2.0A Synchronous Step-Down Converter

SSP9312

General Description

The SSP9312 is a high frequency, synchronous, rectified, step-down, switch-mode converter with internal power MOSFETs. It offers a very compact solution to achieve a 2A continuous output current over a wide input supply range, with excellent load and line regulation.The SSP9312 requires a minimal number of readily available, external components and is available in a space saving SOT23-6 package.

SOT23-6

Features

- Wide 3.5V to 16V Operating input Range
- 2A Continuous Output Current
- 500 kHz Frequency Operation
- Built-in Over Current Limit
- Built-in Over Voltage Protection
- PFM Mode for High Efficiency Under Light Load
- Internal Soft start
- 110 mΩ/70 mΩ Low RDS(ON) Internal Power MOSFETs
- Output Adjustable from 0.6V
- Integrated internal compensation
- No Schottky Diode Required
- Thermal Shutdown
- Available in SOT23-6 Package
- -40℃ to +85℃ Temperature Range

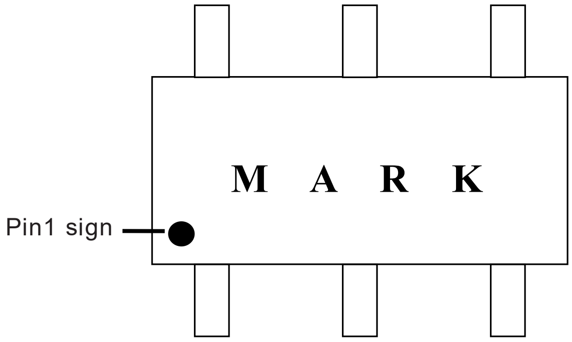
Applications

- Digital Set-top Box (STB)
- Tablet Personal Computer (Pad)
- Flat-Panel Television and Monitor
- Wi-Fi Router / AP
- Digital Video Recorder (DVR)
- Portable Media Player (PMP)
- Cable Modem / XDSL
- General Purpose

Order specification

Part No	Marking	Description	Package	Devices per bag/reel
SSP9312	BAXXX	SSP9312 Buck, 3.5-16V, 2.0A, 500KHz, VFB 0.6V, SOT23-6	SOT23-6	3000PCS/reel

Marking Information

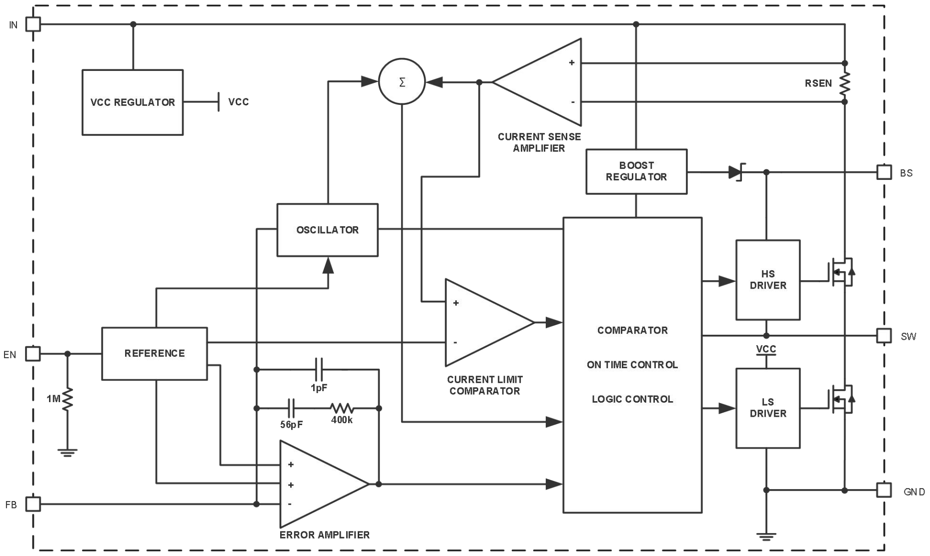


SOT23-6
(TOP VIEW)

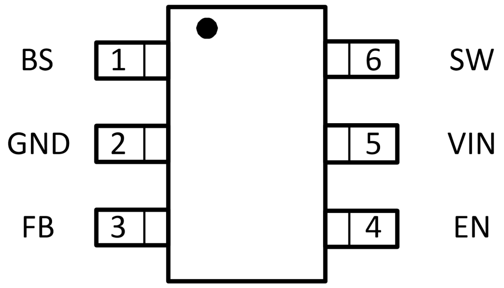
Top marking：BAXXX (device code: BA, lot number code：XXX).

Remark If there are other requirements, please contact our sales office.

Block Diagram



Pin Assignment



(SOT23-6)

Pin No.	Pin Name	Function
1	BS	Bootstrap. A capacitor connected between SW and BST pins is required to form a floating supply across the high-side switch driver.
2	GND	GROUND Pin.
3	FB	Adjustable Version Feedback input. Connect FB to the center point of the external resistor divider.
4	EN	Drive this pin to a logic-high to enable the IC. Drive to a logic-low to disable the IC and enter micro-power shutdown mode.
5	VIN	Power Supply Pin
6	SW	Switching Pin

Functional Description

Internal Regulator

The SSP9312 is a current mode step down DC/DC converter that provides excellent transient response with no extra external compensation components. This device contains an internal, low resistance, high voltage power MOSFET, and operates at a high 500K operating frequency to ensure a compact, high efficiency design with excellent AC and DC performance.

Error Amplifier

The error amplifier compares the FB pin voltage with the internal FB reference (VFB) and outputs a current proportional to the difference between the two. This output current is then used to charge or discharge the internal compensation network to form the COMP voltage, which is used to control the power MOSFET current. The optimized internal compensation network minimizes the external component counts and simplifies the control loop design.

Under-Voltage Lockout (UVLO)

Under-voltage lockout (UVLO) protects the chip from operating at an insufficient supply voltage. UVLO protection monitors the internal regulator voltage. When the voltage is lower than UVLO threshold voltage, the device is shut off. When the voltage is higher than UVLO threshold voltage, the device is enabled again.

Thermal Shutdown

Thermal shutdown prevents the chip from operating at exceedingly high temperatures. When the silicon die temperature exceeds 160℃, it shuts down the whole chip. When the temperature falls below its lower threshold (Typ. 130℃) the chip is enabled again.

Internal Soft-Start

The soft-start is implemented to prevent the converter output voltage from overshooting during startup. When the chip starts, the internal circuitry generates a soft-start voltage (SS) ramping up from 0V to 0.6V. When it is lower than the internal reference (REF), SS overrides REF so the error amplifier uses SS as the reference. When SS is higher than REF, REF regains control. The SS time is internally max to 4.0ms.

Over Current Protection & Hiccup

The SSP9312 has cycle-by-cycle over current limit when the inductor current peak value exceeds the set current limit threshold. Meanwhile, output voltage starts to drop until FB is below the Under-Voltage (UV) threshold, typically 25% below the reference. Once a UV is triggered, the SSP9312 enters hiccup mode to periodically restart the part. This protection mode is especially useful when the output is dead-short to ground. The average short circuit current is greatly reduced to alleviate the thermal issue and to protect the regulator. The SSP9312 exits the hiccup mode once the over current condition is removed.

Startup and Shutdown

If both VIN and EN are higher than their appropriate thresholds, the chip starts. The reference block starts first, generating stable reference voltage and currents, and then the internal regulator is enabled. The regulator provides stable supply for the remaining circuitries. Three events can shut down the chip: EN low, VIN low and thermal shutdown. In the shutdown procedure, the signaling path is first blocked to avoid any fault triggering. The COMP voltage and the internal supply rail are then pulled down. The floating driver is not subject to this shutdown command.

Absolute Maximum Ratings

Item	**Min**	**Max**	**Unit**
Vin,EN,Voltage	-0.3	18	V
Operating Temperature Range	-40	+85	℃
FB Voltages	-0.3	6	V
Lead Temperature(Soldering,10s)		+260	℃
SW Voltage	-0.3	VIN+0.5	V
Storage Temperature Range	-55	150	℃
BS Voltage	Vsw-0.3	Vsw+5	V
ESD(Machine Made)MM		±250	V
ESD(Human Body Made)HBM		±4	KV
Latch-up		±200	mA
Thermal Resistance (θJA)		105	℃/W
Thermal Resistance(θJC)		55	℃/W

Note 1: Exceeding these ratings may damage the device.

Note 2: The device is not guaranteed to function outside of its operating conditions.

Electrical Characteristics(1) (2)

V_{IN}=12V，T_A=25°C,unless otherwise specified.

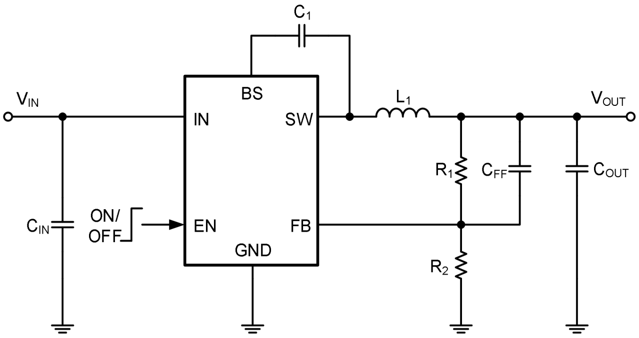
Parameter	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range		3.5(3)		16	V
Supply Current (Quiescent)	V_{EN}=3.0V		0.6	0.8	mA
Supply Current (Shutdown)	V_{IN}=5V, EN=GND			10	µA
	V_{IN}=12V, EN=GND			24	µA
Feedback Voltage		0.585	0.600	0.615	V
High-Side Switch On-Resistance	I_{SW}=100mA		110	120	mΩ
Low-Side Switch On-Resistance	I_{SW}=-100mA		70	80	mΩ
Upper Switch Current Limit		2.5	3	3.5	A
Over Voltage Protection Threshold			18.6	19.5	V
Switching Frequency		400	500	600	KHz
Maximum Duty Cycle	V_{FB}=90%		97		%
Minimum On-Time		65	72	110	nS
EN Rising Threshold		3.3			V
EN Falling Threshold				1.0	V
Under-Voltage Lockout Threshold	Wake up VIN Voltage		3.5	3.8	V
Soft Start			4.0		mS
Thermal Shutdown		150	160		℃
Thermal Hysteresis			30		℃

Note (1): MOSFET on-resistance specifications are guaranteed by correlation to wafer level measurements.

Note (2): Thermal shutdown specifications are guaranteed by correlation to the design and characteristics analysis.

Note (3): When the power supply voltage is between 3.5V and 4.5V, the output current of the chip will be limited. Under the condition of meeting the low dropout requirement, the maximum output current of the chip is approximately 1.5A.

Application Circuits



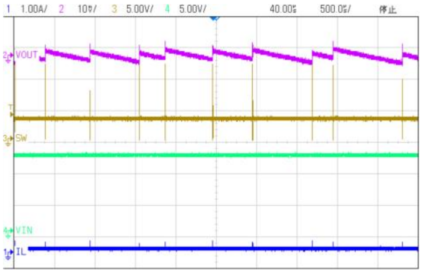
Typical Performance Characteristics

Note (1): Performance waveforms are tested on the evaluation board.

Note (2): VIN =12V, VOUT=3.3V, TA = +25ºC, unless otherwise noted.

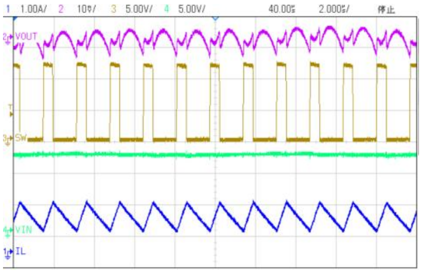
Output Ripple Voltage

V_{IN}=12V,V_{OUT}=3.3V,I_{OUT}=0A



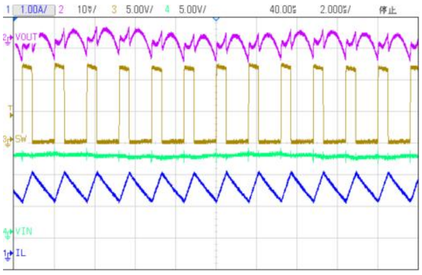
Output Ripple Voltage

V_{IN}=12V,V_{OUT}=3.3V,I_{OUT}=1A



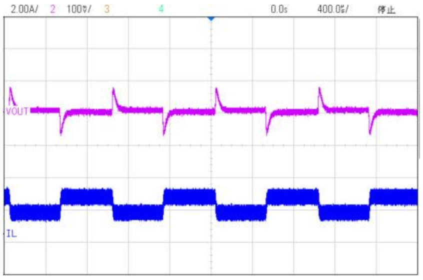
Output Ripple Voltage

V_{IN}=12V,V_{OUT}=3.3V,I_{OUT}=2A



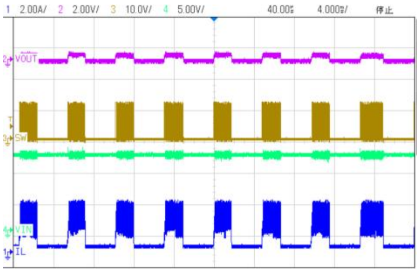
Loop Response

V_{IN}=12V,V_{OUT}=3.3V,I_{OUT}=1A-2A



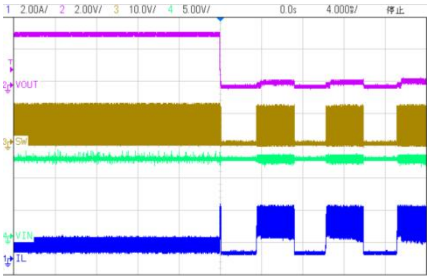
Output Short

V_{IN}=12V,V_{OUT}=3.3V



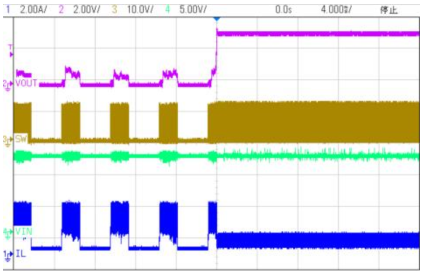
Short Circuit Entry

V_{IN}=12V,V_{OUT}=3.3V， I_{OUT}=0.5A



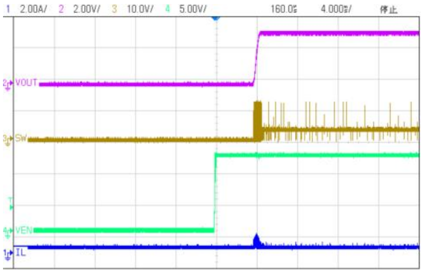
Short Circuit Recovery

V_{IN}=12V,V_{OUT}=3.3V， I_{OUT}=0.5A



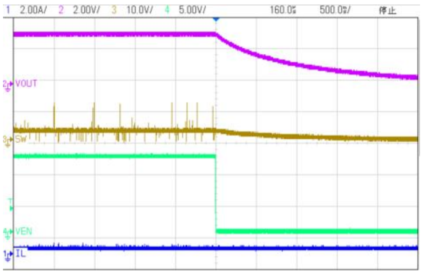
Enable Startup at No Load

V_{IN}=12V,V_{OUT}=3.3V， I_{OUT}=0A



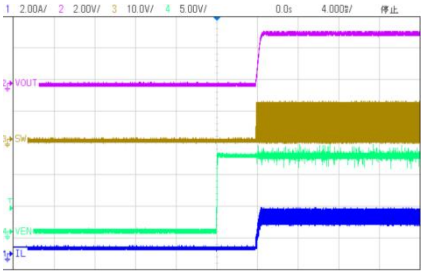
Enable Shutdown at No Load

V_{IN}=12V,V_{OUT}=3.3V， I_{OUT}=0A



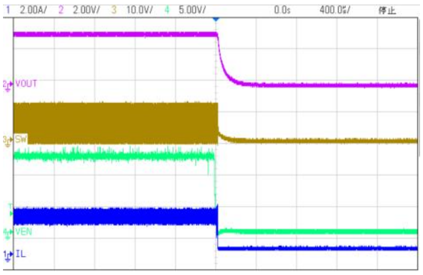
Enable Startup at Full Load

V_{IN}=12V,V_{OUT}=3.3V， I_{OUT}=2A



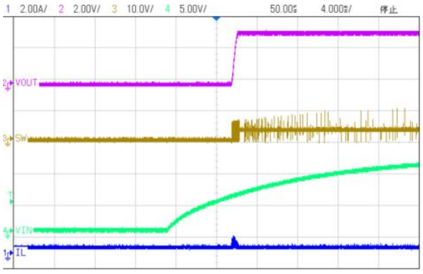
Enable Shutdown at Full Load

V_{IN}=12V,V_{OUT}=3.3V， I_{OUT}=2A



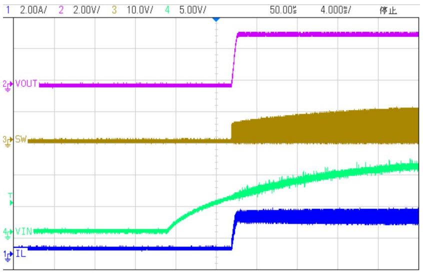
Power Up at No Load

V_{IN}=12V,V_{OUT}=3.3V， I_{OUT}=0A



Power Up at Full Load

V_{IN}=12V,V_{OUT}=3.3V， I_{OUT}=2A



Applications Information

Setting the Output Voltage

SSP9312 require an input capacitor, an output capacitor and an inductor. These components are critical to the performance of the device. SSP9312 are internally compensated and do not require external components to achieve stable operation. The output voltage can be programmed by resistor divider.

$$V_{OUT} = V_{FB} \times \frac{R1 + R2}{R2}$$

V_{OUT}(V)	R1(KΩ)	R2(KΩ)	L1(μH)	C1(nF)	C_{IN}(μF)	C_{OUT}(μF)	C_{FF} (pF) Opt.
1.0	6.67	10	2.2	100	22	22×2	C_{FF} Chapter
1.05	7.5	10	2.2	100	22	22×2	C_{FF} Chapter
1.2	10	10	2.2	100	22	22×2	C_{FF} Chapter
1.5	15	10	2.2	100	22	22×2	C_{FF} Chapter
1.8	20	10	3.3	100	22	22×2	C_{FF} Chapter
2.5	31.67	10	3.3	100	22	22×2	C_{FF} Chapter
3.3	45	10	4.7	100	22	22×2	C_{FF} Chapter
5.0	73.3	10	4.7	100	22	22×2	C_{FF} Chapter

All the external components are the suggested values, the final values are based on the application testing results.

Selecting the Inductor

The recommended inductor values are shown in the Application Diagram. It is important to guarantee the inductor core does not saturate during any foreseeable operational situation. The inductor should be rated to handle the maximum inductor peak current: Care should be taken when reviewing the different saturation current ratings that are specified by different manufacturers. Saturation current ratings are typically specified at 25℃, so ratings at maximum ambient temperature of the application should be requested from the manufacturer. The inductor value can be calculated with:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times F_{OSC}}$$

Where ΔI_L is the inductor ripple current. Choose inductor ripple current to be approximately 30% to 40% of the maximum load current. The maximum inductor peak current can be estimated as:

$$I_{L(MAX)} = I_{LOAD} + \frac{\Delta I_L}{2}$$

Under light load conditions below 100mA, larger inductance is recommended for improved efficiency. Larger inductances lead to smaller ripple currents and voltages, but they also have larger physical dimensions, lower saturation currents and higher linear impedance. Therefore, the choice of inductance should be compromised according to the specific application.

Selecting the Input Capacitor

The input current to the step-down converter is discontinuous and therefore requires a capacitor to supply AC current to the step-down converter while maintaining the DC input voltage. For a better performance, use ceramic capacitors placed as close to VIN as possible and a 0.1μF input capacitor to filter out high frequency interference is recommended. Capacitors with X5R and X7R ceramic dielectrics are recommended because they are stable with temperature fluctuations.

The capacitors must also have a ripple current rating greater than the maximum input ripple current of the converter. The input ripple current can be estimated with Equation:

$$I_{CIN} = I_{OUT} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)}$$

From the above equation, it can be concluded that the input ripple current reaches its maximum at VIN=2VOUT where $I_{CIN} = \frac{I_{OUT}}{2}$. For simplification, choose an input capacitor with an RMS current rating greater than half of the maximum load current.

The input capacitance value determines the input voltage ripple of the converter. If there is an input voltage ripple requirement in the system, choose the input capacitor that meets the specification. The input voltage ripple can be estimate with Equation:

$$\Delta V_{IN} = \frac{I_{OUT}}{F_{OSC} \times C_{IN}} \times \frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Similarly, when VIN=2VOUT, input voltage ripple reaches its maximum of $\Delta V_{IN} = \frac{1}{4} \times \frac{I_{OUT}}{F_{OSC} \times C_{IN}}$.

Selecting the Output Capacitor

An output capacitor is required to maintain the DC output voltage. The output voltage ripple can be estimated with Equation:

$$\Delta V_{OUT} = \frac{V_{OUT}}{F_{OSC} \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR} + \frac{1}{8 \times F_{OSC} \times C_{OUT}}\right)$$

There are some differences between different types of capacitors. In the case of ceramic capacitors, the impedance at the switching frequency is dominated by the capacitance. The output voltage ripple is mainly caused by the capacitance. For simplification, the output voltage ripple can be estimated with Equation:

$$\Delta V_{OUT} = \frac{V_{OUT}}{8 \times {F_{OSC}}^2 \times L \times C_{OUT}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

A larger output capacitor can achieve a better load transient response, but the maximum output capacitor limitation should also be considered in the design application. If the output capacitor value is too high, the output voltage will not be able to reach the design value during the soft-start time and will fail to regulate. The maximum output capacitor value (C_{OUT_MAX}) can be limited approximately with Equation:

$$C_{OUT\_MAX} = \left(I_{LIM\_AVG} - I_{OUT}\right) \times T_{SS} / V_{OUT}$$

Where L_{LIM_AVG} is the average start-up current during the soft-start period, and T_{SS} is the soft-start time.

On the other hand, special attention should be paid when selecting these components. The DC bias of these capacitors can result in a capacitance value that falls below the minimum value given in the recommended capacitor specifications table.

The ceramic capacitor’s actual capacitance can vary with temperature. The capacitor type X7R, which operates over a temperature range of −55℃ to +125℃, will only vary the capacitance to within ±15%. The capacitor type X5R has a similar tolerance over a reduced temperature range of −55℃ to +85℃. Many large value ceramic capacitors, larger than 1uF are manufactured with Z5U or Y5V temperature characteristics. Their capacitance can drop by more than 50% as the temperature varies from 25℃to 85℃. Therefore, X5R or X7R is recommended over Z5U and Y5V in applications where the ambient temperature will change significantly above or below 25℃.

Feed-Forward Capacitor (CFF)

SSP9312 has internal loop compensation, so adding C_{FF} is optional. Specifically, for specific applications, if necessary, consider whether to add feed-forward capacitors according to the situation.

The use of a feed-forward capacitor (C_{FF}) in the feedback network is to improve the transient response or higher phase margin. For optimizing the feed-forward capacitor, knowing the cross frequency is the first thing. The cross frequency (or the converter bandwidth) can be determined by using a network analyzer. When getting the cross frequency with no feed-forward capacitor identified, the value of feed-forward capacitor (C_{FF}) can be calculated with the following Equation:

$$C_{FF} = \frac{1}{2\pi \times F_{CROSS}} \times \sqrt{\frac{1}{R1} \times \left(\frac{1}{R1} + \frac{1}{R2}\right)}$$

Where F_{CROSS} is the cross frequency.

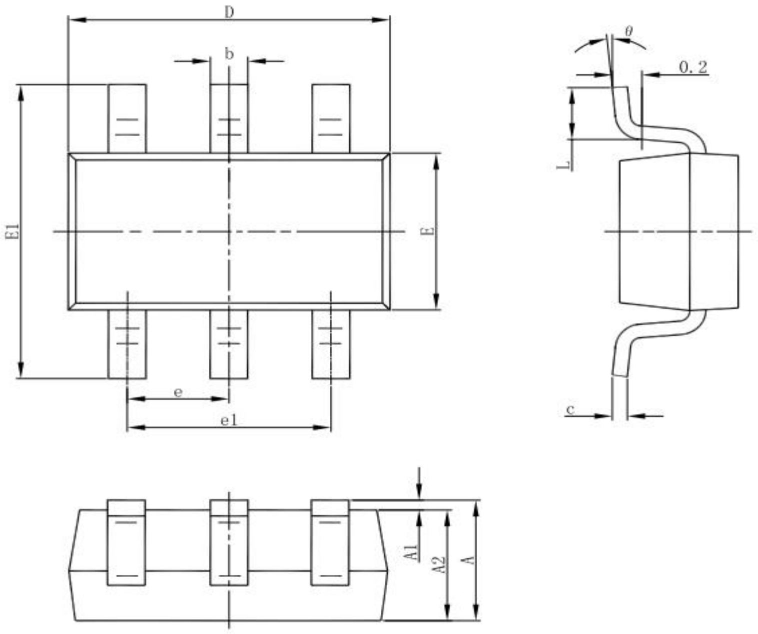
To reduce transient ripple, the feed-forward capacitor value can be increased to push the cross frequency to higher region. Although this can improve transient response, it also decreases phase margin and cause more ringing. In the other hand, if more phase margin is desired, the feed-forward capacitor value can be decreased to push the cross frequency to lower region.

PCB Layout

PCB layout is very important to achieve stable operation. It is highly recommended to duplicate EVB layout for optimum performance. If change is necessary, please follow these guidelines for reference.

1. Keep the path of switching current short and minimize the loop area formed by Input capacitor, high-side MOSFET and low-side MOSFET.
2. Bypass ceramic capacitors are suggested to be put close to the VIN Pin.
3. Ensure all feedback connections are short and direct. Place the feedback resistors and compensation components as close to the chip as possible.
4. VOUT, SW away from sensitive analog areas such as FB.
5. Connect IN, SW, and especially GND respectively to a large copper area to cool the chip to improve thermal performance and long-term reliability.

Package Information（SOT23-6）



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°

Special Instructions

The company reserves the right of final interpretation of this specification.

Version Change Description

Version：V1.0 Author：Yang Time：2025.2.12

Modify the record：

1. Editio princeps

Statement

The information in the usage specification is correct at the time of publication, Shanghai Siproin Microelectronics Co.,Ltd. has the right to change and interpret the specification, and reserves the right to modify the product without prior notice. Users can obtain the latest version information from our official website or other effective channels before confirmation, and verify whether the relevant information is complete and up to date.

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