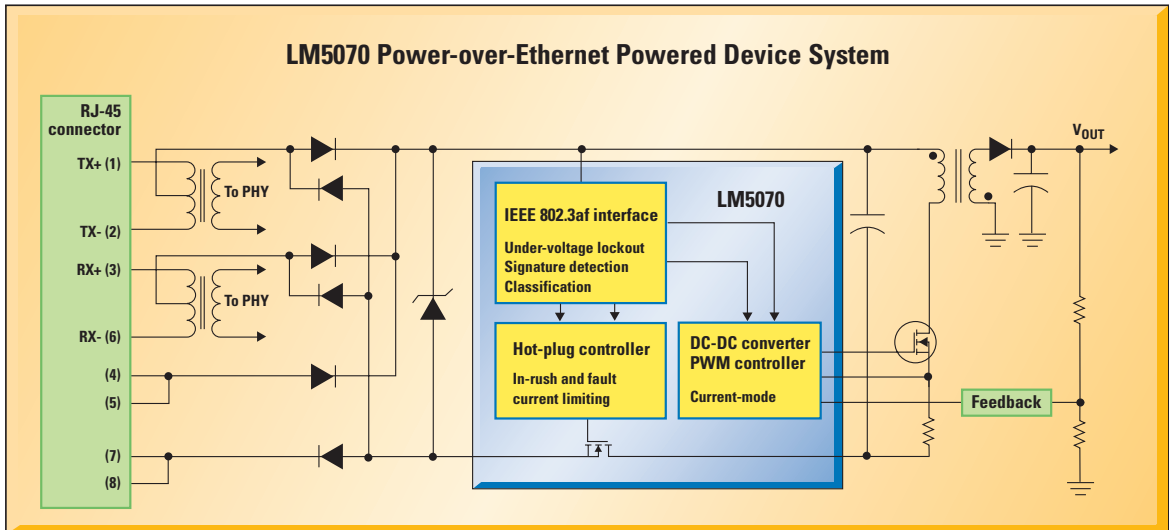


# Highly integrated, most reliable PoE PD solution with versatile programmability

## LM5070 PoE PD interface and PWM controller serves isolated or non-isolated applications



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- Combines a fully compliant IEEE 802.3af PD interface with a high-performance current-mode controller
- Integrates all PD system management including power up/down sequencing and fault protection
- Provides user programmability of signature impedance, UVLO thresholds, in-rush current, classification current, and DC-DC converter operating parameters
- Protection for in-rush/fault current limiting, cycle-by-cycle limiting with auto retry, and thermal shutdown
- Voltage reference and error amplifier for non-isolated applications
- Available in TSSOP-16 and tiny (5 mm x 5 mm), thermally enhanced LLP-16 packages

Critical PoE Application Features	National	Maxim	TI	LTC
Programmable UVLO and hysteresis	✓	—	—	—
Current limiting + cycle-by-cycle + thermal protection	✓	—	—	✓
Single solution for isolated and non-isolated	✓	—	—	✓
Highly integrated single-chip solution	✓	✓	—	✓
Programmable switching frequency	✓	—	✓	—

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The Sight & Sound of Information

# Smallest footprint, highest power density 1A buck regulators

## Feature-rich LM2734/36 in SOT-23 package requires no compensation

### Features

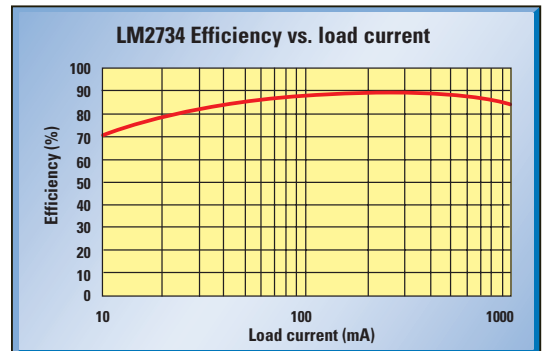
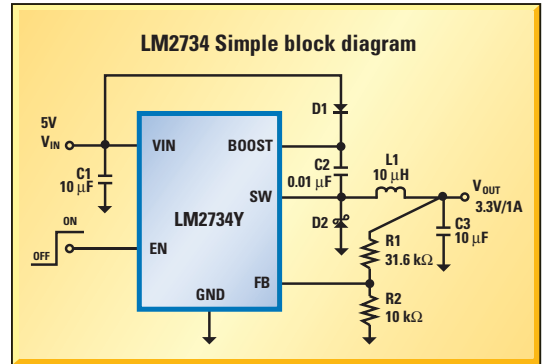
- Complete, easy-to-use switcher solution has smallest footprint and highest power density in the industry
- State-of-the-art 13 ns minimum ON-time allows for high conversion ratios without the need to reduce switching frequency or increase solution size
- Choice of switching frequencies allows designers to trade off efficiency against solution size and EMI
- Current mode control improves phase margin, line regulation and rejection of transients
- PWM provides a predictable, easily filtered switching frequency for reduced output noise
- Internal softstart circuitry, cycle-by-cycle, thermal shutdown, and over-voltage protection
- Available in Thin SOT-23 packaging (1.0 mm height)

Ideal for systems that need to convert 3.3V, 5V, 12V, or 16V intermediate rails to 1.5V or less where solution size is critical



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Feature	LM2734	LM2736
Input range	3.0V to 20V	3.0V to 18V
Output load	1A	750 mA
Output range	0.8V to 18V	1.25V to 16V
Internal references	0.8V, 2%	1.25V, 2%
Operating frequency	550 kHz / 1.6 MHz / 3 MHz	

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# BASICS

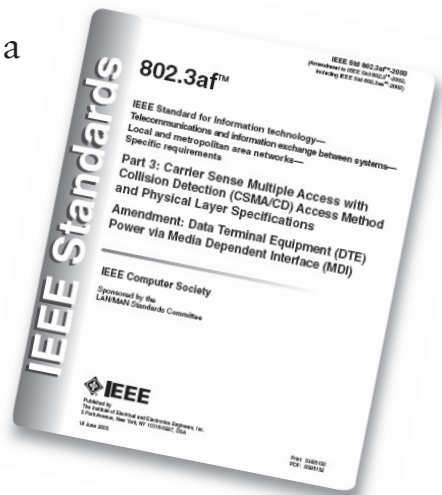
POWER OVER  
ETHERNET

*of Design*

Don Tuite, Analog/Power Editor

## Designing IEEE 802.3af Powered Devices

**P**ower over Ethernet (PoE), or IEEE Standard 802.3af, defines a method for powering Ethernet-connected “powered devices” (PDs) over the same cable that’s used for data. The actual circuitry that takes the power off the cable and delivers it to the power converter for servicing the load is called the power interface (PI). When the standard was conceived in 1999, the most common PD envisioned was an enterprise telephone set based on Voice over Internet Protocol (VoIP). Since then, and particularly after the standard’s approval in June 2003, a host of novel PD applications has been developed to take advantage of the marriage between data and power.



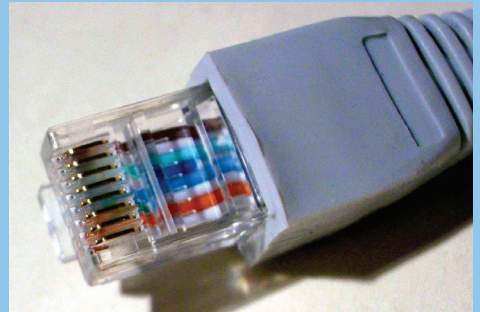
**ED Online 9126**

A Supplement to *Electronic Design*/November 29, 2004

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## Picking off the Power

The RJ-45 connector is the business end of an Ethernet cable in the photo on the right. PoE uses the data pairs or the spare pairs in the cable to carry -48 V dc from an endpoint switch or midspan hub to the PD. On the data pairs, pins 3 and 6 supply one side of the dc, and pins 1 and 2 supply the other. On the spare pairs, pins 4 and 5 are paralleled for one side of the dc supply, and pins 7 and 8 are paralleled for the other side.



## Spare Pairs and Data Pairs

The figure to the right shows the normal (top) and crossover (bottom) wire-color codes in an Ethernet cable. Note that a crossover does not affect which pins in the RJ-45 connector are active, but it flips the sense of the dc voltage. The PoE standard specifies a diode bridge in the PD to normalize either cable configuration. The photo of the connector above shows the end of a crossover cable that has the bottom configuration. (Tracer colors on the white wires in each pair in the photo are less conspicuously barber-poled than they are in the drawing.)



# Highest efficiency, 600 mA synchronous buck regulators

## Tiny SOT-23 LM3670/71 with lowest $I_q$ uses 2.2 $\mu\text{H}$ inductor

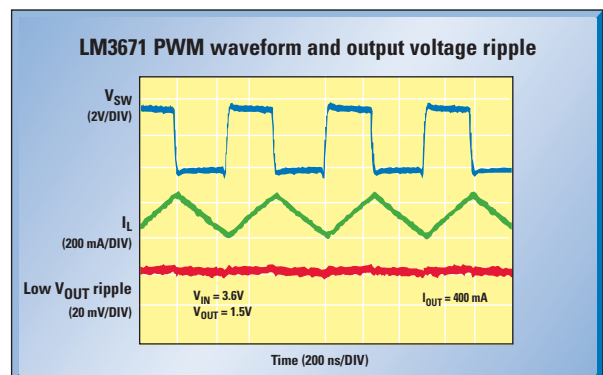
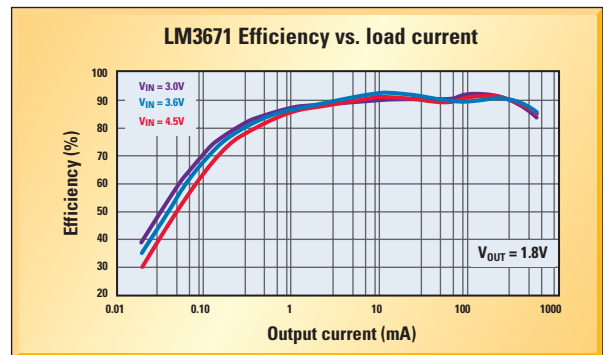
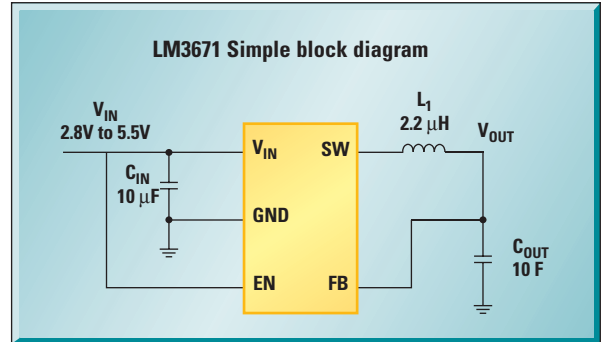
- High switching frequency, ceramic capacitors, and SOT23-5 package enables an extremely small solution with industry standard components
- Internal compensation minimizes external components and simplifies design
- Automatic PFM-PWM mode switching provides high efficiency at light loads
- Features high output-voltage accuracy, low output-voltage ripple in PFM mode, and fast transient response
- 2 MHz, 600 mA output current (LM3671) or 1 MHz, 300 mA output current (LM3670)
- Available in SOT23-5 packaging

Ideal for powering digital processors in systems where size and efficiency are at a premium



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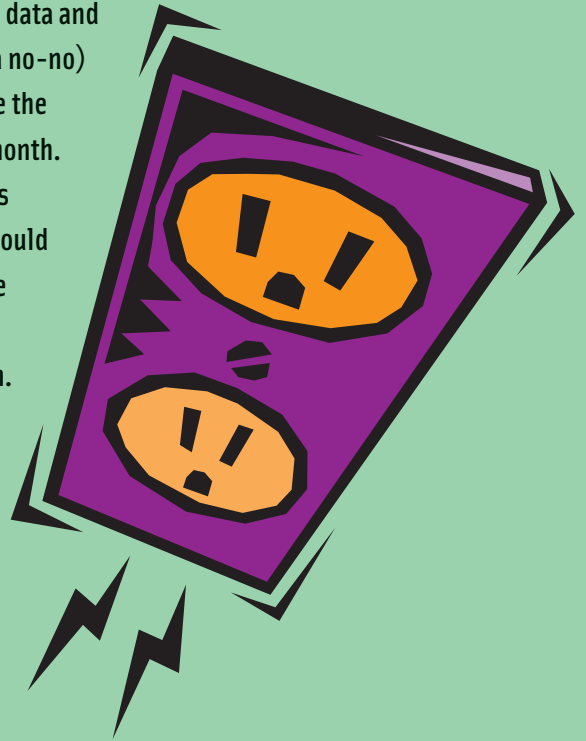
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## Power and Voltage

**A** PoE-enabled Ethernet switch or hub (designated Power Source Equipment, or PSE in the standard) injects 56.5 V dc at 350 mA (max) onto the cable. That's 15.4 W, but a PD designer can only count on something between 37 and 57 V and a maximum power (averaged over 1 second) of 12.95 W at the downstream end of the cable.

That's the power limit for now, though proposals for increasing current or paralleling data and spare pairs (presently a no-no) are being placed before the 802.3 committee this month.

Even if one proposal or the other is accepted, equipment designers should account for two things. First, those proposals will take some time to work their way through the system. Second, a considerable amount of 12.95-W PSE equipment will have been deployed by that time, so it's wise to not rely on higher currents in all systems.



## Detection and Classification

**P**SEs must not apply power to the Ethernet cable unless there is a PoE-enabled PD on the other end. To be powered-up by the PSE, a PD must have a 25-k $\Omega$  resistor across the input of the PI. The specs for the resistance are 23.5 to 26.25 k $\Omega$  with less than 0.1  $\mu$ F in parallel.

During the “discovery” phase of power-up, the PSE applies a small, current-limited voltage to the cable. Because of the voltage drops on the diode bridge, the PSE must measure current at two voltages (separated by 1 V and a 20-ms interval) and use the resulting delta-V/delta-I slope to verify the resistor.

Even if one detects the resistor, some smart PSEs may opt against applying power to the PD that, if in combination with other PDs already connected to the PSE, will draw more total current than the PSE can supply. To determine whether that’s the case, the PSE may implement a “classification” phase of power-up by asserting a higher voltage on the cable. If the PD does nothing at this point, the PSE may decide that the PD can draw any amount of current up to the 350-mA limit, and the PSE can assign the PD to class 0.

A PD can be configured to communicate to the PSE that it will never need more than a certain power level by asserting a signature current draw, which the PSE then uses to classify the PD. The flowchart on the right shows the criteria for classifications. Current readings that fall into the gaps between the listed currents may be treated as either the higher or lower class.

### The power range for each class is:

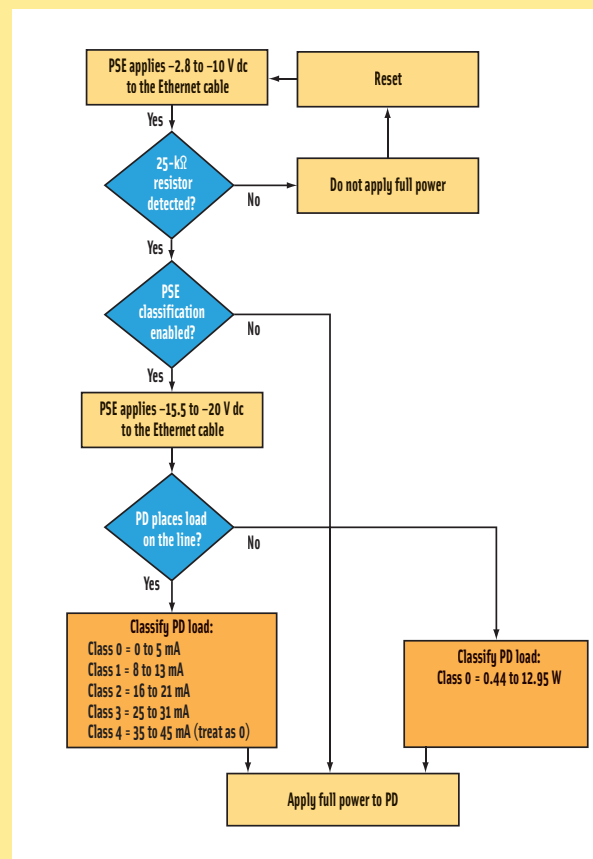
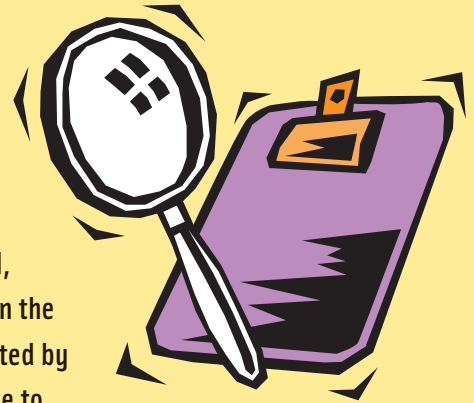
Class 0 = 0.44 to 12.95 W

Class 1 = 0.44 to 3.84 W

Class 2 = 3.84 to 6.49 W

Class 3 = 6.49 to 12.95 W

(“Class 4” is reserved but not yet defined.)



If the PD declares itself to be class 1 or 2, it must limit the peak current it draws to 120 mA for class 1 or 210 mA for class 2. The limit for classes 0 and 3 is 400 mA. Discovery and classification must take no more than one second, with 500 ms (max) for detection, 10 to 75 ms for classification, and 400 ms for power turn-on.

## Further Issues

### Inrush-Current Limiting

Powering up a PD is frequently a “hot-plug” event. The standard requires the PSE to limit input inrush current at startup, but only if CPort, the capacitance looking into the PI from the Ethernet cable, is less than 180  $\mu\text{F}$ . (The minimum allowable capacitance for CPort is 5  $\mu\text{F}$ .) If CPort is equal to or greater than 180  $\mu\text{F}$ , the PD must limit input inrush current to 400 mA.

### UVLO

Although not part of the standard, PoE’s sequence of detection, classification, and full-power voltages argues for an undervoltage-lockout (UVLO) function in the PD. This prevents the power converter that follows the PI from operating during detection and classification. It may be desirable for this function to provide 5 V or so of hysteresis.

### Soft-Start

Because the standard also doesn’t address what happens at the load when power is applied, it’s obviously a good idea to provide a soft-start capability in the power converter. This slows the voltage ramp-up to the load and prevents overshoot.

### Restart

A power converter also must be able to deal with possible faults and repairs to the circuitry making up the load by responding to short and open conditions and implementing a “hiccough” restart-attempt scheme.

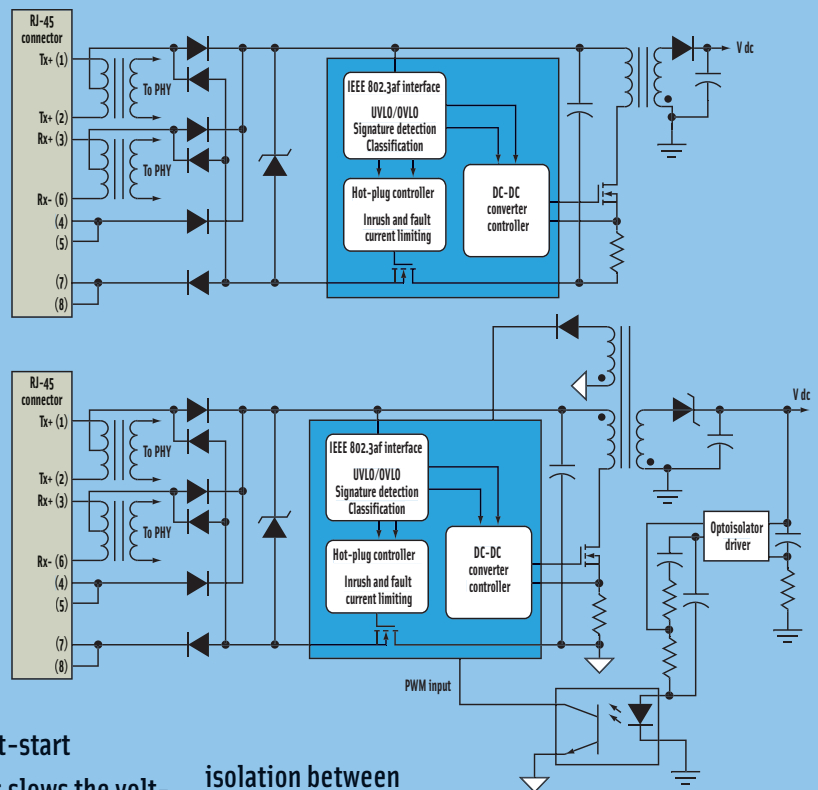
### Integrated Solutions

Several chipmakers provide custom chips for PD

designs. From most vendors, customers have a choice of separate ICs for PI and power-converter functions, as well as chips that combine the two. Beyond that, there are differences in UVLO implementation, power conversion, and basic specifications.

### Isolation

If the PD has no external wiring, as would be the case for a wireless access point or an RFID tag reader, no



isolation between the Ethernet cable and the load is required (see the figure, above). In most cases, however, there are external connections. And, the standard says the PD must provide electrical isolation between all external conductors, including frame ground (if any) and all power interface leads. It then invokes subclause 6.2 of IEC 60950-1:2001, which specifies hi-pot testing, either 1500 V rms for 60 seconds, or a repetitive 1500-V impulse test.