



## SGM3785

### 2MHz, 1.5A Flash LED Driver in TDFN-3×2-14L Package

#### GENERAL DESCRIPTION

The SGM3785 is the ideal power solution for high-power flash LEDs used with cell phone camera modules or digital still cameras. It is a highly integrated step-up DC/DC converter with very high switching frequency, fixed at 2MHz, providing a very small total solution for portable photo flash. The SGM3785 has separate Flash mode and Movie/Torch mode enable pins for maximum flexibility. Flash mode is usually used with 660ms timer control to generate a high intensity flash. The Flash mode and Movie/Torch mode maximum LED current is programmed by external resistors respectively, making the flash LED solution simple to control. The real LED current at Flash mode and Movie/Torch mode can be programmed by external PWM signal at ENM pin.

The two LED output sinks can be shorted together externally for higher power single flash LEDs, up to 1.5A continuous LED current. Thermal regulation is integrated in Flash mode to limit the IC's temperature and continuously provide the maximum allowed output current.

Various protection features are built into the SGM3785, including cycle-by-cycle input current limit protection, output over-voltage protection, LED fault (open or short) protection and thermal shutdown protection. The leakage current in shutdown is less than 1 $\mu$ A.

The SGM3785 is available in Green TDFN-3×2-14L package. It operates over an ambient temperature range of -40°C to +85°C.

#### FEATURES

- **Input Voltage Range: 3V to 5V**
- **Dual Flash LED Outputs**
- **Drive Up to Total 1.5A or 0.75A per Channel**
- **High Efficiency LED Driver (Up to 90%)**
- **2MHz Step-Up Converter**
- **Very Small Inductor: 1.0 $\mu$ H**
- **Independent Flash Mode Enable and Movie/Torch Mode Enable Pins**
- **Flash Mode and Movie/Torch Mode LED Current Can be Programmed via PWM Signal at ENM Pin**
- **One Resistor Sets Flash Mode LED Current**
- **One Resistor Sets Movie/Torch Mode LED Current**
- **Integrated Thermal Regulation Control**
- **660ms Flash Timer Control**
- **330k $\Omega$  Pull-Down Resistor on ENM or ENF Pin**
- **LED Open or Short Protection**
- **Output Over-Voltage Protection**
- **Cycle-by-Cycle Inductor Current Limit**
- **Less than 1 $\mu$ A Shutdown Current**
- **Available in Green TDFN-3×2-14L Package**
- **Temperature Range: -40°C to +85°C**

#### APPLICATIONS

Portable Equipments



**PACKAGE/ORDERING INFORMATION**

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDER NUMBER	MARKING INFORMATION	PACKAGE OPTION
SGM3785	TDFN-3x2-14L	-40°C to +85°C	SGM3785YTDP14G/TR	3785DP XXXXXX	Tape and Reel, 3000

NOTE: XXXXX = Date Code and Vendor Code.

**ABSOLUTE MAXIMUM RATINGS**

VIN, VOUT, D1 and D2 Voltages..... -0.3V to 6V  
 ENF, ENM, RSETF, RSETM .....-0.3V to VIN + 0.3V  
 SW Voltage..... -0.3V to 6.5V  
 Storage Temperature Range.....-65°C to +150°C  
 Junction Temperature.....150°C  
 Operating Temperature Range.....-40°C to +85°C  
 Lead Temperature (Soldering 10 sec)  
 .....260°C  
 ESD Susceptibility  
 HBM.....2000V  
 MM.....200V

NOTE:

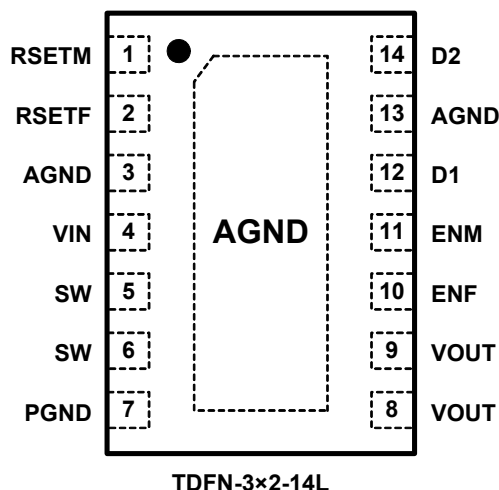
Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**CAUTION**

This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

SGMICRO reserves the right to make any change in circuit design, specification or other related things if necessary without notice at any time. Please contact SGMICRO sales office to get the latest datasheet.

## PIN CONFIGURATION (TOP VIEW)



## PIN DESCRIPTION

PIN	NAME	FUNCTION
1	RSETM	Movie/Torch Mode Current Setting Pin.
2	RSETF	Flash Mode Current Setting Pin.
3, 13	AGND	Analog Ground Pin.
4	VIN	Input Supply Pin for the IC.
5, 6	SW	Switching Node of the Step-Up Converter.
7	PGND	Power Ground Pin.
8, 9	VOUT	Output Voltage Pin.
10	ENF	Flash Mode Enable Pin. This pin has an internal 330kΩ pull-down resistor to AGND. No matter the status of ENM, only when ENF = "High", Flash mode is in active and the flashing current is equal to $I_{SETF} \times D$ . D is the duty cycle of PWM signal at ENM pin. The frequency of PWM is larger than 15kHz.
11	ENM	Movie/Torch Mode Enable Pin and PWM Dimming Pin of Flash Mode. This pin has an internal 330kΩ pull-down resistor to AGND. In Flash mode, the PWM signal at ENM pin is the flashing current dimming control. When ENF = "Low" and the time of ENM = "High" is not less than 5ms, Movie/Torch mode will be in active. The LED current should be equal to $I_{SETM} \times D$ . D is the duty cycle of PWM signal at ENM pin. This PWM signal is sent to ENM pin after the first pulse which "High" level time is more than 5ms. When ENF = "Low" and the time of ENM = "Low" is not less than 5ms, the chip will enter into shutdown mode.
12	D1	Regulated Output Current Sink 1. Up to 0.75A current. D1 and D2 pins can be connected together to sink 1.5A combined.
14	D2	Regulated Output Current Sink 2. Up to 0.75A current. D1 and D2 pins can be connected together to sink 1.5A combined.
Exposed Pad	AGND	Exposed Pad. Connected to ground for electrical and thermal usage. Exposed pad is internally connected to analog ground pin.

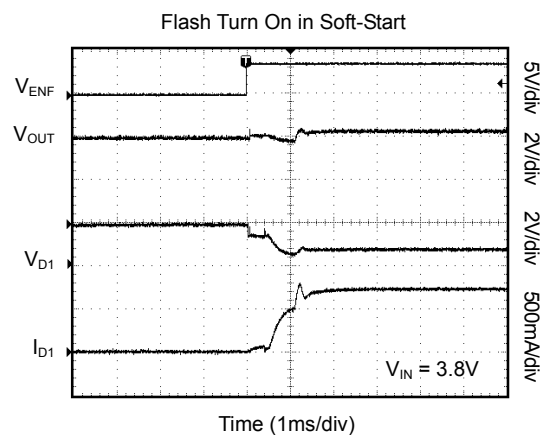
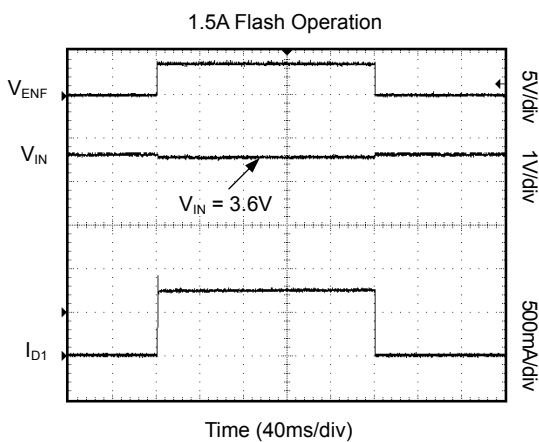
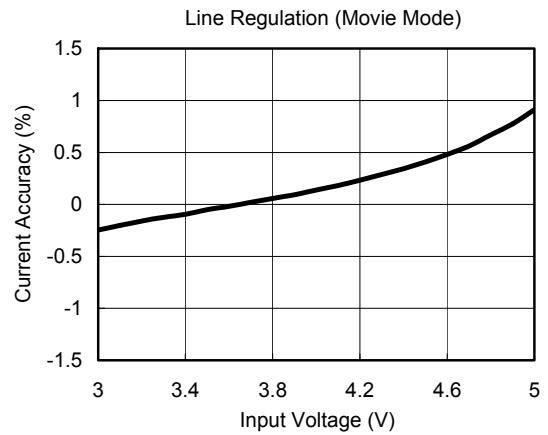
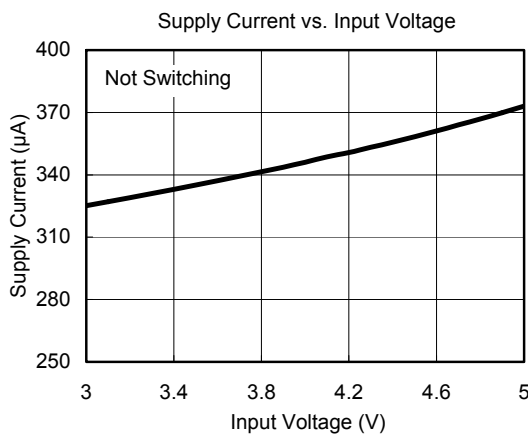
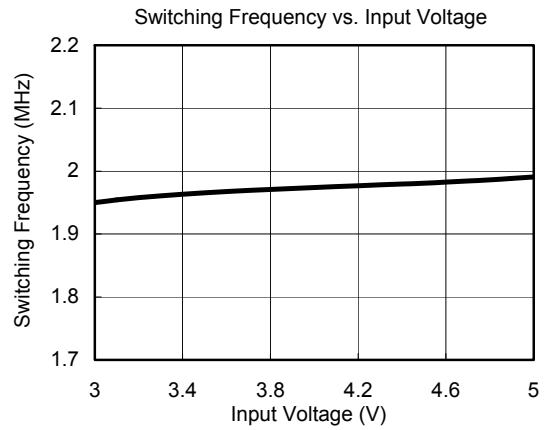
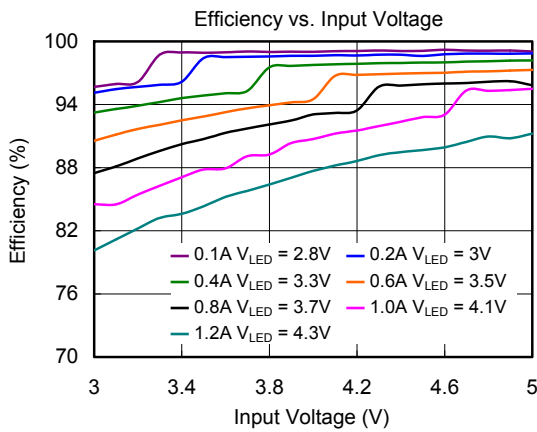
**ELECTRICAL CHARACTERISTICS**(V<sub>IN</sub> = V<sub>EN</sub> = 3.6V, T<sub>A</sub> = 25°C, unless otherwise specified.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>IC SUPPLY</b>						
Input Voltage Range	V <sub>IN</sub>		3		5	V
Under-Voltage Lockout Threshold	UVLO	Rising edge	2.18	2.4	2.62	V
Under-Voltage Lockout Hysteresis	V <sub>HYS</sub>			0.2		V
Supply Current	I <sub>Q</sub>	Not switching		340	450	μA
Supply Current in Shutdown	I <sub>SHDN</sub>	ENF = ENM = GND		0.1	1	μA
<b>STEP-UP CONVERTER</b>						
Peak NMOS Current Limit	I <sub>LIM</sub>			3.4		A
Oscillator Frequency	f <sub>S</sub>			2		MHz
Internal Over-Voltage Threshold of OUT	V <sub>OVF</sub>			5.3		V
Flash Mode Soft-Start Time	t <sub>S</sub>			1		ms
<b>CURRENT SINK</b>						
Total Output Current, Movie/Torch Mode	I <sub>D</sub>	ENM = HIGH, R <sub>SETM</sub> = 71.5kΩ, D1 + D2, T <sub>A</sub> = 25°C	175	200	225	mA
Total Output Current, Flash Mode		ENF = HIGH, ENM = GND, R <sub>SETF</sub> = 11.5kΩ, D1 + D2, T <sub>A</sub> = 25°C	1.32	1.5	1.68	A
Output Current Matching <sup>(1)</sup>		100mA each channel, T <sub>A</sub> = 25°C, Movie/Torch mode		1.5	12	%
		750mA each channel, T <sub>A</sub> = 25°C, Flash mode		0.7	10	%
LED Short Checking Current	I <sub>SHORT</sub>			2.5		mA
<b>CONTROL</b>						
ENF, ENM Pin Logic Low Threshold	V <sub>IL</sub>				0.6	V
ENF, ENM Pin Logic High Threshold	V <sub>IH</sub>		1.5			V
ENF Internal Pull-Down Resistance	R <sub>PD(ENF)</sub>			330		kΩ
ENM Internal Pull-Down Resistance	R <sub>PD(ENM)</sub>			330		kΩ
Junction Thermal Shutdown Threshold				150		°C
Junction Thermal Shutdown Hysteresis				28		°C
<b>DELAY TIME TO SHUTDOWN STATUS IN MOVIE/TORCH MODE (FOR PWM DIMMING LED CURRENT)</b>						
Delay Time	t <sub>D</sub>		5			ms
<b>FLASH TIMER</b>						
Hardware Flash Timer	t <sub>TIME</sub>		600		800	ms
<b>DELAY TIME OF ENM = "HIGH" TO ENTER INTO MOVIE/TORCH MODE</b>						
Delay Time (Entering into Movie/Torch Mode)	t <sub>M</sub>		5			ms
<b>MINIMUM TIME OF LOGIC "HIGH" OF PWM SIGNAL</b>						
Minimum Time of Logic "High" of PWM Signal	t <sub>H</sub>		5			μs

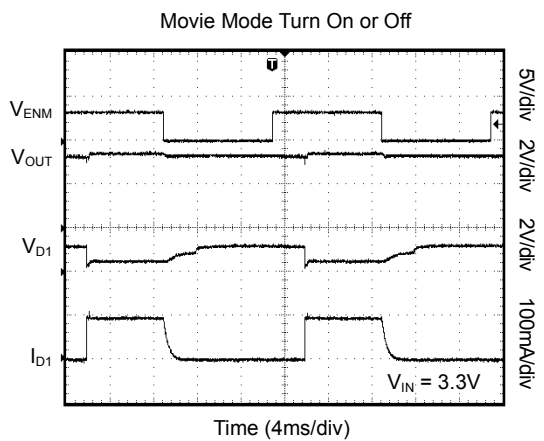
## NOTE:

1. The current matching between channels is defined as  $|I_{D1} - I_{D2}| / (I_{D1} + I_{D2})$ .

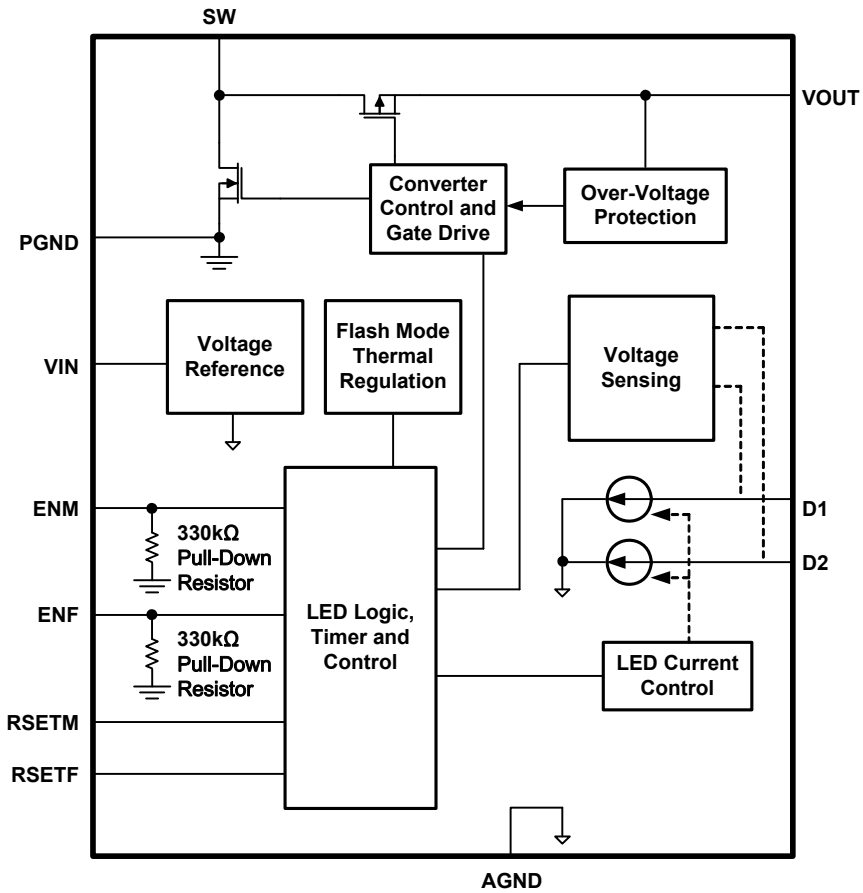
TYPICAL PERFORMANCE CHARACTERISTICS



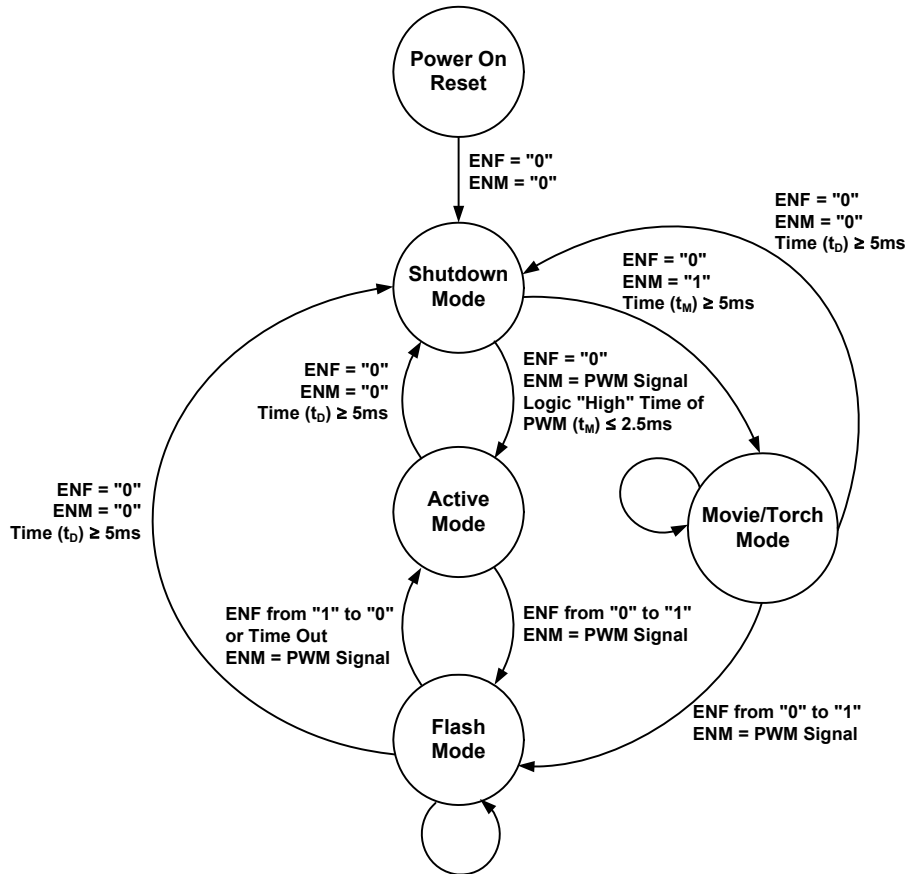
TYPICAL PERFORMANCE CHARACTERISTICS



FUNCTIONAL BLOCK DIAGRAM

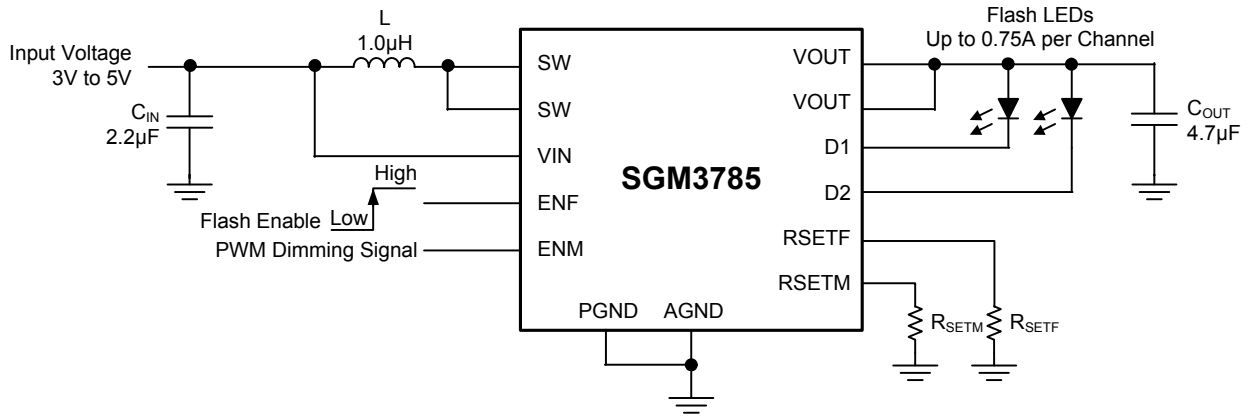


STATE DIAGRAM

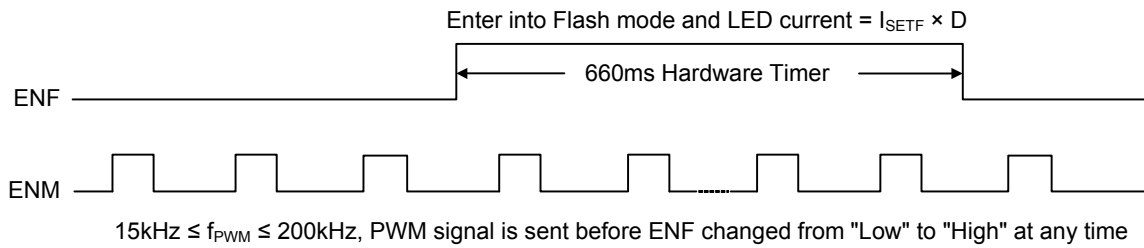




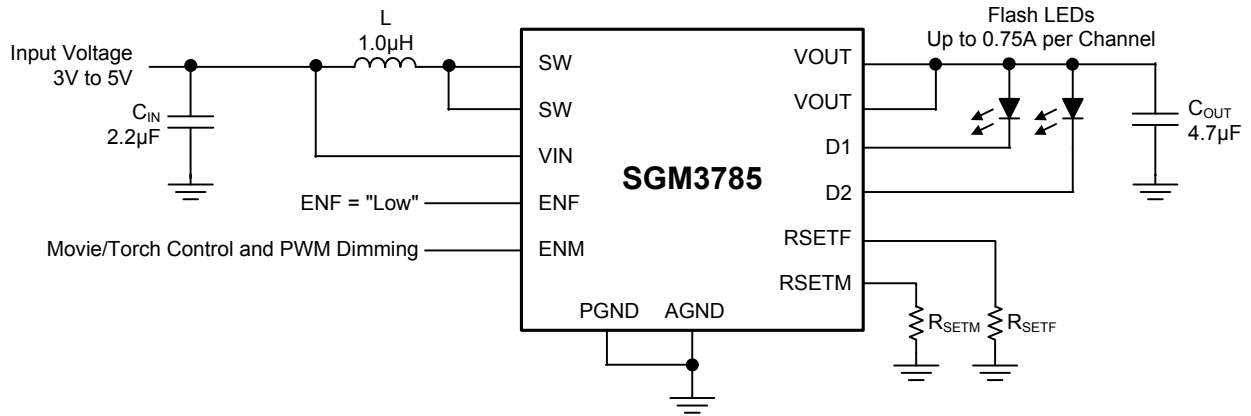
TYPICAL APPLICATION OF FLASH MODE



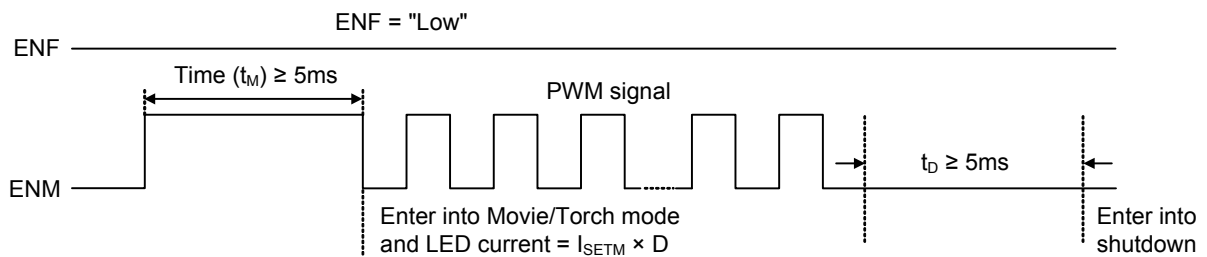
TIMING DIAGRAM OF FLASH MODE



TYPICAL APPLICATION OF MOVIE/TORCH MODE



TIMING DIAGRAM OF MOVIE/TORCH MODE



## FUNCTIONAL DESCRIPTION

The SGM3785 is a very high switching frequency step-up (boost) flash LED driver. Two current regulating devices are integrated to drive up to 2 flash LEDs.

The voltage step-up is accomplished by a boost topology, using an inductor-based DC/DC switching converter, in which the inductor serves as an energy storage device. By integrating optimized power MOSFETs, the SGM3785 internal switching frequency is 2MHz while still maintaining high power efficiency. Unlike a traditional DC/DC boost converter with a fixed output voltage, the SGM3785 dynamically changes its output voltage depending on the flash LED forward voltage and current. The use of unique control schemes maintains accurate current regulation in each of the two current sinks while leaving the output voltage at a minimum, increasing the overall conversion efficiency. The internal step-up converter boosts the output voltage high enough to drive the LEDs with the highest forward voltage. The two current sinks can be shorted together to drive a higher current single flash LED, sinking up to 1.5A combined.

The control interface is designed for maximum design flexibility and compatibility with various types of system controls. After Power on, SGM3785 stays in shutdown mode. One PWM signal ( $5\mu\text{s} \leq t_H \leq 5\text{ms}$ ) at ENM pin will let SGM3785 enter into active mode, PWM signal will adjust the flash LED current. Once ENF changed from “0” to “1”, it enters into Flash mode. The output flashing LED current is equal to  $I_{\text{SETF}} \times D$ ; If SGM3785 is wanted to work in Movie/Torch mode, one long time logic “High” pulse must be provided at ENM pin. The time of logic “High” must be larger than 5ms. The falling edge of this long time pulse will reset the LED current control, and the LED current will be programmed by the PWM signal following this long time pulse. The LED current in Movie/Torch mode is  $I_{\text{SETM}} \times D$ .

### Flash Mode LED Current

D1 and D2 Flash mode LED current can be programmed up to a maximum total current of 1.5A or up to 0.75A per channel. The sink current in D1 and D2 are internally matched in the SGM3785. The Maximum Flash mode current in each channel is set by the  $R_{\text{SETF}}$  resistor. For the desired Flash mode current in each output, the

resistor value can be calculated using the following equation:

$$I_{\text{SETF}} = 8556/R_{\text{SETF}}$$

The real flashing current is dimmed by the PWM signal at ENM pin, D is the Duty cycle of PWM signal:

$$I_{\text{FLASH (D1)}} = I_{\text{FLASH (D2)}} = I_{\text{SETF}} \times D$$

For SGM3785, here is a 600ms hardware timer, which will turn off the LED flashing current after time is over.

Automatic thermal regulation control is active when SGM3785 is in Flash mode. If Flash mode is enabled and the flash current is set to a high current value, the temperature of the IC can increase quickly. Once the IC's temperature goes above 100°C, the two sinks' currents will be automatically decreased according to the thermal regulation control loop. This can prevent the IC from triggering thermal shutdown and causing the LEDs to flicker. Depending on the thermal layout of the PCB and the Flash mode current setting, the SGM3785 sink current can be lower than the programmed value due to the thermal regulation protection feature.

### Movie/Torch Mode LED Current

D1 and D2 Movie/Torch mode LED current can be programmed up to a maximum total current of 400mA or up to 200mA per channel. Just as in Flash mode operation, the output currents in D1 and D2 are internally matched. The Movie/Torch mode current in each channel is set by the  $R_{\text{SETM}}$  resistor. For the desired Movie/Torch mode current in each output, the resistor value can be calculated using the following equation:

$$I_{\text{SETM}} = 7063/R_{\text{SETM}}$$

The real LED current is dimmed by the PWM signal at ENM pin, D is the Duty cycle of PWM signal:

$$I_{\text{MOVIE (D1)}} = I_{\text{MOVIE (D2)}} = I_{\text{SETM}} \times D$$

A Movie/Torch mode event is initiated by asserting a long time logic “High” pulse at the ENM pin.

## FUNCTIONAL DESCRIPTION

### LED Open Protection

In case of LED open, the open channel will control the loop so that  $V_{OUT}$  will be clamped at OVP (approximately 5.3V).

### LED Short Protection

When the SGM3785 is enabled, there is a 2.5mA (typical) LED sensing current through each current sink. It is used to detect whether either LED is shorted by generating a voltage drop through each LED. The IC internally compares the voltage difference between  $V_{OUT}$  and each sink node (D1 and D2). If this difference is below a preset threshold, the IC will treat the respective LED as shorted and disable its Flash/Movie mode current through this LED channel. However, the 2.5mA sensing current will be kept to generate the LED's voltage drop. Because some

normal flash LEDs may have larger than desired leakage current (up to hundreds of microamps) even it's not fully turned on, this 2.5mA sensing current can guarantee that a properly functioning LED will not mistakenly be treated as a shorted LED. If the short circuit is removed during operation, the channel will automatically recover to the programmed current setting.

### Single/Dual LED Applications

Each of the sinks' (D1 and D2) current is regulated and matched for applications requiring two LEDs. For single LED applications, D1 and D2 can be connected together to drive one LED (see Figure 1). The current per sink follows the equations in Flash mode LED Current and Movie/Torch mode LED Current sections above.

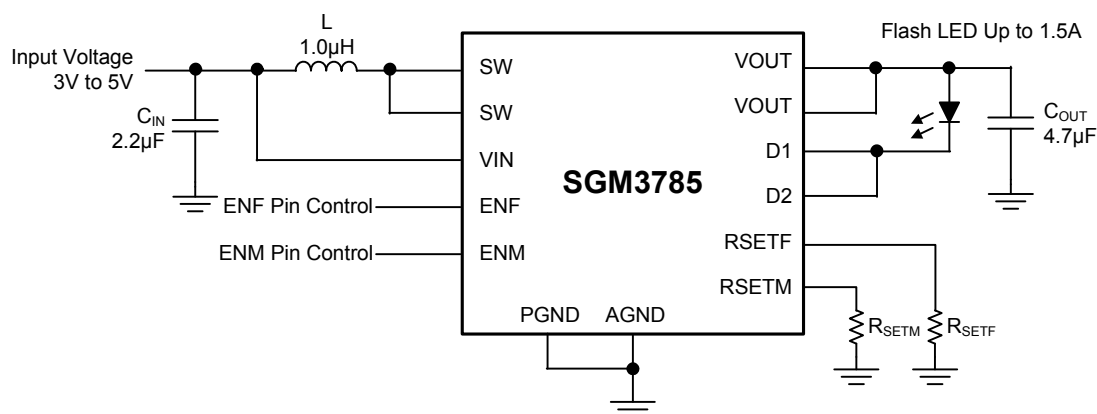


Figure 1. Optional Single LED Configuration

## FUNCTIONAL DESCRIPTION

### Inductor Selection

The SGM3785 is designed to use a 1.0μH to 2.2μH inductor. To prevent core saturation, ensure that the inductor-saturation current rating exceeds the peak inductor current for the application. The worst-case peak inductor current can be calculated with the following formula:

$$I_{\text{PEAK(L)}} = \frac{V_{\text{O(MAX)}} \times I_{\text{LED(MAX)}}}{0.8 \times V_{\text{IN(MIN)}}} + \frac{V_{\text{IN(MIN)}} \times t_{\text{ON(MAX)}}}{2 \times L}$$

Where:

0.8 is the estimated efficiency of 80%.

For example, for a 1.5A total (or 0.75A per channel) LED current, the peak inductor current for a 1.0μH inductor could be as high as (estimated 50% as the maximum duty ratio at the minimum input voltage, maximum LED forward voltage and maximum load current conditions):

$$I_{\text{PEAK(L)}} = \frac{4\text{V} \times 1.5\text{A}}{0.8 \times 3.5\text{V}} + \frac{3.5\text{V} \times 0.25}{2 \times 1} = 2.6\text{A}$$

If the inductor value is smaller, the inductor peak current will increase. To maintain stable operations for the boost converter, the inductor peak current must be less than both the SGM3785 current limit threshold (3.4A TYP) and the inductor saturation current rating. Manufacturer's specifications of inductors list both the inductor DC current rating, which is a thermal limitation, and peak inductor current rating, which is determined by the saturation characteristics. Measurements at full load and

high ambient temperature should be performed to ensure that the inductor does not saturate or overheat due to its parasitic resistance. Bench measurements are recommended to confirm actual inductor peak current  $I_{\text{PEAK}}$  and to ensure that the inductor does not saturate at maximum LED current and minimum input supply voltage.

### Capacitor Selection

For good input voltage filtering low ESR ceramic capacitors are recommended. At least a 2.2μF input capacitor is recommended for high current flash LEDs to improve transient behavior of the regulator and EMI behavior of the total power supply circuit. The input capacitor should be placed as close as possible to the input pin and the PGND pin of the SGM3785.

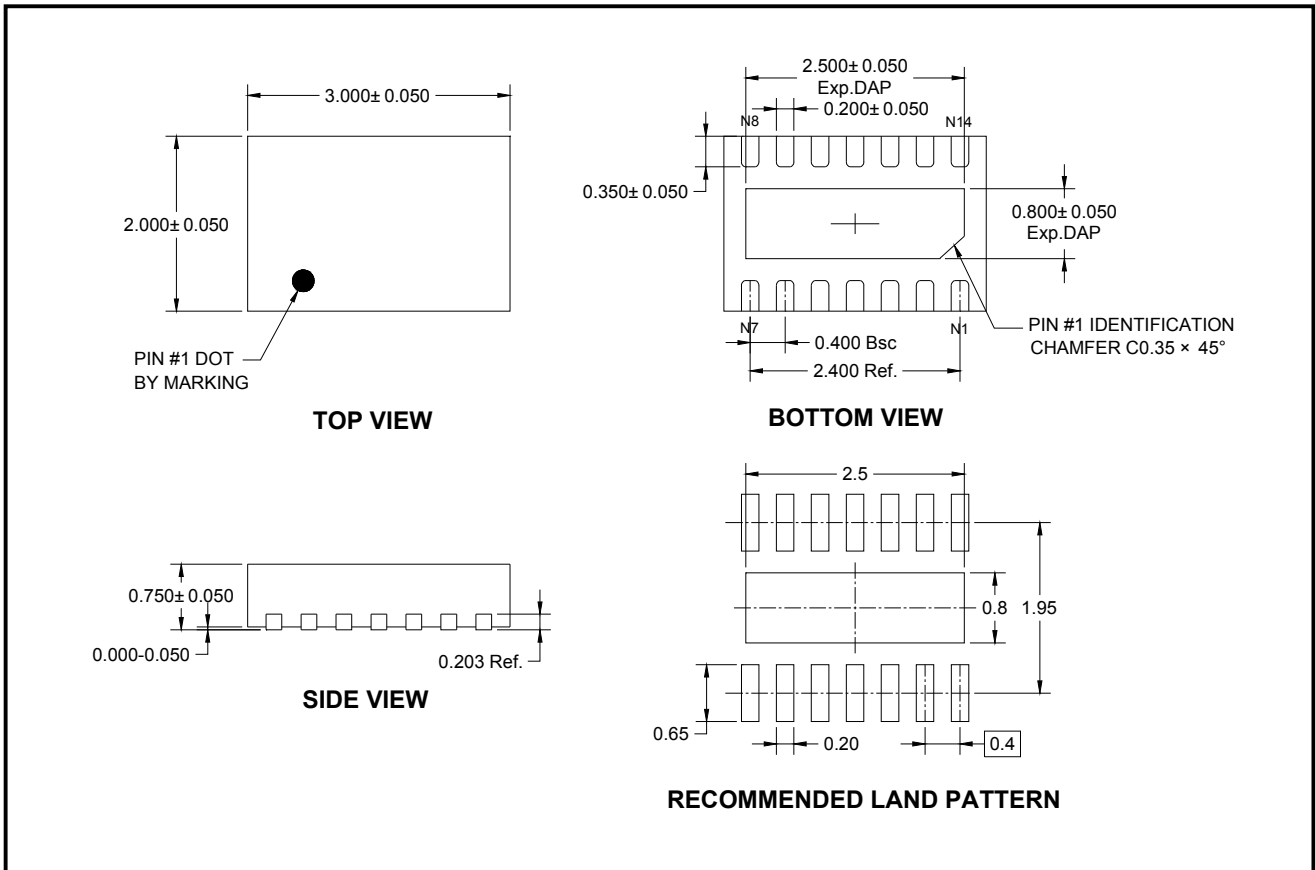
The output capacitance required depends on the required LED current. A 2.2μF or 4.7μF ceramic capacitor works well in most situations.

### PC Board Layout

Due to the fast switching transitions and high-current paths, careful PC board layout is required. Connect AGND pin directly to the exposed paddle underneath the IC; connect the exposed paddle to the PCB ground plane. The output bypass capacitor should be placed as close to the IC as possible. Minimize trace lengths between the IC and the inductor, the input capacitor, and the output capacitor; keep these traces short, direct, and wide. The ground connections of  $C_{\text{IN}}$  and  $C_{\text{OUT}}$  should be as close together as possible and connected to PGND.

PACKAGE OUTLINE DIMENSIONS

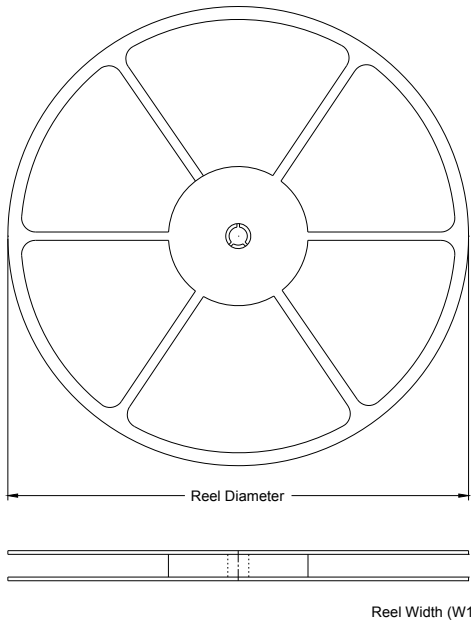
TDFN-3x2-14L



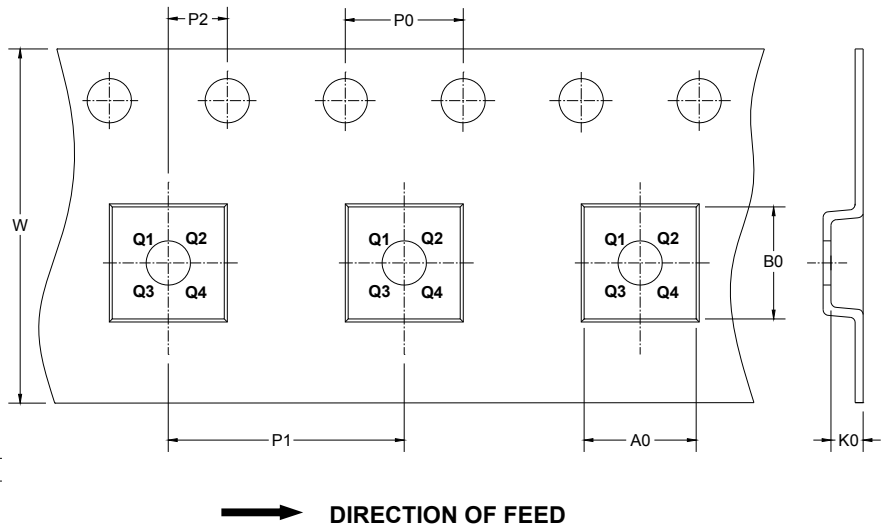
NOTE: All linear dimensions are in millimeters.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

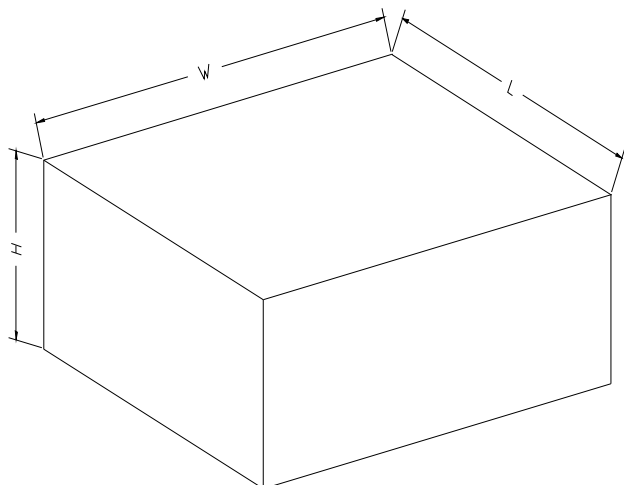
KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
TDFN-3×2-14L	7"	9.0	2.30	3.30	1.10	4.00	4.00	2.00	8.00	Q1

## SGM3785

## 2MHz, 1.5A Flash LED Driver in TDFN-3×2-14L Package

### CARTON BOX DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

### KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
7" (Option)	368	227	224	8
7"	442	410	224	18