- PARTS OF THE CAMERA
  The lens, the camera Itself, and the viewfinder
- FROM LIGHT TO VIDEO SIGNAL
  The beam splitter and the imaging device
- CAMERA CHAIN
  The camera head, camera control unit, sync generator, and power supply
- TYPES OF CAMERAS
  Analog and digital cameras, studio cameras, ENG/EFP cameras and camcorders, consumer camcorders, and prosumer camcorders
- ELECTRONIC CHARACTERISTICS
  Aspect ratio, white balance, resolution, operating light level, gain, video noise and signal-to-noise ratio, image blur and electronic shutter, smear and moire, contrast, and shading
- OPERATIONAL CHARACTERISTICS
  Power supply, camera cable, connectors, filter wheel, viewfinder, tally light, intercom, and additional ENG/EFP elements

PARTS OF THE CAMERA

Despite their electronic complexity, all television cameras (including the consumer video cameras) consist of three main parts. The first is the lens, which selects a certain field of view and produces a small optical image of it. The second part is the camera itself, with its imaging, or pickup, device that converts into electrical signals the optical image as delivered by the lens. The third is the viewfinder, which shows a small video image of what the lens is seeing. Some cameras have a small foldout screen that enables you to forgo looking through an eyepiece to see the camera picture.

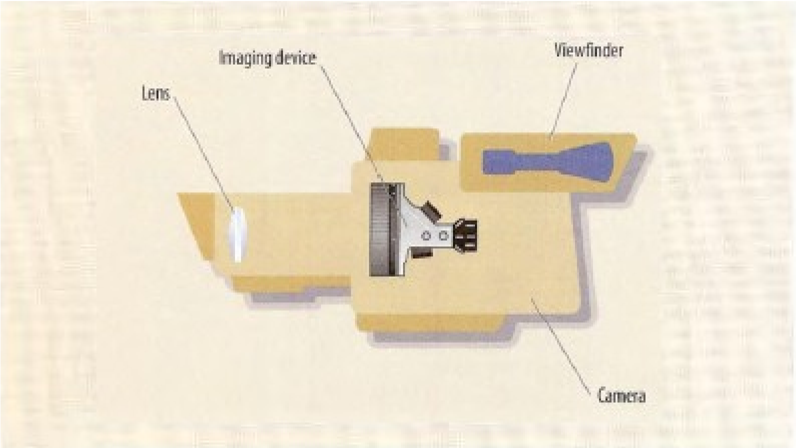


Fig.: Parts of the Camera

FROM LIGHT TO VIDEO SIGNAL

All television cameras, whether digital or analog, big or small, work on the same basic principle: the conversion of an optical image into electrical signals that are reconverted by a television set into visible screen images. Specifically, the light that is reflected off an object is gathered by a lens and focused on the imaging (pickup) device. The imaging device is the principal camera element that transduces (converts) the light into electric energy—the video signal. That signal is then amplified and processed so that it can be reconverted into visible screen images. With these basic camera functions in mind, we can examine step-by-step the elements and the processes involved in the transformation of light images into color television images. Specifically, we look at (1) the beam splitter and (2) the imaging device.

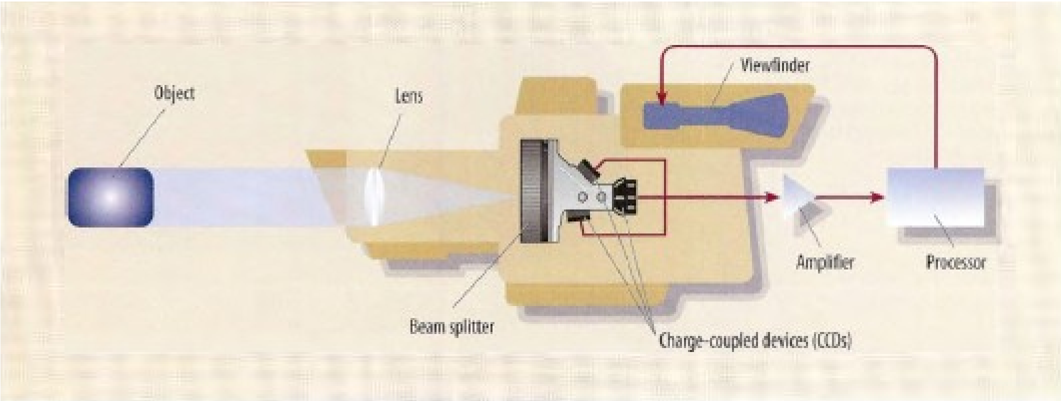


Fig.: Camera Process for capturing images

BEAM SPLITTER

The beam splitter contains various prisms and filters. They separate the white light that passes through the camera lens into the three light beams—red, green, and blue, usually referred to as RGB. These three primary colors are then electronically "mixed" into the many colors we see on the television screen. Because all of these prisms and filters are contained in a small block, the beam splitter is often called the prism block. Most consumer camcorders use a filter rather than a prism block to split the white light into the three RGB primaries. That filter, located behind the lens and in front of the chip (CCD imaging device), consists of many narrow stripes that separate the incoming white light into the three primary colors or into only two colors, with the third one generated electronically in the camera. More efficient systems use a mosaic-like filter that transforms the colors of the lens image into the additive primaries of red, green, and blue.

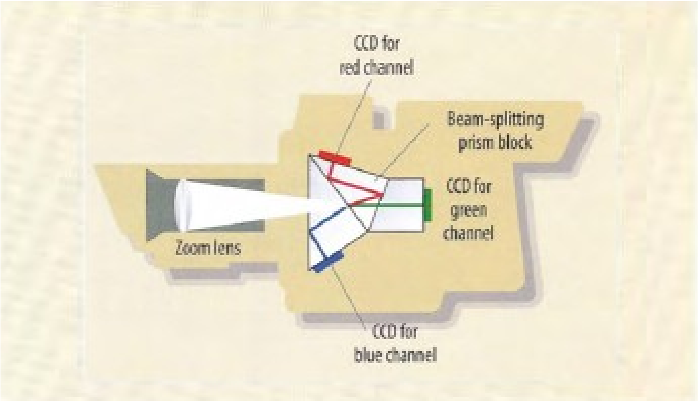


Fig.: The Beam Splitter

IMAGING DEVICE

Once the white light that enters the lens has been divided into the three primary colors, each light beam must be translated into electrical signals. The principal electronic component that converts light into electricity is called the imaging device. This imaging, or pickup, device consists of a small solid-state device (about the size of a button on a standard telephone keypad) normally called a chip or, technically, a charge-coupled device (CCD). A CCD normally contains hundreds of thousands or, for a high-quality CCD, millions of image-sensing elements, called pixels (a word made up of pix, for picture, and els for elements), that are arranged in horizontal and vertical rows.

Pixels function very much like tiles that compose a complete mosaic image. A certain amount of such elements is needed to produce a recognizable image. If there are relatively few mosaic tiles, the object maybe recognizable, but the picture will not contain much detail. The more and the smaller the tiles in the mosaic, the more detail the picture will have. The same is true for CCDs: the more pixels the imaging chip contains, the higher the resolution of the video image.

Fig.: Pixelized Subject

Each pixel is a discrete image element that transforms its color and brightness information into a specific electric charge. In digital cameras each pixel has a unique computer address. The electric charges from all the pixels eventually become the video signals for the three primary light colors. These RGB signals make up the chrominance (color) information, or the C signal. The black-and-white, or luminance, information is provided by an additional signal, the Y signal.

Fig.: The CCD

CAMERA CHAIN

When looking at a high-quality studio camera, we can see that it is connected by cable to an electrical outlet. This cable connects the camera to a chain of equipment necessary to produce pictures. The major parts of the camera chain are (1) the actual camera, called the camera head because it is at the head of the chain; (2) the camera control unit, or CCU; (3) the sync generator that provides the synchronization pulses to keep the scanning of the various pieces of television equipment in step; and (4) the power supply.

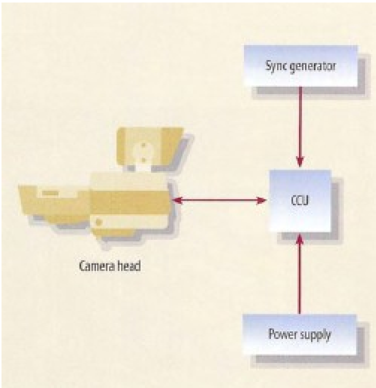


Fig.: Standard Camera Chain

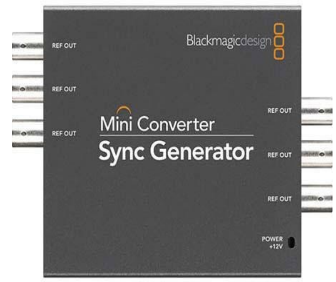
CAMERA CONTROL UNIT

Each studio camera has its own camera control unit (CCU). The CCU performs two main functions: setup and control. During setup each camera is adjusted for the correct color rendition, the white balance (manipulating the three color signals so that they reproduce white correctly under a variety of lighting conditions), the proper contrast range between the brightest and the darkest areas of a scene, and the brightness steps within this range.

Assuming that the cameras are set up properly and have fair stability (which means that they retain their setup values), the video operator (VO) usually needs control only "master black" or "pedestal" (adjusting the camera for the darkest part of the scene), and the "white level" or "iris" (adjusting the *f*-stop of the lens so that it will permit only the desired amount of light to reach the imaging device). The VO has two primary instruments for checking the relative quality of the color signal: the waveform monitor, also called the oscilloscope, that displays the luminance (brightness) information, and the vector scope that shows the chrominance (color) signals. Both displays enable the VO to achieve optimal pictures.

Sometimes, when the actual operational controls are separated from the CCU, they are known as a remote control unit (RCU) or, more accurately, an operation control panel (OCP). For example, the actual CCUs may be located in master control, but the OCPs are in the studio control room. This arrangement allows the video operator to do the initial camera setup in master control and then sit in the control room with the production crew and "shade" the pictures (maintain optimal picture quality) according to not only the technical standards but also to the aesthetic requirements of the production. This is why the VO is also called a shader. The term RCU also refers to a small CCU that can be taken to EFP locations to make field cameras perform at optimal levels.

SYNC GENERATOR AND POWER SUPPLY



The sync generator produces electronic synchronization pulses—sync pulses—that keep in step the scanning in the various pieces of equipment (cameras, monitors, and videotape recorders). A genlock provides various pieces of studio equipment with a general synchronization pulse, called house sync. Through the genlocking process, the scanning of video signals is perfectly synchronized, allowing to switch among and intermix the video signals of various cameras and/or videotape recorders (VTRs) without the need for additional digital equipment.

The power supply generates the electricity (direct current) that drives the camera. In a studio the power supply converts AC (alternating current) to DC (direct current) power and feeds it to the cameras.

The camera cable feeds all the CCU functions to the camera and transports the video signals from the camera back to the CCU.

Field (ENG/EFP) cameras and all camcorders are self-contained, which means that the camera itself holds all the elements of the chain to produce and deliver acceptable video images to the VTR, which is either built into the camera, attached to it, or connected to it by cable. The only part of the normal camera chain that can be detached from the field camera or camcorder is the power supply—the battery. All other controls are solidly built-in and automated. Some of the more sophisticated field cameras accept external sync, which means that they can be genlocked with other cameras and/or an RCU.

Most cameras have built-in control equipment that can execute the CCU functions automatically. Why bother with a CCU or an RCU if you can have the camera do it automatically? Because the automated controls cannot exercise aesthetic judgment; that is, they cannot adjust the camera to deliver pictures that suit the artistic rather than the routine technical requirements.

TYPES OF CAMERAS

Television cameras can be classified by their electronic makeup and by how they are used. Cameras grouped by electronic makeup are either analog or digital. Cameras classified by function are for either studio or ENG/EFP use.

ANALOG VERSUS DIGITAL CAMERAS

Although most cameras are digital, regardless of whether they are large studio cameras or small camcorders, there are nevertheless many analog cameras still in use, mainly because of their high initial cost (such as Sony Betacam) and their remarkably good picture quality (such as the S-VHS and Sony Hi8 camcorders). Regardless of the type of camera, all of them—analog and digital, large and small—start out with an analog video signal. The light that is transported through the lens to the beam splitter and from there to the imaging device remains analog throughout. Even after the translation of the three RGB light beams by the CCDs, the resulting video signals are still analog, but from there analog and digital part company.

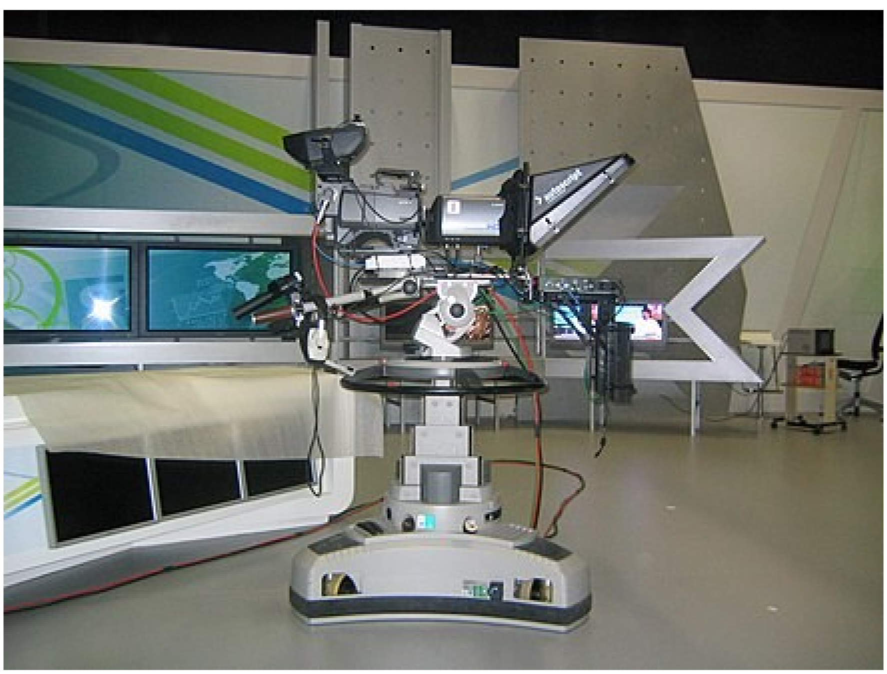
In the analog camera, the video signal remains analog throughout the processing inside the camera and during the recording, assuming that the VTR is also analog. In the digital camera, however, the analog RGB video signals are digitized and processed right after leaving the CCDs.

Although digital signals are much more robust than analog ones (that is, less prone to distortion), they are not automatically high-definition. Despite their superior picture quality, many digital cameras still operate on the traditional 480i (interlaced), 30-frames-per-second NTSC system and therefore are not considered high-definition. Sometimes you will hear the 480p system described as high definition, which is not surprising when looking at its high resolution pictures, but only the 720p and 1080i systems, or some variations thereof, are truly high-definition.

Despite the differences between analog and digital, standard or high-definition, high-end or low-end, television cameras fall into four groups: (1) studio cameras, (2) ENG/EFP cameras and camcorders, (3) consumer camcorders, and (4) prosumer camcorders. This classification is more useful because it is based on the primary production function of the camera, not on its electronic makeup. Some camera types are better suited for studio use, others for the coverage of a downtown fire or the production of a documentary on pollution, and still others for taking along on vacation to record the more memorable sights.

STUDIO CAMERAS

The term studio camera is generally used to describe high-quality cameras, including high-definition television (HDTV) cameras. They are so heavy they cannot be maneuvered properly without the aid of a pedestal or some other camera mount. Studio cameras are used for various studio productions, such as news, interviews, and panel shows, and for daily serial dramas, situation comedies, and instructional shows that require high-quality video. But you can also see these cameras used in such "field" locations as concert and convention halls, football and baseball stadiums, tennis courts, and medical facilities.



The obvious difference between the standard studio camera and ENG/EFP and consumer cameras is that studio cameras can function only as part of a camera chain; all other camera types can be self-contained, capable of delivering a video signal to a recording device, such as a VTR, without any other peripheral control equipment.

Because the picture quality of a studio camera is determined by the VO who is operating the CCU, there are relatively few buttons on studio cameras compared with ENG/EFP models.

ENG/EFP CAMERAS AND CAMCORDERS

As mentioned before, the cameras for electronic news EFP gathering (ENG) and electronic field production (EFP) are portable, which means that they are usually carried by a camera operator or put on a tripod. They are also self-contained and hold the entire camera chain in the camera head. With their built-in control equipment, ENG/EFP cameras and camcorders are designed to produce high quality pictures (video signals) that can be recorded on a separate VTR, on a small VTR or disk-recording device that is docked with the camera, or on a built-in VTR or disk recorder. As noted, when docked with a recording device, the camera forms a camcorder.

ENG/EFP camcorders operate on the same basic principle as the smaller consumer models except that the CCDs, the video-recording device, and especially the lens are of much higher quality. Most newer digital camcorders use either the Sony DVCAM or the Panasonic DVCPRO system and record on Vi-inch (6.35mm) videocassettes. In conforming to a tapeless production environment, an ever increasing number of camcorders use small hard drives or optical discs as the recording device.

The ENG/EFP camera has many more buttons and switches than does a studio camera or a home camcorder mainly because the video control (CCU) functions, the VTR operation, and the audio control functions must be managed by the camera operator. These can be preset using an electronic menu or by switching to automatic, similar to the auto-controls on a consumer camcorder. These automatic features make it possible to produce acceptable pictures even under drastically changing conditions without having to manually readjust the camera.

The picture quality of the high-end ENG/EFP camera is so good that it is frequently used as a studio camera. To make it operationally compatible with regular studio cameras, the ENG/EFP model is placed in a specially made camera frame; a large external tally light is added; the small (1 -inch) eyepiece viewfinder is replaced with a larger (5 or 7-inch) one; and zoom and focus controls that can be operated from the panning handles are added. The ENG/EFP lens, which offers a relatively wide-angle view, must be substituted with a zoom lens that is more suitable to the studio environment. Other important conversion factors include an intercom system for the camera operator and a cable connection to the CCU that enables the VO to control the camera from a remote position just like a standard studio camera.

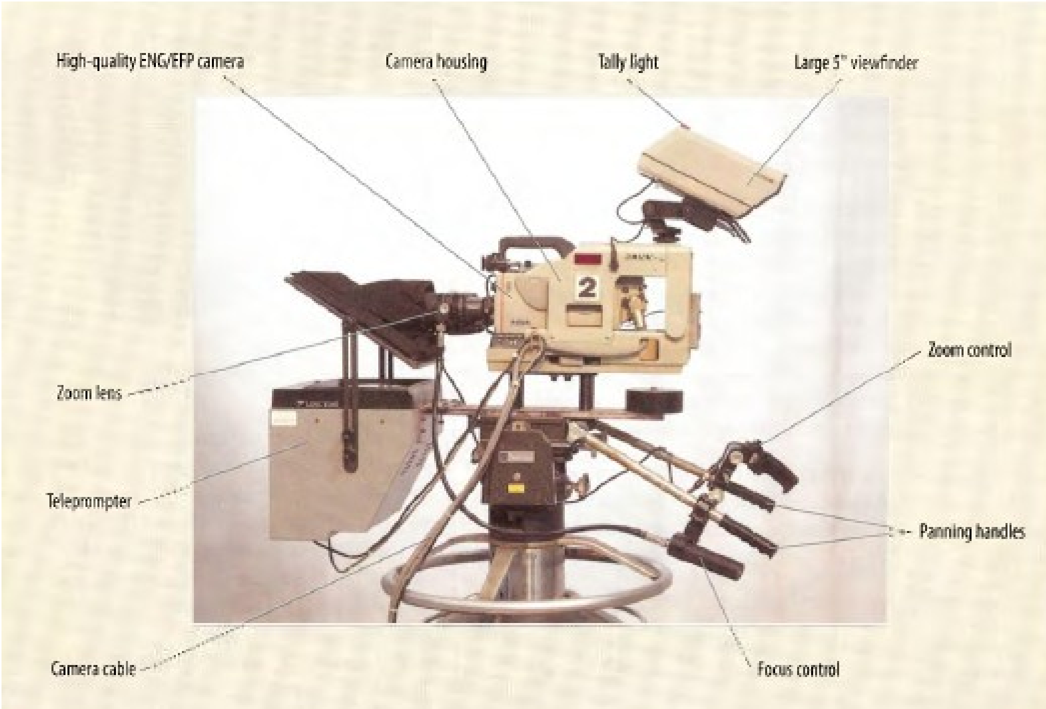


Fig.: ENG/EFP Camera in Studio Configuration

CONSUMER CAMCORDERS

Most consumer cameras have a single-chip imaging device and a built-in VTR. All have automated features, such as auto-focus, which focuses on what the camera presumes to be the target object, and auto-iris, which regulates the incoming light. In addition to the regular eyepiece viewfinder, most consumer camcorders have a fold-out screen on which you can see the picture you are taking without having to hold the camera close to your eye.

Even very small digital camcorders produce astonishingly good pictures and, if everything is done correctly, acceptable sound. The VTR of the consumer camcorder uses the digital video (DV) system, which records o n a very compact (V4-inch, or 6.35mm) mini tape cassette.

PROSUMER CAMCORDERS

Nevertheless, there are smaller camcorders on the market that incorporate many of the aforementioned features of professional camcorders. These high-end consumer models, called prosumer camcorders, are finding more and more acceptance in news and documentary productions.

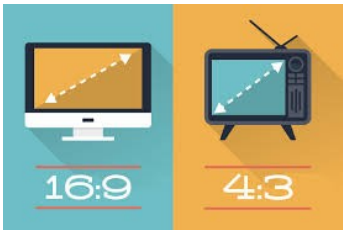
HDV camcorders: High-definition video (HDV) digital camcorders are the prosumer model for high-definition television. The HDV camcorder captures video with three fairly high-quality imaging devices. They can be the standard high-quality CCDs or high-resolution CMOS chips, which are similar to CCDs but draw less power. This is an important consideration when using a relatively small battery as the energy source. The HDV camcorder uses a high-definition VTR that records on V4-inch full-sized or mini-cassettes just like other digital video prosumer camcorders. And, like the HDTV camcorder, the HDV camcorders use the 720p/30 (720 progressively scanned lines at 30 frames per second) or the 1080i (1080 interlaced scanning lines at 30 frames per second) system.

ELECTRONIC CHARACTERISTICS

There are certain electronic characteristics common to all television cameras: (1) aspect ratio, (2) white balance, (3) resolution, (4) operating light level, (5) gain, (6) video noise and signal-to-noise ratio, (7) image blur and electronic shutter, (8) smear and moire, (9) contrast, and (10) shading.

ASPECT RATIO

Most digital cameras allow you to switch electronically between the standard 4 x 3 aspect ratio and the horizontally stretched HDTV aspect ratio of 16 x 9. This switchover occurs in the CCD imaging device. In low-end cameras such switchover inevitably reduces the image resolution, regardless of whether the transition is from 16 x 9 to 4 x 3 or from 4 x 3 to 16 x 9.

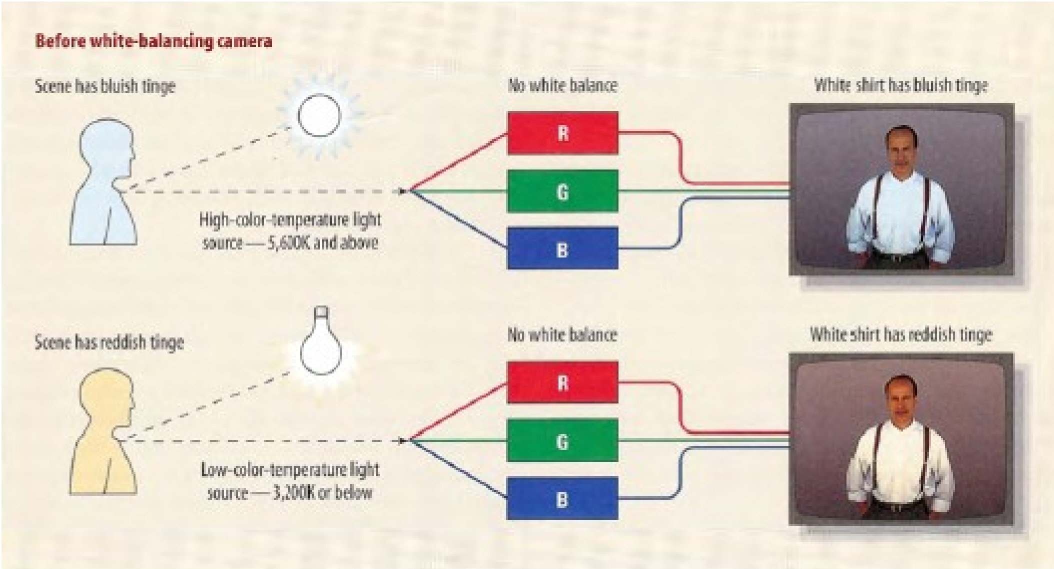


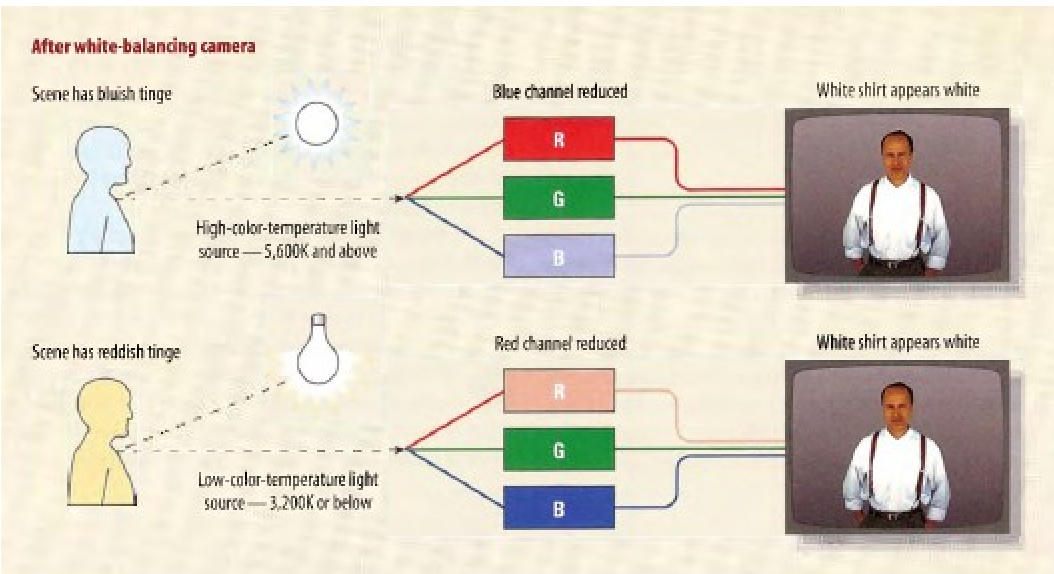
WHITE BALANCE

To guarantee that a white object looks white under slightly reddish (low Kelvin degrees) or bluish (high Kelvin degrees) light, you need to tell the camera to compensate for the reddish or bluish light and to pretend that it is dealing with perfectly white light. This compensation by the camera is called white balance. When a camera engages in white-balancing, it adjusts the RGB channels in such a way that the white object looks white on-screen regardless of whether it is illuminated by reddish or bluish light.

In the studio the white-balancing is usually done by the VO, who adjusts the RGB channels at the CCU. When operating a studio camera, you will probably be asked by the VO to zoom in on a white card in the primary set area and remain on it until the white balance is accomplished.

All ENG/EFP cameras have semiautomatic white-balance controls, which mean that you need to point the camera at something white and press the white balance button. Instead of the VO, the electronic circuits in the camera will do the adjusting of the RGB channels to make the object look white under the current lighting conditions.





RESOLUTION

Resolution refers to measuring detail in t h e picture and is the major factor that distinguishes standard television from HDTV pictures. Resolution is measured by numbers of pixels per screen area, much like in print, where resolution is often measured in dpi, which means dots (pixels) per inch.

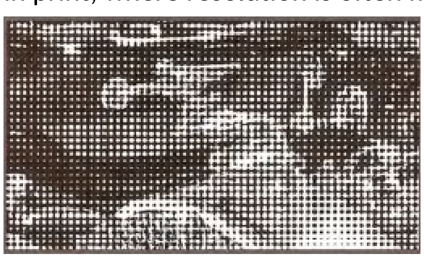


Fig.: Low Resolution Image

Fig.: High Resolution Image

The quality of a television camera is determined primarily by the degree of resolution of the video it produces. High-quality cameras produce high-resolution pictures; lower-quality cameras produce lower-resolution pictures. The picture resolution a camera can deliver depends on various factors: (1) the quality of the lens, (2) the number of pixels, (3) the number of scanning lines and the scanning system, and (4) the general signal processing.

i. Quality of lens

The camera's electronic system is ultimately at the mercy of what the lens delivers. If the lens does not produce a high-resolution image, the rest of the camera functions will have a hard time producing a higher-resolution picture. Sometimes the signal processing can improve on picture resolution, but the average camera must work with the picture the lens produces.

ii. Number of pixels

Even if you have a high-quality lens, it is primarily the number of pixels in the camera's imaging device that determines the image resolution. CCDs are usually measured by total number of pixels. The CCDs in a good digital camera may have a half million or more pixels each, and those in a high-definition camera may have several million (megapixels). The resolution of a video image can also be measured by how many pixels (dots) are used to make up a scanning line.

iii. Number of scanning lines

The picture resolution that a television camera or video monitor can deliver can be measured not only by the number of pixels but also by the number of lines that compose the image. In effect, resolution is measured by the way the lines are stacked. Standard NTSC television has a vertical stack of 525 lines, of which 480 are visible. In HDTV the 1,080 active scanning lines increase the vertical resolution because the vertical stack comprises more than twice the number of lines.

The scanning system also has a say in how sharp we perceive a picture to be. Generally, progressive scanning, such as in a 480p system, produces sharper pictures than a 480i image. The progressive scanning system produces twice as many frames per second (60) than does the interlaced scanning system (30 fps). Hence with progressive scanning you perceive twice the picture information each second.

iv. Signal processing

Once the CCD has changed the light image into electrical video signals, these digitized signals can be manipulated considerably. This manipulation in digital cameras can enhance and even improve on the resolution. Most digital cameras use image enhancers. In this signal manipulation, the electronic circuits are designed to sharpen the contour of the picture information, but they do not increase the number of pixels. You will not see more picture detail but rather a sharper demarcation between one picture area and the next. Human perception translates this outline into a higher resolution and hence a sharper, higher-definition picture.

OPERATING LIGHT LEVEL

The camera obviously needs light to produce a video signal. But just how much light is required to produce an adequate signal? The answer depends again on a variety of interacting factors, such as the light sensitivity of the imaging device and how much light the lens transmits.

The operating light level, also called baselight level, is the amount of light needed by the camera to produce acceptable pictures ("acceptable" meaning a video image that is relatively free of color distortion and electronic noise, which shows up as black-and-white or colored dots in the dark picture areas). When looking at technical camera specifications, you may come across two terms that refer to operating light levels. Minimum illumination means that you get some kind of picture under very low light levels. These images are just one cut above the greenish, ghostlike pictures you get when switching your camcorder to the nightshot mode. The other operating light level specification is sensitivity, which describes the amount of light necessary to produce acceptable, if not optimal, pictures with good detail and color fidelity.

GAIN

A video camera can produce pictures in extremely low light levels because it can boost the video signal electronically—a feature called gain. In effect, the electronic gain is fooling the camera into believing that it has adequate light.

In studio cameras the gain is adjusted through the CCU. In ENG/EFP cameras gain is manipulated by the gain control switch. In a consumer camcorder, you can use the gain switch or you can change to automatic gain. When operating an ENG/EFP camera, you can move the gain control switch to one of several boosting positions— marked by units of dB (decibels), such as a +6, +12, +18, or even +24 dB gain—to compensate for low light levels. When it is really dark and you can't worry about picture quality, you can switch to a hypergain position, which makes the camera "see".

The higher the gain, the more the picture suffers from excessive video noise and color distortion—called artifacts. Nevertheless, because of improved low-noise CCDs, more and more ENG/EFP cameras follow the consumer camcorder's lead, enabling you to switch between the manual and the automatic gain controls. The advantage of an automatic gain control is that you can move from bright outdoor light to a dark interior or vice versa without having to activate the gain. Such a feature is especially welcome when covering a news story that involves people walking from a sunlit street into a dark hotel lobby or a dark corridor. The problem with automatic gain is obvious when focusing, for example, on a person in a dark suit standing in front of a fairly bright background: the automatic gain will not lighten up the dark suit but will reduce the brightness of the background. Thus, the dark suit will appear to be darker than before. When this happens you will have to switch back to manual gain so that you can adjust the gain for an optimal exposure.

VIDEO NOISE AND SIGNAL-TO-NOISE RATIO

The term noise is borrowed from the audio field and applied to unwanted interference in video. You can recognize "noisy" pictures quite readily by the amount of "snow"—white or colored vibrating spots or color-distorting artifacts—that appears throughout an image, causing it to be less crisp.

Technically, video noise works very much like audio noise. If the picture signal is strong (mainly because the imaging device receives adequate light), it will cover up the snow. This relationship between signal and noise is appropriately enough called signal-to-noise (S/N) ratio. It means that the signal is high (strong picture information) relative to the noise (picture interference) under normal operating conditions. A high number, such as 62 dB, is desirable.

IMAGE BLUR AND ELECTRONIC SHUTTER

One of the negative aspects of the CCD imaging device is that it tends to produce blur in pictures of fast-moving objects, very much like photos taken with a regular still camera at a slow shutter speed. For example, if a yellow tennis ball moves from camera-left to camera-right at high speed, the ball does not appear sharp and clear throughout its travel across the screen—it looks blurred and even leaves a trail. To avoid this blur and get a sharp image of a fast-moving object, CCD cameras are equipped with an electronic shutter.

Like the mechanical shutter on the still camera, the electronic shutter controls the amount of time that light is received by the chip. The slower the shutter speed, the longer the pixels of the CCD imaging surface are charged with the light of the traveling ball and the more the ball will blur. The higher the shutter speed, the less time the pixels are charged with the light of the moving ball, thus greatly reducing or eliminating the blur. But because the increased shutter speed reduces the light received by the CCD, the yellow ball will look considerably darker than without electronic shutter. As with a regular still camera, the faster the shutter speed, the more light the camera requires. Most professional CCD cameras (studio or ENG/EFP) have shutter speeds that range from 1/60 to 1/2000 second. Some digital camcorders can go to 1/4000 second or even higher. Fortunately, most high-action events that require high shutter speeds occur in plenty of outdoor or indoor light.

SMEAR AND MOIRE

Both smear and moiré are specific forms of video noise. On occasion, extremely bright highlights or certain colors (especially bright reds) cause smears in the camera picture. Smears show up adjacent to highlights as dim bands that weave from the top of the picture to the bottom. The highly saturated color of a red dress may bleed into the background scenery, or the red lipstick color may extend beyond the mouth. Digital cameras with high-quality CCDs are practically smear-free.

Moiré interference shows up in the picture as vibrating patterns of rainbow colors. You can see the moiré effect on a television screen when the camera shoots very narrow and highly contrasting patterns, such as the herringbone weave on a jacket. The rapid change of light and dark occurs at a frequency the camera uses for its color information, so it looks for the color that isn't there. It cycles through the entire color palette, causing the moving color patterns. Although the more expensive studio monitors have moiré compression circuits built-in, the ordinary television set does not.

CONTRAST

The range of contrast between the brightest and the darkest picture areas that the video camera can accurately reproduce is limited. That limit, called contrast range, is expressed as a ratio. Even the better cameras have trouble handling high contrast in actual shooting conditions. You will run into this problem every time you videotape a scene in bright sunlight. When you adjust the camera for the extremely bright sunlit areas, the shadow becomes uniformly dark and dense. When you then adjust the lens (open its iris), you will promptly overexpose—or, in video lingo, "blow out"—the bright areas. It is best to limit the contrast and stay within a contrast ratio of about 50:1, meaning that for optimal pictures the brightest picture area can be only fifty times brighter than the darkest area. Digital cameras with high-quality CCDs can tolerate higher contrast ratios.

SHADING

By watching a waveform monitor, which graphically displays the white and black levels of a picture, the video operator adjusts the picture to the optimal contrast range, an activity generally called shading. To adjust a less-than-ideal picture, the VO tries to "pull down" the excessively bright values to make them match the established white level (which represents a 100 percent video signal strength). But because the darkest value cannot get any blacker and move down with the bright areas, the darker picture areas are "crushed" into a uniformly muddy, noisy dark color. If you insist on seeing detail in the dark picture areas, the video operator can "stretch the blacks" toward the white end, but, in all but the top-of-the-line cameras, that causes the bright areas to lose their definition and take on a uniformly white and strangely flat and washed-out color. In effect, the pictures look as though the contrast is set much too low with the brightness turned too high. Again, before the VO can produce optimal pictures through shading, you must try to reduce the contrast to tolerable limits.

OPERATIONAL ITEMS AND CONTROLS:

STUDIO CAMERAS

This section focuses on the major operational items and controls of studio cameras: (1) power supply, (2) camera cable, (3) connectors, (4) filter wheel, (5) viewfinder, (6) tally light, and (7) intercom.

i. Power supply

All studio cameras receive their power from a DC power supply, which is part of the camera chain.
The power is supplied through the camera cable.

ii. Camera cables

Camera cables differ significantly in how they carry the various electronic signals to and from the camera.

iii. Connectors

When in the studio, the camera cable is generally left plugged into the camera and the camera wall jack (outlet). When using studio cameras in the field, however, you need to carefully check whether the cable connectors fit the jacks of the remote truck.

iv. Filter wheel

The filter wheel is located between the lens and the beam splitter. It normally holds two neutral density filters (NDs), referred to as ND-1 and ND-2, and some color-correction filters. The NDs reduce the amount of light transmitted to the imaging device without affecting the color of the scene. You use them when shooting in bright sunlight. The color-correction filters compensate for the relative bluishness of outdoor and fluorescent light and the relative reddishness of indoor and candlelight. In some studio cameras, these filters can be operated from the CCU. In most others you can rotate the desired filter into position, usually with a small thumb wheel or with a switch that activates the filter wheel.

v. Viewfinder

The viewfinder is a small television set that shows the picture the camera is getting. Studio cameras usually have a 5- or 7-inch viewfinder that can be rotated and tilted so you can see what you are doing even when you're not standing directly behind the camera. Most viewfinders are monochrome, which means you see only a black-and-white picture of the scene you are shooting. Even HDTV cameras are not always equipped with a color viewfinder. The reason for using monochrome viewfinders is that the luminance (black-and-white) signal produces a higher-resolution image than the color channels. This feature is especially important for HDTV cameras, whose high-definition pictures are always difficult to focus.

Besides displaying the sometimes extensive electronic control menu, the camera viewfinder also acts as a small information center, indicating the following items and conditions:

- Center marker. This shows the exact center of the screen.
- Safe title area. A rectangle in the viewfinder within which you should keep all essential picture information.
- Electronic setup. This includes a variety of control functions, such as electronic gain, optimal video levels, electronic shutter, and so forth.
- Lens extenders. These are magnifying devices that extend the telephoto power of a lens.
- Multiple views. The viewfinder of studio cameras allows you to see the pictures other studio cameras are taking as well as special effects. Viewing the picture of another camera helps you frame your shot so that it will complement the shot of the other camera and avoid meaningless duplication. When special effects are intended, the viewfinder displays the partial effect so that you can place your portion of the effect in the exact location within the overall screen area.

vi. Tally light

The tally light is the red light on top of a studio camera that signals which of the two or more cameras is "hot," that is, on the air. The light indicates that the other cameras are free to line up their next shots. It also helps the talent address the correct camera. There is also a small tally light inside the viewfinder hood that informs the camera operator when the camera is hot. When two cameras are used simultaneously, such as for a split-screen effect or a superimposition, the tally lights of both cameras are on. When operating a studio camera, wait until your tally light is off before repositioning the camera. Consumer cameras usually do not have a tally light. When using prosumer camcorders for a multicamera production, you need to rig a tally light system that is activated by the switcher in the program control section.

vii. Intercom

The intercom, or intercommunication system, is especially important for multicamera productions because the director and the technical director have to coordinate the cameras' operations. All studio cameras and several high-end field cameras have at least two channels for intercommunication—one for the production crew and the other for the technical crew. Some studio cameras have a third channel that carries the program sound.

When ENG/EFP cameras are converted to the studio configuration, intercom adapters are an essential part of the conversion. As the camera operator, you can listen to the instructions of the director, producer, and technical director and talk to them as well as to t h e VO. When using ENG/EFP cameras in isolated (iso) positions, or prosumer cameras in a multicamera configuration, you need to provide for an intercom system. Sometimes it is easier to use walkie-talkies, which let you listen to the sound via small earphones, than to string cables for intercom headsets.

OPERATIONAL ITEMS: ENG/EFP CAMERAS AND CAMCORDERS

Although the operational features of ENG/EFP cameras are similar to those of studio cameras, they differ considerably in design and function. This section explains the operational items of field cameras and their functions: (1) power supply, (2) camera cable, (3) connectors, (4) interchangeable lenses, (5) filter wheel, and (6) viewfinder.

i. Power supply

Most professional camcorders are powered by a 13-volt (13.2 V) or 14-volt (14.4 V) battery that is clipped on, or inserted in, the back of the camera. Consumer camcorders have lower-voltage batteries that are also clipped on the back of the camera-VTR unit. Depending on the power consumption of the camera or camcorder, most batteries can supply continuous power for up to two hours before they need recharging.

ii. Camera cable

When using an ENG/EFP camera rather than a camcorder, you may need to connect the camera to a videotape recorder or a remote control unit. Even a camcorder needs cables when connecting it to external equipment, such as monitor feeds, audio recorders, and so forth.

iii. Connectors

Before going to the field location, carefully check that the connectors on the various cables actually fit in to the camera jacks (receptacles) and the jacks of the auxiliary equipment. Cables are available that come with a different connector on each end to avoid the need for adapters.

iv. Interchangeable lenses

Some high-end consumer models allow you to exchange the standard zoom lens with a wide-angle one, but in most cases you can do so only with an adapter. Most professional ENG/EFP cameras let you attach the zoom lens that provides the necessary wide-angle view and a good zoom range.

v. Filter wheel

Much like studio cameras, field cameras and camcorders have a filter wheel that contains at least two ND and a variety of color-correction filters. You can rotate the desired filter into position by activating a filter switch on the side of t h e camera or by selecting the appropriate filter position on the menu. The switch is sometimes labeled "color temperature."

vi. Viewfinder

Unless converted to the studio configuration, all ENG/EFP cameras and camcorders have a 1 and half inch high-resolution monochrome viewfinder. It is shielded from outside reflections by a flexible rubber eyepiece that you can adjust to your eye. You can swivel the viewfinder in several directions—an important feature when the camera cannot be operated from the customary shoulder position.

Most small ENG/EFP cameras and consumer camcorders have an additional foldout screen whose color image consists of a liquid crystal display (LCD) similar to that of a laptop computer. Most consumer and prosumer cameras display the electronic control menu on the foldout screen.

The viewfinder also acts as an important communications system, showing the status of camera settings when the camera is in operation. Although the actual display modes vary from model to model, most studio and field camera viewfinders include the following indicators:

- VTR record. This indicates whether the videotape in the VTR is rolling and recording. This indicator is usually a steady or flashing red light, or letters such as REC keyed over the scene. When you use the foldout screen on a camcorder, it will display the same information but will deactivate the regular viewfinder.
- End-of-tape warning. The viewfinder may display a message of how much tape time remains.
- White balance. The white balance adjusts the colors to the relative reddishness or bluishness of the white light in which the camera is shooting so that a white card looks white when seen on a well-adjusted monitor. Color temperature controls are part of the white-balance adjustment.
- Battery status. This indicator shows the remaining charge or a small icon, such as a crossed-out battery or one that shows the "juice" level. Such warnings come only before the battery has lost its useful charge.
- Maximum and minimum light levels. The zebra pattern can be set for a particular maximum light level. When this level is exceeded, the pattern begins to flash or vibrate.
- Gain. In low-light conditions, the viewfinder indicates whether the gain is active and at what level it is set.
- Optical filter positions. The display tells you which specific filter is in place.
- Playback. The viewfinder or foldout screen can serve as a monitor when playing back from the camcorder's VTR the scenes you have just recorded. This playback feature allows you to immediately check whether the recording turned out all right technically as well as aesthetically.

EXTERNAL OPERATIONAL CONTROLS: ENG/EFP CAMERAS AN D CAMCORDERS

Although the specific operational controls differ from one camcorder to another, you will find the following external switches on almost all camcorders.

- The power switch obviously turns the camera on and off. On a camcorder it turns on the whole system, including the camera and the VCR.

- The standby switch keeps the camera turned on at reduced power, therefore lessening the drain on the battery while keeping the camera ready to perform almost instantly.
- The gain control keeps the camera operational in low light levels.
- The white-balance indicator shows whether the camera is adjusted to the particular tint of the light (reddish or bluish) in which you are shooting.
- The filter wheel enables you to select the appropriate color filter to facilitate a white balance or a neutral density filter to cut down excessive light.
- The VTR switch starts and stops the built-in or docked VTR or the one connected to the camera by cable.
- The shutter speed control lets you select the specific shutter speed necessary to avoid a blurred image of a rapidly moving object.
- The camera/bars selection switch lets you choose between the video (pictures the camera sees) and the color bars that serve as reference for the color monitors or the playback of the recording.
- The audio level control helps you adjust the volume of the connected audio sources.
- Sound volume and audio monitor controls let you set an optimal volume for monitoring incoming audio sources.
- VTR controls help you load and eject the videocassette and put the camcorder in the record mode.
- Various jacks enable you to connect camera, audio, intercom, and genlock cables, as well as the RCU and the setup equipment.