Almamoun University collage

Power electrical Engineering

المسيطرات الرقمية والمعالج الدقيق

Third year Class

Dr Hussam Asper

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Lecture 4

2.1 The I/O Section

The input/output (I/O) section of a PLC is the section to which all field devices are connected and provides the interface between them and the CPU. Input/output arrangements are built into a fixed PLC while modular types use external I/O modules that plug into the PLC.
Figure 2-1 illustrates a rack-based I/O section made up of individual I/O modules. Input interface modules accept signals from the machine or process devices and convert them into signals that can be used by the controller. Output interface modules convert controller signals into external signals used to control the machine or process. A typical PLC has room for several I/O modules, allowing it to be customized for a particular application by selecting the appropriate modules. Each slot in the rack is capable of accommodating any type of I/O module.
The I/O system provides an interface between the hardwired components in the fi eld and the CPU. The input interface allows *status information* regarding processes to be communicated to the CPU, and thus allows the CPU to communicate *operating signals* through the output interface to the process devices under its control.
Allen-Bradley controllers make a distinction between a PLC chassis and rack as illustrated in Figure 2-2 . The hardware assembly that houses I/O modules, processor modules, and power supplies is referred to as the chassis. Chassis come in different sizes according to the number of slots they contain. In general, they can have 4, 8, 12, or 16 slots.

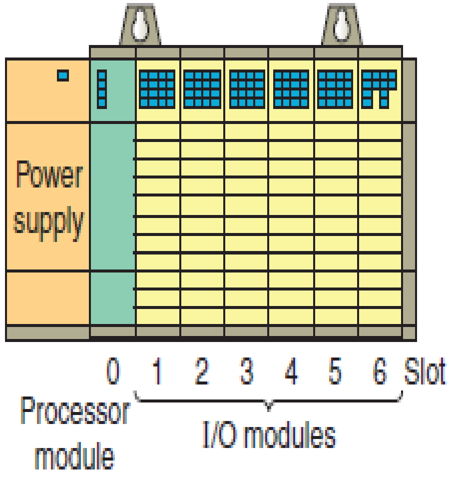

Figure 2-1 Rack-based I/O section.

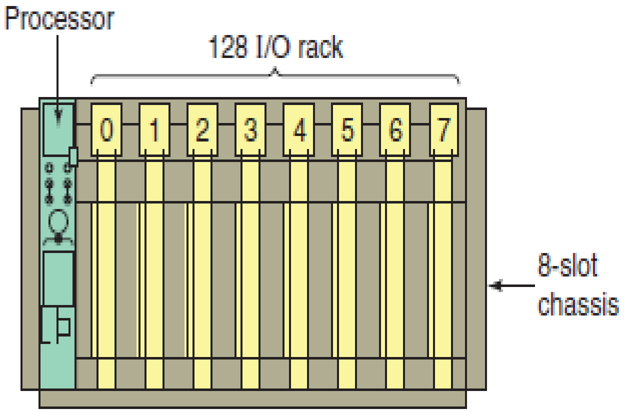

Figure 2-2 Allen-Bradley PLC chassis and rack.

A *logical rack* is an addressable unit consisting of 128 input points and 128 output points. A rack uses 8 words in the input image table fi le and 8 words in the output image table fi le. A word in the output image table fi le and its corresponding word in the input image table fi le are called an *I/O group*. A rack can contain a maximum of 8 I/O groups (numbered from 0 through 7) for up to 128 discrete I/O. There can be more than one rack in a chassis and more than one chassis in a rack.
One benefit of a PLC system is the ability to locate the I/O modules near the field devices, as illustrated in Figure 2-3 , in order to minimize the amount of wiring required. The processor receives signals from the remote input modules and sends signals back to their output modules via the communication module.

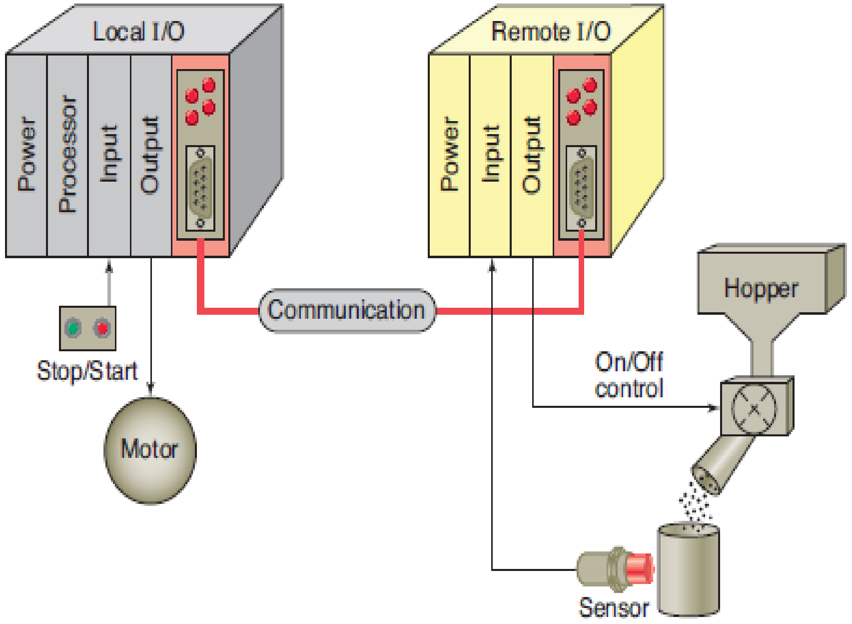

Figure 2-3 Remote I/O rack.

A rack is referred to as a *remote* rack when it is located away from the processor module. To communicate with the processor, the remote rack uses a special communications network. Each remote rack requires a unique station number to distinguish one from another. The remote racks are linked to the local rack through a *communications module.* Cables connect the modules with each other. If fiber optic cable is used between the CPU and I/O rack, it is possible to operate I/O points from distances greater than 20 miles with no voltage drop. Coaxial cable will allow remote I/O to be installed at distances greater than two miles. Fiber optic cable will not pick up noise caused by adjacent high power lines or equipment normally found in an industrial environment. Coaxial cable is more susceptible to this type of noise.

The PLC's memory system stores information about the status of all the inputs and outputs. To keep track of all this information, it uses a system called *addressing.* An address is a label or number that indicates where a certain piece of information is located in a PLC's memory. Just as your home address tells where you live in your city, a device's or a piece of data's address tells where information about it resides in the PLC's memory. That way, if a PLC wants to find out information about a field device, it knows to look in its corresponding address location. Examples of addressing schemes include *rack/slot-based,* versions of which are used in Allen-Bradley PLC-5 and SLC 500 controllers, *tag-based* used in Allen-Bradley ControlLogix controllers, and PC-based control used in soft PLCs.

In general, rack/slot-based addressing elements include:

Type— The type determines if an input or output is being addressed.

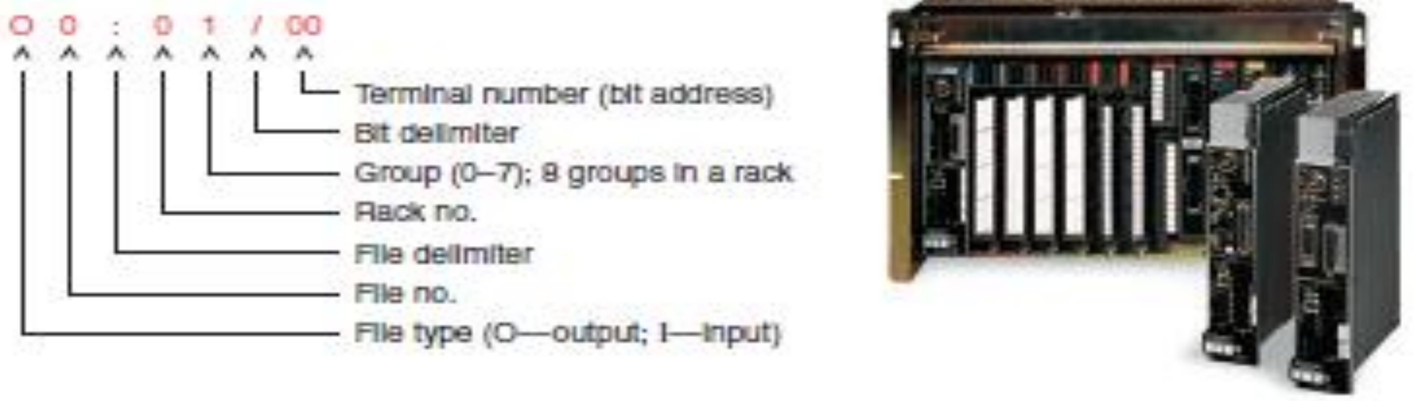

Figure 2-4 Allen-Bradley PLC-5 rack/slot-based addressing format.
Source: Image Used with Permission of Rockwell Automation, Inc.

Slot— The slot number is the physical location of the I/O module. This may be a combination of the rack number and the slot number when using expansion racks.

Word and Bit— The word and bit are used to identify the actual terminal connection in a particular I/O module. A discrete module usually uses only one word, and each connection corresponds to a different bit that makes up the word.

With a rack/slot address system the location of a module within a rack and the terminal number of a module to which an input or output device is connected will determine the device's address. Figure 2-4 illustrates the Allen-Bradley PLC-5 controller addressing format. The following are typical examples of input and output addresses:

I1:27/17	Input, file 1, rack 2, group 7, bit 17
O0:34/07	Output, file 0, rack 3, group 4, bit 7
I1:0/0	Input, file 1, rack 0, group 0, bit 0 (Short form blank = 0)
O0:1/1	Output, file 0, rack 0, group 1, bit 1 (Short form blank = 0)

Figure 2-5 illustrates the Allen-Bradley SLC 500 controller addressing format. The address is used by the processor to identify where the device is located to monitor or control it. In addition, there is some means of connecting field wiring on the I/O module housing. Connecting the field wiring to the I/O housing allows easier disconnection and reconnection of the wiring to change modules.

Lights are also added to each module to indicate the ON or OFF status of each I/O circuit. Most output modules also have blown fuse indicators. The following are typical

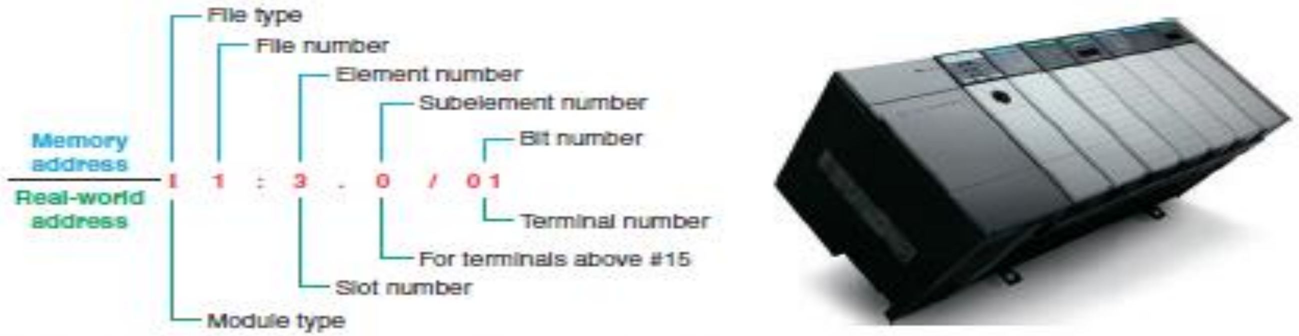

Figure 2-5 Allen-Bradley SLC 500 rack/slot-based addressing format.
Source: Image Used with Permission of Rockwell Automation, Inc.

examples of SLC 500 real-world general input and output addresses:

O:4/15	Output module in slot 4, terminal 15
I:3/8	Input module in slot 3, terminal 8
O:6.0	Output module, slot 6
I:5.0	Input module, slot 5

Every input and output device connected to a discrete I/O module is addressed to a specifi c *bit* in the PLC's memory. A bit is a binary digit that can be either 1 or 0. Analog I/O modules use a *word* addressing format, which allows the entire words to be addressed. The bit part of the address is usually not used; however, bits of the digital representation of the analog value can be addressed by the programmer if necessary. Figure 2-6 illustrates bit level and word level addressing as it applies to an SLC 500 controller. Figure 2-7 illustrates the Allen-Bradley ControlLogix tag-based addressing format. With Logix5000 controllers, you use a tag (alphanumeric name) to address data (variables). Instead of a fi xed numeric format the tag name itself identifi es the data. The fi eld devices are assigned tag names that are referenced when the PLC ladder logic program is developed. PC-based control runs on personal or industrial hardened computers. Also known as soft PLCs, they simulate the functions of a PLC on a PC, allowing open architecture systems to replace proprietary PLCs. This implementation uses an input/output card (Figure 2-8) in conjunction with the PC as an interface for the fi eld devices. Combination I/O modules can have both input and output connections in the same physical module as illustrated in Figure 2-9 . A module is made up of a printed circuit board and a terminal assembly.

The printed circuit board contains the electronic circuitry used to interface the circuit of the processor with that of the input or output device. Modules are designed to plug into a slot or connector in the I/O rack or directly into the processor. The terminal assembly, which is attached to the front edge of the printed circuit board, is used for making fi eld-wiring connections. Modules contain terminals for each input and output connection, status lights for each of the inputs and outputs, and connections to the power supply used to power the inputs and outputs. Terminal and status light arrangements vary with different manufacturers.

Most PLC modules have plug-in wiring terminal strips. The terminal block is plugged into the actual module as illustrated in Figure 2-10 . If there is a problem with a module, the entire strip is removed, a new module is inserted, and the terminal strip is plugged into the new module.

Unless otherwise specifi ed, never install or remove I/O modules or terminal blocks while the PLC is powered.

A module inserted into the wrong slot could be damaged by improper voltages connected through the wiring arm. Most faceplates and I/O modules are keyed to prevent putting the wrong faceplate on the wrong module.

In other words, an output module cannot be placed in the slot where an input module was originally located.

Input and output modules can be placed anywhere in a rack, but they are normally grouped together for ease of wiring. I/O modules can be 8, 16, 32, or 64 point cards (Figure 2-11). The number refers to the number of inputs or outputs available. The standard I/O module has eight inputs or outputs. A *high-density* module may have up to 64 inputs or outputs. The advantage with the high-density module is that it is possible to install up to 64 inputs or outputs in one slot for greater space savings. The only disadvantage is that the high-density output modules cannot handle as much current per output.

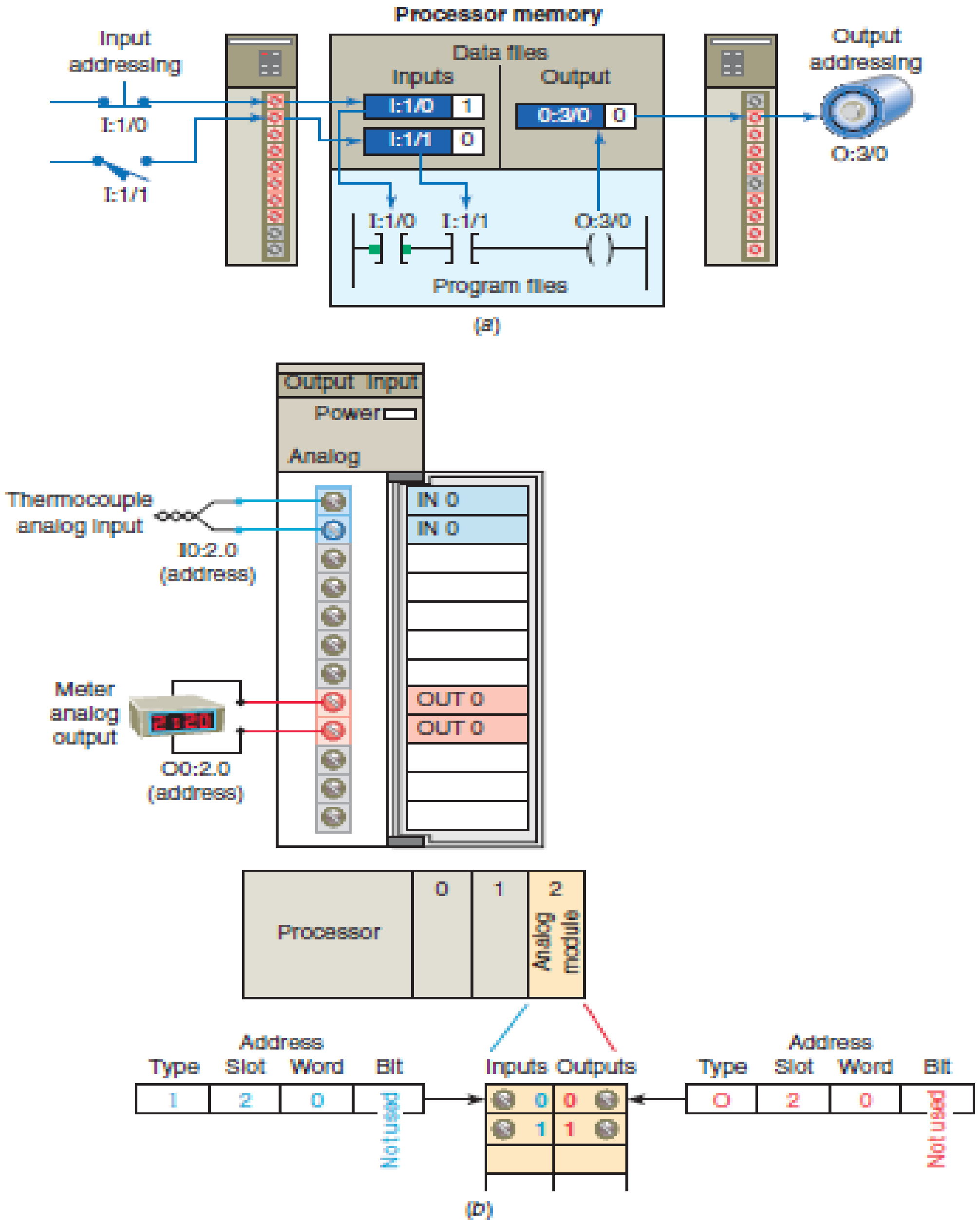

Figure 2-6 SLC 500 bit level and word level addressing. (*a*) Bit level addressing. (*b*) Word level addressing.

Figure 2-7 Allen-Bradley ControlLogix tag-based addressing format.

Source: Image Used with Permission of Rockwell Automation, Inc.

Figure 2-8 Typical PC interface card.
Source: Photo © Beckhoff Automation GmbH.

2.2 Discrete I/O Modules

The most common type of I/O interface module is the *discrete* type (Figure 2-12). This type of interface connects fi eld input devices of the ON/OFF nature such as selector switches, pushbuttons, and limit switches. Likewise, output control is limited to devices such as lights, relays, solenoids, and motor starters that require simple ON/OFF switching. The classification of discrete I/O covers *bit oriented* inputs and outputs. In this type of input or output, each bit represents a complete information element in itself and provides the status of some external contact or advises of the presence or absence of power in a process circuit. Each discrete I/O module is powered by some *field supplied* voltage source. Since these voltages can be of different magnitude or type, I/O modules are available at various AC and DC voltage ratings, as listed in Table 2-1.

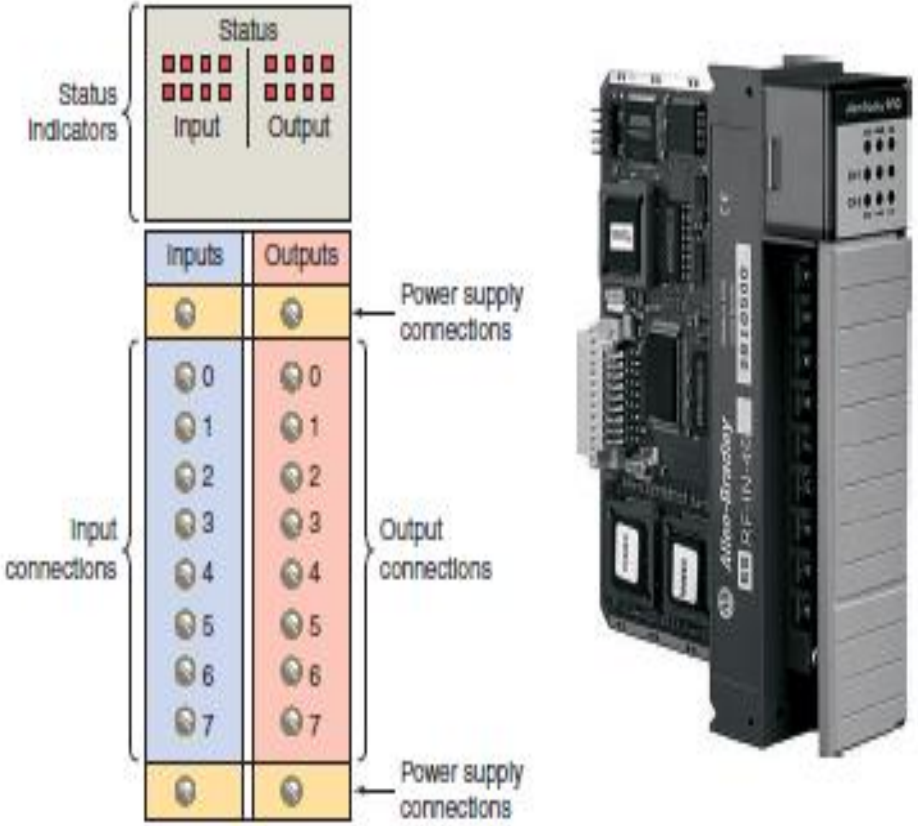

Figure 2-9 Typical combination I/O module.
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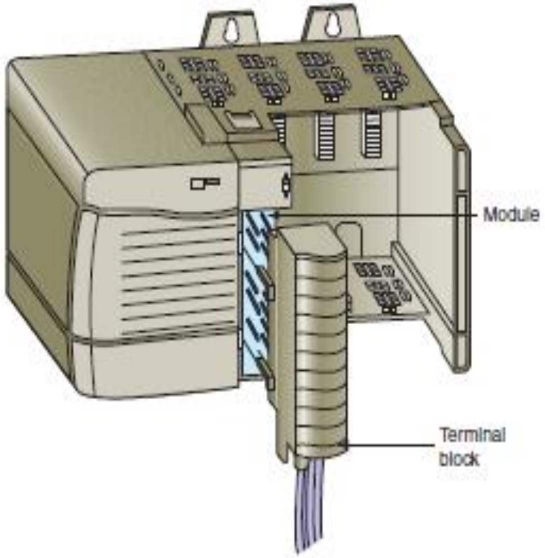

Figure 2-10 Plug-in terminal block.

Figure 2-11 16, 32, and 64 point I/O modules.
Source: (all) Photos courtesy Omron Industrial Automation, **www.ia.omron.com**.

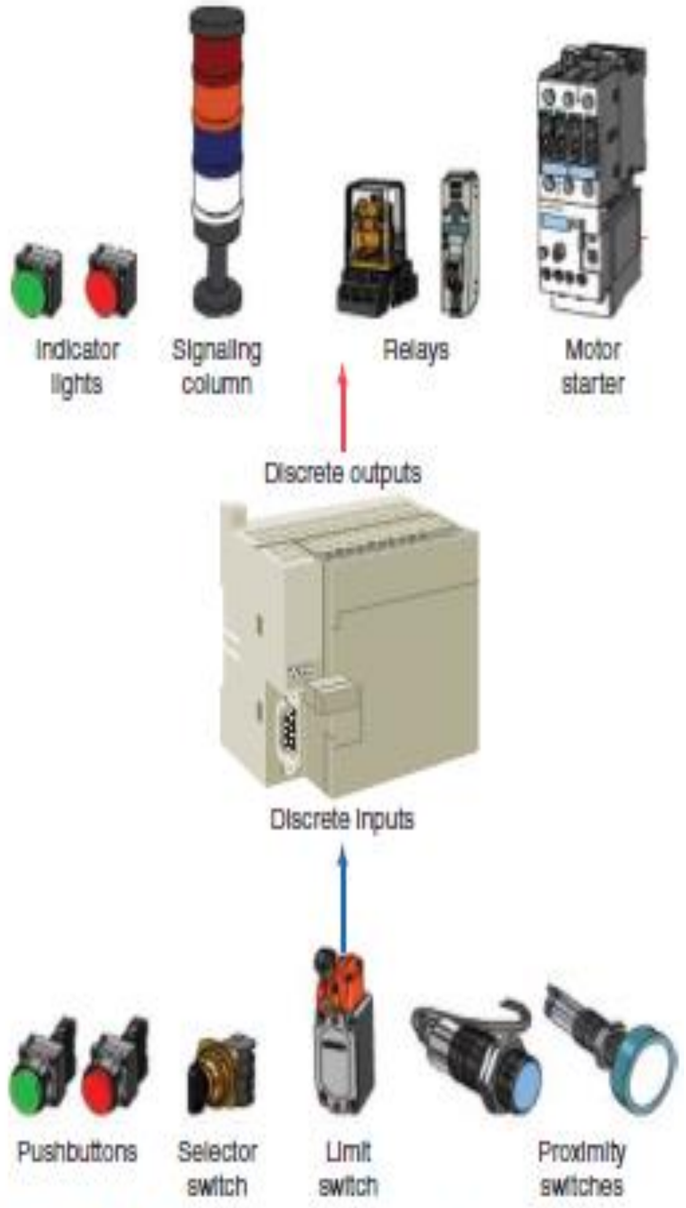

Figure 2-12 Discrete input and output devices.

Table 2-1 Common Ratings for Discrete I/O Interface Modules

Input Interfaces	Output Interfaces
12 V AC/DC /24 V AC/DC	12–48 V AC
48 V AC/DC	120 V AC
120 V AC/DC	230 V AC
230 V AC/DC	120 V DC
5 V DC (TTL level)	230 V DC
	5 V DC (TTL level)
	24 V DC

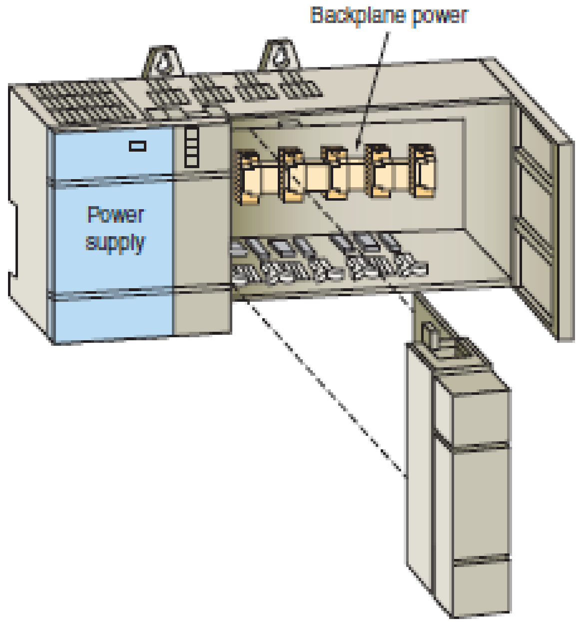

Figure 2-13 Modules receive their voltage and current from the backplane.

The modules themselves receive their voltage and current for proper operation from the backplane of the rack enclosure into which they are inserted, as illustrated in Figure 2-13 . Backplane power is provided by the PLC module power supply and is used to power the electronics that reside on the I/O module circuit board. The relatively higher currents required by the loads of an output module are normally provided by user-supplied power. Module power supplies typically may be rated for 3 A, 4 A, 12 A, or 16 A depending on the type and number of modules used.

Figure 2-14 shows the block diagrams for one input of a typical alternating current (AC) *discrete input module.* The input circuit is composed of two basic sections: the *power* section and the *logic* section. An optical isolator is used to provide electrical isolation between the fi eld wiring and the PLC backplane internal circuitry. The input LED turns on or off, indicating the status of the input device. Logic circuits process the digital signal to the processor. Internal PLC control circuitry typically operates at 5 VDC or less volts.

A simplifi ed diagram for a single input of a discrete AC input module is shown in Figure 2-15 . The operation of the circuit can be summarized as follows:

- The input noise fi lter consisting of the capacitor and resistors R1 and R2 removes false signals that are due to contact bounce or electrical interference.
- When the pushbutton is closed, 120 VAC is applied to the bridge rectifi er input.
- This results in a low-level DC output voltage that is applied across the LED of the optical isolator.

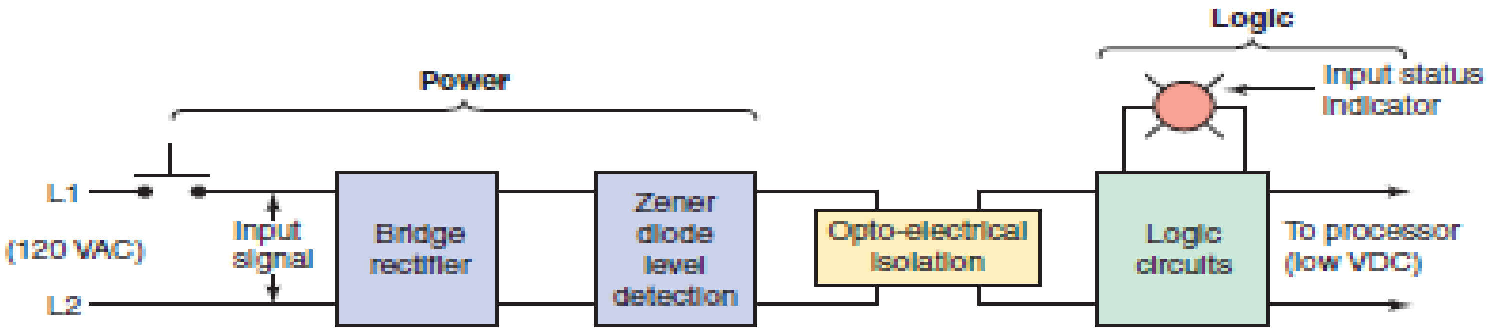

Figure 2-14 Discrete AC input module block diagram.

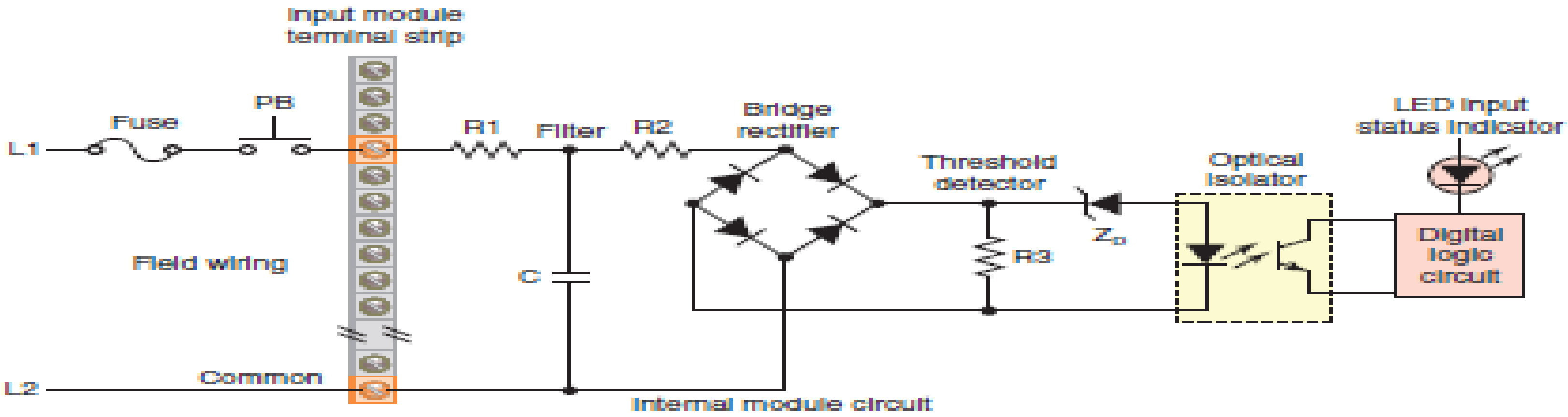

Figure 2-15 Simplified diagram for a single input of a discrete AC input module.

- The zener diode (Z D) voltage rating sets the minimum threshold level of voltage that can be detected.
- When light from the LED strikes the phototransistor, it switches into conduction and the status of the pushbutton is communicated in logic to the processor.
- The optical isolator not only separates the higher AC input voltage from the logic circuits but also prevents damage to the processor due to line voltage transients. In addition, this isolation also helps reduce the effects of electrical noise, common in the industrial environment, which can cause erratic operation of the processor.
- For fault diagnosis, an input state LED indicator is on when the input pushbutton is closed. This indicator may be wired on either side of the optical isolator.
- An AC/DC type of input module is used for both AC and DC inputs as the input polarity does not matter.
- A PLC input module will have either all inputs isolated from each other with no common input connections or groups of inputs that share a common connection.

Discrete input modules perform four tasks in the PLC control system. They:
• Sense when a signal is received from a fi eld device.
• Convert the input signal to the correct voltage level for the particular PLC.
• Isolate the PLC from fluctuations in the input signal's voltage or current.
• Send a signal to the processor indicating which sensor originated the signal.

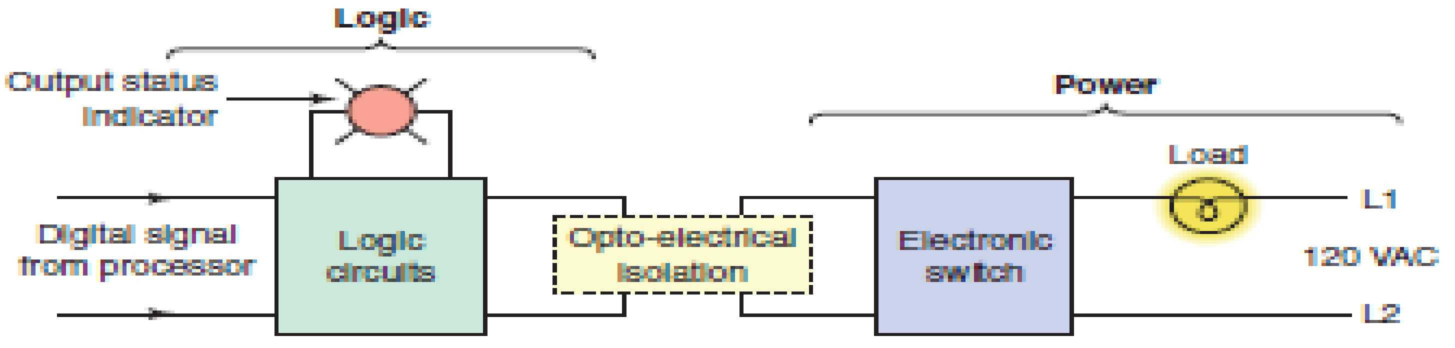

Figure 2-16 Discrete AC output module block diagram.

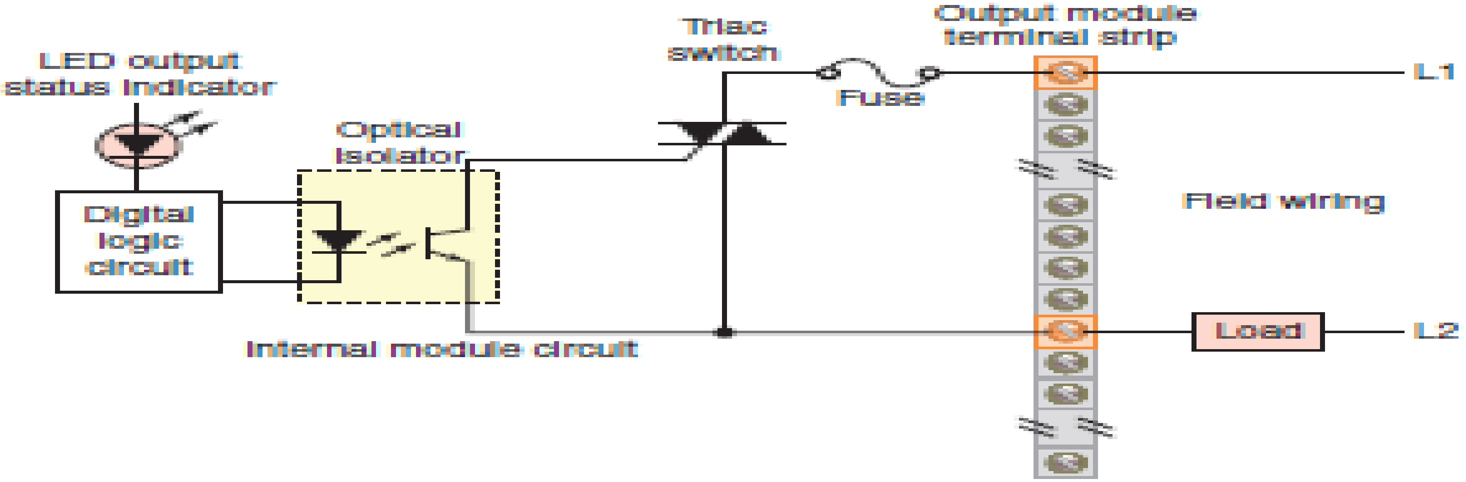

Figure 2-17 Simplified diagram for a single output of a discrete AC output module.

Figure 2-16 shows the block diagram for one output of a typical discrete output module. Like the input module, it is composed of two basic sections: the power section and the logic section, coupled by an isolation circuit. The output interface can be thought of as an electronic switch that turns the output load device on and off. Logic circuits determine the output status. An output LED indicates the status of the output signal.

Asimplified diagram for a single output of a discrete AC output module is shown in Figure 2-17 . The operation of the circuit can be summarized as follows:
• As part of its normal operation, the digital logic circuits of the processor sets the output status according to the program.
• When the processor calls for an output load to be energized, a voltage is applied across the LED of the opto-isolator.
• The LED then emits light, which switches the phototransistor into conduction.
• This in turn triggers the triac AC semiconductor switch into conduction allowing current to fl ow to the output load.
• Since the triac conducts in either direction, the output to the load is alternating current.
• The triac, rather than having ON and OFF status, actually has LOW and HIGH resistance levels, respectively. In its OFF state (HIGH resistance), a small leakage current of a few milliamperes still flows through the triac.
• As with input circuits, the output interface is usually provided with LEDs that indicate the status of each output.
• Fuses are normally required for the output module, and they are provided on a per circuit basis, thus allowing for each circuit to be protected and operated separately. Some modules also provide visual indicators for fuse status.
• The triac cannot be used to switch a DC load.

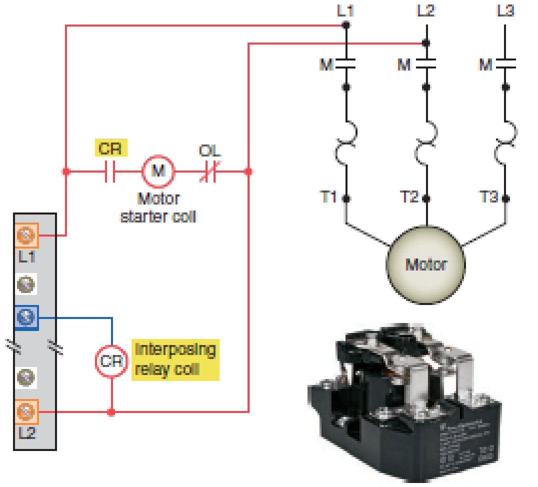

Figure 2-18 Interposing relay connection.
Source: Photo courtesy Tyco Electronics, www.tycoelectronics.com.

• For fault diagnosis, the LED output status indicator is on whenever the PLC is commanding that the output load be switched on.

Individual AC outputs are usually limited by the size of the triac to 1 A or 2 A. The maximum current load for any one module is also specifi ed. To protect the output module circuits, specifi ed current ratings should not be exceeded.

For controlling larger loads, such as large motors, a standard control relay is connected to the output module. The contacts of the relay can then be used to control a larger load or motor starter, as shown in Figure 2-18 . When a control relay is used in this manner, it is called an *interposing* relay.

Discrete output modules are used to turn fi eld output devices either on or off. These modules can be used to control any two-state device, and they are available in AC and DC versions and in various voltage ranges and current ratings. Output modules can be purchased with *transistor, triac,* or *relay* output as illustrated in Figure 2-19 .

Triac outputs can be used only for control of AC devices, whereas transistor outputs can be used only for control of DC devices. The discrete relay contact output module uses electromechanical as the switching element. These relay outputs can be used with AC or DC devices, but they have a much slower switching time compared to solidstate outputs. Allen-Bradley modules are color-coded for identifi cation as follows:

Color	Type of I/O
Red	AC inputs/outputs
Blue	DC inputs/outputs
Orange	Relay outputs
Green	Specialty modules
Black	I/O wiring; terminal blocks are not removable

Certain DC I/O modules specify whether the module is designed for interfacing with current-source or currentsink devices. If the module is a current-sourcing module, then the input or output device must be a current-sinking device. Conversely, if the module is specifi ed as currentsinking, then the connected device must be currentsourcing.

Some modules allow the user to select whether the module will act as current sinking or current sourcing, thereby allowing it to be set to whatever the fi eld devices require.

The internal circuitry of some fi eld devices requires that they be used in sinking or sourcing circuits. In general, *sinking (NPN)* and *sourcing (PNP)* are terms used to describe a current signal fl ow relationship between fi eld input and output devices in a control system and their power supply. Figure 2-20 illustrates the current fl ow relationship between sinking and sourcing inputs to a DC input module.

Figure 2-21 illustrates the current fl ow relationship between sinking and sourcing outputs to a DC output module. DC input and output circuits are commonly connected with fi eld devices that have some form of internal

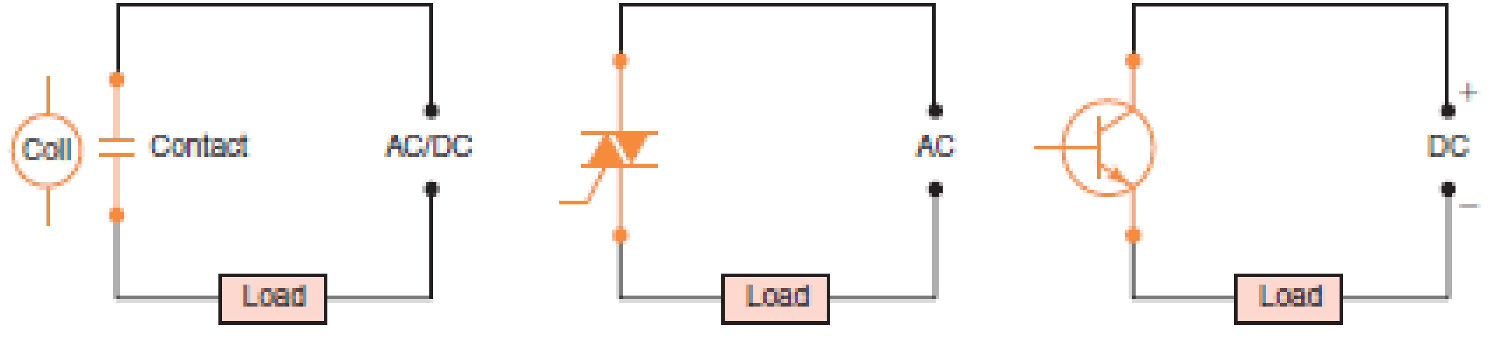

Figure 2-19 Relay, transistor, and triac switching elements.

solid-state circuitry that needs a DC signal voltage to function. Field devices connected to the positive (1) side of the fi eld power supply are classifi ed as sourcing field devices. Conversely, field devices connected to the negative (2) side or DC common of the fi eld power supply are sinking fi eld devices.

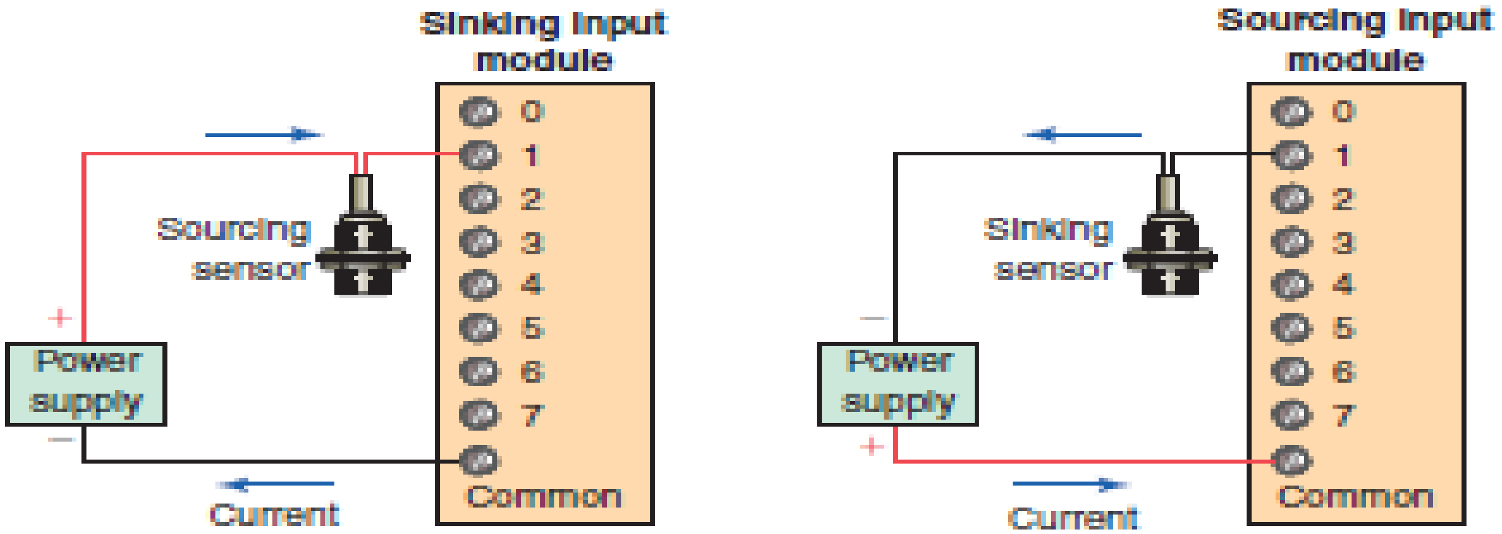

Figure 2-20 Sinking and sourcing inputs.

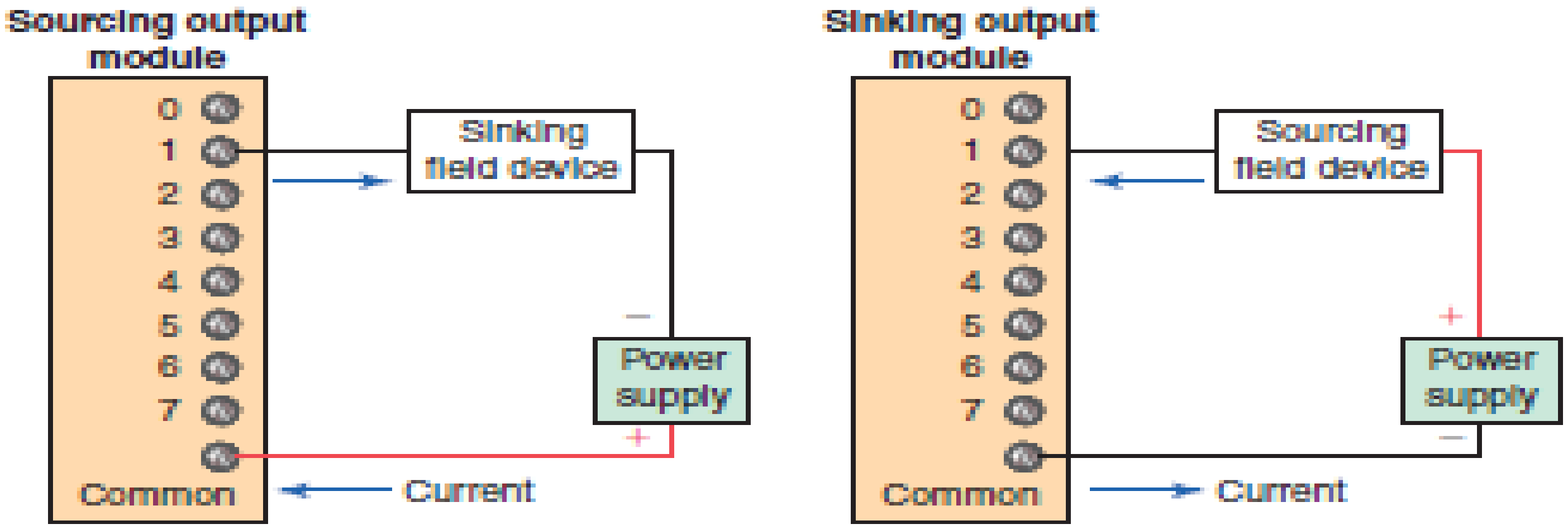

Figure 2-21 Sinking and sourcing outputs.

2.3 Analog I/O Modules

Earlier PLCs were limited to discrete or digital I/O interfaces, which allowed only on/off-type devices to be connected. This limitation meant that the PLC could have only partial control of many process applications. Today, however, a complete range of both discrete and analog interfaces are available that will allow controllers to be applied to practically any type of control process. Discrete devices are inputs and outputs that have only two states: on and off. In comparison, analog devices represent physical quantities that can have an infinite number of values. Typical analog inputs and outputs vary from 0 to 20 milliamps, 4 to 20 milliamps, or 0 to 10 volts. Figure 2-22 illustrates how PLC analog input and output modules are used in measuring and displaying the level of fluid in a tank. The analog input interface module contains the circuitry necessary to accept an analog voltage or current signal from the level transmitter fi eld device. This input is converted from an analog to a digital value for use by the processor. The circuitry of the analog output module accepts the digital value from the processor and converts it back to an analog signal that drives the fi eld tank level meter.

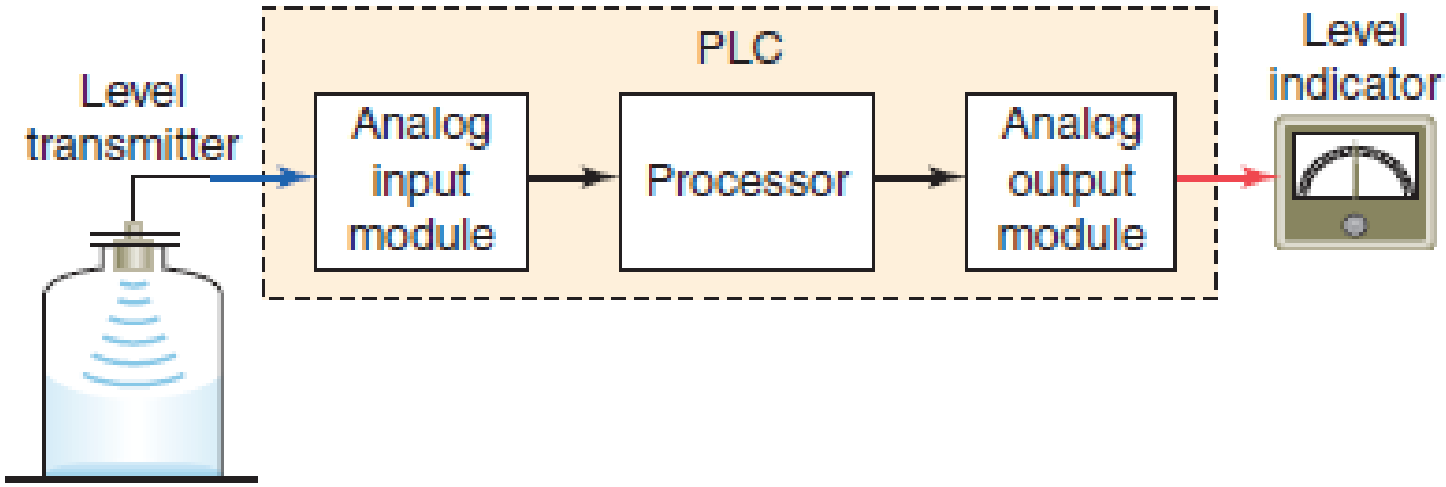

Figure 2-22 Analog input and output to a PLC.

Analog input modules normally have multiple input channels that allow 4, 8, or 16 devices to be interface to the PLC. The two basic types of analog input modules are *voltage* sensing and *current* sensing. Analog sensors measure a varying physical quantity over a specific range and generate a corresponding voltage or current signal. Common physical quantities measured by a PLC analog module include temperature, speed, level, flow, weight, pressure, and position. For example, a sensor may measure temperature over a range of 0 to 500°C, and output a corresponding voltage signal that varies between 0 and 50 mV.

Figure 2-23 illustrates an example of a voltage sensing input analog module used to measure temperature. The connection diagram applies to an Allen-Bradley Micro-Logic 4-channel analog thermocouple input module. A varying DC voltage in the low millivolt range, proportional to the temperature being monitored, is produced by the thermocouple. This voltage is amplifi ed and digitized by the analog input module and then sent to the processor on command from a program instruction. Because of the low voltage level of the input signal, a twisted shielded pair cable is used in wiring the circuit to reduce unwanted electrical noise signals that can be induced in the conductors from other wiring. When using an ungrounded thermocouple, the shield must be connected to ground at the module end. To obtain accurate readings from each of the channels, the temperature between the thermocouple wire and the input channel must be compensated for. A cold junction compensating (CJC) thermistor is integrated in the terminal block for this purpose.

The transition of an analog signal to digital values is accomplished by an analog-to-digital (A/D) converter, the main element of the analog input module. Analog voltage input modules are available in two types: unipolar and bipolar. *Unipolar* modules can accept an input signal that varies in the positive direction only. For example, if the fi eld device outputs 0 V to 110 V, then the unipolar modules would be used. Bipolar signals swing between a maximum negative value and a maximum positive value. For example, if the fi eld device outputs 210 V to 110 V a bipolar module would be used. The *resolution* of an analog input channel refers to the smallest change in input signal value that can be sensed and is based on the number of bits used in the digital representation. Analog input modules must produce a range of digital values between a maximum and minimum value to represent the analog signal over its entire span. Typical specifi cations are as follows:

Span of analog input	Bipolar	10 V	−10 to +10 V
		5 V	−5 to +5 V
	Unipolar	10 V	0 to +10 V
		5 V	0 to +5 V
Resolution			0.3 mV

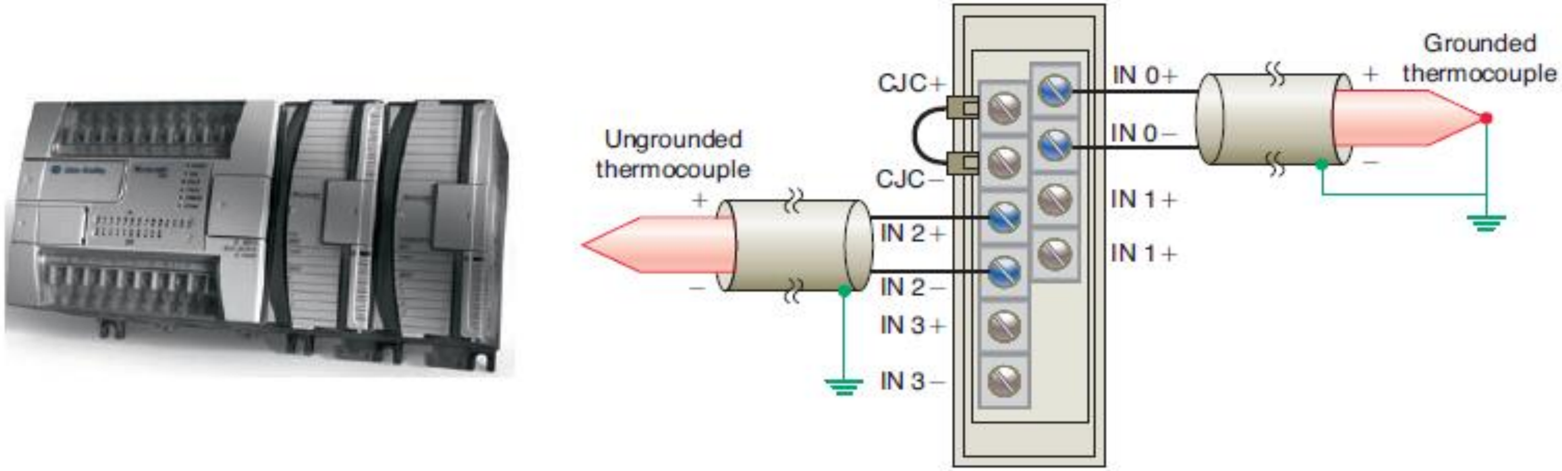

Figure 2-23 MicroLogix 4-channel analog thermocouple input module.
Source: Image Used with Permission of Rockwell Automation, Inc.

When connecting voltage sensing inputs, close adherence to specifi ed requirements regarding wire length is important to minimize signal degrading and the effects of electromagnetic noise interference induced along the connecting conductors. Current input signals, which are not as sensitive to noise as voltage signals, are typically not distance limited. Current sensing input modules typically accept analog data over the range of 4 mA to 20 mA, but can accommodate signal ranges of –20 mA to 120 mA. The loop power may be supplied by the sensor or may be provided by the analog output module as illustrated in Figure 2-24 . Shielded twisted pair cable is normally recommended for connecting any type analog input signal.

The *analog output interface module* receives from the processor digital data, which are converted into a proportional voltage or current to control an analog fi eld device.

The transition of a digital signal to analog values is accomplished by a digital-to-analog (D/A) converter, the main element of the analog output module. An analog output signal is a continuous and changing signal that is varied under the control of the PLC program. Common devices controlled by a PLC analog output module include instruments, control valves, chart recorder, electronic drives, and other types of control devices that respond to analog signals.

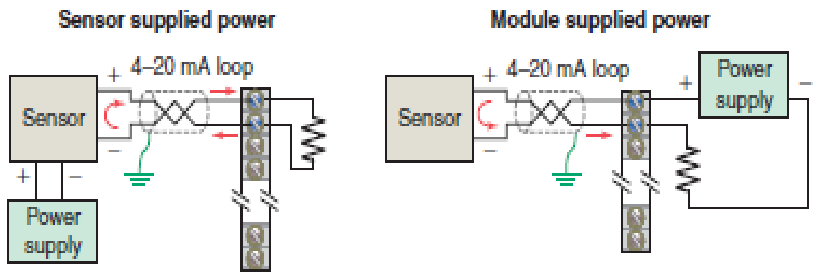

Figure 2-24 Sensor and analog module supplied power.

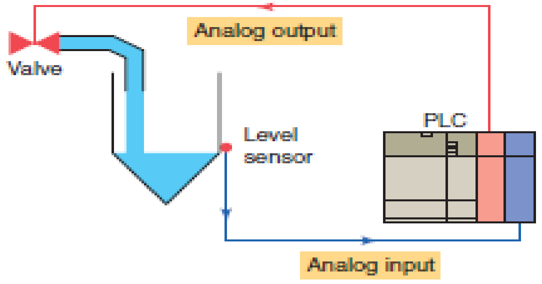

Figure 2-25 Typical analog I/O control system.

Figure 2-27 Thumbwheel switch.
Source: Photo courtesy Omron Industrial Automation, www.ia.omron.com.

Figure 2-25 illustrates the use of analog I/O modules in a typical PLC control system. In this application the PLC controls the amount of fl uid placed in a holding tank by adjusting the percentage of the valve opening. The analog output from the PLC is used to control the fl ow by controlling the amount of the valve opening. The valve is initially open 100 percent. As the fl uid level in the tank approaches the preset point, the processor modifi es the output, which adjusts the valve to maintain a set point.

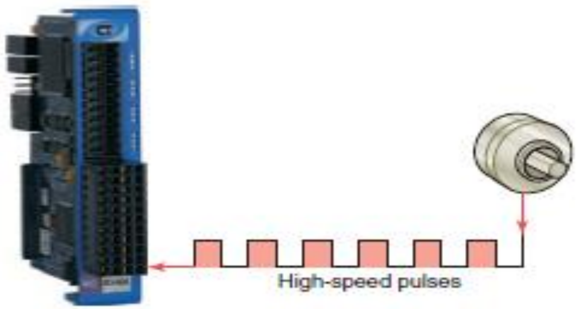

Figure 2-26 High-speed counter module.
Source: Courtesy Control Technology Corporation.

2.4 Special I/O Modules

Many different types of I/O modules have been developed to meet special needs. These include:

HIGH-SPEED COUNTER MODULE

The high-speed counter module is used to provide an interface for applications requiring counter speeds that surpass the capability of the PLC ladder program. High-speed counter modules are used to count pulses (Figure 2-26) from sensors, encoders, and switches that operate at very high speeds. They have the electronics needed to count independently of the processor. A typical count rate available is 0 to 100 kHz, which means the module would be able to count 100,000 pulses per second.

THUMBWHEEL MODULE

The thumbwheel module allows the use of thumbwheel switches (Figure 2-27) for feeding information to the PLC to be used in the control program.

TTL MODULE

The TTL module (Figure 2-28) allows the transmitting and receiving of TTL (Transistor-Transistor-Logic) signals. This module allows devices that produce TTL-level signals to communicate with the PLC's processor.

Figure 2-28 TTL module.
Source: Courtesy Control Technology, Inc.

ENCODER-COUNTER MODULE

An encoder-counter module allows the user to read the signal from an encoder (Figure 2-29) on a real-time basis and stores this information so it can be read later by the processor.

BASIC OR ASCII MODULE

The BASIC or ASCII module (Figure 2-30) runs userwritten BASIC and C programs. These programs are independent of the PLC processor and provide an easy, fast interface between remote foreign devices and the PLC processor. Typical applications include interfaces to bar code readers, robots, printers, and displays.

Figure 2-29 Encoder.
Source: Photo courtesy of Allied Motion Technologies, Inc.

STEPPER-MOTOR MODULE

The stepper-motor module provides pulse trains to a stepper-motor translator, which enables control of a stepper motor (Figure 2-31). The commands for the module are determined by the control program in the PLC.

BCD-OUTPUT MODULE

The BCD-output module enables a PLC to operate devices that require BCD-coded signals such as seven- segment displays (Figure 2-32).

Figure 2-31 Stepper-motor.
Source: Courtesy Sherline Products.

Some special modules are referred to as *intelligent I/O* because they have their own microprocessors on board that can function in parallel with the PLC. These include:

PID MODULE

The proportional-integral-derivative (PID) module (Figure 2-33) is used in process control applications that incorporate PID algorithms. An algorithm is a complex program based on mathematical calculations. A PID module allows process control to take place outside the CPU. This arrangement prevents the CPU from being burdened with complex calculations. The basic function of this module is to provide the control action required to maintain a process variable such as temperature, fl ow, level, or speed within set limits of a specifi ed set point.

MOTION AND POSITION CONTROL MODULE

Motion and position control modules are used in applications involving accurate high-speed machining and packaging operations. Intelligent position and motion control modules permit PLCs to control stepper and servo motors.

Figure 2-33 PID module.
Source: Courtesy Red Lion Controls.

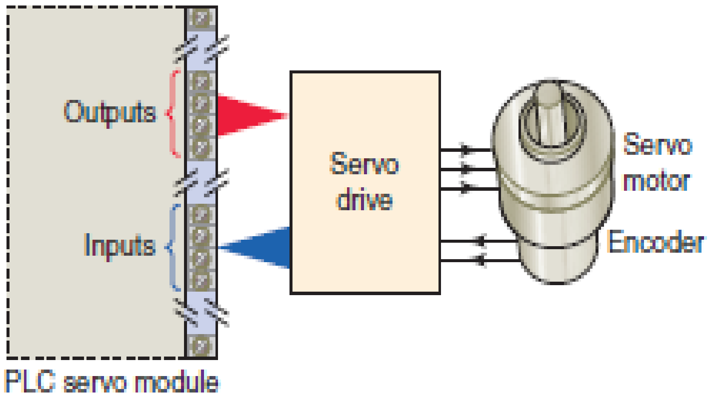

Figure 2-34 PLC servo module.

These systems require a drive, which contains the power electronics that translate the signals from the PLC module into signals required by the motor (Figure 2-34).

COMMUNICATION MODULES

Serial communications modules (Figure 2-35) are used to establish point-to-point connections with other intelligent devices for the exchange of data. Such connections are normally established with computers, operator stations, process control systems, and other PLCs. Communication modules allow the user to connect the PLC to high-speed local networks that may be different from the network communication provided with the PLC.

Figure 2-35 Serial communications module.
Source: Photo courtesy Automation Direct, **www.automationdirect.com**.

2.5 I/O Specifi cations

Manufacturers' specifi cations provide information about how an interface device is correctly and safely used. These specifi cations place certain limitations not only on the I/O module but also on the fi eld equipment that it can operate. Some PLC systems support *hot swappable* I/O modules designed to be changed with the power on and the PLC operating. The following is a list of some typical manufacturers' I/O specifi cations, along with a short description of what is specifi ed.

Typical Discrete I/O Module Specifi cations

NOMINAL INPUT VOLTAGE

This discrete input module voltage value specifi es the magnitude (e.g., 5 V, 24 V, 230 V) and type (AC or DC) of user-supplied voltage that a module is designed to accept. Input modules are typically designed to operate correctly without damage within a range of plus or minus 10 percent of the input voltage rating. With DC input modules, the input voltage may also be expressed as an operating range (e.g., 24–60 volts DC) over which the module will operate.

INPUT THRESHOLD VOLTAGES

This discrete input module specifi cation specifi es two values: a minimum ON-state voltage that is the minimum voltage at which logic 1 is recognized as absolutely ON; and a maximum OFF-state voltage which is the voltage at which logic 0 is recognized as absolutely OFF.

NOMINAL CURRENT PER INPUT

This value specifi es the minimum input current that the discrete input devices must be capable of driving to operate the input circuit. This input current value, in conjunction with the input voltage, functions as a threshold to protect against detecting noise or leakage currents as valid signals.

AMBIENT TEMPERATURE RATING

This value specifi es what the maximum temperature of the air surrounding the I/O modules should be for best operating conditions.

INPUT ON/OFF DELAY

Also known as *response time* , this value specifi es the maximum time duration required by an input module's circuitry to recognize that a fi eld device has switched ON (input ON-delay) or switched OFF (input OFF- delay). This delay is a result of fi ltering circuitry provided to protect against contact bounce and voltage transients. This input delay is typically in the 9 to 25 mil lisecond range.

OUTPUT VOLTAGE

This AC or DC value specifies the magnitude (e.g., 5 V, 115 V, 230 V) and type (AC or DC) of user-supplied voltage at which a discrete output module is designed to operate. The output fi eld device that the module interfaces to the PLC must be matched to this specification. Output modules are typically designed to operate within a range of plus or minus 10 percent of the nominal output voltage rating.

OUTPUT CURRENT

These values specify the maximum current that a single output and the module as a whole can safely carry under load (at rated voltage). This rating is a function of the module's components and heat dissipation characteristics. A device drawing more than the rated output current results in overloading, causing the output fuse to blow. As an example, the specification may give each output a current limit of 1 A. The overall rating of the module current will normally be less than the total of the individuals. The overall rating might be 6 A because each of the eight devices would not normally draw their 1 A at the same time. Other names for the output current rating are *maximum continuous current* and *maximum load current.*

INRUSH CURRENT

An inrush current is a momentary surge of current that an AC or DC output circuit encounters when energizing inductive, capacitive, or fi lament loads. This value specifies the maximum inrush current and duration (e.g., 20 A for 0.1 s) for which an output circuit can exceed its maximum continuous current rating.

SHORT CIRCUIT PROTECTION

Short circuit protection is provided for AC and DC output modules by either fuses or some other current-limiting circuitry. This specification will designate whether the particular module's design has individual protection for each circuit or if fuse protection is provided for groups (e.g., 4 or 8) of outputs.

LEAKAGE CURRENT

This value specifies the amount of current still conducting through an output circuit even after the output has been turned off. Leakage current is a characteristic exhibited by solid-state switching devices such as transistors and triacs and is normally less than 5 milliamperes. Leakage current is normally not large enough to falsely trigger an output device but must be taken into consideration when switching very low current sensitive devices.

ELECTRICAL ISOLATION

Recall that I/O module circuitry is electrically isolated to protect the low-level internal circuitry of the PLC from high voltages that can be encountered from fi eld device connections. The specification for electrical isolation, typically 1500 or 2500 volts AC, rates the module's capacity for sustaining an excessive voltage at its input or output terminals. Although this isolation protects the logic side of the module from excessive input or output voltages or current, the power circuitry of the module may be damaged.

POINTS PER MODULE

This specification defines the number of fi eld inputs or outputs that can be connected to a single module. Most commonly, a discrete module will have 8, 16, or 32 circuits; however, low-end controllers may have only 2 or 4 circuits. Modules with 32 or 64 input or output bits are referred to as *high-density* modules. Some modules provide more than one common terminal, which allows the user to use different voltage ranges on the same card as well as to distribute the current more effectively.

BACKPLANE CURRENT DRAW

This value indicates the amount of current the module requires from the backplane. The sum of the backplane current drawn for all modules in a chassis is used to select the appropriate chassis power supply rating.

Typical Analog I/O Module Specifications

CHANNELS PER MODULE

Whereas individual circuits on discrete I/O modules are referred to as points, circuits on analog I/O modules are often referred to as channels. These modules normally have 4, 8, or 16 channels. Analog modules may allow for either single-ended or differential connections. *Single-ended* connections use a single ground terminal for all channels or for groups of channels. *Differential* connections use a separate positive and negative terminal for each channel. If the module normally allows 16 single-ended connections, it will generally allow only 8 differential connections. Single-ended connections are more susceptible to electrical noise.

INPUT CURRENT/VOLTAGE RANGE(S)

These are the voltage or current signal ranges that an analog input module is designed to accept. The input ranges must be matched accordingly to the varying current or voltage signals generated by the analog sensors.

OUTPUT CURRENT/VOLTAGE RANGE(S)

This specification defines the current or voltage signal ranges that a particular analog output module is designed to output under program control. The output ranges must be matched according to the varying voltage or current signals that will be required to drive the analog output devices.

INPUT PROTECTION

Analog input circuits are usually protected against accidentally connecting a voltage that exceeds the specified input voltage range.

RESOLUTION

The resolution of an analog I/O module specifies how accurately an analog value can be represented digitally. This specification determines the smallest measurable unit of current or voltage. The higher the resolution (typically specified in bits), the more accurately an analog value can be represented.

INPUT IMPEDANCE AND CAPACITANCE

For analog I/Os, these values must be matched to the external device connected to the module. Typical ratings are in Megohm (MV) and picofarads (pF).

COMMON-MODE REJECTION

Noise is generally caused by electromagnetic interference, radio frequency interference, and ground loops. Common-mode noise rejection applies only to differential inputs and refers to an analog module's ability to prevent noise from interfering with data integrity on a single channel and from channel to channel on the module. Noise that is picked up equally in parallel wires is rejected because the difference is zero. Twisted pair wires are used to ensure that this type of noise is equal on both wires. Common-mode rejection is normally expressed in decibels or as a ratio.