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June 2015

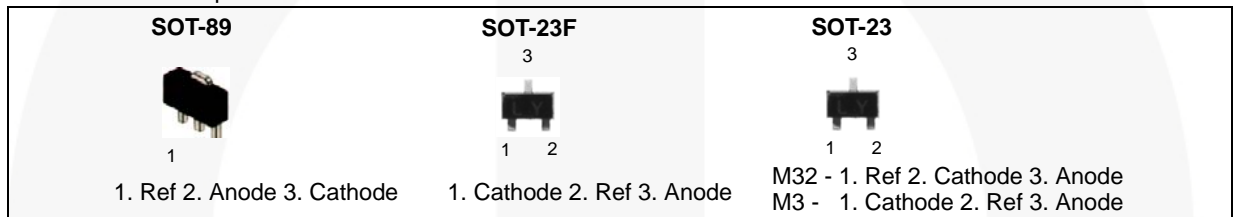
LM431SA / LM431SB / LM431SC Programmable Shunt Regulator

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 ⁽¹⁾ | 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 | 43J | | SOT-23 3L | | |
| LM431SAIMFX | 2% | | -40 to +85°C | 43AI | |

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

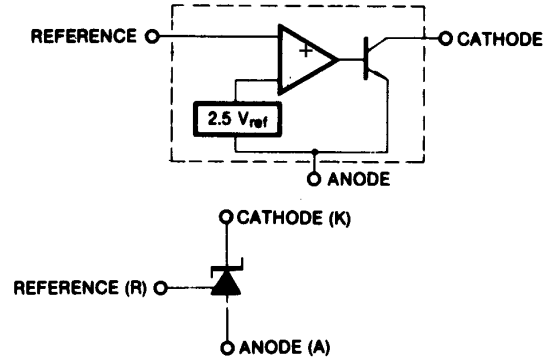


Figure 1. Block Diagram

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 ^(2,3) | ML Suffix Package (SOT-89) | 220 |
| | | MF Suffix Package (SOT-23F) | 350 |
| | | M32, M3 Suffix Package (SOT-23) | 400 |
| P_D | Power Dissipation ^(4,5) | 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°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⁽⁶⁾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 | μA | |
| $\Delta I_{REF} / \Delta T$ | 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 | μA |
| | | | SOT-23 | | 0.8 | 2.0 | | 0.8 | 2.0 | | 0.8 | 2.0 | μA |
| $I_{KA(MIN)}$ | 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 | μA | |
| 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 | Ω | |

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

Electrical Characteristics^(7, 8) (Continued)

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

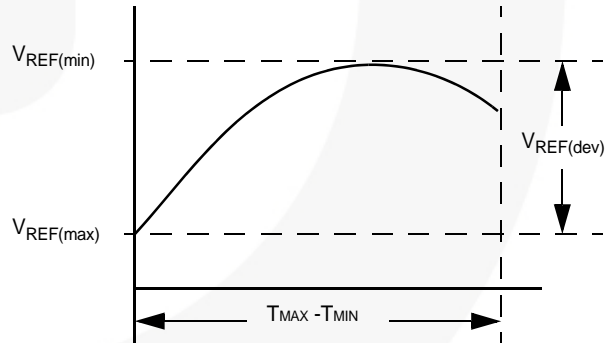
| Symbol | Parameter | Conditions | LM431SAI | | | Unit |
|--------------------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|---------------------------------------------|-------|-------|---------------|
| | | | 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 | μA |
| $I_{REF(dev)}$ | 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 | μA |
| $I_{KA(MIN)}$ | 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 | μA |
| 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 | Ω |

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, αV_{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.

αV_{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

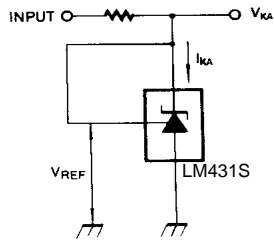


Figure 2. Test Circuit for $V_{KA} = V_{REF}$

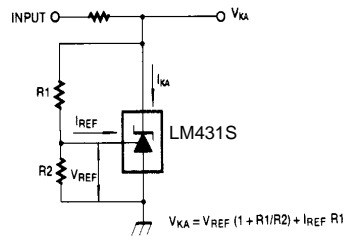


Figure 3. Test Circuit for $V_{KA} \geq V_{REF}$

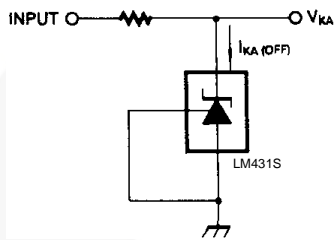


Figure 4. Test Circuit for $I_{KA(OFF)}$



Typical Applications

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

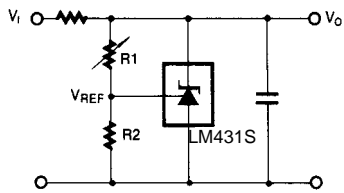


Figure 5. Shunt Regulator

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

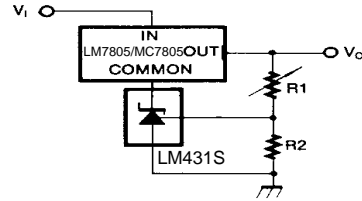


Figure 6. Output Control for Three-Terminal Fixed Regulator

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

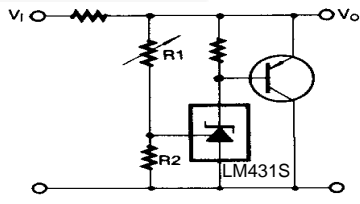


Figure 7. High Current Shunt Regulator

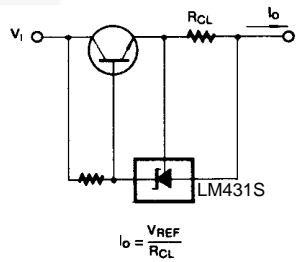


Figure 8. Current Limit or Current Source

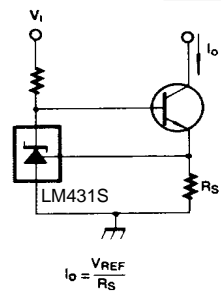


Figure 9. Constant-Current Sink

Typical Performance Characteristics

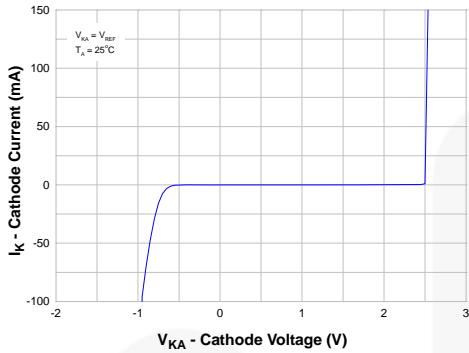


Figure 10. Cathode Current vs. Cathode Voltage

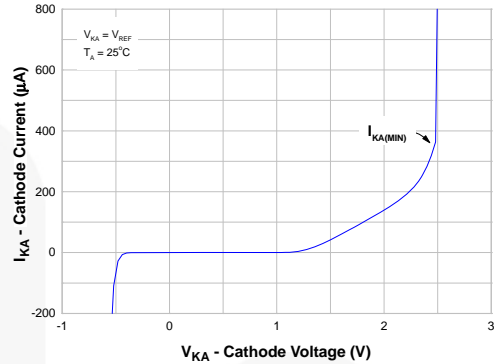


Figure 11. Cathode Current vs. Cathode Voltage

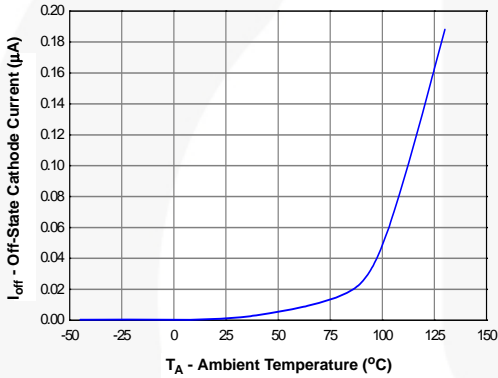


Figure 12. OFF-State Cathode Current vs. Ambient Temperature

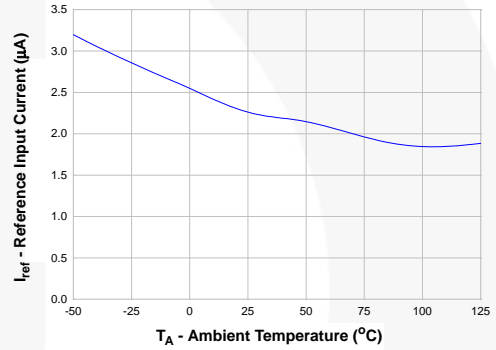


Figure 13. Reference Input Current vs. Ambient Temperature

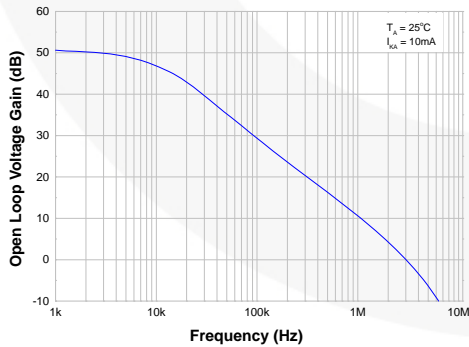


Figure 14. Frequency vs. Small Signal Voltage Amplification

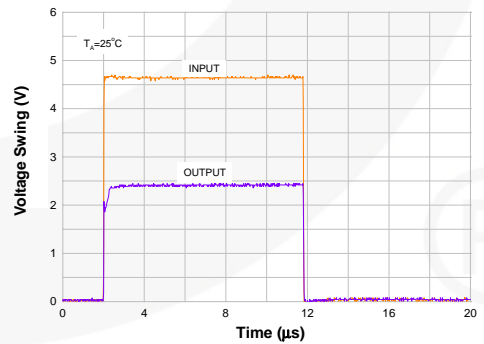


Figure 15. Pulse Response

Typical Performance Characteristics (Continued)

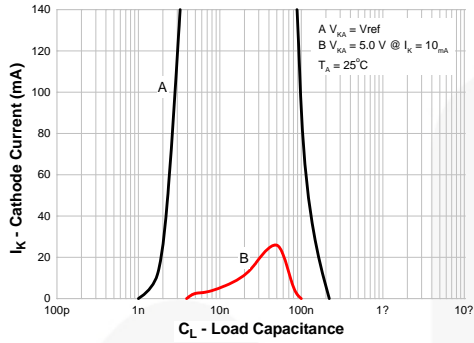


Figure 16. Stability Boundary Conditions

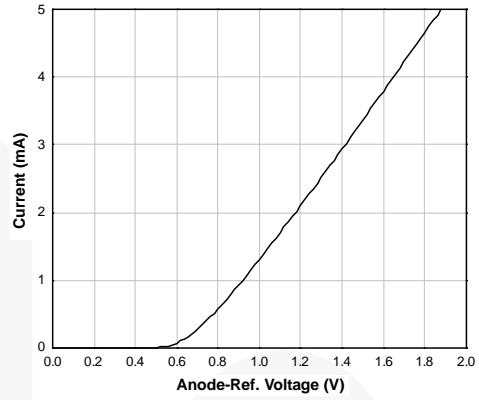


Figure 17. Anode-Reference Diode Curve

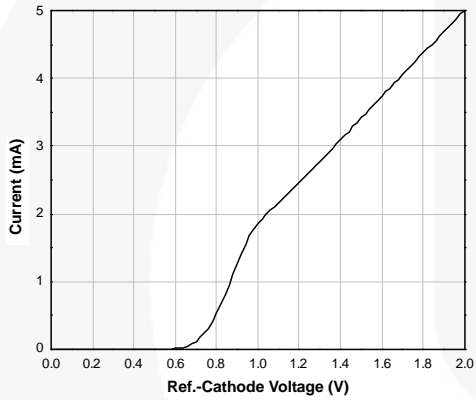


Figure 18. Reference-Cathode Diode Curve

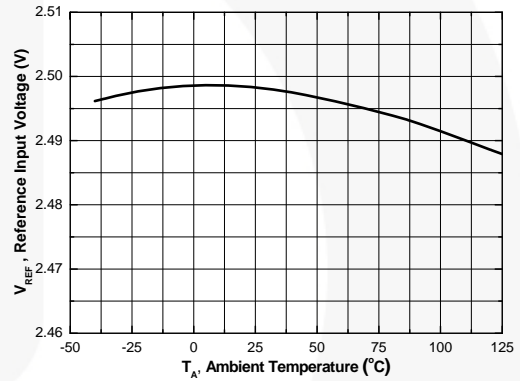
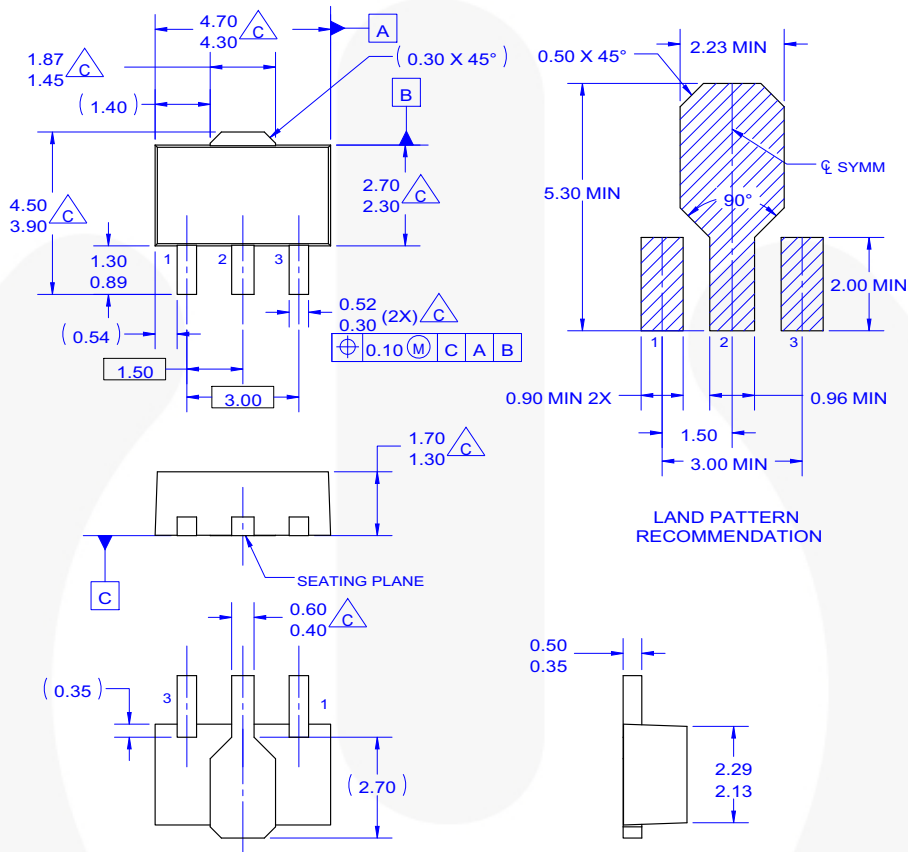


Figure 19. Reference Input Voltage vs. Ambient Temperature

Physical Dimensions



NOTES: UNLESS OTHERWISE SPECIFIED.

A. REFERENCE TO JEDEC TO-243 VARIATION AA.
 B. ALL DIMENSIONS ARE IN MILLIMETERS.

$\triangle C$ 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)

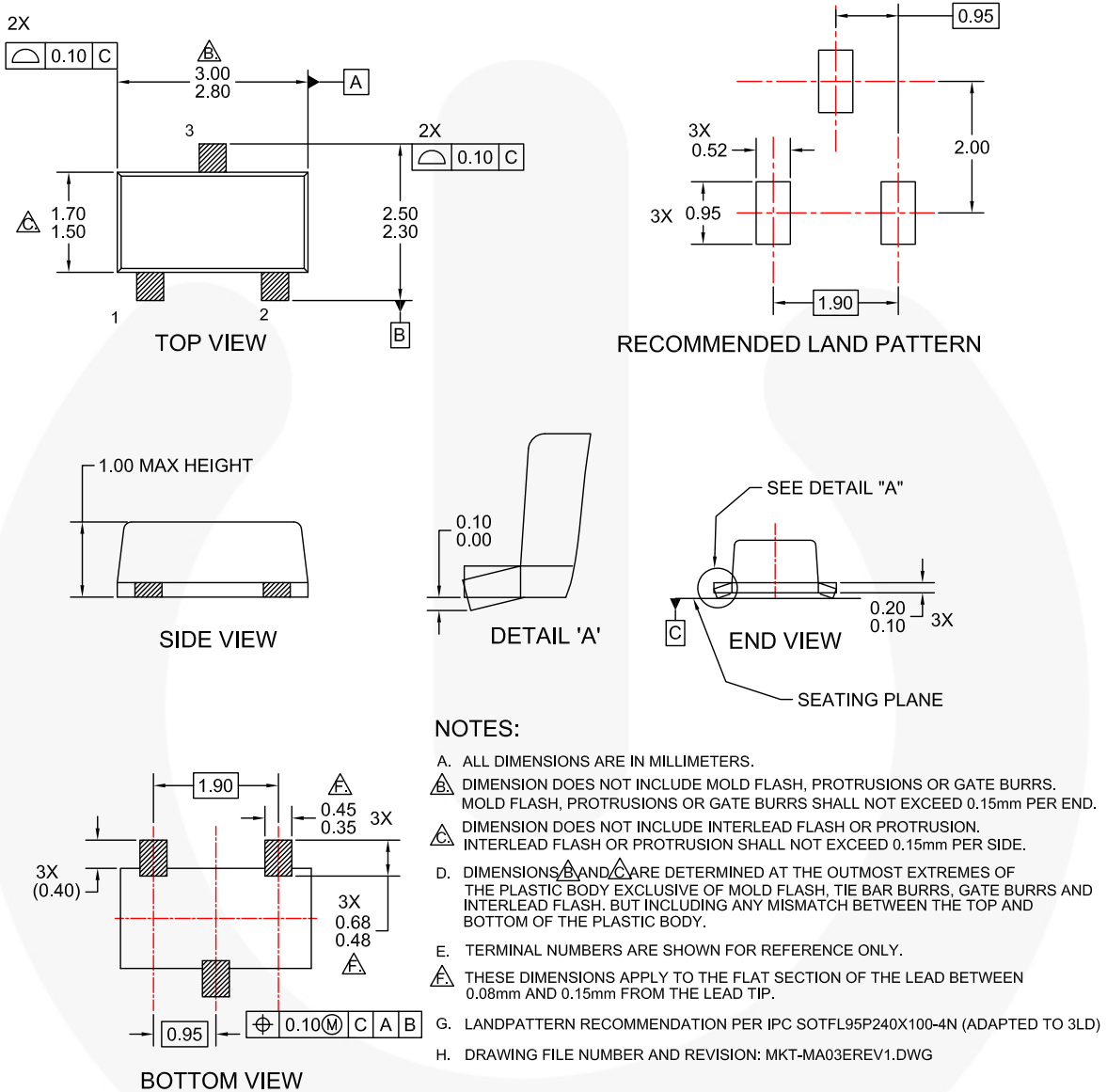


Figure 21. 3-LEAD, SOT23F, FLAT LEAD, LOW PROFILE

Physical Dimensions (Continued)

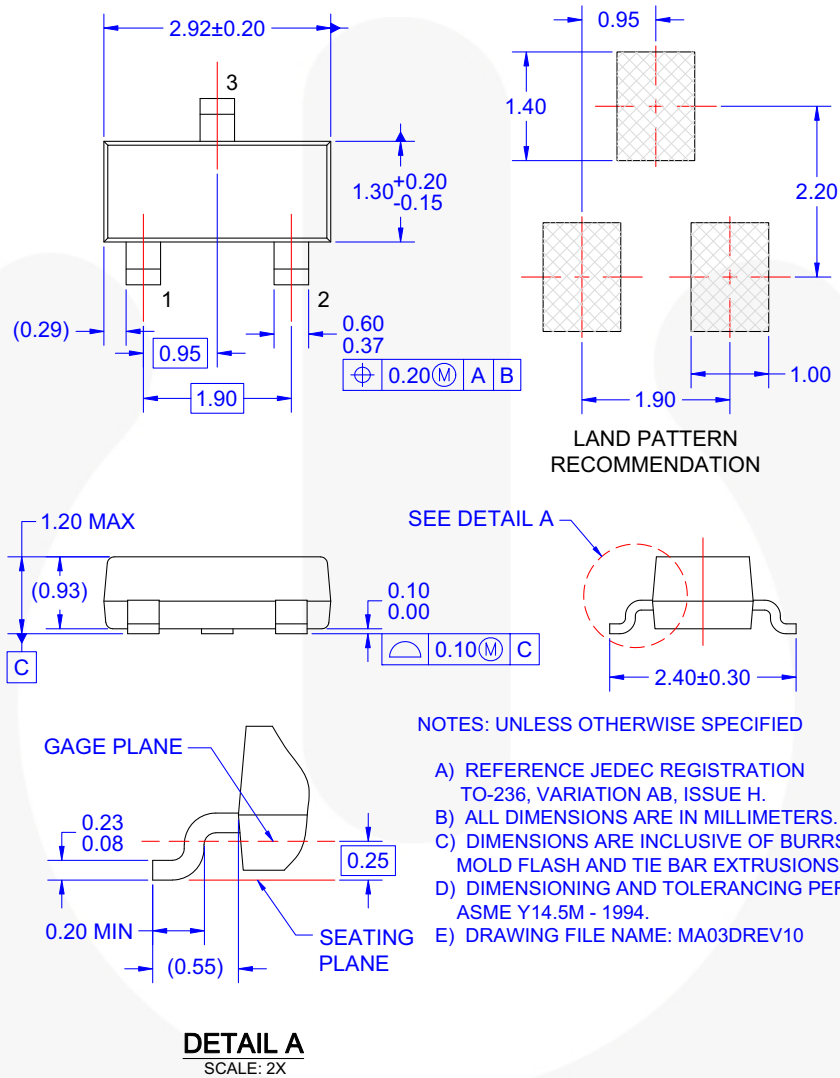


Figure 22. 3-LEAD, SOT-23, JEDEC TO-236, LOW PROFILE





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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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| Datasheet Identification | Product Status | Definition |
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