MIC5309

Low V_{IN}/V_{OUT} 300mA High PSRR ULDO™ with Ultra-Low IQ

General Description

The MIC5309 is a high performance, μCap low dropout regulator, offering ultra-low operating current while maintaining very fast transient response. The MIC5309 can source up to 300mA of output current and can regulate down from a low input supply voltage to increase system efficiency.

Ideal for battery operated applications; the MIC5309 offers extremely low dropout voltage 100mV typically @ 300mA load, and low ground current at all load conditions (typically 23μA). The MIC5309 can also be put into a zero-off-mode current state, drawing virtually no current when disabled.

The MIC5309 is available in fixed output voltages in the tiny 6-pin 1.6mm x 1.6mm thin MLF® leadless package as well as the 6-pin TSOT-23 for cost sensitive applications.

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

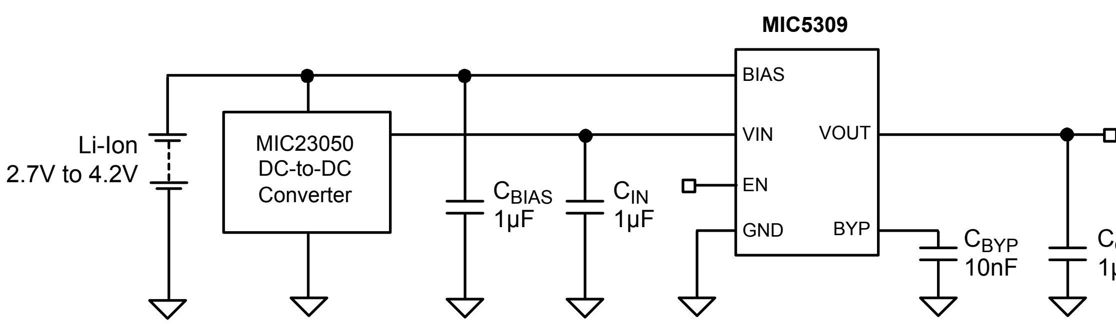
Features

- Input voltage range: 1.7V to 5.5V
- Guaranteed 300mA over temperature
- Ultra Low dropout voltage of 100mV typical 300mA
- High PSRR, up to 90dB @ 1kHz
- Output Voltage range: 0.8V to 2.0V
- Very low ground current – 23μA under full load
- Bias supply voltage range: 2.5V to 5.5V
- Stable with 1μF ceramic output capacitor
- 300mA maximum output current at 1.7V input voltage
- Very fast transient response – ideal for digital loads
- Thermal shutdown and current limit protection
- Tiny 6-pin 1.6mm x 1.6mm Thin MLF® package
- Cost effective 6-pin TSOT-23 package

Applications

- Mobile Phones
- PDAs
- GPS Receivers
- Portable Electronics

Typical Application



Ordering Information

Part Number	Voltage	Marking Codes	Temperature Range	Package
MIC5309-1.2YMT	1.2V	▲1S2	–40° to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5309-1.5YMT	1.5V	▲1S5	–40° to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5309-1.8YMT	1.8V	▲1S8	–40° to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5309YMT	Adj.	▲ASA	–40° to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5309-1.2YD6	1.2V	QS12	–40° to +125°C	6-Pin TSOT-23
MIC5309-1.5YD6	1.5V	QS15	–40° to +125°C	6-Pin TSOT-23
MIC5309-1.8YD6	1.8V	QS18	–40° to +125°C	6-Pin TSOT-23
MIC5309YD6	Adj.	QSAA	–40° to +125°C	6-Pin TSOT-23

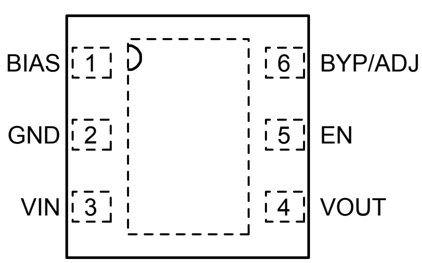
Notes

For other voltage options. Contact Micrel Marketing for details.

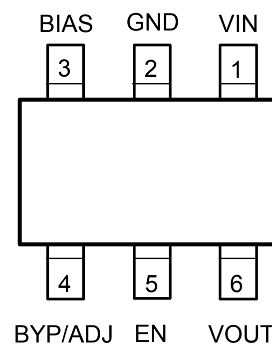
Pin 1 identifier = ▲.

MLF® is a GREEN RoHS compliant package. Lead finish is NiPdAu. Mold compound is Halogen Free.

Pin Configuration



6-Pin 1.6mm x 1.6mm Thin MLF® (MT)



6-Pin TSOT-23 (D6)

Pin Description

Pin Number Thin MLF-6	Pin Number TSOT-23-6	Pin Name	Pin Function
3	1	VIN	Power Input for LDO.
2	2	GND	Ground
1	3	BIAS	Bias Input Voltage.
6	4	BYP	Bypass: Connect a capacitor to ground to reduce noise and reduce ripple rejection.
		ADJ	Adjustable: Feedback input from external resistor divider.
5	5	EN	Enable Input: Active High Input. Logic High = On; Logic Low = Off; Do not leave floating.
4	6	VOUT	Output of regulator.
HS Pad	–	EPAD	Exposed heatsink pad connected to ground internally.

Absolute Maximum Ratings[1]

Supply Voltage (V_{IN}) .... 0V to V_{BIAS}
Bias Supply Voltage (V_{BIAS}) .... 0V to +6V
Enable Voltage (V_{EN}) .... 0V to V_{BIAS}
Power Dissipation, ... Internally Limited[3]
Lead Temperature (soldering, 10µsec.) .... 260°C
Storage Temperature (T_s) .... –65°C to +150°C
ESD Rating[4] 3kV

Operating Ratings[2]

Supply Voltage (V_{IN}) .... +1.7V to V_{BIAS}
Bias Supply Voltage (V_{BIAS}) .... +2.5V to +5.5V
Enable Input Voltage (V_{EN}) 0V to V_{BIAS}
Junction Temperature (T_J) .... –40°C to +125°C
Junction Thermal Resistance
1.6x1.6 MLF-6 (θ_{JA}) .... 90°C/W
TSOT-23-6 (θ_{JA}) .... 235°C/W

Electrical Characteristics

V_{BIAS} = 3.6V; V_{IN} = V_{OUT} + 1V; $V_{IN} \leq V_{BIAS}$; C_{OUT} = 1.0µF; I_{OUT} = 100µA; T_J = 25°C, **bold** values indicate –40°C to +125°C, unless noted.

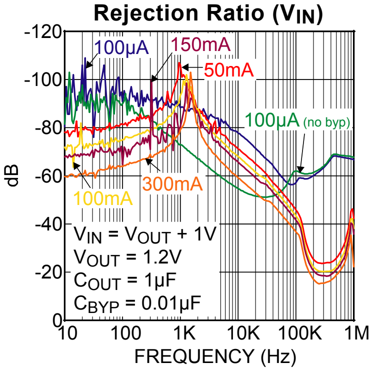
Parameter	Condition	Min	Typ	Max	Units
Output Voltage Accuracy	Variation from nominal V_{OUT}	**–2.0**		**+2.0**	%
Reference Voltage	ADJ pin voltage	**0.7595**	0.775	**0.7905**	V
V_{BIAS} Line Regulation	V_{BIAS} = 3.6 to 5.5V, V_{IN} = V_{OUT} + 1V		0.01	**0.3**	%/V
V_{IN} Line Regulation	V_{IN} = V_{OUT} + 1V , V_{BIAS} = 5.5V		0.02	**0.2**	%/V
Load Regulation	I_{OUT} = 100µA to 300mA		0.4	**2**	%
Dropout Voltage	I_{OUT} = 300mA		100	**200**	mV
Ground Pin Current[5]	I_{OUT} = 100µA to 300mA , V_{EN} = V_{BIAS}		23	**35**	µA
Ground Pin Current in Shutdown	V_{EN} ≤ 0.2V		0.01	2.0	µA
V_{IN} Ripple Rejection	f = up to 1kHz; C_{OUT} = 1.0µF; no C_{BYP}		70		dB
	f = up to 1kHz; C_{OUT} = 1.0µF; C_{BYP} = 10nF	50	90		dB
	f = 20kHz; C_{OUT} = 1.0µF; C_{BYP} = 10nF		80		dB
Current Limit	V_{OUT} = 0V	350	550	800	mA
Output Voltage Noise	C_{OUT} = 1.0µF, C_{BYP} = 10nF, 10Hz to 100kHz		28		$µV_{RMS}$
Enable Inputs (EN)					
Enable Input Voltage	Logic Low			**0.2**	V
	Logic High	**1.2**			V
Enable Input Current	V_{IL} ≤ 0.2V		0.17	**1**	µA
	V_{IH} ≥ 1.2V		1.5	**1**	µA
Turn-on Time	C_{OUT} = 1.0µF, C_{BYP} = 10nF		150	**500**	µs

Notes:

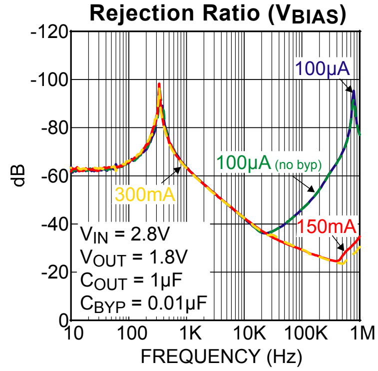
1. Exceeding the absolute maximum rating may damage the device.
2. The device is not guaranteed to function outside its operating rating.
3. The maximum allowable power dissipation of any T_A (ambient temperature) is $P_{D(max)} = T_{J(max)} - T_A) / \theta_{JA}$. Exceeding the maximum allowable power 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. $I_{GND} = I_{IN} + I_{BIAS} - I_{OUT}$.

Typical Characteristics

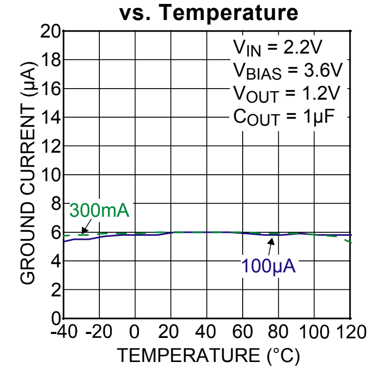
Power Supply Rejection Ratio (V_{IN})



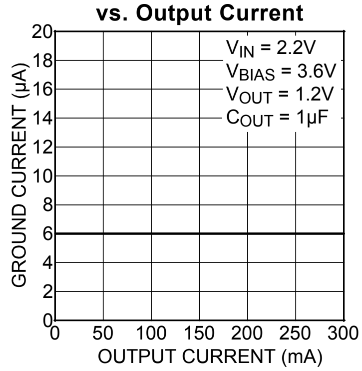
Power Supply Rejection Ratio (V_{BIAS})



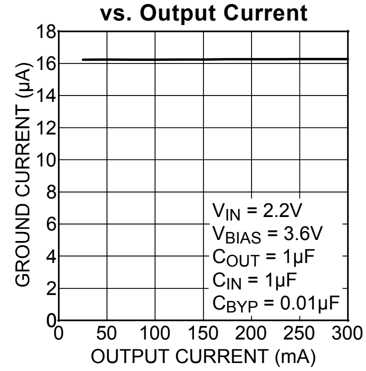
Ground Current (V_{IN}) vs. Temperature



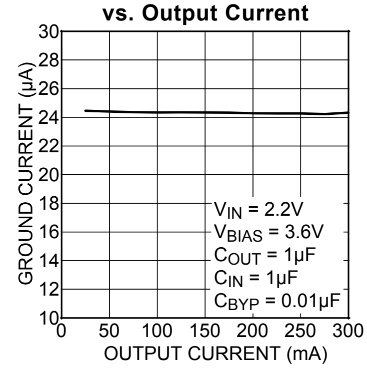
Ground Current (V_{IN}) vs. Output Current



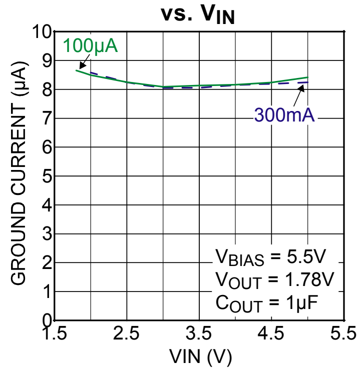
Ground Current (V_{BIAS}) vs. Output Current



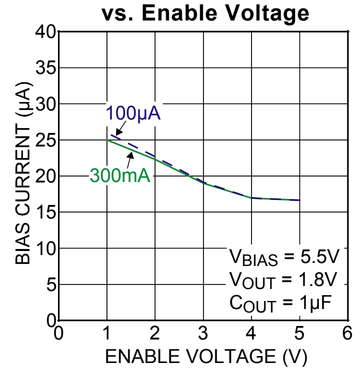
Ground Current (Total) vs. Output Current



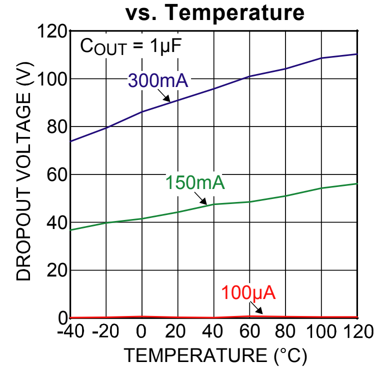
Ground Current (V_{IN}) vs. V_{IN}



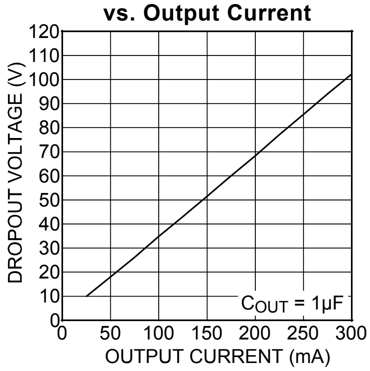
Bias Current vs. Enable Voltage



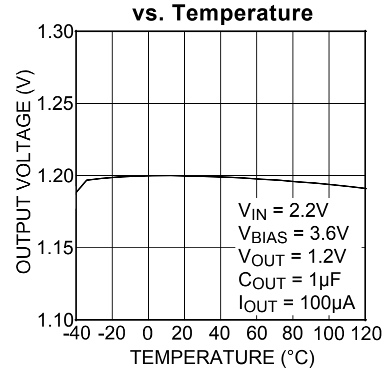
Dropout Voltage vs. Temperature



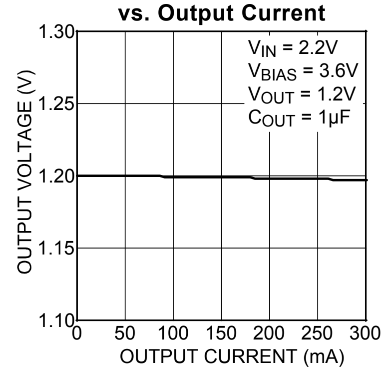
Dropout Voltage vs. Output Current



Output Voltage vs. Temperature

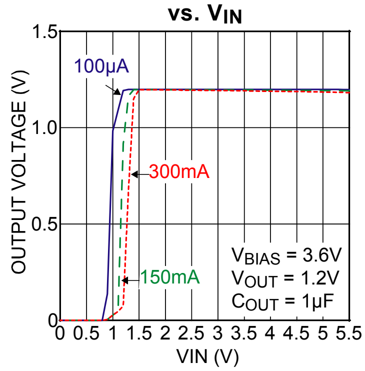


Output Voltage vs. Output Current

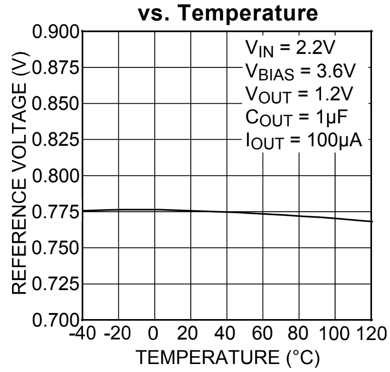


Typical Characteristics

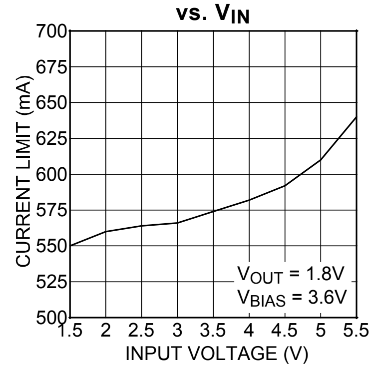
Output Voltage vs. V_{IN}



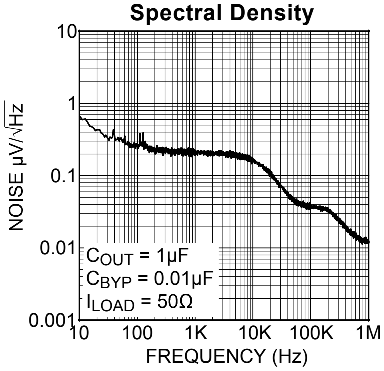
Reference Voltage vs. Temperature



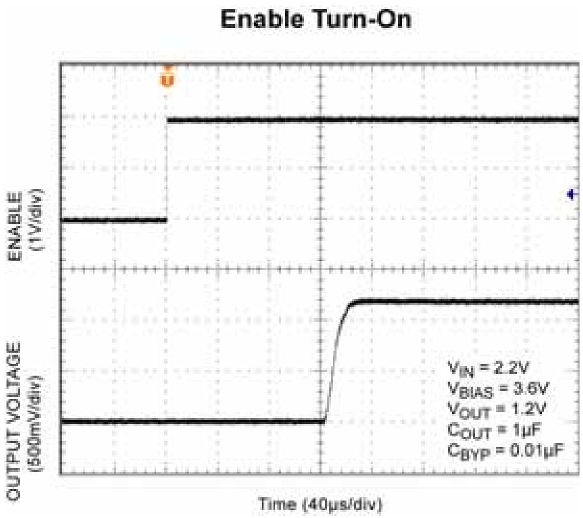
Current Limit vs. V_{IN}

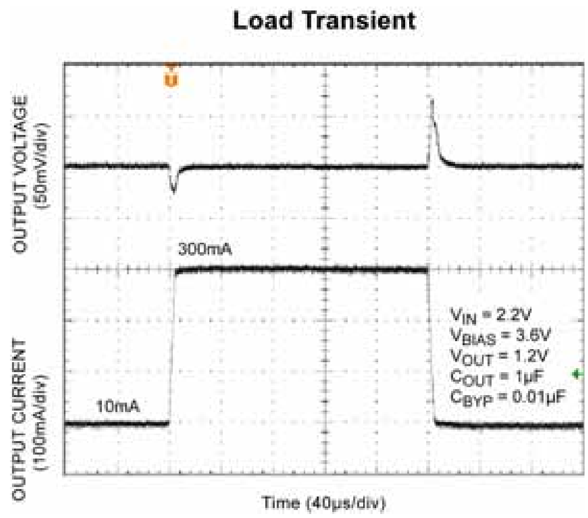


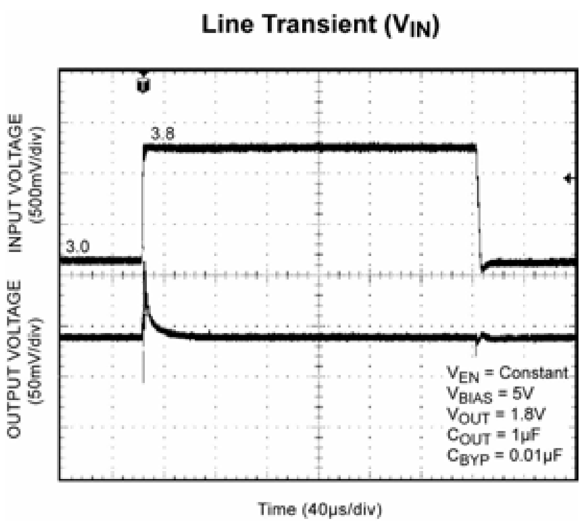
Output Noise Spectral Density

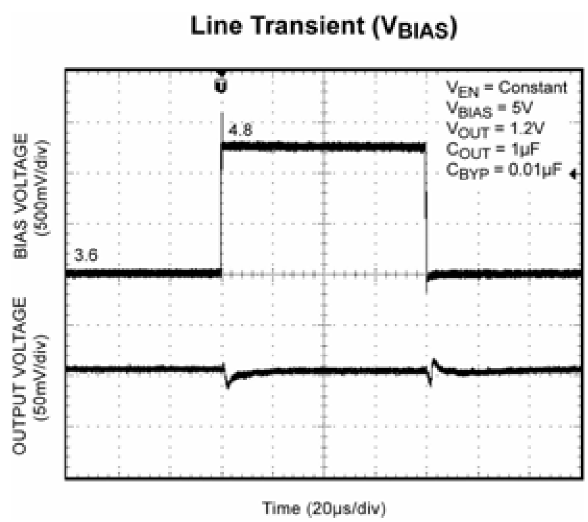


Functional Characteristics

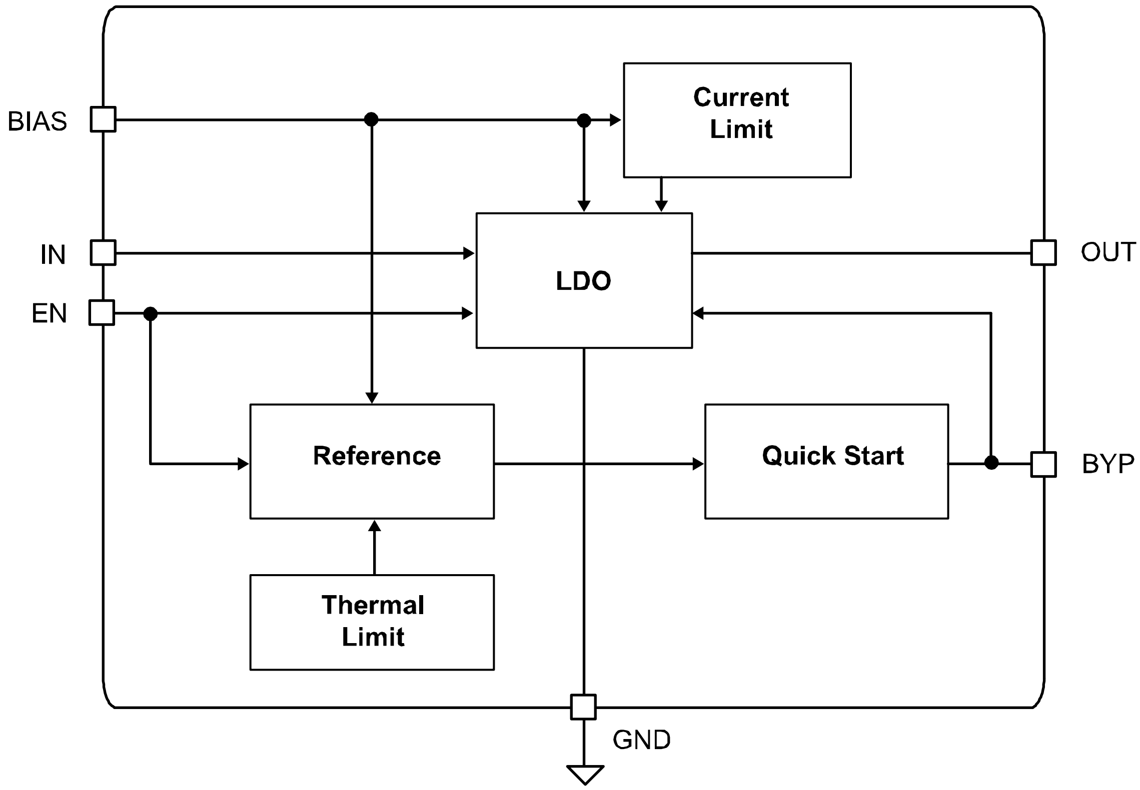








Functional Diagram



MIC5309 Block Diagram

Applications Information

The MIC5309 is a high performance, low-dropout linear regulator designed for low current applications requiring fast transient response. The MIC5309 utilizes two input supplies, significantly reducing dropout voltage, perfect for low-voltage, DC-to-DC conversion. The MIC5309 requires a minimum of external components.

The MIC5309 regulator is fully protected from damage due to fault conditions, offering linear current limiting and thermal shutdown.

Bias Supply Voltage

V_{BIAS}, requiring relatively light current, provides power to the control portion of the MIC5309. Bypassing on the bias pin is recommended to improve performance of the regulator during line and load transients. 1µF ceramic capacitor from V_{BIAS} to ground helps reduce high frequency noise from being injected into the control circuitry from the bias rail and is good design practice.

Input Supply Voltage

V_{IN} provides the supply to power the LDO. The minimum input voltage is 1.7V, allowing conversion from low voltage supplies.

Output Capacitor

The MIC5309 requires an output capacitor of 1µF 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 1µF 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.

Input Capacitor

The MIC5309 is a high-performance, high bandwidth device. Therefore, it requires a well-bypassed input supply for optimal performance. A 1µF 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.

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 0.01µF 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 MIC5309 to drive a large capacitor on the bypass pin without significantly slowing turn-on time.

Minimum Load Current

The MIC5309, unlike most other regulators, does not require a minimum load to maintain output voltage regulation.

Adjustable Regulator Design

The MIC5309 adjustable version allows programming the output voltage anywhere between 0.8Vand 2V. Two resistors are used. The resistor values are calculated by:

$$R1 = R2 \times \left(\frac{V_{OUT}}{0.775} - 1 \right)$$

Where V_{OUT} is the desired output voltage.

Enable/Shutdown

The MIC5309 comes with a single active-high enable pin that allows the regulator to be disabled. 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.

Thermal Considerations

The MIC5309 is designed to provide 300mA 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 1.8V, the output voltage is 1.2V and the output current = 300mA. The actual power dissipation of the regulator circuit can be determined using the equation:

$$P_D = (V_{IN} - V_{OUT1})\, I_{OUT} + V_{IN}\, I_{GND}$$

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.

$$P_D = (1.8V - 1.2V) \times 300mA$$

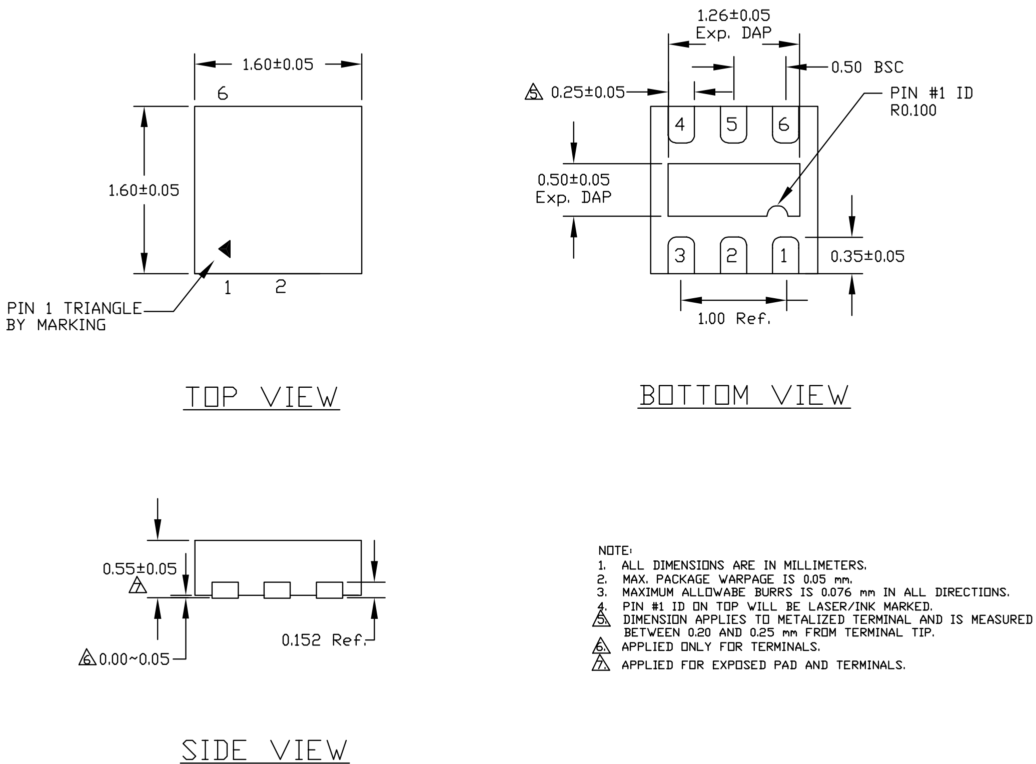
$$P_D = 0.18W$$

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:

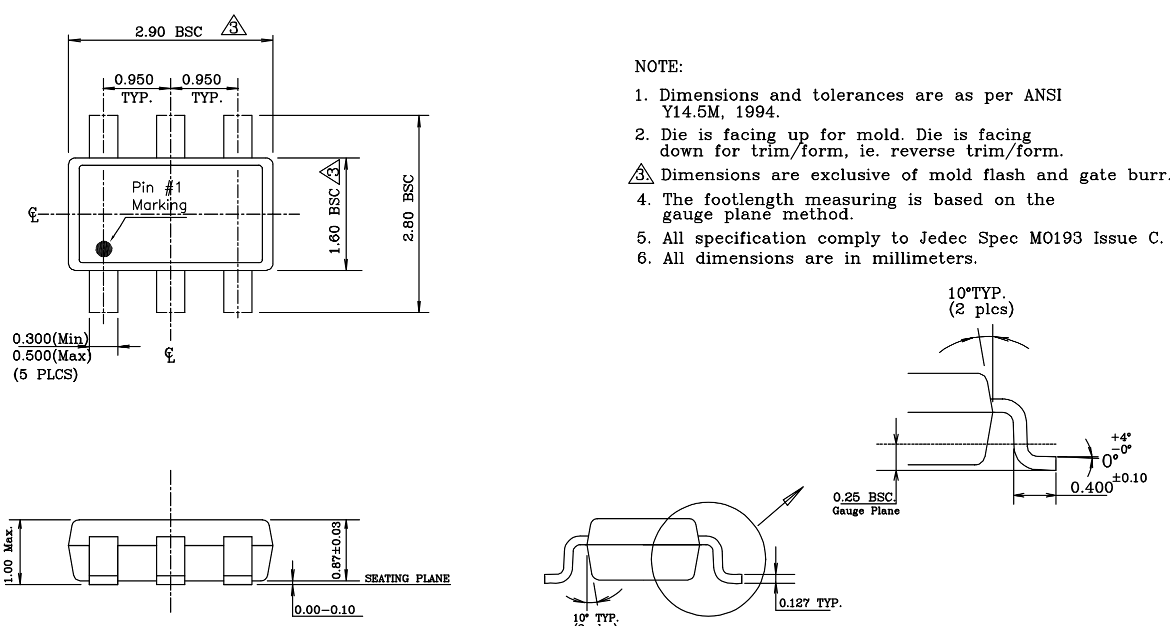
$$P_{D(max)} = \left(\frac{T_{J(max)} - T_A}{\theta_{JA}} \right)$$

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

Package Information



6-Pin 1.6mm x 1.6mm Thin MLF® (MT)



6-Pin TSOT-23 (D6)

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