

## General Description

The MIC5332 is a tiny, dual, low quiescent current LDO ideal for applications that are power sensitive. The MIC5332 integrates two high-performance 300mA LDOs, and a power-on-reset (POR) generator into a 2mm x 2mm Thin MLF® package. This solution occupies the same PC board area of a single SOT-23 package.

The MIC5332 is designed to reject input noise and provide low output noise with fast transient response so as to respond to any load change quickly even though it is a low quiescent current part. This combination of PSRR, low noise and transient response, along with low power consumption makes for a very-high performance, yet general purpose product.

The MIC5332 is a  $\mu$ Cap design, operating with very-small ceramic output capacitors, which reduces required board space and component cost. It is available in fixed output voltages in a tiny 8-pin 2mm x 2mm Thin MLF leadless package.

Data sheets and support documentation can be found on Micrel's web site at: [www.micrel.com](http://www.micrel.com).

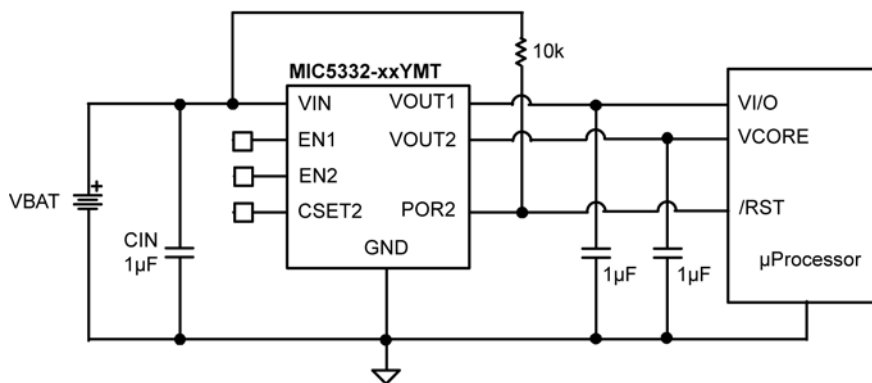
## Features

- 2.3V to 5.5V input voltage range
- 300mA output current per LDO
- Very-low quiescent current: 25 $\mu$ A per LDO
- POR output with programmable delay on LDO2
- High PSRR - >65dB on each LDO
- Stable with 1 $\mu$ F ceramic output capacitors
- Tiny 8-pin 2mm x 2mm Thin MLF package
- Ultra-low dropout voltage – 120mV @ 300mA
- Low output voltage noise – 50 $\mu$ Vrms
- Current-limit and thermal-shutdown protection

## Applications

- Camera phones
- Mobile phones
- PDAs
- GPS receivers
- Portable devices

## Typical Application



Camera DSP Power Supply Circuit

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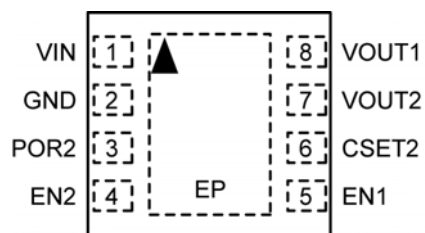
## Ordering Information

Part Number	Marking Code	Manufacturing Part Number	Voltage (V) <sup>(1, 2)</sup>	Junction Temperature Range	Package <sup>(3)</sup>
MIC5332-1.8/1.2YMT	WG4	MIC5332-G4YMT	1.8/1.2	-40° to +125°C	8-Pin 2mm x 2mm Thin MLF
MIC5332-2.5/1.2YMT	WJ4	MIC5332-J4YMT	2.5/1.2	-40° to +125°C	8-Pin 2mm x 2mm Thin MLF
MIC5332-2.8/2.8YMT	WMM	MIC5332-MMYMT	2.8/2.8	-40° to +125°C	8-Pin 2mm x 2mm Thin MLF
MIC5332-2.8/2.85YMT	WMN	MIC5332-MNYMT	2.8/2.85	-40° to +125°C	8-Pin 2mm x 2mm Thin MLF
MIC5332-2.85/2.85YMT	WNN	MIC5332-NNYMT	2.85/2.85	-40° to +125°C	8-Pin 2mm x 2mm Thin MLF
MIC5332-3.0/2.8YMT	WPM	MIC5332-PMYMT	3.0/2.8	-40° to +125°C	8-Pin 2mm x 2mm Thin MLF
MIC5332-3.0/2.85YMT	WPN	MIC5332-PNYMT	3.0/2.85	-40° to +125°C	8-Pin 2mm x 2mm Thin MLF
MIC5332-3.0/3.0YMT	WPP	MIC5332-PPYMT	3.0/3.0	-40° to +125°C	8-Pin 2mm x 2mm Thin MLF
MIC5332-3.3 /3.3YMT	WSS	MIC5332-SSYMT	3.3/3.3	-40° to +125°C	8-Pin 2mm x 2mm Thin MLF

### Notes:

- For other voltage options, contact Micrel Marketing for details.
- Pin 1 identifier = ▲.
- MLF is a GREEN RoHS-compliant package. Lead finish is NiPdAu. Mold compound is Halogen Free.

## Pin Configuration



8-Pin 2mm x 2mm Thin MLF (MT)  
(Top View)

## Pin Description

Pin Number	Pin Name	Pin Function
1	VIN	Supply Input.
2	GND	Ground.
3	POR2	Power-On Reset Output (Regulator 2): Open-drain output. Active low indicates an output under-voltage condition on regulator 2 when the device is enabled.
4	EN2	Enable Input (Regulator 2): Active High Input. Logic High = On; Logic Low = Off. Do not leave floating.
5	EN1	Enable Input (Regulator 1): Active High Input. Logic High = On; Logic Low = Off. Do not leave floating.
6	CSET2	Delay Set Input (Regulator 2): Connect external capacitor to GND to set the internal delay for the POR2 output. When left open, there is no delay. This pin cannot be grounded.
7	VOUT2	Regulator Output – LDO2.
8	VOUT1	Regulator Output – LDO1.
EP	ePad	.Exposed Heat Sink Pad. Connect to GND for best thermal performance.

**Absolute Maximum Ratings<sup>(1)</sup>**

Supply Voltage ( $V_{IN}$ )	0V to +6V
Enable Input Voltage ( $V_{EN1}$ , $V_{EN2}$ )	0V to $V_{IN}$
POR2 Voltage ( $V_{POR2}$ )	0V to +6V
Power Dissipation	Internally Limited <sup>(3)</sup>
Lead Temperature (soldering, 10sec.)	260°C
Storage Temperature ( $T_s$ )	-65°C to +150°C
ESD Rating <sup>(4)</sup>	2kV

**Operating Ratings<sup>(2)</sup>**

Supply Voltage ( $V_{IN}$ )	+2.3V to +5.5V
Enable Input Voltage ( $V_{EN1}$ , $V_{EN2}$ )	0V to $V_{IN}$
POR2 Voltage ( $V_{POR2}$ )	0V to +5.5V
Junction Temperature ( $T_J$ )	-40°C to +125°C
Junction Thermal Resistance 2mm x 2mm Thin MLF-8 ( $\theta_{JA}$ )	90°C/W

**Electrical Characteristics<sup>(5)</sup>**

$V_{IN} = V_{EN1} = V_{EN2} = V_{OUT} + 1.0V$ , higher of the two regulator outputs;  $I_{OUT1} = I_{OUT2} = 100\mu A$ ;  $C_{OUT1} = C_{OUT2} = 1\mu F$ ;  
 $T_J = 25^\circ C$ , **bold** values indicate  $-40^\circ C \leq T_J \leq +125^\circ C$ ; unless noted.

Parameter	Condition	Min.	Typ.	Max.	Units
Output Voltage Accuracy	Variation from nominal $V_{OUT}$	-1.0		+1.0	%
	Variation from nominal $V_{OUT}$ ; -40°C to +125°C	<b>-2.0</b>		<b>+2.0</b>	
Line Regulation	$V_{IN} = V_{OUT} + 1V$ to 5.5V; $I_{OUT} = 100\mu A$		0.02	0.3 <b>0.6</b>	%/V
Load Regulation	$I_{OUT} = 100\mu A$ to 300mA		0.2	0.5	%
Dropout Voltage	$I_{OUT} = 50mA$		20	<b>40</b>	mV
	$I_{OUT} = 300mA$		120	<b>240</b>	mV
Ground Current	$V_{EN1} = \text{High}$ ; $V_{EN2} = \text{Low}$ ; $I_{OUT} = 100\mu A$ to 300mA		25	<b>50</b>	$\mu A$
	$V_{EN1} = \text{Low}$ ; $V_{EN2} = \text{High}$ ; $I_{OUT} = 100\mu A$ to 300mA		25	<b>50</b>	
	$V_{EN1} = V_{EN2} = \text{High}$ ; $I_{OUT1} = 300mA$ , $I_{OUT2} = 300mA$		40	<b>75</b>	
Ground Current in Shutdown	$V_{EN1} = V_{EN2} \leq 0.2V$		0.01	1.0	$\mu A$
Ripple Rejection	$f = 1kHz$ ; $C_{OUT} = 2.2\mu F$ ;		65		dB
	$f = 20kHz$ ; $C_{OUT} = 2.2\mu F$ ;		45		
Current Limit	$V_{OUT} = 0V$	350	550	800	mA
Output Voltage Noise	$C_{OUT} = 1\mu F$ , 10Hz to 100kHz		50		$\mu V_{RMS}$
<b>Enable Inputs (EN1/EN2)</b>					
Enable Input Voltage	Logic Low			<b>0.2</b>	V
	Logic High	<b>1.2</b>			
Enable Input Current	$V_{IL} \leq 0.2V$		0.01	<b>1.0</b>	$\mu A$
	$V_{IH} \geq 1.2V$		0.01	<b>1.0</b>	
<b>Turn-on Time</b>					
Turn-On Time (LDO1 and 2)	$C_{OUT} = 1\mu F$ (Enable of First LDO)		140	<b>500</b>	$\mu s$
	$C_{OUT} = 1\mu F$ (Enable of Second LDO after First Enabled)		110	<b>500</b>	

**Notes:**

- Exceeding the absolute maximum rating may damage the device.
- The device is not guaranteed to function outside its operating rating.
- 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, and the regulator will go into thermal shutdown.
- Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5k $\Omega$  in series with 100pF.
- Specification for packaged product only.

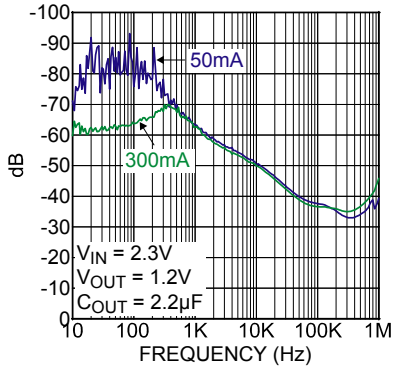
## Electrical Characteristics<sup>(5)</sup> (Continued)

$V_{IN} = V_{EN1} = V_{EN2} = V_{OUT} + 1.0V$ , higher of the two regulator outputs;  $I_{OUT1} = I_{OUT2} = 100\mu A$ ;  $C_{OUT1} = C_{OUT2} = 1\mu F$ ;  
 $T_J = 25^\circ C$ , **bold** values indicate  $-40^\circ C \leq T_J \leq +125^\circ C$ ; unless noted.

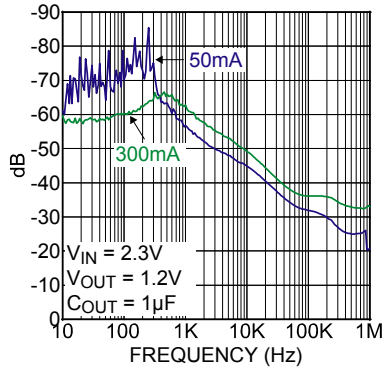
Parameter	Condition	Min.	Typ.	Max.	Units
<b>POR2 Output (LDO2 only)</b>					
$V_{TH}$	Low Threshold, % of $V_{OUT2}$ (POR2 ON)	88			%
	High Threshold, % of $V_{OUT2}$ (POR2 OFF)			98	
$V_{OL}$	POR2 Output Logic Low Voltage; $I_L = 250\mu A$		0.02	<b>0.1</b>	V
$I_{POR2}$	POR2 Leakage Current, POR2 OFF	<b>-1.0</b>	0.01	<b>+1.0</b>	$\mu A$
<b>CSET2 INPUT</b>					
CSET2 Pin Current Source	$V_{CSET2} = 0V$	<b>0.8</b>	1.4	<b>2</b>	$\mu A$
CSET2 Pin Threshold Voltage	POR2 = High	<b>1.21</b>	1.25	<b>1.29</b>	V

# Typical Characteristics

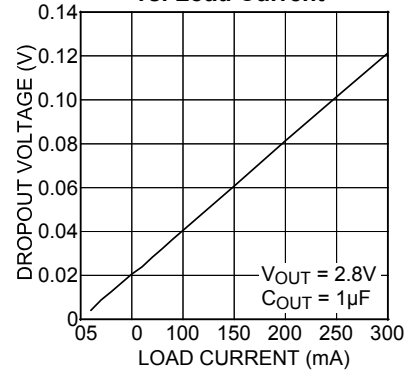
**PSRR**



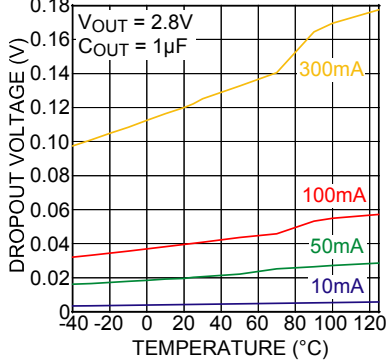
**PSRR**



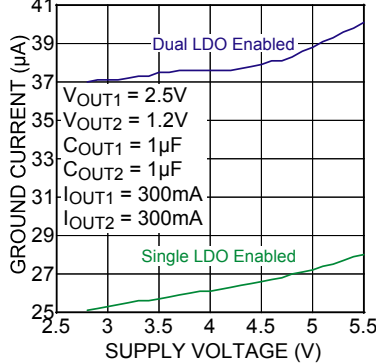
**Dropout Voltage vs. Load Current**



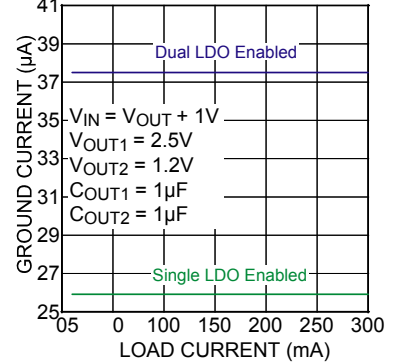
**Dropout Voltage vs. Temperature**



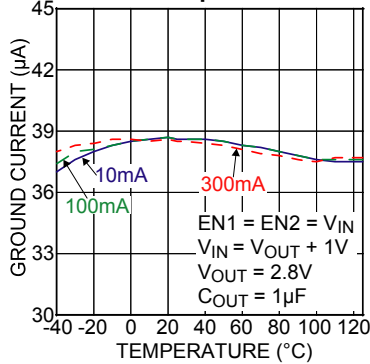
**Ground Current vs. Supply Voltage**



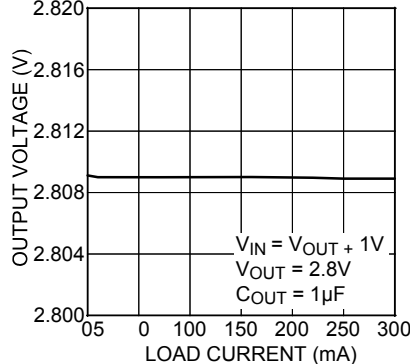
**Ground Current vs. Load Current**



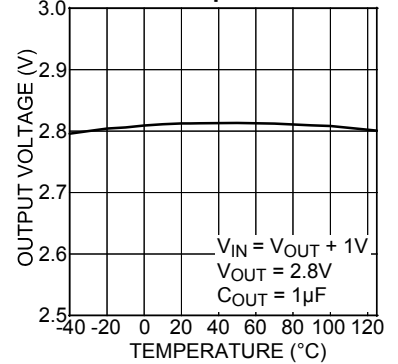
**Ground Current vs. Temperature**



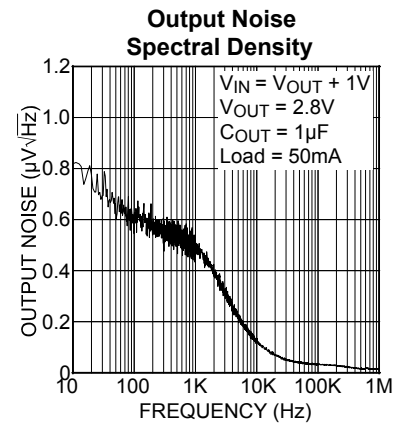
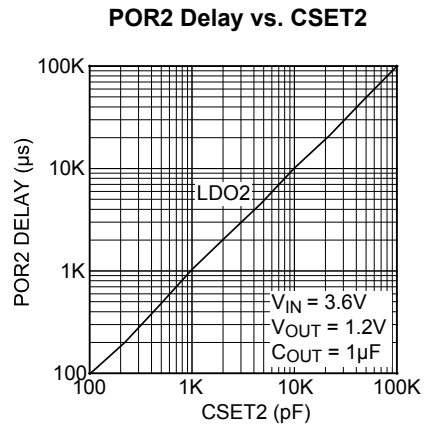
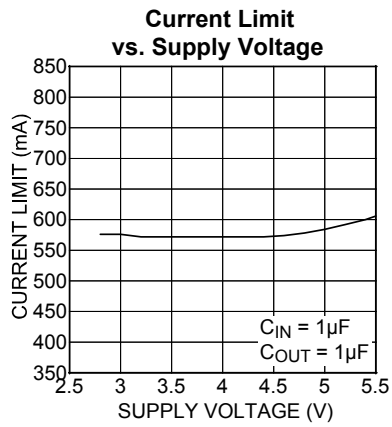
**Output Voltage vs. Load Current**



**Output Voltage vs. Temperature**

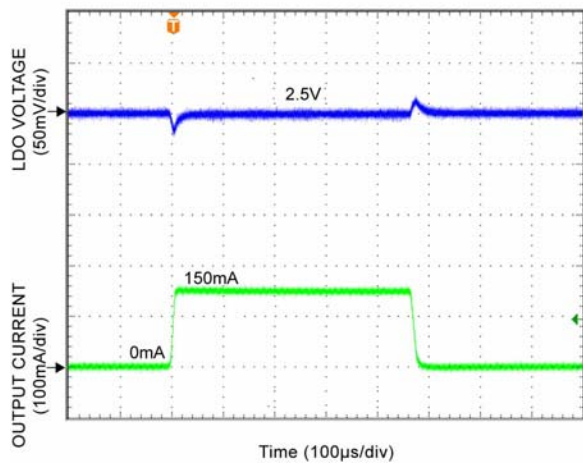


### Typical Characteristics (Continued)

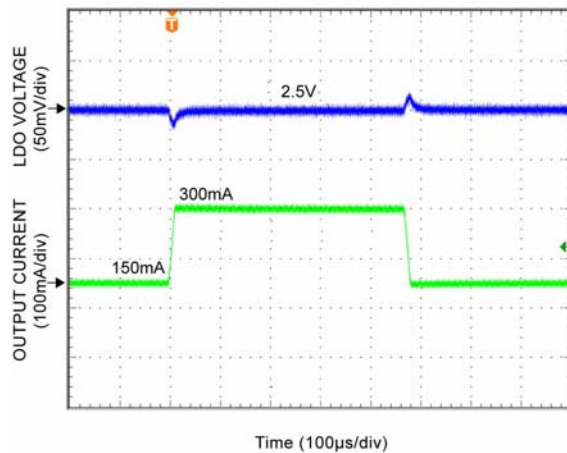


## Functional Characteristics

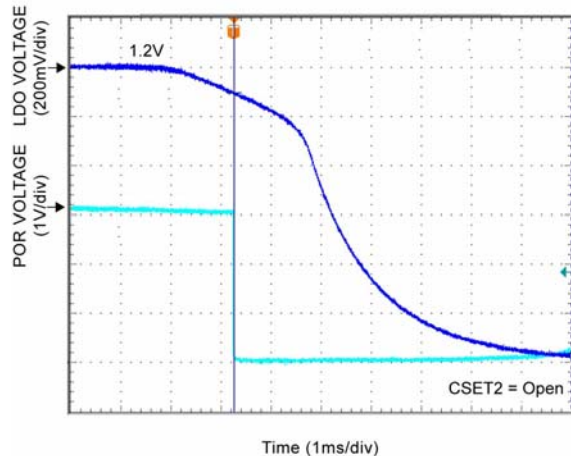
**Load Transient (0mA-150mA)**



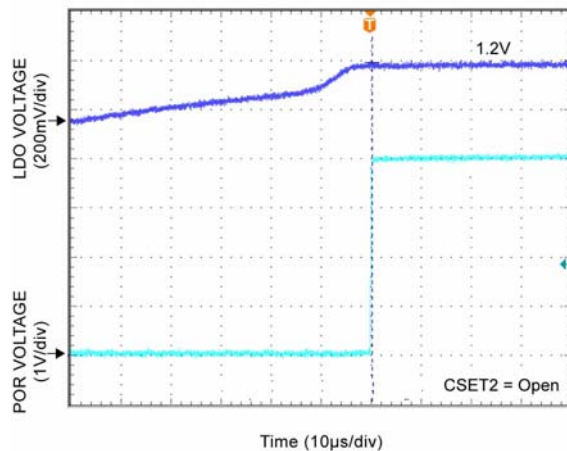
**Load Transient (150mA-300mA)**



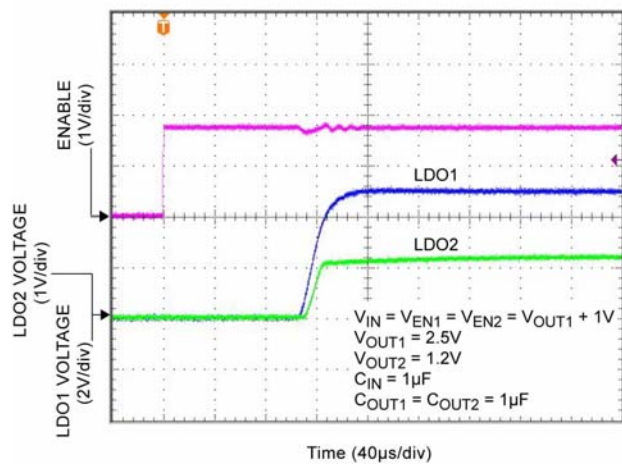
**POR2 Signal (High-Low)**



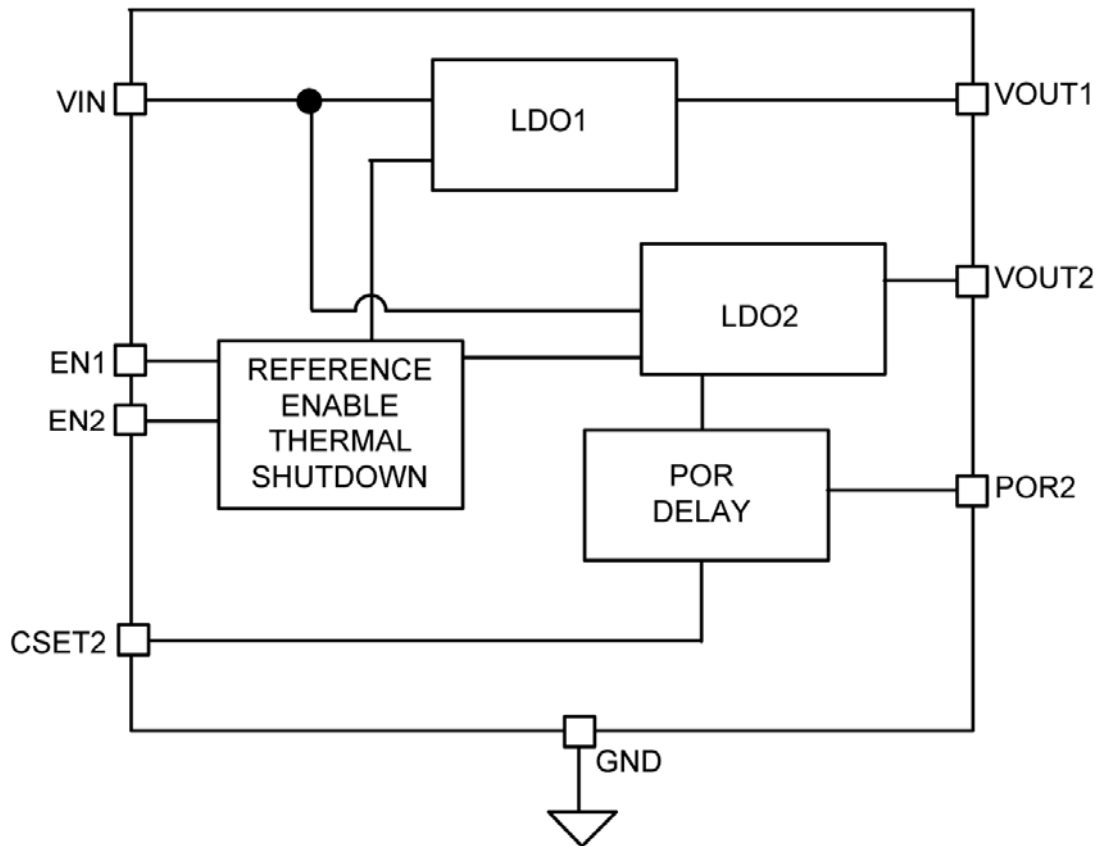
**POR2 Signal (Low-High)**



**Enable Turn-On**



### Functional Diagram



MIC5332 Block Diagram



## Application Information

MIC5332 is a dual, 300mA LDO, with an integrated power-on reset (POR) for the second regulator. The MIC5332 regulator is fully protected from damage due to fault conditions, offering linear current limiting and thermal shutdown.

### Input Capacitor

The MIC5332 is a high-performance, high-bandwidth device. Therefore, it requires a well-bypassed input supply for optimal performance. A 1 $\mu$ F capacitor is required from the input to ground to provide stability. Low-ESR ceramic capacitors provide optimal performance at a minimum of space. Additional high-frequency capacitors, such as small-valued NPO dielectric-type capacitors, help filter out high-frequency noise and are good practice in any RF-based circuit. X5R or X7R dielectrics are recommended for the input capacitor. Y5V dielectrics lose most of their capacitance over temperature and are therefore, not recommended.

### Output Capacitor

The MIC5332 requires an output capacitor of 1 $\mu$ F or greater to maintain stability. The design is optimized for use with low-ESR ceramic chip capacitors. High-ESR capacitors may cause high frequency oscillation. The output capacitor can be increased, but performance has been optimized for a 1 $\mu$ F ceramic output capacitor and does not improve significantly with larger capacitance.

X7R/X5R dielectric-type ceramic capacitors are recommended because of their temperature performance. X7R-type capacitors change capacitance by 15% over their operating temperature range and are the most stable type of ceramic capacitors. Z5U and Y5V dielectric capacitors change value by as much as 50% and 60%, respectively, over their operating temperature ranges. To use a ceramic chip capacitor with Y5V dielectric, the value must be much higher than an X7R ceramic capacitor to ensure the same minimum capacitance over the equivalent operating temperature range.

### No-Load Stability

Unlike many other voltage regulators, the MIC5332 will remain stable and in regulation with no load. This is especially important in CMOS RAM keep-alive applications.

### Enable/Shutdown

The MIC5332 comes with dual active-high enable pins that allow each regulator to be disabled independently. Forcing the enable pin low disables the regulator and sends it into a “zero” off-mode-current state. In this state, current consumed by the regulator goes nearly to zero. Forcing the enable pin high enables the output voltage. The active-high enable pin uses CMOS technology and the enable pin cannot be left floating; a floating enable pin may cause an indeterminate state on the output.

### Power-On-Reset

The second regulator has a power-on-reset status pin (POR2). This pin is an open drain output. When LDO2 is enabled an active low POR2 indicates an undervoltage condition on  $V_{OUT2}$ .

The POR2 status signal can be programmed for a delay of 1sec/ $\mu$ F by placing a capacitor from the CSET2 pin to ground. Zero delay is added by leaving the CSET2 pin open circuit.

### Thermal Considerations

The MIC5332 is designed to provide 300mA of continuous current for both outputs in a very small package. Maximum ambient operating temperature can be calculated based upon the output current and the voltage drop across the part. For example if the input voltage is 3.6V, the output voltage is 3.0V for  $V_{OUT1}$ , 2.8V for  $V_{OUT2}$  and the output current = 300mA. The actual power dissipation of the regulator circuit can be determined using the equation:

$$P_D = (V_{IN} - V_{OUT1}) I_{OUT1} + (V_{IN} - V_{OUT2}) I_{OUT2} + V_{IN} I_{GND}$$

Because this device is CMOS and the ground current is typically <100 $\mu$ A over the load range, the power dissipation contributed by the ground current is < 1% and can be ignored for this calculation:

$$P_D = (3.6V - 3.0V) \times 300mA + (3.6V - 2.8) \times 300mA$$

$$P_D = 0.42W$$

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:

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

$T_{J(max)} = 125^{\circ}\text{C}$ , and the maximum junction temperature of the die,  $\theta_{JA}$ , thermal resistance =  $90^{\circ}\text{C/W}$ .

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  $90^{\circ}\text{C/W}$ .

The maximum power dissipation must not be exceeded for proper operation.

For example, when operating the MIC5332-PMYMT at an input voltage of 3.6V and 300mA loads at each output with a minimum footprint layout, the maximum ambient operating temperature  $T_A$  can be determined as follows:

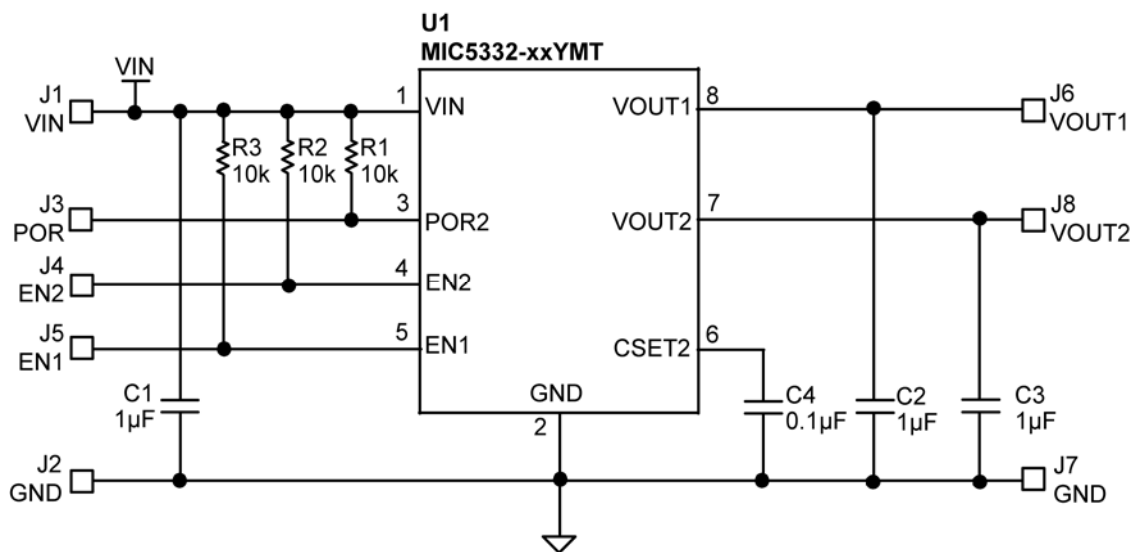
$$0.42\text{W} = (125^{\circ}\text{C} - T_A)/(90^{\circ}\text{C/W})$$

$$T_A = 87.2^{\circ}\text{C}$$

Therefore, a 3.0V/2.8V application with 300mA at each output current can accept an ambient operating temperature of  $87^{\circ}\text{C}$  in a 2mm x 2mm MLF 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](http://www.micrel.com/PDF/other/LDOBk_ds.pdf)

### MIC5332 Typical Application Circuit



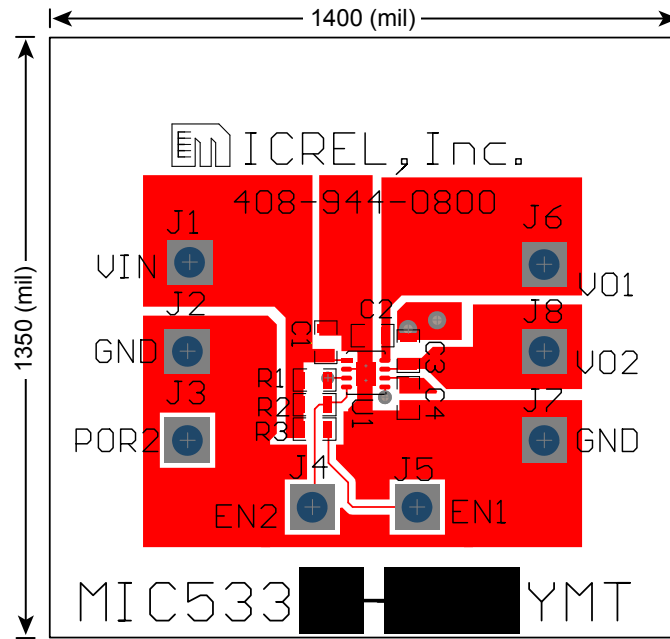
### Bill of Materials

Item	Part Number	Manufacturer	Description	Qty.
C1, C2, C3	C1608X5R0J105K	TDK <sup>(1)</sup>	Capacitor, 1µF Ceramic, 6.3V, X5R, Size 0603	3
C4	VJ0603Y104KXXAT	Vishay <sup>(2)</sup>	Capacitor, 0.1µF Ceramic, 10V, X7R, Size 0603	1
R1, R2, R3	CRCW06031002FKEYE3	Vishay	Resistor, 10kΩ, 1%, 1/16W, Size 0603	3
U1	MIC5332-XXYMT	Micrel <sup>(3)</sup>	µCAP LDO, Dual 300mA, Size 2mm x 2mm Thin MLF	1

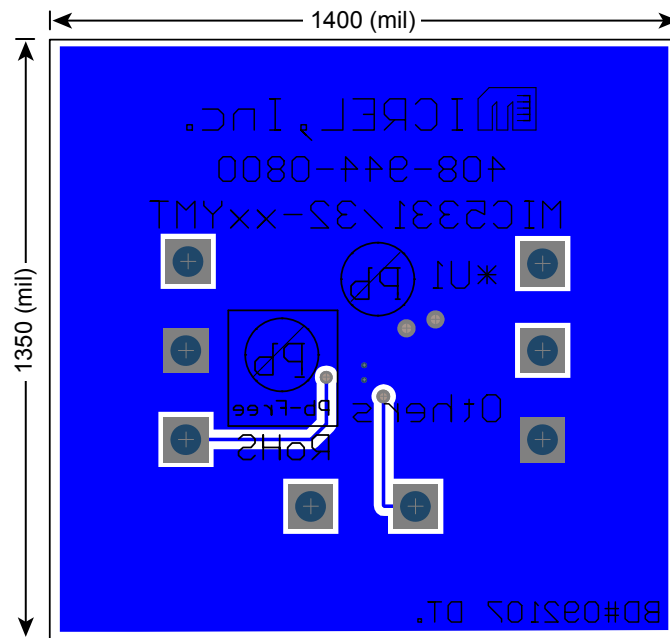
**Notes:**

1. TDK: [www.tdk.com](http://www.tdk.com).
2. Vishay: [www.vishay.com](http://www.vishay.com).
3. Micrel, Inc.: [www.micrel.com](http://www.micrel.com).

### PCB Layout Recommendations

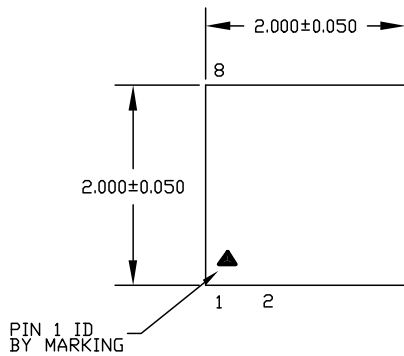


Top Layer

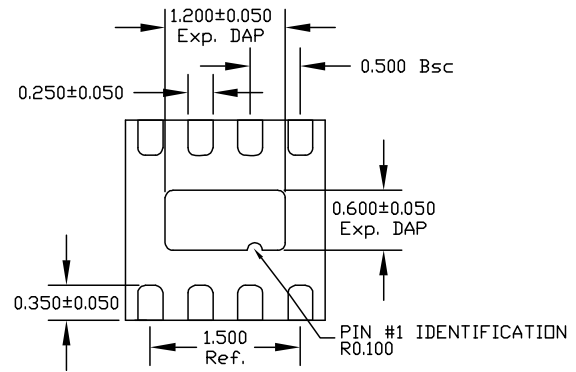


Bottom Layer

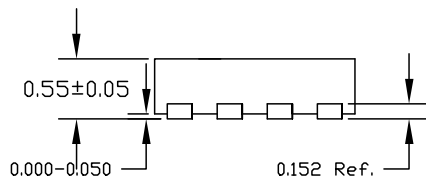
**Package Information**



TOP VIEW



BOTTOM VIEW



SIDE VIEW

**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. MAX. PACKAGE WARPAGE IS 0.08 mm.
3. MAXIMUM ALLOWABLE BURRS IS 0.076 mm IN ALL DIRECTIONS.
4. PIN #1 ID WILL BE LASER MARKED.

**8-Pin 2mm x 2mm Thin MLF (MT)**

**MICREL, INC. 2180 FORTUNE DRIVE SAN JOSE, CA 95131 USA**

TEL +1 (408) 944-0800 FAX +1 (408) 474-1000 WEB <http://www.micrel.com>

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[NCV8664CST33T3G](#) [NCV8752AMX28TCG](#) [L9454](#) [AP7362-HA-7](#) [LX13043CLD](#) [TCR3DF185,LM\(CT](#) [TCR3DF24,LM\(CT](#)  
[TCR3DF285,LM\(CT](#) [TCR3DF31,LM\(CT](#) [TCR3DF45,LM\(CT](#) [TLF4949EJ](#) [MP2013GQ-33-Z](#) [L9708](#) [L970813TR](#) [030014BB](#) [059985X](#)  
[NCP121AMX173TCG](#) [NCP4687DH15T1G](#) [NCV8703MX30TCG](#) [701326R](#) [702087BB](#) [755078E](#) [TCR2EN28,LF\(S](#) [LM1117DT-1.8/NO](#)  
[LT1086CM#TRPBF](#) [AZ1085S2-1.5TRE1](#) [MAX15101EWL+T](#) [NCV8170AXV250T2G](#) [SCD337BTG](#) [TCR3DF27,LM\(CT](#)  
[TCR3DF19,LM\(CT](#) [TCR3DF125,LM\(CT](#) [TCR2EN18,LF\(S](#) [MAX15103EWL+T](#) [TS2937CZ-5.0 C0](#) [MAX8878EUK30-T](#) [MAX663CPA](#)  
[NCV4269CPD50R2G](#) [NCV8716MT30TBG](#) [AZ1117IH-1.2TRG1](#) [MP2013GQ-P](#) [AP2112R5A-3.3TRG1](#)