MIC5353

500 mA LDO in 1.6 mm x 1.6 mm Package

Features

- 500 mA Guaranteed Output Current
- Input Voltage Range: 2.6V to 6V
- Ultra Low Dropout Voltage: 160 mV @ 500 mA
- ±2% initial Accuracy
- Ultra-Low Output Noise: 30 µVrms
- Low Quiescent Current: 90 µA
- Stable with Ceramic Output Capacitors
- 35 µs Turn-On Time
- Thermal Shutdown and Current Limit Protection
- Tiny 6-Pin 1.6 mm x 1.6 mm Thin UDFN Leadless Package

Applications

- Mobile Phones
- GPS, PDAs, PMP, Handhelds
- Portable Electronics
- Digital Still and Video Cameras
- Digital TV

General Description

The MIC5353 is a high-performance, single-output, ultra-low LDO regulator, offering a low total output noise of 30 µVRMS. The MIC5353 is capable of sourcing 500 mA output current and offers high-PSRR and low-output noise, making it an ideal solution for RF applications.

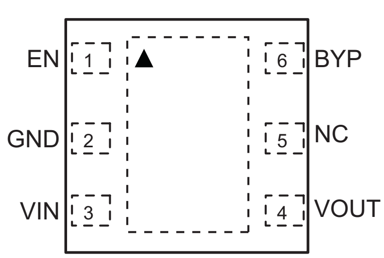
The MIC5353 provides 2% accuracy, extremely low dropout voltage (160 mV @ 500 mA), and low ground current (typically 90 µA) making it ideal for battery-operated applications. When disabled, the MIC5353 enters a zero-off-mode current state, thereby drawing almost no current.

The MIC5353 is available in the 1.6 mm x 1.6 mm Thin UDFN package, occupying only 2.56 mm^2 of PCB area, a 36% reduction in board area compared to SC-70 and 2 mm x 2 mm Thin UDFN packages.

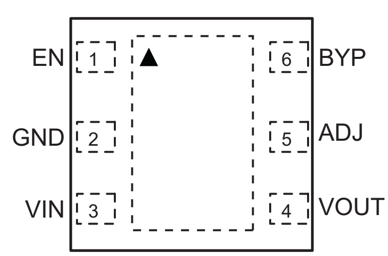
The MIC5353 has an operating junction temperature range of –40°C to +125°C and is available in fixed and adjustable output voltages in lead-free (RoHS-compliant) Thin UDFN package.

Package Type

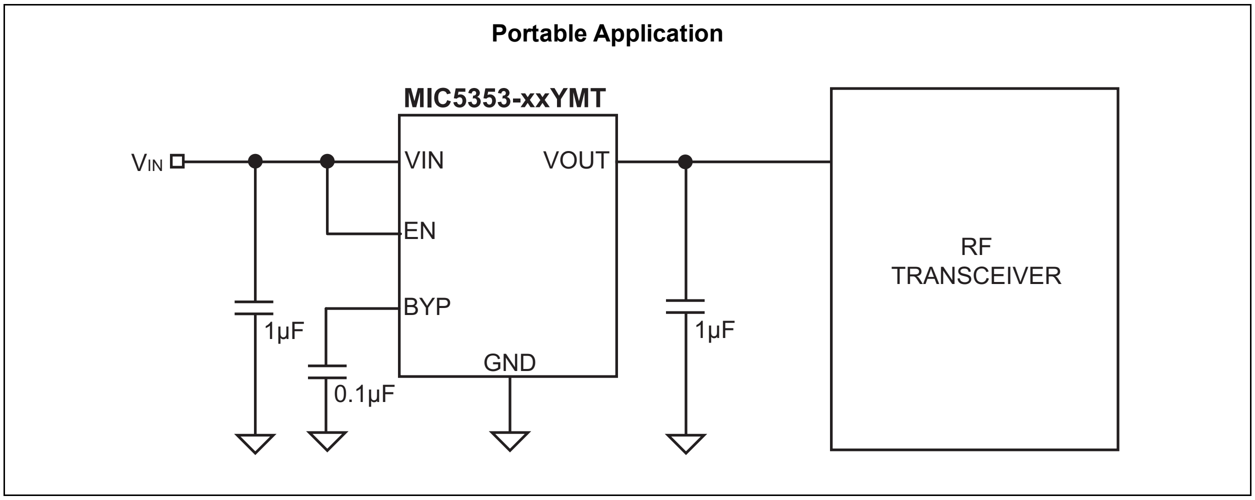
MIC5353
6-Pin UDFN (MT)
Fixed
(Top View)



MIC5353
6-Pin UDFN (MT)
Adjustable
(Top View)

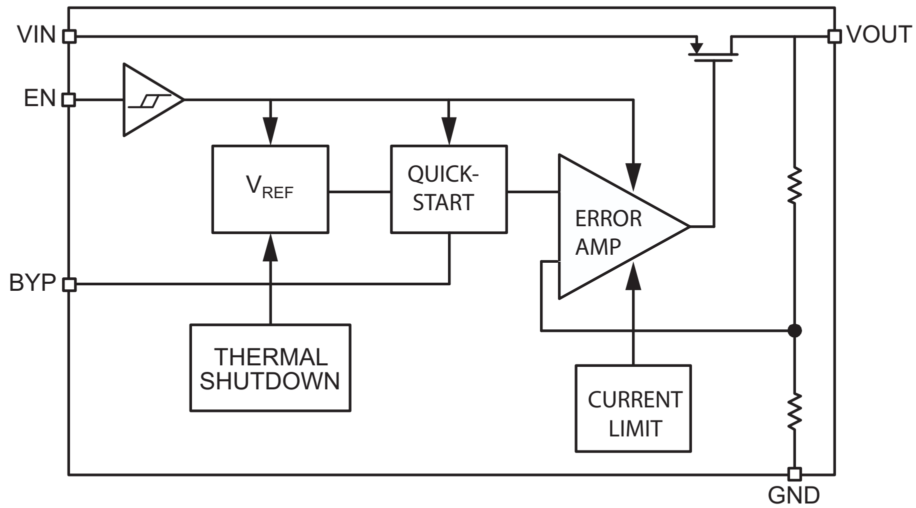


Typical Application Schematic

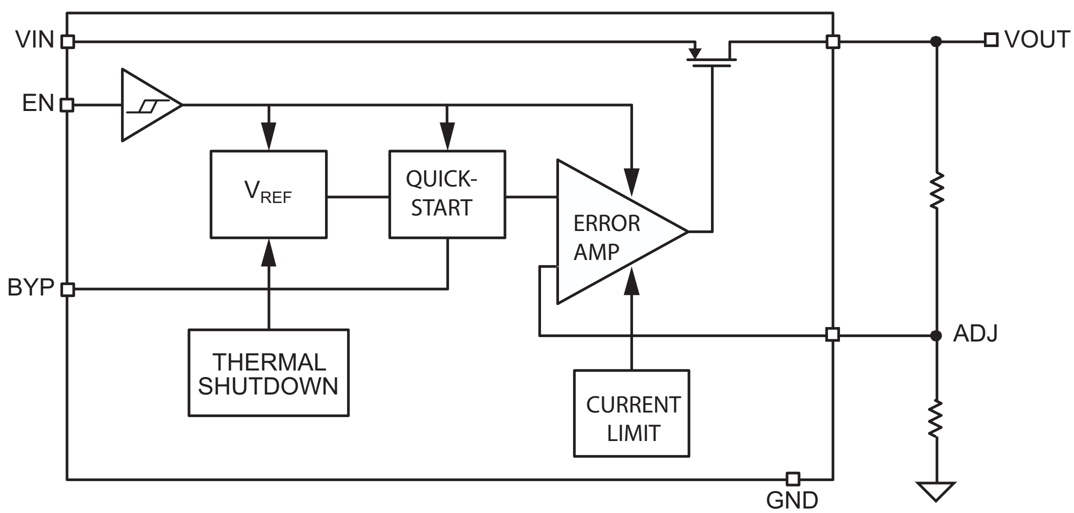


Functional Block Diagrams

MIC5353 (Fixed)



MIC5353 (Adjustable)



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN}) ..... –0.3V to +6.5V
Enable Input Voltage (V_{EN}) ..... –0.3V to V_{IN}
Power Dissipation (P_D), Note 1 ..... Internally Limited
ESD Rating, Note 2 ..... 2 kV

Operating Ratings ‡

Supply Voltage (V_{IN}) ..... +2.6V to +6.0V
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 $P_{D(max)} = (T_{J(max)} – T_A) / θ_{JA}$. 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 are recommended. Human body model, 1.5 kΩ in series with 100 pF.

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: $V_{IN} = V_{OUT}$ + 1V; I_{OUT} = 100 µA; C_{OUT} = 1.0 µF; T_J = +25°C;
Bold values indicate –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**		Variation from nominal V_{OUT}; –40°C to +125°C
Line Regulation	ΔV_{OUT}/ (V_{OUT} x ΔV_{IN})	—	0.05	0.3	%/V	$V_{IN} = V_{OUT}$ + 1V to 6V, I_{OUT} = 100 µA
		—	—	**0.6**		
Load Regulation	$\Delta V_{OUT}/V_{OUT}$	—	0.15	**2.0**	%	I_{OUT} = 100 µA to 500 mA
Dropout Voltage (Note 2)	V_{DO}	—	50	**100**	mV	I_{OUT} = 150 mA
		—	100	**200**		I_{OUT} = 300 mA
		—	160	**350**		I_{OUT} = 500 mA
Ground Pin Current	I_{GND}	—	90	**175**	µA	I_{OUT} = 0 mA to 500 mA
Ground Pin Current in Shutdown	I_{SHDN}	—	0.01	2	µA	V_{EN} ≤ 0.2V
Ripple Rejection	PSRR	—	60	—	dB	f = 1 kHz; C_{OUT} = 1.0 µF, C_{BYP} = 0.1µF
		—	45	—		f = 20 kHz; C_{OUT} = 1.0 µF; C_{BYP} = 0.1 µF
Current Limit		600	1100	**1600**	mA	V_{OUT} = 0V
Output Voltage Noise	e_N	—	30	—	$µV_{RMS}$	C_{OUT} = 1.0 µF; C_{BYP} = 0.1 µF; 10 Hz to 100 kHz

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: $V_{IN} = V_{OUT} + 1V$; $I_{OUT} = 100\ \mu A$; $C_{OUT} = 1.0\ \mu F$; $T_J = +25°C$;
Bold values indicate –40°C to +125°C unless noted. (**Note 1**).

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Enable Input						
Enable Input Voltage	V_{EN}	—	—	**0.2**	V	Logic Low
		1.2	—	—		Logic High
Enable Input Current	I_{EN}	—	0.01	1	µA	$V_{IL} \leq 0.2V$
Turn-On Time						
Turn-On Time	t_{ON}	—	35	**100**	µs	$C_{OUT} = 1\ \mu F$

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 value measured at 1V differential.

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, 3 sec.
Package Thermal Resistances						
Thermal Resistance, UDFN-6	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.

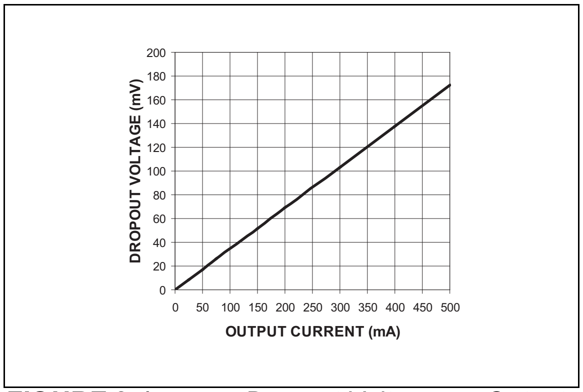


FIGURE 2-1: *Dropout Voltage vs. Output Current.*

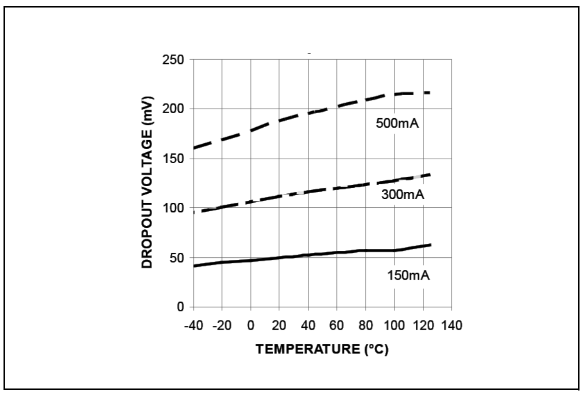


FIGURE 2-2: *Dropout Voltage vs. Temperature.*

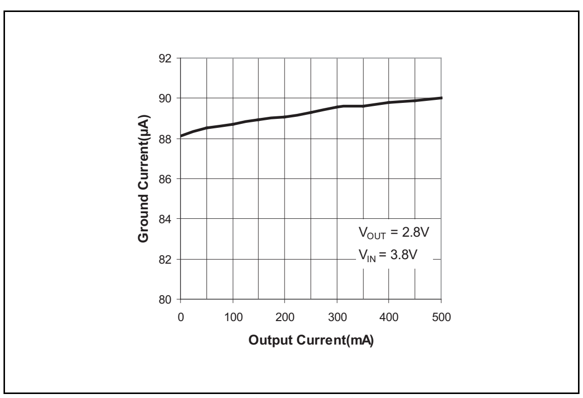


FIGURE 2-3: *Ground Current vs. Output Current.*

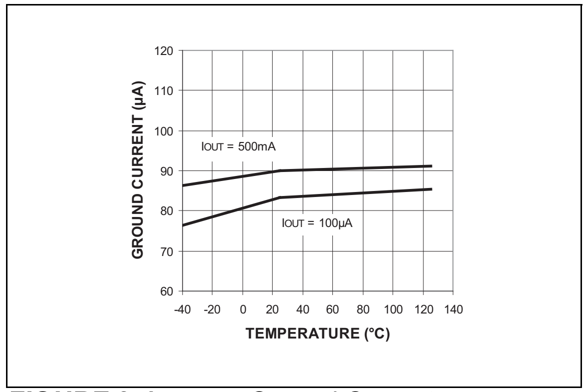


FIGURE 2-4: *Ground Current vs. Temperature.*

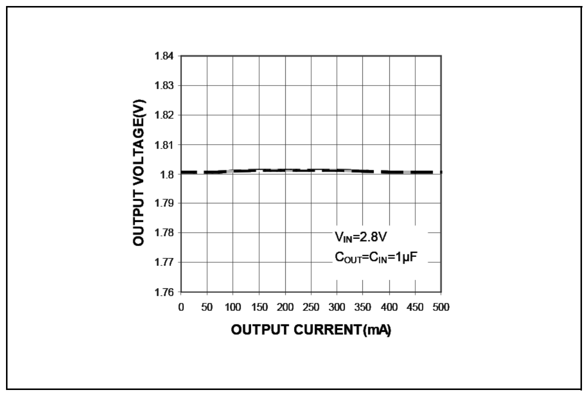


FIGURE 2-5: *Output Voltage vs. Output Current.*

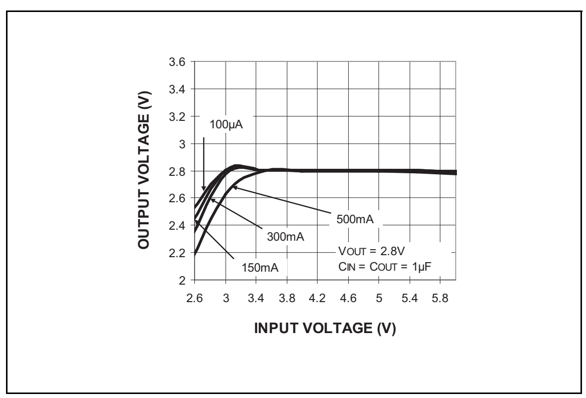


FIGURE 2-6: *Output Voltage vs. Input Voltage.*

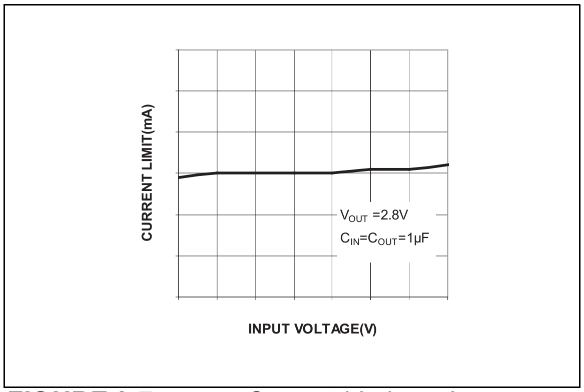


FIGURE 2-7: *Current Limit vs. Input Voltage.*

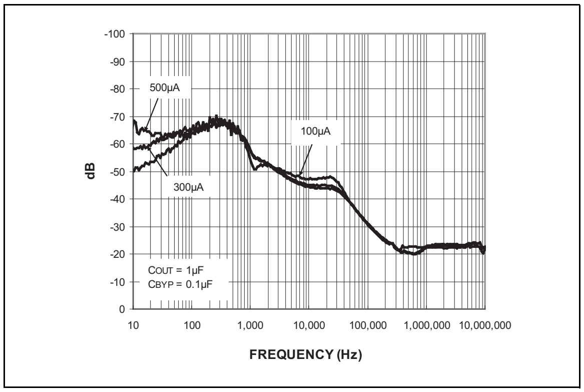


FIGURE 2-8: *PSRR.*

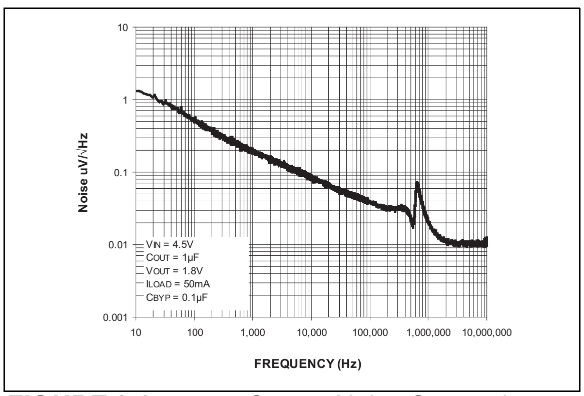


FIGURE 2-9: *Output Noise Spectral Density.*

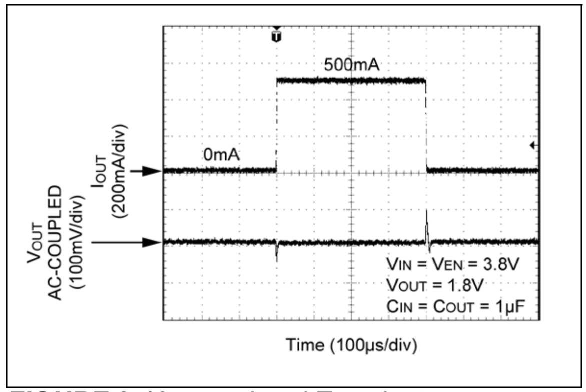


FIGURE 2-10: *Load Transient (V_{IN} = 0 mA to 500 mA).*

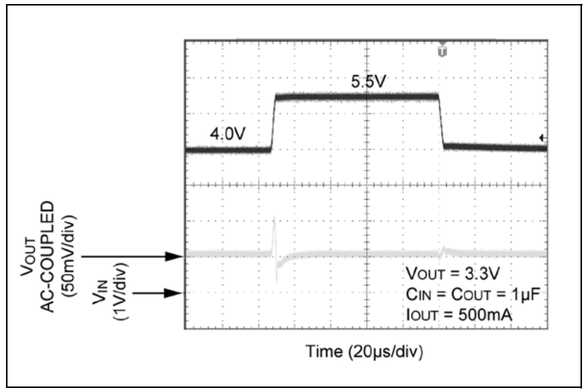


FIGURE 2-11: *Line Transient (V_{IN} = 4.0V to 5.5V).*

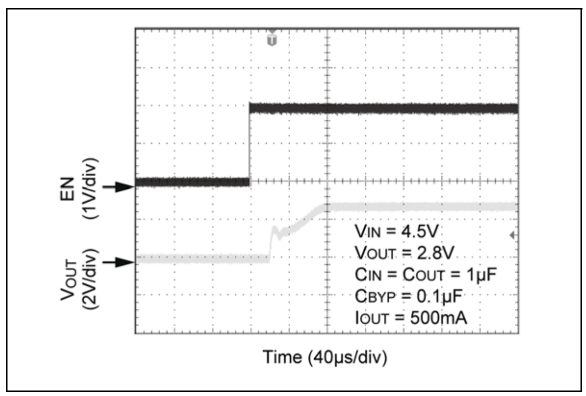


FIGURE 2-12: *Turn-On Time.*

3.0 PIN DESCRIPTIONS

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

TABLE 3-1: PIN FUNCTION TABLE

Pin Number Thin UDFN-6 Fixed	Pin Number Thin UDFN-6 Adjustable	Pin Name	Description
1	1	EN	Enable Input. Active High. High = ON, Low = OFF. Do not leave floating.
2	2	GND	Ground.
3	3	VIN	Supply input.
4	4	VOUT	Output voltage.
5	—	NC	No connection.
—	5	ADJ	Adjust Input. Connect to external resistor voltage divider network.
6	6	BYP	Reference Bypass: Connect external 0.1 µF to GND for reduced Output Noise. May be left open.
EP	EP	HS PAD	Exposed Heatsink Pad. Pad connected to ground internally.

4.0 APPLICATION INFORMATION

4.1 Enable/Shutdown

The MIC5353 comes 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.

4.2 Input Capacitor

The MIC5353 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. The use of 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 MIC5353 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, although performance has been optimized for a 1 µF ceramic output capacitor and doing so does not improve significantly with larger capacitance.

X7R/X5R dielectric-type ceramic capacitors are recommended because of their temperature performance. The 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 thereby ensuring the same minimum capacitance over the equivalent operating temperature range.

4.4 No-Load Stability

Unlike many other voltage regulators, the MIC5353 will remain stable and in regulation with no load. This is especially important in CMOS RAM keep-alive applications.

4.5 Bypass Capacitor

A capacitor can be placed from the noise bypass pin-to-ground to reduce output voltage noise. The capacitor bypasses the internal reference. A 0.1 µF capacitor is recommended for applications that require low-noise outputs. The bypass capacitor can be increased, further reducing noise and improving PSRR. Turn-on time increases slightly with respect to bypass capacitance.

A unique, quick-start circuit allows the MIC5353 to drive a large capacitor on the bypass pin without significantly slowing turn-on time.

4.6 Adjustable Regulator Application

Adjustable regulators use the ratio of two resistors to multiply the reference voltage to produce the desired output voltage. The MIC5353 can be adjusted from 1.25V to 5.5V by using two external resistors (Figure 1). The resistors set the output voltage based on the following equation:

EQUATION 4-1:

$$V_{OUT} = V_{REF}\left(1 + \frac{R1}{R2}\right)$$

Where:

V_{FEF} = 1.25V

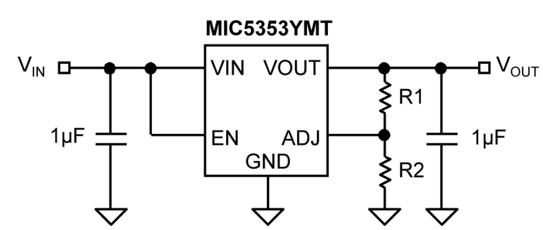


FIGURE 4-1: *Adjustable Voltage Output.*

4.7 Thermal Considerations

The MIC5353 is designed to provide 500 mA of continuous current. Maximum ambient operating temperature can be calculated based on the output current and the voltage drop across the part. Given that the input voltage is 3.3V, the output voltage is 2.8V and the output current = 500 mA.

The actual power dissipation of the regulator circuit can be determined using Equation 4-2:

EQUATION 4-2:

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

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 the calculation in Equation 4-3:

EQUATION 4-3:

$$P_D = (3.3V - 2.8V) \times 500mA$$

$$P_D = 0.25W$$

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 4-4:

EQUATION 4-4:

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

Where:

$T_{J(MAX)}$ = 125°C

θ_{JA} = 92.4°C/W

4.8 Thermal Resistance

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 MIC5353-2.8YMT at an input voltage of 3.3V and 500 mA load with a minimum footprint layout, the maximum ambient operating temperature T_A can be determined as follows: in Equation 4-5:

EQUATION 4-5:

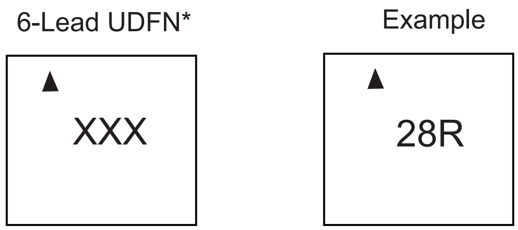
$$0.25W = (125°C - T_A)/(92.4°C/W)$$

$$T_A = 101°C$$

Therefore, a 2.8V application with 500 mA at each output current can accept an ambient operating temperature of 101°C in a 1.6 mm × 1.6 mm UDFN 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 PACKAGING INFORMATION

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

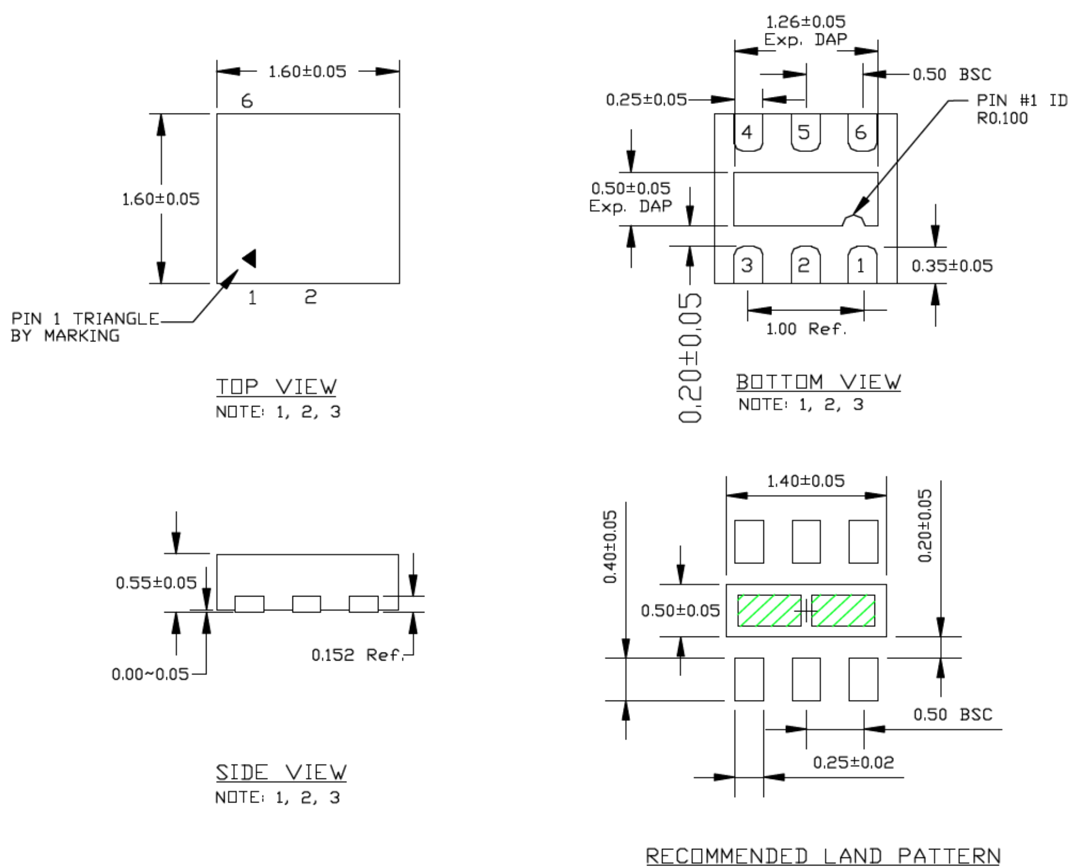
TABLE 5-1: PACKAGE MARKING CODES FOR MIC5353

Part Number	Output Voltage	Marking Codes
MIC5353-1.8YMT	1.8V	18R
MIC5353-2.5YMT	2.5V	25R
MIC5353-2.6YMT	2.6V	26R
MIC5353-2.8YMT	2.8V	28R
MIC5353-3.0YMT	3.0V	30R
MIC5353-3.3YMT	3.3V	33R
MIC5353-YMT	ADJ	AAR

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.

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (March 2021)

- Converted Micrel document MIC5353 to Microchip data sheet DS20006507A.
- 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	Voltage Option	Junction Temperature Range	Package	Media Type

Device:	MIC5353: 500 mA LDO in 1.6 mm x 1.6 mm Package	
Voltage Option	18R = 1.8V 25R = 2.8V 26R = 3.3V 28R = 1.2V 30R = 2.8V 33R = 3.3V AAR = ADJ	
Junction Temperature Range:	Y =	–40°C to +125°C (RoHS Compliant)
Package:	MT =	6-Lead 1.6 mm x 1.6 mm Thin UDFN (Pb-Free)
Media Type:	TR =	5,000/Reel

Examples:

a) MIC5353-1.8YMT-TR	500 mA LDO, 1.8V, –40°C to +125°C, 6-Lead 1.6 mm x 1.6 mm UDFN, 5,000/Reel
b) MIC5353-3.3YMT-TR	500 mA LDO, 3.3V, –40°C to +125°C, 6-Lead 1.6 mm x 1.6 mm UDFN, 5,000/Reel
c) MIC5353YMT-TR	500 mA LDO, ADJ, –40°C to +125°C, 6-Lead 1.6 mm x 1.6 mm UDFN, 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:

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