

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 42 μ A 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 <u>www.micrel.com</u>.

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 (±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



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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	_	Х	–40° to +125°C	8-Pin 1.2x1.6 XTDFN
MIC5398-P4YMX	E5	3.0V/1.2V	Х	_	–40° to +125°C	8-Pin 1.2x1.6 XTDFN
MIC5399-SSYMX	H4	3.3V/3.3V	Х	Х	–40° to +125°C	8-Pin 1.2x1.6 XTDFN
MIC5399-SMYMX	H6	3.3V/2.8V	Х	Х	–40° to +125°C	8-Pin 1.2x1.6 XTDFN
MIC5399-SGYMX	H5	3.3V/1.8V	Х	Х	–40° to +125°C	8-Pin 1.2x1.6 XTDFN
MIC5399-MMYMX	H7	2.8V/2.8V	Х	Х	–40° to +125°C	8-Pin 1.2x1.6 XTDFN
MIC5399-GPYMX ⁽³⁾	H8	1.8V/3.0V	Х	Х	–40° to +125°C	8-Pin 1.2x1.6 XTDFN
MIC5399-GMYMX	H1	1.8V/2.8V	Х	Х	–40° to +125°C	8-Pin 1.2x1.6 XTDFN

Notes:

1. Other voltages are available. Contact Micrel for details.

2. Extra Thin DFN is a GREEN RoHS-compliant package. Level finish is NiPdAu. Mold compound is Halogen Free.

3. 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⁾

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^{\circ}C to +125°C, unless noted.

Parameter	Condition	Min	Тур	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} = 100μA to 300mA		8	40	mV
Dropout Voltage	$I_{OUT} = 150 \text{mA}$		80	190	mV
	I _{OUT} = 300mA		160	380	mV
Ground Pin Current	V_{EN1} = High; V_{EN2} = Low; I_{OUT1} = 0mA		37	55	μA
	$V_{EN1} = Low; V_{EN2} = High; I_{OUT2} = 0mA$		37	55	μA
	$V_{EN1} = V_{EN2} = High; I_{OUT1} = I_{OUT2} = 0mA$		74	110	μA
	V_{EN1} = High; V_{EN2} = Low; I_{OUT1} = 300mA		42	65	μA
	V_{EN1} = Low; V_{EN2} = High; I_{OUT2} = 300mA		42	65	μA
	$V_{EN1} = V_{EN2} = High; I_{OUT1} = I_{OUT2} = 300mA$		84	130	μΑ
Shutdown Current	$V_{EN1} = V_{EN2} = 0V$		0.05	1	μA
Ripple Rejection	$f = 1 kHz; C_{OUT} = 1 \mu F$		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		MΩ
Enable Input Voltage	Logic Low			0.2	V
	Logic High	1.2			V
Enable Input Current	$V_{EN} = 0V$		0.01	1	μA
MIC5396, MIC5397	$V_{EN} = 5.5V$		0.01	1	μA
Enable Input Current	$V_{EN} = 0V$		0.01	1	μA
MIC5398, MIC5399	V _{EN} = 5.5V		1.4	2	μA
Turn-on Time	C _{OUT} = 1µF		50	125	μs

Notes:

1. Exceeding the absolute maximum ratings can damage the device.

2. 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) / θ_{JA}. Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown.

4. Devices are ESD sensitive. Handling precautions recommended. Human body model, $1.5k\Omega$ in series with 100pF.

5. Specification for packaged product only.

Typical Characteristics



Typical Characteristics (Continued)



Functional Characteristics



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, highbandwidth 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 1μ F or greater to maintain stability. The design is optimized for use with low-ESR ceramic chip capacitors. High-ESR capacitors may cause high frequency oscillation. The output capacitor can be increased, but performance has been optimized for a 1μ F 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 $<100\mu$ A 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:

 $\begin{array}{l} 0.33W = (125^{\circ}C - T_{A})/(172.6^{\circ}C/W) \\ T_{A} = 68.04^{\circ}C \end{array}$

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

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Typical Application Schematic



Bill of Materials

ltem	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: <u>www.tdk.com</u>.

2. Vishay: <u>www.vishay.com</u>.

3. Micrel, Inc.: <u>www.website.com</u>.

PCB Layout Recommendations



Top Layer



Bottom Layer

Package Information⁽¹⁾



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 <u>www.micrel.com</u>.

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Microchip:

MIC5399-GMYMX TI	R MIC5397-GPYMX T	MIC5397-GPYMX TR	MIC5399-SSYMX TR	MIC5396-P4YMT TR
MIC5399-SMYMT T5	MIC5399-MMYMX TR	MIC5399-SMYMX TR	MIC5399-MMYMT TR	MIC5398-P4YMX T5
MIC5399-GMYMT T5	MIC5399-SGYMX TR	MIC5396-GMYMX TR	MIC5396-GMYMX T5	MIC5398-P4YMX TR
MIC5397-GPYMT-TR	MIC5396-GMYMX-TR	MIC5399-GMYMT-TR	MIC5399-SGYMX-TR	MIC5397-GPYMX-T5
MIC5399-MMYMX-T5	MIC5399-GMYMX-T5	MIC5399-SGYMX-T5	MIC5396-P4YMT-TR	MIC5397-GPYMX-TR
MIC5396-GMYMX-T5	MIC5399-GMYMX-TR	MIC5396-P4YMT-T5	MIC5399-SSYMX-TR	MIC5399-SMYMX-T5
MIC5399-MMYMT-TR	MIC5397-GPYMT-T5	MIC5399-GMYMT-T5	MIC5399-SMYMT-T5	MIC5398-P4YMX-TR
MIC5399-SMYMT-TR	MIC5399-MMYMX-TR	MIC5399-SSYMX-T5	MIC5399-MMYMT-T5	MIC5398-P4YMX-T5
MIC5399-SMYMX-TR				