



MIC5396/7/8/9

Low-Power Dual 300mA LDO in
1.2mm x 1.6mm Extra Thin DFN

General Description

The MIC5396/7/8/9 is an advanced dual LDO ideal for powering general purpose portable devices. The MIC5396/7/8/9 provides two high-performance, independent 300mA LDOs in a single package. This makes it possible to improve system efficiency by providing two independent supply inputs that can be optimized for each individual LDO. The MIC5396/7/8/9 also features a wide output voltage range down to 1.0V.

Its full feature set and low dropout voltage make it ideal for battery-powered applications. The MIC5396/7/8/9 offers 2% accuracy, low dropout voltage (160mV at 300mA), and low ground current (typically 42μA per LDO at full load). The MIC5396/7/8/9 can also be put into a zero off mode current state, drawing virtually no current when disabled.

When the MIC5397/9 is disabled an internal resistive load is automatically applied to the output to discharge the output capacitor. In addition, the MIC5398/9 offers an internal enable pull-down resistor to ensure that the output is disabled when the enable is in tri-state mode. These LDO's also offer fast transient response and high PSRR while consuming a minimum operating current. The family is available in a tiny 8-pin, 1.2mm x 1.6mm leadless Extra Thin DFN package.

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

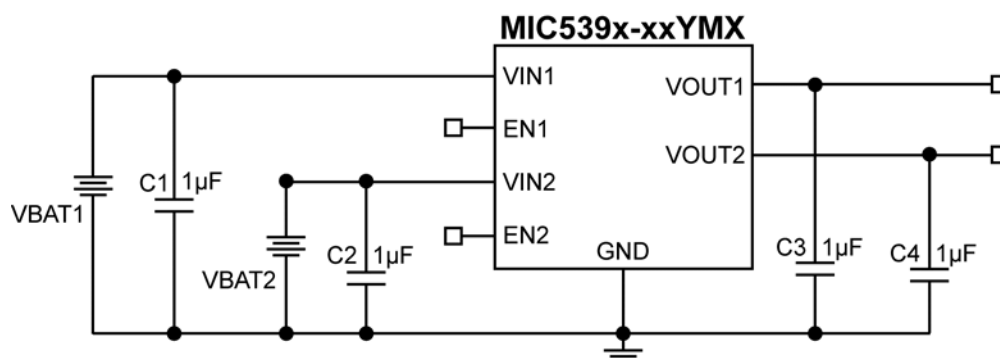
Features

- 2.5V to 5.5V input voltage range
- Independent power inputs
- Output voltage range from 1V to 3.3V
- Two 300mA outputs
- High output accuracy ($\pm 2\%$)
- Low quiescent current – 37μA typical/LDO
- Stable with 1μF ceramic output capacitors
- Low dropout voltage (160mV at 300mA)
- Independent enable pins
- Internal enable pull-down (MIC5398, MIC5399)
- Output discharge circuit (MIC5397, MIC5399)
- Thermal-shutdown protection
- Current-limit protection
- 8-pin 1.2mm x 1.6mm Extra Thin DFN package

Applications

- Camera phones
- Mobile phones
- DSC, GPS, PMP and PDAs
- Portable medical devices
- Portable electronics

Typical Application



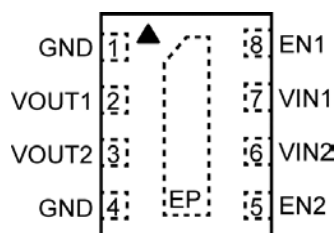
Ordering Information

| Part Number | Marking | V _{OUT1} /V _{OUT2} ⁽¹⁾ | EN Discharge Circuit | Output Discharge Circuit | Junction Temp. Range | Package |
|------------------------------|---------|---|----------------------|--------------------------|----------------------|---------------------|
| MIC5396-GMYMX | F2 | 1.8V/2.8V | — | — | –40° to +125°C | 8-Pin 1.2x1.6 XTDFN |
| MIC5397-GPYMX | D4 | 1.8V/3.0V | — | X | –40° to +125°C | 8-Pin 1.2x1.6 XTDFN |
| MIC5398-P4YMX | E5 | 3.0V/1.2V | X | — | –40° to +125°C | 8-Pin 1.2x1.6 XTDFN |
| MIC5399-SSYMX | H4 | 3.3V/3.3V | X | X | –40° to +125°C | 8-Pin 1.2x1.6 XTDFN |
| MIC5399-SMYMX | H6 | 3.3V/2.8V | X | X | –40° to +125°C | 8-Pin 1.2x1.6 XTDFN |
| MIC5399-SGYMX | H5 | 3.3V/1.8V | X | X | –40° to +125°C | 8-Pin 1.2x1.6 XTDFN |
| MIC5399-MMYMX | H7 | 2.8V/2.8V | X | X | –40° to +125°C | 8-Pin 1.2x1.6 XTDFN |
| MIC5399-GPYMX ⁽³⁾ | H8 | 1.8V/3.0V | X | X | –40° to +125°C | 8-Pin 1.2x1.6 XTDFN |
| MIC5399-GMYMX | H1 | 1.8V/2.8V | X | X | –40° to +125°C | 8-Pin 1.2x1.6 XTDFN |

Notes:

- Other voltages are available. Contact Micrel for details.
- Extra Thin DFN is a GREEN RoHS-compliant package. Level finish is NiPdAu. Mold compound is Halogen Free.
- Contact Micrel Marketing to order.

Pin Configuration



8-Pin 1.2mm x 1.6mm Extra Thin DFN (MX)

Pin Description

| Pin Number | Pin Name | Pin Function |
|------------|----------|---|
| 1, 4 | GND | Ground. |
| 2 | VOUT1 | Output regulator 1: Connect a capacitor to ground. |
| 3 | VOUT2 | Output regulator 2: Connect a capacitor to ground. |
| 5 | EN2 | Enable input for regulator 2: Active-high input. Logic high = On; Logic low = Off. MIC5396/7 Do not leave floating. MIC5398/9 internal pull-down resistor, tri-state = Off. |
| 6 | VIN2 | Input voltage supply for regulator 2: Connect a capacitor to ground. |
| 7 | VIN1 | Input voltage supply for regulator 1: Connect a capacitor to ground. |
| 8 | EN1 | Enable input for regulator 1. Active-high input. Logic high = On; Logic low = Off. MIC5396/7 Do not leave floating. MIC5398/9 internal pull-down resistor, tri-state = Off. |
| EP | ePad | Heatsink pad: Connect to ground. |

Absolute Maximum Ratings⁽¹⁾

Supply Voltage (V_{IN1} , V_{IN2}) -0.3V to +6V
 Enable Voltage (V_{EN1} , V_{EN2}) -0.3V to V_{IN}
 Power Dissipation (P_D) Internally Limited⁽³⁾
 Lead Temperature (soldering, 10sec.) 260°C
 Junction Temperature (T_J) -40°C to +125°C
 Storage Temperature (T_s) -65°C to +150°C
 ESD Rating⁽⁴⁾ 3kV

Operating Ratings⁽²⁾

Supply Voltage (V_{IN1} , V_{IN2}) +2.5V to 5.5V
 Enable Voltage (V_{EN1} , V_{EN2}) 0V to V_{IN}
 Junction Temperature (T_J) -40°C to +125°C
 Junction Thermal Resistance
 1.2mm x 1.6mm Extra Thin DFN (θ_{JA}) 172.6°C/W

Electrical Characteristics⁽⁴⁾

$V_{IN1} = V_{EN1} = V_{OUT1} + 1V$, $V_{IN2} = V_{EN2} = V_{OUT2} + 1V$, $I_{OUT1} = I_{OUT2} = 100\mu A$; $C_{IN1} = C_{IN2} = C_{OUT1} = C_{OUT2} = 1\mu F$;
 $T_J = 25^\circ C$. **Bold** values indicate -40°C to +125°C, unless noted.

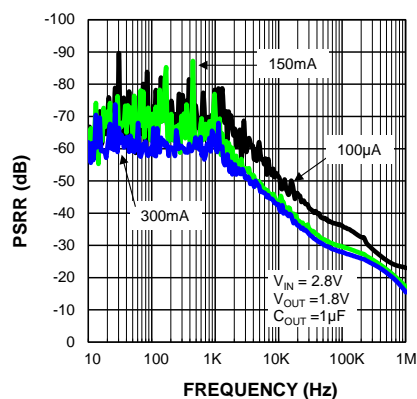
| Parameter | Condition | Min | Typ | Max | Units |
|--|--|-------------|------|-------------|---------------|
| Output Voltage Accuracy | Variation from nominal V_{OUT} | -2.0 | | +2.0 | % |
| | Variation from nominal V_{OUT} | -3.0 | | +3.0 | % |
| Line Regulation | $V_{IN} = V_{OUT} + 1V$ to 5.5V, $I_{OUT} = 100\mu A$ | | 0.02 | 0.3 | %/V |
| Load Regulation | $I_{OUT} = 100\mu A$ to 300mA | | 8 | 40 | mV |
| Dropout Voltage | $I_{OUT} = 150mA$ | | 80 | 190 | mV |
| | $I_{OUT} = 300mA$ | | 160 | 380 | mV |
| Ground Pin Current | $V_{EN1} = \text{High}$; $V_{EN2} = \text{Low}$; $I_{OUT1} = 0mA$ | | 37 | 55 | μA |
| | $V_{EN1} = \text{Low}$; $V_{EN2} = \text{High}$; $I_{OUT2} = 0mA$ | | 37 | 55 | μA |
| | $V_{EN1} = V_{EN2} = \text{High}$; $I_{OUT1} = I_{OUT2} = 0mA$ | | 74 | 110 | μA |
| | $V_{EN1} = \text{High}$; $V_{EN2} = \text{Low}$; $I_{OUT1} = 300mA$ | | 42 | 65 | μA |
| | $V_{EN1} = \text{Low}$; $V_{EN2} = \text{High}$; $I_{OUT2} = 300mA$ | | 42 | 65 | μA |
| | $V_{EN1} = V_{EN2} = \text{High}$; $I_{OUT1} = I_{OUT2} = 300mA$ | | 84 | 130 | μA |
| Shutdown Current | $V_{EN1} = V_{EN2} = 0V$ | | 0.05 | 1 | μA |
| Ripple Rejection | $f = 1kHz$; $C_{OUT} = 1\mu F$ | | 60 | | dB |
| Current Limit | $V_{OUT} = 0V$ | 400 | 630 | 900 | mA |
| Output Voltage Noise | $C_{OUT} = 1\mu F$, 10Hz to 100kHz | | 93 | | μV_{RMS} |
| Auto-Discharge NFET Resistance | MIC5397, MIC5399 Only; $V_{EN1} = V_{EN2} = 0V$; $V_{IN} = 3.6V$; $I_{OUT} = -3mA$ | | 25 | | Ω |
| Enable Inputs (EN1/EN2) | | | | | |
| Enable Pull-Down Resistor | MIC5398, MIC5399 | | 4 | | M Ω |
| Enable Input Voltage | Logic Low | | | 0.2 | V |
| | Logic High | 1.2 | | | V |
| Enable Input Current MIC5396, MIC5397 | $V_{EN} = 0V$ | | 0.01 | 1 | μA |
| | $V_{EN} = 5.5V$ | | 0.01 | 1 | μA |
| Enable Input Current MIC5398, MIC5399 | $V_{EN} = 0V$ | | 0.01 | 1 | μA |
| | $V_{EN} = 5.5V$ | | 1.4 | 2 | μA |
| Turn-on Time | $C_{OUT} = 1\mu F$ | | 50 | 125 | μs |

Notes:

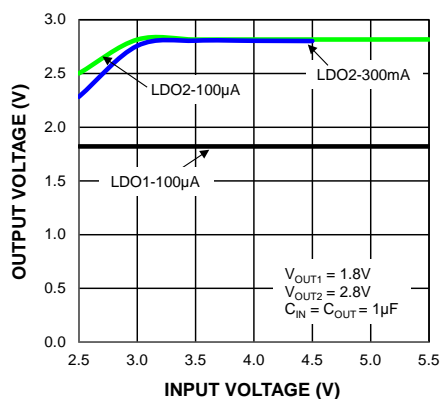
- Exceeding the absolute maximum ratings can damage the device.
- The device is not guaranteed to function outside its operating rating.
- The maximum allowable power dissipation of any T_A (ambient temperature) is $P_{D(max)} = (T_{J(max)} - T_A) / \theta_{JA}$. Exceeding the maximum allowable power 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 Ω in series with 100pF.
- Specification for packaged product only.

Typical Characteristics

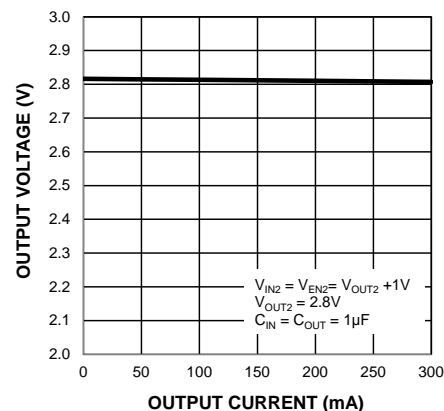
**Power Supply
Rejection Ratio**



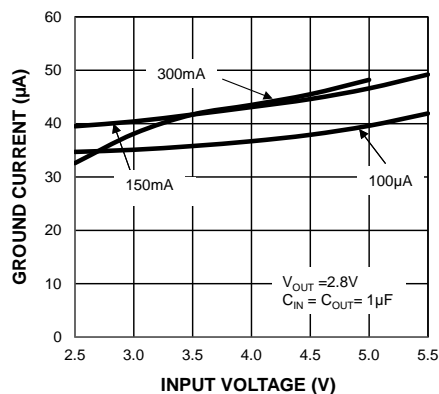
**Output Voltage
vs. Input Voltage**



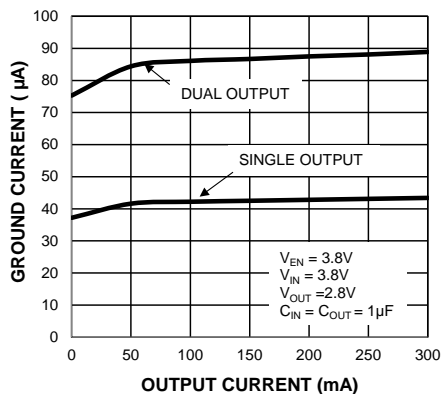
**Output Voltage
vs. Output Current**



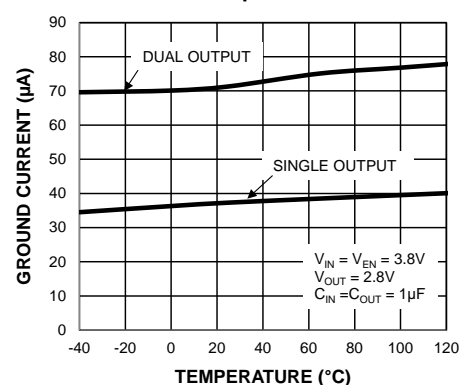
**Ground Current
vs. Input Voltage**



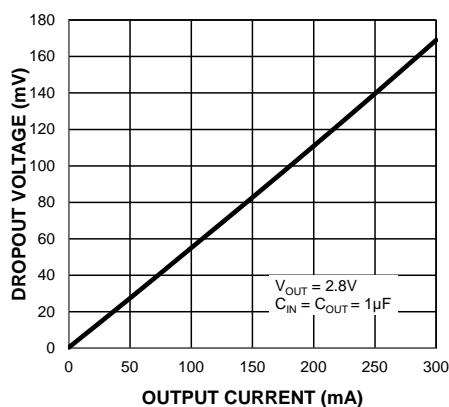
**Ground Current
vs. Output Current**



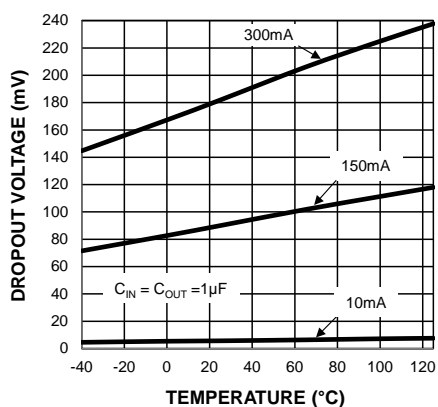
**Ground Current
vs. Temperature**



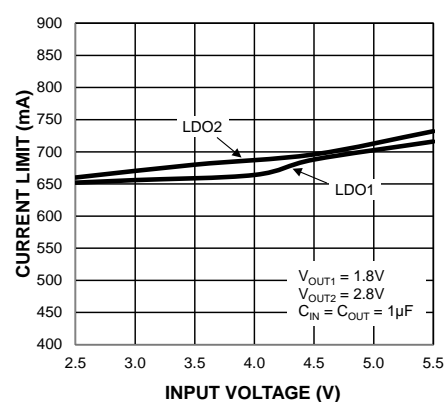
**Dropout Voltage
vs. Output Current**



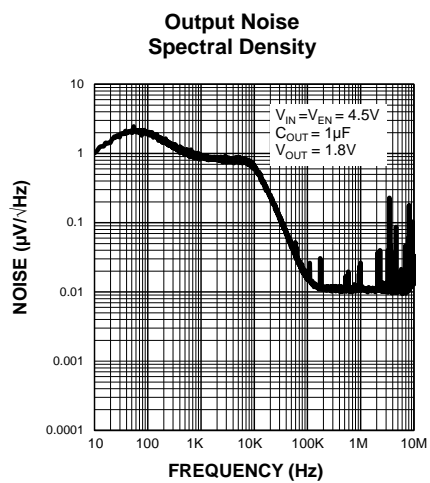
**Dropout Voltage
vs. Temperature**



**Current Limit
vs. Input Voltage**

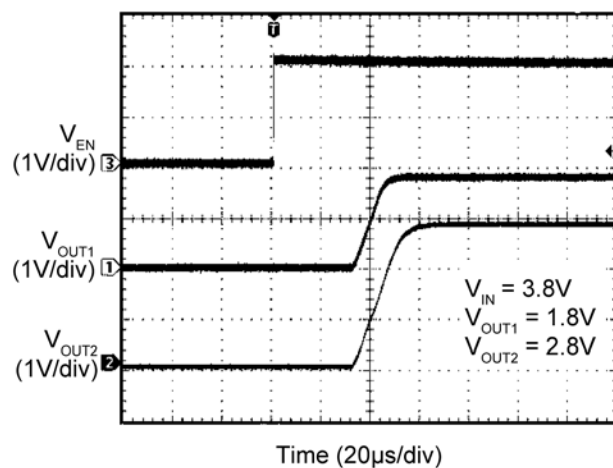


Typical Characteristics (Continued)

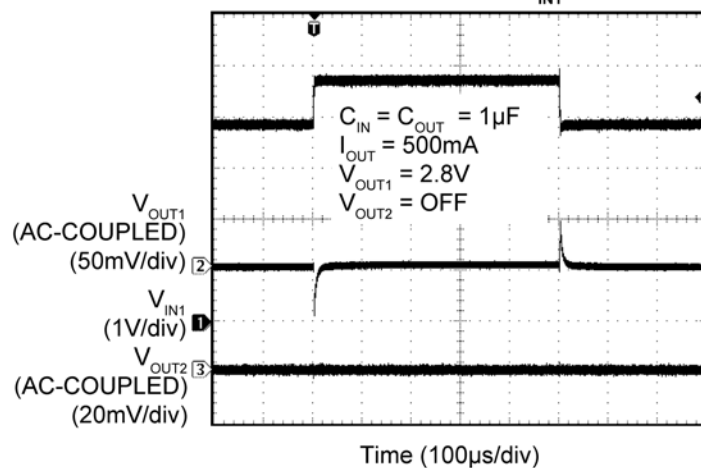


Functional Characteristics

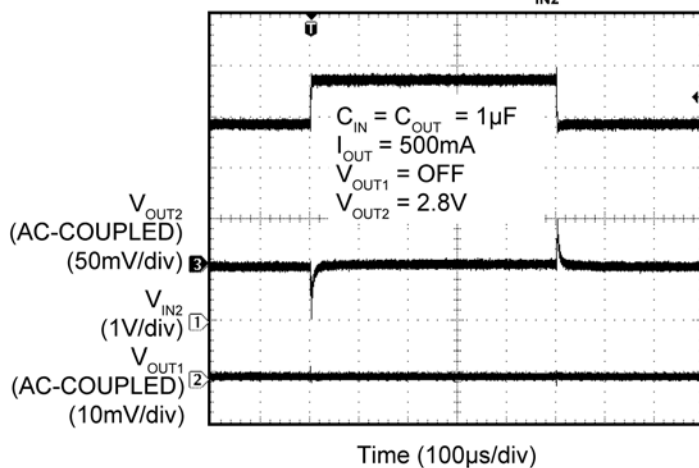
Turn-On Time



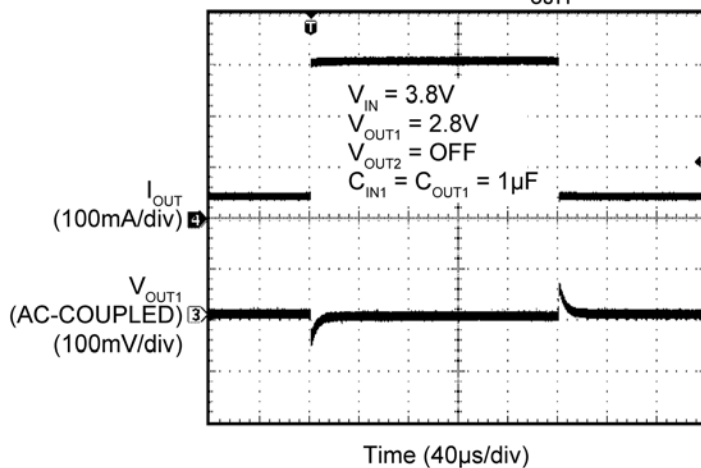
Line Transient V_{IN1}



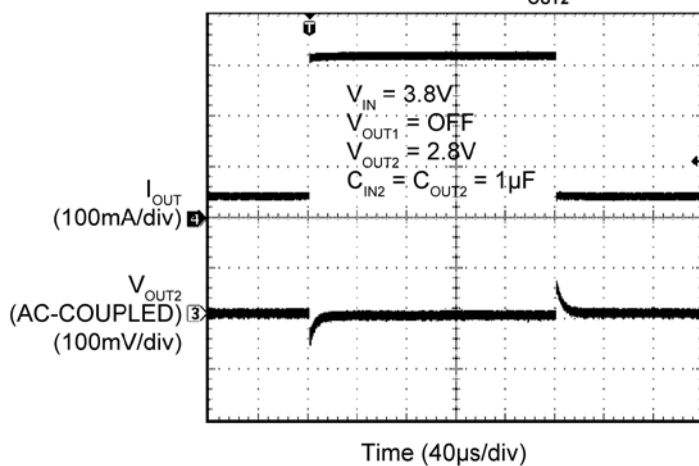
Line Transient V_{IN2}



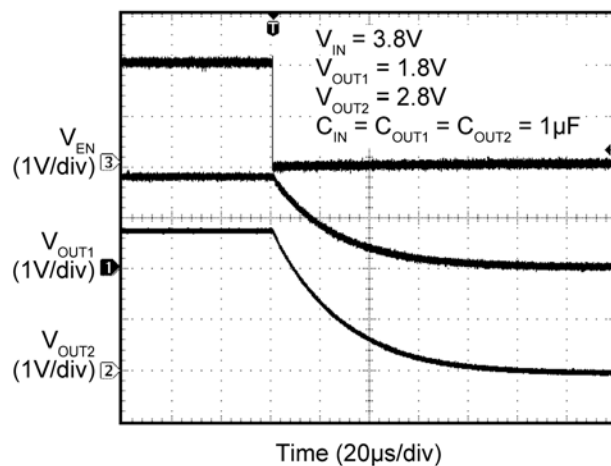
Load Transient V_{OUT1}



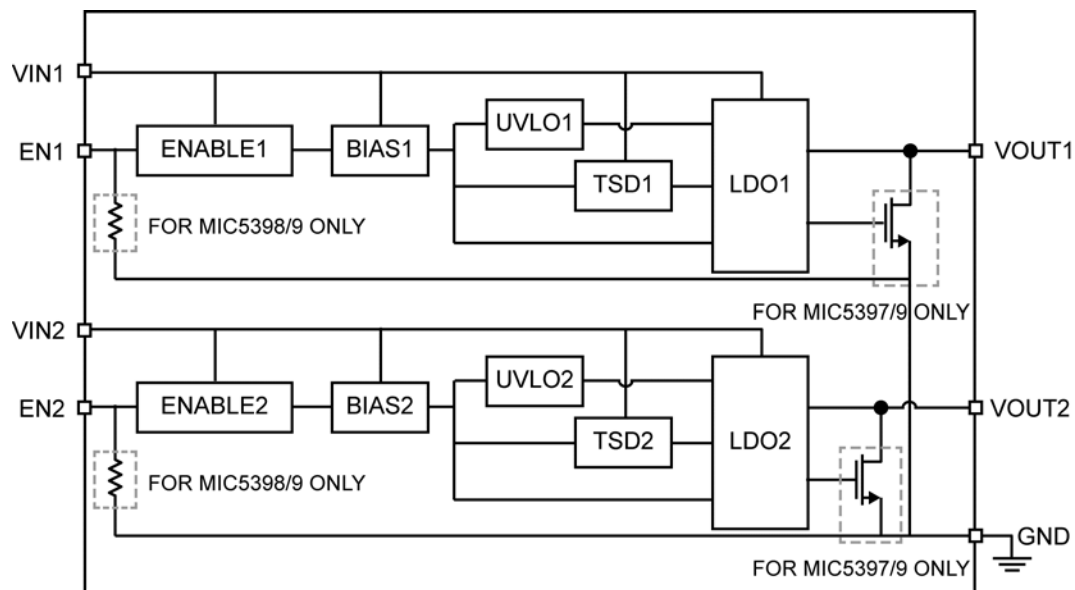
Load Transient V_{OUT2}



Turn-Off Time



Functional Diagram



MIC5396/7/8/9 Block Diagram

Application Information

MIC5396/7/8/9 is a dual 300mA LDO in a tiny 8-pin 1.2mm x 1.6mm extra thin DFN package. The MIC5397 and MIC5399 include an auto-discharge circuit for each LDO output, which is activated when the output is disabled. The MIC5398 and MIC5399 have an internal pull-down resistor on the enable pin to ensure that the output is disabled if the control signal is tri-stated. The MIC5396/7/8/9 regulator is fully protected from damage due to fault conditions using linear current limiting and thermal shutdown.

Input Capacitor

The MIC5396/7/8/9 is a high-performance, high-bandwidth device. An input capacitor of 1μF is required from the input pin to ground to provide stability. Low-ESR ceramic capacitors provide optimal performance in a small board area. 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. X5R or X7R dielectrics are recommended for the input capacitor. Y5V dielectrics lose most of their capacitance over temperature and are therefore not recommended.

Output Capacitor

The MIC5396/7/8/9 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 and X5R dielectric ceramic capacitors are recommended because of their temperature performance. X7R 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.

No Load Stability

Unlike many other voltage regulators, the MIC5396/7/8/9 will remain stable and in regulation with no load.

Enable/Shutdown

The MIC5396/7/8/9 comes with two active-high enable pins that allow each regulator to be disabled independently. Forcing the enable pin low disables the regulator and sends it into an off mode current state drawing virtually zero current. When disabled, the MIC5397 and MIC5399 switch an internal 25Ω load on the regulator output to discharge the external capacitor.

Forcing the enable pin high enables the output voltage. The MIC5396 and MIC5397 active-high enable pin uses CMOS technology and cannot be left floating. A floating enable pin may cause an indeterminate state on the output. The MIC5398 and MIC5399 have an internal pull-down resistor on the enable pin to disable the output when the enable pin is floating.

Thermal Considerations

The MIC5396/7/8/9 is designed to provide two 300mA continuous current outputs in a very small package. Maximum operating temperature can be calculated based on the output currents and the voltage drop across the part. For example, if the input voltage is 3.6V, $V_{OUT1} = 3.3V$, $V_{OUT2} = 2.8V$, each with an output current of 300mA. The actual power dissipation of the regulator circuit can be determined using the equation:

$$P_D = (V_{IN} - V_{OUT1}) I_{OUT1} + (V_{IN} - V_{OUT2}) I_{OUT2} + V_{IN} I_{GND}$$

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

$$P_D = (3.6V - 3.3V) \times 300mA + (3.6V - 2.8V) \times 300mA \\ P_D = 0.33W$$

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:

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

$$T_{J(MAX)} = 125^{\circ}C$$

$$\theta_{JA} = 172.6^{\circ}C/W$$

Substituting P_D for $P_{D(MAX)}$ and solving for the ambient operating temperature gives the maximum operating conditions for the regulator circuit. The junction to ambient thermal resistance for the minimum footprint is 172.6°C/W .

For proper operation, do not exceed the maximum power dissipation.

For example, when operating a 3.3V/2.8V application with an input voltage of 3.6V and 300mA at each output with a minimum footprint layout, the maximum ambient operating temperature T_A can be determined as follows:

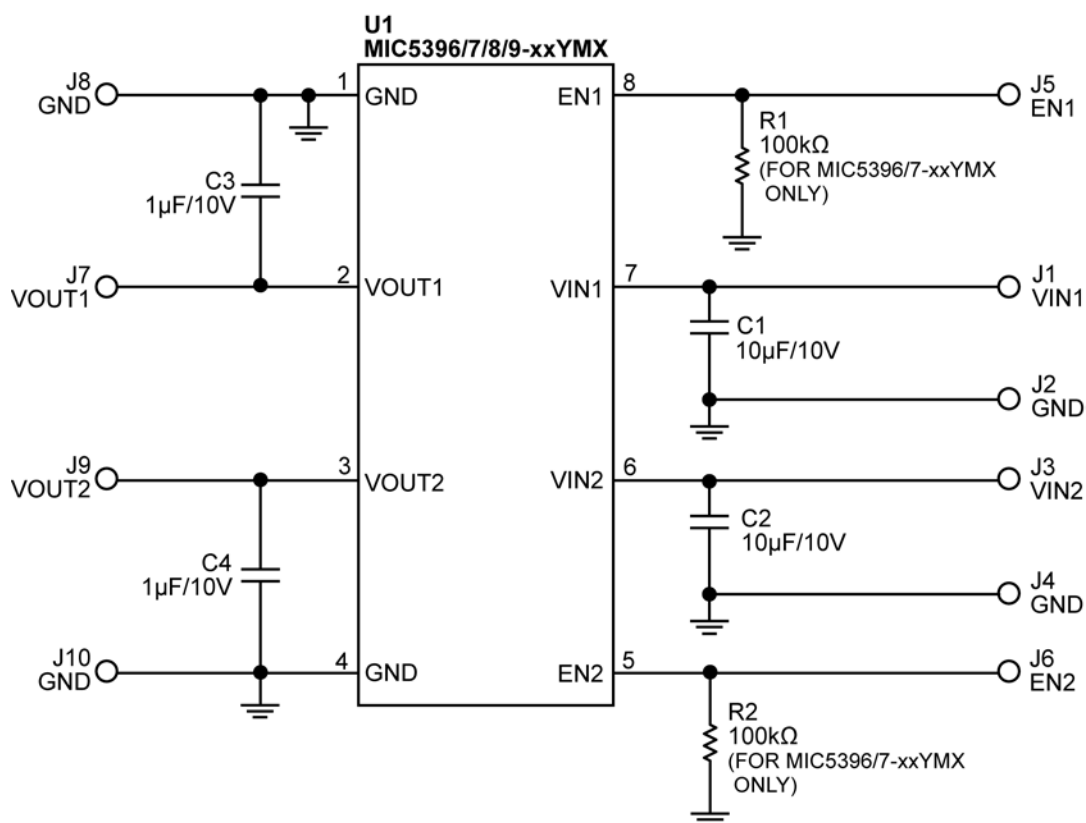
$$0.33\text{W} = (125^{\circ}\text{C} - T_A)/(172.6^{\circ}\text{C/W})$$

$$T_A = 68.04^{\circ}\text{C}$$

Therefore, a MIC5396-SMYMX application with 300mA at each output current can accept an ambient operating temperature of 68.04°C in a 1.6mm x 1.2mm Extra Thin DFN 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

Typical Application Schematic



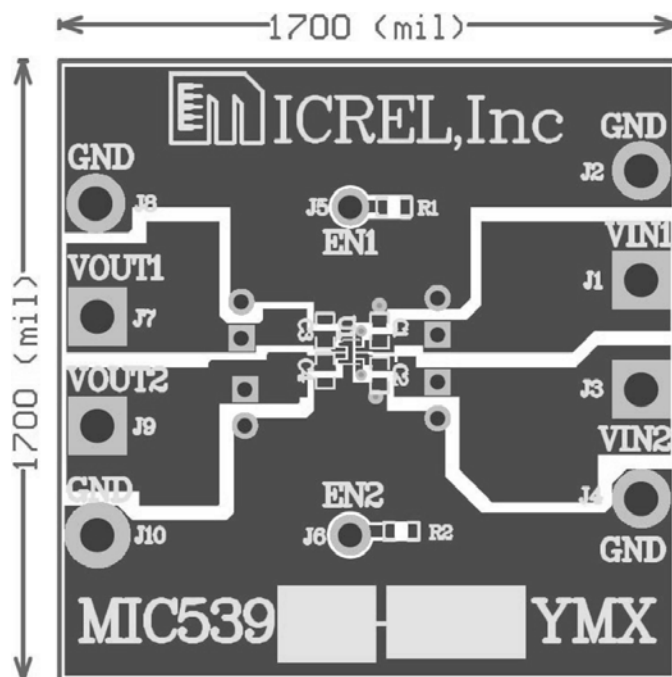
Bill of Materials

| Item | Part Number | Manufacturer | Description | Qty. |
|--------|---------------------|-----------------------------|--|------|
| C1, C2 | C1608X5R0J106K | TDK ⁽¹⁾ | Capacitor, 10µF Ceramic, 6.3V, X5R, Size 0603 | 2 |
| C3, C4 | C1005X5R1A105K | TDK | Capacitor, 1µF Ceramic, 10V, X5R, Size 0402 | 2 |
| R1, R2 | CR0603100KFKEA | Vishay ⁽²⁾ | Resistor, 100kΩ, 1/16W, Size 0603 | 2 |
| U1 | MIC5396/7/8/9-xxYMX | Micrel, Inc. ⁽³⁾ | Dual, 300mA LDO, Size 1.2mm × 1.6mm Extra Thin DFN | 1 |

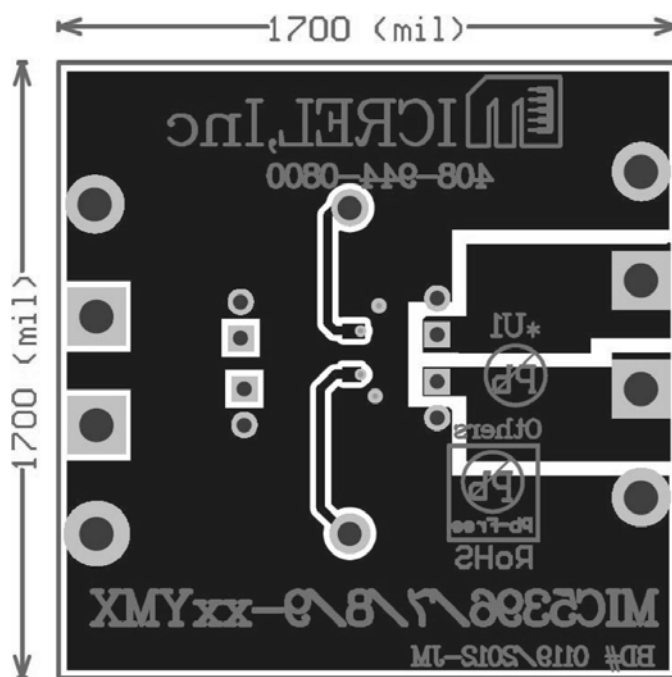
Notes:

1. TDK: www.tdk.com.
2. Vishay: www.vishay.com.
3. Micrel, Inc.: www.website.com.

PCB Layout Recommendations

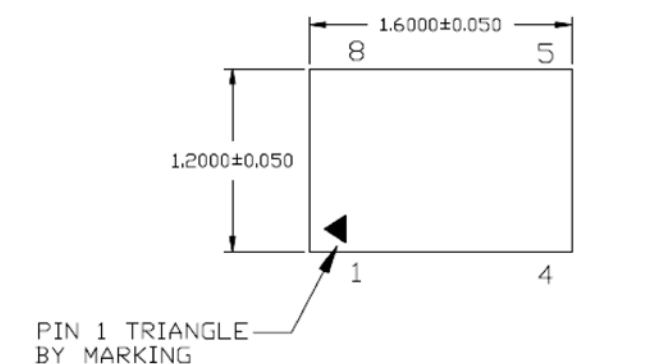


Top Layer



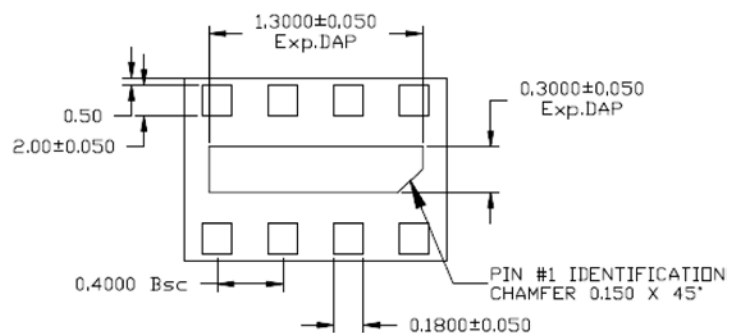
Bottom Layer

Package Information⁽¹⁾



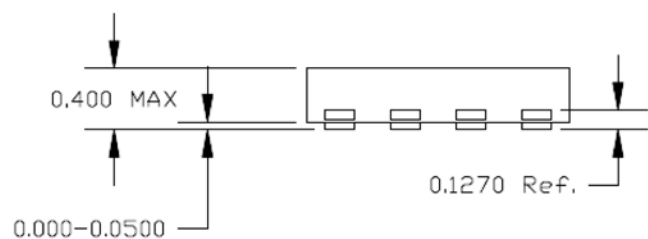
TOP VIEW

NOTE: 1, 2



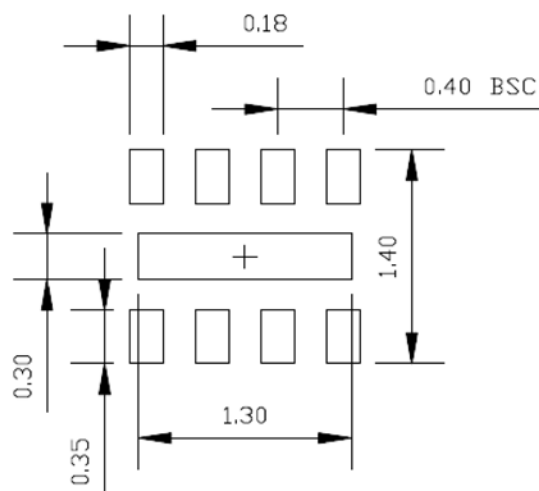
BOTTOM VIEW

NOTE: 1, 2, 3



SIDE VIEW

NOTE: 1, 2



RECOMMENDED LAND PATTERN

NOTE:

1. MAX PACKAGE WARPAGE IS 0.05 MM
2. MAX ALLOWABLE BURR IS 0.076MM IN ALL DIRECTIONS
3. LEAD AND EPAD CORNER MAXIMUM RADIUS 0.075MM

8-Pin 1.2mm x 1.6mm Thin DFN (MX)

Note:

1. Package information is correct as of the publication date. For updates and most current information, go to www.micrel.com.

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[MIC5399-MMYMT TR](#) [MIC5399-GMYMT T5](#) [MIC5399-SGYMX T5](#) [MIC5399-MMYMX T5](#) [MIC5399-SGYMX TR](#)
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