A BETTER UNDERSTANDING OF POWER OVER ETHERNET FOR INDUSTRIAL ETHERNET APPLICATIONS
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Power over Ethernet or PoE technology has become a popular technology nowadays owing to the advantages that it is a system that can transfer electrical power, along with data, to remote devices over standard twisted-pair cable in an Ethernet network. But how is PoE important in industrial applications? What are the benefits? Is it time now?

What is PoE?

The PoE is an abbreviation of “Power over Ethernet”, and is a short form to describe a technology that transmits both power and data to a remote device via a single twisted-pair cable. So, what is this PoE technology used for? The PoE technology enables the end devices like Wireless Access Point, IP Phone, IP Camera, IP Access Control terminal, RFID reader and other IP-based appliances to get power supply from a Cat-3, Cat-5/5e or Cat-6 LAN cable without extra power connection needed. This technology is particular useful when deploying environments which may not have convenient power source for these equipments, and the extra power outlet may not be feasible and expensive to implement, or when adding these equipments to an existing Ethernet infrastructure without the need to make any modification in it.

What is IEEE 802.3af standard?

The IEEE802.3af standard is a first international standard to standardize the way how PoE should function. This revolutionary technology was ratified in June 2003 by IEEE Organization as “IEEE802.3af DTE Power via MDI”, Data Terminal Equipment (DTE) Power via Media Dependant Interface (MDI), and since the official full name may hard to be remembered so the common understanding today is “IEEE802.3af”. IEEE802.3af compliant means “Power over Ethernet” compliant.

The Secrets behind PoE Technology: PSE and PD

To understand how PoE works, first we have to understand what PSE and PD are, as stated in IEEE802.3af standard; we can simply define these two terms:

- **PSE (Power Sourcing Equipment):** it refers to equipment that supplies power to the end device (PD) such as an Ethernet Switch. A PSE should operate between 44-57VDC but the common standard is 48VDC which allows a maximum output DC current at 350mA to prevent the cable wire against over-heating problem. The overloading current checks at approximately 400mA and continues power output at 15.4 watts.

- **PD (Powered Device):** it refers to an end devices that getting power supplied from a PSE such as a Wireless AP, IP Phone, IP Camera...etc. A PD is operated with 48VDC and with a maximum current of 350mA which supplied by PSE, and after counting the cable lost, the maximum power consumption should be within 12.95 watts.
After having a brief understanding about PSE and PD, then we may take a look on how to insert a PSE into a LAN environment. Basically there are two types of implementations.

**ENDSPAN**

The Endspan implementation is referring to a switch with integrated PSE function that can supply the data and power directly to the powered device. Illustration is shown in Figure 1.

**MIDSPAN**

The Midspan implementation is referring to adding a PoE switch in between a existing non-PoE switch and PD devices, the data cable connects from non-PoE switch into a Midspan PoE switch, and a Midspan PoE switch receives data from non-PoE switch and adds power into a cable that connects to powered devices. Illustration is shown in Figure 2.

Regardless to the implementation needed, an UPS (Uninterrupted Power Supply) is usually recommended for continued PSE operation in an event of AC power failure. From the above diagram we can see that the Endspan implementation is using less cable and might help to prevent the problem on lost signals, so it should be the most cost effective way for a new installation project.
According to IEEE802.3af standard, the PoE cable wiring should work with Cat-3, Cat-5/5e and Cat-6 Ethernet cables. Cat-3 and Cat-5/5e cable are consisting of 4 pairs of unshielded twisted wires, 2 pairs for data and the other 2 pairs are spares, and there are 2 wiring options of these cables:

**ENDSPAN**

- **Alternative A Wiring**
  The power is carried over the data pairs (1/2 & 3/6) but with different polarities. The method is also called as “Phantom Feeding” method. This method has taken into account that the cable wiring for a gigabit Ethernet (Cat-6 wiring) where all 4 pairs wire are used out for data.

- **Alternative B Wiring**
  The power is carried over the spare pairs (4/5 & 7/8), and this method is the most common method used for PSE.

  For the maximum compatibility, a PD is required to adopt both wiring standard, but for a PSE it will only support either Alternative A or Alternative B standard.

**How Does PoE Works?**

As per IEEE802.3af standard, in order to make the PoE work, we need to have a PSE and a PD. A PSE will do the following tasks (Illustration shown in Figure 3.)

- **Detection:** To detect if there is a PD connection when there is new device plugged in, the maximum detection time is within 500ms. In detection, the PSE detects the PD port with voltages range between 2.7 V to 10.1 V. The PSE checks if the incremental resistance is within a guard-banded range of 23.75 KΩ to 26.25 KΩ. The detection mechanism prevents sending power to the non-PoE devices in order to avoid damaging them.

- **Classification:** After PSE detects there is a PD connected, it will perform a Classification to classify the PD, and there are 5 classifications as the table listed in Figure 4.

- **Startup:** After it goes through the detection and classification stage, the PSE will start power supply with maximum 15ms to the PD from low voltage to the maximum full load of 48V.

- **Normal Operation:** During operation, the PSE will continue monitoring the PD for overload current, short circuit and the loss of MPS (Maintain Power Signature). When any of these conditions are detected the power supply may interrupt or stop.

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\textbf{Disconnection:} When PD is disconnected, or cable failure, it will result in the loss of the MPS, so when this condition occurs the PSE will remove its power from the cable link, at this moment the PSE will start the cycle again from detection stage.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure3.png}
\caption{Figure 3.}
\end{figure}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure4.png}
\caption{Figure 4.}
\end{figure}

\begin{table}
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
Class & PD Max. Power Level & Valid Class Signature Current \\
\hline
 & From | To | From | To \\
\hline
0 (Default) & 0.44 watts | 12.95 watts | 0mA | 4mA \\
\hline
1 & 0.44 watts | 3.84 watts | 9mA | 12mA \\
\hline
2 & 3.84 watts | 6.49 watts | 17mA | 20mA \\
\hline
3 & 6.49 watts | 12.95 watts | 26mA | 30mA \\
\hline
4 (Reserved) & Reserved | Reserved | 36mA | 44mA \\
\hline
\end{tabular}
\caption{Class Max. Power Level and Valid Class Signature Current}
\end{table}

\section*{The Different Between Injector \& Splitter}

Many of the people are confused about the terminologies “Injector” and “Splitter.” Here is a brief introduction:

- Injector: The role for “Injector” is to help integrate the data and power in the same cable wiring.
- Splitter: the role for “Splitter” is to help separate the data and power into the different cable wiring.
Today, more and more IP based devices are hoping to include the PoE technology. Unfortunately the current technology is only supporting those devices with the power consumption within 13 watts, and this power range is insufficient to the devices like dual band wireless AP, the IP camera with Pan/Tilt/Zoom function or even more other IP based devices requiring the power between 13~30 watts. To overcome this shortage, a PoE Plus (some may call it as PoE+) study group was formed in December 2004. The goal is to enhance the current PoE standard to extend the power supply range. Currently the latest progress was in Draft 3.0 stage and the proposed power supply is at least up to 24 watts. The new specification is called “IEEE802.3at” standard and everybody hopes that can be ratified by the year 2009. In the meantime, some companies already launched their pre IEEE802.3at standard products, not only the PSE equipments, but companies like Linear Technology, On Semi, Molex…. etc. has began to offered their PoE+ controller chipsets. And we can foresee the new standard will help to build up this market with wider range power supply, and maybe a POS in 7-11, a Laptop or even a Digital Signage can benefit from it.
About Ethernet Direct Corporation

Ethernet Direct brings a control system engineering perspective to networking technology. The principals of Ethernet Direct come from process-control and PLC system backgrounds.

The Global Ethernet Direct team covers operations from Product know-how, design implementation, quality assurance, manufacturing, logistics, sales, marketing & technical support. We are well-positioned to fulfill customers’ needs and markets’ demands by providing a great variety of tailor-made products and services. When you work with us, you will experience confidence and dependability. By choosing Ethernet Direct, you have chosen excellence & long-term commitment.

Our corporate headquarter is located in Taiwan with Ethernet Direct Partners across United States, Canada, Asia Pacific, Latin America, Europe, and Middle East.