Powering Ethernet Devices Over Data Cabling

Christopher T. Di Minico
MC Communications

The forthcoming IEEE standard enables a new class of low power Ethernet devices over copper cable.

The prime objective of the IEEE 802.3af task group is to develop a standard[1] that will extend the capability of Ethernet over twisted-pair. The implementation will allow power to be delivered along with data over 10BASE-T, 100BASE-T, and 1000BASE-T twisted-pair link segments.

The standard is poised to enable a new class of low power Ethernet devices in markets where there are a plethora of proprietary vendor solutions in need of a unifying communication protocol and a common networking infrastructure. Examples include building automation systems, industrial automation, home automation, security access control and monitoring systems, lighting control and gaming and entertainment equipment.

It is also implemented in applications where the lack of remote power provisioning has limited the use of an Ethernet solution. Examples include IP Telephony, wireless access points and point-of-sale terminals.

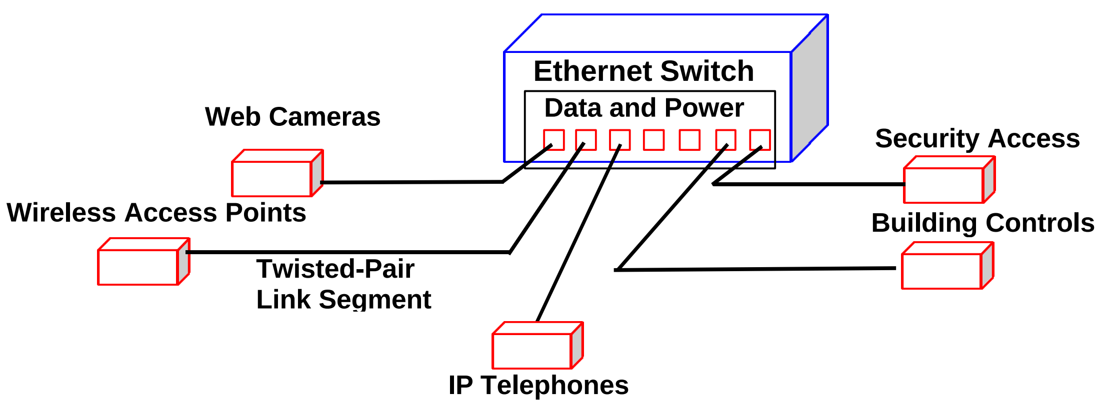

Figure 1: Applications of Powering over Ethernet

Structured Cabling Applications: 10/100/1000BASE-T twisted-pair Ethernet devices are designed to operate over a twisted-pair link segment that consists of cable, connecting hardware, and a recommended topology (Figure 2). The topology is similar to the ANSI/TIA/EIA-568-B.1 cabling channel[2].

[1] All references to the standard apply to IEEE P802.3af/ D3.0: Data Terminal Equipment (DTE) Power via issued November 15, 2001 and is subject to change.

[2] Cabling channels as specified in ANSI/TIA/EIA-568-B.1 exclude the equipment connectors and may include an optional transition/consolidation point connector. The building cable is referred to as horizontal cable.

Two types of power sourcing equipment (PSE) are specified in the 802.3af standard.

DTE PSE: Power can be sourced directly from the network equipment providing the data; the network equipment that sends and receives Ethernet data is called data terminal equipment (DTE). These types of power devices are called DTE power sourcing equipment (DTE PSE). Figure 2 illustrates this configuration where power is provided from the DTE PSE to the powered device (PD) across the twisted-pair link segments through the media dependent interfaces (MDIs) at each end of the link. The DTE PSE is referred to as Alternative A (Table 1). The DTE PSE supports 10/100/1000BASE-T.

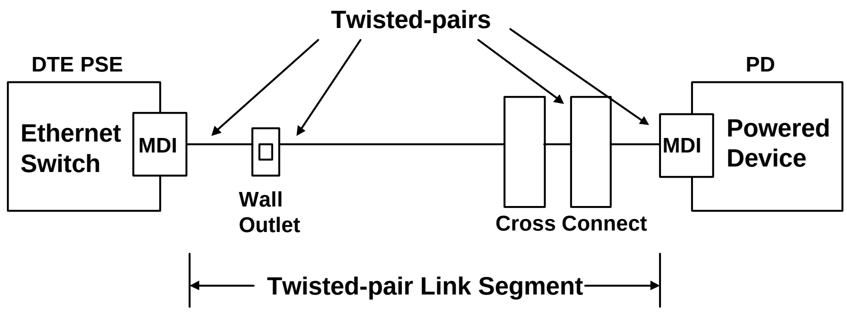

Figure 2: IEEE 802.3 - Twisted-pair Link Segment with DTE power

Midspan PSE: Power can be implemented by inserting power sourcing equipment on pin-pair assignments (4,5) and (7,8) of the twisted-pair link segment between the DTE and the device to be powered (Figure 3). These powering devices are called “midspan” power sourcing equipment (midspan PSE). The midspan PSE allows for the power to be supplied externally to the Ethernet equipment. This implementation will offer both data and power on the twisted-pair link segment without burdening each port of the Ethernet equipment with the need to provide power, and will allow for the support of legacy Ethernet equipment that lacks the powering capability. The midspan PSE is referred to as Alternative B (Table 1). Midspan power cannot be used with 1000BASE-T.

Some guidance for the implementation of a midspan PSE is given in the current draft. Work remains to validate the assumptions and practicality of these implementations. The current specification requires that the transmission performance and the length of the cabling channel be maintained after insertion of the midspan PSE. In order to insert the midspan PSE and maintain the channel performance, the transmission performance of the midspan PSE is assumed to be either equivalent to a mated connector or equivalent to an equipment cable or work area cable. Based on these assumptions, it is proposed that the midspan PSE can replace one of these components in the allowed topology without affecting the cabling channel performance. Two examples are given in the standard: a midspan PSE and an interconnect may be used to replace the cross connect; or the midspan PSE may replace the equipment cable or the work area cable with a cable that includes a PSE.

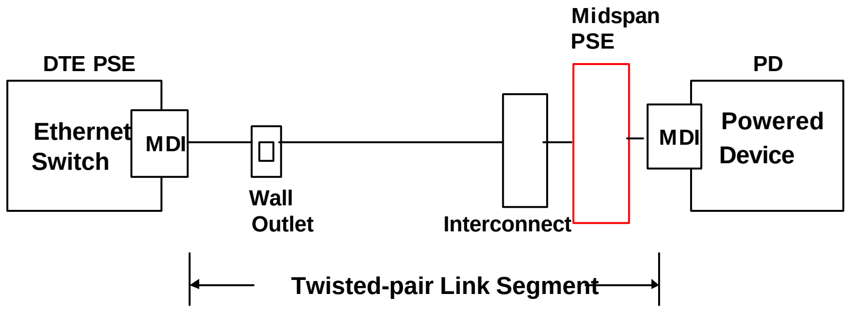

Figure 3: Power inserted in Midspan

<u>Power and Data: Pin-Pair Assignments:</u> The media dependent interface (MDI) for 10/100/1000BASE-T is the 8-position modular jack (specified in ISO/IEC 603.7). For power sourced from 10BASE-T and 100BASE-T devices (DTE PSE), the power is provided on the same pin-pair assignments as the data, that is TX(1,2) and RX(3,6). For power inserted midspan (midspan PSE) the pin-pair assignments (4,5) and (7,8) are used. The midspan power is implemented on the pairs not used for 10/100BASE-T equipment. Midspan power cannot be used with 1000BASE-T. Alternate A MDIX and Alternate A MDI polarities are reversed in order to account for the MDI-X which provides an internal crossover function.

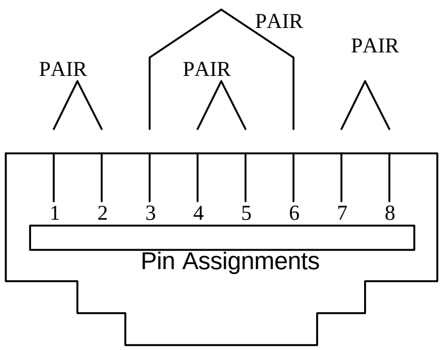

Figure 4 10/100/1000BASE-T MDI - 8-position modular jack (front view) pin/pair assignments

Table 1 MDI – Pin-Pair Assignments for DTE Power

Pin Assignment	**10/100BASE-T**	**1000BASE-T** MDI	**DTE PSE** (Alt A) MDIX	**DTE PSE** (Alt A) MDI	**Midspan PSE** Alt B
1	Tx+	BI_DA+	-Vport	+Vport	
2	Tx-	BI_DA-	-Vport	+Vport	
3	Rx+	BI_DB+	+Vport	-Vport	
4	Not used	BI_DC+			+Vport
5	Not used	BI_DC-			+Vport
6	Rx-	BI_DB-	+Vport	-Vport	
7	Not used	BI_DD+			-Vport
8	Not used	BI_DD-			-Vport

Power design: Power is superimposed on the data pairs similar to the "phantom" dc circuits in token ring used to insert a station into the ring. In 802.3af, the powering is implemented utilizing the secondary winding center taps of the transmitter and receiver transformers at each end of the link. The conductors of the pairs, connected across the transmit and receive secondary windings, provide both halves of the dc powering circuit (Figure 5). Midspan power is implemented in a similar fashion by inserting power sourcing equipment on pin-pair assignments (4,5) and (7,8) of the twisted-pair link segment .

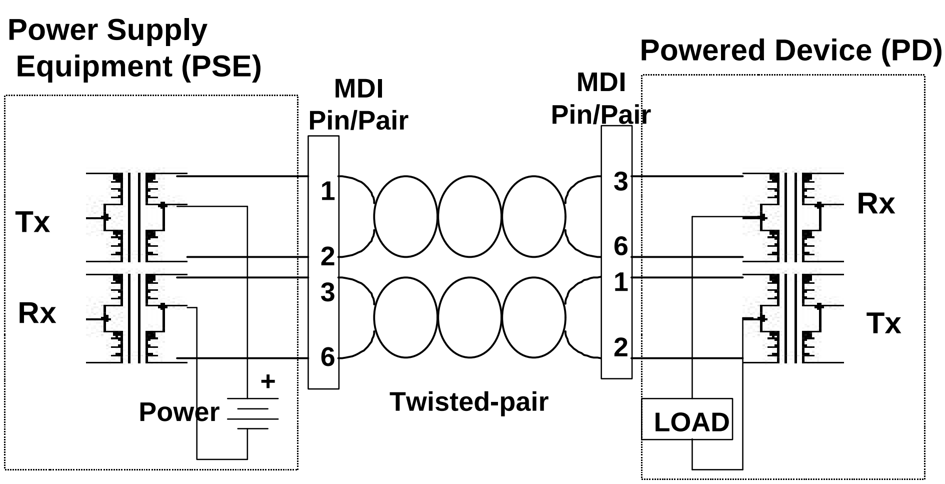

Figure 5 Simplified Phantom Circuit

Cabling Issues: Although powering over Ethernet is targeted to operate on the10/100/1000BASE-T twisted-pair link segments, it has been recognized that there are additional transmission performance parameters required for operation that are not completely characterized in either of the telecommunication cabling standards referenced by IEEE 802.3 (TIA/EIA-568-A, and ISO/IEC 11801) or in the 10/100/1000BASE-T standards.

The missing cabling channel performance parameters not completely characterized are related to the power delivery method. They include resistance, resistance unbalance, current capacity, voltage capacity and power capacity. In addition, cabling performance parameters need to be added that will limit the mode coupling between the data and power circuits. Mode coupling can allow power supply noise to interfere with the data signals and create conducted and radiated emissions. The mode coupling performance is associated with the cabling conversion loss characteristics.

TIA-TR42, the TIA/EIA Engineering Committee responsible for User Premises Telecommunications Cabling Infrastructure, is in the process of evaluating the IEEE 802.3af specification. A task group has been assigned to lead the investigation. The scope of the task group work includes identifying the cabling channel performance required, and evaluating the use of the midspan PSE, both the implementation and transmission performance.

It is anticipated that the outcome of the work will result in an addendum to TIA/EIA-568-B.1 and TIA/EIA-568-B.2. The addendum will address all of the requirements to ensure full support of IEEE 802.3af. IEEE 802.3 uses the TIA-568 series of standards and their addenda as a normative cabling reference.

Operation of the PSE and PD: The PSE recognizes whether or not to supply power to the PD by applying test voltages. The test voltages are used to determine the load characteristic of the PD. The load characteristics of the PD are called the PD detection signature. The PSE reads the PD detection signature to determine whether to supply power and how much power to supply. The detection signature enables the PSE to provide the right level of power, providing a form of power regulation.

The important functions of the PSE are to identify the PD’s that are enabled to receive power, provide required power levels, and remove power in the event the PD is disconnected from the link. The detection mechanism is an extremely important function of the PSE in order to circumvent the application of power to the wide range of devices that can be plugged into the 8-position modular jack. The PSE output voltage range is 44V-to-57V providing a maximum output current of 350 ma and a continuous output power minimum of 15.4 Watts over the range of output voltages.

Application to Building Automation Systems: The integration of building automation systems in support of an intelligent building design have been proposed in a variety of manifestations over the last decade, each failing to generate much interest. Examples of intelligent buildings are scattered about the world, each promoting their uniqueness. Therein lies the problem. Unique, one-of-a-kind solutions are, by definition, not easily repeatable, scalable, or extensible. A contributing factor to the lack of acceptance of integrated building automation systems, and the Intelligent Building concept, is the absence of a standards based design.

The framework for the design of a standards based integrated building automation system must include a unifying communication protocol between building technologies, and a common networking infrastructure. For example, Ethernet provides a standards based protocol with a common networking infrastructure. With the addition of the 802.3af standard, enabling remote power provisioning for building technologies, Ethernet can provide a viable solution for the design of interoperable building technologies and the framework for the design of standards based building automation systems.

In support of defining a common network infrastructure for BAS, TIA-TR42 has initiated a project (SP-3-4655-A) to develop a standard to enable the planning and installation of a structured cabling system for building automation systems in commercial buildings. The Standard will be released as TIA/EIA-862. The project is running in parallel with the 802.3af development.

Application to Internet Protocol Telephony: IP Phones: Power for the early telephone sets was sourced from batteries located near the telephones. Over time, the source of power was provided remotely from the Telephone Company. Centralized remote power, with battery back-up, provided on the same wires as the communication circuits, has enhanced the reliability and ease of use of the telephone. The simplicity and reliability of the traditional telephone has set the bar against which all other contenders are judged.

In order to succeed, the IP telephone must offer more functionality than is currently available in competing telephony products. Traditional phone operation does not require plugging the phone into the AC outlet. The 802.3af standard will simplify the operation of IP telephones by providing both power and data on one cable.

Summary: The 802.3af standard will extend the benefits of Ethernet functionality to markets in need of a simple, reliable, and cost effective networking solution. Steven B. Carlson, Chair, IEEE 802.3af DTE Task Force and Co-Chair, Entertainment Industry Technology Association (ESTA) Protocol Working Group, states, "Power over Ethernet (P802.3af) will act as a terrific enabling force in building networks for the entertainment Industry where compact, remotely-powered networked control devices will save on system cost and complexity and increase reliability for our end-users."

Biography: Mr. Christopher T. Di Minico is President of MC Communications, a telecommunications consulting firm and a partner with Spectrum Strategies, a telecommunications network design services provider. Mr. Di Minico has over 30 years of experience in the telecommunication industry and plays an active role in the development of a number of telecommunication industry standards. Mr. Di Minico is chairman of the IEEE 802.3 10GBASE-T Ad Hoc Cabling group, the chairman of the IEEE 802.3 10GBASE-CX4 Ad Hoc Cabling group, and the co-chair of the sub-committee developing the new TIA-TR42 Data Center Standard. In addition, Mr. Di Minico is the liaison for the IEEE 802.3 working group to the TIA TR-42 Engineering Committee.

Mr. Di Minico is a frequent speaker on a wide range of topics concerning telecommunications networking designs at conferences such as Networld+Interop and the Building Industry Consulting International (BICSI) and has published numerous trade articles and technical abstracts on the subject.