PRODUCING HIGH PICTURE QUALITY ON LONG CCTV CABLES

BY Frank McClatchie

Long Coaxial and Unshielded Twisted Pair (UTP) cables are a major cause of picture quality loss on Closed Circuit Television (CCTV) systems. No matter how sharp the picture a Camera can produce, or how clear the Monitor, the cables connecting them can appear to "defocus" the resulting picture to the point that faces are hard to recognize. This article describes exactly how to overcome this limitation to CCTV system performance and how to estimate under which conditions these techniques should be employed to obtain specific performance results.

MEASURE OF PICTURE QUALITY

One measure of picture quality is how fine a detail may be observed in a picture. This is usually defined in terms of "Lines" that can be transmitted. This does not refer to the number of horizontal lines in a complete picture, which is always the same (525 lines for NTSC in North America), but to the maximum number of vertical lines that could be discerned on the CCTV system

CCTV Cameras and Monitors are often specified by the number of "Lines" that they can generate and display. The larger the number of "Lines", the finer the quality. On any given system the Camera and Monitor should have similar "Lines" capability.

Recorders must also be able to record and play back at least an equal number of "Lines" as the Camera and Monitor. Video Tape Reorders pose and additional problem in that the tapes used my also limit the "Lines" capability as well as the tapes losing "Lines" through repeated use. Digital Recorders do not suffer from worn tape, but their "Lines" capability must also be considered.

There is a relationship between "Lines" and Bandwidth (Frequency Response). Since various video equipment quality may be defined in "Lines" or frequency response, the following table may help resolve these issues.

LINES TRANSMITTED	BANDWIDTH REQUIRED
330	3.1 MHz
331	3.6 MHz
400	3.7 MHz
460	4.3 MHz
470	4.4 MHz
480	4.5 MHz
570	5.3 MHz
700	6.5 MHz
800	7.5 MHz

RELATIONSHIP BETWEEN 'LINES' AND CABLE LENGTH

One frequently used measure of picture quality loss, is when more than ½ of the energy at that frequency is lost. Thus at the cable length that ½ the energy at the desired quality level is lost, that defines the maximum length of cable that can transmit that level of quality. This leads to the following limits for maximum cable length at given picture quality levels.

LINES	RG59/U COAX	UTP PAIR
330	686 Feet	282 Feet
400	615 Feet	254 Feet
470	585 Feet	234 Feet
570	521 Feet	215 Feet
700	471 Feet	189 Feet
800	444 Feet	175 Feet

These un-equalized cable length limits can, of course, be exceeded, but only by decreasing the number of "Lines" of definition as viewed at the receiving location.

HOW TO INCREASE CABLE LENGTH WITHOUT QUALITY LOSS

Both Coaxial and UTP cables can be extended far beyond the limits shown on the previous table by amplifying and equalizing the video signal, while at the same time insuring the highest possible picture quality. While these Amplifier/Equalizers can improve the resultant pictures by simply adjusting the Amplitude and Equalization controls for the best looking picture, to obtain the best possible picture requires some Test Equipment. This Test Equipment not only saves many hours otherwise wasted in "knob twisting", but also results in perfect picture alignment every time, the first time out!

TEST EQUIPMENT NEEDED FOR PERFECT EQUALIZATION

The VLTG-800 Video Line Test Generator creates an NTSC test signal that contains a Color Burst signal and 100,200,300,400,500,600,700, and 800 "Lines" patterns for observation on Monitors to measure system performance. This Video Line Test Generator signal may be inserted at any 75 Ohm location in a CCTV system as a quality testing signal for trouble shooting or quality testing purposes.

The CM-1 Camera Master numerically measures CCTV system performance and enables precise Amplifier/Equalizer adjustment. The CM-1 is a small, battery operated digital meter that measures Sync amplitude, Color Burst amplitude, Composite Video amplitude, and Camera Focus. The Sync and Color Burst amplitude measurement enable the user to precisely set Amplifier/Equalizers to flat frequency response and correct amplitude.

WHAT ARE IRE UNITS?

IRE Units are used worldwide to measure video signal amplitude instead of Volts Peak-to-Peak. This system of measurement is much easier to use than Volts Peak to Peak and can be directly measured on the CM-1 hand-held, battery-operated Camera Master instead of a bulky Wave Form Monitor that requires 120 VAC power. The following table defines the amplitude of various parts of a video signal. In terms of IRE Units and Volts.

MEASUREMENT	IRE UNITS	VOLTS
Sync Pulse	40	0.285714----
Color Burst (p-p)	40	0.285714----
B/W Picture	100	0.714285----
Color Picture	120	0.857142----
B/W Composite (p-p)	140	1.000000----
Color Composite (p-p)	160	1.142857----

Note that a 50% grey (B/W) is 50 IRE, but 0.357142 Volts Peak. These are difficult to measure on a scope, but very easy to measure with a CM-1 Camera Master. Also note that a composite Color picture is 1.142857 Volts, not 1.0Volt.

An additional complication is that many Automatic Shutter Cameras are set at the factory to produce as much as 1.3 Volts Peak-to-Peak output in an effort to overcome cable losses. Since this level is sometimes not adjustable at the Camera, there must be a provision such as an Amplifier/Equalizer, to reduce the composite video level to 140 IRE Units prior to a Digital Recorder to prevent digital overload that will cause the Digital Recorder to cease operation. Many failures of digital recorders are simply due to digital overload on high video levels. Placing an Amplifier/Equalizer ahead of a digital recorder and correcting the video level will usually correct this type of failure.

TYPICAL EFFECT OF UNEQUALIZED UTP CABLE LOSS

As the UTP or Coaxial cable gets longer, of course the picture becomes weaker (due to low frequency cable loss), and the picture detail becomes fuzzier (due to high frequency cable loss), unless an Amplifier/Equalizer is provided to compensate for these losses. The following table shows the sort of losses that can be expected for various lengths of 24 gauge UTP facilities.

24 GAUGE UN-EQUALIZED UTP CABLE

	SYNC (Low Frequency)			COLOR BURST (High Frequency)		
LENGTH	IRE UNITS	%LOSS	NOTES	IRE UNITS	%LOSS	NOTES
0’	40	0%		40	0%	
500’	35.2	12 %	#1	21	47.5%	#6
1000’	31	22.5 %	#2	11	72.5%	#7
1500’	27.4	31.5%	#3	5.8	85.5%	#8
2000’	24.1	39.8%	#4	3	92.5%	#9
3000’	18.7	53.3%	#5	0.5	98.0%	#10

NOTES:

#1 Slight brightness loss
#2 Moderate brightness loss
#3 Serious brightness loss
#4 Possible loss of sync
#5 Probable loss of sync
#6 Weak Color, 50% detail loss
#7 Very weak color, poor detail
#8 Color faded out, very poor detail
#9 Color gone, low quality picture
#10 No color, very poor quality picture

It is clear that while the picture brightness does degrade on longer UTP cables, the loss of picture definition suffers far more. The loss of definition on longer UTP cables can be catastrophic even when the brightness of the monitor is increased to make up for low frequency loss on the cable.

The BALUNS often used to convert from 75 Ohm cable to UTP facilities add even more to the losses identified above and can only degrade performance further. Baluns can be used on very short UTP facilities, but on cables more than 500 feet, Amplifier/Equalizers should provided to overcome the losses.

PRECISION AMPLIFIER/EQUALIZER ALIGNMENT PROCEEDURES

After the complete CCTV system has been installed, and tested overall to ensure that all parts are operational, disconnect the coaxial cable from the Camera and connect it instead to the to the VLTG-800. Connect the VLTG-800 Power Cable to the 24 VAC power supply of the Camera. The VLTG-800 pilot light should turn on. At this time the “Lines” test signal should be traversing the CCTV system.

Connect the CM-1 Camera Master to the output of the Amplifier/Equalizer and loop through to the Monitor equipment. Set the “LEVEL’ and ‘DEFINITION’ control on the Amplifier/Equalizer fully counterclockwise.

1. Set the CM-1 Camera Master to “SYNC” and read the meter.
2. Adjust the Amplifier/Equalizer “LEVEL” control to read 40 IRE on the CM-1.
3. Set the CM-1 to “COLOR BURST” and read the meter.
4. Adjust the Amplifier/Equalizer “DEFINITION” control to 40 IRE on the CM-1.
5. You now have completed a perfect equalization of the cable to 40-40 standards.

The CCTV system is now equalized to a flat frequency response (the 40-40 condition) and thus has the best possible frequency response. Now remove the CM-1 Camera Master from the Amplifier/Equalizer and connect the Amplifier/Equalizer to the Recorder and Monitor. If there is a Recorder, be sure to recorder some of the VLTG-800 test signal. Observe the monitor. The test signal consists of nine horizontal bars containing various numbers of vertical stripes. Each horizontal stripe is labeled according to the number of “Lines” each bar represents. As the number of “Lines” increase, they become less distinct and merge into a gray color. The last clearly distinct “Lines” represents that system “Lines” quality level. Retest while viewing the Recording. This may be a lower level of “Lines” than testing the signal directly and thus indicate a Recorder problem.

After the VLTG-800 is disconnected and the Camera reconnected you may note a different amplitude as read on the CM-1 at the Monitor location. This is probably caused by excess video output from the Camera (a very common occurrence). This can easily be corrected with the “LEVEL” control of the Amplifier/Equalizer back to a reading of 140 IRE Units at “COMPOSITE VIDEO” on the CM-1 Camera Master meter at the Monitor location.

PERFECT PICTURE TRANSMISSION

Once this Amplifier/Equalizer alignment procedure is completed, the transmission system between the Camera location and the Monitor location will now support more than 500 “Lines” of picture definition, the only limit to the picture definition then will be the quality of the Camera, Recorder, and Monitor.

AMPLIFIER/EQUALIZER EQUIPMENT AVAILABLE FOR CCTV

There are two families of Amplifier/Equalizers to choose from. One family is used for Coaxial Cable and the other is for Unshielded Twisted Pair "UTP" facilities.

COAXIAL CABLE FAMILY OF AMPLIFIER/EQUALIZERS

RG59/U type of Coaxial Cable can be equalized to 500 lines Definition with the GB60 or the GB464 Amplifier/equalizers over a distance of 2500 feet. These devices are to be located at the Monitor location and are known as Post-Equalizers, since they are connected after the cable. The GB60 and GB464 can each handle up to four individual video channels. The GB60 is in a plastic box and is intended where only a few channels come together in one place. The GB464 is a circuit board and is plugged into a RMS-400 Main Frame with as many as nine circuit boards, providing a maximum of 36 channels in one location. Each channel can equalize up to 2500 feet of coaxial cable, and each channel has two 75 Ohm outputs and can therefore drive two Monitors, Recorders, or remote locations.

UTP FAMILY OF AMPLIFIER/EQUALIZERS

Unshielded Twisted Pair (UTP) cables up to 3000 feet long can be equalized to 500 "Line" definition with the GB60-UTP or the GB464-UTP equipments. They are Post-Equalizers, so are located at the end of the cable at the Monitor location. Both units can handle up to four channels each. The GB60-UTP is housed in a plastic box and in intended for location requiring only a small number of channels. The GB464-UTP is a circuit board and plugs into a RMS-400 Main Frame that can hold nine circuit boards for a maximum of 36 channels per Main Frame. Each channel can equalized up to 3000 feet of UTP cable and also has two 75 Ohm coaxial outputs so that it can drive two Monitors, Recorders, or Remote locations.

Even longer spans of UTP cable can be equalized by placing a TPS-2000 Twisted Pair Sender at the Camera location. This is called a Pre-Equalizer since it is ahead of the cable and can add up to 2000 feet to the length of equalized cable. This Pre-Equalizer can add additional equalization in 1000 foot and 2000 foot increments, while the GB60-UTP or GB464-UTP builds out the remaining cable equalization. With the additional 2000 feet of equalization provided by the TPS-2000, in combination with GB464-UTP, the total span can now be 5000 feet of fully equalized cable pairs.

Intermediate Monitor and Repeater stations can be provided by installing a TPT-4000 Repeater Station between the Camera and the Monitor. The input (post-equalizer) can equalize up to 2000 feet of cable and the output (pre-equalizer) can also pre-equalize either 1000 or 2000 feet of cable. In this way a maximum of 4000 feet can be added to the 5000 feet, using both pre-equalizers, post equalizers and intermediate amplifiers. The Repeater Station also provides a 75 Ohm output to connect a local monitor or test point. The TPT-4000 has two UTP video outputs to drive two separate UTP facilities.

SUMMARY

When all is said and done, the only product that the CCTV industry has to offer is PICTURE QUALITY sufficient to identify objects being viewed, whether faces or license plates. Cameras and lenses may capture an image, recorders and Monitors can be made to record and display that scene, but the job is not completed until the Camera delivers that picture to the Monitor. With the pressure now on to deliver the best possible picture, it is high time to equalize cable losses to get the best pictures possible.