# COAXIAL CABLE – AN OVERVIEW

The most common means of conducting video signals from one piece of equipment to another is coaxial cable. Coaxial cable is often referred to as simply "coax". Not only is coax the most commonly used cable, but it is also the least expensive, most reliable, most convenient, and easily maintained way of transferring electronic images in a CCTV system.

Coax is available from many manufacturers and comes in a variety of sizes, shapes, colors, specifications, and capabilities. The most commonly recommended coax type is RG59/U, but this designation actually represents a family of cables with widely varying electrical characteristics. Other varieties like RG59/U are RG6/U and RG11/U; these are used predominately in CCTV and video work.

Though similar in many ways, each cable group has its own various physical and electrical characteristics, which must be taken into consideration.

All three coax cable groups are included in the same general family classification for coaxial cables. The RG reference is the cable specification for use as a "radio guide," while the numerical value helps differentiate the specifications of each individual cable. Although each cable has its own number, characteristics, and size, there is no difference in the way these different numbered cables work.

## Coax Construction

Common coax cable RG59/U, RG6/U, and RG11/U is circular. Each has a center conductor surrounded by dielectric insulating material, which in turn is covered by a braid to shield against electromagnetic interference (EMI). The outer covering is the jacket.

The coaxial cable's two conductors are separated by a nonconductive or dielectric material. The outer conductor (braid) acts as a shield and helps isolate the center conductor from spurious electromagnetic interference. The outer covering helps physically protect the conductors.

### Center Conductor

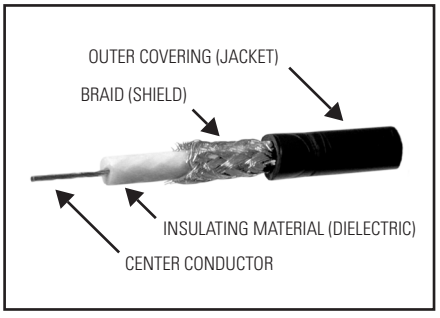
*For CCTV applications, solid copper conductors are required.*

The center conductor is the primary means of carrying a video signal. The center conductor comes in varying diameters, usually ranging from 14 gauge to 22 gauge. The structure of the center conductor generally is solid copper or copper-clad steel, designated as bare copper weld, or BCW. For CCTV applications, solid copper conductors are required. Copper clad, copper weld, or BCW cables have much greater loop resistance at baseband video frequencies and should never be used for CCTV. To determine the type, look at the cut end of the center conductor. Copper clad cable will be silver in the center instead of copper all the way through. Variation in the size of the center conductor has an overall effect on the amount of DC resistance offered by cable. Cables which contain large diameter center conductors have lower resistances than cables with smaller diameters. This decreased resistance of large diameter cable enhances the ability of a cable to carry a video signal over a longer distance with better clarity, but it is also more expensive and harder to work with.

For applications where the cable may move up/down or side-to-side, select cable that has a center conductor consisting of many small strands of wire. As the cable moves, these strands flex and resist wear due to fatigue better than a cable with a solid center conductor.

### Dielectric Insulating Material

Surrounding the center conductor is an evenly made dielectric insulating material which is available in some form of either polyurethane or polyethylene. This dielectric insulator helps determine the operating characteristics of coax cable by maintaining uniform spacing between the center conductor and its outer elements over the entire length of the cable. Dielectrics made of cellular polyurethane or foam are less likely to weaken a video signal than those made with solid polyethylene. This lower attenuation is desirable when calculating the loss/length factor of any cable. Foam also gives a cable greater flexibility, which may make an installer's job easier. Although foam dielectric material offers the best performance, it can absorb moisture, which will change its electrical behavior.




Because of its rigid properties, solid polyethylene maintains its shape better than foam and withstands the pressures of accidental pinching or crimping, but this characteristic also makes it slightly more difficult to handle during installation. In addition, its loss/length attenuation factor is not quite as good as foam, which should be considered in long cable runs.

## Braid or Shield

Wrapped around the outside of the dielectric material is a woven copper braid (shield), which acts as a second conductor or ground connection between the camera and the monitor. It also acts as a shield against unwanted external signals commonly called electromagnetic interference, or EMI, which may adversely affect a video signal.

The amount of copper or wire strands in the braid determine how much EMI it keeps out. Commercial grade coax cables containing loosely woven copper braid have shielding coverages of approximately 80 percent. These cables are suitable for general purpose use in applications where electrical interference is known to be low. They also work well when the cable is to be installed in metal conduit or pipe, which also aids in shielding.

If you are not sure of the conditions and are not running pipe to screen out more EMI, use a cable with a "maximum shield" or heavy braid-type cable containing more copper than those of commercial grade coax. This extra copper obtains the higher shielding coverage by having more braid material made in a tighter weave. For CCTV applications, copper conductors are needed.

Cables using aluminum foil shielding or foil wrap material are not suitable for CCTV installations. Instead, they usually are intended to transmit radio frequency signals such as those employed in transmitter systems or in master antenna distribution systems.

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Aluminum or foil cable may distort a video signal to such a point that signal quality may be far below the level required for proper system operation, especially over long cable runs, and therefore is not recommended for CCTV use.

## Outer Jacket

The last component comprising a coax cable is the outer jacket. Although other materials are used, polyvinyl chloride, or PVC, is commonly used in its construction. Available in many colors, such as black, white, tan, and gray, the jacket lends itself to both indoor and outdoor applications.

# SELECTING VIDEO CABLE

There are two factors that govern the selection of cable: the location of cable runs, either indoor or outdoor, and the maximum length of the individual cable runs.

Video coaxial cable is designed to transmit maximum signaling energy from a 75-ohm source to a 75-ohm load with minimum signal loss. Excessive signal loss and reflection occurs if cable rated for other than 75 ohms is used. Cable characteristics are determined by a number of factors (core material, dielectric material, and shield construction, among others) and must be carefully matched to the specific application. Moreover, the transmission characteristics of the cable will be influenced by the physical environment through which the cable is run and the method of installation.

*Use only high quality cable and be careful to match the cable to the environment (indoor or outdoor). Solid core, bare-copper conductor is best suited to video applications, except where flexing occurs. In locations where the cable must be continuously flexed (that is, when used with scanners or pan/tilts), use cable intended for such movement. This cable will have a stranded wire core. Use only cable with pure copper stranding. Do not use cable with copper-plated steel stranding because it does not transmit effectively in the frequency range used in CCTV.*

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*The preferred dielectric material is foam polyethylene. Foam polyethylene has better electrical characteristics and offers the best performance over solid polyethylene, but it is more vulnerable to moisture. Use cable with solid polyethylene dielectric in applications subject to moisture.*

In the average CCTV installation, with cable lengths of less than 750 feet (228 m), RG59/U cable is a good choice. Having an outside dimension of approximately 0.25 inches, it comes in 500- and 1,000-foot rolls.

For short cable runs, use RG59/U with a 22-gauge center conductor, which has a DC resistance of about 16 ohms per 1,000 feet (304 m). For longer runs, the 20-gauge variety which has a DC resistance of approximately 10 ohms per 1,000 feet will work well. In either case, cables with polyurethane or polyethylene as the dielectric material are readily available.

For installations requiring cable runs between 800 (244 m) and 1,500 feet (457 m), RG6/U is best. Having the same electrical characteristics as RG59/U, its outer dimension also is about equal to that of RG59/U. RG6/U comes in 500-, 1,000- and 2,000-foot rolls, and it may be obtained in a variety of dielectric and outer-jacket materials. Due to its large-diameter center conductor of about 18 gauge, RG6/U has a DC resistance of approximately 8 ohms per 1,000 feet (304 m) and can deliver a signal farther t.han RG59/U.

Use RG11/U to exceed the capability of RG6/U. Once again, the electrical characteristics of this cable are basically the same as the others. The center conductor can be ordered in 14- or 18-gauge sizes, producing a DC resistance of approximately 3-8 ohms per 1,000 feet (340 m). Being the largest of the three cables at 0.405 inches, it is more difficult to handle and install. RG11/U cable usually is delivered in 500-, 1,000- and 2,000-foot rolls.

Because of special applications, variations of RG59/U, RG6/U and RG11/U frequently are introduced by manufacturers.

Due to changes in fire and safety regulations throughout the country, Teflon® and other fire-retardant materials are becoming more popular as outer-jacket and dielectric materials. In case of a fire, these materials do not give off the same poisonous fumes as PVC-type cables, and therefore, are considered safer.

For underground applications, direct burial cables, made specifically for that purpose, are recommended. The outer jacket of this type of cable contains moisture-resisting and other materials that protect the cable, allowing it to be placed directly into a trench.

With numerous choices available, finding the right video cable for each camera application should be easy. After the installation has been properly assessed, read the equipment specifications and complete the appropriate calculations.

## Cable Runs

Although coax cable has built-in losses, the longer and smaller the cable is, the more severe the losses become; and the higher the signal frequency, the more pronounced the losses. Unfortunately this is one of the most common and unnecessary problems currently plaguing CCTV security systems as a whole.

If, for example, your monitor is located 1,000 feet (304 m) from the camera, approximately 37-percent of the high frequency information will be lost in transmission. The unfortunate aspect of this condition is that it is not obvious. You cannot see information that is not there and may not even realize that information has been deleted. Because many CCTV security systems have cable runs that exceed several thousand feet, unless you are aware of this characteristic of cable, your system may be providing a seriously degraded image.

So, if your cameras and monitors are separated by lengths greater than 750 feet (228 m), you should check to make certain that some provision has been made to guarantee the video signal's transmission strength.

## Cable Termination

In video security systems, camera signals must travel from the camera to the monitor. The method of transmission is usually coax cable. Proper termination of cables is essential to a system's reliable performance.

Because the characteristic impedance of coax cable ranges from 72 to 75 ohms, it is necessary that the signal travels on a uniform path along any point in the system to prevent any picture distortion and to help ensure proper transfer of the signal from the camera to the monitor. The impedance of the cable must remain constant with a value of 75 ohms. To properly transfer power between two video devices with acceptable losses, the signal output from the camera must match the input impedance of the cable, which in turn must match the input impedance of the monitor. The end point of any video cable run must be terminated in 75 ohms. Usually, the cable run will end at the monitor, which will ensure that this requirement is met.

*"The end point of any video cable run must be terminated in 75 ohms."*

Usually the video input impedance of the monitor is controlled by a switch located near the looping video (input/output) connectors. This switch allows for either 75-ohm termination if the monitor is the end point, or Hi-Z for looping to a second monitor. Check equipment specifications and instructions to determine the proper termination requirements. Failure to terminate signals properly usually results in a high contrast, slightly grainy picture. Ghosting and other signal imperfections also may be evident.

## 24 VAC Wiring Distance Chart

The following chart can be used as a guideline to determine the necessary wire gauge and maximum cable distance for 24 VAC applications where 2-conductor wire is used to power equipment such as enclosures with 24 VAC accessories (heater, blower, etc.), 24 VAC domes (such as Spectra®), 24 VAC receivers, or other equipment using low voltage input.

(Do not use this chart to determine wire runs for pan/tilts; conductor requirements and cable distances are specified on the applicable pan/tilt spec sheet.)

The following are the recommended maximum distances for 24 VAC applications and are calculated with a 10-percent voltage drop. (10-percent is generally the maximum allowable voltage drop for AC-powered devices.)

**Example**: An enclosure that requires 80 VA and is installed 35 feet (10 m) from the transformer would require a minimum wire gauge of 20 AWG.

Note: Distances are calculated in feet; values in parentheses are meters.

| Total VA | Wire Gauge | | | | | |
|---|---|---|---|---|---|---|
| | 20 AWG (0.5 $mm^2$) | 18 AWG (1.0 $mm^2$) | 16 AWG (1.5 $mm^2$) | 14 AWG (2.5 $mm^2$) | 12 AWG (4.0 $mm^2$) | 10 AWG (6.0 $mm^2$) |
| 10 | 283 (86) | 451 (137) | 716 (218) | 1142 (348) | 1811 (551) | 2880 (877) |
| 20 | 141 (42) | 225 (68) | 358 (109) | 571 (174) | 905 (275) | 1440 (438) |
| 30 | 94 (28) | 150 (45) | 238 (72) | 380 (115) | 603 (183) | 960 (292) |
| 40 | 70 (21) | 112 (34) | 179 (54) | 285 (86) | 452 (137) | 720 (219) |
| 50 | 56 (17) | 90 (27) | 143 (43) | 228 (69) | 362 (110) | 576 (175) |
| 60 | 47 (14) | 75 (22) | 119 (36) | 190 (57) | 301 (91) | 480 (146) |
| 70 | 40 (12) | 64 (19) | 102 (31) | 163 (49) | 258 (78) | 411 (125) |
| 80 | 35 (10) | 56 (17) | 89 (27) | 142 (43) | 226 (68) | 360 (109) |
| 90 | 31 (9) | 50 (15) | 79 (24) | 126 (38) | 201 (61) | 320 (97) |
| 100 | 28 (8) | 45 (13) | 71 (21) | 114 (34) | 181 (55) | 288 (87) |
| 110 | 25 (7) | 41 (12) | 65 (19) | 103 (31) | 164 (49) | 261 (79) |
| 120 | 23 (7) | 37 (11) | 59 (17) | 95 (28) | 150 (45) | 240 (73) |
| 130 | 21 (6) | 34 (10) | 55 (16) | 87 (26) | 139 (42) | 221 (67) |
| 140 | 20 (6) | 32 (9) | 51 (15) | 81 (24) | 129 (39) | 205 (62) |
| 150 | 18 (5) | 30 (9) | 47 (14) | 76 (23) | 120 (36) | 192 (58) |
| 160 | 17 (5) | 28 (8) | 44 (13) | 71 (21) | 113 (34) | 180 (54) |
| 170 | 16 (4) | 26 (7) | 42 (12) | 67 (20) | 106 (32) | 169 (51) |
| 180 | 15 (4) | 25 (7) | 39 (11) | 63 (19) | 100 (30) | 160 (48) |
| 190 | 14 (4) | 23 (7) | 37 (11) | 60 (18) | 95 (28) | 151 (46) |
| 200 | 14 (4) | 22 (6) | 35 (10) | 57 (17) | 90 (27) | 144 (43) |

**Maximum distance from transformer to load**

# VOLTAGE AND WIRING INFORMATION

## Typical Video Coaxial Cable Requirements

| Cable Type* | Maximum Distance |
|---|---|
| RG59/U | 750 ft (228 m) |
| RG6/U | 1,000 ft (304 m) |
| RG11/U | 1,500 ft (457 m) |
| Consult factory | Above 1,5000 ft (457 m) |

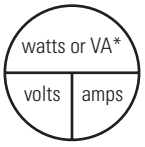
* Minimum cable requirements:
  - 75 ohms impedance
  - All-copper center conductor
  - All-copper braided shield with 95% braid coverage

## RS-485 Communication Recommendations

Maximum cable distance for RS-485 communication over 24-gauge wire is 4,000 feet (1,219 m). Pelco recommends using shielded twisted pairs such as Belden 9843, or similar cable that meets or exceeds the basic requirements for EIA RS-485 applications.

## Voltage Conversion Formulas

Within our various product specification sheets we often list the power consumption and voltage requirements for that particular product. In order to determine power source requirements, refer to the following conversion formulas.




To determine amps (**using watts**):
watts ÷ volts = amps (e.g., 85.5 ÷ 24V = 3.56 amps)

To determine amps (**using volt amps**):
volt amps ÷ volts = amps (e.g., 75 VA ÷ 24V = 3.12 amps
75 VA ÷ 115V = 0.64 amp)

To determine watts (**using amps**):
volts x amps = watts (e.g., 24V X 3.56 - 85.44 watts)

To determine volt amps (**using amps**):
amps x volts = volt amps (e.g., 3.12 X 24V = 74.88 VA
0.64 X 115V = 73.6 VA)

* Watts and VA are the same in a DC circuit, but they are different in an AC circuit. VA, which is higher than watts in an AC circuit, is used when calculating AC power requirements. The same formula can be used, however.

## Measurement Conversion Formulas

Other conversion formulas you may need to know are listed below.

| When you Know | Multiply by | To Find |
|---|---|---|
| meters | 100 | centimeters (cm) |
| inches | 2.54 | centimeters (cm) |
| inches | 25.40 | millimeters (mm) |
| centimeters | .03280 | feet (ft) |
| meters | 3.28 | feet (ft) |
| pounds | 0.45 | kilograms (kg) |
| kilograms | 2.21 | pounds (lb) |
| feet | .3048 | meters (m) |
| miles | 1.61 | kilometers (km) |