TS9002

300 mA CMOS LDO

SOT-25

Voltage Range 1.5 to 3.8 Volts

General Description

The TS9002 family of positive, linear regulators feature low quiescent current (30μA typ.) with low dropout voltage, making them ideal for battery applications. The space-saving SOT-23-5 package is attractive for “Pocket” and “Hand Held” applications.

These rugged devices have both Thermal Shutdown, and Current Fold-back to prevent device failure under the “Worst” of operating conditions.

An additional feature is a “Power Good” detector, which pulls low when the output is out of regulation. The TS9002 is stable with an output capacitance of 2.2μF or greater.

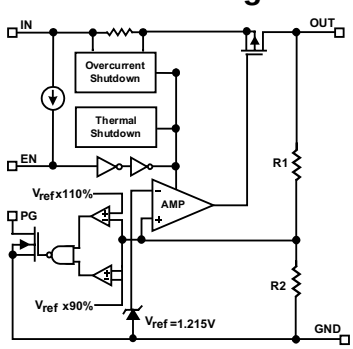
Features

- ✧ Very Low Dropout Voltage
- ✧ Guaranteed 300mA Output
- ✧ Accurate to within 1.5%
- ✧ 30μA Quiescent Current
- ✧ Over-Temperature Shutdown
- ✧ Current Limiting
- ✧ Short Circuit Current Fold-back
- ✧ Power Good Output Function
- ✧ Power-Saving Shutdown Mode
- ✧ Space-Saving SOT-25 (SOT-23-5)
- ✧ Factory Pre-set Output Voltages
- ✧ Low Temperature Coefficient

Applications

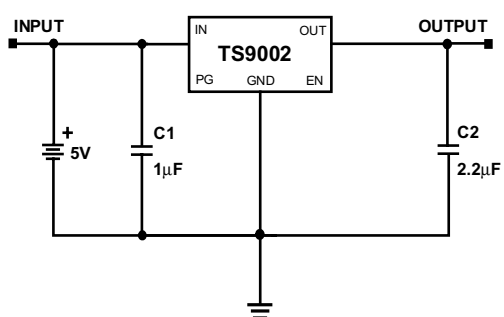
- ✧ Instrumentation
- ✧ Portable Electronics
- ✧ Wireless Devices
- ✧ Cordless Phones
- ✧ PC Peripherals
- ✧ Battery Powered Widgets
- ✧ Electronic Scales

Functional Block Diagram



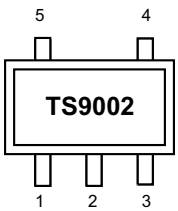
Note: If output voltage specification is lower than 1.215V, Vref will be trimmed to 1.2V

Typical Application



Pin configuration

SOT-25
Top View



TS9002

1. V_{IN}
2. GND
3. EN
4. PG
5. V_{OUT}

Ordering Information

PART NUMBER	MARKING	OUTPUT VOLTAGE	PACKAGE	OPERATING TEMP. RANGE
TS9002AEEV	TAKww	3.3V	SOT-25	- 40°C to + 85°C
TS9002BEEV	TALww	3.0V	SOT-25	- 40°C to + 85°C
TS9002CEEV	TAMww	2.8V	SOT-25	- 40°C to + 85°C
TS9002DEEV	TANww	2.5V	SOT-25	- 40°C to + 85°C
TS9002EEEV	TAOww	3.8V	SOT-25	- 40°C to + 85°C
TS9002FEEV	TBPww	3.6V	SOT-25	- 40°C to + 85°C
TS9002GEEV	TCGww	3.5V	SOT-25	- 40°C to + 85°C
TS9002HEEV	TEHww	2.7V	SOT-25	- 40°C to + 85°C
TS9002IEEV	TEPww	3.4V	SOT-25	- 40°C to + 85°C
TS9002JEEV	TGRww	2.85V	SOT-25	- 40°C to + 85°C
TS9002KEEV	THTww	3.7V	SOT-25	- 40°C to + 85°C
TS9002LEEV	TJMww	1.5V	SOT-25	- 40°C to + 85°C
TS9002MEEV	TJNww	1.8V	SOT-25	- 40°C to + 85°C
TS9002NEEV	TKQww	2.9V	SOT-25	- 40°C to + 85°C
TS9002OEEV	TKRww	3.1V	SOT-25	- 40°C to + 85°C
TS9002TEEV	TRVww	1.2V	SOT-25	- 40°C to + 85°C
TS9002UEEV	TSDww	3.2V	SOT-25	- 40°C to + 85°C

Note: ww represents the date code
Please consult TSC sales office or authorized Rep./Distributor for other output voltage and package type availability.

Absolute Maximum Ratings

PARAMETER	MAXIMUM	UNIT
Input Voltage	8	V
Output Current	$P_D / (V_{IN} - V_O)$	mA
Output Voltage	GND - 0.3 to V_{IN} + 0.3	V
ESD Classification	B	

Caution:Stress above the listed absolute rating may cause permanent damage to the device

Recommended Operating Conditions

PARAMETER	RATING	UNIT
Ambient Temperature Range	- 40 to + 85	^oC
Junction Temperature	- 40 to + 125	^oC

Thermal Information

PARAMETER		MAXIMUM	UNIT
Thermal Resistance (θ_{ja})	SOT-25	260	^oC / W
Internal Power Dissipation (P_D) ($\Delta T = 100^oC$)	SOT-25	380	mW
Maximum Junction Temperature		150	^oC
Maximum Lead Temperature (10 Sec)		300	^oC

Electrical Characteristics

TA=25 °C unless otherwise noted

PARAMETER	SYMBOL	TEST CONDITIONS		MIN	TYP	MAX	UNITS
Input Voltage	V_{IN}			Note 1		7	V
Output Voltage Accuracy	V_O	I_O=1mA		-1.5		1.5	%
Dropout Voltage	$V_{DROPOUT}$	I_O=300mA $V_O=V_{O(NOM)}$ -2.0%	1.2V<$V_{O(NOM)}$≦2.0V		See chart	1300	mV
			2.0V<$V_{O(NOM)}$≦2.8V			400	
			2.8V<$V_{O(NOM)}$			300	
Output Current	I_O	V_O>1.2V		300			mA
Current Limit	I_{LIM}	V_O>1.2V		300	450		mA
Short Circuit Current	I_{SC}	V_O<0.8V			150	300	mA
Quiescent Current	I_Q	I_O=0mA			30	50	µA
Ground Pin Current	I_{GND}	I_O=1mA to 300mA			35		µA
Line Regulation	REG_{LINE}	I_O=1mA $V_{IN}=V_O$+1 to V_O+2	V_O < 2.0V	-0.15		0.15	%
			2.0V≦V_O < 4.0V	-0.1	0.02	0.1	%
			4.0V ≦ Vo	-0.4	0.2	0.4	%
Load Regulation	REG_{LOAD}	I_O=1mA to 300mA		-1	0.2	1	%
Over Temerature Shutdown	OTS				150		°C
Over Temerature Hysterisis	OTH				30		°C
V_O Temperature Coefficient	TC				30		ppm/°C
Power Supply Rejection	PSRR	I_O=100mA C_O=2.2µF	f=1kHz		50		dB
			f=10kHz		20		
			f=100kHz		15		
Output Voltage Noise	eN	f=10Hz to 100kHz I_O=10mA	Co=2.2µF		30		µVrms
EN Input Threshold	V_{EH}	V_{IN}=2.7V to 7V		2.0		Vin	V
	V_{EL}	V_{IN}=2.7V to 7V		0		0.4	V
EN Input Bias Current	I_{EH}	$V_{EN}=V_{IN}$, V_{IN}=2.7V to 7V				0.1	µA
	I_{EL}	V_{EN}=0V, V_{IN}=2.7V to 7V				0.5	µA
Shutdown Supply Current	I_{SD}	V_{IN}=5V, V_O=0V, $V_{EN}<V_{EL}$			0.5	1	µA
Shutdown Output Voltage	$V_{O,SD}$	I_O=0.4mA, $V_{EN}<V_{EL}$		0		0.4	V
Output Under Voltage	V_{UV}	2.5V≦$Vo_{(NOM)}$≦ 5.0V				85	%$V_{O(NOM)}$
		1.2V≦$Vo_{(NOM)}$< 2.5V				75	
Output Over Voltage	V_{OV}	2.5V ≦$Vo_{(NOM)}$≦ 5.0V		115			%$V_{O(NOM)}$
		1.2V≦$Vo_{(NOM)}$< 2.5V		125			
PG Leakage Current	I_{LC}	V_{PG}=7V				1	µA
PG Voltage Rating	V_{PG}	V_O in regulation				7	V
PG Voltage Low	V_{OL}	I_{SINK}=0.4mA				0.4	V

Note 1 $V_{IN(MIN)}=V_{OUT}+V_{DROPOUT}$

Detailed Description

The TS9002 family of CMOS regulators contain a PMOS pass transistor, voltage reference, error amplifier, over-current protection, thermal shutdown, and power good function.

The P-channel pass transistor receives data from the error amplifier, over-current shutdown, and thermal protection circuits. During normal operation, the error amplifier compares the output voltage to a precision reference. Over-current and Thermal shutdown circuits become active when the junction temperature exceeds 150^{o}C, or the current exceeds 300mA. During thermal shutdown, the output voltage remains low. Normal operation is restored when the junction temperature drops below 120^{o}C.

The TS9002 switches from voltage mode to current mode when the load exceeds the rated output current. This prevents over-stress. The TS9002 also incorporates current foldback to reduce power dissipation when the output is short circuited. This feature becomes active when the output drops below 0.8volts, and reduces the current flow by 65%. Full current is restored when the voltage exceeds 0.8 volts.

External Capacitors

The TS9002 is stable with an output capacitor to ground of 2.2µF or greater. Ceramic capacitors have the lowest ESR, and will offer the best AC performance. Conversely, Aluminum Electrolytic capacitors exhibit the highest ESR, resulting in the poorest AC response. Unfortunately, large value ceramic capacitors are comparatively expensive. One option is to parallel a 0.1µF ceramic capacitor with a 10µF Aluminum Electrolytic. The benefit is low ESR, high capacitance, and low overall cost.

A second capacitor is recommended between the input and ground to stabilize Vin. The input capacitor should be at least 0.1µF to have a beneficial effect.

All capacitors should be placed in close proximity to the pins. A "Quiet" ground termination is desirable. This can be achieved with a "Star" connection.

Enable

The Enable pin normally floats high. When actively, pulled low, the PMOS pass transistor shuts off, and all internal circuits are powered down. In this state, the quiescent current is less than 1µA. This pin behaves much like an electronic switch.

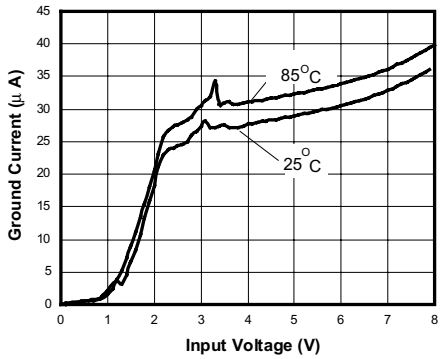
Power Good

The TS9002 includes the Power Good feature. When the output is not within ±15% of the specified voltage, it pulls low. This can occur under the following conditions:

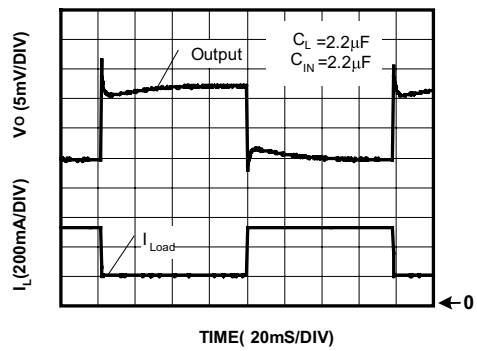
1) Input Voltage too low. 2) During Over-Temperature. 3) During Over-Current. 4) If output is pulled up.

(Note: PG pin is an open-drain output.)

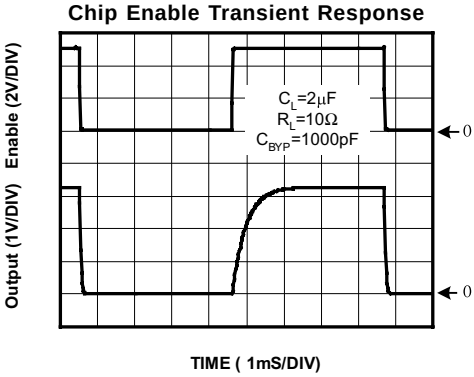
Ground Current vs. Input Voltage



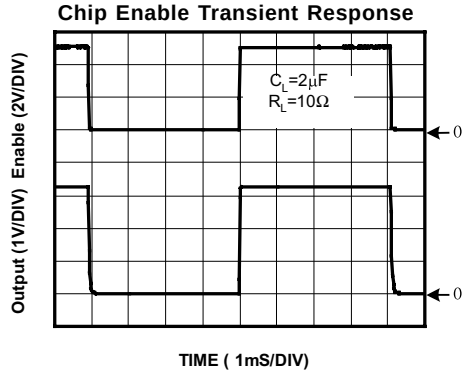
Load Step (1mA-300mA)



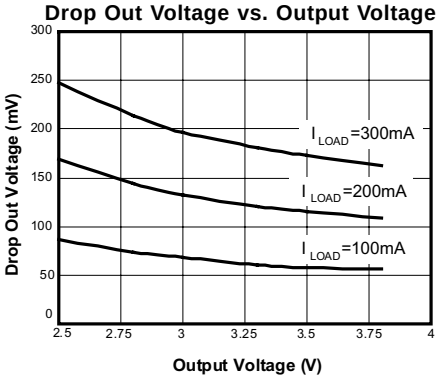
Chip Enable Transient Response



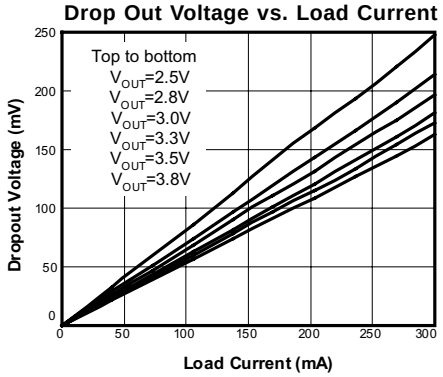
Chip Enable Transient Response



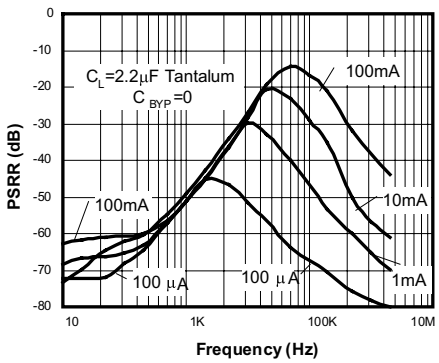
Drop Out Voltage vs. Output Voltage



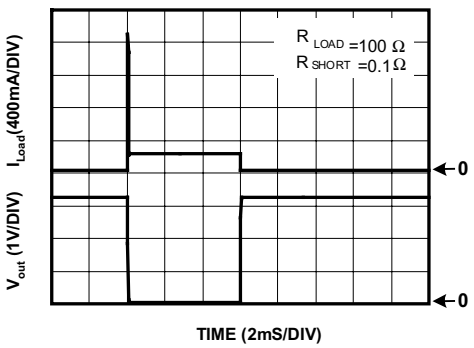
Drop Out Voltage vs. Load Current



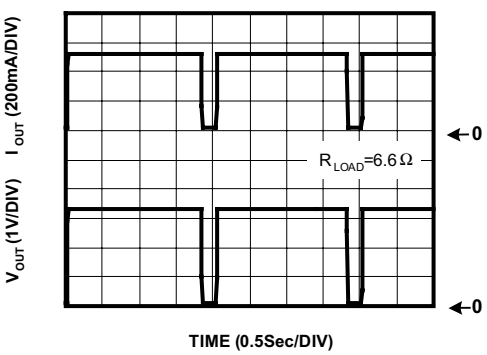
Power Supply Rejection Ratio



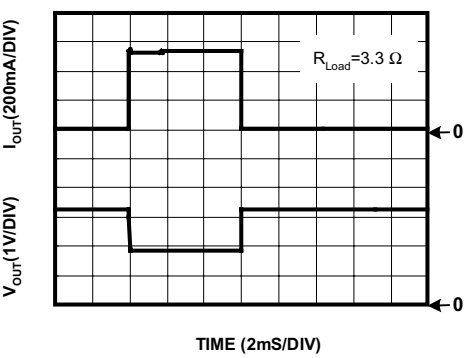
Short Circuit Response



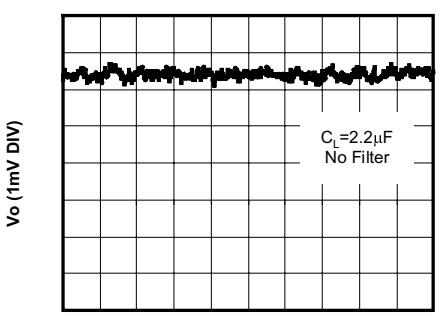
Overtemperature Shutdown



Current Limit Response

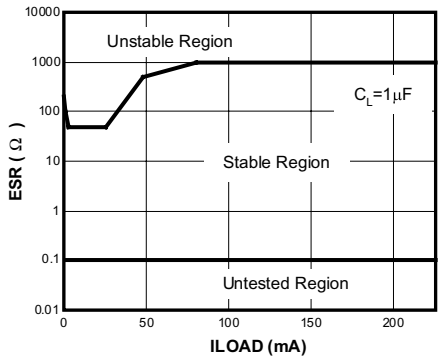


Noise Measurement

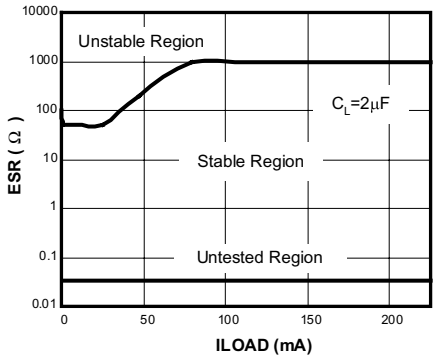


Line Transient Response

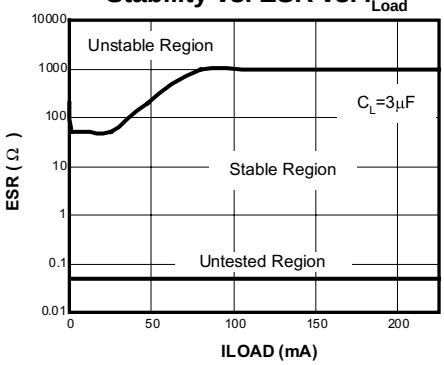
Stability vs. ESR vs. I_{Load}



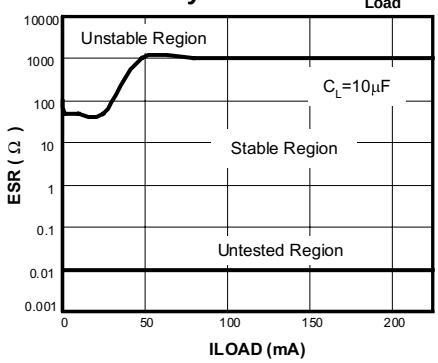
Stability vs. ESR vs. I_{Load}



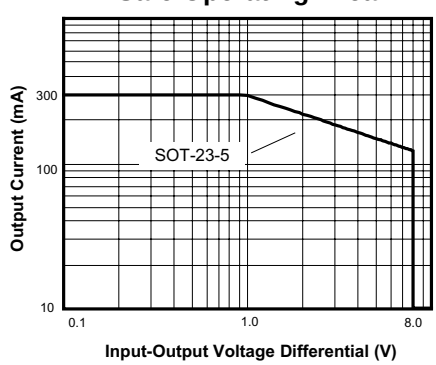
Stability vs. ESR vs. I_{Load}



Stability vs. ESR vs. I_{Load}

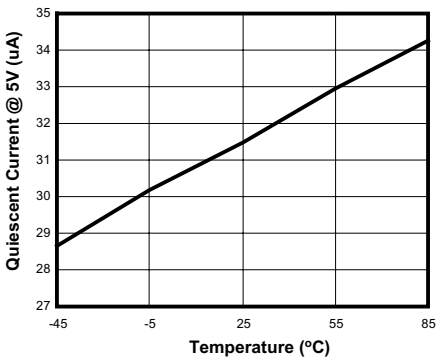


Safe Operating Area

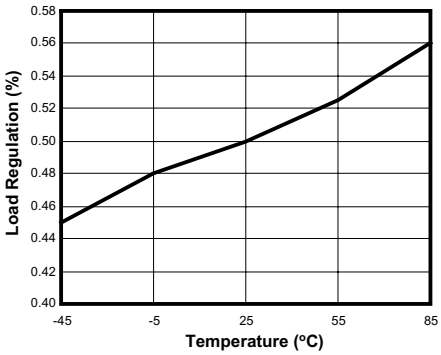


TSC

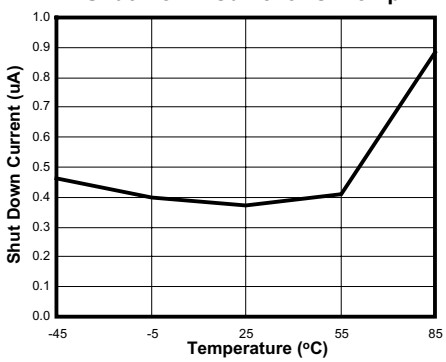
Quiescent Current vs. Temp.



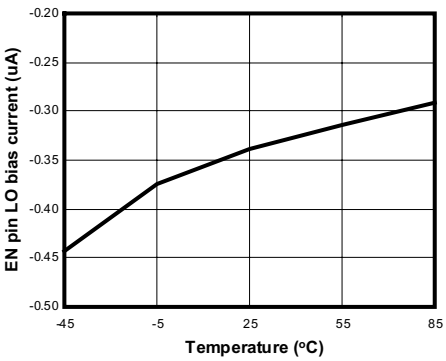
Load Regulation vs. Temp.



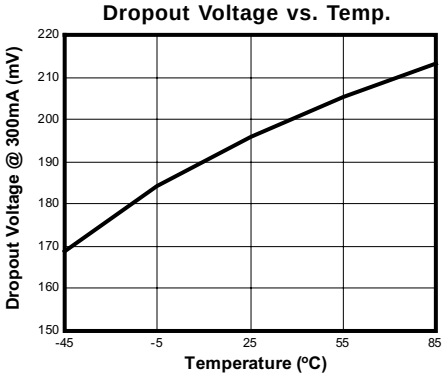
Shut Down Current vs. Temp.



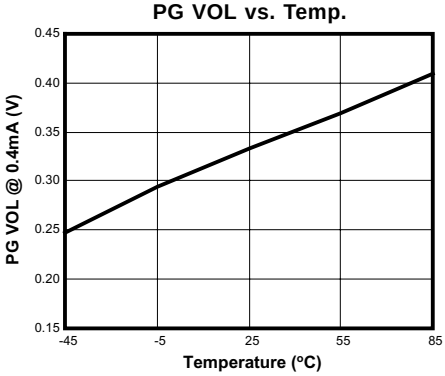
EN pin LO bias Current vs. Temp.



Dropout Voltage vs. Temp.

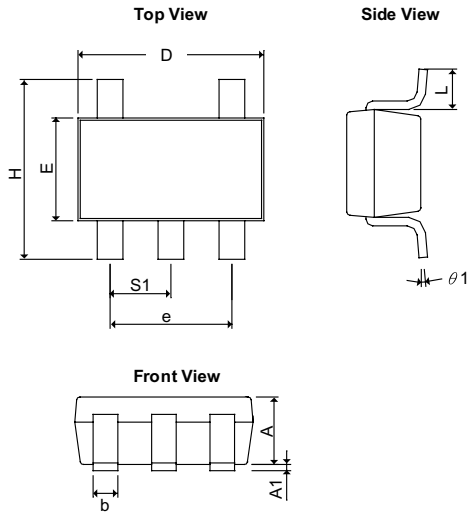


PG VOL vs. Temp.



Package Dimension

SOT-25



SYMBOLS	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.20REF		0.0472REF	
A1	0.00	0.15	0.0000	0.0059
b	0.30	0.55	0.0118	0.0217
D	2.70	3.10	0.1063	0.1220
E	1.40	1.80	0.0551	0.0709
e	1.90BSC		0.0748BSC	
H	2.60	3.00	0.10236	0.11811
L	0.37BSC		0.0146BSC	
θ1	0°	10°	0°	10°
S1	0.95BSC		0.0374BSC	