CCTV Troubleshooting

Below you will find hyperlinks to different areas of CCTV trouble shooting. To find the area you are searching for, just click the category. That will move the page up to the specific category.

Troubleshooting signal attenuation in a CCTV system.

This case history shows how decibel knowledge, a handheld oscilloscope, and intuitive thinking can be used to solve a troublesome problem.

Now that we have a somewhat complete understanding of the decibel and how it applies to various types of signals, we can apply this knowledge, along with the many modern test instruments available today, in troubleshooting any electronic equipment operation problems that may come our way.

As an example of how this may work, let's review a case history involving closed circuit television, coaxial cable, and shoddy workmanship.

Background site information

We were called in by a client who complained about a very poor picture generated by a security camera on a closed circuit television (CCTV) video monitor on a simple point-to-point link. The picture had degraded from good to unusable over a short period of time and really got bad in the few days following a recent lightning and rainstorm. The general opinion was that lightning had somehow caused the problem.

Upon inspection, we found that the CCTV system consisted of National Television System Committee (NTSC) standard video generated and displayed in black-and-white. The main monitoring point of the CCTV system was a loading dock and a weather-proofed housed camera located on a 10-ft high post mounted atop the building's roof was used to monitor that location.

The camera was connected to a video monitor in a security shack some 200 ft away via a 75 ohm coaxial cable, which was routed down into the shack by means of a vent pipe type of entry. Power to the camera was provided via a low-voltage DC link on another coaxial cable, which was installed right alongside the coaxial cable used to transport the video signal. Both the monitor and camera low-voltage DC supplies were simply plugged into a wall outlet convenient to the operator at the guard's shack.

Symptom

The picture on the video monitor looked as though someone had turned the contrast control all the way in one direction so that there was no contrast at all; the picture looked washed-out and was barely visible on the screen, which was a nearly uniform light gray.

Testing procedures carried out

Our first task was to go up to the camera at the roof and see what the video signal looked like as it exited the camera. This test was much aided by the fact that our handheld, 50 MHz bandwidth, solid state, digitizing oscilloscope with LCD display had an internal battery pack and did not require any AC power for operation.

First test. First, the coaxial cable was disconnected at the camera and a BNC style "TEE" fitting was installed. This fitting was equipped with a 75 ohm terminator resistor on one leg. Then, we connected our handheld oscilloscope into the remaining open end of the TEE. The result, as shown in Fig. 1, was a healthy NTSC composite video signal. Conclusion: the camera was clearly putting out a good signal, which was about 1.8V peak-to-peak across the 75 ohm termination. (There is also a DC component with the AC video signal.)

We then placed our handheld oscilloscope into its meter-mode and the above signal at the camera into the 75 ohm load was taken as a zero dB reference and stored into memory. This is shown in Fig. 2, where + 000.1 dBV DC is taken as being close enough to zero to do the job. Now, the "good" signal right out of the camera was available to be used again and again as a comparison with signals we would measure at different locations. We then would be able to see how much loss of signal occurred along the path, all of which was supposed to be a consistent 75 ohm.

The TEE was removed and the 75 ohm coaxial cable was reconnected.

Second test

The next test was made at the video monitor end of the cable and right at the point where the cable was connected to the monitor. Again, the TEE was used, but this time no 75 ohm termination resistor was used with it since the TEE was attached to both the monitor and the cable. Thus, there was a fairly good 75 ohm load on everything. The result of this test was that almost no video signal could be seen on our handheld oscilloscope's screen.

We then changed the oscilloscope's vertical scale from 500 mV/cm to 100 mV/cm and another measurement was taken, which is shown in Fig. 3. As you can see, the video signal is simply attenuated but does not appear to be distorted in any way that is easy to see. Conclusion: the signal loss was occurring along the 75 ohm cable path, or was it?

Video monitors have been seen to "load down" a signal due to an internal failure on its input circuit; as such, we didn't want to rule this possibility out. A quick test with the TEE and the 75 ohm termination resistor in place of the video monitor quickly ruled out this possibility; the signal was essentially unchanged from that shown in Fig. 3. Now, we really could conclude that the signal's loss was occurring along the 75 ohm cable.

Third test. We next placed our handheld oscilloscope into its meter-mode, while maintaining the connection to the TEE at the junction of the cable and video monitor. This allowed us to take a relative dB measurement reading, as shown in Fig. 4, using the original zero-level as the reference. (Remember, we did this at the camera end to establish a comparison reference.) Here we see that a - 13.7 dBV DC loss exists. This loss represents a voltage loss ratio of 4.84:1, or a signal loss of nearly 5V for every volt put into the cable!

How much signal attenuation should you expect on a 200-ft long, 75 ohm coaxial cable? A quick look at the coaxial cable manufacturer's Master Catalog gave us the approximate answer: around 2 dB of loss at 10 MHz for 200 ft of RG-59/U type cable as used in CATV applications. The whole attenuation chart is shown in the accompanying table below.

What we were seeing in this path was more than 11 dB loss over and above that stated in the manufacturer's literature. Also, the baseband video we were looking at shouldn't have a lot of really high-frequency in it; thus, the cable probably shouldn't attenuate as much as 2 dB (per manufacturer's literature) for 200 ft in any case.

Oh yes, since the manufacturer's information was provided only in dB form, what would we have done if we didn't understand dB and weren't working in terms of dB on our handheld oscilloscope? You guessed it. We would have had no idea what was "normal" and what was not on a coaxial cable run of the type being investigated. All we would have had was some guesswork, which is not a very good way to go in most cases.

Further analysis

What was happening on the cable? The BNC connector at the video monitor end was inspected and it looked OK, except that it seemed to be a little wet after it was handled and the cable was flexed.

Following this the same examination of the BNC at the camera end also failed to show any problems. We also made sure that the connections were well protected from the environment by the camera's enclosure.

Was the moisture a clue? Was it significant, or not? Past experience with coaxial cables with water inside of them showed that this condition caused severe signal attenuation.

Back to the rooftop we went to make a closer examination of the 75 ohm cable and its route back to the video monitor. First, we looked at the vent pipe, the rooftop penetration through which the cable was passed. We found that it was not equipped with a weatherhead and that the cable was simply stuck down into it from its open top. Sealing was done with some kind of putty or caulking material and it looked as though it was really dried-out. Thus, water (from the storm, remember?) could follow the cable's sheath down into the building around the bad seal.

But how did this condition let the water into the cable? We pulled the sealing material out of the vent pipe and then hauled the coaxial cable up out of it. About 10 feet down, we found a connection made up of two BNC fittings and a male-male adapter. The end of the cable going into the bottom BNC fitting from the building was mostly pulled out of the connector and the braid/sheath was fully exposed to any water flowing down the cable from above. In fact, the arrangement was a pretty good funnel for the water to flow into the cable between the outer sheath/shield and the inner dielectric material. Corrosion was also rampant in the damaged connector set since it had not been sealed from moisture in any way. Obviously, this was not good for reliable signal transport.

Where did this splice come from? After a little discussion with the personnel, we learned that the camera came from the factory with about 10 ft of cable. Rather than throw this cable away, it was simply kept in place and used by connecting it to the end of the cable being routed from the video monitor. There was no explanation as to why such a poor rooftop penetration was made; nobody would own up to it while we were there.

Solution

The whole existing 75 ohm coaxial cable run was replaced with a continuous length one. Where this cable came from and what its quality was, we didn't know and couldn't find out; it might have been surplus stock from somewhere (World War II?). After installation of the "new" cable, the signal at the video monitor end was again checked with the test TEE and the monitor in place. This signal is shown in Fig. 5. Here we see that there is still some attenuation, but nowhere near as much as before.

Again, using our handheld oscilloscope in its meter-mode, we made a relative dB measurement reading using the original zero-level as the reference. The "new" cable's signal loss, as shown in Fig. 6, is about -4.5 dB. Compared to the previous dB measurement readings [ILLUSTRATION FOR FIGURES 2 AND 4 OMITTED], this amount of signal loss is acceptable in this application, as was evidenced by the good picture on the video monitor.

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[back to top]

Producing High Picture Quality on Long CCTV Cables

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 / 3.1MHz
- 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 a 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 | I.R.E. 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. This is 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)

LENGTH | I.R.E | % Loss | Notes

- 0 Feet | 40 | 0% | -----
- 500 Feet | 35.2 | 12 % | #1
- 1000 Feet | 31 | 22.5 % | #2
- 1500 Feet | 27.4 | 31.5% | #3
- 2000 Feet | 24.1 | 39.8% | #4
- 3000 Feet | 18.7 | 53.3% | #5

COLOR BURST (High Frequency)

I.R.E. | % LOSS | NOTES:

- 40 | 0% | ----
- 21 | 47.5% | #6
- 11 | 72.5% | #7
- 5.8 | 85.5% | #8
- 3 | 92.5% | #9
- 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 Procedures

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.

11. Set the CM-1 Camera Master to "SYNC" and read the meter
12. Adjust the Amplifier/Equalizer "LEVEL" control to read 40 IRE on the CM-1
13. Set the CM-1 to "COLOR BURST" and read the meter
14. Adjust the Amplifier/Equalizer "DEFINITION" control to 40 IRE on the CM-1
15. 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.

This article shows exactly how to do this.

[back to top]

Aligning a CCTV Twisted Pair System For Maximum Performance & a Proposal To Establish a System Quality Measurement Standard

This article defines a procedure that enables a CCTV installer to obtain the best possible picture that any given Camera can send over Twisted Pair wires to any given Monitor. When the Camera and Monitor are connected together "on the Bench" with short wires, what you see on the Monitor will be the best picture that this Camera and Monitor can produce. No additional equipment can improve on that picture, baring that there is no defect in either the Camera or Monitor. Good Monitors will display all of the Lines of Definition that the Camera can produce.

Once connected together through long Twisted Pair wires "in the field", you will at once notice a reduction in picture detail. If it is a Color Camera and Color Monitor, there will also be a noticeable reduction in color brightness or even no color at all. This condition is due entirely to losses that take place in the Twisted Pair wires and the Baluns used to connect into the Twisted Pairs. This signal loss can be corrected using video amplifiers and equalizers such as the CCTV Twisted Pair Picture Clarifying System.

SOURCE OF THE PROBLEM

Twisted Pair wire and the associated Baluns both create signal losses across the entire 30 Hz to 4.5 MHz span of frequencies encompasses by a video signal. The longer the wires the greater the loss of signal, until, with a long enough wires, there will be no usable picture signal left. The higher frequencies, which convey fine detail in a picture, suffer much greater losses than the lower frequencies which mainly contribute to picture brightness.

A high definition Camera (say 570 Line Definition) looses more of its rated Lines of Definition while traversing the Twisted Pairs than a low definition Camera (say 380 Line Definition) on any specific length of wire. After all, the 570 Line Camera has more Lines to lose that the 380 Line Camera. Therefore a long pair of wires will impact the received detail more on a 570 Line Camera than a 380 Line Camera, but the 380 Line Camera will never look better than the 570 Line Camera on any length of Twisted Wire. However, if an amplifier and equalizer is added onto a long Twisted Wire pair, and correctly adjusted, all of the Lines the Camera can generate will appear at the Monitor location, greatly improving the quality of the picture as seen on the Monitor.

JUST WHAT ARE LINES (OF DEFINITION)?

Now that we have broached the term Lines of Definition, let us define the term as used in video. First of all, it has absolutely nothing to do with the number of horizontal lines that are seen in the picture! In fact, all CCTV Cameras (in the USA) create exactly the same number of horizontal lines in a picture (that number happens to be 480 lines in each picture).

The video system does create 525 sync pulses per picture, but only 480 produce visible lines. What a statement like "570" Lines refers to when discussing the detail a Camera can produce, is actually the maximum number of VERTICLE lines that could be distinguished on a Monitor screen. If you tried to show more than 570 lines on the screen, instead of actual lines the screen would appear grey.

BAND WIDTH REQUIRED

The larger the number of Lines a Camera can show, the wider the bandwidth of the video signal (see TABLE 1).

Table 1

LINES	BAND WIDTH REQUIRED
300	3.1 MHz
380	3.6 MHz
400	3.7 MHz
460	4.3 MHz
470	4.4 MHz
480	4.5 MHz
570	5.3 MHz

It can be seen from TABLE 1 that, for instance, a 380 Line Camera will be less affected by high frequency loss in a Twisted Pair than a 570 Line Camera, but then again the 380 Line Camera can never deliver the definition of a 570 Line Camera, even under the best of circumstances.

As Twisted Pair wires become longer, the losses increase at all frequencies, but high frequencies suffer much more loss than low frequencies.

One handy measurement for the low frequencies that affects mainly picture brightness and contrast, that can be easily measured using a CM-1 Camera Master, is the Sync Pulse amplitude.

As the Twisted Pair get longer and longer, the Sync Pulse gets shorter and shorter. The Sync Pulse amplitude is an exact measure of the Twisted Pair loss at low frequencies because all Sync Pulses are the same amplitude at the Camera, so measuring Sync Pulse amplitude at the Monitor also measures the loss of brightness and contrast as the video picture traverses the intervening wire facilities and associated Baluns. The Sync Pulse amplitude is always the same, even when the Camera lens is capped.

A handy measure of high frequency loss that best reflects the Lines of Definition transmittable over the Twisted Pair wires is the measure of the Color Burst amplitude that is generated by a Color Camera and measured at the Monitor.

A Color Burst is always the same at the Camera even when the Camera lens is capped and is not influenced by the actual picture transmitted. Thus the amplitude measured at the Monitor is an exact measure of the loss caused by the Twisted Pair and Baluns. This measurement, using a Color Camera, is an accurate measure of the wire facility loss even when the camera is later replaced by a black and white Camera.

THE KEY TO MEASURING SYSTEM PERFORMANCE

These two measurements (Sync Pulse and Color Burst amplitude), thus provide an exact and specific measure of the ability of any given Twisted Pair (and Balun at each end) to transmit a quality picture.

The easiest way to measure the Sync Pulse (SP) and Color Burst (CB) amplitude is with a CM-1 Camera Master. This is a digital, hand-held meter that reads these two (and also other) characteristics of CCTV video signals accurately in I.R.E. Units of measurement. All video measurements, world wide are measured in I.R.E. Units, so we must know exactly what an I.R.E. Unit is and why this measurement is universally used by the Video Industry.

WHAT ARE I.R.E. UNITS AND WHY ARE THEY USED?

The main reason for measuring in I.R.E. Units instead of Volts peak-to-peak is simplicity of the numbers created while measuring a video signal. For instance a standard amplitude video signal in Volts peak-to-peak and I.R.E. Units measure exactly:

VIDEO COMPONENT | I.R.E. UNITS | VOLTS peak-to-peak

- B/W (picture only) | 100 | 0.714285714---
- Color (picture only) | 120 | 0.857142857---
- Sync Pulse | 40 | 0.285714286---
- Color Burst | 40 | 0.285714286---
- B/W (peak to peak) | 140 | 1.00
- Color (peak to peak) | 160 | 1.142857143---

Notice that only the Black and White video signal (at 1.00 Volts peak-to-peak) is easy to measure in Volts peak-to-peak while all of the important parameters are easier to remember and use as a reference when video signals are measured in I.R.E. Units. It is no wonder that the entire Video Industry uses I.R.E. Units when measuring the video amplitude of any part of a TV signal.

What Is A 40;40 Video Signal?

Also notice that the video signals of particular interest to us (Sync Pulse and Color Burst) both have a standard amplitude of 40 I.R.E. Units. So, for our purposes, a no loss signal would measure 40:40. A very easy number to remember to represent a perfect picture. Any more or less represents an impairment of the picture!

In this article we will use the first of these two numbers to denote the Sync Pulse (SP) amplitude, and the second number to denote the Color Burst (CB) amplitude as in SP:CB.

TABLE 2 shows what can be expected for various lengths of Twisted Pair wire. These are measured losses of a pair of wires only and do not include losses that are caused by the Baluns at each end since there is a wide variation in Balun loss and frequency response in the commercially available Baluns).

Table 2

TWISTED PAIR | SYNC PULSE

LENGTH I.R.E % LOSS NOTES

- 0 Feet | 40 | 0% | ----
- 100 Feet | 39 | 2.4% |
- 500 Feet | 35.2 | 11.9% |
- 1000 Feet | 31 | 22.4% | #1
- 1500 Feet | 27.4 31.6% | #2
- 2000 Feet | 24.1 | 39.7% | #3
- 3000 Feet | 18.7 | 53.2% | #4

- **NOTES:**
  - #1. Low contrast and brightness
  - #2. Lower contrast and brightness
  - #3. Very low contrast and brightness
  - #4. Possible picture roll
  - #5. Slight loss of color
  - #6. Weak color
  - #7. Faded out color
  - #8. Possible loss of color
  - #9. Probable total loss of color

Table 2 shows that there is a very serious loss of high frequency response as the Twisted Pair wires extend beyond a few hundred feet. Obviously something must be done to be able to obtain high definition pictures at more than a few hundred feet, especially when color is to be carried.

THE ANSWER TO TWISTED WIRE LOSS!

The answer to Twisted Pair loss is to off-set this loss by careful amplification and equalization to exactly replace the energy lost at each frequency. This type of equipment is now manufactured by several manufacturers, including F M Systems, Inc. that is capable of correcting this cable loss.

What this article offers is an exact way to measure and thus correct these losses using measurement of the Sync Pulse and Color Burst amplitude. To do this, simply connect a CM-1 Camera Master at the receiving location (with a Color Camera at the sending end) and adjust the Gain and Equalization controls until a 40:40 measurement is achieved.

At this point the Twisted Pair loss will have been completely off-set and the combination of Twisted Pair loss, Balun loss, and Amplifier/Equalizer gain will just balance each other out to achieve a perfect 40:40 result. Under these conditions the Monitor will display all of the Lines that the Camera can generate.

[back to top]

Pre-Digital Control What is it and Why is it Needed

The digital revolution has brought about many changes in the way signals are stored and transmitted. With this new age of DIGITAL SIGNAL TRANSMISSION come new problems that must be solved.

The world around us is an analog one. The human body experiences everything with infinite levels. Light is not just on and off, but comes in varying levels of brightness. We hear changing levels of sound, Heat, Pressure, Motion all come in infinite levels. This article will focus on Audio and Video signals and the problems associated with digital transmission.

All Audio Video signals begin their journey as an analog signal. All audio and video signals start out as sound levels and changing light levels, both of which are analog in nature.

The first process that occurs in any digital processor is the conversion of the analog signal into a digital signal. This is accomplished with an Analog-to-Digital converter (A/D). The A/D is an integral part of every digital product and is directly connected to any incoming analog signal. The A/D converter samples the incoming analog signal and assigns a digital number to each level it detects, provided the level does not exceed the highest number that can be assigned.

The designers of digital devices must choose a sampling rate and maximum sample size that best fits the signal type. They balance this against the complexity and cost of manufacturing the product. This means that they must make a trade-off when designing the equipment. Often that trade-off causes the equipment to over-load with real world signals.

This brings us back to the analog signal, in the real world these signal levels vary greatly; occasionally the levels are extraordinarily high and at other times vary low. If the designers built the equipment to handle the extraordinarily high signals that occasionally occur, the price and complexity of the digital process would be to expensive to sell.

So occasionally the digital equipment will fail to transmit the signal momentarily when the level is extraordinarily high. This is caused by the over-load created by the D/A converter in the digital equipment.

An example of video digital overload is seen as a "comet tail" or streaking to the right side of a bright part of the video picture, diminishing as it moves to the right side of the screen.

The bright spot in the video caused the digital system to reach its maximum number and over flow the highest number possible. The recovery time produces the "comet tail". In other equipment video overloads or "number overflow" will cause break up of the video picture.

This is especially true with any video compression system. You can experience "tiling" or complete failure of video transmission during these high level periods.

If you adjust the input signal down below the standard input to allow for more headroom before overload, then your signal will have greater noise all of the time. Some times the signal will be vary low level which causes the signal to be closer to the digitizing noise level which makes the signal much noisier. To solve this, the incoming level should be automatically raised to nominal level during low level inputs.

Similarly the level should be automatically lowered during high level signals to prevent the overload. This level control must be done before the signal enters the digital equipment, before the A/D converters inside the digital equipment. This is referred to as PRE-DIGITAL CONTROL.

The basis of PRE-DIGITAL CONTROL is to regulate the audio and video as analog signals before the digital system receives the signal so that all signals presented to the digital equipment will have regulated, controlled levels. This will prevent digital noise caused by to low a level and eliminate over-load due to high level signals.

Level control features built into the digital equipment cannot prevent the overload and under level noise problem, because the A/D converter is ahead of any control features.

Using True Pre-Digital Control will help to maintain the digital signals integrity and prevent the most common failures of the digital transmission system.

Requirement for an audio and video PRE-DIGITAL CONTROL system should include:

- **AUDIO:**
    - Automatic control of audio loudness over 30 dB range.
    - Automatic Gating to prevent "pumping" of background sounds.
    - Program-Dependent Time Constants to prevent "ducking".
    - Dual-Band control system for both high and low frequencies.
    - High frequency overload control system to prevent "S-ing".

- **VIDEO:**
    - Handle signals video from 0.5 Vpp to 2.0 Vpp.
    - Automatic SYNC control to 40 I.R.E. units.
    - Automatic Luminance control to 100 I.R.E. units.
    - Automatic Chrominance Equalization.
    - Automatic DC Restoration (Clamping). Automatic 60 Hz elimination (Hum Bucking).

To start with an analog signal requires a certain amount of bandwidth to transmit the signal. A digital signal requires at least 5 times as much bandwidth to transmit the same signal.

A COMPARISON OF ANALOG AND DIGITAL AUDIO TRANSMISSION SYSTEMS

ARE DIGITAL SYSTEMS NECESSARILY BETTER?

Good digital disc players can play back recorded music with fidelity unrivaled by any other home type tape or record system. In fact the improvement over LP discs or commercial tapes borders on the spectacular. No wonder then that many people are lead to believe that if it is digital, it is necessarily better and that it would follow that if digital recording is better, then digital transmission must also be better than analog transmission. But is this really so, are recording and transmission considerations the same ? It turns out that for the transmission of music, nothing could be further from the truth.

RECORDING vs TRANSMISSION

Why should transmission be any different than recording when deciding between analog and digital processes? Both are degraded by noise introduced within the medium, but in recording no one really cares what power density or bandwidth is required to lay down and retrieve the music from the record medium, whereas the power density and occupied bandwidth are a price concern when transmitting the music on cable systems.

DIGITAL vs ANALOG TRANSMISSION OF AUDIO

To compare digital with analog transmission, one must first construct a level playing field, this can be done by requiring each process to:

5. Occupy the same time duration to play a given piece. Here we will consider music played in real time, but "time" expansion and contraction would be OK as long as the same rules applied to both digital and analog.
6. Signal power and injected noise level must be the same for each.
7. The occupied bandwidth must be the same for each process.

Examining past comparisons between analog and digital transmission systems, we find that where a digital system was declared to be greatly superior, we also find the digital system typically occupying one or more orders of magnitude greater bandwidth than the analog system it is being compared with.

Back to Fundamentals

When it comes to comparing various transmission processes, information Theory is as fundamental as you can get, and is the best place to start. This paper is not intended to be a tutorial on the subject of information theory, so I will not trot out statistical theory or even write down one dazzling formula, instead I will extract a fundamental theorem that applies directly to the subject at hand, to witch:

Given that each of two transmission processes are constrained to the same power level, and

Given that each must encounter the same noise level in transmission (equal Carrier-to-Noise Level), and also

Given to occupy the same transmission band width, and also further

Given that the two processes have equal signal energy distribution efficiencies, then

Consequently both systems will have an equal demodulated signal to noise ratio.

In other words, on a level playing field, there is no "digital advantage" at all, and in fact neither system is superior, merely because of the type of process. We must be more discerning and look carefully at the specific advantages and disadvantages of each system.

Practical Considerations

What we are left with is a choice between two systems that are basically equal, given equal transmission parameters. However, the digital system is by nature a wide band beast, while analog systems are at home in either narrow band or wide band channels. Let us explore the performance of the two systems in WIDE BAND and NARROW BAND transmission facilities.

WIDE BAND CHANNELS are hereby defined as transmission channels two or more orders of magnitude wider than the base-band bandwidth of the signal to be transmitted.

Digital transmission is in its natural home in the wide band channel, for transmission in such a channel, the signal can be sampled sufficiently higher than the minimum Nyquist rate to ensure transmission of the highest modulating frequencies without aliasing distortion and also a sufficient number of sampling levels to reduce quantizing noise and minimize distortion at low modulation levels. At these band-widths the digital systems are capable of Super Quality audio transmission.

Analog frequency modulation can also spread the base-band bandwidth efficiently over the same band-width as the digital systems, and will result in similar received signal to noise ratios. What differences could be measured between the two processes would only reflect the differences in evenness of energy distribution over the pass band that each system produced. The system that spread the signal energy most evenly over the allocated bandwidth would produce the best signal to noise ratio. Both transmission systems are capable of similar energy distribution, so differences would be minimal.

NARROW BAND CHANNELS are hereby defined as being less than two orders of magnitude wider than the modulating signal (but not less than the base-band bandwidth for real time transmission).

Analog transmission has special advantages in narrow band channels, since there need be no impairment of the signal as there will be in digital systems that must use sub-optimal analog-to-digital (A/D) encoding to narrow transmitted bandwidth appreciably.

Once constrained to occupy a narrow band width a digital system must sacrifice some signal fidelity, while an analog system does not need to limit signal fidelity.

Typical techniques employed in digital systems to reduce occupied band width include:

8. Bit compression, wherein one transmitted bit does not represent one of two data states, but one of four states, or one of eight states, etc.. The greater the compression the less bandwidth required to transmit the signal. However there is a price and that is that the power of the signal must be increased to overcome the greater noise susceptibility of the multistate transmission process that is required for this bit compression. There goes the level playing field.
9. Use fewer sampling levels, and use a shorter word length. However this causes increased quantizing noise and also greater distortion at low music

levels, where only a few quantizing steps must accurately reproduce the complex audio wave form.

10. Use a lower sampling rate. The nyquist rate (of twice the highest frequency to be transmitted) sets the absolute lower limit, but in practice almost all digital systems already use the lowest practical rate anyway, so very little is to be gained by applying this maneuver.
11. Use some form of digital companding. This usually takes the form of gradually increasing quantizing step sizes, with very small steps near zero voltage and rather large steps near 100% modulation. This has the advantage of reducing the word length needed to describe a sampled voltage, thus reducing the band width required to send the signal, while at the some time keeping the quantizing noise and low volume level distortion low during soft music passages.

    Unfortunately there are side effects. For one, distortion at high music levels is now greater due to the much larger quantizing steps near 100% modulation. Second, low level, high frequency components riding on low frequency high level signals (that being the condition of most musical signals) are only reproduced near zero crossings, with the high frequencies chopped off as the low frequency sound nears the negative and positive peaks.

    This is because the sample step size exceeds the amplitude of the high frequency ripple, and is not recognized by the sampling process. The result? The violins are turned on and off at the low frequency rate. Not exactly what the composer had in mind.
12. Use analog companding followed by linear encoding. This process holds some promise of success by combining some of the analog advantages with digital processes. The author is not aware of any operating systems of this type.
13. Stop trying to define the exact voltage at each sample interval with a binary word. In other words abandon pure digital transmission for a process such as Delta Modulation. This is a sort of half-way house between pure digital and pure analog.

    In this process the delta modulator waits until the audio wave form departs from its previous voltage by some specified delta increment (or decrement). At this time a pulse is sent to increment or decrement the voltage at the receiving point by that amount. The faster the wave form changes in time the more pulses must be sent. Many variations on this basic process are possible that help to reduce the total bandwidth.

    The best known delta modulation scheme being the Dolby Digital Audio System. This system is very complex, in that the signal must be carefully analyzed prior to encoding, resulting in a very expensive transmitter, but a fairly inexpensive receiver. Super Quality Audio can be achieved with this process at band-widths intermediate between narrow band and wide band. This process is not entirely digital and not entirely analog, so it is left to the reader to decide which category it belongs in.
14. Reduce the redundancy in the music prior to transmission and hope that the missing pieces of redundancy won't be missed. On a coarse basis, there is much redundancy to be exploited in music, so perhaps a great reduction in bandwidth could be obtained this way. It all depends on how much you think you can tinker with the signal without also changed the timbre and fine nuances in the music. Certainly the melody and basic harmony would remain, but I doubt that the composer would be pleased

with the result if enough processing of this sort were done to reduce the bandwidth significantly.

Conclusion

Information theory tells us that if occupied band width, Carrier-to-Noise Ratio and signal energy distribution are equal, all modulation processes result in the same basic signal to noise ratio.

If very wide transmission band width is used (approximately 100 times the base-band band width) either digital or analog modulation processes can provide Supper Quality Stereo.

Where it is desirable to transmit stereo over narrow band channels (approximately 10 times the base-band band width), it is necessary to somehow modify the digital or analog modulation technique to accommodate the bandwidth reduction.

The techniques available that enable narrow band transmission of digital signals all operate on the instantaneous shape of the musical wave form, and tend to be perceived as some form of distortion to the ear on the continuing basis. Depending on the digital band width reduction system employed, either background (digitizing) noise increases, high level distortion or low level distortion increases, or some change in the character of the music is noticed by the listener. The grater the bandwidth reduction, the grater the degree of distortion perceived. this is true even for digital bandwidth reduction systems that seem to test very well with simple sine wave test.

The bandwidth reduction techniques available, using modern analog companding, operate on the RMS or average level of the music wave form, with no wave shape alteration during passages of relatively constant amplitude. There is no constant level of distortion as would be perceived in a digital band width reduction system. Instead, the artifacts of analog bandwidth reduction occur only during musical level changes, not for the entire duration of the music passage. Therein lies the principal advantage that analog has over digital in narrow band transmission systems.

The human ear is particularly sensitive to distortion products that are continuously present, such as those caused by digital bandwidth compression, whereas analog bandwidth reduction processes induce very short term distortion products with a duration less than 20 milliseconds, which are difficult, if not impossible for the ear to detect. Modern analog companding systems operate within this acoustic "deaf spot", so the analog companding artifacts will not be perceived.

This article shows that given the same bandwidth availability and equal noise and signal power both analog and digital transmission systems will generate similar signal-to-noise ratio and distortion performance.

As the noise level increases in an analog transmission system, the overall signal-to-noise ratio also increases linearly with a consequent decrease in quality. Analog systems tend toward graceful failures, whereas a digital transmission system suffering a similar increase of noise increase in the transmission system will suffer a sudden cataclysmic total loss of signal (if squelched) or even worse, extreme high level crashing sounds (if not squelched). Digital systems are either "perfectly fine" or crash cataclysmically upon exceeding a certain threshold of noise.

Given equal transmission considerations, the principle difference between analog and digital performance is that the digital system fails cataclysmically while the analog system fails gracefully.

[back to top]

How to Create Superior Quality CCTV Pictures on UTP & How to Prove Results with the 40-40 Quality Test

Very high quality video pictures can be sent over Unshielded Twisted Pair (UTP) wires, provided that suitable cable slope equalizers and amplifiers are provided to completely off-set the losses incurred when the video signal traverses the UTP cable pairs. When this is done, the picture received at the far end of the cable will be every bit as good as the Camera , Recorder, and Monitor are able to produce, with no degradation due to losses in the intervening transmission facilities, whether UTP, Coaxial Cable, or Impedance Converters such as Senders and Receivers. In fact, once the cable losses have been correctly equalized, further picture quality improvement can only be achieved by using superior quality Cameras, Recorders, and Monitors.

Many CCTV installers have found that high quality Cameras, Recorders, and Monitors do not seem to provide better overall picture quality than lower quality terminal equipment when used on long UTP transmission facilities. The reason is simple. All of the crisp high quality detail created by the high quality terminal equipment (cameras, etc.) has been lost trying to get through the losses created by the Senders, UTP wires, and Receivers. The only way to upgrade picture quality is to correct the transmission facility losses by using cable equalizers and amplifiers to off-set these losses. It is also very important to realize that, in the case of twisted wire equalization, "more is not better". Only the correct amount of equalization will do. More of the same will only make the video picture worse, instead of better.

So to get the best possible picture with any given terminal equipment / transmission facility, careful measurement of cable losses at both low and high frequencies need to be made with suitable test generators and measurement equipment. Then adjustable cable equalizers and can be installed to off-set transmission losses.

When dealing with UTP transmission facilities, the test equipment will have to operate at both 75 Ohm unbalanced impedance and also 105 Ohm balanced impedance. Both of these kinds of measurements can be made using the CM-1 Camera Master (a 75 Ohm video signal tester) together with the CM-1-UTP (a balanced 105 Ohm adapter). The CM-1 measures the video signal in I.R.E. Units of measurement. The I.R.E. Unit is the International standard for video measurements, not Volts peak-to-peak. The reason is, that I.R.E. Units are much easier to read and calculate with (i.e., a correct SYNC. pulse amplitude in IRE Units is 40, while in Volts peak-to-peak the measurement is 0.285714 Volts).

The VLTG-800 Video Line Test Generator is used to generate the full range of signals needed to test a transmission facility for quality. If the VLTG-800 is not available, these quality tests can be performed using a Color Camera as a signal generator (with somewhat less accuracy). The 15,750 Hz Sync. pulse of the VLTG-800 or Color Camera provides the test signal for low frequency "luminance" amplitude test, while the 3.579 MHz Color Burst, also transmitted by the VLTG-800 or Color Camera generates the high frequency "Chrominance" amplitude test signal.

The Sync. pulse from the test generator will have an amplitude of 40 I.R.E. Units and the Color Burst will also measure 40 I.R.E. Units at the test generator output. The longer the transmission facility, the smaller these measurements will be, with the Color Burst measurement reducing much faster than the Sync. signal. A perfect transmission would read 40 I.R.E. Units of sync. and 40 I.R.E. Units of Color Burst at the far end of the system (at the Monitor) and could be designated a 40-40 perfectly equalized system, whereas either a higher or lower reading would constitute a non-equalized less than optimum transmission of the video signal.

A perfect 40-40 test signal will be degraded to about 35-21 by the time that 500 feet of UTP wire has been traversed. this means that the luminance (brightness) of the picture will be 35/40, or 87.5% of normal level, and the picture detail will be 21/40, or about 52.5 % of what the camera generated ! Almost one-half of the picture detail is now gone. This results in the dull less than sharp picture image.

At about 1000 feet the test signal will be degraded to 31-11. The picture brightness will be down to 31/40 or 77.5% of normal (or a loss of 22.5% of the original signal. The picture detail will now be 11/40 or 27.5 % of the original picture detail, a loss of 72.5%!

In each case, the picture brightness can be compensated for by increasing the contrast control of the Monitor, but who wants to keep changing that control each time a new camera is switched on-line. No such adjustable control is readily available to off-set the loss of high frequency response. the picture detail is lost forever unless equalizers are provided to compensate for this loss.

As the UTP or coaxial cable gets longer, of course the picture gets dimmer and the detail gets fuzzier unless equalizers are provided in the CCTV design. The following chart shows the sort of loss that can be expected for various lengths of UTP wires. Losses incurred by passive Senders and Receiver can add significantly to the total losses that may be incurred

24 Gauge UN-equalized UTP Cable Loss

Sync. (low frequency)

LENGTH | IRE UNITS | % LOSS | NOTES

- 0' | 40 | 0%
- 500' | 35.2 | 11.9% | #1
- 1000' | 31 | 22.4% | #2
- 1500' | 27.4 | 31.6% | #3
- 2000' | 24.1 | 39.7% | #4
- 3000' | 18.7 | 53.2% | #5

Color Burst (high frequency)

IRE UNITS | % LOSS | NOTES

- 40 | 0% |
- 21 | 52.6% | #6
- 11 | 72.4% | #7
- 5.8 | 85.5% | #8
- 3 | 92.4% | #9
- 0.8 | 97.9% | #10

- **NOTES:**
  - #1. Slight loss of brightness
  - #2. Greater brightness loss
  - #3. Serious loss of brightness
  - #4. Possible Sync. Loss
  - #5. Probable Sync. Loss
  - #6. Week color, one-half the detail
  - #7. Very weak color, poor detail
  - #8. Color faded out, very poor detail
  - #9. Color gone, low quality picture
  - #10.No color, very poor detail

It is clear from the chart above, that while picture brightness does degrade on longer UTP wires, the picture details and color brightness degrade at a much greater rate with wire pair length.

To attempt SUPERIOR QUALITY CCTV OVER UTP FACILITIES, it is clear that any UTP wire pair length greater than about one hundred feet or so will need to be equalized to compensate for cable pair loss as well as the losses in passive Senders which can exhibit up to 50% loss of high frequencies.

[back to top]

Digital Video Recorder Problem Solving

NEW TECHNOLOGY:

The new digital revolution has brought us many new and exciting products for the CCTV industry. The DIGITAL VIDEO RECORDER or (DVR) may be one of the most important upgrades that can be made to any CCTV system. The DVR takes a camera video signal and converts it to a digital bit stream and saves it on a computer hard drive. It can then be played back with remarkable fidelity. This new technology brings with it a new set of problems and solutions. This article will discuss some of the problems and solutions for DVR installations. To understand the problem we must look at the standards.

Standards:

A video standard was developed by the Institute of Radio Engineers so that all manufactured video equipment would be compatible. The unit of measure for this standard is the I.R.E. Unit. One I.R.E. unit is equal to .007142 Volts peak to peak. A Black and White (B/W) video signal is 140 I.R.E. units equal to 1 Volt peak to peak. A color video signal has three vital standard measurements the SYNC = 40 I.R.E. units, the WHITE = 100 I.R.E. units, and the COLORBURST = 40 I.R.E.

units. Both the B/W and Color signal measure a total of 140 I.R.E. units, but unlike the B/W signal the Color signal measures 1.142857 Volts peak to peak. The additional 0.142857 Volts peak to peak is caused by the color information called "CHROMA" in the video picture. It is a common misunderstanding that all video is 1 Volt peak to peak. Only a B/W video signal is 1 Volt peak to peak, a Color signal is 1.142857 Volts peak to peak. Now how does all this relate to the DVR problem?

The Problem

When properly installed the DVR does not output a video picture, displays a "NO VIDEO" image or has a blank blue video screen. Yet if the video input signal is connected to a monitor it displays a video picture. At first you might think that the DVR is defective, that is very unlikely. It is more likely to be a video level standards problem.

Headroom in the DVR:

Most DVR's are designed to accept a video signal of 1 Volt peak to peak with some extra range known as "headroom". This headroom allows the video signal to exceed the 1 Volt peak to peak by some percentage. Usually 20% over the 1 Volt peak to peak video level. That makes it possible for the equipment to accept a video signal of up to 1.2 Volts peak to peak. The standard Color signal measures 1.142857 Volts peak to peak so this amount of headroom should be adequate. The amount of headroom varies from one manufacturer to another, so you may discover one brand works better than another under certain circumstances, but the problem does not necessarily lie with the DVR.

The Real Problem

One of the most over looked problems in CCTV installation is the output level adjustment of the camera. The standard for camera output is SYNC = 40 I.R.E. units, WHITE = 100 I.R.E. units, and the COLORBURST = 40 I.R.E. units. However some camera manufacturers have "fudged" the standards some what. We find that WHITE levels in auto iris and auto shutter control systems to be padded up to 120 I.R.E. units (1.285714 Volts peak to peak). That is 20% above the standard maximum level established by the Institute of Radio Engineers.

When a camera's WHITE level is set anywhere above 100 I.R.E. units the video signal can exceed the maximum headroom allowed by the DVR and the system will go into digital overload resulting in the failure of the DVR to record a video signal. When a monitor is attached to the video signal the video can be viewed because a video monitor is not sensitive to overload. This would lead you to believe that the DVR is non-functional, when actually the camera level is not set correctly.

Solution

To avoid DVR problems at installation and subsequent service calls the camera's in the system must be adjusted to the proper standard levels so that the video will not overload the DVR. It is recommended that a Camera Master or waveform monitor be obtained to set the camera's level accurately. If the type of camera you are using will not allow the WHITE level to be set to 100 I.R.E. and you have already purchased the camera's, then you can insert a video correction amplifier like the GB-60 and adjust the gain below unity (a loss of signal) to solve the problem. Any amplifier that works with video and will adjust below unity gain will do the job. Video attenuator pads can also be used if you measure the amount of over level and correct it with a fixed value in line attenuator.

Proper setting of the video levels will correct the problem and an understanding of what causes the problem will help you to solve other level related problems with digital equipment in the future.

[back to top]

A Comparison of Analog & Digital Audio Transmission Systems

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It turns out that for the transmission of music, nothing could be further from the truth, the popular press to the contrary notwithstanding.

Recording VS Transmission

Why should transmission be any different than recording when deciding between analog and digital processes? Both are degraded by noise introduced within the medium, but in recording no one really cares what power density or bandwidth is required to lay down and retrieve the music from the record medium, whereas the power density and occupied bandwidth are a price concern when transmitting the music on cable systems.

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17. Use analog companding followed by linear encoding. This process holds some promise of success by combining some of the analog advantages with digital processes. The author is not aware of any operating systems of this type.
18. Stop trying to define the exact voltage at each sample interval with a binary word. In other words abandon pure digital transmission for a process such as Delta Modulation. This is a sort of half-way house between pure digital and pure analog. In this process the delta modulator waits until the audio wave form departs from it's previous voltage by some specified delta increment (or decrement). At this time a pulse is sent to

increment or decrement the voltage at the receiving point by that amount. The faster the wave form changes in time the more pulses must be sent. Many variations on this basic process are possible that help to reduce the total bandwidth. The best known delta modulation scheme is the Dolby Digital Audio System. This system is very complex, in that the signal must be carefully analyzed prior to encoding, resulting in a very expensive transmitter, but a fairly inexpensive receiver. Super Quality Audio can be achieved with this process at band-widths intermediate between narrow band and wide band. This process is not entirely digital and not entirely analog, so it is left to the reader to decide which category it belongs in.

19. Reduce the redundancy in the music prior to transmission and hope that the missing pieces of redundancy won't be missed. On a coarse basis, there is much redundancy to be exploited in music, so perhaps a great reduction in bandwidth could be obtained this way. It all depends on how much you think you can tinker with the signal without also changed the timbre and fine nuances in the music. Certainly the melody and basic harmony would remain, but I doubt that the composer would be pleased with the result if enough processing of this sort were done to reduce the bandwidth significantly.

Conclusions

Information theory tells us that if occupied band width, Carrier-to-Noise Ratio and signal energy distribution are equal, all modulation processes result in the same basic signal to noise ratio.

If very wide transmission band width is used (approximately 100 times the base-band band width) either digital or analog modulation processes can provide Supper Quality Stereo.

Where it is desirable to transmit stereo over narrow band channels (approximately 10 times the base-band band width), it is necessary to somehow modify the digital or analog modulation technique to accommodate the bandwidth reduction.

The techniques available that enable narrow band transmission of digital signals all operate on the instantaneous shape of the musical wave form, and tend to be perceived as some form of distortion to the ear on the continuing basis.

Depending on the digital band width reduction system employed either, background (digitizing) noise increases, high level distortion or low level distortion increases, or some change in the character of the music is noticed by the listener. The grater the bandwidth reduction, the grater the degree of distortion perceived. this is true even for digital bandwidth reduction systems that seem to test very well with simple sine wave test.

The bandwidth reduction techniques available, using modern analog companding, operate on the RMS or average level of the music wave form, with no wave shape alteration during passages of relatively constant amplitude. There is no constant level of distortion as would be perceived in a digital band width reduction system. Instead, the artifacts of analog bandwidth reduction occur only during musical level changes, not for the entire duration of the music passage. Therein lies the principal advantage that analog has over digital in narrow band transmission systems. The human ear is particularly sensitive to distortion products that are continuously present, such as those caused by digital bandwidth compression, whereas analog bandwidth reduction processes induce very short term distortion products with a duration less than 20 milliseconds, which are difficult, if not impossible for the ear to detect. Modern analog companding systems operate within this acoustic "deaf spot", so the analog companding artifacts will not be perceived.

This article shows that given the same bandwidth availability and equal noise and signal power both analog and digital transmission systems will generate similar signal-to-noise ratio and distortion performance.

As the noise level increases in an analog transmission system, the overall signal-to-noise ratio also increases linearly with a consequent decrease in quality. Analog systems tend toward graceful failures, whereas a digital transmission system suffering a similar increase of noise increase in the transmission system will suffer a sudden cataclysmic total loss of signal (if squelched) or even worse, extreme high level crashing sounds (if not squelched). Digital systems are either "perfectly fine" or crash cataclysmically upon exceeding a certain threshold of noise.

Given equal transmission considerations, the principle difference between analog and digital performance is that the digital system fails cataclysmically while the analog system fails gracefully.

[back to top]

CCTV VIDEO CAMERA FOCUS PROBLEM SOLVING

Have you ever wondered why Auto Iris cameras seem to go out of focus at night? Many installers have had to return to the job site at night and reset the focus of a camera to solve this problem. This can be costly to your company's pocket book and reputation. There is a solution to the problem that will enable you to set the cameras focus correctly every time, day or night.

Let's examine what causes the Auto Iris camera to go out of focus when the lighting level changes, as it does day to night. All lenses and Auto Iris cameras exhibit this effect to a greater or lesser degree.

The causes, depth of field, what is it?

All lenses have a characteristic called Depth of Field. Depth of Field is an zone in front of the lens that is in focus. It is measured as the minimum distance and maximum distance from the lens where objects are in focus. All objects inside this minimum and maximum bracketed zone will be in focus. The further away you go from this bracketed "in focus zone", either toward or away from the camera the more out of focus the objects become.

The problem with auto iris lenses:

The Auto Iris lens has a movable aperture inside the lens that controls the amount of light allowed to pass through it. This aperture also directly controls the Depth of Field of the lens. So an Auto Iris lens will have a variable Depth of Field depending on the amount of light entering the lens. This causes the minimum and maximum bracketed zone of focus to change when the lighting level changes.

During the day or in bright lighting conditions the Iris is closed down to a small opening, and the Depth of Field is quite large. So called Pin-Hole cameras exhibit this effect where all objects in the scene are in focus. At night or in low lighting conditions the Iris is open wide, this causes the Depth of Field to collapse down to a smaller minimum and maximum bracketed zone of focus. An object that was inside the zone of focus during the day can be outside the zone of focus at night.

The solution:

One way to set up the camera to minimize the Depth of Field problem is to adjust cameras focus at a time when the light level is at its lowest. This may not be convenient for your installers.

The best way is to use a SHADE 5 FILTER PLATE also called a #5 welders glass filter. It is the filter plate that welders look through to protect their eyes during welding operations. When you have full daylight or bright lighting conditions the filter plate is placed over the cameras lens to simulate half lighting conditions.

This filter plate costs only a few dollars and should be carried by installation personnel to every job site for use with Auto Iris lenses, especially those jobs using outdoor cameras. By using the filter plate to adjust the Auto Iris, you will be centering the control range of the Auto Iris system. This will give you optimum performance from your cameras Iris control system.

Hand held focus meters such as the CM-1 Camera Master are also useful in determining the maximum focus of any scene. They are more accurate than large screen monitors and much easier to take up a ladder. They display the maximum focus numerically on an LCD type display. By eliminating the subjective nature of focus setting, you will insure that all cameras will be set to their maximum focus by any installer.

An understanding of Depth of Field and the proper setting requirements for Auto Iris cameras will save you time and reduce the frustration of having to return to the job site to refocus cameras.

[back to top]

CCTV VIDEO GROUND LOOP PROBLEM SOLVING

This article will discuss video ground loop problems in CCTV installations. The cause and how it affects picture quality with solutions to eliminate the problem.

Click here for our in-line GL01 Ground Loop Isolator.

When Video Ground Loop problems or 60 cycle Bars occur, they are easy to see on a video monitor. They look like a horizontal band or bar across the video monitor that slowly moves up the video screen. These bars can be barely noticeable, or can be so bad that the video monitor loses lock and breaks up the picture. If the video camera is Line-Locked to the 60 cycle main power, the bars may stand still in the picture, but they still obscure picture definition and create customer complaints.

The source of the 60 cycle bar originates from the power industries use of local grounds to balance their power grid. Everywhere 60 cycle power is used, a local ground is attached to the power grid to return all unbalanced current flow to ground. As an example, you will notice that every main power breaker box will have a ground wire or conduit going to a ground rod or similar device connected to an earth ground. Every correctly installed power outlet will have a connection to this ground.

Not all grounds are created equal. In fact the earth ground in one building is most likely to have a different voltage potential relative to any other building, even grounds inside the same building will have different voltages between them, based on the uneven current flow of the power load.

Here is how the 60 cycle bar gets into your video picture. If you connect a coaxial cable to a monitor or other equipment that plugs into the 60 cycle main power and the other end of the coaxial cable becomes grounded locally for any reason a Ground Loop is created. Any difference in the 60 cycle voltage between these two ground points will create a current flow in the shield of the coax that induces the 60 cycle AC voltage into your video signal. It is easy to measure these differential voltages, simply disconnect the video cables at the monitor point and using your voltmeter on AC volts, measure between any two shields of the incoming video cables, you will be amazed at the difference.

The solution is to never connect both ends of a video cable to local grounds. Any cable can be grounded at one end without inducing the ground loop current. When you run coax cable from one building to another, it is acceptable to install through connection points, but do not allow the shields to come into contact with one another or the local ground.

A coaxial connector lying in a cable tray or conduit box can accidentally contact ground, don't let this happen. Use tape on the connector to prevent accidental grounding. Also try not to attach the camera to any structure that is likely to be grounded. Remember that the camera is already grounded at the opposite end of the coaxial cable by the monitor equipment.

At the monitor station you may have many pieces of equipment connected together, like a (Quad, Tape Recorder, Monitor) all of which plug into the main 60 cycle power. This will not present a problem if you plug all of the equipment into the same power line at the monitor point, making sure that all the equipment shares the same ground point at the monitor station. Also try to keep the video cables between equipment, (the service loops) as short as possible.

If you already have an installation that has 60 cycle bars, there are some steps you can take to solve the problem. If coaxial cable shields are connected together anywhere in the system, separate them if possible. Similarly remove all but one ground connection on each coaxial cable if possible; the ground is usually at the monitor end of the coaxial cable because the monitor equipment plugs into the 60 cycle main power supply which is grounded.

Sometimes a ground loop problem can be reduced by reversing the AC plug on the power transformer used to power the camera, or reverse the 24 VAC power connections to the camera. This technique will not work on DC powered cameras.

If the problem still persists, video isolation transformers can be installed at one end of the coaxial cable to block the shield current flow and eliminate the 60 cycle bars. These transformers must be installed at the coaxial cable that is originating the 60 cycle bar problem. Isolation transformers only work when they can block the current flow in the shield. Once 60 cycle bars become part of the video signal, no economical down stream solution will remove the bars. Use a portable monitor to find the origin of the ground loop problem, start at the camera and move down the coaxial cable until you see the bars appear on the portable monitor. This then is the coaxial cable with the current in the shield. Clear the ground connection or install an isolation transformer at this point.

The type of AC power transformers you use to power your camera can contribute to Ground Loop problems. A ground can be introduced to your camera "Capacitively" through the power transformer windings depending on the type and construction technique used to build the AC transformer. Some transformers are built by winding a primary (the 110 VAC side) on a metal core, then simply winding the secondary coil (24VAC) directly over the primary coil. This puts the primary and the secondary in direct capacitive contact. This type can cause Ground Loop problems.

Other manufacturers build their AC transformers with a split bobbin where each winding is separately mounted on the metal core. The separation of the primary and secondary coils are greatly increased, reducing the capacitive coupling and removing the unwanted second ground in your system. This type of transformer usually does not cost any more, and may prevent the 60 cycle ground loop from occurring. It would help if you determine which transformers are built to minimize capacitive coupling between windings and purchase that type only.

With an understanding of Ground Loop problems and the use of good single ended grounding techniques, you should be able to keep the 60 cycle bars out of your CCTV installations.

[back to top]

CCTV Line-Lock Problem Solving Tips

Someone once said "Timing is everything". The same thing can be said about Line-Lock CCTV camera installations. The Line-Lock feature is available on most CCTV camera's, and is used to prevent picture rolling on the monitor during switching from one camera to another. Picture Roll will cause the loss of vital picture information in the video recorder and is irritating to view. This article will discuss the problems encountered by installation and maintenance personnel along with solutions to save time and make your job more profitable.

The CCTV camera puts out a series of pulses called "Sync" pulses that allow a video monitor to synchronize the picture on the screen. Special sync pulses called "Vertical Interval Pulses" tell the monitor to begin a new picture. The Vertical Interval Pulses from multiple camera's must be synchronized if you wish to switch from one camera to another without the monitor producing a picture roll. When a roll in the monitor occurs, the Vertical Interval can be seen as a black horizontal bar that appears momentarily on the screen.

Let’s look at how the Line-Lock system keeps CCTV camera's in synchronism. To synchronize multiple camera's you must first have a common reference, that is all the camera's must share the same timing information. The term Line-Lock refers to the 60 cycle AC (alternating current) supplied by the power company. This 60 cycle line frequency is the common reference used to lock the camera's together. For this reason only AC powered camera's have the Line-Lock feature. DC powered camera's are not capable of being Line-Locked.

When you select the Line-Lock feature in a camera there is internal circuitry that samples the 60 cycle AC frequency and uses it to time the Vertical Interval Pulses. All Line-Lock camera's have a Phase control that must be adjusted when the camera is installed. The Phase control is adjusted so that all the camera's Vertical Intervals occur at the same time.

One way to adjust this Phase control is to switch between camera's and adjust the control until you no longer see the roll. This trial and error method is time consuming, requires 2 installers (one at the camera and one at the monitor) and is frustrating to accomplish.

The preferred method is to use a VTM (Video Timing Meter) or an oscilloscope to adjust the Phase control.

An oscilloscope is an instrument that displays the waveform of the Vertical Interval Pulse. It is hard to set up, requires interpretation of the waveform, and is bulky in size.

The VTM timing meter is specifically designed to quickly adjust the timing error to zero with a digital readout that does not require interpretation of the waveform.

To make the Phase adjustment, you must select one camera as the reference. At the monitor point connect the output of the reference camera directly into the output of the camera that you wish to adjust, use a BNC Barrel connector. This makes the reference signal available at the camera to be adjusted.

Next go to the camera you wish to adjust and insert the VTM or oscilloscope between the camera and the cable you previously connected to the reference camera. Now adjust the camera Phase control to zero on the meter display or zero coincidence of the Vertical Interval Pulses on the oscilloscope. Repeat this step for each camera in the system using the same reference camera. When all camera's in the system are adjusted, no roll of picture will occur when you switch from one camera to another. Once the Phase controls have been carefully set in the system no further timing adjustments will be needed.

There is one exception. This carefully set Phase adjustment can be upset if the power circuits are re-balanced by an electrician at the power breaker box. When an electrician installs new power circuits into a commercial building, sometimes they will move the circuit breakers to a different Phase in the breaker box. In commercial buildings the utility power is Three Phase, which is three separate 60 cycle lines whose phase is 120 degrees apart. Moving the power line that your camera is on to a different phase will throw off the timing and require a re-adjustment of the phase control on the camera.

If monitor personnel complain about picture roll, a fast check of timing can be made. Go to the monitor station and connect one camera as a reference to the VTM or oscilloscope and then connect each camera one at a time to make the measurement. The timing should be zero +/- 3 Video Lines or Sync Pulses. A roll can be noticed if the difference between camera's is more than a few lines. As the line difference between camera's increase so does the noticeable roll. If you measure a camera and the readings seem to change that indicates the camera is not Line-Locked. The solution is to select the Line-Lock feature on that camera or replace it with one that can Line-Lock.

A clear understanding of how the Line-Lock system works combined with a way of measuring the Phase of each camera will let you set them quickly and correctly with confidence.

[back to top]

A New Way to Synchronize Video Cameras

Switching between non-synchronized CCTV cameras usually causes the picture to "roll" for several frames. This wipes out the very frames that are to be recorded. Many cameras are now equipped with synchronizing adjustments that can be used to synchronize the camera to the 60 cycle power line. One of the problems is that any given camera could be locked to either polarity of the power line, depending on which way the power plug or low voltage AC power wires are connected. Furthermore the camera on most industrial AC power systems may be wired to any one of three phases, thus creating at least six different phase conditions. Not only that, but reactive power loads can also cause additional AC power phase shifts. All of these possibilities means that each camera must e "phased" to a "master camera". In the past this has been a very time consuming process, requiring considerable technical know-how and expensive test equipment.

The new VTM Video Timing Meter manufactured by F M Systems, Inc. enables installers to synchronize two or more cameras by connecting the two cameras to be tested to the connectors on the VTM, pressing a button, observing the digital display, and adjusting the synchronizing control of one camera until the digital display reads zero. The display actually indicates the number of TV lines one camera leads or lags the other. A positive number indicates leading by that number of lines and a negative number indicates lagging by that number of lines. Therefore, a zero reading indicates that the cameras are synchronized. This process is then repeated for each camera, using one camera as the master.

The VTM measurements may be made at the control hub where all the coaxial cables come together. The VTM is connected to the cable from the "master" camera and also to the cable from the camera to be synchronized. A portable radio or other communications system links the operator that observes the VTM with the operator that will adjust the camera to be synchronized. The operator at the VTM then "talks" the camera adjuster to the desired synchronous condition.

An alternative process requires only one technician and no radio. In this process the two coaxial cables at the hub are connected together with a BNC "barrel" and the cable at the camera to be adjusted is removed from the camera. The cable leading to the hub at the camera under adjustment is connected to one connector on the VTM. The camera is now connected to the VTM with a short patch cord. Since the VTM is now at the camera that is to be adjusted, the technician can now synchronize the camera by himself and without the need of a radio. While this process does not measure the phase at the hub site, it will not incur significant error as long as the cable runs do not exceed 20,000 feet in the loop between the cameras. Also note that this process requires that there be no video amplifiers in the cable from the camera being adjusted (unless the direction of the video amp is also temporarily reverse).

A third method enables one technician to synchronize all cameras to the 60 cycle phase at the hub site. In this process, all coaxial cables coming into the hub site are connected to a VTG Video Timing Generator (also made by F M Systems, Inc.) which transmits a common video sync signal to all cameras, then each camera is synchronized with the VTM at the camera location. Again, only one technician is needed and each camera is now synchronized to the power line phase at the hub site. The advantage of synchronizing to the hub site phase is that changes of phase at a chosen "master camera" will not throw off subsequent measurements.

As a practical matter, cameras may be synchronized in a matter of a minute or so per camera by technicians using the VTM. Minimal training is required to become proficient in the use of the VTM, and the $295 cost of the VTM is far below the oscilloscopes and specialized monitors that have been used in the past. In addition to using the VTM for initial set up, it is highly recommended to use it to do routine synchronization measurement at some regular intervals. The reason for this is that Electricians occasionally will reverse the phase of an AC line when balancing the load on a power panel. This simply requires removing a circuit breaker and re-installing in onto the opposite phase. There will be no notice, and the camera is now 180 out of phase. In this condition it may or may not roll. Rolls then become intermittent. It is best to make routine synchronization tests to avoid this condition.

The VTM Video Timing Meter is hand-held (3 1/2" x7"x 1 1/2") and battery operated so that it can be carried in a pocket or tool kit and operated at the job site without requiring AC power connections. The VTM also has a "video present" indicator for each of the two video input connectors so that the technician can be certain that a video signal is actually present from each camera. The VTM can thus be used to verify that a video signal is actually present on a coaxial cable. The rocker-arm power switch requires only momentary actuation to start measurements, and then the VTM will remain ON for about three minutes. This usually provides more than enough time to synchronize the camera, and then the automatic shut-off activates to conserve the battery.

The VTM Video Timing Meter and the VVM Video Volt Meter together make a complete test set for CCTV cameras. The VVM measures video sync and white Level, while the VTM measures relative timing of CCTV cameras.

[back to top]

How CCTV Terminations Affect Picture Quality

Why, where, when, and how to terminate video coaxial cables raises the basic question of what is a termination and why is a termination used in the first place.

First, what is a termination? It is a resistor of a particular value (in video, usually 75 Ohms) that is connected to each end of the transmission cable. In the case of RG59/U type of cable, the resistive value is 75 Ohms. Good terminations use 1% accuracy resistors. Professional Grade terminations are 0.1% accurate.

The Why of termination use is that a picture being sent down the cable will reflect back from an un-terminated end of the cable, causing two or more "ghosts" of the original picture to be viewed on the monitor. On very short cables the "ghost" will be almost on top of the original picture and may have the appearance of "ringing" or "edge enhancement". When the cable is short enough, this edge enhancement may be interpreted as making the picture look "crisper". In reality any ghosting will result in a loss of picture definition. As the cable length gets greater, the double image effect becomes quite pronounced and is very undesirable.

When a signal propagates down a cable, it travels at about 70% of the speed of light (.7 times 186,000 miles per second). That means that 500 feet of cable will cause an echo delayed by about 1/4 inch on a 12" monitor.

Why does any reflection occur at all? The reason lies in the stored energy in the transmission line. Both the inductance and the capacity residing in the cable store this energy. The relationship between the inductance and capacity in a given type of cable determines what the characteristic impedance of that cable is. If there is a resistance at the end of the cable that is equal to the characteristic impedance of that cable, all of the energy will be absorbed by the resistor. If the terminating resistor is either too high or too low, a percentage of the received energy will be reflected back onto the cable to travel back to the source.

For a ghost to be seen at the monitor, any reflected energy from the monitor must first return to the source (camera), then be reflected back to the monitor. Ghosts make two trips down the length of the cable. If the camera is accurately source- terminated, then the reflection is absorbed there and does not return to the monitor. Camera's that are correctly source-terminated will not cause ghosts, even if the monitor is not correctly terminated.

All Broadcast quality and most CCTV cameras are correctly source terminated with 75 Ohms. However, some low-cost cameras on the market are not correctly source terminated and thus can cause a host of problems. These camera's omit the source termination and thus appear to be almost zero Ohm source impedance. Not only will these cameras cause ghosting reflections, but they will also prevent proper operation of various kinds of interfacing equipment such as Elevation-azimuth (pan and tilt) control and other systems that utilize the Vertical Interval of the video picture for control purposes. The camera's zero Ohm output impedance effectively shorts out these control signals.

There is an easy way to sort out cameras with source terminations from those that are built without source terminations. Connect the camera to be tested to any un-terminated Video Voltmeter or Oscilloscope. Read the Peak-to-Peak voltage, then terminate the metering device with a known good 75 Ohm terminator. Again read the Peak-to-Peak voltage. If the camera is properly source terminated inside of the camera, the voltage will drop to one-half the value when terminated. A non source terminated camera will reduce in voltage only 1-5 percent when the measuring device is terminated.

Source-termination is not the same as terminating the monitor. Simply placing a termination at the camera will not provide the necessary source termination. The reason for that is that while the monitor termination is placed between the center conductor of the coax and the shield, the source termination must be in series between the output video amplifier (inside the camera) and the output connector.

There are two right and several wrong ways to connect two or more monitors or equipment to a single coaxial cable. The best way is to connect a Video Distribution Amplifier as shown in figure A.

The next best way is as shown in figure B. One prime consideration is that only one termination may be used, it is also important where the termination is placed to avoid reflections and the consequent ringing or ghosting. The correct multiple equipment hook up requires that the signal from the camera be "looped through" each piece of equipment, and only the last piece of equipment may be terminated as in figure B.

Connecting two pieces of equipment to the same camera with a BNC "T" will work as long as only one piece of equipment is terminated and the coaxial cable connected to the un-terminated monitor equipment is very short (one foot or less). If both cables connecting the BNC "T" to the monitor equipment are long, the coaxial cable coming from the camera to the BNC "T" will "see" a 37.5 Ohm (1/2 of 75 Ohm) termination at the BNC "T", thus reflecting energy back to the camera. Also the un-terminated cable will reflect energy back to the BNC "T", causing multiple reflections of various time delays creating a rich source of ghosts and ringing in the picture. Where there will be long cables between monitors, and the loop-through configuration is not practical, a Distribution Amplifier must be used at the junction to enable correct termination of each cable.

The key to good clean picture transmission is to insure that each end of every coaxial cable is terminated with the characteristic impedance of that cable.

[back to top]

CCTV Video Troubleshooting Tips

Someone once said "Knowledge is the key to success". This rule also applies to the installation and maintenance of CCTV camera equipment. Have you ever installed a CCTV camera system and then had to go back to solve a problem that was overlooked. A basic understanding of CCTV video signals, can save you hundreds of man hours, improve customer relations and increase job profitability all at the same time. This article will discuss problems and solutions for CCTV camera installations.

To discuss video let's start with the unit of measure, the I.R.E. unit. I.R.E. stands for Institute of Radio Engineers, this regulating body set the standards of measure for the video industry. This standard has been adopted by all industries in the United States and other parts of the world. 140 I.R.E. units is equal to 1 Volt Peak to Peak. I.R.E. units are easier to use because they divide into a video signal evenly.

For example proper Sync on a camera is 40 I.R.E. units, the Voltage equivalent would be 0.2857143 Volts. Unfortunately this voltage cannot be measured on the Volt Ohm Milliamp Meter that you use for checking contacts. An oscilloscope has been used by some for this purpose, but it is bulky and does not read in I.R.E. Most people would rather use the simple 40 I.R.E. units of measure.

.Fortunately some equipment manufacturers sell hand-held battery operated meters to measure the video signal in I.R.E. units. This equipment is compact, extremely accurate and simple to use. Some units like the "CAMERA MASTER" can even help to set the focus of a camera more accurately.

Sync Pulse Amplitude, How It Effects CCTV Installations.

A CCTV video camera creates synchronization pulses to lock the viewing monitor on the picture. These pulses occur at a rate of 15,750 times a second. There is

one synchronization pulse or (sync pulse) for each line in the picture frame. The sync pulse tells the video monitor to start drawing a video line across the picture screen. When it gets to the end of the screen another sync pulse begins the next line, and so forth until the screen has been filled with lines. It take 262 and a half lines to form a frame, and two frames to form the video picture we see on the monitor.
The proper level for sync is 40 I.R.E. units. If the sync signal from the camera is too small in amplitude the picture will break up or roll. If the sync pulse is too big, any black portion of the picture will be grayer and the dynamic range of the picture will be degraded. Peak white level will also be compressed causing a blooming effect (loss of picture definition).

White level iris setting, how much is enough?

There is a standard for Iris setting, or white level and it is 100 I.R.E. units. When setting a manual iris, or an automatic iris the level should be the same, 100 I.R.E. units. If you set the iris below 100 I.R.E. units, the picture will be dim with less than desired dynamic range and the white picture elements will not be pure white. If you set the iris for more than 100 I.R.E. units, the picture can be washed out causing loss of picture definition.

Some cameras can be set to 120 I.R.E. units, but it should be noted that the standard is 100 I.R.E. units and in any case all camera's in the system should be set to the same level of white. This will ensure that the white portion of the picture will be the same brightness when a monitor is switched between them.

Peak to peak measurement of the CCTV signals

A quick measurement of the peak to peak video signal will re-assure you that the CCTV camera is putting out the right level. The standard level is 140 I.R.E. units.

Color camera's and what is color burst anyway?

More color camera's are being used in CCTV installations. The color camera adds a chrominance component (color information) to the signal, also known as Chroma. This Chroma signal operates at 3.58 Mega-Hertz. The standard level for the Chroma is 40 I.R.E. units. When the chroma level is low, the colors will be dull. If this level is too low, the color monitor will turn its color receiver off causing a Black and White only picture. This condition also indicates a loss of picture detail. You can see this effect on long cable runs.

The solution is to install a video equalizer in the line and adjust the color burst back to 40 I.R.E. units. If the Chroma signal is too high the picture will display color flaring and reduction of detail at the edge of the color flare.

Vertical Interval, Its Many Uses

The Vertical Interval (V.I.) is the part of the video signal that tells the monitor to start drawing a new screen. It is made up of special SYNC pulses with no picture elements. The standard level for these SYNC pulses are 40 I.R.E. units. All video SYNC pulses should be 40 I.R.E. units. The Vertical Interval is a very useful place to put alarm and control signals. Some manufacturers make equipment for pan and tilt camera control, alarm contact information, and data transmission that is inserted into the V.I. signal and sent up or down the cable.

Termination, the end of the line

A termination for video is a 75 Ohm resistor placed at the end of any video cable to prevent signal reflections that cause ghosting or multiple images on the monitor. Some CCTV equipment have built-in terminations some of which are switchable. If you are using this equipment in series, you must switch off all terminations except the termination at the last piece of equipment in the cable run. Proper termination can be checked by measuring the SYNC pulse amplitude anywhere in the video cable. It should read 40 I.R.E. with the termination ON, and 80 I.R.E. with the termination OFF. If the SYNC level does not change when you remove the termination, the camera or video source is not standard 75 Ohms and should be serviced or replaced. Problems with V.I. control systems can result if the level does not double when you remove the termination.

The Basic Three

To check performance of any CCTV camera installation make sure the SYNC level is 40 I.R.E. units +/- 5 I.R.E.. WHITE level should be 100 I.R.E. units +/- 5 I.R.E.. Remember if you want to run high white level say 120 I.R.E., be sure that all camera's in the system have the same level of I.R.E +/- 5 I.R.E. Color burst level should be 40 I.R.E. units +/- 5 I.R.E.. SYNC, WHITE, and COLOR BURST are the three basic measurements to make to insure proper operation of your CCTV system.

The Measure of Success: IRE Units

To measure video, we use the IRE unit. IRE stands for Institute of Radio Engineers, the regulating body that sets the standards of measure for the video industry. This standard has been adopted by all industries in the United States and other parts of the world. One hundred forty IRE units equals 1 V peak to peak. IRE units are easier to use because they divide into a video signal evenly. For example, proper sync on a camera is 40 IRE units. The voltage equivalent would be 0.2857 V, a voltage that cannot be measured on the volt ohm millimeter that you use for checking contacts. An oscilloscope has been used by some for this purpose, but it is bulky and does not read IRE.

Fortunately some equipment manufacturers sell hand-held, battery-operated meters to measure video signal in IRE units. This equipment is compact, extremely accurate and simple to use. Some units, such as the Camera Master, can even help to set the focus of a camera more accurately.

[back to top]

Why and How to Measure CCTV Camera Output Impedance

Why The 75 Ohm Standard

The vast majority of coaxial cables are either 50 Ohms or 75 Ohms Characteristic Impedance. This Characteristic Impedance is determined by the ratio of the diameters of the shield and core wire and the Dielectric Constant of the insulating material between the core wire and the shield. The CCTV Industry chose to use the 75 Ohm standard for coaxial cable.

Since a coaxial cable must be terminated at both ends of the cable with resistances equal to the cable Characteristic Impedance to prevent reflections from impairing the picture, cameras must have an internal source impedance of 75 Ohms, and Monitors must be provided with a 75 Ohm termination.

The Problem

In the past, CCTV cameras could be counted on to have proper 75 Ohm source impedances, but recently there have been a rash of cameras showing up on the market that do not have a 75 Ohm source impedance. In fact they exhibit an almost zero output impedance even though the specification sheets that come with them specify 75 ohms! Clearly the cameras do not meet their own specifications and thus could be returned for not meeting their own published specifications.

Problems Caused By Incorrect Terminations

The worst of miss-termination problems occur when the camera has a zero source impedance, or the 75 Ohm impedance is left off at the Monitor location. By far the worst effects occur when both zero Ohm source impedance exists and the 75 Ohm termination is removed at the Monitor.

Ghosts and Ringing become more evident as the length of the coaxial cable becomes greater. The ringing effect (where a white-to-black or black-to-white transition in the picture is repeated many times in close succession) occurs with short cable runs of 50 to 200 feet. Obvious Ghosts appear when the cable is 500-1000 feet long. The first of many successive Ghosts will be about 1/2 inch to the right of the original object on a TV monitor screen with about 1000 feet of cable.

Another problem caused by zero source impedance cameras is that signals placed on the coaxial cable to control Pan and Tilt of the camera will be shorted out by the zero Ohm output of the camera and may cause remote Pan and Tilt systems to be intermittent or fail.

The same intermittent or failed condition may be induced into other equipment that is using the same coaxial cable to transmit special signals. The key idea here is that such intermittent or failed conditions are caused by a CCTV camera with a zero output impedance, not a failure in the Pan and Tilt or other equipment.

The Solution

Buy only CCTV cameras that exhibit 75 Ohm output impedance! But how can you be sure a particular camera really has 75 Ohm output impedance when the spec sheets for that camera proclaim 75 Ohms? The answer of course is to test the output impedance yourself before installing them in the field. Unfortunately this measurement cannot be made directly with your trusty Volt- Ohmmeter. The output impedance of a CCTV camera is not a static Resistance reading, but a dynamic AC Reactance measurement.

Correct Method For Measuring CCTV Camera Output Impedance

Connect the camera to be tested through a short 75 Ohm coaxial cable to an Oscilloscope, Waveform Monitor or CM-1 Camera Master. Arrange to be able to place a precision Termination (75 Ohms +/- 1%) at the Oscilloscope or meter. Measure the amplitude of the sync pulse with the termination in place. The sync pulse should read about 40 I.R.E (0.286 Volts Peak-to-Peak). Now remove only the 75 Ohm Termination. The sync level will Double (80 I.R.E 0.571 Volts Peak-to-Peak) if the camera has a correct source impedance. A typical defective camera well read almost the same amplitude with or without the termination on it.

An actual output impedance measurement may be made by using the formula following TABLE 1.

Pass / Fail Test (Table 1)

Sync Pulse Un-terminated | Source Impedance

- o Vp-p | IRE | 75 Ohms (=/- 5%)
- o 0.571 | 80 | NEAR ZERO Ohms
- o 0.286 | 40 |

SYNC PULSE TERMINATED (Vp-p, IRE) | Source Impedance

- o Vp-p |IRE | 75 Ohms (=/- 5%)
- o 0.286 | 40 PASS | NEAR ZERO Ohms
- o 0.286 | 40 FAIL |

Even though exact readings will vary between various CCTV cameras, this test will suffice as a PASS/FAIL test. If a more exact measurement is desired, the following formula may be used.

Calculation of Precise Source Impedance

S= U – T / T X 75

- U = Un-terminated Reading of Sync IRE or Voltage
- T = Terminated Reading of Sync IRE or Voltage
- S = Internal Source Termination in Ohms

[back to top]

Augmenting CCTV Systems with Audio Surveillance

Up until now, CCTV surveillance has been mostly a Silent World. Without sound, much of what you do see on the monitor screen provides considerably less security value than if you can also hear what is going on. Not only that, a security camera in, say, a public garage can only see what is in front of the lens, whereas a security microphone can hear calls for "help" from any direction. After all, what good is Television without sound.

Augmenting video monitoring with audio surveillance enhances the security provided by the CCTV system. The ability to hear ambient audio in the surveillance zone more than doubles the security of that area. Security personnel will be alerted to danger in the observed area, even if the danger is out of sight of the CCTV camera. Personnel will be alerted to security problems without having to observe them visually. Breaking glass, footsteps where they don't belong or cries for help would instantly alert security personnel even if the camera did not "see" anything. A video camera looks only in one direction at a time, whereas sound surveillance monitors all directions all the time. Furthermore, sound surveillance alerts the operators even when they are not looking at the monitor screen. In certain industrial application, it is vital to hear as well as see machine operations. Often the first indication of trouble are abnormal sounds, often long before a camera will show a problem.

There are many opportunities for a CCTV installation company to augment new CCTV systems or retrofit previous installations with Audio Surveillance capabilities.

Building an entirely separate audio monitoring system in addition to the video monitoring system is feasible, but probably difficult and expensive. In addition, in a system that requires switching cameras to various monitors becomes even more complex, since the audio lines must then be switched in synchronism with the video switches. A better solution is to integrate the audio surveillance system with the CCTV system. An integrated audio/video system should incorporate these parameters.

0. The coaxial cables connecting the CCTV cameras to the monitoring location should also carry the audio signal as well. This not only reduces the total cabling job, but also enables video switches to also switch the audio signals
1. A wide ranging audio volume control must be incorporated so that footsteps and shouts are equally audible at the monitor
2. The transmitting unit (located near the camera) must contain a built-in microphone and audio processing system
3. The Transmitting Unit should operate from the same power source as the camera (typically 24VAC)
4. The audio transmission system should not interfere with the video signal, or any signal transmitted on the coaxial cable that is used to control the camera (remote camera controls). The transmission system should be able to operate over coax cables at least as far as CCTV cameras can reach, and even transmit the sound through any video amplifiers that may be used to extend the reach of the CCTV cameras
5. There should be provisions for recording the audio signals
6. It should be small, self contained, unobtrusive, easy to install and require no installation adjustments or periodic maintenance

All of the above conditions are satisfied in a new audio surveillance system manufactured by FM SYSTEMS, INC. called the CAMERA-COM. The Transmitting Unit, containing the microphone, is the CCT-1 (CAMERA-COM TRANSMITTER) and the Receiving Unit at the monitoring location is called the CCR-1 (CAMERA-COM RECEIVER). These modules will transmit audio in excess of 2500 feet on RG-59-U cable even if the camera is out of order or the lens is capped. This technology is a new application for CCTV but is a well proven audio transmission system used in the microwave and satellite industry.

The audio signal is applied onto the coax cable by an RF carrier whose frequency is higher than the video signal so that no interference to the picture can occur. This carrier is Frequency Modulated by the audio signal from the microphone. The sounds that are received by the microphone are electronically processed so that all sounds can be heard equally well, whether they be shouts or foot steps.

Any CCTV system may be retro-fitted with audio surveillance simply by connecting a CCT-1 Transmitter module to the camera with a short RG-59-U patch cord, connecting the coax camera cable to the CCT-1 module, and wiring the same 24VAC powering the camera to the Transmit module. At the Monitoring location, connect the CCR-1 Receiving module in the coaxial line feeding the CCTV monitor, connect 24VAC power, and then listen with the Earphones or connect the Hi-Fi type patch cord to an Amplified Speaker or the audio connector on the

CCTV Monitor.

There are no initial field adjustments or periodic maintenance test to make. Just connect and listen!

[back to top]

Over-The-Coax Audio for CCTV, A sound Investment

Hearing and speech are one of mankind's most powerful tools. We rely heavily on the use of these faculties for our day to day living. Yet in the average security installation this audio information is not available to security personnel responsible for the safety and security of the facility. Having this audio information can speed the reaction time of security personnel, possibly saving lives and reducing law suits. This article will examine the opportunities and benefits provided by the use of audio with video.

The addition of audio to any CCTV camera installation magnifies the security of the facility. Security personnel will be alerted to danger in the observed area even if the danger is out of sight of the CCTV camera. Personnel will be alerted to security problems without having to observe them visually. A camera can only look in one direction at a time, but audio is omni-directional and picks up its sound information from all directions inside the security zone.

One example is an audio installation inside a parking garage. A person's cry for help, the sound of an auto collision, or breaking glass would be noticed above the normal sounds of the garage. Security personnel can easily pick out a sound that is not normal from all the other sounds in the garage.

Two way audio has even greater benefit to the security of the facility. Personnel can respond verbally with people in the security zone. They can direct the actions of others or help guide rescue personnel inside the building without leaving the monitor control room. Unwanted intruders can often be persuaded to exit the premises without security personnel having to leave the monitor room. Emergency announcements can be made and compliance can be verified by the use of a video camera with two way audio.

An example of a two-way audio system, other than the obvious front door intercom is jail or prison cell surveillance and communication between guard buildings. Security is increased when the guards can communicate two-way.

The main problem with the installation of audio is the wiring process. Laying twisted pair wires along side the video cable is time consuming and labor intensive. For retro-fit installations the problem is complicated by having to trace the old video cables through the building. This makes it hard to estimate the labor required to complete the job.

Modern CCTV 2-way voice communication uses the existing coaxial cable, so no additional wiring is required. The 2-way audio travels on the same coaxial cable as the video picture and the video is unaffected by the audio signal. The audio follows the video where ever it goes. This makes retro-fit installations easy to estimate and build.

This new CCTV intercom technology also incorporates 2-way signaling or contact closures for remote control of doors, gates or alarm devices. Two way signaling allows the installer to wire a switch at the camera and control a contact closure at the monitor site. This can be used for a panic button, door bell or any device that needs a contact closure to operate. It allows someone at the camera to contact the monitor personnel and indicate which video camera they are near. Equipment such as the CAMERA-COM 2 has a built-in automatic volume control that lets you hear footsteps and shouts equally well. In a quite environment the volume is automatically turned up allowing security personnel to hear footsteps or other sounds where they don't belong alerting them to security violations.

This new 2-way audio intercom technology allows the installer the ability to go back to old previously installed accounts and sell an audio upgrade without having to cut holes in the building or pull new coaxial cable. Installation time is reduced, and the customer can easily recognize the increased security and safety of the system. In many cases the addition of 2-way communication with the camera sites can reduce the number of security personnel required to monitor the facility. The customer will see the long term savings in the cost of personnel.

Audio surveillance for CCTV security is opening up a new horizon for security sales and installation. Dealers and installers looking for new products and services to sell to their new and existing customers should have a look at over-the-coax audio for CCTV video.

[back to top]

Video Multi-Meters Find Niche In CCTV Market

By Charlie Pierce

CCTV technicians can use upgraded technology to improve skill level, which can't be measured in price.

For more than 15 years, I have been a discernible oscilloscope technician. I have held on, with the last fibers of my being, to the belief that the only way to properly adjust a video camera and/or system was with an oscilloscope. I have watched as various hand-held video meters have appeared on the scene and I have waited. I have waited until I was convinced that we truly had meters that could be portable, save money and, most importantly, do an accurate job. Well, the time is here. Video multi-meters finally have their niche in the market and are reaching for their potential.

Video multi-meters are somewhat limited in their individual capabilities compared to the oscilloscope. Thus, you will need at least two meters to do the job of one oscilloscope. Unlike the oscilloscope, however, these meters require little or no training, can be used straight out of the box, are significantly less intimidating and cost substantially less. The two most common meters on the market today are the video meter and the synchronizing meter. As with all solid state tools, there are several things that you should review prior to purchasing one of these meters.

There are four important criteria when choosing which video meter to invest in: readout, flexibility, accuracy and durability. I purposely omit size and cost. The size varies only slightly; they range form fitting into the palm of your hand to being held comfortably with one hand. Cost, in my opinion, is never a factor with any quality tool. First, you usually get what you pay for; second, a good tool that is properly used will pay for itself in a short time.

A video signal is made
up of three important parts:

video, pedestal or black level, and
synchronization pulses

I understand that your company doesn't pay for your tools and you have house payments to make. I also understand that you want to be a professional, make more money and be considered irreplaceable. This means investing in yourself and reaching out to become the best that you can. Cost is not a factor.

Currently, there are several different types of video multi-meters on the market. Some units are climbing LED scales to give their measurements; other use digital displays. LED scales tend to hold cost down, but digital displays lend to the accuracy of the results. Some meters measure the video signal in voltage (peak to peak) while others measure the video signal in IRE units.

IRE units were established as the true measurement medium for video in the late forties. It wasn't until the sixties and the increased availability of the oscilloscope that we started relating the video signal in peak-to-peak voltage measurements. A video signal is made up of three important parts: video, pedestal, or black level, and synchronization pulses. Color signals have the above as well as a color burst. Composite video is the combination of all three pieces measured together.

Each portion of the video signal has its own separate level. Video should measure at 100 IRE (0.7143 volts peak to peak). Sync should measure 40 IRE (0.2857 volts peak to peak). In color cameras, the color burst will measure 40 IRE, and the composite video signal on all cameras should equal 140 IRE (1.000 volts peak to peak). A good hand-held video meter will give you the ability to measure sync, luminance (video white level), composite video and color bursts individually. In addition, you should be able to set the focus and/or back-focus of the camera, based on the video signal. The better the meter, the more variety or options for measurements you will have.

One key portion of the video signal that we used to balance the iris of the lens to the camera is the luminance, which is the white level of the video. Too much luminance will result in a bright, washed out picture. Too little will give you a flat, low contrasting, blah picture. Wide-bank oscilloscopes, unless equipped with an IRE luminance filter, combine the luminance with the chrominance of the video signal.

To the inexperienced technician, this combination of signals can result in false readings on the oscilloscope that can be 10% to 20% higher than the true luminance. Quality, hand-held video meters will have an IRE luminance filter built in. This ultimately makes the hand-held meter a more accurate tool for adjusting manual and auto irises than the oscilloscope.

One problem that has developed with the introduction of electronic shuttering in cameras is low video signals. This is primarily due to the fact that activation of the electronic shuttering cuts back on video level out-puts of the camera. If the iris is not properly compensated after initiation of the electronic shutter, video levels will remain low and pictures will be poor. Again the oscilloscope was the best tool for the field technician. However, this notion has been challenged and beaten by the hand-held digital video meters.

Another feature that a quality digital video meter offers is focus, which is accomplished through the high-frequency levels of the video signal. It is not always feasible to have a monitor in the field. In addition, monitor screens can favy in focus accuracy. A well-trained, experienced technician can use an oscilloscope to set the focus on a camera without a monitor. A novice, with a quality hand-held digital video meter can set the focus of a camera without a monitor and be as, or more, accurate than if they had used a monitor. (Where were these meters when I was in the field 15 years ago?)

In multiple camera systems, it is always important to ensure that the composite video levels of all cameras are balanced to each other. Nothing is more aggravating than watching a series of cameras switching where one picture is bright, one flat, one dark and another altogether different than the other three. In addition to the aggravation of viewing an out-of-balance system are the technical problems, including picture rolling, horizontal tearing, jumpy playback and poor resolution.

Signal losses (assuming the use of appropriate copper coaxial cables) are quite often attributed to partial or complete short circuits between center conductors and shields, double terminations of the video cables, lock of termination of the video cable or improper impedance connectors. Regardless of the cause, the problems must be identified and corrected. In the past, the oscilloscope was the only tool that gave the well-trained field technician the ability to identify signal losses. Today, with the use of high-quality, digital video meters, a field technician can quickly and easily narrow in on a whole barrage of signal symptoms.

Digital video multi-meters can be used to measure luminance-to-chrominance level inequalities. This is the slope loss of the video signal in the high-frequency range, cause by long cable runs. In simpler terms, this information will help the field technician determine whether to install a simple video amplifier or a more complex line equalization unit.

The major problem in making these types of readings with the hand-held units is that a color camera must be installed, temporarily, in place of the black and white camera at the end of the line, because the hand-held units use the color burst to do comparisons. If you used an oscilloscope to do the same "slope loss" checks, you wouldn't need to switch to a color camera. This is one advantage that the oscilloscope still holds over the hand-held meters. The end result in installing a proper amplifier and balancing it to the cable accurately will be improved picture detail and resolution.

The one point where I am still a strong supporter of the filed oscilloscope is in the location and identification of noise in the video signal. Hand-held meters can save you time and money in making a large variety of accurate video level adjustments. They cannot, however, show you the type of RF or electromagnetic noise that is infecting your video signal.

Likewise, these meters cannot show you if the noise is traveling on the video or sync; the oscilloscope is still the only tool that does this well and can be used a s a major troubleshooter. If I had to advise today as to which is the better investment, I would sway the serious field technician toward a high-quality, hand-held, digital video meter. I would save recommendation on the field oscilloscope for the companies that were installing 100 cameras or more per year. Even then, the oscilloscope would be a consideration after the video multi-meter.

One feature that I look for in all field tools that work on batteries is "timed shut-down." This means, simply, that a unit will shut itself off after a predetermined amount of time. I for one am constantly forgetting to shut my field meters off, which results in arriving at a job site and not being able to use the meter because of dead batteries. Some video multi-meters have auto-shutoff circuits and some don't. If you never forget to turn off the power to your equipment, don't worry about it. If you are like me, you will look for this feature and engulf it.

When comparing the durability of the video multi-meter to that of the field oscilloscope, there is no contest. Oscilloscopes have a CRT that is easily knocked out of center if the unit id dropped or bumped. Hand-held meters are 100% solid state. This gives them the advantage of going to the field as a partner of the technician. It doesn't mean the technician can drop the units from 20 feet. And expect them to stay in one piece. It does mean that if an oscilloscope and a video multi-meter were both knocked about and dropped equally, the multi-meter would stand a better chance of surviving.

As far as cost of the various hand-held video multi-meters compared to oscilloscopes, there is a large gap. Low end video multi-meters start in the $100 range, while your higher-quality, digital units will be closer to $500. Oscilloscopes start on the low end at $600 or $700 and go as high as your imagination.

I am sold on the ability of the hand-held, digital, video multi-meters. I finally have been impressed and look forward to carrying my units into the field versus lugging my oscilloscope with me everywhere. There are still times where I will not be able to work without an oscilloscope, due primarily to the advanced nature of my position in troubleshooting video signals.

I can honestly say, however, that for the first time in 15 years my portable oscilloscope, a long and trusted friend, is starting to gather dust as I refer to it less and less. My new-found, hand-held, digital friends, on the other hand, are starting to show the battle scars of field work as the nicks, bumps and knocks earn them a position in my respect of accuracy, ease of operation and easy portability.

[back to top]

Standards and Procedures for Video Level Measurement

Setting video levels would be easy if only the cable operator could call up a test pattern when he was ready to set levels. In that sense the broadcast engineer has it much easier. The cable-TV headend technician must make-do with whatever TV signal happens to be on at the time he is ready to set levels, A video waveform can be subjected to a wide variety of measurement that are outside the scope of this paper. We will limit our discussion to measurement of the voltage of the video waveform.

Video level measurement trouble can exist because the peak voltage, as seen on a wideband oscilloscope, and maximum brightness are not necessarily the same thing. Only the luminance component of the signal contributes to the picture brightness. Thus, if there is considerable color saturation (chrominance) in the picture at the time that peak-to-peak video voltage is measured, the scope reading could be 10 percent to 20 percent higher than the actual luminance component of the video signal.

The chrominance component of a color television signal can be found clustered about the color burst and occupies the frequency bank from about 3 Mhz to 4 Mhz. The luminance component of the color television signal is located primarily in the 2 kHz to 600 kHz frequency band. Fine luminance picture detail does of course overlap the band occupied by chrominance, but since the energy of the luminance component in the 3 Mhz to 4 Mhz band is usually quite low, it may be filtered out to make luminance measurements without significantly impairing test accuracy.

Since only the luminance component of the video waveform contributes to picture brightness, a filter must be provided to separate the chrominance signal from the luminance signal when the brightness produced by a given video waveform is to be measured.

A talented video professional can closely estimate the actual luminance amplitude on a test pattern, even when buried by chrominance signals.

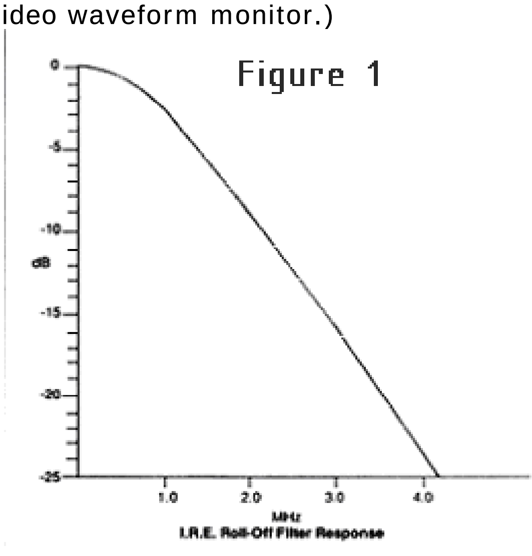
However, even the experts disagree when the picture content continually changes. Technicians often interpret the waveform they observe differently according to their own experience and the setting of the oscilloscope controls. This is particularly true if a regular oscilloscope is used. Even with a video waveform monitor a significant reading error will occur if the wrong video low-pass filter is switched in.

New technology

An entirely new type of test instrument has recently become available, called the VVM Video Volt Meter, that measures sync, white and composite video amplitude on a digital scale instead of an oscilloscope. This video volt meter is the size of an ordinary had-held digital voltmeter, and is battery-operated for portability. Since the VVM read-out is digital, video level setting becomes more consistent.

This measurement technique recognized that high frequency chroma information can cause error in TV luminance measurement, so a special filter was proposed that retains the luminance part of the TV signal but filters out the chroma component. This filter is generically known as the "IRE" filter (see Figure 1). Television waveform monitors are equipped with this filter (as well as others) which must be switched in when making video voltage measurements.

(Unfortunately, ordinary scopes do not have such a filter. If you do not have a proper television waveform monitor with the IRE filter, do not despair, you can obtain an IRE filter to connect to your scope. With this filter connected to the broad band scope you can at least get the same volts peak-to-peak reading as with a standard video waveform monitor.)



The IRE (now IEEE) standard measures video I IRE units instead of volts peak-to-peak. Since most cable companies and equipment manufacturers consider 1.0 Vp-p as representing the maximum brightness of a video picture, then this translates to 140 IRE units. Of that, 40 IRE units constitute the amplitude of the sync pulse as measured from the "back porch," and 100 IRE units constitute maximum brightness, also as measured from back porch (see Figure 2).

For 1.0 Vp-p video signal, each IRE unit represents 7.14 millivolts peak-to-peak. So when the video signal is 1.00 volt peak-to-peak, then the sync pulse should be 0.2857 volts or 28.6 percent and the picture component should be 71.4 percent of the composite video signal.

Waveform monitors are also equipped with a special scale (see Figure 3) calibrated in IRE units.
However, it is not necessary to use this unit of measurement when the main interest is to set video to 1 Vp-p everywhere that the television signal appears at baseband in the headend. Thus, an ordinary scope, without the special IRE graticule can be used , as long as an external IRE filter is used with it to remove the chrominance component.

The maximum video carrier power occurs during the tip of the sync pulse, therefore -40 IRE units corresponds to 100% carrier power (see Figure 2). Also note that 100 IRE units equals 12.5% video carrier power, not zero carrier power. Since 12.5 carrier power corresponds to 87.5% depth of modulation (100% - 12.5% = 87.5%), then this is the maximum modulation permitted for the luminance component of the video signal.

The extra 12.5% remaining of the video carrier is reserved for the chrominance components, otherwise color would be "wiped out" on bright scenes. These relationships reveal why "scope" readings (without the IRE filters) can easily result in serious misadjustments of the TV modulator.

Measurement of the video signal amplitude can be made without interrupting service by including a "BNC-T" connector in the cabling between the baseband video source (i.e. the satellite receiver video output connector) and the input to the television modulator. Since the video volt meter has a high impedance input, the video signal can be measured without changing the level when the meter is connected.

The video volt meter or waveform monitor, or scope with the IRE filter, should be directly connected to the BNC-T because a long cable attached at this point could create reflections that may impair the picture by causing ghosts or ringing to appear.

It is particularly useful to provide a panel-mounted BNC-T so that all of the TV modulators in one rack of equipment can be measured from the front of the rack. A short 10-inch to 12-inch cable can be used to connect the video voltmeter to this panel-mounted connector without impairing the video signal.

Accuracy

Even with an IRE filter, scopes do get out of adjustment so that calibration for 1.0 Vp-p becomes "iffy." Also, the waveform amplitude can be read differently according to the interpretation of each operator.

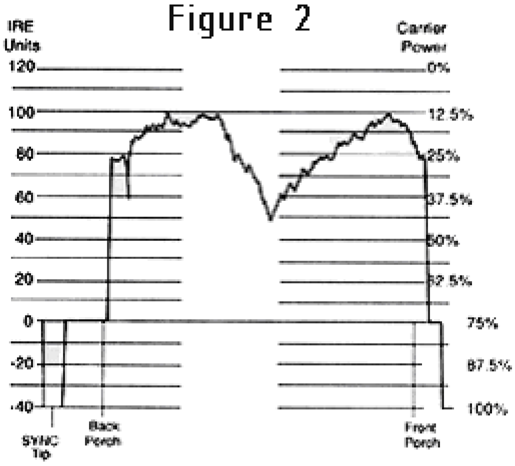
A digital video volt meter ensures consistent video voltage readings independent of operator "eye." It reads sync amplitude, white luminance amplitude and peak-to-peak composite video amplitude. The scale is calibrated in IRE units as well as volts peak-to-peak. Since the meter has a digital read-out, there is a minimum of interpretation required. The IRE filter is built-in, insuring measurement according to IRE standards.

The video volt meter has a basic accuracy of 1 percent ±1 IRE unit or 1 percent ±0.01 volts, so readings taken with this meter will be many times more accurate than even a recently calibrated scope.

Conclusion

This paper emphasizes that video peak-to-peak readings must be made with a filter that blocks out the chrominance component and that measurements made with a standard broadband oscilloscope can lead to substantial errors in headend level setting. Video waveform monitors are available that enable video level measurements according to IRE standards, but these monitors are quite expensive. Ordinary scopes can be used, provided that an IRE roll-off filter is used in conjunction with them. Finally, it is proposed that peak-to-peak voltage measurements of video can be made much more accurately and conveniently by a digital video volt meter than with a waveform monitor.

Figure 2



I.R.E. Scale
Video signal with I.R.E. low pass filter
(Note that "color burst" on back porch
is filtered out as part of chroma signal)

[back to top]