Television and Video Display Units

Objectives

After studying this chapter, you will be able to:
- Explain the steps in the transmission of a television signal.
- Discuss the scanning process.
- Identify circuits in both black-and-white and color television receivers and explain their functions.
- Identify the size and makeup of a television channel.
- Discuss a variety of television innovations including video cassette recorders, remote control, and satellite television.
- List the benefits of HDTV as compared to analog television.
- Explain the difference between multicasting and datacasting.
- Discuss the compression technique of MPEG2.
- Discuss the various flat-panel technologies.

Key Words and Terms

The following words and terms will become important pieces of your electricity and electronics vocabulary. Look for them as you read this chapter.

- active-matrix
- advanced television systems committee (ATSC)
- aspect ratio
- brightness control
- charged coupled device (CCD)
- datacasting
- deflection yoke
- electro-luminescence
- enhanced definition television (EDTV)
- feedhorn
- fine-tuning
- focal point
- frame
- frame rate
- geostationary orbit
- high-definition television (HDTV)
- liquid crystal display (LCD)
- multichannel
- national television standards committee (NTSC)
- passive-matrix
- picture element
- pixel
- polarized light
- progressive scanning
- raster resolution
- scanning
- synchronization (sync)
- video detector
- video head
- pulse

23.1 TELEVISION SIGNALS

Taking a picture from one location and reproducing it in your home is a combination of several processes. First, a television camera must record the images to be transferred. Next, those images must be turned into radio waves and sent out into the air, or turned into electrical signals and transmitted through cables. Finally, the signals must be received and translated back into pictures.

Television Cameras

What looks like a solid picture is really an extremely large number of dots. In a black-and-white picture, these dots are varying degrees of black and white. They are called picture elements. Look closely at a photo in a daily newspaper and you will see that these picture elements are clearly visible.
The vertical deflection oscillator causes the beam to move from top to bottom. The vertical deflection oscillator must have a frequency of 60 cycles per second. This is a field frequency.

Closer study of the scanning process reveals that the beam scans as it moves from left to right. After it has read one line, it quickly retraces to the left and starts reading the next line in the same way we read a book. The retrace time is very rapid, but still shows a line in the picture. Therefore, the picture must be black during this retrace time. Also, when the beam reaches the bottom of the picture, the beam must be returned to the top to scan again. The picture must also be black during vertical retrace, or trace lines would be visible.

The oscillators that make the scanning and retrace voltages for both the horizontal and vertical sweep must produce a waveform as shown in Figure 23-3. This is a sawtooth waveform. Notice the gradual increase in voltage during the sweep and the rapid decrease during retrace. These voltages are applied to coils that surround the picture tube. These coils are called the deflection yoke. An increase in the strength of the magnetic fields in the coils causes the electron beam to move. See Figure 23-4.

Scanning at the studio and scanning on a television must be in step. For this to occur, a pulse generator triggers the horizontal and vertical oscillators at the studio. This same pulse is also sent over the air and received by the television set. This pulse, known as the synchronization pulse, or sync pulse, triggers the oscillators in the receiver and keeps them at exactly the same frequency. Older televisions have horizontal hold and vertical hold controls. These controls are used to make slight adjustments so that the oscillators can lock in with the sync pulses. Newer televisions make the adjustments automatically.

### Composite Video Signals

All video signals are formed in the same way so that a television can be used in any geographic area. These standards are set by the FCC and are used by all TV broadcasting stations.

The television signals received by TVs contain picture (video) and sound (aural) information. The video information is an AM signal. The audio information is an FM signal.

The amplitude of the modulation is divided into two parts. The first 75 percent is used to transmit video information. The remaining 25 percent is for the sync pulses.

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As the beam scans each black bar, a similar action takes place. At the end of the line, the screen is driven back to the pedestal, or blanking level. During this blanking pulse, beam flyback occurs and a sync pulse is sent in the blacker-than-black, or infrablack, region (upper 25 percent) for oscillator synchronization. A second line to be scanned would be an exact copy of the first unless the picture is changed. At the bottom of the picture, a series of pulses trigger the vertical oscillator and keep it synchronized.

### Basic Cathode Ray Tube Controls

The cathode ray tube (CRT) is used to produce images in television sets. The control grid determines the flow of electrons through the tube. In the CRT this is also true. Figure 23-8. At zero bias the CRT is at maximum current; therefore, the screen is bright or white. At cutoff bias, the current is zero and the screen is black. The tube operates at a selected bias on the control grid. This bias can be controlled by the knob on the TV or a button on the TV remote called the brightness control.

When no picture is being received on the TV, the scanning electron beam can be seen in the form of lines on the TV screen. This is called the raster. Turn a TV to a vacant channel and observe this raster. Now adjust the brightness control from black to bright. The incoming, detected video signal is applied to the grid of the CRT (sometimes to the cathode, depending on polarity of signal). The video signal adds to, or subtracts from, the bias on the tube. This action results in a modulated electron stream that conforms to the picture information in the video signal. The picture is produced on the fluorescent screen.

The sharpness or focus of the electron beam can be controlled by the knob on the TV or a button on the TV remote called the brightness control.

Review Questions for Section 23.1

1. Briefly explain how an orthicon television camera works.

#### Composite Video Signals

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- When no picture is being received on the TV, the scanning electron beam can be seen in the form of lines on the TV screen. This is called the raster.
2. __________ is the point-to-point examination of a picture.
3. One scan of 262 1/2 lines represents a(n) ________.
4. What is a deflection yoke and what is its purpose?
5. The ________ triggers the oscillators in the receiver and keeps them at exactly the same frequency.
6. What is a raster?

23.2 TELEVISION RECEIVERS

The television receiver is a fairly complex electronic device. As you work through the block diagram of the receiver shown in Figure 23-9, take note of the similarities between your television set and the radio receivers you just studied in Chapter 22.

Black-and-White Television Receiver

Figure 23-9 shows the parts of the television receiver. This block diagram shows the links between the parts of the television. Trace the signal path through the stages. The purpose of each group of components will be apparent. The name of each block reflects its purpose in the circuit. The following text takes you stage by stage through a television receiver.

The RF amplifier serves a function similar to that in the superheterodyne radio. The incoming television signal is chosen by switching fixed inductors into the tuning circuit. These tuned circuits provide constant gain and selectivity for each television channel. In this stage, the video signal, with all its information, is amplified and fed to the mixer.

In the mixer stage, the incoming video signal is mixed with the signal from a local oscillator to produce an intermediate frequency. The commonly used IF is 45.75 megahertz. When a channel is chosen with the channel selector, the tuning circuit is changed. The frequency of the oscillator is also changed so that it is always producing the IF of the correct frequency. A fine-tuning changes the frequency of the oscillator slightly in order to provide the best response.

The RF, mixer, and oscillator are combined in one unit. The unit is called the tuner or front end of a television. These units are usually put together in the factory. Adjustments should not be made on these units unless you have the correct instruments and thorough knowledge of procedures.

The PIX-IF amplifiers amplify the output of the mixer stage. This includes the 45.75 megahertz intermediate frequency, the video, and the aural information. To provide maximum frequency response for each stage up to 45.75 MHz, each stage must amplify a broad band of frequencies. The voltage gain of each stage is reduced. More stages of IF amplification are required in this system, the sound is passed through the IF amplifier with the video signal. It is called the intercarrier system.

The output from the last IF stage is fed to the video detector or demodulator. The detection process is the same as in the radio. The video signal used to amplitude modulate the transmitted carrier wave is separated and fed to the next stage.

In the video amplifier stages, the demodulated video signal is amplified and fed to the grid (sometimes cathode) of the CRT. This signal modulates or varies the strength of the electron beam and produces the picture on the screen.

The FM sound signal is amplified in the sound IF amplifier. Later in this chapter, you will learn that the FM sound of the television program is separated from the video carrier wave by 4.5 megahertz. This produces a 4.5 MHz FM signal at the output of the video detector, which is coupled to the sound IF amplifiers.

The FM audio detector detects the frequency variations in the modulated signal and converts them to an audio signal.

AF amplifiers are the same as those used in the conventional radio or audio system discussed in the previous chapter. The audio signal is amplified enough to drive the power amplifier and the speaker.

The output of the video amplifier is fed to the sync separator. This circuit removes the horizontal and vertical sync pulses that were transmitted as part of the composite video signal. These sync pulses trigger the horizontal and vertical oscillators and keep them in step with the television camera.

The sync amplifier is a voltage amplifier stage that increases the sync pulses.

In the horizontal AFC, the horizontal oscillator frequency is compared to the sync pulse frequency. If they are not the same, voltages are developed that change the horizontal oscillator to the same frequency.

The horizontal oscillator operates on a frequency of 15,750 Hz. It provides the sawtooth waveform needed for horizontal scanning.

The horizontal output stage correctly shapes the sawtooth waveform for the horizontal deflection coils. It also drives the horizontal deflection coils and provides power for the high voltage rectifier.

The output of the horizontal oscillator shocks the horizontal output transformer (HOT). The high ac voltage developed by this autotransformer is rectified by the high voltage rectifier and is filtered for the anode in the CRT. See Figure 23-10.

The damper stage dampens out oscillations in the deflection yoke after retrace.

The output of the sync amplifier is fed through a vertical integration network to the vertical oscillator. The

Figure 23-10. Horizontal output transformer (HOT).
provide a fairly constant output from the detector by varying the gain of the amplifiers in previous stages. This is done by rectifying the video signal to produce a negative voltage. This voltage is applied to the bias of the previous amplifiers to change their gain.

**Color Television Receiver**

Color television was developed in the late 1940s. The system currently used in the United States was pioneered by RCA Laboratories. In March, 1950, a color television demonstration was given in Washington, DC, to FCC personnel, reporters, and other interested people. As a result of this demonstration, color television development was launched.

An invention that made color television possible was the **shadow mask picture tube**, Figure 23-11. The three basic colors used in color television are red, blue, and green, Figure 23-12. By combining these colors, any color can be produced on the screen.

The first color picture tube produced for retail sale was the **delta-type** tube. It was invented in 1950, and was basically the same tube used in the color television demonstrations given by RCA Laboratories in Washington, DC. The delta-type tube uses three electron guns placed in the neck assembly of the picture tube. The electrons are emitted by the three guns toward the screen. The screen is filled with hundreds of thousands of dots containing the colors red, blue, and green. In between the electron gun and the color-producing screen, the three electron beams are focused through an aperture or shadow mask, Figure 23-13. This shadow mask ensures that the electron beams strike the dots properly.

A line is made by one complete scan (from left to right) of all three electron beams hitting all the dots across the screen. If all electron beams are adjusted properly, the result will be a white line. A color line is made by mixing the electron beams.

**Television Channel**

The FCC has assigned a portion of the radio frequency spectrum for each television channel. There are two types of television channels: **very high frequency (VHF)** and **ultra high frequency (UHF)**. Each channel is 6 MHz wide. The VHF channels, 2 to 13, are listed in Figure 23-16 along with frequency bands and carrier frequencies.

Examine channel 4 in Figure 23-17. The basic video carrier frequency is 67.25 MHz. Recall that when an RF carrier wave is amplitude modulated, sideband frequencies appear. These stand for the sum and difference between the carrier frequency and the modulating frequencies.

To send a very clear, sharp picture, frequencies of at least 4 MHz are needed for modulation. These frequencies combine in channel 4 for a band occupancy of 63.25 MHz (67.25 + 4 MHz) to 71.25 MHz (67.25 + 4 MHz). It is a total channel width of 8 MHz. However, the FCC allows only 6 MHz, therefore, a compromise must be made.

In commercial TV broadcasting the upper sideband is transmitted without attenuation. The lower sideband is partly removed by a vestigial-sideband filter at the transmitter. The curve in Figure 23-17 shows the basic response traits of the TV transmitter. The sound is transmitted as a frequency-modulated signal at a center frequency 4.5 MHz above the video carrier. In channel 4, the sound is at 71.75 MHz.

The ultra high frequency (UHF) television band covers from channel 14 to 83. As in VHF, the bandwidth of each channel is 6 MHz. The same frequency bandwidths are used for the picture carrier as VHF.

The UHF channels used for commercial TV are set by the FCC. See Figure 23-18.
Chapter 23  Television and Video Display Units

Review Questions for Section 23.2

1. What is the purpose of an RF amplifier in a television receiver?

2. The output of the mixer stage is amplified by the:
   a. PIX-IF amplifier.
   b. video amplifier.
   c. AF amplifier.
   d. None of the above.

3. The __________ __________ stage correctly shapes the sawtooth waveform for the horizontal deflection coils.

4. What is the purpose of a shadow mask?

5. A Sony Trinitron color tube uses a(n) __________ aperture.

6. Each TV channel bandwidth is:
   a. 6 Hz.
   b. 60 MHz.
   c. 6 MHz.
   d. None of the above.

23.3 TELEVISION INNOVATIONS

In addition to the electronics of television itself, there are a number of other electronic innovations that have been created to work with television. A few of these innovations are detailed here.

Video Cassette Recorders

Video cassette recorders (VCRs) can be used to play videotapes. They also can be used to record and play back television broadcasts.

Most VCRs have four heads. A video head is a tiny electromagnet that reads information from the recorded tape during playback. It writes information onto the tape during recording. VCRs can have extra heads that provide better sound and picture quality.

Look at Figure 23-19. Recording information on a magnetic tape is simple. The tape is plastic with a thin coating of iron oxide on one side. The iron oxide is a
magnetic material. The voice or picture message is converted to electrical impulses. These electrical impulses are applied to the coil winding on the recording head. The fluctuations of the electrical impulses make the magnetic recording head fluctuate at the same rate as the electrical impulses. The magnetic head induces a magnetic pattern on the metal-oxide tape. The magnetic patterns uniquely match the original voice or picture patterns.

The videotape not only records voice and video but also speed information, end of tape location, copyright, and anticopy coding.

**Digital Video Recorder**

A digital video recorder (DVR) combines computer and television components to form a television receiver. A DVR receives a television signal and can record the television program as well. A hard disk drive is used for the recording medium rather than magnetic tape as found in a VCR system. A hard disk drive is capable of recording and storing hundreds of hours of television programming. See Figure 23-20.

**Remote Control**

A remote control is an application of infrared light and digital techniques. When a button on the remote control is pushed, a digital code is sent out of the remote control to an infrared sensor on the TV. The sensor on the TV amplifies and decodes the signal. See Figure 23-21.

**Large-Screen Projection TV**

Most large-screen projection TVs use a special electron gun assembly that projects three separate images onto a screen. Early projection TVs had screens with a significant curvature. As these televisions became more popular and more advanced, engineers were able to develop a flat screen projection. Figure 23-22 shows how the electron gun is assembled.

The main performance problem with large-screen or projection TVs is the loss of clarity of the video image. Remember there are only 525 lines per frame of display. As the picture is increased in size, the lines become a distraction. The image does not magnify; it simply gets larger. Some large projection TVs offer a slight improvement in video image by scanning the same lines twice for a total of 1050 lines across each frame. These sets do have a sharper, more appealing video image to the human eye, but no real magnification has taken place.

**Satellite TV**

Arthur C. Clarke first introduced the idea of launching satellites to improve communications. He did this in an article in the fall, 1945 issue of *Wireless World* magazine. He stated that if satellites could be launched high enough (35,880 kilometers or 22,300 miles) above the equator, they would be in geostationary orbit. Geostationary orbit means an object rotates with the earth.

The first communications satellite, Telstar I, was launched by the National Aeronautics and Space Administration (NASA) in 1962. It was a small, experimental satellite that only operated a few hours each day. This satellite made communication between the United States and Europe possible. In April, 1965, NASA launched the first commercial satellite, Early Bird. This satellite was owned by the International Telecommunications Satellite Organization (INTELSAT), a group created in 1964. Now there are many satellites in orbit allowing for television, telephone, radio, data, and other communications messages.

Rockets and space shuttles place satellites into space. Figure 23-23. Figure 23-24 shows an SBS communications satellite now in orbit. This satellite was designed to provide voice, video teleconferencing, data, and electronic mail services to U.S. businesses.

From its geostationary, or synchronous, orbit 22,300 miles above the equator, AUSSAT, Australia’s first national communication satellite, links that entire country and Papua, New Guinea, through an advanced telecommunications system. See Figure 23-25. When the satellite is in orbit, the antennas point south, making the spacecraft look upside down if viewed from earth.

Refer to Figure 23-26. It shows the inside of a satellite. A traveling wave tube amplifier increases the strength of the communication signal for its broadcast back to earth. It is being adjusted by an engineer. The amplifier is onboard a communication satellite. This satellite is built to carry both standard traveling wave tubes and solid-state power amplifiers. This type of satellite is reliable and has a long life.

The diagram of the parts of a satellite are shown in Figure 23-27. Figure 23-28 shows satellites in orbit over North America.
Once a signal is made by a communication station on earth, it is beamed up to the satellite. The satellite picks up the signal on its receiving antenna, amplifies the signal, and then sends it back down to earth. See Figure 23-29. The signal sent back down from the satellite is a wide signal designed to cover a large area of the earth.

Satellite transmission

The signal transmitted by the satellite is picked up on earth by a receiving dish or parabolic antenna. The dish focuses the received signals into a small area called the focal point. The feedhorn, which acts as a receiver, is located here. Figure 23-30. Located near the feedhorn is a low noise amplifier (LNA) that amplifies the received signal. The signal is then fed through a piece of electrical coaxial cable to the TV receiver. A coaxial cable has a conductor inside another conductor. The two conductors are insulated from each other.

Coaxial cable

The signal that is supplied by the local cable television company or through a satellite dish system typically connects to the initial receiver in the home from a single coaxial cable. Coaxial cable is designed to carry high frequency signals. The coaxial cable is designed to limit the radio waves generated from the center core conductor to the area between the core conductor and the shield. The shield will absorb the radio signal emanating from the core conductor when the high frequency passes through. See Figure 23-33. The shield also protects the inner core.
Chapter 23  Television and Video Display Units

from outside radio interference. The shield of the coaxial cable is grounded in most applications.

FAKRA SMB connector
A FAKRA SMB connector is a very small connector especially designed for small diameter coaxial cable known as micro-coaxial cable. Micro-coaxial cable is used for automotive satellite radio and antenna connections. It is the smallest connector used at this time.

Review Questions for Section 23.3
1. A(n) _______ pattern is left on a recording tape.
2. A remote control sends a(n) _______ to the TV.
3. How is an image projected onto a large-screen TV?
4. Why is the resolution limited for a typical large-screen TV?
5. Who first proposed the concept of communication satellites?
6. How does a receiving dish work?
7. Which part of a coaxial cable is normally grounded?

23.4 HIGH DEFINITION TELEVISION (HDTV)

The analog television display system had remained the same for over fifty years without any major improvements to the quality of the transmitted image. This condition may have continued if not for the development of the computer monitor. The computer monitor had a greater image resolution than the analog television. By merging the analog television system with the digital system, many features that were not possible with the traditional analog system could be added. When converting to the digital system, there was greater ability to manipulate screen images. For example, since there is greater color depth control in a digital system, images could be easily reprocessed as the image horizontal-to-vertical ratio changed between digital and analog television reception.

The FCC’s approval in 1996 of a digital television standard was the first step toward an improved and a higher quality picture. Although the switch to digital has progressed slowly, with more and more television stations switching to digital broadcasts and many digital television formats emerging, high definition television (HDTV) has become the dominant digital television technology.

HDTV allows for higher resolutions and a wider display screen than an analog display system. HDTV uses digital broadcasting techniques, allowing more information-rich data to be transmitted by airwaves than by analog broadcasts. Digital broadcasting can broadcast multiple channels in the same bandwidth as that used for one analog channel. Broadcasting multiple channels is referred to as multicasting. Multicasting allows not only for the image to be broadcast, but also for two to four channels to be broadcast in the same single-channel bandwidth. The additional channels can be used to transmit additional images, resulting in “picture-in-picture” and information such as stock prices, weather reports, sports scores, or background information about the actors in the movie being viewed. Any information found on the Internet can be incorporated into the display screen. When additional information is transmitted along with the video image, it is referred to as datacasting. You will soon likely be able to integrate a digital camera into the system so that you can see the baby sleeping in the next room while watching your favorite television show.

To be considered a complete HDTV system, three major system components are required, Figure 23-34:
• A digital camera to record the images at the higher resolution.
• A digital receiver (HDTV tuner) to convert received broadcasts into image and sound.
• A display unit capable of producing images at the high definition TV resolution.

If any of the three major parts are missing, the HDTV system is incomplete and will not produce an HDTV picture. There are many television variations that
use HDTV terminology but do not produce the desired HDTV effect. For example, a television system may be capable of receiving a transmitted HDTV broadcast, but incapable of displaying the higher resolution HDTV image.

**Digital Camera Technology**

Traditional analog television uses vacuum tube imaging to capture images, while HDTV uses the **charged coupled device (CCD)**. The CCD is an integrated circuit consisting of an array of photo sensors that convert light from a camera’s focused image to electrical energy. Figure 23-35. The level of electrical energy is directly proportional to the level of light captured by the photo sensors. The CCD converts the individual packets of electrical charge into a series of analog signals representing the level of light amplitude at each photo sensor location. An analog-to-digital converter (ADC) converts the series of analog signals to digital signals. The digital pattern can then be sent to a block of computer memory to be stored as a still image, recorded to CD or DVD, transmitted across a computer network, or broadcast using the existing assigned television bands.

For full-color images and higher resolutions, three sets of CCD sensors are used. A beam splitter inside the camera separates the incoming light into three colors: blue, red, and green. Figure 23-36. Each color is sent to a corresponding CCD. The three images are then overlaid, producing a picture rich in color. Since the full array of each CCD is used for each color, the three-CCD camera is capable of higher HDTV resolutions.

**HDTV Picture Quality**

The most impressive attribute of HDTV is the picture’s visual quality. To compare the HDTV image to the analog television image, we must first convert the typical analog image to an equal digital resolution.

The **National Television Standards Committee (NTSC)** formulated the standards for analog television and video in the United States. The NTSC standard calls for 525 scan lines at a 60 Hz refresh-rate based on the interlace technique. NTSC is not compatible with most computer video systems and must be converted before it can be displayed. The **Advanced Television Systems Committee (ATSC)** was established in 1983. The committee spent years developing standards that were eventually adopted by the FCC for digital television broadcasting and receivers. These standards have been designed to eventually replace the NTSC standards.

There are 18 scanning formats described in the ATSC standards. Variations in the standards are derived from concerns about interlace scanning and progressive scanning, frame rates, and aspect ratio. Earlier, in the section about the analog television system, you learned about interlacing. Interlace scanning is a two-step process of transmitting the odd lines of the scan and then going back over the image, filling in the even lines to make a complete image. Figure 23-37. Progressive scanning is the capture and transmission of the entire image at one time. Each line is placed on the screen progressively in one sweep.

**Frame rate** is how often the image is updated on the screen. Currently, three frame rates (in frames per second) exist: 60, 30, and 24. **Aspect ratio** is the relationship of the horizontal to vertical screen presentation measurements. Aspect ratio standards can be either 4:3 or 16:9. The 16:9 is a wide-screen aspect ratio similar to common movie theaters. The 4:3 aspect ratio is a standard television rectangle. The various factors of aspect ratio, frame rates, and scanning method combine to form the 18 different screen standards. Figure 23-38 lists the 18 ATSC digital TV compression formats.

HDTV has a vertical scanning rate equal to 720p (progressive) and 1080i (interlaced) vertical lines. The actual display may have a higher vertical scan rate than the 1080i standard. This is especially important as the size of the display area increases.

To compare the quality of analog television to HDTV, you must convert scan lines to maximum number of pixels. A pixel is the smallest unit of an image on a graphic display. It can be thought of as a single dot in the entire image.

Analog television approximates a screen composed of 480 × 440 pixels, producing 211,200 total pixels. HDTV approximates a screen composed of 1920 × 1080 pixels, producing 2,073,600 total pixels and by far a greater detailed image than the analog system.

The Moving Picture Experts Group developed the **MPEG2** image compression standard to increase the amount of video data transmitted in an HDTV system. By compressing the broadcast video data, more information could be broadcast in the same amount of bandwidth. The MPEG2 compression technique can reduce the image information by as much as 97 percent, but an average of 50 percent is typical. The compression technique is based on the fact that the majority of the video images on a television screen do not change from frame to frame. For example, a news broadcast has a persistent image, such as a background, with very little movement requiring new data. Parts of the image that are persistent do not need to
be broadcast in each frame. This reduces the total amount of image information that has to be transmitted. The same technique is used for DVD, CD-RW, and still cameras. Because more information can be transmitted using a completely digital system, sound quality has also greatly improved. HDTV incorporates the 5.1 channels of surround sound, and a subwoofer signal. This is the same quality audio used in the best stereo systems available.

There are some misleading terms used when describing advanced television systems. The fast evolution of these systems and the terminology used by advertisers can often lead to disappointed consumers. Enhanced definition television (EDTV) is a system that receives digital transmissions and displays images at 480p or higher. The fact that it can receive high definition television transmissions and decode them makes it an enhanced system. However, actual HDTV displays images at 720p or 1080i. You may have an HDTV receiver connected to a display unit that cannot produce the higher display quality, thus defeating the purpose of HDTV. Some systems simply take the existing NTSC system and double the number of scanning lines, but this does not provide any new image information. This is like using a photocopier to double the size of an original image. Since no new image information has been added, picture quality cannot be enhanced.

**Digital Light Projection Television**

One of the latest developments in television is digital light projection (DLP) developed by Texas Instruments based on their digital mirror device (DMD). The DMD is a precision light switch consisting of a rectangular array of microscopic mirrors. Look at Figure 23-39. Each mirror is controlled separately. The entire array of mirrors span across one chip. A DMD can contain an array of over 1.3 million mirrors.

The DMD technology is combined with a light source and lens to create a DLP system. Each individual mirror corresponds to a digital signal that represents a single pixel in the image to be created on the television screen. The array of mirrors can be switched on and off over one thousand times per second. The length of time each mirror is switched on and off is used to produce an array of light and dark spots on the target screen. Varying the amount of time each mirror changes from light to dark will produce a specific shade of gray on the screen.

For a full-color image to be produced, the DLP uses a color filter. The reflected light passes through the color wheel at the exact moment the required specific color is needed to produce the desired image onto a screen. The transparent lens on the filter can create over 16 million different colors. A DLP television typically consists of a single DMD chip, lamp, color wheel, and a projection lens. See Figure 23-40. You can see the light source shining through the spinning color wheel. The light passes through the color wheel filter and then strikes the DMD and is reflected through the lens which projects the image on the television screen.

Flat-panel displays have been associated with portable computer systems for some years now. As electronic display technology evolves, display units for computers, televisions, and other forms of communication are merging. Many televisions now use flat-panel technologies instead of picture tube technologies. Flat-panel displays are lightweight, thin, and have more applications than the bulky CRT. Figure 23-41.

While a CRT uses a mask to isolate the individual pixels on a screen display, the flat-panel display does not. The flat-panel display controls the individual pixels electrically. Flat-panel displays typically sandwich a thin film of phosphorescent material or liquid crystal between two thin surfaces. Figure 23-42. One surface is covered with vertical conductors and the other with horizontal conductors.
forming a grid. At each point on the grid is a pixel. Each pixel can produce a dot of light on the display unit.

**Gas-plasma displays**

Gas-plasma displays operate on the principle of electro-luminescence. Electro-luminescence is the display of light created when a high frequency passes through a gas to a layer of phosphor, resulting in the release of photons. The electrical energy from releasing photons is better known as producing light.

A gas-plasma display consists of millions of tiny cells sandwiched between two glass plates. See Figure 23-43. Each cell contains an inert gas and is coated with a phosphorous material of red, blue, or green. Transparent electrodes run horizontally behind the front panel on top of the cells, and address electrodes run vertically along the rear glass panel beneath the cells. When the address electrode and its corresponding transparent electrode are energized, the gas, in an excited plasma state, releases an ultraviolet light. The ultraviolet light strikes the phosphorus coating inside the cell, causing the cell to release a light corresponding to its color. By varying the pulses of current, the entire light spectrum can be duplicated.

**Liquid crystal display (LCD) panels**

The most common flat-panel display is the liquid crystal display (LCD). The liquid crystal display (LCD) operates on the principle of polarized light passing through tiny crystals of liquid. Light is composed of many different light waves. Each light wave travels at different angles. A voltage applied to the crystal causes the crystal to warp and, in turn, determine the amount of polarized light passing through to the display screen.

The LCD is classified according to the electronic circuitry and method used to apply light to the display’s surface. There are two categories of LCD: active and passive. Passive displays are more affordable than active displays because they require fewer transistors and are less complex. Active-matrix displays are costly because they use one or more transistors at every pixel.

Both active and passive displays are made up of groups of individual screen areas referred to as pixel areas. Each pixel area is made up of three color dots or pixels: red, green, and blue. The combined effect of the three pixels produces pixel areas representing different colors. Varying the intensity of each pixel can produce millions of colors. Combined with the surrounding areas, the pixels form an image on the display screen.

**How color liquid crystal displays work**

To understand how LCD technology works, follow along with Figure 23-44. The typical LCD panel is simple in construction. A backlight is required to generate light. The light passing through the first filter results in polarized light. Polarized light consists of light waves all the same shape and of a single frequency rather than the entire spectrum of light frequencies generated by the backlight. The light passing through the first filter consists only of vertical waves.

A liquid crystal sits between the two filters. When a voltage is applied to the liquid crystal, the molecules in the crystal rotate from the vertical position. When the vertical light passes through the energized liquid crystal, it too rotates, changing into a horizontal light wave that is blocked by the second filter. The second filter allows only vertical waves to pass through. The amount of voltage applied to the crystal determines the amount of rotation from the vertical position to a horizontal position. The more voltage applied, the less light that will pass through the second filter.

**Passive-matrix display**

There are two types of electrical circuitry used to energize the crystal area, active and passive, Figure 23-45. In a passive-matrix display, a grid of semitransparent conductors run to each crystal used as part of the individual pixel area. The grid is divided into two major circuits, columns and rows. Transistors running along the top and the side of the display unit head the columns and rows. A ground applied to a row and a charge applied to a column activates a pixel area. The voltage is applied briefly and must rely on screen persistence and a fast refresh rate. Because current must travel along the row and column until it arrives at the designated pixel, response time is slow.

**Active-matrix display**

In an active-matrix display, each individual pixel in the grid has its own individual transistor. The active-matrix provides a better image than the passive-matrix. The active-matrix image is brighter because each cell can have a constant supply of voltage.

The most common active-matrix display is the thin film transistor liquid crystal display (TFT-LCD). Often, this type of display is referred to simply as a TFT display. The TFT display consists of a matrix of thin film transistors spread across the entire screen. Each transistor controls a single pixel on the display. There are over one million transistors in a display, three transistors at each pixel area, and one transistor for each color pixel, Figure 23-46. The liquid crystals in the TFT display are energized in a pattern representing the data to be displayed.

The conventional television has used the CRT to display images because the original LCD design had limitations that could not compete with larger display units. As the size of the display unit grew to over 18 inches, problems developed with the brightness of the display and in converting the analog television signal to a digital signal and to a wide-angle viewing area without image distortions. These problems were solved with the introduction of thin film transistor LCD technology.
Advantages of LCD displays over CRT displays:
- LCDs can be constructed much smaller and are lighter in weight than CRT displays.
- LCDs are more economical to run because they require less power.
- LCDs generate less heat.
- LCDs create images that are more detailed.
- LCDs produce less electromagnetic interference (EMI).

Disadvantages of LCD displays as compared to CRT displays:
- Lack of an industry-wide standard.
- Higher cost for a comparable size.
- Complexity of scaling images without distortion.

Display Resolution

Resolution is a measurement of an image's quality. The higher the resolution, the higher the quality or more detailed the image. Each pixel area on the TFT display consists of three transistor-controlled color fields. The three color fields—red, green, and blue—are combined to form various shades and hues of color.

A display unit designed to accept input from many different sources. It allows a display to be used with television systems and PC systems as well.

Philips SXGA Triple-Input Display Controller

To illustrate how one display system can be used in multiple applications, let's look at the Philips SXGA triple-input TFT display system controller, Figure 23-48. The triple input display system controller accepts input from analog, digital, and parallel sources. The analog input accepts the traditional UHF and VHF frequencies. The digital input accepts HDTV broadcasts over cable, as well as from personal computer systems. The parallel interface accepts input from other sources such as USB connection devices like a camera or a recorder.

The block diagram for the SXGA triple input is different from traditional television. This system requires a microprocessor and special modules to process digital information. At the opposite end there is just one output, the panel port.

Standards Organizations

There are several organizations that are presently creating standards for LCD type panel displays. They are as follows: Video Electronics Standards Organization (VESA), Digital Flat Panel (DFP), and Digital Visual Interface (DVI). The variance has caused much confusion concerning video display standards, not only for screen display resolution, but also for standard connector construction. Look at the table in Figure 23-49 for a brief summary of the three major standards groups involved in the development of a standard for their individual interest. The VESA workgroup is headed by the VESA standards organization. The DFP is led by Compaq, and the DVI is led by Intel. Each group consists of members from across the television and computer industry.
Home Theater Connector Types

There are many different connector types developed for HDTV and various other displays. The display connectors are designed either for digital or analog transmissions, or for a combination of both digital and analog. Some manufacturers have tried to cut production costs by designing connectors to work with both television and computer systems. While making multiple-application connections is reasonable, it has caused some physical and electrical incompatibility between designs due to a lack of one general standard for all manufacturers. As long as different standards exist, compatibility issues will arise between the devices from different manufacturers. Look at the various connection designs in Figure 23-50.

A home theater center can consist of many different electronic devices connected together. The equipment that comprises a complete home theater may involve a wide variety of cable connections. Audio cable does not require shielding from interference or cause interference the way video signals do. The speaker wiring has a low frequency and does not use a carrier wave because it transmits the sound pattern as an analog signal. Video cables must be shielded to protect the video signal from interference and, in turn, so the video cable does not broadcast radio wave interference to surrounding devices. You need to be able to identify each type of connection and understand its capabilities.

RF and F-type
RF and F-type connections support the poorest quality video images and are found on the oldest technologies. The RF and F-type cables use standard coaxial cable made of a solid or stranded copper core conductor. The core conductor is surrounded by a thick insulator material. The insulator material is completely wrapped around by a conductive mesh or foil referred to as the shield. The shield protects the core conductor from outside electromagnetic interference. RF and F-type cables provide the poorest signal quality transfer between support home entertainment devices. Refer to Figure 23-33.

Composite video
Composite video cables use only one cable for the video signal and two or more for stereo sound. See Figure 23-51. The composite video will provide a better signal than RF or F-type cable connections but worse than S-video or component video.

S-video
S-video is a four-pin connector that delivers separate signals for video signal chrominance (color) and luminance (brightness). It is a very simple way to connect components together because there is no way to miscon-nect the audio and video cables. There is a nine-pin ver-sion that is used for video-in and video-out (VIVO) configurations. The nine-pin connector allows for video to be streamed in both directions. The four-pin connector is used for applications that only require video in one direction. See Figure 23-51B.

Component video
The component video is found on high-performance devices and produces better quality pictures than S-video or composite video. The cables used are constructed from flexible coaxial cable. Each individual cable consists of a single conductor surrounded by a dielectric and a shield to protect it from receiving or generating interference. See Figure 23-51C. Component video does not carry the audio signal. Audio signals are typically supplied through two separate ports.

Figure 23-50. Various connection designs.


High Definition Multimedia Interface
High Definition Multimedia Interface (HDMI) is used to supply video and audio in an uncompressed all-digital signal format. See Figure 23-52. HDMI supports high definition television and Dolby 5.1 using a single cable. The digital audio is as high as 192 kHz and the digital video is as high as 350 MHz and 10.2 Gbps of signal data. At the time of this writing, HDMI provides the best picture and sound quality available. The HDMI uses the new xvYCC standard which is an enhanced color standard that exceeds the HDTV standard. The xvYCC is short for Extended YCC Colorimetry for Video Applications. The term “colorimetry” means identification of colors using three sets of numbers representing red, green and blue. This new standard was designed to enhance the viewing experience and can support 1.8 times as many colors as existing HDTV signals. The new standard is also designed to support Blu-ray technologies for digital movie disc and newest video game technology.

ToskLink
The ToskLink optical connector, Figure 23-52B, is a proprietary connection developed jointly by Sony and Phillips. The ToskLink cable is limited to audio at this time and used to support audio signals between home theater equipment. The ToskLink provides a connection for fiber optic cable. Fiber optic cable is immune to interference because it utilizes light to transfer the signal, not radio waves. A light signal is not susceptible to interference emitting from other cables and radio signal sources.

Display systems, still evolving, have yet to designate one universal standard. This evolution is similar to when the video tape recording systems introduced the Beta and VHS taping systems. While the Beta system was technically
superior to the VHS system, the VHS system became the designated standard because of its convenience.

Review Questions for Section 23.4

1. What three things are needed to have a complete high definition television system?
2. What is multicasting?
3. What is datacasting?
4. What does the acronym ATSC represent?
5. What does the acronym NTSC represent?
6. What do the lowercase letters i and p represent in association with frame rates?
7. What are the two common display formats for HDTV?
8. What does the 5.1 channel surround sound system consist of?
9. How many pixels are required for each color display’s pixel area?
10. What are the two classifications of LCD displays based upon the number of transistors in relation to the number of points in the image?
11. What does the acronym DMD represent?

Summary

1. A television picture is produced by scanning an image captured from a television camera onto a cathode ray tube.
2. Scanning is the point-to-point examination of a picture.
3. The scanning system used in the United States is the interlace system. It consists of 525 scanning lines.
4. Black-and-white signals are made by a single color picture tube. Color signals are made by a three color (red, blue, and green) picture tube.
5. The bandwidth of a TV signal is 6 megahertz. The VHF band covers channels 2 through 13. The UHF band covers channels 14 through 83.
6. Video cassette recorders are used for recording and playback of magnetic tapes.
7. The image on a large-screen TV is made by projecting three color images onto a screen.
8. Satellite TV is used for communication worldwide through the use of satellites that orbit the earth in a geostationary (synchronous) position.
9. Traditional analog television uses vacuum tube imaging to capture images, while HDTV uses CCD cameras to capture images and convert them to digital information.
10. A digital camera uses a charged coupled device (CCD) to capture an image and convert it into digital signals that can be stored or transmitted.
11. A pixel is a single color element of a color pixel area.
12. HDTV is associated with display formats 720p and 1080i.
13. MPEG2 is the most commonly used video compression standard for HDTV.
14. Dolby surround sound consists of 5.1 channels.
15. The most popular LCD technology for high-quality color images is the TFT-LCD.

Test Your Knowledge

Please do not write in the text. Place your answers on a separate sheet of paper.

1. The dots that make up a picture are called_______.
2. Briefly explain the interlace scanning system.
3. What causes an electron beam to move from left to right?
4. The speed of an electron stream from an electron gun is increased by:
   a. grids.
   b. target plates.
   c. scanning.
   d. None of the above.
5. A composite video signal contains the:
   a. video information.
   b. sound information.
   c. Both of the above.
   d. None of the above.
6. The______ image compression standard to increase the amount of video data transmitted in an HDTV system.
7. What are the two classifications of LCD displays based upon the number of transistors in relation to the number of points in the image?
8. What does the acronym DMD represent?
9. Traditional analog television uses vacuum tube imaging to capture images, while HDTV uses CCD cameras to capture images and convert them to digital information.
10. A digital camera uses a charged coupled device (CCD) to capture an image and convert it into digital signals that can be stored or transmitted.
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15. The most popular LCD technology for high-quality color images is the TFT-LCD.

Matching Questions

Match the following terms with their correct definitions.

- Sync separator
- Sync amplifier
- Mixer
- Vertical oscillator
- Video amplifier
- Horizontal AFC
- The output of this device provides the sawtooth voltage to the deflection coils.
- Removes the horizontal and vertical sync pulses transmitted as part of the composite video signal.
- Compares the frequencies of the horizontal oscillator and sync pulse.
- Amplifies the demodulated picture signal and feeds it to the grid of the CRT.
- Combines the incoming video signal with a local oscillator signal.
- A voltage amplifier stage in which the sync pulse is changed.
- A voltage amplifier stage in which the sync pulse is increased.
- A video information.
- A sound information.
- Both of the above.
- None of the above.

For Discussion

1. Discuss the function of each of the following controls found in a TV receiver. State the circuit that is regulated by each control.
   a. Horizontal hold.
   b. Brightness.
   c. Vertical hold.
   d. Fine-turning.
   e. Channel selector.
   f. Vertical linearity.
   g. Horizontal linearity.
   h. Height control.
   i. Contrast.
   j. Width control.
2. Explain the process of negative transmission used in television in the United States.
3. How does the vertical integration network separate the vertical sync pulse?
4. If dc amplifiers were used in the video section, would dc restoration be necessary?
5. Why are both UHF and VHF channels needed for television?
6. Research and discuss the various types of video display.
7. Discuss what you think television will be like in the year 2020.
8. How did development of the shadow mask picture tube promote the reality of color TV?
9. Why would a digital television image be sharper than a conventional television image?