40V,3.0A, DCDC Step-Down Converter
SSP9467

DESCRIPTION

The SSP9467 is a high frequency step-down switching regulator with integrated internal high-side, high voltage power MOSFET. It provides 3.0A output with current mode control for fast loop response and easy compensation.

The wide 6V to 40V input range accommodates a variety of step-down applications, including those in automotive systems. A 110μA operational quiescent current allows use in battery-powered applications.

High power conversion efficiency over a wide load range is achieved by scaling down the switching frequency at light load condition to reduce theswitching and gate driving losses.

The frequency foldback prevents inductor current runaway during startup and thermal shutdown provides reliable, fault tolerant operation.

The SSP9467 is available in thermally enhanced ESOIC8 package.

FEATURES

- 110 μ A Quiescent Current
- Wide 6V to 40V Operating Input Range
- 150mΩ Internal Power MOSFET
- 500kHz Fixed Switching Frequency
- Ceramic Capacitor Stable
- Internal Soft-Start
- Precision Current Limit without a Current Sensing Resistor
- Up to 90% Efficiency
- Output Adjustable from 0.8V to 30V
- Available in ESOIC8 with Exposed Pad Packages

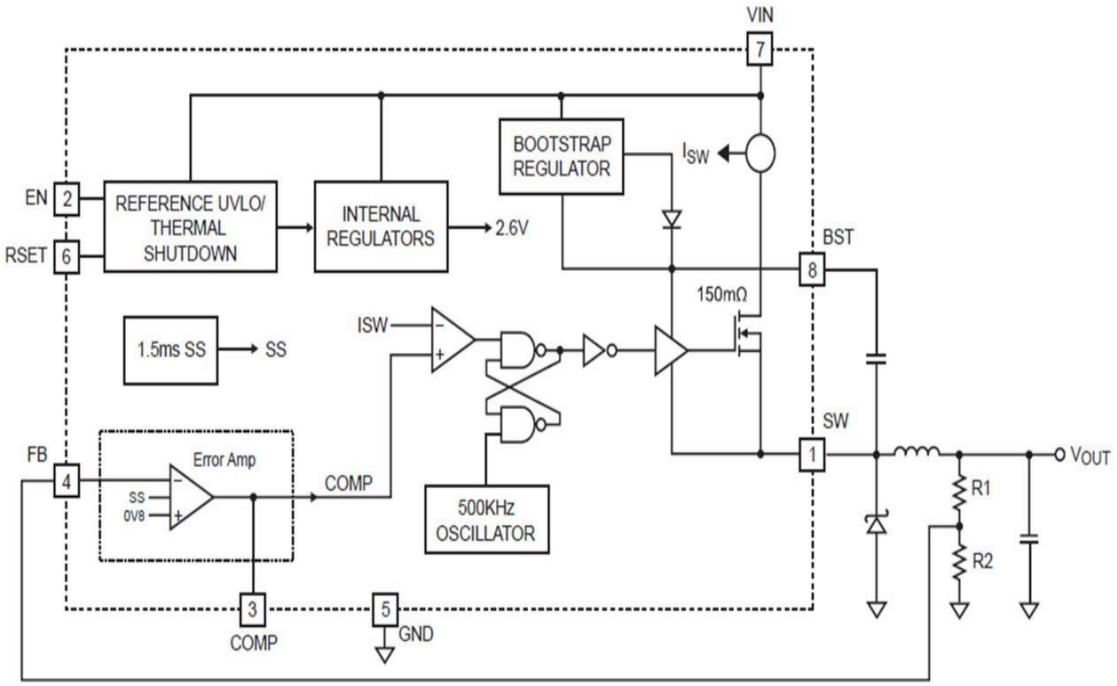
APPLICATIONS

- Game Machines
- Automotive Systems
- Industrial Power Systems
- Distributed Power Systems
- Printer Systems
- Battery Powered Systems

Order specification

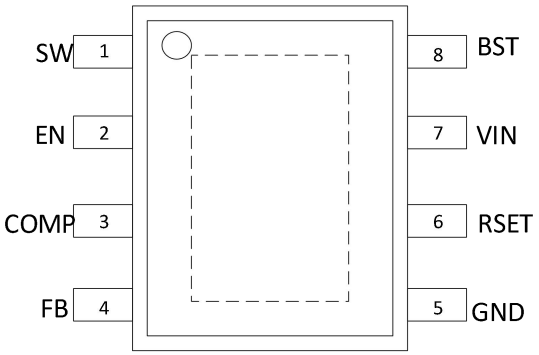
Part No	Package	Manner of Packing	Devices per bag/reel
SSP9467	ESOIC8	Reel	4000

BLOCK DIAGRAM



PACKAGE REFERENCE

TOPVIEW



ESOIC8

PIN FUNCTIONS

Pin	Name	Description
1	SW	Switch Node.This is the output from the high-side switch. A low Vf Schottky rectifier to ground.The rectifier must be close to the SW pins to reduce switching spikes.
2	EN	Enable Input. Pulling this pin below the specified threshold shuts the chip down.Pulling it above the specified threshold or leaving it floating enables the chip.
3	COMP	Compensation. This node is the output of error amplifier.Control loop frequency compensation is applied to this pin.
4	FB	Feedback. This is the input to the error amplifier. An external resistive divider connected between the output and GND is compared to the internal +0.8V reference to set the regulation voltage.
5	GND	Ground. It should be connected as close as possible to the output capacitor avoiding the high current switch paths.
6	RSET	Internal Bias Setting. Connect a 200kΩ resistor to this pin.
7	VIN	Input Supply. This supplies power to all the internal control circuitry, including bootstrap regulator and the high-side switch.A decoupling capacitor to ground must be placed close to this pin to minimize switching spikes.
8	BST	Bootstrap. This is the positive power supply for the internal floating high-side MOSFET driver.Connect a bypass capacitor between this pin and SW pin.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{IN})..... ....–0.3V to 43V
Switch Voltage (V_{SW})..... ....–0.3V to V_{IN} + 0.3V
BST to SW ....–0.3V to +5V
All Other Pins..... ....–0.3V to +5V
Continuous Power Dissipation (T_A = + 25°C).....2.5W
Junction Temperature..... ....150°C
Lead Temperature ....260°C
Storage Temperature..... ....–65°C to +150°C

Recommended Operating Conditions

Supply Voltage V_{IN} ....6V to 40V
Output Voltage V_{OUT}..... ....1V to 30V
Operating Junct. Temp (T_J)..... .... –40°C to +85°C

Thermal Resistance θ_{JA} θ_{JC}

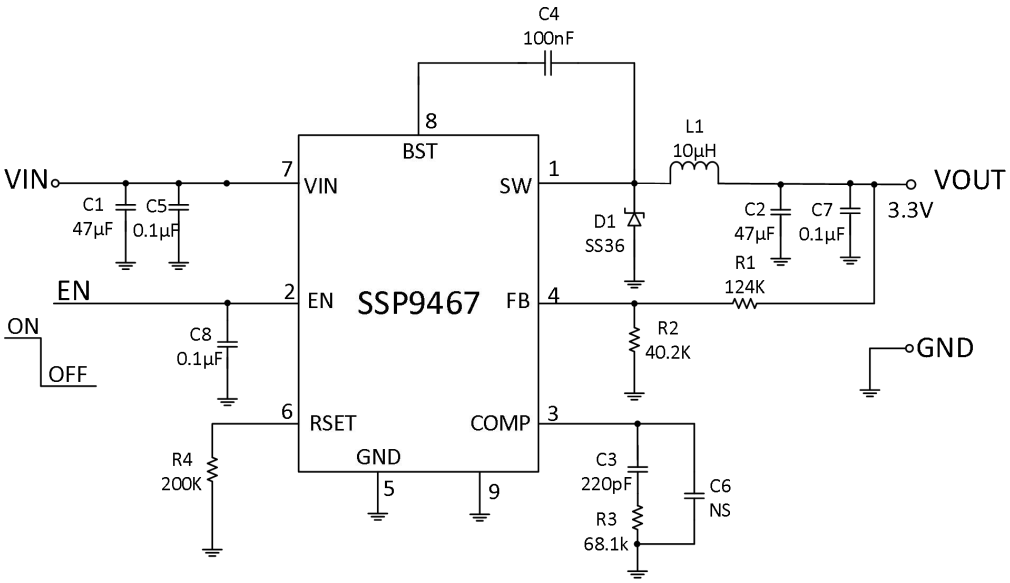
ESOIC8 ..... 50..... 10...°C/W

ELECTRICAL CHARACTERISTICS

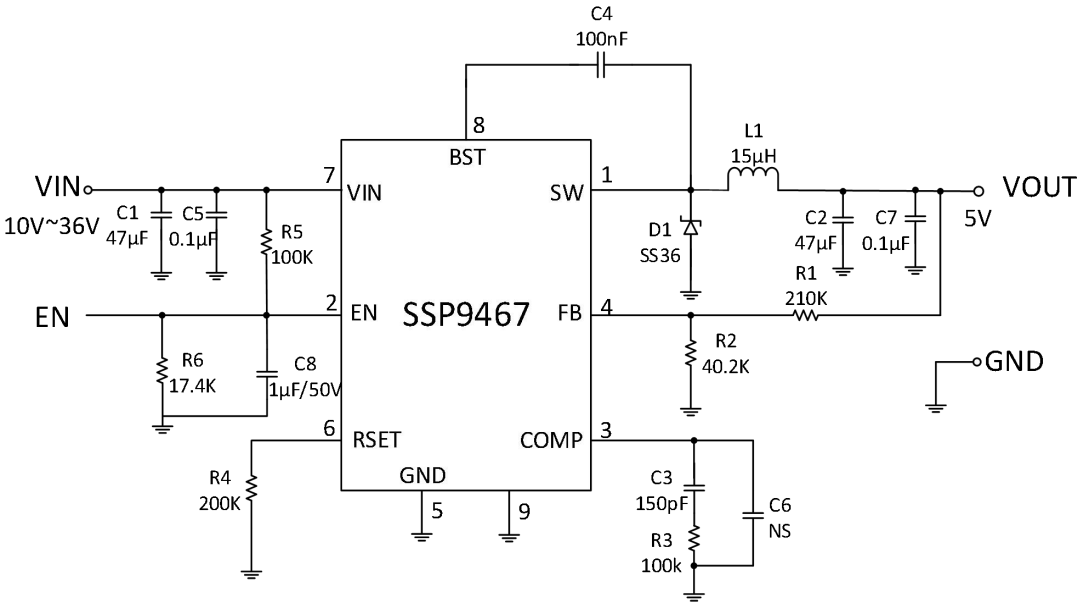
V_{IN} = 12V, V_{EN} = 2.5V, V_{COMP} = 1.4V, T_A = +25°C, unless otherwise noted.

Parameter	Sym.	Condition	Min.	Typ.	Max.	Units
Feedback Voltage	VFB	6V<Vin<40V	0.776	0.8	0.824	V
Upper Switch On Resistance	RDS(ON)	VBST – VSW = 5V		150		mΩ
Upper Switch Leakage		VEN=0V, VSW=0V		1		μA
Current Limit				3.5		A
COMP To Current Sense Transconductance	Gcs			6		A/V
Error Amp Voltage Gain				200		V/V
Error Amp Transconductance		ICOMP = ±3μA	40	60	80	μA/V
Error Amp Min Source current		VFB = 0.7V		5		μA
Error Amp Min Sink current		VFB = 0.9V		-5		μA
VIN UVLO Threshold			2.7	3.0	3.3	V
VIN UVLO Hysteresis				0.35		V
Soft-Start Time		0V<VFB<0.8V		1.5		ms
Oscillator Frequency			400	500	600	KHz
Minimum Switch On Time				100		ns
Shutdown Supply Current		VEN=0V		12	30	μA
Quiescent Supply Current		No load, VFB = 0.9V		110	125	μA
Thermal Shutdown				170		℃
Thermal Shutdown Hysteresis				20		℃
EN Up Threshold			1.8			V
EN Down Threshold					1.25	V
Minimum Off Time				200		ns

TYPICAL APPLICATION



3.3V Output Typical Application Schematic



5V Output Typical Application Schematic

OPERATION

The SSP9467 is a fixed frequency,non-synchronous, step-down switching regulator with an integrated high-side high voltage power MOSFET. It provides a single highly efficient solution with current mode control for fast loop response and easy compensation. It features a wide input voltage range, internal soft-start control and precision current limiting. Its very low operational quiescent current makes it suitable for battery powered applications.

The SSP9467 operates in a fixed frequency, peak current control mode to regulate the outputvoltage. A PWM cycle is initiated by the internal clock. The power MOSFET is turned on and remains on until its current reaches the value set by the COMP voltage. When the power switch is off, it remains off for at least 200ns before the next cycle starts. If, in one PWM period,

the current in the power MOSFET does not reach the COMP set current value, the power MOSFET remains on, saving a turn-off operation.

Error Amplifier

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

During operation, the minimum COMP voltage is clamped to 0.9V and its maximum is clamped to 2.0V. COMP is internally pulled down to GND in shutdown mode. COMP should not be pulled above 2.6V.

Internal Regulator

Most of the internal circuitries are powered from the 2.6V internal regulator. This regulator takes the VIN input and operates in the full VIN range. When VIN is greater than 3.0V, the output of the regulator is in full regulation. When VIN is lower than 3.0V, the output decreases.

Enable Control

The SSP9467 has a dedicated enable control pin(EN). With high enough input voltage, the chip can be enabled and disabled by EN. Its falling threshold is 1.2V, and its rising threshold is 1.8V (600mV higher).

If left open, EN is pulled up to about 3.0V by an internal 1μA current source. To disable the part, EN pin must be pulled down with greater than 2μA current.

Under-Voltage Lockout (UVLO)

Under-voltage lockout (UVLO) is implemented to protect the chip from operating at insufficient supply voltage. The UVLO rising threshold is about 3.0V while its falling threshold is a consistent 2.6V.

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 2.6V. 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.

Thermal Shutdown

Thermal shutdown is implemented to prevent the chip from operating at exceedingly high temperatures. When the silicon die temperature is higher than its upper threshold, it shuts down the whole chip. When the temperature is lower than its lower threshold, the chip is enabled again.

Floating Driver and Bootstrap Charging

The floating power MOSFET driver is powered by an external bootstrap capacitor. This floating driver has its own UVLO protection. This UVLO's rising threshold is 2.2V with a hysteresis of 150mV.

At higher duty cycle operation condition, the time period available to the bootstrap charging may be too short to sufficiently recharge the bootstrap capacitor.

In case the internal circuit does not have sufficient voltage and the bootstrap capacitor is not charged, extra external circuitry can be used to ensure the bootstrap voltage is in the normal operational region.

The DC quiescent current of the floating driver is about 20μA. Make sure the bleeding current at the SW node is higher than this value, such that:

$$I_O + \frac{V_O}{(R1+R2)} > 20\mu A$$

Current Comparator and Current Limit

The power MOSFET current is accurately sensed via a current sense MOSFET. It is then fed to the high speed current comparator for the current mode control purpose. The current comparator takes this sensed current as one of its inputs. When the power MOSFET is turned on, the comparator is first blanked till the end of the turn-on transition to avoid noise issues. The comparator then compares the power switch current with the COMP voltage. When the sensed current is higher than the COMP voltage, the comparator output is low, turning off the power MOSFET. The cycle-by-cycle maximum current of the internal power MOSFET is internally limited.

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.

While the internal supply rail is up, an internal timer holds the signaling path of the power MOSFET turn-on at OFF for about 50μs to blank the startup glitches. When the internal soft-start block is enabled, it first holds its SS output low to ensure the reamining circuitries are ready and then slowly ramps up.

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.

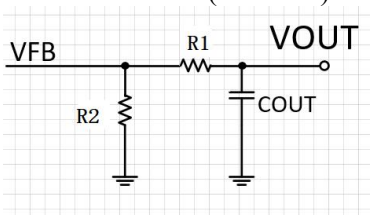
APPLICATION INFORMATION

COMPONENT SELECTION

Setting the Output Voltage

The output voltage is set using a resistive voltage divider from the output voltage to FB pin.
The voltage divider divides the output voltage down to the feedback voltage by the ratio:

VOUT=VFB*(1+R1/R2)



A few μA current from high side BST circuitry can be seen at the output when the SSP9467 is at no load. In order to absorb this small amount of current, keep R2 under 40KΩ.

Inductor

The inductor is required to supply constant current to the output load while being driven by the switched input voltage. A larger value inductor will result in less ripple current that will result in lower output ripple voltage. However, the larger value inductor will have a larger physical size, higher series resistance, and/or lower saturation current.
A good rule for determining the inductance to use is to allow the peak-to-peak ripple current in the inductor to be approximately 30% of the maximum switch current limit. Also, make sure that the peak inductor current is below the maximum switch current limit. The inductance value can be calculated by:

$$L1 = \frac{V_{OUT}}{f_S \times \Delta I_L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where VOUT is the output voltage, VIN is the input voltage, fS is the switching frequency, and ΔIL is the peak-to-peak inductor ripple current.

Output Rectifier Diode

The output rectifier diode supplies the current to the inductor when the high-side switch is off. To reduce losses due to the diode forward voltage and recovery times, use a Schottky diode.
Choose a diode whose maximum reverse voltage rating is greater than the maximum input voltage, and whose current rating is greater than the maximum load current.

Input Capacitor

The input current to the step-down converter is discontinuous, therefore a capacitor is required to supply the AC current to the step-down converter while maintaining the DC input voltage. Use low ESR capacitors for the best performance. Ceramic capacitors are preferred, but tantalum or low-ESR electrolytic capacitors may also suffice.
The input capacitor can be electrolytic, tantalum or ceramic. When using electrolytic or tantalum capacitors, a small, high quality ceramic capacitor, i.e. 0.1μF, should be placed as close to the IC as possible. When using ceramic capacitors, make sure that they have enough capacitance to provide sufficient charge to prevent excessive voltage ripple at input. The input voltage ripple caused by capacitance can be estimated by:

$$\Delta V_{IN} = \frac{I_{LOAD}}{f_S \times C1} \times \frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Output Capacitor

The output capacitor (C2) is required to maintain the DC output voltage. Ceramic, tantalum, or low ESR electrolytic capacitors are recommended. Low ESR capacitors are preferred to keep the output voltage ripple low. The output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR} + \frac{1}{8 \times f_S \times C2}\right)$$

Where L is the inductor value and RESR is the equivalent series resistance (ESR) value of the output capacitor.

PCB LAYOUT GUIDE

PCB layout is very important to achieve stable operation.
If change is necessary, please follow these guidelines .

1) Keep the path of switching current short and minimize the loop area formed by Input cap, high-side MOSFET and external switching diode.

2) Bypass ceramic capacitors are suggested to be put close to the VIN Pin.

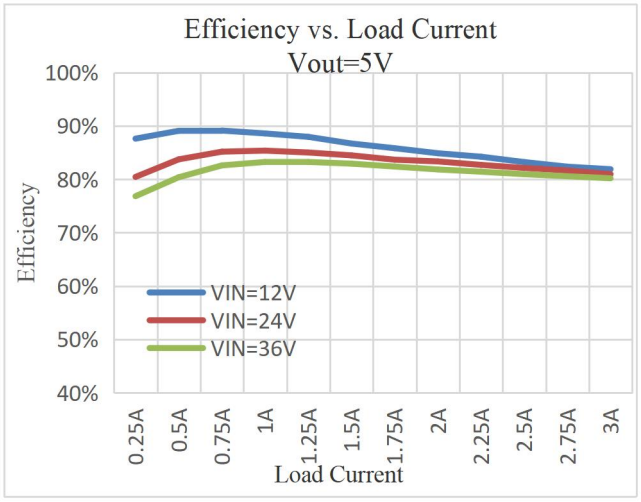
3) Ensure all feedback connections are short and direct. Place the feedback resistors and compensation components as close to the chip as possible.

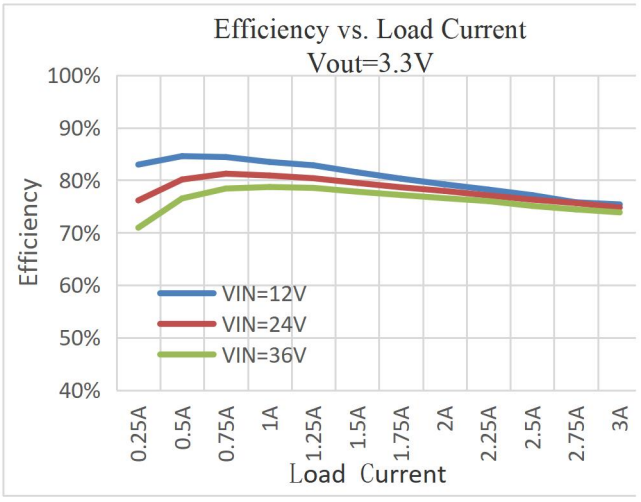
4) Route SW away from sensitive analog areas such as FB.

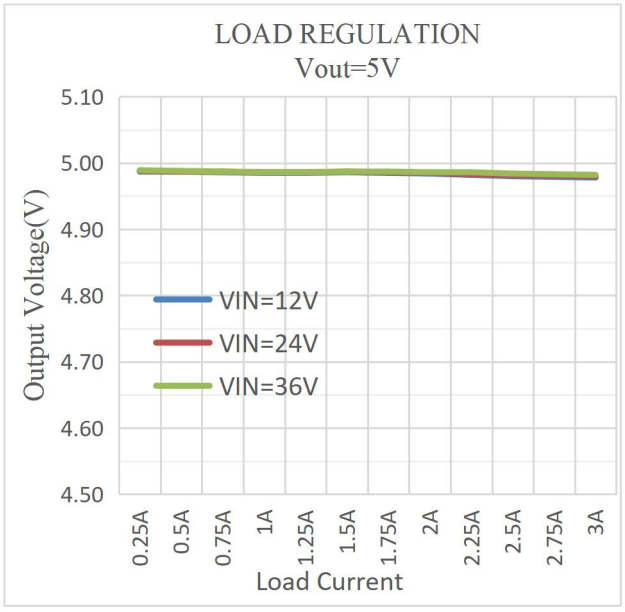
5) Connect IN, SW, and especially GND(Exposed Pad) respectively to a large copper area(GND) to cool the chip to improve thermal performance and long-term reliability.

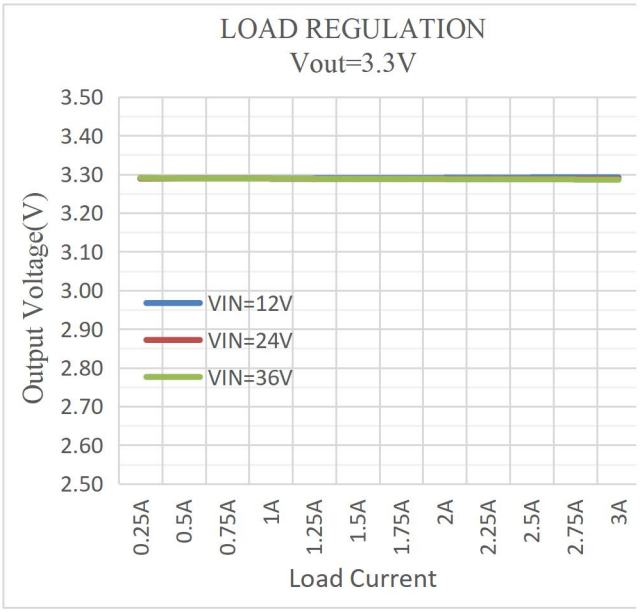
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 12V, Cin = 47µF, Cout = 47µF, L = 4.7µH and T_A = +25°C, unless otherwise noted.

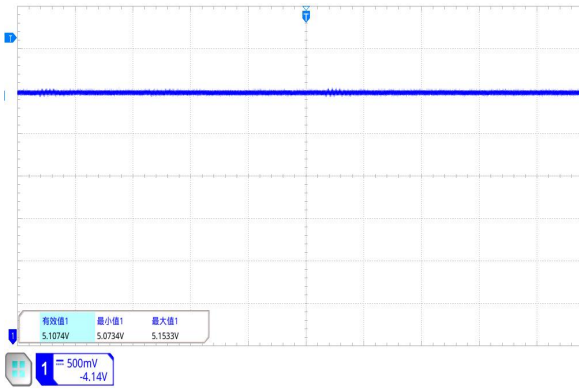




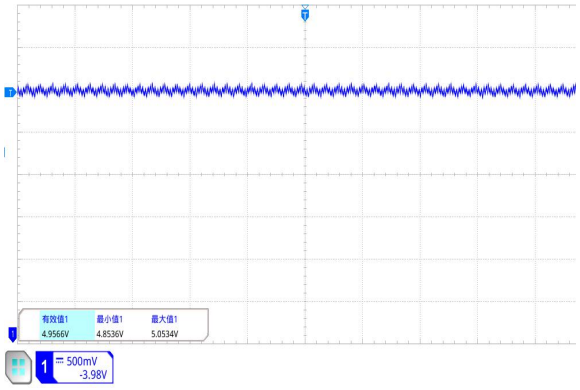




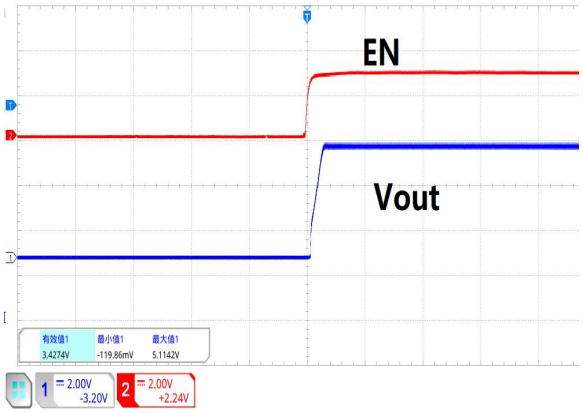
TYPICAL PERFORMANCE CHARACTERISTICS



Vin=12V,Vout=5V,Io=NO Load Time (10μs/div)



Vin=12V,Vout=5V,Io=1A Time (10μs/div)



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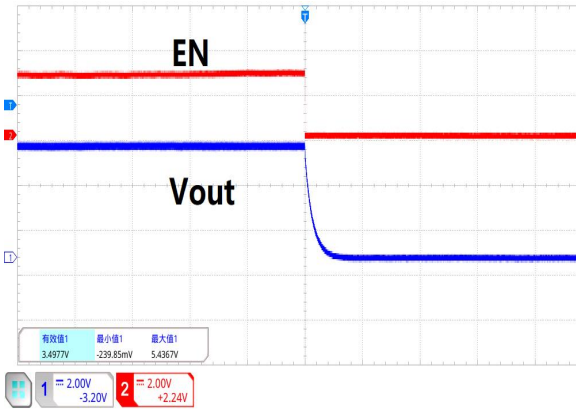
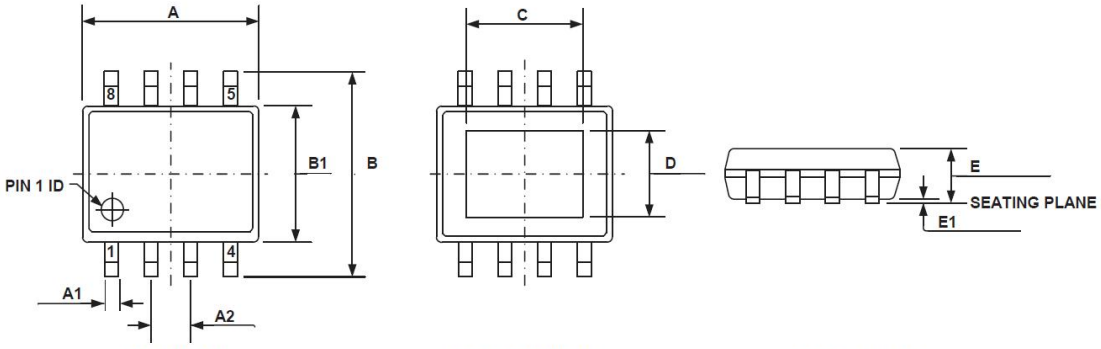
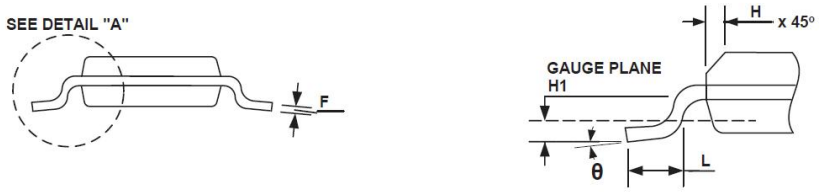


Vin=12V,Vout=5V,Io=1A Time (2ms/div)

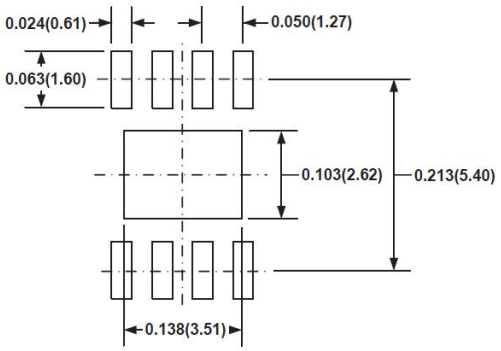
PACKAGE INFORMATION(ESOIC8)



TOP VIEW　　BOTTOM VIEW　　FRONT VIEW



SIDE VIEW　　DETAIL "A"



RECOMMENDED LAND PATTERN

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	4.80	5.00	0.189	0.197
A1	0.33	0.51	0.013	0.020
A2	1.27(BSC)		0.05(BSC)	
B	5.80	6.20	0.228	0.244
B1	3.80	4.00	0.150	0157
C	3.15	3.45	0.124	0.136
D	1.500	1.700	0.059	0.067
E	1.30	1.700	0.051	0.067
E1	0.00	0.15	0.000	0.006
F	0.19	0.25	0.0075	0.0098
H	0.25	0.5	0.010	0.020
H1	0.25(BSC)		0.010(BSC)	
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：XinCHun Li Time：2022.10.12

Modify the record：

1. Original Version

Version：V1.1 Author：XinCHun Li Time：2022.11.25

Modify the record：

1. Update typical application diagrams

Version：V1.2 Author：Yang Time：2023.04.11

Modify the record：

1. Update Application information

Statement

The information in the usage specification is correct at the time of publication, Shanghai Siproin Microelectronics Co. 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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