



# Integrating PoL (Power over LAN) with Ethernet Switches

September 29<sup>th</sup>, 2002

Amnon Ptashek

Director of Technology

Radlan Inc.

[ptashek@radlan.com](mailto:ptashek@radlan.com)

Amir Lehr

Vice President, Marketing and Strategic Planning

PowerDsine Ltd.

[amirl@powerdsine.com](mailto:amirl@powerdsine.com)

## Copyright © 2002 RADLAN Inc

RADLAN and the RADLAN logo are registered trademarks of RADLAN Inc. All other trademarks or registered trademarks appearing in this document are the property of their respective owners.

PowerDsine is a registered trademark and Power over LAN is a trademark of PowerDsine.

All rights reserved.

---

Contact Information

# Table of Contents

<b>Abstract.....</b>	<b>1-3</b>
<b>1 Powered Ethernet Network.....</b>	<b>1-4</b>
1.1 Integrating voice data and powered network. ....	1-4
1.2 The “Topographic” Challenge .....	1-2
1.3 IEEE Takes the Role.....	1-2
<b>2 IEEE 802.3af in a Glance: A New Standard for Powering LAN Devices .....</b>	<b>2-3</b>
2.1 The “new” components .....	2-3
2.2 Architecture.....	2-4
2.3 WIRING and Power .....	2-5
2.4 Power devices (PD) DISCOVERY PROCESS and Protection.....	2-5
2.5 Adding a PoL Device .....	2-5
<b>3 Integrating PoL technology with Ethernet Switches .....</b>	<b>3-6</b>
3.1 The Integration Challenge .....	3-6
3.2 Hardware Challenges and Solutions .....	3-6
3.2.1 The real estate factor: Reduction of the PCB footprint .....	3-6
3.2.2 Voltage Isolation according to Class A .....	3-7
3.2.3 Mix Signal and EMC Issues.....	3-7
3.2.4 Power Supply and Heat Dissipation .....	3-7
3.3 Software Challenges and Solutions .....	3-7
3.3.1 Driving and Monitoring the PoL System .....	3-7
3.3.2 Power Management.....	3-8
3.3.3 MIB Support and System management.....	3-8
<b>4 Summary .....</b>	<b>4-9</b>

## Abstract

Power over LAN is becoming an integral feature of Ethernet switches. It's the ideal power solution for a vast array of data and telecom equipment for business, industry and home use. Primary markets include virtually any enterprise with an Ethernet network supporting or installing an IP telephony system, wireless LAN, or low-power application need.

The IEEE standard organization, took the role of leading the Power over LAN activity and the 802.3af group is currently working on the final draft.

The paper presents the 802.3af standard in a glance, introducing two major approaches: the Midspan and the Endpoints. Finally it presents an analysis of the hardware and software requirements for an Ethernet switch design, in order to support the integrated endpoint approach.

# 1 Powered Ethernet Network

## 1.1 Integrating voice data and powered network

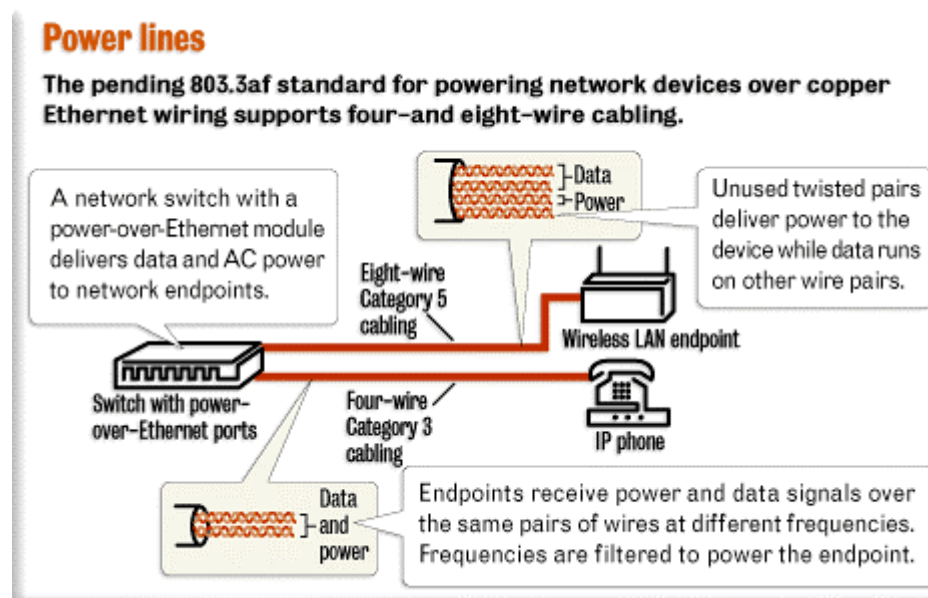
The enterprise IP telephony hype has quieted down during the recent economic turmoil, and now, silently, implementations have begun. IP telephony systems in enterprises are becoming mainstream and are widely installed. Now there's no slowing the VoIP train. All manufacturers have stopped investing in PBXs and devoted development resources to IP technologies. However, when end users begin installing their shiny new IP phones, they'll likely scratch their heads looking for that extra AC outlet per phone, not to mention a cost-effective solution to cope with occasional AC power outages. Here's where a new technology called Power over LAN (PoL) comes in handy.

Power over LAN can be used to support a wide array of devices (which already appearing in the market) including:

- SIP phones
- Wireless LAN access points
- Bluetooth access points
- Mini Ethernet switches and printer-sharing devices
- Desktop PCs
- Web cameras
- Personal Digital Assistants (PDAs)
- IP security systems
- IP industrial automation and sensors
- Multimedia miniature kiosks

Power over LAN is an exciting new technology and industry standard that creates an integrated data, voice and powered network. The concept is a simple one: using the standard Ethernet network infrastructure and cabling, electrical power is distributed to drive connected telephones, wireless LAN access points, network cameras and the like.

Simple idea, but its implications are enormous. With PoL, IP Telephony and Wireless LAN become more reliable, enabling companies to save tens of thousands of dollars on their communications infrastructure. Wireless infrastructure is dramatically simplified allowing companies to benefit from mobility. Outside of the office, PoL can be used in smart homes, integrated in Internet access on airplanes, trains and in public areas like airports, theaters and conference halls, a universal power standard for traveling users and so much more.



Source: NetworkFusion ([www.nwfusion.com](http://www.nwfusion.com))

## 1.2 The “Topographic” Challenge

Traditionally, static LAN networking devices required operating power to be delivered separately. Given the increasing quantity of LAN devices installed on a given project, this is a costly task. Furthermore, many of these specialized devices have to be installed in specific locations for proper operation. For instance, to achieve an effective area coverage and radio reception, wireless LAN access points are mounted above the ceiling plates. IP surveillance cameras are mounted at particular locations and at a defined angle; door entry card readers are placed outside the protected facility. At these unique placements, it is rare to find an available AC outlet. Furthermore, backup power may be required for some of these devices in order to assure continuous operation. Traditionally, a dedicated UPS would be installed for each device, or a separate backed-up premises AC network would be created, but in some cases both alternatives are prohibitively expensive. Enabling remote feeding with PoL affords point-to-multipoint power distribution architecture, parallel to the data network. This allows you to use a single UPS located at the network core to backup scattered devices wired to this core.

## 1.3 IEEE Takes the Role

At the urging of PowerDsine and 3Com in mid 1999, the Institute of Electrical and Electronics Engineers (IEEE) formed a taskforce to standardize an approach for passing power over Ethernet, the most widely implemented data networking specification. The taskforce, called 802.3af, is run under the auspices of the 802.3 workgroup, the same group that developed the original Ethernet specification. This new standard specifies the way to build Ethernet power sourcing equipment and powered terminals. Currently, Draft 3.1 of this standard is available and a ratified standard is expected by the end of 2002.

## 2 IEEE 802.3af in a Glance: A New Standard for Powering LAN Devices

### 2.1 The “new” components

The 802.3af is focusing on the 10 and 100 Mbps Ethernet operating over category 5 UTP. The basic network architecture and the underlying cabling of the 802.3af compliant network remains the same as a standard 802.3 network, yet there are four “new” significant differences:

- **Power Sourcing Equipment (PSE)** - This is basically the source of power and the mean to integrate that power onto the network. Most vendors today implement the PSE technology outside of the existing switch, a technique called a midspan solution. Implementing this technology inside the switch, called an end-span solution. Management may also be added to monitor and control the PSE. This management function may be integrated into a standard network management platform using the simple network management protocol (SNMP) or through a custom platform. Beyond the basic control of the PSE, the management stations provides additional power management functions, like power quality of service (QoS) where key users are given higher priority to power in the event of a outage.
- **Powered Device (PD) detection**- Not only does the PSE inject power into the Ethernet network, it also provides a detection method for determining whether the Ethernet device on the other end of the cable, the Powered Device (PD), is 802.3af compliant or not.
- **Uninterrupted power supply (UPS)** - Attached to the PSE is the UPS. Today's networks rely on discrete power-backup solutions. A UPS is connected to each device that requires alternative power. With the PoL solution, this function is centralized in a UPS connected to the PSE, which in turn may require further changes in the environmental conditions of the room needing to support this UPS with all of its electrical and cooling requirements.
- **Splitter** - At the periphery, if required, the device, like an Ethernet phone, can use a splitter to separate power from the Ethernet signal. This splitter can be integrated into the device or for new devices be situated in the wall or the desktop. No other changes are required to the network. The cabling and all existing Ethernet devices remain unaffected.

## 2.2 Architecture

The IEEE's proposed 802.3af standard that involves in delivering 48 volts of DC power to networked devices can be applied over four wire or eight wire of unshielded twisted pair cabling. The standard, commonly used, Category 5 cable is composed of 8 wires arranged into four pairs. 10/100BaseT Ethernet utilizes one pair for transmission and a second for receiving data. The other two pairs are free.

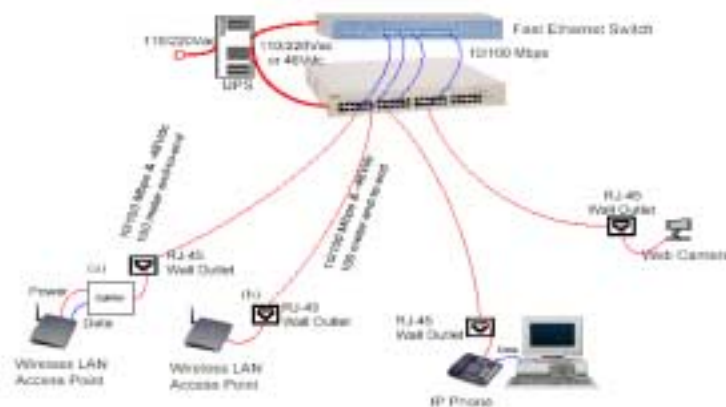
In-line power gear, or so-called power source equipment (PSE), can deliver an AC current in two ways:

- Midspan PSE: carrying the power over the unused twisted pair of wires
- Endpoint PSE: carrying the power over live wire pairs that deliver data or the unused one. Meaning 4 wires cable is enough.

In both scenarios the power is transferred over four conductors, between the two pairs. The powered device (PD) should be able to present a valid PoL signature and accept power from either pairs. Endpoint PSE is particularly useful for connections where all wires are used for data transmission, such as 10 bit/sec signals on four-wire Category 3 cabling, and Gigabit Ethernet on eight-wire Cat 5, 5e or 6 cabling - both of which have no "spare" wire pairs for transmitting power.

With Endpoint PSE, the Ethernet switch is embedded PoL technology. Midspan is a patch panel resembling device, with multiple channels (typically 6 to 24), that is placed between any standard switch and the powered terminal. Each of the midspan channels has data input and a data+power RJ-45 output connector. Midspans are the ideal solution for upgrading a network without replacing switches and for low PoL port density.

PoL delivers its promise while maintaining Ethernet data integrity and avoiding any potential damage to existing legacy, locally powered Ethernet devices and cabling infrastructure. Practically, PoL does not require any modification to previously installed cabling infrastructure and safely allows mixing legacy Ethernet devices and new LAN-powered ones. A "detection" mechanism, embedded in each power feeding port is responsible for unambiguous classification of the attached terminal. Only terminals that present an authenticated PoL signature will receive power. The rest will receive only data.



A Midspan approach (Source: PowerDsine LTD.)

## 2.3 WIRING and Power

The wiring presents the biggest challenge to the 802.3af networks. It's the wiring (and patch panel connectors) that impacts the amount of current that can be carried and how the power can be inserted into the line.

The delivered power's nominal voltage is 48 VDC. The current delivered to each node is limited to 350 mA, to comply with safety standards and existing wiring limitations. Hence, the total amount of power that can be delivered to each node, taking into account some power loss over a 100-meter maximum allowed cable run, is approximately 13 watts. For reference, typical IP phone sets, wireless LAN access points and network surveillance cameras consume 3.5 to 9 watts (It is even sufficient to charge a laptop battery, while on standby!).

Ethernet data is transferred in a differential mode. The power is "phantom" fed between two wire pairs, in a common mode, making data and power splitting over the line transformers simple and eliminating mutual interference.

## 2.4 Power devices (PD) DISCOVERY PROCESS and Protection

An "easy to install" solution, prevents any changes in the configuration of an existing network.

Insuring that devices can remain attached to an 802.3af network without being damaged requires a robust detection mechanism for identifying whether or not the installed device is 802.3af compatible. The mechanism must identify the devices as 802.3af compatible without modifying the end-node.

The 802.3af calls for resistor detection. The PD incorporates a circuit, which presents a 25K Ohm resistor to the line. When the power source injects current into the line, the device measures the voltage on the input line. If a resistor is identified, the PSE turns on the 48V power, and the PD automatically connects the DC/DC stage and powers on.

An additional "disconnect" protection mechanism, in each feeding port, is responsible for shutting down power once a valid PD has been disconnected. The "detection" and the "disconnect" automatic mechanisms allow activation of power only while a valid PD is attached. Installers and users are automatically protected against wiring mistakes and can freely mix devices.

## 2.5 Adding a PoL Device

How does one upgrade an Ethernet device to become LAN powered? Not that complicated. You have to design the device to operate from a 36-57 VDC input voltage, to consume not more than 12.95 watts of continuous power and to present a valid PoL signature consisting of a 25 kOhm input resistance. Obviously, there are other details to fulfill.

# 3 Integrating PoL technology with Ethernet Switches

## 3.1 The Integration Challenge

As was mentioned, the 802.3af standard defines two alternatives for power sourcing equipment (PSE), end-span and midspan. Midspans are the ideal solution for upgrading a legacy network without replacing switches and for low PoL port density. However the integrated approach, the endspans, introduces some technical challenges. No doubt that in the coming years PoL is going to be another expected feature of an Ethernet switch.

## 3.2 Hardware Challenges and Solutions

### 3.2.1 The real estate factor: Reduction of the PCB footprint

A typical 24 ports PoL system, built with discrete components, contains more than 400 components. Such a solution will require large footprint area, which needs to be implemented in the most densely populated area of the switch main PCB, between the Pulse Transformers and the RJ45 gang.

Footprint reduction may be achieved by integrating all required peripheral components into the Driver and Controller SIPs (Single Inline Package), together with vertical mounting. Such a solution for 24 ports SIP set requires only 4.52" footprint, thus simplifies the main switch PCB layout and enables the switch designer to reduce significantly the PCB size.

The following pictures describe a typical 24 ports SIP.



SIP Controller



SIP Driver

### **3.2.2 Voltage Isolation according to Class A**

According to IEEE 802.3 and IEEE 802.3af standards, 1500 VAC isolation is required between the main board circuitry of the switch, including protective and frame ground, and the Media Dependent Interface (MDI). Due to the fact that both the switch and the LAN infrastructure -connected to it- are located within the building, switches are considered as "Environment A" equipment. The serial communication digital signals interfacing between the PoL module's CPU to the host CPU on the switch's main board must be 1500 VAC isolated with opto-couplers as well. The Hardware design of an Ethernet switch must maintain these requirements.

### **3.2.3 Mix Signal and EMC Issues**

Due to the fact that the PoL solution is a mixed-signal circuitry, which contains high current high voltage analog lines adjacent to high speed low voltage digital lines, special care must be taken during the routing of ground and power signals. Ground planes are the most crucial for proper operation and should be designed cautiously. Un-careful design can lead to EMC issues and degradation in the switch's communication performance. Again, the Hardware design of an Ethernet switch must take into consideration the PCB layout schemes needed to meet these requirements.

### **3.2.4 Power Supply and Heat Dissipation**

Implementing PoL system within a switch requires additional power source, in order to support the IEEE 802.3af power requirements per output port. The additional power required can be as high as 720W for a 48 ports system. Part of this power is dissipated onto the switch main PCB from the PoL system components, which requires additional fans and careful cooling system design.

A well designed SIP set reduces significantly both heat dissipation to the switch main board, as well as power supply requirements, due to vertical mounting of the ceramic substrate based SIPs. Additional techniques of Power Management may be applied as well by the PoL system CPU.

## **3.3 Software Challenges and Solutions**

### **3.3.1 Driving and Monitoring the PoL System**

The PoL system requires large real-time resources in order to control and monitor ports output power, overload and disconnect situations and full system power limitations. These resources are often not available in the switch host CPU. More than that, special S/W module is required to be written for the host CPU in order to allow it to support IEEE 802.3af requirements and handle all PoL system operations.

A solution may be an integrated low cost CPU within the Controller SIP that includes all the required Software to enable it as a fully autonomous operation, thus enables minimum host CPU real-time resources.

### **3.3.2 Power Management**

According to the IEEE 802.3af requirements, a PoL compliant system must support a minimum of 15.4W per port. This means that for a 48 ports system, additional power supply unit of 720W @ 48Vdc is required. Such PSU is not an off-the-shelf product and can add significant amounts of \$ to the switch cost.

A unique solution would be to apply advanced Power Management techniques for PoL system. This can be managed by PoL CPU. The power management is done Per port & per whole PoL system, while Minimizing power supply requirements. Channels priority, Dynamic power allocation and Maximum continuous power per port can be handled as determined in factory presets or according to the user's setting.

Power Management allows switch vendors to use smaller PSUs, thus saving tens of dollars off the switch cost.

### **3.3.3 MIB Support and System management**

In order to allow IT manager to monitor the PoL system status, as well as Software downloads and parameters changing using remote SNMP via the host CPU, a special module needs to be added to the switch management software. This software module needs to include all "Power MIB" requirements.

Status and Command registers are needed in the SIP set for full "Power MIB" support, as well as embedded SNMP drivers (Get & Set, Interrupt mechanism) that can reduce the software integration process of the PoL system into the switch. All the MIB information can be transferred to the host CPU management agent. In addition, software download and upload can be done remotely, as well as PoL system parameters changes.

## 4 Summary

The enthusiasm for Power over LAN as generated the need for an industry standard that is currently led by the IEEE802.3af working group. This is an exciting new technology and industry standard that creates an integrated data, voice and powered network. It creates new opportunities for physical network topology, as there is no need for the traditional AC power near the networked device.

Trying to implement the integrated endpoint approach, the Ethernet switch designers have to take into account many software and hardware considerations. In the case of an integrated design the switch embedded software needs to support for driving and monitoring the PoL system. It needs a full compliance with the IEEE802.3af standard. Extensive control and management achieved through the "Power MIB" and the SNMP application. On the hardware side, the design has to reflect a reduction of the PCB footprint and full support for the voltage isolation, EMC and heat dissipation per the IEEE802.3af standard.

Power over LAN is just another step toward a full converge IP/Ethernet voice, data and video network. However this is on the physical layer, enabling a powered network over Ethernet.

---

### About Radlan:

Radlan has more than a decade of networking experience in design and integration of advanced routing and switching systems. More than 80 percent of the company's employees are engineers with expertise in ASIC-based Layer 2/3/4 networking software. Radlan offers system vendors a technology that fills the gap between the applications and the hardware components - to create a complete system with the fastest time-to-market. Radlan is a member of the multi-billion dollar RAD Group of companies with headquarters in Tel Aviv, Israel and Santa Clara, Calif., USA. For more information, contact Radlan at (US 408-982-9222), (Israel +972-3-645-8555) or email [info.us@radlan.com](mailto:info.us@radlan.com). More information is available on the Internet at [www.radlan.com](http://www.radlan.com)

### About PowerDsine:

PowerDsine ([www.powerdsine.com](http://www.powerdsine.com)) is the leading player in Power over LAN™ technology providing the ability to deliver both power and data over a single network cable. PowerDsine's product line offers a variety of Power over LAN midspan devices as well as integrated solutions, which are embedded directly into Ethernet switches. A variety of chipsets, such as a 4-component SIP (Single Inline Package) set solution and a module combining the switch power supply and the Power over LAN circuitry in a single-component, are available. PowerDsine is a founding member of the IEEE 802.3af Task Force leading the development of an industry standard for remotely powering Ethernet devices over the LAN infrastructure. In June 2002, the company was awarded most outstanding emerging European hi-tech company of 2002 at Tornado Insider's UpStart Europe event in Amsterdam.