

Sinking and Sourcing Concepts

When choosing the type of input or output module for your system (or DL05/DL06/DL105 I/O type), it is very important to have a solid understanding of sinking and sourcing concepts. Use of these terms occurs frequently in discussion of input or output circuits. It is the goal of this section to make these concepts easy to understand, so you can make the right choice the first time when selecting the type of I/O points for your application. This section provides short definitions, followed by general example circuits.

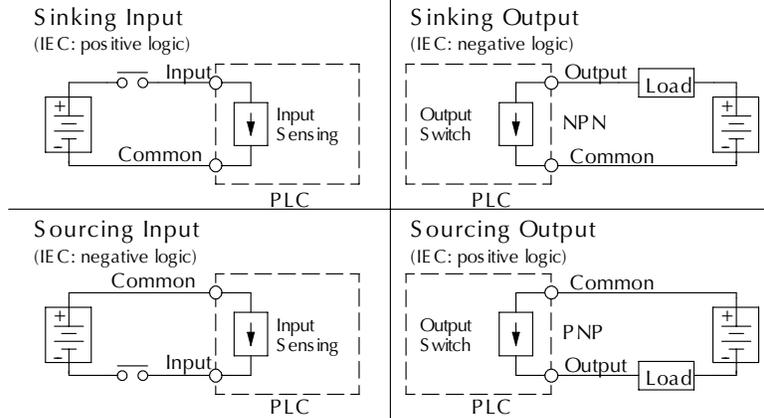
First you will notice that the diagrams on this page are associated with only DC circuits and not AC, because of the reference to (+) and (-) polarities. *Therefore, sinking and sourcing terminology applies only to DC input and output circuits.* Input and output points that are sinking or sourcing can conduct current in one direction only. 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, the supply and field device can be connected every time based on an understanding of sourcing and sinking.

The figure below depicts a *sinking* input. To properly connect the external supply, it must be connected so the input *provides a path to supply common(-)*. So, 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, the circuit is completed. Current flows in the direction of the arrow when the switch is closed.

By applying the circuit principles to the four possible combinations of input/output sinking/sourcing types, there are four circuits, as shown above. The common terminal is the terminal that serves as the common return path for all I/O points in the bank.

Sinking = provides a path to supply **common (-)**

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

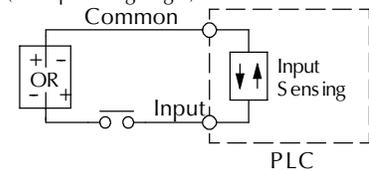


Sink/source I/O circuits combine sinking and sourcing capabilities. This means that the I/O circuitry in the PLC will allow current to flow in either direction, as shown at the right. The common terminal connects to one polarity, and the I/O point connects to the other polarity (through the field device). This provides flexibility in making connections to your field power supply. Please note:

- Wire all I/O points with a shared common as either sinking or sourcing.
- Do not use an AC power supply on a DC sink/source I/O point.

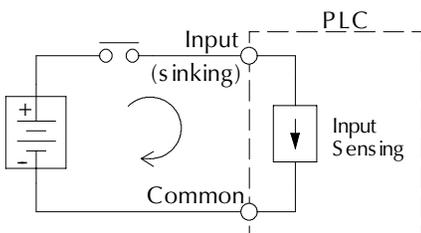
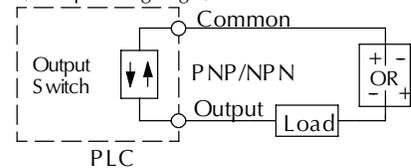
Sink/Source Input

(IEC: pos./neg. logic)

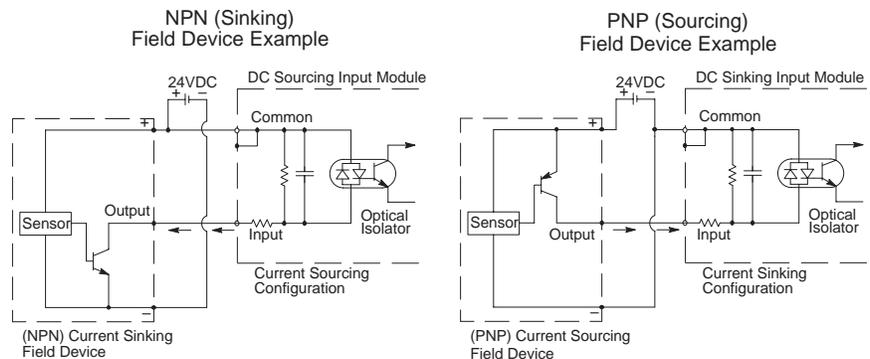


Sink/Source Output

(IEC: pos./neg. logic)



Field device examples - 3 wire connections



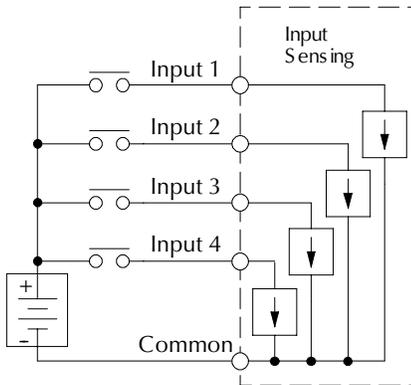
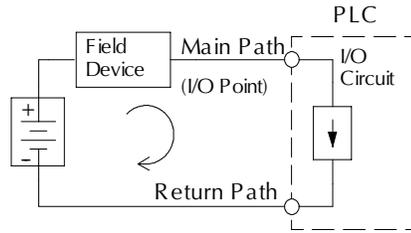
Sinking and Sourcing Concepts

Common terminals and how to use them

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 at 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. Together, the main path and the return path create a loop, or a complete circuit for current to flow.

If there was unlimited space and budget for I/O terminals, then every I/O point could have two dedicated terminals. 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 that share the return path (called *commons*). The figure at the right shows a group (or bank) of four input points that share a common return path. In this way, the four inputs require only five terminals instead of eight.

NOTE: Assuming all input circuits have a similar resistance, the current at the common terminal is four times greater than the current at any one of the inputs. This effect is especially important to note for output circuits, where the current through a common terminal can reach several amperes. You will need to decide whether to fuse each output point individually, or to put a fuse in the common terminal path.



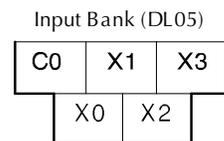
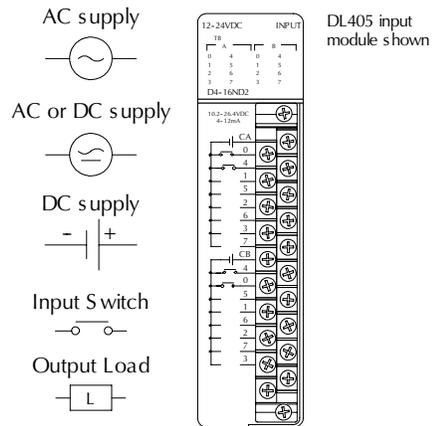
grouped into banks that share a common return path. The best indication of I/O common grouping is on the wiring label. Sample DL05, DL06 and DL105 wiring labels and their meanings are shown below.

Wiring labels and how to interpret them

DL205, DL305, DL405 - Most DL205, DL305 and 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 at the right. The miniature schematic shows two circuit banks with eight input points in each. The common terminals are labeled "CA" and "CB," respectively.

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

DL05/DL06/DL105 — Most DL05, DL06 and DL105 input and output circuits are



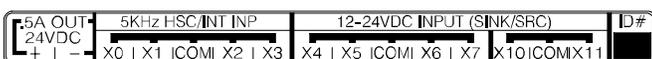
Two banks of four inputs and two banks of three outputs (DL05)

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

I/O Common Grouping Bar (DL105)



Two banks of four inputs and one bank of two (DL105)



Sink or Source?

Lesson #1

Prerequisites: NONE

Estimated time: 20 minutes

Sink or source? PNP or NPN? Normally Open or Normally Closed? Input v. output?

When it comes to mastering the language of electronics, nothing causes more confusion than the “sink” or “source” question. This area causes problems for those trying to sort out machine electronics. When ordering parts, we often find ourselves unable to answer the question “do you need sink or source?”

Questions such as these often confront automation engineers and technicians:

If you replace a sinking input with a sourcing input, does it mean that everything that was “on” will now be “off”, and vice-versa?

Is “sinking with normally closed” the same as “sourcing with normally open”?

If your application call specifically for “sinking” or “sourcing”, does that mean you need pnp or npn or does it not matter?

You will be surprised to find out just how easy it is to understand this concept.

Take a look at the circuit in Figure 1. This is our most basic circuit. Even though it is a simple circuit, we can use this circuit to explain sinking and sourcing.

The circuit in Figure 1 shows a light bulb that is connected to a battery with two wires. DC (direct current) flows from the battery, through the light bulb, and back to the battery. That is all it takes to light the bulb. Connect positive (+) to one side of the bulb, connect negative (-) to the other side of the bulb, and it turns on. This circuit contains the basic requirements of a digital system: a power source (the battery), a device that is turned on and off (the bulb) and wires to connect them together. Now we will add one more feature: suppose you want to turn the light on and off? You need to add a switch (or two?). Here is the big question: Do you add the switch to wire A or do you add switch to wire B? Or do you add two switches?

Figure 2 shows two switches installed in the circuit. You probably already know that one switch will do the job. After all, you have been turning lights on and off all your life with just once switch. So you probably also guessed that it would be foolish to use two switches where one will do the job. But which switch do you choose? Do you install a switch on Wire A as shown in Figure 3; or do you install a switch on Wire B as shown in Figure 4.

Drum roll please... the answer is: it doesn't make any difference; either switch will work fine! Either switch will break the flow of current through the circuit. Now here is the part that causes all of the confusion: we need a way to describe using switch 1 vs. switch 2. If you examine Figure 3 you will see that switch 1 is installed on the wire that runs from the negative (-) side of the battery to the light bulb. You can see in Figure 4 that switch 2 is installed on the wire that runs from the positive (+) side of the battery to the light bulb.

You can see that the final circuit, which contains just one switch (either figure 3 or 4), has two parts: there is an “inactive” part of the system and also an “active” part of the system. Figure 5 shows these two parts. The bulb, the battery and the wire that runs from the (+) side of the battery to the bulb are inactive.

These 3 items sit there all day long and never change. The switch however, is active. It has two states: it can be either ON or OFF. Sometimes people refer to this as OPEN or CLOSED; but those are just different words for the same thing.

Now consider what is happening from the switches point of view in Figure 5. As the switch is opened and closed it takes the negative (-) from the battery and connects or disconnects it with the bulb. In Figure 4, the switch takes the positive (+) from the battery and connects it to the bulb. Now imagine that you want to tell someone how to wire a circuit. You need to tell them whether they should wire the circuit as shown in Figure 3 or as in Figure 4. Imagine further that you have lots of people wiring lots of circuits and you need to give these instructions all day long. It's too much of a mouthful to say "Wire one side of the bulb permanently to positive and install the switch so it connects and disconnects the negative from the battery to the bulb." Besides, if you say that, you don't sound very sophisticated. So someone made up terms to shorten the instructions and help us to sound more sophisticated. And these terms are... SINK and SOURCE. I have no idea why they chose these terms. They could have used any two terms: "Sink" and "Swim" would have worked just fine; or why not "Source" and "Resource"? For all we care they can call these two different conditions Moe and Larry. The name is not important, what is important is that when you set up a DC system to turn something on and off, you will switch either the positive or the negative and leave the other permanently wired.

Now, in order to communicate intelligently, all you need to know is... which is Sink and which is Source? Here is something that may surprise you: the terms sink and source are NOT standardized enough across the industry to be relied on. As incredible as it sounds, when one person refers to what you may call "source" the other person may picture what you would call "sink". So I recommend that you never use these terms. Instead, you can review the wiring diagrams, or say something like "switch the negative" or "switch the positive". Leave the terms "sink" and "source" for those who are so pressed for time that they want to optimize their speech while risking wiring the machine improperly.

So now you know. Next time you here the words "sink" or "source", just ignore the terminology and focus on what you actually have: are you are switching the positive (+) or the negative (-)? That's your deciding factor.

Normally open vs. normally closed:

The concept of "normally open" vs. "normally closed" is often confused with sink and source, but these two are not related. Please see the MulteX lesson on normally open v. normally closed.

PNP v. NPN

The concept of "PNP" vs. "NPN" is often confused with sink and source, but these two are not related. Please see the MulteX lesson on PNP v. NPN

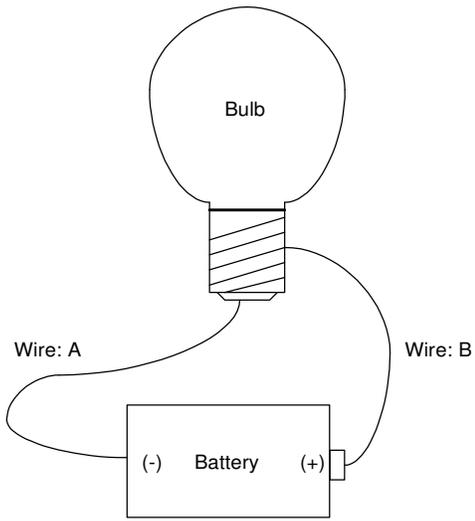


Figure 1

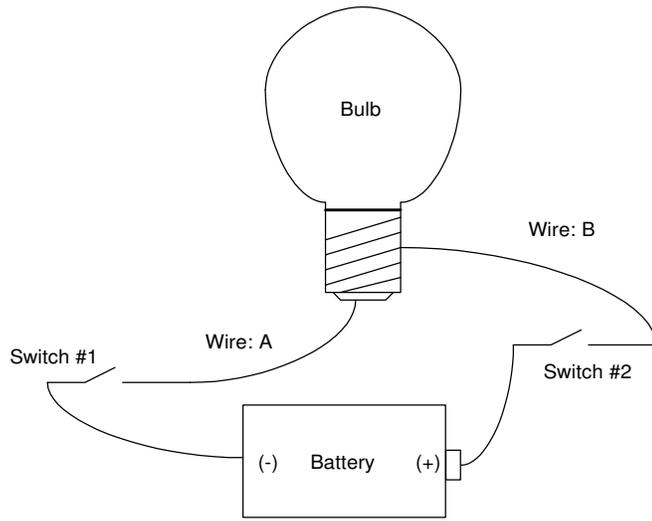


Figure 2

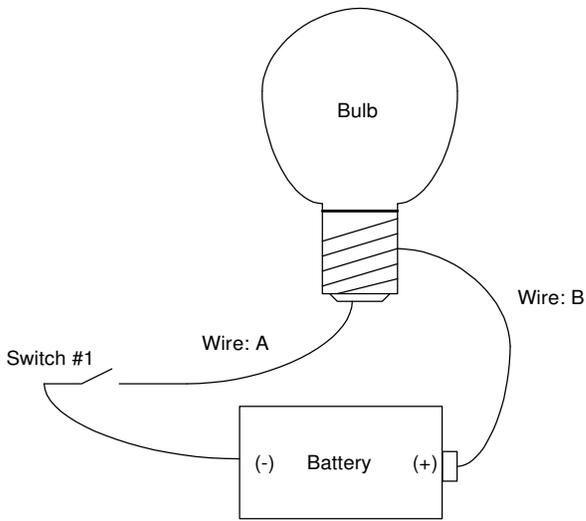


Figure 3

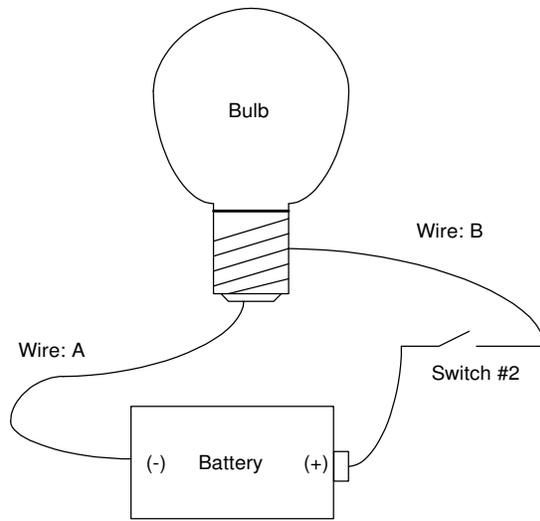


Figure 4

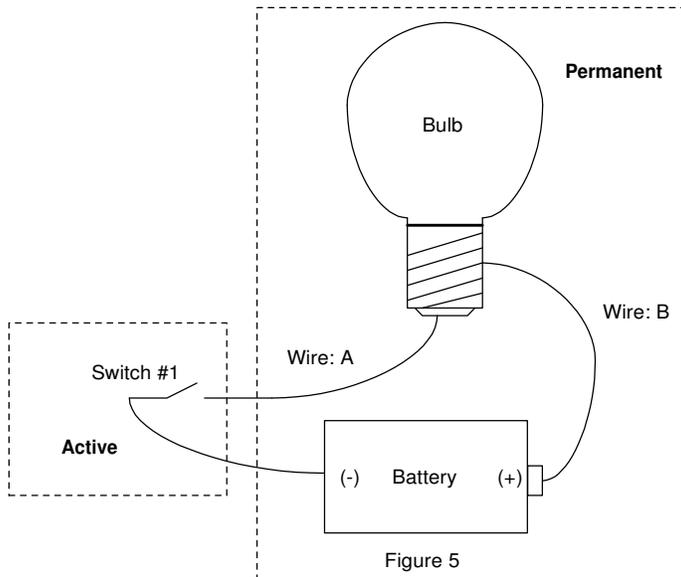


Figure 5

Title Sink - Source		
Author Gary Multer MulteX Automation		
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Revision 1.0	Date February 2006	Sheets 1 of 1

Encoder Information

WHAT IS A SHAFT ENCODER

A Shaft Encoder is an electromechanical transducer, which converts a rotary position into an electronic signal suitable for providing input data to a vast range of electronic control devices. Shaft Encoders are being used for an ever-increasing variety of mechanical applications. Following are just a few examples:

- ❑ Measuring the length of raw material during a winding process, then again when the material is cut to size for final use.
- ❑ Determining angular positions when synchronising machine movements, such as those found in packaging machines.
- ❑ Monitoring the position of products on a conveyor.
- ❑ Positioning of indexing tables, stacker cranes, etc.
- ❑ Tracking the position of automated robots, and their arm movements.
- ❑ Some of the more unusual applications include satellite tracking, road surface analysis and automobile suspension studies.

In 1981 PCA commenced assembly of incremental encoders in Australia with one body style, that had only two output options. Currently we assemble five body styles. Each of these is available with a range of shaft sizes, output options, and connecting methods, providing over 3500 different model possibilities. In addition, we have a large library of incremental disks, with increments ranging from 1 to 100,000 per revolution.

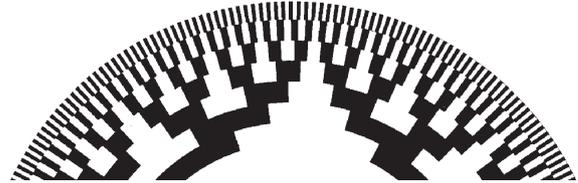
When we receive an order, the optical disc and output circuit board are assembled into the bearing housing. The completed encoder is normally shipped to the customer within seven days of placing an order. A 24/48 hour build service is also available for those unforeseen emergencies.

WHICH ONE ? INCREMENTAL OR ABSOLUTE

Incremental encoders provide a serial output train of square wave signals as the shaft rotates. To determine the angular position or direction of rotation, external electronic circuitry is required. The number of signals per revolution of the shaft is determined by the customer's selection when placing an order.



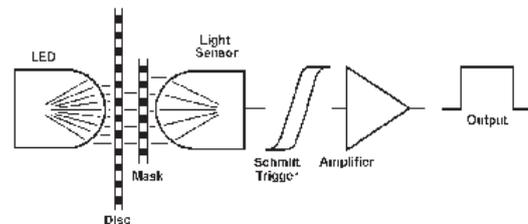
Absolute encoders provide a parallel output structure, the code of which gives a direct reading of the shaft's angular position, there is an optical reading device for each of the tracks. All disks are formatted with a Gray code; to ensure there are no reading errors, this code has only one bit change between divisions. E-PROMs inside the encoder are used to program the individual output code and add direction.



INCREMENTAL READING PRINCIPLE

Most of our encoders are fitted with unique laminated plastic disks produced with very specialised equipment. These disks have a low mass, excellent shock resistance and can be reproduced economically, making our encoders better suited to harsh environments than those normally using glass or fine metal disks.

As the disk rotates, it interrupts an inferred light path sending signals to a Schmitt Trigger and then to the final output amplifier. Except for very low increment models the light path has a stationary mask or grid with the same increment pattern as the disk. This is known as the Moiré Fringe principle. The grid is divided into two halves with a 90° offset between the two, providing the quadrature function essential for direction control.



INCREMENTAL ENCODERS

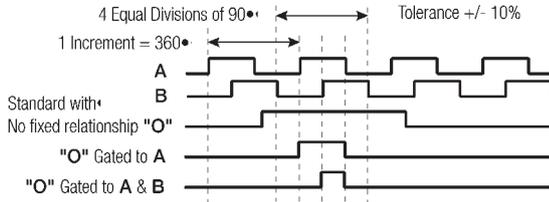
Incremental encoders are the most common type. They have only one graduated track around the disk perimeter and a serial output pulse train, making them much simpler internally than Absolute encoders, and are therefore a little more economical.

The main point to consider is that the actual shaft position is an assumed relationship between the shaft and associated external counting equipment. If the power is removed it is normally necessary to provide a means of resetting the associated circuitry to a known reference point.

Up to three independent optical channels are available in each encoder. In addition the complement of each channel is available, making a total of six output signal lines.

Encoder Information

The output signals are referred to as 'A', 'B' & 'O'. The 'A' & 'B' outputs are setup with a 90° offset, commonly referred to as quadrature. Associated counting equipment monitors this relationship and determines the shaft direction. This feature provides up/down information for counters and with the right circuitry prevents incorrect counting in applications where vibration causes problems.



The quadrature relationship in association with external circuitry can also provide the ability to multiply the output signals by four. Thus a 5000 increment model can provide 20,000 increments per revolution.

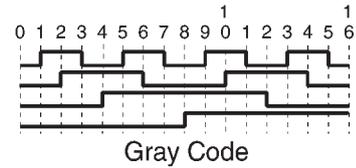
The 'O' output provides one signal for each revolution of the shaft. The signal is used as an exact reference point to coordinate the serial pulse train with a known mechanical location. To use this effectively, it is necessary to install the encoder with a clamp mounting bracket, or some other means that will allow the body of the encoder to be turned.

The state (high or low) of the 'O' or output pulse can be selected. However, it is important to note that there is not necessarily any fixed relationship between the edges of the 'O' output and the incremental channels. A known relationship can be provided if specified in the part number selected. NOTE: this option is not available for some high increment models.

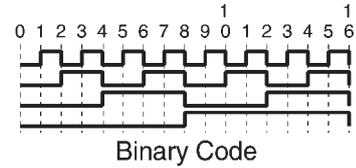
ABSOLUTE ENCODERS

These encoders have a multiple track gray coded optical disk that has one track for each 'Bit' of its stated resolution. This code has the advantage that only one 'Bit' changes for each change in output code. The final output code, Gray, Binary or BCD, and the direction of shaft rotation to increment the output value in most models is programmed into E-PROMs.

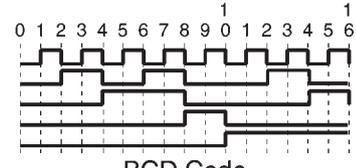
Each individual increment forms its own unique code on a parallel output bus. Therefore, even if the power fails, once restored, the position of the shaft is immediately known without any resetting routine, as is required with Incremental encoders.



Gray Code



Binary Code



BCD Code

The main consideration is that standard Absolute encoders only provide this feature for one shaft revolution. Therefore their use is restricted to synchronising machinery based on a 360° cycle. If more turns are required it is necessary to use some form of mechanical reduction, or select one of our Multi-Turn Absolute encoders. This type has an internal mechanical arrangement that drives multiple absolute code disks.

Multi-turn absolute encoders are available with resolutions up to 30 bits, this is achieved with a mechanical build that has 14 bit (16,384) turns of the shaft, and 16 bits (65,536) for each shaft revolution. Encoders are available with both parallel and serial outputs; the serial protocols are the preferred option today, this approach considerably reduces the field wiring and the I/O ports of the control devices.

Encoders are available with all the most common industrial interfaces, DeviceNET, Ethernet in a number of formats, CanOPEN, InterBUS, ProfiBUS-DP and SSI the simplest of all the protocols. Refer to our web site for full technical details for each interface.

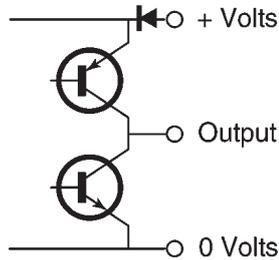
OUTPUT CIRCUITS

In the past there was a range of five different output options, available for some of the series, providing for all types of input structures to which encoders may be connected. Today most of our encoders have the same output driver regardless of the rated voltage. Encoders rated for 5 Volt operation simply have the reverse voltage protection diode removed to ensure that the logic "1" is as close as possible to the + 5 Volt rail.

The maximum output frequency is typically 300kHz, but depends upon the length of the connecting cable, as the line capacitance increases, the rise and fall time of the square waves also increases.

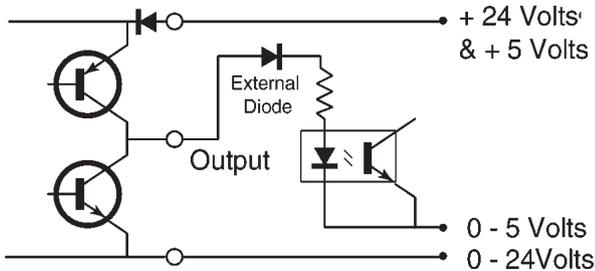
Encoder Information

Push Pull: This is now the most widely used output configuration, and will normally operate at any voltage from 11 to 30 Volts. The main feature of this structure is that it can be used to switch either NPN or PNP input circuits, thus reducing spares inventory if both types are required on the one site.

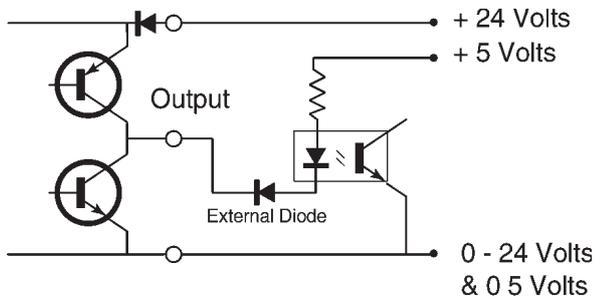


Connection for normal Push Pull output

Most of our encoders today are only made with Push Pull output, if a true open collector is required or the output is required to switch a different voltage than the encoder power supply, this can be achieved with one external diode.

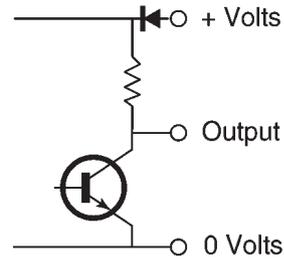


Connection for PNP using Push Pull output
NOTE: Common + Volt Supply

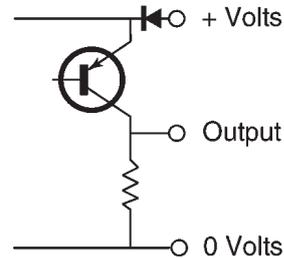


Connection for NPN using Push Pull output
NOTE: Common 0 Volt Supply

NPN or current sink: Has a 40mA switching action between the output signal and the 0 Volt supply. Pull up resistors are fitted between the output and the + Volt power supply line.



PNP or current source: Has a 40mA switching action between the + Volt supply and the output. Pull down resistors are fitted between the output and the 0 Volt power supply line.



Line Driver: Uses a push pull line driver output circuit which provides a 5 to 15 Volt 40mA output signal capable of driving cable runs up to 100 metres.

This type has the highest frequency response capability and the best noise immunity, provided the installation is equipped with a differential line receiver. To utilise this function output signal options must be selected to provide both the true and compliment signals.

5 Volt Only: The output circuit is essentially the same as the Push Pull circuit shown above, but it has the reverse voltage protection diode removed for 5 Volt TTL operation.

NOTE: The output and voltage information is typical, refer to the individual Series data sheets for specific details about the model you have selected.

PLEASE NOTE

Every effort has been made to ensure the information contained within this catalogue is correct at the time of production, however we have an ongoing development program and upgrades are made. Normally these will have no effect to applications however, current information is always available upon request. Neither PCA nor our prime suppliers accept any responsibility for incorrect use of the product or liability for any damage it may cause to any other part of your equipment.

When to Use Open-Collector and Relay Outputs

Open Collector Output

The Open-Collector Output is a transistor circuit configuration used in a wide variety of electronic designs including many integrated circuits (ICs). Three parts make up a transistor: the emitter, the base and the collector. These three parts form two distinct junctions, the emitter-base junction and the base-collector junction. These regions are either forward-biased or reversed biased depending on current flow through the transistor. Other components are added to control the rate of current flow.

In the open-collector circuit the current flow is either fully on or completely shut-off. The output acts as either an open circuit (no connection to anything) or a short circuit (to ground). The transistor's collector is typically connected to an external pull-up resistor, which sets a higher voltage to the output when the transistor is open. When any transistor connected to this resistor is turned on, the output is forced to 0 volts. Open-collector outputs are useful in many applications including summing, limiting and switching circuits.

For the switching circuit, instead of outputting a signal of a specific voltage or current, a control signal is applied to the base of an internal NPN transistor whose collector is externalized (open) on a pin of the IC. The emitter of the transistor is connected internally to the ground pin. The open collector provides a pull-up resistor that does not need to be connected to a voltage at the same potential as the chip supply (VCC). It is possible to use a lower or higher voltage. Therefore, open collector circuits are often used to interface different families of devices that have different voltage levels in their operating logic or to control external circuitry that requires a higher voltage level (for example a 12 V relay).

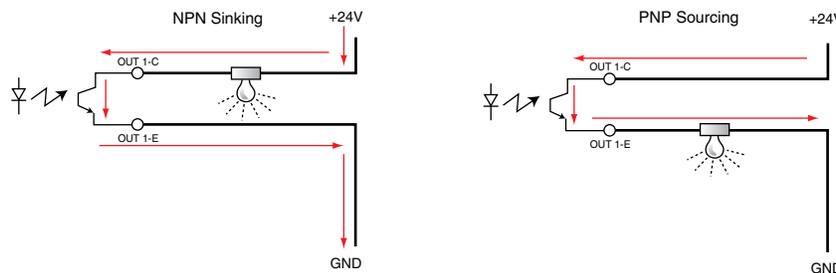


Figure 1: Current Sinking (NPN) and Current Sourcing (PNP)

Most Lenze-AC Tech drives use current-sinking (NPN) outputs with the exception of the SCL and SCM that use a current-sourcing (PNP) output transistor circuit. To utilize the open-collector (OC) output on Lenze-AC Tech drives, a separate relay must be inserted between the drive and the intended control or indicating device (monitor or PLC). A power supply source is also required to operate the relay. For example, the SCF drive has an internal 12 VDC power supply that can be used in conjunction with the open collector circuit and a 12V relay. Its OC output is rated for 50mA at up to 30VDC. The 12VDC power supply is rated for 50 mA. If a 12V 50mA relay is used, then the 12VDC power supply will be able to power that relay. However, if a 24V relay is used, then a separate 24V power supply will be necessary. Keep in mind that the 50 mA maximum rating for the open-collector output still applies.



WARNING

Never use 120 VAC relays with any Lenze-AC Tech open-collector output circuits. This will damage the drive.

If the SCF's 12 VDC power supply is used, the connections for the relay coil go between TB14 (or TB15) and TB11. The dry contacts from that relay can control the circuit as illustrated in Figure 2. The MC, SMVector, TCF and SCD Series Drives use open collector outputs. For details on the wiring and circuit requirements refer to the "Drive Status Digital Outputs" section of the respective drive's Installation and Operation manual.

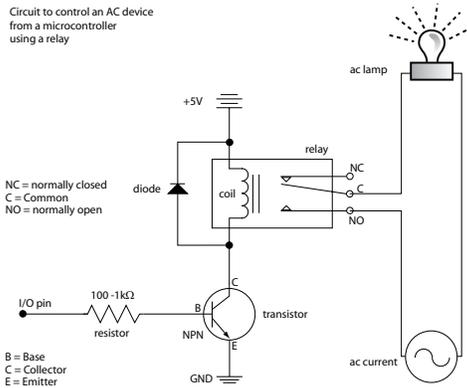


Figure 2a: Relay Control Circuit (Generic)

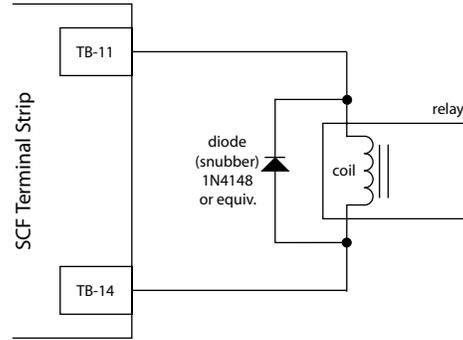


Figure 2b: SCF Example - 12V Relay



STOP!

It is strongly recommended to connect a separate protection diode (a.k.a. "snubber") across the relay coil terminals as well.

This protection diode is illustrated in Figure 2. A diode snubber circuit can be added when ordering from some relay manufacturers. This diode is installed in the direction that does not ordinarily allow current to conduct. When current to the inductive load is rapidly interrupted, a large voltage spike is produced in the reverse direction as the inductor attempts to keep current flowing in the circuit. Placing the snubber diode in parallel with the inductive load for reversed-bias flow allows the current from the inductor to flow through the diode rather than through the switching element, dissipating the energy stored in the inductive load from its series resistance and instead goes through the much smaller resistance of the diode.

Relay Output

The Relay Output is either a Form-A type with one normally open (NO) set of contacts, or a Form-C type with one normally open (NO) and one normally-closed (NC) set of contacts. Neither the Form-A nor Form-C relays require an additional power supply voltage or protection diodes. There is no separate biasing because there are no transistors involved in this circuit. They are dedicated circuits that can be directly connected in-line with the desired control or indicating device. The Form-A relay in Lenze-AC Tech drives is rated for 3 amps up to 250V AC or 2 amps up to 24 VDC. The Form-C relay in Lenze-AC Tech drives is rated for 2 amps for both 28 VDC and 120 VAC.

Figure 3 illustrates a basic relay output circuit.

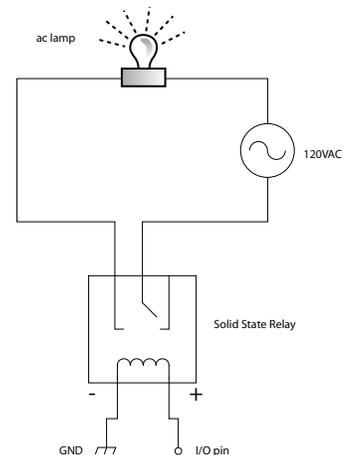


Figure 3: Typical Relay Circuit

Using an Open-Collector Output vs. the Form-C Relay Output

Customers wiring or commissioning a drive commonly inquire about using an open-collector output or the Form-C relay output. The difference between the two is that the open-collector output requires a separate interposing relay in conjunction with a power supply source suitable to operate that relay. The relay's current and voltage ratings must be matched to meet the tolerance of the open-collector output and the power supply used. The Form-C relay output is self-contained and needs only be directly connected to the desired circuit to activate the desired function. The Form-A and Form-C relay output tolerances for voltage and current must not be exceeded.

The MC Series has two open-collector outputs and one Form-C relay output. An optional second Form-C relay is available. Figure 4 illustrates how to connect the MC series drive for an open collector output. Note that the negative (-) of the external supply should always be connected to TB2 (circuit common) of the drive to complete the path to ground.

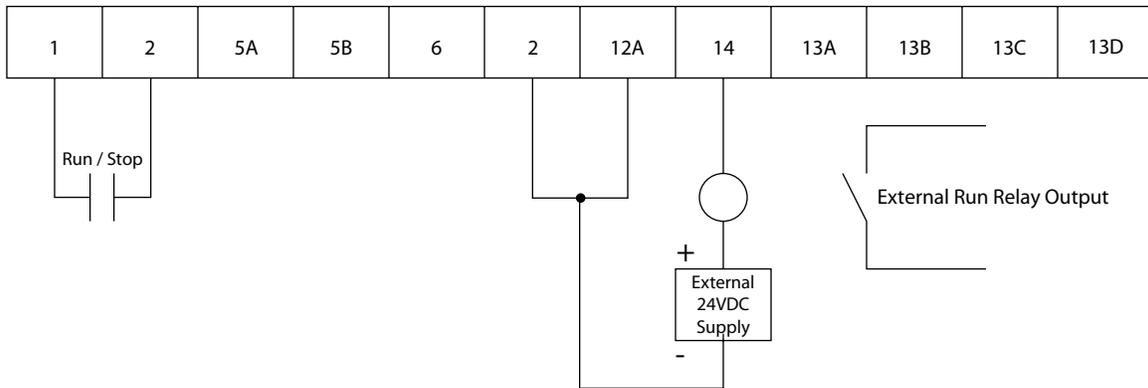


Figure 4: Wiring the Open-Collector Output of the MC Series Drive

Figure 5 illustrates a Form-C relay output configuration. Any external voltage fed through the relay should have its negative side connected to TB2 (circuit common) of the drive to keep the same reference to ground.

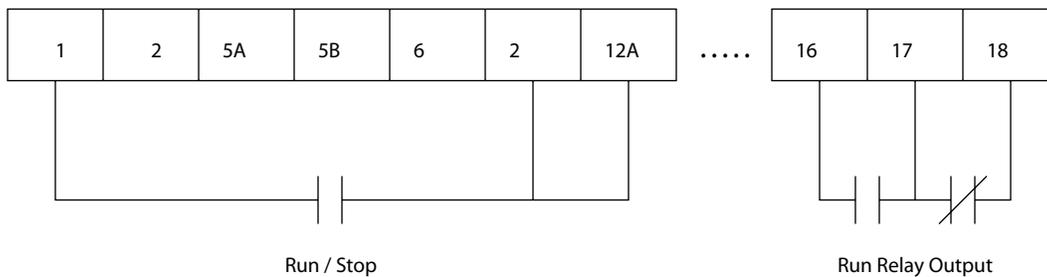


Figure 5: Wiring the Form-C Relay Output of the MC Series Drive