LM185/LM285/LM385 Adjustable Micropower Voltage References

Check for Samples: LM185-ADJ, LM285-ADJ, LM385-ADJ

FEATURES

- **Adjustable from 1.24V to 5.30V**
- **Operating Current of 10µA to 20mA**
- **1% and 2% Initial Tolerance**
- **1Ω Dynamic Impedance**
- **Low Temperature Coefficient**

DESCRIPTION

The LM185/LM285/LM385 are micropower 3-terminal adjustable band-gap voltage reference diodes. Operating from 1.24 to 5.3V and over a 10µA to 20mA current range, they feature exceptionally low dynamic impedance and good temperature stability. On-chip trimming is used to provide tight voltage tolerance. Since the LM185 band-gap reference uses only transistors and resistors, low noise and good long-term stability result.

Careful design of the LM185 has made the device tolerant of capacitive loading, making it easy to use in almost any reference application. The wide dynamic operating range allows its use with widely varying supplies with excellent regulation.

The extremely low power drain of the LM185 makes it useful for micropower circuitry. This voltage reference can be used to make portable meters, regulators or general purpose analog circuitry with battery life approaching shelf life. Further, the wide operating current allows it to replace older references with a tighter tolerance part.

The LM185 is rated for operation over a −55°C to 125°C temperature range, while the LM285 is rated −40°C to 85°C and the LM385 0°C to 70°C. The LM185 is available in a hermetic TO package and a LCCC package, while the LM285/LM385 are available in a low-cost TO-92 package, as well as SOIC.
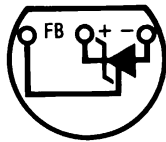
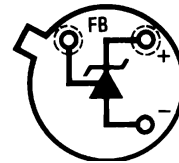## Connection Diagram

Figure 1. TO-92 Package Bottom View

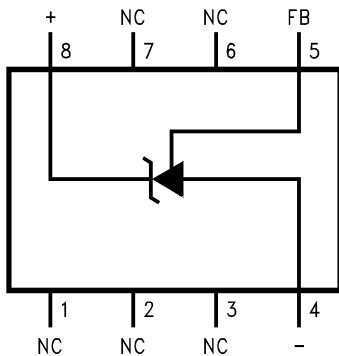**Figure 2. TO Package Bottom View**
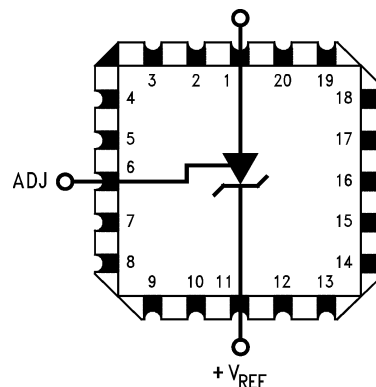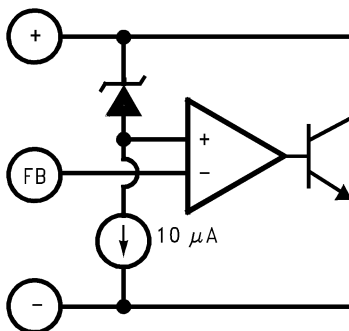
Figure 3. SOIC Package Top View

Figure 4. 20-LCCC Top View

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Block Diagram

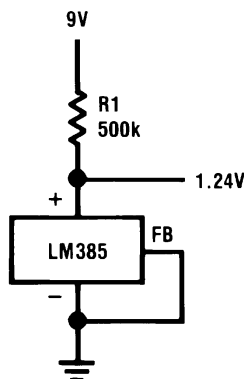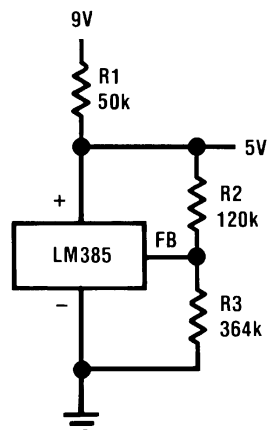## Typical Applications

Figure 5. 1.2V Reference

$$V_{OUT} = 1.24 \left(\frac{R3}{R2} + 1 \right)$$

Figure 6. 5.0V Reference

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.

Product Folder Links: *LM185-ADJ LM285-ADJ LM385-ADJ*

Absolute Maximum Ratings[(1)(2)(3)]

Reverse Current	30mA
Forward Current	10mA
Operating Temperature Range [(4)]	
LM185 Series	−55°C to 125°C
LM285 Series	−40°C to 85°C
LM385 Series	0°C to 70°C
ESD Susceptibility [(5)]	2kV
Storage Temperature	−55°C to 150°C
Soldering Information	
TO-92 Package (10 sec.)	260°C
TO Package (10 sec.)	300°C
SOIC Package	
Vapor Phase (60 sec.)	215°C
Infrared (15 sec.)	220°C
See An-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.	

(1)   Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional. For specifications and test conditions, see the Electrical Characteristics. The specifications apply only for the test conditions listed.
(2)   Refer to RETS185H for military specifications.
(3)   If Military/Aerospace specified devices are required, please contact the TI Sales Office/Distributors for availability and specifications.
(4)   For elevated temperature operation, see Table 1 and Thermal Characteristics.
(5)   The human body model is a 100 pF capacitor discharged through a 1.5 kΩ resistor into each pin.

Table 1. $T_{J(max)}$ for Elevated Temperature Operation

DEVICE	$T_{J(max)}$ (°C)
LM185	150
LM285	125
LM385	100

Thermal Characteristics

Over operating free-air temperature range (unless otherwise noted)

Thermal Resistance	TO-92	TO-46	SOIC
θ_{JA} (Junction to Ambient)	180°C/W (0.4″ leads)	440°C/W	165°C/W
	170°C/W (0.125″ leads)		
θ_{JC} (Junction to Case)	N/A	80°C/W	N/A

Electrical Characteristics[1]

Parameter	Conditions	LM185, LM285					LM385					Units (Limit)
		Typ	LM185BX, LM185BY, LM185B, LM285BX, LM285BY		LM285		Typ	LM385BX, LM385BY		LM385		
			Tested Limit [2]	Design Limit [3]	Tested Limit [2]	Design Limit [3]		Tested Limit [2]	Design Limit [3]	Tested Limit [2]	Design Limit [3]	
Reference Voltage	I_R = 100μA	1.240	1.252 **1.255**		1.265	**1.270**	1.240	1.252	**1.255**	1.265	**1.270**	V (max)
			1.228 **1.215**		1.215	**1.205**		1.228	**1.215**	1.215	**1.205**	V (min)
Reference Voltage Change with Current	I_{MIN}< I_R < 1mA	0.2	1	**1.5**	1	**1.5**	0.2	1	**1.5**	1	**1.5**	mV (max)
	1mA < I_R < 20mA	4	10	**20**	10	**20**	5	15	**25**	15	**25**	
Dynamic Output Impedance	I_R = 100μA, I_{AC} = 0.1 I_R	f = 100Hz, V_{OUT} = V_{REF}	0.3					0.4					Ω
		V_{OUT} = 5.3V	0.7					1					
Reference Voltage Change with Output Voltage	I_R = 100μA	1	3	**6**	3	**6**	2	5	**10**	5	**10**	mV (max)
Feedback Current		13	20	**25**	20	**25**	16	30	**35**	30	**35**	nA (max)
Minimum Operating Current (see curve)	V_{OUT} = V_{REF}	6	9	**10**	9	**10**	7	11	**13**	11	**13**	μA (max)
	V_{OUT} = 5.3V	30	45	**50**	45	**50**	35	55	**60**	55	**60**	
Output Wideband Noise	I_R = 100μA, 10Hz < f < 10kHz											μV$_{rms}$
	V_{OUT} = V_{REF}	50					50					
	V_{OUT} = 5.3V	170					170					
Average Temperature Coefficient [4]	I_R = 100μA	X Suffix		**30**					**30**				ppm/°c (max)
		Y Suffix		**50**					**50**				
		All Others			**150**		**150**			**150**		**150**	
Long Term Stability	I_R = 100μA, T = 1000 Hr, T_A = 25°C ± 0.1°C	20					20					ppm

(1) Parameters identified with **boldface type** apply at temperature extremes. All other numbers apply at T_A = T_J = 25°C. Unless otherwise specified, all parameters apply for V_{REF} < V_{OUT} < 5.3V.
(2) Production tested.
(3) Not production tested. These limits are not to be used to calculate average outgoing quality levels.
(4) The average temperature coefficient is defined as the maximum deviation of reference voltage at all measured temperatures from T_{MIN} to T_{MAX}, divided by $T_{MAX} − T_{MIN}$. The measured temperatures are −55, −40, 0, 25, 70, 85, 125°C.

Typical Performance Characteristics

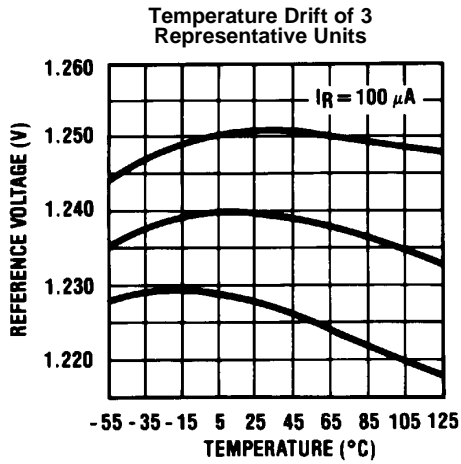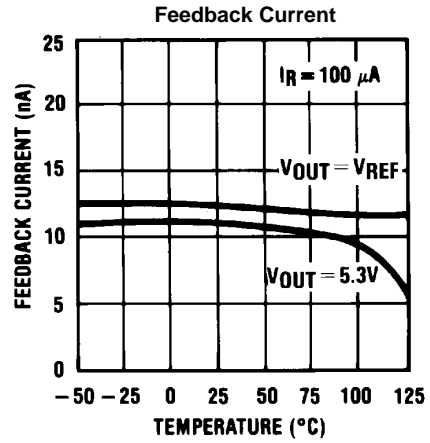**Temperature Drift of 3 Representative Units**
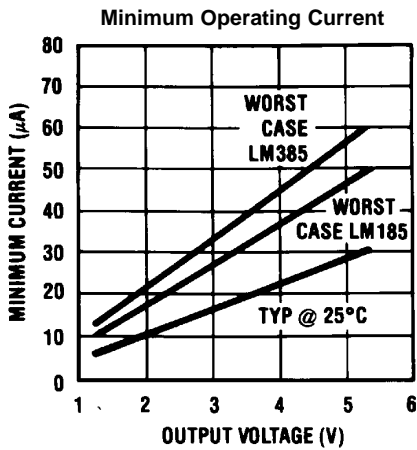

Figure 7.

Feedback Current

Figure 8.

Minimum Operating Current

Figure 9.

Reverse Characteristics

Figure 10.

Reverse Characteristics
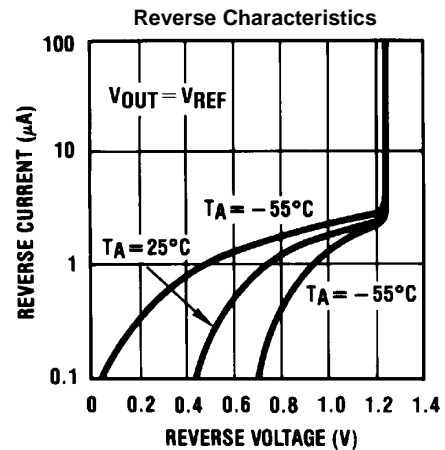
Figure 11.
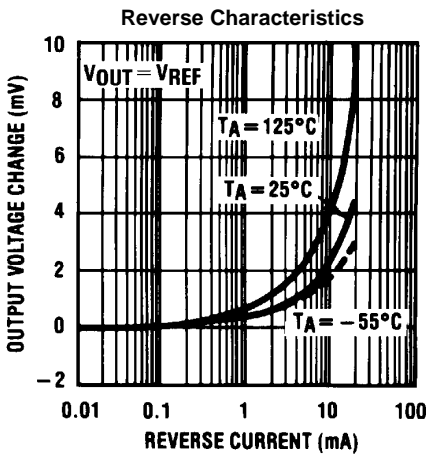
Forward Characteristics
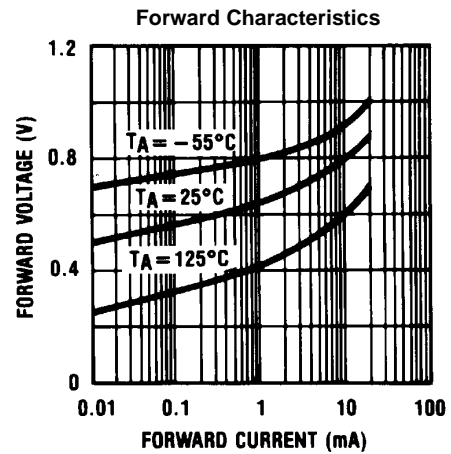
Figure 12.

Typical Performance Characteristics (continued)

Output Noise Voltage

Figure 13.

Dynamic Output Impedance

Figure 14.

Response Time
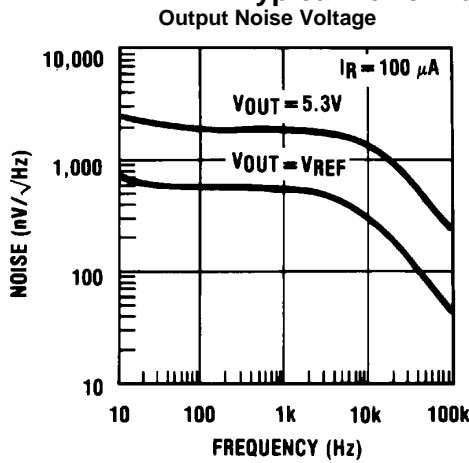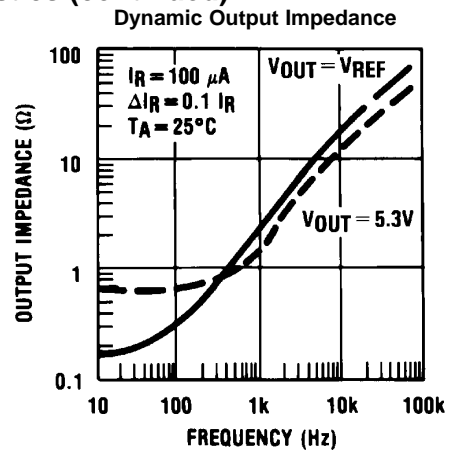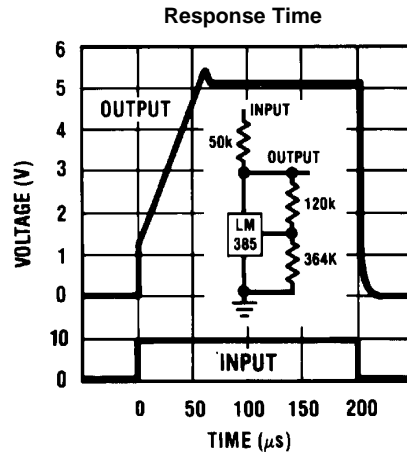
Figure 15.

Temperature Coefficient Typical
LM185 (left), LM285 (center), LM385 (right)

Figure 16.

$$TEMPCO = \frac{TOTAL\ \Delta Y\ IN\ ppm}{TOTAL\ \Delta T}$$

$$TEMPCO = \frac{\Delta Y}{\Delta T}$$

Product Folder Links: LM185-ADJ LM285-ADJ LM385-ADJ
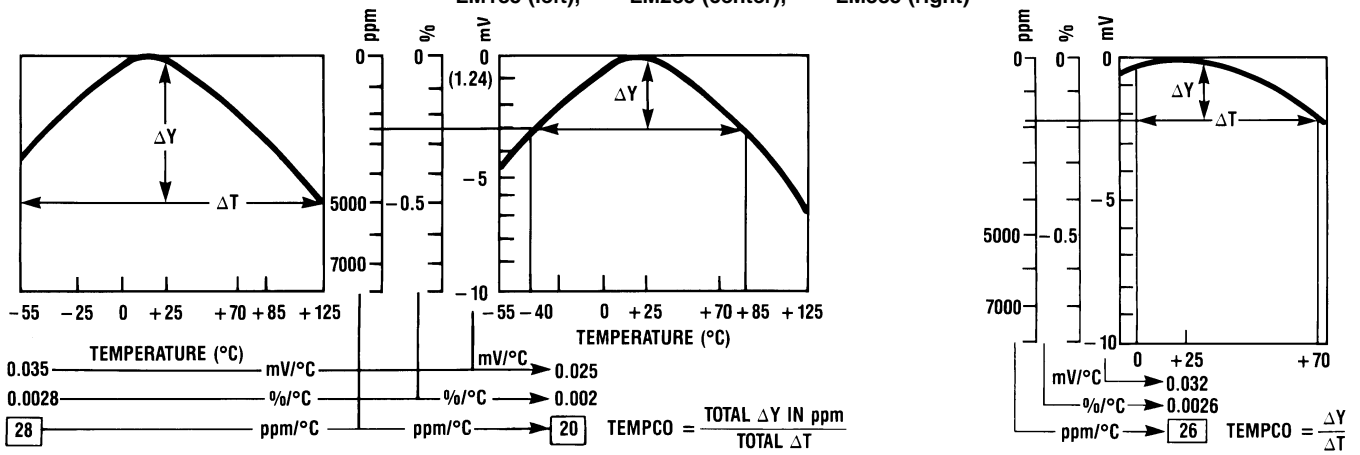
TYPICAL APPLICATIONS
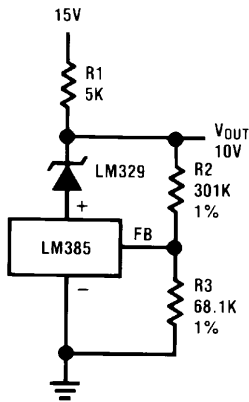
Figure 17. Precision 10V Reference
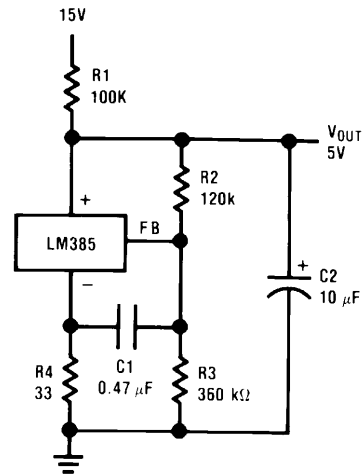
Figure 18. Low AC Noise Reference
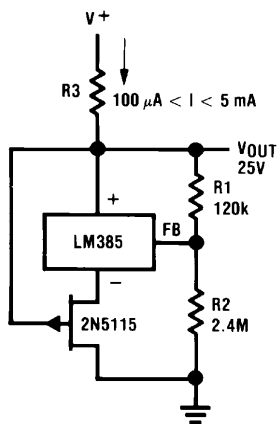
Figure 19. 25V Low Current Shunt Regulator
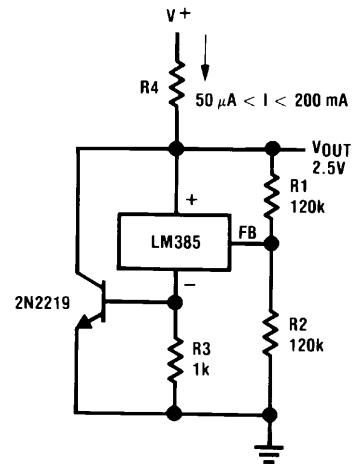
Figure 20. 200 mA Shunt Regulator
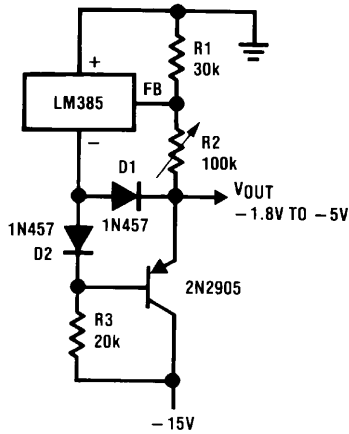
Figure 21. Series-Shunt 20 mA Regulator
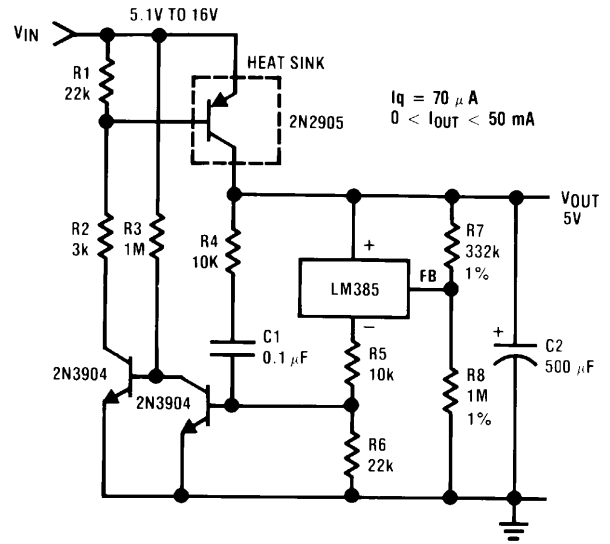
Figure 22. High Efficiency Low Power Regulator
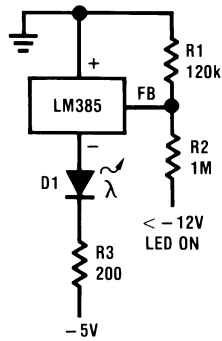
Figure 23. Voltage Level Detector
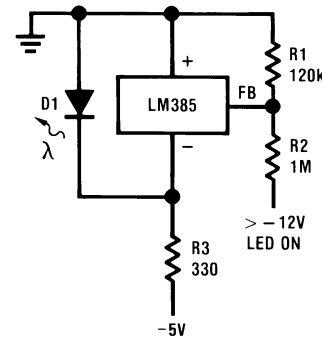
Figure 24. Voltage Level Detector
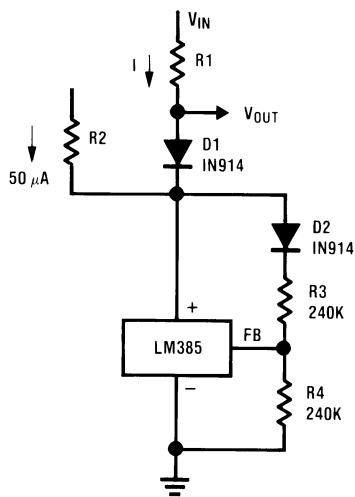
Figure 25. Fast Positive Clamp
2.4V + ΔV$_{D1}$
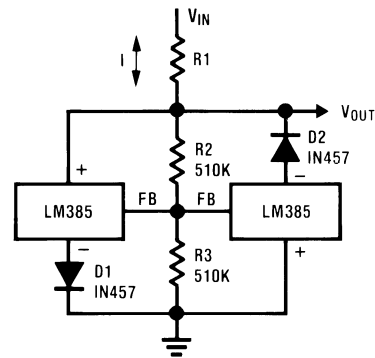
Figure 26. Bidirectional Clamp
±2.4V

Product Folder Links: *LM185-ADJ LM285-ADJ LM385-ADJ*
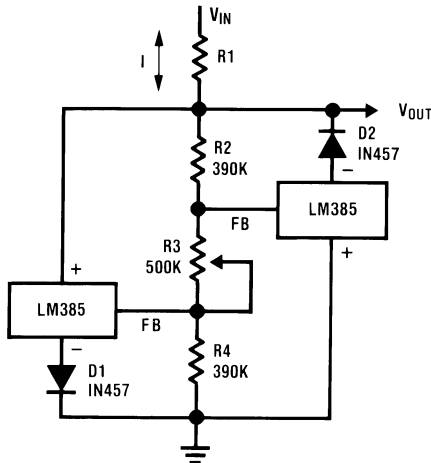
**Figure 27. Bidirectional Adjustable Clamp
±1.8V to ±2.4V**
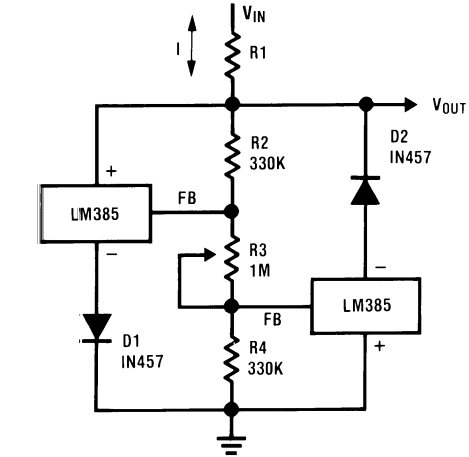
**Figure 28. Bidirectional Adjustable Clamp
±2.4V to ±6V**

$$I_{THRESHOLD} = \frac{1.24V}{R1} + \frac{5\,\mu A}{4N28\ GAIN} \cong 3.2\ mA$$
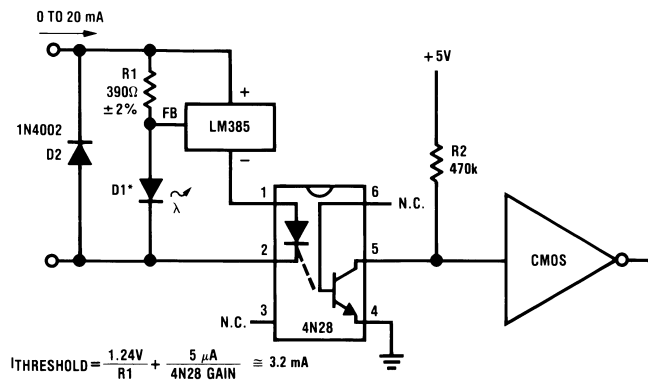
Figure 29. Simple Floating Current Detector

$$1\,\mu A < I_{OUT} < 100\ mA$$
$$I_{OUT} = \frac{1.24V}{R1}$$
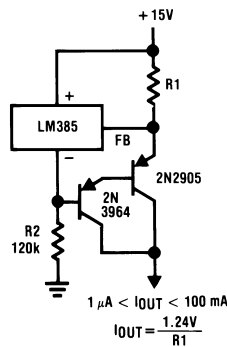
Figure 30. Current Source
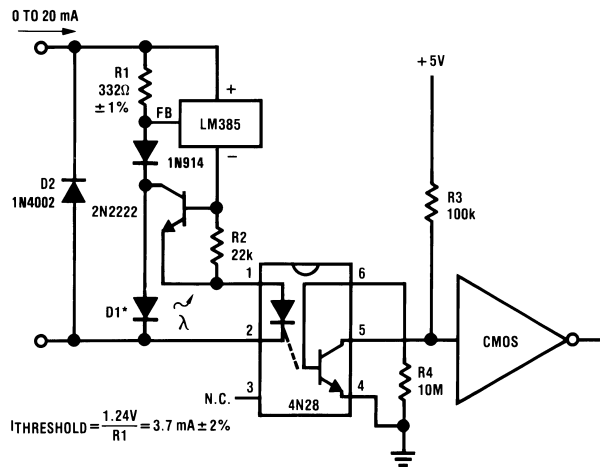
*D1 can be any LED, V_F=1.5V to 2.2V at 3 mA. D1 may act as an indicator. D1 will be on if $I_{THRESHOLD}$ falls below the threshold current, except with I=O.

Figure 31. Precision Floating Current Detector
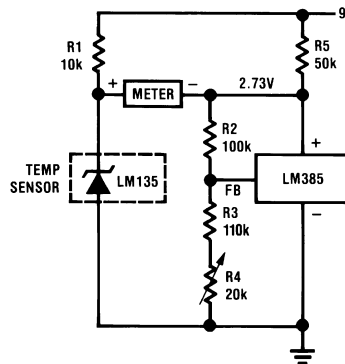
Figure 32. Centigrade Thermometer, 10mV/°C
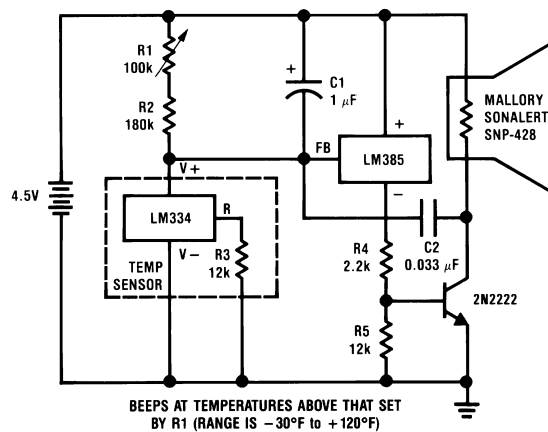
Figure 33. Freezer Alarm

Product Folder Links: *LM185-ADJ LM285-ADJ LM385-ADJ*

Schematic Diagram
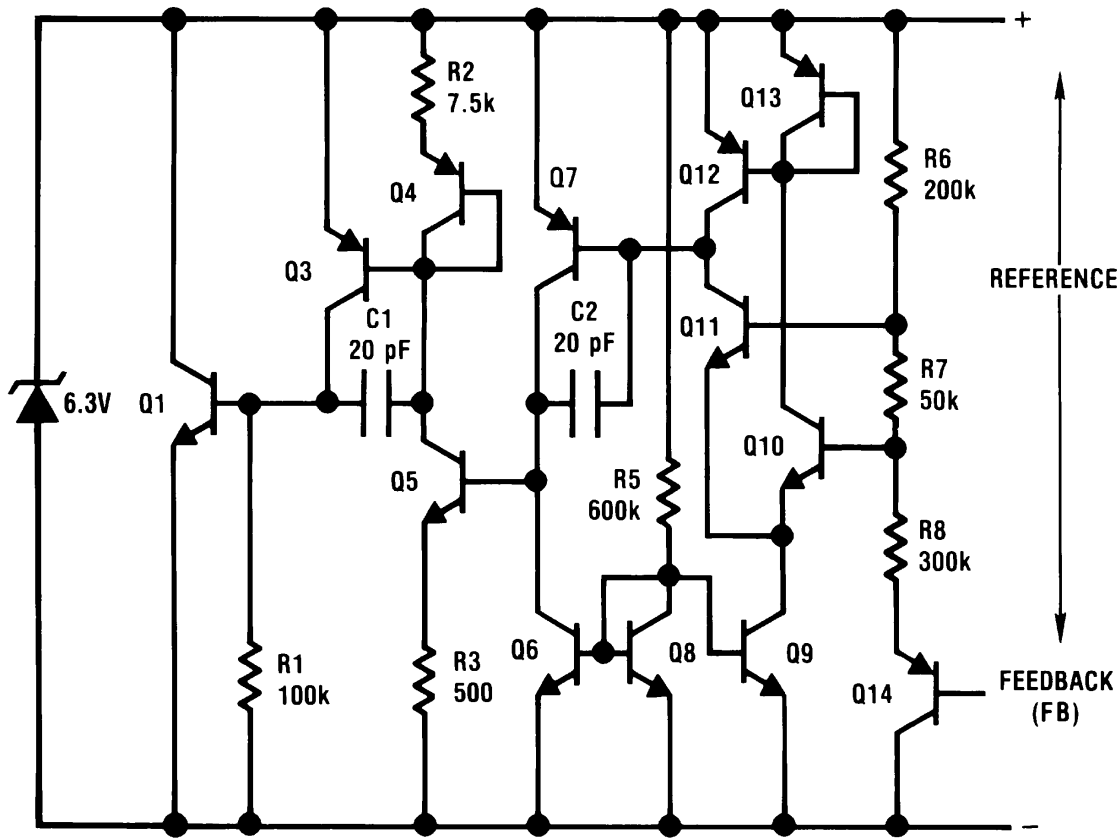
REVISION HISTORY

Changes from Revision E (April 2013) to Revision F   **Page**

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
LM185BH	ACTIVE	TO	NDV	3	1000	TBD	Call TI	Call TI	-55 to 125	LM185BH	Samples
LM185BH/NOPB	ACTIVE	TO	NDV	3	1000	Green (RoHS & no Sb/Br)	POST-PLATE	Level-1-NA-UNLIM	-55 to 125	LM185BH	Samples
LM185H-2.5	ACTIVE	TO	NDU	2	1000	TBD	Call TI	Call TI	-55 to 125	LM185H2.5	Samples
LM185H-2.5/NOPB	ACTIVE	TO	NDU	2	1000	Green (RoHS & no Sb/Br)	POST-PLATE	Level-1-NA-UNLIM	-55 to 125	LM185H2.5	Samples
LM285BXZ/NOPB	ACTIVE	TO-92	LP	3	1800	Green (RoHS & no Sb/Br)	SN | CU SN	N / A for Pkg Type	-40 to 85	LM285 BXZ	Samples
LM285BYM/NOPB	ACTIVE	SOIC	D	8	95	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	LM285 BYM	Samples
LM285BYMX/NOPB	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	SN | CU SN	Level-1-260C-UNLIM	-40 to 85	LM285 BYM	Samples
LM285BYZ/NOPB	ACTIVE	TO-92	LP	3	1800	Green (RoHS & no Sb/Br)	SN | CU SN	N / A for Pkg Type	-40 to 85	LM285 BYZ	Samples
LM285M/NOPB	ACTIVE	SOIC	D	8	95	Green (RoHS & no Sb/Br)	SN | CU SN	Level-1-260C-UNLIM	-40 to 85	LM285 M	Samples
LM285MX/NOPB	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	SN | CU SN	Level-1-260C-UNLIM	-40 to 85	LM285 M	Samples
LM285Z/NOPB	ACTIVE	TO-92	LP	3	1800	Green (RoHS & no Sb/Br)	SN | CU SN	N / A for Pkg Type	-40 to 85	LM285 Z	Samples
LM385BM	NRND	SOIC	D	8	95	TBD	Call TI	Call TI	0 to 70	LM385 BM	
LM385BM/NOPB	ACTIVE	SOIC	D	8	95	Green (RoHS & no Sb/Br)	SN | CU SN	Level-1-260C-UNLIM	0 to 70	LM385 BM	Samples
LM385BMX/NOPB	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	SN | CU SN	Level-1-260C-UNLIM	0 to 70	LM385 BM	Samples
LM385BXZ/NOPB	ACTIVE	TO-92	LP	3	1800	Green (RoHS & no Sb/Br)	SN | CU SN	N / A for Pkg Type	0 to 70	LM385 BXZ	Samples
LM385BYZ/NOPB	ACTIVE	TO-92	LP	3	1800	Green (RoHS & no Sb/Br)	SN | CU SN	N / A for Pkg Type	0 to 70	LM385 BYZ	Samples
LM385BZ/NOPB	ACTIVE	TO-92	LP	3	1800	Green (RoHS & no Sb/Br)	SN | CU SN	N / A for Pkg Type	0 to 70	LM385 BZ	Samples
LM385M	NRND	SOIC	D	8	95	TBD	Call TI	Call TI	0 to 70	LM385

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
										M	
LM385M/NOPB	ACTIVE	SOIC	D	8	95	Green (RoHS & no Sb/Br)	SN | CU SN	Level-1-260C-UNLIM	0 to 70	LM385 M	Samples
LM385MX	NRND	SOIC	D	8	2500	TBD	Call TI	Call TI	0 to 70	LM385 M	
LM385MX/NOPB	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	SN | CU SN	Level-1-260C-UNLIM	0 to 70	LM385 M	Samples
LM385Z/NOPB	ACTIVE	TO-92	LP	3	1800	Green (RoHS & no Sb/Br)	SN | CU SN	N / A for Pkg Type	0 to 70	LM385 Z	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.

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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.

PACKAGE MATERIALS INFORMATION

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
LM285BYMX/NOPB	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1
LM285MX/NOPB	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1
LM385BMX/NOPB	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1
LM385MX	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1
LM385MX/NOPB	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS

*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM285BYMX/NOPB	SOIC	D	8	2500	367.0	367.0	35.0
LM285MX/NOPB	SOIC	D	8	2500	367.0	367.0	35.0
LM385BMX/NOPB	SOIC	D	8	2500	367.0	367.0	35.0
LM385MX	SOIC	D	8	2500	367.0	367.0	35.0
LM385MX/NOPB	SOIC	D	8	2500	367.0	367.0	35.0

NDU0002A

Ø.214±.005
[5.44±0.12]

Ø.100
[2.54]

.038±.010
[0.97±0.25]

.041±.005
[1.04±0.12]

45°

SEATING PLANE

.500 MIN
[12.7]

.080-.105
[2.03-2.67]

Ø.187±.008
[4.75±0.2]

Ø.0175±.0015 TYP
[0.445±0.038]

.030 MAX
[0.76]

.025 MAX
[0.64]
UNCONTROLLED
LEAD DIA
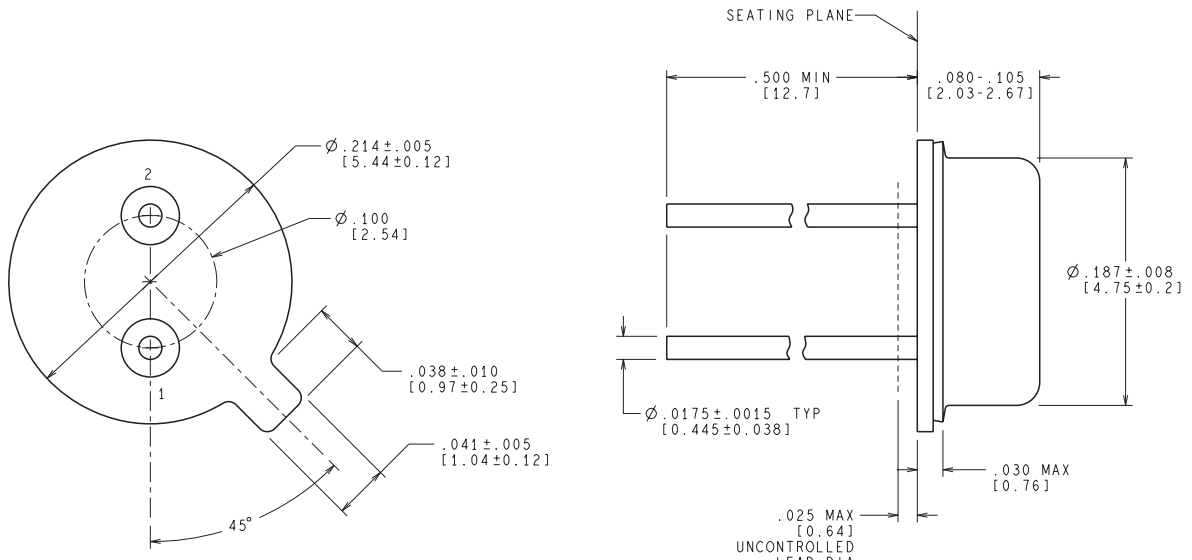
CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE MILLIMETERS

H02A (Rev F)

NDV0003H

Ø.214±.005
[5.44±0.12]

Ø.100
[2.54]

3

2

1

.038±.010
[0.97±0.25]

.041±.005
[1.04±0.12]

45°

SEATING PLANE

.500 MIN
[12.7]

.080-.105
[2.03-2.67]

Ø.187±.008
[4.75±0.2]

Ø.0175±.0015 TYP
[0.445±0.038]

.030 MAX
[0.76]

.025 MAX
[0.64]
UNCONTROLLED
LEAD DIA
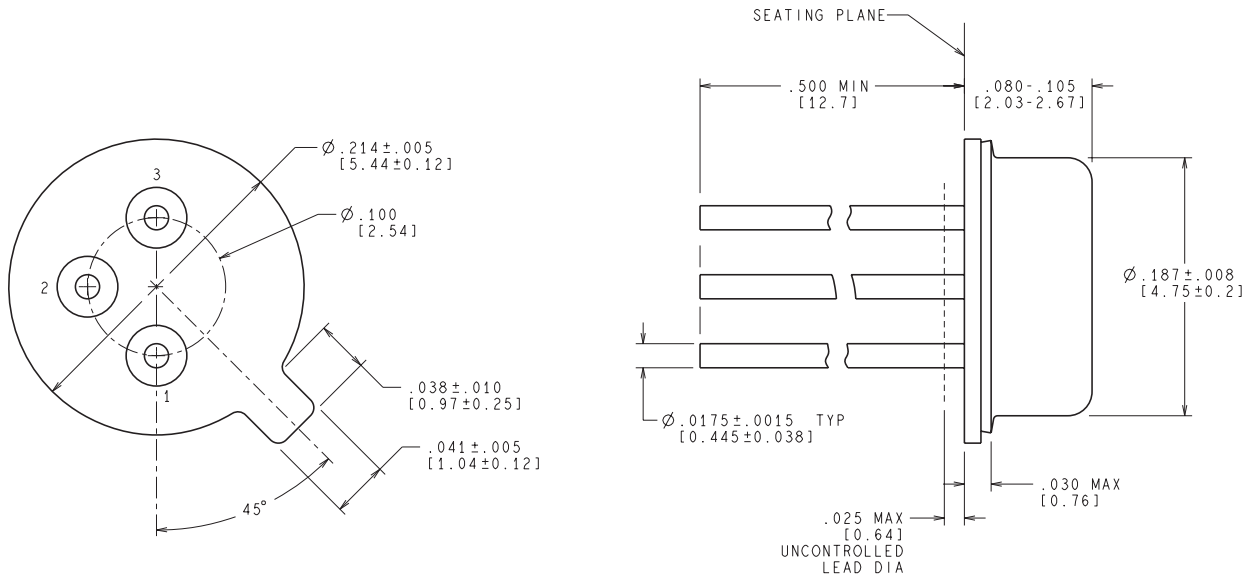
CONTROLLING DIMENSION IS INCH
VALUES IN [ ] ARE IN MILLIMETERS

H03H (Rev F)

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D (R−PDSO−G8)   PLASTIC SMALL OUTLINE

0.197 (5,00)
0.189 (4,80)
⚠C

8   5

0.244 (6,20)
0.228 (5,80)

0.157 (4,00)   ⚠D
0.150 (3,80)

Pin 1
Index Area

1   4

0.050 (1,27)   0.020 (0,51)
0.012 (0,31)

⊕ 0.010 (0,25) Ⓜ

0.069 (1,75) Max   0.010 (0,25)
0.004 (0,10)

0.010 (0,25)
0.005 (0,13)

Gauge Plane

☐ 0.004 (0,10)

Seating Plane

0.010 (0,25)   0°−8°

0.050 (1,27)
0.016 (0,40)

4040047−3/M   06/11

NOTES: A. All linear dimensions are in inches (millimeters).
         B. This drawing is subject to change without notice.
       ⚠C Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall
            not exceed 0.006 (0,15) each side.
       ⚠D Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
         E. Reference JEDEC MS−012 variation AA.

TEXAS
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LP (O−PBCY−W3)   PLASTIC CYLINDRICAL PACKAGE

0.205 (5,21)
0.175 (4,44) DIA

0.165 (4,19)
0.125 (3,17)

0.210 (5,34)
0.170 (4,32)

0.157 (4,00) MAX

Seating Plane

0.050 (1,27)

C

0.500 (12,70) MIN

0.104 (2,65)

FORMED LEAD OPTION

0.022 (0,56)
0.016 (0,41)

STRAIGHT LEAD OPTION

D

0.016 (0,41)
0.014 (0,35)

0.135 (3,43) MIN

0.105 (2,67)
0.095 (2,41)

0.055 (1,40)
0.045 (1,14)

1 2 3

0.105 (2,67)
0.080 (2,03)

0.105 (2,67)
0.080 (2,03)

4040001−2/E 08/13

NOTES: A. All linear dimensions are in inches (millimeters).
        B. This drawing is subject to change without notice.
        C. Lead dimensions are not controlled within this area.
        D. Falls within JEDEC TO−226 Variation AA (TO−226 replaces TO−92).
        E. Shipping Method:
            Straight lead option available in bulk pack only.
            Formed lead option available in tape & reel or ammo pack.
            Specific products can be offered in limited combinations of shipping mediums and lead options.
            Consult product folder for more information on available options.

TEXAS
INSTRUMENTS
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LP (O–PBCY–W3)   PLASTIC CYLINDRICAL PACKAGE

$\dfrac{0.539\ (13,70)}{0.460\ (11,70)}$

$\dfrac{1.260\ (32,00)}{0.905\ (23,00)}$

$\dfrac{0.650\ (16,50)}{0.610\ (15,50)}$

0.098 (2,50)

0.020 (0,50) MIN

$\dfrac{0.384\ (9,75)}{0.335\ (8,50)}$

$\dfrac{0.433\ (11,00)}{0.335\ (8,50)}$

$\dfrac{0.748\ (19,00)}{0.217\ (5,50)}$

$\dfrac{0.748\ (19,00)}{0.689\ (17,50)}$

$\dfrac{0.114\ (2,90)}{0.094\ (2,40)}$

$\dfrac{0.114\ (2,90)}{0.094\ (2,40)}$

$\dfrac{0.169\ (4,30)}{0.146\ (3,70)}$ DIA

$\dfrac{0.266\ (6,75)}{0.234\ (5,95)}$

$\dfrac{0.512\ (13,00)}{0.488\ (12,40)}$

TAPE & REEL

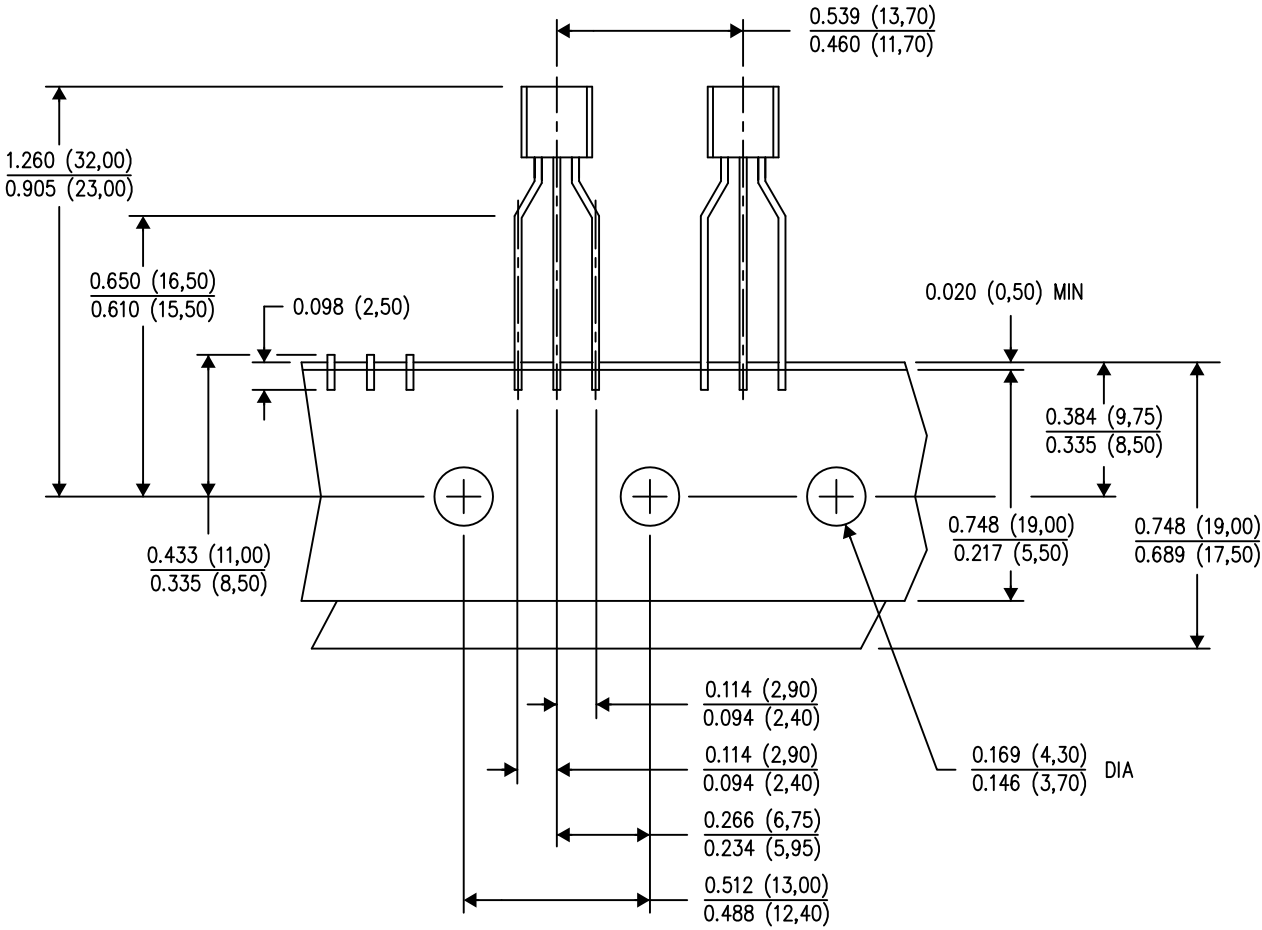4040001–3/E 08/13

NOTES: A.   All linear dimensions are in inches (millimeters).
          B.   This drawing is subject to change without notice.
          C.   Tape and Reel information for the Formed Lead Option package.

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