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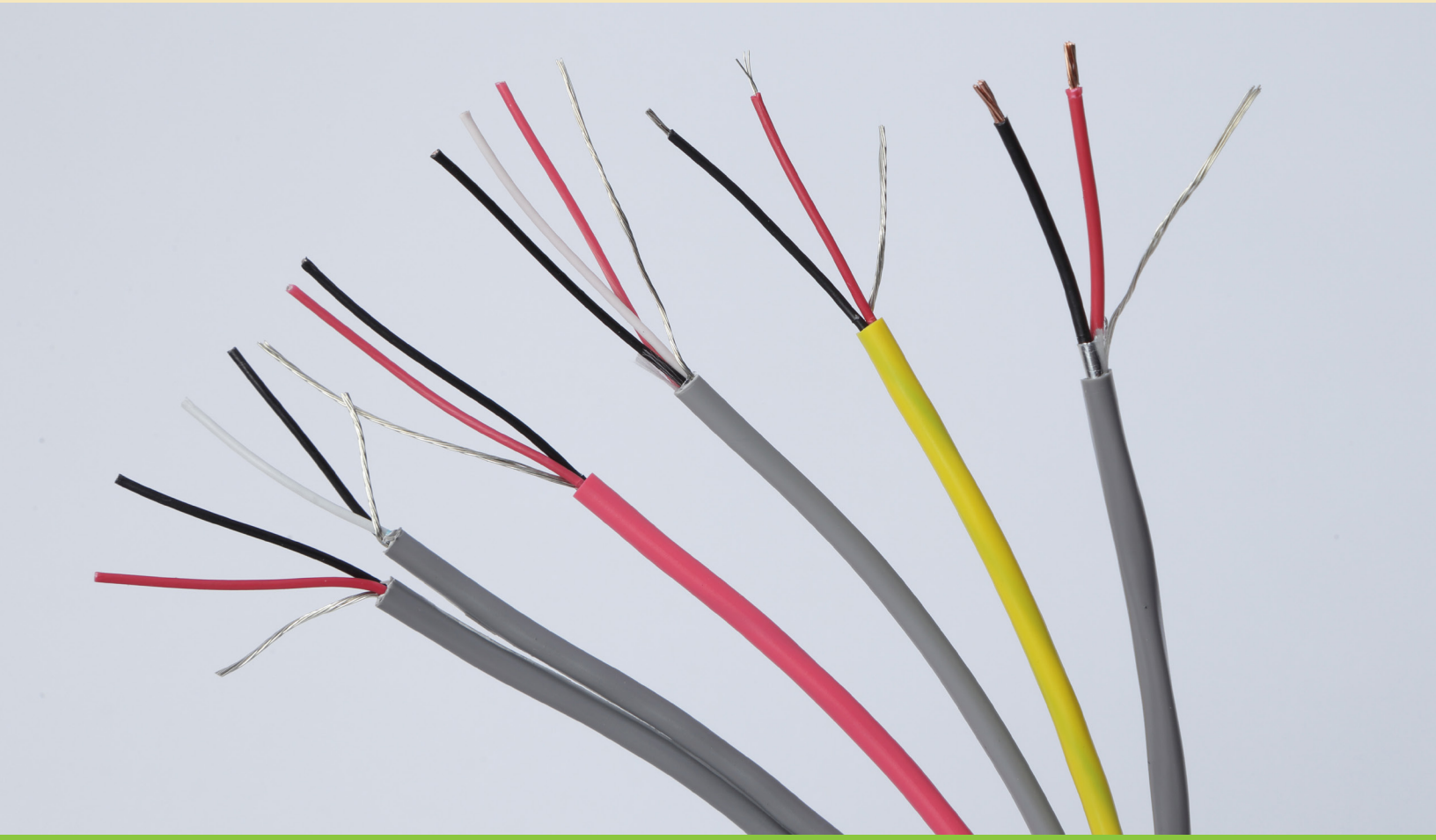
Product Guide

Audio Design

Audio Systems

Line Level Audio
Wireless Audio



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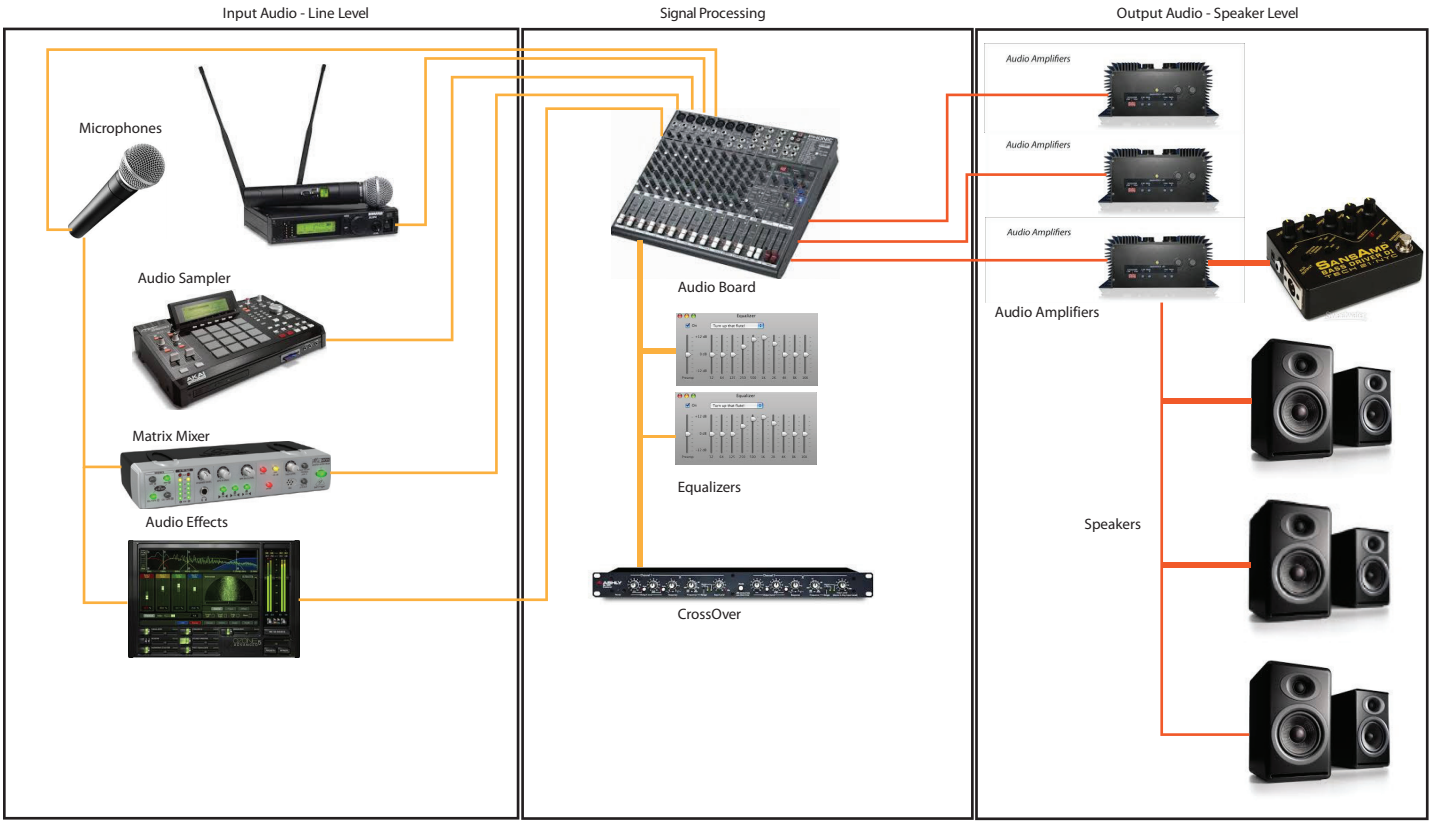
Audio Simplified Design:

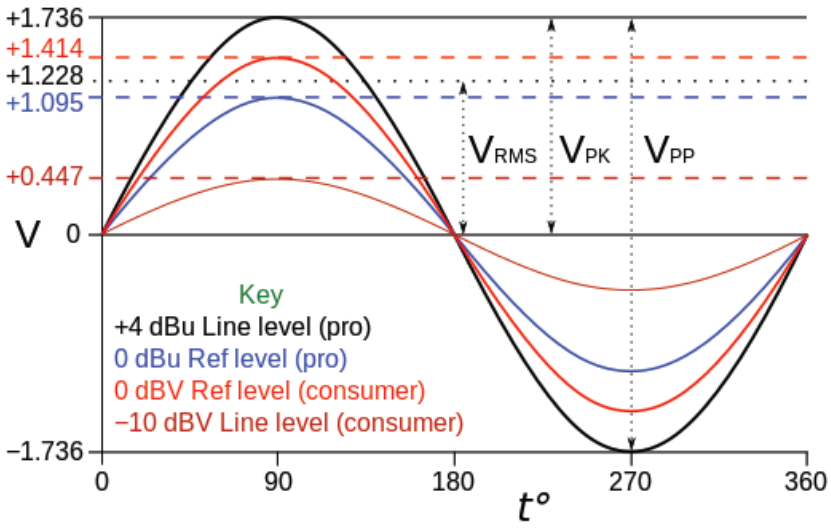


Audio Levels:

Line Level / Mic Level Audio: Input Audio

Line level is the specified strength of an audio signal used to transmit analog sound between audio components such as CD and DVD players, television sets, audio amplifiers, and mixing consoles.

Nominal Levels:



A line level describes a line's nominal signal level as a ratio, expressed in decibels, against a standard reference voltage. The nominal level and the reference voltage against which it is expressed depend on the line level being used. While the nominal levels themselves vary, only two reference voltages are common: decibel volts (dBV) for consumer applications, and decibels unloaded (dBu) for professional applications.

The decibel volt reference voltage is 1 VRMS = 0 dBV.[1] The decibel unloaded reference voltage, 0 dBu, is the AC voltage required to produce 1 mW of power across a 600 Ω impedance (approximately 0.7746 VRMS).[2] This awkward unit is a holdover from the early telephone standards, which used 600 Ω sources and loads, and measured dissipated power in decibel-milliwatts (dBm). Modern audio equipment does not use 600 Ω matched loads, hence dBm unloaded (dBu).

The most common nominal level for consumer audio equipment is −10 dBV, and the most common nominal level for professional equipment is +4 dBu (by convention, decibel values are written with an explicit sign symbol).

Expressed in absolute terms, a signal at −10 dBV is equivalent to a sine wave signal with a peak amplitude (VPK) of approximately 0.447 volts, or any general signal at 0.316 volts root mean square (VRMS). A signal at +4 dBu is equivalent to a sine wave signal with a peak amplitude of approximately 1.736 volts, or any general signal at approximately 1.228 VRMS.

Peak-to-peak (sometimes abbreviated as p-p) amplitude (VPP) refers to the total voltage swing of a signal, which is double the peak amplitude of the signal. For instance, a signal with a peak amplitude of ±0.5 V has a p-p amplitude of 1.0 V.

Audio Levels:

Line levels and their approximate nominal voltage levels

Use	Nominal level	Nominal level, VRMS	Peak amplitude, VPK	Peak-to-peak amplitude, VPP
Professional audio	+4 dBu	1.228	1.736	3.472
Consumer audio	−10 dBV	0.316	0.447	0.894

The line level signal is an alternating current signal without a DC offset, meaning that its voltage varies with respect to signal ground from the peak amplitude (for example +1.5 V) to the equivalent negative voltage (−1.5 V).[3]

Microphone Level: Mic

-50 to -60dB signal level- Very weak signals.
The length of the average Mic run is very short, so electrical parameters are not an issue.
Once the cable runs start exceeding a few hundred feet, the electrical parameters start becoming issues.

Mic Systems can be broken down into two categories:
Portable Installations:

- Rugged
- High Flex Conductor
- No UL Listing
- Flexible
- Braid Shielding

Permanent Installations:

- UL Rating
- Flex Conductor
- Flame / Smoke
- Foil shield (Braid Shield - Optional)

Microphone level changes to line level as soon as possible- (+4dBu) or more.

You can run Mic cables a longer distance than a few hundred feet, there will be noise and interference that may show up, depending on the installation environment. The construction of a mic cable becomes an issue when running longer distances. A low capacitance design is preferable for long distant Mic applications. Shielding becomes a factor. When Mic cable (signals) need to go longer distances, they are best suited to beplaced in a conduit. By doing this, the ruggedness, and fexibility benefts, and cost are not utilized. Hence, go to a permanent high quality install cable, a good electrical characteristic line level audio, or digital audio design.

Balanced Line/Mic Level Cables Impedance

Line Level:

+4dBu-	Professional	A Stronger Signal than Microphone Level
-10dBv-	Consumer	

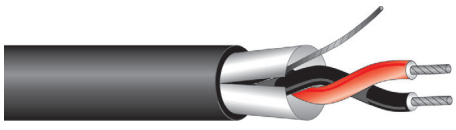
Line Level cables are physically the same as an permanent Mic cable and is distinguished by the fact that it carries balanced line level signals. Line level cables can carry the signals over 1000ft. Line Level signals have to be more robust than Mic cables, line level carries +/-2Volts with current measured in milliamps.

The cable Impedance (Z) is normally between 45-70Ω which closely matches the system Impedance which is close to 60Ω.

$$Z=\sqrt{L/C}$$

Good Quality Line Level Cable
Inductance (L)= .170uH/f
Capacitance (C)= 35pf/ft* (67pf/ft)**

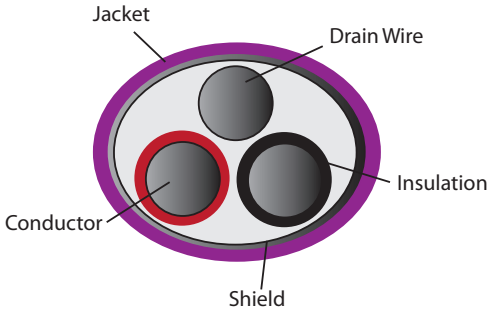
$$Z=\sqrt{.170/67} = 50\Omega$$



Line Level
There are two types of Line Level cables: Balanced and Unbalanced
Balanced vs. Unbalanced Signals:
Balanced audio circuits offer three connections points

- Conductor carrying the signal just as it originated (+)
- Conductor carrying the same signal with opposite polarity (-)
- Electrical Ground (usually shield)
- Connector (XLR, 1/4", 3.5mm)

Line Level Cable Design



Because a line level cable carries less power than a speaker cable the cable is more susceptible to noise. A good line level audio cable contains a shield of some sort (foil, braid, foil/braid)- EMI noise emanates from florescent lighting, lighting dimmers, and electric motors. These EMI signals may penetrate into the line level audio and disrupt the audio signals.

Conductor:

Balanced Mic and Line Level Audio cables consist of stranded conductors- In a portable Mic application a high stranded conductor may be used.

22AWG - 7x30 - 7 Strands of 30AWG= 22AWG conductor

The conductor can be either bare copper or tinned copper. For most Mic and Line Level Applications, a tinned copper center conductor is used. The tinned conductor has been implied that it creates a better solder. This is a question for individual system installer. A tinned conductor will help in corrosion.

Insulation - Dielectric

The insulation is an important part of the construction of the Line Level Cables. A low loss insulation is used to create a flat frequency response, a lower capacitance, and a higher velocity of propagation.
For critical audio cables or audiophile applications, the capacitance between conductors of a cable may be a consideration. This is determined by the dielectric or insulation and the spacing between conductors.
In the highest quality audio circuits the dissipation factor (dielectric loss) of capacitors in the audio path is chosen to be as small as possible.

Dielectric Constant:

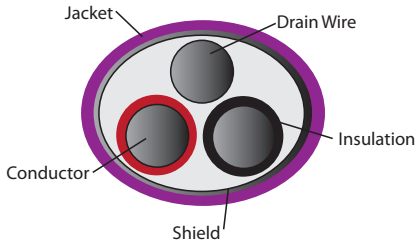
Ratio of the electrical conductivity of a dielectric material to free space

- Air- 1.05
- Polypropylene(PP)- 2.20-2.30-
- PP- Can cause some piezoelectric noise -due to the crystalline structure
- Piezoelectric Noise- When moved or struck, the crystalline structure generates noise by itself.
- Polyethylene (PE)- 2.30 See Frequency Ressponsse chart
- Polyvinl Chloride (PVC) 3.40
- Teflon (FEP) 2.10

Low dielectric constant will provide better electrical characteristics to a cable.
Capacitance would become lower and Velocity of propagation will increase.
Line Level Cables utilize a low dielectric polyolefin insulation.

Cable Design for Mic/Line Level Audio Cables:

Line Level Cable Design



Shield:

Shielding is also important to the construction of a line level audio cable. Shielding prevents unwanted noise to penetrate into the cable. Shielding also provides protection for any audio signals that try to leak out from the cable.

Portable Microphone cables- Because of the low signal levels, these cables are susceptible to noise.
Braid shields are excellent for low frequency noise shielding. (EMI interference)
Permanent Microphone and Line Level Audio Cables do not need the expensive braid, because the signal is stronger on line level, the interference protection of the braid is not needed.

Foil Shields are excellent for higher frequency noise shielding (RFI interference)and provide good shielding for EMI noise.

Jacket:

The jacket is dependent on the environment the cable is used:
- Portable Mic Cables: Rubberized, Flexible type Matte PVC- Usually not a UL Rating
- Permanent Mic/ Line Level Cables: Non-Plenum - PVC CM or CMR Rated
  Plenum - Low Smoke PVC - CMP Rated

Connectors:

Line Level Analog and Digital Audio Connectors have a three prong design. Tip/Ring/Sleeve (TRS).

- 3 Pin XLR
  - CN-NC3MXB — 3Pin XLR Male Bk/Gold
  - CN-NC3MXBAG — 3Pin XLR Male Bk/Nickel
  - CN-NC3MX — 3Pin XLR Male Nickel/Nickel
  - CN-NC3FXB — 3Pin XLR Female Bk/Gold
  - CN-NC3FXBAG — 3Pin XLR Female Bk/Nickel
  - CN-NC3FX — 3Pin XLR Female Nickel/Nickel
- Stereo Mini 3.5mm
  - CN-NYS231B — Stereo Mini 3.5mm Black
  - CN-NYS231 — Stereo Mini 3.5mm Metal
- 1/4” TRS or TS
- RCA

Line/Mic Level Permanent Cables

West Penn Wire Analog Line Level Cables

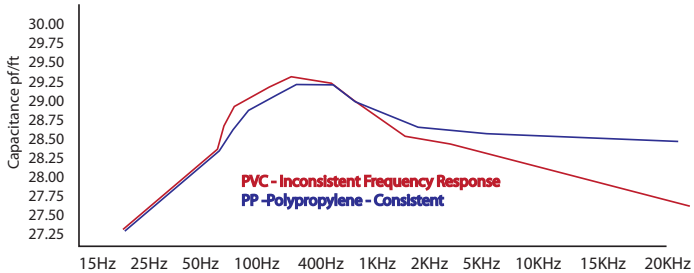
	Professional Miniature Audio Cables
454-xx	1pr. 22AWG Shielded Bonded Jacket Full AWG Drain Wire CMR - Available in xx: 12 Colors
452	1pr. 22AWG Shielded CMR
D25454	1pr. 22AWG Shielded Bonded Jacket Full AWG Drain Wire CMP
210454	Dual Design - 2pr. 22AWG Shielded CMR
	Broadcast Quality CMR
77291	1pr. 22AWG Shielded CMR - Low Capacitance
77292	1pr. 20AWG Shielded CMR - Low Capacitance
77293	1pr. 18AWG Shielded CMR - Low Capacitance
77294	1pr. 16AWG Shielded CMR - Low Capacitance
	Broadcast Quality CMP - Plenum
D25291	1pr. 22AWG Shielded CMP - Low Capacitance
D25292	1pr. 20AWG Shielded CMP - Low Capacitance
D25293	1pr. 18AWG Shielded CMP - Low Capacitance
D25294	1pr. 16AWG Shielded CMP - Low Capacitance
	Commercial Quality CMR
291	1pr. 22AWG Shielded CMR
292	1pr. 20AWG Shielded CMR
293	1pr. 18AWG Shielded CMR
	Commercial Quality CMP
25291B	1pr. 22AWG Shielded CMP
25292B	1pr. 20AWG Shielded CMP
25293B	1pr. 18AWG Shielded CMP

Frequency Response and Capacitance:

Capacitance is an important electrical characteristics that is related to frequency response and overall quality of the signal integrity. Lower the capacitance the better the frequency response.

Frequency response is one of the most fundamental indicators of a devices ability to faithfully record, reproduce, or transmit a complex signal.
Frequency response is a plot of the input signal to the output signal over a frequency band for the component or system.

Signal input is normally a fat frequency response, only the output is measured. Having a fat frequency response on the input and a flat frequency response over the medium will assure a measured flat frequency response at the output



Audio Ranges:
20Hz - Lowest Audible Frequency
440Hz - A key on the piano
20KHz - Highest Audible Frequency

Line Level Design - AES/EBU Digital Audio

Digital Audio is partly digital and partly audio. It is digital in that the analog signals are converted to digital data at one of a number of data rates. The analog audio rules do not apply to digital applications.

The cable must have specific electrical characteristics, such as impedance and capacitance. This is needed to transmit the digital (square wave data signals) effectively and effectiently.

The Audio Engineering Society (AES) along with the European Broadcast Union (EBU) has developed the AES/EBU digital audio standards. The development of this standard has led audio recording and reproduction in digitized signaling.

Digital is very stable and reliable. With digital signals being used it reduces equipment adjustments significantly. More and more audio tape recorders and studio equipment signals are being sent in digital form. The digitized form retains the quality of the original source. Degradation of signals are basically eliminated, noise effectiveness is greatly improved, and signal transparency is excellent. The trend in broadcast and production technology is towards the use of digital systems. All aspects of recording, processing, and transmission take place in the digitized form. Using a digital system it becomes extremely important to select the proper cable. Without the proper cable, the system will not meet performance expectations.

DIGITAL AUDIO ADVANTAGES

- Improves audio tape recording
- Suitable for storage and computer-based production system
- Improves signal transparency
- Noise reduction
- Degradation of signals are eliminated

DIGITAL AUDIO STANDARDS

The specification for digital audio is developed by the AES/EBU. The two main electrical parameters in this specification pertaining to cable are:

- Data Rates- Depends on Sampling Rate
- 3.072 Mbps is the normal standard
- Impedance- 110Ω +/- 20% (88-132Ω)

Sampling Rates (kHZ)	Bandwidth (Mbps)
32	4.096
38	4.864
44.1	5.645
48	6.144
96	12.228
192	24.576

Sampling rates:

- 32kHZ- Professional transmission (Voice recording, reportage)
- 38kHZ- (Music, FM station quality)
- 44.1kHZ- Consumer - (CD sampling rate for music)
- 48kHZ- Broadcast- common use -- audio tracks on professional video machines
- 96kHZ- Top of the line professional machines
- 192kHZ- Double quality of 96kHZ

Line Level Cable Design - AES/EBU Digital Audio

Twisted Pair Cable Construction

Conductor:

- 22, 24 or 26 AWG
- Tinned copper conductors

Insulation:

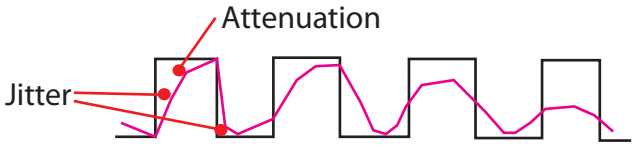
- Low loss foam dielectric
- Foam technique - blowing a percentage of air into the dielectric. This will decrease the the dielectric constant and improve the dielectric constant. The technique to adding air to the dielectric is an important aspect of manufacturing processes.
- Low loss foam dielectric will allow better electrical characteristics.

Digital signals are sequences of ones and zeros, looking like a square wave.

The original signal will shrink due to the pure resistance of the conductor (Attenuation). Adding capacitance and impedance variations will cause the square waves to become rounded.

As the cable length increases, the square wave becomes less and less square. With impedance imperfections there will be some reflections in the signal back to the source. This is measured in VSWR or voltage standing wave ratio, which is related to SRL or structural return loss.

Capacitance tends to make the edges of each square ragged. There will be timing errors also known as jitter in the signal. These variations will cause the receiving devices not to function.



Shield:

Shielding is also important to the construction of a digital level audio cable. Shielding prevents unwanted noise to penetrate into the cable. Shielding also provides protection for any audio signals that try to leak out from the cable.

Jacket:

The jacket is dependent on the environment the cable is used:

- Permanent Digital Audio Cables: Non-Plenum - PVC CM or CMR Rated
- Plenum - Low Smoke PVC - CMP Rated

Standards:

AES3-ID - Professional version of digital audio
S/PDIF - Consumver version of digital adio - BNC connectors
SDIF - Consumer - RCA connectors - short distance runs

Line Level Design - AES/EBU Digital Audio

West Penn Wire Digital Line Level Cables

	AES/EBU Digital Audio Cables Non-Plenum
DA2401	1pr. 24AWG Shielded 110 Ohms CM
DA2402	2pr. 24AWG Shielded 110 Ohms CM
DA2406	6pr. 24AWG Shielded 110 Ohms CM
	AES/EBU Digital Audio Cables Plenum
DA252401	1pr. 24AWG Shielded 110 Ohms CMP
DA252402	2pr. 24AWG Shielded 110 Ohms CMP
DA252406	6pr. 24AWG Shielded 110 Ohms CMP

Maximum Recommended Transmission Distance at Digital Audio Rates

Cat. No.	2Mhz	4Mhz	5Mhz	6Mhz	12Mhz	25Mhz
	ft.	ft.	ft.	ft.	ft.	ft.
All DA Series	1540	1282	1176	1105	877	649

* Longer transmission distances are achievable but are contingent upon system component quality of input/output voltages.
+ Transmission distance calculations assume minimum allowable output signal amplitude and minimum allowable input signal amplitude.

Installation Guidelines Line Level Cables

Pull Tension: Nominal Number in lbs.

When calculating the pull tension of a cable, take the AWG Size Pull Tension + Number of Conductors + Insulation Pull Shield Pull Tension + Jacket Pull Tension.

AWG Pull Tension:
24 AWG: 4lbs.
22 AWG: 7lbs.
20 AWG: 12lbs.
18 AWG: 19lbs.
16 AWG: 30lbs.

Insulation Pull Tension:
All: 4lbs.

Shield Pull Tension:
100% Foil 6lbs.
Braid 90% 8lbs.
Foil+Braid 10lb.s

Jacket Pull Tension:
All: 4lbs.

Example
West Penn PN. 454
22/2 Shielded CMR
Conductor: 7 + 7 = 14lbs.
Insulation: 4lbs.
Shield: 6lbs.
Jacket: 4lbs.

Total: 8lbs. Pull Tension - Actual 26-33lbs.

Bend Radius: General Rules

Audio Cables: 6 x the cable OD
Network Cables 4 x the cable OD
Coaxial Cables 10 x the cable OD
Fiber Optics 10 to 15 x the cable OD

Example:
West Penn PN 454
Cable OD .135
.135 x 6 = .81 inches is the Radius

WireLess Mic Distribution

Wireless Microphone Distribution is become more popular for many reasons
1. Greater freedom of movement for speakers or musicians
2. Cabling problems
    - Cable stress - distance
    - Tripping hazards

Types of Cables

Wireless Microphone Cables are designed for RF. These cables have an Impedance of 50 ohms and are connected by BNC Connectors. The cable design can determine the distance of transmission from Wireless Receiver to the Rack. The loss or attenuation associated to the Frequency is the primary electrical characteristics to determine length.

Coaxial Cables 50 ohm

RG58 20-22AWG
RG8X 16 AWG
RG213 12-13 AWG
RG8 10 AWG

West Penn Wire Cables

RG58/U 50 Ohm RF Cables		
Catalog No.	Description	BNC Connector
813	20AWG Stranded - 50 Ohm CM	CN-BM53-13
812	20AWG Solid - 50 Ohm CM	CN-BM53-13
25812	20AWG Solid - 50 Ohm CM	CN-BM53-25
RG8X 50 Ohm RF Cables		
807x	16AWG Stranded - 50 Ohm CM	CN-BM53-8X
RG213/U 50 Ohm RF Cables		
810	13 AWG Stranded - 50 Ohm Cable CM	CN-BM53-8
25810	13 AWG Stranded - 50 Ohm Cable CMP	CN25810KBNC
RG8/U 50 Ohm Cables		
98G8	10AWG Solid - 50 Ohm Cable CM	CN-BM98G8
2598G8	10AWG Solid - 50 Ohm Cable CMP	CN-BM2598G8

Wire Less Mic Distribution

Determine the Cable Type:

Cable Attenuation

Cat. No	1 Mhz	10 Mhz	50 Mhz	100 Mhz	200 Mhz	400 Mhz	900 Mhz	1 Ghz
812	.5	1.3	32.	4.6	6.8	10.1	16.7	18.2
813	.6	1.5	3.5	4.8	6.9	10.3	16.8	18.3
25812	.5	1.3	3.2	4.6	6.8	10.1	16.7	18.2
810	.2	.6	1.3	2.0	2.8	4.0	6.8	7.3
25810	.2	.6	1.3	2.0	2.8	4.0	6.7	7.4
98G8	.1	.5	1.0	1.4	1.8	2.6	4.1	4.4
2598G8	.1	.4	1.0	1.6	2.3	3.4	6.0	6.9
807X	.3	.9	2.1	3.1	4.5	6.6	10.7	

Example:

Wireless Mic Remote Antenna
RF Frequencies: 470-698 Mhz
Mic Gain: +8dB
Cable length needed: 300ft.

What cable is needed?

RG8 98G8 has a 2.6dB/100ft of loss
at 300ft is 7.8dB.

RG8 would work!

West Penn Cross Reference:

ANALOG LINE LEVEL AUDIO

Wire	Description	Belden	Liberty
(X)454	Miniature Audio Line Level Audio 1 pr. 22AWG Shielded 12 Colors	9451	22-1P-EZ
D25454	Miniature Audio Line Level Audio 1 pr. 22AWG Shielded Plenum	9451P	--
210454	Dual Miniature Audio Line Level 9 Audio 2 pr. 22AWG Shielded	451D	--
77291	Miniature Audio Line Level Audio 1 pr. 22AWG Shielded	8761	--
77292	Miniature Audio Line Level Audio 1 pr. 20AWG Shielded	8762	--
77293	Miniature Audio Line Level Audio 1 pr. 18AWG Shielded	8760	--
77294	Miniature Audio Line Level Audio 1 pr. 16AWG Shielded	8719	--
77295	Miniature Audio Line Level Audio 1 pr. 14AWG Shielded	8720	--
77296	Miniature Audio Line Level Audio 1 pr. 12AWG Shielded	8718	--
77510	Miniature Audio Line Level Audio 2 pr. 22AWG Ind.Shielded		
D25291	Miniature Audio Line Level Audio 1 pr. 22AWG Shielded Plenum	87761	--
D25292	Miniature Audio Line Level Audio 1 pr. 20AWG Shielded Plenum		
D25293	Miniature Audio Line Level Audio 1 pr. 18AWG Shielded Plenum	87760	--
D25294	Miniature Audio Line Level Audio 1 pr. 16AWG Shielded Plenum		

AES/EBU DIGITAL AUDIO

DA2401	1 Pair 24 AWG Shielded Digital Audio Non-Plenum	1800B	24-1P DIG-SNAKE
DA2402	2 Pair 24 AWG Shielded Digital Audio Non-Plenum	9729	24-2P DIG-SNAKE
DA2406	6 Pair 24 AWG Shielded Digital Audio Non-Plenum	1803F	
DA2404S	4 Pair 24 AWG Shielded Digital Audio Non-Plenum	9731	24-4P DIG-SNAKE
DA2408S	8 Pair 24 AWG Shielded Digital Audio Non-Plenum	1805A	24-8P DIG-SNAKE
DA24012S	12 Pair 24 AWG Shielded Digital Audio Non-Plenum	1806A	24-12P DIG-SNAKE
DA252401	1 Pair 24 AWG Shielded Digital Audio Plenum	1801B	24-1P P DIG-SNAKE
DA252402	2 Pair 24 AWG Shielded Digital Audio Plenum	89729	--
DA252406	6 Pair 24 AWG Shielded Digital Audio Plenum	89732	--

RF COAXIAL WIRELESS MIC

807X	RG8X 16AWG	9258	--
989G8	RG8 - 10AWG CM	9913	--
2598G8	RG8 - 10AWG CMP	89913	--

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