

Video and UTP

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By Stephen H. Lampen
Multimedia Technology Manager
Belden Electronics Division
Belden CDT
shlampen@aol.com

Abstract

In the eight years since this paper was originally presented, a great deal has been written and demonstrated using ‘category’ cables to run video signals. What was originally presented as a cutting-edge option, using premise/data cables to carry video, is now an accepted application. Surveillance cameras, for instance, now often provide an RJ-45 data connector, as well as the standard BNC or F, allowing the direct use of premise/data cables. Many thousands of installations attest to the practicality of such use.

Extensive testing in Belden’s Engineering Center and other test facilities have been made, and will continue to be made, and will no doubt spur further expansion and updates. In the last year, there have emerged premise/data cables whose *primary* application is video. Some of these have network data as a *secondary* application! This paper is an overview of existing video applications and the suitability of various types of premise/data cables to carry these signals

Category 6 cable, as defined in the TIA/EIA 568B.2 specifications, further advances the non-data possibilities for installers and system integrators. For instance, Belden has *four* different *lines* of Category 6 cable. Some are specified up to 600 MHz per pair, twisted pair bandwidth unheard of only a decade ago. We are truly approaching coax cable performance in a twisted pair. Still, because of the differences between unbalanced coaxial cable and balanced-line twisted pairs, the differences between analog video and digital video, and the wide range of picture quality attainable, there continues to be some confusion. This paper is an attempt to sort out the various parameters and requirements and allow an end-user to make an informed decision. This paper also lists manufacturers of matching networks or “baluns” that make possible many of these video applications. Readers are urged to contact the author (shlampen@aol.com) if you know of other balun manufacturers. We will be glad to add their contact information and products to the lists below.

Each video application has its own set of requirements and system parameters. Twisted pair technology is ideal for a few applications, acceptable with some, and difficult or even impossible with others.

Twisted Pair Technology

Historically, computer data was sent over coaxial cable. In the late 1970's, IBM began to consider special constructions of twisted pairs cables. These were very large constructions and bear little resemblance to current twisted pairs except for the fact that they showed the advantages of twisted pair technology in the data world. The key advantage was that these pairs could be run as "balanced lines" that feature common-mode noise rejection, a performance feature unavailable in coax. IBM Type 1 and IBM Type 2 were two versions of this cable. Originally intended to carry a 4 Mbps (Megabits per second) data rate, later versions were specified to carry 16 Mbps (IBM "Token Ring"). The last generation featured wider bandwidth (300 MHz) to carry FDDI-over-copper and video-to-the-desktop.

For over fifteen years, a wiring scheme has emerged in the data world that has overtaken every other. The idea was to make twisted pairs, a technology as old as the telephone itself, into higher-grade data versions. The data-grade twisted pairs used domestically in the United States, and many other countries, are commonly called UTP (unshielded twisted pairs). While shielded versions (STP, ScTP) also exist, they are rarely used in the United States. The vast majority of domestic installed premise/data cable is UTP. Any non-data applications should be able to make use of the most commonly installed cable, so this paper solely addresses the use of UTP in alternate applications. Part of the on-going testing in the Belden laboratory will be to compare performance including noise immunity of shielded versus unshielded cables, and is beyond the scope of this paper.

Users should note that some baluns and active matching networks mentioned below require *shielded* Category cables (STP, ScTP). These cables are harder to find, more expensive, and considerably harder to install. In some performance specifications, such as crosstalk, UTP designs can often be superior.

As data rates increased, it became apparent that some way of indicating the performance of the cable was needed. It was then that Anixter, a major distributor of cable products, suggested a system of "Levels". The TIA/EIA, two groups that set standards for the data industry, adopted the plan and separated the data rates and other parameters into "Categories". Thus, we now have Category 2, 3, 4, 5, 5e, and 6. Category 2 is POTS, "plain old telephone service" and Category 4, a 16 MHz bandwidth version, is no longer recognized in the TIA/EIA standard. When Category 5e was ratified, Category 5 was also dropped from the standard. It is included here, however, because of the hundreds of millions of feet of installed Cat 5 already in the field. Each category has more stringent requirements with higher performance than the previous category. The specifications for current "standard" categories, Category 3, 5e, and 6, are spelled out in TIA/EIA 568B.2.

To the uninitiated, these cables often look identical to POTS cable. They use the same color code and come in many of the same pair counts and often use the same gage conductors. However, the specifications they are made to, the materials used to make them, and the requirements to connect them, become more and more critical as the data rate increases.

Basic UTP Specifications for Category 3, 5, 5e, and 6

Note that the specifications below are the EIA/TIA 568B.2 standard. While appropriate Belden part numbers are listed in the right hand column, actual cable performance is often better, sometimes dramatically better, than the specifications shown. See the Belden catalog elsewhere on this web page for full performance details, or see [Mediaspec](#).

The "Belden Products" listed below are just the tip of the iceberg. Many of them are available in other versions, different pair counts, dual cables, low-smoke/zero halogen, low combustibility, stranded patch cable, shielded (STP and ScTP) and many other configurations. The full product line can be seen elsewhere on this web page.

TIA/EIA 568A Specifications (Partial) per 100 meters (328 feet)								
Category	Frequency	Minimum PSNEXT	Maximum Attenuation	Minimum ELFEXT	Return Loss	Min. PSACR	Delay Skew	Belden Products
3	1 MHz	41 dB	---	Not specified	Not specified	Not specified	Not specified	
	4 MHz	32 dB	5.6 dB					
	10 MHz	26 dB	9.7 dB					
	16 MHz	23 dB	13.1 dB					
5	.772 MHz	---	1.8 dB	---	---	---	45 nanoseconds	1229A1
	1 MHz	62.3 dB	2.0 dB		17 dB	60.3 dB		1245A2
	4 MHz	53.3 dB	4.1 dB		18.8 dB	49.2 dB		
	8 MHz	48.8 dB	5.8 dB		19.7 dB	43 dB		7854A
	10 MHz	47.3 dB	6.5 dB		20 dB	40.8 dB		7811A
	16 MHz	44.3 dB	8.2 dB		---	---		
	20 MHz	42.8 dB	9.3 dB		20 dB	36 dB		
	25 MHz	---	---		19.3 dB	33.5 dB		
	31.25 MHz	39.9 dB	11.7 dB		18.6 dB	28.2 dB		
	62.5 MHz	35.4 dB	17 dB		16.5 dB	18.4 dB		
	100 MHz	32.3 dB	22 dB		15.1 dB	10.3 dB		
5e	.772 MHz	64 dB	1.8 dB	---	---	---	45 nanoseconds	1583A
	1 MHz	62.3 dB	2.0 dB		20 dB	60.3 dB		1585A
	4 MHz	53.3 dB	4.1 dB		23 dB	49.2 dB		
	8 MHz	48.8 dB	5.8 dB		24.5 dB	43 dB		1500A
	10 MHz	47.3 dB	6.5 dB		25 dB	40.8 dB		1501A
	16 MHz	44.3 dB	8.2 dB		25 dB	---		
	20 MHz	42.8 dB	9.3 dB		24.3 dB	36 dB		1700A
	25 MHz	---	---		---	33.5 dB		1701A
	31.25 MHz	39.9 dB	11.7 dB		23.6 dB	28.2 dB		
	62.5 MHz	35.4 dB	17 dB		21.5 dB	18.4 dB		7988R
	100 MHz	32.3 dB	22 dB		20.1 dB	10.3 dB		7988P
6	.772 MHz	74 dB	1.8 dB	---	---	---	45 nanoseconds	7881A
	1 MHz	72.3 dB	2 dB		20 dB	70.3 dB		7882A
	4 MHz	63.3 dB	3.8 dB		23 dB	59.5 dB		1872A
	8 MHz	58.8 dB	5.3 dB		24.5 dB	53.4 dB		1874A
	10 MHz	57.3 dB	6 dB		25 dB	51.4 dB		
	16 MHz	54.3 dB	7.6 dB		---	46.7 dB		7851A
	20 MHz	52.8 dB	8.5 dB		25 dB	44.3 dB		7852A
	25 MHz	---	---		24.3 dB	---		7989R
	31.25 MHz	49.9 dB	10.7 dB		23.6 dB	39.2 dB		7989P
	62.5 MHz	45.4 dB	15.4 dB		21.5 dB	30 dB		
	100 MHz	42.3 dB	19.8 dB		20.1 dB	24.3 dB		
	125 MHz	40.9 dB	22.4 dB		---	18.5 dB		
	150 MHz	---	---		18.9 dB	---		
	155 MHz	39.5 dB	25.2 dB		18.8 dB	14.3 dB		
	160 MHz	---	---		18.7 dB	---		
	175 MHz	38.7 dB	26.9 dB		---	11.8 dB		
	200 MHz	37.8 dB	29 dB		18.0 dB	8.8 dB		
	225MHz	37 dB	31 dB		---	6.1 dB		
	250 MHz	36.3 dB	32.8 dB		17.3 dB	3.5 dB		
	300 MHz	---	36.4 dB		---	---		

NEXT means "near-end crosstalk". At the near end (source end), the transmitted signal is the strongest. Transmitting pairs can energize pairs around them causing their signal to interfere with other signals on other pairs. This is called "crosstalk". The 568B.2 standard specifies the minimum crosstalk value at various frequencies. Video engineers may be surprised that good crosstalk numbers at analog video frequencies are obtainable in UTP.

PSNEXT is "power sum near-end crosstalk", that looks at the effect of all adjacent pairs to the one under test rather than just pair-to-pair. Such testing is then the "worst case" where all pairs are energized. Results of each combination are averaged.

ATTENUATION is signal loss and is common to all signal carrying systems. Attenuation is measured in decibels (dB). Decibels are logarithmic. Data signals -40 dB down (one-ten thousandth of the original intensity) are fully and easily recovered. This is not surprising to most audio/video engineers considering that analog microphone signals are often -60 dB.

ACR is "attenuation-to-crosstalk ratio". By subtracting the crosstalk from the attenuation, a number is generated which can indicate the overall performance of a cable. Positive ACR, especially at high frequencies, can be an indicator of superior cable performance. ACR is very similar to "signal-to-noise ratio" in the analog audio/video world. Therefore, ACR can be valuable where multiple data signals travel down a four-pair cable, such as parallel gigabit networking. It can also be valuable for non-data applications that also use all pairs such as RGBS, VGA, or multiple baseband or broadband video signals.

PSACR is "power-sum attenuation-to-crosstalk ratio" where all pairs are energized around the measured pair and the results averaged.

DELAY SKEW is timing differences on a multipair cable. For all cables listed above, the maximum allowed by TIA/EIA 568B.2 is 45 nsec/100m (nanoseconds per 100 meters, 328 feet). Delay skew is especially interesting to designers who are using more than one pair to simultaneously deliver data. Formats such as Gigabit Ethernet™ require that the data be split between the four pairs. In such systems, it is essential that the signals arrive at the other end of the cable at the same time. Timing variations for a complete system should not exceed 50 nsec (nanoseconds) between any of the four paths. When looking at cable alone, the maximum delay is 45 nsec/100m. This is one of the reasons Belden's MediaTwist® (delay skew 25nsec/100m maximum, 12nsec/100m typical) is popular in non-data applications where this is critical such as RGB or VGA. Category cables are now available with delay skew of 10nsec/100m or better.

PAIR TWISTING ("Lay Length"). Tight pair twisting can greatly reduce crosstalk but also has a number of negative effects on the cable. There is more copper used per unit length so the price goes up. And more copper means the signal will take longer to travel down that pair (compared to other pairs) so attenuation and delay skew are worse. It doesn't matter how high your ACR is, or how low your crosstalk is, if you don't have enough signal strength to be recovered at the receiving end! What you truly want is a cable that improves both crosstalk and attenuation to improve ACR, to have positive ACR at a higher frequency, without affecting, or possibly even reducing, delay skew.

IMPEDANCE indicates the ability of a data cable to transfer a signal from one box to another. The impedance of the systems, and boxes it is attached to, specifies the impedance of the cable. The TIA/EIA standard for Category 5 is $100\Omega \pm 15\Omega$ (ohms). Some Category 5 cables meet this spec. Others require the use of a smoothing formula called "Zo-fit". This allows manufacturers to ignore rapid changes in impedance. Bonded-pair data cables, such as Belden DataTwist 350 (1700A, 1701A), Belden MediaTwist® (1872A, 1874A), Belden 600E (7851A, 7852A), and Belden Category 5e and 6 "VideoTwist" (7988R, 7988P, 7989R, 7989P) are tighter than $\pm 15\Omega$ *without* the Zo-fit function.

RETURN LOSS shows all the variations in impedance within a cable. Impedance variations cause the signal to reflect back to the source, so return loss is the ratio between direct signal and reflected signal. It is measured in decibels (dB). With a larger negative number, more signal reaches its destination, and less of the signal is reflected back to the source. Return loss is especially effective in showing flaws in cable construction and installation, such as excessive bending or stretching, which affect the impedance of the cable. In link and channel tests, return loss can show the effect of poor, or badly installed, connectors, patch panels, and other passive hardware.

BANDWIDTH is the range of frequencies available to be used for signal carrying. It is the "size of the tunnel". However, knowing the size of the tunnel tells you nothing of how the traffic will move through it. This is because data can be *compressed* to take up less bandwidth. For instance, a 100 Mbps data signal can fit in a 100 MHz bandwidth. Or the data can be arranged and coded to fit in a 50 MHz bandwidth, a 30 MHz bandwidth, or even smaller. In fact, the 31.25 MHz numbers commonly seen in cable specifications are for a compressed 155 Mbps ("ATM") protocol. Since the coding scheme is not apparent, only the bandwidth in Megahertz (MHz) can be used to compare potential data handling capacity. You will know the size of the tunnel. Knowing how many cars will fit depends on how you arrange them. If you want to compare the signal-carrying capacity of a cable, compare bandwidths.

COST. The advantage of twisted pairs is the cost/performance ratio. Dollar-for-dollar, you can buy and install twisted pairs significantly cheaper than coax or fiber. And, while the other two systems offer advantages in bandwidth, this advantage is rapidly decreasing. Standard premise/data cable contains four pairs in a single cable so the actual cost per pair is one-quarter of the per-foot price.

TESTING. While some manufacturers say that their cable is "tested to 350 MHz" (or some other high frequency), many offer no data (impedance, crosstalk, attenuation, ACR, delay skew etc.) at frequencies beyond the required 100 MHz for 100baseT. Impedance variation at higher frequencies can often be $100\Omega \pm 50\Omega$, rendering these cables virtually useless. If the cable chosen might be used at these elevated frequencies, it is essential to know just what performance to expect. As will be seen, some applications, such as broadband/CATV, can require frequencies and bandwidths far beyond even the most advanced twisted pairs.

DataTwist[®] 350, MediaTwist[®], and 600E[®].

There are four families of Belden cables designed for improved performance over Category 5. The first is Belden DataTwist 350. The second is Belden MediaTwist. The third is Belden 600E. The following table compares the TIA/EIA 568B.2 standard with Belden DataTwist 350, MediaTwist, and 600E. The last family is Belden's new Brilliance[®] VideoTwist[®] (7988R, 7988P, 7989R, 7989P). The detailed specifications for these products will be added to this white paper at a later date.

Cable	Frequency	Return Loss DataTwist 350	POWER SUM NEXT DataTwist 350	Attenuation DataTwist 350	ACR DataTwist 350	Skew DataTwist 350
Belden 1700A DataTwist [®] 350 Category 5e	1 MHz	-65 dB	53 dB	4 dB	49 dB	25 nsec max 15 nsec typical
	4 MHz	-56 dB	47 dB	6.4 dB	40.6 dB	
	8 MHz	-51 dB	44 dB	8.1 dB	35.9 dB	
	10 MHz	-50 dB	40 dB	11.6 dB	28.4 dB	
	16 MHz	-47 dB	35 dB	16.8 dB	18.2 dB	
	20 MHz	-45 dB	32 dB	21.7 dB	10.3 dB	
	25 MHz	-44 dB	30 dB	27.6 dB	2.4 dB	
	31.25 MHz	-42 dB	28 dB	32 dB	-4 dB	
	62.5 MHz	-38 dB	25 dB	41.3 dB	-16.3 dB	
	100 MHz	-35 dB	24 dB	44.3 dB	-20.3 dB	
	150 MHz	-19 dB	-	-	-	
	155 MHz	-19 dB	-	-	-	
	160 MHz	-19 dB	-	-	-	
	200 MHz	-18 dB	-	-	-	
	250 MHz	-18 dB	-	-	-	
	310 MHz	-18 dB	-	-	-	
	350 MHz	-17 dB	-	-	-	

Cable	Frequency	Return Loss MediaTwist	POWER SUM NEXT MediaTwist [®]	Attenuation MediaTwist [®]	PSACR MediaTwist	Skew MediaTwist
Belden 1872A MediaTwist [®] Category 6	0.772 MHz	-	74 dB	1.7 dB	72.3 dB	25 nsec max 15 nsec typical
	1 MHz	-20 dB	72.3 dB	1.9 dB	70.4 dB	
	4 MHz	-23 dB	63.3 dB	3.7 dB	59.6 dB	
	8 MHz	-24.5 dB	58.8 dB	5.3 dB	53.5 dB	
	10 MHz	-25 dB	57.3 dB	5.9 dB	51.4 dB	
	16 MHz	-	54.4 dB	7.5 dB	46.7 dB	
	20 MHz	-25 dB	52.8 dB	8.4 dB	44.4 dB	
	25 MHz	-24.3 dB	49.9 dB	10.6 dB	39.2 dB	
	31.25 MHz	-23.6 dB	45.4 dB	15.4 dB	30 dB	
	62.5 MHz	-21.5 dB	42.3 dB	19.8 dB	25 dB	
	100 MHz	-21 dB	40.9 dB	22.3 dB	18.5 dB	
	150 MHz	-21 dB	39.5 dB	25.1 dB	14.3 dB	
	155 MHz	-21 dB	38.7 dB	26.9 dB	11.8 dB	
	160 MHz	-21 dB	37.8 dB	29 dB	10 dB	
	200 MHz	-21 dB	37.0 dB	30.9 dB	6.1 dB	
	250 MHz	-18 dB	36.3 dB	32.8 dB	3.5 dB	
	300 MHz	-18 dB	35.2 dB	36.4 dB	0 dB	
	310 MHz	-17 dB	-	-	-	
	350 MHz	-18 dB	34.2 dB	39.8 dB	-	

Cable	Frequency	Return Loss Belden 600E	POWER SUM NEXT Belden 600E	Attenuation Belden 600E	ACR Belden 600E	Skew Belden 600E
Belden 7851A 600E Category 6	1 MHz	-20 dB	80.3 dB	1.9 dB	80.5 dB	38 nsec Maximum
	4 MHz	-23 dB	71.3 dB	3.6 dB	69.7 dB	
	8 MHz	-24.5 dB	66.8 dB	5.1 dB	63.7 dB	
	10 MHz	-25 dB	65.3 dB	5.7 dB	61.6 dB	
	16 MHz	-25 dB	62.3 dB	7.2 dB	57 dB	
	20 MHz	-25 dB	60.8 dB	8.1 dB	54.7 dB	
	25 MHz	-25 dB	59.3 dB	9.1 dB	52.3 dB	
	31.25 MHz	-25 dB	57.9 dB	10.2 dB	49.7 dB	
	62.5 MHz	-25 dB	53.4 dB	14.7 dB	40.7 dB	
	100 MHz	-25 dB	50.3 dB	18.9 dB	33.4 dB	
	155 MHz	-22.8 dB	47.5 dB	23.9 dB	25.5 dB	
	200 MHz	-21.6 dB	45.8 dB	27.5 dB	20.3 dB	
	250 MHz	-20.5 dB	44.3 dB	31.2 dB	15.3 dB	
	350 MHz	-19.8 dB	40.2 dB	37.7 dB	6.5 dB	
	400 MHz	-19.5 dB	39.3 dB	40.6 dB	2.6 dB	
	500 MHz	-18.4 dB	37.8 dB	46.2 dB	0 dB	
	550 MHz	-18 dB	37.2 dB	48.8 dB	-	
	600 MHz	-17.6 dB	36.6 dB	51.4 dB	-	

Analog Baseband Video

"Analog baseband video" is single channel point-to-point video with a bandwidth of (typically) DC to 4.2MHz. There are three key problems using UTP for analog video. First, the majority of video equipment uses coaxial connectors, BNC's for professional installations and RCA's for consumer applications. The second is the output impedance of coaxial systems is 75Ω while UTP has an impedance of 100Ω. The third difference is that UTP technology is a "balanced line" system while coax is "unbalanced".

You can solve all three problems with a device called a "balun". Balun, in fact, means BALAnced to UNBalanced. This is a small box that contains a transformer and other matching components. These allow the signal to be converted from 75Ω impedance to 100Ω impedance. They also change the system from unbalanced to balanced; or vice versa, and can be easily built with a BNC or RCA on one side of the box and an RJ-45, the most common UTP connector, on the other side.

Low frequencies are one of the major problems with baluns, not the high-frequency limit. Very low frequencies are difficult to pass through a transformer and other similar devices. Higher frequencies are much easier to pass. If you wish to use UTP for analog video, be sure you get performance data on the baluns that show the entire operating range. Broadcast-quality video requires performance all the way down to DC. Since a traditional transformer cannot pass DC, other methods are used to design these baluns, such as a "common-mode choke".

Balance is also a critical parameter. The nature of a balanced line means that the two conductors in the twisted pair are identical (identical length, identical size). The more identical they are, and the closer together they are, the easier it is for the balun to reject noise and interference generated outside the pair. When you realize that the noise hits both conductors, and a resultant noise "pulse" is generated in both wires, the more identical the noise on each wire at the end of the cable, the greater the noise rejection ('common mode rejection') can be obtained in the balanced line. The less identical the two conductors, and standard POTS lines are often *very* unequal, the more noise that will be passed through. To help reduce this problem, a number of companies have special passive and active devices to attempt to balance lines more perfectly. As you might assume, the active ones (active meaning they must be plugged in to work) contain circuitry to "adjust" the balancing can send a video signal much farther than a passive device, but often cost more.

Another solution to balancing problems is to choose a cable that is very well balanced. Category 5 is better balanced than Category 3. Belden bonded-pair products, such as Belden DataTwist 350[®], MediaTwist[®], 600E[®], and VideoTwist[®], are better still. Balancing is specified by the amount of capacitance difference ('capacitance unbalance') built up over a given distance. Capacitance in cables is measured in picofarads (pF). The standard for Category 5 is 1000 pF/1000 ft. capacitance unbalance. Belden 1872A MediaTwist[®] is less than 150 pF/1000 ft.

Point-to-point wiring is most common for analog baseband video. Video surveillance, one such as in casinos, is only *one image per cable*. Monitors in airports carry *one image per cable*. Classroom closed-circuit television (CCTV) is one image per cable. In classroom, and similar installations, the choice of program material is often made by remote control from a distant central facility. Control is most often provided by using the telephone. One dials the correct number, enters a security code, and selects the video to be watched from a master list. The tape is loaded manually, automatically, or played from a master server (and converted to analog). The player (or server) is switched to the appropriate cable for the classroom requesting the video. Thus, one may have hundreds of videos to choose from but the medium to deliver it is still a *single pair of UTP*. In this application, the difference with the Categories (3, 5, DT350) is the distance from that central room to the classroom, and the interference rejection of signals within the cable ("pair-to-pair crosstalk"), or from other nearby cables ("alien crosstalk"). The higher the quality of the cable, the lower the attenuation, the lower the crosstalk, the farther the signal can go.

Vendors – Baseband Analog Video

Below are vendors of active and passive baseband point-to-point analog-video-over-twisted-pairs devices, listed in alphabetical order. If you know of other vendors, the author would like product specifications and system parameters to add them to the list. (steve.lampen@belden.com)

Manufacturer	Model/Part #	Passive/ Active	Cable	Distance	Picture Quality
Anixter International, Inc. 2301 Patriot Blvd. Glenview, IL 60025-8020 224-521-8000 www.anixter.com	CCTP	Active	Special Cat 6	100m (328 ft.)	Surveillance
BH Electronics 12219 Wood Lake Dr Burnsville MN 55337 (612) 894-9590 www.bhelectronics.com info@bhelectronics.com	Fox VMA 040-0045	Passive	Cat 3, 4, 5	1200 ft.	10 MHz bandwidth
ETS 43353B Osgood Rd. Fremont CA 94539 800.752.8208 www.etslan.com info@etslan.com	PV843 PV844B PV845 PV848 PV849 PV860 PV861B PV862 PV863 PV864B PV950	All passive All passive	Any UTP Any UTP	2000 ft B&W 1000 ft .color	Depends on cable performance 1300 ft. color with Belden MediaTwist®
Foresight CCTV 800 Richmond St. West #1112 Toronto Ontario CANADA M6J 3N8 416-203-9271 1-888-GO-2-CCTV www.foresight-cctv.com info@foresight-cctv.com	TTP111V TTP111VT TTP111VL TTP111VH TTA111V TTP111VP TTP111VPJ GB001	Passive Passive Passive Passive Active Passive Passive Passive	Cat 5	600m (1968 ft.) B&W 400m (1312 ft.) color 50m (164 ft.) 1km (3280 ft.)	Inserts power in Cat 5 W/ground loop isolator
FSR 244 Bergen Blvd. West Paterson NJ 07424 973-785-4347 www.fsrinc.com sales@fsrinc.com	Twister	Active	Cat 5e	800 ft.	
Intelix 8001 Terrace Ave, Middleton, WI 53562 866-4MATMIX (462-8649) 608-831-0880 intelix@intelix.com www.intelix.com	V1 V1-AR V1-PTZ V1-CV V1-ST		Cat 3 or 5	2500 ft.	
Jensen Transformers, Inc. 7135 Hayvenhurst Avenue Van Nuys, CA 91406 (818) 374-5857 (818) 763-4574 www.jensen-transformers.com info@jensen-transformers.com	ISO-MAX VB- 1BT transmitter ISO-MAX VB- 1TB receiver	Active	Category 5	up to 1,500 feet	broadcast - quality color
Knoll Systems 145 Tye Drive, #1206 Point Roberts, WA 98281 (604) 272 4555 (800) 566 5579 (800-KNOLL-SY) www.knollsystems.com mail@knollsystems.com	UB-Send UTP-Send UB-Receive UTP-Receive UR-P3 UR-V3 US-P3 US-V3	Active	Category 5	1,000 ft.	50 MHz -3dB
Leviton Voice & Data Division 2222 - 222nd Street S.E. Bothell, WA 98021-4422 425.486.2222 800.722.2082 www.levitonvoicedata.com	Decora Media System	Active	Category 5/5e	300m (1000 ft.)	50 MHz bandwidth -75 dB THD

[illegible]

Visual Circuits 5155 East River Rd. # 401 Minneapolis, MN 55421 763 571-7588 800 250-5533 www.visualcircuits.com info@visualcircuits.com	Marathon AV	Active 4-channel transmitter 1-channel receiver	Category 2 and above	5000 ft,	"No signal degradation."
Visions Televideo Technologies. 2000E West Governors Circle • Houston, TX 77092. 713-686-8409 www.vtti.com	VTT747 VTT1000 VTT2000 VTT3000 VTT3000S VTT5000 VTT7000	Passive Active	Category 2-5 Category 2-5	<800 ft. <1200 ft <3000 ft <3500 ft. (Repeaters every 3500 ft, to 5 miles)	Max. 1.5 dB attenuation down listed length. Bandwidth 50Hz- 10MHz. 36 dB CMRR 800 lines 61 dB S/N Meets RS-170A
Vortex Communications Ltd. 75 The Grove Ealing, London W5 5LL ENGLAND 011-44(0)20-8579 2743 www.vtx.co.uk info@vtx.co.uk	PBE-920 PB301SC-301R PB303SR PBE840 PBE845				

CCTP[®]

First on the list above is a recent addition to UTP Category 6 applications called CCTP, "Closed Circuit over Twisted Pairs". This is a surveillance camera system marketed by Anixter, a major distributor of cable and other products. It features a unique 22AWG Category 6 bonded-pair cable with associated devices for handling analog cameras. The four-pair data cable is also used to carry power for the camera and PTZ (pan-tilt-zoom) controls, all on the same cable. The extra large conductors (22AWG) help extend the distance for DC power which is the distance limiting factor.

When digital cameras are substituted, no cable change is necessary. Further, when surveillance cameras are networked, again, no cable change is necessary as the Category 6 UTP has a 250 MHz bandwidth. You can get more information at this link:
<http://web.anixter.com/anixter/anixter.nsf/0/1933F7341E766AEE86256D7A0045D761?OpenDocument>

Shared-Sheath Non-Data Applications

One advantage to the use of video on UTP is the associated uses of that cable. Data cables such as Category 6 can, of course, carry data, such as 10baseT, 100baseT, 1000baseT, Token Ring or Ethernet networks. Applications can include not only networked data for computers, but also telephone, fax, modem, DSL, ISDN, T-1 or other data lines furnished by the phone company. Analog and digital audio, up to eight channels of digital audio on a four-pair UTP, are also possible. Thus, one could wire up a building, school, hospital or other facility with nothing but Category 6 UTP and do almost anything one might want.

Installers should be aware that in TIA/EIA 568B.2, while it does not specifically disallow multiple uses for any cable, if such multiple uses are installed, that cable will *not be certifiable as being 568B.2 compliant* even if other requirements are met. Failure, while difficult to predict, is usually based on the belief that crosstalk (NEXT) will be compromised for the data signals. This does not mean that the cable *next to it* in the bundle is or isn't compliant. So the best idea is to designate which cables will be 568B.2 compliant

and to install them to that standard. The shared-sheath, non-standard cables, can be wired as needed.

It is also possible to install *all cables* to be 568B.2 compliant, and to make the non-standard applications appear *outside* each wall jack. In that way, all wiring could, at any time, be part of a 568B.2 compliant network and yet, at the change of a patch cord, be a video feed, telephone, T-1 line, RGB cable, or many other uses.

The Analog Video Image

In analog video, the quality and bandwidth requirements are well known. Only the quality of the image is unspecified. Below is a chart of picture quality based on frame rate and line resolution:

Analog Bandwidth	Frame Speed	Line Resolution	Picture Quality
4.2 MHz	< 15 fps	< 100 lines	Very poor, jumpy
4.2 MHz	> 15 fps	> 100 lines	Tolerable
4.2 MHz	30 fps	> 200 lines	Standard home reception quality
4.2 MHz	30 fps	> 400 lines	Standard in-studio quality
4.2 MHz	30 fps	RGB component	Very high resolution

Bandwidth. In an analog color television, the signals required for a picture are standardized as "luminance" (black and white picture information), and "chrominance" (color picture information which overlays the black and white). Audio, commonly stereo audio, is included. The total bandwidth for these signals is 4.2 MHz. Therefore, the only way to limit or reduce the amount of information in its analog form is to send each picture as black-and-white only or send each "frame" slower than normal. Cables that carry the entire video signal are *composite* video cables.

Frame Speed is the number of images per second displayed. In broadcast receivers, the standard is 30 frames per second or "fps". Each frame is split into two "fields", each 1/60th of a second. In Europe, the frame rate is 25 fps and the field rate 50. These fields are "interlaced" which means each field shows every other line (i.e., the first field shows its image on odd-numbered lines and the second field shows its image on even-numbered lines). You only see half of the picture at any instant in time. This compromises picture detail. However, latency (flickeriness sometimes visible when viewing motion pictures) is greatly reduced. An effect in the human brain called "persistence of vision" puts these two fields together and we see a whole picture. Motion pictures are shot at 24 fps (25 in Europe) and latency (flicker), especially with bright objects on screen, can be very noticeable. 30 frames per second/60 fields per second (25/50 in Europe) is broadcast quality. Fewer frames is less than broadcast quality.

In computer monitors and displays, the picture information is displayed in "progressive" scan, that is one line right after another. This gives these displays excellent detail (which is required in the computer field) but poor in image latency and requiring double the amount of information as an analog broadcast receiver to display a picture.

Line resolution is the measure of detail in an analog picture. Horizontal and vertical resolution are the two kinds of resolution measured. Resolution is the ability of a television screen to show detail and is usually determined by the number of lines that can be discerned. A test pattern can be shown on a television screen from which the lines of resolution can be determined.

In North America, the number of horizontal lines is standardized by the NTSC (National Television Systems Committee) at 525 lines. European television (PAL) uses 625 lines. So, all other things being equal, PAL has the potential to deliver higher resolution and more detail. The vertical resolution of each line, therefore, is really the only measure of resolution and detail over which a broadcaster has any control. Cameras and monitors, especially those used for broadcast purposes, specify their horizontal resolution as so many "lines". As can be seen in the previous chart, 200 lines or so is what the average consumer receives off the air. Cable, while theoretically able to deliver more lines, rarely does. Most camcorders used for home recording can do 200 to 300 lines. Broadcast facilities, especially in-house, are capable of recording and playing back 400 to 700 lines, 2-1/2 times the quality they are able to transmit to the customer! It is interesting to note that many television receivers made in the late 1960's and 1970's *reduced* horizontal resolution. Doing so reduced noise on the screen dramatically and gave the *appearance* of a sharper, clearer picture which was not, in fact, the case.

S-Video

S-video stands for "super-video" or "super-video home system" (S-VHS™) [VHS is a trademark of JVC]. To increase sharpness, the video signal is split into two components, the black & white signal, ("Y"), 'luminance', and the color signal ("C") 'chrominance'. Thus, we have the official designation of Y-C for such a signal.

While originally intended as a high-quality consumer format, S-video has found its way into professional, or "prosumer" applications where the low cost of equipment and the decent image quality are hard to resist. It is especially popular for news and other reportage applications where ultimate image quality is not of paramount importance.

Below is a list of S-video (Y-C) balun manufacturers:

Manufacturer	Model/Part #	Passive or Active	Cable	Distance
ETS 43353B Osgood Rd. Fremont CA 94539 800.752.8208 www.etslan.com info@etslan.com	PV900 PV901	Passive	Any UTP	Unspecified
Intelix 8001 Terrace Ave, Middleton, WI 53562 866-4MATMIX (462-8649) 608-831-0880 intelix@intelix.com www.intelix.com	SVA2	Passive	Cat 3 or 5	1,000 ft.
Knoll Systems 145 Tyee Drive, #1206 Point Roberts, WA 98281 (604) 272 4555 (800) 566 5579 (800-KNOLL-SY) www.knollsystems.com mail@knollsystems.com	UDR-SVID	Active	Cat 5	1,000 ft.
MuxLab Inc. 5450 Cote De Liesse, Montreal, Quebec, H4P 1A5 877-689-5228 514-905-0588 www.muxlab.com videocase@muxlab.com	500016 500017 500200	Passive Passive Active	Cat 5 Cat 5 Cat 5	1,000 ft 1,000 ft + Audio 1,000-2,200 ft
NVT 4005 Bohannon Dr. Menlo Park CA 94025 (800) 959-9870 650.462.8100 www.nvt.com info@nvt.com	NV418A NF411A RV518A NV652R	Passive Active		
Smarthome 16542 Millikan Avenue Irvine, CA 92606-5027 800-SMARTHOME (800-762-7846) (949) 221-9200 x109 www.smarthome.com custsvc@smarthome.com	7805SV	Passive	Cat 3 or 5	
Vortex Communications Ltd. 75 The Grove Ealing, London W5 5LL ENGLAND 011-44(0)20-8579 2743 www.vtx.co.uk info@vtx.co.uk	PBE902	Passive	Any UTP	

RGB

RGB stands for the three primary colors in a video image: red, green, and blue. Your television shows a color image based on groups of colored pixels. The eye blends them into the rainbow of colors we expect to see. When working in analog video, separating the picture into its component colors is called "component" television. While images are never transmitted through the air in this format, they are often processed in this format in studios or editing facilities to increase the quality and detail. Groups of coaxial cables (often colored red, green, and blue to aid in their connection) are used to carry these signals from place to place.

Below is a list of manufacturers that are supporting RGB down twisted pairs.

Manufacturer	Model/Part #	Passive or Active	Cable	Distance	Picture Quality
ETS 43353B Osgood Rd. Fremont CA 94539 800.752.8208 www.etslan.com info@etslan.com	PV890 PV891 PV894 PV920 PV921	All passive	Any UTP		
FSR 244 Bergen Blvd. West Paterson NJ 07424 973-785-4347 www.fsrinc.com sales@fsrinc.com	MMTP-RGBTX MMTP-RGBRX	Active transmitter Active receiver	Cat 5	>800 ft.	RGBHV YUV
Intelix 8001 Terrace Ave, Middleton, WI 53562 866-4MATMIX (462-8649) 608-831-0880 intelix@intelix.com www.intelix.com	V3	Passive	Category 3 or 5	500 ft.	
MuxLab Inc. 5450 Cote De Liesse, Montreal, Quebec, H4P 1A5 Tel: 877-689-5228 Intl: 514-905-0588 www.muxlab.com videocase@muxlab.com	500002 500021	Passive Passive	Category 5 Category 5	500 to 1,000ft 1000 ft.	RGB YPbPr (HD) YPbPr/480/720pHD
NVT 4005 Bohannon Dr. Menlo Park CA 94025 (800) 959-9870 650.462.8100 www.nvt.com info@nvt.com	202A NV-1702A 314A 418A 518A	Passive Passive, (PC module) Passive Passive Active	Category 2, 3, 4, or 5	500 ft. 500 ft 500 ft. 500 ft. 2000 ft.	Capable Capable Passable Receive Receive
Videobaluns Unlimited Framingham MA 508-620-1002 info@videobaluns.com	BL3265 BL3725	Passive Passive	Category 3 or 5		
Visual Circuits 5155 East River Rd. # 401 Minneapolis, MN 55421 763 571-7588 800 250-5533 www.visualcircuits.com info@visualcircuits.com	Marathon AV	Active 4-channel transmitter 1-channel receiver	Category 2 and above	5000 ft,	"No signal degradation."
Visions Televideo Technologies. 2000E West Governors Circle • Houston , TX 77092. 713-686-8409 www.vtti.com/	VTT747 VTT1000 (+ control) VTT2000 VTT3000 (+audio) VTT3000S (+ stereo) VTT5000 (+ control) VTT7000	Passive Active	Category 2-5 Category 2-5	<800 ft. <1200 ft <3000 ft " " <3500 ft. (Repeaters every 3500 ft, to 5 miles)	max. 1.5 dB attenuation down listed length. Bandwidth 50Hz- 10MHz. 36 dB common mode rejection 800 lines 61 dB S/N Meets RS-170A
Vortex Communications 75 The Grove Ealing, London W5 5LL ENGLAND 011-44(0)20-8579 2743 www.vtx.co.uk info@vtx.co.uk	PBE890	Passive		1968 ft.	

Multiple pairs are now used to carry the video image instead of just one pair. Since each pair handles a portion of the final picture, the delivery or “timing” of the arrival of picture elements is critical. Called *skew* or *delay skew* in the data world, timing is the different arrival times of the picture elements. Broadcast standards require a maximum timing error (skew) of 40nsec between all the picture elements.

No Skew and Low Skew Cables

In component video, the red, green, and blue (“RGB”) component colors of video are sent separately. This produces the highest quality analog video image. Normally, a cable with multiple coaxes is used to carry the components. However, it was recognized early on that this might be one of the non-data applications for ‘category’ cables.

One of the key problems using data cables is the skew (sometimes called “delay skew”) of the cables. If you send RGB down multiple cables, you need to have the signals arrive at the same time. Multiple coaxes then need to be “timed” or trimmed by hand to the same *electrical* length. That electrical length may not be the same as the physical length so, especially in long runs, one coax might be significantly longer or shorter than the others to keep the “timing” in line. In pre-bundled coaxes (Belden makes six different families of bundled coaxes), we guarantee the timing variations.

The *de facto* broadcast standard is a timing error of less than 40 nanoseconds (nsec) between the coaxes delivering the signal. This means that identical signals fed into one end should arrive at no more than 40 nsec difference at the destination. With 40 nsec of timing difference between the primary colors, an expert eye could discern shifts of colors on a video monitor and the detail in an image could suffer. This is why Belden’s bundled RGB coaxes are typically guaranteed to have no more than 4 nsec per 100 ft. timing variation, (some products are 5-nsec/100 ft.) For a bundled coax guaranteed to be 4-nsec/100 ft., when compared to the 40 nsec maximum, such a cable could go 1000 ft. before it is *out of time*.

Does that mean you could send an RGB signal a thousand feet? That depends on the attenuation of the cable. For many smaller cables the attenuation would make the signal unusable, too low in level, long before that 1,000 ft. distance. What Belden’s timing guarantee means, therefore, is that timing is simply not a consideration. Just cut and connectorize the cable. No hand timing is required.

On twisted-pairs, the timing variations are now between the four pairs. Since one is required to connectorize all four pairs at the same time, you cannot lengthen or shorten any pair. You are dependant upon the delay skew built into the cable. In the data world, “timing”, now called “skew” or “delay skew”, has exactly the same effect. This measurement becomes important when applications, such as 1000baseT “gigabit” networking, are introduced. Gigabit networking runs data simultaneously down all four pairs, and in both directions. Signals sent at one end need to arrive at the same time at the other end. Interestingly, the maximum delay skew in TIA/EIA568B.2 is 45 nsec between all four pairs at 100 meters, 328 feet (surprisingly close to the 40 nsec of RGB).

A skew of 45 nsec, and a video component requirement of 40 nsec, means that a generic Category cable could go $40/45 \times 328 = 292$ feet before it is “out of time”. While 292 feet may seem like a long way, there are a number of vendors who feel this is a serious limitation to the use of UTP for RGB. For a long time, MediaTwist (25 nsec) was the lowest skew cable available. $40/25 \times 328 = 525$ ft. One would think that would certainly be far enough.

But then someone hit upon the idea of cable with *no* skew. It was apparent that the reason there was skew at all was that all four pairs in a UTP cable were twisted differently. This was essential to reduce crosstalk between pairs. But, if crosstalk wasn’t at issue, why couldn’t you simply twist all the pair identically? Extron and others had cables manufactured for them with identical lay length (pair twists). Belden produced such a cable called Nanoskew[®] (7987R, 7987P), but don’t look for Belden to include the specifications with the other UTP premise/data cables above. Because the twists are identical in all four pairs, we don’t even test this cable for crosstalk. We know that it will not even pass Category 3 requirements. Its only recommended applications are where crosstalk is a non-issue, and timing is everything. In fact, the delay skew on this cable is 2.2 nsec/100m (a timing distance of almost 6,000 ft. to the 40 nsec maximum).

The advantages over bundled coaxes are obvious. These cables are much smaller than even miniature RGB cables. They are easy to connectorize with RJ-45 data connectors, and easy to install. Where plenum RGB coaxes are quite time-consuming to strip and connectorize, plenum versions of Category-style cables are significantly easier and faster to install.

The one unproven part is the effect of crosstalk on RGB signals. Won’t these color signals bleed into each other? Perhaps the ability of the eye to see color bleed is considerably less sensitive than timing variations and detail. The empirical evidence, both from vendors of equipment and installers of the cable, is that this crosstalk color bleed seems to be of no consequence. The other limitation is that this cable design is specifically for RGB and VGA-type signals. Even though it looks like, and connects like, data cable, it is not data cable. It only has one family of applications, RGB, VGA, and similar applications.

Wouldn’t it make sense if we could produce a cable that could be a true UTP data cable, like a Category 5e or Category 6, that also had very low skew? Belden has produced a whole line of low-skew VideoTwist[®] cables. These include Belden 7988R and 7988P, which are Category 5e UTP with a skew of 9 nsec/100m, and Belden 7989R and 7989P, which are Category 6 UTP with a skew of 10 nsec/100m.

All of these use Belden’s patented bonded-pair technology for very stable and consistent impedance performance. These cables can be used as either RGB or premise/data cables. More data on the cables can be found in the new product bulletin, [NP 212](#).

VGA

One additional application for these cables is VGA, “Video Graphics Array”, and its offshoots (SVGA, XGA, SXGA, UXGA). Many of these applications are beyond the 100 MHz limit of Cat 5 or 5e, some up to 245 MHz. Care should be taken to choose a cable that has bandwidth specifications that match or exceed the signal to be carried. Belden VideoTwist® 7988R and 7988P (Category 5e), 7989R and 7989P (Category 6), were produced for these extended-bandwidth applications. These cables are fully tested to 350 MHz specifically for high-resolution applications, such as SXGA or UXGA. New product bulletin [NP212](#) also contains distance and loss charts to determine maximum recommended distances.

Here is a list of VGA balun manufacturers:

Manufacturer	Model/Part #	Passive or Active	Cable	Distance
ETS 43353B Osgood Rd. Fremont CA 94539 800.752.8208 www.etslan.com info@etslan.com	PV930	Passive	Any UTP	Unspecified
	PV931 PV932 PV937-2 PV938 PV939-2	Active	Cat 5 or better	
FSR 244 Bergen Blvd. West Paterson NJ 07424 973-785-4347 www.fsrinc.com sales@fsrinc.com	MMTP-RGBTX MMTP-RGBRX	Active transmitter Active receiver	Cat 5	>800 ft. UXGA compatible with low skew cable
Intelix 8001 Terrace Ave, Middleton, WI 53562 866-4MATMIX (462-8649) 608-831-0880 intelix@intelix.com www.intelix.com	VGA9	Active	Cat 3 or better	350 ft.
	VGA2	Passive	Shielded Cat 5	450 ft.
MuxLab Inc. 5450 Cote De Liesse, Montreal, Quebec, H4P 1A5 Tel: 877-689-5228 Intl: 514-905-0588 www.muxlab.com videoease@muxlab.com	500010 500011 500014	Passive Passive Passive	Cat 5 STP Cat5 STP Cat5 STP	350 ft (800x600) 350 ft (800x600) 350 ft (800x600)
Vortex Communications Ltd. 75 The Grove Ealing, London W5 5LL ENGLAND 011-44(0)20-8579 2743 www.vtx.co.uk info@vtx.co.uk	PBE930	Passive	Cat 5 or better	
	PBE937-2	Active	Any UTP	328 ft.

Digital Baseband Video

Digital video is different from analog. It is already data, ones-and-zeros. It is very robust (like data) and is much more immune to interference. It can be easily broken up, transmitted, and reassembled. The thousandth copy of a digital signal is identical to the original, making digital the ideal medium for recording, duplication, and playback. The only real stumbling block is data rates.

The data rate for true broadcast quality video is at least 45 Mbps, and broadcast manufacturers usually specify 143 Mbps to 270 Mbps. Category 6 data cables are only now covering these data rates. The cutting edge in the *data world* is ATM at a data speed of 155 Mbps, and even this is extremely difficult to handle. This pushes cable, connectors, and hardware to their limit; and the word size (how the data is arranged) for ATM is not compatible with standards already set for digital video. A single 143 Mbps video signal would almost fill up an entire ATM network - not much of a network left!

Network designers who create "video-to-the-desktop" have three solutions to this problem. The first trick is a compression scheme that reduces the bandwidth dramatically, called "bit rate reduction" or BRR, without affecting picture quality. Image quality in digital can be very subjective, especially to those familiar with home-video quality. Compression or BRR of 100-1 is considered "high-quality-video-to-the-desktop" (close to a T-1 data rate of 1.544 Mbps). Very few end-users have this quality available to them. Most of the time, the video to the desktop is a quarter T-1 (384Kbps) or even less.

The second trick is to hide the lack of data. The video image is placed on a small portion of the display monitor. If you only have a few thousand pixels responding, the lost data will be imperceptible. It is only when you fill the screen completely with the image, or have a very large monitor, that the lack of quality will be apparent.

The third trick is to reduce the frame rate. Since this is just another form of data, it is very easy to reduce the frame rate to 20 or less frames per second. Once below 15 frames, however, the latency in the human eye will begin to see the transition between frames and watching such an image can become tiring.

One of the key advantages to a digital video image, even of low quality, is the lack of noise and interference. To many who have grown up with an analog picture full of snow (low signal strength) or ghosts (multipath), a digital image is noiseless and ghostless, thus appearing "sharp" when, in fact, the actual data being viewed is orders-of-magnitude worse than a standard home television picture.

Below is a list of balun manufacturers for digital video:

	Part Number	Cable	Data Rate	Distance
ETS 43353B Osgood Rd. Fremont CA 94539 800.752.8208 www.etslan.com info@etslan.com	DVMC 850 (Passive)	Belden DataTwist 350™ Belden MediaTwist®	143 Mbps 177 Mbps 270 Mbps	>400 ft. >450 ft.
Gyrr 1515 S. Manchester Anaheim, CA 92802 (800) 854-6853 http://www.silentwitness.com/	FasTrans 2000 (Active)	Any UTP	Variable 8 fps "Low Quality" 20 sec/frame "High Quality"	Unlimited
NVT 4005 Bohannon Dr. Menlo Park CA 94025 (800) 959-9870 650.462.8100 www.nvt.com	VideoExpress™ (Active)	Any UTP	T-1 1.544 Mbps	Unlimited
Pairgain 14402 Franklin Ave. Tustin CA 92680 (714) 832-9922	Campus-TI (Active) Campus E-1 (Active)	Any UTP	784 Kbps per pair (1.544 Mbps for 2-pair) 1 Mbps per pair (2.048 Mbps for 2-pair)	2.3 miles 2.2 miles Based on 24 AWG copper.
Vortex Communications Ltd. 75 The Grove Ealing, London W5 5LL ENGLAND 011-44(0)20-8579 2743 www.vtx.co.uk info@vtx.co.uk	PBE-SDI	Cat 5e or better	SMPTE 259M	

For lower data rates, the lower the rate the easier it is to ship signals around. Category cables are specified to run up to 100 meters (328 ft.) at their maximum data rate. At T-1 or lower data rates, high quality twisted pairs could go much farther.

DVI and HDMI

These are two new applications for sending digital video to consumer/home high-definition display devices, such as plasma screens. DVI ("Digital Video Initiative") and HDMI ("High-Definition Multimedia Interface") both use twisted pairs for delivery. Currently there is only one company making baluns to put these applications on UTP. The only question is how the bandwidth of the DVI and HDMI signals, over 1.5 GHz, can work on Cat 5 cables that are tested and verified to 100 MHz. Even Belden 7851A ("600E") is only specified to 600 MHz.

Manufacturer	Part Number	Cable	Distance	Notes
svideo.com 711 E. Main St. Riverton, WY 82501 307-851-0215 www.svideo.com sales@svideo.com	EXT-DVI-CAT5 EXT-HDTV-CAT5	Cat 5 Cat 5	150 ft. 150 ft,	

Analog Broadband Video

A number of system manufacturers are looking at UTP for broadband delivery. Also known as CATV, broadband systems transmit groups of channels simultaneously down one cable in a multiplex protocol. Where these channels fall on standard television broadcast frequencies, standard televisions can de-multiplex the channels for viewing. Where the multiplexed channels are scrambled, sent in other bands or groups of frequencies, converters are used to convert them to standard broadcast frequencies.

To fully understand how coax or UTP can handle broadband/CATV channels or off-air broadcast television channels, one must understand how these channels are assigned. The assignment of channels by the FCC is anything but sensible. Off-air transmitted television channels cover a number of frequency bands. These sometimes do, and sometimes do not, correspond to the cable television industry channel assignments. In fact, as will be seen from the chart below, some CATV channel numbers have no relationship to their frequency. For instance, CATV assigned channels 14-22 come between off-air channels 6 and 7. Below is a chart of cable and off-air assigned channels:

BAND	FREQUENCY (MHz)	BROADBAND/CATV CHANNELS	OFF-AIR TV CHANNELS	NOTES
	6 - 48	T-7 through T-13		Interactive/ experimental
VHF	54 - 72	Channels 2, 3, 4	Channels 2, 3, 4	
VHF	76 - 88	Channels 4, 5, 6	Channels 4, 5, 6	
FM+	88 -118	Channels A-1 to A-5		Channels in reverse order
UHF	120 - 174	Channels 14 through 22		
VHF	174 -216	Channels 7 - 13	Channels 7 - 13	
UHF	216 - 1002	Channels 23 - 158		Channels assignments do not align
UHF	470 - 764		Channels 14 - 60	

Frequencies in between are assigned to various non-television services by the FCC, such as FM radio, aircraft navigation, land and fixed mobile, and are therefore beyond the scope of this paper. However, it should be realized that many of these application could also be supported by UTP (as they are currently supported by coax.)

Not in the chart above is the progression to digital television (DTV). This is a reassignment of a second channel to existing broadcasters. The second channel is specifically for digital transmission. These digital signals can include *high-definition* video. Also not shown is direct broadcast satellite television (DBS) as these systems extend beyond 1 GHz and are therefore far beyond the current capabilities of UTP.

There are many differences between coaxial cable, the standard copper cable for broadband/CATV, and twisted pairs. First is bandwidth. Standard broadband coaxial cable can handle up to 1 Gigahertz (1000 Megahertz) of bandwidth (158 channels). Special versions can handle up to 2.25 GHz (~300 channels). The broadband capability of UTP/STP is still *nowhere near* this bandwidth.

The second difference between coax and twisted pairs is attenuation. Industry standards require 24 AWG twisted pairs for Category 5 or 5e, 23 AWG or 22 AWG for Category 6. The resistance of the wires is higher than a standard RG-6 coax cable. And there are many other factors, such as return loss or crosstalk, where twisted pairs cannot compete with coax. It is doubly amazing to consider that this application, broadband/CATV delivery over twisted pairs, is the *most requested* non-data application! In many broadband/CATV applications the 150+ channel capacity of coaxial cable is not essential. In schools, hospitals and other controlled environments, only a small number of channels are required. In those instances, UTP could be a very cost-effective solution. All that is required is a broadband balun. Below is a list of CATV/broadband balun manufacturers for UTP:

MANUFACTURER	MODEL	PASSIVE/ ACTIVE	CABLE	DISTANCE	NO. OF CHANNELS
AMP PO Box 3608 Harrisburg PA 17105 (800) 526-5142 FAX (800) 522-6752	BOB 415337-1 BOB 415521-1	Active Unidirectional Active Bi-directional	Cat 5	328 ft. (568A)	29 NTSC (T7-T14, 2-22) 5-216 MHz
AT&T 505 N. 51st Ave. Phoenix AZ 85043 (800) 344-0223	384A	Passive	Cat 5	328 ft.	28 channels (Bandwidth 55.25MHz to 253.25MHz)
BH Electronics 12219 Wood Lake Dr. Burnsville MN 55337 (612) 894-9590	Lynx	Passive	Cat 3 Cat 5	? 154 ft.	Channels 2 - 61 (54-450 MHz)
ETS 43353B Osgood Rd. Fremont CA 94539 800.752.8208 www.etslan.com info@etslan.com	PV882 PV883 PV884 PV885	Passive	MediaTwist Cat 6	55 meters (180 ft.)	Channels 2-77 Channels 2-120
Intelix 8001 Terrace Ave, Middleton, WI 53562 866-4MATMIX (462-8649) 608-831-0880 intelix@intelix.com www.intelix.com	VB	Passive	Cat 3 or better	180 ft.	Channel 120
MuxLab Inc. 5450 Cote De Liesse, Montreal, Quebec, H4P 1A5 Tel: 877-689-5228 Intl: 514-905-0588 www.muxlab.com videoease@muxlab.com	500006	Passive	Cat. 5	100m (330 ft)	Channels 77 (550 MHz Bandwidth)
Vortex Communications Ltd. 75 The Grove Ealing, London W5 5LL ENGLAND 011-44(0)20-8579 2743 www.vtx.co.uk info@vtx.co.uk	PBE850SR				

The VHF television broadcast band does not start until 54 MHz (Channel 2) and covers Channel 2 through 13. While the bandwidth, 54 MHz to 216 MHz, is equal to 27 channels, the off-air equivalence is only 12 channels. But a dozen channels is still sufficient for many educational or commercial applications.

Impedance variations, mismatches, and structural return loss seem to indicate that the limiting factor is less and less the cable and more and more the baluns and other hardware. Belden MediaTwist[®], specified out to 350 MHz, and Belden 600E[®], with a bandwidth of 600 MHz per pair, are ideal cables for use with any broadband balun.

Emission

One key subject that seems to have been successfully avoided, especially when discussing broadband/CATV applications, is the emission off UTP running at high frequencies. In the data world, significant work has been completed to keep actual running frequencies low. Below 30 MHz, the FCC has no radiation/emission specifications. Therefore, one of the key drivers to compression technology has been to get systems at or near that number to avoid the requirements of the FCC.

Broadband/CATV applications cannot use such compression technology and are required to meet very stringent emission specifications. These are spelled out in the FCC Rules and Regulations, 47, Part 15, Subpart B. Any device, and the cable that wires it up, must meet one of these specifications. It is interesting to note the only category cables that have ever been tested for emission, are bonded-pairs such as Belden 1700A "DataTwist 350" and 1872A "MediaTwist[®]". (Or, if others have been tested, they suspiciously have not released the test results.) MediaTwist was tested with Sony 270 Mbps/135 MHz digital video machines, and PV850 digital video baluns manufactured by ETS, and was awarded a certificate for "*Class A Digital Devices*". A copy of the UL certificate can be found at <http://bwcecom.belden.com/college/Techpprs/tpewmawd.htm>

It should be pointed out that this application, Component Serial Digital Baseband Video, is only 135 MHz bandwidth, and does not mean that MediaTwist, or any other UTP product, is functionally equal to coax cable. We are 'approaching' coax performance, but we're not there yet. And meeting the FCC broadband emission standards, especially at UHF frequencies, even with Category 6, is something yet to be verified.

Internet Video

Our last application is video over the internet. This is different from all previous delivery systems as the delivery "medium" is the internet and not a network cable. While Cat 5, 5e, or 6 are no doubt part of the delivery chain, at the beginning and end of the chain, they are incidental to this application, and their performance has little effect on the actual video image. As long as the network requirements are met for each end-user computer, server, or other device, the performance and quality of the video image will be directly related to the *data speed on the IP connection*.

Recent experiments have delivered uncompressed (1.5 Gbps) digital HD signals through internet connections. However, these experiments were done ‘in the lab’ and no current equipment exists to accomplish this amazing feat. Just the idea that this HD signal, a thousand times a T-1 signal, could be carried by the Internet is staggering, and the possibility of many such huge data signals travelling across the ‘net will require even more bandwidth. Current top-speed for “standard” technology twisted pairs is 1000baseT which is “only” one gigabit per second. There is significant work being done in the 10gig world of tomorrow. Whether this can be done on today’s cable designs, or even on copper cables of tomorrow, remains to be seen.

“Non-Baluns”

It should be mentioned that some manufacturers of connectors and connecting hardware have begun to produce video modules that fit in wall plates. The ‘footprint’ for these modules is the same as the standard RJ-45 data connector. These manufacturers offer RCA, F, BNC, S-video, and even fiber connections. Where they are *feed-through* style, where the connector type is the same in the front and back of the module, they work very well, and can be very versatile.

However, there are some, specifically RCA and S-video, which offer those connectors on the front and a “110-style” punch-down block on the back. These modules look like they offer a very fast way to attach these connectors, but they both suffer from one fatal flaw. RCA and S-video connect to coaxial cable. S-video is, in fact, two coaxial cables. Those cables, and the signals they carry are, by definition, *unbalanced*. The cable most likely to be punched down to the 110-block on the other side is a UTP Category premise/data cable, but those UTP twisted pair cables are *balanced*.

To adapt a balanced-to-unbalanced signal, one simply uses a balun, as we have discussed here at great length. However, in these “modules”, there are no baluns, no transformers, no matching networks of any kind. Simply attaching an unbalanced signal to a twisted pair makes that pair unbalanced as well. All noise rejecting properties are removed and it can radiate signals to other cables and pick up external noise.

Further, the very limited distance of unbalanced audio (usually less than 30 feet), and the similar restrictions of S-video (usually less than 50 feet) are not improved by these “adaptors” and, in fact, may be reduced because of the susceptibility to noise and interference.

We would strongly suggest avoidance of these RCA-to-110 and S-video-to-110 adaptors until they are actually made with an internal balun. The distances that signals could travel when these adaptors do contain true baluns will be much greater, possibly many hundreds of feet.

Postscript

This is the fourth revision of the original paper. No doubt, there will be more revisions as technology progresses, manufacturers change or refine their product lines, and more information and testing data becomes available. If any reader of this paper has information to add, or questions any part of this document, you are urged to contact the author, Steve Lampen, at shlampen@aol.com

Steve Lampen is Multimedia Technology Manager for Belden Electronics Division, Belden CDT. He has worked for Belden for thirteen years. Prior to Belden, Steve had an extensive career in radio broadcast engineering and installation, film production, and electronic distribution. Steve holds an FCC Lifetime General License (formerly a First Class FCC License) and is an SBE Certified Radio Broadcast Engineer. On the data side he is a BICSI Registered Communication Distribution Designer. His latest book, "The Audio-Video Cable Installer's Pocket Guide" is published by McGraw-Hill. His column "Wired for Sound" appears monthly in Radio World Magazine.