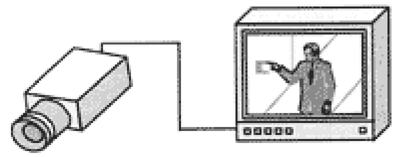
How To Guide For System Designs

The following "How To" guide is designed to help less experienced CCTV dealers become accustomed to basic systems design.



What Good is it?

Advances in CCTV technology are turning video surveillance into one of the most valuable loss prevention, safety/security and management tools available today. Retailers use CCTV to monitor for shoplifters and dishonest employees, compile recorded evidence against bogus accident claims and monitor merchandising displays in stores that may be hundreds of miles away. Manufacturers, governments, hospitals and universities use CCTV to identify visitors and employees, monitor hazardous work areas, thwart theft and ensure the security of their premises and parking facilities. New opportunities for CCTV are growing as fast as the technology and security environments are phenomenal.

Security Applications:

- Observe and record theft or violence by overtly monitoring retail floor space, office buildings, building perimeters, warehouses, loading docks, and parking garages
- Monitor sensitive areas, where infrequent activities, occur (i.e. confidential records, safes, ect.)
- Monitor point-of-sale exceptions (cash register voids, over-rings, ect.) to reduce cashier theft
- Observe and record shoplifting activities
- "Walk a beat" by programming a moving camera to pan, tilt, and zoom within a defined pattern
- Perform covert surveillance (where legally applicable)
- Integrate with access control systems to provide video of persons entering and leaving the premises
- Complement asset tracking systems to provide video when a tagged asset leaves the premises

Safety Applications:

- Allow operators to see into areas where the environment is hazardous to life or

health (i.e. hazardous materials, chemical toxins, ect.)
- Monitor potential accident areas
- Monitor residence halls, common areas, or high-risk areas to ensure safety of an educational institution's students and faculty
- Help reduce the severity of some incidents by the timely dispatch of security, police, fire and emergency medical personnel.

Management Tool:

- Train employees, check stock on store shelves and monitor retail sales floor coverage, production lines, ect.
- Demonstrate management's due diligence towards protecting employees, clients, and visitors, and perhaps avert or minimize litigation and negative publicity
- Document video images on magnetic tape or optical hard discs to record events. This information may be reviewed and later presented as evidence for prosecution of criminals, or as a training tool

When integrated with access control, asset tracking, fire systems and other life safety and security measures, CCTV's "silent witness" provides an additional advantage: the ability to see and review the impact of these systems on people and property.

LETS GET STARTED

Many elements must be considered when designing/installing a CCTV system.

1) Scene & Lighting
2) The Camera
3) The Lens
4) Video Transmissions Methods
5) The Monitor
6) Peripheral Equipment

Scene and Lighting

The scene refers to the objects or area to be observed and the total environment in which they exist.

A scene often contains different colors, surfaces and materials that reflect varying levels of light. To select proper equipment, it is necessary to determine the minimum lighting level (day or night) that will arrive from the scene to the camera lens. The "available" light will affect everything from picture clarity to focus (see figure 1).

A scene or target area can be illuminated by natural or artificial light sources. Natural sources include the sun, the moon and stars. Artificial sources include incandescent, sodium, fluorescent, infrared, and other man-made lights. An axiom in CCTV security applications is: The better the light, the better the picture.

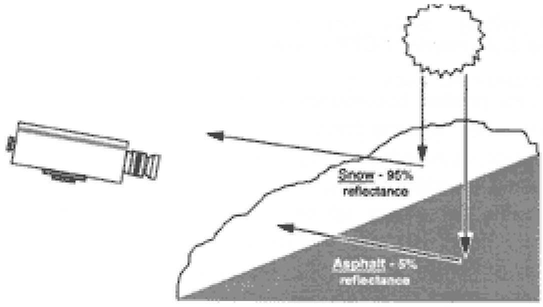
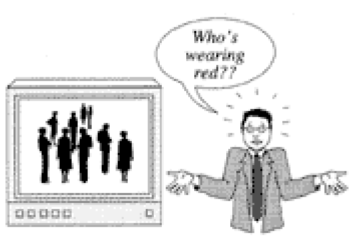


Figure 1: Cameras respond the amount of light reflected from the scene.

Color vs. Black & White
Color cameras generally require a higher level of lighting than their monochrome (black & white) counterparts.

Color produces a more natural, richer image than black & white and may keep the operators' interest for longer periods of time. It also makes it easier to detect subjects. For example, with a color system a viewer can easily distinguish a red car from a green one, while on a black & white system both cars would appear a similar shade of gray. In retail applications, a color system can help security personnel identify shoplifters and their clothing more easily and convincingly. Color accuracy is extremely important in gambling casinos, where hundreds of dollars can ride on the ability to recognize the difference between a maroon chip and a red one.



While the use of color cameras is growing, black & white cameras continue to offer some distinct advantages. Black & white cameras are better suited for extremely low light situations.

The ability to capture good quality images in low light situations increases the cost of both black & white and color cameras. Before purchasing cameras, organizations should consider the crossover point between lighting costs and camera costs. It's possible that low-light cameras (which are expensive) will cost less than paying to increase the lighting in a parking lot.

The Camera

Cameras convert the visible scene captured by a lens into an electric signal and transmit that signal to a monitor for viewing.

Several considerations should be taken into account when choosing the proper camera/lens for any video system:

- The purpose of the video system (detection, assessment, identification, ect.)
- The overall sensitivity of the camera needed based upon the actual application
- The amount and varying levels of light available at the scene
- The environment in which the camera will operate (indoors/outdoors)
- The field of view (FOV) required by the application (see figure 3)
- The lens
- Cost

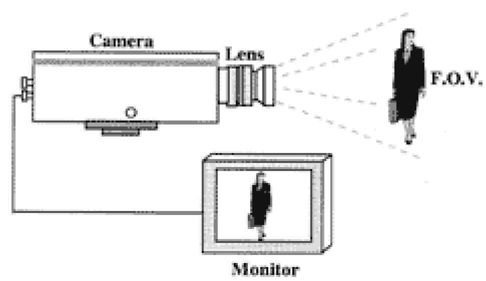


Figure 3: Field of view.

Camera performance depends largely upon the reflected light at the scene and the quality of the cameras imager (see figure 4).

Where the level of available light can change dramatically, a camera equipped with automatic iris control can help assure consistent image quality. Automatic iris control enables cameras to open or close an auto iris lens to adjust the amount of light passing through the lens. On a bright, sunny day, for example, an auto iris camera will close the lens' iris to prevent strong light from reaching the camera's imager. At night, the camera will open the iris to allow a greater amount of light into the camera.

Cameras are available in various "formats" expressed as1/2, 1/3, or1/4 inches. These measurements represent the overall usable size of the camera's imager. In general, you should match the camera's
format to the lens format. For example, a half-inch camera should be paired with a half-inch lens.

Today, thanks to design improvements, high quality images are possible with smaller formats.

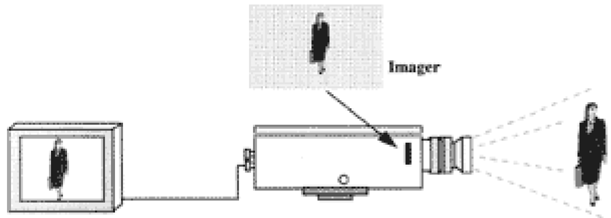


Figure 4: The imager (or chip).

Fixed and PTZ Cameras
CCTV cameras can be fixed or have pan, tilt and zoom (PTZ) capability. Fixed cameras are mounted on a fixed bracket and cannot move in response to operator commands. PTZ cameras are motor driven and can pan left and right, tilt up and down and zoom in and out for close-up or wide-angle viewing. (See figure 5)

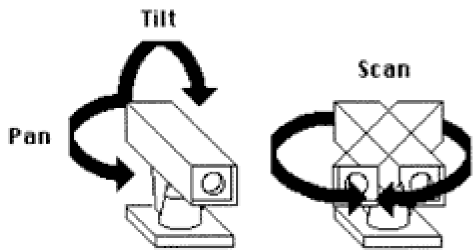


Figure 5: PTZ camera.

A cameras housing protects the camera and lens from vandalism and the environment. It also can enhance the appearance of the camera installation and conceal the equipment from casual observation. All outdoor cameras require a housing of some type. The National Electrical Manufacturers Association (NEMA) rates housings on their ability to withstand environmental conditions. Protection from cold, heat, dust, dirt or other elements is needed to ensure optimum performance and extend the life of the camera.

Dome Cameras
Many PTZ cameras today are disguised in dark colored Plexiglas housings called domes. Dome cameras are found practically every major department store and in many industrial/commercial locations, hospital, colleges and government facilities (See figure 6). They are particularly popular wherever aesthetics are valued.

Dome cameras provide three primary benefits:

1) Deterrence	Domes make it virtually impossible for suspects to determine where the camera is pointed. Individuals planning to commit criminal activity are unable to detect whether or not they are under active surveillance.
2) Economy	Domes equipped with a camera, lens, and pan/tilt unit can be augmented with "drones" that have the same outward appearance, but have no equipment inside. The

	result is more apparent camera coverage with a much lower system expense.
3) Aesthetic Appearance	An exposed camera, lens, pan/tilt unit and associated wires are unsightly. A dome makes the collection of equipment more aesthetically acceptable, and does not detract from the interior design of a retail or business office environment.

Placing a mirrored finished or smoked bubble around the dome can conceal a dome camera further.

However, when this is done, the bubble has the effect of sunglasses, reducing the amount of light reaching the lens and affecting the color accuracy picked up by the camera.

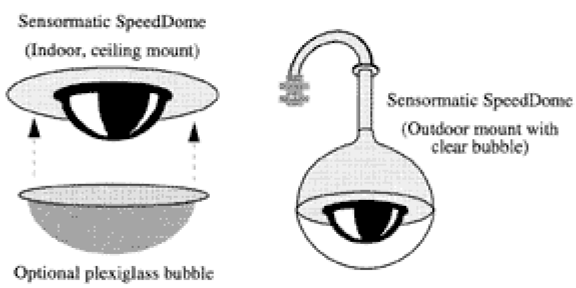


Figure 6: Dome cameras.

The Lens (Optics)

Lenses (Optics) play an important role in the design of a CCTV system. Their primary function is to collect reflected light from a scene and focus a clear, sharp image on the camera's imager. Typically, the more light that passes through a lens, the better the quality of the picture.

Selection of a lens is especially critical because it directly affects the size, shape, and sharpness of the image to be displayed on the imager. Factors such as distance from the scene, focal length, desired field of view, lighting and format affect the size and clarity of the image on the camera's imager.

Field of View
The field of view (FOV) is the actual picture size (height and width) produced by a specific lens. If the field of view is not suitable, you may consider using a different lens (wide angle, telephoto, etc.) to increase or decrease the field of view. Tables are available to calculate the proper imager size, lens and distance combination needed to produce a desired field of view. See page 92 of this catalog.

Camera lenses can be divided into two basic types: fixed focal and varifocal (or zoom).

A fixed focal lens has a constant focal length, while a varifocal lens can change its focal length. Focal length is simply the distance from the optical center of the lens to a focal point near the back of the lens. This distance is written on the lens (in millimeters) and indicates the field of view produced by the lens (See figure 7)

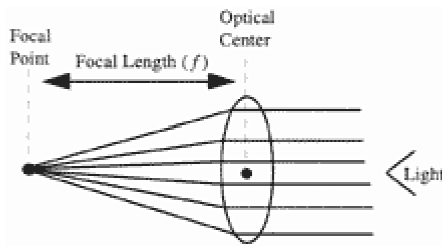


Figure 7: Focal length.

Fixed focal length lenses are available in various wide, medium, and narrow fields of view. A lens with a "normal" focal length (Ex: 8.0mm on a 1/3" camera) produces a picture that approximates the field of view produced by the human eye. A wide-angle lens has a short focal length, while a telephoto lens has a long focal length (See figure 8). When you select a fixed lens for a particular field of view, bear in mind that if you want to change the field of view, you must change the lens.

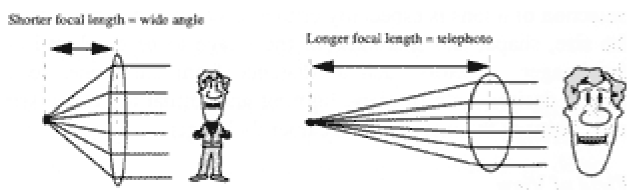


Figure 8: Wide angle vs. telephoto.

When both wide scenes and close-up views are needed, a varifocal or zoom lens is best. A zoom lens is an assembly of lens elements that move to change the focal length from a wide angle to telephoto while maintaining focus on the camera's imager. This permits you to change the field of view between narrow, medium, and wide angles, all on one lens.

F-Stop

The ability of a lens to gather light depends on the relationship between the lens opening (aperture) and the focal length. This relationship is symbolized by the letter f, which is commonly referred to as the "F-stop," and can be found printed on the side or front of the lens (see figure 9). The lower the F-stop number, the larger the maximum lens aperture and the greater the lens' ability to pass light through to the camera's imager.

For example, a lens with an F-stop of f/1.2 can gather a great deal more light than a lens with an F-stop of f/4.0. A lens with a low F-stop number is called a "fast" lens

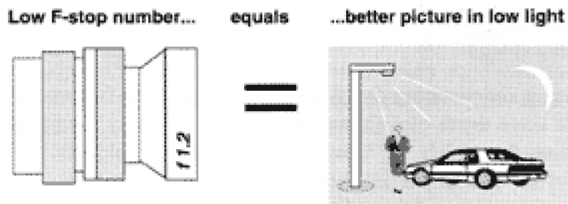


Figure 9: The F-stop indicates the lens' light gathering ability.

Depth of Field
Another consideration when determining the proper lens is depth of field. Depth of field is the area in focus before and behind a subject (see figure 10). This means that when you focus precisely on a subject, a certain distance in front of and behind the subject also will be in focus, although not as sharp. Depth of field increases or decreases based on the 1.) Length of the lens, 2.) The lens aperture and 3.) Distance from the camera to the subject.

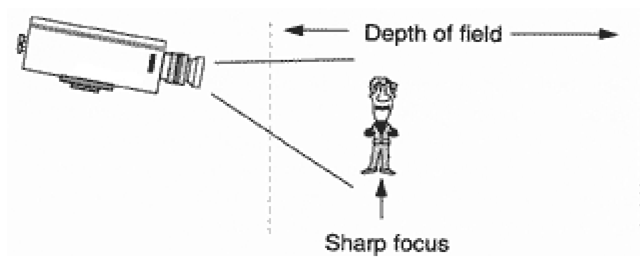


Figure 10: Depth of field.

Each of the three depth of field factors will yield the following:

1) Lens length	Short lens (i.e. wide angle)	= longer depth of field
	Long lens (i.e. telephoto)	= shorter depth of field
2) Aperture	Wide aperture (low F-stop)	= shorter depth of field
	Narrow aperture (high F-stop)	= longer depth of field
3) Distance to subject	Short distance	= shorter depth of field
	Long distance	= longer depth of field

Purchasing and planning decisions should take these factors into account since depth of field can affect image quality (and may jeopardize the ability to identify and prosecute subjects). If depth of field is important, you may want to explore options such as increasing artificial lighting or installing cameras with normal lenses rather than telephoto lenses, etc.

Lens Mounts
Camera lenses generally come with either a C-mount or CS-mount and must be matched appropriately to the camera's mounting requirements. The difference between the two mounts is the distance of the lens optics from the camera imager. The C-mount

lens is 17.5mm from the imager; the CS-mount lens is 12.5mm from the imager.

Follow these guidelines when purchasing equipment:

- A C-mount lens can be used on a CS-mount camera only if a 5mm spacer ring is added
- A CS-mount lens cannot be used on a C-mount camera

Video Transmission Methods

The purpose of the transmission medium is to carry the video signal from the camera to the monitor. Today, many video transmission methods exist: coaxial cable, fiber optic, phone lines, microwave, and radio frequency. Due to varying application needs, it is possible to find several video transmission technologies in use within the same CCTV system.

The choice of transmission medium depends on factors such as distance, environment, cost and facility layout. In addition, nearly all methods of transmission suffer from various forms of interference or loss. The essence of good design is to minimize this impact. Examples of current video transmission mediums include:

Coaxial Cable
A coaxial cable is one that provides a continuous physical connection - or closed circuit - between the camera and the monitor (see figure 11). The cable is shielded to minimize interference from any nearby electronic devices or electrical wires. Copper braided coaxial cable is recommended to maximize conductivity and minimize potential interference. For traditional CCTV systems, as well as many applications today, this is the most common and economical method of signal transmission over relatively short distances.

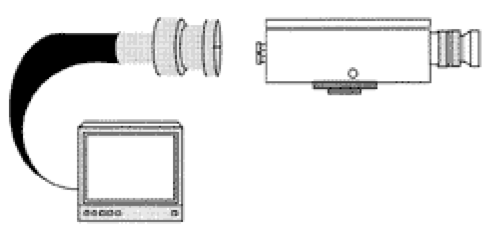


Figure 11: Coaxial Cable

Fiber Optics
Fiber optic technology changes an electronic video signal into pulsed or laser light and injects (transmits) it into one end of a glass rod (the fiber optic cable). At the other end, a receiver translates the pulsed light back into an electronic signal capable of being displayed on a monitor. The transmission is unaffected by any kind of interference, water in conduit or high voltage being run in the same conduit. Fiber optic cables have a large signal capacity (bandwidth) and no possibility of a spark from a broken fiber. Hence, there is no fire hazard to a facility even in the most flammable environment.

Fiber optics offers a cost-effective method of sending large transmissions over long distances.

Telephone Line
A telephone line is a standard twisted pair of wires that can transmit the image for distances up to one kilometer without video signal boosting. This dedicated line connects the transmitter (camera end) with a receiver (monitor end). Through the use of specialized transmission and receiver equipment, it is possible to use standard telephone lines for video signal transmission.

Microwave
If already in place, microwave can be a very efficient and cost-effective method of delivering black & white or color video. Microwave turns the video and data signals into high radio frequency signals and transmits them from one point to another via free air and space. A receiver then converts the transmission back into the video and data signals and displays the scene on a monitor. Good quality transmission can be achieved over a line of sight path (see figure 12). Microwave technology offers a large bandwidth to carry video, however, it can be affected by environmental conditions. It is a practical option when a wire path between the camera and monitor locations cannot be established or is prohibitively expensive. Microwave transmission is regulated by the FCC, and a license is required.

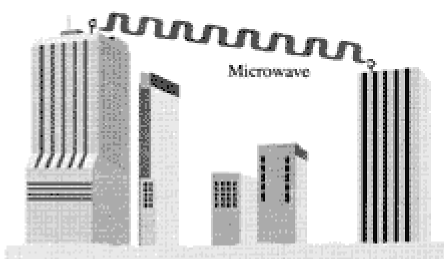


Figure 12: Microwave requires a line-of-site transmission.

Radio Frequency
Radio frequency (RF) is a reliable, but short distance, line-of-sight video transmission technology. It is becoming increasingly popular where hardwiring methods are either impossible or impractical, and has been used successfully to reduce cabling costs even within large buildings. Environmental conditions or other RF in the area can affect it.

The Monitor

The monitor receives the transmitted electronic video signal from the camera and paints it across a cathode ray tube (CRT) to display an image to a viewer. Although similar in function to a TV set, a CCTV monitor provides higher lines of resolution (better picture quality) and accepts only video signals rather than RF/antenna signals.

Lines of resolution refers to the total number of horizontal lines the camera or monitor is able to reproduce. The more lines on a screen, the better or sharper the video picture will appear. CCTV monitors can provide up to 1000 lines of resolution compared to an average of 300 lines provided by television sets.

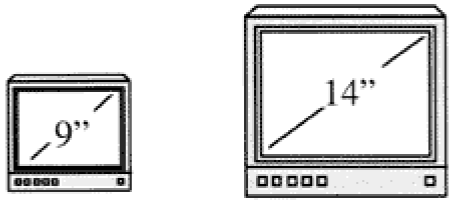


Figure 13: Nine and fourteen inch monitors often serve as dedicated monitors. The 14-inch size is also popular for call-up monitors. Monitor size is measured diagonally.

Several factors can affect the monitoring function: Size of the monitor (9" and 14" are popular sizes), its positioning and angle relative to where the viewer sits, the quantity of monitors, and the quality (resolution) of the monitor itself (see figure 13). In all cases, sufficient growth must be factored into any console design. It's also important to note that all monitors generate heat. Whether on a table or enclosed in a console, be sure to provide adequate ventilation and air-conditioning.

Most CCTV systems use both dedicated monitors and call-up, or switchable, monitors. A dedicated monitor displays the video from only one camera. A call-up, or switchable, monitor enables operators to "call or switch" different cameras to the monitor. Generally, call-up/switchable monitors are larger than dedicated monitors and give operators the ability to view multiple images simultaneously (multiplexed) as well as scrutinize the camera image more closely.

There are many different monitor sizes available. When choosing the proper size of monitor, you must first determine the distance of the monitor in relationship to the user. Also determine the quantity of cameras to be displayed on a given monitor simultaneously (multiplexed).

The Peripheral Equipment

As the number of cameras and monitors increase, simple system designs eventually give way to more complex designs that require peripheral components. These peripheral components may include switchers, VCRs, multiplexers, quad splitters, video printers and time date generators.

Switchers
A video switcher enables different cameras to be switched to different call-up monitors. In a smaller, cost-conscious application, a manual switcher allows users to select the camera they want to see by pressing a button associated with the camera (see figure 14).

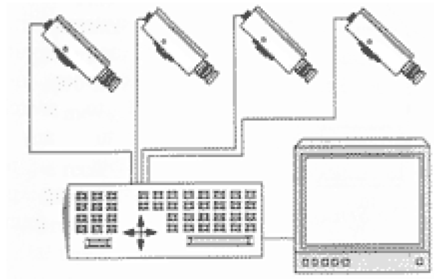


Figure 14: A switcher makes it possible to switch cameras on a call-up monitor.

The most popular type of switcher, a sequential switcher, contains circuitry that will switch one camera to another automatically. The operator can set the length of time (dwell time) that a scene remains on the monitor before sequencing automatically to the next camera. This allows operators to keep tabs on numerous cameras with only one monitor, but also creates a drawback known as "switcher dilemma."

To illustrate switcher dilemma, imagine a system with eight cameras, each programmed to switch after "dwelling" on the monitor for five seconds. In this scenario, a considerable gap will occur between the time the first image is displayed and the time the eighth image is displayed. If the dwell time is shortened, operators may not be able to assimilate each camera image before it switches. The situation worsens when recording the video for review at a later time. On playback, you may see a door opening on camera 1, then suddenly see the video switch to camera 2, followed by camera 3, camera 4, and so on. By the time camera 1 appears again, the door is closed, and you are left wondering who came through the door while cameras 2 through 8 were flashing sequentially on the monitor.

Switcher dilemma can be solved with more sophisticated switchers, more operators or an alarm feature that will display video image automatically when an alarm point is activated.

Matrix Switcher

A matrix switcher is a more complex design enabling the user to switch any video signal to any call-up monitor in a large-scale system. They normally incorporate P/T/Z control and other features such as presets and alarm inputs/outputs.

Multiplexers

Unlike conventional recording systems, a video multiplexer collects full-screen pictures from up to 16 cameras and displays them simultaneously on a monitor (see figure 15).

Operators have the option of displaying any camera full-screen or multiple cameras in reduced size.

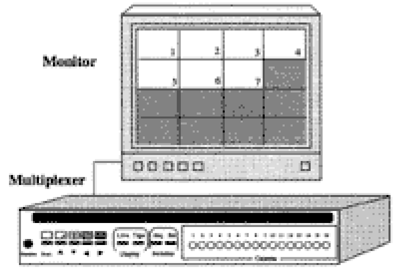


Figure 15: A 16-position multiplexer currently displaying only 7 cameras.

Multiplexers also can record all cameras in the system onto a single videotape. The cameras are recorded sequentially at a high rate of speed. As mentioned earlier, a standard video signal is comprised of 30 separate frames each second. In a video system containing 15 cameras, the multiplexer selects two frames from each camera and records them to a single videotape. The result is an effective frame rate of 2 frames per second, instead of the standard 30.

Most multiplexers today contain a motion detection feature that enables the system to record more frames of video from cameras showing motion than from those not showing any motion. The multiplexer does this by reallocating frames from one camera to another as needed. The net result is higher quality recordings of scenes that are more likely to be important to security personnel.

When a time lapse VCR is used with a multiplexer, the recording mode should be as short as possible to reduce the number of seconds required to record all cameras (remember, cameras are recorded sequentially) (see figure 16).

This is why it is a great advantage to use hi-density or virtual real-time TLR's when using multiplexers. Virtual real-time VCRs record 4 times the frames per second of conventional time-lapse VCRs.

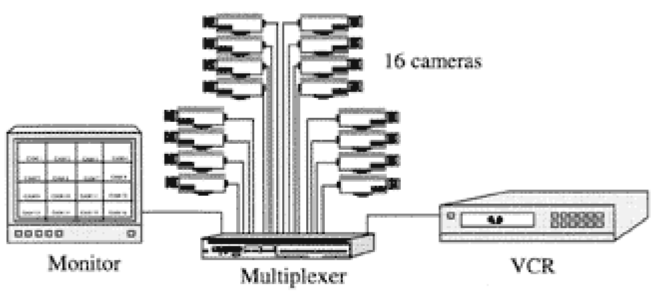


Figure 16: The VCR, working with a multiplexer and several cameras, records fewer frames per second in time-lapse mode.

One of the strongest advantages of using multiplexers is that during playback, the multiplexer decodes the tape allowing investigators to display only selected frames with the same address. This pullout feature saves investigators hours of time reviewing recorded actions. Another advantage is that during playback, any desired camera can be displayed full-screen.

Multiplexers offer system administrators an effective means of managing multi-camera surveillance systems:

- With the high-speed switching technique, multiplexers offer maximum coverage of all cameras without the gaps created by sequential switchers
- Multiplexers may be able to reduce CCTV costs by reducing the number of monitors, VCRs, and videotapes needed
- The number of tapes needed for video storage may be reduced
- Savings in space, heat, power, and ventilation also may be possible

Quad Splitters
The main feature of a quad splitter is the ability to compress images from four separate cameras and simultaneously display them on a single monitor screen (see figure 17). When four cameras are displayed, each occupies a quarter of the screen. A single camera can be selected and displayed full-screen, as well.

Unlike multiplexer recording, quad splitter recording yields only what appears on the monitor screen. If the VCR is recording a four-camera display, then playback will show four cameras.

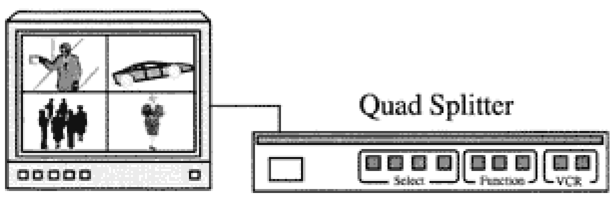


Figure 17: Quad splitters can display four cameras on one monitor.

Recording CCTV
Most CCTV systems use VCRs to record video images from the dedicated and/or call-up/switchable monitors (see figure 18). Recordings make it possible to view events that may have gone unnoticed at the time they occurred or that may require close scrutiny later. Technological advances now make it possible to record images in digital form on a computer disk. While this technology shows great promise for the near future, VCRs presently are the most prevalent recording method.

Figure 18. A simple CCTV system with VCR recording.

VCRs designed for CCTV can record video images in either real-time or time-lapse modes. In the real-time recording mode, the tape moves at the same speed as home VCRs (2 to 6 hours) and captures 30 pictures per second. This produces high quality recordings, but requires operators to change tapes every two to six hours. The 24-hour real time VCR will record 24 hours of video on a single tape at 20 pictures per second.

It is considered a real time recorder because 20 pictures per second approximates the ability of the human eye to easily distinguish moving images.

Time-lapse recording makes it possible to record video over long periods of time on a relatively small amount of videotape. Time-lapse recording can capture from 12 to 960 hours of video on one T-120 tape. However, the number of pictures recorded per second in time-lapse mode decreases significantly as the recording time increases. As fewer pictures are recorded per second, critical images may not appear on tape, and movement (e.g. a car traveling across a parking lot) may appear jerky (see figure 19).

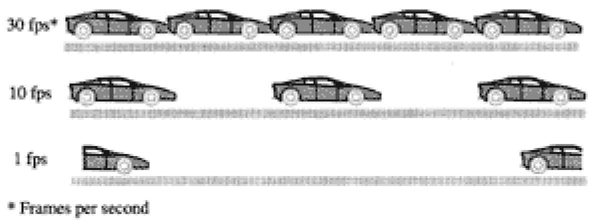


Figure 19: Fewer pictures are recorded when using time-lapse mode, causing motion to appear jerky. Notice how cars "disappear" when fewer frames per second are recorded.

The seconds per picture and number of pictures per second rendered by various time- lapse VCR recording modes are shown in the next table:

Recording mode	Seconds/pictures	Pictures/second
2 hr.	.0333	30
6 hr.	.0333	30
12 hr.	.1	10
24 hr.	.2	5
48 hr.	.4166	2.4
72 hr.	.625	1.6
96 hr.	.8333	1.2
120 hr.	1	1
240 hr.	2	.5
480 hr.	4	.25
960 hr.	8	.125

Another way to capture video on tape is through alarm recording. With this method, the VCR usually runs in time-lapse mode until an alarm occurs. The VCR then switches from time-lapse mode to real time mode, capturing video images at a rate of 30 pictures per second. After the alarm resets, the VCR returns to time-lapse mode to conserve tape. The CCTV system will need an alarm switching mechanism in order to perform this function.

When a time-lapse recording is played back at normal playback speed, the playback will present events at a speed faster than real time. It is common to play back a time-lapse recording in real time mode to speed the time necessary to review the tape. If necessary, the tape can be slowed to review those events that require greater attention.

Digital Recording
A more recently developed method of recording video images is that of Digital Recording (see figure 20).

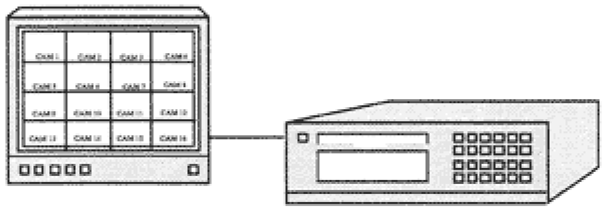


Figure 20: A Basic Digital Recorder System.

Digital recorders compress and store images to a computer hard drive using various compression techniques. These techniques include JPEG, MPEG, Wavelet and a host of other proprietary methods. Images can be stored at a rate of 20 frames per second (fps) to as many as 480fps depending on the software features offered by the manufacturer.

Operating systems offered by manufacturers vary from Linux to Unix to Windows based systems. Although Windows is the most user friendly and familiar system, it tends to be less stable than it's lesser-known counterparts.

Archived recording time varies depending on the size hard drive in the recorder. Hard drive sizes range from 0 (external only) to 400gb internally with option of raid storage for virtually infinite capacity. Hard drive size should be considered conjunctively with the time period necessary to archive.

Many Digital Recorders incorporate multiplexing with inputs varying from 4, 9, 16 and as many as 32 inputs. Similar to the conventional multiplexer/VCR setup, the frame rate will be divided among the cameras being recorded. However, unlike conventional methods, each camera input of a digital recorder can be programmed to record more or less frames per second depending on camera priority (Ex: camera #1 = 10fps, camera # 2 = 5fps, camera # 3 = 12fps, camera # 4 = 3fps using a 4 input recorder with maximum 30fps).

Another very distinct advantage to digital recording is the ease of locating events. No more fast- forward and rewind. Just type in a time, date and camera number and you can playback instant images.

Other options available with DVRs include motion detection, remote viewing via LAN, WAN, or Internet, on board media such as CD Rom, DAT storage or removable hard drives, SCSI and USB ports as well as remote control of pan-tilt devices and the list grows everyday!