Synopsis

The provision of Power over Ethernet (POE) is defined by IEEE 802.3af to support a range of devices over 4-pair structured cabling. This will be used initially to supply remote power to wireless access points and Ethernet-based IP telephones, and later to a much larger family of low-power devices whose applications require connection to LANs. Power over Ethernet may be implemented in two ways; with the power source embedded in a switch or hub, or as a dedicated "mid-span" unit typically located near a cabling patch panel.

1. The Market for Remote Powering

The emergence of Voice over IP (VoIP) raises the issue of "lifeline voice" or emergency callout service, which requires the terminal equipment to be permanently powered. Power over Ethernet has been developed to support this and a series of other requirements, such as remotely powered wireless access points, web cameras, point-of-sale terminals and building management systems.

The market requirement for remote powering was recently estimated as 10 million IP telephony units plus 1 million wireless LAN base stations in the US alone. The electrical power envisaged to operate IP telephony *Etherphones* is 3-6 watts, wireless access points 4-11 watts, Ethernet NICs 8-12 watts and switches 100-250 watts. The latter is judged to be beyond the capability of remote powering via structured cabling.

A study group was established in 1999 under the auspices of IEEE 802.3 to evaluate the technical and economic feasibility of remote powering over Ethernet. IEEE 802.3af was approved as a standard in 2003.

2. IEEE 802.3af Objectives

IEEE 802.3af objectives were as follows:

1. Economically provide power over a twisted-pair link to 10BASE-T, 100BASE-TX and 1000BASE-T.
2. Select a single power transmission technique for global use.
3. Not cause damage and interoperate with compliant RJ-45 Ethernet devices (switch-to-switch connections, crossover cables, common mode termination implementations, shorted conductors, pairs or loopback plug).
4. Define a capability detection function that works with powered and unpowered devices.
5. Select the voltage, min/max current and power to be applied.
6. Add appropriate management objects for power capability and status.
7. Support standards for 4-pair horizontal cabling infrastructure for installed Cat 3 and Cat 5 cabling.
8. Preserve signal transmission and isolation characteristics of existing equipment and cabling.
9. Maintain normal functionality of link integrity test function in legacy and new devices.
10. Consider mid-span power insertion, powering over signal pairs and interaction with other RJ-45 devices, including Token Ring, ATM, FDDI TP-PMD, 1000BASE-T, ISDN, test equipment, PBX, IEEE 1394b.

3. IEEE 802.3af Overview

Only 4-pair cabling is supported, with optional use of power over spare pairs and power over signal pairs. This was actually a complex decision, as many felt that power over signal pairs was too expensive and technically challenging, while others wanted to support power over 1000BASE-T, which is based on 4-pair signalling.

Spare pair powering uses pin pairs 4,5 & 7,8 however this may only be used for 10BASE-T & 100BASE-TX.

The arrangement for power over signal pairs is illustrated in figure 1. This applies dc power via a "phantom circuit" via pin pairs 1,2 and 3,6. The "phantom circuit" ensures that any offset current is minimised by using centre-tapped signal transformers. Any offset current caused by imbalance in transformers and cabling would bias the signal transformer in a way that would deteriorate its high frequency characteristics. Signal pair powering may be used for 10BASE-T, 100BASE-TX and 1000BASE-T.

Mid-span powering may be used to support legacy hubs or switches, which do not have integral Power Supply Equipment (PSE). However, it is only possible to use spare pair powering for mid-span insertion, as any additional transformers would degrade the link performance.

Brand-Rex
viewfield industrial estate • glenrothes • fife • united kingdom • KY6 2RS
T: +44 (0) 1592 772124 F: +44 (0) 1592 775314
E: brexinfo@brand-rex.co.uk W: www.brand-rex.com

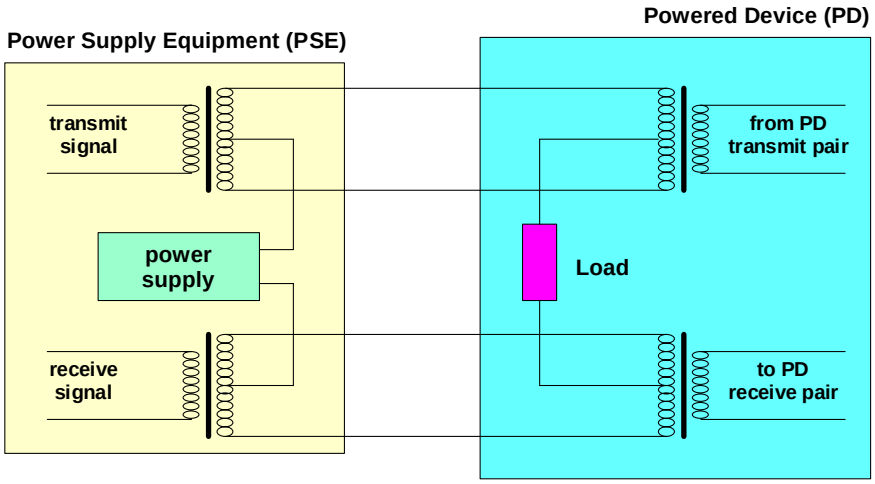

Figure 1: Power over Signal Pairs using Phantom Circuit

Maximum PD power is determined by the characteristics of installed cabling plus safety limits on PSE voltage. It was decided to limit the source voltage to 44-57 volts dc and cable pair current to 350mA (175mA per conductor). Maximum PD power is then determined by a maximum dc loop resistance of the cabling plus signal transformers, or a total of 12.95 watts. There are 5 classes of PD power, as defined in figure 2.

Class	Usage	Power levels at PSE output	Power levels at PD input
0	Default	0.50w - 15.40w	0.44w - 12.95w
1	Optional	0.50w - 4.00w	0.44w - 3.84w
2	Optional	4.00w - 7.00w	3.84w - 6.49w
3	Optional	7.00w - 15.40w	6.49w - 12.95w
4	Reserved	0.50w - 15.40w	Reserved

Figure 2: PD Power Classification

A “discovery” protocol has been developed to interrogate remote, power-enabled devices for functionality and readiness. Low-power signals are used to discover configuration and capabilities at the remote end of a cabled link without applying potentially harmful power. Power is only applied when the configuration is valid and the power requirements are established. Disconnection of a remote device is also detected, and power is then removed.

Auto-polarity has been adopted as an option; this is the ability to supply the correct voltage polarity automatically.

Extensive bench testing has been conducted to check for incompatibilities and malfunctions. Over 300 devices have been subjected to “hazard matrix testing”, with a high level of success.

4. Changes to Cabling Specifications

ISO/IEC 11801 and CENELEC 50173 2nd edition cabling standards specify the additional characteristics to support IEEE 802.3af remote powering. Channel dc loop resistance for Classes D, E and F has been reduced to 25 ohms, which is more realistic. This was specified as 40 ohms by ISO/IEC 11801 and CENELEC 50173 1st editions. Dc resistance imbalance of 3% has also been introduced. Current capacity per conductor has been specified as 175mA (-10 to +60degC). A power limit of 10 watts per pair has also been imposed in order to control the thermal behaviour of installed cables. This information will be introduced to EIA/TIA-568-C.

Brand-Rex
viewfield industrial estate • glenrothes • fife • united kingdom • KY6 2RS
T: +44 (0) 1592 772124 F: +44 (0) 1592 775314
E: brexinfo@brand-rex.co.uk W: www.brand-rex.com

About Brand-Rex

Brand-Rex is a designer and manufacturer of copper and fibre based cabling systems, headquartered in Glenrothes, Scotland with facilities across Europe. Brand-Rex has two primary businesses: Connectivity and Speciality. Its Connectivity division designs and manufactures cabling systems (both copper and fibre) for data communications and is the No.2 player in Europe. The Speciality division exclusively produces cables that are used for control, communications, power and instrumentation within hostile environments.

White Paper

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