Micropower Voltage Regulator

Check for Samples: SM72238

FEATURES

- **Renewable Energy Grade**
- **High-Accuracy Output Voltage**
- **Guaranteed 100mA Output Current**
- **Extremely Low Quiescent Current**
- **Low Dropout Voltage**
- **Extremely Tight Load and Line Regulation**
- **Very Low Temperature Coefficient**
- **Use as Regulator or Reference**
- **Needs Minimum Capacitance for Stability**
- **Current and Thermal Limiting**
- **Stable With Low-ESR Output Capacitors (10mΩ to 6Ω)**

DESCRIPTION

The SM72238 is a micropower voltage regulator with very low quiescent current (75µA typ.) and very low dropout voltage (typ. 40mV at light loads and 380mV at 100mA). It is ideally suited for use in battery-powered systems. Furthermore, the quiescent current of the SM72238 increases only slightly in dropout, prolonging battery life.

The SM72238 is available in the surface-mount D-Pak package.

Careful design of the SM72238 has minimized all contributions to the error budget. This includes a tight initial tolerance (.5% typ.), extremely good load and line regulation (.05% typ.) and a very low output voltage temperature coefficient, making the part useful as a low-power voltage reference.

Block Diagram and Typical Applications

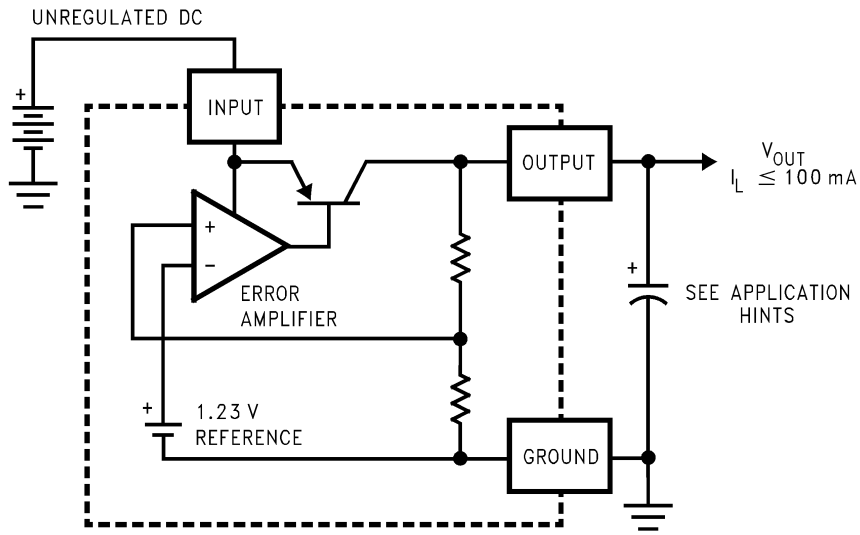


Figure 1. SM72238

Connection Diagrams

Front View

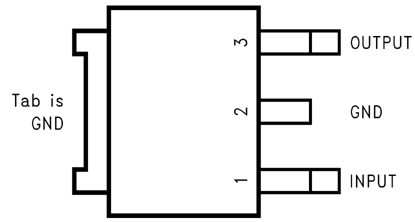


Figure 2. PFM Package
See Package Number NDP0003B

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)

Input Supply Voltage		−0.3 to +30V
Power Dissipation		Internally Limited
Junction Temperature (T_J)		+150°C
Ambient Storage Temperature		−65° to +150°C
Soldering Dwell Time, Temperature	Wave	4 seconds, 260°C
	Infrared	10 seconds, 240°C
	Vapor Phase	75 seconds, 219°C
ESD Rating	Human Body Model(3)	2500V

(1) Absolute Maximum Ratings are limits beyond which damage to the device may occur. Operating Ratings are conditions under which operation of the device is guaranteed. Operating Ratings do not imply guaranteed performance limits. For guaranteed performance limits and associated test conditions, see the Electrical Characteristics tables.
(2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/ Distributors for availability and specifications.
(3) Human Body Model 1.5kΩ in series with 100pF.

Operating Ratings (1)

Maximum Input Supply Voltage	30V
Junction Temperature Range, (T_J) (2)	−40° to +125°C

(1) Absolute Maximum Ratings are limits beyond which damage to the device may occur. Operating Ratings are conditions under which operation of the device is guaranteed. Operating Ratings do not imply guaranteed performance limits. For guaranteed performance limits and associated test conditions, see the Electrical Characteristics tables.
(2) Junction-to-case thermal resistance for the PFM package is 5.4°C/W.

Electrical Characteristics(1)

Parameter	Conditions (1)	Typ	Tested Limit (2)	Design Limit (3)	Units
3V Versions					
Output Voltage	T_J = 25°C	3.0	3.030		V max
			2.970		V min
	−25°C ≤ T_J ≤ 85°C	3.0		3.045	V max
				2.955	V min
	Full Operating Temperature Range	3.0		**3.060**	V max
				2.940	V min

(1) Unless otherwise specified all limits guaranteed for V_{IN} = (V_{ONOM} + 1)V, I_L = 100µA and C_L = 1µF. Limits appearing in **boldface** type apply over the entire junction temperature range for operation. Limits appearing in normal type apply for T_A = T_J = 25°C.
(2) Guaranteed and 100% production tested.
(3) Guaranteed but not 100% production tested. These limits are not used to calculate outgoing AQL levels.

Electrical Characteristics(1) (continued)

Parameter	Conditions (1)	Typ	Tested Limit (2)	Design Limit (3)	Units
Output Voltage	100µA ≤ I_L ≤ 100mA, T_J ≤ T_{JMAX}	3.0		**3.072**	V max
				2.928	V min
3.3V Versions					
Output Voltage	T_J = 25°C	3.3	3.333		V max
			3.267		V min
	−25°C ≤ T_J ≤ 85°C	3.3		3.350	V max
				3.251	V min
	Full Operating Temperature Range	3.3		**3.366**	V max
				3.234	V min
Output Voltage	100µA ≤ I_L ≤ 100mA T_J ≤ T_{JMAX}	3.3		**3.379**	V max
				3.221	V min
5.0V Versions					
Output Voltage	T_J = 25°C	5.0	5.05		V max
			4.95		V min
	−25°C ≤ T_J ≤ 85°C	5.0		5.075	V max
				4.925	V min
	Full Operating Temperature Range	5.0		**5.1**	V max
				4.9	V min
Output Voltage	100µA ≤ I_L ≤ 100mA T_J ≤ T_{JMAX}	5.0		**5.12**	V max
				4.88	V min
All Voltage Options					
Output Voltage Temperature Coefficient	(4)	**50**		**150**	ppm/°C
Line Regulation(5)	(V_ONOM + 1)V ≤ V_{in} ≤ 30V (6)	0.04	0.2		% max
				0.4	% max
Load Regulation(5)	100µA ≤ I_L ≤ 100mA	0.1	0.2		% max
				0.3	% max
Dropout Voltage(7)	I_L = 100µA		80		mV max
		50		**150**	mV max
	I_L = 100mA		450		mV max
		380		**600**	mV max
Ground Current	I_L = 100µA	75	120		µA max
				140	µA max
	I_L = 100mA	8	12		mA max
				14	mA max
Dropout Ground Current	V_{in} = (V_ONOM − 0.5)V, I_L = 100µA	110	170		µA max
				200	µA max
Current Limit	V_{out} = 0	160	200		mA max
				220	mA max
Thermal Regulation	(8)	0.05	0.2		%/W max

(4) Output or reference voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.
(5) Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered under the specification for thermal regulation.
(6) For I_L = 100µA and T_J = 125°C, line regulation is guaranteed by design to 0.2%. See Typical Performance Characteristics for line regulation versus temperature and load current.
(7) Dropout Voltage is defined as the input to output differential at which the output voltage drops 100 mV below its nominal value measured at 1V differential. At very low values of programmed output voltage, the minimum input supply voltage of 2V (2.3V over temperature) must be taken into account.
(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 50mA load pulse at V_{IN} = 30V (1.25W pulse) for T = 10ms.

Electrical Characteristics[1] (continued)

Parameter	Conditions [1]	Typ	Tested Limit [2]	Design Limit [3]	Units
Output Noise, 10 Hz to 100 kHz	C_L = 1µF (5V Only)	430			µV rms
	C_L = 200µF	160			µV rms
	C_L = 3.3µF (Bypass = 0.01µF)	100			µV rms

Typical Performance Characteristics

Quiescent Current

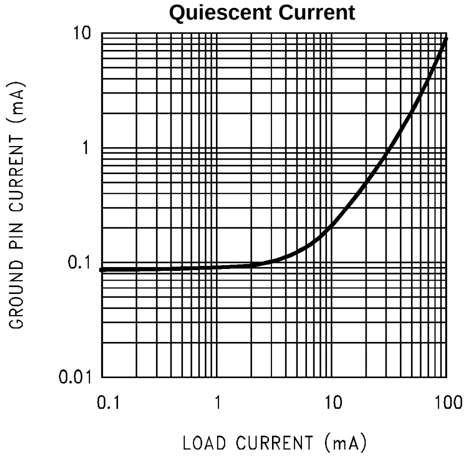


Figure 3.

Dropout Characteristics

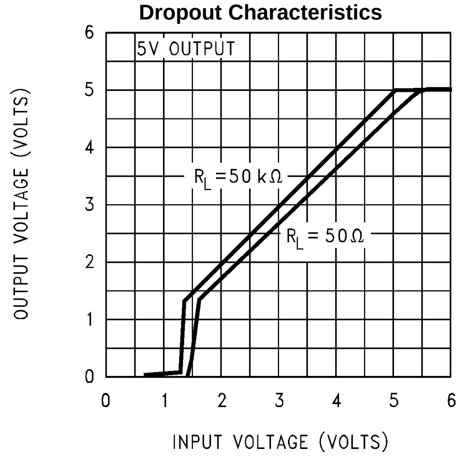


Figure 4.

Input Current

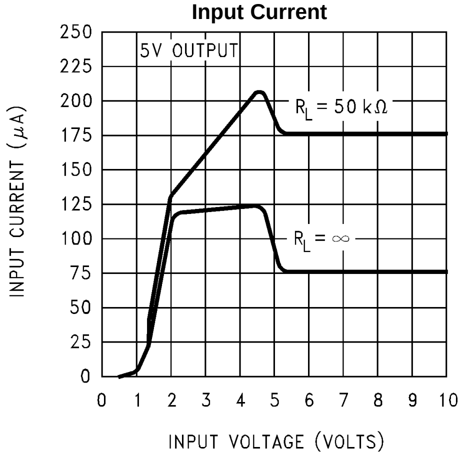


Figure 5.

Input Current

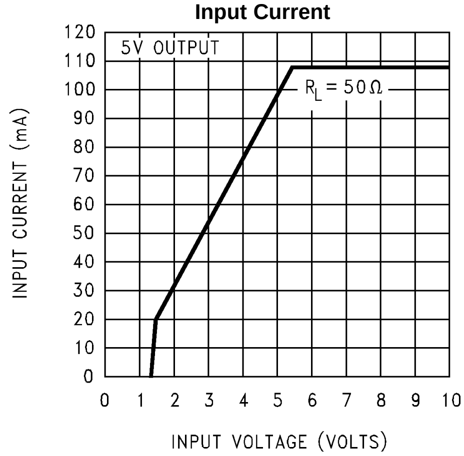


Figure 6.

Output Voltage vs. Temperature of 3 Representative Units

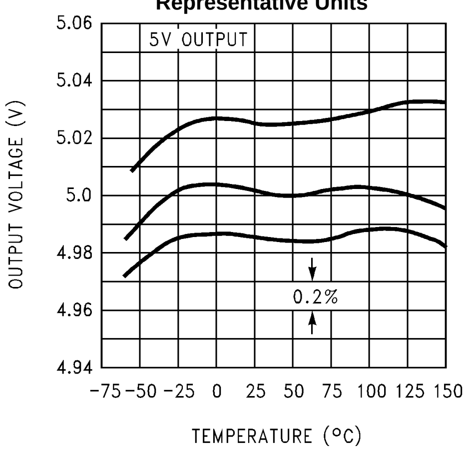


Figure 7.

Quiescent Current

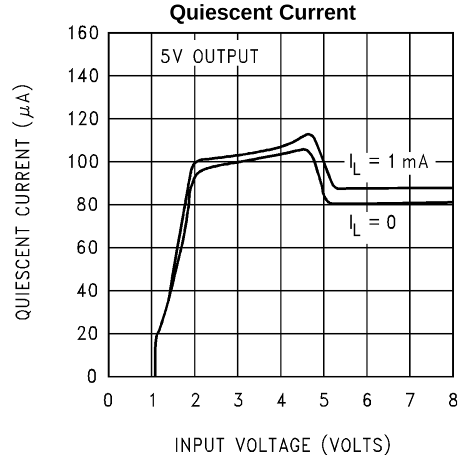


Figure 8.

Typical Performance Characteristics (continued)

Quiescent Current

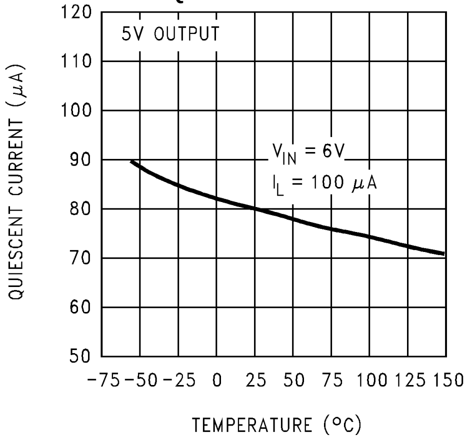


Figure 9.

Quiescent Current

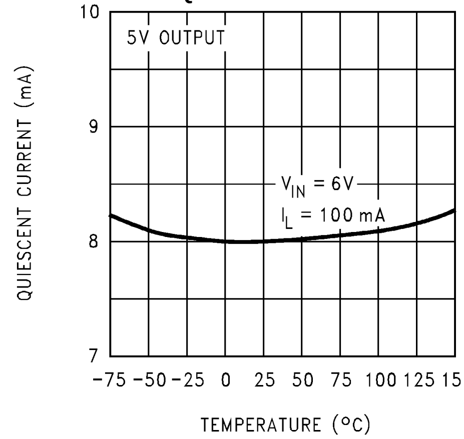


Figure 10.

Quiescent Current

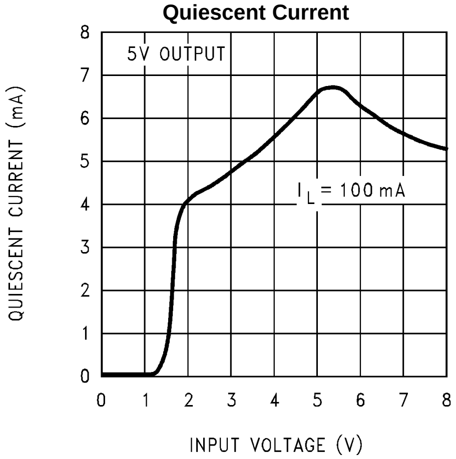


Figure 11.

Short Circuit Current

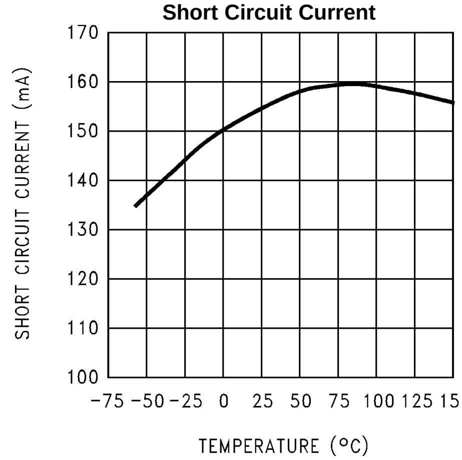


Figure 12.

Dropout Voltage

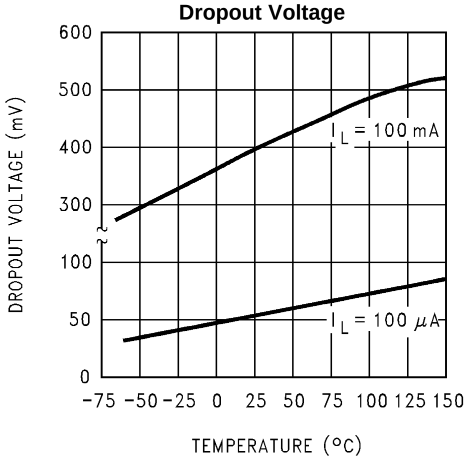


Figure 13.

Line Transient Response

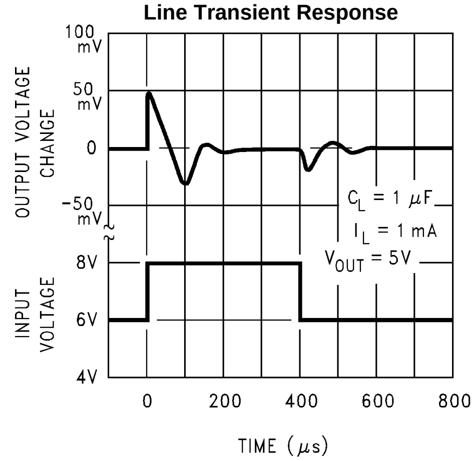


Figure 14.

Typical Performance Characteristics (continued)

Load Transient Response

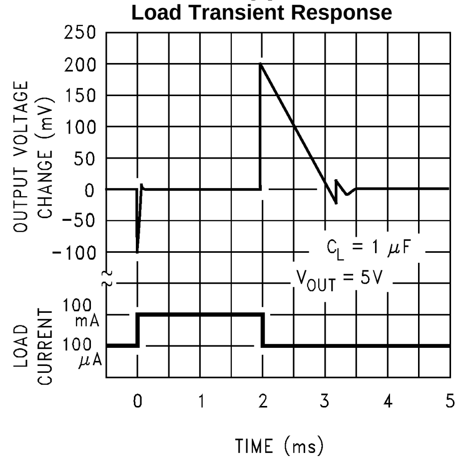


Figure 15.

Load Transient Response

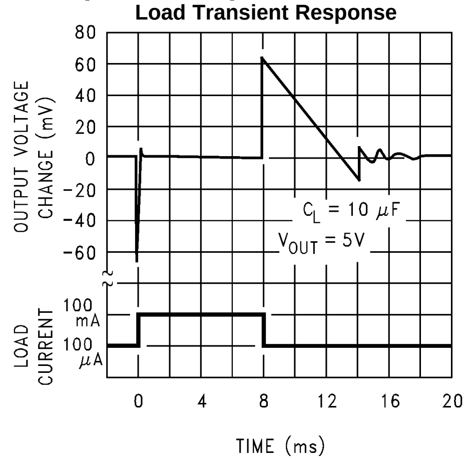


Figure 16.

Output Impedance

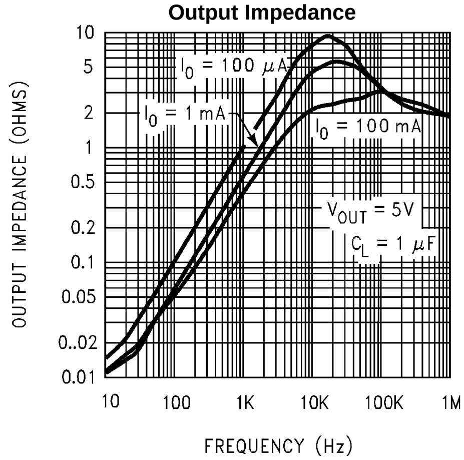


Figure 17.

Ripple Rejection

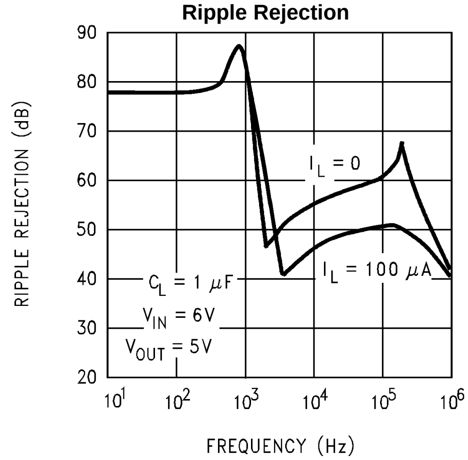


Figure 18.

Ripple Rejection

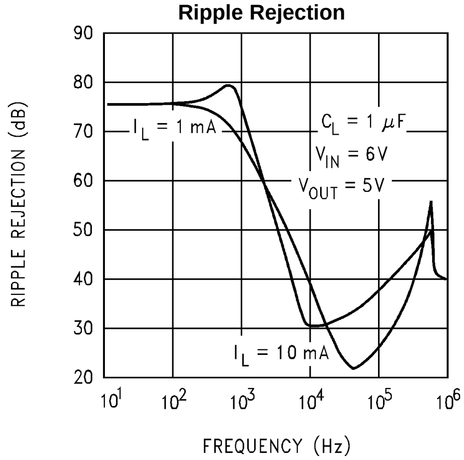


Figure 19.

Ripple Rejection

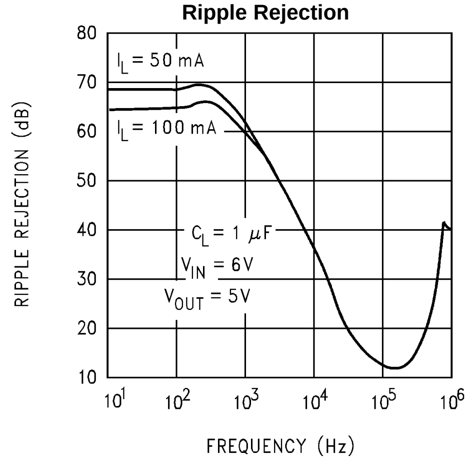


Figure 20.

Typical Performance Characteristics (continued)

Shutdown Threshold Voltage

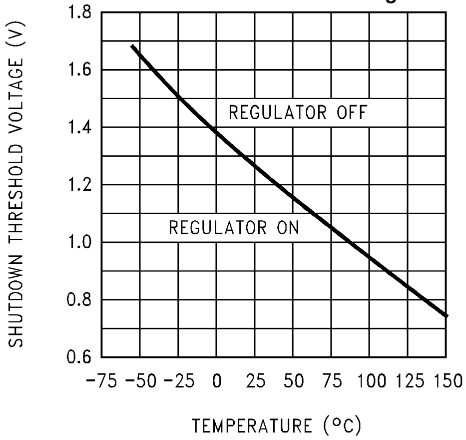


Figure 21.

Line Regulation

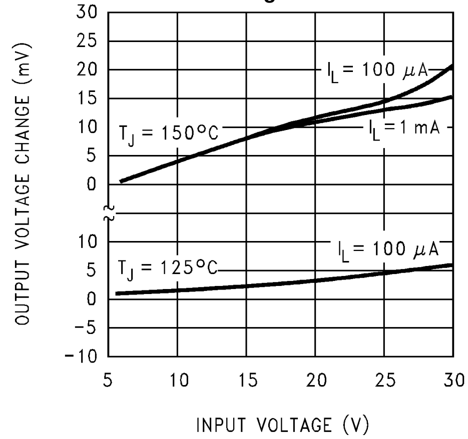


Figure 22.

Maximum Rated Output Current

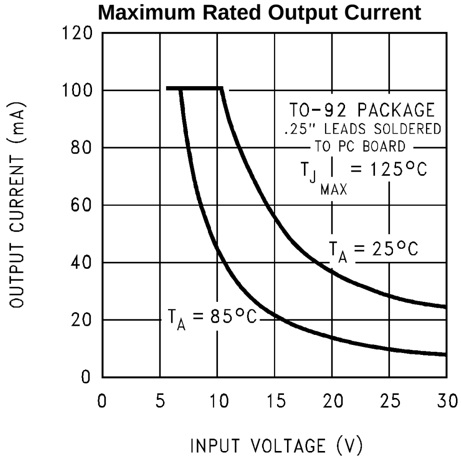


Figure 23.

Thermal Response

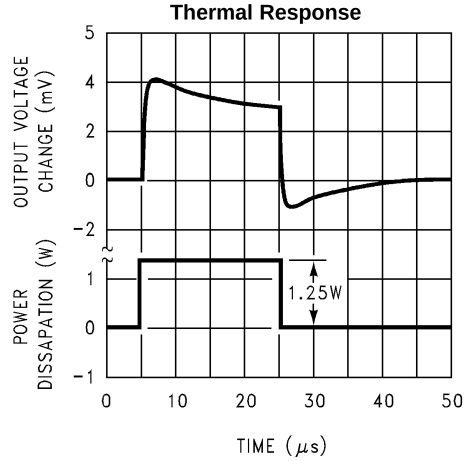


Figure 24.

Output Capacitor ESR Range

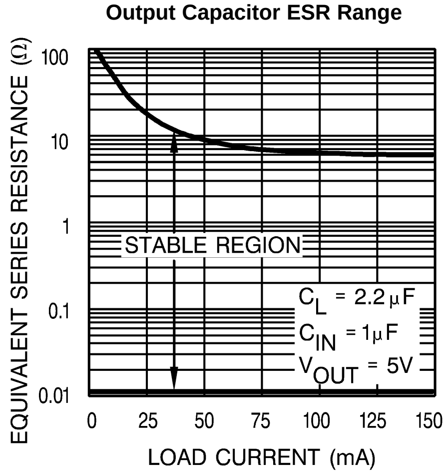


Figure 25.

APPLICATION HINTS

EXTERNAL CAPACITORS

A 1.0µF (or greater) capacitor is required between the output and ground for stability. Without this capacitor the part will oscillate. Most types of tantalum or aluminum electrolytics work fine here; even film types work but are not recommended for reasons of cost. Many aluminum electrolytics have electrolytes that freeze at about −30°C, so solid tantalums are recommended for operation below −25°C. The important parameters of the capacitor are an ESR of about 5Ω or less and a resonant frequency above 500kHz. The value of this capacitor may be increased without limit.

Ceramic capacitors whose value is greater than 1000pF should not be connected directly from the SM72238 output to ground. Ceramic capacitors typically have ESR values in the range of 5 to 10mΩ, a value below the lower limit for stable operation (see Figure 25).

The reason for the lower ESR limit is that the loop compensation of the part relies on the ESR of the output capacitor to provide the zero that gives added phase lead. The ESR of ceramic capacitors is so low that this phase lead does not occur, significantly reducing phase margin. A ceramic output capacitor can be used if a series resistance is added (recommended value of resistance about 0.1Ω to 2Ω).

At lower values of output current, less output capacitance is required for stability. The capacitor can be reduced to 0.33µF for currents below 10mA or 0.1µF for currents below 1mA.

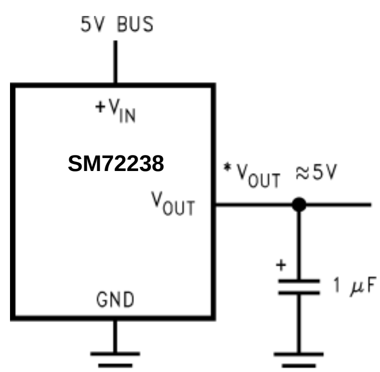
Unlike many other regulators, the SM72238 will remain stable and in regulation with no load in addition to the internal voltage divider. This is especially important in CMOS RAM keep-alive applications.

A 1µF tantalum, ceramic or aluminum electrolytic capacitor should be placed from the SM72238 input to ground if there is more than 10 inches of wire between the input and the AC filter capacitor or if a battery is used as the input.

REDUCING OUTPUT NOISE

In reference applications it may be advantageous to reduce the AC noise present at the output. One method is to reduce the regulator bandwidth by increasing the size of the output capacitor. This is the only way noise can be reduced but is relatively inefficient, as increasing the capacitor from 1µF to 220µF only decreases the noise from 430µV to 160µV rms for a 100kHz bandwidth at 5V output.

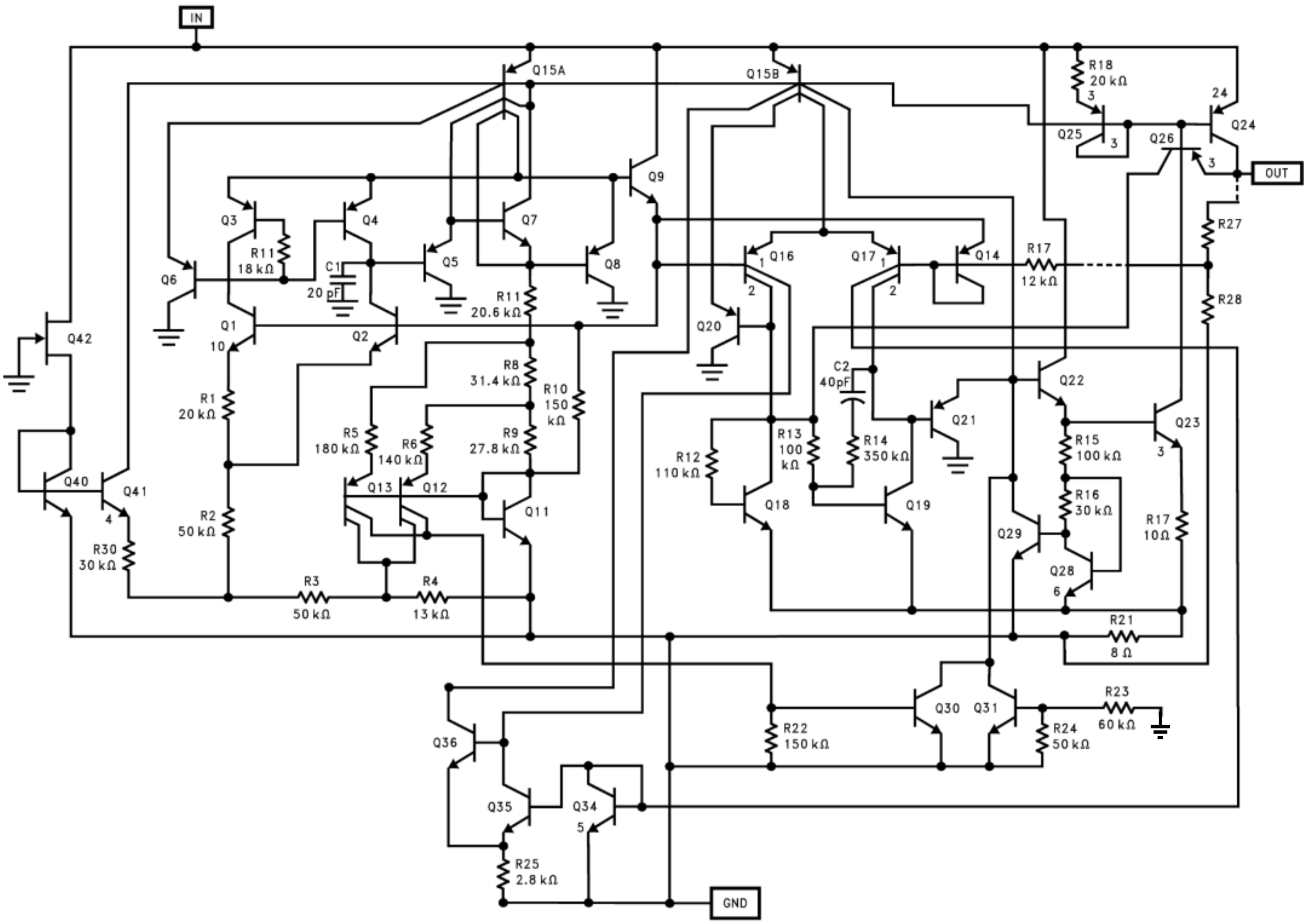
Typical Applications



*Minimum input-output voltage ranges from 40mV to 400mV, depending on load current. Current limit is typically 160mA.

Figure 26. 5 Volt Current Limiter

Schematic Diagram



PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
SM72238TD-3.0/NOPB	ACTIVE	PFM	NDP	3	75	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238 -3.0	Samples
SM72238TD-3.3/NOPB	ACTIVE	PFM	NDP	3	75	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238 -3.3	Samples
SM72238TD-5.0/NOPB	ACTIVE	PFM	NDP	3	75	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238	Samples
SM72238TDE-3.0/NOPB	ACTIVE	PFM	NDP	3	250	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238 -3.0	Samples
SM72238TDE-3.3/NOPB	ACTIVE	PFM	NDP	3	250	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238 -3.3	Samples
SM72238TDE-5.0/NOPB	ACTIVE	PFM	NDP	3	250	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238	Samples
SM72238TDX-3.0/NOPB	ACTIVE	PFM	NDP	3	2500	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238 -3.0	Samples
SM72238TDX-3.3/NOPB	ACTIVE	PFM	NDP	3	2500	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238 -3.3	Samples
SM72238TDX-5.0/NOPB	ACTIVE	PFM	NDP	3	2500	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) Only one of markings shown within the brackets will appear on the physical device.

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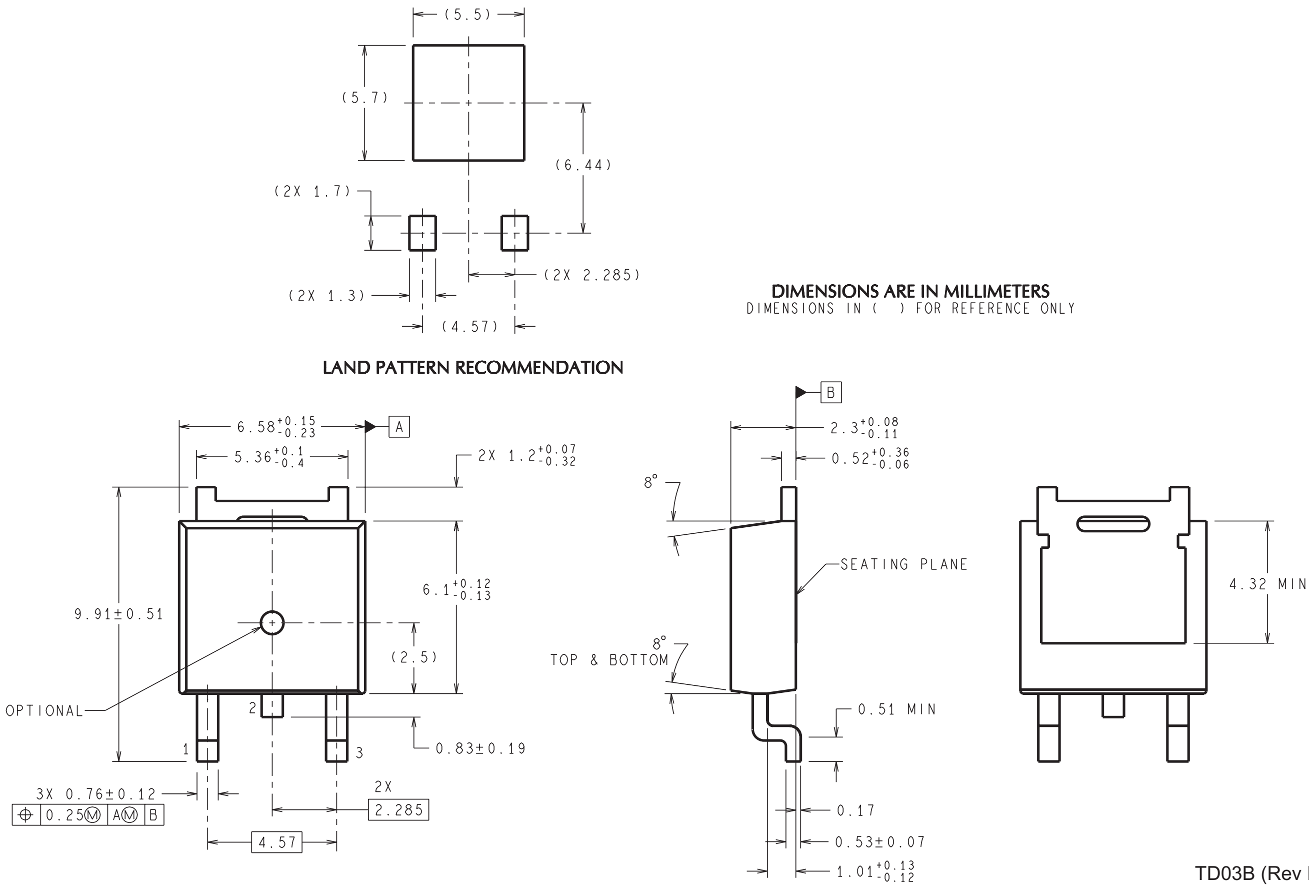
NDP0003B



TD03B (Rev F)