MIC5305

150mA μCap Ultra-Low Dropout LDO Regulator

General Description

The MIC5305 is a high-performance, 150mA LDO regulator, offering extremely high PSRR and very low noise while consuming low ground current.

Ideal for battery-operated applications, the MIC5305 features 1% accuracy, extremely low-dropout voltage (60mV @ 150mA), and low ground current at light load (typically 90μA). Equipped with a logic-compatible enable pin, the MIC5305 can be put into a zero-off-mode current state, drawing no current when disabled.

The MIC5305 is a μCap design operating with very small ceramic output capacitors for stability, thereby reducing required board space and component cost.

The MIC5305 is available in fixed-output voltages and adjustable output voltages in the super-compact 2mm × 2mm MLF™-6 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.

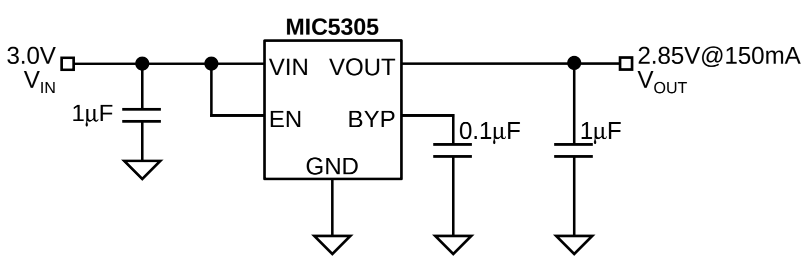
Features

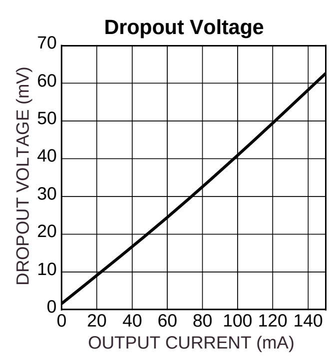
- **Ultra-low dropout voltage of 60mV @ 150mA**
- Input voltage range: 2.25 to 5.5V
- Stable with ceramic output capacitor
- 150mA guaranteed output current
- Low output noise — 20μVrms
- **Low quiescent current of 90μA total**
- **High PSRR, up to 85dB @1kHz**
- Less than 30μs turn-on time w/C_{BYP} = 0.01μF
- High output accuracy:
  - ±1.0% initial accuracy
  - ±2.0% over temperature
- Thermal shutdown protection
- Current limit protection
- Tiny 2mm × 2mm MLF™-6 package
- Thin SOT-23-5 package

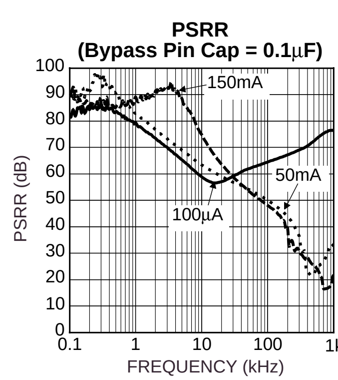
Applications

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

Typical Application







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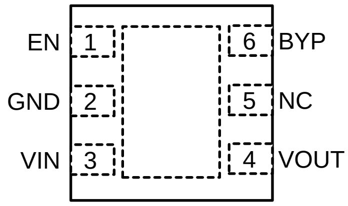
Ordering Information

Part Number	Marking	Voltage	Junction Temp. Range(1)	Package
MIC5305-1.5BML	815	1.5	–40°C to +125°C	6-pin 2×2 MLF™
MIC5305-1.5BD5	N815	1.5	–40°C to +125°C	Thin SOT23-5
MIC5305-1.8BML	818	1.8	–40°C to +125°C	6-pin 2×2 MLF™
MIC5305-1.8BD5	N818	1.8	–40°C to +125°C	Thin SOT23-5
MIC5305-2.5BML	825	2.5	–40°C to +125°C	6-pin 2×2 MLF™
MIC5305-2.5BD5	N825	2.5	–40°C to +125°C	Thin SOT23-5
MIC5305-2.6BML	826	2.6	–40°C to +125°C	6-pin 2×2 MLF™
MIC5305-2.7BML	827	2.7	–40°C to +125°C	6-pin 2×2 MLF™
MIC5305-2.8BML	828	2.8	–40°C to +125°C	6-pin 2×2 MLF™
MIC5305-2.85BML	82J	2.85	–40°C to +125°C	6-pin 2×2 MLF™
MIC5305-2.85BD5	N82J	2.85	–40°C to +125°C	Thin SOT23-5
MIC5305-2.9BML	829	2.9	–40°C to +125°C	6-pin 2×2 MLF™
MIC5305-2.9BD5	N829	2.9	–40°C to +125°C	Thin SOT23-5
MIC5305-3.0BML	830	3.0	–40°C to +125°C	6-pin 2×2 MLF™
MIC5305-3.0BD5	N830	3.0	–40°C to +125°C	Thin SOT23-5
MIC5305-3.3BML	833	3.3	–40°C to +125°C	6-pin 2×2 MLF™
MIC5305-4.75BML	84H	4.75	–40°C to +125°C	6-pin 2×2 MLF™
MIC5305BML(2)	8AA	ADJ	–40°C to +125°C	6-pin 2×2 MLF™

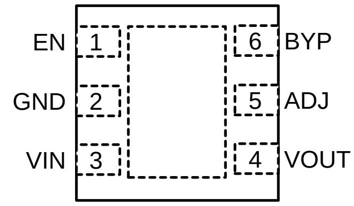
Note:

1. For other output voltage options, contact Micrel marketing.
2. Please contact Micrel marketing regarding availability.

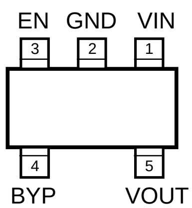
Pin Configuration



MIC5305-x.xBML
6-Pin 2mm × 2mm MLF™ (ML)
(Top View)



MIC5305BML (Adjustable)
6-Pin 2mm × 2mm MLF™ (ML)
(Top View)



MIC5305-x.xBD5
TSOT-23-5 (D5)
(Top View)

Pin Description

Pin Number MLF-6 Fixed	Pin Number MLF-6 Adjust.	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	-	ADJ	Adjust Input: Connect to external resistor voltage divider network.
5	-		NC	No connection for fixed voltage parts.
6	6	4	BYP	Reference Bypass: Connect external 0.01µF 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] 2kV

Operating Ratings[2]

Supply Input Voltage (V_{IN}) .... 2.25V to 5.5V
Enable Input Voltage (V_{EN}) .... 0V to V_{IN}
Junction Temperature (T_J) .... –40°C to +125°C
Package Thermal Resistance (est.)
MLF-6 (θ_{JA}) .... 93 °C/W
TSOT-23 (θ_{JA}) .... 235°C/W

Electrical Characteristics[5]

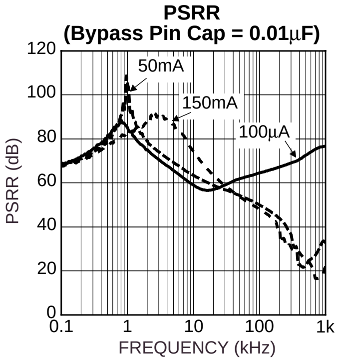
$V_{IN} = V_{OUT}$ +1.0V; C_{OUT} = 1.0µF, I_{OUT} = 100µA; T_J = 25°C, bold values indicate –40°C to + 125°C; unless noted.

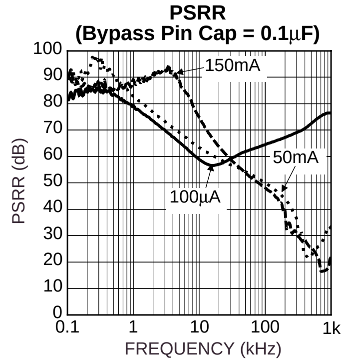
Parameter	Condition	Min	Typ	Max	Units
Output Voltage Accuracy	Variation from nominal V_{OUT}	–1.0		+1.0	%
	Variation from nominal V_{OUT}, I_{OUT} = 100µA to 150mA	**–2.0**		**+2.0**	%
Output Voltage Temp. Coefficient			40		ppm/°C
Line Regulation	$V_{IN} = V_{OUT}$ +1V to 5.5V		0.02	**0.3**	%/V
Load Regulation[6]	I_{OUT} = 100µA to 150mA		0.1	**0.5**	%
Dropout Voltage[7]	I_{OUT} = 50mA		20	**35**	mV
	I_{OUT} = 150mA		60	**85**	mV
Ground Pin Current[8]	I_{OUT} = 0 to 150mA		90	**150**	µA
Ground Pin Current in Shutdown	$V_{EN} \le 0.2V$		0.5		µA
Ripple Rejection	f = up to 1kHz; C_{OUT} = 1.0µF ceramic; C_{BYP} = 0.1µF		85		dB
	f = 10kHz; C_{OUT} = 1.0µF ceramic; C_{BYP} = 0.1µF		65		dB
Current Limit	V_{OUT} = 0V	**300**	600	**900**	mA
Output Voltage Noise	C_{OUT} =1µF, C_{BYP} = 0.01µF, 10Hz to 100kHz		20		µVrms
Turn-On Time	C_{OUT} = 1µF; C_{BYP} = 0.01µF; I_{OUT}= 150mA		30	**100**	µs
Enable Input					
Enable Input Voltage	Logic Low (Regulator Shutdown)			**0.2**	V
	Logic High (Regulator Enabled)	**1.0**			V
Enable Input Current	$V_{IL} \le 0.2V$ (Regulator Shutdown)		0.01	**1**	µA
	$V_{IH} \ge 1.0V$ (Regulator Enabled)		0.01	**1**	µA

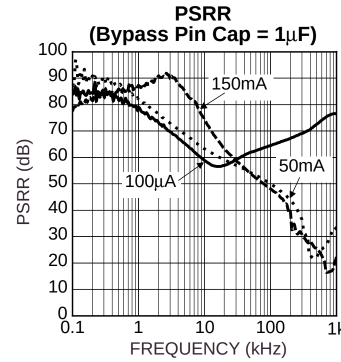
Notes:

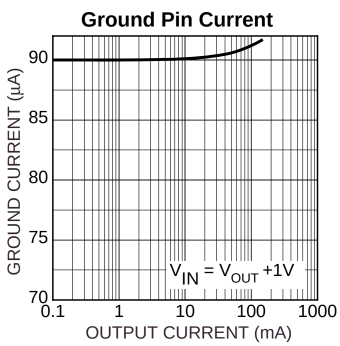
1. Exceeding maximum ratings may damage the device.
2. The device is not guaranteed to work outside its operating ratings.
3. The maximum allowable power dissipation of any T_A (ambient temperature) is $P_D(max) = (T_J(max) - T_A) / \theta_{JA}$. Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown.
4. Devices are ESD sensitive. Handling precautions recommended. Human Body Model.
5. Specification for packaged product only.
6. Regulation is measured at constant junction temperature using low duty cycle pulse testing, changes in output voltage due to heating effects are covered by the thermal regulation specification.
7. 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. For outputs below 2.25V, dropout voltage is the input-to-output differential with the minimum input voltage 2.25V.
8. 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.

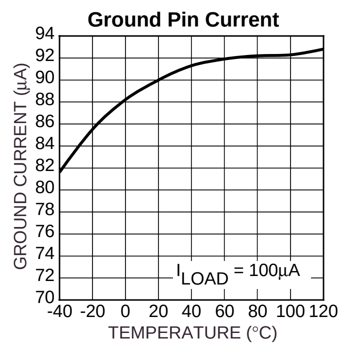
Typical Characteristics

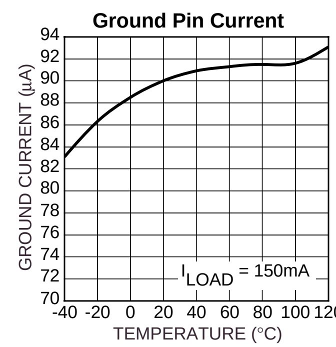


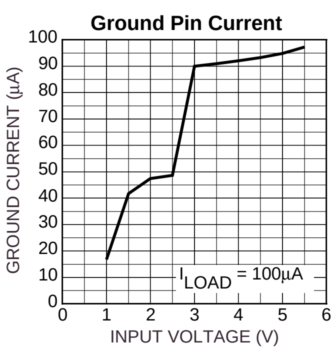


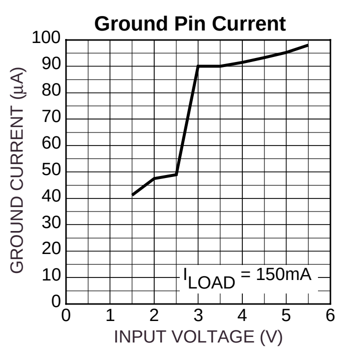


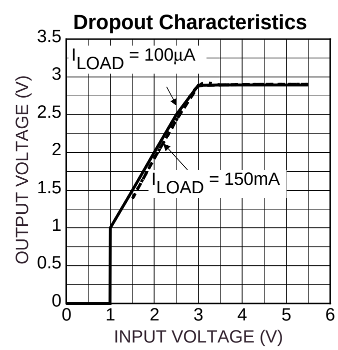


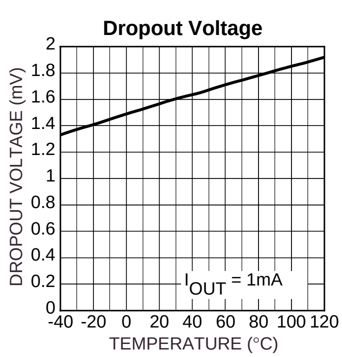


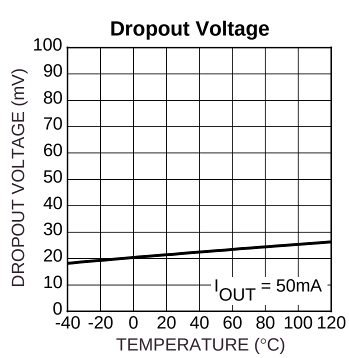


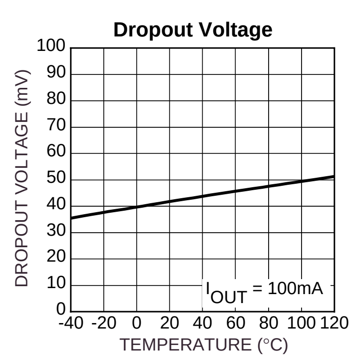


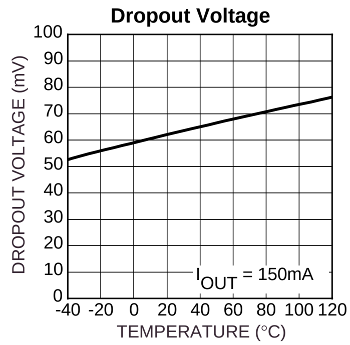


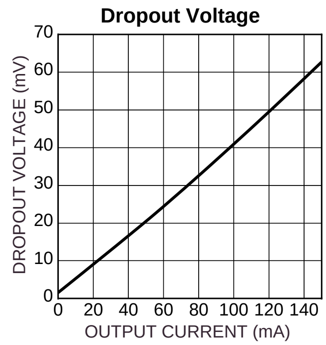


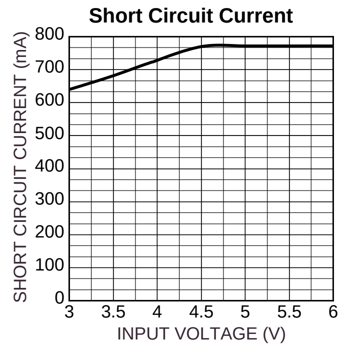


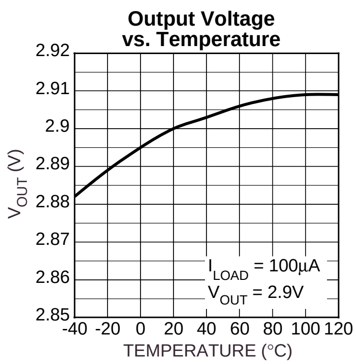


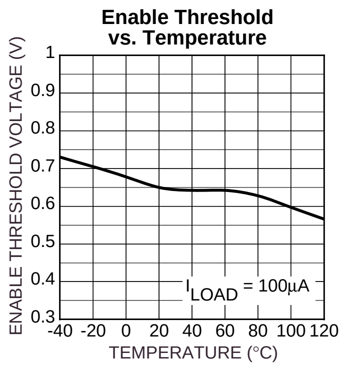


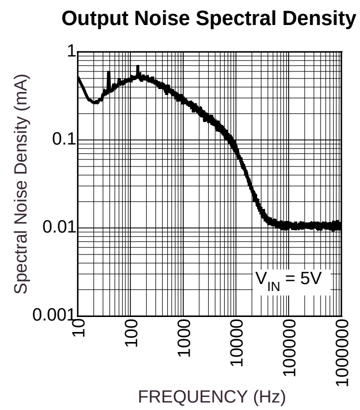

Dropout Voltage
DROPOUT VOLTAGE (mV)
100
90
80
70
60
50
40
30
20
10
0
I_OUT = 150mA
-40 -20 0 20 40 60 80 100 120
TEMPERATURE (°C)

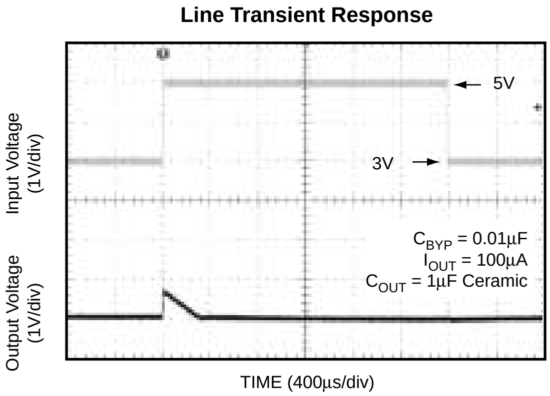

Dropout Voltage
DROPOUT VOLTAGE (mV)
70
60
50
40
30
20
10
0
0 20 40 60 80 100 120 140
OUTPUT CURRENT (mA)


Short Circuit Current
SHORT CIRCUIT CURRENT (mA)
800
700
600
500
400
300
200
100
0
3 3.5 4 4.5 5 5.5 6
INPUT VOLTAGE (V)

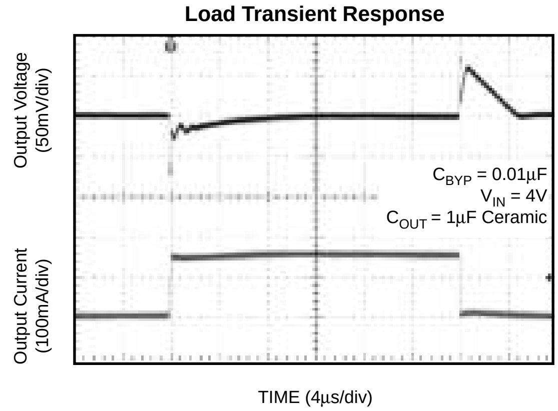

Output Voltage vs. Temperature
V_OUT (V)
2.92
2.91
2.9
2.89
2.88
2.87
2.86
2.85
I_LOAD = 100µA
V_OUT = 2.9V
-40 -20 0 20 40 60 80 100 120
TEMPERATURE (°C)


Enable Threshold vs. Temperature
ENABLE THRESHOLD VOLTAGE (V)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
I_LOAD = 100µA
-40 -20 0 20 40 60 80 100 120
TEMPERATURE (°C)

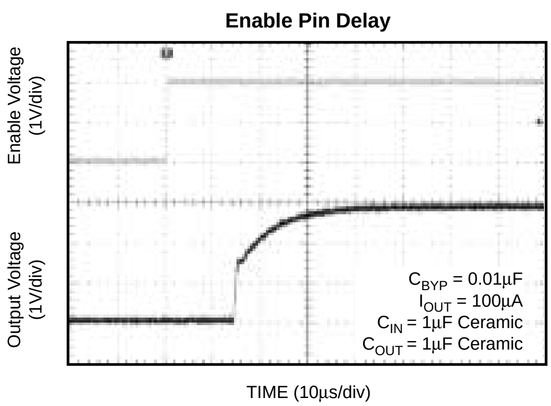

Output Noise Spectral Density
Spectral Noise Density (mA)
1
0.1
0.01
0.001
V_IN = 5V
10
100
1000
10000
100000
1000000
FREQUENCY (Hz)



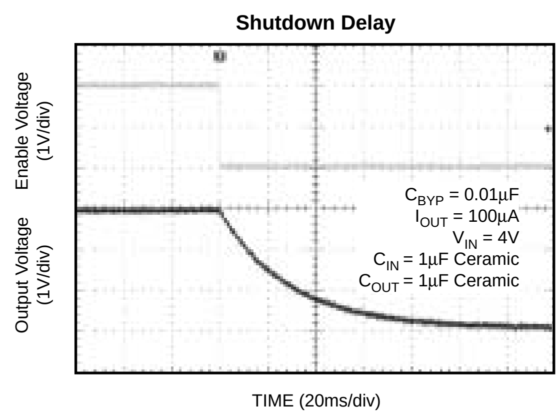
Line Transient Response
Input Voltage (1V/div)
Output Voltage (1V/div)
5V
3V
C_{BYP} = 0.01µF
I_{OUT} = 100µA
C_{OUT} = 1µF Ceramic
TIME (400µs/div)



Load Transient Response
Output Voltage (50mV/div)
Output Current (100mA/div)
C_{BYP} = 0.01µF
V_{IN} = 4V
C_{OUT} = 1µF Ceramic
TIME (4µs/div)

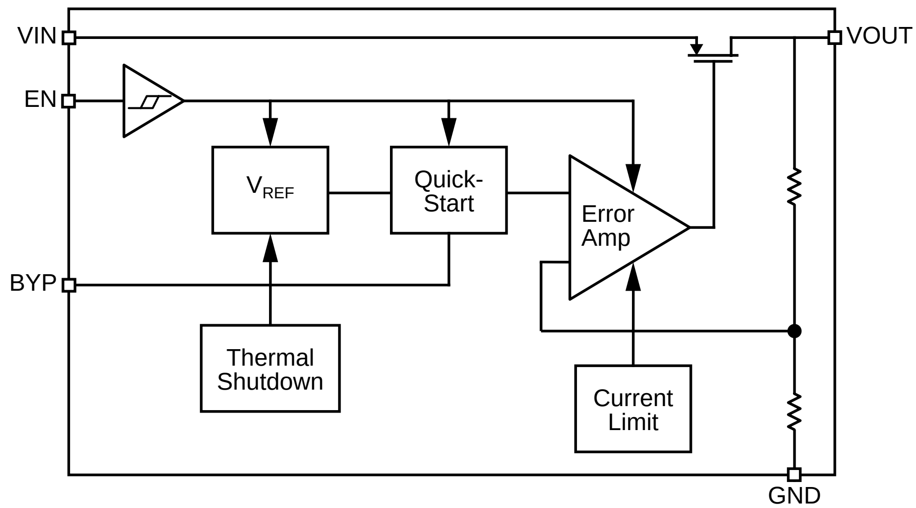


Enable Pin Delay
Enable Voltage (1V/div)
Output Voltage (1V/div)
C_{BYP} = 0.01µF
I_{OUT} = 100µA
C_{IN} = 1µF Ceramic
C_{OUT} = 1µF Ceramic
TIME (10µs/div)



Shutdown Delay
Enable Voltage (1V/div)
Output Voltage (1V/div)
C_{BYP} = 0.01µF
I_{OUT} = 100µA
V_{IN} = 4V
C_{IN} = 1µF Ceramic
C_{OUT} = 1µF Ceramic
TIME (20ms/div)

Functional Diagram



MIC5305 Block Diagram

Applications Information

Enable/Shutdown

The MIC5305 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 MIC5305 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 MIC5305 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 MIC5305 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 MIC5305 will remain stable and in regulation with no load. This is especially import 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 MIC5305 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:

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

$$V_{REF} = 1.25V$$

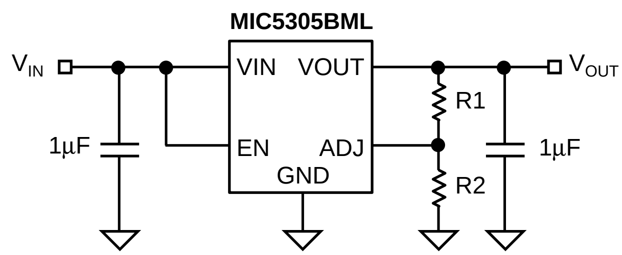


Figure 1. Adjustable Voltage Application

Thermal Considerations

The MIC5305 is designed to provide 150mA 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 5.0V, the output voltage is 2.9V 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.

$$P_D = (5.0V - 2.9V) \times 150mA$$

$$P_D = 0.32W$$

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 max. junction temperture of the die

θ_{JA} thermal resistance = 93°C/W

Table 1 shows junction-to-ambient thermal resistance for the MIC5305 in the 2mm × 2mm MLF™-6 package.

Package	θ_{JA} Recommended Minimum Footprint	θ_{JC}
2 × 2 MLF™-6	93°C/W	2°C/W

Table 1. SOT-23-5 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 93°C/W, from Table 1. The maximum power dissipation must not be exceeded for proper operation.

For example, when operating the MIC5305-2.9BML at an input voltage of 5.0V and 150mA load with a minimum footprint layout, the maximum ambient operating temperature T_A can be determined as follows:

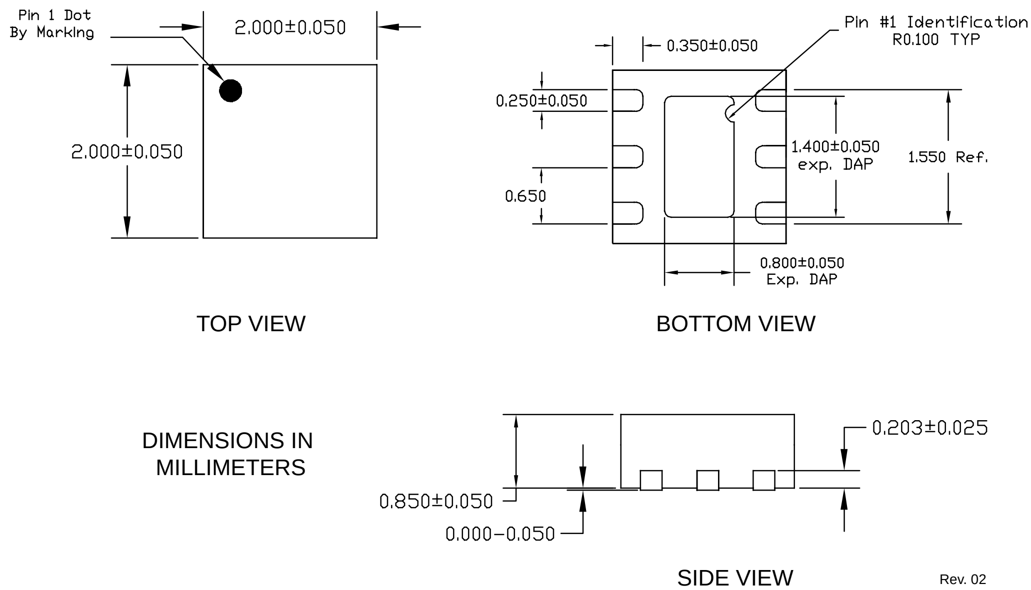
$$0.32W = \frac{125°C - T_A}{93°C/W}$$

$$T_A = 95.2°C$$

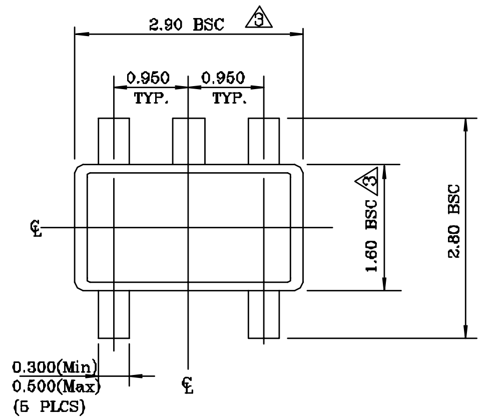
Therefore, a 2.9V application at 150mA of output current can accept an ambient operating temperature of 95.2°C in a 2mm x 2mm MLF™-6 package. For a full discussion of heat sinking and thermal effects on voltage regulators, refer to the “Regulator Thermals” section of *Micrel's Designing with Low-Dropout Voltage Regulators* handbook. This information can be found on Micrel's website at:

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

Package Information

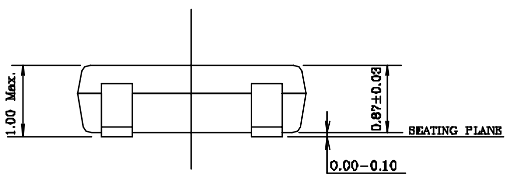


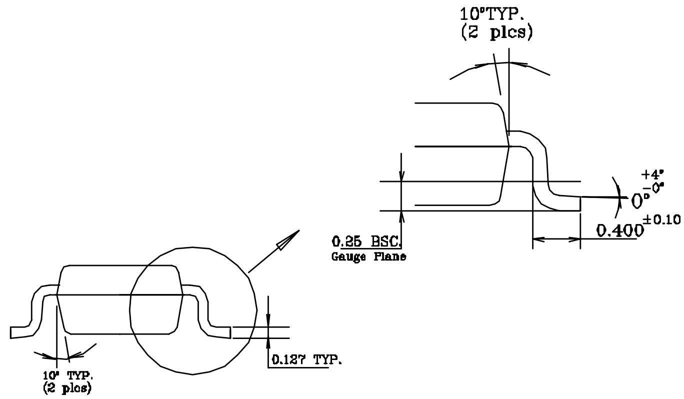
6-Pin MLF™ (ML)



NOTE:

1. Dimensions and tolerances are as per ANSI Y14.5M, 1994.
2. Die is facing up for mold. Die is facing down for trim/form, ie. reverse trim/form.
3. Dimensions are exclusive of mold flash and gate burr.
4. The footlength measuring is based on the gauge plane method.
5. All specification comply to Jedec Spec MO193 Issue C.
6. All dimensions are in millimeters.





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