300mA Low-Noise LDO Regulators

FEATURES

- Ultra low output noise of 30µV (rms)
- Ultra low no-load supply current of 55µA
- Ultra low dropout of 70mV at 50mA load
- Guaranteed 300mA output current
- Over-temperature and short-circuit protection
- Fixed: 3.30V (SS8014-33), 3.0V (SS8014-30)
  2.85V (SS8014-29), 2.80V (SS8014-28)
  2.70V (SS8014-27), 2.50V (SS8014-25)
  1.80V(SS8014-18), 1.50V(SS8014-15)
- Max. supply current in shutdown mode < 1µA
- Stable with low cost ceramic capacitors

DESCRIPTION

The SS8014-xxG is a low supply-current, low-dropout linear regulator that comes in a space-saving SOT23-5 package. The supply current at no-load is 55µA. In the shutdown mode, the maximum supply current is less than 1µA. Operating voltage range of the SS8014 is from 2.5V to 5.5V. The over-current protection limit is set at 500mA typical and 400mA minimum. An over-temperature protection circuit is built-in to the SS8014 to prevent thermal overload. These power saving features make the SS8014 ideal for use in such battery-powered applications as notebook computers, cellular phones, and PDA's.

APPLICATIONS

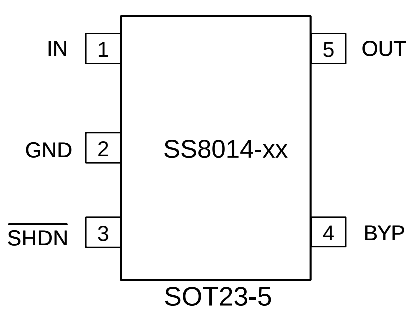
- Notebook Computers
- Cellular Phones
- PDA
- Hand-Held Devices
- Battery-Powered Application

ORDERING INFORMATION

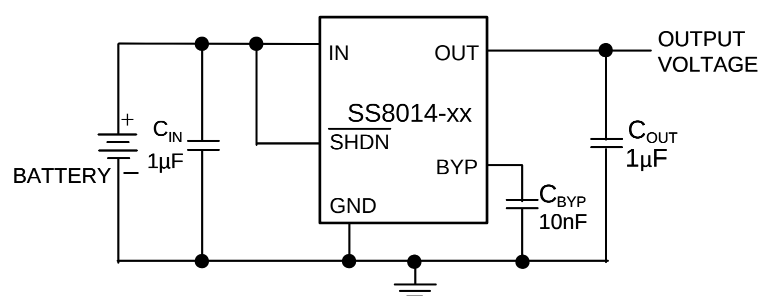
Part Number	Marking	Voltage
SS8014-15GTR	4Gxx	1.50V
SS8014-18GTR	4Hxx	1.80V
SS8014-25GTR	4Exx	2.50V
SS8014-27GTR	4Axx	2.70V
SS8014-28GTR	4Bxx	2.80V
SS8014-29GTR	4Fxx	2.85V
SS8014-30GTR	4Cxx	3.0V
SS8014-33GTR	4Dxx	3.30V

This device is only available with Pb-free lead finish (second-level interconnect).

Pin Configuration



Typical Operating Circuit



Absolute Maximum Ratings

V_{IN} to GND……………………………………………………………………-0.3V to +7V
Output Short-Circuit Duration……………………………………………………………Infinite
All Other Pins to GND……………………………………………………-0.3V to (V_{IN} + 0.3V)
Continuous Power Dissipation (T_A = +25°C)
SOT 23-5 …………………………………………………………………………………520 mW
Operating Temperature Range………………………………………………-40°C to +85°C
Junction Temperature……………………………………………………………………+150°C
θ_{JA} …….See Recommended Minimum Footprint (Figure 2)………………………………240°C/Watt
Storage Temperature Range……………………………………………………-65°C to +160°C
Lead Temperature (soldering, 10sec)……………………………………………………+260°C

Electrical Characteristics

(V_{IN}=$V_{OUT(STD)}$+1V, $V_{\overline{SHDN}}$=V_{IN}, T_A=T_J=25°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Voltage (Note 2)	V_{IN}			Note2	-	5.5	V
Output Voltage Accuracy	V_{OUT}	Variation from specified V_{OUT}, I_{OUT}=1mA,V_{OUT}≥2.5V version		-2	-	2	%
		For SS8014-18, I_{OUT} =1mA		-3	-	3	
		For SS8014-15, I_{OUT} =1mA		-4	-	4	
Maximum Output Current					300	-	mA
Current Limit (Note 3)	I_{LIM}				500	-	mA
Ground Pin Current	I_Q	V_{IN} =3.6V	I_{LOAD} = 0mA		55	120	µA
			I_{LOAD} = 50mA		145		
			I_{LOAD} = 300mA		265		
Dropout Voltage (Note 4)	V_{DROP}	I_{OUT} = 1mA			2		mV
		I_{OUT} = 50mA, V_{OUT} ≥ 2.7V Version			70		
		I_{OUT} = 150mA	$V_{O (NOM)}$ ≥ 3.0V		230		
			2.5V≤$V_{O (NOM)}$≤2.85V		250		
			$V_{O (NOM)}$ = 1.8V		380		
			$V_{O (NOM)}$ = 1.5V		510		
		I_{OUT} =300mA	$V_{O (NOM)}$ ≥ 3.0V		450	600	
			2.5V≤$V_{O (NOM)}$≤2.85V		500	660	
			$V_{O (NOM)}$ = 1.8V		760	960	
			$V_{O (NOM)}$ = 1.5V		910	1220	
Line Regulation	ΔV_{LNR}	V_{IN}=V_{OUT}+100mV to 5.5V, I_{OUT} = 1mA			0.1	0.28	%/V
Load Regulation (Note 5)	ΔV_{LDR}	I_{OUT} = 1mA to 150mA			0.35		%
		I_{OUT} = 1mA to 300mA				2	
Power Supply Rejection Ratio	PSRR	I_{OUT} = 30mA C_{BYP} = 10nF, f = 120HZ			57		dB
Output Voltage Temperature Coefficient	$\Delta V_O / \Delta T$	I_{OUT} = 50mA, T_J = 25°C to 125°C			30		ppm/°C
Output Voltage Noise (10Hz to 100kHz) (SS8014-18)	e_n	V_{IN}=V_{OUT}+1V	C_{OUT} = 1µF, I_{OUT} = 150mA, C_{BYP}=1nF		52		μV_{RMS}
			C_{OUT} = 1µF, I_{OUT} = 150mA, C_{BYP}=10nF		35		
			C_{OUT} = 1µF, I_{OUT} = 150mA, C_{BYP} = 100nF		30		
			C_{OUT} = 1µF, I_{OUT} = 1mA, C_{BYP} = 10nF		26		
SHUTDOWN							
$\overline{SHDN}$ Input Threshold	V_{IH}	Regulator enabled		V_{IN} - 0.7			V
	V_{IL}	Regulator shutdown				0.4	
$\overline{SHDN}$ Input Bias Current	I_{SHDN}	$V_{\overline{SHDN}}$ = V_{IN}	T_A = +25°C		0.003	0.1	µA
Shutdown Supply Current	$I_{Q\ SHDN}$	V_{OUT} = 0V	T_A = +25°C			1	
THERMAL PROTECTION							
Thermal Shutdown Temperature	T_{SHDN}				150		°C
Thermal Shutdown Hysteresis	ΔT_{SHDN}				15		°C

Note 1: Limits are 100% production tested at T_A= +25°C. Low duty pulse techniques are used during test to maintain junction temperature as close to ambient as possible.

Note 2: $V_{IN\ (min)}=V_{OUT\ (STD)}+V_{DROPOUT}$

Note 3: Not tested. For design purposes, the current limit should be considered 400mA minimum to 600mA maximum.

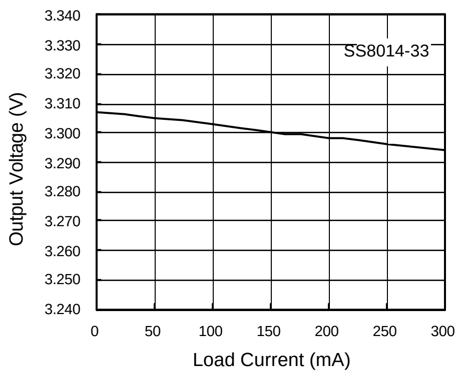
Note 4: The dropout voltage is defined as (V_{IN} - V_{OUT}) when V_{OUT} is 100mV below the value of V_{OUT} for V_{IN} = V_{OUT} +1V. For the performance of each SS8014-xx version, see “Typical Performance Characteristics”.

Note 5: Regulation is measured at constant junction temperature using low duty cycle pulse testing. Parts are tested for load regulation in the load range from 1mA to 300mA. Changes in output due to heating effects are covered by the thermal regulation specification.

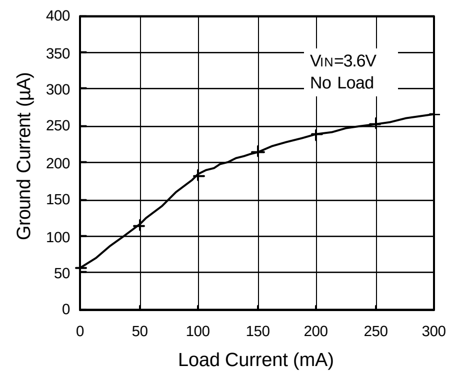
Typical Performance Characteristics

(V_{IN} = V_O+1V, C_{IN}=1µF, C_{OUT}=1µF, $V_{\overline{SHDN}}$ = V_{IN}, SS8014-33, T_A =25°C, unless otherwise noted.)

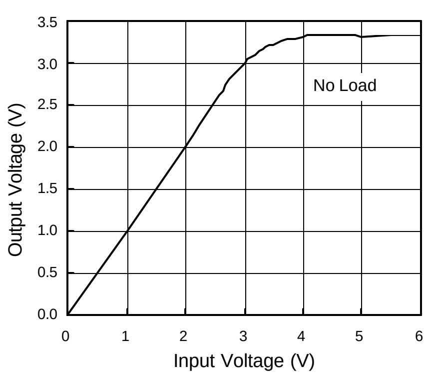
Output Voltage vs. Load Current



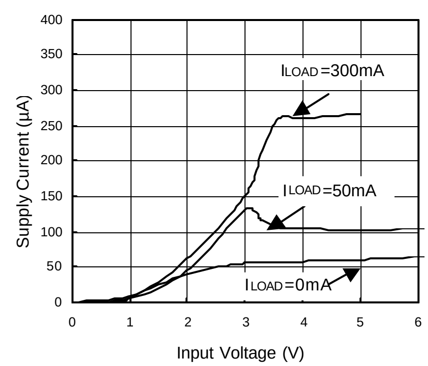
Ground Current vs. Load Current



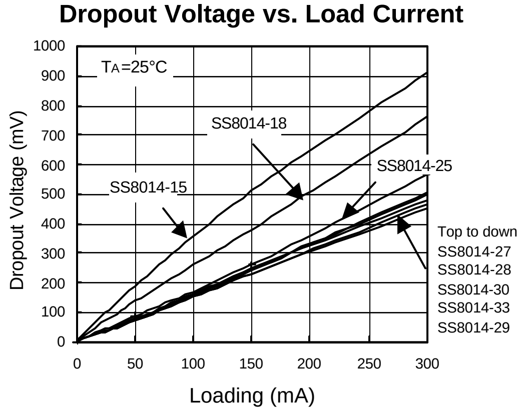
Output Voltage vs. Input Voltage



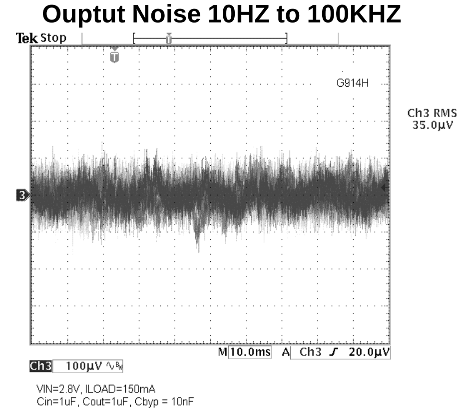
Supply Current vs. Input Voltage



Dropout Voltage vs. Load Current

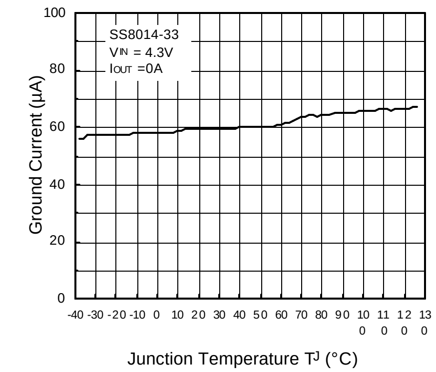


Ouptut Noise 10HZ to 100KHZ

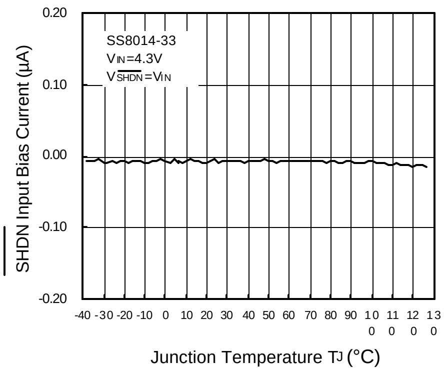


Typical Performance Characteristics (continued)

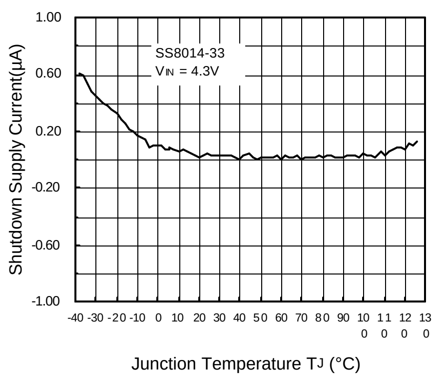
Ground Current vs. Temperature



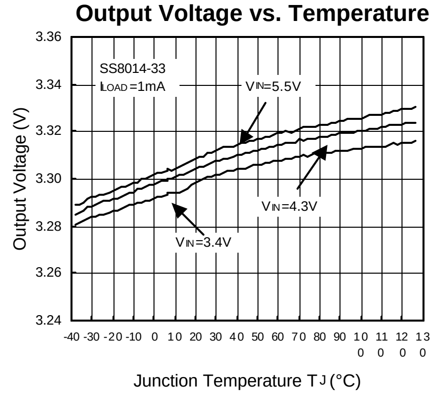
SHDN Input Bias Current vs. Temperature



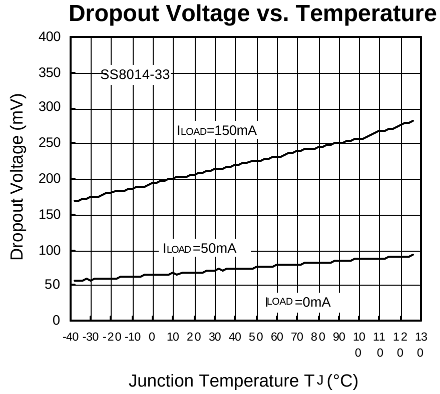
Shutdown Supply Current vs. Temperature



Output Voltage vs. Temperature

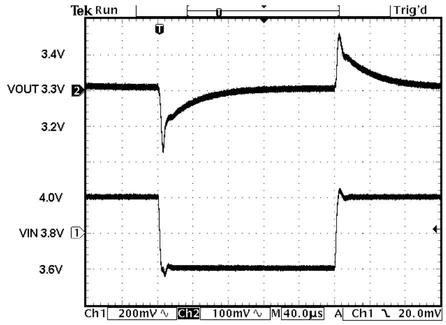


Dropout Voltage vs. Temperature



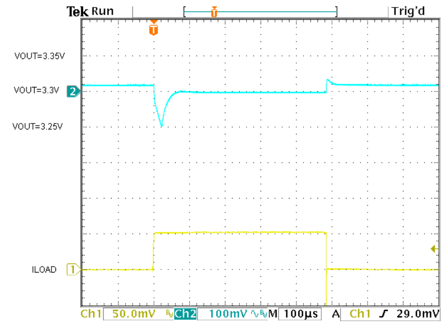
Typical Performance Characteristics (continued)

Line Transient



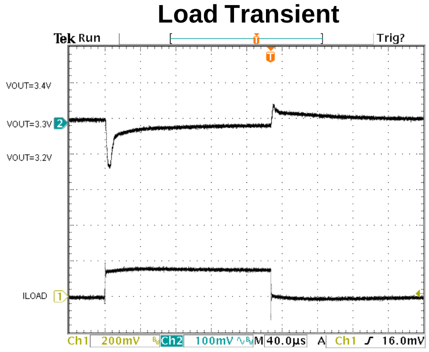
ILOAD = 50mA , VOUT is AC Coupled

Load Transient



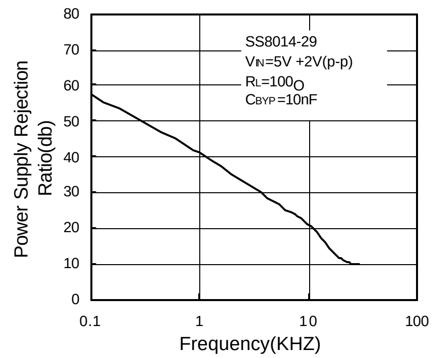
Vin=3.6V, Iload = 0mA to 100mA transient , Vout is AC coupled

Load Transient

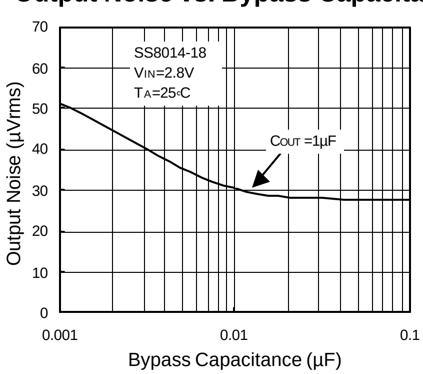


Vin=4.3V, Iload= 0mA to 300mA , Vout is AC coupled

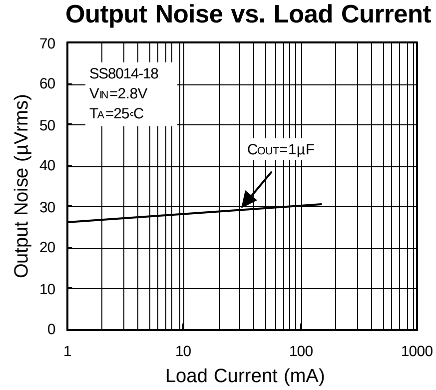
Power Supply Rejection Ripple



Output Noise vs. Bypass Capacitance

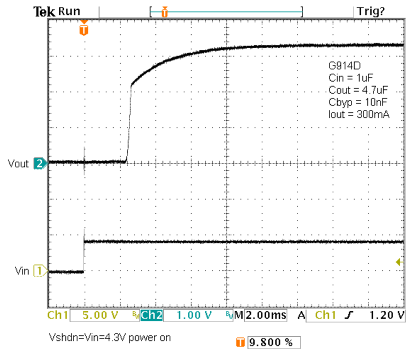


Output Noise vs. Load Current

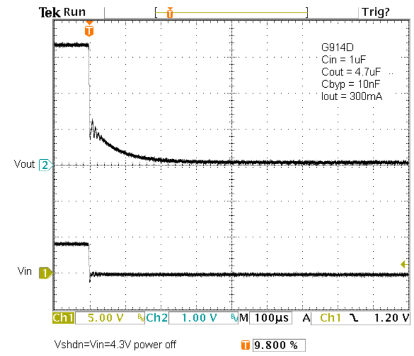


Typical Performance Characteristics (continued)

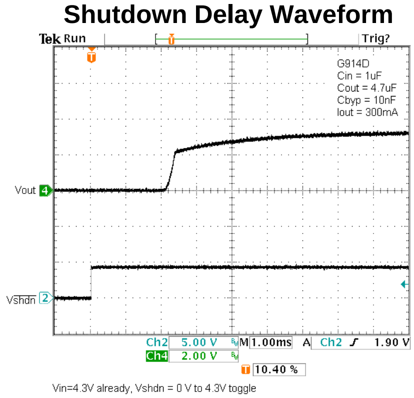
Power On Response Waveform



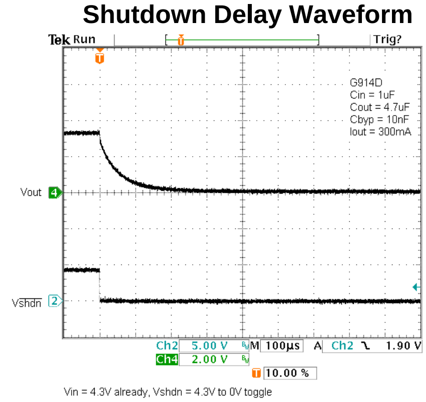
Power Off Response Waveform



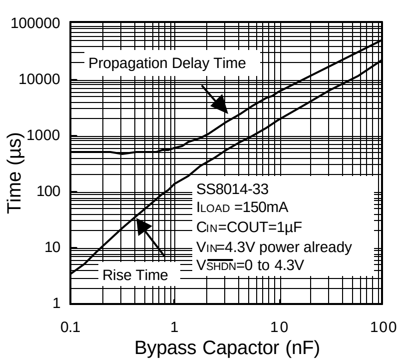
Shutdown Delay Waveform



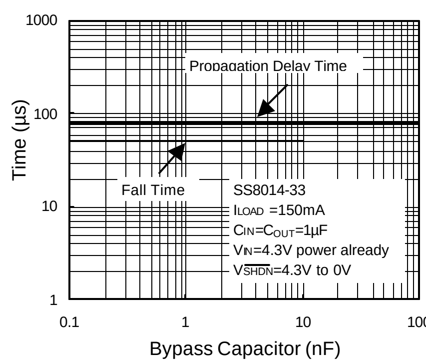
Shutdown Delay Waveform



Turn-On Time vs. Bypass Capacitance



Turn-Off Time vs. Bypass Capacitance



Pin Description

PIN	NAME	FUNCTION
1	IN	Regulator Input. Supply voltage can range from +2.5V to +5.5V. Bypass with 1µF to GND.
2	GND	Ground. This pin also functions as a heatsink. Solder to large pads or the circuit board ground plane to maximize thermal dissipation.
3	$\overline{SHDN}$	Active-High Enable Input. A logic low reduces the supply current to less than 1µA. Connect to IN for normal operation.
4	BYP	This is a reference bypass pin. It should connect external 10nF capacitor to GND to reduce output noise. Bypass capacitor must be no less than 1nF. ($C_{BYP} \geq$ 1nF)
5	OUT	Regulator Output. Sources up to 150mA. Bypass with a 1µF, <0.2Ω typical ESR capacitor to GND.

Detailed Description

The block diagram of the SS8014-xx is shown in Figure 1. It consists of an error amplifier, 1.25V bandgap reference, PMOS output transistor, internal feedback voltage divider, shutdown logic, over current protection circuit, and over temperature protection circuit.

The internal feedback voltage divider's central tap is connected to the non-inverting input of the error amplifier. The error amplifier compares non-inverting input with the 1.25V bandgap reference. If the feedback voltage is higher than 1.25V, the error amplifier's output becomes higher so that the PMOS output transistor has a smaller gate-to-source voltage (V_{GS}). This reduces the current carrying capability of the PMOS output transistor, as a result the output voltage decreases until the feedback voltage is equal to 1.25V. Similarly, when the feedback voltage is less than 1.25V, the error amplifier causes the output PMOS to conduct more current to pull the feedback voltage up to 1.25V. Thus, through this feedback action, the error amplifier, output PMOS, and the voltage-divider effectively form a unity-gain amplifier with the feedback voltage forced to be the same as the 1.25V bandgap reference. The output voltage, V_{OUT}, is then given by the following equation:

$$V_{OUT} = 1.25\ (1 + R1/R2). \qquad (1)$$

Alternatively, the relationship between R1 and R2 is given by:

$$R1 = R2\ (V_{OUT} / 1.25 + 1). \qquad (2)$$

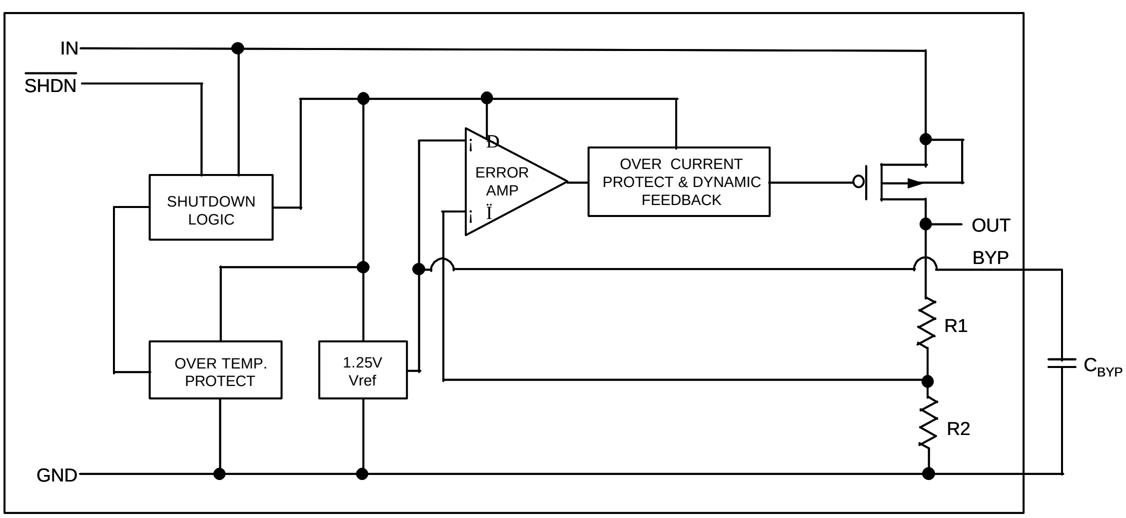


Figure 1. Functional Diagram

Over Current Protection

The SS8014 uses a current mirror to monitor the output current. A small portion of the PMOS output transistor's current is mirrored onto a resistor such that the voltage across this resistor is proportional to the output current. This voltage is compared against the 1.25V reference. Once the output current exceeds the limit, the PMOS output transistor is turned off. Once the output transistor is turned off, the current monitoring voltage decreases to zero, and the output PMOS is turned on again. If the over current condition persist, the over current protection circuit will be triggered again. Thus, when the output is shorted to ground, the output current will be alternating between 0 and the over current limit. The typical over current limit of the SS8014 is set to 350mA. Note that the input bypass capacitor of 1µF must be used in this case to filter out the input voltage spike caused by the surge current due to the inductive effect of the package pin and the printed circuit board's routing wire. Otherwise, the actual voltage at the IN pin may exceed the absolute maximum rating.

Over Temperature Protection

To prevent abnormal temperature from occurring, the SS8014 has a built-in temperature monitoring circuit. When it detects the temperature is above 150°C, the output transistor is turned off. When the IC is cooled down to below 135°C, the output is turned on again. In this way, the SS8014 will be protected against abnormal junction temperature during operation.

Shutdown Mode

When the $\overline{SHDN}$ pin is connected a logic low voltage, the SS8014 enters shutdown mode. All the analog circuits are turned off completely, which reduces the current consumption to only the leakage current. The output is disconnected from the input. When the output has no load at all, the output voltage will be discharged to ground through the internal resistor voltage divider.

Operating Region and Power Dissipation

Since the SS8014 is a linear regulator, its power dissipation is always given by $P = I_{OUT} (V_{IN} - V_{OUT})$. The maximum power dissipation is given by:

$$P_{DMAX} = (T_J - T_A)/\Theta_{JA} = (150\text{-}25) / 240 = 520mW$$

where $(T_J - T_A)$ is the temperature difference between the SS8014 die and the ambient air, and θ_{JA}, is the thermal resistance of the chosen package to the ambient air. For surface mount devices, heat sinking is accomplished by using the heat spreading capabilities of the PC board and its copper traces. In the case of a SOT23-5 package, the thermal resistance is typically 240°C/Watt. (See Recommended Minimum Footprint) [Figure 2]. Refer to Figure 3 for the SS8014 valid operating region (Safe Operating Area) & refer to Figure 4 for the maximum power dissipation of the SOT-23-5.

The die attachment area of the SS8014's lead frame is connected to pin 2, which is the GND pin. Therefore, the GND pin of SS8014 can carry away the heat of the SS8014 die very effectively. To improve the power dissipation, connect the GND pin to ground using a large ground plane near the GND pin.

Applications Information

Capacitor Selection and Regulator Stability

Normally, use a 1µF capacitor on the input and a 1µF capacitor on the output of the SS8014. Larger input capacitor values and lower ESR provide better supply-noise rejection and transient response. A higher-value input capacitor (10µF) may be necessary if large, fast transients are anticipated and the device is located several inches from the power source. For stable operation over the full temperature range, with load currents up to 120mA, a minimum of 1µF is recommended.

Power-Supply Rejection and Operation from Sources Other than Batteries

The SS8014 is designed to deliver low dropout voltages and low quiescent currents in battery powered systems. Power-supply rejection is 57dB at low frequencies as the frequency increases above 20 kHz; the output capacitor is the major contributor to the rejection of power-supply noise.

When operating from sources other than batteries, improve supply-noise rejection and transient response by increasing the values of the input and output capacitors, and using passive filtering techniques.

Load Transient Considerations

The SS8014 load-transient response graphs show two components of the output response: a DC shift of the output voltage due to the different load currents, and the transient response. Typical overshoot for step changes in the load current from 0mA to 100mA is 12mV. Increasing the output capacitor's value and decreasing its ESR attenuates transient spikes.

Input-Output (Dropout) Voltage

A regulator's minimum input-output voltage differential (or dropout voltage) determines the lowest usable supply voltage. In battery-powered systems, this will determine the useful end-of-life battery voltage. Because the SS8014 uses a P-channel MOSFET pass transistor, the dropout voltage is a function of $R_{DS(ON)}$ multiplied by the load current.

Layout Guide

An input capacitance of ~1µF is required between the SS8014 input pin and ground (the amount of the capacitance may be increased without limit), This capacitor must be located a distance of not more than 1cm from the input and return to a clean analog ground.

The input capacitor filters out the input voltage spike caused by the surge current due to the inductive effect of the package pin and the printed circuit board's routing wire. Otherwise, the actual voltage at the IN pin may exceed the absolute maximum rating.

The output capacitor also must be located a distance of not more than 1cm from output to a clean analog ground, so that it can filter out the output spike caused by the surge current due to the inductive effect of the package pin and the printed circuit board's routing wire. Figure 5 is the SS8014 PCB recommended layout.

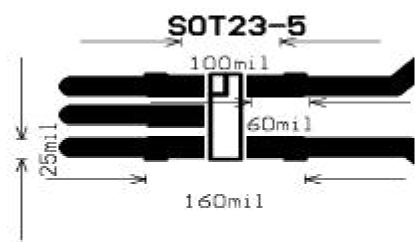
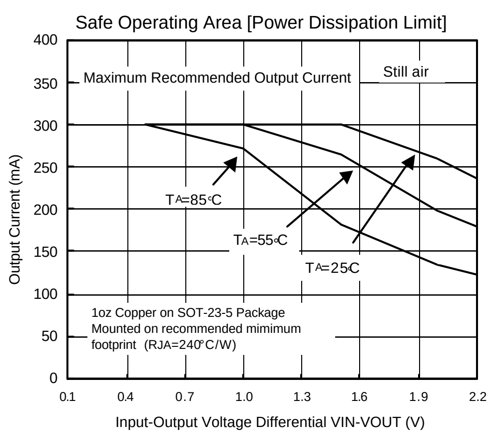


Figure 2. Recommended Minimum Footprint



Note: VIN(max) <= 5.5V

Figure 3. Safe Operating Area

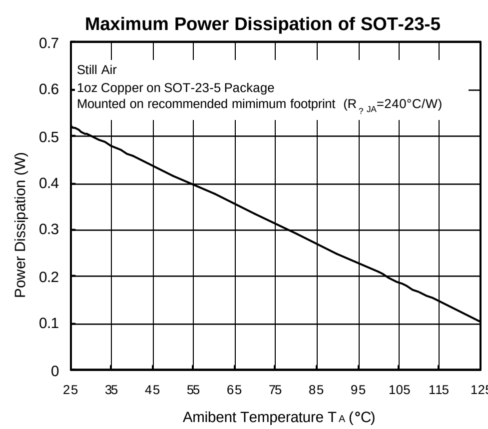


Figure 4. Power Dissipation vs. Temperature

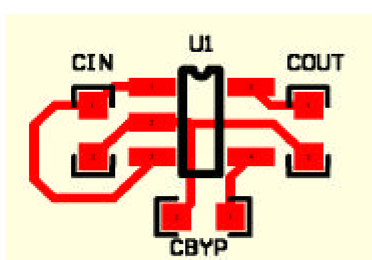
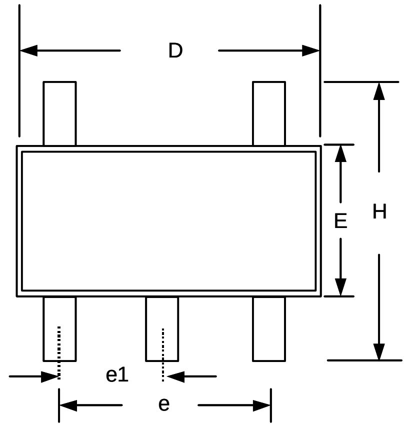
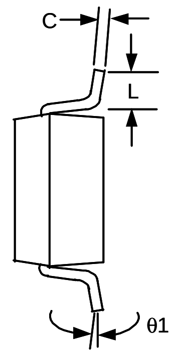


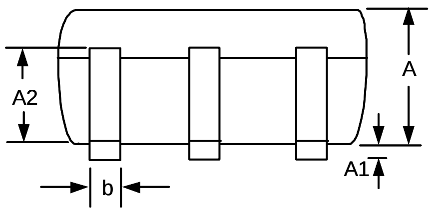
Figure 5. Fixed Mode

*Distance between pin & capacitor must be no more than 1cm

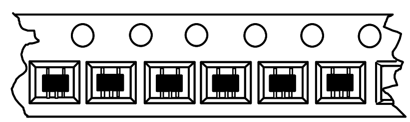
Physical Dimensions







Tape/package orientation



Feed Direction
SOT23-5 package orientation

Note:

1. Package body sizes exclude mold flash protrusions or gate burrs
2. Tolerance ±0.1000 mm (4mil) unless otherwise specified
3. Coplanarity: 0.1000mm
4. Dimension L is measured in gage plane

SYMBOLS	DIMENSIONS IN MILLIMETERS		
	MIN	NOM	MAX
A	1.00	1.10	1.30
A1	0.00	-----	0.10
A2	0.70	0.80	0.90
b	0.35	0.40	0.50
C	0.10	0.15	0.25
D	2.70	2.90	3.10
E	1.40	1.60	1.80
e	-----	1.90(TYP)	-----
e1	-----	0.95	-----
H	2.60	2.80	3.00
L	0.37	------	-----
?1	1º	5º	9º