

General Description

The QX2303 Series are PFM step-up DC-DC converters with high efficiency, low ripple and high operation frequency. The QX2303 Series need only four external components to realize step-up conversion from low input battery voltage to the voltage needed, and they are applied to one to four battery-cells application.

The QX2303 Series adopt low dissipation and high performance reference circuit, with trimming technique in manufacture, which ensure high precision and low temperature drift of the output voltage. The precision of output voltage precede $\pm 2.5\%$, and the highest efficiency is 89%.

The QX2303 Series have four package types: SOT23, SOT23-5, SOT89-3 and TO-92. For SOT23-5 package, an enable pin "EN" is provided so that the operation state of the converter can be controlled. When EN is low, the converter is in power saving mode, which decreases power dissipation to the minimum.

Features

- 300KHz Maximum Operating Frequency
- 2.5V to 5.0V Output Voltage With 0.1V step
- Low Start-up Voltage: 0.8V at 1mA
- $\pm 2.5\%$ Output Voltage Accuracy
- Up to 89% Efficiency
- Output Current: 300mA at 2.5V Input, 3.3V Output voltage
- Low Ripple and Low Noise
- Four external components needed only

Applications

- One to Three Cell Battery Devices
- LED Lamp, LED Flashlight
- Portable Instruments Such As Electronic Dictionary, VCR, PDA And So On

Typical Application

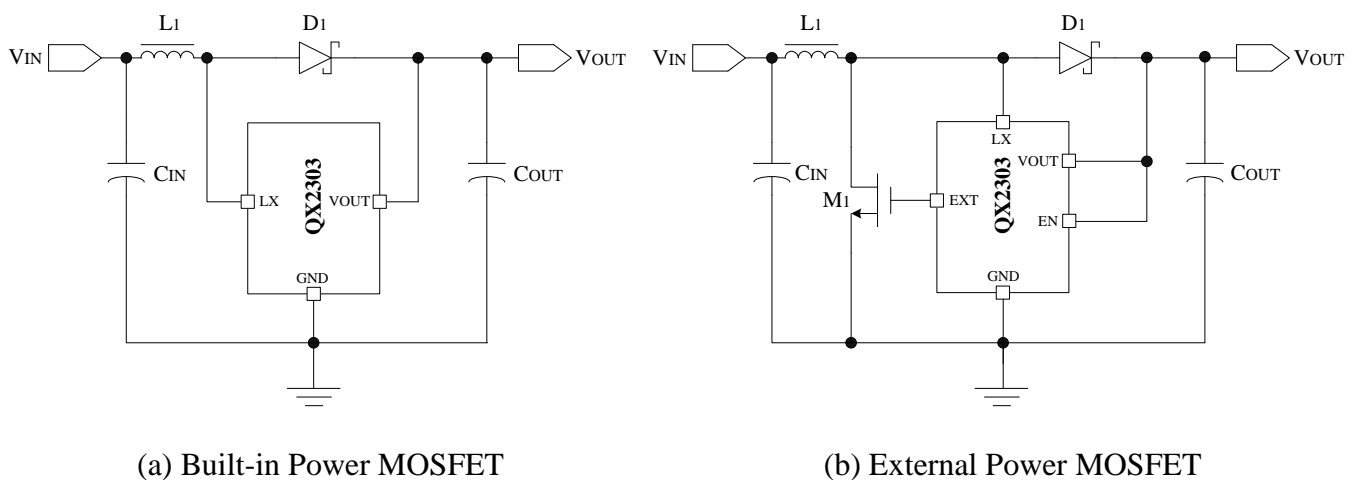
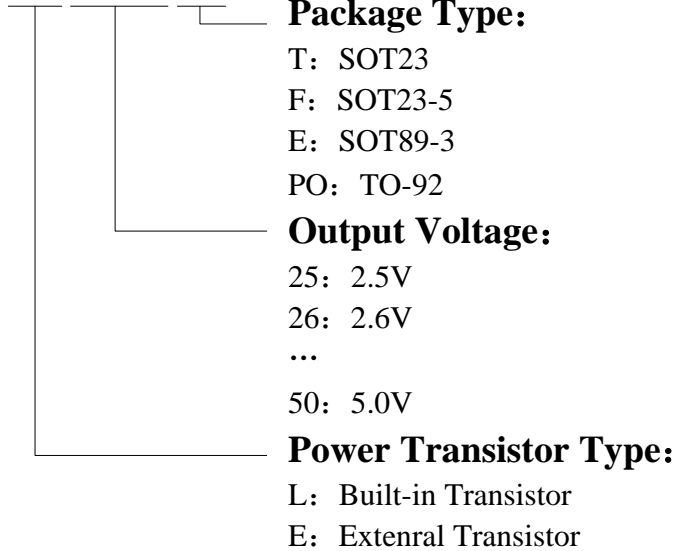


Figure 1: Typical Application Circuit Diagrams of QX2303

Ordering Information

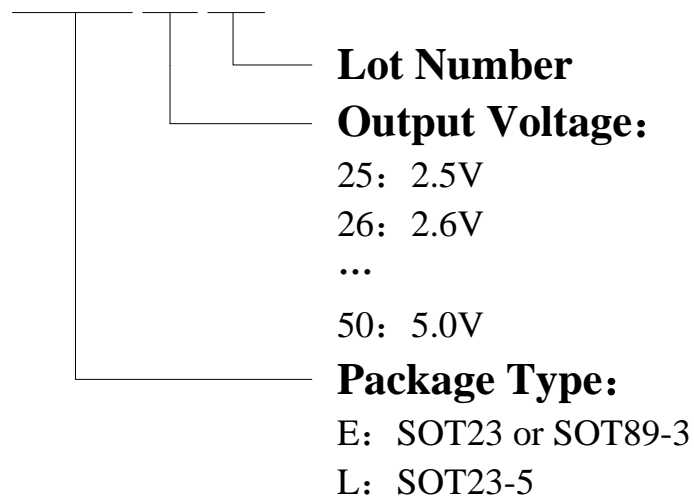
Type Number

QX2303XXXX

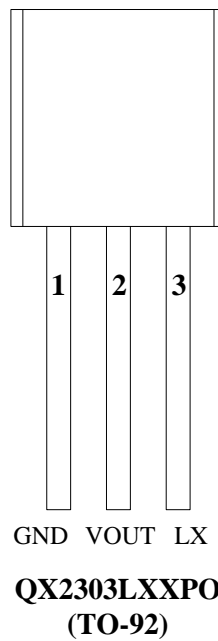
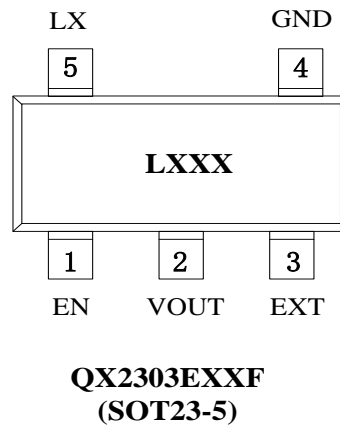
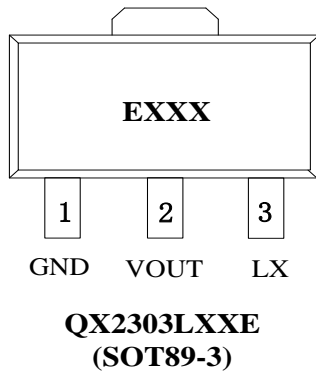
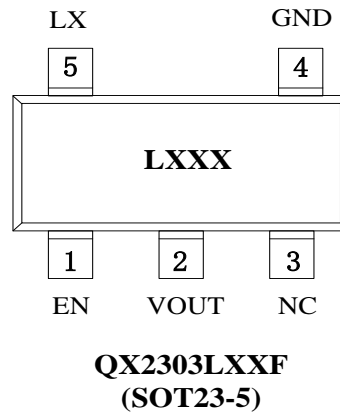
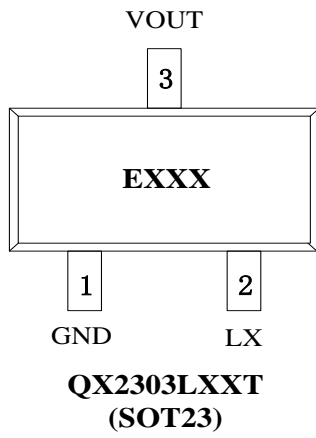


Package Marking

XXXX



Pin Assignments



Pin Description

Pin Name	Type Number and Package Type					Description
	QX2303 LXXT SOT23	QX2303 LXXF SOT23-5	QX2303 EXXF SOT23-5	QX2303 LXXE SOT89-3	QX2303 LXXPO TO-92	
LX	2	5	5	3	3	Switching Pin
EXT	-	-	3	-	-	Buffer Output for External Transistor
VOUT	3	2	2	2	2	Output Voltage
EN	-	1	1	-	-	Chip Enable Pin (Active High)
GND	1	4	4	1	1	Ground
NC	-	3	-	-	-	No Connection

Functional Block Diagram

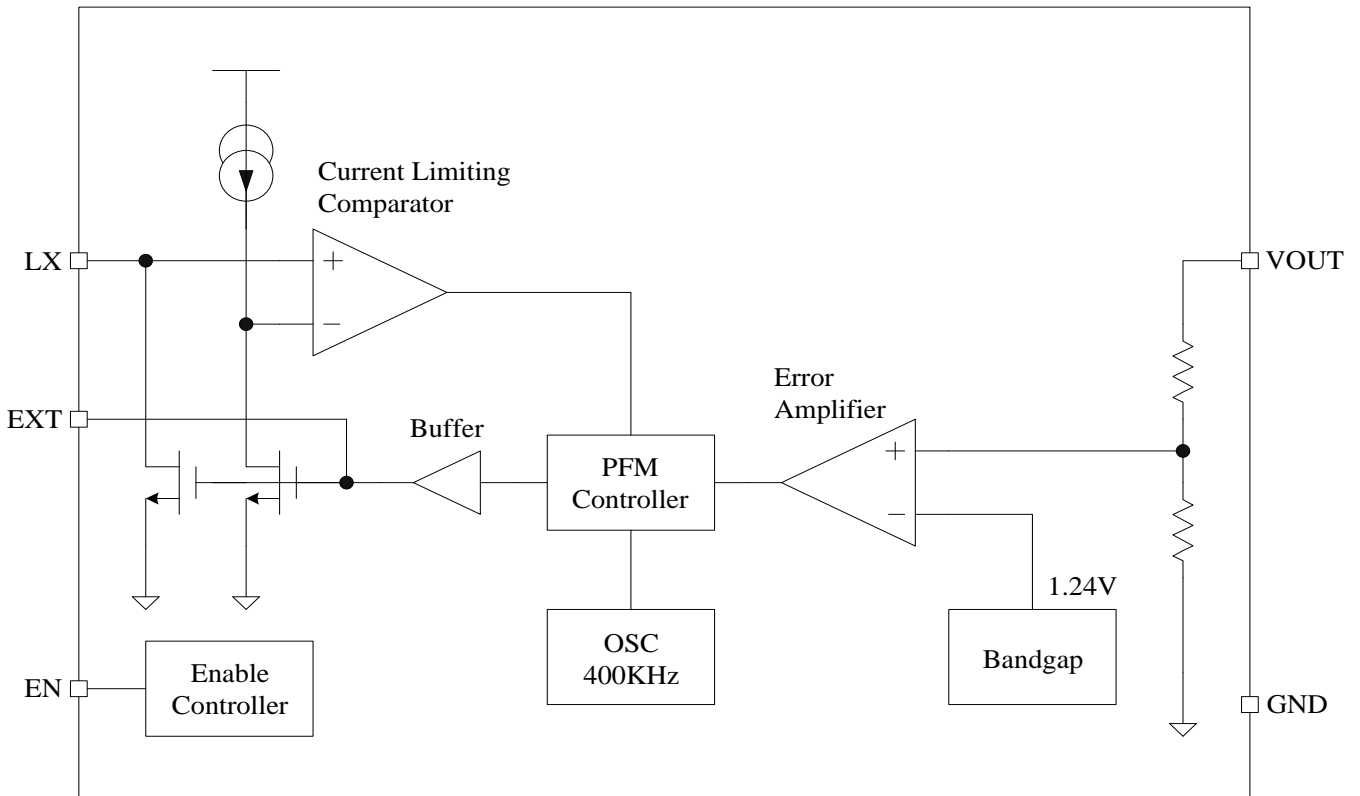


Figure 2: Functional Block Diagram of QX2303

Absolute Maximum Ratings (Note 1)

Parameter	Symbol	Description	Min	Max	Unit
Voltage	V _{MAX}	Maximum Voltage On VOUT and VLX Pins		7	V
	V _{MIN_MAX}	The Voltage Range On EN Pin	-0.3	V _{OUT} +0.3	V
Current	I _{LX_MAX}	Maximum Current On LX Pin		1000	mA
Power Dissipation	P _{SOT23}	Maximum Power Dissipation for SOT23 Package		0.25	W
	P _{SOT23-5}	Maximum Power Dissipation for SOT23-5 Package		0.25	W
	P _{SOT89-3}	Maximum Power Dissipation for SOT89-3 Package		0.5	W
	P _{TO-92}	Maximum Power Dissipation for TO-92 Package		0.75	W
Thermal	T _A	Operating Temperature Range	-20	85	°C
	T _{STG}	Storage Temperature Range	-40	120	°C
	T _{SD1}	Soldering Temperature Rang for SOT23, SOT23-5, SOT89-3 Package (less than 30 sec)	230	240	°C
	T _{SD2}	Soldering Temperature Rang for TO-92 Package (less than 5 sec)	250	260	°C
ESD	V _{ESD}	ESD Voltage for Human Body Mode		2000	V

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

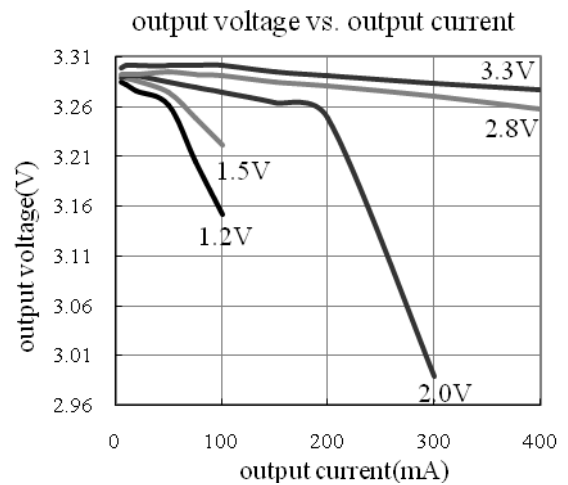
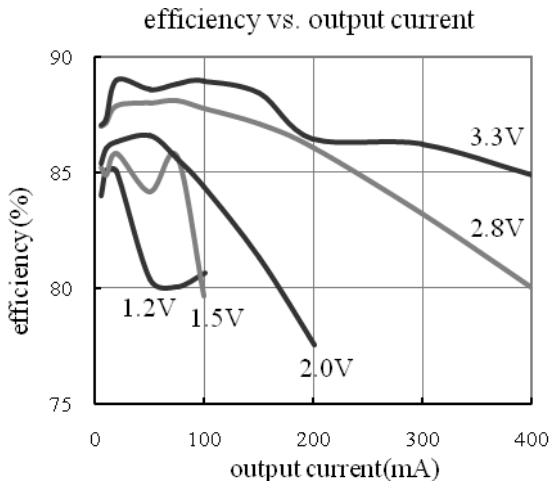
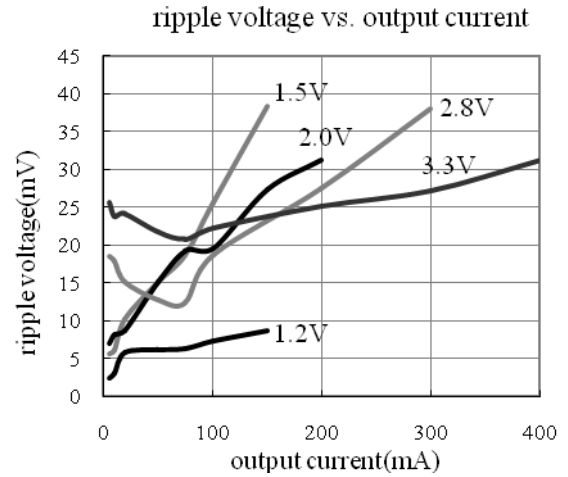
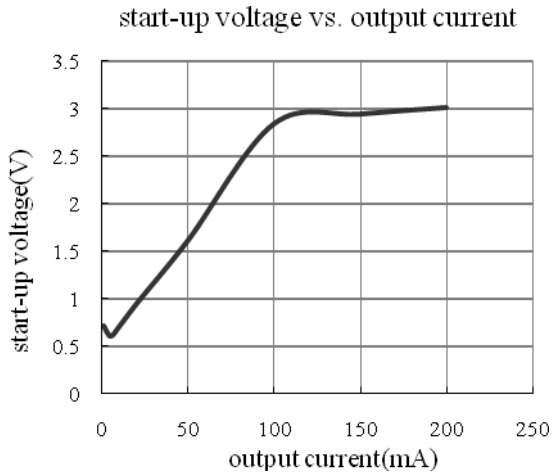
Electronic Characteristics

$V_{IN}=5V$, $T_A=25^\circ C$, $C_{IN}=47\mu F$, $C_{OUT}=100\mu F$, $L_1=47\mu H$, unless otherwise specified

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Supply Voltage						
Maximum Input Voltage	V_{IN_MAX}		0.7		V_{OUT}	V
Start-up Voltage	V_{START}	$I_{LOAD}=1mA$, V_{IN} rises from 0V to 2V			0.8	V
Hold-on Voltage	V_{HOLD}	$I_{LOAD}=1mA$, V_{IN} falls from 2V to 0V	0.6			V
Supply Current						
Current Limiting	I_{LIMIT}		600	800	1000	mA
Input Current Without Load	I_{IN0}	$V_{IN}=1.8V$, $V_{OUT}=3.3V$		15		μA
Standby Input Current	I_{INQ}	Without Load, EN="Low"			1	μA
Output Voltage						
Output Voltage Accuracy	ΔV_{OUT}		-2.5		2.5	%
Enable Input On EN Pin						
"High" Voltage Level On EN Pin			$0.4*V_{OUT}$			V
"Low" Voltage Level On EN Pin					0.2	V
"High" EN input current					0.1	μA
"Low" EN input current			-0.1			μA
Oscillation Characteristics						
Maximum Oscillation Frequency	F_{MAX}			300		KHz
Maximum Duty Cycle	D_{OSC}			83		%

Typical Electrical Curves

$V_{IN}=5V$, $T_A=25^\circ C$, $V_{OUT}=3.3V$, $C_{IN}=47\mu F$, $C_{OUT}=100\mu F$, $L_1=47\mu H$, unless otherwise specified



Applications Information

Detailed Description

The QX2303 Series are step-up DC-DC converters with boost structure and PFM control mode.

The QX2303 Series need only an inductor, a schottky diode, an input capacitor and an output capacitor to provide a 2.5~5.0V low noise output voltage.

The converter has many built-in function blocks including Output Voltage Feedback And Trimming Network, Startup Circuit, Oscillator, Reference Voltage Circuit, PFM Controller, Over Current Protection and Power MOS.

The core circuit of QX2303 is the PFM Controller. This module controls the power MOS to provide the constant output voltage according to the input voltage, the load signal and the current signal. In the PFM Control system, the oscillation frequency and the pulse width are fixed, and the steady output voltage are realized by controlling the ON-time of power MOS in an oscillation cycle according to the ratio of input/output voltage and the load.

Oscillator provides reference oscillation frequency and fixed pulse width. Reference Voltage circuit provides steady reference voltage. With internal trimming technique, the output voltage accuracy can be $\pm 2.5\%$. With temperature compensation technique used in the Reference Voltage circuit, the temperature drift of the output voltage is less than $100\text{ppm}/^\circ\text{C}$. Error Amplifier with high gain ensures the steady of the output voltage under different input voltages and load currents. In order to decrease the ripple and noise of the output voltage, the Error Amplifier adopts schmitt comparator structure, which has rapid response.

The inductor and the schottky diode will sharply influence the conversion efficiency, and the capacitors and inductor will

influence ripple of output voltage, so choosing a suitable inductor, capacitor and schottky diode can acquire high conversion efficiency, low ripple and low noise. Before discussing, we define:

$$D = \frac{V_{OUT} - V_{IN}}{V_{OUT}} \quad (1)$$

Inductor Selection

The selection of inductor value needs to consider these aspects below.

First, the minimum value of inductor should make sure that the BOOST DC-DC converter works in the constant current mode(CCM):

$$L_{MIN} \geq \frac{D(1-D)^2 R_L}{2f} \quad (2)$$

This formula is derived from conversion under the CCM mode, neglecting the parasitic resistors and the forward voltage drop of the diode, and the actual value will be larger.

Secondly, the operating frequency of QX2303 series is 300 KHz, which can decrease the size of the outer inductor. Normally, a 4.7uH value of inductor can make the system work properly, but for larger load current (for example, the output current is higher than 50mA), a larger value of inductor is needed to improve the efficiency.

Under large load current, the parasitical series resistance of the inductor will influence the efficiency greatly. Assuming the parasitical resistance of the inductor is R_L , output load resistor is R_{LOAD} , the power dissipation on the inductor is as follows:

$$\Delta\eta \approx \frac{R_L}{R_{LOAD}(1-D)^2} \quad (3)$$

If the input voltage is 1.5V, the output

voltage is 3.0V, the load resistance is 20Ω (the output current is 150mA) and $R_L = 0.5\Omega$, then the efficiency decreases by 10%.

Considering all these factors, an inductor whose value is 47μH and R_L is less than 0.5 Ω is proposed.

Output Capacitor Selection

Neglecting the ESR of the output capacitor, the ripple of the output voltage is:

$$r = \frac{\Delta V_{OUT}}{V_{OUT}} = \frac{D}{R_{LOAD} * C_{OUT}} \quad (4)$$

In order to decrease the ripple of the output voltage, a large value of output capacitor is required, but too large capacitance will slow down the system response time and increase the cost of the system. A 22μF low ESR tantalum capacitor is recommended.

Diode Selection

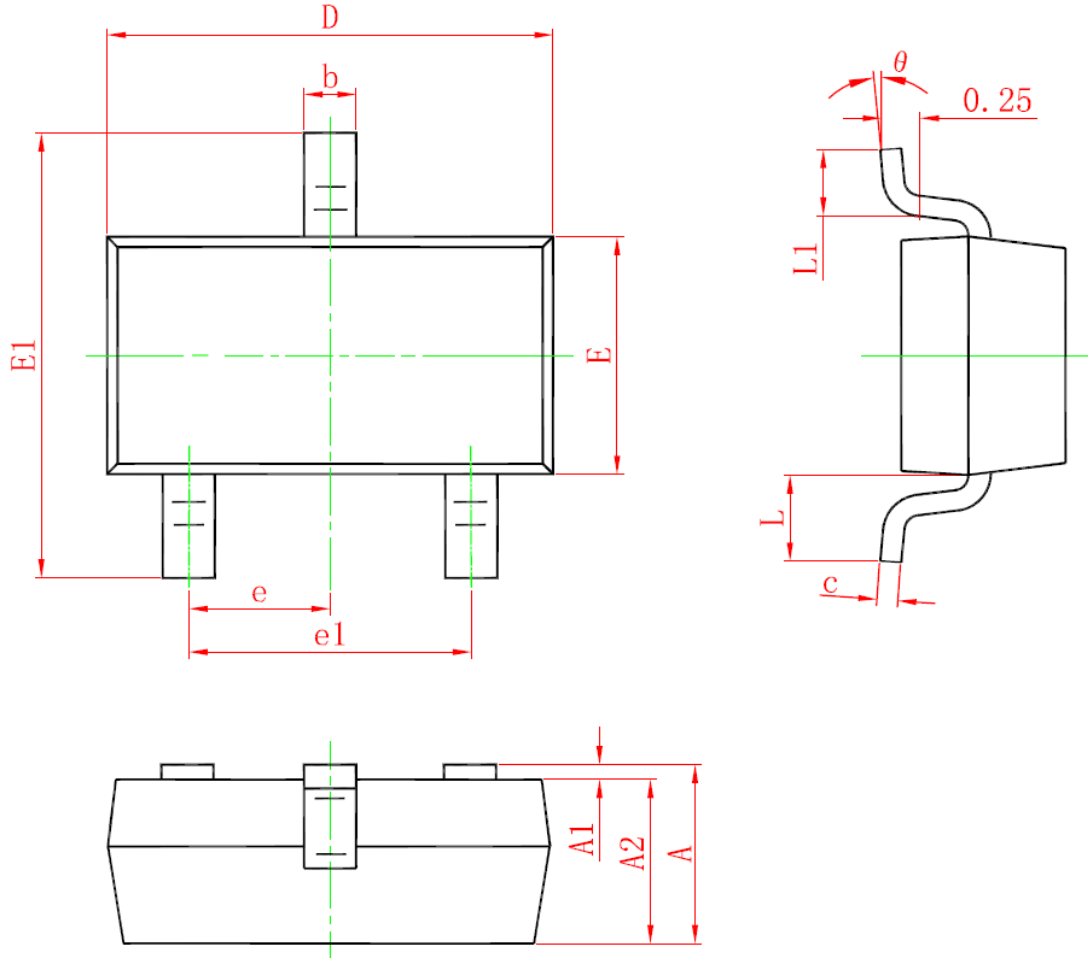
The freewheeling diode will influence the efficiency of DC-DC converter greatly. Though common diodes can also make the DC-DC system work normally, the efficiency will decrease by 5% to 10%. So a schottky diode which has lower forward voltage drop and faster response time is proposed, for example, 1N5817, 1N5819, 1N5822 and so on

Input Capacitor Selection

If the input voltage is steady, there is no need to connect input filter capacitor, however, if the input voltage source is far from the DC-DC system, a 10μF filter capacitor connected to the DC-DC input terminal is recommended to decrease the noise.

Package Information

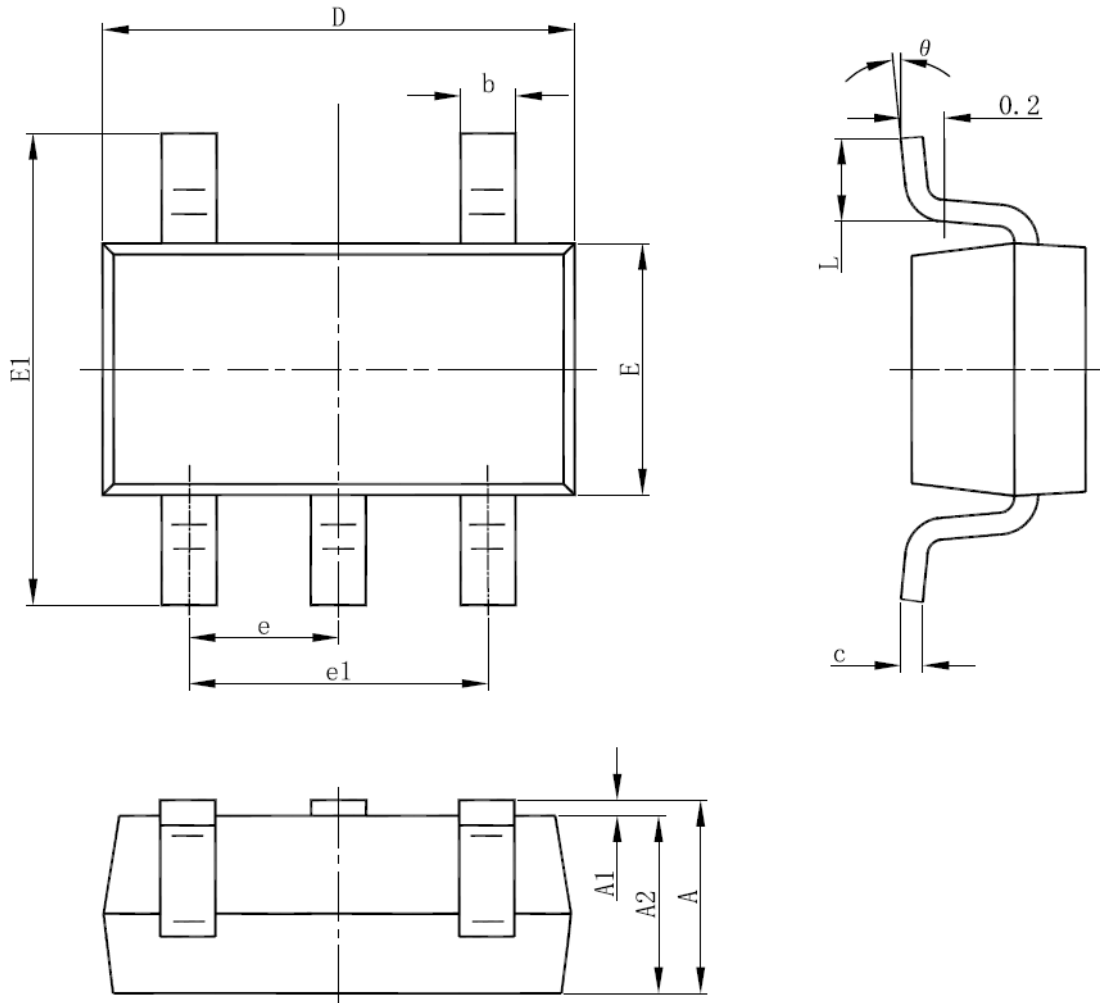
Physical Dimensions for SOT23 Package:



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.900	1.150	0.035	0.045
A1	0.000	0.100	0.000	0.004
A2	0.900	1.050	0.035	0.041
b	0.300	0.500	0.012	0.020
c	0.080	0.150	0.003	0.006
D	2.800	3.000	0.110	0.118
E	1.200	1.400	0.047	0.055
E1	2.250	2.550	0.089	0.100
e	0.950 TYP.		0.037 TYP.	
e1	1.800	2.000	0.071	0.079
L	0.550 REF.		0.022 REF.	
L1	0.300	0.500	0.012	0.020
θ	0°	8°	0°	8°

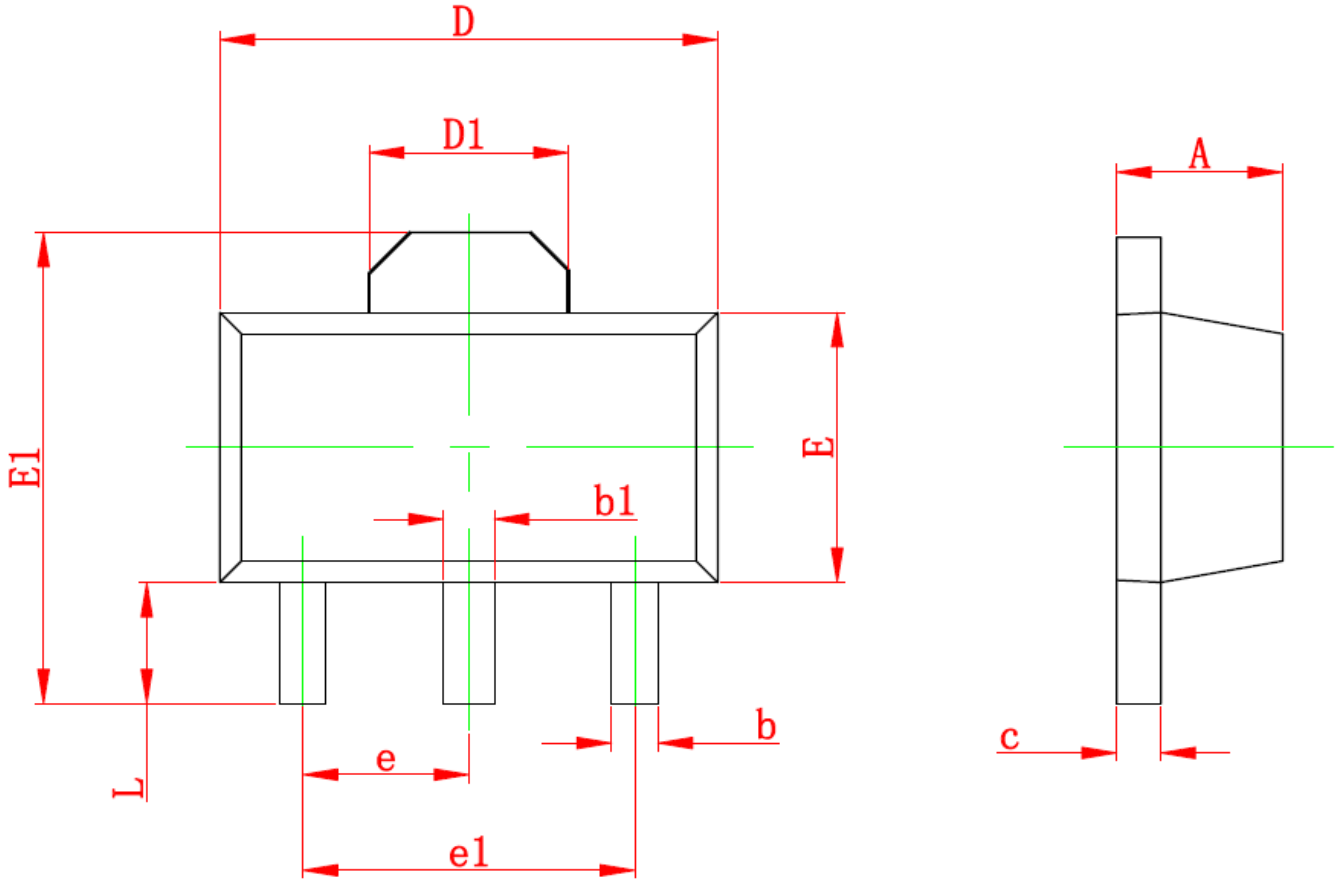


Physical Dimensions for SOT23-5 Package:



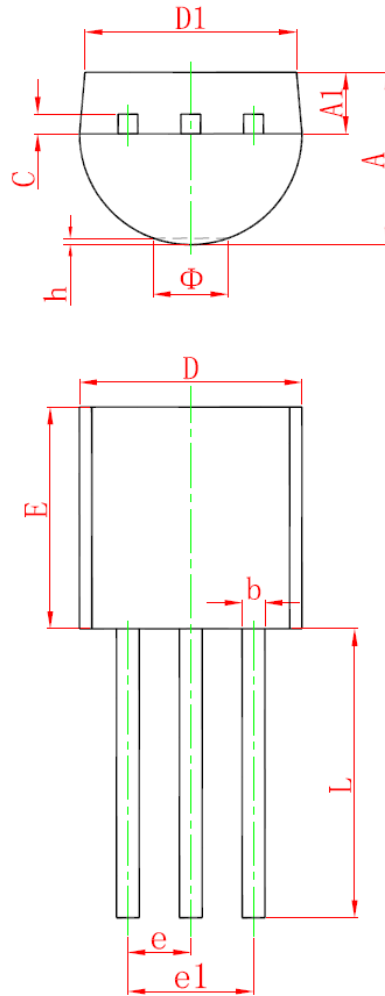
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

Physical Dimensions for SOT89-3 Package:



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.400	1.600	0.055	0.063
b	0.320	0.520	0.013	0.020
b1	0.400	0.580	0.016	0.023
c	0.350	0.440	0.014	0.017
D	4.400	4.600	0.173	0.181
D1	1.550 REF.		0.061 REF.	
E	2.300	2.600	0.091	0.102
E1	3.940	4.250	0.155	0.167
e	1.500 TYP.		0.060 TYP.	
e1	3.000 TYP.		0.118 TYP.	
L	0.900	1.200	0.035	0.047

Physical Dimensions for TO-92 Package:



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	3.300	3.700	0.130	0.146
A1	1.100	1.400	0.043	0.055
b	0.380	0.550	0.015	0.022
c	0.360	0.510	0.014	0.020
D	4.300	4.700	0.169	0.185
D1	3.430		0.135	
E	4.300	4.700	0.169	0.185
e	1.270 TYP.		0.050 TYP.	
e1	2.440	2.640	0.096	0.104
L	14.100	14.500	0.555	0.571
Φ		1.600		0.063
h	0.000	0.380	0.000	0.015

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