MIC5319

500mA μCap Ultra-Low Dropout, High PSRR LDO Regulator

General Description

The MIC5319 is a high-performance, 500mA LDO regulator, offering extremely high PSRR and very low noise while consuming low ground current.

Ideal for battery-operated applications, the MIC5319 features 1% accuracy, extremely low-dropout voltage (200mV @ 500mA), and low ground current at light load (typically 90μA). Equipped with a logic-compatible enable pin, the MIC5319 can be put into a zero-off-mode current state, drawing no current when disabled.

The MIC5319 is a μCap design operating with very small ceramic output capacitors for stability, thereby reducing required board space and component cost.

The MIC5319 is available in fixed-output voltages and adjustable output voltages in the super-compact 2mm x 2mm MLF™ leadless package and thin SOT-23-5 package.

Additional voltage options are available. Contact Micrel marketing.

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

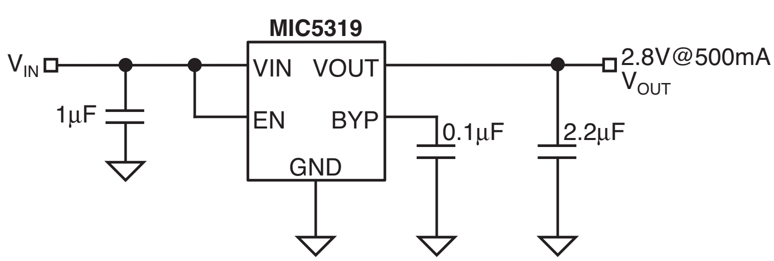
Features

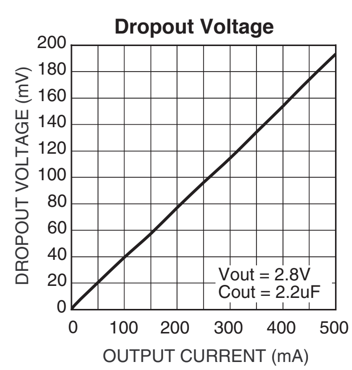
- **Ultra-low dropout voltage 200mV @ 500mA**
- Input voltage range: 2.5 to 5.5V
- Stable with ceramic output capacitor
- Low output noise — 40μVrms
- **Low quiescent current of 90μA total**
- **High PSRR, up to 70dB @1kHz**
- Fast turn-on-time — 40μs typical
- High output accuracy:
  - ±1.0% initial accuracy
  - ±2.0% over temperature
- Thermal shutdown protection
- Current-limit protection
- Logic-controlled Enable
- Tiny 2mm x 2mm MLF™ package, 500mA continuous
- Thin SOT-23-5 package, 500mA peak

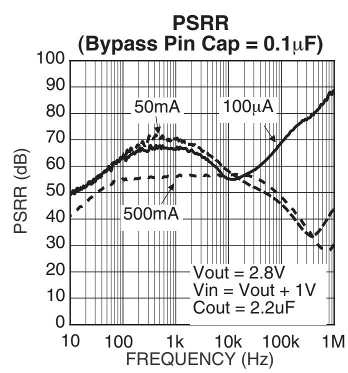
Applications

- Cellular phones
- PDAs
- Fiber optic modules
- Portable electronics
- Notebook PCs
- Audio Codec power supplies

Typical Application







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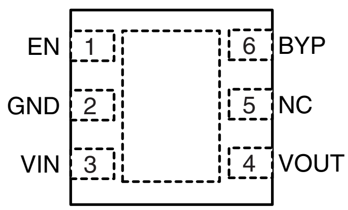
Ordering Information

Part Number	Marking	Voltage	Junction Temp. Range[1]	Package
MIC5319-2.8BD5	N928	2.8	–40°C to +125°C	Thin SOT23-5
MIC5319-2.8BML	928	2.8	–40°C to +125°C	6-pin 2x2 MLF™
MIC5319BML	9AA	ADJ	–40°C to +125°C	6-pin 2x2 MLF™
MIC5319-2.8YD5	N928	2.8	–40°C to +125°C	Thin SOT23-5 Pb-Free
MIC5319-2.8YML	928	2.8	–40°C to +125°C	6-pin 2x2 MLF™ Pb-Free
MIC5319YML	9AA	ADJ	–40°C to +125°C	6-pin 2x2 MLF™ Pb-Free

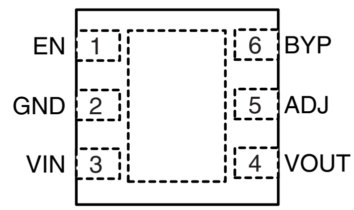
Note:

1. For other output voltage options, contact Micrel marketing.

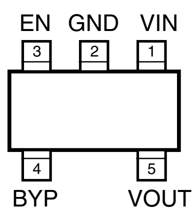
Pin Configuration



MIC5319-x.xBML
6-Pin 2mm x 2mm MLF™ (ML)
(Top View)



MIC5319BML (Adjustable)
6-Pin 2mm x 2mm MLF™ (ML)
(Top View)



MIC5319-x.xBD5
TSOT-23-5 (D5)
(Top View)

Pin Description

Pin Number MLF-6 Fixed	Pin Number MLF-6 Adj.	Pin Number TSOT-23-5 Fixed	Pin Name	Pin Function
1	1	3	EN	Enable Input. Active High. High = on, low = off. Do not leave floating.
2	2	2	GND	Ground.
3	3	1	VIN	Supply Input.
4	4	5	VOUT	Output voltage.
– 5	5 –	–	ADJ NC	Adjust Input: Connect to external resistor voltage divider network. No connection for fixed voltage parts.
6	6	4	BYP	Reference Bypass: Connect external 0.1µF to GND for reduced output noise. May be left open.
HS Pad	HS Pad	–	EPAD	Exposed Heatsink Pad connected to ground internally.

Absolute Maximum Ratings[1]

Supply Input Voltage (V_{IN}) .... 0V to 6V
Enable Input Voltage (V_{EN}) .... 0V to 6V
Power Dissipation (P_D) .... Internally Limited[3]
Junction Temperature(T_J) .... –40°C to +125°C
Storage Temperature (T_S) .... –65°C to 150°C
Lead Temperature (soldering, 5 sec.) .... 260°C
ESD[4] 3kV

Operating Ratings[2]

Supply Input Voltage (V_{IN}) .... 2.5V to 5.5V
Enable Input Voltage (V_{EN}) .... 0V to V_{IN}
Junction Temperature (T_J) .... –40°C to +125°C
Package Thermal Resistance
MLF™ (θ_{JA}) .... 93°C/W
TSOT-23 (θ_{JA}) .... 235°C/W

Electrical Characteristics[5]

$V_{IN} = V_{OUT}$ +1.0V; C_{OUT} = 2.2µF, I_{OUT} = 100µA; T_J = 25°C, bold values indicate –40°C to + 125°C; unless noted.

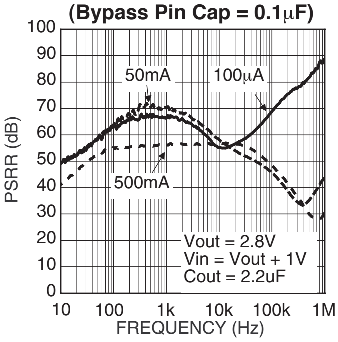
Parameter	Condition	Min	Typ	Max	Units
Output Voltage Accuracy	Variation from nominal V_{OUT}	–1.0		+1.0	%
	Variation from nominal V_{OUT}, I_{OUT} = 100µA to 500mA	**–2.0**		**+2.0**	%
Feedback Voltage		1.2375	1.25	1.2625	V
(ADJ option)		**1.225**	1.25	**1.275**	V
Line Regulation	$V_{IN} = V_{OUT}$ +1V to 5.5V		0.04	**0.3**	%/V
Load Regulation[6]	I_{OUT} = 100µA to 500mA		0.1	**0.5**	%
Dropout Voltage[7][8]	I_{OUT} = 50mA		20	**40**	mV
	I_{OUT} = 500mA		200	**400**	mV
Ground Pin Current[9]	I_{OUT} = 0 to 500mA		90	**150**	µA
Ground Pin Current in Shutdown	V_{EN} ≤ 0.2V		0.5		µA
Ripple Rejection	f = up to 1kHz; C_{OUT} = 2.2µF ceramic; C_{BYP} = 0.1µF		70		dB
	f = 10kHz; C_{OUT} = 2.2µF ceramic; C_{BYP} = 0.1µF		60		dB
Current Limit	V_{OUT} = 0V	**600**	700		mA
Output Voltage Noise	C_{OUT} =2.2µF, C_{BYP} = 0.1µF, 10Hz to 100kHz		40		µVrms
Turn-On Time	C_{OUT} = 2.2µF; C_{BYP} = 0.01µF		40	**100**	µs
Enable Input					
Enable Input Voltage	Logic Low (Regulator Shutdown)			**0.2**	V
	Logic High (Regulator Enabled)	**1.0**			V
Enable Input Current	V_{IL} ≤ 0.2V (Regulator Shutdown)		0.01	**1**	µA
	V_{IH} ≥ 1.0V (Regulator Enabled)		0.01	**1**	µA

Notes:

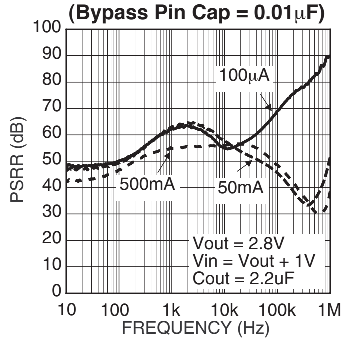
1. Exceeding maximum ratings may damage the device.
2. The device is not guaranteed to work outside its operating rating.
3. The maximum allowable power dissipation of any T_A (ambient temperature) is $P_D(max) = (T_J(max) - T_A) / \theta_{JA}$. Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator may go into thermal shutdown.
4. Devices are ESD sensitive. Handling precautions recommended. Human Body Model.
5. Specification for packaged product only.
6. Regulation is measured at constant junction temperature using low duty cycle pulse testing.
7. 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 2.5V, dropout voltage spec does not apply, as part is limited by minimum V_{IN} spec of 2.5V. There may be some typical dropout degradation at V_{OUT} <3V.
8. For ADJ option, V_{OUT} = 3V for dropout specification.
9. Ground pin current is the regulator quiescent current. The total current drawn from the supply is the sum of the load current plus the ground pin current.

Typical Characteristics

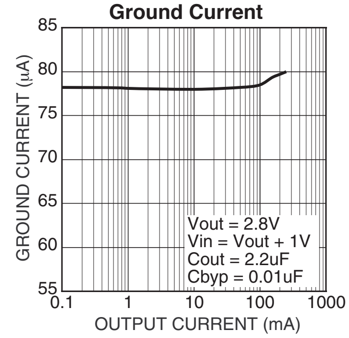
PSRR (Bypass Pin Cap = 0.1µF)



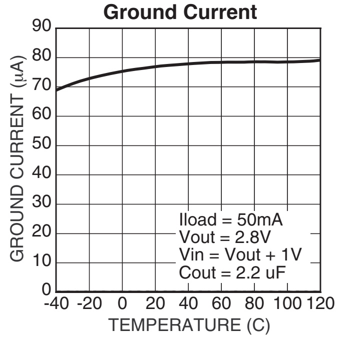
PSRR (Bypass Pin Cap = 0.01µF)



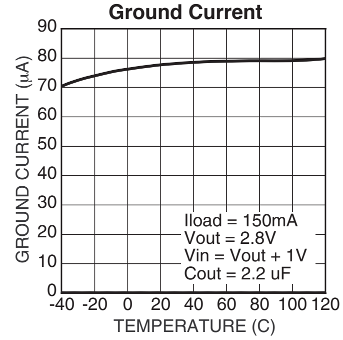
Ground Current



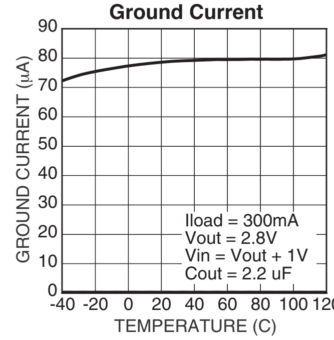
Ground Current



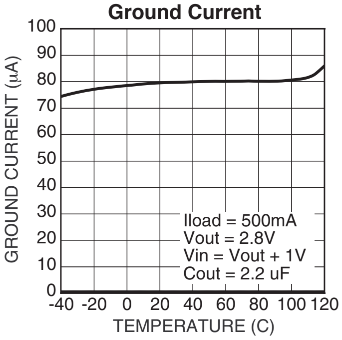
Ground Current



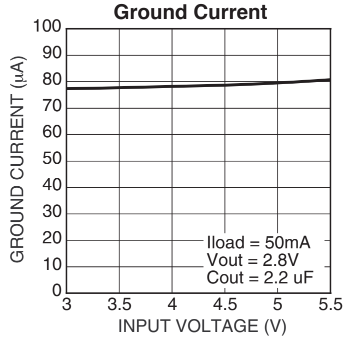
Ground Current



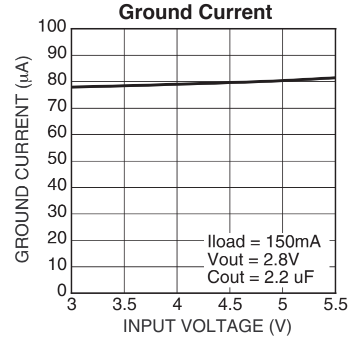
Ground Current



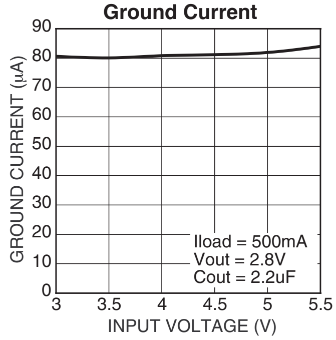
Ground Current



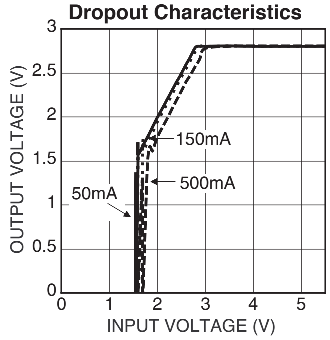
Ground Current



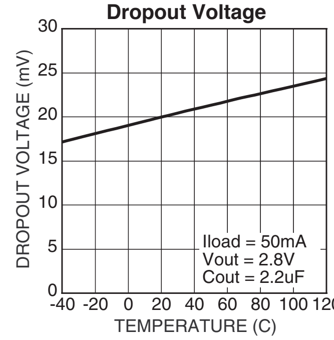
Ground Current

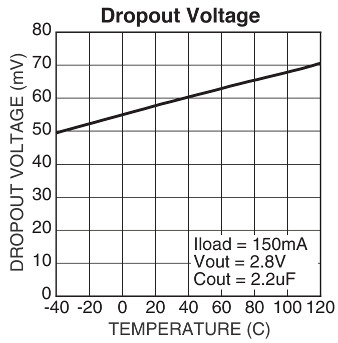


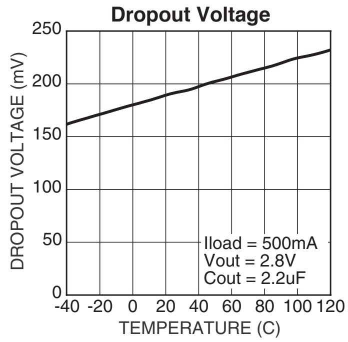
Dropout Characteristics

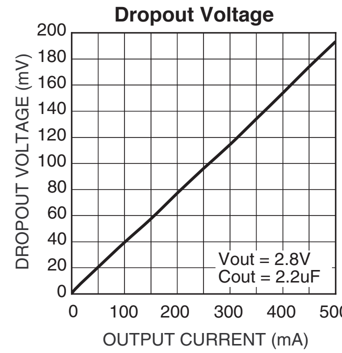


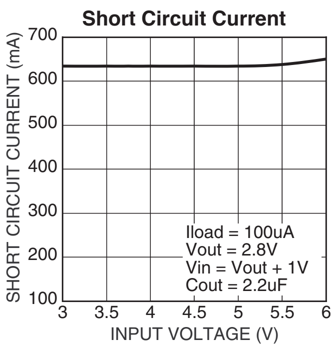
Dropout Voltage

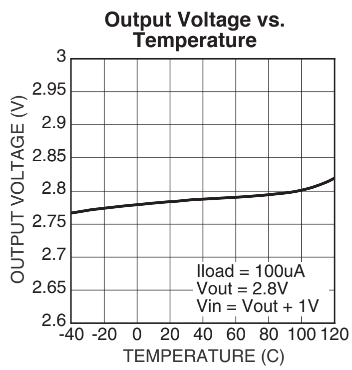


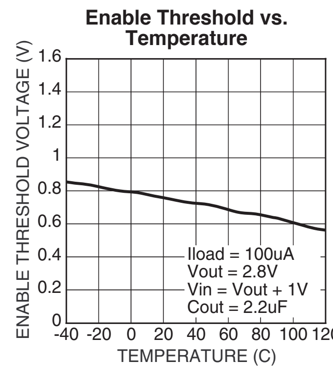

Dropout Voltage
DROPOUT VOLTAGE (mV)
0 10 20 30 40 50 60 70 80
-40 -20 0 20 40 60 80 100 120
TEMPERATURE (C)
Iload = 150mA
Vout = 2.8V
Cout = 2.2uF

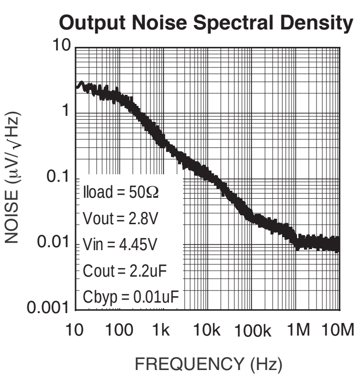

Dropout Voltage
DROPOUT VOLTAGE (mV)
0 50 100 150 200 250
-40 -20 0 20 40 60 80 100 120
TEMPERATURE (C)
Iload = 500mA
Vout = 2.8V
Cout = 2.2uF


Dropout Voltage
DROPOUT VOLTAGE (mV)
0 20 40 60 80 100 120 140 160 180 200
0 100 200 300 400 500
OUTPUT CURRENT (mA)
Vout = 2.8V
Cout = 2.2uF


Short Circuit Current
SHORT CIRCUIT CURRENT (mA)
100 200 300 400 500 600 700
3 3.5 4 4.5 5 5.5 6
INPUT VOLTAGE (V)
Iload = 100uA
Vout = 2.8V
Vin = Vout + 1V
Cout = 2.2uF

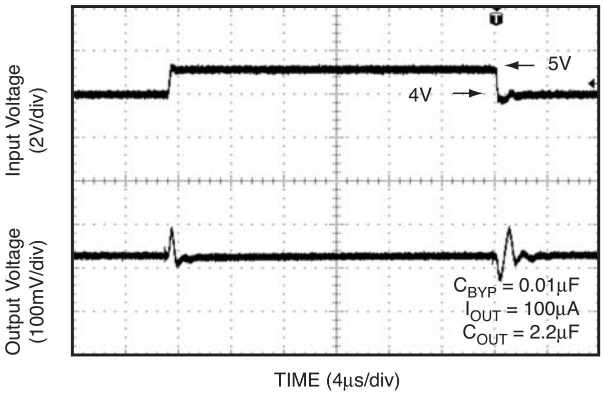

Output Voltage vs.
Temperature
OUTPUT VOLTAGE (V)
2.6 2.65 2.7 2.75 2.8 2.85 2.9 2.95 3
-40 -20 0 20 40 60 80 100 120
TEMPERATURE (C)
Iload = 100uA
Vout = 2.8V
Vin = Vout + 1V


Enable Threshold vs.
Temperature
ENABLE THRESHOLD VOLTAGE (V)
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6
-40 -20 0 20 40 60 80 100 120
TEMPERATURE (C)
Iload = 100uA
Vout = 2.8V
Vin = Vout + 1V
Cout = 2.2uF

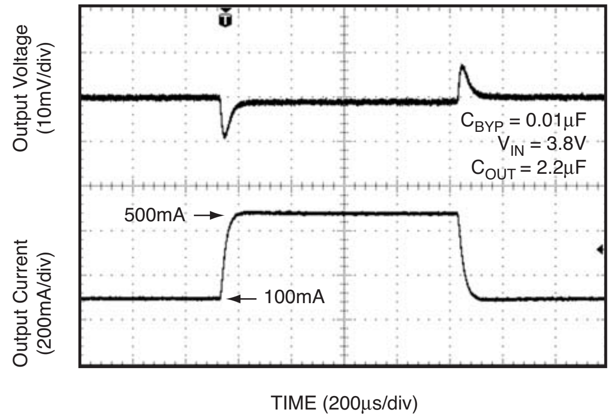

Output Noise Spectral Density
NOISE (μV/√Hz)
0.001 0.01 0.1 1 10
10 100 1k 10k 100k 1M 10M
FREQUENCY (Hz)
Iload = 50Ω
Vout = 2.8V
Vin = 4.45V
Cout = 2.2uF
Cbyp = 0.01uF

Functional Characteristics

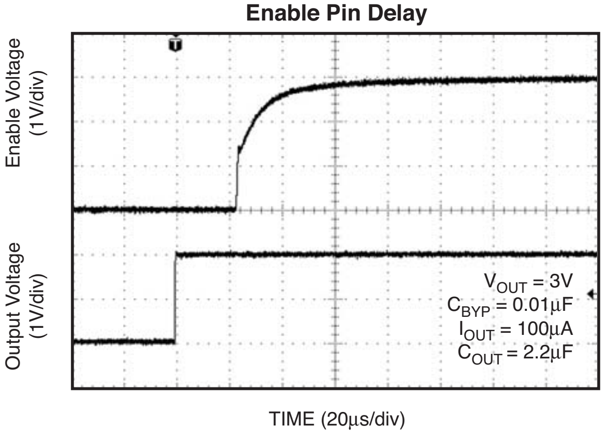
Line Transient Response



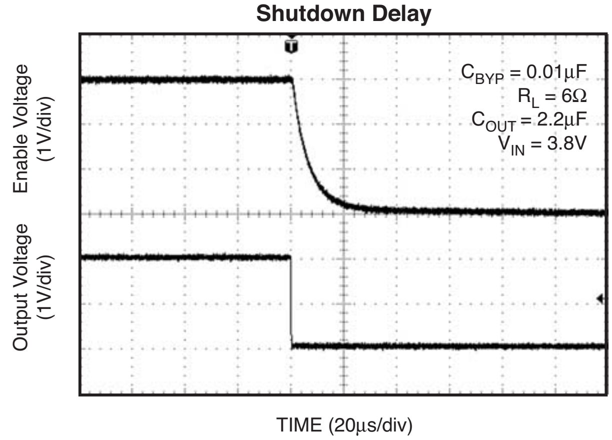
Load Transient Response



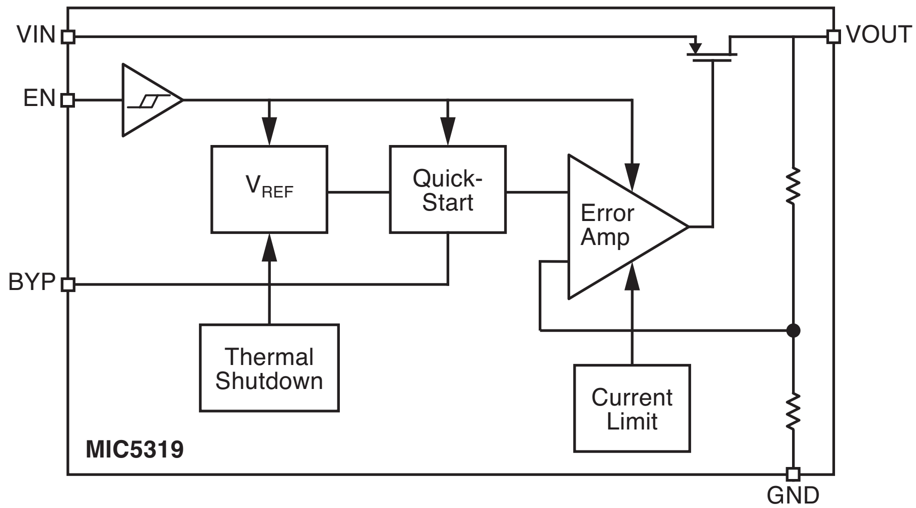
Enable Pin Delay



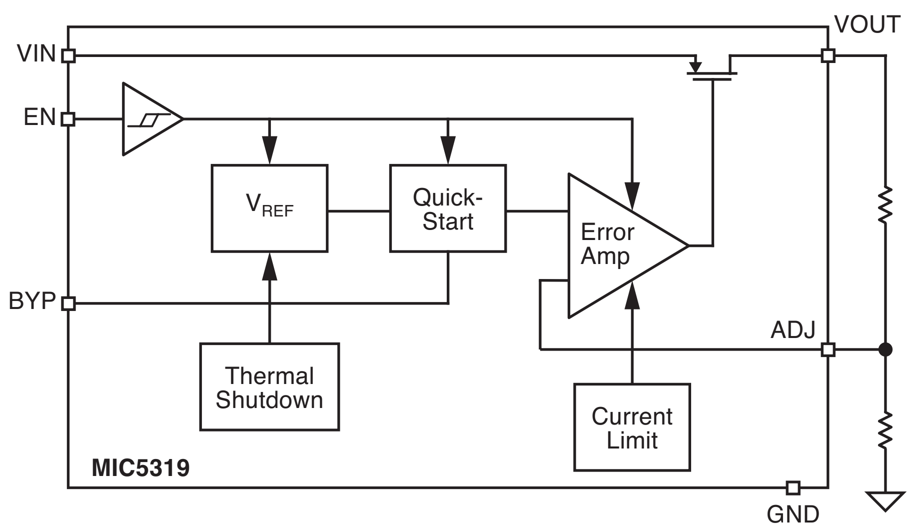
Shutdown Delay



Functional Diagram



MIC5319 Block Diagram - Fixed



MIC5319 Block Diagram - Adjustable

Applications Information

Enable/Shutdown

The MIC5319 features 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, as this may cause an indeterminate state on the output.

Input Capacitor

The MIC5319 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 design practice in any RF-based circuit.

Output Capacitor

The MIC5319 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 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 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 MIC5319 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 MIC5319 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 MIC5319 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:

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

$$V_{REF} = 1.25V$$

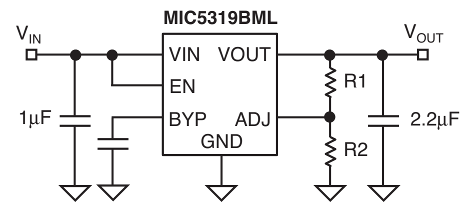


Figure 1. Adjustable Voltage Application

Thermal Considerations

The MIC5319 is designed to provide 500mA of continuous current in a very small MLF package. Maximum ambient operating temperature can be calculated based on the output current and the voltage drop across the part. Given an input voltage of 3.3V, output voltage of 2.8V and output current = 500mA, the actual power dissipation of the regulator circuit can be determined using the equation:

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

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.

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

$$P_D = 0.25W$$

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 = 93°C/W

Table 1 shows junction-to-ambient thermal resistance for the MIC5319 in the 2mm x 2mm MLF package.

Package	θ_{JA} Recommended Minimum Footprint	θ_{JC}
2 x 2 MLF™	93°C/W	2°C/W
SOT-23-5	235°C/W	

Table 1. Thermal Resistance

Substituting 0.25W for P_D(max) and solving for the ambient operating temperature will give the maximum operating conditions for the regulator circuit. The maximum power dissipation must not be exceeded for proper operation.

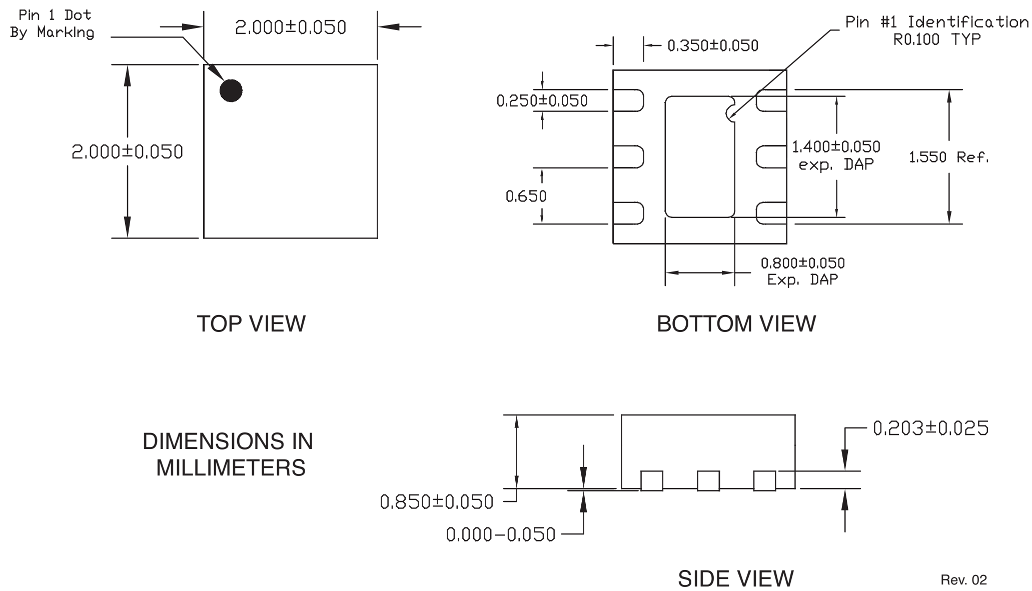
$$0.25W = \frac{125°C - T_A}{93°C/W}$$

$$T_A = 101.75°C$$

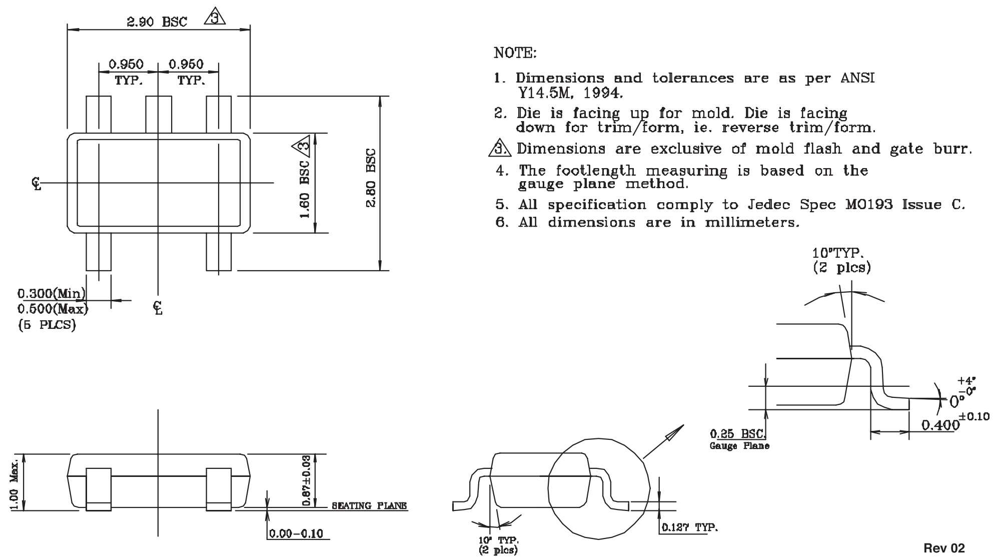
Therefore, a 2.8V application at 500mA of output current can accept an ambient operating temperature of 101.75°C in a 2mm x 2mm MLF package. For a full discussion of heat sinking and thermal effects on voltage regulators, refer to the "Regulator Thermals" section of *Micrel's Designing with Low-Dropout Voltage Regulators* handbook. This information can be found on Micrel's website at:

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

Package Information



6-Pin MLF™ (ML)



TSOT-23-5 (D5)

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