SGM6602
20V Output Voltage Boost Converter

GENERAL DESCRIPTION

The SGM6602 is a fully-integrated synchronous Boost converter which integrates a 20V main power switch and an input/output isolation switch. The isolation switch provides true load disconnection when SGM6602 is in shutdown mode. The SGM6602 is capable to start up from 1.8V to 5.5V input. The device can provide up to 20V output voltage which makes it an excellent choice for PMOLED panel bias and applications requiring high voltage in a small solution size. The SGM6602 has the internal fixed 9V or 12V (different ordering part) default output voltage setting by connecting the FB pin to the VIN pin. The SGM6602 has 900mA typical switch current limit.

The package of SGM6602 is suitable to a tiny size solution. And small energy storage elements (inductor and capacitor) can be used since the high frequency (1.1MHz) switching converter. The SGM6602 implements various protection features to improve device robustness, such as short-circuit protection, output over-voltage protection and thermal shutdown.

The SGM6602 is available in Green WLCSP-0.8×1.2-6B and TDFN-2×2-6AL packages.

FEATURES

- **1.8V to 5.5V Operating Input Voltage Range**
- **Up to 20V Output Voltage**
- **Up to 85% Efficiency at 3.6V Input and 12V Output**
- **900mA (TYP) Switch Current**
- **Internal 5ms Soft-Start Time**
- **Less than 1μA Ultra-Low Shutdown Current**
- **Integrated Isolation Switch**
- **Power-Save Mode at Light Load**
- **Input and Output are Disconnected during Shutdown**
- **Output Short-Circuit and Over-Voltage Protections**
- **Thermal Shutdown**
- **Available in Green WLCSP-0.8×1.2-6B and TDFN-2×2-6AL Packages**

APPLICATIONS

PMOLED and Sensor Power Supplies
Wearable Devices
Portable Medical Equipment

TYPICAL APPLICATION

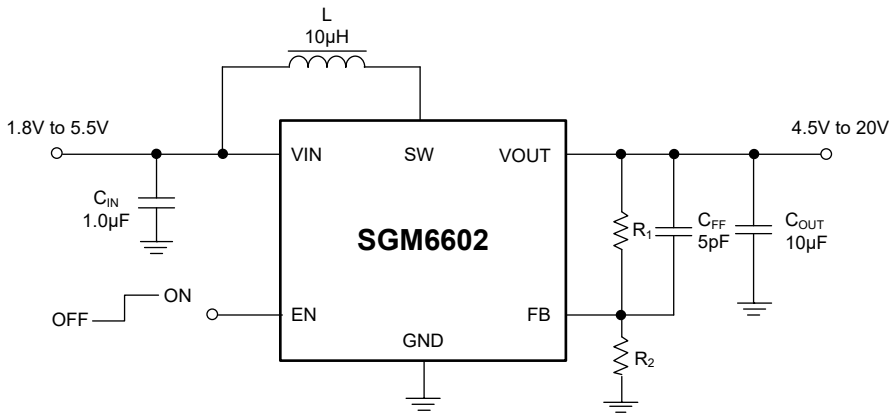


Figure 1. Typical Application Circuit

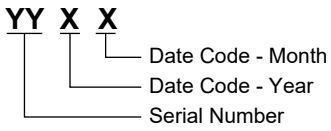
PACKAGE/ORDERING INFORMATION

MODEL	V_{OUT} (V)	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM6602-9	9	WLCSP-0.8×1.2-6B	-40℃ to +85℃	SGM6602-9YG/TR	WDXX	Tape and Reel, 3000
	9	TDFN-2×2-6AL	-40℃ to +85℃	SGM6602-9YTDI6G/TR	M32 XXXX	Tape and Reel, 3000
SGM6602-12	12	WLCSP-0.8×1.2-6B	-40℃ to +85℃	SGM6602-12YG/TR	SBXX	Tape and Reel, 3000
	12	TDFN-2×2-6AL	-40℃ to +85℃	SGM6602-12YTDI6G/TR	GT6 XXXX	Tape and Reel, 3000

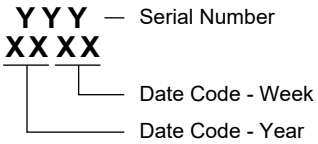
MARKING INFORMATION

NOTE: XX = Date Code, XXXX = Date Code.

WLCSP-0.8×1.2-6B



TDFN-2×2-6AL



Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

ABSOLUTE MAXIMUM RATINGS

Voltage Range at Terminals
- VIN, EN, FB ..... -0.3V to 6V
- SW, VOUT ..... -0.3V to 22V

Package Thermal Resistance
- WLCSP-0.8×1.2-6B, θ_{JA} ..... 110.8℃/W
- WLCSP-0.8×1.2-6B, θ_{JB} ..... 25.2℃/W
- WLCSP-0.8×1.2-6B, θ_{JC} ..... 59℃/W
- TDFN-2×2-6AL, θ_{JA} ..... .79.5℃/W
- TDFN-2×2-6AL, θ_{JB} ..... 39℃/W
- TDFN-2×2-6AL, $\theta_{JC\ (TOP)}$ ..... 84.6℃/W
- TDFN-2×2-6AL, $\theta_{JC\ (BOT)}$ ..... 9.5℃/W

Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility
HBM 5000V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Inductance, Effective Value, L ..... 10μH (TYP)
Input Capacitance, Effective Value, C_{IN} ..... 1μF (MIN)
Output Capacitance, Effective Value, C_{OUT} ..... 4.7μF to 10μF
Input Voltage Range ..... 1.8V to 5.5V
Output Voltage Range ..... 4.5V to 20V
Operating Junction 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

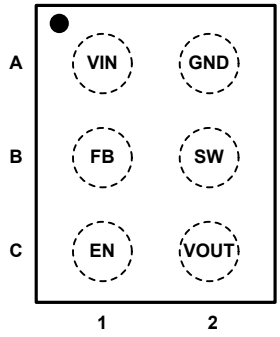
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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

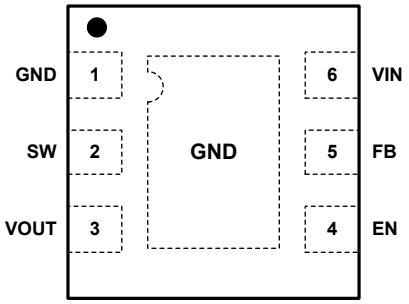
PIN CONFIGURATIONS

(TOP VIEW)



WLCSP-0.8×1.2-6B

(TOP VIEW)



TDFN-2×2-6AL

PIN DESCRIPTION

PIN		NAME	FUNCTION
WLCSP-0.8×1.2-6B	TDFN-2×2-6AL		
A1	6	VIN	Power Supply Input.
A2	1	GND	Ground.
B1	5	FB	Voltage Feedback. The FB pin is connected to the center tap of a resistor divider to program the output voltage.
B2	2	SW	Switch Pin. Connect it to the drain of the internal power MOSFET.
C1	4	EN	Enable Logic Input. Logic high makes the device enabled and logic low makes it disabled. The device enters into shutdown mode.
C2	3	VOUT	Output.
–	Exposed Pad	GND	Be connected to GND.

ELECTRICAL CHARACTERISTICS

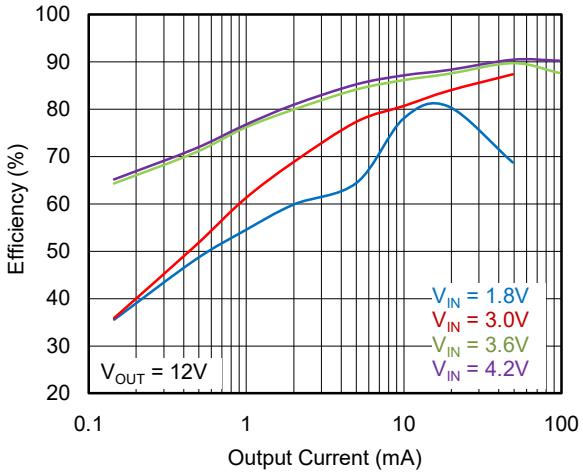
(V_{IN} = 3.6V, V_{OUT} = 12V, C_{IN} = 1.0μF, C_{OUT} = 4.7μF, L = 10μH. T_J = -40℃ to +85℃, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
POWER SUPPLY						
Under-Voltage Lockout Threshold	V_{IN_UVLO}	V_{IN} rising, T_J = +25℃		1.52	1.8	V
VIN UVLO Hysteresis	V_{IN_HYS}	T_J = +25℃		150		mV
Quiescent Current into VIN Pin	I_{Q_VIN}	IC enabled, no load, no switching		41	60	μA
Shutdown Current into VIN Pin	I_{SD}	IC disabled, T_J = +25℃			1	μA
OUTPUT						
12V Output Voltage Accuracy	V_{OUT_12V}	FB pin connected to VIN pin, T_J = +25℃	11.64	12.00	12.36	V
9V Output Voltage Accuracy	V_{OUT_9V}		8.73	9.00	9.27	
Feedback Voltage	V_{FB}	PWM mode, T_J = +25℃	0.771	0.795	0.818	V
Output Over-Voltage Protection Threshold	V_{OVP}	T_J = +25℃	20.2	21.5	22.2	V
Over-Voltage Protection Hysteresis	V_{OVP_HYS}	T_J = +25℃		1.4		V
Leakage Current into FB Pin	I_{FB_LKG}				200	nA
Leakage Current into SW Pin	I_{SW_LKG}	IC disabled			500	nA
POWER SWITCH						
Isolation MOSFET On-Resistance	$R_{DS(ON)}$	WLCSP-0.8×1.2-6B, T_J = +25℃		975		mΩ
Low-side MOSFET On-Resistance				515		
Isolation MOSFET On-Resistance	$R_{DS(ON)}$	TDFN-2×2-6AL, T_J = +25℃		955		mΩ
Low-side MOSFET On-Resistance				485		
Switching Frequency	f_{SW}	V_{IN} = 3.6V, V_{OUT} = 12V, PWM mode, T_J = +25℃	0.8	1.1	1.4	MHz
Peak Switch Current Limit	I_{LIM_SW}	V_{IN} = 3.6V, V_{OUT} = 12V, T_J = +25℃	650	900	1100	mA
Soft Startup Time	$t_{START-UP}$	V_{OUT} from V_{IN} to 12V, $C_{OUT\_EFFECTIVE}$ = 4.7μF, I_{OUT} = 0A, T_J = +25℃		5		ms
LOGIC INTERFACE						
EN Logic High Threshold	V_{EN_H}		1.2			V
EN Logic Low Threshold	V_{EN_L}				0.3	V
PROTECTION						
Thermal Shutdown Threshold	T_{SD}	T_J rising		160		℃
Thermal Shutdown Hysteresis	T_{SD_HYS}	T_J falling below T_{SD}		20		℃

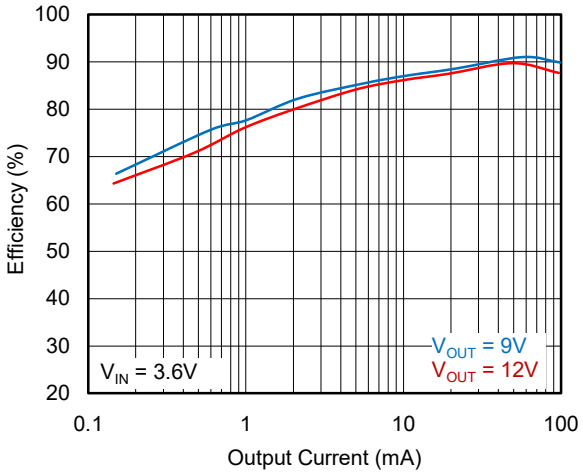
TYPICAL PERFORMANCE CHARACTERISTICS

At T_J = +25℃, V_{IN} = 3.6V, V_{OUT} = 12V, unless otherwise noted.

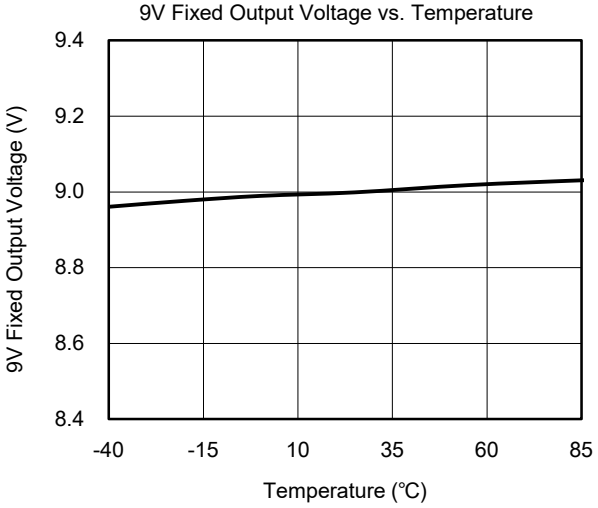
Efficiency vs. Output Current



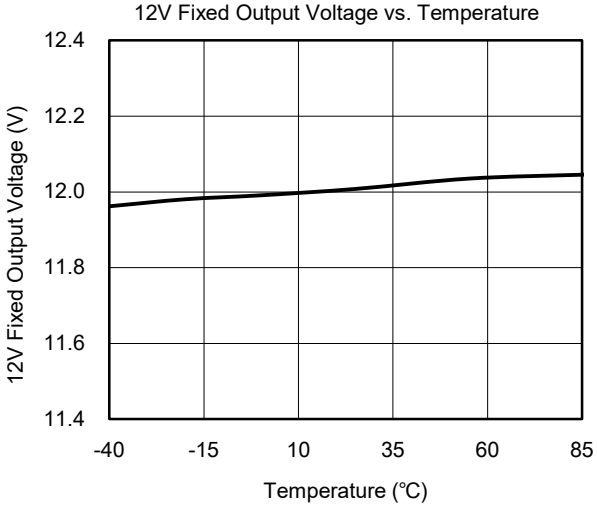
Efficiency vs. Output Current



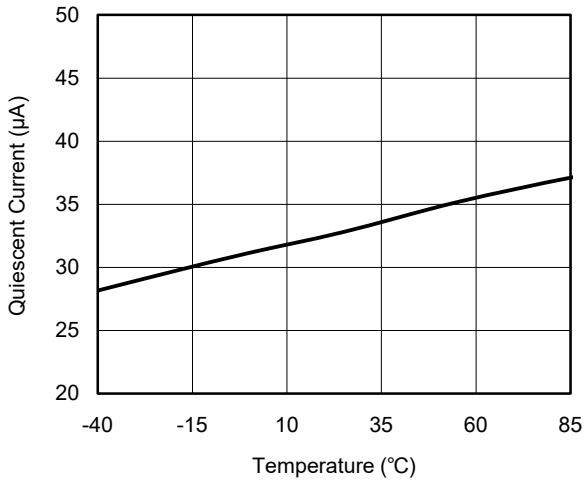
9V Fixed Output Voltage vs. Temperature



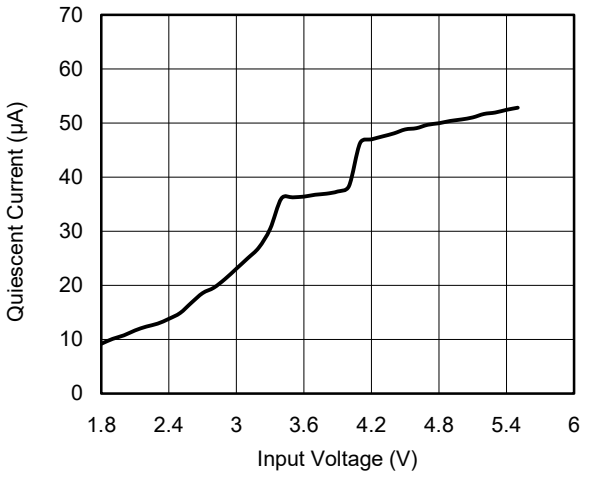
12V Fixed Output Voltage vs. Temperature



Quiescent Current vs. Temperature



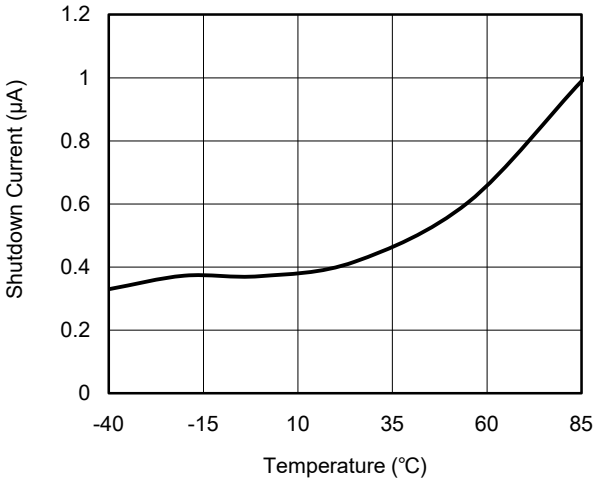
Quiescent Current vs. Input Voltage



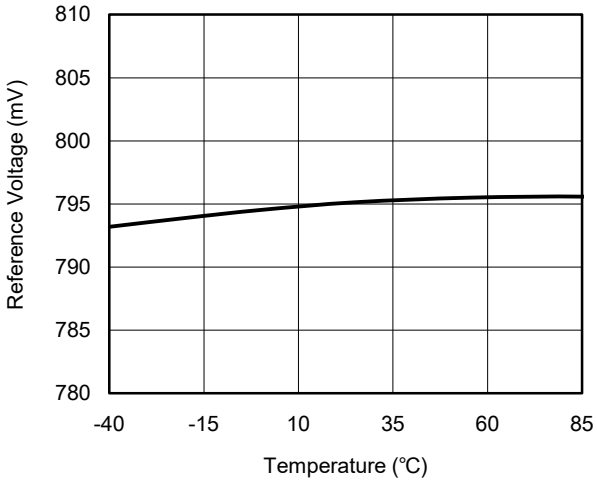
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

At T_J = +25℃, V_{IN} = 3.6V, V_{OUT} = 12V, unless otherwise noted.

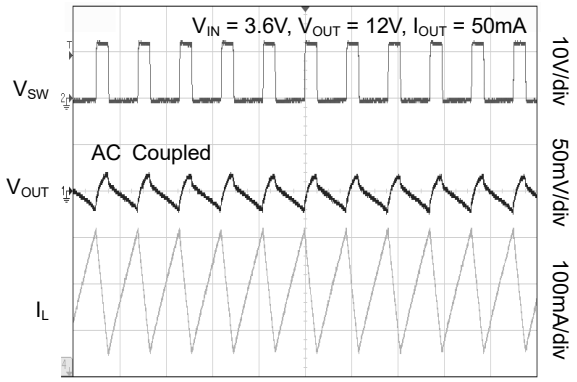
Shutdown Current vs. Temperature



Reference Voltage vs. Temperature

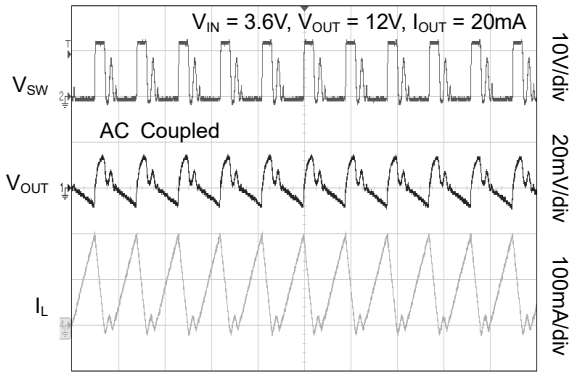


Switching Waveforms in PWM CCM



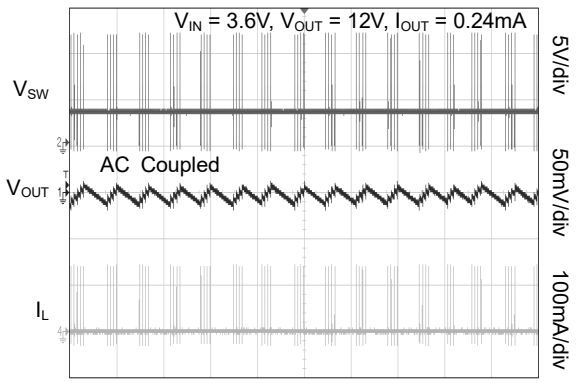
Time (1μs/div)

Switching Waveforms in PWM DCM



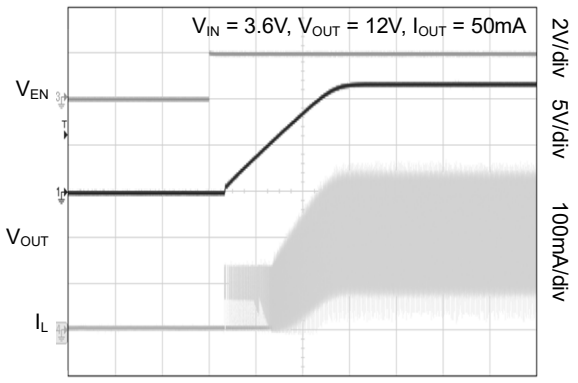
Time (1μs/div)

Switching Waveforms in Power-Save Mode



Time (200μs/div)

Soft Startup

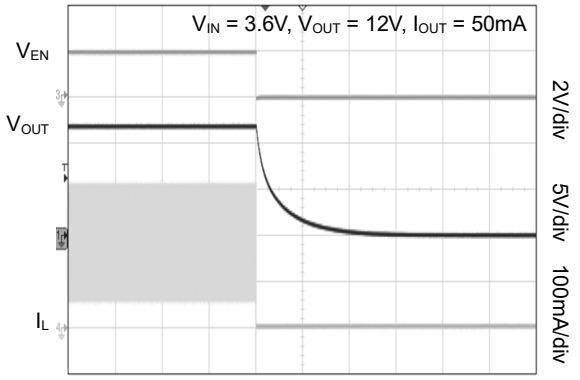


Time (2ms/div)

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

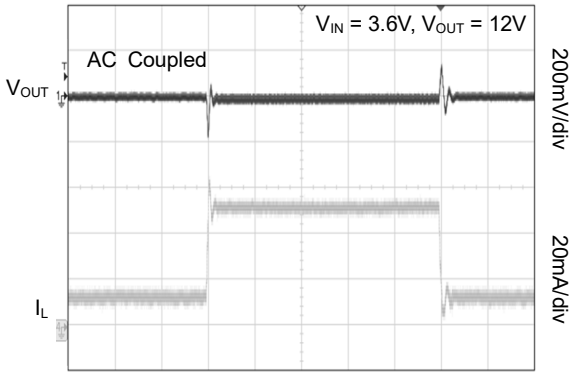
At T_J = +25℃, V_{IN} = 3.6V, V_{OUT} = 12V, unless otherwise noted.

Shutdown Waveforms



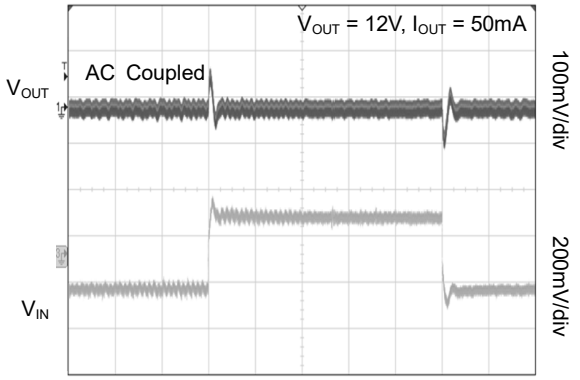
Time (2ms/div)

10mA to 50mA Load Transient Response



Time (1ms/div)

Input Voltage from 3.6V to 3.9V Line Transient Response



Time (500μs/div)

FUNCTIONAL BLOCK DIAGRAM

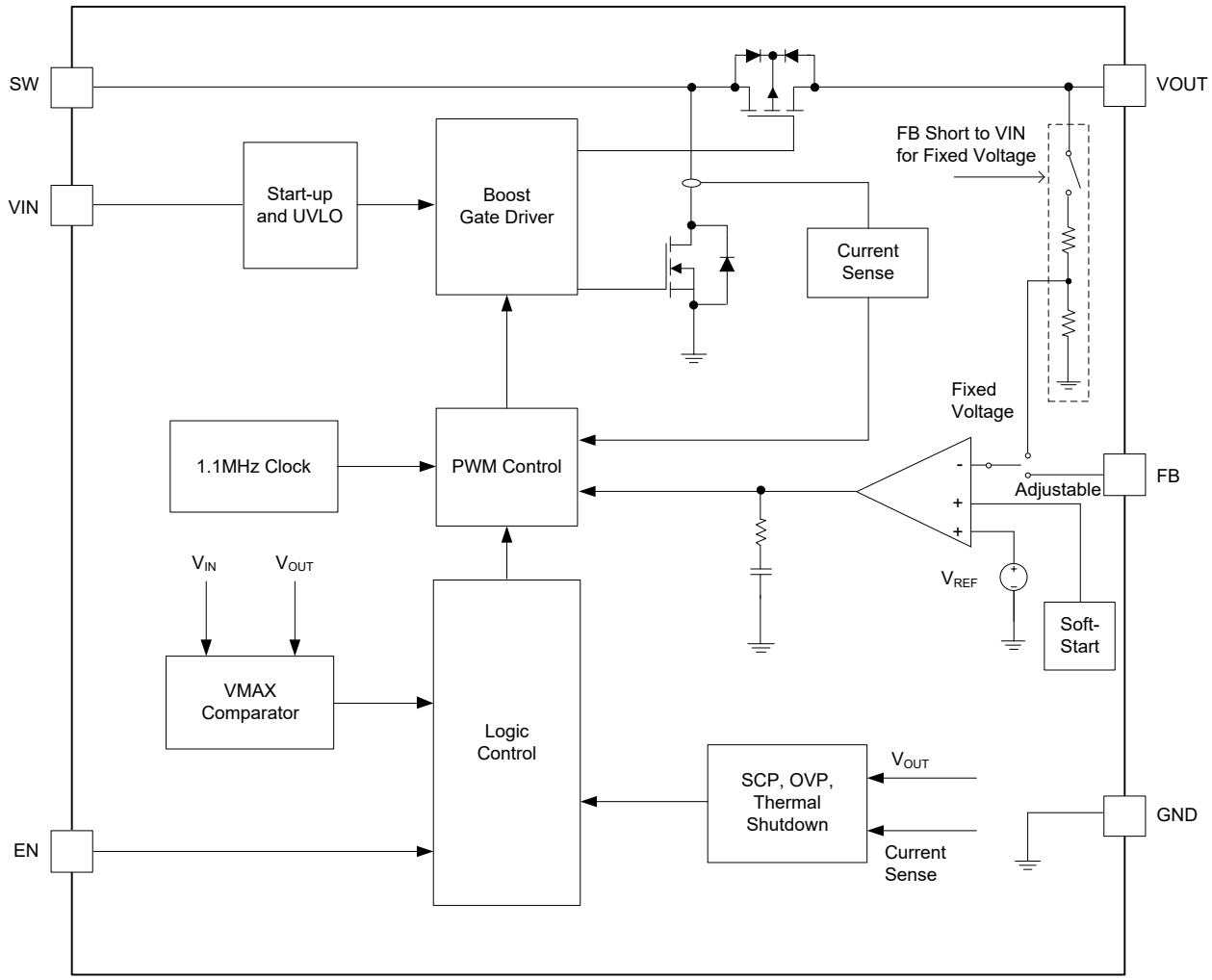


Figure 2. Block Diagram

APPLICATION INFORMATION

The SGM6602 is a fully integrated synchronous Boost converter which integrates a 20V main power switch and an input/output isolation switch. The isolation switch provides true load disconnection when SGM6602 is in shutdown mode to minimize the leakage current. The device is capable to start up from 1.8V to 5.5V input. Under moderate to heavy load condition, the SGM6602 works in PWM mode with 1.1MHz quasi-constant frequency.

The procedure below can be followed to choose peripheral components for the SGM6602.

Table 1. Design Requirements

PARAMETERS	VALUES
Input Voltage	2.7V to 4.4V
Output Voltage	9V or 12V
Output Current	50mA
Output Voltage Ripple	±50mV

Fixed Output Voltage

There are two ways to set the output voltage of the SGM6602. One is the fixed 9V or 12V output voltage. The other is the programmable output voltage. When the FB pin is connected to the input voltage, the output voltage is set for fixed 9V or 12V by the ordering part. This feature eliminates the divider resistors, which minimizes the overall solution PCB size as small as possible and also reduces the BOM cost. Figure 3 shows the fixed output voltage application.

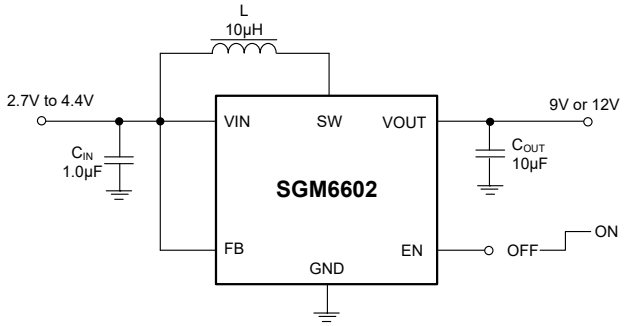


Figure 3. Fixed Output Voltage Application Circuit

Programmable Output Voltage

The SGM6602 supports an output voltage up to 20V. The desired output voltage can be programmed by an external resistor divider. Figure 4 shows the programmable output voltage application.

The values of R_1 and R_2 (upper and lower resistors) can be calculated by Equation 1 based on the desired output voltage (V_{OUT}) and V_{FB}.

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

where V_{FB} = 0.795V.

For the best accuracy, the current flowing through R_2 is at least 100 times higher than the FB pin leakage current. Then, it is recommended that R_2 value is not larger than 80kΩ. The smaller R_2 value can increase immunity to noise injection. The larger R_2 value can reduce static current and achieve higher efficiency at light load.

In order to meet most applications, it is recommended to add a 5pF ceramic capacitor as the C_{FF} capacitor.

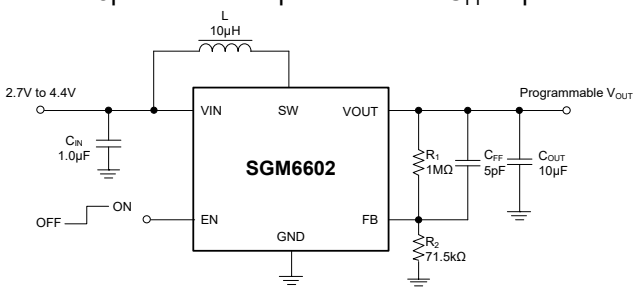


Figure 4. Programmable Output Voltage Application Circuit

Inductor Selection

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

The SGM6602 is designed to support inductor values between 4.7μH and 10μH. The inductor's peak current of the application can be calculated by Equation 2 to Equation 4. Use the minimum input voltage, maximum output voltage, and maximum load current of the application to calculate the worst case. It is recommended to choose low power conversion efficiency for calculation and choose an inductor value with a tolerance of -30% for enough design margin.

APPLICATION INFORMATION (continued)

Follow Equation 2 to calculate the inductor's DC current in a Boost regulator.

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

where V_{OUT} = output voltage, I_{OUT} = output current, V_{IN} = input voltage, and η = power conversion efficiency, use 80% for most applications.

For the given inductor value (L), follow Equation 3 to calculate the peak-to-peak ripple current ($\Delta I_{L(P-P)}$).

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

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

Therefore, follow Equation 4 to calculate the inductor peak current.

$$I_{L(P)} = I_{L(DC)} + \frac{\Delta I_{L(P-P)}}{2} \quad (4)$$

For general rule of thumb, it is recommended that peak-to-peak ripple current ($\Delta I_{L(P-P)}$) is lower than 40% of the average inductor current for maximum output current. Larger inductor values result in lower output ripple voltage EMI and higher efficiency, but a slightly degraded transient response. Lower inductance values allow for smaller case size, but the larger ripple current increases the AC losses in the inductor.

When the SGM6602 with a small value inductor is applied to light load, the inductor peak current can be up to 200% of the average current, which means the device always works in discontinuous conduction mode (DCM). Table 2 shows the recommended inductor for the SGM6602.

Input Capacitor Selection

For input capacitor, a ceramic capacitor with more than 1.0μF is enough for most applications.

Output Capacitor Selection

The output capacitor is mainly selected according to the output ripple required by the specification. The output ripple composes of two parts which are caused by equivalent series resistance (ESR) and capacitor's capacitance. Assuming a ceramic capacitor with zero ESR (ESR is usually very small and can be neglected), Equation 5 can be used to calculate and estimate the minimum capacitance needed for a given ripple.

$$C_{OUT} = \frac{I_{OUT} \times D_{MAX}}{f_{SW} \times V_{RIPPLE}} \quad (5)$$

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

The effect of the ESR of the tantalum capacitor or electrolytic capacitor on the output ripple must be considered.

The SGM6602 is an internally compensated device. The output capacitor will affect the loop stability. The recommended effective output capacitance ranges from 4.7μF to 10μF. When the output capacitance falls below the range, the device may become unstable. Thus, please be careful to consider the DC bias, aging, and AC signal natures of ceramic capacitors when choosing the capacitance value, rated voltage and case size. Need to verify capacitor manufacture's datasheet to ensure enough effective capacitance at desired output voltage.

Table 2. Recommended Inductors for the SGM6602

PART NUMBER	L (μH)	DCR MAX (mΩ)	SATURATION CURRENT (A)	SIZE (L × W × Hmm^3)	VENDOR
FDSD0420-H-100M	10	200	2.5	4.2 × 4.2 × 2.0	Toko
CDRH3D23/HP	10	198	1.02	4.0 × 4.0 × 2.5	Sumida
1239AS-H-100M	10	460	1.0	2.5 × 2.0 × 1.2	Toko
VLS4012-4R7M	4.7	132	1.1	4.0 × 4.0 × 1.2	TDK

APPLICATION INFORMATION (continued)

Power Supply Recommendations

The SGM6602 can operate with an input voltage range of 1.8V to 5.5V. Usually, the input power supply is very stable and located close to the converter. For some special applications where the input source is more than a few inches far away, an additional electrolytic or tantalum capacitor more than 47μF may be needed. The input power supply's output current needs to comply with the supply voltage, output voltage and output current of the SGM6602.

Layout Guidelines

In addition to component selection, layout is a critical step to ensure the performance for all switching power supplies. Poor layout could result in system instability, noise and EMI problems, even device damage. Thus, place the inductor, input and output capacitors as close to the IC as possible. All traces connected to the SW pin should be short and the area should be small. In order to reduce inter-plane coupling, usually place a ground plane under the switching regulator.

For Boost converter, the output capacitor's current loop from VOUT pin back to the GND pin of the device is also particularly critical, which should be as small as possible.

Layout Example

The ground plane of the bottom layer is connected to the ground pin of the top layer through vias.

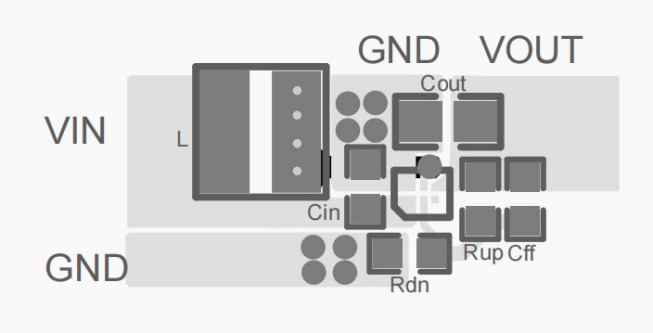


Figure 5. WLCSP-0.8×1.2-6B PCB Layout Example

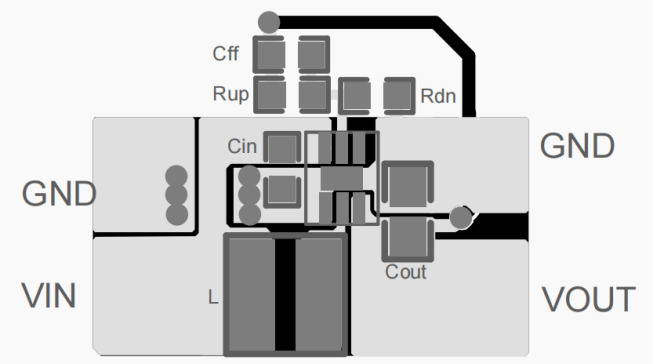


Figure 6. TDFN-2×2-6AL PCB Layout Example

REVISION HISTORY

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

JUNE 2024 – REV.A.1 to REV.A.2

Updated Switching Waveforms in PWM CCM and PWM DCM	6

MAY 2024 – REV.A to REV.A.1

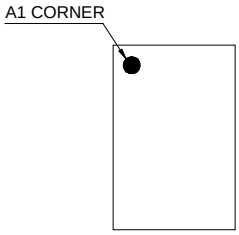
Updated GENERAL DESCRIPTION, APPLICATION INFORMATION sections	1, 9, 10, 11
Added Package Thermal Resistance	2
Updated TDFN-2×2-6AL PACKAGE OUTLINE DIMENSIONS	13

Changes from Original (DECEMBER 2017) to REV.A

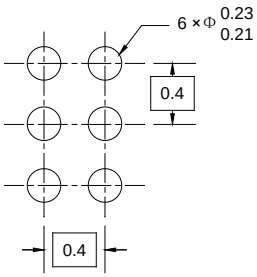
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

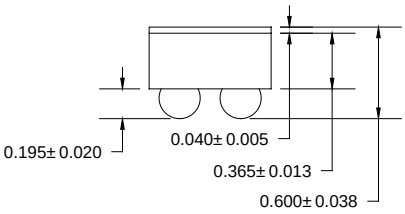
WLCSP-0.8×1.2-6B



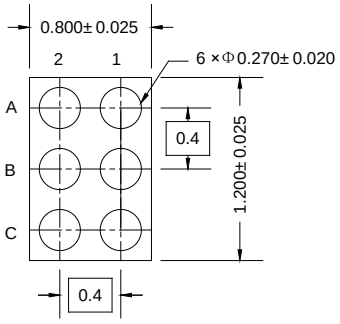
TOP VIEW



RECOMMENDED LAND PATTERN



SIDE VIEW

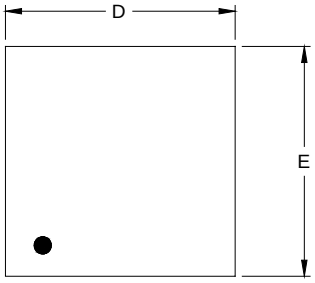


BOTTOM VIEW

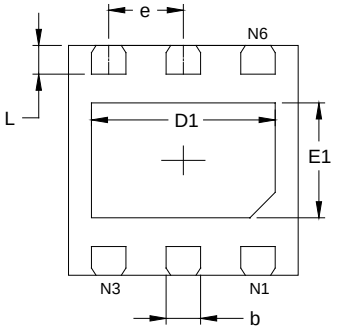
NOTES:
1. All linear dimensions are in millimeters.
2. This drawing is subject to change without notice.

PACKAGE OUTLINE DIMENSIONS

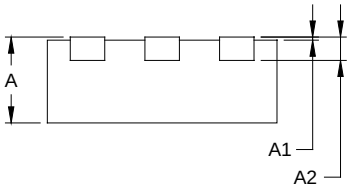
TDFN-2×2-6AL



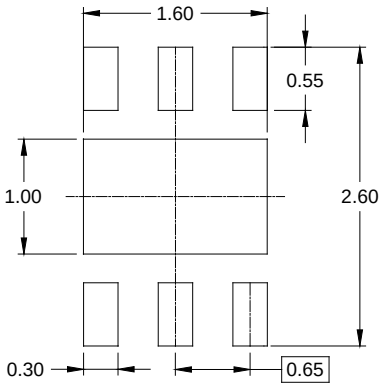
TOP VIEW



BOTTOM VIEW



SIDE VIEW



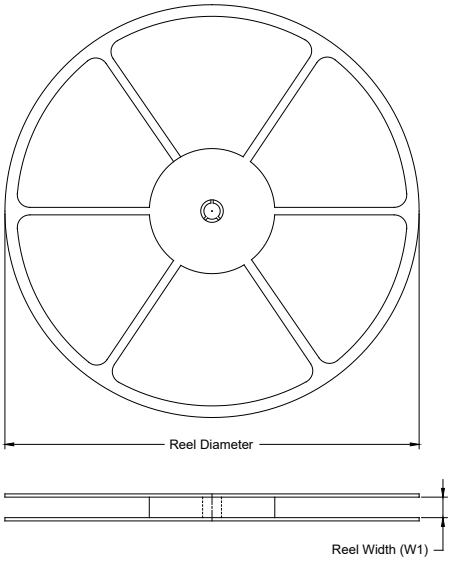
RECOMMENDED LAND PATTERN (Unit: mm)

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	1.900	2.100	0.075	0.083
D1	1.500	1.700	0.059	0.067
E	1.900	2.100	0.075	0.083
E1	0.900	1.100	0.035	0.043
b	0.250	0.350	0.010	0.014
e	0.650 BSC		0.026 BSC	
L	0.174	0.326	0.007	0.013

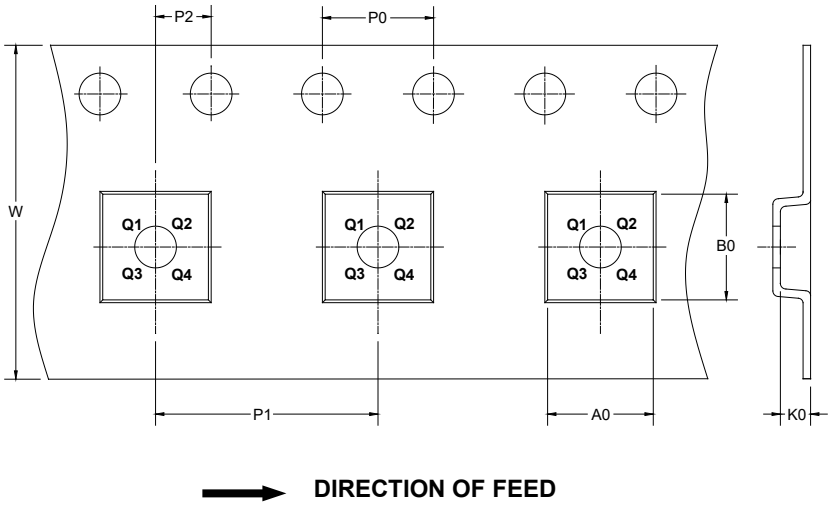
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



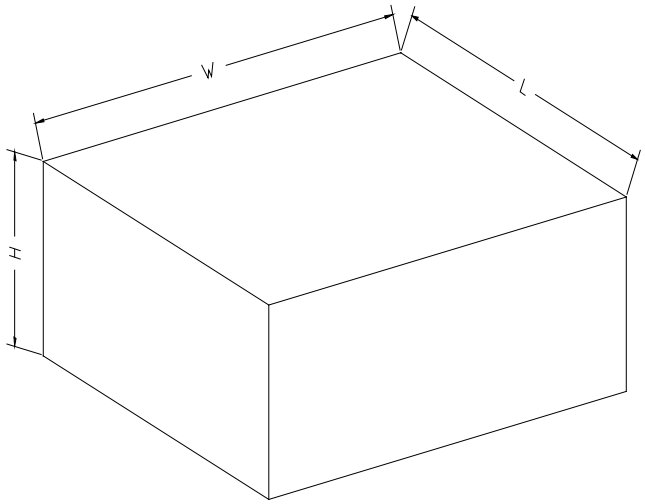
NOTE: The picture is only for reference. Please make the object as the standard.

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
WLCSP-0.8×1.2-6B	7″	9.2	0.91	1.31	0.71	4.0	4.0	2.0	8.0	Q1
TDFN-2×2-6AL	7″	9.5	2.30	2.30	1.10	4.0	4.0	2.0	8.0	Q1

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
7″ (Option)	368	227	224	8
7″	442	410	224	18

DD0002