High Performance 200 mA Peak LDO in 1.6 mm x 1.6 mm TDFN

Features

- Input Voltage Range: 2.5V to 5.5V
- 200 mA Peak (150 mA Continuous) Output Current
- Stable with 1 µF Ceramic Output Capacitors
- Low Dropout Voltage: 180 mV @ 150 mA
- Excellent Load/Line Transient Response
- Low Quiescent Current: 29 µA
- High PSRR: 65 dB
- Output Discharge Circuit: MIC5368
- High Output Accuracy
  - ±2% Initial Accuracy
- Tiny 1.6 mm x 1.6 mm TDFN Package
- Thermal Shutdown and Current Limit Protection

Applications

- Mobile Phones
- Digital Cameras
- GPS, PDAs, PMP, Handhelds
- Portable Electronics

General Description

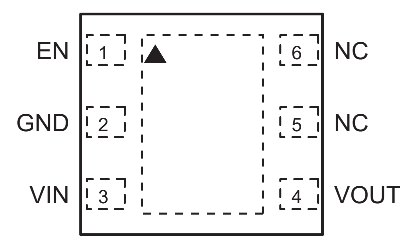
The MIC5367 and MIC5368 are advanced general purpose linear regulators that offer high power supply rejection (PSRR) in an ultra-small 1.6 mm x 1.6 mm package. The MIC5368 includes an auto-discharge feature that is activated when the enable pin is low. The MIC5367/8 are capable of sourcing 200 mA peak (150 mA continuous) output current and offer high PSRR, making it an ideal solution for any portable electronic application.

Ideal for battery powered applications, the MIC5367/8 offer 2% initial accuracy, low dropout voltage (180 mV @ 150 mA), and low ground current (typically 29 µA). The MIC5367/8 can also be put into a zero off-mode current state, drawing virtually no current when disabled.

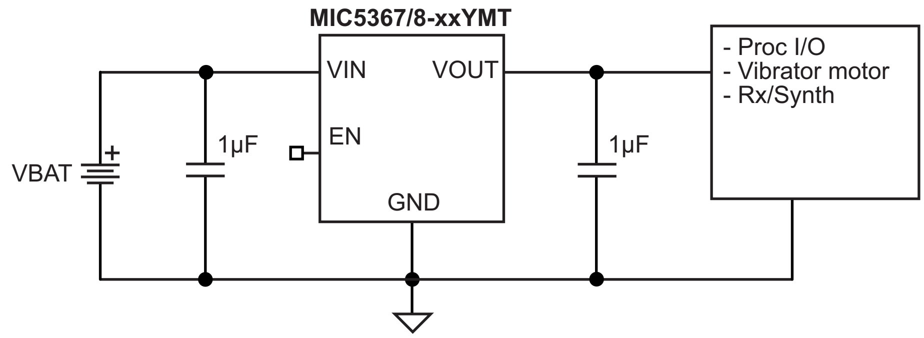
The MIC5367/8 have an operating junction temperature range of –40°C to 125°C.

Package Type

MIC5367/8
6-Lead TDFN (M)
(Top View)

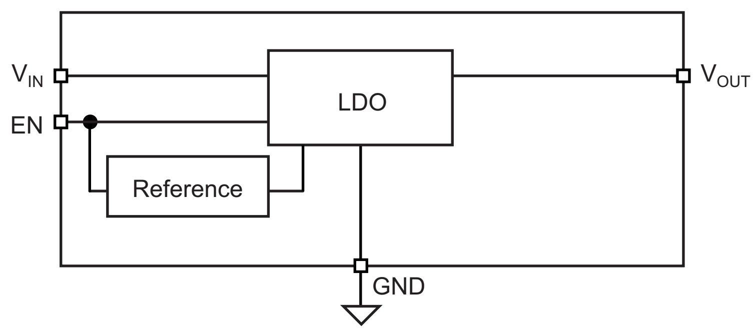


Typical Application Circuit

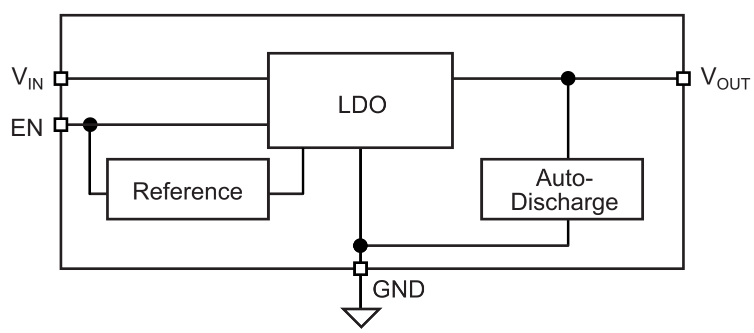


Functional Block Diagrams

MIC5367 BLOCK DIAGRAM



MIC5368 BLOCK DIAGRAM



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN}) .... 0V to +6V
Enable Voltage (V_{EN}) .... 0V to V_{IN}
Power Dissipation (P_D) (Note 1) .... Internally Limited
ESD Rating (Note 2) .... 2 kV

Operating Ratings ††

Supply Voltage (V_{IN}) .... +2.5V to +5.5V
Enable Input Voltage (V_{EN}) .... 0V to V_{IN}

† 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: $V_{IN} = V_{EN} = V_{OUT}$ + 1V; $C_{IN} = C_{OUT}$ = 1 µF; I_{OUT} = 100 µA; T_J = +25°C, **bold** values indicate –40°C to +125°C, unless noted. Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Voltage Accuracy	V_{OUT}	–2.0	—	2.0	%	Variation from nominal V_{OUT}
		–3.0	—	**3.0**		Variation from nominal V_{OUT}; –40°C to +125°C
Line Regulation	$\Delta V_{OUT}/V_{OUT}$	—	0.02	**0.3**	%	$V_{IN} = V_{OUT}$ + 1V to 5.5V; I_{OUT} = 100 µA
Load Regulation (Note 2)	$\Delta V_{OUT}/V_{OUT}$	—	0.3	1	%	I_{OUT} = 100 µA to 150 mA
Dropout Voltage (Note 3)	V_{DO}	—	60	**135**	mV	I_{OUT} = 50 mA
		—	180	**380**		I_{OUT} = 150 mA
Ground Pin Current (Note 4)	I_{GND}	—	29	**39**	µA	I_{OUT} = 0 mA
Ground Pin Current in Shutdown	I_{SHDN}	—	0.05	1	µA	$V_{EN} \leq 0.2V$
Ripple Rejection	PSRR	—	65	—	dB	f = up to 1 kHz; C_{OUT} = 1 µF
		—	55	—		f = 1 kHz to 10 kHz; C_{OUT} = 1 µF
Current Limit	I_{LIM}	200	325	550	mA	V_{OUT} = 0V

Note 1: Specification for packaged product only.

2: Regulation is measured at constant junction temperature using low duty cycle pulse testing; changes in output voltage due to heating effects are covered by the thermal regulation specification.

3: Dropout voltage is defined as the input-to-output differential at which the output voltage drops 2% below its nominal value measured at 1V differential. For outputs below 2.5V, dropout voltage is the input-to-output differential with the minimum input voltage 2.5V.

4: Ground pin current is the regulator quiescent current. The total current drawn from the supply is the sum of the load current plus the ground pin current.

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: $V_{IN} = V_{EN} = V_{OUT} + 1V$; $C_{IN} = C_{OUT} = 1\ \mu F$; $I_{OUT} = 100\ \mu A$; $T_J = +25°C$, **bold** values indicate –40°C to +125°C, unless noted. Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Voltage Noise	e_N	—	200	—	μV_{RMS}	$C_{OUT} = 1\ \mu F$, 10 Hz to 100 kHz
Auto-Discharge NFET Resistance	R_{DCH}	—	30	—	Ω	MIC5368 Only; $V_{EN} = 0V$; $V_{IN} = 3.6V$; $I_{OUT} = –3\ mA$
Enable Input						
Enable Input Voltage	V_{IL}	—	—	**0.2**	V	Logic Low
	V_{IH}	**1.2**	—	—		Logic High
Enable Input Current	I_{IL}	—	0.01	**1**	µA	$V_{IL} \leq 0.2V$
	I_{IH}	—	0.01	**1**		$V_{IH} \geq 1.2V$
Turn-On Time	t_{ON}	—	50	**125**	µs	$C_{OUT} = 1\ \mu F$; $I_{OUT} = 150\ mA$

Note 1: Specification for packaged product only.

2: Regulation is measured at constant junction temperature using low duty cycle pulse testing; changes in output voltage due to heating effects are covered by the thermal regulation specification.

3: Dropout voltage is defined as the input-to-output differential at which the output voltage drops 2% below its nominal value measured at 1V differential. For outputs below 2.5V, dropout voltage is the input-to-output differential with the minimum input voltage 2.5V.

4: Ground pin current is the regulator quiescent current. The total current drawn from the supply is the sum of the load current plus the ground pin current.

TEMPERATURE SPECIFICATIONS

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Maximum Junction Temperature	T_J	–40	—	+150	°C	—
Storage Temperature Range	T_S	–65	—	+150	°C	—
Lead Temperature	T_{LEAD}	—	—	+260	°C	Soldering, 10 sec.
Junction Temperature Range	T_J	–40	—	+125	°C	—
Package Thermal Resistance						
Thermal Resistance, TDFN 6-Lead	θ_{JA}	—	92.4	—	°C/W	—

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.

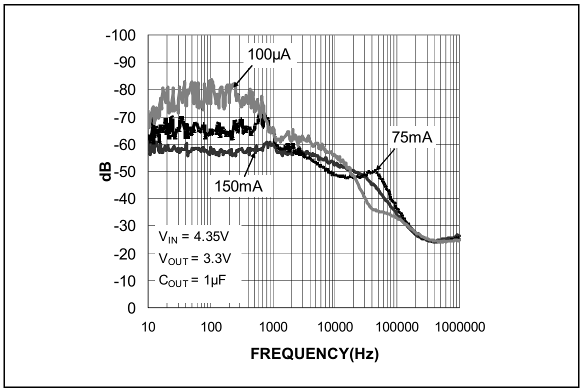


FIGURE 2-1: *Power Supply Rejection Ratio.*

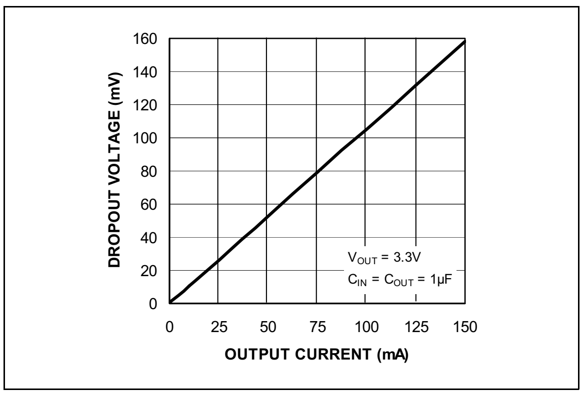


FIGURE 2-2: *Dropout Voltage vs. Output Current.*

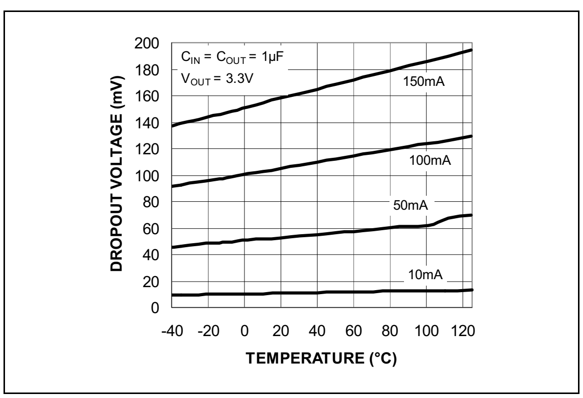


FIGURE 2-3: *Dropout Voltage vs. Temperature.*

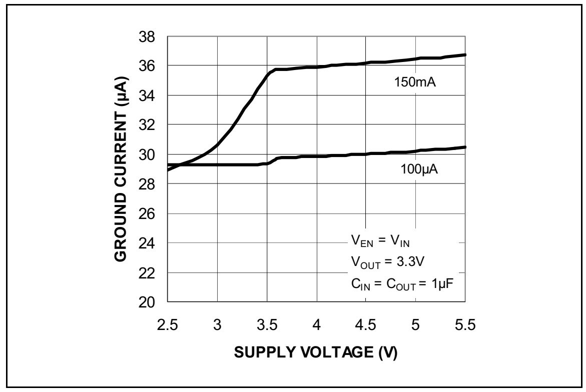


FIGURE 2-4: *Ground Current vs. Supply Voltage.*

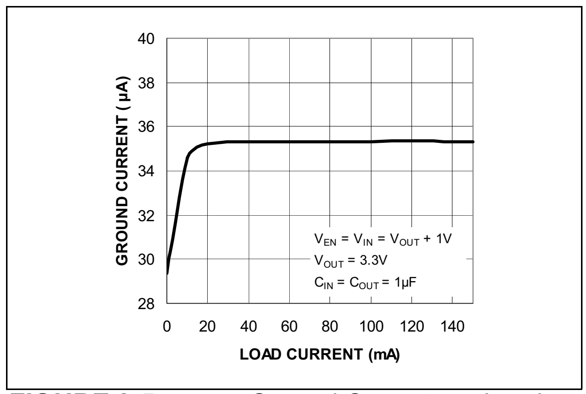


FIGURE 2-5: *Ground Current vs. Load Current.*

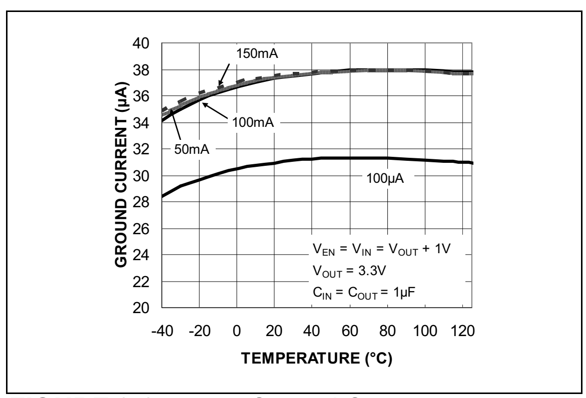


FIGURE 2-6: *Ground Current vs. Temperature.*

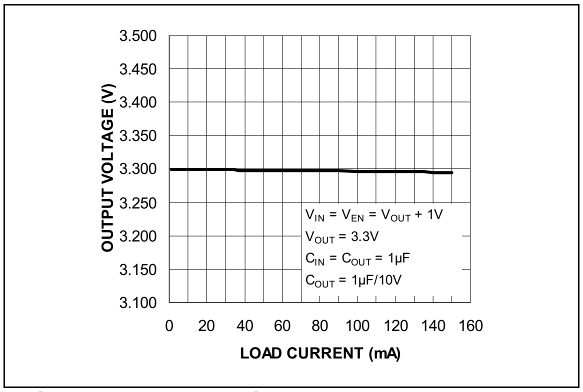


FIGURE 2-7: *Output Voltage vs. Load Current.*

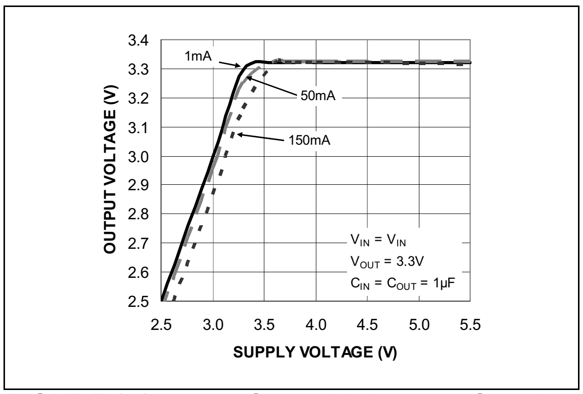


FIGURE 2-8: *Output Voltage vs. Supply Voltage.*

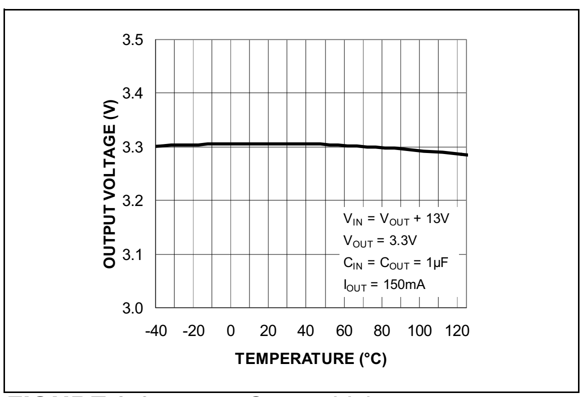


FIGURE 2-9: *Output Voltage vs. Temperature.*

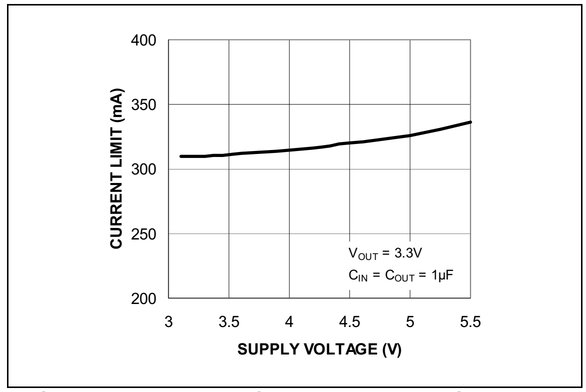


FIGURE 2-10: *Current Limit vs. Supply Voltage.*

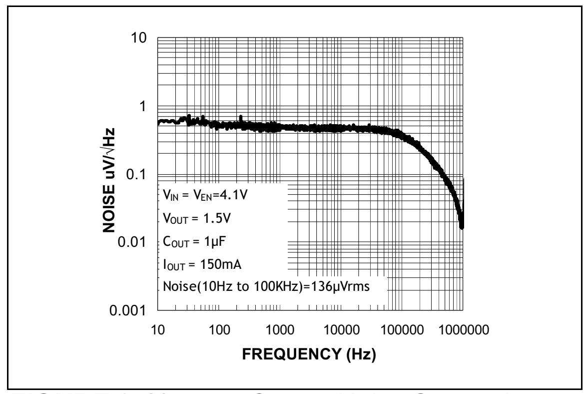


FIGURE 2-11: *Output Noise Spectral Density.*

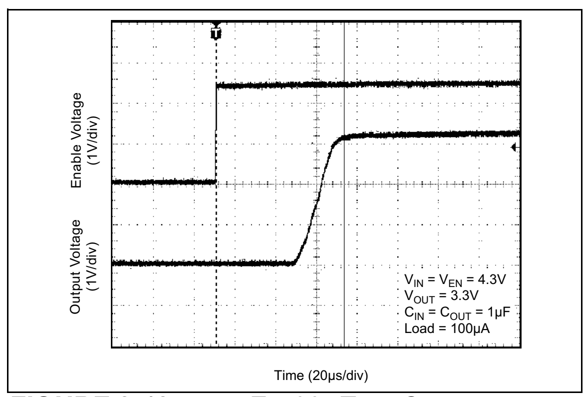


FIGURE 2-12: *Enable Turn-On.*

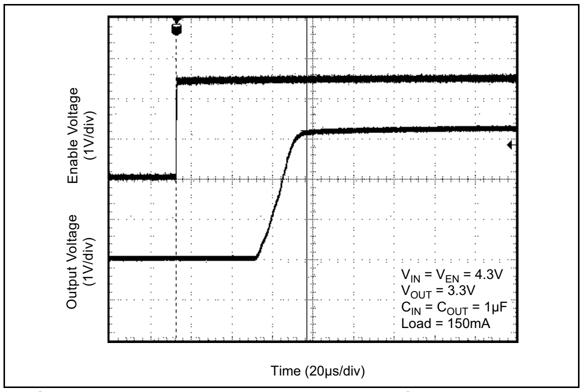


FIGURE 2-13: *Enable Turn-On.*

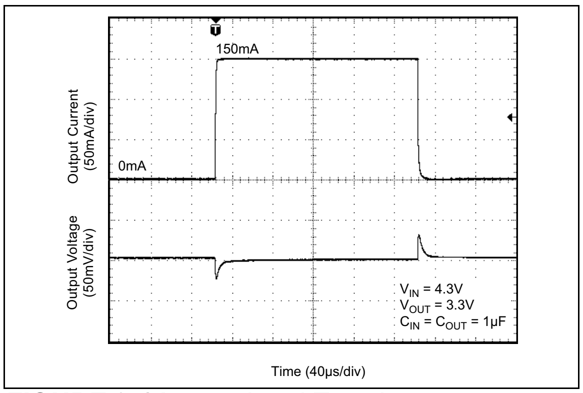


FIGURE 2-14: *Load Transient.*

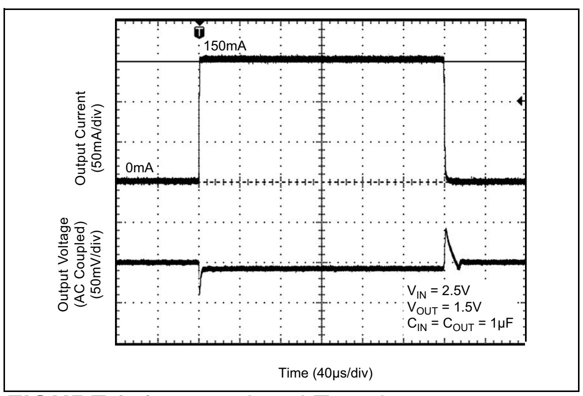


FIGURE 2-15: *Load Transient.*

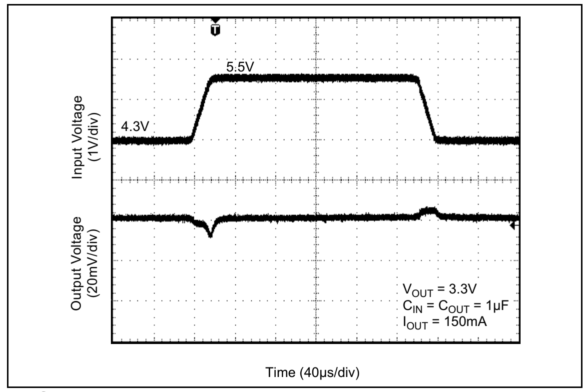


FIGURE 2-16: *Line Transient.*

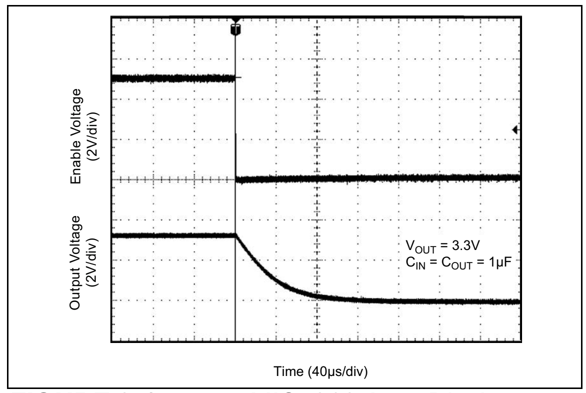


FIGURE 2-17: *MIC5368 Auto-Discharge (No Load).*

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	EN	Enable Input: Active-High. High = ON; Low = OFF. Do not leave floating.
2	GND	Ground.
3	VIN	Supply input.
4	VOUT	Output voltage.
5	NC	No Connect (Not internally connected).
6	NC	No Connect (Not internally connected).
EP	ePAD	Exposed Heatsink Pad.

4.0 APPLICATION INFORMATION

MIC5367 and MIC5368 are low-noise 150 mA LDOs. The MIC5368 includes an auto-discharge circuit that is switched on when the regulator is disabled through the Enable pin. The MIC5367/8 regulators are fully protected from damage due to fault conditions, offering linear current limiting and thermal shutdown.

4.1 Input Capacitor

The MIC5367/8 are high-performance, high bandwidth devices. An input capacitor of 1 µF 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 MIC5367/8 require 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 are not recommended because they 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 MIC5367/8 will remain stable and in regulation with no load. This is especially important in CMOS RAM keep-alive applications.

4.4 Enable/Shutdown

The MIC5367/8 come 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. 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.

4.5 Thermal Considerations

The MIC5367/8 are designed to provide 150 mA of continuous current 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 3.3V, the output voltage is 1.5V, and the output current is 150 mA. The actual power dissipation of the regulator circuit can be determined using the following equation:

EQUATION 4-1:

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

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 this calculation.

EQUATION 4-2:

$$P_D = (3.3V - 1.5V) \times 150mA = 0.27W$$

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:

EQUATION 4-3:

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

$T_{J(MAX)}$ is +125°C, the maximum junction temperature of the die. θ_{JA} is thermal resistance (92.4°C/W for the YMT package).

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 92.4°C/W.

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

For example, when operating the MIC5367-1.5YMT at an input voltage of 3.3V and 150 mA load with a minimum footprint layout, the maximum ambient operating temperature T_A can be determined as follows:

EQUATION 4-4:

$$0.27W = (125°C - T_A)/(92.4°C/W)$$

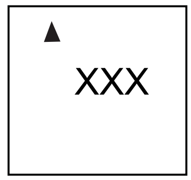
$$T_A = 100°C$$

Therefore, the maximum ambient operating temperature of +100°C is allowed in a 6-lead TDFN package. For a full discussion of heat sinking and thermal effects on voltage regulators, refer to the “Regulator Thermals” section of Microchip’s Designing with Low-Dropout Voltage Regulators handbook.

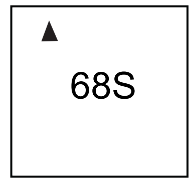
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

6-Lead TDFN*



Example



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 (_) and/or Overbar (‾) symbol may not be to scale.

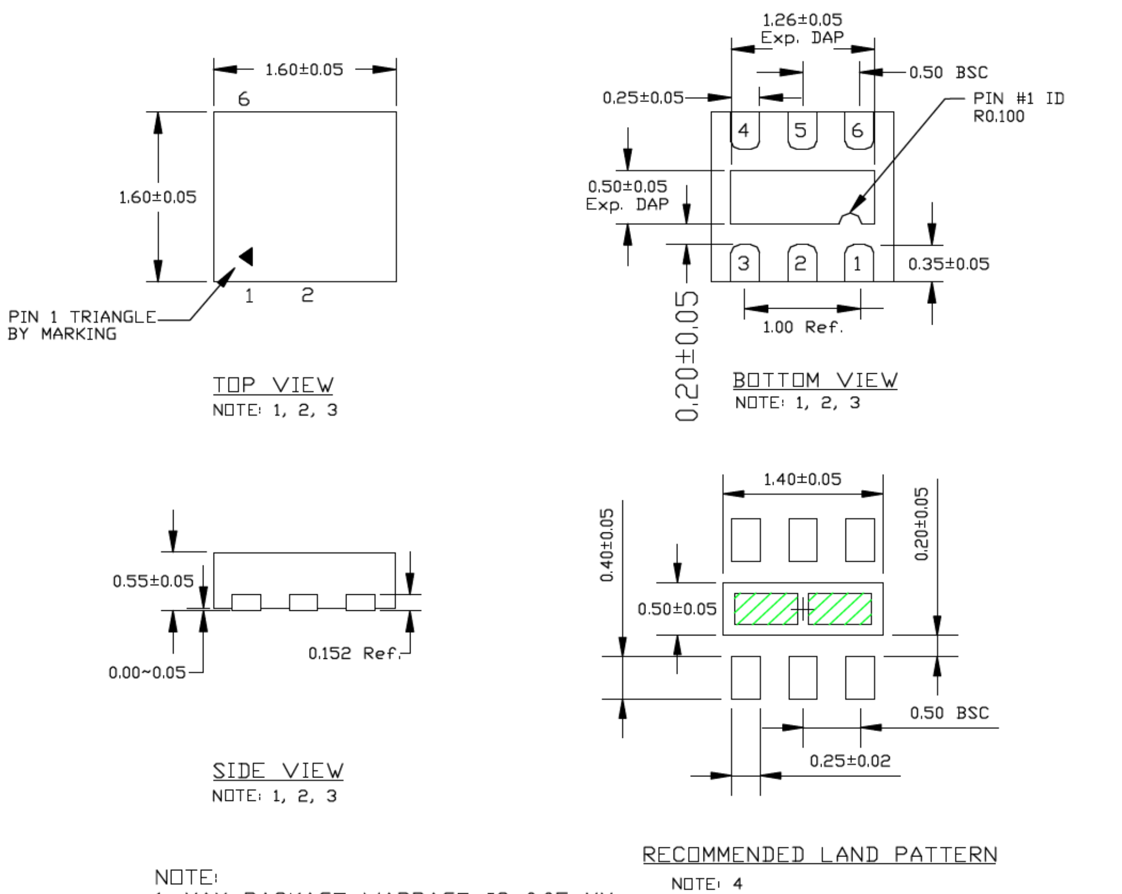
TABLE 5-1: PACKAGE MARKING CODES FOR MIC5367/68

Part Number	Output Voltage	Marking Codes
MIC5367	1.2V	674
MIC5367	1.5V	F67
MIC5367	3.3V	67S
MIC5368	1.2V	684
MIC5368	1.5V	F68
MIC5368	3.3V	68S

6-Lead TDFN Package Outline and Recommended Land Pattern

TITLE
6 LEAD TDFN 1.6x1.6mm PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	TDFN1616-6LD-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
4. GREEN SHADED AREA REPRESENT SOLDER STENCIL OPENING (OPTIONAL) FOR IMPROVED THERMAL PERFORMANCE. SIZE: 0.55x0.30MM

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

APPENDIX A: REVISION HISTORY

Revision A (October 2021)

- Converted Micrel document MIC5367/8 to Microchip data sheet template DS20006606A.
- Minor grammatical text changes throughout.
- Evaluation Board Schematic and BOM sections from original data sheet moved to the part's Evaluation Board User's Guide.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

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

Device	-X.X	X	XX	-XX
Part No.	Voltage Option	Junction Temp. Range	Package	Media Type

Device:	MIC5367: High Performance 200 mA Peak LDO MIC5368: High Performance 200 mA Peak LDO with Output Discharge Circuit
Voltage Option	1.2 = 1.2V 1.5 = 1.5V 3.3 = 3.3V
Junction Temperature Range:	Y = –40°C to +125°C (RoHS Compliant)
Package:	MT = 6-Lead 1.6 mm x 1.6 mm Thin DFN (Pb-Free)
Media Type:	TR = 5,000/Reel

Examples:

a) MIC5367-1.2YMT-TR	High Performance 200 mA Peak LDO, 1.2V, –40°C to +125°C, 6-Lead 1.6 mm x 1.6 mm TDFN, 5,000/Reel
b) MIC5368-3.3YMT-TR	High Performance 200 mA Peak LDO with Output Discharge Circuit, 3.3V, –40°C to +125°C, 6-Lead 1.6 mm x 1.6 mm TDFN, 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:

ISBN: 978-1-5224-9210-8

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China - Shenzhen
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China - Wuhan
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China - Xian
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China - Xiamen
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China - Zhuhai
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India - New Delhi
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India - Pune
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Japan - Osaka
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Japan - Tokyo
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Korea - Daegu
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Malaysia - Kuala Lumpur
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Malaysia - Penang
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Philippines - Manila
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Taiwan - Hsin Chu
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Taiwan - Kaohsiung
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Thailand - Bangkok
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Vietnam - Ho Chi Minh
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Finland - Espoo
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Israel - Ra'anana
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Italy - Milan
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Netherlands - Drunen
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