System Troubleshooting for

Dealers

Users

Managers

Installers

Engineers

Salespeople

Part 2 of 4
Welcome to Part 2 of the latest of Security Sales & Integration's acclaimed "D.U.M.I.E.S." series: "System Troubleshooting for D.U.M.I.E.S." Brought to you by Pelco, this four-part series has been designed to help educate readers on the fine art of video surveillance system troubleshooting. If you'll recall, "D.U.M.I.E.S." stands for dealers, users, managers, installers, engineers and salespeople.

When troubleshooting CCTV systems, it is all about the number, and the number that causes the most problems in CCTV is 75 (ohms). As mentioned at the conclusion of Part 1, termination of any video loop is the No. 1 problem associated with the CCTV industry. More than seven leading equipment manufacturers have reported in excess of 10,000 trouble-related service calls per year concerning improper 75-ohm terminations.

The first step is to understand what is meant by termination and what its function is within a standard video loop. To start, if you are familiar with audio, card access systems, fire and burglar alarm systems, then you already have some knowledge about termination.

Defining Impedance, Termination

When we discussed the type of coaxial cable required for CCTV, we talked about a copper center conductor and a copper outer shield with 75-ohm impedance. What is the difference between 75-ohm impedance and 75-ohm termination?
According to “Webster’s Dictionary”: Impedance (Z) is a measure of the total opposition to current flow in an alternating current circuit, made up of two components, ohmic resistance and reactance, and usually represented in complex notation as $Z = R + iX$, where $R$ is the ohmic resistance and $X$ is the reactance.

On the other hand, termination is stated as: An ideal load of impedance $Z_0$, when connected to the end of a transmission line whose characteristic impedance is also $Z_0$ will absorb all power in the transmission line traveling toward the load.

In short, impedance is a characteristic of the cable’s ability to propagate the video signal, while the job of termination is to absorb this signal. While both are measured in ohms, the electronic symbols for both are not the same. Termination is measured in ohms (W) and impedance (Z) is referenced in ohms.

Problems Linked to Termination

Unlike what you may find in your home TV system, composite video (baseband) requires a different method to terminate the signal. In regular home cable systems, every unit has a 75-ohm termination built in.

As shown in the “Home Television Signal Distribution” diagram below, the signal to be distributed is in a star configuration. The “Composite Video Distribution” figure below indicates the method required by composite video signal for distribution. In a composite or baseband system, only the last device in the video loop is terminated.

What happens if the composite video signal is not properly terminated? This question can be answered in two parts.

First, if a system has two termination points instead of just one, 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. (IRE stands for Institute of Radio Engineers.)

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.

Identifying 3 Termination Methods

There are three methods for terminating equipment: manual, on-screen menu and auto-termination.

Manual termination is the first and most common type. Located on the rear panel of the equipment, whether it is a monitor, video switcher, video multiplexer, etc., you will find a switch next to a set of BNC connectors. The switch will read 75-ohm (on) or HiZ (which stands for high impedance); some units will read 75-ohm, on and off. In this method, it is the responsibility of the installer to properly select the termination option for the equipment.

As a rule, if the video is being looped to another device the switch must be
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Video Signal Loop Termination

Proper Termination

Double Termination

No Termination

Here are examples of three ways in which termination can affect a simple video surveillance system. A single termination point is preferred as a double termination can cut the video signal in half, while a lack of termination will overload the monitor and DVR.

in the “off” condition. If the video signal stops at that piece of equipment, the switch must be in the 75-ohm or “on” state. So far, it sounds simple enough. However, the problem lies in determining the starting and ending points of a single video loop.

Many security applications, as they gain complexity, will have more than a single video loop within the overall system. It is in this identification that will cause the majority of difficulties.

A few basic statements can help in identifying the start and stop points of any video signal loop:

1. BNC connectors labeled “video in” and “video out” are usually in the same loop.
2. Any BNC connector labeled “monitor output” usually indicates the start of a new video loop.
3. Any equipment that has only a single BNC input with no evidence of switching between HiZ and 75-ohm usually indicates that equipment should be placed last in the video signal loop.

The second method of termination is on-screen menus. Many of today’s digital products offer menus to select the equipment termination. The rules are the same for both on-screen and manual termination. However, instead of a mechanical switch, on-screen termination is just a “click” away.

Regarding the troubleshooting aspect of on-screen termination, technicians must be careful when reconfiguring or resetting the equipment. Many on-screen termination menus will return to a factory default if the equipment is rebooted. Most factory defaults return the equipment back to the 75-ohm termination mode of operation.

The last method is automatic termination. This is the easiest form of termination mainly because it removes most of the problem associated with improper system setups. In fact, this method was developed due to the concern about improper termination. Today, many manufacturers have designed equipment with circuitry that automatically senses the application and applies the proper termination resistance.

As always, installers and integrators should be aware of the automatic termination process. Some equipment constantly monitors the layout and will correct for changes in termination, while others only check for termination upon startup of the equipment. In these cases, each time a change is made to the system configuration the equipment must be restarted in order to provide proper termination.

Last Device Must Be 75 Ohms Point

As the story goes, the video signal is a lonely signal and requires a home. Its home is a 75-ohm termination. If the signal does not find its home at

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the end of the line, it starts to look for
another one.
The time it takes the signal to locate
another 75-ohm termination point
causes a delay in the video signal path
and, when combined with the signal
that is already at that point, ghosting
will occur.

This ghosting causes an image that
appears out of focus with the rest of
the video image. The longer the time
required for the signal to locate a 75-
ohm termination point, the greater
the ghosting.

To recap, a termination of 75-ohms
per video loop is a must to ensure prop-
er video images. The absence of any
termination or double termination will
affect the image quality and
pan/tilt/zoom (PTZ) camera control
information if the system is incorpo-
rating an over-the-coax control system.

Over-the-coax control systems use
a portion of the video signal generat-
ed by the camera equipment to trans-
mitt the control signals. If the system
termination is incorrect, not only will
the video image be affected but also
the PTZ control signal.

How to Test for Proper Termination
Recall the section on cable resistance
from Part 1 of this series. This will again
play a very important part in our trou-
bleshooting procedures. As mentioned,
we need to find the total resistance
value of our overall video loop. But now,
we have added additional parameters:
the 75-ohm termination point.

Basic electronic theory states that re-
sistors placed in a series circuit are ad-
ditive. Referring to the “Video Loop
Block Diagram” on page A6, the total
resistance of a simple CCTV video loop is
equal to the combination of R1 + R2 + R3.

The total cable resistance should
never exceed 10 to 15 ohms, and the
termination resistance will always be
75 ohms (with proper termination).

The total loop resistance of any video
loop with maximum cable distances
(in ohms) plus 75 ohms for termina-
tion should be between 85 and 90
ohms of DC resistance.

What happens to these numbers if
improper termination is applied to
the video loop? We have already dis-
cussed the results of either a double-
terminated or a non-terminated video
loop. But how can installers deter-
mine which situation they face?

Take a look at the “Video Loop Ef-
effects of Double Termination” figure
on page A6. According to theory, two
resistors in a parallel circuit of equal
value will divide by two. So how do
these resistors get to be in a parallel
circuit? Easy — with double termina-
tions. Let us discuss how a double ter-
novation occurs.

In any video loop, each looping de-
vice is added as a series device. How-
ever, each device when placed in the
“on” termination (75-ohm) position
now appears as a parallel circuit. So a
simple switch can cause a major prob-
lem in the system.

The following four steps can be
used as a simple testing procedure to
determine the nature of termination
for a given video system:
1. Remove the BNC connection from
the output of the camera
2. Connect a standard ohmmeter into
the circuit (black test lead to the
shield of the connector, the red lead
to the center pin of the connector)
3. Check the DC resistance value on the meter
4. If the reading is: 76 to 90 ohms, you have proper cable length as well as proper system termination; 36 to 52 ohms, you have double terminated your system; no reading, you have forgotten to terminate your system.

This is only a simple form of testing. There is additional information that will help the more advanced system troubleshooter. The numbers previously mentioned will give most installers a guide, however, one will encounter situations in which the numbers will cause total confusion. So, for those who would like to step up to the next level, please read on.

Dealing With Ground-Fault Devices

All of the information presented so far is for a simple video signal loop. But what happens if a system incorporates a ground-loop corrector or if it is an auto-termination system? What type of readings should an installer or integrator expect?

Let us first start with a ground-fault corrector. As a refresher, ground faults or ground loops are caused by a difference of grounds between equipment. The result is a 60Hz sine wave embedded with the video signal. This causes two gray or black bars to appear on the monitor screen. A ground corrector’s job is to eliminate that situation.

The most common ground-fault corrector is nothing more than a transformer assembly that induces the video from one point to another, thus eliminating the current flow. No current, no ground fault. The device, however, when inserted in the video loop, will produce strange readings on the meter if anyone is trying to check for proper cable distances or termination.

If the reading falls between 3 to 15 ohms at the camera end, there is a ground-loop corrector in the system. The higher the number, the greater the cable distance to locating the device.

If you want to continue to check for proper termination, locate the ground fault corrector and connect your meter to the output BNC of the corrector to finish out your testing.

Advanced Testing Techniques

What happens to the test measurement when on-screen or auto-termination methods are incorporated?

Without trying to confuse too many people by explaining detailed electronic theory, we will briefly underline what will happen to the previously listed resistive readings when any form of on-screen or auto-termination devices are located in the system.

The first area to understand is how on-screen and auto-termination devices work. For the most part, many manufacturers simply use transistor logic circuitry. By either placing the transistor in an “on” state or “off” state, one can change the system’s termination from 75-ohm to HiZ.

Referring to the “On-Screen and Auto-Termination Basic Block Diagram” on www.securitysales.com — MAY 2006

Video Loop Block Diagram

Resistors placed in a series circuit are additive; thus, the total resistance of a simple CCTV video loop is equal to the combination of $R_1 + R_2 + R_3$. The total cable resistance should never exceed 10 to 15 ohms and the termination resistance will always be 75 ohms.

**Video Loop Effects of Double Termination**

Two same value resistors in parallel

Total = \( \frac{R_1 \times R_2}{R_1 + R_2} \)

A typical video loop should measure no more than 80 to 90 ohms. However, when the total resistance of a video loop is less than 75 ohms, it’s likely that the termination switches on two or more attached devices are engaged, placing their 75-ohm termination resistors in parallel.
this page, by placing different voltages at the base of the transistor, one can create either an “on” or “off” state. Note, however, that this is a very simple explanation. Many equipment manufacturers use different and more complicated methods to achieve these goals.

Why and how will these devices affect the testing results for system termination? A volt-ohm-meter (VOM) inserts voltage into any circuit that it is testing, especially when testing for resistance. Since we are using the resistance testing function of the meter to check termination, you can now see that this voltage may upset the test reading of the video loop.

Depending on the polarity of the leads placed on your cable BNC connector, the meter could change the state of the on-screen or auto-termination of the device under test. If you are not sure what method the equipment is using, simply reverse the meter leads. If the readings are completely different when the leads are reversed, you can assume the test reading for this circuit is invalid.

Here is the testing procedure:

- Red lead of meter to center conductor of coaxial cable
- Black lead of meter to shield of cable

Result: Ohmmeter reading 2,000 to 4,000 ohms

- Black lead of meter to center conductor of coaxial cable
- Red lead of meter to shield of cable

Result: Ohmmeter reading 75 to 90 ohms

The test results must be the same when the leads are reversed in order to consider the test numbers reliable.

A Foundation on Which to Build

With improper termination being the top system problem leading to undesirable results such as poor video images, loss of over-the-coax control features and, in some cases, loss of digital recording, it should not be taken lightly. The test procedures described in this article should help security contractors overcome these issues.

However, keep in mind that with so many different circuits, auto-terminating designs, alternative engineering methods and new techniques being developed every day, this information should only be used as a general guideline. No test procedure is completely foolproof. Some thought must be used when troubleshooting the 75-ohm system termination problem.

Part 3 of this series will discuss and analyze the standard video waveform and how to use this information to correctly troubleshoot an overall CCTV system.

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