HIRSCHMANN
A BELDEN BRAND

White Paper

Power over Ethernet

IEEE 802.3af

Contents

Introduction

The networking of industrial installations is an important and steadily expanding topic in the field of automation. Just as office networking once did, Ethernet networking is now advancing into industry and making strides to replace existing standards such as Profibus. A number of companies now offer networking solutions under the name Industrial Ethernet. Their offers range from small entry level switches through modular Gigabit switches right up to wireless LAN (WLAN) access points. The IEEE 802.3af standard, which supports the simultaneous network transfer of data and power, was introduced to reduce installation costs and provide more flexible networking facilities. It means that, instead of separate network cables for data, power and telephones (VoIP), everything can now be conveyed via a single LAN cable. Many offices are already successfully using equipment such as IP telephones and access points with PoE functionality. Unlike office networks with their star-shaped network structures, industrial applications generally use a linear arrangement. The industrial use of Power over Ethernet (PoE) is somewhat restricted by the fact that the PoE standard describes only point-to-point connections.

Basic principles of PoE

The Power over Ethernet (PoE) facility, which is standardized under IEEE 802.3af, was developed to reduce the cost of network planning, cabling and installation. The equipment is powered directly over the data line (e.g. for distances up to 100m via a CAT 5/5e cable). PoE makes network planning flexible and independent of switch cabinets and power sources, and also saves additional outlay for power and telephone networks (VoIP). The principal advantage of Power over Ethernet is that it renders power cables unnecessary, so that equipment with Ethernet interfaces can be installed even in inaccessible locations or where extra cables would be in the way. This not only makes it possible to make massive savings on installation costs, it also facilitates the operation of uninterruptible power supply systems (UPS) to improve the reliability of the attached equipment. PoE is primarily used for low-powered terminal devices, typically IP telephones, cameras and wireless transmission equipment such as WLAN or Bluetooth access points, but it can also provide a redundant power supply for switches to increase the network's reliability. For example, if the power supply to a switch should fail, it can continue to operate under PoE power, which markedly increases the availability of the network. PoE can be used in four-wire or eight-wire networks. In four-wire networks can only be used phantom power, but eight-wire networks can use both phantom and spare-pair power. Power over Ethernet is specified and standardized by IEEE 802.3af standard, which subdivides devices into two groups

1. Power over Ethernet PSE (power sourcing equipment): this type of device functions as a power source and supplies PoE PD devices with power via the data line.

2. Power over Ethernet PD (powered device): this type of device consumes power that it receives via the data line from a PoE PSE device.

PD detection and classification

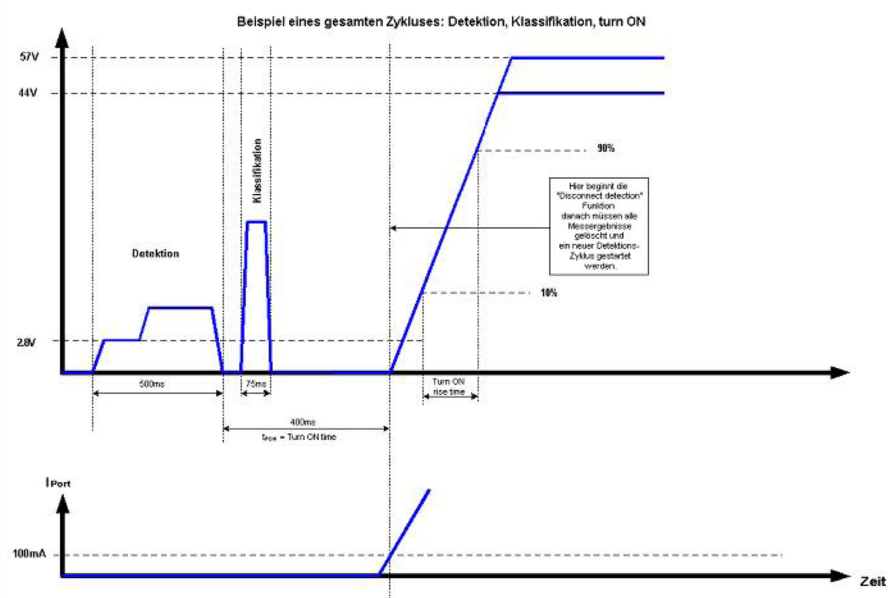
PSE devices as defined under IEEE 802.3af incorporate a checking mechanism in order to prevent damage to any incompatible equipment that may be connected. This means that only devices that possess an authenticating characteristic based on the IEEE 802.3af standard can receive power via the data line.
The following input parameters are checked in order to establish whether or not a PD is connected:

- characteristic resistance = R_{GOOD}(19k – 26, 5k),
- typical resistance = RTY P (25k),
- characteristic capacity = C_{GOOD}(max.150nF).

This method is called "resistive power discovery". The detection voltage Vdetect must lie within the valid range Vvalid. The PSE measures the current at the power interface (PI) of the PD at two different Vdetect voltages and uses these measurements to generate a ΔVtest and a ΔItest. From these it is then possible to calculate the PD's differential input resistance, which is the decisive factor in the PSE's decision as to whether to activate the external power feed:

- R = RGOOD -> PD present
- R = RBAD -> no PD present

Once the PSE has recognized that a PD is present it begins the classification process, i.e. it establishes the power requirements of the attached device. It does this by applying a specific voltage, Vclass, to the PD's PI and measuring the resultant current, Iclass. The PD's assignment to a power class depends on the value of this current. Only when this has been done is the entire voltage, Vport, switched to the PI.



Example of a complete cycle: detection, classification, turn ON

Item	Parameter	Symbol	Unit	Min	Max	Additional information
1	Idle voltage	V_{oc}	V		30	Only in detection mode
2	Short-circuit current	I_{SC}	mA		5	Only in detection mode
3	Valid test voltage	V_{valid}	V	2.8	10	
4	Classification voltage	V_{elas}	V	15.5	20.5	
5	Potential difference between test points	ΔV_{test}	V	1		
6	Interval between two measurements	T_{BT}	ms	2		at max. f = 500Hz
7	Slew rate	V_{slew}	V/µs		0.1	
8	Valid signature resistance	R_{GOOD}	KΩ	19	26.5	
9	Invalid signature resistance	R_{BAD}	KΩ	15	33	
10	Idle resistance	R_{open}	KΩ	500		
11	Valid signature capacity	C_{GOOD}	nF		150	
12	Invalid signature capacity	C_{BAD}	µF	10		
13	Signature offset voltage tolerance	V_{OS}	V	0	2.0	
14	Signature offset current tolerance	I_{OS}	µA	0	12	

Table 2.1: PSE PI detection requirements

PD rejection criterion

- Resistance less or equal RBADmin (≤15k) or
- Resistance greater or equal RBADmax (≥ 33k) oder
- Capacity greater or equal CBADmin (≥10µF)

PoE power classes

The IEEE 802.3af standard subdivides the power supplied at the PSE side (see Table 2.2) and the current consumption of the PD at the PSE side (see Table 2.3) into five different classes. Transmission losses (see Figure 2.5) mean that the PD no longer has the total power available to it (see Table 2.4).

Transmission losses

The PSE provides the PD with at most 15.4W with 350mA at a minimum voltage of 44V. A standard 100m Cat5 cable has a resistance of ca. 20Ω, corresponding to a transmission loss of ca. 2.45W.

RCABLE = (20Ω||20Ω) + (20 Ω||20Ω) = 20Ω
PCABLE = (350mA)2 *20Ω = 2.45W
PPD = 15.4W – 2.45W = 12.95W

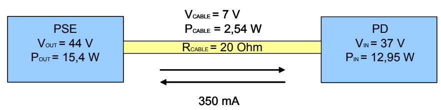


Figure 2.5: Transmission losses

Class	Purpose	Min. power level at the PSE output
0	default	15.4 watt
1	optional	4.0 watt
2	optional	7.0 watt
3	optional	15.4 watt
4	reserved for future applications	handle as class 0

Table 2.2: PoE PSE power classes

Measured classification current	Classification
0mA to 5mA	Class 0
>5mA and <8mA	Class 0 or 1
8mA to 13mA	Class 1
>13mA and <16mA	Class 0, 1 or 2
16mA to 21mA	Class 2
>21mA and <25mA	Class 0, 2 or 3
25mA to 31mA	Class 3
>31mA and <35mA	Class 0, 2 or 3
35mA to 45mA	Class 4
>45mA and <51mA	Class 0 or 4
≥ 51mA	Class 0

Table 2.3: PD classification

Class	Purpose	Power at the PD input
0	15.4 W	0.44 to 12.95 W
1	4.0 W	0.44 to 3.84 W
2	7.0 W	3.84 to 6.49 W
3	15.4 W	6.49 to 12.95 W
4	Like class 0	Reserved for future applications

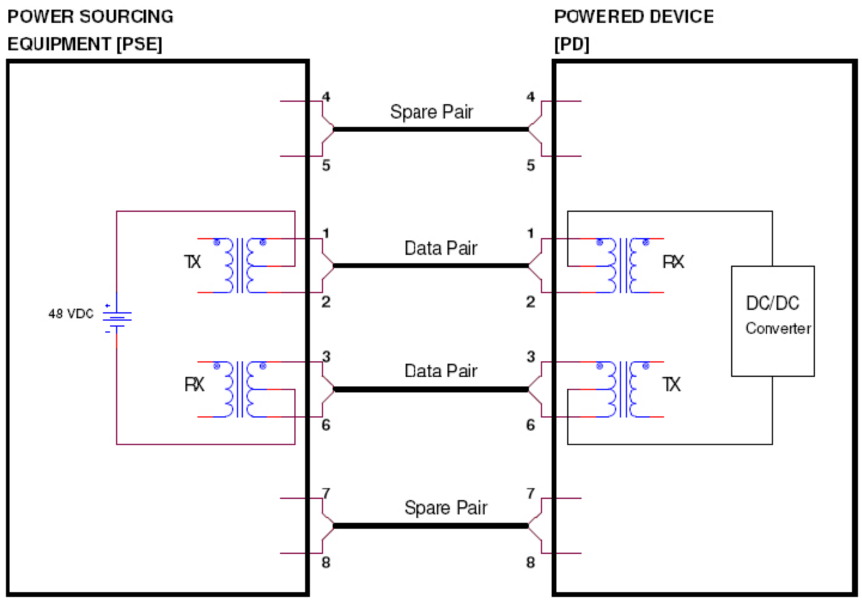
Table 2.4: PD power classes

Power supply methods

Two different methods are used for feeding power into the data line:

1. Phantom power feed
2. Spare-pair power feed

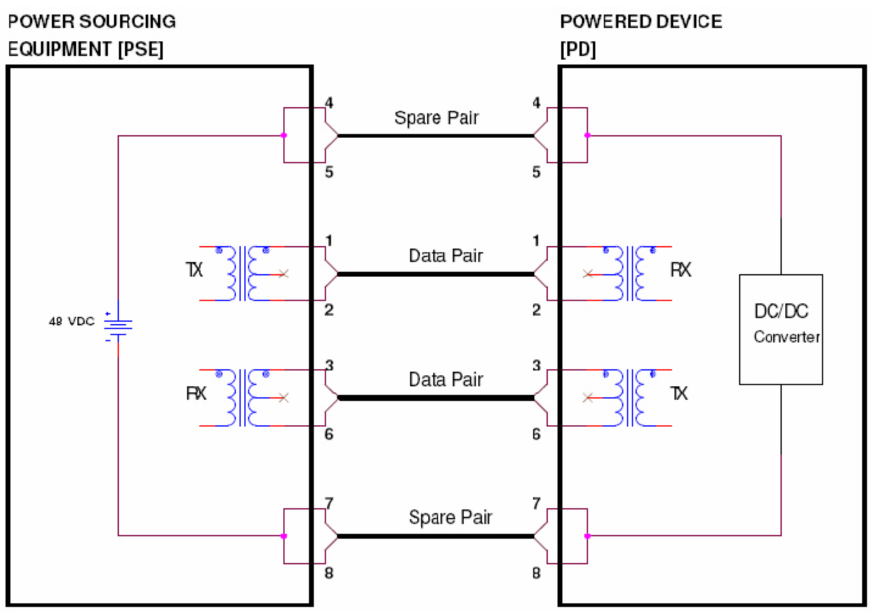
All power devices must always support both of these. For power sourcing equipment it is up to the manufacturer which is supported.



Phantom power feed

A phantom power feed has the voltage coupled to wire pairs 1/2 ( ) and 3/6 (+). This method can be used for networks with four-wire or eight-wire cabling.

Spare-pair power feed



Spare pair power feeds utilize wire pairs that are not otherwise used, the voltage being placed directly on the spare pairs 4/5 (+) and 7/8 (-). This method can be used only on networks with eight-wire cabling. This does not apply to Gigabit Ethernet, because here all eight wires are used for signal transmission and there are therefore no spares.

Power insertion points

When using PoE it is also necessary to decide between midspan and endspan power insertion.

Midspan

A midspan module is a device that can be integrated into an existing network in order to make power available on the data lines. This is a relatively easy way of incorporating a PoE powered device (PD) into a non-PoE network and an easy way to upgrade existing networks.

Figure 2.6: PoE midspan power insertion

Endspan

In the case of an endspan module, the PSE is already integrated into the switch. This means that the switch can make PoE available to its Ethernet ports: there is no need for midspan modules or for any other power supply provision.

Figure 2.7: PoE endspan power insertion

Example of detection and classification – the PoE controller MAX5945

The MAX5945 is a four-port power management controller marketed by Maxim. It incorporates all the necessary circuitry (PD detection, classification, ...) for setting up standards-compliant power sourcing equipment.

The MAX5945 can be operated in three different modes.

1. fully automatic
2. semi automatic
3. manual

In fully automatic mode the MAX5945 takes complete control, from detection through classification right down to switching the PoE voltage to the appropriate ports. Semi automatic mode is designed to have the PoE controller deal with detection and classification and use an additional controller to activate the PoE voltage.

In manual mode the MAX5945 passes all control to another controller.

We can describe the wiring and operation of the MAX5945 on the basis of a sample PoE-capable RJ45 port.
Detection voltages are applied via the OUT pin and the resultant current measured at the detection pin (DET). If the device is recognized as a valid PD, the classification voltage is applied via OUT and the resultant classification current again measured at the DET input. Only when the power class has been established and found to be within a valid range is the power transistor activated via the GATE output to make the full 57V available to the PD.

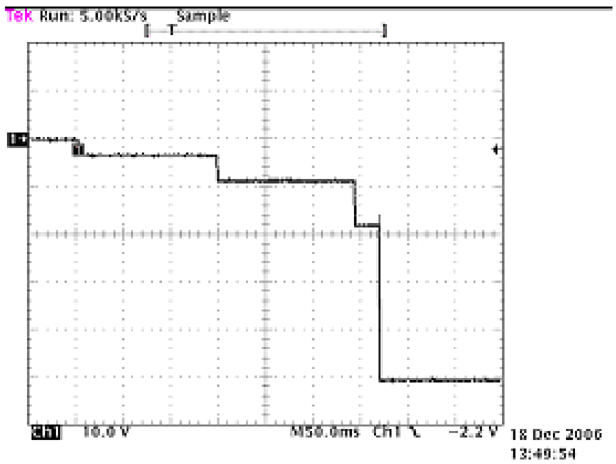


Figure 3.6: Signature of a valid PD

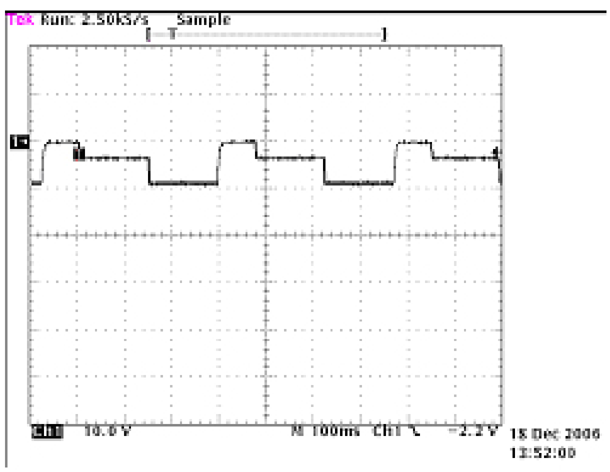


Figure 3.7: Signature of an invalid PD

Figure 3.6 shows the signature of a valid PD: the two detection phases and the classification are clearly visible. Figure 3.7 shows the signature of an invalid PD: at the end of the detection phase the device switches off and initiates a new detection cycle.

The SENSE pin is linked to a comparator circuit that is responsible for monitoring the port while a PD is in operation (DC disconnect). If the connection to the PD is interrupted, i.e. if the voltage at the SENSE pin drops below the DC-disconnect threshold for longer than at most 400ms, the controller will deactivate the port. The overcurrent cutout is also controlled using the SENSE pin.

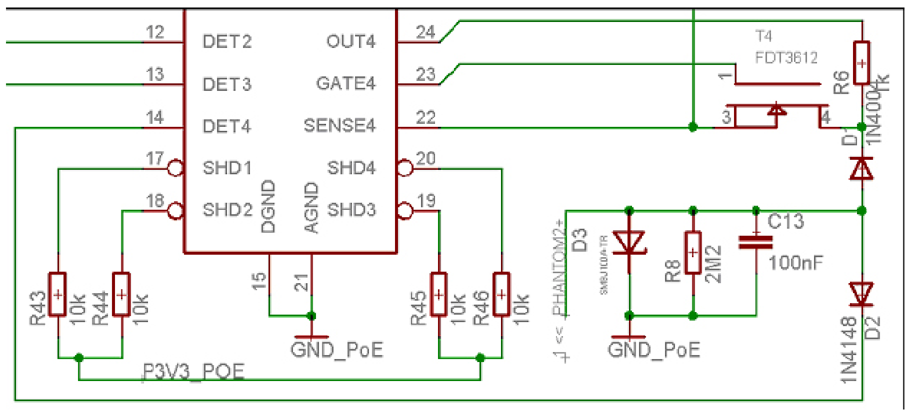


Figure 3.8 shows the wiring of a PoE port on the MAX5945.

PoE solutions from Hirschmann™

Hirschmann Automation and Control GmbH offers Power over Ethernet solutions from the top-hat rail to the backbone. Firstly we have the modular system MICE, with a four-port PoE media module, then the compact PoE devices in our OpenRail range, and finally the MACH1000 series that offers PoE switches in 19" format. This range, which is especially designed for rugged environmental conditions, offers up to four PoE ports. Our MACH4000 backbone switches can also be equipped with PoE modules, enabling them to support up to 32 PoE ports (up to 163W).

Power over Ethernet is set to gain further significance in future, so the Wireless LAN access points in our BAT range can already be powered via PoE.

A new addition to our portfolio is the PoE Plus media module for switches in the MACH102 range. This supports eight PoE Plus ports with a power rating of up to 120W per module. Other entirely new arrivals are the MACH104-16TX PoEP devices with 16-port Gigabit PoE Plus and 10GBit/s uplinks – ensuring no more lost video signals.

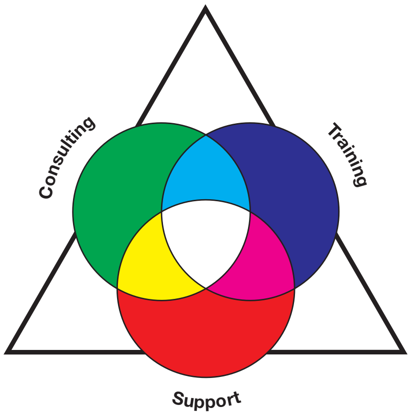
Annex:
Further Support

Technical Questions and Training Courses

In the event of technical queries, please contact your local Hirschmann™ distributor or Hirschmann™ office. You can find the addresses of our distributors on the Internet: www.hirschmann.com.

Our support line is also at your disposal:
Tel. +49 1805 14-1538
Fax +49 7127 14-1551

The current training courses to technology and products can be found under http://www.hicomcenter.com.



Belden Competence Center

In the long term, excellent products alone do not guarantee a successful customer relationship. Only comprehensive service makes a difference worldwide. In the current global competition scenario, the Belden Competence Center is ahead of its competitors on three counts with its complete range of innovative services:

- Consulting incorporates comprehensive technical advice, from system evaluation through network planning to project planing.
- Training offers you an introduction to the basics, product briefing and user training with certification.
- Support ranges from the first installation through the standby service to maintenance concepts.

With the Belden Competence Center, you have decided against making any compromises. Our client-customized package leaves you free to choose the service components you want to use. Internet: http://www.hicomcenter.com.

Phone **+49 (0) 7127 / 14-1809**
www.hirschmann.com

WP1002HE
06.11