

### General Description

The MIC5249 is an efficient, precise 300mA CMOS voltage regulator with power-on reset delay which can be implemented via an external capacitor. It offers 1% initial accuracy, extremely-low-dropout voltage (typically 400mV @ 300mA), and low ground current (typically 85mA) over load.

Designed specifically for noise-critical applications in hand-held or battery-powered devices, the MIC5249 comes equipped with a noise reduction feature to filter the output noise via an external capacitor. Other features of the MIC5249 include a logic compatible enable pin, current limit, thermal shutdown, ultra-fast transient response, and an active clamp to speed up device turnoff.

The MIC5249 also works with low-ESR ceramic capacitors, reducing the amount of board space necessary for power applications, critical in hand-held wireless devices.

The MIC5249 is available in the MSOP-8 package.

Data sheets and support documentation can be found on Micrel's web site at [www.micrel.com](http://www.micrel.com).

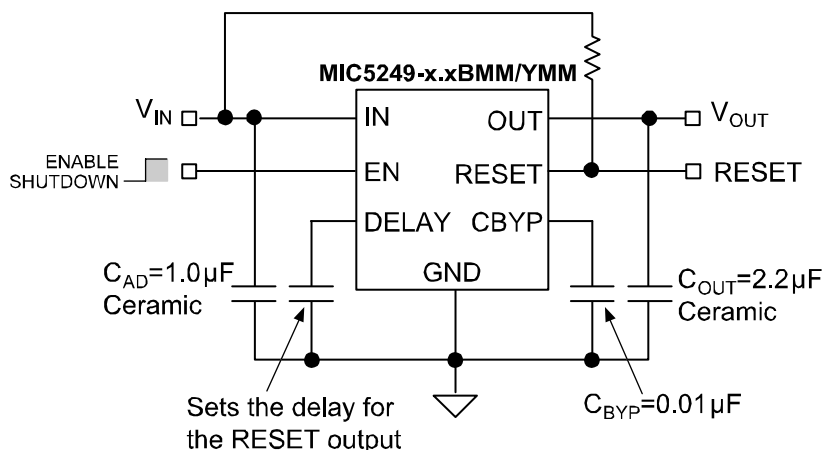
### Features

- 300mA output current
- High PSRR: 65dB@120Hz
- Stable with ceramic output capacitor
- Power-on RESET output with adjustable delay time
- High output accuracy:
  - $\pm 1.0\%$  initial accuracy
  - $\pm 3.0\%$  over temperature
- Low dropout voltage of 400mV @ 300mA
- Low quiescent current: 85 $\mu$ A
- Zero current shutdown mode
- Thermal shutdown protection
- Current-limit protection
- Tiny MSOP-8 package

### Applications

- Cellular phones
- PDAs
- Fiber optic modules

### Typical Application



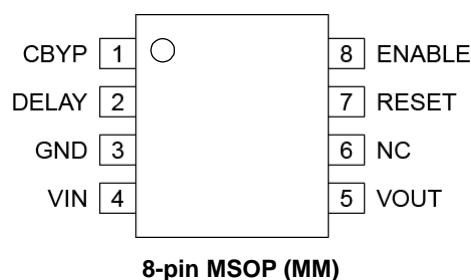
**Ultra-Low Noise Application**

## Ordering Information

| Part Number     |                 | Voltage* | Junction Temperature Range | Package    |
|-----------------|-----------------|----------|----------------------------|------------|
| Standard        | Pb-Free         |          |                            |            |
| MIC5249-1.8BMM  | MIC5249-1.8YMM  | 1.8V     | -40°C to +125°C            | 8-Pin MSOP |
| MIC5249-2.5BMM  | MIC5249-2.5YMM  | 2.5V     | -40°C to +125°C            | 8-Pin MSOP |
| MIC5249-2.6BMM  | MIC5249-2.6YMM  | 2.8V     | -40°C to +125°C            | 8-Pin MSOP |
| MIC5249-2.8BMM  | MIC5249-2.8YMM  | 2.8V     | -40°C to +125°C            | 8-Pin MSOP |
| MIC5249-2.85BMM | MIC5249-2.85YMM | 2.85V    | -40°C to +125°C            | 8-Pin MSOP |
| MIC5249-3.0BMM  | MIC5249-3.0YMM  | 3.0V     | -40°C to +125°C            | 8-Pin MSOP |
| MIC5249-3.3BMM  | MIC5249-3.3YMM  | 3.3V     | -40°C to +125°C            | 8-Pin MSOP |

**Note:** Other Voltage available. Contact Micrel Marketing for details.

## Pin Configuration



## Pin Description

| Pin Number | Pin Name | Pin Function  |
|------------|----------|---|
| 1          | CBYP     | Reference Bypass: Connect external 0.01F capacitor to GND to reduce output noise. May be left open. |
| 2          | DELAY    | Delay Set Input: Connect external capacitor to GND to set the delay of the Error Flag.              |
| 3          | GND      | Ground.   |
| 4          | VIN      | Supply Input.   |
| 5          | VOUT     | Regulator Output.   |
| 6          | NC       | No Connect.   |
| 7          | RESET    | RESET Output: Open-drain output. Active low indicates an output undervoltage condition.             |
| 8          | ENABLE   | Enable Input: CMOS compatible input. Logic high = enable; Logic low = shutdown. Do not leave open.  |

**Absolute Maximum Ratings<sup>(1)</sup>**

|                                     |                                   |
|-------------------------------------|-----------------------------------|
| Supply Voltage ( $V_{IN}$ )         | 0V to +7V                         |
| Power Dissipation ( $P_D$ )         | Internally Limited <sup>(3)</sup> |
| Junction Temperature ( $T_J$ )      | -40°C to +125°C                   |
| Lead Temperature (soldering, 5sec.) | 260°C                             |
| Storage Temperature ( $T_S$ )       | -65°C to +150°C                   |
| EDS Rating <sup>(4)</sup>           |                                   |

**Operating Ratings<sup>(2)</sup>**

|  |                 |
|--|-----------------|
| Supply voltage ( $V_{IN}$ )                          | +2.7V to +6V    |
| Enable Voltage ( $V_{EN}$ )                          | 0V to $V_{IN}$  |
| Junction Temperature ( $T_J$ )                       | -40°C to +125°C |
| Package Thermal Resistance<br>MSOP ( $\theta_{JA}$ ) | 200°C/W         |

**Electrical Characteristics**

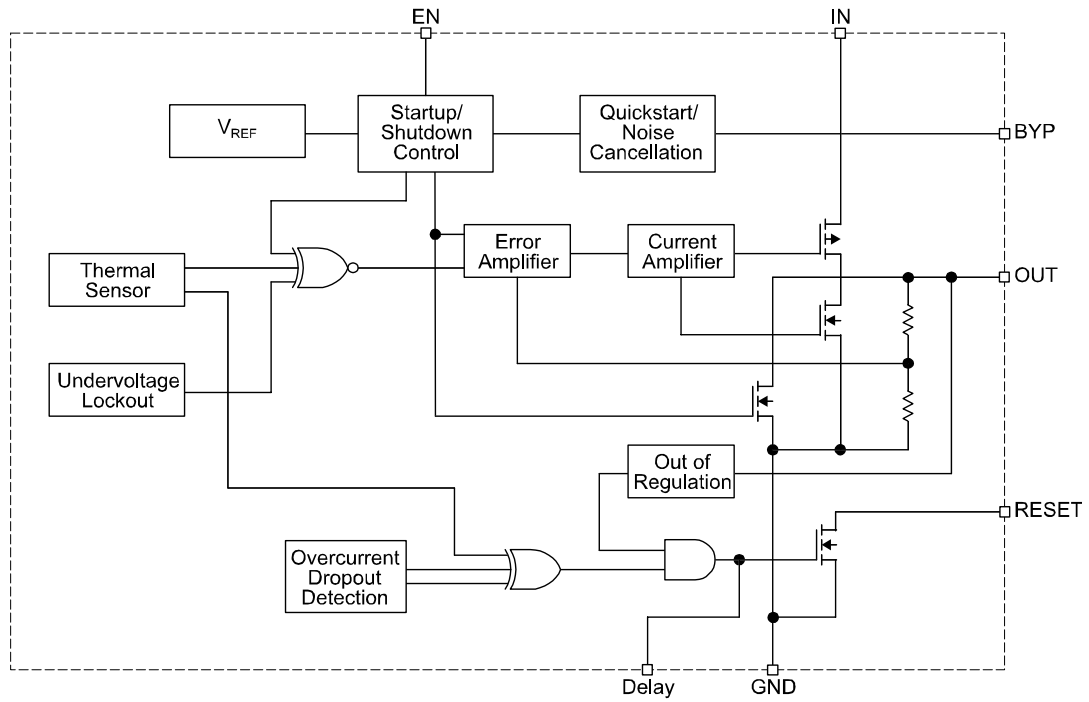
$V_{IN} = V_{OUT} + 1V$ ;  $C_{OUT} = 1\mu F$ ,  $I_{OUT} = 100\mu A$ ;  $T_J = 25^\circ C$ , **bold** values indicate -40°C to +125°C, unless noted.

| Parameter                      | Condition  | Min         | Typ   | Max         | Units   |
|--------------------------------|--|-------------|-------|-------------|---------|
| Output Voltage Accuracy        | Variation from nominal $V_{OUT}$   | -1.0        |       | +1.0        | %       |
|                                |  | <b>-3.0</b> |       | <b>+3.0</b> | %       |
| Line Regulation                | $V_{IN} = V_{OUT} + 1V$ to 6V  | -0.3        | 0.02  | +0.3        | %/V     |
| Load Regulation                | $I_{OUT} = 0.1mA$ to 300mA   |             | 1.5   | 3.0         | %       |
| Dropout Voltage                | $I_{OUT} = 100\mu A$   |             | 1     |             | mV      |
|                                | $I_{OUT} = 150mA$  |             | 160   | 225         | mV      |
|                                | $I_{OUT} = 300mA$  |             | 340   | 500         | mV      |
| Ground Pin Current             | $I_{OUT} = 0mA$  |             | 85    | <b>150</b>  | $\mu A$ |
|                                | $I_{OUT} = 300mA$  |             | 100   | <b>200</b>  | $\mu A$ |
| Ground Pin Current in Shutdown | $V_{EN} < 0.4V$ (Regulator OFF)  |             | 0.35  | 1           | $\mu A$ |
| Ripple Rejection               | $f = 120Hz$ , $C_{OUT} = 2.2\mu F$   |             | 65    |             | dB      |
| Current Limit                  | $V_{OUT} = 0V$   | <b>300</b>  | 440   |             | mA      |
| <b>Enable Input</b>            |  |             |       |             |         |
| Enable Input Voltage           | Logic low (regulator shutdown)   |             |       | <b>0.4</b>  | V       |
|                                | Logic high (regulator enabled)   | <b>1.6</b>  |       |             | V       |
| Enable Input Current           | $V_{IL} < 0.4V$ (regulator shutdown)   |             | 0.01  |             | $\mu A$ |
|                                | $V_{IH} > 1.6V$ (regulator enabled)  |             | 0.01  |             | $\mu A$ |
| <b>Delay Input</b>             |  |             |       |             |         |
| Delay Pin Current Source       |  |             | 0.55  | 1           | $\mu A$ |
| Delay Pin Threshold Voltage    | Threshold for RESET = Logic high   |             | 1.40  |             | V       |
| <b>RESET Output</b>            |  |             |       |             |         |
| $V_{TH}$                       | Low threshold, % of $V_{OUT}$ (Flag ON)  | <b>89</b>   | 91    |             | %       |
|                                | High threshold, % of $V_{OUT}$ (Flag OFF)  |             | 93    | <b>96</b>   | %       |
| $V_{OL}$                       | RESET output logic – low voltage; $I_{RESET} = 100\mu A$ output in fault condition |             | 0.020 | <b>0.1</b>  | V       |
| $I_{RESET}$                    | Flag leakage current, Flag OFF   |             | 0.01  |             | $\mu A$ |

**Notes:**

- Exceeding the absolute maximum rating may damage the device.
- The device is not guaranteed to function outside its operating rating.
- The maximum allowable power dissipation of any  $T_A$  (ambient temperature) is  $P_{D(max)} = T_{J(max)} - T_A \div \theta_{JA}$ . Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown.
- Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5k in series with 100pF.

# Functional Diagram



## Application Information

### Enable/Shutdown

The MIC5249 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. This part is CMOS and the enable pin cannot be left floating; a floating enable pin may cause an indeterminate state on the output.

### Input Capacitor

The MIC5249 is a high performance, high bandwidth device. Therefore, it requires a well-bypassed input supply for optimal performance. A 1.0 $\mu$ 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 to filter out high frequency noise and are good practice in any RF-based circuit.

### Output Capacitor

The MIC5249 requires an output capacitor for stability. The design requires 2.2 $\mu$ F or greater on the output to maintain stability. The design is optimized for use with low-ESR ceramic chip capacitors. High-ESR capacitors may cause high frequency oscillation. The maximum recommended ESR is 300m $\Omega$ . The output capacitor can be increased, but performance has been optimized for a 2.2 $\mu$ 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.

### Delay Pin Input

The power-on reset function can be implemented on the MIC5249 by adding an external capacitor from the delay pin to ground. This external capacitor sets the delay time (T<sub>DELAY</sub>) of the RESET output. The capacitor value required can be easily calculated using the formula:

$$C_{\text{DELAY}} = \left( \frac{T_{\text{DELAY}} \times I_{\text{DELAY}}}{V_{\text{DELAY}}} \right)$$

where I<sub>DELAY</sub> is 0.55 $\mu$ A and the V<sub>DELAY</sub> is 1.4V. When no capacitor is used, there will be no delay and the POR output acts like a standard error FLAG output.

### Reset Output

The RESET output of the MIC5249 provides the power-on reset signal based on the capacitor from the DELAY pin to ground when input power is applied to the regulator. The reset signal stays low for a preset time period after power is applied to the regulator, and then goes high (see “Timing Diagram”).

The reset output is an active-low, open-drain output that drives low when a fault condition AND an undervoltage detection occurs. Internal circuitry intelligently monitors overcurrent, overtemperature and dropout conditions and ORs these outputs together to indicate some fault condition. The output of that OR gate is ANDed with an output voltage monitor that detects an undervoltage condition. The output drives an open-drain transistor to indicate a fault. This prevents chattering or inadvertent triggering of the reset. The reset must be pulled up using a resistor from the RESET pin to either the input or the output.

### Bypass Pin Input

A bypass capacitor is required from the noise bypass pin to ground to reduce output voltage noise. The capacitor bypasses the internal reference. A 0.01 $\mu$ 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 MIC5249 to drive a large capacitor on the bypass pin without significantly slowing the turn-on time.

### Active Shutdown

The MIC5249 also features an active shutdown clamp, which is a N-Channel MOSFET that turns on when the device is disabled. This allows the output capacitor and load to discharge, de-energizing the load.

### No-Load Stability

The MIC5249 will remain stable and in regulation with no load unlike many other voltage regulators. This is especially important in CMOS RAM keep-alive application.

### Thermal Consideration

The MIC5249 is designed to provide 300mA of continuous current in a very small package. Maximum power dissipation can be calculated based on the output current and the voltage drop across the device. To determine the maximum power dissipation of the package, use the junction-to-ambient thermal resistance of the device and the following basic equation:

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

$T_{J(\max)}$  is the maximum junction temperature of the die, 125°C and  $T_A$  is the ambient operating temperature.  $\theta_{JA}$  is layout dependent; Table 1 shows examples of the junction-to-ambient thermal resistance for the MIC5249.

| Package | $\theta_{JA}$ Recommended Minimum Footprint |
|---------|---|
| MSOP-8  | 200°C/W                                     |

**Table 1. MSOP-8 Thermal Resistance**

The actual power dissipation of the regulator circuit can be determined using the equation:

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

Substituting  $P_{D(\max)}$  for  $P_D$  and solving for the operating conditions that are critical to the application will give the maximum operating conditions for the regulator circuit. For example, when operating the MIC5249-3.0BMM at

50°C with a minimum footprint layout, the maximum input voltage for a set output current can be determined as follows:

$$P_{D(\max)} = \left( \frac{125^\circ\text{C} - 50^\circ\text{C}}{200^\circ\text{C/W}} \right)$$

The junction-to-ambient thermal resistance for the minimum footprint is 200°C/W, from Table 1. The maximum power dissipation must not be exceeded for proper operation. Using the output voltage of 3.0V, and an output current of 300mA, the maximum input voltage can be determined. Because this device is CMOS and the ground current is typically 90µA over the load range, the power dissipation contributed by the ground current is < 1.0% and can be ignored for this calculation.

$$375\text{mW} = (V_{IN} - 3.0\text{V}) 300\text{mA}$$

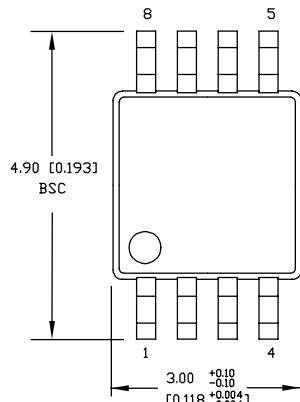
$$375\text{mW} = V_{IN} \times 300\text{mA} - 900\text{mW}$$

$$1275\text{mW} = V_{IN} \times 300\text{mA}$$

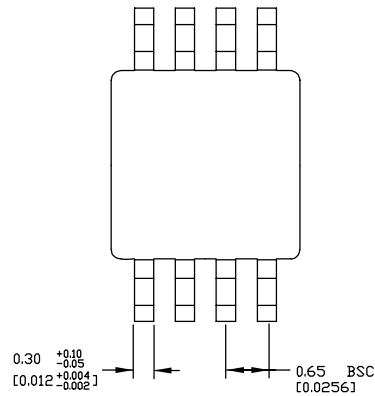
$$V_{IN(\max)} = 4.25\text{V}$$

Therefore, a 3.0V application at 300mA of output current can accept a maximum input voltage of 4.25V in the MSOP-8 package. For a full discussion of heat sinking and thermal effects on the voltage regulators, refer to the "Regulator Thermals" section of *Micrel's Designing with Low-Dropout Voltage Regulators Handbook*.

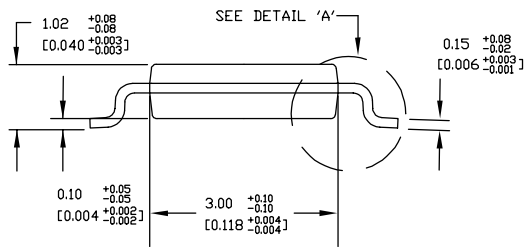
**Package Information**



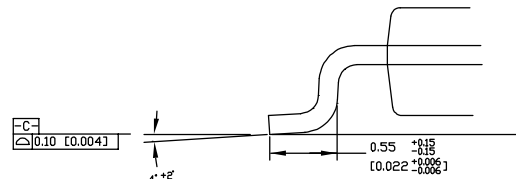
TOP VIEW



BOTTOM VIEW



SIDE VIEW



DETAIL A

**NOTES:**

1. DIMENSIONS ARE IN MM [INCHES].
2. CONTROLLING DIMENSION: MM
3. DIMENSION DOES NOT INCLUDE MOLD FLASH OR PROTRUSIONS, EITHER OF WHICH SHALL NOT EXCEED 0.20 [0.008] PER SIDE.

**8-Pin MSOP (MM)**

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