



Practical TV & Video Systems Repair

John Ross

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John Ross
Fort Hays State University



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PREFACE

Rapid changes in consumer electronics technology have prompted corresponding changes in technology education. Throughout the past decade, the emphasis in technology has moved away from the use of analog circuits to more efficient digital circuitry. Circuits once housed on removable, replaceable modules are now found encapsulated within integrated circuit packages. Because of these primary and complex changes, the quantity of knowledge required to service and maintain modern electronic products has grown substantially. As a result, technology education demands new approaches in teaching and new opportunities for learning. *Practical TV & Video Systems Repair* addresses those approaches and opportunities.

ORGANIZATION

Practical TV & Video Systems Repair is a text designed for use in technology curricula by second-year students who emphasize electronics. While providing an overview of basic concepts, the text also establishes an in-depth treatment of each subject. Because of this, at least one course in analog and digital fundamentals is suggested as a prerequisite for any course using *Practical TV & Video Systems Repair*.

Chapters are presented in individual learning segments that begin with elementary concepts and build until each chapter provides complete coverage of the subject matter. Instructors may choose to present lectures in short discussions or divide each chapter into 40- or 50-minute lectures. The layout of the book ensures that students will have a firm grasp of basic concepts before moving onto more complex concepts, by dividing the chapters into five basic sections, the book follows the design of a television from the integration of power supplies to the incorporation of signal-processing circuits and CRTs. The concluding chapter allows the instructor to emphasize the type of skills needed to become a successful technician.

The fourteen chapters of *Practical TV & Video Systems Repair* are divided into five parts: 1) Building a Foundation, 2) Power Supplies and Deflection Circuits, 3) Processing Signals, 4) Reproducing the Image,

and 5) Focusing on the Customer. In turn, each chapter contains performance-based Objectives and Key Terms. Each chapter concludes with a chapter-end review that includes objective questions, essay questions, and multiple-choice questions. A comprehensive glossary is located at the end of the text. A number of real-world schematics are placed in the Appendix and in the attached Fold-outs at the end of the book. These numerous drawings are referenced and used within the book.

FEATURES OF THE BOOK

Balance of Theory and Troubleshooting Practice

Combining a clear, easy-to-read style with a technician's intuitive knowledge of the circuitry, *Practical TV & Video Systems Repair* integrates basic electronic theory with descriptions for circuits and components that make up television receivers and computer monitors.

While the text provides a theoretical base, there is an emphasis on practical troubleshooting applications. The text stresses a hands-on, troubleshooting approach to servicing consumer electronics. Each chapter includes lessons on Troubleshooting techniques and description of Service Calls. In addition, a number of the chapters provide lessons on the proper use of test equipment. The many Fundamental Reviews throughout the text maintain the link between the advanced readings and basic knowledge acquired in previous courses. *Practical TV & Video Systems Repair* includes numerous individual circuit diagrams, waveform illustrations, and manufacturer diagrams that combine to make it a great reference and practical textbook.

Building Block Approach

The text uses a consistent building-block approach that introduces the student to basic concepts and then builds to the complex circuit designs. With an emphasis on fundamental knowledge at the beginning of and

throughout the text, the student goes on a journey through each stage of technology needed to reproduce an image or a sound, including switched-mode power supplies, microprocessor-controlled tuners, deflection circuits, luminance and chrominance signal-processing circuits, and projection television circuits.

Technology Advancements

The rapidly changing technology curriculum is addressed in the book with outstanding coverage of the latest technology advancements, including: coverage of circuit designs, circuits, and components used in a broad array of consumer electronic products; switched-mode power supplies; digital video electronics, high-definition television (HDTV), projection television, and more.

LEARNING TOOLS

Practical TV & Video Systems Repair has been carefully designed to enhance the study of consumer electronics products such as televisions and computer monitors. For best results, you may want to become acquainted with the following features that are incorporated into the text:

Real-world Schematics

The text is full of drawings within the chapters, appendix and fold-outs. The text guides the student on reading, understanding and analyzing the drawings to solve troubleshooting problems. This will help to improve students' troubleshooting skills in preparation for entry into the job market.

- Fundamental Reviews
- Service Calls
- Test Equipment Primers

Fundamental Reviews

As students learn how components and circuits operate and then how to troubleshoot problems, they will need to apply knowledge about properties, components, and circuits first seen in other electronics classes. To assist their understanding of subjects covered in this text, "Fundamental Review" boxes accompany many of the reading assignments. When linked with the information provided throughout the chapter, the "Fundamental Review" boxes will help students understand how different properties and components affect the operation of the entire circuit.

Service Calls

While reading about technology concepts and circuit designs, students also need to link that knowledge with applications and troubleshooting. Each "Service Call" takes students into a service area and acquaints them with the thought processes and methods used to successfully solve electronic circuit problems. The "Service Calls" appear at the conclusion of eleven chapters.

Test Equipment Primers

Many of the troubleshooting methods illustrated throughout the text rely on the use and application of electronics test equipment. The sections entitled "Test Equipment Primers" provide clear explanations about the use of logic probes and analyzers, multimeters, oscilloscopes, counters, and signal generators.

ACKNOWLEDGMENTS

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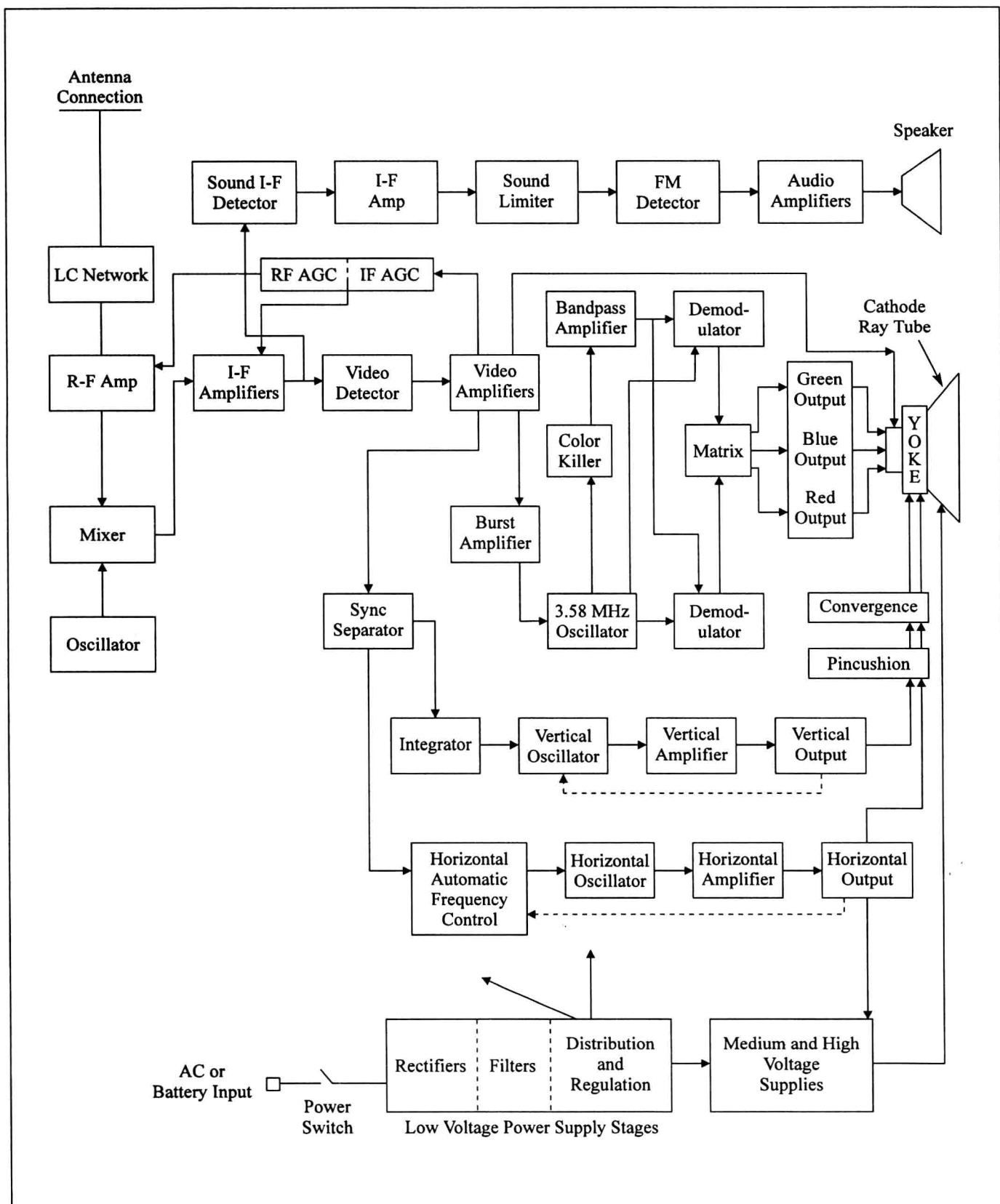
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The author of *Practical TV & Video Systems Repair*, John A. Ross, is involved in technology education and administration at Fort Hays State University in Hays,

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DEDICATION

I would like to thank God for giving me the skills, knowledge, patience, and desire needed to write this text. My parents, John C. and Lorraine N. Ross, have listened to my ideas and complaints and have given me priceless support and encouragement. I could not have completed the work without their presence and thank them many times over. I would also like to thank students for their reviews and suggestions, my colleagues for their support, and the staff at Delmar Publishers for their assistance.



COLOR TELEVISION RECEIVER STAGES AND SIGNAL PATHS

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PART 1

Building a Foundation

Chapters one and two emphasize the fundamentals of electronic circuits, analog electronics, and digital electronics. The concepts reviewed in these two chapters provide a foundation for understanding both how modern electronic circuits operate and how the various stages produce functions needed for the proper functioning of the system. With a solid understanding of those fundamentals, you will be able to progress through the remainder of the text with few problems. In addition, you will achieve an understanding of designs, circuits, and processes used in all types of electronic equipment.

CHAPTER 1

Fundamentals

OBJECTIVES

Upon completion of this chapter, you should be able to:

1. Explain electronic systems.
2. Explain source voltages and the difference between low, medium, and high voltages.
3. Discuss energy and signals.
4. Discuss different types of waveforms.
5. Explain the frequency spectrum.
6. Describe harmonics, subharmonics, and noise.
7. Discuss the characteristics of R-F signals.
8. Explain how R-F signals affect circuit components.
9. Define gain, attenuation, bandwidth, coupling, phase relationships, and feedback.
10. Define amplification, oscillation, and switching.
11. Discuss modulation, heterodyning, and demodulation.
12. Understand basic troubleshooting methods and safety practices.

KEY TERMS

amplification	frequency	phase
amplitude modulation	frequency modulation	pulse
attenuation	gain	resonance
bandpass filter	heterodyne	signal
bandwidth	intermediate frequency	source
coupling	modulation	stage
demodulation	noise	superheterodyne receiver
electromagnetic waves	oscillator	switch
electronic system	oscilloscope	wavelength
feedback		

INTRODUCTION

Chapter one defines terms and concepts associated with the operation of electronic systems while establishing the format for the complete text. Beginning with the opening section, the chapter considers electronic systems as a series of input-to-process-to-output blocks.

Using the block diagram of a television shown in Figure 1-1 as a guide, you can see that source voltages and input signals feed into the input of the system. The source voltages become rectified, filtered, regulated, divided, and multiplied before becoming suitable for use in the receiver circuits. Heavy black arrows represent the source voltages in the figure. Energy in the form of high-frequency, information-carrying signals enters the receiver at the tuner and then goes through a series of processes that change the signals into more usable, lower frequency signals. The radio-frequency signals make up part of the frequency spectrum and can be categorized according to frequency bands.

Fine gray arrows represent the signal paths within the receiver. As the signals travel along those paths, a series of processes eliminates portions of the signals, reduces the signals in frequency, and removes information. Those processes become possible through amplification, oscillation, and switching and produce

usable information. In turn, amplification, oscillation, and switching depend on basic concepts such as gain, feedback, attenuation, and phase reversal.

This chapter also provides a strategy for troubleshooting electronic problems and introduces basic safety concepts. By applying the concepts introduced in this strategy, your troubleshooting skills will become more efficient and effective. Along with this overall approach to troubleshooting, the chapter also defines the differences between static and dynamic troubleshooting.

As you study chapter one, note that each of the discussed fundamental terms and concepts will have consistent use throughout the text. Your understanding of terms such as gain and concepts such as frequency bands will increase your understanding of the complex circuits seen in the following chapters. All this will make the task of servicing modern electronic products much easier.

1-1 ELECTRONIC SYSTEMS

A group of electronic components interconnected to perform a function or group of related functions makes up an **electronic system**. All electronic systems have the three basic parts shown in Figure 1-2. Those parts

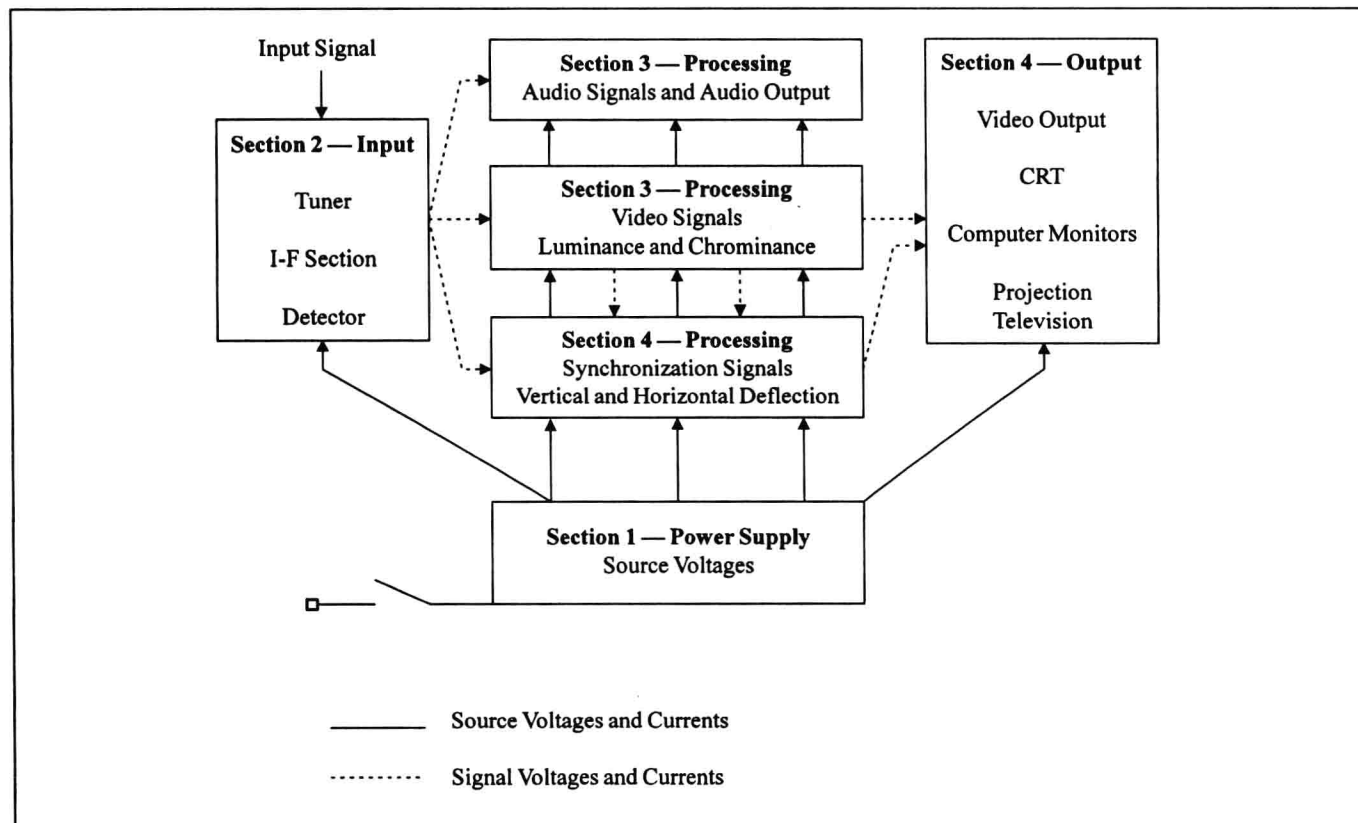


Figure 1-1 Block Diagram of a Television

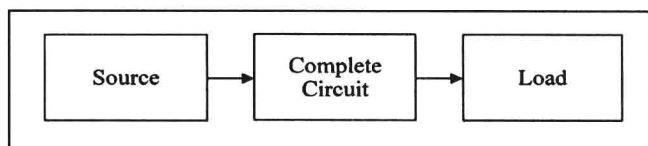


Figure 1-2 Three Basic Parts of an Electronic System

are the source, circuit, and load. The **source** is a device, such as a power supply in a television receiver, that develops a voltage or a combination of voltages.

To take advantage of the force associated with an electric charge and use that force to produce work, we must control the flow of electrons. A load is some type of device that performs a specific function when current flows through the device. Because a load opposes current in an electric circuit, it has resistance. We can define resistance as the property of a device that opposes current in an electric circuit. Resistance is measured in ohms. A resistor is a device that offers a certain amount of opposition to the flow of current.

Electron flow can only occur if a complete path exists from the source to the load and back to the source. Therefore, a complete circuit must exist for electron flow. The insertion of a switch—one of the simplest of control devices—allows the control of the electron flow. A **switch** is a device that opens and closes the path for electrons.

Electronic systems divide into analog and digital circuits. An analog circuit has an output that varies smoothly over a given range and has an infinite number of voltage and values. Each of those values corresponds with some portion of the input. Digital circuits have either an “on” or an “off” output state. The application of an input signal to a digital circuit produces either of the output states but, unlike the analog circuit, no intermediate output conditions.

✓ PROGRESS CHECK

You have completed Objective 1. Explain electronic systems.

Source Voltages

In electricity and electronics, the term “voltage” describes a “difference in potential,” or the amount of electric force that exists between two charged bodies. Voltage is defined as either a positive or negative force with reference to another point. A volt is the standard unit of measurement for expressing the difference in potential. Because this force in volts causes the movement of electrons, it is defined as the electromotive force, or emf.

If we have two bodies with opposite charges, or a difference in potential, and then connect those bodies

with a conductor, the charged body with a more positive potential will attract free electrons from the conductor. As the free electrons move from the conductor to the charged body, the conductor assumes a positive charge because of the loss of electrons. Because of this, excess electrons in the other, more negatively charged body begin to flow into the conductor. This flow of electrons or current, continues as long as the difference in potential exists. The basic measure of current is the ampere.

The current in a circuit may be either a direct current (dc) or an alternating current (ac). In a dc circuit, the polarity of the source voltage does not change; electrons flow in only one direction. In ac circuits, the direction of electron flow changes periodically. Because of the changes in direction, the polarity of the source voltage also changes from positive to negative.

Resistors with different values of resistance are connected into circuits to control the amount of current. Because resistance opposes current, the current in a circuit is always inversely proportional to the resistance. If the resistance increases, the amount of current decreases. If the resistance decreases, the amount of current increases.

The ability of a circuit or device to pass current is defined as conductance. Depending on its size and type of material, a conductor carries electricity in varying quantities and over varying distances. A large-diameter wire provides a greater surface area, has less resistance to current, and can carry more current. A material such as copper has better conductance characteristics than a material such as platinum. An inverse relationship exists between conductance and resistance. Conductance is measured in either mhos or siemens.

Voltage Supplies Every stage in an electronic device requires some type of voltage supply because of the signal amplification required to make the system function. **Amplification** is an increase in the voltage, current, or power gain of an output signal. Although systems may utilize an ac power line input, the components within the system rely on dc voltages. We can categorize dc voltages into the low (12–35 Vdc), medium (150–400 Vdc), and high (15–25 kVdc) ranges. Using a television receiver as an example, the low voltage supply provides the necessary voltages for semiconductor operation while the mid-range and high voltages are required for the deflection, focus, and CRT circuits.

Every electronic voltage supply has four distinct parts that involve rectification, regulation, and filtering of the source voltages. Transformers either step up or step down the voltages to the levels required by circuits. Rectification involves the conversion of the required ac voltage value to a pulsating dc voltage. Regulation is defined as the maintenance of a consistent output at the power supply source. With

a regulated power supply, changes in the input voltage do not affect the operation of some stages in the system. Filtering smooths the pulsating dc voltage into a usable, constant dc supply voltage.

✓ PROGRESS CHECK

You have completed Objective 2. Explain source voltages and the difference between low, medium, and high voltages.

1-2 ENERGY, SIGNALS, AND FREQUENCIES

Generally, electronic equipment used for communications operates with electrical energy that takes the form of electromagnetic waves. That energy may take the form of radio waves, infrared light, visible light, ultraviolet light, X rays, and other forms. **Electromagnetic waves** are made up of magnetic and electric fields placed at right angles to each other and at right angles to their direction of travel. The wave-like nature of those fields becomes apparent as the magnetic and electric fields vary continually in intensity and periodically in direction at any given point.

Each complete series of variations forms a wave. As one wave travels through space, another wave immediately follows. **Frequency** is the number of waves that passes a point each second and the rate of polarity change. Frequency is measured in hertz (Hz). The distance from any given point or condition in one wave to the corresponding point of the next wave is defined as **wavelength**. We designate wavelength with the Greek letter λ , or lambda, and can calculate a value by dividing the velocity (V) of the waves by the frequency (f) in hertz:

$$\lambda = V/f$$

Because the velocity of radio waves through space equals the speed of light (300,000,000 meters or 984,000,000 feet per second), we can measure wavelength either in meters or feet per second.

Signals

In terms of electronics, we can define a **signal** as a voltage or current that has deliberately induced, time-varying characteristics. A signal voltage or current is different than a source voltage or current for several reasons. Every electrical signal has a distinctive shape described in terms of the time domain, or the amplitude of the signal as a function of time, and frequency domain, or the magnitude and relative phase of the energy. **Phase** is defined as when the repetitions of the signals occur in time, and we further describe signals that have the same frequency and shape in terms of phase. In-phase signals have repetitions occurring at the same time, while out-of-phase signals are displaced along the time axis.

✓ PROGRESS CHECK

You have completed Objective 3. Discuss energy and signals.

Signals can be found at transmission points, may be generated within electronic systems, and may take different forms. We can observe different signal waveforms through the use of an **oscilloscope**, which provides a visual representation of electrical signals. One of the most basic signal waveforms is the sinusoidal wave, or sine wave. Other basic types include the rectangular, ramp, triangular, and sawtooth waveforms, and rectangular pulses.

Sine Waves The sinusoidal wave, or sine wave, shown in Figure 1-3A represents a mathematical relationship of an alternating voltage or current produced by an alternator, inverter, or oscillator. When a sine wave goes above and below the zero line twice, each combination of maximum positive and negative values equals one cycle. In turn, each cycle subdivides into two alternations, or one-half cycle. We can view an alternation as the rise and fall of voltage or current in one direction.

The value of the voltage or current at any particular point on the sine wave is an instantaneous value.

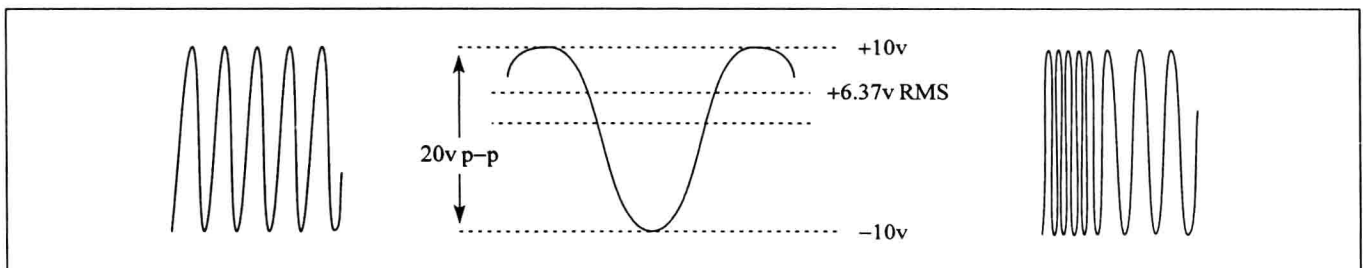


Figure 1-3A Sine Wave

That is, time passes while the voltage or current goes through its cycle. Each point on the curve occurs only once per cycle and at a particular instant in time. The amount of voltage from zero to either the positive or negative maximum is defined as the peak value and occurs twice during each ac cycle.

When we measure the overall amplitude of a sine wave, we measure the voltage difference between the upper and lower maximum points on the curve. Going back to Figure 1-3A, the upper point on the curve represents +10 volts, while the lower point on the curve represents -10 volts. With the distance between the two points representing 20 volts, the overall amplitude, or peak-to-peak value, equals 20 volts.

If one ampere represents the peak amplitude of alternating current, that value has the same heating effect as .707 ampere of direct current. As a result, we can say that the effective value of an alternating current or voltage is .707 of its peak value. Many times, the effective value is referred to as the root mean square, or rms, value. All values of alternating voltage or current are given as rms values.

When working with alternating voltages or currents, you should also remember that each sine curve alternation has an average value .637 times the peak value. If a curve has a peak value of +10 volts, the average value is less than the rms value and equals:

$$\text{average} = .637 \times 10 = 6.37 \text{ volts}$$

Rectangular Waves A pulse is a fast change from the reference level of a voltage or current to a temporary level, and then an equally fast change back to the original level. Any waveform consisting of high and low dc voltages has a pulse width and a space width and is defined as a rectangular waveform. The pulse width is a measure of the time spent in the high dc voltage state, while the space width is the measure of the time spent in the low dc voltage state. Adding the pulse width to the space width gives the cycle time or duration of the waveform. The values for the pulse width and space width are always taken at the halfway points of the waveform.

As shown in Figure 1-3B, a square wave is a rectangular waveform that has equal pulse width and space width values. While the pulse width and space width for a square wave are equal, the opposite is true for

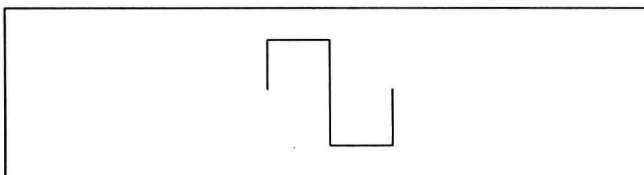


Figure 1-3B Square Wave

pulses. Shown in Figure 1-3C, pulses usually appear in a series, called a train, and are measured in terms of pulse repetition rate and repetition time period.

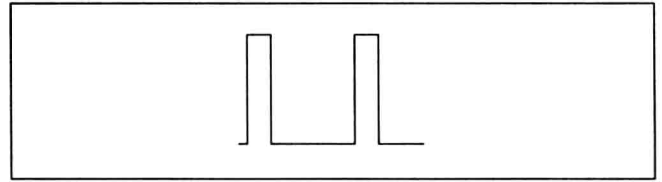


Figure 1-3C Pulse

Ramp, Triangular, and Sawtooth Waves Illustrated in Figure 1-3D, a ramp waveform has a slow linear rise and a rapid linear fall. In contrast, the triangular waveform shown in Figure 1-3E rises and falls at a constant rate and has a symmetrical shape. The sawtooth waveform shown in Figure 1-3F appears similar to the triangular wave but has a longer rise time and a shorter fall time.

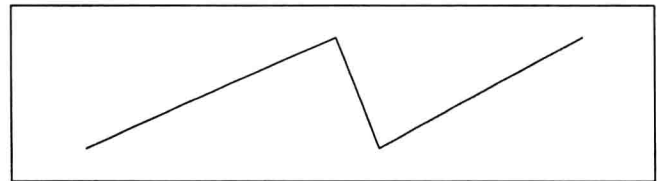


Figure 1-3D Ramp Waveform

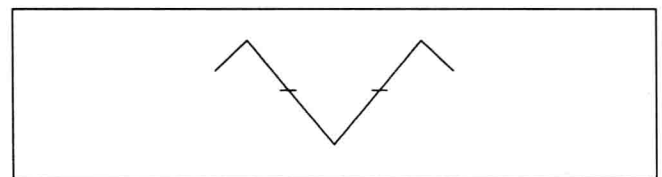


Figure 1-3E Triangular Waveform

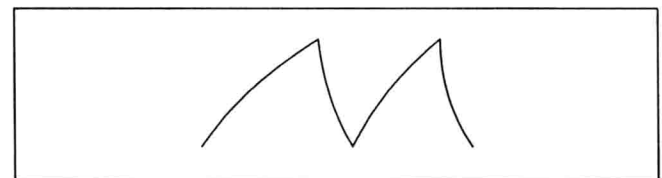


Figure 1-3F Sawtooth Waveform



PROGRESS CHECK

You have completed Objective 4. Discuss different types of waveforms.