LM8365 Micropower Undervoltage-Sensing Circuit With Programmable Output Delay

1 Features

- Extremely-Low Quiescent Current: 0.62 µA at V_{IN} = 2.6 V
- High Accuracy Threshold Voltage (±2.5%)
- Open-Drain Output
- Programmable Output Delay by External Capacitor (130 ms Typical With 0.1 µF)
- Input Voltage Range: 1 V to 6 V
- Pin-for-Pin Compatible With MC33465

2 Applications

- Portable Electronics
- Low-Battery Detection
- Microprocessor Reset Controllers
- Power Fail Indicators
- Battery Backup Detection

3 Description

The LM8365 device is a micropower undervoltage sensing circuit that is ideal for use in battery-powered microprocessor based systems, where extended battery life is a key requirement.

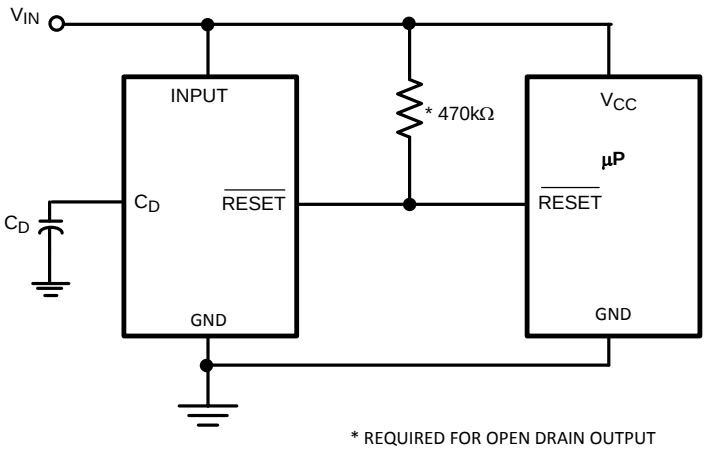
Threshold voltages of 2.7 V and 4.5 V are available with an active-low, open-drain output. These devices feature a very-low quiescent current of 0.65 µA typical. The LM8365 features a highly accurate voltage reference, a comparator with precise thresholds and built-in hysteresis to prevent erratic reset operation, a time delayed output which can be programmed by the system designer, and specified Reset operation down to 1 V with extremely-low standby current.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM8365	SOT-23 (5)	2.90 mm × 1.60 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Microprocessor $\overline{\text{Reset}}$ Circuit



An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

Table of Contents

1 Features ... 1
2 Applications ... 1
3 Description ... 1
4 Revision History ... 2
5 Pin Configuration and Functions ... 3
6 Specifications ... 4
6.1 Absolute Maximum Ratings ... 4
6.2 ESD Ratings ... 4
6.3 Recommended Operating Conditions ... 4
6.4 Thermal Information ... 4
6.5 Electrical Characteristics ... 5
6.6 Typical Characteristics ... 7
7 Detailed Description ... 9
7.1 Overview ... 9
7.2 Functional Block Diagram ... 9
7.3 Feature Description ... 9
7.4 Device Functional Modes ... 10
8 Application and Implementation ... 11
8.1 Application Information ... 11
8.2 Typical Application ... 11
8.3 System Examples ... 12
9 Power Supply Recommendations ... 14
10 Layout ... 14
10.1 Layout Guidelines ... 14
10.2 Layout Example ... 14
11 Device and Documentation Support ... 15
11.1 Device Support ... 15
11.2 Documentation Support ... 15
11.3 Community Resources ... 15
11.4 Trademarks ... 15
11.5 Electrostatic Discharge Caution ... 15
11.6 Glossary ... 15
12 Mechanical, Packaging, and Orderable Information ... 16

4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision B (April 2013) to Revision C — **Page**

- Added, updated, or revised the following sections in accordance with new datasheet standards: *Description*, *Pin Configuration and Functions*, *Specifications*, , *Detailed Description*, *Application and Implementation*, *Power Supply Recommendations*, *Layout*, *Device and Documentation Support*, *Mechanical, Packaging, and Ordering Information*. ... 1
- Removed all references of the 22 Suffix and 30 Suffix from the *Electrical Characteristics* table ... 5
- Removed all references of the LM8365BCLMF30 in the *Typical Characteristics* section ... 7

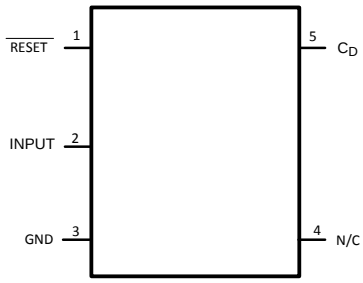
Changes from Revision A (April 2013) to Revision B — **Page**

- Changed layout of National Data Sheet to TI format ... 11

Copyright © 2003–2015, Texas Instruments Incorporated

5 Pin Configuration and Functions

DBV Package
5-Pin SOT-23
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
C_D	5	O	Delay Capacitor Pin
GND	3	—	Ground
INPUT	2	I	Input Supply
N/C	4	—	No Connection
$\overline{\text{RESET}}$	1	O	Active Low Reset Output

Copyright © 2003–2015, Texas Instruments Incorporated

6 Specifications

6.1 Absolute Maximum Ratings

See (1)(2).

		MIN	MAX	UNIT
Supply voltage		−0.3	6.5	V
$\overline{\text{RESET}}$ output voltage		−0.3	6.5	V
$\overline{\text{RESET}}$ output current		70		mA
Mounting temperature	Lead temp. (soldering 10 sec)		260	°C
	Junction temperature		125	°C
Storage temperature, T_{stg}		−65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101 (2)	±200	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process. Manufacturing with less than 500-V HBM is possible with the necessary precautions. Pins listed as ±2000 V may actually have higher performance.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process. Manufacturing with less than 250-V CDM is possible with the necessary precautions. Pins listed as ±200 V may actually have higher performance.

6.3 Recommended Operating Conditions (1)

	MIN	MAX	UNIT
Temperature	−40	85	°C

(1) *Absolute Maximum Ratings* indicate limits beyond which damage to the device may occur. *Recommended Operating Conditions* indicate conditions for which the device is intended to be functional, but specific performance is not ensured. For ensured specifications and the test conditions, see the *Electrical Characteristics*.

6.4 Thermal Information

THERMAL METRIC (1)		LM8365 DBV (SOT-23) 5 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	191.1	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	144.6	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	35.9	°C/W
ψ_{JT}	Junction-to-top characterization parameter	31.1	°C/W
ψ_{JB}	Junction-to-board characterization parameter	35.3	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.

Copyright © 2003–2015, Texas Instruments Incorporated

6.5 Electrical Characteristics

Unless otherwise specified, all limits specified for T_A = 25°C.

PARAMETER		TEST CONDITIONS		MIN(1)	TYP(2)	MAX(1)	UNIT
V_{DET-}	Detector threshold voltage	High-to-low state output (V_{IN} decreasing)	27 suffix	2.633	2.7	2.767	V
			45 suffix	4.388	4.5	4.613	
V_{HYS}	Detector threshold hysteresis	V_{IN} increasing	27 suffix	0.081	0.135	0.189	V
			45 suffix	0.135	0.225	0.315	
ΔVdet/ΔT	Detector threshold voltage temperature coefficient				±100		PPM/°C
V_{OL}	$\overline{\text{RESET}}$ output voltage	Open-drain I_{SINK} = 1 mA			0.25	0.5	V
I_{OL}	$\overline{\text{RESET}}$ output sink current	V_{IN} = 1.5 V, V_{OL} = 0.5 V		1	2.5		mA
I_{OH}	$\overline{\text{RESET}}$ output source current	V_{IN} = 4.5 V, V_{OL} = 2.4 V		1	7		mA
I_{CD}	Delay pin output sink current	V_{IN} = 1.5 V, V_{CD} = 0.5 V		0.2	1.8		mA
R_D	Delay resistance			0.5	1	2	MΩ
V_{IN}	Operating input voltage range			1		6	V
I_{IN}	Quiescent input current	27 suffix	V_{IN} = 2.6 V		0.62	0.9	μA
			V_{IN} = 4.7 V		0.75	1.3	
		45 suffix	V_{IN} = 4.34 V		0.7	1	
			V_{IN} = 6 V		0.85	1.4	

(1) All limits are specified by testing or statistical analysis.
(2) Typical values represent the most likely parametric norm.

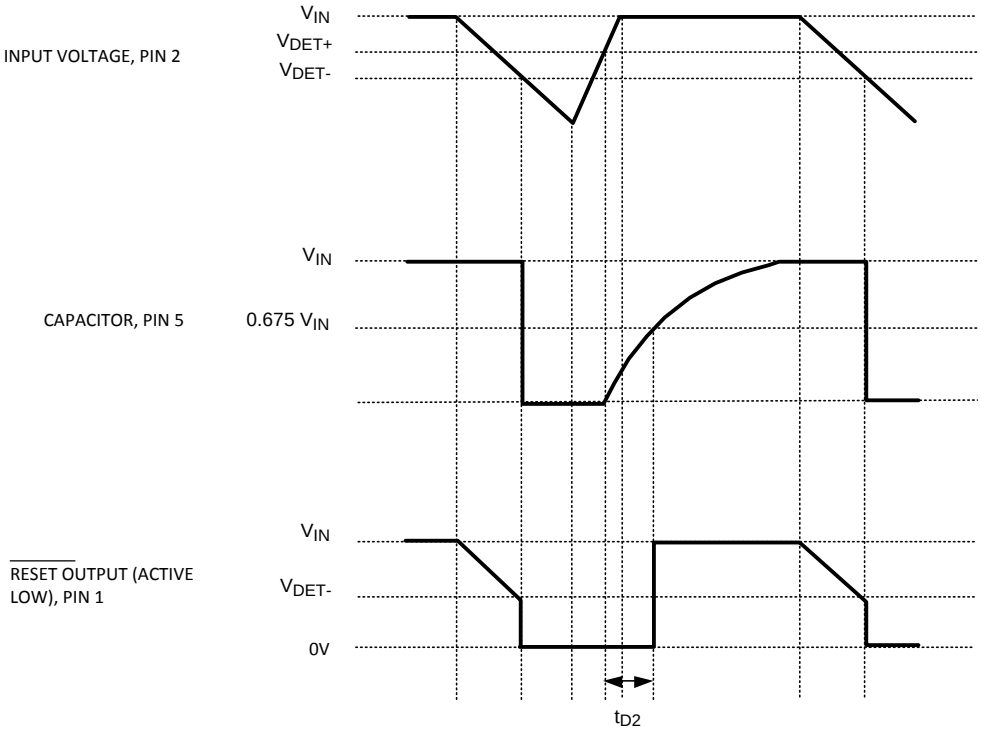


Figure 1. Timing Waveforms

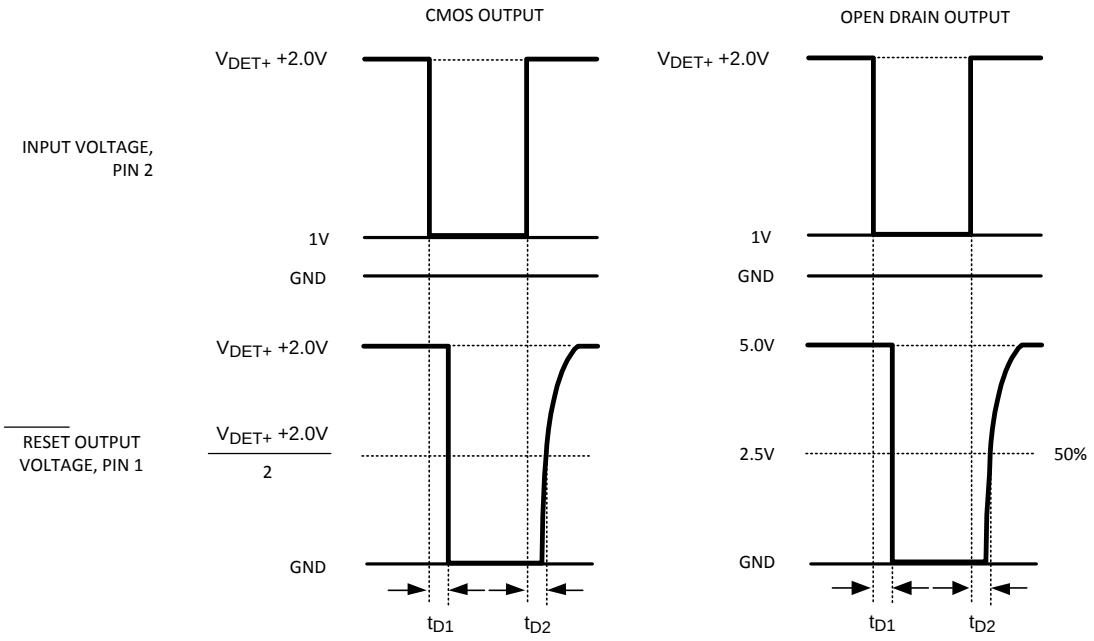


Figure 2. Propagation Delay Timing Diagrams

Copyright © 2003–2015, Texas Instruments Incorporated

6.6 Typical Characteristics

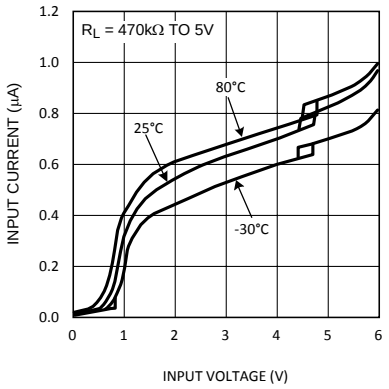


Figure 3. Input Current vs Input Voltage LM8365BALMF45

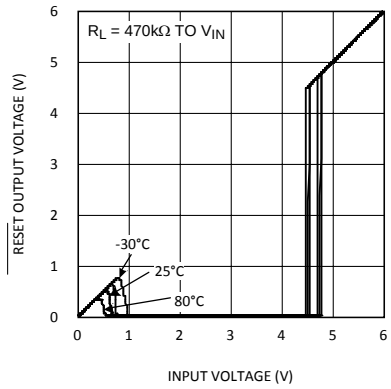


Figure 4. $\overline{\text{Reset}}$ Output Voltage vs Input Voltage LM8365BALMF45

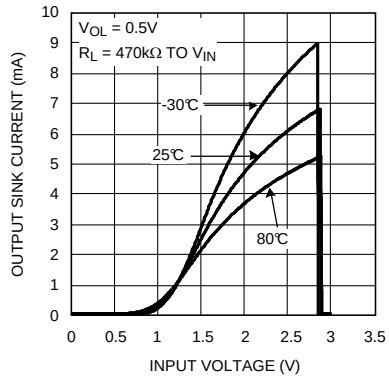


Figure 5. $\overline{\text{Reset}}$ Output Sink Current vs Input Voltage LM8365BALMF27

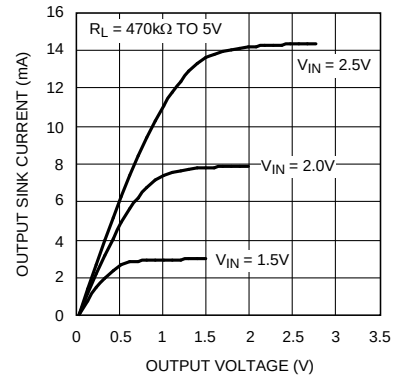


Figure 6. $\overline{\text{Reset}}$ Output Sink Current vs $\overline{\text{Reset}}$ Output Voltage LM8365BALMF45

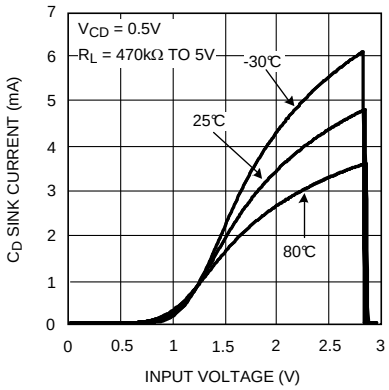


Figure 7. C_D Sink Current vs Input Voltage LM8365BALMF27

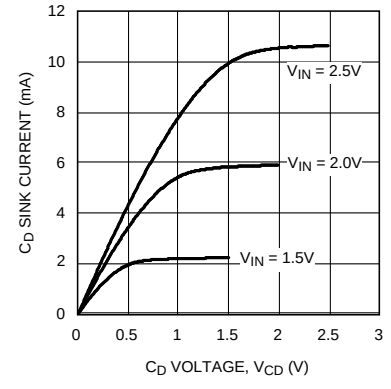


Figure 8. C_D Sink Current vs C_D Voltage

Copyright © 2003–2015, Texas Instruments Incorporated

Typical Characteristics (continued)

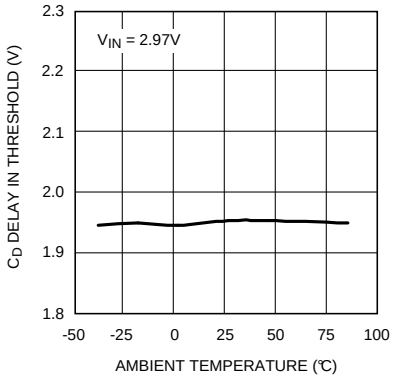


Figure 9. C_D Delay Pin Threshold Voltage vs Temperature LM8365BALMF27

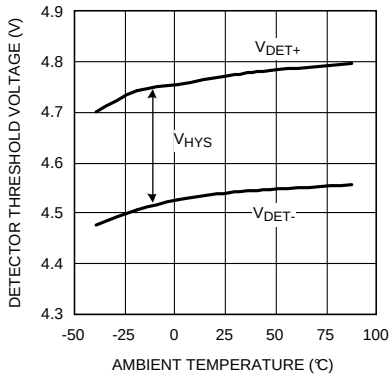


Figure 10. Detector Threshold Voltage vs Temperature LM8365BALMF45

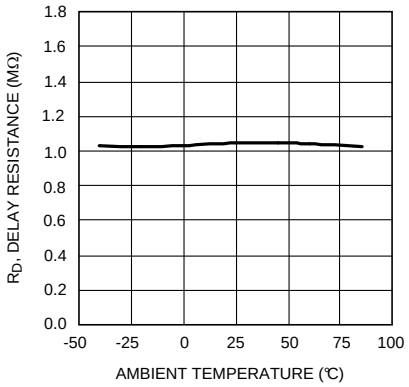


Figure 11. Delay Resistance vs Temperature

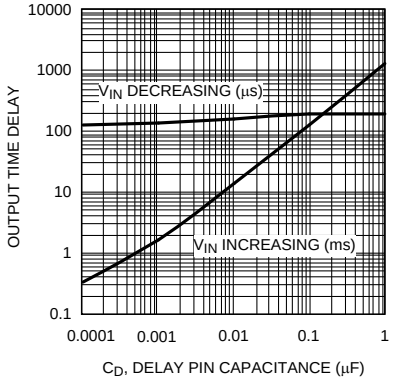


Figure 12. Output Time Delay vs Capacitance

Copyright © 2003–2015, Texas Instruments Incorporated

7 Detailed Description

7.1 Overview

The LM8365 ultra-low current voltage detector was designed to monitor voltages and to provide an indication when the monitored voltage, V_{IN}, dropped below a precisely trimmed threshold voltage. The voltage detector of the LM8365 drives a time delay generator that may be programmed for fixed lengths of time depending on the application needs. This characteristic is displayed in the typical operating timing diagram in Figure 1.

7.2 Functional Block Diagram

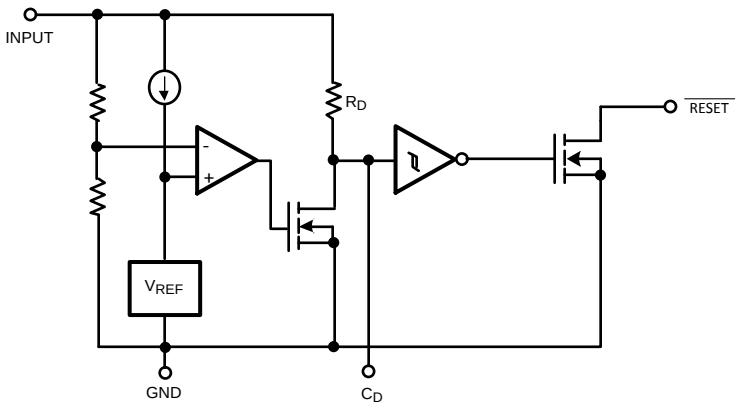


Figure 13. Open-Drain Output

7.3 Feature Description

V_{IN} is the voltage that is being monitored and as it decreases passed the precisely trimmed threshold V_{DET-}, the Active Low $\overline{\text{RESET}}$ output drops to a Logic Low state and the C_D pin drops to 0 V. During this state the external capacitor connected to the C_D pin is immediately discharged by an internal N-Channel MOSFET. When V_{IN} increases above the threshold V_{DET+} (V_{DET-} + V_{HYS}) the capacitor connected to the C_D pin starts to charge up to V_{IN} through an internal pullup resistor R_D. Once the capacitor has charged up past the internal Delay Pin Threshold, which is typically 0.675 V_{IN}, the $\overline{\text{RESET}}$ output will revert back to it's original state. The LM8365 have built-in hysteresis to help prevent erratic reset operation when the input voltage crosses the threshold.

The LM8365 has a wide variety of applications that can take advantage of its precision and low current consumption to monitor Input voltages even though it was designed as a reset controller in portable microprocessor based systems. It is a very cost-effective and space-saving device that will protect your more expensive investments of microprocessors and other devices that need a specified supply voltage and time delay for proper operation.

The propagation delay time for the LM8365 is measured using a 470-kΩ pullup resistor connected to from the $\overline{\text{RESET}}$ output pin to 5 V in addition to a 10-pF capacitive load connected from the same pin to GND. Figure 2 shows the timing diagram for the measurement for the propagation delay. V_{DET+} is equal to the sum of the detector threshold, V_{DET-}, and the built in hysteresis, V_{HYS}. t_{D1} is the propagation time from High-to-Low and t_{D2} is the propagation from Low-to-High.

Copyright © 2003–2015, Texas Instruments Incorporated

7.4 Device Functional Modes

7.4.1 $\overline{\text{Reset}}$ Output Low

When V_{IN} decreases below the precisely trimmed threshold V_{DET-}, the C_D pin voltage will drop to 0 V and the $\overline{\text{Reset}}$ pin will output low.

7.4.2 $\overline{\text{Reset}}$ Output High

When V_{IN} increases above the precisely trimmed threshold V_{DET+} (V_{DET-} + V_{HYS}), the capacitor connected to the C_D pin starts to charge up to V_{IN} through an internal pull-up resistor R_D. Once the capacitor has charged up past the internal Delay Pin Threshold, which is typically 0.675 V_{IN}, the $\overline{\text{RESET}}$ output will be pulled high, assuming an external pullup resistor is connected from $\overline{\text{Reset}}$ to V_{IN}.

Copyright © 2003–2015, Texas Instruments Incorporated

8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

The LM8365 is a supervisor that is ideal for use in battery powered microprocessor based systems. With an external delay capacitor, C_D, a time delay can be accurately programmed to allow for use in many types of applications. The LM8365 can ensure system reliability and ensures that a connected microprocessor will operate only when a minimum V_{IN} supply is satisfied.

8.2 Typical Application

The LM8365 can be used as a simple supervisor circuit to monitor the input supply to a microprocessor as shown in Figure 14.

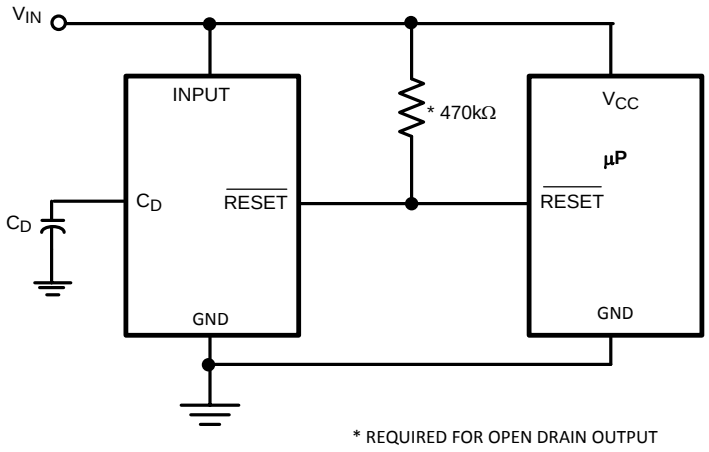


Figure 14. Microprocessor $\overline{\text{Reset}}$ Circuit

8.2.1 Design Requirements

For this design example, use the parameters listed in Table 1 as the input parameters.

Table 1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Input Supply voltage range	1 V to 6 V
$\overline{\text{Reset}}$ Output voltage, high	Input Supply
$\overline{\text{Reset}}$ Output voltage, low	0 V
Output Time delay, C_D = 0.1 µF	130 ms
Output Time delay, C_D = 1 µF	1.2 s

Copyright © 2003–2015, Texas Instruments Incorporated

8.2.2 Detailed Design Procedure

The Bill of Materials shown in Table 2 reflects the components used on the LM8365EVM. A layout of the EVM can be seen in Figure 19.

Table 2. Bill of Materials

DESIGNATOR	DESCRIPTION	PART NUMBER	QUANTITY	MANUFACTURER
U1	LM8365, 2.7V Threshold	LM8365	1	Texas Instruments
R1	470K Resistor, 0603	CRCW0603470KJNEA	1	Vishay
C1	0.01µF Capacitor, 0603	GRM188R71C103KA01D	1	MuRata
C2	0.1µF Capacitor, 0805	GRM219R71C104KA01D	1	MuRata
C3	1µF Capacitor, 0805	C0805C105K4RACTU	1	Kemet
C4	Input Capacitor	–	0	–

8.2.3 Application Curves

Two capacitor values for C_D (0.1 µF and 1 µF) are used as examples to show the programmability of the output time delay as shown in Figure 15 and Figure 16.

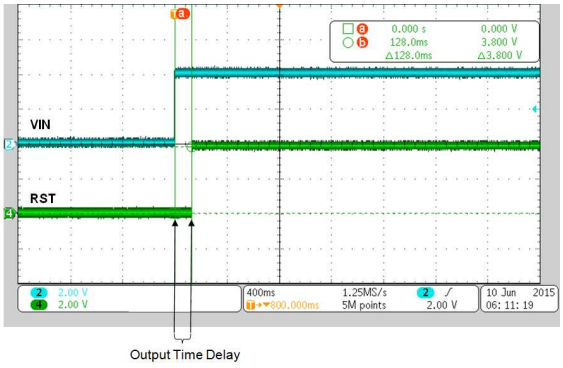


Figure 15. 0.1-µF Capacitor Programmed Delay

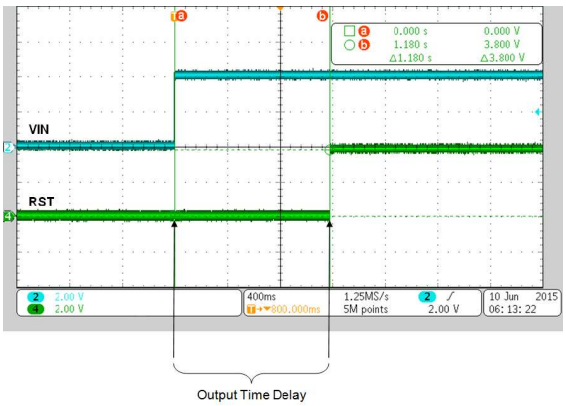


Figure 16. 1-µF Capacitor Programmed Delay

8.3 System Examples

The LM8365 can be used as a missing pulse detector. As shown in Figure 17, if a high-to-low transition pulse were to be missing, the C_D voltage would continue to increase until it reaches its threshold of 0.675 × V_{IN}, causing the Reset pin to output high and signal a missing pulse.

Copyright © 2003–2015, Texas Instruments Incorporated

System Examples (continued)

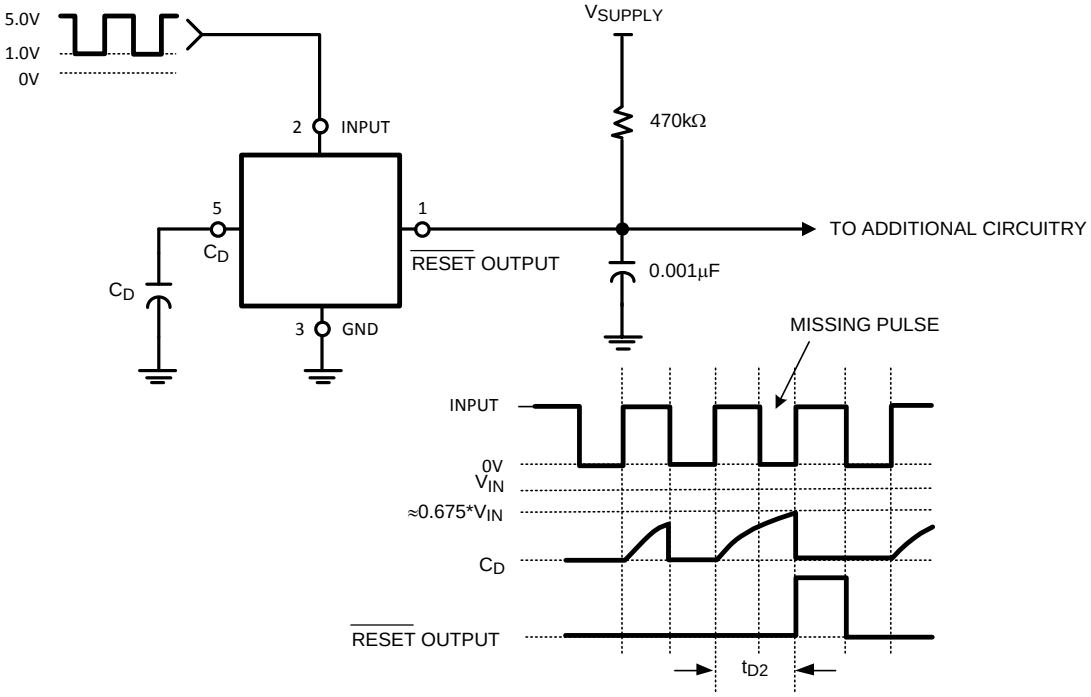


Figure 17. Missing Pulse Detector Using LM8365BALMF45

9 Power Supply Recommendations

The input of the LM8365 is designed to handle up to the supply voltage absolute maximum rating of 6.5 V. If the input supply is susceptible to any large transients above the maximum rating, then extra precautions should be taken. An input capacitor is recommended to avoid false Reset output triggers due to noise.

10 Layout

10.1 Layout Guidelines

- Place the input capacitor as close as possible to the IC.
- Keep traces short between the IC and the C_D capacitor to ensure the timing delay is as accurate as possible.

10.2 Layout Example

Figure 18 and Figure 19 are layout examples for the LM8365, which is taken from the LM8365EVM. For information on the operation and schematic of the EVM, see the *LM8365EVM User's Guide* (SNVU493).

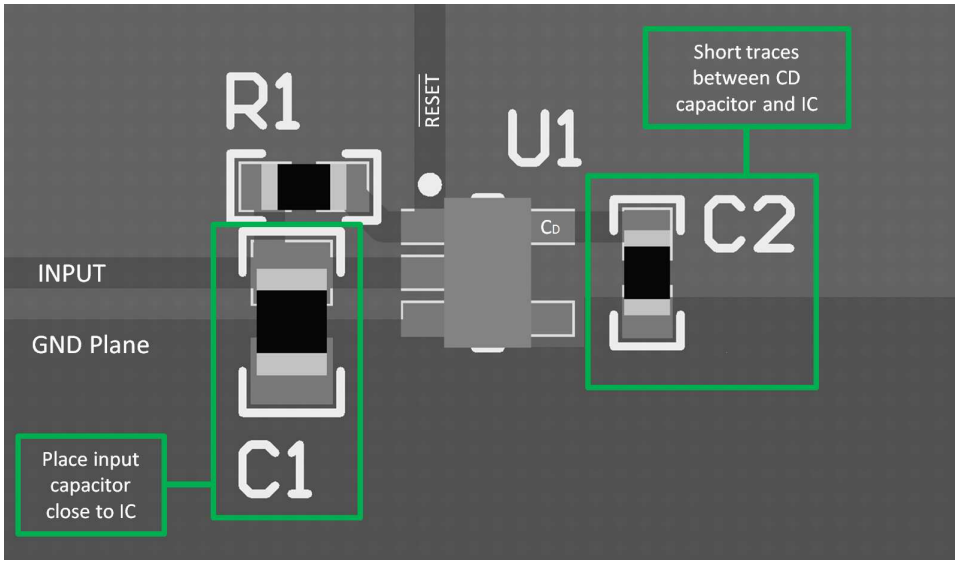


Figure 18. Layout Example

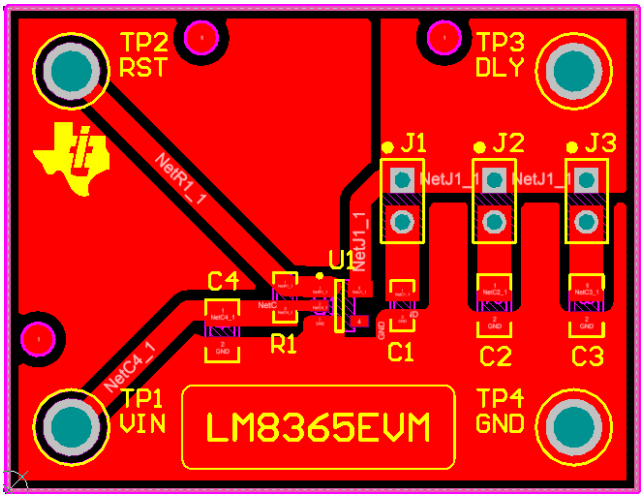


Figure 19. Top Layer Layout

Copyright © 2003–2015, Texas Instruments Incorporated

11 Device and Documentation Support

11.1 Device Support

11.1.1 Device Nomenclature

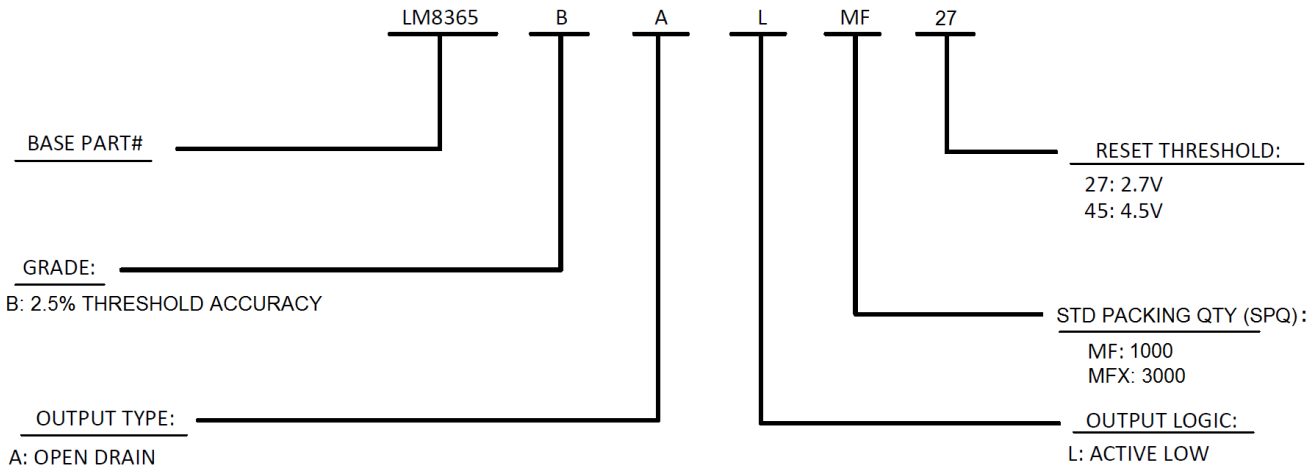


Figure 20. LM8365 IC Nomenclature

11.2 Documentation Support

11.2.1 Related Documentation

For related documentation, see the following:

LM8365EVM User's Guide, SNVU493

11.3 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

11.4 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

11.5 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

11.6 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

Copyright © 2003–2015, Texas Instruments Incorporated

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

Copyright © 2003–2015, Texas Instruments Incorporated

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM8365BALMF27/NOPB	ACTIVE	SOT-23	DBV	5	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	F07A	Samples
LM8365BALMFX27/NOPB	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	F07A	Samples
LM8365BALMFX45/NOPB	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	F06A	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

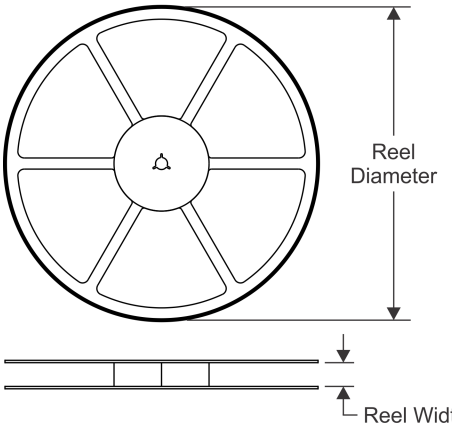
Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and

continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals.
TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

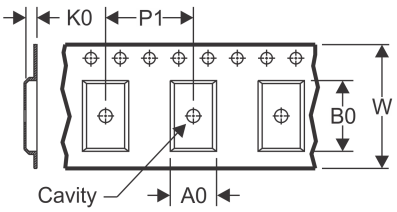
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

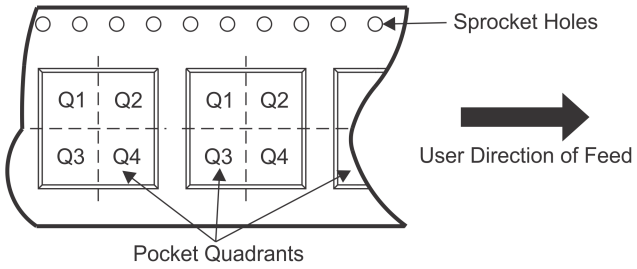


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

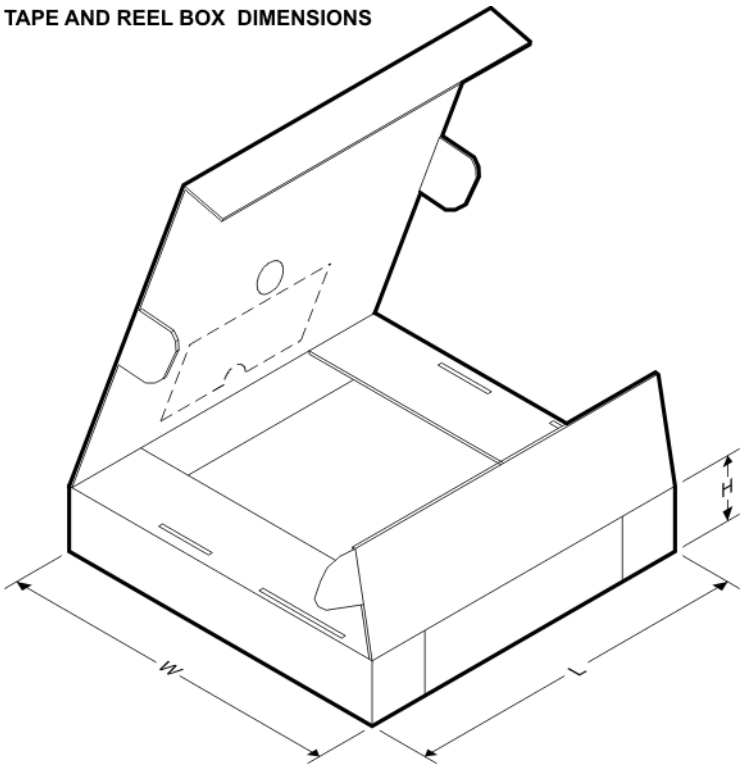
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM8365BALMF27/NOPB	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LM8365BALMFX27/NOPB	SOT-23	DBV	5	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LM8365BALMFX45/NOPB	SOT-23	DBV	5	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

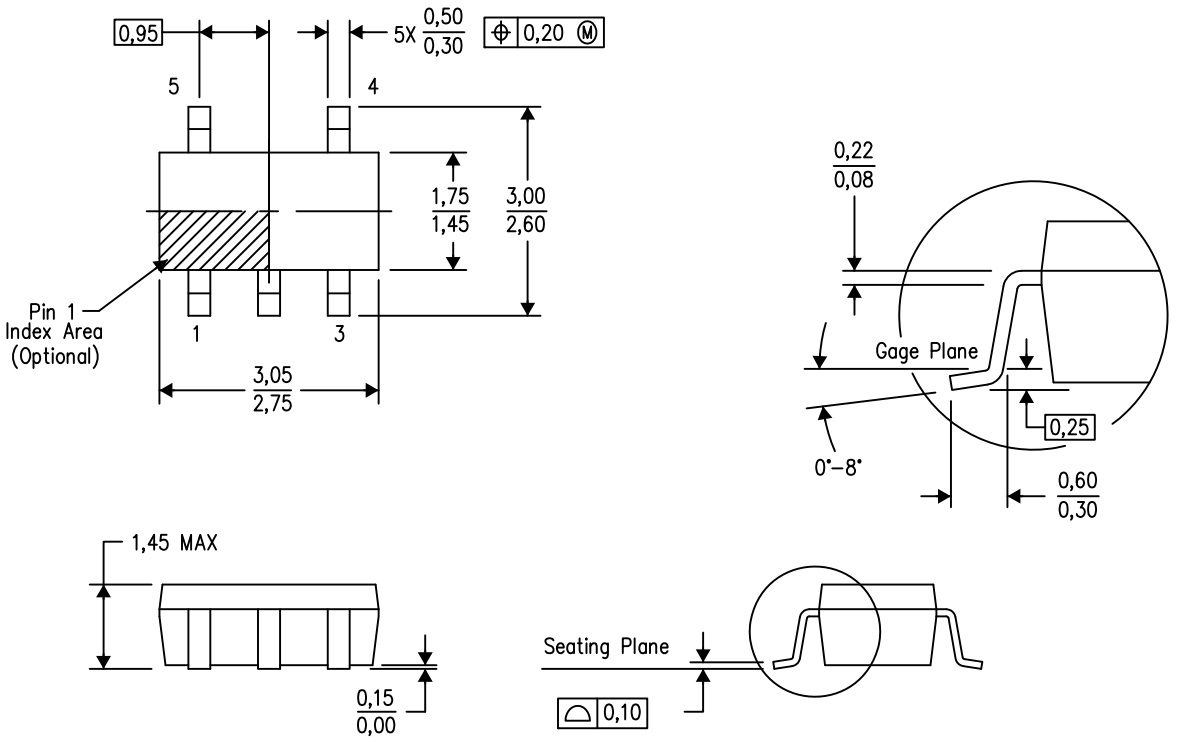
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM8365BALMF27/NOPB	SOT-23	DBV	5	1000	210.0	185.0	35.0
LM8365BALMFX27/NOPB	SOT-23	DBV	5	3000	210.0	185.0	35.0
LM8365BALMFX45/NOPB	SOT-23	DBV	5	3000	210.0	185.0	35.0

DBV (R–PDSO–G5) PLASTIC SMALL–OUTLINE PACKAGE



4073253–4/N 12/14

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
D. Falls within JEDEC MO–178 Variation AA.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2016, Texas Instruments Incorporated