LED Lighting
Solutions Guide

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LED Lighting

The Expanding Role for LED Lighting

Light-emitting diodes (LEDs) are a rapidly evolving technology and are becoming viable for many general lighting applications, usually referred to as solid-state lighting (SSL). The most relevant examples of LED lighting applications are indoor uses in commercial, industrial, and residential environments; outdoor applications like street lights and parking lights; and architectural and decorative lighting where LEDs were initially adopted because of their ability to emit the whole spectrum of colors.

LEDs have been an effective solution for architectural lighting for some time. Today LEDs are penetrating the mainstream general lighting market, thanks to their higher performance compared to other lighting technologies:

- **They have a much longer lifetime than other lighting technologies**. LEDs can operate for 50,000 hours versus 1,000 to 2,000 hours for incandescent lamps and about 5,000 to 10,000 hours for compact fluorescent lights (CFLs). This markedly longer lifetime makes LEDs ideal for many commercial and industrial lighting applications where the labor cost to replace a lamp is high.

- **Their energy efficiency is superior to incandescent and halogen lamps, and often equivalent to fluorescent lamps**. Additionally, the efficacy of LEDs is continuously improving; the efficacy of white LEDs (WLEDs) is now forecasted to improve by about 50% over the next three to four years.

- **They have a small form factor**. LEDs fit in some form factors like MR16 and GU10 lamps where CFLs do not.

- **They can be dimmed with the appropriate driver**. Fluorescent lamps pose technical limitations when the application requires dimming. Although conventional LED designs have encountered similar issues, innovative LED drivers from Maxim are compatible with triac and trailing-edge dimmers.

- **They can provide focused light**. Unlike other lighting technologies, LEDs are more appropriate for applications like narrow-angle reflector lamps that require a very directional light.

- **Their efficacy improves at lower temperatures**. The efficacy of fluorescent lamps degrades at lower temperatures. In contrast, LEDs are ideal for applications with a low ambient temperature like refrigerator lighting.

- **It is very easy to change the color of their emitted light**. This makes RGB LEDs ideal for applications like architectural and mood lighting where the color of the light must change in real time.

In summary, LEDs offer many advantages over incandescent, halogen, and fluorescent lamps. Consequently, designers continue to find more applications for LED lighting, but that discussion could consume us for a long while. This review will focus on only two, but quite timely, applications: LED retrofit lamps and remote-controlled LED lighting.

LED retrofit lamps are made to replace incandescent, halogen, or fluorescent lamps in the same socket. These LED lamps must fit in the existing form factor and be compatible with the existing infrastructure.

LEDs for remote-controlled lighting allow greater flexibility in dimming and changing the color of the light. LED lamps are inherently digital systems, making it straight forward

Maxim provides dimmable, flicker-free LED driver solutions for retrofit lamps.

to integrate communications for lighting automation. The use of wireless or powerline-communication (PLC) remote control reduces power consumption, lowers operation and maintenance costs, and enables new LED applications.

LED Retrofit Lamps

Many would argue that the LED retrofit lamp market is the fastest growing application for LED lighting today. The reason for this fast growth is actually quite straightforward: these lamps do not require a new electrical infrastructure (i.e., cabling, transformers, dimmers, and sockets), a significant advantage for LED technology.

Fitting an LED lamp into the existing infrastructure challenges the designer in two principal ways:

1. **The form factor**. Retrofit lamps must fit in the form factor of the previous light source.

2. **Electrical compatibility**. Retrofit lamps must work correctly and without light flicker in the existing electrical infrastructure.

We shall discuss each challenge in turn.

Fitting the Existing Form Factor

The existing form factor imposes both a physical limitation (i.e., the driver board has to be small

enough) and a thermal limitation on a retrofit lamp. These limitations pose challenges for the design of a replacement lamp (e.g., PAR, R, and A form factors), challenges that are particularly hard to overcome for smaller form factors like MR16 and GU10. For this reason, Maxim offers a driver IC with integrated MOSFET (MAX16840) for MR16 applications.

While size is important for a retrofit, thermal limitation is often more critical. LEDs emit only visible light; they do not irradiate energy at infrared wavelengths like other technologies. Thus, while LEDs are more energy efficient than incandescent or halogen lamps, they dissipate much more heat through thermal conduction in the lamp.

Thermal dissipation is also the main limiting factor for the amount of light that a lamp can produce. Today's LED technology in retrofit lamps can barely achieve a level of brightness that is acceptable for the mainstream

market. Pushing the limits of brightness and, consequently, thermal design are essential for designing a commercially successful product.

A corollary issue to the thermal dissipation is the lifetime of the driver board. To emit more light, the lamp must work at a fairly high temperature (+80°C to +100°C). At these temperatures, the lifetime of the driver board can limit the operation of the whole lamp. Electrolytic capacitors are the biggest challenge since they are the first component that fails at high temperature.

Maxim's driver solutions for 120VAC/230VAC and 12VAC give customers the option of not having electrolytic capacitors, if they can accept higher LED ripple current. If instead the customer decides to use electrolytic capacitors, Maxim driver solutions are fault tolerant: a deterioration of the electrolytic capacitors causes the LED ripple current to increase, but the lamp does not fail.

Matching the Electrical Infrastructure

Retrofit LED lamps must work correctly in infrastructures that include cut-angle (triac or trailing-edge) dimmers and electronic transformers.

Working off the 120VAC/230VAC line, the lamp can be preceded by a triac dimmer. Triac dimmers are designed to work well with incandescent and halogen lamps, which are perfectly resistive loads. With LED retrofit lamps, however, the LED driver is generally a very nonlinear and not purely resistive load; its input bridge rectifier typically draws brief, high-intensity peaks of current when the AC input voltage is at its positive and negative peaks. This LED behavior does not allow the triac dimmer to work properly, because it provides neither the needed start current nor the hold current. As a result, the dimmer does not start properly or turns off while operating, and the LED lamp flickers.

LOW-VOLTAGE LED LIGHT BULB

LINE-POWERED LED LIGHT BULB
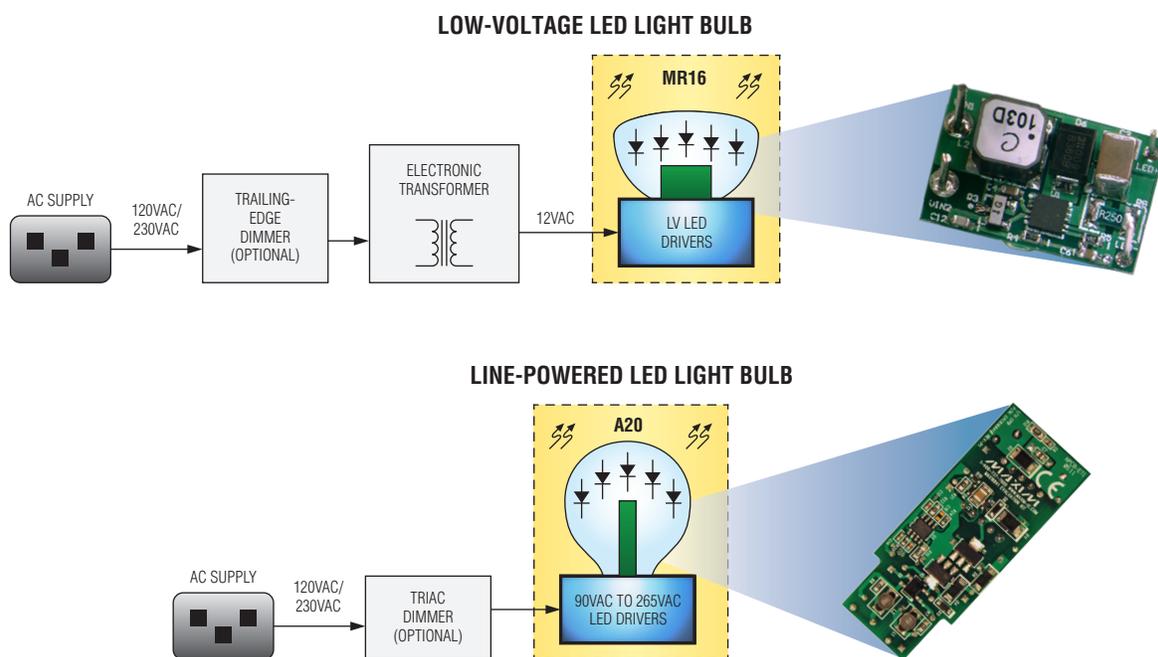
Block diagrams for MR16 and offline lamps. For a list of Maxim's recommended solutions, please go to www.maxim-ic.com/lighting.

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The electrical infrastructure is even more complicated for 12VAC input lamps, because an electronic transformer and trailing-edge dimmer can be connected at the lamp's input. Again, a 12VAC input lamp driver that uses the traditional bridge rectifier and DC-DC converter topology flickers because of incompatibility with the transformer and dimmer.

Maxim's LED solutions for 120VAC/230VAC and 12VAC input lamps use a single-stage conversion. By shaping the input current so that the light does not flicker even when dimmed, these solutions are compatible with triac and trailing-edge dimmers and electronic transformers. No other solutions for MR16 lights offer this feature; few solutions for PAR, R, and A lamps offer it. In addition, these solutions provide better than 0.9 power-factor correction and require a very limited number of external components. The 120VAC/230VAC input solution uses the MAX16841, while the 12VAC solution employs the MAX16840. Both parts are available for evaluation and use in mass production.

## Remote-Controlled Applications in Street, Parking, and Indoor Lights

As stated above, LEDs offer more design flexibility for dimming and changing the light color. This versatility makes them ideal for applications like architectural lighting, indoor ambient lighting, and dimmable street and outdoor lighting. All these applications require a technology to control the LED light remotely. For the application to be successful in the marketplace, the cost of upgrading the lighting infrastructure to new LED technology must be minimized. Not surprising, solutions that can reuse the present infrastructure will likely be the first to penetrate the market.

When converting to remote-controlled LED lighting, the most costly infrastructure upgrade to anticipate is the wiring to control the LED lights. Fortunately, LED lamps can be controlled through existing power lines using PLC technology.

PLC technology allows communication over a long range. New OFDM-based PLC technology, including emerging standards such as G3-PLC™, is simplifying integration of lighting control applications by providing noise immunity and interoperability.

The main design requirements for remote-controlled LED lighting solutions are:

- **The communication range**, which is dictated by the application. For an indoor residential application, something in the range of 30m is sufficient. Street lighting can require a range of several kilometers.

- **Low power consumption**. An important selling point of LEDs is their high energy efficiency. It is important that an LED lamp
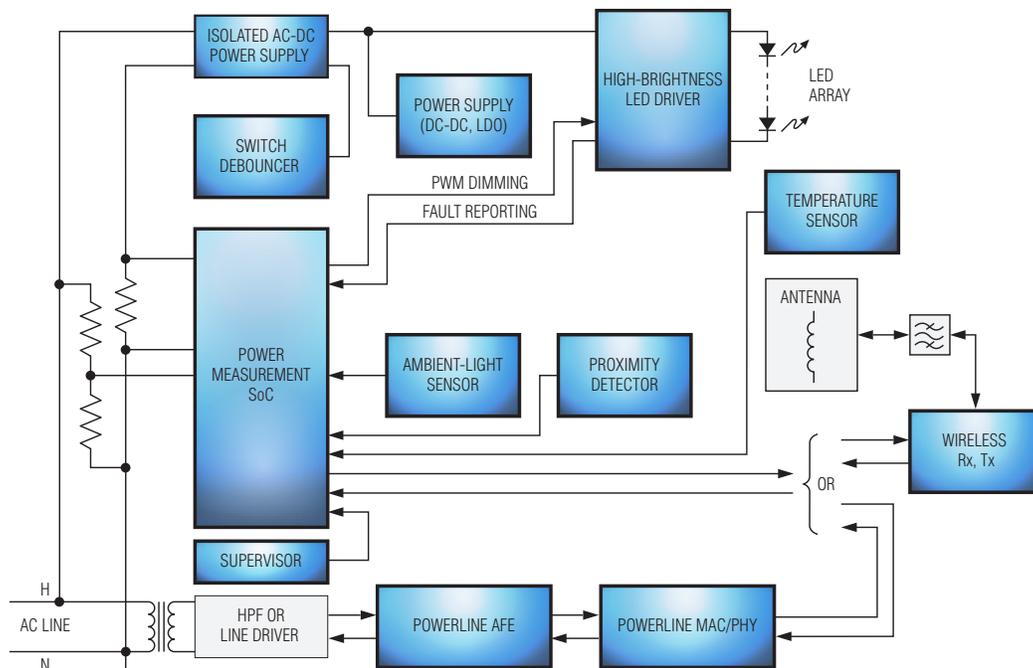
Block diagram of an LED lighting system controlled through PLC or wireless links. View recommended solutions at www.maxim-ic.com/lighting.

consume the least power possible when the light is off and only the communication circuit is active.

- **The communication rate**. Some lighting applications require only a low communication bit rate (i.e., a few kbps) to control light dimming and perhaps read possible faults. Large networks of lamps and architectural lighting, however, can sometimes require data rates up to 100kbps. An example would be a run of several hundred street lamps on a single PLC-controlled network.

A remote-controlled lamp often includes a microcontroller, either as a discrete component or integrated in another IC. Unless a complex communication protocol is adopted with a complex stack, a basic microcontroller is typically sufficient. The microcontroller's duties will typically include decoding of the communication protocol, generation of dimming signals for the LED driver, reading faults, and controlling the lighting effects of the lamp (e.g., theater dimming).

For wireless communication for indoor lighting applications, Maxim offers the MAX1473 receiver and the MAX1472 transmitter. These products allow communication in the 300MHz to 450MHz free bands, over a range of 30m to 50m in an indoor environment.

For PLC, Maxim's solution includes the G3-PLC compliant MAX2992 baseband and MAX2991 analog front-end (AFE). These devices form a complete powerline transmitter/ receiver chipset that can transmit data at distances from hundreds of meters to 10km or more, and at data rates up to 300kbps. This range makes the parts ideal for street-lighting applications. The MAX2992 uses OFDM and adaptive tone mapping to provide robust communications over power lines. It conforms to the IEEE® P1901.2 prestandard.

Energy Measurement

Energy demand around the world is predicted to increase at a rate that will likely outstrip our ability to generate power. The International Energy Agency (IEA) calculates that lighting accounts for about 17.5% of global electricity use. That equates to over 2,200 terawatt-hours (TWh), more than all the world's nuclear plants generate in a single year. As an energy-efficiency advisor to the G8, IEA has stated that electricity consumption for lighting could increase dramatically by 2030 unless concerted action is taken to implement new technologies. Increased energy efficiency and improved energy management are critical to averting this potential energy crisis.

Traditional open-loop strategies for managing power usage are crude and inefficient, resulting in lower reliability and reduced distribution stability. Engineers are working to improve power efficiency in all electronic applications; however, increasing efficiency is only part of the equation.

Better energy management and, consequently, comprehensive measurement systems are essential. Incorporating feedback about how power is consumed yields the benefits of a closed-loop system and reduces waste. Additionally, giving energy users greater visibility into their power consumption can help overcome consumer indifference to energy concerns.

Accurate measurement provides the feedback necessary to understand, confirm, and modify power consumption behavior. It is critical to implementing an energy-management control loop and providing insight for maintenance and failure diagnostics.

For outdoor lighting, accurate measurement provides the opportunity for municipalities to reduce electricity cost by dimming lights and by being billed on actual power consumption. In relay control panels, accurate measurement provides the energy management monitoring and verification feedback to qualify for LEED credits, ISO 50001, and time-of-use billing adjustments.

www.maxim-ic.com/lighting

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LED Driver with Integrated MOSFET Enables Drop-In Replacements for Retrofit MR16 Lamps
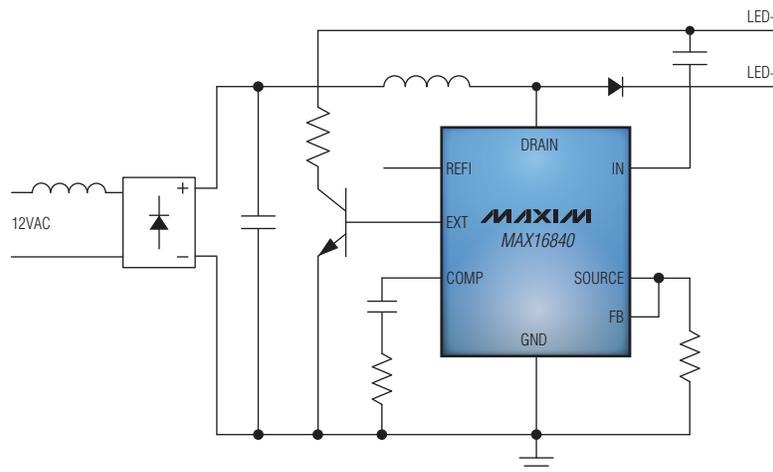
MAX16840

The MAX16840 is a switch-mode LED driver designed for retrofit MR16s and other 12VAC input applications. It employs a proprietary input-current control scheme to ensure compatibility with electronic transformers and dimmability with trailing-edge dimmers. This innovative architecture enables the design of retrofit LED lamps that can replace halogen MR16s without any changes to the existing electrical infrastructure. This removes an important obstacle to commercial viability, allowing end users to enjoy all the benefits of LED lighting with substantially lower deployment costs.

Applications

- **12VAC input lamps**
  - MR16
  - AR111

Benefits

- **Flicker-free 12VAC input lamps**
  - Compatible with majority of electronic transformers
  - Dimmable with trailing-edge dimmers and electronic transformers
- **Highly reliable solution extends lamp lifetime**
  - Does not require electrolytic capacitors
  - -40°C to +125°C operating temperature
- **Smaller board and lower BOM cost**
  - Single-converter solution
  - Low external component count
  - Does not require electrolytic capacitors

Typical operating circuit for the MAX16840.

Industrial-Grade LED Drivers Reduce External Component Count

MAX16822/MAX16832

The MAX16822/MAX16832 are high-input-voltage, buck-mode, high-brightness (HB) LED drivers for up to 1A or 500mA current. With hysteretic control of the LED current, they do not need a compensation circuit. They require very few external components, thus reducing BOM cost and board area substantially compared to other solutions. A switching MOSFET is included, and they feature an analog dimming input with nonlinear behavior for thermal foldback.

Applications

- Street and other outdoor lamps
- Architectural lighting
- Luminaires
- High- and low-bay lamps

Benefits

- **Low component count and BOM cost**
  - Hysteretic current control eliminates the need for external compensation
  - Integrated switching MOSFET: up to 1A (MAX16832) or 500mA (MAX16822) output current
  - Low 1µF input capacitor
- **Industrial-grade devices for harsh environments**
  - 6.5V to 65V input range is compatible with 12V/24V/48V inputs and robust for input voltage spikes
  - -40°C to +125°C operating temperature
  - High-power-dissipation capability in an 8-pin SO-EP package (MAX16832) for environments with high ambient temperatures
  - Thermal-foldback input protects LEDs in case of overheating

Typical operating circuit for the MAX16822/MAX16832.

HB LED Drivers Reduce BOM Cost
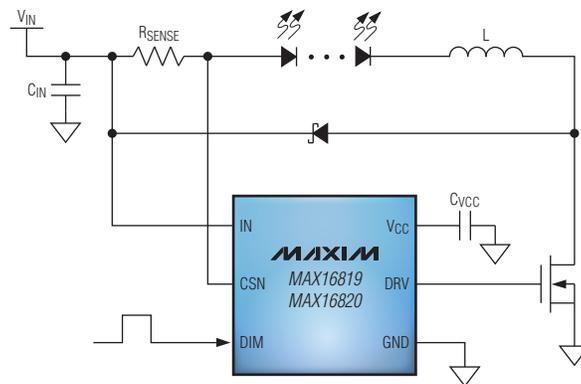
MAX16819/MAX16820

The MAX16819/MAX16820 are buck-mode HB LED drivers featuring an external switching MOSFET for applications with more than 1A current. They provide hysteretic control of the LED current so that they do not need a compensation circuit. They require very few external components, are low in cost, and are available in a small package size (3mm x 3mm). These are dependable products for the harsh operating environment of industrial applications.

Applications

– Street and other outdoor lamps
– Architectural lighting
– Luminaires
– High- and low-bay lamps
– MR16 and AR111 lamps

Benefits

- **Low component count and BOM cost**
  – Hysteretic current control needs no external compensation
  – Simple, low-cost ICs
- **Ideal for applications with limited board area**
  – Small, 3mm x 3mm, 6-pin TDFN package
- **Industrial-grade products for harsh environments**
  – 4.5V to 28V input voltage range
  – -40°C to +125°C operating temperature

Typical operating circuit for the MAX16819/MAX16820.

Offline LED Driver Provides Smooth Dimming While Maximizing Energy Efficiency
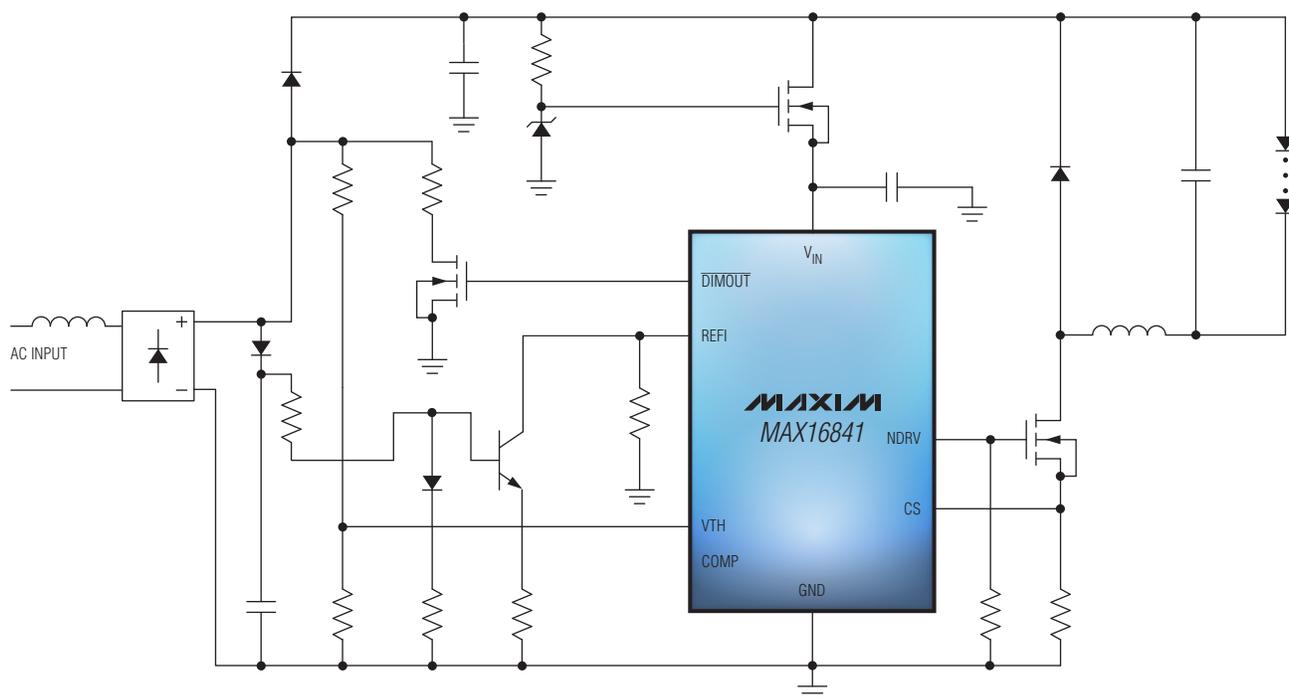
MAX16841*

The MAX16841 LED driver is designed for dimmable offline retrofit lamps (A, R, PAR, GU10, etc.). This product allows seamless replacement of incandescent and halogen lamps with LED technology, eliminating issues of compatibility with preinstalled dimmers. Its proprietary active PFC approach enables very smooth dimming from 0 to 100% of the light output. A universal input (90VAC to 265VAC) dimmable design is available.

Applications

- Dimmable retrofit lamps
- Universal LED bulbs
- Industrial and commercial lighting
- Residential lighting

Benefits

- **Excellent dimming performance**
  - Flicker-free dimming with triac dimmers, from maximum intensity down to zero
  - Lamps dim without flicker with digital dimmers (e.g. Lutron Maestro)
- **High efficiency**
  - Requires only one start-up bleeder for smooth dimming—no hold-current bleeder
  - Constant frequency control optimizes efficiency at high and low AC line voltage
- **Reduce inventory and design costs**
  - Universal input (90VAC to 265VAC), dimmable solution
- **Longer lamp lifetime**
  - Option to have no electrolytic capacitors on the driver board
  - If electrolytic caps are present, lamp continues to operate even if they fail

Block diagram for the MAX16841.

*Future product—contact the factory for availability.

## G3-PLC Chipset Automates Lighting in Large Buildings and Cities

MAX2991/MAX2992

The MAX2991 AFE and MAX2992 MAC/PHY transceiver provide a complete PLC solution for large lighting arrays. The MAX2992 utilizes OFDM techniques with DBPSK, DQPSK, and D8PSK modulation along with forward error correction to enable robust data communication using the electrical power grid. An enhanced CSMA/CA and ARQ scheme, together with a mesh routing protocol, supports large lighting arrays and communication over long distances. These mechanisms enable it to communicate over distances from hundreds of meters to 10km or more, and with data rates up to 300kbps. The chipset is well suited for long runs of street lamps and other large-scale lighting networks.

The MAX2992 MAC incorporates a 6LoWPAN adaptation layer to support IPv6 packets. IPv6 addressing facilitates network management and increases scalability. Intelligent communication mechanisms simplify installation by enhancing system performance over a range of channel conditions. These mechanisms include channel estimation, adaptive tone mapping, and best-path routing protocols. An on-chip authentication coprocessor with AES-128 encryption/decryption provides security and authentication.

Benefits

- **Worldwide compliance**
  – Prestandard conformance: IEEE P1901.2, ITU G.9955 (G.hnem), and IEC/CENELEC
  – Frequency-band compliant with CENELEC™, FCC, and ARIB

- **IPv6-compatible networking simplifies integration**
  – 6LoWPAN IPv6 header compression maximizes payload size
  – Dynamic routing mechanism supports mesh networking
  – CSMA/CA controls traffic in multinode networks

- **Built-in robustness mechanisms ensure reliable, high-speed communication**
  – Data rates up to 300kbps
  – Two layers of forward error correction and cyclic redundancy check
  – CCM authentication coprocessor featuring AES-128 encryption/decryption
  – ARQ enhances error detection and data reliability
  – Dynamic link adaptation to select optimum data rate based on channel conditions
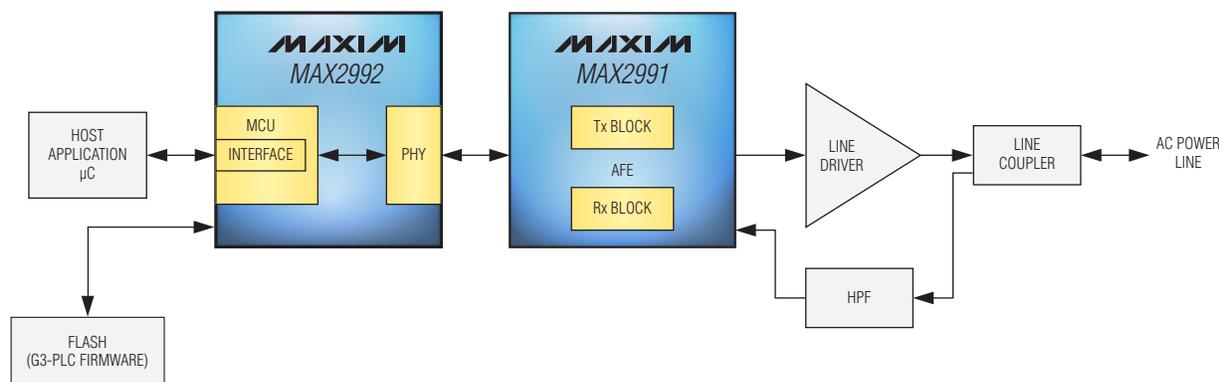
Block diagram of the MAX2991/MAX2992 G3-PLC chipset.

Programmable Energy Measurement Processor Provides Accuracy and Manages Dimming and Relay Control as a DALI Slave

78M6613

The 78M6613 is a highly integrated single-phase energy measurement processor designed to measure both the input AC power of a luminaire and the DC power output of the LED lamp.

Watt-hour accuracy relative to a known reference is measured with less than 0.5% error over a 2000:1 current range, over any power factor and over the industrial temperature range. Performance and functionality is equivalent to what one would typically find in a multichip utility meter: a 32-bit computation engine, an MPU core, 32KB flash memory, 2KB shared RAM, two UARTs, and an I^{2}C/MICROWIRE® EEPROM interface or an SPI™ interface. It also features Teridian's Single Converter Technology® design, which incorporates a 22-bit delta-sigma ADC, four analog inputs, digital temperature compensation, and a precision voltage reference. Needing very few external components and short calibration time, this single chip also greatly reduces the cost of implementation and manufacturing.

A complete array of in-circuit emulation and development tools assists customers and reduces design time. Metrology libraries are specifically designed for measurement and switch control of single-phase relays. A software development kit, reference design, and design guide expedite development and certification of power and energy measurement.

The 78M6613 is available in a lead-free 32-pin QFN package.

Benefits

- **Provides the metrology accuracy typically found in multichip utility meters**
  - Watt-hour measurement accuracy: < 0.5% error with up to 15s calibration or 2.5% error without calibration

- **Adds intelligence to energy monitoring**
  - Data available for predicting failure by measuring the power factor for each luminaire
  - Control and extend relay life expectancy by reducing spark with integrated zero-crossing information

- **Shortens time to market**
  - Software support tools and hardware design guide simplify design cycles
  - No code development is required by the customer
  - Low-level application programming interface (API) available
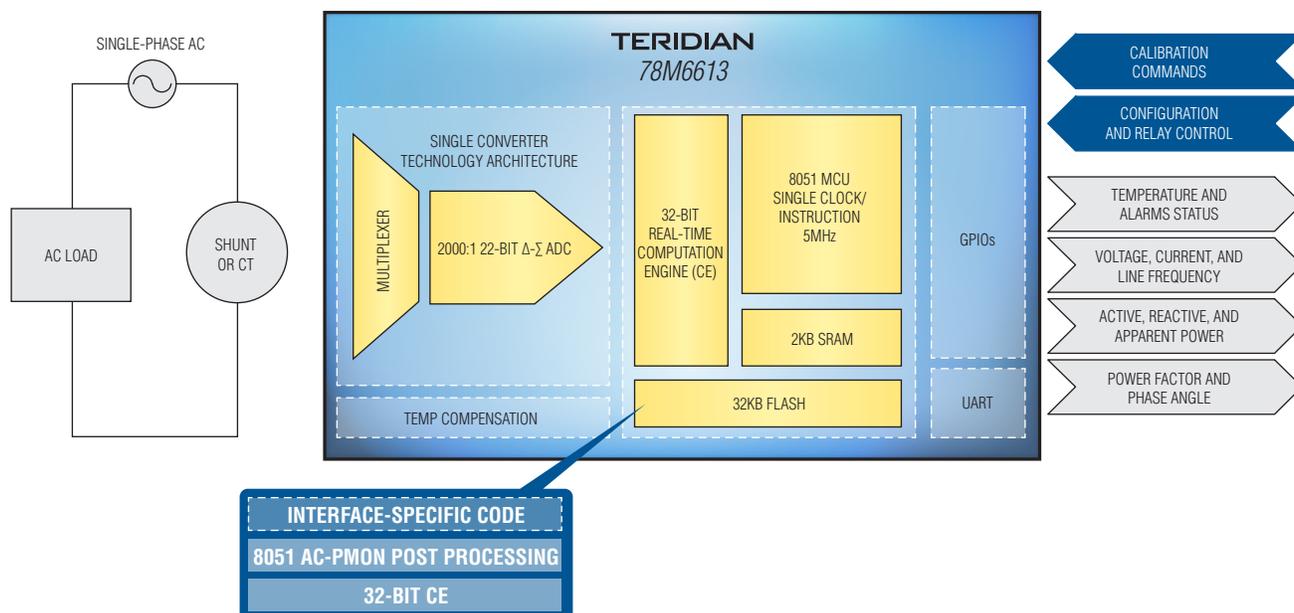 - One energy measurement subsystem SKU suitable for any luminaire or combination of luminaires

Diagram of the 78M6613 embedded in a single-phase application.

Programmable Energy Measurement Processor Monitors Up to Eight Single-Phase Loads in a Lighting and Power Control Box

78M6618

The 78M6618 is a highly integrated, single-phase, energy measurement processor designed to monitor up to eight single-phase loads in a lighting control panel.

Watt-hour accuracy relative to a known reference is measured with less than 0.5% error over a 2000:1 current range, over any power factor and over the industrial temperature range. Performance and functionality is equivalent to what one would typically find in a multichip utility meter: a 32-bit CE, an MPU core, 128KB flash memory, 4KB shared RAM, two UARTs, and an I^2C/MICROWIRE EEPROM interface or an SPI interface. It also features Teridian's Single Converter Technology design, which incorporates a 22-bit delta-sigma ADC, ten analog inputs, digital temperature compensation, and a precision voltage reference. Needing very few external components and short calibration time, this single chip also greatly reduces the cost of implementation and manufacturing.

A complete array of in-circuit emulation and development tools assists customers and reduces design time. Metrology libraries are specifically designed for measurement and switch control of eight single-phase relay branches (same phase). A software development kit, reference designs, and a design guide expedite development and certification of power and energy measurement.

The 78M6618 is available in a lead-free 68-pin QFN package.

(Block diagrams on following pages)

Benefits

- **Single chip provides the metrology accuracy typically found in multichip utility meters**
  - < 0.5% watt-hour measurement error per relay branch from low-current load (0.01A) up to maximum operating load (20A)
- **Adds intelligence to energy monitoring**
  - Data available for predicting failure by measuring the power factor for each relay branch
  - Control up to eight relays and extend each relay's life expectancy by reducing spark with integrated zero-crossing information
- **Shortens time to market**
  - Software support tools and hardware design guide simplify design cycles
  - No code development is required by the customer
  - Low-level API available

Programmable Energy Measurement Processor Monitors Up to Eight Single-Phase Loads in a Lighting and Power Control Box *(continued)*
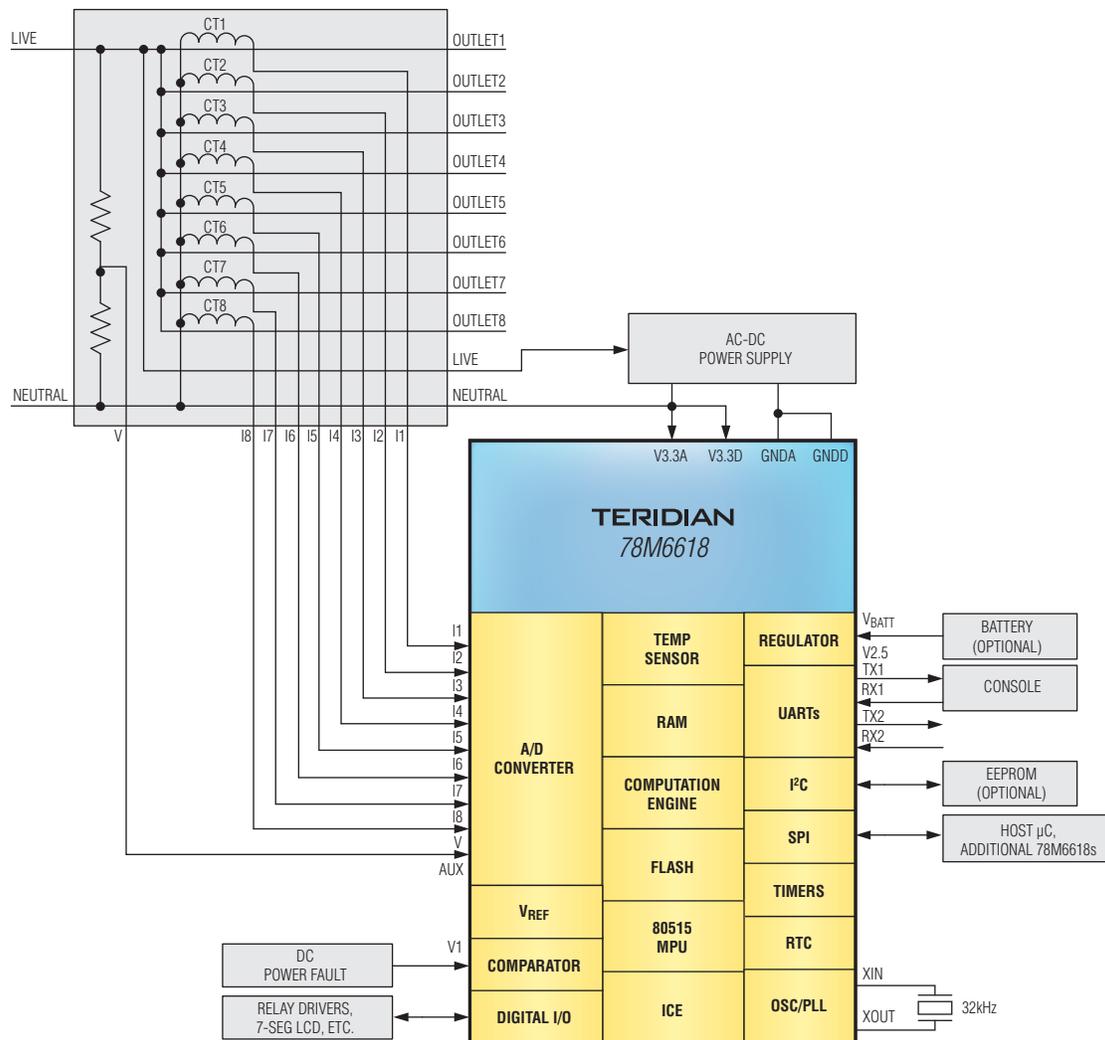
Block diagram of the 78M6618 power and energy measurement IC.

LED Lighting

Recommended Solutions

Part	Description	Features	Benefits
Energy Measurement			
78M6613	Single-phase AC power measurement and monitoring SoC with embedded AC load monitoring and control firmware	On-chip MPU+flash; < 0.5% Wh error over 2000:1 dynamic range; built-in intelligent switch control; cost-optimized for embedded energy-measurement systems; allows customization of measurement algorithms, data formatting, and host interface protocol	Enables real-time energy measurement; eliminates need for external components to boot/load calibration parameters; provides flexibility for field upgrades
78M6618	Industry's first and only SoC for real-time, simultaneous monitoring of up to eight single-phase AC loads	On-chip MPU+flash; < 0.5% Wh error over 2000:1 dynamic range; built-in intelligent switch control; allows customization of measurement algorithms, data formatting, and host interface protocol	Enables revenue-grade accuracy at point of load; maintains accuracy from standby power modes up to maximum operating load
Isolated Power Supply			
MAX17499/ MAX17500	Isolated AC-DC and DC-DC current-mode PWM controllers with programmable switching frequency	Rectified 85V to 265V AC and 9.5V to 24V DC isolated and nonisolated; programmable switching frequency up to 625kHz; 50µA start-up supply current	Enable design for low-noise interference and small solution footprint
LED Power			
MAX16841	Dimmable offline LED driver with universal input range (90VAC to 265VAC)	Proprietary control and shaping of the input current for triac dimmability	Smooth dimming with triac dimmers; dimmable universal input design
MAX16840	Boost and buck-boost LED driver for MR16 and other 12VAC input lamps	Proprietary control and shaping of the input current; integrated 48V switching MOSFET; needs no electrolytic capacitors	Flicker-free operation with most electronic transformers; fits in small MR16 lamp; extends lamp lifetime
MAX16822	500mA, buck, switch-mode driver with integrated MOSFET	6.5V to 65V input; LED current thermal foldback; few external components	Small board area; low BOM cost
MAX16832	1A, buck, switch-mode driver with integrated MOSFET	6.5V to 65V input; LED current thermal foldback; few external components	Small board area; high-power-dissipation package reduces need for heatsink
MAX16820	Buck, switch-mode driver	External MOSFET; > 1A output; no compensation circuit	Flexible with few external components
MAX16834	Boost and buck-boost driver	Internal driver for PWM dimming MOSFET; analog dimming input	3000:1 dimming range; supports multiple topologies
Operational Amplifiers			
MAX44009	Industry's lowest power ambient-light sensor with ADC	Less than 1µA operating current; ultra-wide 22-bit dynamic range from 0.045 lux to 188,000 lux	On-chip photodiode's spectral response mimics the human eye's perception of ambient light; incorporates IR and UV blocking capability
MAX44000*	Integrated ambient-light and proximity sensor	Operates from 1.7V to 3.6V V_{DD}; 5µA in ambient mode; 7µA in proximity mode; 11µA in ambient plus proximity mode, including external IR LED current; wide dynamic range (0.03 lux to 65,535 lux)	Improves noise immunity; reduces system software overhead; minimizes power consumption
MAX9613/ MAX9615	Low-power, high-efficiency, single/dual, rail-to-rail I/O op amps	Precision MOS inputs powered from an internal charge pump to eliminate crossover distortion; excellent RF immunity	Ideal for signal processing applications such as photodiode transimpedance amplifiers and filtering/amplification; self-calibration system eliminates the effects of temperature and power-supply variations
MAX4245	Ultra-small, low-power, rail-to-rail I/O op amp with disable	320µA quiescent current; 2.5V to 5.5V single-supply operation; unity-gain stable with a 1MHz gain-bandwidth product driving capacitive loads up to 470pF	Suitable for harsh environments (specified from -40°C to +125°C); available in ultra-small 6-pin SC70 and SOT23 packages
MAX9140/ MAX9142	High-speed, low-power, 3V/5V single-supply comparators with rail-to-rail I/O	Single/dual comparators optimized for 3V or 5V systems; 40ns propagation delay; consume 150µA per comparator	Higher-speed, lower-power, and lower-cost upgrades to industry-standard comparators
MAX9030/ MAX9032	Low-cost, ultra-small, single/dual comparators	Optimized for single supply (2.5V to 5.5V) but can operate from dual supplies; 188ns propagation delay; consume 35µA per comparator over -40°C to +125°C range	Ideal for portable applications; combine low-power, single-supply operation down to 2.5V and an ultra-small footprint

Recommended Solutions *(continued)*

Part	Description	Features	Benefits
Powerline Controllers			
MAX2981/ MAX2982*	Broadband powerline chipset comprising a modem transceiver and AFE	HomePlug® 1.0 compliant MAC/PHY SoC with integrated ARM9™ processor; Ethernet, MII/RMII, FIFO, and UART interfaces; fully integrated AFE with line driver requires only coupling circuit to interface to powerline; -40°C to +105°C operation	Industrial-grade modem supports data rates up to 14Mbps over AC or DC power lines within buildings; point-to-multipoint addressing to control groups of lights
MAX2991/ MAX2992	G3-PLC compliant powerline chipset comprising a modem transceiver and AFE	MAC/PHY SoC with high-performance 32-bit MAXQ® processor; SPI and UART host interfaces; fully integrated AFE requires only line driver and coupling circuit to interface to AC or DC power lines; variable sampling rate up to 1.2MHz; -40°C to +105°C operation	Prestandard conformance (IEEE P1901.2, ITU G.9955, and IEC/CENELEC); supports large lighting arrays over long distances using IPv6 compatible networking
Power Supply (DC-DCs, LDOs)			
MAX5033/ MAX5035	500mA/1A, high-efficiency step-down DC-DC converters with 7.5V to 76V input	Adjustable output down to 1.25V; internal compensation; 270µA quiescent current at no load	Enable efficiency up to 94%; reduce external component count and BOM cost; high efficiency at light load
MAX6765– MAX6774	Low-quiescent-current, high-voltage linear regulators	31µA quiescent current; 4V to 72V input range; active-low RESET with fixed or adjustable thresholds; small, thermally-enhanced, 1.9W, 3mm x 3mm TDFN package	Low quiescent current improves energy savings
RF ICs			
MAX1472	300MHz to 450MHz, low-power, crystal based, ASK transmitter	Crystal based; low power; 3mm x 3mm package	Superior performance; long battery life; compact
MAX1473	300MHz to 450MHz ASK receiver with automatic gain control (AGC)	High sensitivity and AGC; 5mm x 5mm package; single supply	Long range; low solution cost; compact
Switch Debouncer			
MAX16054	Pushbutton on/off controller	±15kV ESD protection	Improves reliability; small size saves space
Supervisors			
MAX6443– MAX6452	Single/dual µP reset circuits with manual-reset inputs	Two manual-reset inputs with extended setup period (6.72s); precision voltage monitoring down to 0.63V	Avoid nuisance resets; eliminate the need for a pinhole in the equipment case
Temperature Sensor			
DS18B20	Digital temperature sensor with ±0.5°C accuracy and 1-Wire® communication interface	1-Wire interface with parasitic power option enables operation with just two connections (data and ground); ±0.5°C accurate over -10°C to +85°C range; ±2.0°C over full operating range of -55°C to +125°C; user-selectable resolution of 9 to 12 bits (0.5°C to 0.0625°C)	Minimizes wiring and simplifies design of multisensor configurations; high accuracy and resolution enable precise temperature measurement of thermally sensitive systems