Experiments with MediaTwist®

MediaTwist® is Belden's first cable designed specifically for multimedia and shared sheath applications. Based on Belden's very successful DataTwist® 350, MediaTwist, (Part numbers 1872A, non-plenum, and 1874A, plenum), improves on every electrical specification compared to generic Category 5. These performance improvements allow applications never before possible with UTP.

What is Multimedia Cable?

To Belden, Multimedia means multi-applications. Multimedia cable is designed to play less of a role in determining the limitations of whatever system it is attached to. Multimedia cable is less application sensitive and can support a wide range of signal types, bandwidths, lengths, and data rates.

What is Shared Sheath?

One of the most dramatic improvements in MediaTwist is crosstalk. The improvements are so great that multiple signals, even mixing analog and digital, can potentially be performed on a single four-pair piece of MediaTwist. Introducing multiple different signals to a four-pair construction is called "shared sheath". Because of the fear of one signal interfering with another, shared sheath has been avoided or even disallowed by many standards and systems.

Emission

One of the key problems with UTP is the potential for signal emission. Especially at high frequencies and data rates, twisted pair cables will radiate part of the signal out of the cable and interfere with surrounding cables. Emission is caused by variations in impedance which create standing waves (also called structural return loss or SRL). These tend to radiate part of the signal energy out the cable.

MediaTwist exhibits impedance tolerance and SRL closer to a coaxial cable and dramatically better than any other UTP. Since emission was such a key, we had MediaTwist tested at the UL Emission Test Facility in Oakbrook, Illinois. MediaTwist easily passed and was awarded a certificate for Class A emission, equivalent to coaxial cable.
Balance

MediaTwist is the best balanced cable ever made. This means that, in any given pair, the conductors are as close to identical as technology allows and the location within the dielectric is as centered as possible. With bonded pairs, the spacing between the conductors is equally controlled. This means that such a pair exhibits extremely stable impedance, similar to coaxial cable, with very low emission.

However, such a balanced twisted pair is only as good as the signal fed into it. If the signal fed into the pair is unbalanced, the pair will radiate. Thus, signal balancing is as critical as cable choice for low emission. Signal balancing can be affected by anything attached to the cable including transmission or reception devices, baluns, patch panels and connectors.

The Proof is in the Pudding

Since applications for MediaTwist include multimedia and shared sheath, it has always been our intention to show MediaTwist's capabilities by laboratory testing and live demonstrations. Below are a number of experiments we have done in laboratory settings and in public:

Experiment #1: MediaTwist versus Category 5
Shown publicly at the BICSI Convention, Orlando, Florida, January, 1997

A standard consumer video disc player was set-up playing a movie. The output ("Channel 3") was fed via standard coax cable to a CATV Modulator. This allowed the video signal to be placed on any channel from CATV Channel 4 (66-72 MHz) to CATV Channel 60 (438-444 MHz). This signal was then split through a standard CATV coax splitter. Each split went through identical baluns made by BH Electronics, Burnsville MN. The balun converted the coax to UTP with an RJ-45 format. On one split, the UTP was generic Category 5, on the other split, MediaTwist. At the end of 450 ft. Of each, the UTP when through identical baluns and each image was displayed on a large-screen consumer television. By changing the channel on the modulator, and re-tuning each of the
televisions, one could compare the MediaTwist to the Category 5 UTP at any desired frequency up to 444 MHz.

Results:

Reception difference were quite dramatic between the two. However, there was one interesting factor between MediaTwist and Category 5 UTP. MediaTwist was very gradual in the reduction of picture quality. Based purely on the author's visual interpretation, the MediaTwist seemed excellent up to CATV Channel 45 (348-354 MHz) and slowly degraded from there. Channel 60 was "noisy" and it is felt that a standard distribution amplifier would have more than compensated at that channel.

Category 5 seemed identical to MediaTwist in the lower channels. But, as the channels increased, some channels would look excellent while others, sometimes even the very next channel, would be unwatchable. We have postulated that this was due to the tremendous impedance variation of Category 5 after 100 MHz (Channel 6). Those variations created huge swings in SRL. These variations were so wide and so frequent that you could find some high channel number that looked great on Category 5, and the very next channel looked terrible.

Conclusions:

The wide-bandwidth limitations of MediaTwist are based almost exclusively on basic attenuation and that impedance variations and SRL are very minimal factors up to at least Channel 60. Most cable failings could be overcome by simple in-line amplification.

Experiment #2: Shared Sheath - Analog and Digital
Shown publicly at the BICSI Convention, Orlando, Florida, January, 1997
The Test Set-Up:

A feed was obtained from the hotel's cable television system. This consisted of 22 channels (216 MHz). Because hotel feeds are notorious for being low-level, we placed an in-line broadband amplifiers (+10 dB) to increase the cable television signal. The output of the broadband amplifier was sent through a balun made by BH Electronics, Burnsville MN and into a "Y" made of two pieces of MediaTwist into a Krone Category 5 block.

A standard consumer video disc player was connected to a Nemesys AVA-300 video codec transmitter. The output of the transmitter was fed to a Fore Systems ASX-200BX ATM switch. The output of that switch was fed into the other part of the "Y" cable going into the Krone Category 5 block. The output of the Krone block was fed to a single piece of 4-pair MediaTwist through a standard Category 5 RJ-45 connector.

After a 295 ft. run, the MediaTwist went through another Krone jack and into a 15 ft. piece of MediaTwist which had been twisted, knotted, jumped on, and otherwise well-abused. That piece then went into another Krone block. The ATM used two of the pairs in the MediaTwist and the cable television used one pair.

At the end, the cable television pair was split out with another "Y" cable, fed through a balun and any of the 22 channels could be viewed on the standard consumer television. Two other pairs in the "Y" fed an identical Fore Systems ASX-200BX ATM switch, which fed a Nemesys ATV-300 video codec receiver. The output of the receiver directly fed another standard consumer television.

The Results:

To understand the results, it should be noted that the ATM signal is purely a digital signal while the CATV hotel feed is purely analog. The ATM switch takes up a data rate of 155 Mbps with an effective bandwidth of 77.5 MHz.

The Nemesys/Fore combination can carry up to four video program simultaneously over a single ATM. While only one channel was used to show video from the video disc player, the ATM signal still has a data rate/occupied bandwidth of 155 Mbps/77.5 MHz because of the encoding scheme. It might as well be carrying four simultaneous video signals.

The key question is interference. Were there any bit errors or data problems? Despite the fact that the adjacent analog video signal was amplified, not one was observed during the four hours of the demonstration. Was there added noise or interference on the CATV channels? No. Even on Channel 5 (76-82 MHz), which is just where the ATM energy is most concentrated (77.5 MHz), there was absolutely no indication of any interference or added noise.
The Conclusion:

Shared-sheath operation, even those mixing analog and digital signals, are possible with MediaTwist. Even with elevated signals, it is possible to operate analog and digital signals or adjacent pairs without interference, bit errors or otherwise-compromised performance.

Experiment #3: Gigabit Networking
Shown publicly at the BICSI Convention, Orlando, Florida, January, 1997

The Test Set-Up:

A generic PC was loaded with a proprietary NIC (network interface card) made by WideBand. This was wired to a gigabit server which transfers its data by parallel architecture. The total data rate is 800 Mbps divided between the four pairs of MediaTwist UTP. The total cable length was 110 meters.

In such an installation, skew (timing differences between the four pairs) is a critical factor since each contains one-quarter of the total signal. The signal sent was a simple animated sequence from server to server and then displayed on another generic PC monitor.

The Results:

No timing errors or data errors were observed. No transfer errors were observed or measured.

The Conclusion:

Because of its excellent skew performance, MediaTwist is the best cable available for parallel data transfer applications.
Experiment #4: Component Serial Digital Video
Shown publicly at the BICSI Convention, Orlando, Florida, January, 1997

The Test Set-Up:

A Sony broadcast-standard serial digital VCR (DVW-500), with a digital bit stream of 270 Mbps (occupied bandwidth 135 MHz) was connected through a short coax jumper (Belden 1694A) with BNC connectors through a PV-850 balun (ETS, Menlo Park CA) to 500 ft of MediaTwist. The MediaTwist was wrapped into a ball by pulling, twisting, folding and otherwise abusing the cable. At the other end, the MediaTwist connected to another ETS balun, another jumper of 1694A coax, and to a Sony digital monitor (BVM20F1U).

The Results:

Bit errors caused by impedance variations, SRL or other properties, would have been immediately visible on the monitor. Despite the horrific appearance of the "ball of wire", there was a perfect picture and no bit errors were observed.

Conclusion:

MediaTwist can support very high data rates for extended distances, such as component serial digital video, with very low bit error rates.
Experiment #5: Broadband Applications
Performed in public at the University of Toledo in Toledo, Ohio, February, 1997

Test Set-up:

A tap from a broadband ring was obtained. The location was one drop away from the university head-end site, indicating that the signal quality was as good as could be found anywhere on campus. The actual number of channels working was from Channel 2 to Channel 57. Channel 57 contained color bars. Channels up to 64 were also on the system but they contained no picture information and could not be judged for signal quality. Channels up to 64 were measured by signal strength. To read signal strength, a signal strength meter was alternated with a standard television. Signal strength at the tap itself was also read. A broadband balun (BH Electronics, Burnsville MN) was inserted at the source end of the tap and a length of MediaTwist was attached. This length was cut progressively shorter and shorter, picture quality judged and signal strength noted. To mimic the actual campus environment, a generic broadband amplifier (+25 dB) was inserted on the source end of the line.

Most of the hardware used (as noted in the table below) was Krone high-band blocks and connectors with Category 5 RJ-45's attached to the baluns.

Results:

The first thing noted was the absolute lack of ghosting. This meant that the balance and impedance tolerance of the MediaTwist was excellent with resulting very low SRL (structural return loss). As expected, attenuation of MediaTwist was not as good as standard coaxial cable. However, much for the drop off at higher frequencies was felt to be due to the broadband amplifier which was not of professional quality. Every channel viewable (up to 57) was deemed wholly acceptable at every length tested.

It was also noted at one point, when a 3 ft. Patch cord at the destination end was changed from Category 5 to DataTwist 350, a 2 dB increase in signal strength was noted on Channel 64.
Here are the actual signal strength results:

<table>
<thead>
<tr>
<th>MediaTwist Length</th>
<th>Connector</th>
<th>Channel 2 (60) Signal Strength</th>
<th>Channel 3 (66) Signal Strength</th>
<th>Channel 57 (426) Signal Strength</th>
<th>Channel 62 (456) Signal Strength</th>
<th>Channel 63 (462) Signal Strength</th>
<th>Channel 64 (468) Signal Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>At Tap</td>
<td>N/A</td>
<td>+6 dB</td>
<td>+8 dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tap w/amp</td>
<td></td>
<td>+35 dB</td>
<td>+32 dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>390 ft. high band</td>
<td></td>
<td>+17 dB</td>
<td>-23 dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>330 ft. high band</td>
<td></td>
<td>+18 dB</td>
<td>-15 dB</td>
<td></td>
<td></td>
<td>-23 dB</td>
<td></td>
</tr>
<tr>
<td>270 ft. high band</td>
<td></td>
<td>+21 dB</td>
<td>-5 dB</td>
<td>-12 dB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Krone patch panel</td>
<td></td>
<td>+21 dB</td>
<td>-6.5 dB</td>
<td></td>
<td></td>
<td>-14 dB</td>
<td></td>
</tr>
<tr>
<td>210 ft. high band</td>
<td></td>
<td>+24 dB</td>
<td>+24 dB</td>
<td>+2 dB</td>
<td>+2 dB</td>
<td>-3.5 dB</td>
<td>-6.5 dB</td>
</tr>
<tr>
<td>210 ft. Krone patch</td>
<td></td>
<td>+24 dB</td>
<td>+24.5 dB</td>
<td>+1 dB</td>
<td></td>
<td></td>
<td>-6.5 dB</td>
</tr>
</tbody>
</table>

Ultimately, the University and their consultants decided to use standard coaxial cable. The main stumbling block was the cost of the baluns, together with the realization that a non-standard tilt amp would be required to equalize MediaTwist.

**Conclusion:**

MediaTwist is effective up to at least Channel 64. Basic attenuation can be overcome by the use of broadband amplifiers. Installers wishing to install tilt (EQ) amplifiers should consult the attenuation data for MediaTwist for the correct values. It is suggested that the linearity of any baluns, amplifiers or other hardware be established to the highest frequencies intended before being used in such an application. Care should be taken in the selection of patch cords and other cable.

It should also be noted that MediaTwist is not superior to coax cable. The value in MediaTwist is in its ability to support many varied system standards. If a user is simply trying to replace one single type of cable with MediaTwist, it may be more cost effective to stay with the original cable (such as broadband CATV coax, in this example). The cost savings comes from replacing a myriad of cable types, each with their own connector and crimp tool. In that instance, MediaTwist can offer significant savings in cable, installation labor, versatility, and future-proofing.
Experiment #6: Analog Video and Analog Audio
Performed at the University of St. Louis Medical Center, in February-March, 1997
This involved a pre-install experiment and some post-install problem-solving.

Pre-install Experiment

Using two AT&T 384A baluns, two analog video signals (4.2 MHz bandwidth) were put on two adjacent pairs of MediaTwist at a length of 375 ft. Two analog audio signals were connected through the baluns to the two remaining pairs at a length of 375 ft. The audio had problems mainly because the balun inputs are unbalanced RCA connectors and the source was balanced. It was suggested, therefore that the two audio signals be connected directly to the MediaTwist without the use of a balun. One audio was then removed and substituted by a phone connection from a digital PBX with a phone connected at the other end.

To test the noise immunity of UTP, which was a serious concern of the end-user, the MediaTwist was draped down a hallway over a series of fluorescent lamp fixtures and ballasts (eight in all).

Results

The video images were excellent and wholly acceptable. There was no evidence that the fluorescent lights or ballasts produced any discernible noise in the picture. At first, the audio was very low level and distorted. Since the audio input to the 380A is unbalanced (RCA) and the source was balanced, it was suggested that the audio source be connected directly to the MediaTwist. With this change, the audio level and quality was excellent. One audio was disconnected and substituted with a telephone connection, which worked well. However, it was noted that a rolling bar appeared on the video images on the adjacent pairs.
This bar disappeared when the phone was disconnected. It was suggested that there may be a 60 Hz ground loop hum unbalancing the phone connection. This problem was a hint of things to come in the final installation.

Installation

This installation was headed by John Barr (Network Analyst with SLU) and the MediaTwist was supplied through Michelle McBride (Anixter).

While the MediaTwist was intended to do a number of things, the key "unknown" was its long-run baseband video performance. The installation uses MediaTwist to ship analog baseband video from various meeting rooms and offices to a central control room and back again. In a test after installation, they hooked up a camera at one end, went 700 ft. to the control room (the longest run), patched across an RJ-45 patch panel to a 600 ft. run leading to another room. The image quality of the baseband video image, with 1300 ft. of MediaTwist, they described as excellent.

However, when they put in another 1300 ft. line going in reverse, both video images had serious noise problems consisting of ghosts around images and diagonal lines running across the screen. When they manipulated one of the pictures (fading color bars in and out) and you could definitely see changes in interference on the video image fed by the other line. In other words, the interference on the second line was definitely the picture information on the first line, and not just random noise. This meant that the lines were radiating. And this indicated that something connected to the MediaTwist was either not a balanced line or was somehow becoming unbalanced, allowing the video image in each line to cross over to the other line.

There was discussion to attempt to isolate the cause and determine a solution. First he tried short runs. With runs even as short as 100-ft. the problem was still there. Second, I had him run continuity on the baluns (AT&T 380A). These did show DC continuity, which I believe to be a major cause of their problems.

Results:

In their original test, they had run the cable out and back to the same room. Within any single room, most equipment is attached to one set of racks. Ground, therefore, is the same on both ends of the cable since the cable starts and ends in the same room. Once the cable is laid out in the building however, especially a building like this with old and new sections (some as old as 100 years), it was very likely that the ground potential in one room was very different than another room.

Because the balun did not isolate DC, it meant that there were significant differences in ground from one end of the cable to the other. By not isolating the DC, this made the cable a conductor of that difference in potential (voltage) from room to room. This is normally referred to as a "ground loop". The introduction of this voltage into the cable unbalanced the MediaTwist putting more signal (so to speak) on one conductor than the
other. This immediately made the cable a wonderful antenna, radiating both low and high frequency energy in all directions. The low frequency (60 Hz and harmonics) energy would show up in video as diagonal bars moving slowly across the screen. (It's beating against 59.94 Hz which is the frame rate of the video.)

Just because one cable is radiating energy, you wouldn't know it until you had another cable nearby. That's why they didn't see it on the first cable but when you had two cables, they both interfered with each other. The problem is balance!

The solution is isolating baluns: baluns which cannot pass DC and are therefore immune from ground problems. For instance, the original analog audio baluns were true isolated baluns. SLU has been simultaneous doing analog audio, but have had no problems with that because the baluns are true DC isolation and have kept the MediaTwist in balance.

SLU called ETS and got them to send some of their baseband baluns. While these are not isolating, they are very good "forced balanced" choke style. Putting these on the line, while I was there, dramatically reduced noise, eliminated ghosting. Ultimately, ETS supplied true isolating baluns and all radiation and isolation problems were solved.

**Experiment #7**
Currently installed at Alcoa Aluminum

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**Background**

In this facility, Alcoa manufactures sheet aluminum for the aerospace industry. Part of the process involves checking sheets of aluminum for flaws. This is done by immersing the sheet in a 275-foot (84m) long water tank and running a sensor grid over the surface of the aluminum sheet. These sensors are fed directly into a PC which travels up and down the tank.

The system runs 10baseT on a Cabletron Twisted Pair Hub using the AUI port on the PC. The data is fed, in turn, to a Chipcom Ethermodem 10broad36 (coax) RF modem. This is
fed to a broadband (coax) backbone. Total twisted-pair length from hub to PC is 402-ft. (123m)

**The Problem**

The motors which run the assembly are fed by a 480-volt festoon cable. This power cable plays out as the assembly moves down the tank. When fully extended, the festoon cable is drawn tight. When fully retracted the festoon creates a 4-foot loop every 3 inches. The requirement was to run the data cable by attaching it to the 480-volt festoon cable.

A number of cables were tried previously but the bit error rates, cased by the EMI from the 480-volt cable, were excessive.

**The Solution**

A 402 ft. Piece of MediaTwist was installed. While MediaTwist is solid conductors, and will not have the flex-life of a stranded cable, no stranded cable would have the noise rejection of MediaTwist. Therefore, the cable will have to replaced on a regular basis to avoid flex-failure. This should be easy to estimate so that replacement can be done during routine maintenance.

**The Results**

The system has worked flawlessly since the installation despite the fact that MediaTwist is an unshielded twisted pair. This solution has been so successful that Alcoa has extended its use to a second machine which uses *dual PCS*, and therefore *dual MediaTwist runs*, all connected to a 480-volt festoon cable.

**Conclusions:**

In any system, the transmission quality is only as good as the weakest link. In the case of MediaTwist, providing a true balanced-line source and receiver is critical to its ability to avoid signal and noise emission, or to avoid noise pick-up. Also, isolation from ground is equally critical to noise pickup and emission. True floating balanced line circuits are greatly preferred when using MediaTwist.
Experiment # 8: Consumer analog video and audio
Presented at a BICSI Luncheon, Westin Hotel, Thursday, October 2, 1997, Santa Clara CA

The Problem

From previous experiments, such as Experiments #4 and #6 above, it is evident that professional balanced audio and professional video can easily be run over MediaTwist. A high-quality balun is required to convert the video into balanced format, but these professional systems are designed to reject noise.

What about home-quality audio and video? These non-professional systems run on significantly lower signal levels (-10dB vs. +4 dB for the audio portion, for instance). And home systems are much less quality and noise conscious.

The Solution

We used a home-quality VCR, a home-quality video camera and two home televisions. As can be seen from the drawing above, these were all converted using ETS baluns (PV841 for the video, PA803 for the audio). Each was then fed to one of the four pairs of MediaTwist in a single cable. (In the illustration above, the arrows on the baluns indicate the signal flow.)

The analog audio outputs, and video baseband outputs, were used. These all appear on RCA connectors on both the VCR, camera and televisions. Generic low-quality (non-Belden) RCA interconnect cables were used between each video jack and each balun. There were two video feeds (one live, one tape) on adjacent pairs of MediaTwist, and two stereo channels of audio on the other two pairs. A standard 1,000 ft. Roll of MediaTwist was unspooled and rolled into a ball as in Experiment #4 above.

The Results
The quality was excellent. In fact, the difference between the immediate signal (running directly from VCR or camera to television) and the 1,000 ft. of MediaTwist was imperceptible. We even opened up the jacket in the middle of the cable to expose the four pairs. This had no discernible effect.

We then asked members of the audience to come up and by twisting, bending or otherwise 'manhandling' the cable to get any of the signals to stop. Each was given 20 seconds. The first four attempts had no effect. It was only when one contestant (using what looked like all his strength) stepped on the cable and literally pulled it apart, thus breaking the conductors. At that point, the video feeds stopped.