Driver for Flashlight Applications in Mobil Phones

Application Note

Abstract

This application note introduces various possibilities for driving a flash light LED along with their most important advantages and disadvantages.

Introduction

The U-I characteristics of an LED are most often used as a basis when developing driver circuitry. Due to the production technology and the associated process tolerances, not all LEDs of a particular type are the same; rather, they vary within certain limits.

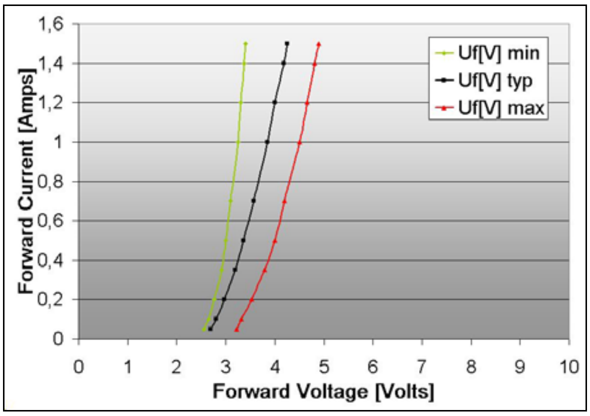

Figure 1: U-I-Diagram of LW F65G

Figure 1 shows these circumstances for the LW F65G LED. As shown in the figure, the forward voltage (U_f) can vary between lower and upper limits. The diagram also shows the characteristics which are typical for the majority of LW F65G LEDs.

Due to this variation, LED brightness measurements and thus the classification according to brightness groups, occurs at a particular, type-specific forward current, (I_f = grouping current), whereby the costs for the measurement process are reduced.
LEDs of a type and within a brightness group have the same forward current; the forward voltage, however, can vary between $U_{f,min}$ and $U_{f,max}$.

When designing driver circuitry, it is preferable to wire the LEDs in series so that all LEDs are supplied with the same current and therefore, all have the same brightness. This also has the advantage that the adjustment (series resistance) for all LEDs must only be made once. With parallel circuitry, however, the adjustment must be individually performed for every single LED.

Electrical Switching Possibilities

The following describes a few possibilities for driving the LW F65G LED in flash and/or torch light modes of operation.
When selecting the appropriate driver circuitry, the battery properties should also be taken into account. For the current generation of cell phones, batteries with voltages up to 4 V are typically used.
Since the battery discharges during cell phone operation, the voltage also sinks to a certain minimum level (typ. 3.1 - 3.4 V), after which the functionality is impaired or ceases altogether. The voltage changes which arise should be taken into account when designing the driver circuitry.

1. Circuit with series resistance

The simplest and most cost effective solution for driving an LED, although most prone to underlying effects, is the use of a series resistance.

The resistance allows the current flowing through the LED to be set to a specific level.
In operation, LEDs with the same forward voltage illuminate or flash with a particular brightness.

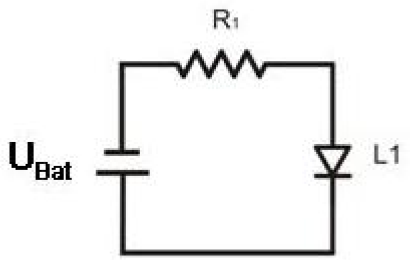

Figure 1: Circuit with series resistance

For mass production, a typical value for the forward voltage should be specified for the driver circuitry.
For LEDs which exhibit a lower forward voltage, more current will flow when a typical series resistance is used, causing the application to be correspondingly brighter.
If LEDs with a higher forward voltage are used, the current is reduced, and the application appears accordingly dimmer.
In addition, this simple solution does not permit additional modes of operation. These must be implemented with additional switching circuitry.
The continual decrease in voltage as the battery discharges leads to an ongoing reduction in brightness.

2. Voltage Regulator with series resistance

Compared to a driver circuit with a single series resistance, the use of an additional voltage regulator provides the advantage that the forward voltage is held constant up to a particular discharge level.
The influence of the battery is therefore reduced. Variations in brightness due to differing LED forward voltages still arise, however.

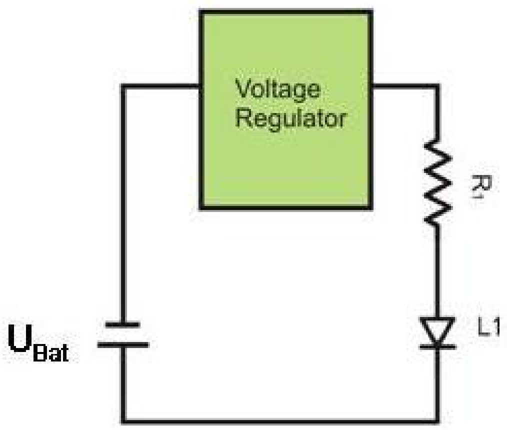

Figure 2: Voltage regulator with series resistance

3. Current Sink

An additional, cost effective solution is to drive the LEDs with a current sink. This has the effect that all LEDs are supplied with the same current, independent of their forward voltages.
Variations in brightness due to differing forward voltages are thus eliminated.

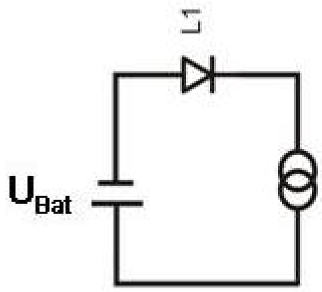

Figure 3: Current sink

In this case, the circuitry is also influenced by the available battery voltage, however. A decrease in battery voltage also leads to a general decrease in LED brightness.
Moreover, the circuit ceases to function when the operating voltage falls below a certain level.

4. Voltage Booster with Current Sink

For operation of the LEDs at low battery voltages (e.g. 3 V), an additional inductive or capacitive voltage booster is required. Figure 4 shows an example with a current sink.

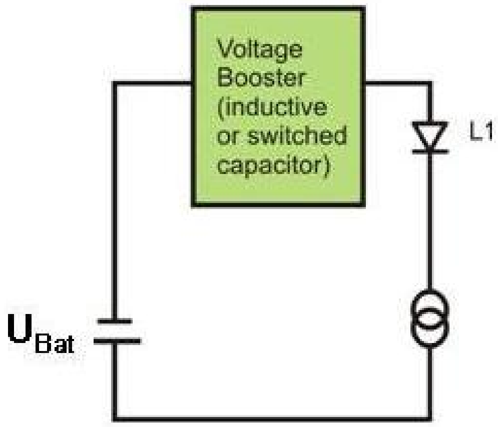

Figure 4: Voltage Booster with Current Sink

The voltage booster only serves to increase the supply voltage to the required LED operating voltage.
As with the previous circuits, one is limited to a particular operating mode (flash or flashlight).

5. Boosting Current Source

A more complicated, and therefore more expensive solution is a circuit with a voltage boosted current source.

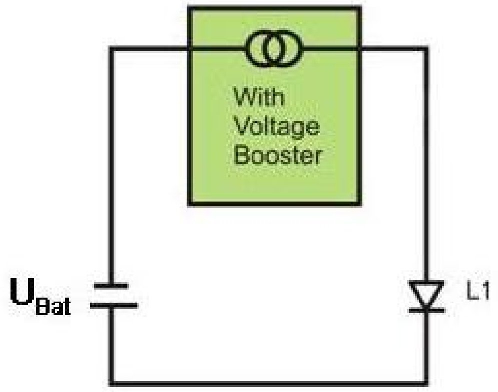

Figure 5: Boosting Current Source

In spite of additional costs, this circuitry is considerably easier to use and offers additional features such as:

- Various operating modes (flash or flashlight)
- Greater battery voltage range
- LED monitoring
- Thermal Protection
- etc.

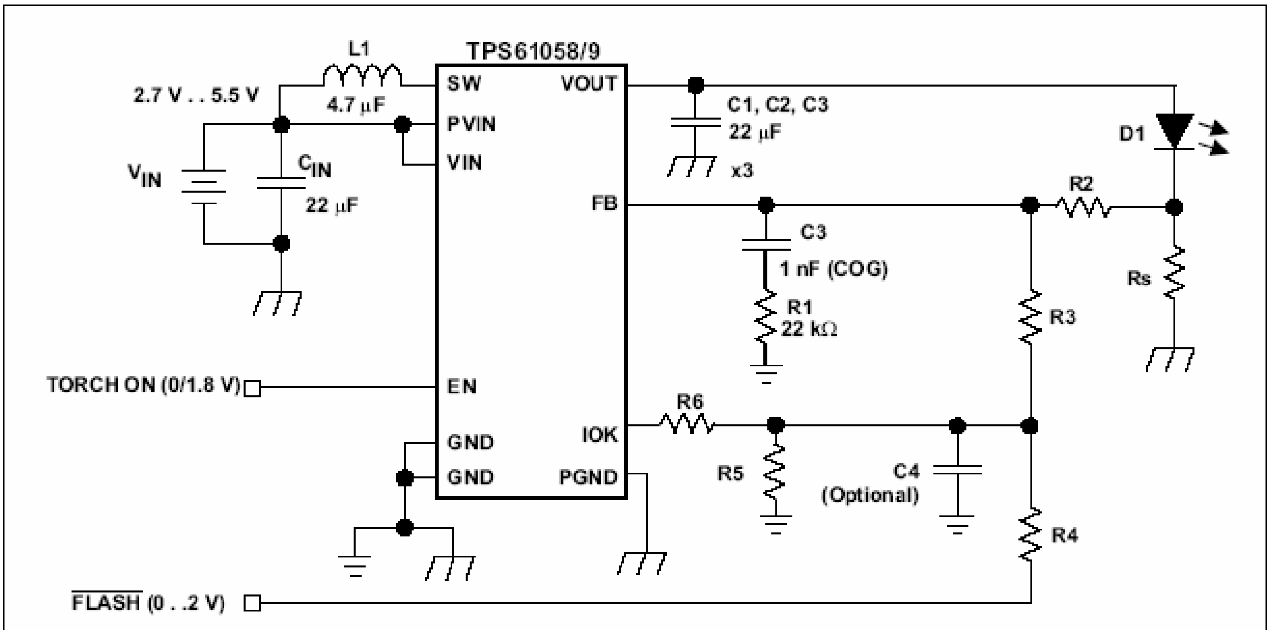

Figure 6: Example of a synchronous boost converter up to If = 700mA from Texas Instruments

In this case, two different designs can be used: either an inductive DC-DC converter or a charge pump. In general, both designs can provide up to 1 A of current for flash mode operation.

The main advantage of both designs is that across nearly the entire battery voltage range, a constant current source is available for the LEDs.

However, inductive DC-DC converters (Figure 6) use coils and therefore might cause electromagnetic interference, which has to be properly handled.
Within their working range, DC-DC converters can convert an input voltage to any output voltage.

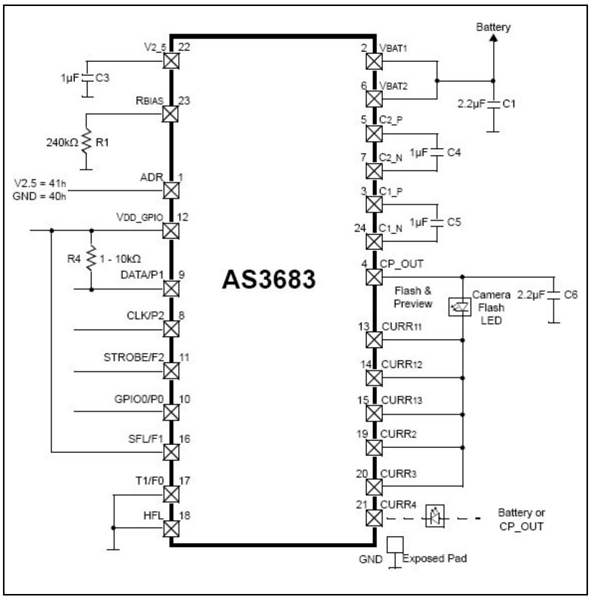

Figure 7: Example of a charge pump up to If = 1000mA from Austria Microsystems

Charge pumps (Figure 7) use capacitors instead of coils. For this reason, charge pumps support automatic mode switching of input and output voltage, e.g. 1.5x or 2x mode.
This means that the output voltage can only be stepped up in multiples of the input voltage.

Regarding a suitable LED driver for a high current flash, please see the links in the appendix or contact OSRAM Opto Semiconductors.

Conclusion

When one compares the various possibilities for driving flash LEDs, driver circuits which utilize a DC-DC converter or a charge pump are the only recommendable solutions.
Both designs minimize variations in LED forward voltage and provide constant current for flash applications.

In general, with a low forward voltage (U_{fmax}= 4.5 V, @ 1000 mA), the LW F65G makes electrical control easier in comparison to other flash LEDs available on the market.

Appendix

Links for LED Flashlight Drivers

austriamicrosystems	www.austriamicrosystems.com
Linear Technologies	www.linear.com
ON Semiconductor	www.onsemi.com
Maxim	www.maxim.com
Monolithic Power	www.monolithicpower.com
National Semiconductor	www.national.com
STMicroelectronics	www.st.com
Supertex	www.supertex.com
Texas Instruments	www.ti.com

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