- When multiple switches are connected in series with each other, they all must be in the closed position for current to travel through the circuit, thereby energizing the load. Safety switches, for example, are always connected in series.
- The current in a series circuit is the same at all points.
- Parallel circuits operating with the same power supply have the same voltage applied to them.
- Parallel circuits operating with the same power supply can (and normally do) have different currents flowing through each branch.
- Loads connected in parallel can be (and often are) controlled by different switches and controls.
- Electric current always follows the path of least resistance.

The last point listed above is very important when considering safe working practices. A service technician is always at risk when working with energized power circuits—you must make sure that *you* never become the path of least resistance for electric current!

HEAT PUMP WIRING DIAGRAMS

A variety of wiring diagrams is used in the HVACR industry. Each plays an important role in the troubleshooting process. The basic diagrams used are the *component arrangement* (or "pictorial") diagram, the *point-to-point schematic* diagram, the *ladder* diagram, and the type of combination diagram that contains both the component arrangement diagram and the ladder diagram in the same document. All other wiring diagrams are basically variations of one of these types of drawings. Unless otherwise noted, all wiring diagrams depict switches and contacts in the *de-energized* or *normal* mode. This means that they are shown as they are when the power to the equipment is off. A *normally open* switch or contact is open when power to the unit is off, and a *normally closed* switch or contact is closed when power to the unit is off. Supplying power to the coil of a relay will result in a reversal of position for all switches or contacts in the relay. Normally open contacts will close when the relay coil is energized, and normally closed contacts will open.

Component arrangement diagram

A *component arrangement* diagram (sometimes called a "pictorial" diagram) is used to determine the physical location of all of the components in a control cabinet. Components are identified using either their full descriptive names or abbreviations spelled out in the legend. The component arrangement diagram for a three-phase heat pump is shown in Figure 6-2 on the next page. Connecting wires are not shown in this particular diagram. It is common for inexperienced technicians to attempt to use the component arrangement diagram for troubleshooting purposes, especially when the wiring is drawn on the diagram. This is an unwise practice—it is very difficult to determine the functions of individual circuits and system components using a component arrangement diagram. A ladder diagram more clearly shows which switches control specific loads in the equipment. Use the ladder diagram to troubleshoot a system, and the component arrangement diagram to locate the physical component that needs to be checked.

Point-to-point schematic diagram

A *point-to-point schematic* diagram is intended to provide the field technician with a detailed representation of the actual wiring in a specific system. Each wire in the circuit is depicted and, when necessary, the color of each wire is provided. Factory wiring and field wiring are identified. Component placement and location within the control panel also are shown on some diagrams.

The point-to-point schematic diagram shown in Figure 6-3 illustrates the electrical wiring for a 200/230-V indoor air handler unit that is controlled by a 24-V circuit. You can

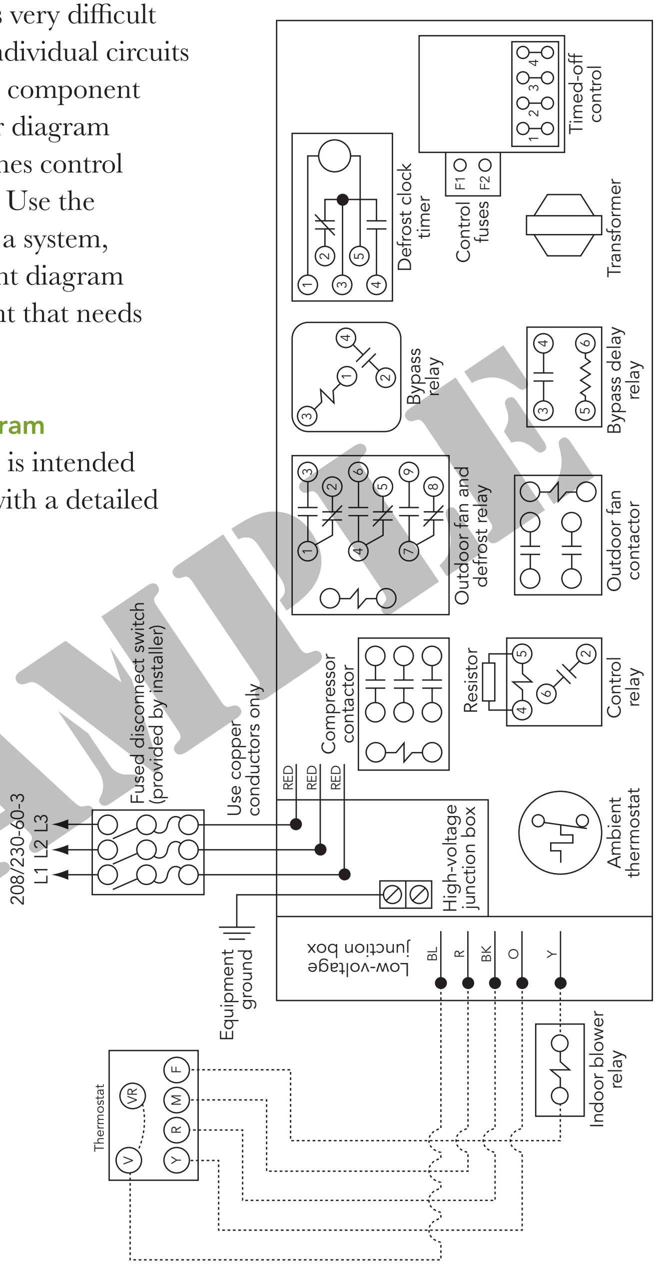
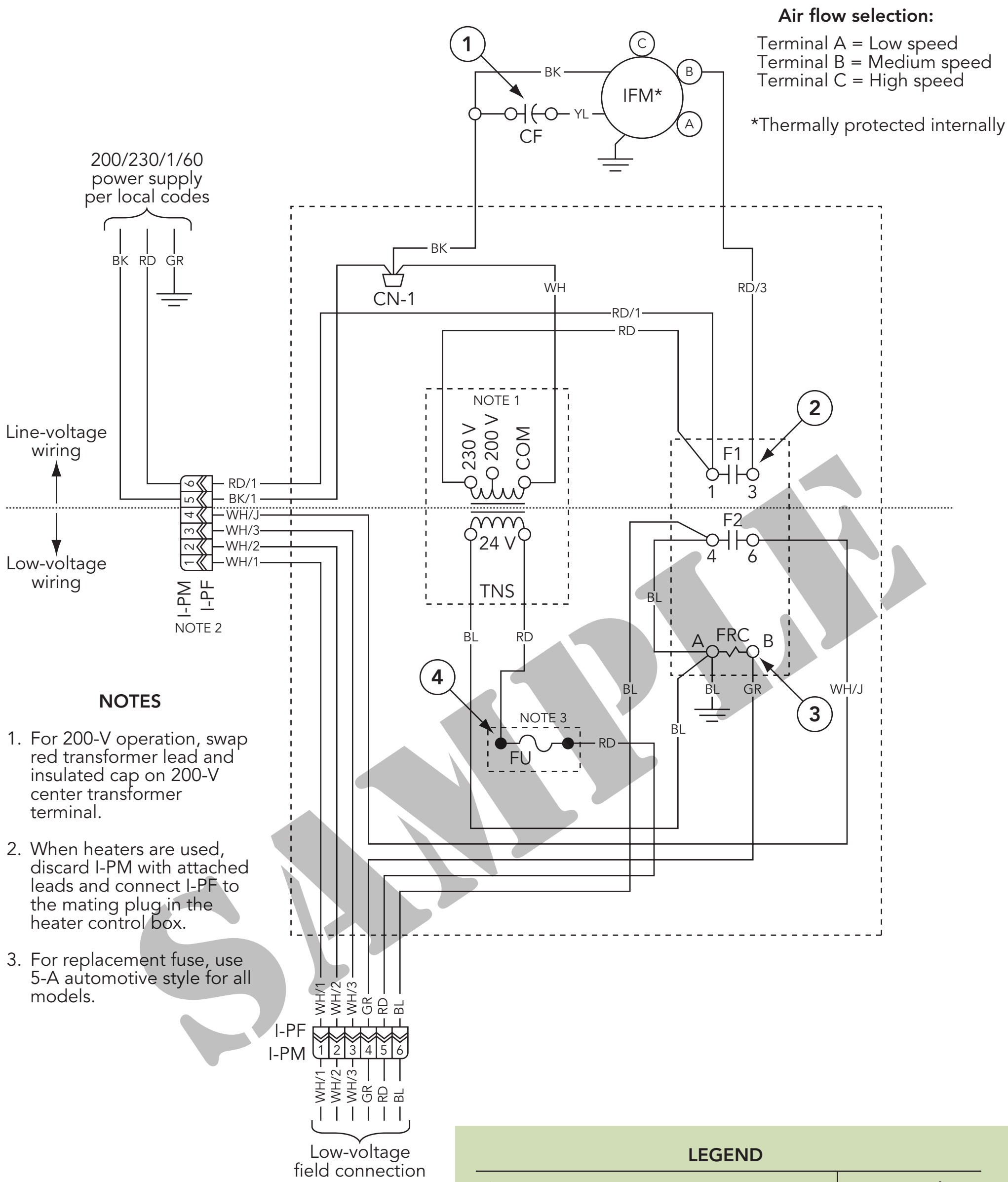


Figure 6-2. *Component arrangement diagram*



NOTES

1. For 200-V operation, swap red transformer lead and insulated cap on 200-V center transformer terminal.
2. When heaters are used, discard I-PM with attached leads and connect I-PF to the mating plug in the heater control box.
3. For replacement fuse, use 5-A automotive style for all models.

LEGEND

		Wire colors	
CF	Fan capacitor	BK	Black
CN	Wire connector	BL	Blue
FRC	Fan relay coil	GR	Green
FU	Fuse	RD	Red
IFM	Indoor fan motor	WH	White
PF	Polarized plug (female housing)	YL	Yellow
PM	Polarized plug (male housing)		
TNS	Transformer		

Figure 6-3. Point-to-point schematic diagram

make the following observations about the indoor section of this heat pump by examining Figure 6-3:

1. The indoor fan motor (IFM) is equipped with a permanently connected run capacitor (CF, see item 1 on the drawing), which means that it can be properly identified as a permanent split-capacitor (PSC) motor.
2. The indoor fan motor is controlled by fan relay contacts 1-3 (see item 2 on the drawing).
3. The indoor fan motor is controlled by a 24-V circuit that connects to the fan relay coil (FRC) at terminals A-B (see item 3 on the drawing).
4. The transformer (TNS) is protected with a 5-A automotive-type fuse (see item 4 and Note 3 on the drawing).

Note that dashed lines are used to draw boxes around some components. This indicates that the component is itself made up of several parts that are internally connected, either mechanically or electrically, with each other. Notice also that the colors of individual wires are given, and that the actual point-to-point connections made at the factory are shown. A close study of the diagram reveals that power wiring is shown in the upper portion of the drawing and control wiring is shown in the lower portion of the drawing.

The legend explains the meaning of the abbreviations used to identify various components in the drawing. Notes also are provided to convey important installation requirements. For example, Note 1 informs you that a wiring change must be made at the transformer when the unit is not supplied 230-V power. Obviously, a close reading of this diagram is necessary for installers and service technicians working with this equipment.

Ladder diagram

A *ladder* diagram is designed to allow a technician to isolate various electric circuits in a system, making it easier to understand the functions of the different switches and loads that may be present in each circuit. Unlike the previous diagram, the ladder schematic does not illustrate the actual point-to-point wiring connections. Rather, the ladder diagram utilizes the least number of lines possible to describe the operating functions of each circuit. The ladder diagram illustrated in Figure 6-4 is a representation of the same circuit shown in Figure 6-3.

As you can see, the vertical lines identified as L1 and L2 represent the power supply to the unit and are located on the far left and right sides of the diagram. Individual circuits are represented by horizontal lines drawn from L1 to L2 like rungs on a ladder. Loads and components are represented by symbols placed on the horizontal "rungs." This basic construction remains the same as circuits are added to the system. A ladder diagram is read by tracing power supplied on L1 to switches and loads, and back to the source on L2. If either side of a circuit supplying power to a load is open, the load cannot operate.

The control part of the system is drawn in the same way. It is often the lower portion of the diagram, as in Figure 6-4, or it may be drawn as a separate diagram in some cases. Wire colors usually are not identified on a ladder diagram.

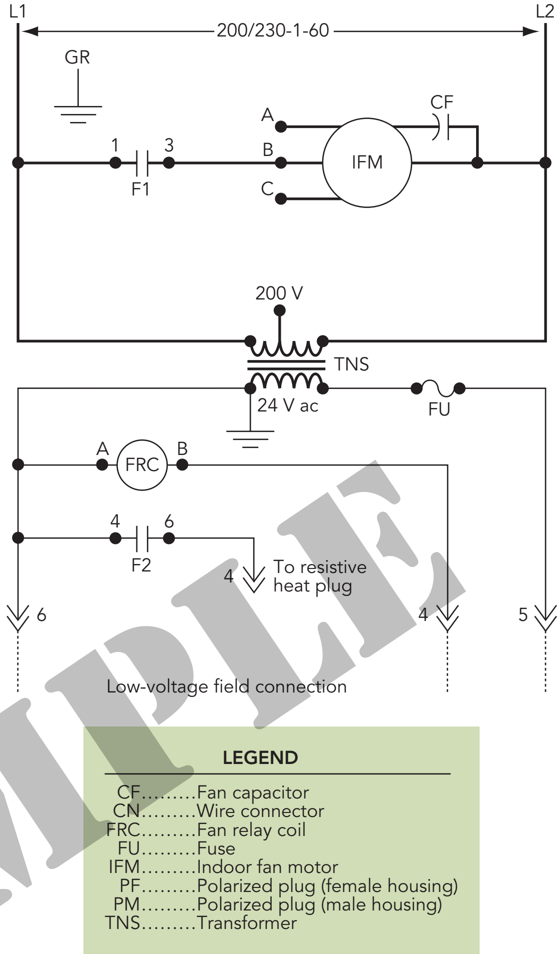


Figure 6-4. Ladder diagram

The purpose of this type of diagram is to show clearly how each circuit in a system operates. Notice that it is a simple matter to read the controlling function of each circuit when using a ladder diagram. For example, you can quickly determine that fan relay contacts 1-3 (F1) are used to control the indoor fan motor, while fan relay contacts 4-6 (F2) are used when resistive heaters are installed in this particular air handler.

When a low-voltage circuit is completed between points 4 and 6 at the polarized plug, the fan relay coil (FRC) will be energized (at A-B), thus causing contacts 1-3 and 4-6 to close. When the fan relay contacts 1-3 close, the indoor fan motor operates on medium speed (because motor terminal B is connected to the contacts).