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

DESCRIPTION

The SGM6612A is a 20V synchronous boost converter with the gate driver built-in for load disconnect. The device integrates a 15mΩ low-side power switch and a 15mΩ high-side power switch, and provides a high efficiency and small size power solution for portable equipment.

The SGM6612A uses peak current control topology with fixed frequency to regulate the output voltage. In moderate to heavy load condition, the SGM6612A works in the PWM (pulse width modulation) mode. In light load condition, the SGM6612A enters into the auto PFM (pulse frequency modulation) mode to improve the efficiency.

The SGM6612A provides a gate driver for external MOSFET to disconnect the output from input side during shutdown or output short condition. When the output is shorted and the short protection is triggered, the device enters into the hiccup mode for safety. In addition, the device also provides output over-voltage protection, inductor current limit protection and thermal shutdown protection.

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

FEATURES

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

APPLICATIONS

Portable Speaker
Source Driver of LCD Display
Supply for the Power Amplifier
Supply for the Motor Driver
USB Type-C Power Delivery

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	SGM6612A YTQX13 XXXXX	Tape and Reel, 4000

MARKING INFORMATION

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

XXXXX
- Vendor Code
- Trace Code
- Date Code - Year

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, θ_{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.

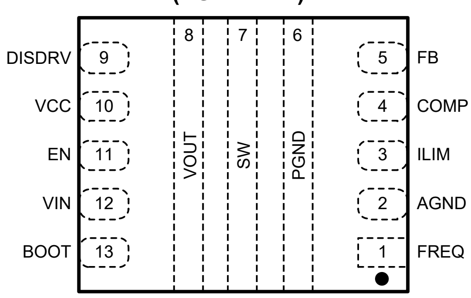
ESD SENSITIVITY CAUTION

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



TQFN-3×3.5-13L

PIN DESCRIPTION

PIN	NAME	I/O	FUNCTION
1	FREQ	I	Adjustable Switching Frequency Pin. Put a resistor between this pin and the AGND to program the switching frequency. Do not leave this pin floating in application.
2	AGND	-	Analog Signal Ground of the IC.
3	ILIM	I	Adjustable Switch Peak Current Limit. Put a resistor between this pin and AGND to program the switching peak 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. It is connected to the source of the low-side MOSFET.
7	SW	PWR	The Switching Node Pin of the Converter. It is connected to the internal power MOSFETs.
8	VOUT	PWR	Boost Converter Output.
9	DISDRV	O	A Gate Drive Output for the External Disconnect MOSFET. Connect this pin to the gate of the external MOSFET. Without using the load disconnect function, leave it floating.
10	VCC	O	Output of the Internal Regulator. Put a capacitor of more than 1.0μF between this pin and ground.
11	EN	I	Enable Logic Input. 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. Put a capacitor between this pin and the SW pin.

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	1.186	1.203	1.221	V
		Auto PFM operation		100.2%		V_{REF}
Leakage Current into FB Pin	I_{FB_LKG}			10	50	nA

ELECTRICAL CHARACTERISTICS (continued)

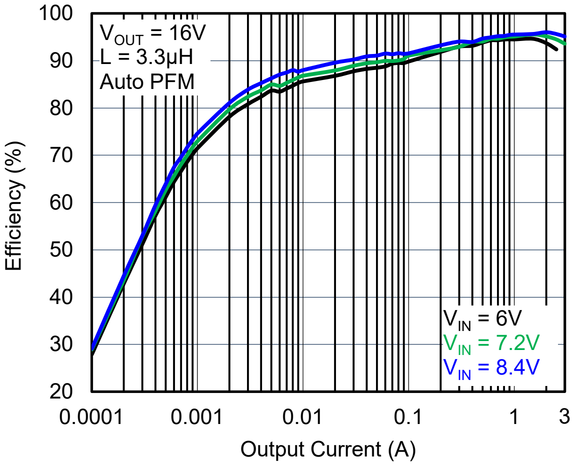
(V_{IN} = 2.7V to 14V and V_{OUT} = 16V, T_J = -40℃ to +125℃, typical values are at T_J = +25℃, unless otherwise noted.)

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

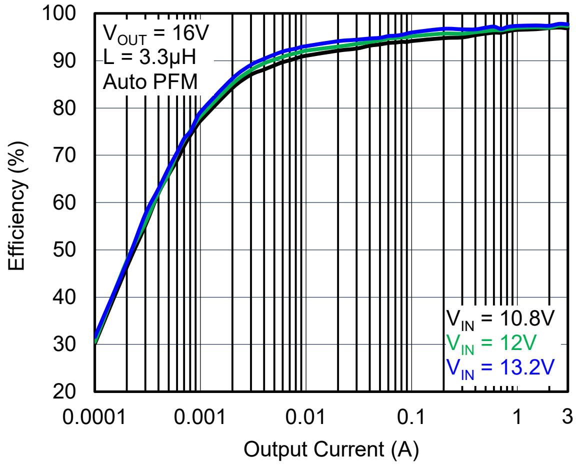
TYPICAL PERFORMANCE CHARACTERISTICS

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

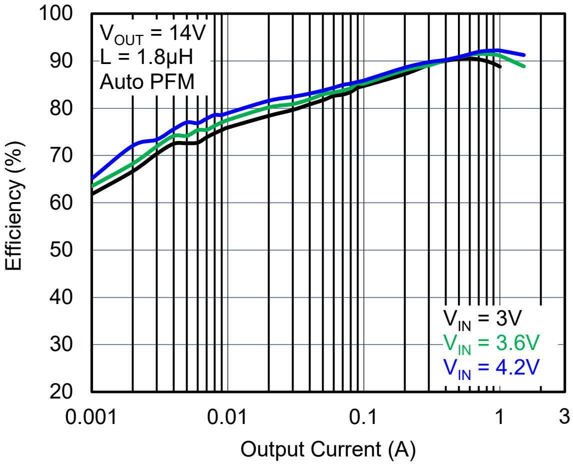
Efficiency vs. Output Current



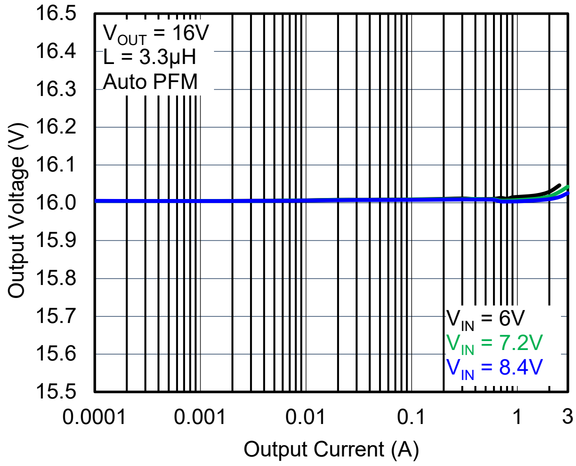
Efficiency vs. Output Current



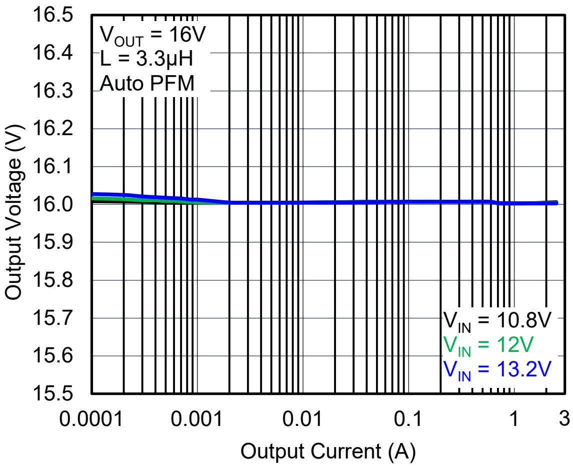
Efficiency vs. Output Current



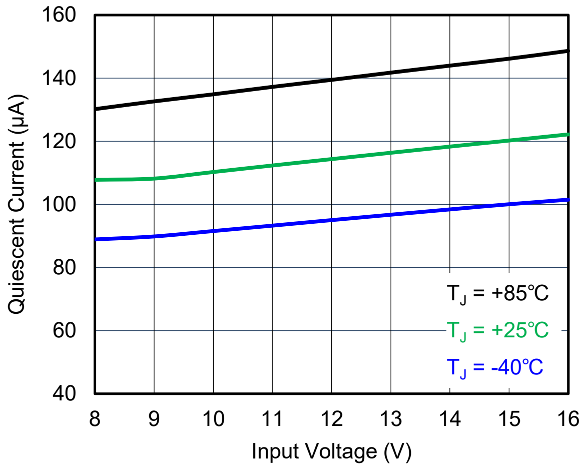
Output Voltage vs. Output Current



Output Voltage vs. Output Current

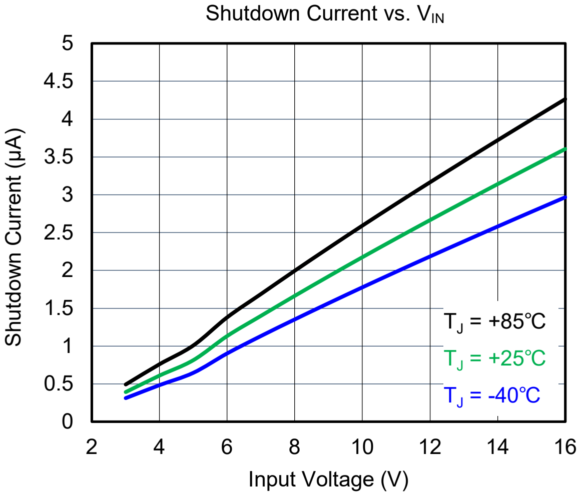


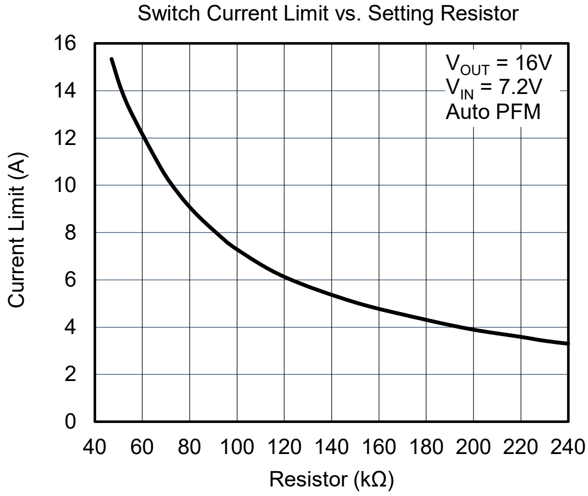
Quiescent Current vs. V_{IN}

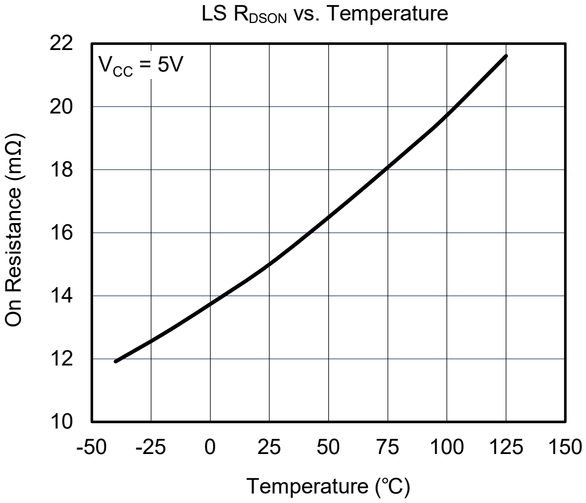


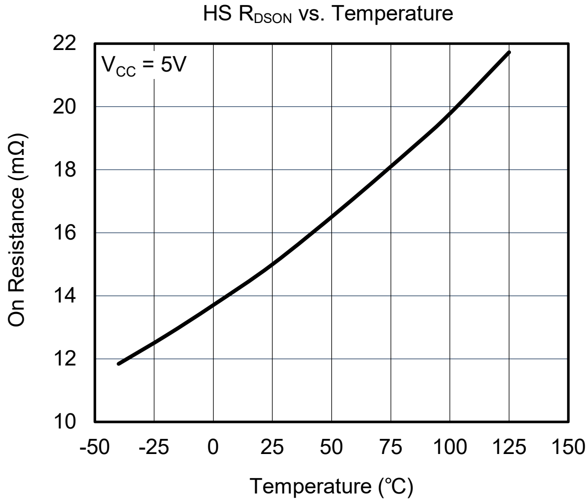
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

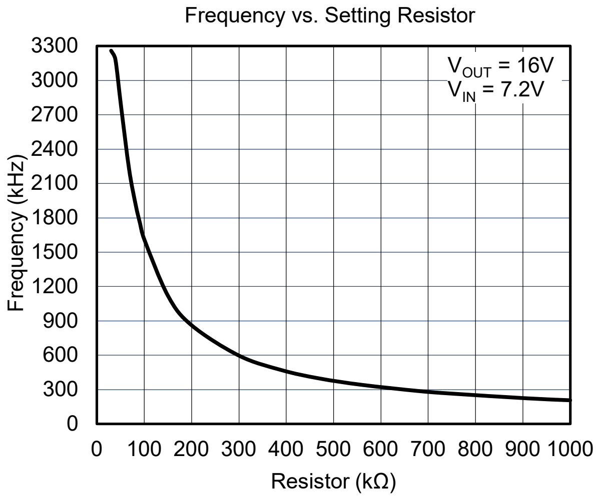
At T_J = +25℃, V_{IN} = 7.2V and V_{OUT} = 16V, unless otherwise noted.

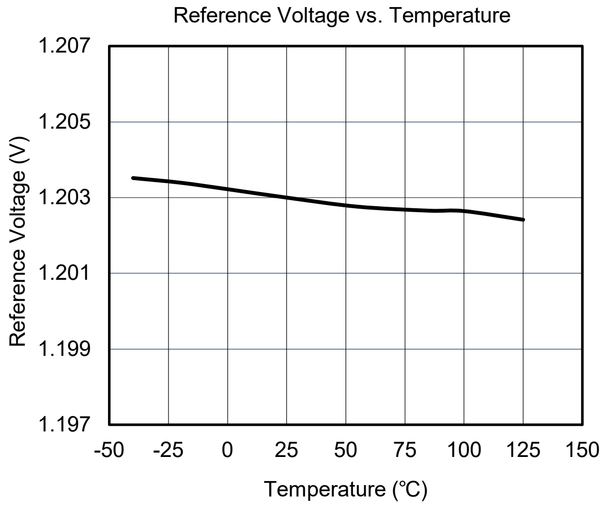








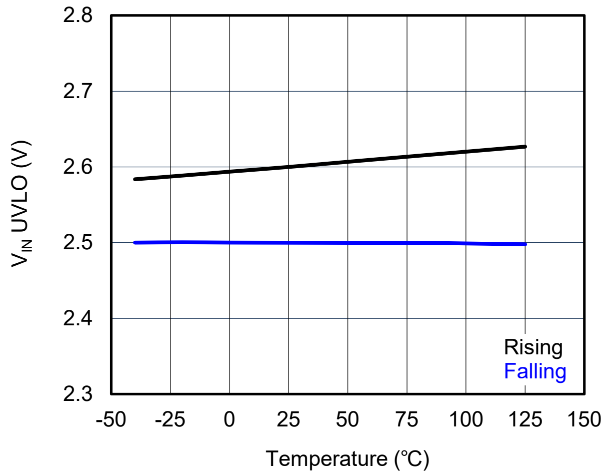




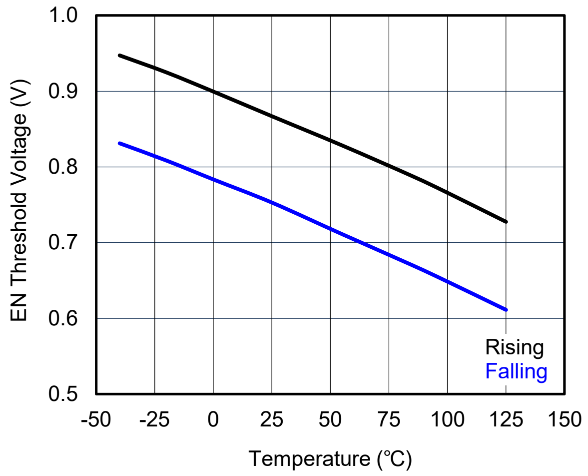
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

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

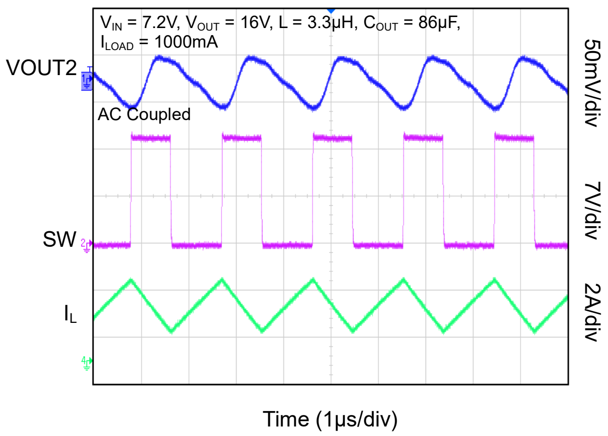
V_{IN} UVLO Rising/Falling vs. Temperature



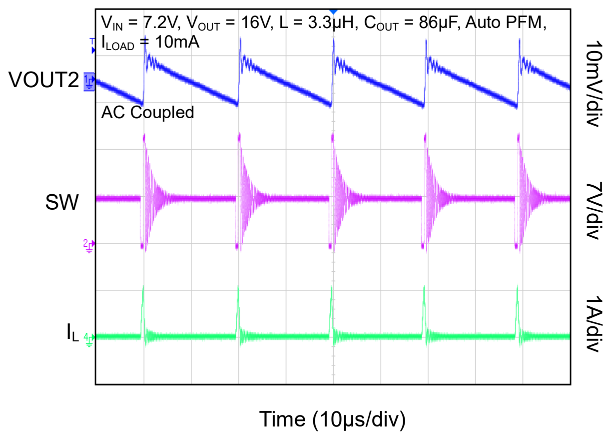
EN Threshold Rising/Falling vs. Temperature



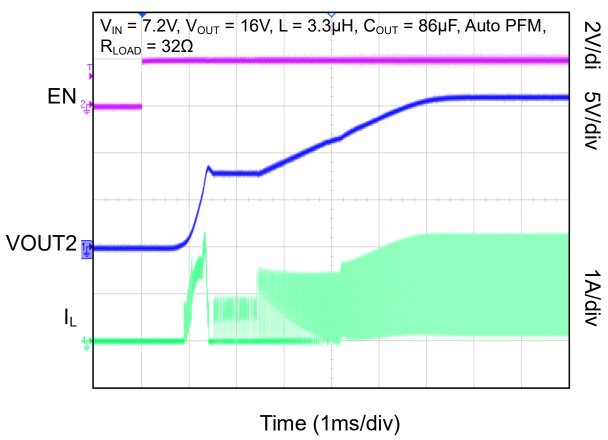
Steady State 1000mA



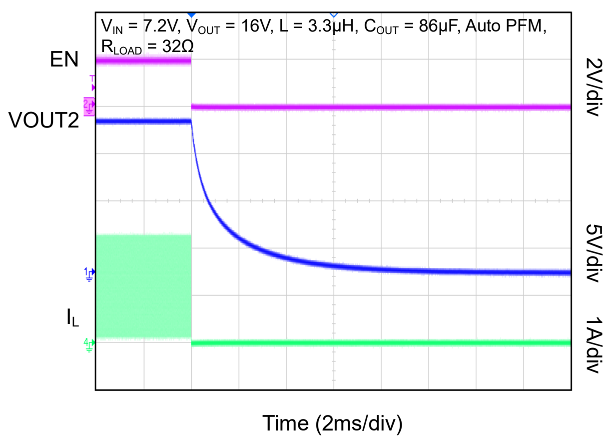
Steady State 10mA



Start-Up by EN



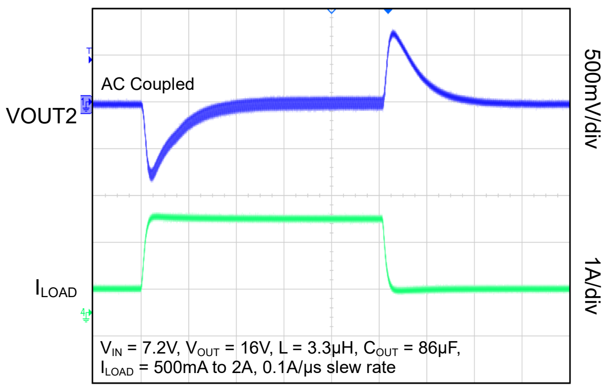
Shutdown by EN



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

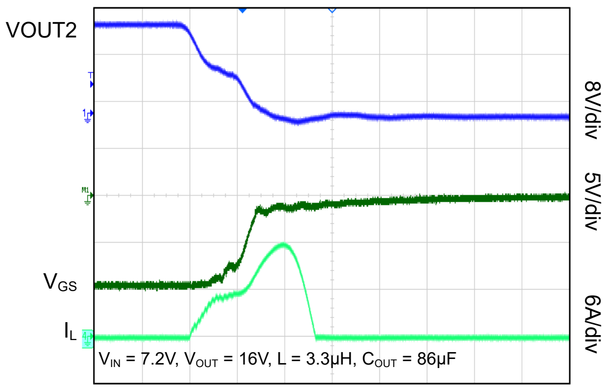
At T_J = +25℃, V_{IN} = 7.2V and V_{OUT} = 16V, unless otherwise noted.

Load Transient



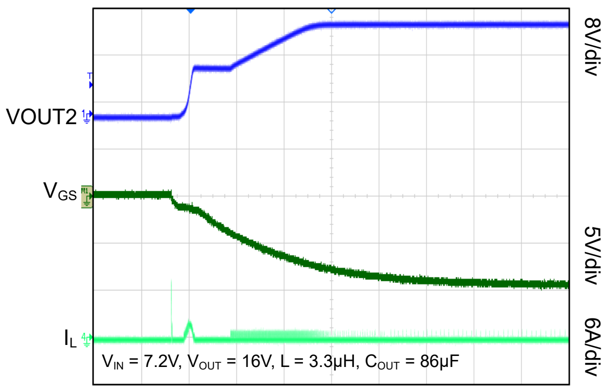
Time (200μs/div)

Output Short (with Disconnect MOSFET)



Time (10μs/div)

Output Short Release (with Disconnect MOSFET)



Time (2ms/div)

FUNCTIONAL BLOCK DIAGRAM

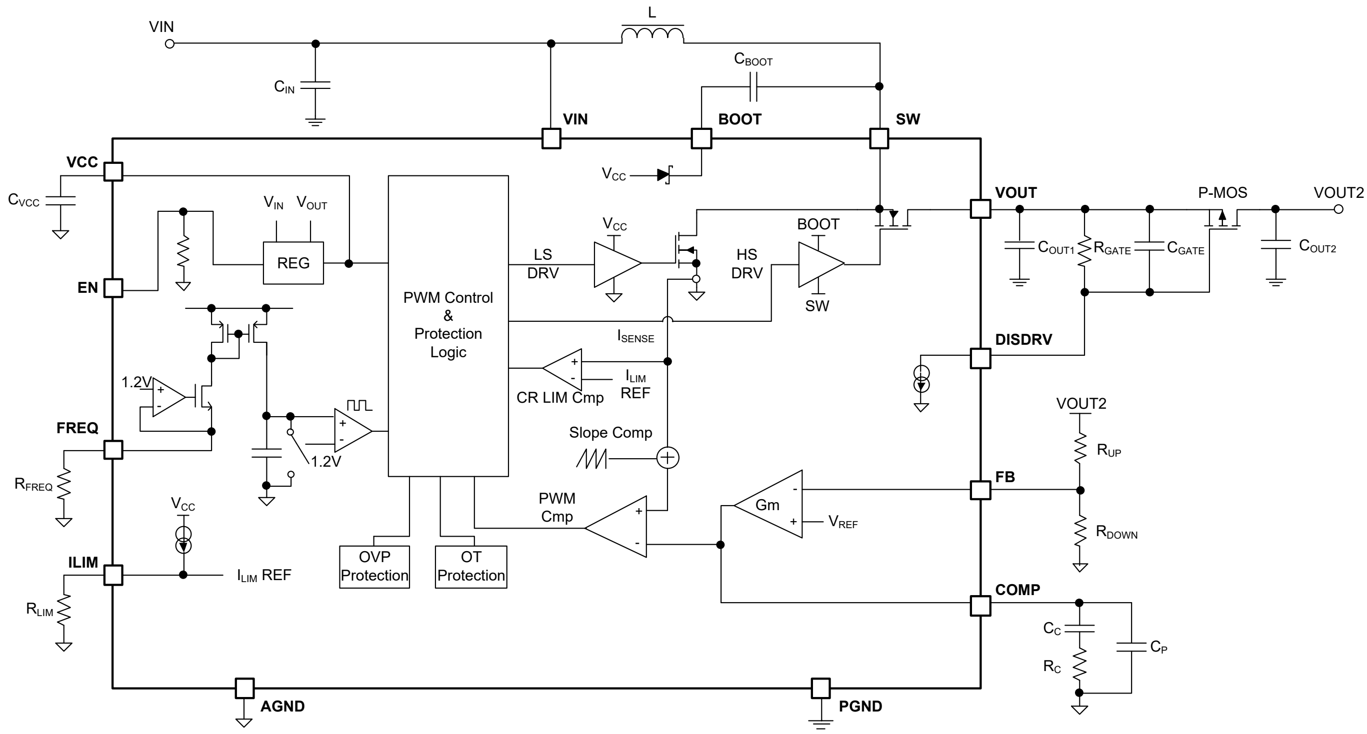


Figure 1. Block Diagram

DETAILED DESCRIPTION

The SGM6612A is a synchronous boost converter integrating two 15mΩ power switches. It is capable of delivering the switch peak current up to 10A and output voltage reaching to 20V. In moderate to heavy load condition, the SGM6612A operates at a fixed frequency PWM mode. In light load condition, the SGM6612A operates in the auto PFM mode to improve the efficiency. The SGM6612A uses peak current control topology which provides the excellent line and load transient responses with the minimal output capacitance. It is flexible for external loop compensation to bring a wider range of the inductor and output capacitor combinations.

The SGM6612A supports the resistor-programmable switching frequency up to 2.2MHz. The device uses peak current control topology to protect the device from overloading during the boost operation phase. In addition, if the output current increases above the short current threshold or the output voltage drops below the short voltage threshold, the SGM6612A enters into hiccup mode to provide a 90ms short protection and recovers automatically once the short condition releases. The SGM6612A features a gate driver for the external MOSFET to disconnect the output from input end during shutdown state or output short condition.

Under-Voltage Lockout

An under-voltage lockout (UVLO) circuit prevents operation of the device at input voltages below typical 2.5V 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 goes into the shutdown mode and stops switching.

DETAILED DESCRIPTION (continued)

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-change phase. After the pre-charge phase ends (2.5ms, TYP), the output voltage will rise gradually and linearly to the target value. The soft-start time is typical 3.2ms. After that the switching frequency is set by the resistor connected through the FREQ pin.

Load Disconnect Gate Driver

The device provides a DISDRV pin to drive the external MOSFET at the output side to disconnect the output from the input end during shutdown or output short condition. During the start-up phase, the disconnect MOSFET is gently turned on by an internal sink current (55μA, TYP). The load disconnect MOSFET connection is shown as Figure 2.

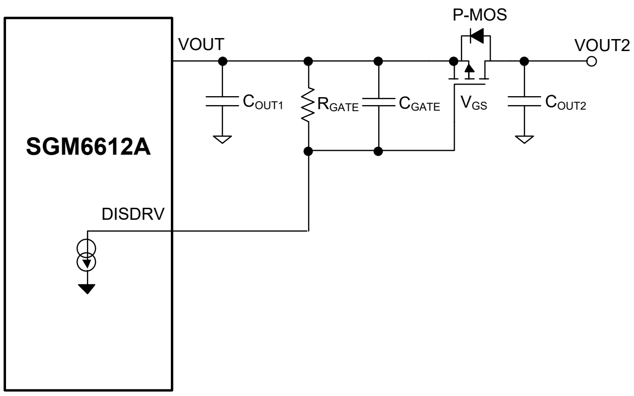


Figure 2. The Load Disconnect MOSFET Connected

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

Adjustable Peak Current Limit

To avoid an 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 for setting the current limit, with the unit of kΩ.

I_{LIM} is switching peak current limit, and the unit is A.

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

Figure 3 shows the current limit versus the setting resistor for the SGM6612A (Auto PFM) with 7.2V input to 16V output.

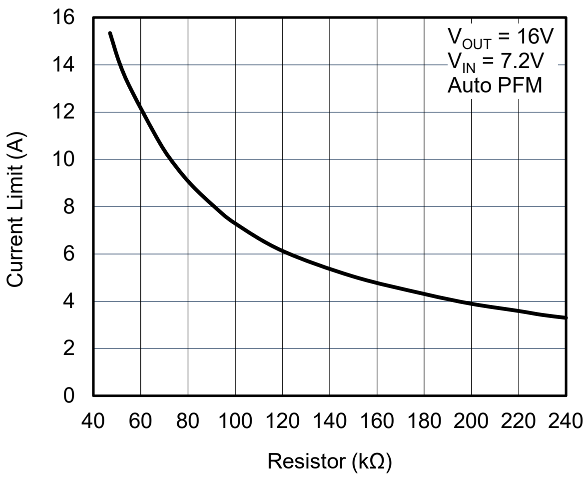


Figure 3. Switch Current Limit vs. Setting Resistor

Output Short Protection (with Load Disconnected MOSFET)

The device features the hiccup protection mode when the inductor current reaches the short protection limit threshold (20A, TYP) or the output voltage drops below 70% (TYP) of the normal output voltage. In the hiccup mode, the device shuts down itself and keeps a 90ms (TYP) waiting time. After the short condition releases, the device recovers automatically. The hiccup protection scheme is illustrated in Figure 4.

DETAILED DESCRIPTION (continued)

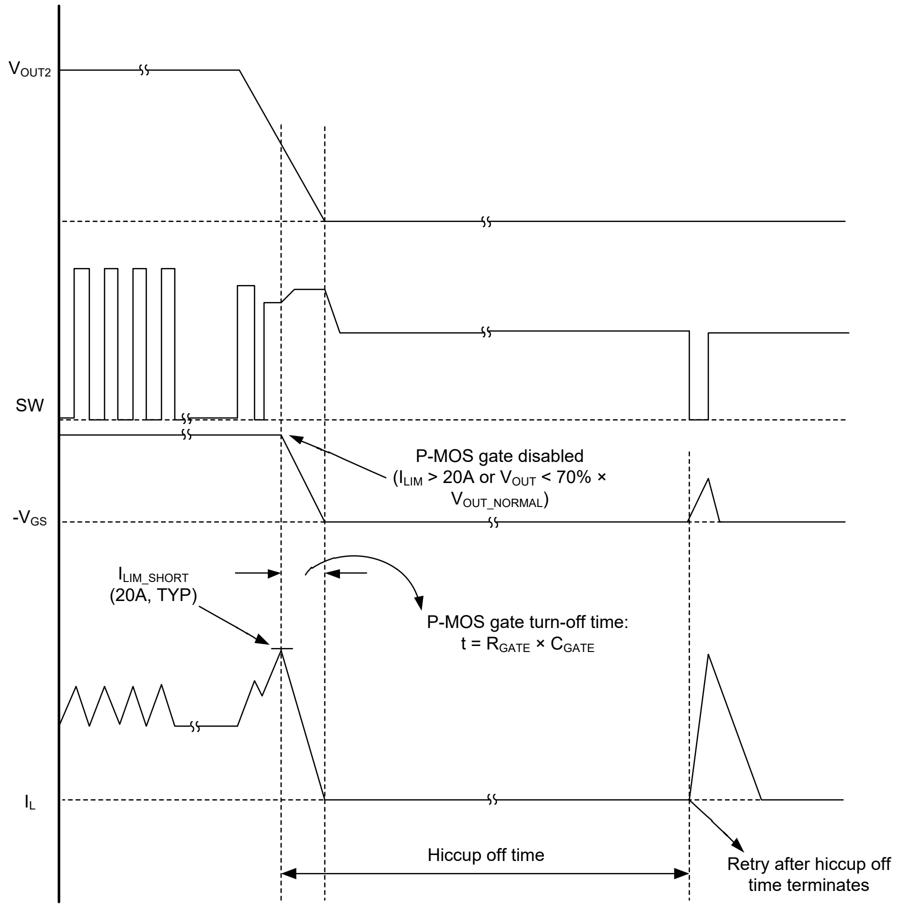


Figure 4. Output Short Protection

Adjustable Switching Frequency

The SGM6612A has a wide adjustable switching frequency ranging 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. Use Equation 2 and Equation 3 to calculate the resistor value for a desired frequency.

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

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

where:

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

For instance, if the R_{FREQ} is 348kΩ, the frequency is 530kHz.

Figure 5 shows the switching frequency versus the setting resistor, which is measured with V_{OUT} = 16V from V_{IN} = 7.2V.

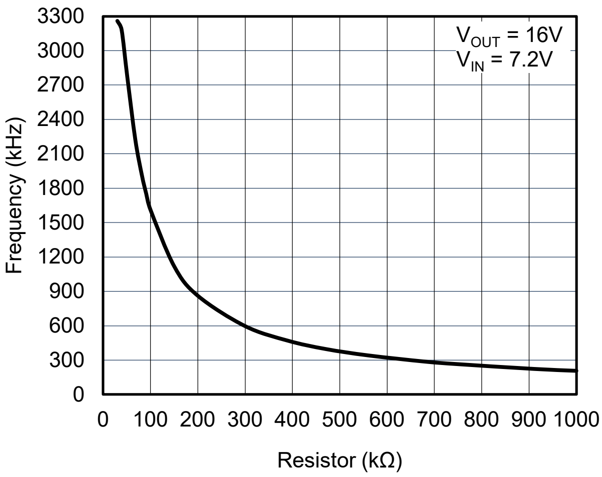


Figure 5. Switching Frequency vs. Setting Resistor

DETAILED DESCRIPTION (continued)

Start-Up with the Output Pre-Biased

The SGM6612A prevents the low-side MOSFET from discharging a pre-biased output. It is not allowed to turn on either high-side or low-side MOSFET during the pre-biased start-up until the internal soft-start voltage is higher than the sensed output voltage at FB pin.

Bootstrap Voltage (BOOT)

A small ceramic capacitor between the BOOT pin and SW pin supplies the gate current to charge the high-side MOSFET device gate during each cycle's turn-on and also supplies charge for the bootstrap capacitor. The value of this capacitor is recommended above 0.1μF.

Over-Voltage Protection

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 stop switching. Once the temperature drops below +130℃ (TYP), the power supply resumes operation.

Device Functional Modes

The synchronous boost converter SGM6612A operates at a constant frequency PWM mode in moderate to heavy load condition. At the beginning of each switching cycle, the low-side N-MOSFET switch, shown in Functional Block Diagram, is turned on, and the inductor current ramps up to a peak current that is determined by the output of the internal error amplifier. After the peak current is reached, the current comparator trips, and it turns off 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 higher 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 at the light load. When the output load is reduced, the peak current is also decreasing but has a minimum value. If the load is further reduced and the peak current will be clamped and won't be reduced further, and then the error amplifier output (COMP pin) will be low enough to reach the pre-set low threshold and the device stops switching.

The auto PFM mode reduces the switching losses and improves efficiency in light load condition by reducing the average switching frequency.

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 and regulates the output voltage. The efficiency during Diode-Mode operation is reduced so that it is recommended that V_{IN} should be at least 1V lower than V_{OUT}.

APPLICATION INFORMATION

Typical Application

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

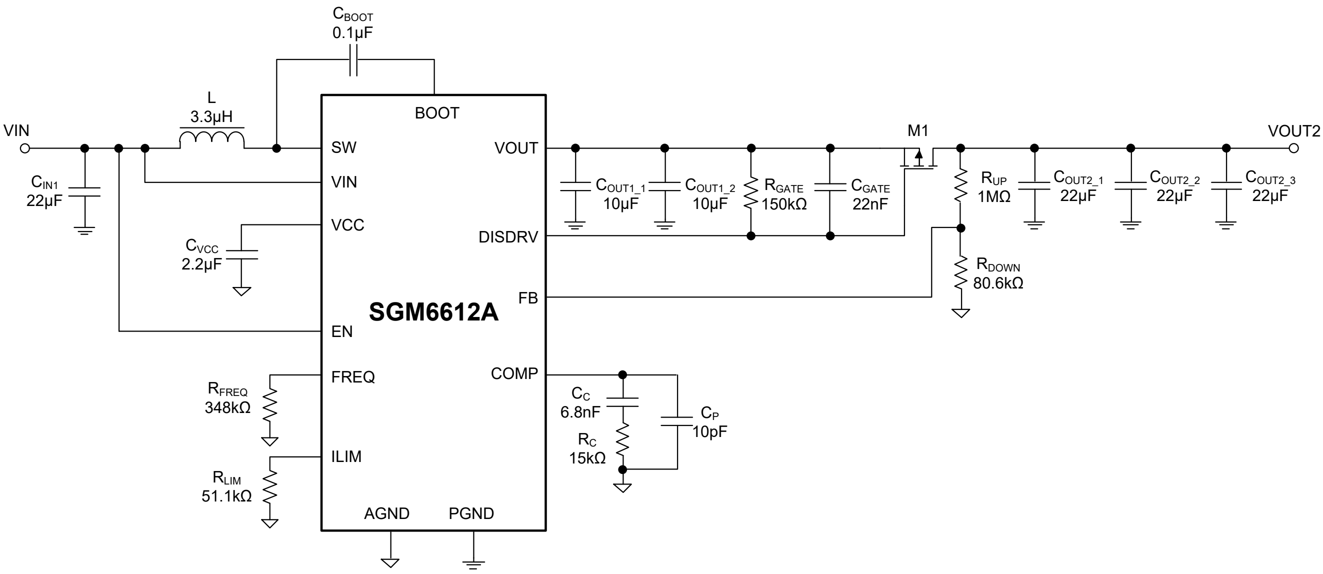


Figure 6. SGM6612A 16V Output with Load Disconnect Schematic

Design Requirements

For this design example, use Table 1 as the design parameters.

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)	Vendor
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 calculated resistor value is 56kΩ. Due to the distribution of the current limit, it is recommended that select a resistor about 10% less than the calculated value for safety. Here, 51.1kΩ resistor is a very good 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 approximately 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 changed into two parts, shown in Figure 7. C_{OUT2} should be no larger than 10 × C_{OUT1} to avoid the inrush current when turning on the disconnect MOSFET.

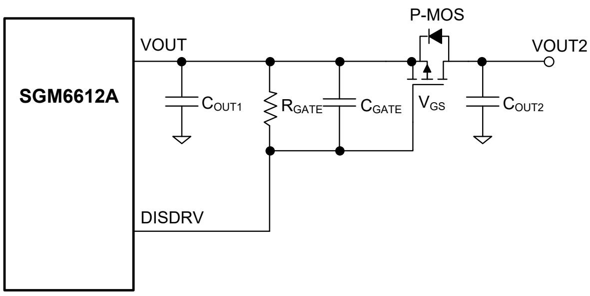


Figure 7. Output Capacitor Configuration with the Load Disconnect MOSFET

Selecting the Input Capacitors

While a 22μF input capacitor is sufficient for the most applications, larger values may be used to reduce input current ripple. Refer to Table 3.

Loop Stability and Compensation

Table 4. Recommended L, R_C and C_C for Different Output Voltage and Frequency

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 features a gate driver to control an external MOSFET, which disconnects the output from the input end during shutdown or output short condition, shown in Figure 8.

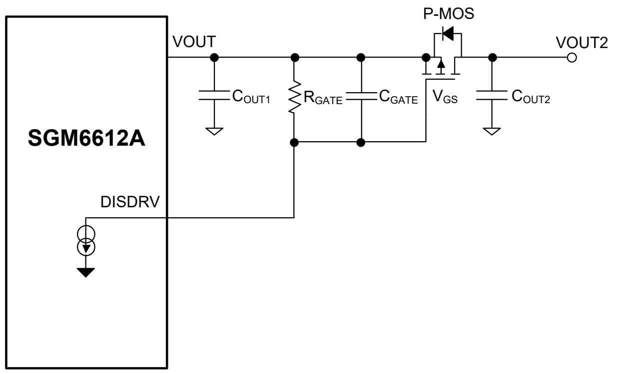


Figure 8. Load Disconnect MOSFET Connection

When selecting the MOSFET, it should be taken into consideration for the V_{DS}, I_{DS} and safe operation area (SOA):

- The drain-to-source voltage rating should be higher than the maximum output $V_{DS\_DIS\_MAX} = V_{OUT}$.
- The drain-to-source RMS current rating is the maximum output current $I_{DS\_DIS\_RMS} = I_{OUT}$.
- Taking consideration of the SOA when the output short occurs, there is heat caused by the short protection response time and surge current, 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 triggered.
- Q_{SHORT} is the heat generated for 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 slow the turn-on speed, it is required that an additional capacitor 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 connected 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 1.5V threshold, C_{GS_P-MOS} is 10nF, and t_{ON_P-MOS} is about 300μs. It should be aware that the maximum turn-on time should no more than 3ms, and the maximum capacitance C_{GS_P-MOS} should be less than 100nF. That is to say, if the disconnect MOSFET could not be turned on within the 3ms, the device could not start up normally.

The gate resistor depends on the gate-source voltage of the external MOSFET.

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

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

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

Selecting the Bootstrap Capacitor

A 0.047μF ~ 0.1μF capacitor value range is recommended for bootstrap capacitor. A value of 0.1μF was selected for this design example. Refer to Table 3.

V_{CC} Capacitor

The value of C_{VCC} should be at least 10 times greater than the value of C_{BOOT}. A 1μF ~ 2.2μF capacitor value range is recommended for V_{CC} capacitor. A value of 2.2μF was selected for this design example. Refer to Table 3.

Layout Guidelines

As for all switching power supplies, especially those high frequency and high current ones, layout is an important design step. If layout is not carefully done, the regulator could suffer from instability as well as noise problems. Therefore, use wide and short traces for high current paths. The input capacitor C_{IN} needs to be close to VIN pin and GND pin in order to reduce the input ripple seen by the IC. If possible choose higher capacitance value for it. The SW pin carries high current with fast rising and falling edge, therefore, the 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. Place the noise sensitive network like the feedback and compensation being far away from the SW trace. Use a separate ground trace to connect the feedback, compensation, frequency set, and the current limit set circuitries. Connect this ground trace to the main power ground at a single point to minimize circulating currents.

APPLICATION INFORMATION (continued)

System Examples

SGM6612A with 14V Output from 2.7V to 4.4V Input Voltage

The Figure 9 is the typical application schematic for 2.7V to 4.4V input (single-cell Li+ battery) to output 14V output converter. The inductor can be lower to 1.8μH for the 14V output.

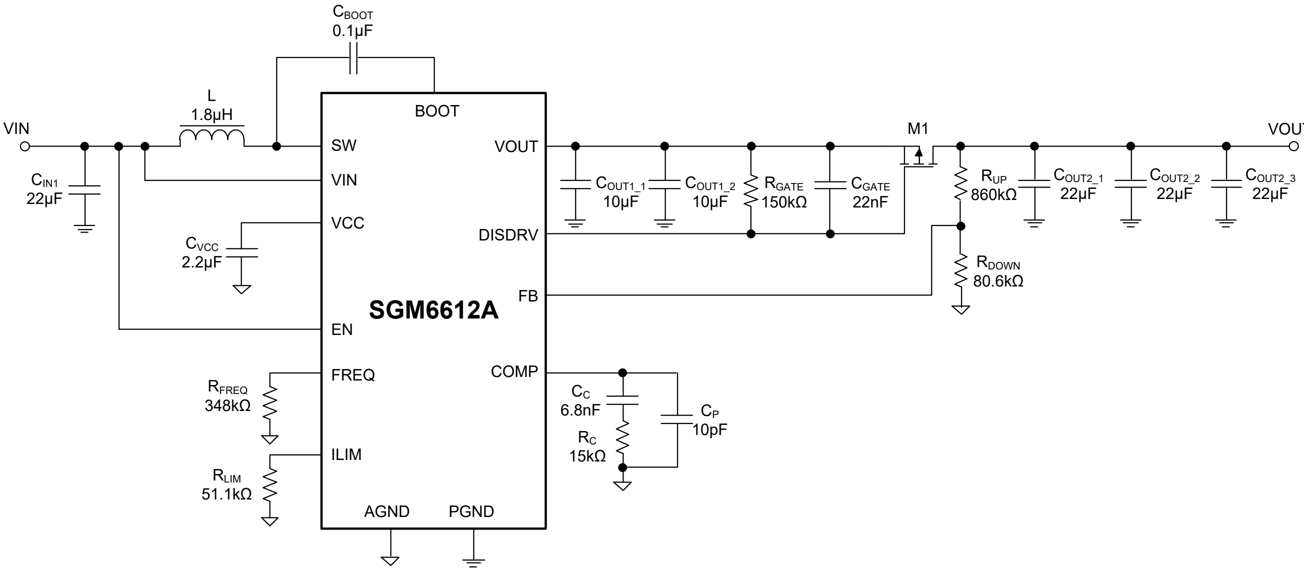


Figure 9. SGM6612A 14V Output Voltage from 2.7V to 4.4V Input Voltage

SGM6612A without Load Disconnect Function

The Figure 10 is the typical application schematic is for 6V to 14V input (2- or 3-cell Li+ batteries or 12V BUS) to output 16V output converter without load disconnect. With removing the load disconnect MOSFET, it simplifies the design and minimizes the external components.

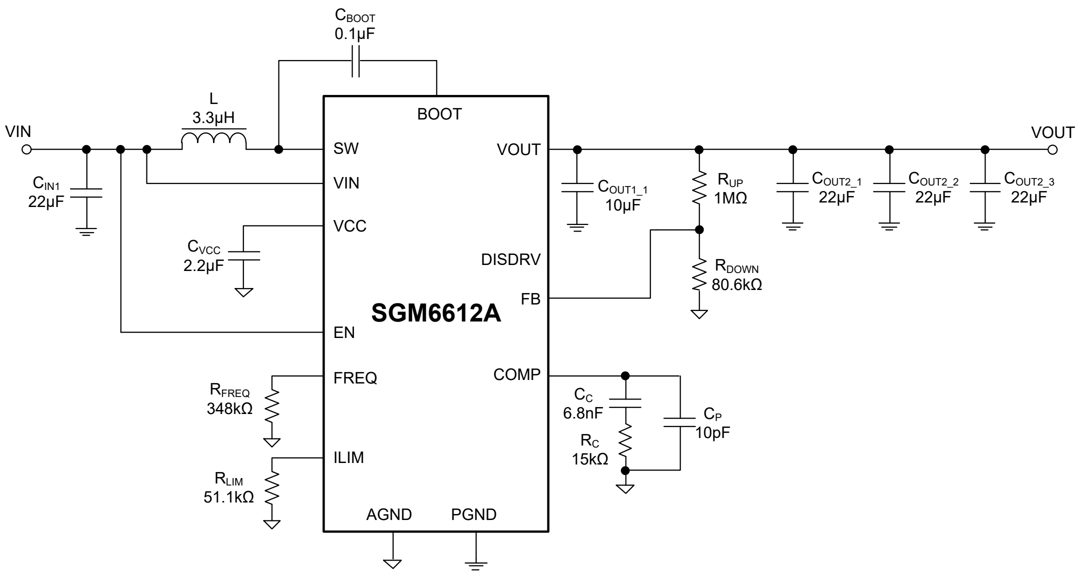


Figure 10. SGM6612A 16V Output Voltage without Load Disconnect Function

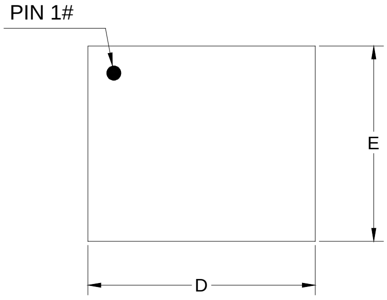
REVISION HISTORY

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

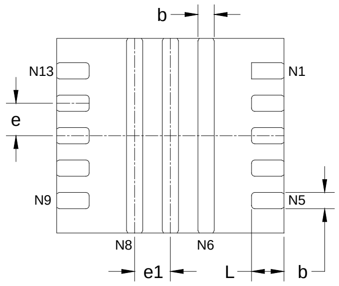
Changes from Original (OCTOBER 2020) to REV.A	Page
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

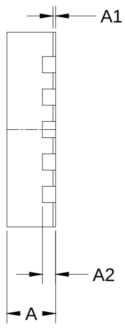
TQFN-3×3.5-13L



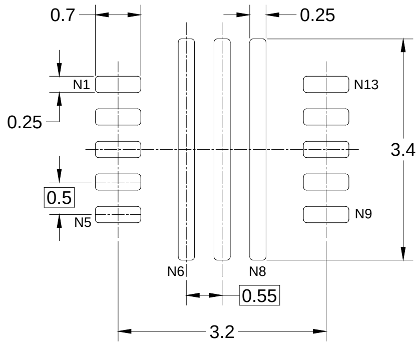
TOP VIEW



BOTTOM VIEW



SIDE VIEW



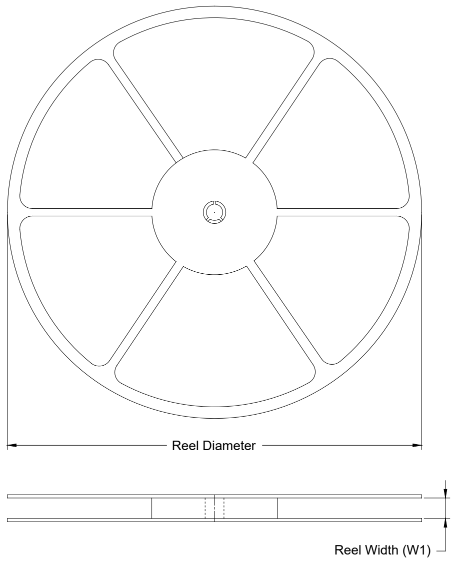
RECOMMENDED LAND PATTERN (Unit: mm)

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		

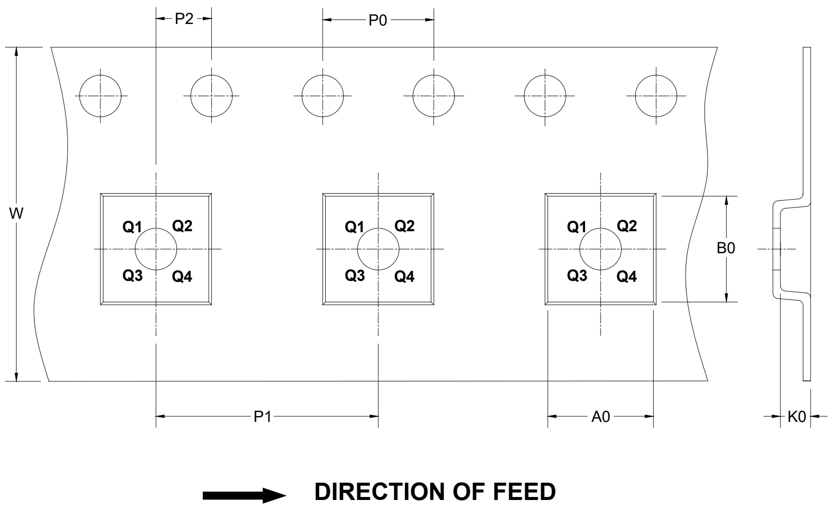
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



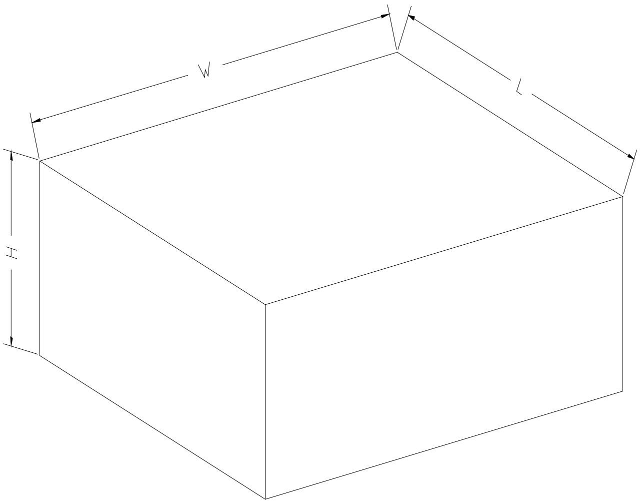
NOTE: The picture is only for reference. Please make the object as the standard.

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