Features

- **1.0V Low Start-up Input Voltage at 1mA Load**
- **Deliver 180mA at 3.3V Output with 1.5V Input**
- **87% High Efficiency (V_{IN}=2.0V, V_{OUT}=3.3V, I_{LOAD}=60mA)**
- **± 2.5% Output Voltage Accuracy**
- **8μA Low Switch-Off Supply Current**
- **0.5μA Low Shutdown Supply Current**
- **SOT-23-5 or SOT-89 Package**
- **RoHS Compliant and 100% Lead (Pb)-Free and Green (Halogen Free with Commercial Standard)**

General Description

The EC9206 is a compact PFM step-up DC/DC converter that operates from an input voltage as low as 1.0 Volt. The low start-up input voltage makes EC9206 specially designed for portable devices from one or two cell battery, delivering up to 180mA load current at V_{IN}=1.5V V_{OUT}=3.3V. Typical efficiency for EC9206 is 85% when V_{IN}>=2.0V V_{OUT}=3.3V I_{LOAD}=1~60mA. Potential applications include low powered consumer products and battery powered portable products.

The EC9206 features a minimum off-time, current -limited, PFM control scheme which combines the advantages of PWM (higher output power and efficiency) and those of traditional PFM (ultra-low quiescent current). The internal 0.6 ohm low turn-on resistance NMOS power switch provides stable and high-efficiency operation over a board load current range. Chip enable feature is provided for SOT-23-5 package to power down the device.

The EC9206 devices are available in both SOT-89 and SOT-23-5 packages with 6 standard regulated output voltages.

Applications

- PDA
- DSC
- MP3 Player
- Electronic Games
- Camcorders
- Portable Devices
- Single-and Dual-Cell Battery Operated Products

Typical Application Circuit

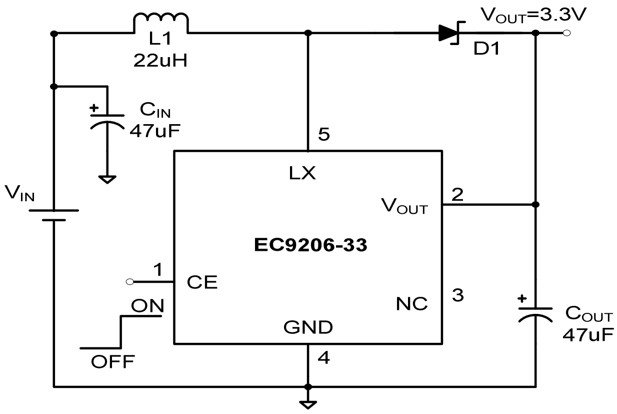
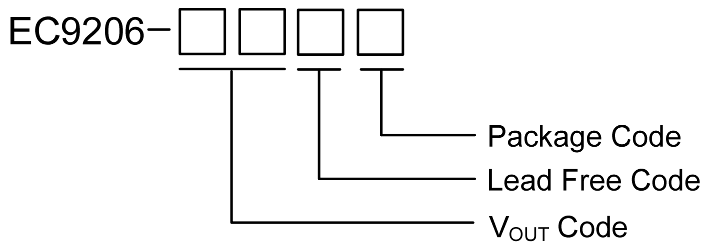


Figure 1. EC9206 Typical Application for 3.3V

Ordering Information



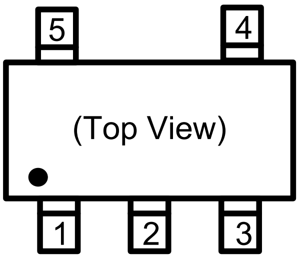
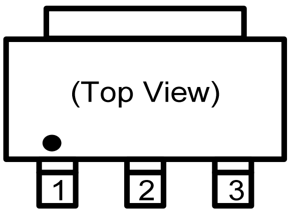
Vout Code：
33：3.3V **50**：5.0V

Lead Free Code：
F：Commercial Standard, Lead Free

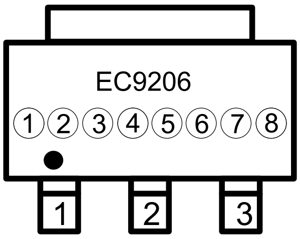
G：Green (Halogen Free with Commercial Standard)

Package Code：
B2：SOT-23-5 **B6**：SOT-89

Pin Description

Part No.	Pin		Symbol	Pin Description
	SOT-25	SOT-89		
 SOT-25  SOT-89-3	1	---	CE	Chip enable. Set CE pin to low to shutdown the device. Must be set to V_{OUT} or higher voltage to enable the device. Do not float this pin. For SOT-89 package, this pin is shorted to V_{OUT} internally.
	2	2	V_{OUT}	IC Power Supply Pin. Connect This Pin to the Regulator Output.
	3	---	NC	No Connection.
	4	1	GND	Ground Pin.
	5	3	LX	Switch Pin. Connect Inductor/Diode Here.

Package Marking Information



SOT-89
(Top View)

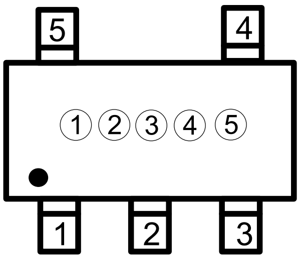
Top Point Represents Products Series

Mark	Products Series
Top Point	Part No.：EC9206

①、②、③、④ Represents Products Series

Mark		Description
①、②		Voltage Code
③	F, G	Pb-Free or Green Code
④	3	Package Code (SOT-89-3)

⑤、⑥、⑦、⑧ Represents Production Date Code



SOT-25
(Top View)

Top Point Represents Products Series

Mark	Products Series
Top Point Dot	Dot above Product Code: Lot Code (see note*1)

Middle Represents Products Series

	Mark	Description
①②	00	EC9206
③④	Voltage	Voltage Code：33、50
⑤	Dot, G	Dot for Pb-free package G for Green package

Bottom Point Represents Production Date Code

Mark	Products Series
Bottom Dot	Dot under Product Code : Year Code (see note*2)
The last Dot	Week Code： i.1-26 week : A~Z ii.27-52 week : A~Z (add underscore)

TEL : 886-3-5785888
FAX : 886-3-5783630

Note：

Lot Code：

Lot	Code				
1					•
2				•	
3				•	•
4			•		
5			•		•
6			•	•	
7			•	•	•
8		•			
9		•			•
10		•		•	
11		•		•	•
12		•	•		
13		•	•		•
14		•	•	•	
15		•	•	•	•

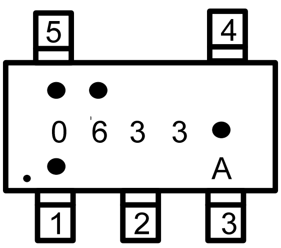
16	•				
17	•				•
18	•			•	
19	•			•	•
20	•		•		
21	•		•		•
22	•		•	•	
23	•		•	•	•
24	•	•			
25	•	•			•
26	•	•		•	
27	•	•		•	•
28	•	•	•		
29	•	•	•		•
30	•	•	•	•	
31	•	•	•	•	•

Year Code：

Year	Code		
2003			
2004			•
2005	•	•	
2006		•	•

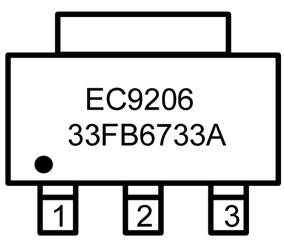
Year	Code		
2007	•		
2008	•		•
2009	•	•	
2010	•	•	•

Example：



SOT-25
(Top View)

Part No.:EC9206-33FB2
Lot Code:24
Year Code:2007
Week Code:1st week
Pb-Free Package



SOT-89
(Top View)

Part No.:EC9206-33FB6
Year Code:2007
Week Code: 33th week
Lot Code: 1st
Pb-Free Package

TEL : 886-3-5785888
FAX : 886-3-5783630

Absolute Maximum Ratings

Parameter		Symbol	Ratings	Units
Supply Voltage			-0.3~+10	V
LX Pin Switch Voltage			-0.3~V_{OUT}+0.3	V
CE Pin Voltage			-0.3~V_{OUT}+0.3	V
LX Pin Switch Current			700	mA
Junction Temperature		T_J	+150	°C
Thermal Resistance	SOT-89	$θ_{JA}$	180	°C/W
	SOT-23-5		250	
Power Dissipation	SOT-89	P_D	550	mW
	SOT-23-5		400	
Operating Ambient Temperature		T_{OPR}	-20 ~ +70	°C
Storage Temperature		T_{STG}	-55 ~ +150	°C
Lead Temperature (soldering, 10sec)			+260	°C
ESD Ratings	Human Body Model, per MIL-STD-883D-3015.7		1.5	KV
	Machine Model, MIL-STM5.2-1999		150	V

Electrical Characteristics

(V_{IN}=1.8V, V_{OUT} =3.3V, Load Current=1mA, T_A=25˚C, unless otherwise noted.)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{ST}	Start-up Voltage	I_L=1mA	---	1.0	1.2	V
V_{HOLD}	Holding Voltage	I_L=20mA	---	0.70	---	V
V_{OUT}	Output Voltage	Preset V_{OUT}=3.3V	3.218	3.3	3.383	V
		Preset V_{OUT}=5.0V	4.875	5.0	5.125	V
I_{DD1}	Switch On Current (V_{OUT})	V_{OUT}= Preset V_{OUT}*0.95	---	100	---	μA
I_{DD2}	Switch Off Current (V_{OUT})	V_{OUT}= Preset V_{OUT}*1.1	---	8	---	μA
I_{OFF}	Shutdown Current (V_{IN})	CE = 0V, V_{IN}=4.5V	---	0.5	1	μA
	CE Input Voltage Threshold		0.2	0.6	1.4	V
T_{ON}	Switch Maximum On Time	V_{OUT}=3.3V	2	4	7	μS
T_{OFF}	Switch Minimum Off Time	V_{OUT}=3.3V	0.7	1	1.3	μS
$R_{DS(ON)}$	Switch on Resistance		---	0.6	---	Ω
V_{LXLIM}	Switch Voltage Limit		---	0.425	---	V

Function Block Diagram

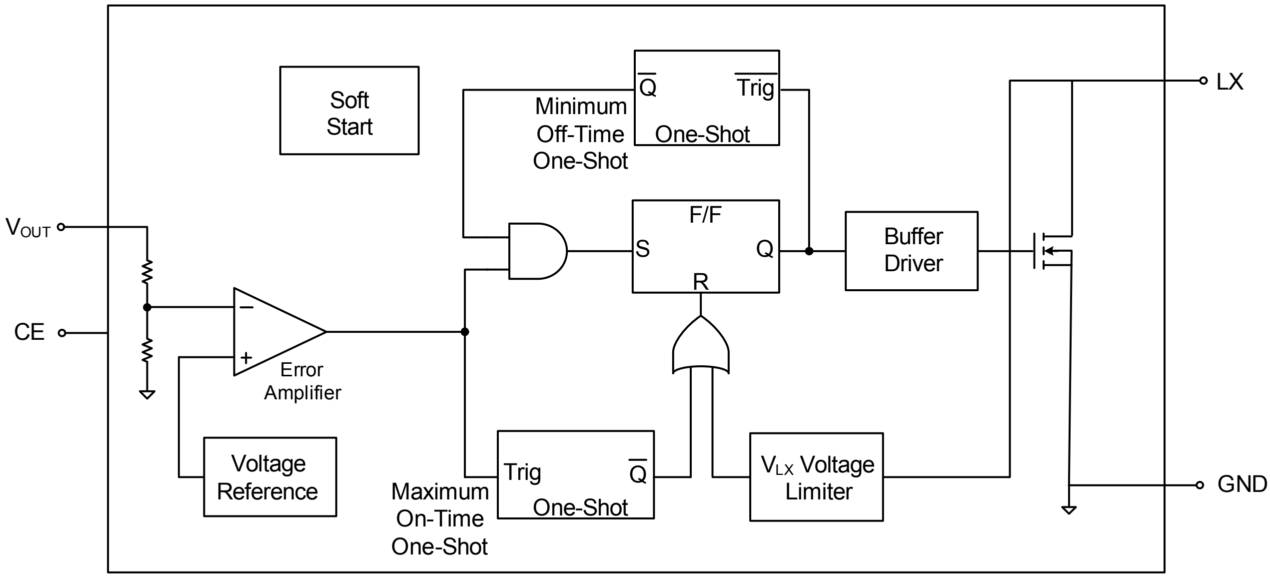


Figure 2.EC9206 Simplifed Functional Block Diagram

Detail Description

The EC9206 is a variable frequency voltage-mode step-up DC-DC converter for portable devices like DSC and PDA. The EC9206 combines a PFM step-up switching regulator, 0.7A/0.6Ω N-channel power MOSFET, precision band-gap reference, soft start, shutdown control, and a resistive divider for preset output. The switching DC-DC converter boosts a 1- to 4-cell input to a preset output between 2.5V and 6.0V. The 6 standard output voltages are 2.7V, 3.0V, 3.3V, 3.6V, 4.0V and 5V. The EC9206 starts from a low 1.0V input at 1mA load current, and remains operational down to 0.7V at 20mA load.

Step-Up Converter

The step-up DC-DC converter operation can be understood by referring to the block diagram in Figure 2. PFM comparator monitors the output voltage via the feedback resistor. When the feedback voltage is higher than the reference voltage, the MOSFET switch is turned off. As the feedback voltage is lower than reference voltage and the MOSFET switch has been off for at least a period of minimum off-time decided by the minimum off-time one-shot, the MOSFET switch is then turned on for a period of on-time decided by maximum on-time one-shot, or until the V_{LXLIM} voltage limit signal is asserted.

During the first part of each switching cycle, the internal N-channel MOSFET switch is turned on. This allows current to ramp up in the inductor and store energy in a magnetic field. During the second part of each cycle, the MOSFET is turned off, the voltage across the inductor reverses and forces current through the diode to the output filter capacitor and load. As the energy stored in the inductor is depleted, the current ramps down and the output diode turns off. The output filter capacitor stores the charge while the inductor current is higher than the output current, then sustains the output voltage until the next switching cycle.

Low-Voltage Start-Up Oscillator

The EC9206 use a CMOS, low-voltage start-up oscillator for a typically 1.0V startup input voltage at +25°C. On start-up, the low-voltage oscillator switches the N-channel MOSFET until the output voltage reaches 2.2V. Above this level, the normal PFM step-up converter and control circuitry take over. Once the device is in regulation, it can operate down to a 0.7V input since internal power for the IC is bootstrapped from the output voltage. Do not apply full load until the output exceeds 2.4V.

Soft Start

The EC9206 has internal soft start circuit that limits current draw at startup, reducing transients on the input source. Soft-start is particularly useful for higher impedance input sources, such as Li+ and alkaline cells. When power is applied to the device, the soft start circuit first pumps up the output voltage to approximately 2.2 V at a fixed duty cycle. This is the voltage level at which the controler can operate normally. In addition to that, the start up capability with heavy loads is also improveed.

Current Limit

The EC9206 utilizes cycle-by-cycle current limiting by means of protecting the output MOSFET switch from overstress and preventing the small value inductor from saturation. Current limiting is implemented by monitoring the output MOSFET current build-up during conduction, and upon sensing an over-current conduction immediately turning off the switch for the duration of the oscillator cycle. The voltage across the output MOSFET is monitored and compared against a reference by the V_{LXLIM} limiter. When the threshold is reached, a signal is sent to the PFM controller block to terminate the power switch conduction. The current limit threshold is typically set at 700mA.

Shutdown

The EC9206 enters shutdown to reduce quiescent current to typically 0.5μA when CE pin is low. For normal operation, drive CE high or connect CE to V_{OUT}. During shutdown, the reference, gain block, and all feedback and control circuitry are off. The boost converter's output drops to one Schottky diode voltage drop below the input voltage and LX remains high impedance. The capacitance and load at V_{OUT} determine the rate at which V_{OUT} decays. Shutdown can be pulled as high as 6V, regardless of the voltage at V_{OUT}.

Application Information

Inductor Selection

The EC9206 is designed to work well with a 22μH to 47μH inductor in most applications. Low inductance values supply higher output current, but also increase the ripple and reduce efficiency. Higher inductor values reduce ripple and improve efficiency, but also limit output current. Choose a low DC-resistance inductor, usually less than 1Ω to minimize loss. It is necessary to choose an inductor with saturation current greater than the peak current that the inductor will encounter in the application. Saturation occurs when the inductor's magnetic flux density reaches the maximum level the core can support and inductance falls.

Capacitor Selection

The input capacitor stabilizes the input voltage and minimizes the peak current ripple from the source. The value of the capacitor depends on the impedance of the input source used. Small ESR (Equivalent Series Resistance) Tantalum or ceramic capacitor with value of 10μF to 47μF would be suitable.

The output capacitor is used to sustain the output voltage when the internal MOSFET is switched on and smoothing the ripple voltage. Low ESR capacitor should be used to reduce output ripple voltage. Use a 47μF to 68μF SMD tantalum output capacitor with about 50mΩ to 150mΩ ESR to provide stable switching. For applications where space is a critical factor, two parallel 22μF low profile SMD ceramic capacitors can be used. Smaller capacitors are acceptable for light loads or in applications that can tolerate higher output ripple.

The input capacitor reduces peak currents and noise at the voltage source. Input capacitors must meet the input ripple requirements and voltage rating. The ESR of both input and output capacitors affects efficiency and output ripple. Output voltage ripple is the product of the peak inductor current and the output capacitor ESR. Use low ESR capacitors for best performance, or connect two or more output capacitors in parallel.

Schottky Diode Selection

The diode is the largest source of loss in DC–DC converters. The most important parameters which affect the efficiency are the forward voltage drop, VF, and the reverse recovery time. The forward voltage drop creates a loss just by having a voltage across the device while a current flowing through it. The reverse recovery time generates a loss when the diode is reverse biased, and the current appears to actually flow backwards through the diode due to the minority carriers being swept from the P–N junction. A Schottky diode with the following characteristics is recommended:

Small forward voltage, V_F < 0.3 V
Small reverse leakage current
Fast reverse recovery time/switching speed
Rated current larger than peak inductor current
Reverse voltage larger than output voltage

Layout Considerations

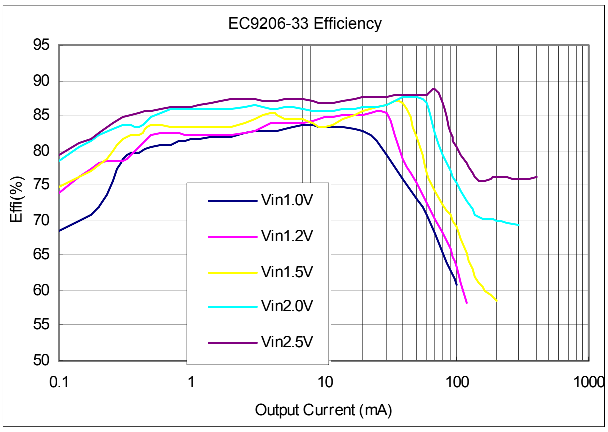
High switching frequencies make PC board layout a very important part of design. Good design minimizes excessive EMI on the feedback paths and voltage gradients in the ground plane, both of which can result in instability or regulation errors. Connect the inductor, input filter capacitor, and output filter capacitor as close to the device as possible, and keep their traces short, direct, and wide to reduce power loss so as to improve efficiency. Connect their ground pins at a single common node in a star ground configuration, or at a full ground plane.

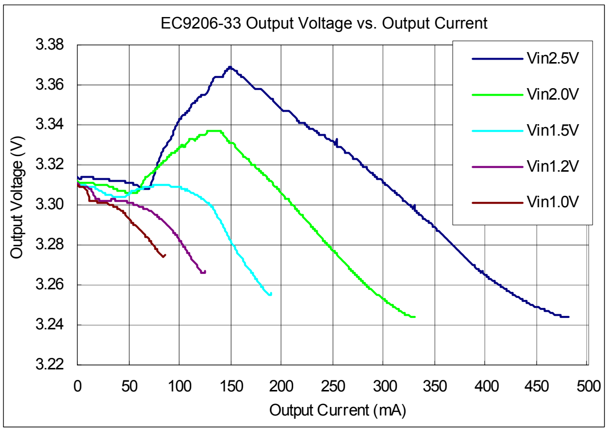
The output capacitor should be placed close to the output terminals to obtain better smoothing effect on the output ripple.

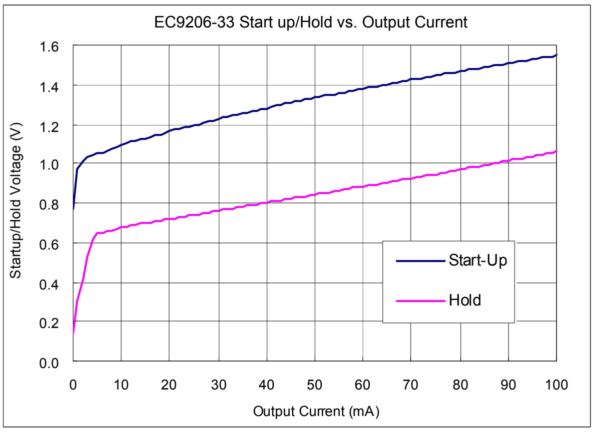
TEL : 886-3-5785888
FAX : 886-3-5783630

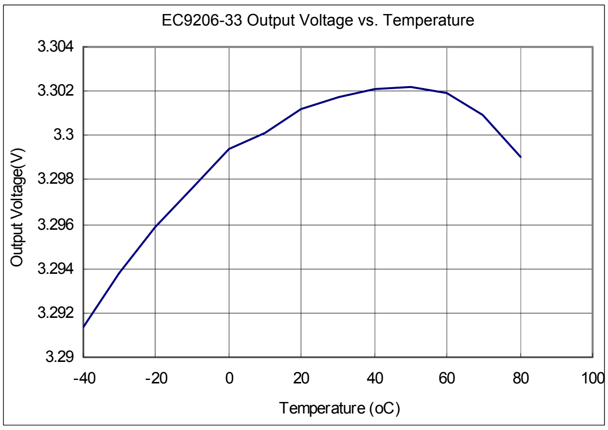
Typical Operating Characteristic

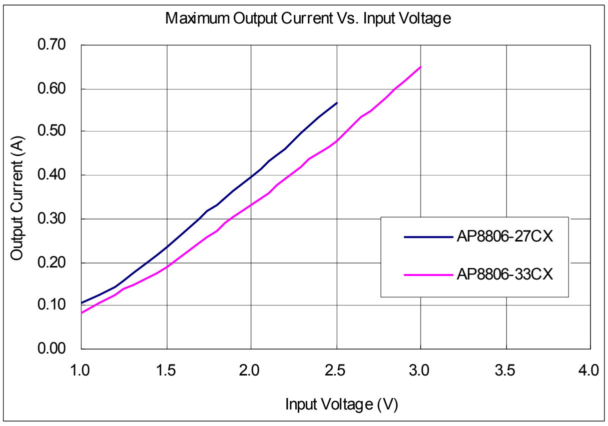
(V_{IN}=+1.8V, V_{OUT}=3.3V, L=47μH, C2=47μF, T_A=+25℃, unless otherwise noted.)





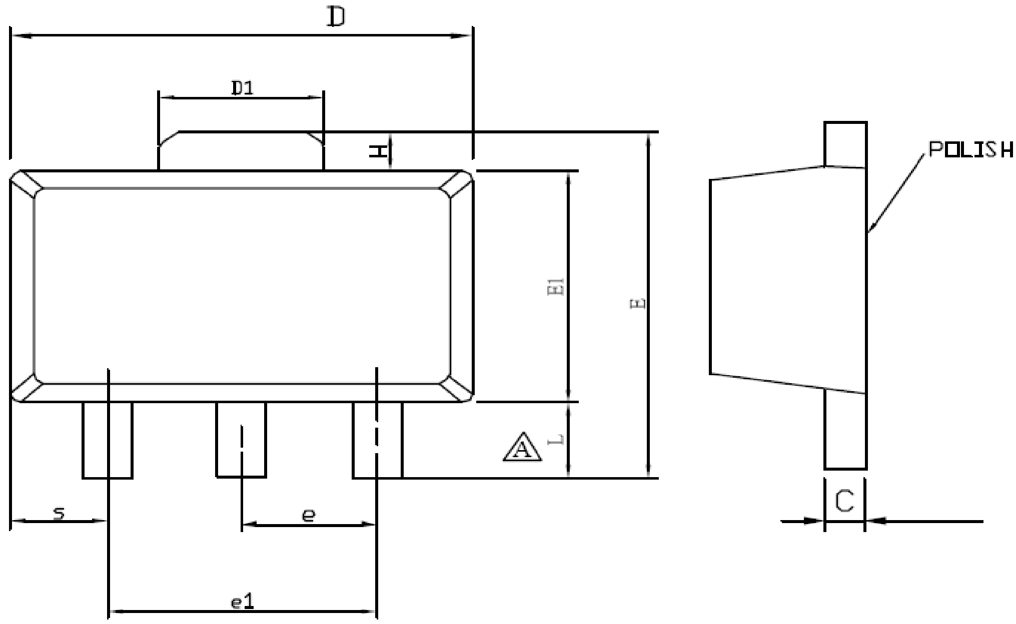


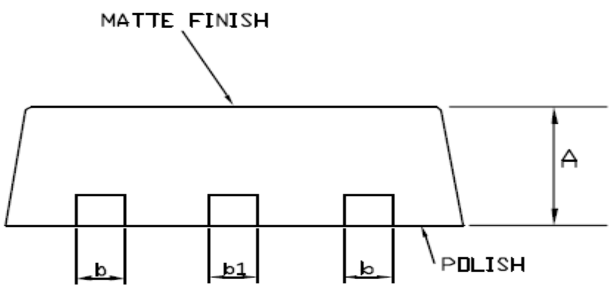




Package Outline

A) SOT-89





Symbol	Dimensions in millimeters			Dimensions in inches		
	Min	Nom	Max	Min	Nom	Max
A	1.40	1.50	1.60	0.055	0.059	0.063
L	0.89	1.04	1.20	0.0350	0.041	0.047
b	0.36	0.42	0.48	0.014	0.016	0.018
b1	0.41	0.47	0.53	0.016	0.018	0.020
C	0.38	0.40	0.43	0.014	0.015	0.017
D	4.40	4.50	4.60	0.173	0.177	0.181
D1	1.40	1.60	1.75	0.055	0.062	0.069
E	3.64	---	4.25	0.143	---	0.167
E1	2.40	2.50	2.60	0.094	0.098	0.102
e1	2.90	3.00	3.10	0.114	0.118	0.122
H	0.35	0.40	0.45	0.014	0.0169	0.018
S	0.65	0.75	0.85	0.026	0.030	0.034
e	1.40	1.50	1.60	0.054	0.059	0.063

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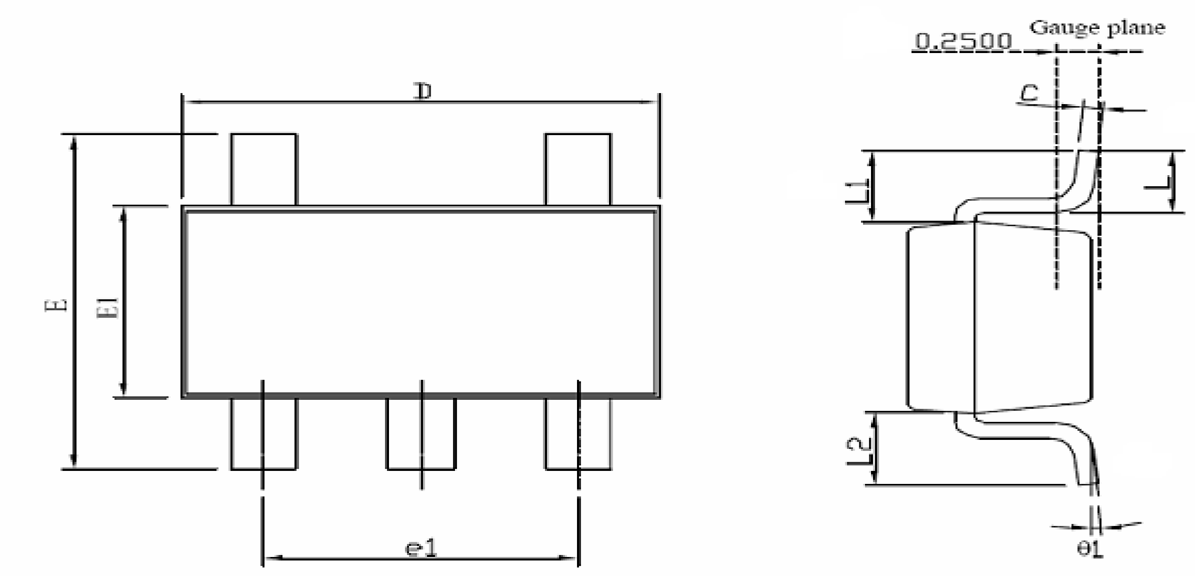
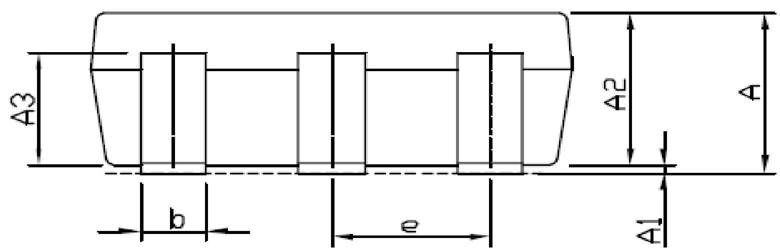
B) SOT-25





Symbols	Dimensions in Millimeters		
	Min	Nom	Max
A	1.00	1.10	1.40
A1	0.00	---	0.10
A2	1.00	1.10	1.30
A3	0.70	0.80	0.90
b	0.35	0.40	0.50
C	0.12	0.125	0.225
D	2.70	2.90	3.10
E1	1.40	1.60	1.80
e1	---	1.90(TYP)	---
E	2.60	2.80	3.00
L	0.37	---	---
θ1	1°	5°	9°
e	---	0.95(TYP)	---
L1	---	0.6(REF)	---
LI-L2	---	---	0.12

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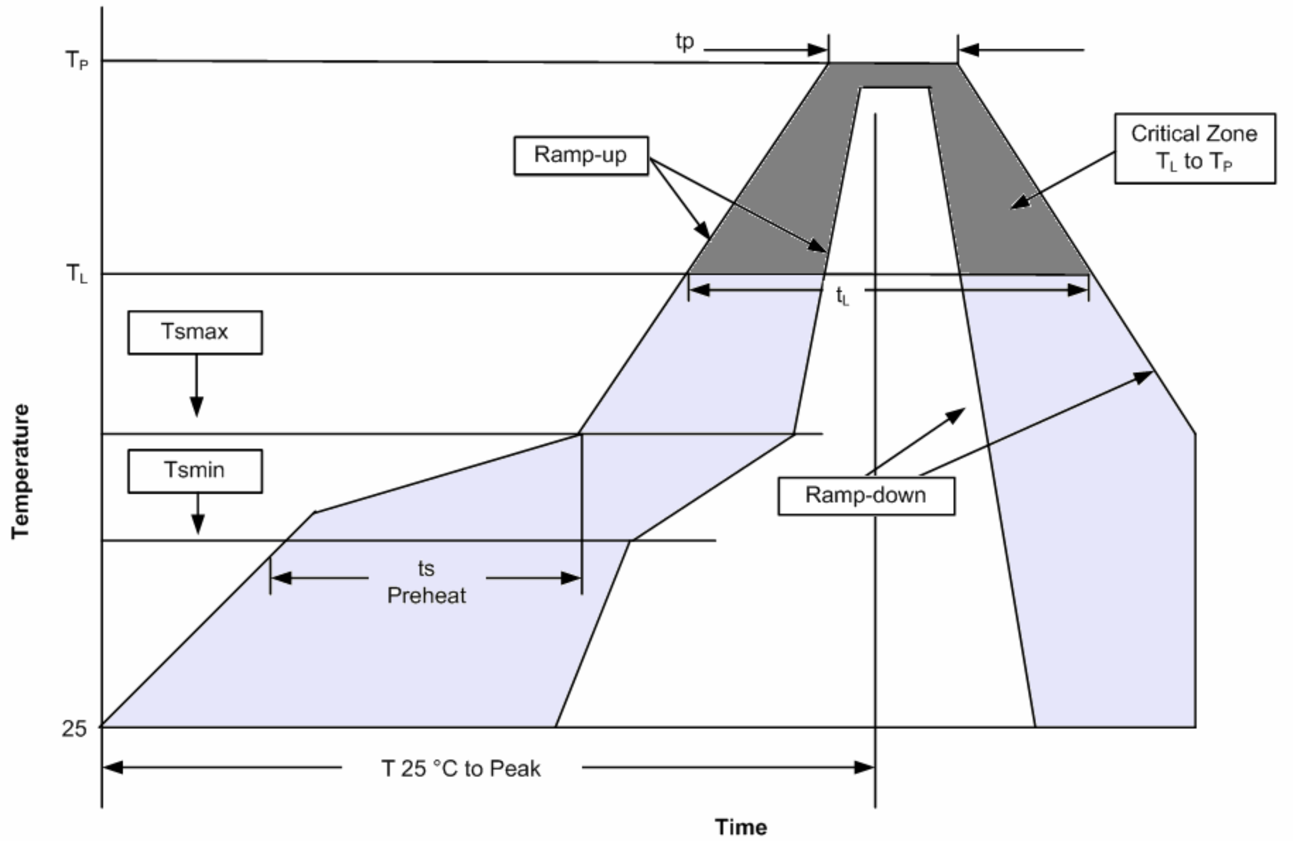
FAX : 886-3-5783630

Reflow Condition (IR/Convection or VPR Reflow)



Classification Reflow Profiles

Profile Feature	Pb-Free / Green Assembly
Average ramp-up rate (T_L to T_P)	3°C/second max
Preheat - Temperature Min (Tsmin) - Temperature Max (Tsmax) - Time (min to max) (ts)	150°C 200°C 60-180 seconds
Time maintained above: - Temperature (T_L) - Time (t_L)	217°C 60-150 seconds
Peak/Classification Temperature (Tp)	See table 1
Time within 5°C of actual Peak Temperature (tp)	20-40 seconds
Ramp-down Rate	6°C/second max
Time 25°C to Peak Temperature	8 minutes max

Notes：
1) All temperatures refer to topside of the package.
2) Measured on the body surface.

Classification Reflow Profiles (Continued)

Table 1. Pb-free / Green Process – Package Classification Reflow Temperatures

Package Thickness	Volume mm³ <350	Volume mm³ 350~2000	Volume mm³ ≧2000
<2.5 mm	260 +0°C*	260 +0°C*	260 +0°C*
1.6-2.5 mm	260 +0°C*	250 +0°C*	245 +0°C*
≧2.5 mm	250 +0°C*	245 +0°C*	245 +0°C*

Notes：
* Tolerance: The device manufacturer/supplier shall assure process compatibility up to and including the stated classification temperature (this means Peak reflow temperature +0°C. For example 260°C+0°C) at the rated MSL level.