



## MIC5392/3

### High-Performance Dual 150mA LDO

#### General Description

The MIC5392/3 is a tiny dual low-dropout linear regulator ideally suited for portable electronics. It is ideal for general purpose/digital applications which require high-power supply ripple rejection (PSRR) >60dB, eliminating the need for a bypass capacitor and providing two enable pins for maximum flexibility. The MIC5392/3 integrates two high-performance; 150mA LDOs into a tiny 6-pin, 1.2mm × 1.2mm leadless DFN package, which provides exceptional thermal package characteristics.

The MIC5392/3 is a  $\mu$ Cap design which enables operation with very small ceramic output capacitors for stability, thereby reducing required board space and component cost. The combination of low-drop-out voltage, high power supply rejection and exceptional thermal package characteristics makes it ideal for powering mobile phones camera modules, image sensors, PDAs, MP3 players and audio codec power applications.

The MIC5392/3 is available in fixed-output voltages in the tiny 6-pin 1.2mm × 1.2mm leadless DFN package which is only 1.44mm<sup>2</sup> in area. Additional voltage options are available.

Datasheets and support documentation are available on Micrel's web site at: [www.micrel.com](http://www.micrel.com).

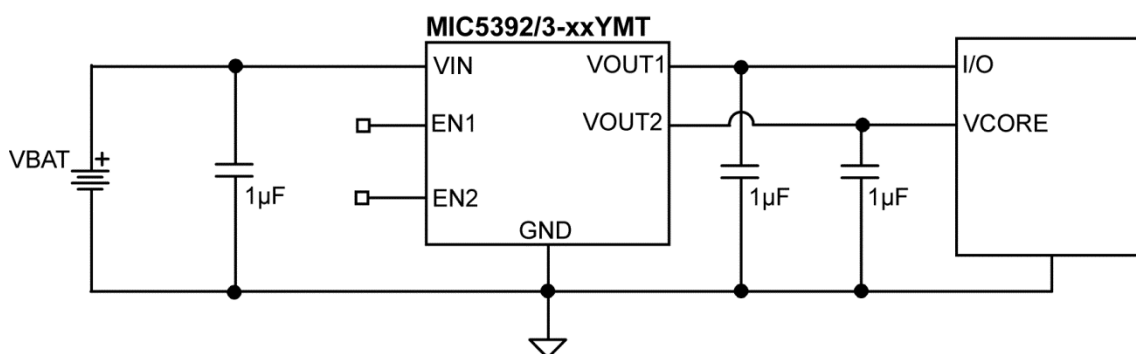
#### Features

- 2.5V to 5.5V input voltage range
- Two 150mA output current LDOs
- High output accuracy
  - $\pm 2\%$  initial accuracy
- Low quiescent current (32 $\mu$ A per LDO)
- Stable with 1 $\mu$ F ceramic output capacitors
- Independent enable pins
- Low dropout voltage (155mV at 150mA)
- Thermal-shutdown protection
- Current-limit protection
- Internal 25 $\Omega$  output discharge circuit (MIC5393)
- 1.2mm × 1.2mm Extra Thin DFN package (H  $\leq$  0.4mm)
- 1.2mm × 1.2mm Thin DFN package

#### Applications

- Smart phones
- Tablet PCs
- GPS, PMP, PDAs, and handhelds
- Audio codec power
- Portable electronics
- 5V systems

#### Typical Application



Camera DSP Power Supply Circuit

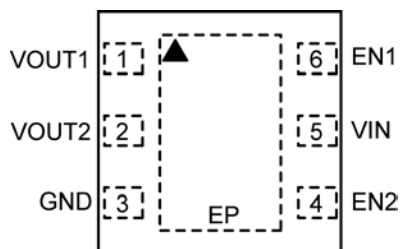
## Ordering Information

| Part Number <sup>(1)</sup>           | Manufacturing Part Number | Marking Code | Voltage  | Junction Temperature Range | Package <sup>(2)</sup>             |
|--------------------------------------|---------------------------|--------------|----------|----------------------------|------------------------------------|
| MIC5392-1.2/1.0YMT                   | <b>MIC5392-4CYMT</b>      | RJ           | 1.2/1.0V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Thin DFN       |
| MIC5392-1.5/2.8YMX <sup>(4)</sup>    | <b>MIC5392-FMYMX</b>      | RX           | 1.5/2.8V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Extra Thin DFN |
| MIC5392-2.8/1.5YMT                   | <b>MIC5392-MFYMT</b>      | RP           | 2.8/1.5V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Thin DFN       |
| MIC5392-2.8/1.8YMT                   | <b>MIC5392-MGYMT</b>      | RD           | 2.8/1.8V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Thin DFN       |
| MIC5392-3.0/1.8YMX <sup>(4)</sup>    | <b>MIC5392-PGYMX</b>      | 1R           | 3.0/1.8V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Extra Thin DFN |
| MIC5392-3.0/2.8YMT                   | <b>MIC5392-PMYMT</b>      | RM           | 3.0/2.8V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Thin DFN       |
| MIC5392-3.0/2.8YMX <sup>(4)</sup>    | <b>MIC5392-PMYMX</b>      | 2R           | 3.0/2.8V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Extra Thin DFN |
| MIC5392-3.0/3.0YMX <sup>(4)</sup>    | <b>MIC5392-PPYMX</b>      | 3R           | 3.0/3.0V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Extra Thin DFN |
| MIC5392-3.3/1.8YMX <sup>(4)</sup>    | <b>MIC5392-SGYMX</b>      | 4R           | 3.3/1.8V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Extra Thin DFN |
| MIC5392-3.3/3.3YMT                   | <b>MIC5392-SSYMT</b>      | RL           | 3.3/3.3V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Thin DFN       |
| MIC5392-3.3/3.3YMX <sup>(4)</sup>    | <b>MIC5392-SSYMX</b>      | 5R           | 3.3/3.3V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Extra Thin DFN |
| MIC5393-1.5/2.8YMX <sup>(3)</sup>    | <b>MIC5393-FMYMX</b>      | U6           | 1.5/2.8V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Extra Thin DFN |
| MIC5393-2.8/2.8YMX <sup>(3)</sup>    | <b>MIC5393-MMYMX</b>      | UV           | 2.8/2.8  | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Extra Thin DFN |
| MIC5393-3.0/1.8YMX <sup>(3)</sup>    | <b>MIC5393-PGYMX</b>      | U5           | 3.0/1.8V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Extra Thin DFN |
| MIC5393-3.0/2.8YMX <sup>(3)(4)</sup> | <b>MIC5393-PMYMX</b>      | UU           | 3.0/2.8V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Extra Thin DFN |
| MIC5393-3.0/3.0YMT <sup>(3)</sup>    | <b>MIC5393-PPYMT</b>      | UL           | 3.0/3.0V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Thin DFN       |
| MIC5393-3.0/3.0YMX <sup>(3)</sup>    | <b>MIC5393-PPYMX</b>      | U3           | 3.0/3.0V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Extra Thin DFN |
| MIC5393-3.3/1.8YMT <sup>(3)</sup>    | <b>MIC5393-SGYMT</b>      | UB           | 3.3/1.8V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Thin DFN       |
| MIC5393-3.3/1.8YMX <sup>(3)</sup>    | <b>MIC5393-SGYMX</b>      | U2           | 3.3/1.8V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Extra Thin DFN |
| MIC5393-3.3/3.3YMT <sup>(3)</sup>    | <b>MIC5393-SSYMT</b>      | UR           | 3.3/3.3V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Thin DFN       |
| MIC5393-3.3/3.3YMX <sup>(3)</sup>    | <b>MIC5393-SSYMX</b>      | U4           | 3.3/3.3V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Extra Thin DFN |
| MIC5393-1.5/2.8YMT                   | <b>MIC5393-FMYMT</b>      | UP           | 1.5/2.8V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Thin DFN       |
| MIC5393-1.8/2.8YMT                   | <b>MIC5393-GMYMT</b>      | UT           | 1.8/2.8V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Thin DFN       |
| MIC5393-1.8/2.8YMX                   | <b>MIC5393-GMYMX</b>      | U7           | 1.8/2.8V | –40°C to +125°C            | 6-Pin 1.2mm × 1.2mm Extra Thin DFN |

### Notes:

1. Other voltages available. Contact Micrel for details.
2. Thin DFN and Extra Thin DFN are GREEN, RoHS-compliant package. Lead finish is NiPdAu. Mold compound is Halogen Free.
3. MIC5393 offers Auto-Discharge function.
4. Contact factory for availability.

## Pin Configuration



6-Pin 1.2mm × 1.2mm Thin DFN (MT)  
6-Pin 1.2mm × 1.2mm Extra Thin DFN (MX)  
(Top View)

## Pin Description

| Pin Number | Pin Name | Pin Function                                                                                                                            |
|------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------|
| 1          | VOUT1    | Output regulator 1. Connect a capacitor to ground.                                                                                      |
| 2          | VOUT2    | Output regulator 2. Connect a capacitor to ground.                                                                                      |
| 3          | GND      | Ground.                                                                                                                                 |
| 4          | EN2      | Enable input for regulator 2. Logic High enables operation of regulator 2. Logic Low will shut down regulator 2. Do not leave floating. |
| 5          | VIN      | Input voltage supply. Connect a capacitor to ground.                                                                                    |
| 6          | EN1      | Enable input for regulator 1. Logic High enables operation of regulator 1. Logic Low will shut down regulator 1. Do not leave floating. |
| EP         | ePad     | Exposed heat sink pad. Connect to ground.                                                                                               |

## Absolute Maximum Ratings<sup>(5)</sup>

|                                          |                                   |
|------------------------------------------|-----------------------------------|
| Supply Voltage ( $V_{IN}$ )              | –0.3V to +6V                      |
| Enable Voltage ( $V_{EN1}$ , $V_{EN2}$ ) | –0.3V to $V_{IN}$                 |
| Power Dissipation ( $P_D$ )              | Internally Limited <sup>(7)</sup> |
| 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 <sup>(8)</sup>                | 2kV                               |

## Operating Ratings<sup>(6)</sup>

|                                                |                   |
|------------------------------------------------|-------------------|
| Supply Voltage ( $V_{IN}$ )                    | +2.5V to +5.5V    |
| Enable Voltage ( $V_{EN1}$ , $V_{EN2}$ )       | –0.3V to $V_{IN}$ |
| Junction Temperature ( $T_J$ )                 | –40°C to +85°C    |
| Junction Thermal Resistance                    |                   |
| 1.2mm×1.2mm Thin DFN-6 ( $\theta_{JA}$ )       | 173°C/W           |
| 1.2mm×1.2mm Extra Thin DFN-6 ( $\theta_{JA}$ ) | 173°C/W           |

## Electrical Characteristics<sup>(9)</sup>

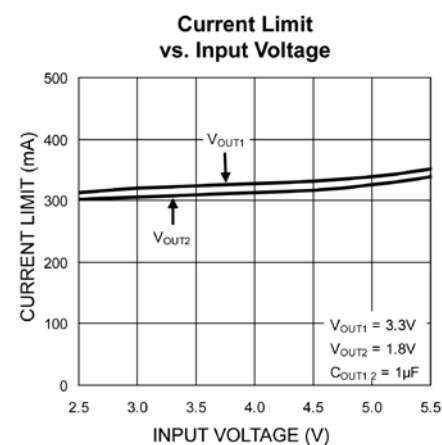
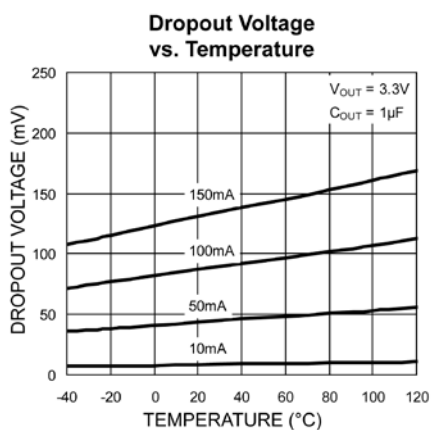
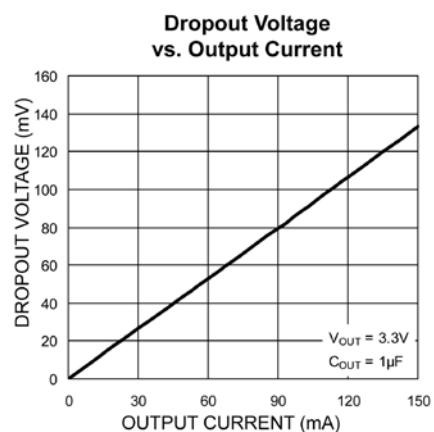
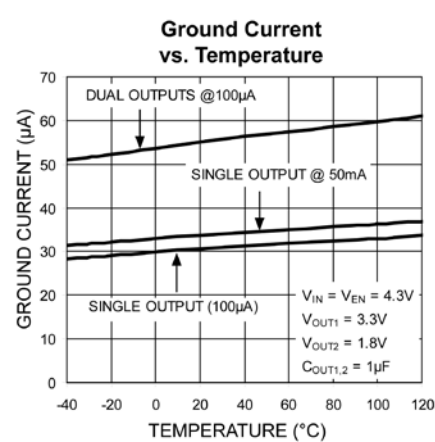
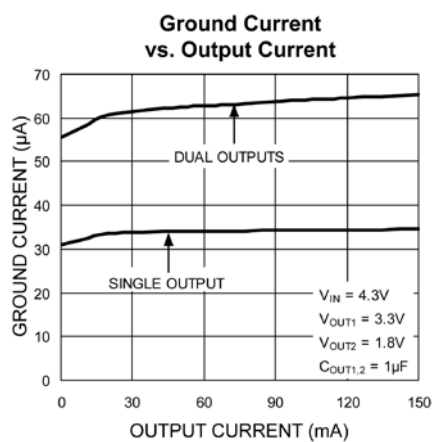
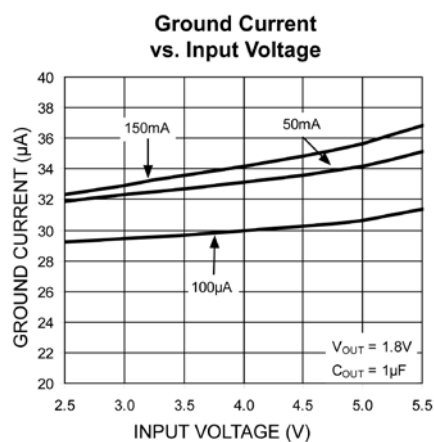
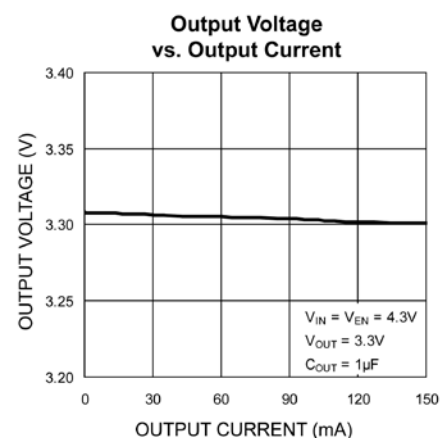
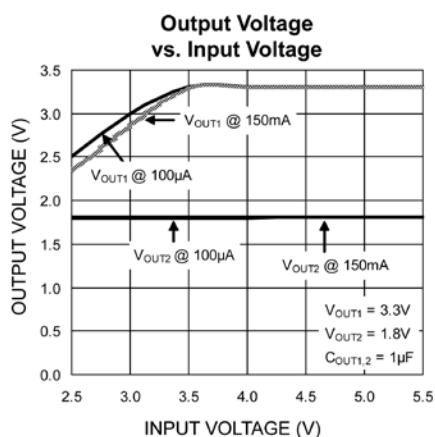
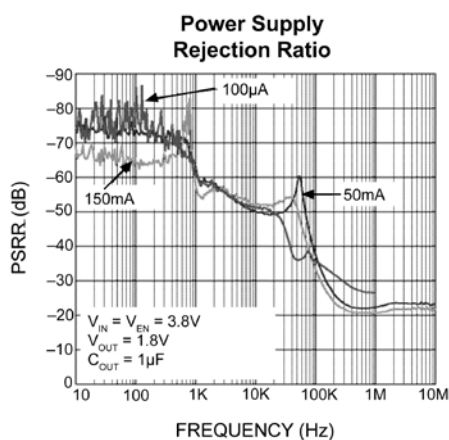
$V_{IN} = V_{EN1} = V_{EN2} = V_{OUT} + 1V$ ; higher of the two regulator outputs;  $I_{OUTLDO1} = I_{OUTLDO2} = 100\mu A$ ;  $C_{OUT1} = C_{OUT2} = 1\mu F$ ;  $T_J = 25^\circ C$ , **Bold** values indicate –40°C to +125°C, unless noted.

| Parameter                      | Condition                                                          | Min.        | Typ. | Max.        | Units         |
|--------------------------------|--------------------------------------------------------------------|-------------|------|-------------|---------------|
| Output Voltage Accuracy        | Variation from nominal $V_{OUT}$                                   | –2.0        |      | +2.0        | %             |
|                                | Variation from nominal $V_{OUT}$ ; –40°C to +125°C                 | <b>–3.0</b> |      | <b>+3.0</b> |               |
| Line Regulation                | $V_{IN} = V_{OUT} + 1V$ to 5.5V                                    |             | 0.02 | <b>0.3</b>  | %/V           |
| Load Regulation                | $I_{OUT} = 100\mu A$ to 150mA                                      |             | 0.3  | 1           | %             |
| Dropout Voltage                | $I_{OUT} = 50mA$                                                   |             | 50   | <b>110</b>  | mV            |
|                                | $I_{OUT} = 150mA$                                                  |             | 155  | <b>310</b>  |               |
| Ground Pin Current             | $V_{EN1} = \text{High}$ ; $V_{EN2} = \text{Low}$ ; $I_{OUT} = 0mA$ |             | 32   | <b>45</b>   | $\mu A$       |
|                                | $V_{EN1} = \text{Low}$ ; $V_{EN2} = \text{High}$ ; $I_{OUT} = 0mA$ |             | 32   | <b>45</b>   |               |
|                                | $V_{EN1} = V_{EN2} = \text{High}$ ; $I_{OUT1} = I_{OUT2} = 0mA$    |             | 57   | <b>85</b>   |               |
| Ground Pin Current in Shutdown | $V_{EN1} = V_{EN2} = 0V$                                           |             | 0.05 | 1           | $\mu A$       |
| Ripple Rejection               | $f = 1kHz$ ; $C_{OUT} = 1\mu F$                                    |             | 60   |             | dB            |
| Current Limit                  | $V_{OUT} = 0V$                                                     | 200         | 325  | 550         | mA            |
| Output Voltage Noise           | $C_{OUT} = 1\mu F$ , 10Hz to 100kHz                                |             | 100  |             | $\mu V_{RMS}$ |
| Auto-Discharge NFET Resistance | MIC5393 Only; $V_{EN1} = V_{EN2} = 0V$ ; $V_{IN} = 3.6V$           |             | 25   |             | $\Omega$      |
| <b>Enable Inputs (EN1/EN2)</b> |                                                                    |             |      |             |               |
| Enable Input Voltage           | Logic Low                                                          |             |      | <b>0.2</b>  | V             |
|                                | Logic High                                                         | <b>1.2</b>  |      |             |               |
| Enable Input Current           | $V_{IL} \leq 0.2V$                                                 |             | 0.01 | <b>1</b>    | $\mu A$       |
|                                | $V_{IH} \geq 1.2V$                                                 |             | 0.01 | <b>1</b>    |               |
| Turn-On Time                   | $C_{OUT} = 1\mu F$                                                 |             | 50   | <b>125</b>  | $\mu s$       |

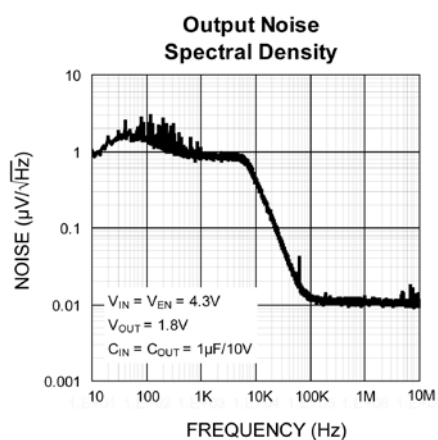
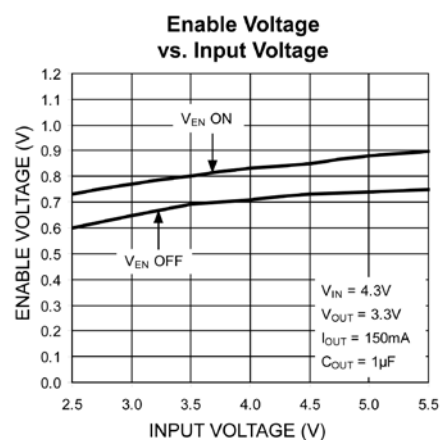
### Notes:

- 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  $P_{D(max)} = (T_J(max) - T_A) / \theta_{JA}$ . 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 $\Omega$  in series with 100pF.
- Specification for packaged product only.

## Typical Characteristics

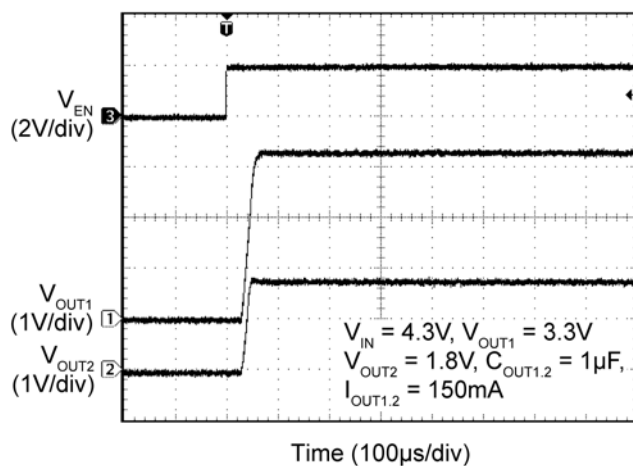


## Typical Characteristics (Continued)

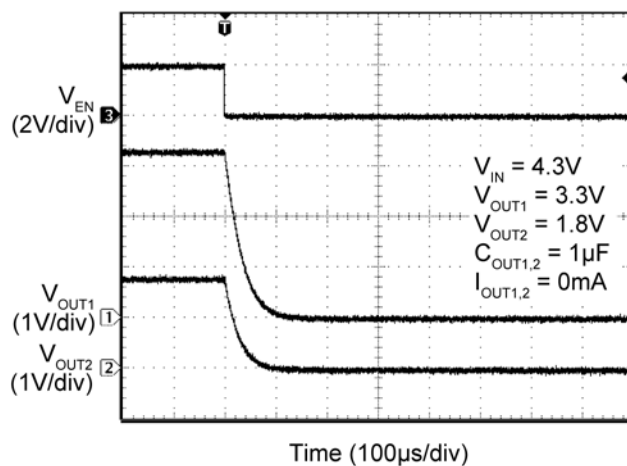


## Functional Characteristics

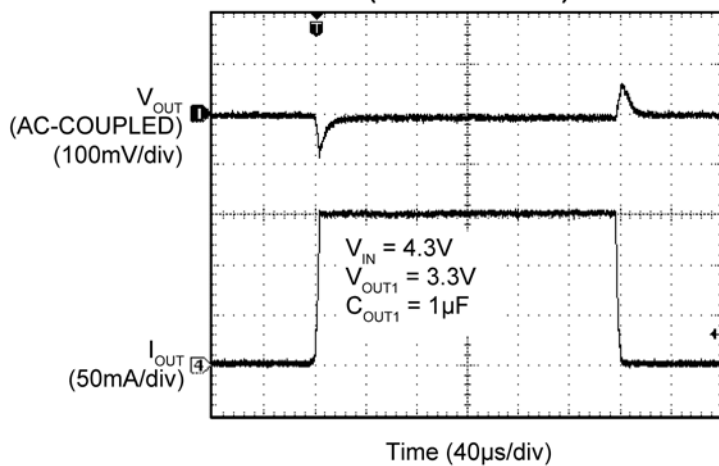
### Turn-On Time



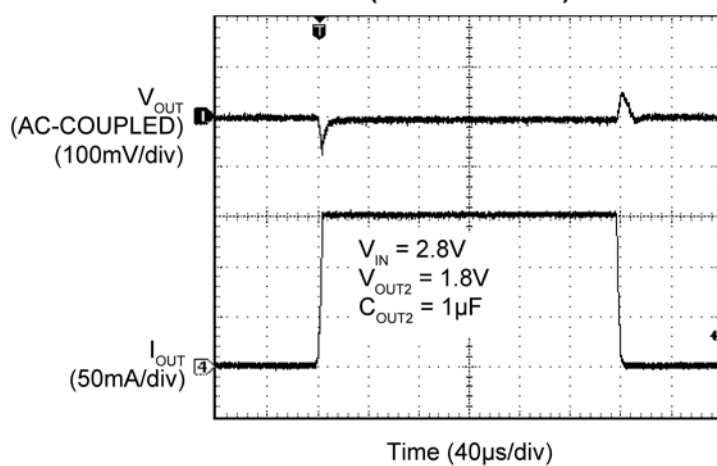
### MIC5393 Turn-Off Time (Auto-Discharge)



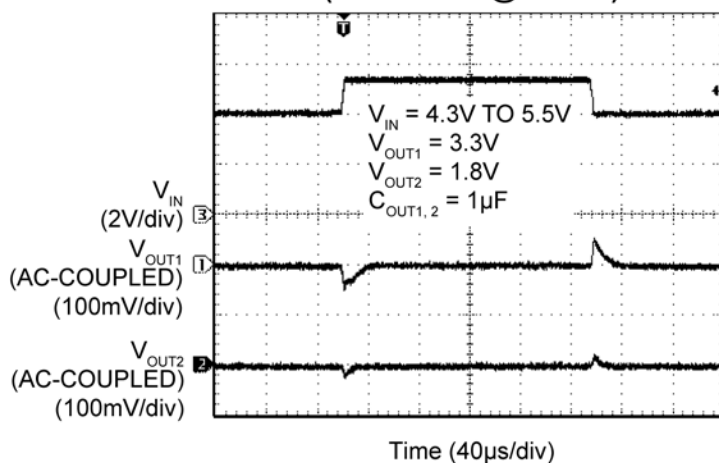
### Load Transient (5mA to 150mA)



### Load Transient (5mA to 150mA)



### Line Transient (4.3V to 5.5V @ 150mA)



## Functional Diagram

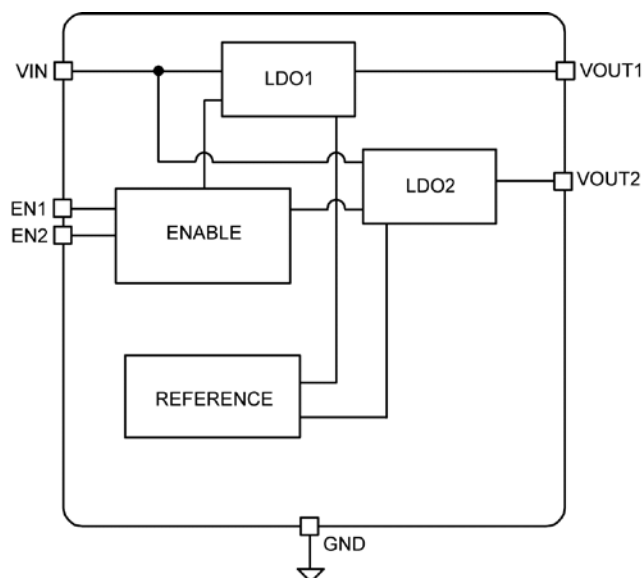


Figure 1. Simplified MIC5392 Functional Block Diagram

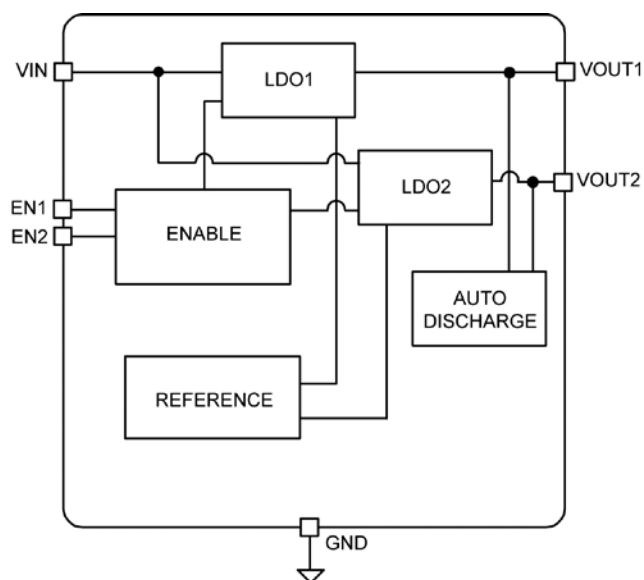


Figure 2. Simplified MIC5393 Functional Block Diagram

## Application Information

MIC5392/3 is a dual 150mA LDO in a small 1.2mm × 1.2mm package. The MIC5393 includes an auto-discharge circuit for each of the LDO outputs that are activated when the output is disabled. The MIC5392/3 regulator is fully protected from damage due to fault conditions through linear current limiting and thermal shutdown.

### Input Capacitor

The MIC5392/3 is a high-performance, high-bandwidth device. An input capacitor of 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. 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 MIC5392/3 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.

### No-Load Stability

Unlike many other voltage regulators, the MIC5392/3 will remain stable and in regulation with no load. This is especially important in CMOS RAM to keep applications alive.

### Enable/Shutdown

The MIC5392/3 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 a “zero” off-mode-current state. In this state, current consumed by the regulator goes nearly to zero. When disabled the MIC5393 switches a 25Ω (typical)

load on the regulator output to discharge the external capacitor.

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 MIC5392/3 is designed to provide 150mA of continuous current for both outputs in a very small package. Maximum ambient operating temperature can be calculated based on the output current and the voltage drop across the part. For example if the input voltage is 3.6V, the output voltage is 3.0V for VOUT1, 2.8V for VOUT2 and the output current = 150mA. The actual power dissipation of the regulator circuit can be determined using [Equation 1](#):

Eq. 1

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

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 the calculation in [Equation 2](#):

Eq. 2

$$P_D = (3.6V - 3.0V) \times 150mA + (3.6V - 2.8V) \times 150mA$$

$$P_D = 0.21W$$

To determine the maximum ambient operating temperature of the package, use the junction-to-ambient thermal resistance of the device and the following basic formula in [Equation 3](#):

Eq. 3

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

$T_{J(MAX)} = 125^\circ\text{C}$ , and the maximum junction temperature of the die,  $\theta_{JA}$ , thermal resistance =  $173^\circ\text{C/W}$ .

Substituting PD for PD(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  $173^\circ\text{C/W}$ .

The maximum power dissipation must not be exceeded for proper operation.

For example, when operating the MIC5392-PMYMT at an input voltage of 3.6V and 150mA loads at each output with a minimum footprint layout, the maximum ambient operating temperature  $T_A$  can be determined in [Equation 4](#):

**Eq. 4**

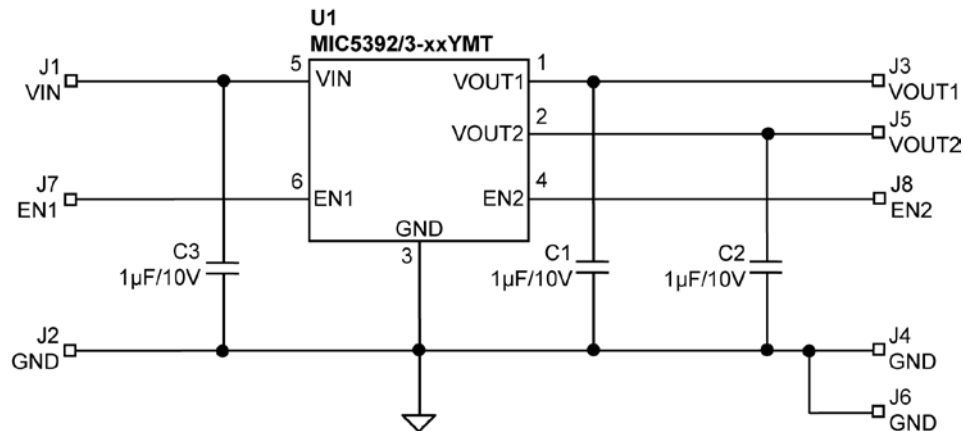
$$0.21W = (125^{\circ}\text{C} - T_A)/(173^{\circ}\text{C/W})$$

$$T_A = 89^{\circ}\text{C}$$

Therefore, a 2.8V/1.8V application with 150mA at each output current can accept an ambient operating temperature of 58°C in a 1.2mm × 1.2mm 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](http://www.micrel.com/PDF/other/LDOBk_ds.pdf)

Typical Application Circuit



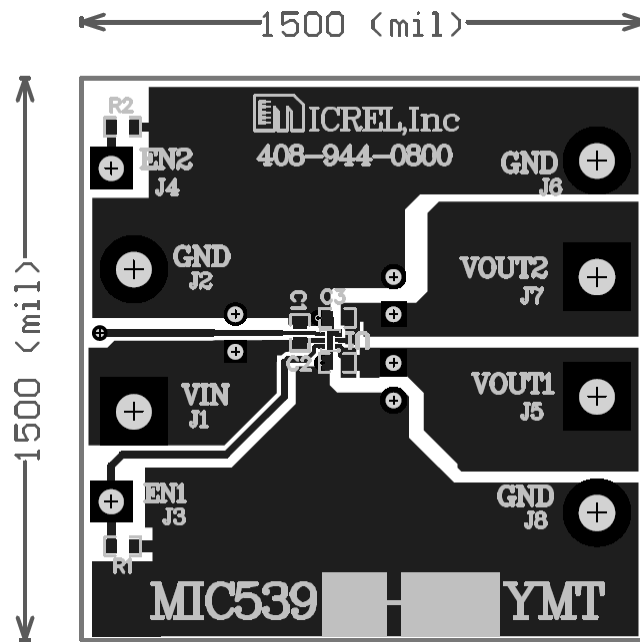
Bill of Materials

| Item       | Part Number                        | Manufacturer                | Description                     | Qty. |
|------------|------------------------------------|-----------------------------|---------------------------------|------|
| C1, C2, C3 | GRM188R61A105KE19D                 | Murata <sup>(10)</sup>      | Capacitor, 1µF, 10V, X5R, 0603  | 3    |
| U1         | MIC5392/3-xxYMT<br>MIC5392/3-xxYMX | Micrel, Inc. <sup>(9)</sup> | High-Performance Dual 150mA LDO | 1    |

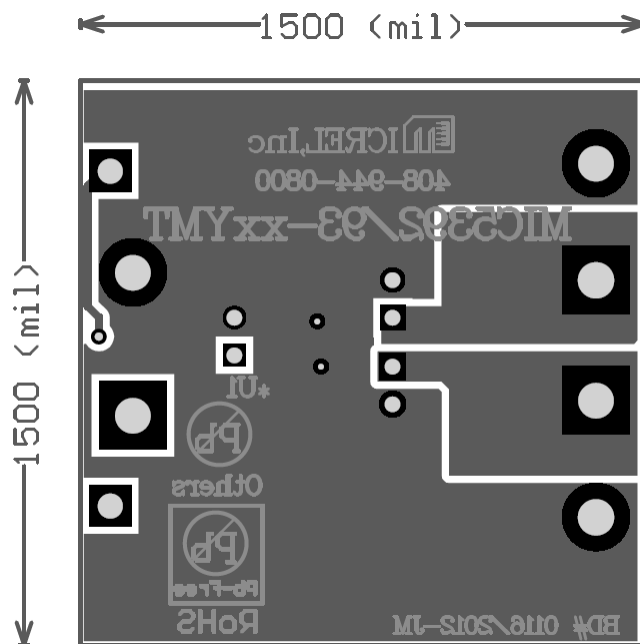
Notes:

10. Murata: [www.murata.com](http://www.murata.com).  
11. Micrel, Inc.: [www.micrel.com](http://www.micrel.com).

## PCB Layout Recommendations

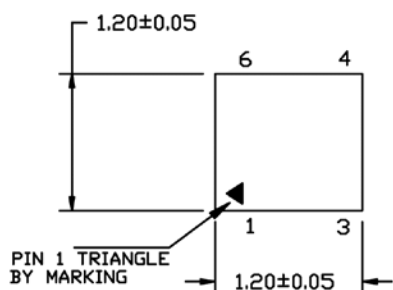


## Top Layer



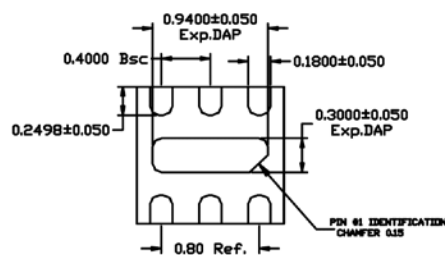
### Bottom Layer

## Package Information and Recommended Landing Pattern<sup>(12)</sup>



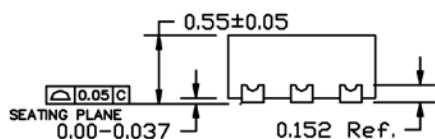
TOP VIEW

NOTE: 1, 2, 3



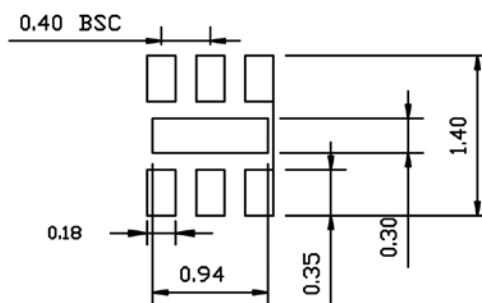
BOTTOM VIEW

NOTE: 1, 2, 3



SIDE VIEW

NOTE: 1, 2, 3



RECOMMENDED LAND PATTERN

NOTE:

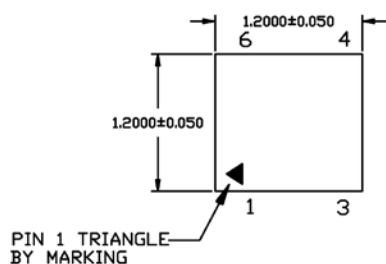
1. MAX PACKAGE WARPAGE IS 0.05 MM
2. MAX ALLOWABLE BURR IS 0.076MM IN ALL DIRECTIONS
3. PIN #1 IS ON TOP WILL BE LASER MARKED

### 6-Pin 1mm x 1mm Thin DFN (MT)

#### Note:

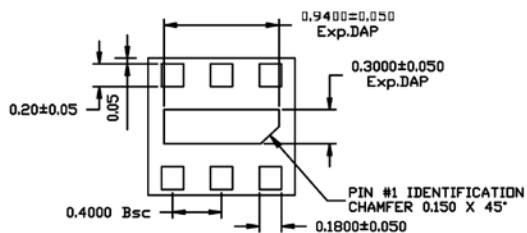
12. Package information is correct as of the publication date. For updates and most current information, go to [www.micrel.com](http://www.micrel.com).

# Package Information and Recommended Landing Pattern<sup>(12)</sup> (Continued)



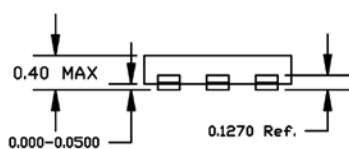
TOP VIEW

NOTE: 1, 2



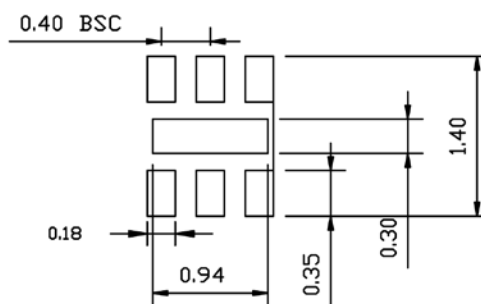
BOTTOM VIEW

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

## 6-Pin 1.2mm × 1.2mm Extra Thin DFN (MX)

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