MIC5350

Dual 300mA/500mA LDO in 2mm x 2mm Thin MLF®

General Description

The MIC5350 is a tiny Dual Ultra Low-Dropout (ULDO™) linear regulator ideally suited for portable electronics due to its low output noise. The MIC5350 integrates two high-performance; 300mA (V_{OUT1}) and 500mA (V_{OUT2}) ULDOs™ into a tiny 2mm x 2mm leadless Thin MLF® package, which provides exceptional thermal characteristics.

The MIC5350 is designed to be stable with small ceramic output capacitors thereby reducing required board space and component cost. The combination of extremely low-drop-out voltage, low output noise and exceptional thermal package characteristics makes it ideal for powering RF and noise-sensitive circuitry, cellular phone camera modules, imaging sensors for digital still cameras, PDAs, MP3 players and WebCam applications.

The MIC5350 ULDO™ is available in fixed-output voltages in the tiny 8-pin 2mm x 2mm leadless Thin MLF® package which occupies less than half the board area of a single SOT23-6 package. Additional voltage options are available. For more information, contact Micrel marketing.

Data sheets and support documentation can be found on Micrel's web site at www.micrel.com.

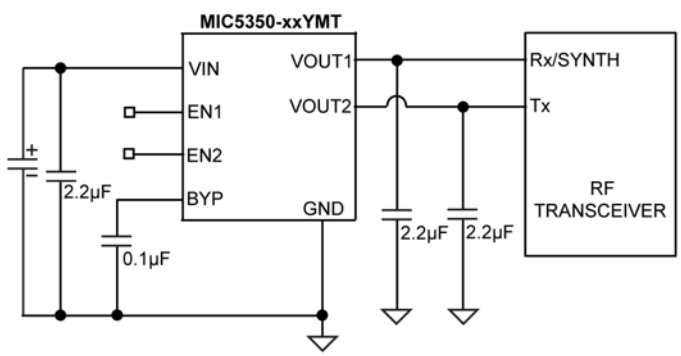
Features

- 2.6V to 5.5V input voltage range
- Ultra-low dropout voltage: 75mV @ 300mA and 125mV @ 500mA
- Ultra-low output noise: 30µV_{RMS}
- ±2% initial output accuracy
- Tiny 8-pin 2mm x 2mm Thin MLF® leadless package
- Excellent Load/Line transient response
- Fast start-up time: 30µs
- µCap stable with 2.2µF ceramic capacitors
- Thermal shutdown protection
- Low quiescent current: 130µA with both outputs at maximum load
- Current-limit protection

Applications

- Mobile phones
- PDAs
- GPS receivers
- Portable electronics
- Portable media players
- Digital still and video cameras

Typical Application

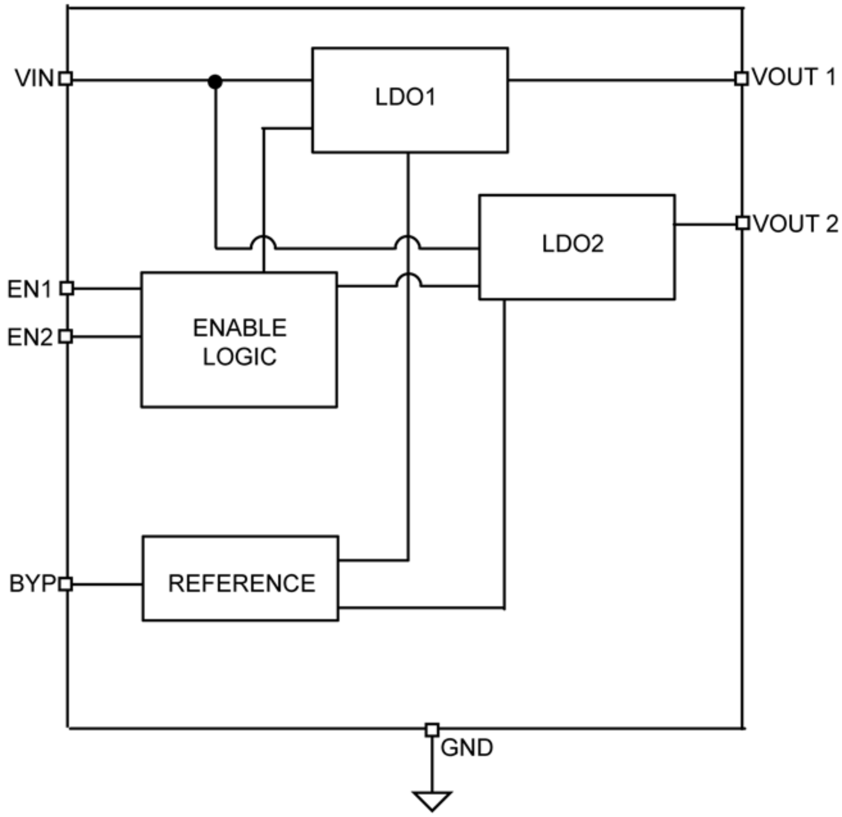


RF Power Supply Circuit

ULDO is a trademark of Micrel, Inc

MLF and *Micro*LeadFrame are registered trademarks of Amkor Technology, Inc.

Block Diagram



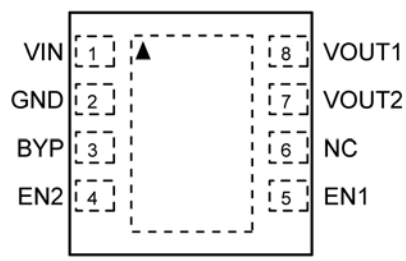
Ordering Information

Part Number	Manufacturing Part Number	Marking	Voltage(V)		Junction Temperature Range	Package
			V_{OUT1}	V_{OUT2}		
MIC5350-2.8/1.8YMT	MIC5350-MGYMT	FMG	2.8V	1.8V	–40°C to +125°C	8-Pin 2x2 TMLF®
MIC5350-2.8/2.8YMT	MIC5350-MMYMT	FMM	2.8V	2.8V	–40°C to +125°C	8-Pin 2x2 TMLF®
MIC5350-3.0/1.8YMT	MIC5350-PGYMT	FPG	3.0V	1.8V	–40°C to +125°C	8-Pin 2x2 TMLF®
MIC5350-3.3/1.8YMT	MIC5350-SGYMT	FSG	3.3V	1.8V	–40°C to +125°C	8-Pin 2x2 TMLF®
MIC5350-3.3/2.8YMT	MIC5350-SMYMT	FSM	3.3V	2.8V	–40°C to +125°C	8-Pin 2x2 TMLF®

Notes

1. Pin 1 identifier= "▲".
2. For other voltage options contact Micrel Marketing.
3. Thin MLF® is a GREEN RoHS compliant package. Lead finish is NiPdAu, Mold compound is Halogen Free.

Pin Configuration



8-Pin 2mm x 2mm TMLF (MT)
TOP VIEW

Pin Description

Pin Number	Pin Name	Pin Function
1	VIN	Supply Input.
2	GND	Ground.
3	BYP	Reference Bypass: Connect external 0.1µF to GND to reduce output noise. May be left open when bypass capacitor is not required.
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	NC	Not internally connected.
7	VOUT2	Regulator Output – LDO2 (500mA output).
8	VOUT1	Regulator Output – LDO1 (300mA output).
EPAD	HS Pad	Heatsink Pad internally connected to ground.

Absolute Maximum Ratings[1]

Supply Voltage (V_{IN}) .... –0.3V to +6V
Enable Input Voltage (V_{EN1}, V_{EN2}) .... –0.3V to V_{IN}
Power Dissipation .... Internally Limited[3]
Lead Temperature (soldering, 3sec) .... 260°C
Storage Temperature (T_S) .... –65°C to +150°C
ESD Rating[4] 2kV

Operating Ratings[2]

Supply Voltage (V_{IN}) .... +2.6V to +5.5V
Enable Input Voltage (V_{EN1}, V_{EN2}) .... 0V to V_{IN}
Junction Temperature .... –40°C to +125°C
Junction Thermal Resistance
8-Pin 2mm x 2mm Thin MLF® (θ_{JA}) .... 90°C/W

Electrical Characteristics[5]

$V_{IN} = V_{EN1} = V_{EN2} = V_{OUT} + 1.0V$; higher of the two regulator outputs, $I_{OUTLDO1} = I_{OUTLDO2} = 100\mu A$; $C_{OUT1} = C_{OUT2} = 2.2\mu F$; $C_{BYP} = 0.1\mu F$; $T_J = 25°C$, **bold** values indicate –40°C ≤ T_J ≤ +125°C, unless noted.

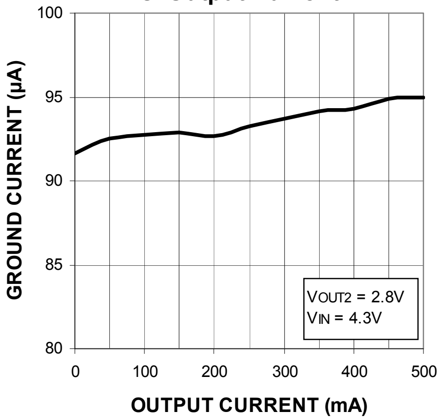
Parameter	Conditions	Min.	Typ.	Max.	Units
Output Voltage Accuracy	Variation from nominal V_{OUT}	-2.0		+2.0	%
	Variation from nominal V_{OUT}; –40°C to +125°C	**-3.0**		**+3.0**	
Line Regulation	$V_{IN} = V_{OUT}$ + 1V to 5.5V; I_{OUT} = 100µA		0.05	0.3 **0.6**	%/V
Load Regulation	$I_{OUT1,\,2}$ = 100µA to 300mA		0.5	**2.0**	%
	I_{OUT2} =100µA to 500mA		0.7	**2.5**	
Dropout Voltage[6]	$I_{OUT1,\,2}$ = 100µA		0.1		mV
	$I_{OUT1,\,2}$ = 50mA		12	**50**	
	$I_{OUT1,\,2}$ = 300mA		75	**200**	
	I_{OUT2} = 500mA		125	**300**	
Ground Current	V_{EN1} ≥ 1.2V; V_{EN2} ≤ 0.2V; I_{OUT} = 0mA to 300mA		95	**175**	µA
	V_{EN1} ≤ 0.2V; V_{EN2} ≥ 1.2V; I_{OUT2} = 0mA to 500mA		95	**175**	
	$V_{EN1} = V_{EN2}$ = 1.2V; I_{OUT1} = 300mA, I_{OUT2} = 500mA		130	**240**	
Ground Current in Shutdown	$V_{EN1} = V_{EN2}$ = 0V		0.01	2	µA
Ripple Rejection	f = 1kHz; C_{OUT} = 2.2µF; C_{BYP} = 0.1µF		50		dB
	f = 20kHz; C_{OUT} = 2.2µF; C_{BYP} = 0.1µF		35		
Current Limit	V_{OUT1} = 0V	350	560	**850**	mA
	V_{OUT2} = 0V	550	950	**1500**	
Output Voltage Noise	C_{OUT} = 2.2µF; C_{BYP} = 0.1µF; 10Hz to 100kHz		30		μV_{RMS}
Enable Inputs (EN1 / EN2)					
Enable Input Voltage	Logic Low			**0.2**	V
	Logic High	**1.2**			
Enable Input Current	V_{IL} ≤ 0.2V		0.01		µA
	V_{IH} ≥ 1.2V		0.01		
Turn-on Time (See Timing Diagram)					
Turn-on Time (LDO1 and 2)	C_{OUT} = 2.2µF; C_{BYP} = 0.01µF		30	**100**	µs

Notes:

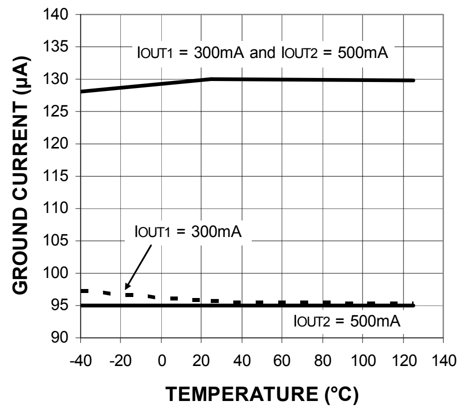
1. Exceeding the absolute maximum rating may damage the device.
2. The device is not guaranteed to function outside its operating rating.
3. The maximum allowable power dissipation of any T_A (ambient temperature) is $P_{D(max)} = (T_{J(max)} - T_A) / \theta_{JA}$. Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown.
4. Devices are ESD sensitive. Handling precautions recommended. Human body model 1.5kΩ in series with 100pF.
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 2.6V, the dropout voltage is the input-to-output differential with the minimum input voltage 2.6V.

Typical Characteristics

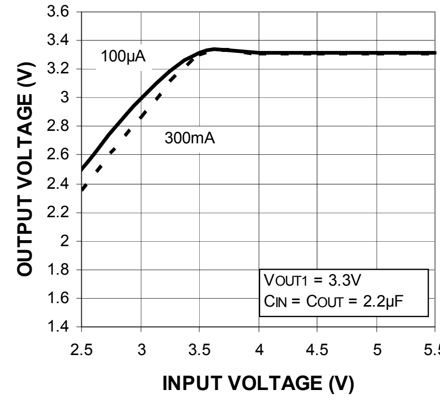
Ground Current vs. Output Current



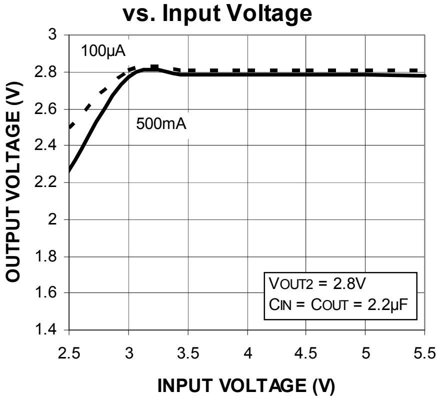
Ground Current vs. Temperature



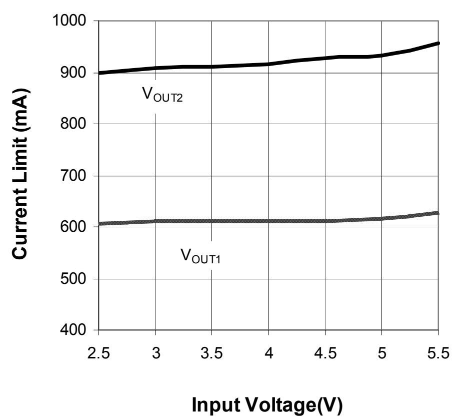
Output Voltage vs. Input Voltage



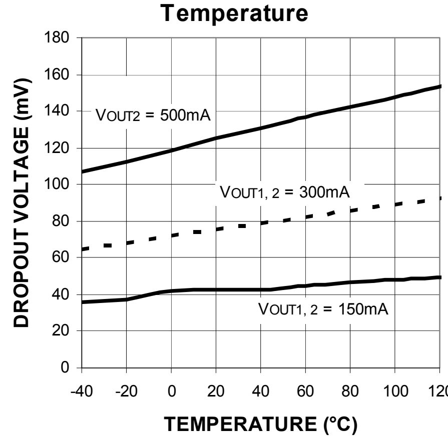
Output Voltage vs. Input Voltage



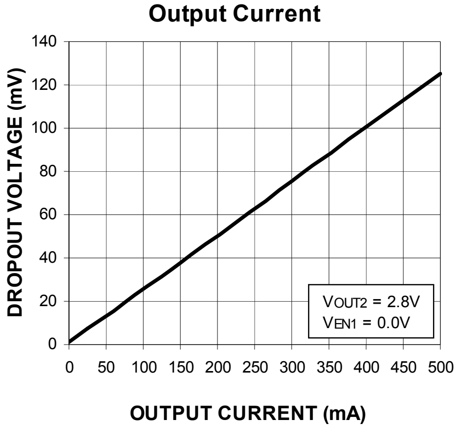
Current Limit vs. Input Voltage



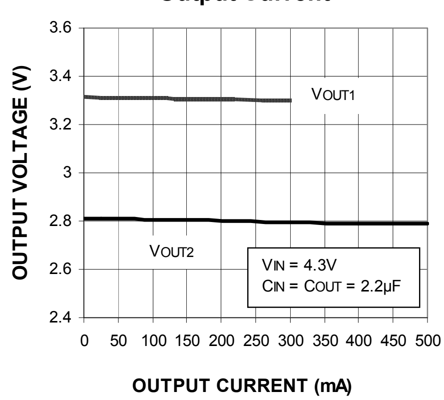
Dropout Voltage vs. Temperature



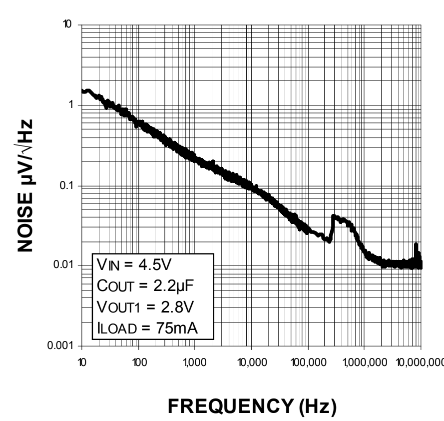
Dropout Voltage vs. Output Current



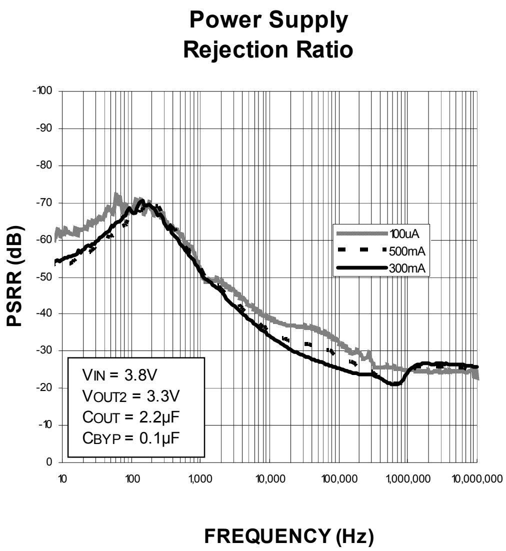
Output Voltage vs. Output Current



Output Noise Spectral Density

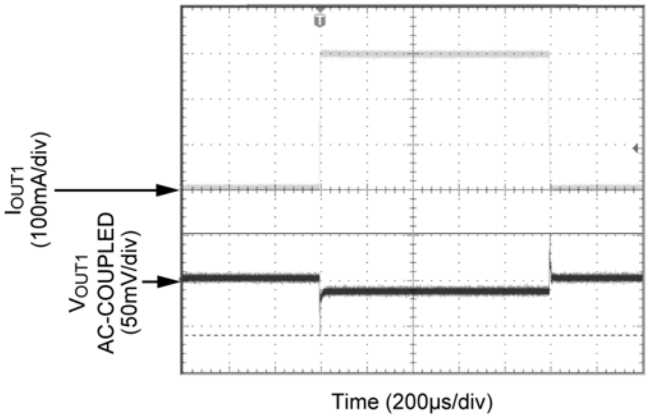


Typical Characteristics (Continued)

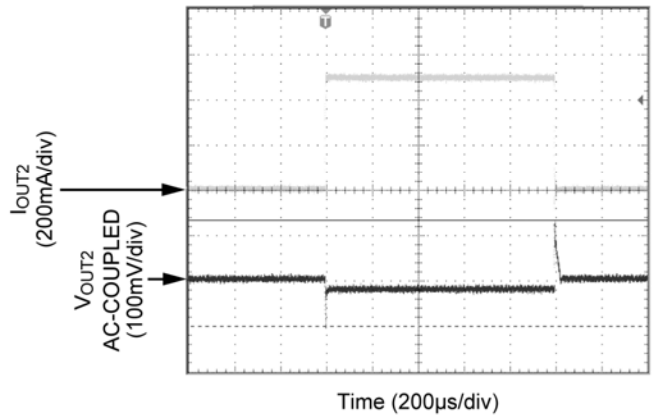


Functional Characteristics

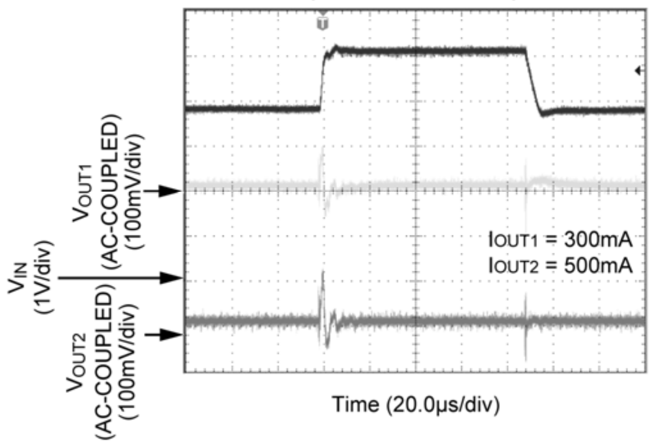
Load Transient (0 to 300mA)
(V_{OUT1} = 3.3V)



Load Transient (0 to 500mA)
(V_{OUT2} = 2.8V)



Line Transient
(V_{IN} = 3.8V to 5.2V)



Applications Information

Enable/Shutdown

The MIC5350 comes with dual active-high enable pins that allow each regulator to be enabled independently. Forcing both enable pins low disables the regulators 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.

Input Capacitor

The MIC5350 is a high-performance, high-bandwidth device. Therefore, it requires a well-bypassed input supply for optimal performance. A 2.2µF 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.

Output Capacitor

The MIC5350 requires an output capacitor of 2.2µF 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 2.2µF ceramic output capacitor and does not improve significantly with larger capacitance.

X7R/X5R dielectric-type ceramic capacitors are recommended because of their superior 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.

Bypass Capacitor

A capacitor can be placed from the noise bypass pin-to-ground to reduce output voltage noise. The capacitor bypasses the internal reference. A 0.1µF capacitor is recommended for applications that require low-noise outputs. The bypass capacitor can be increased, further reducing noise and improving PSRR. Turn-on time increases slightly with respect to bypass capacitance.

A unique, quick-start circuit allows the MIC5350 to drive a large capacitor on the bypass pin without significantly slowing turn-on time.

No-Load Stability

Unlike many other voltage regulators, the MIC5350 will remain stable with no load. This is especially important in CMOS RAM keep-alive applications.

Thermal Considerations

The MIC5350 is designed to provide 300mA of continuous current for V_{OUT1} and 500mA for V_{OUT2} 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 3.3V, the output voltage is 2.8V for V_{OUT1}, 2.8V for V_{OUT2} and the output current 300mA and 500mA respectively. 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 <100µA over the load range, the power dissipation contributed by the ground current is < 1% and can be ignored for this calculation.

$$P_D = (3.3V – 2.8V) \times 300mA + (3.3V - 2.8) \times 500mA$$

$$P_D = 0.4W$$

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°C, the maximum junction temperature of the die θ_{JA} thermal resistance = 90°C/W.

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.

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

For example, when operating the MIC5350-MMYMT at an input voltage of 3.3V with 300mA on V_{OUT1} and 500mA on V_{OUT2} and a minimum footprint layout, the maximum ambient operating temperature T_A can be determined as follows:

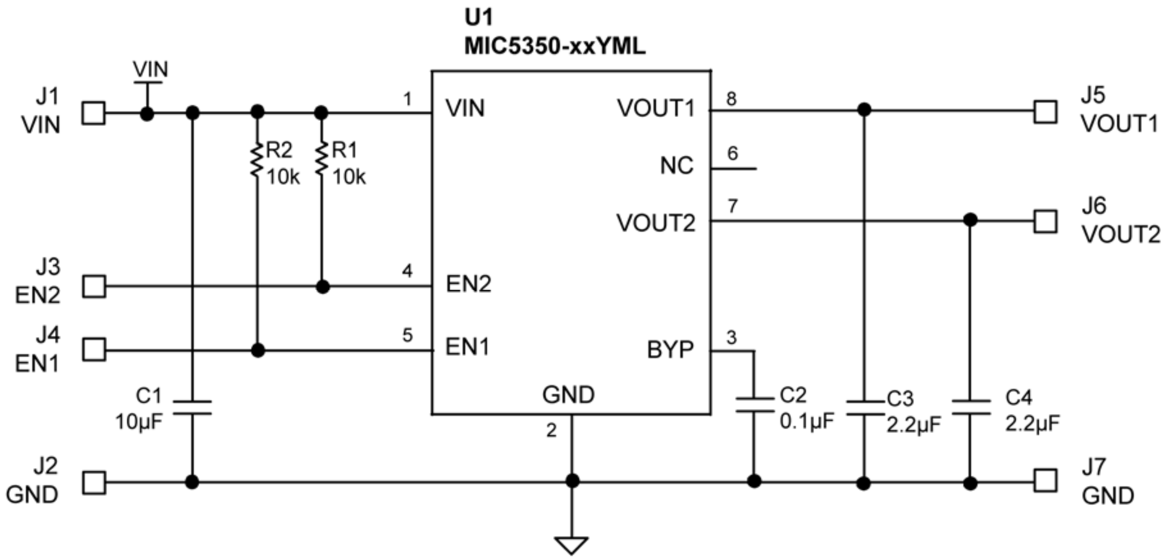
$$0.4W = (125°C – T_A)/(90°C/W)$$

$$T_A = 89°C$$

Therefore, a 2.8V/2.8V application with 300mA and 500mA output currents can accept an ambient operating temperature of 89°C in a 2mm x 2mm Thin 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

Typical Application Schematic



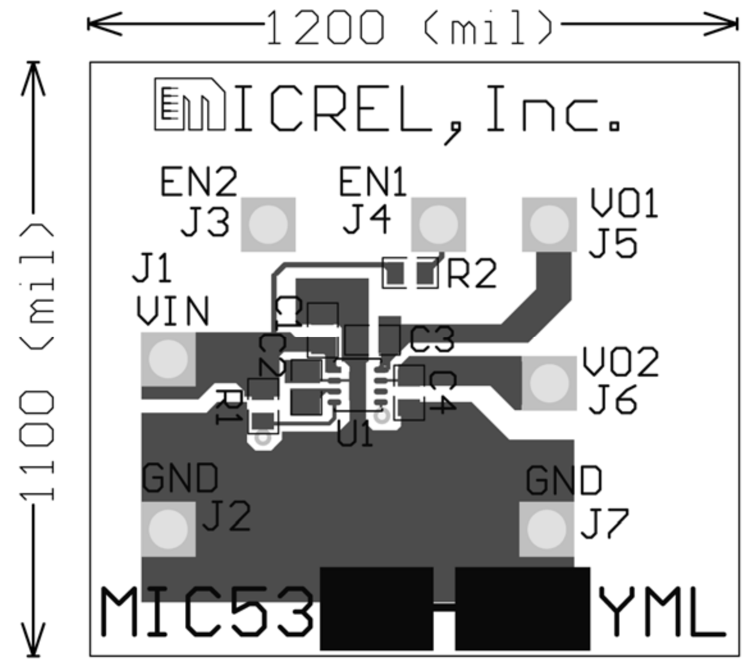
Bill of Materials

Item	Part Number	Manufacturer	Description	Qty.
C1	C1608X5R0J106M	TDK(1)	Capacitor, 10µF Ceramic, 6.3V, X5R, Size 0603	1
C2	VJ0603Y104KXQ	Vishay(2)	Capacitor, 0.1µF Ceramic, 10V, X7R, Size 0603	1
C3, C4	C1608X5R0J225M	TDK(1)	Capacitor, 2.2µF Ceramic, 6.3V, X5R, Size 0603	2
R1, R2	CRCW06031002FKEYE3	Vishay(2)	Resistor, 10kΩ, 1%, 1/16W, Size 0603	2
U1	**MIC5350-XXYML**	**Micrel, Inc.(3)**	**Dual 300mA/500mA LDO, 2mm x 2mm Thin MLF®**	**1**

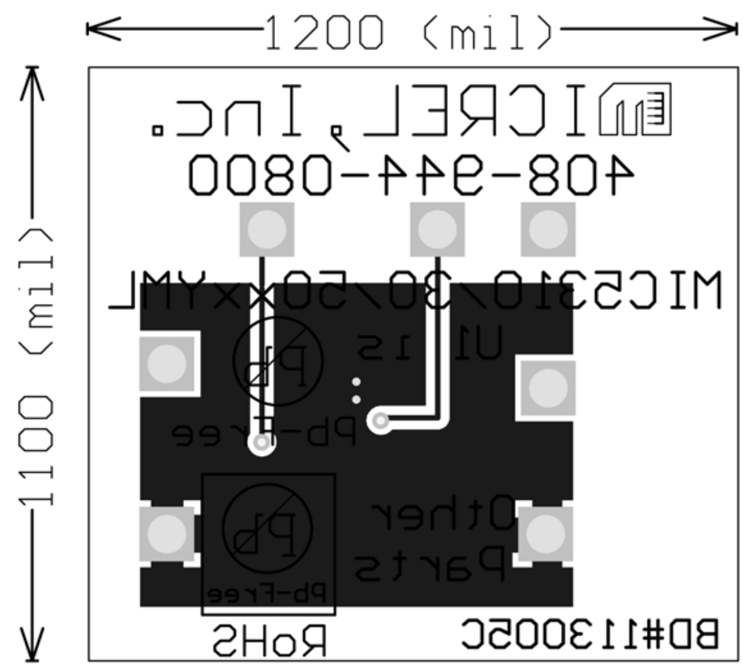
Notes:

1. TDK: www.tdk.com.
2. Vishay Tel: www.vishay.com.
3. **Micrel, Inc.: www.micrel.com.**

PCB Layout Recommendations

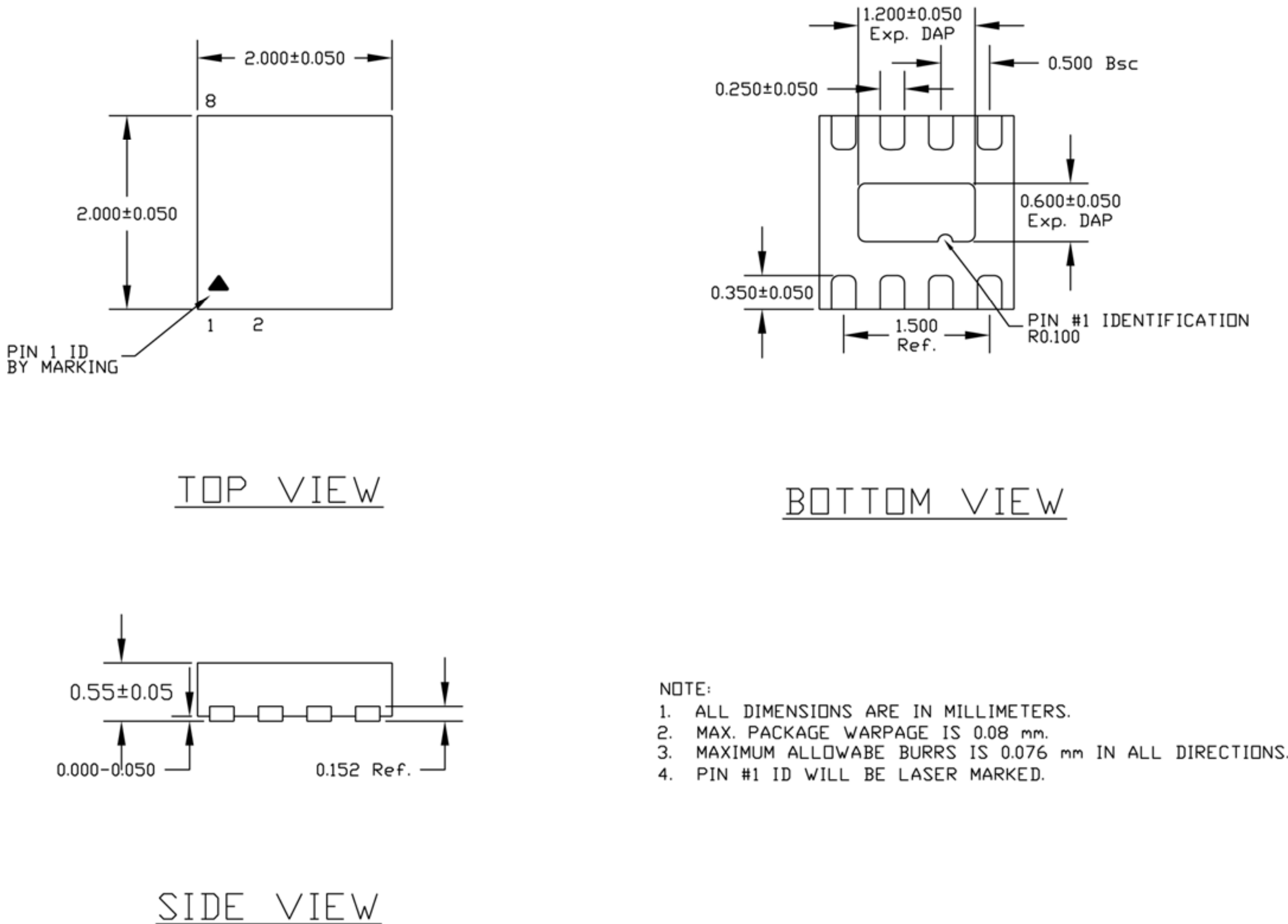


TOP LAYER



BOTTOM LAYER

Package Information



8-Pin 2mm x 2mm TMLF (MT)

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