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## Precision Adjustable Shunt Regulator

### FEATURES

- Trimmed Bandgap: 0.5%, 1% and 2%
- Wide Operating Current: 1mA to 150mA
- Extended Temperature Range: 0°C to 105°C
- Low Temperature Coefficient: 30 ppm/°C
- Improved Replacement in Performance for TL431
- Low Cost Solution
- Available in Lead Free, RoHS compliant packaging: SOIC, SOT-89, SOT-23-3, SOT-23-5, and TO-92

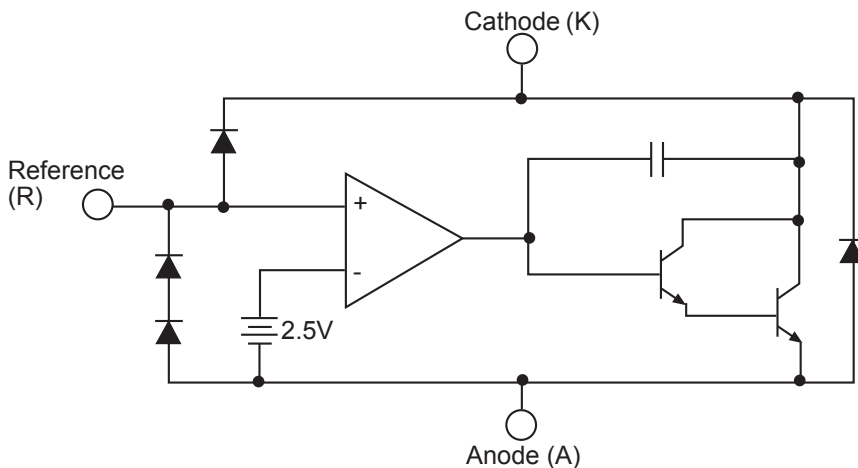
### APPLICATIONS

- Battery Operated Equipment
- Adjustable Supplies
- Switching Power Supplies
- Error Amplifiers
- Single Supply Amplifier
- Monitors/VCRs/TVs
- Personal Computers

### DESCRIPTION

The SPX431 is a three-terminal adjustable shunt voltage regulator providing a highly accurate bandgap reference. The SPX431 acts as an open-loop error amplifier with a 2.5V temperature compensation reference. The SPX431 has thermal stability, wide operating current of 150mA and broad temperature range of 0°C to 150°C, making it suitable for a variety of applications which require a low-cost, high performance solution. SPX431A tolerance of 0.5% is proven to be sufficient to overcome all other errors in the system to virtually eliminate the need for trimming in the power supply manufacturer's assembly line and contribute a significant cost savings. The output voltage may be adjusted to any value between  $V_{REF}$  and 36 volts with two external resistors. The SPX431 is available in SOIC-8, SOT-23-3, SOT-23-5, SOT89, and TO-92 packages.

### TYPICAL APPLICATIONS CIRCUIT



## ABSOLUTE MAXIMUM RATINGS

Cathode-Anode Reverse Breakdown $V_{KA}$	.....37V
Anode-Cathode Forward Current, (<10ms) $I_{AK}$	.....1A
Operating Cathode Current $I_{KA}$	.....150mA
Reference Input Current $I_{REF}$	.....10mA
Continuous Power Dissipation at 25°C $P_D$	
SOIC-8	.....750mW
SOT-23-5	.....200 mW
SOT-23-3	.....417 mW
SOT-89	.....1000mW
TO-92	.....775mW
Junction Temperature $T_J$	.....150 °C
Storage Temperature $T_{STG}$	.....-65 to 150 °C

**NOTE:** Stresses greater than those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

## RECOMMENDED CONDITIONS

PARAMETER	SYMBOL	RATING	UNIT
Cathode Voltage	$V_{KA}$	$V_{REF}$ to 36	V
Cathode Current	$I_K$	10	mA

## TYPICAL THERMAL RESISTANCES

PACKAGE	$\theta_{JA}$	$\theta_{JC}$	TYPICAL DERATING
SOIC-8	124.8°C/W	45°C/W	5.7 mW/°C
TO-92	131.9°C/W	80°C/W	6.3 mW/°C
SOT-89	107.1°C/W	8°C/W	9.1 mW/°C
SOT-23-5	191°C/W	150°C/W	1.7 mW/°C
SOT-23-3	300°C/W	136°C/W	3.3 mW/°C

Typical deratings of the thermal resistances are given for ambient temperature >25°.

## ELECTRICAL CHARACTERISTICS

Electrical characteristics at 25°C  $I_K = 10mA$   $V_K = V_{REF}$ , unless otherwise specified.

Parameter	Symbol	Test Conditions	Test Circuit	SPX431A			SPX431B			SPX431C			Unit
				Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Reference Voltage	$V_{REF}$	$T_J = 0^\circ\text{C}$ to $105^\circ\text{C}$	1 1	2.490 2.469	2.503	2.515 2.536	2.470 2.449	2.495	2.520 2.541	2.445	2.495	2.545	V V
$\Delta V_{REF}$ with Temp.	TC		1		0.07	0.20		0.07	0.20		0.07	0.20	mV/ °C
Ratio of Change in $V_{REF}$ to Cathode Voltage	$\frac{\Delta V_{REF}}{\Delta V_K}$	$V_{REF}$ to 10V 10V to 36V	2	-2.7 -2	-1.0 -0.4	0.3	-2.7 -2.0	-1.0 -0.4	0.3	-2.7 -2	-1.0 -0.4	0.3	mV/ V
Reference Input Current	$I_{REF}$		2		0.7	4		0.7	4		0.7	4	µA
$I_{REF}$ Temp Deviation	$\Delta I_{REF}$	$T_J = 0^\circ\text{C}$ to $105^\circ\text{C}$	2		0.4	1.2		0.4	1.2		0.4	1.2	µA
Min $I_K$ for Regulation	$I_{K(MIN)}$		1		0.4	1		0.4	1		0.4	1	mA
Off State Leakage	$I_{K(OFF)}$	$V_{REF} = 0V$ , $V_{KA} = 36V$	3		0.04	250		0.04	500		0.04	1000	nA
Dynamic Output Impedance	$Z_{KA}$	$f_z = 1\text{kHz}$ $I_K = 1$ to 150mA	1		0.15	0.5		0.15	0.5		0.15	0.5	Ω

## CALCULATING AVERAGE TEMPERATURE COEFFICIENT (TC)

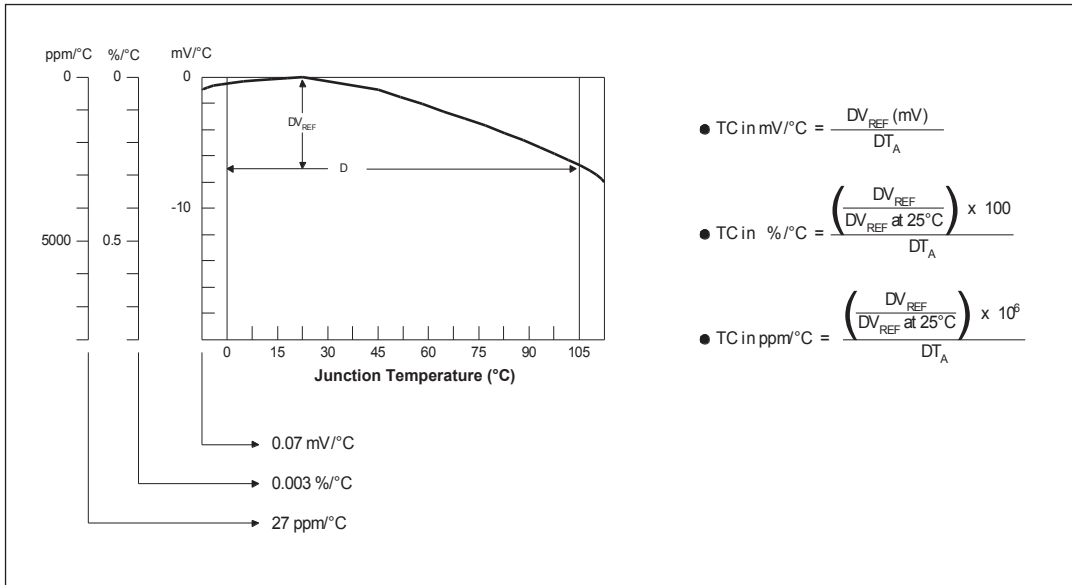
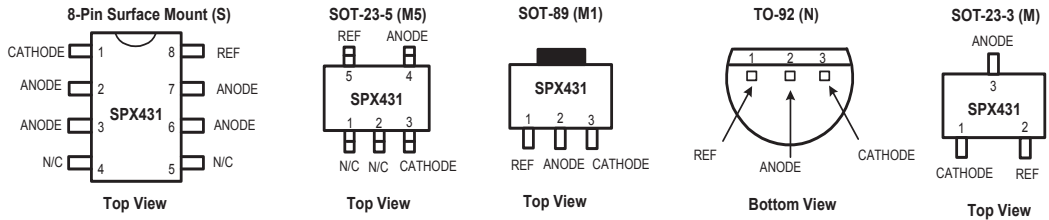
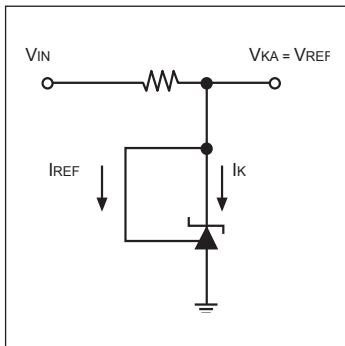


Figure 1. VREF VS Temperature.

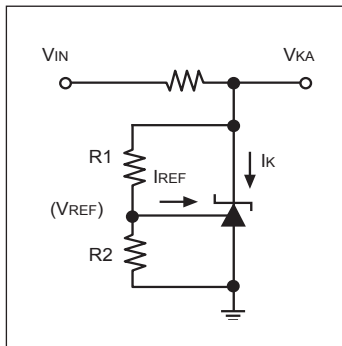
## PACKAGE PINOUTS



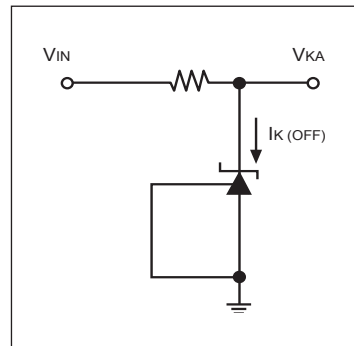
## TEST CIRCUITS



Test Circuit 1.  
Test Circuit for  $V_{KA} = V_{REF}$

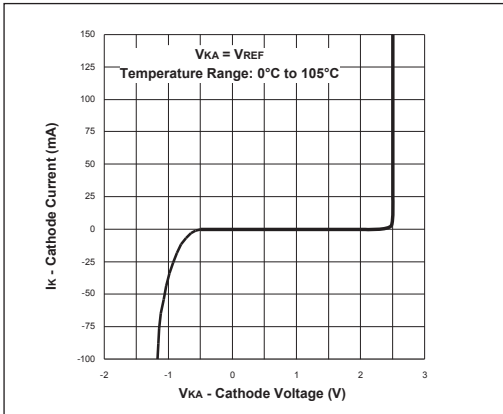


Test Circuit 2.  
Test Circuit for  $V_{KA} > V_{REF}$

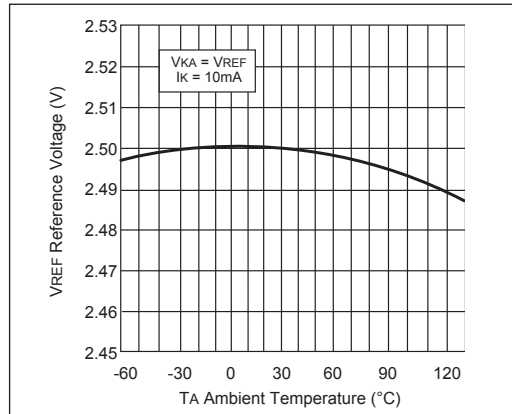


Test Circuit 3.  
Test Circuit for  $I_{k(OFF)}$

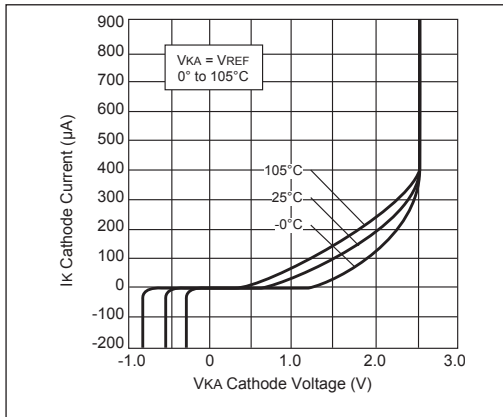
# TYPICAL PERFORMANCE CHARACTERISTICS



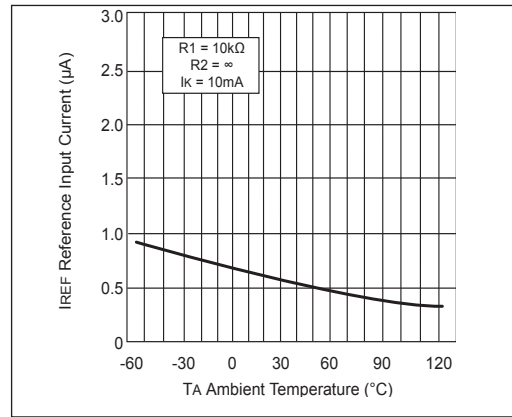
High Current Operating Characteristics



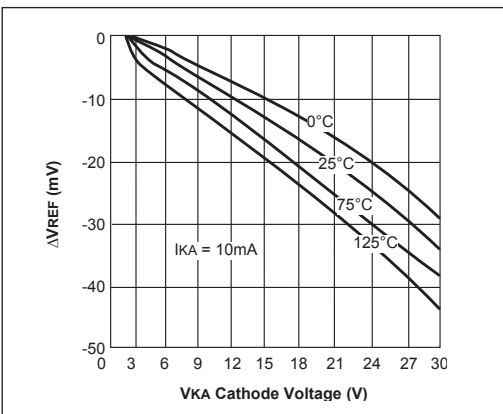
Reference Voltage vs. Ambient Temperature



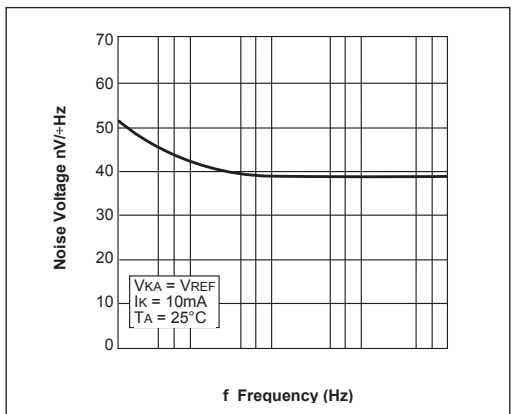
Low Current Operating Characteristics



Reference Input Current vs. Ambient Temperature

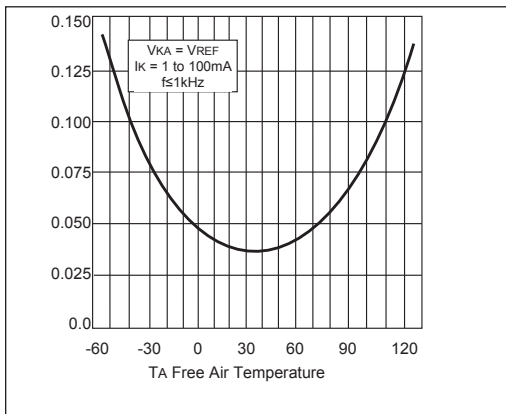


Reference Voltage Line Regulation vs. Cathode Voltage and  $T_{AMBIENT}$

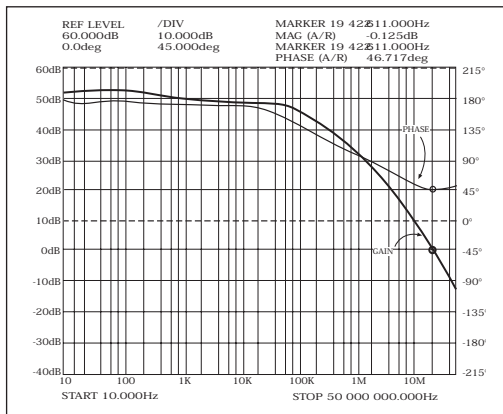


Noise Voltage vs. Frequency

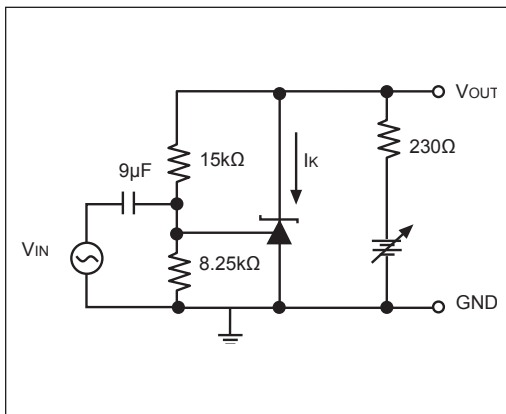
# TYPICAL PERFORMANCE CHARACTERISTICS (continued)



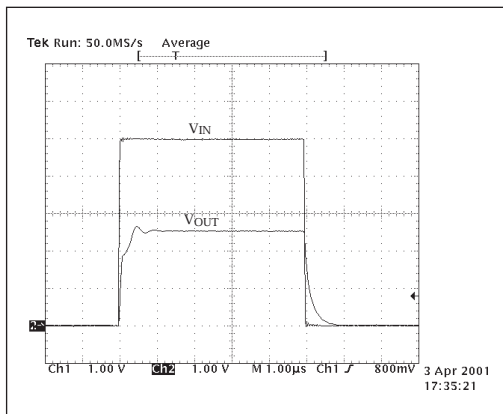
Low Frequency Dynamic Output Impedance vs.  $T_{AMBIENT}$



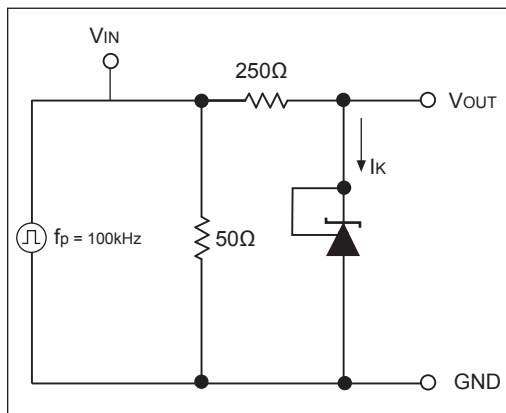
Small Signal Gain and Phase vs. Frequency;  $I_k = 10\text{mA}$ ,  $T_A = 25^\circ\text{C}$



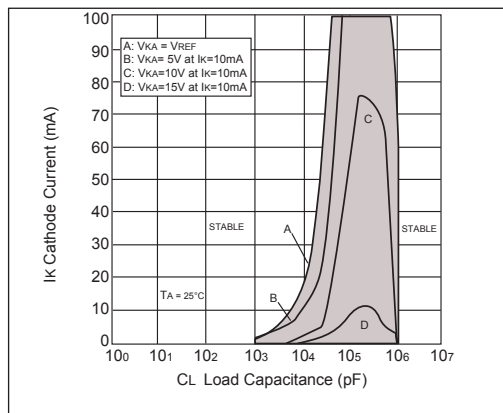
Test Circuit for Gain and Phase Frequency Response



$f_z = 100\text{kHz}$ ,  $I_k = 10\text{mA}$ ,  $T_A = 25^\circ\text{C}$

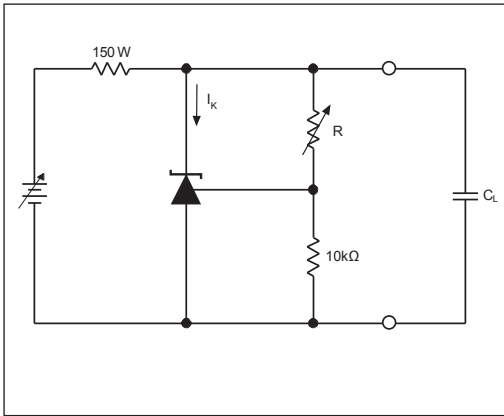


Test Circuit for Pulse Response

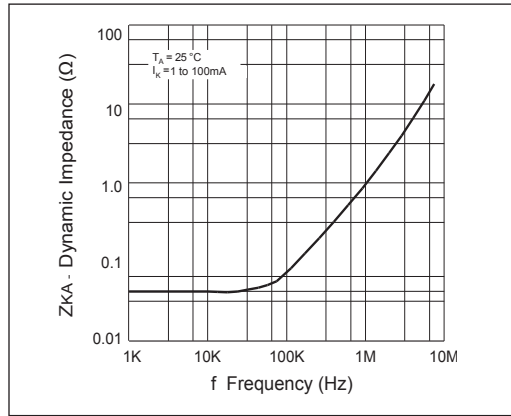


Stability Boundry Conditions

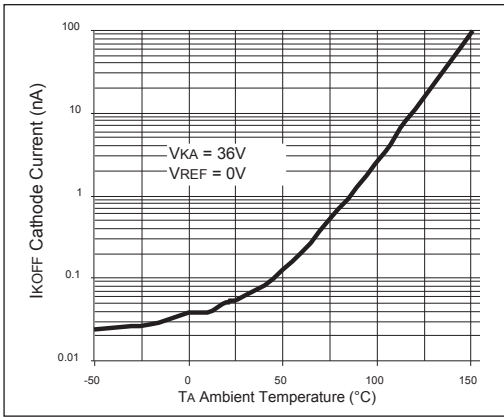
TYPICAL PERFORMANCE CHARACTERISTICS (continued)



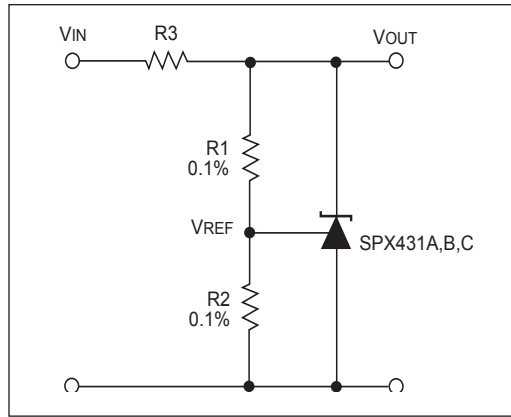
Test Circuit for Stability



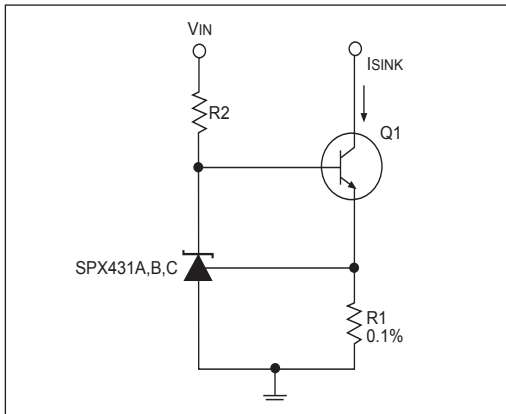
Dynamic Output Impedance T<sub>A</sub> = 25 °C, I<sub>K</sub> = 1 to 100mA



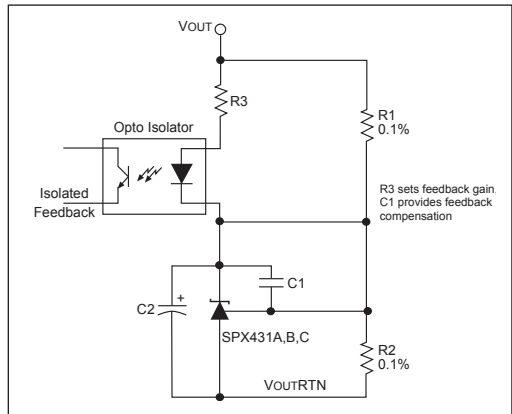
Off-State Leakage



Shunt Regulator V<sub>OUT</sub> = (1+R<sub>1</sub>/R<sub>2</sub>)V<sub>REF</sub>



Constant Current, Sink, I<sub>SINK</sub> = V<sub>REF</sub>/R<sub>1</sub>



Reference Amplifier for Isolated Feedback in Off-Line DC-DC Converters

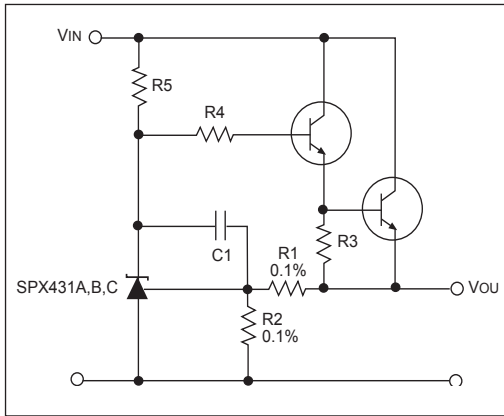


Figure 23. Precision High Current Series Regulator  
 $V_{OUT} = (1+R1/R2)V_{REF}$

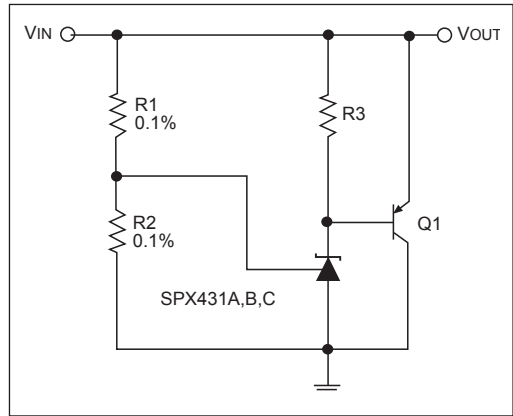


Figure 24. High Current Shunt Regulator  
 $V_{OUT} = (1+R1/R2)V_{REF}$

\* Resistor values are chosen such that the effect to  $I_{REF}$  is negligible.

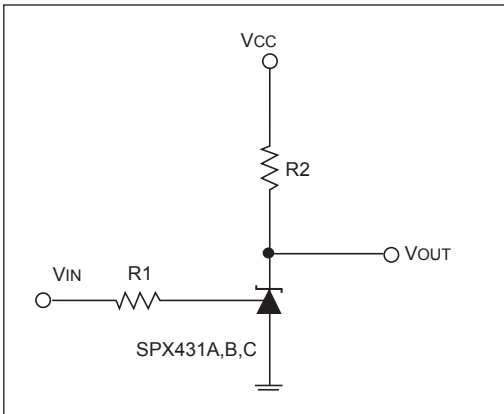
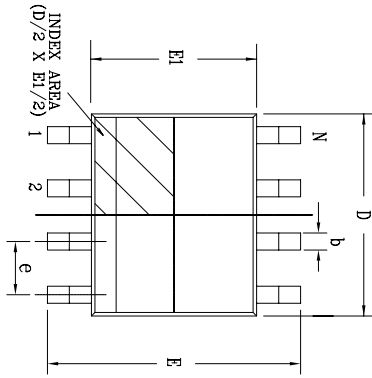


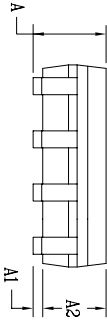
Figure 25. Single Supply Comparator with Temperature Compensated Threshold.  $V_{IN}$  Threshold = 2.5V



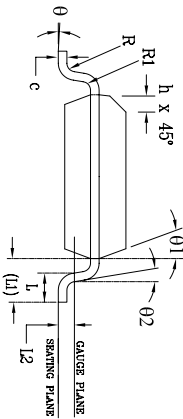
REVISION HISTORY			
REV.	DESCRIPTION	DATE	APP'D
A	DRAWING ORIGINATION	08/16/05	JL
B	DRAWING FORMAT MODIFICATION	07/19/06	JL



Top View



Side View

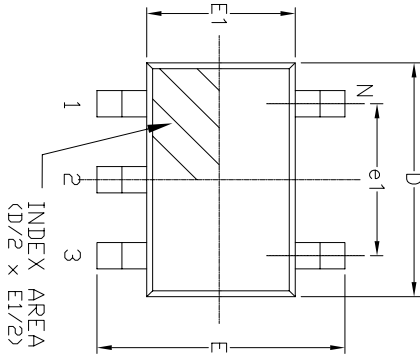


Front View

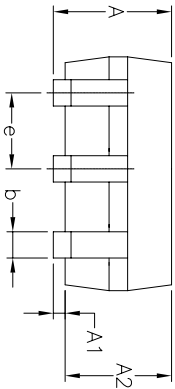
8 Pin SOICN		JEDEC MS-012		Variation AA		
SYMBOLS	DIMENSIONS IN MM (Control Unit)			DIMENSIONS IN INCH (Reference Unit)		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	1.35	—	1.75	0.053	—	0.069
A1	0.10	—	0.25	0.004	—	0.010
A2	1.25	—	1.65	0.049	—	0.065
b	0.31	—	0.51	0.012	—	0.020
c	0.17	—	0.25	0.007	—	0.010
E	6.00	BSC	—	0.236	BSC	—
E1	3.90	BSC	—	0.154	BSC	—
e	1.27	BSC	—	0.050	BSC	—
h	0.25	—	0.50	0.010	—	0.020
L	0.40	—	1.27	0.016	—	0.050
L1	1.04	REF	—	0.041	REF	—
L2	0.25	BSC	—	0.010	BSC	—
R	0.07	—	—	0.003	—	—
R1	0.07	—	—	0.003	—	—
0	0°	—	8°	0°	—	8°
01	5°	—	15°	5°	—	15°
02	0°	—	—	0°	—	—
D	4.90	BSC	—	0.193	BSC	—
N	8	—	—	8	—	—

		SIPEX CORPORATION	
		8 PIN SOICN PACKAGE OUTLINE	
Packaging Approval:	By: JL	Date: 07/19/06	Revision: B
Drawing No:	8-PIN SOICN		Sheet: 1 OF 1

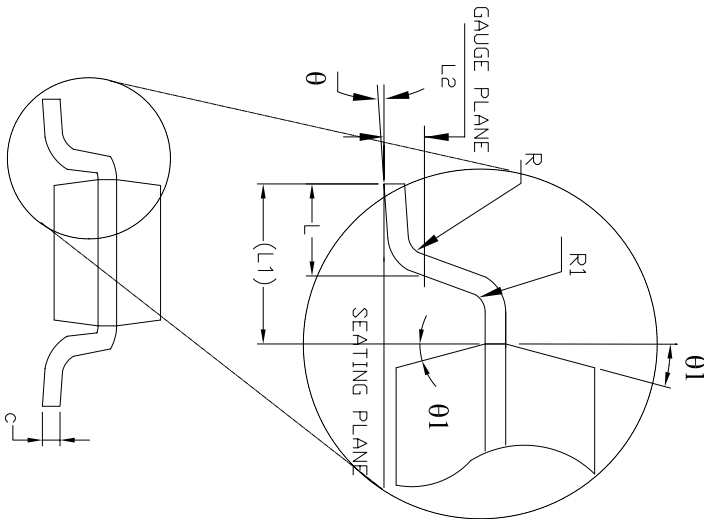
Top View



Side View




Front View

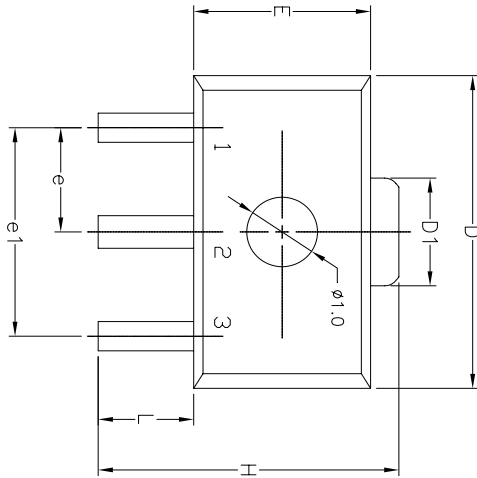


5 Pin SOT-23 JEDEC MO-178 Variation AA		DIMENSIONS IN MM (Control Unit)				DIMENSIONS IN INCH (Reference Unit)			
SYMBOLS	MIN	NOM	MAX	MIN	NOM	MAX			
A	—	1.45	—	—	0.057	—			
A1	0.00	—	0.15	0.000	—	0.006			
A2	0.90	1.15	1.30	0.036	0.045	0.051			
b	0.30	—	0.50	0.012	—	0.020			
c	0.08	—	0.22	0.003	—	0.009			
D	2.90	BSC	—	0.115	BSC	—			
E	2.80	BSC	—	0.111	BSC	—			
E1	1.60	BSC	—	0.063	BSC	—			
e	0.95	BSC	—	0.038	BSC	—			
e1	1.90	BSC	—	0.075	BSC	—			
L	0.30	0.45	0.60	0.012	0.018	0.024			
L1	0.60	REF	—	0.024	REF	—			
L2	0.25	BSC	—	0.010	BSC	—			
R	0.10	—	—	0.004	—	—			
R1	0.10	—	0.25	0.004	—	0.010			
theta	0°	4°	8°	0°	4°	8°			
theta1	5°	10°	15°	5°	10°	15°			
N	5	5	5	5	5	5			

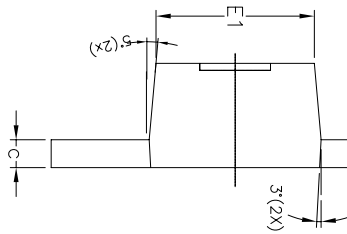
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REV.	DESCRIPTION	DATE	APP'D
A	DRAWING ORIGINATOR	10/27/05	JL
B	DRAWING FORMAT MODIFICATION	07/25/06	JL

	<b>SIPEX CORPORATION</b>	
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Packaging Approval:	Drawing No:	5-PIN SOT-23
By: JL Date: 07/25/06	Revision: B	Sheet: 1 OF 1

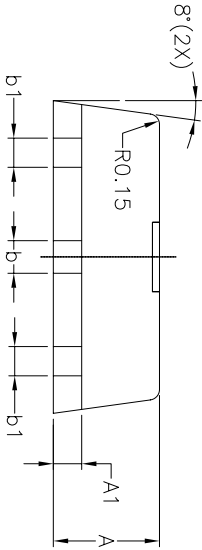
Top View



Front View




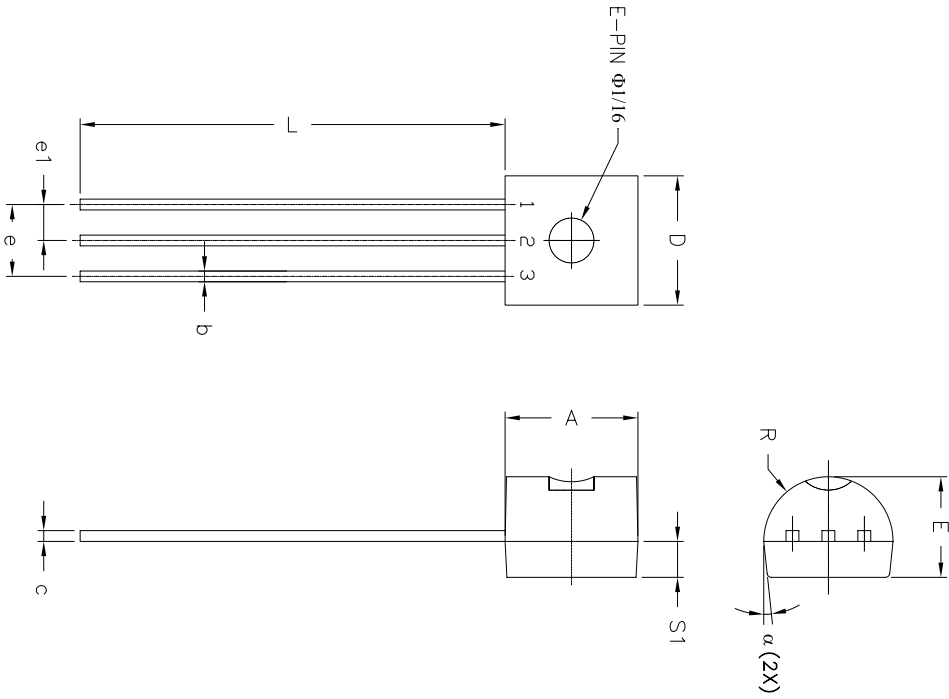
Side View



REVISION HISTORY			
REV.	DESCRIPTION	DATE	APP'D
A	DRAWING ORIGINATION	02/02/06	JL
B	DRAWING FORMAT MODIFICATION	09/11/06	JL


3 Pin SOT-89 JEDEC TO-243 Variation AA							
SYMBOLS	DIMENSIONS IN MM (Control Unit)			DIMENSIONS IN INCH (Reference Unit)			
	MIN	NOM	MAX	MIN	NOM	MAX	
A	1.40	1.50	1.60	0.055	0.059	0.063	
A1	0.30	0.40	0.50	0.011	0.015	0.019	
b	0.44	0.47	0.56	0.017	0.018	0.022	
b1	0.36	0.42	0.48	0.014	0.016	0.019	
c	0.35	0.40	0.44	0.014	0.015	0.017	
D	4.40	4.50	4.60	0.173	0.177	0.181	
D1	1.62	1.60	1.83	0.064	0.062	0.072	
E	2.29	2.50	2.60	0.090	0.098	0.102	
E1	2.13	—	2.29	0.084	—	0.090	
e	1.50	BSC	—	0.059	BSC	—	
e1	3.00	BSC	—	0.118	BSC	—	
H	3.94	—	4.25	0.155	—	0.167	
L	0.89	—	1.20	0.035	—	0.047	
N	—	3	—	—	3	—	

		<b>SIPLEX CORPORATION</b>		
				3 PIN SOT-89 PACKAGE OUTLINE
Packaging Approval:	By: JL	Date: 09/11/06	Drawing No.:	Revision: B
		3-PIN SOT-89		Sheet: 1 OF 1

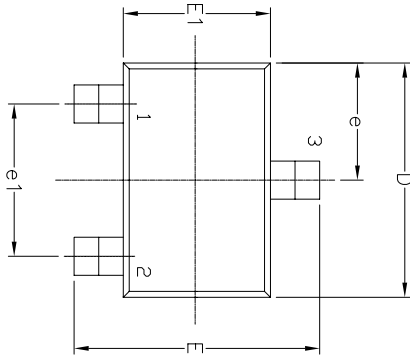


3 Pin TO-92		JEDEC TO-226-AA		
SYMBOLS	DIMENSIONS IN INCH (Control Unit)		DIMENSIONS IN MM (Reference Unit)	
	MIN	MAX	MIN	MAX
A	0.170	0.210	4.32	5.33
b	0.014	0.020	0.36	0.51
c	0.016	0.022	0.41	0.55
D	0.175	0.205	4.45	5.20
E	0.125	0.165	3.18	4.19
e	0.095	0.105	2.42	2.66
e1	0.045	0.055	1.15	1.39
L	0.500	0.610	12.70	15.49
R	0.045	0.095	2.16	2.41
S1	0.045	0.060	1.14	1.52
alpha	4°	6°	4°	6°
N	3		3	

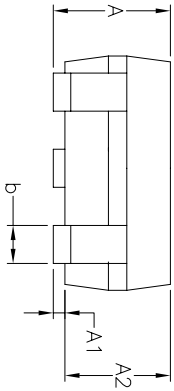
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REV.	DESCRIPTION	DATE	APP'D
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B	DRAWING FORMAT MODIFICATION	08/15/06	JL

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Packaging Approval:		Drawing No.:	
By: JL	Date: 08/15/06	Revision: B	Sheet: 1 OF 1

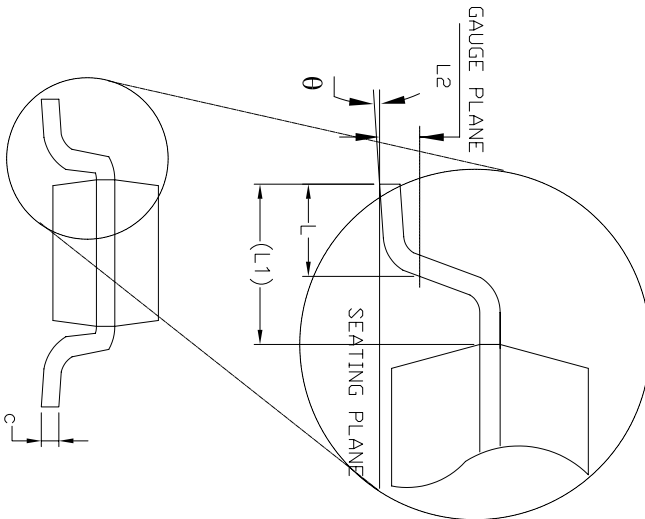
Top View



Side View




Front View



3 Pin SOT-23 JEDEC TO-236 Variation AB				
SYMBOLS	DIMENSIONS IN MM (Control Unit)		DIMENSIONS IN INCH (Reference Unit)	
	MIN	NOM	MIN	MAX
A	0.89	1.12	0.035	0.044
A1	0.01	0.10	0.000	0.004
A2	0.88	0.95	1.02	0.035
b	0.30	0.50	0.012	0.020
c	0.08	0.20	0.003	0.008
D	2.80	2.90	3.04	0.110
E	2.10	2.64	0.083	0.104
E1	1.20	1.30	1.40	0.047
e	0.95	BSC	0.038	BSC
e1	1.90	BSC	0.075	BSC
L	0.40	0.50	0.60	0.016
L1	0.54	REF	0.021	REF
L2	0.25	BSC	0.010	BSC
theta	0°	8°	0°	8°
N	3	3	3	3

REVISION HISTORY			
REV.	DESCRIPTION	DATE	APP'D
A	DRAWING ORIGINATOR	10/25/05	JL
B	DRAWING FORMAT MODIFICATION	07/25/06	JL

	SIPLEX CORPORATION		
	3 PIN SOT-23 PACKAGE OUTLINE		
Packaging Approval:	Drawing No:	3-PIN SOT-23	
By: JL	Date: 07/25/06	Revisions: B	Sheet: 1 OF 1

**ORDERING INFORMATION**

<b>PART NUMBER</b>	<b>ACCURACY</b>	<b>OUTPUT VOLTAGE</b>	<b>PACKAGE</b>
SPX431AM5 .....	0.5%	2.503V .....	5-Pin SOT-23
SPX431AM5/TR .....	0.5%	2.503V .....	5-Pin SOT-23
SPX431AM1 .....	0.5%	2.503V .....	3-Pin SOT-89
SPX431AM1/TR .....	0.5%	2.503V .....	3-Pin SOT-89
SPX431AS .....	0.5%	2.503V .....	8-Pin SOIC
SPX431AS/TR .....	0.5%	2.503V .....	8-Pin SOIC
SPX431AN .....	0.5%	2.503V .....	3-Pin TO-92
SPX431AM .....	0.5%	2.503V .....	3-Pin SOT-23
SPX431AM/TR .....	0.5%	2.503V .....	3-Pin SOT-23
SPX431BM5 .....	1.0%	2.495V .....	5-Pin SOT-23
SPX431BM5/TR .....	1.0%	2.495V .....	5-Pin SOT-23
SPX431BM1 .....	1.0%	2.495V .....	3-Pin SOT-89
SPX431BM1/TR .....	1.0%	2.495V .....	3-Pin SOT-89
SPX431BS .....	1.0%	2.495V .....	8-Pin SOIC
SPX431BS/TR .....	1.0%	2.495V .....	8-Pin SOIC
SPX431BN .....	1.0%	2.495V .....	3-Pin TO-92
SPX431BM .....	1.0%	2.495V .....	3-Pin SOT-23
SPX431BM/TR .....	1.0%	2.495V .....	3-Pin SOT-23
SPX431CM5 .....	2.0%	2.495V .....	5-Pin SOT-23
SPX431CM5/TR .....	2.0%	2.495V .....	5-Pin SOT-23
SPX431CM1 .....	2.0%	2.495V .....	3-Pin SOT-89
SPX431CM1/TR .....	2.0%	2.495V .....	3-Pin SOT-89
SPX431CS .....	2.0%	2.495V .....	8-Pin SOIC
SPX431CS/TR .....	2.0%	2.495V .....	8-Pin SOIC
SPX431CN .....	2.0%	2.495V .....	3-Pin TO-92
SPX431CM .....	2.0%	2.495V .....	3-Pin SOT-23
SPX431CM/TR .....	2.0%	2.495V .....	3-Pin SOT-23

Available in lead free packaging. To order add "-L" suffix to part number.

Example: SPX431AM5/TR = standard; SPX431AM5-L/TR = lead free

/TR = Tape and Reel

TR pack quantity is 3000 for SOT-23-3, 2500 for SOT-23-5, SOT-89 and NSOIC, and 2000 for TO-92 in ammo pack.



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