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# CABLES FOR VIDEO PROJECTION

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**Courtesy of:** Belden Wire & Cable Company

Recent advances in video projection have made the choice of cables for those systems equally critical. With contrast ratios in the hundreds, and thousand-pixel resolution commonplace, poor cable choices may be immediately visible. So how do you know what cable to buy? And how can you tell a high quality cable from one of lesser grade?

There are four basic video systems available today: composite analog baseband, RGB analog, digital baseband, and S-VHS. Each of these has a specialized family of cables with performance requirements targeted specifically to that system. All coax video systems are based on a standard impedance of 75 ohms for low signal loss (attenuation).

## Basic Parameters

All video cables have the same general parameters. Here is a list with basic meanings and what to look for:

Word/Phrase	Basic Meaning	What to Look For	Comments
Center conductor	Wire down center of coax	Bare copper (no copper-clad steel)	Solid is better performance than stranded
Dielectric	Plastic around center conductor	Polyethylene = good Foam polyethylene = better Gas-injected foam Polyethylene = best	Check "Velocity of Propagation" Vp. Critical at high frequencies
Shield	Metal covering around dielectric	Double braid = analog Foil/braid = digital	Check braid and shield coverage in %.
Jacket	Plastic covering cable	PVC is most common. Not critical to performance	Check for colors available.
Impedance	System Matching	Always 75 ohms	Use compatible connectors.
Impedance Tolerance	How consistent is manufacturing?	±1.5 ohms solid dielectric ±3 ohms foam dielectric	Many foam cables are ±4 ohms or more.
Hard-cell foam (in foam dielectrics)	Resists conductor migration. Preserves impedance tolerance.	Many foam cables are soft foam. Poor impedance tolerance, hard to strip, and prone to crushing.	Compare cables side-by-side.

## Composite Analog Baseband

Often described as "NTSC", this type of system contains all picture elements on one cable. The key factors for the cable are good frequency response to 4.2 MHz and beyond, good braid shielding, and cable consistency. Below are specifications for the most common styles of composite analog baseband cable. Attenuation is compared at 3.58 MHz, a critical frequency in analog composite systems.

Center Conductor	Dielectric	Shield	Impedance Tolerance	Loss/100 ft. @ 3.58 MHz	Diameter
Solid	Solid bare copper	Double Polyethylene	±1.5 ohms braid	.54 dB	.305"
Stranded	Gas-injected Polyethylene	Foil/braid	±3 ohms	.95 dB	.150"
Solid bare copper	Gas-injected Polyethylene	Foil/braid	±3 ohms	.77 dB	.159"
Solid bare copper	Gas-injected Polyethylene	Foil/braid	±3 ohms	.55 dB	.235"
Solid bare copper	Gas-injected Polyethylene	Foil/braid	±3 ohms	.45 dB	.275"
Solid bare copper	Gas-injected Polyethylene	Foil/braid	±3 ohms	.29 dB	.405"

**Note: Impedance tolerances and attenuations given are for one manufacturer's cables and are not industry standards. Check with your cable manufacturer for pertinent electrical properties.**

The first style of cable listed above, (8281) is the most common in analog broadcast installs. You will note that the size often correlates to performance. You will further note that foam cables offer smaller size with equivalent or superior loss. By adding air into the dielectric (air being the best dielectric material), you can change the dielectric constant of a plastic. Since the dielectric constant is a factor in determining the impedance of a cable, and since video cables are required to be 75 ohms, foamed cables will be smaller diameter, all other things will be equal. Since foam is softer than solid plastic, the center conductor can move more, creating variations in impedance (called impedance tolerance). If you crush a foam cable, at that crush point, you have changed the dimensions of that cable and, therefore, changed the impedance. Hard cell foam can also minimize the effects of crushing.

### RGB Component Analog

RGB systems divide the video signal into its red, green and blue component parts, hence the term RGB. It is also called GBR, YUV, or Y, R-Y, B-Y. It requires at least three coaxes to run the individual signals. RGB systems allow very precise control of detail and so are often used for graphics, animation, and projection systems, where detail is important.

RGB can be handled by either three separate coaxes or three coaxes pre-bundled. Most bundled RGB cables have their internal coaxes color coded red, green and blue, to aid in installation. If you're going to install three separate coaxes, it is advisable to buy identical cables with colored jackets, red, green, and blue, for the same reason.

A "sync" signal is also sent with the color information to allow the picture to be reassembled. This can either ride with the green component (on the green coax) or can be sent as a separate signal (a fourth coax). There is no color standard for sync, but it is often on a white or yellow coax. There is also a five-coax bundle. The two extra coaxes can be any number of things: horizontal and vertical sync, sync and blackburst, sync and digital audio etc. These are sometimes called RGBS coax, or RGBHV, etc.

There are two key considerations in RGB systems: attenuation (the same as in composite video above) and timing.

Timing is the relationship of the signals coming out of the

multiple coaxes at their destination. These signals went in at the same time and so should come out at the same time. In long RGB runs, timing can be a critical issue. Since no two coaxes are exactly the same, one may be slower than the other. If the signals are more than 40 nanoseconds (nsec) different in time, they are considered non-broadcast quality and may be beyond the ability of projection systems to realign them. Timing differences are much more pronounced in smaller coaxes where slight differences in manufacturing can produce large differences in timing.

Smaller coaxes, by their very nature, also exhibit more attenuation. It is therefore recommended that small coaxes be used only for short run applications. And the smaller the coaxes, the shorter they should run.

### Timing RGB

If you are running RGB down separate coaxes, many of the same considerations apply. Cable impedance tolerance for the individual coaxes is an immediate indication of how tightly controlled the manufacturing process is. Therefore, if you must do separate coax RGB, a cable with a tolerance of ±1.5 ohms would be a much better choice than one which is ±3 ohms tolerance. With separate coaxes and long runs (more than 25 ft.) you will have to time the cables, that is verify their timing. This can be done with a Time-Domain Reflectometer (TDR) or using a standard broadcast Vectorscope.

The TDR will show the exact electrical length of the cable. This electrical length may be different than the physical length. Therefore, you must start with the cable which is electrically the shortest, make sure it is physically long enough to reach the equipment, and cut the other two cables to electrically (NOT physically) match its length.

With a Vectorscope, which shows the relationship between the three signals, you must connectorize and check the cable over and over, each time trimming the cables which are electrically long until they all hit the points on the vectorscope. On very long runs, with poor tolerance cable, this difference can be a number of feet. No matter how ugly this may look, this extra cable must be maintained to assure the correct timing of signals to that device. Thus, tight tolerance cable can have the added advantage of allowing a neat installation and can often come too close to a straight "cut and connect" length.

Some manufacturers make pre-bundled RGB cables which are “pre-timed”. That means there is a guaranteed maximum timing difference between any of the cables in the group. Some of this pre-timing is so good that the cables will run out of signal strength (attenuation) before they reach the maximum of 40 nsec timing difference! Other manufacturers of bundled coaxes do not specify timing between coaxes. It is suggested that, for long-run RGB applications, these cables be avoided as you will have to time this cable by hand and it may not look very pretty when you’re done. For short runs, of a few feet, you’re probably fine.

Here are some basic RGB types of cable and some of their parameters:

Coaxes	Diameter of 1 coax	Diameter of 3 bundled	Loss/100 ft. @ 5 MHz	Timing Guarantee
3,4,5	.102”	.283”	1.5 dB	Quality cables can have a timing guarantee 5nsec/100 ft.
3,4,5	.146”	.388”	1.3 dB	
3,4,5 plenum	.200	.475	.57 dB	
3,4,5, 10	.275”	.770	.55 dB	

Timing between individual coaxes in a bundled configuration can be as low as 5nsec/100 ft.

**Note: Impedance tolerances and attenuations given are for one manufacturer’s cables and are not industry standards. Check with your cable manufacturer for pertinent electrical properties.**

If you check the diameters of single coaxes above with the list of video cables in the single coax table, you’ll see how many the bundled cables are much smaller than regular coaxes and therefore have greater attenuation. You should be very cautious of super-small RGB cables. Not only is attenuation greater, but timing variations also increase, limiting it to very, very short runs only. In fact, some RGB coaxes are so small, they aren’t even close to 75 ohms. Those manufacturers are hoping your cable will be so short, you won’t even notice the difference.

### Digital Baseband

Digital baseband is commonplace in the broadcast area, but fairly rare in the projected image arena. However, the quality of the digital image is every bit as good as RGB, and, with the coming HDTV will even be superior. You can use the same cables as you can with analog video, as you can see from the list below, but note that the loss is now compared at 270 Mbps/135 MHz. This is the data rate (and fundamental frequency) for current top-of-the-line in-studio component digital video.

But don’t get confused. Even though this is component (that is there is a digital signal for R,G and B), they are all carried down one coax as a serial bitstream. And be aware that full-throttle uncompressed HDTV will be 1.5 Gb/s at a fundamental frequency of 750 MHz.

Center Conductor	Dielectric	Shield	Impedance Tolerance	Loss/100 ft. @ 3.58 MHz	Distance at HDTV	Diameter
Stranded	Gas-injected Polyethylene	Foil/braid	±3 ohms	5 dB	150 ft.	.150”
Solid bare copper	Gas-injected Polyethylene	Foil/braid	±3 ohms	4.1 dB	193 ft.	.159”
Solid bare copper	Solid Polyethylene	Double braid	±1.5 ohms	3 dB	238 ft.	.305”
Solid bare copper	Gas-injected Polyethylene	Foil/braid	±3 ohms	2.7 dB	272 ft.	.235”
Solid bare copper	Gas-injected Polyethylene	Foil/braid	±3 ohms	2.25 dB	335 ft.	.275”
Solid bare copper	Gas-injected Polyethylene	Foil/braid	±3 ohms	1.47 dB	494 ft.	.405”

HDTV distance shown is calculated for 90% of the distance to the “digital cliff” maximum, for Belden standard design. Manufacturers of equalization equipment and signal processors are realizing distances of 150%-200% of these calculated values. Check with equipment manufacturers for their characterization of specific cables.

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## S-VHS

Super-Video Home System (VHS is a trademark of Panasonic, Inc.) is an in-between quality system. It separates the video signal into chrominance (color) and luminance (black and white) information. It runs down cables which are dual-coaxes. This gives significantly better resolution than standard home video but in no way compares with high-quality professional RGB or digital systems. It is the low-budget version. For industrial or moderate quality video, it is probably acceptable. For large audience projection it is not the best choice. And it is doubly the least choice because the cables are, by design, only intended for short runs.

Type	Construction	Loss per 100 ft. @ 5 MHz
Dual-coax	Zip-style	1.5 dB
Round	2-coax jacketed	1.5 dB
Plenum	Zip-style	1.7 dB

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## Other Technology

There are emerging technologies which may have some significant impact on projection video. Here are some of them:

### Fiber

If you want wide bandwidth, very long runs, and no noise pickup, fiber optic cable is the ideal choice. Unfortunately, the conversion from electrical to optical and back again at the projector is still a major expense and more than outweighs the cost of even the most exotic low-loss cable. Fiber is relatively cheap. But even multimode fiber, relatively inexpensive and easy to connectorize, requires conversion to work in the world of copper cables. Unless there is some price-breakthrough in fiber conversion hardware, or some new super-definition system renders copper cables obsolete, it may be a while before fiber enters the arena.

### UTP

This cable, an outgrowth of unshielded twisted pair (UTP) data cables, has recently crossed the data-video line. Cable designs, such as Belden MediaTwist® (1872A) are now being used for non-data applications, such as RGB. Many data applications (such as Gigabit Ethernet®) require very precise timing as the data is split up between all four pairs. (The data world calls this timing difference "skew".) In fact, MediaTwist has better timing than our coax cables (typically >3 nsec/100 ft.). On the other hand, MediaTwist has greater attenuation, due in the most part to the fact that the pairs are 24 AWG, much less copper than a coax cable.

With any twisted pair used for video, baluns are needed to convert from the coax format to twisted pairs. There is one company (ETS, Menlo Park, California, 1-800-752-8208) which makes many baluns between UTP and coax. One of them is a box with four BNC's on one side and an RJ-45 data connector on the other, for RGBS applications.

### A Word About "Plenum"

Many of the cables listed above are available in various versions to meet special fire ratings. Domestically, these ratings follow the National Electrical Code (NEC) voluntary guidelines. Being a voluntary code, the architects, building inspectors, or Fire Marshall in your area may or may not conform to the code. If you are putting in a permanent install, you may want to check with them first.

The highest fire rating in the NEC code is the "plenum rating". This means the cable can go through a drop ceiling, or under a raised floor, without being in conduit. But the

cable must be specially made, and have the correct printed code on it, to meet the plenum specifications. If you need plenum rating, be sure to specify it when you buy your cable.

### CONNECTORS:

The connector of choice for video systems is the BNC. Systems which use "F" connectors, like those used to hook up CATV/broadband signals, or RCA connectors, like home stereo, usually indicate non-professional, lower-quality hardware. S-Video systems use European multi-pin DIN connectors. Not an ideal choice for video.

Each of the coax and RGB cables described above have specific BNC's. Like everything else, there is a wide range of quality and performance and you should base your choice on experience, testing, and data provided by the manufacturer.

Until recently all BNC's were 50 ohms perfectly acceptable for analog video. When used in digital video systems, it is generally agreed that true 75 ohms BNC's should be used. This is doubly true at HDTV frequencies, where even a few connectors of the wrong impedance can have a disastrous effect on digital signals.

### CONCLUSION:

Ultimately, the basic choice of cable, single coax, RGB, etc., will most likely be dictated by the equipment you buy. Still, you have a number of choices regarding different types of individual coaxes, different performance of pre-bundled RGB cables and other advantages offered by newer technologies.

The correct choice is the one which gives you the best performance, with the least cost. And cost is not just the cable and connectors, but the labor to connectorize and install the system. In fact, the cost of cable and connectors is only a small percentage of any installation (generally around 5%) so it doesn't make sense to pick a cable type which is a few pennies cheaper but will cost double to install.

The highest performance, and highest cost, in an RGB installation, is individual timed coaxes, timed by hand. Timing and loss characteristics can be as low as possible. At the other end of the spectrum is untimed, tiny bundled coaxes which can be so different in timing (and impedance) that they can only be used for a couple of feet. The correct choice for you is the one which reaches your acceptable performance point with whatever other characteristics you require.

For more information call Belden Customer Service—1-800-BELDEN-1.