MIC5237

500 mA Low Dropout Regulator

Features

- Guaranteed 500 mA Output Over the Full Operating Temperature Range
- Low 300 mV Typical Dropout Voltage at Full Load
- Extremely Tight Load and Line Regulation
- Current and Thermal Limiting
- Reversed-Battery Protection
- TO-220 and TO-263 Packages
- Low Temperature Coefficient
- No-Load Stability
- Low Noise Output

Applications

- Portable and Laptop Computers
- Desktop Computer
- Battery Chargers
- SMPS Post-Regulator and DC/DC Modules
- Consumer and Personal Electronics

General Description

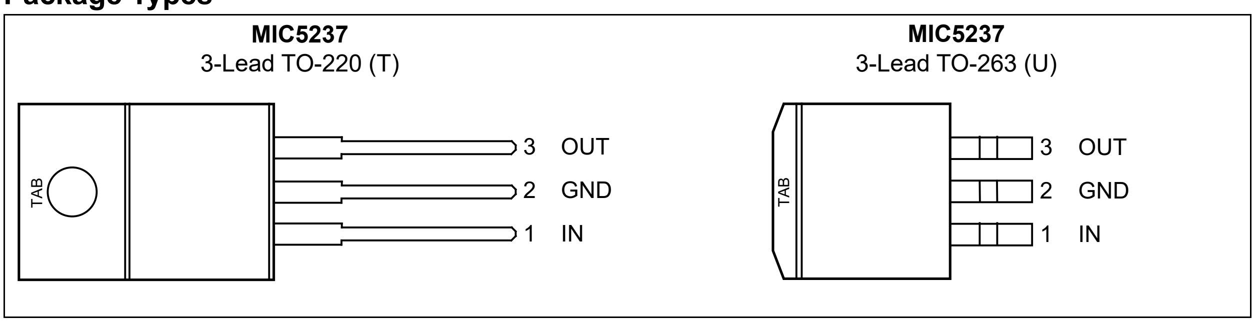
The MIC5237 is a general-purpose low-dropout regulator capable of 500 mA output current with better than 3% output voltage accuracy. Using Microchip's proprietary Super ßeta PNP process with a PNP pass element, these regulators feature less than 300 mV dropout voltage and typically 8 mA ground current at full load.

Designed for applications that require moderate current over a broad input voltage range, including hand-held and battery-powered devices, the MIC5237 is intended for applications that can tolerate moderate voltage drop at higher current.

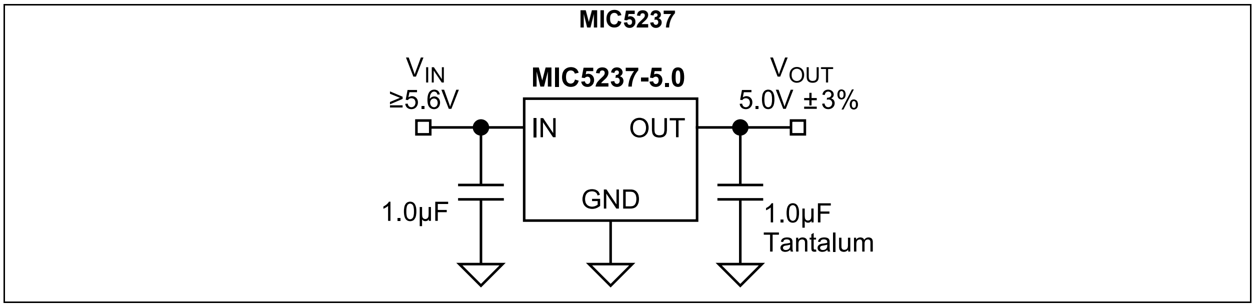
Key features include low ground current to help prolong battery life, reversed-battery protection, current limiting, overtemperature shutdown, and thermally efficient packaging. The MIC5237 is available in fixed output voltages only.

For space-critical applications and improved performance, see the MIC5209 and MIC5219. For output current requirements up to 750 mA, see the MIC2937.

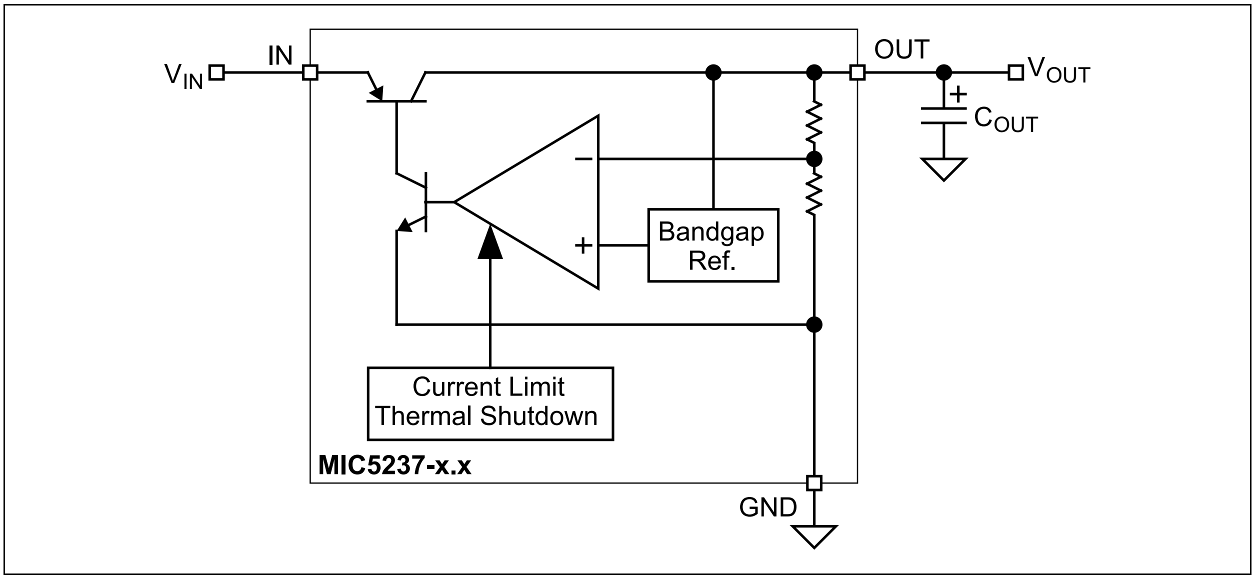
Package Types



Typical Application Circuit



Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Input Voltage (V_{IN}) .... –20V to +20V
Power Dissipation (P_D) (Note 1) .... Internally Limited

Operating Ratings ‡

Supply Input Voltage (V_{IN}) .... +2.5V to +16V

† 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 at any T_A (ambient temperature) is calculated using: $P_{D(max)} = (T_{J(max)} – T_A) \div \theta_{JA}$. Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown.

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: $V_{IN} = V_{OUT} + 1.0V$; $C_{OUT} = 4.7\ \mu F$; $I_{OUT} = 100\ \mu A$; $T_J = +25°C$, **bold** values indicate $–40°C \le T_J \le +125°C$; unless noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Voltage Accuracy	V_{OUT}	–3	—	3	%	Variation from nominal V_{OUT}.
		–5	—	**5**		
Output Voltage Temperature Coefficient	$\Delta V_{OUT}/\Delta T$	—	**40**	—	ppm/°C	Note 1
Line Regulation	$\Delta V_{OUT}/V_{OUT}$	—	—	0.05	%/V	$V_{IN} = V_{OUT} + 1V$ to 16V
		—	0.015	**0.1**		
Load Regulation	$\Delta V_{OUT}/V_{OUT}$	—	0.05	0.5	%	I_{OUT} = 100 µA to 500 mA, Note 2
		—	—	**0.7**		
Dropout Voltage, Note 3	$V_{IN} – V_{OUT}$	—	10	70	mV	I_{OUT} = 100 µA
		—	—	**90**	mV	
		—	115	190	mV	I_{OUT} = 50 mA
		—	—	**280**	mV	
		—	165	350	mV	I_{OUT} = 150 mA
		—	—	**450**	mV	
		—	300	600	mV	I_{OUT} = 500 mA
		—	—	**700**	mV	
Ground Pin Current, Note 4	I_{GND}	—	80	130	µA	I_{OUT} = 100 µA
		—	—	**170**	µA	
		—	350	650	µA	I_{OUT} = 50 mA
		—	—	**900**	µA	
		—	1.8	2.5	mA	I_{OUT} = 150 mA
		—	—	**3.0**	mA	
		—	8	15	mA	I_{OUT} = 500 mA
		—	—	**20**	mA	
Ripple Rejection	PSRR	—	75	—	dB	f = 120 Hz

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: $V_{IN} = V_{OUT} + 1.0V$; $C_{OUT} = 4.7\ \mu F$; $I_{OUT} = 100\ \mu A$; $T_J = +25°C$, **bold** values indicate $–40°C \le T_J \le +125°C$; unless noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Current Limit	I_{LIMIT}	—	700	900	mA	$V_{OUT} = 0V$
		—	—	**1000**		
Thermal Regulation	$\Delta V_{OUT}/\Delta P_D$	—	0.05	—	%/W	Note 5
Output Noise	e_{no}	—	500	—	nV/√Hz	$V_{OUT} = 5.0V$, $I_{OUT} = 50$ mA, $C_{OUT} = 2.2\ \mu F$

Note 1: Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.

2: Regulation is measured at constant junction temperature using low duty cycle pulse testing. Parts are tested for load regulation in the load range from 100 µA to 500 mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

3: 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.

4: Ground pin current is the regulator quiescent current plus pass transistor base current. The total current drawn from the supply is the sum of the load current plus the ground pin current.

5: Thermal regulation is defined as the change in output voltage at a time “t” after a change in power dissipation is applied, excluding load or line regulation effects. Specifications are for a 500 mA load pulse at V_{IN} = 16V for t = 10 ms.

TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Junction Operating Temperature Range	T_J	–40	—	+125	°C	—
Lead Temperature	—	—	—	+260	°C	Soldering, 5s
Package Thermal Resistances						
Thermal Resistance TO-263	θ_{JC}	—	3	—	°C/W	—
Thermal Resistance TO-220	θ_{JC}	—	3	—	°C/W	—
	θ_{JA}	—	55	—	°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.

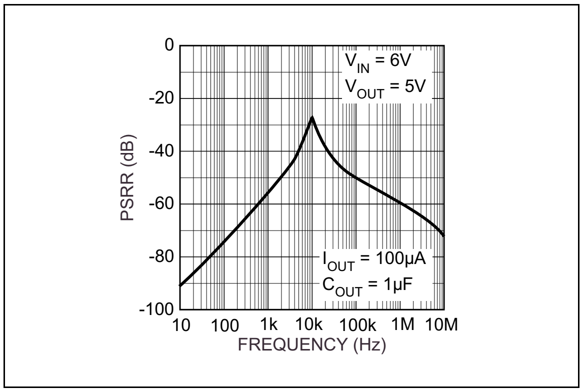


FIGURE 2-1: *Power Supply Rejection Ratio.*

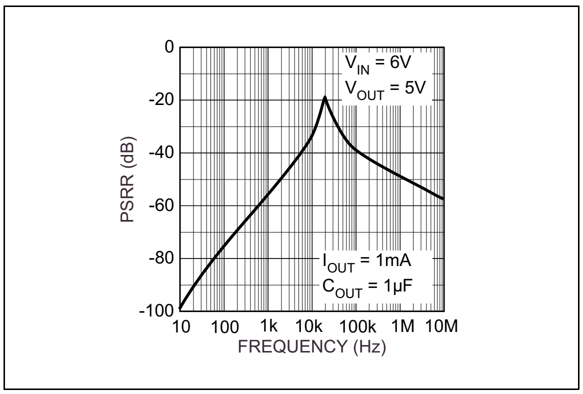


FIGURE 2-2: *Power Supply Rejection Ratio.*

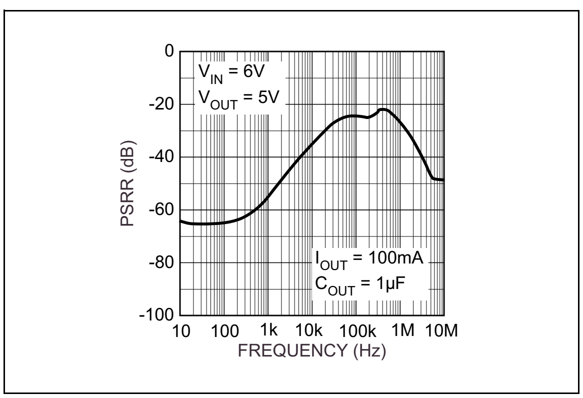


FIGURE 2-3: *Power Supply Rejection Ratio.*

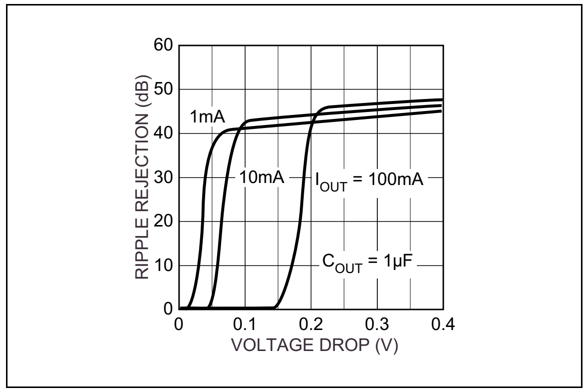


FIGURE 2-4: *Power Supply Ripple Rejection vs. Voltage Drop.*

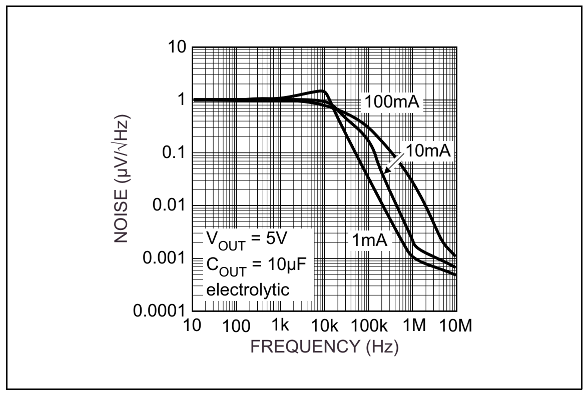


FIGURE 2-5: *Noise Performance.*

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, TAB	GND	Ground: TO-220 and TO-263 pin 2 and TAB are internally connected.
3	OUT	Regulator output.

4.0 APPLICATION INFORMATION

The MIC5237 is intended for general purpose use and can be implemented in a wide variety of applications where 500 mA of output current is needed. It is available in several voltage options for ease-of-use. For voltage options that are not available on the MIC5237, consult the MIC5209 for a 500 mA adjustable LDO regulator, or the MIC5219 for applications that require only short-duration peak output current.

4.1 Input Capacitor

A 1 µF capacitor should be placed from IN to GND if there is more than 10 inches of wire between the input and the ac filter capacitor or if a battery is used as the input.

4.2 Output Capacitor

An output capacitor is required between OUT and GND to prevent oscillation. 1 µF minimum is recommended for standard applications. Larger values improve the regulator's transient response. The output capacitor value may be increased without limit.

The output capacitor should have an ESR (equivalent series resistance) of about 5Ω or less and a resonant frequency above 1 MHz. Ultra low-ESR capacitors can cause low-amplitude oscillations and/or under-damped transient response. Most tantalum or aluminum electrolytic capacitors are adequate; film types will work, but are more expensive. Because many aluminum electrolytics have electrolytes that freeze at about –30°C, solid tantalums are recommended for operation below –25°C.

At lower values of output current, less output capacitance is needed for output stability. The capacitor can be reduced to 0.47 µF for current below 10 mA or 0.33 µF for currents below 1 mA.

For 2.5V applications a 22 µF output capacitor is recommended to reduce startup voltage overshoot.

4.3 No-Load Stability

The MIC5237 will remain stable and in regulation with no load (other than the internal voltage divider) unlike many other voltage regulators. This is especially important in CMOS RAM keep-alive applications.

4.4 Thermal Considerations

Proper thermal design can be accomplished with some basic design criteria and some simple equations. The following information is required to implement a regulator design.

- V_{IN} = Input Voltage
- V_{OUT} = Output Voltage
- I_{OUT} = Output Current
- T_A = Ambient Operating Temperature
- I_{GND} = Ground Current

The regulator ground current, I_{GND}, can be measured or read from the data sheet. Assuming the worst case scenario is good design procedure, and the corresponding ground current number can be obtained from the data sheet. First, calculate the power dissipation of the device. This example uses the MIC5237-5.0YT, a 13V input, and 500 mA output current, which results in 20 mA of ground current, worst case. The power dissipation is the sum of two power calculations: voltage drop × output current and input voltage × ground current.

EQUATION 4-1:

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

EQUATION 4-2:

$$\begin{aligned} P_D &= [(13V - 5V) \times 500mA] + (13V \times 20mA) \\ &= 4.260W \end{aligned}$$

From this number, the heat sink thermal resistance is determined using the regulator's maximum operating junction temperature ($T_{J(max)}$) and the ambient temperature (T_A) along with the power dissipation number already calculated.

- T_{JMAX} = 125°C
- θ_{JC} = Junction-to-Case Thermal Resistance
- θ_{CS} = Case-to-Sink Thermal Resistance
- θ_{JA} = Junction-to-Ambient Thermal Resistance
- θ_{SA} = Sink-to-Ambient Thermal Resistance

To determine the heat sink thermal resistance, the junction-to-case thermal resistance of the device must be used along with the case-to-heat sink thermal resistance. These numbers show the heat sink thermal resistance required at T_A = 25°C that does not exceed the maximum operating junction temperature.

EQUATION 4-3:

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

EQUATION 4-4:

$$\theta_{SA} = \theta_{JA} - \theta_{JC}$$

θ_{CS} is approximately 1°C/W and θ_{JC} for the TO-220 is 3°C/W in this example.

EQUATION 4-5:

$$\theta_{JA} = \frac{125°C - 25°C}{4.260W} = 23.5°C/\mathrm{W}$$

EQUATION 4-6:

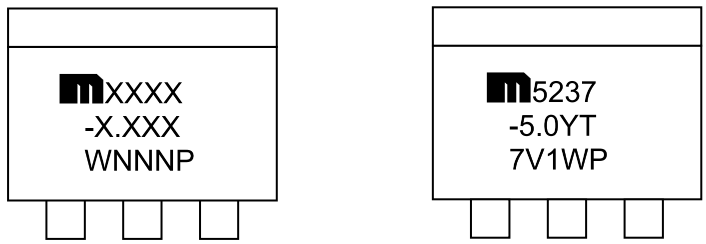
$$\theta_{SA} = 23.5°C/\mathrm{W} - (3°C/\mathrm{W} + 1°C/\mathrm{W}) = 19.5°C/\mathrm{W}$$

Therefore, a heat sink with a thermal resistance of 19.5°C/W will allow the part to operate safely and it will not exceed the maximum junction temperature of the device. The heat sink can be reduced by limiting power dissipation, by reducing the input voltage or output current. Either the TO-220 or TO-263 package can operate reliably at 2W of power dissipation without a heat sink. Above 2W, a heat sink is recommended.

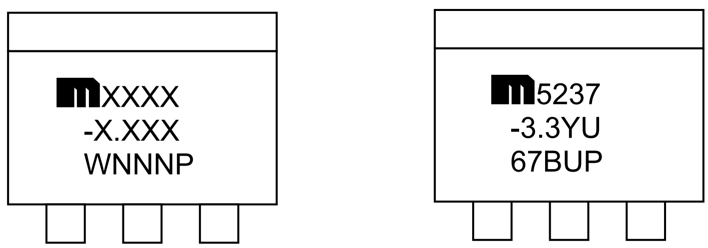
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

3-Lead TO-220* | Example



3-Lead TO-263* | 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.

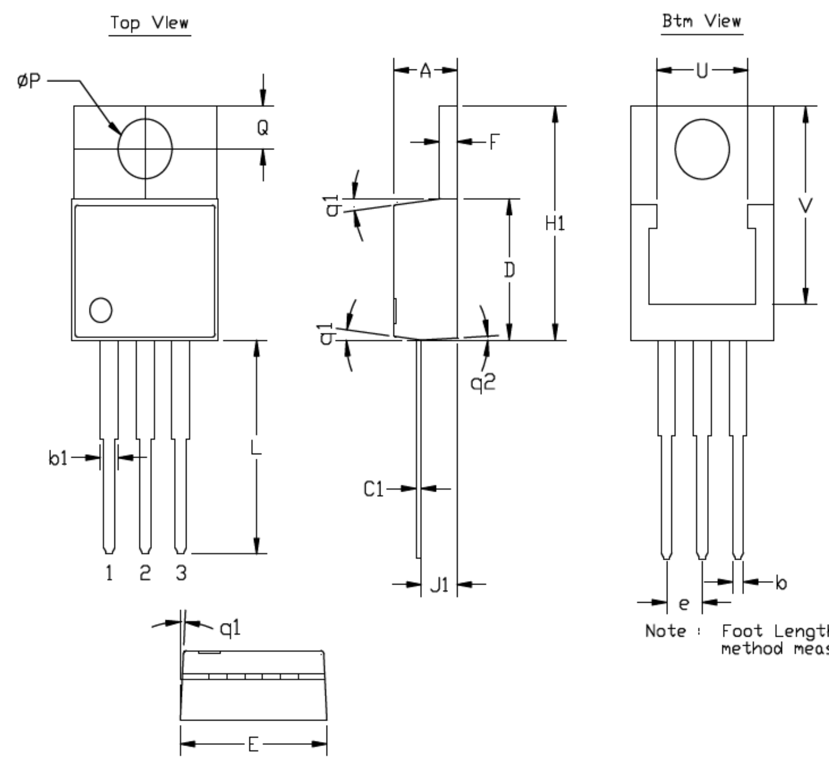
Note: If the full seven-character YYWWNNN code cannot fit on the package, the following truncated codes are used based on the available marking space:
6 Characters = YWWNNN; 5 Characters = WWNNN; 4 Characters = WNNN; 3 Characters = NNN;
2 Characters = NN; 1 Character = N

3-Lead TO-220 Package Outline and Recommended Land Pattern

TITLE

3 LEAD TO220 PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	TO220-3LD-PL-1	**UNIT**	INCH
Lead Frame	Copper Alloy	**Lead Finish**	Matte Tin



POS	INCH	
	MIN	MAX
A	0.160	0.190
b	0.025	0.040
b1	0.045	0.060
C1	0.012	0.022
D	0.348	0.360
E	0.385	0.420
e	0.090	0.110
F	0.045	0.055
H1	0.541	0.619
J1	0.080	0.120
ØP	0.146	0.156
Q	0.103	0.113
L	0.500	0.580
q1	3°	10°
q2	1°	7°
U	0.256 Ref.	
V	0.486 Ref.	

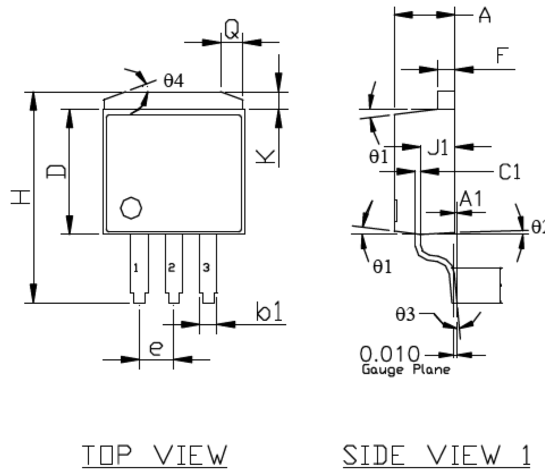
Note : Foot Length using gauge plane method measurement 0.010".

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

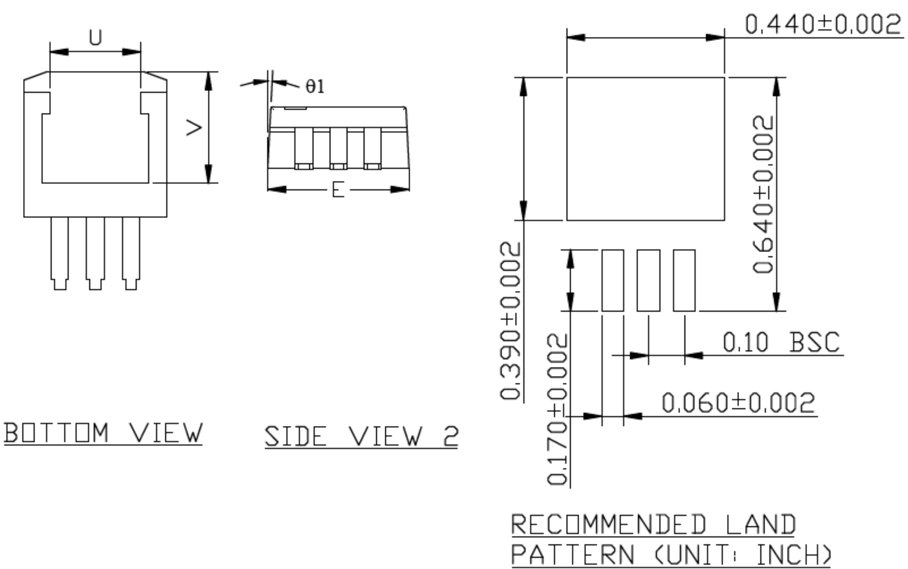
3-Lead TO-263 Package Outline and Recommended Land Pattern

TITLE
3 LEAD TO263 PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	TO263-3LD-PL-1	**UNIT**	INCH/MM



	INCH		MM	
POS	MIN	MAX	MIN	MAX
A	0.170	0.181	4.318	4.597
A1	0.000	0.012	0.000	0.305
b1	0.047	0.053	1.194	1.346
C1	0.012	0.023	0.305	0.584
D	0.330	0.361	8.382	9.169
E	0.396	0.420	10.058	10.668
e	0.095	0.105	2.413	2.667
F	0.045	0.055	1.143	1.397
H	0.575	0.625	14.605	15.875
J1	0.080	0.120	2.032	3.048
L1	0.090	0.110	2.286	2.794
K	0.045	0.066	1.143	1.676
θ1	3°	10°	3°	10°
θ2	1°	7°	1°	7°
θ3	0°	8°	0°	8°
θ4	18°	22°	18°	22°
Q	0.055	0.075	1.397	1.905
U	0.256 Ref.		6.502 Ref.	
V	0.303 Ref.		7.696 Ref.	



NOTES:
FOOT LENGTH USE GUAGE PLANE METHOD MEASUREMENT 0.010"

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

APPENDIX A: REVISION HISTORY

Revision A (October 2018)

- Converted Micrel document MIC5237 to Microchip data sheet DS20006095A.
- Minor text changes throughout.

Revision B (February 2022)

- Updated the Package Marking Information drawing with the most current marking information.

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	Temperature	Package	Media Type

Device:	MIC5237:		500 mA Low Dropout Regulator
Voltage:	2.5	=	2.5V (TO-263 Only)
	3.3	=	3.3V (TO-263 Only)
	5.0	=	5.0V (Both Packages)
Temperature:	Y	=	–40°C to +125°C
Package:	T	=	3-Lead TO-220
	U	=	3-Lead TO-263
Media Type:	<blank>	=	50/Tube (Both Packages)
	TR	=	750/Reel (TO-263 Only)

Examples:

a) MIC5237-2.5YU:	500 mA Low Dropout Regulator 2.5V, –40°C to +125°C, 3-Lead TO-263, 50/Tube
b) MIC5237-2.5YU-TR:	500 mA Low Dropout Regulator 2.5V, –40°C to +125°C, 3-Lead TO-263, 750/Reel
c) MIC5237-3.3YU:	500 mA Low Dropout Regulator 3.3V, –40°C to +125°C, 3-Lead TO-263, 50/Tube
d) MIC5237-3.3YU-TR:	500 mA Low Dropout Regulator 3.3V, –40°C to +125°C, 3-Lead TO-263, 750/Reel
e) MIC5237-5.0YU:	500 mA Low Dropout Regulator 5.0V, –40°C to +125°C, 3-Lead TO-263, 50/Tube
f) MIC5237-5.0YU-TR:	500 mA Low Dropout Regulator 5.0V, –40°C to +125°C, 3-Lead TO-263, 750/Reel
g) MIC5237-5.0YT:	500 mA Low Dropout Regulator 5.0V, –40°C to +125°C, 3-Lead TO-220, 50/Tube

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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