TURCK

Industrial Automation

Bonded Pair Cable: Does it Have a Place in Factory Automation

A WHITE PAPER

Published 7/12/2013

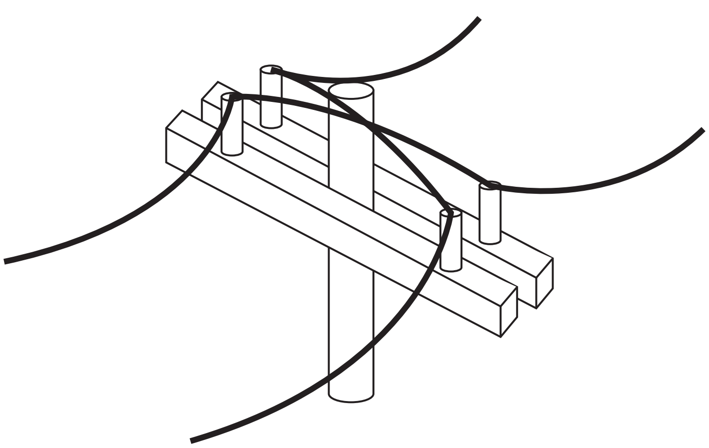
As the manufacturing industry continues to become more communication-centric, it is relying more on unified data communication and automation systems. High-performance cabling solutions not only ensure the success of these systems, but also help to enhance productivity and streamline operation.

Reliable connectivity is a cornerstone for virtually any industrial application, providing the foundation for continued operation for everything from machinery and manufacturing equipment to industrial Ethernet and field instrumentation. Compared to cables in commercial environments, industrial cabling solutions will likely be moved or flexed, and many factory applications require continuous movement and flexing of the cable. It is essential to determine the appropriate type of cable for a specific application prior to installation or use.

This white paper will provide an overview of twisted pair cable, examine the use of bonded pair cables and compare bonded pair to non-bonded pair cable with illustrated, detailed examples of cable flex and its effect on the cable itself.

WHAT IS TWISTED PAIR CABLE

Alexander Graham Bell invented twisted pair cable in 1881 as a means to reduce noise through cabling on telegraph systems. The wires were run so they crossed and changed positions after a certain distance to reduce cross talk from the opposing cable.



This same technology is used today in Ethernet cable and is commonly referred to as twisted pair. Twisted pair technology is made up of a series of two conductor pairs from the same circuit twisted together with the purpose of canceling electromagnetic interference (EMI). EMI is often referred to as noise and can be generated from many external sources, including motors and drives or crosstalk between neighboring conductors. When current flows through the wires, a small magnetic field is created around the wire. When two wires from the same circuit are put together the magnetic fields are opposite of each other and they cancel each other out. Twisting the pair enhances the noise cancelling effects of EMI even more.

There are two variations of twisted pair cables: solid and stranded. This topic is thoroughly discussed in our white paper Ethernet Cable: A Guideline to Implementing Solid or Stranded Cables. Identifying the differences and purposes of solid and stranded twisted pair cable, this white paper provides a good introduction to the main topic of this paper.

BONDED PAIR VS. NON-BONDED PAIR IN INDUSTRIAL APPLICATIONS

Traditional twisted pair cable (non-bonded) was originally designed for use in horizontal and patch cable applications in commercial and office environments. The conductors were designed to allow the twisted pairs to separate during installation as the cable is being fed through walls and cubicles. If the pairs gap or separate too much during the installation process, the integrity of the magnetic field could be damaged which causes the cable to allow EMI into the system.

Bonded pair cable is designed to not separate at the twist, thus preventing the separation of pairs. During installation, bonded pair cable reliably holds the twist of the pairs together to ensure they do not separate or fray at the ends. This allows for sufficient termination at the ends.

Several standards exist regarding pull, bend and flex for commercial Ethernet cable and, when applied properly, will prevent the possibility of damage to the cable during the installation process. However, most commercial installations are subject to conditions that include excess strain on the cable, as well as bending and pressure, which can cause weakness or the possibility of degradation over time. It is important to keep in mind that commercial installations of Ethernet twisted pair cable generally consist of raw bulk IP20 grade cable being pulled through walls and then field terminated using standard IP20 RJ45 connectors. This makes bonded pair an attractive option for commercial installers because it is quick and easy, and provides for a successful termination with little to no rework.

Industrial Ethernet installations differ greatly from commercial applications for many reasons, including the installation process, the connector and the cable jacketing. These applications are ideally suited for non-bonded cables because of the extreme conditions the cables are exposed to.

Industrial applications are subject to environmental conditions that require higher IP rating and special cable jacket that prevent the cable from damage during normal use rather than installation practices. These cables are generally assembled offsite by experienced assembly companies specializing in over-molded connectors. The connectors are most often IP67 rated or higher and made to the correct length for the application, ensuring protection against liquid ingress from exposure. Ease of assembly is not the most crucial concern for most system users. Long life expectancy and reliability are much more critical to the elimination of downtime after a system has been commissioned.

FLEX PERFORMANCE

Twisted pair cable was designed to allow for conductor separation during the installation process as the cable is fed through walls and around objects. In industrial applications, the cable is more likely subject to movement such as continuous bending and flexing.

The following images illustrate what happens when a cable is repeatedly flexed.

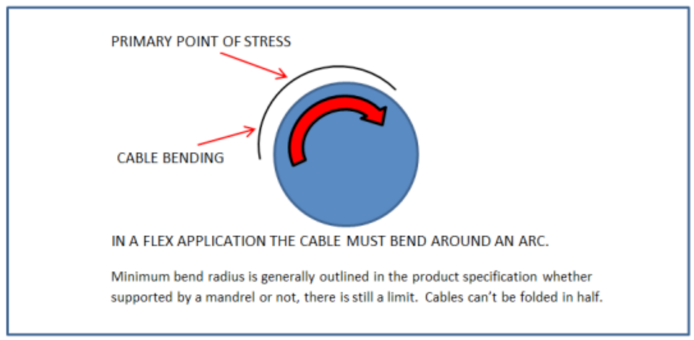


Figure 1

As shown in ***Figure 1***, when a cable flexes, it bends around an arc. Now, when the arc becomes larger around the center point, there is a greater distance. (***Figure 2***)

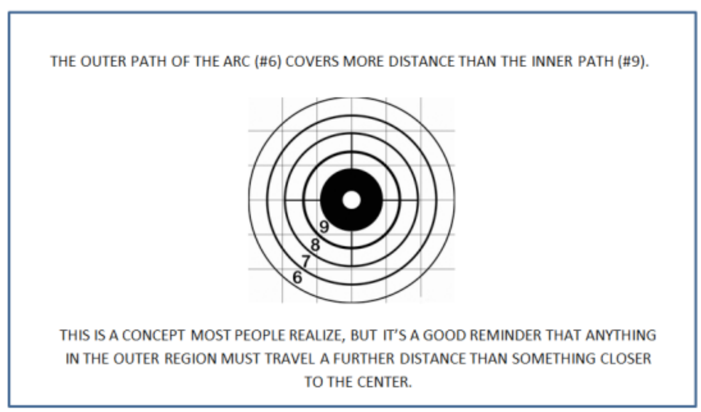


Figure 2

When objects are subjected to bending and flex forces, they should not be completely rigid. For example, consider a mature oak tree versus a young sapling. After a severe windstorm the powerful oak lays broken on the ground and the weak sapling is no worse for the wear. This happens because the oak tries to resist the wind while the sapling bent and swayed in the wind, only to pop back up afterward unscathed.

This same principle applies to flex cable. Although a bonded pair may have assembly advantages, the fact that the pairs are essentially glued together could cause them to be the weak link in a flex application. Bonded pairs behave more like the mature oak than the sapling, as shown in ***Figure 3***.

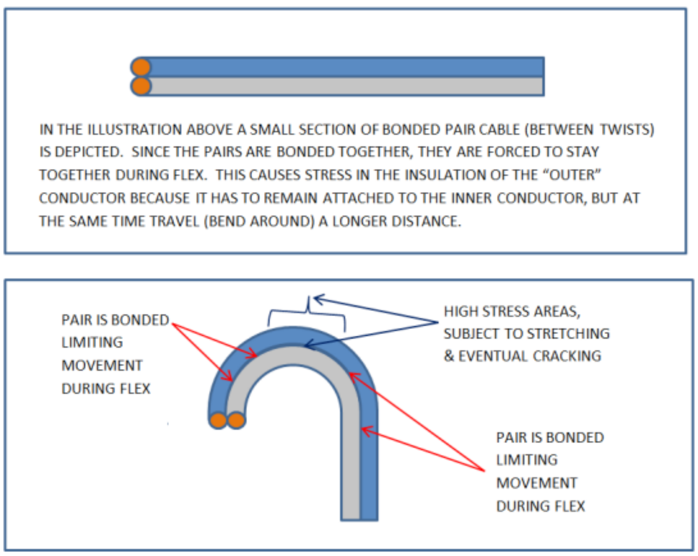


Figure 3

When a bonded pair flexes around an unsupported bend there are two high stress areas, as shown in ***Figure 3***. The first is the area where the pairs are bonded and the second is the space around the outer most edge of the jacket. The outer conductor of the pair has to travel a greater distance than the inner conductor and, since it is attached to the inner conductor, it has no choice but to stretch. The bonded area that holds the pair together has forces induced by the flexing of the cable that are trying to tear the bond between the conductors apart.

In a static bend, (one time bend for install) the bonded pairs hold together. After repeated flexing the bond will eventually fail, leaving an area of the pair now non-bonded. (As shown in ***Figure 4***) Since the rest of the pair remains bonded, the cable still doesn't allow much movement except in the area of the failed bond. This tends to concentrate the majority of flex movement on a very small area of the conductor, which will eventually lead to failure. These failures will spread down the cable as it continues to flex, leading to a lapse in connectivity and downtime.

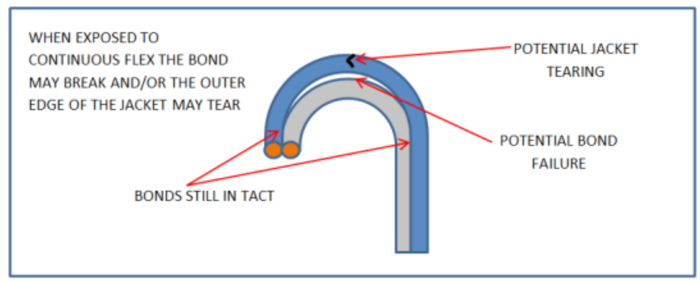


Figure 4

PRESSURE EXTRUDED JACKETS

For continuous motion flex applications, non-bonded pairs have greater life expectancy in comparison to bonded pairs. Non-bonded pairs allow the individual conductors enough freedom of movement to accommodate the abuse of a flex application, however, they too must be protected and kept in close proximity to each other. A pressure extruded cable jacket allows individual conductors to slip over each other during motion, while still limiting the pairs from moving too far apart. Pressure jacketing is a totally different philosophy from using a classic "tubed" jacket and bonding the pairs. These differences are displayed in

Figure 5

Note: the jacket should show the jacket pushing into and partially filling the interstices of the pairs.

A tubed jacket is a tube or sleeve surrounding the pairs in a cable. It has room within it for the pairs to move around and even untwist in certain circumstances. One way of preventing the pairs from untwisting is to bond them together. As discussed earlier, this bonding is suitable for a completely static commercial environment, but is not the best option for an industrial flex application. In a flex application, the pairs require some freedom of movement to allow the individual conductors to accommodate the flex motion by essentially, "going with the flow".

The amount of movement should not be limitless, though, and the individual conductors in a pair must be held in check. This can be done using a pressure extruded jacket. A pressured jacket is created when the extruder head applying the jacket is run under higher pressure with more jacket material. The result is a thicker jacket that not only protects and cushions the pairs while allowing movement, but also limits the amount of conductor-to-conductor gap present in the pair. Pressured jackets also have a firm round profile that is crush resistant and ideal for obtaining a reliable seal with over-molded connectors.

CONDUCTOR-TO-CONDUCTOR GAP

Bonded pair cables keep the pairs together during flex, thus limiting the conductor-to-conductor gap in the pair and may provide a slight benefit to return loss. However, the conductor-to-conductor rigidness can eventually lead to their destruction. Pairs cabled well and held together with a pressure extruded jacket have a minimal conductor-to-conductor gap. This limited conductor-to-conductor gap is desirable because it allows the conductors some freedom of movement which keeps the cable from self-destructing as it performs millions of flex cycles.

In order to test this, pressure jacketed industrial Ethernet cables were flexed 10 million cycles in a flex-testing device that simulates an unsupported bend. An unsupported bend test is much more abusive than a C-Track or tick tock test, both of which add protection to the cable by supporting the bend. When running a sample of bonded pair cable through the same unsupported bend test, failure came in under 600,000 cycles. This means that the possibility exists for cable to fail sooner when the pairs are bonded compared to pressure extruded Industrial Ethernet cables in applications that are subject to bending and flexing.

CONCLUSION

Cabling is important for connectivity and determining the appropriate type of cabling for the specific application is even more crucial. In a factory environment where installed cables are not subject to movement; bonded pair can be a good solution. Alternately, in applications where bending and flexing is required or the environmental demands are greater, non-bonded pairs provide the enhanced solution.