

MAX8863/64 Pin Compatible, Low Dropout, 120 mA Linear Regulators

Features

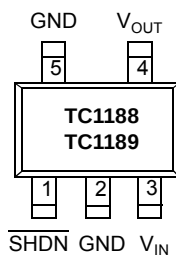
- Input Voltage Range: 2.7 V to 6.0 V
- 120 mA Output Current
- Low Supply Current: 50 μ A, (typical)
- Low Dropout Voltage: 110 mV, (typical at 100 mA)
- Fast Turn-On from Shutdown: 140 μ sec (typical)
- Low Output Noise
- Over-Current and Over-Temperature Protection
- Low Power Shutdown Mode
- Auto Discharge of Output Capacitor (TC1189)

Applications

- Battery Powered Systems
- Portable Computers
- Medical Instruments
- Cellular, Cordless Phones
- PDAs
- Pagers

Package Type

5-Pin SOT-23A



NOTE: 5-Pin SOT-23A is equivalent to the EIAJ (SC-74A)

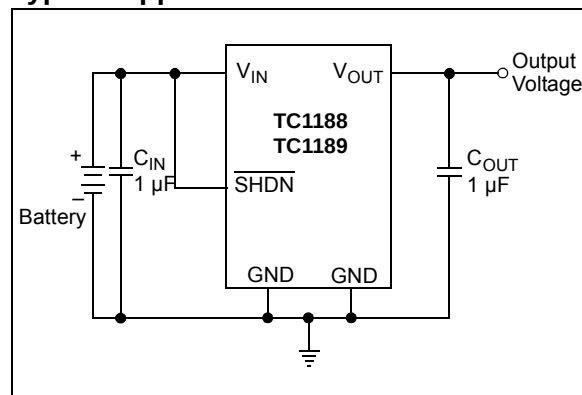
General Description

The TC1188 and TC1189 are fixed output, low dropout linear regulators that operate from a 2.7V to 6.0V input voltage source. The output is capable of delivering up to 120 mA while consuming only 50 μ A of quiescent current. The low dropout voltage, 120 mV, make the TC1188 and TC1189 good choices for battery powered applications. Integrated over-current and over-temperature protection features provide for a fault tolerant solution.

The TC1189 includes an output voltage auto discharge feature. When shutdown, the TC1189 will automatically discharge the output voltage using an internal N-Channel MOSFET switch.

Fixed output voltage options for the TC1188/TC1189 are: 1.80V, 2.80V, 2.84V and 3.15V. Both the TC1188 and TC1189 are available in SOT23-5 packages.

Typical Application Circuit



TC1188/TC1189

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings*

Input Voltage	6.5V
Output Short-Circuit Duration	Infinite
Output Voltage.....	(-0.3V) to ($V_{IN} + 0.3V$)
Maximum Voltage On Any Pin....	(-0.3V) to ($V_{IN} + 0.3V$)
Continuous Power Dissipation ($T_A = +70^{\circ}C$)	
SOT-23-5 (derate 7.1 mW/ $^{\circ}C$ above $+70^{\circ}C$)	
.....	571 mW
Operating Temperature Range.....	$-40^{\circ}C$ to $85^{\circ}C$
Storage Temperature.....	$-65^{\circ}C$ to $+160^{\circ}C$
Lead Temperature (Soldering, 10 Sec.)	$+300^{\circ}C$

***Notice:** *Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions above those indicated in the operation sections of the specifications is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

DC SPECIFICATIONS

Electrical Characteristics: $V_{IN} = +3.6V$, $GND = 0V$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^{\circ}C$. (Note 1)						
Parameters	Symbol	Min	Typ	Max	Units	Conditions
Input Voltage	V_{IN}	$V_{OUT} + 0.5V$ 2.7	—	6.0 6.0	V	$V_{OUT} \geq 2.5V$ $V_{OUT} = 1.8V$ (Note 2)
Output Voltage	V_{OUT}	3.05	3.15	3.25	V	$0 mA \leq I_{OUT} \leq 50 mA$ T
		2.75	2.84	2.93	V	$0 mA \leq I_{OUT} \leq 50 mA$ S
		2.70	2.80	2.88	V	$0 mA \leq I_{OUT} \leq 50 mA$ R
		1.745	1.80	1.85	V	$0 mA \leq I_{OUT} \leq 50 mA$ Q
Maximum Output Current	I_{OUT}	120	—	—	mA	
Current Limit	I_{LIM}	—	280	—	mA	Note 3
Input Current	I_{IN}	—	50	90	μA	$I_{OUT} = 0$
Dropout Voltage		—	1.1	—	mV	$I_{OUT} = 1 mA$
		—	55	120	mV	$I_{OUT} = 50 mA$
		—	110	240	mV	$I_{OUT} = 100 mA$ (Note 4)
Line Regulation	ΔV_{LNR}	-0.10	0.001	0.10	%/V	$V_{IN} = V_{OUT} + 0.5V$ to $6.0V$
		—	—	—	%/V	$I_{OUT} = 1 mA$
Load Regulation	ΔV_{LDR}	—	0.01	0.040	%/mA	$I_{OUT} = 0 mA$ to $50 mA$
Output Voltage Noise		—	350	—	μV_{RMS}	10 Hz to 1 MHz, $C_{OUT} = 1 MF$
		—	220	—	μV_{RMS}	10 Hz to 1 MHz $C_{OUT} = 100 MF$
Wake Up Time (from Shutdown Mode)	t_{WK}	—	10	—	μsec	$V_{IN} = 3.6V$ $C_{IN} = 1 \mu F$, $C_{OUT} = 1 \mu F$ $I_L = 30 mA$, (See Figure 3-1)
Setting Time (from Shutdown Mode)	t_S	—	140	—	μsec	$V_{IN} = 3.6V$ $C_{IN} = 1 \mu F$, $C_{OUT} = 1 \mu F$ $I_L = 30 mA$, (See Figure 3-1)

- Note 1:** Limits are 100% production tested at $T_A = +25^{\circ}C$. Limits over the operating temperature range are ensured through correlation using Statistical Quality Control (SQC) methods.
- 2:** Validated by line regulation test.
- 3:** Not tested. For design purposes, the current limit should be considered 150 mA minimum to 410 mA maximum.
- 4:** The dropout voltage is defined as ($V_{IN} - V_{OUT}$) when V_{OUT} is 100 mV below the value of V_{OUT} for $V_{IN} = V_{OUT} + 2V$.

DC SPECIFICATIONS (CONTINUED)

Electrical Characteristics: $V_{IN} = +3.6V$, $GND = 0V$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$. (Note 1)						
Parameters	Symbol	Min	Typ	Max	Units	Conditions
Shutdown:						
SHDN Input Threshold	V_{IH}	2.0	—	—	V	
	V_{IL}	—	—	0.4	V	
SHDN Input Bias Current	I_{shdn}	—	0.1	100	nA	$V_{SHDN} = V_{IN}$, $T_A = +25^\circ C$, $T_A = T_{MAX}$
		—	50	—	nA	$V_{SHDN} = V_{IN}$, $T_A = +25^\circ C$, $T_A = T_{MAX}$
Shutdown Supply Current	I_{qshdn}	—	0.002	1	μA	$V_{OUT} = 0V$, $T_A = +25^\circ C$, $T_A = T_{MAX}$
		—	0.02	—	μA	$V_{OUT} = 0V$, $T_A = +25^\circ C$, $T_A = T_{MAX}$
Shutdown to Output Discharge Delay (TC1189)		—	1	—	msec	$C_{OUT} = 1 \mu F$, no load at 10% of V_{OUT}
Thermal Protection						
Thermal Shutdown Temperature	T_{SHDN}	—	170	—	$^\circ C$	
Thermal Shutdown Hysteresis	ΔT_{SHDN}	—	20	—	$^\circ C$	

- Note 1:** Limits are 100% production tested at $T_A = +25^\circ C$. Limits over the operating temperature range are ensured through correlation using Statistical Quality Control (SQC) methods.
- 2:** Validated by line regulation test.
- 3:** Not tested. For design purposes, the current limit should be considered 150 mA minimum to 410 mA maximum.
- 4:** The dropout voltage is defined as $(V_{IN} - V_{OUT})$ when V_{OUT} is 100 mV below the value of V_{OUT} for $V_{IN} = V_{OUT} + 2V$.

TC1188/TC1189

2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

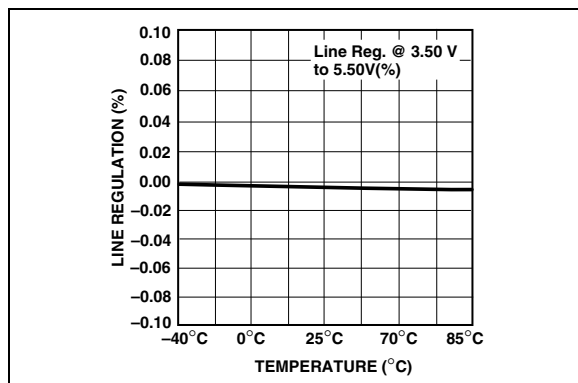


FIGURE 2-1: Line Regulation vs. Temperature. (TC1188)

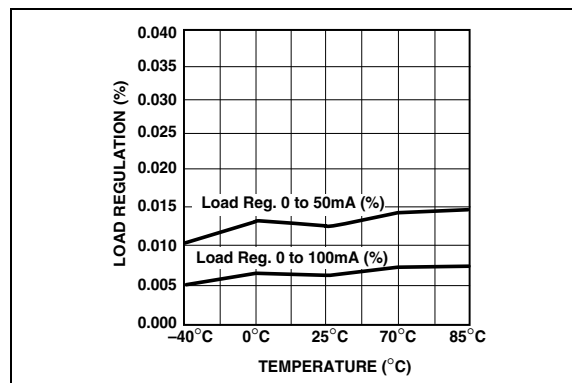


FIGURE 2-4: Load Regulation vs. Temperature. (TC1188)

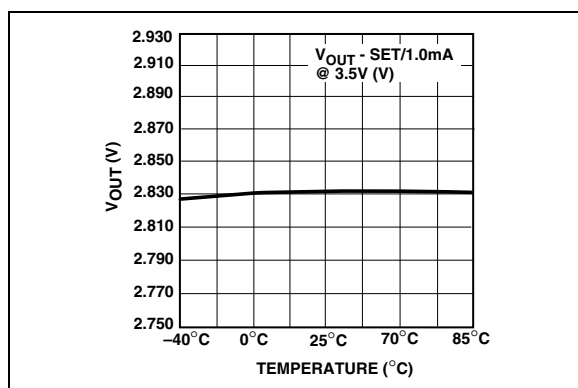


FIGURE 2-2: Output Voltage vs. Temperature. (TC1188)

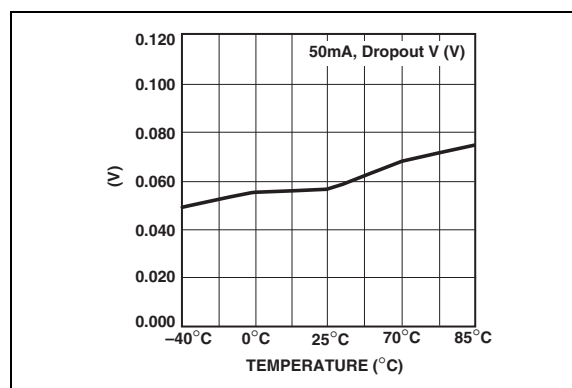


FIGURE 2-5: Dropout Voltage vs. Temperature. (TC1188)

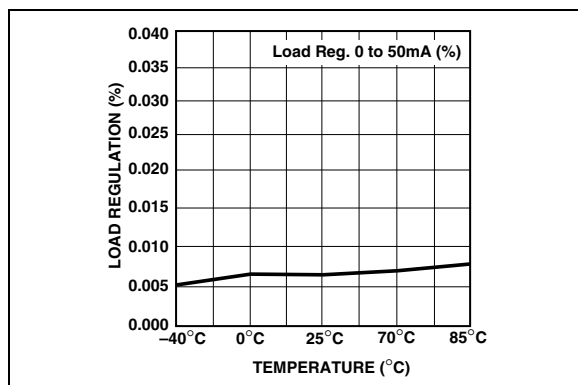


FIGURE 2-3: Load Regulation vs. Temperature. (TC1188)

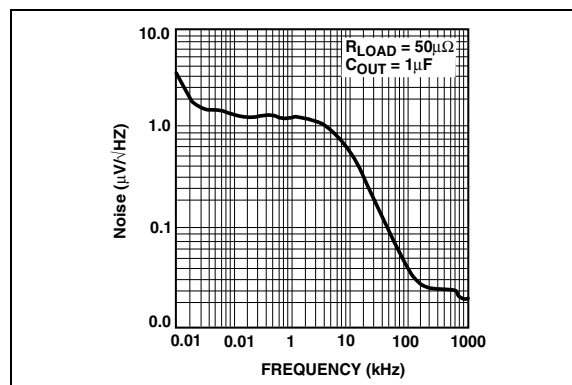


FIGURE 2-6: Output Noise vs. Frequency. (TC1188)

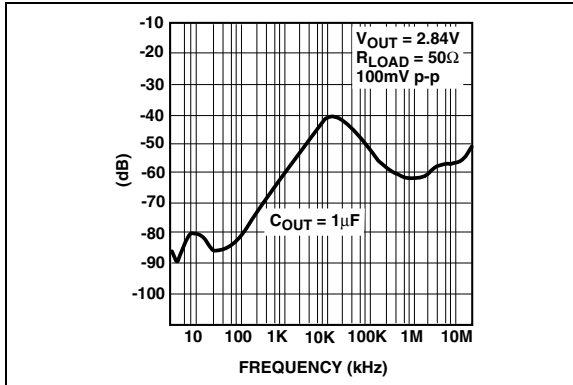


FIGURE 2-7: Power Supply Rejection Ratio vs. Frequency. (TC1188)

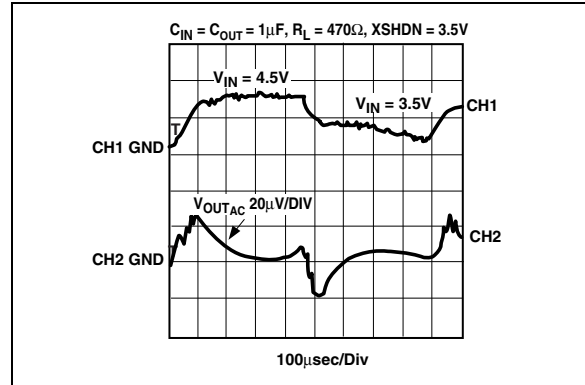


FIGURE 2-10: TC1189 Line Response.

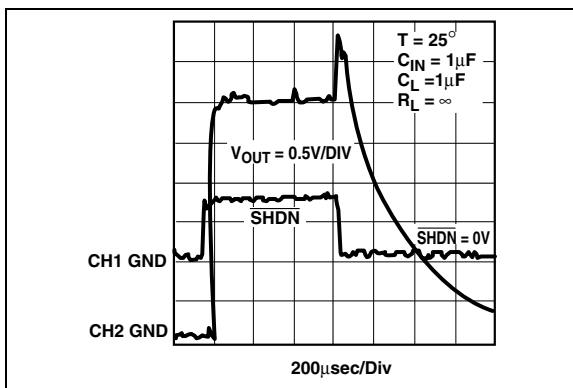


FIGURE 2-8: TC1189 Shutdown Transient Response.

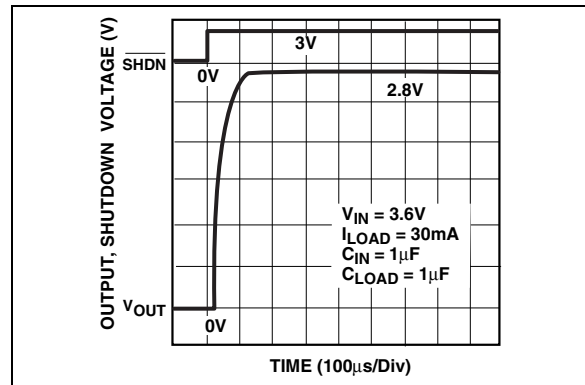


FIGURE 2-11: Wake-Up Response Time.

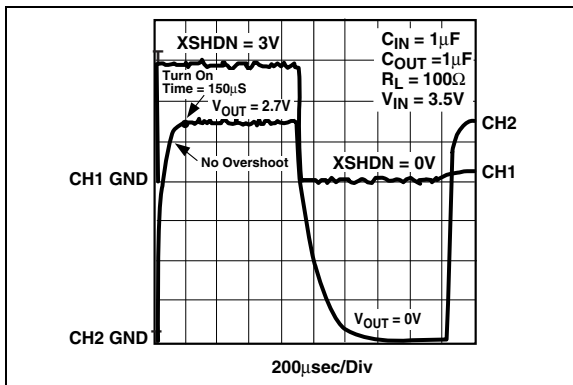


FIGURE 2-9: TC1189 Shutdown Transient Response.

TC1188/TC1189

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

Symbol	Description
SHDN	Active Low Shutdown Input. When the SHDN input is low ($< 0.2V$), the quiescent current for the TC1188/TC1189 is reduced to 0.1 nA. When the input voltage to the SHDN pin is high ($> 2.0V$) the output of the TC1188/TC1189 is enabled. For the TC1189 only, the output capacitor is discharged by an internal switch when the SHDN is low.
GND	Ground. Connect to ground.
V _{IN}	Unregulated Input Voltage. The input voltage can range from 2.7V to 6.0V.
V _{OUT}	Regulator Output. Sources up to 120 mA. Bypass with a 1 μF , $<1 \Omega$ typical ESR capacitor to GND.
GND	Connect to GND.

3.1 Detailed Description

The TC1188/TC1189 devices are fixed output, low dropout linear regulators. Utilizing CMOS construction, the internal quiescent current consumed by the regulator is minimized when compared to older bipolar low dropout regulators.

The LDO output voltage is sensed at the non-inverting pin of the internal error amplifier. The internal voltage reference is sensed at the inverting pin of the internal error amplifier. The error amplifier adjusts the gate source voltage of the internal P-channel pass device until the divided down output voltage matches the internal reference voltage. When it does, the LDO output voltage is in regulation.

The SHDN, when pulled low, is used to turn off the P-Channel MOSFET and lower the internal quiescent current to less than 1 μA maximum. For normal operation, the SHDN pin is pulled to a high level. ($> 2.0V$).

The TC1189 incorporates an internal N-Channel MOSFET, which is used to discharge the output capacitor when shutdown. The TC1188 does not have the internal N-Channel MOSFET, therefore, when the device is shutdown, the output voltage will decrease at a rate which is dependant on the load current.

3.2 Turn-On Response

The turn-on response is defined as two separate response categories: Wake-Up Time (t_{WK}) and Settling Time (t_S).

The TC1188/TC1189 have fast wake-up times (10 μsec typical) when released from shutdown. See Figure 3-1 for the wake-up time, designated as t_{WK} . The wake-up time is defined as the time it takes for the output to rise to 2% of the V_{OUT} value after being released from shutdown.

The total turn on response is defined as the Settling Time (t_S) (Figure 3-1). Settling Time (inclusive with t_{WK}) is defined as the condition when the output is within 2% of its fully enabled value (140 μsec typical) when

released from shutdown. The settling time of the output voltage is dependent on load conditions and output capacitance on V_{OUT} (RC response).

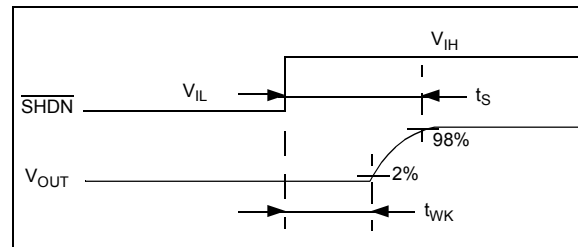


FIGURE 3-1: Wake-Up Response Time.

3.3 Internal P-Channel Pass Transistor

The Internal P-Channel MOSFET is operated in the linear region to regulate the LDO output voltage. The RDSon of the P-Channel MOSFET is approximately 1.1 Ω , making the LDO able to regulate with little input to output voltage differential, "Low Dropout". Another benefit of using CMOS construction is that the P-Channel MOSFET is a voltage controlled device, so it doesn't consume a fraction of the bias current required of bipolar PNP LDOs.

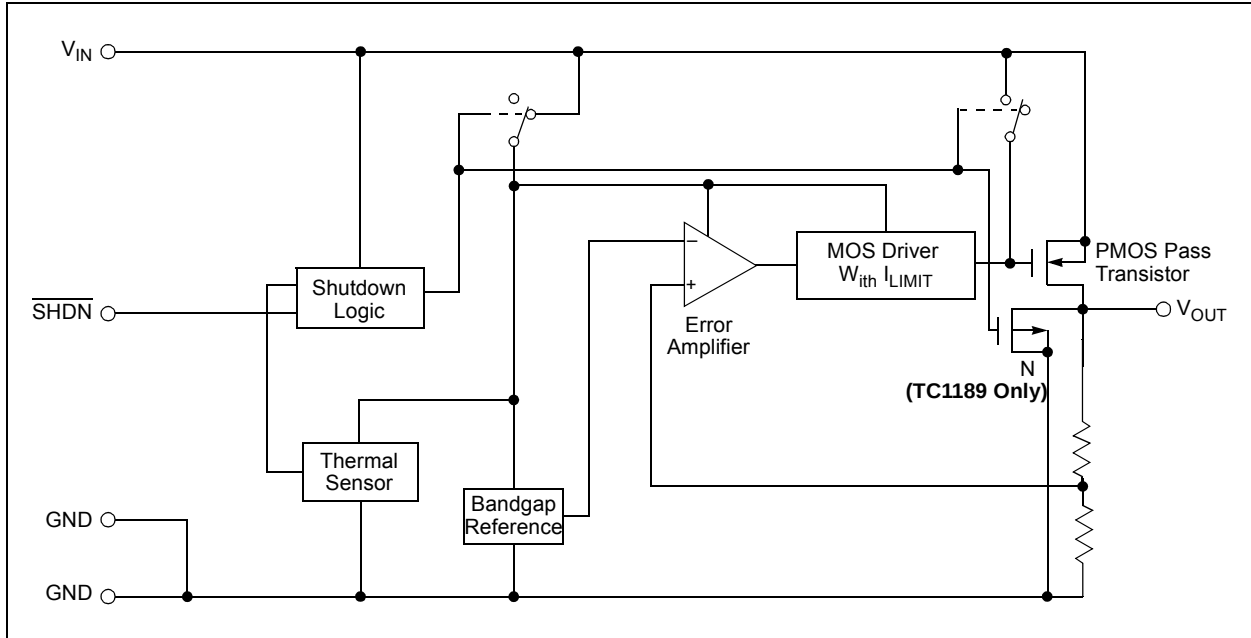


FIGURE 3-2: Functional Block Diagram.

3.4 Shutdown

The $\overline{\text{SHDN}}$ input is used to turn off the LDO P-Channel pass MOSFET and internal bias. When shutdown, the typical quiescent current consumed by the LDO is 0.1 nA. A logic low (< 0.4V) at the $\overline{\text{SHDN}}$ input will cause the device to operate in the shutdown mode. A logic high (> 2.0V) at the $\overline{\text{SHDN}}$ input will cause the device to operate in the normal mode.

3.5 Current Limit

The LDO output current is monitored internal to the TC1188/TC1189. The internal current sense will limit the LDO output current to a typical value of 280 mA. The current limit can range from approximately 50 mA to 410 mA from device to device. The internal current limit protects the device from a continuous output short circuit.

3.6 Thermal Overload Protection

Integrated thermal protection circuitry shuts the TC1188/TC1189 off when the internal die temperature exceeds approximately 170°C. The regulator output remains off until the internal die temperature drops to approximately 150°C.

3.7 Operating Region and Power Dissipation

The internal power dissipation to the LDO is primarily determined by the input voltage, output voltage and output current. The following equation is used to approximate the worst case for power dissipation:

EQUATION

$$P_D = V_{IN(MAX)} - V_{OUT(MIN)} \times I_{LOAD(MAX)}$$

Where:

P_D = Worst case internal power dissipation.

$V_{IN(MAX)}$ = Maximum input voltage.

$V_{OUT(MIN)}$ = Minimum output voltage.

$I_{LOAD(MAX)}$ = Maximum output current.

The maximum power dissipation is a function of the maximum ambient temperature, $T_{A(MAX)}$, the maximum junction temperature, $T_{J(MAX)}$, and the package thermal resistance from junction to air, θ_{JA} . The 5-Pin SOT23A package has a θ_{JA} of approximately 220°C/Watt.

EQUATION

$$P_D = (T_{J(MAX)} - T_{A(MAX)})/\theta_{JA}$$

Where all terms are previously defined.

EXAMPLE 3-1:

The previously defined power dissipation equations can be used to ensure that the regulator thermal operation is within limits.

Given:

$$\begin{aligned}V_{IN(MAX)} &= 3.0V + 10\% \\V_{OUT(MAX)} &= 2.7V - 2.5\% \\I_{LOAD(MAX)} &= 40 \text{ mA} \\T_{J(MAX)} &= 125^{\circ}\text{C} \\T_{A(MAX)} &= 55^{\circ}\text{C}\end{aligned}$$

Find:

1. Actual power dissipation.
2. Maximum allowable dissipation.

Actual power dissipation:

$$\begin{aligned}P_D &= V_{IN(MAX)} - V_{OUT(MIN)} \times I_{LOAD(MAX)} \\P_D &= ((3.0 \times 1.1) - (2.7 \times 0.975)) \times 40 \text{ mA} \\P_D &= 26.7 \text{ mWatts}\end{aligned}$$

Maximum allowable power dissipation:

$$\begin{aligned}P_D &= (T_{J(MAX)} - T_{A(MAX)})/\theta_{JA} \\P_{D(MAX)} &= (125 - 55) / 220 \\P_{D(MAX)} &= 318 \text{ mWatts.}\end{aligned}$$

In this example, the TC1188/TC1189 dissipates a maximum of 26.7 mW below the allowable limit of 318 mW. In a similar manner, the power dissipation equation, as a function of V_{IN} , V_{OUT} and I_{LOAD} , along with the power dissipation equation, as a function of maximum junction temperature, maximum ambient temperature and junction to air thermal resistance, can be used to calculate maximum current and/or maximum input voltage limits.

4.0 APPLICATIONS INFORMATION

4.1 Input Capacitor

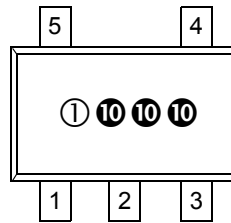
A 1 μF (or larger) capacitor is recommended to bypass the LDO input and lower input impedance for circuit stability when operating from batteries or high impedance sources. The input capacitor can be ceramic, tantalum or aluminum electrolytic. For applications that require low noise and input power supply rejection, low effective series resistance (ESR) ceramic capacitors are recommended over higher ESR electrolytic capacitors. Larger value input capacitors can be used to improve circuit performance.

4.2 Output Capacitor

A 1 μF (minimum) capacitor is required from V_{OUT} to ground to ensure circuit stability. The output capacitor should have an ESR greater than 0.1 ohms and less than 2 ohm. Tantalum or aluminum electrolytic capacitors are recommended. Since many aluminum electrolytic capacitors freeze at approximately -30°C , solid tantalums are recommended for applications operating below 25°C .

5.0 PACKAGING INFORMATION

5.1 Package Marking Information



Part Number	(V)	Code
TC1188-XECT	1.80	G4
TC1188-XECT	2.80	G3
TC1188-XECT	2.84	G2
TC1188-XECT	3.15	G1
TC1189-XECT	1.80	H4
TC1189-XECT	2.80	H3
TC1189-XECT	2.84	H2
TC1189-XECT	3.15	H1

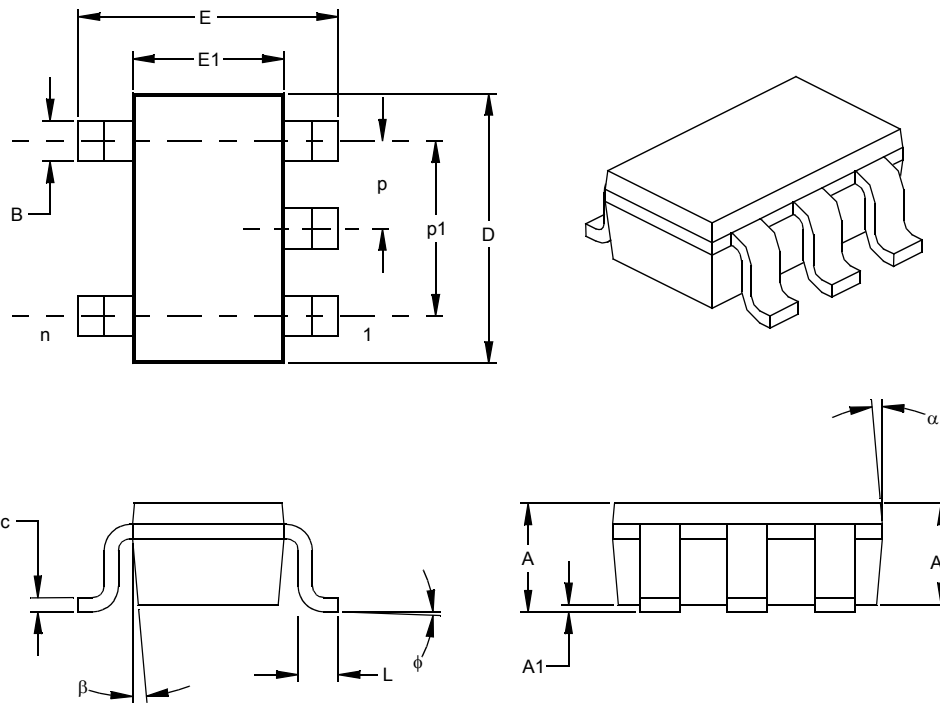
Legend: XX...X Customer-specific information
Y Year code (last digit of calendar year)
YY Year code (last 2 digits of calendar year)
WW Week code (week of January 1 is week '01')
NNN Alphanumeric traceability code
(e3) Pb-free JEDEC designator for Matte Tin (Sn)
* This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

TC1188/TC1189

5-Lead Plastic Small Outline Transistor (OT) (SOT23)

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Units		INCHES*			MILLIMETERS		
Dimension Limits		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		5			5	
Pitch	p		.038			0.95	
Outside lead pitch (basic)	p1		.075			1.90	
Overall Height	A	.035	.046	.057	0.90	1.18	1.45
Molded Package Thickness	A2	.035	.043	.051	0.90	1.10	1.30
Standoff §	A1	.000	.003	.006	0.00	0.08	0.15
Overall Width	E	.102	.110	.118	2.60	2.80	3.00
Molded Package Width	E1	.059	.064	.069	1.50	1.63	1.75
Overall Length	D	.110	.116	.122	2.80	2.95	3.10
Foot Length	L	.014	.018	.022	0.35	0.45	0.55
Foot Angle	φ	0	5	10	0	5	10
Lead Thickness	c	.004	.006	.008	0.09	0.15	0.20
Lead Width	B	.014	.017	.020	0.35	0.43	0.50
Mold Draft Angle Top	α	0	5	10	0	5	10
Mold Draft Angle Bottom	β	0	5	10	0	5	10

* Controlling Parameter
§ Significant Characteristic

Notes:

Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side.

JEDEC Equivalent: MO-178

Drawing No. C04-091

REVISION HISTORY

Revision C (November 2012)

Added a note to the package outline drawing.

TC1188/TC1189

NOTES:

THE MICROCHIP WEB SITE

Microchip provides online support via our WWW site at www.microchip.com. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQ), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

CUSTOMER CHANGE NOTIFICATION SERVICE

Microchip's customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, access the Microchip web site at www.microchip.com. Under "Support", click on "Customer Change Notification" and follow the registration instructions.

CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the web site at: <http://microchip.com/support>

TC1188/TC1189

READER RESPONSE

It is our intention to provide you with the best documentation possible to ensure successful use of your Microchip product. If you wish to provide your comments on organization, clarity, subject matter, and ways in which our documentation can better serve you, please FAX your comments to the Technical Publications Manager at (480) 792-4150.

Please list the following information, and use this outline to provide us with your comments about this document.

TO: Technical Publications Manager Total Pages Sent _____

RE: Reader Response

From: Name _____

Company _____

Address _____

City / State / ZIP / Country _____

Telephone: (____) _____ - _____ FAX: (____) _____ - _____

Application (optional):

Would you like a reply? ___Y___N

Device: TC1188/TC1189

Literature Number: DS21364C

Questions:

1. What are the best features of this document?

2. How does this document meet your hardware and software development needs?

3. Do you find the organization of this document easy to follow? If not, why?

4. What additions to the document do you think would enhance the structure and subject?

5. What deletions from the document could be made without affecting the overall usefulness?

6. Is there any incorrect or misleading information (what and where)?

7. How would you improve this document?

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

<u>PART NO.</u>	<u>X</u>	<u>IXX</u>
Device	Voltage Output	Package
Device:	TC1188: 100 mA, MAX8863/64 Pin Compatible LDO TC1189: 100 mA, MAX8863/64 Pin Compatible LDO	
Voltage Output Options:	Q = 1.80V R = 2.80V S = 2.84V T = 3.15V	
Package:	ECTTR = SOT-23A, 5-Pin (Tape and Reel)	

Examples:
a) TC1188QECTTR: 1.80V, 100 mA, MAX8863/64 Pin Compatible LDO
b) TC1188RECTTR: 2.80V, 100 mA, MAX8863/64 Pin Compatible LDO
c) TC1188SECTTR: 2.84V, 100 mA, MAX8863/64 Pin Compatible LDO
d) TC1188TECTTR: 3.15V, 100 mA, MAX8863/64 Pin Compatible LDO
a) TC1189QECTTR: 1.80V, 100 mA, MAX8863/64 Pin Compatible LDO
b) TC1189RECTTR: 2.80V, 100 mA, MAX8863/64 Pin Compatible LDO
c) TC1189SECTTR: 2.84V, 100 mA, MAX8863/64 Pin Compatible LDO
d) TC1189TECTTR: 3.15V, 100 mA, MAX8863/64 Pin Compatible LDO

Sales and Support

Data Sheets

Products supported by a preliminary Data Sheet may have an errata sheet describing minor operational differences and recommended workarounds. To determine if an errata sheet exists for a particular device, please contact one of the following:

1. Your local Microchip sales office
2. The Microchip Worldwide Site (www.microchip.com)

Please specify which device, revision of silicon and Data Sheet (include Literature #) you are using.

New Customer Notification System

Register on our web site (www.microchip.com/cn) to receive the most current information on our products.

TC1188/TC1189

NOTES:

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights.

Trademarks

The Microchip name and logo, the Microchip logo, dsPIC, FlashFlex, KEELoQ, KEELoQ logo, MPLAB, PIC, PICmicro, PICSTART, PIC³² logo, rPIC, SST, SST Logo, SuperFlash and UNI/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

FilterLab, Hampshire, HI-TECH C, Linear Active Thermistor, MTP, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Silicon Storage Technology is a registered trademark of Microchip Technology Inc. in other countries.

Analog-for-the-Digital Age, Application Maestro, BodyCom, chipKIT, chipKIT logo, CodeGuard, dsPICDEM, dsPICDEM.net, dsPICworks, dsSPEAK, ECAN, ECONOMONITOR, FanSense, HI-TIDE, In-Circuit Serial Programming, ICSP, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, mTouch, Omniclient Code Generation, PICC, PICC-18, PICDEM, PICDEM.net, PICkit, PICTail, REAL ICE, rLAB, Select Mode, SQL, Serial Quad I/O, Total Endurance, TSHARC, UniWinDriver, WiperLock, ZENA and Z-Scale are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

GestIC and ULPP are registered trademarks of Microchip Technology Germany II GmbH & Co. & KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2002-2012, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.



Printed on recycled paper.

ISBN: 9781620767450

QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
= ISO/TS 16949 =

Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELoQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.



Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
<http://www.microchip.com/support>
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Cleveland
Independence, OH
Tel: 216-447-0464
Fax: 216-447-0643

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Farmington Hills, MI
Tel: 248-538-2250
Fax: 248-538-2260

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608

Santa Clara
Santa Clara, CA
Tel: 408-961-6444
Fax: 408-961-6445

Toronto
Mississauga, Ontario,
Canada
Tel: 905-673-0699
Fax: 905-673-6509

ASIA/PACIFIC

Asia Pacific Office
Suites 3707-14, 37th Floor
Tower 6, The Gateway
Harbour City, Kowloon
Hong Kong
Tel: 852-2401-1200
Fax: 852-2401-3431

Australia - Sydney
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

China - Beijing
Tel: 86-10-8569-7000
Fax: 86-10-8528-2104

China - Chengdu
Tel: 86-28-8665-5511
Fax: 86-28-8665-7889

China - Chongqing
Tel: 86-23-8980-9588
Fax: 86-23-8980-9500

China - Hangzhou
Tel: 86-571-2819-3187
Fax: 86-571-2819-3189

China - Hong Kong SAR
Tel: 852-2401-1200
Fax: 852-2401-3431

China - Nanjing
Tel: 86-25-8473-2460
Fax: 86-25-8473-2470

China - Qingdao
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

China - Shanghai
Tel: 86-21-5407-5533
Fax: 86-21-5407-5066

China - Shenyang
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

China - Shenzhen
Tel: 86-755-8203-2660
Fax: 86-755-8203-1760

China - Wuhan
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

China - Xian
Tel: 86-29-8833-7252
Fax: 86-29-8833-7256

China - Xiamen
Tel: 86-592-2388138
Fax: 86-592-2388130

China - Zhuhai
Tel: 86-756-3210040
Fax: 86-756-3210049

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-3090-4444
Fax: 91-80-3090-4123

India - New Delhi
Tel: 91-11-4160-8631
Fax: 91-11-4160-8632

India - Pune
Tel: 91-20-2566-1512
Fax: 91-20-2566-1513

Japan - Osaka
Tel: 81-66-152-7160
Fax: 81-66-152-9310

Japan - Yokohama
Tel: 81-45-471-6166
Fax: 81-45-471-6122

Korea - Daegu
Tel: 82-53-744-4301
Fax: 82-53-744-4302

Korea - Seoul
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or
82-2-558-5934

Malaysia - Kuala Lumpur
Tel: 60-3-6201-9857
Fax: 60-3-6201-9859

Malaysia - Penang
Tel: 60-4-227-8870
Fax: 60-4-227-4068

Philippines - Manila
Tel: 63-2-634-9065
Fax: 63-2-634-9069

Singapore
Tel: 65-6334-8870
Fax: 65-6334-8850

Taiwan - Hsin Chu
Tel: 886-3-5778-366
Fax: 886-3-5770-955

Taiwan - Kaohsiung
Tel: 886-7-213-7828
Fax: 886-7-330-9305

Taiwan - Taipei
Tel: 886-2-2508-8600
Fax: 886-2-2508-0102

Thailand - Bangkok
Tel: 66-2-694-1351
Fax: 66-2-694-1350

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

UK - Wokingham
Tel: 44-118-921-5869
Fax: 44-118-921-5820

10/26/12