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Twisted pair AV systems design considerations

Introduction

Sending computer video signals over twisted pairs is widely used in AV installations. Twisted pair based AV systems are easier to install, yet they have limitations, that need to be understood. A clear understanding of these limitations simplifies the AV design process and assures proper operation once an AV system is installed.

Compatibility

Currently there is no universal standard for transmitting VGA type signals over twisted pairs. Different manufacturers select different way of doing it. When designing an AV system with twisted pairs, always standardize on one manufacturer to assure compatibility from end to end.

There are two ways of transmitting a video signal over twisted pairs: passive using baluns and active using differential line drivers. Although passive devices are sufficient for composite video and S-video type signals, active devices are required for VGA and HDTV type signals.

Since sources and displays do not have twisted pair inputs or outputs, transmission of video signals using twisted pairs requires use of transmitters and receivers.

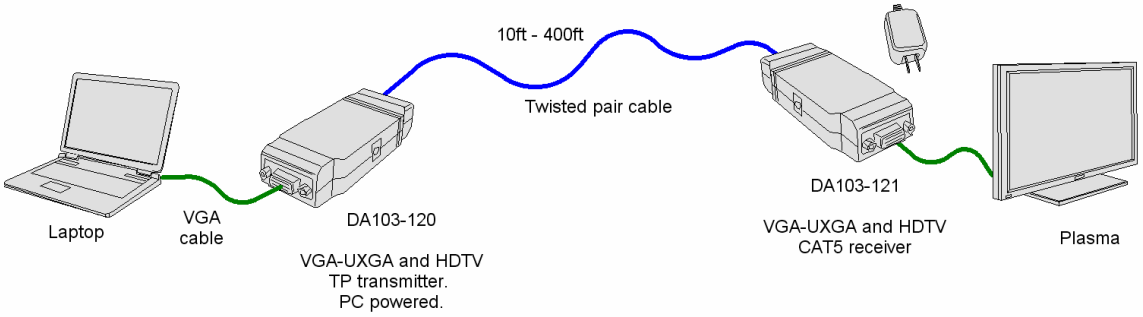

Figure 1

Transmitters are used to encode a VGA type signal into 4 twisted pairs. The encoding schemes vary from manufacturer to manufacturer and most of the time are not compatible or interchangeable.

ALTINEX uses proprietary encoding configuration on all of its twisted pair products utilizing all 4 twisted pairs of CAT5, CAT6 or low skew cable. Figure 2 outlines coding configuration for ALTINEX twisted pair transmitters.

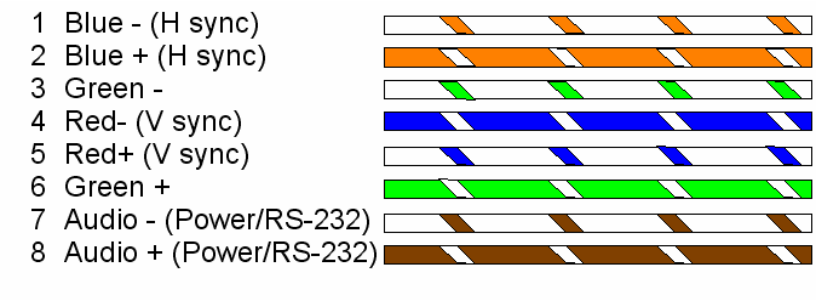

Figure 2

Receivers are used to decode twisted pair VGA type signals into separate components, RGBHV and audio. It is not possible to combine different encoding and decoding techniques into one AV system unless it is a point to point transmission only.

Cable selection and skew control

Probably the most crucial part of designing an AV system with twisted pairs is to select proper cable. There are few selections to choose from:

1. CAT5 cable (Shielded/unshielded) (100MHz)
2. CAT5e cable (Shielded/unshielded) (350MHz)
3. CAT6 cable (Shielded/unshielded) (250MHz)
4. CAT6e cable (Shielded/unshielded) (500MHz)
5. CAT6a cable (Shielded/unshielded) (625MHz)
6. Low skew cable (Shielded/unshielded) (250MHz to 500MHz)

From this selection it is possible to conclude that the highest bandwidth cable should be used for the best performance. In reality, besides the bandwidth, the signal delay between pairs is a very important factor in selecting proper cable.

Figure 3

Since all of the CAT5 and higher rated cables were designed for digital data transmission, the important design criteria was to minimize crosstalk between channels. To do this each pair was twisted at a slightly different rate. So in essence each twisted pair within a CATx cable is slightly different in length.

Even though it is not a significant issue for digital signals, it becomes extremely important for the VGA/RGBHV type analog signals that extend above 100ft. Here are simple calculations of the cable skew due to the different twists in CATx type cables.

Typical twisted pair cable (CAT5 / 6) will have 1.5ns delay per foot. Due to the different twist ratio of each pair, the length of each twisted pair within CAT5 / 6 cable can vary by as much as 0.5” per foot. So for a 100ft cable the individual twisted pairs can vary by 5 ft. The longer the cable is the larger variation between individual pairs.

100 ft	variation 5 ft	skew between pairs 7.5 ns
200 ft	variation 10 ft	skew between pairs 15 ns
300 ft	variation 15 ft	skew between pairs 22.5 ns
400 ft	variation 10 ft	skew between pairs 30 ns

In other words a video signal on one twisted pair can be delayed by as much as 30ns relative to other video signals. Since RGB type signals must arrive at the same time for proper color conversion, this delay will produce color shift that is difficult to tolerate.

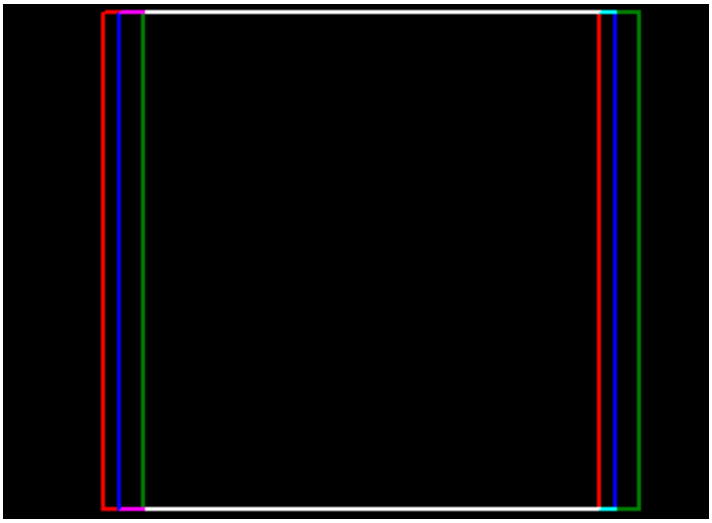

Figure 4

In Figure 4 above, the green color is delayed the most and the red color is delayed the least due to the skew variations in CAT5/6 type cable at 600 ft.

As a rule of thumb, the skew control is not necessary for cables less then 100ft because the total delay is less then 1 pixel of the video image. Once cable exceeds 100ft it is recommended that a low skew cable is used to optimize video image.

Low skew cables are designed to provide minimum variation between pairs of cable and eliminate any color miss-convergence on a long cable runs.

Maximum twisted pair cable length

The maximum cable length depends on the signal resolution, cable type used and customer expectations. The table below shows approximate distances for different signal resolutions and cable type.

Signal resolution	Cable type	Cable length
1024x768 @ 60Hz	CAT5/6	125 ft
	Low skew	600 ft
1280x1024 @ 60Hz	CAT5/6	110 ft
	Low skew	550 ft
1600x1200 @ 60Hz	CAT5/6	100 ft
	Low skew	500 ft
1080p	CAT5/6	300 ft
	Low skew	550 ft

Although CAT5/6 cable can be used to run longer distances, in many cases the skew of the cable produces images that look out of focus and difficult to view. On the other hand if the images are mainly HDTV type signals the skew limitation is not visible on moving images.

Looping multiple twisted pair products together

Cable lengths for a twisted pair run is the total length of cable used from a source to destination. The distances specified above can be exceeded by as much as 100% and still provide acceptable images but the skew and bandwidth limitation artifacts become more visible.

In many applications once the computer video signal is converted to a twisted pair format, it is best to keep it in this format until it is converted back to computer video format next to a display. Encoding and decoding computer video signals multiple times is not recommended. If your specific design requires multiple conversions, please contact Altinex technical support for additional information.

Conclusion

An AV system designed using computer video over twisted pair technology can significantly simplify system installation. With clear understanding of twisted pair limitations it is easy to design an AV system that meets customer's requirements and provides signal quality rival to systems designed with coaxial cables.