Application Note: SQ25250

High Efficiency 1MHz, 600mA Step Up Regulator

General Description

The SQ25250 is a high efficiency, current-mode control Boost DC to DC regulator with an integrated 400mΩ $R_{DS(ON)}$ N-channel MOSFET. The fixed 1MHz switching frequency and internal compensation reduce external component count and save the PCB space. The build-in internal soft start circuitry minimizes the inrush current at start-up.

Ordering Information

Ordering Number	Package type	Note
SQ25250ABC	SOT23-6	----

Features

- Wide Input Range: 3-30V Bias Input, $33V_{OUT, MAX}$
- 1MHz Switching Frequency
- Minimum ON Time: 100ns typical
- Minimum OFF Time: 100ns typical
- Low $R_{DS(ON)}$: 400mΩ
- RoHS Compliant and Halogen Free
- Accurate Reference: $1.24V_{REF}$
- Compact Package: SOT23-6

Applications

- Digital Camera
- Cell Phone
- PDA, PMP, MP3

Typical Applications

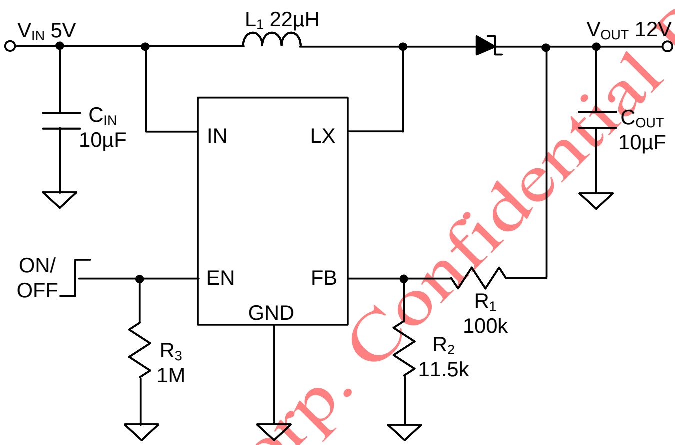

Figure 1. Schematic Diagram

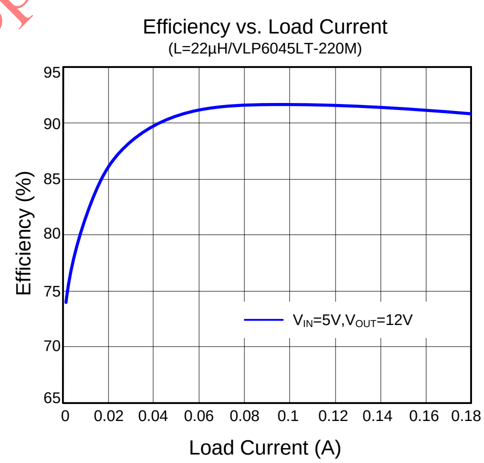

Figure 2. Efficiency vs. Load Current

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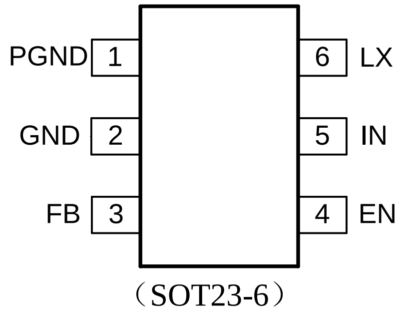
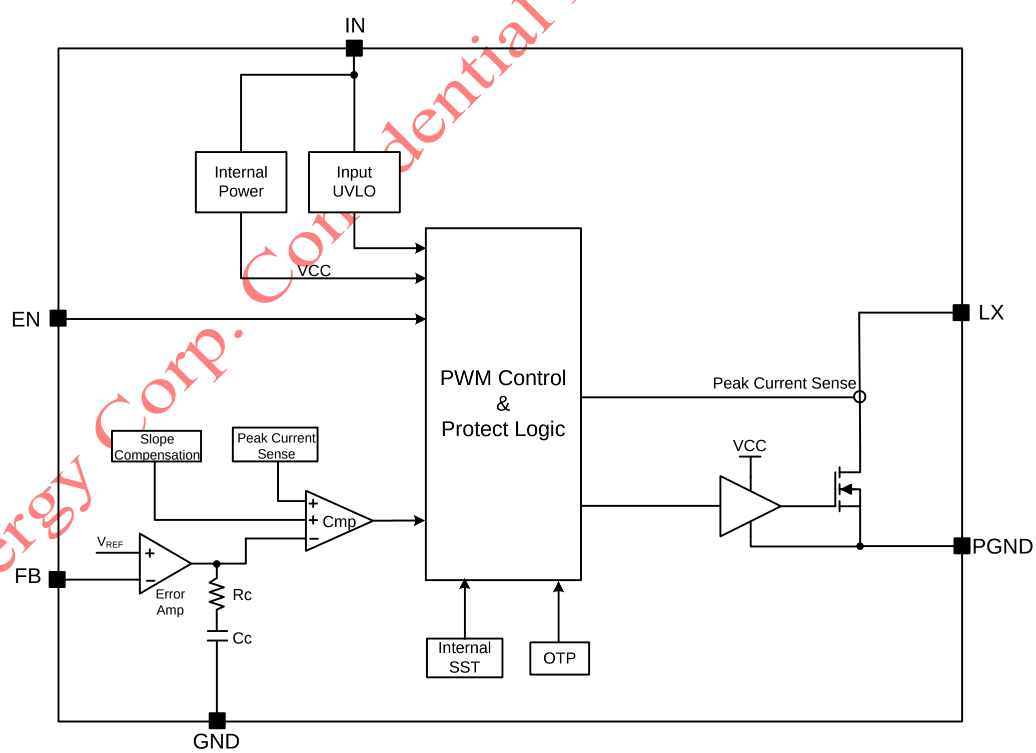
Pinout (top view)



Top Mark: Y8*xyz* (Device code: Y8, ***x=year code, y=week code, z= lot number code*)**

Pin Name	Pin Number	Pin Description
PGND	1	Power ground pin.
GND	2	Signal ground pin.
FB	3	Feedback pin. Connect a resistor R_1 between V_{OUT} and FB, and a resistor R_2 between FB and GND to program the output voltage: $V_{OUT}=1.24V\times(R_1/R_2+1)$.
EN	4	Enable control. High to turn on the IC. Don't leave it floating.
IN	5	Input pin. Decouple this pin to the GND pin with a 1µF ceramic capacitor.
LX	6	Inductor node. Connect an inductor between the IN pin and the LX pin.

Function Block



Figue3. Block Diagram

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Absolute Maximum Ratings (Note 1)

LX Voltage ---------- -0.3V to 36V
IN, EN Voltage ---------- -0.3V to 33V
FB Voltage ---------- -0.3V to 4V
Power Dissipation, P_D @ T_A = 25°C SOT23-6 ---------- 0.6W
Package Thermal Resistance (Note 2)
θ_{JA} ---------- 161°C/W
θ_{JC} ---------- 130°C/W
Junction Temperature Range ---------- -40°C to 150°C
Lead Temperature (Soldering, 10 sec.) ---------- 260°C
Storage Temperature Range ---------- -65°C to 150°C
Dynamic LX voltage in 50ns duration ---------- IN+3V to GND-4V

Recommended Operating Conditions (Note 3)

Input Voltage Supply---------- 3V to 30V
Junction Temperature Range ---------- -40°C to 125°C
Ambient Temperature Range ---------- -40°C to 85°C

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Electrical Characteristics

(V_{IN} = 5V, V_{OUT}=12V, I_{OUT}=100mA, T_J= -40°C to +125°C. Typical values are at T_J=25°C, unless otherwise specified. The values are guaranteed by test, design or statistical correlation.)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range	V_{IN}		3		30	V
IN UVLO Rising Threshold	$V_{IN,UVLO}$		1.3		2.2	V
Quiescent Current	I_Q	V_{FB}=1.3V		100	150	µA
Shutdown Current	I_{SHDN}	EN=0		5	20	µA
Low Side Main FET R_{ON}	$R_{DS(ON)}$			400	600	mΩ
Main FET Current Limit	I_{LIM1}	55% Duty cycle	450	750	925	mA
Main FET Leakage Current	I_{LK}	EN=0			1	µA
Switching Frequency	fsw		0.8	1	1.32	MHz
Feedback Reference Voltage	V_{REF}		1.21	1.24	1.265	V
EN Rising Threshold	V_{ENH}		1.5			V
EN Falling Threshold	V_{ENL}				0.4	V
EN Leakage Current	I_{EN}	EN=5V	-1		1	µA
Max Duty Cycle	D_{MAX}		85	90		%
Min ON Time	$t_{ON, MIN}$			100	150	ns
Min OFF Time	$t_{OFF, MIN}$			10%	15%	T_S
Thermal Shutdown Temperature	T_{SD}			150		°C
Thermal Shutdown Hysteresis	T_{HYS}			10		°C

Note 1: Stresses beyond "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Note 2: θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard. Test condition: Device mounted on 2" x 2" FR-4 substrate PCB, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.

Note 3: The device is not guaranteed to function outside its operating conditions.

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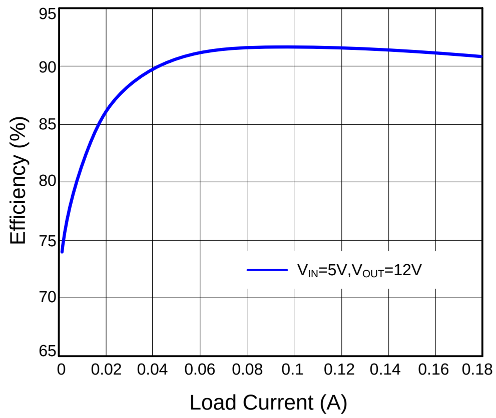
Typical Performance Characteristics

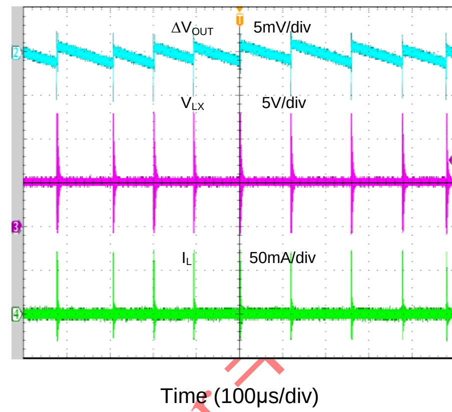
Efficiency vs. Load Current

(L=22µH/VLP6045LT-220M)



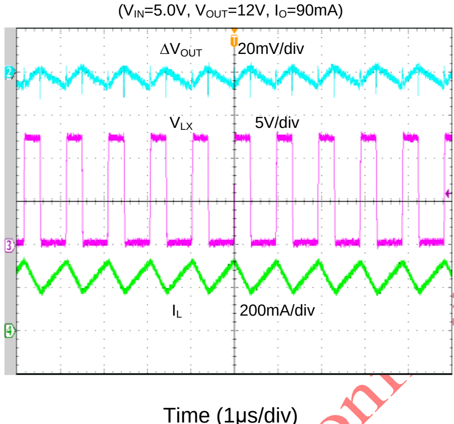
Output Ripple

(V_{IN}=5.0V, V_{OUT}=12V, I_O=0mA)



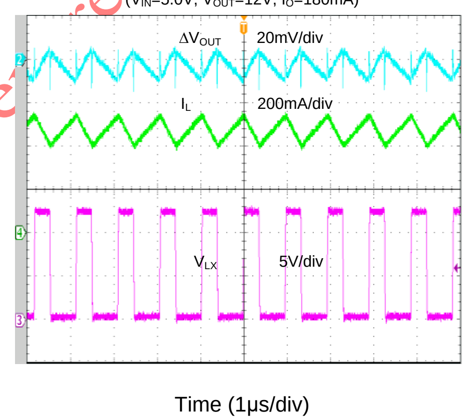
Output Ripple

(V_{IN}=5.0V, V_{OUT}=12V, I_O=90mA)



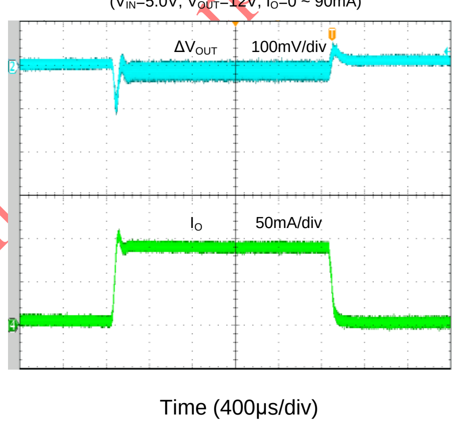
Output Ripple

(V_{IN}=5.0V, V_{OUT}=12V, I_O=180mA)



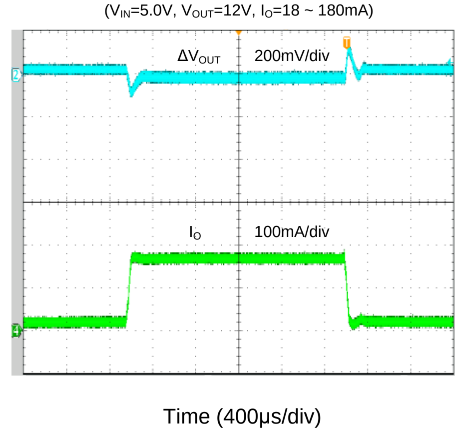
Load Transient

(V_{IN}=5.0V, V_{OUT}=12V, I_O=0 ~ 90mA)



Load Transient

(V_{IN}=5.0V, V_{OUT}=12V, I_O=18 ~ 180mA)



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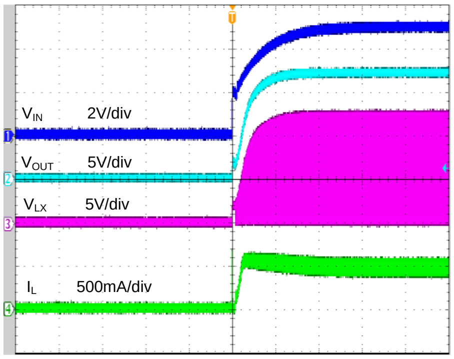
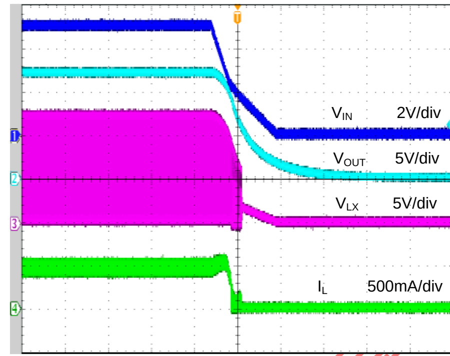
Startup from V_{IN}
(V_{IN}=5.0V, V_{OUT}=12V, I_O=180mA)



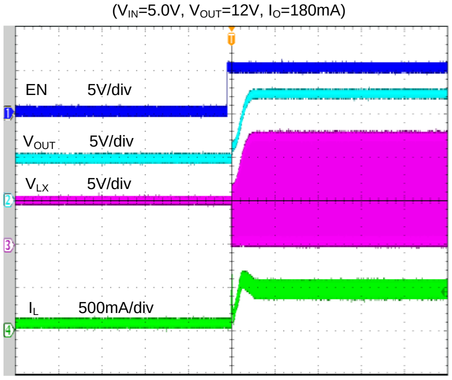
Time (4ms/div)

Shutdown from V_{IN}
(V_{IN}=5.0V, V_{OUT}=12V, I_O=180mA)



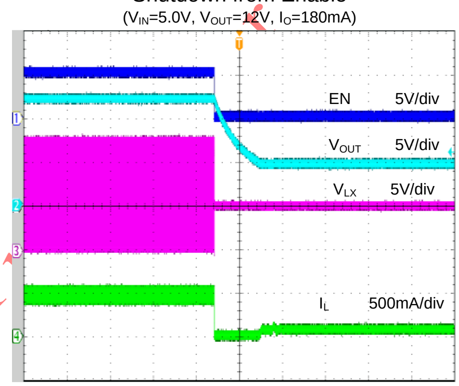
Time (2ms/div)

Startup from Enable
(V_{IN}=5.0V, V_{OUT}=12V, I_O=180mA)



Time (2ms/div)

Shutdown from Enable
(V_{IN}=5.0V, V_{OUT}=12V, I_O=180mA)



Time (800μs/div)

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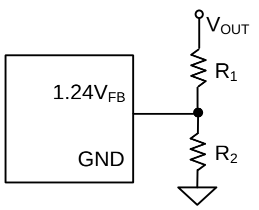
Applications Information

Because of the high integration in the SQ25250, the application circuit based on this IC is rather simple. Only the input capacitor C_{IN}, the output capacitor C_{OUT}, the inductor L and the feedback resistors (R_1 and R_2) need to be selected for the targeted applications specifications.

Feedback Resistor Dividers R_1 and R_2:

Choose R_1 and R_2 to program the proper output voltage. To minimize the power consumption under light loads, it is desirable to choose large resistance values for both R_1 and R_2. A value of between 10k and 1M is recommended for both resistors. If R_1=200k is chosen, then R_2 can be calculated to be:

$$R_2=(R_1\times 1.24V)/(V_{OUT}-1.24V)$$



Input Capacitor C_{IN}:

The ripple current through input capacitor is calculated as:

$$I_{CIN\_RMS}=\frac{V_{IN}\times(V_{OUT}-V_{IN})}{2\sqrt{3}\times L\times f_{SW}\times V_{OUT}}$$

To minimize the potential noise problem, place a typical X5R or better grade ceramic capacitor really close to the IN and GND pins. Care should be taken to minimize the loop area formed by C_{IN}, and IN/GND pins. In this case a 10μF low ESR ceramic is recommended.

Output Capacitor C_{OUT}:

The output capacitor is selected to handle the output ripple noise requirements. Both steady state ripple and transient requirements must be taken into consideration when selecting this capacitor. For the best performance, it is recommended to use an X5R or better grade ceramic capacitor with 50V rating and more than 10μF capacitance.

Boost Inductor L:

There are several considerations in choosing this inductor.

1) Choose the inductance to provide the desired ripple current. It is suggested to choose the ripple current to be about 40% of the maximum average input current. The inductance is calculated as:

$$L=\left(\frac{V_{IN}}{V_{OUT}}\right)^2\frac{(V_{OUT}-V_{IN})}{f_{SW}\times I_{OUT\_MAX}\times 40\%}$$

Where f_{SW} is the switching frequency and $I_{OUT,MAX}$ is the maximum load current.

The SQ25250 is quite tolerant of different ripple current amplitude. Consequently, the final choice of inductance can be slightly off the calculation value without significantly impacting the performance.

2) The saturation current rating of the inductor must be selected to be greater than the peak inductor current under full load conditions.

$$I_{SAT,MIN}>\left(\frac{V_{OUT}}{V_{IN}}\right)\times I_{OUT\_MAX}+\frac{V_{IN}(V_{OUT}-V_{IN})}{2\times f_{SW}\times L\times V_{OUT}}$$

3) The DCR of the inductor and the core loss at the switching frequency must be low enough to achieve the desired efficiency requirement. It is desirable to choose an inductor with DCR<50mΩ to achieve a good overall efficiency.

Enable Operation

Pulling the EN pin low (<0.4V) will shut down the device. During the shutdown mode, the SQ25250 shut down current drops to lower than 5μA. Driving the EN pin high (>1.5V) will turn on the IC again.

Soft-start (EN Control)

The SQ25250 has a built-in soft-start to control the rise rate of the output voltage and limit the inrush current during the IC start-up.

Diode Selection

Schottky diode is a good choice for high efficiency operation because of its low forward voltage drop and fast reverse recovery.

The Schottky diode reverse breakdown voltage should be higher than the output voltage.

Applications with Large Bulk Capacitance

In applications with large bulk capacitance on the output, a very high inrush current can be seen flow through the inductor during power on. To avoid this inrush current flow into the IC and cause any unexpected damage, a Schottky diode connected from power input to the output or an RC delay circuit added on the EN pin of the IC can be used. Refer to the circuit below.

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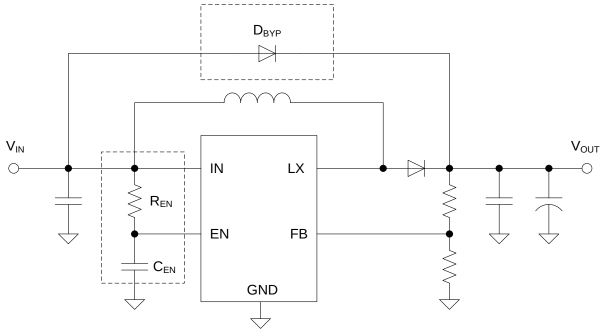

Layout Design:
The layout design of the SQ25250 regulator is relatively simple. For the best efficiency and minimum noise problems, the following components should be placed close to the IC: C_{IN}, L, R_1 and R_2.

1) It is desirable to maximize the PCB copper area connecting to ground pin to achieve the best thermal and noise performance. If the board space allowed, a ground plane is highly desirable.

2) C_{IN} must be close to the IN pin and ground pin. The loop area formed by C_{IN} and ground pin must be minimized.

3) The PCB copper area associated with the LX pin must be minimized to avoid the potential noise problem.

4) The components R_1, R_2 and the trace connecting to the FB pin must NOT be adjacent to the LX net on the PCB layout to avoid the noise problem.

5) If the system chip interfacing with the EN pin has a high impedance state at shutdown mode and the IN pin is connected directly to a power source such as a Li-Ion battery, it is desirable to add a pull-down 1MΩ resistor between the EN and ground pins to prevent the noise from falsely turning on the regulator at shutdown mode.

Other Application Example

Figure4 and figure5 show other application example of using the SQ25250.

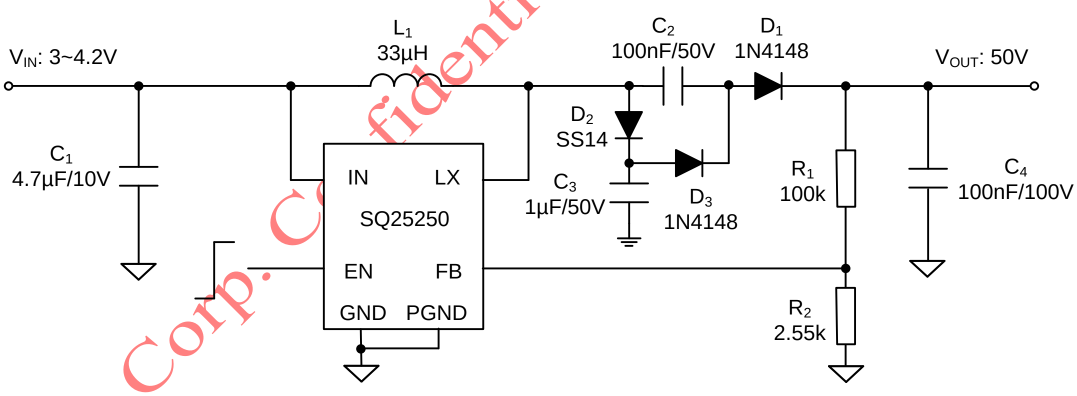

Figure 4. Schematic Diagram

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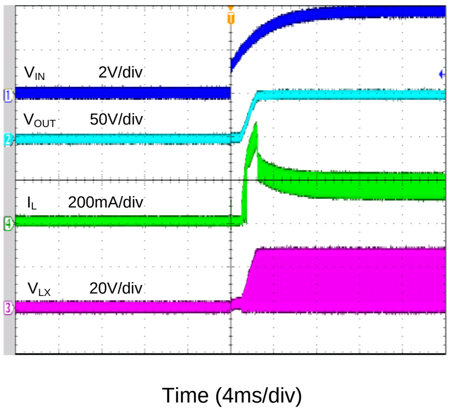
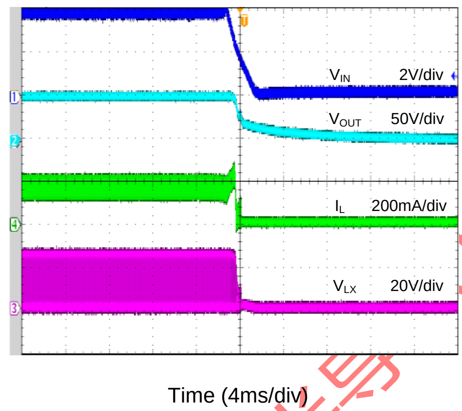
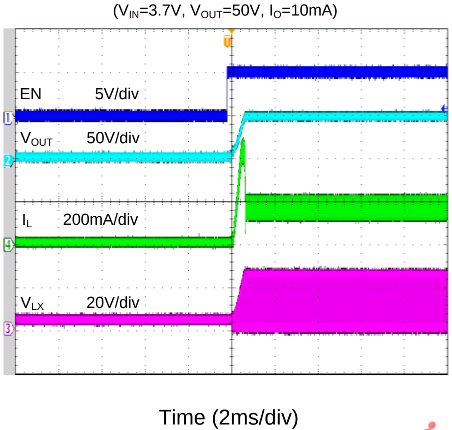
Startup from V_{IN}
(V_{IN}=3.7V, V_{OUT}=50V, I_O=10mA)



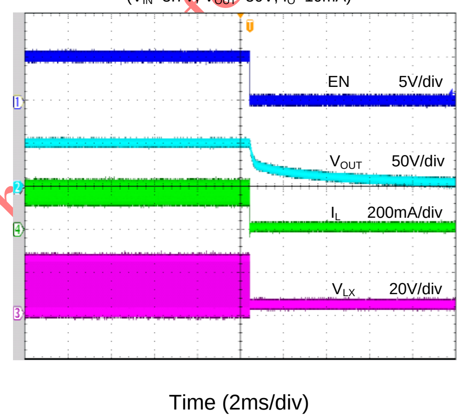
Shutdown from V_{IN}
(V_{IN}=3.7V, V_{OUT}=50V, I_O=10mA)



Startup from Enable
(V_{IN}=3.7V, V_{OUT}=50V, I_O=10mA)



Shutdown from Enable
(V_{IN}=3.7V, V_{OUT}=50V, I_O=10mA)



Output Ripple
(V_{IN}=3.7V, V_{OUT}=50V, I_O=10mA)

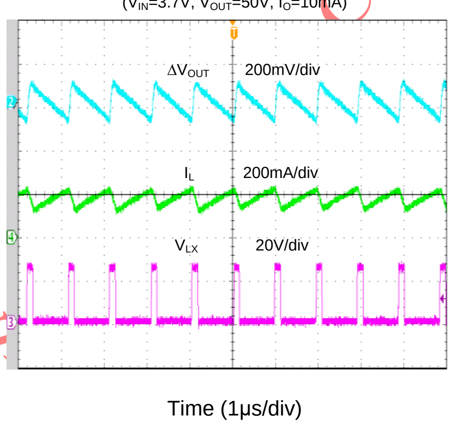


Figure 5. Typical Performance Characteristics

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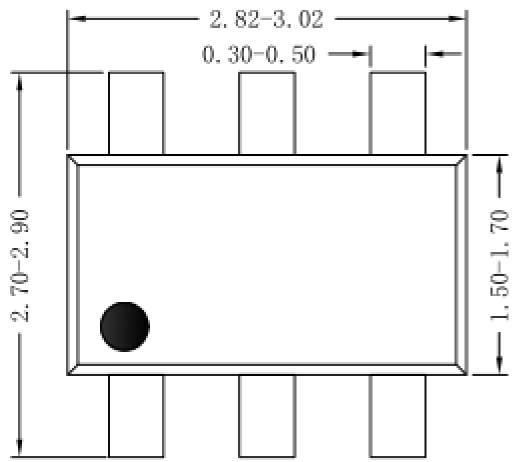
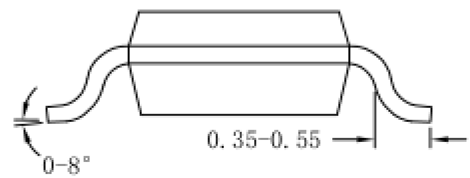
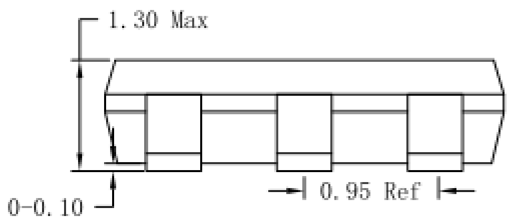
SOT23-6 Package Outline & PCB Layout Design



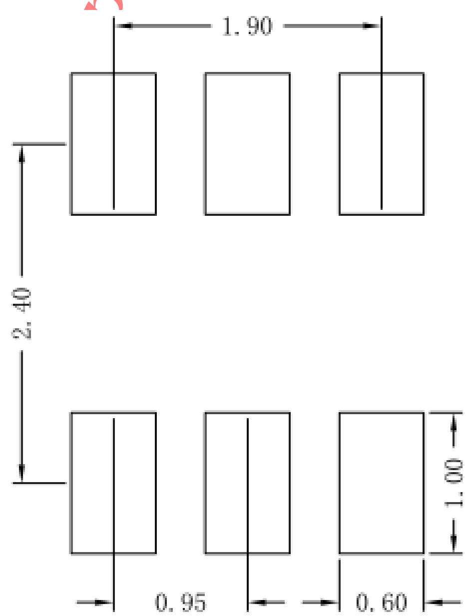
Top View



Side View



Side View



Recommended Pad Layout

Notes: **All dimension in millimeter and exclude mold flash & metal burr.**

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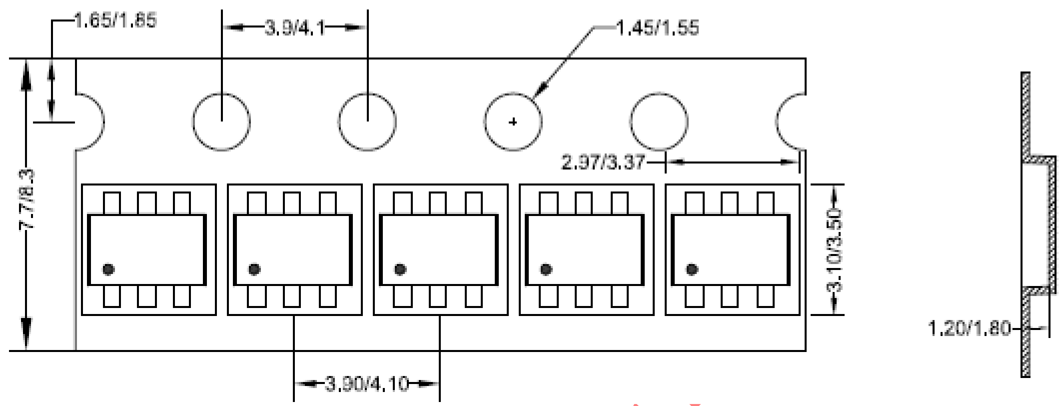
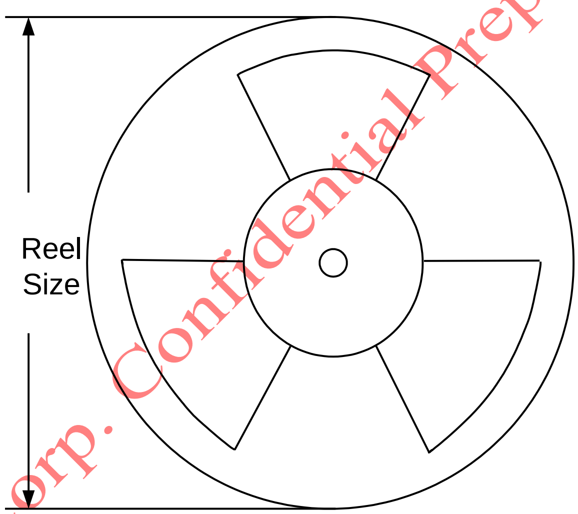
Taping & Reel Specification

1. Taping orientation for packages（SOT23-6）



Feeding direction →

2. Carrier Tape & Reel specification for packages



Package type	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer length(mm)	Leader length (mm)	Qty per reel
SOT23-6	8	4	7"	280	160	3000

3. Others: NA

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