

Reduce LED power requirements using advanced LED driver technology

The global demand for highly efficient LED products has grown dramatically over the past 10 years, to the extent that today's products are rapidly encroaching on the \$100 billion fluorescent light market which has flourished over the past 130 years⁽¹⁾. Recent improvements in this 40-year technology have resulted in "clean," reliable and highly efficient products which are already dominating in many rapidly growing applications. LEDs are now the preferred lighting source for mobile phones, full-motion signs, traffic signals, automotive dashboards, digital cameras, backlighting units for displays in notebook computers, desktop monitors, flat-panel televisions, and stadium signage.

According to "Global and China LED Industry Report 2009-2010" (Research In China) the global LED market has expanded from \$7 billion in 2009 to \$10.7 billion in 2010 and is expected to reach \$20.4 billion in 2012.

The U.S. Department of Energy reports that over the next 20 years, the application of LED lights in the US alone will:

- Reduce electricity consumption for lighting applications by 25%
- Save enough electricity to illuminate 95 million homes in the U.S. today
- Yield a monetary savings of \$120 billion
- Save the equivalent electrical output of 24 large power plants
- Reduce greenhouse gas emissions by 246 metric tons of carbon

The Evolution of LEDs and LED Drivers

The development of the first visible spectrum red LED was by GE in 1962. A steady advancement in the technology saw the subsequent development of other colors of the light spectrum with exponential improvements in brightness. In the 1970's, LEDs that once cost about \$200 per device were then being manufactured for less than \$0.05 per device.

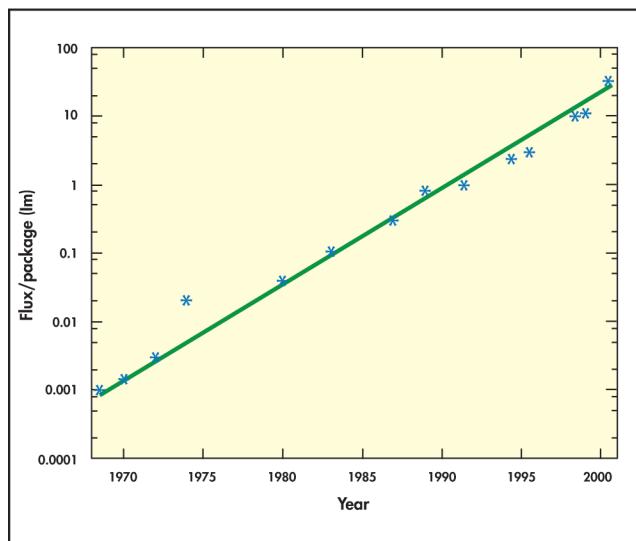


Figure 1: Hail茨's Law
The light output of LEDs has essentially doubled every 36 months since 1960.

As LED capabilities improved, so too did the importance of driver technology. Performance criteria such as LED color temperature and shifting, efficacy and flickering, and overall operating efficiency all became associated with the LED driver. Legacy LED driver topologies that had used older solid state designs and voltage regulators cannot support new LED design performance targets. An industry benchmark referred to as Hail茨's law cites the expected improvements in LEDs over time as light levels increase. Thus we can expect the cost per lumen of a packaged LED to decrease by a factor of 10 as the light generated per LED to increase by a factor of 20 for a given color of light, per decade (Figure 1). These continuous advancements in LED performance have the effect of requiring new topologies and more LED driver choices for specific output power ranges.

Other design requirements that are having a dramatic influence on LED drivers include:

- The ability to handle increased temperatures, greater safety, circuit protection and overall reliability demands
- Compliance with global energy regulations, particularly trends calling for the minimization of power in the standby and power-down modes
- The ability to meet a limited circuit board footprint. Integrated ICs today are eliminating the need for separate capacitors, inductors, MOSFETs and transformers, while improved switching frequencies allow for the minimization of magnetics
- And the ability to function in existing lighting installation and manufacturing schemes

The consequences of this complex set of requirements mean that LED driver manufacturers, like Fairchild Semiconductor, must develop new topologies and new components optimized for specific power ranges. And it means that LED lighting system manufacturers must deal with the prospect of multiple vendors and more complicated supply chains.

Design Factors

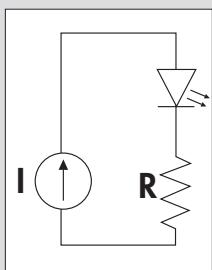


Figure 2:
LED Biasing Circuit

Given that the light output from an LED is proportional to the forward current drive, the "ideal" LED driver consists of a constant current source (Figure 2). The forward voltage of the LED can also vary, therefore, the amount of power delivered to the LED will fluctuate.

Furthermore, the brightness of LEDs also varies, as a function of the manufacturing process, which means that it is necessary to account for variations in both driver current and the forward voltage characteristics of the device.

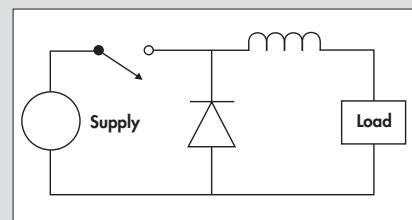


Figure 3: Buck Topology

Two primary topologies are used in order to properly bias the LED. One topology is the traditional Buck regulator. The Buck topology is the most common DC-DC implementation since it is in many ways an "ideal source" providing a constant current output and very high output impedance (Figure 3).

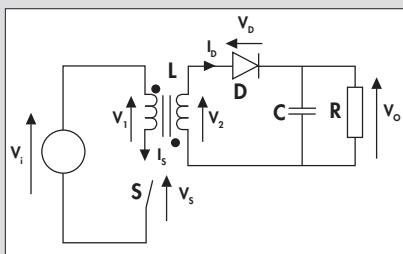


Figure 4: Flyback Topology

Another popular topology is the flyback regulator (Figure 4), and it is a compact, low cost, high efficiency (85%), isolated AC-DC converter solution for direct LED drive. (Constant power is not important; it is controlling the current)

Application Characteristics

Low Power Designs (<20W), include applications such as light strips (1.5-5.0W), R-Lamps (5-10W), bulbs (3-20W) and down lights (10-20W). The specific implementation challenges with these applications include: (1) small lamp size which limits component selection to the smallest available packages, (2) small design volume, which requires the use of low profile components and (3) cost.



Examples of Fairchild's solutions for low power designs include a family of intelligent, versatile LED drivers.

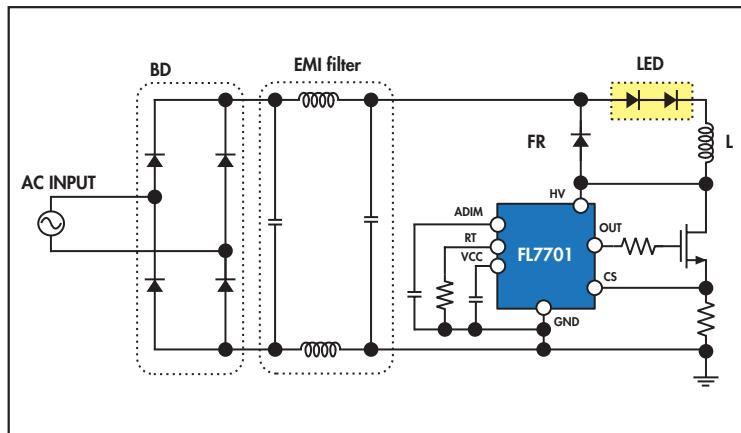


Figure 5: FL7701 Application Diagram

The FL7701 LED driver incorporates a PFC optimization function. The unique digital technique automatically detects input voltage conditions and sends an internal reference signal for achieving high power factor. When AC input is applied to the IC, PFC function is automatically enabled. Otherwise, when DC input is applied to the IC, the PFC function is automatically disabled.

The FL7730 features Fairchild's proprietary topology, TRUECURRENT™, which enables a highly simplified design for LED lighting applications. TRIAC dimming is smoothly managed by dimming brightness control without flicker. The use of a single-stage topology with primary-side minimizes external components cost.

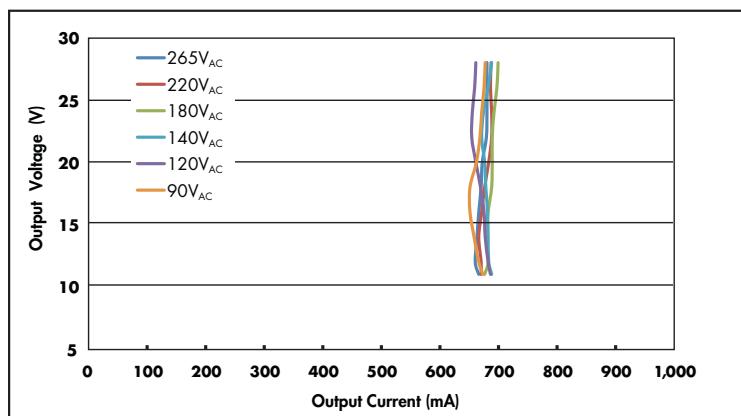
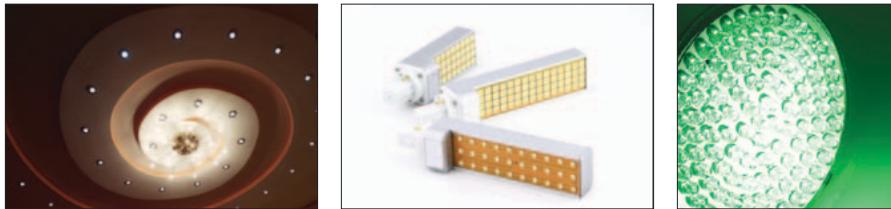


Figure 6: Constant Current Regulation

The FL7732 is a highly integrated PWM controller. The FL7732 provides open-LED, short-LED, and over-temperature protection features. The current limit level is automatically reduced to minimize output current and protect external components in a short-LED condition

Mid-Power Designs (20-50W), include applications in the range of 20-50W, such as down lights, and L-lights. The designer's challenges with these applications include: (1) limited board space, (2) available topologies that are inherently low-efficiency, (3) need for high reliability components and (4) power factor correction (PFC) is required, which then increases component count.



Fairchild's solutions for mid-power designs utilize a Single Stage PFC flyback topology.

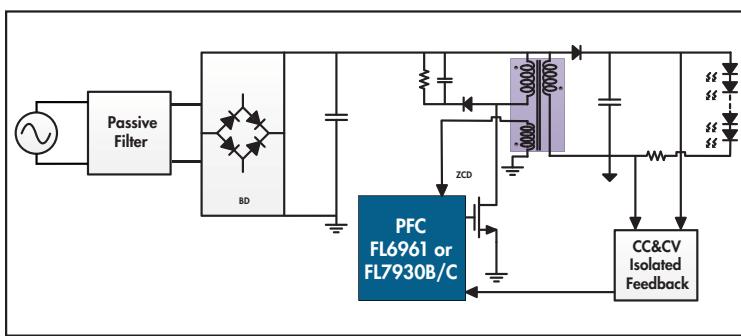


Figure 7: Single Stage Flyback Topology

The primary objectives of Fairchild's mid-power solutions are to address the designer's needs for smaller component count and higher system reliability. A key building block in the implementation of these architectures is the PFC and error amp module. Fairchild's growing family of mid-power design products provides highly integrated solutions to meet the needs of the designer.

The Single Stage PFC flyback topology from Fairchild features:

- High power factor of >0.91, and therefore meets global energy requirements for solid-state lighting
- Low total harmonic distortion (THD) to meet Class-C THD
- High integration, low component count
- Improved efficiency (>80%)
- High reliability
- Elimination of the input bulk capacitor

High-Power Designs (50-400W), include applications in the range of 50-400W such as flat lights, street, stadium, stage lighting, wall washing and signage. The designer's challenges with these applications include: (1) high component count, (2) cost, (3) low overall system efficiency and (4) increased complexity.



Fairchild offers two highly integrated high-power solutions:

- Two-stage PFC flyback and Quasi-Resonant (QR) flyback topology:
 - A. Ideal for applications <100W
 - B. Solution reduces switching losses associated with the MOSFET output capacitance and the MOSFET soft switching also reduces EMI (Reducing losses results in higher efficiency)
 - C. Feature rich controllers enhance design flexibility while minimizing complexity
- Two-stage PFC flyback and LLC half-bridge topology:
 - A. Ideal for applications <400W
 - B. Offers best efficiency >92% due to zero voltage switching capability
 - C. FAN7346 used for secondary control on multiple LED strings
 - D. LLC solutions include:
 - Integrated MOSFETs and high side driver
 - External MOSFETs for design flexibility – allows matching MOSFETs to the power level of your load

Applications and Design Support

Fairchild's constantly expanding product portfolio, coupled with manufacturing process enhancements, innovative topologies and our deep systems expertise allow circuit designers to develop the most advanced solution to their present and future needs.

We offer a broad range of integrated controllers, MOSFETs, phototransistors, diodes and bridge rectifiers for every LED output power range and application. Also available are reference designs and evaluation boards that guide engineers in the development of specific LED design solutions.

Rather than deal with the problems of multiple vendors and supply chain concerns, LED lighting manufacturers can find an advanced LED lighting solution for every application from a pioneer in the LED industry, Fairchild.

For data sheets, application notes, samples and more, please visit: www.fairchildsemi.com

PRODUCTS

APPLICATIONS

DESIGN SUPPORT

ABOUT FAIRCHILD

POWER MANAGEMENT

Power Factor Correction

- Continuous Conduction Mode (CCM) PFC Controllers
- Critical/Boundary Conduction Mode (CrCM/BCM) PFC Controllers
- Interleaved PFC Controllers
- PFC + PWM Combination (Combo) Controllers

Off-Line and Isolated DC-DC

- AC-DC Linear Regulators
- Flyback & Forward PWM Controllers
- Flyback & Forward PWM Controllers with Integrated MOSFET
- LLC Resonant & Asymmetric Half Bridge PWM Controllers
- LLC Resonant & Asymmetric Half Bridge PWM Controllers with Integrated MOSFETs
- Primary-Side Regulation CV/CC Controllers
- Primary-Side Regulation CV/CC Controllers with Integrated MOSFET
- Standard PWM Controllers
- Supervisory/Monitor ICs
- Synchronous Rectifier Controllers

Non-Isolated DC-DC

- Charge-pump Converters
- DrMOS FET plus Driver Multi-Chip Modules
- Step-down Controllers (External Switch)
- Step-down Regulators, Non-Synchronous (Integrated Switch)
- Step-down Regulators, Synchronous (Integrated Switch)
- Step-up Regulators (Integrated Switch)

MOSFET and IGBT Gate Drivers

- 3-Phase Drivers
- Half-Bridge Drivers
- High- & Low-Side Drivers
- High-Side Drivers
- Low-Side Drivers
- Synchronous Rectifier Drivers

Voltage Regulators

- LDOs
- Positive Voltage Linear Regulators
- Negative Voltage Linear Regulators
- Shunt Regulators
- Voltage Detector
- Voltage Stabilizer
- Voltage to Frequency Converter

Motion Control

- BLDC/PMSM Controller
- Motion-SPM™ (Smart Power Modules)
- PFC SPM® (Smart Power Modules)

Diodes & Rectifiers

- Bridge Rectifiers
- Circuit Protection & Transient Voltage Suppressors (TVS)
- Diacs
- Rectifiers
- Schottky Diodes & Rectifiers
- Small Signal Diodes
- Zener Diodes

IGBTs

- Discrete IGBTs
- Ignition IGBTs

MOSFETs

- Discrete MOSFETs
- Level-Shifted Load Switches
- MOSFET/Schottky Combos

Transistors

- BJTs
- Darlingtons
- Digital/Bias-Resistor Transistors
- JFETs
- RF Transistors
- Small Signal Transistors

Advanced Load Switches

- Advanced Current Limited Load Switches
- Slew Rate Controlled Load Switches

Battery Management

- Battery Charger ICs
- Current Sensing

Ground Fault Interrupt Controllers

- Ground Fault Interrupt (GFI) Controllers

Backlight Unit (BLU)

- CCFL Inverter ICs

SIGNAL PATH ICs

Amplifiers & Comparators

- Comparators
- Operational Amplifiers

Audio Amplifiers

- Audio Subsystems
- Audio Headphone Amplifiers
- Digital Microphone Amplifiers
- Audio Speaker Amplifiers

Battery Protection ICs

- Battery Protection ICs

Interface

- LVDS
- Serializers/Deserializers (μSerDes™)
- USB Transceivers

Signal Conditioning

- Video Filter Drivers
- Video Switch Matrix/Multiplexers

Signaling, Sensing & Timing

- Signaling, Sensing & Timing
- Timing

Switches

- Accessory Switches
- Analog Switches
- Audio Jack Detection Switches
- Audio Switches
- Bus Switches
- MIPI Switches
- Multi-media Switches
- USB Switches
- Video Switches

LOGIC

Buffers, Drivers, Transceivers

- Buffers
- Line Drivers
- Transceivers

Flip Flops, Latches, Registers

- Counters
- Flip Flops
- Inverters
- Latches
- Registers

Gates

- AND Gates
- NAND Gates
- OR Gates
- NOR Gates
- Schmitt Triggers
- Configurable Gates

Multiplexer/Demultiplexer/Decoders

- Decoders
- Demultiplexers
- Multiplexers
- Multivibrators

Voltage Level Translators

- Voltage Level Translators

LIGHTING ICs

- Fluorescent Lamp ICs
- HID ICs
- LED Lighting ICs
- Portable LED Drivers

OPTOELECTRONICS

High Performance Optocouplers

- Low Voltage, High Performance
- High Speed Logic Gate
- High Performance Transistor
- IGBT/MOSFET Gate Driver
- Specific Function

Infrared

- Emitting Diodes
- Photo Sensors
- Photo Sensor – Transistors
- Ambient Light Sensors
- Reflective Sensors
- Optical Interrupt Switches

Phototransistor Optocouplers

- Isolated Error Amplifier
- Phototransistor Output - DC Sensing Input
- Phototransistor Output - AC Sensing Input
- Photo Darlington Output

TRIAC Driver Optocouplers

- Random Phase TRIAC Driver
- Zero Crossing TRIAC Driver

AUTOMOTIVE PRODUCTS

Automotive Discrete Power

- Automotive Ignition IGBTs
- Automotive IGBTs
- Automotive N-Channel MOSFETs
- Automotive P-Channel MOSFETs
- Automotive Rectifiers

Automotive High Voltage Gate Drivers (HVICs)

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High Side Smart Switches

- High Side Smart Switches