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## Comparator and Reference with Adjustable Hysteresis

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### Features

- Optimized for Handheld Electronics, Cellular Telephones, and Other Battery-Powered Devices
- Inputs and Output Can Pull-Up to 6V Regardless of Supply Voltage
- Independently Adjustable High- and Low-Voltage Thresholds
- High  $\pm 1.5\%$  Voltage Threshold Accuracy
- Extremely Low 1  $\mu\text{A}$  Typical Supply Current
- Immune to Brief Input Transients
- 5-Lead SOT-23 Package

### Applications

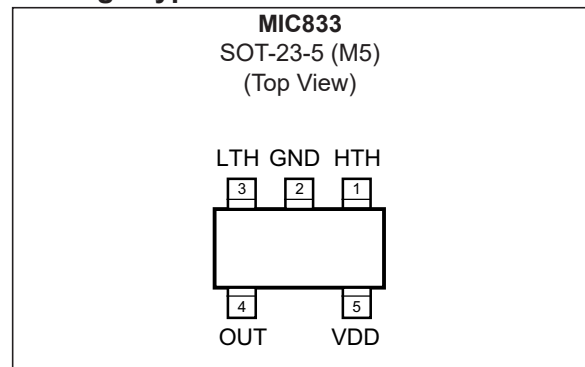
- Handheld Electronics
- Mobile Phones
- Consumer Electronics
- Embedded Controllers
- Personal Electronics

### General Description

The MIC833 is a micropower precision dual-voltage comparator with an on-chip reference and latch. High-voltage and low-voltage thresholds are adjusted independently, allowing for wide hysteresis. Three external resistors determine the threshold voltages. Voltage detection thresholds are accurate to 1.5%. Supply current is extremely low (1  $\mu\text{A}$ , typical), making it ideal for portable applications.

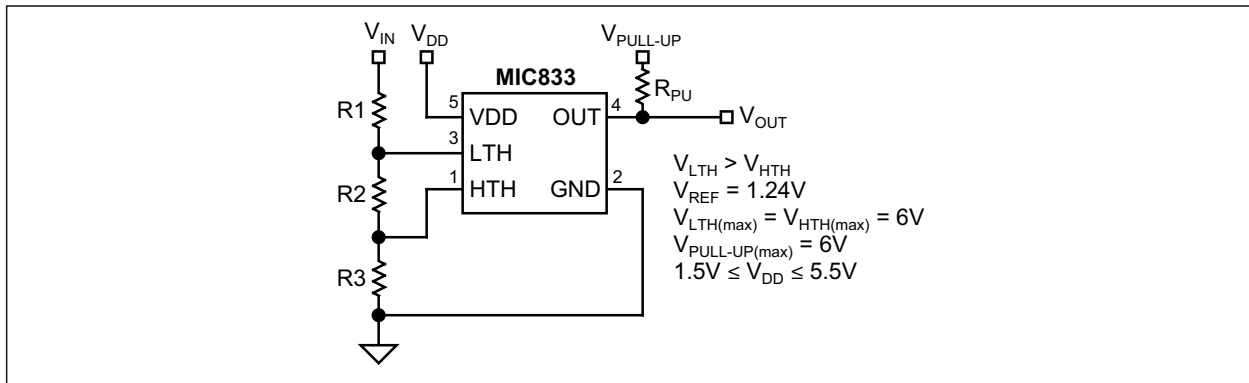
The MIC833 is supplied in a 5-lead SOT-23 package. See the MIC2778 for applications that require an output delay.

### Package Type

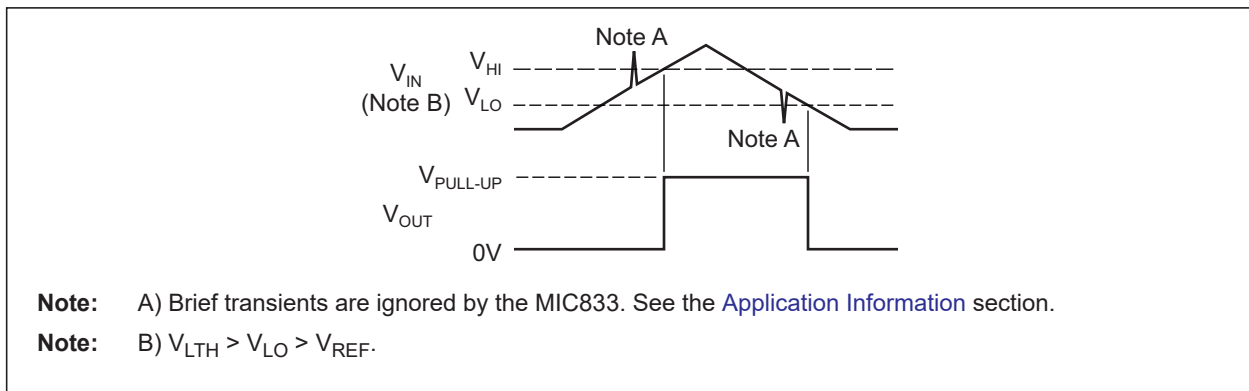


# MIC833

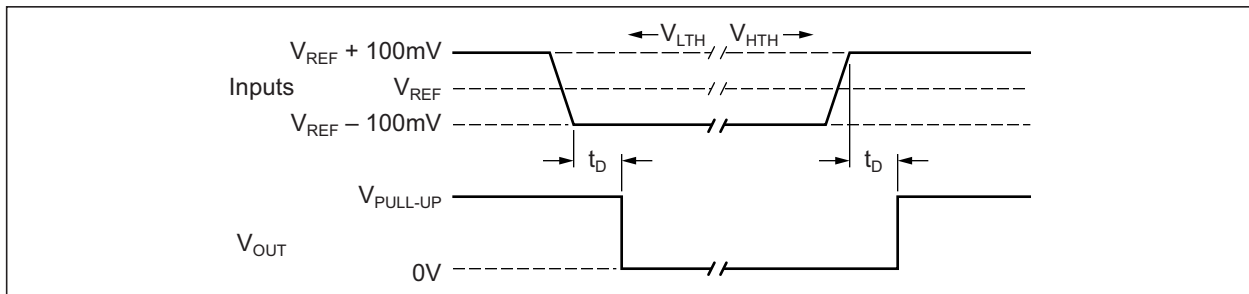
## Typical Application Circuit



## Functional Diagram



## Timing Diagram



## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings †

Supply Voltage ( $V_{DD}$ )	-0.3V to +7V
Input Voltages ( $V_{LTH}$ , $V_{HTH}$ )	+7V
Output Current ( $I_{OUT}$ )	20 mA
Output Voltage ( $V_{OUT}$ )	-0.3V to +7V
ESD Rating (Note 1)	2 kV

### Operating Ratings ††

Supply Voltage ( $V_{DD}$ )	+1.5V to +5.5V
Input Voltage ( $V_{LTH}$ , $V_{HTH}$ )	0V to +6V
Output Voltage ( $V_{OUT}$ )	0V to +6V

† **Notice:** Exceeding the absolute maximum rating may damage the device.

†† **Notice:** The device is not guaranteed to function outside its operating rating.

**Note 1:** Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5 k $\Omega$  in series with 100 pF.

## ELECTRICAL CHARACTERISTICS

Electrical Characteristics: $1.5V \leq V_{DD} \leq 5.5V$ ; $T_A = +25^\circ C$ , unless noted.						
Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Supply Current	$I_{DD}$	—	1	2	$\mu A$	Outputs not asserted, $-40^\circ C \leq T_A \leq +85^\circ C$
Input Leakage Current	$I_{LTH}$ , $I_{HTH}$	—	0.005	10	nA	$-40^\circ C \leq T_A \leq +85^\circ C$
Reference Voltage	$V_{REF}$	1.221	1.240	1.259	V	$-40^\circ C \leq T_A \leq +85^\circ C$
Propagation Delay	$t_D$	—	5	—	$\mu s$	$V_{LTH} = 1.352V$ to $1.128V$
		—	5	—		$V_{HTH} = 1.128V$ to $1.352V$
Output Voltage-Low (Note 1)	$V_{OUT}$	—	—	0.3	V	OUT de-asserted, $I_{SINK} = 1.6$ mA, $V_{DD} \geq 1.6V$ , $-40^\circ C \leq T_A \leq +85^\circ C$
		—	—	0.4		OUT de-asserted, $I_{SINK} = 100$ $\mu A$ , $V_{DD} \geq 1.2V$ , $-40^\circ C \leq T_A \leq +85^\circ C$

**Note 1:**  $V_{DD}$  operating range is 1.5V to 5.5V. Output is guaranteed to be held low down to  $V_{DD} = 1.2V$ .

## TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
<b>Temperature Ranges</b>						
Lead Temperature	—	—	—	+260	$^\circ C$	Soldering, 10s
Storage Temperature Range	$T_S$	-65	—	+150	$^\circ C$	—
Ambient Temperature	$T_A$	-40	—	+85	$^\circ C$	—
<b>Package Thermal Resistances</b>						
Thermal Resistance, SOT-23-5Ld	$\theta_{JA}$	—	260	—	$^\circ C/W$	—

## 2.0 PIN DESCRIPTIONS

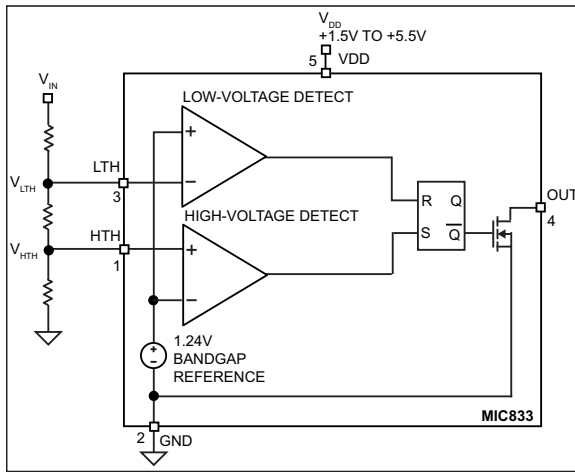
The descriptions of the pins are listed in [Table 2-1](#).

**TABLE 2-1: PIN FUNCTION TABLE**

Pin Number	Symbol	Description
1	HTH	High-Voltage Threshold (Input): Analog input to a comparator. This is the voltage input assigned to detect a high-voltage condition when the level on this pin exceeds $V_{REF}$ . OUT is asserted and the condition is latched until $V_{LTH} < V_{REF}$ .
2	GND	Ground
3	LTH	Low-Voltage Threshold (Input): Analog input to a comparator. This is the voltage input assigned to detect a low voltage condition. When the level on this pin falls below $V_{REF}$ , OUT is de-asserted and the condition is latched until $V_{HTH} > V_{REF}$ .
4	OUT	Output: Active-high, open-drain output. This output is de-asserted and latched when $V_{LTH} < V_{REF}$ , indicating a low voltage condition. This state remains latched until $V_{HTH} > V_{REF}$ .
5	VDD	Power Supply (Input): Independent supply input for internal circuitry.

## 3.0 FUNCTIONAL DESCRIPTION

The MIC833 monitors a voltage and detects when it is below or above two independently programmed levels.



**FIGURE 3-1:** MIC833 Block Diagram.

### 3.1 Voltage Low Output

The output (OUT) is an active-high, open-drain output that sinks current when the MIC833 detects a low input voltage at its LTH input. This condition is latched until the HTH input is presented with a voltage higher than the internal  $V_{REF}$  (+1.24V).

### 3.2 Trip Points

Input voltage is monitored by the comparators via a voltage divider network. The divided voltage is compared to an internal reference voltage. When the voltage at the LTH input pin drops below the internal reference voltage, the output pulls low. Because of the voltage divider, the voltage at HTH is assured to be below the reference voltage.

# MIC833

## 4.0 APPLICATION INFORMATION

### 4.1 Output

Because the MIC833 output is an open-drain MOSFET, most applications will require a pull-up resistor. The value of the resistor should not be too large or leakage effects may dominate. 470 kΩ is the maximum recommended value. Note that the output may be pulled up as high as 6V regardless of IC supply voltage. See the [Electrical Characteristics](#) section for details.

### 4.2 Programming the Thresholds

The low-voltage threshold is calculated by [Equation 4-1](#).

#### EQUATION 4-1:

$$V_{IN(LO)} = V_{REF} \left[ \frac{R1 + R2 + R3}{R2 + R3} \right]$$

Where:

$$V_{REF} = 1.240V$$

The high-voltage threshold is calculated by [Equation 4-2](#).

#### EQUATION 4-2:

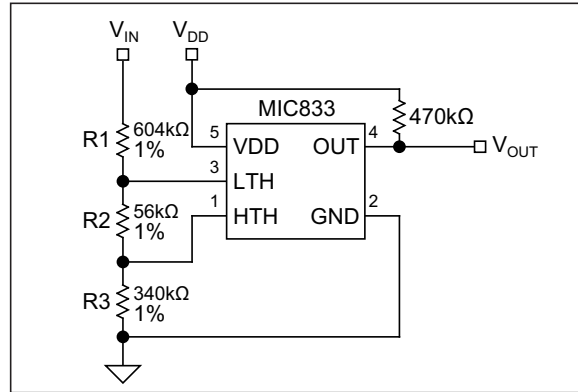
$$V_{IN(HI)} = V_{REF} \left[ \frac{R1 + R2 + R3}{R3} \right]$$

Where:

$$V_{REF} = 1.240V$$

In order to provide the additional criteria needed to solve for the resistor values, the resistors can be selected such that they have a given total value of  $R1 + R2 + R3 = R_{TOTAL}$ . A value such as 1 MΩ for  $R_{TOTAL}$  is a reasonable value because it draws minimum current but has no significant effect on accuracy.

When working with large resistors, a small amount of leakage current can cause voltage offsets that degrade system accuracy. The maximum recommended total resistance from  $V_{IN}$  to ground is 3 MΩ.



**FIGURE 4-1:** Example Circuit.

Once the desired trip points are determined, set the  $V_{IN(HI)}$  threshold first.

For example, use a total of  $1\text{ M}\Omega = R1 + R2 + R3$ . For a typical single-cell lithium ion battery, 3.6V is a good high threshold because at 3.6V the battery is moderately charged. Solving for R3:

#### EQUATION 4-3:

$$V_{IN(HI)} = 3.6V = 1.24V \left( \frac{1\text{M}\Omega}{R3} \right)$$

Where:

$$R3 = 344\text{ k}\Omega$$

Once R3 is determined, the equation for  $V_{IN(LO)}$  can be used to determine R2. A single lithium-ion cell, for example, should not be discharged below 2.5V. Many applications limit the drain to 3.1V. Using 3.1V for the  $V_{IN(LO)}$  threshold allows calculation of the two remaining resistor values.

#### EQUATION 4-4:

$$V_{IN(LO)} = 3.1V = 1.24V \left( \frac{1\text{M}\Omega}{R2 + 344\text{k}\Omega} \right)$$

Where:

$$R2 = 56\text{ k}\Omega$$

$$1\text{ M}\Omega - (R2 - R3) = R1$$

$$R1 = 600\text{ k}\Omega$$

The accuracy of the resistors can be chosen based upon the accuracy required by the system.

The inputs may be subjected to voltages as high as 6V steady state without adverse effects of any kind, regardless of the IC supply voltage. This applies even if the supply voltage is zero. This permits the situation in which the IC supply is turned off, but voltage is still present on the inputs. See [Electrical Characteristics](#).

## 4.3 Input Transients

The MIC833 is inherently immune to very short negative going glitches. Very brief transients may exceed the  $V_{IN(LO)}$  threshold without tripping the output.

As shown in Figure 4-2, the narrower the transient, the deeper the threshold overdrive that will be ignored by the MIC833. The graph represents the typical allowable transient duration for a given amount of threshold overdrive that will not toggle the output.

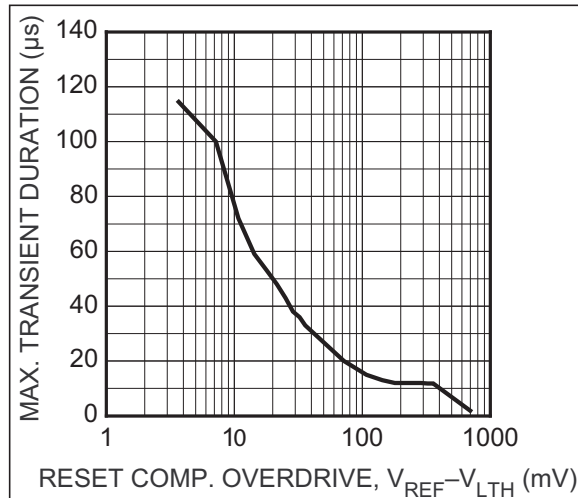


FIGURE 4-2: Input Transient Response.

## 4.4 Initialization Behavior

When the MIC833 is powered up, the comparators and latch become active before the reference voltage reaches its final value. In most applications, this presents no problems. However, the user should be aware of applying power to the part; if the input voltage

is between the two thresholds, the output of the part will be high because input HTH will have been higher than the 1.24V reference during initialization.

It is not very likely the part would be powered up in this state. It is more likely the same power supply will power the part and develop its inputs. However, if the above-described condition should occur, the next HTH threshold crossing would not be processed because the latch would have been already set. The next valid input condition would have to be a crossing of the LTH threshold, which resets the latch, after which “normal” operation is restored.

## 4.5 Example Application

The battery charger of Figure 4-3 uses the MIC833 to detect a low-battery voltage condition ( $V_{DIS}$ ) and enables a constant-current source ( $I_{CHG}$ ). Charging current is enabled until a charged-battery voltage condition ( $V_{CHG}$ ) is detected; at which time the charging-current source is disabled.

Diode D1 was added to Figure 4-3 to ensure the disabled current source does not draw battery current. Whether or not D1 is required is a function of the output stage of the current source and how it is disabled.

The circuitry of Figure 4-3 is deliberately generalized to imply flexibility of application. Depending on the application, it may not be possible to power the MIC833 from the charger supply voltage, see Note 2 in Figure 4-3. It may be necessary to provide a separate voltage regulator, or a resistive voltage divider to reduce the  $V_{DD}$  applied to the MIC833. The part can be supplied by the battery voltage ( $V_{BAT}$ ) if this voltage is never lower than 1.5V, the minimum operating  $V_{DD}$  of the part.

Voltage thresholds,  $V_{DIS}$  and  $V_{CHG}$ , are programmed as described in the appropriate above paragraph.

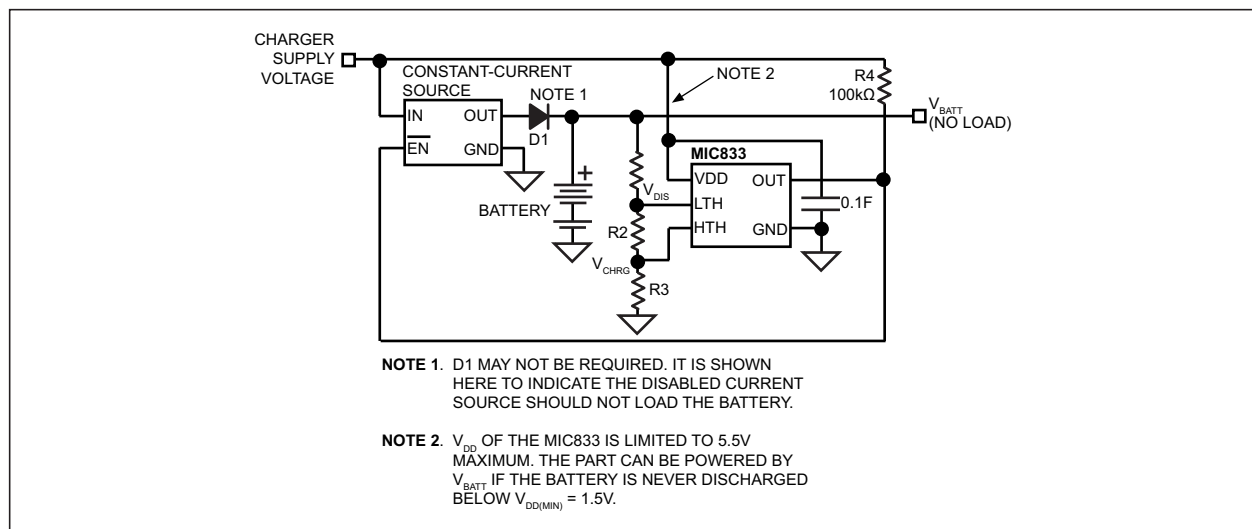


FIGURE 4-3: Battery Charger.

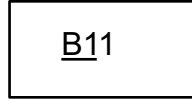
## 5.0 PACKAGING INFORMATION

### 5.1 Package Marking Information

5-Lead SOT-23\*  
(Front)



Example



5-Lead SOT-23\*  
(Back)



Example



<b>Legend:</b>	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).
<b>Note:</b>	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.	

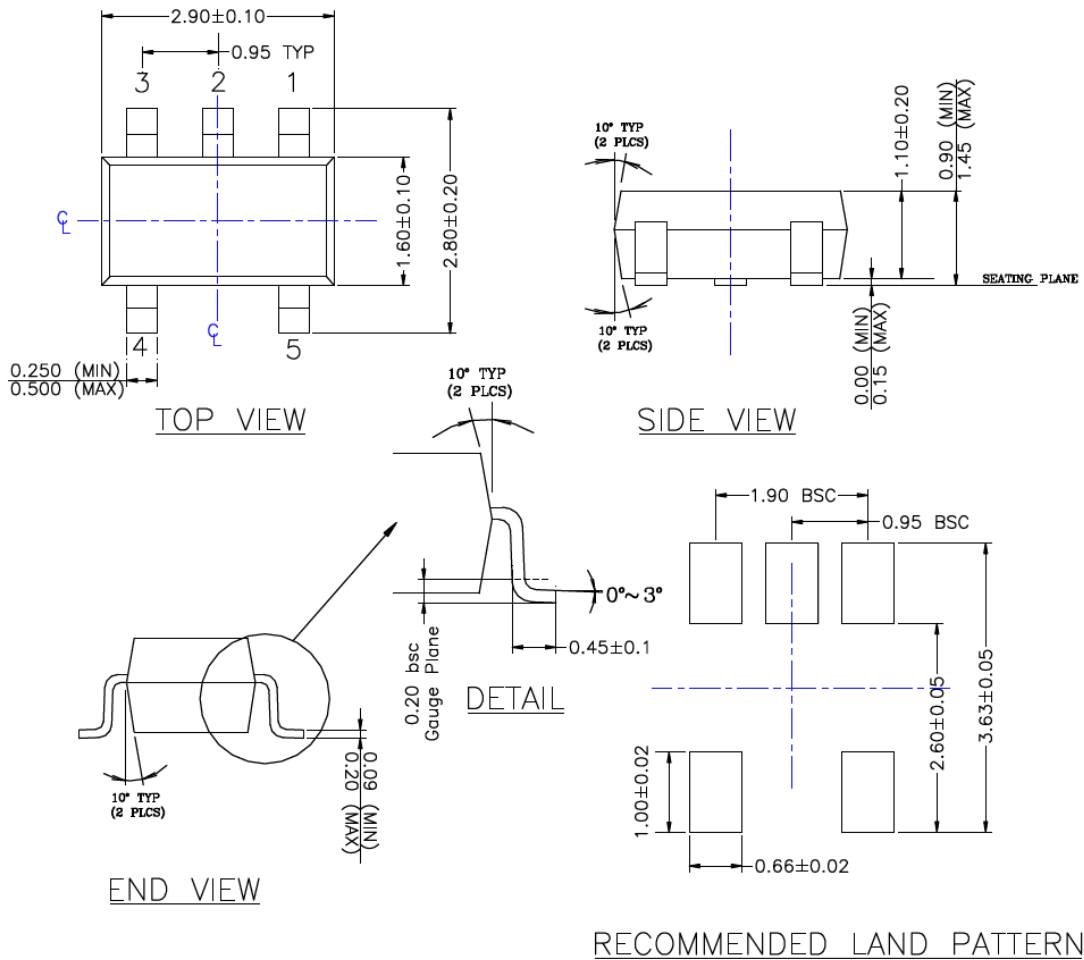


## 5-Lead SOT-23 Package Outline & Recommended Land Pattern

**TITLE**

5 LEAD SOT23 PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

<b>DRAWING #</b>	SOT23-5LD-PL-1	<b>UNIT</b>	MM
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**NOTE:**

1. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & BURR.
2. PACKAGE OUTLINE INCLUSIVE OF SOLER PLATING.
3. DIMENSION AND TOLERANCE PER ANSI Y14.5M, 1982.
4. FOOT LENGTH MEASUREMENT BASED ON GAUGE PLANE METHOD.
5. DIE FACES UP FOR MOLD, AND FACES DOWN FOR TRIM/FORM.
6. ALL DIMENSIONS ARE IN MILLIMETERS.

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

# MIC833

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NOTES:

## APPENDIX A: REVISION HISTORY

### Revision A (April 2020)

- Converted Micrel document MIC833 to Microchip data sheet template DS20006336A.
- Minor grammatical text changes throughout.

# MIC833

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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 NO.</u>		<u>X</u>	<u>XX</u>	<u>-XX</u>
Device		Temperature Range	Package	Media Type
<b>Device:</b>	MIC833:	Comparator and Reference with Adjustable Hysteresis		
<b>Temperature Range:</b>	Y	=	-40°C to +85°C (RoHS Compliant)	
<b>Packages:</b>	M5	=	5-Lead SOT-23	
<b>Media Type:</b>	TR	=	3,000/Reel	

**Examples:**

a) MIC833YM5-TR: Comparator and Reference with Adjustable Hysteresis, -40°C to +85°C (RoHS Compliant), 5LD 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.

# MIC833

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NOTES:

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