MIC5311

LowQ™ Mode Dual 300mA LDO

General Description

The MIC5311 is a high performance, dual µCap low dropout regulator offering ultra-low operating current and a second, even lower operating current mode, LowQ™ mode, reducing operating current by 75%. Each regulator can source up to 300mA of output current maximum.

Ideal for battery operated applications, the MIC5311 offers 1% accuracy, extremely low dropout voltage (60mV @ 150mA), and low ground current (typically 28µA total). When put into LowQ™ mode, the internal current draw drops down to 7µA total. The MIC5311 also comes equipped with a TTL logic compatible enable pin that allows the part to be put into a zero-off-mode current state, drawing no current when disabled.

The MIC5311 is a µCap design, operating with very small ceramic output capacitors for stability, reducing required board space and component cost.

The MIC5311 is available in fixed output voltages in the 3mm x 3mm MLF-10 leadless package. Data sheets and support documentation can be found on Micrel's web site at www.micrel.com.

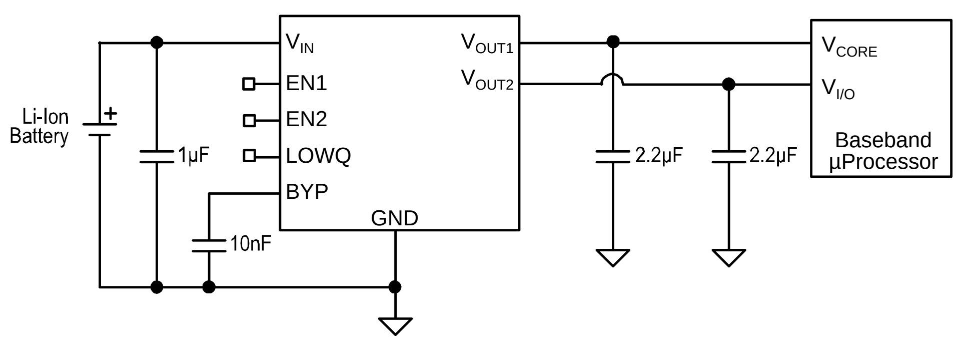
Features

- Input voltage range: 2.5V to 5.5V
- LowQ™ Mode
  - 7µA total quiescent current
  - 10mA output current capable LowQ™ mode
  - Logic level control with external pin
- Stable with ceramic output capacitor
- 2 LDO Outputs – 300mA each
- Tiny 3mm x 3mm MLF™-10 package
- Low dropout voltage of 60mV @ 150mA
- Ultra-low quiescent current of 28µA total in Full Current Mode
- High output accuracy
  - ±1.0% initial accuracy
  - ±2.0% over temperature
- Thermal Shutdown Protection
- Current Limit Protection

Applications

- Cellular/PCS phones
- Wireless modems
- PDAs
- MP3 Players

Typical Application



MIC5311-xxBML

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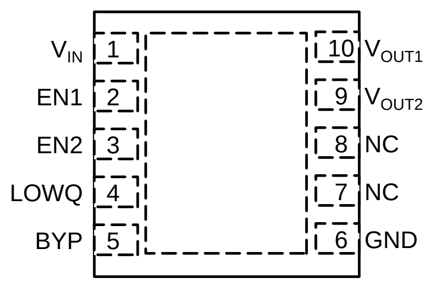
Ordering Information

Part Number		Output Voltage*	Junction Temp. Range	Package
Standard	Pb-Free			
MIC5311-GMBML	MIC5311-GMYML	1.8V/2.8V	–40°C to +125°C	10-Pin 3×3 MLF™
MIC5311-DKBML	MIC5311-DKYML	1.85V/2.6V	–40°C to +125°C	10-Pin 3×3 MLF™
	MIC5311-NLYML	2.85V/2.7V	–40°C to +125°C	10-Pin 3×3 MLF™

Note: *Other Voltage options available between 1.25V and 5V. Contact Micrel for details.

Pin Configuration



MIC5311-xxBML (3x3)

Pin Description

Fixed	Pin Name	Pin Function
1	V_{IN}	Supply Input. (V_{IN1} and V_{IN2} are internally tied together)
2	EN1	Enable Input (regulator 1). Active High Input. Logic High = On; Logic Low = Off; Do not leave floating
3	EN2	Enable Input (regulator 2). Active High Input. Logic High = On; Logic Low = Off; Do not leave floating
4	LowQ™	LowQ™ Mode. Active Low Input. Logic High = Full Power Mode; Logic Low = Light Load Mode; Do not leave floating.
5	BYP	Reference Bypass: Connect external 0.01µF to GND to reduce output noise. May be left open.
6	GND	Ground.
7	NC	
8	NC	
9	$V_{OUT}2$	Output of regulator 2
10	$V_{OUT}1$	Output of regulator 1
EP	GND	Ground. Internally connected to the Exposed Pad.

Absolute Maximum Ratings(1)

Supply Input Voltage (V_{IN}) .... 0V to 6V
Enable Input Voltage (V_{EN}) .... 0V to 6V
LowQ™ Input Voltage ($V_{LowQ™}$) .... 0V to 6V
Power Dissipation (P_D) .... Internally Limited (3)
Junction Temperature .... -40°C to +125°C
Lead Temperature (soldering, 5sec.) .... 260°C
Storage Temperature (T_s) .... -65°C to +150°C

Operating Ratings(2)

Supply Input Voltage (V_{IN}) .... 2.5V to 5.5V
Enable Input Voltage (EN1/EN2/LowQ™) ...... 0V to V_{IN}
Junction Temperature (T_J) .... -40°C to +125°C
Package Thermal Resistance
MLF-10 (θ_{JA}) .... 63°C/W

Electrical Characteristics (Full Power Mode)

V_{IN} = V_{OUT} + 1.0V for higher output of the regulator pair; LowQ™ = V_{IN}; C_{OUT} = 2.2µF, I_{OUT} = 100µA; T_J = 25°C, **bold** values indicate -40°C to +125, unless noted.

Parameter	Conditions	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	**-2.0**		**+2.0**	%
Line Regulation	V_{IN} = V_{OUT} +1V to 5.5V		0.02	0.3 **0.6**	%/V
Load Regulation	I_{OUT} = 100µA to 150mA I_{OUT} = 100µA to 300mA		0.35 0.7	**1.0** **1.5**	% %
Dropout Voltage	I_{OUT} = 150mA I_{OUT} = 300mA		60 120	 **240**	mV mV
Ground Pin Current	$I_{OUT}1$ = $I_{OUT}2$ = 100µA to 300mA		28	45 **50**	µA µA
Ground Pin Current in Shutdown	V_{EN} ≤ 0.2V		0.1		µA
Ripple Rejection	f = up to 1kHz; C_{OUT} = 2.2µF ceramic; C_{BYP} = 10nF f = 1kHz – 20kHz; C_{OUT} = 2.2µF ceramic; C_{BYP} = 10nF		65 35		dB dB
Current Limit	V_{OUT} = 0V (Both Regulators)	350	450	700	mA
Output Voltage Noise	C_{OUT} = 2.2µF, C_{BYP} = 0.01µF, 10Hz to 100kHz		45		µVrms
Enable and LowQ™ Input (EN1/EN2/LowQ™)					
Enable Input Voltage	Logic Low			**0.2**	V
	Logic High	**1.0**			V
Enable Input Current	V_{IL} ≤ 0.2V		0.1	**1**	µA
	V_{IH} ≥ 1.0V		0.1	**1**	µA
Turn-on Time	C_{OUT} = 2.2µF; C_{BYP} = 0.01µF		300	**500**	µs
Light Load Response					
Response Time (4)	Into Light Load		50		µs
	Out of Light Load		50		µs

Electrical Characteristics (LowQ™ Mode)

$V_{IN} = V_{OUT}$ + 1.0V for higher output of the regulator pair; LowQ™ = 0V; C_{OUT} = 2.2µF, I_{OUT} = 100µA; T_J = 25°C, **bold** values indicate -40°C to +125°C, unless noted.

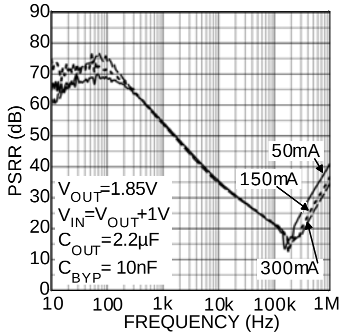
Parameter	Conditions	Min	Typ	Max	Units
Output Voltage Accuracy	Variation from nominal V_{OUT}	-2.0 **-3.0**		+2.0 **+3.0**	% %
Line Regulation	$V_{IN} = V_{OUT}$ +1V to 5.5V		0.02	0.3 **0.6**	%/V
Load Regulation	I_{OUT} = 100µA to 10mA		0.1	**0.5**	%
Dropout Voltage	I_{OUT} = 10mA		100	**200**	mV
Ground Pin Current	Both outputs enabled		7	10 **12**	µA µA
Ground Pin Current in Shutdown	$V_{EN} \leq 0.2V$		0.01	**1.0**	µA
Ripple Rejection	f = up to 1kHz; C_{OUT} = 2.2µF ceramic; C_{BYP} = 10nF f = 1kHz – 20kHz; C_{OUT} = 2.2µF ceramic; C_{BYP} = 10nF		45 30		dB dB
Current Limit	V_{OUT} = 0V (Both regulators)	**40**	75	**150**	mA

Notes:

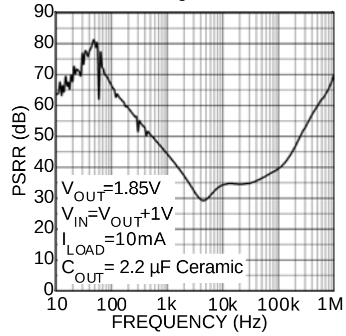
1. Exceeding the absolute maximum rating may damage the device.
2. The device is not guaranteed to function outside its operating rating.
3. The maximum allowable power dissipation of any T_A (ambient temperature) is $P_{D(max)} = T_{J(max)} - T_A / \theta_{JA}$. Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown.
4. Response time defined as the minimum hold-off time after the LowQ™ command before applying load transients.

Typical Characteristics

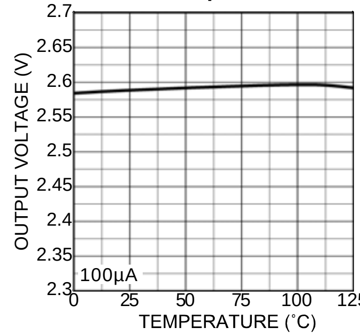
Ripple Rejection vs. I_{LOAD} (Normal Mode)



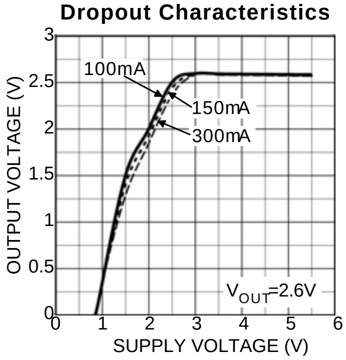
Ripple Rejection LowQ Mode



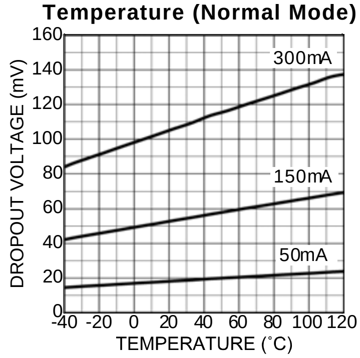
Output Voltage vs. Temperature



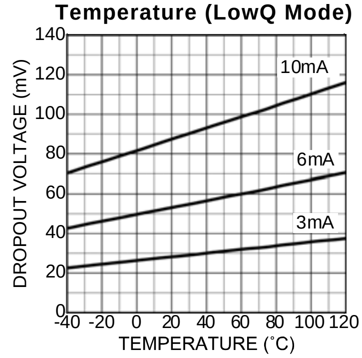
Dropout Characteristics



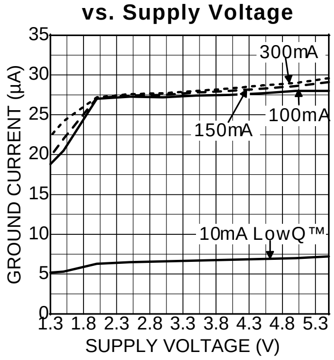
Dropout vs. Temperature (Normal Mode)



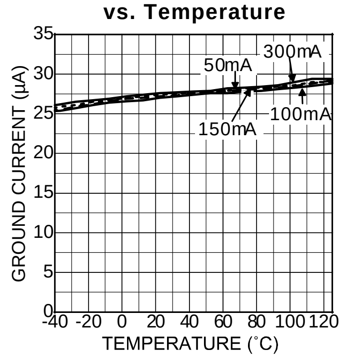
Dropout vs. Temperature (LowQ Mode)



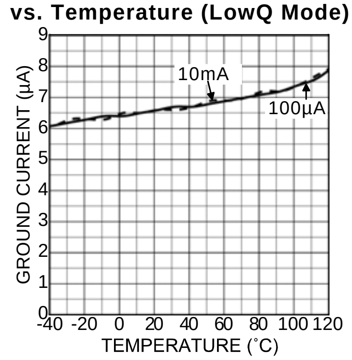
Ground Current vs. Supply Voltage



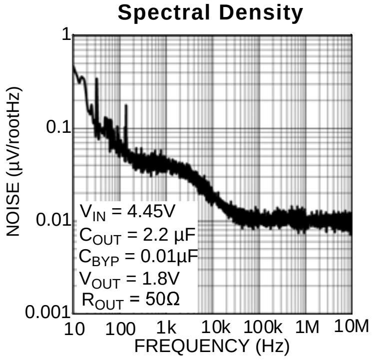
Ground Current vs. Temperature



Ground Current vs. Temperature (LowQ Mode)



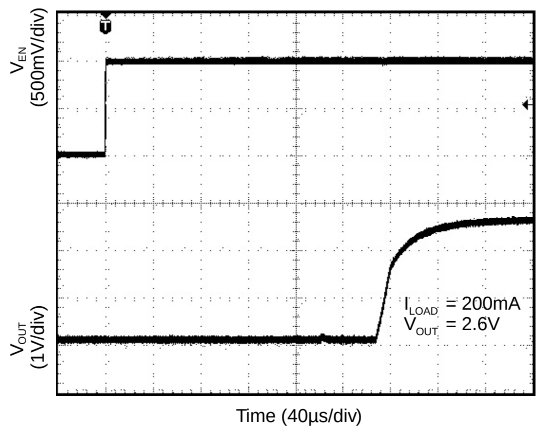
Output Noise Spectral Density



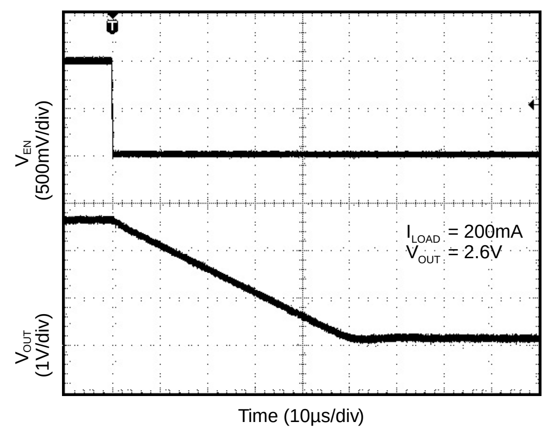
(408) 955-1690

Functional Characteristics

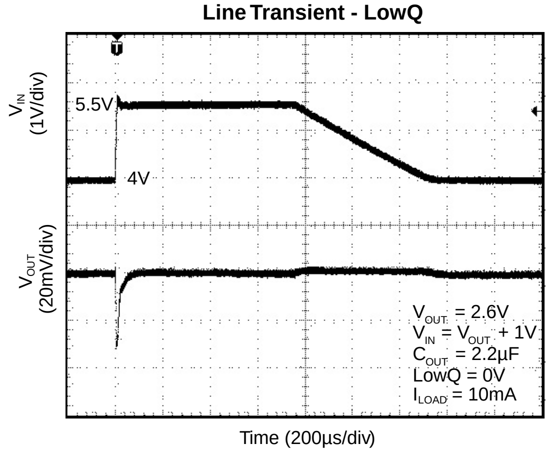
Enable On- Normal



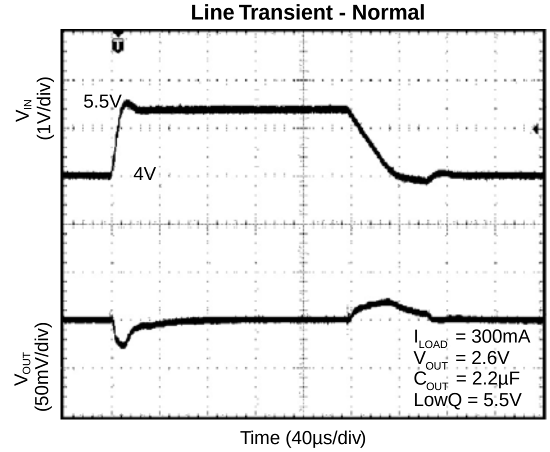
Enable Off - Normal



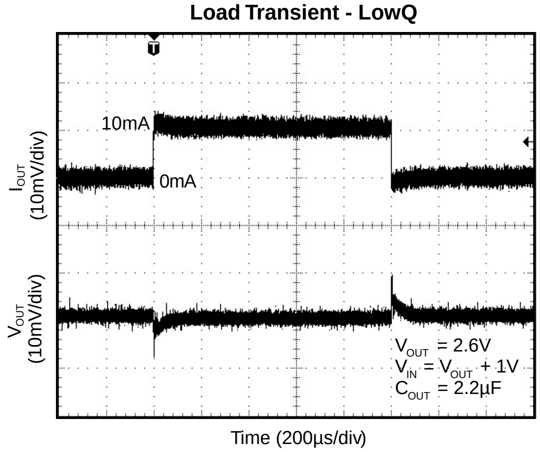
Line Transient - LowQ



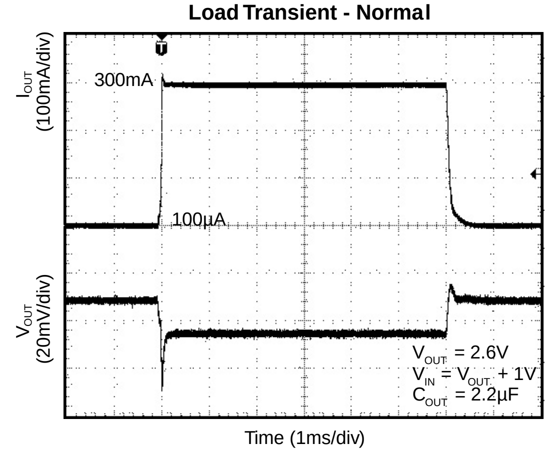
Line Transient - Normal



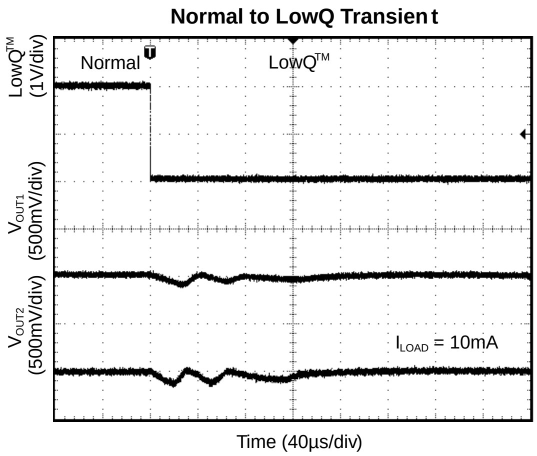
Load Transient - LowQ

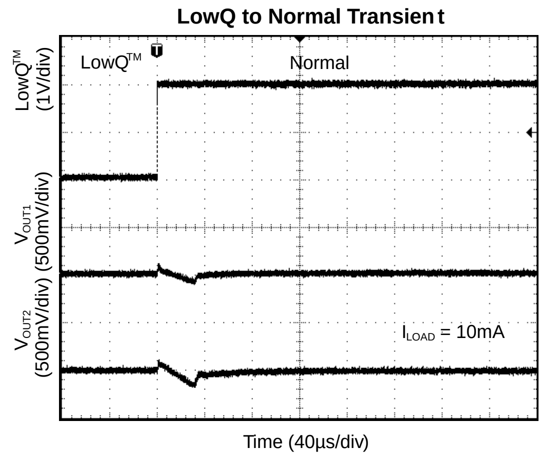


Load Transient - Normal

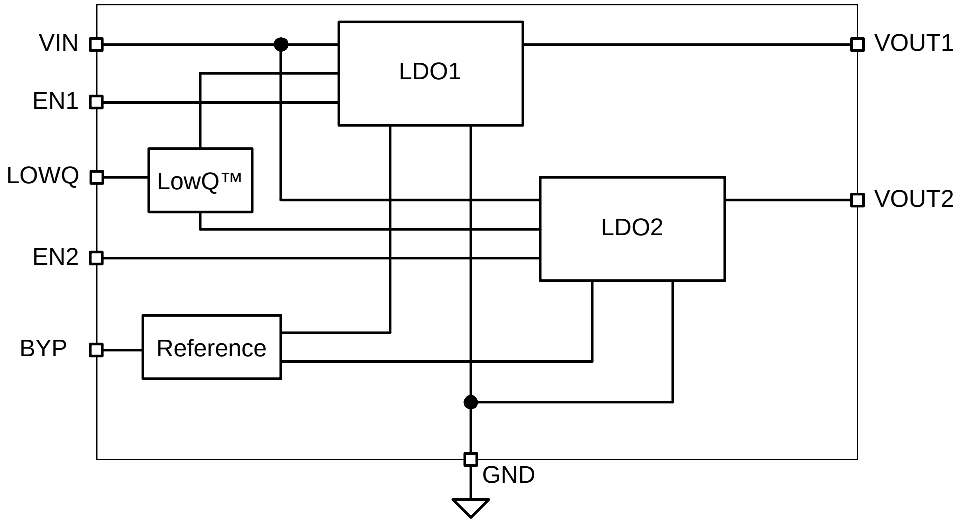


Functional Characteristics (cont.)





Functional Diagram



MIC5311 Block Diagram

Functional Description

The MIC5311 is a high performance, low quiescent current power management IC consisting of two µCap low dropout regulators with a LowQ™ mode featuring lower operating current. Both regulators are capable of sourcing 300mA.

Enable 1 and 2

The enable inputs allow for logic control of both output voltages with individual enable inputs. The enable input is active high, requiring 1.0V for guaranteed operation. The enable input is CMOS logic and cannot be left floating.

LowQ™ Mode

The LowQ™ pin is logic level low, requiring <0.2V to enter the LowQ™ mode. The LowQ™ pin cannot be left floating. Features of the LowQ™ mode include lower total quiescent current of typically 7uA.

Input Capacitor

Good bypassing is recommended from input to ground to help improve AC performance. A 1µF capacitor or greater located close to the IC is recommended. Larger load currents may require larger capacitor values.

Bypass Capacitor

The internal reference voltage of the MIC5311 can be bypassed with a capacitor to ground to reduce output noise and increase input ripple rejection (PSRR). A quick-start feature allows for quick turn-on of the output voltage. The recommended nominal bypass capacitor is 0.01µF, but an increase will result in longer turn on times t_{on}.

Output Capacitor

Each regulator output requires a 2.2µF ceramic output capacitor for stability. The output capacitor value can be increased to improve transient response, but performance has been optimized for a 2.2µF ceramic type output capacitor. 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% to 60% respectively over their operating temperature ranges. To use a ceramic chip capacitor with Y5V dielectric, the value must be much higher than a X7R ceramic capacitor to ensure the same minimum capacitance over the equivalent operating temperature range.

Thermal Considerations

The MIC5311 is designed to provide 300mA of continuous current per channel in a very small MLF package. Maximum power dissipation can be calculated based on the output current and the voltage drop across the part. To determine the maximum power dissipation of the package, use the junction-to-ambient thermal resistance of the device and the following basic equation:

$$P_D\,(max) = (T_J\,(max) - T_A)\,/\theta_{JA}$$

T_J (max) is the maximum junction temperature of the die, 125°C, and T_A is the ambient operating temperature. θ_{JA} is layout dependent; Table 1 shows examples of the junction-to-ambient thermal resistance for the MIC5311.

Package	θ_{JA} Recommended Minimum Footprint	θ_{JC}
3x3 MLF™-10	63°C/W	2°C/W

Table 1. MLF™ Thermal Resistance

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

$$P_{DTOTAL} = P_{D\,LDO1} + P_{D\,LDO2}$$

$$P_{D\,LDO1} = (V_{IN}-V_{OUT1}) \times I_{OUT1}$$

$$P_{D\,LDO2} = (V_{IN}-V_{OUT2}) \times I_{OUT2}$$

Substituting $P_{D(max)}$ for P_D and solving for the operating conditions that are critical to the application will give the maximum operating conditions for the regulator circuit. For example, when operating the MIC5311 at 60°C with a minimum footprint layout, the maximum load currents can be calculated as follows:

$$P_D\,(max) = (T_J\,(max) - T_A)\,/\theta_{JA}$$

$$P_D\,(max) = (125°C - 60°C)\,/\,63°C/W$$

$$\mathbf{P_D\,(max) = 1.03W}$$

The junction-to-ambient thermal resistance for the minimum footprint is **63°C/W**, from Table 1. The maximum power dissipation must not be exceeded for proper operation. Using a lithium-ion battery as the supply voltage of 4.2V, 1.8V_{OUT}/150mA for channel 1 and 2.8V_{OUT}/100mA for channel 2, power dissipation can be calculated as follows:

$$P_{D\,LDO1} = (V_{IN}-V_{OUT1}) \times I_{OUT1}$$

$$P_{D\,LDO1} = (4.2V-1.8V) \times 150mA$$

$$P_{D\,LDO1} = 360mW$$

$$P_{D\,LDO2} = (V_{IN}-V_{OUT2}) \times I_{OUT2}$$

$$P_{D\,LDO1} = (4.2V-2.8V) \times 100mA$$

$$P_{D\,LDO1} = 140mW$$

$P_{DTOTAL} = P_{D\ LDO1} + P_{D\ LDO2}$

$P_{DTOTAL} = 360mW + 140mW$

$P_{DTOTAL} = 500mW$

The calculation shows that we are well below the maximum allowable power dissipation of **1.03W** for a 60° ambient temperature.

After the maximum power dissipation has been calculated, it is always a good idea to calculate the maximum ambient temperature for a 125° junction temperature. Calculating maximum ambient temperature as follows:

$T_{A(max)} = T_{J(max)} – (P_D \times \theta_{JA})$

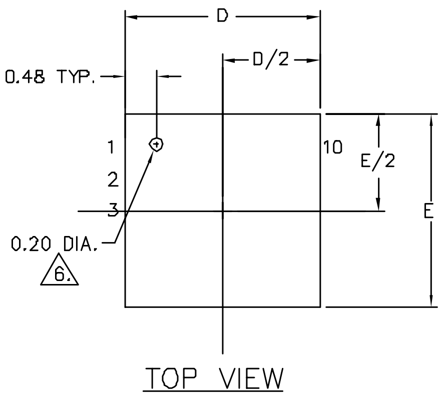
$T_{A(max)} = 125°C – (500mW \times 63°C/W)$

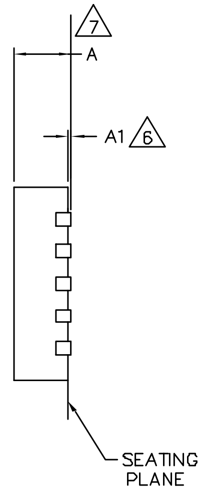
$T_{A(max)} = 93.5°C$

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.

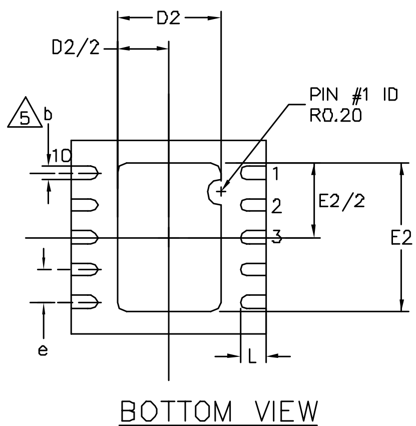
This information can be found on Micrel's website at: http://www.micrel.com/_PDF/other/LDOBk_ds.pdf

Package Information





	DIMENSION (mm)		
	MIN.	NOM.	MAX.
A	0.80	0.85	1.00
A1	0.00	0.01	0.05
D	3.00 BSC		
D2	1.45	1.60	1.75
E	3.00 BSC		
E2	2.15	2.30	2.45
e	0.50 BSC		
L	0.35	0.40	0.55
b	0.18	0.23	0.30



NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. MAX. PACKAGE WARPAGE IS 0.05 mm.
3. MAXIMUM ALLOWABE BURRS IS 0.076 mm IN ALL DIRECTIONS.
4. PIN #1 ID ON TOP WILL BE LASER/INK MARKED.
5. DIMENSION b APPLIES TO METALIZED TERMINAL AND IS MEASURED BETWEEN 0.20 AND 0.25 mm FROM TERMINAL TIP.
6. APPLIED ONLY FOR TERMINALS.
7. APPLIED FOR EXPOSED PAD AND TERMINALS.

10-Pin 3x3 MLF (MLF)

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