



DESCRIPTION

A7531 is CMOS-based PFM step-up DC-DC converter with low supply current and high output voltage accuracy. Quiescent current drawn from power source is as low as 6uA. It is capable of delivering 500mA output current at 4.0V output with 2V input voltage. Only four external components are necessary: An inductor, a Schottky diode, an output filter capacitor and a NMOSFET or a NPN transistor.

These entire features make A7531 be suitable for the portable devices, which are supplied by a single battery to four-cell batteries.

A7531 has a drive pin (EXT) for external transistor. So it is possible to load a large output current with a power transistor which has a low saturation voltage.

A7531 integrates stable reference circuits and trimming technology, so it can afford high precision and low temperature-drift coefficient of the output voltage.

A7531 can be switch on or off easily by CE pin, to minimize the standby supply current in SOT-25 package.

A7531 is available in SOT-23 and SOT-25 packages.

ORDERING INFORMATION

Package Type	Part Number	
SOT-23	E3	A7531E3R-XXY
		A7531E3VR-XXY
SOT-25	E5	A7531E5R-XXY
		A7531E5VR-XXY
Note	XX: Output Voltage 2.5=2.5V, 3.3=3.3V... Y: Function Type 1: W/O Enable Circuit 2: With Enable Circuit V: Green Package R: Tape & Reel	
AiT provides all Pb free products Suffix " V " means Green Package		

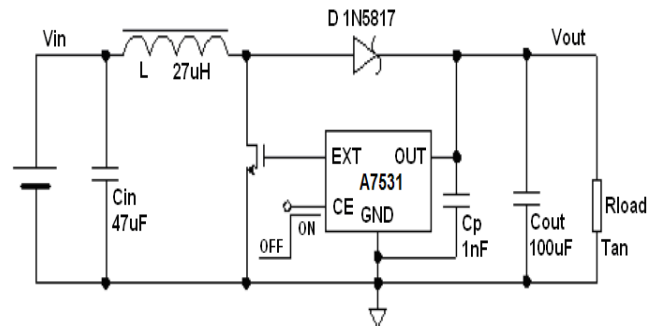
FEATURES

- Deliver 500mA at 4.0V Output Voltage with 2V Input Voltage
- The Converter Output Voltage Can Be Adjusted From 2.5V~6.0V (in 0.1V step)
- Output Voltage Accuracy:±2%
- Low Temperature-Drift Coefficient of the Output Voltage: ±100ppm/°C
- Only Four External Components are needed: an Inductor, a Schottky Diode and an Output Filter Capacitor and NMOSFET or a NPN Transistor
- High Power Conversion Efficiency: 90%
- Low Quiescent Current Drawn from Power Source: <6uA
- Available in SOT-23 and SOT-25 package

APPLICATION

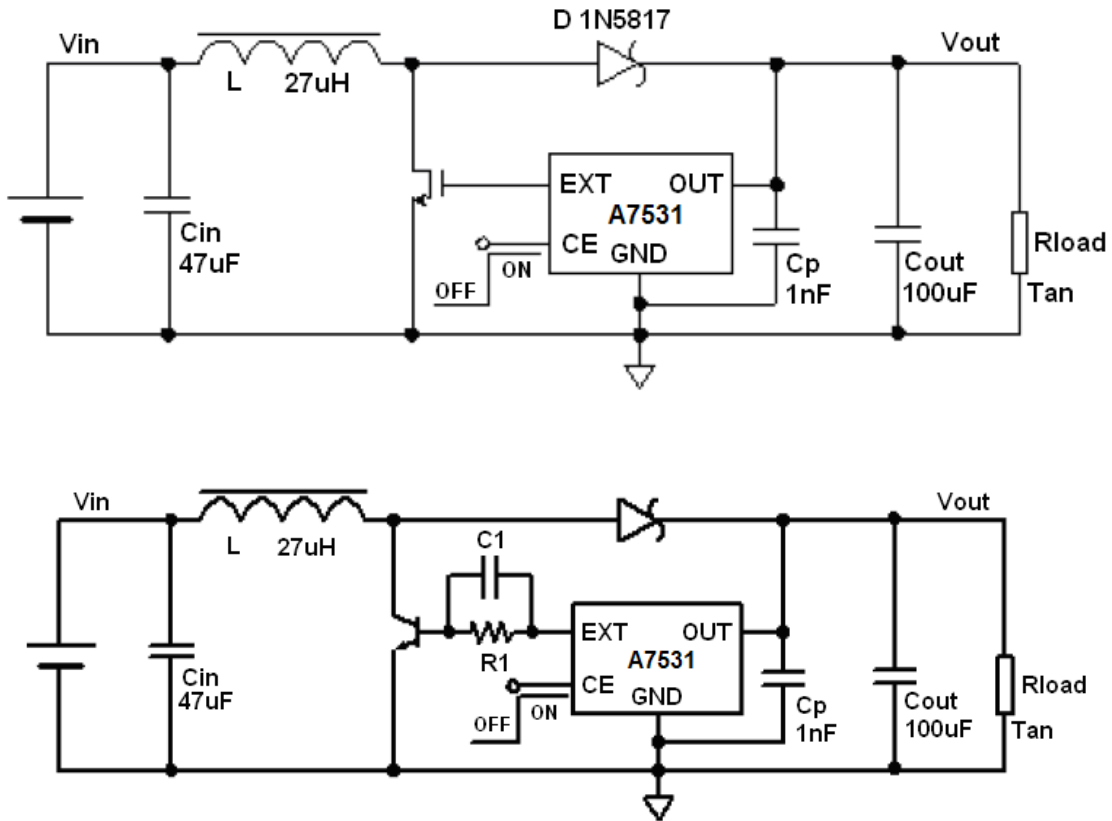
- Portable Source for PDA, DSC, MP3 Player, Electronic Toy and Wireless Mouse
- Power Source for a Single or Dual-Cell Battery-Powered Equipments
- Power Source for LED

Typical Application





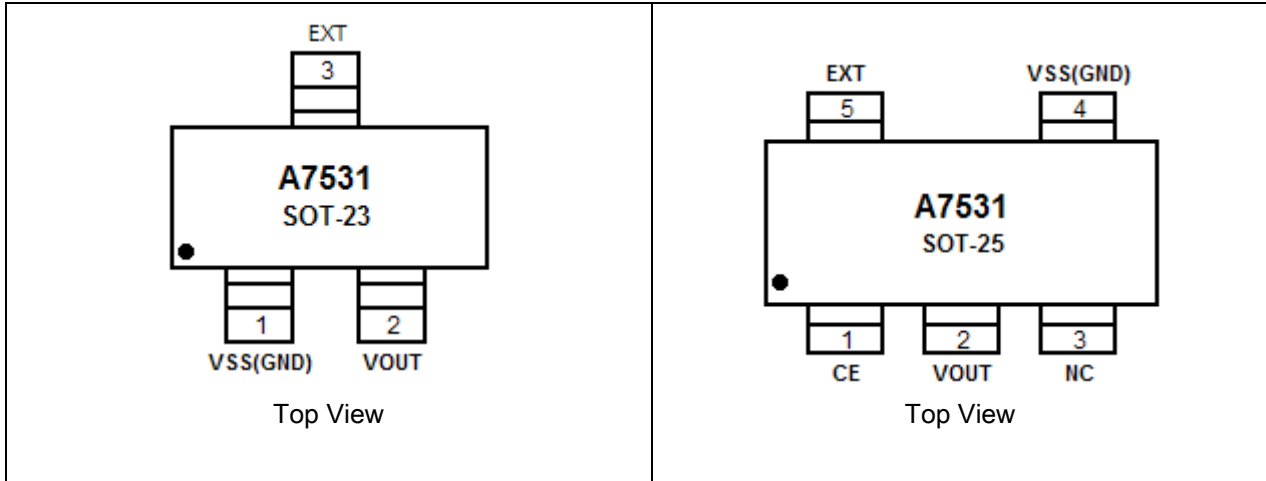
TYPICAL APPLICATION



Note: $R_1=330\Omega$, $C_1=10nF$. (R_1 can be calculated by load. If load is light R_1 's value can be added. If load is heavy R_1 's value can be smaller.)



PIN DESCRIPTION



Pin#		Symbol	Function
SOT-23	SOT-25		
1	4	Vss (GND)	Ground Pin
2	2	V _{OUT}	Output Pin, Power Supply for Internal Circuits
3	5	Ext	Switching Pin
	3	NC	-
	1	CE	Chip Enable Pin (Active high)

FUNCTION TYPE

Type (Y)	Function
1	External Tr. Driver, W/O Enable Circuit
2	External Tr. Driver, W/Enable Circuit



ABSOLUTE MAXIMUM RATINGS

Input Voltage Range	0.3V~+6V
Input Voltage: V _{EXT}	0.3V ~ (V _{out} +0.3V)
CE Pin Voltage	0.3V ~ (V _{out} +0.3V)
LX Pin Output Current	0.7A
Maximum Power Dissipation, T=25°C	
SOT-23	0.25W
SOT-25	0.15W
Maximum Junction Temperature	+150°C
Operating Free-air Temperature	-20 °C ~+80 °C
Storage Temperature Range	-40°C ~ +125°C
Lead Temperature (Soldering, 10s)	260°C ,10s

Stresses above may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the Electrical Characteristics is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED OPERATION CONDITIONS

Parameter	Min.	NOM	Max.	Unit
Input voltage range	0.8		V _{out}	V
Inductor	10	27	100	uH
Input Capacitor	0	≥10		uF
Output Capacitor	47	100	220	uF
V _{out} Pin Filter Capacitor		1		nF
Operating Junction Temperature	-20		85	°C

Suggestion: Use tantalum type capacitor to reduce the ripple of the output voltage. Use 1nF filter ceramic type capacitor to connect V_{OUT} pin and GND pin. The filter capacitor is recommended as close as possible to V_{OUT} pin and GND pin.



ELECTRICAL CHARACTERISTICS

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V _{OUT}	Output Voltage		2.450	2.5	2.55	V
			2.646	2.7	2.754	
			2.94	3.0	3.06	
			3.234	3.3	3.366	
			3.528	3.6	3.672	
			3.920	4.0	4.080	
			4.900	5.0	5.100	
			5.880	6.0	6.120	
V _{IN}	Input Voltage				12	V
I _{IN}	Input Current(no load)	I _{OUT} =0mA, V _{IN} = V _{OUT} x 0.6		20	25	uA
I _{DD}	Quiescent Current	No external components, V _{OUT} = V _{OUT} x 1.05		6	8	uA
I _{STANDBY}	Chip Leakage Current	V _{CE} =0V			1	uA
V _{CEH}	CE "H" threshold voltage	V _{CE} : 0→2V	0.6	0.9	7	uA
V _{CEL}	CE "L" threshold voltage	V _{CE} : 2→0V		0.3	0.6	V
F _{OSC}	Oscillator Frequency	V _{OUT} = V _{OUT} x 0.96 Test EXT pin frequency	300	350	400	kHz
I _{CEH}	CE "H"	V _{OUT} = V _{CE} =6V	-0.5	0	0.5	uA
I _{CEL}	CE "L"	V _{OUT} = V _{CE} =6V	-0.5	0	0.5	uA
I _{EXTH}	EXT "H" output current	3.0V ≤ V _{OUT} ≤ 3.9V		-21		mA
		4.0V ≤ V _{OUT} ≤ 4.9V		-35		
		5.0V ≤ V _{OUT} ≤ 6.9V		-41		
I _{EXTL}	EXT "L" output current	3.0V ≤ V _{OUT} ≤ 3.9V		23		mA
		4.0V ≤ V _{OUT} ≤ 4.9V		24		
		5.0V ≤ V _{OUT} ≤ 6.9V		31		
Duty	Oscillator duty	On (V _{Ix} "L") side	70	75	80	%
η	Efficiency			90		%

Note:

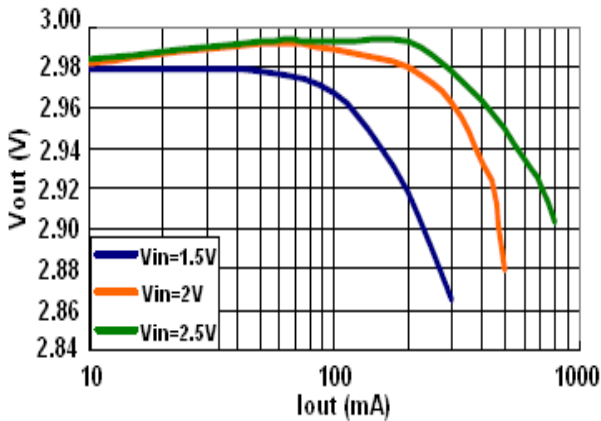
1. Diode: Schottky type, such as: 1N5817, 1N5819, 1N5822
2. Inductor: 27uH(R<0.5Ω)
3. Output capacitor: 100uF (tantalum type)
4. V_{OUT} V_{OUT} pin filter capacitor: 1nF (Ceramic type)
5. Input capacitor: 47uF



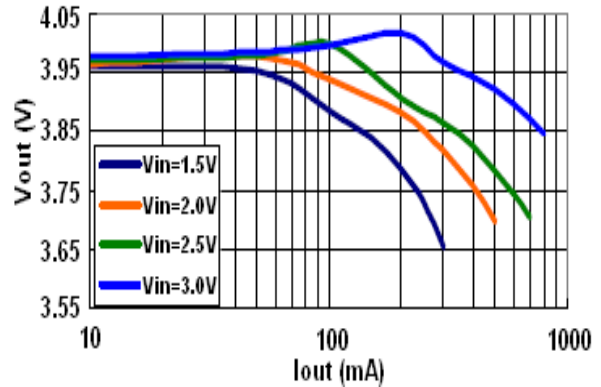
TYPICAL PERFORMANCE CHARACTERISTICS

$C_{IN}=47\mu F$, $C_{OUT}=100\mu F$, $L=10\mu H$, $T_{opt}=25^{\circ}C$, otherwise specified.

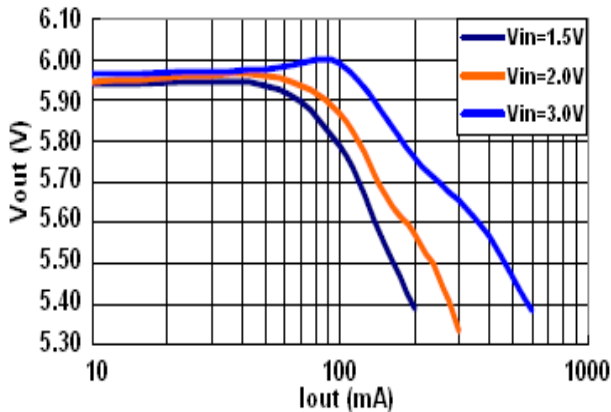
1. Output Voltage vs. Output Current
A7531E5-302



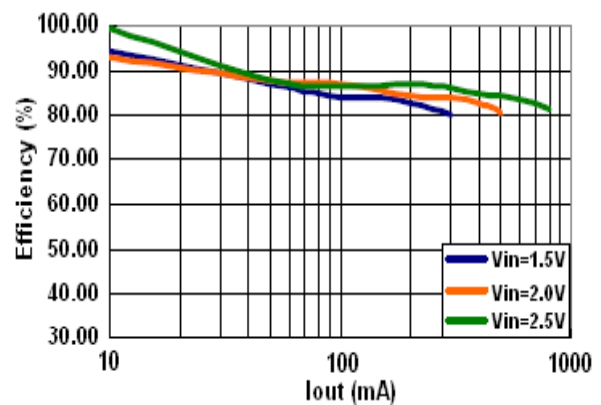
2. Output Voltage vs. Output Current
A7531E5-402



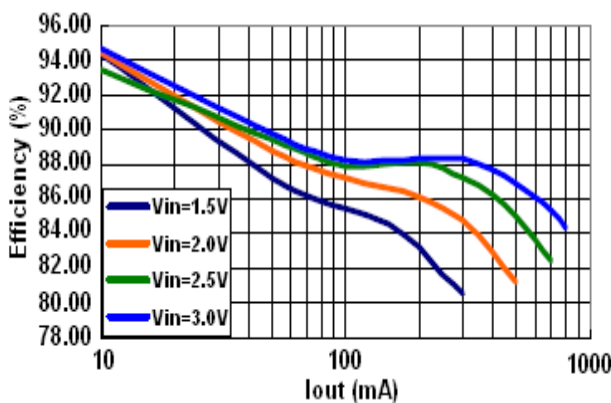
3. Output Voltage vs. Output Current
A7531E5-602



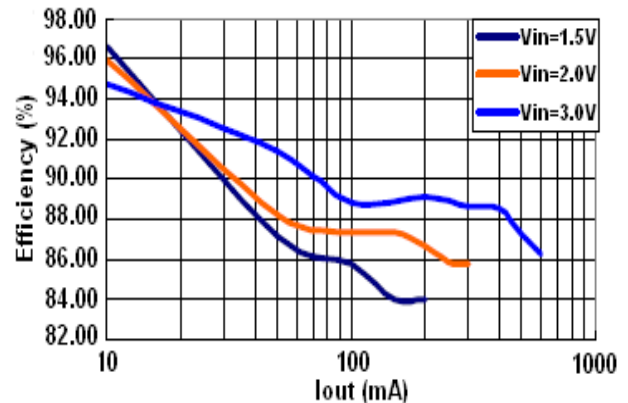
4. Efficiency vs. Output Current
A7531E5-302



5. Efficiency vs. Output Current
A7531E5-402

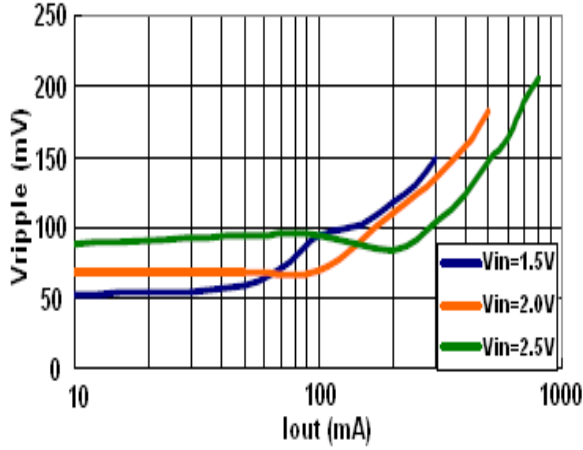


6. Efficiency vs. Output Current
A7531E5-602

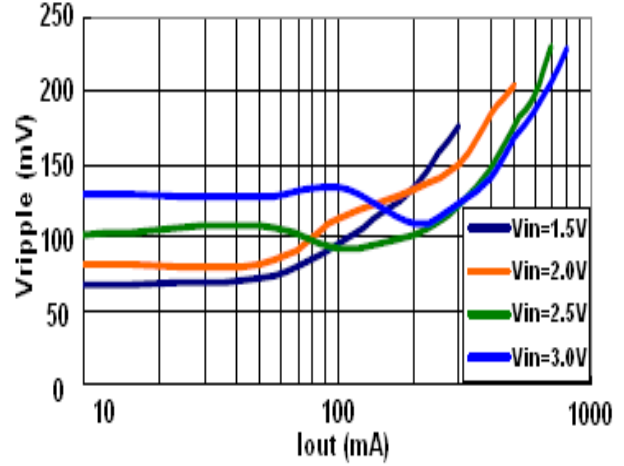




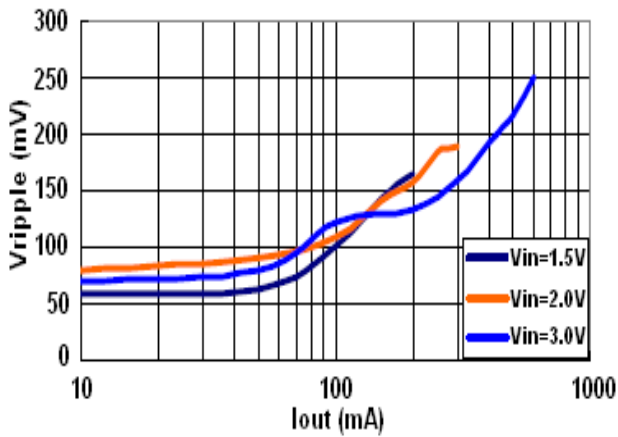
7. Ripple vs. Output Current
A7531E5-302



8. Ripple vs. Output Current
A7531E5-402

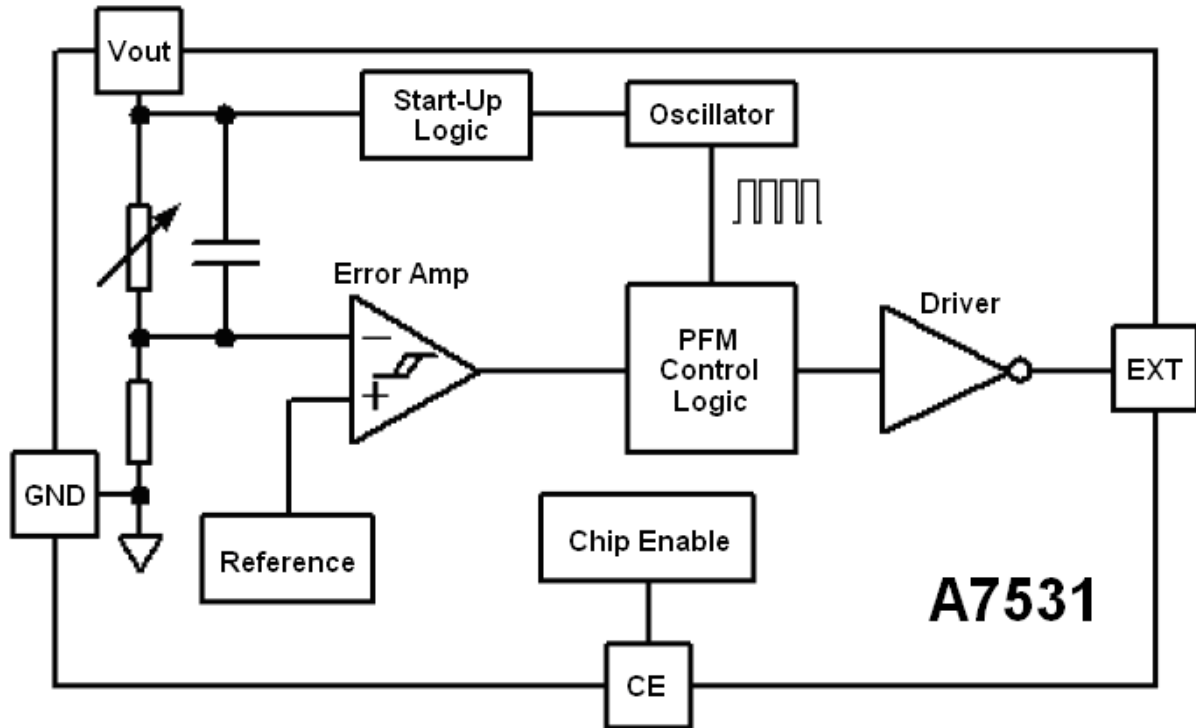


9. Ripple vs. Output Current
A7531E5-602





BLOCK DIAGRAM





DETAILED INFORMATION

The A7531 is boost structure, voltage-type pulse-frequency modulation (PFM) step-up DC-DC converter. Only four external components are necessary: an inductor, a schottky diode, and output filter capacitor and a NMOSFET or a NPN transistor. The step-up DC-DC converter, constructed by A7531, can be adjusted from 2.5V to 6.0V, 0.1V step. By using the depletion technique, the quiescent current drawn from power source is lower than 8uA. The high efficiency device consists of resistors for output voltage detection and trimming, a start-up voltage circuit, an oscillator, a reference circuit, a PFM control circuit, a switch protection circuit and a driver transistor.

A7531 integrates PFM control system. This system controls fixed power switch on duty cycle frequency to stabilize output voltage by calculating results of other blocks which sense input voltage, output voltage, output current and load conditions. In PFM modulation system, the frequency and pulse width is fixed. The duty cycle is adjusted by skipping pulses, so that switch on-time is changed based on the conditions such as input voltage, output current and load. The oscillate block inside A7531 provides fixed frequency and pulse width wave.

The reference circuit provides stable reference voltage to output stable output voltage. Because internal trimming technology is used, the chip output changes less than $\pm 2\%$. At the same time, the problem of temperature-drift coefficient of output voltage is considered in design, so temperature-drift coefficient of output voltage is less than 100ppm/ $^{\circ}\text{C}$.

High-gain differential error amplifier guarantees stable output voltage at difference input voltage and load. In order to reduce ripple and noise, the error amplifier is designed with high band-width.

A7531 has a drive pin (EXT) for external transistor. So it is possible to load a large output current with a power transistor and a low saturation voltage. At very light load condition, the switch current and quiescent current of chip will effect efficiency certainly. So in very light load condition, the efficiency will drop. Therefore, it is recommended that user use A7531 in the condition of load current as large as several tens of mA to several hundreds of mA.

Selection of the External components

Thus it can be seen, the inductor, schottky diode and external NMOSFET or NPN transistor affect the conversion efficiency greatly. The inductor and the capacitor also have great influence on the output voltage ripple of the converter. So it is necessary to choose a suitable inductor, a capacitor, an external NMOSFET or NPN transistor and a right schottky diode, to obtain high efficiency and low ripple.

Before discussion, we define $D \equiv (V_{\text{OUT}} - V_{\text{IN}}) / V_{\text{OUT}}$



1. Inductor selection

Above all, we should define the minimum value of the inductor that can ensure the boost DC-DC to operate in the continuous current-mode condition.

$$L_{min} \geq [D(1-D)^2 R_L] / 2f$$

The above expression is go under conditions of continuous current mode, neglect schottky diode's voltage, ESR of both inductor and capacitor. The actual value is greater that it. If inductor's value is less than L_{min} , the efficiency of DC-DC converter will drop greatly, and the DC-DC circuit will not be stable.

Secondly, consider the ripple of the output voltage,

$$\Delta I = D \cdot V_{IN} / Lf$$

$$I_{max} = V_{IN} / (1-D)^2 R_L + DV_{IN} / 2Lf$$

If inductor value is too small, the current ripple through it will be great. Then the current through diode and power switch will be great. Because the power switch on chip is not ideal switch, the energy of switch will improve. The efficiency will fall.

Thirdly, in general, smaller inductor values supply more output current while larger values start up with lower input voltage and acquire high efficiency.

An inductor value of 3uH to 1mH works well in most applications. If DC-DC converter delivers large output current (for example: output current is great than 50mA), large inductor value is recommended in order to improve efficiency. If DC-DC must output very large current at low input supply voltage, small inductor value is recommended.

The ESR of inductor effects efficiency greatly. Suppose ESR value of inductor is r_L , R_{load} is load resistor, then the energy can be calculated by following expression:

$$\Delta \eta \approx r_L / R_{load} (1 - D)^2$$

For example: input 1.5V, output is 3.0V, $R_{load}=20\Omega$, $r_L=0.5\Omega$. The energy loss is 10%. Consider all above, inductor value of 47uH, $ESR<0.5$ is recommended I n most applications. Large value is recommended in high efficiency applications and small value is recommended.



2. Output capacitor selection

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

$$R = \Delta V_{OUT} / V_{OUT} = D / R_{load} C_f$$

So large value capacitor is needed to reduce ripple. But too large capacitor value will slow down system reaction and cost will improve. So 100uF capacitor is recommended. Larger capacitor value will be used in large output current system. If output current is small (<10mA), small value is needed.

Consider ESR of capacitor, ripple will increase:

$$r' = r + (I_{max} \cdot R_{ESR}) / V_{OUT}$$

When current is large, ripple caused by ESR will be main factor. It may be greater than 100mV. The ESR will affect efficiency and increase energy loss. So low-ESR capacitor (for example: tantalum capacitor) is recommended or connect two or more filter capacitors in parallel.

3. Diode selection

Rectifier diode will affect efficiency greatly, though a common diode (such as 1N4148) will work well for light load, it will reduce about 5%~10% efficiency for heavy load. For optimum performance, a schottky diode (such as 1N5817, 1N5819, 1N5822) is recommended.

4. Input capacitor

If supply voltage is stable, the DC-DC circuit can output low ripple, low noise and stable voltage without input capacitor. If voltage source is far away from DC-DC circuit, input capacitor value greater than 10uF is recommended.

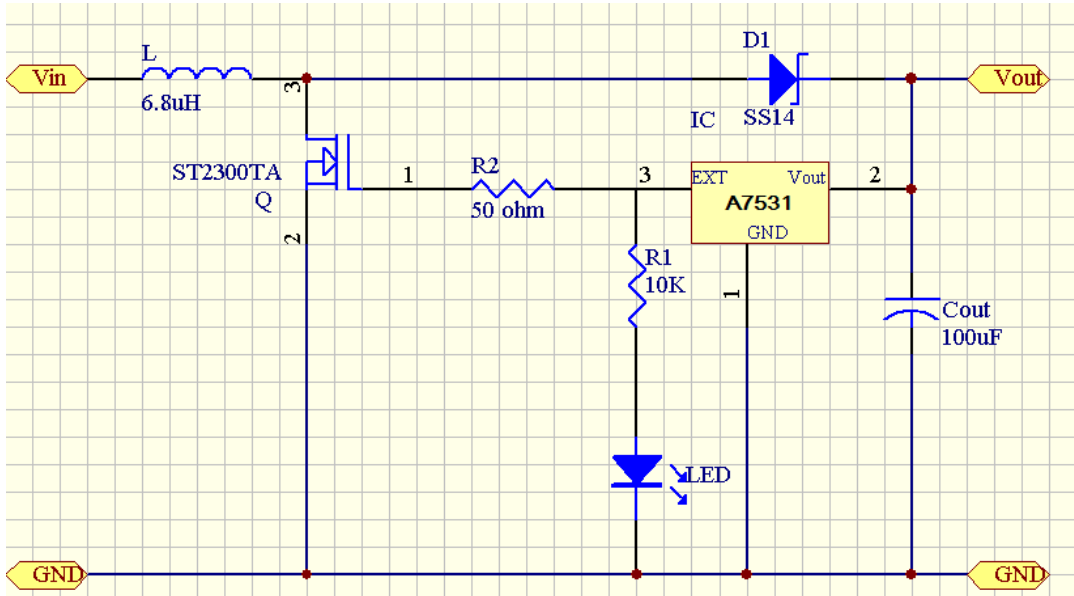
5. V_{OUT} ~GND filter capacitor

Because the chip's switch current flows from V_{OUT} pin, then through the chip into GND pin. Therefore if the output capacitor's two pins were not very near the chip's V_{OUT} pin and GND pin, V_{OUT} 's stable would be affected. User will find that the output voltage will drop when load grows up if the output capacitor's two pins are not very near the chip's V_{OUT} pin and GND pin. In this condition, 1nF ceramic capacitor is recommended at very near the chip's V_{OUT} pin and GND pin. So in all A7531 application, two capacitors are needed to obtain stable output voltage. The 100uF tantalum output capacitor is recommended to stable output voltage nearby load. The 1nF V_{OUT} pin to GND pin ceramic filter capacitor is recommended to stable chip's sense voltage.

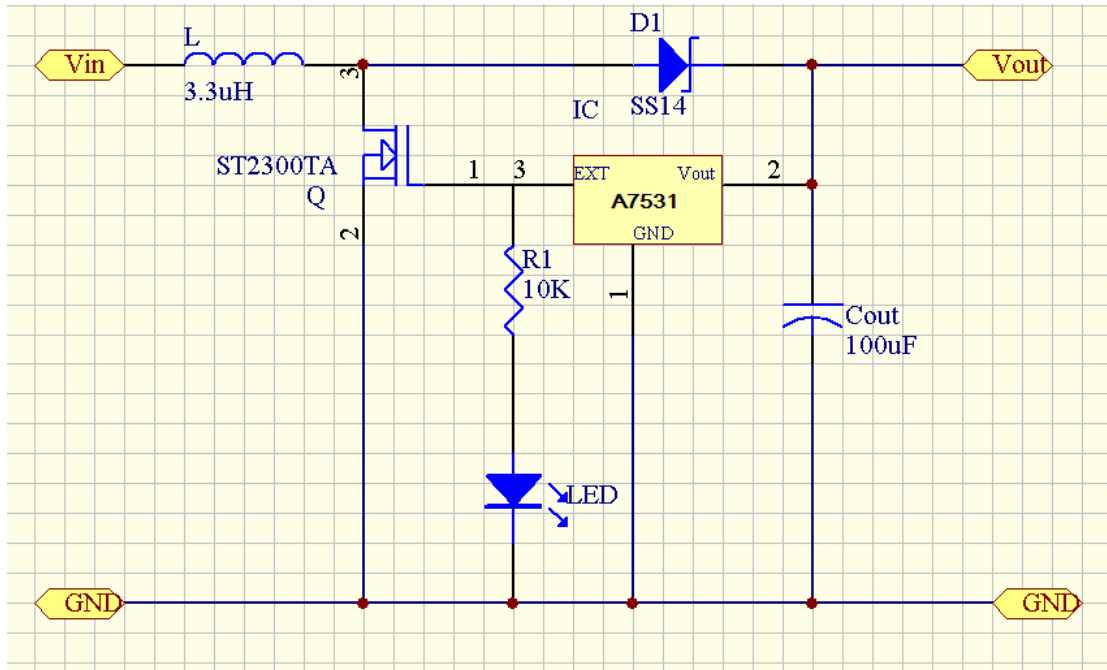


6. External Switch Application Example

Start-Up Voltage = 1.1V

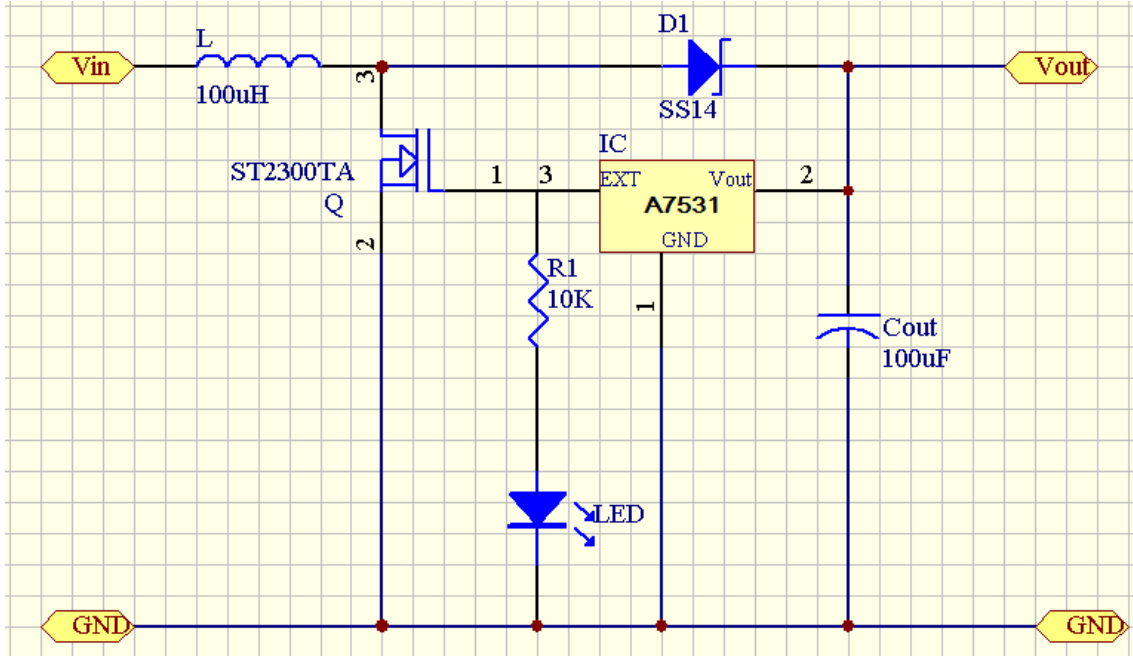


Start-Up Voltage=1.2V

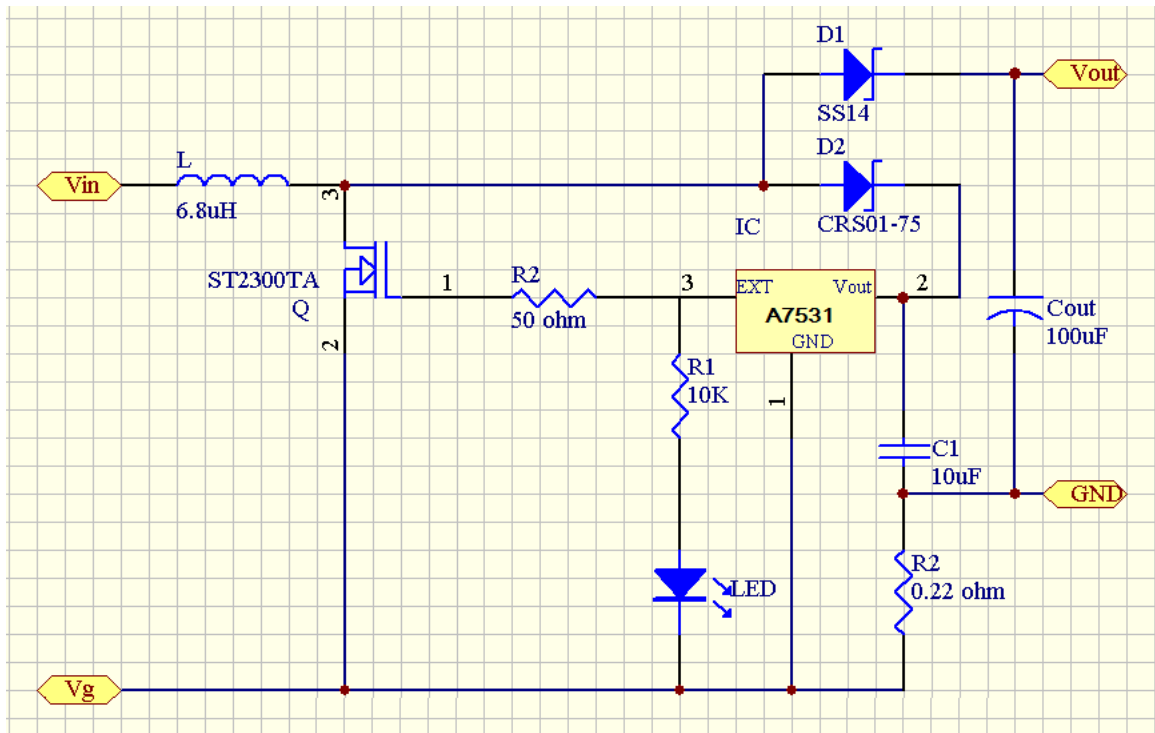




Start-Up Voltage = 3V, Current = 700mA



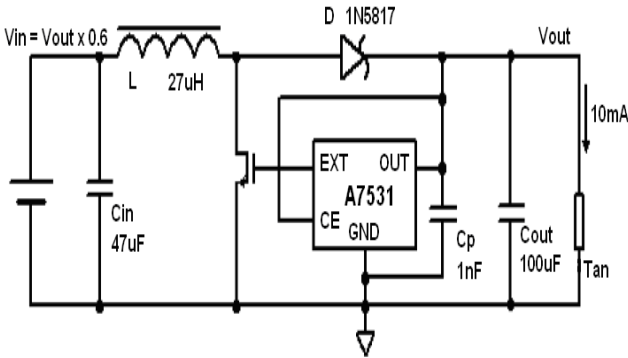
Start-Up Voltage = 3V, Current = 500mA



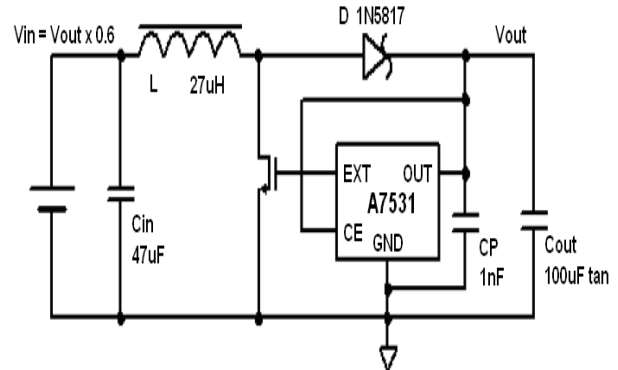


Test Circuits

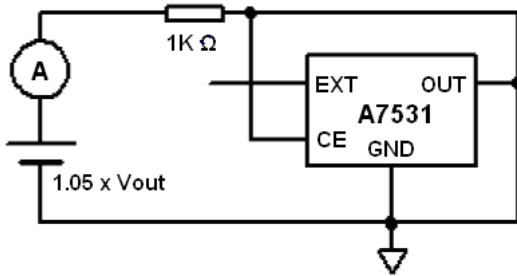
1. Output voltage test circuit



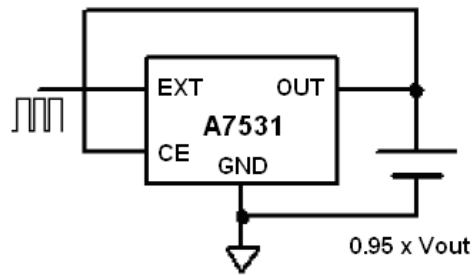
2. Input current (no load) test circuit



3. Quiescent current test circuit

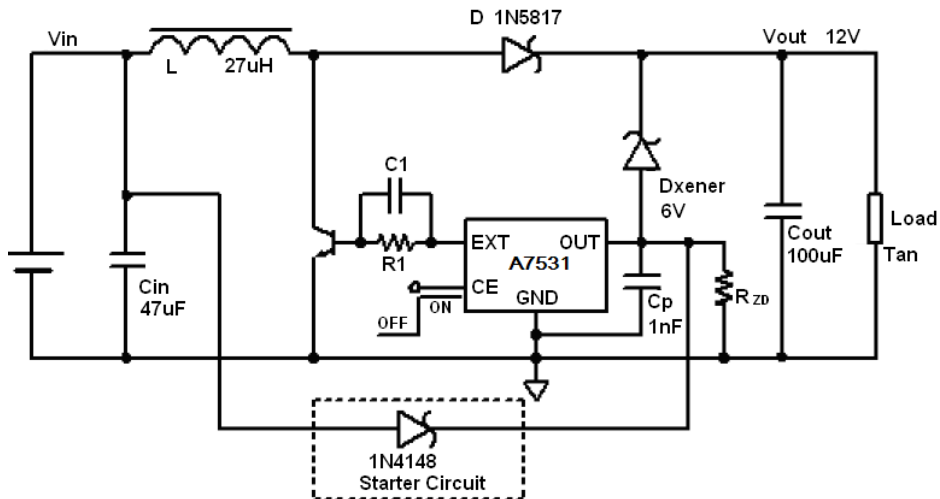


4. Oscillator frequency and duty cycle test circuit



Extend Application

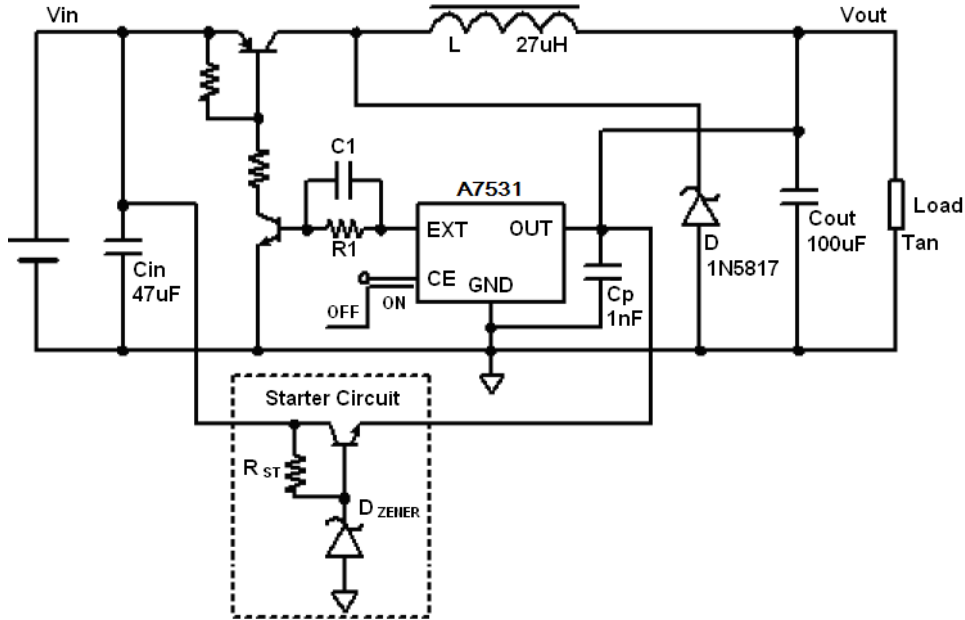
1. 12V step-up application



Note: A7531's output voltage is 6V. When the output current is small or no load, the output voltage will be unstable, use the R_{ZD} for flowing the bias current through the zener diode. For step-up application, a diode (for example: 1N4148) is needed as starter circuit.

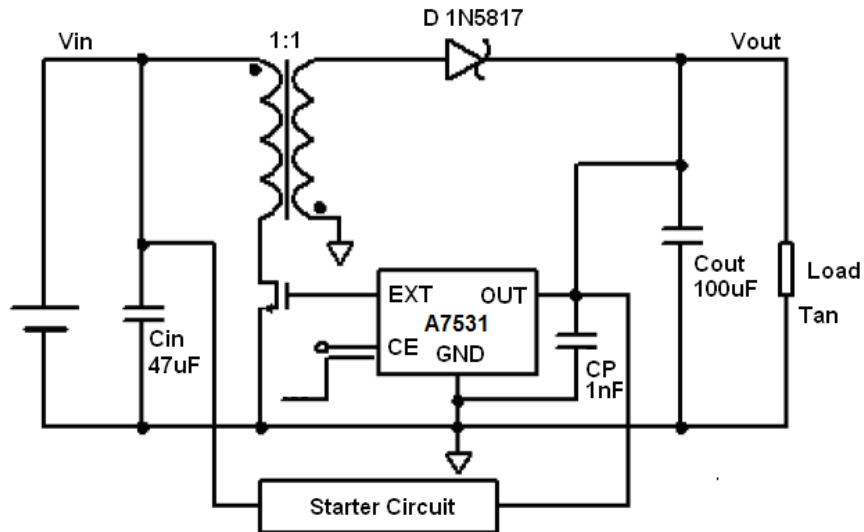


2. Step-down application



Note: In step-down application, use starter circuit as above. $2.5V \leq V_{zener} \leq V_{out}$. R_{ST} is needed for bias current of zener diode. This starter circuit also can be used in high voltage step-up application.

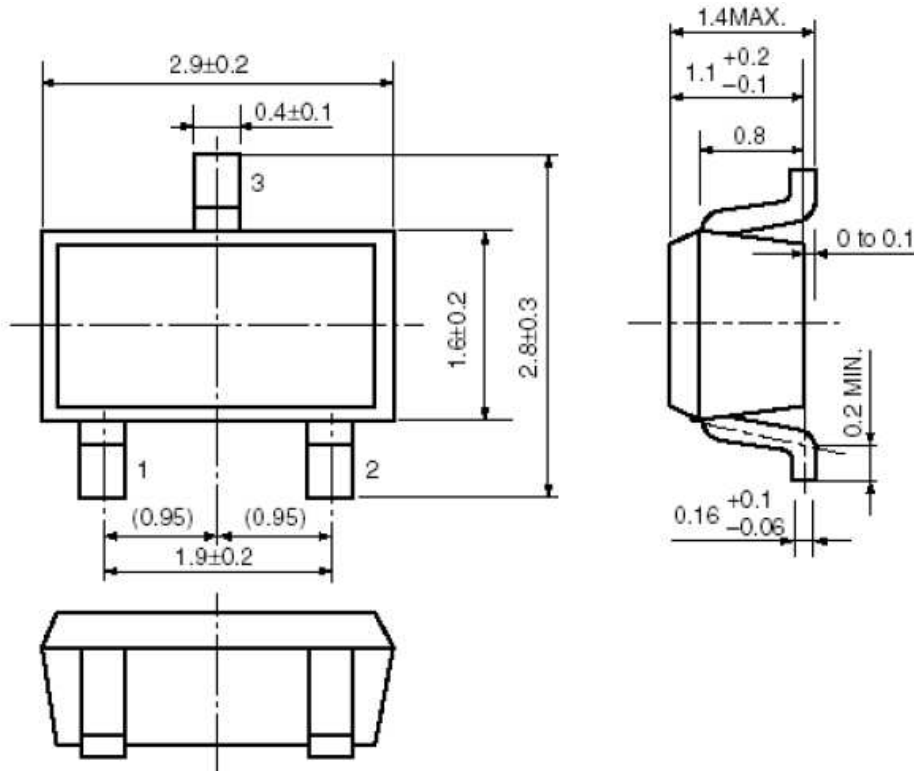
3. Fly back step-up/step-down application





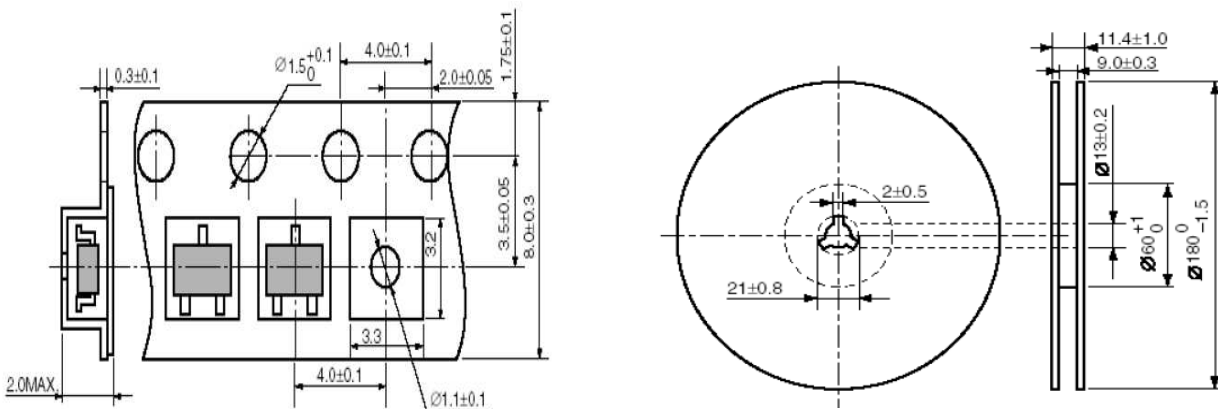
PACKAGE INFORMATION

Dimension in SOT-23 Package (Unit: mm)



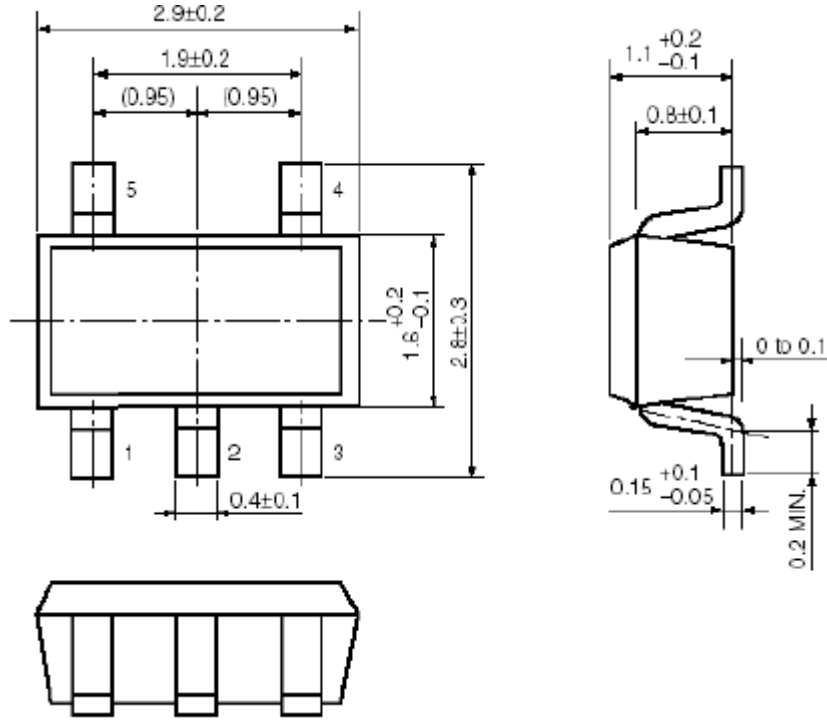
Tape Dimension

Reel Dimension

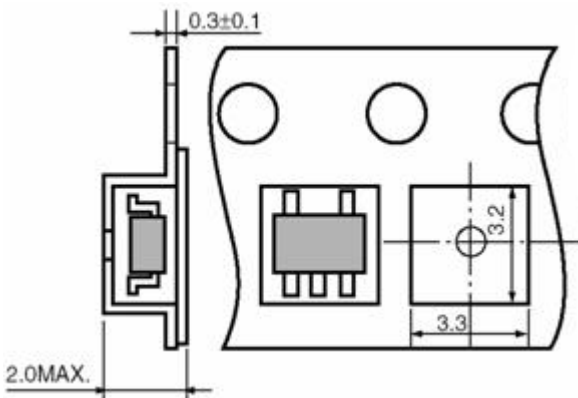




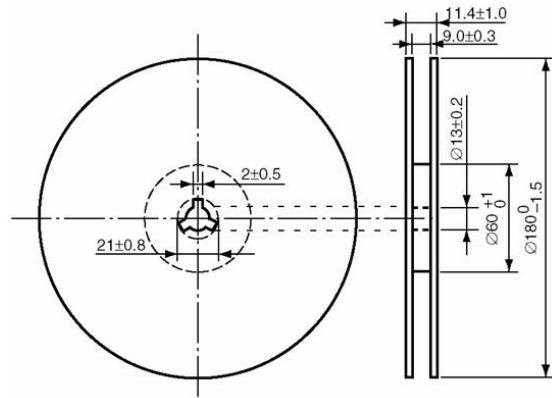
Dimension in SOT-25 Package (Unit: mm)



Tape Dimension



Reel Dimension





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