LUMISSIL MICROSYSTEMS

Lighting on a Power Budget

Efficient LED driver design for extending battery life

In battery-powered applications, LED lighting subsystems often receive insufficient attention during power budgeting. Achieving long battery life requires optimizing the complete energy path from battery to light output, including conversion losses, driver quiescent current, and control overhead. LED power must be managed with the same discipline applied to MCU sleep current and wireless standby current. This article examines two Lumissil LED drivers targeting opposite ends of the power spectrum: the IS31BL3557 and the IS31FL3713.

TWO LIGHTING JOBS, TWO POWER PROBLEMS

Portable products usually contain two very different LED lighting loads at opposite ends of the power curve. Display backlights are high power illumination loads that require voltage boosting and precise multi-string white LED current regulation. LED status indicators are low power information loads that benefit from minimal MCU intervention and ultra-low average current. Although these applications represent two very different power loads, Lumissil provides optimized drivers for both: the IS31BL3557 hybrid boost backlight driver and the IS31FL3713 boost matrix LED driver.

BACKLIGHTS: CONVERTING BATTERY ENERGY INTO LIGHT, NOT HEAT

LCD backlights are among the largest energy consumers in portable systems, often accounting for 30–40% of total battery capacity. White LED strings used for LCD backlighting typically require a voltage higher than the battery rail, especially with 2- or 3-cell Li-ion inputs. A simple resistor or linear driver cannot raise the LED supply above the battery rail, and any excess voltage is dissipated as heat rather than delivered as useful light. As the battery voltage falls, the available headroom also decreases, causing LED current and brightness to become less consistent.

The IS31BL3557 solves this challenge with a two-stage architecture: a synchronous inductive boost converter followed by a 2× charge-pump stage. This hybrid approach enables up to 42V output from a 4.5V to 15V battery input while achieving peak efficiencies up to 96%, with >94% efficiency demonstrated at VIN = 7.5V, VOUT = 30V, and total IOUT = 100mA. By splitting the voltage step-up, the design reduces stress on the inductive stage, allowing smaller inductors and lower-profile components ideal for thin notebooks, tablets, and portable displays.

The device integrates an output disconnect switch and eight high-precision current sinks (up to 33mA each, with 1% matching at 20mA). This combination maintains tight current regulation across battery voltage, LED Vf variation, and temperature, delivering consistent brightness with minimal wasted headroom. See Figure 1 for a typical application and diagram showing key IS31BL3557 blocks: Synchronous Inductive boost, charge pump, 8 LED strings and MCU interface.

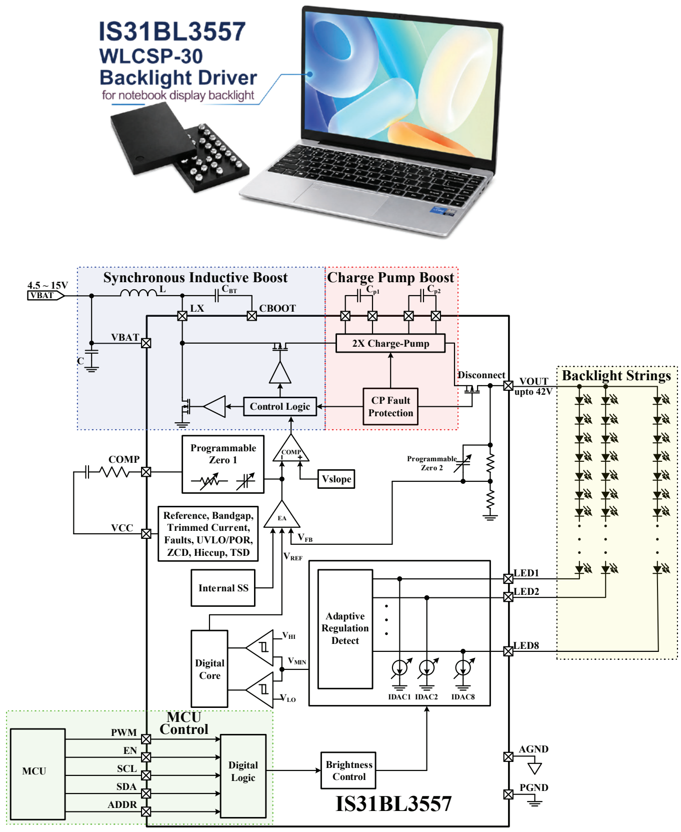

Figure 1: IS31BL3557 Typical Application Circuit and key design blocks

DIMMING STRATEGY IMPACTS BATTERY LIFE

Effective dimming is critical for both battery life and visual quality. The IS31BL3557 supports analog dimming, PWM dimming, and hybrid mixed-mode dimming. Programmable linear or logarithmic fade profiles further enhance the user experience with smooth transitions.

These features allow designers to optimize the backlight for real-world usage, bright during active interaction and dimmed or timed-out otherwise, which directly extends runtime. In portable displays, even small improvements in backlight driver efficiency can translate into meaningful runtime gains, with estimates showing that every 2% improvement in LCD backlight efficiency can extend battery life by approximately 7–10 minutes.

HIGH EFFICIENCY FOR COOLER, LONGER-LASTING SYSTEMS

One of the IS31BL3557's key features for battery-powered designs is its hybrid (mixed-mode) dimming. Rather than relying on a single dimming method, the driver dynamically combines analog and PWM dimming using a programmable transition point. Refer to Figure 2 graph showing the transition between analog and PWM dimming regions.

Analog dimming is used at high brightness levels to reduce LED current amplitude while maintaining continuous current flow. This approach maximizes efficiency, lowers system noise and ripple, and allows the boost converter to operate with minimal headroom as LED forward voltage decreases. At lower brightness levels, the driver transitions to PWM dimming, keeping a higher fixed peak current and modulating brightness via PWM duty cycle. This helps preserve LED chromaticity, avoids color shift common at very low LED currents, and extends the usable dimming range.

The transition threshold is programmable (default 25%, with options for 12.5%, 50%, or 100%) via the CONFIG3 register, and the device further supports up to 12-bit resolution plus 3-bit PWM dithering. Phase-shifted PWM across strings and spread-spectrum modulation help minimize audible noise and EMI. The result is high efficiency at typical usage levels combined with stable chromaticity and wide dimming range, directly contributing to longer battery runtime.

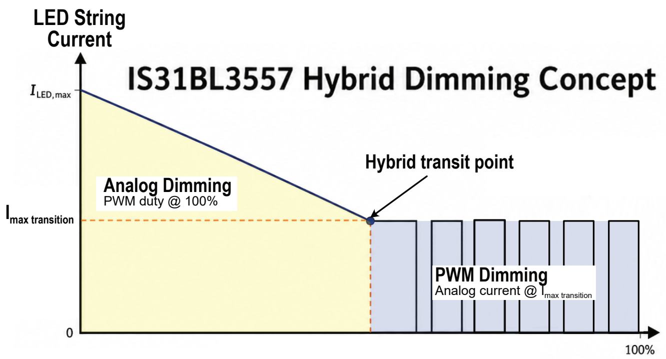

Figure 2. Hybrid (Mixed-Mode) Dimming Operation

INDICATORS USE LIGHT ONLY WHERE INFORMATION IS NEEDED

Moving from high power backlighting to indicator lighting shifts the driver design priority to low power operation. At the low power end, status LEDs, battery gauges, RGB icons, and small symbolic displays present a different challenge. While individual LEDs appear negligible, multiple indicators with always-on or poorly managed animations can drain compact batteries. Furthermore, driving them discretely via MCU GPIOs consumes pins and increases software overhead.

The IS31FL3713 LED driver (4×3 matrix) with inductive boost architecture addresses this efficiently. The integrated boost converter supports low battery voltages with pass-through mode when boosting is unnecessary, and input-output disconnect in shutdown to minimize standby drain. It drives up to 12 single-color LEDs or 4 RGB LEDs in a tiny WLCSP-12 package, with individual 6+4-bit PWM dimming plus 8-bit current scaling. In a 4×3 matrix, the LEDs are multiplexed rather than driven continuously, so the average LED current is lower than the programmed peak sink current. For example, a 50mA peak current in a 1/4-scan system corresponds to approximately 12.5mA average LED current before additional PWM dimming, current scaling, or pattern duty-cycle effects are applied.

Autonomous Animation Reduces Controller Overhead

Battery life is affected not only by LED current, but also by MCU wakeups, I²C transactions, and software refresh activity. The IS31FL3713 can reduce this overhead by running autonomous fade, and pattern effects after the MCU has configured the device through the I²C interface. Once the LED pattern registers are loaded and the device is operating autonomously, the host MCU does not need to continuously refresh the LED sequence, allowing the system to reduce MCU activity or place the MCU into a lower-power state.

Figure 3 shows a typical implementation using an external load switch or MOSFET to isolate the MCU and I²C bus while keeping the IS31FL3713 powered. The key point is that the LED driver must remain powered for autonomous animation to continue; the switch isolation is intended to remove MCU bus loading, not to remove power from the IS31FL3713 itself.

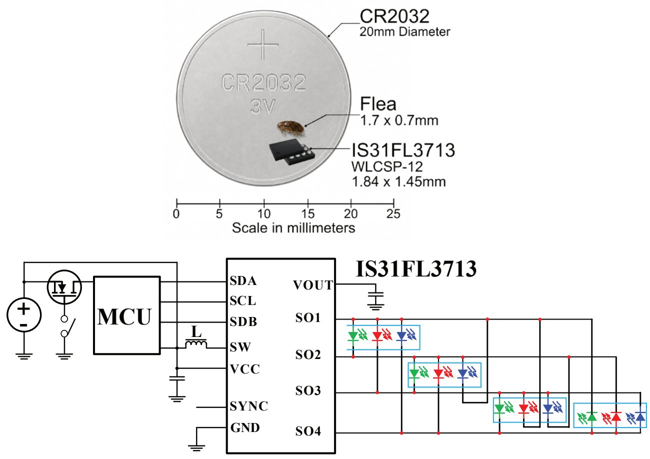

Figure 3. IS31FL3713 Application with 4RGB LEDs

CONCLUSION: TREAT LIGHTING AS A MANAGED ENERGY LOAD

Maximizing battery life requires viewing LED lighting as a core part of the power budget rather than an afterthought. Designers should evaluate LED architectures early in the development cycle to quantify improvements in runtime, form factor, and system efficiency. The IS31BL3557 delivers high-efficiency boosted drive with flexible dimming for LCD backlights, while the IS31FL3713 provides ultra-low-power matrix control with autonomous operation for indicators and icons. Both devices reduce external component count, simplify design, and enable compact, long-running portable products.

Whether your next design needs a high-power backlight or subtle status lighting, selecting the right architecture early in the process provides measurable improvements in runtime, size, and user experience. Lumissil Microsystems has LED driver solutions for both ends of this portable lighting power curve. Contact your Lumissil sales representative to request evaluation boards or IC samples for your next battery-powered design.