Cracking the Color Code

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Q. WHEN TERMINATING A FOUR-PAIR CABLE, SOMETIMES IT IS VERY HARD TO TELL THE DIFFERENCE BETWEEN THE BLUE AND GREEN PAIR AND ALSO BETWEEN THE BROWN AND ORANGE PAIR. WHERE DID THESE COLORS ORIGINATE FROM AND HOW COME THERE IS A DIFFERENCE OF COLOR INTENSITY BETWEEN CABLES?

A. I hear you loud and clear. This seems to be an on-going challenge with installers. In the times that I have had to actually punchdown a four-pair into an RJ-45 jack, it has been a very slow process if done with inadequate lighting (such as on a trade show floor during demo set-up). And the problem is that color-coding and proper termination of each insulated wire color is very important in LAN cabling because the signals are polarity sensitive – reversing a pair will cause a failure, as I quickly found out the hard way.

Let's take a look at the reasoning and history behind the color-coding and also why some cable pair colors are more vibrant.

PRIMARY COLORS

Dating back to the 1940's, four-conductor cables were developed by Bell System for Plain Old Telephone Service (POTS) applications. The insulation on the separate conductors were solid colors – red, green, yellow and black. The primary phone line was the red and green, and if there was a second line, it consisted of the yellow and black wires. Called "quad" cabling, these did not employ twisted-pair technology, and so often lent itself to the cause of crosstalk between the two lines. In fact, most of those quad cables are only found in older homes, and should be replaced.

Certainly, because the colors of the quad cable are primary colors and are easily distinguishable from one another, it would have alleviated some of the challenges today. However, they did play a part in the color-coding of the 25-pair cable and subsequently the "white" is used in four-pair.

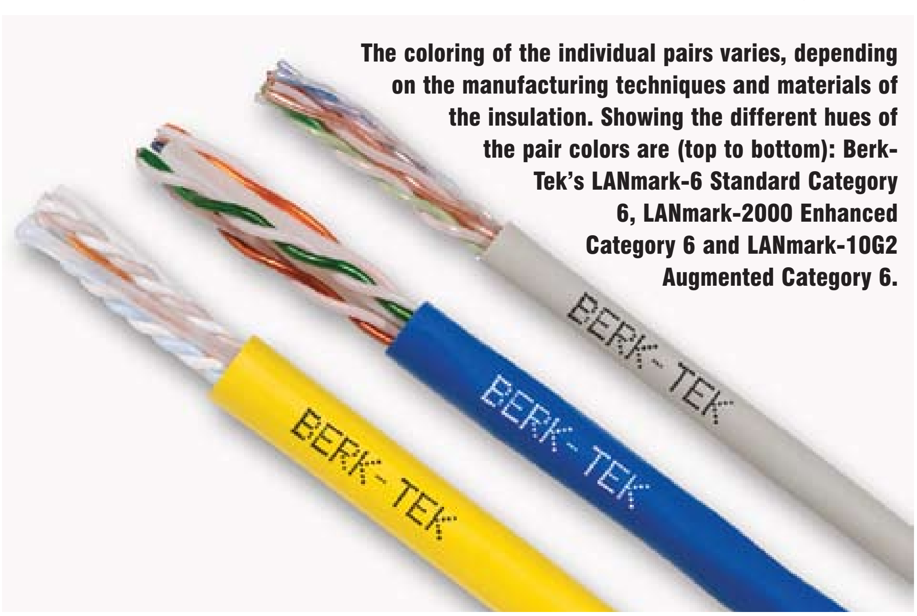
RING AND TIP

About a decade after the quad cable, AT&T®, a division of Bell Labs, developed twisted pair, to alleviate crosstalk, due to the different twist rates in the pairs. These cables were primarily installed for large telephone systems, or outside plant, grouping the cables in bundles of 25 pairs. Each pair consists of two colors, which was referred to as "ring" and "tip" – a term descended from the original manual cord boards used by early telephone operators, since two wires were needed to make that circuit – one through the tip of the cord and the second was through the ring or the "sleeve," but the cable itself resembles today's A/V or headphone cable. So, for twisted pairs, by designating one wire as the "tip" and one wire as the "ring," it makes it easy to distinguish the polarity, as the tip is positive and the ring is negative – hence the term, "balanced cable."

To come up with the color-coding, the 25 pairs are divided into five groupings. The first grouping, which is the primary color, or the "tip," utilizes the colors of the old quad cable – white, red, black yellow, and added violet as the fifth color. A fun mnemonic to memorize these colors is: Why Run Backwards, You'll Vomit.

The second group of colors was selected from the conventional colors of the rainbow, or optical spectrum and are (in order): blue, orange, green, brown and slate. An old industry mnemonic for this group is: Bell Operators Give Better Service.

So when combining the groupings in the twist, the first five combinations (pairs 1-5) are: white twisted with blue, white with orange, white with green, white with brown and white with slate. The second five combinations are: red and blue pairs, red and orange, red and green, red and



The coloring of the individual pairs varies, depending on the manufacturing techniques and materials of the insulation. Showing the different hues of the pair colors are (top to bottom): Berk-Tek's LANmark-6 Standard Category 6, LANmark-2000 Enhanced Category 6 and LANmark-10G2 Augmented Category 6.

brown, red and slate. Get the gist?

COLORS OF THE RAINBOW

When the standards were being developed, following the AT&T divestiture in the 1980's, the standards bodies, for which Bell Labs was a major participant, selected this combination of colors for outside plant and multi-pair telephone cable. Subsequently, with the development of four-pair cabling to the workstation outlet for telephone and then data, it was an easy transition to utilize the first four pairs in the 25-pair color scheme: white and blue, white and orange, white and green, and white and brown. So, there's your answer as to the origins of the colors, now let's look at the applications and why the colors can vary.

For telephone applications, the first line is white and blue and, if there are more phone lines, the second is the white and orange, the third is the white and green and the fourth is the white and brown. However, data applications over twisted pair cabling customarily employ the white and orange and white and green pairs. The white and brown and white and blue pairs were spares or sometimes used for other applications, such as ISDN or in today's Power over Ethernet (PoE)

Color-coding and proper termination of each wire (insulation) color is very critical to the performance of the cable, and ultimately of the application. The color-coding of the four-pair cable has evolved to utilize complementary colors to make sure that the pairs are not mixed up, as it could be confusing with four white conductors paired with blue, orange, green and brown. For Category 5e or higher, an optional stripe of the complementary color is often added to the white insulated wire, which helps with proper termination. In doing so, the color-coding for four-pair then becomes blue and white/blue, orange and white/orange, green and white/green, brown and white/brown.

DISCRIMINATING COLORS

As questioned, the exact hue of these colors can vary greatly from cable to cable. The reasoning is the difference in insulation materials and also manufacturing process. "Colors can appear somewhat muted on plenum cables, because the insulation materials, such as fluoropolymers, are less susceptible to absorb the color than insulation materials used in non-plenum (or riser) cables, such as polyolefin," explains Eric Lawrence, Technical Director of North America for Nexans, Inc. "To make the colors more vibrant would entail adding too much colorant, which could affect the electrical performance of the cable," he further explains.

The design of the cable and the manufacturing processes surely affect the insulation color and the end result. In fact, recently Berk-Tek introduced their small diameter 10G cable, LANmark™-10G2, which uses a newly engineered insulating process, but affects the colors and makes them appear pastel. While the unique geometry and pair configuration in this cable created a significantly reduced cable diameter and preserved the industry leading alien crosstalk performance, the process used altered the insulation color. To add space between the pairs, Berk-Tek employed a unique foam (cellular) technique for insulating the conductors. The foaming made the insulation opaque, as opposed to transparent. As a result, the intensity of the colors are reduced, giving them a pastel appearance. "Because of this process, the foam will not be tainted by the color of the copper conductor, like plenum colorants, and therefore, prove to be a better performing cable," notes Lawrence, who was instrumental in the development of this cable.

In summary, although each insulated conductor of a twisted-pair cable can slightly deviate from a standard uniform color, it is more critical to mate the proper pair to the like color-coded connector, to assure proper termination. Mismatching the pairs to the connector scheme will certainly cause loss of network connectivity. Therefore, it is always a good idea that when you are terminating four-pair cable, make sure you have a flashlight, because you can never be assured of the installation environment and the light will aid in properly identifying the pair colors. ■

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