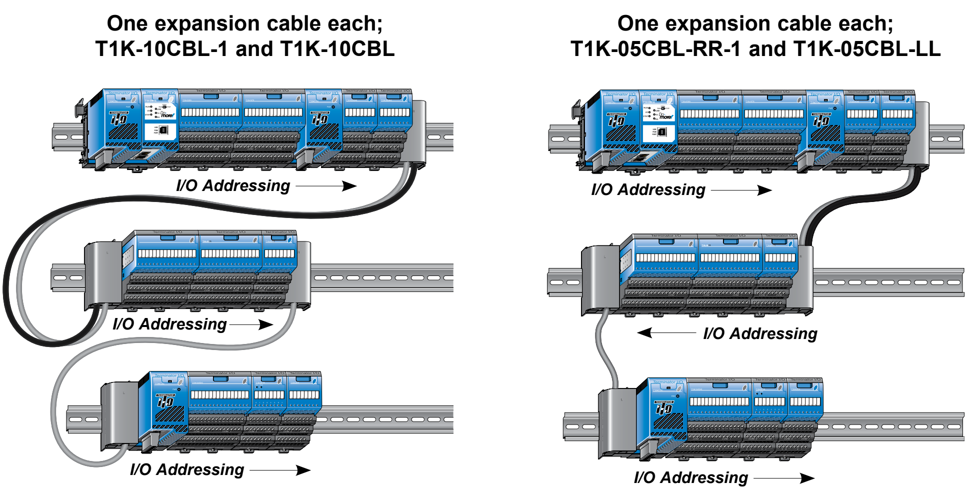
Multiple Power Supply Configuration

It is possible to have multiple power supplies in a single slave (node) system to meet power budget requirements. **One power supply is required in the leftmost component position followed by the CPU.** Additional power supplies should be added between I/O modules as necessary to meet power budget requirements. There are some restrictions on where power supplies can be placed in the system when using the T1K-05CBL-RR(-1) expansion base cable. Each power supply powers the modules to its right, but is interrupted by the next power supply. Each slave (node) system can be divided into one row of base I/O plus two rows of local expansion I/O up to a total of 16 I/O modules.

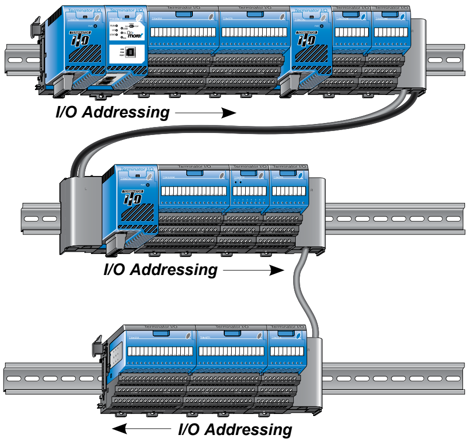
Expansion cables are available in two configurations: one that allows 24VDC base power to pass and one that does not (both cables pass the 5VDC base power). The ("-1") version of the expansion cables pass 24VDC on an isolated wire. Any local expansion DC input modules configured for "internal power" (current sourcing) must either have a power supply preceding it on the same base or have a ("-1") version cable pass 24VDC from a power supply on the preceding base.

Overview of I/O Expansion Configurations

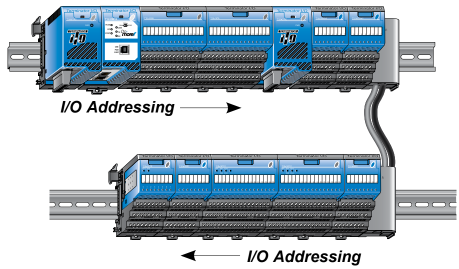
There are several expansion I/O system configurations that can be created by using the local expansion cables. There are some restrictions on where power supplies can be placed in the system when using the T1K-05CBL-RR-1 expansion base cable.



One expansion cable each; T1K-10CBL-1 and T1K-05CBL-RR

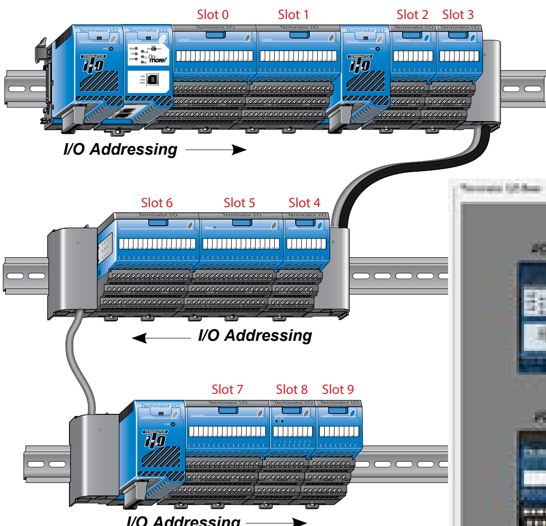


T1K-05CBL-RR-1 Expansion Cable



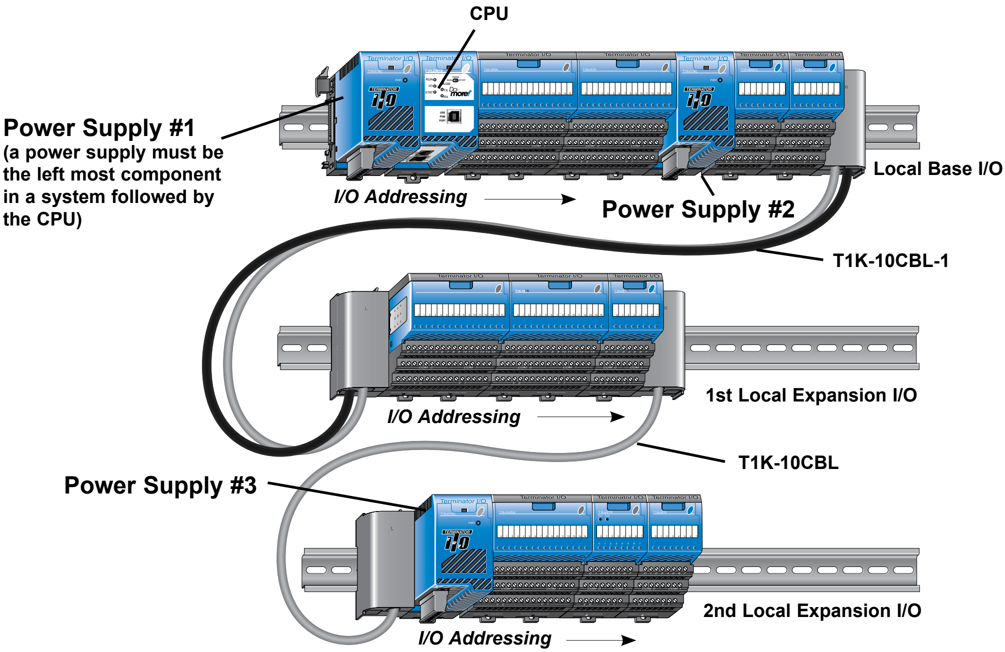
***NOTE:** When an expansion cable connects the right side of two units together (RR in the cable part number), note that the I/O addressing of the downstream I/O is numbered right to left instead of left to right. However, the CPU detects modules in sequence from the nearest to the furthest and is unaware of the presence of expansion cables and extra power supplies. The display in Do-more Designer will reflect that. Do-more Designer only shows units left to right, in order (see below). The display in Do-more Designer is not intended to represent the physical layout, just the layout as the I/O is addressed.*

Physical Layout



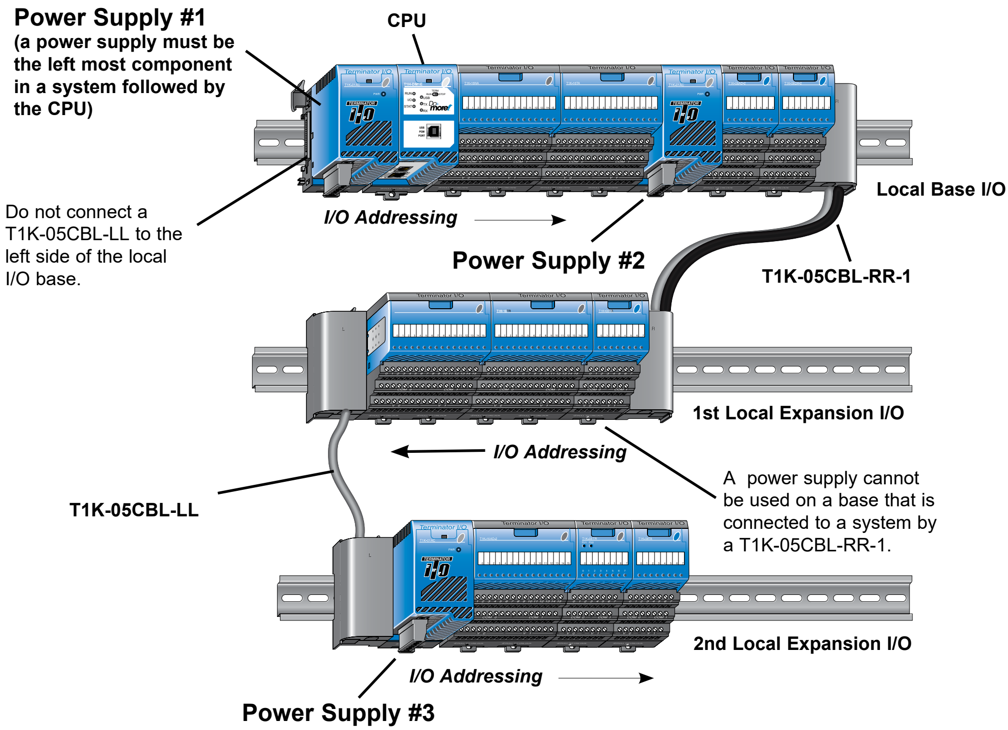
Layout represented in Do-more Designer

Example Using T1K-10CBL-1 and T1K-10CBL Expansion Cables



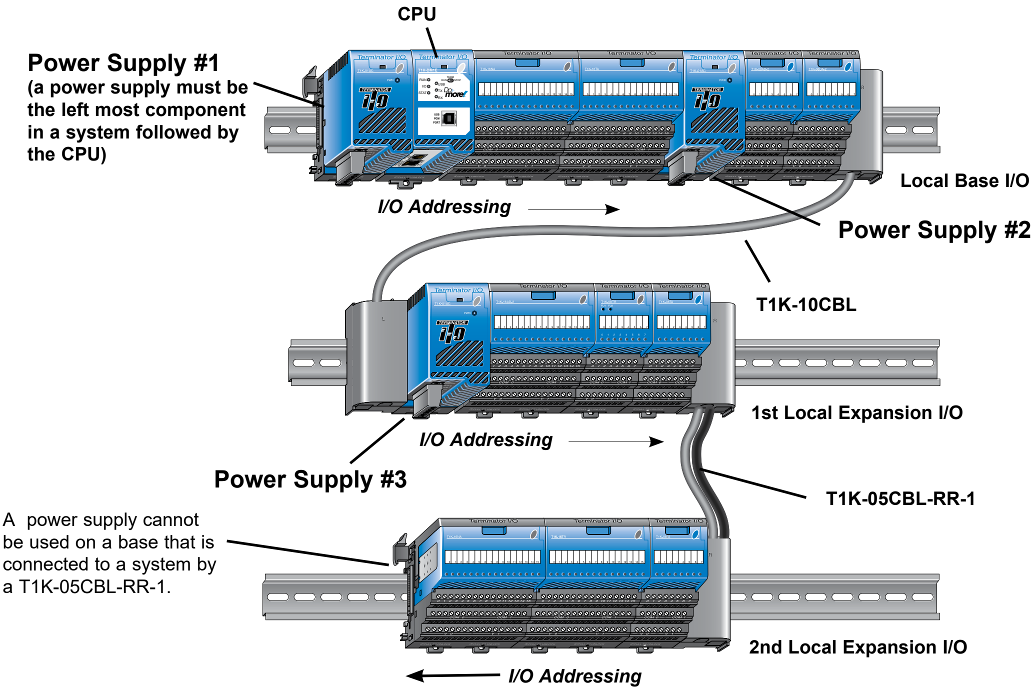
System shown above: The first power supply powers the CPU and the two I/O modules to its right. The second power supply powers the two modules to its right and the three I/O modules on the first local expansion base. Power Supply #3 powers the three I/O modules to its right on the second local expansion base. This is only an example and the power budget requirements vary depending on the I/O modules used.

Example Using T1K-05CBL-RR-1 and T1K-05CBL-LL Expansion Cables



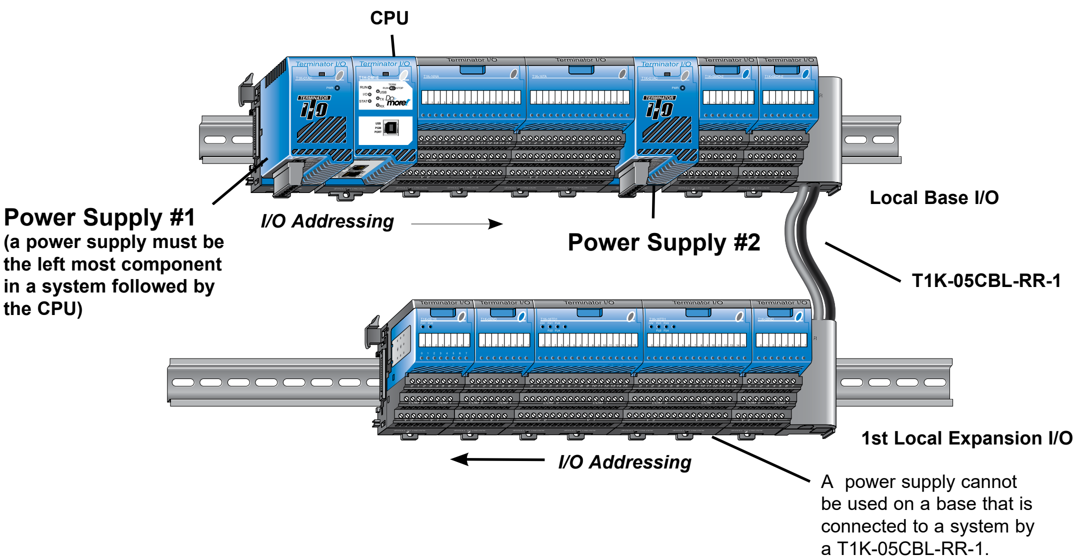
System shown above: The first power supply powers the CPU and the two I/O modules to its right. The second power supply powers the two modules to its right and the three I/O modules on the first local expansion base. When a T1K-05CBL-RR-1 is used, the expansion I/O assignments are from right to left (reversed). A power supply cannot be used on a base that is connected to a system by a T1K-05CBL-RR-1. Power Supply #3 powers the three I/O modules to its right on the second local expansion base. This is only an example and the power budget requirements vary depending on the I/O modules used.

Example Using T1K-10CBL and T1K-05CBL-RR-1 Expansion Cables



System shown above: The first power supply powers the CPU and the two I/O modules to its right. The second power supply powers the two modules to its right. Power Supply #3 powers the three I/O modules to its right on the first local expansion base and the three I/O modules on the second local expansion base. When a T1K-05CBL-RR-1 is used, the expansion I/O assignments are from right to left (reversed). A power supply cannot be used on a base that is connected to a system by a T1K-05CBL-RR-1. This is only an example and the power budget requirements vary depending on the I/O modules used.

Example Using T1K-05CBL-RR-1 Expansion Cables

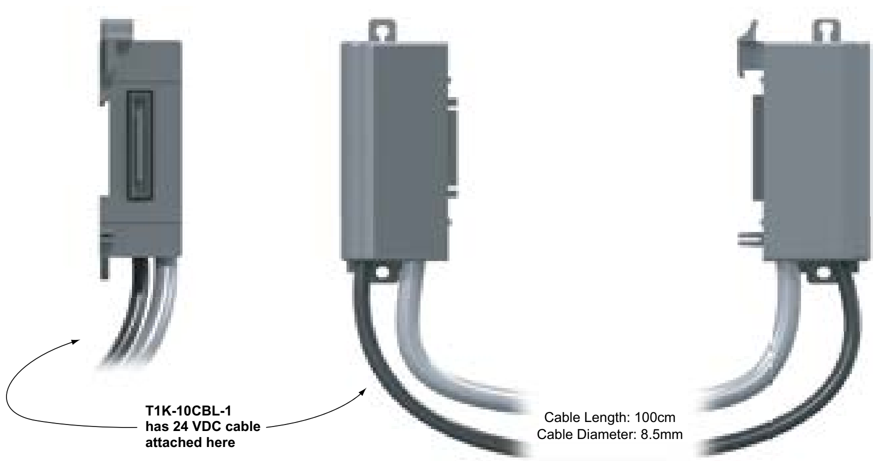


System shown above: The first power supply powers the CPU and the two I/O modules to its right. The second power supply powers the two modules to its right and the five I/O modules on the first local expansion base. When a T1K-05CBL-RR-1 is used, the expansion I/O assignments are from right to left (reversed). A power supply cannot be used on a base that is connected to a system by a T1K-05CBL-RR-1. This is only an example and the power budget requirements vary depending on the I/O modules used.

T1K-10CBL, T1K-10CBL-1 Expansion Cable Specifications

Specifications			
Specification		***T1K-10CBL***	***T1K-10CBL-1***
Cable Length		100cm (3.28 ft.)	
Cable Diameter		8.5 mm	
Shielding		None	
Temperature Range		-25°C to 80°C (-13°F to 176°F)	
Jacket Material		PVC	
Auxiliary 24VDC Cable	Cable Diameter	N/A	2 cables used: 1.42 mm each
	Insulation Voltage	N/A	2000VAC / 1 minute

T1K-10CBL(-1)



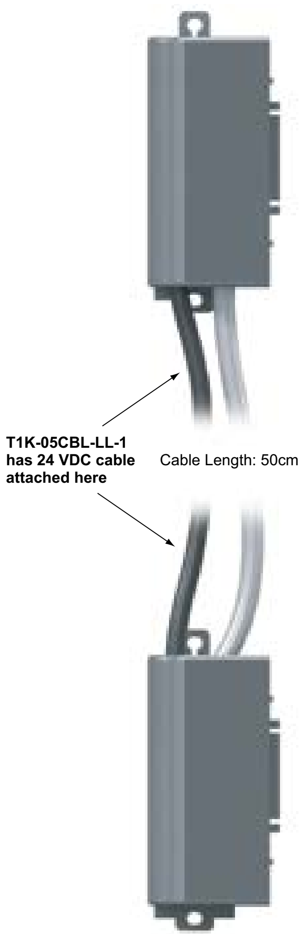
T1K-5CBL-LL(-1) Expansion Cable Specifications

Specifications			
Specification		***T1K-05CBL-LL***	***T1K-05CBL-1-LL-1***
Cable Description		Left-to-left Side Expansion Cable	
Cable Length		50cm (1.64 ft.)	
Cable Diameter		8.5 mm	
Shielding		None	
Temperature Range		-25°C to 80°C (-13°F to 176°F)	
Jacket Material		PVC	
Auxiliary 24VDC Cable	Cable Diameter	N/A	Two 1.42 mm cables used in a 6mm sheath
	Insulation Voltage	N/A	2000VAC / 1 minute

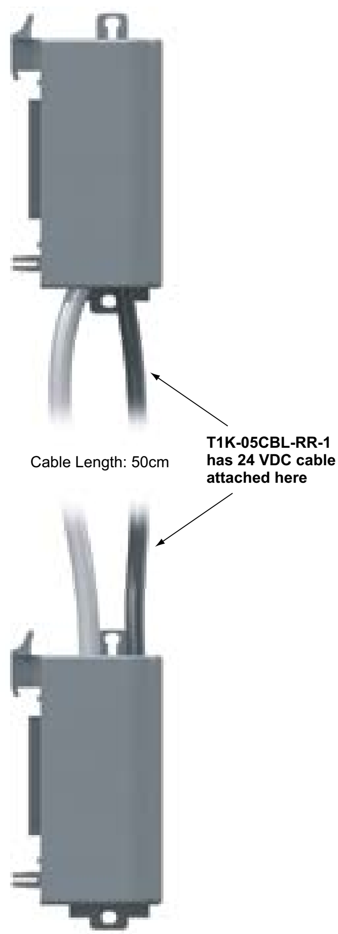
T1K-5CBL-RR(-1) Expansion Cable Specifications

Specifications			
Specification		***T1K-05CBL-RR***	***T1K-05CBL-1-RR-1***
Cable Description		Right-to-right Side Expansion Cable	
Cable Length		50cm (1.64 ft.)	
Cable Diameter		8.5 mm	
Shielding		None	
Temperature Range		-25°C to 80°C (-13°F to 176°F)	
Jacket Material		PVC	
Auxiliary 24VDC Cable	Cable Diameter	-	Two 1.42 mm cables used in a 6mm sheath
	Insulation Voltage	-	2000VAC / 1 minute

T1K-5CBL-LL(-1)



T1K-5CBL-RR(-1)



Wiring Guidelines

Power Wiring

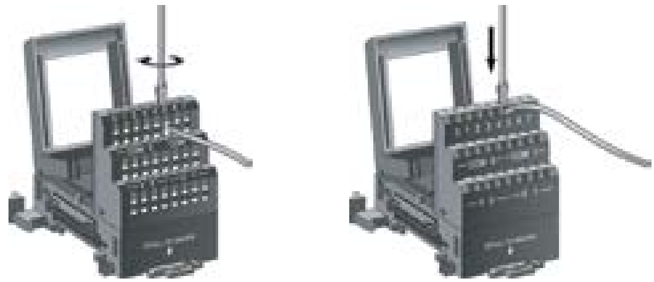
The diagram below shows the terminal connections located on the Terminator AC and DC power supplies. The table below shows the wire size and recommended torque for the power supply screw terminals.

Power Supply	T1K-01AC	T1K-01DC
Wire Size	Solid: 24–12 AWG Stranded: 24–12 AWG	Solid: 24–12 AWG Stranded: 24–12 AWG
Recommended Torque	4.43–5.31 lb·in (0.5–0.6 N·m)	4.43–5.31 lb·in (0.5–0.6 N·m)

Wiring the I/O Module Bases

There are two types of terminal bases for the Terminator I/O modules: screw clamp and spring clamp connectors. The recessed screw heads help minimize the risk of someone accidentally touching active wiring.

WARNING: For some modules, field device power may still be present on the terminal block even though the Terminator I/O system power is turned off. To minimize the risk of electrical shock, check all field device power before you remove a wire.

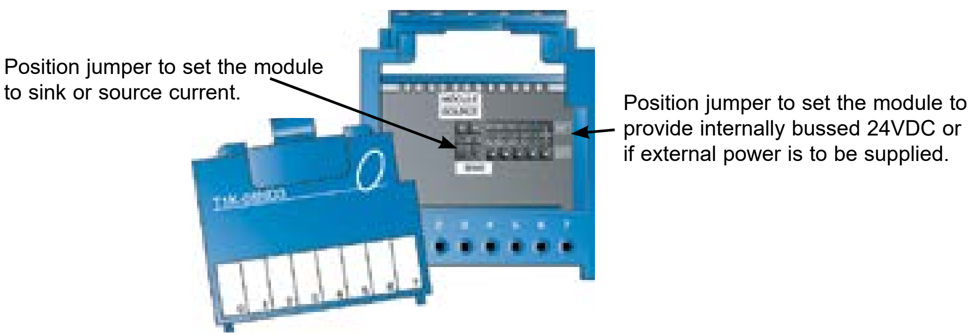


Terminal Type	Screw Type	Spring Clamp
Recommended Torque	1.77–3.54 lb·in (0.2–0.4 N·m)	N/A
Recommended Screwdriver Blade Size	0.02 in. x 0.125 in. (0.5 mm x 3mm)	Push in on clamp using screwdriver blade size: (0.016 x 0.079 to 0.032 x 0.16) in. (0.4 x 2 to 0 .8 x 4) mm
Wire Gauge	Solid conductor: 24–12 AWG Stranded conductor: 24–12 AWG	Solid conductor: 24–14 AWG Stranded conductor: 24–14 AWG (Twist stranded conductors before inserting into gate)

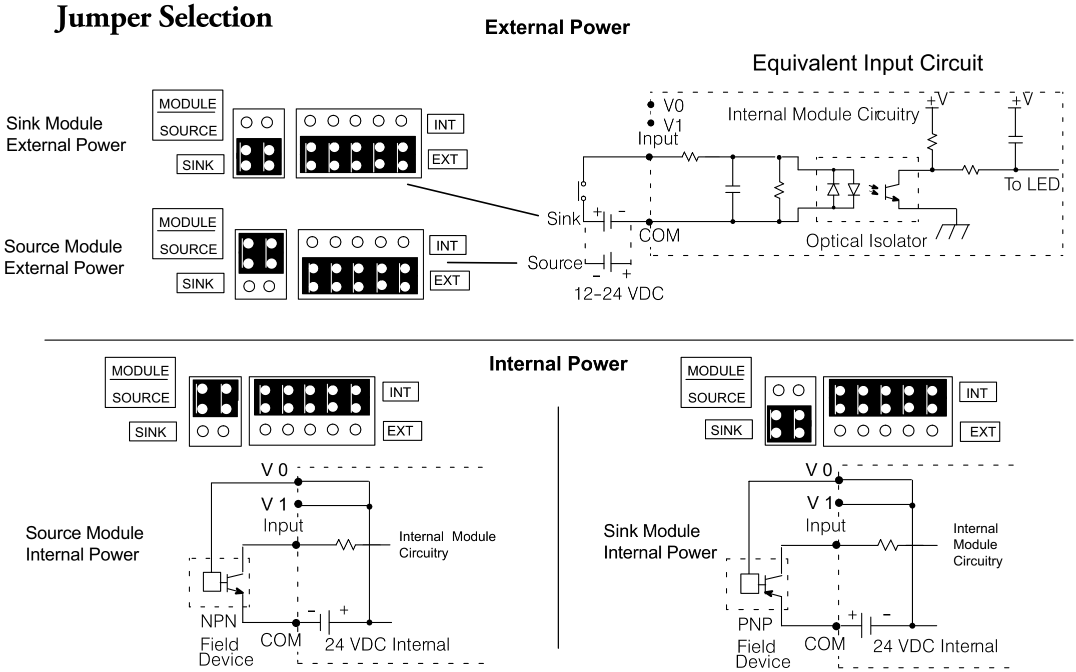
Selecting Internal 24 VDC Power Supply

The DC input field devices can be powered from the integrated 24VDC power supply from the power supply bus. The T1K-08ND3 and T1K-16ND3 DC input modules have jumpers for selecting internal 24VDC power supply available for 2 and 3-wire field devices. The analog I/O and DC output modules do not have direct access to the internal bussed 24VDC.

Jumpers located under top cover of T1K-08ND3 and T1K-16ND3



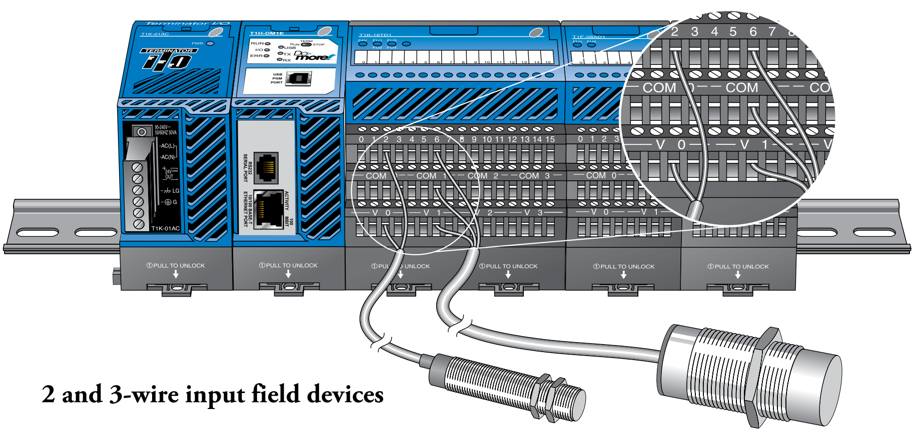
Jumper Selection



Using Internal 24VDC Base Power

The diagram below shows DC input devices using internally bussed 24VDC for power. If the module is set to "sink" current, +24VDC power is supplied to the input module base "COM" terminals and 0VDC is supplied to the module base "V" terminals. If the module is set to "source" current, +24VDC is supplied to the input module base "V" terminals and 0VDC is supplied to the module base "COM" terminals.

Using Internally Bussed 24VDC (T1K-08ND3, T1K-16ND3 only)



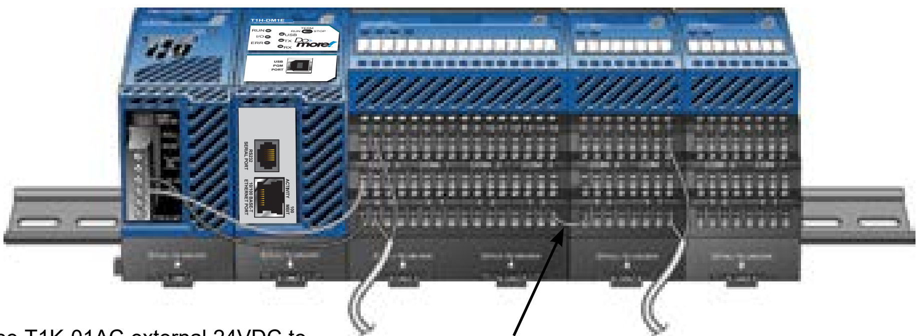
2 and 3-wire input field devices

External 24VDC Wiring Options

DC output and analog I/O modules do not have direct access to the internally bussed 24VDC. External user supplied 24VDC power, or auxiliary 24VDC from the T1K-01AC, can be applied directly to one end of the DC I/O module base terminal (V and COM) rows and jumpered across each base as needed in a system. This creates a "bus" (row) of 24VDC and a bus of 0VDC power. Be sure not to exceed the supply's power budget.

WARNING: The T1H Series PLC does not support any Hot-Swap features.

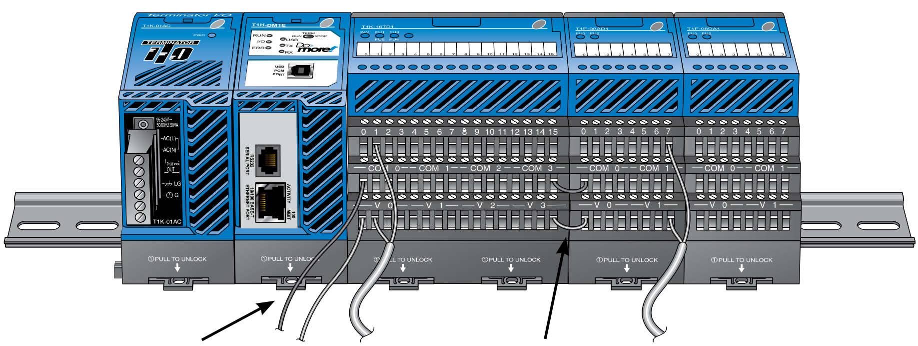
Using T1K-01AC for External 24VDC Power



Use T1K-01AC external 24VDC to create a power bus for DC modules.

Place wire jumpers from one DC I/O module base to another as necessary to continue the external 24VDC power bus.

Using an External 24VDC Power Supply



Use an external 24VDC power supply to create a power bus for the DC modules.

Place wire jumpers from one DC I/O module base to another as necessary to continue the external 24VDC power bus.

I/O Wiring Checklist

Use the following guidelines when wiring the base terminals in your system.

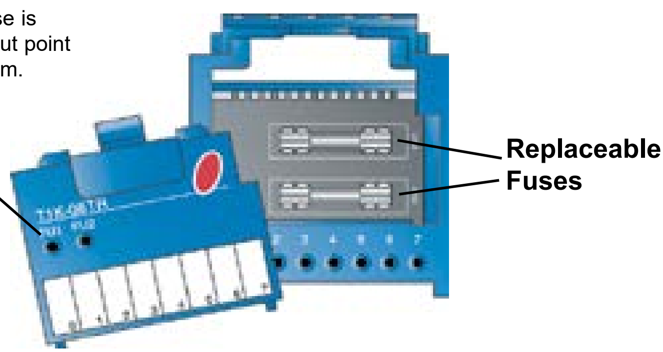
1. There is a limit to the size of wire the terminals can accept. The table on page 8-20 lists the suggested nominal AWG for each terminal base type.
2. Always use a continuous length of wire, do not combine wires to attain a needed length.
3. Use the shortest possible wire length.
4. Use wire trays 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. To reduce the risk of 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.

Output Module Fusing

All Terminator I/O discrete output modules have internal user–replaceable fuses. For fuse specifications and part numbers for a specific output module, refer to the output module specifications in Chapter 5. Be sure to remove system power before attempting to remove the I/O module from its base.

Fuses located under top cover of output modules

Note: A blown fuse indicator illuminates only when a fuse is blown and associated output point is turned ON by the program.

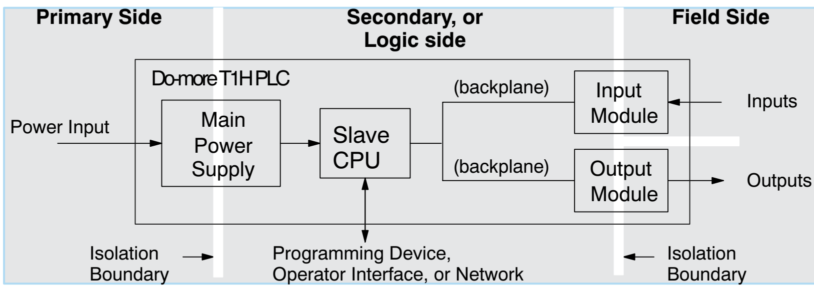


I/O Wiring Strategies

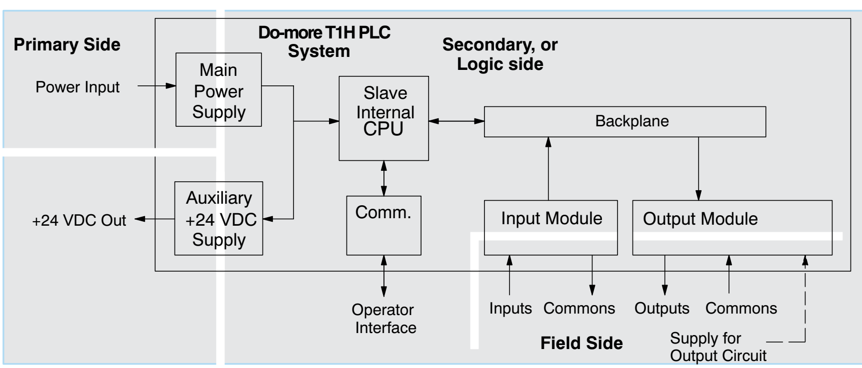
Terminator System Isolation Boundaries

The Terminator 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.

Terminator system 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 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 Terminator I/O system, it is extremely important to avoid making external connections that connect logic side circuits to any other.



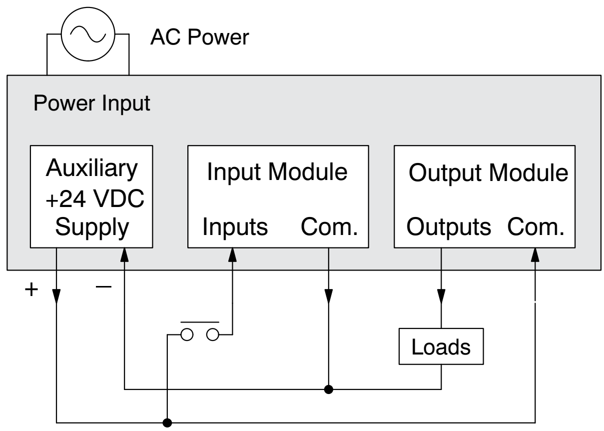
The next figure shows the physical layout of a Terminator system, as viewed from the front. In addition to the basic circuits covered above, AC-powered bases include an auxiliary +24VDC power supply with its own isolation boundary. Since the supply output is isolated from the other three circuits, it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



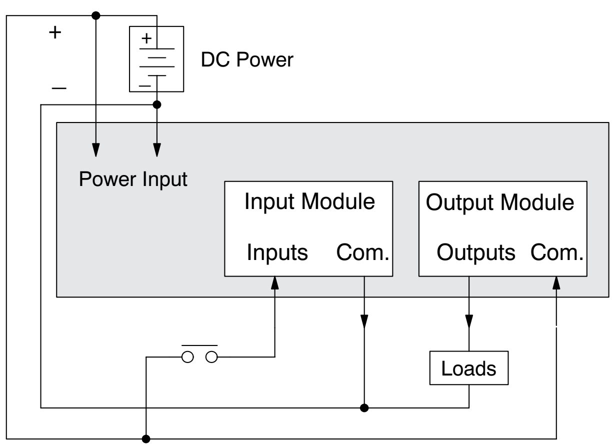
In some cases, using the built-in auxiliary +24VDC supply can result in a cost savings for your control system. It can power combined loads up to 500mA if power budget allows. Be careful not to exceed the current rating of the supply. If you are the system designer for your application, you may be able to select and design in field devices which can use the +24VDC auxiliary supply.

Powering I/O Circuits with the Auxiliary Supply

All AC power supplies feature an 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.



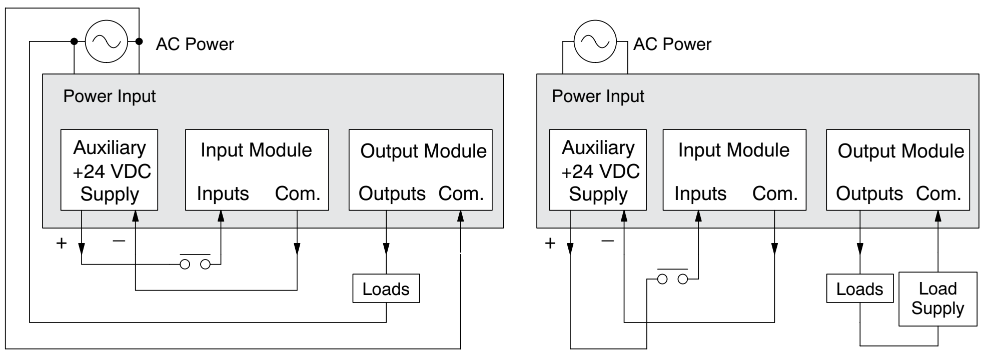
DC-powered units are designed for application environments in which low-voltage DC power is more readily available than AC. These include a wide range of battery-powered applications, such as remotely-located control, in vehicles, portable machines, etc. For this type of application, all input devices 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

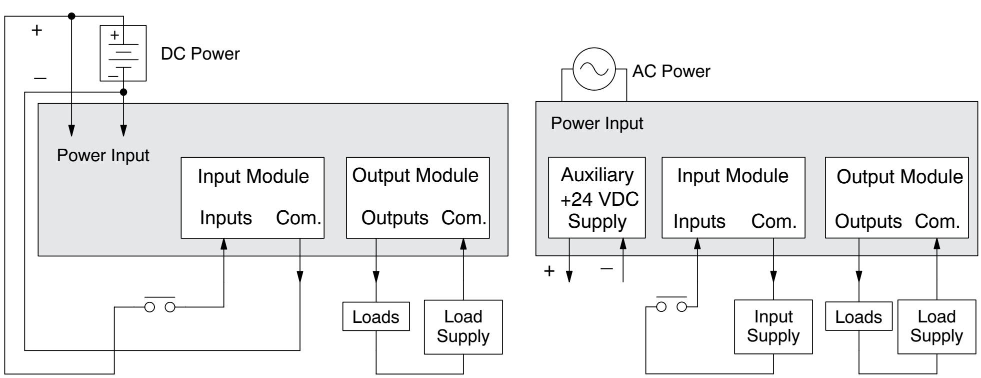
In most applications it will be necessary to power the input devices from one power source, and to power output loads from another source. Loads often require high-energy AC power, while input sensors use low-energy DC. If a machine operator is likely to come in close contact with input wiring, then 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 Terminator I/O system, 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 system supply, then a separate supply must be used as shown to the right in the figure below.



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

A worse-case scenario, from a cost and complexity view-point, is an application which requires separate power sources for the Terminator I/O system, input devices, and output loads. The example wiring diagram below on the right shows how this can work, but also the auxiliary supply output is an unused resource. You will want to avoid this situation if possible.



Sinking / Sourcing Concepts

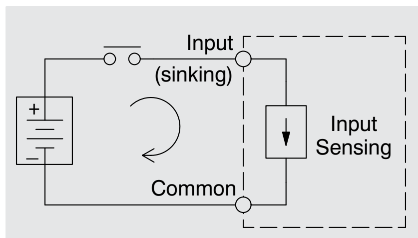
Before going further in the study of wiring strategies, you must have a solid understanding of "*sinking*" and "*sourcing*" concepts. Use of these terms occurs frequently in input or output circuit discussions. It is the goal of this section to make these concepts easy to understand, further ensuring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

Sinking = provides a path to supply ground (-)

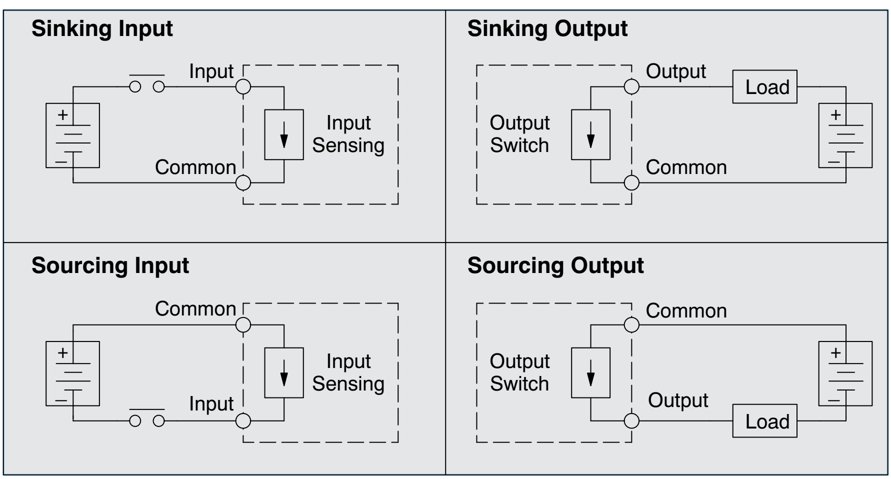
Sourcing = provides a path to supply source (+)

First you will notice 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, you 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, you will have to connect it so the input provides a path to ground (-). Start at the Terminator I/O system 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, the circuit has been completed. Current flows in the direction of the arrow when the switch is closed.

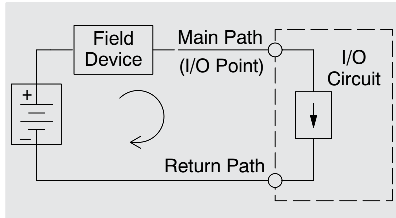


By applying the circuit principle above to the four possible combinations of input/output sinking/sourcing types as shown below. The I/O module specifications at the end of this chapter list the input or output type.

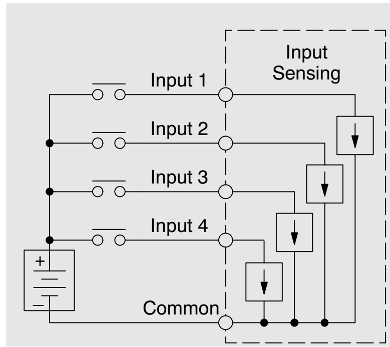


I/O "Common" Terminal Concepts

In order for an I/O circuit to operate, current must enter at one terminal and exit at another. Therefore, 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..

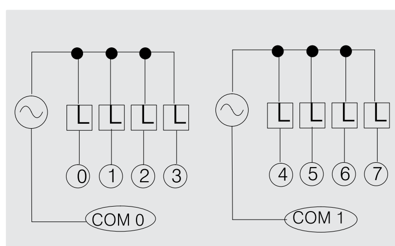


If there was unlimited space and budget for I/O terminals, every I/O point could have two dedicated terminals as the figure above shows. However, providing this level of flexibility is not practical or even necessary for most applications. So, most Input or Output points are in groups which share the 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.

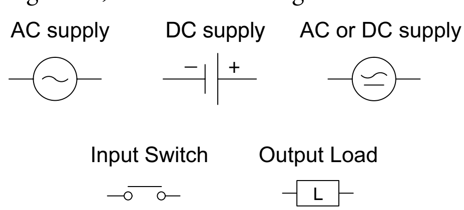


NOTE: *In the circuit above, the current in the common path is 4 times any channel's input current when all inputs are energized. This is especially important in output circuits, where heavier gauge wire is sometimes necessary on commons.*

Most Terminator I/O 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 banks of circuits with four output points in each. The common terminal for each is labeled COM 0 and COM 1, respectively.



In this 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:

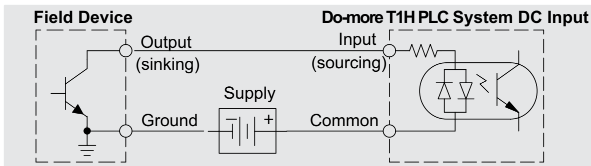


Connecting DC I/O to Solid State Field Devices

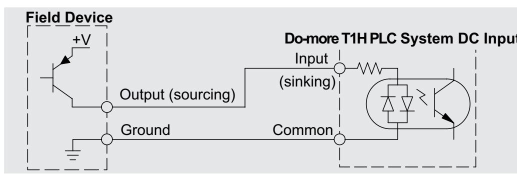
In the previous section on Sourcing and Sinking concepts, the DC I/O circuits were explained to only allow current to flow one way. This is also true for many of the field devices which have solid-state (transistor) interfaces. In other words, field devices can also be sourcing or sinking. *When connecting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

Solid State Input Sensors

Terminator I/O DC input modules are flexible because 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 input point, which sources current. The power supply can be the +24V auxiliary supply or another supply (+12VDC or +24VDC), as long as the input specifications are met.



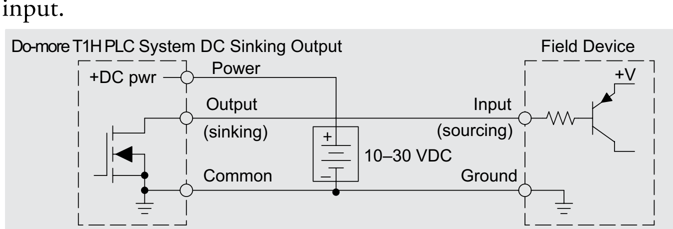
In the next circuit, a field device has an open-emitter PNP transistor output. It sources current to the input point, which sinks the current back to ground. Since the field device is sourcing current, no additional power supply is required.



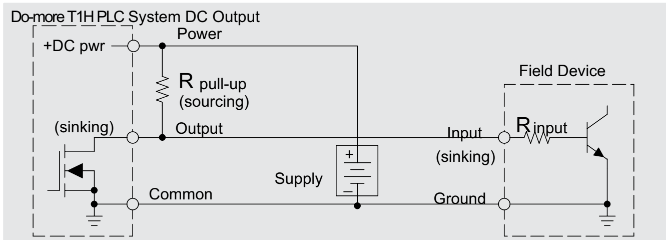
Solid State Output Loads

Sometimes an application requires connecting an 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 Terminator I/O 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 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 a sinking DC output point is connected to the sinking input of a field device. This is a little tricky, because both the Terminator I/O system output and field device input are sinking type. Since the circuit must have one sourcing and one sinking device, a sourcing capability needs to be added to the Terminator I/O system output by using a pull-up resistor. In the circuit below, an $R_{pull\text{-}up}$ is connected from the output to the DC power input circuit.



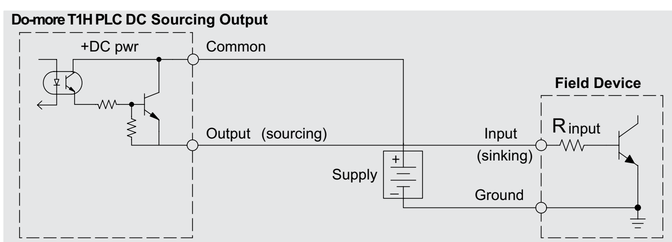
***NOTE 1**: DO NOT attempt to drive a heavy load (>25mA) with this pull-up method.*
***NOTE 2**: Using the pull-up resistor to implement a sourcing output has the effect of inverting the output point logic. In other words, the field device input is energized when the Terminator I/O system output is OFF, from a ladder logic point-of-view. Your ladder program must comprehend this and generate an inverted output. Or, you may choose to cancel the effect of the inversion elsewhere, such as in the field device.*

It is important to choose the correct value of R pull-up. In order to do so, you 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

Several output modules in the Terminator I/O family feature relay outputs: T1K-08TR, T1K-16TR, and T1K-08TRS. 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)

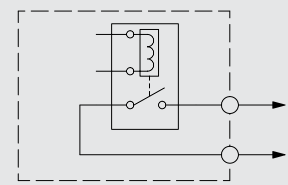
Some applications in which NOT to use relays:

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

Relay output module contacts are available in Form A type, or SPST (single pole, single throw) normally open.

Some relay output module's share common relay 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 Outputs - Transient Suppression for Inductive Loads in a Control System

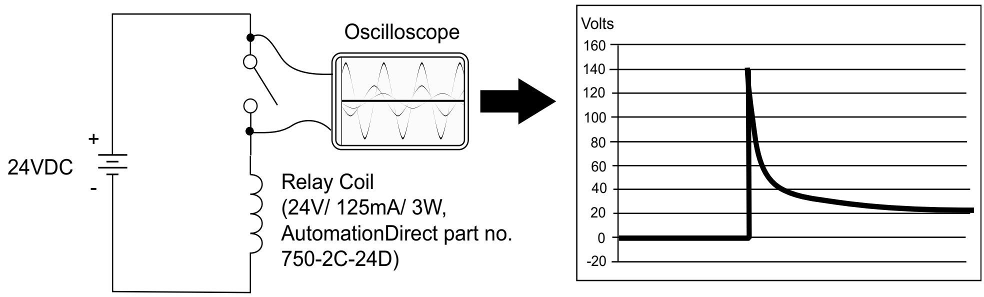
The following pages are intended to give a quick overview of the negative effects of transient voltages on a control system and provide some simple advice on how to effectively minimize them. The need for transient suppression is often not apparent to the newcomers in the automation world. Many mysterious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

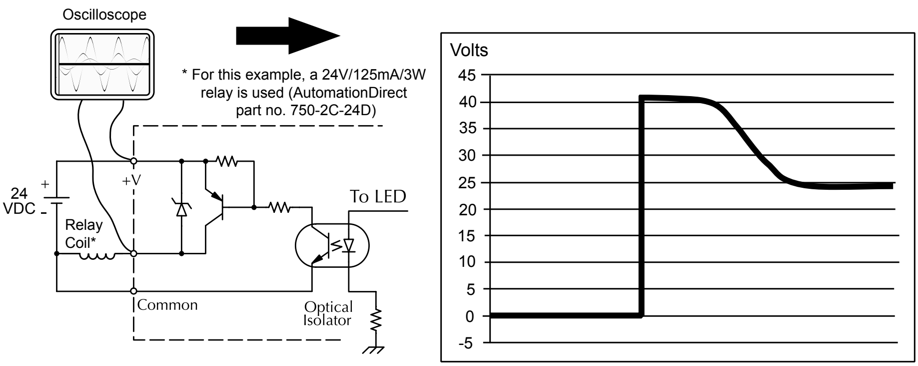
PLC's Integrated Transient Suppressors

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.

The next example uses 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.

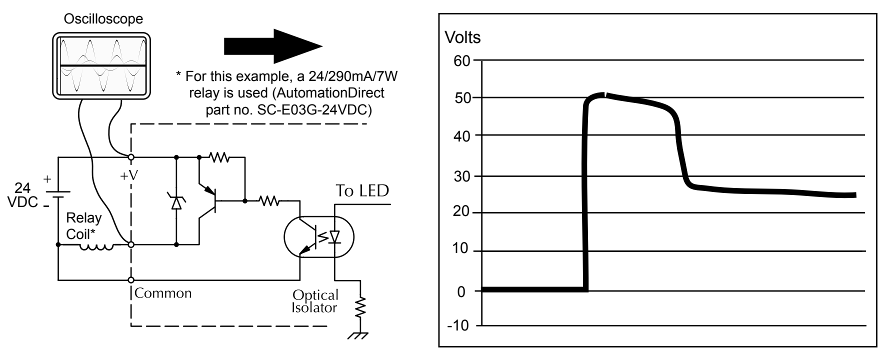
Example: Small Inductive Load with Only Integrated Suppression

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

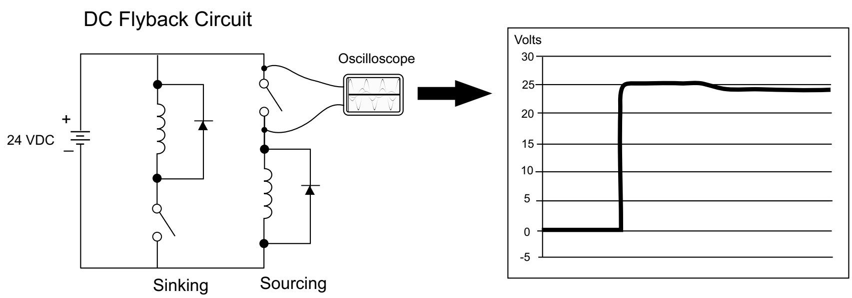
Additional transient suppression should be used in both these examples. If you are unable to measure the transients generated by the connected loads of your control system, using additional transient suppression on all inductive loads would be the safest practice.



Types of Additional Transient Protection

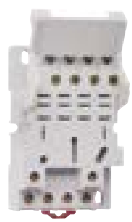
DC Coils:

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.

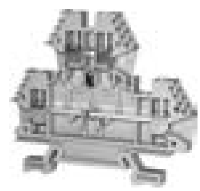


Many AutomationDirect socketed relays and motor starters have add-on flyback diodes that plug or screw into the base, such as the AD-ASMD-250 protection diode module and 784-4C-SKT-1 socket module shown below. If an add-on flyback diode is not available for your inductive load, an easy way to add one is to use an AutomationDirect 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

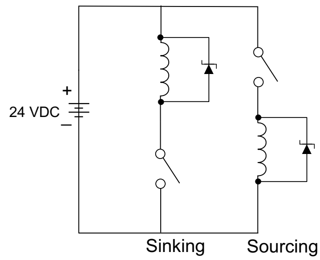


DN-D10DR-A
Diode Terminal Block

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.

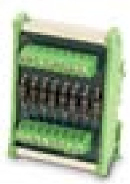
An AutomationDirect ZL-TSD8-24 transorb module is a good choice for 24VDC circuits. It is a bank of 8 uni-directional 30V TVS diodes. Since they are uni-directional, be sure to observe the polarity during installation. MOVs or bi-directional TVS diodes would install at the same location, but have no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

DC MOV or TVS Diode Circuit

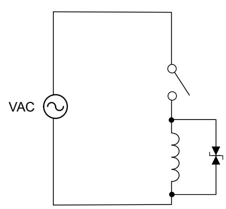


AC Coils:

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.



AC MOV or Bi-Directional Diode Circuit



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

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 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.