Fact sheet Single Pair Ethernet

Matthias Fritsche – product manager device connectivity &
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HARTING Technology group – October 2016– November 2016

Pushing Performance

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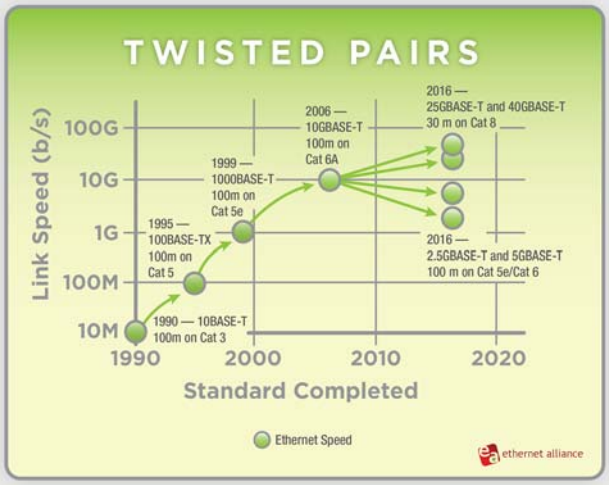
Wireless technology and optical cable have already been often heralded as the future transmission technology. However, simple twisted pair cable based on plain old copper, often pronounced dead, is the most common transmission medium. Simple, robust, and perhaps with 100GBASE T1 soon to be also incredibly fast. From the beginnings of Ethernet in the 1970s, then via diverse multi-pair Ethernet developments with multiple parallel transmission paths, now apparently we are taking a step back. Back to single twisted-pair. With a new protocol and new PHYs transmission rates of up to 10 Gbit/s and PoDL capacities of up to 60 W are no longer a problem. Ultimately one pair is enough.

When the team surrounding David Boggs and Robert Metcalf in the 1970s developed Ethernet at the Xerox Palo Alto Research Center (PARC), no one could foresee that this transmission method would develop so dynamically and dominate data transmission worldwide to this day. The original 10BASE5 Ethernet still used coax cable as the common medium. Today, next to wireless and optical cables, twisted-pair cable, often pronounced dead, is the most frequently used transmission medium. Starting in 1990 with 10BASE-T, the data transmission rate of the IEEE standards increased by a factor of 10 approximately every 5 years over 100BASE-TX and 1000BASE-T up to 10GBASE-T. This series could not be continued for the jump to 100GBASE-T, instead however four new IEEE standards were finalized in 2016. In order to make previously installed Cat. 5 /(5e) and Cat.6 networks fit for higher data rates, in particular for connection of data-hungry WLAN access points, 2.5GBASE-T 5GBASE-T were specified. All of these standards can be implemented for transmission lengths of up to 100 m and thus they are predestined for classic building and industry cabling. For the high-capacity cabling in computing centers 25GBASE-T and 40GBASE-T were added for transmission lengths of up to 30 m. As the next steps 50GBASE-T and certainly in the near future also 100GBASE-T1 will be taken up.



Overview of the IEEE 802.3 standards for Ethernet over twisted pair cable (Source: http://www.ethernetalliance.org/)

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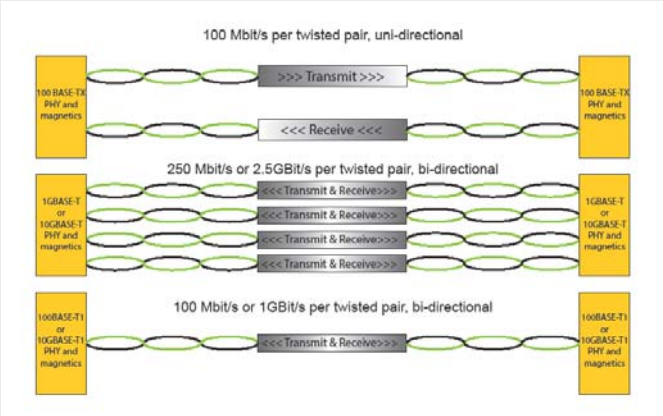
The synapses

To date the determining plug connector interface for the cabling is RJ45. For the industrial application area this plug connector has been packaged in different designs robust, as well as waterproof and dustproof. The most common designs in this area are the industrial plug connector design Han® 3 A (variant 5), as well as the small HARTING PushPull (variant 4), and the Han® PushPull (variant 14) designs. Moreover, in the industrial environment the 4-pin M12 d-coded design and the 8-pin M12 x-coded design are widespread. In addition to other advantages, these internationally standardized plug connectors are an important prerequisite for the worldwide pervasiveness and use of Ethernet.

In this regard up to 100BASE-TX the data transmission occurs via two twisted pairs of wires. One pair is used for transmitting and the other pair is used for receiving. With 1000BASE-T transmission occurred on a parallel, bidirectional data transmission over all four pairs of wires. In this case 250 bits/s are transmitted per pair of wires. The BroadR-Reach® technology from Broadcom uses this bidirectional data transmission for transmission of 100 Mbit/s Ethernet over only one twisted pair of wires.



Overview of the Ethernet transmission principles

Initially this technology met with great interest in the automotive industry, which needed a cost-effective replacement of the still dominant CAN bus for the increasing data rates, in particular required for driver assistance systems and future autonomous vehicles, but also for infotainment systems. Ethernet over only one twisted pair of wires is ideal for this. It is inexpensive and in comparison to the CAN bus it is virtually weight neutral. Thus through IEEE 802.3 Working Groups 100BASE-T1 (IEEE 802.3bw) and 1000BASE-T1 (IEEE 802.3bp) were specified. In these two standards a 15 m channel over one unshielded twisted pair of wires is defined for use in the vehicle. Furthermore, both standards also include the parameter definitions for a 40 m transmission channel over one shielded and twisted pair of wires for use in trucks, buses, aircraft, trains, and industrial applications.

Connection sought

Deviating from the multi-pair Ethernet standards with the clearly defined RJ45 plug connector (the correct designation is actually 8P8C modular connector), the single-pair standards for T1 Ethernet not include any specifications concerning execution of the plug connector interface. If vehicles are considered as closed systems this procedure makes sense, since even today different interfaces are installed in vehicles from different manufacturers. However, for the use and spread of T1 Ethernet in industrial applications or building automation, with a variety of market participants, a clearly defined plug connector standard is just as necessary as it is for 4-pair Ethernet. This applies all the more for the new standard 10BASE-T1, which is currently still a work progress, that should enable transmission of 10 Mbit/s Ethernet over distances of up to 1000 - 1200 m. Thus in the long term this new standard has the potential of completely replacing all fieldbus systems in use today.

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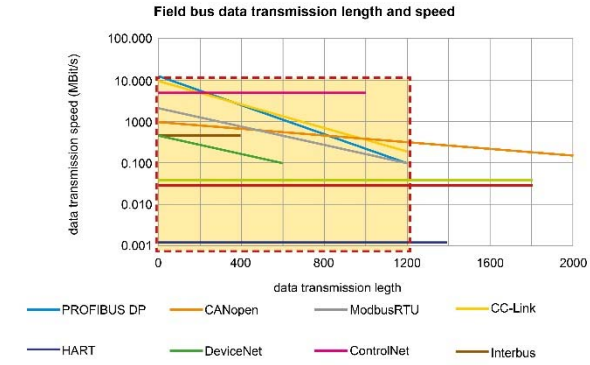

Diagram of the typical data rates and transmission lengths for popular fieldbuses (Source: IEEE 802.3 10 Mbit/s Single Twisted Pair Ethernet Call for Interest (CFI))

This applies all the more because analogously to PoE (Power over Ethernet), a power standard with the name Power over Data Line (PoDL) is also specified for single-pair Ethernet. Publication of this standard IEEE 802.3bu is anticipated in early 2017. Thus a single pair of wires can be used simultaneously for power supply and data transmission.

As the proverb states: "Give him an inch and he'll take a mile." And likewise, the previously standardized 1 Gbit/s over a single pair of wires is not yet the end. Whether radar systems and LiDAR systems or high resolution cameras and displays, the necessity already exists today of transmitting higher data rates exists in the vehicle, as well as in industrial applications. These requirements will be the object of the discussion at the next IEEE 802.3 Plenary Session in November, and it is considered quite likely that a working group will be established for this standardization project. The desire is to standardize 10GBASE-T1. However, it is also possible that this objective will be achieved with intermediate steps from 2.5GBASE-T1 or 5GBASE-T1.

Minimalistic but with incredible potential

There is immense potential in this new technology. As compared with multi-pair Ethernet, cables and plug connectors will become smaller and simpler. Sensors, actuators, and network nodes can be networked and supplied with power with only a single pair of wires. What is still lacking for worldwide success of this ingenious technology is the uniform standard for the connection technology – the uniform T1 interface so that network components from different manufacturers can be easily interconnected without complex adapters. Standardization of such a uniform T1 connector face for plug-compatible IP20 or IP 65/67 designs is the objective of an IEC standardization project submitted by the HARTING Technology Group headquartered in Espelkamp Germany. The starting point of this draft standard is a shielded 2-pin plug connector with an active and robust metallic locking mechanism. Precisely this connector face is provided in two round IP65/67 connector faces. In this regard for one variant a snap-in locking mechanism of plastic, similar to the mechanism for standardized for M8 plug connectors in accordance with IEC 61076-3-104, is recommended. The second variant is even more robust and is based on a PushPull locking mechanism of metal. Thus the many possible application scenarios are taken into account and a product assortment is introduced into the standardization process that can be used for applications in automation technology, robotics, and machinery & plant manufacturing, as well as in building automation or the transportation market. And this is not the only IEC project for T1 Ethernet Another expert group is working on a corresponding IEC standard for T1 cable and a Technical Report will deal with the issue of how T1 Ethernet cabling can be structured Thus it is clear that the market potential and the advantages of T1 Ethernet are identified, and that the necessary actions for making this technology ready for market implementation are well underway worldwide.

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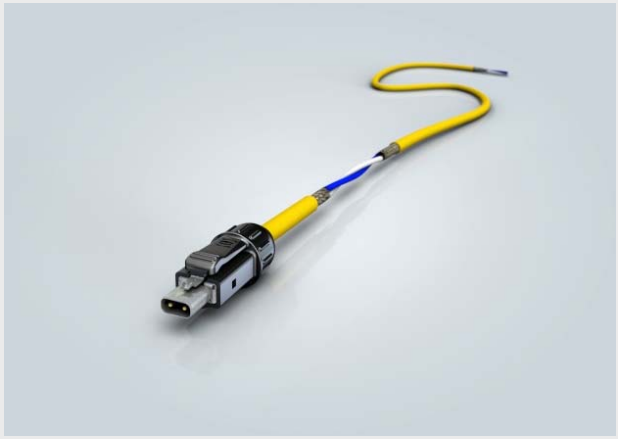


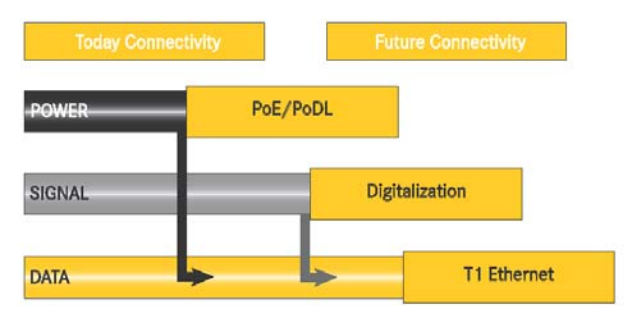
Concept for a T1 plug connector in IP20 protection degree

The pair needs predictability

Only the last Achilles' heel of standard Ethernet, as compared to fieldbuses and Industrial Ethernet systems, still remains, and that is the lack of determinism. With Time Sensitive Networking (TSN), currently the IEEE is developing a new future technology that supplements conventional Ethernet in accordance with IEEE 802.1 and IEEE 802.3 with a degree of determinism for the data transmission, which was previously not possible.

Conclusion

The advantages of transmitting Ethernet via just a single twisted pair of wires at gigabit transmission speed and simultaneously supplying devices with power are diverse and ingenious. The issue that are still open today, such as standardization of the T1 connection technology and open cabling standards are identified and are already being worked on. Also the supply for the necessary PHY chipsets will soon quickly increase and be available at favorable costs, particularly under the influence of the automotive industry. Thus the two lifelines, data and power, can be realized with a single pair of wires up to a power range of currently 60 W. Under the influence of digitalization signals will be digitally converted directly in the sensor. Thus in the future, T1 Ethernet will cover what today are frequently still individual lifelines, data – signal – power for a variety of sensors and actuators in one wire pair. With Time Sensitive Networking (TSM) the last problem, i.e. Ethernet's lack of determinism, will also be eliminated. More extensive information concerning TSN standards is provided on the IEEE 802.1 and 802.3 Internet sites, and current TSN white papers from various companies are available on the Internet. Thus T1 Ethernet is the means of choice for developing with Ethernet the field level, which today is still dominated by fieldbuses. In addition to simpler cabling and simpler connection technology, the interfering interfaces and gateways are also dispensed with. Thanks to what will then be a uniform network protocol, specialized knowledge will no longer be required for fieldbus systems, and engineering, installation, and maintenance of these networks will be greatly facilitated. Why then pursue expensive and complicated paths? In the foreseeable future it could be that: "One pair is enough!"



"One pair is enough" for transmission of data, power, and signals

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