# SGM6612A
# 20V, 10A Fully-Integrated Synchronous Boost Converter with Load Disconnect Control

## DESCRIPTION

The SGM6612A is a 20V high-efficient synchronous Boost converter integrated with two 15mΩ power switches. This device offers small size power solution for portable equipment. The device has high switching frequency up to 2.2MHz with resistor programmable.

The SGM6612A has two operation modes, the pulse width modulation (PWM) mode and pulse frequency modulation (PFM) mode. The PWM mode is applied at moderate to heavy load. The PFM mode is applied at light load to improve the efficiency.

The SGM6612A features a built-in gate driver for external MOSFET, which can isolate the output from the input when the device shuts down or in output short condition. When the output is shorted and the short protection is triggered, the device goes to the hiccup mode for safety. In addition, the device also provides output over-voltage protection, inductor current limit protection and thermal shutdown.

The SGM6612A is available in a Green TQFN-3×3.5-13L package.

## FEATURES

- **2.7V to 16V Input Voltage Range**
- **4.5V to 20V Output Voltage Range**
- **Up to 10A Resistor-Programmable Current Limit**
- **Up to 2.2MHz Resistor-Programmable Switching Frequency**
- **15mΩ Low $R_{DSON}$ Internal MOSFETs**
- **Up to 95% Efficiency (at $V_{IN}$ = 7.2V, $V_{OUT}$ = 16V, $I_{OUT}$ = 2A)**
- **Gate Driver for Load Disconnection**
- **Hiccup Short Protection**
- **Over-Voltage Protection**
- **Auto PFM Mode at Light Load**
- **Available in a Green TQFN-3×3.5-13L Package**

## APPLICATIONS

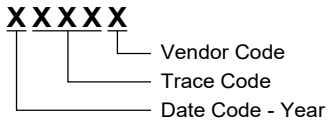
Portable Loudspeaker Boxes
LCD Display Source Driver
Supply for Power Amplifier and Motor Driver
Supply for USB Type-C

# PACKAGE/ORDERING INFORMATION

| MODEL | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE | ORDERING NUMBER | PACKAGE MARKING | PACKING OPTION |
|---|---|---|---|---|---|
| SGM6612A | TQFN-3×3.5-13L | -40℃ to +85℃ | SGM6612AYTQX13G/TR | 6612A<br>YTQX13<br>XXXXX | Tape and Reel, 4000 |

## MARKING INFORMATION

NOTE: XXXXX = Date Code, Trace Code and Vendor 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.

## ABSOLUTE MAXIMUM RATINGS

BOOT Voltage ..... -0.3V to $V_{SW}$ + 6V
VIN, SW, VOUT, DISDRV, EN Voltages ..... -0.3V to 23V
VCC, FB, COMP, FREQ, ILIM Voltages ..... -0.3V to 6V
Package Thermal Resistance
TQFN-3×3.5-13L, $\theta_{JA}$ ..... 66℃/W
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility
HBM ..... 2000V
CDM ..... 1000V

## RECOMMENDED OPERATING CONDITIONS

Input Voltage Range ..... 2.7V to 16V
Output Voltage Range ..... 4.5V to 20V
Operating Ambient Temperature Range ..... -40℃ to +85℃
Operating Junction Temperature Range ..... -40℃ to +125℃

## 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

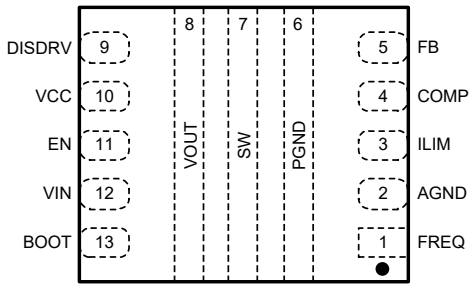
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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

(TOP VIEW)




TQFN-3×3.5-13L

## PIN DESCRIPTION

| PIN | NAME | I/O | FUNCTION |
|---|---|---|---|
| 1 | FREQ | I | Adjustable Switching Frequency Pin. A resistor is placed between FREQ and the AGND to program the switching frequency. Do not leave this pin floating in application. |
| 2 | AGND | - | Analog Signal Ground. |
| 3 | ILIM | I | Adjustable Peak Switch Current Limit. A resistor is placed between ILIM and AGND to program the peak switch current limit. |
| 4 | COMP | O | Output of the Internal Error Amplifier. Put the loop compensation network between this pin and the AGND. |
| 5 | FB | I | Voltage Feedback. Connect to the resistor divider to program the output voltage. |
| 6 | PGND | PWR | Power Ground. Connect to the source of the low-side MOSFET. |
| 7 | SW | PWR | Switch Node of the Converter. Connect to the internal power MOSFETs. |
| 8 | VOUT | PWR | Boost Converter Output. |
| 9 | DISDRV | O | Gate Drive Output for the External Disconnect MOSFET. Connect this pin to the gate of the external MOSFET. When the load disconnect function is not used, leave it floating. |
| 10 | VCC | O | Output of the Internal Regulator. Connect this pin to ground with a capacitor more than 1.0μF. |
| 11 | EN | I | Enable Input Pin. Logic high enables the device. Logic low shuts down the device. |
| 12 | VIN | I | Power Supply. |
| 13 | BOOT | O | Gate Driver Supply of High-side MOSFET. Connect this pin to SW pin with a ceramic capacitor. |

NOTE: I: input, O: output, PWR: power for the circuit.

## ELECTRICAL CHARACTERISTICS

($V_{IN}$ = 2.7V to 14V and $V_{OUT}$ = 16V, $T_J$ = -40℃ to +125℃, typical values are at $T_J$ = +25℃, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **Power Supply** | | | | | | |
| Input Voltage Range | $V_{IN}$ | | 2.7 | | 16 | V |
| Minimum Input Voltage Range for Start-up | $V_{IN_SS}$ | $T_J$ = +25℃ | | 3.0 | 3.3 | V |
| Input Voltage Under-Voltage Lockout Threshold | $V_{IN_UVLO}$ | $V_{IN}$ rising, $T_J$ = -40℃ to +85℃ | | 2.6 | 2.7 | V |
| | | $V_{IN}$ falling, $T_J$ = -40℃ to +85℃ | | 2.5 | 2.6 | |
| VIN UVLO Hysteresis | $V_{IN_HYS}$ | | | 100 | | mV |
| VCC Regulation Voltage | $V_{CC}$ | $I_{CC}$ = 5mA, $V_{IN}$ = 6V | | 5 | | V |
| VCC UVLO Threshold | $V_{CC_UVLO}$ | $V_{CC}$ falling | | 2.2 | | V |
| Quiescent Current into VIN Pin | $I_Q$ | IC enabled, no load, no ext. MOSFET, $V_{IN}$ = 6V, $V_{OUT}$ = 20V, $V_{FB}$ = 1.23V, $T_J$ = -40℃ to +85℃ | | 0.35 | 0.5 | μA |
| Quiescent Current into VOUT Pin | | | | 125 | 200 | |
| Shutdown Current into VIN Pin | $I_{SD}$ | IC disabled, $V_{IN}$ = 6V, $T_J$ = -40℃ to +85℃ | | 1.2 | 3 | μA |
| | | IC disabled, $V_{IN}$ = 16V, $T_J$ = -40℃ to +85℃ | | 3.7 | 6 | |
| Leakage Current of Low-side MOSFET | $I_{LS_LKG}$ | IC disabled, $V_{IN}$ = 16V, $V_{OUT}$ = $V_{SW}$ = 20V, $T_J$ = -40℃ to +85℃ | | 0.1 | 5 | μA |
| **Output Voltage** | | | | | | |
| Output Voltage Range | $V_{OUT}$ | $f_{SW}$ = 530kHz | 4.5 | | 20 | V |
| Output Over-Voltage Protection Threshold | $V_{OVP}$ | $V_{IN}$ = 8V, $V_{OUT}$ rising | 20.4 | 21 | 21.7 | V |
| **Power Switches** | | | | | | |
| High-side MOSFET On-Resistance | $R_{DSON}$ | $V_{CC}$ = 5V | | 15 | 27 | mΩ |
| Low-side MOSFET On-Resistance | | $V_{CC}$ = 5V | | 15 | 27 | mΩ |
| Power Stage Trans-Conductance (peak current ratio with comp voltage) | $G_m$ | $V_{CC}$ = 5V | | 12 | | A/V |
| **Current Limit** | | | | | | |
| Resistor-Programmable Current Limit | $I_{LIM}$ | $R_{LIM}$ = 80.6kΩ, $T_J$ = +25℃ | 7.6 | 9 | 10.8 | A |
| Short Current Limit | $I_{LIM_SHORT}$ | | | 20 | | A |
| **Voltage Reference** | | | | | | |
| Reference Voltage at FB Pin | $V_{REF}$ | PWM operation | 1.180 | 1.198 | 1.215 | V |
| | | Auto PFM operation | | 100.2% | | $V_{REF}$ |
| Leakage Current into FB Pin | $I_{FB_LKG}$ | | | 10 | 50 | nA |

## ELECTRICAL CHARACTERISTICS (continued)

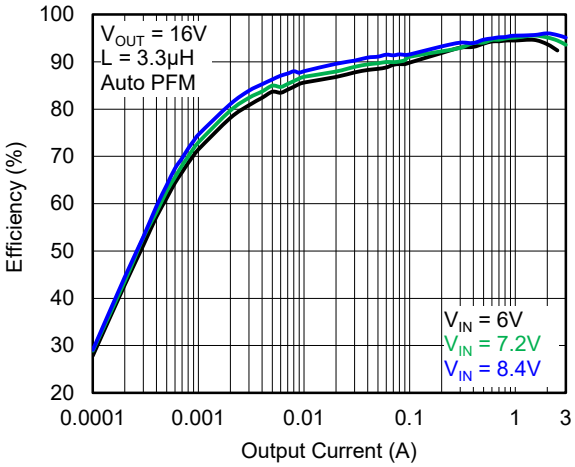
($V_{IN}$ = 2.7V to 14V and $V_{OUT}$ = 16V, $T_J$ = -40℃ to +125℃, typical values are at $T_J$ = +25℃, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| **EN Logic** | | | | | | |
| EN Pin Logic High Threshold | $V_{EN_H}$ | | 1.3 | | | V |
| EN Pin Logic Low Threshold | $V_{EN_L}$ | | | | 0.4 | V |
| EN Pin Pull-Down Resistor | $R_{EN}$ | | | 700 | | kΩ |
| **Error Amplifier** | | | | | | |
| COMP Pin Output High Voltage | $V_{COMP_H}$ | High threshold, $V_{FB}$ = $V_{REF}$ - 100mV, $R_{LIM}$ = 80.6kΩ | | 2.0 | | V |
| COMP Pin Output Low Voltage | $V_{COMP_L}$ | Low threshold, $V_{FB}$ = $V_{REF}$ + 100mV, $R_{LIM}$ = 80.6kΩ | | 0.4 | | V |
| Error Amplifier Trans-Conductance | $G_{mEA}$ | $V_{COMP}$ = 1.2V | | 270 | | μS |
| COMP Pin Sink Current | $I_{SINK}$ | $V_{FB}$ = $V_{REF}$ + 100mV, $V_{COMP}$ = 1.2V | | 160 | | μA |
| COMP Pin Source Current | $I_{SOURCE}$ | $V_{FB}$ = $V_{REF}$ - 100mV, $V_{COMP}$ = 1.2V | | 25 | | μA |
| **Current Limit** | | | | | | |
| Waiting Time for Restart in Hiccup Mode | $t_{HIC_OFF}$ | | | 90 | | ms |
| **Soft-Start** | | | | | | |
| Start-Up Time | $t_{START-UP}$ | | | 3.2 | | ms |
| Pre-Charge Time | $t_{PRE_CHARGE}$ | $T_J$ = +25℃ | 1.8 | 2.5 | 3.2 | ms |
| **Protection** | | | | | | |
| Thermal Shutdown Rising Threshold | $T_{SD_R}$ | $T_J$ rising | | 155 | | ℃ |
| Thermal Shutdown Falling Threshold | $T_{SD_F}$ | $T_J$ falling | | 130 | | ℃ |
| **Switching Frequency** | | | | | | |
| Switching Frequency | $f_{SW}$ | $R_{FREQ}$ = 348kΩ | 460 | 530 | 600 | kHz |
| | | $R_{FREQ}$ = 842kΩ | 205 | 245 | 285 | |
| | | $R_{FREQ}$ = 75kΩ | 1750 | 2050 | 2350 | |
| Minimum On-Time | $t_{ON_MIN}$ | | | 120 | | ns |
| **Gate Driver for Load Disconnect** | | | | | | |
| Driver Current for the External MOSFET | $I_{GD_SINK}$ | | | 55 | | μA |

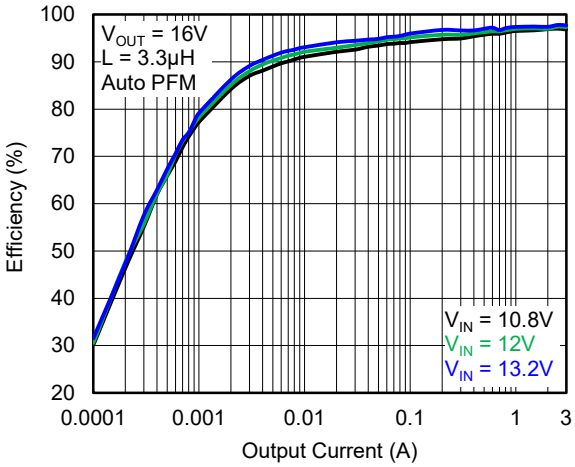
## TYPICAL PERFORMANCE CHARACTERISTICS

At $T_J$ = +25℃, $V_{IN}$ = 7.2V and $V_{OUT}$ = 16V, unless otherwise noted.

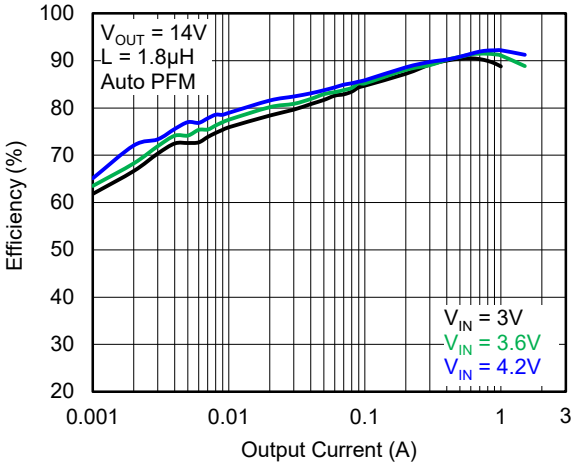
Efficiency vs. Output Current



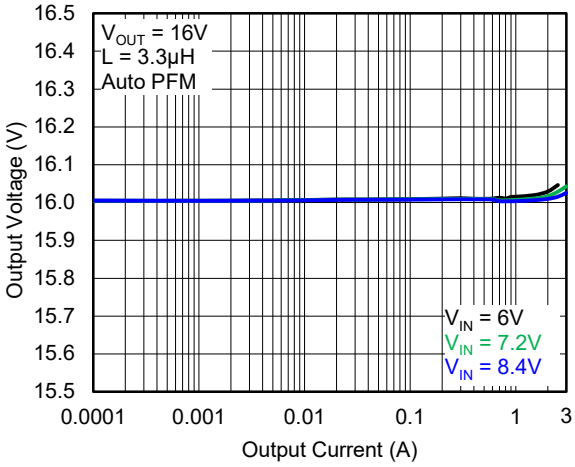

Efficiency vs. Output Current



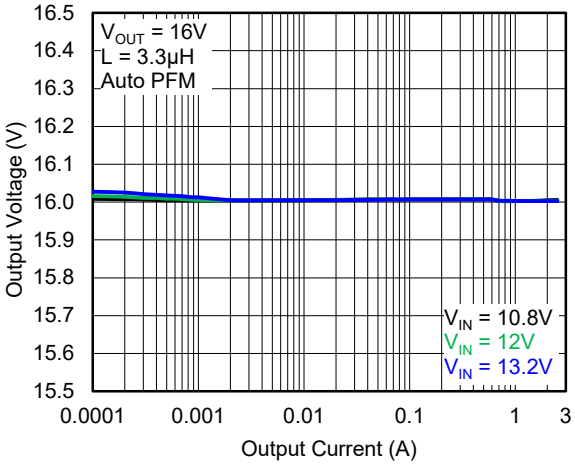

Efficiency vs. Output Current



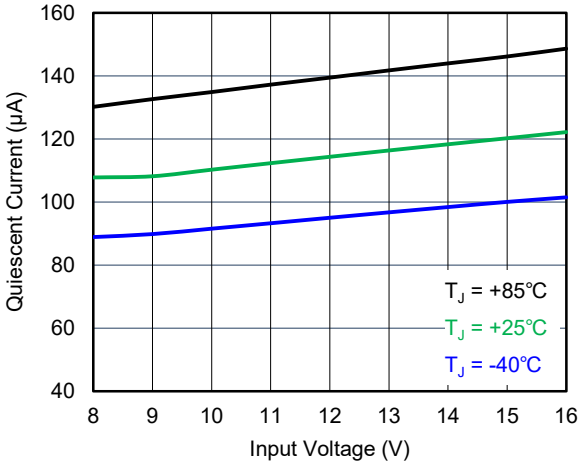

Output Voltage vs. Output Current




Output Voltage vs. Output Current



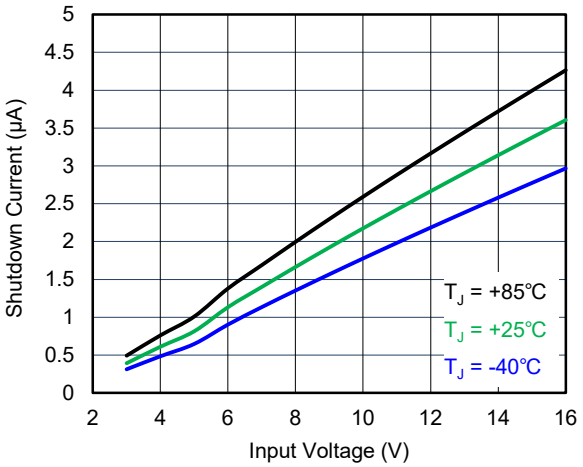

Quiescent Current vs. $V_{IN}$



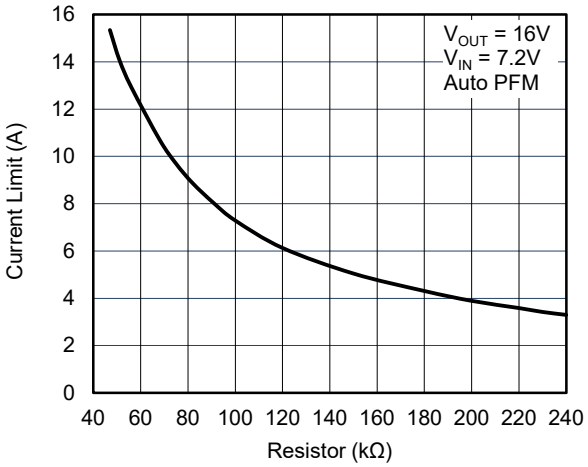
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_J$ = +25℃, $V_{IN}$ = 7.2V and $V_{OUT}$ = 16V, unless otherwise noted.

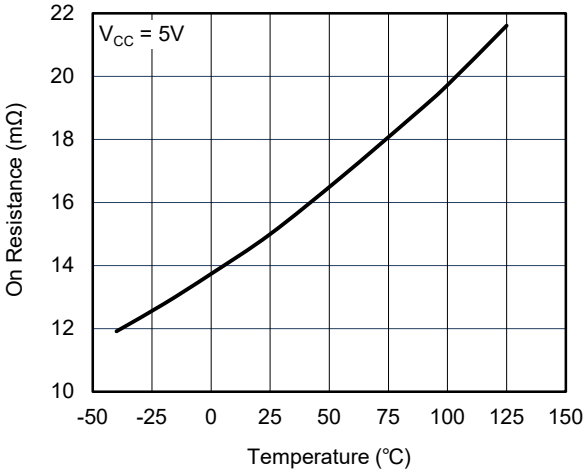
Shutdown Current vs. $V_{IN}$



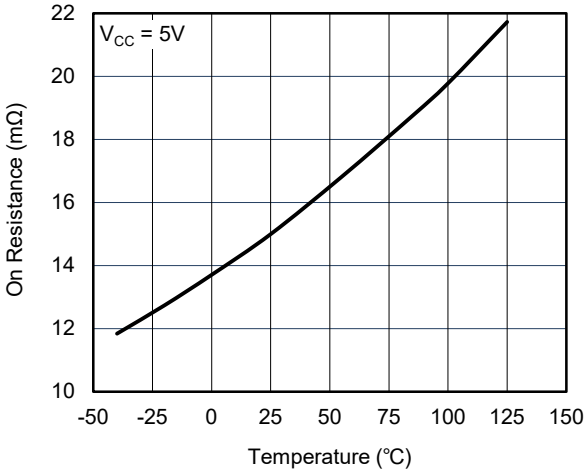

Switch Current Limit vs. Setting Resistor



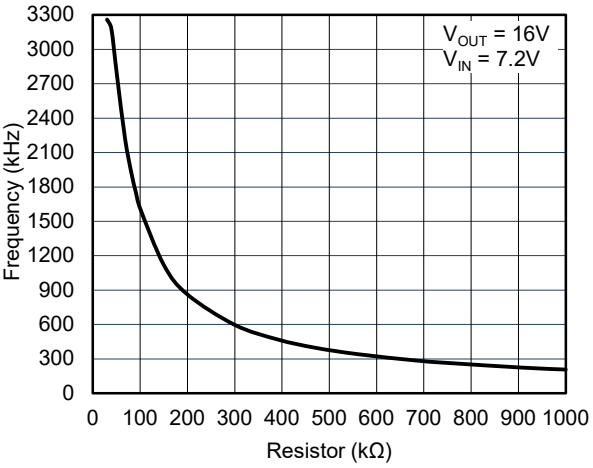

LS $R_{DSON}$ vs. Temperature



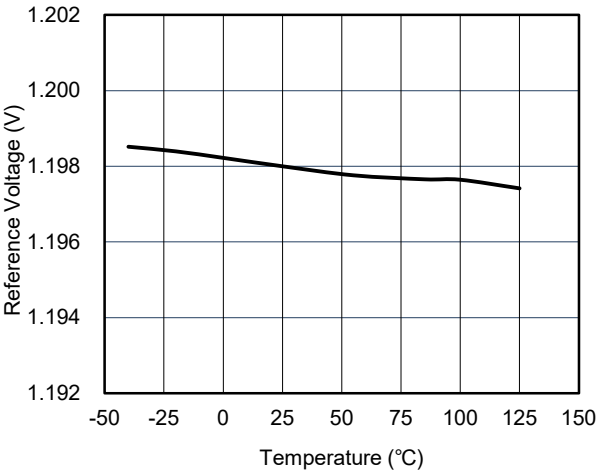

HS $R_{DSON}$ vs. Temperature




Frequency vs. Setting Resistor



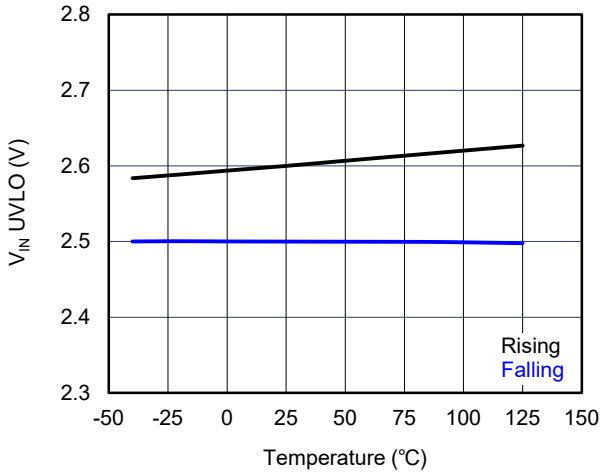

Reference Voltage vs. Temperature



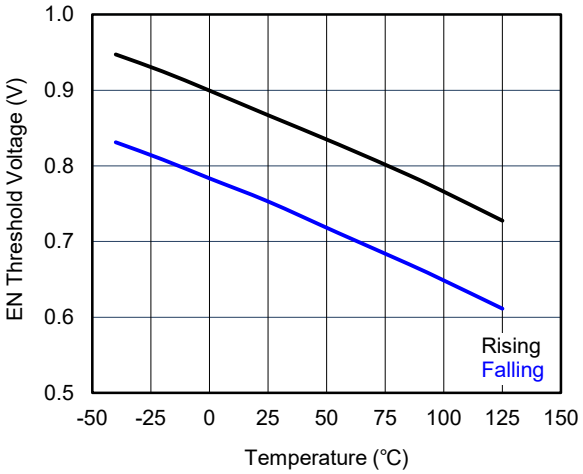
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At $T_J$ = +25℃, $V_{IN}$ = 7.2V and $V_{OUT}$ = 16V, unless otherwise noted.

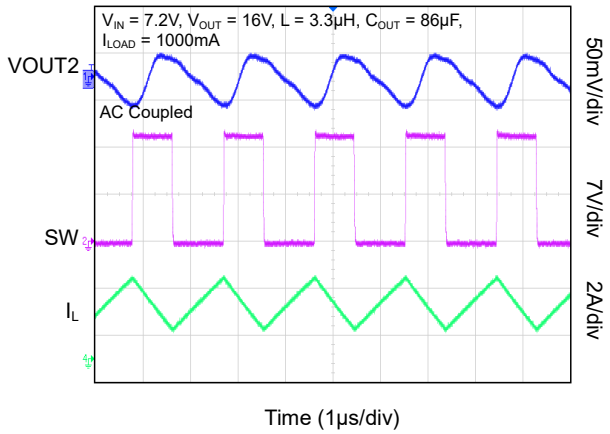
$V_{IN}$ UVLO Rising/Falling Threshold vs. Temperature



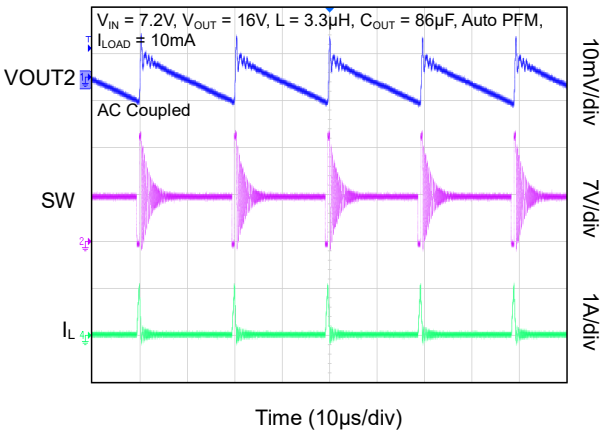

EN Rising/Falling Threshold vs. Temperature



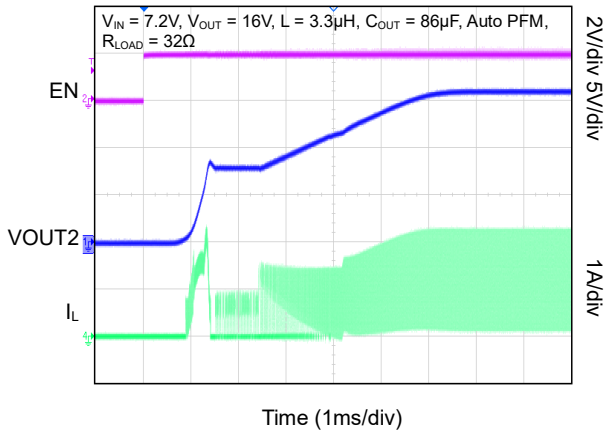

Steady State 1000mA



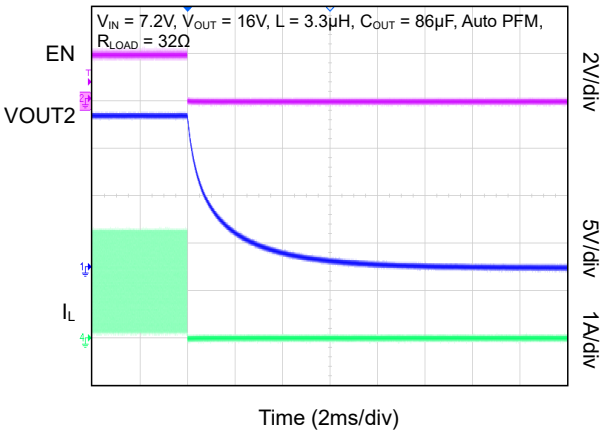

Steady State 10mA




Start-Up by EN



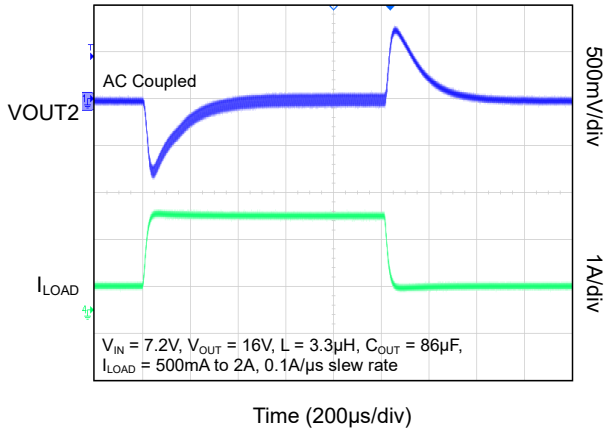

Shutdown by EN



## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

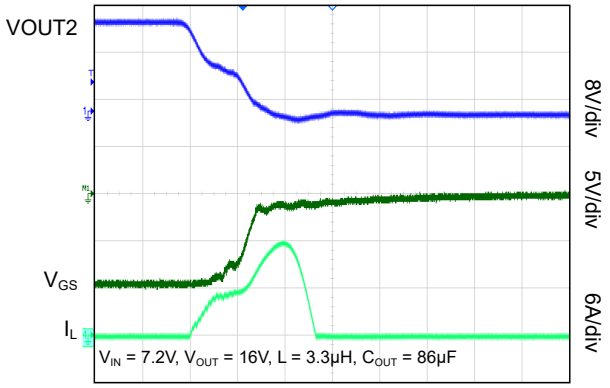
At $T_J$ = +25℃, $V_{IN}$ = 7.2V and $V_{OUT}$ = 16V, unless otherwise noted.

Load Transient



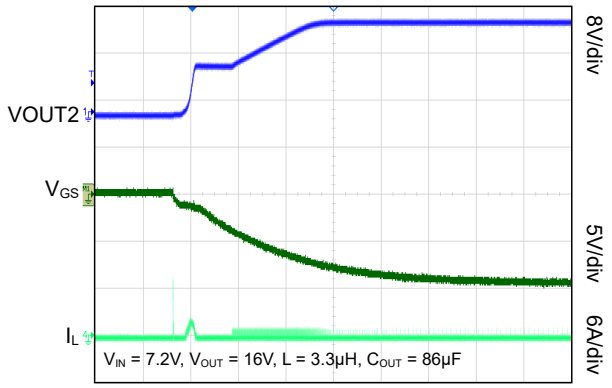

Time (200μs/div)

Short-Circuit Protection




Time (10μs/div)

Output Short Release (with Load Disconnect MOSFET)




Time (2ms/div)

# FUNCTIONAL BLOCK DIAGRAM

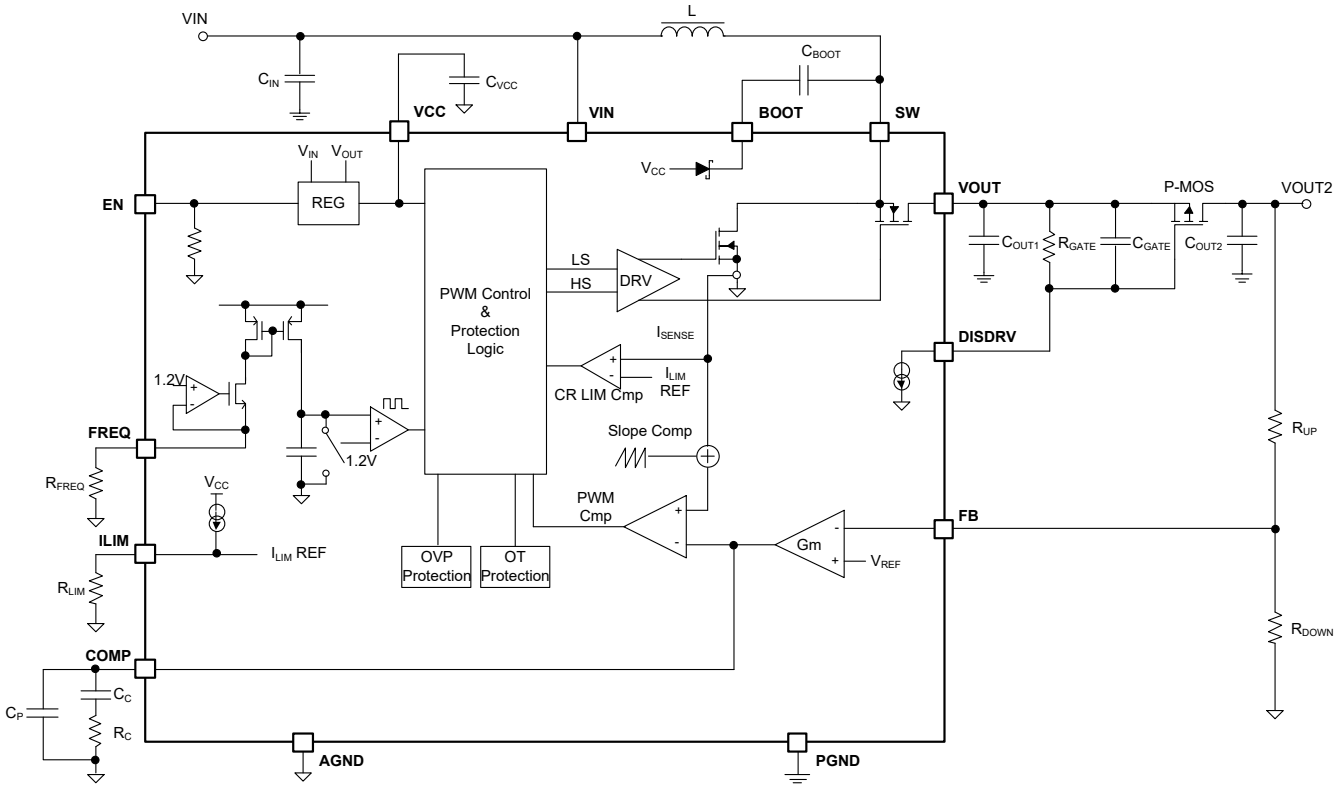



**Figure 1. Block Diagram**

# DETAILED DESCRIPTION

The SGM6612A, a synchronous Boost converter, integrates two 15mΩ power switches. It is capable of delivering up to 10A peak switch current and up to 20V output voltage. In moderate to heavy load condition, the SGM6612A works in PWM mode with fixed frequency. In light load condition, the SGM6612A operates in the auto PFM mode to improve the efficiency. Excellent line and load transient response can be achieved with minimal output capacitance by applying a peak current control topology. The external loop compensation makes a wider range of inductor and output capacitor combinations available.

The SGM6612A supports the resistor-programmable switching frequency of up to 2.2MHz. In Boost operation, the device can avoid overload with the help of peak current control topology. In addition, if the output current is higher than the short current threshold or the output voltage is less than the short voltage threshold, hiccup current protection will be started in which the regulator remains off for 90ms before restarting the converter. The device has a gate driver for external MOSFETs to disconnect the output from the input side in off-state or output short-circuit conditions.

## Under-Voltage Lockout (UVLO)

An under-voltage lockout circuit prevents operation at input voltages below 2.5V (TYP) with a hysteresis of 100mV. Therefore, if the input voltage rises and exceeds 2.6V (TYP), the device restarts.

## Enable and Disable

When the input voltage exceeds minimum input voltage during start-up and the EN voltage is higher than its logic high threshold, the SGM6612A is enabled. When the EN voltage is lower than its logic low threshold, the SGM6612A enters shutdown mode.

## Start-up

The SGM6612A implements the soft-start function to reduce the inrush current during start-up. The device first charges the output voltage to 1.1 × $V_{IN}$ with the fixed 500kHz switching frequency during pre-charge phase. After the precharge phase (2.5ms, TYP), the output voltage will rise gradually and linearly to the target value. The soft-start time is 3.2ms (TYP). Then, the switching frequency is set by the resistor connected through the FREQ pin.

## Load Disconnect Gate Driver

The external MOSFET is driven by the DISDRV pin at the output to isolate the output from the input in shutdown or output short-circuit condition. During the start-up phase, the load disconnect MOSFET is softly turned on by an internal sink current (55μA, TYP). The load disconnect MOSFET connection is shown in Figure 2.

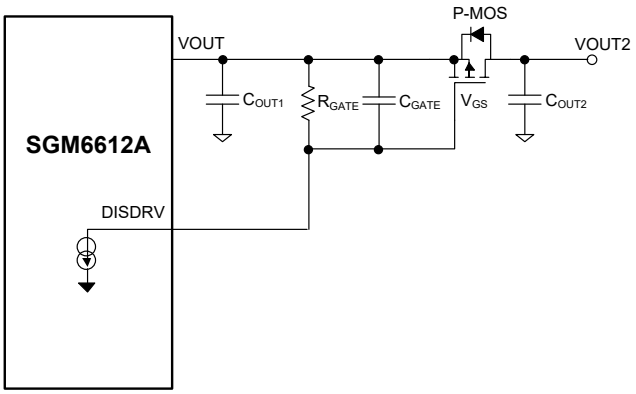



**Figure 2. The Load Disconnect MOSFET Configuration**

The driver voltage and turn-on/off timing can be set by the resistor and capacitor which are connected between DISDRV pin and VOUT pin.

# DETAILED DESCRIPTION (continued)

## Adjustable Peak Current Limit

To avoid accidental large peak current, an internal cycle-by-cycle current limit is adopted.

By connecting a resistor to the ILIM pin, the peak switch current limit can be set. Calculate the correct resistor value according to Equation 1 as below:

$$R_{LIM} = \frac{730}{I_{LIM}} \quad (1)$$

where:

$R_{LIM}$ is the resistor used to set the current limit (kΩ).

$I_{LIM}$ is the peak switch current limit (A).

For example, a 50kΩ resistor gives a 14.6A peak current limit.

Switch current limit and resistor setting of SGM6612A (Auto PFM) with 7.2V input and 16V output is in Figure 3.

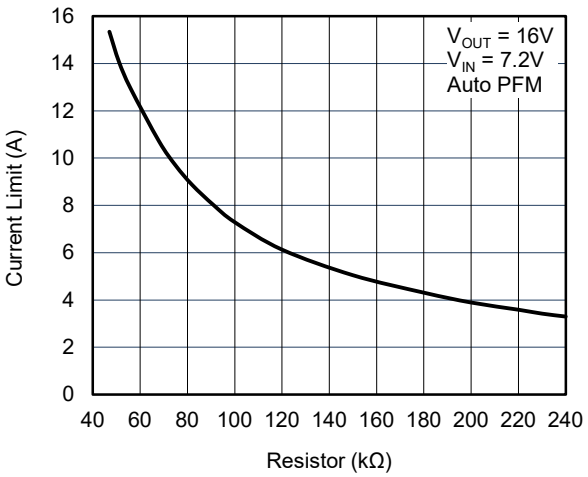



**Figure 3. Switch Current Limit vs. Setting Resistor**

## Adjustable Switching Frequency

The SGM6612A has an adjustable switching frequency up to 2.2MHz. The switching frequency is set by an external resistor connected between the FREQ pin and the AGND. Do not leave the FREQ pin floating. For VIN close to VOUT applications, it is recommended to program the switching frequency under 1.1MHz to avoid triggering device minimum on-time. The resistor value is calculated by Equations as follows.

$$T = \frac{1}{Freq} = k \times C_{FREQ} \times R_{FREQ} + t_{DELAY} \quad (2)$$

$$R_{FREQ} = \frac{\frac{1}{Freq} - t_{DELAY}}{k \times C_{FREQ}} \quad (3)$$

where:

$t_{DELAY}$ = 50ns, k = 3, $C_{FREQ}$ = 1.8pF.

For example, when $R_{FREQ}$ is 348kΩ, the frequency is 530kHz.

Switching frequency versus setting resistor please see Figure 4 ($V_{OUT}$ = 16V and $V_{IN}$ = 7.2V).

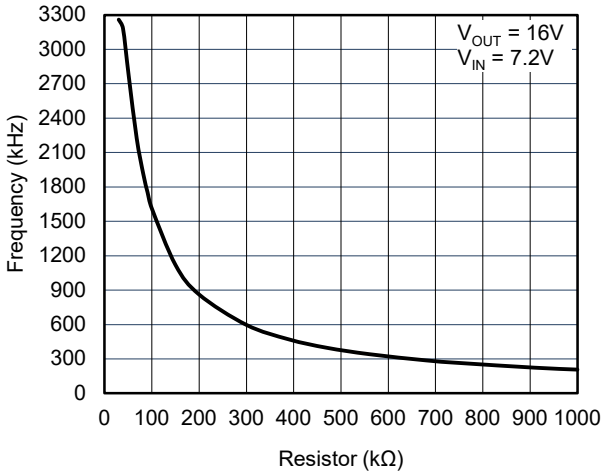



**Figure 4. Switching Frequency vs. Setting Resistor**

## DETAILED DESCRIPTION (continued)

### Start-up with Pre-biased Output

The low-side switch is prohibited from turning on and discharging the output if a pre-biased voltage is sensed on the output before start-up. As long as the internal soft-start voltage is higher than $V_{FB}$, the low-side switch is allowed to sink current to have a monotonic start-up with pre-biased output.

### Bootstrap Voltage (BOOT)

A small ceramic capacitor between the BOOT pin and the SW pin provides gate current to charge the gate of the high-side MOSFET device during the on-time of each cycle and to charge the bootstrap capacitor. The value of this capacitor is recommended to be above 0.1μF.

### Device Functional Modes

The synchronous Boost converter SGM6612A operates at a constant frequency PWM mode 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 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 N-MOSFET in a dead-time duration. After the dead-time duration, the high-side N-MOSFET switch is turned on. Because 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 SGM6612A has internal slope compensation.

The device features a power-save PFM mode in light load condition. When the output load is reduced, the peak current is also decreasing but has a minimum value. When the load is further reduced and the peak current is clamped and cannot be reduced further, then the error amplifier output (COMP pin) will be low enough to reach the pre-set low threshold and the device stops switching. In light load condition, the frequency is reduced depending on the load to minimize the switching and gate driving losses and keep the efficiency high.

When $V_{OUT}$ is close to $V_{IN}$, the Boost converter cannot support the duty cycle anymore. It enables its built-in Diode Mode which enables the converter to regulate the output voltage. When operating in Diode Mode, the converter's rectifier switch stops switching to regulate the output voltage. The efficiency during Diode Mode operation is reduced so that it is recommended that $V_{IN}$ be at least 1V lower than $V_{OUT}$.

### Hiccup Mode Short Protection (with Load Disconnect MOSFET)

SGM6612A equips a hiccup protection mode. When the inductor current reaches the short-circuit protection limit threshold of 20A (TYP) or the output voltage is less than 30% of the normal output voltage (TYP), hiccup protection mode starts. In this mode, the device turns off for a 90ms (TYP) wait time. After the short-circuit condition is removed, the device recovers automatically.

### Over-Voltage Protection (OVP)

The SGM6612A provides 21V (TYP) OVP threshold. The device stops switching immediately until the voltage at the VOUT pin drops 500mV below the output over-voltage protection threshold. The OVP circuitry monitors the output voltage ($V_{OUT}$) and protects VOUT 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℃ (TYP), the device stops switching. Once the temperature drops below +130℃ (TYP), the device resumes operation.

# APPLICATION INFORMATION

## Typical Application

The typical application is for 6V to 14V input, 16V output converter.

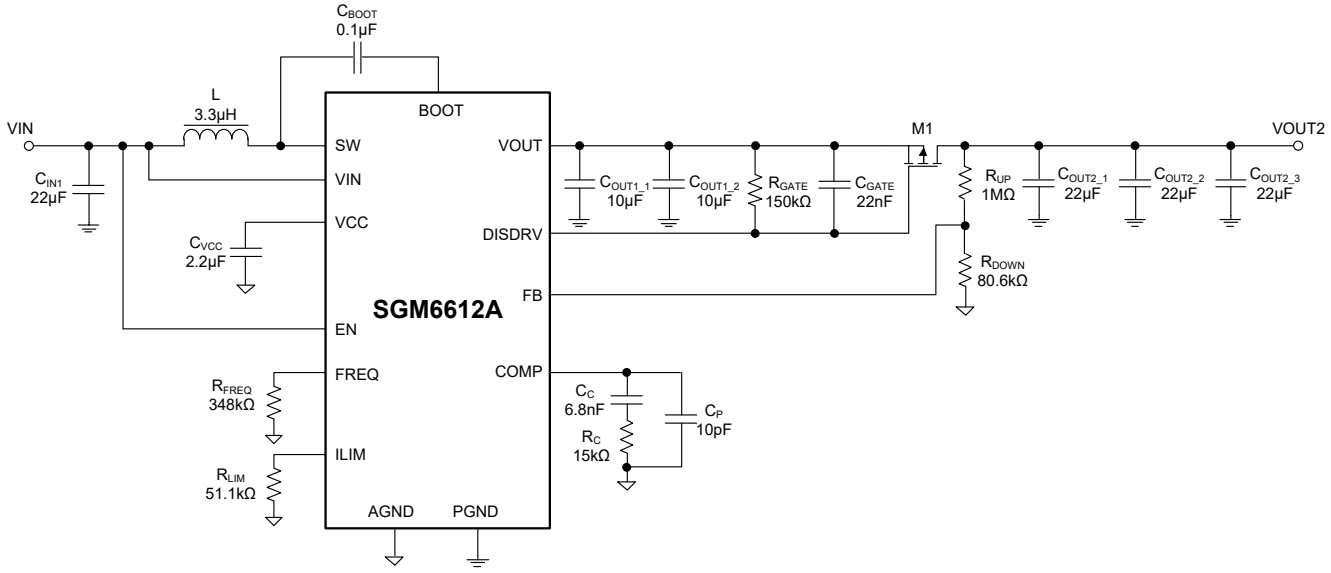



**Figure 5. SGM6612A Typical Application Circuit with 16V Output**

## Design Requirements

Table 1 shows the design parameters in this design.

**Table 1. Design Parameters**

| Parameter | Value |
|---|---|
| Input Voltage Range | 6V to 14V |
| Output Voltage | 16V |
| Output Ripple Voltage | ±3% |
| Output Current Rating | 3A |
| Operating Frequency | 530kHz |

**Table 2. Recommended Inductors for SGM6612A**

| Part Number | L (μH) | DCR TYP (mΩ) | Saturation Current/Heat Rating Current (A) | Size (L × W × H mm$^3$) | Manufacturer |
|---|---|---|---|---|---|
| 744325180 | 1.8 | 3.5 | 18 | 5 × 10 × 4 | Würth |
| 74437368033 | 3.3 | 11.8 | 23/8 | 10 × 10 × 3.8 | Würth |
| DFEH10040D-3R3M# | 3.3 | 12 | 10/10 | 10.9 × 10 × 4 | Murata/TOKO |
| PIMB104T-4R7MS | 4.7 | 20.0 | 15/8.5 | 10.9 × 10 × 3.8 | Cyntec |
| 74437368068 | 6.8 | 17.5 | 14 | 11 × 10 × 3.8 | Würth |
| 74437368100 | 10 | 27 | 12.5 | 11 × 10 × 3.8 | Würth |

**Table 3. Recommended Capacitors for SGM6612A**

| Designator | Qty | Value | Description | Package | Part Number | Manufacturer |
|---|---|---|---|---|---|---|
| $C_{IN1}$, $C_{OUT2_1}$, $C_{OUT2_2}$, $C_{OUT2_3}$ | 4 | 22μF | CAP, CERM, 22μF, 25V, ±10%, X5R, 1210 | 1210 | GRM32ER61E226KE15L | Murata |
| $C_{OUT1_1}$, $C_{OUT1_2}$ | 2 | 10μF | CAP, CERM, 10μF, 25V, ±20%, X5R, 0603 | 0603 | GRM188R61E106MA73D | Murata |
| $C_{BOOT}$ | 1 | 0.1μF | CAP, CERM, 0.1μF, 16V, ±10%, X5R, 0402 | 0402 | GRM155R61C104KA88D | Murata |
| $C_C$ | 1 | 6.8nF | CAP, CERM, 6.8nF, 25V, ±10%, X7R, 0402 | 0402 | GRM155R71E682KA01D | Murata |
| $C_{VCC}$ | 1 | 2.2μF | CAP, CERM, 2.2μF, 10V, ±20%, X5R, 0402 | 0402 | GRM155R61A475MEAAD | Murata |

# APPLICATION INFORMATION (continued)

### Setting the Peak Current Limit

The peak current limit of the SGM6612A is set by an external resistor. For setting a current limit of 13A, the resistor value is 56kΩ after calculation. Due to the distribution of the current limit, it is recommended to select a resistor about 10% less than the calculated value for safety. Here, 51.1kΩ resistor is a preferable choice.

### Setting the Output Voltage

The output voltage is set by a resistor divider network. Calculate the output voltage by Equation 4:

$$V_{OUT} = V_{FB} \times \left(1 + \frac{R_{UP}}{R_{DOWN}}\right) \quad (4)$$

where:

- $V_{OUT}$ is the output voltage.
- $R_{UP}$ is the top divider resistor.
- $R_{DOWN}$ is the bottom divider resistor.

For setting an output voltage of 16V, choose $R_{DOWN}$ to be about 80.6kΩ, calculated by Equation 4, and $R_{UP}$ is 1MΩ.

### Selecting the Output Capacitors

It is recommended to use 3 × 22μF X5R or X7R MLCC capacitors connected in parallel for most applications. Refer to Table 3.

With the connection of the load disconnect MOSFET, the output capacitor should be divided into two parts, shown in Figure 6. $C_{OUT2}$ should be no greater than 10 × $C_{OUT1}$ to avoid the inrush current when the disconnect MOSFET is turned on.

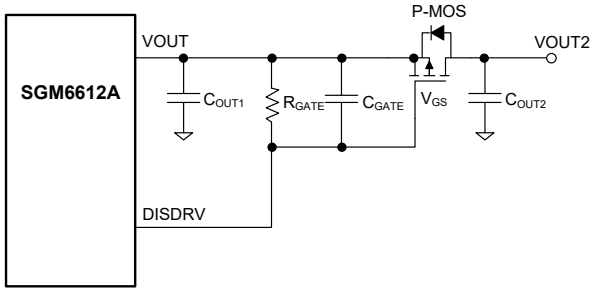



**Figure 6. Output Capacitor Configuration with Load Disconnect MOSFET**

### Selecting the Input Capacitors

A 22μF input capacitor is enough for most applications. To reduce the input current ripple, larger values may also be allowed. See Table 3.

### Loop Stability and Compensation

**Table 4. Recommended L, $R_C$ and $C_C$ for Different Output Voltages and Frequencies**

| $f_{SW}$ (kHz) | $V_{OUT}$ (V) | L (μH) | $C_C$ (nF) | $R_C$ (kΩ) |
|---|---|---|---|---|
| 530 | 20 | 1.8/3.3 | 6.8 | 15 |
| 530 | 16 | 1.8/3.3 | 6.8 | 15 |
| 530 | 5 | 1.2 | 6.8 | 5 |
| 2050 | 20 | 1.8 | 2.2 | 50 |
| 2050 | 16 | 1.8 | 2.2 | 50 |
| 2050 | 5 | 0.68 | 2.2 | 20 |
| 240 | 20 | 6.8 | 10 | 5 |
| 240 | 16 | 6.8 | 10 | 5 |
| 240 | 5 | 3.3 | 10 | 2 |

### Selecting the Disconnect MOSFET

The SGM6612A has a gate driver to control an external MOSFET. When the device shuts down or output shorts, it disconnects the output from the input, shown in Figure 7.

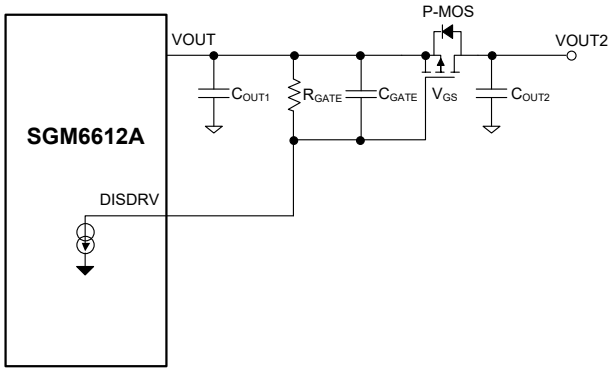



**Figure 7. Load Disconnect MOSFET Connection**

$V_{DS}$ and $I_{DS}$ ratings and safe operating area (SOA) should be considered when MOSFET is selected.

- The drain-to-source voltage rating should be larger than the maximum output $V_{DS_DIS_MAX} = V_{OUT}$.
- The drain-to-source RMS current rating is the maximum output current $I_{DS_DIS_RMS} = I_{OUT}$.
- Considering the SOA when the output is short-circuited, the short protection response time and surge current can result in heat, SOA > $Q_{SHORT}$.

$$Q_{SHORT} = \frac{1}{2} \times V_{OUT} \times I_{SHORT} \times t_{SHORT} \quad (5)$$

## APPLICATION INFORMATION (continued)

where:

- $V_{DS_DIS_MAX}$ is the drain-source maximum voltage.
- $I_{DS_DIS_RMS}$ is the drain-source RMS current.
- $I_{SHORT}$ is the short current.
- $t_{SHORT}$ is the response time before the short protection is triggered.
- $Q_{SHORT}$ is the heat generated by the output short.

For instance: $V_{OUT}$ = 16V, $I_{SHORT}$ = 20A, $t_{SHORT}$ = 30μs.

SOA ≥ 4.8mJ, $V_{DS_DIS_MAX}$ ≥ 16V.

The CSD25404Q3-20V P-Channel Power MOSFET is recommended for this design example.

To reduce the turn-on speed, an additional capacitor is recommended to put between the gate and source of the external MOSFET.

$$t_{ON_P-MOS} = \frac{V_{TH_P-MOS} \times C_{GS_P-MOS}}{I_{DIS_P-MOS}} \quad (6)$$

where:

- $t_{ON_P-MOS}$ is the on-time of external MOSFET.
- $V_{TH_P-MOS}$ is the gate threshold of external MOSFET.
- $C_{GS_P-MOS}$ is the total gate capacitance between gate and source of external MOSFET (including the self-gate-source capacitance of the MOSFET).
- $I_{DIS_P-MOS}$ is a typical 55μA discharge current inside the device.

Given $V_{TH}$ = 1.5V and $C_{GS_P-MOS}$ = 10nF, $t_{ON_P-MOS}$ is about 300μs. It should be noted that the maximum turn-on time should be no more than 3ms, and the maximum capacitance $C_{GS_P-MOS}$ should be less than 100nF. That is to say, if the disconnected MOSFET could not be turned on within the 3ms, the device would not start up normally.

When selects the gate resistor, the gate-source voltage of the external MOSFET should be referenced.

$$V_{GATE} = R_{GATE} \times I_{DIS_P-MOS} \quad (7)$$

$$R_{GATE} = \frac{V_{GATE}}{I_{DIS_P-MOS}} \quad (8)$$

Given the 5V $V_{GATE}$, the $R_{GATE}$ = 100kΩ.

**Selecting the Bootstrap Capacitor**

A range of 0.047μF ~ 0.1μF capacitor is recommended for bootstrap capacitor. And 0.1μF is used in this design. Refer to Table 3.

**$V_{CC}$ Capacitor**

The value of $V_{CC}$ capacitor should be at least 10 times larger than the value of $C_{BOOT}$. A 1μF ~ 2.2μF capacitor value range is recommended for $V_{CC}$ capacitor. A value of 2.2μF is recommended in this example, please see Table 3.

### Layout Guidelines

As for all switching power supplies, especially those high frequency and high current ones, layout is an important design step. Poor layout could result in system instability, EMI failure, and device damage. Therefore, use wide and short traces for high current paths. Thus, place input capacitor as close to the VIN pin and GND pin as possible. If possible, choose higher capacitance value for $C_{IN}$. The SW pin carries high current with fast rising and falling edges, therefore, all connections to the SW pin should be kept as short and wide as possible. The output capacitor $C_{OUT}$ should be put close to VOUT. It is also beneficial to have the ground of $C_{OUT}$ close to the GND pin since there is large ground return current flowing between them. Sensitive signals like FB, COMP traces must be placed away from SW trace. The ground of these signals should be connected to GND pin and separated with power ground.

# APPLICATION INFORMATION (continued)

## System Examples

**SGM6612A (14V Output, 2.7V to 4.4V Input)**

The schematic of a typical application circuit that is used for 14V output voltage from 2.7V to 4.4V input voltage of SGM6612A is given in Figure 8. The inductor has a minimum of 1.8μH for the 14V output.

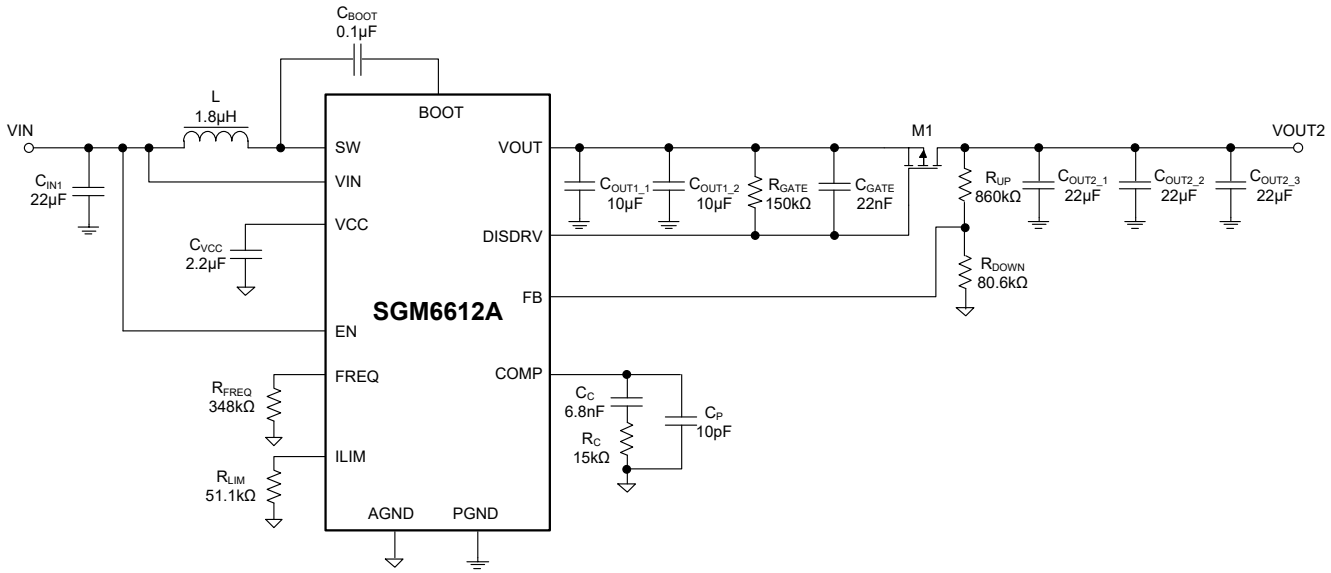



**Figure 8. SGM6612A 14V Output Voltage from 2.7V to 4.4V Input Voltage**

**SGM6612A without Load Disconnect Function**

The schematic of a typical application circuit that is used for 16V output voltage without load disconnect function of SGM6612A is given in Figure 9. Without the load disconnect MOSFET, the device has a simplified design and minimized external components.

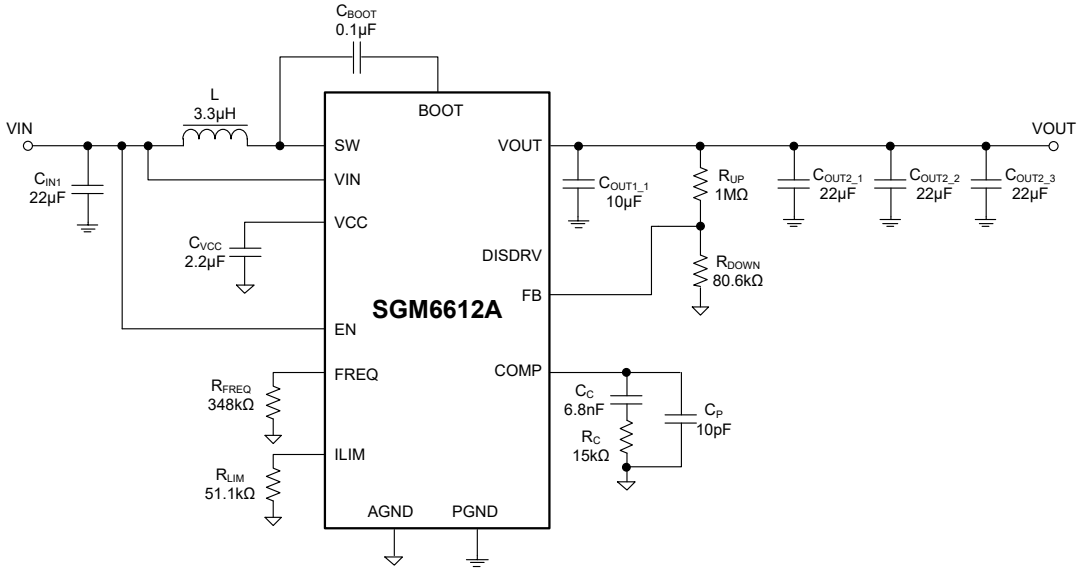



**Figure 9. SGM6612A 16V Output Voltage without Load Disconnect Function**

# REVISION HISTORY

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

| DECEMBER 2023 – REV.A.3 to REV.A.4 | Page |
|---|---|
| Updated Detailed Description section | 12, 13 |

| JUNE 2022 – REV.A.2 to REV.A.3 | Page |
|---|---|
| Updated Detailed Description and Application Information sections | 10, 11, 13 |

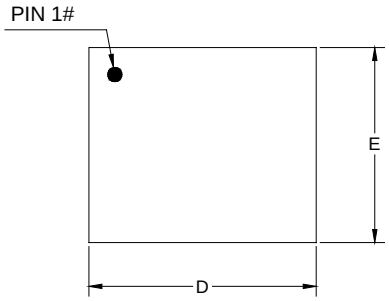
| MAY 2021 – REV.A.1 to REV.A.2 | Page |
|---|---|
| Updated Electrical Characteristics section | 4 |

| DECEMBER 2020 – REV.A to REV.A.1 | Page |
|---|---|
| Updated Package/Ordering Information section | 2 |

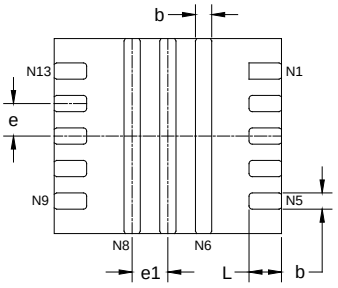
| Changes from Original (OCTOBER 2020) to REV.A | Page |
|---|---|
| Changed from product preview to production data | All |

# PACKAGE OUTLINE DIMENSIONS

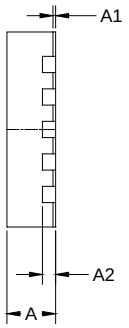
## TQFN-3×3.5-13L



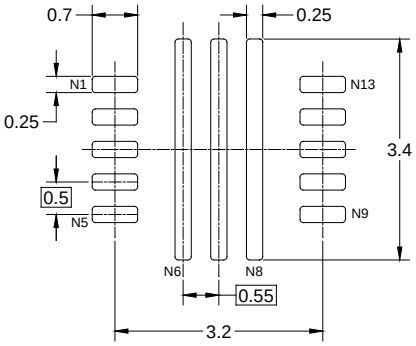

**TOP VIEW**




**BOTTOM VIEW**




**SIDE VIEW**



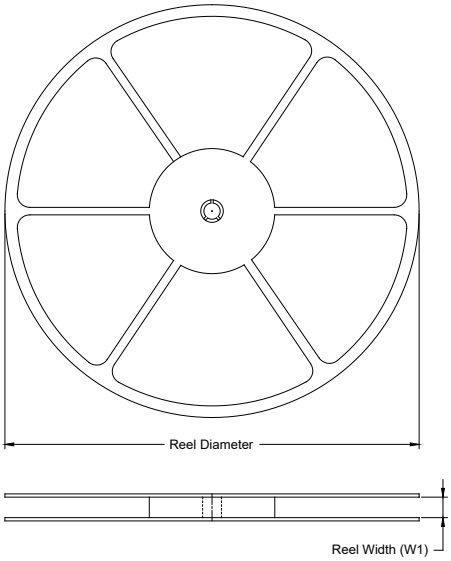

**RECOMMENDED LAND PATTERN** (Unit: mm)

| Symbol | Dimensions In Millimeters | | |
|---|---|---|---|
| | MIN | MOD | MAX |
| A | 0.700 | 0.750 | 0.800 |
| A1 | 0.000 | 0.020 | 0.050 |
| A2 | 0.203 REF | | |
| b | 0.200 | 0.250 | 0.300 |
| D | 3.450 | 3.500 | 3.550 |
| E | 2.950 | 3.000 | 3.050 |
| L | 0.450 | 0.500 | 0.550 |
| e | 0.500 BSC | | |
| e1 | 0.550 BSC | | |

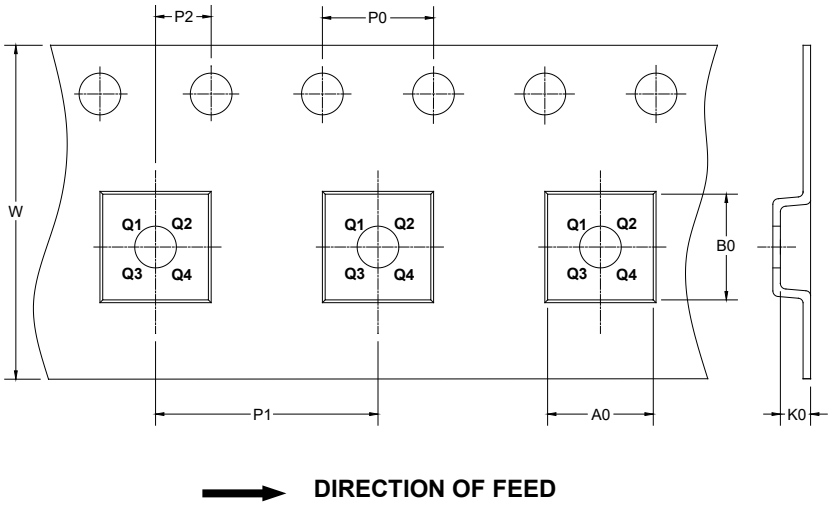
NOTE: This drawing is subject to change without notice.

# TAPE AND REEL INFORMATION

### REEL DIMENSIONS




### TAPE DIMENSIONS



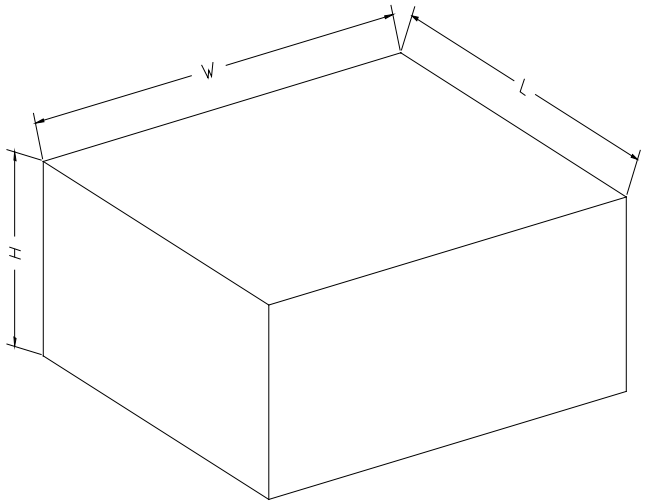

NOTE: The picture is only for reference. Please make the object as the standard.

## 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| TQFN-3×3.5-13L | 13″ | 12.4 | 3.30 | 3.80 | 1.05 | 4.0 | 8.0 | 2.0 | 12.0 | Q2 |

DD0001

## CARTON BOX DIMENSIONS




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

## KEY PARAMETER LIST OF CARTON BOX

| Reel Type | Length (mm) | Width (mm) | Height (mm) | Pizza/Carton |
|---|---|---|---|---|
| 13″ | 386 | 280 | 370 | 5 |

DD0002