

GENERAL DESCRIPTION

The SGM6604 is a fully integrated synchronous Boost converter which integrates a 20V main power switch and an input/output isolation switch. The isolation switch provides true load disconnection when SGM6604 is in shutdown mode. The SGM6604 is capable to start up from 1.85V input, which is suitable for single-cell Li-Ion battery or two-cell alkaline batteries in series. The device can provide up to 20V output voltage which makes it an excellent choice for PMOLED panel bias and applications requiring high voltage in a small solution size.

The SGM6604 has an internal fixed 12V output voltage setting by connecting the FB pin to the VIN pin. Thus, it only needs three external components to achieve 12V output voltage. The SGM6604 has 1.12A typical switch current limit and 6ms built-in soft-start time to minimize the inrush current. When the SGM6604 is disabled via EN pin, the isolation switch disconnects the output from input to minimize the leakage current. The SGM6604 also implements various protection features such as output short-circuit protection, output over-voltage protection and thermal shutdown.

The SGM6604 is available in a Green SOT-23-6 package. It operates over an ambient temperature range of -40°C to +85°C.

FEATURES

- 1.85V to 5V Input Voltage Range, 1.6V after Start-up
- Output Voltage up to 20V
- Integrated Isolation Switch
- 1.12A (TYP) Switch Current
- Up to 92% Efficiency at 3.6V Input and 12V Output
- Ultra-Low Shutdown Current:
1.5μA (MAX) at $V_{IN} = 3.6V$
- Auto Power-Save Operation Mode at Light Load
- Internal 6ms Soft-Start Time
- True Disconnection between Input and Output during Shutdown
- Output Short-Circuit Protection (SCP)
- Output Over-Voltage Protection (OVP)
- Thermal Shutdown Protection
- -40°C to +85°C Operating Temperature Range
- Available in a Green SOT-23-6 Package

APPLICATIONS

PMOLED Power Supply
Wearable Devices
Portable Medical Equipment
Sensor Power Supply

TYPICAL APPLICATION

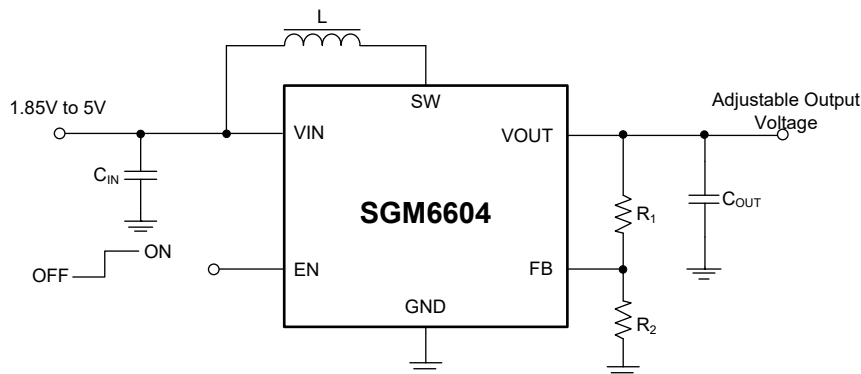


Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

| MODEL | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE | ORDERING NUMBER | PACKAGE MARKING | PACKING OPTION |
|---------|---------------------|-----------------------------|-----------------|-----------------|---------------------|
| SGM6604 | SOT-23-6 | -40°C to +85°C | SGM6604YN6G/TR | 04SXX | 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

Voltage Range at Terminals

VIN, EN, FB -0.3V to 6V

SW, VOUT -0.3V to 22V

Package Thermal Resistance

SOT-23-6, θ_{JA} 150.3°C/W

Junction Temperature +150°C

Storage Temperature Range -65°C to +150°C

Lead Temperature (Soldering, 10s) +260°C

ESD Susceptibility

HBM 1000V

CDM 1000V

RECOMMENDED OPERATING CONDITIONSInput Voltage Range, V_{IN} 1.85V to 5VOutput Voltage Range, V_{OUT} 4.5V to 20VInductance, Effective Value, L 10 μ H (TYP)Input Capacitance, Effective Value, C_{IN} 1 μ F (MIN)Output Capacitance, Effective Value, C_{OUT} 4.7 μ F to 10 μ F

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.

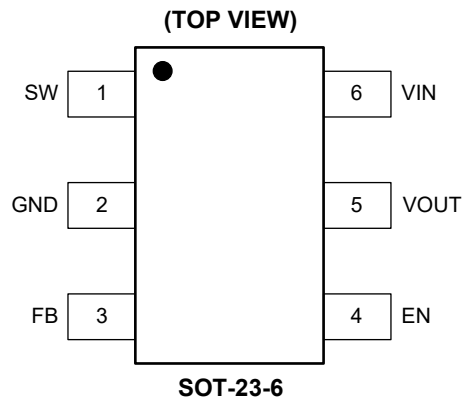
ESD SENSITIVITY CAUTION

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 | P | IC Switch Pin. Drain connection of internal synchronous rectifier. |
| 2 | GND | G | Power Ground Pin. Source connection of internal synchronous rectifier. |
| 3 | FB | I | Output Voltage Feedback Pin. Connect a resistor divider on this pin to program the output voltage. |
| 4 | EN | I | Enable Pin. Logic high enables the device; logic low disables the device. Do not leave it floating. |
| 5 | VOUT | P | Output of the Boost Converter. |
| 6 | VIN | P | IC Input Supply Pin. |

NOTE: I = input, O = output, P = Power, G = Ground.

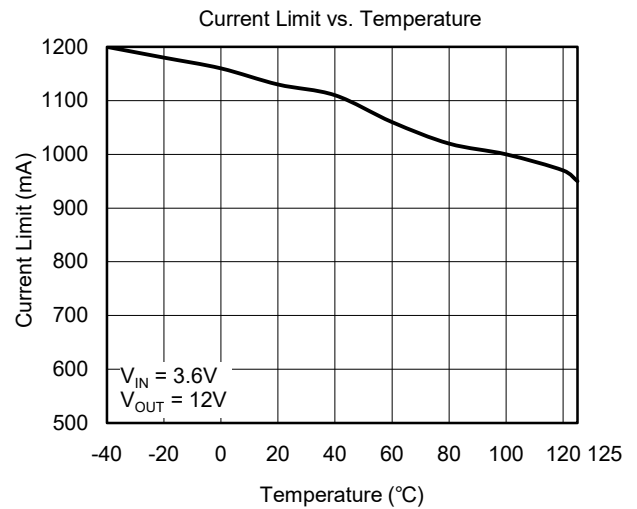
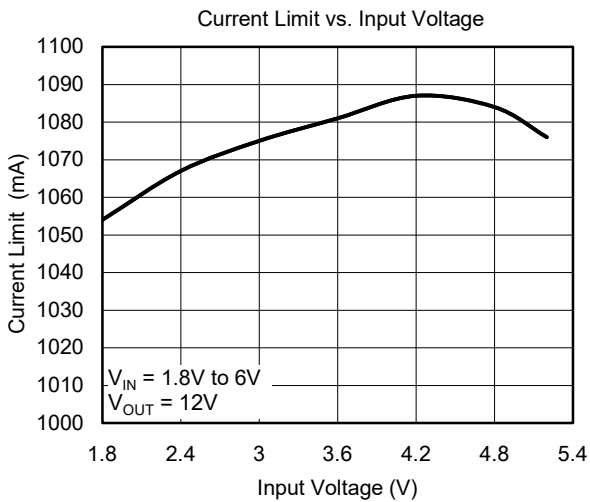
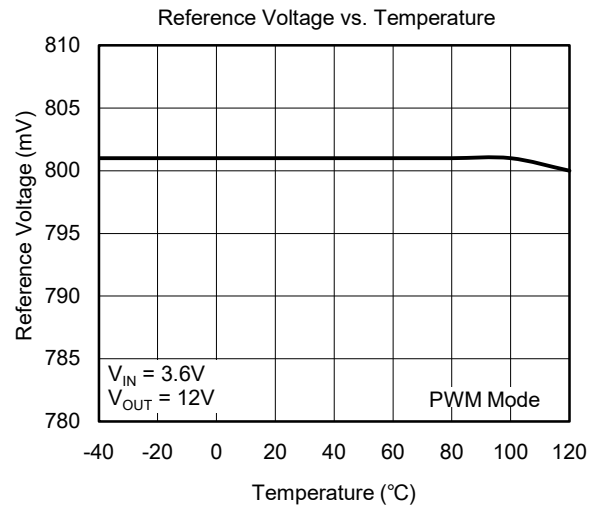
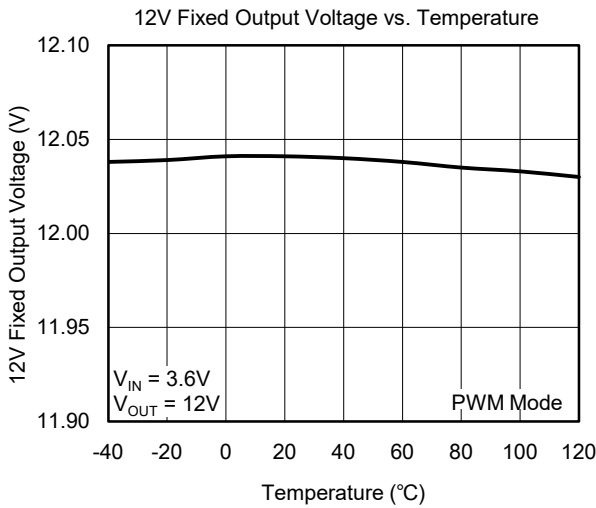
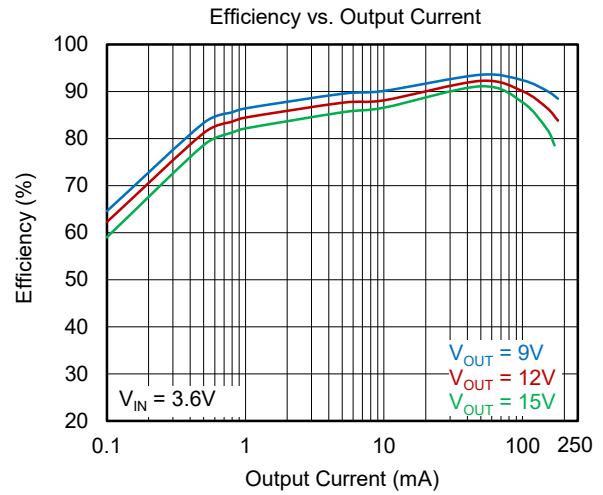
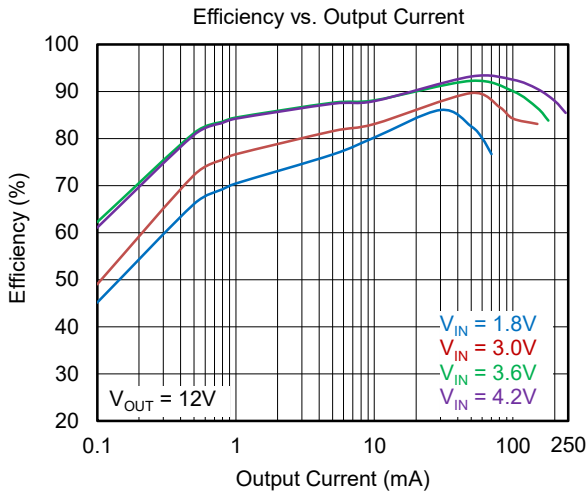
ELECTRICAL CHARACTERISTICS

($T_A = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$, $V_{IN} = 3.6\text{V}$, $V_{OUT} = 12\text{V}$, $C_{IN} = 1.0\mu\text{F}$, $C_{OUT} = 4.7\mu\text{F}$, $L = 10\mu\text{H}$, typical values are measured at $T_A = +25^{\circ}\text{C}$, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | TEMP | MIN | TYP | MAX | UNITS |
|--|----------------|--|-----------------------|-------|-------|-------|--------------------|
| Power Supply | | | | | | | |
| Under-Voltage Lockout Threshold | V_{IN_UVLO} | V_{IN} rising | Full | | 1.58 | 1.85 | V |
| VIN UVLO Hysteresis | V_{IN_HYS} | | Full | | 150 | | mV |
| Quiescent Current into VIN Pin | I_{Q_VIN} | IC enabled, no load, no switching | Full | | 45.0 | 85.0 | μA |
| Shutdown Current into VIN Pin | I_{SD} | IC disabled | Full | | | 1.5 | μA |
| Output | | | | | | | |
| 12V Output Voltage Accuracy | V_{OUT_12V} | FB pin connected to VIN pin | Full | 11.5 | 12.0 | 12.5 | V |
| Feedback Voltage | V_{FB} | PWM mode | Full | 0.765 | 0.795 | 0.825 | V |
| Output Over-Voltage Protection Threshold | V_{OVP} | | Full | 20.6 | 21.5 | 22.2 | V |
| Over-Voltage Protection Hysteresis | V_{OVP_HYS} | | Full | | 2.5 | | V |
| Leakage Current into FB Pin | I_{FB_LKG} | | Full | | | 200 | nA |
| Leakage Current into SW Pin | I_{SW_LKG} | IC disabled | Full | | | 500 | nA |
| Power Switch | | | | | | | |
| Isolation MOSFET On-Resistance | R_{DSON} | | $+25^{\circ}\text{C}$ | | 615 | | m Ω |
| Low-side MOSFET On-Resistance | | | $+25^{\circ}\text{C}$ | | 300 | | |
| Switching Frequency | f_{SW} | $V_{IN} = 3.6\text{V}$, $V_{OUT} = 12\text{V}$, PWM mode | Full | 0.9 | 1.3 | 1.6 | MHz |
| Peak Switch Current Limit | I_{LIM_SW} | $V_{IN} = 3.6\text{V}$, $V_{OUT} = 12\text{V}$ | Full | 0.75 | 1.12 | 1.50 | A |
| Soft-Start Time | t_{SS} | V_{OUT} from V_{IN} to 12V, $C_{OUT_EFFECTIVE} = 4.7\mu\text{F}$, $I_{OUT} = 0\text{A}$ | $+25^{\circ}\text{C}$ | | 6 | | ms |
| Logic Interface | | | | | | | |
| EN Logic High Threshold | V_{EN_H} | | Full | 1.2 | | | V |
| EN Logic Low Threshold | V_{EN_L} | | Full | | | 0.3 | V |
| Protection | | | | | | | |
| Thermal Shutdown Threshold | T_{SD} | T_A rising | | | 155 | | $^{\circ}\text{C}$ |
| Thermal Shutdown Hysteresis | T_{SD_HYS} | T_A falling below T_{SD} | | | 25 | | $^{\circ}\text{C}$ |

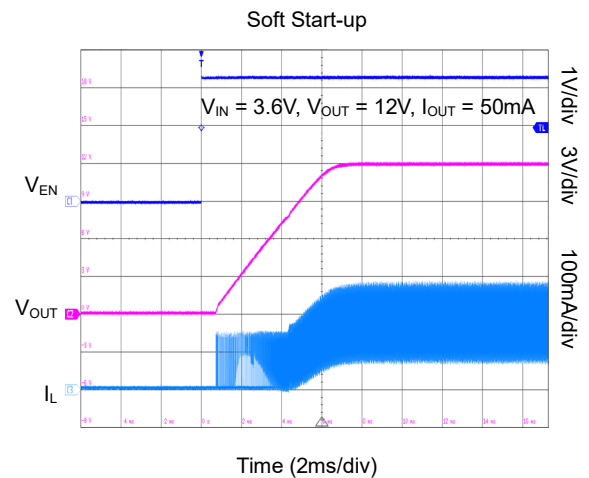
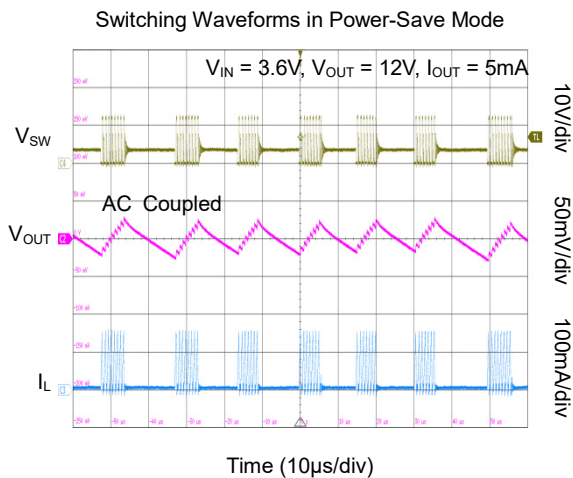
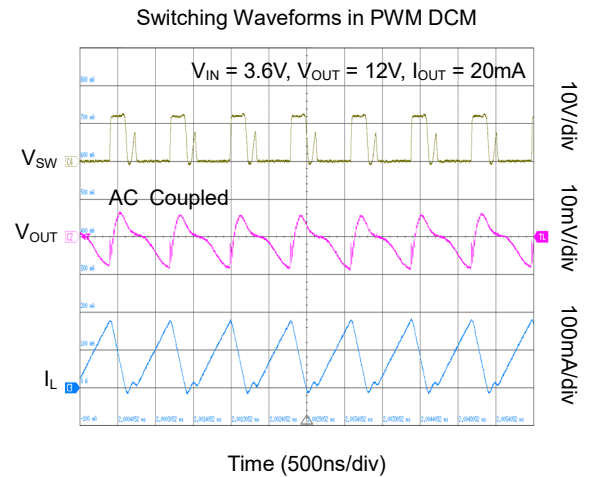
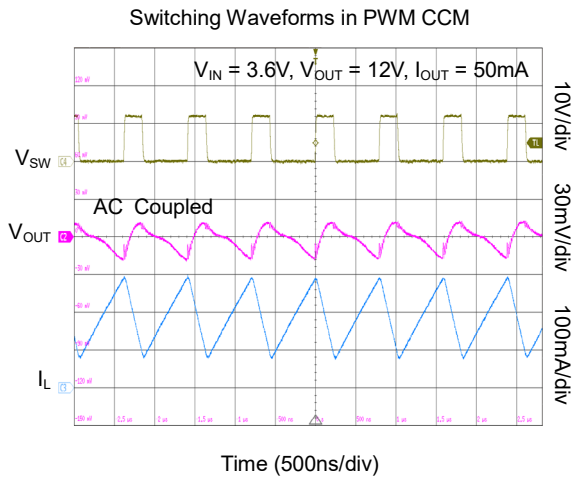
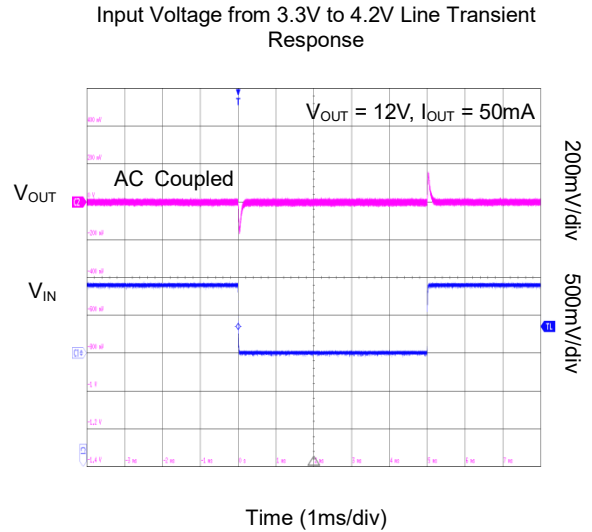
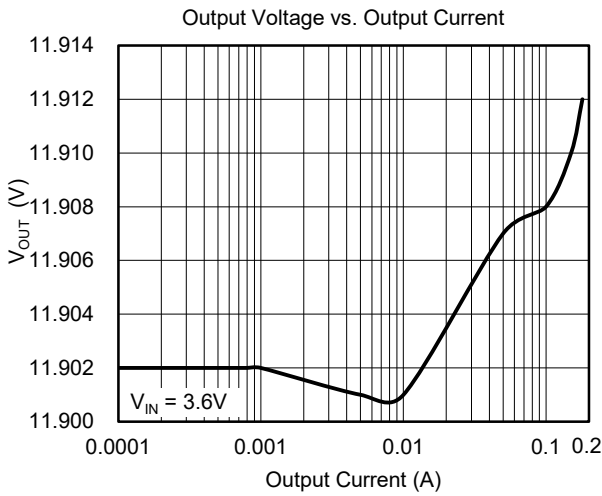
TYPICAL PERFORMANCE CHARACTERISTICS

At $T_A = +25^\circ\text{C}$, $V_{IN} = 3.6\text{V}$, $V_{OUT} = 12\text{V}$, unless otherwise noted.



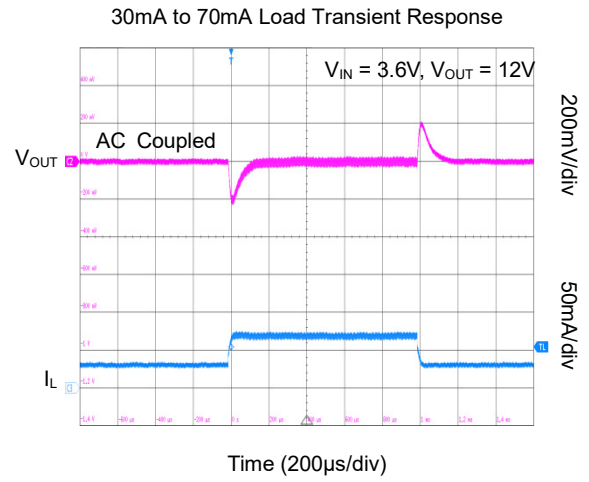
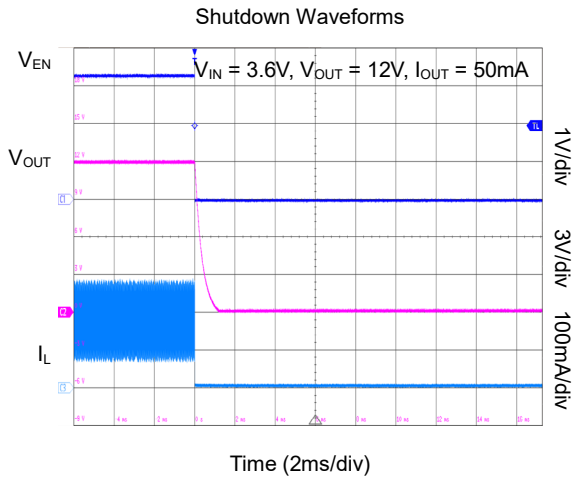
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_A = +25^\circ\text{C}$, $V_{IN} = 3.6\text{V}$, $V_{OUT} = 12\text{V}$, unless otherwise noted.



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_A = +25^\circ\text{C}$, $V_{IN} = 3.6\text{V}$, $V_{OUT} = 12\text{V}$, unless otherwise noted.



FUNCTIONAL BLOCK DIAGRAM

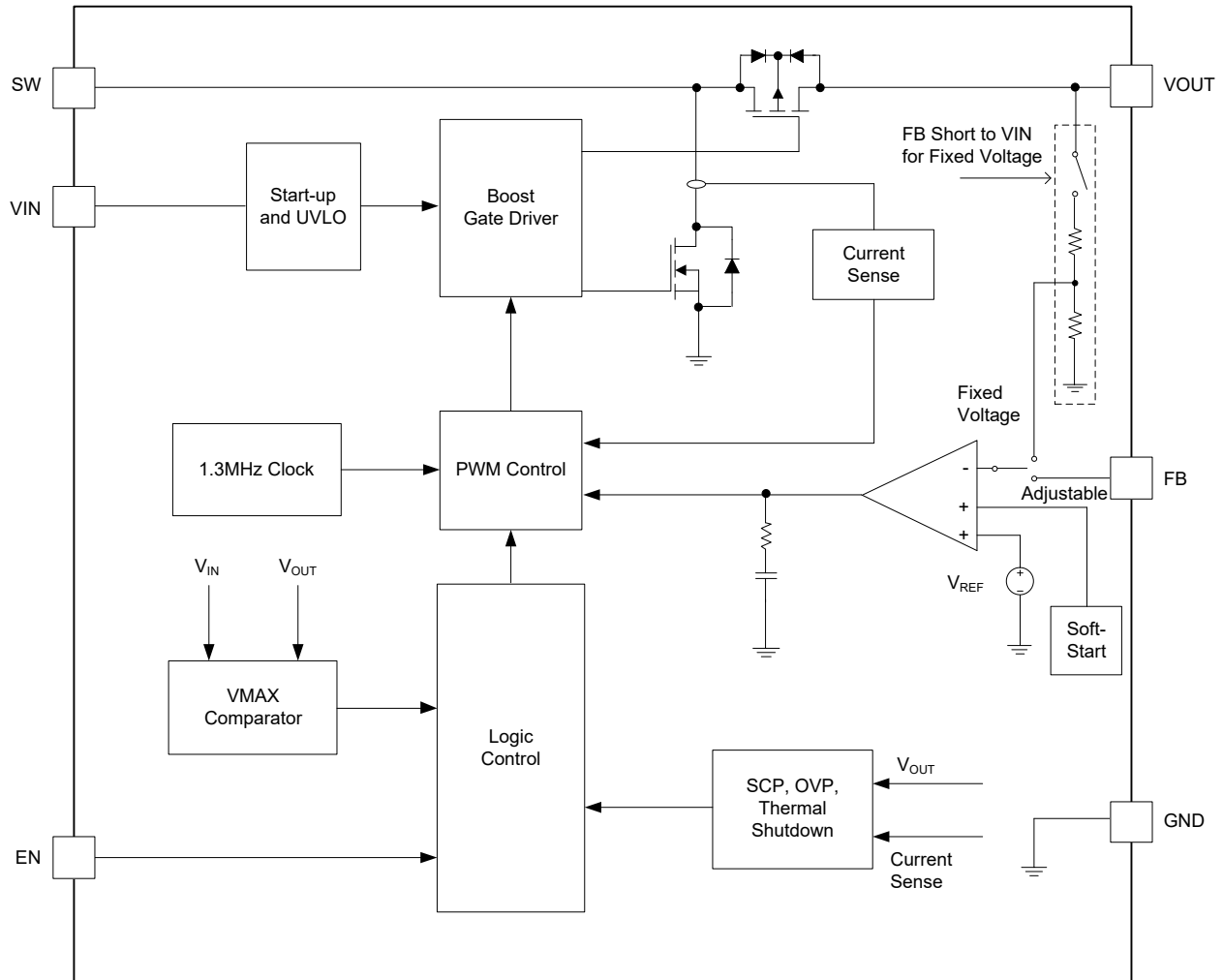


Figure 2. Block Diagram

DETAILED DESCRIPTION

The SGM6604 is a peak current mode synchronous Boost converter which has a high efficiency over the 1.85V to 5V input range. It is capable of providing up to 20V output. The SGM6604 features the PWM and power-save mode (PSM). Under moderate to heavy load condition, the SGM6604 works in PWM mode with 1.3MHz quasi-constant frequency. In light load condition, the SGM6604 operates in the auto PSM to improve the efficiency. Excellent line and load transient responses can be achieved with minimal output capacitance by applying a peak current control topology.

Under-Voltage Lockout (UVLO)

An under-voltage lockout circuit prevents operation at input voltages below 1.43V (TYP) with a hysteresis of 150mV. Therefore, if the input voltage rises and exceeds 1.58V (TYP), the device restarts.

Enable and Shutdown

The SGM6604 implements the EN function to turn on/off the device. A logic signal higher than 1.2V turns on the device, and a logic signal lower than 0.3V turns off the device and enters shutdown mode. Never leave the EN pin floating.

Soft-Start

The built-in soft-start function is adopted to limit the inrush current. When the input voltage is lower than 4.5V, V_{OUT} starts up with a 150mA soft-start current limit. If the input voltage exceeds 4.5V, soft-start current limit is further decreased from 150mA to 100mA. Once V_{OUT} ramps up to 80% of the programmed voltage, the full current limit becomes active immediately (1.12A, TYP). This feature effectively reduces the inrush current during start-up.

Peak Current Limit

The peak current mode control of SGM6604 provides inherent over-current protection. The low-side FET is turned off when the peak current reaches the current limit threshold of 1.12A (TYP), and the low-side FET is not turned on again until the next clock cycle. This function protects it from being damaged by overload.

Short-Circuit Protection (SCP)

The built-in under-clocking function is adopted to protect the device well. When the output voltage is lower than 25% of the programmed voltage, it is considered as short-circuit, then the switching frequency decreases to 200kHz. During start-up period,

the frequency fold-back operation is also implemented before the output voltage reaches above 25% of the programmed voltage. This feature efficiently reduces the heat as starting up into short-circuit of output and makes the device more safe.

Device Functional Modes

The synchronous Boost converter SGM6604 operates at PWM mode with a constant frequency in moderate to heavy load condition. The low-side N-MOSFET switch is turned on at the start of a cycle, and the inductor current increases to a peak current determined by the error amplifier (EA). After the peak current is reached, the current comparator trips, and it disables the low-side N-MOSFET switch and the inductor current goes through the body diode of the high-side P-MOSFET in a dead-time duration. After the dead-time duration, the high-side P-MOSFET switch is turned on. As the output voltage is larger than the input voltage, the inductor current decreases. After a short dead-time duration, the low-side switch is turned on again and the switching cycle is repeated. To avoid sub-harmonic oscillation, the SGM6604 implements internal slope compensation.

The device features a power-save mode (PSM) in light load condition. The peak current will decrease as the output load reduces until it is clamped to a set minimum value. After that, if the output load is further reduced, the device starts to operate in power-save mode.

Load Disconnect

The high-side switch can isolate the output from the input under shutdown, which minimizes the leakage current.

Over-Voltage Protection (OVP)

The SGM6604 provides 21.5V (TYP) OVP threshold. The device stops switching immediately until the voltage at the VOUT pin drops 2.5V below the output OVP threshold. The OVP circuitry monitors the output voltage (V_{OUT}) and protects V_{OUT} and SW from exceeding safe operating voltages.

Thermal Shutdown

To prevent thermal damage, the device has an internal temperature monitor. If the die temperature exceeds 155°C (TYP), the device stops switching. Once the temperature drops below 130°C (TYP), the device resumes operation.

APPLICATION INFORMATION

The procedure below can be followed to choose peripheral components for the SGM6604.

Table 1. Design Requirements

| PARAMETERS | VALUES |
|-----------------------|--------------|
| Input Voltage | 2.7V to 4.4V |
| Output Voltage | 12V |
| Output Current | 50mA |
| Output Voltage Ripple | ±50mV |

Fixed Output Voltage

There are two ways to set the output voltage of the SGM6604. One is the fixed 12V output voltage. Another is the programmable output voltage. When the FB pin is connected to the input voltage, the output voltage is set for fixed 12V. This feature eliminates the divider resistors, which minimizes the overall solution PCB size as small as possible and also reduces the BOM cost. Figure 3 shows the fixed 12V output voltage application.

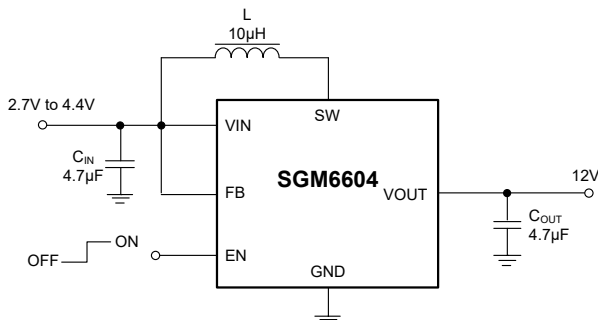


Figure 3. Fixed 12V Output Voltage Application Circuit

Programmable Output Voltage

The SGM6604 supports an output voltage up to 20V. The desired output voltage can be programmed by an external resistor divider. The resistive divider value is calculated via Equation 1. Figure 4 shows the programmable output voltage application.

$$R_1 = \left(\frac{V_{OUT}}{V_{FB}} - 1 \right) \times R_2 \tag{1}$$

where V_{OUT} is the desired output voltage, and V_{FB} is approximate 0.795V (TYP) at the FB pin.

For the best accuracy, the current flowing through R_2 is at least 100 times higher than the FB pin leakage current. Then, it is recommended that R_2 value is not larger than 80kΩ.

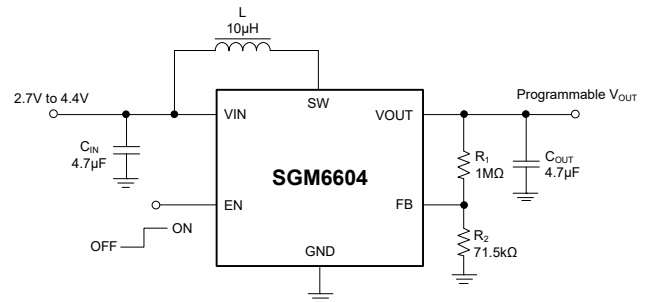


Figure 4. Programmable Output Voltage Application Circuit

Inductor Selection

The inductor selection makes trade-offs among the size, cost, efficiency, transient response and loop stability requirements. Generally, key inductor parameters are specified for operation with the device: inductance value (L), rated current (I_{RATE}), saturation current (I_{SAT}), and DC resistance (DCR).

In a Boost regulator, the inductor DC current $I_{L(DC)}$ can be calculated with Equation 2.

$$I_{L(DC)} = \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times \eta} \tag{2}$$

where V_{OUT} is output voltage, I_{OUT} is output current, V_{IN} is input voltage, and η is the power conversion efficiency (85% for most applications). The rated current (I_{RATE}) of selected inductor should be bigger than the calculated $I_{L(DC)}$. If the device is applied in higher temperature field, for example above +75°C, it is recommended that I_{RATE} of selected inductor usually has 25% margin over the needed $I_{L(DC)}$.

APPLICATION INFORMATION (continued)

Equation 3 shows the calculation of inductance selection. For general rule of thumb, a good compromise between size and loss is around 30% peak-to-peak ripple current $\Delta I_{L(P-P)}$ to the IC rated current at nominal output voltage.

$$L = \frac{V_{IN} \times (V_{OUT} - V_{IN})}{\Delta I_{L(P-P)} \times f_{SW} \times V_{OUT}} \quad (3)$$

where f_{SW} is the switching frequency, $\Delta I_{L(P-P)}$ is the inductor ripple current, V_{IN} is input voltage and V_{OUT} is output voltage.

The SGM6604 is designed to support inductor values between 4.7 μ H and 10 μ H. Larger inductance values result in lower output ripple voltage and higher efficiency, but a slightly degraded transient response. Lower inductance values allow for smaller case size, but the larger ripple current increases the AC losses in the inductor. The loop compensation of SGM6604 is optimized with 10 μ H inductance. Therefore, the optimal inductance value for SGM6604 is 10 μ H.

Table 2. Recommended Inductors for the SGM6604

| PART NUMBER | L (μ H) | DCR MAX (m Ω) | SATURATION CURRENT (A) | SIZE (L \times W \times H mm ³) | VENDOR |
|-----------------|--------------|-----------------------|------------------------|---|---------|
| FDSD0420-H-100M | 10 | 200 | 2.5 | 4.2 \times 4.2 \times 2.0 | Toko |
| 74438336100 | 10 | 322 | 3 | 3.2 \times 3.2 \times 2 | Würth |
| SWPA5020S100MT | 10 | 143 | 1.7 | 2.5 \times 2.0 \times 1.2 | Sunlord |
| SWPA4020S4R7MT | 4.7 | 98 | 2.35 | 4.0 \times 4.0 \times 2.0 | Sunlord |

Input Capacitor Selection

Boost converter's input capacitor sees continuous current throughout the entire switching cycle. A 4.7 μ F ceramic capacitor is recommended to place as close as possible between the VCC pin and GND pin of SGM6604.

Output Capacitor Selection

The output capacitor is mainly selected according to the output ripple required by the specification. The output ripple composes of two parts which are caused by equivalent series resistance (ESR) and capacitor's capacitance.

Assuming a ceramic capacitor with zero ESR (ESR is usually very small and can be neglected), Equation 6 can be used to calculate and estimate the minimum capacitance needed for a given ripple. This is because the output capacitor supplies the entire output load current during the power stage on-state.

The inductor value determines not only the ripple current but also the load current of boundary between DCM and CCM.

For the given inductance value (L), the peak-to-peak ripple current $\Delta I_{L(P-P)}$ is calculated with Equation 4.

$$\Delta I_{L(P-P)} = \frac{V_{IN} \times (V_{OUT} - V_{IN})}{L \times f_{SW} \times V_{OUT}} \quad (4)$$

Therefore, the inductor peak current $I_{L(Peak)}$ is calculated with Equation 5.

$$I_{L(Peak)} = I_{L(DC)} + \frac{\Delta I_{L(P-P)}}{2} \quad (5)$$

The selected inductor should have a saturation current rating higher than the 1.12A (TYP) current limit of the device.

To enhance the efficiency, choose a low-loss inductor with the lowest possible DC resistance that fits in the allotted dimensions.

$$C_{OUT} = \frac{I_{OUT} \times D_{MAX}}{f_{SW} \times \Delta V_{RIPPLE}} \quad (6)$$

where D_{MAX} is the maximum duty cycle, and ΔV_{RIPPLE} is the maximum allowed peak-to-peak ripple.

The ESR impacts on the output ripple and the transient response must be considered if tantalum or aluminum electrolytic capacitors are used.

The SGM6604 is an internally compensated device. The output capacitor will affect the loop stability. The recommended output ceramic capacitor with effective capacitance is in the range of 0.47 μ F to 10 μ F at an output voltage above 9V, where loop response is optimized. When the output capacitance falls below the range, the device may become unstable. Thus, please be careful to consider the DC bias nature of ceramic capacitors when choosing the capacitance value, rated voltage and case size. Need to verify capacitor manufacture's datasheet to ensure enough effective capacitance at desired output voltage.

APPLICATION INFORMATION (continued)

Power Supply Recommendations

The SGM6604 can operate over an input voltage range of 1.85V to 5V. Usually, the input power supply is very stable and located close to the converter. A 4.7µF ceramic bypass capacitor is enough. For some special applications where the input source is more than a few inches far away, an additional electrolytic or tantalum capacitor more than 47µF may be needed. The input power supply's output current needs to comply with the supply voltage, output voltage and output current of the SGM6604.

Layout Guidelines

In addition to component selection, layout is a critical step to ensure the performance. Poor layout could result in system instability, noise and EMI problems, even device damage. Thus, place the inductor, input and output capacitors as close to the IC as possible, and use wide and short traces for current carrying traces to minimize PCB inductance. The length and area of all traces connected to the SW pin should be minimized.

For Boost converter, the output capacitor's current loop

from VOUT pin back to the GND pin of the device is also particularly critical, which should be as small as possible.

Layout Example

A large ground plane on the bottom layer connects the ground pins of the components on the top layer through vias.

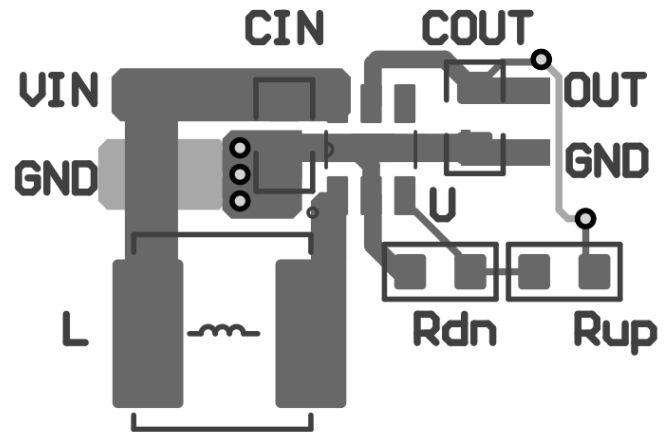


Figure 5. PCB Layout Example

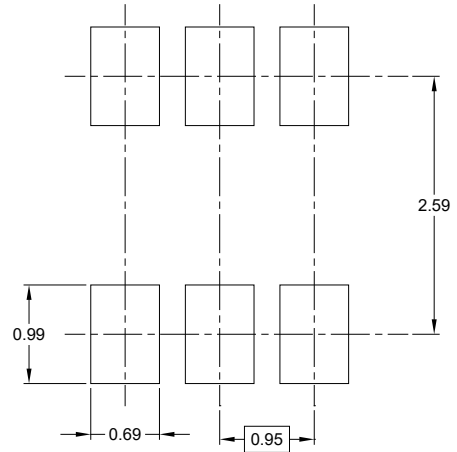
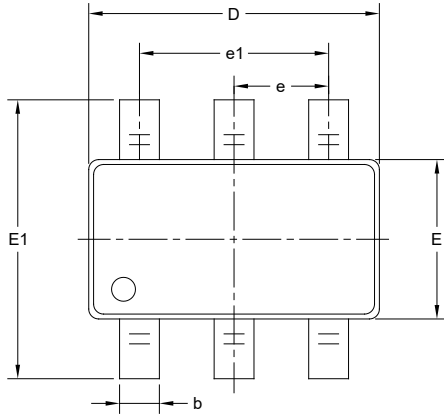
REVISION HISTORY

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

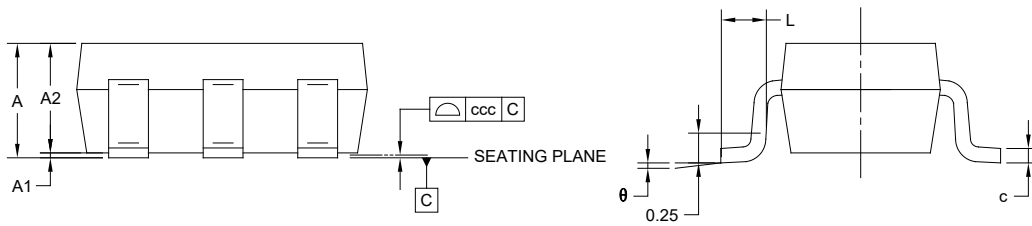
| Changes from Original (DECEMBER 2023) to REV.A | Page |
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| Changed from product preview to production data..... | All |

PACKAGE OUTLINE DIMENSIONS

SOT-23-6



RECOMMENDED LAND PATTERN (Unit: mm)



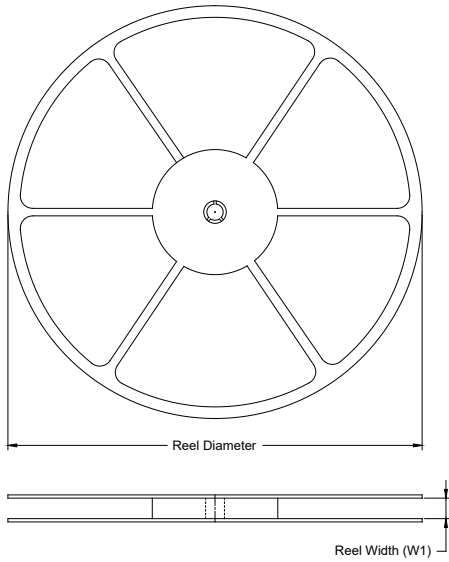
| Symbol | Dimensions In Millimeters | | |
|----------|---------------------------|-----|-------|
| | MIN | MOD | MAX |
| A | - | - | 1.450 |
| A1 | 0.000 | - | 0.150 |
| A2 | 0.900 | - | 1.300 |
| b | 0.300 | - | 0.500 |
| c | 0.080 | - | 0.220 |
| D | 2.750 | - | 3.050 |
| E | 1.450 | - | 1.750 |
| E1 | 2.600 | - | 3.000 |
| e | 0.950 BSC | | |
| e1 | 1.900 BSC | | |
| L | 0.300 | - | 0.600 |
| θ | 0° | - | 8° |
| ccc | 0.100 | | |

NOTES:

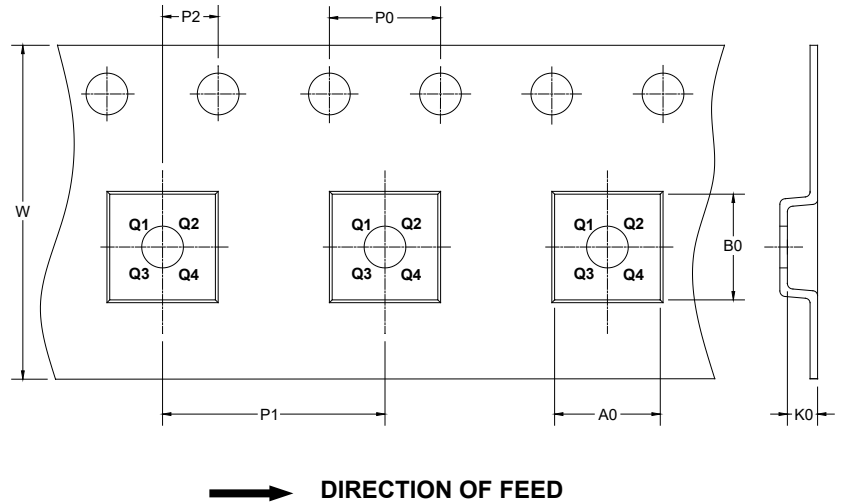
1. This drawing is subject to change without notice.
2. The dimensions do not include mold flashes, protrusions or gate burrs.
3. Reference JEDEC MO-178.

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 |

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