REVISION HISTORY

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

Rev 1.0: Released to Market

DEVICE ORDER INFORMATION

PART NUMBER	PACKAGE MARKING	PACKAGE DISCRIPTION
SCT2231TVA	2231	SOT563-6L
SCT2231TVB	2231	TSOT23-6L

* (1) FOR TAPE & REEL, ADD SUFFIX R (E.G. SCT2231TVAR).

ABSOLUTE MAXIMUM RATING

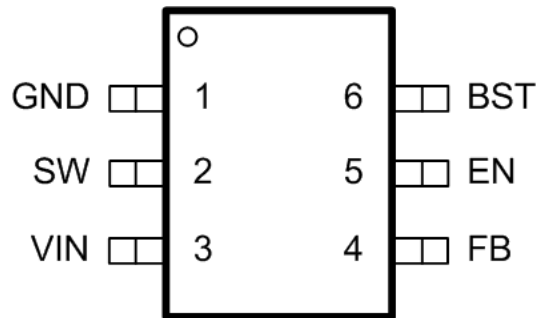Over operating free-air temperature unless otherwise noted[1]

SYMBOL	PARAMETER	RATING	UNIT
V_{IN}	Supply Voltage	-0.3 to 20	V
V_{SW}	Switch Node Voltage	-1 to 20	V
V_{SW} (<10ns)	Switch Node Transient Voltage	-2.5 to 22	V
V_{BST}	Bootstrap	V_{SW}-0.3 to V_{SW}+6	V
V_{FB}	Feedback Voltage	-0.3 to 6.5	V
V_{EN}	Enable/UVLO Voltage	-0.3 to 6.5	V
T_J	Operating junction temperature[2]	-40 to 125	°C
T_{STG}	Storage temperature	-65 to 150	°C

(1) Stresses beyond those listed under Absolute Maximum Rating may cause device permanent damage. The device is not guaranteed to function outside of its Recommended Operation Conditions.
(2) The IC includes over temperature protection to protect the device during overload conditions. Junction temperature will exceed 150°C when over temperature protection is active. Continuous operation above the specified maximum operating junction temperature will reduce lifetime

PIN CONFIGURATION
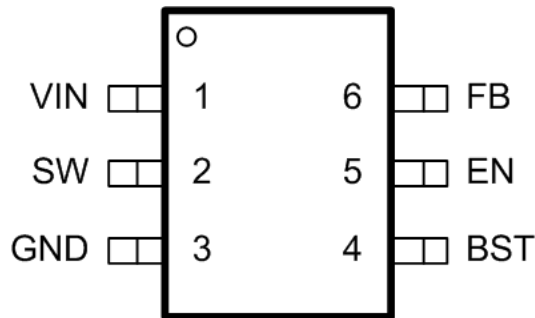
SOT563 Top View

(1.6mm x 1.6mm)

TSOT23-6 Top View

(2.8mm x 2.8mm)

PIN FUNCTIONS

NAME	PIN NUMBER		PIN FUNCTION
	SOT563	TSOT23-6	
VIN	1	3	Power supply input. VIN supplies the power to the IC, as well as the step-down converter switches. Drive VIN with a 4.2V to 17V power source. Bypass VIN to GND with a suitably large capacitor to eliminate noise on the input to the IC. See Input Capacitor.
SW	2	2	Power Switching Output. SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load. Note that a capacitor is required from SW to BST to power the high-side switch.
GND	3	1	Power ground. Must be soldered directly to ground plane.
BST	4	6	Power supply for the high-side power MOSFET gate driver. Must connect a 0.1uF or greater ceramic capacitor between BST pin and SW node.
EN	5	5	

SCT2231

ELECTRICAL CHARACTERISTICS

V_{IN}=12V, T_J=-40°C~125°C, typical values are tested under 25°C.

SYMBOL	PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
Power Supply and Output						
V_{IN}	Operating input voltage		4.2		17	V
V_{IN_UVLO}	Input UVLO	V_{IN} rising		4.0	4.15	V
	Hysteresis			300		mV
I_{SD}	Shutdown current	EN=0, No load, VIN=12V		1.5	5	uA
I_Q	Quiescent current	EN=2V, No load, No switching. VIN=12V. BST-SW=5V		275		uA
Enable, Soft Start and Working Modes						
V_{EN_H}	Enable high threshold			1.18	1.25	V
V_{EN_L}	Enable low threshold		1.03	1.1		V
I_{EN}	Enable pin input current	EN=1V	1	1.5	2	uA
I_{EN_HYS}	Enable pin hysteresis current	EN=1.5V		5.5		uA
Power MOSFETs						
R_{DSON_H}	High side FET on-resistance			70		
R_{DSON_L}	Low side FET on-resistance			42		
Feedback and Error Amplifier						
V_{FB}	Feedback Voltage	T_J=25°C	0.792	0.8	0.808	V
		T_J=-40°C~125°C	0.784	0.8	0.816	V
Current Limit						
I_{LIM_LSD}	LSD valley current limit		3.2	3.7	4.2	A
Switching Frequency						
F_{SW}	Switching frequency	V_{IN}=12V, V_{OUT}=5V		750		kHz
t_{ON_MIN}	Minimum on-time			90		ns
t_{OFF_MIN}	Minimum off-time			220		ns
Soft Start Time						
t_{SS}	Internal soft-start time			2.5		ms

Protection
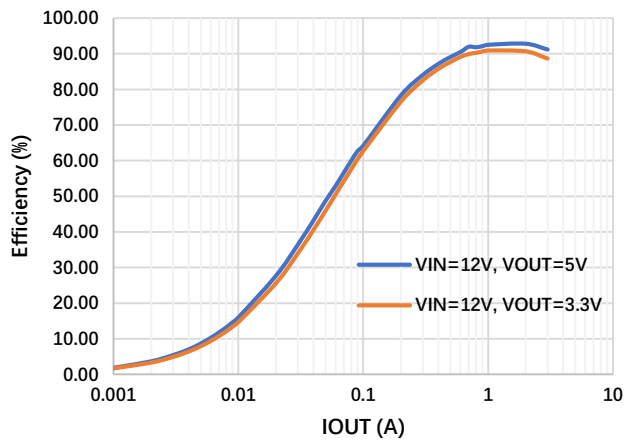
T_{SD}

TYPICAL CHARACTERISTICS

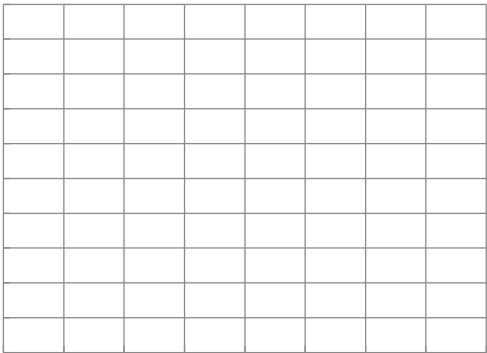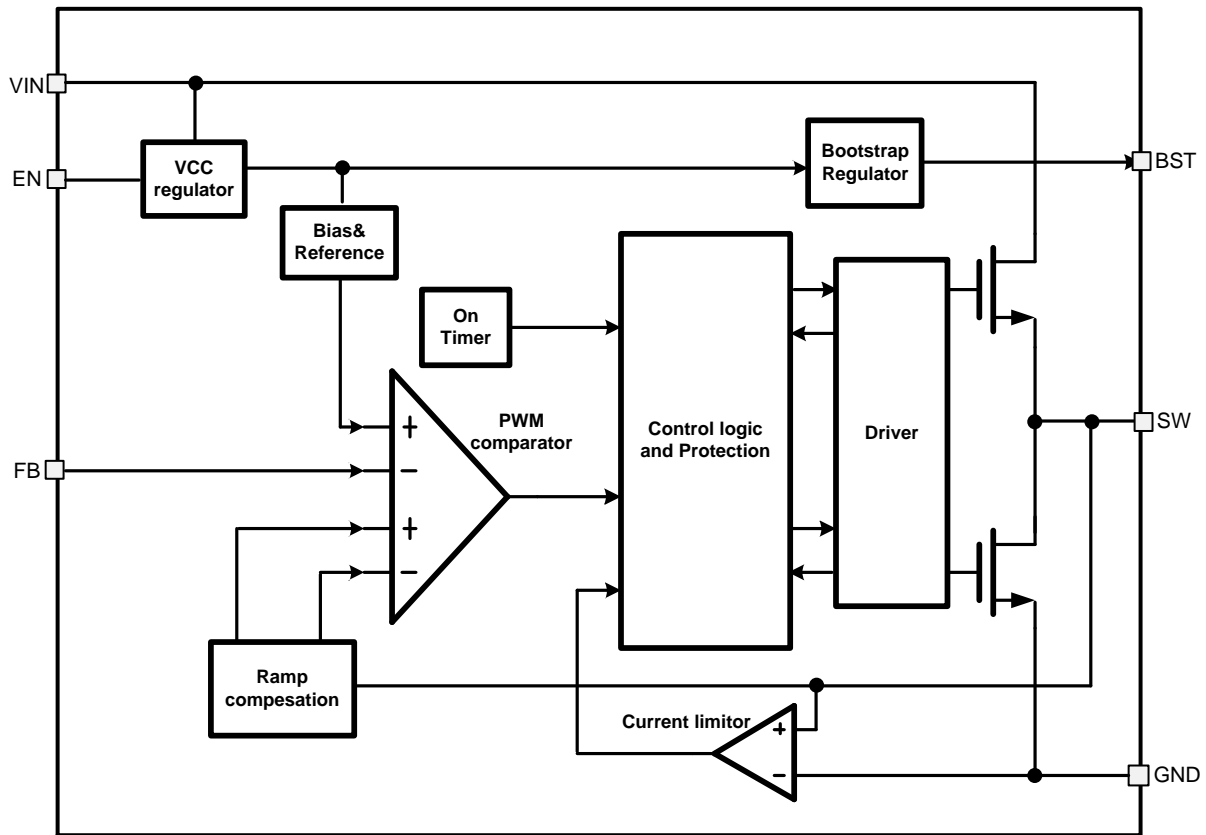**Figure 1. SCT2231 Efficiency, Vin=12V**

Figure 2. Vout Vs. VIN

Figure 3. Load Regulation

Figure 4. FB Vs. Temperature

Figure 5. UVLO Vs. Temperature

Figure 6. Line Regulation

FUNCTIONAL BLOCK DIAGRAM

OPERATION

Adaptive On-time Control

The SCT2231 device is 4.2-17V input, 3A output, and synchronous step-down converters with internal power MOSFETs. Adaptive constant on-time (ACOT) control is employed to provide fast transient response and easy loop stabilization. At the beginning of each cycle, the high-side MOSFET is turned on for a fixed one shot time ON-time period. The one shot time   - by-cycle based to maintain a pseudo-fixed frequency over the input voltage range, hence it is called adaptive on-time control. SCT2231 turns off high-side MOSFET after the fixed on time and turns on the low-side MOSFET. SCT2231 turns off the low-side MOSFET once the output voltage dropped below the output regulation, the one-shot timer then reset and the high-side MOSFET is turned on again. The on-time is inversely proportional to the input voltage and proportional to the output voltage. It can be calculated using the following equation (1):

$$t_{ON} = \frac{V_{OUT}}{V_{IN} \times f_S} \tag{1}$$

Where:
- VOUT is the output voltage.
- VIN is the input voltage.
- fs is the switching frequency.

After an ON-time period, the regulator goes into the OFF-time period. The OFF-time period length depends on VFB in most cases. It will end when the FB voltage decreases below 0.8V, at which point the ON-time period is triggered. If the OFF-time period is less than the minimum OFF time, the minimum OFF time will be applied, which is around 200ns typical.

Forced Pulse Width Modulation (FPWM)

The SCT2231 is designed with Forced Pulse Width Modulation (FPWM) at light load conditions for small output voltage ripple. In light load, the inductor current falls below 0A, the buck converter operates at forced continuous current mode. The SCT2331 operates at quasi 750kHz switching frequency.

VIN Power

The SCT2231 is designed to operate from an input voltage supply range between 4.2V to 17V, at least 0.1uF decoupling ceramic cap is recommended to bypass the supply noise. If the input supply locates more than a few inches from the converter, an additional electrolytic or tantalum bulk capacitor or with recommended 10uF may be required in addition to the local ceramic bypass capacitors.

Under Voltage Lockout UVLO

The SCT2231 Under Voltage Lock Out (UVLO) default startup threshold is typical 3.9V with VIN rising and shutdown threshold is 3.6V with VIN falling. The more accurate UVLO threshold can be programmed through the precision enable threshold of EN pin.

Enable and Start up

When applying a voltage higher than the EN high threshold (typical 1.2V/rise), the SCT2231 enables all functions and the device starts soft-start phase. The SCT2231 has the built in 2ms soft-start time to prevent the output overshoot and inrush current. When EN pin is pulled low, the internal SS net will be discharged to ground. Buck operation is disabled when EN voltage falls below its lower threshold (typically 1.1V/fall).

SCT2231

Thermal Shutdown

Once the junction temperature in the SCT2231 exceeds 160°C, the thermal sensing circuit stops converter switching and restarts with the junction temperature falling below 140°C. Thermal shutdown prevents the damage on device during excessive heat and power dissipation condition.
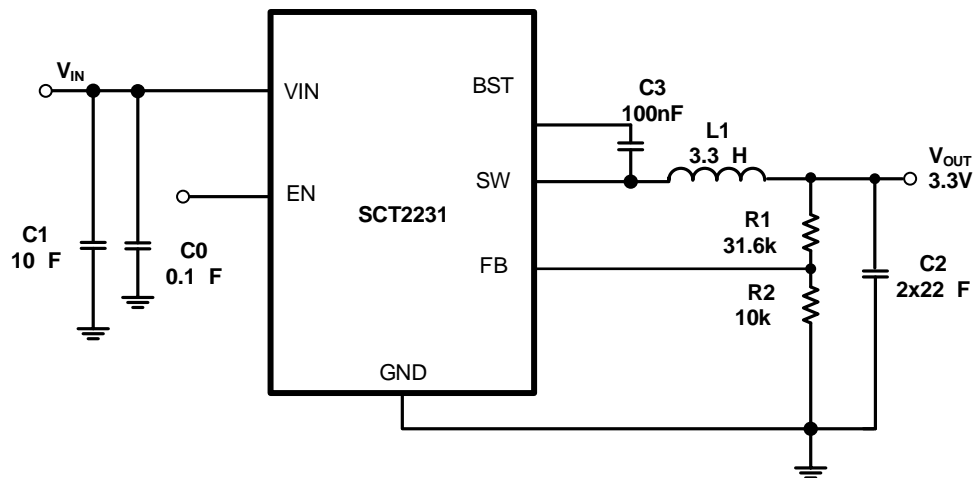
APPLICATION INFORMATION

Typical Application

Figure 8. 12V Input, 3.3V/3A Output

Design Parameters

Design Parameters	Example Value
Input Voltage	12V
Output Voltage	3.3V

ripple less than 100mV. Generally, a 25V/10uF input ceramic capacitor is recommended for most of applications. Choose the right capacitor value carefully with considering high-capacitance ceramic capacitors DC bias effect, which has a strong influence on the final effective capacitance.

Inductor Selection

The performance of   avior, loop stability, and buck converter efficiency. The inductor value, DC resistance (DCR), and saturation current influences both efficiency and the magnitude of the output voltage ripple. Larger inductance value reduces inductor current ripple and therefore leads to lower output voltage ripple. For a fixed DCR, a larger value inductor yields higher efficiency via reduced RMS and core losses. However, a larger inductor within a given inductor family will generally have a greater series resistance, thereby counteracting this efficiency advantage.

Inductor values can have ±20% or even ±30% tolerance with no current bias. When the inductor current approaches saturation level, its inductance can decrease 20% to 35% from the value at 0-A current depending on how the inductor vendor defines saturation. When selecting an inductor, choose its rated current especially the saturation current larger than its peak current during the operation.

To calculate the current in the worst case, use the maximum input voltage, minimum output voltage, maxim load current and minimum switching frequency of the application, while considering the inductance with -30% tolerance and low-power conversion efficiency.

For a buck converter, calculate the inductor minimum value as shown in equation (5).

$$\overline{\hspace{4cm}} \tag{5}$$

Where:
- K_{IND} is the coefficient of inductor ripple current relative to the maximum output current.

Therefore, the peak switching current of inductor, I_{LPEAK}, is calculated as in equation (6).

$$\overline{\hspace{1cm}} \tag{6}$$

Set the current limit of the SCT2231 higher than the peak current I_{LPEAK} and select the inductor with the saturation current higher than the current limit. The   the core loss significantly affect the efficiency of power conversion. Core loss is related to the core material and different inductors have different core loss. For a certain inductor, larger current ripple generates higher DCR and ESR conduction losses and higher core loss.

Table 1 lists recommended inductors for the SCT2231. Verify whether the recommended inductor can support the user's target application with the previous calculations and bench evaluation. In this application, the WE's inductor 744325330 is used on SCT2231 evaluation board.

Table 1. Recommended Inductors

Part Number	L (uH)	DCR Max	Saturation Current/Heat Rating Current (A)	Size Max (LxWxH mm)	Vendor
744325330	3.3	5.9	15	10.5x10.5x4.7	Wurth Electronik

Output Feedback Resistor Divider Selection

The SCT2231 features external programmable output voltage by using a resistor divider network R1 and R2 as shown in the typical application circuit Figure 8. Use equation (7) to calculate the resistor divider values.
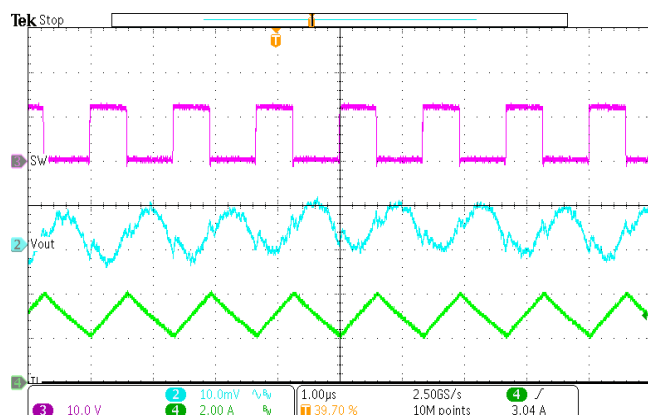
(7)

Application Waveforms

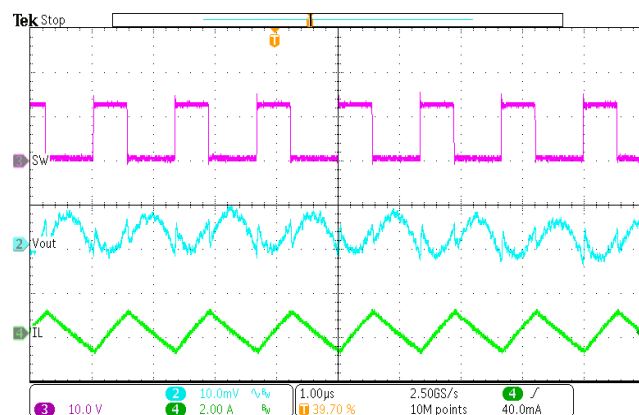**Figure 9. SW node waveform and Output Ripple**
VIN=12V, IOUT=3A

Figure 10. SW node Waveform and Output Ripple
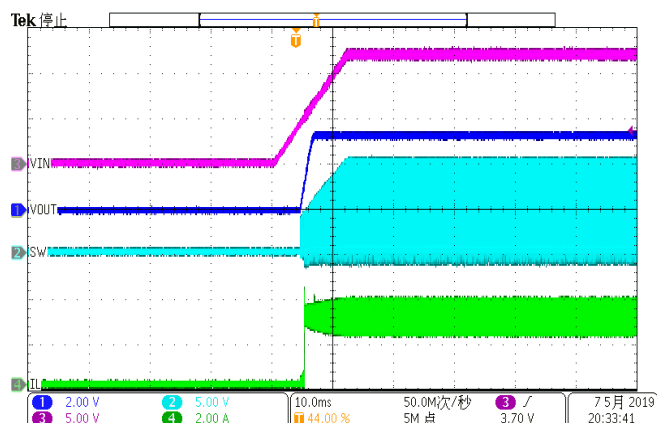**VIN=12V, IOUT=10mA**

Figure 11. Power Up
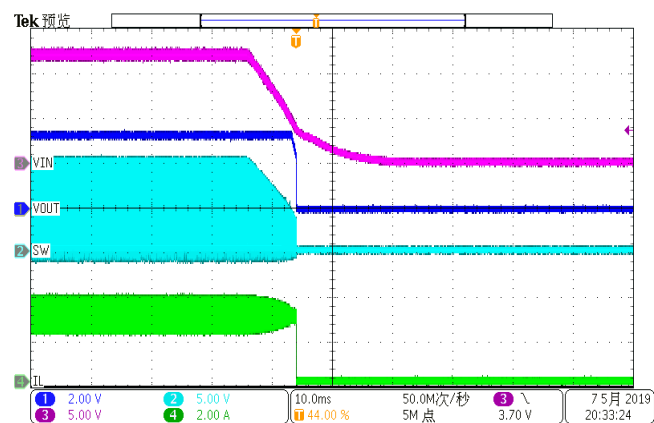**VIN=12V, VOUT=3.3V, IOUT=3A**

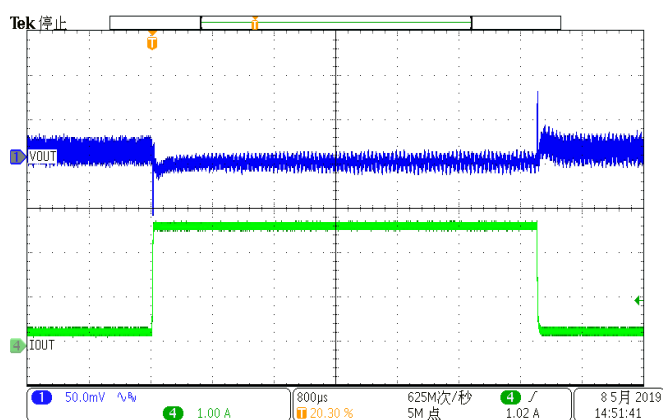**Figure 12. Power Down**
VIN=12V, VOUT=3.3V, IOUT=3A

Figure 13. Load Transient
VOUT=3.3V, IOUT=0.3A to 2.7A, SR=250mA/us
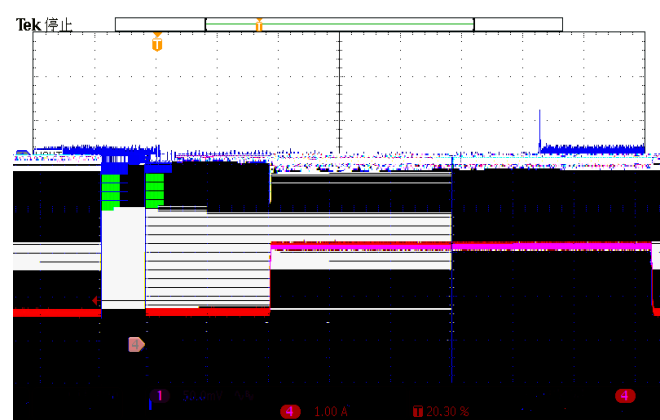

Figure 14. Load Transient
VOUT=3.3V, IOUT=0.75A to 2.25A, SR=250mA/us

SCT2231

Layout Guideline

The regulator could suffer from instability and noise problems without carefully layout of PCB. Radiation of high-frequency noise induces EMI, so 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 coupling. The input capacitor needs to be very close to the VIN pin and GND pin to reduce the input supply ripple. Place the capacitor as close to VIN pin as possible to reduce high frequency ringing voltage on SW pin as well. Figure 15 is the recommended PCB layout of SCT2231.

The layout needs be done with well consideration of the thermal. A large top layer ground plate using multiple thermal vias is used to improve the thermal dissipation. The bottom layer is a large ground plane connected to the top layer ground by vias.
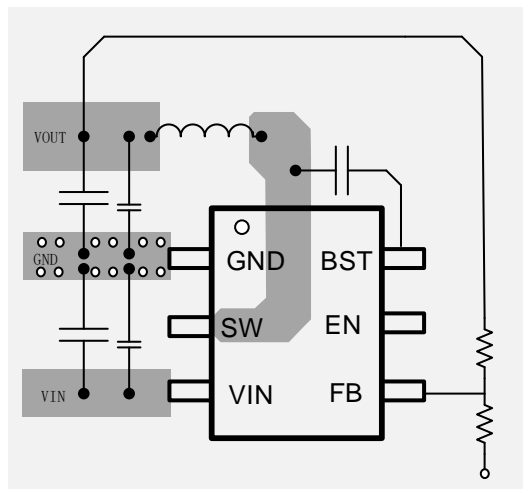

Figure 15. PCB Layout Example

Thermal Considerations

The maximum IC junction temperature should be restricted to 125°C under normal operating conditions. Calculate the maximum allowable dissipation, $P_{D(max)}$, and keep the actual power dissipation less than or equal to $P_{D(max)}$. The maximum-power-dissipation limit is determined using Equation (8).

$$\overline{\qquad\qquad} \tag{8}$$

where
- T_A is the maximum ambient temperature for the application.
- R   is the junction-to-ambient thermal resistance given in the Thermal Information table.

The real junction-to-ambient thermal resistance R   of the package greatly depends on the PCB type, layout, thermal pad connection and environmental factor. Using thick PCB copper and soldering the GND to a large ground plate enhance the thermal performance. Using more vias connects the ground plate on the top layer and bottom layer around the IC without solder mask also enhance the thermal capability.
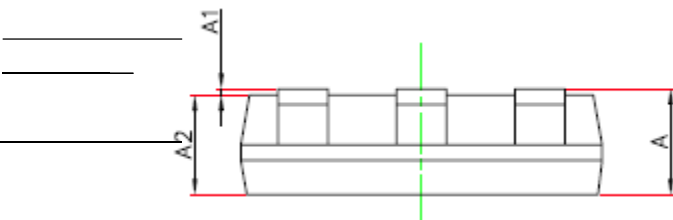
PACKAGE INFORMATION (TSOT23-6)
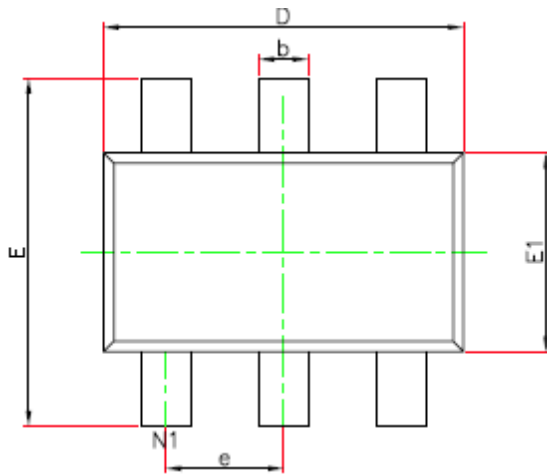
TSOT23-6 TOP VIEW
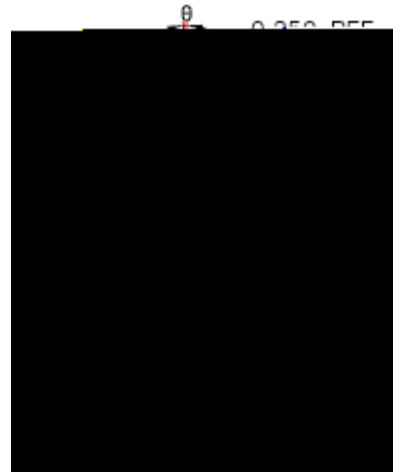
TSOT23-6 BOTTOM VIEW

TSOT23-6 SIDE VIEW

SYMBOL	Unit: Millimeter		
	MIN	TYP	MAX
A	-------		1.10
A1	0.000		0.10
A2	0.70		1.00

NOTE:

1. Drawing proposed to be made a JEDEC package outline MO-220 variation.
2. Drawing not to scale.
3. All linear dimensions are in millimeters.
4. Thermal pad shall be soldered on the board.
5. Dimensions of exposed pad on bottom of package do not include mold flash.
6. Contact PCB board fabrication for minimum solder mask web tolerances between the pins.

TAPE AND REEL INFORMATION

Orderable Device	Package Type	Pins	SPQ
SCT2231TVBR	TSOT23-6L	6	3000

Feeding Direction

Pro TmD8 2.16 ref*QQQQQQQQQQQQQQQQQQQQQQQQQQQ-5(d)t/F3 8.04Foldf3 eW*:/F3 8.04]TJT22F