MIC5331

Micro-Power High Performance Dual 300 mA ULDO

Features

- 2.3V to 5.5V Input Voltage Range
- 300 mA Output Current per LDO
- Low Quiescent Current: 25 µA per LDO
- High PSRR: >65 dB on Each LDO
- Stable with 1 µF Ceramic Output Capacitors
- Tiny 8-pin 2 mm x 2 mm Thin DFN Package
- Ultra-Low Dropout Voltage: 120 mV @ 300 mA
- Low Output Voltage Noise: 50 μV_{RMS}
- Thermal Shutdown Protection
- Current-Limit Protection

Applications

- Camera Phones
- Mobile Phones
- PDAs
- GPS Receivers
- Portable Devices

General Description

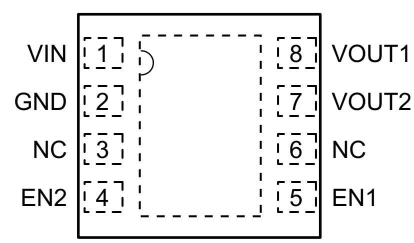
The MIC5331 is a tiny dual low quiescent current LDO ideal for applications that are power sensitive. The MIC5331 integrates two high performance, 300 mA LDOs into a tiny 2 mm x 2 mm Thin DFN package, which occupies less PC board area than a single SOT-23 package.

The MIC5331 is designed to reject input noise and provide low output noise with fast transient response to any load change quickly even though it is a low quiescent current part. This combination of PSRR, low noise and transient response along with low power consumption makes for a very high performance, yet general purpose product.

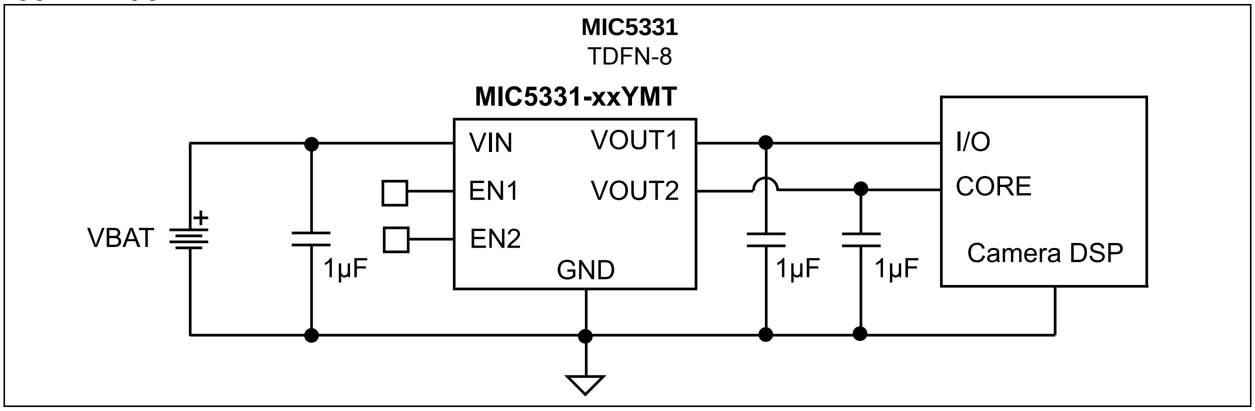
The MIC5331 is a µCap design, operating with very small ceramic output capacitors, which reduces required board space and component cost; and it is available in fixed output voltages in the tiny 8-pin 2 mm x 2 mm Thin DFN lead-less package.

Package Type

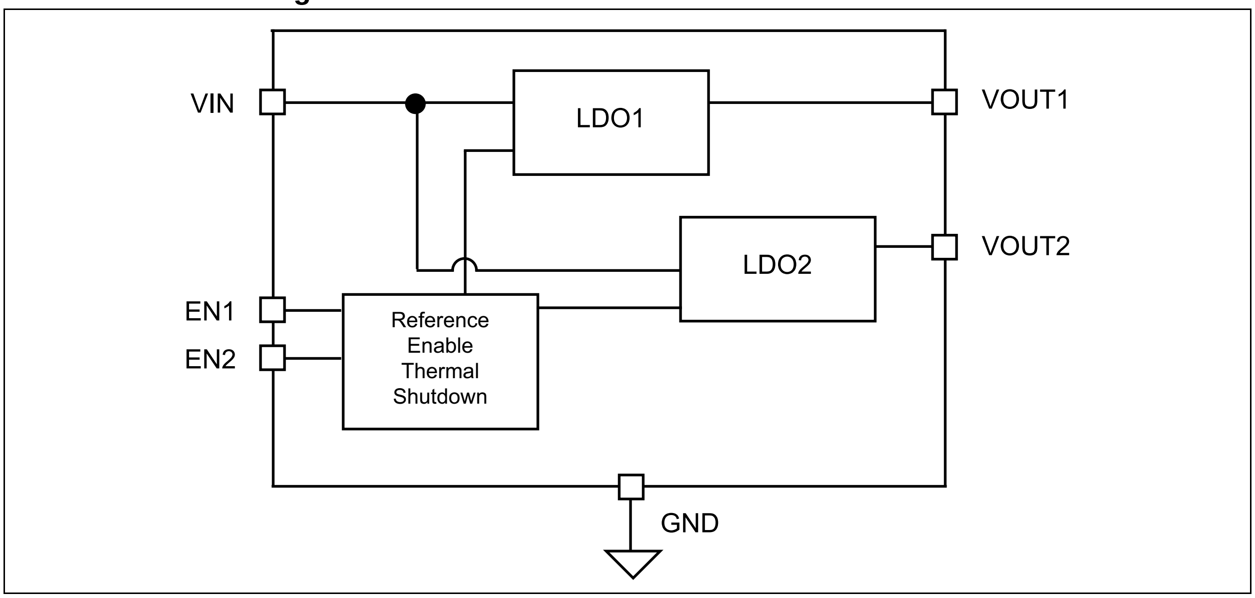
MIC5331
8-Lead TDFN (MT)



Typical Application Circuit



Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN}) .... 0V to +6V
Enable Input Voltage (V_{EN1}, V_{EN2}) .... 0V to V_{IN}
Power Dissipation (P_D, Note 1) .... Internally Limited
ESD Rating .... Note 2

Operating Ratings ‡

Supply Voltage (V_{IN}) .... +2.3V to +5.5V
Enable Input Voltage (V_{EN1}, V_{EN2}) .... 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 $P_{D(max)} = (T_{J(max)} – T_A)/θ_{JA}$. 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 recommended.

TABLE 1-1: ELECTRICAL CHARACTERISTICS

Electrical Characteristics: $V_{IN} = V_{EN1} = V_{EN2} = V_{OUT}$ + 1.0V, higher of the two regulator outputs; $I_{OUT1} = I_{OUT2}$ = 100 µA; $C_{OUT1} = C_{OUT2}$ = 1 µF; T_J = +25°C, **bold** values indicate –40°C ≤ T_J ≤ +125°C; unless noted. Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Voltage Accuracy	$ΔV_{OUT}$	–1.0	—	1.0	%	Variation from nominal V_{OUT}
		–2.0	—	**2.0**	%	Variation from nominal V_{OUT}; –40°C to +125°C
Line Regulation	$ΔV_{OUT}/(V_{OUT} \times ΔV_{IN})$	—	0.02	0.3	%/V	$V_{IN} = V_{OUT}$ +1V to 5.5V; I_{OUT} = 100 µA
		—	—	**0.6**		
Load Regulation	$ΔV_{OUT}/V_{OUT}$	—	0.2	0.5	%	I_{OUT} = 100 µA to 300 mA
Dropout Voltage	V_{DO}	—	20	**40**	mV	I_{OUT} = 50 mA
		—	120	**240**	mV	I_{OUT} = 300 mA
Ground Current	I_{GND}	—	25	**50**	µA	V_{EN1} = High; V_{EN2} = Low; I_{OUT} = 100 µA to 300 mA
		—	25	**50**	µA	V_{EN1} = Low; V_{EN2} = High; I_{OUT} = 100 µA to 300 mA
		—	40	**75**	µA	$V_{EN1} = V_{EN2}$ = High; I_{OUT1} = 300 mA, I_{OUT2} = 300 mA
Ground Current in Shutdown	I_{SHDN}	—	0.01	1.0	µA	$V_{EN1} = V_{EN2}$ < 0.2V
Ripple Rejection	PSRR	—	65	—	dB	f = 1 kHz; C_{OUT} = 2.2 µF
		—	45	—	dB	f = 20 kHz; C_{OUT} = 2.2 µF
Current Limit	I_{LIMIT}	350	550	800	mA	V_{OUT} = 0V
Output Voltage Noise	e_N	—	50	—	$µV_{RMS}$	C_{OUT} = 1 µF; 10 Hz to 100 kHz
Enable Inputs (EN1/EN2)						
Enable Input Voltage	V_{ENABLE}	—	—	**0.2**	V	Logic Low
		1.2	—	—	V	Logic High

TABLE 1-1: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: $V_{IN} = V_{EN1} = V_{EN2} = V_{OUT}$ + 1.0V, higher of the two regulator outputs; $I_{OUT1} = I_{OUT2}$ = 100 µA; $C_{OUT1} = C_{OUT2}$ = 1 µF; T_J = +25°C, **bold** values indicate –40°C ≤ T_J ≤ +125°C; unless noted. Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Enable Input Current	I_{ENABLE}	—	0.01	**1.0**	µA	V_{IL} ≤ 0.2V
		—	0.01	**1.0**	µA	V_{IH} ≥ 1.2V
Turn-On Time						
Turn-On Time (LDO1 and 2)	t_{ON}	—	140	**500**	µs	C_{OUT} = 1 µF (Enable of First LDO)
		—	110	**500**	µs	C_{OUT} = 1 µF (Enable of Second LDO after First Enabled)

Note 1: Specification for packaged product only.

TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Junction Operating Temperature Range	T_J	–40	—	+125	°C	—
Storage Temperature Range	T_S	–65	—	+150	°C	—
Lead Temperature	—	—	—	+260	°C	Soldering, 3s
Package Thermal Resistances						
Thermal Resistance 2 mm x 2 mm TDFN 8-Ld	θ_{JA}	—	90	—	°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.

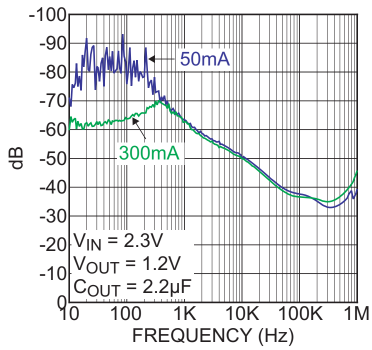


FIGURE 2-1: *Power Supply Rejection Ratio.*

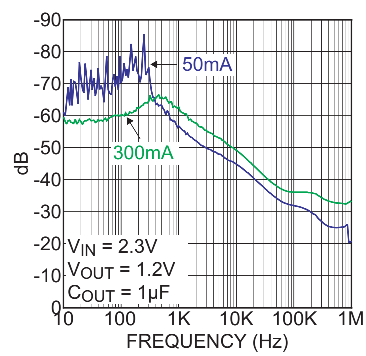


FIGURE 2-2: *Power Supply Rejection Ratio.*

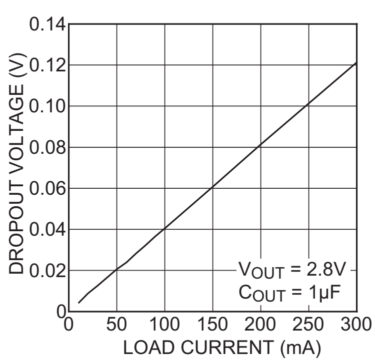


FIGURE 2-3: *Dropout Voltage vs. Load Current.*

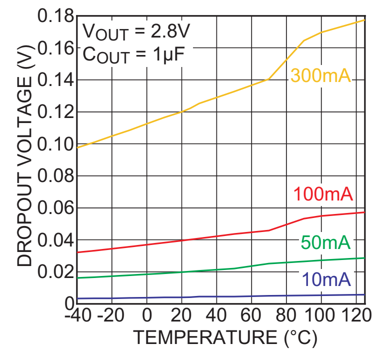


FIGURE 2-4: *Dropout Voltage vs. Temperature.*

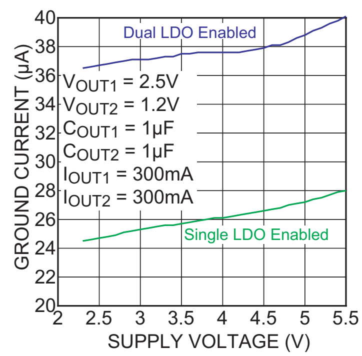


FIGURE 2-5: *Ground Current vs. Supply Voltage.*

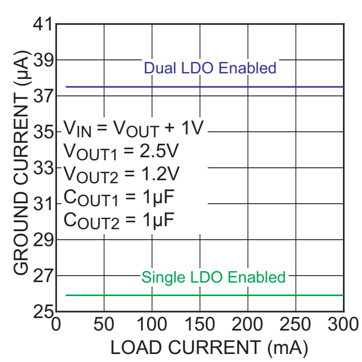


FIGURE 2-6: *Ground Current vs. Load Current.*

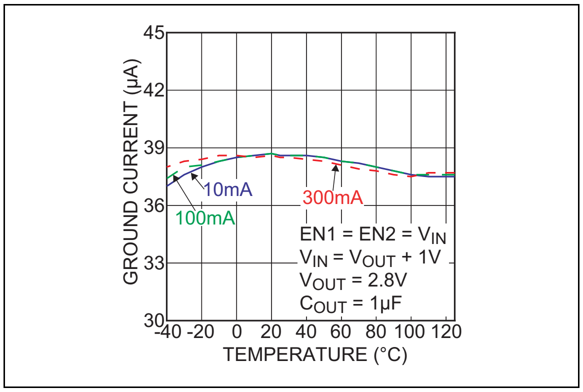


FIGURE 2-7: *Ground Current vs. Temperature.*

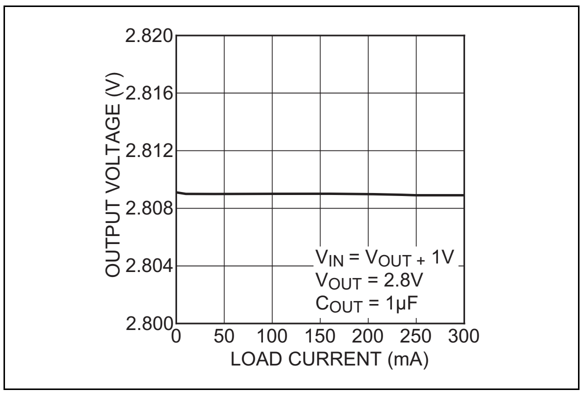


FIGURE 2-8: *Output Voltage vs. Load Current.*

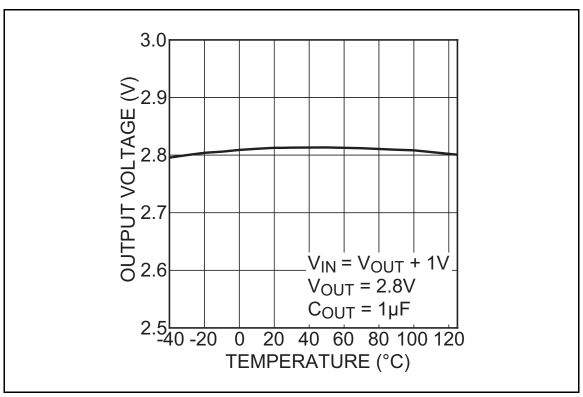


FIGURE 2-9: *Output Voltage vs. Temperature.*

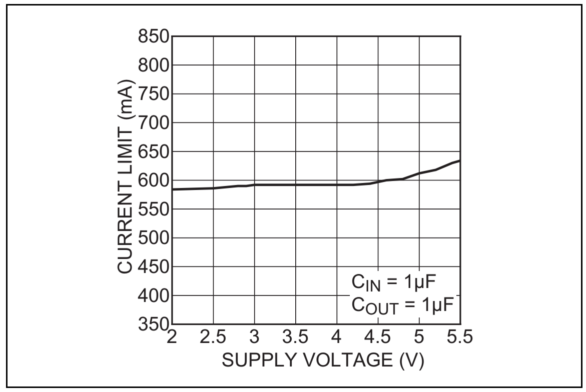


FIGURE 2-10: *Current Limit vs. Supply Voltage.*

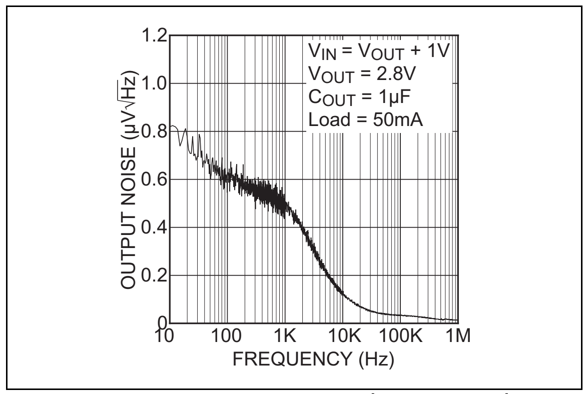


FIGURE 2-11: *Output Noise Spectral Density.*

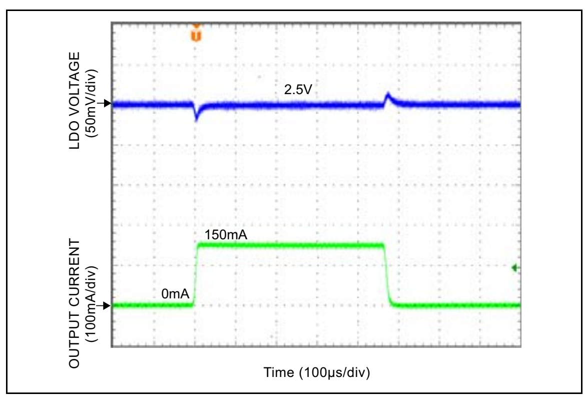


FIGURE 2-12: *Load Transient (0 mA – 150 mA).*

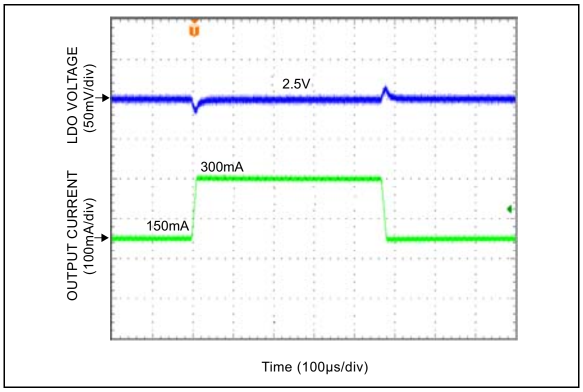


FIGURE 2-13: *Load Transient (150 mA – 300 mA).*

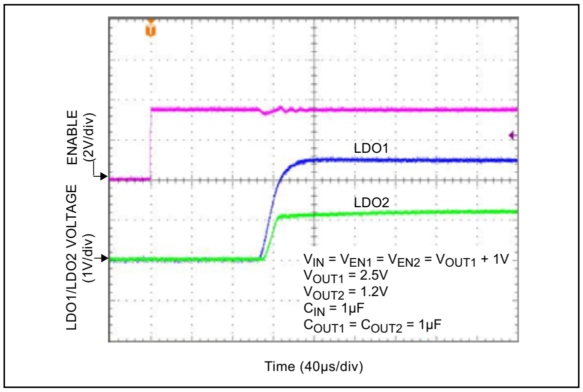


FIGURE 2-14: *Enable Turn-On.*

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	VIN	Supply Input.
2	GND	Ground.
3	NC	Not Internally Connected.
4	EN2	Enable Input (Regulator 2): Active-High Input. Logic-High = On; Logic-Low = Off. Do not leave floating.
5	EN1	Enable Input (Regulator 1): Active-High Input. Logic-High = On; Logic-Low = Off. Do not leave floating.
6	NC	Not Internally Connected.
7	VOUT2	Regulator Output: LDO2.
8	VOUT1	Regulator Output: LDO1.

4.0 APPLICATION INFORMATION

MIC5331 is a tiny, dual, low quiescent current, 300 mA LDO. The MIC5331 regulator is fully protected from damage due to fault conditions, offering linear current limiting and thermal shutdown.

4.1 Input Capacitor

The MIC5331 is a high-performance, high bandwidth device. Therefore, it requires a well-bypassed input supply for optimal performance. A 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 MIC5331 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 MIC5331 will remain stable and in regulation with no load. This is especially important in CMOS RAM keep-alive applications.

4.4 Enable/Shutdown

The MIC5331 comes with dual 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. 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 MIC5331 is designed to provide 300 mA 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 V_{OUT1}, 2.8V for V_{OUT2} and the output current equals 300 mA for each output. The actual power dissipation of the regulator circuit can be determined using Equation 4-1:

EQUATION 4-1:

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

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 this calculation.

EQUATION 4-2:

$$P_D = (3.6V - 3.0V) \times 300mA + (3.6V - 2.8V) \times 300mA = 0.42W$$

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:

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

Where:

$T_{J(MAX)}$ = 125°C
θ_{JA} = 90°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 90°C/W.

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

For example, when operating the MIC5331-PMYMT at an input voltage of 3.6V and 300 mA loads at each output with a minimum footprint layout, the maximum ambient operating temperature T_A can be determined as follows:

EQUATION 4-4:

$$0.42W = (125° - T_A) \div 90°C/W$$

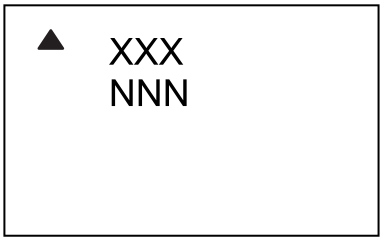
$$T_A = 87.2°C$$

Therefore, a 3.0V/2.8V application with 300 mA at each output current can accept an ambient operating temperature of 87°C in a 2 mm x 2 mm 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

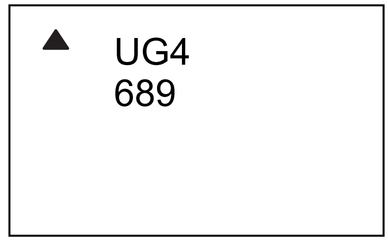
5.1 Package Marking Information

8-Pin TDFN*



Manufacturing Part Number	Marking	Voltage
MIC5331-G4YMT	UG4	1.8V/1.2V
MIC5331-J4YMT	UJ4	2.5V/1.2V
MIC5331-MMYMT	UMM	2.8V/2.8V
MIC5331-MNYMT	UMN	2.8V/2.85V
MIC5331-NNYMT	UNN	2.85V/2.85V
MIC5331-PMYMT	UPM	3.0V/2.8V
MIC5331-PNYMT	UPN	3.0V/2.85V
MIC5331-PPYMT	UPP	3.0V/3.0V

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).

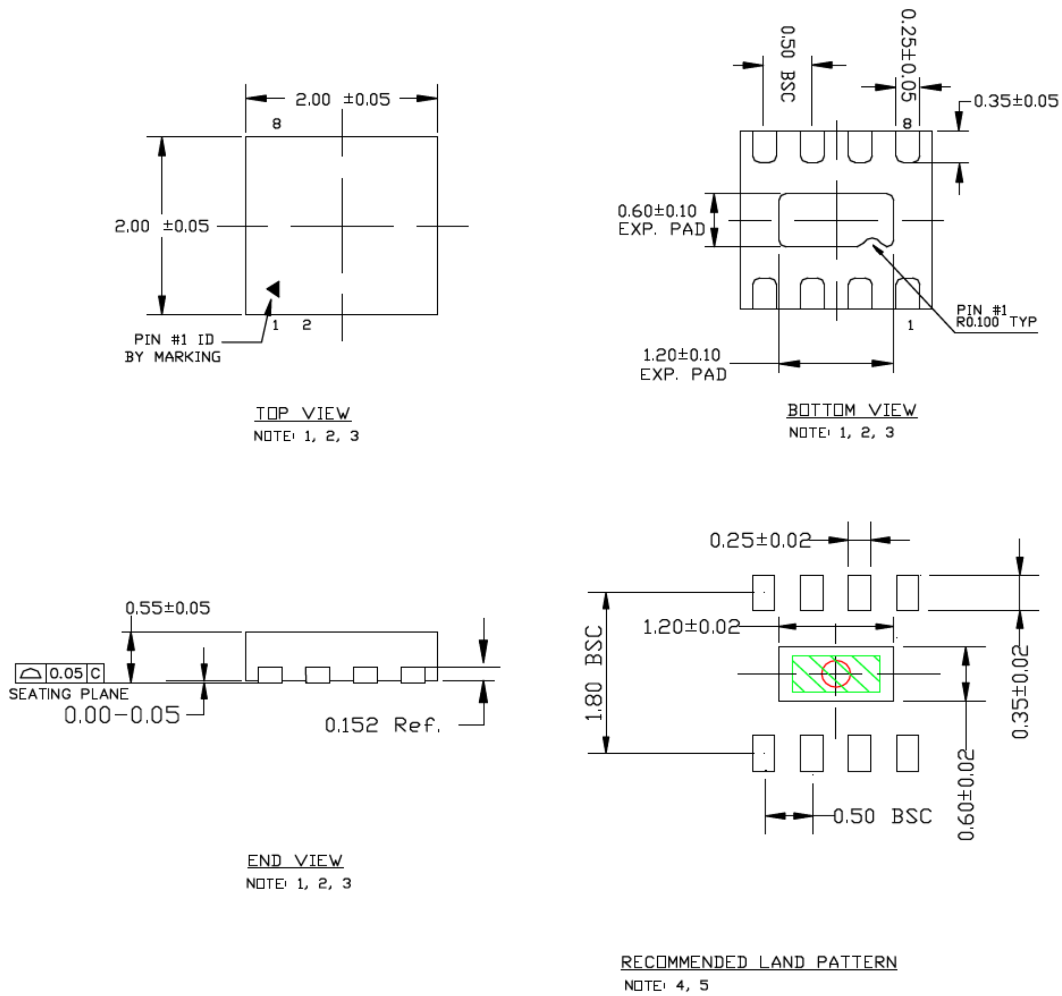
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

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

8-Lead 2 mm x 2 mm TDFN Package Outline and Recommended Land Pattern

TITLE
8 LEAD TDFN 2x2mm PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	TDFN22-8LD-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
4. RED CIRCLE IN LAND PATTERN REPRESENTS THERMAL VIA. SIZE SHOULD BE 0.30-0.3 MM IN DIAMETER AND SHOULD BE CONNECTED TO GND FOR MAX THERMAL PERFORMANCE
5. GREEN RECTANGLES (SHADED AREA) REPRESENTS SOLDER STENCIL OPENING ON EXPOSED PAD AREA. SIZE SHOULD BE 0.40x0.90 MM.

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 2017)

- Converted Micrel document MIC5331 to Microchip data sheet DS20005874A.
- Minor text changes throughout.

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	Output Voltage	Junction Temp. Range	Package	Media Type

Device:	MIC5331:		Micro-Power High Performance Dual 300 mA ULDO
Output Voltage:	G4	=	1.8V/1.2V
	J4	=	2.5V/1.2V
	MM	=	2.8V/2.8V
	MN	=	2.8V/2.85V
	NN	=	2.85V/2.85V
	PM	=	3.0V/2.8V
	PN	=	3.0V/2.85V
	PP	=	3.0V/3.0V
Junction Temperature Range:	Y	=	–40°C to +125°C
Package:	MT	=	8-Lead 2 mm x 2 mm x 0.6 mm TDFN
Media Type:	TR	=	5,000/Reel

Examples:

a) MIC5331-G4YMT-TR: Micro-Power High Performance Dual 300 mA ULDO, 1.8V/1.2V Output Voltage, –40°C to +125°C, 8-Lead TDFN, 5,000/Reel

b) MIC5331-MMYMT-TR: Micro-Power High Performance Dual 300 mA ULDO, 2.8V/2.8V Output Voltage, –40°C to +125°C, 8-Lead TDFN, 5,000/Reel

c) MIC5331-PMYMT-TR: Micro-Power High Performance Dual 300 mA ULDO, 3.0V/2.8V Output Voltage, –40°C to +125°C, 8-Lead TDFN, 5,000/Reel

d) MIC5331-NNYMT-TR: Micro-Power High Performance Dual 300 mA ULDO, 2.85V/2.85V Output Voltage, –40°C to +125°C, 8-Lead TDFN, 5,000/Reel

e) MIC5331-PPYMT-TR: Micro-Power High Performance Dual 300 mA ULDO, 3.0V/3.0V Output Voltage, –40°C to +125°C, 8-Lead 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:

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

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- 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.
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- 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."

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QUALITY MANAGEMENT SYSTEM CERTIFIED BY DNV

== ISO/TS 16949 ==

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