SGM62112
1.8A Switch Current Single Inductor Buck-Boost Converter

GENERAL DESCRIPTION

The SGM62112 is a fully-integrated synchronous Buck-Boost converter which is capable of operating from 1.8V to 5.5V input and suitable for battery powered applications such as 1-cell Li-ion battery, 2-cell or 3-cell Alkaline/NiMH batteries. The device supports up to 1200mA output current at higher than 3.6V input voltage, and 800mA output current at higher than 2.4V input voltage.

The SGM62112 adopts the current mode control with a fixed 1.4MHz switching frequency to regulate the output voltage. In addition, the SGM62112 offers configurable light load PWM (pulse width modulation) operation or auto PFM (pulse frequency modulation) mode via MODE/SYNC pin configuration. PFM mode enables higher light load efficiency, while forced PWM operation ensures constant switching frequency throughout entire load range.

The SGM62112 offers various protection features to improve device robustness such as soft-start to reduce inrush current during startup, cycle-by-cycle over-current protection and thermal shutdown protection. In addition, the device features true load disconnect when the EN pin is pulled low.

The SGM62112 is available in a Green TDFN-3×3-10L package.

FEATURES

- **1.8V to 5.5V Input Voltage Range**
- **1.2V to 5.5V Output Voltage Range (Fixed and Adjustable)**
- **Up to 96% Efficiency**
- **Less than 50μA Quiescent Current**
- **Output Current at 3.3V:**
  - ◆ **Up to 1200mA in Buck Mode (V_{IN} = 3.6V to 5.5V)**
  - ◆ **Up to 800mA in Boost Mode (V_{IN} > 2.4V)**
- **Real Buck, Boost and Buck-Boost Modes**
- **Automatic Mode Transition**
- **Auto PFM and Forced PWM Selectable**
- **External Clock Synchronization**
- **True Shutdown Function with Load Disconnect**
- **OTP Protection**
- **Available in a Green TDFN-3×3-10L Package**

APPLICATIONS

Medical Equipment
System Bias
TEC
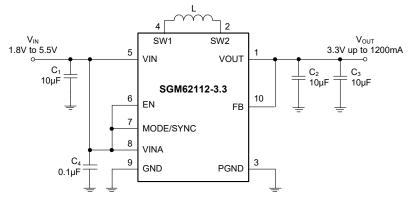
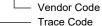## TYPICAL APPLICATION

Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM62112-3.3	TDFN-3×3-10L	-40℃ to +85℃	SGM62112-3.3YTD10G/TR	SGM G5MD XXXXX	Tape and Reel, 4000
SGM62112-ADJ	TDFN-3×3-10L	-40℃ to +85℃	SGM62112-ADJYTD10G/TR	SGM SXTD XXXXX	Tape and Reel, 4000

MARKING INFORMATION

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

X X X X X
— 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

Voltage on VIN, VINA, SW1, SW2, VOUT, MODE/SYNC, EN, FB .... -0.3V to 7V
Junction Temperature ....+150℃
Storage Temperature Range ....-65℃ to +150℃
Lead Temperature (Soldering, 10s)............................+260℃

RECOMMENDED OPERATING CONDITIONS

Supply Voltage at VIN, VINA ....1.8V to 5.5V
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.
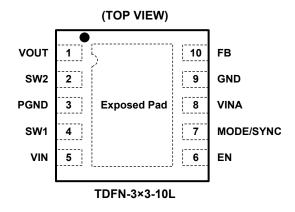
ESD SENSITIVITY CAUTION

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)

```
          VOUT  1 ┌─────┐ 10  FB
          SW2   2 │     │  9  GND
          PGND  3 │ Exposed Pad │ 8  VINA
          SW1   4 │     │  7  MODE/SYNC
          VIN   5 └─────┘  6  EN
```

TDFN-3×3-10L

PIN DESCRIPTION

PIN	NAME	TYPE	FUNCTION
1	VOUT	O	Buck-Boost Converter Output Pin.
2	SW2	I	Inductor Connection 2. Boost leg inductor pin.
3	PGND	G	Power Ground Pin.
4	SW1	I	Inductor Connection 1. Buck leg inductor pin.
5	VIN	I	Power Stage Supply Voltage Pin.
6	EN	I	Enable Input Pin. Logic High Enabled, Logic Low Disabled.
7	MODE/SYNC	I	Mode Selection Pin or External Clock Synchronization Input. Logic high for forced PWM operation, logic low for auto PFM operation.
8	VINA	I	Control Stage Supply Voltage Pin.
9	GND	G	Ground Pin.
10	FB	I	ADJ Version: Voltage Feedback Pin. Fixed Output Voltage Version: Connected it to VOUT pin.
Exposed Pad	–	G	Exposed Pad. Connect it to GND.

NOTE: O = output; I = input; G = ground.

ELECTRICAL CHARACTERISTICS

(Typical values are at T_A = +25℃, unless otherwise noted.)

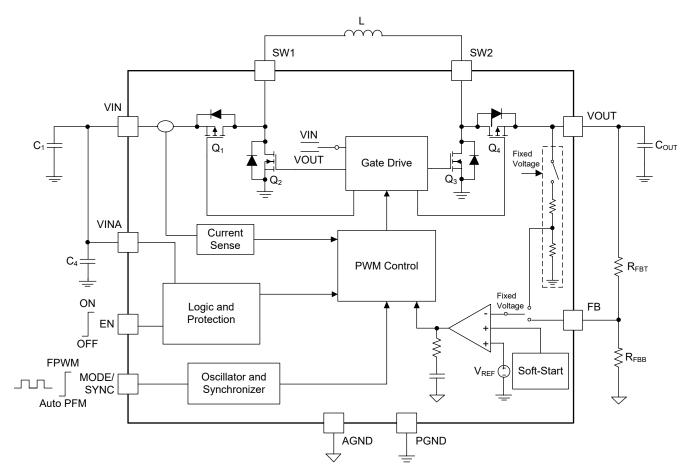| PARAMETER		SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
DC/DC Stage							
Input Voltage Range		V_{IN}		1.8		5.5	V
Input Voltage Range for Startup		V_{IN}		1.9		5.5	V
Output Voltage Range		V_{OUT}	SGM62112-ADJ	1.2		5.5	V
Feedback Voltage		V_{FB}	SGM62112-ADJ, MODE/SYNC = V_{IN}		500		mV
Oscillator Frequency		f			1480		kHz
Frequency Range for Synchronization				1250		1800	kHz
Switch Current Limit		I_{SW}	V_{IN} = V_{INA} = 5V, T_A = +25℃		2200		mA
High-side Switch ON-Resistance		R_{Q1}	V_{IN} = V_{INA} = 5V		81		mΩ
		R_{Q4}			92		
Low-side Switch ON-Resistance		R_{Q2}	V_{IN} = V_{INA} = 5V		56		mΩ
		R_{Q3}			51		
Line Regulation						0.5	%
Load Regulation						0.5	%
Quiescent Current	VIN and VINA	I_Q	I_{OUT} = 0mA, V_{EN} = V_{IN} = V_{INA} = 3.6V, V_{OUT} = 3.6V		42		μA
	VOUT (Adjustable Output Voltage)				3.5		μA
FB Input Impedance (Fixed Output Voltage)					0.945		MΩ
Shutdown Current		I_S	V_{EN} = 0V, V_{IN} = V_{INA} = 3.6V		0.1	1	μA
Control Stage							
Under-Voltage Lockout Threshold		V_{UVLO}	V_{IN} voltage decreasing		1.7		V
EN, MODE/SYNC Input Low Voltage		V_{IL}				0.4	V
EN, MODE/SYNC Input High Voltage		V_{IH}		1.2			V
EN, MODE/SYNC Input Current			Clamped on GND or VINA		0.01	0.1	μA
Over-Temperature Protection					140		℃
Over-Temperature Hysteresis					20		℃

FUNCTIONAL BLOCK DIAGRAM

Figure 2. Block Diagram

DETAILED DESCRIPTION

The SGM62112 contains 4 MOSFETs for synchronous operation to improve system efficiency. In EN logic low case, the Buck-leg high-side MOSFET enables a load disconnect function.

The SGM62112 senses the average inductor current through the Buck-leg high-side MOSFET which is controlled by a current loop. The voltage loop formed by the feedback network then controls the current loop to regulate the output voltage. The SGM62112 implements input and output voltage feedforward and monitors the input and output voltage, any changes are immediately responded to achieve fast load transient response. The output voltage of SGM62112 is programmed via a resistive voltage divider connected at FB pin. Loop compensation network is integrated to reduce external component count.

The SGM62112 senses the peak inductor current for PWM duty cycle generation. In addition, the peak input current is also sensed to limit the maximal input power consumed by the load. This additional feature works in conjunction with the maximal peak inductor current to provide safe and stable operation of SGM62112. Some protection features are also implemented such as the thermal shutdown.

Device Enable

Pulling the EN pin logic high starts up the SGM62112, while a logic low turns off the device. During startup period, the SGM62112 limits the peak current to control the inrush current being pulled from the input supply.

Under-Voltage Lockout (UVLO)

The SGM62112 separates the power stage input and device's internal power supply input via VIN and VINA pins. An under-voltage lockout function is implemented to prevent insufficient voltage applied on VINA pin. Voltage below the UVLO threshold will turn off the SGM62112.

Over-Temperature Protection

The SGM62112 implements the over-temperature protection which prevents the device from over-heating.

If the sensed temperature in the IC exceeds the thermal shutdown threshold (see Electrical Characteristics), the device terminates the operation. The device resumes operating once the junction temperature falls 20℃ below the thermal shutdown threshold.

Soft-Start and Short Circuit Protection

The SGM62112 starts switching once the device is enabled and voltage at VINA pin exceeds the UVLO threshold. The average current limit is set to 400mA to raise the output voltage from 0V. Current limit is released to the nominal value once the voltage is higher than 1.2V. If the output voltage fails to reach 1.2V or higher, it indicates that a short circuit condition is present. Current limit is reduced in the short circuit condition to prevent the device from damage. The reduced current limit prevents output voltage overshoot and large inrush current at startup.

Buck-Boost Operation

The SGM62112 is a fully-integrated synchronous Buck-Boost converter which can automatically switch to boost, Buck or Buck-Boost operation to ensure regulated output throughout entire input range. The SGM62112's Buck-leg and Boost-leg half-bridge switches alternately in pure Buck and pure Boost mode, while one of the either high-side MOSFET remains fully turn-on in either Buck or Boost mode. There is no mode where all 4 switches are permanently switching.

Power-Save Mode and Synchronization

The SGM62112 allows programmable PFM operation or forced PWM operation at light loads via MODE/SYNC pin. Power-save mode is used to improve efficiency at light loads. The SGM62112 also supports external frequency synchronization function. An external clock signal applied at MODE/SYNC pin forces the device to synchronize to the applied clock frequency. The internal phase-locked loop (PLL) ensures smooth operation when a lack of synchronous clock pulse does not cause malfunction.

APPLICATION INFORMATION

The SGM62112 DC/DC converter supports various popular battery chemistries in the 1.8V to 5.5V range. The fully-integrated power-stage MOSFETs reduce solution size as well as achieving high efficiency.
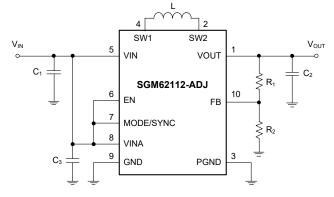
Typical Application

Figure 3. Typical Application Circuit for Adjustable Output Voltage Option

Design Requirements

The SGM62112-ADJ Buck-Boost converter's loop compensation is integrated to reduce external component counts. The external LC filter combination should be carefully designed to ensure control loop stability. Please follow Table 1 for the recommended component selections.

Table 1. List of Components

Reference	Description	Manufacturer
L_1	VLF4012-2R2	TDK
C_1	10µF, 6.3V, 0603, X7R ceramic	
C_2	2 × 10µF, 6.3V, 0603, X7R ceramic	
C_3	0.1µF, X7R ceramic	
R_3	100Ω	
R_1, R_2	Depending on the output voltage at SGM62112-ADJ, not used at SGM62112-3.3	

Programming the Output Voltage

To program the output voltage, an external resistor divider is used to adjust the output voltage. The current through the resistive divider should be about 100 times greater than the current into the FB pin to not affect the output voltage accuracy since there is 0.01µA (TYP) leakage current into the FB pin. To not violate the 100

times condition, the recommended value for R_2 should be lower than 500kΩ to set the divider current at 1µA or higher. Depending on the needed output voltage (V_{OUT}), the resistor R_1 that connected between VOUT and FB can be calculated using equation 1.

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

1MΩ resistor is chosen for R_1 to program 3.3V output. To further improve the device's loop response, a feedforward capacitor in parallel to R_1 is recommended. Please follow equation 2 for feedforward capacitor calculation.

$$C_{FF} = \frac{2.2\mu s}{R_1} \qquad (2)$$

Inductor Selection

The inductor used on DC/DC performs important roles to ensure proper operation of the device. Table 2 listed readily available inductor series from various vendors.

Table 2. List of Recommended Inductors

Vendor	Inductor Series
Coilcraft	LPS3015
	LPS4012
Murata	LQH3NP
Tajo Yuden	NR3015
TDK	VLF3215
	VLF4012

A low DC resistance inductor is recommended to minimize conduction losses. And the core loss of the inductor also affects the efficiency. Large inductance results in large ripple current which reduces core loss, but has better load transient response versus small inductance. Saturation current of the inductor should be taken into account as well. Equation 4 shows the calculation of inductor peak current. The selected inductor's saturation current should be higher than the value calculated in equation 4. Boost mode or lowest operation input has the highest value of current; therefore only Boost mode equation is shown.

APPLICATION INFORMATION (continued)

$$\text{Duty Cycle Boost} \quad D = \frac{V_{OUT} - V_{IN}}{V_{OUT}} \quad (3)$$

$$I_{PEAK} = \frac{I_{OUT}}{\eta \times (1 - D)} + \frac{V_{IN} \times D}{2 \times f \times L} \quad (4)$$

where:

D: Boost mode duty cycle.
L: Inductance.
F: Converter switching frequency, 1.4MHz (TYP).
η: DC/DC conversion efficiency (90% efficiency estimation is a good starting point).

The selected inductor saturation current should be at least 20% higher than the value calculated using equation 4 to ensure enough margin. Table 2 lists some recommended inductors for SGM62112.

Capacitor Selection

Input Capacitor

A 4.7μF or higher value ceramic capacitor should be placed as close as possible to the IC's VIN and PGND pins.

Output Capacitor

A minimal of 15μF effective capacitance ceramic capacitor placed as close as possible to the VOUT and PGND pins of the IC is recommended.

Layout Guidelines

Layout plays a significant role for all switch mode DC/DC power supplies. Improper layout could result in poor EMI performance, device instability, and potential device damage. The input and output capacitors should be placed on the same PCB layer as the IC. In addition, the loop formed by the capacitor's input/output capacitor's return to IC ground pin should be as small as possible. The SGM62112 implements a power ground and control ground pins to minimize the ground noise effect on sensitive analog circuits. Use a separate ground trace to connect the feedback, and connect this ground trace to the main power ground at a single point.
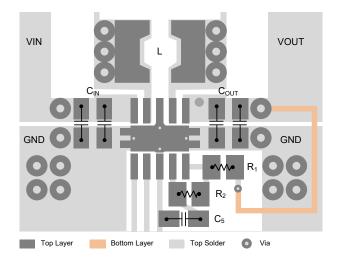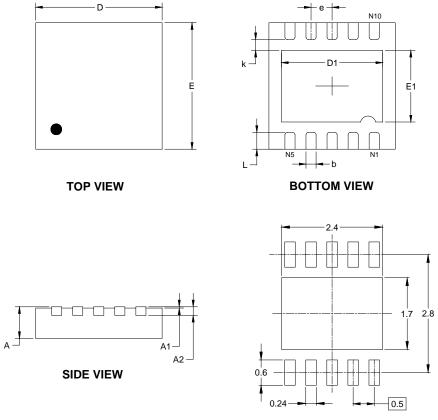

Figure 4. Layout Recommendation
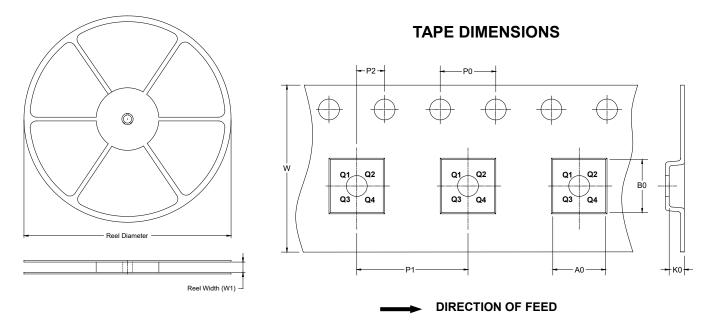
PACKAGE OUTLINE DIMENSIONS

TDFN-3×3-10L

TOP VIEW

BOTTOM VIEW

SIDE VIEW

RECOMMENDED LAND PATTERN (Unit: mm)

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	2.900	3.100	0.114	0.122
D1	2.300	2.600	0.091	0.103
E	2.900	3.100	0.114	0.122
E1	1.500	1.800	0.059	0.071
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.500 TYP		0.020 TYP	
L	0.300	0.500	0.012	0.020

NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

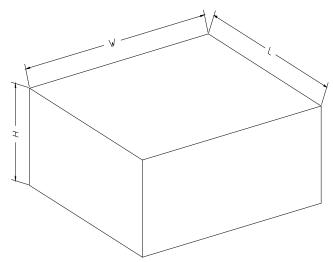### TAPE DIMENSIONS

DIRECTION OF FEED

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

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
TDFN-3×3-10L	13″	12.4	3.35	3.35	1.13	4.0	8.0	2.0	12.0	Q1

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