SGM6613A
28.5V, 7A Fully-Integrated Synchronous Boost Converter

GENERAL DESCRIPTION

The SGM6613A is a synchronous boost converter that can deliver 28.5V output. The device integrates a 17mΩ low-side power switch and a 31mΩ high-side power switch, and provides a high efficiency and small size power solution for portable equipment.

The SGM6613A uses peak current control topology with fixed frequency to regulate the output voltage. In moderate to heavy load condition, the SGM6613A works in the pulse width modulation (PWM) mode. In light load condition, the SGM6613A is in the forced PWM mode to avoid application problems due to low switching frequency.

The SGM6613A provides output over-voltage protection, inductor current limit protection and thermal shutdown protection.

The SGM6613A is available in a Green TQFN-3×3.5-13L package.

FEATURES

- **Wide 4.5V to 22V Input Voltage Range**
- **(V_{IN} + 5V) to 28.5V Output Voltage Range**
- **Up to 7A Resistor-Programmable Current Limit**
- **Integrated 17mΩ/31mΩ Power MOSFETs**
- **Up to 90% Efficiency at V_{IN} = 5V, V_{OUT} = 28.5V and I_{OUT} = 500mA**
- **Up to 700kHz Resistor-Programmable Switching Frequency**
- **Over-Voltage Protection**
- **Forced PWM Mode at Light Load Condition**
- **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
SGM6613A	TQFN-3×3.5-13L	-40℃ to +85℃	SGM6613AYTQX13G/TR	SGM6613A 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

SW and VOUT Voltages .... -0.3V to 31V
VIN and EN Voltages .... -0.3V to 24V
BOOT Voltage .... -0.3V to V_{SW} + 5V
VCC, FB, COMP, FREQ and 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 ....4.5V to 22V
Output Voltage Range ....(V_{IN} + 5V) to 28.5V
Operating Junction Temperature Range ....-40℃ to +85℃
Operating Ambient Temperature Range.........-40℃ to +85℃

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.

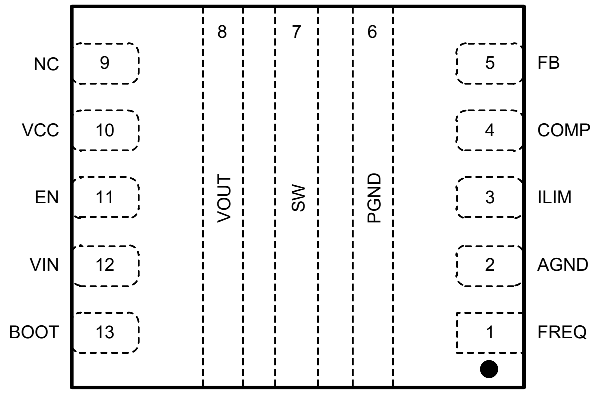
ESD SENSITIVITY CAUTION

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. Place a resistor between this pin and the AGND to program the switching frequency.
2	AGND	-	Analog Signal Ground of the IC.
3	ILIM	I	Adjustable Peak Current Limit. Place a resistor between this pin and AGND to program the 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	Switching Node of the Converter. It is connected to the internal power MOSFETs.
8	VOUT	PWR	Boost Converter Output.
9	NC	-	Not Connected.
10	VCC	O	Output of the Internal Regulator. Connect a capacitor of more than 1.0μF between this pin and ground.
11	EN	I	Enable Logic Input. Logic high level enables the device. Logic low level disables the device and turns it into shutdown mode.
12	VIN	I	Power Supply.
13	BOOT	O	Gate Driver Supply of the High-side MOSFET. Connect a capacitor between this pin and the SW pin.

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

ELECTRICAL CHARACTERISTICS

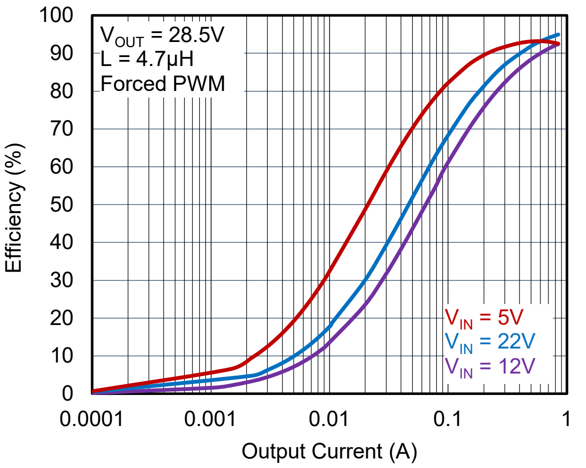
(V_{IN} = 4.5V to 22V, V_{OUT} = 28.5V, T_J = -40℃ to +85℃, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Power Supply						
Input Voltage Range	V_{IN}		4.5		22	V
Input UVLO Threshold	V_{IN_UVLO}	V_{IN} rising		4.1	4.4	V
Input UVLO Hysteresis	V_{IN_HYS}			160		mV
VCC Regulation Voltage	V_{CC}	I_{CC} = 5mA, V_{IN} = 6V		5		V
Quiescent Current into VIN Pin	I_Q	IC enabled, no load, no switching, V_{IN} = 4.5V, V_{OUT} = 28.5V, V_{FB} = 1.23V		420	510	μA
Quiescent Current into VOUT Pin				150	200	
Shutdown Current into VIN Pin	I_{SD}	IC disabled, V_{IN} = 4.5V		0.8	3	μA
		IC disabled, V_{IN} = 22V		4.4	8	
Leakage Current of Low-side MOSFET	I_{LS_LKG}	IC disabled, V_{IN} = 22V, V_{OUT} = V_{SW} = 28.5V		0.1	6	μA
Output Voltage						
Output Voltage Range	V_{OUT}		9.5		28.5	V
Output Over-Voltage Protection Threshold	V_{OVP}	V_{IN} = 5V, V_{OUT} rising, T_J = +25℃	29.2	30.2	31.2	V
Power Switches						
High-side MOSFET On-Resistance	R_{DSON_HS}	V_{CC} = 5V, T_J = +25℃		31	40	mΩ
Low-side MOSFET On-Resistance	R_{DSON_LS}	V_{CC} = 5V, T_J = +25℃		17	25	mΩ
Power Stage Trans-Conductance (peak current ratio with comp voltage)	G_m	V_{CC} = 5V		12.5		A/V
Current Limit						
Resistor-Programmable Current Limit	I_{LIM}	R_{LIM} = 107kΩ, T_J = +25℃	5.3	6.8	8.2	A
Voltage Reference						
Reference Voltage at FB Pin	V_{REF}	Forced PWM operation, T_J = +25℃	1.176	1.200	1.224	V
Leakage Current into FB Pin	I_{FB_LKG}			10	60	nA
EN Logic						
EN Pin Logic High Threshold	V_{EN_H}	V_{IN} = 5V			1.2	V
EN Pin Logic Low Threshold	V_{EN_L}	V_{IN} = 5V	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} = 107kΩ		1.57		V
COMP Pin Output Low Voltage	V_{COMP_L}	Low threshold, V_{FB} = V_{REF} + 100mV, R_{LIM} = 107kΩ		0.46		V
Error Amplifier Trans-Conductance	G_{mEA}	V_{COMP} = 1.2V		260		μS
COMP Pin Sink Current	I_{SINK}	V_{FB} = V_{REF} + 100mV, V_{COMP} = 1.2V		155		μA
COMP Pin Source Current	I_{SOURCE}	V_{FB} = V_{REF} - 100mV, V_{COMP} = 1.2V		25		μA
Soft-Start						
Startup Time	$t_{STARTUP}$			11		ms
Pre-Charge Time	t_{PRE_CHARGE}	T_J = +25℃	2	2.7	3.4	ms
Protection						
Thermal Shutdown Rising Threshold	T_{SD_R}	T_J rising		150		℃
Thermal Shutdown Falling Threshold	T_{SD_F}	T_J falling		130		℃
Waiting Time for Restart in Hiccup Mode	t_{HIC_OFF}			70		ms
Switching Frequency						
Switching Frequency	f_{SW}	R_{FREQ} = 330kΩ	400	500	600	kHz
Minimum On-Time	t_{ON_MIN}			180		ns

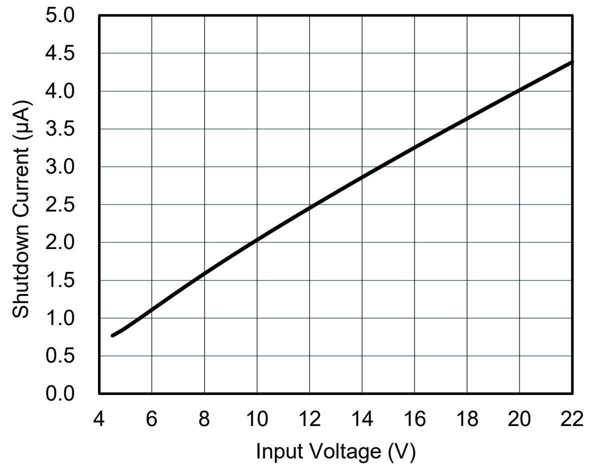
TYPICAL PERFORMANCE CHARACTERISTICS

At T_J = +25℃, V_{IN} = 5V and V_{OUT} = 28.5V, unless otherwise noted.

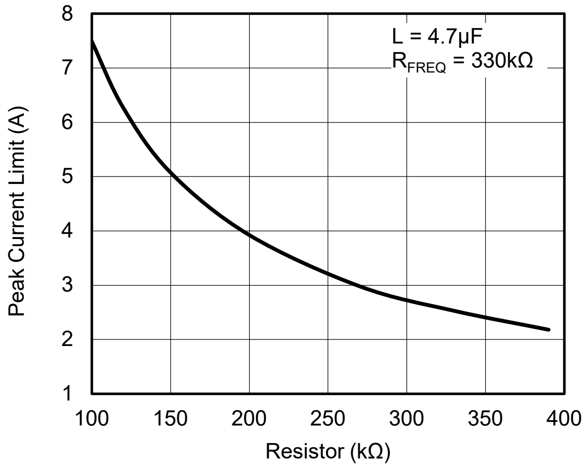
Efficiency vs. Output Current



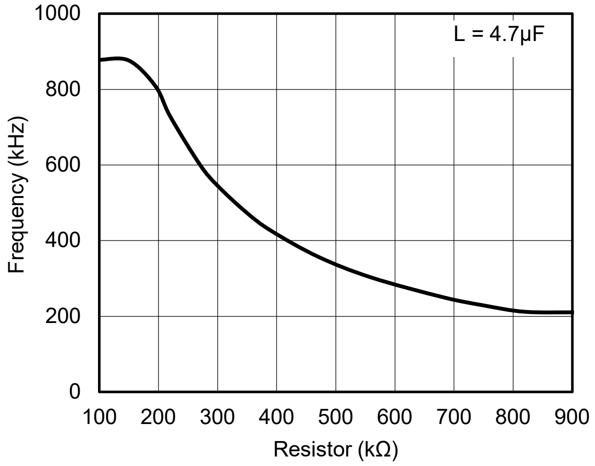
Shutdown Current vs. Input Voltage



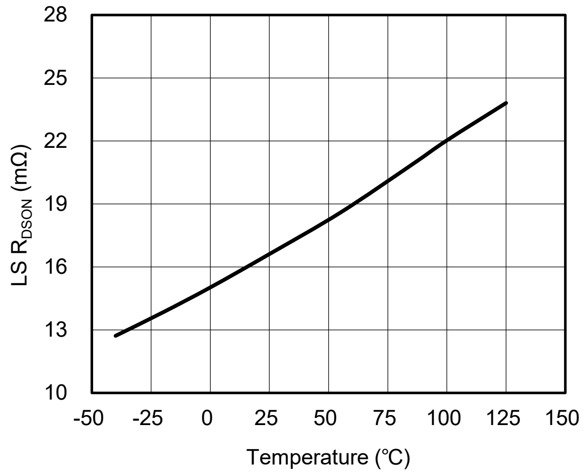
Peak Current Limit vs. Setting Resistor



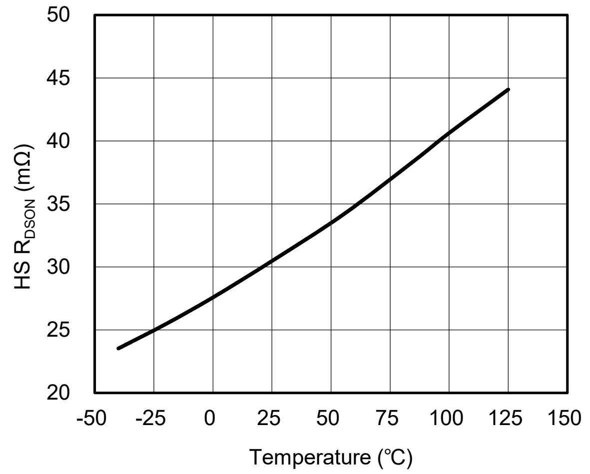
Frequency vs. Setting Resistor



R_{DSON_LS} vs. Temperature



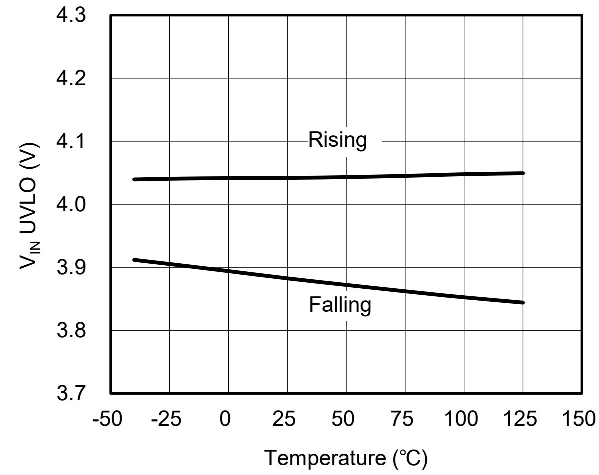
R_{DSON_HS} vs. Temperature



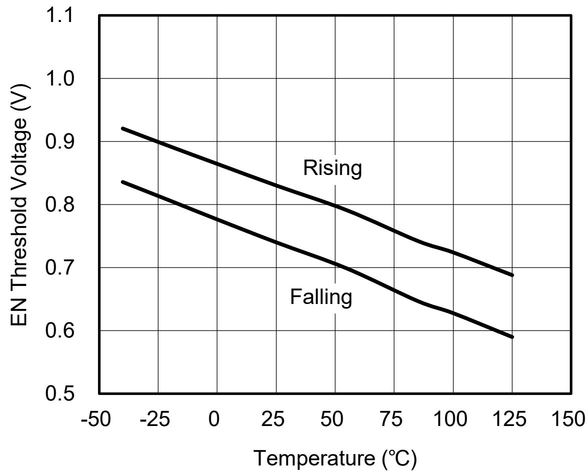
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_J = +25℃, V_{IN} = 5V and V_{OUT} = 28.5V, unless otherwise noted.

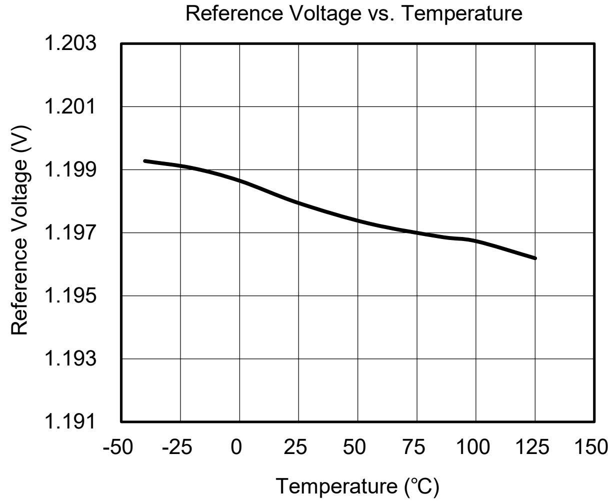
V_{IN} UVLO Rising/Falling Threshold vs. Temperature



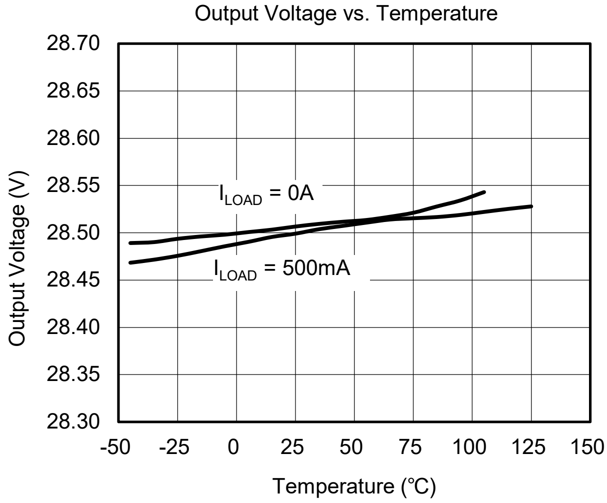
EN Rising/Falling Threshold vs. Temperature



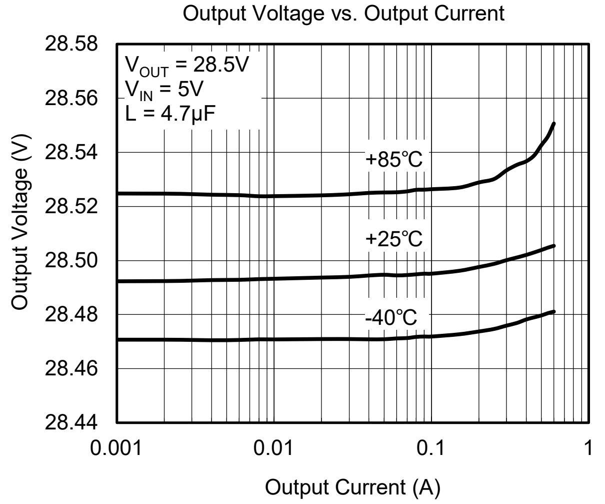
Reference Voltage vs. Temperature



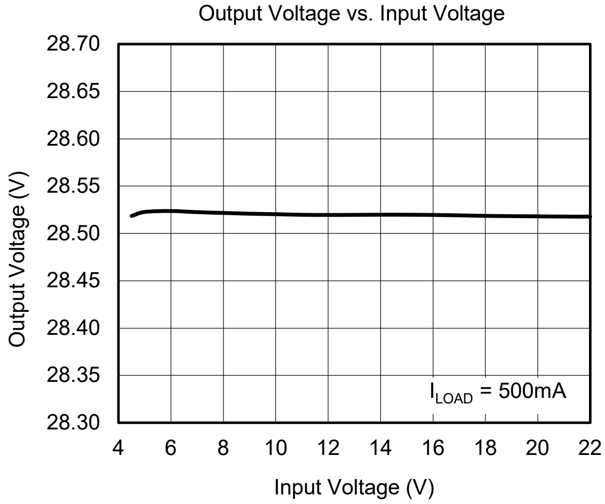
Output Voltage vs. Temperature



Output Voltage vs. Output Current



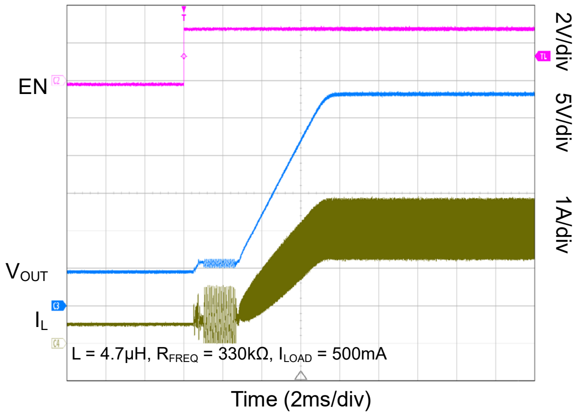
Output Voltage vs. Input Voltage



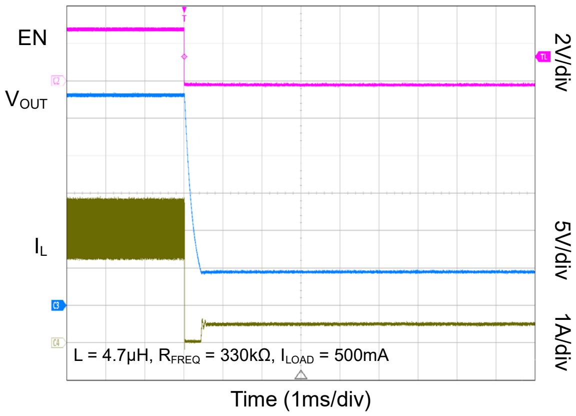
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_J = +25℃, V_{IN} = 5V and V_{OUT} = 28.5V, unless otherwise noted.

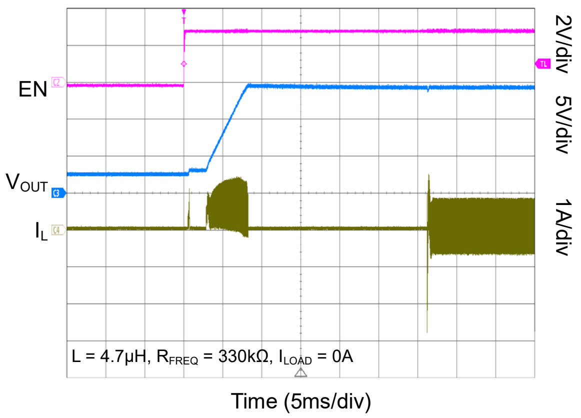
Startup by Enable



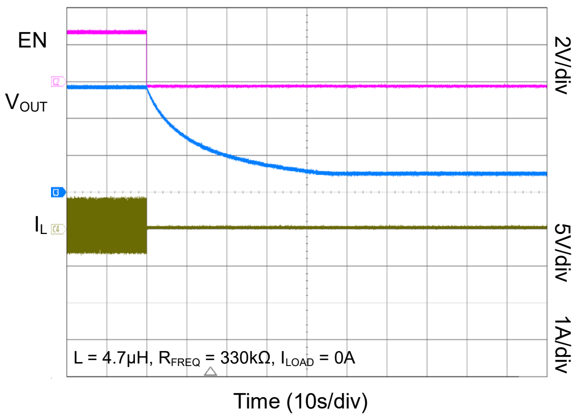
Shutdown by Enable



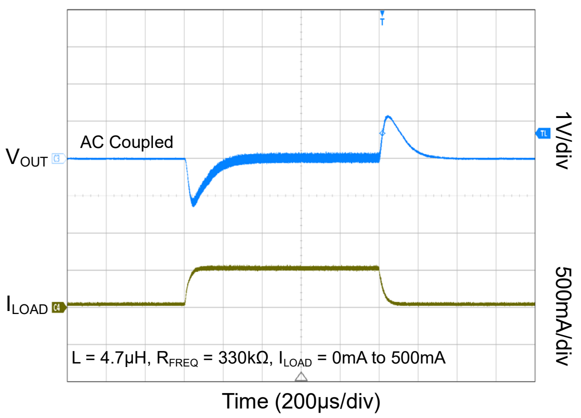
Startup by Enable



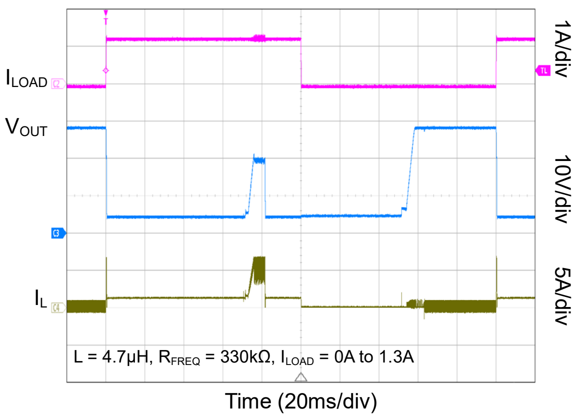
Shutdown by Enable



Load Transient Response



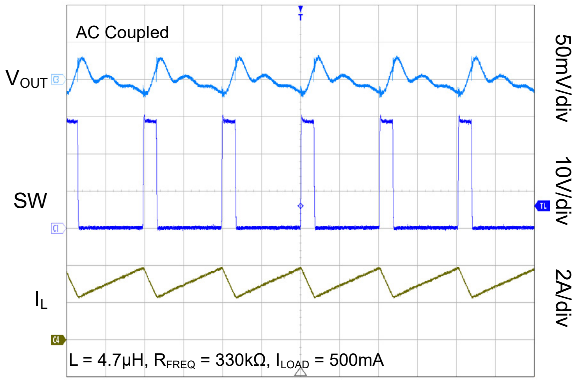
Hiccup Protection



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

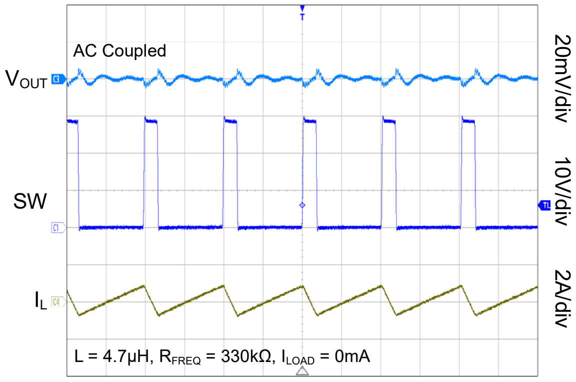
At T_J = +25℃, V_{IN} = 5V and V_{OUT} = 28.5V, unless otherwise noted.

Steady State



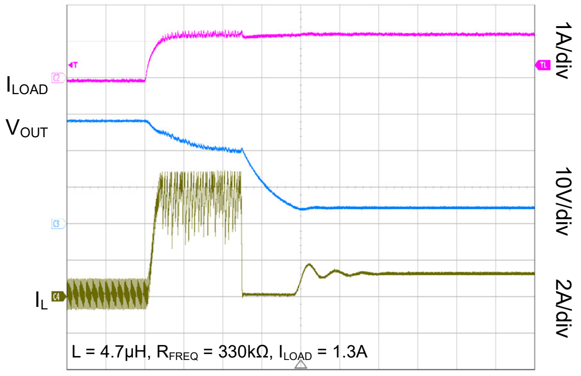
Time (1μs/div)

Steady State



Time (1μs/div)

Over-Current Protection



Time (100μs/div)

FUNCTIONAL BLOCK DIAGRAM

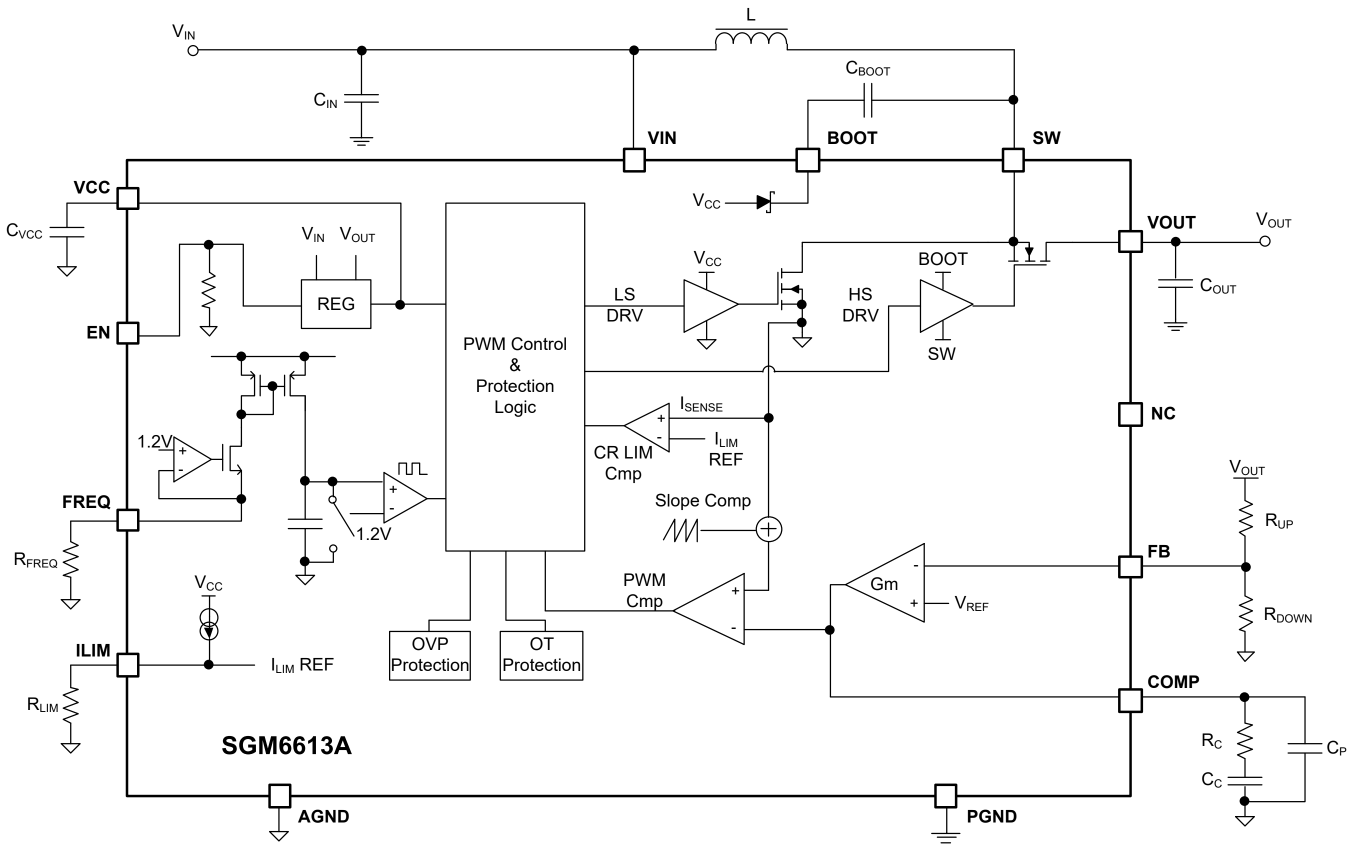


Figure 1. SGM6613A Block Diagram

DETAILED DESCRIPTION

The SGM6613A is a synchronous boost converter integrating a 17mΩ low-side power switch and a 31mΩ high-side power switch. It is capable of delivering up to 7A peak current and up to 28.5V output voltage. In moderate to heavy load condition, the SGM6613A operates at a fixed frequency PWM mode. In light load condition, the SGM6613A operates in the forced PWM mode to avoid the acoustic noise and switching frequency interference. The SGM6613A 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 SGM6613A supports the resistor-programmable switching frequency of up to 700kHz. The device uses peak current control topology to protect the device from overloading during the boost operation phase. In addition, during an over-current event, if the V_{OUT} drops and triggers hiccup mode, the SGM6613A enters into hiccup mode to provide a 70ms hiccup off-time to prevent the IC from overheating, thus triggering thermal shutdown. Device will recover automatically once the over-current condition is removed.

Input Under-Voltage Lockout

An under-voltage lockout (UVLO) circuit prevents operation of the device at input voltages below typical 3.94V with a hysteresis of 160mV. Therefore, if the input voltage rises and exceeds 4.1V (TYP), the device restarts.

Enable and Disable

When the input voltage exceeds minimum input voltage during startup and the EN voltage is higher than its logic high threshold, the SGM6613A is enabled. When the EN voltage is lower than its logic low threshold, the SGM6613A goes into the shutdown mode and stops switching.

Startup

The SGM6613A implements the soft-start function to reduce the inrush current during startup. The device first charges the output voltage to 1.1×V_{IN} with the fixed 500kHz switching frequency during pre-charge phase. After the pre-charge phase ends (2.7ms, TYP), the output voltage will rise gradually and linearly to the target value. The soft-start time is typically 11ms. After that the switching frequency is set by the resistor connected through the FREQ pin.

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 current limit can be set. Calculate the correct resistor value according to Equation 1 as below:

$$R_{LIM} = \frac{730}{I_{LIM}} \tag{1}$$

where:

R_{LIM} is the resistor for setting the current limit, with the unit of kΩ.
I_{LIM} is peak current limit, and the unit is A.

For example, a 107kΩ resistor gives a 6.8A peak current limit.

Adjustable Switching Frequency

The SGM6613A has an adjustable switching frequency up to 700kHz. The switching frequency is set by an external resistor (R_{FREQ}) connected between the FREQ pin and AGND pin. Do not leave the FREQ pin floating. Use Equation 2 and Equation 3 to calculate the resistor value for a desired frequency.

$$T = \frac{1}{f_{FREQ}} = k \times C_{FREQ} \times R_{FREQ} + t_{DELAY} \tag{2}$$

$$R_{FREQ} = \frac{\frac{1}{f_{FREQ}} - t_{DELAY}}{k \times C_{FREQ}} \tag{3}$$

where:
t_{DELAY} = 200ns, k = 3 and C_{FREQ} = 1.8pF.

For instance, if the R_{FREQ} is 330kΩ, the frequency is 500kHz. If the frequency is set to more than 500kHz, lower inductance is recommended such that 1.8μH inductance is selected for 700kHz.

DETAILED DESCRIPTION (continued)

Pre-biased Startup

The SGM6613A 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 startup 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 to be above 0.1μF.

Over-Voltage Protection (OVP)

The SGM6613A provides 30.2V (TYP) OVP threshold. The device stops switching immediately until the voltage at the VOUT pin drops 600mV below the output OVP 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 +150℃ (TYP), the device stops switching. Once the temperature drops below +130℃ (TYP), the device resumes operation.

Device Functional Modes

The synchronous boost converter SGM6613A 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 SGM6613A has internal slope compensation.

In the forced PWM mode, the SGM6613A keeps the switching frequency constant in light load condition. When the load current is reduced, the output of the internal error amplifier decreases as well to make the inductor current limit down and delivers less power from input to output. When the output current is reduced further, the current through the inductor will decrease to zero during the off-time. The high-side MOSFET is not turned off even if the current through the MOSFET goes negative.

This mode is good for mitigating the acoustic noise and switching frequency interference at the light load.

When V_{OUT} is close to V_{IN}, the boost converter cannot support the duty cycle anymore. It enables 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} should be at least 5V lower than V_{OUT}.

APPLICATION INFORMATION

Typical Application

The application described is for 5V input, 28.5V output converter.

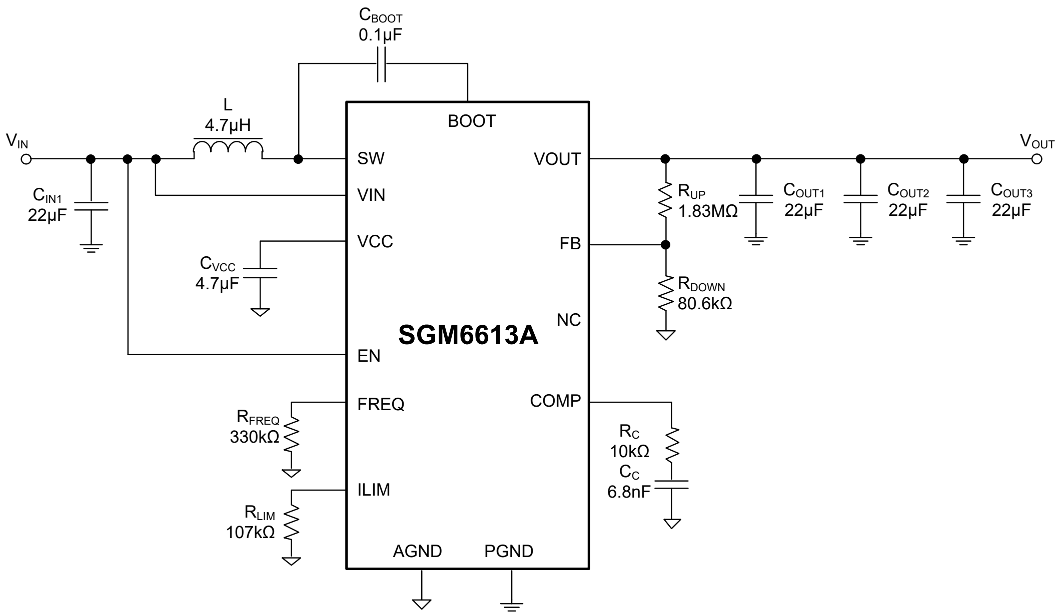


Figure 2. SGM6613A 28.5V Output

Design Requirements

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

Table 1. Design Parameters

Parameter	Value
Input Voltage Range	4.5V to 22V
Output Voltage	28.5V
Output Ripple Voltage	±3%
Output Current Rating	0.5A
Operating Frequency	500kHz

Table 2. Recommended Inductors for SGM6613A

Part Number	L (μH)	DCR TYP (mΩ)	Saturation Current/Heat Rating Current (A)	Size (L × W × H mm)	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
74439369047	4.7	5.4	27/13.5	11.6 × 10.5 × 8.8	Würth
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 SGM6613A

Designator	Qty	Value	Description	Package	Part Number	Manufacturer
C_{IN}	1	22μF	CAP, CERM, 22μF, 25V, ±10%, X5R, 1210	1210	GRM32ER61E226KE15L	Murata
C_{OUT}	3	22μF	CAP, CERM, 22μF, 35V, ±10%, X7R, 2220	2220	KRM55QR7YA226KH01L	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	4.7μF	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 SGM6613A is set by an external resistor. For setting a current limit of 6.8A, the calculated resistor value is 107kΩ. 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, 93.6kΩ 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 28.5V, choose R_{DOWN} to be approximately 80.6kΩ, calculated by Equation 4, and R_{UP} is 1.83MΩ.

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.

Selecting the Input Capacitor

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

Selecting the Bootstrap Capacitor

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

VCC Capacitor

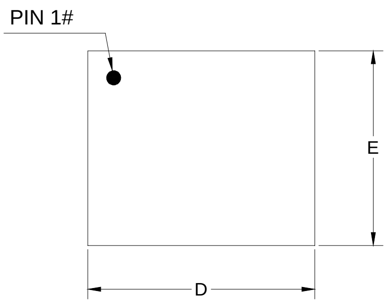
The value of C_{VCC} should be at least 10 times larger than the value of C_{BOOT}. A 1μF ~ 4.7μF capacitor value range is recommended for C_{VCC}. A value of 4.7μF is selected for this design example. Refer to Table 3.

Layout Guidelines

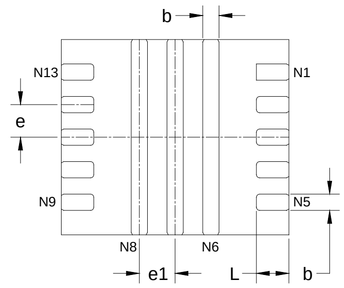
As for all switching power supplies, especially those high frequency and high current ones, layout is an important design step. If layout is not carefully done, the regulator could suffer from instability as well as noise problems. Therefore, use wide and short traces for high current paths. The input capacitor C_{IN} needs to be close to VIN pin and PGND pin in order to reduce the input ripple seen by the IC. 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} (3 × 22μF) should be put close to VOUT pin. It is beneficial to have the ground of C_{OUT} close to the PGND pin since there is large ground return current flowing between them. It is also recommended to place an additional 1μF ceramic capacitor directly across the VOUT and PGND pins. Place the noise sensitive network like the feedback and compensation 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.

PACKAGE OUTLINE DIMENSIONS

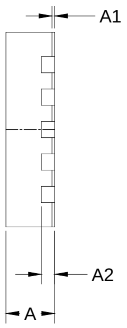
TQFN-3×3.5-13L



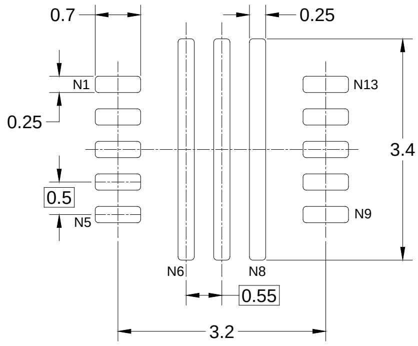
TOP VIEW



BOTTOM VIEW



SIDE VIEW



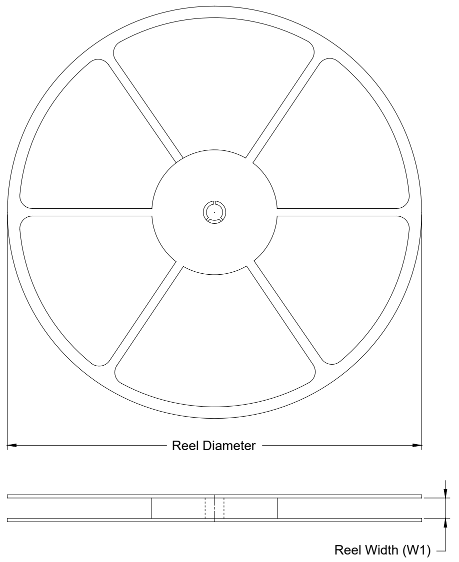
RECOMMENDED LAND PATTERN (Unit: mm)

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		

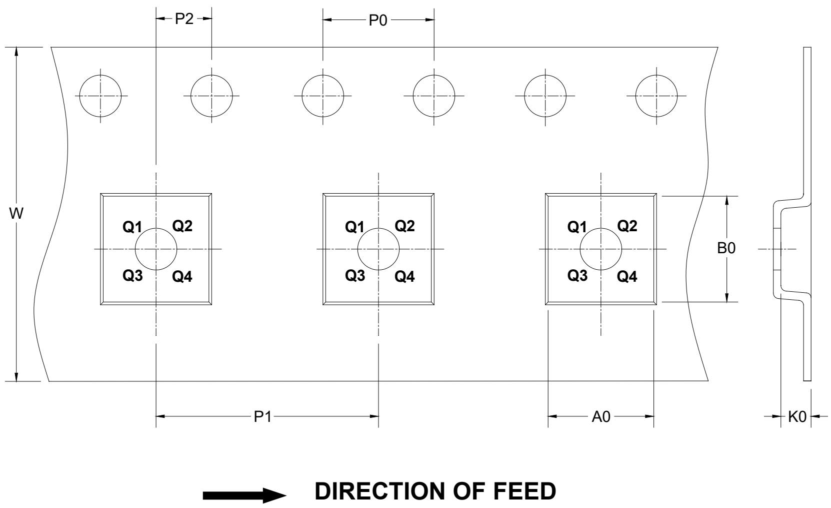
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



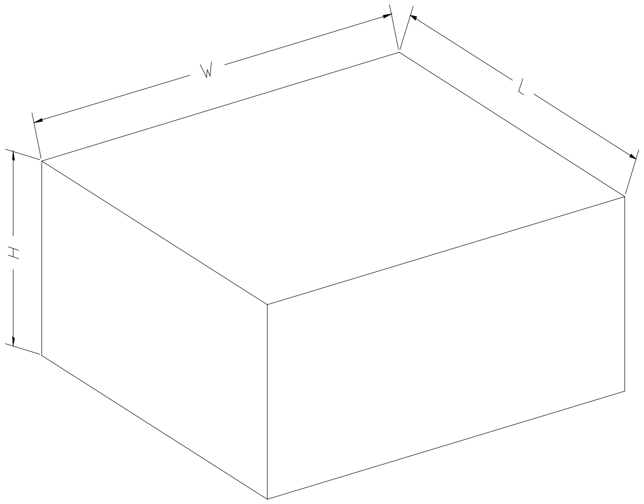
NOTE: The picture is only for reference. Please make the object as the standard.

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

单击下面可查看定价，库存，交付和生命周期等信息

[>>SGMICRO(圣邦微电子)]