SGM6603
90% Efficient Synchronous Step-Up Converter with 1.1A Switch

GENERAL DESCRIPTION

The SGM6603 is a constant frequency, current mode, synchronous step-up switching regulator. Its output currents can go as high as 75mA while using a single-cell alkaline, and discharge it down to 0.9V. It can also be used for generating 5V at 400mA from a 3.3V rail or a Li-Ion battery.

High switching frequency minimizes the sizes of inductor and capacitor. Integrated power MOSFETs and internal compensation make the SGM6603 simple to use and fit the total solution into a compact space.

For light load current, the SGM6603 enters into the power-save mode to maintain high efficiency. Anti-ringing control circuitry reduces EMI concerns by damping the inductor in discontinuous mode. The SGM6603 provides true output disconnect and this allows V_{OUT} to go to zero volt during shutdown without drawing any current from the input source.

The output voltage of SGM6603-ADJ can be programmed by an external resistor divider, and those of SGM6603-3.3/SGM6603-5.0 are fixed internally on the chip. The device is available in SOT-23-6 package. It operates over an ambient temperature range of -40℃ to +85℃.

FEATURES

- **90% Efficient Synchronous Boost Converter**
- **Device Quiescent Current: 30µA (TYP)**
- **Less than 1µA Shutdown Current**
- **Input Voltage Range: 0.9V to 5.5V**
- **3.3V and 5.0V Fixed Output Voltages**
- **Adjustable Output Voltage Up to 5.5V**
- **Output Voltage Clamping: 6V**
- **Power-Save Mode for Improved Efficiency at Low Output Power**
- **Load Disconnect During Shutdown**
- **Over-Temperature Protection**
- **Available in Green SOT-23-6 Package**
- **-40℃ to +85℃ Operating Temperature Range**

APPLICATIONS

Single-Cell Li Battery Powered Products

Portable Audio Players

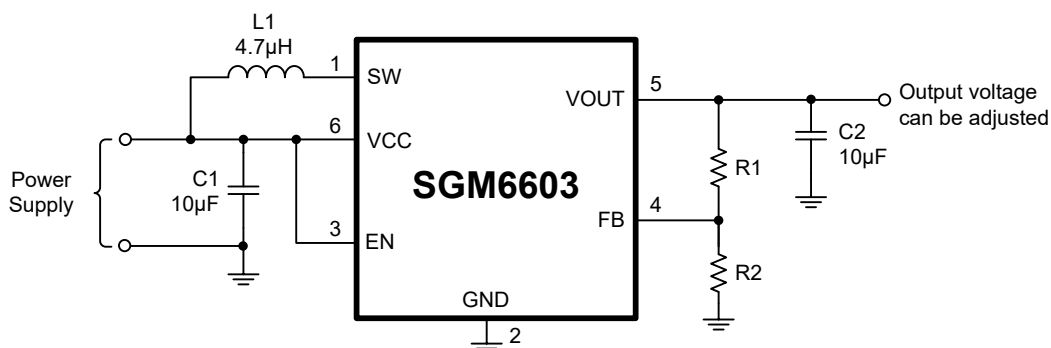Cellular Phones

Personal Medical Products

TYPICAL APPLICATION

Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

MODEL	V$_{OUT}$ (V)	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM6603	Adjustable	SOT-23-6	-40℃ to +85℃	SGM6603-ADJYN6G/TR	SC8XX	Tape and Reel, 3000
	3.3	SOT-23-6	-40℃ to +85℃	SGM6603-3.3YN6G/TR	SC9XX	Tape and Reel, 3000
	5.0	SOT-23-6	-40℃ to +85℃	SGM6603-5.0YN6G/TR	SCAXX	Tape and Reel, 3000

NOTE: XX = Date Code.

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.

MARKING INFORMATION

SYY X X

Date code - Month ("A" = Jan. "B" = Feb. ⋯ "L" = Dec.)
Date code - Year ("A" = 2010, "B" = 2011 ⋯)
Chip I.D.

For example: SC8CA (2012, January)

ABSOLUTE MAXIMUM RATINGS

Input Voltage Range on SW, VOUT, VCC, FB, EN
.... -0.3V to 6V

Package Thermal Resistance

SOT-23-6, θ$_{JA}$ .... 150℃/W
Junction Temperature...+150℃
Storage Temperature Range ....-65℃ to +150℃
Lead Temperature (Soldering, 10s)...........................+260℃
ESD Susceptibility
HBM..4000V
MM..250V

RECOMMENDED OPERATING CONDITIONS

Operating Temperature Range.......................-40℃ to +85℃

OVERSTRESS CAUTION

Stresses beyond those listed may cause permanent damage to the device. Functional operation of the device at these or any other conditions beyond those indicated in the operational section of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.
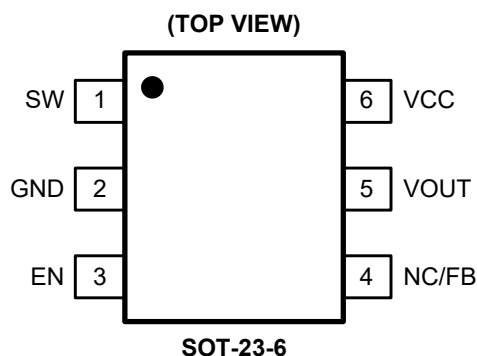
ESD SENSITIVITY CAUTION

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.

DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, specification or other related things if necessary without notice at any time.
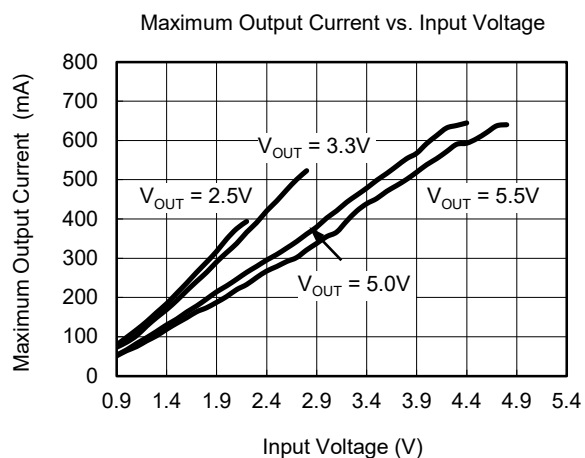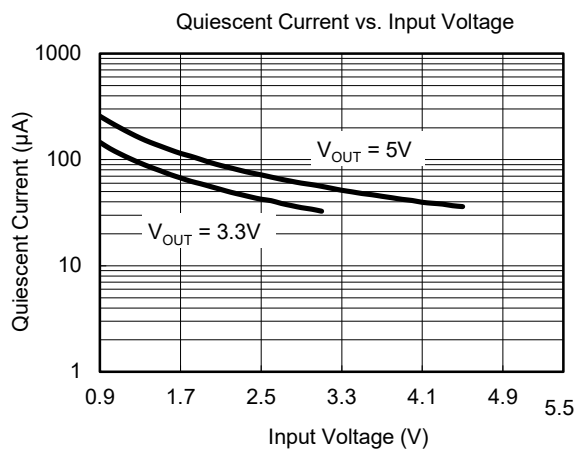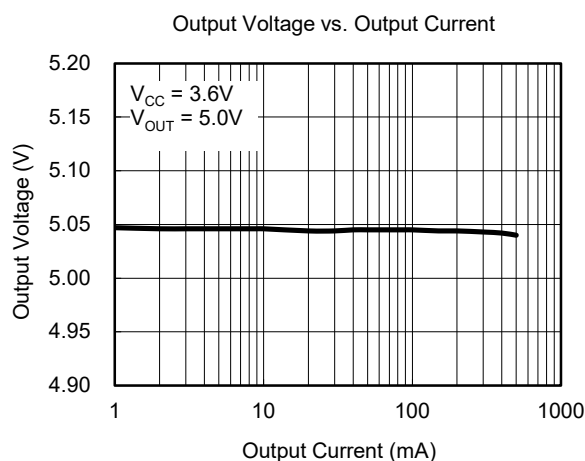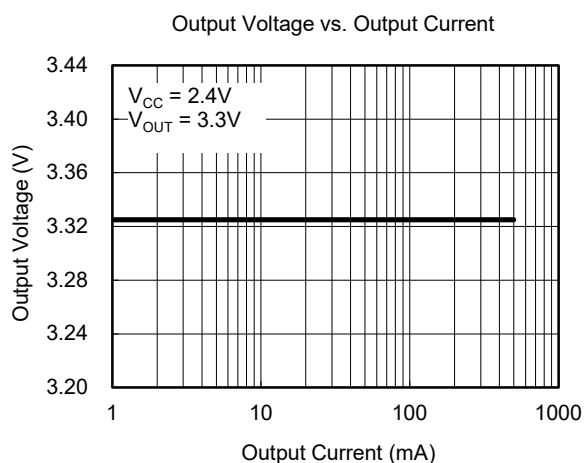
PIN CONFIGURATION

(TOP VIEW)

```
       ┌─────────────┐
SW  1  │ ●           │  6  VCC
GND 2  │             │  5  VOUT
EN  3  │             │  4  NC/FB
       └─────────────┘
```

SOT-23-6

PIN DESCRIPTION

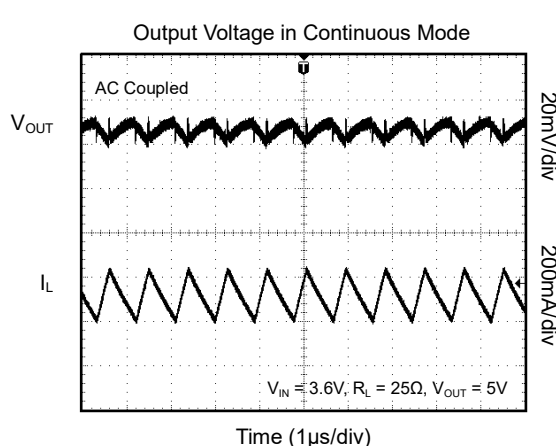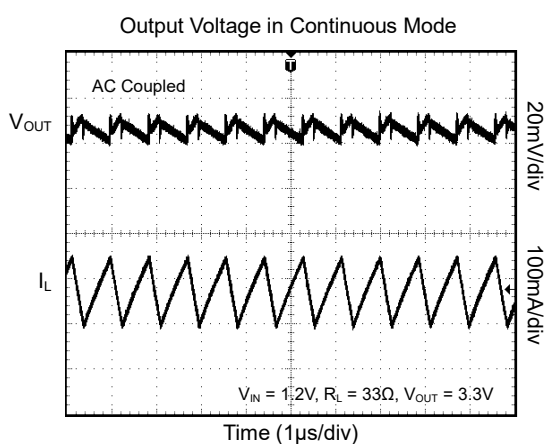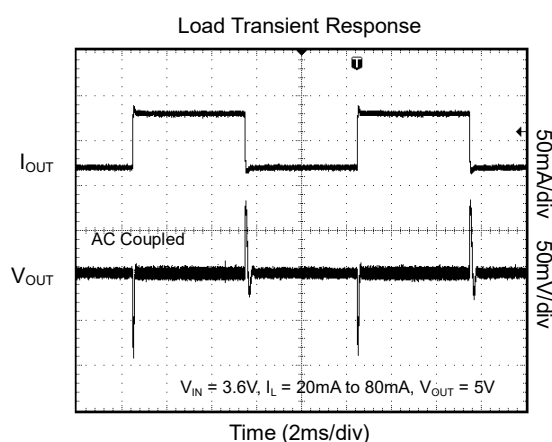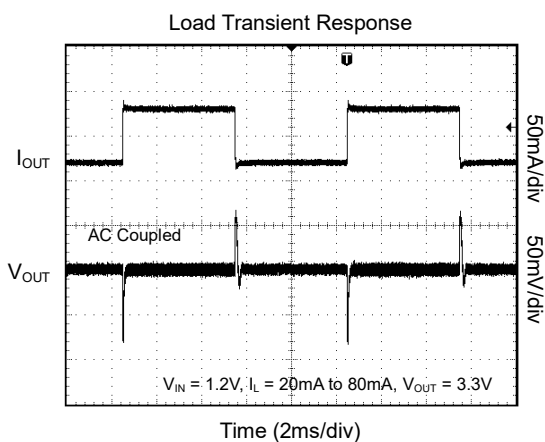| PIN	NAME	FUNCTION
1	SW	Boost and Rectifying Switch Input.
2	GND	Ground.
3	EN	Enable Input. (1/VCC enabled, 0/GND disabled)
4	NC	No Connect. It should be left floating. (SGM6603-3.3/SGM6603-5.0)
	FB	Output Voltage Feedback Pin. Voltage feedback for programming the output voltage. (SGM6603-ADJ)
5	VOUT	Boost Converter Output.
6	VCC	Boost Converter Supply Voltage.

ELECTRICAL CHARACTERISTICS

(Full = -40℃ to +85℃, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER		SYMBOL	CONDITIONS		TEMP	MIN	TYP	MAX	UNITS
DC/DC STAGE									
Output Voltage Range		V_{OUT}			Full	2.5		5.5	V
Minimum Input Voltage Range for Start-Up		V_{IN}	R_L = 3.3kΩ		Full		0.9	1.3	V
			R_L = 270Ω		Full		1.1	1.4	
Input Voltage Range after Start-Up		V_{IN}			+25℃	0.9		5.5	
Feedback Voltage		V_{FB}			Full	485	500	519	mV
Oscillator Frequency		f			Full	870	1200	1470	kHz
Switch Current Limit		I_{SW}			Full	0.75	1.1	1.45	A
Start-Up Current Limit					+25℃		300		mA
Boost Switch-On Resistance			V_{OUT} = 3.3V		+25℃		480		mΩ
Rectifying Switch-On Resistance			V_{OUT} = 3.3V		+25℃		600		mΩ
Output Voltage Accuracy			V_{CC} = 1.2V, I_O = 10mA		Full			3.8	%
Line Regulation			V_{CC} = 0.9V to V_{OUT} - 0.5V, I_O = 10mA		Full		0.1	1	%
Load Regulation					+25℃		0.5		%
Quiescent Current	V_{CC}		V_{EN} = V_{CC} = 1.2V, I_O = 0mA		Full		0.1	1	µA
	V_{OUT}			V_{OUT} = 3.3V	+25℃		30	45	µA
				V_{OUT} = 5V	+25℃		33	55	
Shutdown Current			V_{EN} = 0V, V_{CC} = 1.2V		+25℃			1	µA
CONTROL STAGE									
EN Input Low Voltage		V_{IL}	0.9V ≤ V_{CC} ≤ 1.8V		Full			0.12×V_{CC}	V
			1.8V < V_{CC} ≤ 3 .3V		Full			0.5	
			3.3V < V_{CC} ≤ 4.2V		Full			0.6	
			4.2V < V_{CC} ≤ 5.0V		Full			0.6	
EN Input High Voltage		V_{IH}	0.9V ≤ V_{CC} ≤ 1.8V		Full	0.8×V_{CC}			V
			1.8V < V_{CC} ≤ 3 .3V		Full	2			
			3.3V < V_{CC} ≤ 4.2V		Full	2.4			
			4.2V < V_{CC} ≤ 5.0V		Full	2.6			
EN Input Current			Clamped on GND or VCC		Full			1	µA
Over-Temperature Protection							150		℃
Over-Temperature Hysteresis							20		℃

TYPICAL PERFORMANCE CHARACTERISTICS

Efficiency vs. Input Voltage

Efficiency vs. Input Voltage

Output Voltage vs. Output Current

Output Voltage vs. Output Current

Quiescent Current vs. Input Voltage

Maximum Output Current vs. Input Voltage

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Line Transient Response

AC Coupled

V_{IN}

500mV/div

V_{OUT}

100mV/div

AC Coupled

V_{IN} = 1.8V to 2.4V, R_L = 33Ω, V_{OUT} = 3.3V

Time (2ms/div)

Line Transient Response

AC Coupled

V_{IN}

500mV/div

V_{OUT}

100mV/div

AC Coupled

V_{IN} = 3V to 3.6V, R_L = 25Ω, V_{OUT} = 5V

Time (2ms/div)

Load Transient Response

I_{OUT}

50mA/div

AC Coupled

V_{OUT}

50mV/div

V_{IN} = 1.2V, I_L = 20mA to 80mA, V_{OUT} = 3.3V

Time (2ms/div)

Load Transient Response

I_{OUT}

50mA/div

AC Coupled

V_{OUT}

50mV/div

V_{IN} = 3.6V, I_L = 20mA to 80mA, V_{OUT} = 5V

Time (2ms/div)

Output Voltage in Continuous Mode

AC Coupled

V_{OUT}

20mV/div

I_L

100mA/div

V_{IN} = 1.2V, R_L = 33Ω, V_{OUT} = 3.3V

Time (1μs/div)

Output Voltage in Continuous Mode

AC Coupled

V_{OUT}

20mV/div

I_L

200mA/div

V_{IN} = 3.6V, R_L = 25Ω, V_{OUT} = 5V

Time (1μs/div)

SG Micro Corp
www.sg-micro.com

FEBRUARY 2018

6

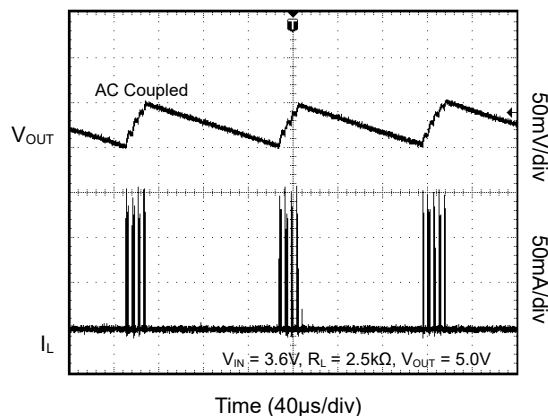## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Output Voltage in Discontinuous Mode

AC Coupled

V_{OUT}

I_L

10mV/div

20mA/div

V_{IN} = 1.2V, R_L = 3.3kΩ, V_{OUT} = 3.3V

Time (400ns/div)
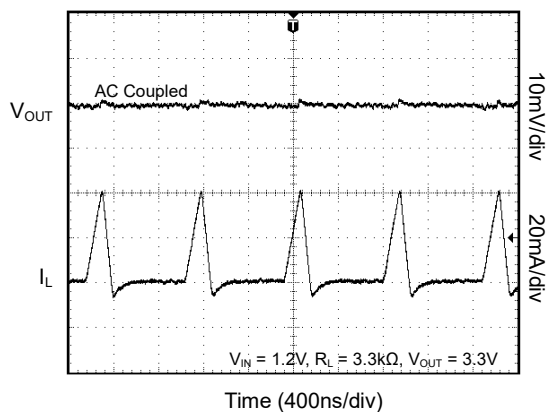
Output Voltage in Power-Save Mode

AC Coupled

V_{OUT}

I_L

50mV/div

50mA/div

V_{IN} = 3.6V, R_L = 2.5kΩ, V_{OUT} = 5.0V

Time (40µs/div)

Start-Up after Enable

EN

V_{OUT}

SW

I_L

2V/div

2V/div

5V/div

200mA/div

V_{IN} = 2.4V, R_L = 33Ω, V_{OUT} = 3.3V

Time (200µs/div)

Start-Up after Enable

EN

V_{OUT}

SW

I_L

5V/div

2V/div

5V/div

200mA/div

V_{IN} = 3.6V, R_L = 50Ω, V_{OUT} = 5V

Time (200µs/div)

Efficiency vs. Output Current

V_{CC} = 1.2V

V_{CC} = 0.9V

V_{CC} =1.8 V

V_{OUT} = 2.5V

Efficiency (%)

Output Current (mA)

Efficiency vs. Output Current

V_{CC} = 1.8V

V_{CC} = 2.4V

V_{CC} = 0.9V

V_{OUT} = 3.3V

Efficiency (%)
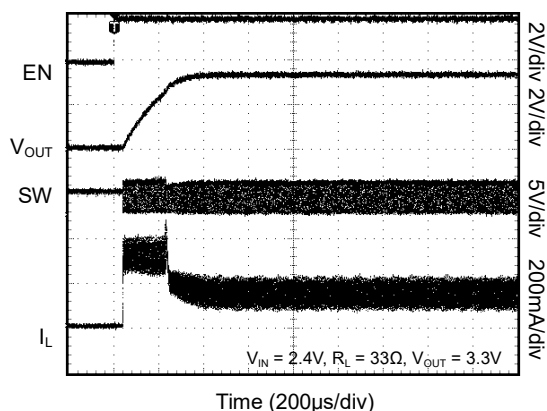
Output Current (mA)

TYPICAL PERFORMANCE CHARACTERISTICS (continued)
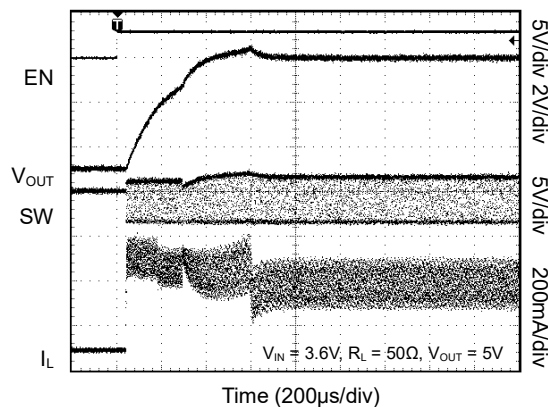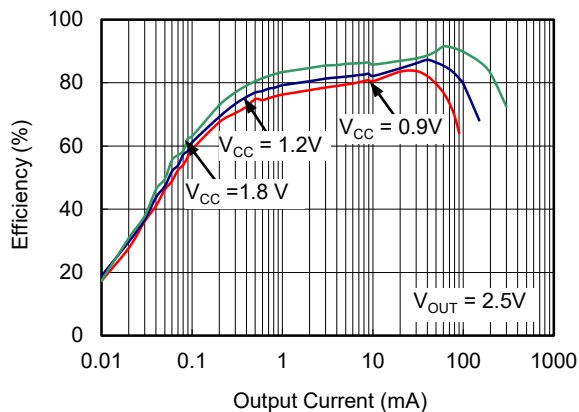
Efficiency vs. Output Current
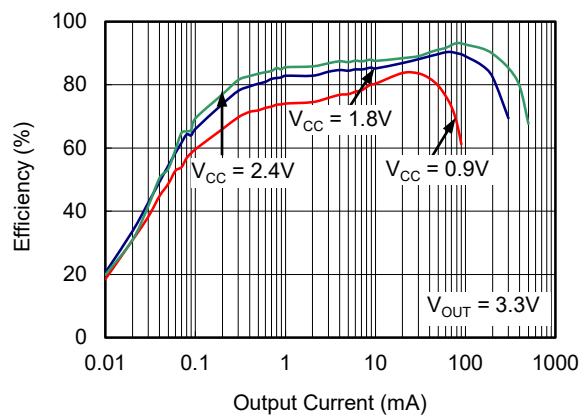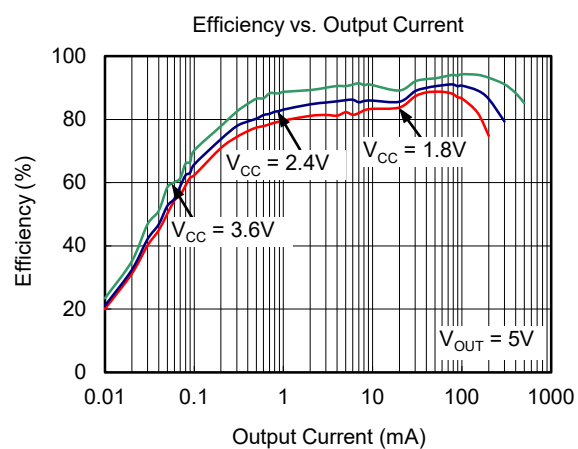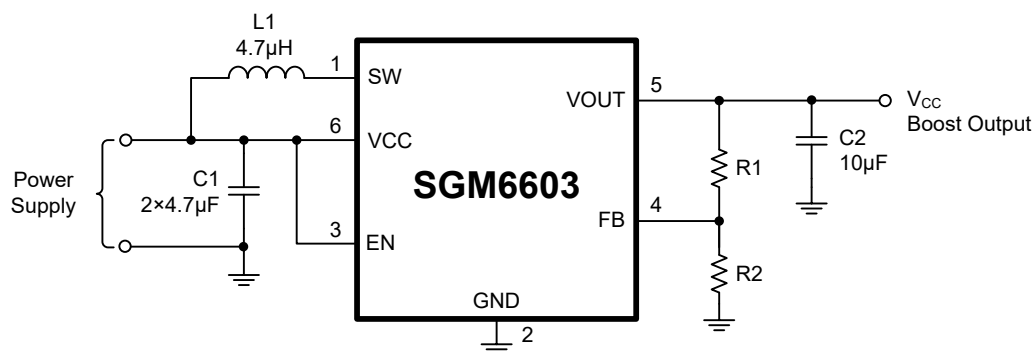
TYPICAL APPLICATION CIRCUITS

Figure 2. Power Supply Solution for Maximum Output Power Operating from a Single or Dual Alkaline Cell
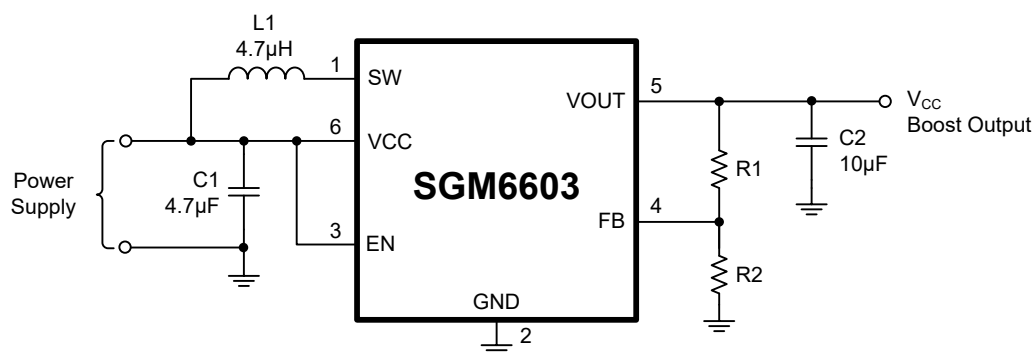

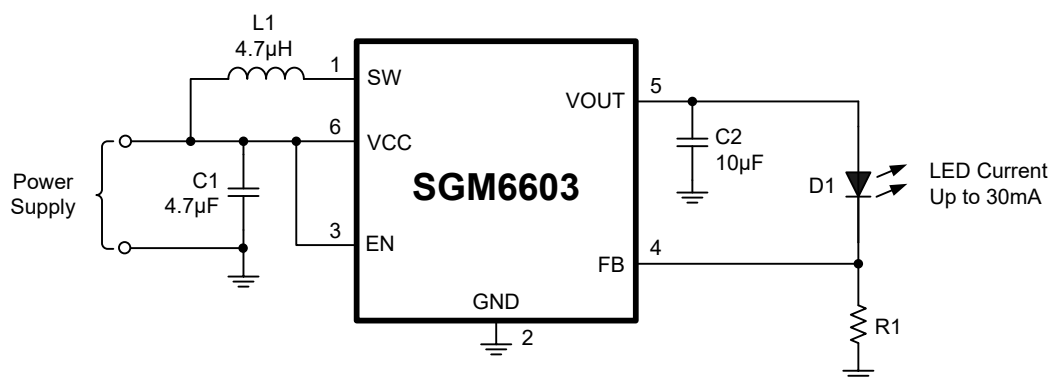**Figure 3. Power Supply Solution Having Small Total Solution Size**

Figure 4. Power Supply Solution for Powering White LEDs in Lighting Applications
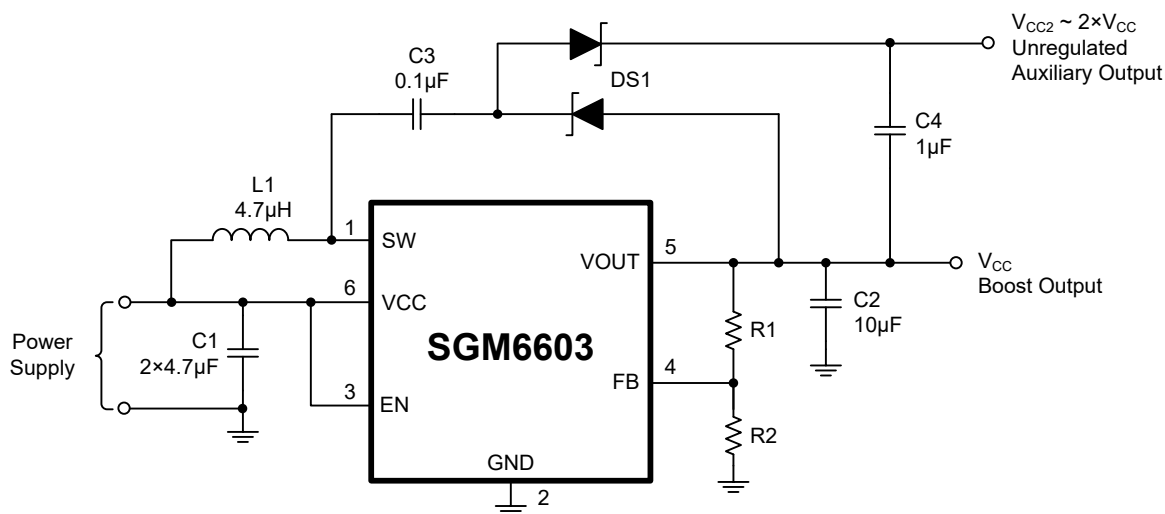
TYPICAL APPLICATION CIRCUITS (continued)

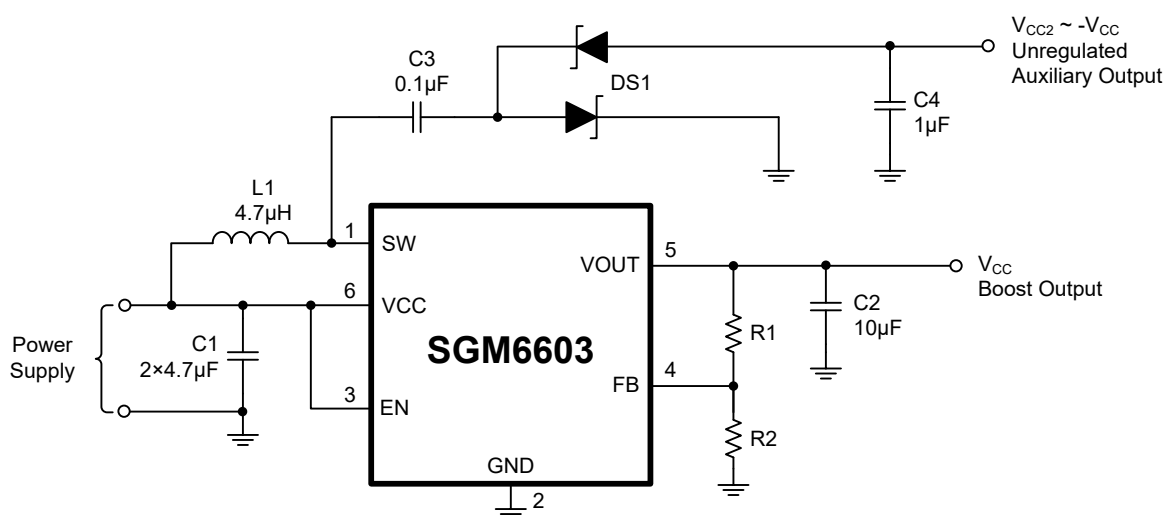**Figure 5. Power Supply Solution with Auxiliary Positive Output Voltage**

Figure 6. Power Supply Solution with Auxiliary Negative Output Voltage

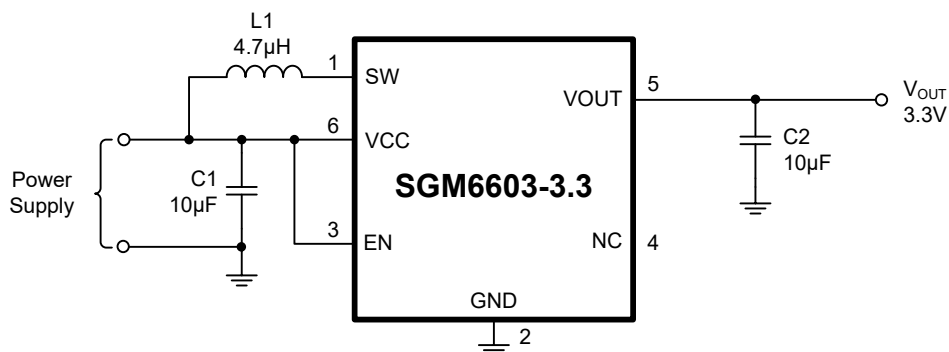## TYPICAL APPLICATION CIRCUITS (continued)

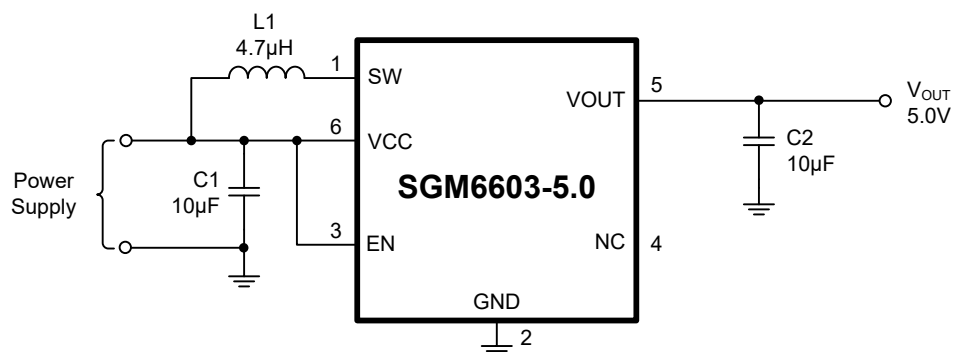**Figure 7a. Basic Application Circuit for the Fixed Output Versions**

Figure 7b. Basic Application Circuit for the Fixed Output Versions

APPLICATION INFORMATION

Design Procedure

The SGM6603 DC/DC converter is intended for systems powered by a single-cell, up to triple-cell alkaline, NiCd, and NiMH battery with a typical terminal voltage between 0.9V and 5.5V. It can also be used in systems powered by one-cell Li-Ion or Li-Polymer with a typical voltage between 2.5V and 4.2V.

Programming Output Voltage

In Figure 1, the output voltage of the SGM6603 DC/DC converter can be adjusted with an external resistor divider. The typical value of the voltage at the FB pin is 500mV. The maximum recommended value for the output voltage is 5.5V. R1 and R2 are calculated using Equation 1:

$$R1 = R2 \times \left(\frac{V_{OUT}}{V_{FB}} - 1 \right) = R2 \times \left(\frac{V_{OUT}}{500mV} - 1 \right) \qquad (1)$$

R2 is recommended to be 100kΩ. For example, if an output voltage of 3.3V is needed, a 560kΩ resistor should be chosen for R1.

Inductor Selection

A boost converter normally requires two main passive components for storing energy during the conversion. A boost inductor and a storage capacitor at the output are required. To select the boost inductor, it is recommended to keep the possible peak inductor current below the current limit threshold of the power switch in the chosen configuration. The highest peak current through the inductor and the switch depends on the output load, the input (V_{CC}), and the output voltage (V_{OUT}). Estimation of the maximum average inductor current is done using Equation 2:

$$I_L = I_O \times \frac{V_{OUT}}{V_{CC} \times 0.8} \qquad (2)$$

For example, for an output current of 75mA at 3.3V, at least an average current of 340mA flows through the inductor at a minimum input voltage of 0.9V.

The second parameter for choosing the inductor is the desired current ripple in the inductor. Normally, it is advisable to work with a ripple of less than 20% of the average inductor current. A smaller ripple reduces the magnetic hysteresis losses in the inductor, as well as output voltage ripple and EMI. But in the same way, regulation time rises at load changes. In addition, a larger inductor increases the total system costs. With these parameters, it is possible to calculate the value for the inductor by using Equation 3:

$$L = \frac{V_{CC} \times (V_{OUT} - V_{CC})}{\Delta I_L \times f \times V_{OUT}} \qquad (3)$$

Parameter f is the switching frequency and ΔI_L is the ripple current in the inductor. In typical applications, a 4.7μH inductance is recommended. The device has been optimized to operate with inductance values between 2.2μH and 10μH. Nevertheless, operation with higher inductance values may be possible in some applications. Detailed stability analysis is then recommended. Care must be taken because load transients and losses in the circuit can lead to higher currents as estimated in Equation 3. Also, the losses in the inductor which include magnetic hysteresis losses and copper losses are a major parameter for total circuit efficiency.

Input Capacitor

At least a 10μF input capacitor is recommended to improve transient behavior of the regulator and EMI behavior of the total power supply circuit. A ceramic capacitor or a tantalum capacitor with a 100nF ceramic capacitor in parallel, placed close to the IC, is recommended.

APPLICATION INFORMATION (continued)

Output Capacitor

The major parameter necessary to define the output capacitor is the maximum allowed output voltage ripple of the converter. This ripple is determined by two parameters of the capacitor, the capacitance and the ESR. It is possible to calculate the minimum capacitance needed for the defined ripple, supposing that the ESR is zero, by using Equation 4:

$$C_{MIN} = \frac{I_O \times (V_{OUT} - V_{CC})}{f \times \Delta V \times V_{OUT}} \quad (4)$$

Parameter f is the switching frequency and ΔV is the maximum allowed ripple.

With a chosen ripple voltage of 10mV, a minimum capacitance of 4.5μF is needed. In this value range, ceramic capacitors are a good choice. The ESR and the additional ripple created are negligible. It is calculated using Equation 5:

$$\Delta V_{ESR} = I_O \times R_{ESR} \quad (5)$$

The total ripple is the sum of the ripple caused by the capacitance and the ripple caused by the ESR of the capacitor. Additional ripple is caused by load transients. This means that the output capacitor has to completely supply the load during the charging phase of the inductor.

The value of the output capacitance depends on the speed of the load transients and the load current during the load change. With the calculated minimum value of 4.5μF and load transient considerations, the recommended output capacitance value is in the range of 4.7μF to 22μF.

Care must be taken on capacitance loss caused by derating due to the applied DC voltage and the frequency characteristic of the capacitor. For example, larger form factor capacitors (in 1206 size) have their self resonant frequencies in the same frequency range as the SGM6603 operating frequency. So the effective capacitance of the capacitors used may be significantly lower. Therefore, the recommendation is to use smaller capacitors in parallel instead of one larger capacitor.

Layout Considerations

As for all switching power supplies, the layout is an important step in the design, especially at high-peak currents and high switching frequencies. If the layout is not carefully done, the regulator could show stability problems as well as EMI problems. Therefore, use wide and short traces for the main current path and for the power ground tracks. The input capacitor, output capacitor, and the inductor should be placed as close as possible to the IC. Use a common ground node for power ground and a different one for control ground to minimize the effects of ground noise. Connect these ground nodes at any place close to the ground pin of the IC.

The feedback divider should be placed as close as possible to the ground pin of the IC. To lay out the control ground, it is recommended to use short traces as well, separated from the power ground traces. This avoids ground shift problems, which can occur due to superimposition of power ground current and control ground current.

Thermal Information

Implementation of integrated circuits in low-profile and fine-pitch surface-mount packages typically requires special attention to power dissipation. Many system-dependent issues such as thermal coupling, airflow, added heat sinks and convection surfaces, and the presence of other heat-generating components affect the power-dissipation limits of a given component.

Three basic approaches for enhancing thermal performance follow.

1. Improving the power dissipation capability of the PCB design.
2. Improving the thermal coupling of the component to the PCB.
3. Introducing airflow in the system.

REVISION HISTORY

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

PACKAGE OUTLINE DIMENSIONS

SOT-23-6

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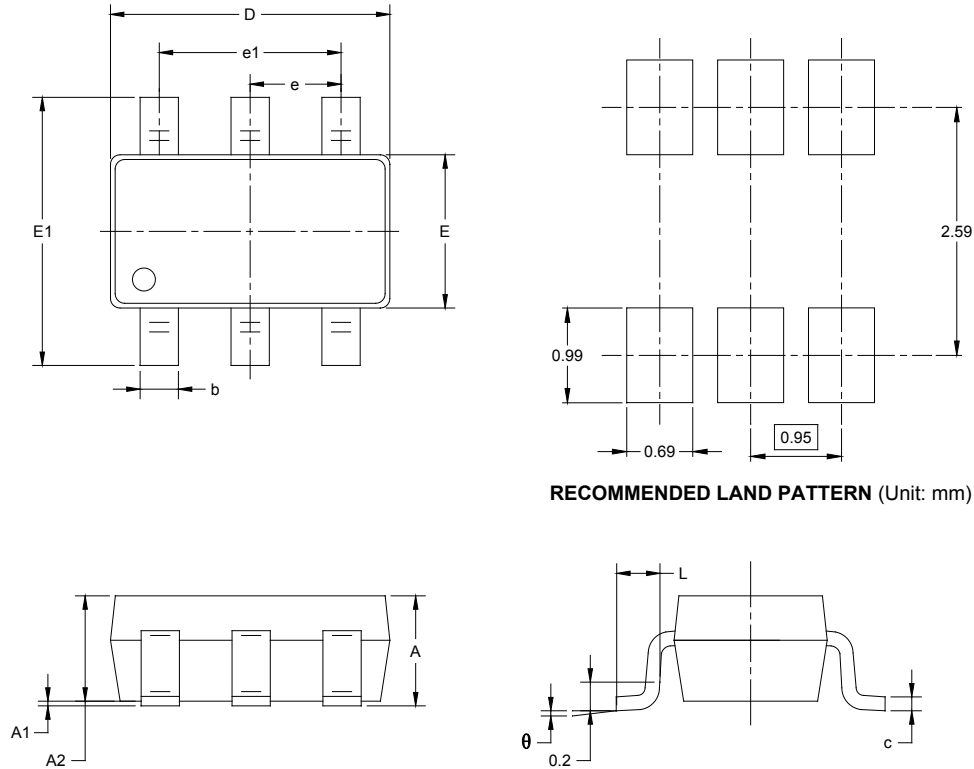
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 BSC		0.037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

SG Micro Corp
www.sg-micro.com

TX00034.000

TAPE AND REEL INFORMATION

REEL DIMENSIONS
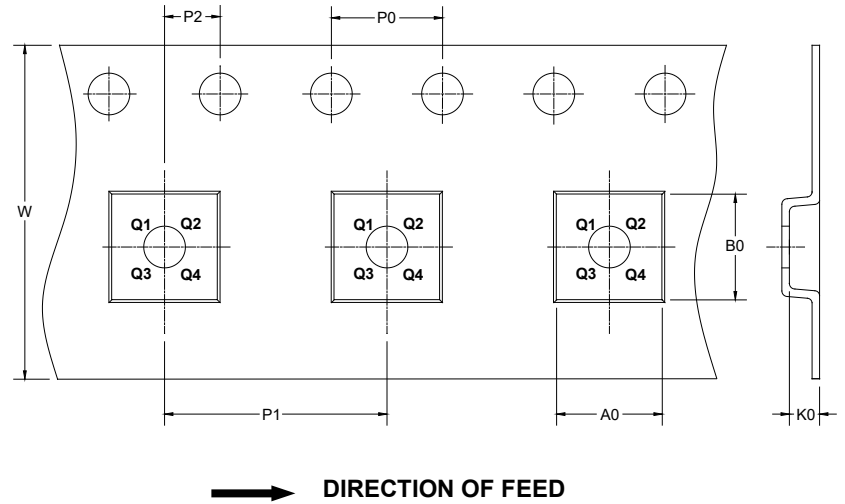
Reel Diameter

Reel Width (W1)

TAPE DIMENSIONS

DIRECTION OF FEED

NOTE: The picture is only for reference. Please make the object as the standard.
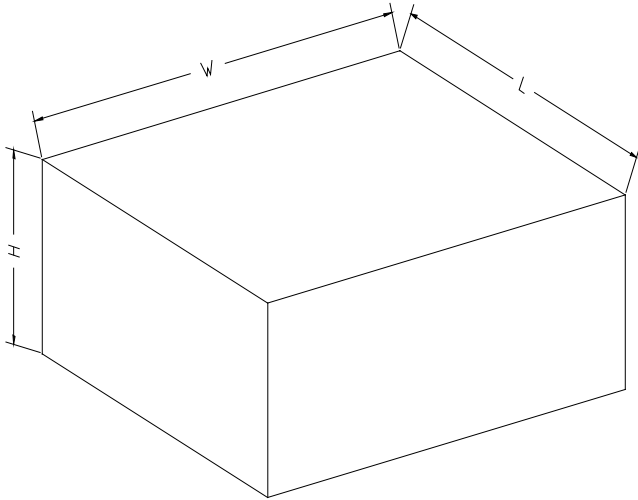
KEY PARAMETER LIST OF TAPE AND REEL

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	3.17	3.23	1.37	4.0	4.0	2.0	8.0	Q3

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

SG Micro Corp
www.sg-micro.com

TX20000.000