MIC5335

Dual-Channel, High-Performance 300 mA μCap ULDO

Features

- 2.3V to 5.5V Input Voltage Range
- Ultra-Low Dropout Voltage: 75 mV @ 300 mA
- Ultra-Small 1.6 mm x 1.6 mm x 0.55 mm 6-Lead Thin DFN Package
- Independent Enable Pins
- High PSRR (over 65 dB @ 1 kHz)
- 300 mA Output Current per LDO
- μCap Stable with 1 μF Ceramic Capacitor
- Low Quiescent Current: 90 μA/LDO
- Fast Turn-On Time: 30 μs
- Thermal Shutdown Protection
- Current Limit Protection

Applications

- Mobile Phones
- PDAs
- GPS Receivers
- Portable Electronics
- Portable Media Players
- Digital Still and Video Cameras

General Description

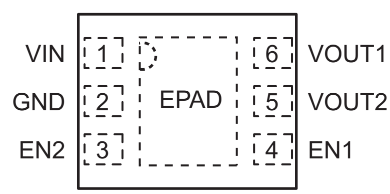
The MIC5335 is a high current density, dual Ultra-Low Dropout (ULDO) linear regulator. The MIC5335 is ideally suited for portable electronics that demand overall high performance in a very small form factor. The MIC5335 is offered in the ultra-small 1.6 mm x 1.6 mm x 0.55 mm 6-lead Thin DFN package, which is only 2.56 mm^2 in area. The MIC5335 has an exceptional thermal performance for applications that demand higher power dissipation in a very small footprint. In addition, the MIC5335 integrates two high-performance 300 mA LDOs with independent enable functions and offers high PSRR, eliminating the need for a bypass capacitor.

The MIC5335 is a μCap design that enables operation with very small output capacitors for stability, thereby reducing required board space and component cost.

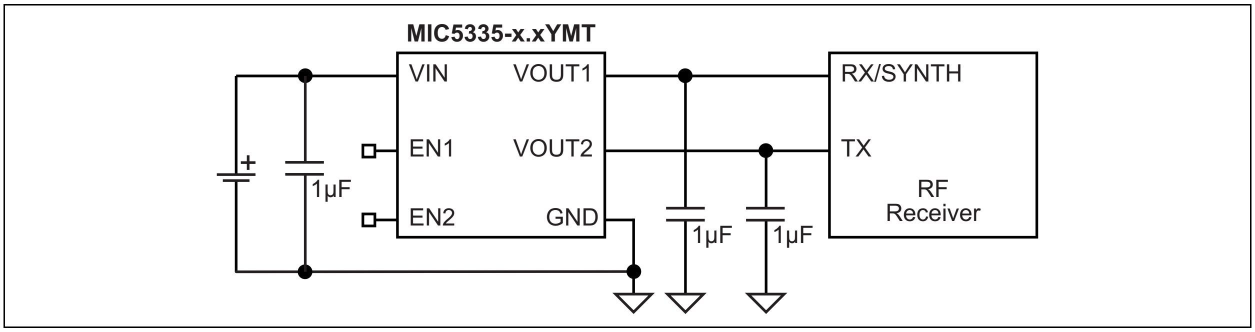
The MIC5335 is available in fixed-output voltages. Additional voltages are available upon customer request.

Package Type

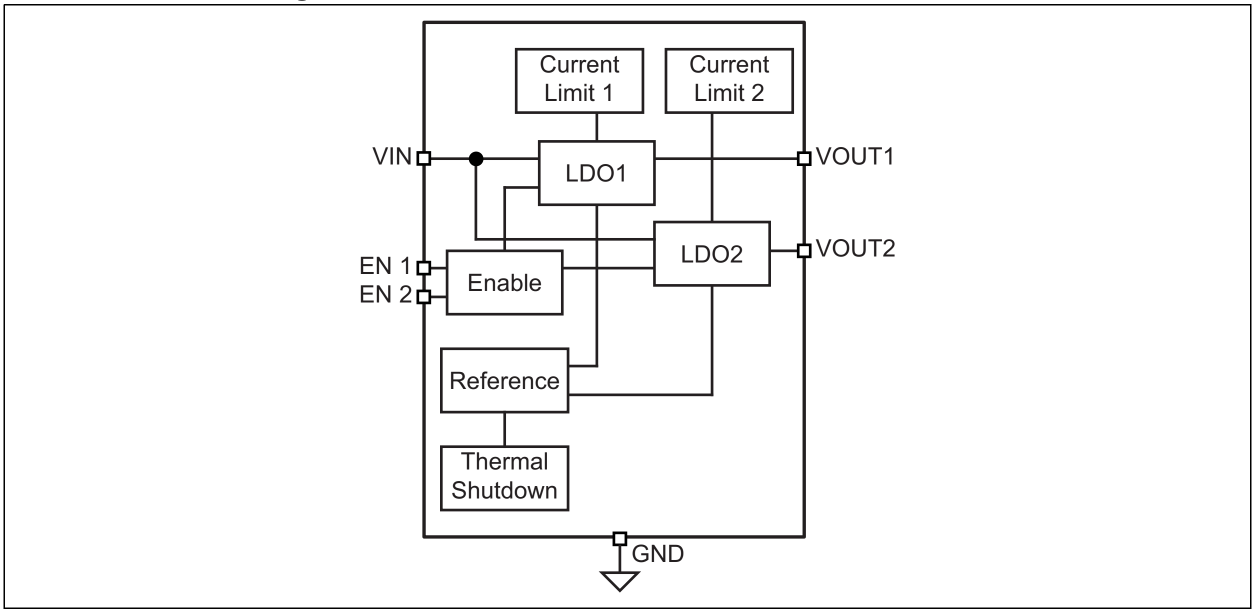
MIC5335
TDFN-6 (MT)
(Top View)



Typical Application Circuit



Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN}) .... 0V to +6V
Enable Input Voltage (V_{EN}) .... 0V to +6V
Power Dissipation .... Internally Limited, Note 1
Lead Temperature (Soldering, 3 sec.) .... +260°C
Storage Temperature (T_S) .... –65°C to +150°C
ESD Rating (Note 2) .... 2 kV

Operating Ratings ††

Supply Voltage (V_{IN}) .... +2.3V to +5.5V
Enable Input Voltage (V_{EN}) .... 0V to V_{IN}
Junction Temperature (T_J) .... –40°C to +125°C
Thermal Resistance, TDFN-6 (θ_{JA}) .... 100°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_{IN} = EN1 = EN2 = V_{OUT} + 1.0V; higher of the two regulator outputs, $I_{OUTLDO1}$ = $I_{OUTLDO2}$ = 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	Sym.	Min.	Typ.	Max.	Units	Conditions
Output Voltage Accuracy		–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	—	—	0.02	0.3	%/V	V_{IN} = V_{OUT} + 1V to 5.5V; I_{OUT} = 100 µA
		—	—	**0.6**		—
Load Regulation	—	—	0.3	**2.0**	%	I_{OUT} = 100 µA to 300 mA
Dropout Voltage, Note 2	V_{DO}	—	0.1	—	mV	I_{OUT} = 100 µA
		—	25	**75**		I_{OUT} = 100 mA
		—	35	**100**		I_{OUT} = 150 mA
		—	75	**200**		I_{OUT} = 300 mA

Note 1: Specification for packaged product only.

2: Dropout voltage is defined as the input-to-output differential at which the output voltage drops 2% below its nominal V_{OUT}. For outputs below 2.3V, the dropout voltage is the input-to-output differential with the minimum input voltage 2.3V.

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: V_{IN} = EN1 = EN2 = V_{OUT} + 1.0V; higher of the two regulator outputs, $I_{OUTLDO1}$ = $I_{OUTLDO2}$ = 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	Sym.	Min.	Typ.	Max.	Units	Conditions
Ground Current	I_{GND}	—	90	**125**	µA	EN1 = High; EN2 = Low; I_{OUT} = 100 µA to 300 mA
		—	90	**125**		EN1 = Low; EN2 = High; I_{OUT} = 100 µA to 300 mA
		—	150	**220**		EN1 = EN2 = High; I_{OUT1} = 300 mA, I_{OUT2} = 300 mA
Ground Current in Shutdown	I_{SHDN}	—	0.01	2	µA	EN1 = EN2 = 0V
Ripple Rejection	PSRR	—	65	—	dB	f = 1 kHz; C_{OUT} = 1.0 µF
		—	45	—		f = 20 kHz; C_{OUT} = 1.0 µF
Current Limit	I_{LIM}	**340**	550	**950**	mA	V_{OUT} = 0V
Output Voltage Noise		—	90	—	μV_{RMS}	C_{OUT} = 1.0 µF; 10 Hz to 100 kHz
Enable Inputs (EN1/EN2)						
Enable Input Voltage	V_{EN}	—	—	**0.2**	V	Logic low
		1.1	—	—		Logic high
Enable Input Current	I_{EN}	—	0.01	1	µA	V_{IL} ≤ 0.2V
		—	0.01	1		V_{IH} ≥ 1.0V
Turn-On Time (see Timing Diagram)						
Turn-On Time (LDO1 and LDO2)	t_{ON}	—	30	**100**	µs	C_{OUT} = 1.0 µF

Note 1: Specification for packaged product only.

2: Dropout voltage is defined as the input-to-output differential at which the output voltage drops 2% below its nominal V_{OUT}. For outputs below 2.3V, the dropout voltage is the input-to-output differential with the minimum input voltage 2.3V.

TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Storage Temperature Range	T_S	–65	—	+150	°C	—
Lead Temperature	—	—	—	+260	°C	Soldering, 3 sec.
Junction Temperature Range	T_J	–40	—	+125	°C	—
Package Thermal Resistances						
Thermal Resistance, 1.6x1.6 TDFN 6-Ld	θ_{JA}	—	100	—	°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.

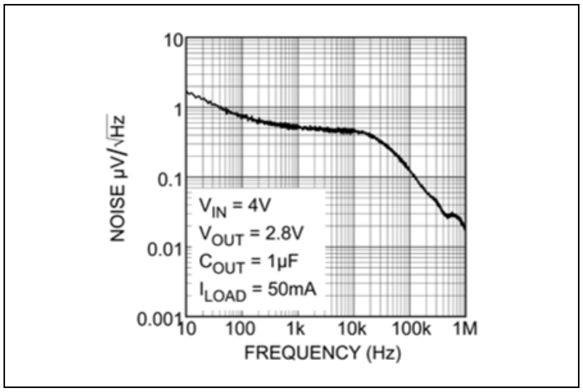


FIGURE 2-1: Output Noise Spectral Density.

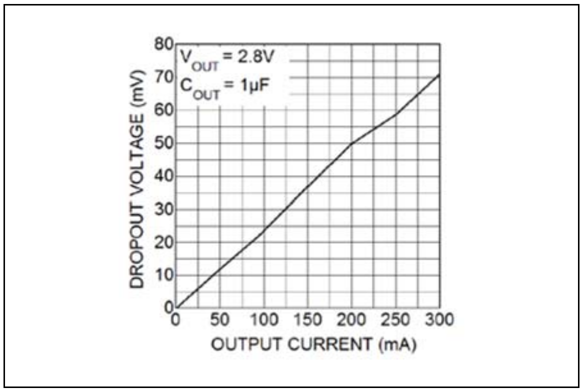


FIGURE 2-2: Dropout Voltage vs. Output Current.

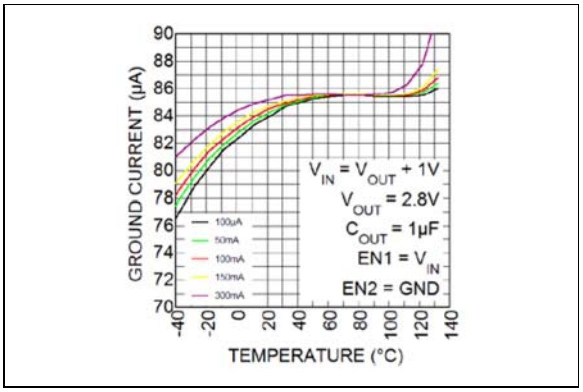


FIGURE 2-3: Ground Current vs. Temperature.

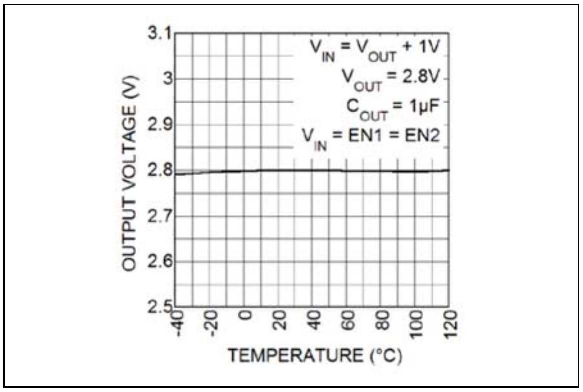


FIGURE 2-4: Output Voltage vs. Temperature.

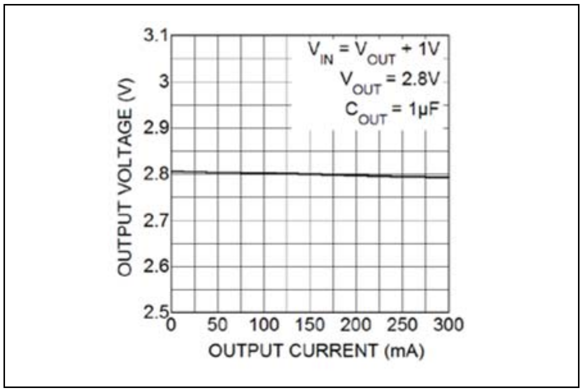


FIGURE 2-5: Output Voltage vs. Output Current.

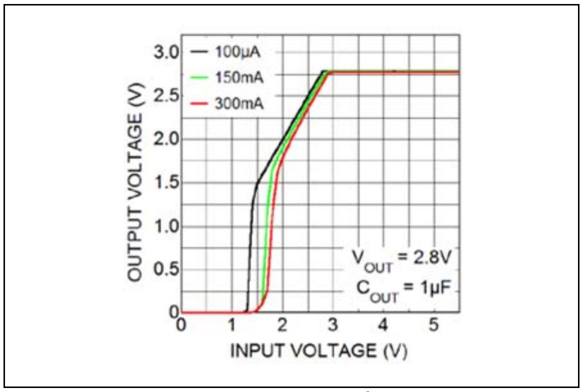


FIGURE 2-6: Output Voltage vs. Input Voltage.

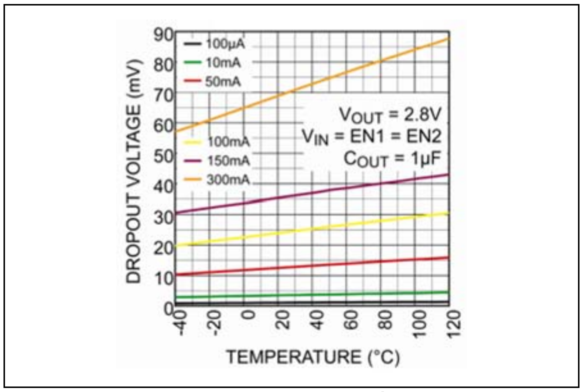


FIGURE 2-7: *Dropout Voltage vs. Temperature.*

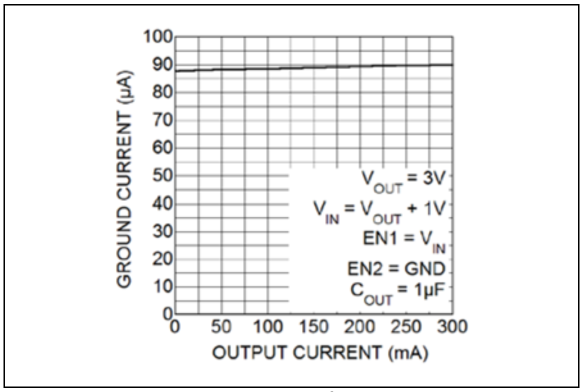


FIGURE 2-8: *Ground Current vs. Output Current.*

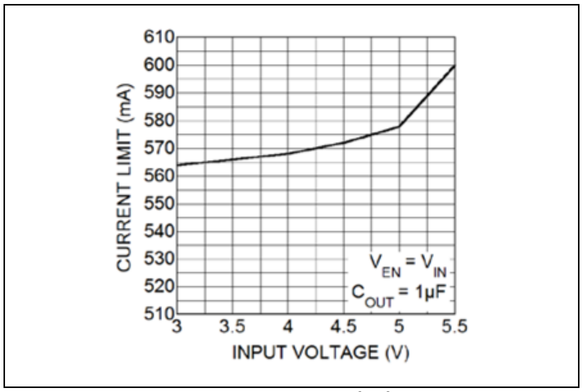


FIGURE 2-9: *Current Limit.*

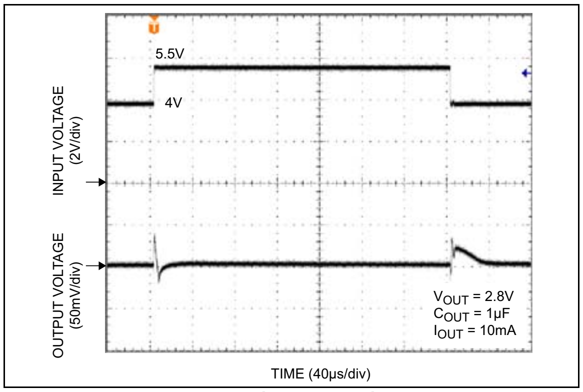


FIGURE 2-10: *Line Transient.*

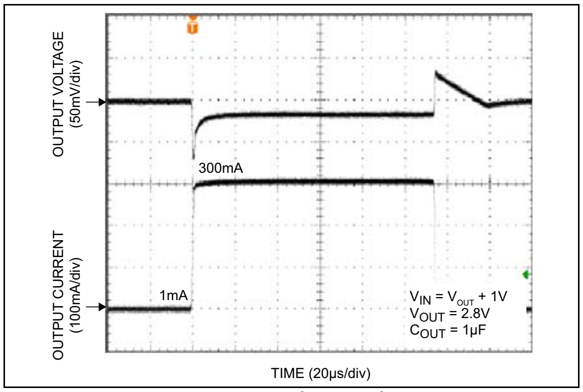


FIGURE 2-11: *Load Transient.*

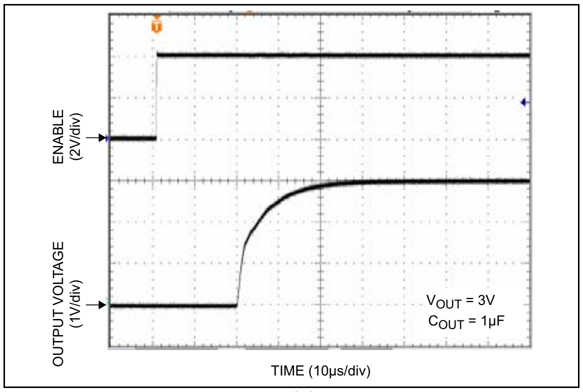


FIGURE 2-12: *Enable Turn-On.*

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	EN2	LDO2 Enable Active-High Input. Logic High = On; Logic Low = Off; Do not leave floating.
4	EN1	LDO1 Enable Active-High Input. Logic High = On; Logic Low = Off; Do not leave floating.
5	VOUT2	Regulator Output – LDO2.
6	VOUT1	Regulator Output – LDO1.
EPAD	ePad	Exposed heat sink pad connected internally to ground.

4.0 APPLICATION INFORMATION

4.1 Enable/Shutdown

The MIC5335 comes with dual active-high enable pins that allow each regulator to be enabled 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.

4.2 Input Capacitor

The MIC5335 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.

4.3 Output Capacitor

The MIC5335 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 on the market. 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.

4.4 No-Load Stability

Unlike many other voltage regulators, the MIC5335 will remain stable and in regulation with no load. This is especially important in CMOS RAM keep-alive applications.

4.5 Thermal Considerations

The MIC5335 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 upon the output current and the voltage drop across the part. Given that the input voltage is 3.3V, the output voltage is 2.8V for V_{OUT1}, 2.5V for V_{OUT2}, and the output current is 300 mA. The actual power dissipation of the regulator circuit can be determined using the equation:

EQUATION 4-1:

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

$$P_D = (3.3V - 2.8V) \times 300mA + (3.3V - 2.5V) \times 300mA$$

$$P_D = 0.39W$$

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 Equation 4-1.

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 4-2:

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

Where:

$T_{J(MAX)}$ = 125°C, the max. junction temp of the die.
θ_{JA} = 100°C/W thermal resistance.

The table that follows shows junction-to-ambient thermal resistance for the MIC5335 in the Thin DFN package.

TABLE 4-1: THERMAL RESISTANCE

θ_{JA} Recommended Minimum Footprint	θ_{JC}
100°C/W	2°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 100°C/W.

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

For example, when operating the MIC5335-MFYML at an input voltage of 3.3V and 300 mA loads on each output with a minimum footprint layout, the maximum ambient operating temperature T_A can be determined as follows:

EQUATION 4-3:

$$0.39W = \frac{125°C - T_A}{100°C/W}$$

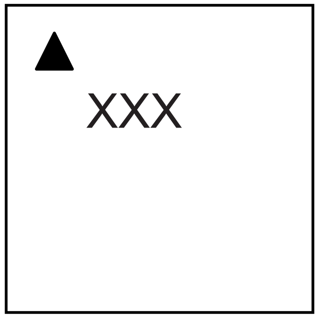
$$T_A = 86°C$$

Therefore, a 2.8V/2.5V application with 300 mA at each output current can accept an ambient operating temperature of 86°C in a 1.6 mm x 1.6 mm Thin DFN package.

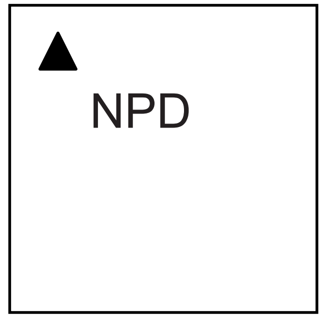
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

6-Lead TDFN*



Example



For a detailed breakdown of part numbers, their markings, and voltages, please see Table 5-1.

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.

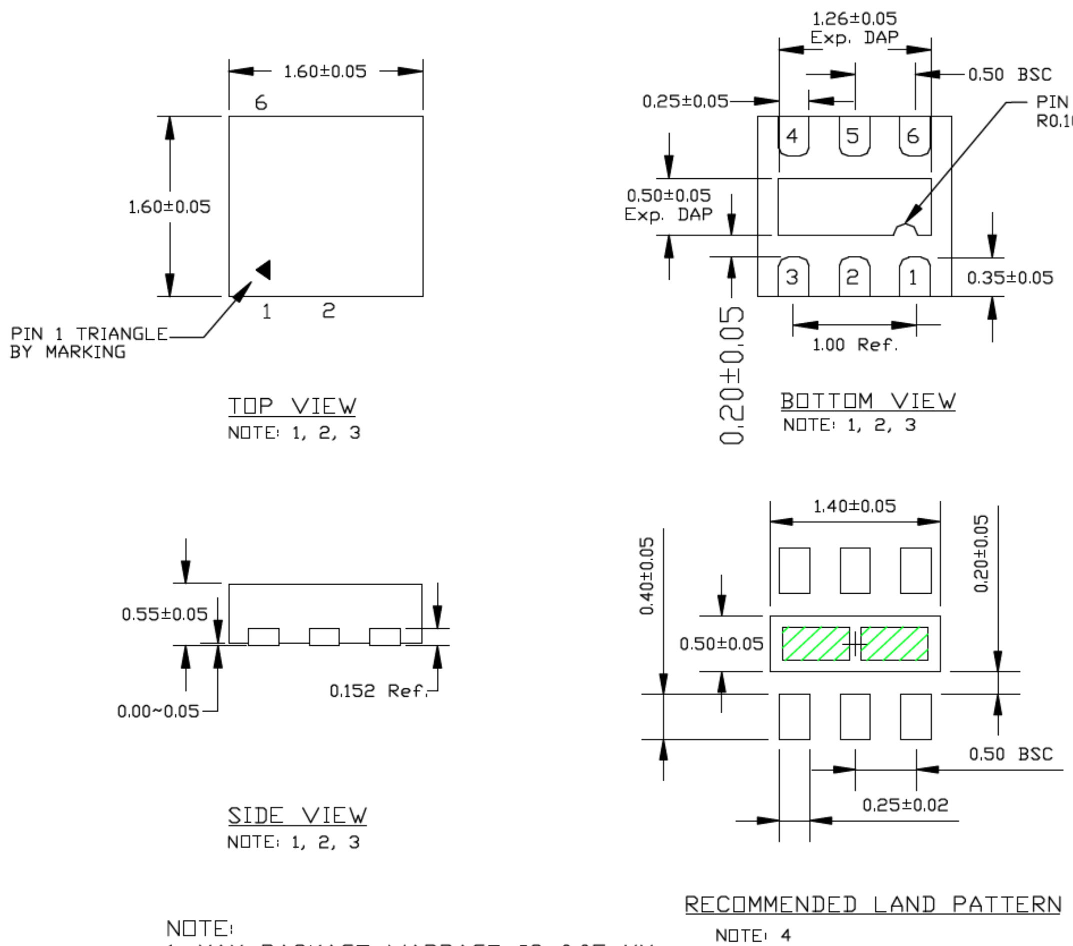
TABLE 5-1: PACKAGE MARKING

Part Number	Marking	Voltage	Part Number	Marking	Voltage
MIC5335-GFYMT	GPF	1.8V/1.5V	MIC5335-PGYMT	PPG	3.0V/1.8V
MIC5335-GWYMT	GPW	1.8V/1.6V	MIC5335-PJYMT	PPJ	3.0V/2.5V
MIC5335-GGYMT	GPG	1.8V/1.8V	MIC5335-PKYMT	PPK	3.0V/2.6V
MIC5335-JGYMT	JPG	2.5V/1.8V	MIC5335-PMYMT	PPM	3.0V/2.8V
MIC5335-JJYMT	JPJ	2.5V/2.5V	MIC5335-PNYMT	PPN	3.0V/2.85V
MIC5335-KDYMT	KPD	2.6V/1.85	MIC5335-PPYMT	PPP	3.0V/3.0V
MIC5335-KGYMT	KPG	2.6V/1.8V	MIC5335-SFYMT	SPF	3.3V/1.5V
MIC5335-LLYMT	LPL	2.7V/2.7V	MIC5335-SGYMT	SPG	3.3V/1.8V
MIC5335-MFYMT	MPF	2.8V/1.5V	MIC5335-SJYMT	SPJ	3.3V/2.5V
MIC5335-MGYMT	MPG	2.8V/1.8V	MIC5335-SKYMT	SPK	3.3V/2.6V
MIC5335-MKYMT	MPK	2.8V/2.6V	MIC5335-SLYMT	SPL	3.3V/2.7V
MIC5335-MMYMT	MPM	2.8V/2.8V	MIC5335-SMYMT	SPM	3.3V/2.8V
MIC5335-NDYMT	NPD	2.85V/1.85V	MIC5335-SNYMT	SPN	3.3V/2.85V
MIC5335-NKYMT	NPK	2.85V/2.6V	MIC5335-SOYMT	SPO	3.3V/2.9V
MIC5335-NNYMT	NPN	2.85V/2.85V	MIC5335-SPYMT	SPP	3.3V/3.0V
MIC5335-OFYMT	OPF	2.9V/1.5V	MIC5335-SRYMT	SPR	3.3V/3.2V
MIC5335-OGYMT	OPG	2.9V/1.8V	MIC5335-SSYMT	SPS	3.3V/3.3V
MIC5335-OOYMT	OPO	2.9V/2.9V	MIC5335-XXYMT	XPX	3.15V/3.15V

6-Lead TDFN 1.6 mm x 1.6 mm Package Outline & 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.

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (June 2018)

- Converted Micrel document MIC5335 to Microchip data sheet template DS20006039A.
- Minor grammatical text changes throughout.
- Addition of MIC5335-XXYMT option in Table 5-1 and Product Identification System.
- Updated Package Type drawing.
- Updated Functional Block Diagram drawing.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

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

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

Device:	MIC5335:	Dual-Channel, High-Performance 300 mA µCap ULDO
Voltage Option:	GF = 1.8V/1.5V GG = 1.8V/1.8V GW = 1.8V/1.6V JG = 2.5V/1.8V JJ = 2.5V/2.5V KD = 2.6V/1.85V KG = 2.6V/1.8V LL = 2.7V/2.7V MF = 2.8V/1.5V MG = 2.8V/1.8V MK = 2.8V/2.6V MM = 2.8V/2.8V ND = 2.85V/1.85V NK = 2.85V/2.6V NN = 2.85V/2.85V OF = 2.9V/1.5V OG = 2.9V/1.8V OO = 2.9V/2.9V PG = 3.0V/1.8V PJ = 3.0V/2.5V PK = 3.0V/2.6V PM = 3.0V/2.8V PN = 3.0V/2.85V PP = 3.0V/3.0V SF = 3.3V/1.5V SG = 3.3V/1.8V SJ = 3.3V/2.5V SK = 3.3V/2.6V SL = 3.3V/2.7V SM = 3.3V/2.8V SN = 3.3V/2.85V SO = 3.3V/2.9V SP = 3.3V/3.0V SR = 3.3V/3.2V SS = 3.3V/3.3V XX = 3.15V/3.15V	
Junction Temperature Range:	Y =	–40°C to +125°C, RoHS-Compliant
Package:	MT =	6-Lead 1.6 mm x 1.6 mm TDFN
Media Type:	TR =	5,000/Reel

Examples:

a) MIC5335-GFYMT-TR:	MIC5335, 1.8V/1.5V Voltage Option, –40°C to +125°C Temperature Range, 6-Lead 1.6 mm x 1.6 mm TDFN, 5,000/Reel
b) MIC5335-JJYMT-TR:	MIC5335, 2.5V/2.5V Voltage Option, –40°C to +125°C Temperature Range, 6-Lead 1.6 mm x 1.6 mm TDFN, 5,000/Reel
c) MIC5335-MKYMT-TR:	MIC5335, 2.8V/2.6V Voltage Option, –40°C to +125°C Temperature Range, 6-Lead 1.6 mm x 1.6 mm TDFN, 5,000/Reel
d) MIC5335-OGYMT-TR:	MIC5335, 2.9V/1.8V Voltage Option, –40°C to +125°C Temperature Range, 6-Lead 1.6 mm x 1.6 mm TDFN, 5,000/Reel
e) MIC5335-PJYMT-TR:	MIC5335, 3.0V/2.5V Voltage Option, –40°C to +125°C Temperature Range, 6-Lead 1.6 mm x 1.6 mm TDFN, 5,000/Reel
f) MIC5335-SGYMT-TR:	MIC5335, 3.3V/1.8V Voltage Option, –40°C to +125°C Temperature Range, 6-Lead 1.6 mm x 1.6 mm TDFN, 5,000/Reel
g) MIC5335-SRYMT-TR:	MIC5335, 3.3V/3.2V Voltage Option, –40°C to +125°C Temperature Range, 6-Lead 1.6 mm x 1.6 mm TDFN, 5,000/Reel
h) MIC5335-XXYMT-TR:	MIC5335, 3.15V/3.15V Voltage Option, –40°C to +125°C Temperature Range, 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:

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.
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Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

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