

# LM185/LM285/LM385

## Adjustable Micropower Voltage References

### General 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 10 $\mu$ A 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.

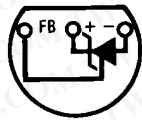
The LM185 is rated for operation over a -55°C to 125°C temperature range, while the LM285 is rated -40°C to 85°C and the LM385 0°C to 70°C. The LM185 is available in a hermetic TO-46 package and a leadless chip carrier package, while the LM285/LM385 are available in a low-cost TO-92 molded package, as well as S.O.

### Features

- Adjustable from 1.24V to 5.30V
- Operating current of 10 $\mu$ A to 20mA
- 1% and 2% initial tolerance
- 1 $\Omega$  dynamic impedance
- Low temperature coefficient

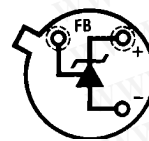
### Connection Diagrams

TO-92  
Plastic Package



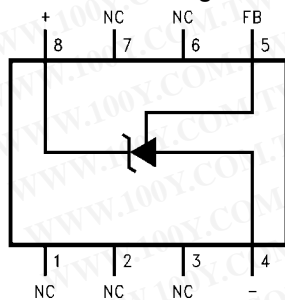
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Bottom View

TO-46  
Metal Can Package



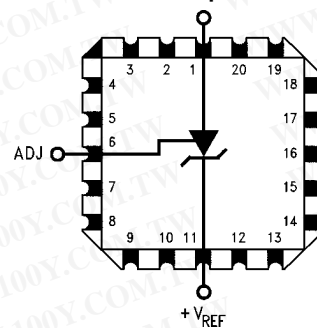
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Bottom View

SOIC Package



525010  
Top View

20-Leadless Chip Carrier

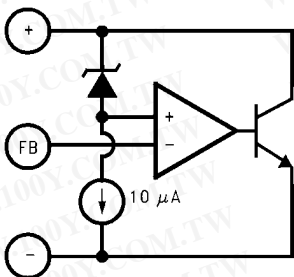


525015  
Top View

## Ordering Information

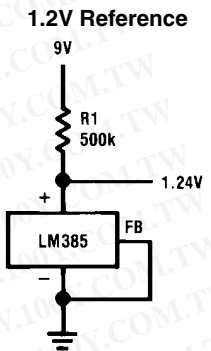
Package	Temperature Range			NSC Drawing
	-55°C to 125°C	-40°C to 85°C	0°C to 70°C	
TO-46	LM185BH			H03H
	LM185BH/883			
	LM185BYH			
	LM185BYH/883			
TO-92		LM285BXZ	LM385BXZ	Z03A
		LM285BYZ	LM385BYZ	
		LM285Z	LM385BZ	
			LM385Z	
8-Pin SOIC		LM285M	LM385M	M08A
		LM285BYM	LM385BM	
20-Leadless Chip Carrier	LM185BE/883			E20A

## Block Diagram

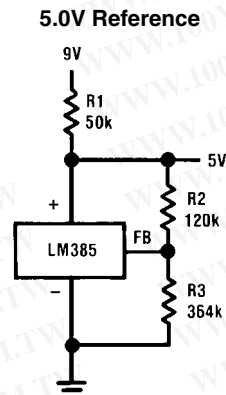


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## Typical Applications



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$$V_{OUT} = 1.24 \left( \frac{R_3}{R_2} + 1 \right)$$

**Absolute Maximum Ratings** (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

(Note 2)

Reverse Current	30mA
Forward Current	10mA
Operating Temperature Range (Note 3)	
LM185 Series	-55°C to 125°C
LM285 Series	-40°C to 85°C
LM385 Series	0°C to 70°C

ESD Susceptibility (Note 8)	2kV
Storage Temperature	-55°C to 150°C
Soldering Information	
TO-92 Package (10 sec.)	260°C
TO-46 Package (10 sec.)	300°C
SO 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.

**Electrical Characteristics** (Note 4)

Parameter	Conditions	LM185, LM285					LM385					Units (Limit)
		Typ	LM185BX, LM185BY LM185B, LM285BX, LM285BY		LM285		Typ	LM385BX, LM385BY		LM385		
			Tested Limit (Note 5)	Design Limit (Note 6)	Tested Limit (Note 5)	Design Limit (Note 6)		Tested Limit (Note 5)	Design Limit (Note 6)	Tested Limit (Note 5)	Design Limit (Note 6)	
Reference Voltage	$I_R = 100\mu A$	1.240	1.252 <b>1.255</b> 1.228 <b>1.215</b>		1.265 <b>1.270</b>	1.240	1.252 <b>1.255</b> 1.228 <b>1.215</b>	1.265 <b>1.270</b>	1.265 <b>1.270</b>	V  (max) V (min)		
Reference Voltage Change with Current	$I_{MIN} < I_R < 1mA$ $1mA < I_R < 20mA$	0.2 4	1 10	<b>1.5</b> <b>20</b>	1 10	<b>1.5</b> <b>20</b>	0.2 5	1 15	<b>1.5</b> <b>25</b>	1 15	<b>1.5</b> <b>25</b>	mV (max)
Dynamic Output Impedance	$I_R = 100\mu A$ , $f = 100Hz$ $I_{AC} = 0.1 I_R$ , $V_{OUT} = V_{REF}$ $V_{OUT} = 5.3V$	0.3 0.7					0.4 1					$\Omega$
Reference Voltage Change with Output Voltage	$I_R = 100\mu A$	1	3	<b>6</b>	3	<b>6</b>	2	5	<b>10</b>	5	<b>10</b>	mV (max)
Feedback Current		13	20	<b>25</b>	20	<b>25</b>	16	30	<b>35</b>	30	<b>35</b>	nA (max)
Minimum Operating Current (see curve)	$V_{OUT} = V_{REF}$ $V_{OUT} = 5.3V$	6 30	9 45	<b>10</b> <b>50</b>	9 45	<b>10</b> <b>50</b>	7 35	11 55	<b>13</b> <b>60</b>	11 55	<b>13</b> <b>60</b>	$\mu A$ (max)
Output Wideband Noise	$I_R = 100\mu A$ , $10Hz < f < 10kHz$ $V_{OUT} = V_{REF}$ $V_{OUT} = 5.3V$	50 170					50 170					$\mu V_{rms}$

Parameter	Conditions	LM185, LM285				LM385				Units (Limit)		
		Typ	LM185BX, LM185BY LM185B, LM285BX, LM285BY		LM285		Typ	LM385BX, LM385BY			LM385	
			Tested Limit (Note 5)	Design Limit (Note 6)	Tested Limit (Note 5)	Design Limit (Note 6)		Tested Limit (Note 5)	Design Limit (Note 6)		Tested Limit (Note 5)	Design Limit (Note 6)
Average Temperature Coefficient (Note 7)	$I_R = 100\mu A$ X Suffix Y Suffix All Others		<b>30</b> <b>50</b>					<b>30</b> <b>50</b>				ppm/ °c (max)
Long Term Stability	$I_R = 100\mu A$ , $T = 1000$ Hr, $T_A = 25^\circ C \pm 0.1^\circ C$	20					20					ppm

**Note 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, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed.

**Note 2:** Refer to RETS185H for military specifications.

**Note 3:** For elevated temperature operation,  $T_{j,max}$  is:

LM185	150°C
LM285	125°C
LM385	100°C

Thermal Resistance	TO-92	TO-46	SO-8
$\theta_{JA}$ (Junction to Ambient)	180°C/W (0.4 leads) 170°C/W (0.125 leads)	440°C/W	165°C/W
$\theta_{JC}$ (Junction to Case)	N/A	80°C/W	N/A

**Note 4:** Parameters identified with **boldface type** apply at temperature extremes. All other numbers apply at  $T_A = T_J = 25^\circ C$ . Unless otherwise specified, all parameters apply for  $V_{REF} < V_{OUT} < 5.3V$ .

**Note 5:** Guaranteed and 100% production tested.

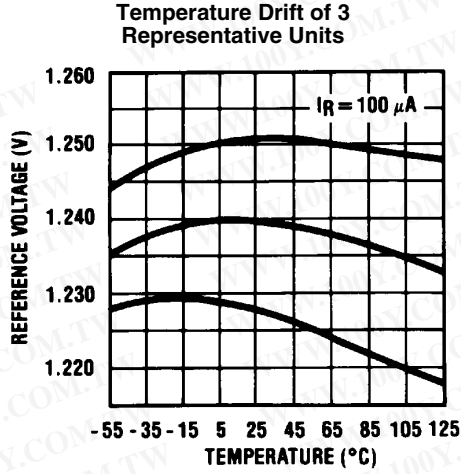
**Note 6:** Guaranteed, but not 100% production tested. These limits are not to be used to calculate average outgoing quality levels.

**Note 7:** 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.

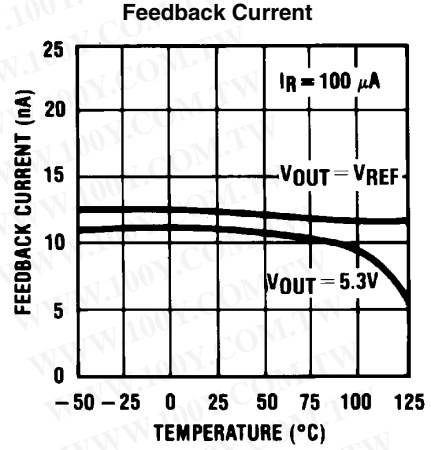
**Note 8:** The human body model is a 100 pF capacitor discharged through a 1.5 kΩ resistor into each pin.

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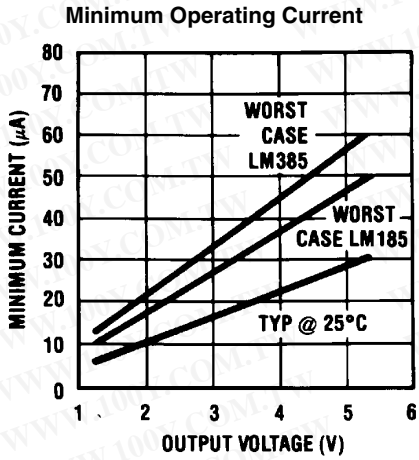
# Typical Performance Characteristics



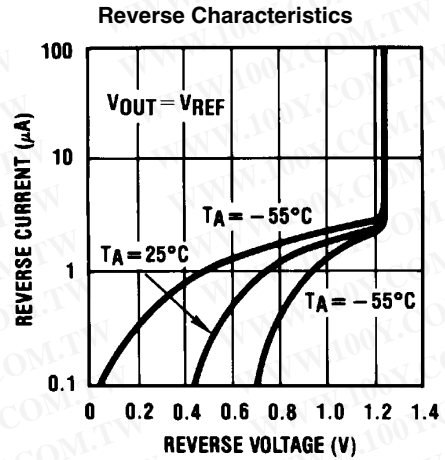
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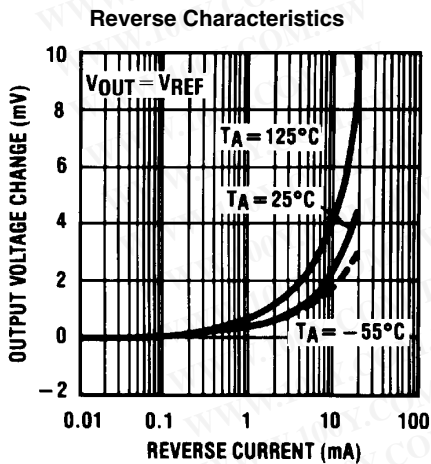
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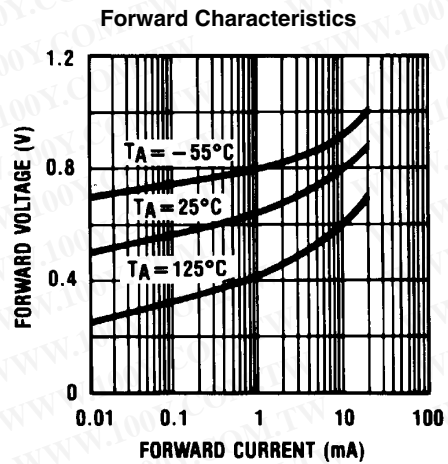
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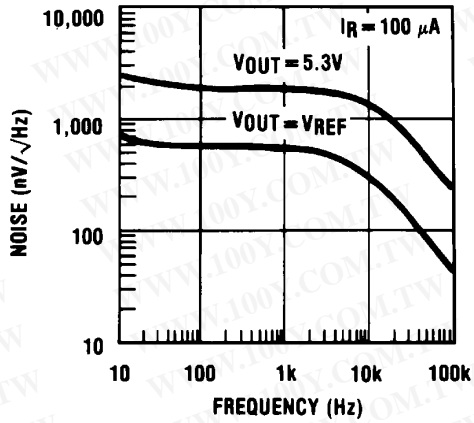


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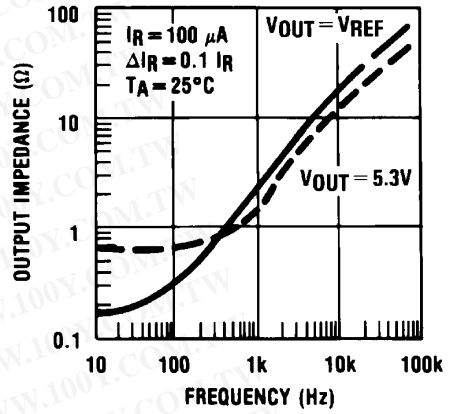
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Output Noise Voltage



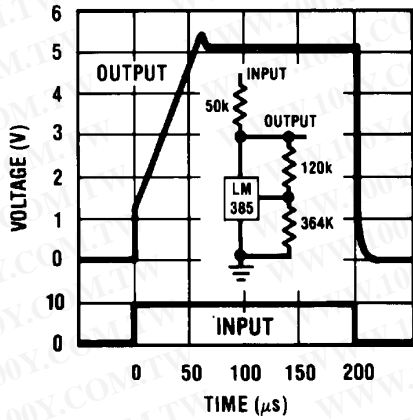
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Dynamic Output Impedance



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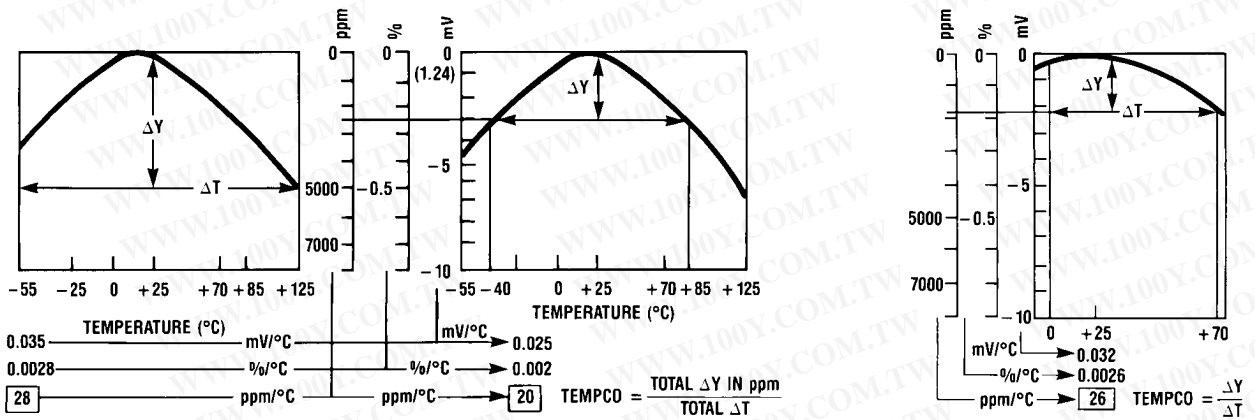
Response Time



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Temperature Coefficient Typical  
 LM185 LM285 LM385

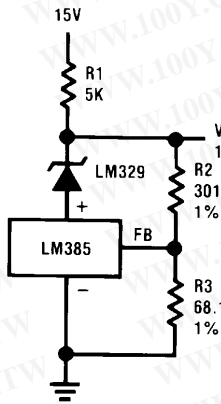


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# Typical Applications

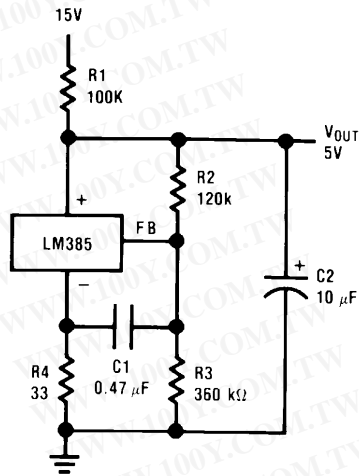
LM185/LM285/LM385

**Precision 10V Reference**



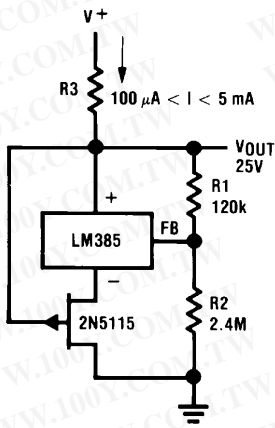
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**Low AC Noise Reference**



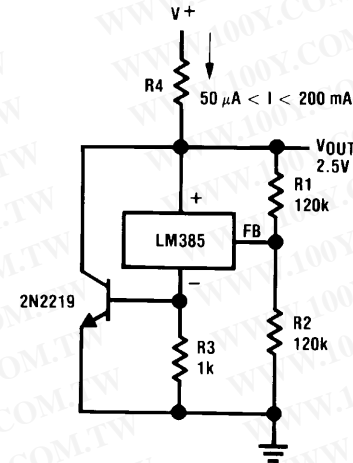
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**25V Low Current Shunt Regulator**



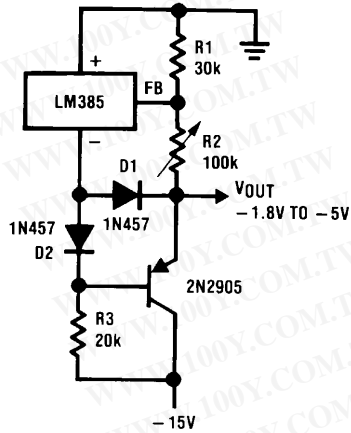
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**200 mA Shunt Regulator**



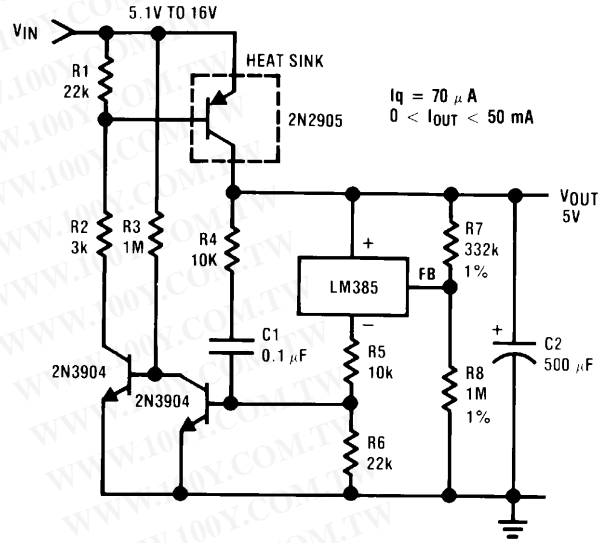
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Series-Shunt 20 mA Regulator



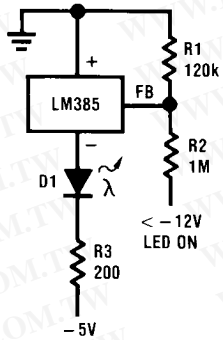
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High Efficiency Low Power Regulator



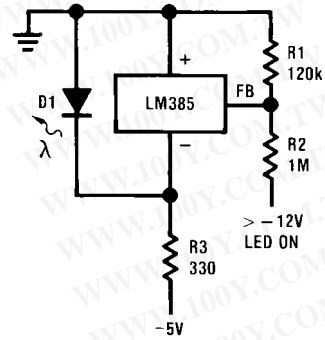
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Voltage Level Detector



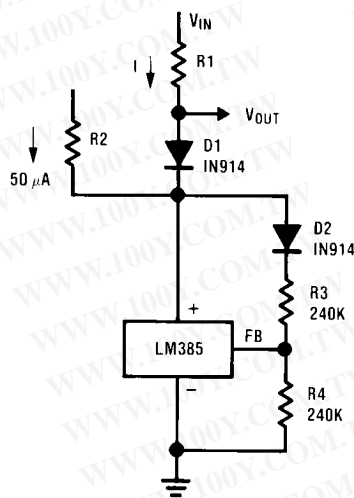
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Voltage Level Detector



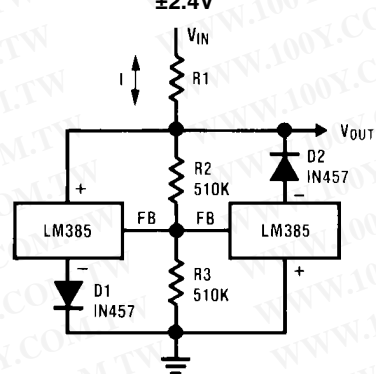
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Fast Positive Clamp  
2.4V + ΔV<sub>D1</sub>



525033

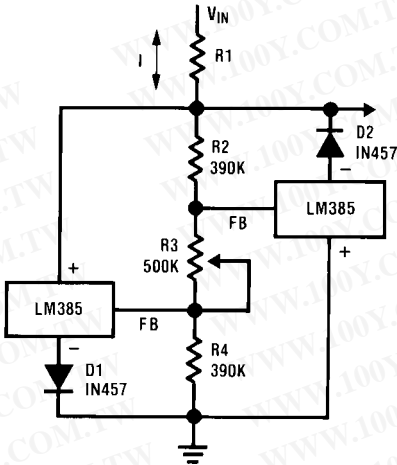
Bidirectional Clamp  
±2.4V



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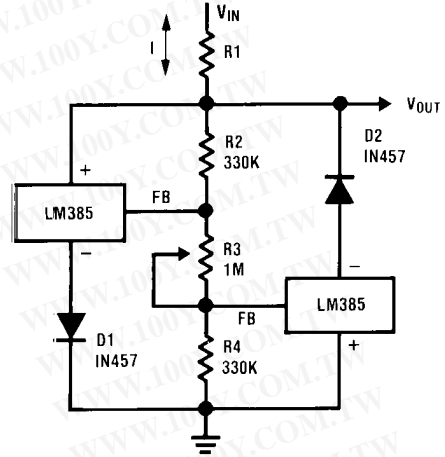
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**Bidirectional Adjustable Clamp**  
±1.8V to ±2.4V



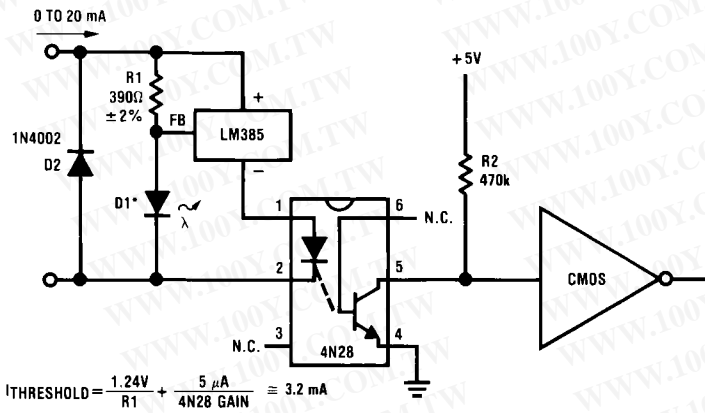
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**Bidirectional Adjustable Clamp**  
±2.4V to ±6V



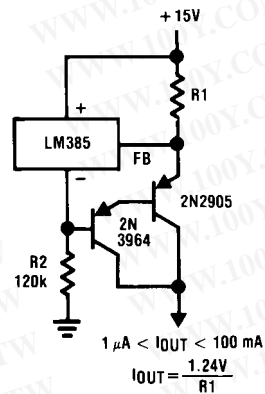
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**Simple Floating Current Detector**



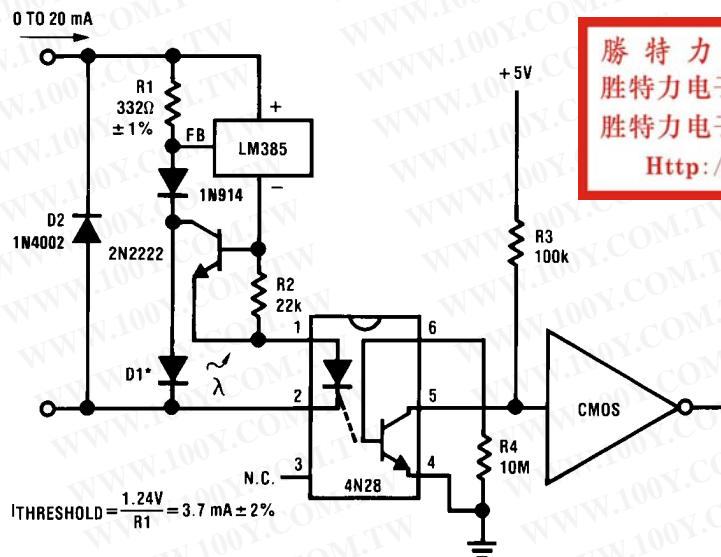
525037

**Current Source**



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**Precision Floating Current Detector**

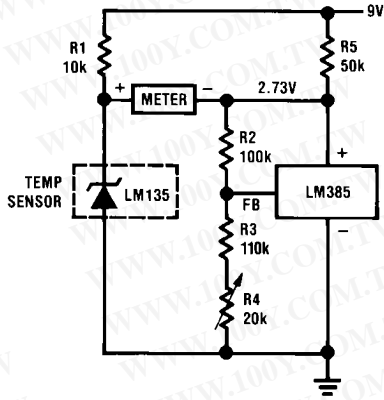


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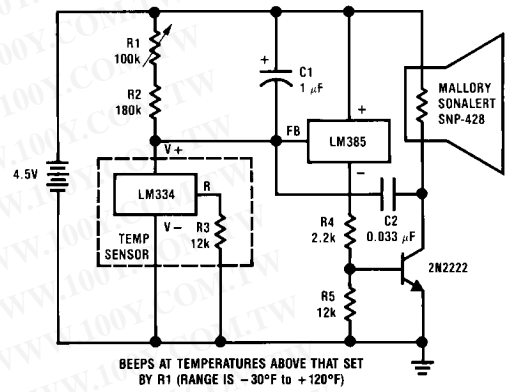
\*D1 can be any LED,  $V_f=1.5V$  to  $2.2V$  at  $3\text{ mA}$ . D1 may act as an indicator. D1 will be on if  $I_{\text{THRESHOLD}}$  falls below the threshold current, except with  $I=0$ .

Centigrade Thermometer,  $10\text{mV}/^\circ\text{C}$



525011

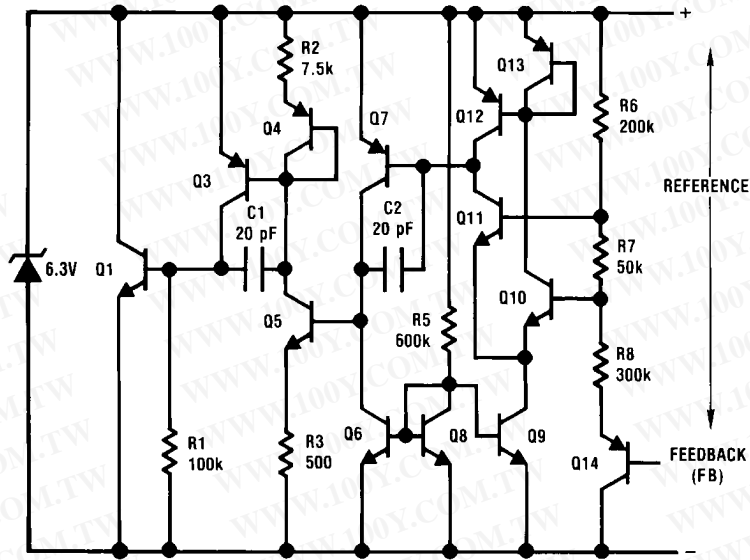
Freezer Alarm



BEEPS AT TEMPERATURES ABOVE THAT SET BY R1 (RANGE IS  $-30^\circ\text{F}$  to  $+120^\circ\text{F}$ )

525012

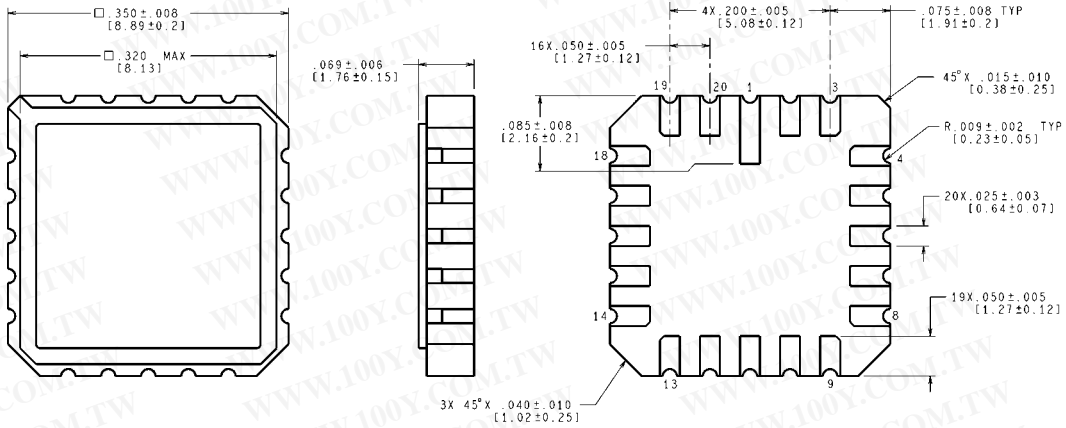
### Schematic Diagram



525008

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**Physical Dimensions** inches (millimeters) unless otherwise noted

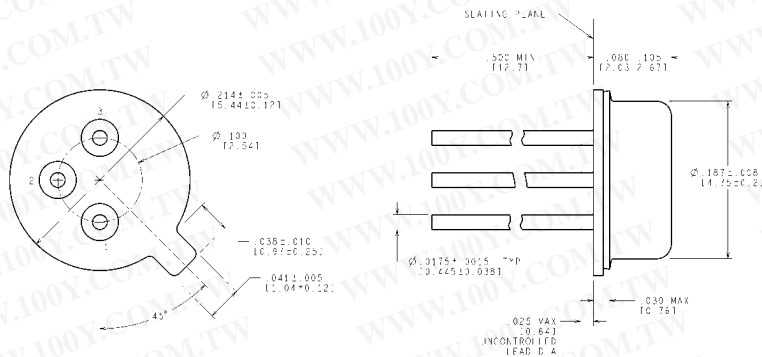


CONTROLLING DIMENSION IS INCH  
VALUES IN [ ] ARE MILLIMETERS

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**20-Leadless Chip Carrier (E)**  
**NS Package Number E20A**

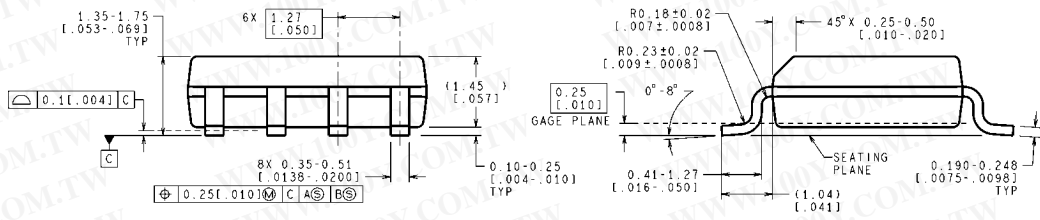
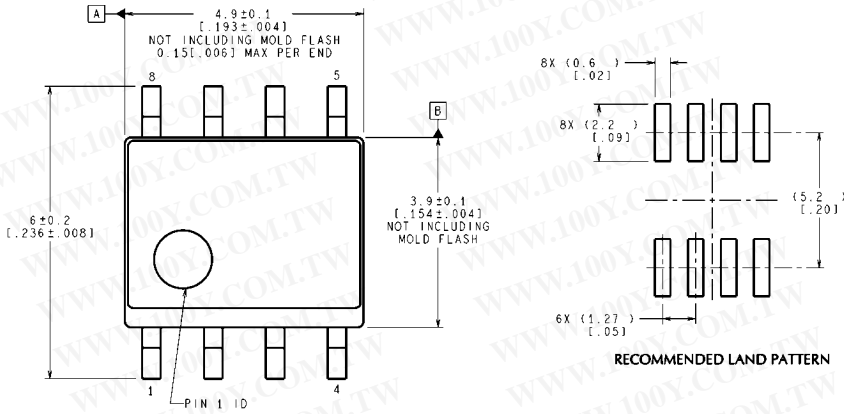
E20A (Rev F)



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**TO-46 Metal Can Package (H)**  
**NS Package Number H03H**

H03H (Rev F)

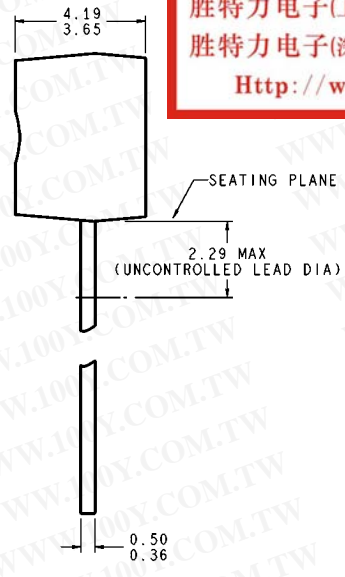
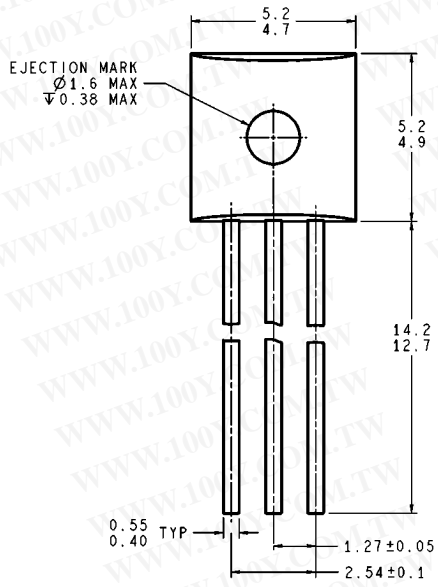


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VALUES IN [ ] ARE INCHES  
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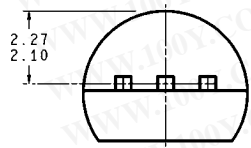
M08A (Rev L)

**SO Package (M)  
NS Package Number M08A**

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DIMENSIONS ARE IN MILLIMETERS



**TO-92 Plastic Package (Z)  
NS Package Number Z03A**

Z03A (Rev G)

## Notes

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## Notes

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Audio	<a href="http://www.national.com/audio">www.national.com/audio</a>	Analog University	<a href="http://www.national.com/AU">www.national.com/AU</a>
Clock Conditioners	<a href="http://www.national.com/timing">www.national.com/timing</a>	App Notes	<a href="http://www.national.com/appnotes">www.national.com/appnotes</a>
Data Converters	<a href="http://www.national.com/adc">www.national.com/adc</a>	Distributors	<a href="http://www.national.com/contacts">www.national.com/contacts</a>
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