

General Description

The FS8806 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 FS8806 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 FS8806 is 85% when $V_{IN} \geq 2.0V$ $V_{OUT}=3.3V$ $I_{LOAD}=1 \sim 60mA$. Potential applications include low powered consumer products and battery powered portable products.

The FS8806 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 FS8806 devices are available in both SOT-89 and SOT-23-5 packages with 6 standard regulated output voltages.

Typical Application

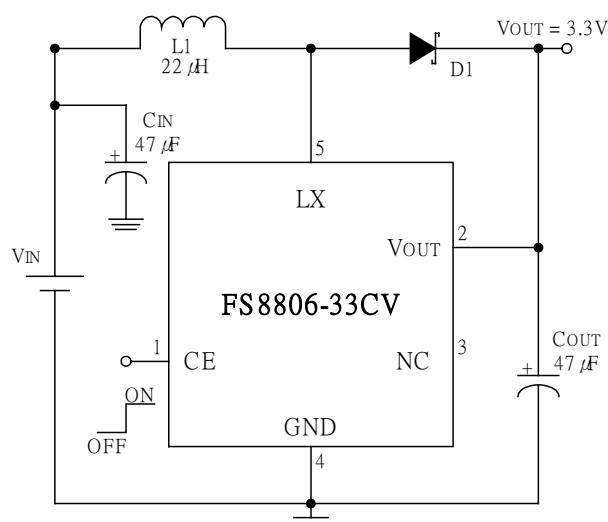


Fig 1. FS8806 Typical Application for 3.3V Output

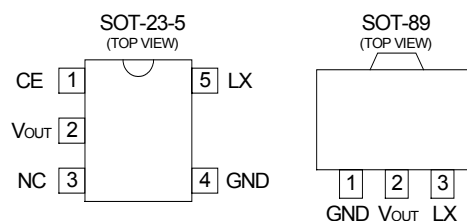
Features

- 1.0V Low Start-up Input Voltage at 1mA Load
- Deliver 180mA at 3.3V Output with 1.5V Input
- 87% High Efficiency ($V_{IN}=2.0V$, $V_{OUT}=3.3V$, $I_{LOAD}=60mA$)
- Output Voltage Accuracy $\pm 2.5\%$
- 8µA Low Switch-Off Supply Current
- 0.5µA Low Shutdown Supply Current
- 5-pin SOT-23 or 3-pin SOT-89 Package

Applications

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

Pin Configurations



Ordering Information

FS8806-XXXX

Package Type

V : SOT-23-5,
X : SOT-89

Operating Temperature Range

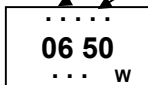
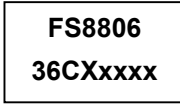
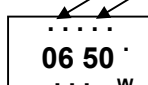
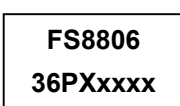
C : Commercial Standard

P : Commercial Standard, Lead(Pb)
Free and Phosphorous(P) Free
Package

Output Voltage

27 : 2.7V	36 : 3.6V
30 : 3.0V	40 : 4.0V
33 : 3.3V	50 : 5.0V

Package Marking Information

SOT-23-5	SOT-89
EX : FS8806-50CV  Top Point: Lot No. Bottom Point: Year w : week, A~Z & A ~ Z	EX : FS8806-36CX  xxxx : Date Code
EX : FS8806-50PV  Top Point: Lot No. Bottom Point: Year w : week, A~Z & A ~ Z A dot after marking : Pb/P Free	EX : FS8806-36PX  xxxx : Date Code P: Pb/P Free

Pin Description

Pin No.		Symbol	Description
SOT-23-5	SOT-89		
1	-	CE	Chip enable. Set CE pin to low to shutdown the device. Must be set to VOUT or higher voltage to enable the device. Do not float this pin. For SOT-89 package, this pin is shorted to VOUT internally.
2	2	VOUT	IC power supply pin. Connect this pin to the regulator output.
3	-	NC	No Connection
4	1	GND	Ground.
5	3	LX	Switch pin. Connect inductor/diode here.

Functional Block Diagram

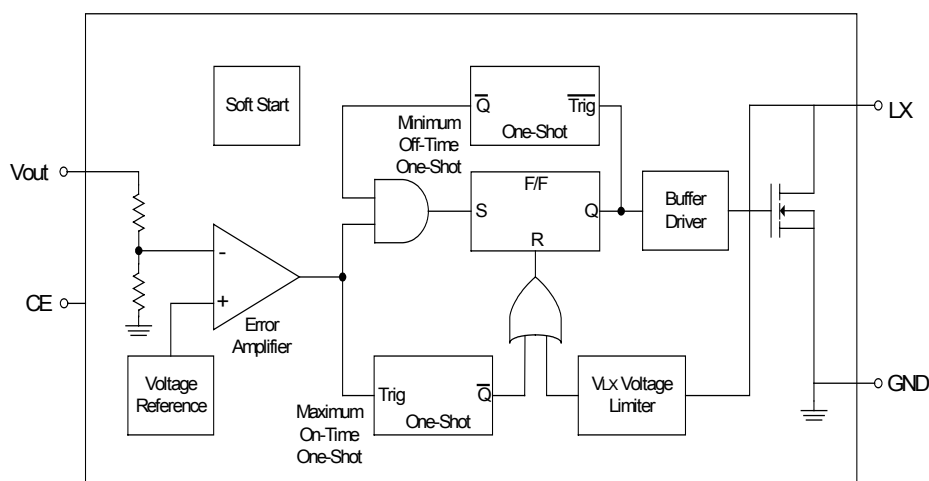


Fig 2. FS8806 Functional Block Diagram

Absolute Maximum Ratings

Supply Voltage	-0.3V to 10V
LX Pin Switch Voltage	-0.3V to (V _{out} +0.3V)
CE Pin Voltage	-0.3V to (V _{out} +0.3V)
LX Pin Switch Current	0.7A
Continuous power dissipation, P _D @ T _A = 25°C	
SOT-89	0.55W
SOT-23-5	0.40W
Package Thermal Resistance	
SOT-89, θ_{JA}	180°C /W
SOT-23-5, θ_{JA}	250°C /W
Maximum Operating Junction Temperature	150°C
Operating temperature range	-20°C to +70°C
Storage temperature range, T _{STG}	-55°C to +150°C
Lead temperature (soldering, 10sec)	260°C
ESD ratings	
Human Body Model, per MIL-STD-883D-3015.7	1.5KV
Machine Model, MIL-STM5.2-1999	150V

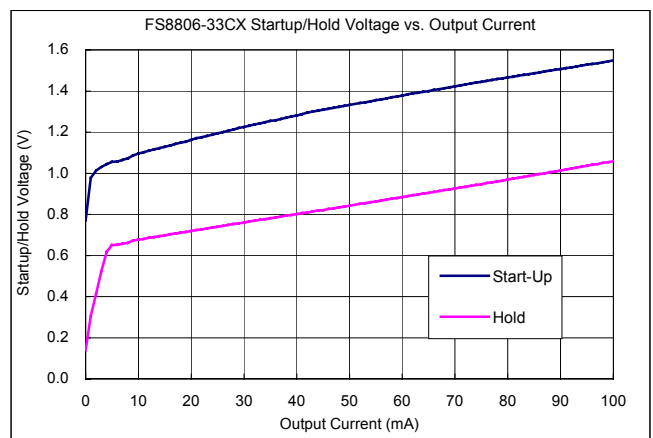
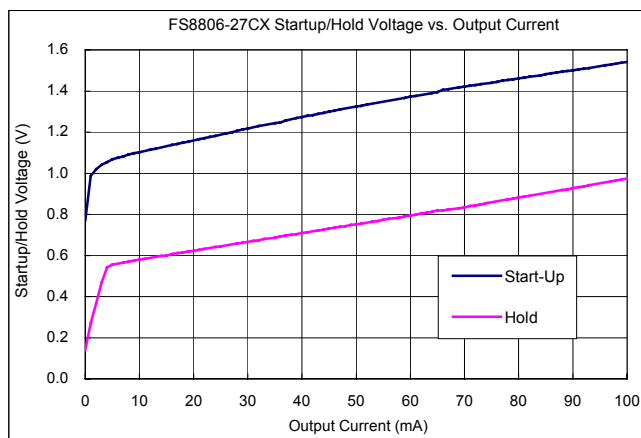
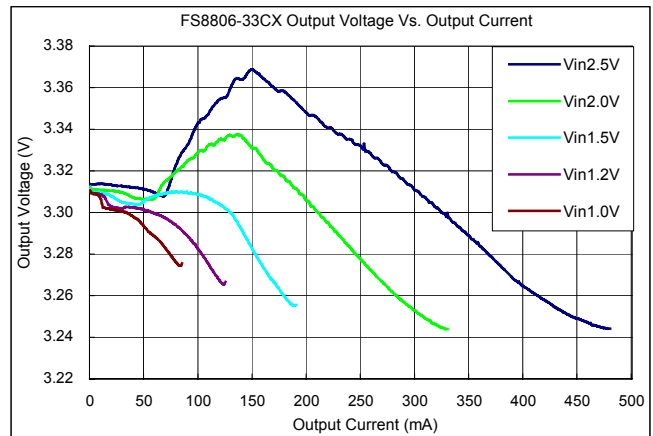
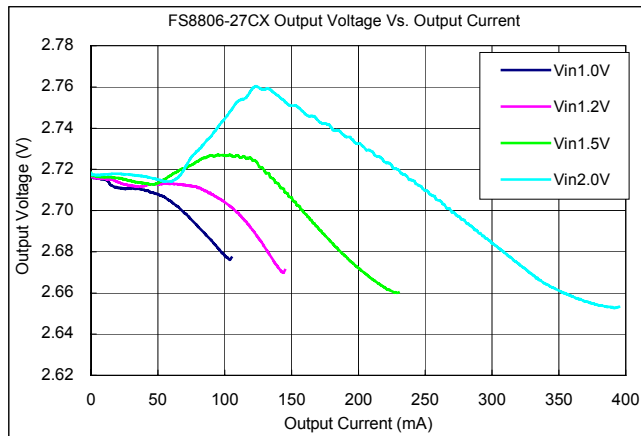
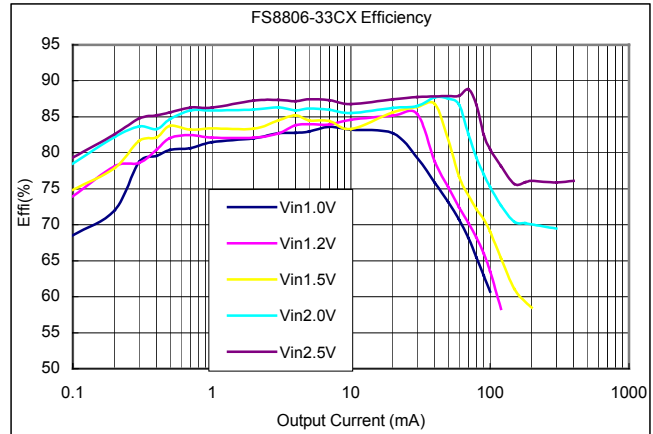
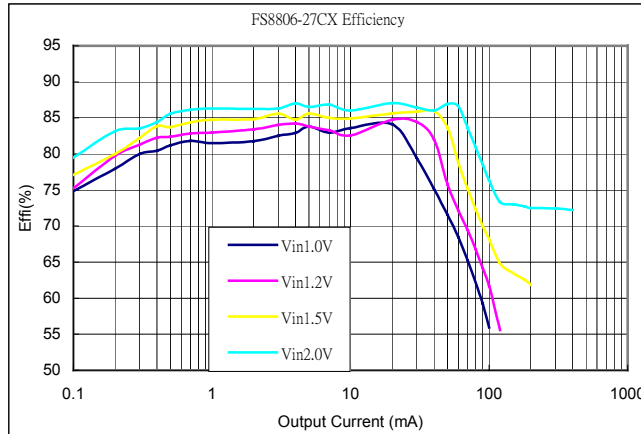
Electrical Characteristics

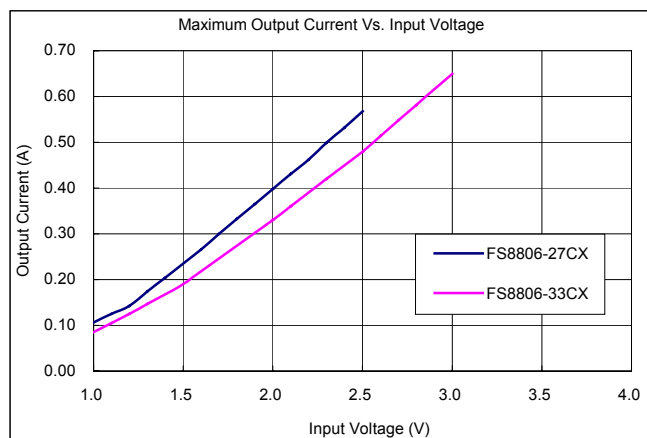
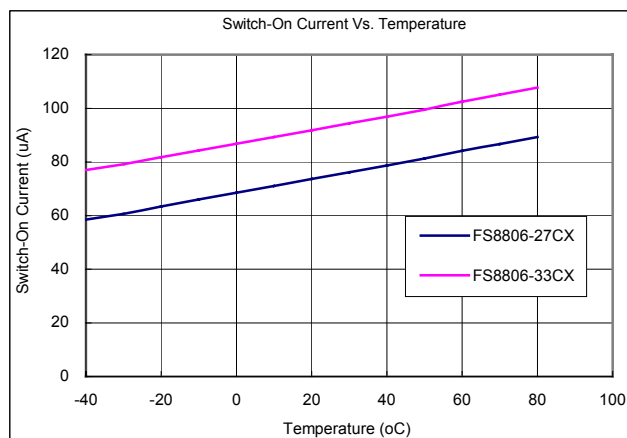
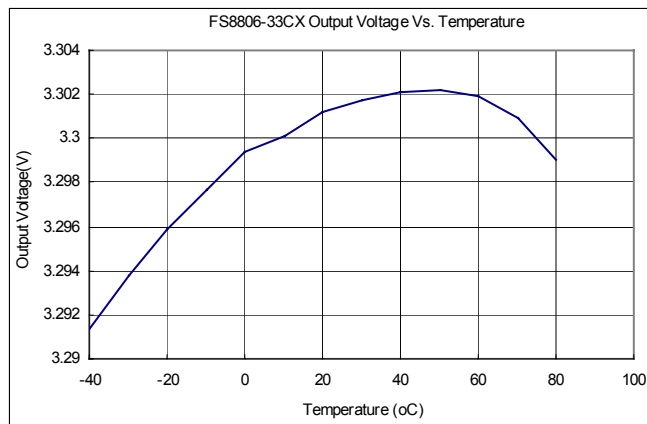
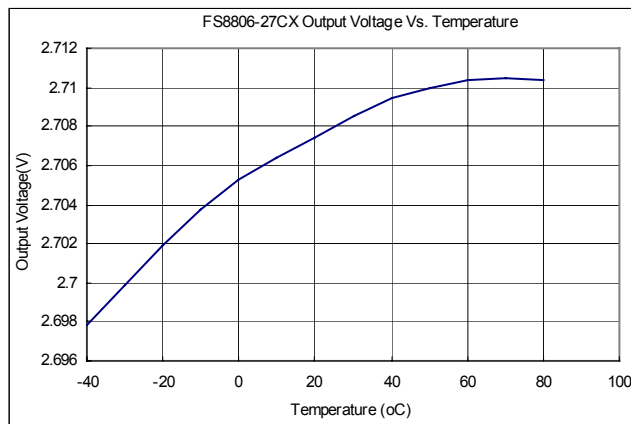
(V_{IN}=1.8V, V_{OUT}=3.3V, Load Current=1mA, T_A=25°C, unless otherwise noted.)

Symbol	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
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} = 2.7V	2.632	2.7	2.768	V
		Preset V _{OUT} = 3.0V	2.925	3.0	3.075	V
		Preset V _{OUT} = 3.3V	3.218	3.3	3.383	V
		Preset V _{OUT} = 3.6V	3.510	3.6	3.690	V
		Preset V _{OUT} = 4.0V	3.900	4.0	4.100	V
		Preset V _{OUT} = 5.0V	4.875	5.0	5.125	V
I _{DD1}	Switch On Current (V _{OUT})	V _{OUT} = Preset Output*0.95	--	100	--	μA
I _{DD2}	Switch Off Current (V _{OUT})	V _{OUT} = Preset Output*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

Typical Operating Characteristics

($V_{IN}=+1.8V$, $V_{OUT}=3.3V$, $L=47\mu H$, $C_{IN}=47\mu F$, $C_{OUT}=100\mu F$, $T_A=+25^\circ C$, unless otherwise noted.)





Detail Description

The FS8806 is a variable frequency voltage-mode step-up DC-DC converter for portable devices like DSC and PDA. The FS8806 combines a PFM step-up switching regulator, 0.7A/0.6Ω N-channel power MOSFET, precision bandgap 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 FS8806 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 FS8806 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 FS8806 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 controller can operate normally. In addition to that, the start up capability with heavy loads is also improved.

Current Limit

The FS8806 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 FS8806 enters shutdown to reduce quiescent current to typically 0.5 μ A 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 FS8806 is designed to work well with a 22 μ H to 47 μ H 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 1 Ω 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 10 μ F to 47 μ F 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 47 μ F to 68 μ F SMD tantalum output capacitor with about 50m Ω to 150m Ω ESR to provide stable switching. For applications where space is a critical factor, two parallel 22 μ F 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, V_F , 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

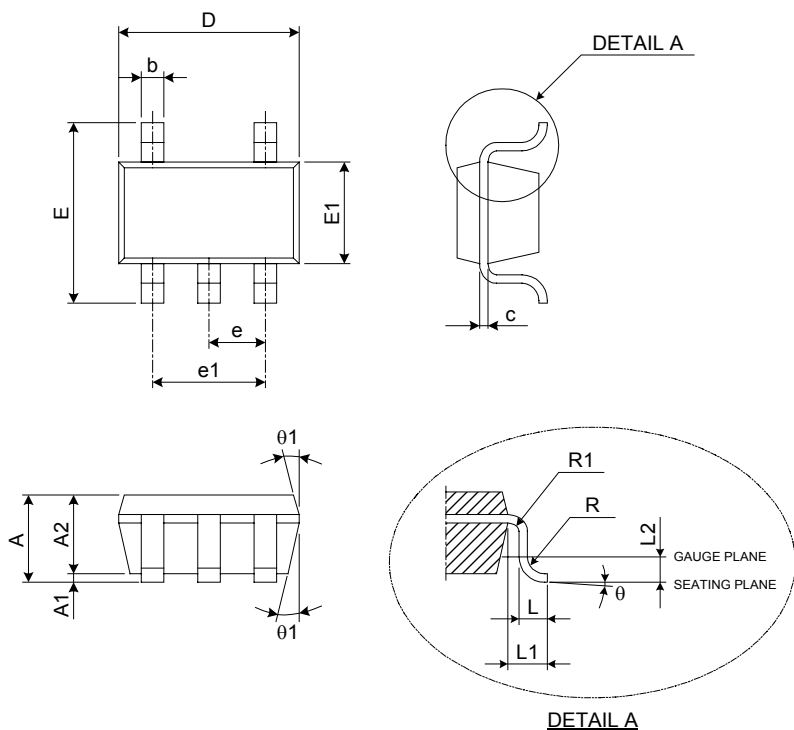
High switching frequencies make PC board layout a very important part of design. Good design minimizes excessive EMI on the feedback paths and voltage gradients in the ground plane, both of which can result in instability or regulation errors.

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.

Package Outline

SOT-23-5



SOT-89

