



UNDERSTANDING ELECTRICAL SCHEMATICS Part 1 (Revised)

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INTRODUCTION

Quite often, when you encounter a problem with a piece of HVAC/R equipment, the problem turns out to be electrical in nature. If you have a clear understanding of how to read wiring diagrams, you frequently can find the source of the trouble simply by checking the wiring of the unit itself against the manufacturer's wiring diagram. The purpose of this chapter is to familiarize service technicians with symbols and conventions commonly used in schematic diagrams, thereby making it easier to identify components and their related circuits. The more you know about the proper procedures for reading and interpreting electrical schematics, the more quickly you'll be able to find the solution to your problem. And that's the primary function of any wiring diagram—to aid the technician in finding the problem and then correcting it.

An intelligent service technician, before he or she can solve a problem, must know how and where to start looking for the source of the trouble. Although a wiring diagram may appear very complex when viewed as a whole, it can be simplified by breaking it down into smaller parts. If you look at the individual circuits, one at a time, the overall diagram and machine functions become much easier to understand. Control systems, for example, usually are designed so that an individual circuit controls only one function of a piece of equipment—starting and stopping a motor by means of a pushbutton, for instance, or controlling a solenoid valve by means of a limit switch. Naturally, many variations are possible, but the main point to remember is that an individual circuit usually is associated with a single, basic apparatus function.

The main schematic that you will be examining in this chapter will be shown in its entirety first, and then will be broken down into individual sections, which will be considered separately. Before you begin looking at wiring diagrams, though, remember that there are always five basic components to any schematic:

- a *power supply*
- a *path* for the power
- a *load* or component that operates from the power
- a *switch* or component that interrupts the power to the load
- a *legend* or key that explains what the various symbols and abbreviations used in the schematic mean.

TYPES OF WIRING DIAGRAMS

There are three basic types of wiring diagrams used in the HVAC/R industry today. The first and most common is the *ladder* diagram, so called because it looks like the symbols that are used to represent the components in the system have been placed on the rungs of a ladder. From this point forward, ladder diagrams will be referred to as "schematic" diagrams, or simply "schematics." A typical schematic of a packaged air conditioner is shown in Figure 1 on the next page. In electrical schematics, the symbols stand for various components in the circuit, and the lines stand for the wires connecting them. The intention of the overall schematic is to show how the circuit *functions*, not how it actually *looks*.

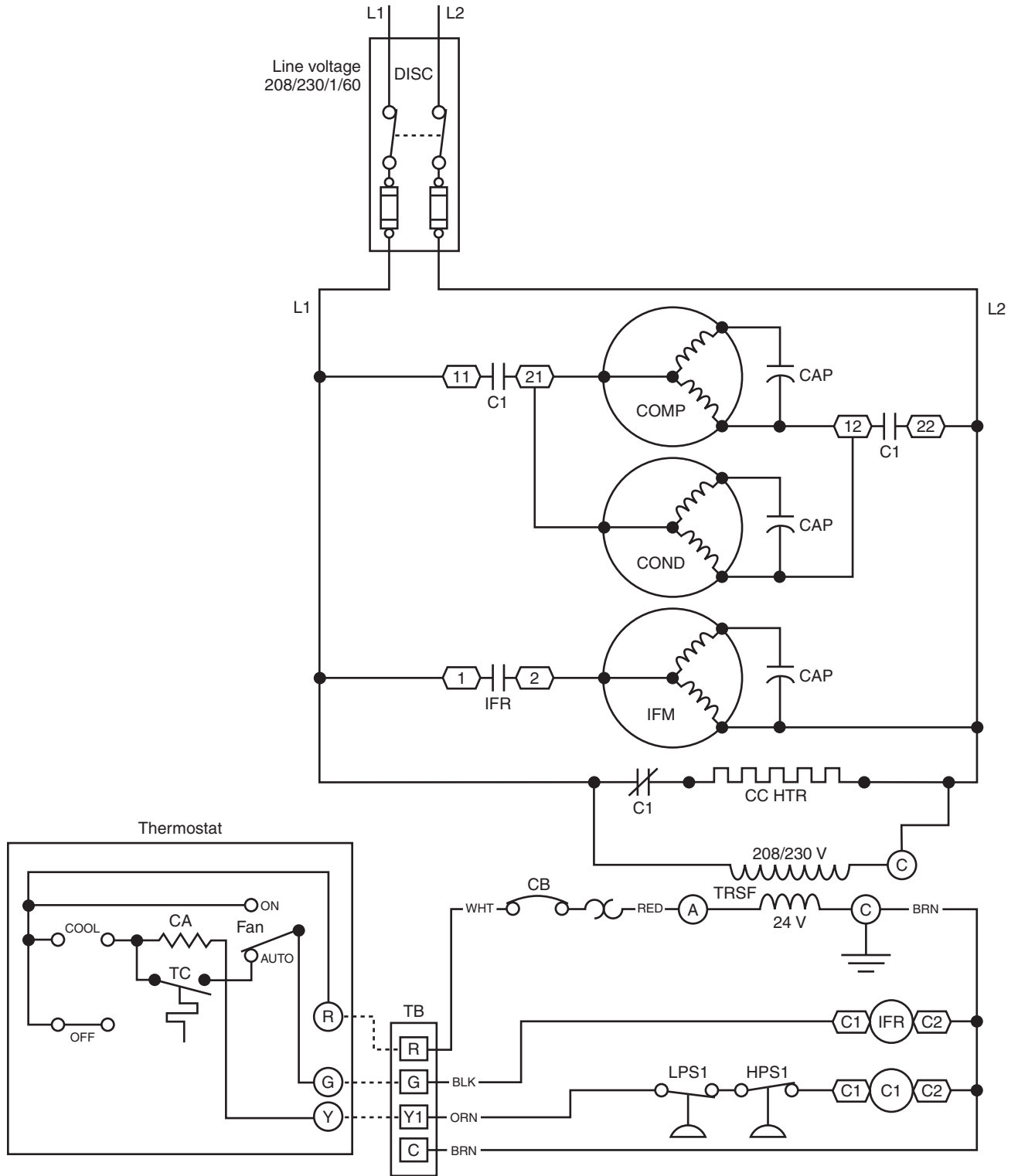


Figure 1. Typical schematic diagram

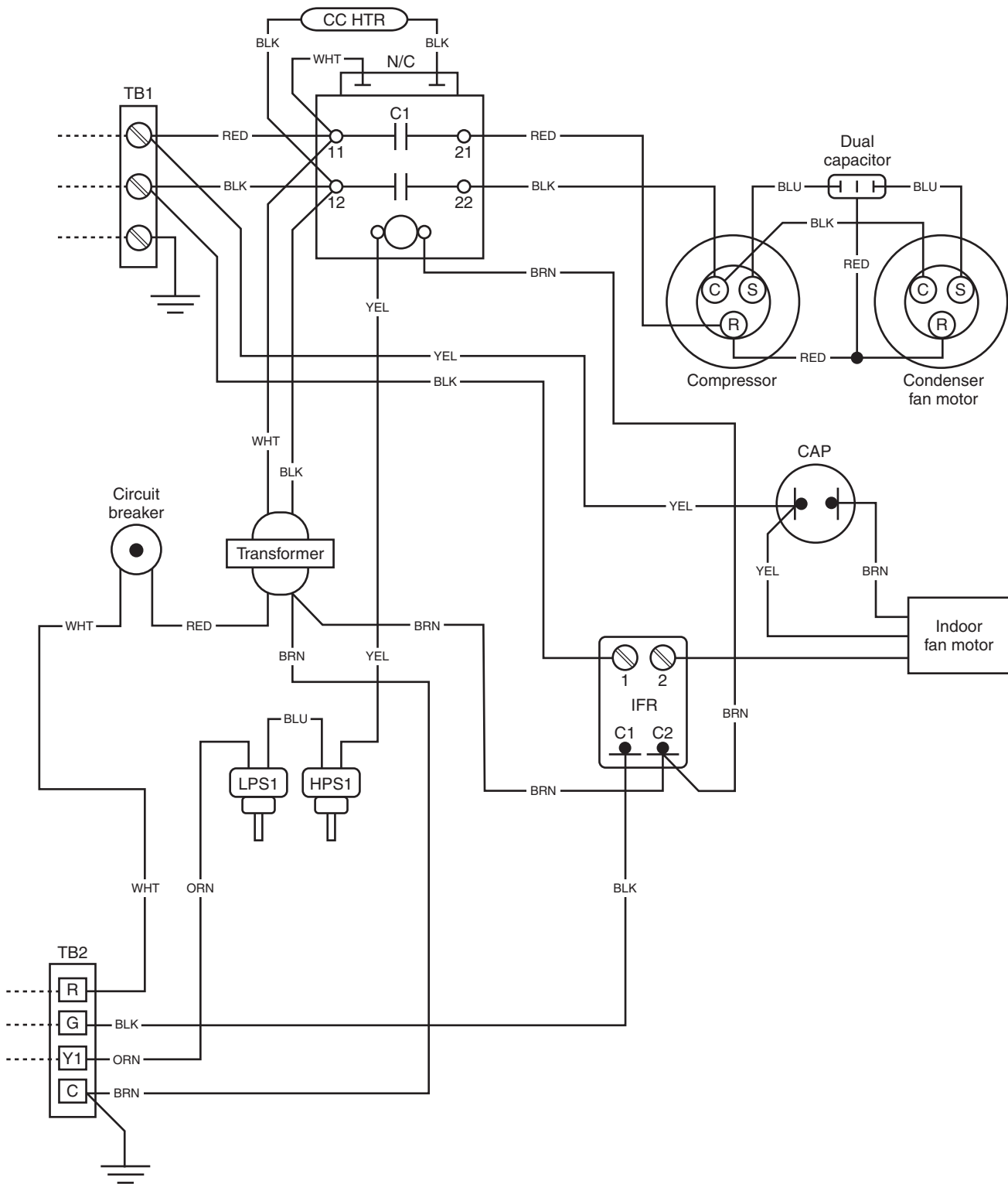


Figure 2. Typical line diagram

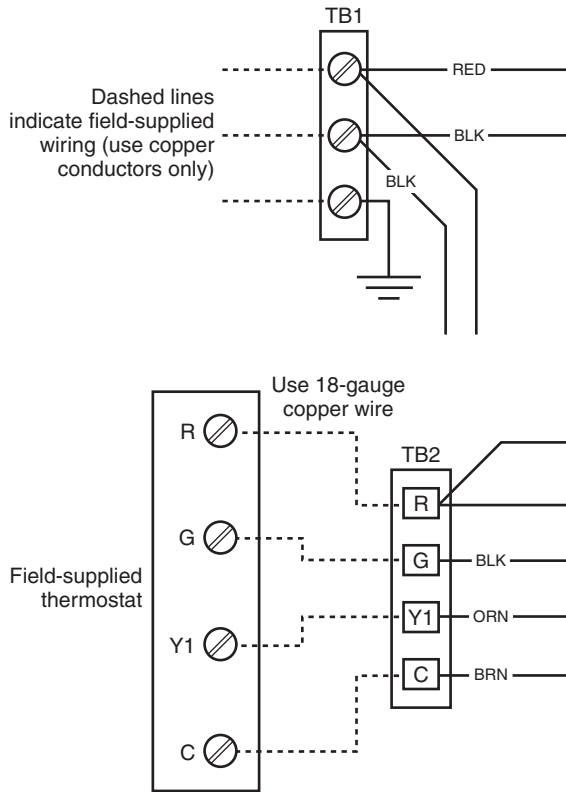


Figure 3. Installation diagram

The second type of diagram is the *line* diagram. It usually includes drawings that more closely resemble the components themselves, rather than symbols. Figure 2 on the previous page is an example of a typical line diagram. Compare Figure 1 and Figure 2 and

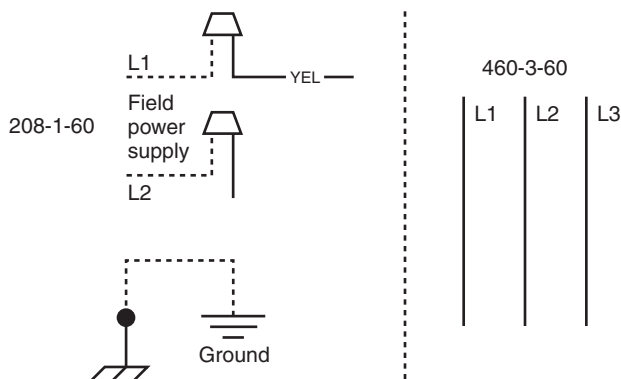


Figure 4. Power supply symbols

note the differences in the way that motors, switches, and transformers are represented. Today it is not uncommon for some manufacturers to show both types of diagrams on their equipment.

The third and last type of diagram is the *installation* diagram. This is a tool that is used primarily by the installing contractor. It normally shows only what the terminal board connections are, and very rarely will it include any internal wiring of the unit. Figure 3 is a typical installation diagram for a residential cooling system.

SYMBOLS USED IN SCHEMATICS

When you look at a road map, you must understand the symbols and signs used by the creator of the map in order to find out where you are and how to get to your destination. The same is true of an electrical schematic.

If you think of a schematic as a road map, then the "roads" are the wires that connect the various components and deliver power to the controls and to the loads that make up the system. Let's take a look at some of the symbols used in electrical schematics.

Power supplies

Many different supply voltages are used in the HVAC/R industry, ranging from 575-V, three-phase power supplies to 24-V control circuit voltages. Power supplies may be indicated by solid lines or by dashed or dotted lines, as shown in Figure 4.

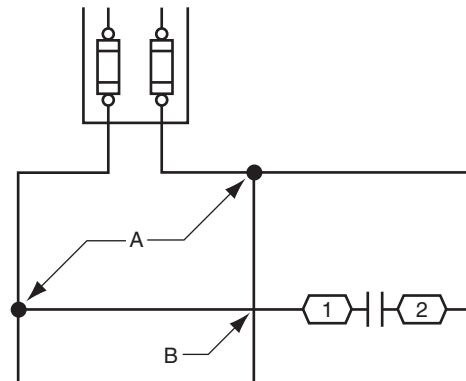


Figure 5. Wiring connections and crossovers

Wiring

Most schematics use straight lines to represent the wires that connect components to each other. If two wires are connected internally, the connection *usually* is shown as a dot (a solid black circle), as illustrated at those points marked “A” in Figure 5. But note that there is no dot to indicate a junction or connection at point “B.” This means that one wire simply crosses over the other wire. Now look at Figure 6. In this drawing, crossover wires are shown with half circles or loops that “jump” over other wires (see those points marked “A”). Note also that in this type of diagram, junctions are shown *without* connection dots (see those points marked “B”).

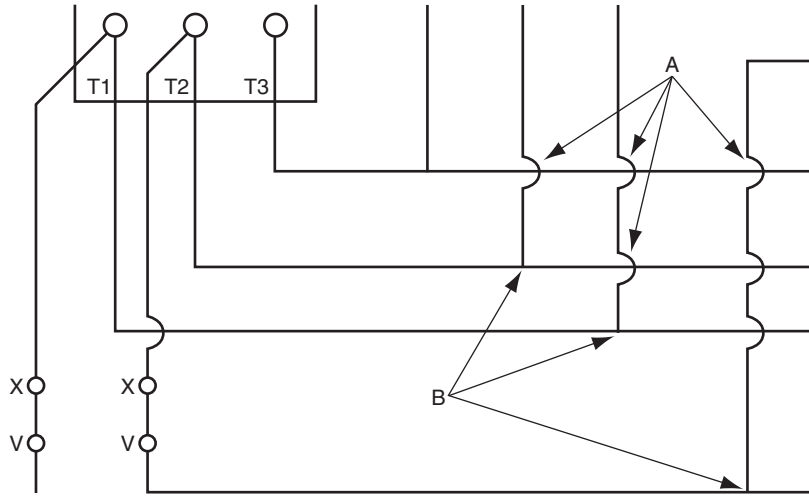


Figure 6. More wiring connections and crossovers

The fact that not all manufacturers follow the same schematic diagram practices can be confusing. You will see several different styles of wiring diagrams in your work, and you need to be aware that not all of them will use exactly the same conventions. Remember: If dots are used to show junctions, then intersecting lines without dots mean that the two wires cross without connecting. If loops or jumps are used to depict crossovers, then wires that meet—even without dots—are connected.

Another variation you may encounter concerns the weight of the lines themselves. Some manufacturers use different line thicknesses to represent different types of wires. Others also may use numbers or colors (or both) to help identify the various wires found in a unit (see Figure 7). These usages should be clearly indicated in the legend that accompanies the drawing.

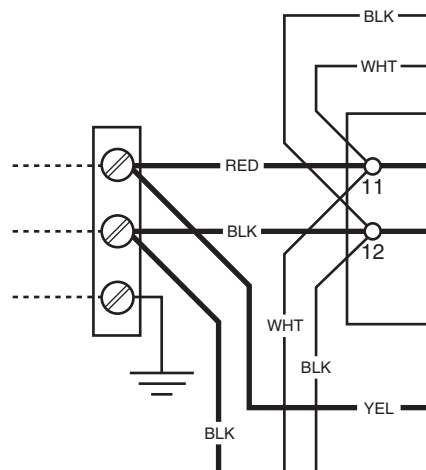


Figure 7. Wiring identification

draw switches and basic controls. A variety of simple single-pole, single-throw (SPST) switches is shown below. All are in the closed position.



Here are the same switch symbols shown in the open position:



Switches

One of the most basic components in any schematic is the *switch*. A switch is a device that interrupts power to the load. It may be manually operated, it may be activated automatically by pressure or temperature, or it may be an electrically controlled switch (relay). Again, there are several different ways to

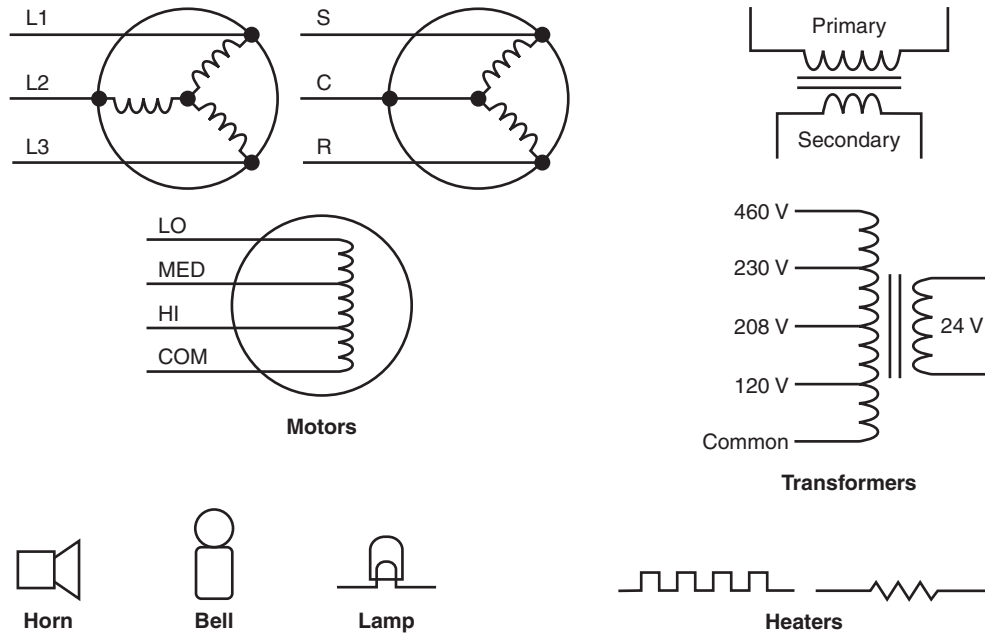


Figure 8. Load symbols

Loads

Loads are devices that consume power and convert it to some other form of energy, such as motion or heat. They may be motors, heaters, lights, or other pieces of equipment. A transformer is a type of power-consuming device, but rather than converting energy, a transformer changes the voltage or current. Figure 8 shows typical symbols for several different kinds of loads.

SCHEMATIC DIAGRAM CONFIGURATIONS

There are two basic configurations used in schematics today to show the approximate placement of loads, switches, and different power or supply voltages. The first is a side-by-side arrangement, an example of which is shown in Figure 9. Manufacturers usually place motors and other power-consuming components on the right side of the diagram. This is called the “load” side. The switches and other controllers are placed on the left side of the diagram. This is called the “line” side.

The second configuration is an up-and-down arrangement that divides the schematic into high-

voltage and low-voltage sections. Normally the high-voltage section is placed at the top of the diagram, and the low-voltage section is placed at the bottom of the diagram (see Figure 10). The vertical lines at the outer edges of the diagram represent the source of electric power. All control devices and load devices are located on the horizontal lines between these outer vertical lines. An easy way to determine the different voltages in this type of schematic is to look for the transformer. It normally is the “dividing line” for voltage changes. (The dashed line used in Figures 9 and 10 to separate the sections does not appear in actual schematics.)

LOCATORS

Think back to our discussion of roadmaps. Almost all mapmakers place numbers and/or letters along the vertical and horizontal edges of maps to help users find particular cities, towns, landmarks, or other locations. Electrical schematics utilize a similar system. Take a look at Figure 11 on page 8. This is the same schematic of a packaged air conditioner that you saw in Figure 1, but notice that now a column of small numbers has been added, running down the left-hand side of the diagram. These numbers are used to

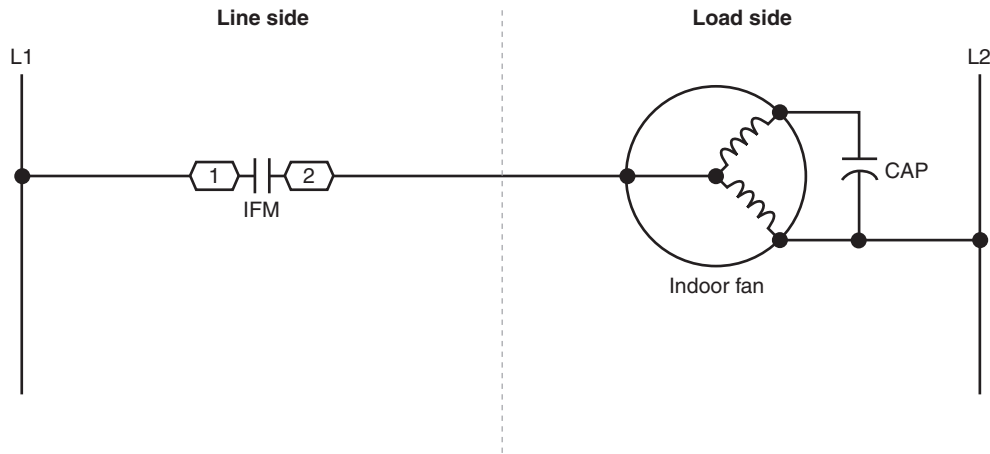


Figure 9. Side-by-side configuration

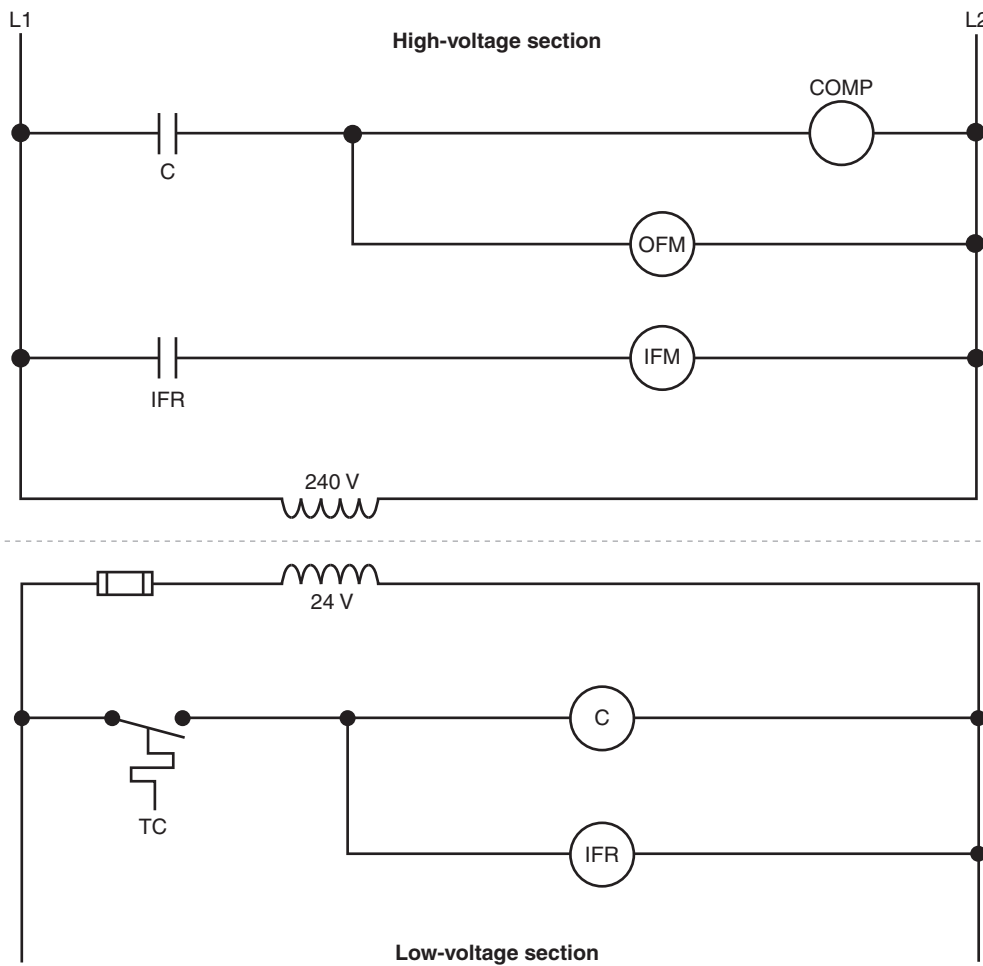


Figure 10. Up-and-down configuration

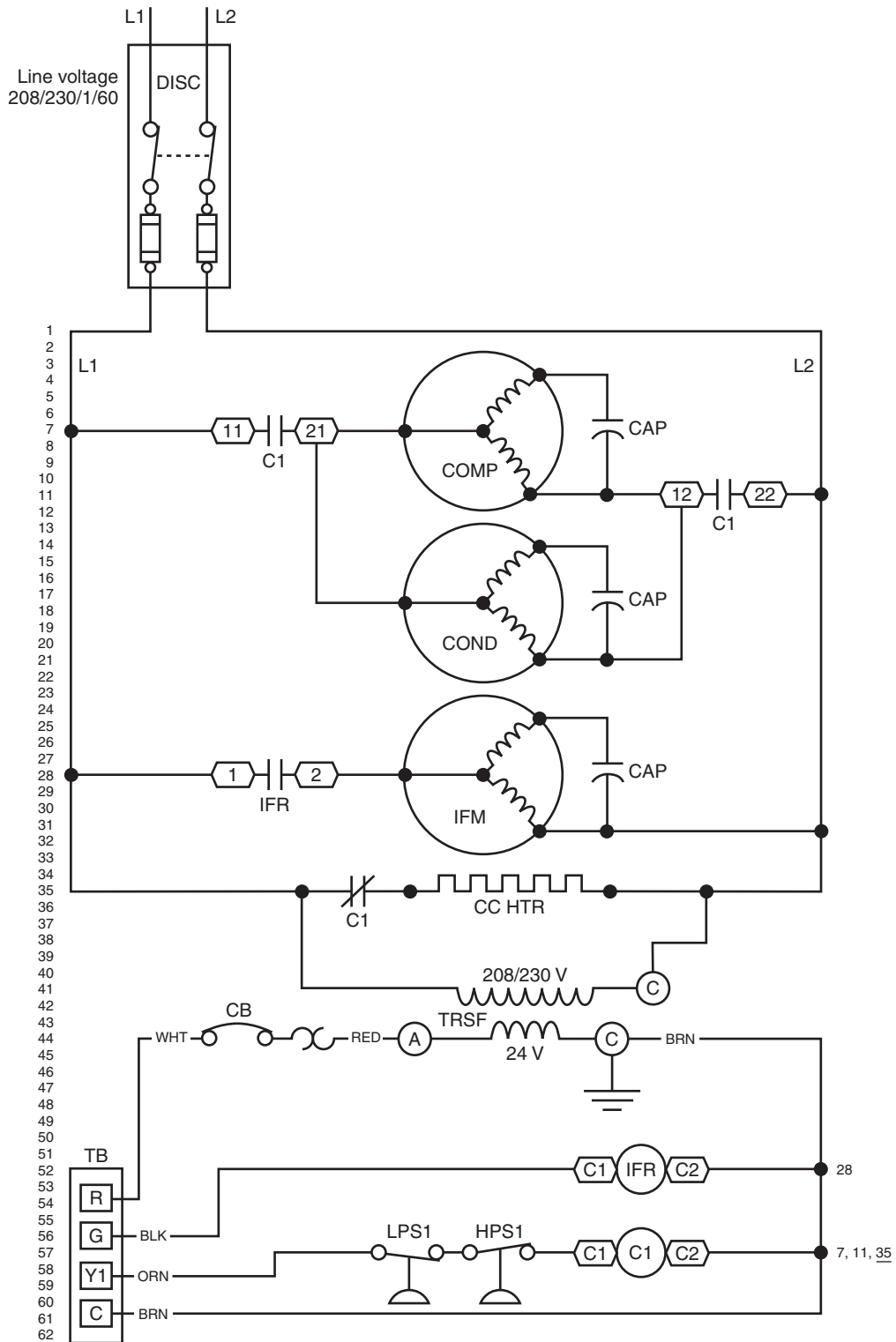


Figure 11. Numerical line locators



indicate the relative location of each horizontal line in the diagram. (If a line falls between two numbers, the number lower on the page generally is used as the location reference.)

This type of line-numbering system can be very useful in helping the reader identify the location of a specific component on the schematic, as well as its controlling switch. In the detail shown in Figure 12A, for example, “C1” contacts are located on lines 7 and 11. Similarly, in Figure 12B, you can find the high-voltage switches “IFR” and “C1” on lines 28 and 35, respectively.

Now look at the lower portion of the wiring diagram in Figure 11 and locate the relay coils “IFR” and “C1” on lines 52 and 57. In the detail shown in Figure 12C, note that there are small numbers along the *right-hand* side of the diagram as well. These numbers designate the line location of relay contacts. The small number 28 in the right-hand margin tells you the line location of the contacts associated with relay coil “IFR.” Look back at line 28 in Figure 12B, and you will find the “IFR” contacts.

Likewise, the numbers 7, 11, and 35 in the right-hand margin of Figure 12C refer you to the lines where the

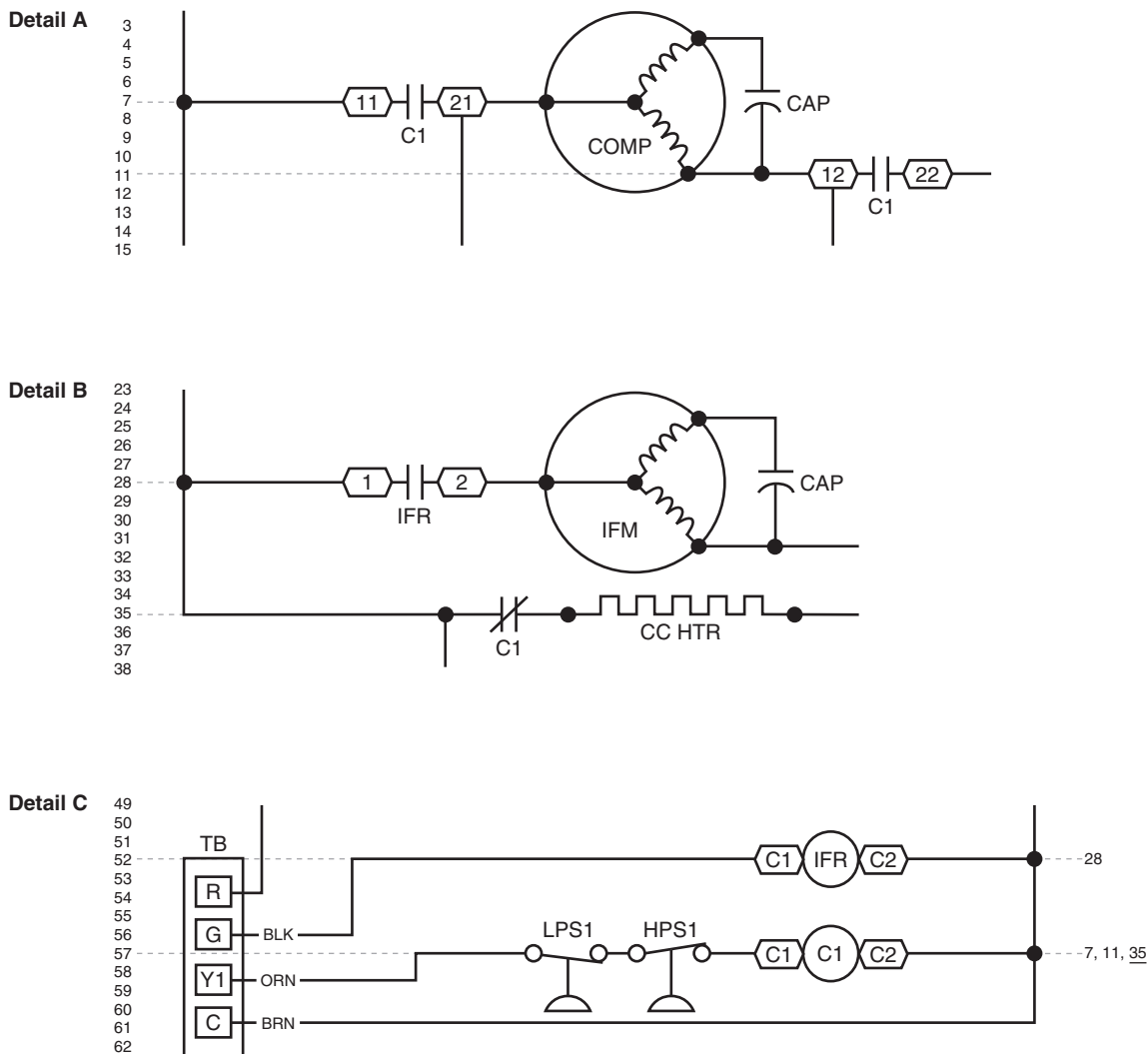


Figure 12. Identifying line location of relay contacts



contacts associated with relay coil “C1” can be found. Note that the 35 is underlined. An underlined number signifies a normally closed contact (and, conversely, a number that is *not* underlined signifies a normally open contact). Accordingly, you will find that the “C1” contacts located on line 35 in Figure 12B are shown as normally closed, and that the “C1” contacts on lines 7 and 11 in Figure 12A are shown as normally open.

LEGENDS

The schematic shown in Figure 1 normally would include a legend like the one pictured below. Many of the abbreviations, acronyms, and symbols used in the schematic are listed in the legend, along with their meanings.

The legend and notes, if any, that accompany a schematic diagram further explain the components that make up the system and provide additional information where needed. When you look at a wiring diagram, always read the notes first, and make sure that you know what the abbreviations used in the diagram stand for.

SUMMARY

This concludes a general overview of the major parts of any schematic or wiring diagram—namely, the power supply, the pathways (wiring), the switches, the loads, and the legend. With a knowledge of these basics, you will be able to advance to Part 2 of this topic and learn how to read more complex electrical schematics.

LEGEND	
—————	Factory wiring
-----	Field wiring
	Ground
C1	Compressor contactor coil
CA	Cooling anticipator
CAP	Run capacitor
CB	Circuit breaker
CC HTR	Crankcase heater
COMP	Compressor
COND	Condenser
DISC	Disconnect
HPS	High-pressure switch
IFR	Indoor fan relay
IFM	Indoor fan motor
LPS	Low-pressure switch
TB	Terminal board
TC	Thermostat, cooling
TRSF	Transformer



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