Top results, every time – **with RS**

Power over Dataline in practice

single-pair Ethernet: World on the Wire II

no.rs-online.com

Image: RS Components

Power over Dataline in practice

Single-pair Ethernet: World on the Wire II

The Ethernet standard is today's most widely used protocol in industrial communication. Copper cables with 2 pairs for Fast Ethernet and 4-pair cables for Gigabit Ethernet are core elements in corporate and industrial networks. Single-pair Ethernet (SPE) technology paves the way for a number of new use cases, to replace analogue sensor applications or industrial bus systems. In addition to the communication capabilities at control level, one of the most 'charming' capabilities of the SPE is that the same pair of cables that transports the data can also transfer power: Power over Data Line.

In 2021, a market study (Fig. 1) by HMS Networks showed that about 65% of all industrial communication protocols were Ethernet-based. It should be noted that a relatively high percentage (28%) of fieldbus systems such as Profibus, Modbus-RTU and CC Link were also in use.

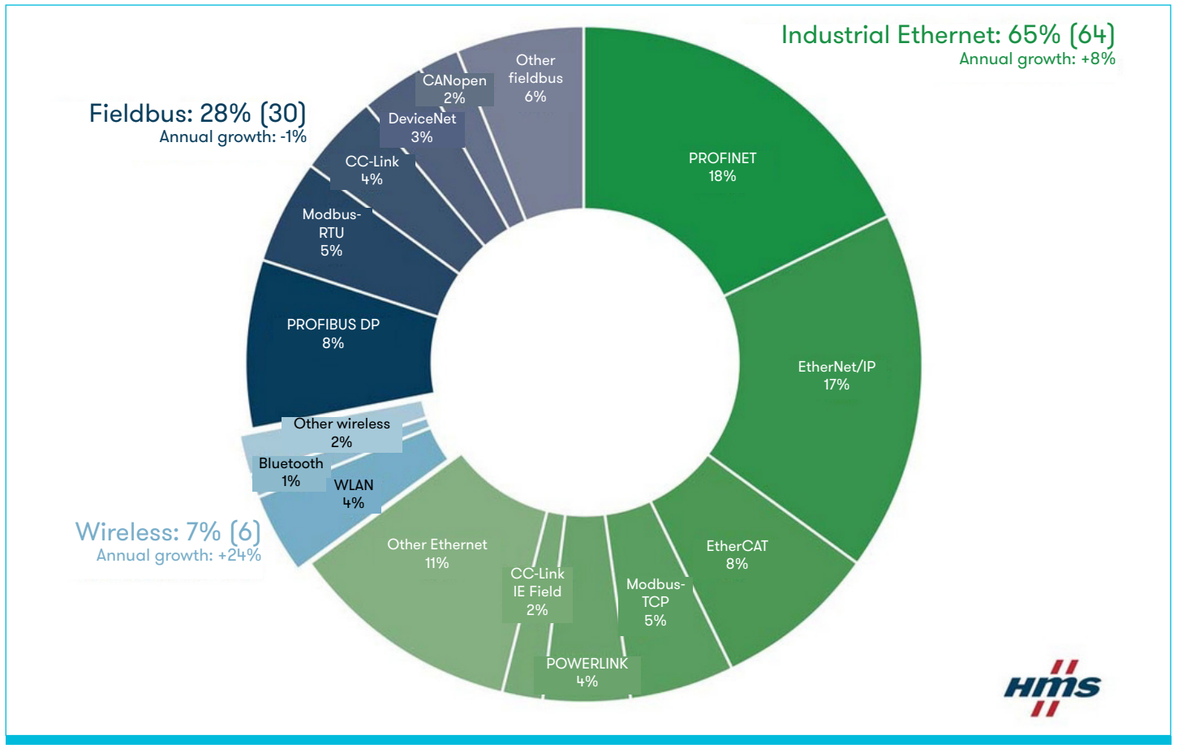

Image 1. Market shares of industrial communication protocols in 2021 (image: HMS)

Sensors or actuators within production automation systems are often expected to bridge distances of more than 200 m to their next connection point, which is usually a switch. This means that industrial Ethernet – which works using conventional office technology – reaches its limits at a maximum cable length of 100 m.

Fieldbuses that bridge further distances become weaker at the transferable data rate (Table 1).

Fieldbus	Data rate	Cable length
Profibus DP	9.6 kb/s to 12 Mb/s	100m to 1200m
Profibus PA	31.25 kb/s	1900m
CANopen	62.5 kb/s to 1 Mb/s	30m to 1000m
DeviceNet	125 kb/s to 500 kb/s	100m to 500m
AS interface	167 kb/s	100m
CC-Link	10 Mb/s	100m
IO-Link	230 kb/s	20m

Table 1. Comparison of common fieldbus solutions (source: Belden)

IP from sensor to the cloud

The fieldbus infrastructures at control and field level are dividing automation technology. The resulting data islands require complex gateways that complicate access to external device data. Eliminating these gateways could significantly reduce the cost and complexity of these facilities and we could altogether remove the data islands they create.

One approach to avoid this fragmentation is to extend the Ethernet communication from control level to sensor/actuator level. However, as described, this approach is complicated by the maximum cable lengths of 100 m, the use of a minimum of two wire pairs and by less usable RJ-45 connectors.

Single-pair Ethernet (SPE) may be the perfect answer to overcome the shortfalls of Industrial Ethernet. Each sensor or actuator can be reached via Internet protocol and can transfer its data smoothly to and from the cloud.

Single-pair Ethernet and its communication capabilities

Single-pair Ethernet can transport data at 10 MB/s, 100 MB/s and 1 GB/s via two-wire copper cables and at the same time power end devices via Power over Data Line (PoDL). The data rates and cable lengths are as follows:

- 10 MB/s (duplex) to 1000 m, transmission at a bandwidth of 20 MHz (10BaseT1L)
- 10 MB/s (semi-duplex) to 40 m, transmission at a bandwidth of 20 MHz (10BaseT1S)
- 100 MB/s (duplex) to 15 m, transmission at a bandwidth of 66 MHz (100BaseT1)
- 1000 MB/s (duplex) to 40m, transmission with a bandwidth of 600 MHz (1000BaseT1)

A central capability – PoDL

One of the core capabilities of single-pair Ethernet is the simultaneous transmission of data and power supply via the cable pair – Power over Dataline (PoDL, Fig. 2). The IEEE 802.3bu standard: "Physical Layer and Management Parameters for Power over Data Lines (PoDL) of Single Balanced Twisted-Pair Ethernet" sets out, as with Power over Ethernet (PoE), the provision of a remote power supply via single-pair Ethernet channels.

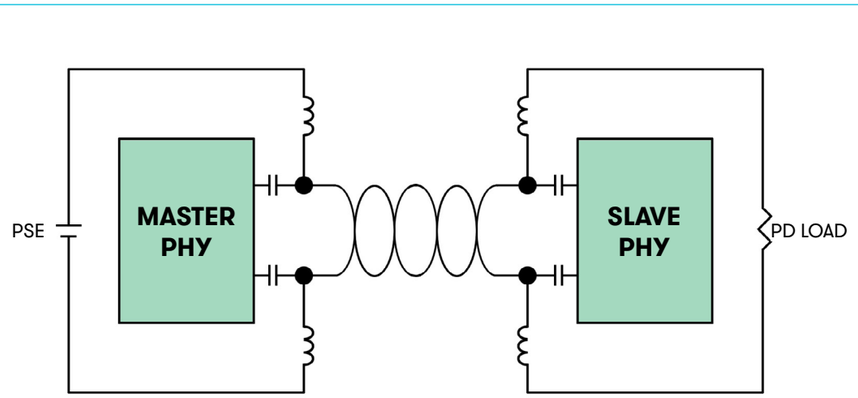

Image 2. Simultaneous transmission of data and power supply via the cable pair. (Image: channel-e)

Goals and targets for PoDL operation include:

- Allowing the operation of a powered device even if no data is available
- Supporting voltage and current levels for the automotive, transportation and automation industries
- Supporting quick-start operation with predefined voltage/current configurations and optional operation with runtime voltage/current configuration

PoDL can transmit electrical energy in 10 voltage/current classes at powers of between 0.5 W and 50 W (consumer power, feed-in power = 63.3 W) (Table 2). IEEE 802.3cg increases this by adding 5 new classes (Table 3). This type of power supply requires two-wire cables in accordance with IEC 61156. Category 7 STP cables are not suitable.

It should be noted that when using PoDL, the transmission distance specified in the standard may not be reached. Depending on the cable diameter, significant reductions in distance are to be expected, especially in the higher performance classes. A 10Base-T1L connection, which has a transmission distance of 1000 m with an AWG 18 cable without power supply, is reduced to a distance of 170 m under PoDL Class 15. With an AWG 22 cable, the transmission distance is reduced from 620 m without PoDL to 70 m in PoDL Class 15 (determined by Reichle & De-Massari).

Class	0	1	2	3	4	5	6	7	8	9
Voltage [V]	5.5-18	5.5-18	14-18	14-18	12-36	12-36	26-36	26-36	48-60	48-60
Current [A]	0.1	0.22	0.25	0.47	0.1	0.34	0.21	0.46	0.73	1.3
PD output [W]	0.5	1	3	5	1	3	5	10	30	50

Table 2. IEEE 802.3bu: PoDL classes (PD = Powered Device)

Class	10	11	12	13	14	15
Voltage [V]	20-30	20-30	20-30	50-58	50-58	50-58
Current [A]	0.092	0.240	0.632	0.231	0.6	1.579
PD output [W]	1.32	3.2	8.4	7.7	20	52

Table 3. IEEE 802.3cg: Additional PoDL classes (PD = powered device)

PoDL offers both reliable fault protection and detection functions to identify and communicate with devices for safe and secure power supply.

We use an additional communication protocol to determine the required supply class: SCCP (Serial Communication Classification Protocol). PSE (Power Sourcing Equipment) and PD (Powered Devices) use this protocol to handle the PD's supply demands.

Similar to standard Ethernet PoE, this standard specifies that a detection and classification phase is required. This means that during detection, the PSE determines if the connecting device is a compatible PD. If so, it switches to the next stage of classification. The PSE reads from the PD which performance class should be supported. If the PSE and PD support the same classes, the PSE turns on the power.

Although the steps are similar to those of standard Ethernet PoE, they are implemented in a different way. For detection, a PoE-PSE must detect a resistance on the PD side, and a PoDL-PSE must detect a Zener diode in the PD. To do this, the PSE places a constant current through the cable and measures the voltage. The Zener diode limits this voltage and the PSE recognises it as valid when it is within a certain range. The classification is implemented at PoDL as a single-wire digital communication, the Serial Classification Protocol (SCCP).

A PoDL system does not always need both detection and classification features; it must have one or the other, or both. It can implement a quick power-on and skip the classification stage, so it only needs to be able to detect. It is also possible to skip the detection stage, in which case, classification is required. The standard does not allow for a system without detection or classification features.

To maintain power supply, the PD must draw a current of more than 11 mA every 10 ms. Otherwise, the PSE assumes that the PD has been disconnected and switches off the connection. This preset is called MVFS (maintain full voltage signature).

We have now covered the theory part.

In practice

For PoDL, the most practical solution would be to use an IC that takes care of both the detection and classification phase. However, such an IC is not yet on the market and a discrete solution is relatively complex (one PoDL training paper states: "SCCP is quite complicated").

The bare minimum

The single-pair Ethernet user organisation, SPE Industrial Partner Network, is working towards "a kind of Industrial PoDL" with 24 VDC and without SCCP (Table 4). Talking about the economic reasons for this initiative, the panel said: "It doesn't make sense for a PSE or PD to support all 16 (PoDL) classes. Especially in switches or PoDL injectors, the effort this calls for would be too great and therefore uneconomical. A restriction, for example, to the usual 24 V for automation seems appropriate here...". Such a solution is quite practicable as well as standard-compliant.

	IEEE 802.3bu								IEEE 802.3cg							
	12V unregulated		12V regulated		24V unregulated		24V regulated		48V regulated		24V			55V		
Class	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
V_{PSE}[V] max	*18*				*36*				*60*		*30*			*58*		
V_{PSE}[V] min	6		14.4		12		26		48		20			50		
I_{PI}[mA] max	101	227	249	471	97	339	215	461	735	1360	92	240	632	231	600	1579
P_{PD}[W] max	0.5	1	3	5	1	3	5	10	30	50	1.23	3.2	8.3	7.7	20	52

Table 4. What the "Industrial PoDL" could look like (source: SPE Industrial Partner Network, power supply to single-pair Ethernet devices)

Hybrid or single-pair plus

Another option for transferring energy is a solution that has an additional pair of wires just for the power supply. This hybrid power supply enables greater output and daisychain structures, which can loop the power supply from device to device while enabling maximum connection lengths.

Image 3. M8 Hybrid interface with SPE and power contacts (image: Harting)

The M8 Hybrid (Fig. 3) has a specially-designed IEC 63171-6-standardized interface for 60V/8A. Further M12-based combination interfaces for SPE and power are in progress and set for IEC 63171-7-standardization. This connector has 5 power supply contacts plus the SPE contact pair built into the M12 design. Different versions from 60VDC/50VAC to 630VAC use plug-in safe coding for a 3-phase configuration.

Based on documentation from:

Texas Instruments
Reichle & De-Massari AG
SPE Industrial Partner Network
Würth Elektronik