Fortune Semiconductor Corporation
富晶半導體股份有限公司

FS8801

Low Start-up Voltage Step-up DC-DC Converter

General Description

The FS8801 is a compact PWM step-up DC/DC converter that operates from an input voltage as low as 1.0 Volt. The low start-up input voltage makes FS8801 specially designed for portable devices from one or two cell battery, delivering up to 250mA load current at V_{IN}=2.5V Vout=3.3V. On-chip phase compensation and soft start circuits ensure excellent transient response and improved performance.

The device features a voltage mode PWM control loop and an internal low turn-on resistance NMOS power switch, providing stable and high-efficiency operation over a broad load current range. High frequency 300KHz switching allows the use of small size external components.

The FS8801 devices are available in both SOT-89 and SOT-23-5 packages with 2 standard regulated output voltage. Adjustable output voltage type in SOT-23-5 package is also available.

Typical Application

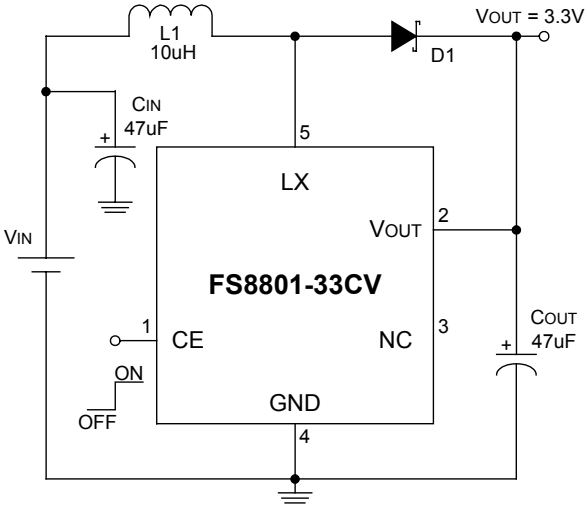


Fig 1. FS8801 Typical Application for 3.3V Output

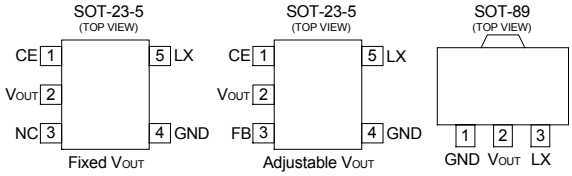
Features

- **1.0V Low Start-up Input Voltage at 1mA Load**
- **Deliver 100mA at 3.3V with 1V Input Voltage**
- **90% High Efficiency (Vin 3.0V/Vout 3.3V)**
- **Output Voltage Accuracy (No load current)**
  Vout 3.3V: 3.3V ± 82mV
  Vout 5.0V: 5.0V ± 125mV
- **300KHz Fixed Switching Frequency**
- **0.5uA Low Shutdown 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

FS8801-xx x x

- 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
  33 : 3.3V
  50 : 5.0V
  Default : Adjustable Output

Package Marking Information

Part Number	Marking
FS8801-33CV	0133
FS8801-50CV	0150
FS8801-CV	01AA
FS8801-33CX	FS8801-33CX
FS8801-50CX	FS8801-50CX
FS8801-33PV	0133 ▪
FS8801-50PV	0150 ▪
FS8801-PV	01AA ▪
FS8801-33PX	FS8801-33PX
FS8801-50PX	FS8801-50PX

SOT-23-5	SOT-89
EX：FS8801-50CV 01 50 w Top Point: Lot No. Bottom Point: Year w : week, A~Z & A ~ Z	EX：FS8801-33CX FS8801 33CXxxxx xxxx：Date Code
EX：FS8801-50PV 01 50 w Top Point: Lot No. Bottom Point: Year w : week, A~Z & A ~ Z A dot after marking : Pb/P Free	EX：FS8801-33PX FS8801 33PXxxxx 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 or FB	No Connection for fixed output type. Feedback input pin for adjustable output type. Connect resistive divider tap here.
4	1	GND	Ground.
5	3	LX	Switch pin. Connect inductor/diode here.

Functional Block Diagram

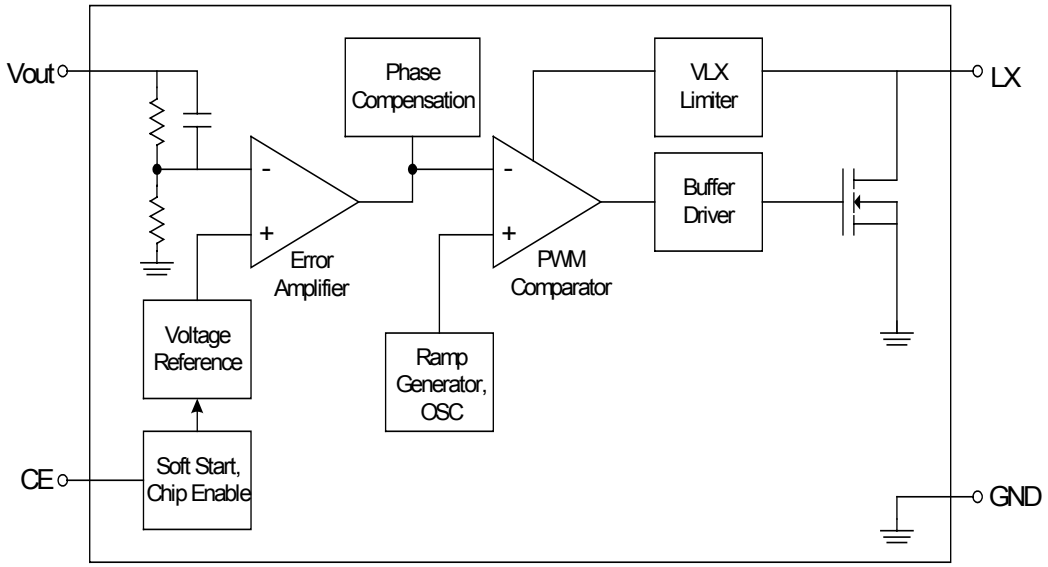


Fig 2. FS8801 Simplified Function Block Diagram

Typical Application Circuit

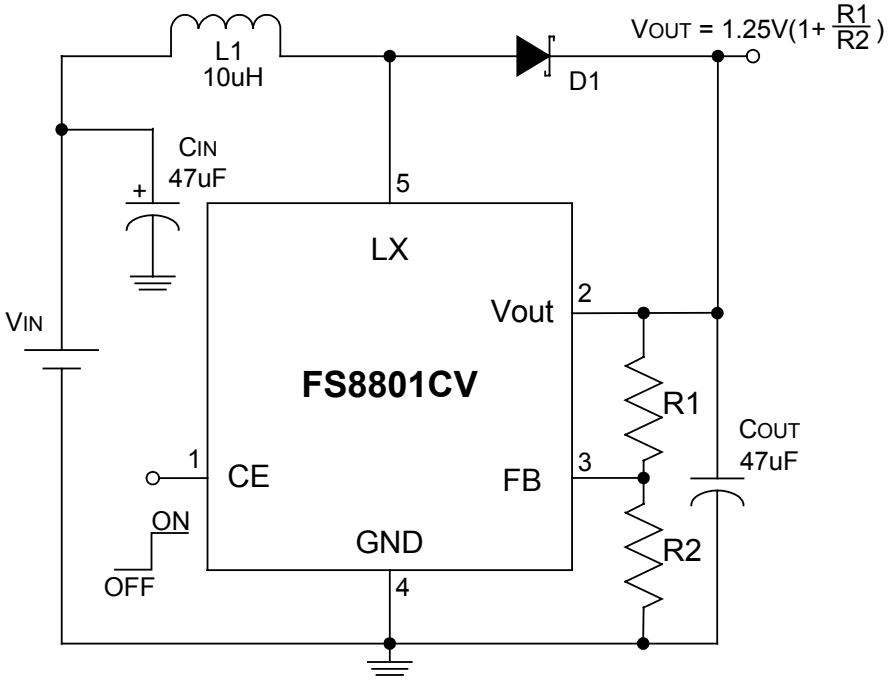


Fig 3. FS8801CV application for adjustable voltage output

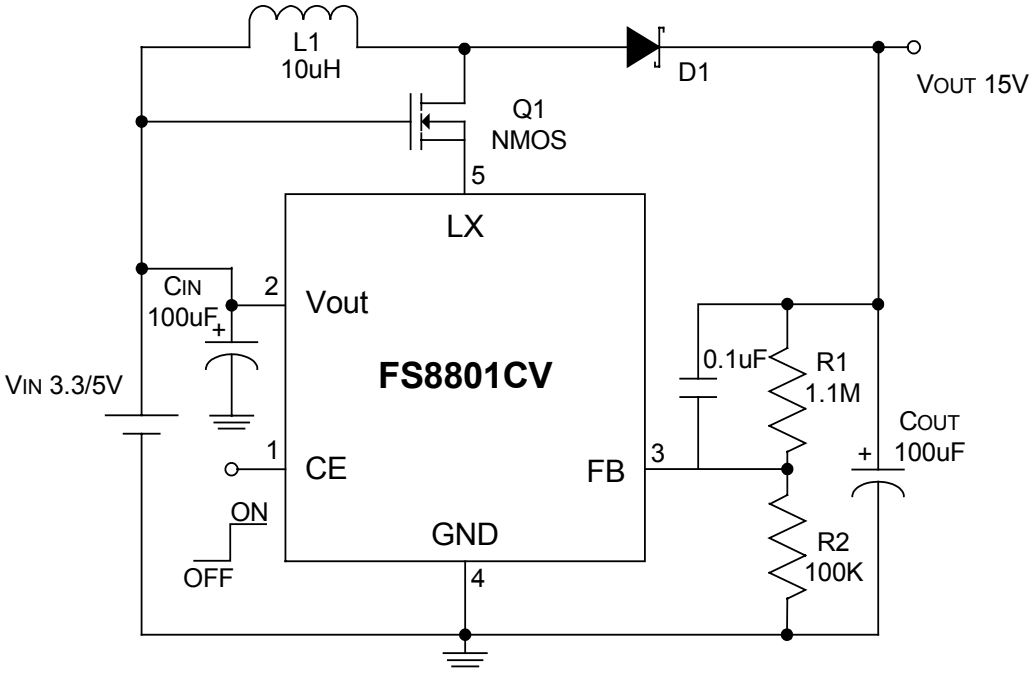


Fig 4. FS8801CV application for high voltage output

Absolute Maximum Ratings

Supply Voltage ---------- -0.3V to 10V
LX Pin Switch Voltage ---------- -0.3V to (Vout +0.3V)
FB Pin Voltage ---------- -0.3V to (Vout +0.3V)
CE Pin Voltage ---------- -0.3V to (Vout +0.3V)
LX Pin Switch Current ---------- 1.2A
Continuous power dissipation, P_D @ T_A = 25˚C
SOT-89 ---------- 0.55W
SOT-23-5 ---------- 0.40W
Package Thermal Resistance
SOT-89, θJA ---------- 180˚C /W
SOT-23-5, θJA ---------- 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 ---------- 1.25KV
Machine Model, MIL-STM5.2-1999 ---------- 200V

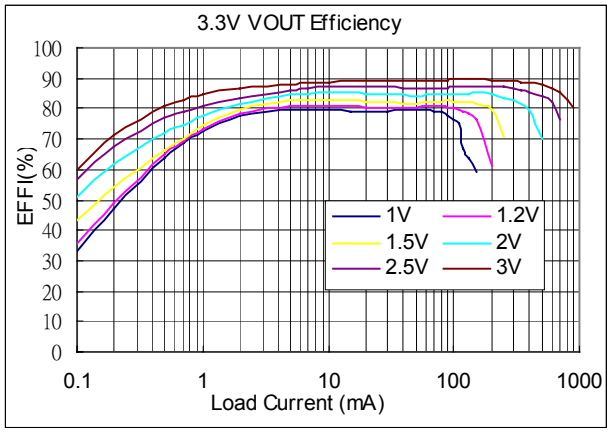
Electrical Characteristics

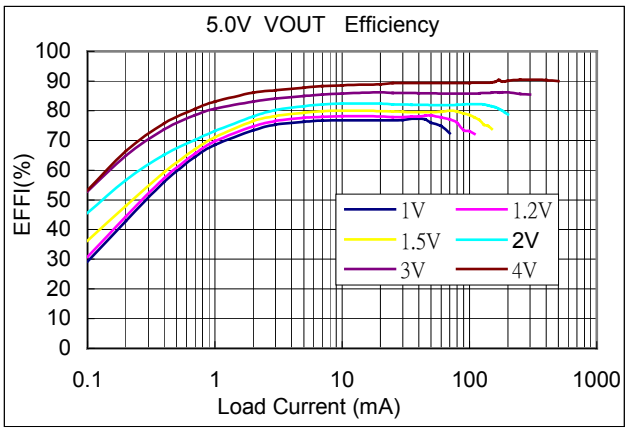
(V_{IN}=2.5V, Vout =3.3V, Load Current=0, T_A=25˚C, unless otherwise noted.)

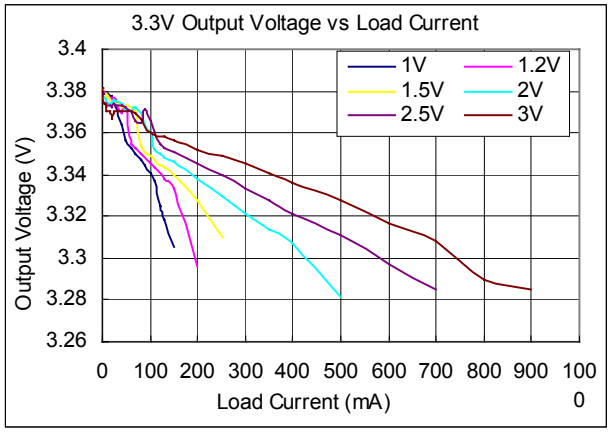
Symbol	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{ST}	Start-up Voltage	I_L = 1mA	--	0.95	1.10	V
V_{ST}	Start-up Voltage	I_L = 100mA	--	1.20	1.30	V
V_{HOLD}	Holding Voltage	I_L = 20mA	--	0.70	--	V
	Operating Vout Range	For adjustable output type	2.5		6.0	V
Vout	Output Voltage	Preset Vout = 3.3V	3.218	3.3	3.382	V
		Preset Vout = 5.0V	4.875	5.0	5.125	V
I_{DD}	No Load Supply Current (Vout)	With External Components		50		μA
I_{DD1}	Switch On Current (Vout)	Vout = Preset Output*0.95	--	90	--	μA
I_{DD2}	Switch Off Current (Vout)	Vout = Preset Output*1.1	--	35	--	μA
I_{OFF}	Shutdown Current (V_{IN})	CE = 0V, V_{IN} = 4.5V		0.5	1	μA
V_{REF}	Feedback Reference Voltage		1.220	1.25	1.280	V
	CE Input Voltage Threshold		0.2	0.6	1.4	V
F_{SW}	Switching Frequency		--	300	--	KHz
D_{MAX}	Maximum Duty Cycle		--	90	--	%
$R_{DS(on)}$	Switch ON Resistance			0.4	--	Ω
V_{LXLIM}	Switch Voltage Limit			0.6		V
ΔV_{LINE}	Line Regulation	V_{IN} = 1.5~2.5V, I_L=1mA		10		mV/V
ΔV_{LOAD}	Load Regulation	V_{IN} = 2.5V, I_L=1~100mA		0.25		mV/mA

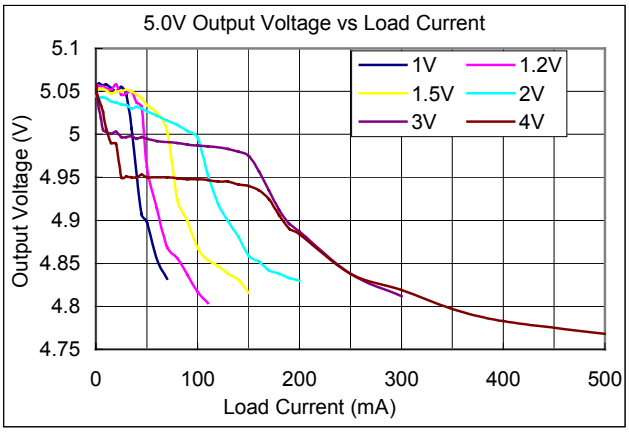
Typical Operating Characteristics

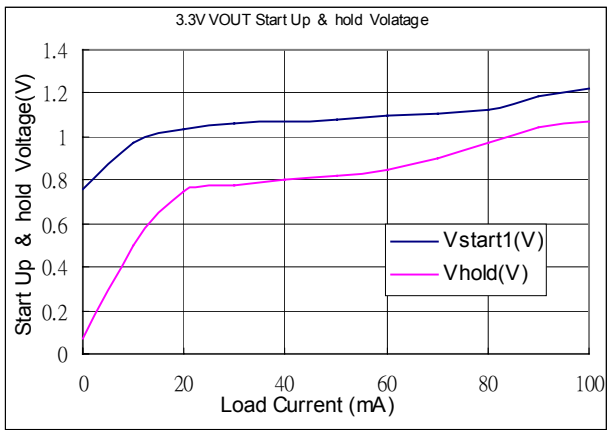
(VIN=+2.5V, Vout=3.3V, L1=10μH, C2=47μF, TA=+25℃, unless otherwise noted.)

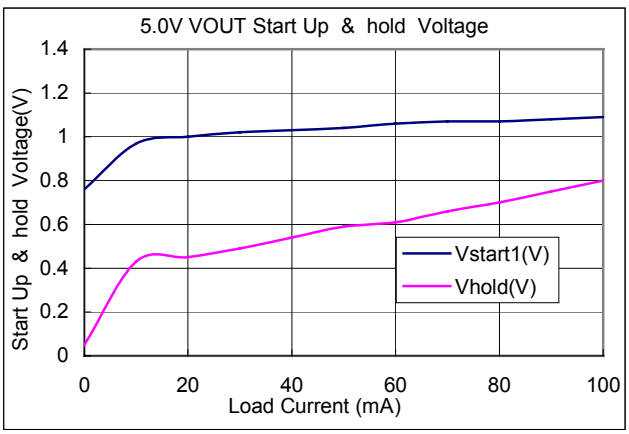


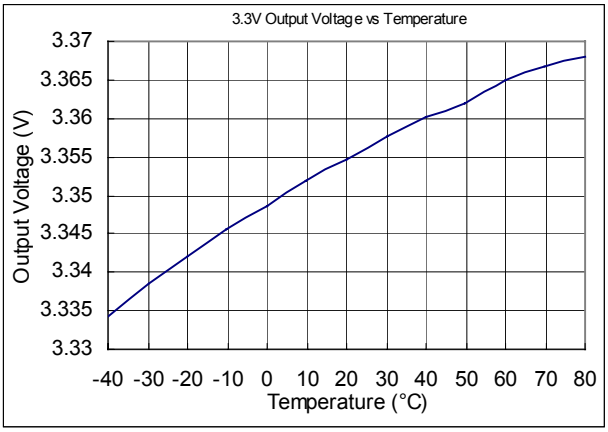


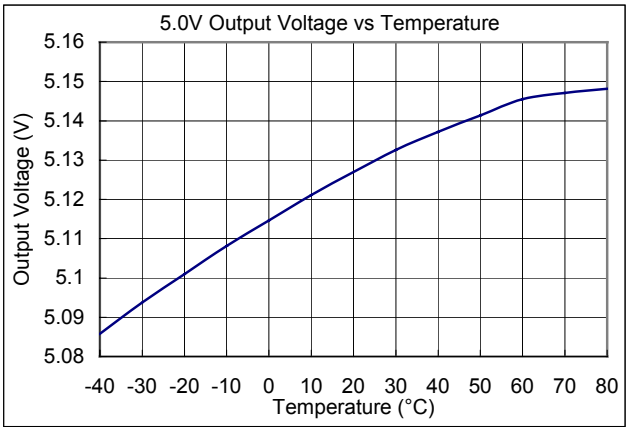


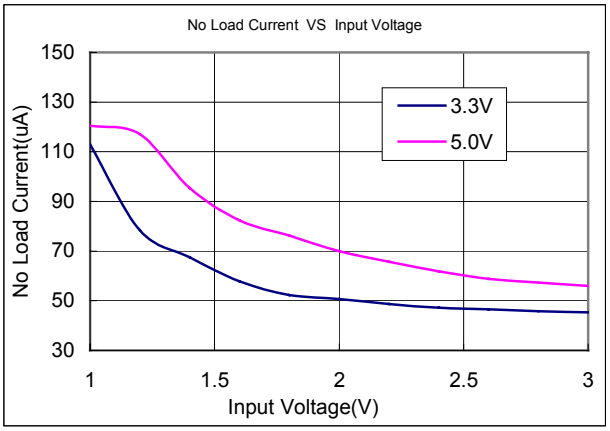







3.3V Output Voltage vs Temperature
Output Voltage (V)
3.37
3.365
3.36
3.355
3.35
3.345
3.34
3.335
3.33
-40 -30 -20 -10 0 10 20 30 40 50 60 70 80
Temperature (°C)


5.0V Output Voltage vs Temperature
Output Voltage (V)
5.16
5.15
5.14
5.13
5.12
5.11
5.1
5.09
5.08
-40 -30 -20 -10 0 10 20 30 40 50 60 70 80
Temperature (°C)


No Load Current VS Input Voltage
No Load Current(uA)
150
130
110
90
70
50
30
1 1.5 2 2.5 3
Input Voltage(V)
3.3V
5.0V

Detail Description

The FS8801 is a high-efficiency, step-up DC-DC converter for portable devices like DSC and PDA. The FS8801 combines a boost switching regulator, 1.2A/0.4Ω N-channel power MOSFET, 1.25V precision 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 two standard output voltages are 3.3V and 5V. Adjustable output voltage type is also available. The FS8801 starts from a low 1.0V input and remains operational down to 0.7V at 20mA load current.

Step-Up Converter

The step-up DC-DC converter operation can be understood by referring to the block diagram in Figure 2. The error amplifier monitors the output voltage by comparing the feedback voltage with the 1.25V reference voltage. When the feedback voltage is lower than the reference voltage, the error amplifier output will decrease. The error amplifier output is then compared with the oscillator ramp voltage at the PWM controller. When the ramp voltage is higher than the error amplifier output, the buffer driver is turned on which will then switch on the internal N-channel MOSFET; and vice versa. As the error amplifier output decreases, the buffer driver turn-on time increases and duty cycle increases. When the feedback voltage is higher than the reference voltage, the error amplifier output increases and the duty cycle decreases.

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.

Output Voltage Selection

For adjustable output type referring to Fig. 3, select an output voltage for adjustable output voltage type FS8801CV by connecting FB pin to a resistive divider between the output and GND. The Vout can be set as:

$$Vout = (1+R1/R2) \times 1.25V$$

Higher R1,R2 values reduce quiescent current, but give bad noise immunity. To keep stable feedback loop operation and better noise immunity, select (R1+R2) value less than 1MΩ

Compensation

An internal phase compensation circuit is designed to guarantee stability over the full input/output voltage and full output load range.

Low-Voltage Start-Up Oscillator

The FS8801 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 boost-converter feedback 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 FS8801 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.

Shutdown

The FS8801 enters shutdown to reduce quiescent current to typically 0.5 μA when CE pin is low . For normal operation, drive CE high or connect CE to Vout. 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 Vout determine the rate at which Vout decays.

Shutdown can be pulled as high as 6V, regardless of the voltage at Vout.

Application Information

Inductor Selection

The FS8801 is designed to work well with a 4.7μH to 10μH 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

Use a 47uF to 100uF SMT tantalum output capacitor with about 50mΩ to 150mΩ equivalent series resistance (ESR) to provide stable switching while minimizing output ripple. 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

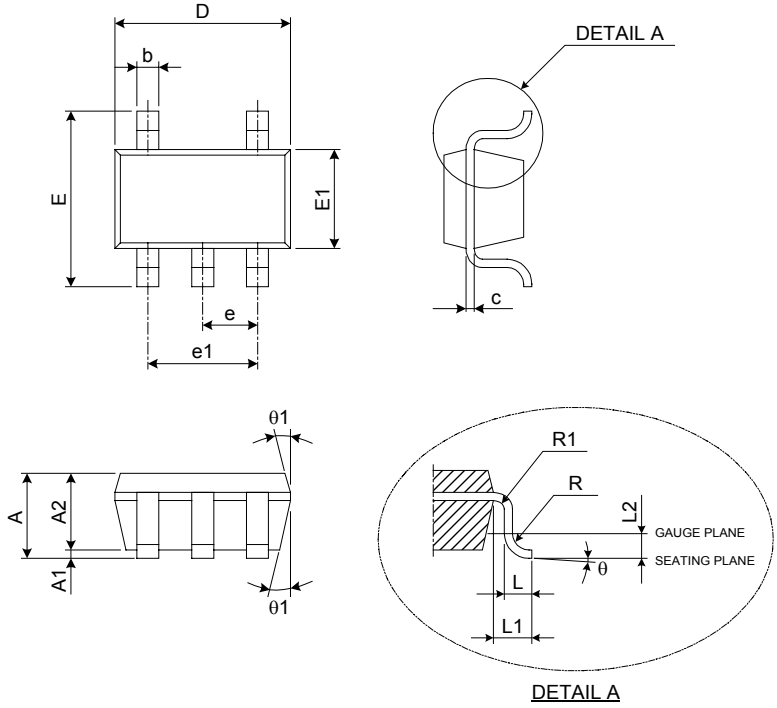
High switching frequencies make PC board layout a very important part of design. Good design minimizes excessive EMI on the feedback paths and voltage gradients in the ground plane, both of which can result in instability or regulation errors.

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 external voltage feedback network should be very close to the FB pin, within 5mm. Keep noisy traces, such as the LX trace, away from the voltage feedback network; also keep them separate, using grounded copper. The output capacitor should be placed close to the output terminals to obtain better smoothing effect on the output ripple.

Package Outline

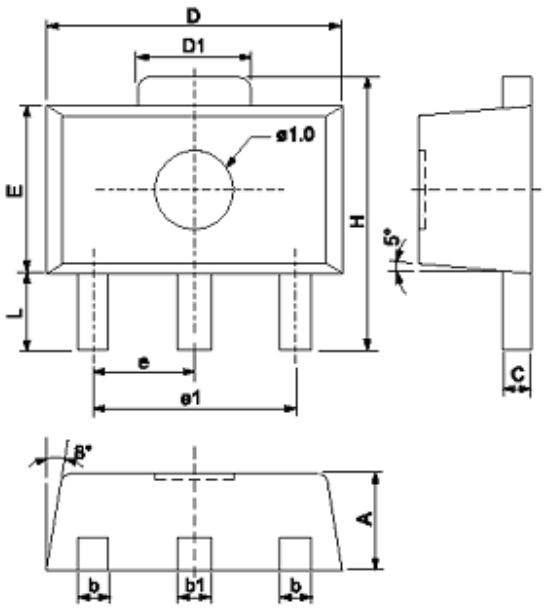
SOT-23-5



Unit : mm

SYMBOL	MIN.	TYP.	MAX.
A	-	-	1.45
A1	-	-	0.15
A2	0.90	1.15	1.30
b	0.30	-	0.50
c	0.08	-	0.22
D	2.90 BSC.		
E	2.80 BSC.		
E1	1.60 BSC.		
e	0.95 BSC.		
e1	1.90 BSC.		
L	0.30	0.45	0.60
L1	0.60 REF.		
L2	0.25 BSC.		
R	0.10	-	-
R1	0.10	-	0.25
θ	0°	4°	8°
θ1	5°	10°	15°

SOT-89



Symbols	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	0.80	--	1.20	0.031	--	0.047
b	0.38	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
H	3.94	--	4.25	0.155	--	0.167
E	2.40	2.50	2.60	0.094	0.098	0.102
e	1.45	1.50	1.55	0.057	0.059	0.061
e1	2.90	3.00	3.10	0.114	0.118	0.122