



# SGM3141

## 700mA Buck/Boost Charge Pump LED Driver

### GENERAL DESCRIPTION

The SGM3141 is a current-regulated charge pump ideal for powering high brightness LEDs for camera flash applications. The charge pump can be set to regulate two current levels for Flash and Torch modes.

The SGM3141 automatically switches modes between step-up and step-down ensuring that LED current does not depend on the forward voltage. It switches at 2.2MHz, allowing the use of tiny components. The supply voltage ranges from 2.7V to 5.5V and is ideally suited for all applications powered by a single Li-ion battery cell or three to four NiCd, NiMH, or Alkaline battery cells.

The SGM3141 also features a very low shutdown current, an automatic soft-start mode to limit inrush current, as well as over-current, over-voltage and over-temperature thermal shutdown control.

A low current-sense reference voltage (47mV) allows the use of small 0603 current sensing resistors.

The SGM3141 is available in Green TDFN-3x3-10L package and is specified over an ambient temperature range of -40°C to +85°C.

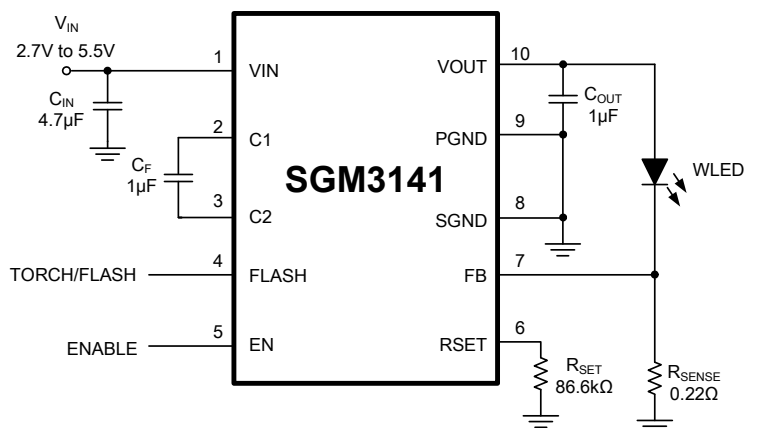
### APPLICATIONS

- White LED Torch, Flash for Cell Phones, DSCs and Camcorders
- White LED Backlighting
- Generic Lighting, Flash and Strobe Applications
- General Purpose High Current Boost

### FEATURES

- Output Current Up to 700mA
- Up to 90% Efficiency in Torch Mode
- Adjustable Flash Mode Current
- 1x and 2x Automatic Modes for High Efficiency
- Input Voltage Range: 2.7V to 5.5V
- Minimum External Components: No Inductors
- High Frequency Operation: 2.2MHz
- Low 47mV Reference for Low Loss Sensing
- $I_Q < 1\mu A$  in Shutdown
- Built-In Soft-Start Limits Inrush Current
- Low Input and Output Ripple and Low EMI
- Output Over-Voltage Protection
- Over-Current and Over-Temperature Protection
- Available in Green TDFN-3x3-10L Package

### TYPICAL APPLICATION



**PACKAGE/ORDERING INFORMATION**

| MODEL   | ORDER NUMBER    | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE | MARKING INFORMATION   | PACKAGE OPTION      |
|---------|-----------------|---------------------|-----------------------------|-----------------------|---------------------|
| SGM3141 | SGM3141YD10G/TR | TDFN-3x3-10L        | -40°C to +85°C              | SGM<br>3141D<br>XXXXX | Tape and Reel, 3000 |

NOTE: XXXXX = Date Code and Vendor Code.

**ABSOLUTE MAXIMUM RATINGS**

V<sub>IN</sub>, V<sub>OUT</sub>, C2.....-0.3V to 6V  
 EN, C1, FLASH, FB, RSET Pins  
 .....-0.3V to V<sub>IN</sub> +0.3V  
 Output Current Pulse (Flash).....1A  
 Output Current Continuous (Torch).....0.4A  
 Package Thermal Resistance  
 TDFN-3x3-10L, θ<sub>JA</sub>.....57°C/W  
 Storage Temperature Range.....-40°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 (EN Pin).....1000V  
 HBM (All Other Pins) .....2000V  
 MM.....200V

**CAUTION**

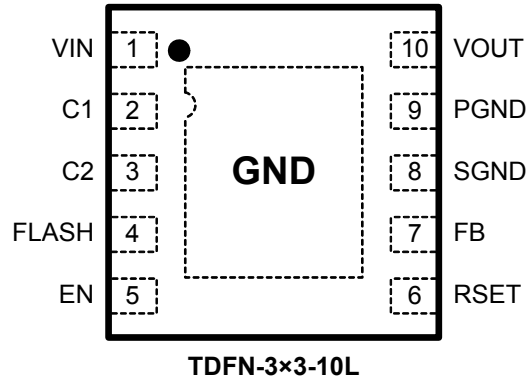
This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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.

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.

## PIN CONFIGURATION (TOP VIEW)



## PIN DESCRIPTION

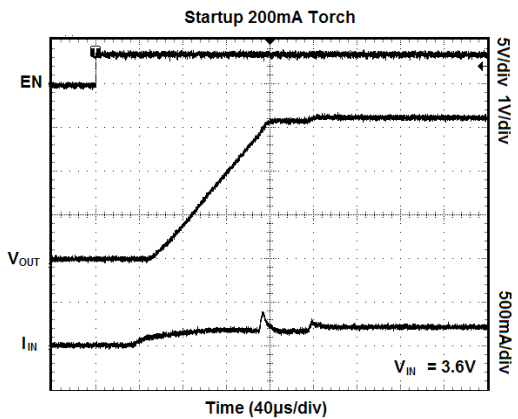
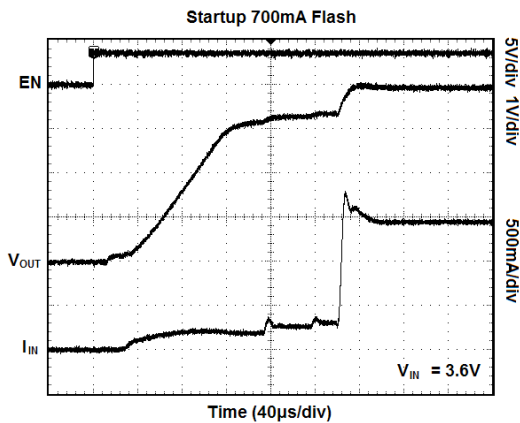
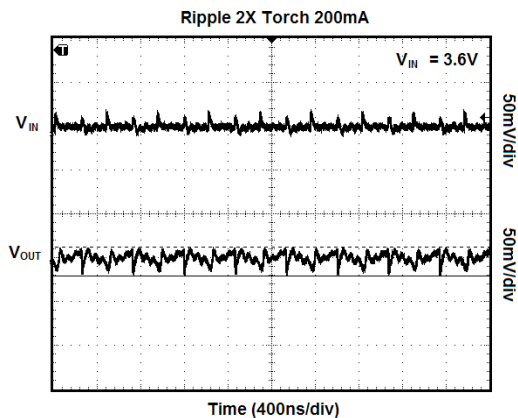
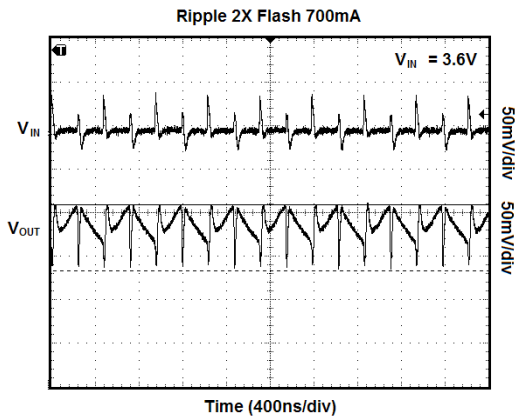
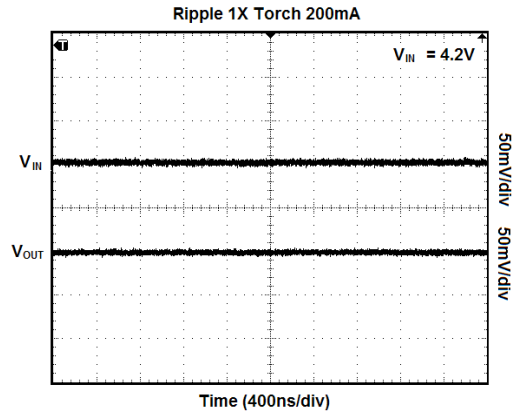
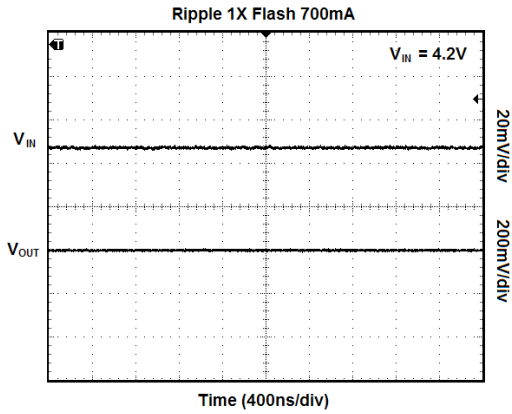
| PIN         | NAME  | FUNCTION   |
|-------------|-------|--|
| 1           | VIN   | Input Voltage for the Charge Pump. Decouple with 4.7μF or 10μF ceramic capacitor close to the pins of the IC.  |
| 2           | C1    | Positive Input for the External Flying Capacitor. Connect a ceramic 1μF capacitor close to the pins of the IC.   |
| 3           | C2    | Negative Input for the External Flying Capacitor. Connect a ceramic 1μF capacitor close to the pins of the IC.   |
| 4           | FLASH | Logic Input to Toggle Operation between Flash and Torch Mode. In Torch mode FB is regulated to the internal 47mV reference. In Flash mode FB reference voltage can be adjusted by changing the resistor from RSET pin to ground. Choose the external current sense resistor ( $R_{SENSE}$ ) based on desired current in Torch mode and Flash mode. |
| 5           | EN    | Shutdown Control Input. Connect to VIN for normal operation. Connect to ground for shutdown. For normal operation, suggest to connect to VIN only after the VIN has settled if the VIN ramping up is slow.   |
| 6           | RSET  | RSET Pin. Connect a resistor from this pin to ground. When in Flash mode (FLASH = High) this resistor sets the current regulation point according to the following:<br>$V_{FB} = (1.26V/R_{SET}) \times 10.2k\Omega.$  |
| 7           | FB    | Feedback Input for the Current Control Loop. Connect directly to the current sense resistor.   |
| 8           | SGND  | Internal Ground Pin. Control circuitry returns current to this pin.  |
| 9           | PGND  | Power Ground Pin. Flying capacitor current returns through this pin.   |
| 10          | VOUT  | Charge Pump Output Voltage. Decouple with an external capacitor. At least 1μF is recommended. If higher value capacitor is used, output ripple is smaller.   |
| Exposed Pad | GND   | Exposed pad should be soldered to PCB board and connected to GND.  |

**ELECTRICAL CHARACTERISTICS**(Full = -40°C to +85°C,  $V_{IN} = 3.6V$ ,  $C_{IN} = 4.7\mu F$ ,  $C_{OUT} = C_F = 1\mu F$ ,  $V_{SHDN} = V_{IN}$ , typical values at +25°C, unless otherwise noted.)

| PARAMETER                                   | SYMBOL     | CONDITIONS   | TEMP | MIN | TYP | MAX | UNITS       |
|---|------------|--|------|-----|-----|-----|-------------|
| Input Supply Voltage                        | $V_{IN}$   |  | Full | 2.7 |     | 5.5 | V           |
| Quiescent Current                           | $I_Q$      | $V_{IN} = 2.7V$ to $5.5V$ , FLASH = 0V,<br>$I_{LOAD} = 100\mu A$ | Full |     | 0.3 | 3   | mA          |
|   |            | FLASH = $V_{IN}$ , 2× Mode                                       |      |     | 2   |     |             |
| Shutdown Current                            | $I_{SHDN}$ | $V_{EN} = 0V$ , $V_{IN} = 5.5V$                                  |      |     |     | 1   | $\mu A$     |
| Oscillator Frequency                        |            |  |      |     | 2.2 |     | MHz         |
| Charge Pump Equivalent Resistance (2× Mode) |            |  |      |     | 5   |     | $\Omega$    |
| Charge Pump Equivalent Resistance (1× Mode) |            |  |      |     | 0.6 | 0.8 | $\Omega$    |
| FB Reference Voltage                        | $V_{FB}$   | FLASH = $V_{IN}$ , $R_{SET} = 86.6k\Omega$                       | Full | 131 | 150 | 165 | mV          |
|   |            | FLASH = GND  | Full | 38  | 47  | 54  |             |
| FB Pin Current                              |            | $V_{FB} = 0.3V$  |      |     |     | 1   | $\mu A$     |
| EN, FLASH Logic Low                         |            |  | Full |     |     | 0.4 | V           |
| EN, FLASH Logic High                        |            |  | Full | 1.3 |     |     | V           |
| EN, FLASH Pin Current                       |            |  | Full |     |     | 1   | $\mu A$     |
| $V_{OUT}$ Turn-On Time                      |            | $V_{IN} = 3.6V$ , FB within 90% of regulation                    |      |     | 250 |     | $\mu s$     |
| Thermal Shutdown Temperature                |            |  |      |     | 145 |     | $^{\circ}C$ |

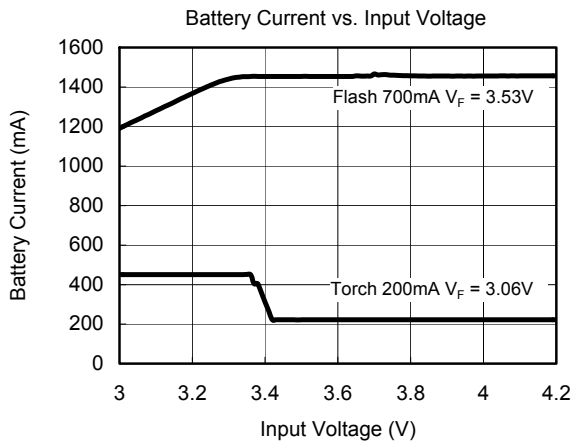
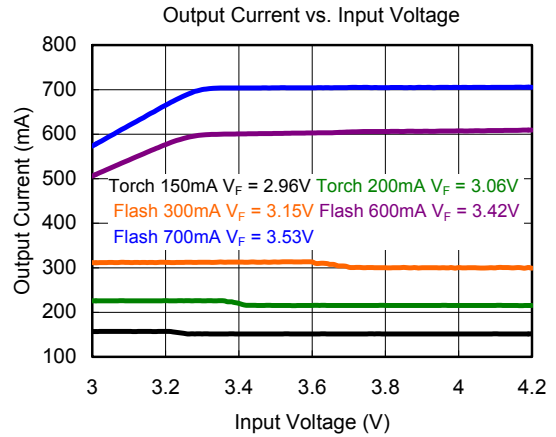
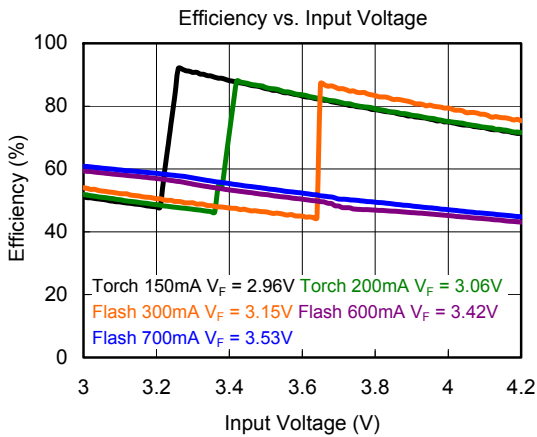
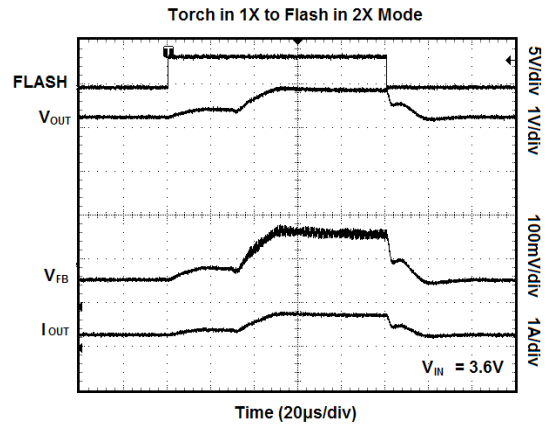
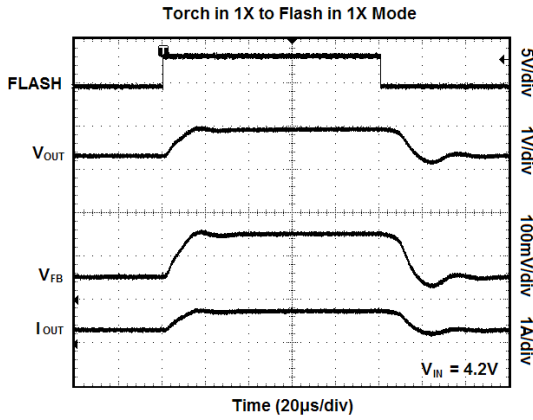
**TYPICAL PERFORMANCE CHARACTERISTICS**

$C_{IN} = 10\mu F$ ,  $C_{OUT} = 4.7\mu F$ ,  $C_F = 1\mu F$ , unless otherwise noted.



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$C_{IN} = 10\mu F$ ,  $C_F = 1\mu F$ ,  $C_{OUT} = 4.7\mu F$ , unless otherwise noted.



TYPICAL APPLICATION

The SGM3141 can be used with multiple LEDs in parallel as shown in Figure 1. For best performance, the LEDs should be in a single package, preferably from a single die to have better matching for forward voltage  $V_F$  for a given forward current  $I_F$ . In practice, if the  $V_F$  of one LED is higher than the others, it will consume a larger  $I_F$ , which will raise its temperature which will then cause its  $V_F$  to decrease, correcting the imbalance. The overall current will be the sum of the individual currents, for example  $I_{TOTAL} = 4 \times I_{LED}$ .

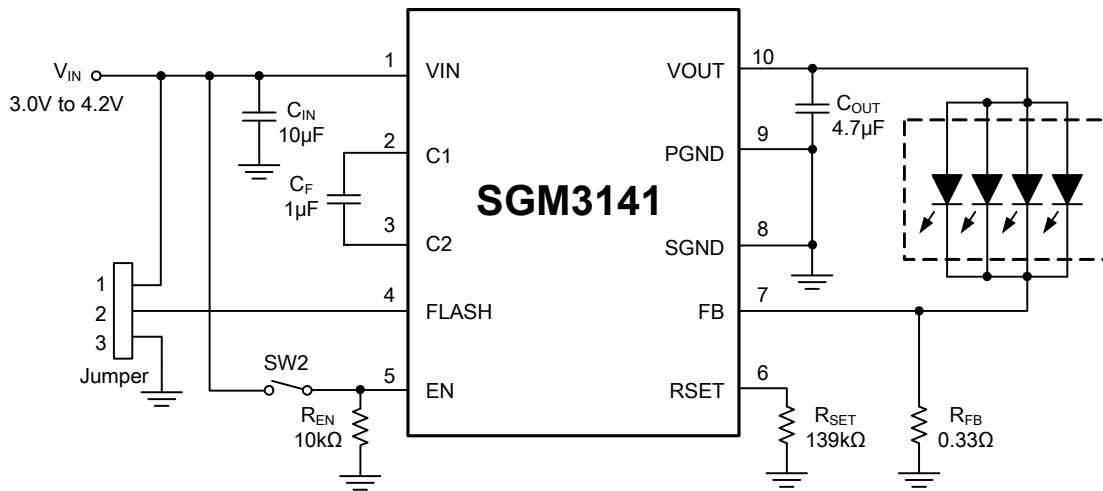


Figure 1. Multiple LED Flash Circuit

The SGM3141 also can be used to drive two flash LEDs in portable equipments. The schematic is shown in Figure 2.

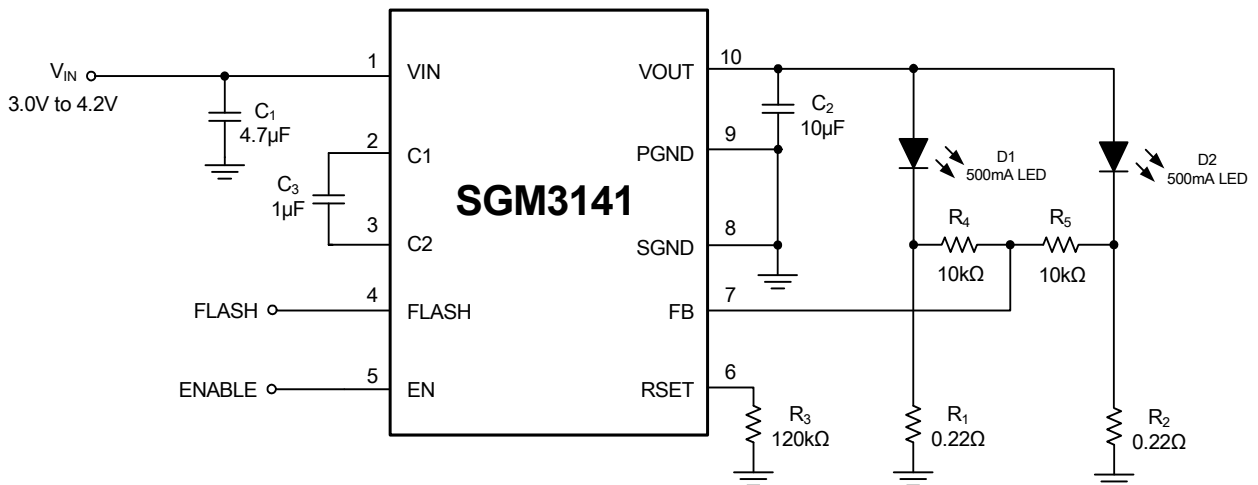


Figure 2. Two Flash LED Drive

## OPERATION

The SGM3141 is a charge pump regulator designed for converting a Li-ion battery voltage of 2.7V to 4.2V to drive a white LED used in digital still camera flash and torch applications. The SGM3141 has two modes of operation which are pin selectable for either Flash or Torch. Flash mode is usually used with a pulse of about 200 to 300 milliseconds to generate a high intensity Flash. Torch can be used continuously at a lower output current than Flash and is often used for several seconds in a digital still camera “movie” mode.

The SGM3141 also has two modes of operation to control the output current: the 1× mode and 2× mode. Operation begins after the enable pin EN receives a logic high, the band-gap reference wakes up after 50μs, and then SGM3141 goes through a soft-start mode designed to reduce inrush current. The SGM3141 starts in the 1× mode, which acts like a linear regulator to control the output current by continuously monitoring the feedback pin FB. In 1× mode, if the SGM3141 auto detects a dropout condition, which is when the FB pin is below the regulation point for more than 15μs, the SGM3141 automatically switches to the 2× mode. The SGM3141 remains in the 2× mode until one of four things happens:

- 1) The enable pin EN has been toggled.
- 2) The FLASH pin has changed from high to low.
- 3)  $V_{IN}$  is cycled or  $V_{IN}$  is at least 1V above  $V_{OUT}$ .
- 4) A thermal fault occurs.

The 2× mode is the charge pump mode where the output can be pumped as high as two times the input voltage, provided the output does not exceed the maximum voltage for the SGM3141, which is internally limited to about 5.5V. In the 2× mode, as in the 1× mode, the output current is regulated by the voltage at the FB pin.

In the Torch mode (FLASH = “GND”), the FLASH pin is set to logic low and the SGM3141 FB pin is regulated to 47mV output:

$$V_{FB} = 47\text{mV (Torch Mode)}$$

When in Flash mode (FLASH = “High”), the FB regulation voltage is set by the resistor  $R_{SET}$  connected between the RSET pin and SGND pin with the equation:

$$V_{FB} = (1.26\text{V} / R_{SET}) \times 10.2\text{k}\Omega \text{ (Flash Mode)}$$

Where 1.26V is the internal band-gap reference voltage and 10.2kΩ is an internal resistance used to scale the RSET current. Typical values of  $R_{SET}$  are 42kΩ to 170kΩ for a range of  $V_{FB} = 300\text{mV}$  to 75mV in Flash mode.

The output current is then set in either Flash or Torch mode by the equation:

$$I_{OUT} = V_{FB} / R_{SENSE}$$



## APPLICATION INFORMATION

### Over-Temperature Protection

When the temperature of SGM3141 rises above 145°C, the over-temperature protection circuitry turns off the output switches to prevent damage to the device. If the temperature drops back down below 130°C, the part automatically recovers and executes a soft-start cycle.

### Over-Voltage Protection

The SGM3141 has over-voltage protection. If the output voltage rises above the 5.5V threshold, the over-voltage protection shuts off all of the output switches to prevent the output voltage from rising further. When the output decreases below 5.2V, the device resumes normal operation.

### Over-Current Protection

The over-current protection circuitry monitors the average current out of the  $V_{OUT} = 47\text{mV}$  (Torch Mode) pin. If the average output current exceeds approximately 1A, then the over-current protection circuitry shuts off the output switches to protect the chip.

### Component Selection

The SGM3141 charge pump circuit requires 3 capacitors: 4.7 $\mu\text{F}$  input, 1 $\mu\text{F}$  output and 1 $\mu\text{F}$  flying capacitors are typically recommended. For the input capacitor, a larger value of 10 $\mu\text{F}$  will help reduce input voltage ripple for applications sensitive to ripple on the battery voltage. All the capacitors should be surface mount ceramic for low lead inductance necessary at the 2.2MHz switching frequency of the SGM3141 and to obtain low ESR, which improves bypassing on the input and output and improves output voltage drive by reducing output resistance. Ceramic capacitors with X5R or X7R temperature grade are recommended for most applications.

The input and output capacitors should be located as close to the VIN and VOUT pins as possible to obtain best bypassing, and the returns should be connected directly to the PGND pin or to the thermal pad ground located under the SGM3141. The flying capacitor should be located as close to the C1 and C2 pins as possible.

To obtain lower output ripple, the  $C_{OUT}$  value can be increased from 1 $\mu\text{F}$  to 2.2 $\mu\text{F}$  or 4.7 $\mu\text{F}$  with a corresponding decrease in output ripple. For output currents of 500mA to 700mA, the recommended  $C_F$  flying capacitor value of 1 $\mu\text{F}$  should be used. Output currents in Flash of 100mA to 400mA can use a 0.47 $\mu\text{F}$   $C_F$  but a minimum 1 $\mu\text{F}$   $C_{OUT}$  is still needed.

### Resistor Selection

The sense resistor  $R_{SENSE}$  is determined by the value needed in the Torch mode for the desired output current by the equation:

$$R_{SENSE} = V_{FB}/I_{OUT} \text{ where } V_{FB} = 47\text{mV (Torch Mode)}$$

Once the  $R_{SENSE}$  resistor has been selected for Torch mode, the  $V_{FB}$  voltage can be selected for Flash mode using the following equation:

$$V_{FB} = I_{OUT} \times R_{SENSE} \text{ (Flash Mode) where } I_{OUT} \text{ is for Flash Mode.}$$

Next, the  $R_{SET}$  resistor can be selected for Flash mode using the following equation:

$$R_{SET} = (1.26\text{V}/V_{FB}) \times 10.2\text{k}\Omega \text{ (Flash Mode)}$$

For an example of 190mA Torch mode and 600mA Flash mode, the values of  $R_{SENSE} = 0.25\Omega$ ,  $V_{FB} = 150\text{mV}$  (Flash Mode), and  $R_{SET} = 86.6\text{k}\Omega$  are calculated. The power obtained in the Flash mode would be:

$$P_{FLASH} = V_{FB} \times I_{OUT} = 150\text{mV} \times 600\text{mA} = 90\text{mW}$$

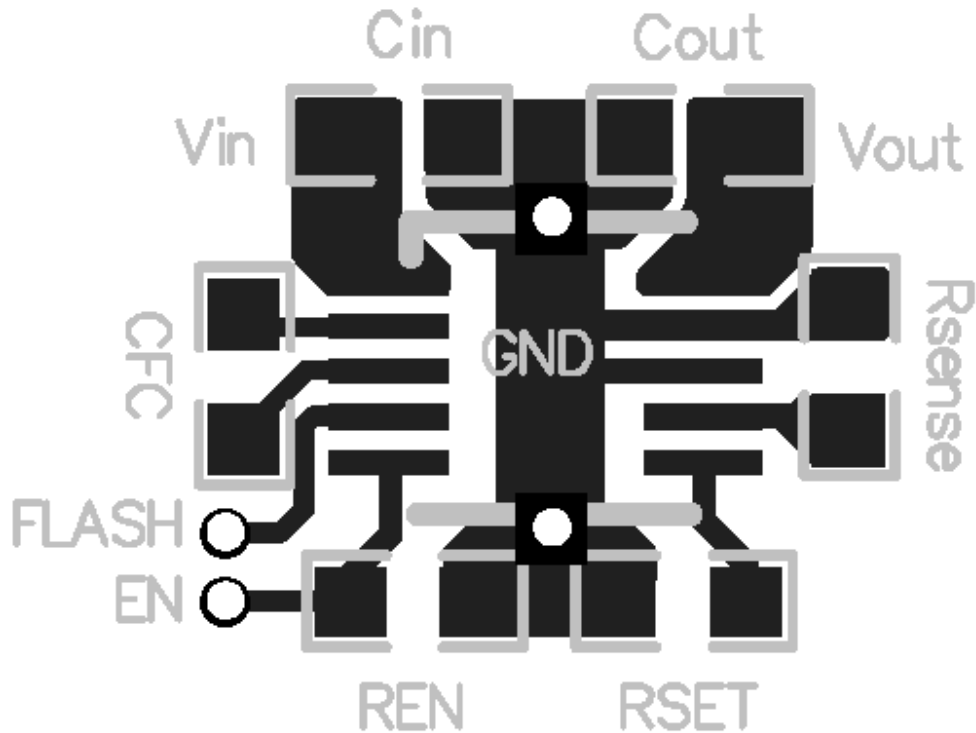
The typical 0603 surface mount resistor is rated 1/10 Watt continuous power and 1/5 Watt pulsed power, more than enough for this application. For other applications, the  $P_{FLASH}$  power can be calculated and resistor size selected. The  $R_{SENSE}$  resistor is recommended to be size 0603 for most applications.

The range of typical resistor values and sizes are shown here in Table 1.

Table 1. Resistor Values and Sizes

| PART REFERENCE     | VALUE | TOLERANCE | SIZE | MANUFACTURERS       |
|--------------------|-------|-----------|------|---------------------|
| R <sub>SET</sub>   | 68kΩ  | 5%        | 0402 | any                 |
| R <sub>SET</sub>   | 75kΩ  | 5%        | 0402 | any                 |
| R <sub>SET</sub>   | 82kΩ  | 5%        | 0402 | any                 |
| R <sub>SET</sub>   | 91kΩ  | 5%        | 0402 | any                 |
| R <sub>SET</sub>   | 100kΩ | 5%        | 0402 | any                 |
| R <sub>SET</sub>   | 110kΩ | 5%        | 0402 | any                 |
| R <sub>SET</sub>   | 120kΩ | 5%        | 0402 | any                 |
| R <sub>SET</sub>   | 130kΩ | 5%        | 0402 | any                 |
| R <sub>SET</sub>   | 140kΩ | 5%        | 0402 | any                 |
| R <sub>SET</sub>   | 150kΩ | 5%        | 0402 | any                 |
| R <sub>SENSE</sub> | 0.22Ω | 5%        | 0603 | Panasonic or Vishay |
| R <sub>SENSE</sub> | 0.27Ω | 5%        | 0603 | Panasonic or Vishay |
| R <sub>SENSE</sub> | 0.33Ω | 5%        | 0603 | Panasonic or Vishay |
| R <sub>SENSE</sub> | 0.39Ω | 5%        | 0603 | Panasonic or Vishay |
| R <sub>SENSE</sub> | 0.47Ω | 5%        | 0603 | Panasonic or Vishay |

## EVALUATION BOARD LAYOUT

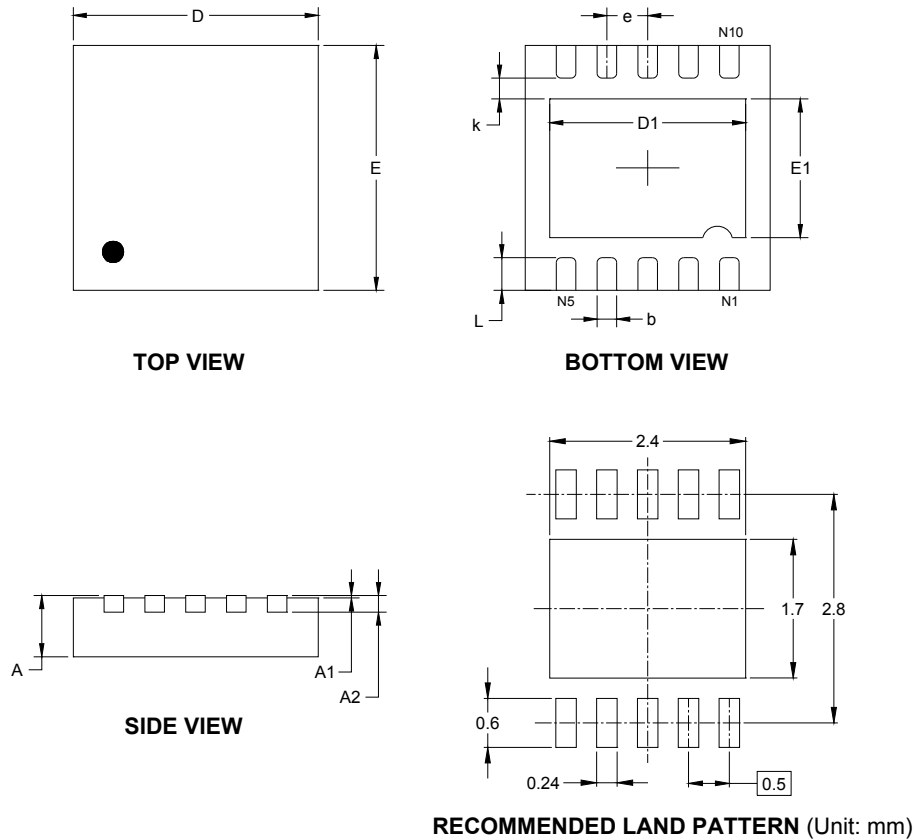
**Printed Circuit Board Layout Recommendations**

Follow the PCB layout guidelines for optimal performance:

1. Place the flying capacitor CF as close to the chip as possible; otherwise 2× mode performance will be compromised. Also keep analog components away from this capacitor.
2. Place input and output decoupling capacitors as close to the chip as possible to reduce switching noise and output ripple.
3. The power traces, consisting of the VIN/GND trace, the VOUT trace and the WLED trace should be kept short and wide. Also minimize the feedback loop area (consisting of WLED/FB) small.
4. Connect the exposed pad to the GND plane to achieve the best power dissipation.

PACKAGE OUTLINE DIMENSIONS

TDFN-3x3-10L

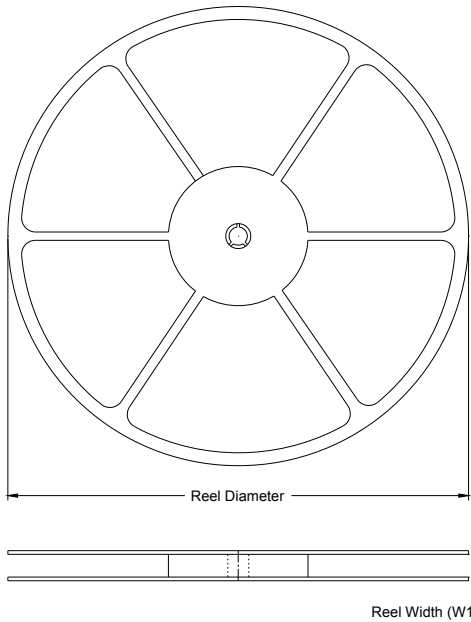


RECOMMENDED LAND PATTERN (Unit: mm)

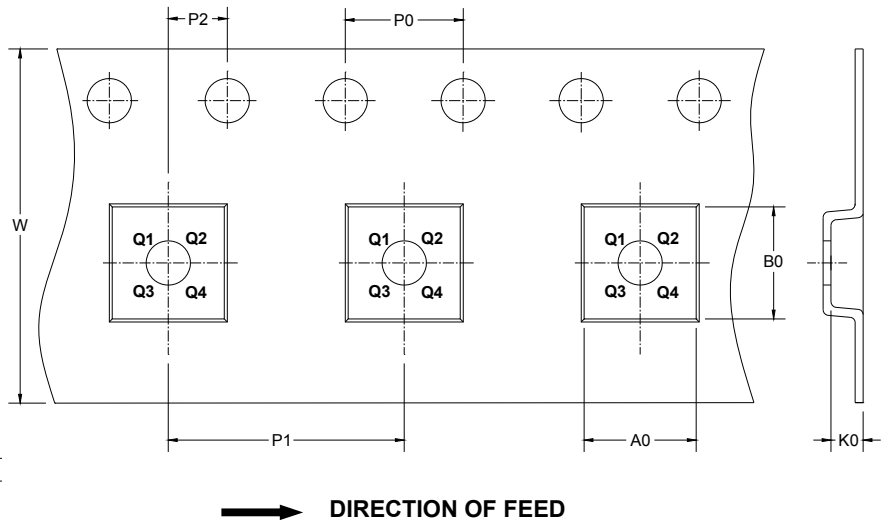
| Symbol | Dimensions<br>In Millimeters |       | Dimensions<br>In Inches |       |
|--------|------------------------------|-------|-------------------------|-------|
|        | MIN                          | MAX   | MIN                     | MAX   |
| A      | 0.700                        | 0.800 | 0.028                   | 0.031 |
| A1     | 0.000                        | 0.050 | 0.000                   | 0.002 |
| A2     | 0.203 REF                    |       | 0.008 REF               |       |
| D      | 2.900                        | 3.100 | 0.114                   | 0.122 |
| D1     | 2.300                        | 2.600 | 0.091                   | 0.098 |
| E      | 2.900                        | 3.100 | 0.114                   | 0.122 |
| E1     | 1.500                        | 1.800 | 0.063                   | 0.071 |
| k      | 0.200 MIN                    |       | 0.008 MIN               |       |
| b      | 0.180                        | 0.300 | 0.007                   | 0.012 |
| e      | 0.500 TYP                    |       | 0.020 TYP               |       |
| L      | 0.300                        | 0.500 | 0.012                   | 0.020 |

**TAPE AND REEL INFORMATION**

**REEL DIMENSIONS**



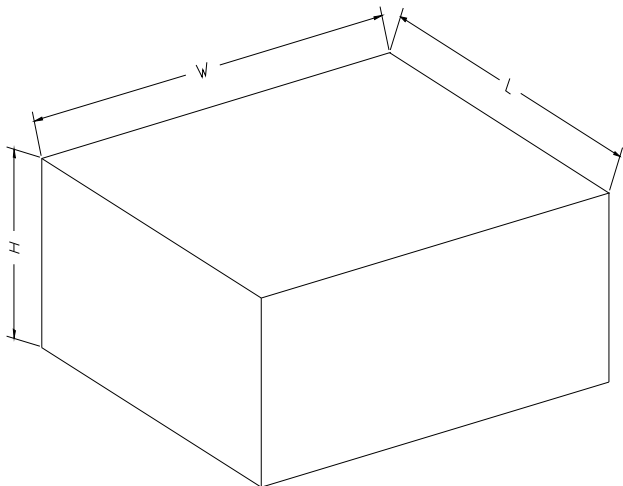
**TAPE DIMENSIONS**



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-3×3-10L | 13"           | 12.4               | 3.35    | 3.35    | 1.13    | 4.00    | 8.00    | 2.00    | 12.00  | 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 |
|-----------|-------------|------------|-------------|--------------|
| 13"       | 386         | 280        | 370         | 5            |