AN10712

Photo flash LED driver

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Document information

Info	Content
Keywords	Photo flash, dual LED, 500 mA LED current, soft start, SSL3252
Abstract	Application guidelines for a photo flash driver for mobile applications, including an application setup.

Revision history

Rev	Date	Description
v.1	20111028	application note; initial version

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1. Introduction

The SSL3252 is a photo flash LED driver designed for battery operated mobile devices such as mobile phones and PDAs. The boost converter delivers high performance and drives a single or dual high brightness LED at up to 500 mA with over 85 % efficiency. The driver can be programmed to operate in Flash mode, Torch mode, Assist light mode, or Indicator mode.

The small silicon size and the high internal switching frequency of 2 MHz minimizes the size of the application and makes the SSL3252 very suitable for mobile phones where space is limited, and only requiring three external components. System protection has been a very important part of the SSL3252 design so a time-out function can be programmed to prevent overstressing the LED, and the driver itself is protected from overheating.

2. Application information

2.1 General description

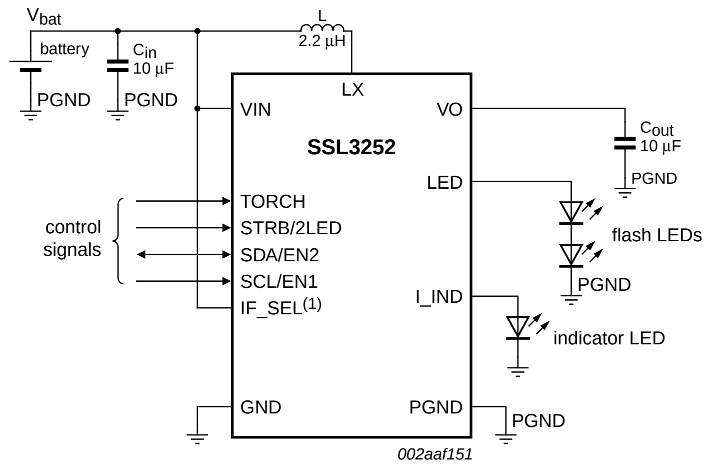
The SSL3252 is a boost converter intended to drive either a single high power flash LED or two high power flash LEDs in series. The main LED current is controlled by the output voltage of the boost converter and the integrated linear current source. The SSL3252 has two interface modes and six operational modes. The Interface mode is selected by the interface select pin IF_SEL. Depending on the interface mode selected, the device can either be controlled by an I^2C-bus interface, or external enable lines.

2.2 Application diagrams

2.2.1 I^2C control mode

Using the SSL3252 as shown in Figure 1 is the typical application for the SSL3252 in I^2C control mode, and therefore gives the advantage of maximum flexibility of the operating features of the SSL3252. Apart from setting the driver into the different operating modes, all of the operating modes can be activated and settings can be altered to match the behavior of the driver to the application, e.g., adjusting the LED brightness intensity to meet the required level for a clear picture.

The device cannot enter Shut-down mode when in I^2C mode. The lowest power consumption can be achieved in Standby mode. When using I^2C, the device can still be put in Shut-down mode by first making all control pins LOW (SDA = SCL = TORCH = 0) and then going to Direct enable Shut-down mode by making IF_SEL LOW.

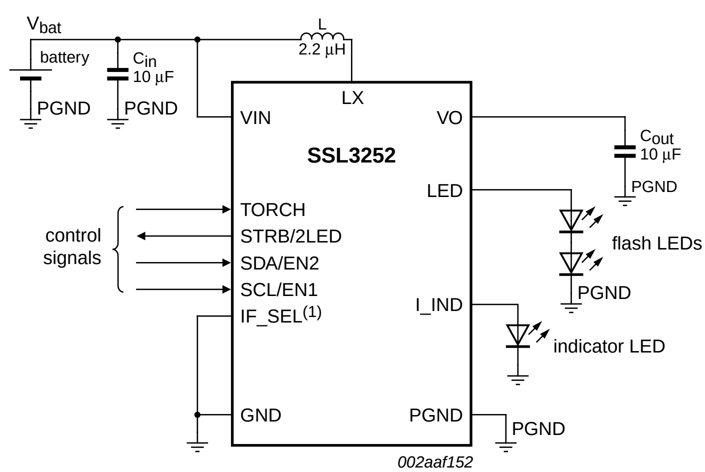


(1) The selection of the mode of the IC is done with I²C. IF_SEL must be connected to VIN.

Fig 1. Typical application diagram of SSL3252 using I²C control

2.2.2 Direct enable control mode

Using the SSL3252 as shown in Figure 2 is the typical application for the SSL3252 in Direct enable control mode. It has the advantage of operating the driver without using I²C communication. This provides a short response time and a less complicated operation, minimizing flash-ON latency. However, it has less flexible control features for the different operating modes. The STRB/2LED pin is functioning as 2LED output.



(1) The selection of the operational mode of the IC is done with EN1 and EN2. IF_SEL must be connected to GND.

Fig 2. Typical application diagram of SSL3252 using Direct enable control

To activate the different modes, EN1, EN2 and TORCH have to be used while IF_SEL remains LOW. The operating modes are Shut-down, Indicator, Torch, Assist light, and Flash mode. See Table 1.

Table 1. Enable definition

TORCH	EN1	EN2	Operational mode	LED active
0	0	0	Shut-down mode	-
1	0	0	Torch mode	main LED
X	0	1	Assist light mode	main LED
X	1	0	Indicator mode	indicator LED
X	1	1	Flash mode	main LED

The result is that the driver uses factory default settings as displayed in the SSL3252 data sheet. In Direct enable control mode the maximum flash time is fixed at 850 ms. When the maximum flash time is exceeded, it generates a fault condition and the IC will stop switching.

To minimize the amount of digital outputs used, some of the SSL3252's inputs can be hardwired to signals already used by other parts of the mobile application. For instance: EN1 and EN2 can be hardwired to the camera module or to the double action shutter button on the application. When the user wants to take a picture, he has to press the button halfway. EN2 should be hardwired to the signal that activates the camera, which then also activates the Assist light mode. The user can use the Assist light mode to focus or to record streaming video. When the user has finished focusing and actually wants to take a picture, he has to press the shutter button fully. This action should also activate EN1 while EN2 is still active. This will activate the Flash mode on the SSL3252 and the 'picture save mode' on the camera module. When the user was recording streaming video, he just releases the shutter button to stop recording. This will also deactivate EN1 and EN2 and stop the Flash mode.

2.3 PCB design and component placement

The components suitable for this design are listed in Table 2. When designing a PCB layout for the SSL3252, special attention should be paid to:

- Component placement
- Track width and length
- Use of vias
- Thermal restrictions

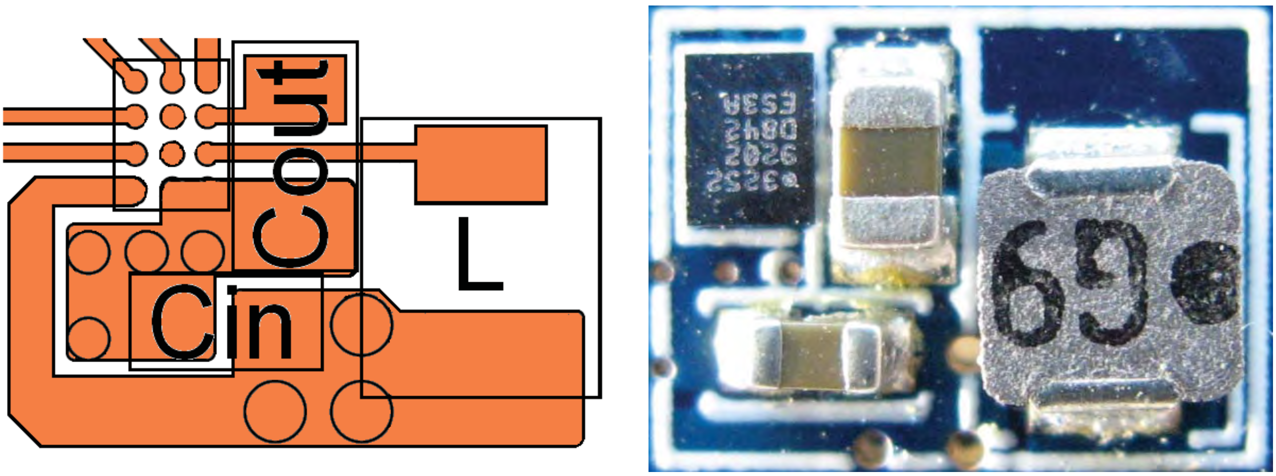
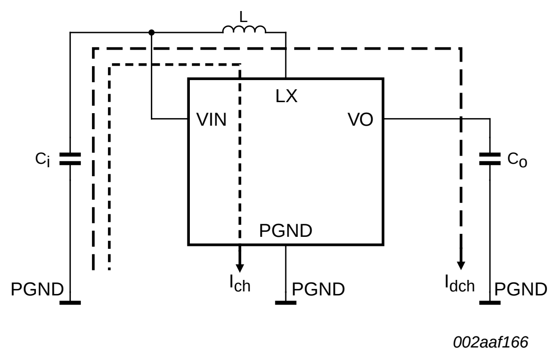


Fig 3. Typical PCB design for SSL3252

In general, the PCB should be designed to accommodate all components as close as possible to the SSL3252 to minimize track resistance. When connecting capacitors the ground connection (GND) should be as short as possible. The pin arrangement of the device can make the usage of vias unavoidable. However it is advised to, if possible, avoid the use vias in tracks to and from those capacitors. If vias are used, use at least two or three to establish a low ohmic connection.

In order to minimize EMI and to maximize the efficiency, the high current tracks to the coil, C_o and to the Flash LED should be short and wide. If routing to another layer is unavoidable for one of the high current tracks, it is advised to use low ohmic vias and where possible to use two or more vias to lower overall track resistance. In general, high-current tracks to and from the same component should run close to each other to minimize the surface of the accompanying current loop. On Figure 4 the main current loops are shown for C_i, L and C_o. The tracks used for these loops should either be in the same plane close to each other or in different planes on top of each other.

Figure 4 also shows the importance of the position of the output capacitor. Within every switching cycle the loop area that carries a large inductor charge and discharge currents changes. This change will cause a change in the magnetic field, which will generate currents in other circuits near this loop. Therefore, to keep the distance between the two current paths to a minimum, C_o must be as close as possible to the SSL3252. C_o has a higher priority to be placed close to the driver than C_i. C_i can best be placed near the inductor L. The positive node of C_i should form a star connection. From this node a separate track (assuming this is supposed to be 1 track) should go to the inductor and to VIN of the SSL3252.



I_{ch} = charge current

I_{dch} = discharge current

Fig 4. Main current loops

Although the driver has a high efficiency, some heat will be generated. To provide good heat dissipation a good connection from the GND plane on the top to the ground plane in the ground layer underneath has to be provided. This can be achieved by using multiple vias. It is advisable also to use as wide as possible tracks on the top layer especially for the high current pins for better heat dissipation.

2.4 Preferred components

Table 2. Component list

Part	Selection	Value	Case	Size (mm)	Supplier	Type
L	Preferred	2.2 μH / 2.3 A / 16 Ω	-	3 × 3 × 1.2	Toko	FDSE0312-2R2M
	Option 1	2.2 μH / 2.5 A / 100 mΩ	-	4 × 4 × 1.2	Coilcraft	LPS4012-222ML
	Option 2	2.2 μH / 2.0 A / 95 mΩ	-	4 × 4 × 1.2	Taiyo Yuden	NR4012T2R2N
C_i	Minimum	4.7 μF / 6.3 V / X5R	0603	1.75 × 0.95 × 0.95	Murata	GRM188R60J475K
	Preferred	10 μF / 6.3 V / X5R	0603	1.75 × 0.95 × 0.95	Murata	GRM188R60J106M
	Option	4.7 μF / 10 V / X5R	0603	1.75 × 0.95 × 0.95	Panasonic	ECJ1VB1A475K
	Preferred	10 μF / 10 V / X5R	0603	1.75 × 0.95 × 0.95	Panasonic	ECJ1VB0J106M
C_o	Minimum	4.7 μF / 16 V / X5R	0805	2.15 × 1.4 × 1.4	Murata	GRM21BR61C475K
	Preferred	10 μF / 16 V / X5R	0805	2.15 × 1.4 × 1.4	Murata	GRM21BR61C106K
	Minimum	10 μF / 10 V / X5R	0603	1.75 × 0.95 × 0.95	Panasonic	ECJ2FB1C475K
	Preferred	22 μF / 10 V / X5R	0805	2.15 × 1.4 × 1.4	Panasonic	ECJ2FB1A226M

2.4.1 C_i capacitor

The C_i capacitor in the typical application serves a double purpose, it is a decoupling capacitor for the internal controller and reference circuits inside the SSL3252 and it is supplying the large input ripple current. For a good input voltage decoupling a low ESR ceramic capacitor is highly recommended. A 4.7 μF (X5R/X7R) / 6.3 V is the minimum recommended value. Since the input capacitor is supplying the input ripple current, a larger capacitor will improve the transient behavior of the regulator and the EMI behavior of the power supply. Taking capacitor DC bias and temperature derating specifications into account, a 10 μF (X5R/X7R) is preferred. In the typical application, the maximum battery input inrush current is less than 200 mA at lower battery voltage levels (worst case).

Although the component count will increase, a further improvement is obtained by placing a smaller capacitor of 100 nF (X5R/X7R) parallel to the input capacitor.

When the circuit is used in other than battery powered applications and the input capacitor is located relatively far from the DC buffer capacitors, it is recommended to add a 150 μF tantalum or 470 μF electrolytic capacitor in parallel to the input capacitor. The ESR of this buffer capacitor is preferably higher as it also dampens the oscillations on the power supply caused by a possible high Q resonant LC circuit formed by the long power lines at the ceramic input capacitor. This electrolytic capacitor is also needed when doing efficiency measurements to obtain a good averaged input current from the supply.

2.4.2 C_o capacitor

C_o supplies the current in the LED when the SSL3252 is charging energy in the inductor. Although a 4.7 μF / 16 V capacitor is sufficient for C_o, it is advised to use 10 μF / 16 V / X5R. The voltage derating characteristics of capacitors show a drop in value near the upper voltage limit of well above 50 %. Therefore a capacitor 4.7 μF / 10 V / X5R will not have sufficient capacitance left when operated near the upper voltage limit. A 16 V capacitor, however, will not be operated near its upper voltage limit and therefore it will still have sufficient capacitance. Currently, the smallest available mass production case size for 4.7 μF / 16 V / X5R is 0805. To squeeze the maximum out of size and performance the Panasonic 10 μF / 10 V / X5R is in 0603 case size. Although it will be driven to the maximum operating voltage the capacitance value left is still higher than that of a 4.7 μF type. Another advantage of this capacitor is that the same part can be used as an input and an output capacitor.

2.4.3 L inductor

The inductor that has the smallest footprint and has proven to be very suitable for LED flash application (large power for short period) is the Toko FDSE 0312-2R2M. If sustained high output power is of main importance, the Coilcraft LPS4012-222_L has proven to be a suitable inductor. It has small overall dimensions and a small footprint, but a higher temperature rise current and lower restive losses. Another option is the Taiyo Yuden NR4012T2R2N. It is similar to Toko inductor for maximum peak current and similar to Coilcraft inductor for continuous output current capability. When selecting a suitable inductor, not only the inductance is important, but the saturation current is also an important parameter. It should be matched to the maximum coil peak current, which is set to 2 A. Since the coil only carries the large flash current for a short period, the temperature rise current is less important.

3. Software examples

3.1 I²C control mode: I²C-bus software controlled 500 ms, 400 mA flash

In this flash mode all the current and time flash settings are set via the I²C-bus. The Flash strobe pin STRB is not used in this flash mode. The flash is triggered by setting Output On bit to ON. After the flash pulse the Output On bit is automatically cleared. For repetitive flashes restart at step 6, but the power supply V_{BAT} must be always ON. If the power supply is OFF between the flashes, then new initialization of the device is necessary.

Reading the status register may be omitted, but could be done to check for any problems of the driver like shorted or open LED pin, and also will clear the fault register.

Table 3. Initialization for 400 mA flash

Step	Action	Terminal	State	I²C commandAdr / reg / data (hex)	Comment
1	Apply power	V_{BAT}	> 2.7 V	-	V_{BAT} = 3.6 V typical
2	Initialize digital lines	IF_SEL	HIGH	-	-
3	Init device Set LED flash timer	SDA/SCL	write	30 02 08	Set flash timer to 500 ms
4	Init device Set LED flash current level	SDA/SCL	write	30 03 A1	Set flash current to 400 mA
5	Init device Select operational mode	SDA/SCL	write	30 04 83	Select I²C software flash operational mode (STRB signal mode is disabled)
6	Trigger flash, Output On bit	SDA/SCL	write	30 04 8B	Set Output On bit to ON
7	Read status register	SDA/SCL	read	30 05 XX	Read (auto clear) status register

3.2 I^2C control mode: Edge-sensitive strobe controlled 500 ms, 400 mA flash

In this flash mode all the current and time flash settings are set via the I^2C-bus. The Flash strobe pin STRB is used to trigger the flash. After the flash pulse, the Output On bit is automatically cleared. For repetitive flashes restart at step 5, but the power supply V_{BAT} must be always ON. If the power supply is OFF between the flashes, then new initialization of the device is necessary.

Reading the status register may be omitted, but could be done to check for any problems of the driver, like shorted or open LED pin, and also will clear the fault register.

Table 4. Initialization for 400 mA flash

Step	Action	Terminal	State	I^2C commandAdr / reg / data (hex)	Comment
1	Apply power	V_{BAT}	> 2.7 V	-	V_{BAT} = 3.6 V typical
2	Initialize digital lines	IF_SEL	HIGH	-	-
3	Init device Set LED flash timer	SDA/SCL	write	30 02 08	Set flash timer to 500 ms
4	Init device Set LED flash current level	SDA/SCL	write	30 03 A1	Set flash current to 400 mA
5	Init device Select operational mode	SDA/SCL	write	30 04 8F	Select I^2C edge sensitive flash operational mode and Output On bit to ON
6	Trigger flash	STRB	LOW to HIGH edge	-	Flash activate on positive edge on STRB signal
7	Read status register	SDA/SCL	read	30 05 XX	Read (auto clear) status register after the flash pulse

3.3 I²C control mode: 100 mA Assist light mode

In Assist light mode the current settings are set via the I²C-bus. The Assist light is switched ON and OFF by setting Output On bit to ON and OFF. For repetitive assist light restart at step 6, but the power supply V_{BAT} must be always ON. If the power supply goes OFF, then new initialization of the device is necessary.

Reading the status register may be omitted, but could be done to check for any problems of the driver, like shorted or open LED pin, and also will clear the fault register.

Table 5. Initialization for 400 mA flash

Step	Action	Terminal	State	I²C commandAdr / reg / data (hex)	Comment
1	Apply power	V_{BAT}	> 2.7 V	-	V_{BAT} = 3.6 V typical
2	Initialize digital lines	IF_SEL	HIGH	-	-
3	Init device Set LED Assist light current level	SDA/SCL	write	30 03 64	Set Assist light current to 100 mA
5	Init device Select operational mode	SDA/SCL	write	30 04 82	Select Assist light
6	Switch on LED output	SDA/SCL	write	30 04 8A	Assist light is ON
7	Read status register	SDA/SCL	read	30 05 XX	Read (auto clear) status register
8	Switch off LED output	SDA/SCL	write	30 04 82	Assist light is OFF
9	Read status register	SDA/SCL	read	30 05 XX	Read (auto clear) status register

3.4 Direct enable control mode: Assist light mode followed by Flash mode

In Direct enable control mode only the control lines EN1 and EN2 control the state of the SSL3252. The STRB/2LED pin is functioning as 2LED output and can be used to read out the number of LEDs connected to LED pin in series. For repetitive flashes repeat step 5 and step 6. Any fault condition in Direct enable control mode will still be detected but cannot be read back. The faults are cleared when the EN1, EN2 and TORCH pins are set to LOW.

Table 6. Initialization for a direct enable controlled Assist light and flash

Step	Action	Terminal	State	I²C commandAdr / reg / data (hex)	Comment
1	Apply power	V_{DD}	> 2.7 V	-	V_{DD} = 3.6 V typical
2	Initialize digital lines	IF_SEL	LOW	-	Connect to GND
		2LED	-	-	Output LED detection
3	Assist light ON	EN2	HIGH	-	Turn on LED9s) with default Assist light current
5	Flash ON	EN1	HIGH	-	LED(s) current ramp-up to the default Flash current
6	Flash OFF	EN1	LOW	-	Turn off LED(s) and clear faults
		EN2	LOW	-	

4. Abbreviations

Table 7. Abbreviations

Acronym	Description
I^2C-bus	Inter-Integrated Circuit bus
IC	Integrated Circuit
EMI	ElectroMagnetic Interference
ESR	Equivalent Series Resistance
LC	inductor-capacitor filter
LED	Light Emitting Diode
PCB	Printed-Circuit Board
PDA	Personal Digital Assistant

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6. Contents

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