

SONY®

The Basics of Camera Technology



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Marketing Communication Group
Product Information Department
Business Planning Division
B&P Company
Sony Corporation

Preface

With the development of technologies and endeavors to reduce production costs, various advanced functions, originally available only on high-end video cameras, have been introduced to a wider range of professional video cameras, designed to target larger markets with their versatility. Thus, it has become imperative for those involved in the marketing and sales activities of such video cameras to understand these functions, as well as become familiar with the meanings of the related terminology.

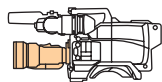
Having considered this background, we have created "The Basics of Camera Technology" a useful document that provides comprehensive explanations of all the camera terminologies we consider to be significant.

These terms have been carefully selected and placed into five categories: Optical System, CCD Mechanism, Camera Functions, VTRs, and Others. This allows readers to quickly find relevant information according to the terminology in question.

We hope this document will be helpful in your business.

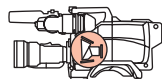
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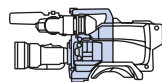
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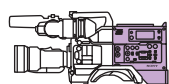


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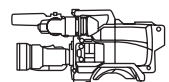
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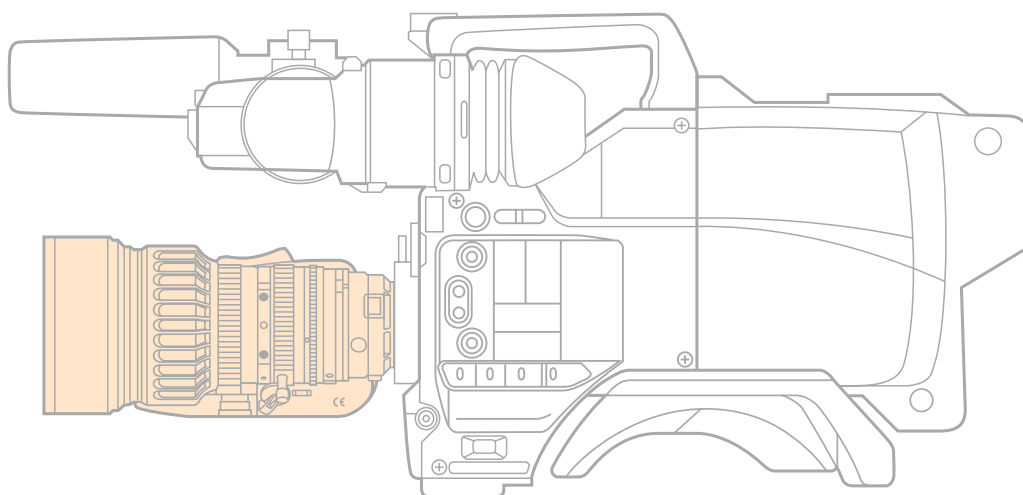
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The Basics of Camera Technology

Optical System



Angle of View

When shooting a landscape with a camera, as in figure A, there is a certain range that will be displayed on a picture monitor. Angle of view indicates the displayable range of the image (plane) measured by the angle from the center of the lens to the width of the image in the horizontal, vertical, and diagonal directions. These are called, the horizontal angle of view, vertical angle of view, and diagonal angle of view, respectively.

Angle of view becomes narrow when a telephoto lens is used. On the other hand, angle of view becomes wider with a wide-angle (that is why it is called "wide-angle"). Consequently, the wider the angle of view is, the wider the displayable range becomes.

The angle of view depends on image size, so lenses intended for 2/3-inch and 1/2-inch CCD cameras have different focal lengths.

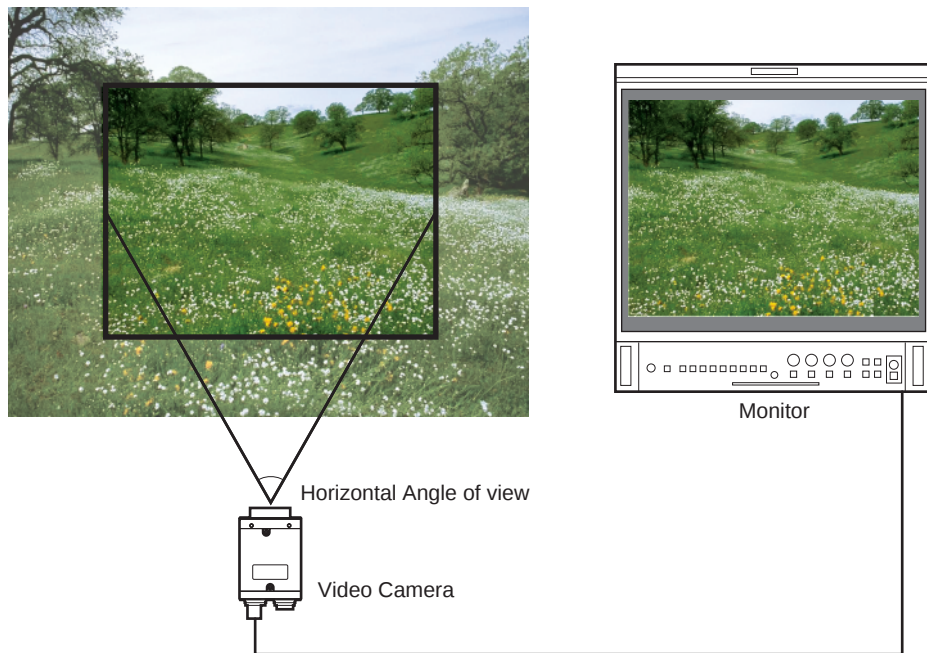


Figure A

Angle of view can be derived from the following equation.

$$w = 2 \tan^{-1} y / 2f$$

w: Angle of view

y: Image size (width of the image in horizontal, vertical, or diagonal direction.)

f: Focal length

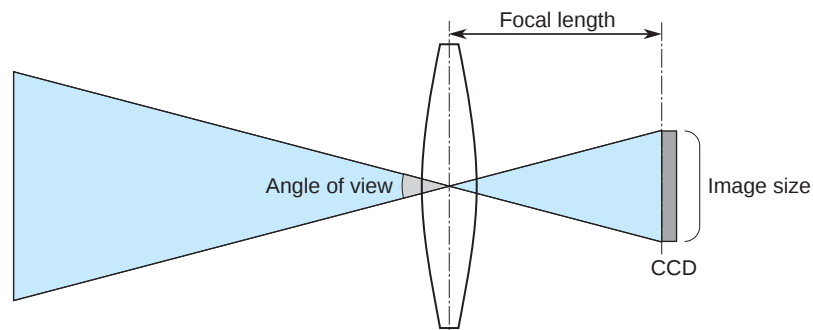


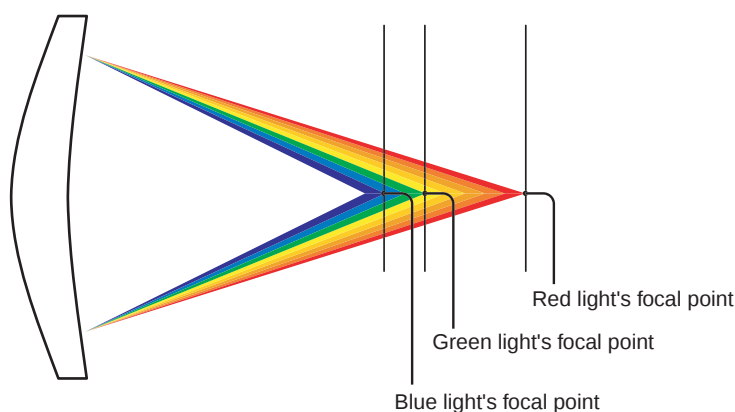
Figure B

Chromatic Aberration

When light passes through glass, the path it follows is 'refracted' or gets bent. The amount of refraction depends on the light's wavelength, which determines its color. This also holds true for lenses used in a video camera lens. The difference in refraction from color to color directly results in each color light (in a color camera RGB) forming focus on a different image plane. For example, if one color is in focus on the CCD imager, the other colors will be slightly out of focus and look less sharp. This phenomenon is more notice-

able in lenses with longer focal lengths, and results in deterioration of the edges of the image.

Recent technology has made it possible to effectively reduce chromatic aberration of a video camera lens. This is achieved by combining a series of converging and diverging lenses with different refraction characteristics to compensate for the aberration. The use of crystalline substances such as fluorite has been practiced to offset the aberration and accordingly the locus of the image reproduced.

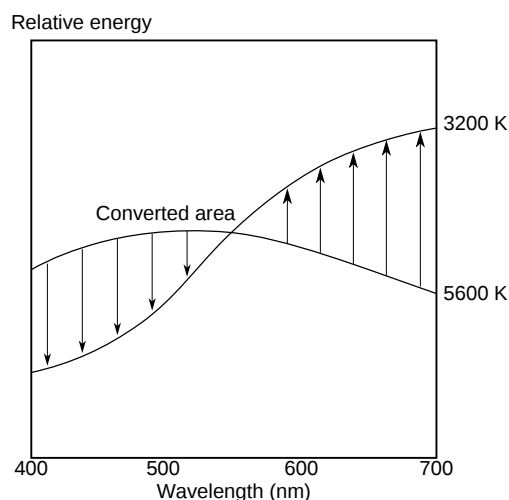


Color Conversion Filters

All color cameras are designed to operate at a certain color temperature. For example, Sony professional video cameras are designed to be color balanced at 3200 K (white balance: *refer to "White Balance"*). This is the color temperature for indoor shooting when using common halogen lamps. However, the camera must also provide the ability to shoot under color temperatures other than 3200 K. For this reason, a number of selectable color conversion filters are placed before the prism (*refer to "Prism"*) system. These filters optically convert the spectrum distribution of the ambient color temperature (illuminant) to that of 3200 K, the camera's operating temperature. For example, when shooting under an illuminant of 5600 K, a 5600 K color conversion filter is used to convert the incoming light's spectrum distribution to that of approximately 3200 K.

Your question now may be, "why do we need color conversion filters if we can correct the change of color temperature electrically (white balance)?". The answer is quite simple. White balance (*refer to "White Balance"*) electrically adjusts the amplitudes of the red (R) and blue (B) signals to be equally balanced to the green (G) by use of video amplifiers. We must keep in mind that using electrical amplification will result in degradation of signal-to-noise ratio. Although it may

be possible to balance the camera for all color temperatures using the R/G/B amplifier gains, this is not practical from a signal-to-noise ratio point of view, especially when large gain up (*refer to "Gain"*) is required. The color conversion filters reduce the gain adjustments required to achieve correct white balance.



Color Temperature

The color reproduced by a camera largely depends on the color of the light source (or the illuminant) under which the camera is used. This is sometimes difficult to understand because the human eye is adaptive to changes in the light source's color and the color of an object will always look the same under any light source: sunlight, halogen lamps, candlelight etc.

The color of light source is defined by using heated carbon (black body absorbing all radiation without transmission and reflection) as a reference. When heating a piece of carbon, it will start glowing and emitting light when it reaches a certain absolute temperature (expressed in Kelvin or (K)). The spectral distribution of the light emitted from the light source is determined by its corresponding absolute temperature, known as color temperature.

Since, cameras cannot adapt automatically to the color temperature of the light source, it is essential to select the appropriate color conversion filter (*refer to "Color Conversion Filters"*) for the shooting environment in order to obtain accurate color reproduction. The combination of electronic White Balance (*refer to "White Balance"*) with appropriate color conversion filter selection will create more accurate color reproduction.

Light Source	Color Temperature (approx.)
Skylight	12000 K - 18000 K
Noon Sunlight	4900 K - 5800 K
Sunrise and Sunset	3000 K
12 V/100 W Halogen Lamp	3200 K
Candlelight	2900 K

Depth of Field

When focusing a lens on an object, there is a certain distance range in front of and behind the object that also comes into focus.

Depth of field indicates the distance between the closest and furthest object that are in focus. When this distance is long, the depth of field is "deep" and when short, the depth of field is "shallow". Needless to say, any object outside the depth of field (range) will be out of focus and look blurred.

Depth of field is governed by the three following factors:

- 1)The larger the iris F-number (*refer to "F-number"*) (stopping down the amount of incident light), the deeper the depth of field.
- 2)The shorter the focal length of the lens, the deeper the depth of field.
- 3)The further the distance between the camera and the subject, the deeper the depth of field.

Thus depth of field can be controlled by changing these factors, allowing the camera operator creative shooting techniques.



Deep depth of field



Shallow depth of field

Flange-Back/Back Focal Length

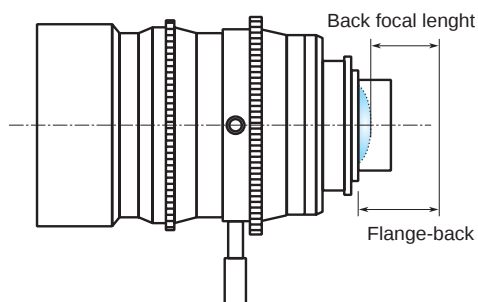
Flange-back is one of the most important matters to consider when choosing a lens. Flange-back describes the distance from the camera's lens-mount reference plane (ring surface or flange) to the image plane (such as CCDs) as shown in the figure below. It is necessary to select a lens with the appropriate flange-back for the given camera. Flange-back is measured differently depending on whether the camera uses glass materials in its light path (like a prism: *refer to "Prism"*) or not. 3-CCD cameras use this system to separate incoming light into their three primary color components, which are then captured by each associated CCD. Single CCD cam-

eras, on the other hand, do not require this system. In a 3-CCD camera, the flange-back additionally includes the distance that the light travels through its prism (the distance the light travels in the glass material, converted to the equivalent distance in air, plus the rest of the distance between the lens mount and CCD surface).

In today's camera systems, flange-back is determined by the lens-mount system that the camera uses. 3-CCD cameras use the bayonet mount system, while single CCD cameras use either the C-mount or CS-mount system. The flange-back of the C-mount and CS-mount systems are standard-

ized as 17.526 mm and 12.5 mm respectively. There are three flange-back standards for the bayonet mount system, 35.74 mm, 38.00 mm, and 48.00 mm.

Similar to flange-back is back focal length, which describes the distance from the very end of the lens (the end of the cylinder that fits into the camera mount opening) to the image plane. The back focal length of the camera is slightly shorter than its flange-back.



Flare

Flare is a phenomenon that is likely to occur when strong light passes through the camera lens. Flare is caused by numerous diffused reflections of the incoming light inside the lens. This results in the black level of each red, green and blue channel being raised, and/or inaccurate color balance between the three channels. On a video monitor, flare

causes the picture to appear as a misty image, sometimes with a color shade.

In order to minimize the effects of flare, professional video cameras are provided with a flare adjustment function, which optimizes the pedestal level and corrects the balance between the three channels electronically.

F-number

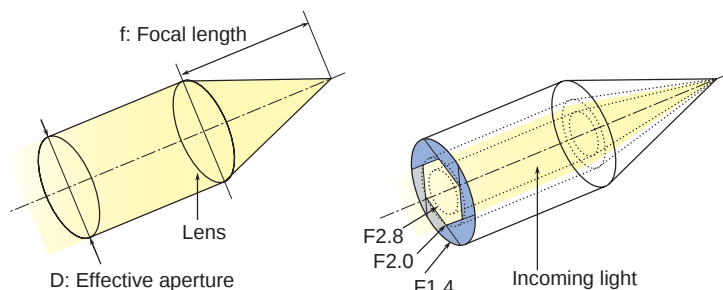
The maximum aperture of a lens indicates the amount of light that can be gathered by the lens and directed to the camera imager. A larger physical diameter lens will receive light over a wider area, and therefore is more efficient. The aperture is expressed as an F-number (or F-stop), where the numerical value of the F-number (F) is mathematically calculated by dividing the focal length (*refer to "Focal Length"*) (f) by the effective aperture of the lens (D), as below:

$$F = f/D$$

This reciprocal relationship means that the smaller the F-number, the "faster" the lens, and the higher the sensitivity it will provide on a camera. The maximum aperture F-number is labeled on the front of the lens, and is an important distinguishing factor when comparing lenses. In lenses used with TV cameras, a mechanism is required to reduce the sensitivity of the lens and camera, and this is achieved by a variable

diaphragm within the lens (*refer to "Iris"*). The lens iris ring is also calibrated in F-stops. These calibrations increase by a factor of $\sqrt{2}$, so lenses normally carry calibrations of 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, and 22. Since the amount of incoming light is proportional to the cross-sectional area, the brightness of an image is in inverse proportion to the second power of the F-number. Simply put, as the value of the F-number increases by one stop, the brightness will decrease to one half.

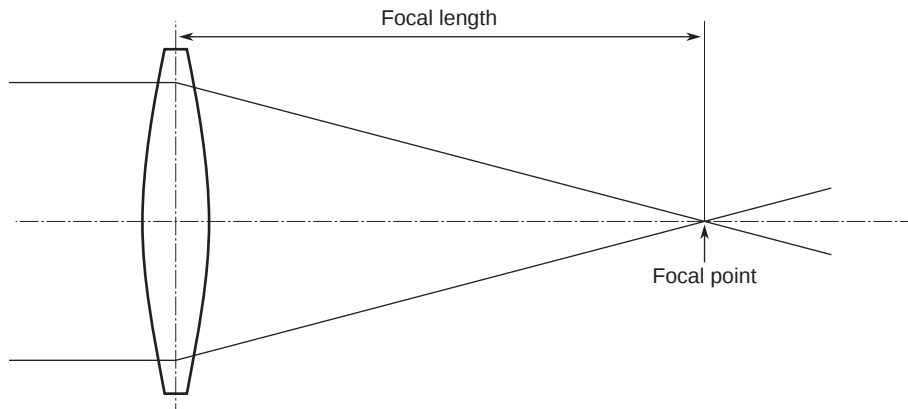
It is important to know that the F-number or F-stop is a key factor that affects the depth of field of the scene shot by the camera (*refer to "Depth of Field"*). The smaller the F-number or F-stop becomes, the shallower the depth of field will become, and vice versa.



Focal Length

Focal length describes the distance between the lens and the point where the light that passes through it converges on the optical axis. This point is where the lens is in focus and is called the focal point. To capture a focused image on a CCD imager, the focal point must coincide with the CCD imager plane by controlling the focus of the lens.

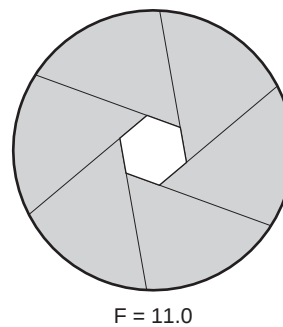
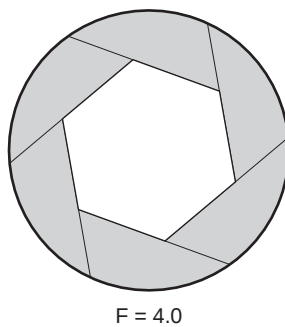
Video camera lenses usually consist of a series of individual lenses for zooming and aberration-compensation purposes (refer to “*Chromatic Aberration*”), and thus have a virtual focal point called the principal point.



Iris

The amount of light taken into a camera and directed to its imager is adjusted by a combination of diaphragms integrated in the lens. This mechanism is called the lens iris and functions just like the pupil of the human eye. By opening

and closing these diaphragms, the diameter of the opening (also called aperture) changes, thus controlling the amount of light that passes through it. The amount of the iris opening is expressed by its F-number (refer to “*F-number*”).



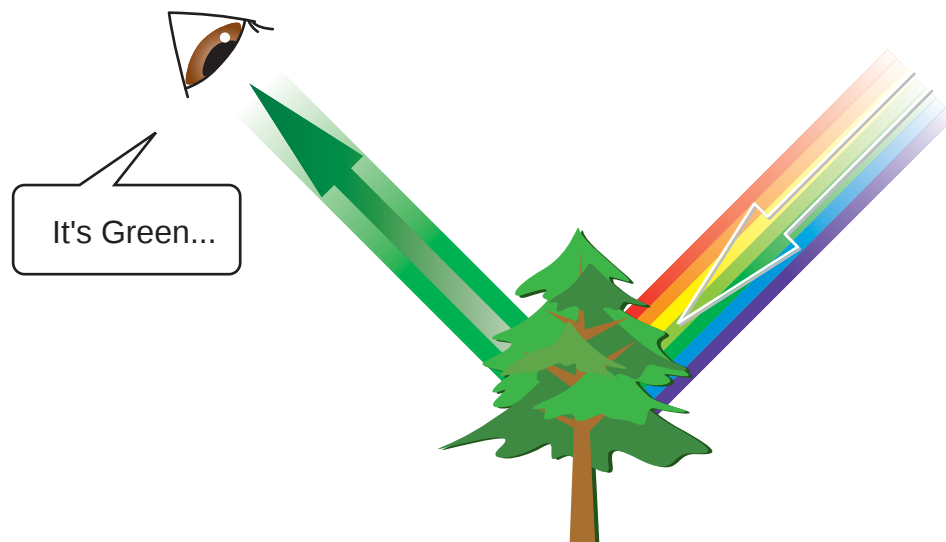
Light and Color

The human eye is sensitive to light. Or in other words, the retina of the human eye reacts to light when we view objects. Technically, light consists of various electromagnetic waves each with a different wavelength. The human eye is only sensitive to electromagnetic waves whose wavelengths fall between approximately 380 and 760 nanometers. This range of electromagnetic waves is called the visible spectrum, and indicates the range of light that the human eye can see. To the human eye, each wavelength is viewed as a different light color.

Light emitted from a typical light source (sunlight, fluorescence/halogen lamps) is a combination of a variety of different light colors, although the light source may seem to look

white (or transparent). This can be explained with a prism (refer to "Prism"), in which the light that passes through it is separated into its individual light components - typically, the colors of the rainbow.

Coming back to our main subject, the reason we see each object with a different color is because each object has different light-reflection/absorption characteristics. For example, a piece of white paper reflects almost all light colors and thus looks white. Similarly, a pure blue object only reflects the blue light (spectrum) and absorbs all other light colors. The light colors that each object reflects are governed by the characteristics of the surface of the objects.



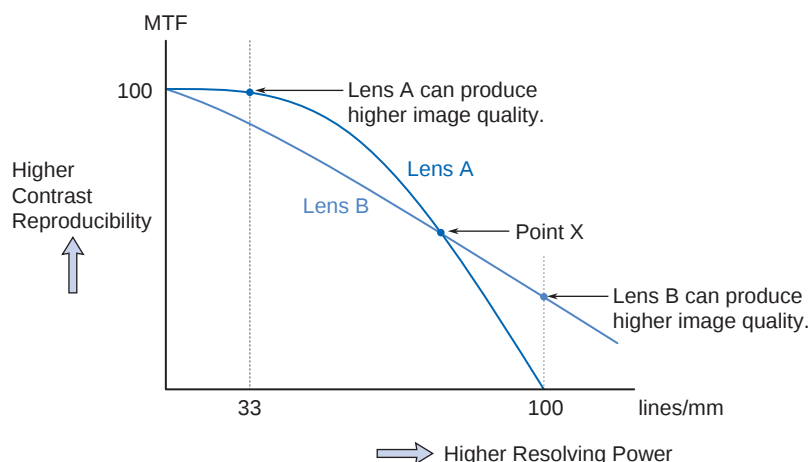
Only a green spectrum is reflected on the leaves.
Other colors are absorbed.

MTF (Modulation Transfer Function)

Modulation Transfer Function (MTF) is an important index that indicates a lens's capability of reproducing the contrast of picture details. MTF is measured as the lens's contrast reproducibility, which is the capability of resolving the fine black and white vertical lines on a resolution chart. Since lenses are typically less sensitive to higher spatial frequencies (narrower black and white lines), the contrast reproducibility attenuates as the frequency increases. The MTF curve indicates this change, shown below as a graph with the spatial frequency on the horizontal axis and contrast reproducibility on the vertical axis. Note that the MTF value changes until it reaches a point where the lines can no longer be resolved. This point indicates the final resolving power of the lens, or the narrowest black and white lines that can be resolved. Needless to say, the higher the value of contrast reproducibility, the more faithfully contrast is reproduced at the given spatial frequency. This means that lenses with higher MTF values at each frequency reproduce contrast bet-

ter. When choosing a television lens, it is equally important to inspect the characteristic of the MTF at the low to mid frequencies in addition to the lens's final resolving power. This is because the low to mid frequency areas of a lens usually represent the main frequency areas used in the NTSC or PAL video signal (*refer to "NTSC/PAL"*). It is essential to have a high response (close to 100%) in this area, otherwise the video picture will not be reproduced with sharp contrast. The figure below shows an example. Lens B is capable of resolving the image at higher spatial frequencies (detailed areas of the image) and may often be misevaluated to having more resolving power than Lens A. However, up to point X, Lens A has the higher resolving power, which can be of more importance in most camera applications.

When choosing a lens, both its MTF curve and final resolving power must be considered with care depending on the application.



Neutral Density (ND) Filters

When shooting outdoors, the camera is often subjected to extreme highlights. In some cases, these highlights cannot be handled even with the smallest iris opening of the lens. For this reason a few types of selectable ND filters are placed before the prism (*refer to "Prism"*) system with the color conversion filters (*refer to "Color Conversion Filters"*). These ND filters attenuate the magnitude of incoming light to allow brighter images to be handled. The use of ND filters does

not affect the color temperature (*refer to "Color Temperature"*) of the incoming light since attenuation is uniform over the entire spectrum. ND filters may also be used to intentionally select a wider iris (*refer to "Iris"*) opening. As the depth of field (*refer to "Depth of Field"*) is in reverse proportion with the iris aperture (opening), the camera operator can intentionally defocus objects in front of and behind the object that is being shot using the appropriate ND filter.

Optical Low Pass Filter

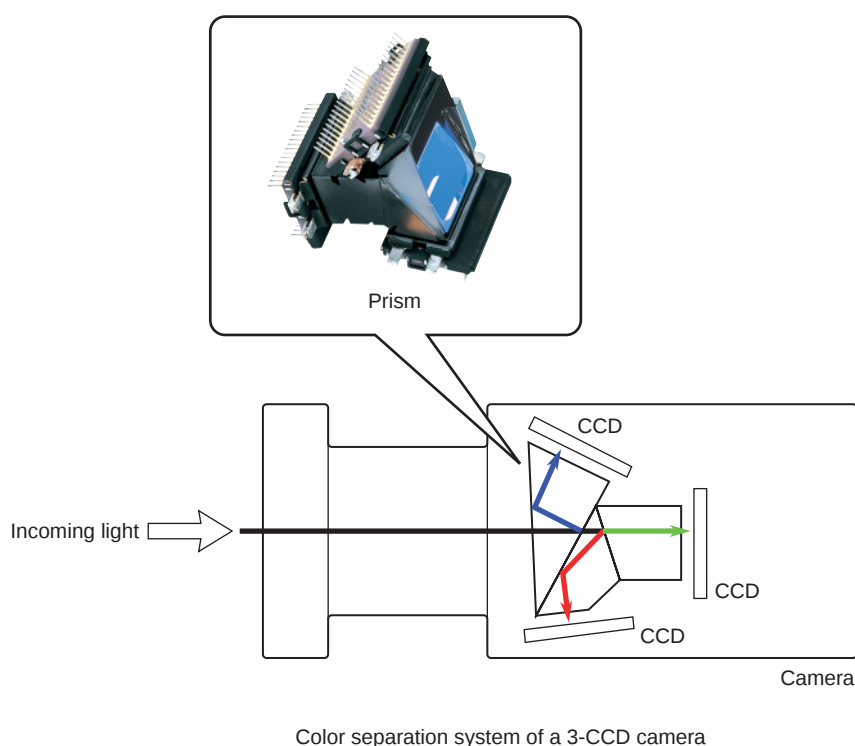
Due to the physical size and alignment of the photo sensors on a CCD imager, when an object with fine detail, such as a fine striped pattern is shot, a rainbow-colored pattern known as Moire may appear across the image. This tends to happen when the frequency of the lens's incoming light exceeds the CCD's spatial-offset frequency (refer to "*Spatial Offset Technology*") determined by the spacing between each photo sensor. In order to reduce such Moire patterns from appearing, optical low pass filters are used in CCD cameras.

An optical low pass filter is placed in front of the CCD prism block and only allows light with relatively lower frequencies to pass through it. Since this type of filtering may also reduce picture detail, the characteristics of an optical low pass filter are determined with special care - to effectively reduce Moire, but without degrading the camera's maximum resolving power.

Prism

As explained in the section titled Additive Mixing (refer to "*Additive Mixing*"), 3-CCD video cameras process color video signals by first separating the incoming light into the three primary colors, red, green, and blue. This is done by the camera's prism system, which is an arrangement of three prisms. The prism system utilizes the different reflection characteristics that light has depending on its color or wave-

length. For example, in the figure below, green is not reflected by any of the prisms and thus is directed straight to the green CCD. Red is not reflected at the surface of the second prism, but gets reflected at the third, and through one more reflection within the second prism, it is directed to the red CCD.



White Shading

White Shading is a phenomenon in which a green or magenta cast appears on the upper and lower parts of the screen, even when the white balance (refer to “White Balance”) is correctly adjusted in the center of the screen (shown below).

White shading is seen in cameras that adopt a dichroic layer (used to reflect one specific color while passing other colors through) in their color separation system. In this system, the three primary colors (red, green, and blue) are separated using color prisms (refer to “Prism”). The three-color prisms use a combination of total reflection layers and color selective reflection layers to confine a certain color. For example, the blue prism will confine only the blue light, and will direct this to the blue CCD imager.

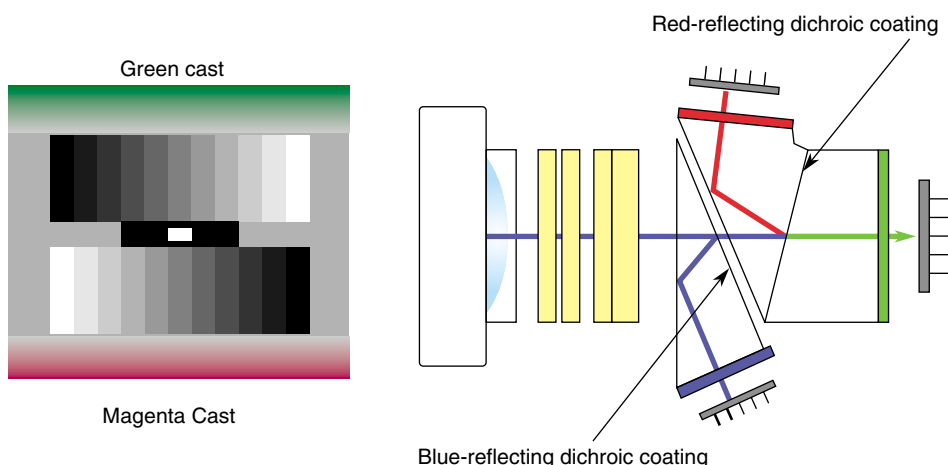
However, the color-filtering characteristics of each prism slightly change depending on the angle that the light enters (angle of incidence) each reflection layer. This angle of incidence causes different light paths in the multi-layer structure of the dichroic coating layer and results in the change of the

spectral characteristics of the prism. This effect is seen as the upper and lower parts of the screen having a green or magenta cast even when the white balance is correctly adjusted in the center.

White shading is more commonly due to the lens having an uneven transmission characteristic and is seen typically as the center of the image being brighter than the edges. This is corrected by applying a parabolic correction waveform to the variable gain amplifiers used for white balancing.

Another cause of White Shading is uneven sensitivity of the photo sensor in the CCD array. In this case, the White Shading phenomenon is not confined in the upper and lower parts of the screen.

Sony high-end professional BC cameras are equipped with circuitry that automatically performs the proper adjustment to suppress the White Shading phenomenon.



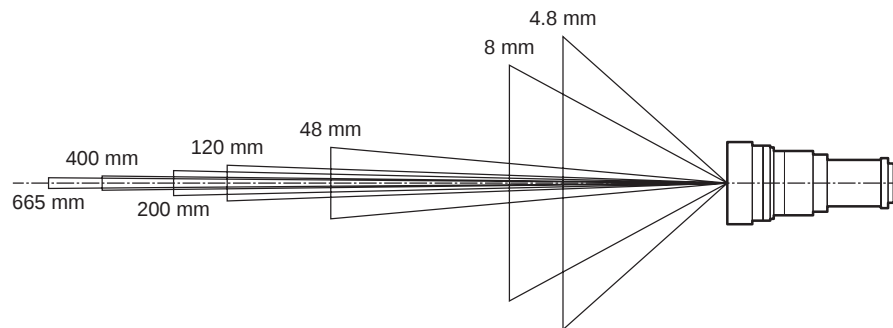
Zoom

Technically, 'zoom' refers to changing a lens's focal length (refer to "*Focal Length*"). A lens that has the ability to continually alter its focal length is well known as a zoom lens. Zoom lenses allow the cameraperson to change the angle of view (refer to "*Angle of View*"). Changing the angle of view in turn changes the area of the image that is directed to the CCD image. For example, by zooming-in to an image (the lens's telephoto position), less of the image will be directed to the lens and thus that area of the image will appear to be magnified. Zooming-out (wide angle position) means that more of the image is directed to the imager and thus, the image will look smaller. It also must be noted that the amount of light directed to the imager also changes when

changing the zoom position. In the telephoto position, less light is reflected from the subject and directed through the lens, and thus the iris must be adjusted accordingly.

Since chromatic aberration (refer to "*Chromatic Aberration*") and other light-diffusion characteristics change when the focal length is changed, high-quality zoom lenses use a series of compensation lenses (which account for the higher purchasing cost).

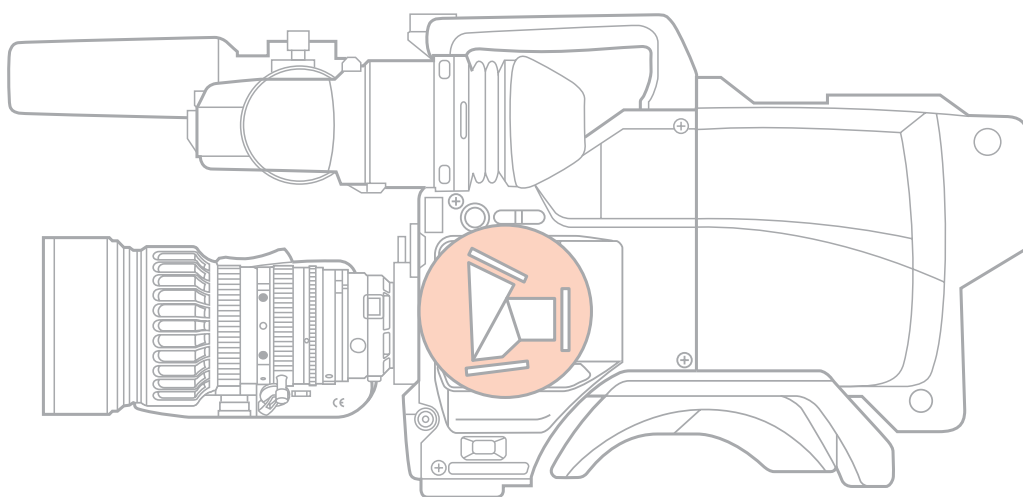
The correlation between the zooming ratio and angle of view can be described as shown in the figure below.



Correlation between zooming and angle of view

The Basics of Camera Technology

CCD Mechanism



EVS/Super EVS

EVS (Enhanced Vertical Definition System) and Super EVS are features that were developed to improve the vertical resolution of a camera. Since Super EVS is an enhanced form of EVS, let's first look into the basic technology used in EVS. EVS has been developed to provide a solution when improved vertical resolution is required. Technically, its mechanism is based on Frame Integration (refer to "Field Integration and Frame Integration Mode"), but reduces the picture blur inherent to this mode by effectively using the electronic shutter.

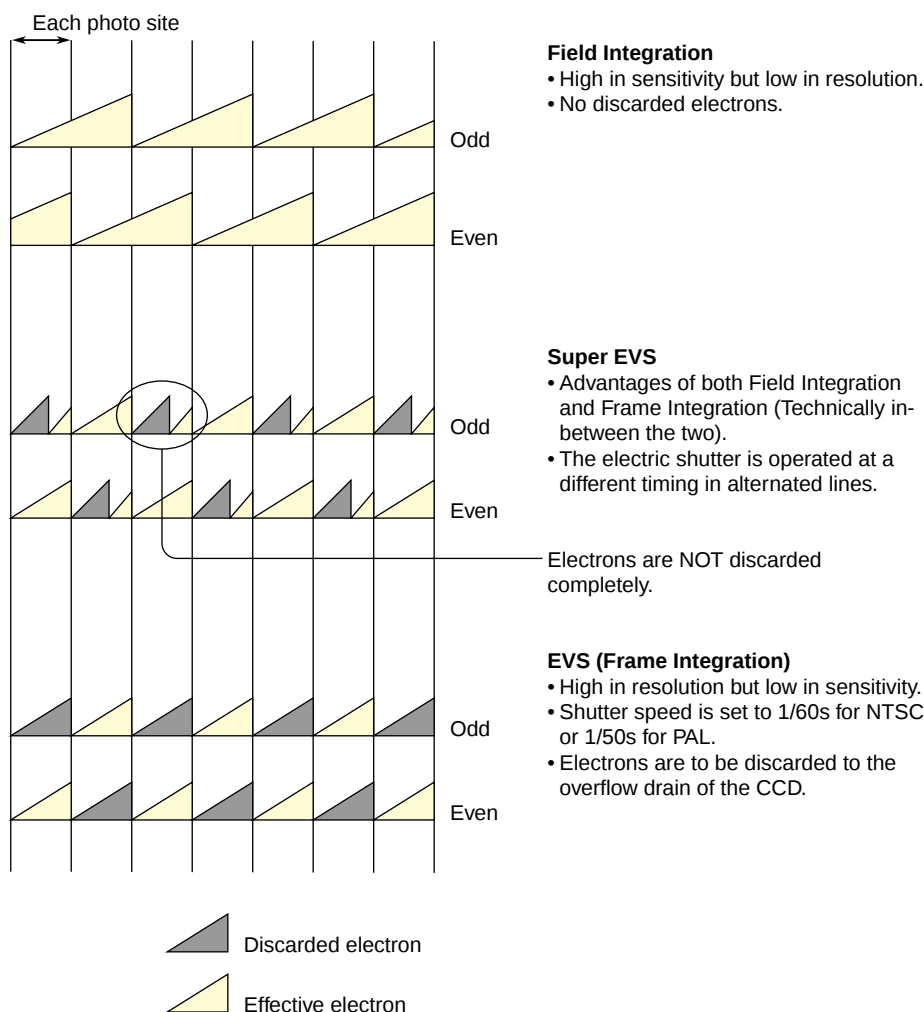
As explained in Frame Integration, picture blur is seen due to the longer 1/30-second accumulation period. EVS eliminates this by discarding the charges accumulated in the first 1/60 seconds ($1/30 = 1/60 + 1/60$), thus keeping only those charges accumulated in the second 1/60 seconds. Just like Frame Integration, EVS uses the CCD's even lines to create even fields and its odd lines to create odd fields - thus provid-

ing the same high vertical resolution. However, since the first 1/60 seconds of accumulated charges are discarded, EVS sacrifices its sensitivity to one-half.

Super EVS has been created to provide a solution to this drop in sensitivity. The charge readout method used in Super EVS sits between the Field Integration and EVS. Instead of discarding all charges accumulated in the first 1/60 seconds, Super EVS allows this discarded period to be linearly controlled. When the period is set to 0, the results will be the same as when using Field Integration. Conversely, when set to 1/60, the results will be identical to Frame Integration. And when set between 0 to 1/60, Super EVS will provide a combination of the improved vertical resolution of EVS but with less visible picture blur. Most importantly, the amount of resolution improvement and picture blur will depend on the selected discarding period. This can be summarized as follows:

When set near 0: less improvement in vertical resolution, less picture blur.

When set near 1/60: more improvement in vertical resolution, more picture blur.



Field Integration and Frame Integration Mode

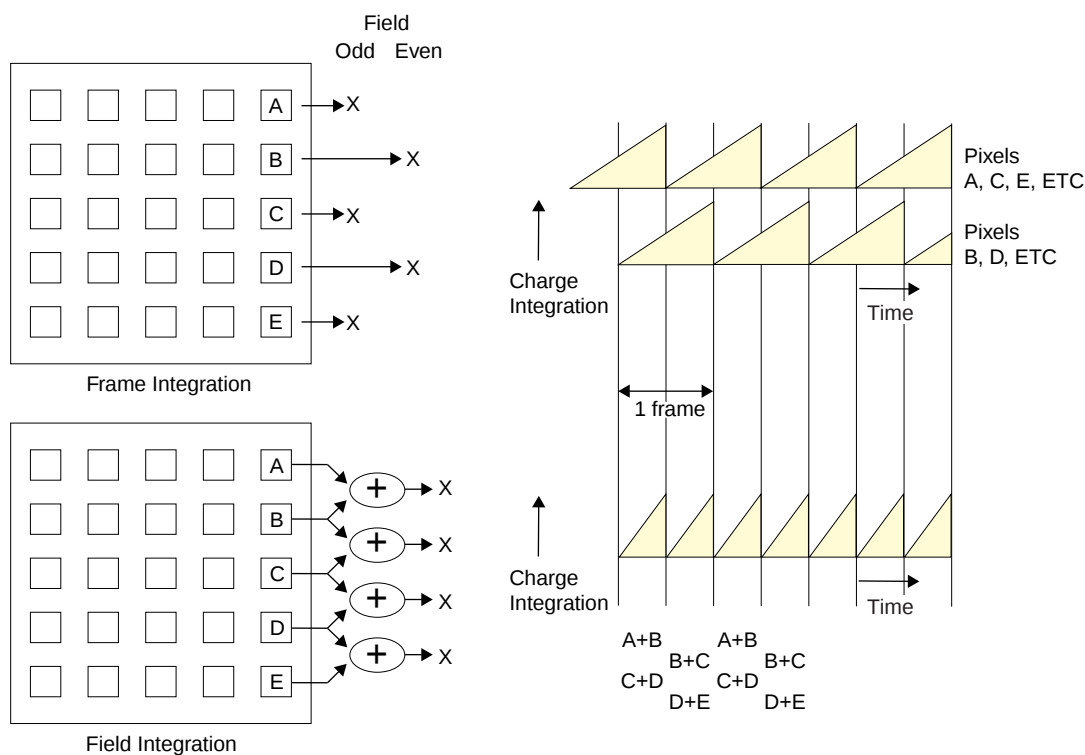
CCDs usually have about the same number of vertical pixels as the number of scanning lines that the TV system does. For example, in the NTSC (refer to "NTSC/PAL") system, there are 480 effective TV scanning lines and therefore CCDs used in this system have about 490 vertical pixels.

In interlace TV systems (such as NTSC or PAL), it is important to keep in mind that only half of the total scanning lines are displayed at a time (known as a field). This also means that the CCD should readout only half the number of its vertical samples to create a picture field. There are two readout methods used - the Frame Integration method or the Field Integration method, which is most commonly used today.

In the Frame Integration method, each pixel in the CCD array accumulates the charge for one full frame (1/30 second/two fields) before it is readout to the vertical register. To create even fields, the charges of the CCD's even lines are readout, and for odd fields, the charges for the odd lines are readout.

This method is known to provide high vertical resolution but has the drawback of picture blur since images are captured across a longer 1/30-second period.

The Field Integration method reduces this blur by shortening the accumulation intervals to match the field rate, 1/60 sec (NTSC). However, if every other line was read out to create an even field or an odd field, this would mean that the charge accumulation would drop to one-half due to the shorter accumulation period. Field Integration avoids this by combining the charges of two vertically adjacent photo sites and reading them to the vertical register in pairs. Each pair represents one pixel on the interlaced scanning line as the aggregation of two adjacent vertical pixels. Odd and even fields are created by altering the photo sites of which charges are combined. Although this method is most commonly used, it must be noted that less vertical resolution is provided compared to the Frame Integration mode. This is simply because the picture information of two adjacent pixels is averaged in the vertical direction due to the physically enlarged sensing area.

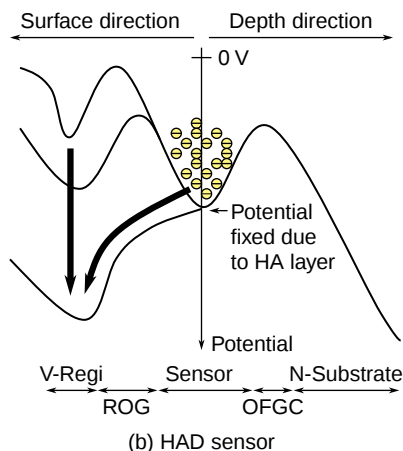
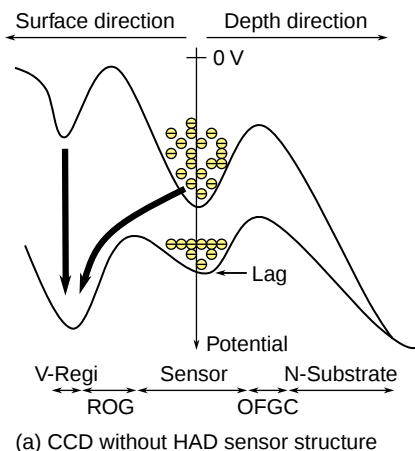


CCD Read Out Modes

HAD Sensor™

The HAD (Hole Accumulated Diode) sensor is a diode sensor which incorporates a Hole Accumulated Layer on its surface. This layer effectively reduced dark current noise, which is caused by electrons randomly generated at the Si-SiO₂ boundary layer. The Hole Accumulated Layer pairs up holes with the electrons generated at the CCD surface, reducing the number of electrons (amount of dark current noise) that enter and accumulate in the sensor. The reduction of dark current noise results in a reduction in fixed pattern noise, a high signal-to-noise ratio (*refer to "S/N (signal-to-noise) Ratio"*), and low dark shading.

The Hole Accumulated Layer also plays an important role in eliminating lag. The amount of lag in CCDs is determined by the efficiency of transferring the electrons accumulated in the photo sensor to the vertical shift register. In CCDs without a Hole Accumulated Layer, the bottom (potential) of the photo-sensing well tends to shift and, as shown in (a), an amount of electrons will remain in the well even after readout. However, with the HAD sensor, since the Hole Accumulated Layer clamps the bottom of the photo-sensing well to the same potential, the accumulated electrons will fall completely into the vertical register (b). Thus, electrons will not remain in the photo-sensing well after readout.



IT/FIT CCD

CCDs are categorized into two types, depending on the CCD's structure and the method used to transfer the charge accumulated at each photo site to the output.

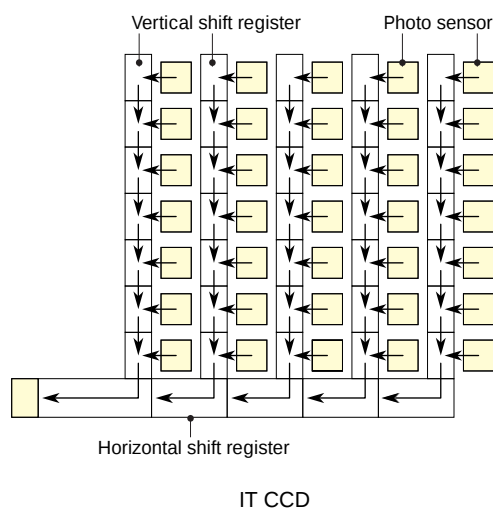
The IT (Interline-Transfer) CCD takes a structure such that the column of photo-sensing sites and vertical registers are arrayed alternately. The photo-sensing sites (so-called pixels) convert the incoming light into electrical charges over a 1/60-sec period (1/60 sec for NTSC, 1/50 sec for PAL) (*refer to "NTSC/PAL"*). After this period, the accumulated charges are transferred to the vertical shift registers during the vertical blanking interval. The charges within the same line (the same row in the CCD array) are then shifted down through the vertical shift register in the same sequence and read into the horizontal register, line by line. Once a given line is read into the horizontal register, it is immediately read out (during the same horizontal interval) so the next scanning line can be read into the register.

The only significant limitation in the IT imager structure is an artifact called vertical smear (*refer to "Vertical Smear"*), which appears when the CCD is exposed to an extreme high-

light. Smear appears as a vertical line passing through the highlight, often seen when shooting a bright object in the dark. This phenomenon is due to electric charges, accumulated in highly exposed photo sites, leaking into the vertical register before the transfer from the photo sites to the vertical register occurs.

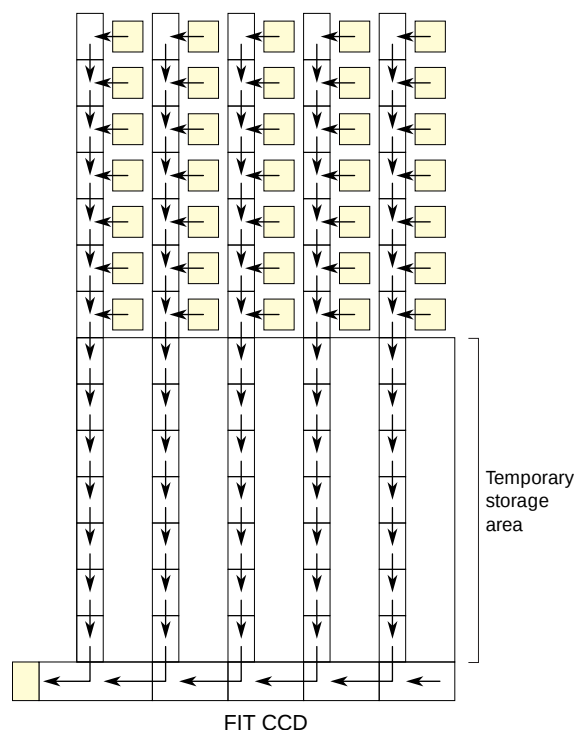
The FIT (Frame Interline Transfer) CCD was primarily designed to overcome this drawback. The upper part of this device operates exactly like an IT CCD, having a separate sensing area and charge shifting registers. The bottom part operates as a temporary storage area for the accumulated charges: immediately after the charges are transferred from the photo-sensing area to the horizontal registers (during the vertical blanking interval), they are quickly shifted to this fully protected storage area. Since the charges travel through the vertical register over a very short period, the effect of unwanted charges leaking into the vertical register from the photo sites is much smaller, especially when the CCD is exposed to highlights.

The FIT structure thus offers superior smear performance but due to its complexity, usually costs more than an IT CCD. However, it must be noted that in recent Sony IT CCDs, the vertical smear has been reduced to an almost negligible level



IT CCD

due to the use of a HAD™ sensor and On Chip Lens technology (refer to “HAD Sensor™” and “On Chip Lens”).

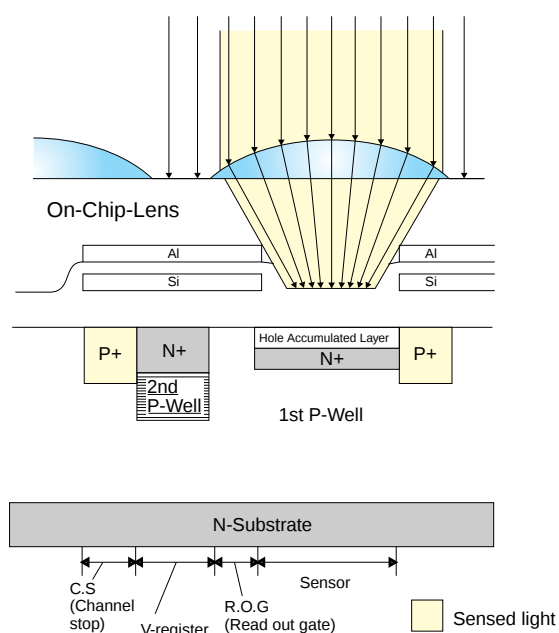


FIT CCD

On Chip Lens

As compared to the human eye's ability to see in the dark, CCD cameras have a limitation in sensitivity (refer to “Sensitivity”). Many technologies have been developed to improve sensitivity - the On Chip Lens being one of the most significant. On Chip Lens (OCL) technology drastically enhances the light-collecting capability of a CCD by placing a micro-lens above each photo sensor so that light is more effectively directed to them. The combination of Sony HAD-sensor technology and OCL has achieved tremendous improvement in image-capture capability, even under extremely low-light conditions.

Since each micro-lens converges the incoming light to each photo-sensing area, less light leaks into the CCD's vertical register, greatly reducing vertical smear (refer to “Vertical Smear”).



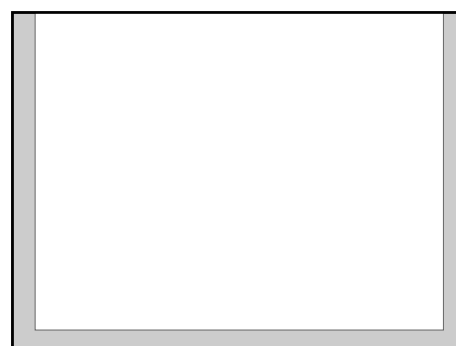
Picture Element

CCD specifications are indicated with the number of horizontal and vertical picture elements they have within their photo-sensitive areas. A picture element contains one photo sensor to sample the intensity of the incoming light directed to it.

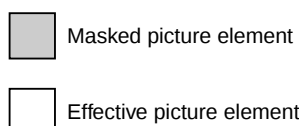
The number of picture elements within the CCD's sensing area is the main factor, which determines the resultant resolution of the camera.

It must be noted that certain areas along the edges of the CCDs are masked. These areas correspond to the horizontal and vertical blanking periods and are used as a reference for absolute black. Thus, there are two definitions in describing the picture elements contained within the CCD chip.

'Total picture elements' refers to the entire number of picture elements within the CCD chip, including those which are masked. 'Effective picture elements' describes the number of picture elements that are actually used for sensing the incoming light.



CCD picture element



Readout Mechanism

CCDs are the most popular imaging devices used in today's video cameras. In brief, CCDs convert incoming light directed through the camera lens into electrical signals that build a video signal. Since the mechanism of a CCD is very similar to the human eye, it is worthwhile to take a look at the how the human eye works and compare this to a CCD. As figure A shows below, in the human eye, an image (= light) is directed to and formed on the retina, which consists of several million photosensitive cells. The retina then converts the light that forms this image into a very small amount of electrical charges. These are then sent to the brain through the brain's nerve system. This is the basic mechanism of how people see.

Coming back to the mechanism of a CCD, the CCD has photo sensors that work exactly like the retina's photosensitive cells. However, the electrical charge readout method is quite different.

Figure C describes the structure of an Interline Transfer (*refer to "IT/FIT CCD"*), with the photo sensors used for the light-to-charge conversion and the charge readout mechanism (to build the video signal) shown. The photo sensors, also called pixels, convert the incoming light into electrical charges. The light conversion and charge accumulation continues over a period of 1/60 seconds. After the 1/60-second period, the electrical charges at each photo sensor are transferred to the vertical shift registers during the vertical blanking interval. The charges within the same lines (the same row in the CCD array) are then shifted down through the vertical shift register, during the next 1/60-second accumulation period, and read into the horizontal register, line by line at a frequency of 15.734 kHz (NTSC format: *refer to "NTSC/PAL"*). Once a given line is read into the horizontal register, it is immediately readout (during the same horizontal interval) so the next scanning line can be read into the horizontal register.

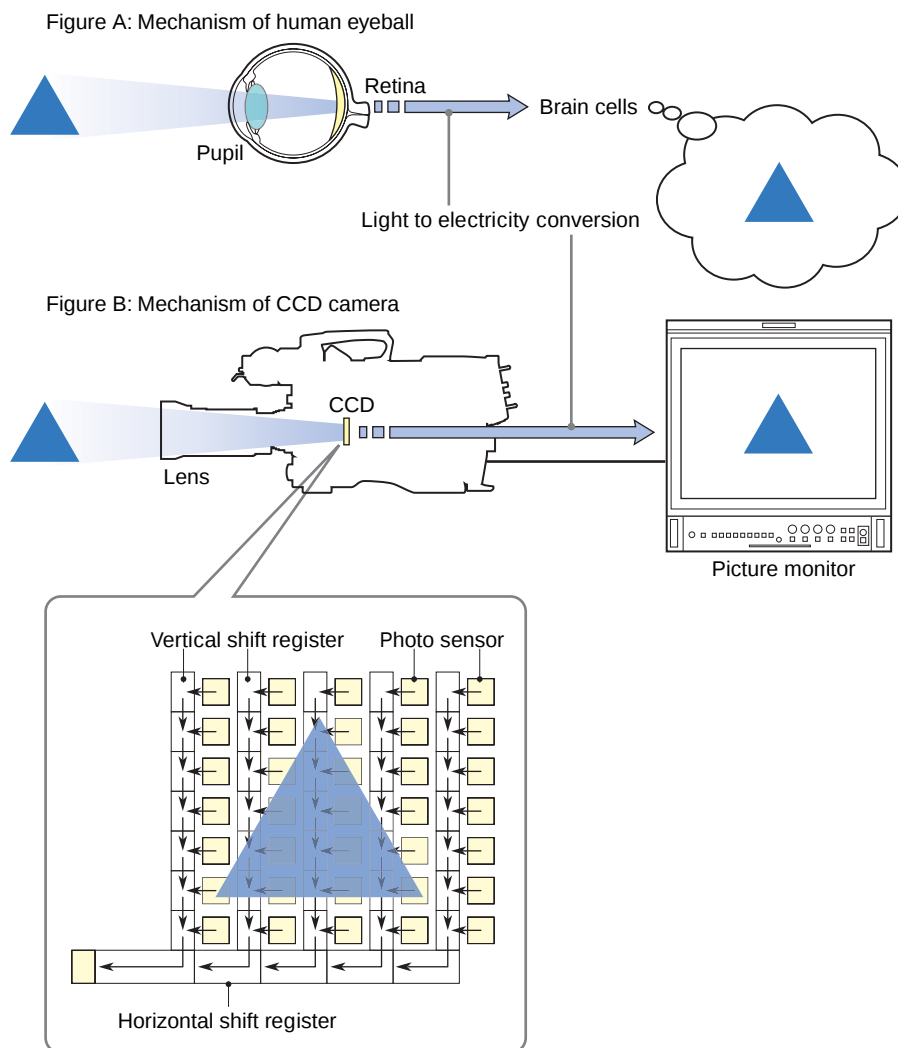


Figure C: CCD Readout mechanism

RPN (Residual Point Noise)

RPN stands for Residual Point Noise. This term refers to a white or black spot seen on a picture monitor due to a defect in the CCD. Generally, these spots consist of up to several numbers of destroyed pixels in the horizontal and/or vertical direction, which cannot reproduce colors properly. These spots can be categorized into two types - dead pixels and blemishes. While dead pixels can no longer reproduce colors, blemishes can; they just cannot reproduce colors properly due to an unwanted level shift of the charges accumulated in their pixels.

Sony has developed concealment and compensation technologies to counter dead pixels and blemishes, respectively. Concealment technology intelligently interpolates dead pixels using adjacent picture data in the horizontal and vertical

directions. On the other hand, compensation technology electrically offsets the unwanted level shift, reducing the blemishing effect.

Distinct causes of dead pixels and blemishes are still under investigation however. Until now, it has primarily been believed that cosmic rays cause damage to the CCD pixels during high-altitude transportation in an aircraft. This is based on the statistics of greater numbers of cameras transported by air, exhibiting more RPN.

Spatial Offset Technology

Spatial Offsetting is a method used to improve the luminance horizontal resolution of CCD cameras. Use of this technique allows a higher resolution to be achieved than theoretically expected with the number of picture elements that each CCD imager has. As shown in (a), the red and blue CCD chips are fixed to the prism block with a one-half pitch offset in horizontal direction in respect to the green CCD chip. Thus, the number of samples (picture elements) within a line to create the luminance signal is double, giving a higher resolution than when spatial offset is not used.

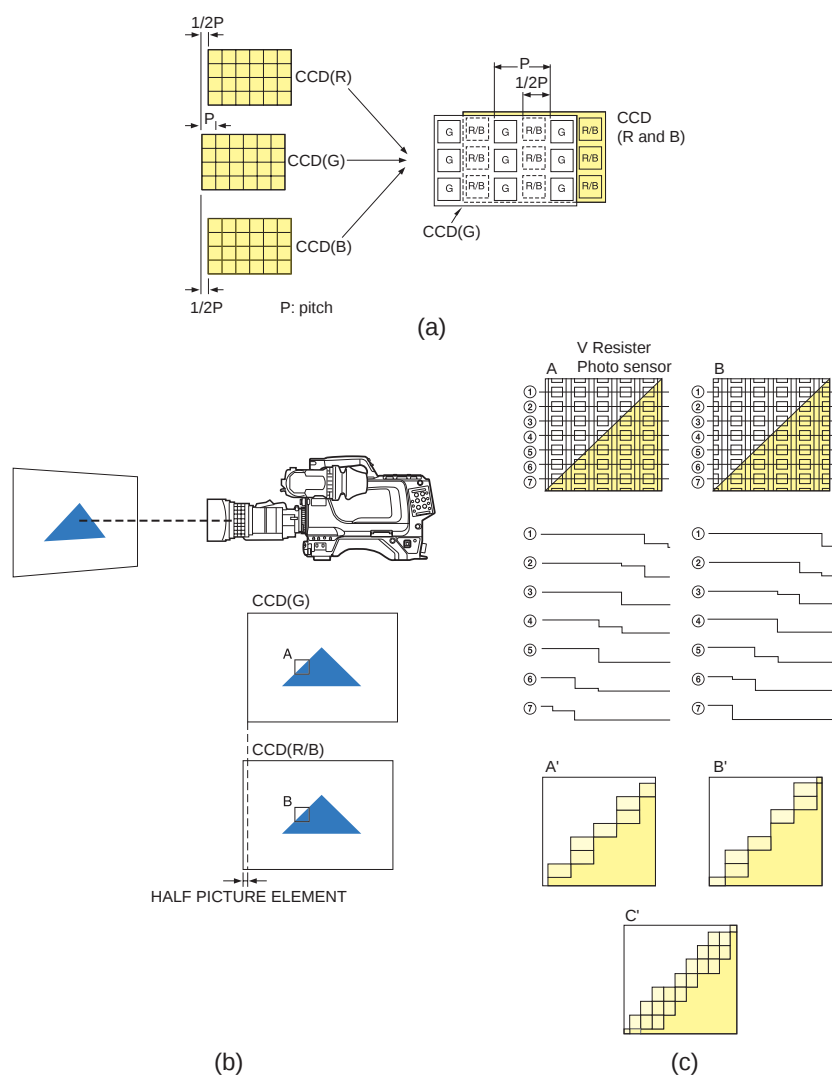
This can also be explained by examining the outputs of the three CCD chips. When shooting a subject (for better understanding, imagine a black triangle written on a white sheet of paper) with a CCD camera using spatial offset, the image is projected on the green, red, and blue CCDs as shown in (b). A and B in (c) are enlargements of areas A and B in (b). The

amount of signal charges accumulated in each photo sensor is shown in 1 through 7 as signal level. If displayed on a video monitor, the green CCD signal levels would appear as shown in A' and the red and blue signal levels would appear as shown in B'.

These represent the resolution without spatial offsetting being used.

The luminance signal, which is defined in TV standards as an addition of R/G/B signals with certain weights on each signal, is equivalently provided by adding A' and B' in spatial offsetting. This is shown in C'. As a result, the resolution is greatly improved.

Furthermore, when Spatial Offsetting is done, unwanted artifacts caused by the CCD clock signal will be decreased and thus contribute to reproducing sharper picture images. "Picture insertion"

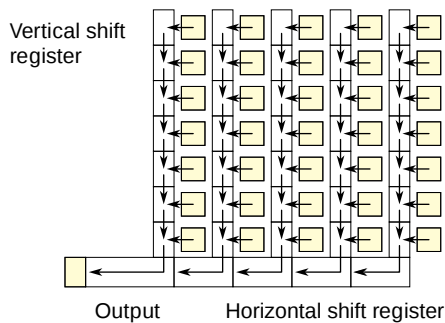


Spatial Offsetting

Variable Speed Electronic Shutter

The use of CCDs in video cameras has enabled the development of an electronic shutter, which was not available in any tube camera. This function is similar to mechanical shutters used in film cameras and can be used in the very same way. When activated, it allows the camera to capture objects moving at high speeds with less picture blur.

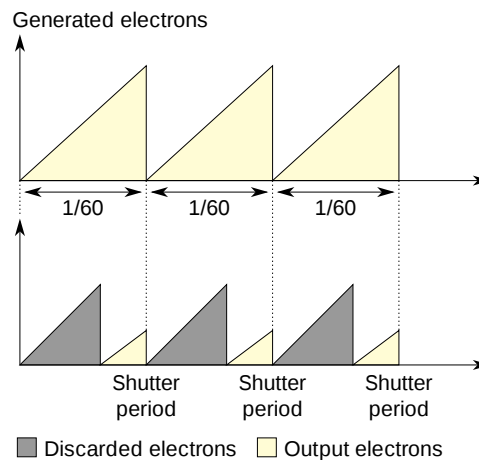
To understand how this function works, it is worthwhile reviewing the mechanism of an IT CCD (refer to “IT/FIT CCD”). Incoming light is converted to electrons (electrical charges) at each photo sensor, where they are accumulated over a certain period and then transferred to the vertical shift register. When the electronic shutter is set to OFF (1/60 second, 1 field), electrons are accumulated over the entire field period (1/60 second) and then readout to the vertical register. However, if there is fast movement in the picture during this accumulation period, picture blur will be seen.



(a) Mechanism of IT CCD

To avoid this blur, CCD cameras allow the electron accumulation period to be shortened using the electronic shutter function. The electronic shutter operates in such a manner that when a certain shutter speed is selected, for example, 1/500 second, electrons accumulated only during this period are output to the vertical register. All electrons accumulated before this period are discarded. The result is that movement capture only within the short shutter period will be captured less, effectively reducing the picture blur of fast-moving objects.

It is also important to note that shortening the accumulation period results in a drop in sensitivity, which must be compensated for by using a wider iris opening. Higher shutter speed is sometimes used for the purpose of getting shallow depth of field (refer to “Depth of Field”) with a wider iris (refer to “Iris”) opening instead of using neutral density filters (refer to “Neutral Density (ND) Filters”).



(b) Principle of electronic shutter

Vertical Smear

Vertical Smear is a phenomenon peculiar to CCD cameras, which occurs when a bright object or light source is shot with the camera. This phenomenon is observed on the video monitor as a vertical streak above and below the object or light source as shown below. A most notable example is when the headlights of a vehicle are shot with a CCD camera in the dark.

Smear is caused by the direct leakage of incoming light into the vertical shift register or the overflow of the electrical charges accumulated in the photo sites. The reason that smear is observed as a vertical streak is because electrons

constantly leak into the vertical register while it shifts down to the horizontal register.

The amount of smear is generally in proportion to the intensity of the light from the subject or light source and the area that these occupy on the CCD. Thus, in order to evaluate smear level, the area must be defined.

Smear in recent Sony CCD cameras has been drastically reduced to a level that is almost negligible due to the use of the HAD sensor (*refer to "HAD SensorTM"*).



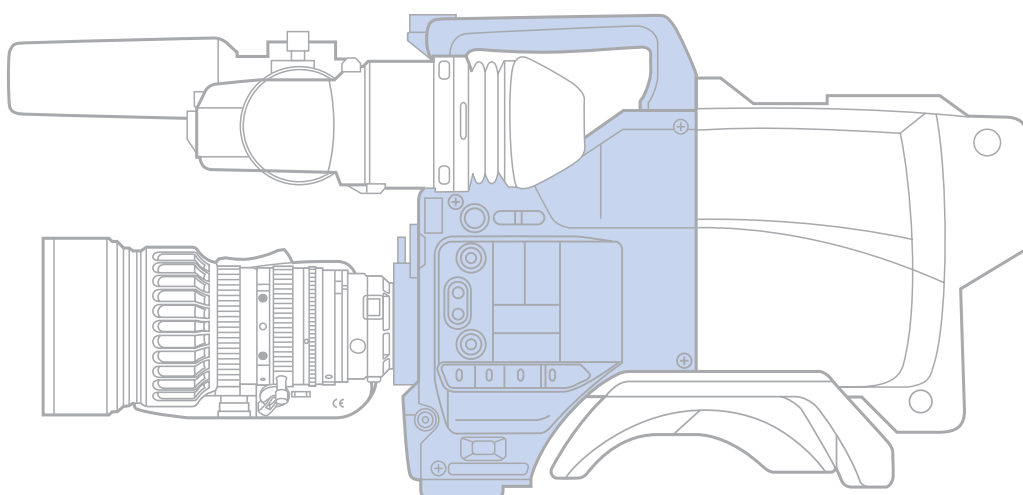
Vertical smear



Vertical smear is reduced by the use of HAD sensor

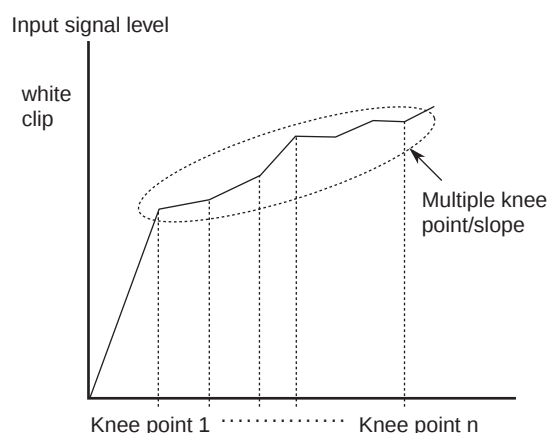
The Basics of Camera Technology

Camera Functions



Adaptive Highlight Control

Conventional cameras only have a single knee point/slope (refer to “Knee Aperture” and “Knee Correction”) characteristic. In contrast, the Sony ADSP (Advance Digital Signal Processing) system has multiple knee point/slope characteristics. The camera intelligently monitors the brightness of all areas of the picture and adapts the knee point/slope for optimum reproduction. A typical example is shooting an interior scene, which includes a sunlit exterior seen through a window. This function applies only to video levels in excess of the knee point, the middle and low luminance parts remaining unchanged.



Normal



On

ATW (Auto Tracing White Balance)

ATW stands for Auto Tracing White Balance. This feature can be considered an extension of AWB (refer to “AWB (Auto White Balance)”) but with much more convenience. While Auto White Balance is used to set the correct color balance for one particular shooting environment or color temperature (refer to “Color Temperature”), Auto Tracing White Balance corrects the color balance automatically and dynamically with any change in color temperature.

For example, imagine shooting a scene that moves from indoors to outdoors. Since the color temperature of indoor lighting and sunlight is obviously different, the white balance

must be changed accordingly. If Auto White Balance was used, the operator would have to activate it each time a small change was seen in the color temperature.

The use of Auto Trace White Balance eliminates this need, since the white balance will be automatically reset according to the change of color temperature. In other words, the white balance will automatically follow the change of color temperature.

It must be noted however, that while Auto Tracing White Balance can be convenient, it does have limitations in the accuracy of white balance adjustments.

AWB (Auto White Balance)

Unlike the human eye, cameras are not adaptive to the changes in color temperature (refer to “Color Temperature”) of different environments. For this reason, all professional cameras allow ‘White Balance’ adjustments to make a ‘white’ object always look white (refer to “White Balance”). Auto White Balance is a feature that allows white balance to be automatically adjusted simply by the press of a switch. This feature comes in handy when there is not time for manual adjustments or for operators not familiar with white balance.

Auto White Balance is often mistaken with Auto Tracing White Balance (ATW) (refer to “ATW (Auto Tracing White Balance)”), a feature equipped in consumer video cameras. While ATW is ‘completely’ automatic and constantly adjusts the white balance in accordance with the change of the lighting environment, AWB is designed to set the correct color balance for only one particular environment. Therefore, the operator must activate it each time a small change is seen in

the color temperature. This may sound somewhat inconvenient, however, AWB achieves much more accurate color reproduction as compared to ATW. AWB is achieved by framing the camera on a white object - typically a piece of white

paper - that occupies more than 70% of the viewfinder display, and then pressing the AWB button located on the camera body.

Black Balance

To ensure accurate color reproduction from a camera, it is imperative that the camera reproduces a true black when the lens iris is closed, otherwise a colorcast may be seen. This requires accurate matching of the R, G, and B black levels.

Most cameras provide an Auto Black Balance function, which automatically closes the lens iris and balances the R, G, and B black levels when activated.

Black Clip

All cameras have a circuit to prevent the camera output signals from falling below a practical video level, which is specified by the television standard. This is known as Black Clip,

which electronically 'clips off' signal levels that are below a given level called the black clip point. The black clip point is set to 0% video level.

Black Gamma

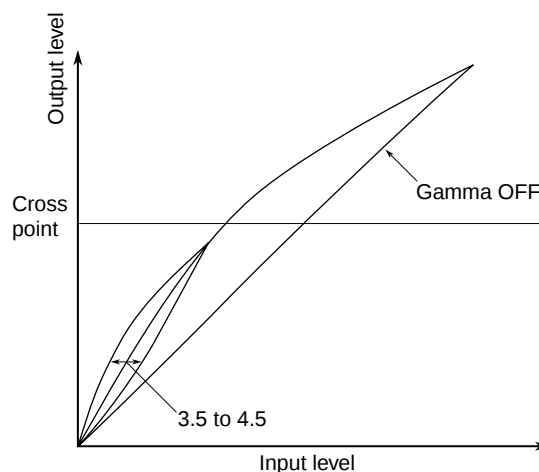
In high-end Sony cameras, the gamma curve near the black signal levels can be adjusted using the Black Gamma feature.

This feature is achieved without affecting the gamma curve of the mid-tone and high tones areas. Adjusting black gamma to obtain a steep gamma curve near the black signal levels allows more contrast to be seen in dark parts of the picture, thus resulting in better reproduction of picture detail.

However, it must be noted that using a steep gamma curve near the black signal levels also results in the increase of noise, and black gamma must be adjusted with care. Conversely, black gamma can be adjusted to reduce noise in dark picture areas but with the drawback of less contrast being seen.

Reproduction of black is extremely important to obtain the desired color reproduction of entire images, accurately and faithfully. Thus, professional video cameras, especially those used in broadcast stations, are required to have this capability to reproduce faithful black level stipulated by each broad-

cast station (different broadcast stations will have their own stipulations on the black level).



Standard video gamma



Gentle gamma curve near the black signal levels

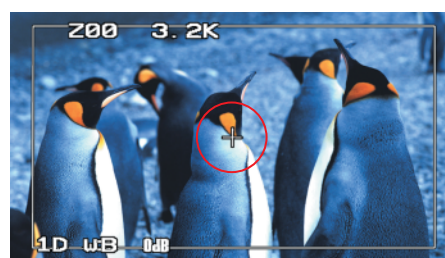
Black Shading

Black Shading is a phenomenon observed as unevenness in dark areas of the image due to the dark current noise of imaging device. Dark current noise describes the noise induced in a CCD by unwanted electric current generated by

various secondary factors, such as heat accumulated within the imaging device. A Black Shading Adjustment function is available in most professional video cameras to suppress this phenomenon to a negligible level.

Center Marker

The Center Marker is a mark in the viewfinder that indicates the center of the image being shot. This is especially useful when zooming in to a particular area of the subject. By using the center marker as a reference, camera operators can zoom in to a subject with the desired area accurately framed. This is most convenient when a high magnification lens and high zooming speed is used.



Center Marker

Clear Scan/Extended Clear Scan (ECS)

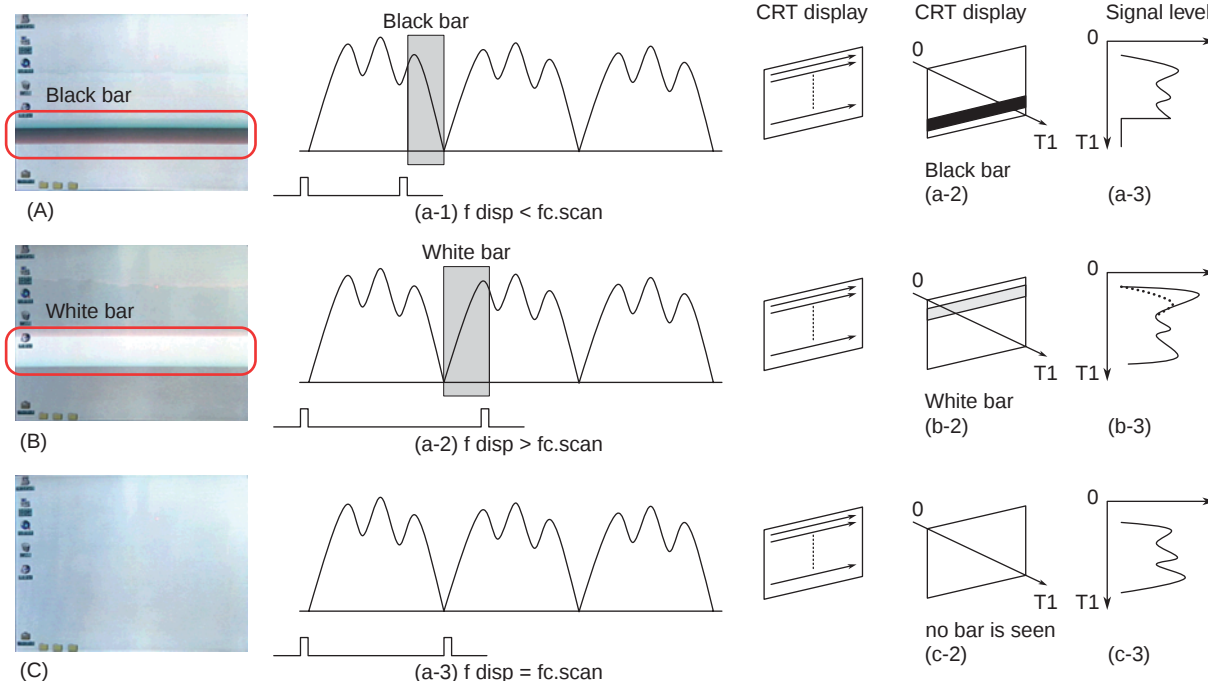
When computer displays are shot with video cameras, either a white or black, half transparent horizontal bar is seen, running from the top to the bottom of the computer screen. This phenomenon is due to the difference in the vertical frequencies of the camera and computer display. In order to eliminate this phenomenon, Clear Scan was developed by applying the technologies of the CCD's Variable Speed Electronic Shutter (*refer to "Variable Speed Electronic Shutter"*).

When the display's vertical frequency is lower (display time longer) than the CCD's accumulation period (for example, 1/60 seconds for NTSC), the CCD will output (readout) the image before the entire computer display is scanned. The computer's lines that were not scanned within the 1/60-second CCD accumulation period will appear black (as shown A). Vice versa, if the display's vertical frequency is higher (display time shorter) than the CCD's accumulation period, then the CCD will capture part of the computer scan twice, resulting in more light being captured on that part of the CCD and a white bar being output (as shown B).

Clear Scan eliminates this phenomenon by allowing the CCD readout accumulation period to be synchronized with the

computer display's vertical frequency. This is done by changing the CCD accumulation period using the electronic shutter. By activating Clear Scan, the electronic shutter speed (CCD accumulation period) can be controlled in a linear-like fashion so it can be matched exactly to the computer display's vertical frequency. In this way, the banding effect mentioned earlier is effectively eliminated (as shown C).

Extended Clear Scan is an advanced form of Clear Scan and is available only on cameras with FIT CCDs (*refer to "IT/FIT CCD"*). Extended Clear Scan expands the range of available shutter speeds down to 30 Hz and 25 Hz, for 59.94i and 50i formats respectively. Thanks to the Clear Scan/Extended Clear Scan functions, almost all monitor scanning frequencies are supported. Clear Scan and Extended Clear Scan are also effective for eliminating the flicker effect when shooting under fluorescent lighting, which may have a different frequency than that of the standard CCD accumulation period. Extended Clear Scan can also be used to eliminate the flicker effect when shooting movie screens operating at 48 Hz.



Color Bars

Color-bar signals are used to maintain consistent color reproduction throughout the entire production chain. They are usually recorded to the source tape at the acquisition stage as a reference to adjust the output encoders of VTRs and other equipment used in subsequent production processes. Adjustments are made so that each device outputs the color-bar signal to show the exact same color and brightness as when recorded in the acquisition stage. Vector scopes are used to adjust the color (hue/saturation) while wave-form monitors are used to adjust the brightness. There are a few color-bar definitions in the NTSC TV system (refer to "NTSC/PAL"). However, all color-bar signals basically look the same (in some cases, additional color bars or blocks are placed below the color bars) when displayed on a picture monitor. There are seven vertical bars - one white bar on the very left, followed with six colored bars to the right. The order of the colored bars from left to right is yellow, cyan, green, magenta, red, and blue. This is the descending order of each color's luminance level. It is also important to know that each color (including the white bar) is a combination (total: seven combinations) of equally adding the three primary colors, red, green, and blue, and all have 100% saturations. A 75% color bar has the same 100% white bar but the levels of R, G and B for the colored bars is 75%. This maintains the level of the peak to 700 mV but reduces the saturation of the color bars.

Shooting a program usually starts by recording a color-bar signal generated in the camera to the top of the tape. For this purpose, production cameras have internal color-bar generators. The color-bar signal from the camera can also be used as a reference for adjusting the chroma, phase, and brightness of a monitor.



Color bar

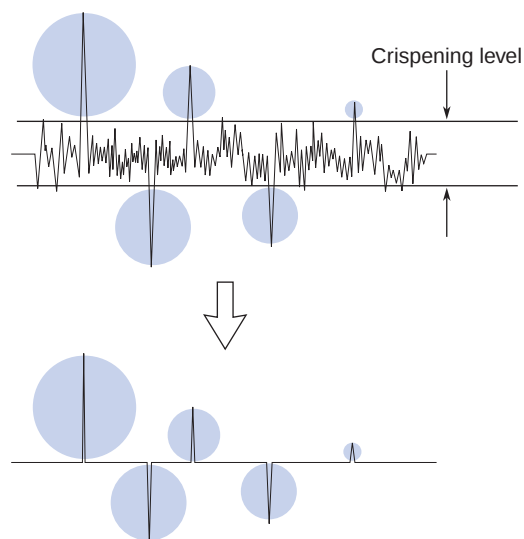
Crispeneing

As mentioned in the section on Detail Level (*refer to "Detail Level"*), detail signals are used to raise the contrast at the dark-to-light and light-to-dark transitions, making the edges of objects appear sharper both horizontally and vertically. Simply put, detail correction makes pictures look sharper than the actual resolution provided by the camera. However, since detail correction is applied to the entire picture, its use also emphasizes the noise of the picture, especially when the detail level is high.

Crispeneing is a circuit implemented to avoid detail signals being generated around noise. By activating the Crispeneing function, detail signals with small amplitudes, which are most likely caused by noise, are removed from the signal.

As shown in the figure below, in the Crispeneing process, only detail signals that exceed a designated threshold are utilized for image enhancement. Conversely, the detail signals with small amplitudes are regarded as noise and removed.

Crispeneing allows detail to be adjusted without worrying about its influence over noise.

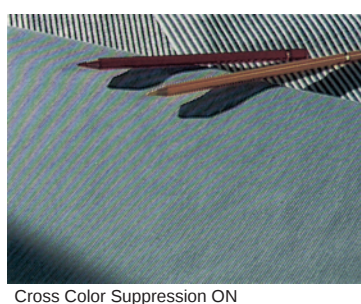
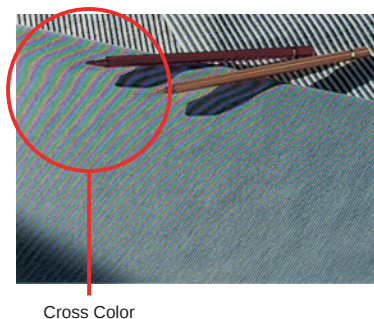


Cross Color Suppression

Cross color is an artifact seen across very fine striped patterns when displaying a composite signal feed on a picture monitor. It is observed as a rainbow-like cast, moving across the stripes. To understand how cross color occurs, it is worthwhile to review the composite signal (*refer to "Color Signal Forms"*).

A composite signal is formed by combining the chrominance and luminance signals together so their spectrums interleave. In the early days of color broadcast, the composite signal introduced the benefit of transmitting a color signal within the same bandwidth as a black and white signal. However, a drawback was seen on the TV receiver side. Since all video signals must be decoded into their R, G, and B components for display on a color video monitor, the composite signal first requires to be separated into its chrominance and luminance components (known as Y/C separation). This is where the problem occurred. Although many techniques

have been developed to separate the composite signal into its luminance and chrominance components, none have been complete even with the most advanced technology. Cross Color Suppression technology - incorporated in the latest Sony professional video cameras - presents a solution to the limitations of Y/C separation on TV receivers. Cross Color Suppression refers to a digital filtering process, which eliminates any luminance components that may result in cross color prior to outputting the composite signal. These frequency components are eliminated from the Y/R-Y/B-Y signals within the camera head by using sophisticated digital three-line comb filtering (NTSC/fine line/PAL). This allows the composite signal to be easily separated back into its chrominance and luminance components at the TV receiver. This results in greatly reduced cross color and dot crawl (dot noise appearing at the boundaries of different colors) than normally observed.



Detail Level

In all cameras, image enhancement is used as a method to improve picture sharpness. In brief, image enhancement raises the contrast at the dark-to-light and light-to-dark transitions, making the edges of objects appear sharper than provided by the actual resolution of the camera. This process is applied electrically within the camera by overshooting the signal at the edges. In most professional cameras, image enhancement is applied to both vertical and horizontal picture edges.

In camera terminology, this process is called 'detail'. Detail level refers to the amount of image enhancement, or in other words, the amount of sharpness added to the picture.

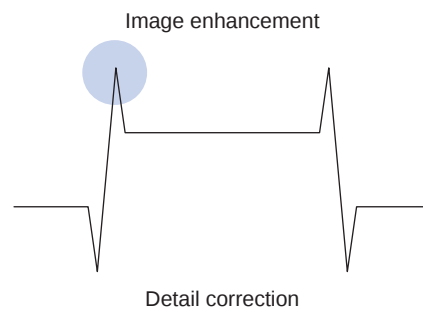
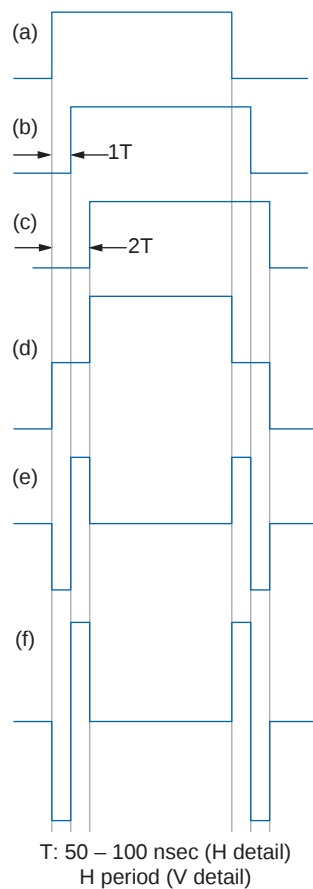
In most professional cameras, this can be altered with the detail-level control circuitry.

It is worthwhile understanding how the horizontal detail signal is created.

For simplicity, let's examine how this is done in an analog detail-correction process. The original signal (a) is delayed by 50 nsec to obtain signal (b) and by 100 nsec to obtain signal (c). By adding (a) and (c) we have signal (d). The detail signal used for enhancement (signal (e)) is obtained by subtracting (d) from two times (b). This is further added to (b), completing the detail correction (f).

The mechanism for creating the vertical detail signal is basically the same as horizontal detail correction. The only difference is that the delay periods for creating signals (b) and (c) are one horizontal scanning line and two horizontal scanning lines, respectively.

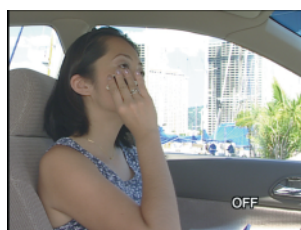
Excessive detail correction will lead to an artificial appearance to the picture, as though objects have been "cut out" from the background.



DynaLatitude™

DynaLatitude is a feature offered on Sony DVCAM camcorders for capturing images with a very wide dynamic range or, in other words, images with a very high contrast ratio. For example, when shooting a subject in front of a window from inside the room, details of the scenery outside will be difficult to reproduce due to the video signal's limited 1 Vp-p dynamic range. However, DynaLatitude is a unique technology that overcomes this limitation so that both dark areas and bright areas of a picture can be clearly reproduced within this 1 Vp-p range.

DynaLatitude functions in such a way that the signal is compressed within the 1 Vp-p range according to the light distribution of the picture. DynaLatitude first analyzes the light distribution or light histogram of the picture and assigns more video level (or more 'latitude') to light levels that occupy a larger area of the picture. In other words, it applies larger compression to insignificant areas of the picture and applies less or no compression to significant areas.



DynaLatitude OFF



DynaLatitude ON

Dynamic Contrast Control (Automatic Knee Control)

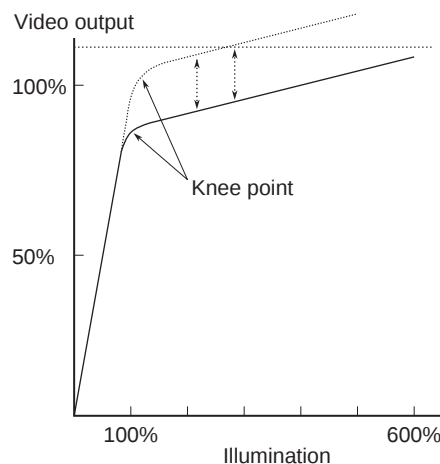
Although many new techniques have been developed for highlight control, Dynamic Contrast Control (DCC) is probably one of the most popular.

As with other methods, DCC allows the camera to reproduce details of a picture, even when extremely high contrast must be handled. A good example is when we try to shoot a person standing in front of a window from inside the room. With DCC activated, details of both the person indoors and the scenery outside can be reproduced on a picture monitor despite the large difference in luminance level inside and outside.

The mechanism of DCC is basically the same as knee correction (refer to "Knee Correction"). The difference is that DCC allows a wider dynamic range by automatically controlling the knee point (and in some cameras, the knee slope) to a video level optimized for the scene that is being taken. For example, when there are no extreme highlights, the knee point will be adjusted to a point near the white clip (refer to "White Clip") so the details of a picture can be reproduced linearly in each area (each video level) with high contrast. On the other hand, when the incoming light far exceeds the white clip level, the DCC circuitry gradually lowers the knee point according to the intensity of the light.

In this way, a scene requiring a wide dynamic range can be reproduced within a standard video level. The DCC circuits employed in Sony CCD cameras allow a dynamic range of up to 600%.

Other contrast control methods including DynaLatitude and Adaptive Highlight Control (refer to "DynaLatitude™" and "Adaptive Highlight Control") are also available on most Sony professional cameras.

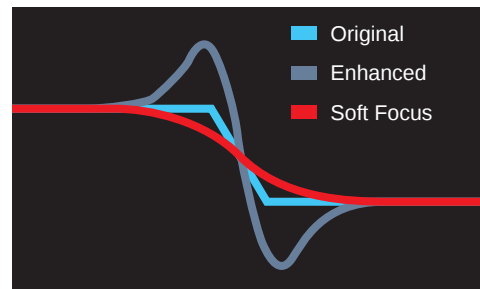


Electric Soft Focus

Skin Tone Detail (refer to “Skin Tone Detail Correction”) can be very effective for reducing picture sharpness of specified color areas. But it also has limits. It does not really apply picture blur, it simply decreases the detail signal level to apply a cinematic or film-like softness.

In order to further apply a cinematic or film-like softness across images with specific colors, most Sony high-end cameras offer a function called Electronic Soft Focus. This uses the detail signal to reduce, rather than increase, the sharpness of a picture. As shown in the diagram, by subtracting the detail signal from the original signal (as opposed to adding it in image enhancement), Electronic Soft Focus provides a picture that is ‘softer’ than that achieved with the detail switcher turned off completely.

Electronic Soft Focus is used in conjunction with Skin Tone Detail to create soft images across only the specified color range.



File System

Professional video cameras allow a variety of detailed and complex adjustments in order to reproduce the desired colorimetry for each shooting scenario as well as to compensate for technical imperfections in certain camera components. In order to reduce the burden of repeating an adjustment each time a shoot is performed, professional cameras provide facilities that allow these to be saved and recalled as “data files” whenever required. This File System greatly contributes to operational efficiency, and has been adopted in all professional video camera systems available today.

Depending on their nature and when they are used in the entire setup procedure, adjustment parameters are categorized into appropriate “data files”, such as Reference File (refer to “Reference File”), Scene File (refer to “Scene File”), Lens File (refer to “Scene File”) etc. In Sony camera systems, the Reference File and the Scene File can be stored on removable recording media such as Memory Stick™ and Memory Card, which enables instant reproduction of shooting conditions for particular scenes as well as the duplication of camera setup adjustments between multiple cameras.

Gain

When shooting with a video camera in low-light conditions, a sufficient signal level can often not be obtained due to a lack of light directed to the imager. For such cases, video cameras have a Gain Up function, which electronically boosts the video signal to a sufficient level for viewing on a monitor or recording to a VTR. The Gain Up function usually offers sev-

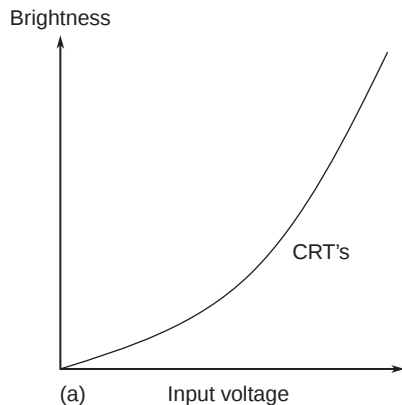
eral Gain Up values, which are selected by the operator depending on the lighting. It must be noted that choosing a large Gain Up value will result in degrading the S/N ratio, since noise is also boosted. Some cameras have a minus Gain Up setting to improve their S/N ratio.

Gamma

Gamma (γ) is a numerical value that shows the response characteristics between the image brightness of an acquisition device (camera) or display device (CRT monitor) and its input voltage. In order to obtain faithful picture reproduction, the brightness of the picture must be in direct proportion to the input voltage. However, in CRTs used for conventional picture monitors, the brightness of the CRT and the input voltage retain a relationship with an exponential function, instead of a directly proportional relationship. As shown in (a), the beam current (which is in proportion to the CRT's brightness) versus the input voltage rises as an exponential curve, in which the exponent is a factor larger than one. On the monitor screen, the dark areas of the signal will look much darker than they actually are, and bright areas of the signal will look much brighter than they should be. Technically, this relation is expressed in the following equation:

$$I = C \times E^{\gamma}$$

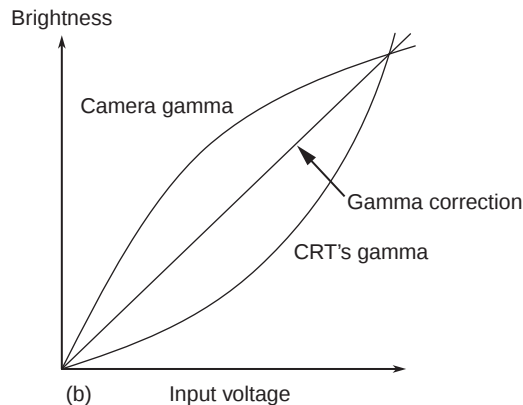
where I is the brightness, E is input voltage and C is a specific constant. The exponent in this equation is called the 'gamma' of the CRT.



It is obvious that the gamma of a picture monitor CRT must be compensated for in order to faithfully reproduce pictures taken by the camera. Such compensation is called 'gamma correction'. Properly speaking, gamma correction should be done within the picture monitor. However, this is done within the camera since it is more economically efficient to perform the correction within the cameras used by the broadcaster, rather than in the huge number of picture monitors that exist in the market.

The goal in compensating (gamma correction) for the CRT's gamma is to output a signal so that the light that enters the camera is in proportion to the brightness of the picture tube, as shown in (b). When the light that enters the camera is proportional to the camera output, it should be compensated for with an exponent of $1/\gamma$. This exponent $\gamma' (1/\gamma)$ is what we call the camera's gamma. The gamma exponent of a monitor is about 2.2. Thus the camera gamma to compensate for this is about 0.45 ($1/2.2$).

Although gamma correction in the camera was originally intended for compensating for the CRT's gamma, in today's cameras, gamma can be adjusted to give the camera image a specific look. For example, a film-like look can be achieved by changing the settings of the camera's gamma.



Genlock

In multi-camera systems, it is necessary to synchronize (*refer to "Synchronization Signal (Sync Signal)"*) the internal sync generators of each camera within the system. More specifically, the frequencies and phases of the V sync, H sync, and sub-carrier of each camera output must be synchronized with each other. Otherwise, picture shifts will occur when switching from camera to camera with the switcher system used. Synchronization is accomplished by feeding the same composite signal to each camera as a timing reference. In video technology, this is described as 'genlock', which refers to the camera's function of locking its internal sync

generator to the signal supplied to its Reference IN connector. The composite signal used to synchronize the cameras can be supplied from a signal generator, the switcher, or one of the cameras within the system designated as the master.

H/V Ratio

As explained in the section on Detail Level (*refer to “Detail Level”*), detail correction is applied to both horizontal and vertical picture edges using separate horizontal detail and vertical detail circuitries. H/V Ratio refers to the ratio between the amount of detail applied to the horizontal and

vertical picture edges. It is important to maintain the balance of the horizontal and vertical detail signals to achieve natural picture enhancement. H/V Ratio should thus be checked every time detail signals are added.

Intercom (Intercommunication) System

Whether the application is for studio or outside broadcasting, verbal communication between the camera crew and staff in the studio/OB-van control room is of vital importance. This is usually done using the Intercom Function, available on all studio-type camera systems and their counterpart camera control units. In actuality, verbal communication between the camera crew and staff in the control room becomes possible by connecting an intercom system to the camera control unit which relays the communication line to the camera head. Intercom systems can have up to three separate channels for

communications. These are the Engineer’s Line (ENG), intended for communication on technical issues between the studio and the control room, the Producer’s Line (PROD), used for communications on how the program should be built, and the Program Audio Line (PGM), used to feedback the studio content of the show to the camera crew. As with all other signals, intercom signals are also transmitted between the camera and camera control unit (*refer to “Camera Control System”*) through the Triax cable (*refer to “Triax”*).

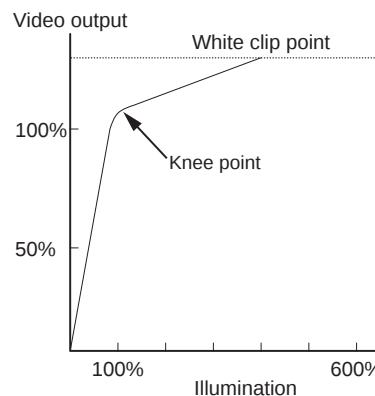
Knee Aperture

When knee correction (*refer to “Knee Correction”*) is applied to the video signal within a camera, reduction in contrast in the highlight areas cannot be avoided. This is because the highlight contrast - and the detail signals generated to emphasize this contrast - are compressed by the knee correction process which follows. To compensate for this loss in contrast, the knee aperture circuit activates to emphasize the edges of only those areas where knee correction is applied (highlights above the knee point). Knee aperture can be adjusted in the same way detail correction can but only for those areas above the knee point.

Knee Correction

When we take a photo against a strong backlight, just like shooting a portrait picture in front of a sunlit window, we can still clearly see the subject's face while being able to see the details of scenery outside the room. This is because the human eye can handle wide dynamic range (*refer to "Dynamic Range"*). However, this is not easily done by video cameras because of the limited video-level dynamic range specified by the television standard. Therefore if the camera lens iris was adjusted for correct exposure of human skin tones, the bright areas of the image would not fit into the video-signal range and would be washed out. Vice versa, if the iris was adjusted for the bright areas, the video level of human skin tones would be very low and would look too dark. In order to obtain an image reproduction like the human eye, as naturally as possible, a function called 'Knee Correction' is widely used on today's video cameras. Knee Correction is a function that compresses the wide dynamic video signals acquired by the imager (CCDs) into the limited video-level range specified by the television standard.

The video level from which signals are compressed is called the knee point. As shown in the figure, the video output above the knee point is compensated for to give a more gradual response. Thus some detail (contrast) can still be observed in the bright areas above the knee point, broadening the dynamic range of the camera.



Lens File

In general, each camera lens introduces different 'offset' characteristics, which are electronically compensated for on a lens basis by making appropriate adjustments to the camera. However, when multiple lenses are used on the same camera, these different characteristics require the camera to be readjusted each time the lens is changed.

In order to eliminate this burden, most high-end professional cameras have a so-called Lens File system. With this system, camera operators can store lens compensation settings for individual lenses within the camera as lens files. Since

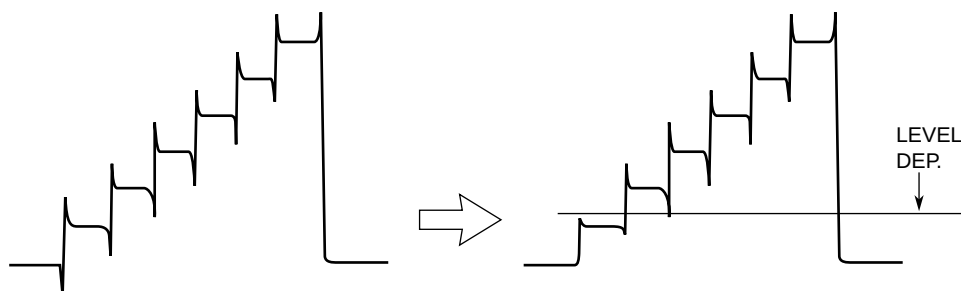
each lens file is assigned a file number designated by the operator, pre-adjusted lens-compensation data can be instantly recalled simply by selecting the correct file number. Simply put, once the setting for a given lens has been made and stored as a lens file, all that need to be done to use this lens again is to select the file number associated to it. Some large studio-type lenses take this a step further by automatically recalling the correct lens file by registering the same number in the lens's memory as that used for the associated lens file.

Level Dependence

Level Dependence is a similar function to Crispening (*refer to "Crispening"*), which is used to prevent unwanted detail signals generated by noise. While 'Crispening' removes detail signals generated by noise at all signal levels, Level Dependence simply reduces the amplitude of detail signals generated in the low luminance areas. In other words, Level

Dependence allows a different amount of detail correction to be applied under a given threshold.

Since noise is most noticeable to the human eye in dark picture areas, Level Dependence improves the signal quality in these areas. Level Dependence is effectively used when the picture content has extremely fine details, which could be mistaken for removed noise if Crispening was used.

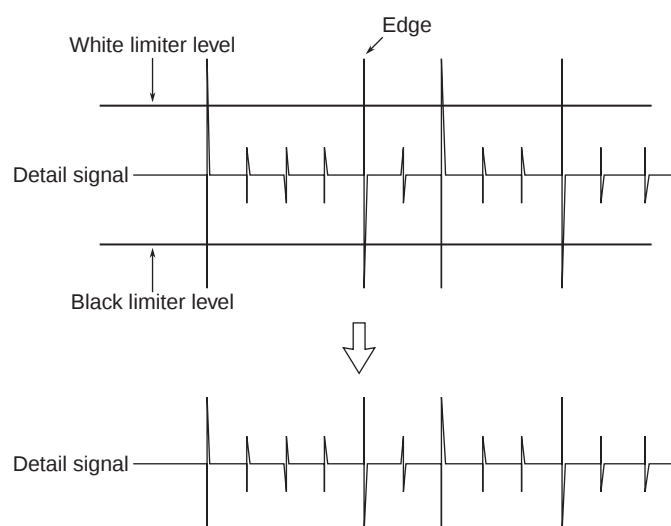


Limiter

As mentioned in the section on Detail Level' (refer to "Detail Level"), detail signals are used to raise the contrast at the dark-to-light and light-to-dark transitions, making the edges of objects appear sharper both horizontally and vertically. However, when there is large difference in the luminance level at the dark-to-light or light-to-dark transitions, the detail circuit is likely to generate an over-emphasized picture edge and objects may appear to 'float' on the background. This is

because detail signals are generated in proportion to the difference in the luminance levels at the dark-to-light or light-to-dark transitions.

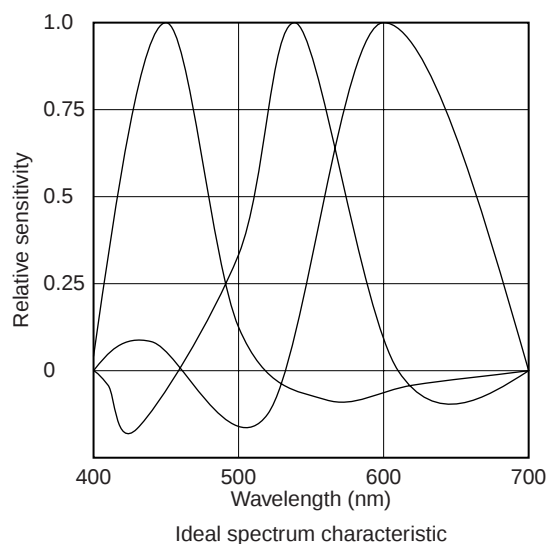
The limiter is a circuit to suppress this unwanted effect. It 'clips off' the top of detail signals that are above a designated threshold, thereby preventing excessive detail correction for both white and black detail signals.



Linear Matrix Circuit

All hues in the visible spectrum can be matched by mixing the three primary colors, red (R), green (G), and blue (B). The spectrum characteristics of these three primary colors are shown in the figure below. Some areas contain negative spectral response. Since negative light cannot be produced, this means that some colors cannot be matched using any R, G, and B combination. In video cameras, this would result in particular colors not being faithfully reproduced.

The Linear Matrix Circuit compensates for these negative light values by electronically generating and adding them to the corresponding R, G, and B video signals. The circuit is placed before the gamma correction (refer to “Gamma”) so that compensation does not vary due to the amount of gamma correction. In today's cameras, the Linear Matrix Circuit is used to create a specific color look, such as one defined by the broadcaster.



Low Key Saturation

With conventional video cameras, low-light areas can be subject to a reduction in saturation. The Low Key Saturation function offered in Sony's professional video cameras brings a solution to this problem. The Low Key Saturation function adjusts the color saturation at low-light levels by boosting it to

an optimized level, thus providing more natural color reproduction. As shown in the figure below, with the Low Key Saturation function, a warmer color is reproduced that is closer to natural human skin.



Low Key Saturation OFF



Low Key Saturation ON

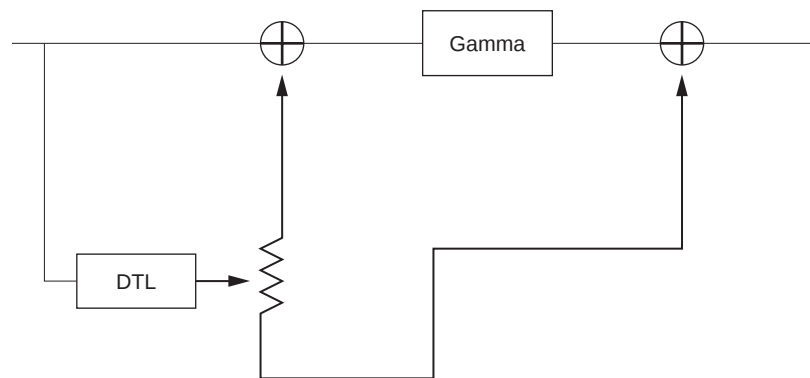
Mix Ratio

In most professional video cameras, image enhancement or detail correction (*refer to "Detail Level"*) is applied both before and after the gamma correction (*refer to "Gamma"*) as shown below. The term, Mix Ratio, describes the ratio of the amount of detail applied at pre-gamma detail correction and post-gamma detail correction.

The reasons that detail correction is applied twice owes to the gamma correction's non-linear nature. Gamma correction used in video cameras boosts the contrast at the dark picture areas and those in the white pictures get com-

pressed. For this reason, pre-gamma correction is effective for enhancing contrast at dark areas of the image. Post-gamma correction, on the other hand, is used to effectively enhance the brighter parts of the image. Unlike H/V ratio (*refer to "H/V Ratio"*), there is no optimum ratio for Mix Ratio. It is a parameter that is adjusted depending on each operator's different preference.

*It should be noted that while the image will appear sharper as the amount of enhancement is increased, noise may also be enhanced.

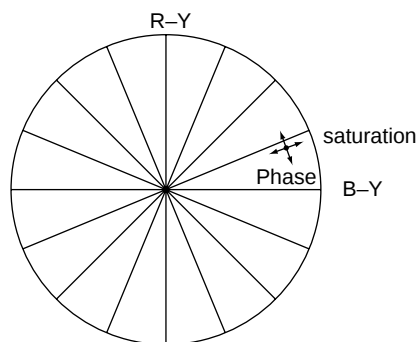


Multi Matrix

Multi Matrix has been developed for further creative control in color adjustments of a scene. Unlike conventional color correction or matrix control, in which all color control parameters interact with each other, the Multi Matrix function allows color adjustments to be applied only over the color range designated by the operator. The color spectrum is divided into 16

areas of adjustment, where the hue and/or saturation of each area can be modified.

For example, the hue and saturation of a flower's red petal can be changed, while keeping other colors unchanged. In addition to such special effects work, this function is also useful for matching color among multiple cameras, or for reproducing the color characteristics of another camera.



Normal



On

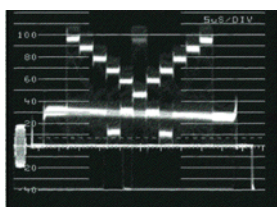
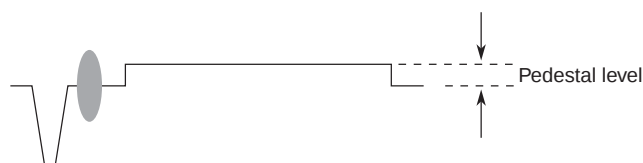
Pedestal/Master Black

Pedestal, also called Master Black, refers to the absolute black level or the darkest black that can be reproduced with the camera. On most cameras, pedestal can be adjusted as an offset to the set-up level. Since pedestal represents the lowest signal level available, it is used as the base reference for all other signal levels.

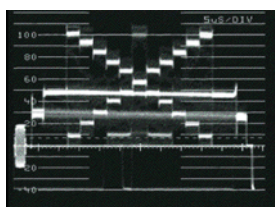
As shown below, if the pedestal level is set too low due to improper adjustment, the entire image will appear darker

than it should do (the image will appear blackish and heavier). If the pedestal level is set too high on the other hand, the image will look lighter than it should do (the image will look foggy with less contrast).

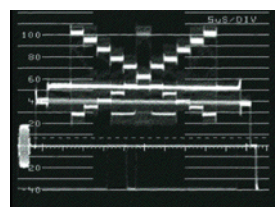
By taking advantage of the pedestal characteristics, it is possible to intentionally increase the clearness of an image when shooting a foggy scene or when shooting subjects through a window simply by lowering the pedestal level.



An image with low pedestal level



Normal



An image with high pedestal level

Preset White

As mentioned in the section on 'Color Temperature' (*refer to "Color Temperature"*), since cameras are not adaptive to the variation of the different spectral distributions of each light source, this variation must be compensated for electronically and optically. Taking white balance (*refer to "White Balance"*) refers to compensating for the different spectral distributions electronically. Choosing the correct color conversion filter (*refer to "Color Conversion Filters"*) is also imperative to achieving accurate white balance - to reduce the amount of white-balance adjustments that must be applied electronically.

Preset White is a white-balance selection used in shooting scenarios when white balance cannot be adjusted or when the color temperature of the shooting environment is already known (3200 K for instance). By selecting Preset White, the R/G/B amplifiers used for white-balance correction are set to their center value. This means that by simply choosing the correct color conversion filter, the approximate white balance can be achieved. It must be noted however, that this method is not as accurate as when taking white balance.

Reference File

For broadcasters and large video facilities, it is imperative that all cameras are setup to have a consistent color tone or 'look', specified by that facility. This is achieved by using common base-parameter settings for all cameras that govern the overall picture reproduction, such as gamma, detail and knee (*refer to "Gamma", "Detail Level", "Knee Aperture" and "Knee Correction"*).

Reference Files are used to store such user-defined reference settings so they can be quickly recalled, reloaded, or transferred from camera to camera. The parameters that can be stored in a camera's reference file may slightly differ between types of cameras. This difference is due to the different design philosophy of what base parameters should be commonly shared between all cameras.

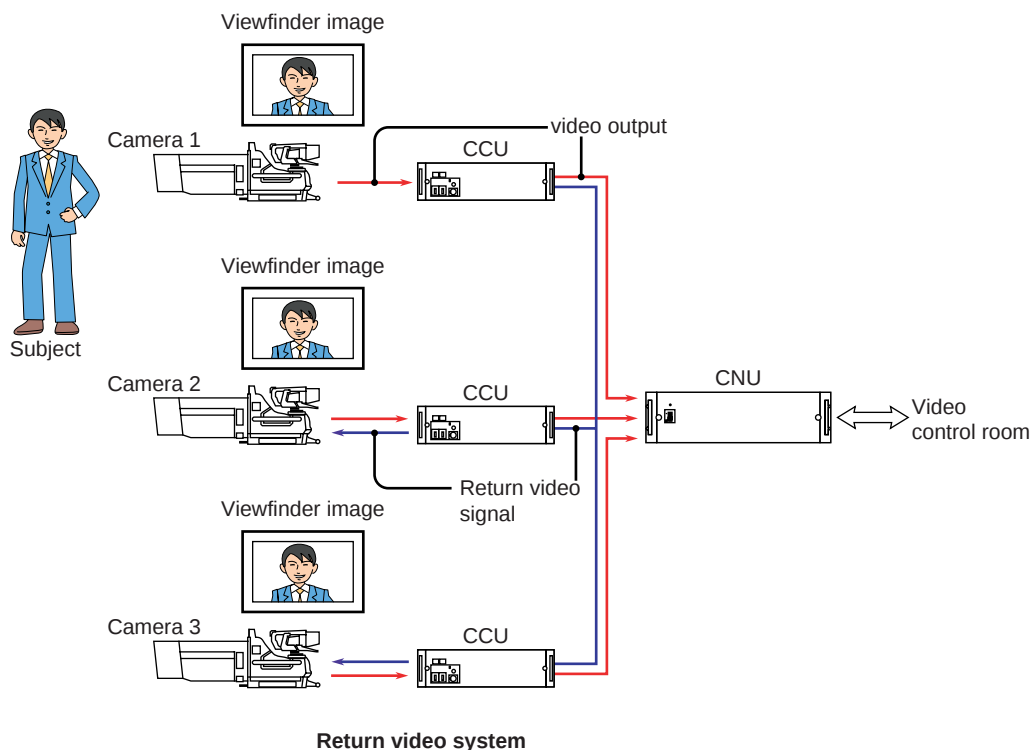
Return Video

In combination with the Intercom System (refer to “Intercom (Intercommunication) System”) and Tally Systems (refer to “Tally”), Return Video plays a vital role in multi-camera systems. The main purpose of Return Video is to allow a camera operator to view images captured by other cameras used in the system (or images being aired) by displaying these in the viewfinder of the camera he or she is operating.

As shown in the figure below, when Camera 1 is shooting a subject, this same image can be simultaneously displayed on the viewfinders of Camera 2 and Camera 3. This is done by routing the output signal of each camera to all other cameras within the system via their CCUs (refer to “Camera Control System”). In camera terminology, this signal is called the

Return Video. By using Return Video, the camera operator can switch the viewfinder to display the output of the camera he/she is operating, or the Return Video from other cameras in the system. In most professional cameras, two to four return-video signals can be accepted. Return-video signals are sent from CCU to CCU using a composite video signal since picture quality is not required.

The use of Return Video allows each camera operator to know how other cameras are framing the subject - camera angle, zoom, etc. This allows each camera operator to always be prepared to go on-air, with seamless switching achieved from camera to camera.



Scene File

Reference Files (refer to “Reference File”) store parameter data that govern the overall 'look' common to each camera used in a facility. Scene Files, on the other hand, are provided to store parameter settings for color reproduction particular to each 'scene'. Scene Files can be easily created and stored for particular scenes by overriding the data in the Reference File.

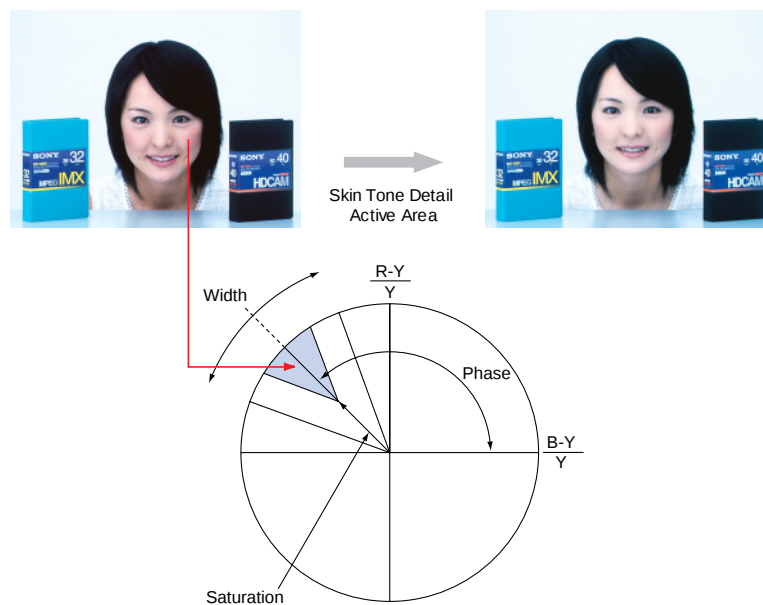
Scene Files allow camera operators to instantly recall the previously adjusted camera data created for scenes taken

outdoors, indoors, or under other lighting conditions whenever demanded.

Skin Tone Detail Correction

Skin Tone Detail Correction is a function that allows the detail level of a user-specified color to be adjusted (enhanced or reduced) without affecting the detail signals of other areas. Skin Tone Detail Correction was originally developed to reduce unwanted image enhancement (detail signals) on wrinkles, thus smoothening the reproduction of human skin. Simply by selecting a specific skin color, the detail signal for that skin can be suppressed.

Latest Sony professional video cameras come equipped with a function called Triple Skin Tone Detail, which allows independent detail control over three specified colors. This enhances the capability of Skin Tone Detail Correction - enabling one color selection to be used for reducing the detail level of skin color, and two other selections to be used for either increasing or decreasing the detail level of two other objects.



Sub-carrier Phase Control/Horizontal Phase Control

As mentioned earlier, genlock (refer to “Genlock”) is accomplished by supplying a master sync signal (refer to “Synchronization Signal (Sync Signal)”) to the genlock IN connectors of each camera within the system. This enables the frequencies and phases of the V sync, H sync, and sub-carrier of the output signals from all cameras to be synchronized with each other. However, when using a switcher in the system to switch from one camera to another, one other factor must be taken into consideration. To understand this, let's briefly review the mechanism of composite switchers.

In composite switchers, the processing for the creation of effects such as MIX and WIPE basically only uses the active picture areas of the input signals. Thus, the H-sync and burst are removed from the input signals at the switcher input. For example, a MIX effect is created by simply adding the active picture areas of the two signals. A WIPE is accomplished by using a key signal, which functions as a switch to determine which parts of the active picture areas of the two signals should be selected for output. In both cases, since the two signals must be combined into one, their sub-carrier phases

and H-sync phases must be perfectly matched before effect processing (at the input terminals of the switcher). After the effect is processed, the switcher adds an H-sync and burst signal generated from its own sync generator. For this reason, the input signals must also be synchronized with the switcher's internal sync generator.

Returning to our main subject, the reason that this system is not complete just by synchronizing the cameras, is because the sub-carrier phase and H-sync phase of each camera output varies due to length of the coaxial cable used between the camera and the switcher. Since the sub-carrier phases and H-sync phases of the two signals must be matched at the switcher inputs above, this variation in phase must be compensated for. This is done on the camera (or CCU) using the sub-carrier phase control and horizontal phase control.

Tally

Tally is a system equipped on professional camcorders and studio cameras that is used to alert those involved in the shoot to the status of each camera. The word 'tally' can be used to describe the entire tally system, the lamps used to indicate the tally signal, or the tally signal itself. In acquisition operations, a tally equipped on a camcorder usually refers to the REC Tally and is often distinguished from those used in a multi-camera studio system.

All professional camcorders have a 'tally lamp' on the front of the viewfinder (for the actor, announcer, etc) and one within the camera viewfinder. The primary purpose of this tally is to inform those who will be shot (all performers who will be shot by the camcorder) that the camcorder is recording (therefore called REC tally). When the camcorder is put into 'record' mode, the tally lamps on the viewfinder light in red.

In multi-camera studio systems, tallies play a different role - they inform both the performer and the camera operators

which camera in the studio is being put to air. In multi-camera systems, the camera output to be put to air (or recorded) is decided by the staff in the control room from the switcher control panel. When a camera is selected for on-air by the switcher, the switcher will also send a tally signal to the camera via the camera control unit controlling that camera. In this way, the camera contributing to the on-air signal will light its tally lamp in red informing both the performers and camera operators which camera is active. There are several tally lamps on studio cameras. The largest tally lamp is located on the upper-front of the camera body to be easily recognized by all staff in the studio. There are also tally lamps located on the viewfinders attached to the cameras that are used to communicate with the crew behind the camera, including the camera operator. Tally lamps are also provided on the camera control unit (usually located in the control room) as well as the video monitors in the control room.



Tele-Prompter

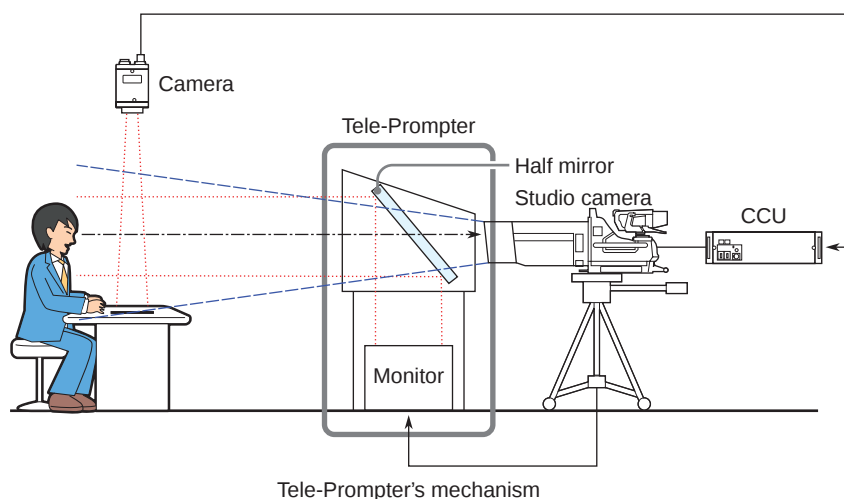
When watching news programs on TV, viewers usually notice newscasters delivering a sequence of stories without referring to a script or taking their eyes off the camera. To some, this may appear as the newscaster having a good memory, yet in most cases, they are actually viewing scripts displayed on a system called a tele-prompter.

As shown below, illustrating the traditional tele-prompter system, a ceiling mount camera above the desk is faced down to shoot the script. The image from this camera is sent to the studio camera via the CCU (refer to "Camera Control System"). In front of the studio camera, there is a device comprising two parts - a picture monitor facing upwards, and a half mirror to display the newscaster's scripts captured by the

ceiling mount camera. Key to this system is the half mirror, which allows the picture monitor screen to be seen by the newscaster, but appear transparent to the camera (operator). The video signal of the script images are fed to this monitor from the prompter output located on side of the studio camera. This mechanism allows the newscasters to view the script while looking straight into the camera lens.

All tele-prompter systems today generate the script from a computer, displayed on a computer screen viewed through the half-silvered mirror.

The tele-prompter system has been a very helpful tool to support newscasters all over the world.



TLCS (Total Level Control System)

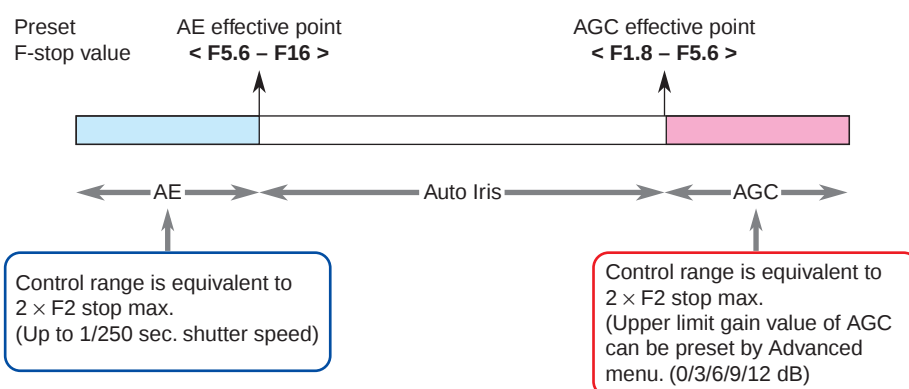
TLCS stands for Total Level Control System and is adopted in many Sony professional cameras and camcorders. TLCS has been developed to extend the Auto Iris range of the camera in a very innovative manner.

With conventional cameras, the Auto Iris range was limited to the smallest and widest opening of the lens iris (refer to "Iris"). TLCS widens this Auto Iris range by effectively using the lens iris, CCD electronic shutter, and Automatic Gain Control together to achieve proper exposure.

When proper exposure can be achieved within the lens iris range, TLCS will only control the lens iris. However, when

shooting dark images and sufficient video level cannot be obtained, even with the widest iris opening, TLCS will activate the Automatic Gain Control and boost the signal to the appropriate level. Vice versa, when shooting bright images and the incoming light is excessive even for the smallest iris opening, TLCS will automatically activate the electronic shutter so the video-signal level falls within the 1.0 V signal range. The overall result is that by activating TLCS, the proper exposure is automatically set for both dark and very bright shooting environments.

An Iris F-stop value for AGC or AE effective point can be pre-set by Advanced menu.



Triax

Triax is a unique transmission system widely used in broadcast camera systems due to its reliability, flexibility, and convenience. In brief, Triax is an interface system used for connecting a camera to its associated camera control unit, for the transmission of signals that must be communicated between the two devices.

In the earlier days of camera systems, multi-core interfaces were used, in which each signal was transmitted through an individual wire bundled within the multi-core cable. Although the multi-core interface was convenient for use in the studio, it also had a serious drawback - a limitation in transmission distance, most notable in outside-broadcasting applications. This was because thin wires had to be used to transmit each of the many signals through one multi-core cable.

The Triax system brought an innovative solution to this drawback. Instead of using one wire per signal, the Triax system allows all signals to be communicated between the camera and the camera control through one cable. Each signal is modulated on a carrier signal (frequency) specific to that signal so that signals do not interfere with each other. This allows the signals to be added together and transmitted through the same wire. It also allows bi-directional transmission from the camera to the camera head through the same wire. Since only one wire is used in a Triax cable, this allows a wide diameter wire to be used. Using a wide diameter wire naturally results in further transmission distances without signal level drop.

The result is a transmission distance of up to 2,000 m with the Triax system (when using a 14.5 mm diameter cable and a full rack CCU). The Triax system is state-of-the-art technology - allowing the communication of all signals between the camera and camera control unit through one simple and flexible cable connection. The figure shows the signals communicated and their frequency allocations.



Triax system

TruEye™ (Knee Saturation Function) Processing

TruEye processing is an innovative function that has been developed to overcome some of the drawbacks of conventional knee correction (refer to “Knee Correction”). This technology makes it possible to reproduce color much more naturally even when shooting scenes with severe highlights. In conventional cameras, knee correction is applied individually to each R, G, and B channels. The drawback of this method is that only those channels that exceed the knee point are compressed. As shown in the figure (a), let's assume that only red channel exceeds the knee point at a given time, T1. Since only the red channel will be compressed at the knee point using a preset knee slope, this results in a shift in the color balance between the red, green, and blue channels. This is observed as hue being rotated and saturation being reduced where the knee correction was applied.

The TruEye process overcomes this problem by applying the same knee correction to all channels, regardless of whether or not they exceed the knee point. This is shown in the figure (b) where only the red channel exceeds the knee point.

Since the green and blue channels are compressed using the same red knee slope, the balance between the three channels is maintained, while effectively achieving highlight compression for the red channel.

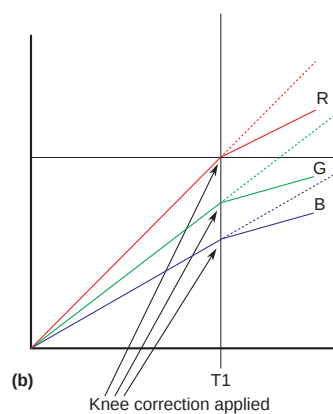
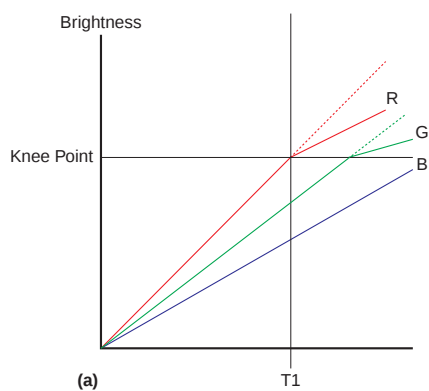
The effect of TruEye processing is observed in the color reproduction of highlight areas. As the below photos demonstrate, with TruEye turned off, the highlight areas are tinged with yellow, and when turned on, the correct color balance 'white' is reproduced.



TruEye OFF



TruEye ON



Turbo Gain

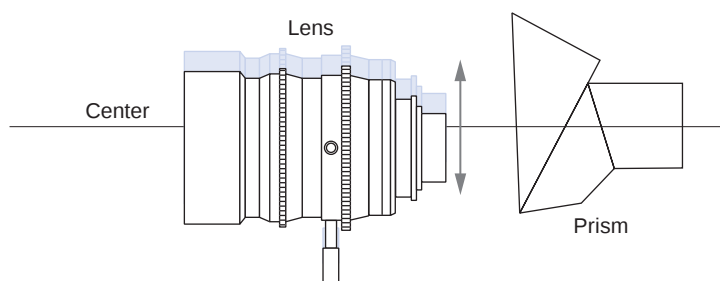
Turbo Gain is a function adopted in Sony video cameras and camcorders that helps shooting in the dark. Turbo Gain is

basically an extension of Gain Up (refer to "Gain") but offers a larger level boost (+42 dB) to the video signal.

V Modulation

V Modulation is a type of white shading (refer to "White Shading") that occurs when there is a vertical disparity in the center of the lens and prism axis. This causes the red and blue light components to be projected 'off center' of their associated CCDs, which results in green and magenta casts to appear on the top and bottom of the picture frame. V Modu-

lation is caused by the different characteristics of each lens and/or the different optical axis of each zoom position and can be compensated for on the camera. Since this compensation data directly relates to the lens, it is automatically recalled as parameters of the Lens File (refer to "Lens File").



White Balance

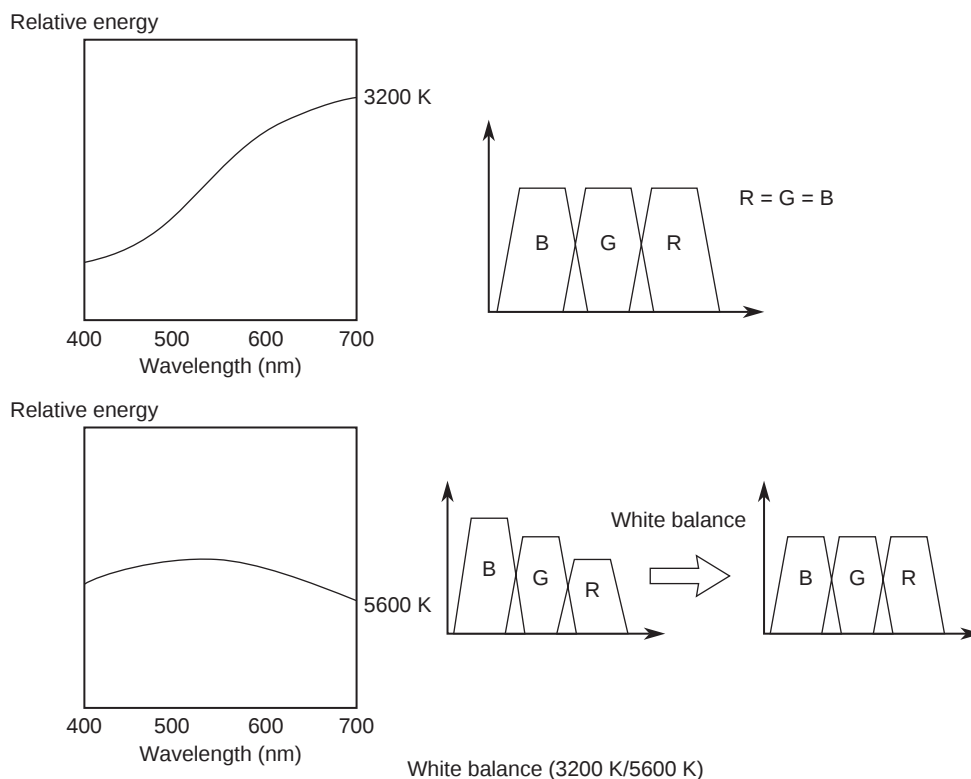
As mentioned in the section on Color Temperature (*refer to "Color Temperature"*), video cameras are not adaptive to the different spectral distributions of each light source color. Therefore, in order to obtain the same color under each different light source, this variation must be compensated for electrically by adjusting the video amps of the camera. For example, imagine shooting a white object. The ratio between the red, green, and blue channels of the camera video output must be 1:1:1 to reproduce white. This ratio must stay the same under any light source (when shooting a white object). However, as in the earlier discussions of Color Temperature, the spectral distribution of light emitted from each light source differs. This also means that the spectral distribution of the light that reflects from the white object and enters the camera prism will also change according to the light source. As a result, the output of the three red, green, and blue CCDs will vary depending on the light source under which the white object is shot. For example, when the white object is shot under 3200 K, the signal output from the blue CCD will be very small while that of the red CCD will be very large.

This relation reverses for a 5600 K light source.

As earlier mentioned, white can only be produced when the red, green, and blue video channels are balanced ($R:G:B = 1:1:1$), and therefore, electrical adjustments must be done at the CCD output. In the latter example (5600 K), the video amp of the blue CCD must be adjusted to have a gain smaller than 1, making the red, green, and blue signals equal in amplitude. This adjustment is called white balance. In brief, white balance refers to the adjustment of the video amps of the three CCDs, according to the color of the light source, to obtain a 1:1:1 ratio for the red, green, and blue signal levels in order to reproduce white.

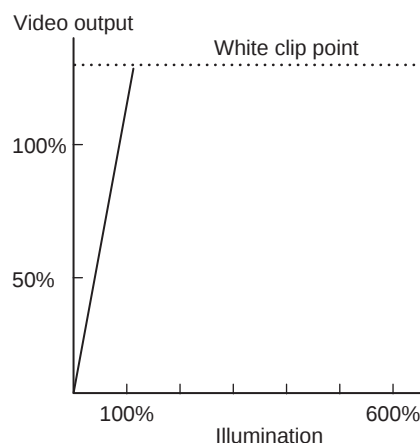
It is most important to note that, once white balance is adjusted, other colors come into balance as well. White balance should be adjusted frequently when the camera is used outdoors as color temperature changes rapidly with time.

Note: in the figure, white balance for 3200 K seems to require more adjustment of the video amps than 5600 K. However, the video amps of most cameras are pre-set to operate on color temperatures around 3200 K, and less gain adjustment is required.



White Clip

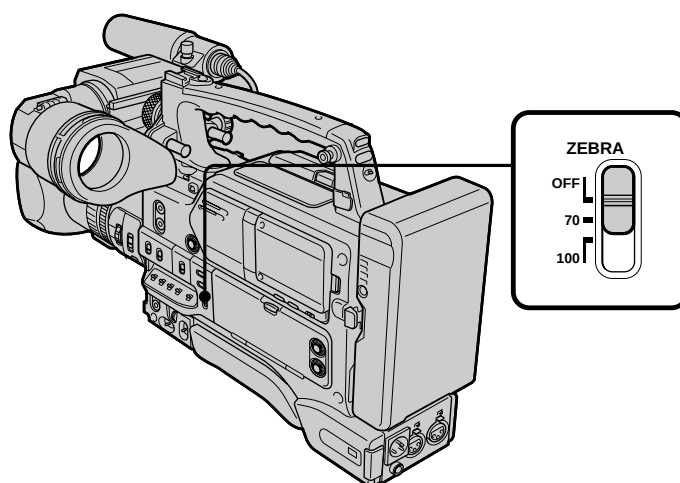
All cameras have white-clip circuits to prevent the camera output signals from exceeding a practical video level, even when extreme highlights appear in a picture. The white-clip circuit clips off or electrically limits the video level of highlights to a level, which can be reproduced on a picture monitor.



Zebra

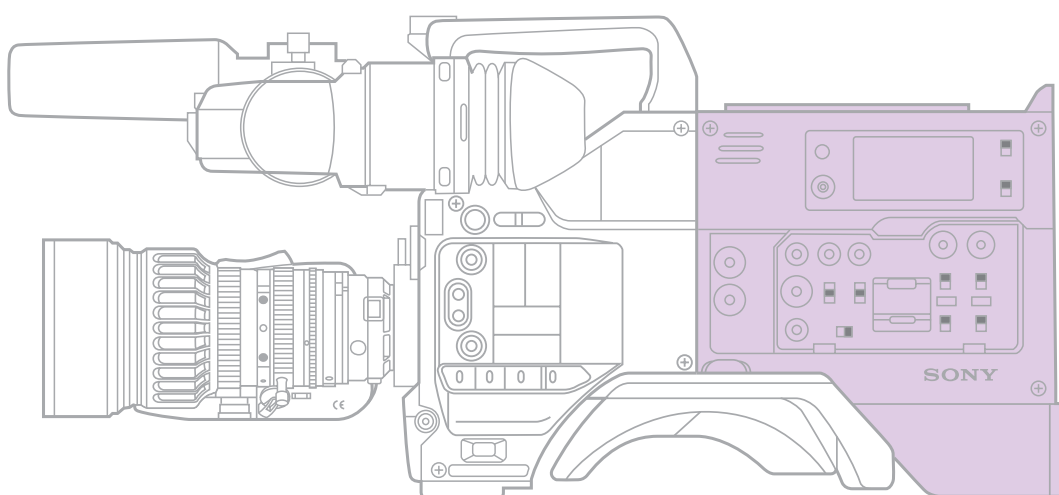
Zebra is a feature used to display a striped pattern in the viewfinder across highlight areas that are above a designated brightness level. This is particularly useful when manually adjusting the iris (F-number) of the lens (*refer to "F-number" and "Iris"*). Two types of zebra modes are available to indicate either 100 IRE or 70-90 IRE brightness level. They are used differently, so it is important to know which one to pay attention to. The 100 IRE Zebra displays a zebra pattern only across areas of the picture which exceed 100 IRE, the upper limit of legal video (100 IRE is pure white in NTSC

(refer to "NTSC/PAL") - even though the camera can expose well above this. White levels above IRE brightness are illegal for broadcast). With this zebra mode, the camera operator adjusts the iris until the zebra becomes visible in highlight areas. The second type, 70-90 IRE zebra, displays a zebra pattern on highlights between 70-90 IRE, and disappears above the 90 IRE level. This is useful to determine the correct exposure for the subject's facial skin tones since properly exposed skin (in the case of Caucasian skin) highlights are likely to fall within the 80 IRE areas.



The Basics of Camera Technology

VTRs



Optical System

CCD Mechanism

Camera Functions

VTRs

Others

ClipLink™/Index Picture/Automatic Logging Function

The ClipLink feature is a unique system adopted in DVCAM camcorders that allows shooting data to be effectively used in the entire production process. With conventional video cameras, shot lists (logging time code, etc.) were typically generated manually using a clipboard, a pencil, and a stopwatch. This method is not only time consuming but also tends to introduce errors, which requires additional work to deliver the correct edit data to the editor at the post-production process. The ClipLink feature relieves shooting crews from such a dilemma.

During acquisition with a ClipLink-equipped camcorder, the in-point/out-point time code of each shot, together with their OK/NG status, is recorded in the DVCAM Cassette Memory.

This data can then be transferred to the appropriate DVCAM editing VTR, and the in-point/out-point time codes can be immediately used as a rough EDL for the editing process. The ClipLink feature also generates a small still image of each in-point, called the Index Picture, which is recorded to the DVCAM tape. This provides visual information of each shot taken. When used with the appropriate logging software, the entire ClipLink data, including the Index Pictures, the in-points/out-points, and the OK/NG status, can be imported. This greatly enhances subsequent editing operation by relieving the editor from having to review all the tapes to pick up and sort the necessary shots before starting editing.

EZ Focus

EZ Focus is a feature employed in the high-end DXC series cameras and some DSR (DVCAM) camcorders to make manual focusing operation easier (this is not an auto-focus function). EZ Focus is activated by the touch of a button located on the control panel of the camera. When activating, the camera will instantly open the lens iris (*refer to "Iris"*) to

its widest opening, which shortens the depth of field (*refer to "Depth of Field"*) and in turn allows for easier manual focusing. During the mode, video level is managed properly by activating the electric shutter. The lens iris will be kept open for several seconds and will then return to the level of iris opening before EZ Focus was activated.



EZ Focus activated



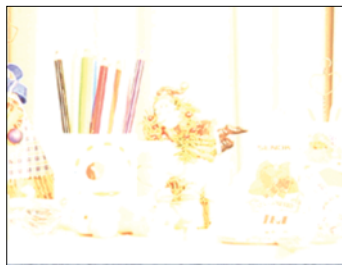
Focusing operation

EZ Mode

In newsgathering, the camera operator must be prepared to immediately start shooting for unexpected incidents. In such situations, it is most likely that there will be no time for adjustments. EZ Mode provides a solution.

EZ Mode is a feature that instantly sets the main parameters of the camera to their standard positions and activates the auto functions such as ATW (refer to “ATW (Auto Tracing

White Balance)”), TLCS (refer to “TLCS (Total Level Control System)”), and DCC (refer to “Dynamic Contrast Control (Automatic Knee Control)”). This is achieved by simply pressing a button located in a position that can easily be accessed when the camera is mounted on the user's shoulder. EZ mode is also fully automatic.



EZ Mode OFF



EZ Mode activated

SetupLog™

SetupLog is a unique feature adopted in high-end DVCAM camcorders. This function automatically records, or logs, the camera settings - including the iris opening (refer to “Iris”), the gain up setting filter selection (refer to “Gain”), as well as basic and advanced menu settings - to a DVCAM tape. SetupLog data is constantly recorded to the Video Auxiliary data area of the DVCAM tape while the camcorder is in Rec mode

- therefore making it possible to recall the camera settings that were used during any given shoot. SetupLog is particularly useful when the camera must be serviced, since the technician can recall the camera settings that were used when a recording was not made correctly to examine what when was wrong.

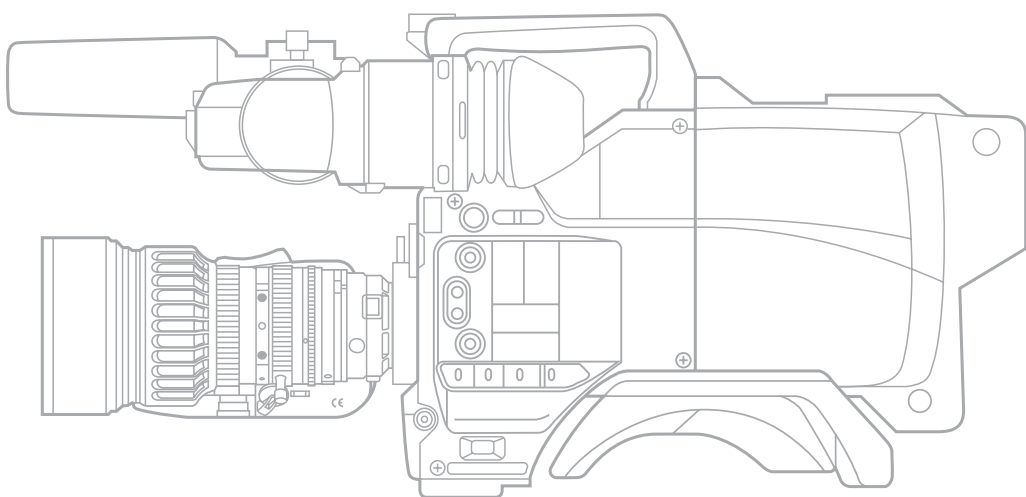
SetupNavi™

SetupNavi is a unique feature adopted in high-end DVCAM camcorders. As opposed to SetupLog (refer to “SetupLog™”), which takes a log of the camera settings in real-time, SetupNavi is specifically intended for copying camera setup data between cameras using a DVCAM tape as the copy medium. Activating this feature allows all camera setup parameters, including the key/button settings, basic and advanced menus, service menus, etc to be recorded to a DVCAM tape. It is important to note that SetupNavi data is recorded only when

activated by the operator and that the DVCAM tape used to record this data cannot be used for other purposes. SetupNavi is particularly useful in the studio to copy setup data between multiple cameras. It is also convenient when the camera is used by multiple operators or for multiple projects, since the exact camera settings can be quickly recalled by inserting the DVCAM tape with the SetupNavi data.

The Basics of Camera Technology

Others



Additive Mixing

Prior to the development of the color video system, experiments in colorimetry proved that most hues visible to the human eye could be composed using the three primary colors, red (R), green (G), and blue (B) (figure A). This fact also holds true when separating a specific hue - that is, any hue can be separated into a combination/amount of these three primary color components. This is called Additive Mixing. The mechanism of reproducing color on a picture monitor is based on this principle and is a good example to understand how Additive Mixing works.

In a video monitor CRT tube, three R, G, and B guns each emit electrons (electron beams) corresponding to the amount of the R, G, and B components in the hue that is to be reproduced (figure B). This results in the emission of light from each of the R, G, and B phosphors with their intensities pro-

portional to their associated electron beams. To the human eye, these lights are seen as one light beam with the appropriate hue reproduced when viewed from a certain distance. The mechanism of a color video camera uses a reverse function as compared to a picture monitor. The light that enters the camera's lens is first separated into the three primary colors, R, G, and B using a prism system (refer to "Prism") known as the dichroic mirror. These color light components are converted into R, G, and B signal voltages at their associated R, G, and B CCD imagers. The R, G, and B signals are then processed into the appropriate signal formats to construct the output signal.

*Note: In the Sony Trinitron®, only one gun is used to emit the three R, G, and B electron beams.

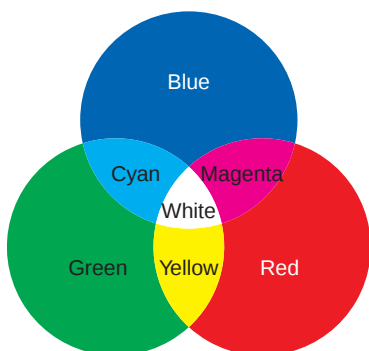


Figure A

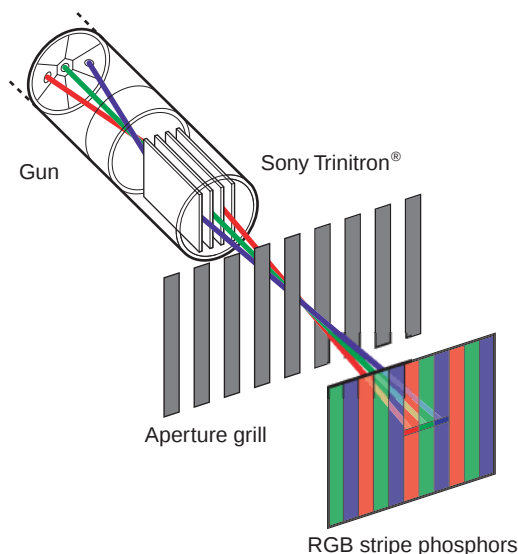


Figure B

Camera Control System

In multi-camera studio systems, it is important to know what each device in the system does and how it is used. In addition to the cameras, multi-camera systems comprise four key elements - Camera Control Units (CCU), a Master Setup Unit (MSU), Remote Control Panels (RCP) and a Camera Command Network Unit (CNU).

Camera Control Unit (CCU)

In multi-camera systems, one CCU is used for each camera as shown below. The CCU plays two important roles. As its name indicates, the CCU functions as the control interface between the camera and the control panels that provide the

control knobs and buttons to setup the camera - the later-mentioned MSU and RCPs. The second key function of a CCU is to provide the interfaces for transmitting video and audio between the camera and external devices. For example, the camera output is sent to the switcher system through the output of the CCU. Conversely, the Prompter (refer to "Tele-Prompter") signals and Intercom Signals (refer to "Intercom (Intercommunication) System") are sent to the camera by supplying them to their associated inputs provided on the CCU.

■ Master Setup Unit (MSU)

The MSU provides central control of all cameras used in the system. In brief, the MSU provides the control buttons and knobs to make all setting changes, including general and detailed, to each camera in the system. The MSU uses a delegation system, meaning that the controls on the MSU panel are delegated to the selected camera. This allows each camera to be centrally setup from a single MSU. The MSU is usually used to make overall or general settings of each camera before the shoot.

■ Remote Control Panel (RCP)

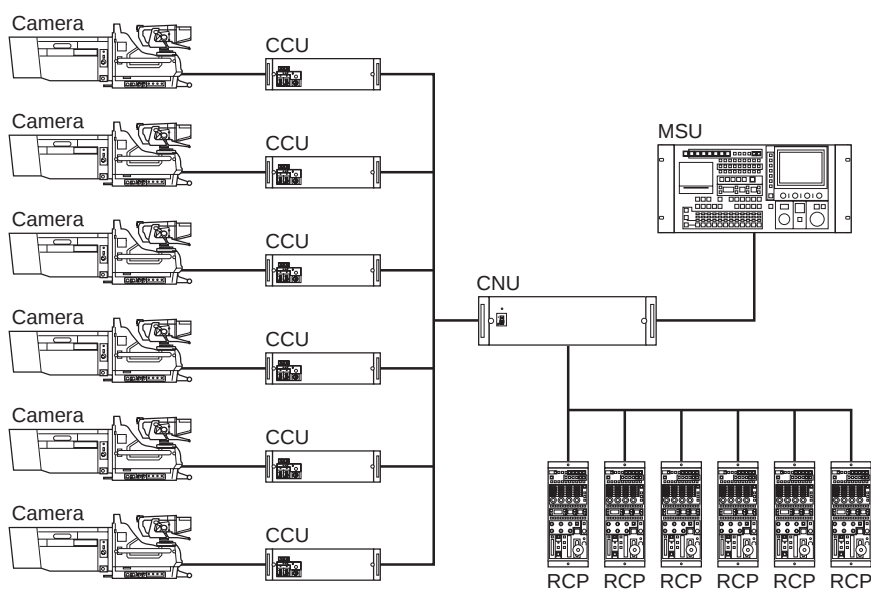
The RCP is a remote control panel for dedicated control of a single camera. Therefore, one RCP is used per camera. The RCP connects either to the CCU or the later mentioned CNU. In a multi-camera system, RCPs are generally used to

override the general settings made on the MSU and make them appropriate for the given camera. Also, any adjustments made during the shoot are made on the RCPs since these are exclusive to each camera.

■ Camera Command Network Unit (CNU)

The CNU can be considered a control signal router since it is used to route the control signals from each control panel (RCP, MSU) to the appropriate CCU. Typical CNUs allow the connection of up to 12 RCPs (for up to 12 cameras) and one MSU. This facilitates the connection of the control panels in a large-scale system since the user can connect all remote panels into a single connector panel.

Smaller multi-camera systems can be built without the use of a CNU. In this case, RCPs must be connected directly to their associated CCUs, and the control from the MSU must be daisy-chained between CCUs.



Color Signal Forms

■ RGB

The RGB signals give most faithful reproduction to both the original brightness and color of the subject shot with a camera as these signals are obtained directly from the R, G, and B imagers. Each one of the R, G, and B signals contains information on both its brightness and color. Maximum information on both brightness and color are provided in this form.

■ Y/R-Y/B-Y

The Y/R-Y/B-Y signal is obtained by applying the RGB signals to a matrix circuit, which uses defined coefficients. Information on the brightness of the three RGB signals is converted into one signal called the luminance signal (Y), while information on color is converted into two signals called the color difference signals (R-Y/B-Y). Information on luminance is equivalent to that of the RGB signal. The bandwidth of the color (R-Y/B-Y) derived from the RGB signal may be limited to some extent (around 1.5 MHz) but sufficiently covers the human eye's sensitivity (resolution) to fine detail of color, which is much lower than that of brightness.

■ Y/C

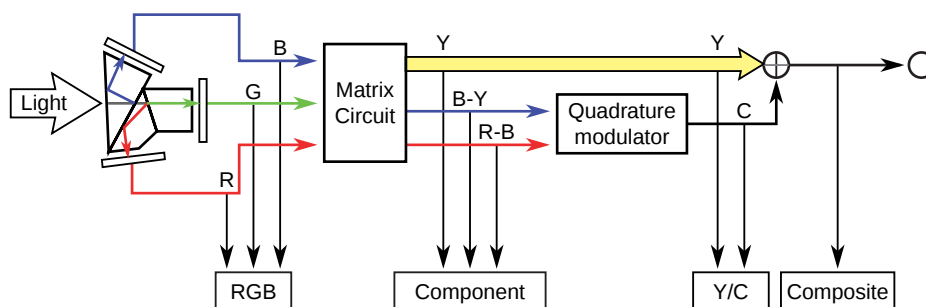
The Y/C signal is obtained by use of an R-Y/B-Y encoder. The R-Y/B-Y signals are modulated on a 3.58-MHz** subcarrier using quadrature modulation and are combined into one chrominance signal (C). The bandwidth of the brightness signal is the same as the Y component of the Y/R-Y/B-Y signal. The bandwidth of the color is equivalent to that of the R-Y/B-Y signals but slightly distorted due to the quadrature modulator and the band-pass filter used to eliminate high-frequency harmonics.

*In actuality, in NTSC system, an I/Q encoder is used.

**3.58-MHz for NTSC, 4.43-MHz for PAL.

■ Composite

The luminance (Y) and chrominance (C) signals of the Y/C signal are added to form one signal, which contains both brightness and color information. The quadrature modulator mentioned above uses a color carrier signal with a frequency of approx. 3.58 MHz for NTSC and 4.43 MHz for PAL, so the resultant chrominance (C) signal's spectrum interleaves with the luminance signal's spectrum. This prevents the two signals from interfering with each other when added together to form the composite signal. This method allows the composite signal to be separated back into its luminance and chrominance components for display on a picture monitor.



Production of color video signals in camera using an R-Y/B-Y encoder

Decibels (dB)

In electronics, it is often required to handle signal levels over a very wide range. The use of logarithm provides an easier way of expressing both small and large values. It is also more convenient to know the ratio between a signal's amplitude and one defined signal (e.g., 1.0 V in video electronics) rather than to know the actual amplitude of the signal. For these reasons, decibels are used to express signal level. Decibels are defined with the following equation:

$$\text{dB} = 20\log(v'/v) \quad (v': \text{typical signal level})$$

By rearranging this we have

$$v' = v \times 10^{\text{dB}/20}$$

As the relative magnitude is being discussed, by substituting $v = 1$ the given equation is

$$v' = 10^{\text{dB}/20}$$

The following chart shows some examples of the above calculation.

dB	ratio
-60	0.001
-50	0.00316
-40	0.01
-30	0.0316
-20	0.1
-10	0.316
-3	0.708

dB	ratio
0	1.0
+3	1.413
+6	1.995
+9	2.818
+12	3.981
+15	5.623
+18	7.943

Here it should be noted that a 20-dB drop in signal level means a one-tenth drop in amplitude, 6 dB is almost equal to a factor of 2, and that conversion from -dB to +dB is given with the reverse proportion.

The use of decibels also allows easier calculation since multiplication is handled as addition. A typical example is the total gain of a series of amplifiers, which is calculated by adding each amplifier's gain expressed in decibels.

Dynamic Range

In general, dynamic range indicates the difference or ratio of the smallest and largest signal that can be handled by a device. Although seldom used in camera technology, the term dynamic range is sometimes used to indicate the ratio between the smallest and largest amount of light that the imaging device can capture. With 2/3-inch CCDs, this is normally 600% while 1/2-inch CCDs have a dynamic range of 300%. The definition in this case is based on the amount of

light required to produce a 1.0 Vp-p video signal, which is 100%. This means that an imager with 600% dynamic range has the capability to produce a video signal with six times the amplitude of the 1.0 V video standard. Technologies such as Knee Correction, DCC, and DynaLatitude are used to compress this amplitude into the 1.0 V range (refer to “Knee Correction”, “Dynamic Contrast Control (Automatic Knee Control)”, and “DynaLatitudeTM”).

HD/SD (High Definition/Standard Definition)

HD and SD stand for High Definition television and Standard Definition television systems respectively. High Definition television provides much higher picture quality due to the use of more effective vertical scanning lines as compared to NTSC (525 lines) PAL (625 lines) standard-definition systems

and more pixels per line 1920 as compared to 720 for SD. Since high-definition equipment is geared towards high-end applications, they are usually designed to provide superior resolution.

Horizontal Resolution

This term describes the camera's capability of reproducing the details of its subject. It is expressed by the number of black and white vertical lines resolvable within three-fourths the width of the picture. It is important to note that horizontal resolution does not refer to the number of resolvable lines within the total picture width. This is because it must be expressed under the same conditions as vertical resolution and thus only three-fourths the picture width. Horizontal resolution is usually measured by framing a resolution chart.

The camera's horizontal resolution is known by reading the maximum calibration of the vertical wedges where the black and white lines can be resolved. Horizontal resolution is also measured as the maximum number of vertical black and white lines where the camera output exceeds 5% video level. Measurement of horizontal resolution must be performed with gamma (refer to “Gamma”), aperture, and detail (refer to “Detail Level”) set to 'On', and masking set to 'Off'.

Interlace/Progressive

Interlace is a scanning method, which has been adopted into today's television broadcast system such as NTSC and PAL (refer to "NTSC/PAL"). In brief, interlace scanning refers to scanning every other TV line of an image as the first field, and then scanning lines in-between as the second field. Interlace scanning is a method that has been inherited from the black and white TV days, it is worthwhile to know why this continues to be used in the NTSC color broadcast system. To display motion pictures on a video monitor with negligible flicker, tests have demonstrated that at least 50 to 60 images must be displayed within one second (here, film is an exception). However, the bandwidth available for broadcasting the TV signal (6 MHz in NTSC areas, 7 MHz in PAL areas) was not wide enough to transmit 60 full images per second. Apparently, it was required to consider a solution to reduce the signal's bandwidth but with minimum quality loss. After thoroughly investigating the human eye characteristics, a solution was found. The result was to use a 1/60-second rate for each scan, but in the first scan, from the top to bottom of the image, only the odd-numbered lines (1, 3, 5...525) are scanned, and for the

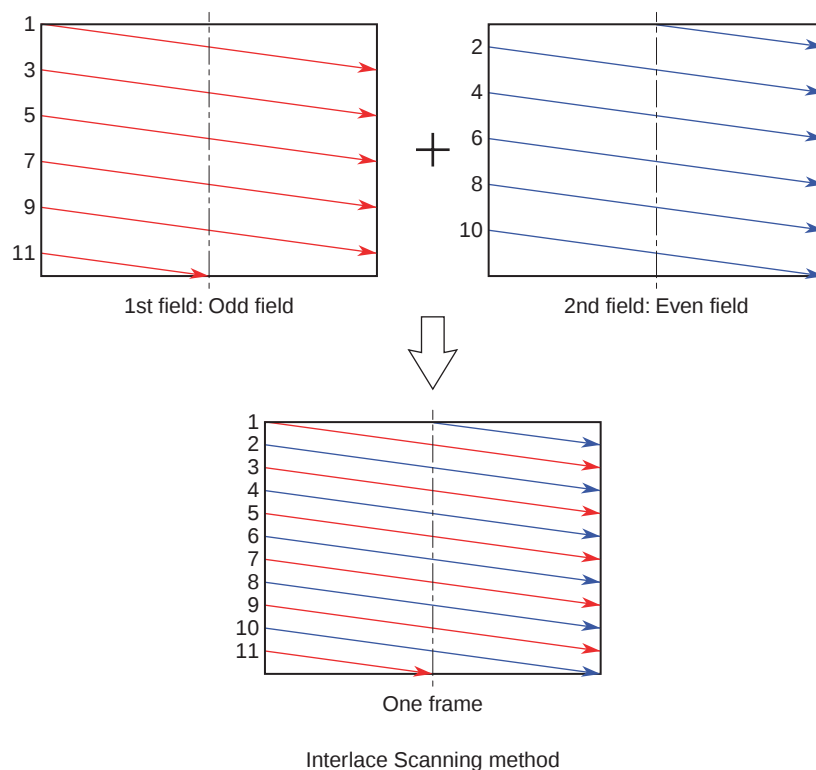
next scan, only the even-numbered lines (2, 4, 6...524) are scanned.

Since the image rate is 60 per second, this was successful in keeping flicker to a negligible level. Also, through visual experiments, it was found that despite the line scan of each frame being reduced to one-half, the drop in vertical resolution was only 70% of the total 525 (625 for PAL) TV lines. This is due to the human eye characteristics of seeing an after-image due to the short 1/60-second field rate. In this way, researchers decided to use the above interlace scanning method for the NTSC and PAL TV systems.

Newer broadcast transmission infrastructures are less limited in bandwidth. This gives the broadcaster the option of using an interlace system or a non-interlaced system - the latter known as progressive scanning.

The progressive scanning system has been adopted in computer displays, which do not require considerable transmission bandwidth.

In progressive scanning, each line is scanned in order from the very top to bottom. The entire 525 lines (or 625 lines for PAL) are displayed in one scanning operation. Thus superior vertical resolution is achieved.



Minimum Illumination

Minimum Illumination indicates the minimum amount of light required for shooting with a certain camera. It is expressed in Lux. When comparing minimum illumination specifications, it is important to consider the conditions they were measured at.

All cameras provide a Gain Up (refer to "Gain") function to boost signal level. Although convenient for shooting under

low light, Gain Up also boosts the signal noise level. Minimum illumination is usually measured with the highest Gain Up setting provided by the camera, and therefore does not represent the camera's sensitivity in any way. Simply put, it is best to have a high minimum illumination at a relatively smaller Gain Up setting.

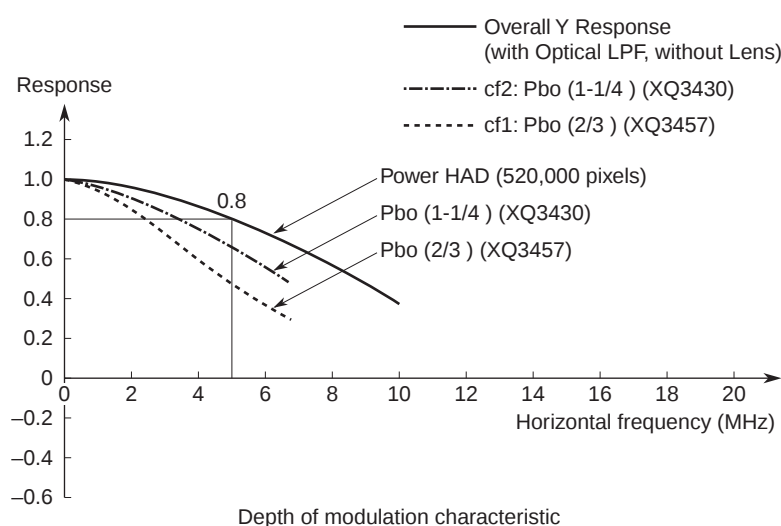
Modulation Depth

Modulation Depth is an important factor that governs the resolving performance of a video camera. While Horizontal Resolution (refer to "Horizontal Resolution") is used to indicate only the resolving ability, it is equally important to know the Modulation Depth - the camera's resolving performance for frequency range practically used in video bandwidth. Although, horizontal resolution does indicate the ability to reproduce fine picture detail, it can somewhat be misleading when judging a camera's performance. This is because horizontal resolution only defines the finest level of detail that is viewable - not clearly or sharply viewable. Modulation Depth, on the other hand, is used to indicate how sharp or how clear an image is reproduced. For this reason, modulation depth focuses on the response of the frequency ranges most used in video.

Simply put, it is the frequency response in practical frequency ranges that governs the camera's sharpness - not the horizontal resolution.

A camera's frequency response is usually measured by shooting a Multi Burst chart. A typical frequency chart has vertical black and white lines which, when converted to video, translate into 0- to 5-MHz signals. When measuring Modulation Depth, usually the 5-MHz area is used. This is because 5 MHz is a frequency that best represents a video camera's performance. The closer the response is to 100% at 5 MHz, the higher the capability to reproduce clear and sharp picture details. Modulation Depth of video cameras for standard definition broadcasting is typically in the range between 50% to 80% (at 5 MHz).

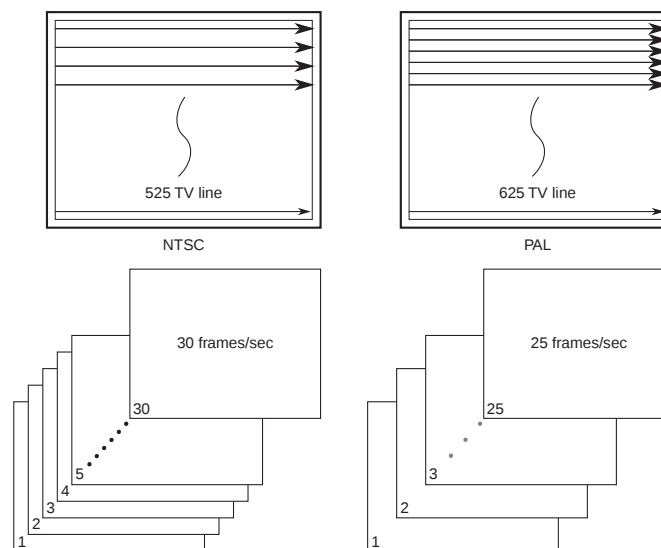
It must be noted that Modulation Depth can be influenced by the performance of the camera lens and thus measurements should be conducted with an appropriate lens.



NTSC/PAL

NTSC is an acronym that stands for National Television Systems Committee. This is an organization that stipulated the standards for the NTSC television systems. When used in video terminology, NTSC refers to color television systems used in North America, Japan, and parts of South America. It employs an interlace scanning system (*refer to “Interlace/Progressive”*) of 525 lines per frame/30 frames per second. PAL is the acronym, which stands for Phase Alternate by Line. This term refers to the color television system mainly

adopted in Europe, China, Malaysia, Australia, New Zealand, the Middle East, and parts of Africa. It has an improved color coding system that reduces the color shift problem that sometimes happens with NTSC color coding. Most countries that use PAL It employs an interlace scanning system with 625 lines per frame/25 frames per second. Some systems, for example, PAL-M as used in Brazil, use PAL color coding with 525 line 60 Hz scanning.



PsF (Progressive, Segmented Frames)

PsF stands for Progressive, Segmented Frames. This abbreviation is used to transcribe types of high-definition progressive video formats (*refer to “Interlace/Progressive”*), which are distinguished from the pure high-definition progressive video formats. The PsF method has been originated to retain the compatibility of progressive frames with interlaced signals represented by the major SDTV formats employed. In the 24 PsF format for example, each progressive frame is handled as two segments and time shifted (each separated segment is treated as an odd and even field) by 1/48th of a second. Complete progressive picture frames from acquisition

devices (telecine, camcorder, studio camera, etc.) are divided into two segments and travel through the HD SDI (*refer to “SDI”*), base-band interface (or through the SDTI infrastructure in a compressed form) in the same manner as an interlaced signal. These are then reconstructed into full progressive frames at the receiving device. Although the segmented signal structurally resembles an interlaced signal, it should NOT be confused with interlace images. The segmented frame format is approved by the ITU Rec. 709-3 and is supported by most major manufacturers.

RS-170A

RS-170A is a color-synchronization signal standard enacted by EIA (Electronic Industries Association). This standard includes additional regulations that did not exist in the original color-synchronization signal standard enacted by FCC (Federal Communication Commission). The main objective of adding these regulations was to prevent hue differences on TV receivers depending on the broadcast station or program. However, the rapid technical advances seen in TV receivers have reduced the above hue differences, and these additional regulations have become of less importance, except in the following cases:

1. When using video switchers with automatic video-delay lines.

In switchers with automatic delay lines, the phases of the input video signals are adjusted by detecting the burst signals. Thus, when switching from one signal to another, the SC-H phase (phase between the sub-carrier and horizontal sync chip) of the input signals must be maintained within a defined range.

S/N (signal-to-noise) Ratio

Although many techniques have been developed for the reduction of noise, it is still unavoidable in any class of device. In cameras and other video equipment, noise level is expressed in terms of S/N ratio (signal-to-noise ratio). S/N ratio is defined in decibels (dB) and is calculated by taking

Otherwise, sync shock may be caused during switching.

2. For color-framing servo control

In composite VTRs, the CTL signal is used for color-frame servo lock. Pulses that indicate the first field of the color-framing sequence are written on the CTL track of the tape by detecting the SC-H of the first field when the video signal is input to the VTR. If the SC-H is not maintained as regulated, the pulses on the CTL track, which should indicate the first field, will not be written in the appropriate area. Thus color-frame capstan lock cannot be accomplished.

3. In digital devices

The A/D converters in digital VTRs and TBCs use the sub-carrier as the reference for A/D conversion timing. If SC-H is not maintained, A/D conversion will take place at the wrong areas, and will result in picture shift when the signal is reproduced on picture monitors.

SDI

SDI is an acronym that stands for Serial Digital Interface. SDI is an industry-standard interface designed for transmitting non-compressed (known as baseband) digital video and audio. SDI has become extremely popular for two reasons - its compatibility with analog coax cables and for its long transmission distance. The SDI interface is offered in three versions: composite digital SDI (standard definition), component digital SDI (standard definition) and HD-SDI (high definition). SDI offers the following advantages over analog I/Os:

1. Virtually degradation-free picture and audio quality by noise-resistant digital transmission.
2. Conventional coax cable can be used.
3. Only one BNC cable required for connecting video, audio, and time code.
4. Longer transmission distance (as compared to analog) allows flexible cabling (up to 200 m for SD and 100 m for HD)

Technically, the transmission rates are 270 Mbps and 1.5 Gbps for standard-definition SDI and high-definition SDI, respectively.

Sensitivity

The sensitivity of a camera is described by the iris (*refer to "Iris"*) opening required to provide a video signal with sufficient level under a specified lighting condition. In general, sensitivity is measured using a 89.9% reflectance grayscale chart illuminated with a 2000 lux, 3200K illuminant. The camera's F-stop (*refer to "F-number"*) provides a white video level of 100% when the chart is shot is the sensitivity of the camera. In CCD cameras, sensitivity is mainly determined by the aperture ratio of the photo-sensing sites. The more light gathered onto each photo sensor, the larger the CCD output, and the higher the sensitivity. However, it is also

important to know that the true sensitivity may differ from the total sensitivity of the camera. This is because the total sensitivity of a camera correlates with the camera's S/N ratio. That is, the camera's sensitivity can be improved by increasing the gain of the video amp, but with a drop in the camera's S/N ratio. An example of sensitivity specification is shown below.

F5.6 at 2000 lux (3200K, 89.9 reflectance)

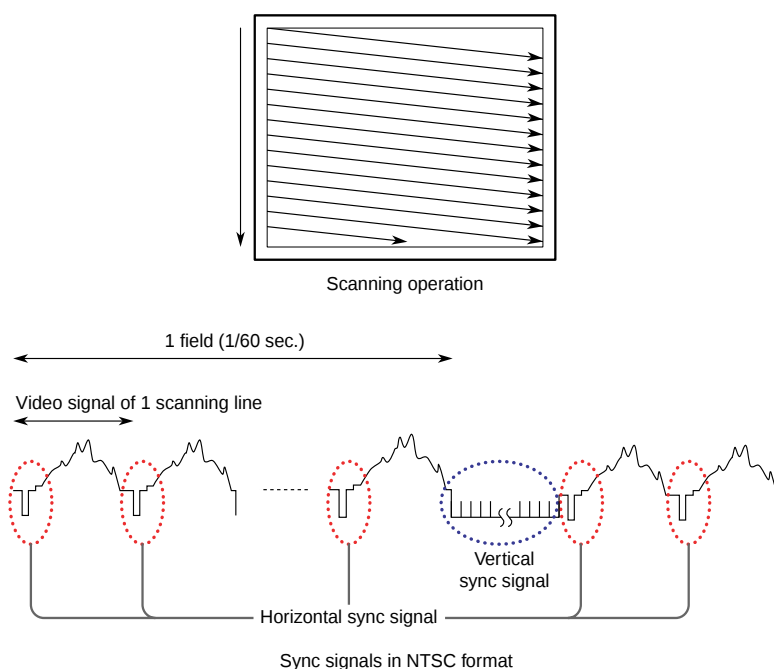
*Note: the gain selector must be set at 0 dB.

Synchronization Signal (Sync signal)

Synchronization signals play important roles for a picture to be correctly displayed on a video monitor. These are mixed in the video signals to lock the timing of the camera images to the picture monitor's scan. There are two kinds of the synchronization signals: the Horizontal synchronization signal (HSYNC) and the vertical synchronization signal (VSYNC). To better understand these sync signals, let's review the scanning operation of a picture monitor.

On the picture monitor, the electron(ic) guns that project the electron beams start scanning the screen phosphor from the upper-left corner, and then move towards the upper right corner. After reaching the upper right corner, the scan is shifted down vertically to scan the subsequent line from the left to right again. This operation repeats until the very bottom line

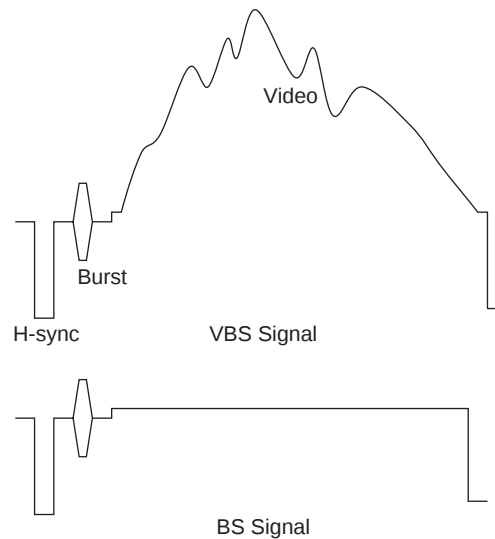
is scanned, the scan then returns to the top center of the display to scan the next field (in case of interlace scanning - *refer to "Interlace/Progressive"*). The horizontal sync synchronizes the timing that the electron beam returns from bottom to top to the first video line in each field. In this way, the video signal is scanned so the picture is correctly positioned in the video monitor. operation will be repeated until the very bottom line is scanned, then go back to the upper-left to scan the next field (in case of interlace scanning - *refer to "Interlace/Progressive"*). HSYNC is the signal that synchronizes the timing when electron beam return from right-end to left-end of the monitor screen in this operation. VSYNC synchronizes the timing of vertical direction when electron beams return from bottom to top.



VBS/BS Signal

The VBS (Video Burst Sync) signal is a composite video signal in which the active video area contains picture content or color bars. As opposed to the VBS signal, the BS (Burst

Sync) signal does not contain picture content and the active video area is kept at setup level.



Vertical Resolution

Vertical resolution describes the fineness of images in the vertical direction. While horizontal resolution (*refer to "Horizontal Resolution"*) varies from camera to camera and is used as a reference to describe picture quality, vertical resolution is determined only by the number of scanning lines in the particular TV format. For example, the vertical resolution

of all existing NTSC video equipment is 525 TV lines (to be precise, the effective vertical resolution is 486 TV lines due to interlace scanning) regardless of the different horizontal resolutions each equipment provides. Therefore, unlike horizontal resolution, vertical resolution is usually of less concern when evaluating a camera's performance.

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Acknowledgement

With the advent of sophisticated information networks made possible by the development of the Internet, we now have the capability to search and access the information we need much more easily and quickly than ever before. However, in my searches for information, I could not locate any documentation or literature that comprehensively explains professional video camera terminology in a manner that is easily understood by the layman. All of my searches turned up documents that were highly technical and very difficult to comprehend for people who are new to this industry or are unfamiliar with technical language and jargon.

I felt that, "There should be some solution to this lack of good information." And, this is how the production of this document began.

My goal in creating this document was to cover most of the basic terminologies that I feel to be significant in understanding professional video cameras. I also paid special attention to write in a style so that explanations are comprehensible to even those who have a limited technical background.

I hope that this document invites its reader to become a part of the world of professional video cameras and that it provide a helpful solution in making a induction process a smooth one.

Creating this document is the result of more than my individual effort. Without the support and cooperation of my colleagues in a number of different departments within Sony Corporation, this document could not have been completed. I would like to thank all of those who have been involved in this project.

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The Basics of Camera Technology