

Electrical Ladder Drawing Basics

Understanding the basic layout, symbols, and cross-reference system of ladder diagrams will help you become a better troubleshooter

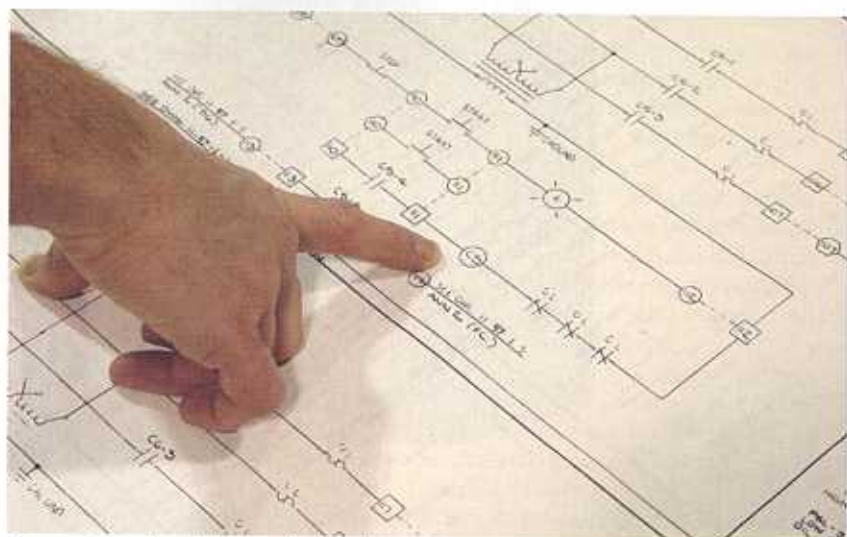
By Roger Zieg, Lewellyn Technology

Electrical ladder drawings are still one of the common and reliable tools used to troubleshoot equipment when it fails. As with any good troubleshooting tool, one must be familiar with its basic features to make the most of the diagram in the field. In other words, possessing a basic understanding of how the drawing is laid out — as well as the meaning of numbers and symbols found on the schematic — will make you that much more seasoned as a maintenance professional.

There are typically two distinct parts of a ladder drawing: the power component and the control component (**Photo**). The power portion consists of items such as the motor, motor starter contacts and overloads, disconnect(s), and protective devices (fuses and circuit breakers). The control part encompasses items that make the power components do their work. For this discussion, we'll focus on the control portion of the drawing. Let's take a look at the most common components.

Symbols. The symbols that go into making a ladder drawing are the ABCs of print reading (**Fig. 1** on page 18). For instance, in an air compressor system there will be a symbol for a pressure switch. If the person doing the troubleshooting and repair does not recognize that symbol, it will be difficult to locate the switch to determine whether or not it is working properly.

Many times, the input devices are said to be either normally open (NO) or normally closed (NC). The normally open or closed status refers to the shelf state of the device. If a device is normally open, a resistance check of the device with a



Strong print reading skills form the foundation of a good troubleshooter.

digital multimeter will give a reading of O.L. If the device is normally closed, a resistance check will give a reading of 0.0.

The normally open and normally closed state of the devices is not labeled on the ladder drawing. Rather, you must recognize the symbol. A helpful hint in trying to determine whether the contacts are open or closed is to think of them in terms of gravity. If gravity is acting on the device, its normal state is as shown in the drawing. An exception to this concept is found in devices that contain springs. For instance, in the drawing of a normally open pushbutton, it appears that the pushbutton should be falling down and closing. However, there is a spring in the pushbutton that holds the contacts in the open (up) position.

Control voltage and safety. The control voltage (AC or DC) for the system may

come from a control transformer that is fed from the power portion of the drawing or a different source. For safety reasons, it's important to determine the source of the control voltage prior to working on the system because the power disconnect switch may not turn off the control voltage. Therefore, an electrically safe condition would not be established. The ladder drawing should clearly show the source of the control voltage, but always check for the absence/presence of voltage before making any off-line resistance checks.

Rails. The drawing is called a ladder drawing because it resembles a ladder in the way it is constructed and presented on the paper. The two vertical lines (wires) that serve as a boundary for the control system and deliver the control voltage to the devices are called the rails. The rails may have overcurrent devices in them

MAINTENANCE FACTS

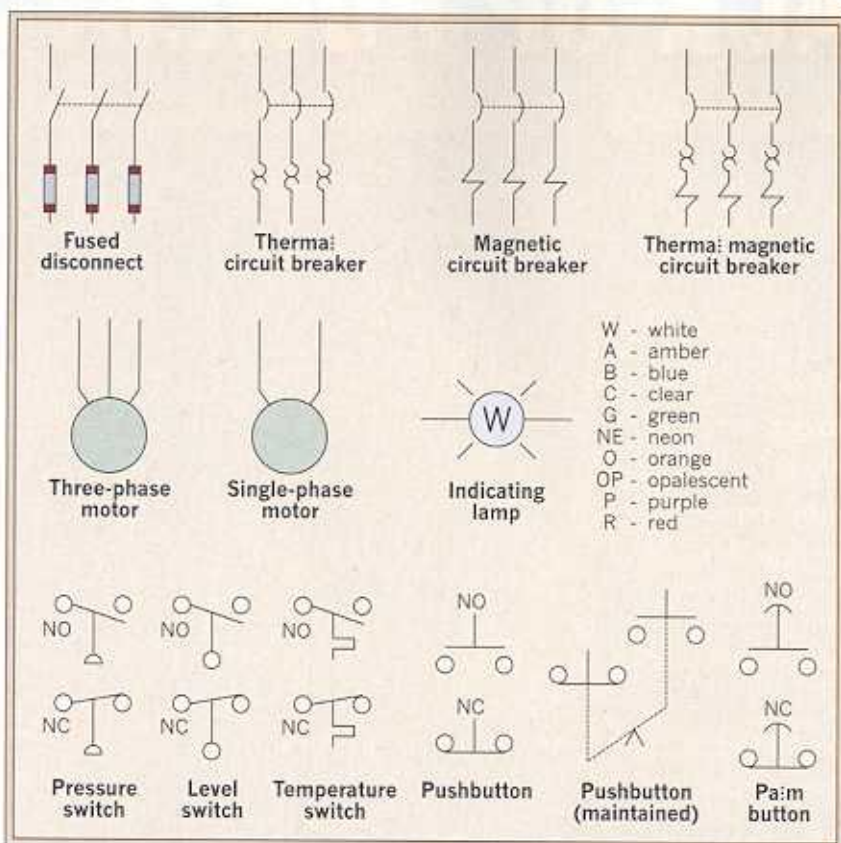


Fig. 1. A sampling of common symbols you'll find on the majority of ladder drawings. The normally open and normally closed symbols are added here to merely serve as an instructional aid.

(fuses and/or circuit breakers) and may have contacts from control devices. These control lines may be thicker than the others to help better identify them. Like a real ladder, the rails are the supports for the rungs.

If the ladder drawing runs across several pages, the control voltage is carried from one page to the next along the rails. There are a number of ways that this may be represented on the drawing. One way this is done is with the use of continuation arrows at the bottom of the first page, which indicates that the rails continue on to another page. The page number on which the rails continue should be noted. On the page where the rails continue, there are also continuation arrows with the page number notation from which the control voltage lines originated.

Rungs. The rungs of the ladder are made up of wires and input devices that either allow current flow or interrupt current flow to the output devices. These lines

may be thin lines when compared to the lines of the rails. From the placement of the input and output devices, you can determine the sequence of events that either energize or de-energize the outputs. The key to good troubleshooting is determining this sequence of events. Input devices are typically placed on the left side of the rungs, while the output devices are placed on the right (Fig. 2).

Placement of input devices. The input devices are placed on the rungs in a way that indicates the current flow

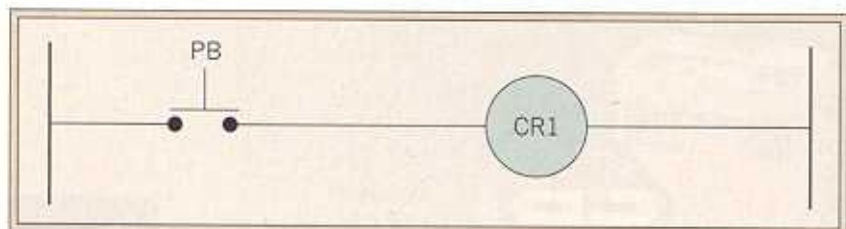


Fig. 2. In this circuit arrangement, the sequence of events could be described as such. When the pushbutton (PB) is pressed down, the circuit is completed and current will flow to energize the coil (CR1).

through the rung when there is a complete path to the outputs. There are several ways in which these input devices can be placed on the rungs, although as stated earlier, they are typically placed on the left side.

The STOP input devices are typically normally closed and are placed in series on the rung. This means that they are placed end to end in the drawing. In order for the current to flow through them, they must be in the closed position. Typical STOP input devices include components such as normally closed pushbuttons and mushroom head buttons, limit switches, and contacts for light curtains, photocells, and proximity switches.

The START input devices are typically normally open and are usually placed in series with and after the STOP devices. If there is more than one START device, it is usually placed in parallel with the others.

When the STOP and START devices are placed in order on the rung, the flow of current to the output devices can be seen. Understanding this flow is a great aide in troubleshooting. A key question to always ask yourself is: "What does it take to energize the output?"

Here's a simple example to analyze. In Fig. 3 on page 20, what does it take to energize the output CR1? When either start pushbutton is depressed, the path is complete, and the coil of CR1 is energized. In following the path for the current, you can see the logic of the placement of the input devices. This logic determines the decision making process of the input devices and the path for current as it travels to energize the outputs.

Logic statements. There are several logic statements that can be used in placing the input devices in the rungs. The most common of these are the AND, the OR, and the combination AND/OR function. In Fig. 3, all three are present.

MAINTENANCE FACTS

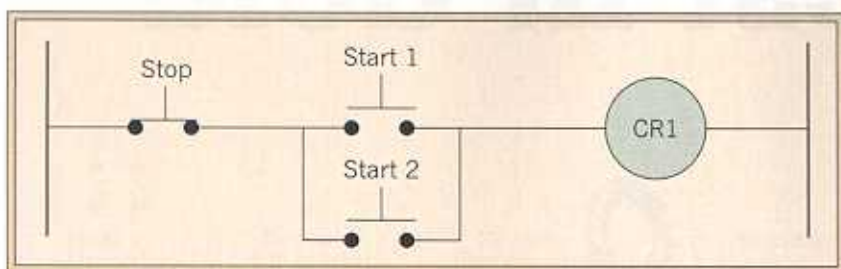


Fig. 3. This circuit arrangement uses all three types of logic functions: AND, OR, and AND/OR.

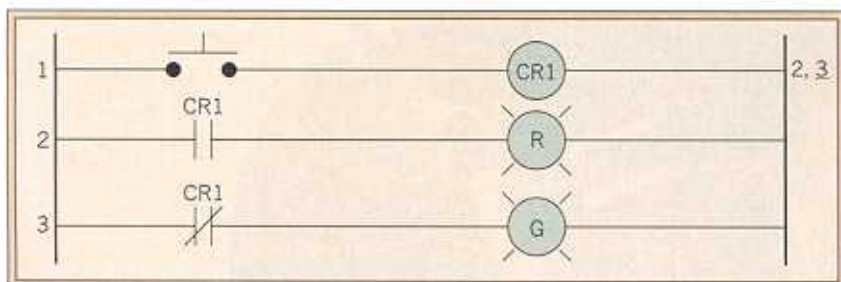


Fig. 4. As noted by the numbers on the right rail, this circuit arrangement indicates there is a normally open contact in Rung 2 and a normally closed contact in Rung 3.

- The end-to-end placement of the stop and start pushbuttons makes an AND logic statement. In other words, both the stop AND the start buttons must be used to energize the coil.

- The parallel placements of the start buttons makes an OR logic statement. Either start pushbutton will complete the path and energize the coil.

- Placing the stop pushbutton in series with the parallel start pushbuttons supports the AND/OR logic statement.

Placement of the output devices.

As noted earlier, the output devices are placed on the right side of the ladder drawing. Unlike input devices, it's important that the output devices only be placed in parallel. If they are placed in series, electrical theory says that the voltage will drop across the resistance of each output. If this happens, they will not operate properly.

Outputs include items such as lights, coils, solenoids, and heating elements. In addition to the commonly accepted symbols shown in Fig. 1, letters and numbers also help to identify the output devices.

Coils will typically have contacts associated with them. These contacts will change state when the coil is energized. The changing contacts will either complete or open the path for current.

As noted in Fig. 4, when the pushbutton is pressed down, the path is completed, and current will flow to energize the coil. When the coil is energized, the contacts associated with the coil will change state. The red light will go on, and the green light will go off.

Locating the contacts. In the ladder drawing, the contacts associated with the coil can be located using a cross-reference system. The rungs are usually numbered on the left side of the rail. A number on the right side of the rail references the contacts associated with the coil (Fig. 4). These numbers are the rungs in which the contacts can be found. A number without a line under it references an open contact. Drawing a line under the number on the right rail references a closed contact. **EC&M**

Zieg is a licensed electrical contractor and instructor for Lewellyn Technology in Linton, Ind.

Super Tough

NEW!

Innovative SUPER-GRIP™ Cable Ties are designed to withstand rough installation practices.

- High grip strength prevents lateral movement of tie on bundle
- Superior strap flexibility conforms tightly to irregular bundle shapes
- Flared neck improves tie strength
- Strong locking wedge provides high loop tensile strength



Flared Neck



Tapered Tip & Aggressive Grips



Various Sizes and Materials

Visit us at www.panduit.com/sg06

Contact Customer Service by email: cs@panduit.com
or by phone: 800-777-3300 and reference ad # sg06



Circle 58 on Reader Service Card or visit freeproductinfo.net/ecm