Introduction

Many portable Universal Serial Bus (USB) devices power themselves from the USB host or hub power supply when plugged into the USB port. Several requirements must be met to ensure the integrity of the bus: the USB specification dictates that the input capacitance of a device must be less than 10\(\mu\)F to minimize inrush currents when the device is plugged into the USB port; when first plugged in, the device must draw less than 100mA from the port and, for high power devices, the current drawn from the port can increase to 500mA only after it is given permission to do so by the USB controller. These requirements can be easily met using the LT1618 DC/DC converter, which provides an accurate input current control ideal for USB applications. The LT1618 combines a traditional voltage feedback loop with a unique current feedback loop to operate as a constant-current, constant-voltage source.

Figure 1. USB to 12V boost converter with selectable 100mA/500mA current limit

Figure 2. USB to 12V boost efficiency

Figure 3. USB to 5V SEPIC converter

Figure 4. USB to 5V SEPIC during start-up

Figure 5. USB to 5V SEPIC start-up with shorted output
In addition to providing an accurate input current limit, the LT1618 can also be used to provide an accurately regulated output current for current-source applications. Driving white LEDs is one application for which the device is ideally suited. With an input voltage range of 1.6V to 18V, the LT1618 works from a variety of input sources. The 36V switch rating allows output voltages of up to 35V to be generated, easily driving up to eight white LEDs in series. The 1.4MHz switching frequency allows the use of low profile inductors and capacitors, which, along with the LT1618’s MSOP-10 package, helps to minimize board area.

**USB to 12V Boost Converter**

Figure 1 shows a 5V to 12V boost converter ideal for USB applications. The converter has a selectable 100mA/500mA input current limit, allowing the device to be easily switched between the USB low and high power modes. Efficiency, shown in Figure 2, exceeds 85%. If the load demands more current than the converter can provide with the input current limited to 100mA (or 500mA), the output voltage will simply decrease and the LT1618 will operate in constant-current mode. For example, with an input current limit of 100mA, about 35mA can be provided to the 12V output. If the load increases to 50mA, the output voltage will reduce to approximately 8V to maintain a constant 100mA input current.

**USB to 5V SEPIC Converter with Short-Circuit Protection**

Unlike boost converters, SEPICs (single-ended primary inductance) converters) have an output that is DC-isolated from the input, so an input current limit not only helps soft start the output, but also provides excellent short-circuit protection. The 5V SEPIC converter shown in Figure 3 is ideal for applications that need the output voltage to go to zero during shutdown. The accurate input current limit ensures USB device compliance even under output fault conditions. Figure 4 shows the startup characteristic of the SEPIC converter with a 50mA load. By limiting the input current to 100mA, the output is effectively soft started, smoothly increasing and not overshooting its final 5V value. Figure 5 shows that the input current does not exceed 100mA even with the output shorted to ground (thus the flat output voltage waveform in the oscilloscope photo). Efficiency is shown in Figure 6. This converter also has a selectable input current limit of either 100mA or 500mA, making it ideal for high power USB applications.

**Li-Ion White LED Driver**

The circuit in Figure 7 is capable of driving six white LEDs from a single Li-Ion cell. LED brightness can be easily adjusted using a pulse width modulated (PWM) signal, as shown, or using a DC voltage to drive the IADJ pin directly, without the R3, C3 low-pass filter. If brightness control is not needed, simply connect the IADJ pin to ground. The typical output voltage is about 22V and the R1, R2 output divider sets the maximum output voltage to around 26V to protect the LT1618 if the LEDs are disconnected. The LT1618’s constant current loop regulates 50mV across the 2.49Ω sense resistor, setting the LED current to 20mA. Efficiency for this circuit, shown in Figure 8, exceeds 70%, which is significantly higher than the 30% to 50% efficiencies obtained when using a charge pump for LED drive. No current flows in the LEDs when the LT1618 is turned off. Their high forward voltages prevent them from turning on, ensuring a true low current shutdown with no excess battery leakage or light output.

![Figure 6. USB to 5V SEPIC efficiency](image)

![Figure 7. Li-Ion white LED driver](image)

![Figure 8. Li-Ion white LED driver efficiency](image)

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**DESIGN FEATURES**

**1MHz Series-Resonant Crystal Oscillator with Square and Sinusoid Outputs**

Figure 5 shows a classic 1MHz series-resonant crystal oscillator. At series resonance, the crystal is a low impedance and the positive feedback connection brings about oscillation at the series resonance frequency. The RC feedback to the – input ensures that the circuit does not find a stable DC operating point and refuse to oscillate. The comparator output is a 1MHz square wave (top trace of Figure 6), with jitter measured at 28psRMS on a 5V supply and 40 psRMS on a 3V supply. At pin 2 of the comparator, on the other side of the crystal, is a clean sine wave except for the presence of the small high frequency glitch (middle trace of Figure 6). This glitch is caused by the fast edge of the comparator output feeding back through crystal capacitance. Amplitude stability of the sine wave is maintained by the fact that the sine wave is basically a filtered version of the square wave. Hence, the usual amplitude-control loops associated with sinusoidal oscillators are not necessary. The sine wave is filtered and buffered by the fast, low noise LT1806 op amp. To remove the glitch, the LT1806 is configured as a bandpass filter with a Q of 5 and unity gain center frequency of 1MHz. The final sinusoidal output is the bottom trace of Figure 6. Distortion was measured at –70dBc and –55dBc on the second and third harmonics, respectively.

**Conclusion**

The fully differential rail-to-rail inputs of the new LT1711 family of fast comparators make them useful across a wide variety of applications. The high speed, low jitter performance of this family, coupled with their small package sizes and 2.4V operation, makes them attractive where PCB real estate is at a premium and bandwidth-to-power ratios must be optimized.

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**High Power White LED Driver**

For larger LCD displays where a greater amount of light output is needed, multiple strings of LEDs can be driven in parallel. When driving parallel strings, ballast resistors should be added to compensate for LED forward voltage variations. The amount of ballasting needed depends on the LEDs used and how well they are matched. The circuit in Figure 9 is ideal for larger displays, providing constant current drive for twenty white LEDs from a single Li-Ion cell. Efficiency reaches a respectable 82%, as seen in Figure 10.

**Conclusion**

The constant-current/constant-voltage operation of the LT1618 makes the device an ideal choice for a variety of constant-current designs. The device provides accurate output current regulation or input current limiting, along with excellent output voltage regulation. With a wide input voltage range and the ability to produce outputs up to 35V, the LT1618 works well in many different applications.

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**References**