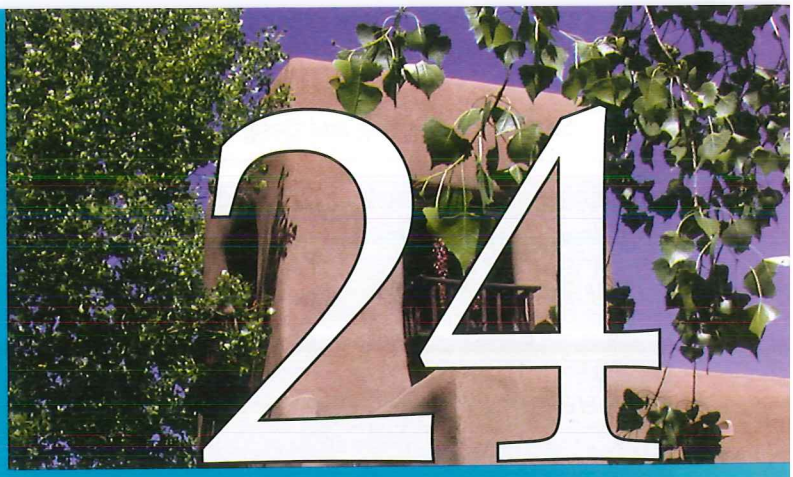
Electrical and Electronics Drafting



Learning Objectives

After studying this chapter, you will be able to:

- List and describe the types of devices for which electrical and electronics drawings are prepared.
- Identify special graphic symbols used on electrical and electronics drawings.
- List and explain the different types of drawings and diagrams used in electrical and electronics drafting.
- Explain the methods used in making drawings for integrated circuits and printed circuit boards.

Technical Terms

Block diagram
Chips
Connection diagram
Continuous line diagram
Integrated circuit (IC)
Interconnection diagram
Interrupted line diagram
Printed circuit board
Schematic diagram
Single-line diagram
Tabular diagram

Growth of the electronics industry has brought increased demand for drafters who are capable of preparing drawings for electrical and electronic circuits. Electrical and electronics drafting involves the same basic principles used in other types of drafting. The difference is in the use of special symbols to represent electrical circuits and wiring devices. Drawing standards for symbols and other drafting practices have been developed by the American National Standards Institute (ANSI) and the Institute of Electrical and Electronics Engineers (IEEE).

The components used in electricity and electronics vary in size from large transformers at an electrical generating plant to microscopic integrated circuits, **Figure 24-1**. Because of the complex devices involved and their relationship to each other in electrical circuits, you must acquire a basic knowledge of electricity and electronics and understand how an electrical or electronic circuit operates if you wish to specialize in electrical and electronics drafting.

It is also important to become familiar with the common graphic symbols used to represent the components of circuits on drawings. Sample symbols used in electrical and electronics drafting are shown in **Figure 24-2**.

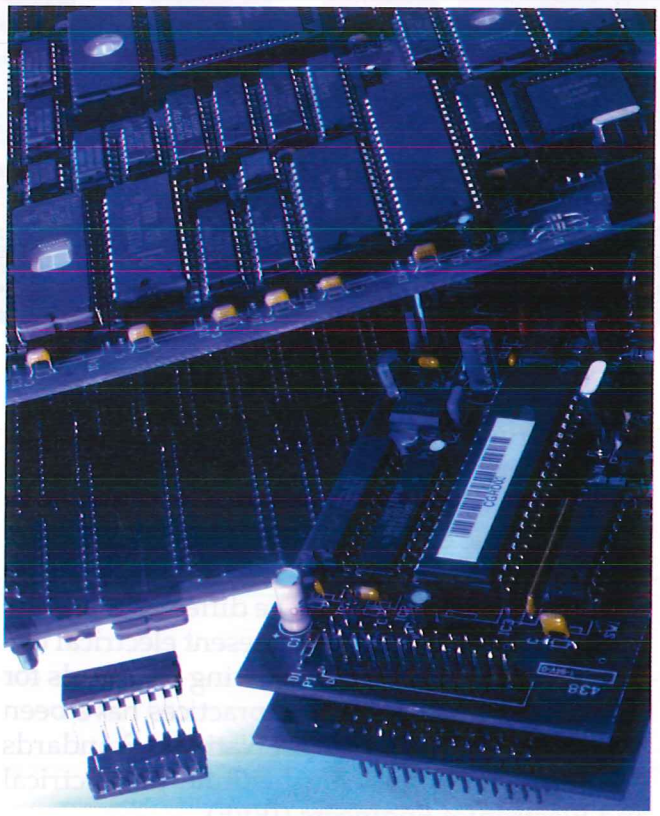


Figure 24-1. Special drafting skills and a basic knowledge of electronics are necessary for making drawings of devices such as integrated circuits and circuit boards.

Electrical and Electronics Drawings

There are common types of drawings used to illustrate different devices in electrical and electronics drafting. These are discussed in the following sections.

Pictorial Drawings

Pictorial drawings using pictorial symbols are sometimes drawn to illustrate component parts in electrical and electronics systems. Pictorials are particularly useful for assembly line workers, do-it-yourself hobbyists, and others who are not trained in reading graphic symbols on electrical and electronics drawings. A pictorial drawing of a transmitter and its components is shown in **Figure 24-3**.

Single-Line Diagrams

A ***single-line diagram*** is a simplified representation of a complex circuit or an entire system. It employs single lines and graphic symbols to describe the component devices of a circuit or a system of circuits.

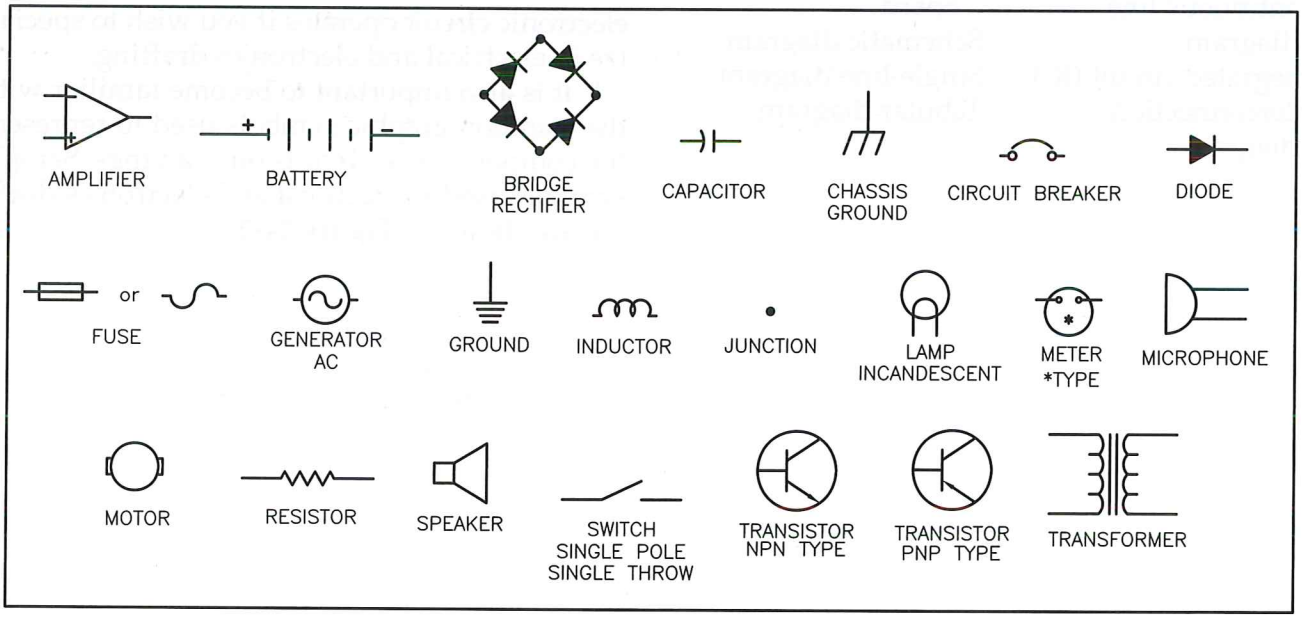


Figure 24-2. Typical graphic symbols used in electrical and electronics drafting.

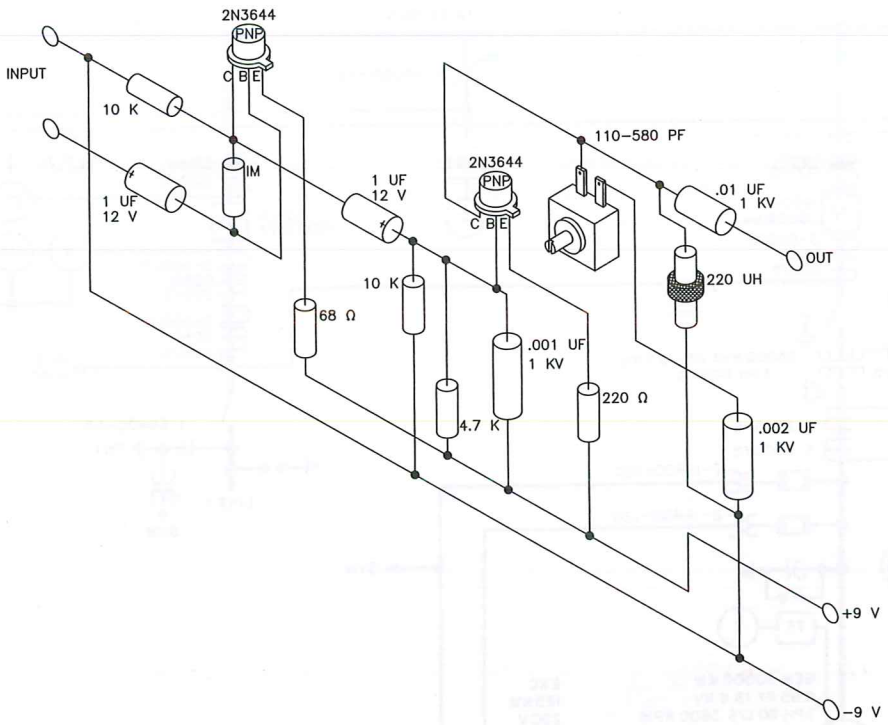


Figure 24-3. Pictorial drawings of electronic devices can show the parts and their relationships in a realistic manner.

Single-line diagrams are used primarily in electrical power and industrial control applications. They also have some limited applications in electronics and communications. A single-line diagram is usually one of the first drawings made in the design of a large electrical power system, because it contains the basic information that will serve as a guide in the preparation of more detailed plans.

A typical single-line diagram used in an electrical power application is shown in **Figure 24-4**. The thick connecting lines on the drawing indicate primary circuits, and the medium lines indicate connections to current or potential sources. In either case, a single line is used to represent a multiconductor circuit.

On single-line diagrams, it is standard practice to use either horizontal or vertical connecting lines with the highest voltages at the top or left of the drawing and successively lower voltages toward the bottom or right of the drawing. When constructing such a diagram, try to maintain a logical sequence while avoiding an excessive number of line crossings.

Block Diagrams

Block diagrams are closely related to single-line diagrams. A ***block diagram*** uses block shapes to present an overview of a system in its simplest form. Squares and rectangles are primarily used on block diagrams, but an occasional triangle or circle may be used for emphasis. Graphic symbols are rarely used, except to represent input and output devices.

The blocks should be arranged in a definite pattern of rows and columns, with the main signal path progressing from left to right whenever possible, **Figure 24-5**. Auxiliary units, such as power supply or oscillator circuits, should be placed below the main diagram. Each block should contain a brief description or function of the stage it represents. Additional information may be placed elsewhere on the drawing. The block that requires the greatest amount of information usually determines the size of all of the blocks. However, the use of two block sizes on one drawing is not objectionable.

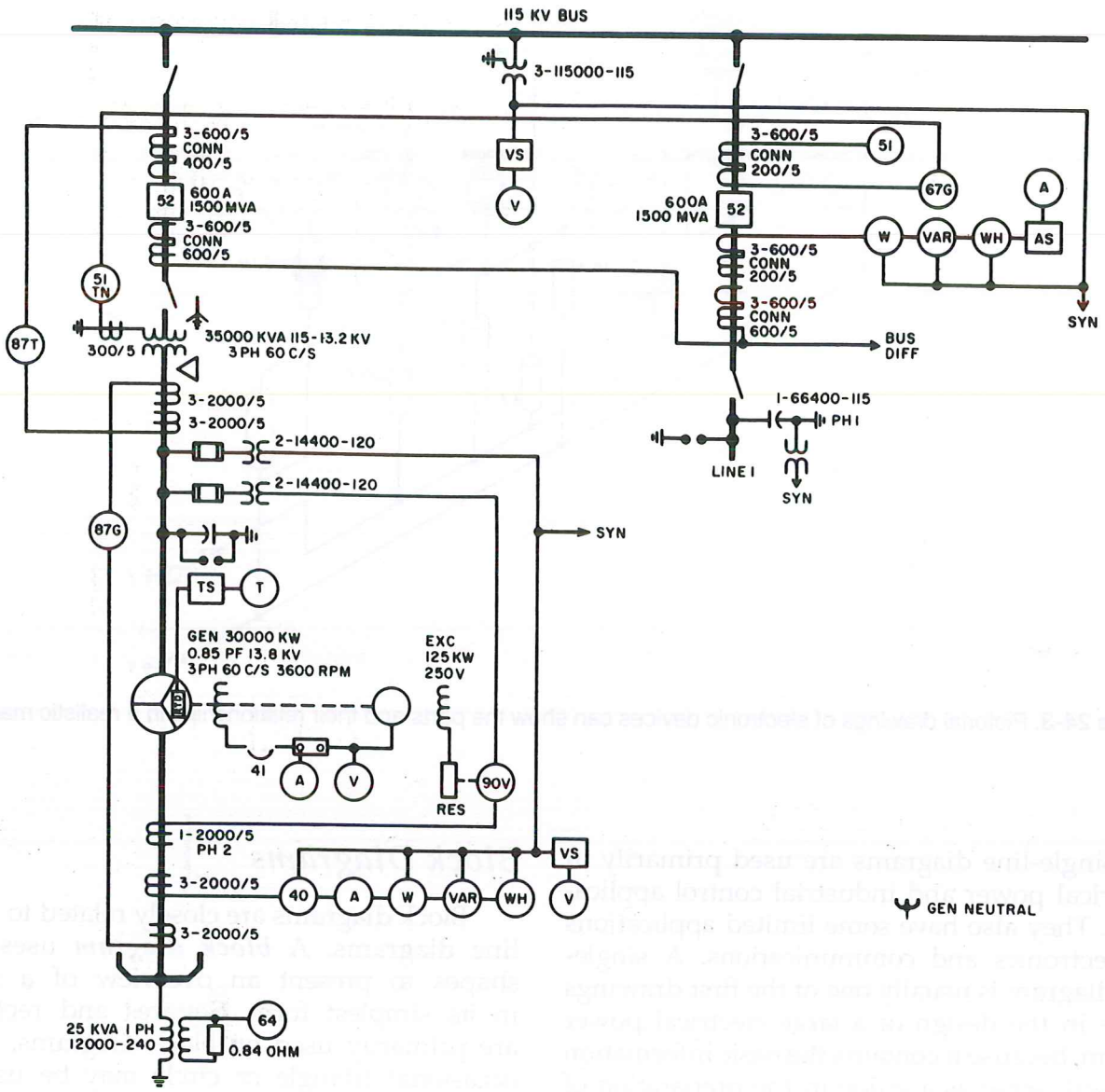


Figure 24-4. A typical single-line diagram for an electrical power system shows power switchgear and complete device designations. (American National Standards Institute)

A heavy line should be used to represent the signal path. In a complex circuit or system, more than one line may lead into or away from a block. Refer to **Figure 24-5**. Arrows should be used to show the direction of the signal flow. The overall layout of the diagram should be a consistent and well-balanced pattern that is organized and easy to read.

Schematic Diagrams

Schematic diagrams are the most frequently used drawings in the electronics field. A ***schematic diagram*** shows, by means of graphic symbols, the electrical connections and functions of a specific circuit. A schematic diagram is also known as an *elementary diagram*. It shows a representation of the components of a circuit without regard to their actual physical size, shape, or location.

Schematic diagrams are typically laid out as sketches by engineers and then developed into final form by drafters, **Figure 24-6**. A schematic diagram serves as the master drawing for production drawings, parts lists, and component specifications. It is used by engineering groups for circuit design and analysis, and by technical personnel for installation and maintenance of the finished product.

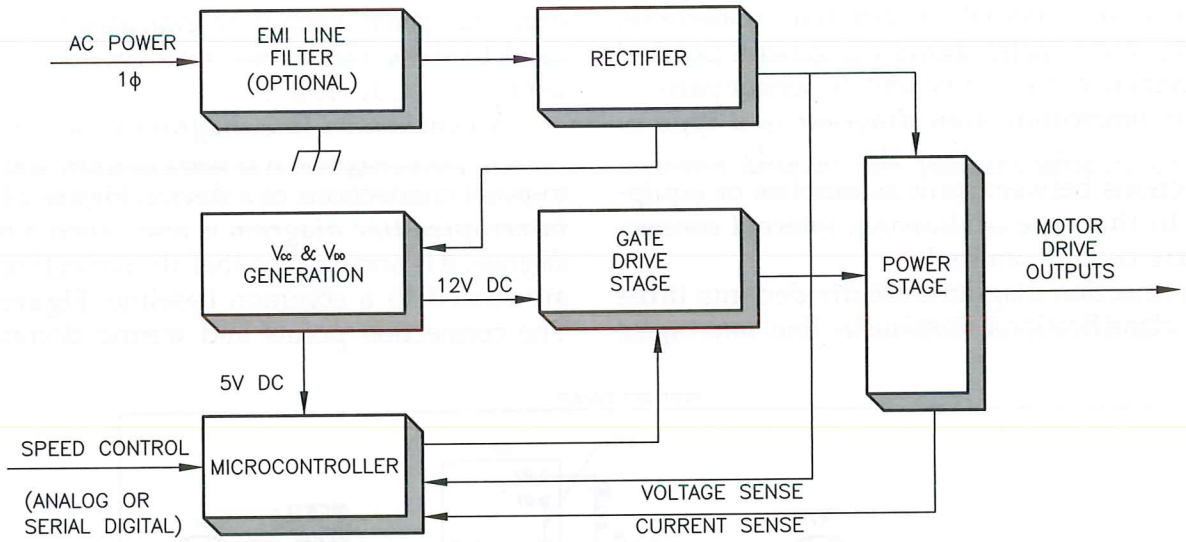


Figure 24-5. A block diagram has blocks arranged in rows and columns to show the operation of a system. (Anacon Systems, Inc.)

Connection Diagrams

Connection diagrams are drawings that supplement schematic diagrams. These drawings contain information used in the manufacture, installation, and maintenance of electrical and electronic equipment. Connection diagrams are also known as *wiring diagrams*. They graphically represent the conducting paths (wiring paths or cable paths) between component devices.

A ***connection diagram*** shows the connections of an installation or its component devices or parts.

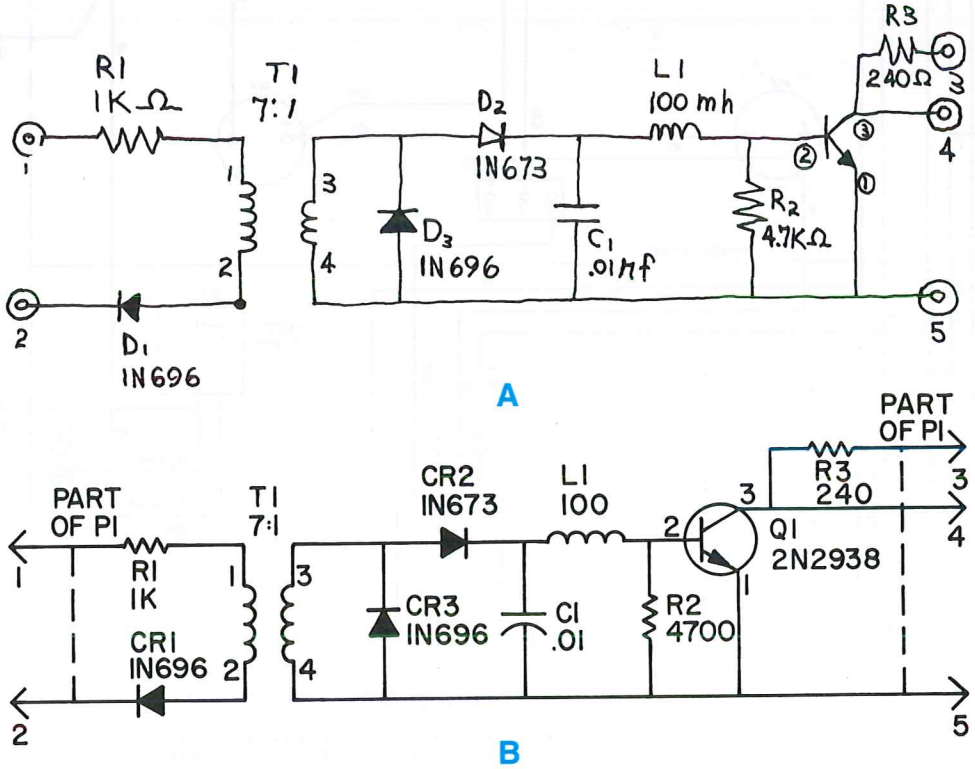


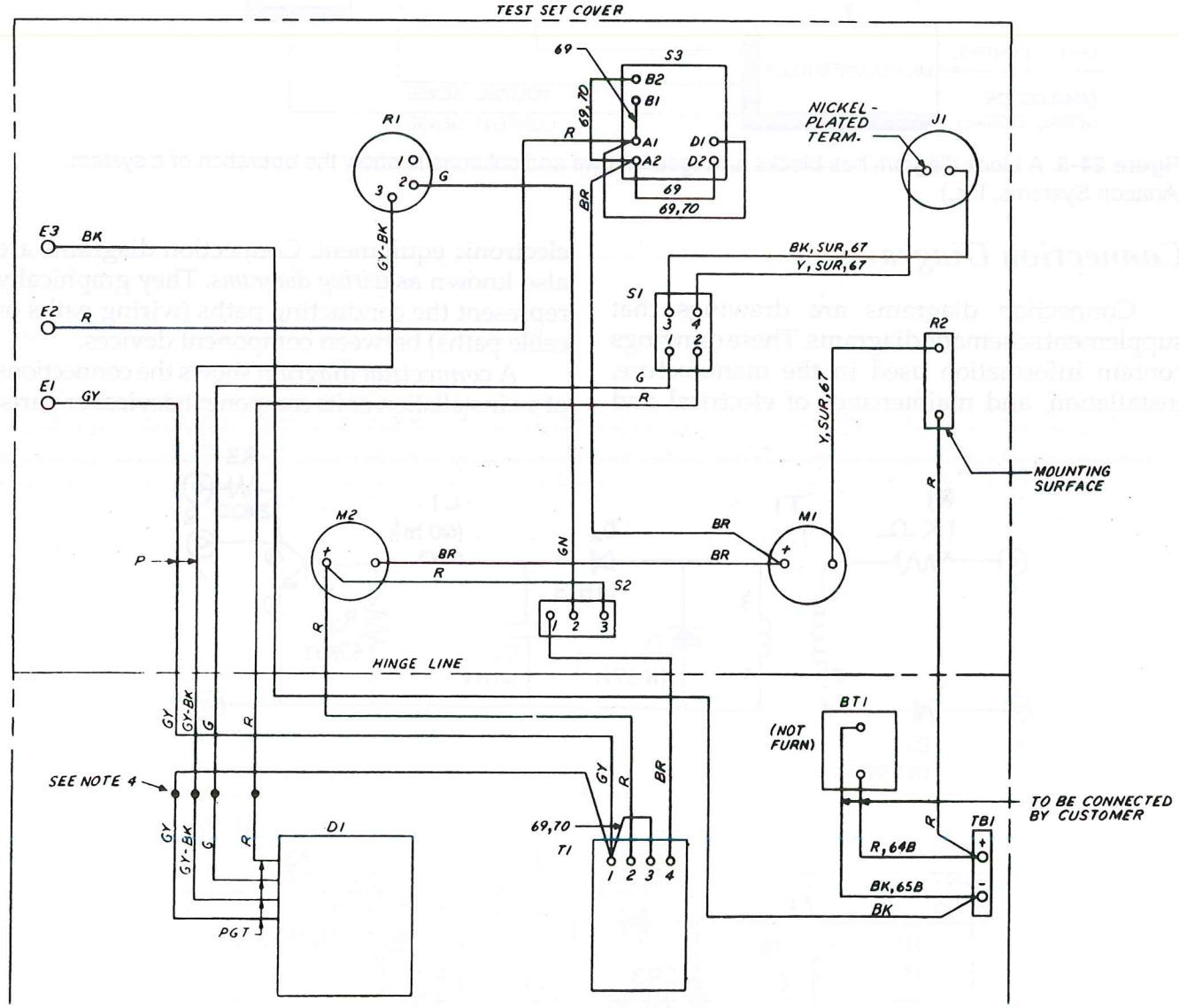
Figure 24-6. A schematic diagram shows the connections and functions of a circuit. A—An engineer's sketch of a circuit will have the basic appearance of a schematic, only less refined. B—A drafter will take the sketch and produce a finished schematic diagram.

It may cover internal or external connections, or both, and usually shows the general physical arrangement of the component devices or parts.

An ***interconnection diagram*** is a type of connection diagram that shows only external connections between unit assemblies or equipment. In this type of drawing, internal connections are usually omitted.

Connection diagrams are divided into three major classifications: *continuous line, interrupted line,* and *tabular.* Each type indicates the method used to show the connections between component parts or devices.

A ***continuous line diagram*** is also called a *point-to-point diagram.* It is used to show the point-to-point connections of a device, **Figure 24-7.** An ***interrupted line diagram*** is also called a *baseline diagram.* It is arranged so that all connecting paths are routed to a common baseline, **Figure 24-8.** The connection points and wiring destinations



NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL WIRES ARE INCLUDED IN THE CABLE ASSEMBLY XXXXX.
2. ITEM NUMBERS REFERRED TO ARE SHOWN IN PARTS LIST OF ASSEMBLY DRAWING XXXXX.
3. ALL SOLDERING SHALL BE IN ACCORDANCE WITH QQ-S-524 METHOD C.
4. SPLICE AND SOLDER AND WRAP WITH ONE LAYER OF TAPE ITEM 58 AND TWO LAYERS OF TAPE ITEM 60.
5. SUR-WIRING-WIRE TO BE DRESSED BACK AND RUN ALONG THE MOUNTING SURFACES IN THE MOST CONVENIENT MANNER.
6. PGT - LEADS FURNISHED WITH PART.

Figure 24-7. A continuous line connection diagram, also called a point-to-point wiring diagram, shows all of the components of a system and how they fit together. (American National Standards Institute)

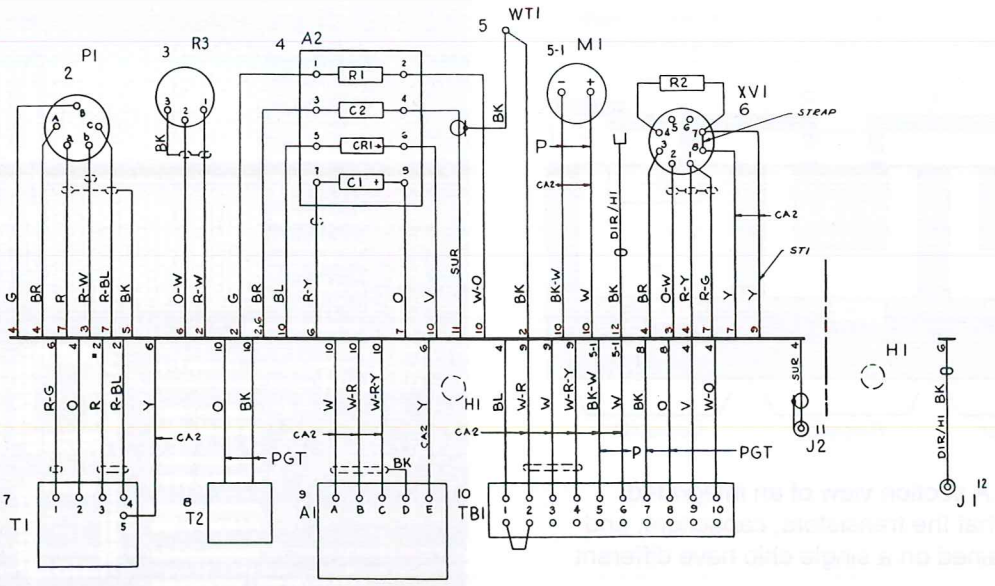


Figure 24-8. An interrupted line diagram, also called a baseline diagram, has labeled wire paths and connection points to identify connections between components or devices.

are labeled to show how the component parts are connected. This type of diagram is used for identifying wiring connections in complex systems. A ***tabular diagram*** presents connection information in tabular form, **Figure 24-9**. This type of diagram is sufficient for many wiring operations. In basic terms, it is a simple "from-to" list, but it may be expanded to show additional information such as wire lengths, sizes, or types.

Integrated Circuits

The greatest advances in the field of electronics in recent years have been the study of microelectronics and the development of integrated circuits. An ***integrated circuit (IC)*** is a complete electronic circuit, usually very small in size, composed of various electronic devices such as transistors, resistors, capacitors, and diodes. See **Figure 24-10**. Integrated circuits are commonly manufactured as small assemblies called ***chips***. The accompanying problems of miniaturization have placed unusual demands upon the drafter. These demands have led to the increased use of computer-aided drafting (CAD) equipment in the design of integrated circuits and printed circuit boards. A ***printed circuit board*** is a laminated board containing integrated circuits and other electronic devices connected by paths "printed" on the board.

REV		WIRE					FROM				TO			
SYM	TRAN	COLOR	AWG	SYMBOL	METHOD OR PATH	NOTE	AREA LOC	TERMINAL		LEVEL	NOTES	AREA LOC	TERMINAL		LEVEL	NOTES
		W–R		ST1	CA2			TB1	2				A1	B		
		W		ST1	CA2			TB1	3				A1	A		
		W–R–Y		ST1	CA2			TB1	4				A1	C		
		BK–W		P1	CA2			TB1	5				M1	NEG		
		W		P1	CA2			TB1	6				M1	POS		
		BK			PGT			TB1	7				T2			
		O			PGT			TB1	8				T2			
		V			CA1			TB1	9				A2	6		
		W–O			CA1			TB1	10				A2	2		

Figure 24-9. A tabular diagram presents wiring connections in the form of a table. (American National Standards Institute)

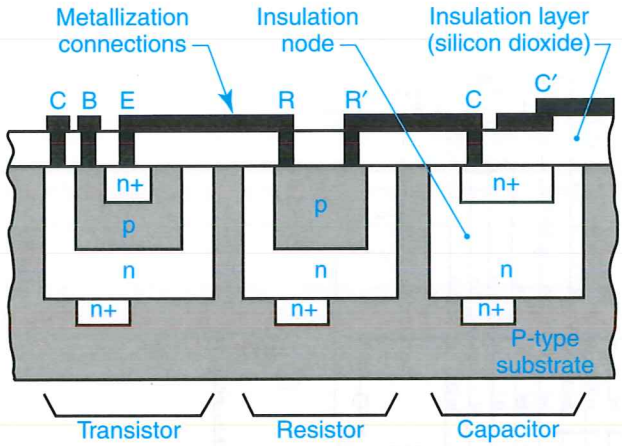


Figure 24-10. A section view of an integrated circuit shows that the transistors, capacitors, and resistors contained on a single chip have different constructions.

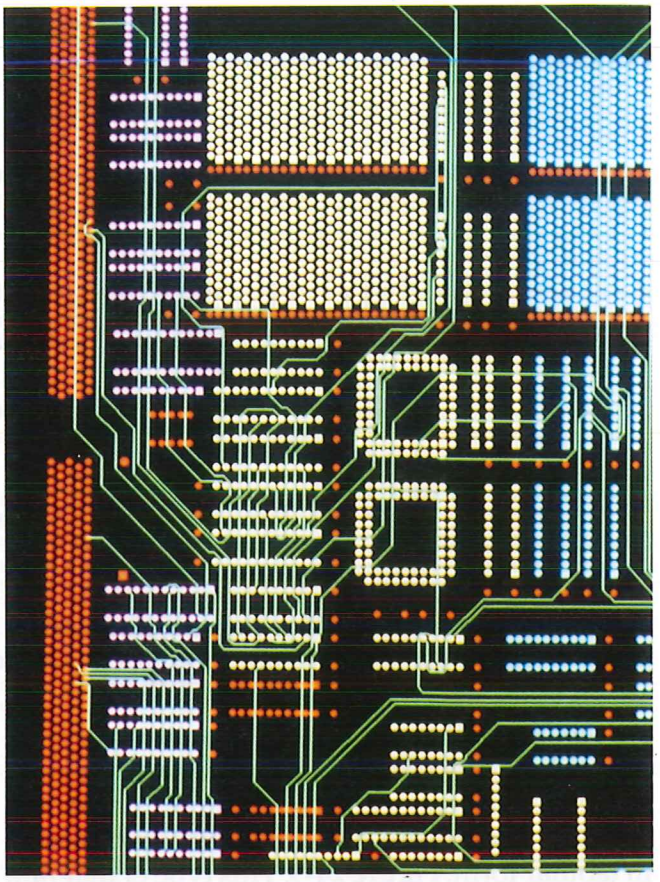


Figure 24-11. A schematic drawing of an integrated circuit design. The drawing can be plotted on a film base. This film is then used in the miniaturization of the circuit. (Lockheed Martin Corp.)

Designs for integrated circuits typically begin as schematic diagrams and layout drawings and are most commonly made using CAD software. A sample computer-generated drawing of a circuit design is shown in **Figure 24-11**. Drawings of integrated circuits may be plotted on a special film base, which is then used in the manufacture of the IC chip. Advanced CAD programs used in automated manufacturing provide tools for creating and testing circuit designs as well as generating the manufacturing materials used in fabricating IC chips.

Chapter Summary

Electrical and electronics drafting is similar to other types of drawing. However, special graphic symbols are used to represent electrical circuits and wiring devices.

Different types of drawings are used to represent designs in electrical and electronics drafting. These include pictorial drawings, single-line diagrams, block diagrams, schematic diagrams, and connection diagrams.

Pictorial drawings using pictorial symbols are sometimes drawn to illustrate component parts in electrical and electronics systems. Single-line diagrams are simplified representations of complex circuits or entire systems. A single-line diagram is usually one of the first drawings made in the design of a large electrical power system.

Block diagrams are closely related to single-line diagrams. It uses block shapes to describe a system in its simplest form.

A schematic drawing shows the electrical connections and functions of a specific circuit. Schematic drawings are the most frequently used drawings in the electronics field.

The greatest advances in the field of electronics in recent years have been the study of microelectronics and the development of integrated circuits. Integrated circuits are developed from schematic drawings and are most typically designed using CAD software.

Additional Resources

Publications

CADCAMNet
www.cadcamnet.com

Electronic Design Automation for Integrated Circuits Handbook
www.crcpress.com

IEEE Circuits and Systems
www.ieee.org

Surface Mount Technology
www.smt.pennnet.com

Computers and CAD Software

Cadence Design Systems
Developer of Allegro design software
www.cadence.com

Dassault Systems
Developer of CATIA
www.eds.com

Novarm Ltd.
Developer of DipTrace
www.novarm.com

Priware Ltd.
Developer of CircuitWorks
www.priware.com

Review Questions

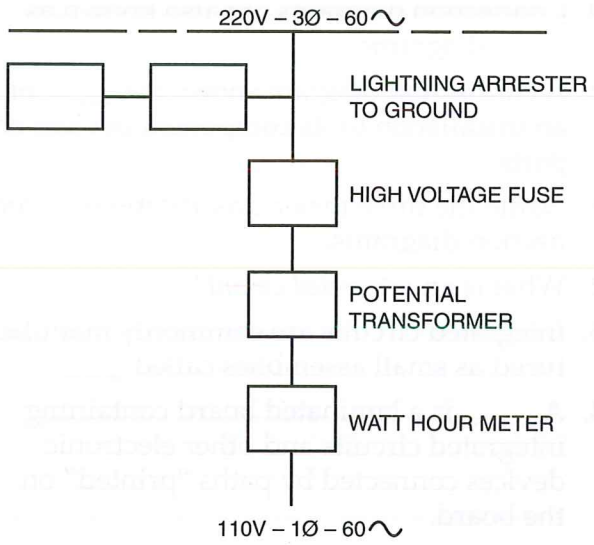
1. What is the basic difference between electrical and electronics drafting and other types of drafting?
2. What is a *single-line diagram*?
3. The thick connecting lines on a single-line diagram indicate _____ circuits.
4. On single-line diagrams, it is standard practice to use either _____ or _____ connecting lines.
5. What is a *block diagram*?
6. Graphic symbols are rarely used in block diagrams except to represent _____ and _____ devices.
7. On a block diagram, a heavy line should be used to represent the _____.
8. _____ diagrams are the most frequently used drawings in the electronics field.
9. Connection diagrams are also known as _____ diagrams.
10. A connection diagram shows the _____ of an installation or its component devices or parts.
11. Name the three major classifications of connection diagrams.
12. What is an *integrated circuit*?
13. Integrated circuits are commonly manufactured as small assemblies called _____.
14. A _____ is a laminated board containing integrated circuits and other electronic devices connected by paths "printed" on the board.

Problems and Activities

The following problems are designed to provide you with the opportunity to apply knowledge gained in your study of electrical and electronics drafting. They require you to apply your problem-solving skills. The problems can be drawn manually or with a CAD system. Complete each problem as assigned by your instructor.

1. Make a pictorial drawing of a small transistor radio or a similar electronic device.
2. Draw and label the following component symbols. Draw each component to the same relative size and include the component designation and part information.
   A. Battery, 9 volts, BT_1
   B. Switch, single-pole, single-throw, S_1
   C. Ammeter, M_1
   D. Resistor, 4700 ohms, R_1
   E. Lamp, incandescent, dial lamp, DS_1

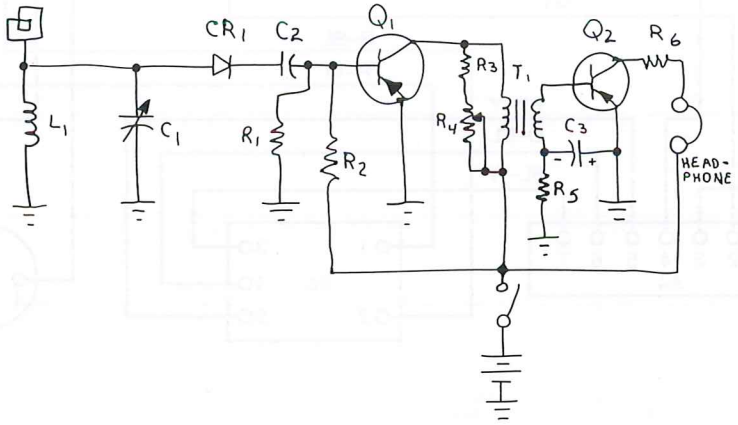
3. Study the following block diagram of an electrical power system. Then, redraw the diagram and replace the blocks with the correct graphic symbol.



Electrical Power System

4. Draw a block diagram of a noise level meter with the following stages:
   A. Input microphone
   B. Audio amplifier, Q_1
   C. Audio amplifier, Q_2
   D. Audio amplifier, Q_3
   E. Decibel meter

5. Redraw the following sketch and add the information listed. Avoid crowding and wasted space.
   A. R_1, R_2, 220K, 1/2W
   B. R_3, R_6, 1K, 1/2W
   C. R_4, 100K, POT
   D. R_5, 100K, 1/2W
   E. CR_1, 1N63
   F. C_1, 0-365 pF
   G. C_2, .01 µF
   H. C_3, 10 µF, 25V
   I. Q_1, Q_2, 2N663



6. Redraw the following continuous line diagram as an interrupted line diagram. For each lead, show the subassembly number, the terminal to which it is going, and the color code. For example, "Lead 3" on "Unit A1" would be labeled "A4/4-GN-BK," meaning it is a green lead with a black tracer stripe that goes to "Unit A4, Terminal 4."