
Micropower, μ Cap LDO Regulator

Features

- Extremely Low Quiescent Current: 0.65 μ A
- No Output Capacitor Requirement
- Stable with Ceramic or Tantalum Capacitors
- SOT-23-5 Surface-Mount Package
- 10 mA Output Drive
- Low 150 mV at 10 mA Dropout Voltage
- Tight Load and Line Regulation
- Low Temperature Coefficient
- Logic-Level Enable Input

Applications

- Real-Time Clocks
- SRAM Backup
- Cellular Telephones
- Laptop, Notebook, and Palmtop Computers
- Battery-Powered Equipment
- Barcode Scanners
- SMPS Post-Regulator and DC-to-DC Modules

General Description

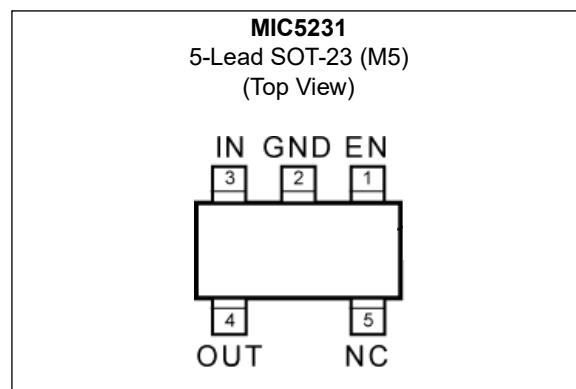
The MIC5231 μ Cap low dropout regulator is intended for low output current biasing applications. It features extremely low ground current, not greater than 4 μ A under all load and temperature conditions, which makes it efficient and ideal for keep-alive applications in devices such as notebook computers.

The MIC5231 offers better than 2% initial accuracy and low dropout (typically 150 mV at 10 mA output current). An output capacitor is not required for stable operation, which decreases cost and board space. Tiny ceramic chip capacitors may be used to improve transient response.

The MIC5231 also features a control pin that allows the regulator to be shut down when not required. Its shutdown state draws zero current, which benefits battery-powered applications.

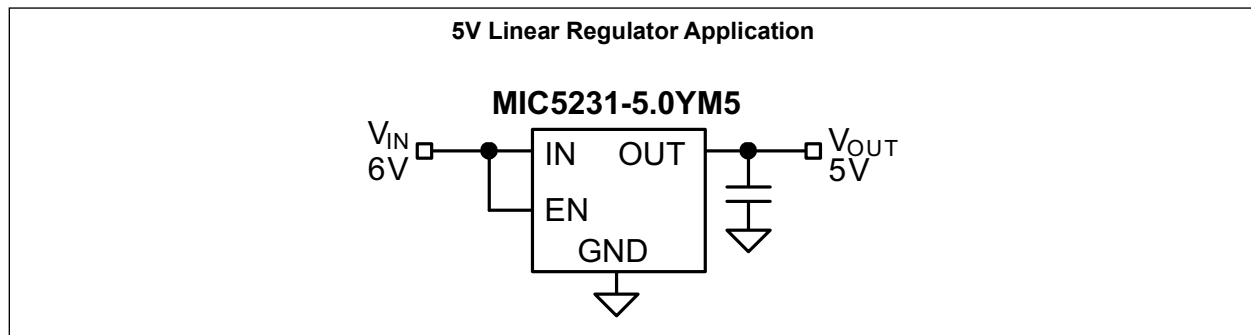
The MIC5231 is available in fixed output voltages of 2.75V, 3.0V, 3.3V, and 5.0V in the small SOT-23-5 package. Contact Microchip for other voltage options.

Package Type

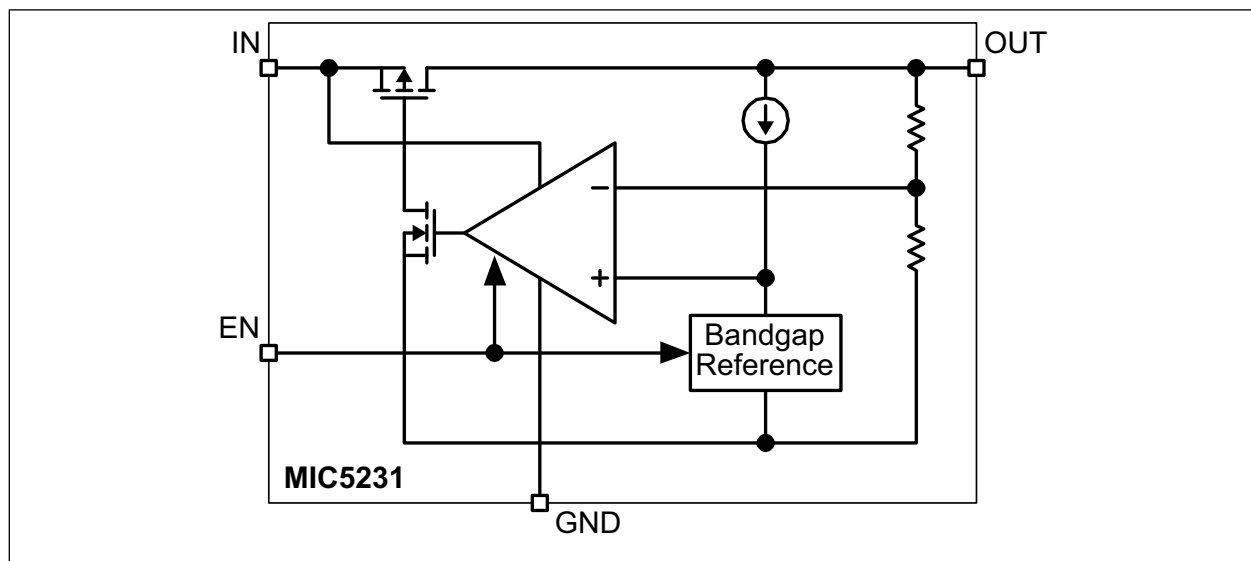


MIC5231

Typical Application Circuit



Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN})	–0.6V to +14V
ESD Rating (Note 1)	2 kV

Operating Ratings ‡

Supply Voltage (V_{IN})	+3.5V to +12V
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† **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: Device is ESD sensitive. Handling precautions are recommended.

ELECTRICAL CHARACTERISTICS

$V_{IN} = V_{OUT} + 1V$; $I_L = 100 \mu A$; $C_L = 0.47 \mu F$; $T_J = +25^\circ C$, **bold** values valid for $-40^\circ C \leq T_J \leq +125^\circ C$, unless noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Voltage Accuracy	V_{OUT}	–2	—	2	%	Variation from nominal V_{OUT}
		–3	—	3		
Output Voltage Temperature Coefficient	$\Delta V_{OUT}/\Delta T$	—	250	—	ppm/°C	Note 1
Line Regulation	$\Delta V_{OUT}/V_{IN}$	—	0.2	0.25	%	$V_{IN} = 6V$ to 12V
Load Regulation	V_{OUT}	—	0.2	1	%	$I_L = 10 \mu A$ to 10 mA, Note 2
Dropout Voltage (Note 3)	V_{DO}	—	15	—	mV	$I_L = 1 mA$
		—	150	300		$I_L = 10 mA$
Ground Pin Current	I_{GND}	—	0.65	3	μA	$V_{IN} = 6V$, $I_L = 10 mA$
		—	1.1	4		$V_{IN} = 12V$, $I_L = 10 mA$
Ripple Rejection	PSRR	—	50	—	dB	$f = 100 Hz$, $I_L = 100 \mu A$
Enable Input						
Enable Input Voltage	V_{EN}	—	0.4	0.18	V	$V_{EN} = \text{logic low}$ (regulator off)
		1.4	—	—		$V_{EN} = \text{logic high}$ (regulator on)
Enable Input Current Low	I_{ENL}	—	1	—	nA	$V_{ENL} \leq 0.18V$ (regulator off)
Enable Input Current High	I_{ENH}	—	1	—	nA	$V_{ENH} \geq 1.4V$ (regulator on)

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.

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. For outputs below 3.5V, dropout voltage is the input-to-output differential with the minimum input voltage 3.5V. Minimum input operating voltage is 3.5V.

MIC5231

TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Junction Temperature Range	T_J	-40	—	+125	°C	—
Ambient Temperature Range	T_A	-40	—	+85	°C	—
Storage Temperature Range	T_S	-60	—	+150	°C	—
Lead Temperature	T_{LEAD}	—	—	+260	°C	Soldering, 5 sec.
Package Thermal Resistances						
Thermal Resistance, 5-Ld SOT-23	θ_{JA}	—	235	—	°C/W	—
	θ_{JC}	—	130	—	°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.

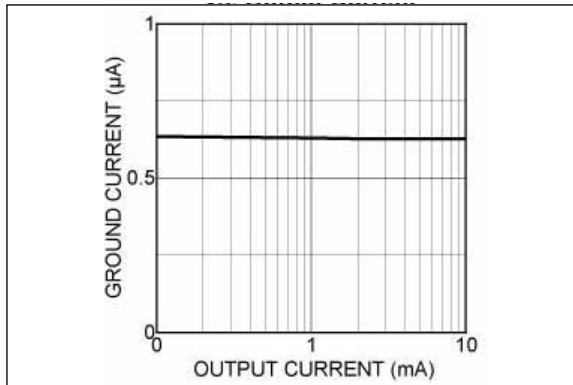


FIGURE 2-1: Ground Current vs. Output Current.

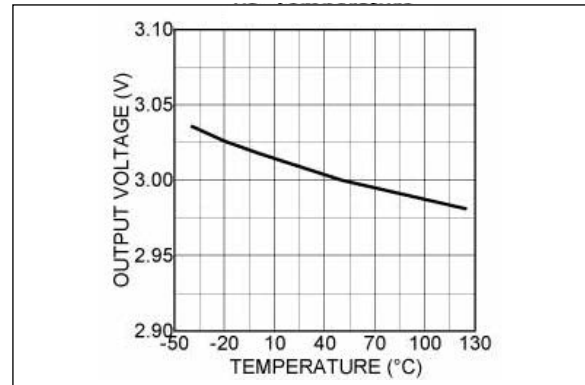


FIGURE 2-4: Output Voltage vs. Temperature.

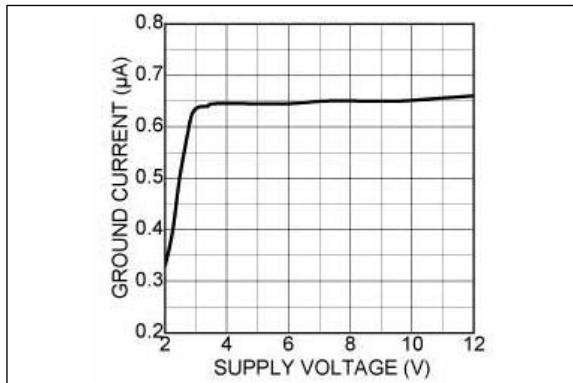


FIGURE 2-2: Ground Current vs. Supply Voltage.

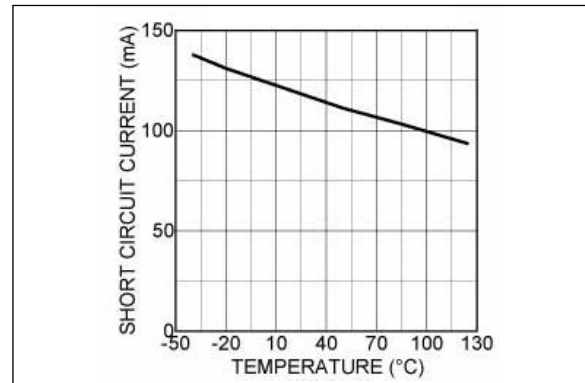


FIGURE 2-5: Short-Circuit Current vs. Temperature.

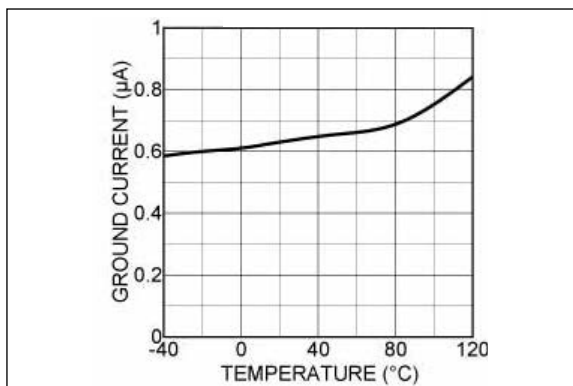


FIGURE 2-3: Ground Current vs. Temperature.

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	EN	Enable (Input): Active high. Logic high = enable; logic low = shutdown. Do not float.
2	GND	Ground.
3	IN	Supply Input.
4	OUT	Regulated Output.
5	NC	Not internally connected.

4.0 APPLICATION INFORMATION

4.1 Input Capacitor

A 0.1 μF (or larger) capacitor should be placed from the supply input (IN) to ground (GND) if there is more than 20 cm of wire between IN and the AC filter capacitor or if supplied from a battery.

4.2 Output Capacitors

The MIC5231 does not require an output capacitor for stability. A 1 μF or larger capacitor is recommended between the output (OUT) and GND to improve the regulator's transient response. A 0.1 μF capacitor can be used to reduce overshoot recovery time at the expense of overshoot amplitude. The ESR (effective series resistance) of this capacitor has no effect on regulator stability, but low-ESR capacitors improve high frequency transient response. The value of this capacitor may be increased without limit, but values larger than 10 μF tend to increase the settling time after a step change in input voltage or output current.

The MIC5231 has no minimum load current; it will remain stable and in regulation with no load (other than the internal voltage divider). This is especially important in real-time clock and CMOS RAM keep-alive applications.

4.3 Minimum Load Current

The MIC5231 does not require a minimum load for proper operation. This allows the device to operate in applications where very light output currents are required for keep-alive purposes. This is important for powering SRAM or Flash memory in low-power modes for handheld devices.

4.4 Safe Operating Conditions

The MIC5231 does not incorporate current limit or thermal shutdown in the design. The output pass element is approximately 15 Ω . Therefore, when a short occurs from the output to ground, the current is self-limited. The pass element has a positive temperature coefficient, such that when the device gets hot, the output impedance goes up, limiting the current even further. The maximum junction temperature for the device is 125°C and it is important that this is not exceeded for any length of time.

4.5 Thermal Considerations

The MIC5231 is not intended for sourcing currents that would cause a large power loss in the device, but because it is not current limited, it is possible to source more than the rated 10 mA. At this point, it is important to ensure that the die temperature does not exceed 125°C.

Power dissipation in the regulator is calculated as follows:

EQUATION 4-1:

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

The MIC5231 consumes only 0.65 μA over load and does not need to consider that contribution in the power dissipation equation. Therefore, the equation is simplified.

EQUATION 4-2:

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

The MIC5231, in the SOT-23-5 package, has a thermal resistance (junction-to-ambient) of 235°C/W. Using this number, the power dissipation capability of that package, without exceeding a +125°C junction temperature rating, can easily be calculated.

EQUATION 4-3:

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

$$P_{D(MAX)} = \frac{125^\circ\text{C} - T_A}{235^\circ\text{C/W}}$$

If the device is being operated at +85°C, the maximum power dissipation allowed can easily be determined.

EQUATION 4-4:

$$P_{D(MAX)} = \frac{125^\circ\text{C} - 85^\circ\text{C}}{235^\circ\text{C/W}} = 170\text{mW}$$

Therefore, the device can only dissipate 170 mW maximum. If the MIC5231 is powered off of a 12V source and the output voltage is 3.3V, the maximum output current is calculated below.

EQUATION 4-5:

$$P_{D(MAX)} = (V_{IN} - V_{OUT}) \times I_{OUT}$$

$$170\text{mW} = (12\text{V} - 3.3\text{V}) \times I_{OUT}$$

$$I_{OUT} = \frac{170\text{mW}}{8.7\text{V}} = 19.5\text{mA}$$

Therefore, the device can source almost 20 mA at an ambient of +85°C before the die temperature exceeds +125°C.

5.0 PACKAGING INFORMATION

5.1 Package Marking Information

5-Lead SOT-23* (Front)	Example	5-Lead SOT-23* (Back)	Example
XXXX	LM2H	NNN	LF1

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).

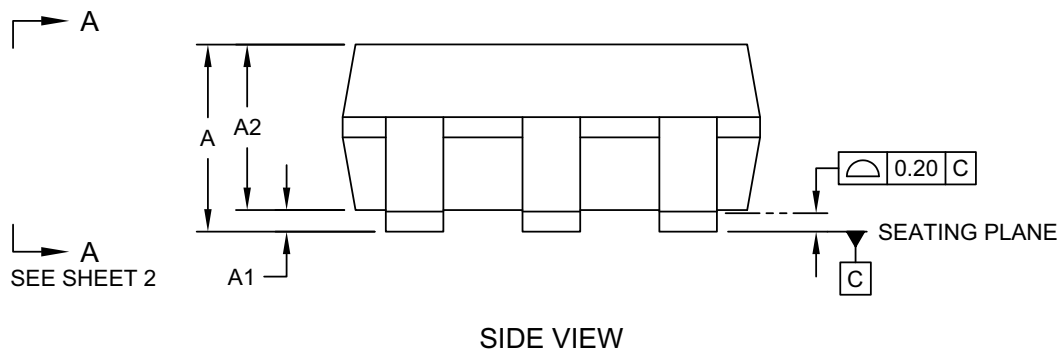
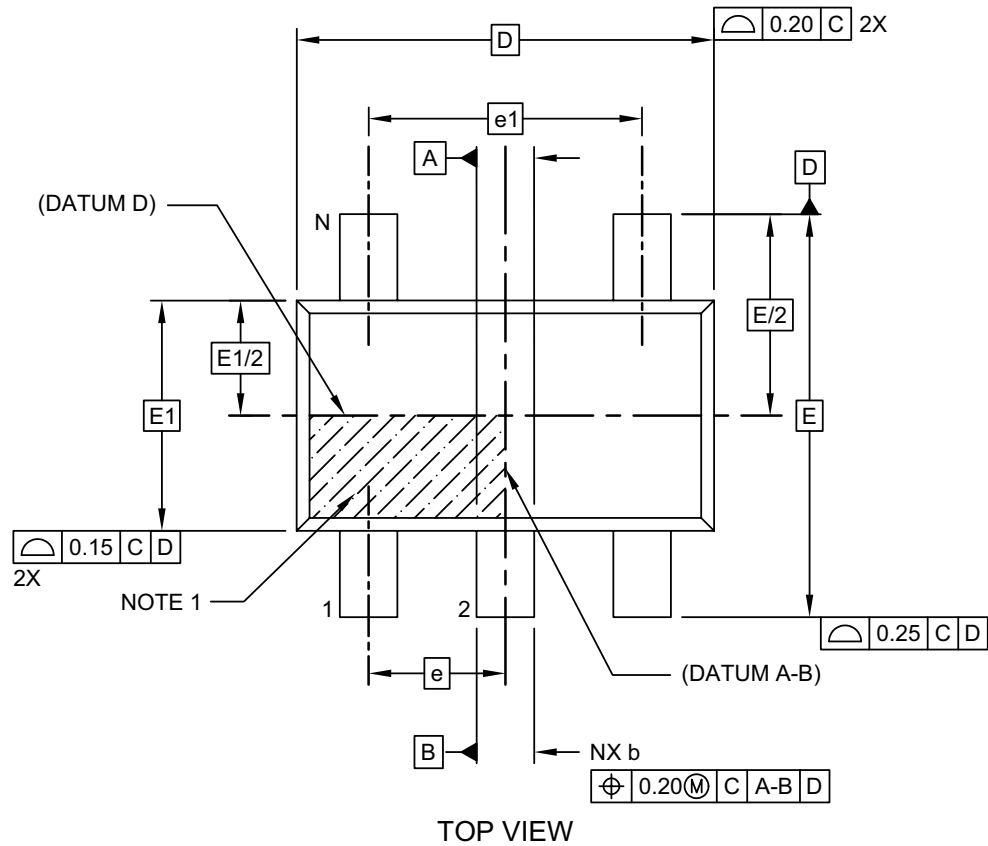
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

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

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

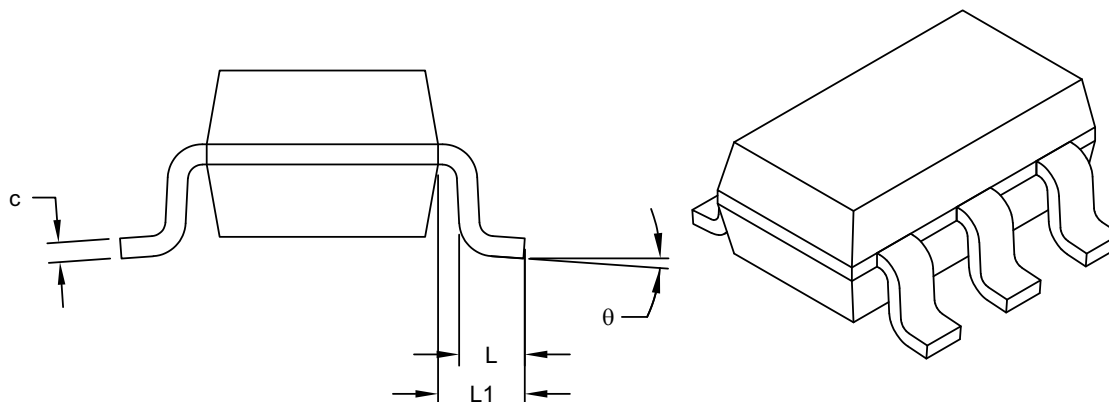
Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



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>



VIEW A-A
SHEET 1

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

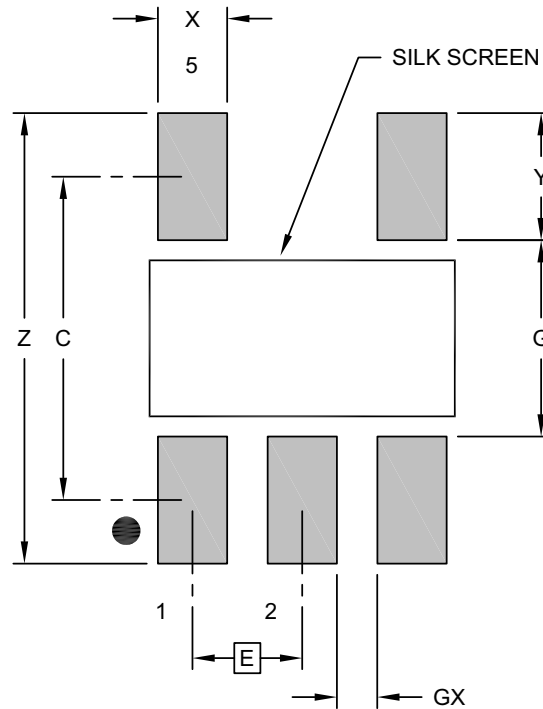
Notes:

- Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.25mm per side.
- 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

Dimension Limits	Units	MILLIMETERS		
		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

MIC5231

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (September 2025)

- Converted Micrel document MIC5231 to Microchip data sheet DS20007026A.
- Minor text changes throughout.

MIC5231

NOTES:

PRODUCT IDENTIFICATION SYSTEM

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

<u>Part Number</u>	<u>-X.XX</u>	<u>X</u>	<u>XX</u>	<u>-XX</u>	Examples:
Device	Voltage	Temperature Range	Package	Media Type	
Device:	MIC5231:	Micropower, μ Cap LDO Regulator			a) MIC5231-2.75YM5-TR: MIC5231, 2.75V Voltage, -40°C to $+125^{\circ}\text{C}$ Temp. Range, 5-Lead SOT-23, 3,000/Reel
Voltage:	2.75	=	2.75V		b) MIC5231-3.0YM5-TR: MIC5231, 3.0V Voltage, -40°C to $+125^{\circ}\text{C}$ Temp. Range, 5-Lead SOT-23, 3,000/Reel
	3.0	=	3.0V		
	3.3	=	3.3V		c) MIC5231-3.3YM5-TR: MIC5231, 3.3V Voltage, -40°C to $+125^{\circ}\text{C}$ Temp. Range, 5-Lead SOT-23, 3,000/Reel
	5.0	=	5.0V		d) MIC5231-5.0YM5-TR: MIC5231, 5.0V Voltage, -40°C to $+125^{\circ}\text{C}$ Temp. Range, 5-Lead SOT-23, 3,000/Reel
Temperature Range:	Y	=	-40°C to $+125^{\circ}\text{C}$		Note: 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.
Package:	M5	=	5-Lead SOT-23		
Media Type:	TR	=	3,000/Reel		

MARKING CODES

Part Number	Marking	Voltage	Package
MIC5231-2.75YM5	<u>LM</u> 2H	2.75V	5-Lead SOT-23
MIC5231-3.0YM5	<u>LM</u> 30	3.0V	5-Lead SOT-23
MIC5231-3.3YM5	<u>LM</u> 33	3.3V	5-Lead SOT-23
MIC5231-5.0YM5	<u>LM</u> 50	5.0V	5-Lead SOT-23

MIC5231

NOTES:

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ISBN: 979-8-3371-2060-7

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