Semiconductor Highlight: Power Management for Low-Power IP Phones and VoIP Devices

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Power Management for Low-Power IP Phones and VoIP Devices

Now that power via media-dependent interface (MDI) was added to the IEEE 802.3af Standard, data terminal equipment (DTE) can receive power over existing data transmission cables. The IEEE 802.3af Standard defines the requirements associated with providing and receiving power over the existing cabling. The power sourcing equipment (PSE) provides the power on the cable, and the powered device (PD) receives the power.

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Power Sourcing Equipment Detection

A powered device (PD) draws power or requests power by participating in a PD detection algorithm [1]. This algorithm requires the power sourcing equipment (PSE) to probe the link looking for a valid PD. The PSE probes the link by sending out a voltage between 2.7 V and 10.1 V across the power lines. A valid PD detects this voltage and places a nominal 25-k? resistance across the power lines. As the voltage varies between 2.7 V and 10.1 V, the V-I slope changes from 12 k? to 45 k?. Any slope in this range with a nominal 25-k? detect resistor is a valid PD signature. Upon detecting this current, the PSE concludes that a valid PD is connected at the end of the Ethernet cable and is requesting power.

After the detection phase, the PSE optionally can initiate a classification of the PD. The PD classification is used by the PSE to determine the maximum power required by the PD during normal operation. Five different levels of classification are shown

in Table 1.

The PSE can classify the PD, but only after a valid PD is detected. To determine PD classification, the PSE increases voltage across the power lines between 14.5 V and 20.5 V. The amount of current drawn by the PD determines the classification (see Table 2).

Choosing a Powered Device Controller
The IEEE802.3af specification defines a method for safely powering a PD over a cable and then removing power if a PD is disconnected. The IP phone is susceptible to electrostatic discharge (ESD), inrush currents, EMI, and line transients. Using a powered device controller (such as the TPS2375) provides protection by containing all the features needed to develop an IEEE 802.3af compliant-powered device. When choosing a powered device, keep in mind that a higher VDD-to-VSS voltage rating helps protect the IP phone from damaging transients [2]. The maximum continuous voltage can be as high as 57 V, but transients can be much higher. If the maximum voltage rating of the powered-device controller is as high as 100 V, the designer is able to employ a low-cost transient suppressing Zener diode.

Otherwise, a higher quality input transient voltage suppressor will be needed to minimize input spikes. During initial turn on, an inrush current occurs during charging of the input capacitor. The powered-device controller has to limit the inrush current to less than 400 mA for 50 ms. If an input capacitor larger than 180 µF is needed, make sure the proper current limit threshold is chosen. It is important to consider ESD and to choose a powered device that can meet 15-kV system level ESD requirements. Additionally, input diode bridges are needed to support both data line and spare line pair Ethernet power connections of either polarity, and an EMI filter is needed to ensure noise compatibility with Ethernet data signals.

Choosing the System Bus Voltage
The next step in designing a POL architecture is to choose a DC/DC topology and a nominal bus voltage. In PoE applications, isolated flyback or forward converters are more popular than synchronous or non-synchronous buck converters since they provide an isolation barrier, have a less stringent low voltage constraint, and can provide more than one output voltage with an additional winding on the transformer. On the other hand, buck converters are easier to design since they require an inductor rather than a transformer, but may have trouble regulating a low voltage such as 3.3 V from a 57-V input due to minimum on-time constraints.

The more popular bus voltage rails in PoE applications are 12 V, 5 V and 3.3 V. Most designers choose the 12 V rail since the need for boost conversion is eliminated. On the other hand, if the highest voltage needed within the IP phone is only 5 V, then choosing 5 V as the main voltage bus rail is ideal.

Point-of-Load DC/DC Conversion
Although the standard allows 15.4 W at the PSE output, only 12.95 W is available at the PD due to worse-case power drops from the Ethernet cable. Therefore, power efficiency is an important consideration in designing a point-of-load architecture. Table 2 shows an estimate for a typical IP phone's power consumption. In that example, the total power is slightly over 7 W.

The power conversion ratio plays a dominant role in the power budget, and it can be the largest contributor, if neglected. All unused power is converted to heat, dissipated onto the PCB, and eventually into the air. Switching regulators have high efficiency greater than 90 percent, but require an external inductor, and will pose a switching noise problem if the circuit board is poorly designed. Many new DC/DC switching regulators have integrated MOSFETs that simplify the design and are stable with low-cost ceramic capacitors to save board space.

Linear regulators provide low noise and space savings, since the pass element does not switch and an inductor is not needed. New linear regulators have been introduced that accept a low-input voltage and provide a low-output voltage as long as a bias voltage is available. For example, it is now possible to convert a 1.8-V rail into 1.5 V at 1 A, as long as 3.3 V is available to power the linear regulator's circuitry. In this case 83 percent efficiency is realized.

Conclusion
Designing a power solution for an IP phone and powering off the Ethernet cable versus using a standard AC/DC wall adapter poses several design challenges. This article is by no means a substitute for the IEE802.3af specification, but by following straightforward design examples, a powered device solution can be implemented within the IP phone to realize the benefits of drawing power off the Ethernet cable when applicable.

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