Joel Goldberg

Fundamentals of Television Servicing

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Preface

Repair of today's complex television sets can be a very simple process if the technician has a sound knowledge of *how* a set functions. The basic process has not changed much since the first commercial television sets were produced in the early 1950s.

There have always been two types of repair persons in the service industry. One can be classified as a "parts changer." This person does not know exactly where in the set the problem is. Repair is accomplished by changing parts, a system that is partially successful. This type of servicing was especially prevalent in the era of the vacuum tube. Because the vacuum tube was the hardest-working part of a set, the odds were in favor of it failing first. The key to this type of repair was to attempt to determine which of several tubes in the set needed to be replaced. Some people actually replaced all of the tubes when making this type of repair.

Often, persons using this technique were unable to repair a set if the problem was not related to a tube failure. The reason for this is that they did not know, or were unable to relate to, how the set actually functioned. Their knowledge of electronic circuit analysis was minimal. A set requiring circuit analysis repair was often left on the shelf for later repair, or it was sent out to someone else for repair.

This style of repair work was not done by all service technicians. Many technicians could be classified as being of the second type. These technicians *knew* electronic theory. They also *knew* how to utilize testing equipment to diagnose faults. In many cases the knowledgeable service technician did not remove any component from the set until *after* tests were made. This person was able to draw conclusions from observation and testing. These conclusions led to the location of defective components. This style of work enabled the service technician to be more productive and to repair a malfunctioning set correctly.

If television set design had remained static, we would still have these two groups of repair people. But rapid technological change occurred in the industry. The introduction of the transistor changed the entire situation. People who were used to replacing tubes to fix a set were often not able to cope with the new devices. They had no idea how they worked. Often, transistors were soldered into the set rather than being plugged into sockets as tubes were. This required further knowledge on the part of the technician. Removal and testing techniques for transistors are different from those used for vacuum tubes. Persons with minimal technical knowledge and a lack of willingness to learn about technical change were unable to repair these receivers quickly.

Another factor that separated these two groups was the introduction of printed-circuit boards to replace hand-wired sets. Technicians had to learn how to follow wiring on the circuit board. Many of the semitechnically trained persons in the service industry were unable to handle these changes. They left the industry and found employment in other fields.

Persons remaining in the television service industry quickly learned that they had to maintain their technical knowledge as the industry brought in new systems. Set manufacturers learned that they had to establish and offer field training programs for both factory and independent service people. Technological changes are still occurring. Today, most television sets use integrated circuits, which replace individual transistors. Many "modular" sets are being manufactured, also. These use plug-in units, or modules, to replace entire sections of a set. Often, several sections are on a single module. This type of technical change, as well as those changes that are certain to come in the future, place the electronic service technician in an unusual situation.

The successful service technician has to have several qualifications. These include a basic knowledge of electronics, how to use electronic test equipment, and how television sets function. In addition, the technician must be willing to attend technical seminars or return to a technical school periodically in order to maintain a high level of competency.

Television set design technology will continue to change in the coming years. Repair technicians who are still able to function as changes occur will be successful.

Technological changes occur daily. It is impossible to identify each change and to include it in a book of this type. It is better to develop fundamental skills and to be able to apply these skills as the need occurs.

This book is written on the basis of fundamental knowledge. I have spent nine years in the electronic service/parts field as well as seventeen years in teaching electronics and electronic service. Over the years, I have visited many service shops and attended a large number of training seminars. The material presented in this book is a result of my learning experiences over the past twenty-six years.

The book is divided into four major sections. The first section describes how television information is transmitted. The second section relates to how this information is processed in a receiver. The third section is devoted to the use of test equipment. The final section explains how each block, or section, of a set functions. The material is developed using integrated-circuit technology. The methods of diagnosis and repair are based on this type of system. The purpose of the book is to present basic material related to the repair of television sets. It is assumed that persons using the book have a good foundation in basic electronic theory.

Any author writing on a technical subject has to have assistance with materials. I wish to thank the many manufacturers of sets and test equipment who have contributed. They are acknowledged individually for photographs or drawings they have supplied. Support is also required from family and friends, and I acknowledge it with thanks. Specifically, I wish to dedicate this book to my wife, Alice. I could not have considered undertaking such a project without her help, understanding, and support.

Joel Goldberg

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Chapter 1

Television Signals

People living in a highly technical society quickly learn to expect "things to happen" when a switch is activated. Rarely is thought given as to why these things do work. Little time is spent on determining what has gone into producing the expected result. When one turns on a light switch, one expects the lamp to glow and give off illuminating light rays. No consideration is given to the generating and distributing network required to accomplish this feat.

This is also true for almost all persons who turn on a radio or television set. If the picture, sound, and color are correct, the viewer is content. The ingredients required to accomplish this are either unknown or overlooked. It is only when trouble occurs that we are concerned with the "how and why" of the television signal. It is important that people employed in the television service field have an understanding of this "how and why" before attempting to repair any set.

This chapter explains how the television signal is created. It covers the specific components of the composite signal. Fundamentals of transmission of electromagnetic energy as well as reception are also presented. An understanding of this material will assist the technician when a repair is required.

COMPOSITION OF THE SIGNAL

The composite television signal has several individual components. These are all (except color) required in order to convey intelligence from the broadcast station to the receiver. The components are:

1. Picture information (video)
2. Synchronizing pulses
3. Blanking pulses
4. Synchronizing pulses (color)
5. Picture information (color)
6. Special control information
7. Sound information

Each of these components must be examined and understood in order to service a television set successfully.

All picture information is first converted into electrical information. This is accomplished by use of a television camera and a special tube called a *vidicon*. A cross-sectional view of this system is shown in Figure 1-1. The vidicon has a light-sensitive plate upon which the light image being viewed is focused. This light-sensitive plate is a part of an electronic circuit. The complete circuit contains a power source, the vidicon electron gun, the light-sensitive plate, and a load resistance. The light-sensitive plate is made of hundreds of individual elements. The image from the light source will be focused on the plate. Each element will then change its resistance. The resistance change is based upon the amount of light on each of the individual elements on the plate. The light energy is now used to control the flow of electrical energy. It must be further processed in order to make it useful.

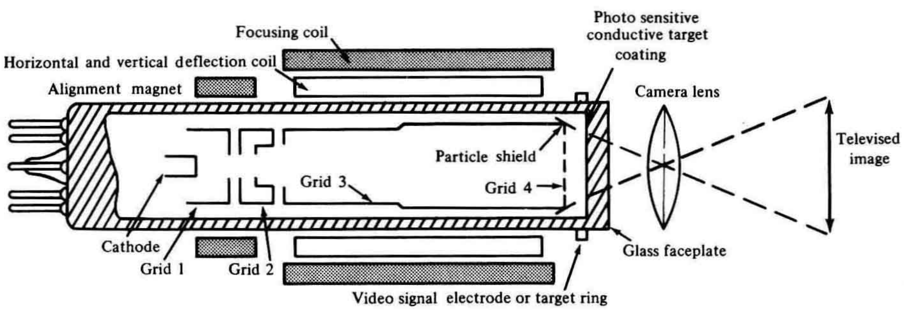

Figure 1-1 Cross-sectional view of the vidicon camera tube. (Clyde N. Herrick, *Television Theory and Servicing: Black/White and Color, 2nd ed.*, 1976. Reprinted with permission of Reston Publishing Co., a Prentice-Hall Co., 11480 Sunset Hills Road, Reston VA 22090)

The method of removing this information is shown in Figure 1-2(a). The system illustrated in Figure 1-1 is shown as an electrical circuit in this illustration. The circuit will have a current flow. The amount of current depends upon the total resistance and the applied source voltage. Each component in the circuit develops a voltage drop. The voltage drops are directly related to the amount of resistance of the component. There is one compo-

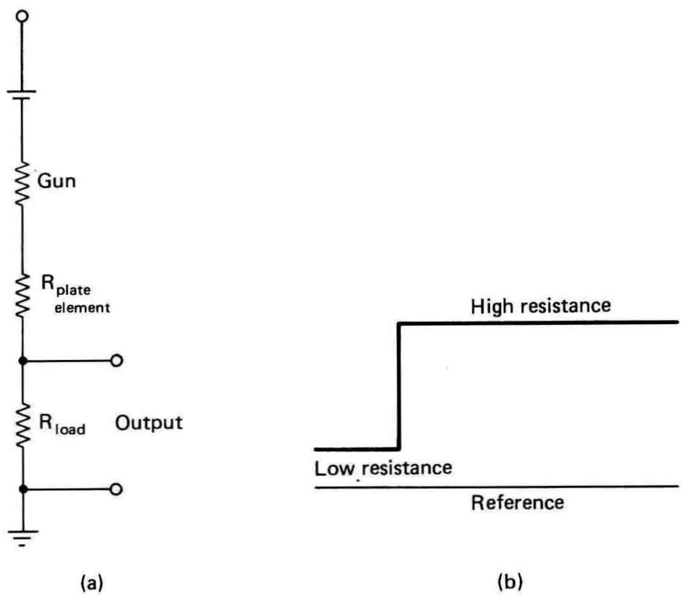

Figure 1-2 (a) Electrical equivalent of the camera and its output circuit. (b) Varying voltage that develops across the load resistor, shown in graphic form.

nent with the capability of varying its resistance. This is the light-sensitive plate in the vidicon. Each element on this plate acts as an individual resistance.

The amount of light striking the picture element determines its resistance. A high level of light, which we call *white level*, raises the resistance to a relatively high value. The voltage developed across the load resistance drops to a low level. If the light source is very low, the resistance of the element is also low. The variations in light develop a voltage across the load resistor that is related to the light intensity striking the element of the vidicon tube. This is illustrated in Figure 1-2(b). This concept is basic to the conversion of light energy into electrical energy for use in the television system.

Broadcast standards used in the television systems dictate that each element of the vidicon is transmitted in sequential order. This requires a method of positioning the electron beam on each picture element. This method is called *scanning*. Two types of movements are required in this system. One relates to the horizontal position of the electron beam. The other relates to the vertical position of the beam. The scanning position is developed by the use of two magnetic fields. A *deflection yoke* is placed around the sides of the vidicon tube. This yoke has two sets of coils. One is connected to a horizontal scanning system. The other is connected to a vertical scanning system. Each set of coils develops a magnetic field. The strength of the magnetic field is related to the electrical current flowing through the coils. The scanning systems produce a sawtooth-shaped waveform. This is illustrated in Figure 1-3. The horizontal waveform, or *signal*, occurs at a rate of 15,734 times a second. This drives the electron beam from left to right across the light-sensitive plate in the vidicon tube. The vertical sawtooth signal drives the electron beam from top to bottom of the plate. Its frequency is 59.9 hertz (Hz).

Industry standards establish a television picture composed of 525 lines of picture information. The system used requires two fields of horizontal lines. Field 1 scans the odd-numbered lines. The scan goes from top to bottom of the light-sensitive plate. Field 2 scans the even-numbered lines in the same manner. Each field has a frequency of about 60 Hz. The sum of the frequencies of the two fields will scan at a frequency of about 30 Hz. Interlacing of the two fields produces a complete picture, or *frame*. This consists of 525

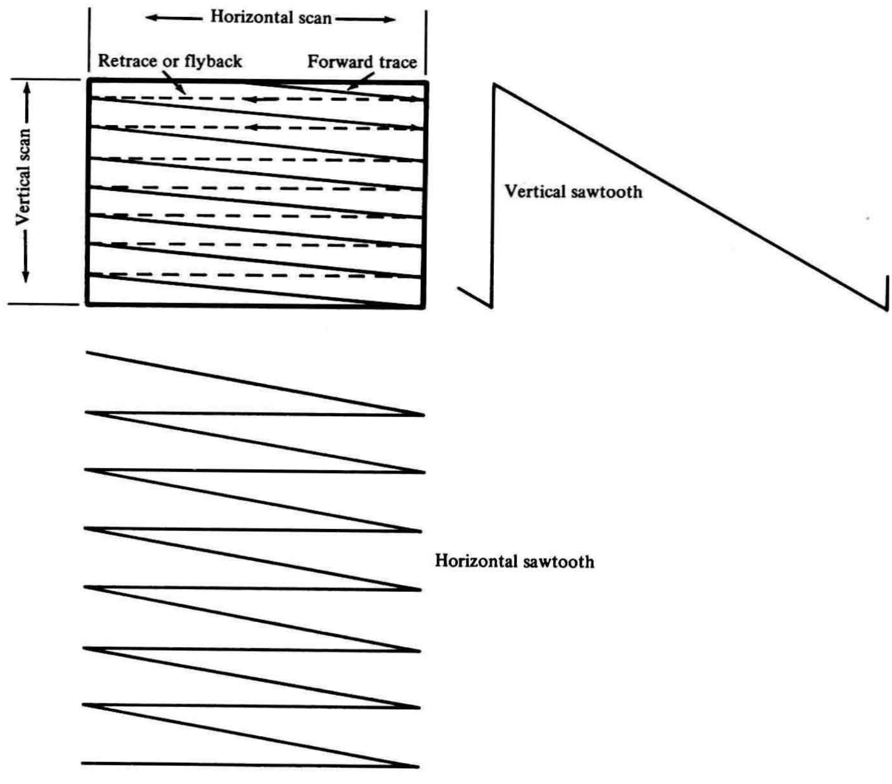

Figure 1-3 Sawtooth-shaped waveform, produced by the scanning section of the system. This waveform is used in positioning the beam in the camera and picture tubes. (Clyde N. Herrick, *Television Theory and Servicing: Black/White and Color, 2nd ed.*, 1976. Reprinted with permission of Reston Publishing Co., a Prentice-Hall Co., 11480 Sunset Hills Road, Reston, VA 22090)

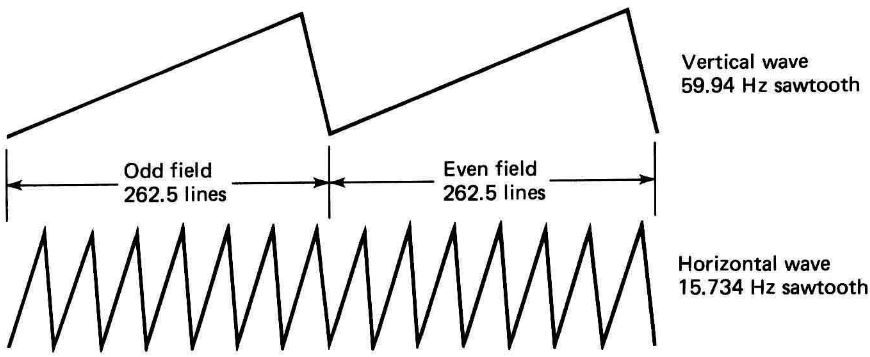

Figure 1-4 The relationship of the horizontal and vertical systems' sawtooth waves.

lines of picture information at a rate about 30 Hz. The horizontal rate of 15,734 Hz is developed from this format (525 X 59.9 = 15,734). The waveforms and an explanation are illustrated in Figure 1-4. This process requires two scanning generators connected to the television camera vidicon-tube deflection circuits.

Each picture element is scanned in this manner. The result is several thousand individual picture elements, each with a voltage, or signal, level of its own. The information developed in this manner is further processed to produce individual lines of picture information. This is illustrated in Figure 1-5. Television standards identify a *white level* and a *black level* of picture information. White has a very low value of signal. Black, at the other extreme, develops a high signal level, or voltage. The camera signal is developed as the electron beam scans an individual line of picture information. The result is an electronic signal that corresponds to the picture being viewed on a specific line. This information is processed by the camera and the transmitter and broadcast to television receivers. This system produces the television picture information and will ultimately be returned into a viewable picture in the receiver.

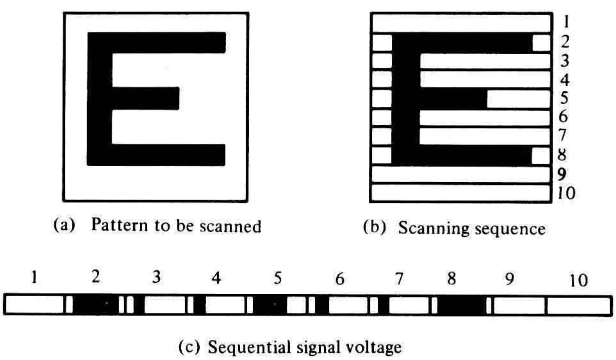

Figure 1-5 Development of a varying signal voltage as the figure is scanned by the camera tube circuits. (Clyde N. Herrick, *Television Theory and Servicing: Black/White and Color, 2nd ed.*, 1976. Reprinted with permission of Reston Publishing Co., a Prentice-Hall Co., 11480 Sunset Hills Road, Reston, VA 22090)

SYNCHRONIZING PULSES

Information collected by the television camera requires further processing before it can be viewed on a receiver. The scanning system in the receiver must be synchronized with the scanning system in the camera. If this did not occur, the picture information would not be the same. It would be possible, and probably happen, that the receiver would show what is called a *floating picture.* Parts of the scene would be reversed. The normal right side might appear on the left of the screen and the left would then be on the right side. This is illustrated in Figure 1-6, which is an "out-of-sync" picture.

Figure 1-6 Sync pulses are used to lock the picture in the receiver. A loss of sync will often produce a picture such as this.

Synchronizing pulses are developed by a *sync generator.* The sync pulses have a specific timing and shape. These pulses become a part of each line of picture information. Both vertical sync and horizontal sync pulses are produced. The vertical pulses are used to synchronize the vertical sweep in the television set with the vertical sweep at the camera. This is also true for the horizontal sync pulses. These pulses have different durations and timing. Both are required to synchronize picture information. Further details related to the function of sync pulses are presented in Chapters 16, 18, and 19.

BLANKING PULSES

The sync pulses are not seen by the viewer of the television set. The picture information is turned off when these pulses are being transmitted. This is accomplished by the addition of another signal on each line of picture information. This signal is called the *blanking pulse.* The composite video signal is shown in Figure 1-7. This shows the relation of the sync, blanking, and video information.

Broadcast standards for television include levels of modulation required for the picture. Absence of any picture information will produce a white

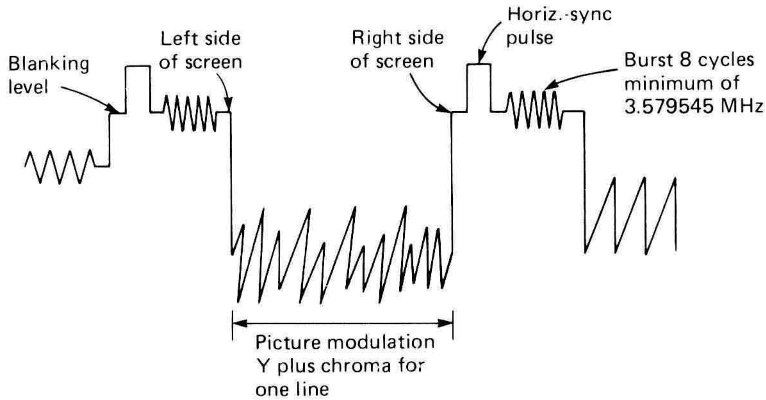

Figure 1-7 A line of composite video information. Note the placement of picture, blanking, color-burst, and sync signals. (Joel Goldberg, *Radio, Television, and Sound System Repair: An Introduction*, © 1978, p. 135. Reprinted by permission of Prentice-Hall, Inc.)

screen. The level of signal for this is about 12.5% of the total allowable signal modulation strength. The systems used to produce a television picture may be described as a *negative system*. In other words, the strongest level of signal produces a black picture. The lowest level of signal produces a white picture. The standard for a black picture is 75% of the allowable signal modulation strength. This point is the black level. The remaining portions of the allowable signal occur between the 75 and 100% level. This portion is called "blacker than black."

Signals transmitted in the blacker-than-black levels are not seen by the viewer. This portion of the picture signal contains synchronizing information. The picture tube is neither conducting nor producing a picture during this period. It is said to be "blanked." Pulses produced at the transmitter for this purpose are blanking pulses.

Figure 1-8 shows the relationship of the blanking pulses, sync pulses, and video information. This information is related to specific portions of the picture being shown on the receiver. The lighted screen of the receiver picture tube is called a *raster*. The shaded areas in the top picture are blanked. These are normally not seen by the viewer. The picture is enlarged or "overscanned" in the receiver so that the blanked areas are off to the sides of the picture tube.

Notice the relationship of the viewable picture and the trace scanning time. Every line has a period when the electron beam moves across the screen from left to right. This is called the *trace time*. The beam has to return to the left side to start the next scan. This period is called the *retrace time*. It is during the retrace time that the sync and blanking pulses are transmitted. The sync and blanking pulses transmitted during this period are used to control

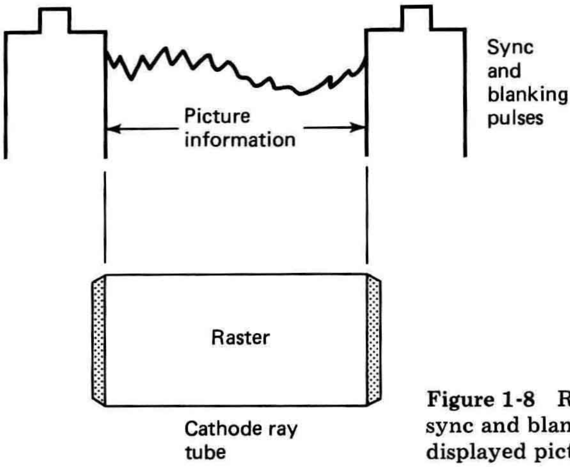

Figure 1-8 Relationship of the sync and blanking pulses to the displayed picture.

the horizontal sweep. They occur during each line of picture information. Additional pulses are required for vertical sync.

The vertical sync information is developed at the end of each picture field. Several lines of picture information are transmitted during a vertical blanking period. This period will blank between 13 and 21 lines per field,

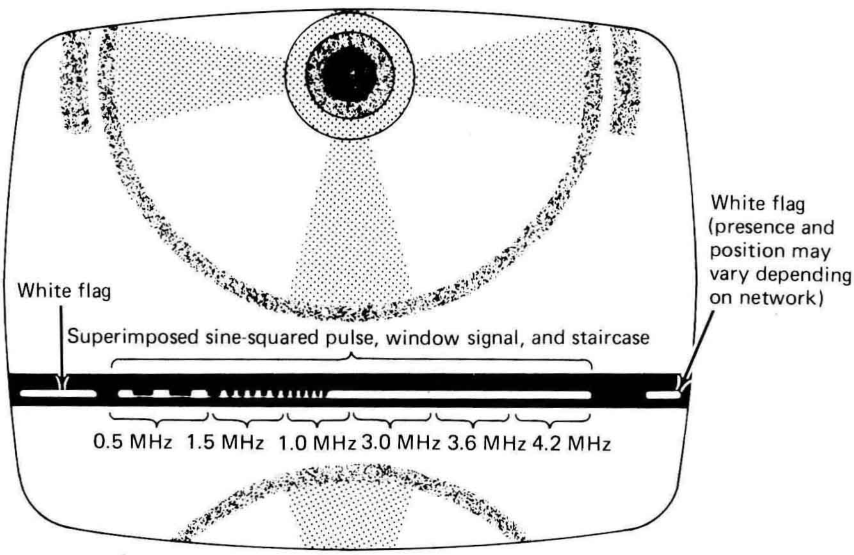

Figure 1-9 Vertical blanking interval and its relation to the observed picture. (Joel Goldberg, *Radio, Television, and Sound System Repair: An Introduction,* © 1978, p. 99. Reprinted by permission of Prentice-Hall, Inc.)

making a total of 26 to 42 lines per frame. A typical vertical blanking signal is shown in Figure 1-9. Most of this information is transmitted during the first one-half to two-thirds of the blanking interval. The equalizing and vertical sync pulses form a pattern often called a *hammerhead* due to its shape. It may be viewed by adjusting the receiver vertical hold control so that the blanking bar appears in the picture. Often, reduction of the contrast and brightness controls helps to bring this bar into view.

MODULATION

The process of transmitting radio frequency information requires a *carrier.* The carrier is necessary because the information is either too weak or on the wrong frequency to be transmitted. The human voice has a frequency range between 20 Hz and 20 kilohertz (kHz). If every person's voice could be broadcast at these frequencies, the resulting noise would be unbearable. Little communication would occur because of the large amount of interference created.

Each broadcast station has an assigned frequency, a *channel,* on which it operates. A signal, called a *carrier wave,* is created to keep the broadcast station on the proper frequency. Normally, no two stations in the same geographic area operate on the same frequency. The intelligence produced by the broadcast station is electronically added to the station carrier signal. This process is called *modulation.* The combined intelligence and carrier signals are called a *modulated carrier* signal. There are a variety of ways in which to modulate a carrier. One method is called *amplitude modulation* (AM). In this system the carrier's amplitude takes on the shape of the modulation signal. This is illustrated in Figure 1-10. The modulating process produces a carrier with the modulating signal shaping both the upper and lower halves of the carrier. If every television station were to broadcast the same information at

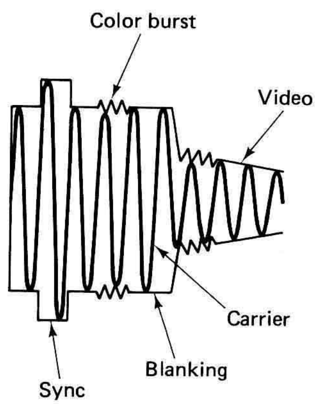

Figure 1-10 Modulated carrier wave, which assumes the shape of the modulation signal.