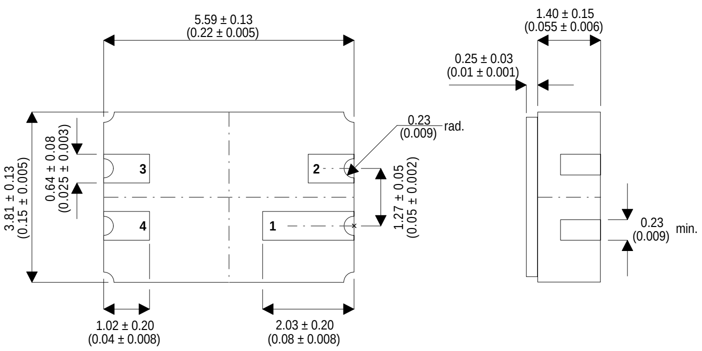
IP431CSM4




# PROGRAMMABLE PRECISION REFERENCE

**LCC3 HERMETICALLY SEALED CERAMIC SURFACE MOUNT PACKAGE**

**PIN 1 - NOT CONNECTED**
**PIN 2 - CATHODE**
**PIN 3 - REFERENCE**
**PIN 4 - ANODE**

| PART NUMBER | AMBIENT TEMP. RANGE |
|---|---|
| IP431CSM4 | -55 TO +125°C |

## FEATURES

- **VOLTAGE REFERENCE TOLERANCE ±1%**
- **PROGRAMMABLE OUTPUT VOLTAGE TO 36V**
- **EQUIVALENT FULL RANGE TEMPERATURE COEFFICIENT OF 30ppm/°C TYPICAL**
- **TEMPERATURE COMPENSATED FOR OPERATION OVER FULL RATED OPERATING TEMPERATURE RANGE**
- **SINK CURRENT CAPABILITY 1 TO 100 mA**
- **FAST TURN–ON RESPONSE**
- **LOW DYNAMIC OUTPUT IMPEDANCE (0.2Ω typical)**
- **LOW OUTPUT NOISE VOLTAGE**

## ABSOLUTE MAXIMUM RATINGS ($T_{case}$ = 25°C unless otherwise stated)

| | | | |
|---|---|---|---|
| $V_{KA}$ | Cathode To Anode Voltage | | 37V |
| $I_K$ | Cathode Current Range | | -100 to +150mA |
| $I_{REF}$ | Reference Input Current Range | | -0.05 to +10mA |
| $P_D$ | Power Dissipation @ $T_A$ = 25°C | CSM4 Package | 0.80W |
| | Derate Above 25°C | | 6.4W/°C |
| $T_J$ | Maximum Operating Junction Temperature | | 150°C |
| $T_A$ | Operating Ambient Temperature Range | | See Table Above |
| $T_{STG}$ | Storage Temperature Range | | –65 to 150°C |

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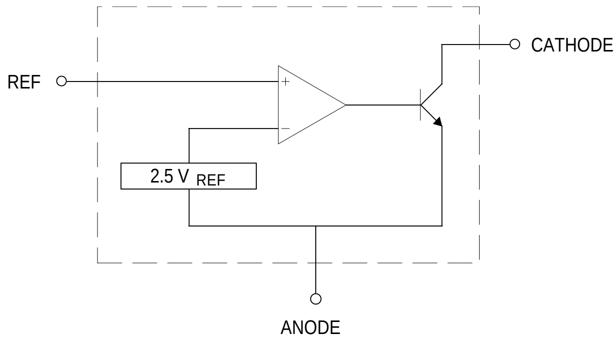
## DESCRIPTION

The IP431A circuit is a monolithic three terminal programmable shunt regulator diode. The voltage reference operates as a low temperature coefficient zener which is programmable between $V_{REF}$ (2.5V) and 36 volts using two external resistors. The device has a wide operating current range of 1 mA to 100mA and a typical dynamic impedance of 0.2Ω. Active output circuitry provides a very sharp turn-on characteristic making these devices excellent replacements for zener diodes in many applications. Being a shunt regulator it can be used as either a positive or negative voltage reference.

## BLOCK DIAGRAM




## RECOMMENDED OPERATING CONDITIONS

| | | |
|---|---|---|
| $V_{KA}$ | Cathode To Anode Voltage | $V_{REF}$ to 36V |
| $I_K$ | Cathode Current Range | 1.0 to 100mA |

## ELECTRICAL CHARACTERISTICS ($T_A$ = 25 °C unless otherwise stated)

| | Parameter | Test Conditions | | IP431AM Min. | IP431AM Typ. | IP431AM Max. | Units |
|---|---|---|---|---|---|---|---|
| $V_{REF}$ | Reference Input Voltage (Figure 1) | $V_{KA} = V_{REF}$ | | 2.47 | 2.495 | 2.52 | V |
| | | $I_K$ = 10mA | $T_A$ = -55 to +125°C * | 2.426 | | 2.564 | |
| $\Delta V_{REF}$ | Reference Input Voltage Over Temperature Range [1] (Figure 1) | $V_{KA} = V_{REF}$<br>$I_K$ = 10mA | $T_A$ = -55 to +125°C * | | 15 | 44 | mV |
| $\frac{\Delta V_{REF}}{\Delta V_{KA}}$ | Ratio of Reference Voltage Change to Change in Cathode to Anode Voltage (Figure 2) | $I_K$ = 10mA | $\Delta V_{KA}$ = 10V to $V_{REF}$ | | -1.5 | -2.7 | mV/V |
| | | | $\Delta V_{KA}$ = 36V to 10V | | -0.7 | -2 | |
| $I_{REF}$ | Reference Input Current (Figure 2) | R1 = 10kΩ | R2 = ∞ | | 1 | 4 | µA |
| | | $I_K$ = 10mA | $T_A$ = -55 to +125°C * | | | 7 | |
| $\Delta I_{REF}$ | Reference Input Current Deviation Over Temperature Range (Figure 2) | R1 = 10kΩ<br>$I_K$ = 10mA | R2 = ∞<br>$T_A$ = -55 to +125°C * | | 1 | 3 | µA |
| $I_{MIN}$ | Minimum Cathode Current For Regulation (Figure 1) | $V_{KA} = V_{REF}$ | | | 0.5 | 1 | mA |
| $I_{OFF}$ | Off–State Cathode Current (Figure 3) | $V_{KA}$ = 36V | $V_{REF}$ = 0 | | 3 | 1000 | nA |
| $\lvert Z_{ka}\rvert$ | Dynamic Impedance [2] (Figure 1) | $V_{KA} = V_{REF}$<br>$\Delta I_K$ = 1mA to 100mA | f ≤ 1kHz | | 0.2 | 0.5 | Ω |

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## ELECTRICAL CHARACTERISTICS ($T_A$ = 25 °C unless otherwise stated)

| | Parameter | | Test Conditions | | IP431AI Min. | IP431AI Typ. | IP431AI Max. | Units |
|---|---|---|---|---|---|---|---|---|
| $V_{REF}$ | Reference Input Voltage | (Figure 1) | $V_{KA} = V_{REF}$ | | 2.47 | 2.495 | 2.52 | V |
| | | | $I_K$ = 10mA | $T_A$ = -40 to +85°C * | 2.44 | | 2.55 | |
| $\Delta V_{REF}$ | Reference Input Voltage Over Temperature Range [1] | (Figure 1) | $V_{KA} = V_{REF}$, $I_K$ = 10mA | $T_A$ = -40 to +85°C * | | 7 | 30 | mV |
| $\frac{\Delta V_{REF}}{\Delta V_{KA}}$ | Ratio of Reference Voltage Change to Change in Cathode to Anode Voltage | (Figure 2) | $I_K$ = 10mA | $\Delta V_{KA}$ = 10V to $V_{REF}$ | | -1.5 | -2.7 | mV/V |
| | | | | $\Delta V_{KA}$ = 36V to 10V | | -0.7 | -2 | |
| $I_{REF}$ | Reference Input Current | (Figure 2) | R1 = 10kΩ | R2 = ∞ | | 1 | 4 | µA |
| | | | $I_K$ = 10mA | $T_A$ = -40 to +85°C * | | | 6.5 | |
| $\Delta I_{REF}$ | Reference Input Current Deviation Over Temperature Range | (Figure 2) | R1 = 10kΩ, $I_K$ = 10mA | R2 = ∞, $T_A$ = -40 to +85°C * | | 0.8 | 2.5 | µA |
| $I_{MIN}$ | Minimum Cathode Current For Regulation | (Figure 1) | $V_{KA} = V_{REF}$ | | | 0.5 | 1 | mA |
| $I_{OFF}$ | Off–State Cathode Current | (Figure 3) | $V_{KA}$ = 36V | $V_{REF}$ = 0 | | 3 | 1000 | nA |
| $\|Z_{ka}\|$ | Dynamic Impedance [2] | (Figure 1) | $V_{KA} = V_{REF}$, $\Delta I_K$ = 1mA to 100mA | f ≤ 1kHz | | 0.2 | 0.5 | Ω |

| | Parameter | | Test Conditions | | IP431AC Min. | IP431AC Typ. | IP431AC Max. | Units |
|---|---|---|---|---|---|---|---|---|
| $V_{REF}$ | Reference Input Voltage | (Figure 1) | $V_{KA} = V_{REF}$ | | 2.47 | 2.495 | 2.52 | V |
| | | | $I_K$ = 10mA | $T_A$ = 0 to +70°C * | 2.453 | | 2.537 | |
| $\Delta V_{REF}$ | Reference Input Voltage Over Temperature Range [1] | (Figure 1) | $V_{KA} = V_{REF}$, $I_K$ = 10mA | $T_A$ = 0 to +70°C * | | 3 | 17 | mV |
| $\frac{\Delta V_{REF}}{\Delta V_{KA}}$ | Ratio of Reference Voltage Change to Change in Cathode to Anode Voltage | (Figure 2) | $I_K$ = 10mA | $\Delta V_{KA}$ = 10V to $V_{REF}$ | | -1.5 | -2.7 | mV/V |
| | | | | $\Delta V_{KA}$ = 36V to 10V | | -0.7 | -2 | |
| $I_{REF}$ | Reference Input Current | (Figure 2) | R1 = 10kΩ | R2 = ∞ | | 1 | 4 | µA |
| | | | $I_K$ = 10mA | $T_A$ = 0 to +70°C * | | | 5.2 | |
| $\Delta I_{REF}$ | Reference Input Current Deviation Over Temperature Range | (Figure 2) | R1 = 10kΩ, $I_K$ = 10mA | R2 = ∞, $T_A$ = 0 to +70°C * | | 0.4 | 1.2 | µA |
| $I_{MIN}$ | Minimum Cathode Current For Regulation | (Figure 1) | $V_{KA} = V_{REF}$ | | | 0.5 | 1 | mA |
| $I_{OFF}$ | Off–State Cathode Current | (Figure 3) | $V_{KA}$ = 36V | $V_{REF}$ = 0 | | 3 | 1000 | nA |
| $\|Z_{ka}\|$ | Dynamic Impedance [2] | (Figure 1) | $V_{KA} = V_{REF}$, $\Delta I_K$ = 1mA to 100mA | f ≤ 1kHz | | 0.2 | 0.5 | Ω |

**FIGURE 1**

**TEST CIRCUIT FOR $V_{KA} = V_{REF}$**

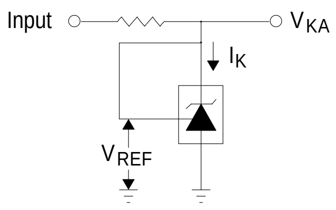
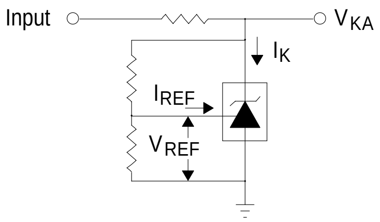



**FIGURE 2**

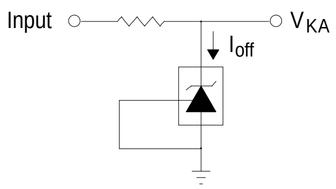
**TEST CIRCUIT FOR $V_{KA} > V_{REF}$**




$$V_{KA} = V_{REF}\left(1+\frac{R1}{R2}\right) + I_{REF} \times R1$$

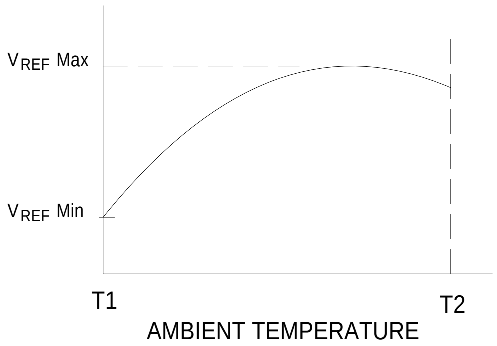
**FIGURE 3**

**TEST CIRCUIT FOR $I_{off}$**




## NOTE 1

The deviation parameter $\Delta V_{REF}$ is defined as the differences between the maximum and minimum values obtained over the full operating ambient temperature range that applies.




$\Delta V_{REF} = V_{REF}$ Max - $V_{REF}$ Min

$\Delta T_A = T2 - T1$

The average temperature coefficient of the reference input voltage, $\propto V_{REF}$ is defined as:

$$\propto V_{REF} = \frac{ppm}{°C} = \frac{\left(\frac{\Delta V_{REF}}{V_{REF}\ @\ 25°C}\right) \times 10^6}{\Delta T_A} = \frac{\Delta V_{REF} \times 10^6}{\Delta T_A\ (V_{REF}\ @\ 25°C)}$$

$\propto V_{REF}$ can be positive or negative depending on whether $\propto V_{REF}$ Min or $\propto V_{REF}$ Max occurs at the lower ambient temperature.

Example: $\Delta V_{REF}$ = 8.0 mV and slope is positive,
$V_{REF}$ @ 25°C = 2.495V, $\Delta T_A$ = 70°C

$$\propto V_{REF} = \frac{0.008 \times 10^6 = 45.8\ ppm/°C}{70\ (2.495)} = 45.8\ ppm/°C$$

## NOTE 2

The dynamic impedance $Z_{ka}$ is defined as:

$$|Z_{ka}| = \frac{\Delta V_{KA}}{\Delta I_K}$$

When the device is programmed with two external resistors, R1 and R2, (refer to Figure 2) the total dynamic impedance of the circuit is defined as:

$$|Z_{ka}| \approx |Z_{ka}|\left(1+\frac{R1}{R2}\right)$$