SGM3780
2MHz, 1.5A Flash LED Driver in TDFN-3×2-14L Package

GENERAL DESCRIPTION

The SGM3780 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 SGM3780 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 LED current is programmed by external resistors respectively, making the flash LED solution simple to control. If both enable pins are at logic high, the LED current will be programmed by the Movie/Torch mode setting resistor.

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 SGM3780, 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 1μA.

The SGM3780 is available in Green TDFN-3×2-14L package. It operates over an ambient temperature range of -40℃ to +85℃.

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: 1.0μH**
- **Independent Flash Mode Enable and Movie/Torch Mode Enable Pins**
- **Flash Mode or Movie/Torch Mode Dimming via PWM Control**
- **10kHz to 200kHz PWM Dimming Frequency**
- **One Resistor Sets Flash Mode LED Current**
- **One Resistor Sets Movie/Torch Mode LED Current**
- **Integrated Thermal Regulation Control**
- **660ms Flash Timer Control**
- **330kΩ 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 1μA Shutdown Current**
- **Available in Green TDFN-3×2-14L Package**
- **Temperature Range: -40℃ to +85℃**

APPLICATIONS

Portable Equipments

PACKAGE/ORDERING INFORMATION

MODEL	ORDER NUMBER	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	MARKING INFORMATION	PACKAGE OPTION
SGM3780	SGM3780YTDP14G/TR	TDFN-3×2-14L	-40℃ to +85℃	3780DP XXXXX	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 V_{IN} + 0.3V
SW Voltage... -0.3V to 6.5V
Storage Temperature Range............................-65℃ to +150℃
Junction Temperature...150℃
Operating Temperature Range...........................-40℃ to +85℃
Lead Temperature (Soldering 10 sec)
....260℃
ESD Susceptibility
HBM...2000V
MM...200V
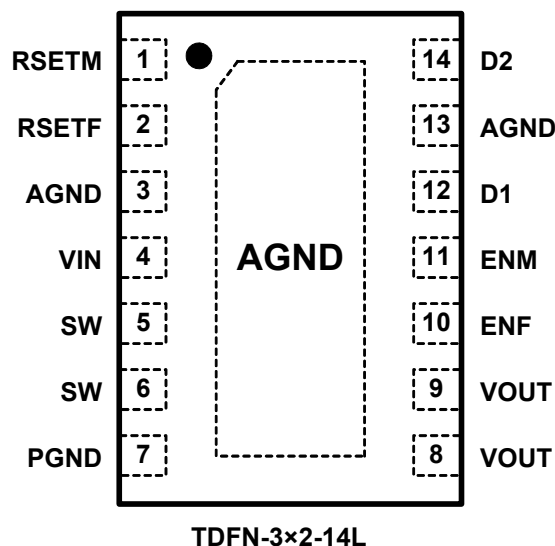
NOTE:
Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. 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)

```
        RSETM  | 1  ●           14 |  D2
        RSETF  | 2             13 |  AGND
         AGND  | 3             12 |  D1
          VIN  | 4    AGND     11 |  ENM
           SW  | 5             10 |  ENF
           SW  | 6              9 |  VOUT
         PGND  | 7              8 |  VOUT
```

TDFN-3×2-14L

PIN DESCRIPTION

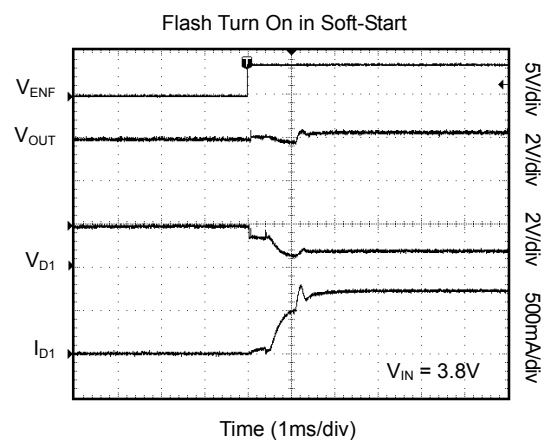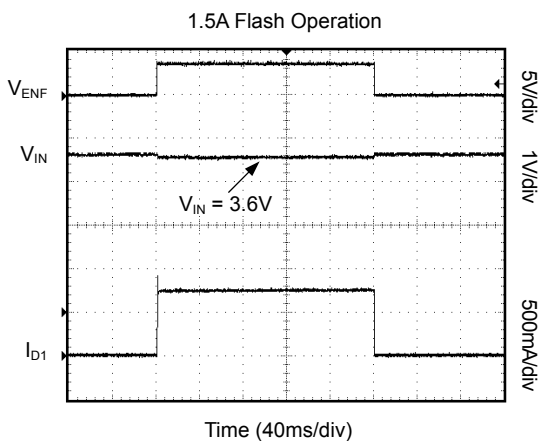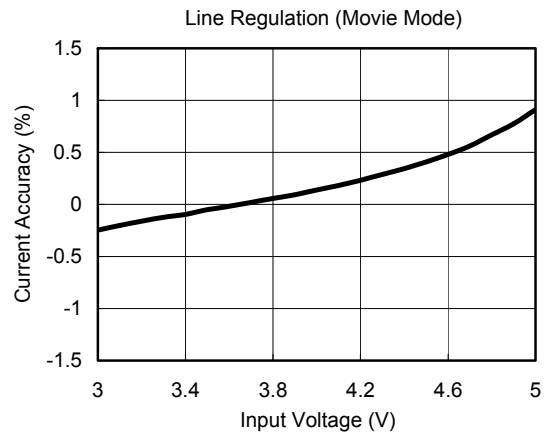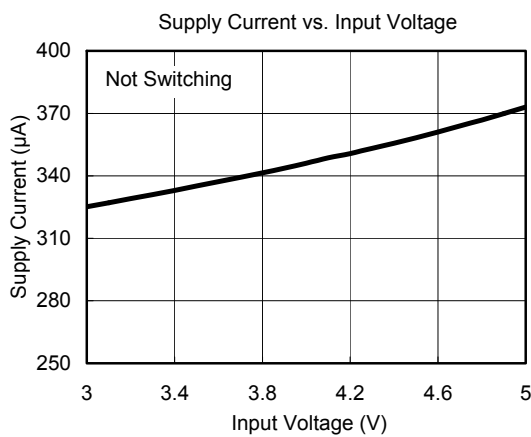| PIN	NAME	FUNCTION
1	RSETM	Movie/Torch Mode Current Setting Pin.
2	RSETF	Flash Mode Current Setting Pin.
3, 13	AGND	Analog Ground Pin.
4	VIN	Input Supply Pin for the IC.
5, 6	SW	Switching Node of the Step-Up Converter.
7	PGND	Power Ground Pin.
8, 9	VOUT	Output Voltage Pin.
10	ENF	Flash Mode Enable Pin. This pin has an internal 330kΩ pull-down resistor to AGND.
11	ENM	Movie/Torch Mode Enable Pin and PWM Pin. This pin has an internal 330kΩ pull-down resistor to AGND.
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_{IN} = V_{EN} = 3.6V, T_A = 25℃, unless otherwise specified.)

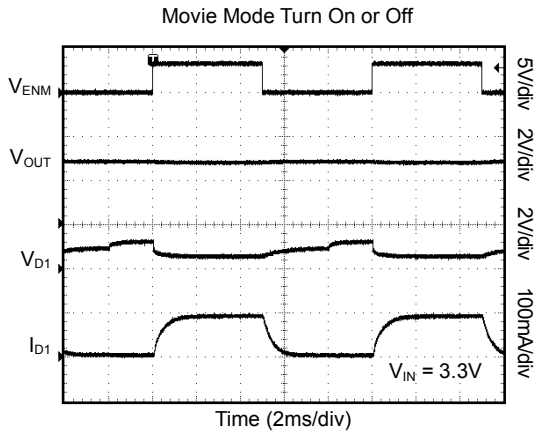| PARAMETR	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
IC SUPPLY						
Input Voltage Range	V_{IN}		3		5	V
Under-Voltage Lockout Threshold	UVLO	Rising edge	2.18	2.4	2.62	V
Under-Voltage Lockout Hysteresis	V_{HYS}			0.2		V
Supply Current	I_Q	Not switching		340	450	µA
Supply Current in Shutdown	I_{SHDN}	ENF = ENM = GND		0.1	1	µA
STEP-UP CONVERTER						
Peak NMOS Current Limit	I_{LIM}			3.4		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		ENM = HIGH, R_{SETM} = 75kΩ, D1 + D2, T_A = 25℃	175	200	225	mA
Total Output Current, Flash Mode	I_D	ENF = HIGH, ENM = GND, R_{SETF} = 12kΩ, D1 + D2, T_A = 25℃	1.32	1.5	1.68	A
Output Current Matching [1]		100mA each channel, T_A = 25℃, Movie/Torch mode		1.5	12	%
		750mA each channel, T_A = 25℃, Flash mode		0.7	10	%
LED Short Checking Current	I_{SHORT}			2.5		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	$R_{PD(ENF)}$			330		kΩ
ENM Internal Pull-Down Resistance	$R_{PD(ENM)}$			330		kΩ
Junction Thermal Shutdown Threshold				150		℃
Junction Thermal Shutdown Hysteresis				28		℃
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}		600		800	ms

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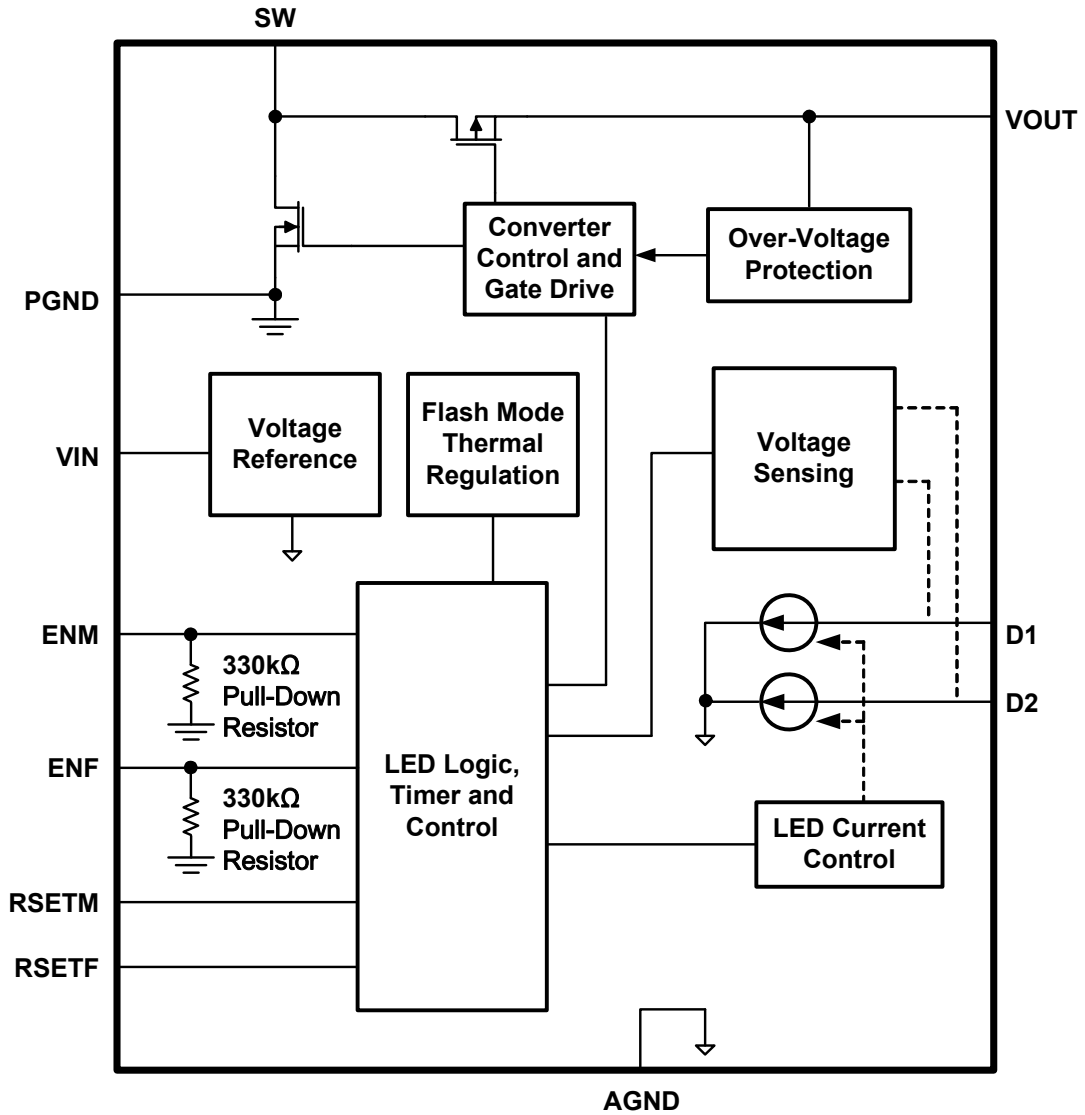1. The current matching between channels is defined as $|I_{D1} - I_{D2}|/(I_{D1} + I_{D2})$.
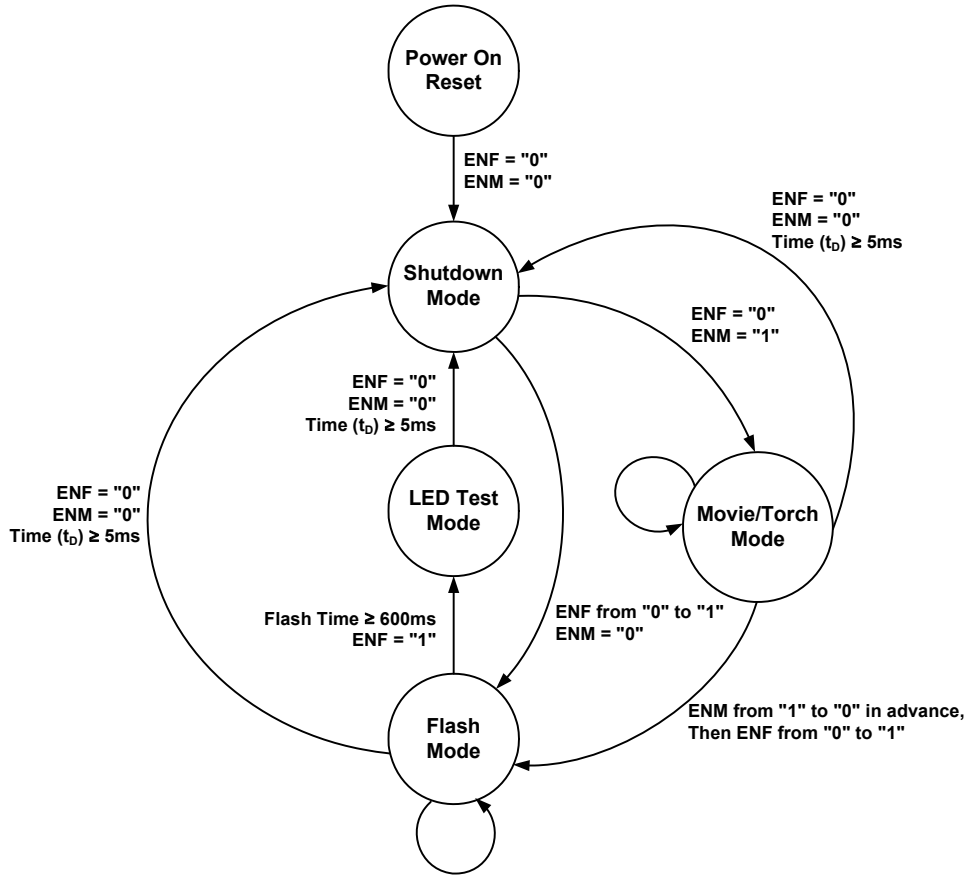
TYPICAL PERFORMANCE CHARACTERISTICS

Efficiency vs. Input Voltage

- 0.1A V_{LED} = 2.8V
- 0.2A V_{LED} = 3V
- 0.4A V_{LED} = 3.3V
- 0.6A V_{LED} = 3.5V
- 0.8A V_{LED} = 3.7V
- 1.0A V_{LED} = 4.1V
- 1.2A V_{LED} = 4.3V

Switching Frequency vs. Input Voltage

Supply Current vs. Input Voltage

Not Switching

Line Regulation (Movie Mode)

1.5A Flash Operation

V_{ENF}

V_{IN}

V_{IN} = 3.6V

I_{D1}

5V/div

1V/div

500mA/div

Time (40ms/div)

Flash Turn On in Soft-Start

V_{ENF}

V_{OUT}

V_{D1}

I_{D1}

V_{IN} = 3.8V

5V/div

2V/div

2V/div

500mA/div

Time (1ms/div)

TYPICAL PERFORMANCE CHARACTERISTICS

Movie Mode Turn On or Off
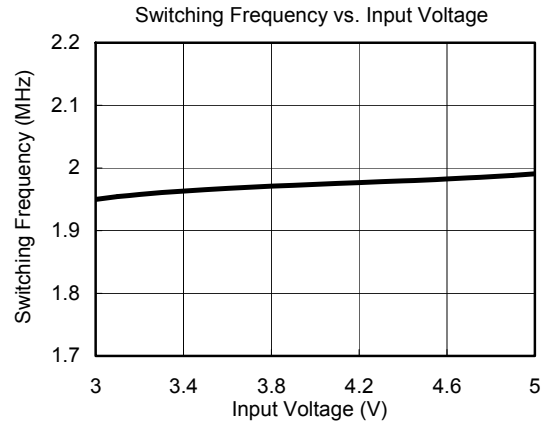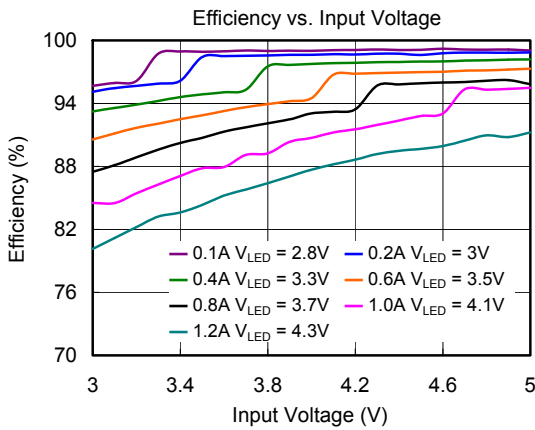
FUNCTIONAL BLOCK DIAGRAM

STATE DIAGRAM

Power On Reset

ENF = "0"
ENM = "0"

Shutdown Mode

ENF = "0"
ENM = "0"
Time (t$_D$) ≥ 5ms

ENF = "0"
ENM = "1"

ENF = "0"
ENM = "0"
Time (t$_D$) ≥ 5ms

LED Test Mode

ENF = "0"
ENM = "0"
Time (t$_D$) ≥ 5ms

Movie/Torch Mode

Flash Time ≥ 600ms
ENF = "1"

ENF from "0" to "1"
ENM = "0"

Flash Mode

ENM from "1" to "0" in advance,
Then ENF from "0" to "1"

TYPICAL APPLICATION
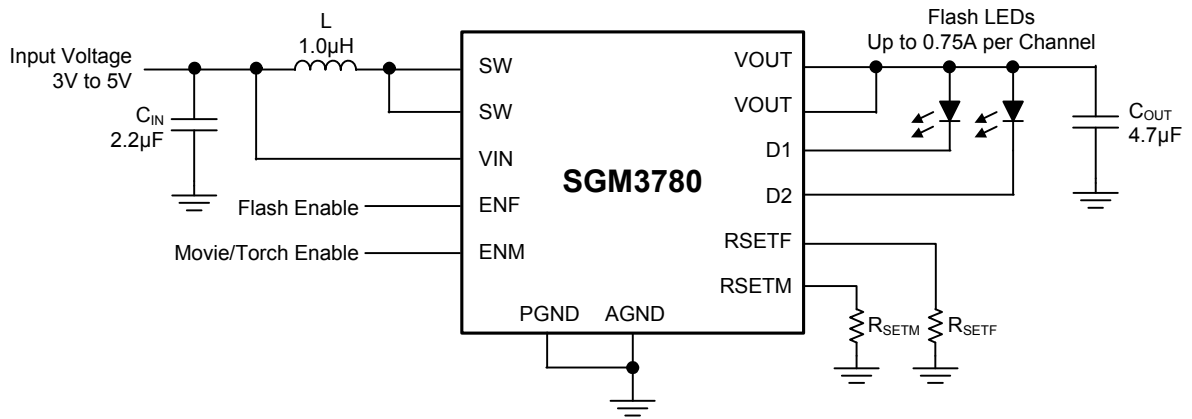
FUNCTIONAL DESCRIPTION

The SGM3780 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 SGM3780 internal switching frequency is 2MHz while still maintaining high power efficiency. Unlike a traditional DC/DC boost converter with a fixed output voltage, the SGM3780 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. When the ENF is pulled high while the ENM is low, the LED current will be ramped up to the Flash mode current level which is programmed by R_{SETF} resistor. When ENM is pulled high while the ENF is low, the LED current will be ramped up to the Movie/Torch mode current level which is programmed by R_{SETM} resistor. However, if both ENM and ENF are high, the LED current ill be set to Movie/Torch mode current. The driver IC and the flash LEDs won't be shut down until the 5ms delay time is finished when both ENF and ENM are at logic low.

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 SGM3780. The Flash mode current in each channel is set by the R_{SETF} resistor. For the desired Flash mode current in each output, the resistor value can be calculated using the following equation:

$$I_{FLASH\ (D1)} = I_{FLASH\ (D2)} = 9000/R_{SETF}$$

A flash event is initiated by asserting the ENF pin while ENM is at logic low level. A flash event is automatically terminated when ENF is deasserted or when ENM is asserted. For additional flexibility, a lower Flash mode current than the value calculated above can be realized by applying a PWM dimming signal (see Figure 2) at ENM pin while ENF is held high. The average Flash mode current will be proportional to $(1 - D_{ENM})$. The maximum ENM duty ratio is 95%. The range of ENM dimming frequency is from 10kHz to 200kHz.
Note: D_{ENM} = ENM duty radio.

For SGM3780, 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 SGM3780 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℃, 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 SGM3780 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_{SETM} resistor. For the desired Movie/Torch mode current in each output, the resistor value can be calculated using the following equation:

$$I_{MOVIE\ (D1)} = I_{MOVIE\ (D2)} = 7500/R_{SETM}$$

A Movie/Torch mode event is initiated by asserting the ENM pin. For additional flexibility, a lower Movie/Torch mode current than the value calculated above can be realized by applying a PWM dimming signal (see Figure 2) at ENM pin while ENF is held low. The average Movie/Torch mode current will be proportional to the ENM duty ratio. The range of ENM dimming frequency is from 10kHz to 200kHz.

FUNCTIONAL DESCRIPTION

LED Open Protection

In case of LED open, the open channel will control the loop first so that V_{OUT} will reach OVP (approximately 5.3V), and then SGM3780 will automatically detect which channel's LED is open and disable that channel. From that point, the other channel with properly operating LED will control the loop and V_{OUT} will be regulated down to a normal operating voltage. This protection feature avoids unnecessary power consumption in the current sink by regulating the output voltage at the lowest level possible to maintain regulation for the active channel. Not only does this protect from open LEDs failures, but also allows only single flash LED operation with the unused channel floating or open. Open-circuit LED fault protection is reset when the IC is powered down and up again.

LED Short Protection

When the SGM3780 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.
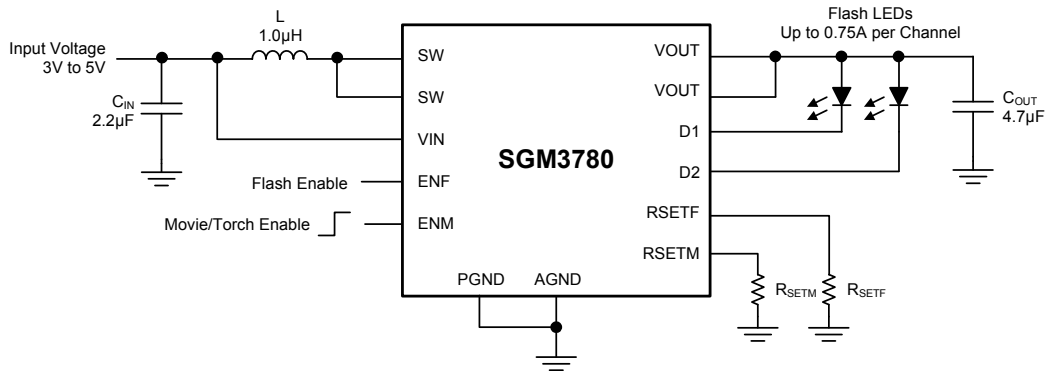

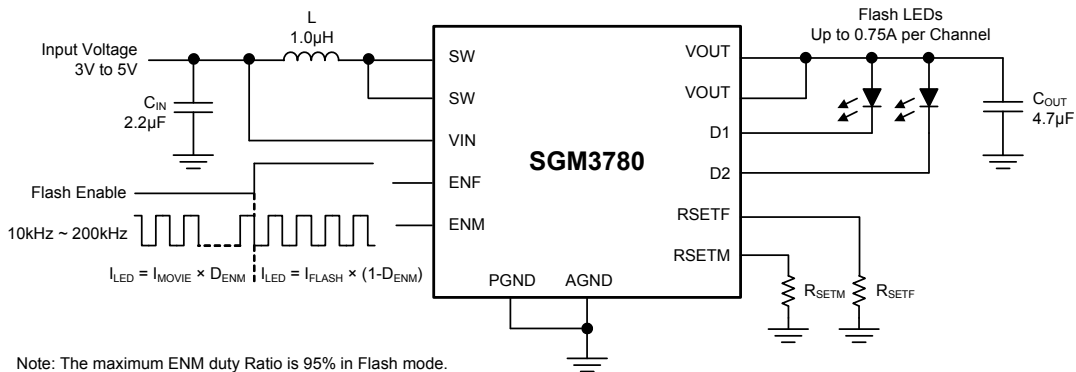**Figure 1. Controlling Movie/Torch Mode with Simple Enable ON/OFF Pulse**

Figure 2. Controlling Flash Mode or Movie/Torch Mode with PWM Dimming Signal

FUNCTIONAL DESCRIPTION

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 3). The current per sink follows the equations in Flash mode LED Current and Movie/Torch mode LED Current sections above.
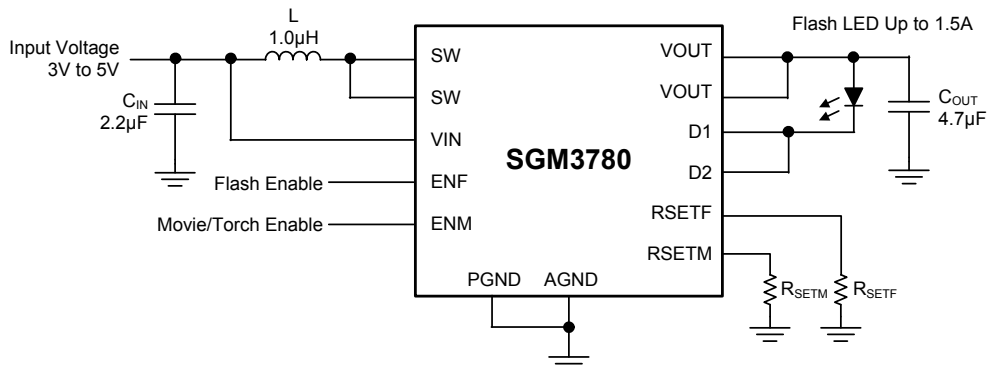

Figure 3. Optional Single LED Configuration

FUNCTIONAL DESCRIPTION

Inductor Selection

The SGM3780 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:

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

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):

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

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 SGM3780 current limit threshold (2.9A 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_{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 SGM3780.
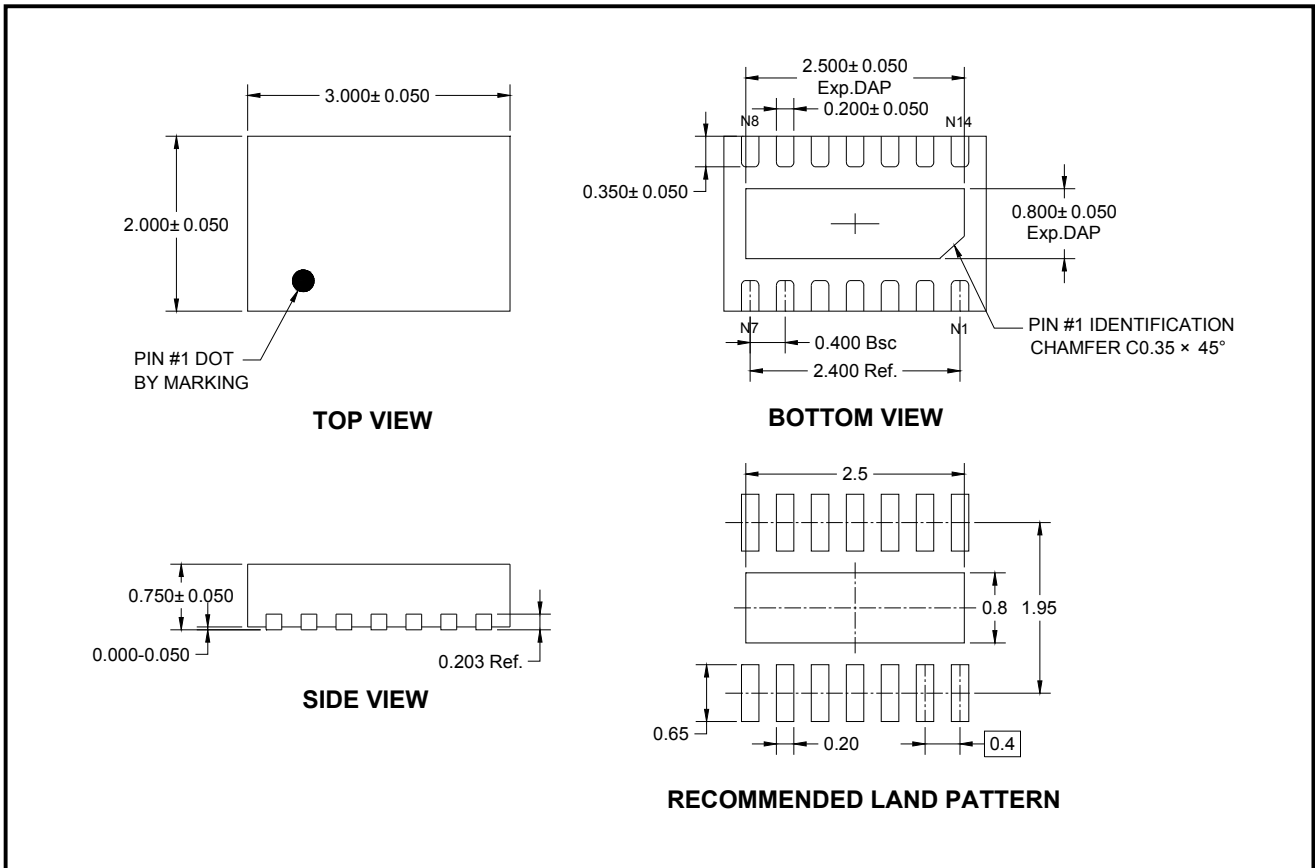
The output capacitance required depends on the required LED current. A 2.2µF or 4.7µF ceramic capacitor works well in most situations.

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_{IN} and C_{OUT} should be as close together as possible and connected to PGND.
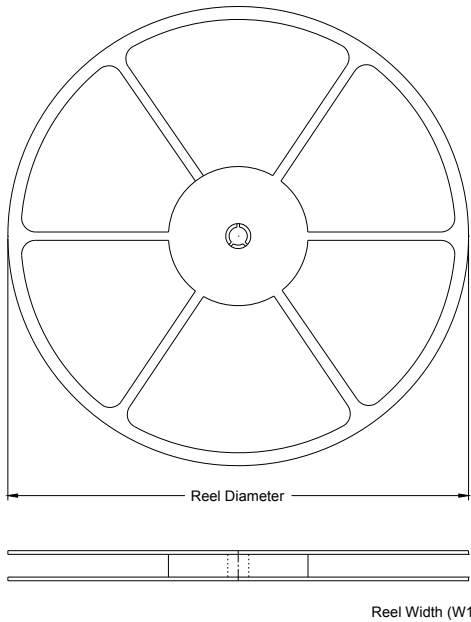
PACKAGE OUTLINE DIMENSIONS

TDFN-3×2-14L

TOP VIEW

3.000± 0.050

2.000± 0.050

PIN #1 DOT
BY MARKING

BOTTOM VIEW

2.500± 0.050
Exp.DAP
0.200± 0.050

N8   N14

0.350± 0.050

0.800± 0.050
Exp.DAP

N7   N1
0.400 Bsc
2.400 Ref.

PIN #1 IDENTIFICATION
CHAMFER C0.35 × 45°

SIDE VIEW

0.750± 0.050
0.000-0.050
0.203 Ref.

RECOMMENDED LAND PATTERN

2.5
0.8   1.95
0.65
0.20
0.4

NOTE: All linear dimensions are in millimeters.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

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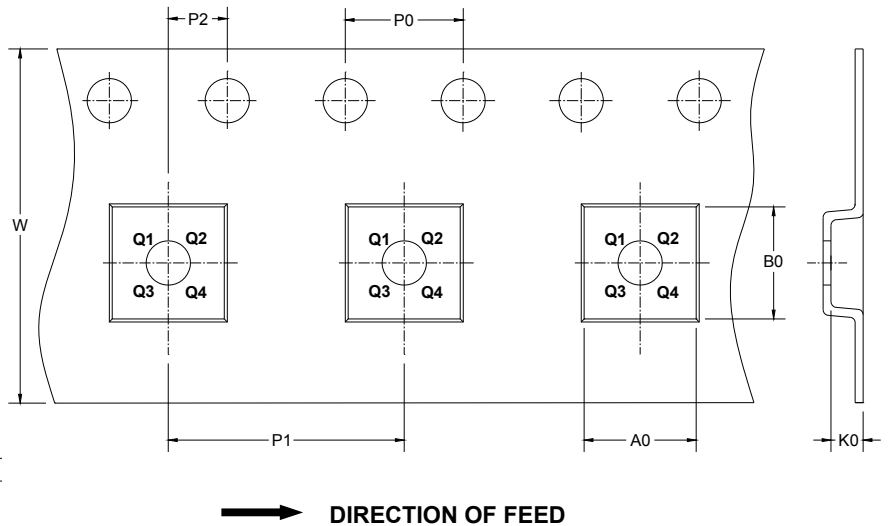
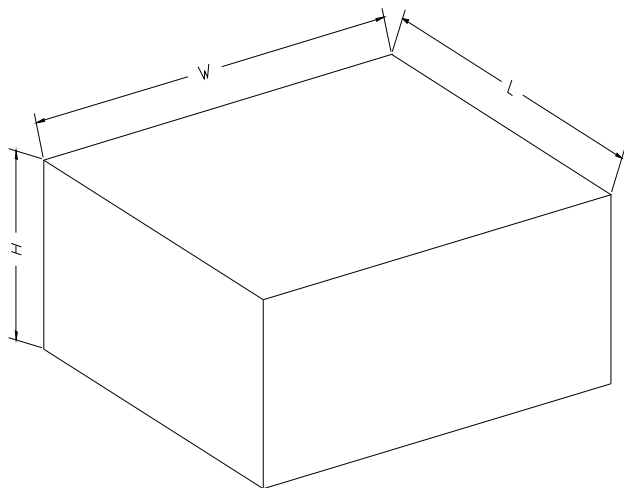NOTE: The picture is only for reference. Please make the object as the standard.

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

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