SGM3140
500mA Buck/Boost Charge Pump LED Driver

GENERAL DESCRIPTION

The SGM3140 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 SGM3140 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 SGM3140 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 SGM3140 is available in Green TDFN-3×3-10L package and is specified over an ambient temperature range of -40℃ to +85℃.

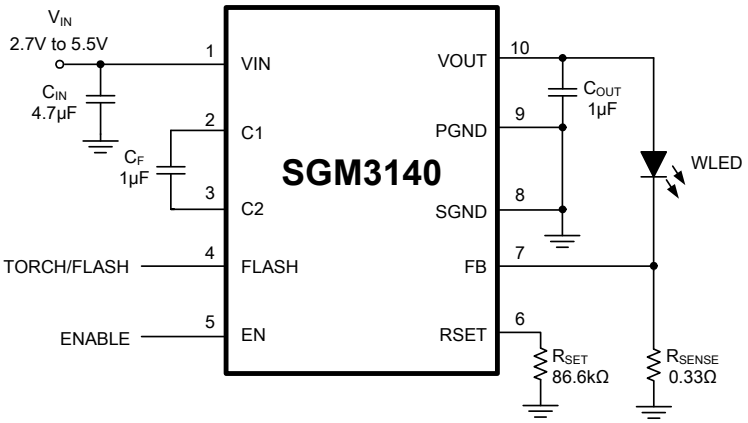
APPLICATIONS

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 500mA**
- **Up to 90% Efficiency in Torch Mode**
- **Adjustable Flash Mode Current**
- **Automatic Buck/Boost Mode Switchover**
- **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 < 1μA in Shutdown**
- **Automatic 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-3×3-10L Package**

TYPICAL APPLICATION



PACKAGE/ORDERING INFORMATION

MODEL	ORDER NUMBER	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	PACKAGE OPTION	MARKING INFORMATION
SGM3140	SGM3140YD10G/TR	TDFN-3×3-10L	-40℃ to +85℃	Tape and Reel, 3000	SGM 3140D XXXXX

NOTE: **XXXXX** = Date Code and Vendor Code.

ABSOLUTE MAXIMUM RATINGS

V_{IN}, V_{OUT}, C2……-0.3V to 6V
EN, C1, FLASH, FB, RSET Pins
……-0.3V to V_{IN} +0.3V
Output Current Pulse (Flash).....0.8A
Output Current Continuous (Torch).....0.4A
Package Thermal Resistance
TDFN-3×3-10L, θ_{JA}……57℃/W
Storage Temperature Range……-40℃ to +150℃
Junction Temperature.....150℃
Operating Temperature Range……-40℃ to +85℃
Lead Temperature (Soldering 10 sec)
……260℃
ESD Susceptibility
HBM (EN Pin)……1000V
HBM (All Other Pins) ……2000V
MM……200V

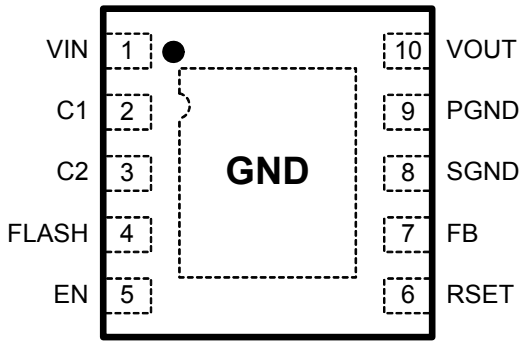
NOTE:
Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. 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)



TDFN-3×3-10L

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: $V_{FB} = (1.26V/R_{SET}) \times 10.2k\Omega$.
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

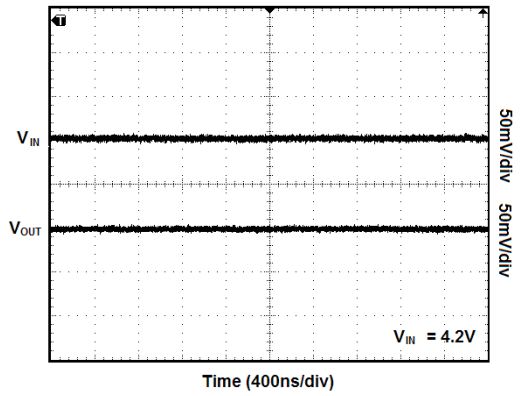
(Full = -40℃ to +85℃, V_{IN} = 3.6V, C_{IN} = 4.7μF, C_{OUT} = C_F = 1μF, V_{SHDN} = V_{IN}, typical values at +25℃, unless otherwise noted.)

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, I_{LOAD} = 100μA	Full		0.3	3	mA
		FLASH = V_{IN}, 2× Mode			2		
Shutdown Current	I_{SHDN}	V_{EN} = 0V, V_{IN} = 5.5V				1	μA
Oscillator Frequency					2.2		MHz
Charge Pump Equivalent Resistance (2× Mode)					5		Ω
Charge Pump Equivalent Resistance (1× Mode)					0.6	0.8	Ω
FB Reference Voltage	V_{FB}	FLASH = V_{IN}, R_{SET} = 86.6kΩ	Full	131	150	165	mV
		FLASH = GND	Full	38	47	54	
FB Pin Current		V_{FB} = 0.3V				1	μA
EN, FLASH Logic Low			Full			0.4	V
EN, FLASH Logic High			Full	1.3			V
EN, FLASH Pin Current			Full			1	μA
V_{OUT} Turn-On Time		V_{IN} = 3.6V, FB within 90% of regulation			250		μs
Thermal Shutdown Temperature					145		℃

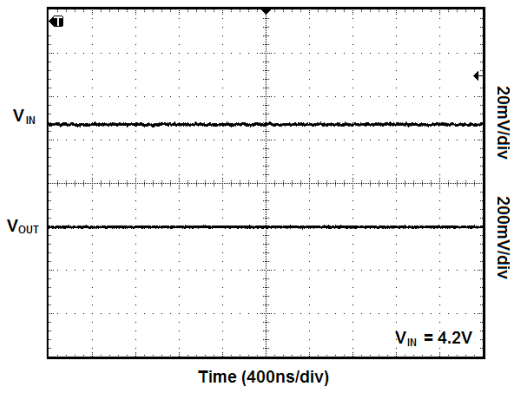
TYPICAL PERFORMANCE CHARACTERISTICS

C_{IN} = 10μF, C_{OUT} = 4.7μF, C_F = 1μF, unless otherwise noted.

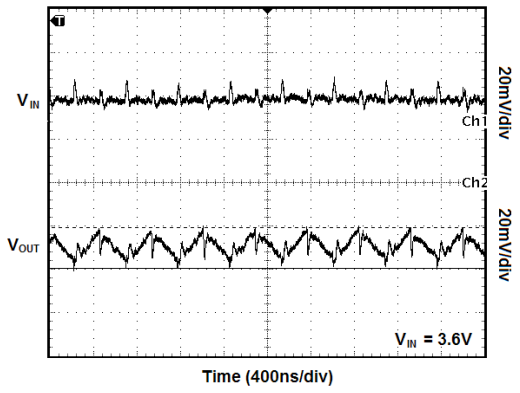
Ripple 1X Torch 160mA



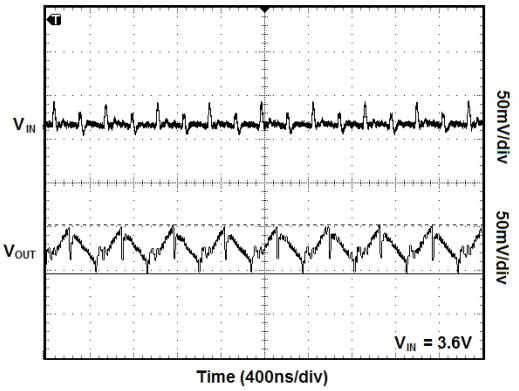
Ripple 1X Flash 500mA



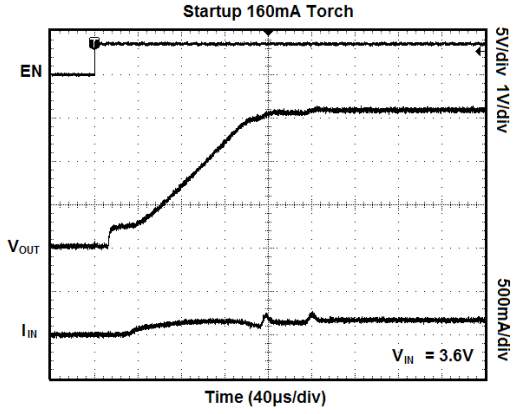
Ripple 2X Torch 160mA



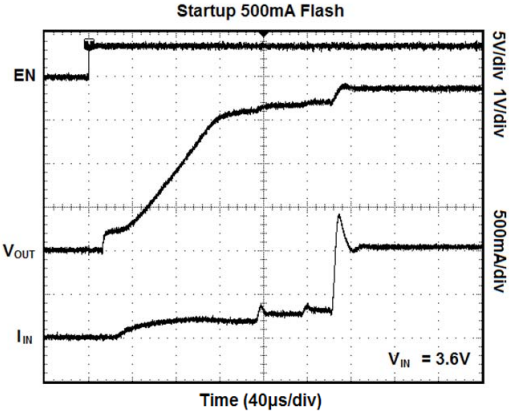
Ripple 2X Flash 500mA



Startup 160mA Torch



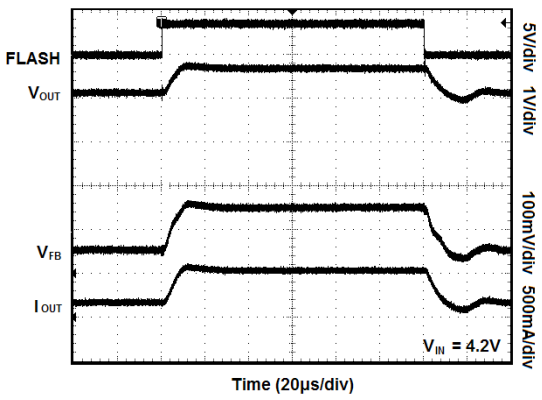
Startup 500mA Flash



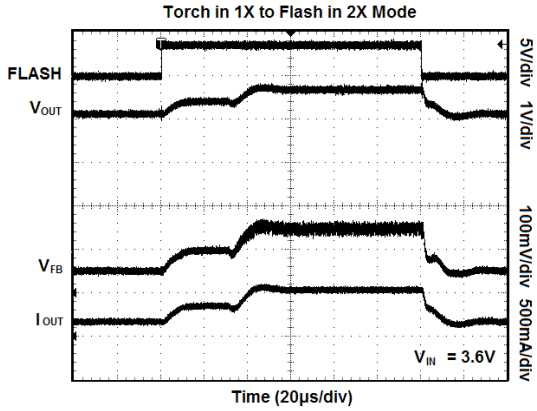
TYPICAL PERFORMANCE CHARACTERISTICS

C_{IN} = 10μF, C_{OUT} = 4.7μF, C_F = 1μF, unless otherwise noted.

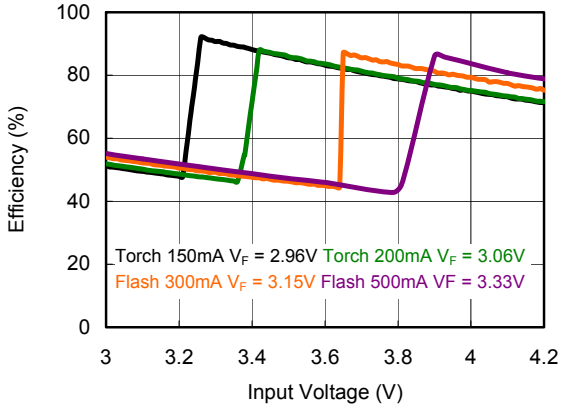
Torch in 1X to Flash in 1X Mode



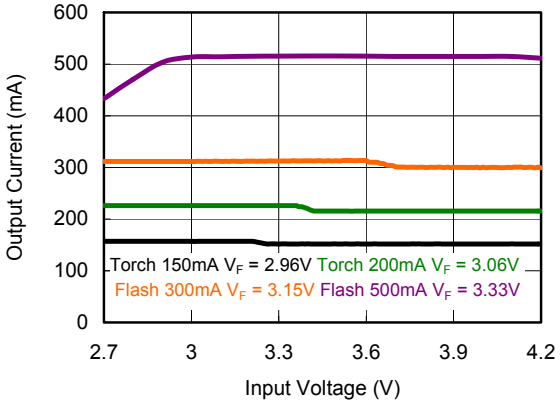
Torch in 1X to Flash in 2X Mode



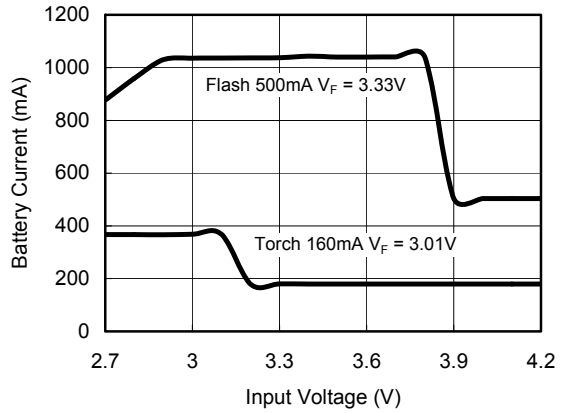
Efficiency vs. Input Voltage



Output Current vs. Input Voltage



Battery Current vs. Input Voltage



TYPICAL APPLICATION

The SGM3140 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 $I_{TOTAL} = 4 \times I_{LED}$.

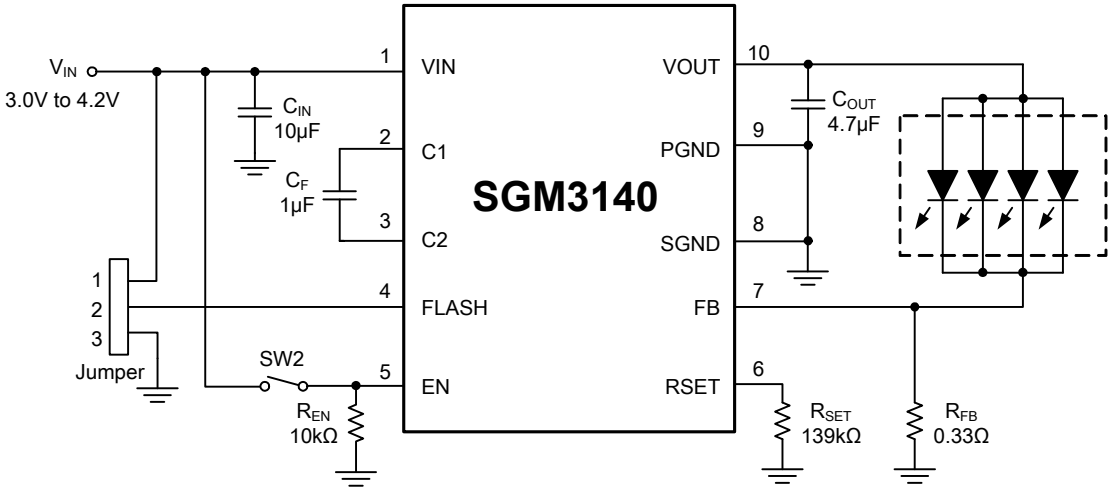


Figure 1. Multiple LED Flash Circuit

OPERATION

The SGM3140 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 SGM3140 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 SGM3140 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 SGM3140 goes through a soft-start mode designed to reduce inrush current. The SGM3140 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 SGM3140 auto detects a dropout condition, which is when the FB pin is below the regulation point for more than 15μs, the SGM3140 automatically switches to the 2× mode. The SGM3140 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 SGM3140, 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 SGM3140 FB pin is regulated to 47mV output:

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

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:

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

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} = 300mV 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 SGM3140 rises above 145℃, the over-temperature protection circuitry turns off the output switches to prevent damage to the device. If the temperature drops back down below 130℃, the part automatically recovers and executes a soft-start cycle.

Over-Voltage Protection

The SGM3140 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} = 47mV (Torch Mode) pin. If the average output current exceeds approximately 0.8A, then the over-current protection circuitry shuts off the output switches to protect the chip.

Component Selection

The SGM3140 charge pump circuit requires 3 capacitors: 4.7μF input, 1μF output and 1μF flying capacitors are typically recommended. For the input capacitor, a larger value of 10μF 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 SGM3140 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 SGM3140. 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 1μF to 2.2μF or 4.7μF with a corresponding decrease in output ripple. For output currents of 400mA to 500mA, the recommended C_F flying capacitor value of 1μF should be used. Output currents in Flash of 100mA to 400mA can use a 0.47μF C_F but a minimum 1μF 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:

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

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:

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

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

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

For an example of 155mA Torch mode and 500mA Flash mode, the values of R_{SENSE} = 0.30Ω, V_{FB} = 150mV (Flash Mode), and R_{SET} = 86.6kΩ are calculated. The power obtained in the Flash mode would be:

$$P_{FLASH} = V_{FB} \times I_{OUT} = 150mV \times 500mA = 75mW$$

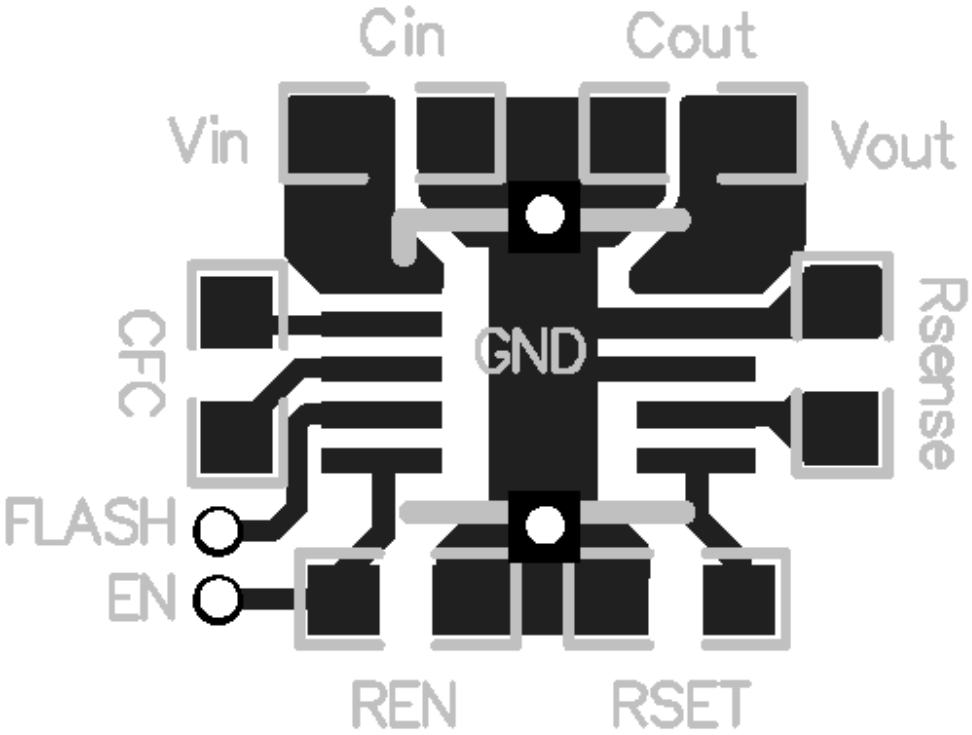
The typical 0603 surface mount resistor is rated 1/10 Watt continuous power and 1/5 Watt pulsed power, more than enough for this application. For other applications, the P_{FLASH} power can be calculated and resistor size selected. The R_{SENSE} resistor is recommended to be size 0603 for most applications.

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_{SET}	68kΩ	5%	0402	any
R_{SET}	75kΩ	5%	0402	any
R_{SET}	82kΩ	5%	0402	any
R_{SET}	91kΩ	5%	0402	any
R_{SET}	100kΩ	5%	0402	any
R_{SET}	110kΩ	5%	0402	any
R_{SET}	120kΩ	5%	0402	any
R_{SET}	130kΩ	5%	0402	any
R_{SET}	140kΩ	5%	0402	any
R_{SET}	150kΩ	5%	0402	any
R_{SENSE}	0.22Ω	5%	0603	Panasonic or Vishay
R_{SENSE}	0.27Ω	5%	0603	Panasonic or Vishay
R_{SENSE}	0.33Ω	5%	0603	Panasonic or Vishay
R_{SENSE}	0.39Ω	5%	0603	Panasonic or Vishay
R_{SENSE}	0.47Ω	5%	0603	Panasonic or Vishay

EVALUATION BOARD LAYOUT



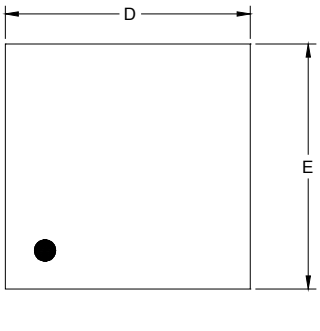
Printed Circuit Board Layout Recommendations

Follow the PCB layout guidelines for optimal performance:

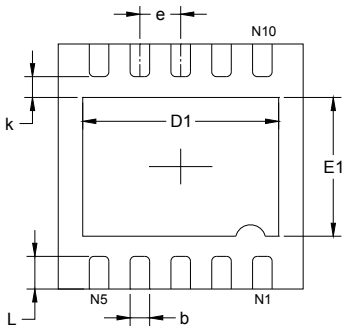
1. Place the flying capacitor CF as close to the chip as possible; otherwise 2× mode performance will be compromised. Also keep analog components away from this capacitor.
2. Place input and output decoupling capacitors as close to the chip as possible to reduce switching noise and output ripple.
3. 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

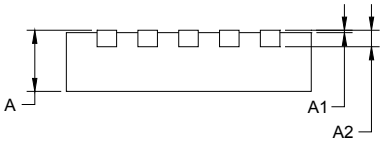
TDFN-3×3-10L



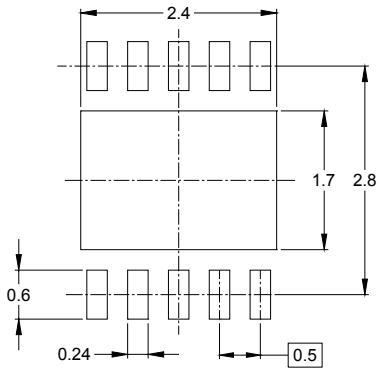
TOP VIEW



BOTTOM VIEW



SIDE VIEW

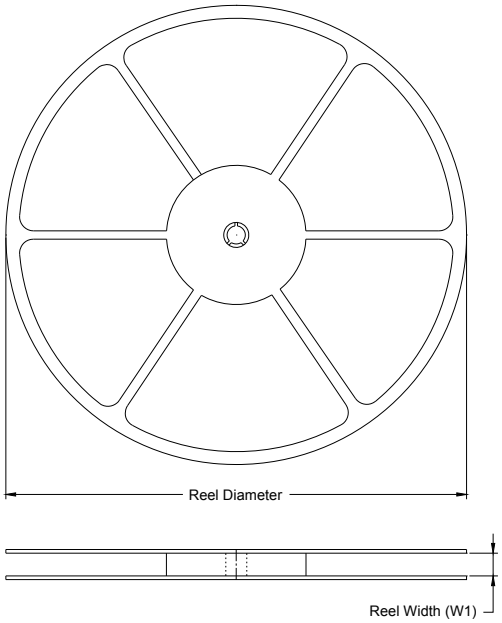


RECOMMENDED LAND PATTERN (Unit: mm)

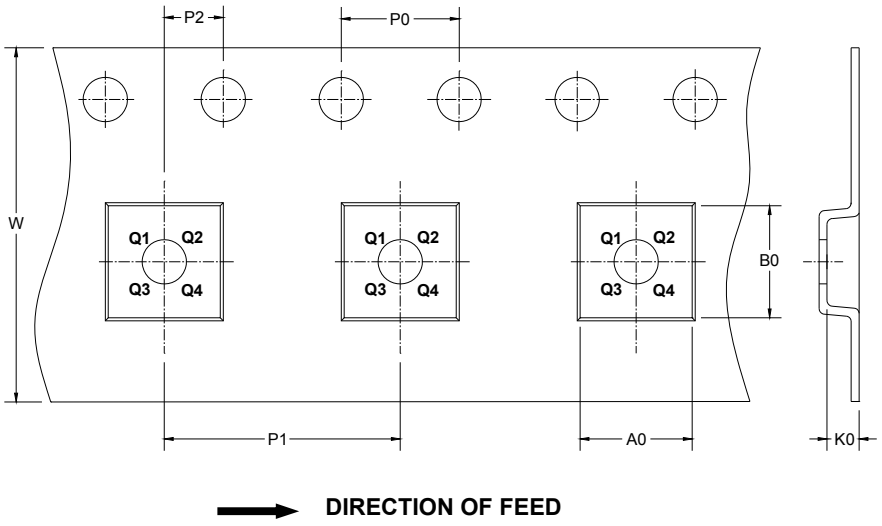
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	2.900	3.100	0.114	0.122
D1	2.300	2.600	0.091	0.098
E	2.900	3.100	0.114	0.122
E1	1.500	1.800	0.063	0.071
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	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

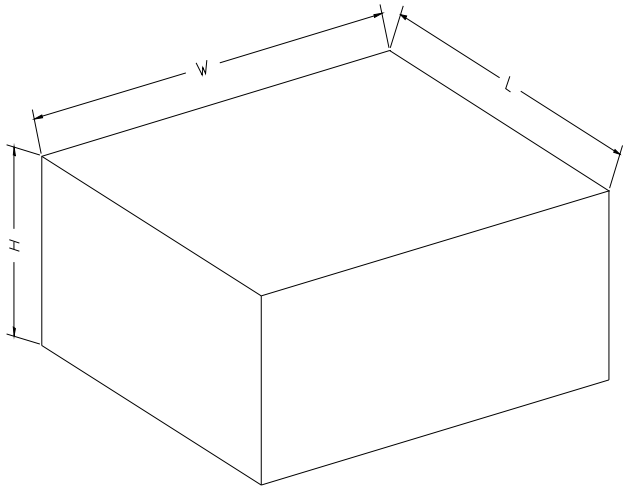


NOTE: The picture is only for reference. Please make the object as the standard.

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