

Micropower Voltage Regulator

Check for Samples: [SM72238](#)

FEATURES

- Renewable Energy Grade
- High-Accuracy Output Voltage
- Ensured 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

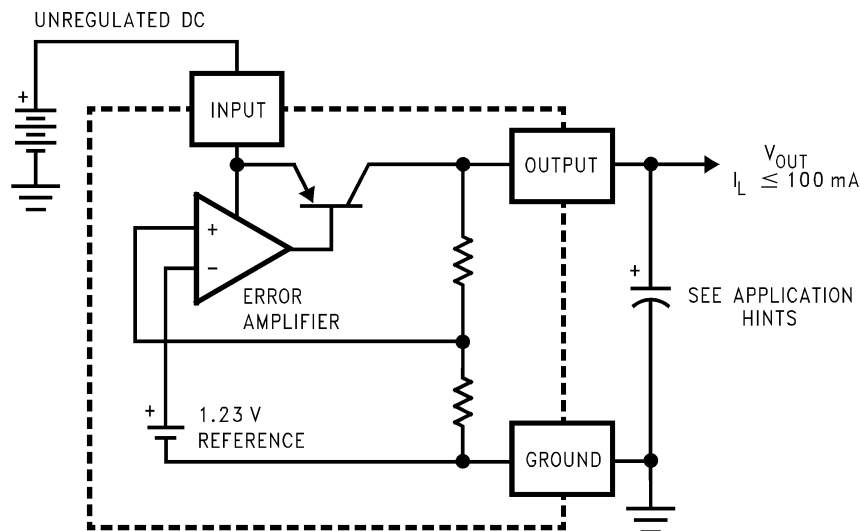


Figure 1. SM72238



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

All trademarks are the property of their respective owners.

Connection Diagrams

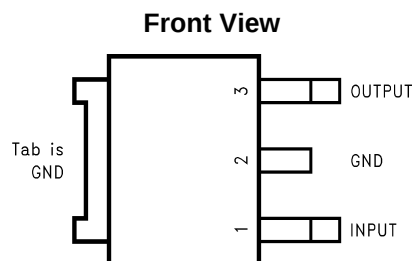


Figure 2. PFM Package
See Package Number NDP0003B



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 ensured. Operating Ratings do not imply ensured performance limits. For ensured 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 ensured. Operating Ratings do not imply ensured performance limits. For ensured 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	
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	See ⁽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	50	80		mV max
				150	mV max
	I _L = 100mA	380	450		mV max
				600	mV max

- (1) Unless otherwise specified all limits ensured for $V_{\text{IN}} = (V_{\text{ONOM}} + 1)\text{V}$, $I_L = 100\mu\text{A}$ and $C_L = 1\mu\text{F}$. Limits appearing in **boldface** type apply over the entire junction temperature range for operation. Limits appearing in normal type apply for $T_A = T_J = 25^\circ\text{C}$.
- (2) Ensured and 100% production tested.
- (3) Ensured but not 100% production tested. These limits are not used to calculate outgoing AQL levels.
- (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 $I_L = 100\mu\text{A}$ and $T_J = 125^\circ\text{C}$, line regulation is ensured 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.

Electrical Characteristics⁽¹⁾ (continued)

Parameter	Conditions ⁽¹⁾	Typ	Tested Limit ⁽²⁾	Design Limit ⁽³⁾	Units
Ground Current	$I_L = 100\mu\text{A}$	75	120		$\mu\text{A max}$
				140	$\mu\text{A max}$
	$I_L = 100\text{mA}$	8	12		mA max
				14	mA max
Dropout Ground Current	$V_{in} = (V_{ONOM} - 0.5)\text{V}$, $I_L = 100\mu\text{A}$	110	170		$\mu\text{A max}$
				200	$\mu\text{A max}$
Current Limit	$V_{out} = 0$	160	200		mA max
				220	mA max
Thermal Regulation	See ⁽⁸⁾	0.05	0.2		$\%/W$ max
Output Noise, 10 Hz to 100 kHz	$C_L = 1\mu\text{F}$ (5V Only)	430			$\mu\text{V rms}$
	$C_L = 200\mu\text{F}$	160			$\mu\text{V rms}$
	$C_L = 3.3\mu\text{F}$ (Bypass = $0.01\mu\text{F}$)	100			$\mu\text{V rms}$

(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 $V_{IN} = 30\text{V}$ (1.25W pulse) for $T = 10\text{ms}$.

Typical Performance Characteristics

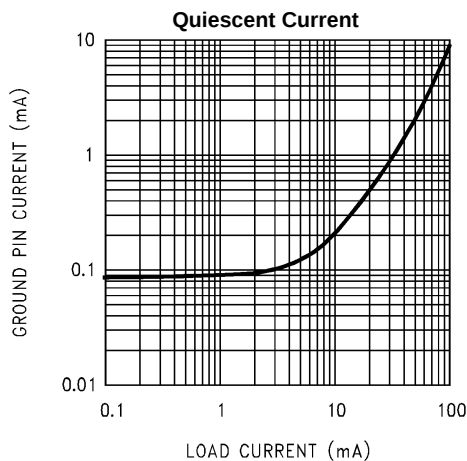


Figure 3.

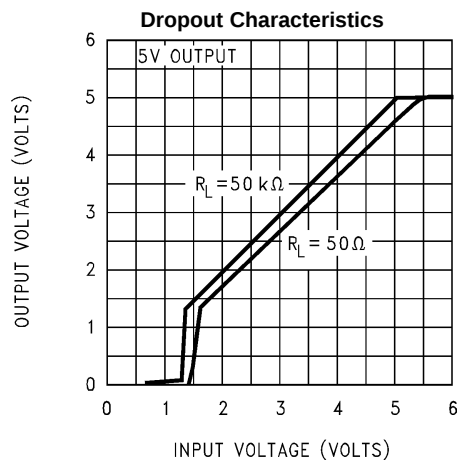


Figure 4.

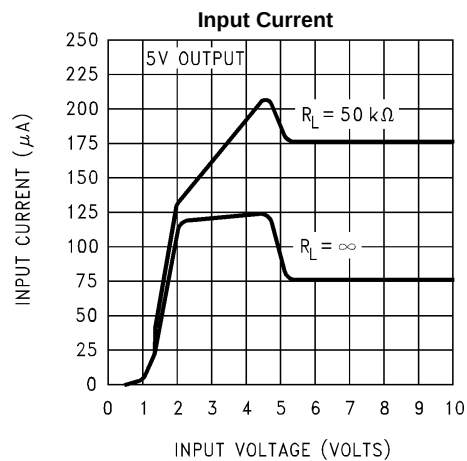


Figure 5.

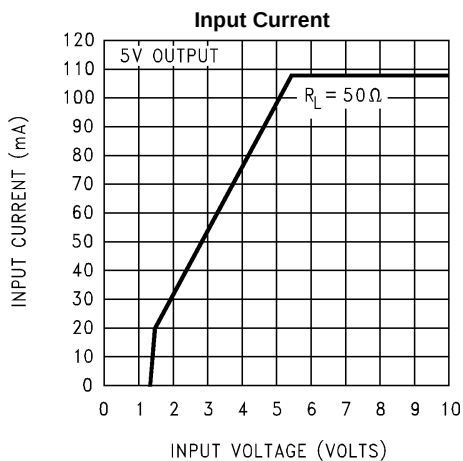


Figure 6.

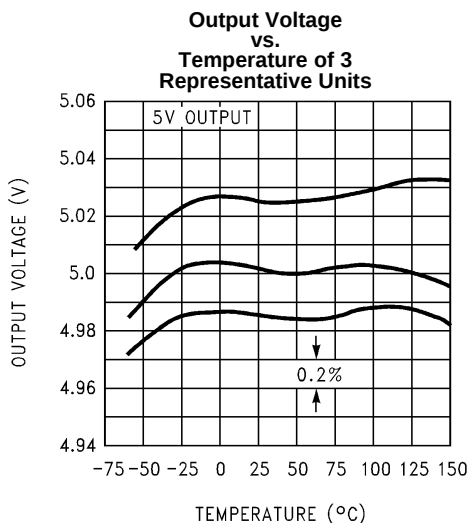


Figure 7.

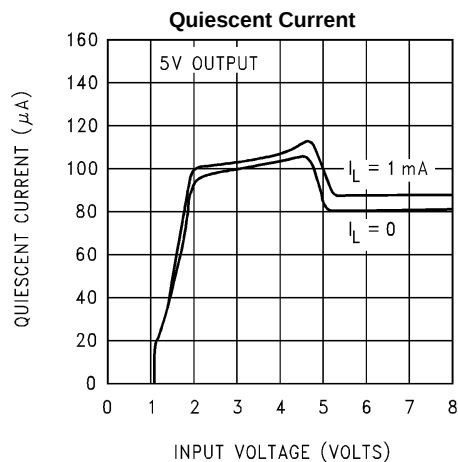


Figure 8.

Typical Performance Characteristics (continued)

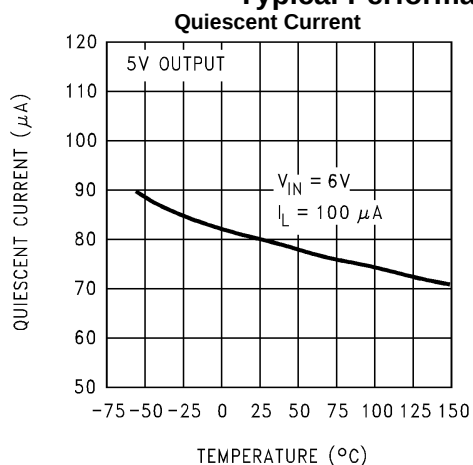


Figure 9.

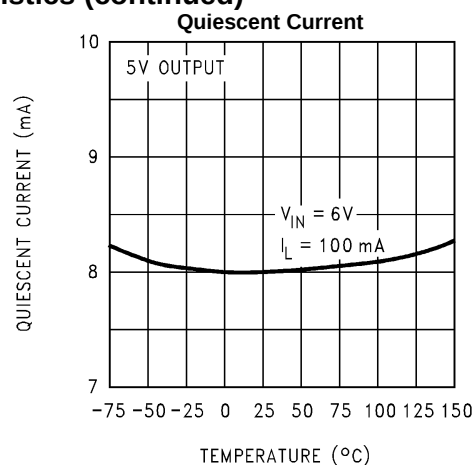


Figure 10.

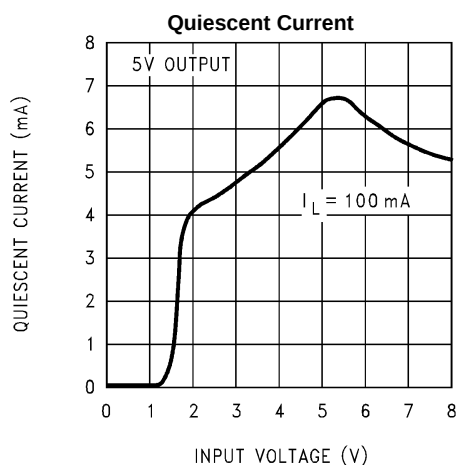


Figure 11.

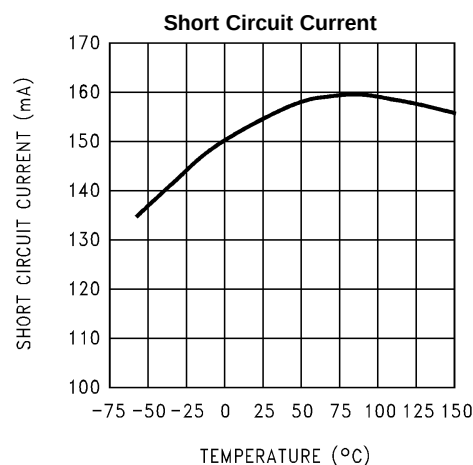


Figure 12.

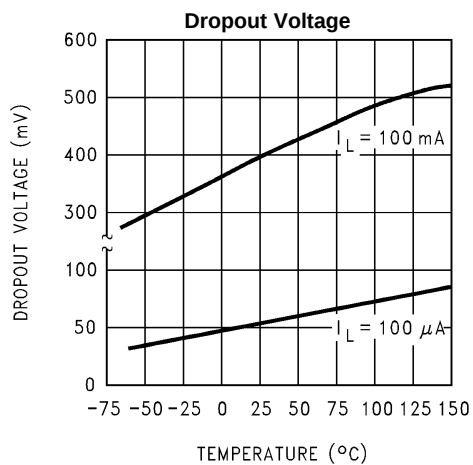


Figure 13.

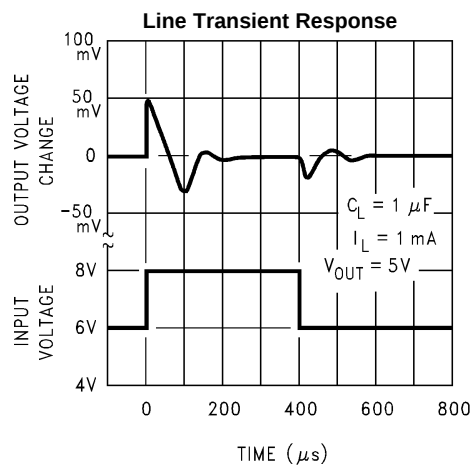


Figure 14.

Typical Performance Characteristics (continued)

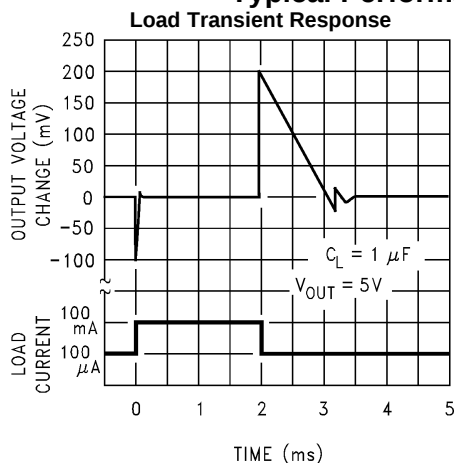


Figure 15.

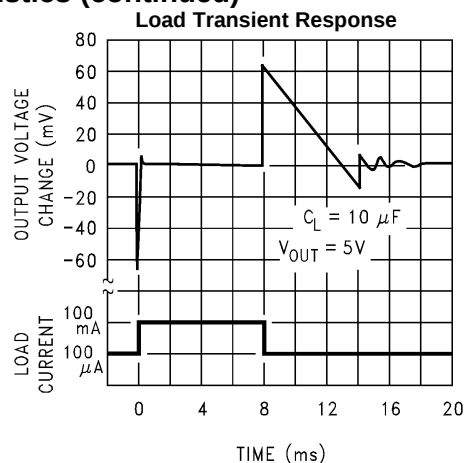


Figure 16.

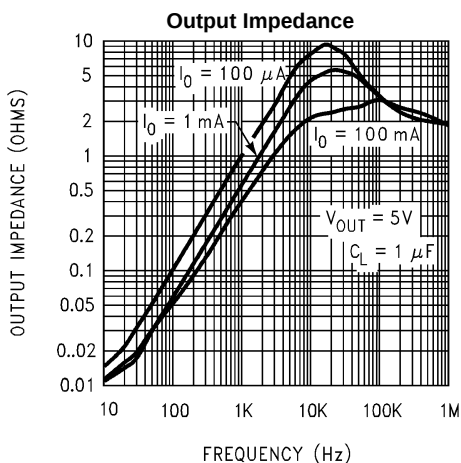


Figure 17.

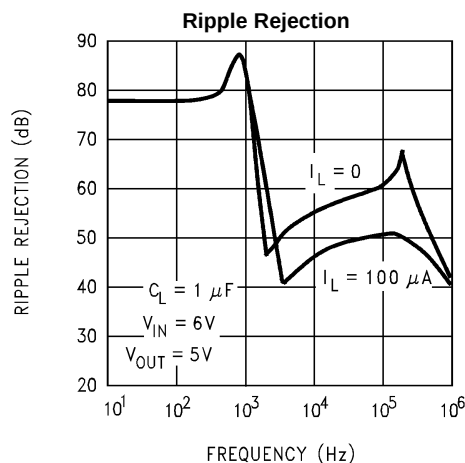


Figure 18.

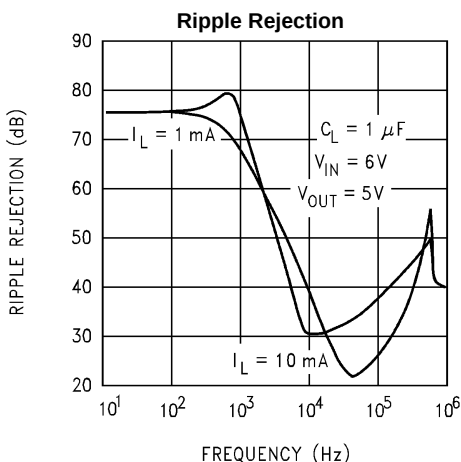


Figure 19.

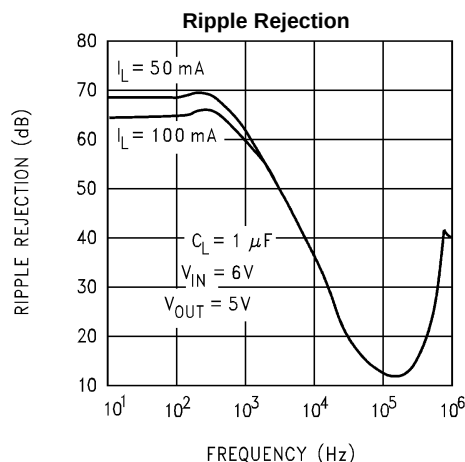


Figure 20.

Typical Performance Characteristics (continued)

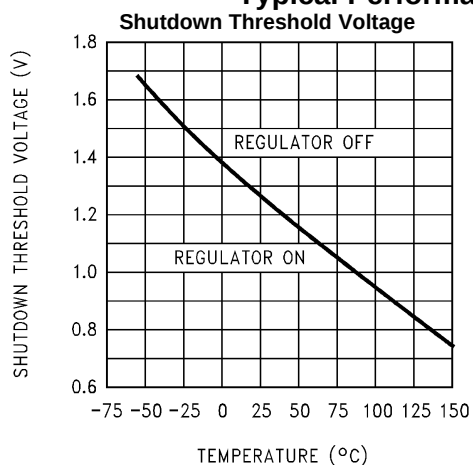


Figure 21.

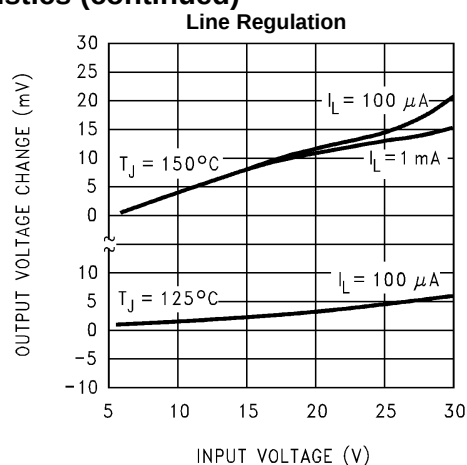


Figure 22.

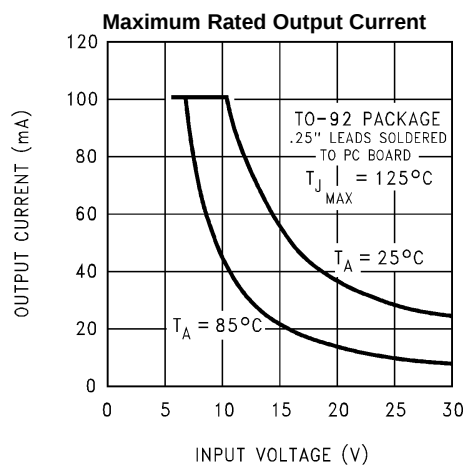


Figure 23.

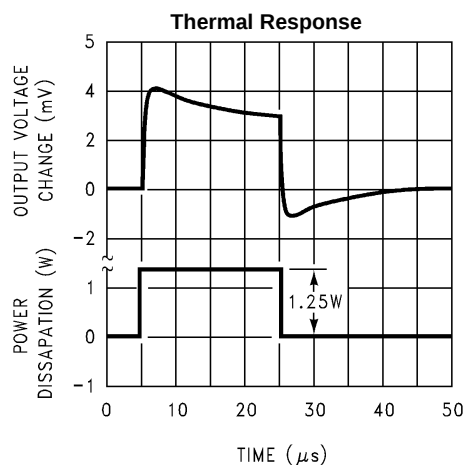


Figure 24.

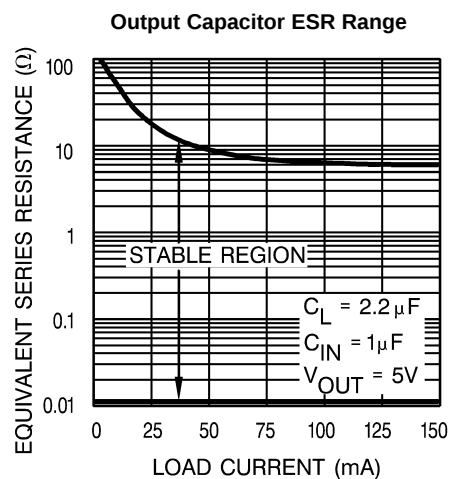


Figure 25.

APPLICATION HINTS

EXTERNAL CAPACITORS

A 1.0 μ F (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 5 Ω 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 10m Ω , 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 0.1 Ω to 2 Ω).

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

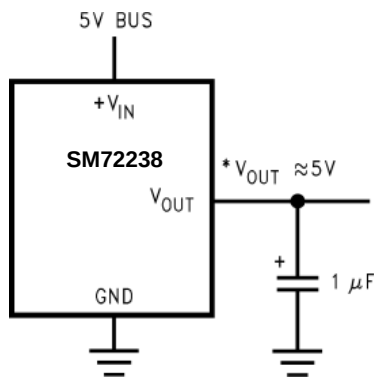
Unlike many other regulators, the SM72238 will remain stable and in regulation with no load in addition to the internal voltage divider. This is especially important in CMOS RAM keep-alive applications.

A 1 μ F 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 1 μ F to 220 μ F only decreases the noise from 430 μ V to 160 μ V rms for a 100kHz bandwidth at 5V output.

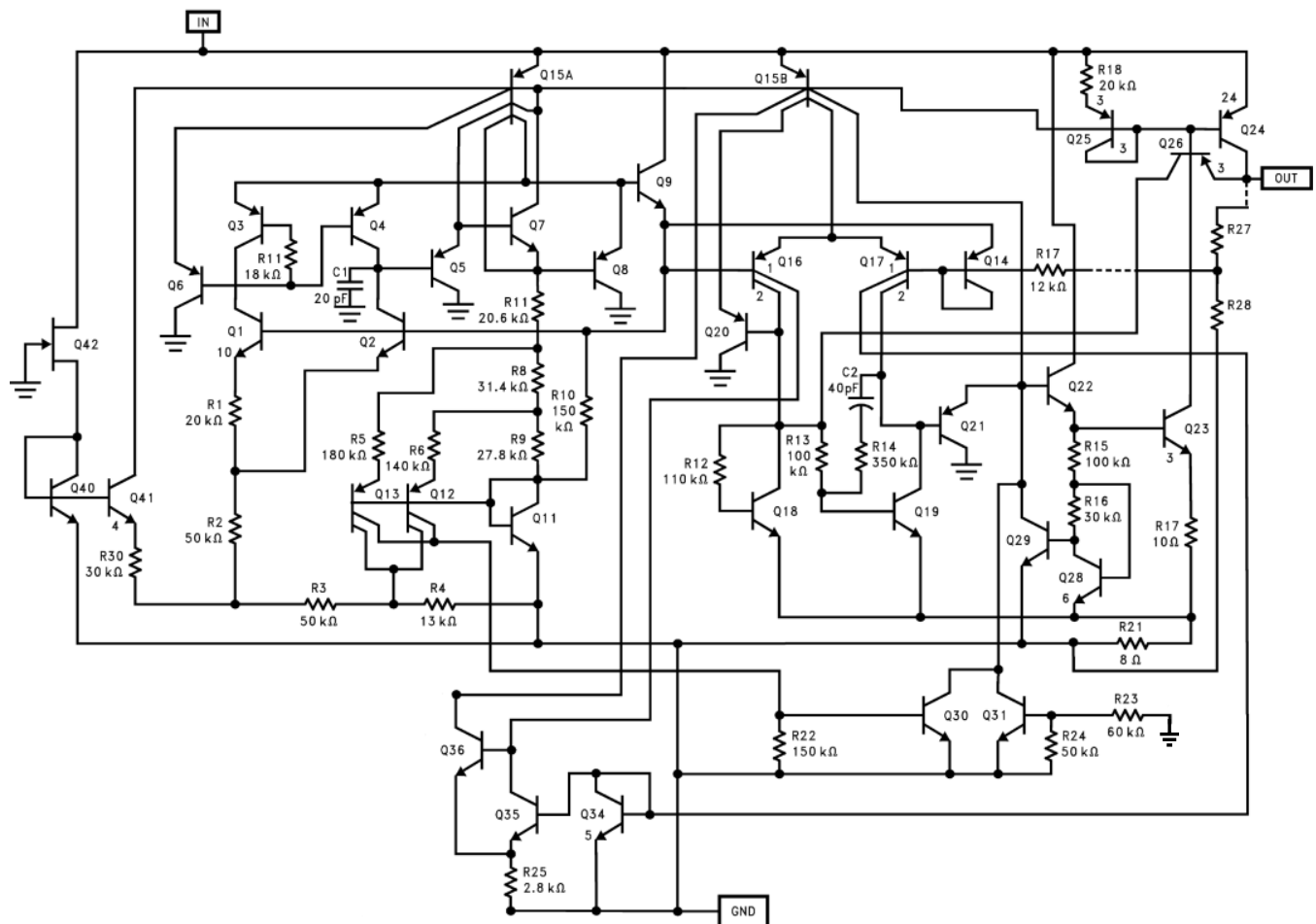
Typical Applications



*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



REVISION HISTORY

Changes from Revision B (April 2013) to Revision C

Page

- Changed layout of National Data Sheet to TI format [10](#)

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
SM72238TD-3.0/NOPB	LIFEBUY	TO-252	NDP	3	75	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238 -3.0	
SM72238TD-3.3/NOPB	NRND	TO-252	NDP	3	75	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238 -3.3	
SM72238TD-5.0/NOPB	NRND	TO-252	NDP	3	75	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238	
SM72238TDE-3.0/NOPB	LIFEBUY	TO-252	NDP	3	250	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238 -3.0	
SM72238TDE-3.3/NOPB	NRND	TO-252	NDP	3	250	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238 -3.3	
SM72238TDE-5.0/NOPB	NRND	TO-252	NDP	3	250	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238	
SM72238TDX-3.0/NOPB	LIFEBUY	TO-252	NDP	3	2500	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238 -3.0	
SM72238TDX-3.3/NOPB	NRND	TO-252	NDP	3	2500	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238 -3.3	
SM72238TDX-5.0/NOPB	NRND	TO-252	NDP	3	2500	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR	-40 to 125	S72238	

(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.

OBSELETE: 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⁾ There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

⁽⁵⁾ Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "-" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

⁽⁶⁾ Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
SM72238TDE-3.0/NOPB	TO-252	NDP	3	250	178.0	16.4	6.9	10.5	2.7	8.0	16.0	Q2
SM72238TDE-3.3/NOPB	TO-252	NDP	3	250	178.0	16.4	6.9	10.5	2.7	8.0	16.0	Q2
SM72238TDE-5.0/NOPB	TO-252	NDP	3	250	178.0	16.4	6.9	10.5	2.7	8.0	16.0	Q2
SM72238TDX-3.0/NOPB	TO-252	NDP	3	2500	330.0	16.4	6.9	10.5	2.7	8.0	16.0	Q2
SM72238TDX-3.3/NOPB	TO-252	NDP	3	2500	330.0	16.4	6.9	10.5	2.7	8.0	16.0	Q2
SM72238TDX-5.0/NOPB	TO-252	NDP	3	2500	330.0	16.4	6.9	10.5	2.7	8.0	16.0	Q2

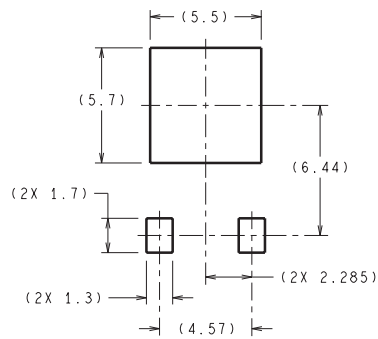
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

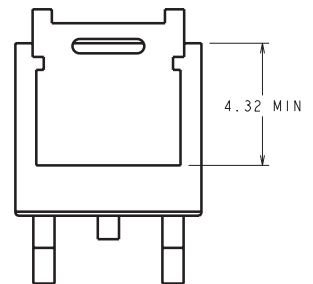
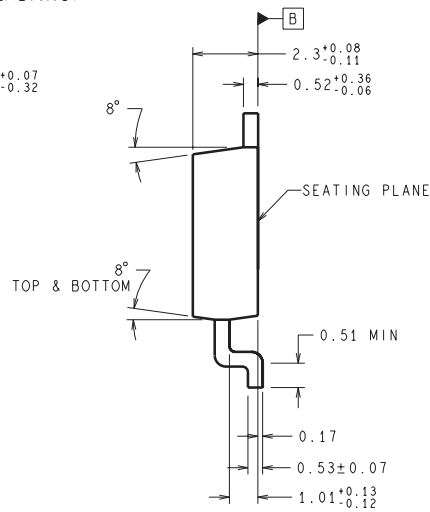
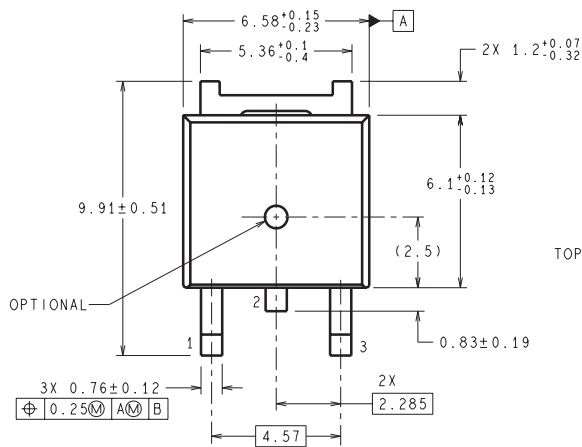
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SM72238TDE-3.0/NOPB	TO-252	NDP	3	250	210.0	185.0	35.0
SM72238TDE-3.3/NOPB	TO-252	NDP	3	250	210.0	185.0	35.0
SM72238TDE-5.0/NOPB	TO-252	NDP	3	250	210.0	185.0	35.0
SM72238TDX-3.0/NOPB	TO-252	NDP	3	2500	367.0	367.0	38.0
SM72238TDX-3.3/NOPB	TO-252	NDP	3	2500	367.0	367.0	38.0
SM72238TDX-5.0/NOPB	TO-252	NDP	3	2500	367.0	367.0	38.0

NDP0003B



DIMENSIONS ARE IN MILLIMETERS
 DIMENSIONS IN () FOR REFERENCE ONLY

LAND PATTERN RECOMMENDATION



TD03B (Rev F)

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

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com