Wouldn’t be nice to start and finish a CCTV System Project without running into any problems before, during and after the installation is completed. Well, in this article we will try and explain why we face problems with some installations that we may have not experienced before, how to resolve the issues and begin to learn the art of troubleshooting a CCTV system. In order to effectively troubleshoot a CCTV system we must become familiar with its components as well as realizing where to look for the common causes of failures, so let’s begin with some basic statistics from within the industry.

Based on collected information from more than 10,000 trouble related service calls from many of the equipment manufacturers, over 65% of failure in a CCTV system is associated with transmission media which includes the type of cable used, connectors, connections and the installation methods. The second biggest area that account for nearly 27% of the problems are power and environment related which includes either excessive or inadequate input power, ineffective or improper grounding or an excessive temperature around the equipment. Incorrect equipment setup, improper equipment termination and improper camera installation account for about 7% of the problems directly associated with the installation personnel. Only 1% of the failures in a CCTV installation are actually caused by equipment failures.

Although CCTV system in general follows an exact science, troubleshooting a CCTV system is more of an art form. There are many questions to ask before the start of any troubleshooting process such as:

1. Has anyone worked on this problem before me?
2. What type of cabling is installed?
3. How long are the cable runs?
4. How and when were the cables installed?
5. Are pull boxes and/or conduits installed?
6. Are there analog or digital recorders?

If you are servicing an installation that was done by someone else, it is a good rule to revert the settings for the electronics used in the installation back to the factory settings. This will ensure that you are not dealing with unknown settings that may affect other areas directly.

With reference to the above statistics related to the transmission media, investigating the cabling should be the very next order of business. What should we look for in the transmission media and its related components?

Transmission media is by far the most important part of an installation. Whether it is a standard video coaxial cable, shielded twisted pair for data, Cat-5e for unshielded twisted pair (UTP) equipment or Cat-5e for networking, all must follow the guidelines set up by this industry. When it comes to coaxial video cable, for many, cable is just cable. However, this is not entirely true. Although the same number or name may refer to each type of cable, they may use different materials in their construction. It is this difference in materials that can affect the system’s performance.
Baseband/Composite vs. RF Video

In a CCTV surveillance system, the signal transmitted by the camera equipment is known as a **baseband** or **composite** type of signal. Even though it produces a standard video signal as found in today’s non-high definition television sets, the actual video signal transmitted is slightly different and causes much confusion and problems in the security industry. Baseband or composite video is a raw signal consisting of video and color information, and vertical and horizontal synchronizing signals. Radio frequency (RF) has all of the same information found in a baseband signal with one exception: It is protected by a frequency shield. This shield protects the actual video data from outside sources, as well as provides a different means to distribute the signal. Those differences require different material in the cable’s construction. Baseband or composite video cable requires a center conductor made of copper (solid or stranded), 75-ohm impedance and an overall shield constructed of copper. In an RF video cable, the center conductor is again made of copper, and the overall impedance is also 75 ohms. However, the cable’s shielding is made out of aluminum, NOT copper.

**Causes and Results**

The main reason for most misuses of coaxial cable is fairly simple — cost! Aluminum-shielded cable is less expensive then cable made with copper shielding. A quick comparison shows that aluminum-shielded cable is half the cost of copper-shielded cable. In a large application, the cost can be substantial. But why is there confusion? The most common reference for standard coax cable is RG-59U — RG stands for radio guide; 59 indicates the impedance and center conductor sizing; and U indicates multiple uses. It does not indicate the type of shielding used, and this is why there is confusion. As for the results of these errors, we must first remember that an RF-video signal is protected by an RF shell and, therefore, signals, such as the vertical and horizontal sync pulses, are not directly affected by the cable type. However, in CCTV, being a raw video signal, the entire signal is dependent on the cabling material. In a nutshell, the frequencies of vertical and horizontal synchronization are ~60Hz and ~15,750Hz, which actually places them within the audio frequency range. The frequency range of coax using aluminum shielding is 50MHz and greater. This mismatch of frequency creates problems like poor, or in some cases, no video images. As we incorporate more and more digital equipment into this industry, the requirement for more stable and distortion-free signals will become a must.

The cable manufacturers provide certain information and usage guidelines for each and every cable they produce. These information and guidelines are for reference only and they do not take into account the affects each installation environment will have on the cable characteristics and performance. When troubleshooting a change over from older and possibly analog CCTV equipment to a digital system, the length, the age and the location of the cable runs are crucial in diagnosing a problem. The old table for recommended cable distances by most manufacturers used to state:

- RG-59U 1,000 feet
- RG-6U 1,500 feet
- RG-11 2,000 feet
As more and more digital equipment are being incorporated in the CCTV system installations, and since digital equipment such as DVRs require much higher video signals at the receiving end than their analog counterpart, the new recommended cable distances look something like:

- RG-59U 500 feet
- RG-6U 1,000 feet
- RG-11 1,500 feet

Why will the cable distances matter you may ask? The simple answer is losses. Each coaxial cable type has a specific amount of losses within a certain length. The signal loss caused by coaxial cable is referred to as attenuation. A coaxial cable attenuation is defined in terms of decibels (dB) per unit of cable length at a given frequency which means, the longer the cable distances, the greater the attenuation, thus greater signal losses. On average, a RG-59U cable could have an attenuation in between 2 ~ 3 dB per 300 feet. There is a signal loss of about 10% for each dB of attenuation. What this means is that there is approximately 20 ~ 30% potential loss of signal for the first 300 feet of RG59 installation. At 600 feet of cable run more than 50% of the original signal is lost to attenuation even if everything else was ideal. These losses due to longer cable distances will require additional electronics to boost the signal level to acceptable levels for digital end equipment such as a DVR.

Another cause of failure or undesirable video quality could be the result of improper pulling practices or extending the maximum bend radius of the cable. Exceeding the maximum pulling tension or the minimum bend radius of a cable can cause permanent damage to both mechanical and electrical characteristics of that cable. The minimum bend radius of a single cable with shielding is about 10 to 12 times the overall diameter of the cable. When pulling cable distribute the pulling tension evenly over the cable. On the other hand, if it turns out the cable has been installed a long time ago; the odds are there are corrosion or moisture problems with the cabling network which includes connectors and splices.

In many applications, conduit is required to meet the local standards for fire prevention. Many think just because conduit is being incorporated that they do not have to concern themselves with special types of cable jackets or environmental conditions, especially for underground applications. Wrong! It is unlikely you would ever find an underground conduit that remains dry for any length of time. For the most part, within a few weeks moisture already surrounds the outer jacket of the installed cabling. With the addition of mechanical splices within a system, corrosion can also play a very important part in video signal strength or total loss of video.

**Analog vs. Digital**

There are major differences between a totally analog system and one that incorporates a DVR. In some cases even when properly installed the DVR may not output a video picture, resulting in a "NO VIDEO" display a blank blue or black video screen. Yet if the video input signal is connected to an analog monitor or a VCR, 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.

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.
This is usually 20% over the 1 Volt peak to peak video levels. 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.

One of the most overlooked problems in CCTV installation is the output level adjustment of the camera or inline video booster. The standard for camera output established by the Institute of Radio Engineers (IRE) is SYNC level at 40 IRE units, WHITE level at 100 IRE units, and the COLORBURST at 40 IRE units. However some camera manufacturers do not follow these standards exactly. At times the WHITE levels in auto iris and auto shutter control systems could be as high as 120 IRE units (1.285714 Volts peak to peak). That is 20% above the standard maximum level. This increase signal could also be the result of improper setting of inline video boosters. When a camera's WHITE level or video booster is set anywhere above 100 IRE 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 display or record a video signal and over time causing damage to the internal DVR components. When the same video signal is attached to a field monitor or a VCR, the video can be viewed without indicating any problem. This would lead you to believe that the DVR is non-functional, when in fact the signal level may not be set correctly. The reason the video appears to display properly on the field monitor or a VCR is because they are not sensitive to overload.

Termination Trouble

In other cases, improper termination will result in undesirable quality such as ghosting, color variation, unstable or total loss of video on a DVR where may not be noticeable on a VCR or a monitor. Unlike what you may find in your home TV system, composite video (baseband) requires a different method to terminate the signal. As shown below, in regular home cable systems, every unit has a 75-ohm termination built in. Thus, splitting a signal using a standard signal splitter does not present a problem.

In a composite or baseband system however, only the last device in the video loop is terminated. If a system has two termination points instead of just one, that is if the video signal from the camera is split into two and then fed into two terminated devices without the required looping equipment, the overall video signal will be reduced by 50 percent. This loss of video signal is more noticeable during low-light...
applications. The reason is simple, during low light levels the output from most cameras is well below the standard 1V peak to peak (140 IRE units) as listed on the camera’s specification sheet. In most cases, the output signal at these conditions is no more than 30 to 50 IRE units.

On the other hand, if the system has no 75-ohm termination, the video signal can reach levels around 2V peak to peak (280 IRE units), which will cause the video image to be overloaded on the monitor and DVR screens. This lack of termination will be more noticeable during high light levels.

Using and fastening proper end connectors to a coaxial cable (BNC) is extremely crucial for a trouble free system installation. There are many forms of BNC connectors and there are advantages and disadvantages to all. Aside from compression type BNC connectors the two-piece and twist-on are the most commonly used BNC connectors in CCTV installation. The two-piece BNC connection provides a solid and long lasting end of cable connection. The important point is to ensure that the braded portion is not excessively removed when striping the cable. The most dangerous to any CCTV system is the twist-on BNC connector. Although no major manufacturer recommend twist-on connectors, they are nevertheless being widely used. Majority of service calls involving connections are related to twist-on type BNC connectors.

Troubleshooting cable problems in a complex system requires professional equipment designed to measure and diagnose cabling and termination issues. However, a quick and inexpensive method for testing coaxial cables for proper resistance and termination is by using an ohm meter.

Referring to the picture below, use the following test procedure to test for proper resistance in a single cable loop:

1. Remove the BNC connection from the output of the camera.
2. Short the center conductor of the cable to the shield or ground of the connector.
3. Locate the other end of the cable under test and remove it from the equipment (monitor, switcher, DVR, etc.).
4. Connect a standard ohm meter to the circuit (black test lead to the shield of the connector, red lead to the center pin of the connector).
5. Check the DC resistance value on the meter. The maximum DC resistance of this cable assembly should be between 10 to 15 ohms. This indicates the resistance loss by the cable, any resistance loss due to connector or splice points, and any breakdown of the copper components of the coaxial cable. This is the maximum resistance that should be between the camera and monitoring location. If a lesser value were found, it would be to your advantage.

Refer to the below picture, use the following procedure to test for proper termination in a single cable loop:

1. Remove the BNC connection from the output of the camera.
2. Locate the other end of the cable under test and make sure that it is attached to the end equipment (monitor, switcher, DVR, etc.).
3. Connect a standard ohm meter to the BNC connector at the camera end (black test lead to the shield of the connector, red lead to the center pin of the connector).
4. Check the resistance value on the meter. If the ohm meter registers 76 to 90 ohms, you have proper cable length and system termination. If your reading is 36 to 52 ohms, the system is double terminated. If the meter does not register any reading, that means that the system is not terminated.

With two third of all CCTV problems being cabling, it is without a doubt the first place to look at when starting to troubleshoot a CCTV system. Although the information provided here will not resolve all of the problems that you may experience in the field, we hope however, it is helpful in making your next installation smoother and the troubleshooting easier.