MIC5301

Single, 150mA µCap ULDO™

General Description

The MIC5301 is a high performance, single output ultra low LDO (ULDO™) regulator, offering low total output noise. The MIC5301 is capable of sourcing 150mA output current and offers high PSRR and low output noise, making it an ideal solution for RF applications.

For battery operated applications, the MIC5301 offers 2% accuracy, extremely low dropout voltage (40mV @ 150mA), and low ground current (typically 85µA total). The MIC5301 can also be put into a zero-off-mode current state, drawing no current when disabled.

The MIC5301 is available in the 1.6mm x 1.6mm Thin MLF® package, occupying only 2.56mm^2 of PCB area, a 36% reduction in board area compared to SC-70 and 2mm x 2mm MLF® packages.

The MIC5301 has an operating junction temperature range of –40°C to +125°C and is available in fixed and adjustable output voltages in lead-free (RoHS compliant) Thin MLF® and Thin SOT-23-5 packages.

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

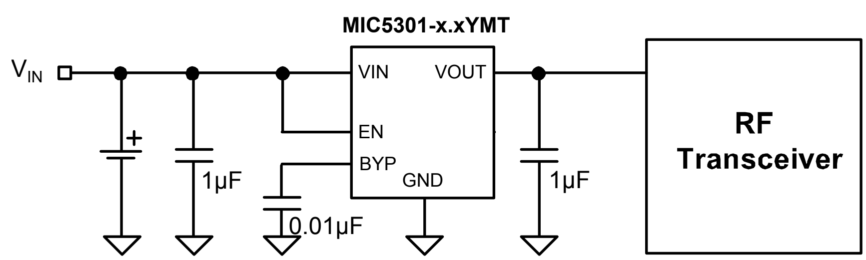
Features

- Ultra low dropout voltage – 40mV @ 150mA
- Input voltage range: 2.3V to 5.5V
- 150mA guaranteed output current
- Stable with ceramic output capacitors
- Ultra low output noise – 30µVrms
- Low quiescent current – 85µA total
- High PSRR – up to 75dB@1kHz
- 35µs turn-on time
- High output accuracy
- ± 2% initial accuracy
- ± 3% over temperature
- Thermal shutdown and current limit protection
- Tiny 6-pin 1.6mm x 1.6mm Thin MLF® leadless package
- Thin SOT-23-5 package

Applications

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

Typical Application



Portable Application

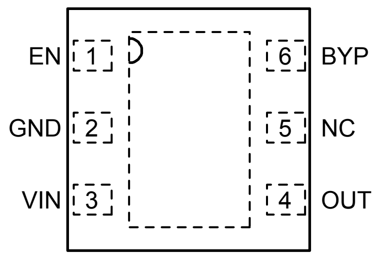
Ordering Information

Part number	Marking Code[1]	Output Voltage[2]	Temperature Range	Package
MIC5301-2.85YML[4]	$\overline{2}$JC	2.85V	–40°C to +125°C	6-Pin 1.6mm x 1.6mm MLF®
MIC5301YML[4]	$\overline{C}$AA	ADJ.	–40°C to +125°C	6-Pin 1.6mm x 1.6mm MLF®
MIC5301-1.3YMT[3,4]	13C	1.3V	–40°C to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5301-1.5YMT[3,4]	15C	1.5V	–40°C to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5301-1.8YMT[3,4]	18C	1.8V	–40°C to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5301-2.1YMT[3,4]	21C	2.1V	–40°C to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5301-2.5YMT[3,4]	25C	2.5V	–40°C to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5301-2.6YMT[3,4]	26C	2.6V	–40°C to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5301-2.8YMT[3,4]	28C	2.8V	–40°C to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5301-2.85YMT[3,4]	2JC	2.85V	–40°C to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5301-2.9YMT[3,4]	29C	2.9V	–40°C to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5301-3.0YMT[3,4]	30C	3.0V	–40°C to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5301-3.3YMT[3,4]	33C	3.3V	–40°C to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5301-4.6YMT[3,4]	46C	4.6V	–40°C to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5301YMT[3,4]	CAA	ADJ.	–40°C to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5301-1.3YD5	$\underline{QC}$13	1.3V	–40°C to +125°C	5-Pin TSOT-23
MIC5301-1.5YD5	$\underline{QC}$15	1.5V	–40°C to +125°C	5-Pin TSOT-23
MIC5301-1.8YD5	$\underline{QC}$18	1.8V	–40°C to +125°C	5-Pin TSOT-23
MIC5301-2.1YD5	$\underline{QC}$21	2.1V	–40°C to +125°C	5-Pin TSOT-23
MIC5301-2.5YD5	$\underline{QC}$25	2.5V	–40°C to +125°C	5-Pin TSOT-23
MIC5301-2.6YD5	$\underline{QC}$26	2.6V	–40°C to +125°C	5-Pin TSOT-23
MIC5301-2.8YD5	$\underline{QC}$28	2.8V	–40°C to +125°C	5-Pin TSOT-23
MIC5301-2.85YD5	$\underline{QC}$2J	2.85V	–40°C to +125°C	5-Pin TSOT-23
MIC5301-2.9YD5	$\underline{QC}$29	2.9V	–40°C to +125°C	5-Pin TSOT-23
MIC5301-3.0YD5	$\underline{QC}$30	3.0V	–40°C to +125°C	5-Pin TSOT-23
MIC5301-3.3YD5	$\underline{QC}$33	3.3V	–40°C to +125°C	5-Pin TSOT-23
MIC5301-4.6YD5	$\underline{QC}$46	4.6V	–40°C to +125°C	5-Pin TSOT-23
MIC5301YD5	$\underline{QC}$AA	ADJ.	–40°C to +125°C	5-Pin TSOT-23

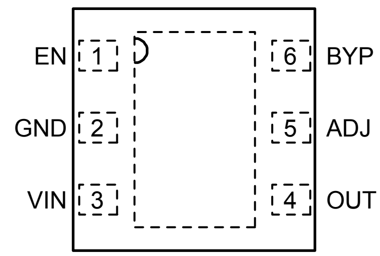
Notes:

1. Under bar / Over bar symbol may not be to scale.
2. Other Voltages available. Contact Micrel for details.
3. Thin MLF® Pin 1 indicator = ▲.
4. MLF® Thin MLF® are GREEN RoHS compliant packages. Lead Finish is NiPdAu. Mold compound is Halogen Free.

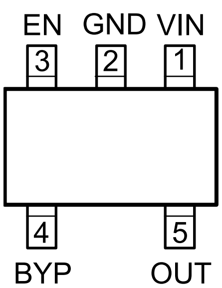
Pin Configuration



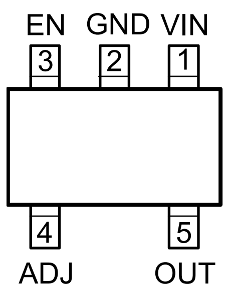
6-Pin 1.6mm x 1.6mm Thin MLF® (MT)
Fixed (Top View)



6-Pin 1.6mm x 1.6mm Thin MLF® (MT)
Adjustable (Top View)



TSOT-23-5 (D5)
Fixed (Top View)



TSOT-23-5 (D5)
Adjustable (Top View)

Pin Description

Pin No. Thin MLF-6 Fixed	Pin No. Thin MLF-6 Adj.	Pin No. TSOT-23-5 Fixed	Pin No. TSOT-23-5 Adj.	Pin Name	Pin Function
1	1	3	3	EN	Enable Input. Active High. High = on, low = off. Do not leave floating.
2	2	2	2	GND	Ground
3	3	1	1	VIN	Supply Input.
4	4	5	5	OUT	Output Voltage.
5	–	–	–	NC	No connection.
–	5	–	4	ADJ	Adjust Input. Connect to external resistor voltage divider network.
6	6	4	–	BYP	Reference Bypass: Connect external 0.01µF to GND for reduced Output Noise. May be left open.
HS Pad	HS Pad	–	–	E PAD	Exposed Heatsink Pad connected to ground internally.

Absolute Maximum Ratings[1]

Supply Voltage (V_{IN}) .... 0V to +6V
Enable Input Voltage (V_{EN}) .... 0V to +6V
Power Dissipation, Internally Limited[3]
Lead Temperature (soldering, 3sec) .... 260°C
Storage Temperature (T_S) .... –65°C to +150°C

Operating Ratings[2]

Supply Voltage (V_{IN}) .... +2.3V to +5.5V
Enable Input Voltage (V_{EN}) .... 0V to V_{IN}
Junction Temperature (T_J) .... –40°C to +125°C
Junction Thermal Resistance
MLF-6 (θ_{JA}) .... 100°C/W
Thin MLF-6 (θ_{JA}) .... 100°C/W
TSOT-23-5 (θ_{JA}) .... 235°C/W

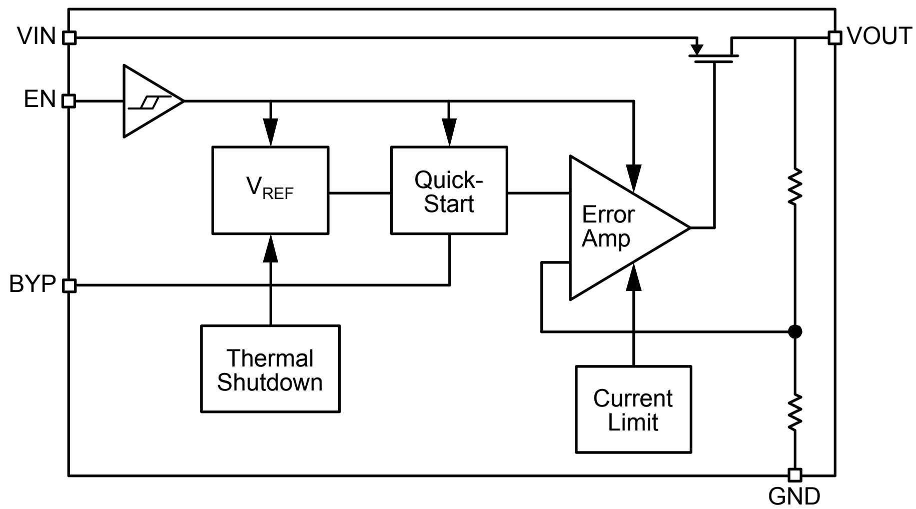
Electrical Characteristics[4]

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

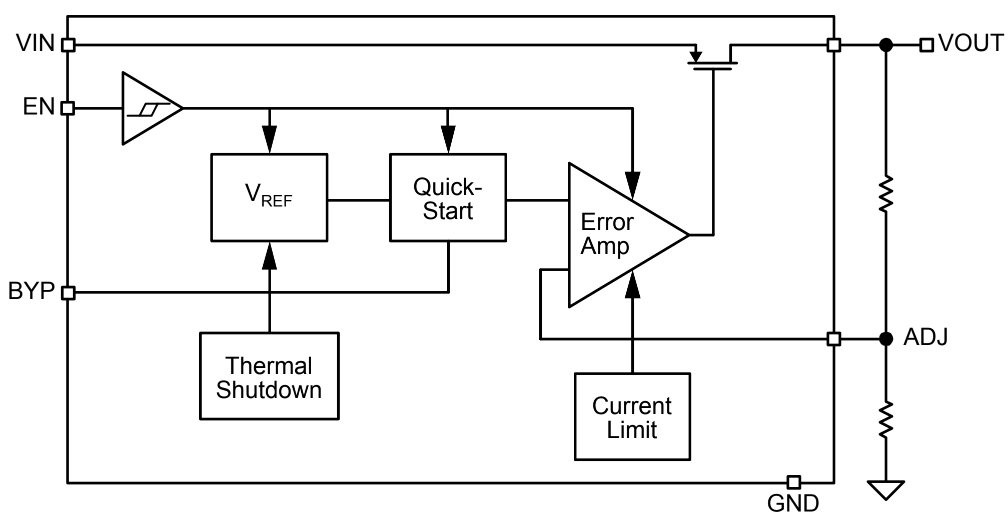
Parameter	Conditions	Min	Typ	Max	Units
Output Voltage Accuracy	Variation from nominal V_{OUT}	-2.0		+2.0	%
	Variation from nominal V_{OUT}; –40°C to +125°C	**-3.0**		**+3.0**	%
Line Regulation	$V_{IN} = V_{OUT}$ + 1V to 5.5V; $I_{OUT} = 100\mu A$		0.02	0.3 **0.6**	%/V %/V
Load Regulation	I_{OUT} = 100µA to 150mA		0.15	**2.0**	%
Dropout Voltage [5]	I_{OUT} = 100µA		0.1		mV
	I_{OUT} = 100mA		25	**75**	mV
	I_{OUT} = 150mA		40	**100**	mV
Ground Pin Current	I_{OUT} = 0 to 150mA		85	**120**	µA
Ground Pin Current in Shutdown	$V_{EN} \le 0.2V$		0.01	2	µA
Ripple Rejection	f = 1kHz; C_{OUT} = 1.0µF; C_{BYP} = 0.1µF		75		dB
	f = 20kHz; C_{OUT} = 1.0µF; C_{BYP} = 0.1µF		50		dB
Current Limit	V_{OUT} = 0V	275	450	**850**	mA
Output Voltage Noise	C_{OUT} = 1.0µF; C_{BYP} = 0.1µF; 10Hz to 100kHz		30		μV_{RMS}
Enable Input					
Enable Input Voltage	Logic Low			**0.2**	V
	Logic High	**1**			V
Enable Input Current	$V_{IL} \le 0.2V$		0.01	1	µA
	$V_{IH} \ge 1.0V$		0.01	1	µA
Turn-on Time					
Turn-on Time	C_{OUT} = 1.0µF; C_{BYP} = 0.1µF		35	**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. Specification for packaged product only.
5. Dropout voltage is defined as the input-to-output differential at which the output voltage drops 2% below its nominal value measured at 1V differential.

Functional Diagram



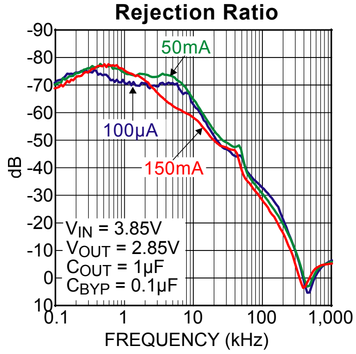
MIC5301 Block Diagram – Fixed



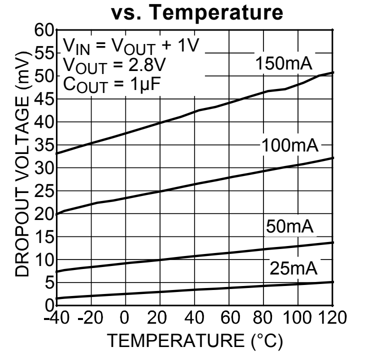
MIC5301 Block Diagram – Adjustable

Typical Characteristics

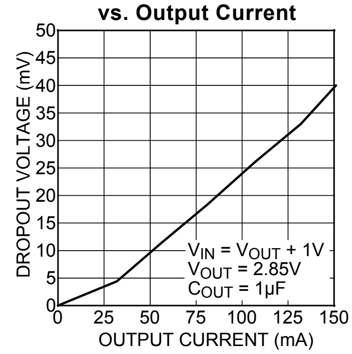
Power Supply Rejection Ratio



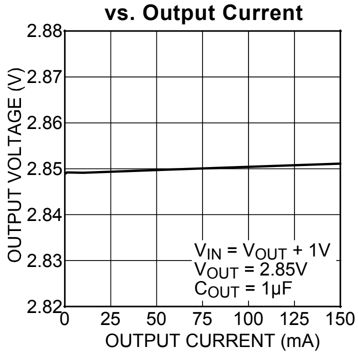
Dropout Voltage vs. Temperature



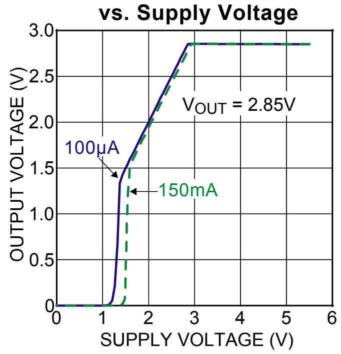
Dropout Voltage vs. Output Current



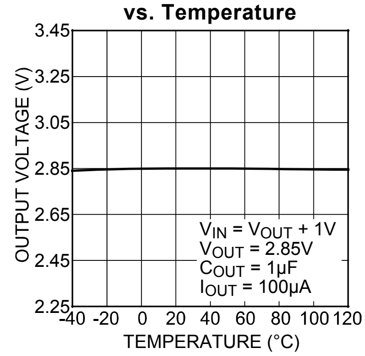
Output Voltage vs. Output Current



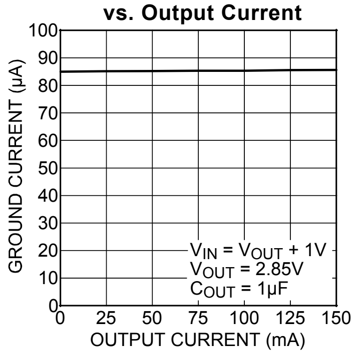
Output Voltage vs. Supply Voltage



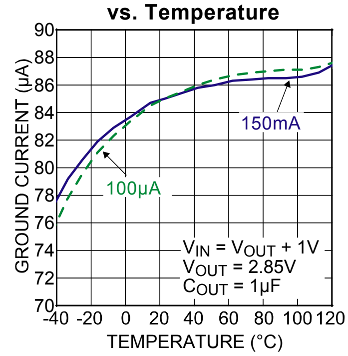
Output Voltage vs. Temperature



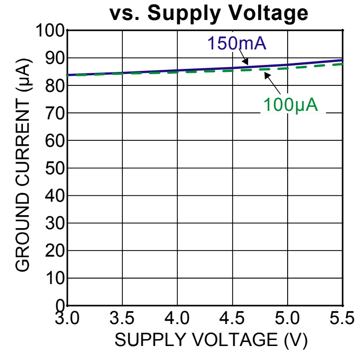
Ground Current vs. Output Current



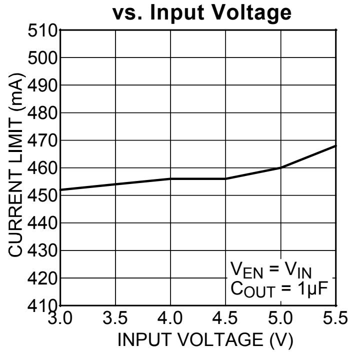
Ground Current vs. Temperature



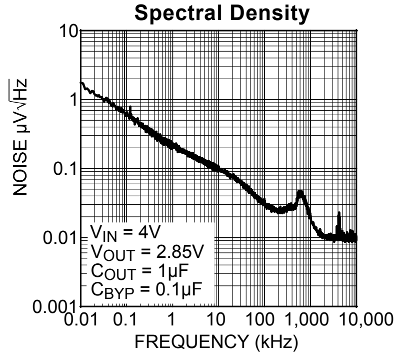
Ground Current vs. Supply Voltage



Current Limit vs. Input Voltage

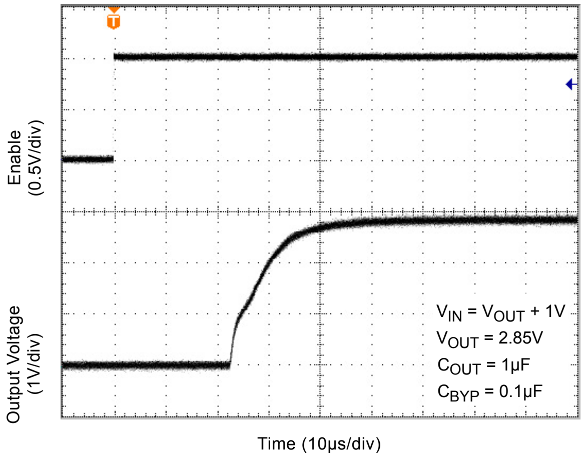


Output Noise Spectral Density

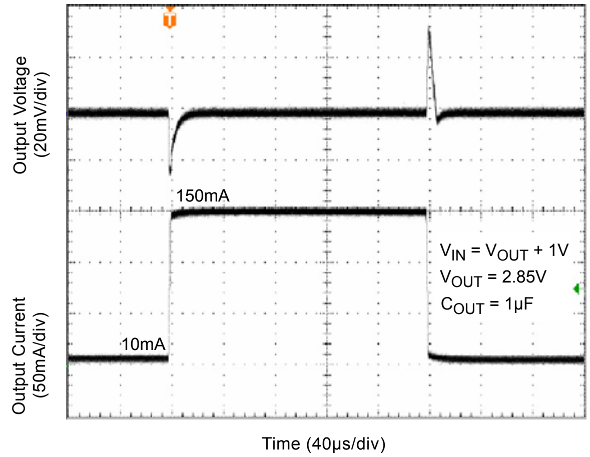


Functional Characteristics

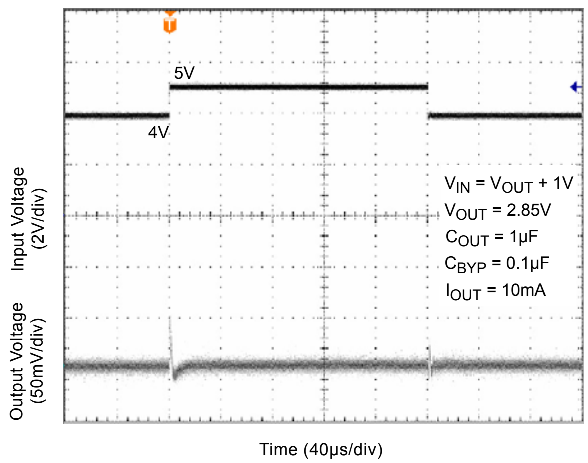
Enable Turn-On



Load Transient



Line Transient



Applications Information

Enable/Shutdown

The MIC5301 comes with an 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.

Input Capacitor

The MIC5301 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.

Output Capacitor

The MIC5301 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.

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 MIC5301 to drive a large capacitor on the bypass pin without significantly slowing turn-on time. Refer to the Typical Characteristics section for performance with different bypass capacitors.

No-Load Stability

Unlike many other voltage regulators, the MIC5301 will remain stable and in regulation with no load. This is especially important in CMOS RAM keep-alive applications.

Adjustable Regulator Application

Adjustable regulators use the ratio of two resistors to multiply the reference voltage to produce the desired output voltage. The MIC5301 can be adjusted from 1.25V to 5.5V by using two external resistors (Figure 1). The resistors set the output voltage based on the following equation:

$$V_{OUT} = V_{REF}\left(1 + \frac{R1}{R2}\right)$$

$$V_{REF} = 1.25V$$

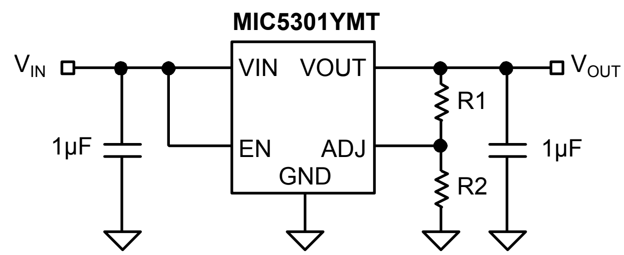


Figure 1. Adjustable Voltage Output

Thermal Considerations

The MIC5301 is designed to provide 150mA of continuous current. 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 5.0V, the output voltage is 2.8V and the output current = 150mA.

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 <100µA over the load range, the power dissipation contributed by the ground current is < 1% and can be ignored for this calculation.

$$P_D = (5V - 2.8V) \times 150mA$$

$$P_D = 0.33W$$

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 = 100°C/W.

The table below shows junction-to-ambient thermal resistance for the MIC5301 in the 6-pin 1.6mm x 1.6mm MLF® package.

Package	θ_{JA} Recommended Minimum Footprint
6-Pin 1.6x1.6 MLF®	100°C/W
6-Pin 1.6x1.6 Thin MLF®	100°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 100°C/W.

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

For example, when operating the MIC5301-2.8YML at an input voltage of 5V and 150mA load with a minimum footprint layout, the maximum ambient operating temperature T_A can be determined as follows:

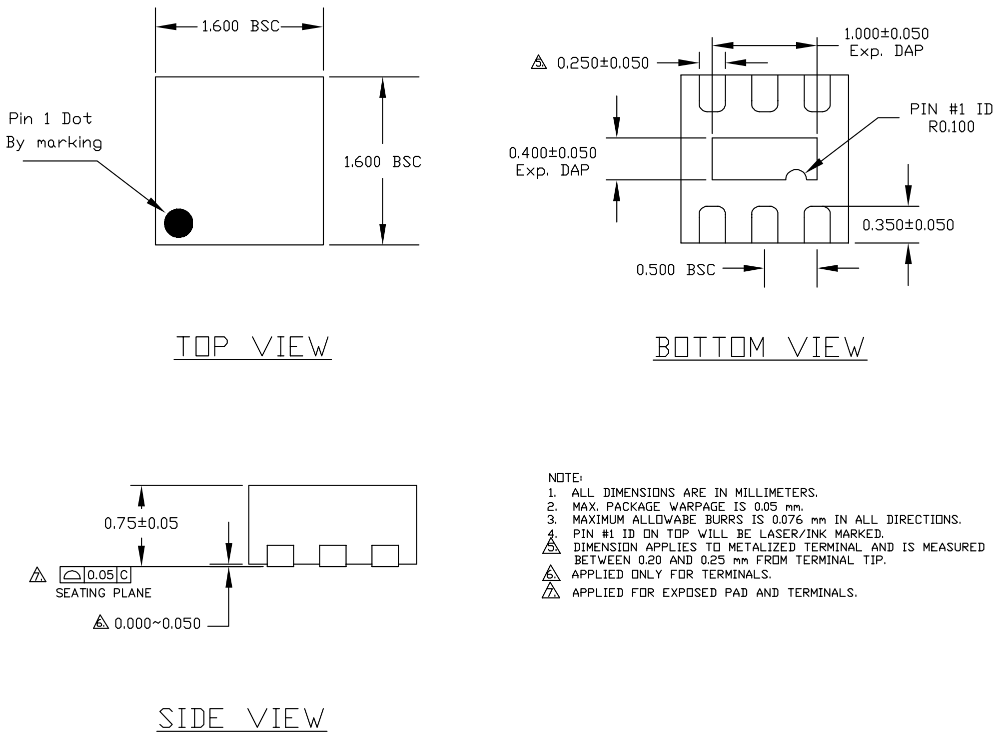
$$0.33W = (125°C – T_A)/(100°C/W)$$

$$T_A=92°C$$

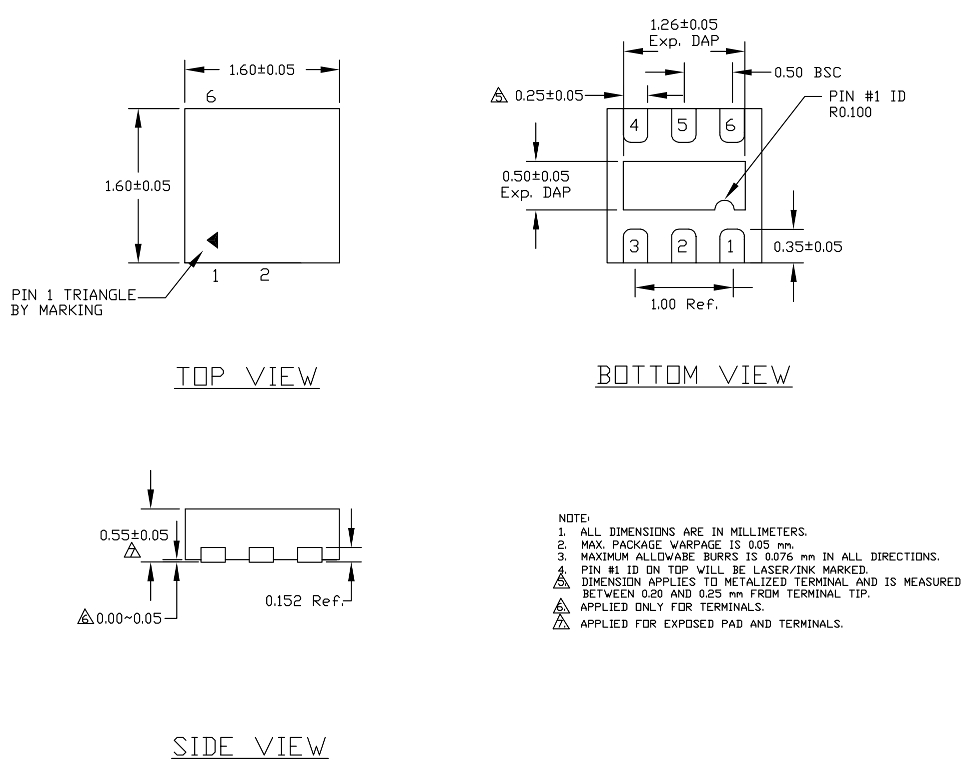
Therefore, a 2.8V application with 150mA of output current can accept an ambient operating temperature of 92°C in a 1.6mm x 1.6mm MLF® package. For a full discussion of heat sinking and thermal effects on voltage regulators, refer to the "Regulator Thermals" section of *Micrel's Designing with Low-Dropout Voltage Regulators* handbook. This information can be found on Micrel's website at:

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

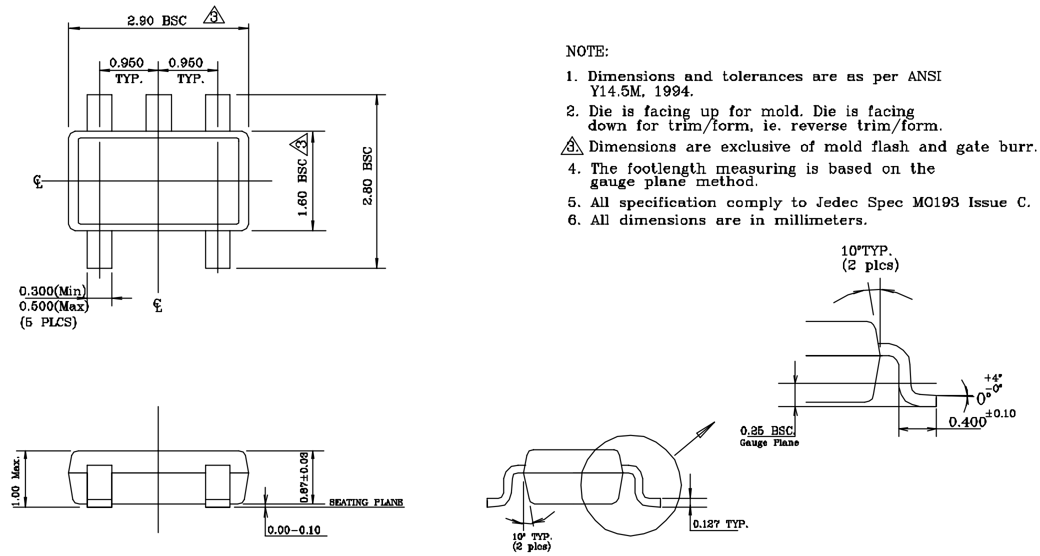
Package Information



6-Pin 1.6mm x 1.6mm MLF® (ML)



6-Pin 1.6mm x 1.6mm Thin MLF® (MT)



5-Pin TSOT-23 (D5)

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