MIC5232

10mA Ultra-Low Quiescent Current µCap LDO

General Description

The MIC5232 is an ultra-low quiescent current, low-dropout linear regulator that is capable of operating from a single-cell lithium ion battery. Consuming only 1.8µA of quiescent current while operating, the MIC5232 is ideal for stand-by applications like powering real-time clocks or memory in battery operated electronics.

The MIC5232 is capable of providing 10mA of output current and has low output noise, providing a small, efficient solution ideal for any keep-alive application. Including reverse current protection, keeping reverse leakage ($V_{OUT} > V_{IN}$) down to 20nA.

The MIC5232 is a µCap design, operating with very small ceramic output capacitors for stability, reducing required board space and component cost.

The MIC5232 is available in fixed output voltages in the miniature 6-pin 2mm x 2mm MLF® package and thin SOT-23-5 package with an operating junction temperature range of -40°C to 125°C.

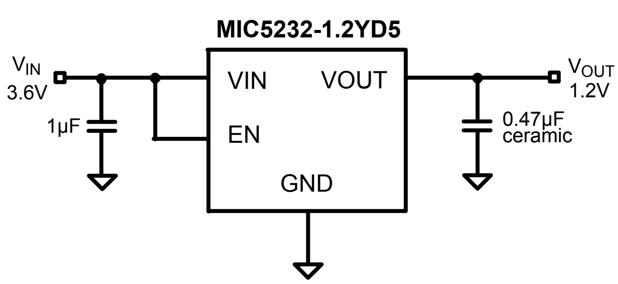
Features

- Input voltage range: 2.7V to 7.0V
- Ultra-low Iq: Only 1.8µA operating current
- Stable with 0.47µF ceramic output capacitor
- Low dropout voltage of 100mV @ 10mA
- Reverse Battery Protection
- High output accuracy:
  - ±2.0% initial accuracy
  - ±3.0% over temperature
- Logic-Level Enable Input
- Miniature 6-pin 2mm x 2mm MLF® package
- Lead-Free Thin SOT-23-5 Package
- Tight Load and Line Regulation

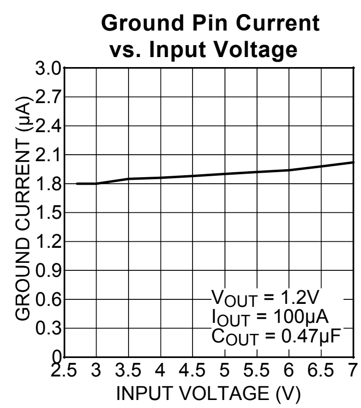
Applications

- Real-Time Clock Power Supply
- Stand-by Power Supply
- SRAM Memory Back-up Supply
- Cellular Telephones and Notebook Computers

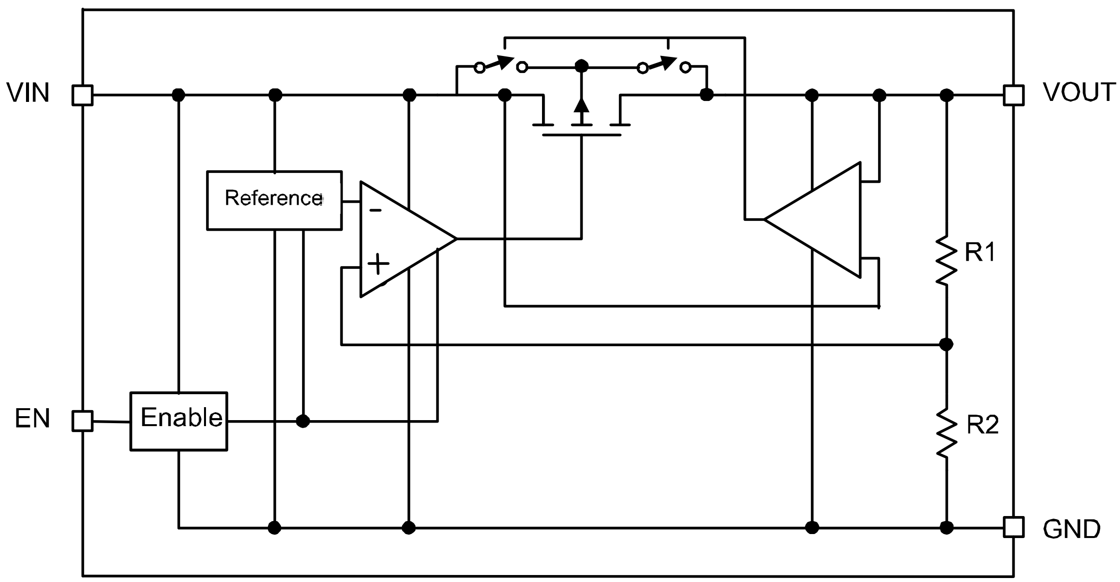
Typical Application



1.5 Real-Time Clock Back-up Supply



Block Diagram



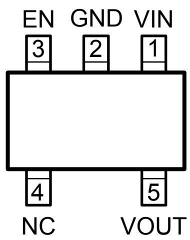
Ordering Information

Part Number	Marking Code[1]	Voltage[2]	Junction Temperature Range	Package	Lead Finish
MIC5232-1.2YD5	ZA12	1.2V	–40°C to +125°C	TSOT-23-5	Pb-Free
MIC5232-2.5YD5	ZA25	2.5V	–40°C to +125°C	TSOT-23-5	Pb-Free
MIC5232-2.8YD5	ZA28	2.8V	–40°C to +125°C	TSOT-23-5	Pb-Free
MIC5232-3.3YD5	ZA33	3.3V	–40°C to +125°C	TSOT-23-5	Pb-Free
MIC5232-1.2YML	12Z	1.2V	–40°C to +125°C	6-Pin 2mm x 2mm MLF®[3]	Pb-Free
MIC5232-2.5YML	25Z	2.5V	–40°C to +125°C	6-Pin 2mm x 2mm MLF®[3]	Pb-Free
MIC5232-2.8YML	28Z	2.8V	–40°C to +125°C	6-Pin 2mm x 2mm MLF®[3]	Pb-Free
MIC5232-3.3YML	33Z	3.3V	–40°C to +125°C	6-Pin 2mm x 2mm MLF®[3]	Pb-Free

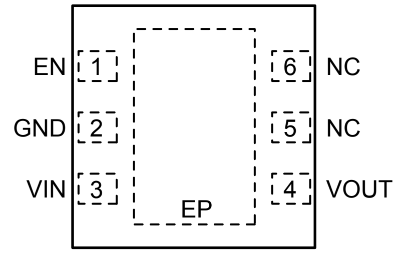
Notes:

1. Overbar/Underbar symbol (‾‾/ __) may not be to scale.
2. Other voltages available. Contact Micrel Inc. for more details.
3. MLF® is a GREEN RoHS compliant package. Lead finish is NiPdAu. Mold compound is Halogen Free.

Pin Configuration



MIC5232-x.xYD5
TSOT-23-5 (D5)



MIC5232-x.xYML
2mm x 2mm MLF® (ML)

Pin Description

Pin Number TSOT-23-5	Pin Number MLF	Pin Name	Pin Name
1	3	VIN	Supply Input.
2	2	GND	Ground.
3	1	EN	Enable Input. Active High. High = on, Low = off. Do not leave floating.
4	5	NC	Not Internally Connected.
5	4	VOUT	Output (10mA output current).
-	6	NC	Not Internally Connected.
-	EP	EP	Exposed pad connected-to-ground.

Absolute Maximum Ratings[1]

Supply Input Voltage (V_{IN}) ....0V to 8V
Enable Input Voltage (V_{EN}) ....0V to 8V
Power Dissipation (P_D) .... Internally Limited[3]
Junction Temperature (T_J) .... –40°C to +125°C
Storage Temperature (T_S) .... –65°C to +150°C
Lead Temperature (soldering, 5 sec.) .... 260°C
ESD Rating[4] .... ±2kV

Operating Ratings[2]

Supply voltage (V_{IN}) .... 2.7V to 7V
Enable Input voltage (V_{EN}) .... 0V to V_{IN}
Thermal Resistance
TSOT-23-5 (θ_{JA}) .... 235°C/W
MLF-6 (θ_{JA}) .... 90°C/W

Electrical Characteristics[5]

$V_{IN} = V_{OUT} + 1.0V$, $C_{OUT} = 0.47\mu F$, $I_{OUT} = 100\mu A$, $T_J = 25°C$, **bold** values indicate –40°C to +125°C, unless noted.

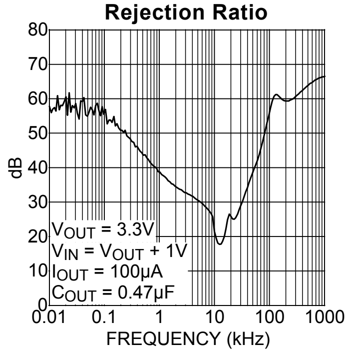
Parameter	Conditions	Min	Typ	Max	Units
Output Voltage Accuracy	Variation from nominal V_{OUT}	-2.0		+2.0	%
	Variation from nominal V_{OUT}; -40C to +125C	**-3.0**		**+3.0**	%
Output Voltage Temp. Coefficient			40		ppm/C
Line Regulation	$V_{IN} = V_{OUT}$ +1V to7V;		0.02	**0.25**	%/V
Load Regulation	I_{OUT} = 10µA to 10mA		0.2	1.0 **1.5**	% %
Dropout Voltage[6]	I_{OUT} = 100µA I_{OUT} = 10mA		60 100	 **300**	mV mV
Ground Pin Current	I_{OUT} = 10µA		1.8	3	µA
Ground Pin Current in Shutdown	$V_{EN} \leq 0.18V$		0.1	**1.5**	µA
Current Limit	V_{OUT} = 0V		70	**120**	mA
Reverse Current ($V_{OUT} > V_{IN}$)	$V_{OUT} = V_{IN}$ + 1V		0.02	**1**	µA
Ripple Rejection	f = 10Hz f = 1kHz		55 35		dB dB
Output Voltage Noise	C_{OUT} =0.47µF; 10Hz to 100kHz		400		µVrms
Enable Input					
Enable Input Voltage	Logic Low (Regulator Shutdown)			**0.18**	V
	Logic High (Regulator Enabled)	**1.4**			V
Enable Input Current	VIL $\leq$ 0.18V (Regulator Shutdown)		1		nA
	VIH $\geq$ 1.4V (Regulator Enabled)		1		nA
Turn-on Time	C_{OUT} = 0.47µF[7]		0.75	1.5	ms

Notes:

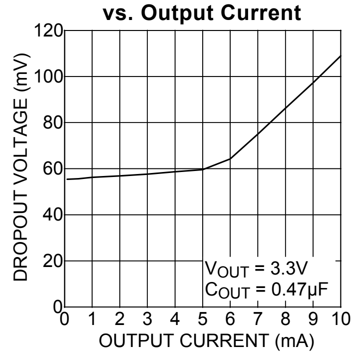
1. Exceeding the absolute maximum rating may damage the device.
2. The device is not guaranteed to function outside its operating rating.
3. The maximum allowable power dissipation of any T_A (ambient temperature) is $P_{D(max)} = T_{J(max)} – T_A) / \theta_{JA}$. Exceeding the maximum allowable power dissipation will result in excessive die temperature.
4. Devices are ESD sensitive. Handling precautions recommended.
5. Specification for packaged product only.
6. Dropout voltage is defined as the input-to-output differential at which the output voltage drops 2% below its nominal V_{OUT}. For outputs below 2.7V, dropout voltage is the input-to-output differential with the minimum input voltage 2.7V.
7. Turn-on time is measured from 10% of the positive edge of the enable signal to 90% of the rising edge of the output voltage of the regulator.

Typical Characteristics

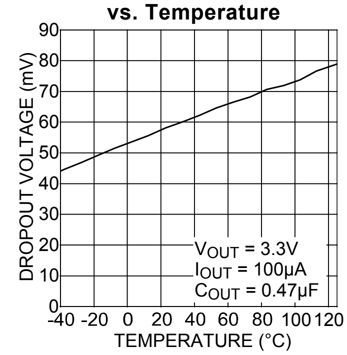
Power Supply Rejection Ratio



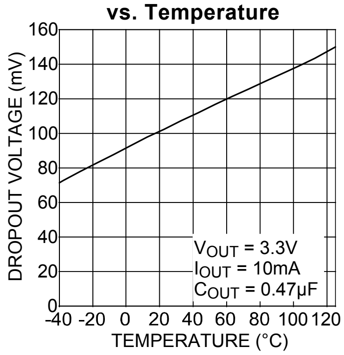
Dropout Voltage vs. Output Current



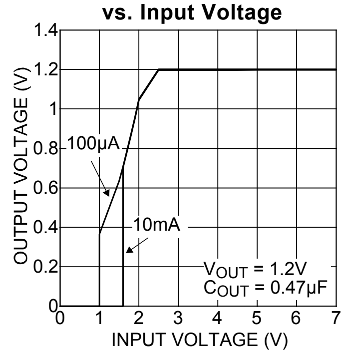
Dropout Voltage vs. Temperature



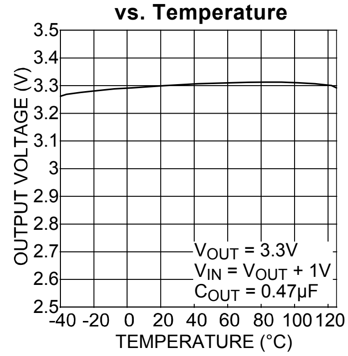
Dropout Voltage vs. Temperature



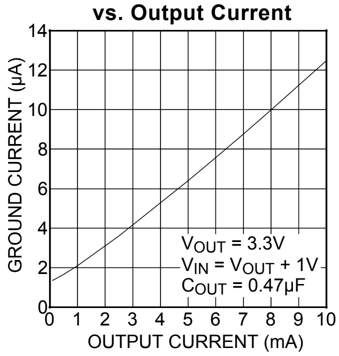
Output Voltage vs. Input Voltage



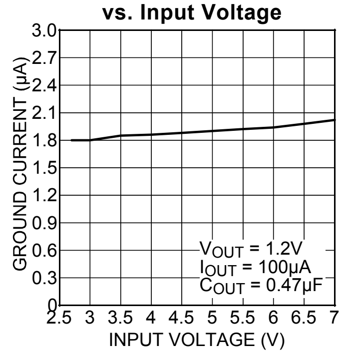
Output Voltage vs. Temperature



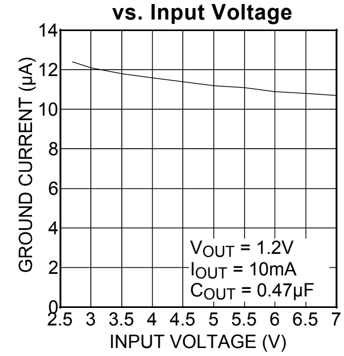
Ground Pin Current vs. Output Current



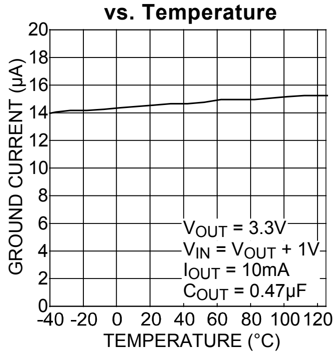
Ground Pin Current vs. Input Voltage



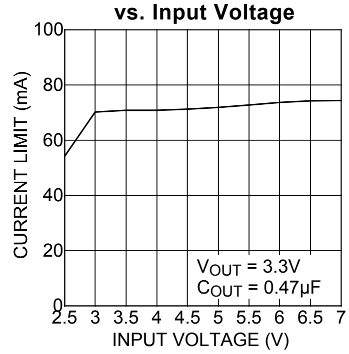
Ground Pin Current vs. Input Voltage



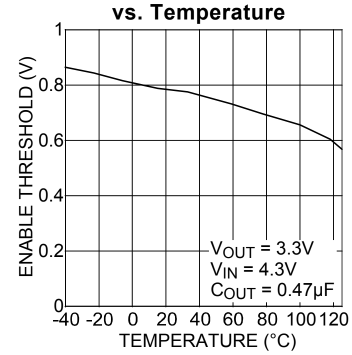
Ground Pin Current vs. Temperature



Current Limit vs. Input Voltage

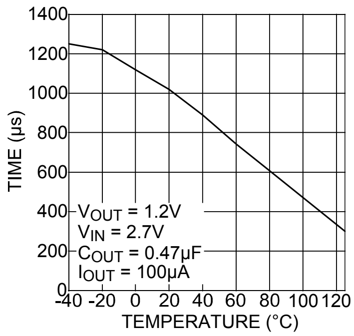


Enable-On Threshold vs. Temperature

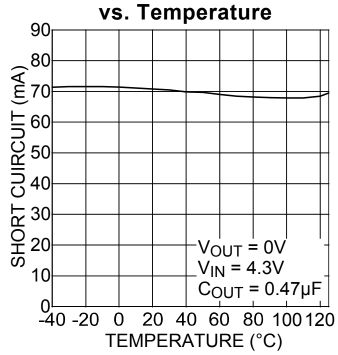


Typical Characteristics (continued)

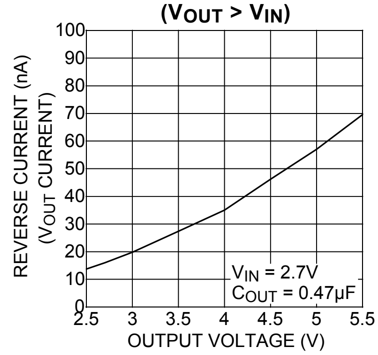
Turn-On Time



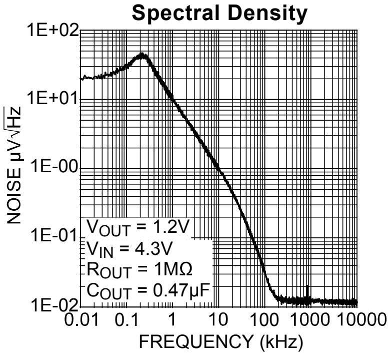
Short Circuit Current vs. Temperature



Reverse Leakage Current (V_{OUT} > V_{IN})

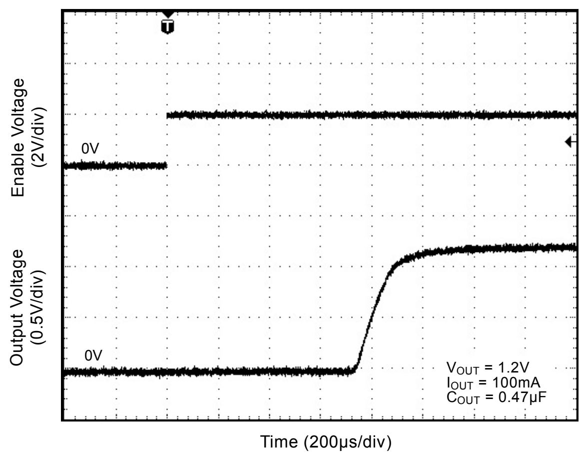


Output Noise Spectral Density

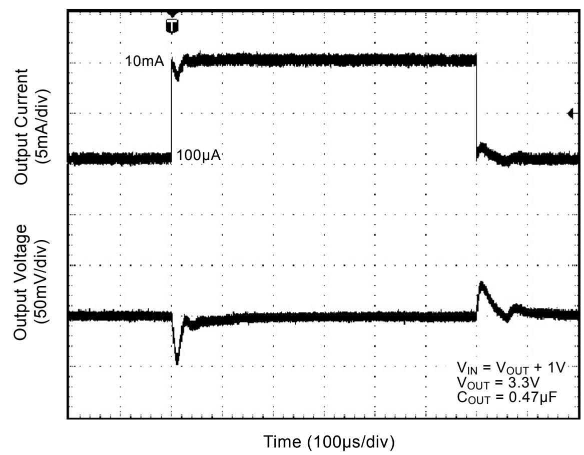


Functional Characteristics

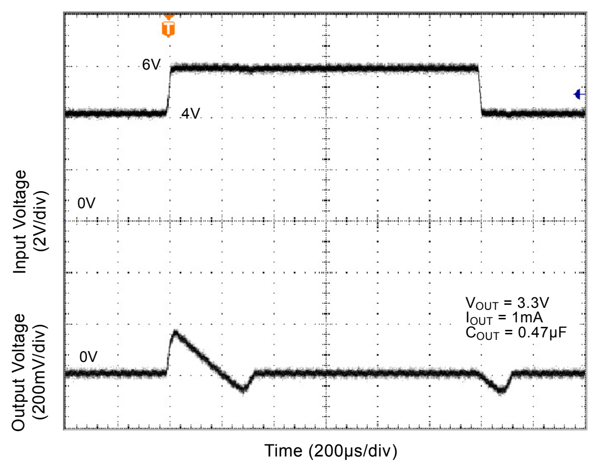
Enable Turn-On Transient



Load Transient Response



Line Transient Response



Application Information

Input Capacitor

If there is more than 20cm of wire between IN and the ac filter capacitor or if supplied from a battery, a 1μF (or larger) capacitor should be placed from the IN (supply input) to GND (ground).

Output Capacitors

The MIC5232 requires an output capacitor for stability. A 0.47μF, or larger capacitor, is recommended between OUT (output) and GND to improve the regulator's transient response. A 0.47μF capacitor can be used to reduce overshoot recovery time at the expense of overshoot amplitude. The ESR (effective series resistance) of this capacitor has no effect on regulator stability, but low-ESR capacitors improve the high frequency transient response. The value of this capacitor may be increased without limit, but values larger than 10μF tend to increase the settling time after a step change in input voltage or output current.

Minimum Load Current

The MIC5232 does not require a minimum load for proper operation. This allows the device to operate in applications where very light output currents are required for keep-alive purposes. This is important for powering SRAM or Flash memory in low-power modes for handheld devices.

Safe Operating Conditions

The MIC5232 incorporates current limit in the design. There is also reverse circuit protection circuitry built into the device. The maximum junction temperature for the device is +125°C, and it is important that this is not exceeded for any length of time.

Thermal Considerations

The MIC5232 is designed to provide 10mA of continuous current in a very small package. Maximum ambient operating temperature can be calculated based on the output current and the voltage drop across the part. Given that the input voltage is 4.3V, the output voltage is 3.3V and the output current = 10mA.

The actual power dissipation of the regulator circuit can be determined using the equation:

$$P_D = (V_{IN} - V_{OUT})\, I_{OUT} + V_{IN}\, I_{GND}$$

Because this device is CMOS and the ground current is typically <15μA over the load range, the power dissipation contributed by the ground current is < 1% and can be ignored for this calculation.

$$P_D = (4.3V - 3.3V) \cdot 10mA$$

$$P_D = 0.01W$$

To determine the maximum ambient operating temperature of the package, use the junction-to-ambient thermal resistance of the device and the following basic equation:

$$P_{D(\max)} = \frac{T_{J(\max)} - T_A}{\theta_{JA}}$$

$T_{J(max)}$ = 125°C, the max. junction temperature of the die, θ_{JA} thermal resistance = 90°C/W

Table 1 shows junction-to-ambient thermal resistance for the MIC5232 in the 2mm x 2mm MLF®-6 package.

Package	θJA Recommended Minimum Footprint	θJC
2mm x 2mm MLF®-6	90°C/W	2°C/W

Table 1. MLF Thermal Resistance

Substituting P_D for P_D(max), and solving for the ambient operating temperature, will give the maximum operating conditions for the regulator circuit. The junction-to-ambient thermal resistance for the minimum footprint is 90°C/W, from Table 1. The maximum power dissipation must not be exceeded for proper operation.

For example, when operating the MIC5232-3.3BML at an input voltage of 4.3V and 10mA load with a minimum footprint layout, the maximum ambient operating temperature T_A can be determined as follows:

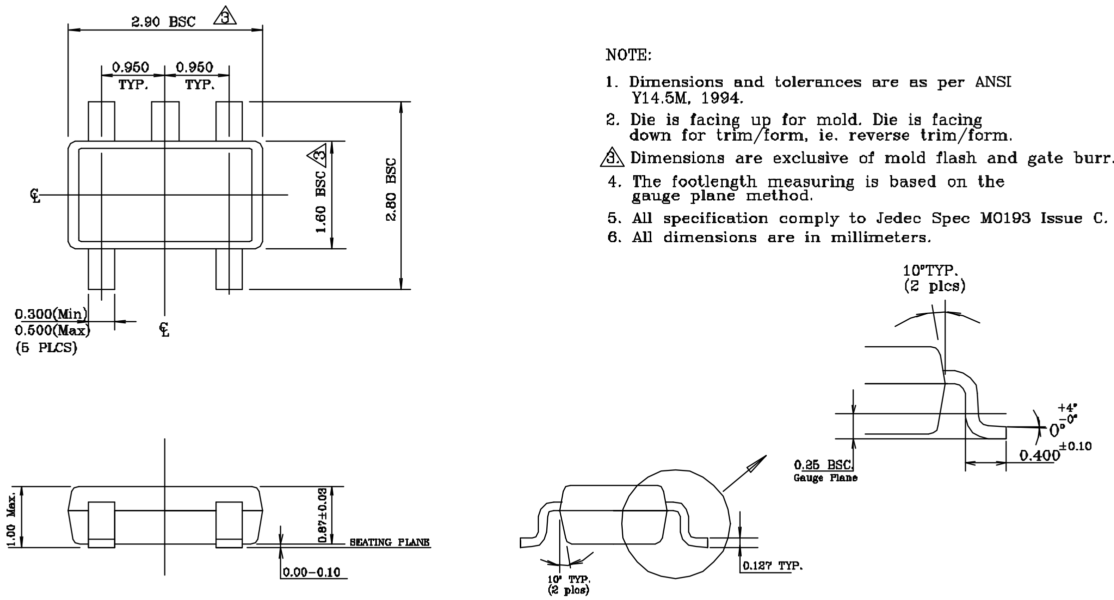
$$0.01W = \frac{125°C - T_A}{90°C/W}$$

$$T_A = 124°C$$

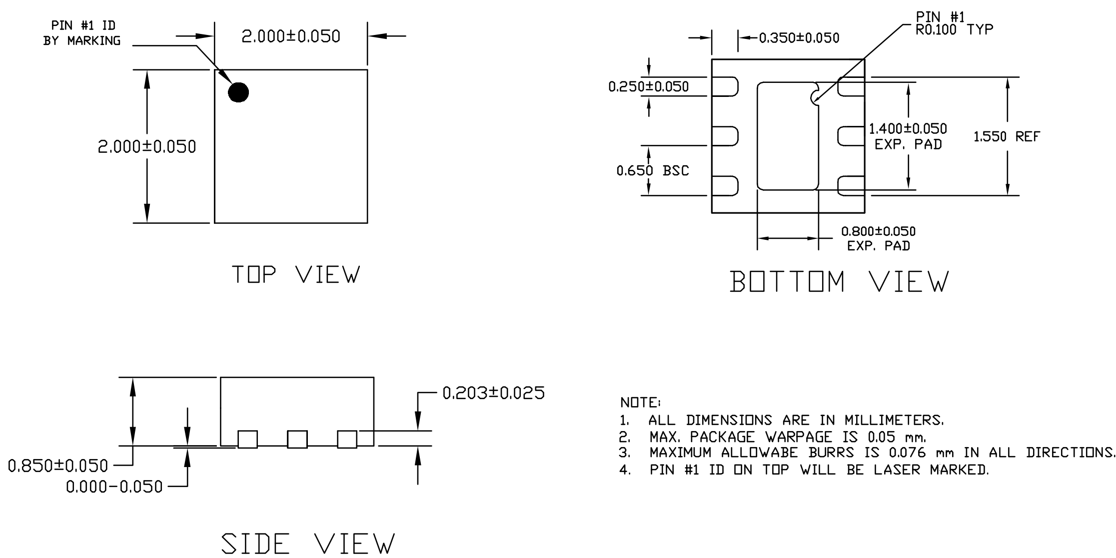
Therefore, a 3.3V application at 10mA of output current can accept an ambient operating temperature of 124°C in a 2mm x 2mm MLF®-6 package. For a full discussion of heat sinking and thermal effects on voltage regulators, refer to the "Regulator Thermals" section of Micrel's "Designing with Low-Dropout Voltage Regulators" handbook. This information can be found on Micrel's website at:

http://www.micrel.com/_PDF/other/LDOBk_ds.pdf

Package Information



5-Pin TSOT-23 (D5)



6-Pin 2mm x 2mm MLF® (ML)

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