High Power LED Flash for the Next Generation Camera Phone

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White Paper

Abstract

Improving image resolution in camera phones escalates the need to have a powerful flash LED to support the camera operation in a low ambient light environment. A multiple-chip fun-flash is no longer able to support this growing demand; now a high-power LED flash is needed. It is important for the camera phone designers to understand the purpose, concept and methodology of a high power flash. This paper describes how Avago's High Power LED flash addresses many of these challenges.

Why High Power Flash?

Consumers no longer see mobile phones as a simple voice communication tool but as a multi-functional device that offers conveniences for photo-imaging, video conferencing, musical-audio, internet surfing and other technology. To keep up with consumer demands, mobile phone makers are continuously improving their technology by upgrading the performance of these key features.

Since their introduction in late 2002, LED flash digital camera phones have grown steadily as that feature becomes a commodity in the phone. The forecast assumes that all camera phones will come equipped with LED flash by 2010. As a result of the increasing performance capabilities of digital cameras, such as camera resolution evolving from VGA, to more than 3 Megapixels; consumers' desire for higher quality pictures has grown in accordance. To meet these higher expectations, the camera phone needs to come with a flash that can support this higher brightness.

Although Xenon flash is commonly used in digital still cameras, and may be a good candidate, its application is still limited. The electromagnetic noise and the size of the transformer is a major concern as they interrupt the signal communication and occupy significant space in the phone.

LED flash is the only viable candidate to support this growing demand. Markets often view LED flash as a fun flash that does not offer significant value in improving the image quality. The development of the High Power LED Flash has started to change this perception. The ability to increase the current above 100mA as well as the resolution brightness above 20cd allows the camera phone to take quality images under low ambient light conditions. At the same time, high power LED flash allows the phone designers to flexibly adjust the brightness level to serve different applications – torch mode for video-recording or flash mode for photo taking. Neither of which is available in the fun flash.

The table below summarizes the performance differences between High Power flash LEDs and normal fun flash. The methodology behind this brightness technology is in the packaging structure. Fun flash utilizes multiple small-sized InGaN chips that are commonly available in chip-type LEDs, while high power chips, for example, Avago's ASMT-FW80, utilizes one InGaN chip in one package.

The multiple-chip concept limits the heat dissipation of the package. Figure 1below illustrates the complex PCB design required to accommodate the soldering pad for the chip-and-wire of the multiple-chip. In the LED package design, a bonding pad is often used as a heat dissipation medium. With a limited area for the bonding pad, the channel for dissipating heat is constrained. For the single-chip concept, the PCB design is simple, enabling a large bonding pad to be allocated to drain the heat from the chip. This capability makes the Flash LED designed with a single-chip more able to sustain a greater driving current than the multiple-chip Flash LED.

Differences between High Power Flash and Fun Flash

	High Power Flash	Fun Flash
Driving Current	Above 100mA	Below 100mA
Pulsing Capability	Yes, usually above 200mA	No, or limited
Brightness Performance	8~16 (DC condition) ≥ 20cd (Pulse condition)	5~12cd (DC condition)

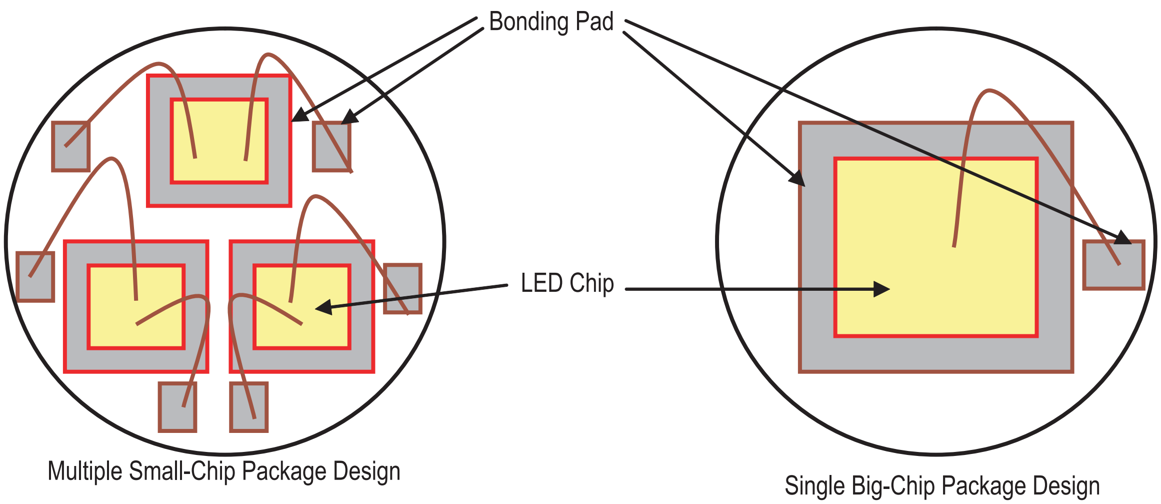

Figure 1. Multi-chip package vs. Single-chip package

Note: The picture above is only for illustration of the concepts. It does not reflect actual dimension or actual design.

Avago ASMT-FW80 Pulsing Capabilities

In some occasions, designers may prefer to pulse the LED rather than drive it with constant current. There are two reasons behind this. One, power saving. Depending on each camera module, the required flash light-up time varies accordingly. As long as the illumination time is no less than the image framing period, it will not affect the image quality. Typically, 200~300ms of light-up time is sufficient. And two, shorter duty cycle time allows higher driving current; hence, a higher brightness flashlight is achievable.

For example, Avago's ASMT-FW80 Flash LED can be driven up to 300mA under a 400ms pulse width to illuminate 28 lux at a 1m distance. Under normal DC conditions, the maximum allowable current is 100mA, the brightness about 13 lux. Figure 2 shows the relationship between the maximum peak current vs. the pulse width. Figure 3 shows the achievable illuminance at various current and distances.

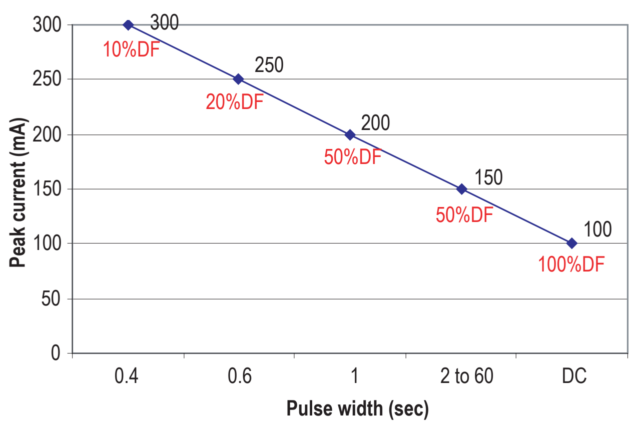

Figure 2. Maximum Peak Current vs. Pulse Width Chart

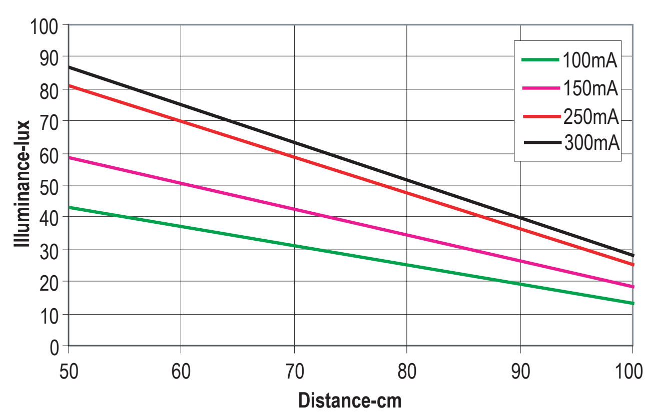

Figure 3. Illuminance vs. Distance

Table 1. Illuminance performance data

Distance (cm)	100mA	150mA	250mA	300mA	
50	43.00	58.35	81.30	87.02	lux
100	13.50	18.40	25.40	28.00	lux

Electrical Design Consideration for Flash LED

Driving flash LED is as simple as driving a discrete LED. LED is a current-driven component and should have a constant current source in order to achieve dependable optical performance. The Li-Ion battery in a mobile phone is a voltage source and fluctuates according to the energy stored in it (fluctuations between 2.8V to 4.2V). This will cause the optical performance of the LED to become unpredictable. Because of this, a direct source from the phone battery to the LED is not recommended.

Before creating a driver, designers needs to look into a few factors:

1. The driving capability of the flash LED (For example: maximum peak current and maximum turn-on duration as shown in Figure 2. Over driving it may cause failure to the LED or the brightness to drop quickly).
2. The required light output at different currents and at various distances as shown in Figure 3.
3. The driver capability, efficiency, accuracy and cost.

Integrating a DC-DC converter is the most effective solution for the LED flash. Figure 4 shows the methodology behind the LED flash configuration. Figure 5 is an example of charge pump topologies used to drive Avago's flash LED.

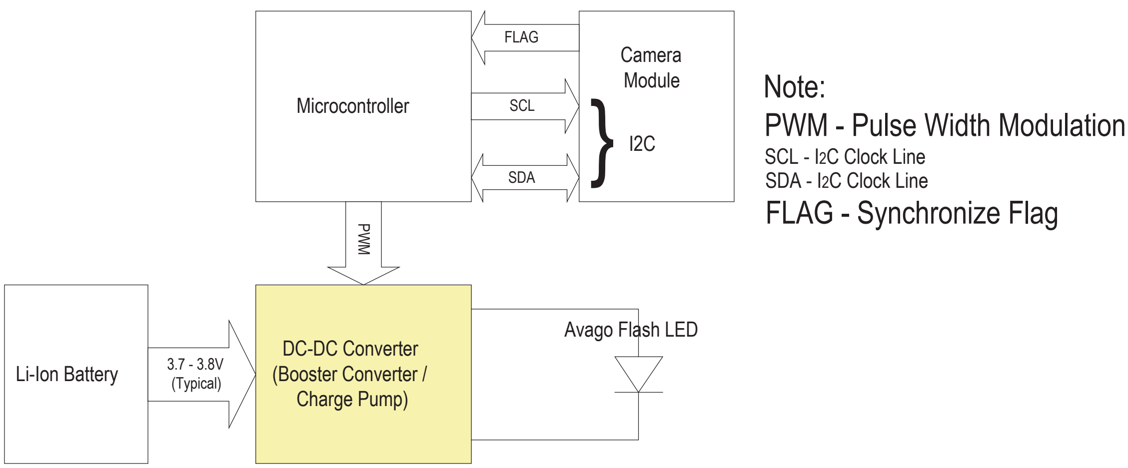

Figure 4. Camera Phone System Diagram

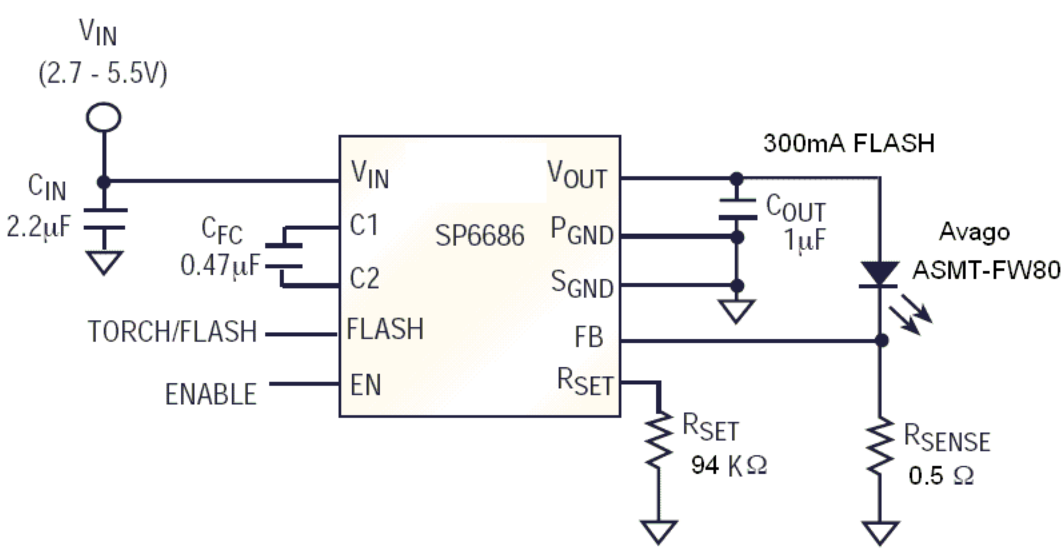

Figure 5. Example of Recommended Circuitry for ASMT-FW80 to Operate under Torch and Flash mode.

A current regulated charge pump driver is ideal for powering high brightness LEDs for camera flash applications. This driver can be set to regulate two current levels: FLASH and TORCH modes. The FLASH pin (Pin 4) is the logic input to toggle operation between the FLASH and TORCH-modes. In TORCH-mode FB is regulated to the internal 50mV reference. FLASH-mode FB reference voltage can be adjusted by changing the resistor from RSET pin, to ground. The driving current in TORCH-mode is dependant on the value of the external current sense resistor (RSENSE).

Avago's ASMT-FW80 is recommended to drive at 100mA for TORCH-mode and 300mA for FLASH-mode. Below is a calculation example (taking the SP6686 manufactured by Sipex for illustration):

Torch mode

(Flash = GND) the Flash pin is set to logic low and the SP6686 FB pin regulates to 50mV output:

V_{FB} = 50mV

The sense resistor Rsense is determined by the value needed in the Torch mode for the desired output current:

$R_{SENSE} = V_{FB} / I_{OUT}$ where V_{FB} = 50mV

R_{SENSE} = 50mV / 100mA = 0.5Ω

The R_{SENSE} will be 0.5Ω in order to drive at 100mA torch mode.

Flash mode

(Flash = V_{IN}), the FB regulation voltage is set by the resistor RSET connected between the RSET pin and S_{GND}:

$V_{FB} = (1.26V/ R_{SET}) \times 11.2K\Omega$

Where 1.26V is the internal band gap reference voltage and 11.2KΩ is an internal resistance used to scale the R_{SET} current. Typical values of R_{SET} are 40KΩ to 180KΩ for a range of V_{FB} = 300mV to 75mV in Flash mode.

The V_{FB} voltage can be calculated using the following equation:

$V_{FB} = I_{OUT} \times R_{SENSE}$ where I_{OUT} is 300mA

$V_{FB} = 300mA \times 0.5\ \Omega$

V_{FB} = 150mV

Next, the R_{SET} resistor can be calculated using the following equation:

$R_{SET} = (1.26V/ V_{FB}) \times 11.2K\ \Omega$

$R_{SET} = (1.26V/150mV) \times 11.2K\Omega$

R_{SET} = 94 KΩ

The R_{SET} needs to be 94 KΩ in order to Flash at 300mA.

The output current can be set in either Flash or Torch mode:

$I_{OUT} = V_{FB} / R_{SENSE}$; V_{FB} = 50mV torch mode/ 150mV Flash mode, R_{SENSE} = 0.5Ω

Thermal Management

Thermal management is also a very critical factor in driving a Flash LED in a mobile phone. All semiconductor devices will generate heat during operation. The power that is consumed will be converted to heat, causing the temperature to rise. Because of this, good thermal management is important; it is able to obtain long term optical/reliability performance for a LED.

Thermal resistance is the ability of a package to dissipate heat out from the package. In other words, it is equivalent to the different temperatures between the package and the environment divided by the total power. The thinner the material, the lower the thermal resistance. The larger the area, the better the heat dissipation.

The definition of junction-to-pin thermal resistance Rjp, is the temperature difference between the dice junction and the lead/heat sink of the package, divided by the total power.

Junction-to-pin thermal resistance, $R_{jp} = (T_j - T_p)/P$

Where T_j = junction temperature

T_p = pin temperature

P = total power dissipated

The advantage of Avago's ASMT-FW80 LED (Figure 6), is that it has a heat sink pad at the bottom of the dice which can directly transfer the heat out from the package.

From the simulation result the dice junction temperature, T_j, will achieve 41°C as shown in Figure 7. The package has a fixed temperature heat sink of 25°C. This is to simulate junction-to-pin thermal resistance (Rjp).

Junction-to-pin thermal resistance, $R_{jp} = (T_j - T_p)/P$

Where dissipated power (P) = Forward Voltage (V) × Input Current (I) = 4.0 V × (0.15 A) = 0.6 W

The junction-to-pin thermal resistance, R_{jp}, for Avago ASMT-FW80 is 27°C/W.

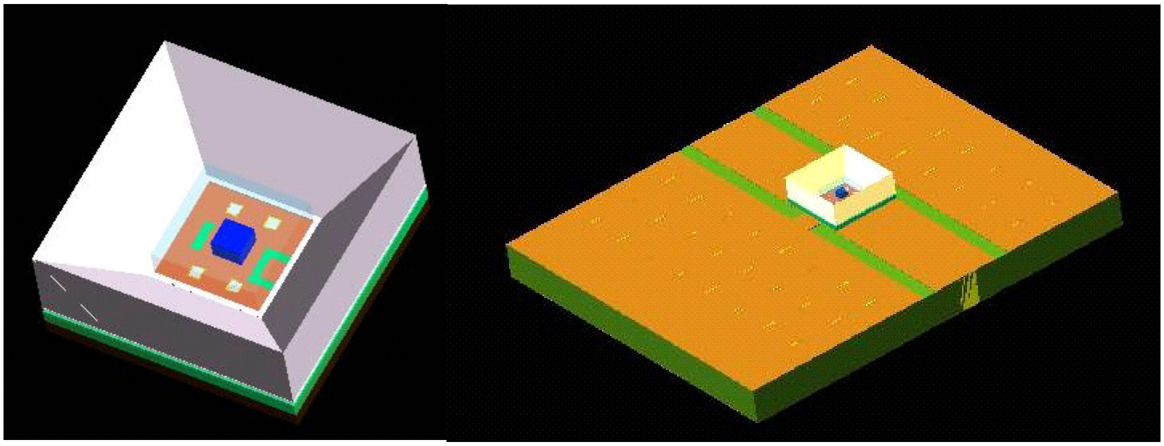

Figure 6. 3D model of Avago Flash LED

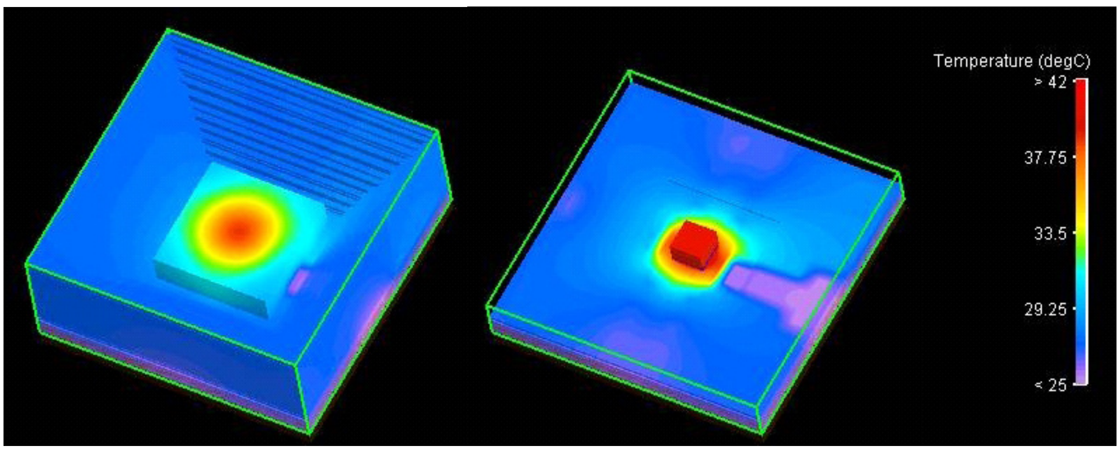

Figure 7. Temperature distribution for the package

Conclusion

The art of integrating a high power flash LED into a mobile phone lies in a balance between the driving current (which governs the brightness performance) and thermal management (which determines the reliability of the LED). Mobile phone designers often face a limitation in thermal management due to a limited space area to accommodate extra heat sinking facilities.

The phone designer will refer to the guidelines set by the LED manufacturer for the boundaries of design. Avago's ASMT-FW80 comes with a package design on thermal management, and will be a good flash option for the camera phone maker. This offers the camera phone designer peace of mind and the ease of following the guidelines set by the manufacturer.

Reference

SP6686 technical data sheet

http://www.sipex.com/productselector.aspx?family=LEDDrivers

AV02-0361EN - April 26, 2007