Power management silicon in PoE apps

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Ethernet refers to the various LAN systems that are covered by the IEEE 802.3 standard. Ethernet is the protocol that is used in the workplace, for example, to connect desktop PCs with centrally located file servers via high-speed data cabling. Any device connected to an Ethernet port such as a data terminal, wireless access point, Webcam or phone would need to provide its own power via batteries or a separate AC outlet.

A more elegant approach would be to allow the simultaneous transmission of power and data to any device connected to the Ethernet. If this transmission scheme could use existing Ethernet cabling and, hence, be 100 percent backward-compatible, then better. This is precisely what is offered by the power over ethernet (PoE) standard embodied in IEEE 802.3af. This standard, approved by the IEEE in June 2003, is for transmitting and receiving power signals over Ethernet. It has several advantages, such as:

- Cabling to each appliance is made simpler and cheaper because only one set of wires is required per appliance.
- AC outlets and adaptors are eliminated, allowing for a safer, neater and less expensive working environment.
- The appliance can easily be moved from one location to another.
- A UPS guarantees power to the appliance in the event of an AC mains failure.
- Appliances connected to the Ethernet may be remotely monitored and controlled.

These advantages make PoE a radical new technology that is changing the way certain lower-power appliances are powered. However, as of today, there are two key powered devices that are driving growth of the PoE test automation manager (TAM): WLAN access points and VoIP telephones.

WLAN access points have a CAGR of 38 percent to 15 million units by 2007, while the enterprise networks that support VoIP phones are forecast to reach 3 million units by 2007. This demand for powered devices drives the requirement for existing Ethernet switches to be PoE-enabled. This is achieved through the use of "midspans" (**Figure 1**). Growth of these units is predicted to reach 8 million by 2007, a growth of 68 percent.

In this example, the original Ethernet switches are PoE-enabled by a midspan hub, which injects the power into the twisted-pair LAN cables. Newer Ethernet switches will incorporate the midspan, providing power to the devices that are connected via high-speed data cabling. These powered devices can be Webcams, VoIP telephones, WLAN access points and other appliances. The UPS will provide backup power, should the main power supply fail.

Power management devices are used to switch voltage and currents in the Ethernet switches and PoE midspan hubs, and as DC/DC conversion elements within the powered devices.

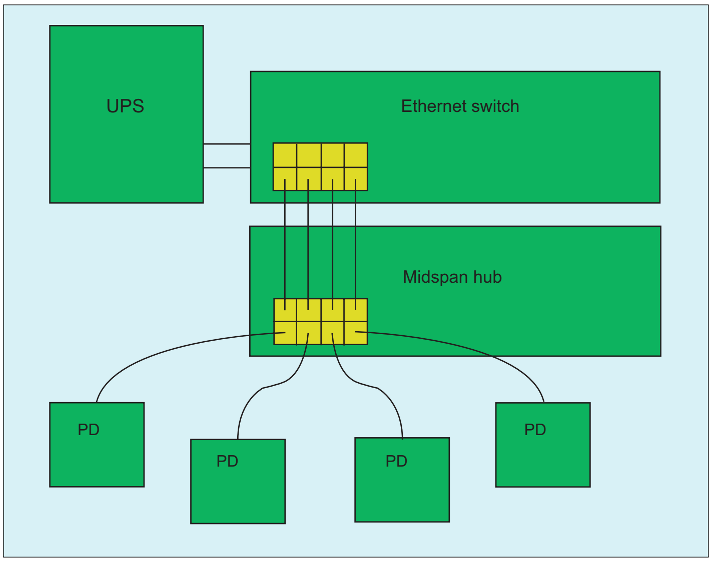

Figure 1: Ethernet switches are PoE-enabled by a midspan hub, which injects the power into the twisted-pair LAN cables.

Devices in E'net switches

The latest Ethernet switches are capable of delivering PoE connectivity to powered devices via either 24 or 48 separate ports and are backward-compatible with non-PoE systems. Each powered device is provided with its own 48V supply at a maximum of 15.4W per powered device, which will be individually managed by the Ethernet switch.

The IEEE 802.3af PoE specification allows for a maximum of around 13W at the powered device; the 15.4W available from the Ethernet switch range allow for a degree of power loss across long cable runs.

The 48V supply is allowed to be any voltage in the range of 36V to 57V, as seen at the powered device terminals. A voltage requirement of roughly 2x the maximum switched voltage (rule of thumb, to allow for switching spikes) dictates that the power switches are discrete MOSFETs with a V_{ds} rating of 100V.

Figure 2 shows a PoE controller that regulates four ports via discrete MOSFETs. In this example, there are four PHT4NQ10Ts and the configuration equates to 12 ICs and 48 MOSFETs per Ethernet switch or midspan. By 2007, the power-management TAM for midspans would equate to $57 million for MOSFETs (384 million pieces) and $48 million for ICs (96 million pieces).

PoE controllers are often referred to as hot-swap controllers. The function of these ICs is to:

- Independently control four separate PoE ports;
- Detect the connection of a valid powered device;
- Monitor the steady-state MOSFET current (via low-ohmic sense resistors);
- Control inrush current and MOSFET dissipation when a powered device is first con-

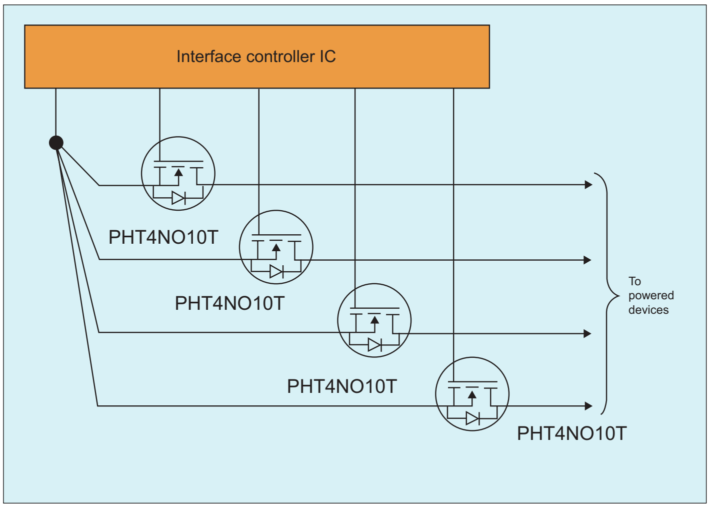

Figure 2: Hot-swap controllers independently control four separate PoE ports and detect the connection of a valid powered device.

nected to a port;
- Undercurrent disconnect to determine when a powered device has been disconnected.

Under normal operation, once a port is powered and the powered devices' bypass capacitor is charged to the port voltage, the external MOSFET dissipates very little power. This suggests that a small MOSFET would be suitable for the job. Unfortunately, other requirements of IEEE 802.3af, such as current surge at turn-on and the risk of a non-compliant powered device being connected to the port, mandate a MOSFET capable of dissipating significant power under transient condition. It is for this reason that discrete MOSFETs are used rather than integrated solutions.

A further requirement for Ethernet switch MOSFETs is that they should exhibit low leakage in the "off" state. IEEE 802.3af requires that the absolute maximum leakage current for a port should be no greater than 12μA, and this includes leakage paths through not just the MOSFET, but also any other protection circuitry that may be present.

Discovery procedure

The block diagram of a powered device is shown in **Figure 3**. The DC power from the Ethernet cables is recovered via the diode bridge rectifiers, thus eliminating any possibility of reverse polarity being applied to the powered device circuitry. When a piece of equipment is connected to a PoE port, the Ethernet switch performs a "discovery" procedure to determine whether the equipment is designed to accept power over the Ethernet or whether it is older equipment, which cannot accept PoE.

Discovery is also used to determine when a connected powered device is subsequently removed. The reason for needing discovery is that high voltages (48V) connected to many legacy devices can cause equipment damage. Hence, discovery takes place at voltages compatible with existing legacy equipment and high-voltage DC is only applied once discovery is satisfied. The IEEE 802.3af discovery is based on the sensing of a characteristic impedance.

Classification procedure

By identifying the power drawn through each port, PSE can assist in the system power management protocol to determine the total number of powered devices it can support, depending on the output capacity of the system power supply. To achieve this type of power management, an optional method was added to the IEEE 802.3af standard called "classification".

Classification allows a powered device to communicate the maximum power it will ever demand to the Ethernet switch/midspan, so that the power management protocol can allocate the unused power to other ports, enabling full use of the installed capacity.

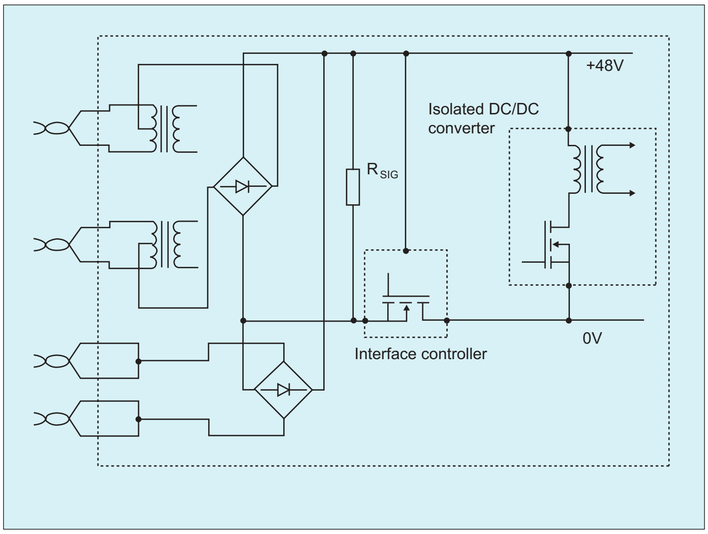

Figure 3: Once the discovery process is complete, the interface controller MOSFET is turned on and power is applied to the DC/DC converter.

The interface controller serves as an on/off switch for the main part of the powered device circuitry and is based around a 100V N-channel MOSFET. The interface controller will only allow the powered device circuitry to be connected when the nominal 48V supply falls within acceptable tolerance limits.

Also, the interface controller typically provides inrush current limiting and fault current limiting. The MOSFET has similar surge capability requirements to the 100V MOSFETs in the Ethernet switch application above.

Once the discovery process has been completed and the interface controller has determined that the power rail voltage falls within acceptable limits, the interface controller MOSFET is turned on and power is applied to the isolated DC/DC converter. The isolated DC/DC converter is required to provide 1.5kV isolation between the powered device front-end and the rest of the powered device circuitry (this is a safety feature) and supplies one or more low-voltage DC rails with a total of 13W maximum power consumption at its input.

Input voltage to this converter is nominally 48V, and common topologies are forward and flyback. This is a common DC/DC converter configuration, being similar to a low-power telecoms supply. Several controller ICs exist to meet this need.

Research firm Venture Development Corp. forecasts that power management silicon will enable 496 million ports by 2007. Since all ports are not used, an estimate of 50 percent use would yield a TAM of 248 million pieces of powered devices. Over time, PoE will become a ubiquitous technology in a plethora of appliances. And it is the power management devices–both ICs and MOSFETs–that will enable this change. □