General Description

The MIC5308 is a high performance, μCap low dropout regulator, offering ultra-low operating current while maintaining very fast transient response. The MIC5308 can source up to 150mA of output current and can regulate down from a low input supply voltage to increase system efficiency.

Ideal for battery operated applications; the MIC5308 offers extremely low dropout voltage 45mV typically @ 150mA, and low ground current at all load conditions (typically 23µA). The MIC5308 can also be put into a zero-off-mode current state, drawing virtually no current when disabled.

The MIC5308 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: 1.6V to 5.5V
- Guaranteed 150mA over temperature
- Ultra Low dropout voltage of 45mV at 150mA
- 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
- 150mA maximum output current at 1.6V 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

![Typical Application Diagram]
Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Voltage</th>
<th>Marking Codes</th>
<th>Temperature Range</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIC5308-1.2YMT</td>
<td>1.2V</td>
<td>▲1R2</td>
<td>–40° to +125°C</td>
<td>6-Pin 1.6mm x 1.6mm Thin MLF®</td>
</tr>
<tr>
<td>MIC5308-1.5YMT</td>
<td>1.5V</td>
<td>▲1R5</td>
<td>–40° to +125°C</td>
<td>6-Pin 1.6mm x 1.6mm Thin MLF®</td>
</tr>
<tr>
<td>MIC5308-1.8YMT</td>
<td>1.8V</td>
<td>▲1R8</td>
<td>–40° to +125°C</td>
<td>6-Pin 1.6mm x 1.6mm Thin MLF®</td>
</tr>
<tr>
<td>MIC5308YMT</td>
<td>Adj.</td>
<td>▲ARA</td>
<td>–40° to +125°C</td>
<td>6-Pin 1.6mm x 1.6mm Thin MLF®</td>
</tr>
<tr>
<td>MIC5308-1.2YD6</td>
<td>1.2V</td>
<td>QR12</td>
<td>–40° to +125°C</td>
<td>6-Pin TSOT-23</td>
</tr>
<tr>
<td>MIC5308-1.5YD6</td>
<td>1.5V</td>
<td>QR15</td>
<td>–40° to +125°C</td>
<td>6-Pin TSOT-23</td>
</tr>
<tr>
<td>MIC5308-1.8YD6</td>
<td>1.8V</td>
<td>QR18</td>
<td>–40° to +125°C</td>
<td>6-Pin TSOT-23</td>
</tr>
<tr>
<td>MIC5308YD6</td>
<td>Adj.</td>
<td>QRAA</td>
<td>–40° to +125°C</td>
<td>6-Pin TSOT-23</td>
</tr>
</tbody>
</table>

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

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

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

Electrical Characteristics

\(V_{\text{BIAS}} = 3.6V; V_{\text{IN}} = V_{\text{OUT}} + 1V; V_{\text{IN}} \leq V_{\text{BIAS}}; C_{\text{OUT}} = 1.0\mu\text{F}; I_{\text{OUT}} = 100\mu\text{A}; T_J = 25^\circ\text{C}\), **bold** values indicate –40°C to +125°C, unless noted.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Voltage Accuracy</td>
<td>Variation from nominal (V_{\text{OUT}})</td>
<td>–2.0</td>
<td>+2.0</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Reference Voltage</td>
<td>(V_{\text{BIAS}})</td>
<td>0.7595</td>
<td>0.775</td>
<td>0.7905</td>
<td>V</td>
</tr>
<tr>
<td>(V_{\text{BIAS}}) Line Regulation</td>
<td>(V_{\text{BIAS}} = 3.6 \text{ to } 5.5V; V_{\text{IN}} = V_{\text{OUT}} + 1V)</td>
<td>0.01</td>
<td>0.3</td>
<td></td>
<td>%/V</td>
</tr>
<tr>
<td>(V_{\text{IN}}) Line Regulation</td>
<td>(V_{\text{IN}} = V_{\text{OUT}} + 1V); (V_{\text{BIAS}} = 5.5V)</td>
<td>0.02</td>
<td>0.2</td>
<td></td>
<td>%/V</td>
</tr>
<tr>
<td>Load Regulation</td>
<td>(I_{\text{OUT}} = 100\mu\text{A to } 150\text{mA})</td>
<td>0.2</td>
<td>1</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Dropout Voltage</td>
<td>(I_{\text{OUT}} = 150\text{mA})</td>
<td>45</td>
<td>150</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>Ground Pin Current(^{(5)})</td>
<td>(I_{\text{OUT}} = 100\mu\text{A to } 150\text{mA})</td>
<td>23</td>
<td>35</td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td>Ground Pin Current in Shutdown</td>
<td>(V_{\text{EN}} \leq 0.2V)</td>
<td>0.01</td>
<td>2.0</td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td>(V_{\text{IN}}) Ripple Rejection</td>
<td>(f = \text{ up to } 1kHz; C_{\text{OUT}} = 1.0\mu\text{F}; \text{ no } C_{\text{BYP}})</td>
<td>70</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>(f = \text{ up to } 1kHz; C_{\text{OUT}} = 1.0\mu\text{F}; C_{\text{BYP}} = 10nF)</td>
<td>50</td>
<td>90</td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td></td>
<td>(f = 20kHz; C_{\text{OUT}} = 1.0\mu\text{F}; C_{\text{BYP}} = 10nF)</td>
<td>80</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Current Limit</td>
<td>(f = \text{ up to } 1kHz; C_{\text{OUT}} = 1.0\mu\text{F}; C_{\text{BYP}} = 10nF)</td>
<td>180</td>
<td>325</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Output Voltage Noise</td>
<td>(f = 20kHz; C_{\text{OUT}} = 1.0\mu\text{F}; C_{\text{BYP}} = 10nF)</td>
<td>28</td>
<td></td>
<td></td>
<td>µV RMS</td>
</tr>
</tbody>
</table>

Enable Inputs (EN)

| Enable Input Voltage                     | Logic Low                                      | 0.2 | V   |
|                                          | Logic High                                    | 1.2 | V   |
| Enable Input Current                     | \(V_{\text{IL}} \leq 0.2V\)                   | 0.17| 1   | µA |
|                                          | \(V_{\text{IH}} \geq 1.2V\)                   | 1.5 | 1   | µA |
| Turn-on Time                             | \(C_{\text{OUT}} = 1.0\mu\text{F}; C_{\text{BYP}} = 10nF\) | 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 \(T_s\) (ambient temperature) is \(P_{\text{D(max)}} = \frac{T_{\text{J(max)}} - T_s}{\theta_{\text{JA}}}\). 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. \(I_{\text{GND}} = I_{\text{IN}} + I_{\text{BIAS}} - I_{\text{OUT}}\)
Typical Characteristics

Power Supply Rejection Ratio (V_IN)

-200 -180 -160 -140 -120 -100 -80 -60 -40 -20 0

FREQUENCY (Hz) 10 100 1K 10K 100K 1M

VIN = VOUT + 1V
VOUT = 1.2V
COUT = 1µF
CBYP = 0.01µF

Ground Current (V_IN) vs. Output Current

0 25 50 75 100 125 150

GROUND CURRENT (µA)

100µA

100mA

Ground Current (V_BIAS) vs. Output Current

0 25 50 75 100 125 150

GROUND CURRENT (µA)

100µA

100mA

Ground Current (Total) vs. Output Current

0 25 50 75 100 125 150

GROUND CURRENT (µA)

100µA

100mA

Bias Current vs. Enable Voltage

0 1 2 3 4 5

BIAS CURRENT (µA)

100µA

150mA

Enable Voltage vs. Temperature

-20 -10 0 10 20 30 40 50 60 70 80

TEMPERATURE (°C)

VIN = 2.2V
VBIAS = 3.6V
VOUT = 1.2V
COUT = 1µF
CBYP = 1µF

Dropout Voltage vs. Output Current

0 5 10 15 20 25 30 35 40

DROPOUT VOLTAGE (mV)

COUT = 1µF

Dropout Voltage vs. Temperature

0 25 50 75 100 125

TEMPERATURE (°C)

VIN = 2.2V
VBIAS = 3.6V
VOUT = 1.2V
COUT = 1µF
IOUT = 100µA

Output Voltage vs. Temperature

1.10 1.15 1.20 1.25 1.30

OUTPUT VOLTAGE (V)

VIN = 2.2V
VBIAS = 3.6V
VOUT = 1.2V
COUT = 1µF
IOUT = 100µA

Output Voltage vs. Output Current

0 25 50 75 100 125 150

TEMPERATURE (°C)

VIN = 2.2V
VBIAS = 3.6V
VOUT = 1.2V
COUT = 1µF
IOUT = 100µA

Power Supply Rejection Ratio (V_BIAS)

-100 -90 -80 -70 -60 -50 -40 -30 -20 -10 0

FREQUENCY (Hz) 10 100 1K 10K

VIN = 2.8V
VBIAS = 3.6V
VOUT = 1.8V
COUT = 1µF
CBYP = 1µF

Bias Current vs. Enable Voltage

0 1 2 3 4 5

BIAS CURRENT (µA)

100µA

150mA

Enable Voltage vs. Temperature

0 25 50 75 100 125

TEMPERATURE (°C)

VIN = 2.2V
VBIAS = 3.6V
VOUT = 1.8V
COUT = 1µF

Dropout Voltage vs. Output Current

0 5 10 15 20 25 30 35 40

DROPOUT VOLTAGE (mV)

COUT = 1µF

Dropout Voltage vs. Temperature

0 25 50 75 100 125

TEMPERATURE (°C)

VIN = 2.2V
VBIAS = 3.6V
VOUT = 1.2V
COUT = 1µF
IOUT = 100µA

Output Voltage vs. Temperature

1.10 1.15 1.20 1.25 1.30

OUTPUT VOLTAGE (V)

VIN = 2.2V
VBIAS = 3.6V
VOUT = 1.2V
COUT = 1µF
IOUT = 100µA

Output Voltage vs. Output Current

0 25 50 75 100 125 150

TEMPERATURE (°C)

VIN = 2.2V
VBIAS = 3.6V
VOUT = 1.2V
COUT = 1µF
IOUT = 100µA
Typical Characteristics (continued)

- **Output Voltage vs. VIN**
- **Reference Voltage vs. Temperature**
- **Current Limit vs. VIN**

- **Output Noise Spectral Density**

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Micrel, Inc.

May 2008
Functional Characteristics

Enable Turn-On

Load Transient

Line Transient ($V_{IN}$)

Line Transient ($V_{BIAS}$)

$V_{IN} = 2.2V$
$V_{BIAS} = 3.6V$
$V_{OUT} = 1.2V$
$C_{OUT} = 1\mu F$
$C_{BYP} = 0.01\mu F$

$V_{IN} = 2.2V$
$V_{BIAS} = 3.6V$
$V_{OUT} = 1.2V$
$C_{OUT} = 1\mu F$
$C_{BYP} = 0.01\mu F$

Time (40\mu s/div)

Time (23\mu s/div)

Output Voltage (V)

Output Voltage (V)

Input Voltage (V)

Output Voltage (V)
Applications Information

The MIC5308 is a high performance, low-dropout linear regulator designed for low current applications requiring fast transient response. The MIC5308 utilizes two input supplies, significantly reducing dropout voltage, perfect for low-voltage, DC-to-DC conversion. The MIC5308 requires a minimum of external components.

The MIC5308 regulator is fully protected from damage due to fault conditions, offering linear current limiting and thermal shutdown.

Bias Supply Voltage

$V_{\text{BIAS}}$, requiring relatively light current, provides power to the control portion of the MIC5308. Bypassing on the bias pin is recommended to improve performance of the regulator during line and load transients. $1\mu\text{F}$ ceramic capacitor from $V_{\text{BIAS}}$ 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

$V_{\text{IN}}$ provides the supply to power the LDO. The minimum input voltage is 1.6V, allowing conversion from low voltage supplies.

Output Capacitor

The MIC5308 requires an output capacitor of $1\mu\text{F}$ 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 $1\mu\text{F}$ 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 MIC5308 is a high-performance, high bandwidth device. Therefore, it requires a well-bypassed input supply for optimal performance. A $1\mu\text{F}$ 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 $0.01\mu\text{F}$ 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 MIC5308 to drive a large capacitor on the bypass pin without significantly slowing turn-on time.

Minimum Load Current

The MIC5308, unlike most other regulators, does not require a minimum load to maintain output voltage regulation.

Adjustable Regulator Design

The MIC5308 adjustable version allows programming the output voltage anywhere between 0.8V and 2V. Two resistors are used. The resistor values are calculated by:

$$R_1 = R_2 \times \left( \frac{V_{\text{OUT}}}{0.775} - 1 \right)$$

Where $V_{\text{OUT}}$ is the desired output voltage.

Enable/Shutdown

The MIC5308 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 MIC5308 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 3.3V, the output voltage is 1.2V and the output current = 150mA. The actual power dissipation of the regulator circuit can be determined using the equation:

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

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.

$$P_D = (3.3V - 1.2V) \times 150mA$$

$$P_D = 0.315\text{W}$$
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:

\[ P_{D_{\text{max}}} = \left( \frac{T_{J_{\text{max}}} - T_A}{\theta_{JA}} \right) \]

\[ T_{J_{\text{max}}} = 125^\circ C, \text{ the maximum junction temperature of the die } \theta_{JA} \text{ thermal resistance} = 90^\circ \text{C/W.} \]
Package Information

6-Pin 1.6mm x 1.6mm Thin MLF® (MT)

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, i.e. reverse trim/form.
3. Dimensions are exclusive of mold flash and gate burr.
4. The footprint measuring is based on the gauge plane method.
5. All specification comply to Jedec Spec MO193 Issue C.
6. All dimensions are in millimeters.

6-Pin TSOT-23 (D6)
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