MICROCHIP

MIC5225

Ultra-Low Quiescent Current 150 mA µCap Low Dropout Regulator

Features

- Wide Input Voltage Range: 2.3V to 16V
- High Output Accuracy of ±2.0% over Temperature
- Ensured 150 mA Output
- Very Low Ground Current: 29 µA
- Low Dropout Voltage of 310 mV at 150 mA
- µCap: Stable with Ceramic or Tantalum Capacitors
- Excellent Line and Load Regulation Specifications
- Reverse Battery Protection
- Reverse Leakage Protection
- Zero Shutdown Current
- Thermal Shutdown and Current Limit Protection
- SOT23-5 Package

Applications

- Cellular Phones
- Keep Alive Supply in Notebook and Portable Computers
- Battery-Powered Equipment
- Consumer/Personal Electronics
- High-Efficiency Linear Power Supplies

General Description

The MIC5225 is a 150 mA, highly accurate low dropout regulator with high input voltage and ultra-low ground current. This combination of high voltage and low ground current makes the MIC5225 ideal for a wide variety of applications including USB and portable electronics applications that use 1-cell, 2-cell, or 3-cell Li-Ion battery inputs.

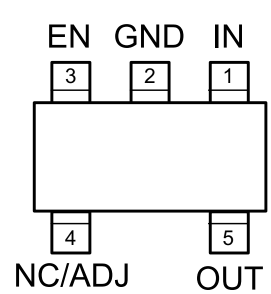
As a µCap LDO design, the MIC5225 is stable with either a ceramic or tantalum output capacitor. It only requires a 2.2 µF capacitor for stability.

Features of the MIC5225 includes enable input, thermal shutdown, current limit, reverse battery protection, and reverse leakage protection.

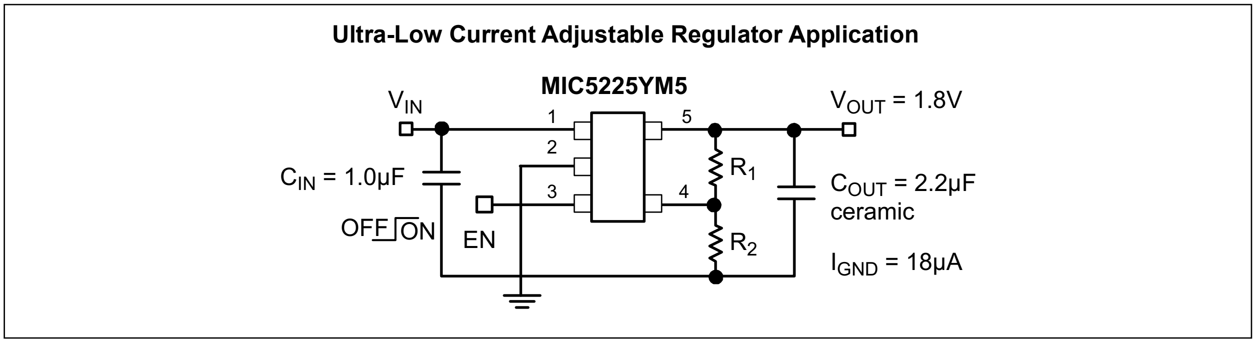
Available in fixed and adjustable output voltage versions, the MIC5225 is offered in the SOT23-5 package with a junction temperature range of -40°C to +125°C.

Package Type

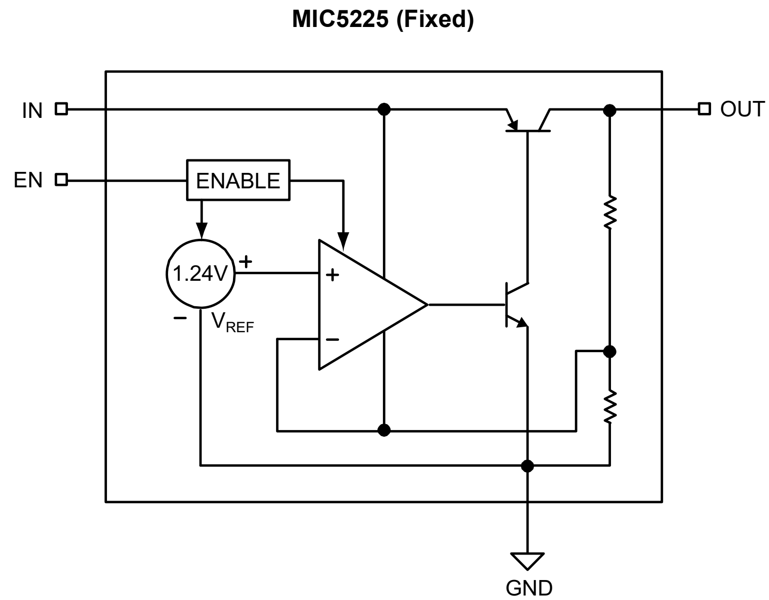
MIC5225
SOT23-5 (M5)
(Top View)

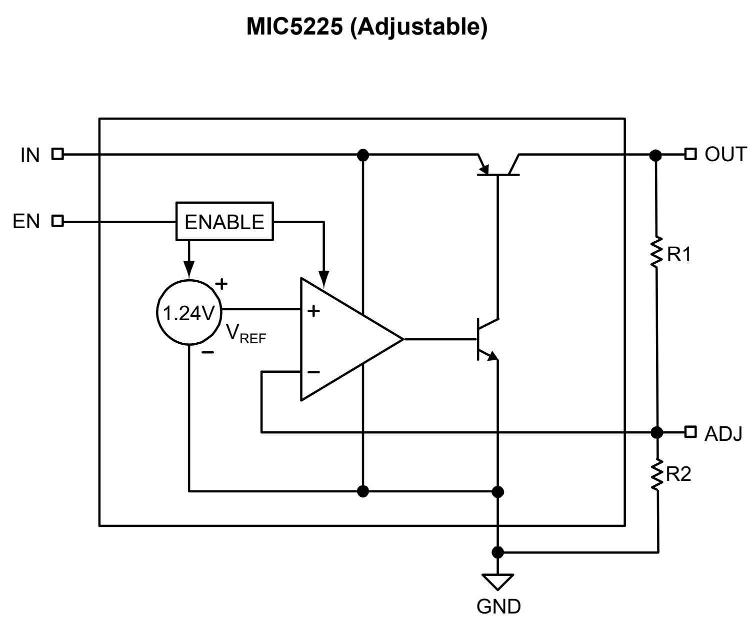


Typical Application Circuit



Functional Block Diagrams





1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN}) .... -20V to +18V
Enable Input Voltage (V_{EN}) .... -0.3V to 18V
Power Dissipation (P_D), Note 1 .... Internally Limited
Lead Temperature (soldering, 3sec.) .... 260°C
Junction Temperature (T_J) .... -40°C to +125°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 +16V
Enable Input Voltage (V_{EN}) .... 0V to 16V
Junction Temperature (T_J) .... -40°C to +125°C
Package Thermal Resistance
SOT23-5 (θ_{JA}) .... 235°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: $V_{IN} = V_{OUT} + 1V$; $I_{OUT} = 100\ \mu A$; $T_A = +25°C$;
Bold values indicate -40°C ≤ T_J ≤ +125°C unless noted. Note 1

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Voltage Accuracy	V_{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	$\Delta V_{OUT}/(V_{OUT} \times \Delta V_{IN})$	—	0.04	0.3	%	$V_{IN} = V_{OUT} + 1V$ to 16V
Load Regulation	$\Delta V_{OUT}/V_{OUT}$	—	0.25	1	%	$I_{OUT} = 100\ \mu A$ to 150 mA
Dropout Voltage	V_{DO}	—	50	—	mV	$I_{OUT} = 100\ \mu A$
		—	230	300		$I_{OUT} = 50$ mA
		—	310	450		$I_{OUT} = 150$ mA
Reference Voltage	—	1.22	1.24	1.26	—	—
Ground Current	I_{GND}	—	29	50	µA	$I_{OUT} = 100\ \mu A$
		—	0.5	0.9	mA	$I_{OUT} = 50$ mA
		—	3	5		$I_{OUT} = 150$ mA
Ground Current in Shutdown	I_{SHDN}	—	0.1	5	µA	$V_{EN} \le 0.6V$; $V_{IN} = 16V$
Short Circuit Current	—	600	300	500	mA	$V_{OUT} = 0V$
Output Leakage, Reverse Polarity Input	e_N	—	-1.0	—	µA	$I_{OUT} = 500\Omega$, $V_{IN} = -16V$
Enable Input						
Input Low Voltage	V_{IL}	—	—	0.6	V	Regulator OFF
Input High Voltage	V_{IH}	2.0	—	—		Regulator ON
Enable Input Current	I_{EN}	-1.0	0.01	+1.0	µA	$V_{EN} = 0.6V$; Regulator OFF
		—	0.15	1.0		$V_{EN} = 2.0V$; Regulator ON
		—	0.5	2.5		$V_{EN} = 16V$; Regulator ON

Note 1: Specification for packaged product only.

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	—
Package Thermal Resistances						
Thermal Resistance, SOT23-5	θ_{JA}	—	235	—	°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.

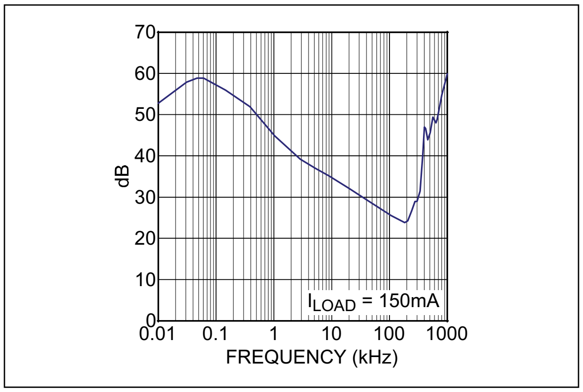


FIGURE 2-1: *Power Supply Rejection Ratio.*

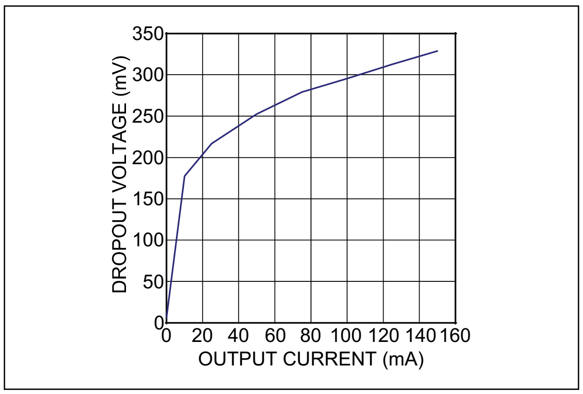


FIGURE 2-2: *Dropout Voltage vs. Output Current.*

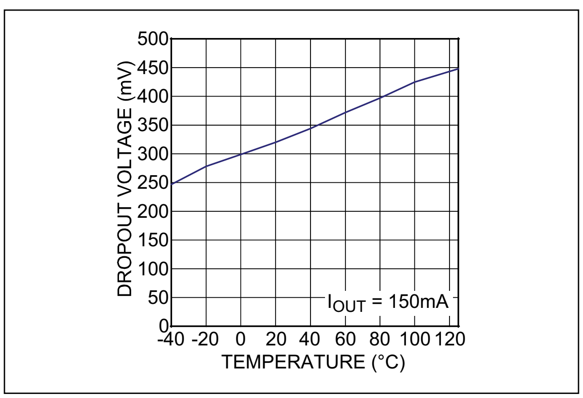


FIGURE 2-3: *Dropout Voltage vs. Temperature.*

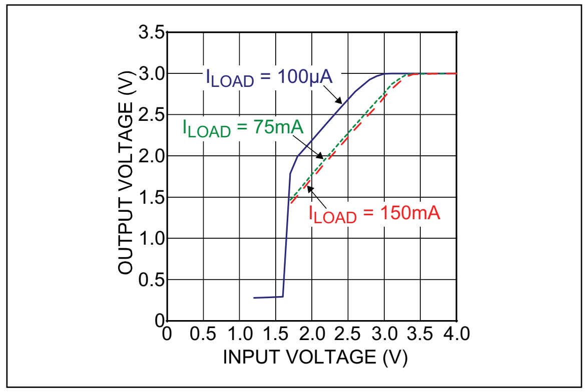


FIGURE 2-4: *Output Voltage vs. Input Voltage.*

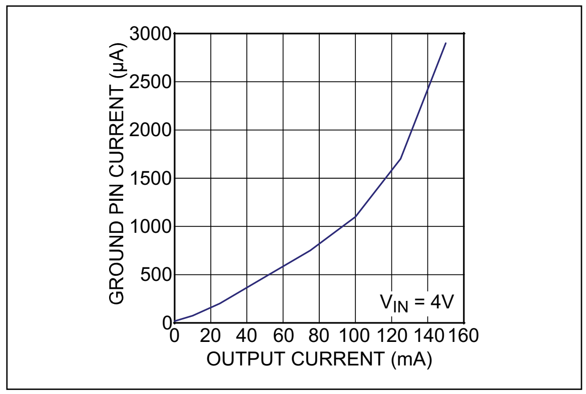


FIGURE 2-5: *Ground Pin Current vs. Output Current.*

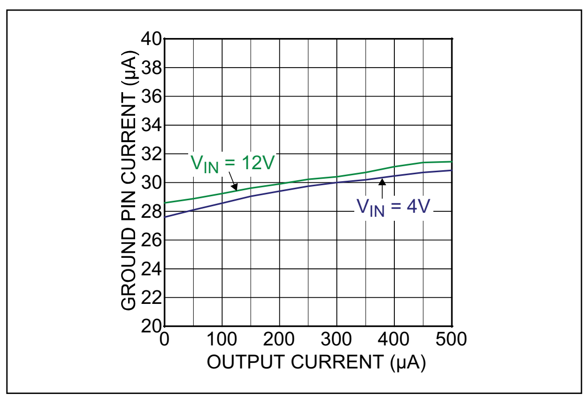


FIGURE 2-6: *Ground Pin Current vs. Output Current.*

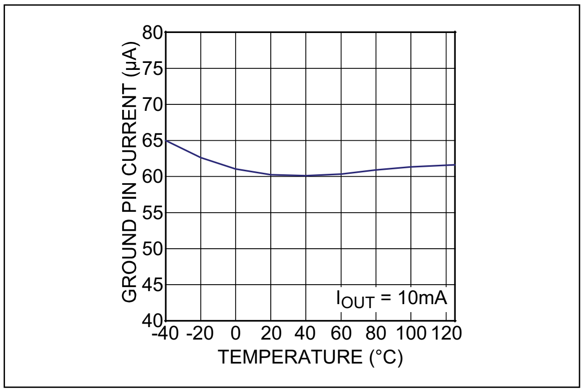


FIGURE 2-7: *Ground Pin Current vs. Temperature.*

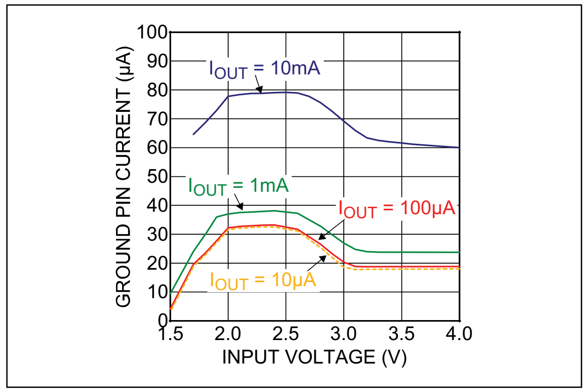


FIGURE 2-10: *Ground Pin Current vs. Input Voltage.*

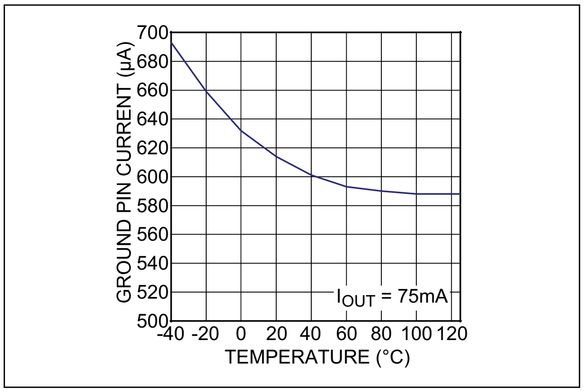


FIGURE 2-8: *Ground Pin Current vs. Temperature.*

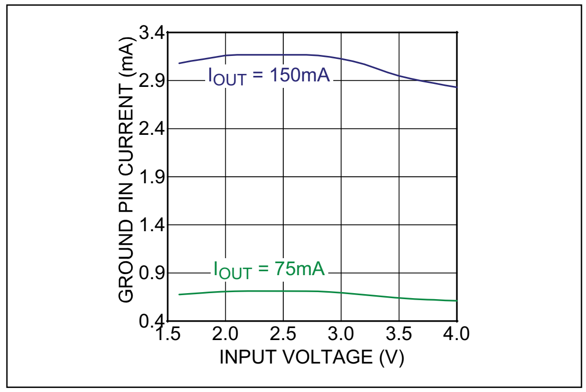


FIGURE 2-11: *Ground Pin Current vs. Input Voltage.*

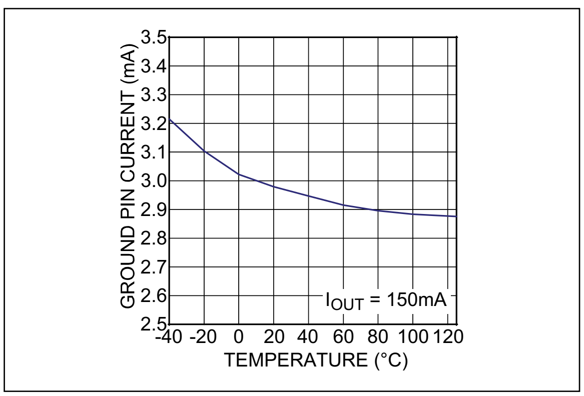


FIGURE 2-9: *Ground Pin Current vs. Temperature.*

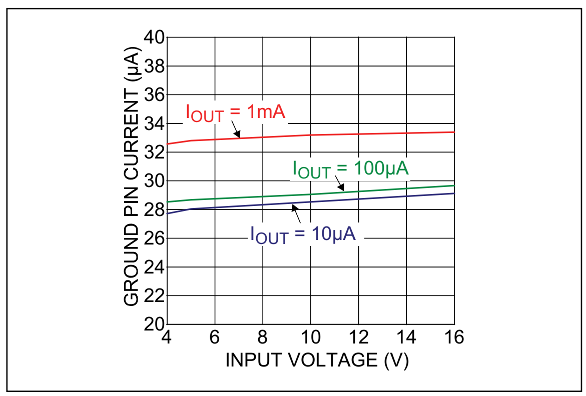


FIGURE 2-12: *Ground Pin Current vs. Input Voltage.*

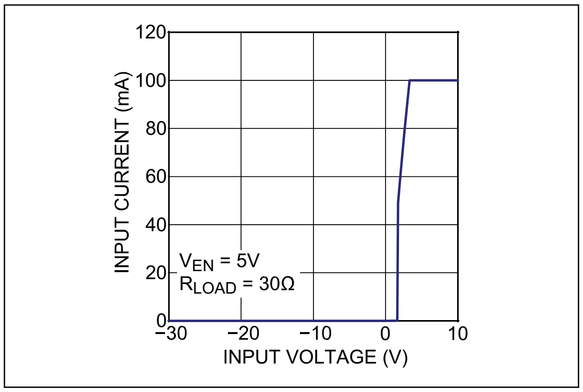


FIGURE 2-13: *Input Current vs. Input Voltage.*

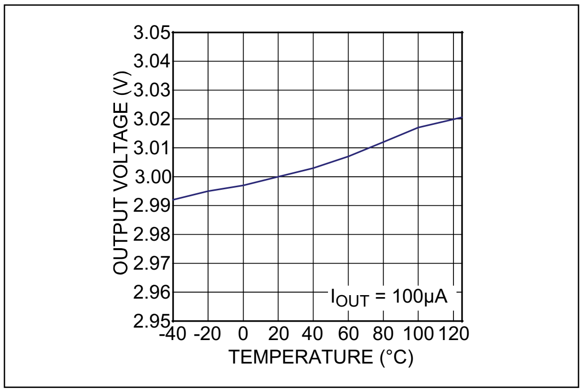


FIGURE 2-14: *Output Voltage vs. Temperature.*

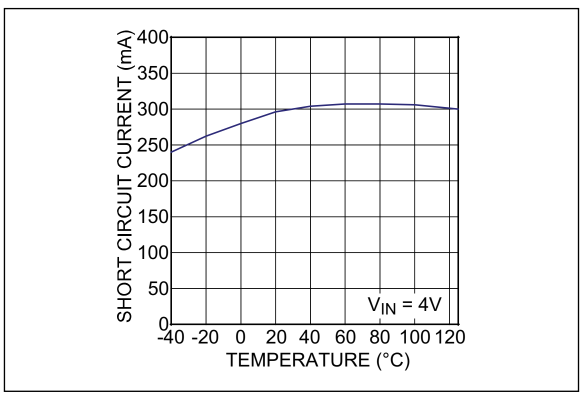


FIGURE 2-15: *Short Circuit Current vs. Temperature.*

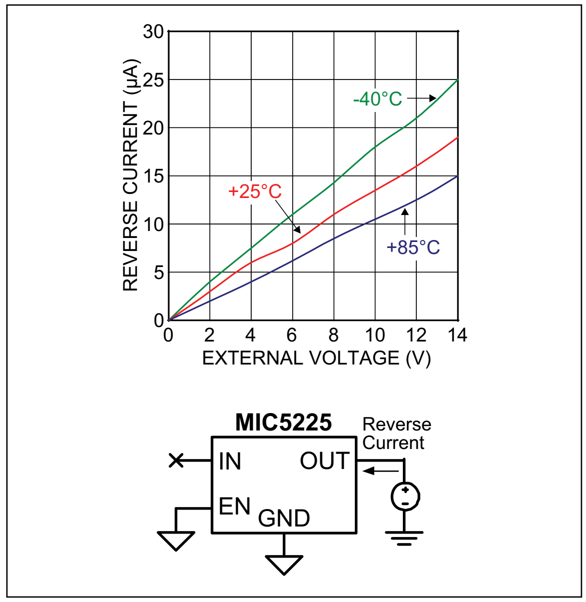


FIGURE 2-16: *Reverse Current (Open Input).*

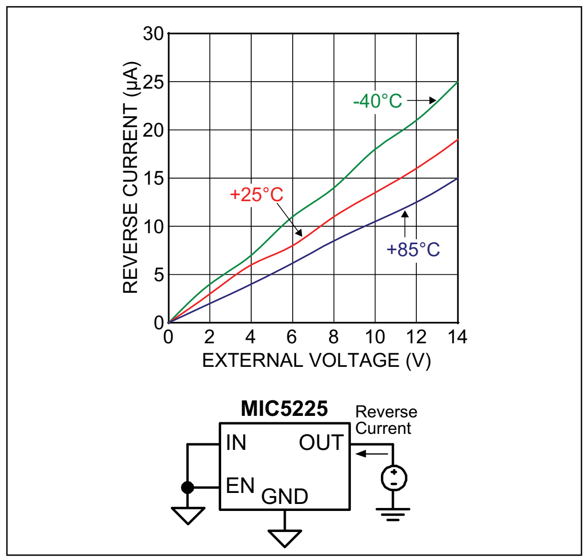


FIGURE 2-17: *Reverse Current (Grounded Input).*

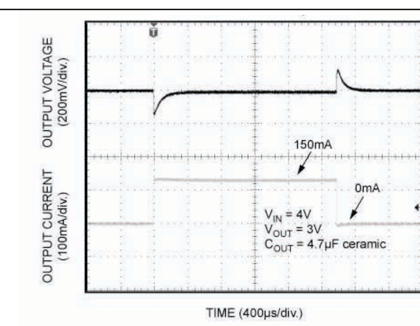


FIGURE 2-18: *Load Transient Response.*

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	IN	Supply input.
2	GND	Ground.
3	EN	Enable (Input): Logic low or Open = Shutdown; Logic high = Enable.
4	NC (Fixed)	Output voltage.
	ADJ	Adjust (Input): Feedback input. Connect to resistive voltage-divider network.
5	OUT	Regulator Output.

4.0 APPLICATION INFORMATION

4.1 Enable/Shutdown

The MIC5225 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.

4.2 Input Capacitor

The MIC5225 has a wide input voltage capability up to 16V. The input capacitor must be rated to sustain voltages that may be used on the input. An input capacitor may be required when the device is not near the source power supply or when supplied by a battery. Small, surface mount, ceramic capacitors can be used for bypassing. Larger value may be required if the source supply has high ripple.

4.3 Output Capacitor

The MIC5225 requires an output capacitor for stability. The design requires 1.0 µF or greater on the output to maintain stability. The design is optimized for use with low-ESR ceramic chip capacitors. High ESR capacitors may cause high frequency oscillation. The maximum recommended ESR is 300 mΩ. The output capacitor can be increased, but performance has been optimized for a 1.0 µF ceramic output capacitor and does not improve significantly with the use of a larger capacitor.

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.

4.4 No-Load Stability

The MIC5225 will remain stable and in regulation with no load unlike many other voltage regulators. This is especially important in CMOS RAM keep-alive application.

4.5 Thermal Considerations

The MIC5225 is designed to provide 150 mA of continuous current in a very small package. Maximum power dissipation can be calculated based on the output current and the voltage drop across the part. To determine the maximum power dissipation of the package, use the junction-to-ambient thermal resistance of the device and the following basic equation:

EQUATION 4-1:

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

Where:

$T_{J(MAX)}$ = The maximum junction temperature of the die, 125°C

T_A = The ambient operating temperature

θ_{JA} = Is layout independent

Table 4-1 shows examples of the junction-to-ambient thermal resistance for the MIC5225.

TABLE 4-1: SOT-23-5 THERMAL RESISTANCE

Package	θ_{JA} Recommended Minimum Footprint
SOT-23-5	235°C/W

The actual power dissipation of the regulator circuit can be determined using the equation:

EQUATION 4-2:

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

Substituting $P_{D(MAX)}$ for P_D and solving for the operating conditions that are critical to the application will give the maximum operating conditions for the regulator circuit. For example, when operating the MIC5225-3.0YM5 at 50°C with a minimum footprint layout, the maximum input voltage for a set output current can be determined as follows:

EQUATION 4-3:

$$P_{D(MAX)} = (125°C - 50°C)/(235°C/W)$$

$$P_{D(MAX)} = 319\ mW$$

The junction-to-ambient thermal resistance for the minimum footprint is 235°C/W, from Table 4-1. The maximum power dissipation must not be exceeded for proper operation. Using the output voltage of 3.0V, and an output current of 150 mA, the maximum input voltage can be determined:

EQUATION 4-4:

$$319\ mW = 150\ mA \cdot (V_{IN} - 3.0V) + V_{IN} \times 3.0\ mA$$

$$319\ mW = V_{IN} \times 153\ mA - 450\ mW$$

$$769\ mW = V_{IN} \times 153\ mA$$

$$V_{IN(MAX)} = 5.02V$$

Therefore, a 3.0V application at 150 mA of output current can accept a maximum input voltage of 5.02V in the SOT-23-5 package. For a full discussion of heat sinking and thermal effects on the voltage regulators, refer to the Regulator Thermals section of Designing with Low-Dropout Voltage Regulators handbook.

4.6 Adjustable Regulator Application

The MIC5225YM5 can be adjusted from 1.24V to 14V by using two external resistors (Figure 4-1). The resistors set the output voltage based on the following equation:

EQUATION 4-5:

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

Where:

V_{REF} = 1.24V

Feedback resistor R2 should be no larger than 300 kΩ.

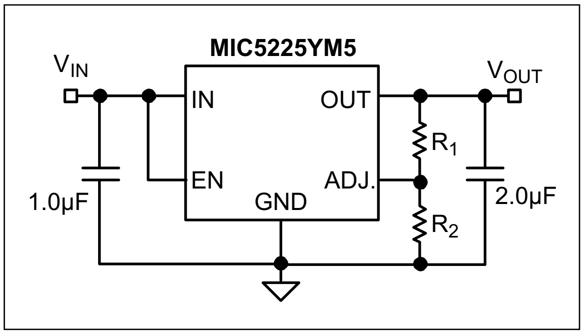


FIGURE 4-1: Adjustable Voltage Application.

5.0 PACKAGING INFORMATION

5.1 Package Marking Information

5-Lead SOT-23*	Example
XXXX NNN	QT25 256

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.

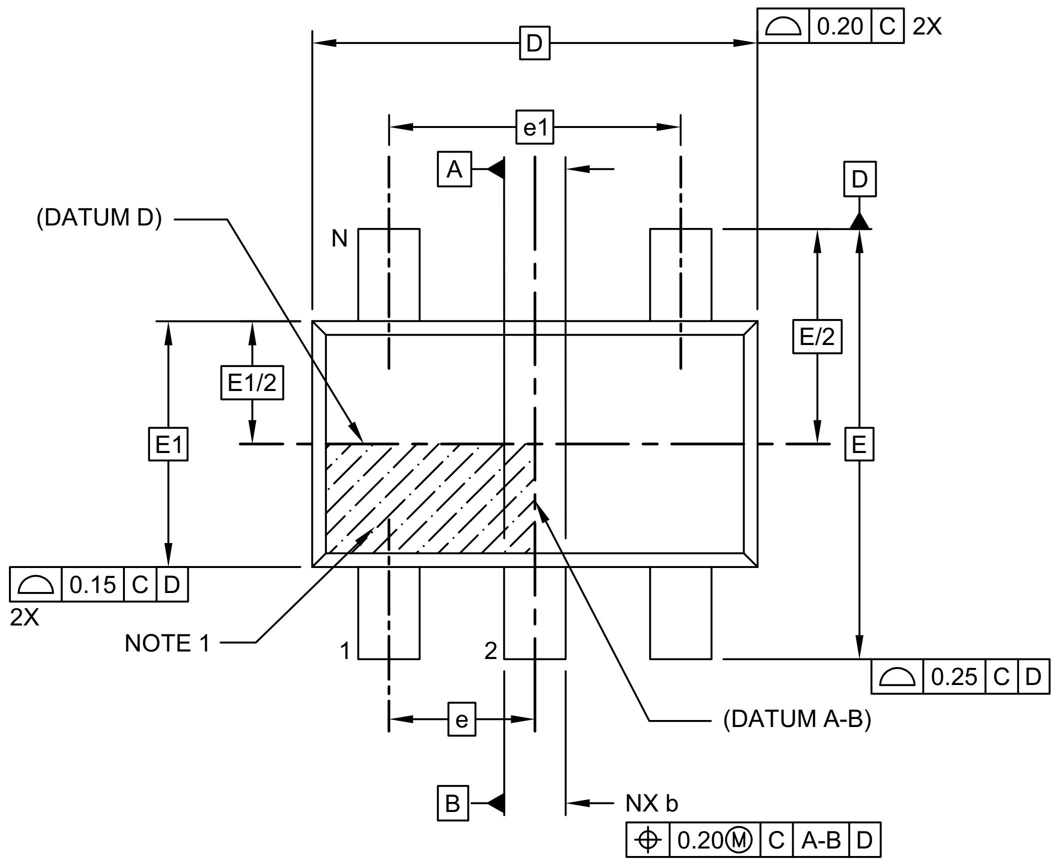
Underbar (_) and/or Overbar (‾) symbol may not be to scale.

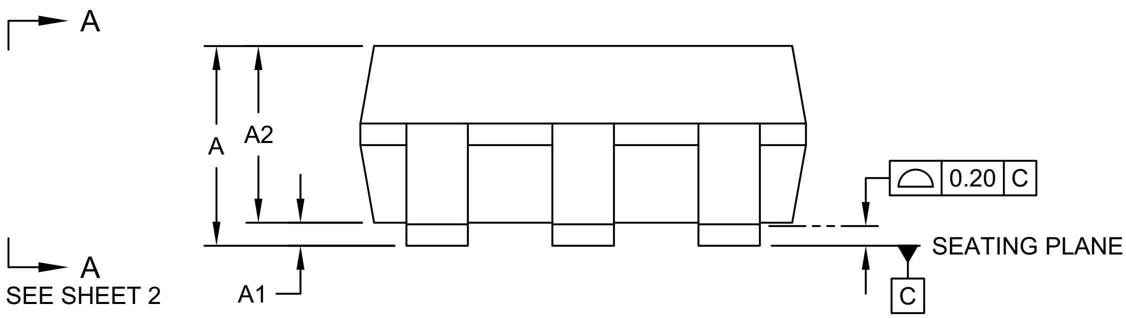
TABLE 5-1: PACKAGE MARKING CODES FOR MIC5353

Part Number	Output Voltage	Marking Codes
MIC5225-1.5YM5	1.5V	QT15
MIC5225-1.8YM5	1.8V	QT18
MIC5225-2.5YM5	2.5V	QT25
MIC5225-2.7YM5	2.7V	QT27
MIC5225-3.0YM5	3.0V	QT30
MIC5225-3.3YM5	3.3V	QT33
MIC5225-5.0YM5	5.0V	QT50
MIC5225YM5	ADJ	QTAA

5-Lead Plastic Small Outline Transistor (6BX) [SOT-23]

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

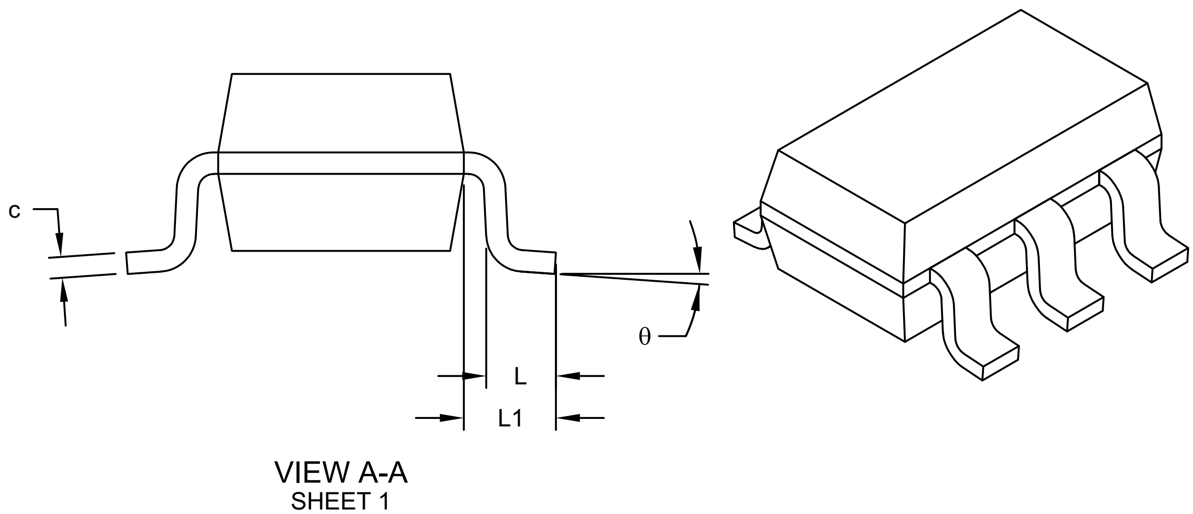




Microchip Technology Drawing C04-091-6BX Rev H Sheet 1 of 2

5-Lead Plastic Small Outline Transistor (6BX) [SOT-23]

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



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		5	
Pitch	e		0.95 BSC	
Outside lead pitch	e1		1.90 BSC	
Overall Height	A	0.90	-	1.45
Molded Package Thickness	A2	0.89	-	1.30
Standoff	A1	-	-	0.15
Overall Width	E		2.80 BSC	
Molded Package Width	E1		1.60 BSC	
Overall Length	D		2.90 BSC	
Foot Length	L	0.30	-	0.60
Footprint	L1		0.60 REF	
Foot Angle	θ	0°	-	10°
Lead Thickness	c	0.08	-	0.26
Lead Width	b	0.20	-	0.51

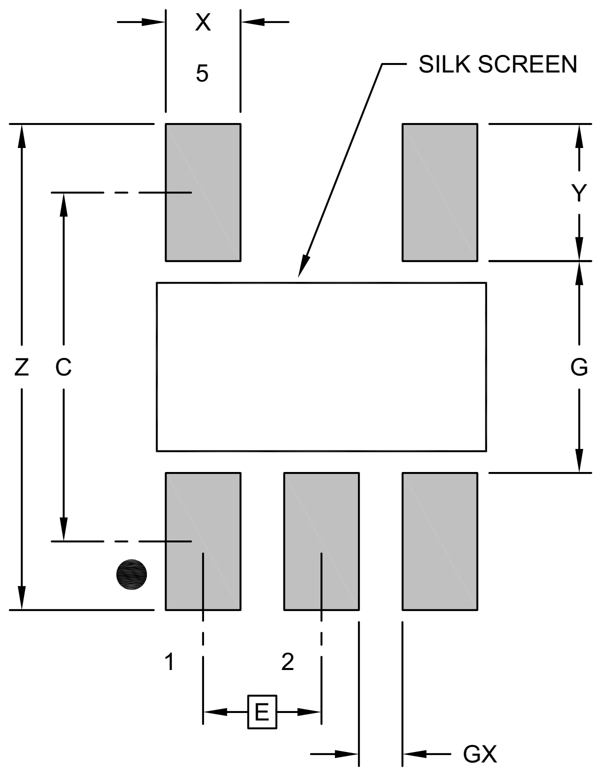
Notes:

1. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.25mm per side.
2. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-091-6BX Rev H Sheet 2 of 2

5-Lead Plastic Small Outline Transistor (6BX) [SOT-23]

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



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E	0.95 BSC		
Contact Pad Spacing	C		2.80	
Contact Pad Width (X5)	X			0.60
Contact Pad Length (X5)	Y			1.10
Distance Between Pads	G	1.70		
Distance Between Pads	GX	0.35		
Overall Width	Z			3.90

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-2091-6BX Rev H

APPENDIX A: REVISION HISTORY

Revision B (May 2024)

- Updated **Section "Applications"** to better describe the part.
- Updated **Section 5.0 "Packaging Information"**.
- Minor text changes throughout.

Revision A (May 2022)

- Converted Micrel document MIC5225 to Microchip data sheet DS20006683A.
- 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.	-X.X	X	XX	-XX
Device	Voltage Option	Junction Temperature Range	Package	Media Type

Device:	MIC5225: Ultra-Low Quiescent Current 150 mA μCap Low Dropout Regulator	
Voltage Option	1.5 = 1.5V 1.8 = 1.8V 2.5 = 2.5V 2.7 = 2.7V 3.0 = 3.0V 3.3 = 3.3V 5.0 = 5.0V <blank> = ADJ	
Junction Temperature Range:	Y =	-40°C to +125°C (RoHS Compliant)
Package:	M5 =	5-Lead SOT-23 (Pb-Free)
Media Type:	TR =	3,000/Reel

Examples:

a) MIC5225-1.8YM5-TR   Ultra-Low Quiescent Current 150 mA μCap Low Dropout Regulator, 1.8V, -40°C to +125°C, 5-Lead SOT-23, 3,000/Reel

b) MIC5225-3.3YM5-TR   Ultra-Low Quiescent Current 150 mA μCap Low Dropout Regulator, 3.3V, -40°C to +125°C, 5-Lead SOT-23, 3,000/Reel

c) MIC5225YM5-TR   Ultra-Low Quiescent Current 150 mA μCap Low Dropout Regulator, ADJ, -40°C to +125°C, 5-Lead SOT-23, 3,000/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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