



# Using Category 5/5e/6 for Audio and Video Applications

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Belden



# How Do We Compare?

## Can you use Cat 5/5e/6 for non data applications?

- What applications?
- What performance requirements?
- Compare to TIA/EIA568-B.2 standard

# Table 1 – Audio Applications

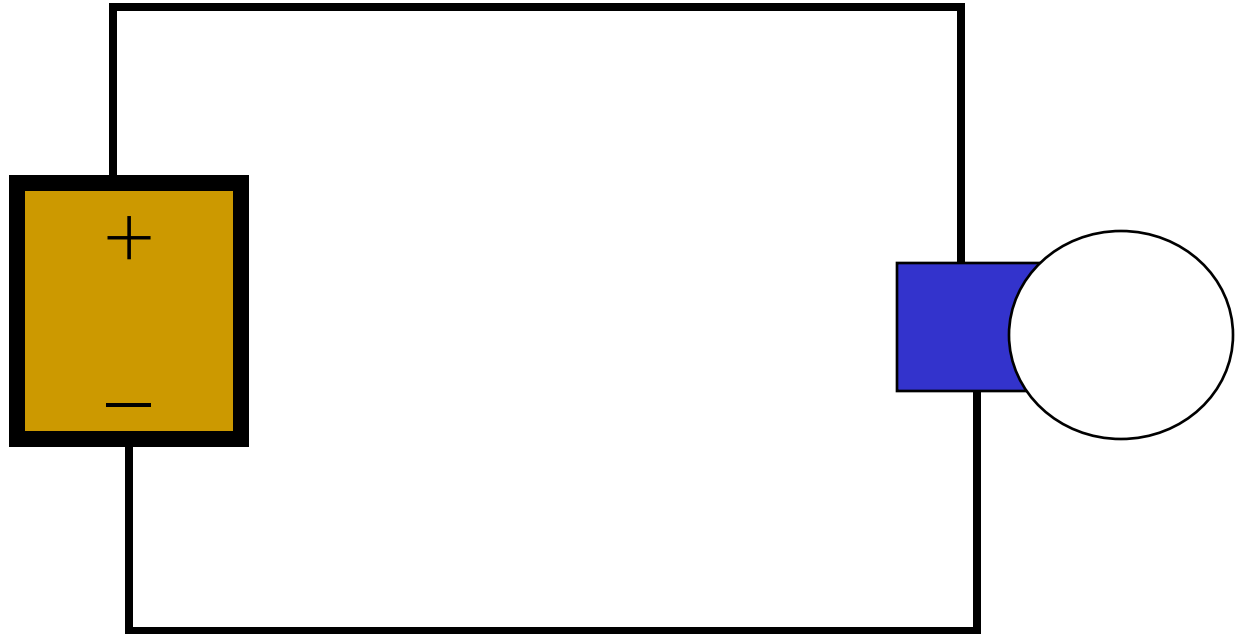
<b>Application</b>	<b>Format</b>	<b>Cable Type</b>	<b>Spec</b>	<b>End-User</b>
Analog audio	Unbalanced	Single-conductor shielded	N/A	Consumer
	Balanced	Shielded twisted-pair	N/A	Professional
Digital audio	Unbalanced	Coaxial cable	S/PDIF	Consumer
			AES3-id	Professional
	Balanced	Shielded twisted-pair	AES3	

# Table 2 – Video Applications

Application	Format	Cable Type	Spec	End-User
Analog video	Unbalanced	Coaxial cable	Surveillance	Consumer
			Home video	
Broadcast			Professional	
SDI (601)				
Digital video		S-video (dual)	Y-C	Pro-Sumer
Analog video		RGB	Component	Professional
		VGA		
		Coaxial cable	Broadband	Consumer

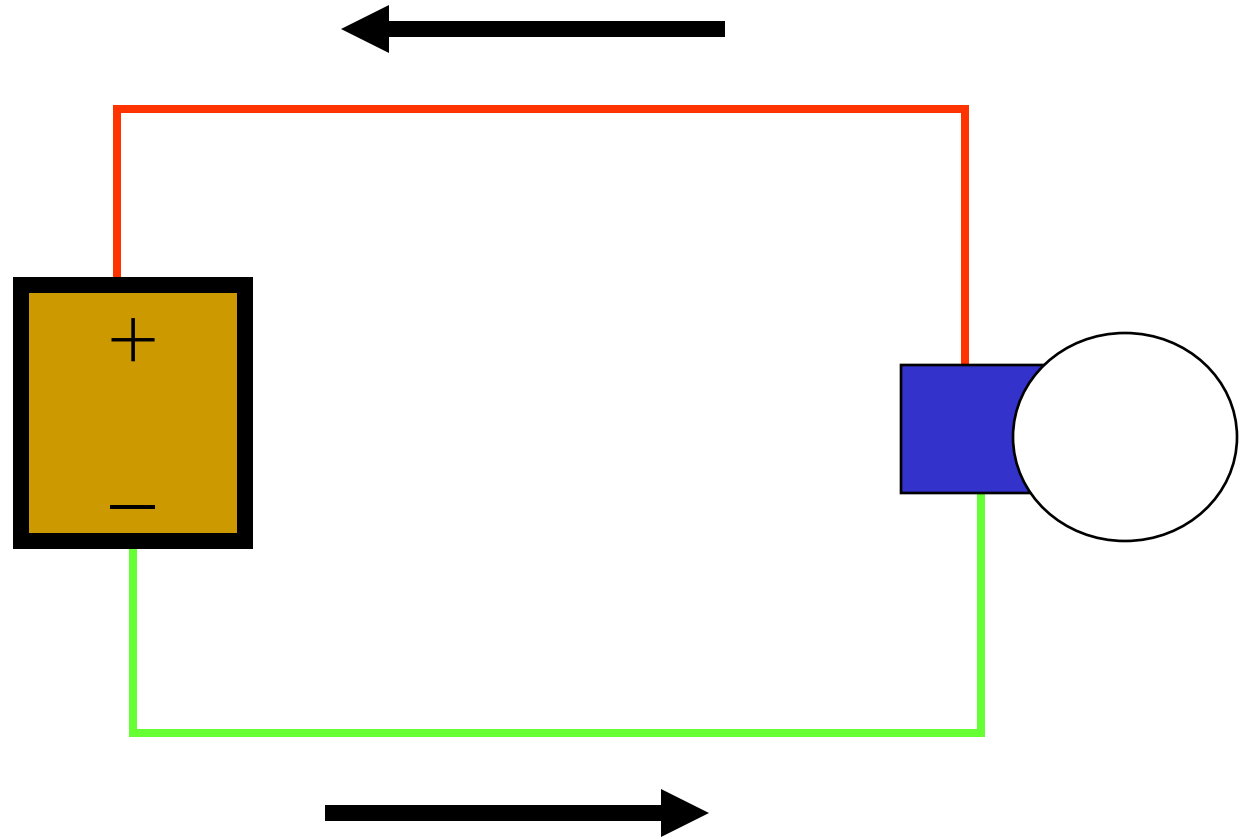


# How Does a Balanced Line Work?

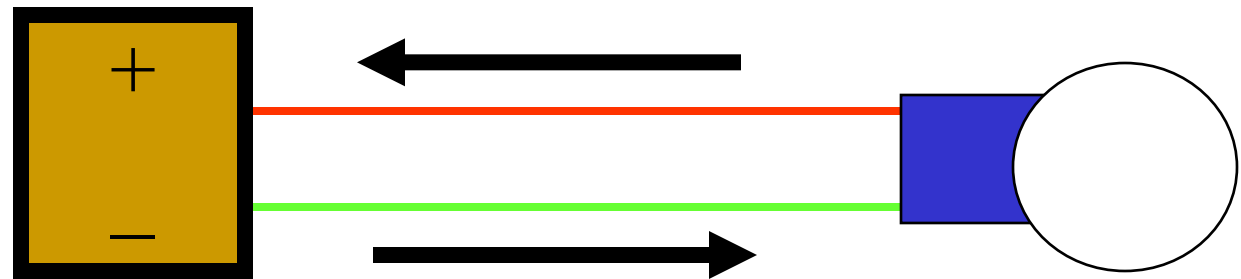




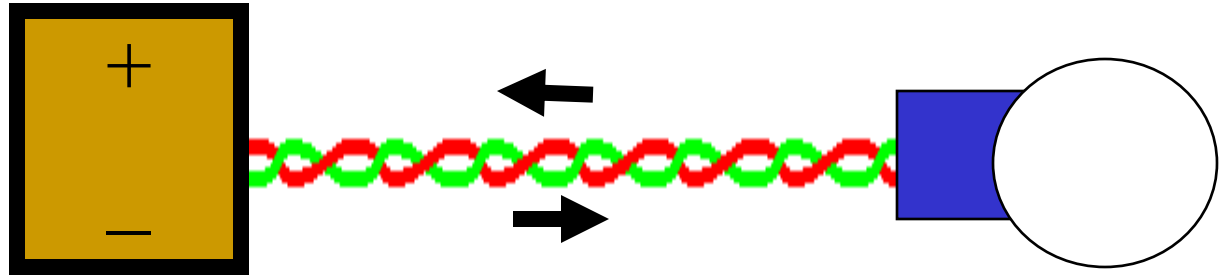
# How Does a Balanced Line Work?



# How Does a Balanced Line Work?

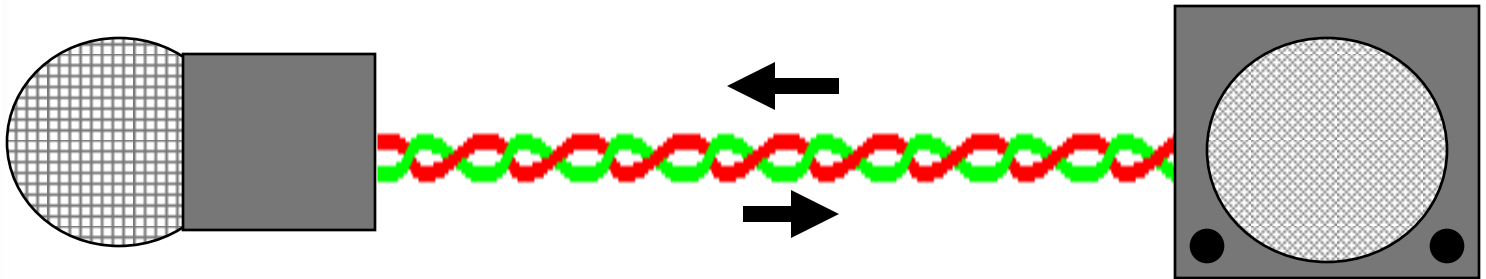


# How Does a Balanced Line Work?



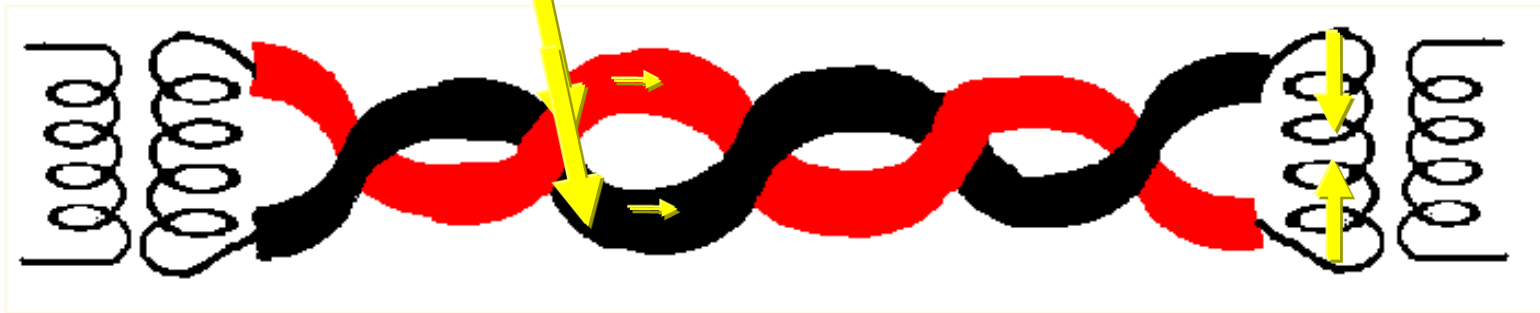


# How Does a Balanced Line Work?





# How Does a Balanced Line Work?



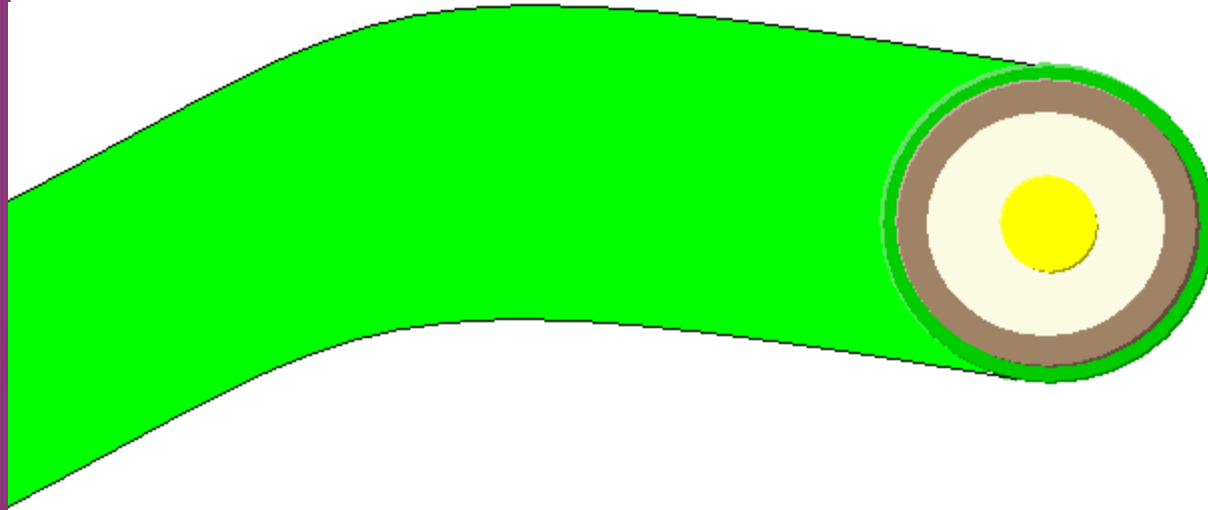
# A Perfect Balanced Line

Requirement	Variations in	Cable Parameter	Measured in
<b>Spacing</b>	Impedance	Return Loss	Decibels (dB)
	Capacitance	Capacitance Unbalance	Picofarads (pF)
<b>Size</b>	Resistance	Resistance Unbalance	Ohms ( $\Omega$ )
<b>Length</b>	Resistance	Resistance Unbalance	Ohms ( $\Omega$ )
	Timing	Phase	Degrees ( )

“A balanced line is one where each of the two conductors, and all passive pieces attached to each conductor, are the same impedance in reference to ground.”

Bill Whitlock, Jensen Transformers

# An Unbalanced Line



- Conductors aren't the same size.
- Conductors aren't the same length.
- Conductors aren't close together.



# Consumer Analog Audio

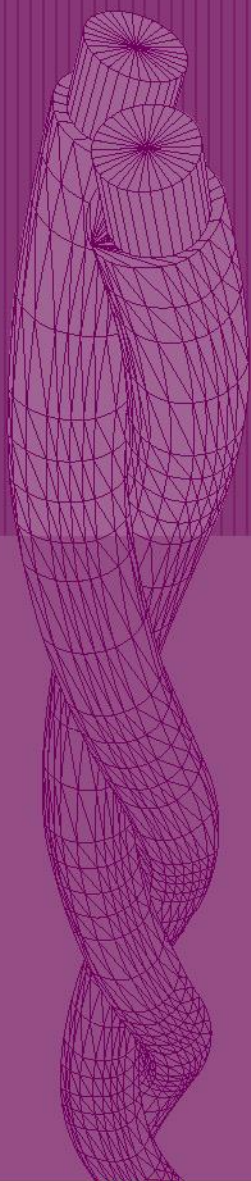
	<b>System Specs</b>	<b>Category 5</b>	<b>Category 5e</b>	<b>Category 6</b>
<b>Format</b>	Unbalanced	<i>Balanced</i>	<i>Balanced</i>	<i>Balanced</i>
<b>Capacitance</b>	30pF/ft. 98 pF/m	15 pF/ft. 49pF/m	15 pF/ft. 49pF/m	15 pF/ft. 49pF/m
<b>Impedance</b>	N/A	100Ω	100Ω	100Ω
<b>Gage</b>	22/24 AWG (?)	24 AWG	24 AWG	23 AWG
<b>Shield</b>	YES	NO	NO	NO



# How Far Can You Go?

-1 dB @ 20 kHz

Source Impedance	15 pF/ft. (49 pF/m)	20 pF/ft. (66 pF/m)	30 pF/ft. (98 pF/m)	50 pF/ft. (164 pF/m)
50 Ω	5406 ft. 1648m	4055 ft. 1236m	2703 ft. 824m	1622 ft. 495m
100 Ω	2707 ft. 825m	2030 ft. 619m	1353 ft. 413m	812 ft. 248m
150 Ω	1873 ft. 571m	1352 ft. 412m	901 ft. 275m	541 ft. 165m
600 Ω	451 ft. 138m	338 ft. 103m	225 ft. 68.6m	135 ft. 41.2m
1 kΩ	271 ft. 82.6m	203 ft. 61.9m	135 ft. 41.2m	81 ft. 24.7m
10 kΩ	27 ft. 8.2m	20 ft. 6.1m	14 ft. 4.3m	8 ft. 2.4m
50 kΩ	5.4 ft. 165cm	4 ft. 122cm	2.7 ft. 82cm	1.6 ft. 49cm



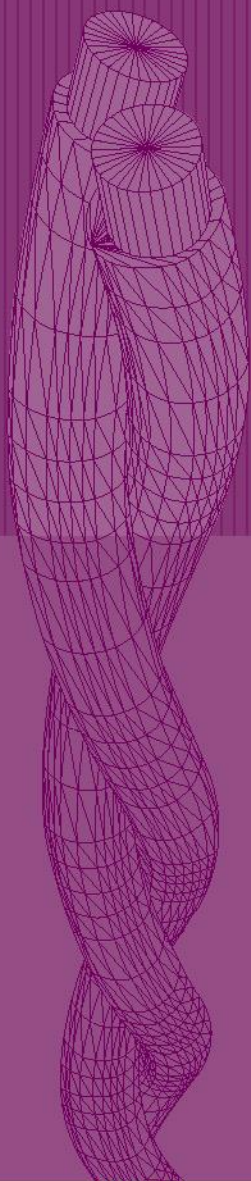


# Balanced Analog Audio

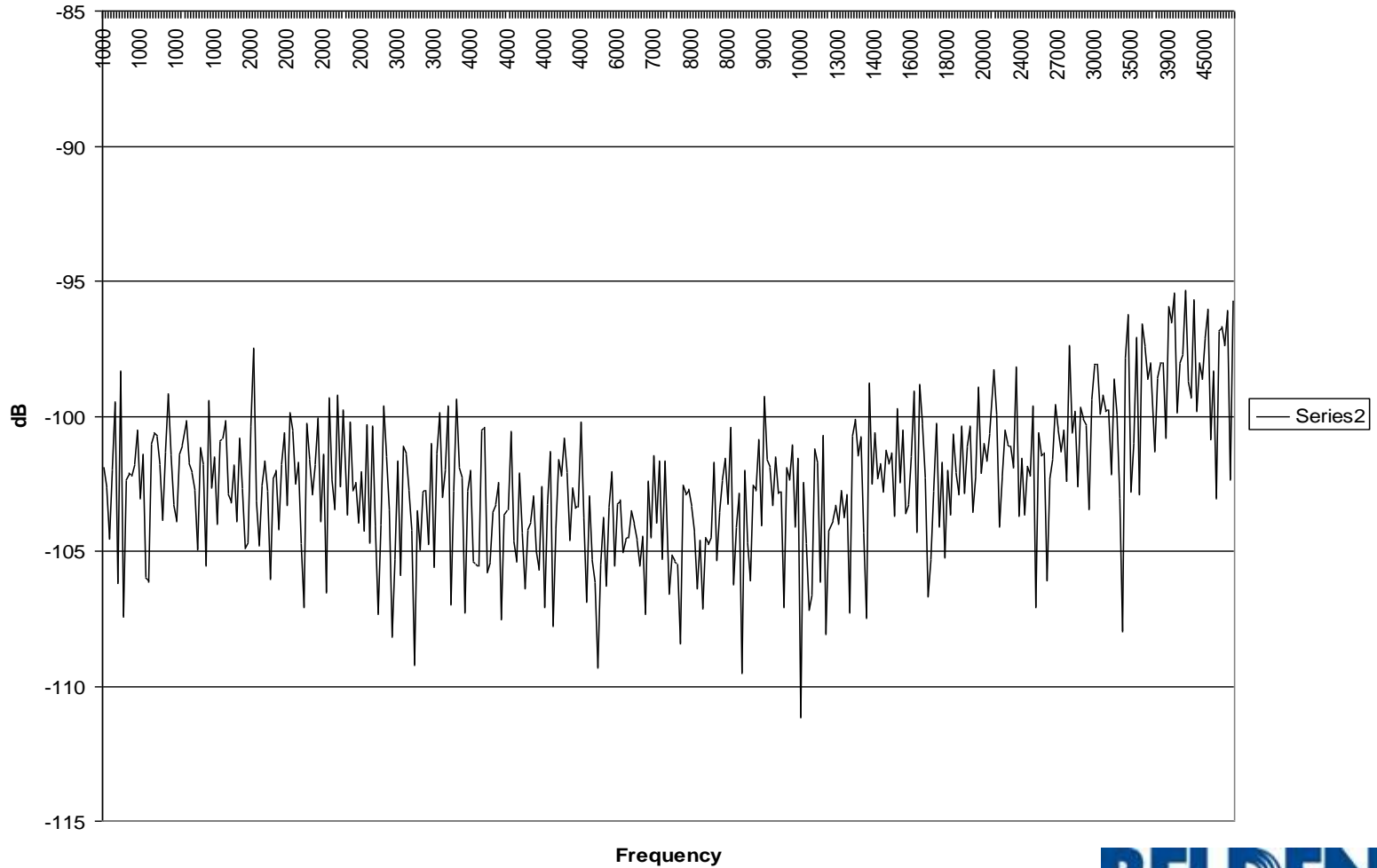
	System Specs	Category 5	Category 5e	Category 6
<b>Format</b>	Balanced	Balanced	Balanced	Balanced
<b>Capacitance</b>	30pF/ft. 98 pF/m	15 pF/ft. 49pF/m	15 pF/ft. 49pF/m	15 pF/ft. 49pF/m
<b>Impedance</b>	N/A	100Ω	100Ω	100Ω
<b>Gage</b>	22-24 AWG	24 AWG	24 AWG	23 AWG
<b>Shield</b>	YES	NO	NO	NO



# Analog Audio FEXT in UTP



1752A FEXT Average

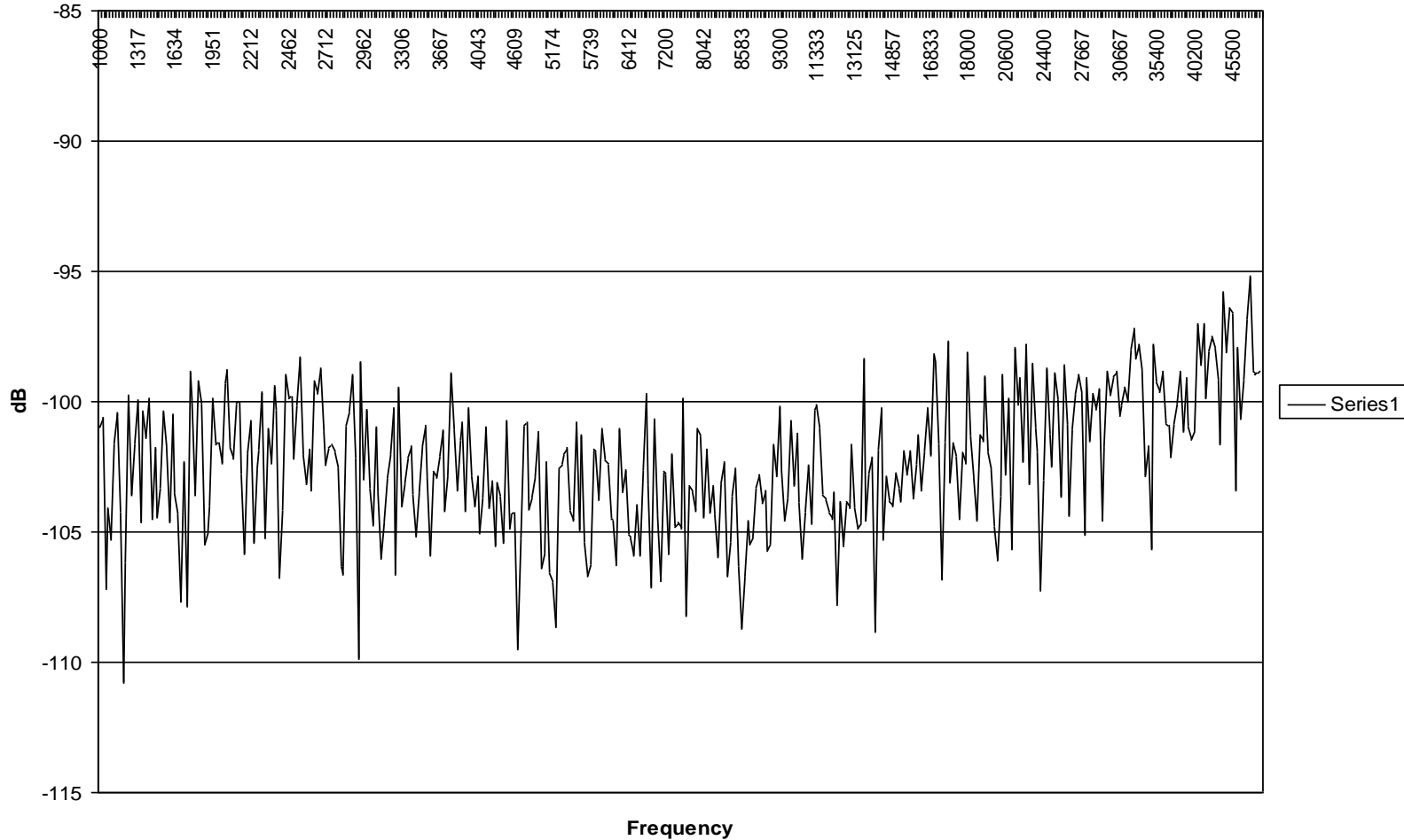






# Analog Audio NEXT in UTP

1752A NEXT AVERAGE

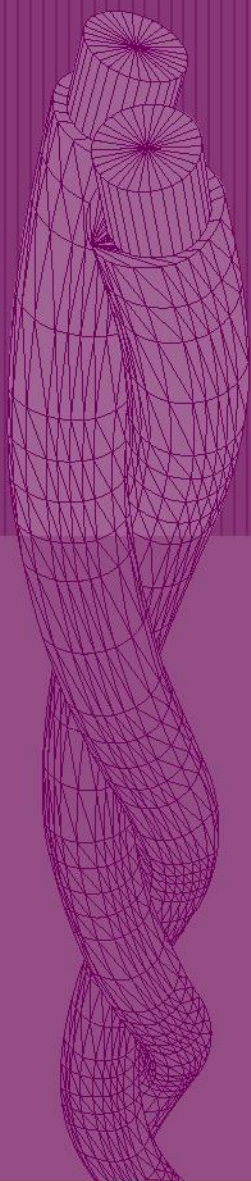
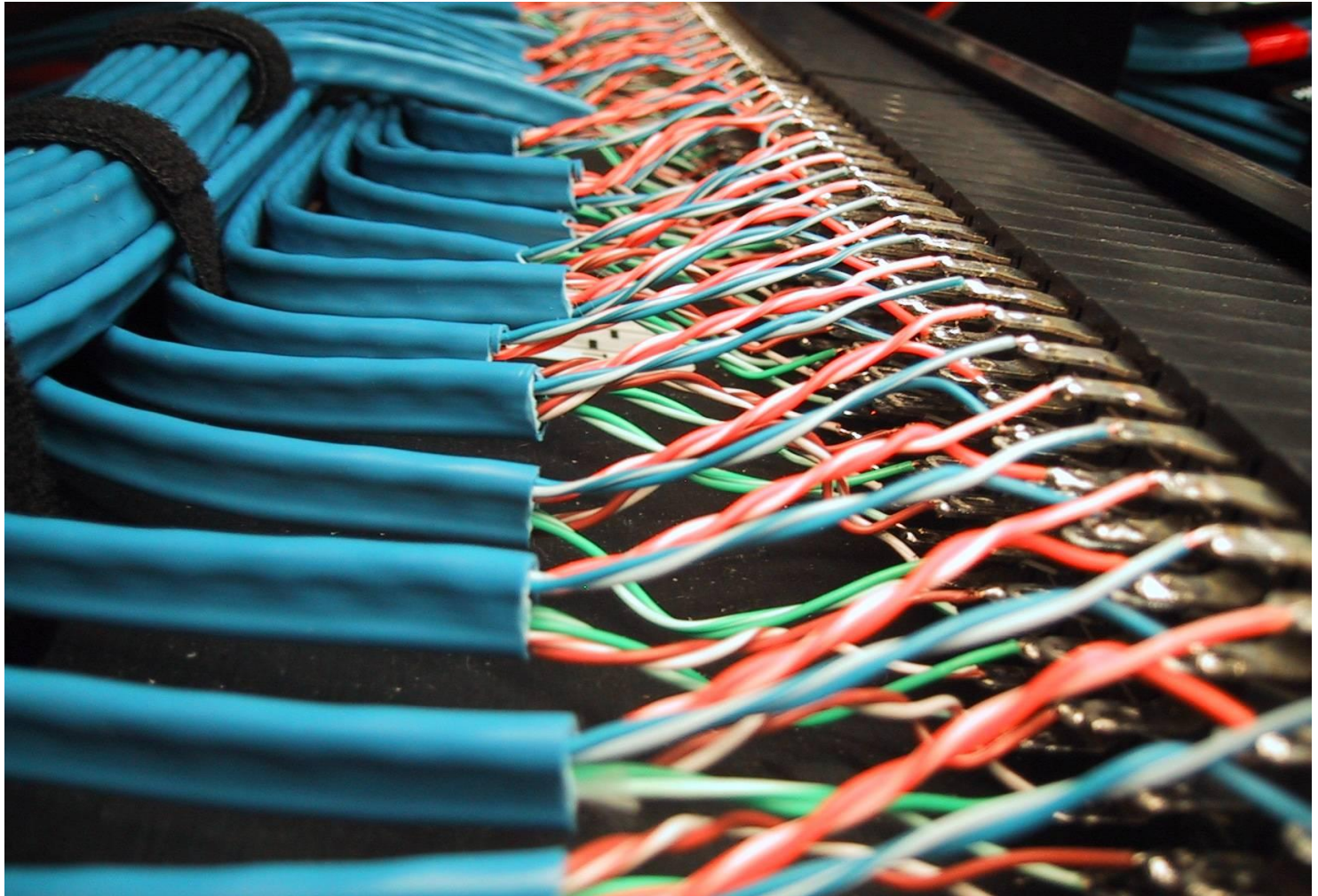


# Balanced Pairs and Shielding

- Ground Loops.
  - Shields can become ‘antennas’.
    - Feed noise into the pair
    - Not protecting the pair from noise.
- With UTP we ‘fixed the pair’.
  - As symmetrical as possible.
  - As balanced as possible
    - No shielding to fall back on.
- And now “InstaSnake”



# Analog Audio and MediaTwist





# AES3-id Professional Coax

	<b>System Specs</b>	<b>Category 5</b>	<b>Category 5e</b>	<b>Category 6</b>
<b>Format</b>	Unbalanced	<i>Balanced</i>	<i>Balanced</i>	<i>Balanced</i>
<b>Capacitance</b>	20pF/ft. 66pF/m	15 pF/ft. 49pF/m	15 pF/ft. 49pF/m	15 pF/ft. 49pF/m
<b>Impedance</b>	75Ω	100Ω	100Ω	100Ω
<b>Gage</b>	20-24 AWG	24 AWG	24 AWG	23 AWG
<b>Shield</b>	YES	NO	NO	NO
<b>Crosstalk</b> 6 MHz (48 kHz)	-30 dB (?)	-47.6 dB PSNEXT	-50.6 dB PSNEXT	-60.6 dB PSNEXT
<b>Crosstalk</b> 25 MHz (192 kHz)	-30 dB (?)	-41.4 dB PSNEXT	-41.4 dB PSNEXT	-51.4 dB PSNEXT
<b>Crosstalk</b> 50 MHz (384 kHz)	-30 dB (?)	-37.6 dB PSNEXT	-37.6 dB PSNEXT	-47 dB PSNEXT

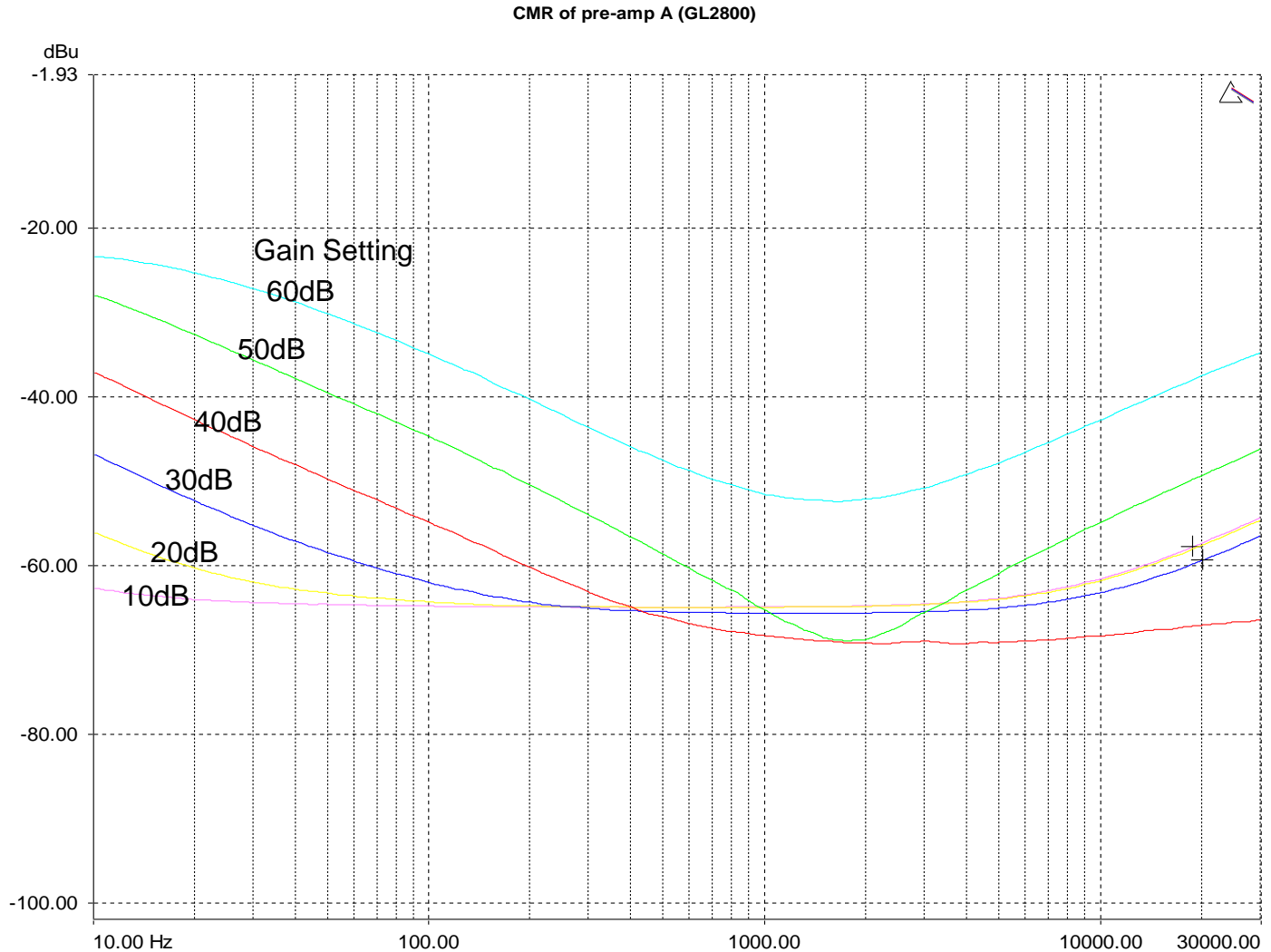
# What is Good CMRR?

- Based on frequency

SSL	
Mic Input	
50 Hz	>115 dB
1 kHz	>100 dB
10 kHz	>70 dB
Line Input	
50 Hz	>90 dB
1 kHz	>100 dB
10 kHz	>50 dB

Mackie	
Mic Input	
50 Hz	>70 dB
1 kHz	>70 dB
10 kHz	>60 dB

# What is Good CMRR?



Allen & Heath GL2800 Mixer

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# Digital Audio

Sampling Rate	To Determine Bandwidth	Actual Bandwidth
44.1 kHz	x128	5.6448 MHz
48 kHz	x128	6.144 MHz
88.2 kHz	x128	11.2896 MHz
96 kHz	x128	12.288 MHz
176.4 kHz	x128	22.5792 MHz
192 kHz	X128	24.576 MHz

AES5 *proposed* X-140 “SuperMAC” uses Category 5, 5e, 6, ‘7’



# S/PDIF Consumer Coax

$$44.1 \text{ kHz} \times 128 = 5.6448 \text{ MHz (6 MHz)}$$

	<b>System Specs</b>	<b>Category 5</b>	<b>Category 5e</b>	<b>Category 6</b>
<b>Format</b>	Unbalanced	<i>Balanced</i>	<i>Balanced</i>	<i>Balanced</i>
<b>Capacitance</b>	20pF/ft. 66pF/m	15 pF/ft. 49pF/m	15 pF/ft. 49pF/m	15 pF/ft. 49pF/m
<b>Impedance</b>	75Ω	100Ω	100Ω	100Ω
<b>Gage</b>	23-24 AWG	24 AWG	24 AWG	23 AWG
<b>Shield</b>	YES	NO	NO	NO
<b>Crosstalk</b> 6 MHz	-30 dB (?)	-47.6 dB PSNEXT	-50.6 dB PSNEXT	-60.6 dB PSNEXT





# Balanced AES

	System Specs	Category 5	Category 5e	Category 6
<b>Format</b>	Balanced	Balanced	Balanced	Balanced
<b>Capacitance</b>	13pF/ft. 43pF/m	15 pF/ft. 49pF/m	15 pF/ft. 49pF/m	15 pF/ft. 49pF/m
<b>Impedance</b>	110Ω 20%	100Ω 15Ω	100Ω 15Ω	100Ω 15Ω
<b>Gage</b>	24 AWG	24 AWG	24 AWG	23 AWG
<b>Shield</b>	YES	NO	NO	NO
<b>Crosstalk</b> 6 MHz (48 kHz)	-30 dB (?)	-47.6 dB PSNEXT	-50.6 dB PSNEXT	-60.6 dB PSNEXT
<b>Crosstalk</b> 25 MHz (192 kHz)	-30 dB (?)	-41.4 dB PSNEXT	-41.4 dB PSNEXT	-51.4 dB PSNEXT
<b>Crosstalk</b> 50 MHz (384 kHz)	-30 dB (?)	-37.6 dB PSNEXT	-37.6 dB PSNEXT	-47 dB PSNEXT

# Four, Three, Two, One-Pair

- Four pair standard
  - 3 pair (RGB) waste a pair
- Two pair standard
- One pair??
  - Belden 1353A

# Analog Baseband Video

	System Specs	Category 5	Category 5e	Category 6
<b>Format</b>	Unbalanced	<i>Balanced</i>	<i>Balanced</i>	<i>Balanced</i>
<b>Capacitance</b>	20pF/ft. 77pF/m	15 pF/ft. 49pF/m	15 pF/ft. 49pF/m	15 pF/ft. 49pF/m
<b>Impedance</b>	75Ω	100Ω	100Ω	100Ω
<b>Gage</b>	20-23 AWG	24 AWG	24 AWG	23 AWG
<b>Shield</b>	YES	NO	NO	NO
<b>Crosstalk</b> 4.2 MHz	-60 dB (?)	-53 dB PSNEXT	-53 dB PSNEXT	-63 dB PSNEXT

[www.belden.com](http://www.belden.com) “Video and UTP”

# Analog Video Crosstalk

- Crosstalk never considered
  - Coax cables are shielded
  - Cables are random
    - -100 dB to -120 dB shield effectiveness
- So with UTP and analog video
  - What crosstalk for multiple video?
  - Suggested: -60 dB

Video Application	Suggested Crosstalk
Surveillance	-40 dB
Standard home video	-50 dB
Professional analog video	-60 dB

- A new twist with UTP: “CCTP”



# S-Video, S-VHS™, Y-C

	<b>System Specs</b>	<b>Category 5</b>	<b>Category 5e</b>	<b>Category 6</b>
<b>Format</b>	Unbalanced	<i>Balanced</i>	<i>Balanced</i>	<i>Balanced</i>
<b>Capacitance</b>	17 pF/ft. 56 pF/m	15 pF/ft. 49 pF/m	15 pF/ft. 49 pF/m	15 pF/ft. 49 pF/m
<b>Impedance</b>	75Ω (?)	100Ω	100Ω	100Ω
<b>Gage</b>	30 AWG	24 AWG	24 AWG	24 AWG
<b>Shield</b>	YES	NO	NO	NO
<b>Crosstalk</b> 4.2 MHz	-60 dB (?)	-53 dB <i>PSNEXT</i>	-53 dB <i>PSNEXT</i>	-63 dB <i>PSNEXT</i>
<b>Timing</b> (Delay Skew)	40 nsec (?)	45 nsec (292 ft., 89m)	45 nsec (292 ft., 89m)	45 nsec (292 ft., 89m)

# RGB Component Video

	<b>System Specs</b>	<b>Category 5</b>	<b>Category 5e</b>	<b>Category 6</b>
<b>Format</b>	Unbalanced	<i>Balanced</i>	<i>Balanced</i>	<i>Balanced</i>
<b>Capacitance</b>	16 pF/ft. 54 pF/m	15 pF/ft. 49 pF/m	15 pF/ft. 49 pF/m	15 pF/ft. 49 pF/m
<b>Impedance</b>	75Ω	100Ω 15Ω	100Ω 15Ω	100Ω 15Ω
<b>Gage</b>	Wide range	24 AWG	24 AWG	24 AWG
<b>Shield</b>	YES	NO	NO	NO
<b>Crosstalk</b> 10 MHz	-60 dB (?)	-44.3 dB PSNEXT	-47.3 dB PSNEXT	-57.3 dB PSNEXT
<b>Timing</b> Delay Skew	40 nsec	45 nsec (292 ft., 89m)	45 nsec (292 ft., 89m)	45 nsec (292 ft., 89m)

# Timing and Distance

<b>Timing (Delay Skew)</b>	<b>RGB Distance</b>
45 nsec	292 ft. (89m)
40 nsec	328 ft. (100m)
35 nsec	375 ft. (114m)
30 nsec	437 ft. (133m)
25 nsec	525 ft. (160m)
10 nsec	1312 ft. (400m)
9 nsec	1458 ft. (446m)
2.2 nsec	5963 ft. (1818m)



# VGA- Video Graphics Array

	System Specs	Category 5	Category 5e	Category 6
<b>Format</b>	Unbalanced	<i>Balanced</i>	<i>Balanced</i>	<i>Balanced</i>
<b>Capacitance</b>	20pF/ft. 66pF/m	15pF/ft. 49pF/m	15 pF/ft. 49 pF/m	15 pF/ft. 49 pF/m
<b>Impedance</b>	75Ω	100Ω	100Ω	100Ω
<b>Gage</b>	Small (?)	24 AWG	24 AWG	23 AWG
<b>Shield</b>	YES	NO	NO	NO
<b>Crosstalk</b> VGA 36 MHz	??	-40 dB PSNEXT	-40 dB PSNEXT	-40 dB PSNEXT
<b>Crosstalk</b> SVGA 61 MHz	??	-35 dB PSNEXT	-35 dB PSNEXT	-45 dB PSNEXT
<b>Crosstalk</b> XGA 100MHz	??	-32.3 dB PSNEXT	-32.3 dB PSNEXT	-42.3 dB PSNEXT
<b>Crosstalk</b> SXGA 173MHz	??	N/A	N/A	-38.8 dB PSNEXT
<b>Crosstalk</b> UXGA 245MHz	??	N/A	N/A	-36.5 dB PSNEXT
<b>Timing</b> (Delay Skew)	40 nsec (?)	45 nsec @ 100 MHz	45 nsec @100 MHz	45 nsec @ 250 MHz



# Pixel Resolution

Resolution	Frequency	One Pixel	45nsec	10nsec
1024x768	60 Hz	21.2 nsec	155 ft. 47m	695 ft. 183m
1024x768	75 Hz	17 nsec	124 ft. 38m	558 ft. 170m
1280x1024	60 Hz	12.7 nsec	93 ft. 28m	417 ft. 127m
1280x1024	75 Hz	10.2 nsec	74 ft. 23m	335 ft. 102m



# SDI – Digital Baseband Video

	<b>System Specs</b>	<b>Category 5</b>	<b>Category 5e</b>	<b>Category 6</b>
<b>Format</b>	Unbalanced	<i>Balanced</i>	<i>Balanced</i>	<i>Balanced</i>
<b>Capacitance</b>	15 pF/ft. 49 pF/m	<i>15 pF/ft. 49 pF/m</i>	<i>15 pF/ft. 49 pF/m</i>	<i>15 pF/ft. 49 pF/m</i>
<b>Impedance</b>	75Ω	<i>100Ω</i>	<i>100Ω</i>	<i>100Ω</i>
<b>Gage</b>	23-20-18 AWG	<i>24 AWG</i>	<i>24 AWG</i>	<i>23 AWG</i>
<b>Shield</b>	YES	<i>NO</i>	<i>NO</i>	<i>NO</i>
<b>Crosstalk</b> 135 MHz	-30 dB (?)	<i>N/A</i>	<i>N/A</i>	<i>-40.4 dB PSNEXT</i>

# Broadband/CATV

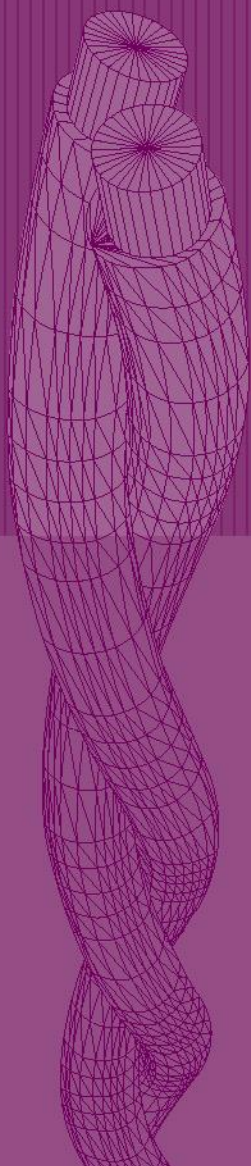
	<b>RG-6 Specs</b>	<b>Category 5</b>	<b>Category 5e</b>	<b>Category 6</b>
<b>Format</b>	Unbalanced	<i>Balanced</i>	<i>Balanced</i>	<i>Balanced</i>
<b>Capacitance</b>	15 pF/ft. 49 pF/m	15 pF/ft. 49 pF/m	15 pF/ft. 49 pF/m	15 pF/ft. 49 pF/m
<b>Impedance</b>	75Ω	100Ω	100Ω	100Ω
<b>Gage</b>	18 AWG	24 AWG	24 AWG	23 AWG
<b>Shield</b>	YES	NO	NO	NO
<b>Best Crosstalk</b>	>-80 dB @ 1 GHz	-32 dB @ 100 MHz	-32 dB @ 100 MHz	-36 dB @ 250 MHz
<b>Max Atten. @100m</b>	-21 dB @ 1GHz	-22 dB @ 100MHz	-22 dB @ 100MHz	-32.8 dB @ 250 MHz
<b>Channels</b>	158 @ 1 GHz	6 @ 100 MHz	6 @ 100 MHz	29 @ 250 MHz
<b>SRL</b>	-20dB @1GHz	N/A	-20dB @100MHz	-17.3 dB @250MHz

# Networked Audio

Product Name	Company	Type	Channels	Top Specs
CobraNet	Peak Audio	100baseT	128	96 kHz 24-bit
EtherSound	Digigram	100baseT	64	48 kHz 24-bit
MaGIC	Gibson	100baseT	32	48 kHz 24-bit
The Bridge	Wheatstone	100baseT	64	48 kHz 24-bit
Ethernet Audio	360 Systems	100baseT	2	48 kHz 16-bit
IQ Net	Crown	100baseT	128	96 kHz 24-bit
Axia	Telos	100baseT	?	48kHz 24 bit
ASI 2416	Audio Science	100baseT	16	48kHz 24-bit
A-Net Pro 64	Aviom	100baseT	64	Aviom.com
E-Snake	Whirlwind	100baseT	64	800-733-9473

Number of channels/sample rate
128@32/38k
96 @ 44/48k
64 @ 88/96k
32 @ 176/192k

See AES47 and  
AES51 standards.





**For More Information...**

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