150mA, µCap, Low Dropout Voltage Regulator with Power Good

Check for Samples: LP8358

FEATURES

- **Low Power Good R_{DSON}: 20Ω**
- **Power Good Indicator**
- **Stability With Low ESR Capacitors**
- **Low Ground Current: 120µA**
- **150mA Output Current**
- **"Zero" Shutdown Current Mode**
- **Fast Transient Recovery Response**
- **Auto Discharge**
- **Thermal Shutdown**
- **Current Limiting**

APPLICATIONS

- **Processor Power-Up Sequencing**
- **Laptop, Notebook and Palm Top Computer**
- **PCMCIA V_{CC} and V_{PP} Regulation Switching**

DESCRIPTION

The LP8358 is a µCap, precise CMOS voltage regulator with low Power good output R_{DSON}.

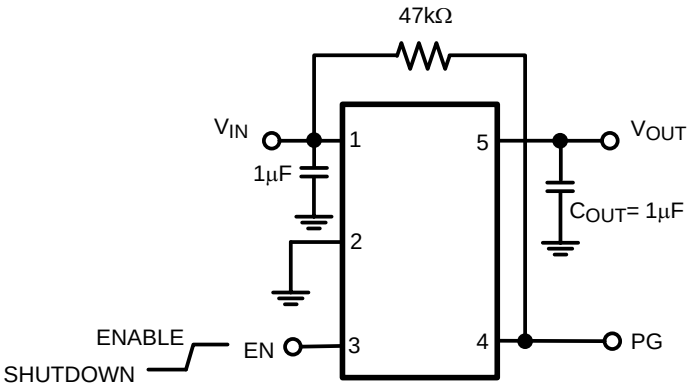
It provides up to 150mA and consumes a typical of 10nA in shutdown mode. The LP8358 output stage is designed with a push pull output for faster transient recovery response.

The LP8358 is optimized to work with low value, low cost ceramic capacitors. The output typically require only 1µF of output capacitance for stability. The enable pin can be tied to V_{IN} for easy board layout.

The LP8358 is designed for portable, battery powered equipment applications with small space requirements.

The LP8358 is available in a 5-pin SOT-23 package. Performance is specified for the −40°C to +125°C temperature range and is available in a fixed 1.2V. For other output voltage options, please contact Texas Instruments.

TYPICAL APPLICATION



CONNECTION DIAGRAM

SOT-5

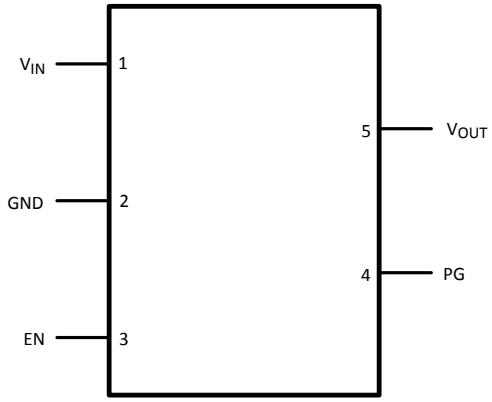
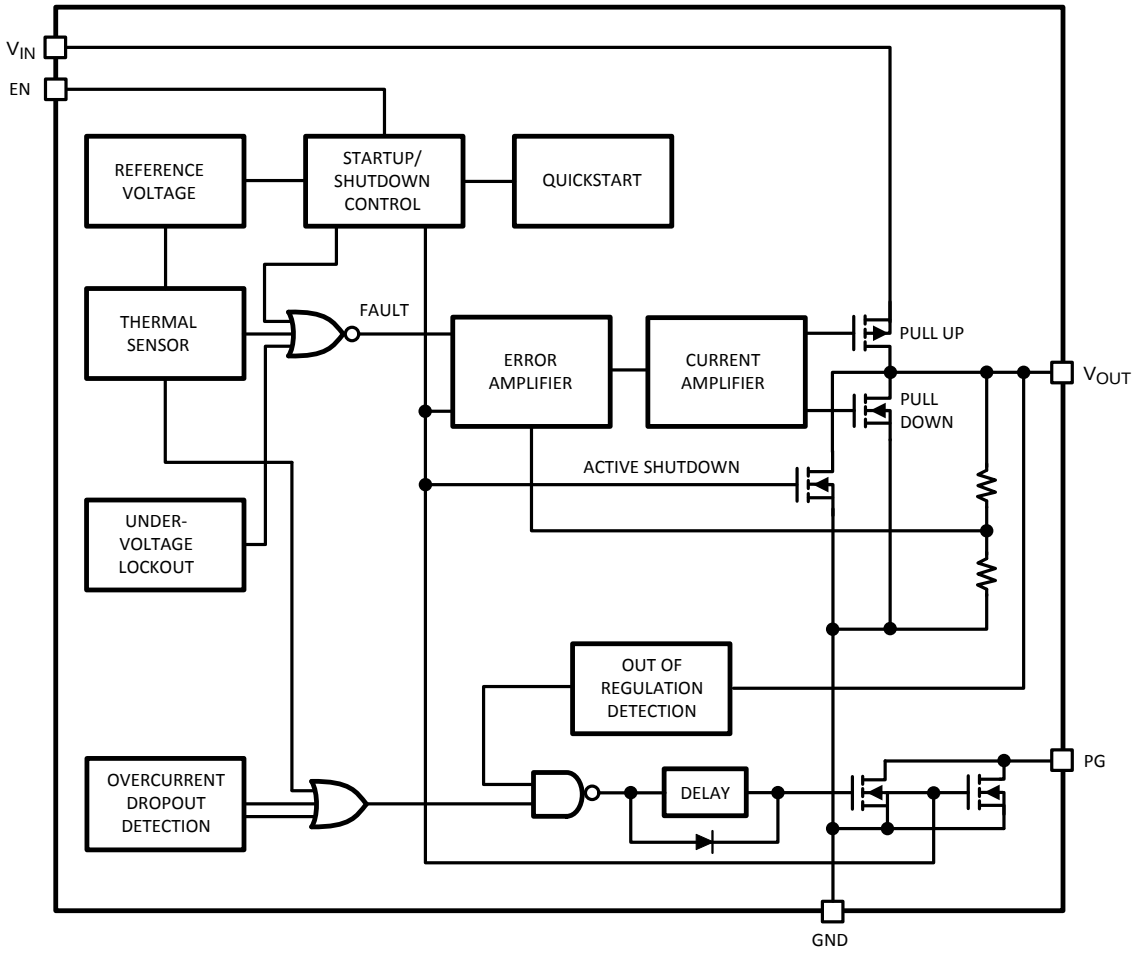


Figure 1. Top View

PIN DESCRIPTIONS

Pin Number	Pin Name	Pin Function
1	V_{IN}	Input Voltage
2	GND	Ground
3	EN	Enable Input Logic, Logic High = Enabled Logic Low = Shutdown (Do not leave open)
4	PG	Power Good Output
5	V_{OUT}	Output Voltage

BLOCK DIAGRAM



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ABSOLUTE MAXIMUM RATINGS(1)(2)

ESD Tolerance (3)	Human Body Model	2000V
Junction Temperature		150°C
V_{IN}, V_{OUT}, V_{EN}		−0.3 TO 6.5V
Soldering Information	Infrared or Convection (20 sec)	235°C
	Wave Soldering (10 sec)	260°C (lead temp)

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not ensured. For ensured specifications and the test conditions, see the Electrical Characteristics.
(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
(3) Human body model, 1.5kΩ in series with 100pF.

OPERATING RATINGS

Supply Voltages	V_{IN}	2.7V to 6V
	V_{EN}	0V to V_{IN}
Junction Temperature Range(1)		−40°C to +125°C
Storage Temperature Range		−65°C to 150°C
Package Themal Resistance	SOT-5	235°C/W

(1) The maximum power dissipation is a function of $T_{J(max)}$, θ_{JA}, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(max)}–T_A)/\theta_{JA}$. All numbers apply for packages soldered directly into a PC board.

ELECTRICAL CHARACTERISTICS

Unless otherwise specified, all limits specified for T_J = 25°C, V_{IN} = 2.7V, I_L = 100µA, C_{OUT} = 1µF, V_{EN} ≥ 2.0V. **Boldface** limits apply over the entire operating temperature range, −40°C to 125°C.

Symbol	Parameter	Conditions	Min(1)	Typ(2)	Max(1)	Units
V_O	Output Voltage Accuracy	I_L = 100µA	-3 **-4**		3 **4**	%
$\Delta V_O/V_O$	Line Regulation	V_{IN} = 2.7V to 6V	**−0.3**		**0.3**	%
$\Delta V_O/V_O$	Load Regulation	I_L = 0.1mA to 150mA (3)		1	4	%
I_Q	Quiescent Current	V_{EN} ≤ 0.4V (Shutdown), PG = NC		0.01	1	µA
I_{GND}	Ground Pin Current(4)	I_L = 0mA, V_{EN} ≥ 2.0V (active), V_{IN} = 6V		120	180	µA
		I_L = 150mA, V_{EN} ≥ 2.0V (active), V_{IN} = 6V		160	225	
PSRR	Power Supply Rejection Ratio	f = 120Hz, C_{OUT} = 4.7µF, I_L= 150mA		62		dB
I_{LIMIT}	Current Limit	V_{OUT} = 0V	**160**	350		mA
Thermal Protection						
	Thermal Shutdown Temperature			150		°C
Enable Input						
V_{IL}	Enable Input Voltage Level	Logic Low (off) , V_{IN} = 5.5V			**0.4**	V
V_{IH}		Logic High (on), V_{IN} = 5.5V	**2**			V
I_{IL}	Enable Input Current	V_{IL} ≤ 0.4V, V_{IN} = 5.5V		0.01		µA
I_{IH}		V_{IH} ≥ 2.0V, V_{IN} = 5.5V		0.01		µA

(1) All limits are specified by testing or statistical analysis.
(2) Typical Values represent the most likely parametric norm.
(3) Regulation is measured at constant junction temperature using low duty cycle pulse testing.
(4) 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.

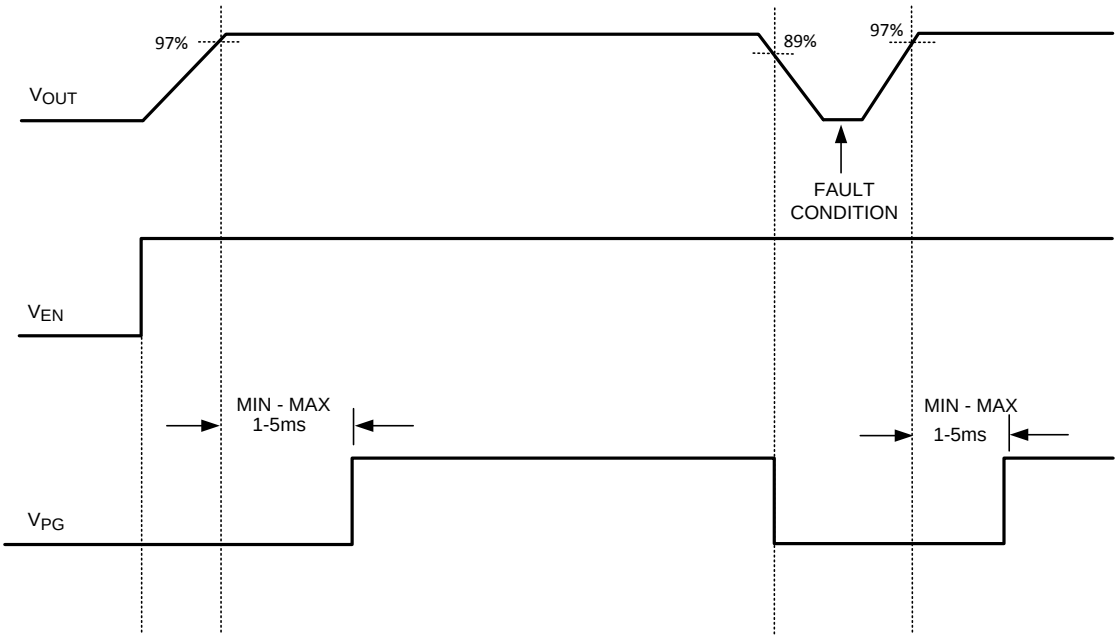
ELECTRICAL CHARACTERISTICS (continued)

Unless otherwise specified, all limits specified for T_J = 25°C, V_{IN} = 2.7V, I_L = 100µA, C_{OUT} = 1µF, V_{EN} ≥ 2.0V. **Boldface** limits apply over the entire operating temperature range, −40°C to 125°C.

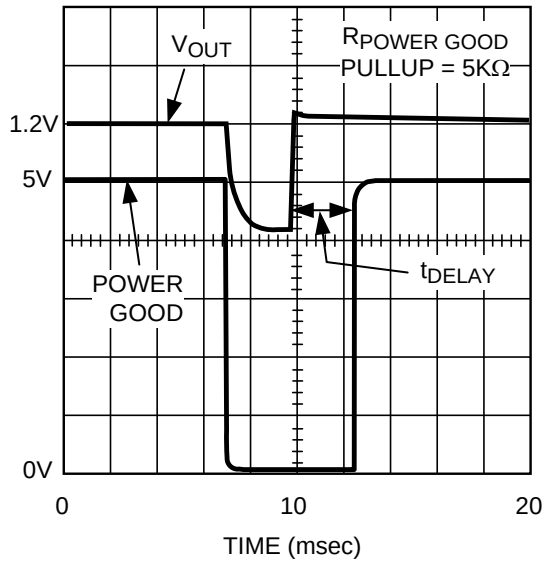
Symbol	Parameter	Conditions	Min(1)	Typ(2)	Max(1)	Units
Power Good						
V_{PG}	Low Threshold	% of V_{OUT} (PG ON)	89			%
	High Threshold	% of V_{OUT} (PG OFF)			97	
V_{OL}	PG Output Logic-Low Voltage	$I_{POWERGOOD}$ = 100µA, Fault Condition		2.0	10.0	mV
R_{DSON}	Power Good Output On - Resistance	$I_{POWERGOOD}$ = 1mA, Fault Condition		20		Ω
I_{PG}	Power Good Leakage Current	Power Good Off, V_{PG} = 5.5V		0.01		µA
V_{PG} Delay	Delay Time to Power Good	See Timing Diagram	1	2.1	5	ms

TEST CIRCUIT DIAGRAMS

TIMING DIAGRAM



TYPICAL DELAY TIME TO POWER GOOD



TYPICAL PERFORMANCE CHARACTERISTICS

Unless otherwise specified, V_{IN} = 3.3V, C_{OUT} = 1µF, T_A = 25°C and powergood pull up resistor = 47kΩ.

Ground Current vs. Output Current

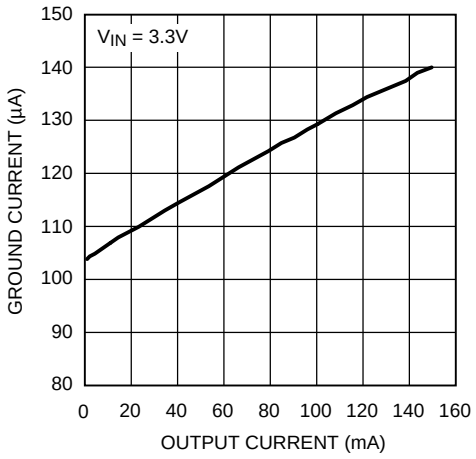


Figure 2.

Ground Current vs. Input Voltage

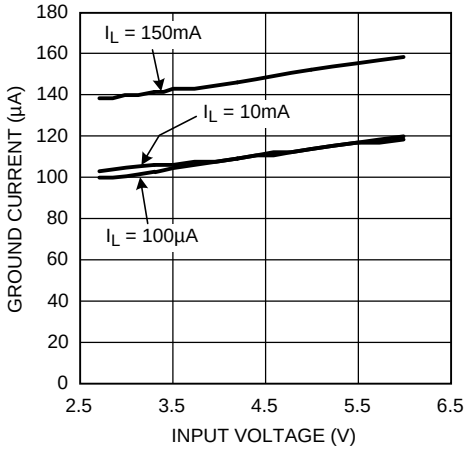


Figure 3.

Ground Current vs. Temperature

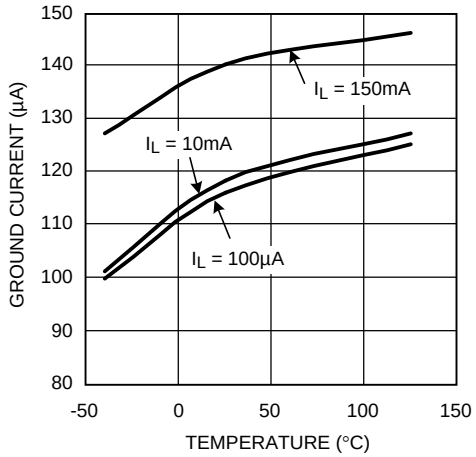


Figure 4.

Short Circuit Current vs. Temperature

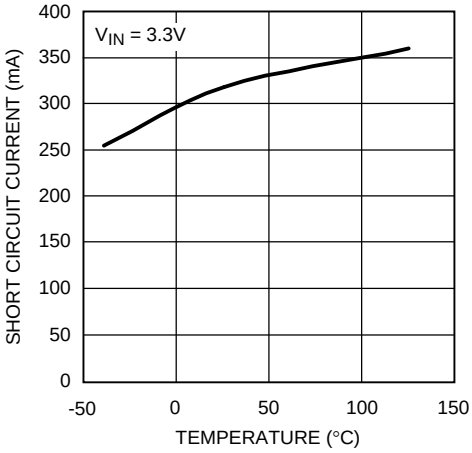


Figure 5.

Short Circuit Current vs. Input Voltage

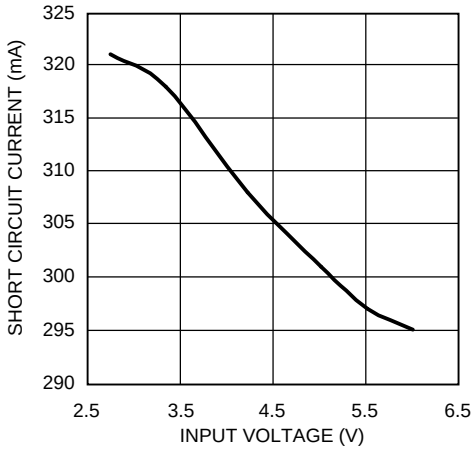


Figure 6.

Power Good Delay vs. Input Voltge

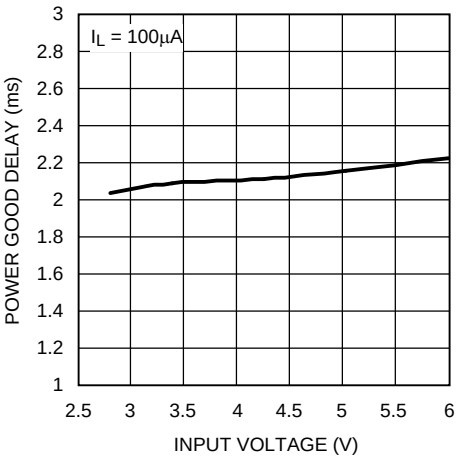


Figure 7.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Unless otherwise specified, V_{IN} = 3.3V, C_{OUT} = 1µF, T_A = 25°C and powergood pull up resistor = 47kΩ.

Power Good Delay vs. Temperature

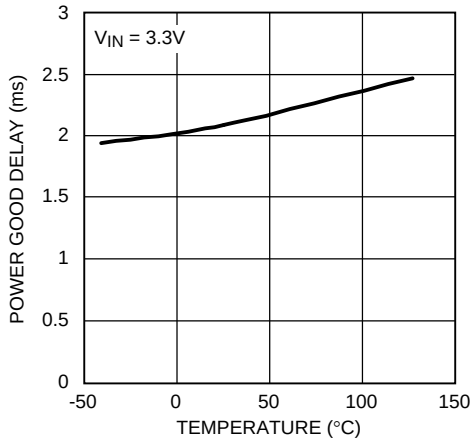


Figure 8.

Power Good R_{DSON} vs. Temperature

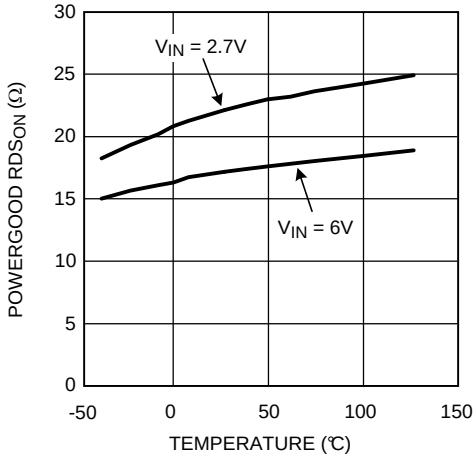


Figure 9.

Output Voltage vs. Temperature

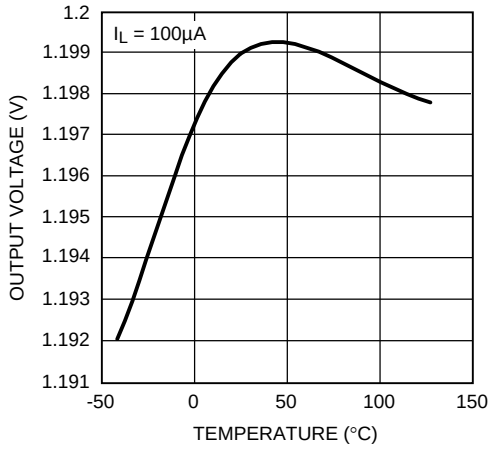


Figure 10.

Output Voltage vs. Input Voltage

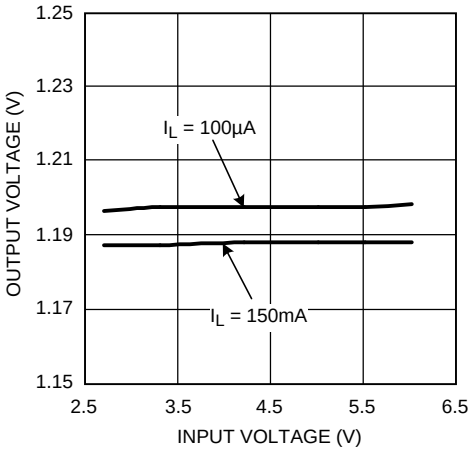


Figure 11.

Output Voltage vs. Output Current

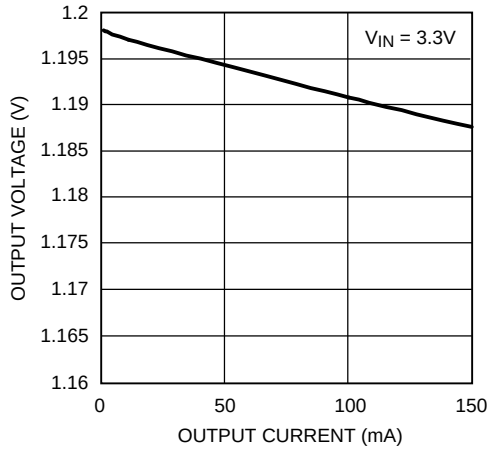


Figure 12.

Enable Voltage vs. Input Voltage

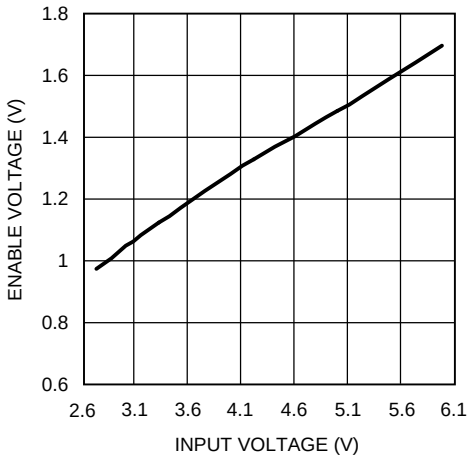


Figure 13.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Unless otherwise specified, V_{IN} = 3.3V, C_{OUT} = 1µF, T_A = 25°C and powergood pull up resistor = 47kΩ.

Enable Voltage vs. Temperature

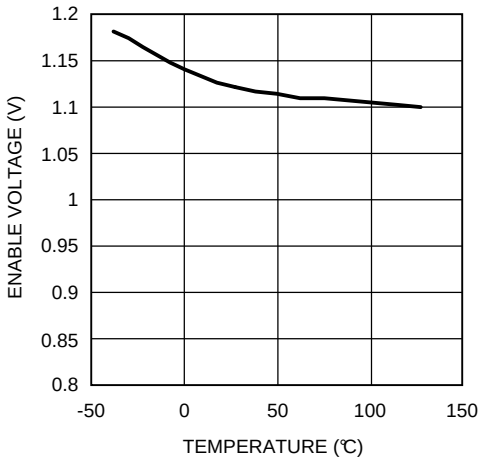


Figure 14.

Voltage Noise vs. Frequency

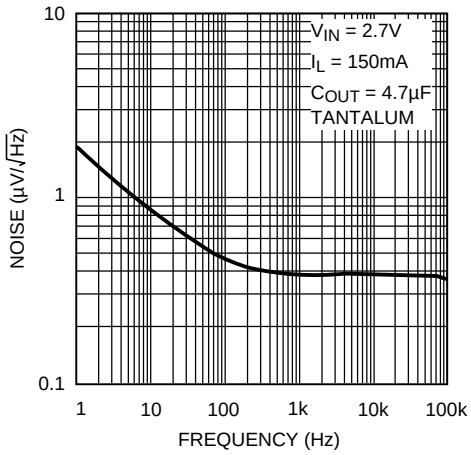


Figure 15.

PSRR vs. Frequency

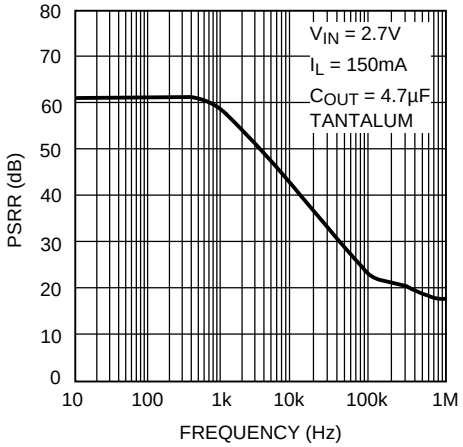


Figure 16.

Power On Reset Delay Time

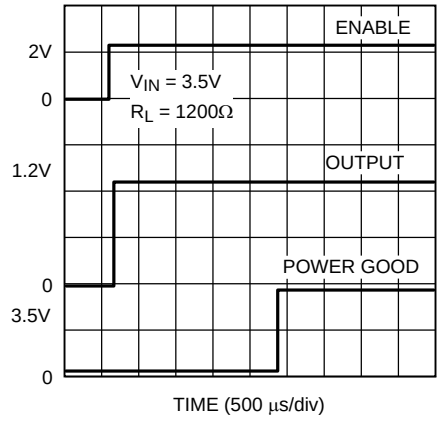


Figure 17.

APPLICATION NOTES

The LP8358 is a linear regulator with power good output designed to be used with a low ESR, low cost ceramic capacitors.

EXTERNAL CAPACITORS

The LP8358 regulator requires an output capacitor to maintain stability. The capacitor must be at least 1µF or greater. The capacitor can be low-ESR ceramic chip capacitor, however for improved capacitance over temperature, tantalum capacitors can be used.

A 1µF input capacitor is recommend when the supply capacitance is more than 10 inches away from the device, or when the supply is a battery.

X7R dielectric ceramic capacitors are recommended because of their temperature performance. X7R-type capacitor change capacitance by 15% over their operating temperature range and are the most stable type of ceramic capacitors. Z5U and Y5V dielectric capacitors change value by as much 50% and 60% respectively over their operating temperature range. To use a ceramic chip capacitor with Y5V dielectric, the value must be much higher than a X7/R ceramic or a tantalum capacitor to ensure the same minimum capacitance value over the operating temperature range. Tantalum capacitors have a very stable dielectric (10% over their operating temperature range) and can also be used with this device.

ENABLE/SHUTDOWN

The LP8358 has an active high enable pin that allows the regulator to be disabled. Applying a Logic Level low (<0.4 V) to the Shutdown pin will cause the output to turn off, in this state current consumed by the regulator goes nearly to zero. Applying a Logic Level high (>2.0V) enables the output voltage. The enable/shutdown pin must not be left floating; a floating enable pin may cause an indeterminate state on the output.

ACTIVE SHUTDOWN

The LP8358 is designed with a N-channel MOSFET that acts as a shutdown clamp. The N-channel turns on when the device is disabled to allow the output capacitor and load to discharge

POWER GOOD

The power good output is an open-drain output with extreme low R_{DSON}. It is designed essentially to work as a power-on reset generator once the regulated voltage is up and/ or a fault condition. When a fault condition occurs, the output of the power good pin goes low. The power good output comes back up once the output has reached 97% of its nominal value and 1ms to 5ms delay has passed , see timing diagram.

The LP8358 internal circuit monitors overcurrent, temperature and falling output voltage. If one of these conditions is flagged this indicates a fault condition.

The flagged condition output is fed into an onchip delay circuit that drives the open drain output transistor.

TRANSIENT RESPONSE

The LP8358 implements a unique output stage to dramatically improve transient response recovery time. The output is a totem-pole configuration with a P-channel MOSFET pass device and a N-channel MOSFET clamp. The N-channel clamp is a significantly smaller device that prevents the output voltage from overshooting when a heavy load is removed. This feature helps to speed up the transient response by significantly decreasing transient response recovery time during the transition from heavy load to light load.

THERMAL BEHAVIOR

The LP8358 regulator has internal thermal shutdown to protect the device from over heating. Under all operating conditions, the maximum junction temperature of the LP8358 must be below 125°C. Maximum power dissipation can be calculated based on the output current and the voltage drop across the part. The maximum power dissipation is

$$P_{D(MAX)} = (T_{J(MAX)} - T_A)/\theta_{JA} \quad (1)$$

θ_{JA} is the junction-to-ambient thermal resistance, 235°C/W for the LP8358 in the SOT-5 package. T_A is the maximum ambient temperature $T_{J(MAX)}$ is the maximum junction temperature of the die, 125°C.

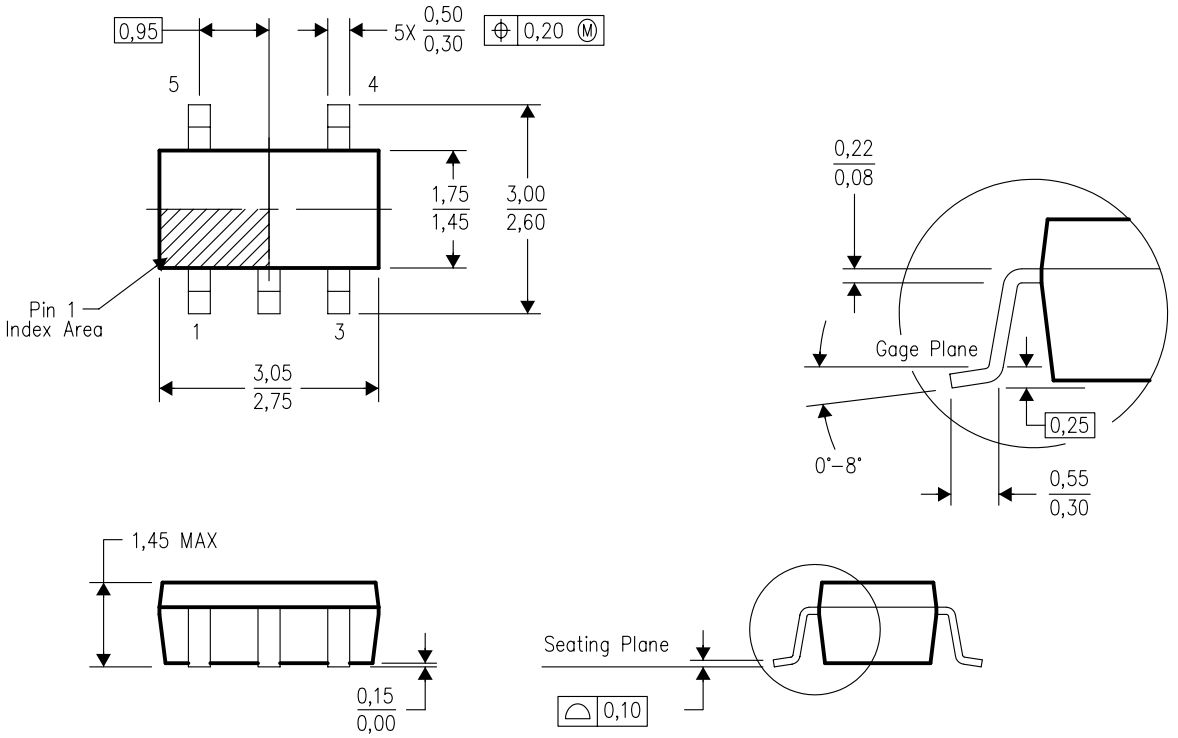
When operating the LP8358 at room temperature, the maximum power dissipation is 425mW.

The actual power dissipated by the regulator is

$$P_D = (V_{IN} - V_{OUT})I_L + V_{IN} I_{GND} \quad (2)$$

Substituting $P_{D(MAX)}$, determined above, for P_D and solving for the operating condition that is critical to the application will give the maximum operating condition for the regulator circuit. To prevent the device from entering thermal shutdown, maximum power dissipation cannot be exceeded.

DBV (R–PDSO–G5) PLASTIC SMALL–OUTLINE PACKAGE



4073253–4/K 03/2006

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
D. Falls within JEDEC MO–178 Variation AA.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265