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June 2015

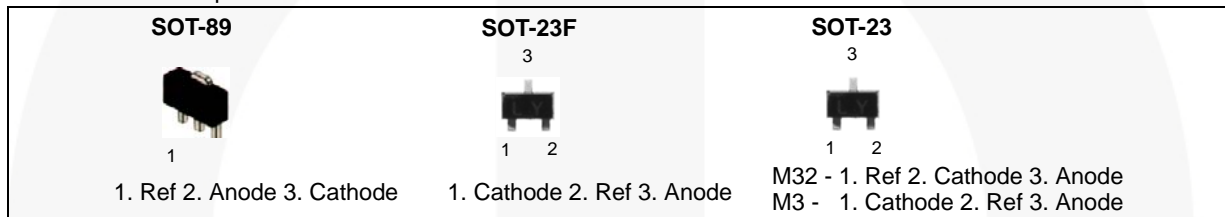
# LM431SA / LM431SB / LM431SC Programmable Shunt Regulator

## Features

- Programmable Output Voltage to 36 V
- Low Dynamic Output Impedance: 0.2 Ω (Typical)
- Sink Current Capability: 1.0 to 100 mA
- Equivalent Full-Range Temperature Coefficient of 50 ppm/°C (Typical)
- Temperature Compensated for Operation Over Full Rated Operating Temperature Range
- Low Output Noise Voltage
- Fast Turn-on Response

## Description

The LM431SA / LM431SB / LM431SC are three-terminal the output adjustable regulators with thermal stability over operating temperature range. The output voltage can be set any value between  $V_{REF}$  (approximately 2.5 V) and 36 V with two external resistors. These devices have a typical dynamic output impedance of 0.2 Ω. Active output circuit provides a sharp turn-on characteristic, making these devices excellent replacement for zener diodes in many applications.



## Ordering Information

Product Number	Output Voltage Tolerance	Operating Temperature	Top Mark <sup>(1)</sup>	Package	Packing Method	
LM431SACMFX	2%	-25 to +85°C	43A	SOT-23F 3L	Tape and Reel	
LM431SACM3X			43L	SOT-23 3L		
LM431SACM32X			43G	SOT-23 3L		
LM431SBCMLX	1%		43B	SOT-89 3L		
LM431SBCMFX			43B	SOT-23F 3L		
LM431SBCM3X			43M	SOT-23 3L		
LM431SBCM32X	0.5%		43H	SOT-23 3L		
LM431SCCMLX			43C	SOT-89 3L		
LM431SCCMFX			43C	SOT-23F 3L		
LM431SCCM3X			43N	SOT-23 3L		
LM431SCCM32X	2%		-40 to +85°C	43J		SOT-23 3L
LM431SAIMFX			43AI	SOT-23F 3L		

### Note:

1. SOT-23 and SOT-23F have basically four-character marking except LM431SAIMFX.

(3 letters for device code + 1 letter for date code)

SOT-23F date code is composed of 1 digit numeric or alphabetic week code adding bar-type year code.

> Week code: Change in every two weeks

> Year code (additional bar): Rotate in three year cycle

Week	01-02	03-04	05-06	07-08	09-10	11-12	13-14	15-16	17-18	19-20	21-22	23-24	25-26
Code	1	2	3	4	5	6	7	8	9	A	D	E	F
Week	27-28	29-30	31-32	33-34	35-36	37-38	39-40	41-42	43-44	45-46	47-48	49-50	51-52
Code	H	J	K	L	N	O	P	R	S	T	U	V	X

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Code	□	□	□	□	□	□	□	□	□	□	□

## Block Diagram

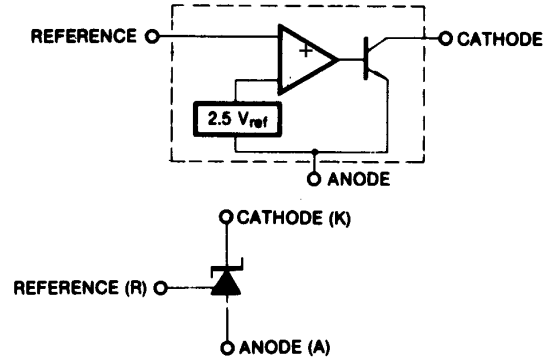


Figure 1. Block Diagram

## Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only. Values are at  $T_A = 25^\circ\text{C}$  unless otherwise noted.

Symbol	Parameter	Value	Unit
$V_{KA}$	Cathode Voltage	37	V
$I_{KA}$	Cathode current Range (Continuous)	-100 to +150	mA
$I_{REF}$	Reference Input Current Range	-0.05 to +10.00	mA
$R_{\theta JA}$	Thermal Resistance Junction-Air <sup>(2,3)</sup>	ML Suffix Package (SOT-89)	220
		MF Suffix Package (SOT-23F)	350
		M32, M3 Suffix Package (SOT-23)	400
$P_D$	Power Dissipation <sup>(4,5)</sup>	ML Suffix Package (SOT-89)	560
		MF Suffix Package (SOT-23F)	350
		M32, M3 Suffix Package (SOT-23)	310
$T_J$	Junction Temperature	150	$^\circ\text{C}$
$T_{OPR}$	Operating Temperature Range	All products except LM431SAIMFX	-25 to +85
		LM431SAIMFX	-40 to +85
$T_{STG}$	Storage Temperature Range	-65 to +150	$^\circ\text{C}$

### Notes:

- Thermal resistance test board  
Size: 1.6 mm x 76.2 mm x 114.3 mm (1S0P)  
JEDEC Standard: JESD51-3, JESD51-7.
- Assume no ambient airflow.
- $T_{JMAX} = 150^\circ\text{C}$ ; ratings apply to ambient temperature at  $25^\circ\text{C}$ .
- Power dissipation calculation:  $P_D = (T_J - T_A) / R_{\theta JA}$ .

## Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fairchild does not recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameter	Min.	Max.	Unit
$V_{KA}$	Cathode Voltage	$V_{REF}$	36	V
$I_{KA}$	Cathode Current	1	100	mA

**Electrical Characteristics<sup>(6)</sup>**Values are at  $T_A = 25^\circ\text{C}$  unless otherwise noted.

Symbol	Parameter	Conditions	LM431SA			LM431SB			LM431SC			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
$V_{REF}$	Reference Input Voltage	$V_{KA} = V_{REF}$ , $I_{KA} = 10\text{ mA}$	2.450	2.500	2.550	2.470	2.495	2.520	2.482	2.495	2.508	V
$\Delta V_{REF} / \Delta T$	Deviation of Reference Input Voltage Over-Temperature	$V_{KA} = V_{REF}$ , $I_{KA} = 10\text{ mA}$ , $T_{MIN} \leq T_A \leq T_{MAX}$	SOT-89 SOT-23F	4.5	17.0		4.5	17.0		4.5	17.0	mV
			SOT-23	6.6	24		6.6	24		6.6	24	mV
$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	$I_{KA} = 10\text{ mA}$	$\Delta V_{KA} = 10\text{ V} - V_{REF}$	-1.0	-2.7		-1.0	-2.7		-1.0	-2.7	mV/V
			$\Delta V_{KA} = 36\text{ V} - 10\text{ V}$	-0.5	-2.0		-0.5	-2.0		-0.5	-2.0	
$I_{REF}$	Reference Input Current	$I_{KA} = 10\text{ mA}$ , $R_1 = 10\text{ K}\Omega$ , $R_2 = \infty$		1.5	4.0		1.5	4.0		1.5	4.0	$\mu\text{A}$
$\Delta I_{REF} / \Delta T$	Deviation of Reference Input Current Over Full Temperature Range	$I_{KA} = 10\text{ mA}$ , $R_1 = 10\text{ K}\Omega$ , $R_2 = \infty$ , $T_A = \text{Full Range}$	SOT-89 SOT-23F	0.4	1.2		0.4	1.2		0.4	1.2	$\mu\text{A}$
			SOT-23	0.8	2.0		0.8	2.0		0.8	2.0	$\mu\text{A}$
$I_{KA(MIN)}$	Minimum Cathode Current for Regulation	$V_{KA} = V_{REF}$		0.45	1.00		0.45	1.00		0.45	1.00	mA
$I_{KA(OFF)}$	Off -Stage Cathode Current	$V_{KA} = 36\text{ V}$ , $V_{REF} = 0$		0.05	1.00		0.05	1.00		0.05	1.00	$\mu\text{A}$
$Z_{KA}$	Dynamic Impedance	$V_{KA} = V_{REF}$ , $I_{KA} = 1\text{ to }100\text{ mA}$ , $f \geq 1.0\text{ kHz}$		0.15	0.50		0.15	0.50		0.15	0.50	$\Omega$

**Note:**6.  $T_{MIN} = -25^\circ\text{C}$ ,  $T_{MAX} = +85^\circ\text{C}$ .

### Electrical Characteristics<sup>(7, 8)</sup> (Continued)

Values are at  $T_A = 25^\circ\text{C}$  unless otherwise noted.

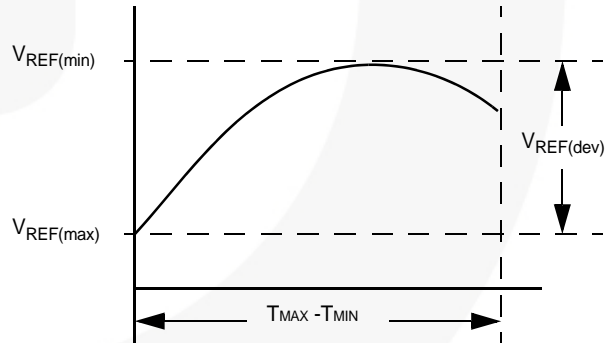
Symbol	Parameter	Conditions	LM431SAI			Unit
			Min.	Typ.	Max.	
$V_{REF}$	Reference Input Voltage	$V_{KA} = V_{REF}, I_{KA} = 10\text{ mA}$	2.450	2.500	2.550	V
$V_{REF(dev)}$	Deviation of Reference Input Voltage Over-Temperature	$V_{KA} = V_{REF}, I_{KA} = 10\text{ mA}, T_{MIN} \leq T_A \leq T_{MAX}$		5	20	mV
$\Delta V_{REF}/\Delta V_{KA}$	Ratio of Change in Reference Input Voltage to Change in Cathode Voltage	$I_{KA} = 10\text{ mA}$	$\Delta V_{KA} = 10\text{ V} - V_{REF}$	-1.0	-2.7	mV/V
			$\Delta V_{KA} = 36\text{ V} - 10\text{ V}$	-0.5	-2.0	
$I_{REF}$	Reference Input Current	$I_{KA} = 10\text{ mA}, R_1 = 10\text{ K}\Omega, R_2 = \infty$		1.5	4.0	$\mu\text{A}$
$I_{REF(dev)}$	Deviation of Reference Input Current Over Full Temperature Range	$I_{KA} = 10\text{ mA}, R_1 = 10\text{ K}\Omega, R_2 = \infty, T_{MIN} \leq T_A \leq T_{MAX}$		0.8	2.0	$\mu\text{A}$
$I_{KA(MIN)}$	Minimum Cathode Current for Regulation	$V_{KA} = V_{REF}$		0.45	1.00	mA
$I_{KA(OFF)}$	Off -Stage Cathode Current	$V_{KA} = 36\text{ V}, V_{REF} = 0$		0.05	1.00	$\mu\text{A}$
$Z_{KA}$	Dynamic Impedance	$V_{KA} = V_{REF}, I_{KA} = 1\text{ to }100\text{ mA}, f \geq 1.0\text{ kHz}$		0.15	0.50	$\Omega$

**Notes:**

7.  $T_{MIN} = -40^\circ\text{C}, T_{MAX} = +85^\circ\text{C}$ .

8. The deviation parameters  $V_{REF(dev)}$  and  $I_{REF(dev)}$  are defined as the differences between the maximum and minimum values obtained over the rated temperature range. The average full-range temperature coefficient of the reference input voltage,  $\alpha V_{REF}$ , is defined as:

$$|\alpha V_{REF}| \left( \frac{\text{ppm}}{^\circ\text{C}} \right) = \frac{\left( \frac{V_{REF(dev)}}{V_{REF(at 25^\circ\text{C})}} \right) \cdot 10^6}{T_{MAX} - T_{MIN}}$$



where  $T_{MAX} - T_{MIN}$  is the rated operating free-air temperature range of the device.

$\alpha V_{REF}$  can be positive or negative, depending on whether minimum  $V_{REF}$  or maximum  $V_{REF}$ , respectively, occurs at the lower temperature.

Example:  $V_{REF(dev)} = 4.5\text{ mV}, V_{REF} = 2500\text{ mV}$  at  $25^\circ\text{C}, T_{MAX} - T_{MIN} = 125^\circ\text{C}$  for LM431SAI.

$$|\alpha V_{REF}| = \frac{\left( \frac{4.5\text{ mV}}{2500\text{ mV}} \right) \cdot 10^6}{125^\circ\text{C}} = 14.4\text{ ppm}/^\circ\text{C}$$

Because minimum  $V_{REF}$  occurs at the lower temperature, the coefficient is positive.

Test Circuits

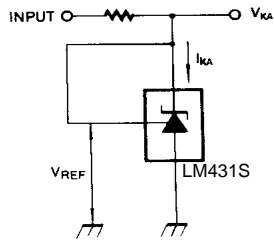


Figure 2. Test Circuit for  $V_{KA} = V_{REF}$

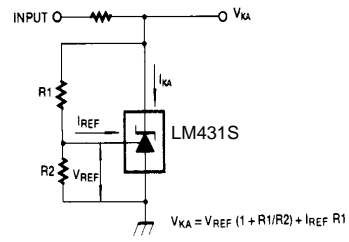


Figure 3. Test Circuit for  $V_{KA} \geq V_{REF}$

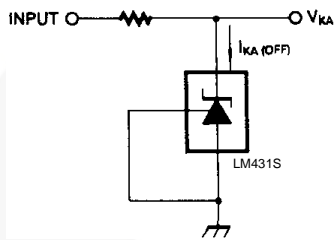


Figure 4. Test Circuit for  $I_{KA(OFF)}$



Typical Applications

$$V_O = \left(1 + \frac{R_1}{R_2}\right) V_{ref}$$

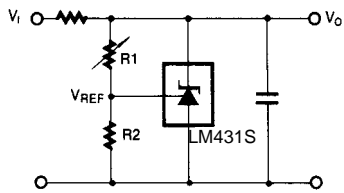


Figure 5. Shunt Regulator

$$V_O = V_{ref} \left(1 + \frac{R_1}{R_2}\right)$$

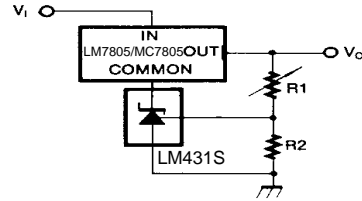


Figure 6. Output Control for Three-Terminal Fixed Regulator

$$V_O = \left(1 + \frac{R_1}{R_2}\right) V_{ref}$$

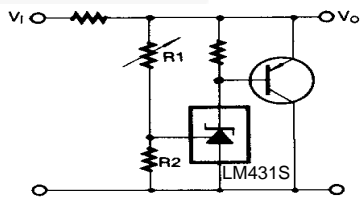


Figure 7. High Current Shunt Regulator

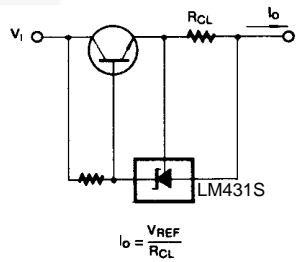


Figure 8. Current Limit or Current Source

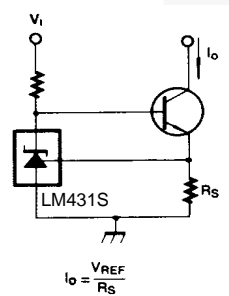


Figure 9. Constant-Current Sink

## Typical Performance Characteristics

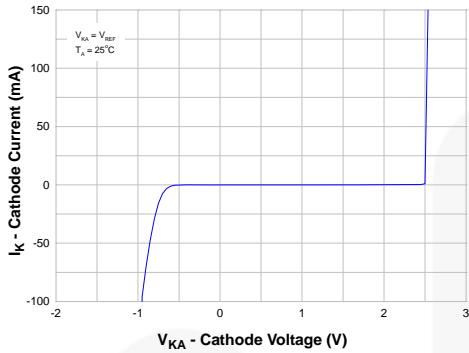


Figure 10. Cathode Current vs. Cathode Voltage

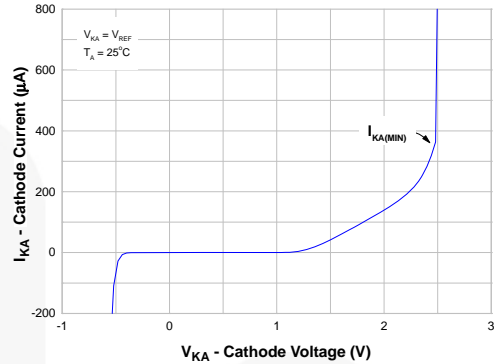


Figure 11. Cathode Current vs. Cathode Voltage

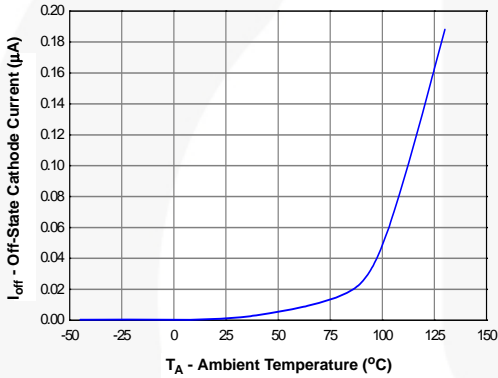


Figure 12. OFF-State Cathode Current vs. Ambient Temperature

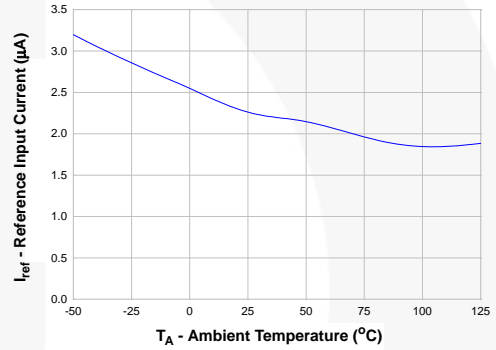


Figure 13. Reference Input Current vs. Ambient Temperature

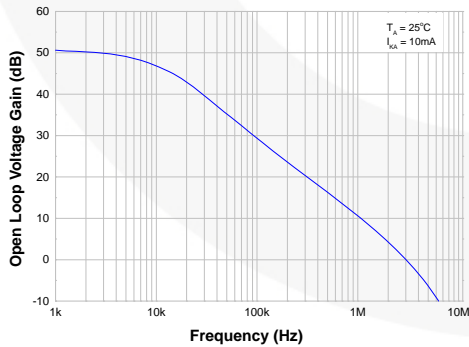


Figure 14. Frequency vs. Small Signal Voltage Amplification

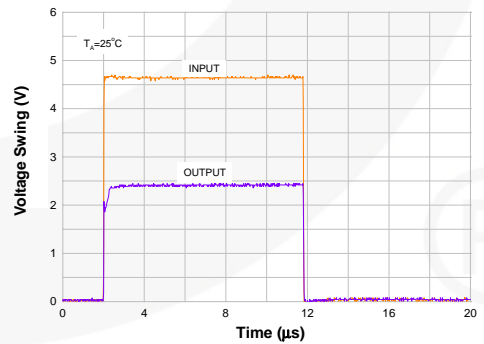


Figure 15. Pulse Response



Typical Performance Characteristics (Continued)

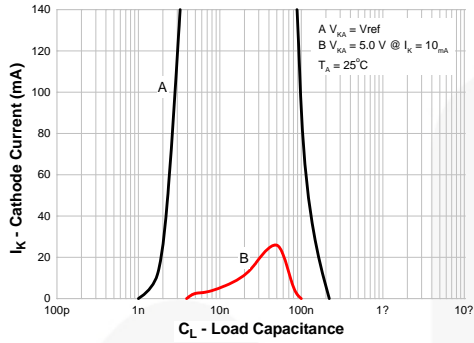


Figure 16. Stability Boundary Conditions

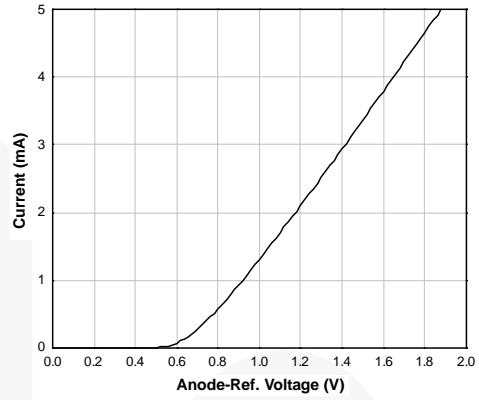


Figure 17. Anode-Reference Diode Curve

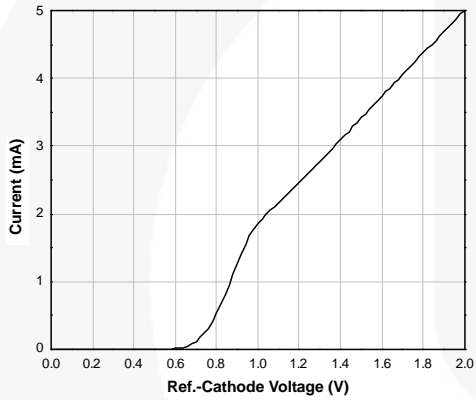


Figure 18. Reference-Cathode Diode Curve

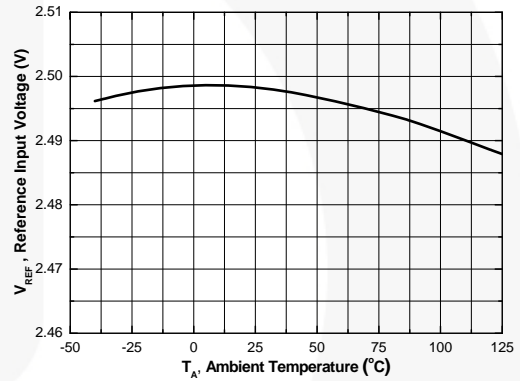
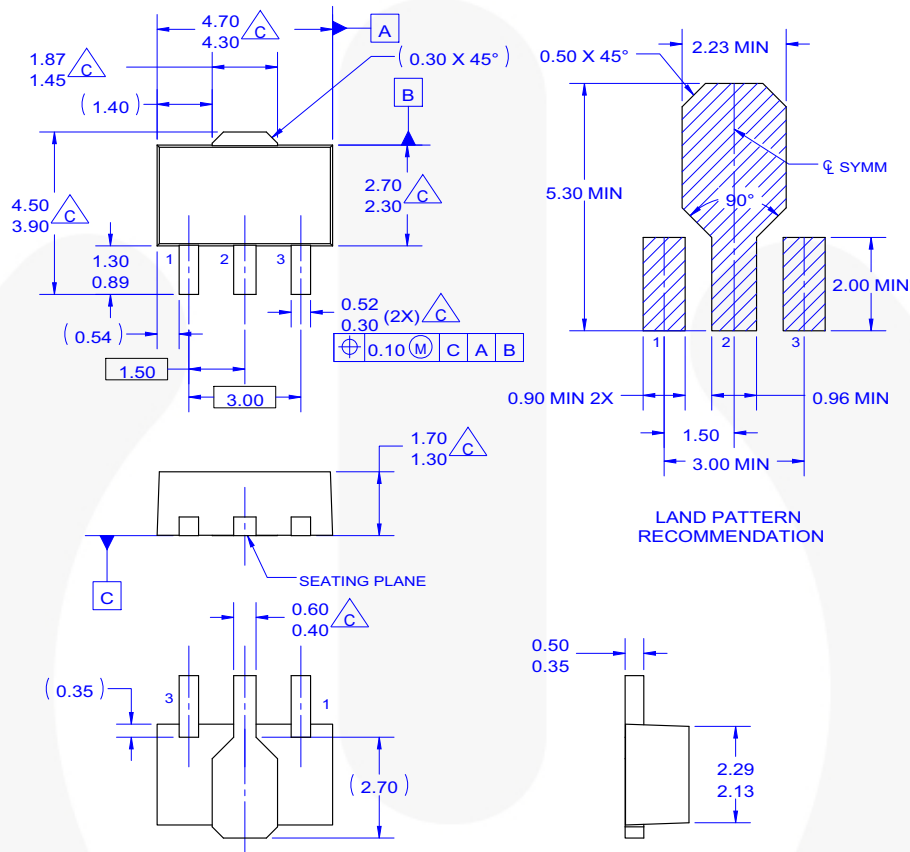


Figure 19. Reference Input Voltage vs. Ambient Temperature

Physical Dimensions

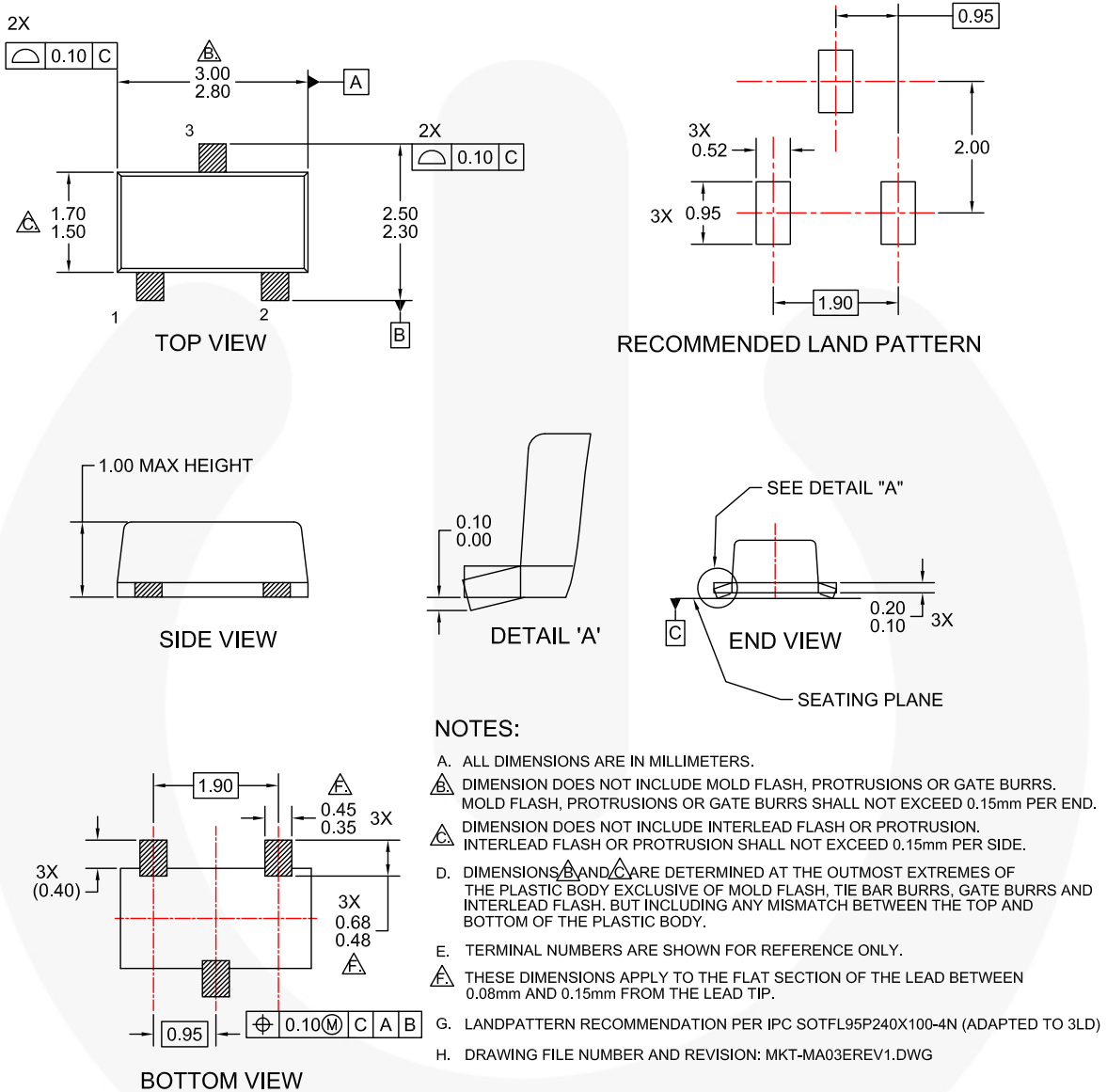


- NOTES: UNLESS OTHERWISE SPECIFIED.
- A. REFERENCE TO JEDEC TO-243 VARIATION AA.
  - B. ALL DIMENSIONS ARE IN MILLIMETERS.
  - C. DOES NOT COMPLY JEDEC STANDARD VALUE.
  - D. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH AND TIE BAR PROTRUSION.
  - E. DIMENSION AND TOLERANCE AS PER ASME Y14.5-1994.
  - F. DRAWING FILE NAME: MA03CREV3

Figure 20. 3-LEAD, SOT-89, JEDEC TO-243, OPTION AA

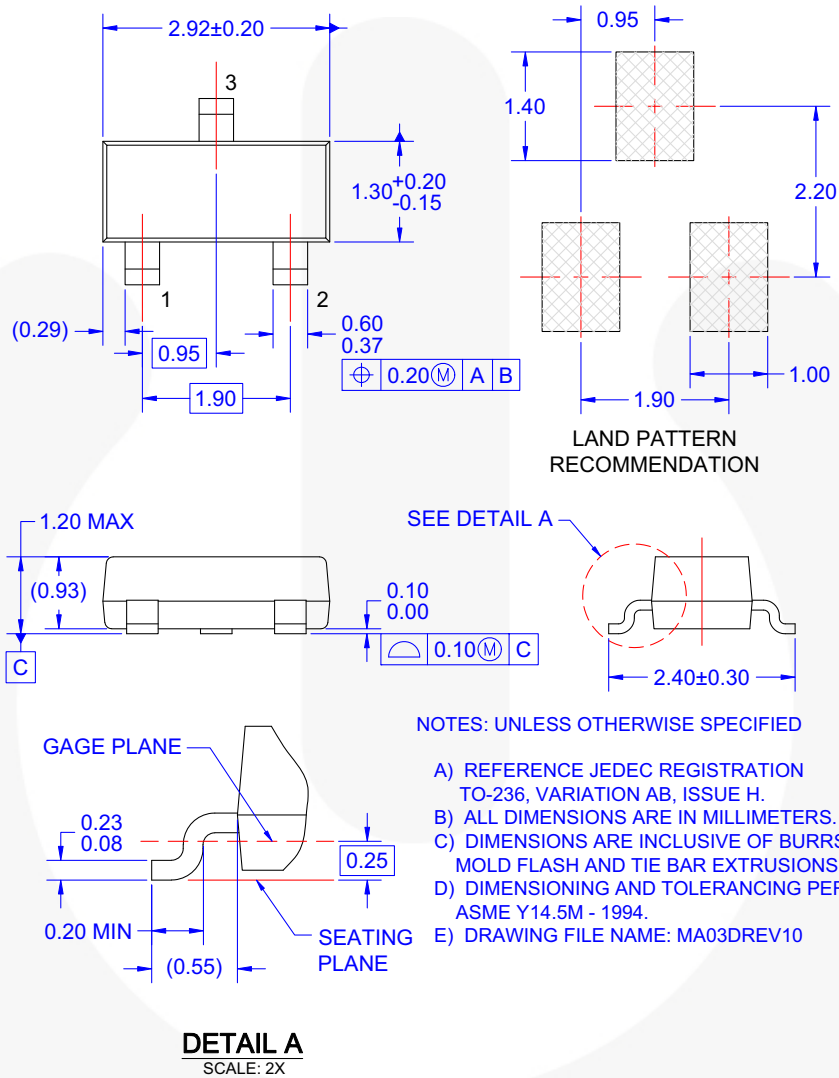


**Physical Dimensions** (Continued)



**Figure 21. 3-LEAD, SOT23F, FLAT LEAD, LOW PROFILE**

**Physical Dimensions** (Continued)



**Figure 22. 3-LEAD, SOT-23, JEDEC TO-236, LOW PROFILE**





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 STEALTH™  
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 SuperSOT™-6  
 SuperSOT™-8  
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 SyncFET™  
 Sync-Lock™

 SYSTEM GENERAL®  
 TinyBoost®  
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 TinyLogic®  
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2. A critical component in any component of a life support, device, or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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**Definition of Terms**

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