MIC94325/45/55

500 mA LDO with Ripple Blocker Technology

Features

- 1.8V to 3.6V Input Voltage Range
- Active Noise Rejection over a Wide Frequency Band
  - >50dB from 10 Hz to 5 MHz at 500 mA Load
- Rated to 500 mA Output Current
- Fixed and Adjustable Output Voltages
- Optional Output Auto-Discharge when Disabled
- Current-Limit and Thermal-Limit Protection
- 1.6 mm x 1.6 mm, 6-Pin Thin DFN
- Logic-Controlled Enable Pin
- –40°C to +125°C Junction Temperature Range

Applications

- Smart Phones
- Tablet PC/Notebooks and Webcams
- Digital Still and Video Cameras
- Global Positioning Systems
- Mobile Computing
- Automotive and Industrial Applications

General Description

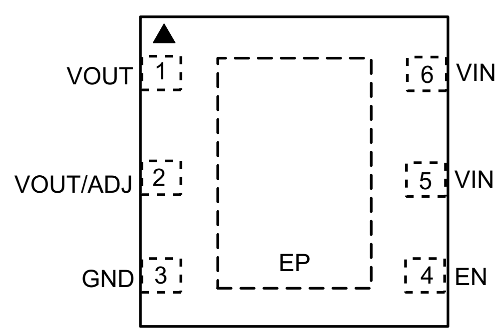
The MIC94325, MIC94345, and MIC94355 Ripple Blocker™ devices are monolithic integrated circuits that provide low-frequency ripple attenuation (switching noise rejection) to a regulated output voltage. This is important for applications where a DC/DC switching converter is required to lower or raise a battery voltage, but where switching noise cannot be tolerated by sensitive downstream circuits such as in RF applications. The MIC94325/45/55 maintain high power supply ripple rejection (PSRR) with input voltages operating near the output voltage level to improve overall system efficiency. A low-voltage logic enable pin facilitates ON/OFF control at typical GPIO voltage levels.

The MIC94325/45/55 operate from an input voltage of 1.8V to 3.6V. Options include fixed (MIC94345/55) or adjustable (MIC94325) output voltages. The MIC94355 version offers an auto-discharge to discharge the output capacitor when the part is disabled.

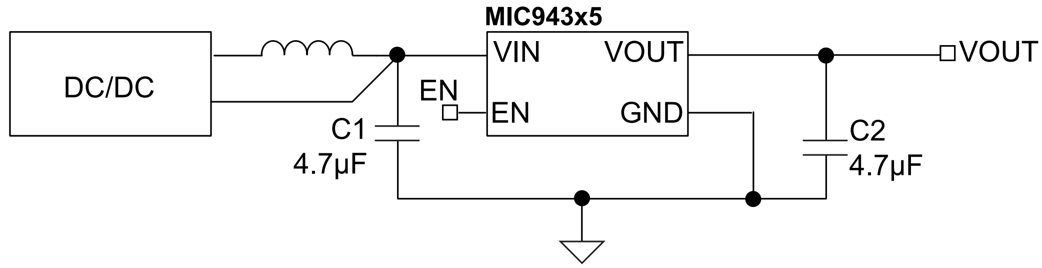
Packaged in a 6-pin 1.6 mm x 1.6 mm Thin DFN, the MIC94325/45/55 have a junction operating temperature range of –40°C to +125°C.

Package Type

MIC94325/45/55
6-Lead TDFN (MT)
(Top View)

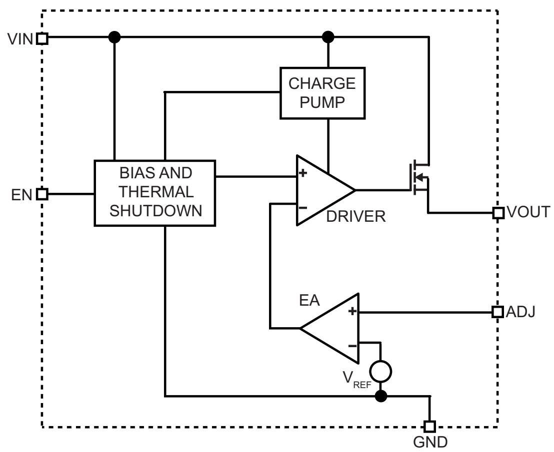


Typical Application Circuit

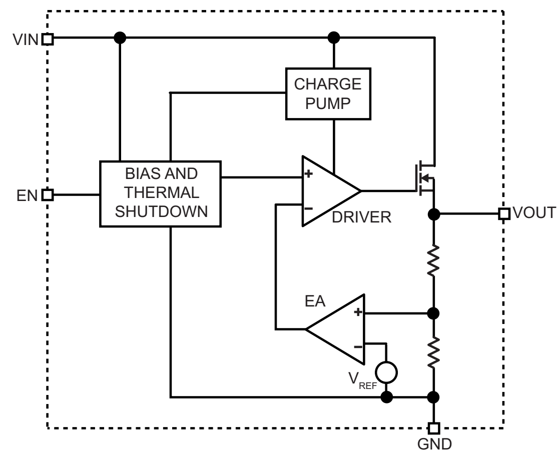


Functional Block Diagrams

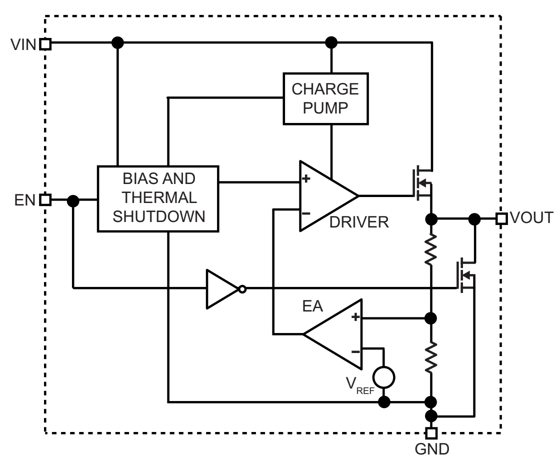
MIC94325 Adjustable Output



MIC94345 Fixed Output



MIC94355 Fixed Output with Auto-Discharge



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Input Voltage (V_{IN}) .... –0.3V to +4V
Output Voltage (V_{OUT}) .... –0.3V to V_{IN} + 0.3V or +4V
Enable Voltage (V_{EN}) .... –0.3V to V_{IN} + 0.3V or +4V
ESD Rating (Note 1) .... 3 kV

Operating Ratings ††

Input Voltage (V_{IN}) .... +1.8V to +3.6V
Enable 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: Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5 kΩ in series with 100 pF.

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: V_{IN} = V_{EN} = V_{OUT} + 500 mV (V_{IN} = V_{EN} = 3.6V for V_{OUT} ≥ 3.1V); I_{OUT} = 1 mA; C_{OUT} = 4.7 µF; T_A = +25°C, **bold** values are valid for –40°C ≤ T_J ≤ +125°C, unless noted. Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Input Voltage	V_{IN}	**1.8**	—	**3.6**	V	—
Output Voltage Range	V_{OUT}	**1.2**	—	**3.4**	V	MIC94325
Output Voltage Accuracy	—	**–3**	±1	**+3**	%	Variation from nominal V_{OUT}
Adjust Reference	V_{ADJ}	—	1.1	—	V	MIC94325
Dropout Voltage	V_{DROP}	—	10	—	mV	V_{IN} to V_{OUT} dropout at 50 mA output current
		—	100	**200**		V_{IN} to V_{OUT} dropout at 500 mA output current
Load Regulation	ΔV_{OUT}	—	10	—	mV	1 mA to 500 mA
Line Regulation	$(\Delta V_{OUT}/V_{OUT})$ x $100\%/\Delta V_{IN}$	—	0.1	**1**	%/V	V_{IN} = V_{OUT} + 500 mV to 3.6V, I_{OUT} = 100 mA
Ground Current	I_{GND}	—	170	**250**	µA	I_{OUT} = 100 µA
Shutdown Current	I_{EN}	—	0.2	5	µA	V_{EN} = 0V
V_{IN} Ripple Rejection	PSRR	—	85	—	dB	f = 100 Hz
		—	85	—		f = 1 kHz
		—	57	—		f = 100 kHz
		—	60	—		f = 1 MHz
		—	50	—		f = 5 MHz
Current Limit	I_{LIMIT}	**530**	800	**1100**	mA	V_{OUT} = 0V
Total Output Noise	e_N	—	83	—	μV_{RMS}	10 Hz to 100 kHz
Turn-On Time	t_{ON}	—	100	**150**	µs	—

Note 1: Specification for packaged product only.

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: $V_{IN} = V_{EN} = V_{OUT}$ + 500 mV ($V_{IN} = V_{EN}$ = 3.6V for $V_{OUT} \geq$ 3.1V); I_{OUT} = 1 mA; C_{OUT} = 4.7 µF; T_A = +25°C, **bold** values are valid for –40°C ≤ T_J ≤ +125°C, unless noted. Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Auto Discharge NFET Resistance	R_{DS}	—	50	—	Ω	V_{IN} = 3.6V, V_{EN} = 0V, I_{OUT} = –3 mA MIC94355 Only
Enable						
Input Logic Low	$V_{EN\text{-}LOW}$	—	—	**0.35**	V	—
Input Logic High	V_{EN_HIGH}	**1.0**	—	—	V	—
Input Current	I_{IN}	—	0.01	1	µA	—

Note 1: Specification for packaged product only.

TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Junction Temperature Range	T_J	–40	—	+125	°C	—
Storage Temperature Range	T_S	–65	—	+150	°C	—
Lead Temperature	—	—	—	+260	°C	Soldering, 10 sec.
Package Thermal Resistances						
Thermal Resistance, TDFN 6-Ld	θ_{JA}	—	92	—	°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.

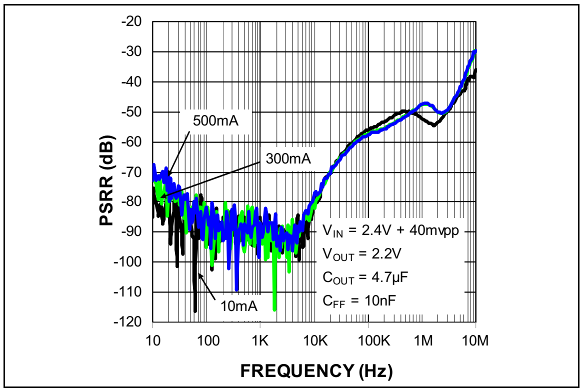


FIGURE 2-1: *MIC94325 PSRR, C_{OUT} = 4.7 µF, C_{FF} = 10 nF.*

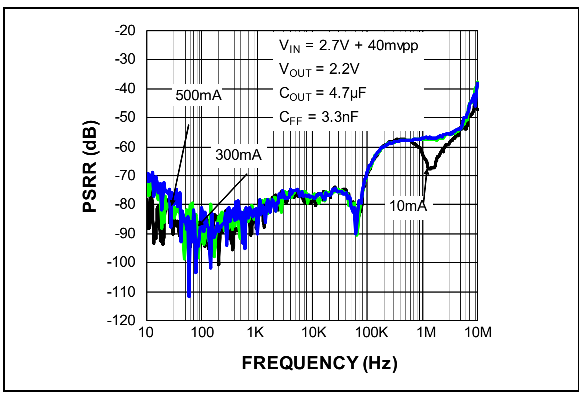


FIGURE 2-2: *MIC94325 PSRR, C_{OUT} = 4.7 µF, C_{FF} = 3.3 nF.*

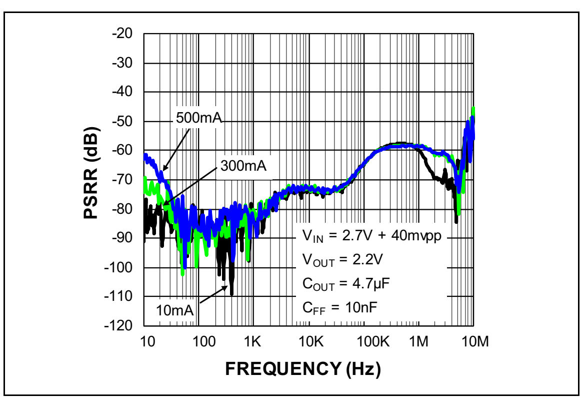


FIGURE 2-3: *MIC94325 PSRR, C_{OUT} = 4.7 µF, C_{FF} = 10 nF.*

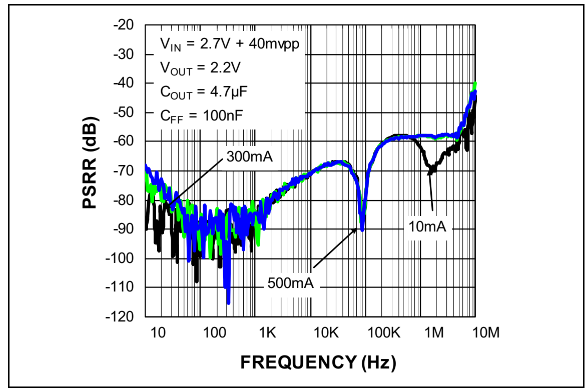


FIGURE 2-4: *MIC94325 PSRR, C_{OUT} = 4.7 µF, C_{FF} = 100 nF.*

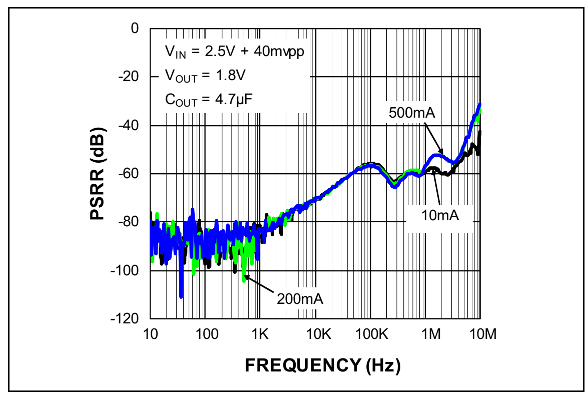


FIGURE 2-5: *MIC94355 PSRR, C_{OUT} = 4.7 µF.*

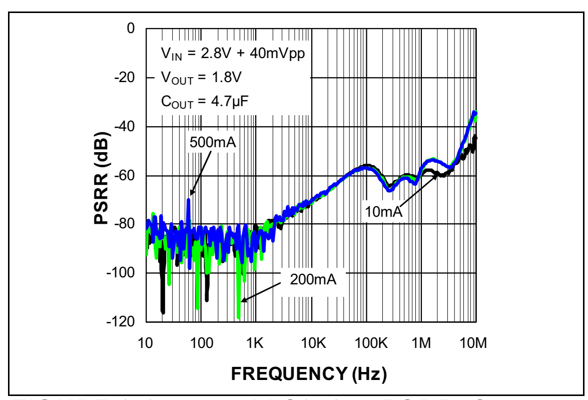


FIGURE 2-6: *MIC94355 PSRR, C_{OUT} = 4.7 µF.*

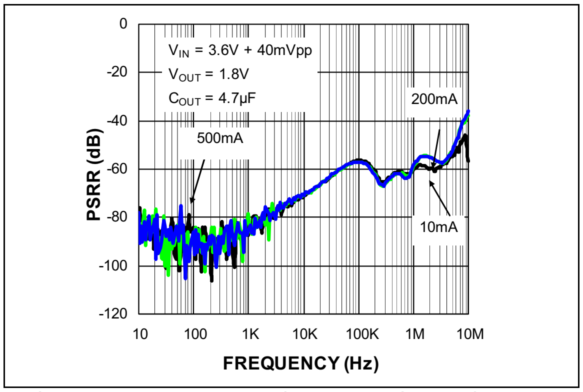


FIGURE 2-7: *MIC94355 PSRR, C_{OUT} = 4.7 µF.*

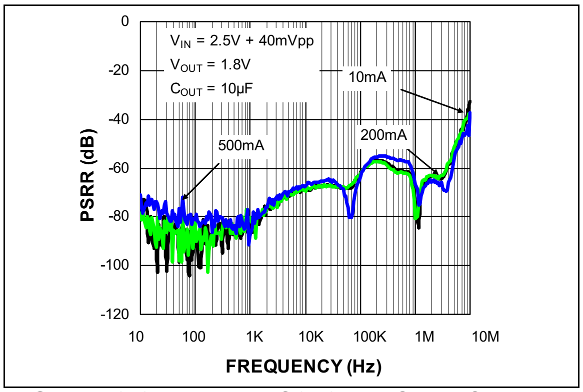


FIGURE 2-8: *MIC94355 PSRR, C_{OUT} = 10 µF.*

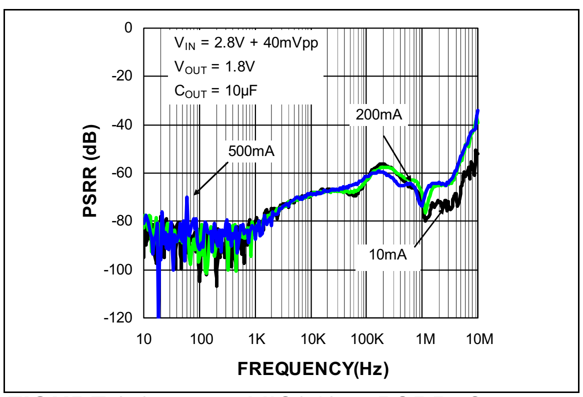


FIGURE 2-9: *MIC94355 PSRR, C_{OUT} = 10 µF.*

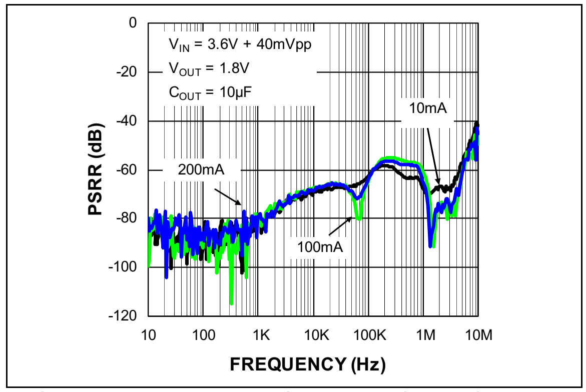


FIGURE 2-10: *MIC94355 PSRR, C_{OUT} = 10 µF.*

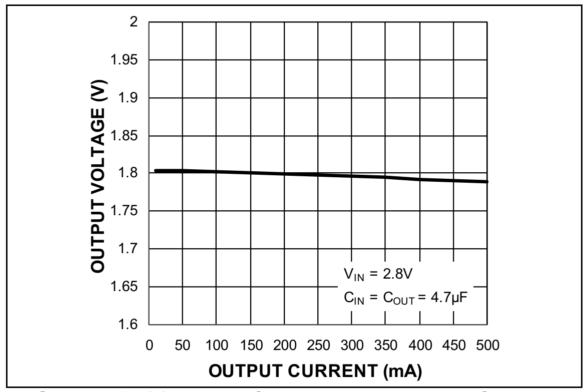


FIGURE 2-11: *Output Voltage vs. Output Current.*

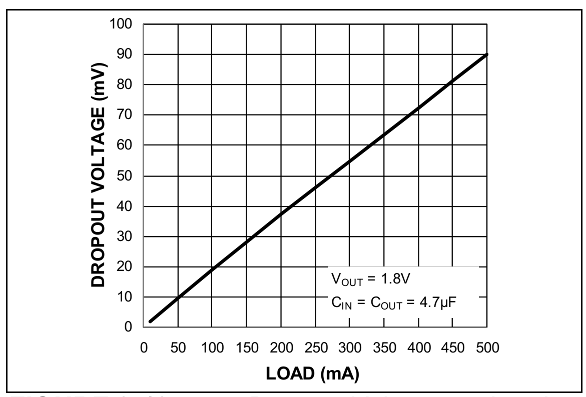


FIGURE 2-12: *Dropout Voltage vs. Load.*

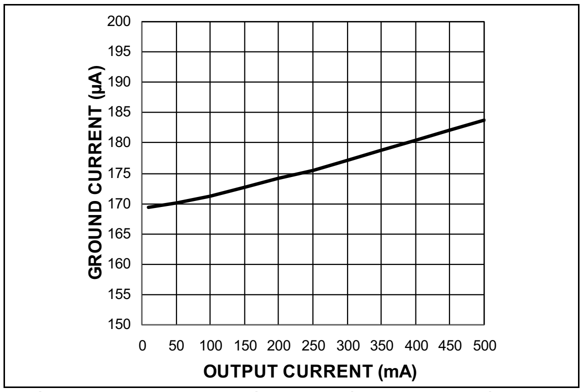


FIGURE 2-13: *Ground Current vs. Output Current.*

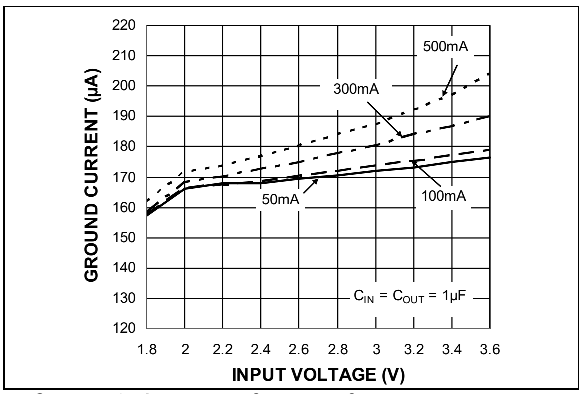


FIGURE 2-14: *Ground Current vs. Input Voltage.*

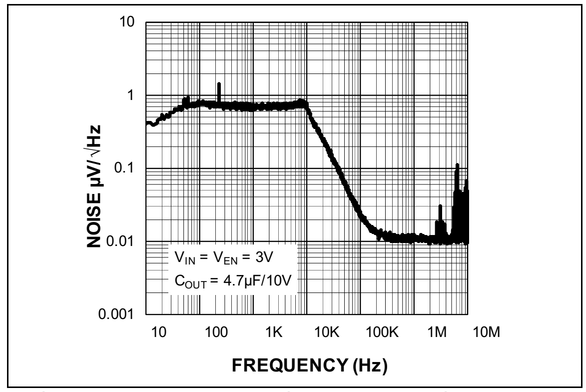


FIGURE 2-15: *MIC94355YMT Output Noise Spectral Density.*

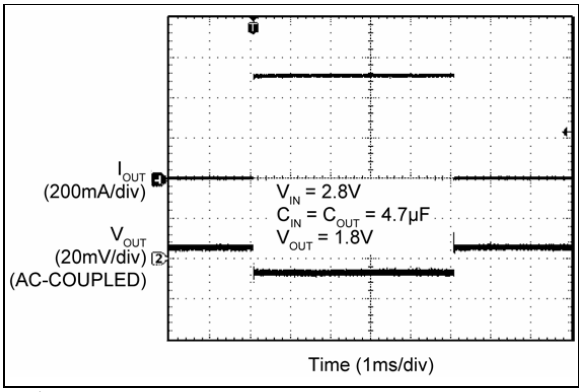


FIGURE 2-16: *Load Transient.*

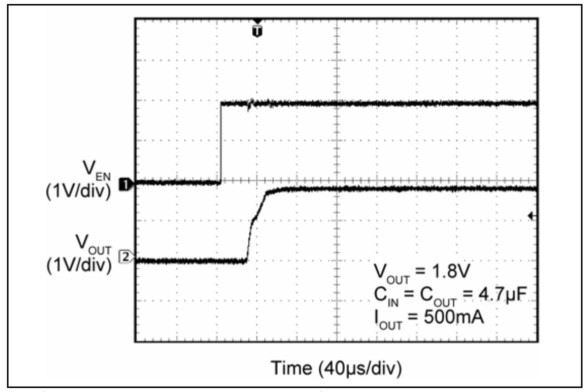


FIGURE 2-18: *Turn-On Time.*

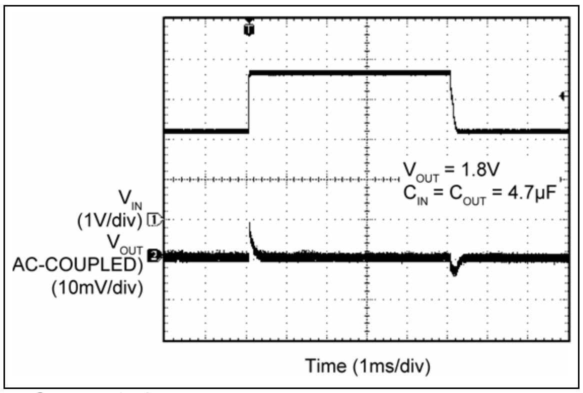


FIGURE 2-17: *Line Transient.*

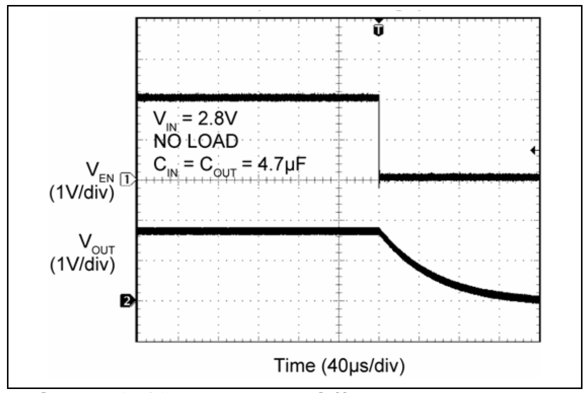


FIGURE 2-19: *Turn-Off Time (Auto-Discharge).*

3.0 PIN DESCRIPTIONS

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

TABLE 3-1: PIN FUNCTION TABLE

Pin Number TDFN, Fixed	Pin Number TDFN, Adj.	Pin Name	Description
1, 2	1	VOUT	Power Switch Output.
—	2	ADJ	Adjust input. Connect to resistive divider at VOUT to set the output voltage. Do not leave floating.
3	3	GND	Ground.
4	4	EN	Enable Input. A logic HIGH signal on this pin enables the part. Logic LOW disables the part. Do not leave floating.
5, 6	5, 6	VIN	Power Switch Input and Chip Supply.
EP	EP	ePAD	Exposed Heatsink Pad. Connect to Ground plane for best thermal performance.

4.0 APPLICATION INFORMATION

The MIC943x5 family of products are very high PSRR, fixed-output, 500 mA LDOs that use Ripple Blocker™ technology. The MIC943x5 are fully protected from damage due to fault conditions, offering linear current limiting and thermal shutdown.

4.1 Input Capacitor

The MIC943x5 are high-performance, high-bandwidth devices. An input capacitor of 4.7 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

In order to maintain stability, the MIC943x5 require an output capacitor of 4.7 µF or greater. For optimal input voltage ripple rejection performance a 4.7 µF capacitor is recommended. 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 4.7 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 their value by as much as 50% and 60%, respectively, over their operating temperature ranges. To use a ceramic chip capacitor with the 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

The MIC943x5 will remain stable and in regulation with no load. This is especially important in CMOS RAM keep-alive applications.

4.4 Enable/Shutdown

Forcing the enable (EN) pin low disables the MIC943x5 and sends it into a “zero” off mode current state. In this state, current consumed by the MIC943x5 goes nearly to zero. Forcing EN high enables the output voltage. The EN pin uses CMOS technology and cannot be left floating as it could cause an indeterminate state on the output.

For the MIC94325 adjustable part, the turn-on time is affected by the selection of the external feedback resistors and feed-forward capacitor. The relationship is approximately 2.2 x R2 x C_{FF}, where R2 is the bottom resistor (connected from ADJ to GND) and C_{FF} is the capacitor connected across R1 (from VOUT to ADJ). For stability, the feed-forward capacitor must be greater than 1 nF. 10 nF is recommended for best performance.

When disabled, the MIC94355 switches a 50Ω (typical) load on the regulator output to discharge the external capacitors.

4.5 Adjustable Regulator Application

The MIC94325 output voltage can be adjusted by using two external resistors (Figure 4-1). The resistors set the output voltage based on the following equation:

EQUATION 4-1:

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

$$V_{ADJ} = 1.1V$$

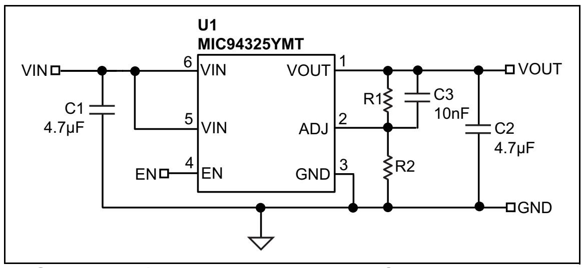


FIGURE 4-1: *Adjustable Output Voltage.*

4.6 Thermal Considerations

The MIC943x5 are designed to provide 500 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 2.5V, the output voltage is 1.8V, and the output current is 500 mA. The actual power dissipation of the Ripple Blocker™ can be determined using the equation:

EQUATION 4-2:

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

Because this device is CMOS and the ground current is typically <170 µA over the load range, the power dissipation contributed by the ground current is <1% and can be ignored for this calculation.

EQUATION 4-3:

$$P_D = (2.5V - 1.8V) \times 500mA = 0.35W$$

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 4-4:

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

Where:

$T_{J(MAX)}$ = 125°C

θ_{JA} = Thermal resistance. 92°C/W for the TDFN 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 maximum power dissipation must not be exceeded for proper operation.

For example, when operating the MIC94325-GYMT at an input voltage of 2.5V and 500 mA load with a minimum footprint layout, the maximum ambient operating temperature T_A can be determined as follows:

EQUATION 4-5:

$$0.35W = (125°C - T_A)/(92°C/W)$$

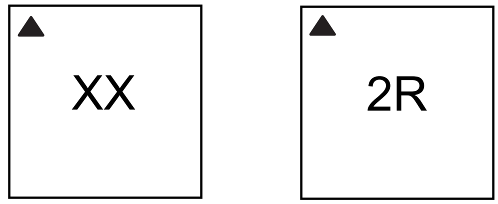
$$T_A = 92°C$$

Therefore, the maximum ambient operating temperature allowed in a 1.6 mm x 1.6 mm Thin DFN package is 92°C. 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.

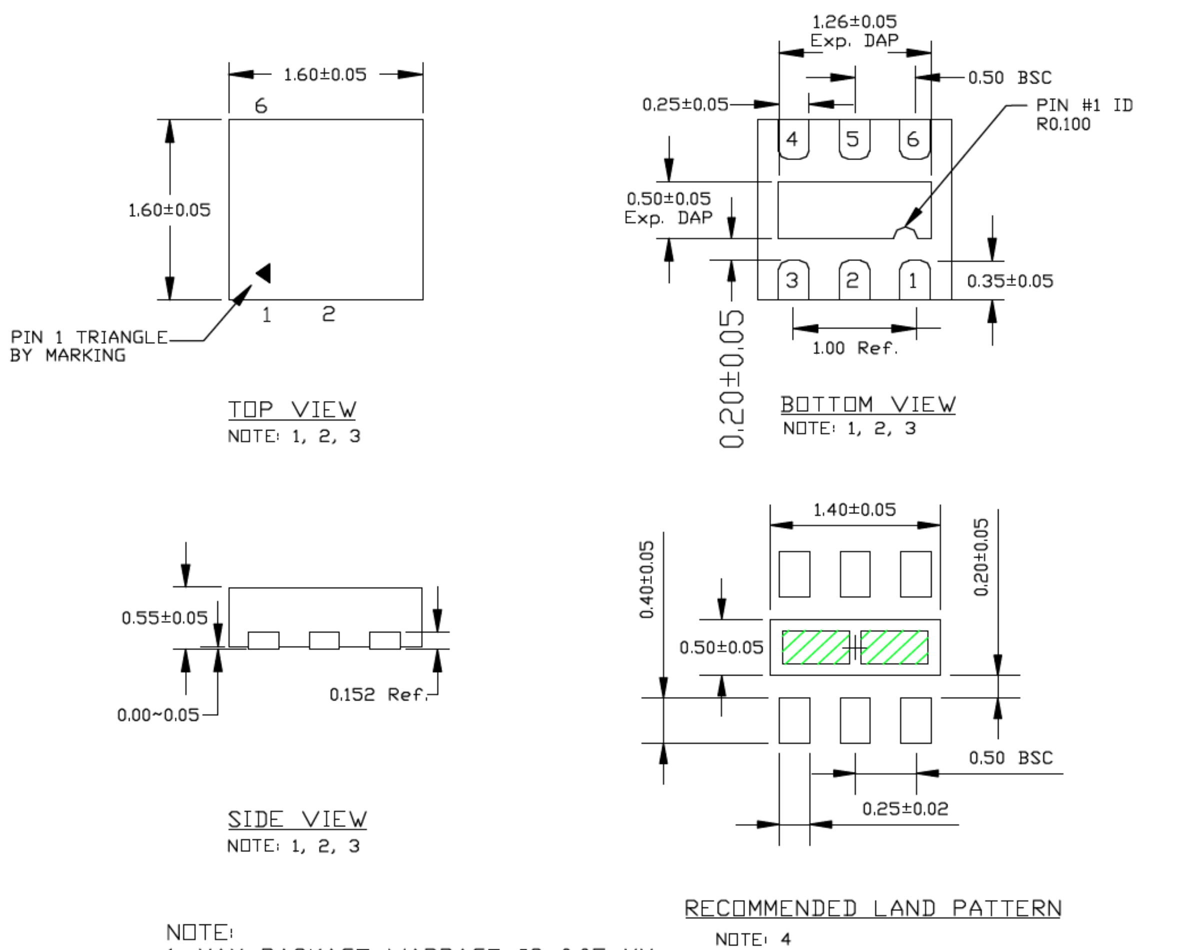
TABLE 5-1: MARKING CODES

Part Number	Marking Code	Output Voltage	Auto-Discharge
MIC94325YMT	2R	Adjustable	No
MIC94345-4YMT	4L	1.2V	No
MIC94345-FYMT	FL	1.5V	No
MIC94345-GYMT	1X	1.8V	No
MIC94345-MYMT	2X	2.8V	No
MIC94345-SYMT	3X	3.3V	No
MIC94355-4YMT	9G	1.2V	Yes
MIC94355-FYMT	0G	1.5V	Yes
MIC94355-GYMT	2G	1.8V	Yes
MIC94355-MYMT	7G	2.8V	Yes
MIC94355-SYMT	8G	3.3V	Yes

6-Lead 1.6 mm x 1.6 mm TDFN 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 (March 2021)

- Converted Micrel document MIC94325/45/55 to Microchip data sheet template DS20006524A.
- Minor grammatical text changes throughout.
- Removed reference to the 6-Ball CSP package option.
- All schematic and BOM references removed as they are found in the User's Guide for these parts.

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	XX	-XX
Part No.	Output Voltage	Junction Temp. Range	Package	Media Type

Device:	MIC94325: 500 mA LDO with Ripple Blocker Technology and Adjustable Output Voltage MIC94345: 500 mA LDO with Ripple Blocker Technology and Fixed Output Voltage MIC94355: 500 mA LDO with Ripple Blocker Technology, Fixed Output Voltage, & Auto-Discharge
Output Voltage:	<blank> = Adjustable (MIC94325 only) 4 = 1.2V F = 1.5V G = 1.8V M = 2.8V S = 3.3V
Junction Temperature Range:	Y = –40°C to +125°C
Package:	MT = 6-Lead 1.6 mm x 1.6 mm TDFN
Media Type:	TR = 5,000/Reel T5 = 500/Reel

Examples:

a) MIC94325YMT-TR: MIC94325, Adjustable Output Voltage, –40°C to +125°C Temperature Range, 6-Lead TDFN, 5,000/Reel

b) MIC94345-FYMT-T5: MIC94345, 1.5V Output Voltage, –40°C to +125°C Temperature Range, 6-Lead TDFN, 500/Reel

c) MIC94355-SYMT-TR: MIC94355, 3.3V Output Voltage, –40°C to +125°C Temperature Range, 6-Lead TDFN, 5,000/Reel

d) MIC94325YMT-T5: MIC94325, Adjustable Output Voltage, –40°C to +125°C Temperature Range, 6-Lead TDFN, 500/Reel

e) MIC94345-4YMT-TR: MIC94345, 1.2V Output Voltage, –40°C to +125°C Temperature Range, 6-Lead TDFN, 5,000/Reel

f) MIC94355-MYMT-T5: MIC94355, 2.8V Output Voltage, –40°C to +125°C Temperature Range, 6-Lead TDFN, 500/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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