MIC5234

Low Quiescent Current 150 mA LDO Regulator

Features

- Ultra-Low Quiescent Current (I_Q = 20 µA @ I_O = 100 µA)
- Wide Input Voltage Range: 2.3V to 30V
- Low Dropout:
  - 230 mV @ 50 mA
  - 320 mV @ 150 mA
- Adjustable Output Voltage
- Typical ±1.0% Initial Output Accuracy
- Logic-Compatible Enable Input
- Overcurrent Protection
- Thermal-Shutdown Protection
- Reverse-Leakage and Reverse-Battery Protection
- Thermally Enhanced 8-Lead ePad SOIC Package

Applications

- Keep-Alive Supply in Notebook and Portable Personal Computers
- Logic Supply from High-Voltage Batteries
- Automotive Electronics
- Battery-Powered Systems

General Description

The MIC5234 is a low quiescent current, microcap low-dropout regulator. With a maximum operating input voltage of 30V and quiescent current of 20 µA, it is ideal for supplying keep-alive power in systems with high-voltage batteries.

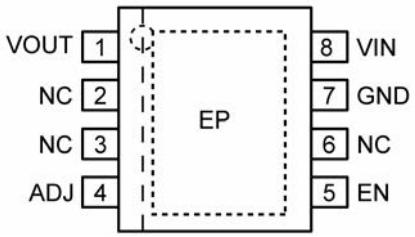
Capable of 150 mA output, the MIC5234 has a dropout voltage of only 320 mV. It can also survive an input transient of –20V to +32V. The MIC5234 requires only a 2.2 µF output capacitor for stable operation.

The MIC5234 includes a logic compatible enable input. Other features of the MIC5234 include thermal shutdown, current limit, overvoltage shutdown, load dump protection, reverse-leakage protection, and reverse battery protection.

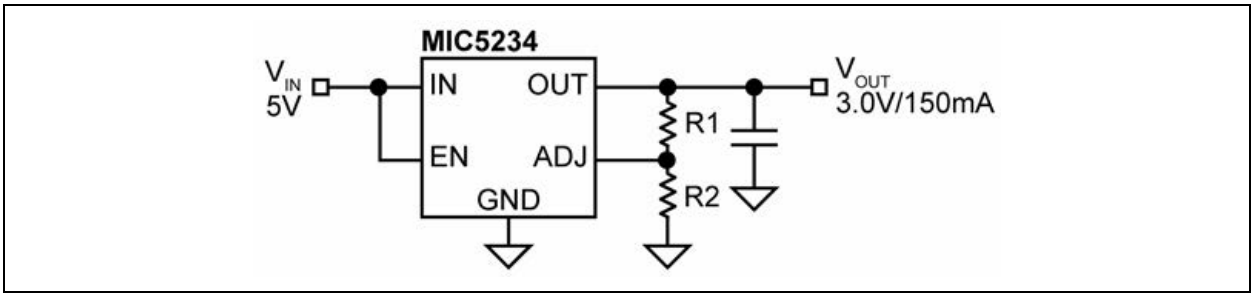
The MIC5234 is available in an 8-lead ePad SOIC package with a junction operating range from –40°C to +125°C.

Package Type

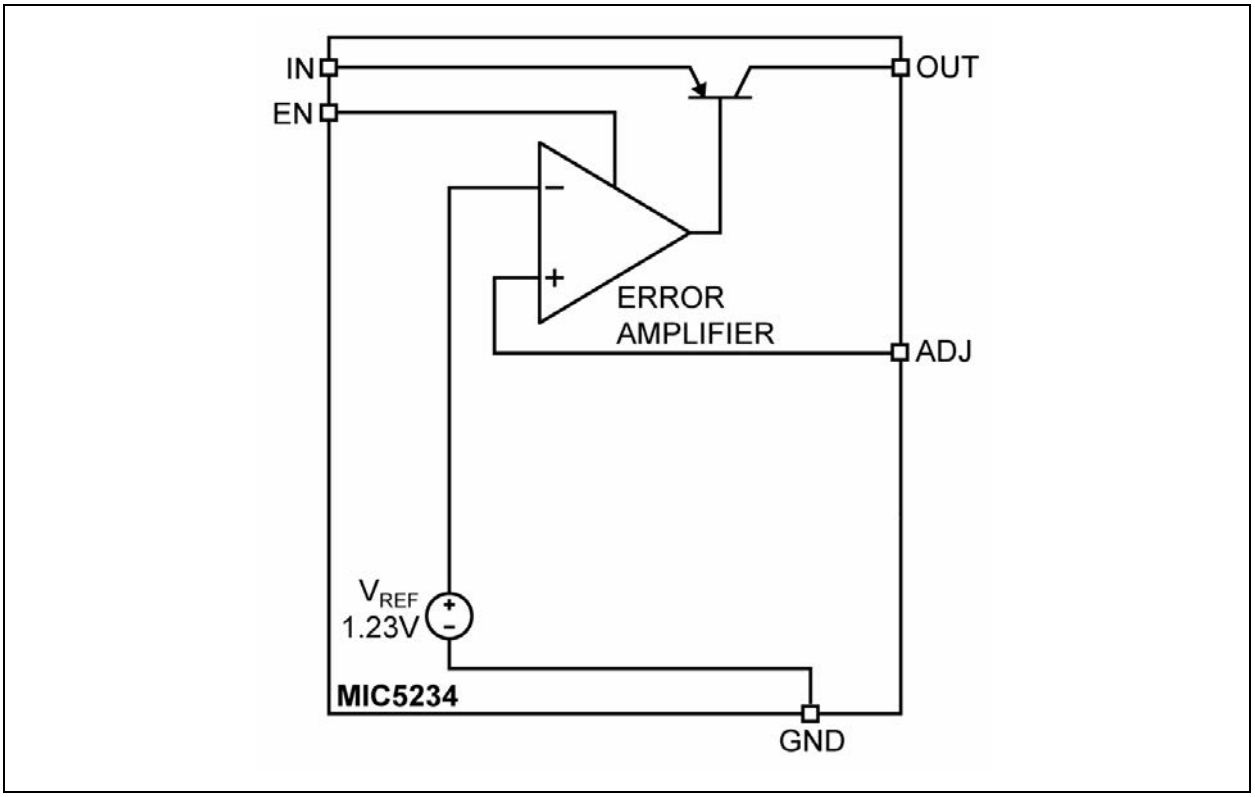
MIC5234
8-Lead SOIC (ME)
(Top View)



Typical Application Circuit



Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN}) ..... –20V to +32V
Power Dissipation (P_D, Note 1) ..... Internally Limited
ESD Rating (Note 2) ..... ESD Sensitive

Operating Ratings ‡

Supply Voltage (V_{IN}) ..... +2.3V to +30V
Enable/Select Voltage (V_{EN}) ..... 0V to +30V

† 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 recommended. Human body model, 1.5 kΩ in series with 100 pF.

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: $V_{IN} = V_{OUT} + 1V$; $V_{EN} = 2.0V$; $C_{OUT} = 4.7\ \mu F$, $I_{OUT} = 100\ \mu A$; $T_J = +25°C$. **Bold** values valid for –40ºC to +125°C; unless otherwise specified. Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Feedback Voltage	V_{ADJ}	**1.2054**	1.23	**1.2546**	V	—
Output Voltage Temperature Coefficient	$\Delta V_{OUT}/\Delta T$	—	50	—	ppm/°C	Note 2
Line Regulation	$\Delta V_{OUT}/V_{OUT}$	—	0.2	0.5	%	$V_{IN} = V_{OUT} + 1V$ to 30V
Load Regulation	$\Delta V_{OUT}/V_{OUT}$	—	0.15	0.3	%	I_{OUT} = 100 µA to 50 mA, Note 3
		—	0.3	0.6		I_{OUT} = 100 µA to 150 mA, Note 3
Dropout Voltage (Note 4)	V_{DROP}	—	50	**120**	mV	I_{OUT} = 100 µA
		—	230	**400**		I_{OUT} = 50 mA
		—	270	—		I_{OUT} = 100 mA
		—	320	**550**		I_{OUT} = 150 mA
Ground Pin Current	I_{GND}	—	20	**30**	µA	$V_{EN} = 2.0V$, I_{OUT} = 100 µA
		—	0.5	**0.9**	mA	$V_{EN} = 2.0V$, I_{OUT} = 50 mA
		—	1.5	—		$V_{EN} = 2.0V$, I_{OUT} = 100 mA
		—	2.8	**5.0**		$V_{EN} = 2.0V$, I_{OUT} = 150 mA
Ground Pin in Shutdown	$I_{GND(SHDN}$	—	0.1	1	µA	$V_{EN} = 0V$, $V_{IN} = 30V$
Short-Circuit Current	I_{SC}	**150**	260	**400**	mA	$V_{OUT} = 0V$
Output Noise	e_N	—	160	—	μV_{RMS}	10 Hz to 100 kHz, $V_{OUT} = 3.0V$, $C_{OUT} = 2.2\ \mu F$
Enable Input						
Input Low Voltage	V_{IL}	—	—	0.6	V	Regulator off
Input High Voltage	V_{IH}	2.0	—	—	V	Regulator on

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: $V_{IN} = V_{OUT} + 1V$; $V_{EN} = 2.0V$; $C_{OUT} = 4.7\ \mu F$, $I_{OUT} = 100\ \mu A$; $T_J = +25°C$. **Bold** values valid for –40ºC to +125°C; unless otherwise specified. Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Enable Input Current	I_{EN}	—	0.01	1.0	µA	V_{EN} = 0.6V, regulator off
		—	—	**2.0**		
		—	0.15	1.0		V_{EN} = 2.0V, regulator on
		—	—	**2.0**		
		—	0.5	2.5		V_{EN} = 30V, regulator on
		—	—	**5.0**		

Note 1: Specification for packaged product only.

2: Output voltage temperature coefficient is defined as the worst-case voltage change divided by the total temperature range.

3: Regulation is measured at constant junction temperature using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered by the speculation for thermal regulation.

4: Dropout voltage is defined as the input-to-output differential at which the output voltage drops 2% below its nominal value measured at $V_{IN} = V_{OUT} + 1V$.

TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Absolute Maximum Junction Temperature	$T_{J(ABS)}$	—	—	+150	°C	—
Junction Temperature Range	T_J	–40	—	+125	°C	—
Storage Temperature	T_S	–65	—	+150	°C	—
Lead Temperature	T_{LEAD}	—	—	+260	°C	Soldering, 10 sec.
Package Thermal Resistances						
Thermal Resistance, SOIC 8-Ld	θ_{JA}	—	41	—	°C/W	—

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.

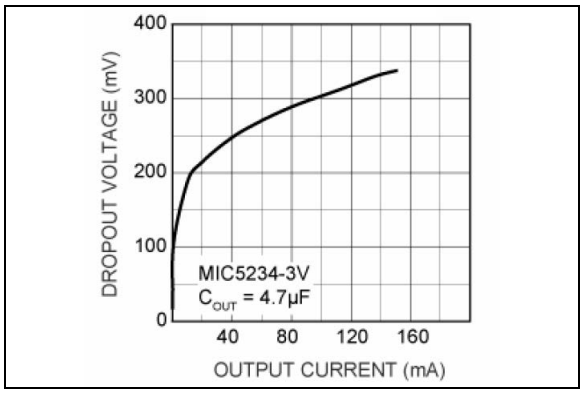


FIGURE 2-1: *Dropout Voltage vs. Output Current.*

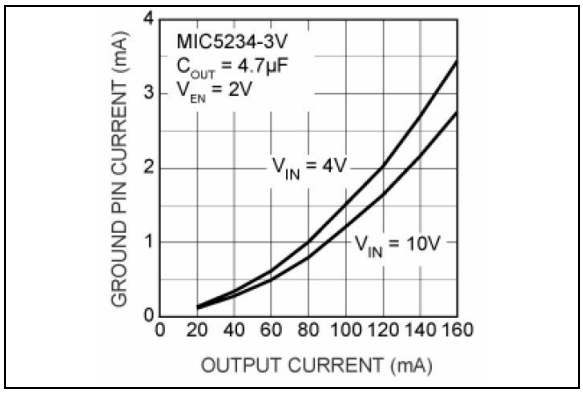


FIGURE 2-4: *Ground Current vs. Output Current.*

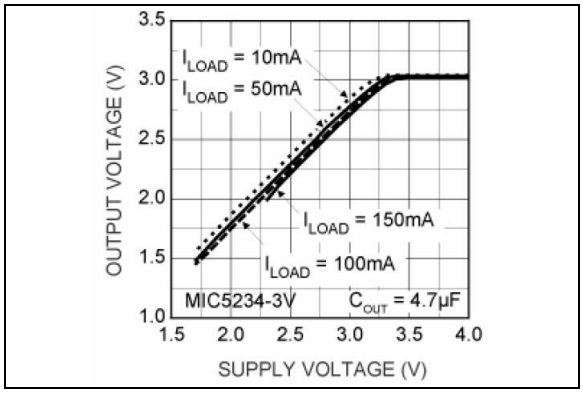


FIGURE 2-2: *Dropout Characteristics.*

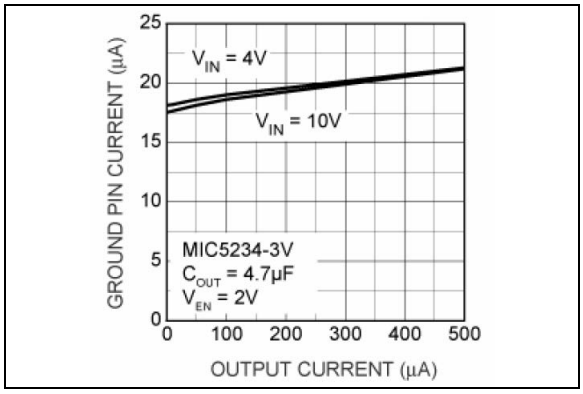


FIGURE 2-5: *Ground Pin Current vs. Output Current.*

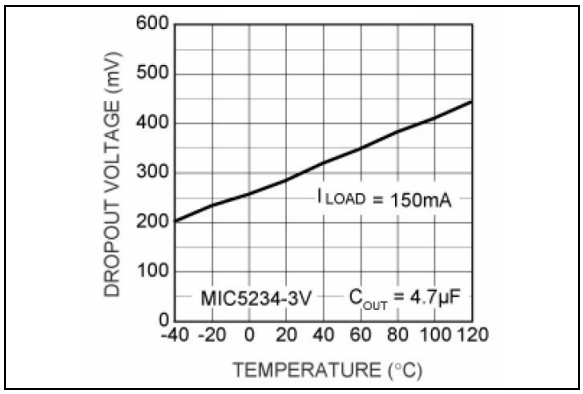


FIGURE 2-3: *Dropout Voltage vs. Temperature.*

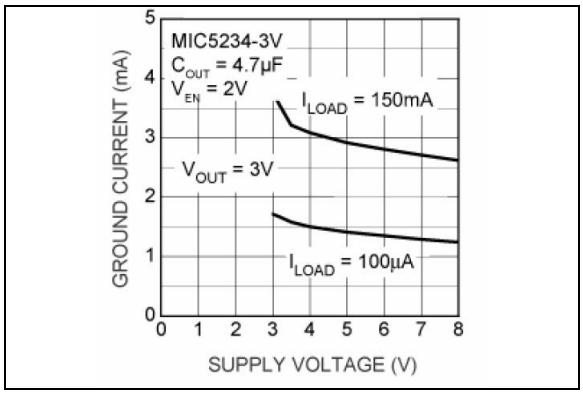


FIGURE 2-6: *Ground Current vs. Supply Voltage.*

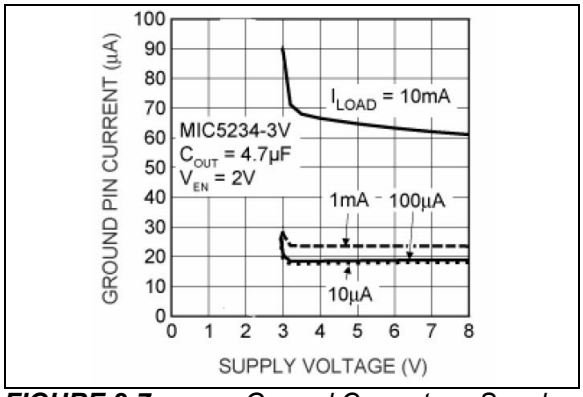


FIGURE 2-7: *Ground Current vs. Supply Voltage.*

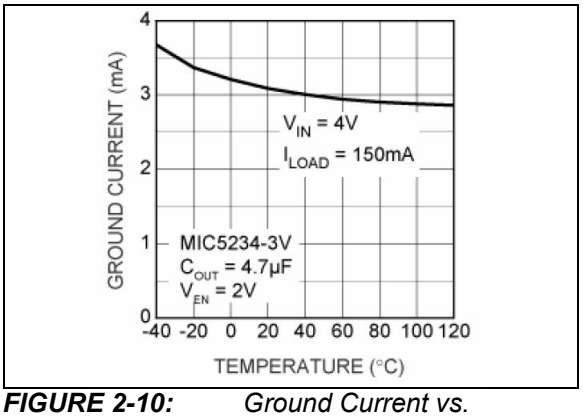


FIGURE 2-10: *Ground Current vs. Temperature.*

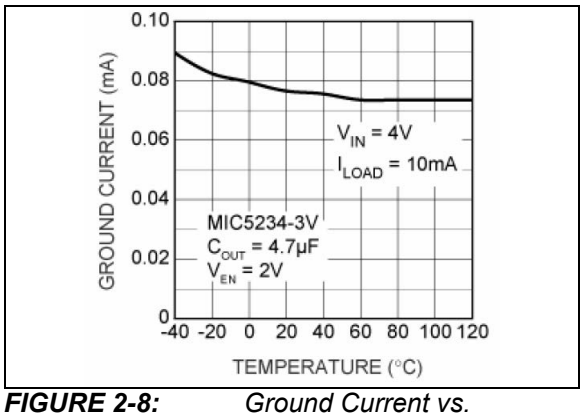


FIGURE 2-8: *Ground Current vs. Temperature.*

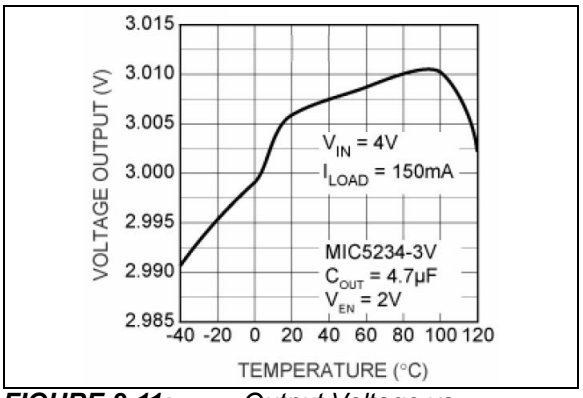


FIGURE 2-11: *Output Voltage vs. Temperature.*

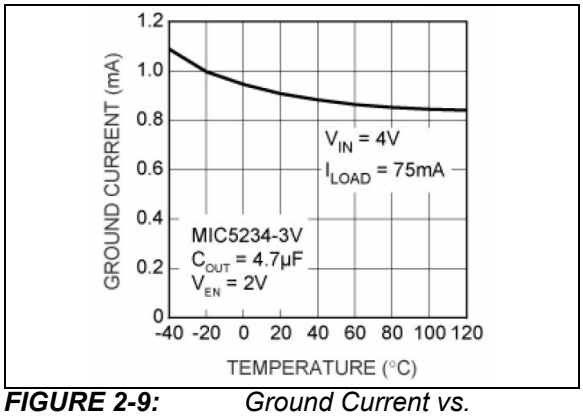


FIGURE 2-9: *Ground Current vs. Temperature.*

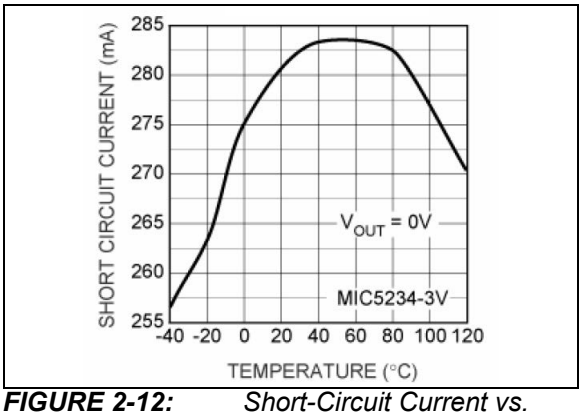


FIGURE 2-12: *Short-Circuit Current vs. Temperature.*

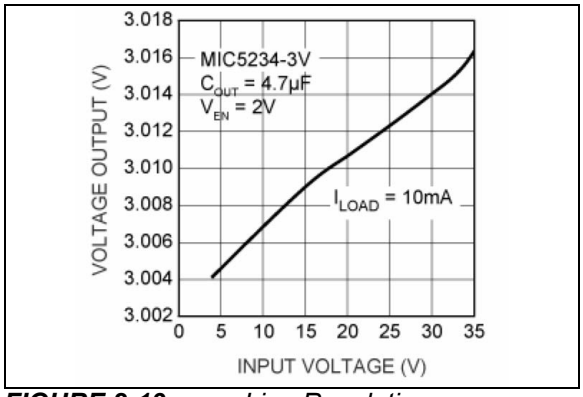


FIGURE 2-13: *Line Regulation.*

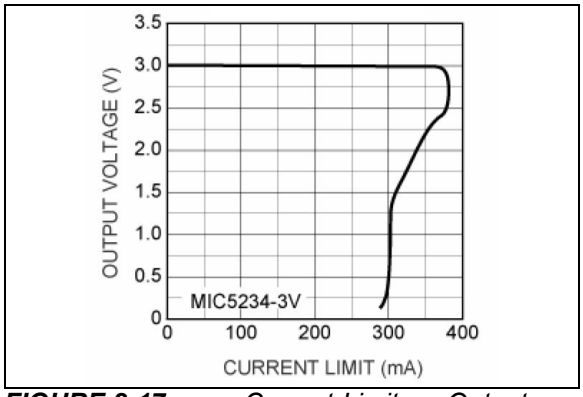


FIGURE 2-17: *Current-Limit vs. Output Voltage.*

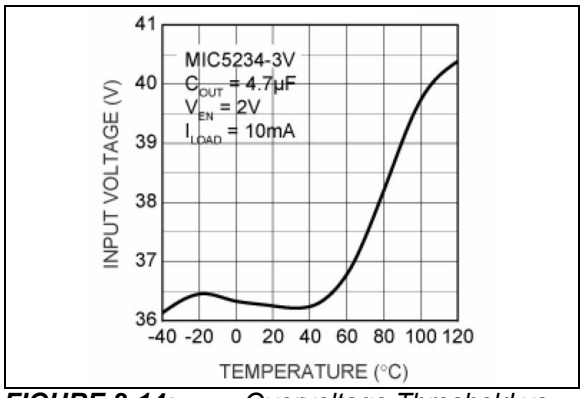


FIGURE 2-14: *Overvoltage Threshold vs. Temperature.*

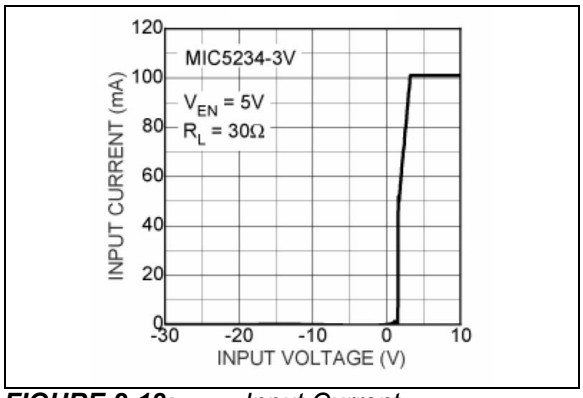


FIGURE 2-18: *Input Current.*

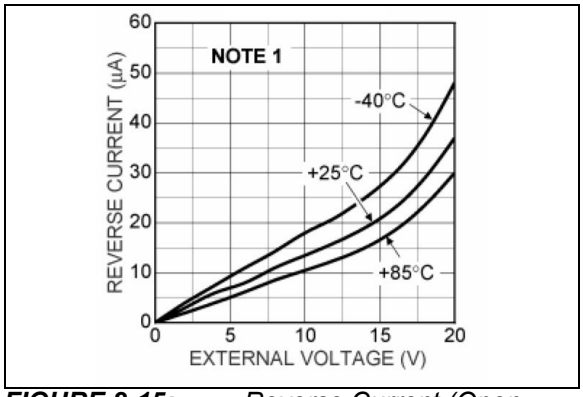


FIGURE 2-15: *Reverse Current (Open Input).*

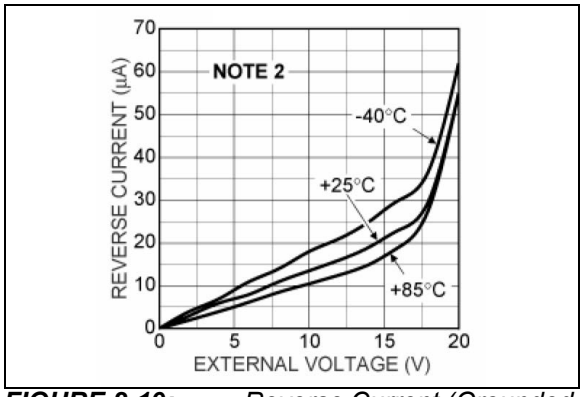


FIGURE 2-19: *Reverse Current (Grounded Input).*

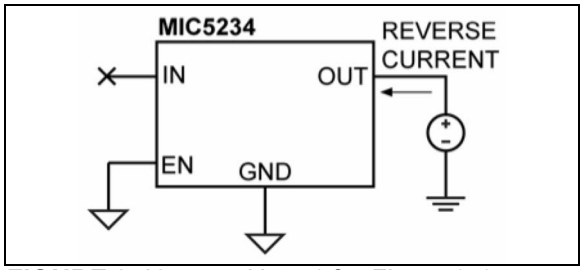


FIGURE 2-16: *Note 1 for Figure 2-15.*

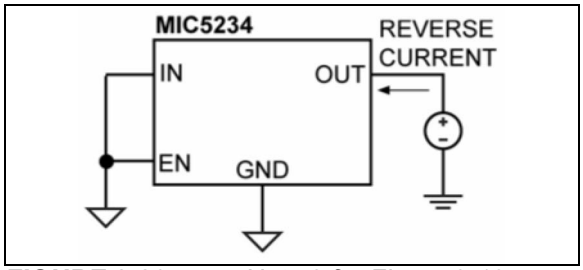


FIGURE 2-20: *Note 2 for Figure 2-19.*

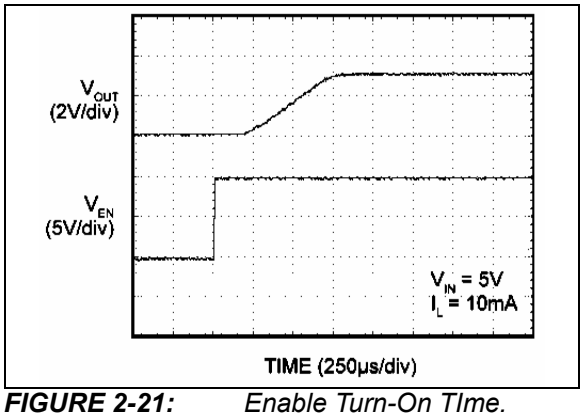


FIGURE 2-21: *Enable Turn-On TIme.*

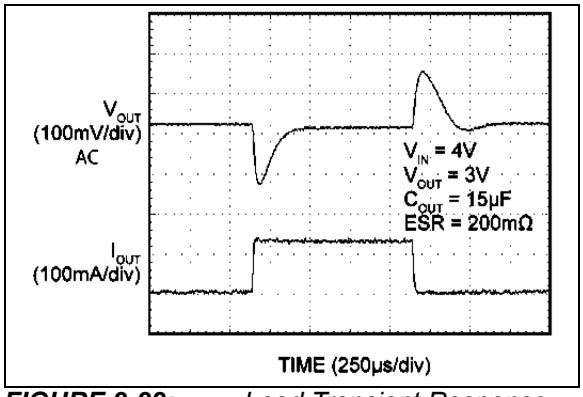


FIGURE 2-22: *Load Transient Response.*

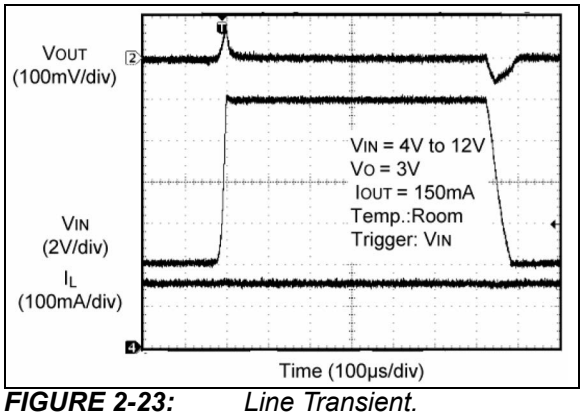


FIGURE 2-23: *Line Transient.*

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	VOUT	Regulated Output.
2, 3, 6	NC	No Connect.
4	ADJ	Adjustable Feedback Input. Connect to voltage divider network.
5	EN	Enable (Input). Logic low = shutdown; logic high = enabled. Do not leave floating.
7	GND	Ground.
8	VIN	Power Supply Input.
EP	ePad	Exposed Thermal Pad. Connect to the ground plane to maximize thermal performance.

4.0 APPLICATION INFORMATION

The MIC5234 is a microcap low dropout linear regulator that provides wide input voltage range, reversed-battery protection, reduced quiescent current, and small package. When disabled, the quiescent current is reduced to 0.1 µA.

4.1 Enable

A low on the enable pin disables the part, forcing the quiescent current to less than 0.1 µA. Thermal shutdown is not functional while the device is disabled. The maximum enable bias current is 2 µA for a 2.0V input. An open collector pull-up resistor tied to the input voltage should be set low enough to maintain 2V on the enable input. Figure 4-1 shows an open collector output driving the enable pin through a 200 kΩ pull-up resistor tied to the input voltage. In order to avoid output oscillations, slow transitions from low to high should be avoided.

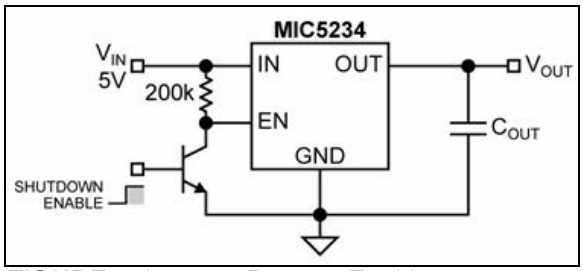


FIGURE 4-1: *Remote Enable.*

4.2 Input Capacitor

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 values may be required if the source supply has high ripple.

4.3 Output Capacitor

The MIC5234 has been designed to minimize the effect of the output capacitor ESR on the closed loop stability. As a result, ceramic or film capacitors can be used at the output. Figure 4-2 displays a range of ESR values for a 10 µF capacitor. A 10 µF capacitor with an ESR less than 3.4Ω is sufficient for stability over the entire input voltage range. Stability can also be maintained throughout the specified load and line conditions with 2.2 µF film or ceramic capacitors.

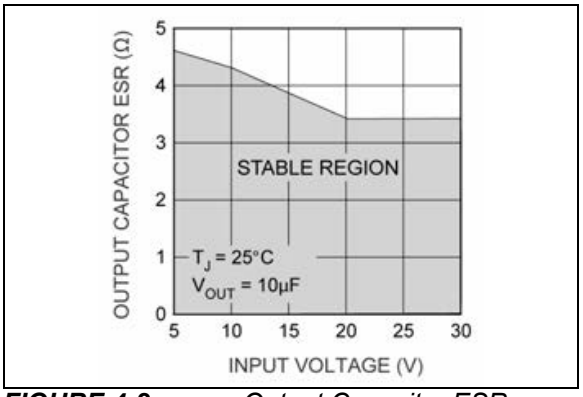


FIGURE 4-2: *Output Capacitor ESR.*

4.4 Reverse-Current Protection

The MIC5234 is designed to limit the reverse current flow from output to input in the event that the MIC5234 output has been tied to the output of another power supply. Refer to the Typical Performance Curves to see the graphs detailing the reverse current flow with the input grounded and open.

4.5 Thermal Shutdown

The MIC5234 has integrated thermal protection. This feature is only for protection purposes. The device should never be intentionally operated near this temperature as this may have detrimental effects on the life of the device. The thermal shutdown may become inactive while the enable input is transitioning a high to a low. When disabling the device via the enable pin, transition from a high to low quickly. This will ensure that the output remains disabled in the event of a thermal shutdown.

4.6 ePad SOIC-8 Thermal Characteristics

The MIC5234 is a high input voltage device intended to provide 150 mA of continuous output current in one a small profile package. The ePad SOIC-8 allows the device to dissipate approximately 50% more power than the SOIC-8 package.

The benefit of the MIC5234 ePad SOIC-8 package is an improvement to less than half the thermal resistance over the standard SO-8 packaging. Lower thermal resistance means more output current or higher input voltage for a given package size. Lower thermal resistance is achieved by joining the die with the die attach paddle to create a single-piece electrical and thermal conductor. This concept has been used by MOSFET manufacturers for years, proving very reliable and cost effective for the user. Thermal resistance consists of two main elements, θ_{JC} (junction-to-case thermal resistance) and θ_{CA} (case-to-ambient thermal resistance). See Figure 4-3. θ_{JC} is the resistance from the die to the case (ePad) of

the package. θ_{CA} is the resistance from the case (ePad) to the ambient air and it includes θ_{CS} case (ePad)-to-sink thermal resistance and θ_{SA} sink-to-ambient thermal resistance.

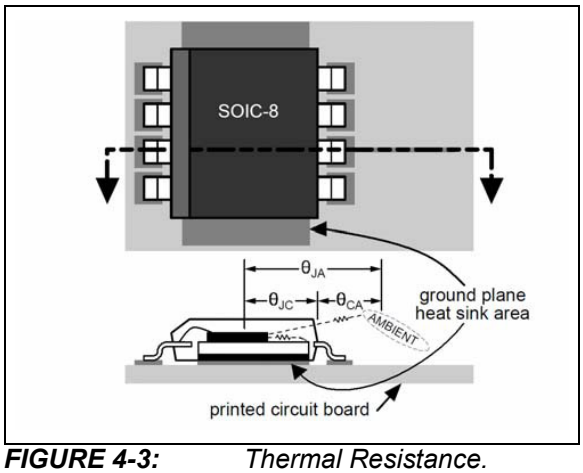


FIGURE 4-3: *Thermal Resistance.*

Using the ePad SOIC-8 reduces the θ_{JC} dramatically and allows the user to reduce θ_{CA}. The total thermal resistance, θ_{JA} (junction-to-ambient thermal resistance) is the limiting factor in calculating the maximum power dissipation capability of the device. Typically, the ePad SOIC-8 has a θ_{JC} of 14.7°C/W. This is significantly lower than the standard SOIC-8, which is typically 48.8°C/W. θ_{CA} is reduced because ePad can now be soldered directly to a ground plane that significantly reduces the case-to-sink thermal resistance and sink-to-ambient thermal resistance.

Low-dropout linear regulators from Microchip are rated to a maximum junction temperature of 125°C. It is important not to exceed this maximum junction temperature during operation of the device. To prevent this maximum junction temperature from being exceeded, the appropriate ground plane heat sink must be used.

The maximum allowable temperature rise must be calculated to determine the required heat sink:

EQUATION 4-1:

$$\Delta T = T_{J(MAX)} - T_{A(MAX)}$$

Where:
$T_{J(MAX)}$ = 125°C
$T_{A(MAX)}$ = Max. ambient operating temperature.

For example, the maximum ambient temperature is 50°C, the ΔT is determined as follows:

EQUATION 4-2:

$$\Delta T = 125°C - 50°C = 75°C$$

Power dissipation in a linear regulator is calculated as follows:

EQUATION 4-3:

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

Using a 3V output device and a 8V input with an output current of 150 mA, then the power dissipation is calculated as follows:

EQUATION 4-4:

$$P_D = (8V - 3V) \times 150mA + (8V \times 2.6mA)$$

$$P_D = 750mW + 20.8mW = 770.8mW$$

A copper plane should be provided to dissipate the heat to keep junction temperature 125°C.

4.7 Adjustable Regulator Application

The MIC5234 can be adjusted from 1.24V to 20V by using two external resistors (see Figure 4-4). The resistors set the output voltage based on Equation 4-5:

EQUATION 4-5:

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

Where:
V_{REF} = 1.23V.

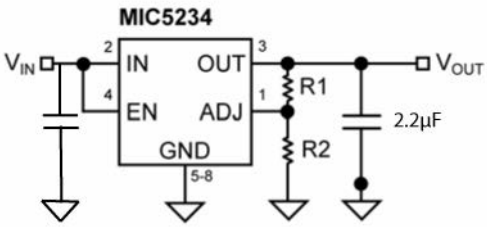


FIGURE 4-4: *Adjustable Voltage Application.*

Example:

If the output voltage is 3.3V and R2 is selected as 1.2 kΩ, then:

EQUATION 4-6:

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

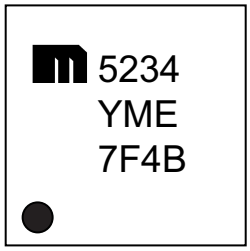
$$R1 = 1.2k\Omega \times \left(\frac{3.3V}{1.23V} - 1\right) = 2.019k\Omega$$

5.0 PACKAGING INFORMATION

5.1 Package Marking Information

8-Lead SOIC*

Example



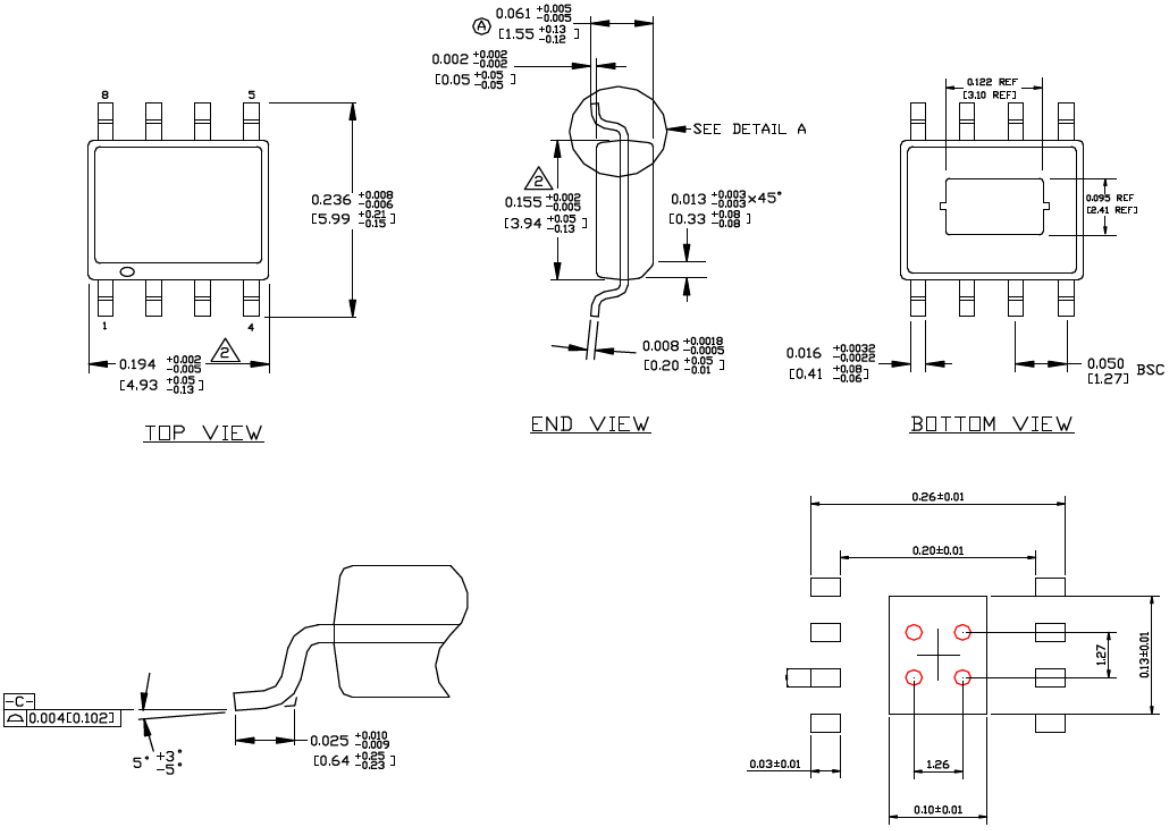
Legend:	XX...X	Product code or customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package 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 (_) symbol may not be to scale.	

Note: If the full seven-character YYWWNNN code cannot fit on the package, the following truncated codes are used based on the available marking space:
6 Characters = YWWNNN; 5 Characters = WWNNN; 4 Characters = WNNN; 3 Characters = NNN;
2 Characters = NN; 1 Character = N

TITLE

8 LEAD SOICN EPAD PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	SOICNEP-8LD-PL-1	UNIT	INCH [MM]



NOTE:

1. DIMENSION DOES NOT INCLUDE MOLD FLASH OR PROTRUSIONS, EITHER OF WHICH SHALL EXCEED 0.006 INCHES PER SIDE
2. RED CIRCLES IN LAND PATTERN REPRESENT THERMAL VIAS. RECOMMENDED SIZE IS 0.30-0.30MM IN DIAMETER AND SHOULD BE CONNECTED TO GND FOR MAXIMUM THERMAL PERFORMANCE

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 2022)

- Converted Micrel document MIC5234 to Microchip data sheet DS20006733A.
- Minor text changes throughout.
- Removed instances of the Schematic, Bill of Materials, and PCB Layout Section because those can be found in the MIC5234 Evaluation Board User's Guide.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

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

Part Number	[X]	X	XX	-XX
Device	Output Voltage	Temp. Range	Package	Media Type

Device:	MIC5234:		Low Quiescent Current 150 mA LDO Regulator
Output Voltage:	<blank>	=	Adjustable
Temperature Range:	Y	=	–40°C to +125°C
Package:	ME	=	8-Lead ePad SOIC
Media Type:	<blank>	=	95/Tube
	TR	=	2,500/Reel

Examples:

a) MIC5234YME: MIC5234, Adjustable Output Voltage, –40°C to +125°C Temp. Range, 8-Lead SOIC, 95/Tube

b) MIC5234YME-TR: MIC5234, Adjustable Output Voltage, –40°C to +125°C Temp. Range, 8-Lead SOIC, 2,500/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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