

GENERAL DESCRIPTION

The SGM6607 is a high voltage switching regulator. It integrates a 40V low-side MOSFET to offer an output voltage up to 38V. It also accepts a wide input voltage range of 3V to 20V from multi-cell batteries or regulated 5V/12V power rails. A 1.2MHz switching frequency makes the use of low-profile inductors and low-value ceramic input and output capacitors available.

The device supports Boost, SEPIC and some other standard switching-regulator topologies. The device regulates the output with PWM (pulse width modulation) control. This device also includes the built-in functions of output over-voltage protection, over-current limit, soft-start and thermal shutdown.

The SGM6607 is available in Green TDFN-2×2-6L and TSOT-23-6 packages and is rated over the -40°C to +85°C temperature range.

FEATURES

- Input Voltage Range: 3V to 20V
- Up to 38V High Output Voltage
- Integrated Switch of 1.1A
- Fixed Switching Frequency of 1.2MHz
- 41V Over-Voltage Protection
- At 5V Input (TYP):
12V at 300mA
24V at 150mA
- Up to 93% Efficiency
- 500kΩ Pull-Down Resistor on EN Pin
- Light Load Skip-Switching
- Soft-Start and Thermal Shutdown Built-in Functions
- -40°C to +85°C Operating Temperature Range
- Available in Green TDFN-2×2-6L and TSOT-23-6 Packages

APPLICATIONS

Mobile Phones
Portable Equipment

TYPICAL APPLICATION

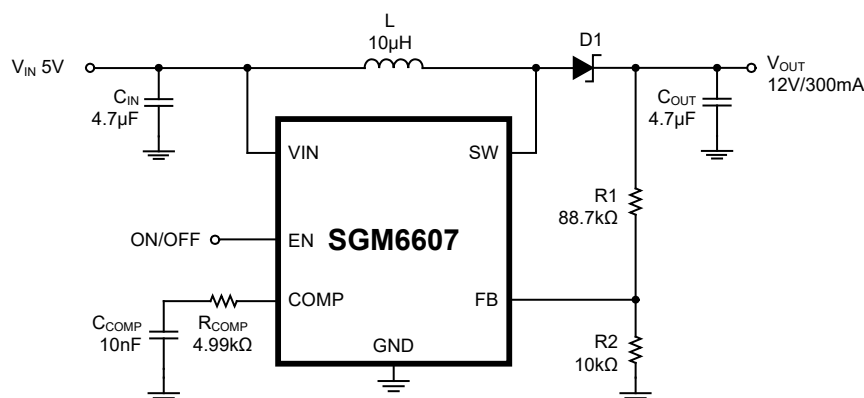


Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM6607	TDFN-2×2-6L	-40°C to +85°C	SGM6607YTDI6G/TR	6607 XXXX	Tape and Reel, 3000
	TSOT-23-6	-40°C to +85°C	SGM6607YTN6G/TR	SKDXX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XX = Date Code. XXXX = Date Code.

SKD X X

└── Date code - Month ("A" = Jan. "B" = Feb. ... "L" = Dec.)

└── Date code - Year ("A" = 2010, "B" = 2011 ...)

└── Chip I.D.

For example: SKDCD (2012, April)

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

Supply Voltage on VIN.....	-0.3V to 22V
Voltage on EN.....	-0.3V to 5V
Voltages on FB and COMP.....	-0.3V to 3V
Voltage on SW.....	-0.3V to 40V
Junction Temperature.....	+150°C
Package Thermal Resistance	
TDFN-2×2-6L, θ_{JA}	120°C/W
TSOT-23-6, θ_{JA}	190°C/W
Storage Temperature Range.....	-65°C to +150°C
Lead Temperature (Soldering, 10s).....	+260°C
ESD Susceptibility	
HBM.....	4000V
MM.....	300V

RECOMMENDED OPERATING CONDITIONS

Operating Temperature Range.....	-40°C to +85°C
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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.

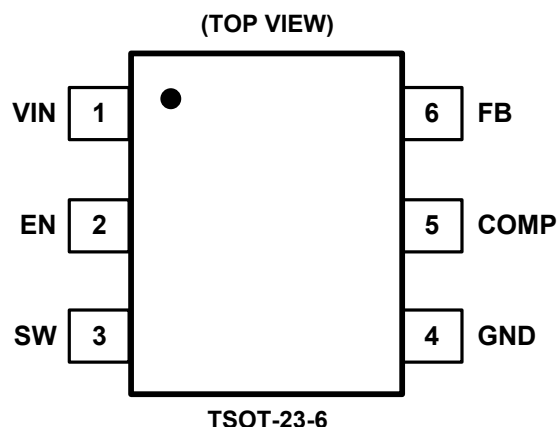
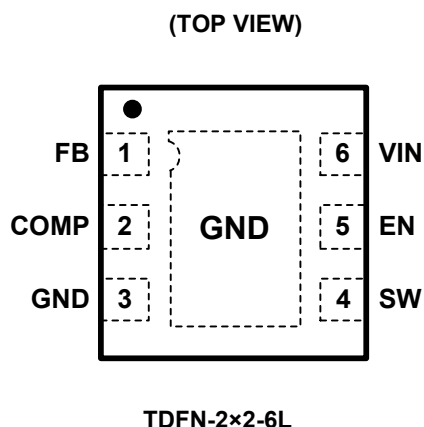
ESD SENSITIVITY CAUTION

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 CONFIGURATIONS



PIN DESCRIPTION

PIN		NAME	I/O	FUNCTION
TDFN-2x2-6L	TSOT-23-6			
6	1	VIN	I	Power Supply Input.
5	2	EN	I	Device Enable Node. Pulling this pin logic high enables the device and pulling it logic low disables the device.
4	3	SW	I	Switch Node. Drain connection of low-side power MOSFET.
3	4	GND	O	Ground Pin of the IC.
2	5	COMP	O	Control Loop Compensation Pin.
1	6	FB	I	Feedback Pin to Program the Output Voltage.
Thermal Pad	—	GND	—	The thermal pad should be soldered to the GND plane. Install thermal via to connect to internal ground plane for better thermal dissipation.

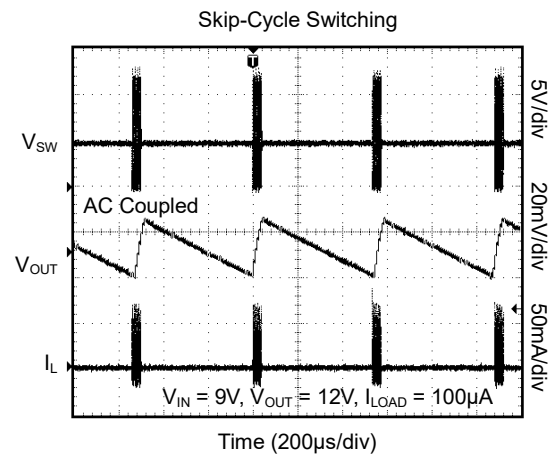
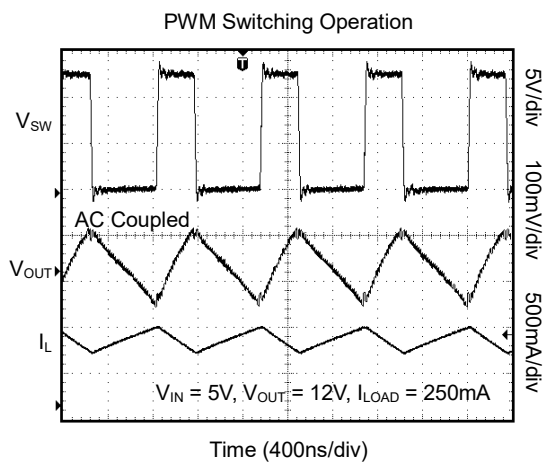
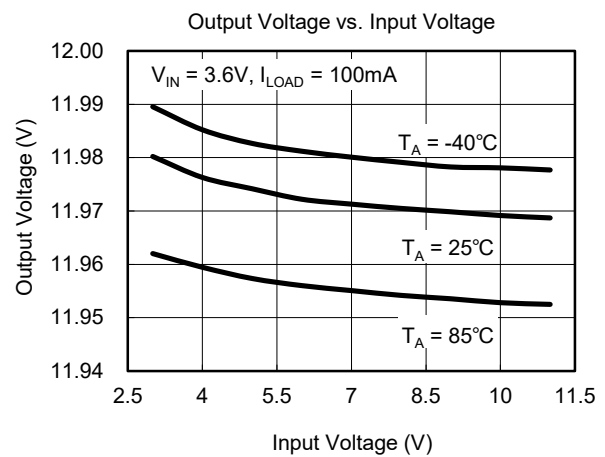
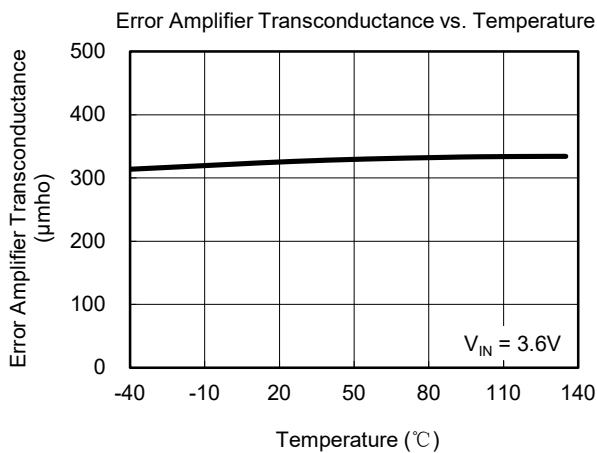
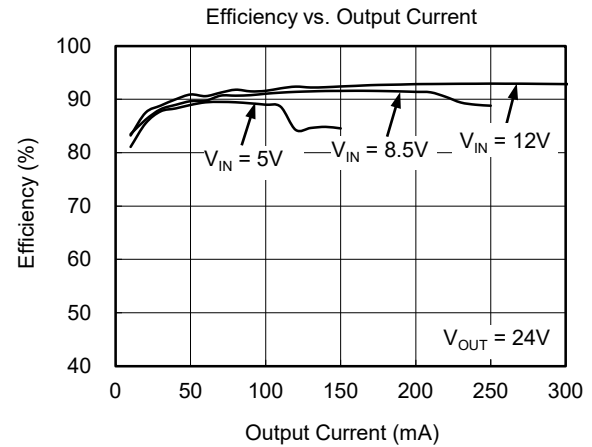
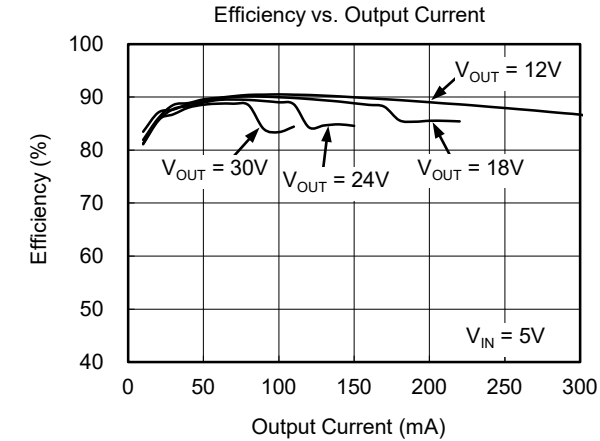
ELECTRICAL CHARACTERISTICS

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

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
SUPPLY CURRENT							
Input Voltage Range	V _{IN}		+25°C	3		20	V
Operating Quiescent Current into VIN	I _Q	Device PWM switching no load	+25°C		400	600	μA
Shutdown Current	I _{SHDN}	V _{EN} = GND, V _{IN} = 4.2V	+25°C			1	μA
Under-Voltage Lockout Threshold	UVLO	V _{IN} falling	+25°C		2.2	2.5	V
Under-Voltage Lockout Hysteresis	V _{HYS}		+25°C		70		mV
ENABLE AND REFERENCE CONTROL							
EN Logic High Voltage	V _{IH}	V _{IN} = 3V to 20V	Full	1.5			V
EN Logic Low Voltage	V _{IL}	V _{IN} = 3V to 20V	Full			0.4	V
EN Pull-Down Resistor	R _{EN}		+25°C	300	500	700	kΩ
VOLTAGE AND CURRENT CONTROL							
Voltage Feedback Regulation Voltage	V _{REF}		Full	1.186	1.211	1.236	V
Voltage Feedback Input Bias Current	I _{FB}	V _{FB} = 1.3V	Full			200	nA
Oscillator Frequency	f _{OSC}		Full	0.96	1.2	1.44	MHz
Maximum Duty Cycle	D	V _{FB} = 1.1V	+25°C	90	94		%
Minimum ON Pulse Width	t _{MIN_ON}		+25°C		80		ns
COMP Pin Sink Current	I _{SINK}		+25°C		55		μA
COMP Pin Source Current	I _{SOURCE}		+25°C		55		μA
Error Amplifier Transconductance	G _{EA}		Full	220	300	440	μmho
POWER SWITCH							
N-Channel MOSFET On-Resistance	R _{DS(ON)}	V _{IN} = 3.6V	+25°C		0.36	0.55	Ω
		V _{IN} = 3.0V	+25°C			0.6	
N-Channel Leakage Current	I _{LN_NFET}	V _{SW} = 35V, V _{EN} = 0V	+25°C			1	μA
OC AND SS							
N-Channel MOSFET Current Limit	I _{LIM}		+25°C	0.8	1.1	1.3	A
V _{REF} Ramp Up Time	t _r		+25°C		2		ms
THERMAL SHUTDOWN							
Thermal Shutdown Threshold	T _{SHDN}				150		°C
Thermal Shutdown Threshold Hysteresis	T _{HYS}				15		°C

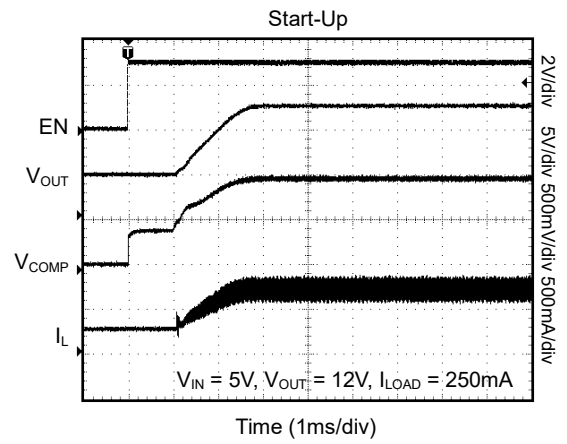
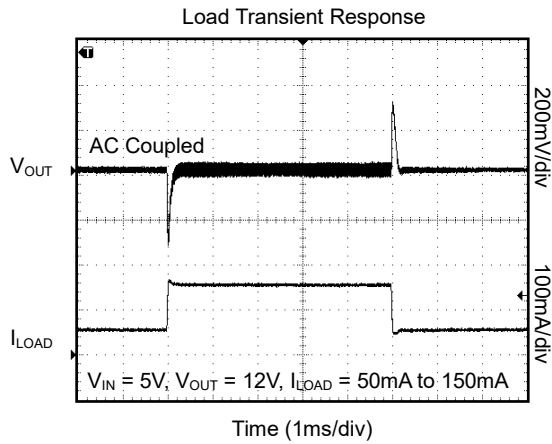
TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = +25^\circ\text{C}$, $L = 10\mu\text{H}$, $D1 = \text{ONsemi MBR0540T1}$, unless otherwise noted.



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$T_A = +25^\circ\text{C}$, $L = 10\mu\text{H}$, $D1 = \text{ONsemi MBR0540T1}$, unless otherwise noted.



TYPICAL APPLICATION CIRCUITS

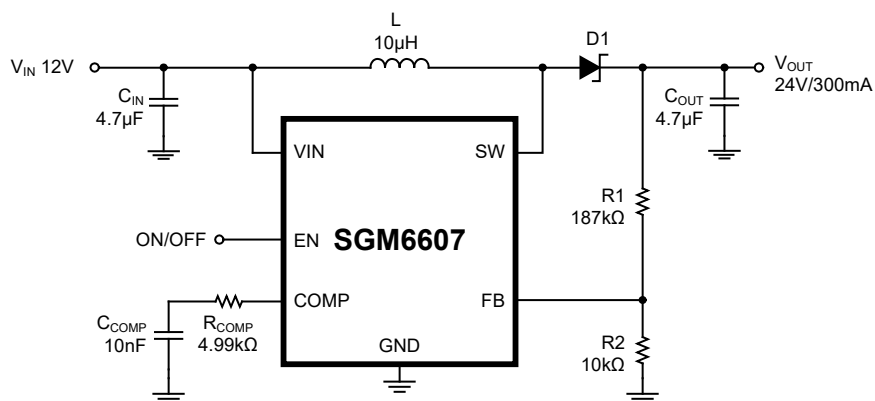


Figure 2. 12V to 24V DC/DC Power Conversion

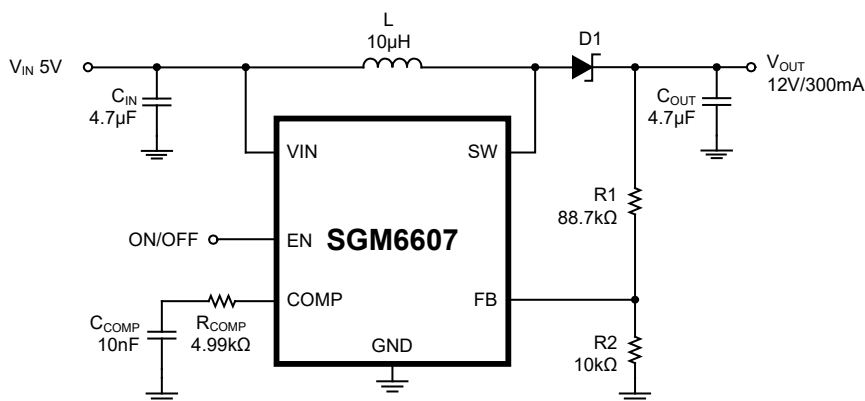


Figure 3. 5V to 12V DC/DC Power Conversion

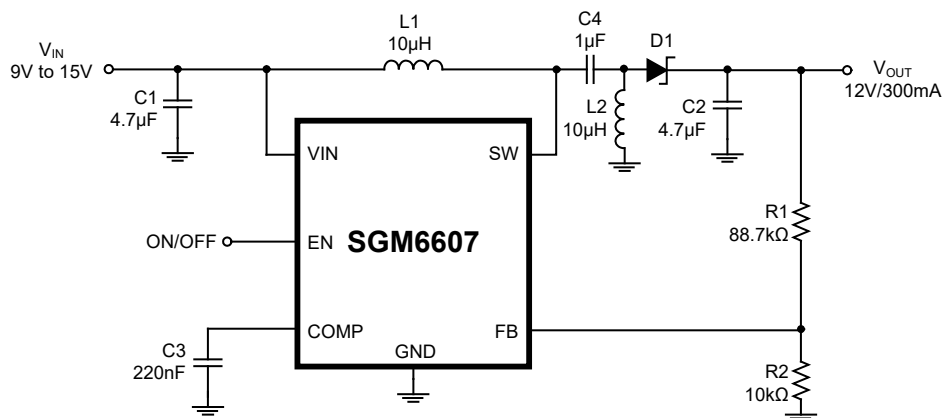


Figure 4. 12V SEPIC (Buck-Boost) Converter

FUNCTIONAL BLOCK DIAGRAM

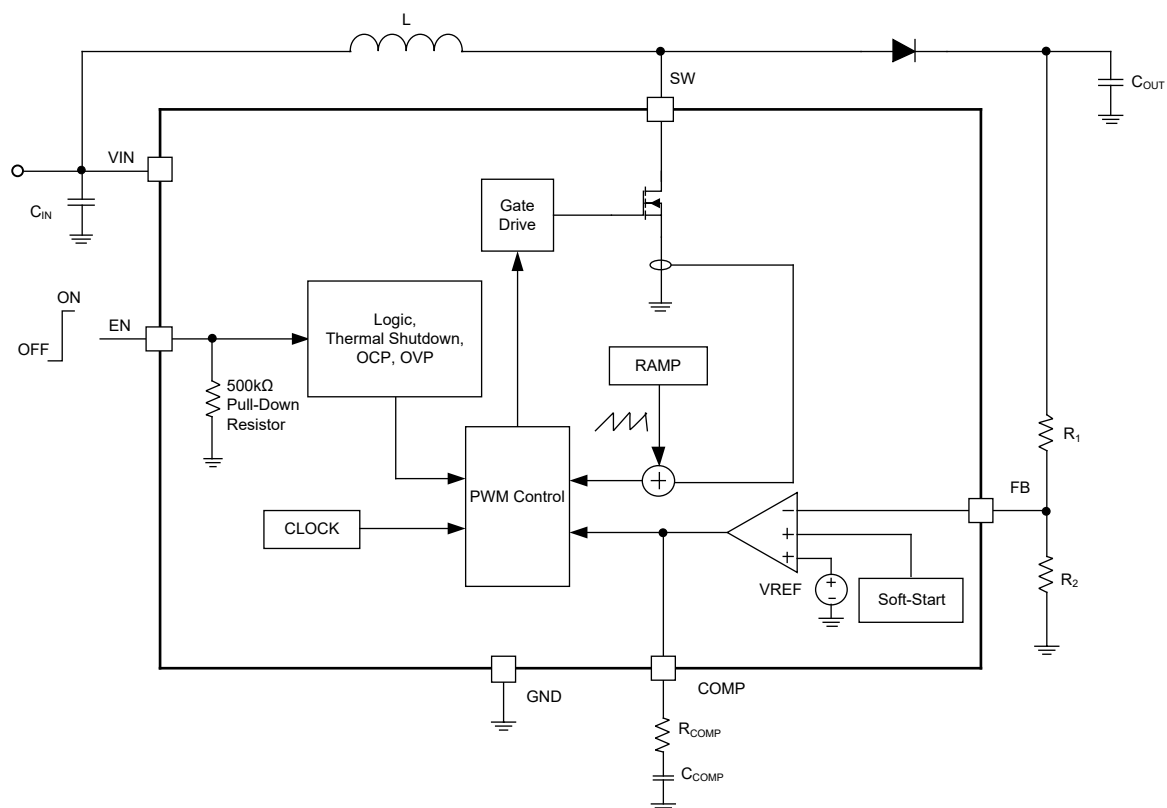


Figure 5. Block Diagram

DETAILED DESCRIPTION

Operation

The SGM6607 is a non-synchronous Boost converter with integrated low-side power FET, capable of delivering up to 38V DC output. The SGM6607 adopts the peak current mode control architecture with fixed 1.2MHz switching frequency. A slope ramp is added to the sensed peak current ramp to avoid sub-harmonic oscillation at operation duty cycle higher than 40%. The error amplifier compares the FB pin voltage with an internal reference signal to provide an error signal for the PWM comparator to adjust the duty cycle which ultimately regulates the output voltage to the desired voltage. At the beginning of each clock cycle, the PWM comparator turns on the low-side (LS) FET to ramp up the inductor current. As the inductor current reaches the level set by the error amplifier's output, the LS FET turns off, which causes the external Schottky diode to be forward biased to ramp down the inductor current which delivers the energy to the load as well as replenishes the output capacitor.

Soft-Start

The SGM6607 implements the internal soft-start feature to reduce the inrush current drawn during start-up. When the voltage applied on VIN pin is higher than 3V and a logic high is applied on the EN pin, the SGM6607 starts operation and ramps up the reference voltage to 1.211V in 2ms. The 2ms soft-start time ensures the output voltage to ramp slowly, which effectively reduces the inrush current during start-up.

Over-Current Protection

The peak current mode control of SGM6607 provides inherent over-current protection. The LS FET is turned off when the peak current reaches the current limit threshold of 1.1A (TYP), and the LS FET is not turned on again until the next clock cycle.

Under-Voltage Lockout (UVLO)

The SGM6607 implements input under-voltage lockout feature. When the input voltage falls below the falling

threshold of 2.2V (TYP), the SGM6607 stops switching and turns off the internal FET.

Over-Voltage Protection (OVP)

Over-voltage protection circuitry prevents IC damage due to output resistor divider disconnection. The SGM6607 monitors the voltage at the SW pin during each switching cycle. The circuitry turns off the switch FET and shuts down the IC when the following condition persists for 8 switching clock cycles: the SW voltage exceeds the V_{OVP} threshold. As a result, the output voltage falls to the level of the input supply. The device remains in shutdown mode until it is enabled by toggling the EN pin logic or its power input falls below UVLO. The V_{OVP} threshold of SGM6607 is set at 41V.

It might cause false over-voltage protection if the load voltage stays high when the device is enabled while the V_{IN} is close to UVLO, in which the internal reference for the OVP comparator ramps more slowly and stays too low after an OVP blanking time of around 100 μ s. If the false protection happens, the SGM6607 stops. Enable this device when $V_{IN} > 3V$ or after the load voltage discharges to avoid false protection.

Thermal Shutdown

A thermal shutdown function is implemented to prevent damage caused by excessive heat and power dissipation. Once a junction temperature of +150°C (TYP) is exceeded, the device is shut down. The device is released from shutdown automatically when the junction temperature decreases by 15°C.

Enable and Shutdown

The SGM6607 implements the EN function to turn on/off the device. A logic signal higher than 1.5V turns on the device, and logic signal lower than 0.4V turns off the device. The EN pin integrates an internal 500k Ω (TYP) pull-down resistor to prevent the device from false turn-on when the EN pin is left floating.

APPLICATION INFORMATION

Program Output Voltage

The output voltage of SGM6607 is configured via a resistive divider connected to the FB pin. Use Equation 1 to program the output voltage. R1 is the top feedback resistor and R2 is the bottom feedback resistor.

$$V_{OUT} = 1.211V \times \left(\frac{R1}{R2} + 1 \right)$$

$$R1 = R2 \times \left(\frac{V_{OUT}}{1.211V} - 1 \right) \quad (1)$$

Due to the leakage current of the resistor divider, the resistance of R2 should be no less than 10kΩ.

Switch Duty Cycle

The Boost converter's duty cycle determines the Boost ratio available for the device. The SGM6607 implements maximum switch duty cycle (D) of 94% (TYP), the duty cycle and input/output voltage relationship is shown in Equation 2. Care should be taken to ensure that the maximum duty cycle limit is not reached.

$$D = \frac{V_{OUT} - V_{IN}}{V_{OUT}} \quad (2)$$

The SGM6607 also implements minimum on-time of 80ns (TYP), which is related to minimum duty cycle. In light load condition, the SGM6607 enters pulse-skipping mode, and the device operates with minimum duty cycle in this mode.

Inductor Selection

Inductor is an essential element for current DC/DC switch mode power supplies regardless of topology. Inductor serves as the energy storage element for power conversion. Inductance and saturation current of inductor are two most important criterions for inductor selection. For general design guidance, the selected inductance should provide a peak to peak ripple current that is around 30% of the average inductor current at full load and nominal input voltage. The average inductor current for a Boost converter is the input current. Equation 3 shows the calculation of inductance selection, where f_{SW} is the switching frequency and ΔI_L is the inductor ripple current.

$$L = \frac{V_{CC}}{\Delta I_L \times f_{SW}} \times \left(1 - \frac{V_{IN}}{V_O} \right) \quad (3)$$

The selected inductor should have a saturation current rating higher than the 1.1A (TYP) current limit of SGM6607.

The inductor also affects the close loop response of the DC/DC converter. The recommended inductor ranges from 6.8μH to 22μH. Since the SGM6607 implements built-in slope compensation to prevent sub-harmonic oscillation, inductance lower than 6.8μH might results in insufficient slope compensation, which ultimately results in unstable operation.

Compensation Capacitor Selection

The control loop's compensation is done externally on SGM6607, which provides design flexibility for various input and output voltage combinations. A series RC connected on the COMP pin forms a pole and zero, in addition to the inherent pole of current mode control, set the close loop frequency response of SGM6607.

Equations 4 to 8 indicate the calculation of corresponding poles and zeros of Boost frequency response. Equation 4 presents the dominant pole formed with C_{COMP} . Equation 5 presents the output load pole, where R_{OUT} is the equivalent load resistance. Equation 6 presents the right half plane zero, the designed loop response cross over frequency should be less than 1/5th of the right half plane zero frequency to ensure enough phase margin at cross over frequency. Equation 7 presents the phase Boost zero. Lastly, Equation 8 presents the DC gain of the system, where G_{EA} can be found in the Electrical Characteristics table, R_{SENSE} is 200mΩ.

$$f_{P1} = \frac{1}{2\pi \times 140M\Omega \times C_{COMP}} \quad (4)$$

$$f_{P2} = \frac{2}{2\pi \times R_{OUT} \times C_{OUT}} \quad (5)$$

$$f_{RHPZ} = \frac{R_{OUT}}{2\pi \times L} \times \left(\frac{V_{IN}}{V_{OUT}} \right)^2 \quad (6)$$

$$f_z = \frac{1}{2\pi \times R_{COMP} \times C_{COMP}} \quad (7)$$

$$A = \frac{1.211V}{V_{OUT}} \times G_{EA} \times 140M\Omega \times \frac{V_{IN}}{V_{OUT} \times R_{SENSE}} \times R_{OUT} \times \frac{1}{2} \quad (8)$$

The recommended value for R_{COMP} and C_{COMP} is 4.99kΩ and 10nF to ensure stable operation and acceptable load transient response, C_{COMP} can be tuned in the range of 1nF to 22nF.

APPLICATION INFORMATION (continued)**Schottky Diode Selection**

The external rectification diode selection is critical to ensure device performance. A high speed and low forward voltage drop diode is recommended to improve efficiency. The average current rating of the diode should be higher than the peak load. The breakdown voltage of the selected diode should be higher than the programmed output voltage with margin, for example, a 12V output application requires a minimal of 20V breakdown voltage.

Input and Output Capacitor Selection

The output capacitors of Boost converter dictate the output voltage ripple and load transient response. Equation 9 is used to estimate the necessary capacitance to achieve desired output voltage ripple, where ΔV is the maximum allowed ripple.

$$C_{\text{MIN}} = \frac{I_O \times (V_{\text{OUT}} - V_{\text{CC}})}{f \times \Delta V \times V_{\text{OUT}}} \quad (9)$$

The recommended output capacitor ranges from 1 μ F to 10 μ F. Due to the DC bias nature of ceramic capacitors, care should be taken by verifying manufacture's datasheet to ensure enough effective capacitance at desired output voltage.

Boost converter's input capacitor has continuous current throughout the entire switching cycle, a 4.7 μ F ceramic capacitor is recommended to place as close as possible between the VIN pin and GND pin of the device. For applications where the SGM6607 is located far away from the input source, a 47 μ F or higher capacitance capacitor is recommended to damp the wiring harness inductance.

REVISION HISTORY

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

MAY 2022 – REV.A.1 to REV.A.2

Updated Detailed Description and Application Information sections 9, 10, 11

FEBRUARY 2018 – REV.A to REV.A.1

Updated Package Thermal Resistance of TDFN-2x2-6L 2

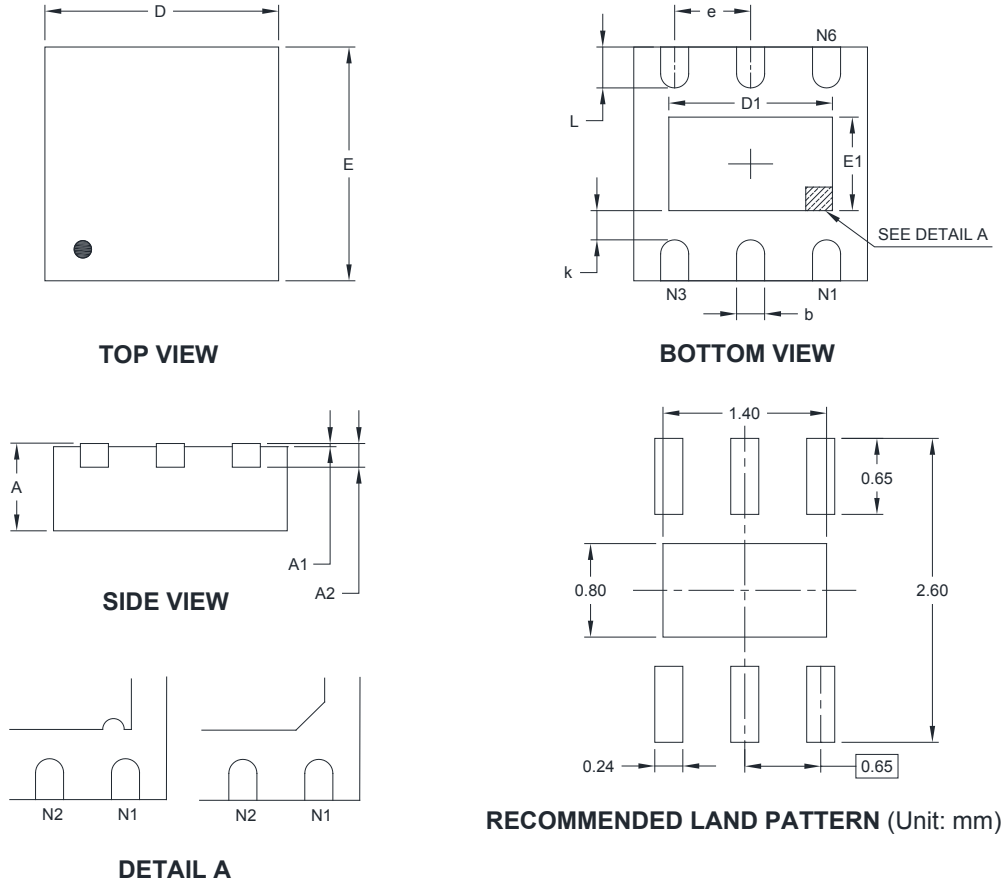
Updated Over-Voltage Protection (OVP) section 9

Changes from Original (FEBRUARY 2014) to REV.A

Changed from product preview to production data All

PACKAGE OUTLINE DIMENSIONS

TDFN-2x2-6L



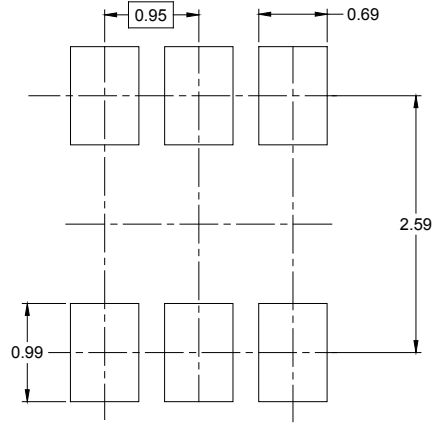
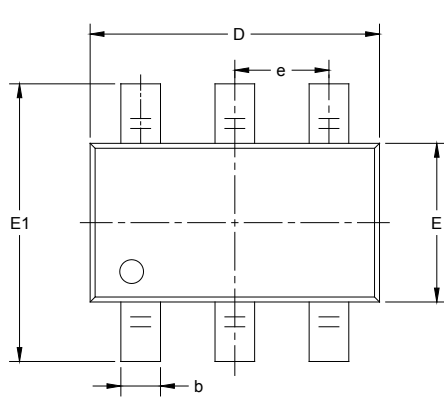
Pin #1 ID and Tie Bar Mark Options

NOTE: The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

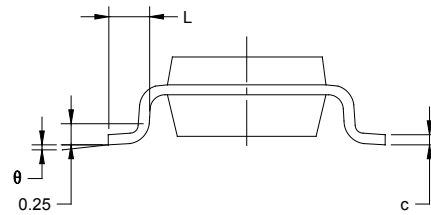
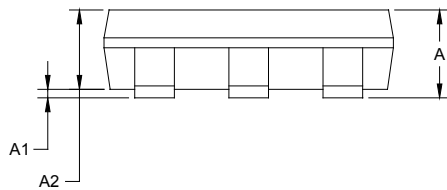
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	1.900	2.100	0.075	0.083
D1	1.100	1.450	0.043	0.057
E	1.900	2.100	0.075	0.083
E1	0.600	0.850	0.024	0.034
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.650 TYP		0.026 TYP	
L	0.250	0.450	0.010	0.018

PACKAGE OUTLINE DIMENSIONS

TSOT-23-6



RECOMMENDED LAND PATTERN (Unit: mm)

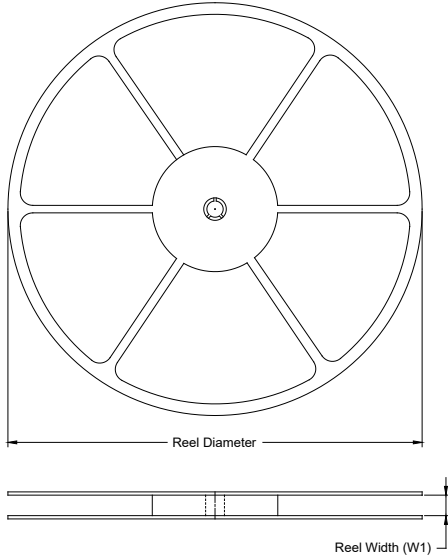


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.000		0.043
A1	0.000	0.100	0.000	0.004
A2	0.700	0.900	0.028	0.039
b	0.300	0.500	0.012	0.020
c	0.080	0.200	0.003	0.008
D	2.850	2.950	0.112	0.116
E	1.550	1.650	0.061	0.065
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

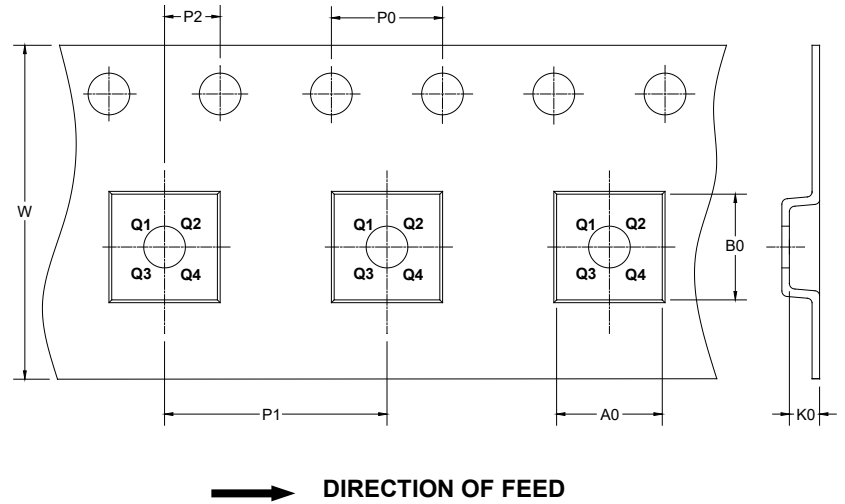
PACKAGE INFORMATION

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-2×2-6L	7"	9.5	2.30	2.30	1.10	4.0	4.0	2.0	8.0	Q1
TSOT-23-6	7"	9.5	3.20	3.10	1.10	4.0	4.0	2.0	8.0	Q3

DD0001

PACKAGE INFORMATION

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