# Professional Digital AV over UTP and Fiber: *THE RIGHT WAY*

The core team at Raven Research has been active in the development, manufacture and support of signal management products since the 1980s.

Ever since then, the team has focused on developing new and unique solutions that don't rely on packaged SOC (system on chip), "app note" driven or cookie cutter approaches. This open thinking harks all the way back to earlier, unique analog long distance solutions (some patented) for VGA transmission over UTP, single coax and fiber, "impossible problems" were solved, like moving 1920X1200 RGBHV over 2000ft of UTP.

Indeed, there were no packaged silicon solutions available. Unconstrained exploration, creativity and open thinking lead to technically successful, practical and industry leading solutions.

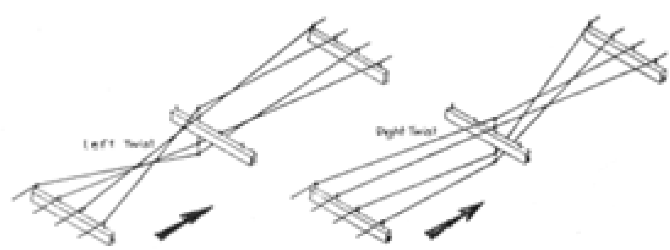
Reflecting on the shape of these challenge driven achievements, Raven has recognized that there are substantial shortcomings with currently available solutions and that a better, more secure and practical approach for transmission of HD & aux signaling over UTP and fiber needed to be undertaken. So the story begins...

## TWISTED PAIR CABLE

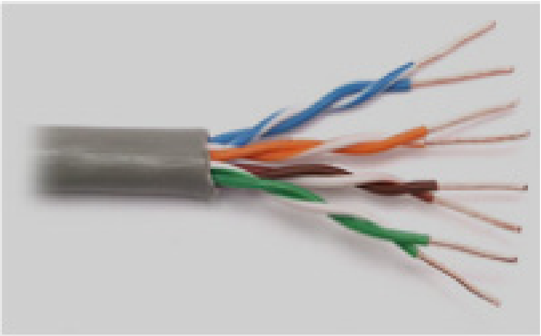
All "category network" cable (UTP, STP, ScTP, FTP, etc.) is descendent from telephone cable. Initially, baseband telephone connectivity was supported by "open line" construction techniques.

The balanced telephonic signals propagated through parallel pairs of conductors were suspended aerially and spaced apart by pole mounted glass insulator knobs.

Periodically, the wires were swapped or "transpositioned" from one side to the other, neutralizing the effects of coupling with adjacent pairs."



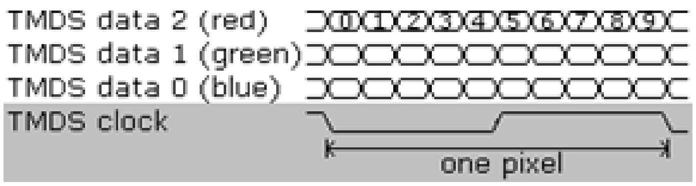
Fundamentally, today's modern UTP is a macro model of the same structure. Glass insulators have given way to plastic insulation and periodic transpositioning of open parallel conductors has given way to four tightly twisted wire pairs residing within a single cable jacket.



Modern category cables boast impressive bandwidth and reasonably low inter-pair crosstalk figures over the specified passband (though not beyond it, and this is an important point). One technique used to minimize the effects of pair to pair coupling is to twist the cable's internal pairs at rates different from one another. This practice does reduce inter-pair crosstalk but introduces signal skew, since twist rate effects overall physical length of the pair. In Ethernet applications, skew is anticipated and managed as part of the PHY layer (or physical signal layer as it is referred to in the Open Systems Interconnection [OSI] model), rendering it harmless to the intended application.

## DIGITAL HD VIDEO

Baseband, multilane digital video signal formats like DVI and HDMI provide excellent AV performance for many applications—at both the consumer and commercial levels. Structurally, HDMI is very similar to DVI, in that it consists of four signal lanes, one being a clock channel and three discreet, high speed TMDS data channels.




For standard HDMI, the combined bandwidth can exceed 3Gbits per second – full-blown, deep color HDMI with multi-channel audio can exceed 12Gbits per second. Development of these signal standards was undertaken as consumer oriented solutions, relying on specialized, short interconnecting cables with controlled attenuation and skew characteristics. At the time of their development, no obvious consideration was given to transporting these formats over distances exceeding the length of the specially designed cables connecting set top boxes, PCs and Bluray™ players to displays.

DVI & HDMI formats work exceptionally well for transporting signals from these typical consumer graphics / AV sources to display equipment. From the standpoint of their electrical characteristics however, these signals tend to be quite frail. Since these formats were not intended to operate over lengths of more than a few feet of cable, little effort was expended to make the signals compatible with longer cable runs or various types of cables, including UTP, etc. It is for that reason, that these meekly driven high bandwidth, TMDS signals degrade over distance. Furthermore, the electronics behind the I/O ports neither include the elements necessary to provide a large common mode operating range, nor much common mode signal rejection—two characteristics that significantly effect a system's ability to discriminate between legitimate signals and disturbances that may couple electromagnetically to the cable. The result is limited usefulness for these signals in applications where there can be significant differences in ground potential between the source and sink port – something that often occurs when source and display equipment reside in divergent locations. An outdoor display use-case is one that can draw groans of recalled-frustration from experienced systems designers and integrators.

Since DVI and HDMI proliferate as format standards in AV production environments, it stands to reason that it is desirable to utilize them for both residential and commercial content delivery applications. In either case, having the ability to extend these signals over greater distances further enhances their value as a solution for the integrator, or for the independent system developer. Enabling extension over inexpensive category cable and fiber further enhances the utility of baseband digital AV signaling.

The high bandwidth requirement and critical time alignment among channels makes DVI & HDMI “less than ideal” as a candidate for extension over multi-pair cables that exhibit non-trivial high frequency attenuation inter-channel skew.

Early efforts to extend DVI and HDMI via category cable relied on some form of frequency dependent equalization at the receiver to restore the original signal’s TMDS eye patterns. Little else was done and because of that, stability, performance and reliability were less than adequate for commercial or uptime-critical use-cases. Performance was also highly dependent on the specific overall length of the category cable. Because of the inter-pair skew, it was possible to find “dead-spots” at various lengths where the clock signal transitions were sufficiently out of phase with the data channels. Sometimes subtracting (or adding, actually!) a few meters of cable could stabilize performance. It was hit or miss and not really appropriate as a solution for the AV professional’s toolbox.

HDBaseT™ signal transmission was introduced several years ago; hailed as a consumer-oriented technology and depending on how it’s implemented by the equipment manufacturer, can provide significant performance and feature set advantages over earlier extension technologies. HDBaseT relies on a bespoke chipset that implements high speed DSP to restore TMDS eye patterns and to actively neutralize inter-pair crosstalk. While it represents a fairly sophisticated and often significant improvement over earlier EQ-only systems, like its ancestors, HDBaseT operates in the four-lane, full bandwidth, baseband domain (brute forcing signals through UTP cable, far, far above the cable’s intended and specified operating bandwidth). For that reason, it continues to be less than ideal for many commercial and industrial implementations. Similar to other approaches that rely on propagating full bandwidth baseband signals over four lanes, HDBaseT’s adaptive receiver equalization makes it susceptible to sources of electromagnetic interference. Sources of interference include electrical system grounding noise, local-wireless & public cellular communication equipment, power tools, high-energy electrical equipment and even hostile crosstalk from other cables carrying HDBaseT signals or Ethernet cables. Susceptibility worsens as the TX to RX link cable length increases, because the adaptive equalization blindly compensates for frequency dependent cable rolloff by increasing high frequency gain at the receiver. As if that’s not challenging enough, the peak gain of the adaptive EQ processing is right in the middle of a popular cell phone band! Yes, cellphones can interfere directly with HDBaseT signals as well as other legacy full bandwidth, four-lane baseband extension technologies. HDBaseT’s adaptive crosstalk neutralization is very effective for the other signals propagating within the same cable sheath, but is completely ineffective for interference from other cables or sources of destructive noise that are located nearby. Video wall installations where the UTP for each of the HDBaseT driven displays is pulled through the same conduit have resulted in complete, disastrous and very visible system failure. Reports of these issues have come from familiar, competent and frustrated integrators.

## SO... BACK TO THE CABLE: ”HEY, DON”T FIGHT IT!”

Category cable is what it is. It’s simply four twisted pairs of wire that when connected together by purpose designed PHY transceivers forms a remarkably capable, resilient, and high performance data transmission linkage. Indeed, this is a configuration that has been undergoing continual development and refinement since the advent of the Ethernet / “XXBASE-T” protocol. PHY transceivers are specifically designed to operate together with and extract the utmost of capability from category cable, period.

Rhetorically, the question begs to be asked; "why not take advantage of inexpensive, robust and readily available PHY transceiver technology to move digital AV signals over UTP the way the cable is intended to be used?" Until recently, the answer has been that there was no direct and practical way to interface HD audiovisual signals directly to the PHY layer.

## BUCKING THE TREND... AGAIN

Considering the value of using such a robust and flexible transport subsystem, Raven elected to move forward with the development of the Talon 5 CODEC. The Talon 5 runs on a high speed FPGA and enables the use of traditional PHY layer topology to transport digital HD audiovisual signals together with high speed auxiliary signals including EDID, DCP, USB2.0, RS-232, IR & bi-directional analog audio.

Talon 5 implements high performance bandwidth compression that adapts to the visual content on the fly and conserves bandwidth, enabling high-quality and reliable transmission via UTP. Motion video is presented in full Bluray™ image quality while stationary graphics, even in the same frame, are presented without compression. The result is truly stunning and the integrator can rest assured that the Digital HD AV signals have been prepared by the Talon to enable effective, reliable and robust transmission over category cable.

## PLUG AND PLAY—REALLY

An expensive service call to reset an unresponsive system is unacceptable. Needing to do so is a bullet aimed squarely at client satisfaction and collective profitability. A large number of systems requiring that kind of attention is unmanageable—and disastrous—from a business standpoint.

Without the need for a cumbersome and unpredictable operating system, the purpose built Talon 5 is extremely robust and resilient. Even rapid and repeated connection/disconnection cycles of the UTP, power or any of the system cables doesn't cause problems—the system simply (in an integrator pleasing fashion) restores operation autonomously.

## DISTRIBUTION OF VALUE

Again, the Talon 5 CODEC adapts or converts HD audiovisual signals and auxiliary signals to a protocol that's portable via available PHY layer components. Processing intensity resides in Raven the transmitter and Raven receiver modules.

Once the signals have been adapted for transmission, the Raven-protocol signals can be distributed, routed and switched through relatively inexpensive equipment. This is in stark contrast to other approaches that require complex equipment to handle distribution (point to multipoint & switching).

With HDBaseT as an example, it's necessary to use an HDBaseT receiver and transmitter (i.e. chipset) at each input and output port respectively. This is not only a costly approach; it unavoidably causes deterioration of the fragile, high bandwidth signal.

In the Raven protocol environment, the signal can be regenerated many times and with a low associated cost. This makes possible the construction of large systems that can cover large installation footprints—even on regular UTP.

## OPTICALLY TRANSPARENT

Talon 5's signal structure is optimized to function in concert with market available PHY components and can also easily be applied to readily available fiber based comms. Using SFP pluggable optics, the newly introduced SX6200 series supports both UTP and fiber applications.

## DECIDING WHICH APROACH IS BEST FOR YOU

Despite limitations imposed by cabling, 10BaseT represents the best of the baseband EQ type solutions and is a candidate for certain applications—such as single links at the consumer level and for applications where latency cannot be tolerated—but not for others...

*to be continued*

## RAVEN TALON 5 vs. HDBaseT: A COMPARISON

| | Raven Talon 5 | HDBaseT™ |
|---|---|---|
| **IMAGE QUALITY** | Excellent | Excellent (if no interference) |
| **COMPRESSION** | Yes, adaptive & non-destructive | None |
| **CABLE BANDWIDTH** | Within CAT6 specification | Exceeds CAT6 specifications |
| **LATENCY** | Less than 20mS | Propagation only |
| **AUX SIGNALING** | USB, 2-way analog audio, full duplex RS-232, broadband IR from RX to TX | Depends on implementation by particular manufacturer |
| **POINT-TO-POINT** | Yes | Yes |
| **POINT-TO-MULTIPOINT** | Yes, $ | Yes, $$$ |
| **MATRIX SWITCHING** | Yes, $ | Yes, $$$$ |
| **REGENERATION** additional distance | Yes, unlimited and no loss of quality, inexpensive mid-line re-clocker available | No |
| **HOSTILE CROSSTALK SUSCEPTIBILITY** okay for video walls with multiple cables in one bundle | Immune | Susceptible |
| **GROUNDING DIFFERENTIAL SUSCEPTIBILITY** | Immune | Susceptible |
| **INTERFERENCE FROM CELL PHONES** | Immune | Susceptible |
| **RESILIENCE** after disconnect/reconnect | Operation re-establishes within 15 seconds, typ. Without user intervention | Varies and in some instances requires source or display to be restarted |
| **FIBER SOLUTION AVAILABILITY** | Immediate | None |



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