SGM6602
20V Output Voltage Step-Up Converter

GENERAL DESCRIPTION

The SGM6602 is a highly integrated boost converter designed for applications requiring high voltage and tiny solution size such as PMOLED panel and sensor module. The SGM6602 integrates a 20V power switch, input/output isolation switch. It can output up to 20V from input of a Li+ battery or two cell alkaline batteries in series.

The SGM6602 operates with a switching frequency at 1.15MHz. This allows the use of small external components. The SGM6602 has an internal default 12V output voltage setting by connecting the FB pin to the VIN pin. Thus it only needs three external components to get 12V output voltage. Together with CSP package, the SGM6602 gives a very small overall solution size. The SGM6602 has typical 1050mA switch current limit. It has 5ms built-in soft-start time to minimize the inrush current. When the SGM6602 is in shutdown mode, the isolation switch disconnects the output from input to minimize the leakage current. The SGM6602 also implements output short circuit protection, output over-voltage protection and thermal shutdown.

The SGM6602 is available in Green WLCSP-0.8×1.2-6B and TDFN-2×2-6L packages. It operates over an ambient temperature range of -40℃ to +85℃.

FEATURES

- **Input Voltage Range: 1.8V to 5.5V, 1.6V after Start-Up**
- **Output Voltage Up to 20V**
- **Integrated Isolation Switch**
- **1050mA (TYP) Switch Current**
- **Up to 85% Efficiency at 3.6V Input and 12V Output**
- **0.1μA Ultra-Low Shutdown Current**
- **Power-Save Operation Mode at Light Load**
- **Internal 5ms Soft-Start Time**
- **True Disconnection between Input and Output during Shutdown**
- **Output Short Circuit Protection**
- **Output Over-Voltage Protection**
- **Thermal Shutdown Protection**
- **-40℃ to +85℃ Operating Temperature Range**
- **Available in Green WLCSP-0.8×1.2-6B and TDFN-2×2-6L Packages**

APPLICATIONS

PMOLED Power Supply
Wearable Devices
Portable Medical Equipment
Sensor Power Supply

TYPICAL APPLICATION

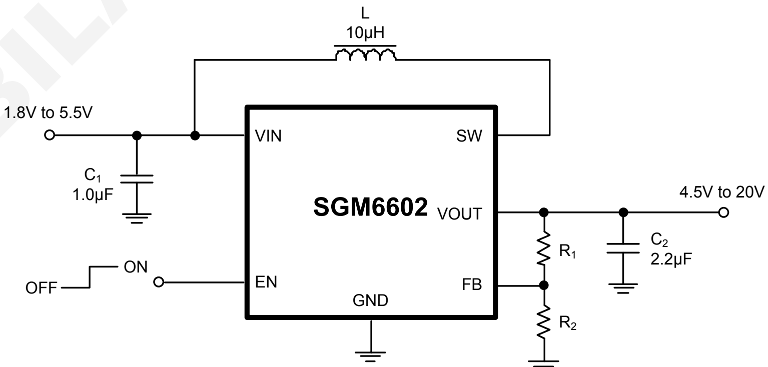


Figure 1. Typical Application Circuit

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-2×2-6L	-40℃ to +85℃	SGM6602-9YTDI6G/TR	GWE 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-2×2-6L	-40℃ to +85℃	SGM6602-12YTDI6G/TR	GT6 XXXX	Tape and Reel, 3000

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

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

ABSOLUTE MAXIMUM RATINGS

Voltage Range at Terminals
VIN, EN, FB .... -0.3V to 6V
SW, VOUT .... -0.3V to 22V
Junction Temperature ....+150℃
Storage Temperature Range ....-65℃ to +150℃
Lead Temperature (Soldering, 10s) ....+260℃

RECOMMENDED OPERATING CONDITIONS

Inductance, Effective Value, L .... 10μH (TYP)
Input Capacitance, Effective Value, C_I.............. 0.22μF (MIN)
Output Capacitance, Effective Value, C_O............1μF to 10μF
Input Voltage Range ....1.8V to 5.5V
Output Voltage Range ....4.5V to 20V
Operating Temperature Range ....-40℃ to +85℃
Operating Junction Temperature Range.......-40℃ to +125℃

OVERSTRESS CAUTION

Stresses beyond those listed may cause permanent damage to the device. Functional operation of the device at these or any other conditions beyond those indicated in the operational section of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

ESD SENSITIVITY CAUTION

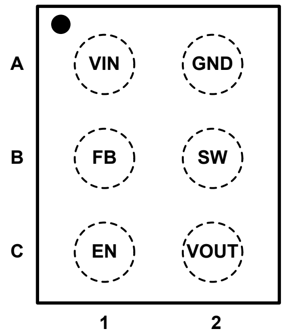
This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, specification or other related things if necessary without notice at any time.

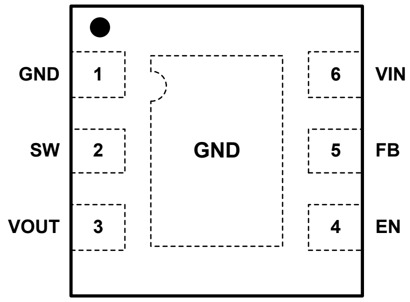
PIN CONFIGURATIONS

(TOP VIEW)



WLCSP-0.8×1.2-6B

(TOP VIEW)



TDFN-2×2-6L

PIN DESCRIPTION

PIN		NAME	I/O	FUNCTION
WLCSP-0.8×1.2-6B	TDFN-2×2-6L			
A1	6	VIN	I	IC Power Supply Input.
A2	1	GND	PWR	Ground.
B1	5	FB	I	Voltage Feedback of Adjustable Output Voltage. Connect to the center tap of a resistor divider to program the output voltage. When it is connected to the VIN pin, the output voltage is set to 12V by an internal feedback.
B2	2	SW	PWR	The Switch Pin of the Converter. It is connected to the drain of the internal power MOSFET.
C1	4	EN	I	Enable Logic Input. Logic high voltage enables the device. Logic low voltage disables the device and turns into shutdown mode.
C2	3	VOUT	PWR	Output of the Boost Converter.
–	Exposed Pad	GND	PWR	Exposed pad should be connected to GND.

ELECTRICAL CHARACTERISTICS

(V_{IN} = 3.6V, V_{OUT} = 12V, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
POWER SUPPLY						
Input Voltage Range	V_{IN}		1.8		5.5	V
Under-Voltage Lockout Threshold	V_{IN_UVLO}	V_{IN} rising		1.7		V
		V_{IN} falling		1.53		
VIN UVLO Hysteresis	V_{IN_HYS}			170		mV
Quiescent Current into VIN Pin	I_{Q_VIN}	IC enabled, no load, no switching		45		μA
Shutdown Current into VIN Pin	I_{SD}	IC disabled		0.1		μA
OUTPUT						
Output Voltage Range	V_{OUT}		4.5		20	V
12V Output Voltage Accuracy	V_{OUT_12V}	FB pin connected to V_{IN} pin		12		V
Feedback Voltage	V_{FB}			796		mV
Output Over-Voltage Protection Threshold	V_{OVP}			21.5		V
Over-Voltage Protection Hysteresis	V_{OVP_HYS}			1.4		V
Leakage Current into FB Pin	I_{FB_LKG}			100		nA
Leakage Current into SW Pin	I_{SW_LKG}	IC disabled		100		nA
POWER SWITCH						
Isolation MOSFET on Resistance	$R_{DS(ON)}$	V_{OUT} = 12V		1050		mΩ
Low-side MOSFET on Resistance		V_{OUT} = 12V		560		
Switching Frequency	f_{SW}	V_{IN} = 3.6V, V_{OUT} = 12V, PWM Mode		1.15		MHz
Peak Switch Current Limit	I_{LIM_SW}	V_{IN} = 3.6V, V_{OUT} = 12V		1050		mA
Start-Up Time	$t_{START-UP}$	V_{OUT} from V_{IN} to 12V, $C_{OUT\_EFFECTIVE}$ = 2.2μF, I_{OUT} = 0A		5		ms
LOGIC INTERFACE						
EN Logic High Threshold	V_{IH}			1		V
EN Logic Low Threshold	V_{IL}			0.4		V
PROTECTION						
Thermal Shutdown Threshold	T_{SD}	T_A rising		165		℃
Thermal Shutdown Hysteresis	T_{SD_HYS}	T_A falling below T_{SD}		20		℃

FUNCTIONAL BLOCK DIAGRAM

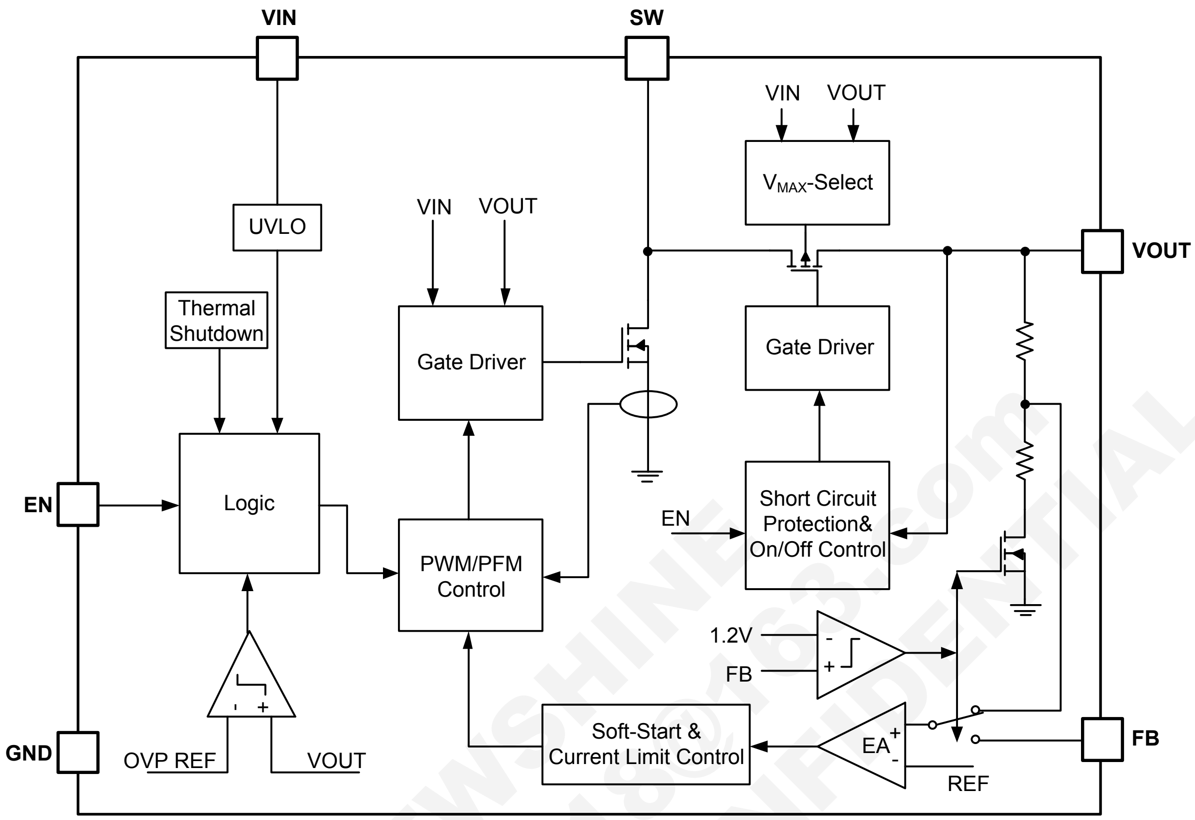


Figure 2. Block Diagram

APPLICATION INFORMATION

The SGM6602 is a boost DC/DC converter with a PWM switch, an input/output isolation switch integrated. The device supports up to 20V output with the input range from 1.8V to 5.5V. The switching frequency is quasi-constant at 1.15MHz. The isolation switch disconnects the output from the input during shutdown to minimize leakage current.

The following design procedure can be used to select component values for the SGM6602.

Table 1. Design Requirements

PARAMETERS	VALUES
Input Voltage	2.7V ~ 4.4V
Output Voltage	12V
Output Current	50mA
Output Voltage Ripple	±50mV

Fixed Output Voltage

There are two ways to set the output voltage of the SGM6602. When the FB pin is connected to the input voltage, the output voltage is fixed to 9V or 12V by the ordering part. This function makes the SGM6602 only need few external components to minimize the solution size. Figure 3 shows the fixed voltage output application.

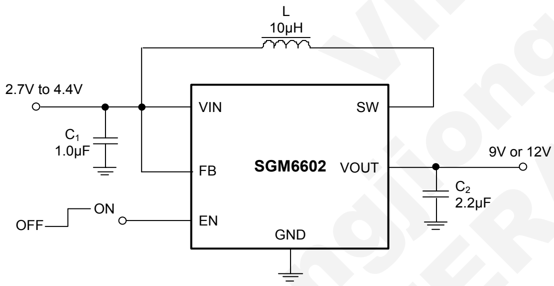


Figure 3. Fixed Voltage Output

Programming the Output Voltage

The second way is to use an external resistor divider to set the desired output voltage. Figure 4 shows the programmable voltage output application.

By selecting the external resistor divider R_1 and R_2, as shown in Equation 1, the output voltage is programmed to the desired value. When the output voltage is regulated, the typical voltage at the FB pin is V_{FB} of 796mV.

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

Where V_{OUT} is the desired output voltage, V_{FB} is the internal reference voltage at the FB pin.

For best accuracy, R_2 should be kept smaller than 80kΩ to ensure the current flowing through R_2 is at least 100 times larger than the FB pin leakage current. Changing R_2 towards a lower value increases the immunity against noise injection. Changing the R_2 towards a higher value reduces the quiescent current for achieving highest efficiency at low load currents.

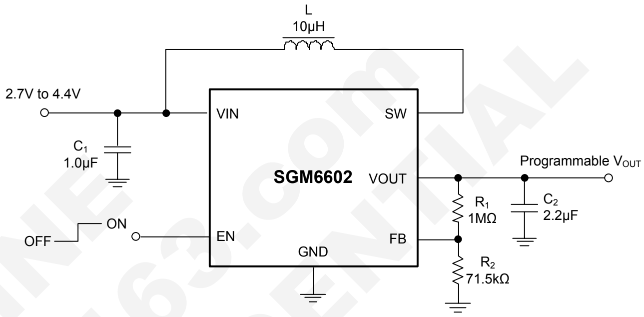


Figure 4. Programmable Voltage Output

Inductor Selection

Because the selection of the inductor affects steady state operation, transient behavior, and loop stability, the inductor is the most important component in power regulator design. There are three important inductor specifications, inductor value, saturation current, and DC resistance (DCR).

The SGM6602 is designed to work with inductor values between 4.7μH and 10μH. Follow Equation 2 to Equation 4 to calculate the inductor's peak current for the application. To calculate the current in the worst case, use the minimum input voltage, maximum output voltage, and maximum load current of the application. To have enough design margin, choose the inductor value with -30% tolerance, and a low power-conversion efficiency for the calculation.

In a boost regulator, the inductor DC current can be calculated with Equation 2.

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

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

APPLICATION INFORMATION (continued)

The inductor ripple current is calculated with the Equation 3.

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

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

Therefore, the inductor peak current is calculated with Equation 4.

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

Normally, it is advisable to work with an inductor peak-to-peak current of less than 40% of the average inductor current for maximum output current. A smaller ripple from a larger valued inductor reduces the magnetic hysteresis losses in the inductor and EMI. Bit in the same way, load transient response time is increased.

Because the SGM6602 is for relatively small output current application, the inductor peak-to-peak current could be as high as 200% of the average current with a small inductor value, which means the SGM6602 always works in DCM mode. Table 2 lists the recommended inductor for the SGM6602.

Table 2. Recommended Inductors for the SGM6602

PART NUMBER	L (μH)	DCR MAX (mΩ)	SATURATION CURRENT (A)	SIZE (L × W × H)	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

Input and Output Capacitor Selection

The output capacitor is mainly selected to meet the requirements for output ripple and loop stability. This ripple voltage is related to the capacitor's capacitance and its equivalent series resistance (ESR). Assuming a ceramic capacitor with zero ESR, the minimum capacitance needed for a given ripple can be calculated by:

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

Where D_{MAX} = maximum switching duty cycle, V_{RIPPLE} = peak-to-peak output voltage ripple.

The ESR impact on the output ripple must be considered if tantalum or aluminum electrolytic capacitors are used.

Care must be taken when evaluating a ceramic capacitor's derating under dc bias, aging, and AC signal. For example, the dc bias can significantly reduce capacitance. A ceramic capacitor can lose more than 50% of its capacitance at its rated voltage. Therefore, always leave margin on the voltage rating to ensure adequate capacitance at the required output voltage.

It is recommended to use the output capacitor with effective capacitance in the range of 1μF to 10μF. The output capacitor affects the small signal control loop stability of the boost regulator. If the output capacitor is below the range, the boost regulator can potentially become unstable. Increasing the output capacitor makes the output voltage ripple smaller in PWM mode.

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

APPLICATION INFORMATION (continued)

Power Supply Recommendations

The device is designed to operate from an input voltage supply range between 1.8V to 5.5V. This input supply must be well regulated. If the input supply is located more than a few inches from the converter, additional bulk capacitance may be required in addition to the ceramic bypass capacitors. A typical choice is an electrolytic or tantalum capacitor with a value of 47μF. The input power supply's output current needs to be rated according to the supply voltage, output voltage and output current of the SGM6602.

Layout Guidelines

As for all switching power supplies, especially those running at high switching frequency and high currents, layout is an important design step. If the layout is not carefully done, the regulator could suffer from instability and noise problems. To maximize efficiency, switch rise and fall time are very fast. To prevent radiation of high frequency noise (for example, EMI), proper layout of the high-frequency switching path is essential. Minimize the length and area of all traces connected to the SW pin, and always use a ground plane under the switching regulator to minimize interplane coupling. The input capacitor needs not only to be close to the VIN pin, but also to the GND pin in order to reduce input supply ripple.

The most critical current path for all boost converters is from the switching FET, then the output capacitors, and back to ground of the switching FET. This high current path contains nanosecond rise and fall time and should be kept as short as possible. Therefore, the output capacitor needs not only to be close to the VOUT pin, but also to the GND pin to reduce the overshoot at the SW pin and VOUT pin.

Layout Example

A large ground plane on the bottom layer connects the ground pins of the components on the top layer through vias.

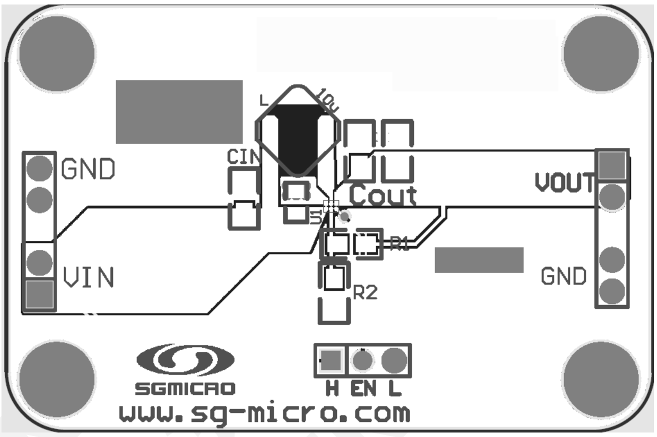


Figure 5. WLCSP-0.8×1.2-6B PCB Layout Example

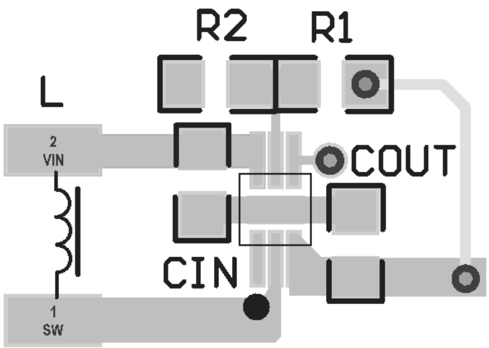
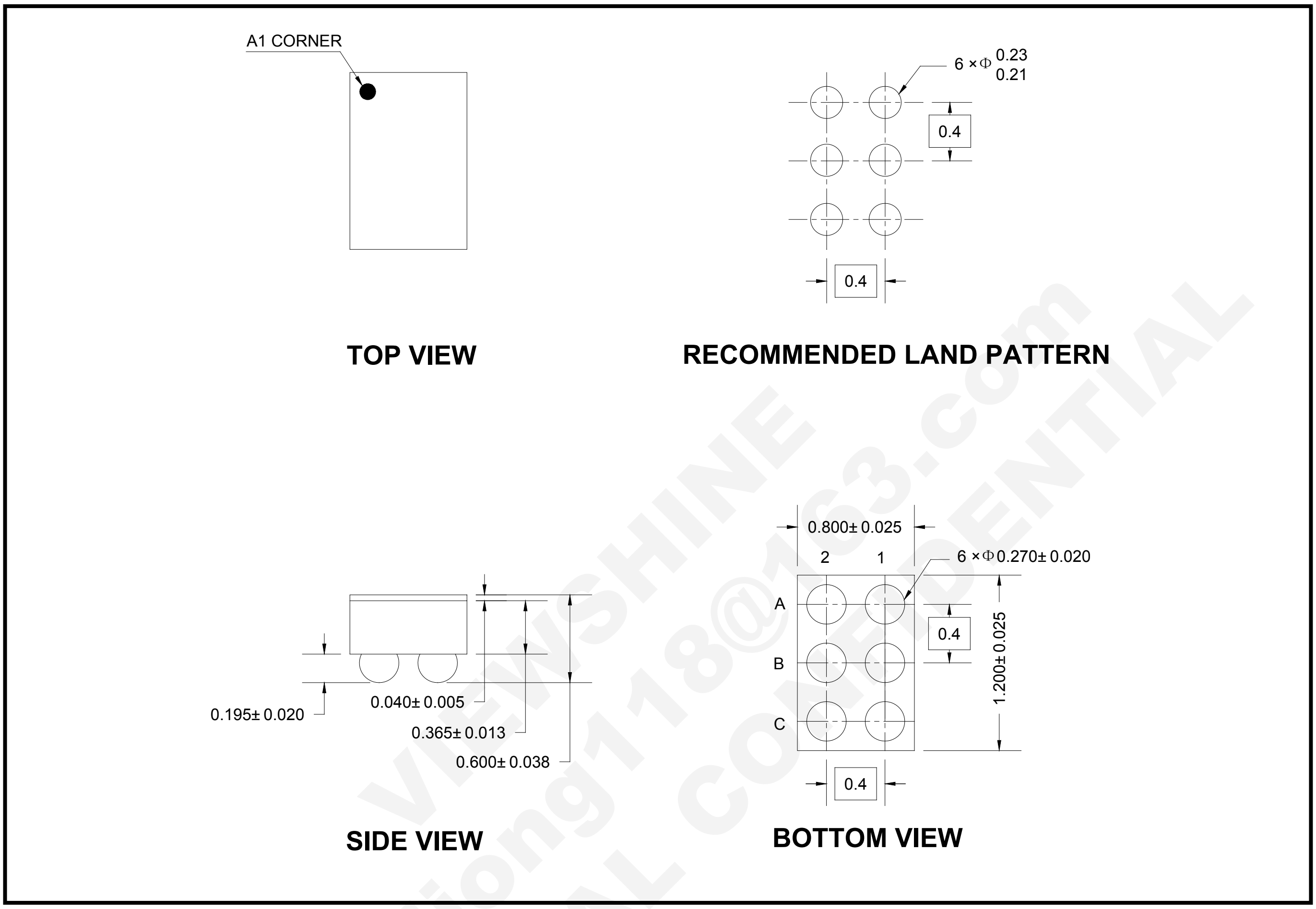


Figure 6. TDFN-2×2-6L PCB Layout Example

PACKAGE OUTLINE DIMENSIONS

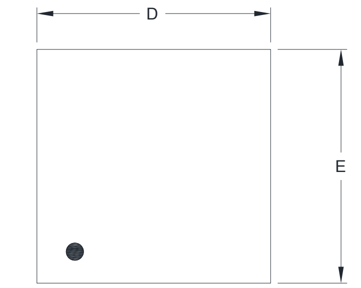
WLCSP-0.8×1.2-6B



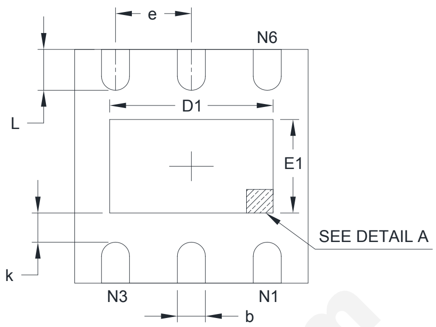
NOTE: All linear dimensions are in millimeters.

PACKAGE OUTLINE DIMENSIONS

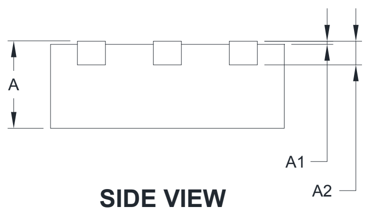
TDFN-2×2-6L



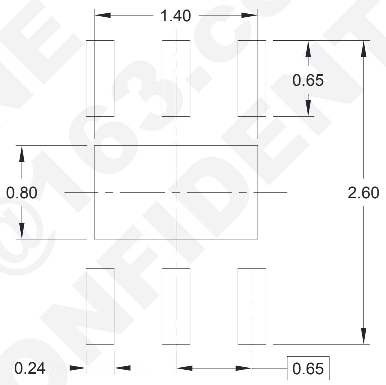
TOP VIEW



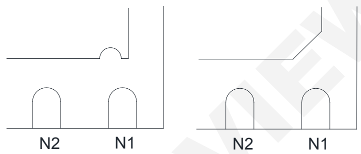
BOTTOM VIEW



SIDE VIEW



RECOMMENDED LAND PATTERN (Unit: mm)



DETAIL A

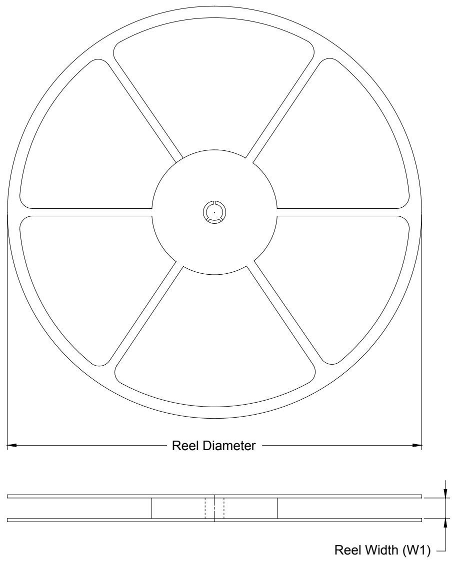
Pin #1 ID and Tie Bar Mark Options

NOTE: The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

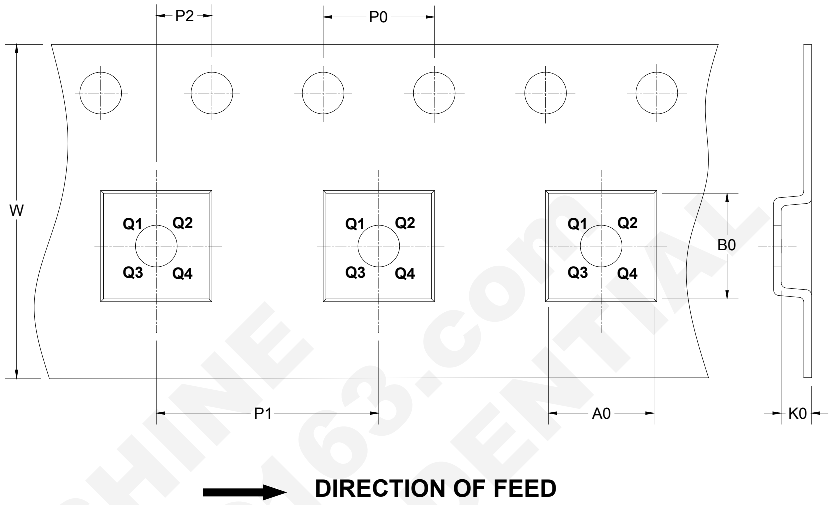
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	1.900	2.100	0.075	0.083
D1	1.100	1.450	0.043	0.057
E	1.900	2.100	0.075	0.083
E1	0.600	0.850	0.024	0.034
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.650 TYP		0.026 TYP	
L	0.250	0.450	0.010	0.018

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



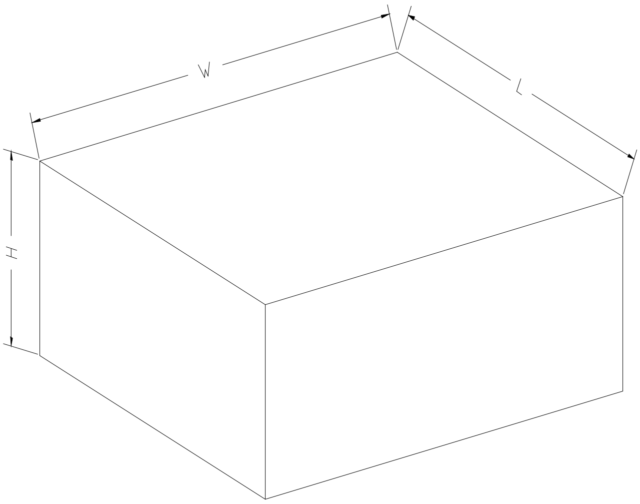
NOTE: The picture is only for reference. Please make the object as the standard.

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-2×2-6L	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