

Selecting the Right CCTV Camera

Introduction

Regardless of the technologies you use to design and implement a CCTV security system, there are a number of issues that must be addressed in all situations. First, what information do you want the system or component to provide? There are three possible answers:

- **Detection** – indicate something is happening in the field of interest
- **Recognition** – determine exactly what is happening
- **Identification** – determine who is involved in the activity



BOSCH

Invented for life



Detection



Recognition



Identification

Your answer will affect the type of equipment you need for a given CCTV application. In addition, there are other basic considerations that influence CCTV system design – and, of course, your budget. These include:

- Required image quality
- Size of the field of interest to be viewed
- Available light (there may be a need for supplemental lighting)
- Environment in which the equipment will be used (indoor vs. outdoor, standard vs. high-risk for damage)
- Power source

Each of these affect your CCTV design. For example, if a more accurate representation of a scene is required, your design specifications might call for color cameras as opposed to monochrome. While more detail and resolution can be acquired using a low-light black and white or day/night camera. As a rule of thumb, color cameras and monitors should be used in systems that will be used for identification purposes.

CCTV Camera Basics

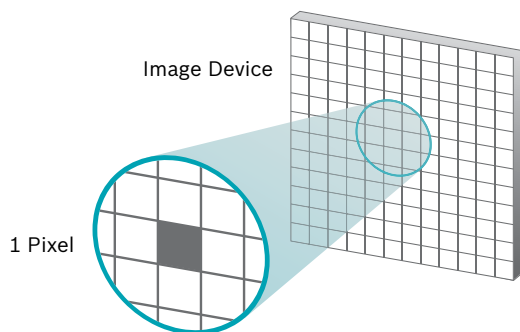
Specification of the right CCTV camera can seem like a complex process: there are many factors to take into account. But overall, all cameras are composed of three basic elements:

- Image sensor – converts light image to electronic signals
- Lens – gathers light reflected from a subject
- Image processing circuitry – organizes, optimizes, and transmits signals

CCTV cameras are available in monochrome, color, and day/night (combines color and monochrome). Monochrome's advantages are higher resolution, less light required, and generally lower cost. Color, on the other hand, offers better overall representation of a scene (with proper light), as well as improved capabilities for identification and prosecution. Day/night cameras offer the best of both worlds – and they are increasingly becoming the camera technology of choice for both outdoor and indoor applications.

Image Sensors

The heart of the modern CCTV camera is the Charge Coupled Device (CCD) sensor. A CCD consists of a flat array of tiny, light-sensitive photodiodes that converts light into an electrical signal. Each diode produces a voltage that's directly proportional to the amount of light falling on it. No light would produce zero voltage, and therefore, a black level. Maximum light would produce a maximum voltage (a white level). In between these extremes are shades of grey. In the case of a color camera, a chrominance signal is superimposed onto the luminance signal to carry the color information.



The camera processes this electrical signal and converts it to a video signal output, which is then recorded or displayed on a monitor. The range of light levels that a CCD can handle is somewhat limited, so the light range that the CCD receives must be restricted within certain limits.

Video Signal

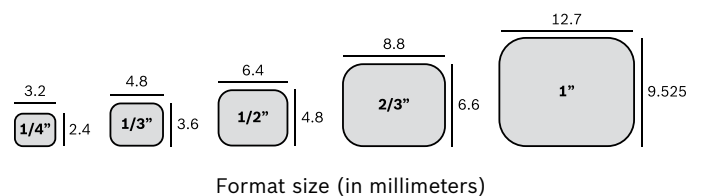
All video motion images are actually made up of still images – or frames. Each frame is composed of two fields. One field of video is created when the CCD is scanned across and down exactly 262 1/2 times – and this is reproduced on your monitor. A second scan of 262 1/2 lines is exactly one-half of a line down and interlaced with the first scan to form a picture with 525 lines. When these two fields are properly synchronized and interlaced in a 2:1 ratio, they form a complete still frame of video.

CCTV cameras use AC voltage to synchronize this process of creating motion video. In countries like the US that use 60 Hz (cycles) alternating current, each second of video contains 60 fields, which forms 30 frames. In Europe and other regions using 50 cycles, there are 50 fields and 25 frames of video per second. To the human eye, these frames of video appear as moving images.

The total voltage produced is one volt from the bottom of the sync pulse to the top of the white level, hence one volt peak-to-peak (p/p). The signal's luminance element is from 0.3 volts to one volt, so the maximum is 0.7 volts. This is known as a composite video signal because the synchronizing and video information are combined into a single signal.

CCD Format Size

Early CCTV cameras had a circular tube as the sensor. The format size was determined by the diameter of the tube, which is the diagonal measurement of the picture. Even though today CCD sensors are flat, rectangular silicon chips, this method of measurement is still used today.



Larger CCDs gather more light, and therefore tend to be more sensitive than smaller-format CCDs. Camera price increases with sensor size, so the selection of sensor size must be balanced against both your budget and application.

Please note that the sensor sizes shown in the diagram must be considered in relation to the lens selected because lenses are also designed for specific sensor sizes.

Lenses

Lenses are the “eyes” of a CCTV system. They are essential for creating video functions. Lenses perform two main functions: First, it determines the scene that will be shown on the monitor – this is a function of the focal length. Second, it controls the amount of light reaching the sensor – this is a function of the iris. Focal length can be fixed or variable (e.g., a zoom lens). The iris may be manually adjusted or automatically controlled by the camera.

Lens Types

How do you determine the best lens for the situation? Lenses have many characteristics that must be matched to your particular requirements:

Fixed focal length lenses

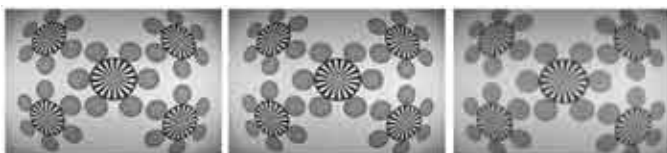
Fixed focus lenses are the simplest type of lens, and therefore the least expensive. Its preset focal length requires a precise calculation to select the lens most suitable for the location. This is based on the desired size of viewing area and its distance from the camera. Typical lens sizes offer either a narrow, 30-degree field of view to allow more detail at a given distance, or a wider, 60-degree field of view.

Varifocal lenses

Varifocal lenses offer more flexibility, allowing you to adjust the field of view manually. Although slightly more expensive, these lenses are popular because you can get a more precise adjustment of the scene. They also simplify the specification process, because the flexible field of view means a single lens can often times be selected for all cameras in an entire system.

IR corrected lenses

The human eye sees in the “visible light” portion of the spectrum. Beyond visible light is a portion of the spectrum that includes infrared (IR). IR light negatively affects the accuracy of color reproduction: for this reason, all color cameras employ an IR cut-filter to minimize or eliminate IR light reaching the imaging sensor. This means IR-corrected lenses are not necessary on standard color cameras.

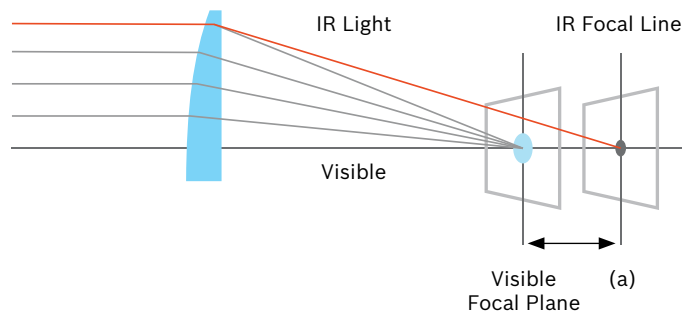


Daylight image

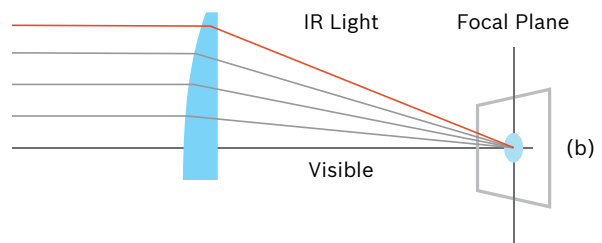
IR image, compensated lens

IR image, normal lens

Day/Night and monochrome cameras can benefit from IR-corrected lenses. The CCD device inside a security camera can detect IR light and use it to help illuminate the area being viewed. In fact, using ordinary lenses on monochrome or day/night cameras typically results in a blurred, or worst-case, completely de-focused picture. This is because the wavelength of IR light differs from visible light, so the focus point of IR light is displaced compared to that of visible light.



Consequently, when using ordinary lenses and setting the focus at daytime, the picture will be defocused or blurred at nighttime when using IR illumination – and vice-versa. The problem can be rectified by using IR-corrected lenses, which focus both visible and infrared light in the same vertical plane.



IR-corrected lenses are not solely for use with IR illumination at nighttime. Many light sources include a portion of the IR light spectrum, so using IR-corrected lenses on a monochrome or day/night camera will provide a sharper picture because all the light is focused. You'll get a far crisper picture compared to ordinary lenses.

Motorized zoom lenses

Zoom lenses are the most complex, but offer the greatest functionality. They can be adjusted remotely to allow variation of the focal length and maintain focus while tracking. This means that a single lens can be used to view a wide area – until an intruder is detected, whereupon you can zoom in to capture facial details. Generally, zoom lenses incorporate a motorized zoom, focus and auto-iris functions to permit maximum usage.

Lens Format

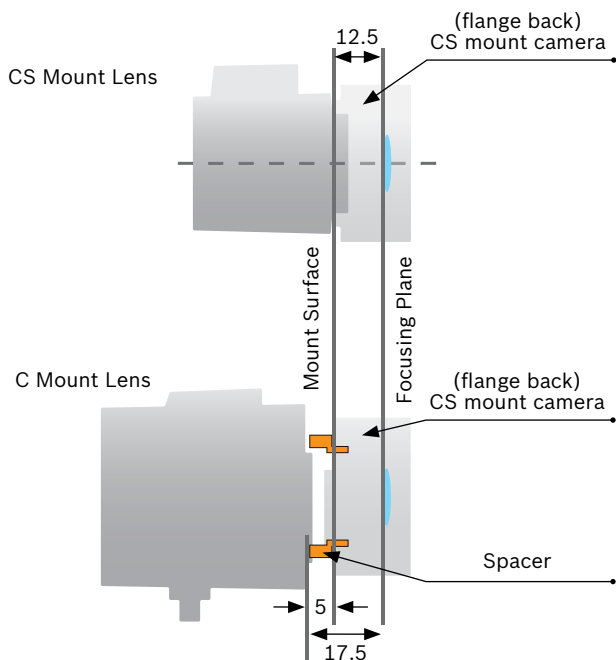
Lenses are also categorized according to format size. The format of the lens (1/2-inch, 1/3-inch, 1/4 inch, etc.) is derived from the ratio of diameter to the viewing image produced. While it's often most cost-effective to match the lens format to the camera's sensor size, it's possible to use a larger lens on a smaller size (imager) camera – since the image only needs to be at least as large as the sensor.

Using a larger lens can often be advantageous, since it offers greater depth of field (the range of distance from the lens before objects too far away to be in focus). Larger lenses also mean that the image area used is taken entirely from the central, flatter part of the lens – which causes much less corner distortion and offers better focus.

Lens Mounts

CCTV lenses utilize either “C” or “CS” mounts that specify the thread type and dimensions. The difference between the two types is the distance from the back of the mounting flange to the face of the sensor. This is known as the “flange back length.” With CS lenses, this distance is shorter, which allows the use of fewer and smaller glass elements, resulting in a more compact lens design.

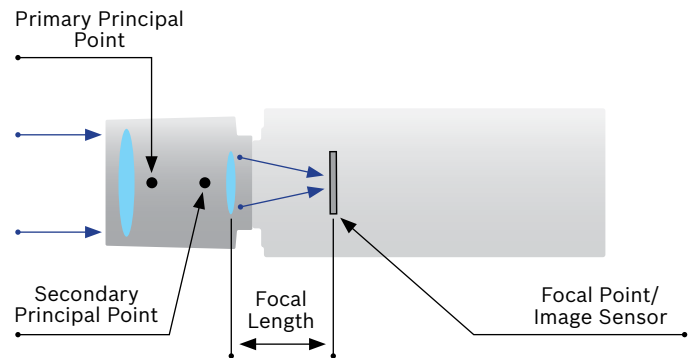
Most cameras today use CS-type lens mount. A CS lens may only be used on a camera with a CS format mounting. A C mount lens may be used on a CS mount camera by adding a 5mm-adaptor ring.



The thread type and its dimensions are identical for both types of lenses, so either may be mounted to cameras with either type of mount without causing any damage. However, the lenses are not totally interchangeable: the wrong lens/mount combination will make it impossible to focus the camera.

Focal Length

Focal length is the distance between the center of the lens and the image sensor. Rays from infinitely distant objects are condensed internally in the lens at a common point on the optical axis. The point at which the CCTV camera's image sensor is positioned is called a focal point. By virtue of design, lenses have two principal points: a primary principal point and a secondary one. The distance between the secondary principal point and the focal point (image sensor) determines the lens's focal length.



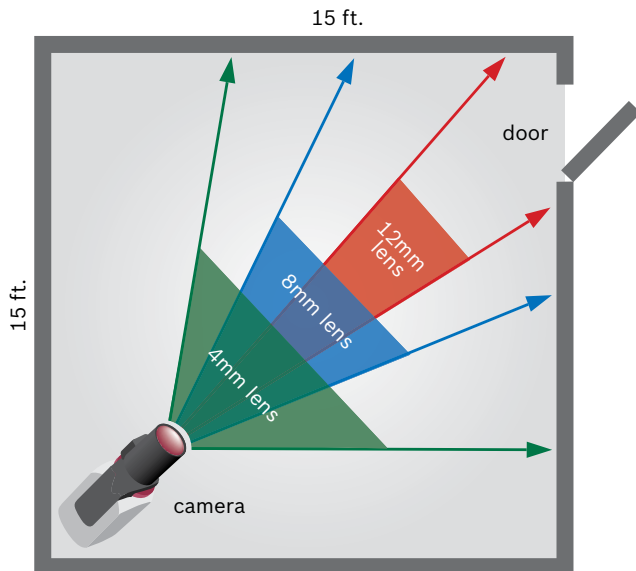
Focal length measurement is expressed in millimeters. Lenses are defined as normal, wide-angle, or telephoto according to their focal length. For example, on a 1/3-inch format camera, an 8mm lens is a wide-angle lens because it's capable of capturing a very wide field of view. Conversely, a 125mm lens on the same camera in the same location sees a much narrower field of view, although the objects are significantly magnified.

Field of View

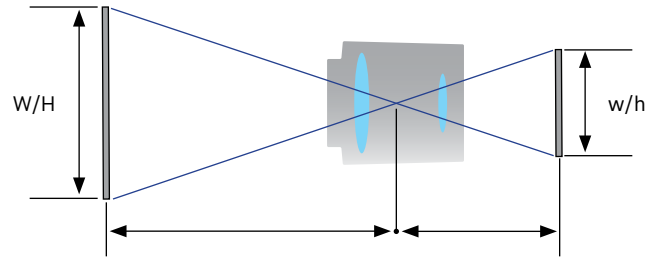
Field of view (FOV) is a measure of how large an area a CCTV camera is capable of viewing. The FOV is based on the camera and lens. For example, a 15' x 15' room is shown in the diagram below. The 4mm lens (green arrows) allows better wide-angle viewing coverage than the 12mm lens (red arrows).

In applications where a closer view is needed (e.g., above a cash register or over a great distance), an 8mm or 12mm lens may be a better choice. The same camera at a distance of 21 feet using an 8mm lens will have a 10' vertical x 13' horizontal FOV. At 21 feet with a 12mm lens, the FOV will be approx 6' vertical x 9' horizontal.

Increasing the lens' focal length decreases the perceived distance to the viewing area, but also decreases the area that the camera is able to view. See the FOV diagram below for approximate views with different focal-length lenses.



The FOV can be calculated as follows:



$$\frac{w}{W} = \frac{h}{H} = \frac{f}{L}$$

- W = width of object
- H = height of object
- w = width of image sensor format
1/2 format = 6.4mm, 1/3 format = 4.8mm, 1/4 format = 3.6mm
- h = height of format
1/2 format = 4.8mm, 1/3 format = 3.6mm, 1/4 format = 2.7mm
- f = focal length
- L = distance to object

Example:

You would like the full image of a 6-foot (1.8m) tall person to appear on a CCTV monitor. The person is approximately 20 feet (6m) away from the security camera. The camera uses a 1/3-inch format CCD sensor.

- h = 3.6mm
- H = 1.8m = 1800mm
- L = 6m = 6000mm

$$\frac{h}{H} = \frac{f}{L} \longrightarrow \frac{3.6}{1800} = \frac{f}{6000} \longrightarrow f = 12\text{mm}$$

You'll need a 12mm lens for the best results for this application.

Iris

The iris controls the amount, or quantity, of light striking the face of the image sensor. To provide optimum performance, it's critical that neither too much nor too little light fall on the camera sensor. If too much light hits the image sensor, the image is "washed-out" (the image is all white or portions of the image are "too hot," where light-colored surfaces lose all detail). Closing the iris corrects this. At the other extreme, too little light hitting the image sensor results in a black image or one in which only the brightest objects are visible. Opening up the iris corrects this situation. Irises may be fixed, operate manually, or operate automatically.

Fixed Iris

A fixed iris lens offers no adjustment for different lighting conditions, so it's limited - and not suitable for applications where fine detail is consistently required. A manual iris can be adjusted at the time of installation, which allows you to obtain an optimum picture for a fixed lighting level.

Manual Iris

Manual iris lenses are best suited to indoor applications, where the lighting level is controllable and consistent. For external use (where conditions generally vary the most), an automatic iris lens offers the best performance, since the iris aperture automatically adjusts to create the optimum image by monitoring the camera's output signal. The final lens characteristic to take into account is the light-gathering speed of the lens, which is expressed as an f-stop number. This literally measures the amount of light captured by the lens in a given period of time; the lower the f-stop range, the more light that can be transmitted.

Electronic Iris

In cameras with automatic (electronic) iris control, the circuitry continuously samples the amount of light hitting the image sensor and opens or closes the iris accordingly. Auto iris is especially valuable in settings where light levels are constantly changing - exterior locations, for example.

Aperture (f-stop)

The aperture is the size of the opening in the iris - aperture openings are expressed in f-stops. A smaller f-stop means a larger opening, which results in a greater amount of light passing through the lens to the image sensor. This is also known as a faster lens. Conversely, a larger f-stop means a smaller opening, with less light transmitted through the lens.

Iris opening at various F-Stops

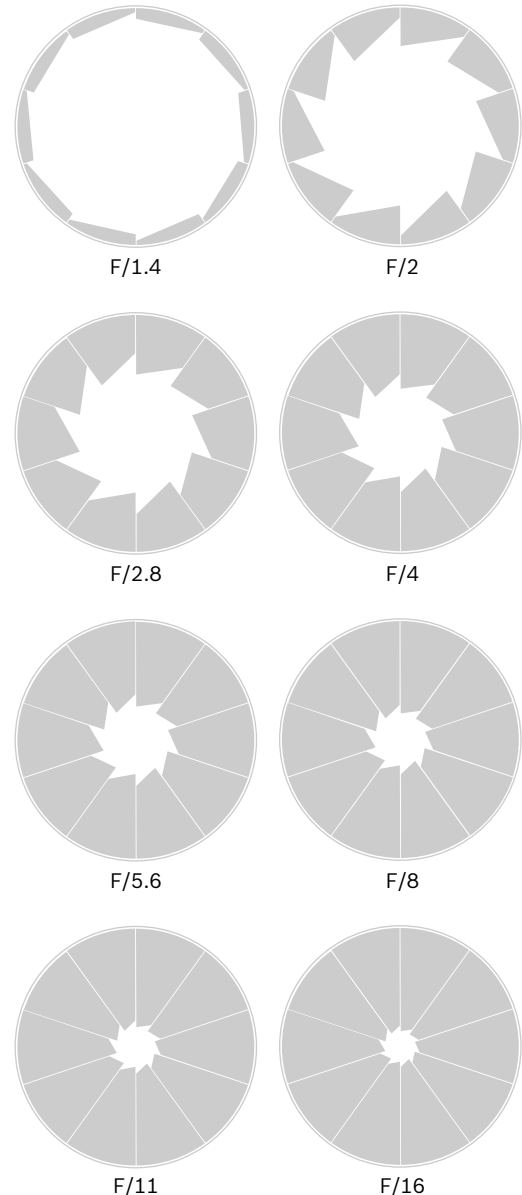


Image Processing

There are several factors that make up a complete camera specification, and they are all inter-related. The three most important considerations in selecting a camera are:

- Sensitivity
- Illumination
- Resolution

Proper camera selection for your CCTV system is vital to maximize your system's effectiveness. On the other hand, with the range of cameras available, you could select "over-qualified" cameras – those with more capabilities than your application actually requires. Choosing cameras with features that closely match the needs of a given job helps you save significant costs and can expand or enhance your entire system. Therefore, when selecting a camera, it's important to know why, where, and under which conditions your camera will be used. You can then match specific camera features and capabilities to your applications.

Camera Sensitivity

Sensitivity describes a camera's ability to "make pictures" in varying levels of light. The higher the sensitivity, the less light required by the camera to produce usable images. The terms "usable video" and "full video" are often heard in discussions of sensitivity. An image that contains some recognizable detail, but also has dark areas with no observable detail may be classified as usable.



Low-Sensitivity Camera



High-Sensitivity Camera

As shown in the figure above, using a camera with higher sensitivity (or adding light to the same scene) will immediately cause details to appear where there was formerly just blackness. When all objects in an image are all visible, it is described as "full video." Full video is 7.14 volts peak-to-peak plus 100 IRE (1 IRE = .714 mvolt). Usable video typically averages between 15 and 50 IRE.

Camera sensitivity measures the amount of light required to provide a standard video signal. Sensitivity values are typically stated in lux. Most camera specifications provide usable and full video light levels. Therefore, when considering camera sensitivity, it's important to know the lighting conditions under which the camera will be used (see "Illumination" below).

You should also determine how high the sensitivity must be to produce usable video with the minimum amount of light available at the surveillance location. There are cameras available that can produce images in extremely low light. For example, day/night (IR-sensitive) cameras can produce images with only the illumination from starlight.

Illumination

Choosing the correct camera to operate in ambient light conditions may be the most important – although most tricky – specification to understand.

Illumination refers to the light falling on a scene. Strictly speaking, illumination is not a camera function; however, it’s a critical issue when considering a camera for a given area. Adequate illumination is essential to acquiring images that allow security personnel to monitor an area (detection), observe activity at the location (recognition), and identify specific actions, objects, or persons (identification).

The amount of illumination reaching a scene depends on the time of day and atmospheric conditions. Direct sunlight produces the highest-contrast scene, allowing maximum object identification. On a cloudy or overcast day, less light is received by the objects in the scene, resulting in less contrast.

To produce an optimum camera picture under a wide variation in light level (such as occurs when the sun is obscured by clouds), you need an automatic-iris camera system. Typically, scene illumination measured in foot-candles (fc) can vary over a range of 10,000 to 1 (or more).

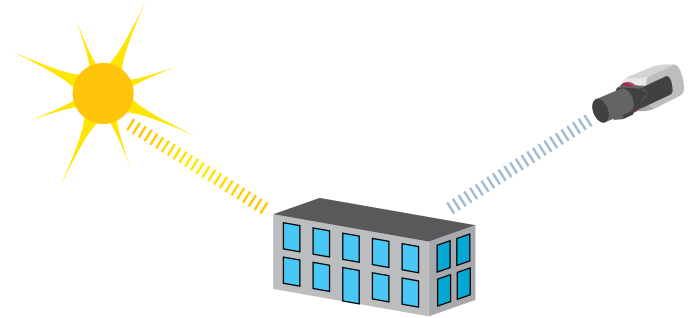
The chart below summarizes the light levels that occur under daylight and low-light conditions. The equivalent metric measure of light level (lux) compared with the condition (fc) is given.

Lux and Low Lighting Chart			
Condition	Illumination		Details
	Footcandles (fc)	LUX	
Sunlight	10,000	107,527	Daylight range
Full daylight	1,000	10,752.7	
Overcast day	100	1,075.3	
Very dark day	1	107.53	
Twilight	10	10.75	
Deep twilight	0.1	1.08	
Full moon	0.01	0.108	Low light Level range
Quarter moon	0.001	0.0108	
Starlight	0.0001	0.0011	
Overcast night	0.00001	0.0001	

The Golden Rule for deciding which camera to use for a given lighting condition is not to choose one that merely delivers a minimally usable picture. Try to give the camera approximately 10 times its quoted minimum scene illumination. Most cameras will be able to handle excess light. The major problem is when they do not have enough light to produce a picture.

Scene Reflectance

Keep in mind that the camera (like the human eye) actually processes reflected light – light that’s reflected off objects and people in the field of view.



Light strikes an object and bounces off it. The light then passes through the lens, strikes the image sensor, and creates an image. Different materials reflect light at different rates. The table below lists several common areas or objects and their reflectance values – or the percentage of light reflected off them.

Scene	Reflectance Factor
Empty asphalt parking lot	5%
Parkland, trees, grass	20%
Red brick building	35%
Unpainted concrete building	40%
Parking lot with cars	40%
Aluminum building	65%
Glass windows and walls	75%
Snow	85%

The amount of illumination available, in conjunction with the camera’s sensitivity, is crucial information when selecting a camera for your application. Illumination and sensitivity have an inverse relationship: more light requires less sensitivity – and with less light, higher sensitivity is required.

Resolution

Resolution is the measure of fine detail that you see in an image. For analog systems, this is typically measured in Television Lines (TVL). The higher the resolution, the better the definition and clarity of the picture. The camera “scans” an image in a series of lines running horizontally. Each horizontal line is made up of a number of elements. Once one line is scanned, the second line is scanned, and so on. Resolution is a measure of the quantity of both individual lines and the component elements making up each line. In a CCD camera, resolution has a direct relationship to the number of pixels on the CCD image sensor.

Resolution measures the number of horizontal lines a camera uses to produce an image. Horizontal resolution measures the number of elements making up each horizontal line. Vertical and horizontal resolutions typically yield a 3:4 ratio relationship (e.g., 600 vertical lines to 800 elements in each line). CCTV camera resolution is usually in the 380 to 540 TVL range. The higher the camera’s resolution, the more detail visible (because the lines are closer together and there are more elements in each individual line). Lower-resolution cameras produce images with less detail.

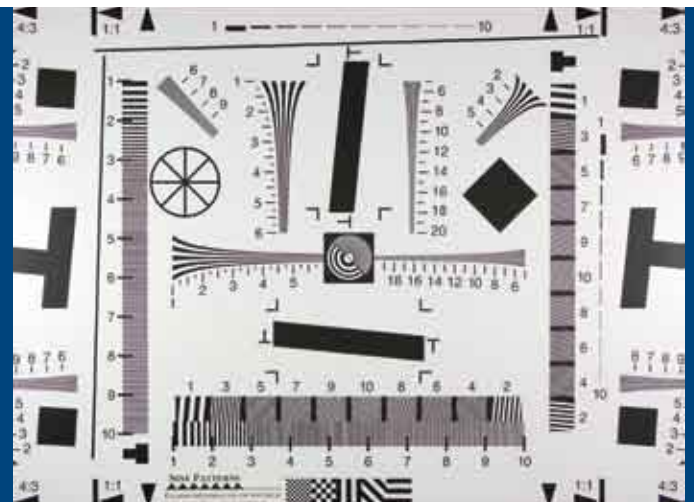
Camera Type	Standard Resolution	High Resolution	Ultra High Resolution
Color	Up to 330TVL	Up to 480TVL	540TVL
Monochrome	Up to 380TVL	Up to 500TVL	570TVL

Other Important Factors

In addition to the primary considerations when selecting a camera, there are several other factors that affect image quality. These include:

- Signal-to-noise ratio
- Automatic gain control
- Automatic shutter
- Backlight compensation
- Manual and electronic adjustments
- Advanced Digital Signal Processing (DSP)

Various resolution charts have been developed for CCTV systems. Most charts are capable of measuring horizontal Television Lines (TVL) ranging between 200 and 1000 TVL. Horizontal TVL is the most important resolution measure in a video system, and can be found by using a test chart such as that depicted to the right. The resolution limit of a camera can be determined by visual inspection of the linear wedge patterns on the test chart. This inspection is performed with the test chart’s full image height visible within the camera’s field of view.



Universal camera test chart (RETMA)

Automatic Shutter

Automatic shutter control adds further flexibility to a camera by controlling the quality of light. Light sources are made up several different wavelengths of light. Sunlight, for example, is an almost pure form of white light – each wavelength is present in roughly equal amounts.

However, in other types of light (fluorescent, household light bulbs, sodium vapor streetlights, etc.), wavelengths are unequally represented. These differences can be extreme, resulting in significantly degraded image quality.

While the human eye is able to compensate for many of these differences, a color camera needs specialized circuitry. Automatic shutters compensate for changes in light quality. Thus, an outdoor camera with automatic shutter control can produce accurate images of activity in a parking lot in daylight, as well as under artificial illumination.

Shuttering is a function of the camera. Basic cameras sample, or “look,” at an image at a rate of 60 times per second, a shutter speed of 1/60. Digital signal processing technology in the camera has been enhanced so that this circuit can now analyze the video signal and, if needed, change the sampling rate of the image up to 100,000 times per second. This allows darker images to be “digitally” sampled more, utilizes existing light, and produces better pictures.



Backlight Compensation (BLC)

Backlight is the light behind the object of interest in a scene. This can be a major problem, especially in cameras with automatic iris control, because the camera will often adjust to keep the bright background within acceptable levels.

Think about a camera aimed at a door at the end of a dark hallway. When someone opens the door and steps into the hallway, the camera will try to compensate for the sudden bright exterior background. The result will be that the person in the doorway appears silhouetted and detail is lost in “shadow.” In extreme cases, there may be no discernible detail at all. Cameras **must** have backlight compensation to overcome this situation.

Backlight compensation is composed of camera circuitry that samples a scene and makes an assumption that objects in focus are the objects of interest, and that light levels should be optimized for these objects. Extremely high background light levels are selectively shut down while maintaining optimum levels on the objects of interest.



Camera without BLC



Camera with BLC

Manual and electronic adjustments

As with all sophisticated electronic components, periodic adjustments to a camera may be required to maintain its optimum performance. These adjustments must be done manually on most cameras. Newer cameras permit adjustments to be made electronically from remote locations – and the benefits of this are clear:

- Immediate corrections can be made as required
- Adjustments are instantly made from one central location

Consider a camera mounted on a pole in a parking lot. A technician can make adjustments to this camera with no concern for the weather, and without having to climb a ladder or use a lift. Valuable time is saved, the chance of injury reduced, and there are fewer interruptions to the security operation.

For example, Bilinx Bi-Directional Communication technology from Bosch uses conventional CCTV coax, unshielded twisted pair (UTP), and fiber optic video transmission links to communicate data to and from the camera. Bilinx technology embeds control and configuration commands in the video signal, enabling many functions that used to require direct camera access or separate wiring to work over a video cable.

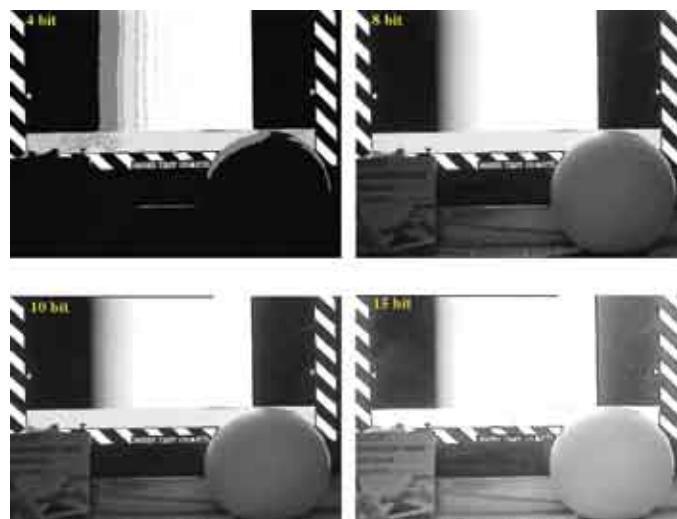
Advanced Digital Signal Processing

Early attempts to develop video cameras with resolution and sensitivity as good as the human eye – in theory, the ultimate aim – were not very successful. This is because the eye presents a three-dimensional image to the brain, which uses a high degree of parallelism in image processing. The brain's ability to interpret the image contents at the same time also contributes to very sophisticated and intelligent image optimization.

The application of digital technology within the camera has come about mainly from the need to improve image quality, sensitivity, and dynamic range. DSP technology and advanced CCD chipsets produce an exceptionally high number of grey levels, resulting in wide dynamic range and high-quality image reproduction of details in high- and low-lit scenes. Clearly, the camera's imaging performance, including imaging and control flexibility, are critical when it comes to making a choice.

The quality of a CCD camera image is directly related to the number of grey levels that can be processed, which is governed by the DSP's architecture. For example, a 1-bit processor can only deliver an image similar to that produced by a matrix printer, while a 4-bit processor delivers 16 grey levels to produce a somewhat better image (see the images below).

Most security cameras use 10-bit processors and are potentially capable of producing pictures with 1024 grey levels, giving relatively smooth variations from light to dark. Bosch Dinion^{XF} cameras employ 15-bit digital signal processing, which delivers a 32-fold increase in the number of grey levels and in color accuracy compared with a 10-bit DSP, producing what the eye interprets as a virtually continuous variation of grey level. This results in exceptionally accurate picture reproduction with broad dynamic range and vivid colors over a broad spectrum.



The Dinion^{XF} camera's 15-bit digital signal processing gives a virtually continuous variation in grey level from light to dark

Wide Dynamic Range

Loosely defined, a camera’s dynamic range is the difference between the maximum and minimum acceptable signal levels. If part of a scene is illuminated too low, chances are there are not enough photons coming from that area to be converted to a meaningful electronic signal. The detail in the dark won’t be “seen” by the camera. Conversely, if part of a scene is very strongly illuminated (e.g. sunlight streaming through a window), the image from that area of the scene could be washed out. In the worst-case scenario, the scene could, and often does, contain areas of extremely low and high levels of illumination.

Dynamic range is the ability of the imaging chip to convert light information. The wider a camera’s dynamic range, the better its ability to deal with these extreme lighting contrasts. To implement the XF-Dynamic feature, Bosch’s 15-bit Dinion DSP uses a function known as histogram control to stretch out the details in the image by amplifying minute variations in illumination (see example). The illumination of every pixel in a scene acquired by the CCD is recorded in a luminance histogram which sorts the pixels into 32,767 grey levels – ranging from black up to maximum scene brightness (see graph “A” below).

The camera’s transfer function (the curve defining output as a function of input), instead of being a simple straight line like a normal camera, automatically increases more sharply in regions of high information density and less sharply in regions of low information density (graph “B” below). This creates a more evenly distributed luminance histogram at the camera output (graph “C” below). Low-contrast scenes are typically characterized by a very high pixel count at just a few grey levels. In such scenes, the histogram reduces the number of pixels at these grey levels. At the same time, the pixel count is increased at other (less well-represented) levels to stretch the overall picture contrast and bring out fine picture details.

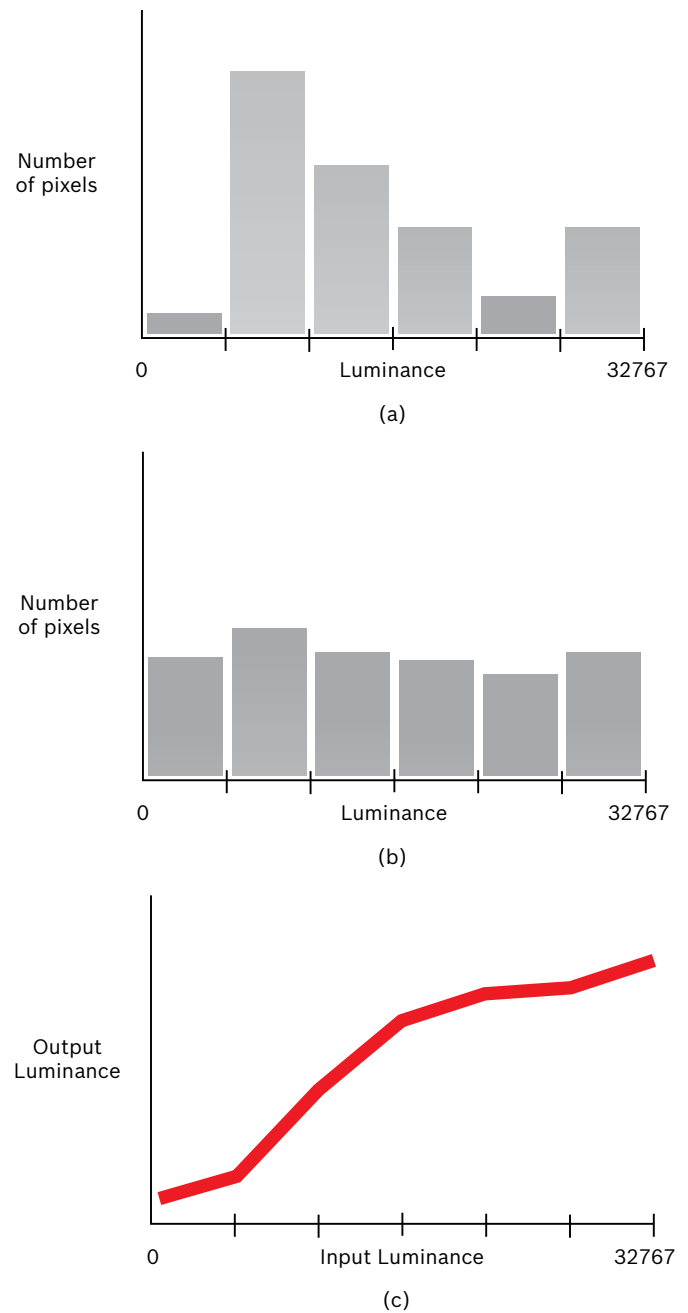


Fig. 2 - The pixels in a scene are automatically grouped by gray level into a luminance histogram (a). This is modulated by a camera transfer function that varies with information density across the scene (b) to create a more even distribution of gray levels (c) and accentuate scene details that would otherwise be lost.

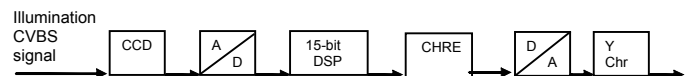


Fig. 3 - Block diagram of a 15-bit DSP CCTV camera

Smart Exposure

Another aspect of the wide dynamic range enabled by the Dinion^{XF}'s XF-Dynamic feature is that it offers an important advantage over the alternative “dual-exposure technology” used in other security camera systems. Here, a long exposure of approximately 1/50 sec (for PAL) accumulation time or 1/60 sec (for NTSC) is used for the dark areas of a scene, and a short exposure of approximately 1/1000 sec or less is used for the bright areas. A “smart” combination of these two exposures is then made – in principle, this should have the best of both worlds, accentuating all scene details without overexposure of highlights. In practice, the optimal combination is difficult to achieve, and compromises, especially at the changeover between light and dark scenes, may result in less than optimal exposure and degraded picture quality (see example).



Comparison of dual-exposure technology (top) with the XF-Dynamic technology used in the Dinion^{XF} camera

Frame Integration

Some cameras include frame integration techniques to attempt to overcome the problems of obtaining clear images in poor light. A slow shutter speed is used to capture enough light in dark areas of the scene.

Bosch increases sensitivity in the Dinion^{XF} by improving the image accumulation time. Reducing the shutter speed increases accumulation time and sensitivity even further. Conventional security cameras are limited by the frame rate of the surveillance monitor to a maximum of 1/50 second (or 1/60 second). The Dinion^{XF} overcomes this by decoupling image accumulation from the video output with a feature called SensUp. This greatly enhances the effective sensitivity. The accumulated image is stored in memory and sampled every 1/50 second (or 1/60 second) to create a video-compatible output signal, with the memory being refreshed with a new image every 1/5 second. The advantage of SensUp is that instead of functioning in steps, as in most cameras, it uses continuous shutter speed adjustment for very smooth video level control. This makes it most effective in situations where there is no artificial lighting (see example).



Detecting an intruder at night. Top: conventional CCTV camera; Bottom: Bosch Dinion^{XF} with SensUp

Dynamic Noise Reduction

Noisy recorded scenes can dramatically increase the size of the digital files (which are usually archived over time on a remote hard disk). In extreme cases, noisy scenes can reduce the archive period – for example, from a month of video to no more than a week. Electronic noise is caused by a number of sources, including cable attenuation, thermal effects, and over-amplification. The camera itself can also be a source of noise, which is seen as snow or graininess in the displayed image.

Some cameras include Dynamic Noise Reduction (DNR) to enhance image quality by reducing or canceling electronic noise, especially in low-light conditions. The DNR system in the Bosch Dinion^{XF} camera cancels out noise by comparing images produced over time. A powerful algorithm developed for the 15-bit DSP then performs a pixel-by-pixel audit of the pictures – and any small, random changes that are symptomatic of noise are automatically eliminated from the scene (see the example below).



Dynamic Noise Reduction (right) significantly improves picture quality

Signal-to-Noise Ratio

The signal-to-noise ratio (s/n ratio) is the ratio of the video signal level to the amount of noise present in the image. Noise in a video image is seen as snow or graininess, resulting in a poorly defined image on the monitor or video recording. The unit for expressing s/n ratio is decibels (dB), but it can also be expressed as a ratio.

A signal-to-noise ratio of 40dB is equivalent to a ratio of 100:1, which means that is the signal is 100 times the noise level. Conversely, the noise is one hundredth of the signal. At a signal-to-noise ratio of 20dB, the noise is 10% of the signal and would produce an unacceptable picture. The following table provides a guide as to the quality you can expect at various signal-to-noise ratio levels.

S/N Ratio dB	Ratio	Picture Quality
60	1,000:1	Excellent, no noise apparent
50	316:1	Good, a small amount of noise but the picture quality is good
40	100:1	Reasonable, fine grain or snow in picture and loss of fine detail
30	32:1	Poor picture quality with a great deal of noise
20	10:1	Unusable picture

There are many sources of noise, including poor circuit design, heat, over-amplification, external influences, and automatic gain control, as well as transmission systems such as microwave and infrared. The signal-to-noise ratio is an important measure of video quality: the higher the camera’s signal-to-noise ratio, the better the image quality delivered by the camera.

Auto Contrast Adjustment

Fog, mist, and glare significantly reduce image contrast and can make recognition (or even detection) nearly impossible. The advanced processing power of 15-bit DSPs provides significant improvement in contrast by increasing the scope of the camera’s dynamic range.

Using XF-Dynamic’s Auto Black function, Bosch’s Dinion^{XF} camera dynamically stretches the illumination levels in scenes to reduce the darkest areas to (near) black. This function enhances contrast in pictures obscured by veiling glare or in which contrast is reduced by fog or mist. The Auto Black function is the most effective in indoor situations, such as a nightclub with low light and cigarette smoke.



Auto Black off



Auto Black on

Motion Blur Reduction

In most still images taken from the recording of moving objects, details lose clarity due to the relatively slow shutter speed of 1/50 sec (or 1/60 sec) used in standard CCTV cameras. This makes identification of individuals and vehicle license plates, for example, difficult or even impossible.

The solution is to increase the shutter speed to freeze the picture, which only works as long as there is enough light. Increasing the shutter speed means increasing the illumination level or the lens aperture to compensate for the shorter exposure. Once the light level goes down and the lens is fully open, the camera's Automatic Gain Control (AGC) can be triggered to provide further gain. However, when this has reached its limit, the image simply degrades until it's no longer usable.

The Bosch Dinion^{XF} camera can obtain images without motion blur for an extended period because it combines several features that work together to maintain optimal performance. By switching the Dinion^{XF} into Default Shutter Mode, you can set the shutter speed at a default value (for example, 1/250 sec). As long as there is sufficient light in the scene for the Auto Iris lens control and AGC to produce a full video signal, the shutter speed remains fixed at the default value. Only when the light fails will the shutter control take over to reduce shutter speed until the standard value is reached. Motion blur will recur at this lower shutter speed, but this is preferable to losing the video signal completely. This Default Shutter system provides video without motion blur for as long as possible, and yet still allows imaging within the full range of lighting conditions.



Bosch Dinion^{XF} Motion Blur Reduction. Shutter control increases shutter speed from 1/50 sec to 1/500 sec as light decreases

Cable Compensation

New image processing techniques have enabled camera manufacturers to boost the resolution of color cameras up to 540 TV lines (TVL). However, 540 TVL can only reach its full benefit if you use short cables; otherwise, the attenuation in the cable reduces the observed resolution.

To eliminate the need for additional amplifiers to compensate for these cable losses, many Bosch cameras have a cable compensation function that adapts the camera's video out-put to minimize cable losses. This function boosts high-frequency components in the output signal that are responsible for fine picture details – which compensates for high-frequency losses in the cable. It also compensates for cable resistance by amplifying DC power and lower-frequency components that are responsible for maintaining correct synchronization of bright pictures. You can select cable compensation right in the camera's on-screen display. It can be set to three types of coaxial cable with equalization levels that are adjustable over a wide range: it can compensate for cable lengths up to 2000 m (6000 ft.). Only Bosch cameras with built-in cable compensation are therefore capable of bringing full 540 TVL resolution to the recorders and monitors at the head-end location.

Learn More

For more information on CCTV – or any security products – call your Bosch Security Systems representative or visit www.boschsecurity.us.