PREDICTING THE EFFECTS OF SIGNAL SKEW ON VIDEO PERFORMANCE

This paper provides technical support for personnel involved with high performance video transmission over UTP cable. The topic pertains to multiple component video signals including VGA, UXGA, YUV and the like. It does not pertain to composite video signals, like NTSC and PAL.

Video signals and skew

Ideally, all of a video signal's components should arrive at their destination (the display equipment) at the same time, exactly. That means that red, green & blue along with sync information are received in unison, as they were generated. When the signals don't arrive at the same time as a result of passing them through multi-pair cable, the condition is termed skew. Visually, the effect of skew is colored fringing that is noticeable to the left and right of vertical character and graphical elements in the video image.

Not introducing any skew is clearly the most desirable situation for video image transmission and display. In the real world however, transmission line cables are not perfect and most impose signal skew due to varying end-to-end propagation times. These variations are typically a manifestation of slightly varying physical lengths and subtle inconsistencies in transmission line characteristics that impact their electrical lengths. This is true for coax, fiber and UTP. For UTP the situation is a result of an intentional variation of the twist rates between pairs, in order to minimize cross talk. An exception to this is NanoSkew UTP cable, the result of a collaborative effort between Magenta and Belden. NanoSkew cable maintains a low level of skew by utilizing the same twist rate for all four pairs. In addition, since all four transmission lines are contained in a single jacket, the physical length matching is "built in."

Certain video applications tend to be more forgiving of skew than others. Very high-resolution graphics or spreadsheets with small characters are examples of applications where skew must be negligible. In those situations, either low skew cable or a suitable skew compensation device must be employed. In high-resolution applications where standard cable is already in place and where it is impractical to pull new, low- skew UTP, the only viable option is to use a skew compensation device. For other situations like virtual signage or where the displayed material contains motion and/or larger scale graphic elements, there is a greater forgiveness of signal skew effects. Under these circumstances and for reasonable cable lengths, skew may not be much of a practical concern.

Quantifying permissible levels of skew

Having a rule of thumb is beneficial when attempting to assess required video performance and equipment requirements. A couple of simple equations can be used to predict the effects of skew on video signal performance. These are presented on the next page.

The observable effects of skew are dominated primarily by three factors. One is cable dynamics, where a certain characteristic amount of electrical skew between the signals is introduced over some specific length. Next is the actual installed length of the cable where the skew characteristics continue to mount up linearly with distance. Last is the video signal's horizontal scan rate.

Not all UTP is the same

Certain cables like CAT5e and CAT6 are primarily designed to function in the digital networking environment. To support high speed networking, NEXT or "near end cross talk" is reduced by twisting each of the four pairs at different rates. Some very high-speed UTP data cables employ profoundly different twist rates between pairs. These cables provide very low NEXT and excellent network performance, but they also introduce severe signal skew. For networking applications, elastic buffering can be used to compensate for the expected skew and as such, it's a non-issue. For video however, NEXT is *not* very important and skew *is*. On this basis, choosing the right type of cable for video signal management is important. As an outcropping of this awareness, Magenta has taken action with regard to cable testing, cable development and skew compensation equipment design.

Horizontal scan rate

Skew becomes more pronounced as the horizontal scan rate is increased. Video images are scanned from left to right, one line at a time starting at the top of the screen and ending at the bottom. The faster the horizontal scan rate is, the greater the horizontal distance covered by the scan in a given segment of time. Skew errors for a particular run of cable are fixed. As an example, a certain 1000 ft. (305m) length of cable introduces 23 nanoseconds of skew between the red and green signals. Regardless of the video format, the skew time will remain constant at 23 nanoseconds. If the video scan rate is 31.5 kHz, the effect of the skew condition will cause an artifact to be displayed that is twice as wide as it would be at a scan rate of 15.75 kHz. This means that the amount of skew in a particular cable can be tolerated in one video signal application, but not in another.

Some simple math

The following equations are intended to provide approximations based on "typical" video formats. To simplify the equations and also to make them work with readily available information, *reset*, *blanking* and *inactive intervals* are estimated to be at a consistent fraction of the entire format geometry.

The maximum suggested *skew limit* in nanoseconds for a particular video format can be estimated as follows:

Equation 1:

Skew Limit =

$$\frac{8.2 \times 10^{8}}{(Hr \times Vr \times Vf)}$$

Where:
Hr is Horizontal Resolution, 1600 as an example
Vr is Vertical Resolution, 1200 as an example
Vf is Vertical Frequency or Refresh Rate in Hertz, 60 as an example

Using the above example, the equation yields a value of 7.12 nanoseconds. Seven nanoseconds of skew in this video format will be noticeable, but not detrimental for most applications.

To take the exercise a step further, the typical skew introduced by a particular type of cable can be factored into the equation.

Typically, the skew imparted by *Comtran 2881* is approximately 16 nanoseconds per 1000 ft. (305m) or 16 picoseconds per ft. (Comtran 2881 is one of the best, low-cost standard UTP cables for video signal transport).

With Equation 2 and by using the same video format data that was plugged into Equation1, we can derive the maximum length that a signal should be run over Comtran 2881 without considering the use of skew compensation. The maximum *length in ft.* for Comtran 2881 without skew compensation:

Equation 2:

Maximum length =

$$\frac{5.125 \times 10^{10}}{(Hr \times Vr \times Vf)}$$

Where:
Hr is Horizontal Resolution, 1600 as an example
Vr is Vertical Resolution, 1200 as an example
Vf is Vertical Frequency or Refresh Rate in Hertz, 60 as an example

The equation yields a value of 445 ft. (136m).

Please note that the lengths quoted are *electrical lengths*, not *physical lengths*. Electrical lengths equate to the lengths as measured by a UTP tester.

Using the presented data and the worksheet accompanying this paper should help to avoid application errors and should also help assure the best cost to benefit ratio for video- over- UTP installations.

Please contact Magenta Research for more details or application support: (203) 740-0592.

Addendum: Skew-negating Products

1) Magenta Research, AkuComp™ - optional skew-compensation feature designed for MultiView AK1000 and AK1500 Series receivers. Removes up to 32 nanoseconds of skew on red, green or blue channels, in one-nanosecond increments.
   Part number: 1201386-01.

2) Belden, Brilliance VideoTwist NanoSkew™ CMR – skew rated at < 0.5ns/100m (average), < 3ns/100m (maximum)
   Part number: 7987R

3) Belden, Brilliance VideoTwist NanoSkew™ CMP – plenum version of above, same skew specification.
   Part number: 7987P

   Note: Belden will be introducing CAT5e and CAT6 low-skew versions at InfoComm in June 2004.