MIC833

Comparator and Reference with Adjustable Hysteresis

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 ±1.5% Voltage Threshold Accuracy
- Extremely Low 1 µA Typical Supply Current
- Immune to Brief Input Transients
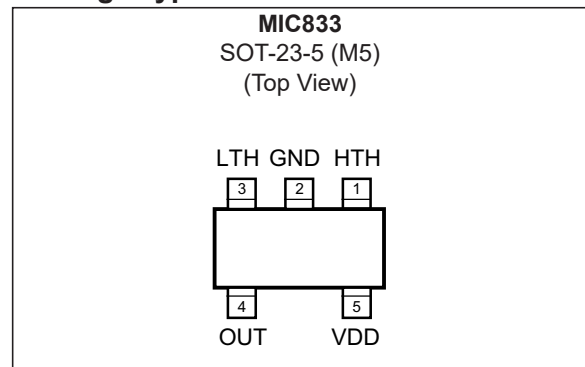- 5-Lead SOT-23 Package

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 µA, typical), making it ideal for portable applications.
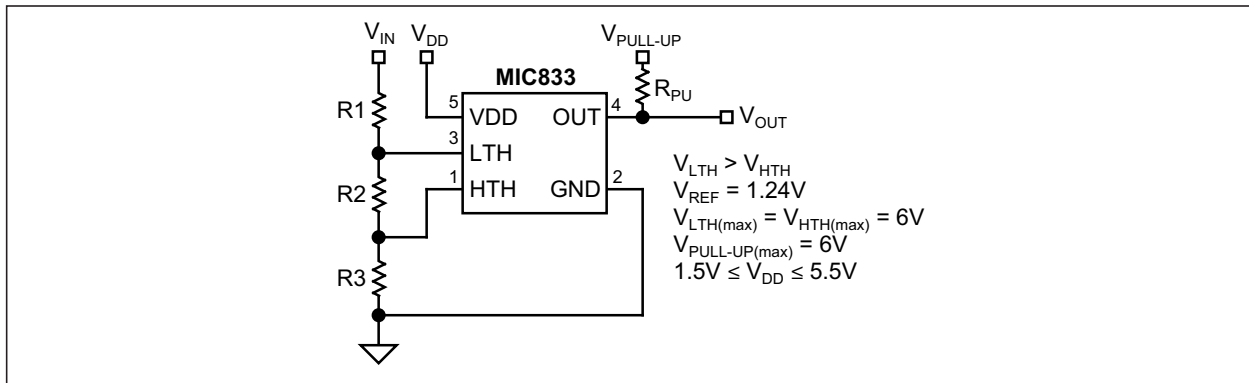
The MIC833 is supplied in a 5-lead SOT-23 package. See the MIC2778 for applications that require an output delay.
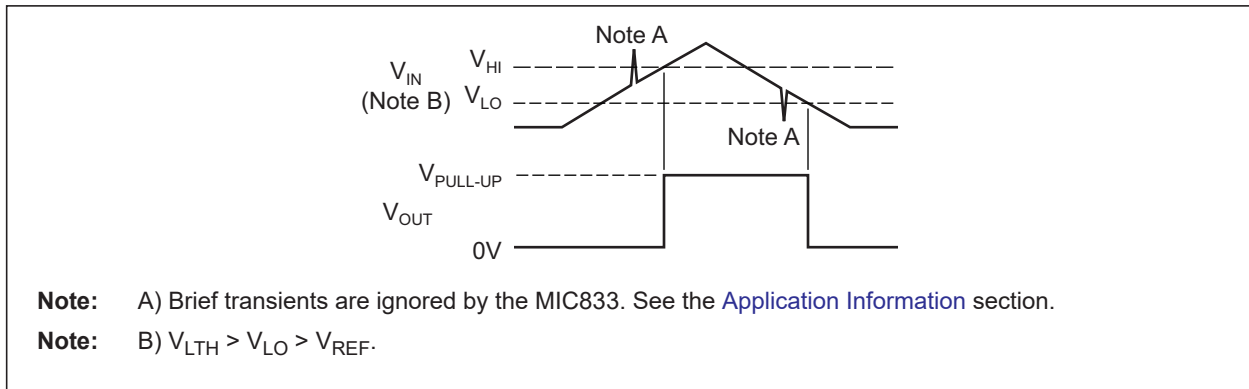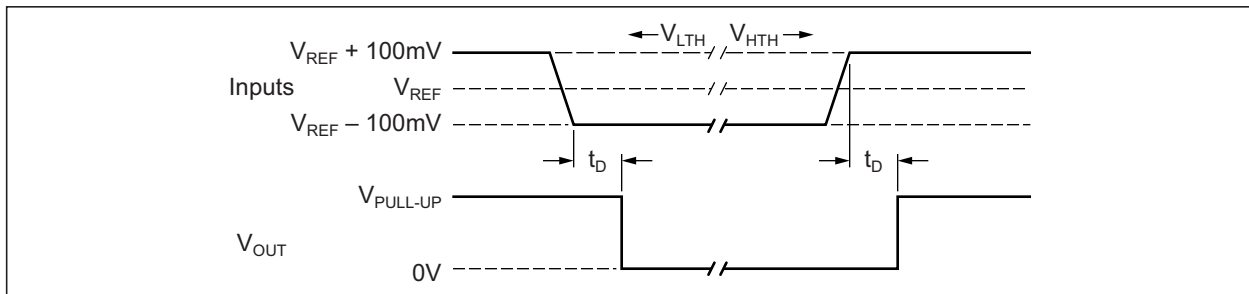
Package Type

MIC833
SOT-23-5 (M5)
(Top View)

LTH GND HTH

| 3 | 2 | 1 |

| 4 | | 5 |

OUT   VDD

MIC833

Typical Application Circuit

$V_{LTH} > V_{HTH}$
$V_{REF} = 1.24V$
$V_{LTH(max)} = V_{HTH(max)} = 6V$
$V_{PULL-UP(max)} = 6V$
$1.5V \leq V_{DD} \leq 5.5V$

Functional Diagram

Note: A) Brief transients are ignored by the MIC833. See the Application Information section.

Note: B) $V_{LTH} > V_{LO} > V_{REF}$.

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 kΩ in series with 100 pF.

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: 1.5V ≤ V_{DD} ≤ 5.5V; T_A = +25°C, unless noted.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Supply Current	I_{DD}	—	1	2	µA	Outputs not asserted, –40°C ≤ T_A ≤ +85°C
Input Leakage Current	I_{LTH}, I_{HTH}	—	0.005	10	nA	–40°C ≤ T_A ≤ +85°C
Reference Voltage	V_{REF}	1.221	1.240	1.259	V	–40°C ≤ T_A ≤ +85°C
Propagation Delay	t_D	—	5	—	µs	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} ≥ 1.6V, –40°C ≤ T_A ≤ +85°C
		—	—	0.4		OUT de-asserted, I_{SINK} = 100 µA, V_{DD} ≥ 1.2V, –40°C ≤ T_A ≤ +85°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
Temperature Ranges						
Lead Temperature	—	—	—	+260	°C	Soldering, 10s
Storage Temperature Range	T_S	–65	—	+150	°C	—
Ambient Temperature	T_A	–40	—	+85	°C	—
Package Thermal Resistances						
Thermal Resistance, SOT-23-5Ld	θ_{JA}	—	260	—	°C/W	—

MIC833

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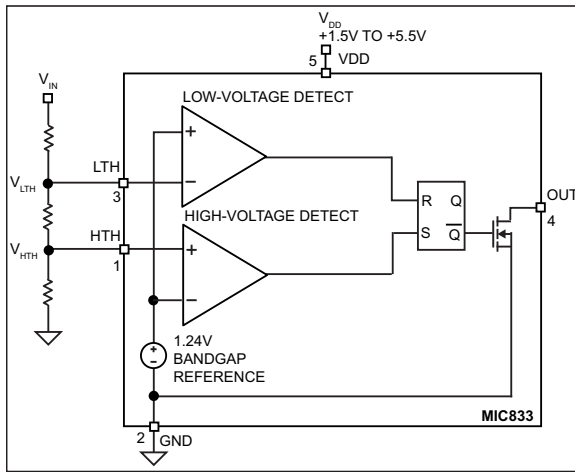
FIGURE 3-1: *MIC833 Block Diagram.*

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.
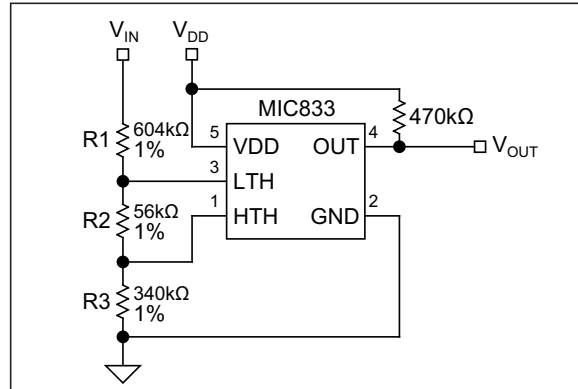
FIGURE 4-1: *Example Circuit.*

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

For example, use a total of 1 MΩ = 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:

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

Where:
R3 = 344 kΩ

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:

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

Where:
R2	=	56 kΩ
1 MΩ–(R2–R3)	=	R1
R1	=	600 kΩ

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.
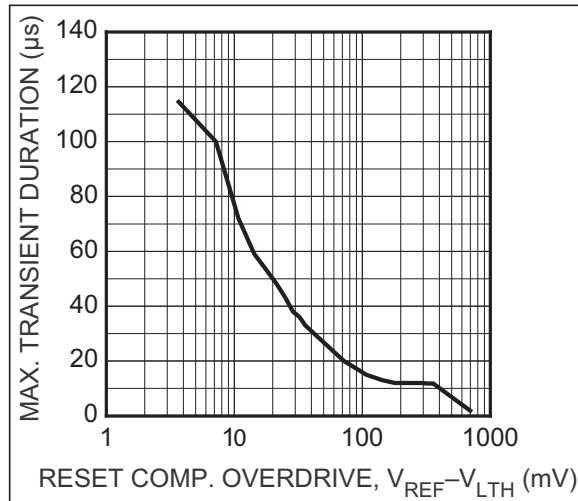

FIGURE 4-2: *Input Transient Response.*

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 possibly 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.

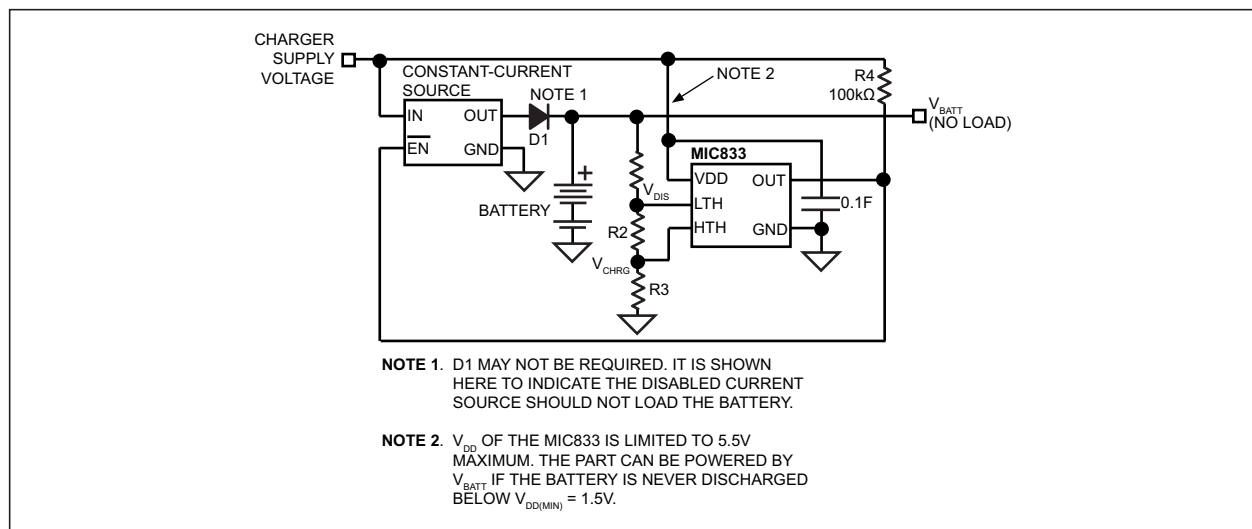Voltage thresholds, V_{DIS} and V_{CHG}, are programmed as described in the appropriate above paragraph.
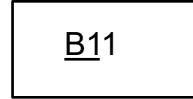

NOTE 1. D1 MAY NOT BE REQUIRED. IT IS SHOWN HERE TO INDICATE THE DISABLED CURRENT SOURCE SHOULD NOT LOAD THE BATTERY.

NOTE 2. V_{DD} OF THE MIC833 IS LIMITED TO 5.5V MAXIMUM. THE PART CAN BE POWERED BY V_{BATT} IF THE BATTERY IS NEVER DISCHARGED BELOW $V_{DD(MIN)}$ = 1.5V.

FIGURE 4-3: *Battery Charger.*

MIC833

5.0 PACKAGING INFORMATION

5.1 Package Marking Information

5-Lead SOT-23* (Front)	Example
XXX	B11
5-Lead SOT-23* (Back)	Example
NNN	460

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.

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

TITLE
5 LEAD SOT23 PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	SOT23-5LD-PL-1	**UNIT**	MM

2.90±0.10
0.95 TYP
3   2   1
1.60±0.10
2.80±0.20
0.250 (MIN)
0.500 (MAX)
TOP VIEW

10° TYP (2 PLCS)
1.10±0.20
0.90 (MIN)
1.45 (MAX)
SEATING PLANE
0.00 (MIN)
0.15 (MAX)
10° TYP (2 PLCS)
SIDE VIEW

10° TYP (2 PLCS)
0.20 bsc Gauge Plane
0°~ 3°
0.45±0.1
DETAIL

10° TYP (2 PLCS)
0.09 (MIN)
0.20 (MAX)
END VIEW

1.90 BSC
0.95 BSC
3.63±0.05
2.60±0.05
1.00±0.02
0.66±0.02
RECOMMENDED LAND PATTERN
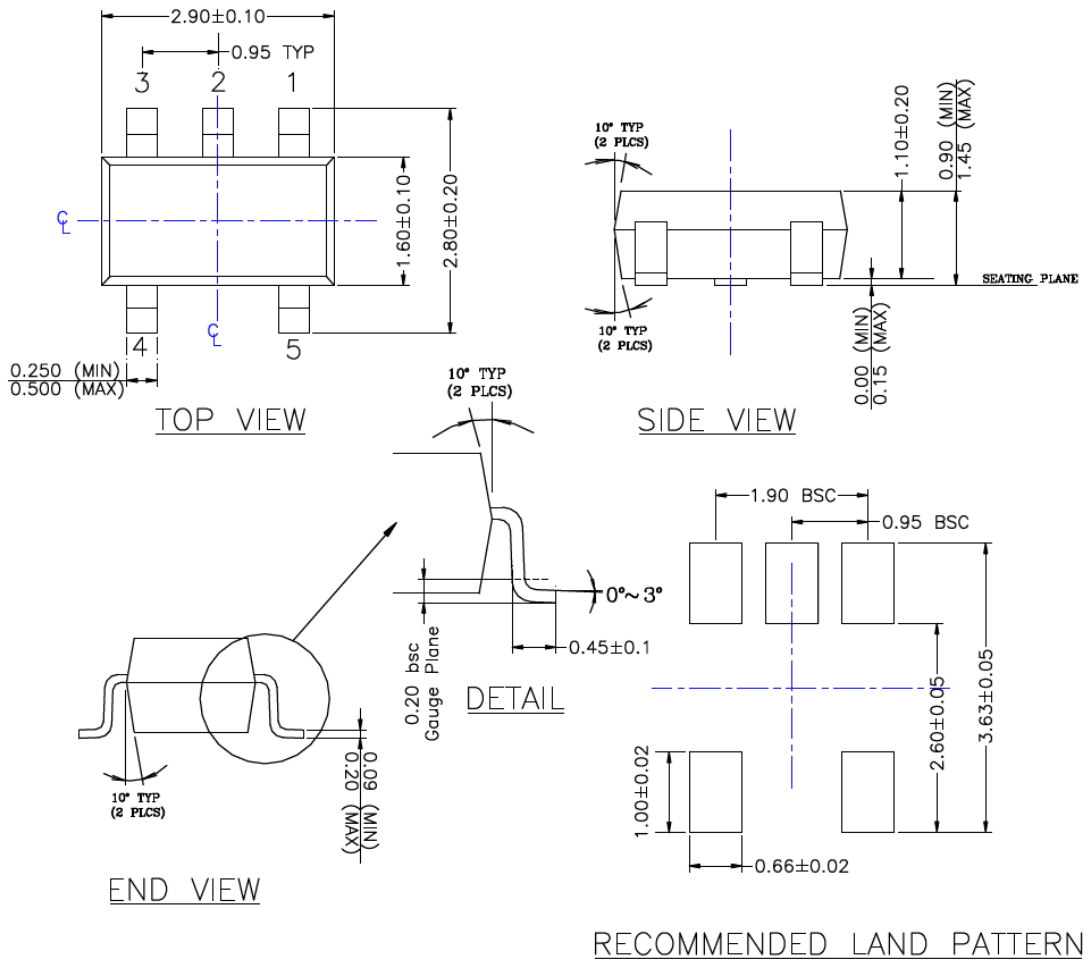
NOTE:
1. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & BURR.
2. PACKAGE OUTLINE INCLUSIVE OF SOLER PLATING.
3. DIMENSION AND TOLERANCE PER ANSI Y14.5M, 1982.
4. FOOT LENGTH MEASUREMENT BASED ON GAUGE PLANE METHOD.
5. DIE FACES UP FOR MOLD, AND FACES DOWN FOR TRIM/FORM.
6. ALL DIMENSIONS ARE IN MILLIMETERS.

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

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (April 2020)

- Converted Micrel document MIC833 to Microchip data sheet template DS20006336A.
- Minor grammatical 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	XX	-XX
Device	Temperature Range	Package	Media Type

Device:	MIC833:		Comparator and Reference with Adjustable Hysteresis
Temperature Range:	Y	=	–40°C to +85°C (RoHS Compliant)
Packages:	M5	=	5-Lead SOT-23
Media Type:	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.

NOTES:

Note the following details of the code protection feature on Microchip devices:

• Microchip products meet the specification contained in their particular Microchip Data Sheet.

• Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.

• There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.

• Microchip is willing to work with the customer who is concerned about the integrity of their code.

• Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Trademarks

Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://www.microchip.com/
support
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Austin, TX
Tel: 512-257-3370

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Novi, MI
Tel: 248-848-4000

Houston, TX
Tel: 281-894-5983

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453
Tel: 317-536-2380

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608
Tel: 951-273-7800

Raleigh, NC
Tel: 919-844-7510

New York, NY
Tel: 631-435-6000

San Jose, CA
Tel: 408-735-9110
Tel: 408-436-4270

Canada - Toronto
Tel: 905-695-1980
Fax: 905-695-2078

ASIA/PACIFIC

Australia - Sydney
Tel: 61-2-9868-6733

China - Beijing
Tel: 86-10-8569-7000

China - Chengdu
Tel: 86-28-8665-5511

China - Chongqing
Tel: 86-23-8980-9588

China - Dongguan
Tel: 86-769-8702-9880

China - Guangzhou
Tel: 86-20-8755-8029

China - Hangzhou
Tel: 86-571-8792-8115

China - Hong Kong SAR
Tel: 852-2943-5100

China - Nanjing
Tel: 86-25-8473-2460

China - Qingdao
Tel: 86-532-8502-7355

China - Shanghai
Tel: 86-21-3326-8000

China - Shenyang
Tel: 86-24-2334-2829

China - Shenzhen
Tel: 86-755-8864-2200

China - Suzhou
Tel: 86-186-6233-1526

China - Wuhan
Tel: 86-27-5980-5300

China - Xian
Tel: 86-29-8833-7252

China - Xiamen
Tel: 86-592-2388138

China - Zhuhai
Tel: 86-756-3210040

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-3090-4444

India - New Delhi
Tel: 91-11-4160-8631

India - Pune
Tel: 91-20-4121-0141

Japan - Osaka
Tel: 81-6-6152-7160

Japan - Tokyo
Tel: 81-3-6880- 3770

Korea - Daegu
Tel: 82-53-744-4301

Korea - Seoul
Tel: 82-2-554-7200

Malaysia - Kuala Lumpur
Tel: 60-3-7651-7906

Malaysia - Penang
Tel: 60-4-227-8870

Philippines - Manila
Tel: 63-2-634-9065

Singapore
Tel: 65-6334-8870

Taiwan - Hsin Chu
Tel: 886-3-577-8366

Taiwan - Kaohsiung
Tel: 886-7-213-7830

Taiwan - Taipei
Tel: 886-2-2508-8600

Thailand - Bangkok
Tel: 66-2-694-1351

Vietnam - Ho Chi Minh
Tel: 84-28-5448-2100

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4485-5910
Fax: 45-4485-2829

Finland - Espoo
Tel: 358-9-4520-820

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Garching
Tel: 49-8931-9700

Germany - Haan
Tel: 49-2129-3766400

Germany - Heilbronn
Tel: 49-7131-72400

Germany - Karlsruhe
Tel: 49-721-625370

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Germany - Rosenheim
Tel: 49-8031-354-560

Israel - Ra'anana
Tel: 972-9-744-7705

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Italy - Padova
Tel: 39-049-7625286

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Norway - Trondheim
Tel: 47-7288-4388

Poland - Warsaw
Tel: 48-22-3325737

Romania - Bucharest
Tel: 40-21-407-87-50

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

Sweden - Gothenberg
Tel: 46-31-704-60-40

Sweden - Stockholm
Tel: 46-8-5090-4654

UK - Wokingham
Tel: 44-118-921-5800
Fax: 44-118-921-5820