MIC5396/7/8/9

Low-Power Dual 300 mA LDO

Features

- 2.5V to 5.5V Input Voltage Range
- Independent Power Inputs
- Output Voltage Range from 1V to 3.3V
- Two 300 mA Outputs
- High Output Accuracy (±2%)
- Low Quiescent Current (37 µA Typ. per LDO)
- Stable with 1 µF Ceramic Output Capacitors
- Low Dropout Voltage (160 mV at 300 mA)
- Independent Enable Pins
- Internal Enable Pull-Down (MIC5398, MIC5399)
- Output Discharge Circuit (MIC5397, MIC5399)
- Thermal Shutdown Protection
- Current Limit Protection
- 8-Pin 1.6 mm × 1.2 mm Extra Thin DFN Package

Applications

- Smartphones
- DSC, GPS, PMP and PDAs
- Medical Devices
- Portable Electronics

General Description

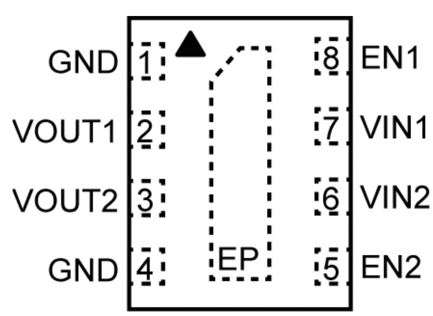
The MIC5396/7/8/9 is an advanced dual LDO ideal for powering general purpose portable devices. The MIC5396/7/8/9 provides two high performance, independent 300 mA LDOs in a single package. This makes it possible to improve system efficiency by providing two independent supply inputs that can be optimized 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 (160 mV at 300 mA), and low ground current (typically 42 µA 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.

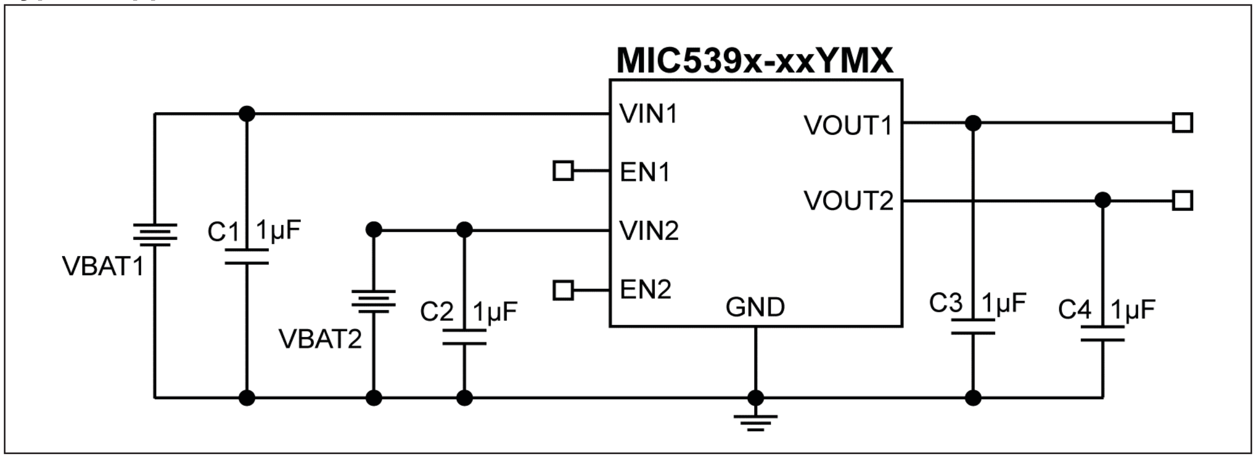
When the MIC5397/9 is disabled, an internal resistive load is automatically applied to the output to discharge the output capacitor. In addition, the MIC5398/9 offers an internal enable pull-down resistor to ensure that the output is disabled when the enable is in tri-state mode. These LDO's also offer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

Package Type

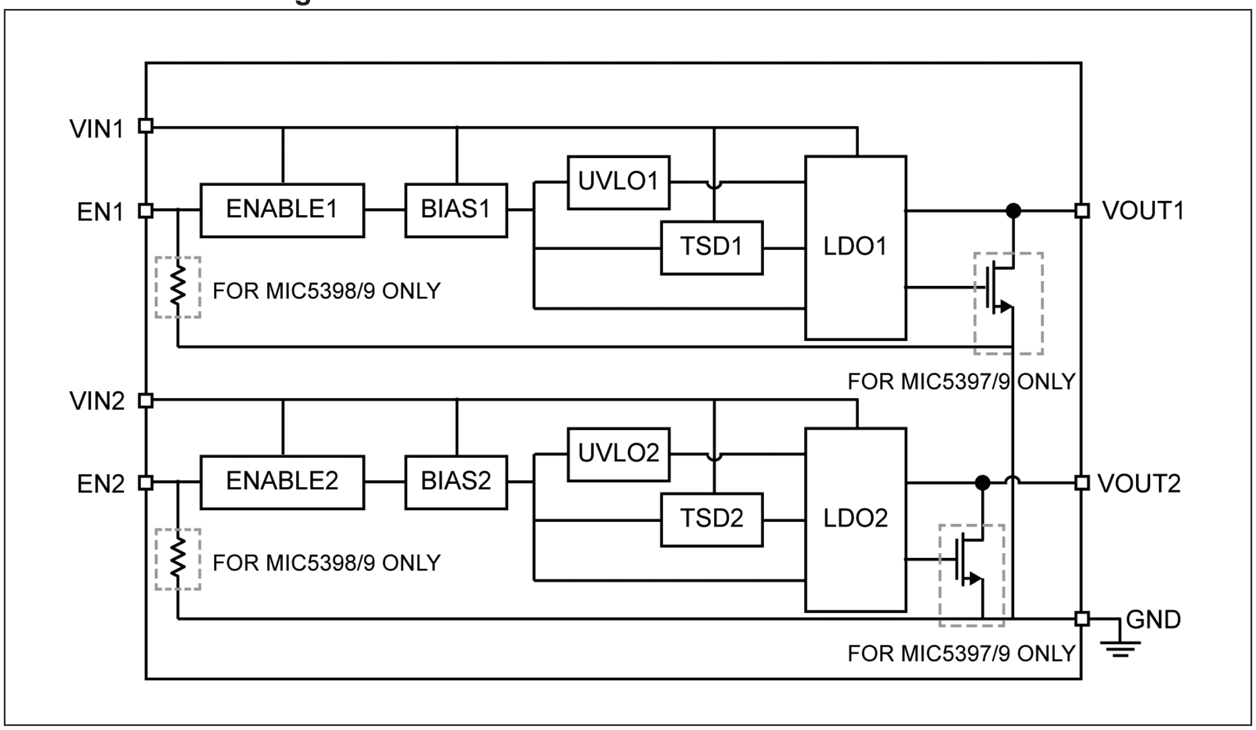
TDFN-8 (MT), XTDFN-8 (MX)
(Top View)



Typical Application Schematic



Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

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) Note 1 .... Internally Limited
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 Note 2 .... 3 kV

Operating Ratings ‡

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
Package Thermal Resistance
1.6 mm x 1.2 mm XTDFN-8 (θ_{JA}) .... 172.6°C/W

† Notice: Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

‡ Notice: The device is not guaranteed to function outside its operating ratings.

Note 1: 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.

2: Devices are ESD sensitive. Handling precautions are recommended. Human body model, 1.5 kΩ in series with 100 pF.

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: $V_{IN1} = V_{EN1} = V_{OUT1} + 1V$, $V_{IN2} = V_{EN2} = V_{OUT2} + 1V$, $I_{OUT1} = I_{OUT2} = 100\ \mu A$; $C_{IN1} = C_{IN2} = C_{OUT1} = C_{OUT2} = 1\ \mu F$; $T_A = +25°C$. **Bold** values are valid for –40°C to +125°C, unless noted. (**Note 1**).						
Parameters	**Symbol**	**Min.**	**Typ.**	**Max.**	**Units**	**Conditions**
Output Voltage Accuracy	V_{OUT}	–2.0	—	+2.0	%	Variation from nominal V_{OUT}
		–3.0	—	**+3.0**		
Line Regulation	—	—	0.02	**0.3**	%/V	$V_{IN} = V_{OUT}$ +1V to 5.5V, $I_{OUT} = 100\ \mu A$
Load Regulation	—	—	8	40	mV	$I_{OUT} = 100\ \mu A$ to 300 mA
Dropout Voltage	V_{DO}	—	80	**190**	mV	$I_{OUT} = 150$ mA
		—	160	**380**		$I_{OUT} = 300$ mA
Ground Pin Current	I_{GND}	—	37	**55**	µA	V_{EN1} = High; V_{EN2} = Low; $I_{OUT2} = 0$ mA
		—	37	**55**		V_{EN1} = Low; V_{EN2} = High; $I_{OUT1} = 0$ mA
		—	74	**110**		$V_{EN1} = V_{EN2}$ = High; $I_{OUT1} = I_{OUT2} = 0$ mA
		—	42	**65**		V_{EN1} = High; V_{EN2} = Low; $I_{OUT1} = 300$ mA
		—	42	**65**		V_{EN1} = Low; V_{EN2} = High; $I_{OUT2} = 300$ mA
		—	84	**130**		$V_{EN1} = V_{EN2}$ = High; $I_{OUT1} = I_{OUT2} = 300$ mA
Shutdown Current	I_{SHDN}	—	0.05	1	µA	$V_{EN1} = V_{EN2} = 0V$
Ripple Rejection	PSRR	—	60	—	dB	f = 1 kHz; $C_{OUT} = 1\ \mu F$
Current Limit	I_{LIM}	400	630	900	mA	$V_{OUT} = 0V$
Output Voltage Noise	e_N	—	93	—	μV_{RMS}	$C_{OUT} = 1\mu F$, 10 Hz to 100 kHz
Auto-Discharge NFET Resistance	$R_{DS(ON)}$	—	25	—	Ω	MIC5397, MIC5399 Only; $V_{EN1} = V_{EN2} = 0V$; $V_{IN} = 3.6V$; $I_{OUT} = –3$ mA
Enable Inputs (EN1/EN2)						
Enable Pull-Down Resistor	$R_{PULL-DN}$	—	4	—	MΩ	MIC5398, MIC5399
Enable Input Voltage	V_{EN-LOW}	—	—	**0.2**	V	Logic Low
	$V_{EN-HIGH}$	**1.2**	—	—		Logic High
Enable Input Current MIC5396, MIC5397	I_{EN}	—	0.01	**1**	µA	$V_{EN} = 0V$
		—	0.01	**1**		$V_{EN} = 5.5V$
Enable Input Current MIC5398, MIC5399	I_{EN}	—	0.01	**1**	µA	$V_{EN} = 0V$
		—	1.4	2		$V_{EN} = 5.5V$
Turn-On Time	t_{ON}	—	50	**125**	µs	$C_{OUT} = 1\ \mu F$

Note 1: Specification for packaged product only.

TEMPERATURE SPECIFICATIONS

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Junction Temperature Range	T_J	–40	—	+125	°C	Note 1
Storage Temperature Range	T_S	–65	—	+150	°C	—
Lead Temperature	—	—	—	260	°C	Soldering, 10 sec.
Package Thermal Resistances						
Thermal Resistance, DFN-8	θ_{JA}	—	172.6	—	°C/W	—
Thermal Resistance, Extra Thin DFN-8						

Note 1: The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e., T_A, T_J, θ_{JA}). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum +125°C rating. Sustained junction temperatures above +125°C can impact the device reliability.

2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

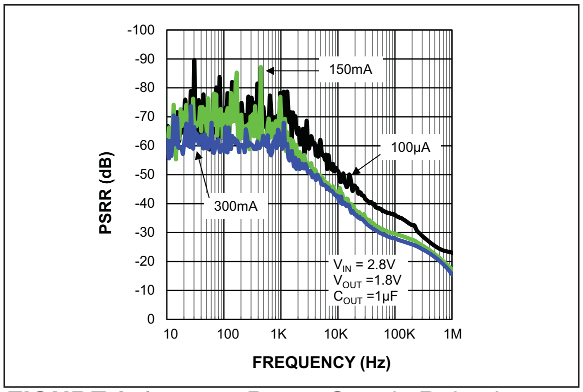


FIGURE 2-1: *Power Supply Rejection Ratio.*

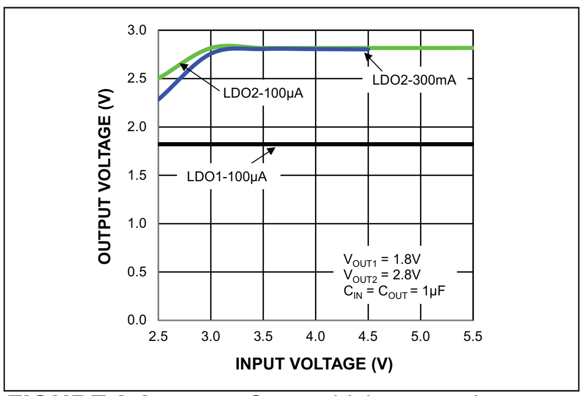


FIGURE 2-2: *Output Voltage vs. Input Voltage.*

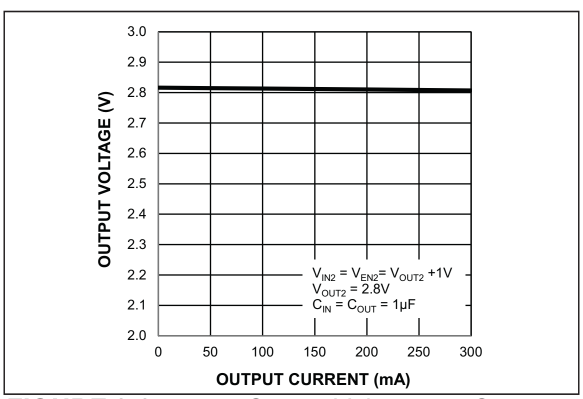


FIGURE 2-3: *Output Voltage vs. Output Current.*

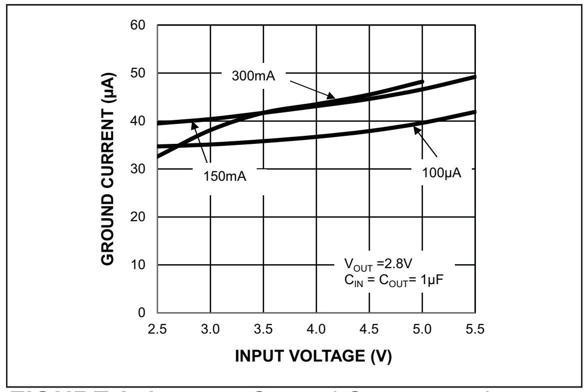


FIGURE 2-4: *Ground Current vs. Input Voltage.*

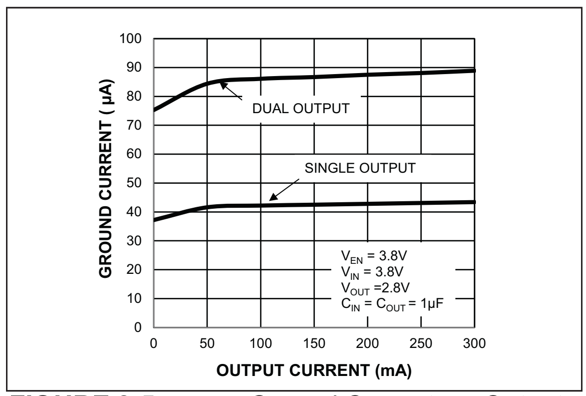


FIGURE 2-5: *Ground Current vs. Output Current.*

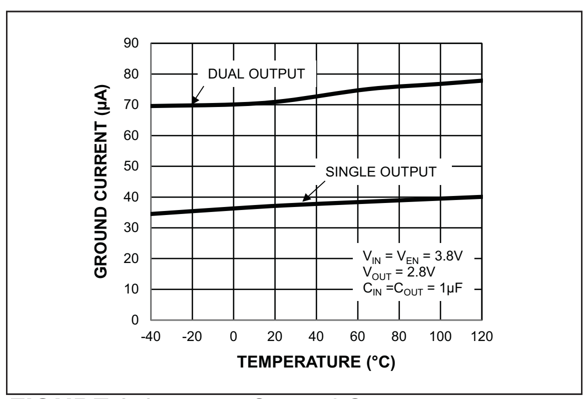


FIGURE 2-6: *Ground Current vs. Temperature.*

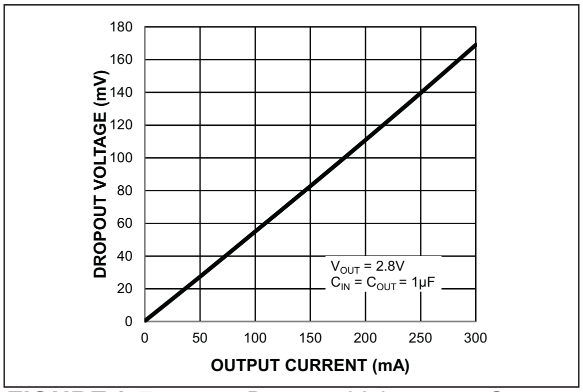


FIGURE 2-7: *Dropout Voltage vs. Output Current.*

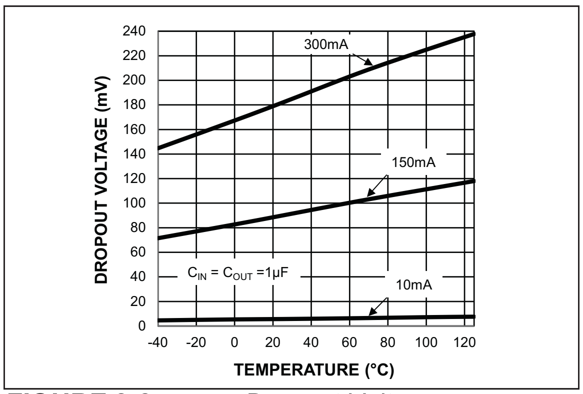


FIGURE 2-8: *Dropout Voltage vs. Temperature.*

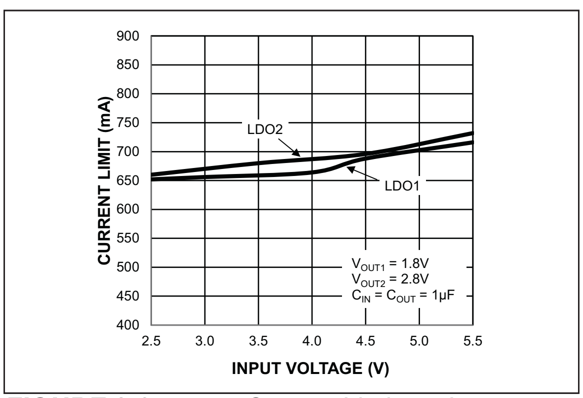


FIGURE 2-9: *Current Limit vs. Input Voltage.*

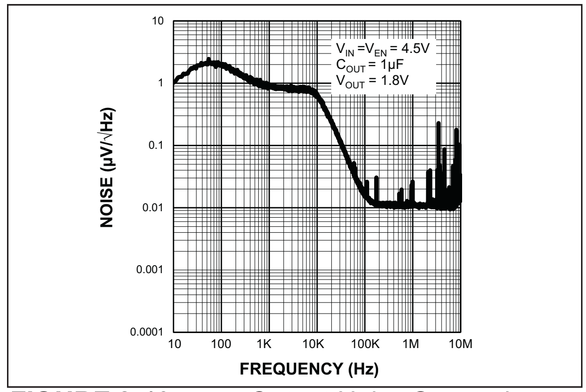


FIGURE 2-10: *Output Noise Spectral Density.*

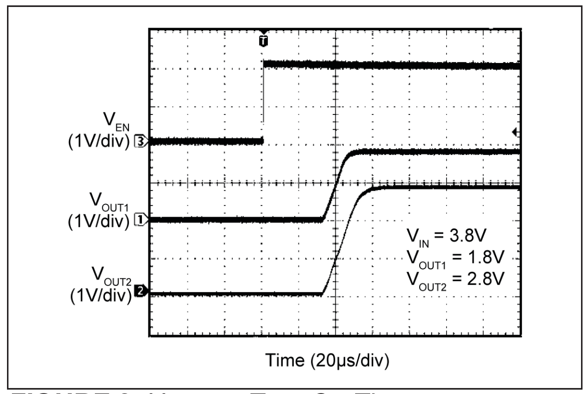


FIGURE 2-11: *Turn-On Time.*

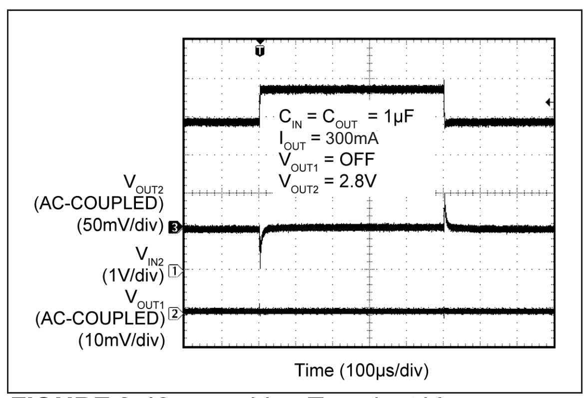


FIGURE 2-12: *Line Transient V_{IN1}.*

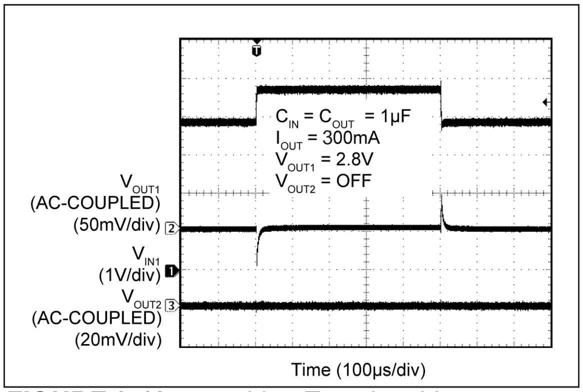


FIGURE 2-13: *Line Transient V_{IN2}.*

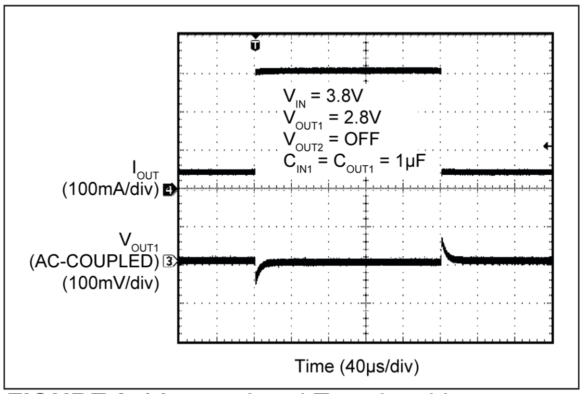


FIGURE 2-14: *Load Transient V_{OUT1}.*

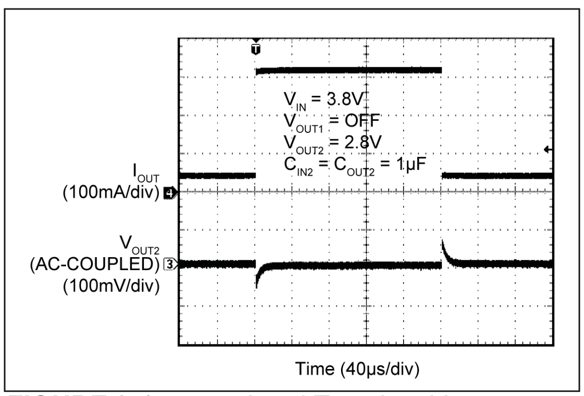


FIGURE 2-15: *Load Transient V_{OUT2}.*

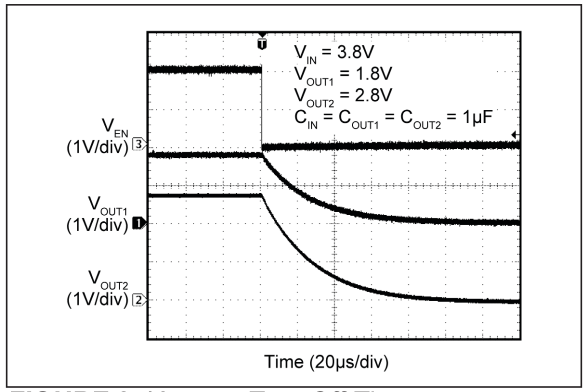


FIGURE 2-16: *Turn-Off Time.*

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

Pin Number	Pin Name	Description
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	Exposed heat sink pad. Connect to ground.

4.0 APPLICATION INFORMATION

MIC5396/7/8/9 is a dual 300 mA LDO in a tiny 8-pin 1.2 mm x 1.6 mm 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. These devices are not suitable for RF transmitter systems.

4.1 Input Capacitor

The MIC5396/7/8/9 is a high-performance, high-bandwidth device. An input capacitor of 1 µF 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.

4.2 Output Capacitor

The MIC5396/7/8/9 requires an output capacitor of 1 µF 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 µF 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.

4.3 No-Load Stability

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

4.4 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.

4.5 Thermal Considerations

The MIC5396/7/8/9 is designed to provide two 300 mA 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 300 mA. The actual power dissipation of the regulator circuit can be determined using Equation 4-1:

EQUATION 4-1:

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

Because this device is CMOS and the ground current is typically <100 µA over the load range, the power dissipation contributed by the ground current is <1% and can be ignored for the calculation in Equation 4-2:

EQUATION 4-2:

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

To determine the maximum ambient operating temperature of the package, use the junction-to-ambient thermal resistance of the device and the following basic formula in Equation 4-3:

EQUATION 4-3:

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

Where:

$T_{J(MAX)}$ =	125°C
θ_{JA} =	172.6°C/W

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 172.6°C/W.

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

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

EQUATION 4-4:

$$0.33W = (125°C - TA)/(172.6°C/\mathrm{W})$$

$$T_A = 68.04°C$$

Therefore, a MIC5396-SMYMX application with 300 mA at each output current can accept an ambient operating temperature of 68.04°C in a 1.6 mm x 1.2 mm Extra Thin DFN package. For a full discussion of heat sinking and thermal effects of voltage regulators, refer to the "Regulator Thermals" section of Designing with Low-Dropout Voltage Regulators handbook.

5.0 TYPICAL APPLICATION SCHEMATIC

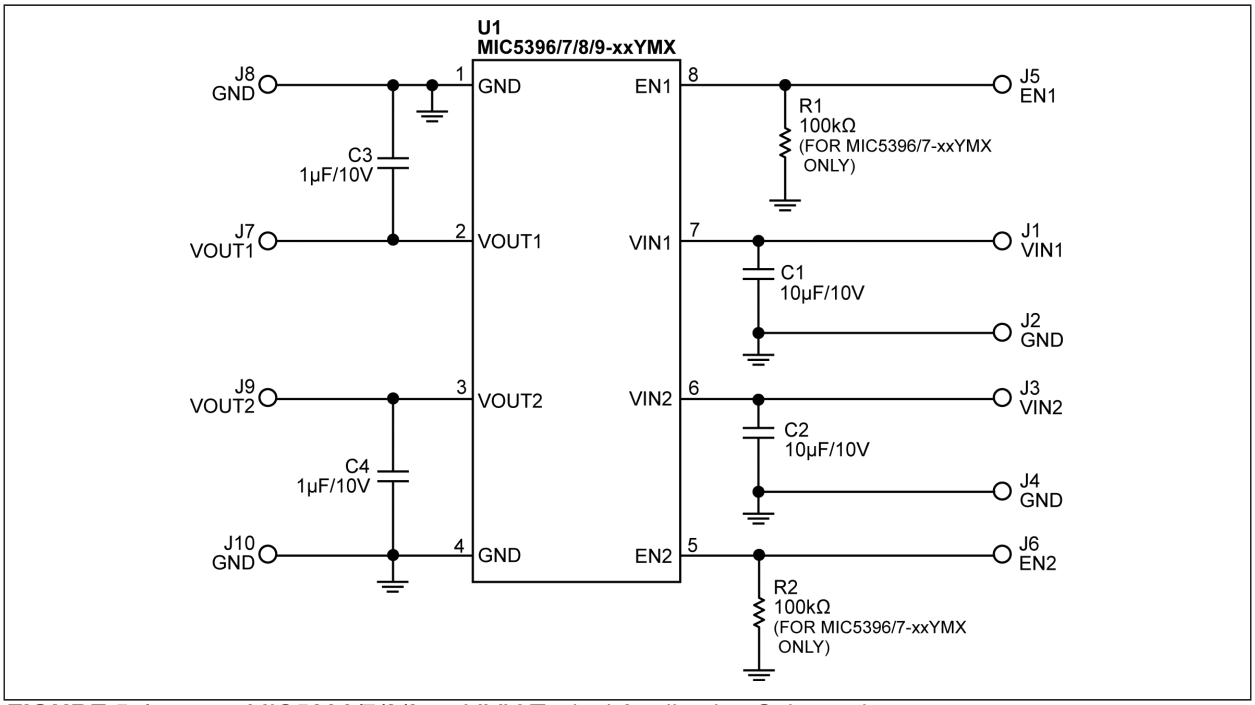


FIGURE 5-1: MIC5396/7/8/9-x.xYMX Typical Application Schematic.

TABLE 5-1: BILL OF MATERIALS

Item	Part Number	Manufacturer	Description	Qty.
C1, C2	C1608X5R0J106K	TDK	Capacitor, 1 µF Ceramic, 10V, X5R, Size 0402	2
C1, C2	C1005X5R1A105K	TDK	Capacitor, 1 µF Ceramic, 10V, X5R, Size 0402	2
C1, C2	CR0603100KFKEA	Vishay	Resistor, 100 kΩ, 1/16W, Size 0603	2
U1	**MIC5396/7/8/9-xxYMX**	**Microchip**	**Dual, 300 mA LDO, Size 1.2mm × 1.6mm Extra Thin DFN**	**1**

6.0 PCB LAYOUT RECOMMENDATIONS

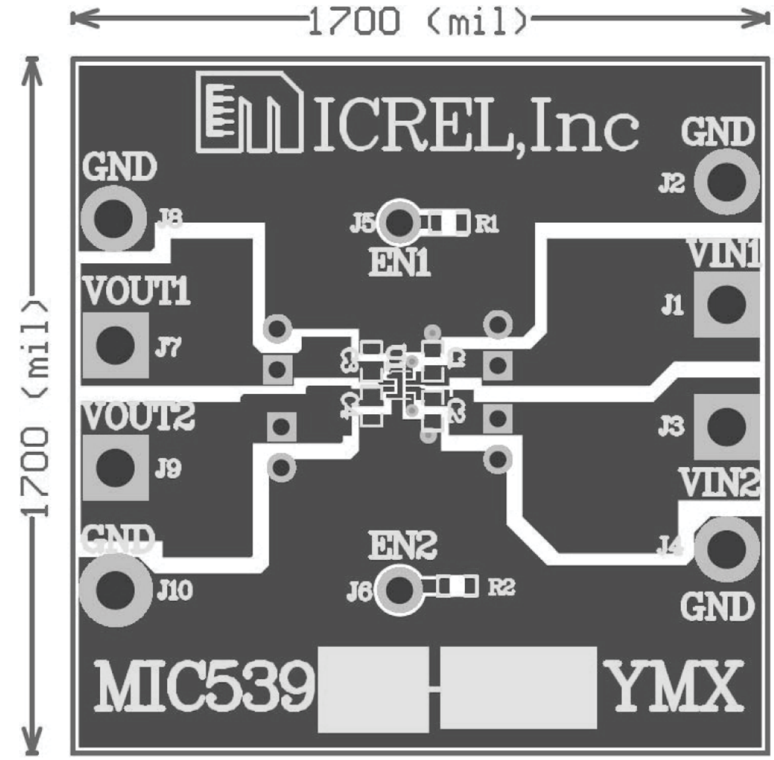


FIGURE 6-1: *Top Layer.*

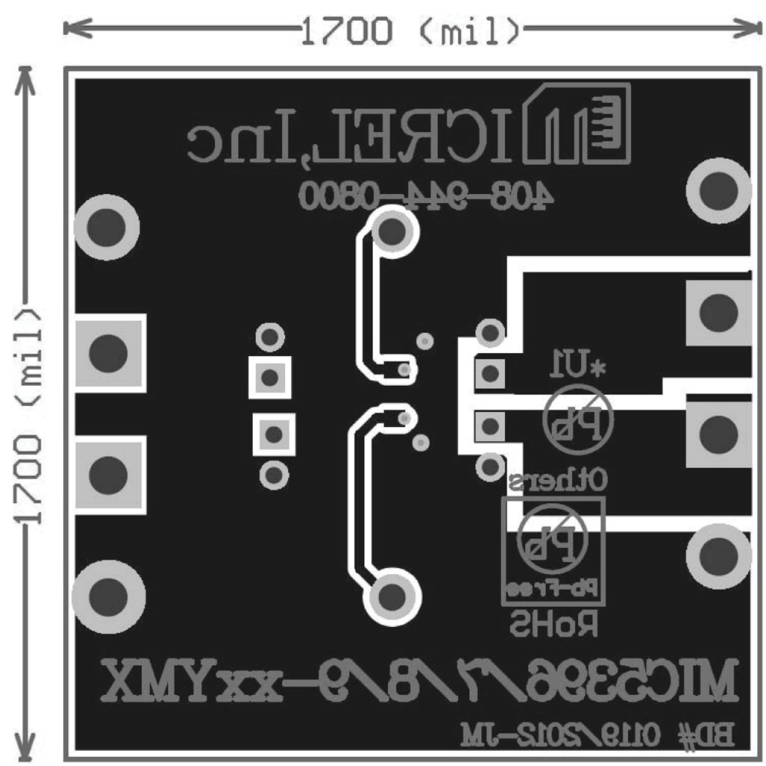
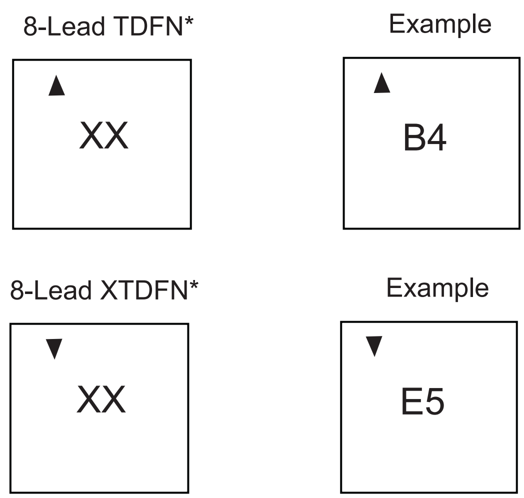


FIGURE 6-2: *Bottom Layer.*

7.0 PACKAGING INFORMATION

7.1 Package Marking Information



Legend:	XX...X	Product code or customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.

●, ▲, ▼ Pin one index is identified by a dot, delta up, or delta down (triangle mark).

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

Underbar (_) symbol may not be to scale.

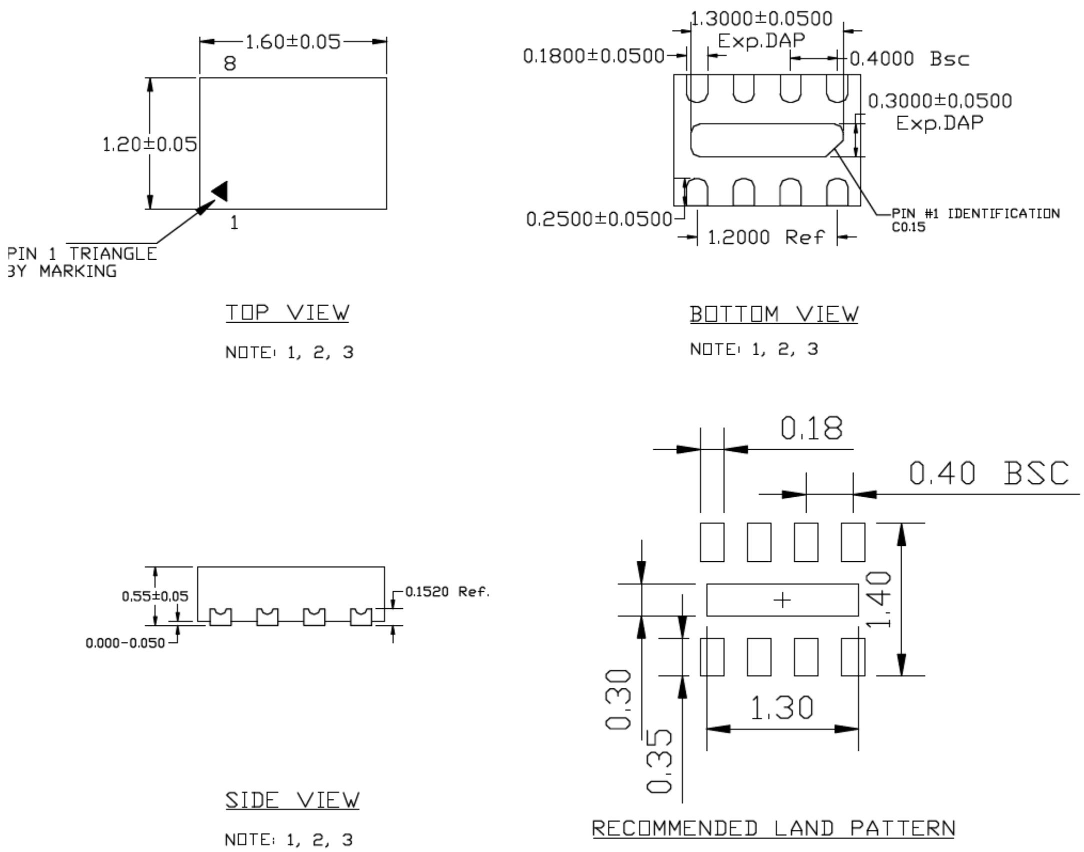
TABLE 7-1: PACKAGE MARKING CODES FOR MIC5396/97/98/99

Part Number	Output Voltage	Marking Codes
MIC5396-GMYMX	1.8V/2.8V	F2
MIC5397-GPYMX	1.8V/3.0V	D4
MIC5398-P4YMX	3.0V/1.2V	E5
MIC5399-SSYMX	3.3V/3.3V	H4
MIC5399-SMYMX	3.3V/2.8V	H6
MIC5399-SGYMX	3.3V/1.8V	H5
MIC5399-MMYMX	2.8V/2.8V	H7
MIC5399-GMYMX	1.8V/2.8V	H1

8-Lead TDFN Package Outline and Recommended Land Pattern

TITLE
8 LEAD TDFN 1.6x1.2mm PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	TDFN1612-8LD-PL-1	**UNIT**	MM



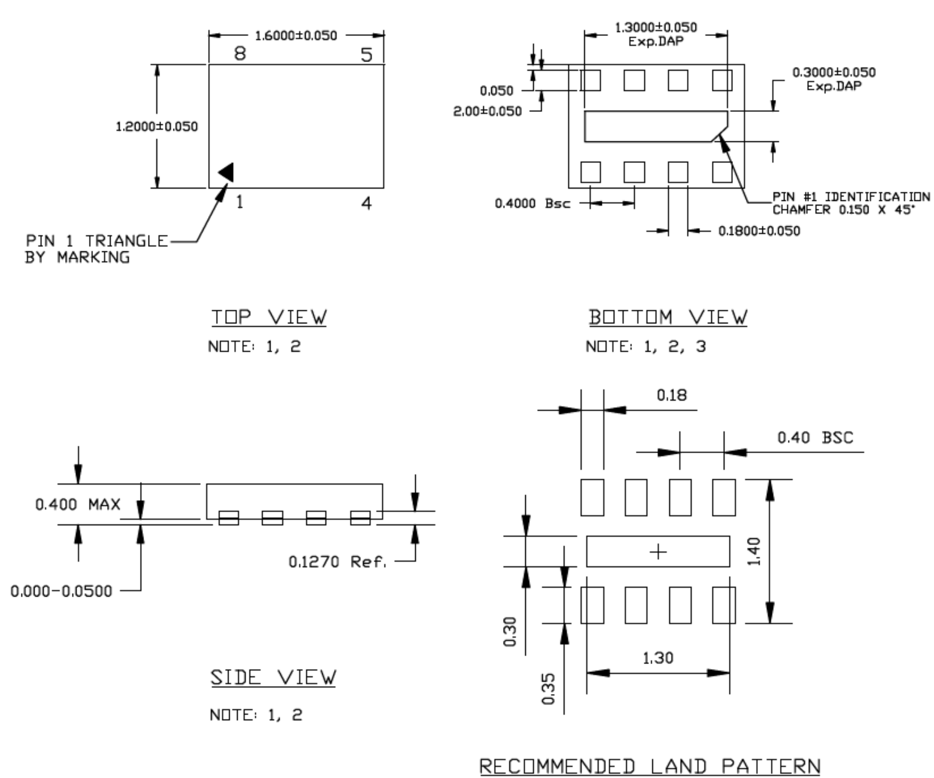
NOTE:
1. MAX PACKAGE WARPAGE IS 0.05 MM
2. MAX ALLOWABLE BURR IS 0.076MM IN ALL DIRECTIONS
3. PIN #1 IS ON TOP WILL BE LASER MARKED

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging.

8-Lead XTDFN Package Outline and Recommended Land Pattern

TITLE
8 LEAD XTDFN 1.6x1.2mm PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	XTDFN1612-8LD-PL-1	**UNIT**	MM
Lead Frame	NiPdAu	**Lead Finish**	NiPdAu



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

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging.

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (October 2019)

- Converted Micrel document MIC5396/7/8/9 to Microchip data sheet DS20006264A.
- Minor text changes throughout.
- Added Symbols column in the **Section "Electrical Characteristics"** table.
- Updated Section 4.0, Application Information with adding this new sentence - These devices are not suitable for RF transmitter systems.
- Changed I_{OUT} = 300 mA from 500 mA in Figure 2-12 and Figure 2-13.

Revision B (January 2020)

- Updates to the Product Information System in the Examples table and in the voltage option segment.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

PART NO.	-XX	X	XX	-XX
Device	Voltage Option	Junction Temperature Range	Package	Media Type

Device:	MIC5396: Low-Power Dual 300 mA LDO MIC5397: Low-Power Dual 300 mA LDO with Output Discharge Circuit MIC5398: Low-Power Dual 300 mA LDO with Internal Enable Pull-Down MIC5399: Low-Power Dual 300 mA LDO with Output Discharge Circuit and Internal Enable Pull-Down
Voltage Option	GM = 1.8V/2.8V (MIC5396) GP = 2.8V/1.5V (MIC5397) P4 = 3.0V/1.2V (MIC5398) SS = 1.8V/3.0V (MIC5399) SM = 3.3V/3.3V (MIC5399) SG = 3.3V/1.8V (MIC5399) MM = 3.3V/2.8V (MIC5399) GM = 2.8/V2.8V (MIC5399)
Junction Temperature Range:	Y = –40°C to +125°C (RoHS Compliant)
Package:	MT = 8-Lead 1.6 mm x 1.2 mm Thin DFN (Pb-Free) MX = 8-Lead 1.6 mm x 1.2 mm Extra Thin DFN (Pb-Free)
Media Type:	T5 = 500/Reel TR = 5,000/Reel

Examples:

a) MIC5396-GMYMT-T5	Low-Power Dual 300 mA LDO, 1.8V/2.8V, –40°C to +125°C, 8-Lead 1.6 mm x 1.2 mm TDFN, 500/Reel
b) MIC5396-GMYMX-TR	Low-Power Dual 300 mA LDO, 1.8V/2.8V, –40°C to +125°C, 8-Lead 1.6 mm x 1.2 mm XTDFN, 5,000/Reel
c) MIC5397-GPYMT-T5	Low-Power Dual 300 mA LDO with Output Discharge Circuit, 2.8V/1.5V, –40°C to +125°C, 8-Lead 1.6 mm x 1.2 mm TDFN, 500/Reel
d) MIC5397-GPYMX-TR	Low-Power Dual 300 mA LDO with Output Discharge Circuit, 2.8V/1.5V, –40°C to +125°C, 8-Lead 1.6 mm x 1.2 mm XTDFN, 5,000/Reel
e) MIC5398-P4YMX-T5	Low-Power Dual 300 mA LDO with Internal Enable Pull-Down, 3.0V/1.2V, –40°C to +125°C, 8-Lead 1.6 mm x 1.2 mm XTDFN, 500/Reel
f) MIC5398-P4YMX-TR	Low-Power Dual 300 mA LDO with Internal Enable Pull-Down, 3.0V/1.2V, –40°C to +125°C, 8-Lead 1.6 mm x 1.2 mm XTDFN, 5,000/Reel
e) MIC5399-GMYMT-T5	Low-Power Dual 300 mA LDO with Output Discharge Circuit and Internal Enable Pull-Down, 1.8V/3.0V, –40°C to +125°C, 8-Lead 1.6 mm x 1.2 mm TDFN, 500/Reel
e) MIC5399-SGYMX-TR	Low-Power Dual 300 mA LDO with Output Discharge Circuit and Internal Enable Pull-Down, 3.3V/1.8V, –40°C to +125°C, 8-Lead 1.6 mm x 1.2 mm XTDFN, 5,000/Reel
g) MIC5399-SSYMX-TR	Low-Power Dual 300 mA LDO with Output Discharge Circuit and Internal Enable Pull-Down, 3.3V/3.3V, –40°C to +125°C, 8-Lead 1.6 mm x 1.2 mm XTDFN, 5,000/Reel

Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

NOTES:

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

For information regarding Microchip's Quality Management Systems, please visit www.microchip.com/quality.

Trademarks

ISBN: 978-1-5224-5211-9

Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://www.microchip.com/support
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Austin, TX
Tel: 512-257-3370

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Novi, MI
Tel: 248-848-4000

Houston, TX
Tel: 281-894-5983

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453
Tel: 317-536-2380

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608
Tel: 951-273-7800

Raleigh, NC
Tel: 919-844-7510

New York, NY
Tel: 631-435-6000

San Jose, CA
Tel: 408-735-9110
Tel: 408-436-4270

Canada - Toronto
Tel: 905-695-1980
Fax: 905-695-2078

ASIA/PACIFIC

Australia - Sydney
Tel: 61-2-9868-6733

China - Beijing
Tel: 86-10-8569-7000

China - Chengdu
Tel: 86-28-8665-5511

China - Chongqing
Tel: 86-23-8980-9588

China - Dongguan
Tel: 86-769-8702-9880

China - Guangzhou
Tel: 86-20-8755-8029

China - Hangzhou
Tel: 86-571-8792-8115

China - Hong Kong SAR
Tel: 852-2943-5100

China - Nanjing
Tel: 86-25-8473-2460

China - Qingdao
Tel: 86-532-8502-7355

China - Shanghai
Tel: 86-21-3326-8000

China - Shenyang
Tel: 86-24-2334-2829

China - Shenzhen
Tel: 86-755-8864-2200

China - Suzhou
Tel: 86-186-6233-1526

China - Wuhan
Tel: 86-27-5980-5300

China - Xian
Tel: 86-29-8833-7252

China - Xiamen
Tel: 86-592-2388138

China - Zhuhai
Tel: 86-756-3210040

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-3090-4444

India - New Delhi
Tel: 91-11-4160-8631

India - Pune
Tel: 91-20-4121-0141

Japan - Osaka
Tel: 81-6-6152-7160

Japan - Tokyo
Tel: 81-3-6880- 3770

Korea - Daegu
Tel: 82-53-744-4301

Korea - Seoul
Tel: 82-2-554-7200

Malaysia - Kuala Lumpur
Tel: 60-3-7651-7906

Malaysia - Penang
Tel: 60-4-227-8870

Philippines - Manila
Tel: 63-2-634-9065

Singapore
Tel: 65-6334-8870

Taiwan - Hsin Chu
Tel: 886-3-577-8366

Taiwan - Kaohsiung
Tel: 886-7-213-7830

Taiwan - Taipei
Tel: 886-2-2508-8600

Thailand - Bangkok
Tel: 66-2-694-1351

Vietnam - Ho Chi Minh
Tel: 84-28-5448-2100

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

Finland - Espoo
Tel: 358-9-4520-820

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Garching
Tel: 49-8931-9700

Germany - Haan
Tel: 49-2129-3766400

Germany - Heilbronn
Tel: 49-7131-72400

Germany - Karlsruhe
Tel: 49-721-625370

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Germany - Rosenheim
Tel: 49-8031-354-560

Israel - Ra'anana
Tel: 972-9-744-7705

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Italy - Padova
Tel: 39-049-7625286

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Norway - Trondheim
Tel: 47-7288-4388

Poland - Warsaw
Tel: 48-22-3325737

Romania - Bucharest
Tel: 40-21-407-87-50

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

Sweden - Gothenberg
Tel: 46-31-704-60-40

Sweden - Stockholm
Tel: 46-8-5090-4654

UK - Wokingham
Tel: 44-118-921-5800
Fax: 44-118-921-5820