SGM3785S
2MHz, 1.5A Flash LED Driver

GENERAL DESCRIPTION

The SGM3785S is a highly integrated Boost DC/DC converter with 2MHz fixed frequency. High switching frequency makes it easy to use small components and optimized for portable photoflash. The SGM3785S is ideal for high power flash LEDs which are suitable for mobile phone camera modules and digital still cameras.

The SGM3785S offers excellent flexibility to enter flash mode and movie/torch mode through the ENF and ENM pins respectively. Flash mode is usually used with 670ms timer control to generate a high intensity flash. The maximal flash current and movie/torch current are respectively programmed through external resistors (R_{SETF} and R_{SETM}), which can provide simple control for the flash LED solution. The real LED current in flash mode and movie/torch mode can be programmed by external PWM signal on ENM pin.

The D1 and D2 pins can be tied together to drive higher power single flash LEDs, sinking up to 1.5A continuous current. The integrated thermal regulation in flash mode limits the temperature of the device to prevent the device from triggering thermal shutdown by reducing the LED sink current below the programmed value.

The SGM3785S provides very low shutdown current. It also includes a comprehensive set of protection features such as over-voltage protection, LED open or short protection and thermal shutdown.

The SGM3785S is available in a Green TDFN-3×2-14L package. It operates over an ambient temperature range of -40℃ to +85℃.

FEATURES

- **Input Voltage Range: 3V to 5V**
- **Up to Total 1.5A LED Current**
- **Up to 90% Efficiency**
- **Dual Flash LED Outputs**
- **Tiny Inductor: 1.0μH**
- **2MHz Boost Converter**
- **Separate Flash Mode Enable and Movie/Torch Mode Enable Control Pins**
- **Flash Current and Movie/Torch Current can be Programmed through PWM Signal on ENM Pin**
- **Independent Resistors Set Flash Current and Movie/Torch Current Respectively**
- **Integrated Thermal Regulation Control**
- **670ms Flash Timer Control**
- **360kΩ Pull-Down Resistor on ENM and ENF Pins**
- **Protection Features**
  - **Output Over-Voltage Protection**
  - **LED Open or Short Protection**
  - **Cycle-by-Cycle Current Limit**
- **Less than 1μA Shutdown Current**
- **Available in a Green TDFN-3×2-14L Package**
- **Temperature Range: -40℃ to +85℃**

APPLICATIONS

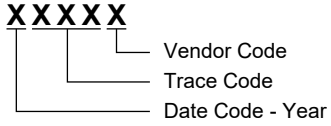
Portable Equipment

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM3785S	TDFN-3×2-14L	-40℃ to +85℃	SGM3785SYTDP14G/TR	028DP XXXXX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XXXXX = Date Code, Trace Code and Vendor Code.



Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

ABSOLUTE MAXIMUM RATINGS

VIN, VOUT, D1 and D2 Voltages ..... -0.3V to 6V
ENF, ENM, RSETF, RSETM ..... -0.3V to V_{IN} + 0.3V
SW Voltage ..... -0.3V to 6V
Package Thermal Resistance
TDFN-3×2-14L, θ_{JA} ..... 59℃/W
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility
HBM 4000V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Operating Ambient Temperature Range ..... -40℃ to +85℃

OVERSTRESS CAUTION

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

ESD SENSITIVITY CAUTION

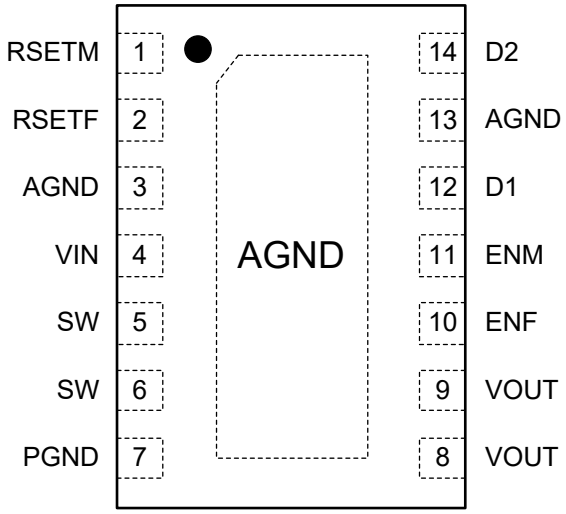
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because even small parametric changes could cause the device not to meet the published specifications.

DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

PIN CONFIGURATION

SGM3785S (TOP VIEW)



TDFN-3×2-14L

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.
5, 6	SW	Boost Converter Switching Node.
7	PGND	Power Ground Pin.
8, 9	VOUT	Output Voltage Pin.
10	ENF	Flash Mode Enable Pin. It has an internal 360kΩ pull-down resistor to AGND. Regardless of ENM, only when ENF = “High”, flash mode is active and the flash current is equal to I_{SETF} × D. D is the duty cycle of PWM signal on ENM pin. The frequency of PWM exceeds 15kHz.
11	ENM	PWM Dimming Pin and Movie/Torch Mode Enable Pin. It has an internal 360kΩ pull-down resistor to AGND. In flash mode, the PWM signal at ENM pin is the flash current dimming control. When ENF = “Low” and the time of ENM = “High” is not less than 5ms, Movie/Torch mode is active. The LED current should be equal to I_{SETM} × D. D is the duty cycle of PWM signal at ENM pin. This PWM signal is sent to ENM pin after the first pulse, high level time of which pulse is more than 5ms. When ENF = “Low” and the time of ENM = “Low” is not less than 5ms, the chip enters shutdown mode.
12	D1	Regulated Current Sink 1. It can sink up to 0.75A current. D1 and D2 pins can be tied together to sink total 1.5A.
14	D2	Regulated Current Sink 2. It can sink up to 0.75A current. D1 and D2 pins can be tied together to sink total 1.5A.
Exposed Pad	AGND	Exposed Pad. It is connected to analog ground internally. Connect this pad to ground plane for good thermal performance.

ELECTRICAL CHARACTERISTICS

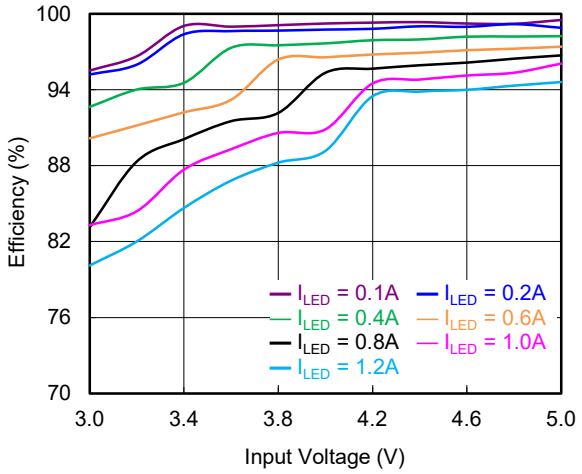
(V_{IN} = V_{EN} = 3.6V, T_A = -40℃ to +85℃, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
IC Supply						
Input Voltage Range	V_{IN}		3		5	V
Under-Voltage Lockout Threshold	UVLO	Rising edge	2.40	2.57	2.75	V
Under-Voltage Lockout Hysteresis	V_{HYS}			0.2		V
Supply Current	I_Q	Not switching		260	360	μA
Supply Current in Shutdown	I_{SHDN}	ENF = ENM = GND		0.1	1	μA
Boost Converter						
Valley PMOS Current Limit	I_{LIM}			2.7		A
Oscillator Frequency	f_S			2		MHz
Internal Over-Voltage Threshold of OUT	V_{OVP}			5.3		V
Flash Mode Soft-Start Time	t_S			1		ms
Current Sink						
Total Output Current, Movie/Torch Mode	I_D	ENM = High, R_{SETM} = 68kΩ, D1 + D2, T_A = +25℃	175	200	225	mA
Total Output Current, Flash Mode		ENF = High, ENM = GND, R_{SETF} = 12kΩ, D1 + D2, T_A = +25℃	1.32	1.50	1.68	A
Output Current Matching		100mA per channel, T_A = +25℃, movie/torch mode		0.5	5	%
		750mA per channel, T_A = +25℃, flash mode		0.6	4	%
LED Short Checking Current	I_{SHORT}	D1 and D2 connected together		5		mA
Control						
ENF, ENM Pin Logic Low Threshold	V_{IL}				0.6	V
ENF, ENM Pin Logic High Threshold	V_{IH}		1.5			V
ENF Internal Pull-Down Resistance	$R_{PD(ENF)}$			360		kΩ
ENM Internal Pull-Down Resistance	$R_{PD(ENM)}$			360		kΩ
Junction Thermal Shutdown Threshold	T_{SD}			143		℃
Junction Thermal Shutdown Hysteresis	T_{HYS}			30		℃
Delay Time to Shutdown Status in Movie/Torch Mode (for PWM Dimming LED Current)						
Delay Time	t_D		5			ms
Flash Timer						
Hardware Flash Timer	t_{TIME}		550	670	780	ms
Delay Time of ENM = "High" to Enter Movie/Torch Mode						
Delay Time (Entering Movie/Torch Mode)	t_M		5			ms
Minimum Time of Logic "High" of PWM Signal						
Minimum Time of Logic “High” of PWM Signal	t_H		5			μs

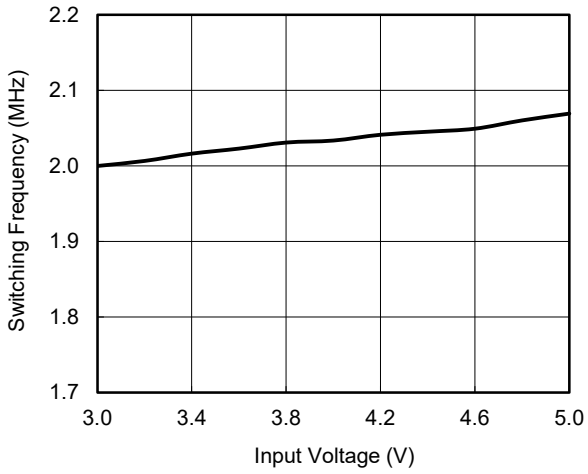
TYPICAL PERFORMANCE CHARACTERISTICS

T_A = +25℃, V_{IN} = 3.6V, L = 1.0μH, C_{IN} = 4.7μF, and C_{OUT} = 4.7μF, unless otherwise noted.

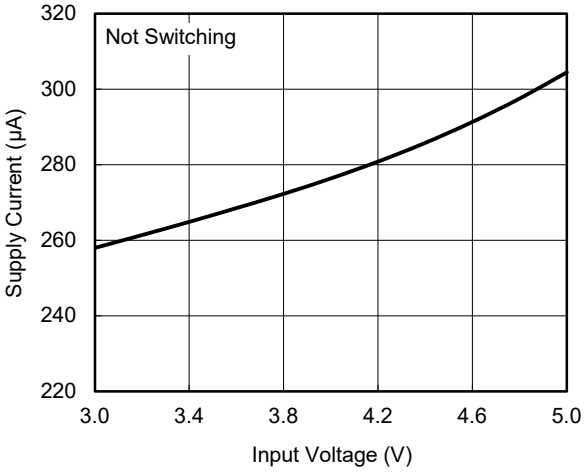
Efficiency vs. Input Voltage



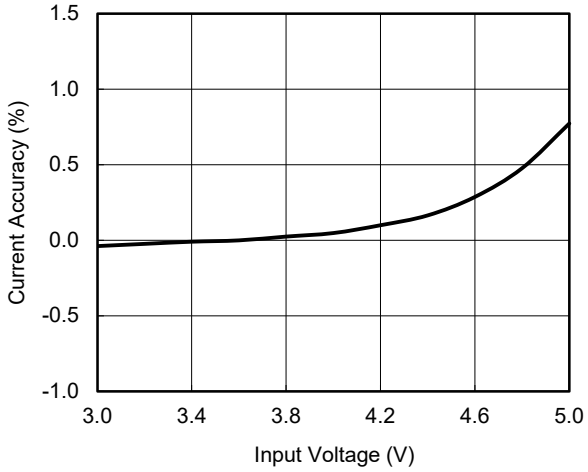
Switching Frequency vs. Input Voltage



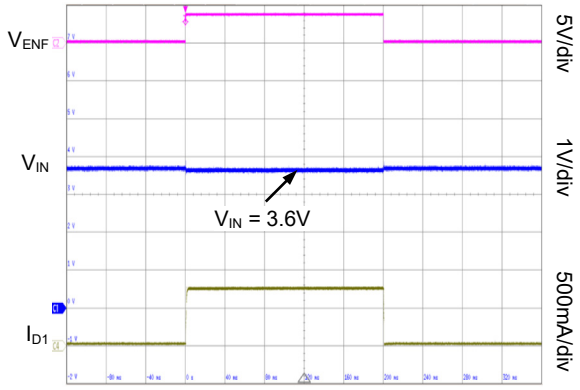
Supply Current vs. Input Voltage



Line Regulation (Movie Mode)

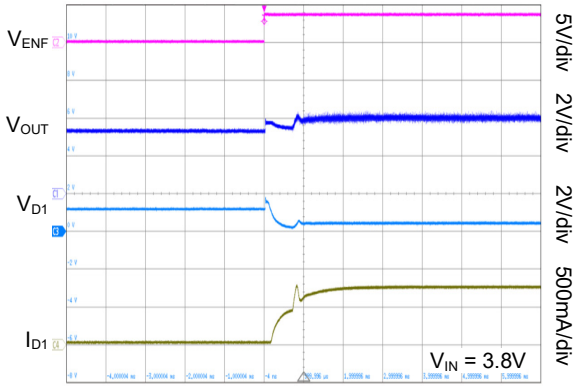


1.5A Flash Operation



Time (40ms/div)

Flash Turn On in Soft-Start

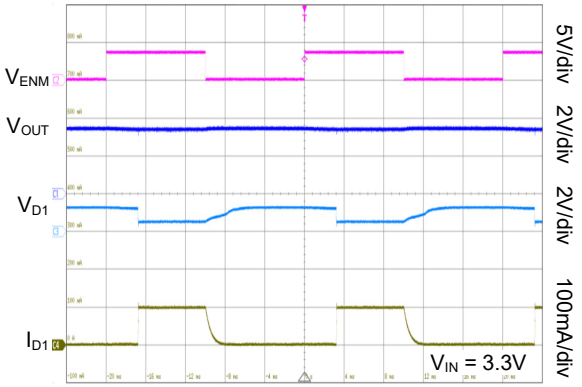


Time (1ms/div)

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_A = +25℃, V_{IN} = 3.6V, L = 1.0μH, C_{IN} = 4.7μF, and C_{OUT} = 4.7μF, unless otherwise noted.

Movie Mode Turn On or Off



Time (4ms/div)

FUNCTIONAL BLOCK DIAGRAM

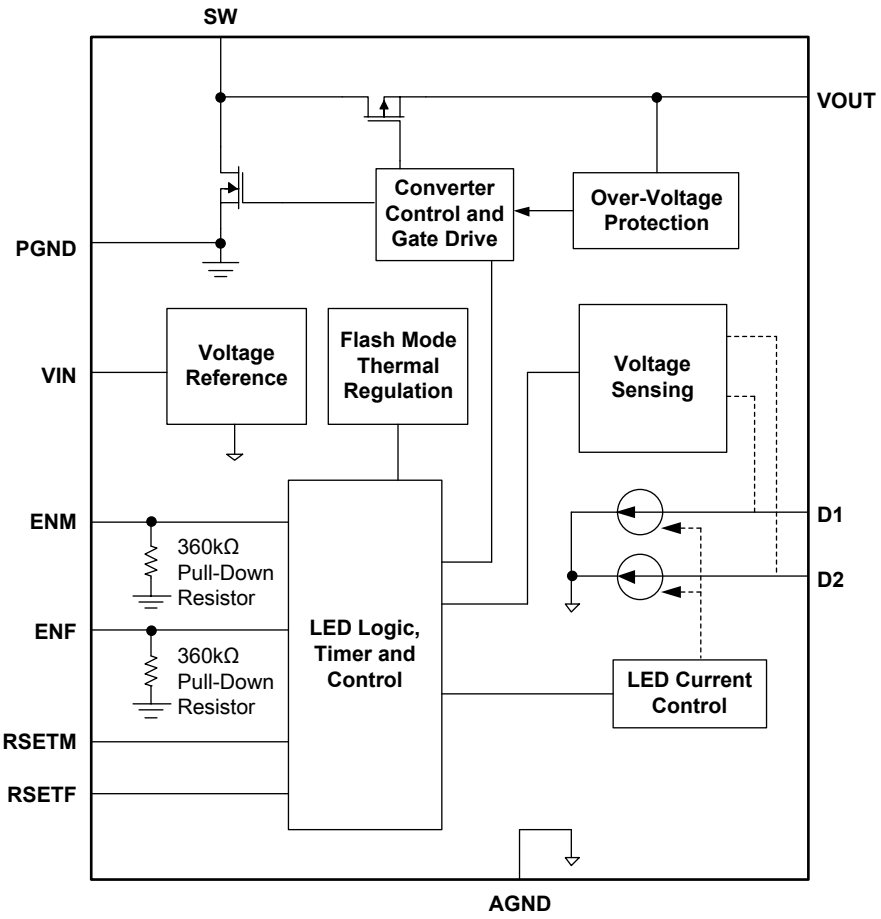


Figure 1. Functional Block Diagram

STATE DIAGRAM

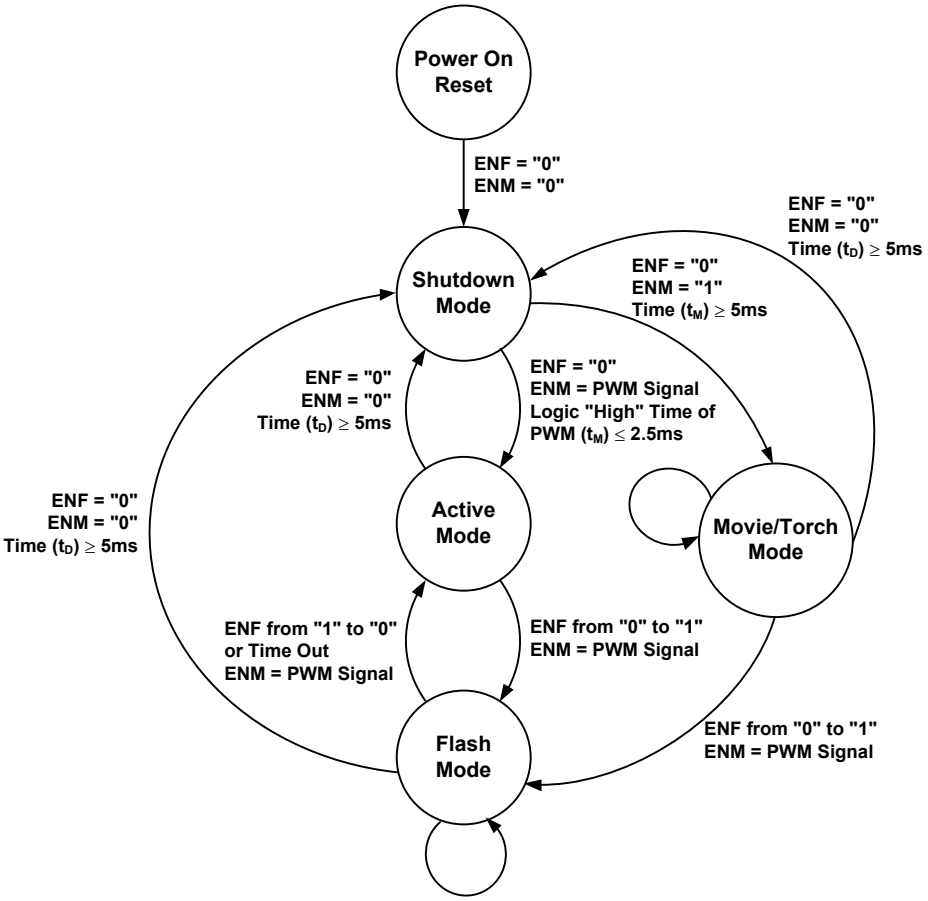


Figure 2. State Diagram

TYPICAL APPLICATION OF FLASH MODE

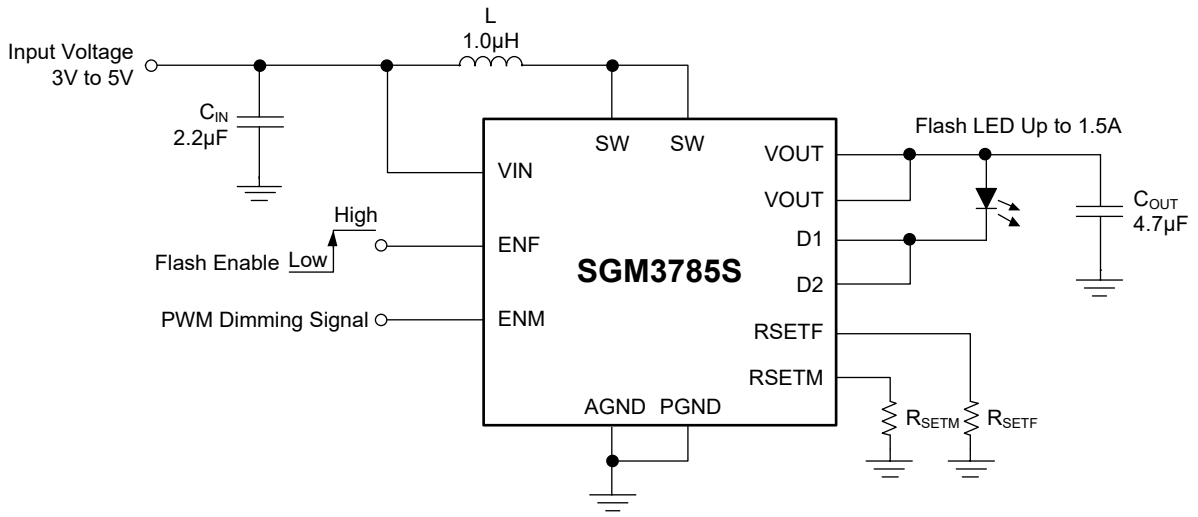


Figure 3. Typical Application of Flash Mode

TIMING DIAGRAM OF FLASH MODE

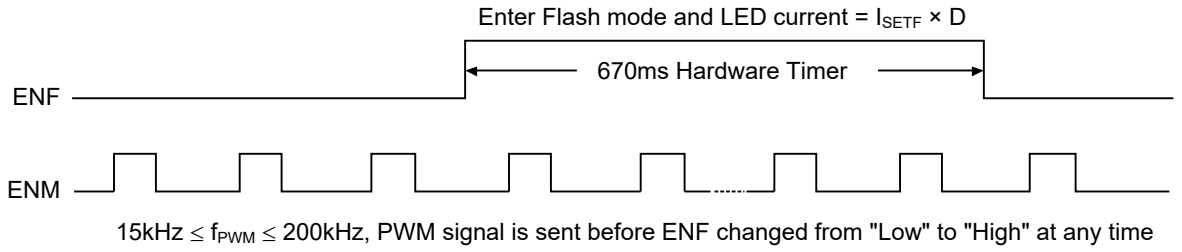


Figure 4. Timing Diagram of Flash Mode

TYPICAL APPLICATION OF MOVIE/TORCH MODE

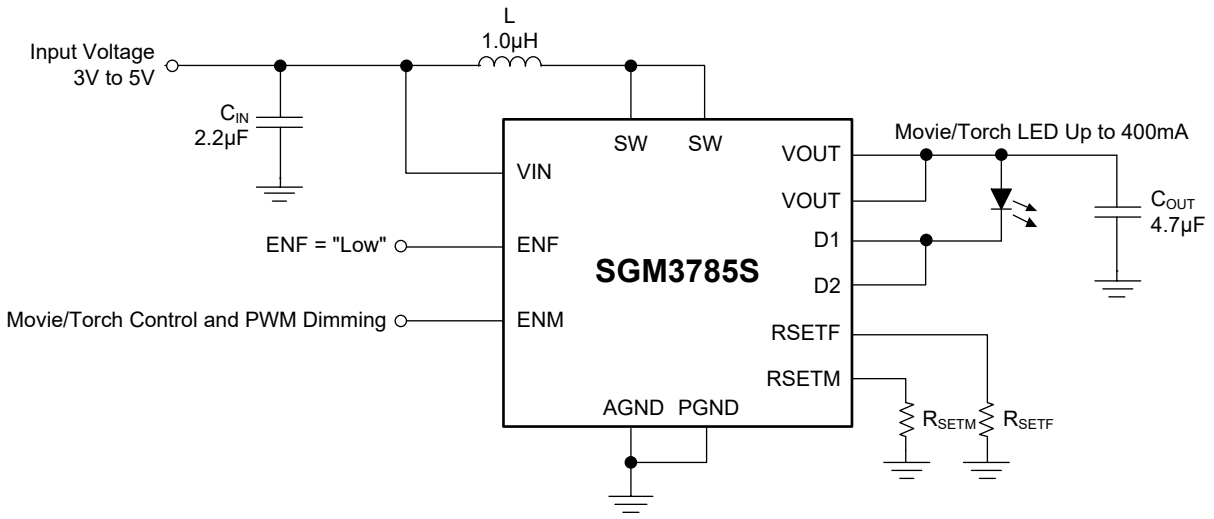


Figure 5. Typical Application of Movie/Torch Mode

TIMING DIAGRAM OF MOVIE/TORCH MODE

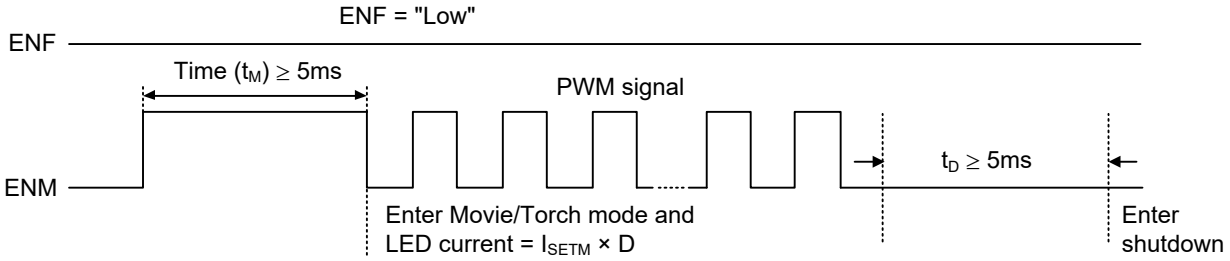


Figure 6. Timing Diagram of Movie/Torch Mode

DETAILED DESCRIPTION

The SGM3785S is a fully integrated synchronous Boost flash LED driver with two independent current sinks to drive up to two flash LEDs.

The integrated Boost DC/DC converter integrates two power FETs with 2MHz switching frequency. Discrete DC/DC converter regulates a fixed output voltage. In contrast, the SGM3785S adaptively regulates the output voltage based on the flash LED forward voltage and current. This method effectively increases the conversion efficiency by maintaining the minimal output voltage for proper LED conduction. The Boost converter regulates the output voltage based on the LEDs with the highest forward voltage. For higher sink current applications, two sinks channels could be shorted together to achieve 1.5A sink capability.

The SGM3785S offers flexible control interface to control the flash, movie/torch mode. After power-on, SGM3785S stays in shutdown mode. One PWM signal ($5\mu s \le t_H \le 5ms$) at ENM pin programs the SGM3785S to enter 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_{SETF} × D. If SGM3785S is desired 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_{SETM} × D.

Flash Mode LED Current

The SGM3785S matches the sink current on D1 and D2 internally. The device supports maximal 1.5A flash mode LED sink current on D1 and D2. An external resistor connected on R_{SETF} pin programs the maximum flash mode current in each sink output. Use Equation 1 to calculate the flash mode sink current.

$$I_{SETF} = 9000/R_{SETF} \quad (1)$$

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

$$I_{FLASH\ (D1)} = I_{FLASH\ (D2)} = I_{SETF} \times D \quad (2)$$

For SGM3785S, there is a 670ms hardware timer, which will turn off the LED flashing current after this time expires.

The SGM3785S implements automatic thermal control when flash mode is programmed. When flash mode is enabled, device temperature could rise quickly. The thermal regulation loop will engage when the IC temperature reaches 100℃. The two channel's sink current is automatically reduced. This implementation effectively prevents the device from triggering thermal shutdown, which causes LEDs to flicker. Due to this thermal regulation loop, good thermal PCB layout is necessary to ensure proper sink current in flash mode current setting.

Movie/Torch Mode LED Current

The SGM3785S supports D1 and D2 LED current up to 400mA total in movie/torch mode. The output current on each channel is matched internally as the flash mode. An external resistor connected on R_{SETM} pin programs the maximum movie/torch mode current in each sink output. Use Equation 3 to calculate the movie/torch mode sink current.

$$I_{SETM} = 6800/R_{SETM} \quad (3)$$

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

$$I_{MOVIE\ (D1)} = I_{MOVIE\ (D2)} = I_{SETM} \times D \quad (4)$$

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

LED Open Protection

The SGM3785S implements LED open protection when the D1 and D2 channels are shorted together. In an open fault event, the device controls the loop to clamp the VOUT at OVP threshold of 5.3V (TYP).

LED Short Protection

During operation, the SGM3785S implements a 5mA (TYP) LED sensing current when D1 and D2 channels are connected together to detect a short event. This sensing current generates a voltage drop on each LED to detect a short event. The SGM3785S compares the VOUT pin and D1/D2 voltages. If the voltage difference is less than a preset threshold, the IC detects this event as a short, and the flash/movie mode sink current is disabled. Care should be taken that some flash LEDs have large leakage current up to hundreds of μA even it is not fully turned on. The 5mA sensing current ensures the proper LED operation and avoids triggering false LED short event. If the short circuit condition is removed, the SGM3785S automatically resumes operation to the programmed current setting.

DETAILED DESCRIPTION (continued)

Single LED Application

Each sink channel of the SGM3785S is well matched and regulated. For single LED applications, D1 and D2 pins can be shorted together to drive a single LED and deliver up to 1.5A sink current, as shown in Figure 7. Each current sink can be calculated by the equations under Flash Mode LED Current and Movie/Torch Mode LED Current sections.

Inductor Selection

The SGM3785S is optimized for 1.0μH to 2.2μH inductor. The selected inductor should have enough saturation current rating that is higher than the worst case peak inductor current given by Equation 5.

$$I_{PEAK(L)} = \frac{V_{O(MAX)} \times I_{LED(MAX)}}{0.8 \times V_{IN(MIN)}} + \frac{V_{IN(MIN)} \times t_{ON(MAX)}}{2 \times L} \quad (5)$$

where 0.8 is the estimated efficiency of 80%.

For 1.5A total current as an example, the peak inductor current for a 1μH assuming 50% as the worst case duty cycle, maximum LED forward voltage of 4V and maximum load current of 1.5A is shown below:

$$I_{PEAK(L)} = \frac{4V \times 1.5A}{0.8 \times 3.5V} + \frac{3.5V \times 0.25}{2 \times 1} = 2.6A \quad (6)$$

For lower inductance, the inductor peak current will increase. To ensure proper operation, the inductor peak current should not exceed the valley PMOS current limit and the inductor saturation current rating. Care should be taken to ensure selected inductor does not saturate at maximum LED sink current, minimum input voltage and high ambient temperature.

Capacitor Selection

A 2.2μF low ESR ceramic capacitor is recommended as the input capacitor to improve transient response and EMI performance for high current flash LEDs. Place the input capacitor as close to the input pin and the PGND pin of the SGM3785S as possible.

The desired LED current determines the required output capacitance. A 2.2μF or 4.7μF ceramic output capacitor is recommended for most applications.

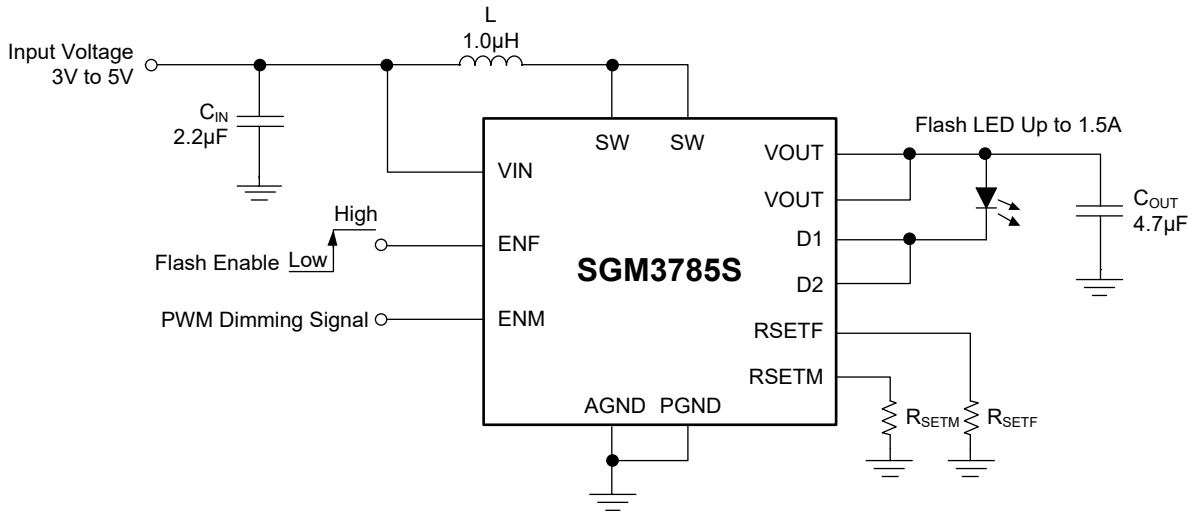


Figure 7. Single LED Application

DETAILED DESCRIPTION (continued)

PCB Layout

In addition to component selection, layout is a critical step to ensure the performance of any switching devices. Poor layout can result in system instability, EMI failure, and device damage. Thus, place the inductor, input and output capacitors as close to the IC as possible. Wide and short traces can be used to minimize PCB inductance for current carrying traces. For Boost converter, the output capacitor's current loop from VOUT pin back to the GND pin of the device should be as small as possible. Figure 8 shows an example of SGM3785S PCB layout.

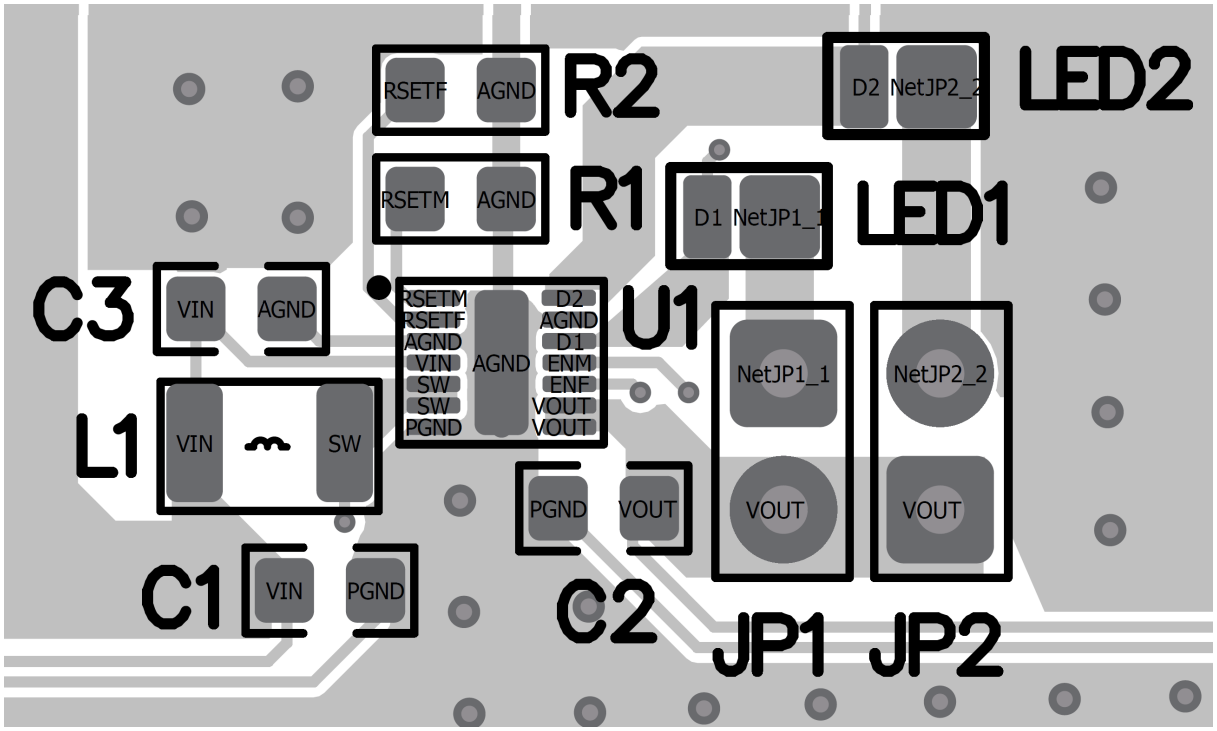


Figure 8. Layout Example

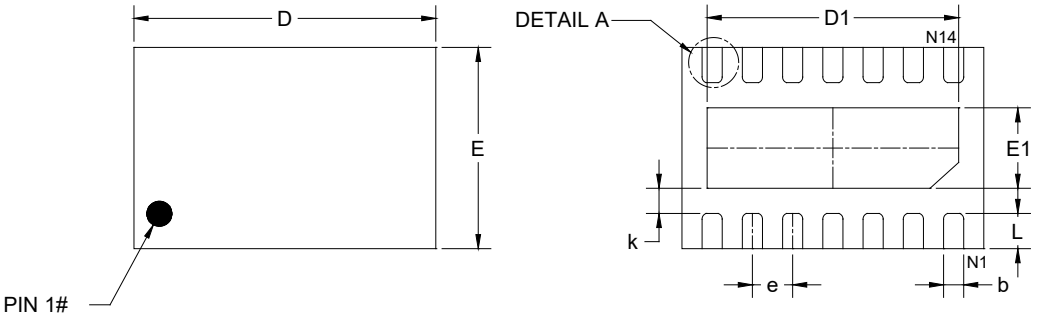
REVISION HISTORY

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

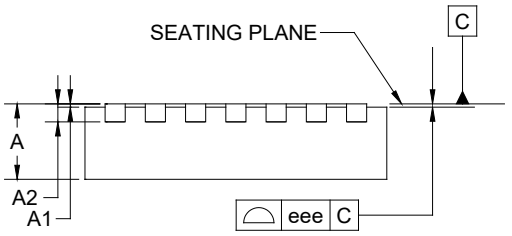
Changes from Original (DECEMBER 2022) to REV.A	Page
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

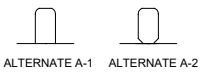
TDFN-3×2-14L



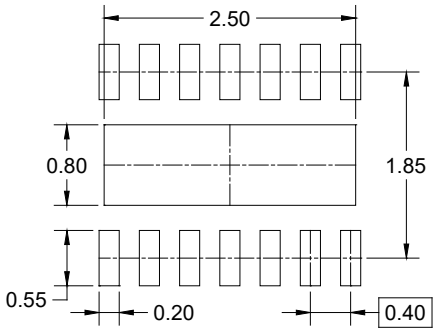
TOP VIEW **BOTTOM VIEW**



SIDE VIEW



DETAIL A
ALTERNATE TERMINAL CONSTRUCTION



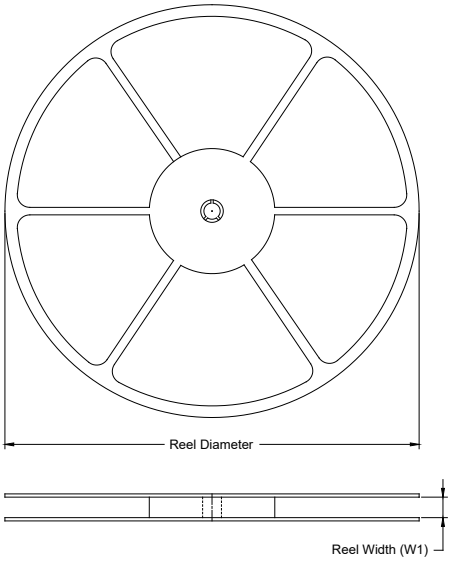
RECOMMENDED LAND PATTERN (Unit: mm)

Symbol	Dimensions In Millimeters		
	MIN	MOD	MAX
A	0.700	-	0.800
A1	0.000	-	0.050
A2	0.203 REF		
b	0.130	-	0.250
D	2.900	-	3.100
E	1.900	-	2.100
D1	2.400	2.500	2.600
E1	0.700	0.800	0.900
e	0.400 BSC		
k	0.150	-	-
L	0.300	-	0.400
eee	0.080		

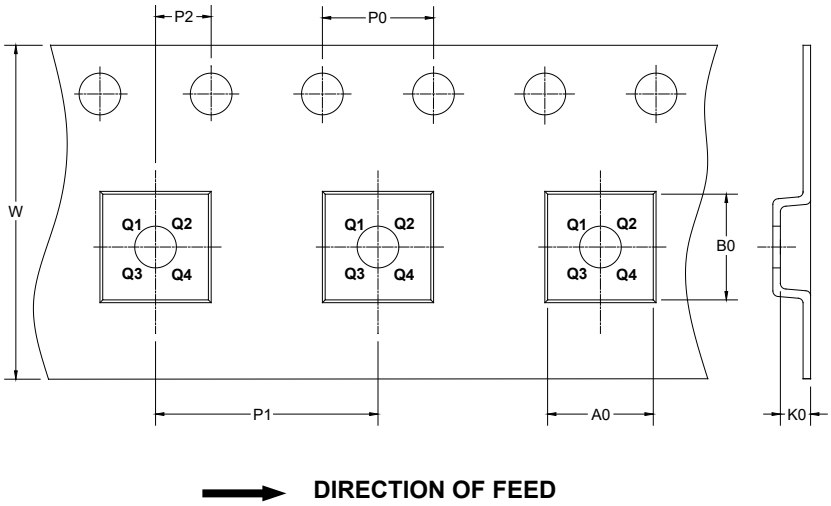
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



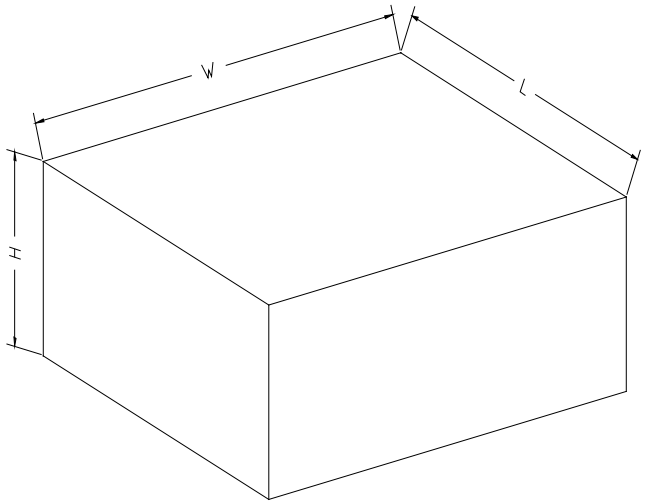
NOTE: The picture is only for reference. Please make the object as the standard.

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	4.0	4.0	2.0	8.0	Q1

DD0001

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

DD0002