

## Description

The TNS6002SE is a high-efficiency monolithic synchronous step down DC/DC regulator using a constant frequency, current mode architecture. The device is available in an adjustable version. Supply current with no load is 70 $\mu$ A and drops to <1 $\mu$ A in shutdown. The 2.5V to 5.5V input voltage range makes the TNS6002SE ideally suited for single Li-Ion battery powered applications. 100% duty cycle provides low dropout operation, extending battery life in portable systems. PWM/PFM mode operation provides very low output ripple voltage for noise sensitive applications.

Switching frequency is internally set at 2MHz, allowing the use of small surface mount inductors and capacitors. Low output voltages are easily supported with the 0.6V feedback reference voltage.

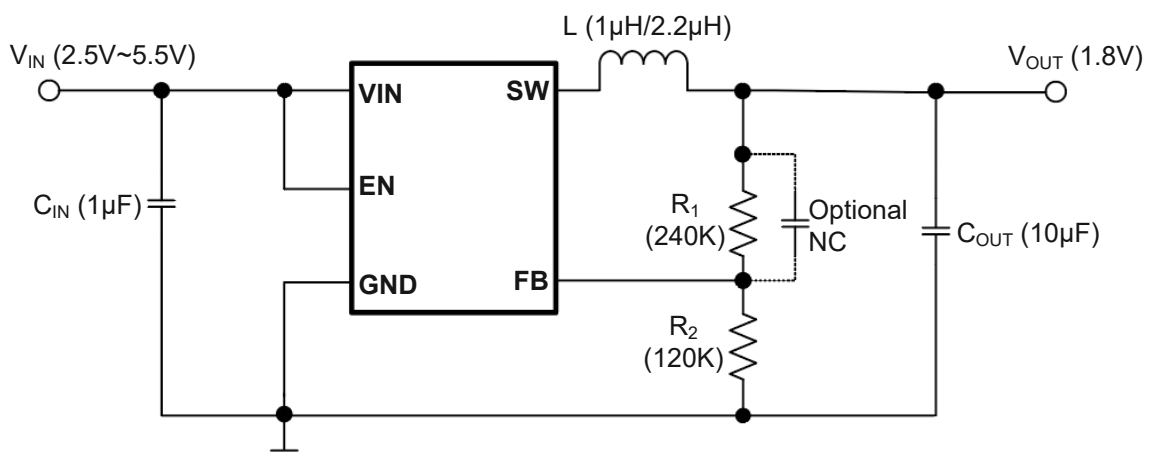
## Features

- High Efficiency: Up to 96%
- 2.5V to 5.5V Input Voltage Range
- 2MHz Constant Frequency Operation
- No Schottky Diode Required
- Low Dropout Operation: 100% Duty Cycle
- PFM Mode for High Efficiency in Light Load
- Low Quiescent Current: 70 $\mu$ A
- Over temperature Protected
- Short Circuit Protection
- Inrush Current Limit and Soft Start
- SOT-23-5 Package

## Applications

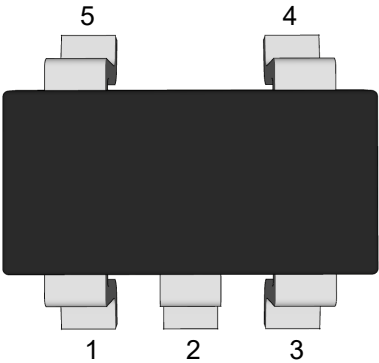
- Cellular and Smart Phones
- Wireless and DSL Modems
- Digital Still and Video Cameras

## Typical Application Circuit



Pin Distribution

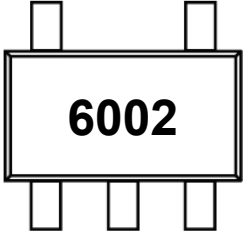
SOT-23-5



Pin Function

Pin	Name	Description
1	EN	Chip Enable Pin. Drive EN above 1.5V to turn on the part.Drive EN below 0.3V to turn it off. Do not leave EN floating.
2	GND	Ground Pin
3	SW	Power Switch Output. It is the switch node connection to Inductor. This pin connects to the drains of the internal P-ch and N-ch MOSFET switches.
4	VIN	Power Supply Input. Must be closely decoupled to GND with a 10μF or greater ceramic capacitor.
5	FB	Output Voltage Feedback Pin. An internal resistive divider divides the output voltage down for comparison to the internal reference voltage.

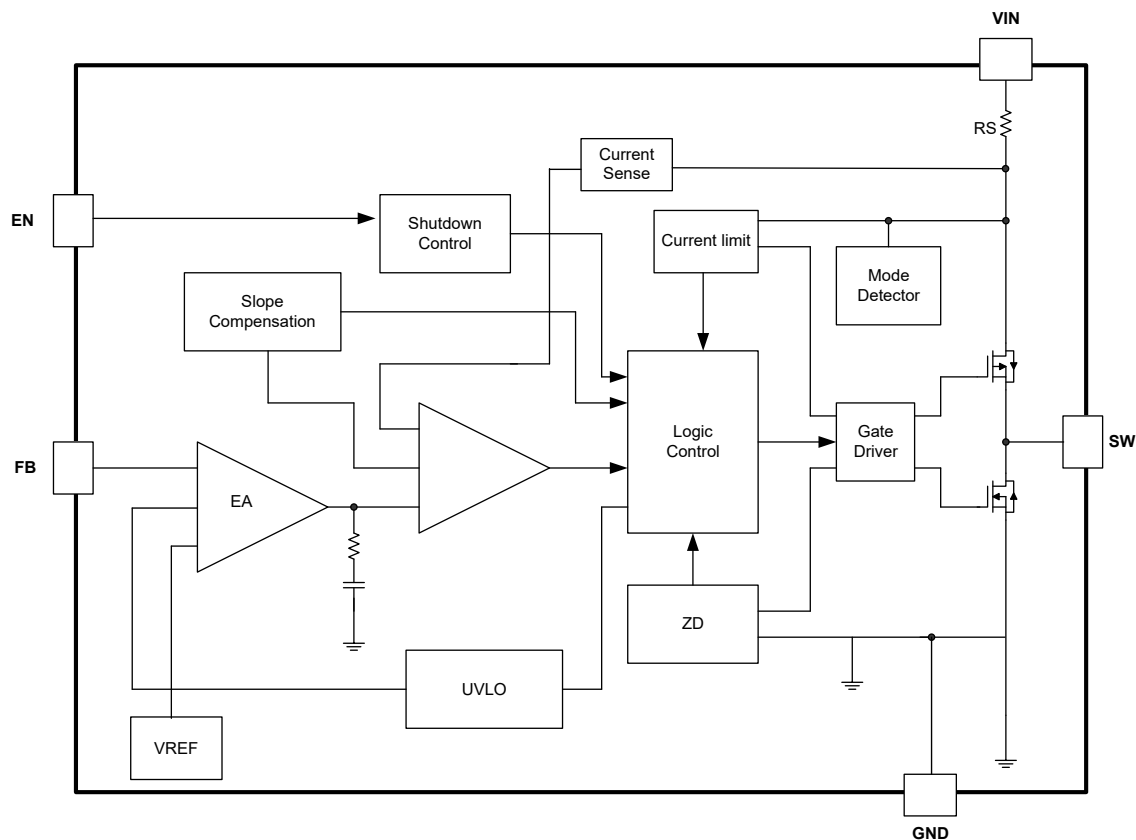
Ordering Information

Orderable Device	Package	Reel (inch)	Package Qty (PCS)	Eco Plan <sup>Note</sup>	MSL Level	Marking Code
TNS6002SE	SOT-23-5	7	3000	RoHS & Green	MSL3	

Note:

RoHS: TN defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials.  
Green: TN defines "Green" to mean Halogen-Free and Antimony-Free.

Functional Block Diagram



Absolute Maximum Ratings <sup>Note1</sup>

Ratings at 25°C ambient temperature unless otherwise specified.

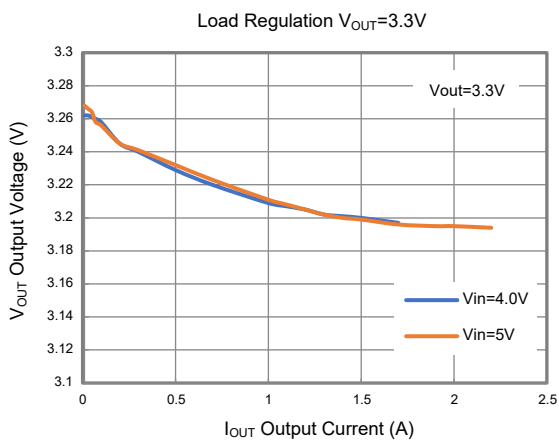
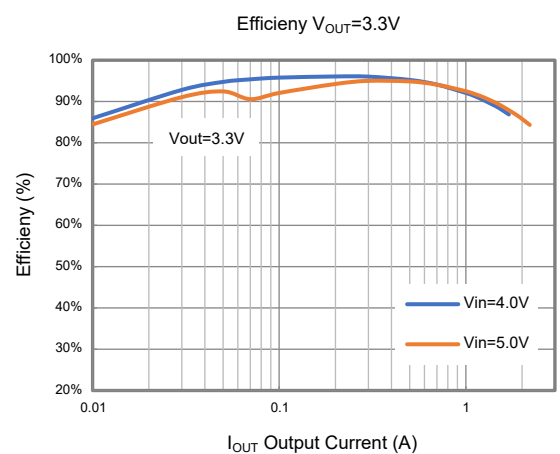
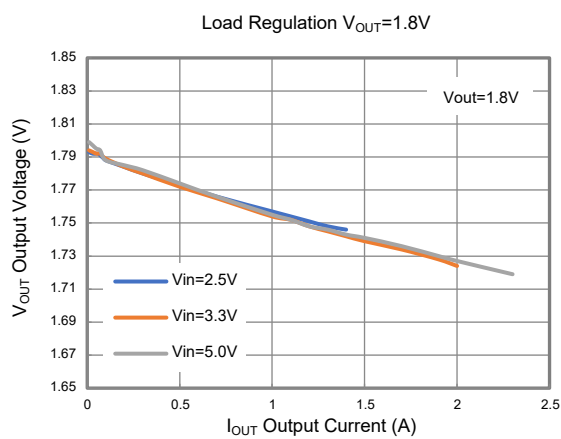
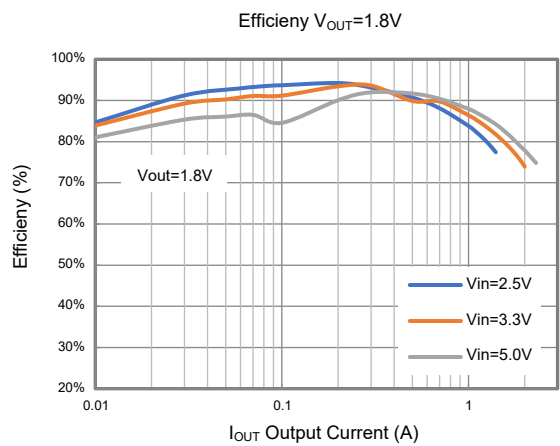
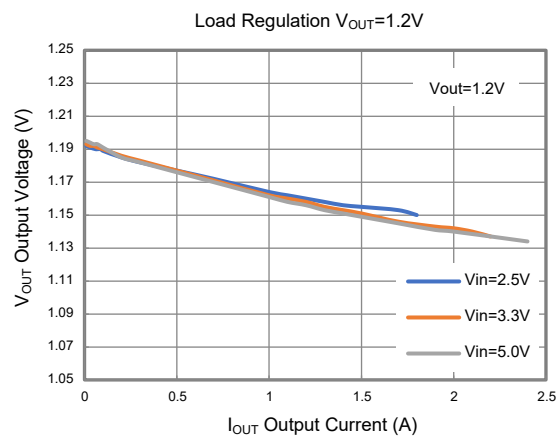
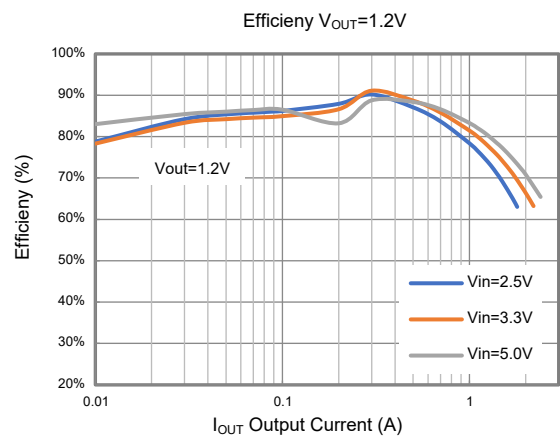
Parameter	Symbol	Rating	Unit
Input Voltage	V <sub>IN</sub>	-0.3~6.0	V
Voltage at EN Pin	V <sub>EN</sub>	-0.3~6.0	V
Voltage at SW Pin	V <sub>SW</sub>	-0.3~(V <sub>IN</sub> +0.3V)	V
Peak SW Sink and Source Current	--	3.0	A
Power Dissipation (T <sub>A</sub> =25°C) <sup>Note2</sup>	P <sub>D</sub>	0.5	W
Thermal Resistance,Junction-to-Ambient <sup>Note3</sup>	R <sub>θJA</sub>	170	°C/W
Thermal Resistance,Junction-to-Case <sup>Note3</sup>	R <sub>θJC</sub>	75	°C/W
Junction Temperature	T <sub>J</sub>	-40 to +165	°C
Package Lead Soldering Temperature and Time	T <sub>L</sub>	260°C, 10S	--
Storage Temperature Range	T <sub>STG</sub>	-65 to +150	°C

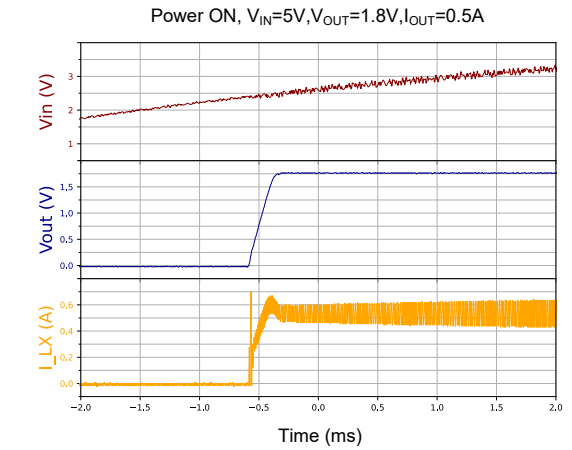
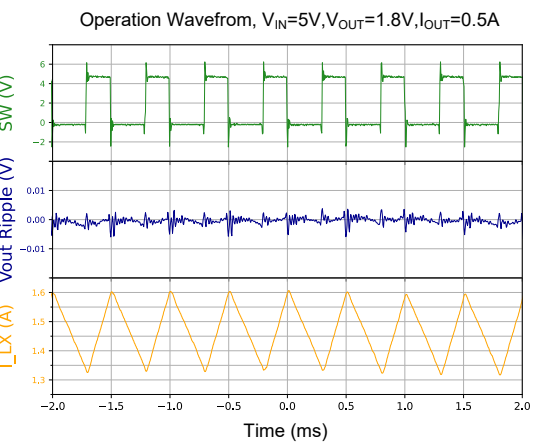
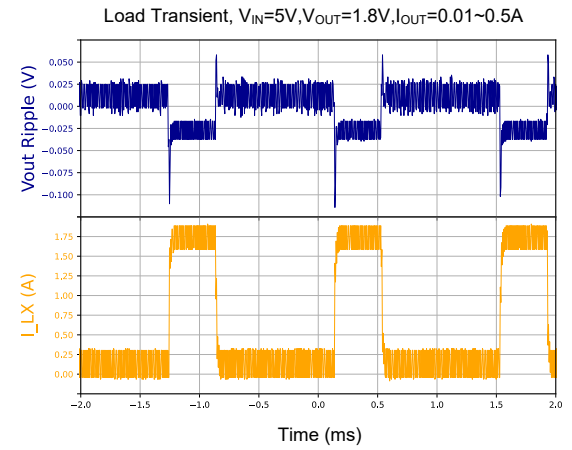
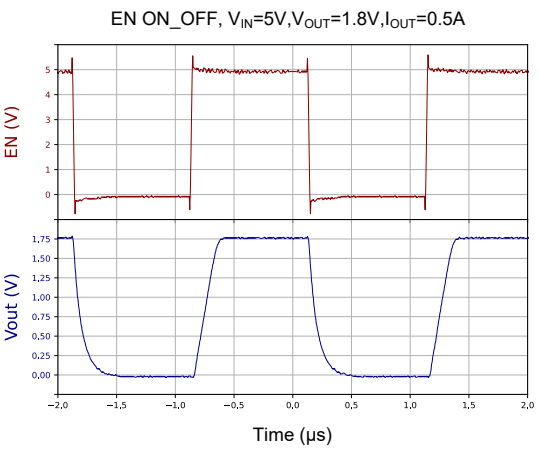
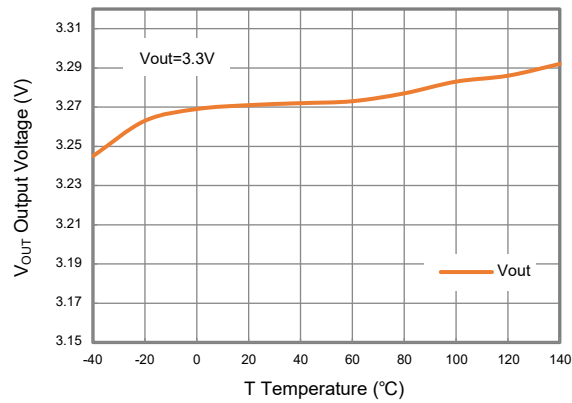
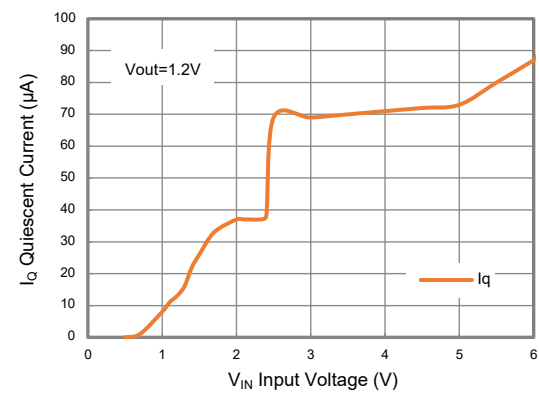
Note: 1.Exceeding these ratings may damage the device.  
2.The maximum allowable power dissipation is a function of the maximum junction temperature T<sub>J</sub>(MAX), the junction-to-ambient thermal resistance θ<sub>JA</sub>, and the ambient temperature T<sub>A</sub>. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P<sub>D</sub>(MAX)=(T<sub>J</sub>(MAX)-T<sub>A</sub>)/R<sub>θJA</sub>. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.  
3.Measured on JESD51-7, 4-layer PCB.

**Electrical Characteristics**(T<sub>J</sub>=25°C , unless otherwise noted.)

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Input Voltage	V <sub>IN</sub>		2.5	--	5.5	V
Overvoltage Voltage	V <sub>OV</sub> P	Input overvoltage threshold	--	6.1	--	V
Feedback Voltage	V <sub>FB</sub>	No load	588	600	612	mV
Under Voltage Lock Out	V <sub>UV</sub> LO		2.1	2.3	2.5	V
UVLO hysteresis	V <sub>UV</sub> LO_H		0.1	0.2	0.3	V
No load supply current a V <sub>IN</sub>	--		--	70	120	μA
Shutdown Supply Current	I <sub>SH</sub> UT	V <sub>EN</sub> =0V	--	0.1	1	μA
Efficiency	--	I <sub>LOAD</sub> =0.6A	85	90	--	%
Line Regulation	ΔV <sub>Line</sub>	I <sub>LOAD</sub> =300mA	--	0.1	0.2	%/V
Load Regulation	ΔV <sub>Load</sub>	I <sub>LOAD</sub> =0A~1A	--	0.1	0.2	%/A
Switching Frequency	f <sub>SW</sub>	V <sub>FB</sub> =5V	1.6	2	2.4	MHz
Maximum Duty Cycle	D <sub>Max</sub>		--	100	--	%
EN Minimum High Level	V <sub>EN</sub> _H		1	--	--	V
EN Maximum Low Level	V <sub>EN</sub> _L		--	--	0.3	V
Peak Current Limit	--		--	3.0	--	A
SW Leakage Current	--	V <sub>IN</sub> = 6V, V <sub>SW</sub> = 0 or 6V, EN=0	--	--	10	μA
OTP	--		135	150	165	°C
OTP Hysteresis	--		20	30	40	°C
NMOS Switch On Resistance	R <sub>ON</sub>	I <sub>SW</sub> =100mA	--	80	160	mΩ
PMOS Switch On Resistance			--	160	320	mΩ

Typical Electrical Curves





## Function Description

The TNS6002SE uses a constant frequency, current mode step-down architecture. Both the main (P-channel MOSFET) and synchronous (N-channel MOSFET) switches are internal. During normal operation, the internal top power MOSFET is turned on each cycle when the oscillator sets the RS latch, and turned off when the current comparator, ICOMP, resets the RS latch. The peak inductor current at which ICOMP resets the RS latch, is controlled by the output of error amplifier EA. When the load current increases, it causes a slight decrease in the feedback voltage, FB, relative to the 0.6V reference, which in turn, causes the EA amplifier's output voltage to increase until the average inductor current matches the new load current. While the top MOSFET is off, the bottom MOSFET is turned on until either the inductor current starts to reverse, as indicated by the current reversal comparator IRCMP, or the beginning of the next clock cycle.

## Application Information

### Setting the Output Voltage

In the adjustable version, the output voltage is set by a resistive divider according to the following formula:

$$R_2 = R_1 / (V_{OUT} / V_{FB} - 1)$$

The external resistive divider is connected to the output, allowing remote voltage sensing as shown in on page 1

### Inductor Selection

For most designs, the TNS6002SE operates with inductors of 1μH to 4.7μH. Low inductance values are physically smaller but require faster switching, which results in some efficiency loss. The inductor value can be derived from the following equation:

$$L = [V_{OUT} * (V_{IN} - V_{OUT})] / (V_{IN} * \Delta I_L * f_{osc})$$

Where  $\Delta I_L$  is inductor Ripple Current. Large value inductors result in lower ripple current and small value inductors result in high ripple current. For optimum voltage-positioning load transients, choose an inductor with DC series resistance in the 50mΩ to 150mΩ range.

### Input Capacitor Selection

Higher values, lower cost ceramic capacitors are now becoming available in smaller case sizes. Their high ripple current, high voltage rating and low ESR make them ideal for switching regulator applications. Because the TNS6002SE's control loop does not depend on the output capacitor's ESR for stable operation, ceramic capacitors can be used freely to achieve very low output ripple and small circuit size. However, care must be taken when ceramic capacitors are used at the input and the output. When a ceramic capacitor is used at the input and the power is supplied by a wall adapter through long wires, a load step at the output can induce ringing at the input, VIN. At best, this ringing can couple to the output and be mistaken as loop instability. At worst, a sudden inrush of current through the long wires can potentially cause a voltage spike at VIN, large enough to damage the part. When choosing the input and output ceramic capacitors, choose the X5R or X7R dielectric formulations. These dielectrics have the best temperature and voltage characteristics of all the ceramics for a given value and size.

**PCB Layout Checklist**

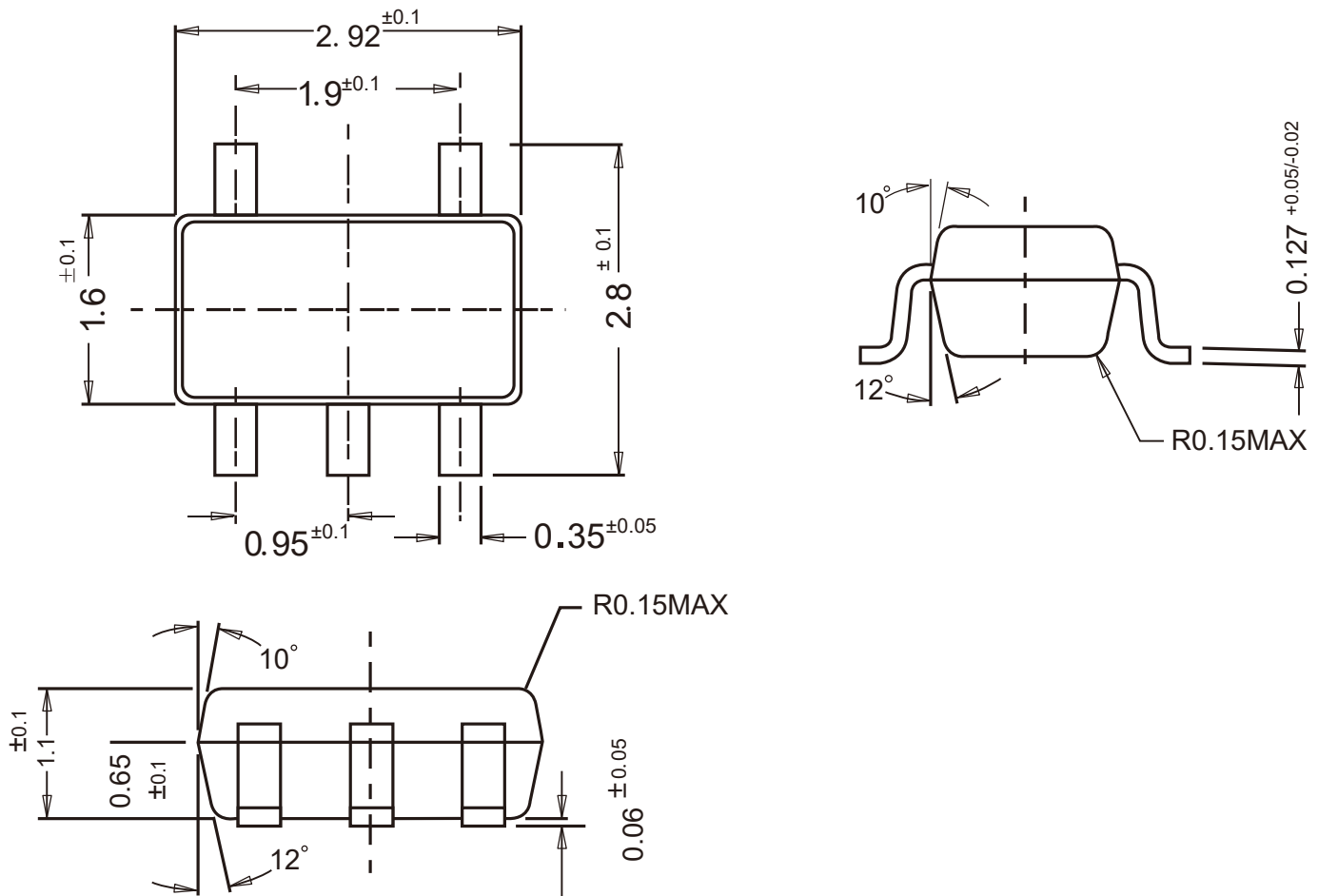
When laying out the printed circuit board, the following checking should be used to ensure proper operation of the TNS6002SE. Check the following in your layout:

1. The power traces, consisting of the GND trace, the SW trace and the VIN trace should be kept short, direct and wide.
2. Place the Cin to TNS6002SE's Vin and GND pins as closely as possible. This capacitor provides the AC current to the internal power MOSFETs.
3. Better to make a star connection of ground node for Cin, TNS6002SE's ground and Cout.
4. Keep the switching node, SW, away from the sensitive feedback node.
5. Keep the (-) terminal of Cin and Cout as close as possible, to minimize current loop area for EMI concern.



## Package Outline

### SOT-23-5 Dimensions in mm



## Contact Information

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For additional information, please contact your local Sales Representative.



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