



**Micropower, 100mA and 200mA CMOS LDO Regulators**

**FEATURES**

- Ultra Low Dropout Voltage
- High Output Voltage Accuracy, 2%
- Guaranteed 200mA Output, SP6201
- Ultra Low Shutdown (Off Mode) Current, <math><1\mu\text{A}</math> Max
- Ultra Low GND Current  
200 $\mu\text{A}</math>@200mA Load  
28 $\mu\text{A}</math>@ No Load$$
- Fast Transient Response
- 78dB PSRR @ 100Hz
- Extremely Tight Load and Line Regulation
- Very Low Temperature Coefficient
- Current and Thermal Limiting
- RESET Output ( $V_{\text{OUT}}$  good)
- Logic-Controlled Electronic Enable
- Stable with no Load using 1 $\mu\text{F}$  Ceramic
- 5 Pin SOT-23 Package
- Fixed Outputs: 2.7V, 2.85V, 3.0V, 3.3V, 5V
- Adjustable Output Available



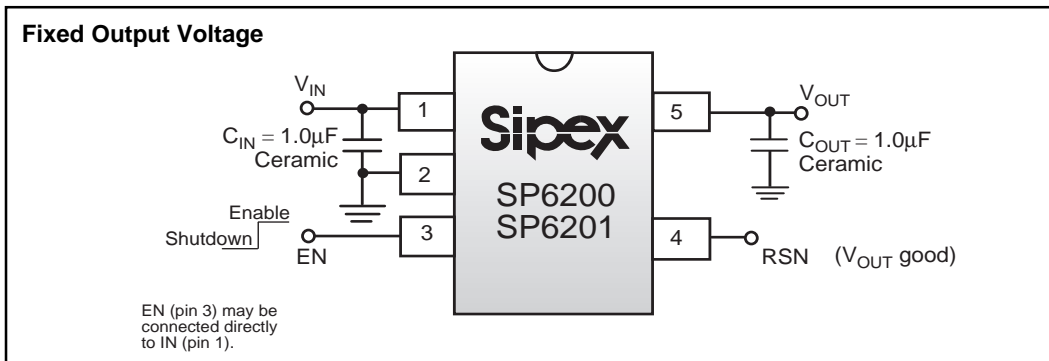
**APPLICATIONS**

- Cellular Telephones
- Laptop, Notebook, and Palmtop Computers
- Battery-Powered Equipment
- Consumer/ Personal Electronics
- SMPS Post-Regulator/ DC-to-DC Modules
- Medical Devices

**DESCRIPTION**

The SP6200/6201 is an efficient linear voltage regulator with ultra-low dropout voltage, ground current and quiescent current. Designed especially for hand-held, battery-powered devices, the SP6200/6201 includes a CMOS or TTL compatible enable/shutdown control pin. When shutdown, power consumption drops nearly to zero. Regulator ground current increases only slightly in dropout, further prolonging battery life.

The SP6200/6201 is available in fixed and adjustable output voltage versions in a small SOT-23-5 package.



## ABSOLUTE MAXIMUM RATINGS

These are stress ratings only and functional operation of the device at these ratings or any other above those indicated in the operation sections of the specifications below is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

Supply Input Voltage ( $V_{IN}$ ).....-2V to 8V  
 Output Voltage ( $V_{OUT}$ ).....-0.6 to  $V_{IN} + 1V$   
 Enable Input Voltage ( $V_{EN}$ ).....-2V to 11V  
 Power Dissipation ( $P_D$ ).....Internally Limited, **Note 3**  
 Lead Temperature (soldering 5s).....260°C  
 Storage Temperature.....-65°C to +150°C

## OPERATING RATINGS

Junction Temperature.....-40°C to +125°C  
 Operating Ratings (Note 2)  
 Input Voltage ( $V_{IN}$ ).....+2.5V to +7V  
 Enable Input Voltage ( $V_{EN}$ ).....0V to 10V  
 Junction Temperature ( $T_J$ ).....-40°C to +125°C  
 Thermal Resistance, SOT-23-5 ( $\theta_{JA}$ ).....Note 3

## SPECIFICATIONS

$V_{IN} = V_{OUT} + 1V$ ,  $I_L = 100\mu A$ ,  $C_{IN} = 1.0\mu F$ ,  $C_{OUT} = 1.0\mu F$ ,  $T_J = 25^\circ C$ , **bold** values indicate  $-40^\circ C \leq T_J \leq 125^\circ C$  unless otherwise noted.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output Voltage Accuracy, ( $V_O$ )	Variation from specified $V_{OUT}$	-2 -3		2 3	%
Output Voltage Temperature Coefficient, ( $\Delta V_O / \Delta T$ )	<b>Note 4</b>		20		ppm/°C
Line Regulation, ( $\Delta V_O / V_O$ )	$V_{IN} = V_{OUT} + 1V$ to 7V		0.07	<b>0.2</b>	%/V
Load Regulation, <b>Note 5</b> , ( $\Delta V_O / V_O$ )	$I_L = 0.1mA$ to 100mA, SP6200 $I_L = 0.1mA$ to 200mA, SP6201		0.1 0.2	<b>0.25</b> <b>0.5</b>	%
Dropout Voltage, <b>Note 6</b> , ( $V_{IN} - V_O$ )	$I_L = 100\mu A$		0.2	4 7	mV
	$I_L = 50mA$		60	120 <b>160</b>	mV
	$I_L = 100mA$		120	250 <b>300</b>	mV
	$I_L = 200mA$ , SP6201 Only		250	400 <b>500</b>	mV
Quiescent Current, ( $I_{GND}$ )	$V_{EN} \leq 0.4V$ (Shutdown)		0.01	<b>1</b>	$\mu A$
Ground Pin Current, <b>Note 7</b> , ( $I_{GND}$ )	$V_{EN} \geq 2.0V$ , $I_L = 100\mu A$		28	45 <b>50</b>	$\mu A$
	$V_{EN} \geq 2.0V$ , $I_L = 50mA$		60	120 150	$\mu A$
	$V_{EN} \geq 2.0V$ , $I_L = 100mA$		100	200 <b>250</b>	$\mu A$
	$V_{EN} \geq 2.0V$ , $I_L = 200mA$ , SP6201 Only		200	400 <b>500</b>	$\mu A$
Power Supply Ripple Rejection, (PSRR)	Frequency = 100Hz, $I_L = 100\mu A$		78		dB
Current Limit, ( $I_{LIMIT}$ ), <b>SP6200</b> <b>SP6201</b>	$V_{OUT} = 0V$	<b>100</b> <b>300</b>	150 450	<b>200</b> <b>600</b>	mA
Thermal Limit	Turns On Turns Off		160 145		°C
Thermal Regulation, ( $\Delta V_O / \Delta P_D$ )	<b>Note 8</b>		0.05		%/W
Output Noise, ( $e_{no}$ )	$I_L = 50mA$ , $C_L = 1\mu F$ 470pF from out to Adj.		TBA		nV/√Hz

## SPECIFICATIONS

$$V_{IN} = V_{OUT} + 1V, I_L = 100mA$$

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
<b>ENABLE INPUT</b>					
Enable Input Logic-Low Voltage, ( $V_{IL}$ )	Regulator Shutdown		0.9	<b>0.4</b>	V
Enable Input Logic-High Voltage, ( $V_{IH}$ )	Regulator Enabled	<b>2.0</b>	0.9		V
Enable Input Current, ( $I_{IL}$ ), ( $I_{IH}$ )	$V_{IL} \leq 0.4V$		0.01	<b>1</b>	$\mu A$
	$V_{IH} \geq 2.0V$		0.01	<b>1</b>	$\mu A$
Reset Not Output	Threshold		-4		%

**Note 1.** Exceeding the absolute maximum rating may damage the device.

**Note 2.** The device is not guaranteed to function outside its operating rating.

**Note 3.** The maximum allowable power dissipation at any  $T_A$  (ambient temperature) is  $P_{D(MAX)} = (T_J(MAX) - T_A) \Pi \theta_{JA}$ . Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown. The  $\theta_{JA}$  of the SP6200/6201(all versions) is 220°C/W mounted on a PC board (see "Thermal Considerations" section for further details)

**Note 4.** Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.

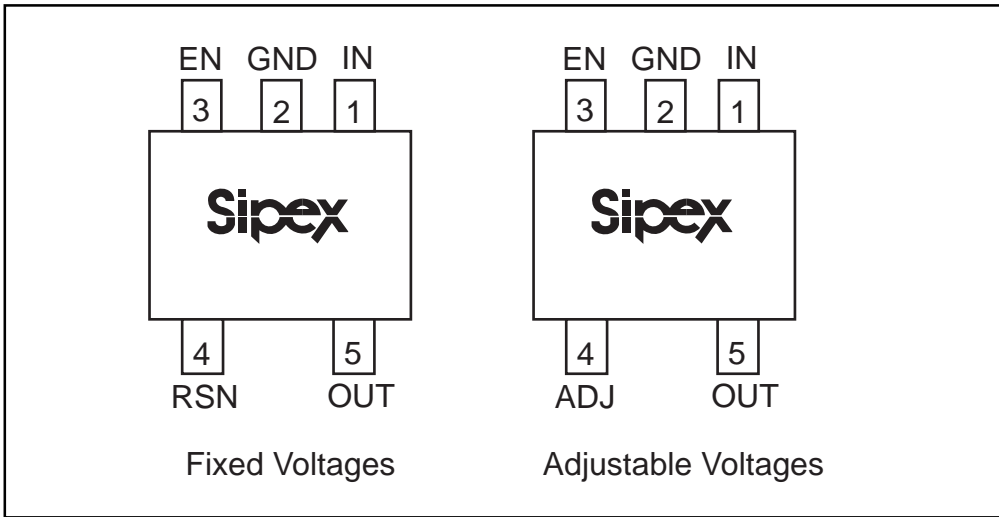
**Note 5.** Regulation is measured at constant junction temperature using low duty cycle pulse testing. Parts are tested for load regulation in the load range; from 0.1mA to 100mA, SP6200; from 0.1mA to 200mA, SP6201. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

**Note 6.** Dropout Voltage is defined as the input to output differential at which the output voltage drops 2% below its nominal value measured at 1V differential.

**Note 7.** Ground pin current is the regulator quiescent current. The total current drawn from the supply is the sum of the load current plus the ground pin current.

**Note 8.** Thermal regulation is defined as the change in output voltage at a time "t" after a change in power dissipation is applied, excluding load or line regulation effects. Specifications are for a 100mA load pulse at  $V_{IN} = 7V$  for  $t = 10ms$ .

**PINOUTS**



**PIN ASSIGNMENTS**

Pin 1 —IN — Supply Input

Pin 2 —GND — Ground

Pin 3 —EN — Enable/Shutdown (Input): CMOS compatible input. Logic high = enable, logic low = shutdown

Pin 4 —RSN (Reset Not) — Open drain indicating that  $V_{OUT}$  is good

Pin 4 —ADJ — Adjustable (Input): Adjustable regulator feedback input. Connect resistor voltage divider.

Pin 5 —OUT — Regulator Output

## THEORY OF OPERATION

### Enable/Shutdown

Forcing EN (enable/shutdown) high (>2V) enables the regulator. EN is compatible with CMOS logic gates. If the enable/shutdown feature is not required, connect EN (pin 3) to IN (supply input, pin 1). See Figure 1.

### Input Capacitor

A 1 $\mu$ F or greater capacitor should be placed from IN to GND.

### Output Capacitor

An output capacitor is required between OUT and GND to prevent oscillation. The minimum size of the output capacitor is 1.0 $\mu$ F. Larger values improve the regulator's transient response. The output capacitor value maybe increased without limit. The output capacitor should have an ESR (effective series resistance) of about 5 $\Omega$  or less and a resonant frequency above 1MHz. At lower values of output current, less output capacitance is required for output stability. The capacitor can be reduced to 0.47 $\mu$ F for current below 10mA or 0.33 $\mu$ F for currents below 1mA.

### No-Load Stability

The SP6200/6201 will remain stable and in regulation with no load (other than the internal voltage divider) unlike many other voltage regulators. This is especially important in CMOS RAM keep-alive applications.

### Thermal Considerations

The SP6200/6201 is designed to provide 100/200mA of continuous current in a very small package. Maximum power dissipation can be calculated based on the output current and the voltage drop across the part. To determine the maximum power dissipation of the package, use the junction-to-ambient thermal resistance of the device and the following basic equation:

$$P_{D(\max)} = \frac{(T_{J(\max)} - T_A)}{\theta_{JA}}$$

$T_{J(\max)}$  is the maximum junction temperature of the die, 125°C, and  $T_A$  is the ambient operating temperature.  $\theta_{JA}$  is layout dependent.

The actual power dissipation of the regulator circuit can be determined using the equation:

$$P_D = (V_{in} - V_{out})I_{out}$$

Substituting  $P_{D(\max)}$  for  $P_D$  and solving for operating conditions that are critical to the application will give the maximum operating conditions for regulator circuit. For example, when operating the SP6201 3.3 at room temperature with a maximum footprint layout, the maximum input voltage for a set output current can be determined as follows:

The junction-to-ambient thermal resistance for the maximum footprint is 220°C/W. The maximum power dissipation must not be exceeded for proper operation. Using the output voltage of 3.3V and an output current of 200mA, the maximum input voltage can be determined.

Therefore, a 3.3V application at 200mA of output current can accept a maximum input voltage of 5.6V in a SOT-23-5 package.

### Adjustable Regulator Applications

The SP6200/6201 can be adjusted to a specific output voltage by using two external resistors (Figure 2). The resistors set the output voltage based on the following equation:

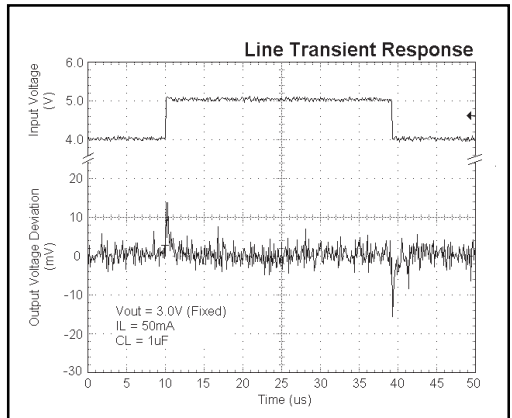
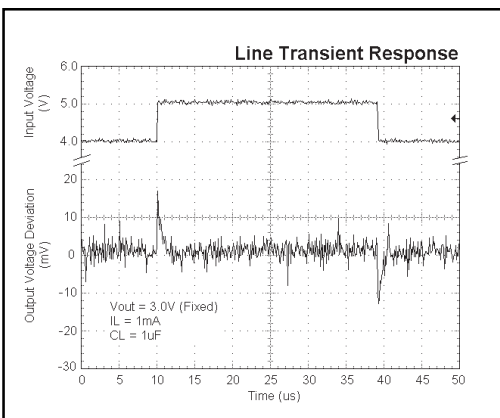
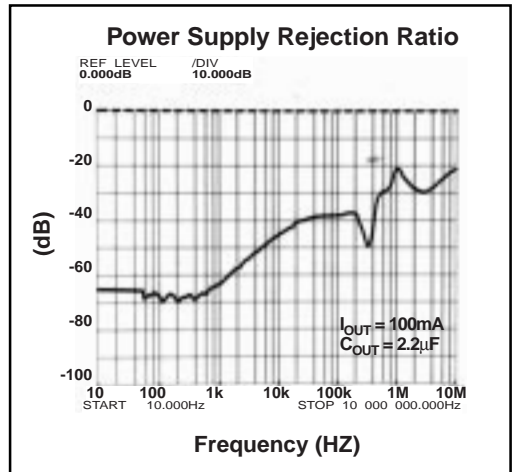
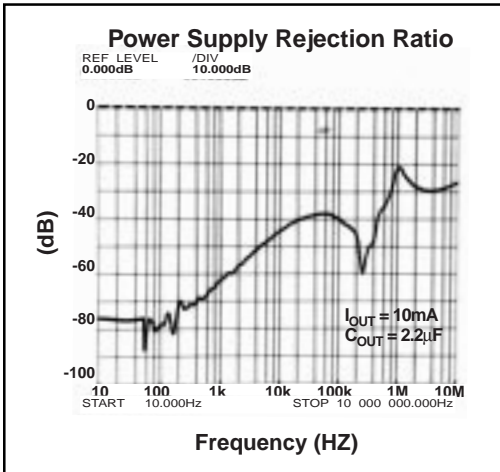
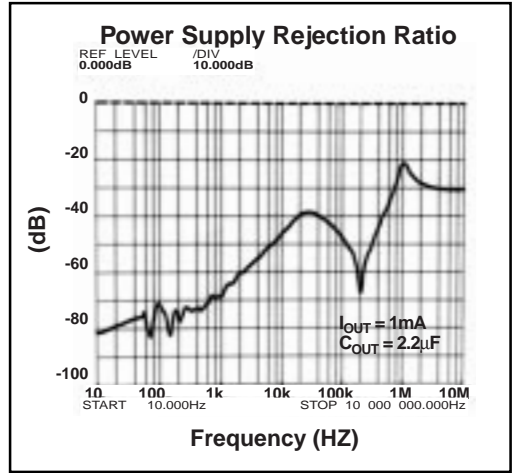
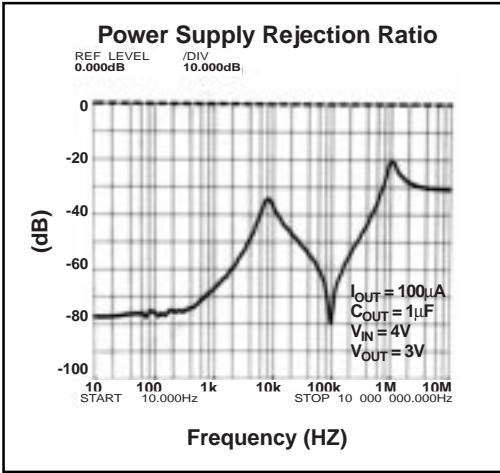
$$V_{OUT} = 1.25 (R2/R1 + 1)$$

Resistor values are not critical because ADJ (adjust) has a high input impedance, but for best results use resistors of 470k $\Omega$  or less. A capacitor from ADJ to  $V_{OUT}$  provides improved noise performance.

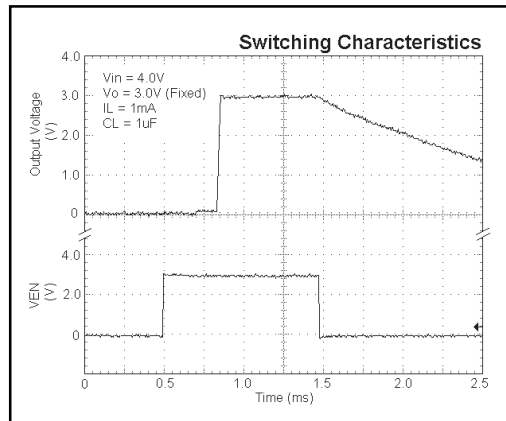
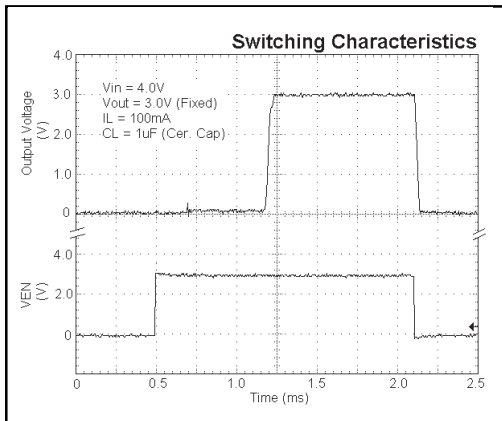
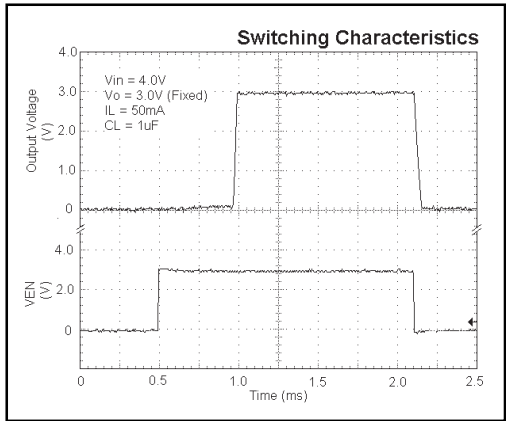
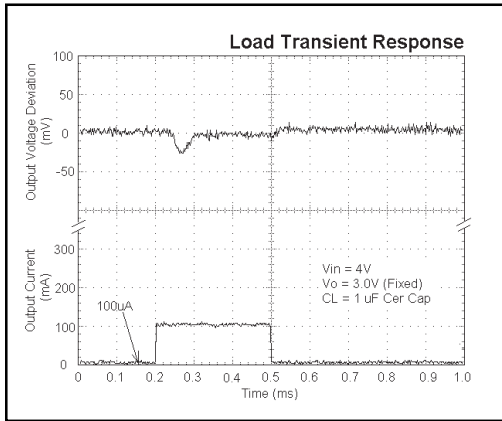
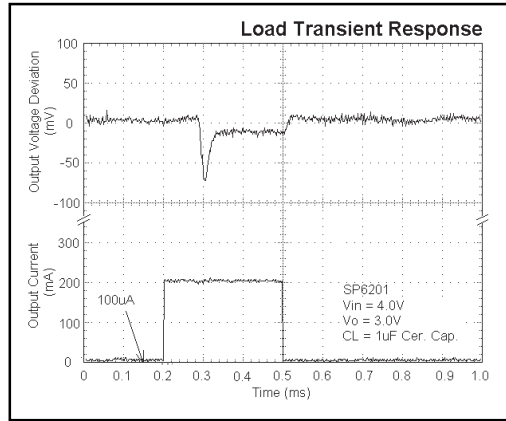
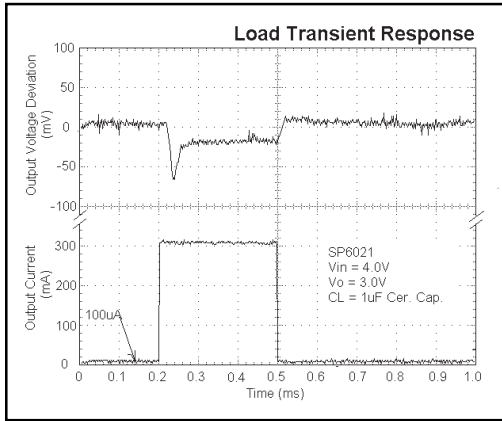
### Dual-Supply Operation

When used in dual supply systems where the regulator load is returned to a negative supply, the output voltage must be diode clamped to ground.

# THERMAL CHARACTERISTICS



# THERMAL CHARACTERISTICS (Continued)



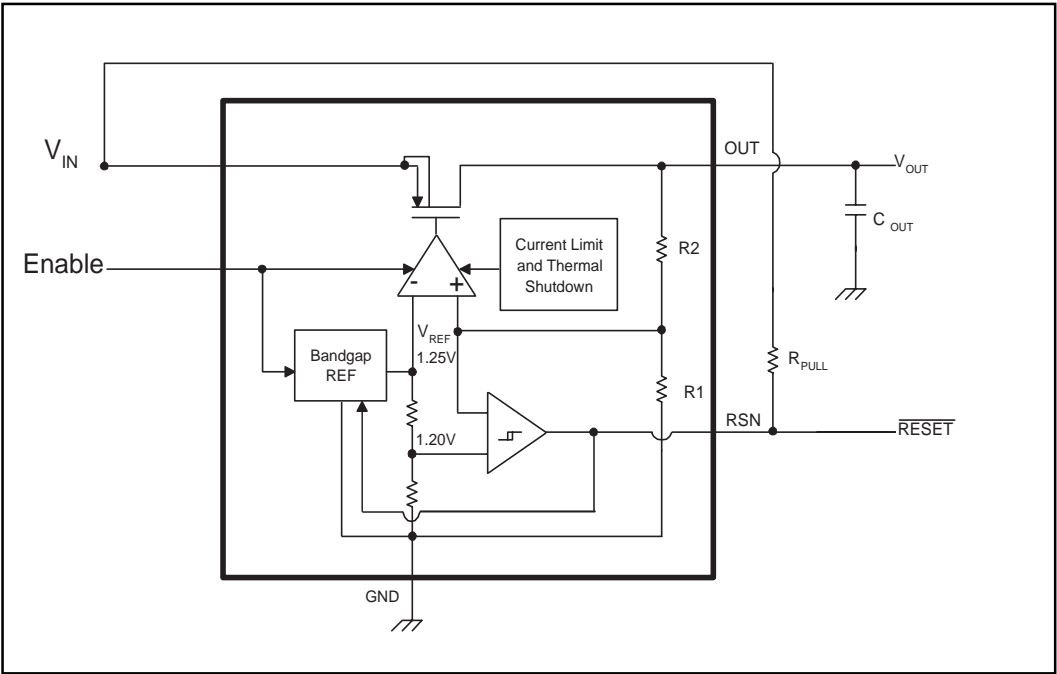


Figure 1. Fixed Voltage Regulator

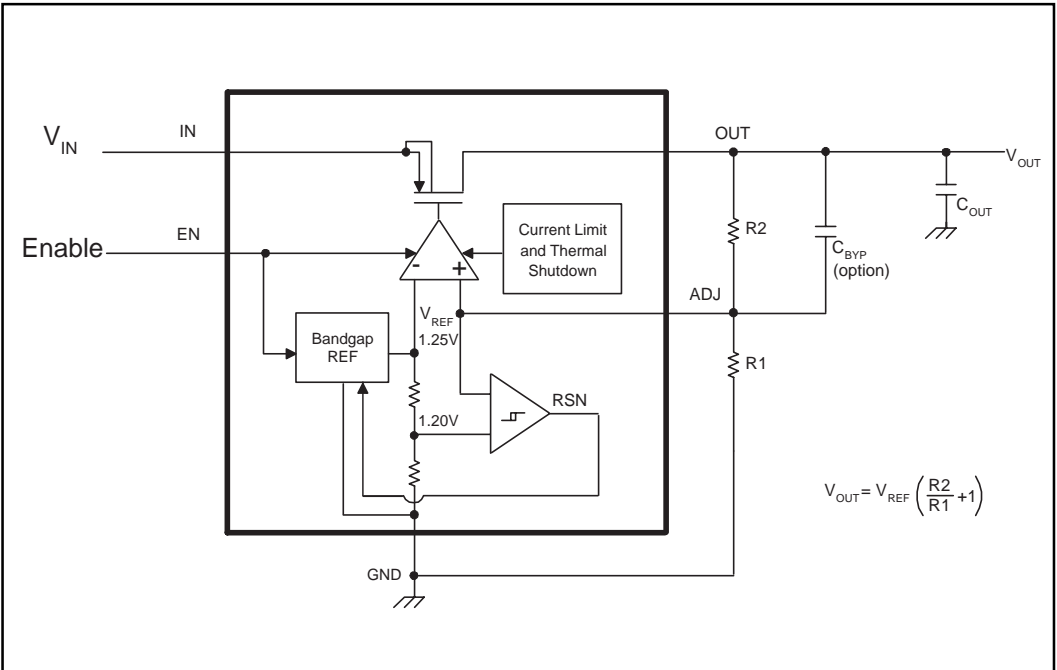
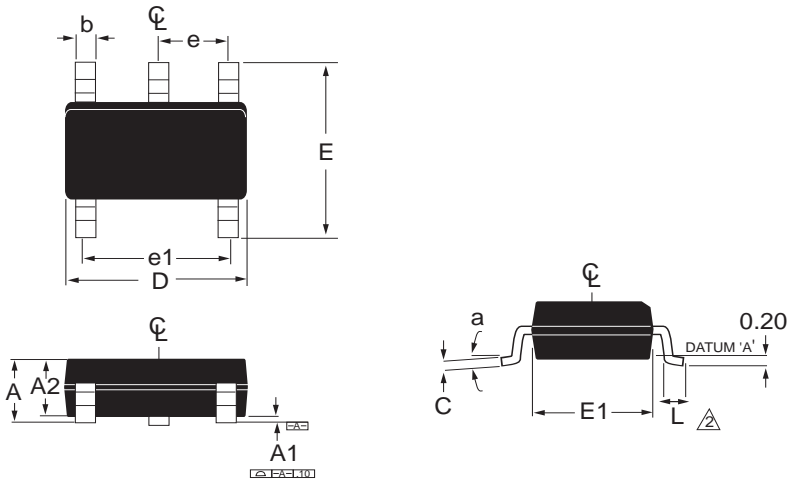


Figure 2. Low Noise Adjustable Regulator



**PACKAGE: 5 Lead SOT23**



SYMBOL	MIN	MAX
A	0.90	1.45
A1	0.00	0.15
A2	0.90	1.30
b	0.25	0.50
C	0.09	0.20
D	2.80	3.10
E	2.60	3.00
E1	1.50	1.75
L	0.35	0.55
e	0.95ref	
e1	1.90ref	
a	0°	10°

**ORDERING INFORMATION**

<b>Model</b>	<b>Temperature Range</b>	<b>Package Type</b>
SP6200EM5-2.7 .....	-40°C to +125°C .....	SOT-23-5
SP6200EM5-2.85 .....	-40°C to +125°C .....	SOT-23-5
SP6200EM5-3.0 .....	-40°C to +125°C .....	SOT-23-5
SP6200EM5-3.3 .....	-40°C to +125°C .....	SOT-23-5
SP6200EM5-5.0 .....	-40°C to +125°C .....	SOT-23-5
SP6200EM5-ADJ .....	-40°C to +125°C .....	SOT-23-5
SP6201EM5-2.7 .....	-40°C to +125°C .....	SOT-23-5
SP6201EM5-2.85 .....	-40°C to +125°C .....	SOT-23-5
SP6201EM5-3.0 .....	-40°C to +125°C .....	SOT-23-5
SP6201EM5-3.3 .....	-40°C to +125°C .....	SOT-23-5
SP6201EM5-5.0 .....	-40°C to +125°C .....	SOT-23-5
SP6201EM5ADJ .....	-40°C to +125°C .....	SOT-23-5



SIGNAL PROCESSING EXCELLENCE

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