

### GENERAL DESCRIPTION

The SGM6623 is a general-purpose miniature Boost DC/DC switching regulator with high efficiency for battery backup and standby power systems. The acceptable input voltage range of 0.8V to 12V can be converted to a regulated 3.3V to 13V output voltage with efficiency as high as 90%. SGM6623 can be used as backup charger for systems with 1- to 4-cell batteries. It operates at a 600kHz (TYP) switching frequency, allowing the use of small and low-profile inductor for compact design. It also has several built-in protection features, such as cycle-by-cycle over-current limit, soft-start, thermal shutdown and open loop over-voltage protection.

The SGM6623 is available in a Green SOT-23-6 package.

### FEATURES

- **0.8V to 12V Input Voltage Range**
- **3.3V to 13V Wide Output Voltage Range**
- **4.4A Current Limited Integrated Switch**
- **47µA (TYP) Quiescent Current (to VS Pin)**
- **0.4µA (TYP) Supply Current in Shutdown**
- **Up to 90% Efficiency**
- **600kHz (TYP) Fixed Switching Frequency with Pulse Skipping at Light Loads**
- **Enable Input Pin**
- **Built-in Soft-Start Function**
- **Open Loop Over-Voltage Protection**
- **Available in a Green SOT-23-6 Package**

### APPLICATIONS

- Mobile Phones
- Portable Equipment
- Hand-Held Instruments
- 1-, 2-, 3- or 4-Cell Battery Systems

### TYPICAL APPLICATION

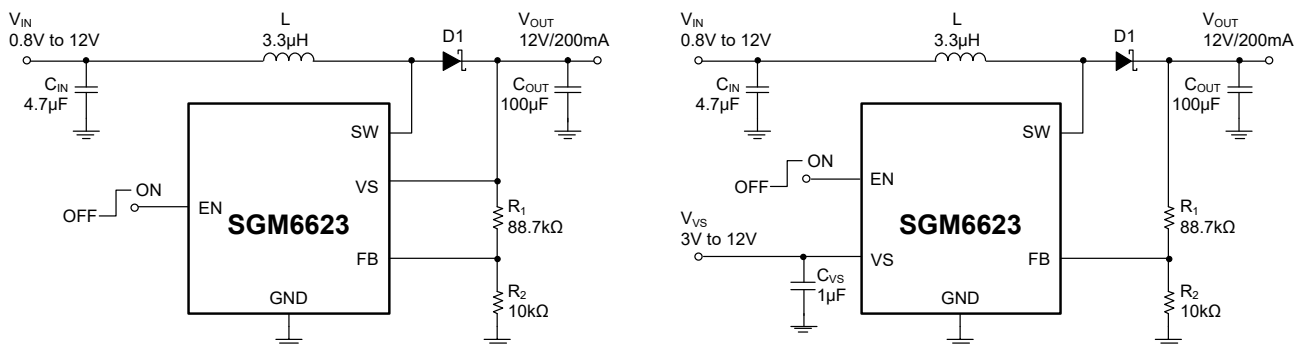


Figure 1. Typical Application Circuits

**PACKAGE/ORDERING INFORMATION**

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM6623	SOT-23-6	-40°C to +85°C	SGM6623YN6G/TR	CB4XX	Tape and Reel, 3000

**MARKING INFORMATION**

NOTE: XX = Date Code.

**YYY X X**

Date Code - Week  
 Date Code - Year  
 Serial Number

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**

Voltages on EN and FB ..... -0.3V to 6V  
 Voltages on SW and VS ..... -0.3V to 14.5V  
 Package Thermal Resistance  
 SOT-23-6,  $\theta_{JA}$  ..... 190°C/W  
 Junction Temperature ..... +150°C  
 Storage Temperature Range..... -65°C to +150°C  
 Lead Temperature (Soldering, 10s) ..... +260°C  
 ESD Susceptibility  
 HBM..... 3000V  
 CDM ..... 1000V

**RECOMMENDED OPERATING CONDITIONS**

Operating Ambient Temperature Range..... -40°C to +85°C  
 Operating Junction Temperature Range..... -40°C to +125°C

**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.

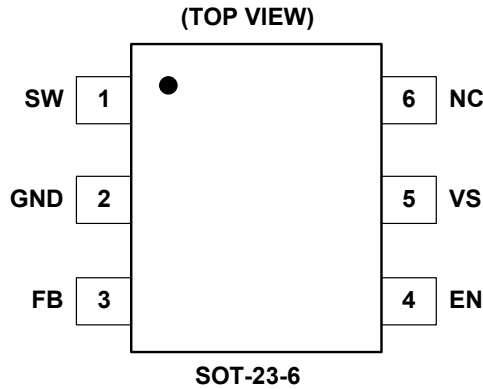
**ESD SENSITIVITY CAUTION**

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**



**PIN DESCRIPTION**

PIN	NAME	I/O	FUNCTION
1	SW	I	Switching Node of the Device. Connect to the input source through the Boost inductor.
2	GND	G	Ground.
3	FB	I	Feedback input to the error amplifier for regulated output.
4	EN	I	Enable Pin of the Boost Regulator. Logic low disables the chip and logic high enables it. It needs to be pulled up to enable the device, otherwise the weak internal pull-down will disable it. Two levels logic or analog bias with edge slope rate > 10V/ms is desired for stable on/off transition.
5	VS	I	Supply Power Input for Internal Circuit. Connect to the output of converter.
6	NC	—	Not connected. Recommend to solder it onto ground plane for better thermal dissipation.

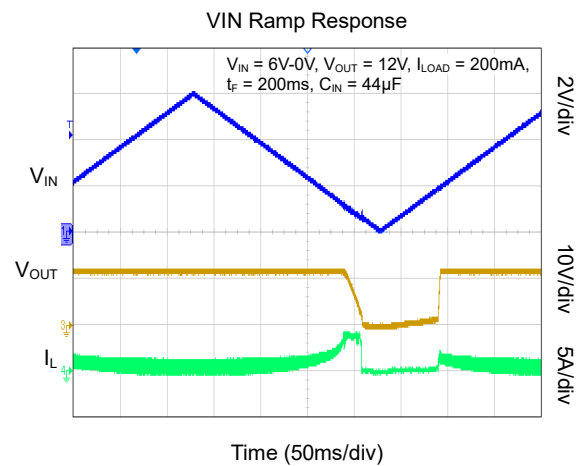
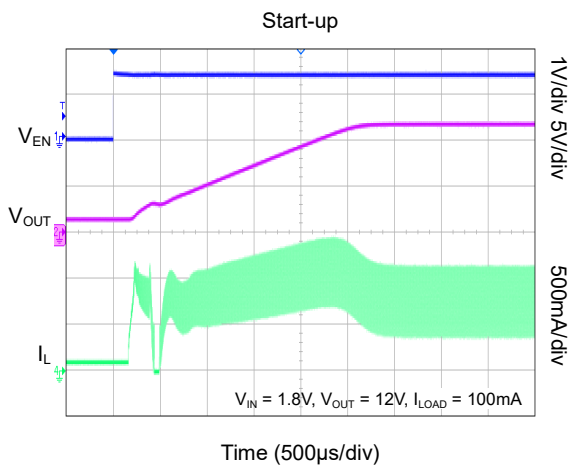
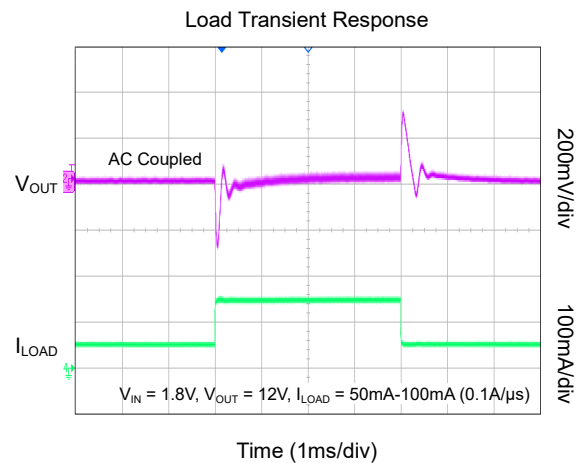
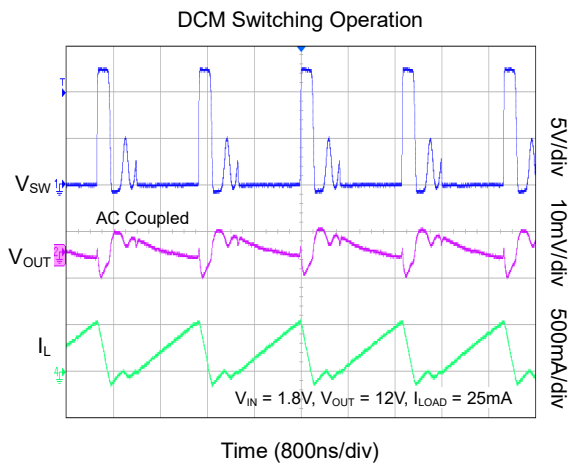
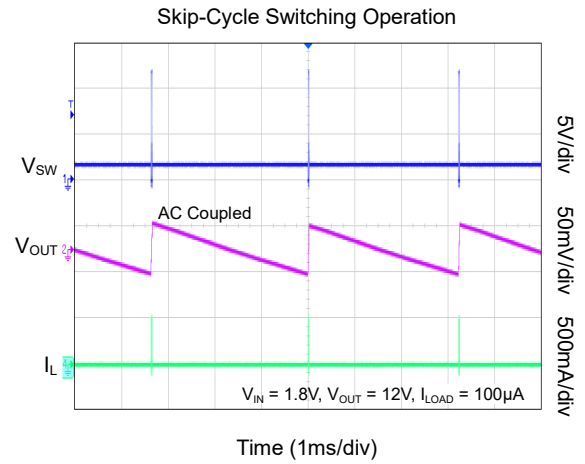
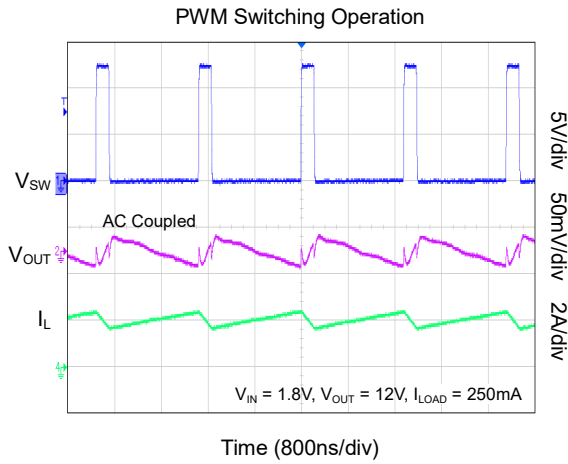
NOTE: I = Input, O = Output, G = Ground.

**ELECTRICAL CHARACTERISTICS**(V<sub>VS</sub> = 3.6V, V<sub>EN</sub> = 3.6V. Full = -40°C to +85°C, typical values are at T<sub>J</sub> = +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
<b>Supply Current</b>							
Sustainable Input Voltage Range	V <sub>IN</sub>	The VS pin connects to output	+25°C	0.8		12	V
Minimum VS Voltage for Start-up	V <sub>VS_START_MIN</sub>	The VS pin connects to output	+25°C		1.5		V
VS Input Voltage Range	V <sub>VS</sub>	V <sub>IN</sub> is in 0.8V to 12.5V range	+25°C	3		13	V
Operating Quiescent Current into VS	I <sub>Q</sub>	No switching, no load	Full		47	65	μA
Shutdown Current	I <sub>SHDN</sub>	V <sub>EN</sub> = GND	+25°C			1	μA
			Full			1.5	
<b>Enable and Reference Control</b>							
EN Logic High Voltage	V <sub>IH</sub>		Full	1.1			V
EN Logic Low Voltage	V <sub>IL</sub>		Full			0.3	V
EN Internal Pull-Down Resistor	R <sub>EN</sub>		Full	400	570	740	kΩ
<b>Voltage and Current Control</b>							
Voltage Feedback Regulation Voltage	V <sub>REF</sub>		Full	1.177	1.205	1.231	V
Voltage Feedback Input Bias Current	I <sub>FB</sub>	V <sub>FB</sub> = 1.3V	Full			170	nA
Switching Frequency	f <sub>SW</sub>		Full	480	600	720	kHz
Maximum Duty Cycle	D <sub>MAX</sub>		+25°C		96		%
Over-Voltage Protection Threshold	V <sub>OVP</sub>		+25°C	13.3	13.8	14.3	V
Over-Voltage Protection Threshold Hysteresis	V <sub>OVP_HYS</sub>		+25°C		0.43		V
<b>Power Switch</b>							
N-Channel MOSFET On-Resistance	R <sub>DSON</sub>	V <sub>VS</sub> = 3.6V	+25°C		70	90	mΩ
			Full			110	
N-Channel Leakage Current	I <sub>LN_NFET</sub>	V <sub>SW</sub> = 13.2V, V <sub>EN</sub> = 0V	+25°C			1	μA
			Full			1.5	
N-Channel MOSFET Current Limit	I <sub>LIM</sub>		+25°C	3.65	4.4	5.25	A
<b>Thermal Shutdown</b>							
Thermal Shutdown Threshold	T <sub>SHDN</sub>				165		°C
Thermal Shutdown Threshold Hysteresis	T <sub>HYS</sub>				15		°C

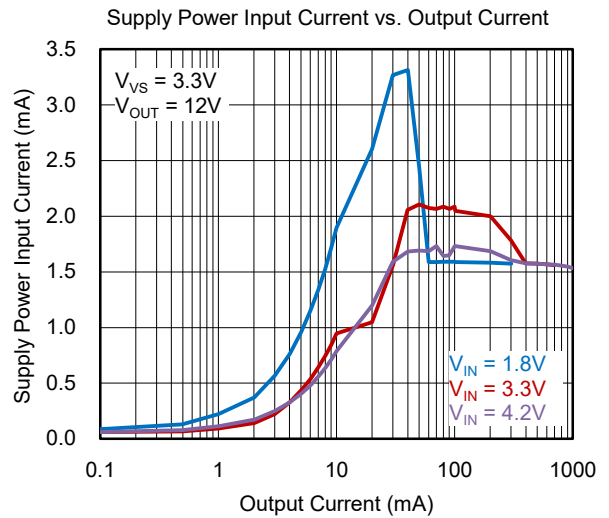
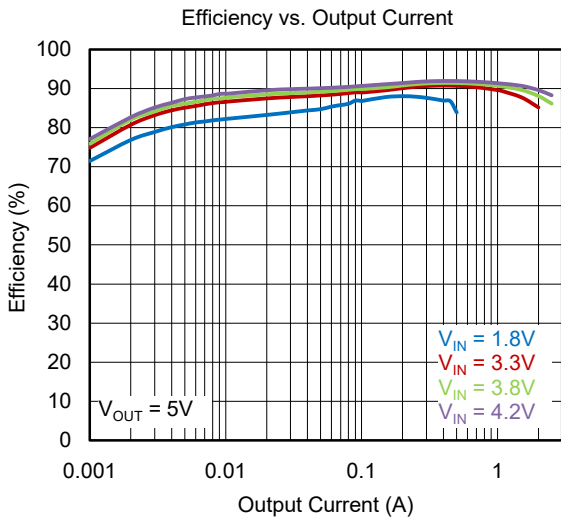
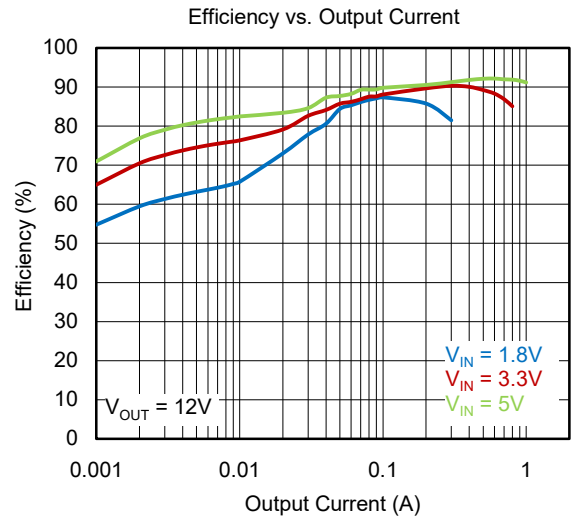
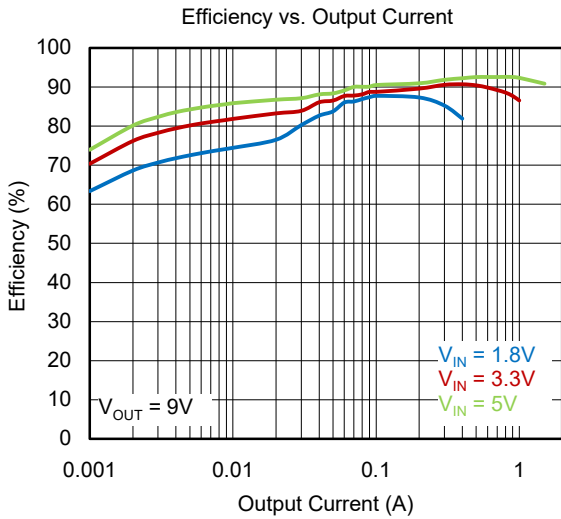
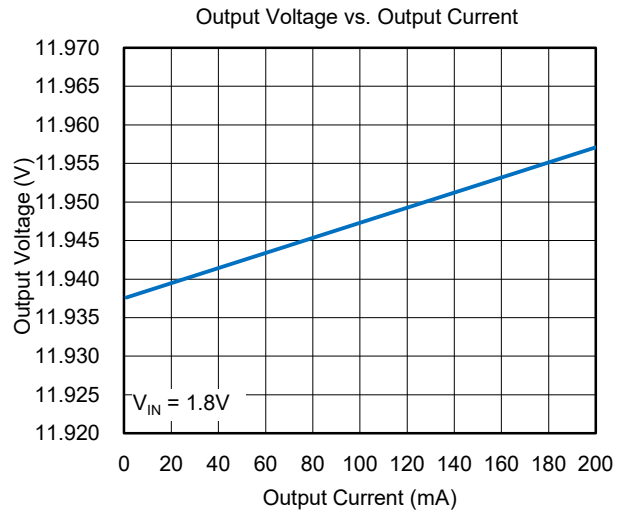
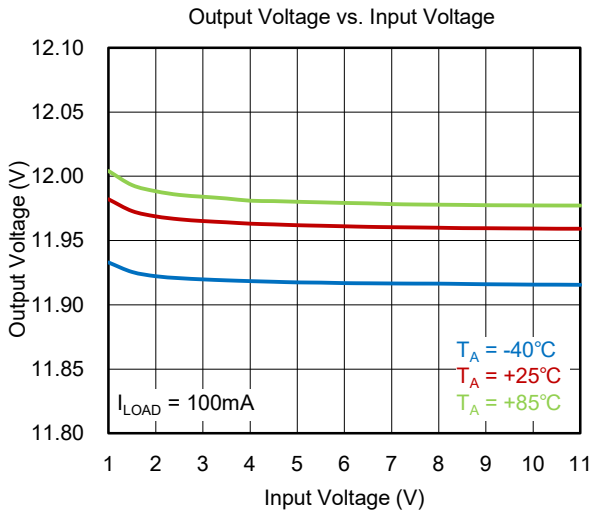
TYPICAL PERFORMANCE CHARACTERISTICS

$T_J = +25^\circ\text{C}$ ,  $C_{IN} = 4.7\mu\text{F}$ ,  $C_{OUT} = 100\mu\text{F}$ ,  $L = 3.3\mu\text{H}$  and  $V_{VS} = V_{OUT}$ , unless otherwise noted.



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$T_J = +25^\circ\text{C}$ ,  $C_{IN} = 4.7\mu\text{F}$ ,  $C_{OUT} = 100\mu\text{F}$ ,  $L = 3.3\mu\text{H}$  and  $V_{VS} = V_{OUT}$ , unless otherwise noted.



FUNCTIONAL BLOCK DIAGRAM

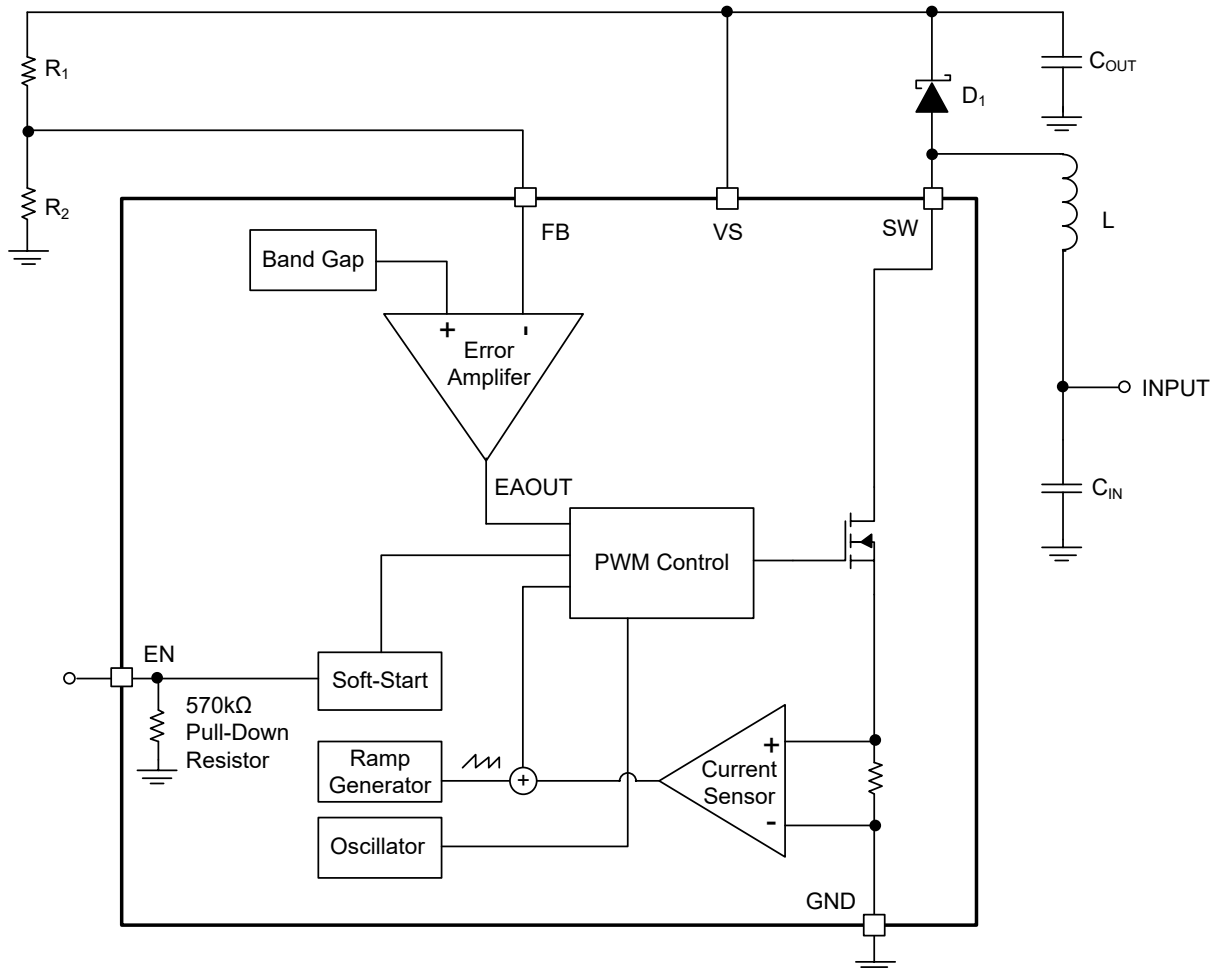


Figure 2. Block Diagram

DETAILED DESCRIPTION

Operation

The SGM6623 is a miniature Boost converter with integrated low-side MOSFET switch, which is capable of delivering up to 13V output voltages that are typically used in battery operated portable devices. Current mode PWM control is used to regulate the output voltage as shown in Figure 2. The device has a fixed switching frequency of 600kHz (TYP). 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 MOSFET to ramp up the inductor current. As the inductor current reaches the level set by the error amplifier's output, the low-side MOSFET turns off, which causes the external Schottky diode to be forward biased to ramp down the inductor current that delivers the energy to the load as well as replenishes the output capacitor.

## DETAILED DESCRIPTION (continued)

### Soft-Start

The SGM6623 implements the internal soft-start feature to reduce the inrush current drawn during start-up. When logic high is applied on the EN pin, the device starts operation and ramps up the reference voltage to 1.205V in 2.5ms. The 2.5ms soft-start time ensures the output voltage to ramp slowly, which effectively reduces the inrush current during start-up.

As shown in Figure 1, the VS pin is the power input for the device itself and is powered from the converter output or a voltage source in proper range. When the VS pin is powered from the converter output, before enabling the chip, the bias to VS comes from the input through the inductor and Schottky diode. The SGM6623 can start up from input voltage as low as 1.5V. During start-up, the controller switches the N-channel MOSFET continuously until the  $V_{OUT}$  reaches 2.7V. When 2.7V is reached, the normal Boost regulator feedback takes over the control. Once the device is in the regulated state, it can work when the input voltage drops to 0.8V.

When the VS is not self-biased with its own output but from an independent power source, enable the device after the VS is biased  $> 3V$  stably to avoid continuous switching without output voltage regulation, in which the output voltage may trigger the over-voltage protection and hiccups to output the maximum possible voltage decided by the OVP threshold.

### Over-Current Protection

The SGM6623 provides inherent over-current protection. The low-side MOSFET is turned off when the peak current reaches the current limit threshold of 4.4A (TYP), and the low-side MOSFET is not turned on again until the next clock cycle.

### Over-Voltage Protection (OVP)

Over-voltage protection circuitry prevents IC damage as the result of output resistor divider disconnection.

The SGM6623 monitors the voltage at the SW pin during each switching cycle. The circuitry turns off the switch FET when the SW voltage exceeds the OVP threshold. The switch FET remains in shutdown mode until SW pin voltage is lower than 13.37V for 100ms. The OVP threshold of SGM6623 is 13.8V.

### Pulse-Skipping Mode

The SGM6623 integrates a pulse-skipping mode at the light load. When a light load condition occurs, the EAOUT voltage naturally decreases and reduces the peak current. When the EAOUT voltage further goes down with the load lowered and reaches the pre-set low threshold, the output of the error amplifier is clamped at this threshold and does not go down any more. If the load is further lowered, the output voltage of SGM6623 exceeds the nominal voltage and the device skips the switching cycles. The pulse-skipping mode reduces the switching losses and improves efficiency at the light load condition by reducing the average switching frequency.

### Enable and Shutdown

The SGM6623 implements the EN function to turn on/off the device. A logic signal lower than 0.3V turns off the device. The EN pin integrates an internal 570k $\Omega$  (TYP) pull-down resistor to prevent the device from false turn-on when the EN pin is left floating. Apply two levels logic or analog bias with edge slope rate  $> 10V/ms$  to enable/shutdown the device stably. Quick toggles during the enabling may cause false over-voltage hiccup if the bias voltage ramps slowly.

### Thermal Shutdown

The internal thermal shutdown protection turns off the device when the junction temperature exceeds 165°C. The chip will resume operation when the junction temperature drops by at least 15°C (TYP).



## APPLICATION INFORMATION

### Supply to Internal Circuit

The internal circuit is biased from the VS pin. The bias voltage could be from 3V to 12V, but not higher than the output voltage + 1V, which could be connected to the VOUT or to any supply rail whose voltage is in the range as mentioned above. But when the supply rail is less than 3V, the voltage of EN must be less than 0.3V. When the VS pin is connected to the VOUT, a 50Ω resistor inserted between VS and VOUT is recommended to isolate the VS from potential voltage surge at the VOUT.

### Program Output Voltage

The output voltage of SGM6623 is configured via a resistive divider connected to the FB pin. Use Equation 1 to program the output voltage. R<sub>1</sub> is the top feedback resistor and R<sub>2</sub> is the bottom feedback resistor.

$$V_{OUT} = 1.205 \times \left( \frac{R_1}{R_2} + 1 \right) \quad \text{or} \quad R_1 = R_2 \times \left( \frac{V_{OUT}}{1.205} - 1 \right) \quad (1)$$

Due to the leakage current of the resistor divider, the resistance of R<sub>2</sub> should be no less than 10kΩ. Thermally stable resistors with 1% or better accuracy and of same type are recommended for R<sub>1</sub> and R<sub>2</sub>. Mount them close to each other for the same thermal variations.

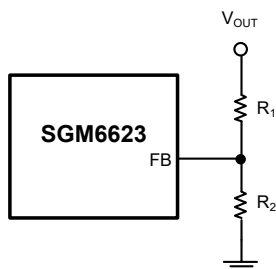


Figure 3. Output Voltage Programming

### Maximum Output Current

For the Boost converter, the maximum input current is generally limited by the over-current limit. And the maximum input power (for a given input voltage) is also limited by the over-current limit. Therefore, the maximum output power is limited to the maximum input power minus losses. So, the actual maximum output current depends on the input current limit, input voltage, output voltage and efficiency. The input current limit clamps the peak inductor current. The maximum input

DC current can be calculated by subtracting half of the inductor ripple current from the current limit value. The inductor ripple current is a function of the switching frequency, inductor value and duty cycle. In summary, the following two equations show the impact of all the above factors on the maximum output current.

$$\Delta I_L = \frac{1}{L \times f_{SW} \times \left( \frac{1}{V_{OUT} + V_F - V_{IN}} + \frac{1}{V_{IN}} \right)} \quad (2)$$

where:

$\Delta I_L$  = Inductor peak-to-peak ripple current.

L = Inductor value.

V<sub>F</sub> = Schottky diode forward voltage.

f<sub>SW</sub> = Switching frequency.

V<sub>OUT</sub> = Output voltage.

V<sub>IN</sub> = Input voltage.

$$I_{OUT\_MAX} = \frac{V_{IN} \times \left( I_{LIM} - \frac{\Delta I_L}{2} \right) \times \eta}{V_{OUT}} \quad (3)$$

where:

I<sub>OUT\_MAX</sub> = Maximum output current of the Boost converter.

I<sub>LIM</sub> = Over-current limit (typically 4.4A for SGM6623).

η = Efficiency.

### Switch Duty Cycle

The maximum duty cycle (D) of the internal power switch in the SGM6623 is 96% (TYP). The duty cycle and input/output voltage relationship under continuous conduction mode (CCM) is shown in Equation 4:

$$D = \frac{V_{OUT} - V_{IN}}{V_{OUT}} \quad (4)$$

For example, in a 5V to 12V application, the duty cycle is almost 58.3%. Care should be taken to ensure that the maximum duty cycle limit (96%, TYP) is not reached.

The SGM6623 also implements minimum on-time switching pulse width, which is related to the minimum duty cycle. In light load condition, the device enters pulse-skipping mode, and the device operates with minimum duty cycle in this mode.

## APPLICATION INFORMATION (continued)

### Inductor Selection

Inductor is the most critical component in the design of a Boost converter with SGM6623 because it affects steady state operation, transient behavior and loop stability (sub-harmonic oscillations). Four parameters of the inductor must be considered in the design: nominal inductance value, DC resistance (DCR), saturation current (or 20%~30% inductance-drop currents) and maximum RMS current (DC plus AC) for a certain temperature rise.

Inductance and saturation current of an inductor are the two most important criterions for the inductor selection. It is recommended to choose a peak-to-peak ripple current (given by Equation 2) that is in the 30%~40% range of the maximum DC current of the inductor in the application. Such ripple factor usually gives a good compromise between inductor core and converter conduction losses (due to the ac ripple) and the inductor size. Inductor DC current can be calculated based on input-output power balance as given in Equation 5:

$$I_{IN\_DC} = \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times \eta} \quad (5)$$

Typically, the inductor value can have a  $\pm 20\%$  initial tolerance. On top of that the inductance may drop another 20%~30% when the inductor current approaches to the maximum (saturation or 20%~30% drops) at maximum current. This drop is usually given by manufacturer. Note that the powder iron core inductors do not have a sharp saturation like ferrite inductors and show a gradual inductance drop even if the current peaks are much higher than their maximum rated currents, which is an important advantage. The manufacturer specifies the 20%~30% drop current level for them instead of saturation. However, they are usually slightly bigger than the similar ferrite inductor. Finally, the total RMS current of the inductor must be limited to keep the total inductor losses low and prevent excessive temperature rise in the inductor. The DCR of an inductor may increase around 50% if the temperature is increased from +25°C to +125°C. Such temperature rises need to be considered in the evaluation of the  $I^2R$  losses of the inductor.

Using an inductor with a smaller inductance in a Boost converter results in having discontinuous conduction mode (DCM) range extended to the higher load currents due to larger ripple. Small inductance can also result in reduced maximum output current, increased

input voltage ripple and reduced efficiency. Large inductors with low DCR values can offer better output current and higher conversion efficiency. However, smaller inductance usually provides better load transient response. For these reasons, an inductance with 30%~40% current ripple (of the peak load current) is recommended.

SGM6623 implements built-in slope compensation to prevent sub-harmonic oscillation. Too small inductance might result in insufficient slope compensation, which ultimately results in unstable operation. Therefore, the designer must verify the selected inductor for the application with the maximum and minimum margins of the input and output voltages if it is not chosen based on the recommended values.

### 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 maximum output voltage (13V) with margin. To achieve smaller size and less cost, Schottky diodes with lower rated voltages can be used. 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 6 is used to estimate the necessary capacitance to achieve desired output voltage ripple, where  $V_{RIPPLE}$  is the peak-to-peak output ripple.

$$C_{OUT} = \frac{(V_{OUT} - V_{IN}) \times I_{OUT}}{V_{OUT} \times f_{SW} \times V_{RIPPLE}} \quad (6)$$

The additional output ripple component caused by ESR can be given by Equation 7.

$$V_{RIPPLE\_ESR} = \Delta I_L \times ESR \quad (7)$$

For ceramic capacitors, the ESR is usually small and  $V_{RIPPLE\_ESR}$  can be neglected, but for tantalum or electrolytic capacitors, the capacitive and ESR components of the ripple must be added to estimate the total output voltage ripple.

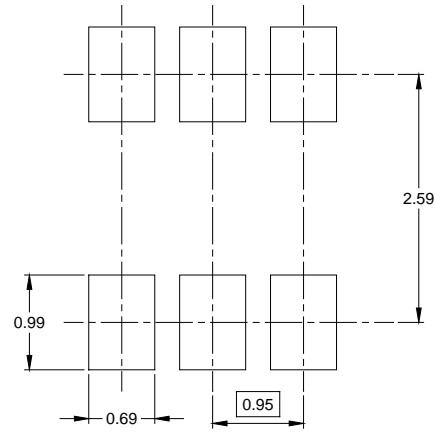
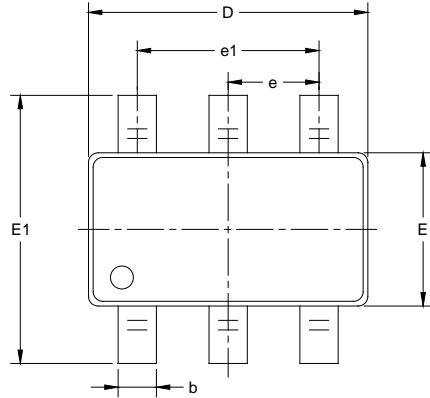
## REVISION HISTORY

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

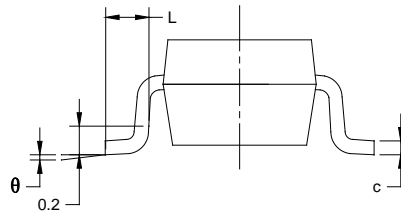
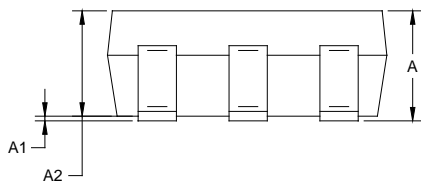
<b>OCTOBER 2022 – REV.A.3 to REV.A.4</b>	<b>Page</b>
Updated Detailed Description and Application Information sections.....	7, 8, 9, 10
<b>SEPTEMBER 2021 – REV.A.2 to REV.A.3</b>	<b>Page</b>
Updated Pin Description section.....	3
<b>JULY 2020 – REV.A.1 to REV.A.2</b>	<b>Page</b>
Updated switching frequency.....	1, 4, 7
<b>FEBRUARY 2020 – REV.A to REV.A.1</b>	<b>Page</b>
Updated Pin Description section.....	3
Updated Detailed Description section.....	8
<b>Changes from Original (SEPTEMBER 2019) to REV.A</b>	<b>Page</b>
Changed from product preview to production data.....	All

PACKAGE OUTLINE DIMENSIONS

SOT-23-6



RECOMMENDED LAND PATTERN (Unit: mm)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037 BSC	
e1	1.900 BSC		0.075 BSC	
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

NOTES:

1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

# 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
SOT-23-6	7"	9.5	3.23	3.17	1.37	4.0	4.0	2.0	8.0	Q3

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# 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

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