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# LM431A / LM431B / LM431C

## Programmable Shunt Regulator

### Features

- Programmable Output Voltage to 36 V
- Low Dynamic Output Impedance: 0.2  $\Omega$  (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 LM431A / LM431B / LM431C are three-terminal output adjustable regulators with thermal stability over the full operating temperature range. The output voltage can be set to 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  $\Omega$ . Active output circuit provides a sharp turn-on characteristic, making these devices excellent replacements for Zener diodes in many applications.

#### TO-92



1. Ref 2. Anode 3. Cathode

#### 8-SOIC



1.Cathode 2.3.6.7.Anode  
4.5.NC 8.Ref

### Ordering Information

| Part Number | Operating Temperature Range | Output Voltage Tolerance | Top Mark | Package | Packing Method |
|-------------|-----------------------------|--------------------------|----------|---------|----------------|
| LM431CCZ    | -25 ~ +85°C                 | 0.5%                     | LM431CCZ | TO-92   | Bulk           |
| LM431CCMX   |                             |                          | LM431CCM | 8-SOIC  | Tape and Reel  |
| LM431BCZX   |                             | 1%                       | LM431BCZ | TO-92   | Tape and Reel  |
| LM431BCZXA  |                             |                          | LM431BCZ | TO-92   | Ammo           |
| LM431BCMXX  |                             |                          | LM431BCM | 8-SOIC  | Tape and Reel  |
| LM431ACZ    |                             | 2%                       | LM431ACZ | TO-92   | Bulk           |
| LM431ACZX   |                             |                          | LM431ACZ | TO-92   | Tape and Reel  |
| LM431ACMX   |                             |                          | LM431ACM | 8-SOIC  | Tape and Reel  |
| LM431CIMX   | -40 ~ +85°C                 | 0.5%                     | LM431CIM | 8-SOIC  | Tape and Reel  |
| LM431BIZX   |                             | 1%                       | LM431BIZ | TO-92   | Tape and Reel  |
| LM431AIZ    |                             | 2%                       | LM431AIZ | TO-92   | Bulk           |
| LM431AIMX   |                             |                          | LM431AIM | 8-SOIC  | Tape and Reel  |

## Block Diagram

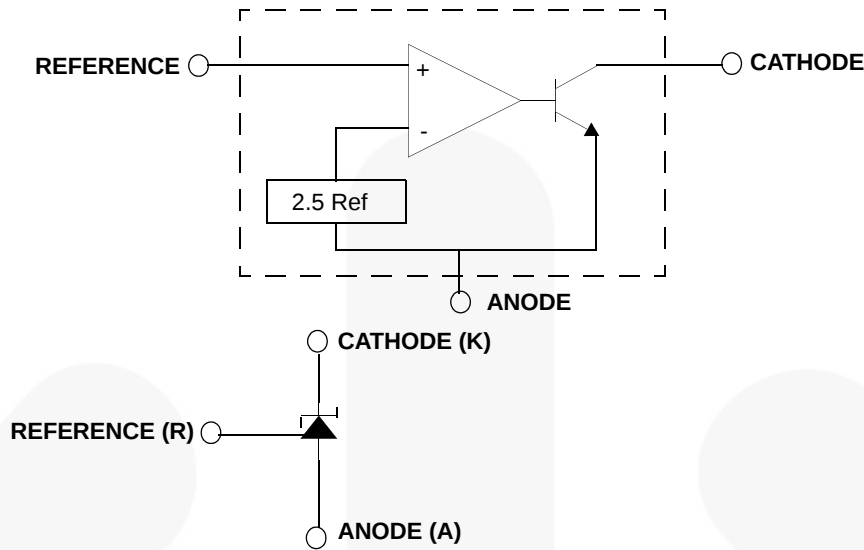


Figure 1. Block Diagram

## 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 ~ +150 | mA                        |
| $I_{REF}$       | Reference Input Current Range                                     | -0.05 ~ +10 | mA                        |
| $P_D$           | Power Dissipation<br>TO-92, 8-SOIC Packages                       | 770         | mW                        |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient<br>TO-92, 8-SOIC Packages | 160         | $^\circ\text{C}/\text{W}$ |
| $T_{OPR}$       | Operating Temperature Range LM431xC                               | -25 ~ +85   | $^\circ\text{C}$          |
|                 | Operating Temperature Range LM431xI                               | -40 ~ +85   | $^\circ\text{C}$          |
| $T_J$           | Junction Temperature                                              | 150         | $^\circ\text{C}$          |
| $T_{STG}$       | Storage Temperature Range                                         | -65 ~ +150  | $^\circ\text{C}$          |

## 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 | 1.0       | 100  | mA   |

## Electrical Characteristics

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

| Symbol                           | Parameter                                                                   | Conditions                                                                                           | LM431A |       |       | LM431B |       |       | LM431C |       |       | Unit          |
|----------------------------------|-----------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|--------|-------|-------|--------|-------|-------|--------|-------|-------|---------------|
|                                  |                                                                             |                                                                                                      | Min.   | Typ.  | Max.  | Min.   | Typ.  | Max.  | Min.   | Typ.  | Max.  |               |
| $V_{REF}$                        | Reference Input Voltage                                                     | $V_{KA} = V_{REF}$ ,<br>$I_{KA} = 10\text{ mA}$                                                      | 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                       | $V_{KA} = V_{REF}$ ,<br>$I_{KA} = 10\text{ mA}$ ,<br>$T_{MIN} \leq T_A \leq T_{MAX}^{(1)}$           |        | 4.5   | 17.0  |        | 4.5   | 17.0  |        | 4.5   | 17.0  | mV            |
| $\Delta V_{REF} / \Delta V_{KA}$ | Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage | $I_{KA} = 10\text{ mA}$ ,<br>$\Delta V_{KA} = 10V - V_{REF}$                                         |        | -1.0  | -2.7  |        | -1.0  | -2.7  |        | -1.0  | -2.7  | mV / V        |
|                                  |                                                                             | $\Delta V_{KA} = 36V - 10V$                                                                          |        | -0.5  | -2.0  |        | -0.5  | -2.0  |        | -0.5  | -2.0  |               |
| $I_{REF}$                        | Reference Input Current                                                     | $I_{KA} = 10\text{ mA}$ ,<br>$R1 = 10\text{ k}\Omega$ , $R2 = \infty$                                |        | 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            | $I_{KA} = 10\text{ mA}$ ,<br>$R1 = 10\text{ k}\Omega$ , $R2 = \infty$ ,<br>$T_A = \text{Full Range}$ |        | 0.4   | 1.2   |        | 0.4   | 1.2   |        | 0.4   | 1.2   | $\mu\text{A}$ |
| $I_{KA(MIN)}$                    | 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                                                 | $V_{KA} = 36\text{ V}$ ,<br>$V_{REF} = 0$                                                            |        | 0.05  | 1.00  |        | 0.05  | 1.00  |        | 0.05  | 1.00  | $\mu\text{A}$ |
| $Z_{KA}$                         | Dynamic Impedance                                                           | $V_{KA} = V_{REF}$ ,<br>$I_{KA} = 1\text{ to }100\text{ mA}$ ,<br>$f \geq 1.0\text{ kHz}$            |        | 0.15  | 0.50  |        | 0.15  | 0.50  |        | 0.15  | 0.50  | $\Omega$      |

### Note:

1. LM431xC:  $T_{MIN} = -25^\circ\text{C}$ ,  $T_{MAX} = +85^\circ\text{C}$ .  
LM431xI:  $T_{MIN} = -40^\circ\text{C}$ ,  $T_{MAX} = +85^\circ\text{C}$ .

## Test Circuits

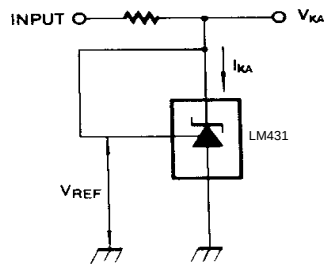


Figure 2. Test Circuit for  $V_{KA} = V_{REF}$

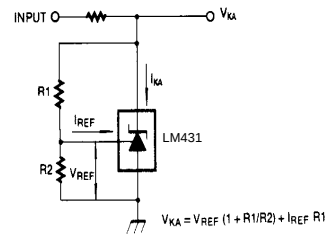


Figure 3. Test Circuit for  $V_{KA} \geq V_{REF}$

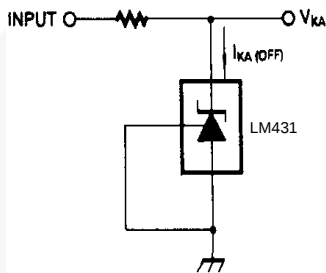


Figure 4. Test Circuit for  $I_{KA(OFF)}$

## Typical Performance Characteristics

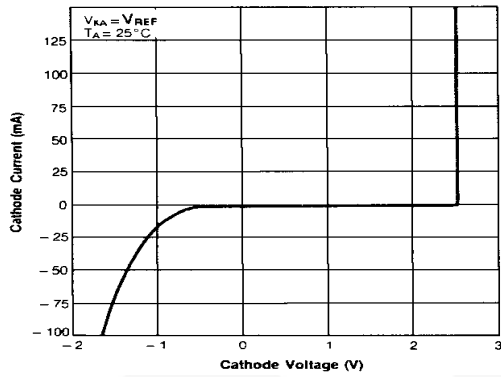


Figure 5. Cathode Current vs. Cathode Voltage

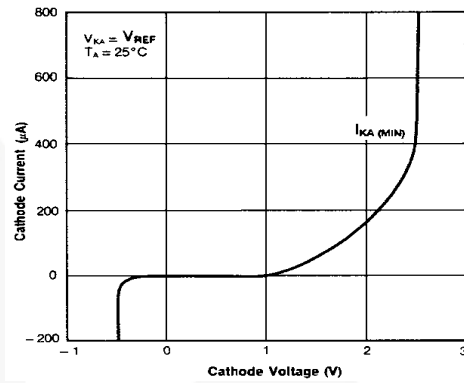


Figure 6. Cathode Current vs. Cathode Voltage

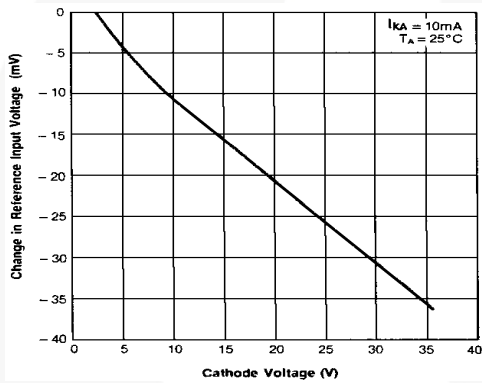


Figure 7. Change In Reference Input Voltage vs. Cathode Voltage

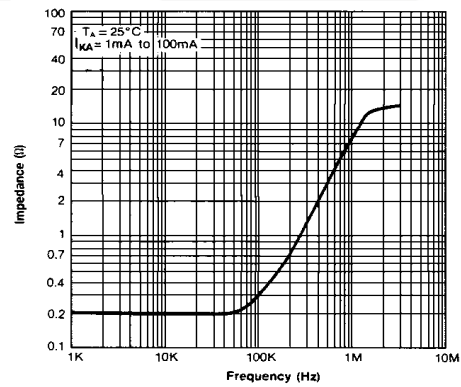


Figure 8. Dynamic Impedance Frequency

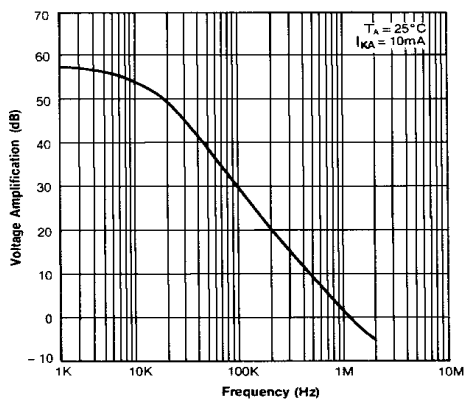


Figure 9. Small Signal Voltage Amplification vs. Frequency

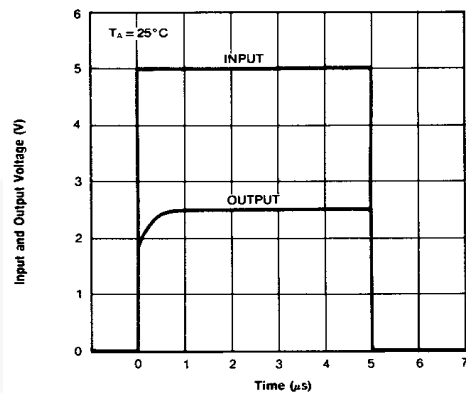


Figure 10. Pulse Response

## Typical Performance Characteristics (Continued)

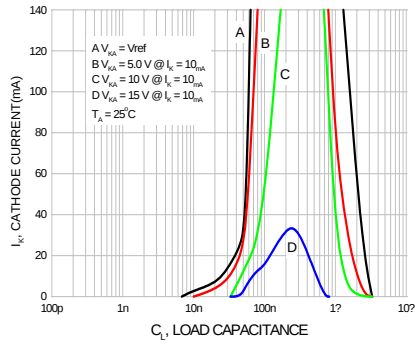


Figure 11. Stability Boundary Conditions

## Typical Application

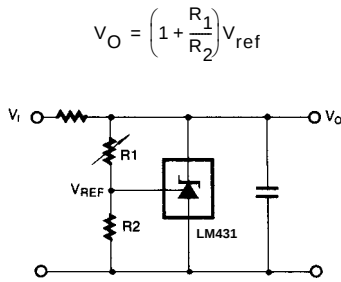


Figure 12. Shunt Regulator

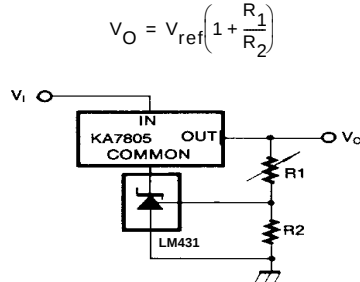


Figure 13. Output Control for Three-Terminal Fixed Regulator

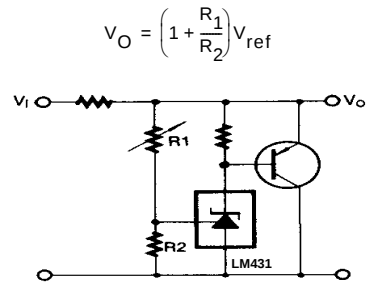


Figure 14. High-Current Shunt Regulator

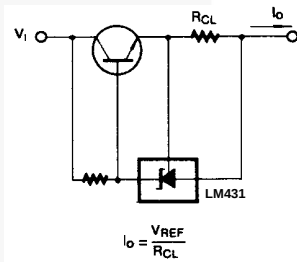


Figure 15. Current Limit or Current Source

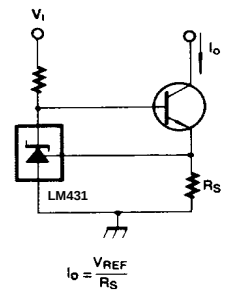
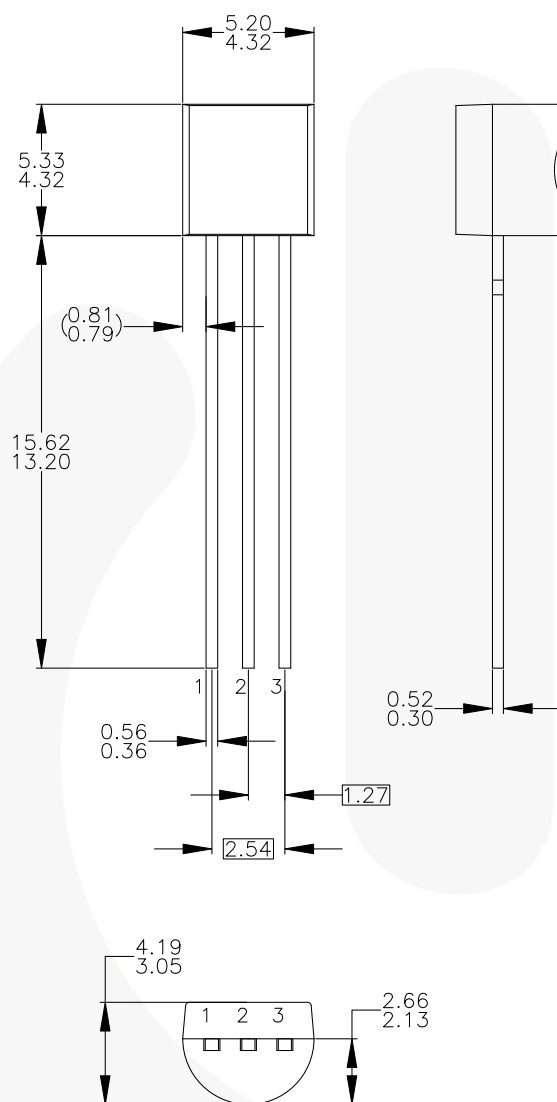


Figure 16. Constant-Current Sink

## Physical Dimensions

## TO-92 Bulk Type



NOTES: UNLESS OTHERWISE SPECIFIED

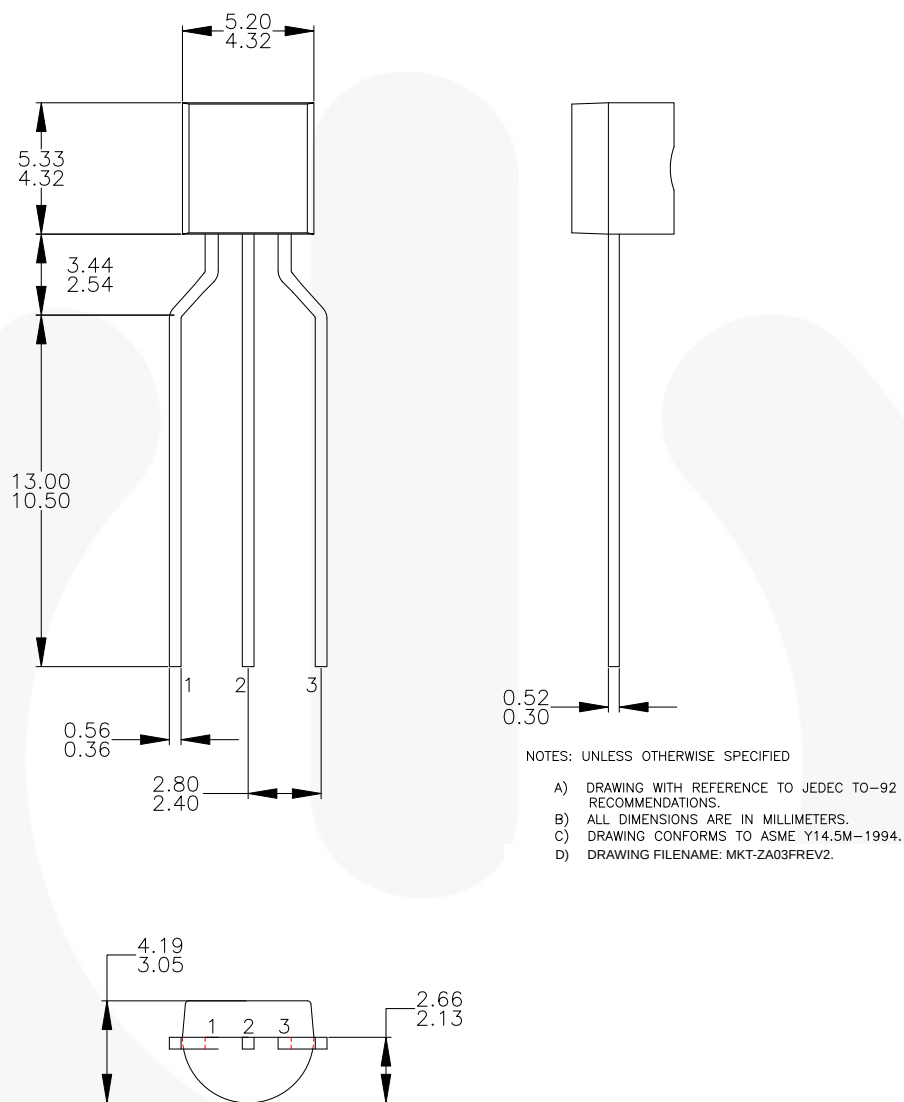
- A) DRAWING WITH REFERENCE TO JEDEC TO-92 RECOMMENDATIONS.  
B) ALL DIMENSIONS ARE IN MILLIMETERS.  
C) DRAWING CONFORMS TO ASME Y14.5M-1994.  
D) DRAWING FILENAME: MKT-7A03DREV3.

**Figure 17. 3-Lead, TO-92, Molded, Standard Straight Lead**

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**Physical Dimensions** (Continued)**TO-92 Ammo Type, Tape and Reel Type****Figure 18. 3-Lead, TO-92, Molded, 0.200 in Line Spacing Lead Form**

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## Physical Dimensions (Continued)

## 8-SOIC

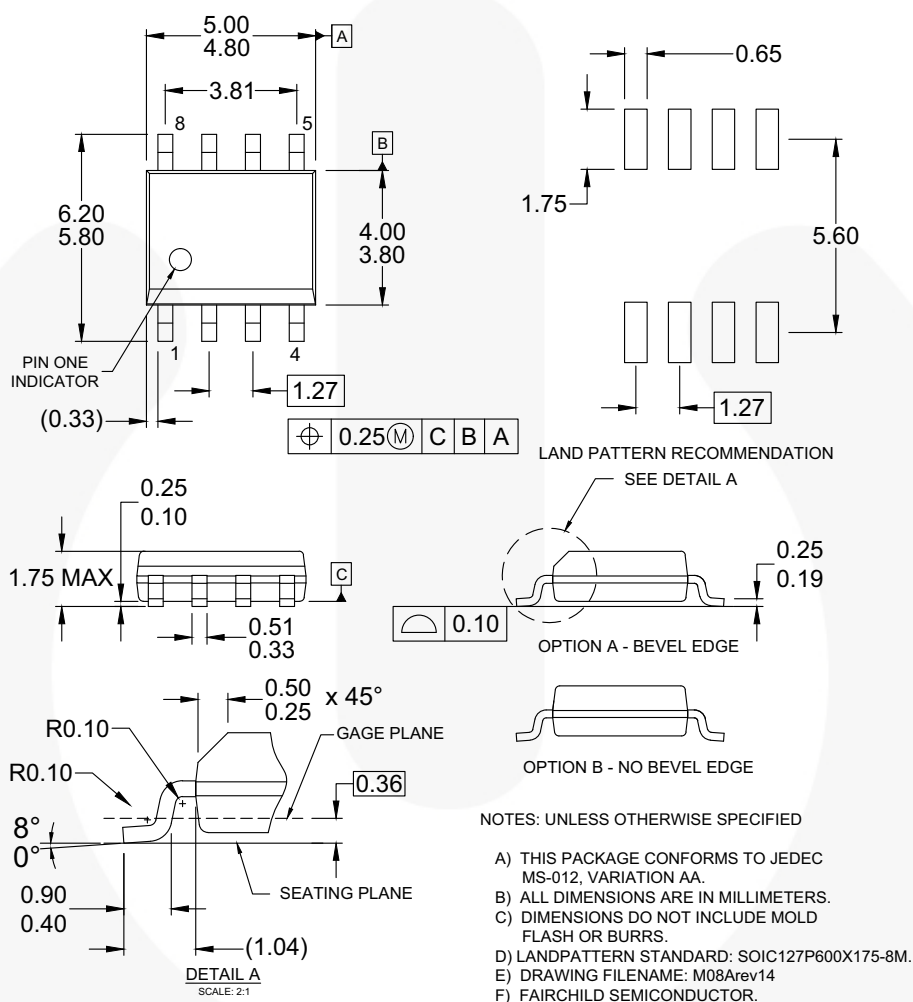


Figure 19. 8-Lead, SOIC, JEDEC MS 0-12, 0.150 inch Narrow Body

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| FastvCore™                                                                        | OPTOLOGIC®                                     | SyncFET™                                                                          | XS™                                                                                 |
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