Why Pay More?

The differences in interconnects…

Most professional audio visual people recognize that the differences between audiophile and high quality interconnects are primarily in marketing and packaging – not performance. Many assume the same difference – none – applies to a high quality interconnect and a cheap interconnect. Nothing could be further from the truth. There are significant construction and material differences that impact performance, application and durability that drive the quality and price of interconnects.

These differences can be summarized in these five categories:

1. Fire Ratings and insulation
2. Wire Gage (AWG) and construction
3. Connector Impedance
4. Mechanical Strength, quality and testing
5. Look and Feel

Each of them contributes to costs and quality so it is reasonable for a cable of similar connectors and length to cost 10% of what a similar cable would cost. We'll talk about each factor and why they matter.

Fire Ratings and Insulation

Fire ratings and their enforcement are a cooperative effort of fire marshals, building inspectors, local building codes, the National Electric Code and certification laboratories including Underwriters Laboratories (UL), Intertek Testing Services (ETL) and other organizations. As a result it is important to understand the exceptions in many locales to the general statements below. Check your local building codes to understand the requirements in your area. Usually exceptions are stricter than the NEC®.

Many tragic events such as the fire at the MGM Hotel in Las Vegas on November 21, 1980, have driven the details of how plastics are used to insulate wire. In that fire 84 people were killed. It was discovered that the cause of death was the smoke from burning insulation on electrical wires. The smoke was circulated throughout the building by the ventilation (HVAC) system. Air was circulated from burning parts of the building to parts that were otherwise safe to occupy.

A space where air from a variety of sources is mixed is called a ***plenum***. Spaces that run between floors (Elevators, stairs, and utility chases) are called ***risers***. Obviously the risks from smoldering wires in those area is much greater than in areas where no air is circulating or the circulation is limited to a single room. Cable run in metal conduits are not subject to the same restrictions as the conduit will prevent the smoldering fires that create problems.

It is extremely common for HVAC engineers in a commercial building to use the space between the suspended ceiling and the roof (or the floor above) as a ***return air plenum***. It is also an extremely convenient location for running wire. Cable run in this type of space is called plenum cable and is insulated with a Teflon®-like product. UL certifies this as CMP, CL2P, or CL3P depending on the electrical application for which it is designed to be used. Note the "P" suffix.

Obviously there are times when it is important to run wire between floors in a building. While not a plenum, there is still a higher fire risk here than in other areas of the building.

Cables suitable for these applications are rated CMR, CL2R or CL3R. Note the “R” suffix.

In commercial applications that are in a conduit, but not in a plenum and not in riser space general purpose cables with ratings such as CM, CMG, CL3, and CL2 cables may be used

There are less stringent requirements for residential applications where it is legal to use a CMX, CL3X, or CL2X rated cable. Wires that are not designed for use inside a wall or ceiling bear the UL certification AWM for Appliance Wiring Material. AWM ratings are not controlled by the NEC® and are not allowed to be substituted for required NEC® requirements.

There are many cables available that do not have a fire certification or have a fake certification. You can determine the certification of the cable in several ways:

1. Certified cables all have an “E” number imprinted on the cable. The UL website can cross reference that “E” number with the manufacturer for verification.
2. Plenum constructions rarely have jackets thicker than .020 inches so they are noticeably smaller and stiffer than the PVC non-plenum cables. Also because of patent restrictions, it is extremely rare to find a plenum cable or assembly that was made in Asia.
3. Use a reputable and established manufacturer. The liabilities for fraudulently representing a cable are much too severe for a manufacturer to take a chance by saving some money by using the wrong plastics.

The cost of certification for a specific cable is significant. Each rating uses progressive less expensive materials. Plenum is the most expensive, AWM being the least expensive material with riser, CMG, CM and CMX in between, in that order.

In most cases the more expensive constructions can be used in the less expensive applications. For example, plenum cables are also legal in most non-plenum applications. The opposite is not true. Consult the Liberty catalog for complete hierarchy chart.

NEC Cable Substitution and Hierarchy Chart

NEC Cable Substitution and Hierarchy Chart										
Fire Resistance level highest to lowest	NEC Reference Article								Canada*	
Test Requirements	800	725	760	820	770		830	Comm.	PCC	
Plenum	CMP		FPLP		OFNP		BLP	CMP	FT6	
NFPA 262, CSA FT6		CL3P		CATVP		OFCP				
UL-910 Steiner Tunnel		CL2P								
Riser	CMR		FPLR		OFNR		BMR	CMR		
UL-1666		CL3R		CATVR		OFCR	BLR			
Vertical Shaft		CL2R								
General Purpose	CMG	PLTC	FPL		OFNG		BM	CMG	FT4	
UL-1685 or CSA FT4	CM	CL3		CATV	OFN	OFCG	BL	CM		
Vertical Tray or CSA FT4		CL2				OFC				
Dwellings	CMX							CMX		
UL-1581 or VW-1		CL3X		CATVX						
Vertical Flame		CL2X					BLX			
								CMH	FT1	

*In 1996 Canada and the US Harmonized the fire codes for Communications Cables. 16 AWG and smaller cable sizes can be certified (UL) and c(UL) CMP, CMR, CMG, CM and CMX for similar applications in the US. The PCC FT code does not need to be marked on the cable in these instances. c(UL), c(ETL), CSA marking, or other approved certification agency marking is required to use these codes.

As an installer, specifier or vendor of cables, you are liable for installing the right cable. Fire Marshals or Building inspectors may force you to remove and replace all non-compliant cable – at your expense. Building owners are becoming more aware of the regulations and may also enforce the rules. Last but not least, the wrong cable could kill someone if there is a fire. The long term risks don’t match the short term rewards of saving a little money. Do the right thing.

Wire Gage (AWG)

The second significant cost factor for wire is the amount and quality of the copper. More copper conducts better. It is heavy. It reduces the flexibility of the cable as it gets thicker. Finally, it is expensive.

For high power circuits (such as loudspeakers, especially 8 ohm systems), the resistance of the cable becomes significant as power increases and the length of the cable increases. This decreases the power reaching the speaker and reduces the

damping factor which muddies the lower frequencies. Some people prefer Oxygen Free Copper compared to standard copper of the same gage.

In high frequency circuits for video and RF, thicker copper increases the bandwidth of the cable at a specific distance. This is due to the greater surface area of the thicker cable. For example 18 AWG Serial Digital coax at 100 feet attenuates a 4500 MHz signal by 14.78 dB. 20 AWG attenuates 4500 MHz by 19.29 db, and 23 AWG attenuates 4500 MHz by 23.67 db. (3 db is means that the voltage is ½ the reference voltage). Smaller cables typically are only rate to 1000 MHz. A 26 AWG coax will typical attenuate a 1000 MHz cable 21.40 db frequencies are attenuated less.

Thicker cables allow the signal to travel further with less attenuation at high frequencies. Therefore HDTV and SXGA computer signals require a thicker cable at longer distances than NTSC or VGA signal.

Loss of bandwidth is visible in a couple different ways. First of all, with any display, narrow horizontal lines will be brighter than narrow vertical lines. In addition, when used with a pixilated display such as an LCD, ILA, LCOS, DLP or plasma, it is more likely that that you will have pixel tracking noise with a low bandwidth cable. The low bandwidth results in a reduced period of time at which the video signal is at the proper voltage, increasing the odds that there will be a pixel tracking error.

For RF or digital signals the lower bandwidth could result in a total loss of signal,

Many professionals prefer 26 AWG coax cables for computer graphics, since they are field repairable with common BNC and RCA tooling. Smaller AWG cables such as inexpensive 28 and 30 AWG cables are not.

Connector Impedance

It is commonly assumed that the connector impedance errors will result in a decrease in picture brightness. Not true. The most obvious result is ghosting in the image. Location and intensity of these ghosts will vary with the frequency of the signal, length of the cable and the degree of mismatch of the connector. Video and computer graphics signals are especially sensitive to impedance mismatches. Audio signals because of their low frequencies are not. Digital signals (AES or S/PDIF) are affected only by severe ghosts. Connectors in the middle of a cable seem to be especially disastrous.

An easy way to reduce the cost of a BNC cable or RCA cable is to use a low cost Ethernet or antenna style BNC connector that is rated at 50 ohms. These can be identified by the dielectric surrounding the female BNC center pin. Of the common connectors only BNC connectors are truly 75 ohms. VGA connectors are about 100 ohms and RCA connectors are in the 25 to 60 ohm range. Higher quality cables use connectors as close to the nominal 75 ohm rating as possible.

Mechanical Strength, Quality and Testing

Strain reliefs, cable shielding, ferrite beads, gold plating, solder/crimp technology and other construction components contribute significantly to the cost of cables. However they also contribute to the durability, reliability of the electrical connection and the likelihood that the signal being transmitted will interfere with other devices.

Strain reliefs protect the vulnerable area where the copper is attached to the connector and not strengthened by the jacket. That joint should never move. The strain relief should be robust and of appropriate flexibility so that the cable bends in a smooth curve

as it exits the connector. In addition, it provides protection from accidental or intentional jerks on the cable, transferring the tension to the jacket, not the copper.

The cable shielding prevents outside electro-magnetic fields from interfering with the signal. Possible sources include motors, florescent lights, transformers, relays and coils. Quality costs more with a high quality coax using foil plus a stranded shield.

Ferrite beads prevent the cable from radiating like an antenna. Especially true with high-frequency VGA and higher singles, it is possible for the cable to cause interference with other electronic devices.

VGA cables are unique in that many will operate without any problem using only 10 connections: red, green, blue, H-sync, and V-Sync with the related shields. However with some displays and computers, the computer may have a limited range of output resolutions and aspect ratios. If your display is a 16:9 aspect ratio such as most flat panel plasma or LCD displays, make sure that your VGA cable is DDC or EDID compatible. In the case of some Macintosh PC's, the monitor output my not function at all without DDC/EDID compatibility. Solving these issues requires wiring 4 additional pins on the connectors. That means more expensive wire and additional connection time, increasing the cost of the assembly.

Gold plating has minor advantages over nickel plating. However no lesser plating should be used on a quality connector.

Quality vendors use recognized test procedures and test equipment. There are a variety of tests that can be run. Clearly open wires, shorted wires are never acceptable. However sweep testing is required to completely diagnose the quality of the cable. Because of the time and cost involved, sweep testing is usually only performed on a small percentage of the cables. Open /short testing should be performed and documented on all cables.

Look and Feel

The look and feel of the cables is the final determinant of the cost. It is subjective, but in general the slicker the cable, the more it costs. Look for sharp edges on connectors, soft jackets, fabric overly on the jackets, and gold plating on the exterior of the connectors. Are the VGA hold-down screws easy to operate? Is the cable easy to coil or does it kink? Is the color appropriate for your application? Can a neater installation be done with a cable that combines multiple functions in a single assembly such a HDMI + component video, VGA + audio + network or USB?

Conclusions

In every case lower cost cables and cable assemblies are possible by reducing the performance of the cable. The major factors that drive the costs include:

1. Fire Ratings and insulation
2. Wire Gage (AWG) and construction
3. Connector Impedance
4. Mechanical Strength, quality and testing
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A recent comparison of 4 leading suppliers of VGA-BNC and S-Video-BNC cables showed how these play out in the market place. Needless to say not all the cables are the same price. Imagine how much more can be saved with truly a low end product! Here's the comparison:

S-Video and VGA to BNC Adaptor Construction Summary

MFG	Type	UL/CSA	AWG	Type	Shield	BNC
VGA						
LWC	**HD15F-5BNCF**	**CL2/FT4**	**26 AWG**	**Coaxial**	**95% TC Spiral 100% Foil**	**75 Ohm**
A		AWM 1354	28 AWG	Insulated conductor	90% TC Spiral	50 Ohm
B		AWM 1354	28 AWG	Coaxial	TC Braid 100% Foil 60%	75 Ohm
C		No ratings listed	26 AWG	Coaxial	95% TC Spiral 100% Foil	75 Ohm
S-Video						
LWC	**SVM-2BNCF**	**CL2/FT4**	**26 AWG**	**Coaxial**	**95% TC Spiral 100% Foil**	**75 Ohm**
A		AWM 2725	30 AWG	Insulated conductor	90% TC Spiral	50 Ohm
B		AWM 2863	26 AWG	Insulated conductor	85% BC Spiral	75 Ohm
C		AWM 20276	28 AWG	Coaxial	95% BC Spiral 100% Foil	75 Ohm

- AWM ratings are not allowed for in-wall installations, CL2 and FT4 are US and Canadian ratings allowing in-wall installations
- Insulated Conductor: A relatively cheap method of making a spiral shielded coaxial construct by utilizing a dielectric insulation on the center conductor and a spiral braid shield that is jacketed or wrapped in Teflon tape. Impedance is usually in the 65-72 Ohm range on this construction. The A's product has dye added to the dielectric which will further degrade the impedance values. This construction is for very low frequencies below 10 MHz.
- Dual Shielding is better construction: Foil for frequencies above 50 MHz and Braid for frequencies under 50 MHz
- LWC is Liberty Wire and Cable, employer of the author of this article

It is entirely possible that in many situations the lower cost product will operate satisfactorily. It is also likely that unexpected problems will occur with those products in different environments. Certainly only one is acceptable for in-wall or in-ceiling installations.

One of my friends recently described an installation where the lowest cost product was used for every product. While every product tested satisfactorily by itself, as a system it failed. Replacing any single product with a higher quality product resulted in a working system. Trying to save a few dollars on materials, end up costing hundreds of dollars in trouble shooting time. That's why you pay more for better products!

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