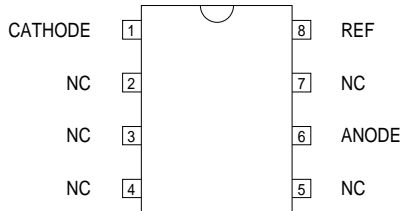
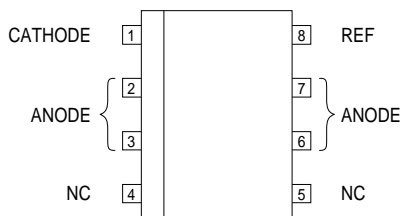


TOP VIEW



J Package – 8 Pin Ceramic DIP  
N Package – 8 Pin Plastic DIP

TOP VIEW



D Package – 8 Pin Plastic (150) SOIC

\* Note that the SOIC package used for the IP431A has a modified lead frame to increase power dissipation capability when appropriately mounted on a PCB.

PROGRAMMABLE  
PRECISION  
REFERENCE

FEATURES

- VOLTAGE REFERENCE TOLERANCE  $\pm 1\%$
- 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
- ALSO AVAILABLE IN TO-92 PACKAGE

Part Number	J-Pack 8 Pin	N-Pack 8 Pin	D-Pack 8 Pin	Amb. Temp. Range	Note:
IP431AM	✓			-55 to +125°C	To order, add the package identifier to the part number. eg. IP431AMJ IP431ACD
IP431AI	✓	✓	✓	-40 to +85°C	
IP431AC	✓	✓	✓	0 to +70°C	

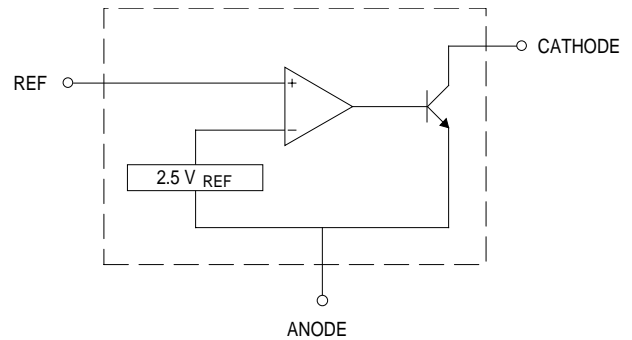
ABSOLUTE MAXIMUM RATINGS ( $T_{case} = 25^\circ C$  unless otherwise stated)

$V_{KA}$	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 @ $T_A = 25^\circ C$	D Package N Package J Package	0.70W 1.10W 1.25W
	Derate Above 25°C		6mW/°C
$P_D$	Power Dissipation @ $T_C = 25^\circ C$	D Package N Package J Package	1.5W 3W 3.3W
$T_J$	Maximum Operating Junction Temperature		150°C
$T_A$	Operating Ambient Temperature Range		See Table Above
$T_{STG}$	Storage Temperature Range		-65 to 150°C

## 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  $0.2\Omega$ . 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 ( $T_A = 25^\circ\text{C}$ unless otherwise stated)

Parameter	Test Conditions	IP431AM			Units
		Min.	Typ.	Max.	
$V_{REF}$ Reference Input Voltage (Figure 1)	$V_{KA} = V_{REF}$	2.47	2.495	2.52	V
	$I_K = 10\text{mA}$ $T_A = -55$ to $+125^\circ\text{C}^*$	2.426		2.564	
$\Delta V_{REF}$ Reference Input Voltage Over Temperature Range <sup>1</sup> (Figure 1)	$V_{KA} = V_{REF}$ $I_K = 10\text{mA}$ $T_A = -55$ to $+125^\circ\text{C}^*$		15	44	mV
$\frac{\Delta V_{REF}}{\Delta V_{KA}}$ Ratio of Reference Voltage Change to Change in Cathode to Anode Voltage (Figure 2)	$I_K = 10\text{mA}$	$\Delta V_{KA} = 10\text{V}$ to $V_{REF}$	-1.5	-2.7	mV/V
		$\Delta V_{KA} = 36\text{V}$ to $10\text{V}$	-0.7	-2	
$I_{REF}$ Reference Input Current (Figure 2)	$R1 = 10\text{k}\Omega$ $R2 = \infty$		1	4	$\mu\text{A}$
	$I_K = 10\text{mA}$ $T_A = -55$ to $+125^\circ\text{C}^*$			7	
$\Delta I_{REF}$ Reference Input Current Deviation Over Temperature Range (Figure 2)	$R1 = 10\text{k}\Omega$ $R2 = \infty$ $I_K = 10\text{mA}$ $T_A = -55$ to $+125^\circ\text{C}^*$		1	3	$\mu\text{A}$
$I_{MIN}$ Minimum Cathode Current For Regulation (Figure 1)	$V_{KA} = V_{REF}$		0.5	1	mA
$I_{OFF}$ Off-State Cathode Current (Figure 3)	$V_{KA} = 36\text{V}$ $V_{REF} = 0$		3	1000	nA
$ Z_{ka} $ Dynamic Impedance <sup>2</sup> (Figure 1)	$V_{KA} = V_{REF}$ $f \leq 1\text{kHz}$ $\Delta I_K = 1\text{mA}$ to $100\text{mA}$		0.2	0.5	$\Omega$

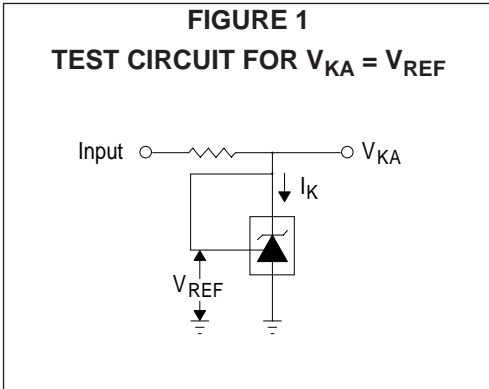
\* This test is not applicable to surface mount (D Package) devices.

## ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = 25 °C unless otherwise stated)

Parameter	Test Conditions	IP431AI			Units
		Min.	Typ.	Max.	
V <sub>REF</sub> Reference Input Voltage (Figure 1)	V <sub>KA</sub> = V <sub>REF</sub>	2.47	2.495	2.52	V
	I <sub>K</sub> = 10mA T <sub>A</sub> = -40 to +85°C *	2.44		2.55	
ΔV <sub>REF</sub> Reference Input Voltage Over Temperature Range <sup>1</sup> (Figure 1)	V <sub>KA</sub> = V <sub>REF</sub> I <sub>K</sub> = 10mA T <sub>A</sub> = -40 to +85°C *		7	30	mV
ΔV <sub>REF</sub> /ΔV <sub>KA</sub> Ratio of Reference Voltage Change to Change in Cathode to Anode Voltage (Figure 2)	I <sub>K</sub> = 10mA	ΔV <sub>KA</sub> = 10V to V <sub>REF</sub>	-1.5	-2.7	mV/V
		ΔV <sub>KA</sub> = 36V to 10V	-0.7	-2	
I <sub>REF</sub> Reference Input Current (Figure 2)	R1 = 10kΩ R2 = ∞		1	4	μA
	I <sub>K</sub> = 10mA T <sub>A</sub> = -40 to +85°C *			6.5	
ΔI <sub>REF</sub> Reference Input Current Deviation Over Temperature Range (Figure 2)	R1 = 10kΩ R2 = ∞ I <sub>K</sub> = 10mA T <sub>A</sub> = -40 to +85°C *		0.8	2.5	μA
I <sub>MIN</sub> Minimum Cathode Current For Regulation (Figure 1)	V <sub>KA</sub> = V <sub>REF</sub>		0.5	1	mA
I <sub>OFF</sub> Off-State Cathode Current (Figure 3)	V <sub>KA</sub> = 36V V <sub>REF</sub> = 0		3	1000	nA
Z <sub>ka</sub>   Dynamic Impedance <sup>2</sup> (Figure 1)	V <sub>KA</sub> = V <sub>REF</sub> f ≤ 1kHz ΔI <sub>K</sub> = 1mA to 100mA		0.2	0.5	Ω

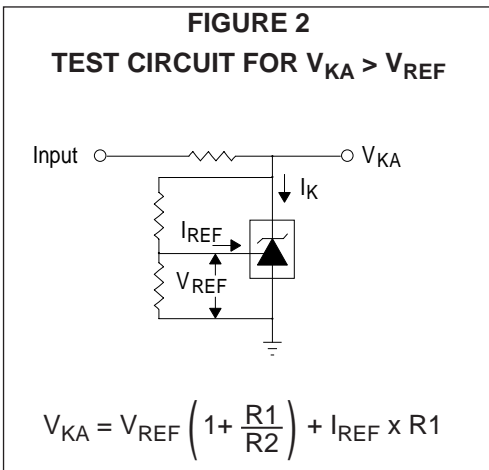
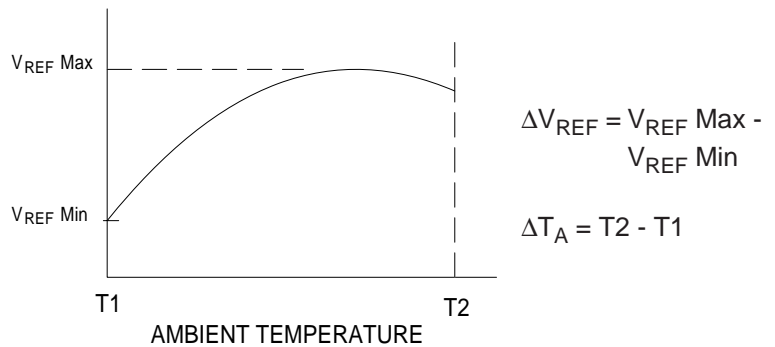
Parameter	Test Conditions	IP431AC			Units
		Min.	Typ.	Max.	
V <sub>REF</sub> Reference Input Voltage (Figure 1)	V <sub>KA</sub> = V <sub>REF</sub>	2.47	2.495	2.52	V
	I <sub>K</sub> = 10mA T <sub>A</sub> = 0 to +70°C *	2.453		2.537	
ΔV <sub>REF</sub> Reference Input Voltage Over Temperature Range <sup>1</sup> (Figure 1)	V <sub>KA</sub> = V <sub>REF</sub> I <sub>K</sub> = 10mA T <sub>A</sub> = 0 to +70°C *		3	17	mV
ΔV <sub>REF</sub> /ΔV <sub>KA</sub> Ratio of Reference Voltage Change to Change in Cathode to Anode Voltage (Figure 2)	I <sub>K</sub> = 10mA	ΔV <sub>KA</sub> = 10V to V <sub>REF</sub>	-1.5	-2.7	mV/V
		ΔV <sub>KA</sub> = 36V to 10V	-0.7	-2	
I <sub>REF</sub> Reference Input Current (Figure 2)	R1 = 10kΩ R2 = ∞		1	4	μA
	I <sub>K</sub> = 10mA T <sub>A</sub> = 0 to +70°C *			5.2	
ΔI <sub>REF</sub> Reference Input Current Deviation Over Temperature Range (Figure 2)	R1 = 10kΩ R2 = ∞ I <sub>K</sub> = 10mA T <sub>A</sub> = 0 to +70°C *		0.4	1.2	μA
I <sub>MIN</sub> Minimum Cathode Current For Regulation (Figure 1)	V <sub>KA</sub> = V <sub>REF</sub>		0.5	1	mA
I <sub>OFF</sub> Off-State Cathode Current (Figure 3)	V <sub>KA</sub> = 36V V <sub>REF</sub> = 0		3	1000	nA
Z <sub>ka</sub>   Dynamic Impedance <sup>2</sup> (Figure 1)	V <sub>KA</sub> = V <sub>REF</sub> f ≤ 1kHz ΔI <sub>K</sub> = 1mA to 100mA		0.2	0.5	Ω

\* This test is not applicable to surface mount (D Package) devices.



**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.



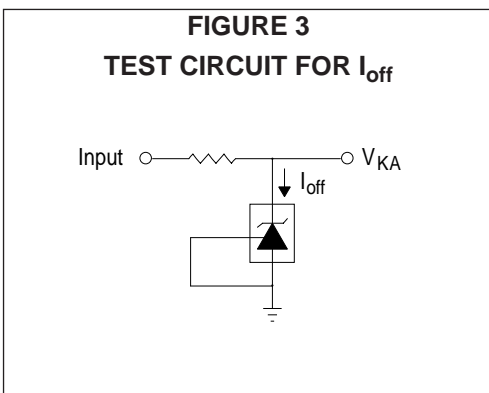
The average temperature coefficient of the reference input voltage,  $\infty V_{REF}$  is defined as:

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

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

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

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



**NOTE 2**

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

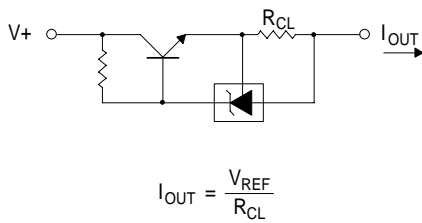
$$|Z_{ka}| = \frac{\Delta V_{KA}}{\Delta I_K}$$

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:

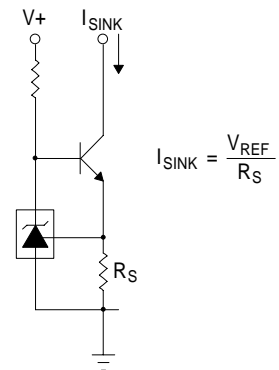
$$|Z_{ka}| \approx |Z_{ka}| \left( 1 + \frac{R1}{R2} \right)$$

TYPICAL APPLICATIONS

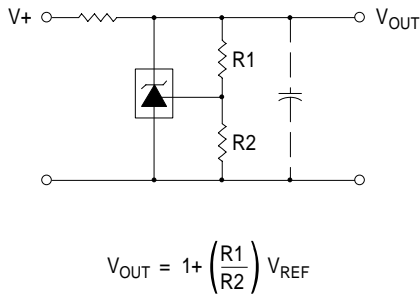
CONSTANT CURRENT SOURCE



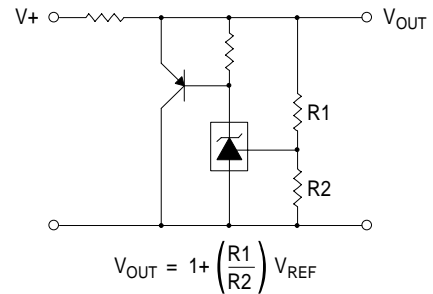
CONSTANT CURRENT SINK



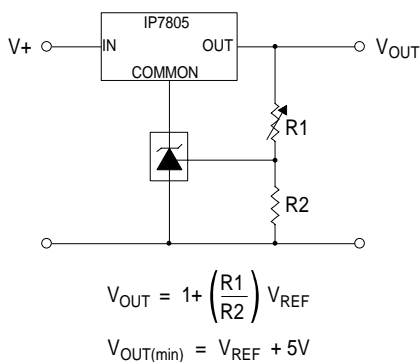
SHUNT REGULATOR



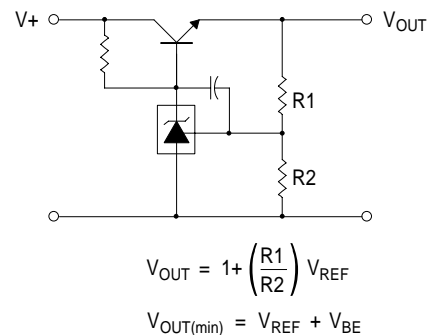
HIGH CURRENT SHUNT REGULATOR



OUTPUT CONTROL OF A THREE-TERMINAL FIXED REGULATOR

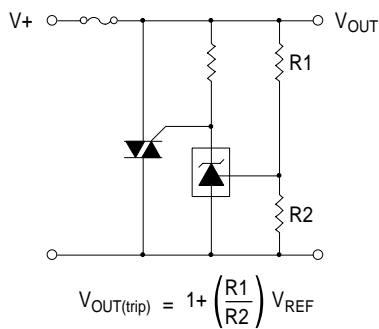


SERIES PASS REGULATOR

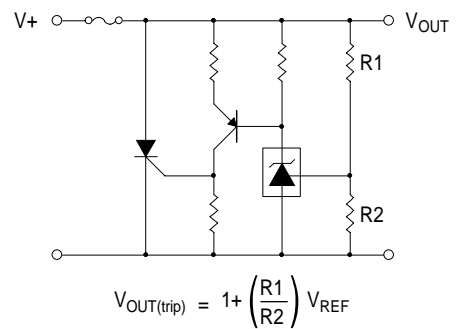


TYPICAL APPLICATIONS

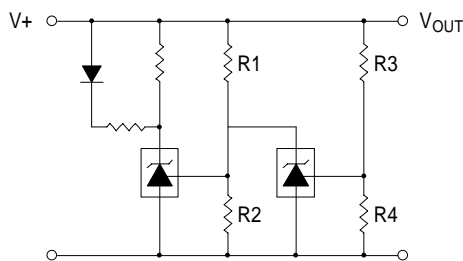
TRIAC CROWBAR



THYRISTOR CROWBAR



VOLTAGE MONITOR

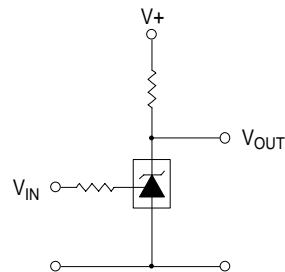


LED is 'on' when V+ is between the upper and lower limits.

$$\text{Lower Limit} = \left( 1 + \frac{R1}{R2} \right) V_{REF}$$

$$\text{Upper Limit} = \left( 1 + \frac{R3}{R4} \right) V_{REF}$$

SINGLE SUPPLY COMPARATOR WITH TEMPERATURE COMPENSATED THRESHOLD



$$V_{TH} = V_{REF}$$

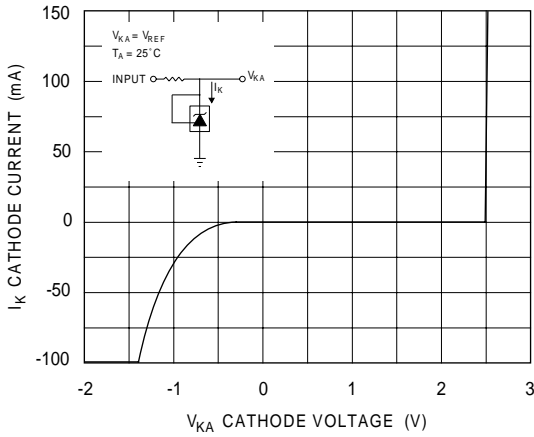
V <sub>IN</sub>	V <sub>OUT</sub>
< V <sub>REF</sub>	V+
> V <sub>REF</sub>	= 2.0 V

THERMAL CHARACTERISTICS

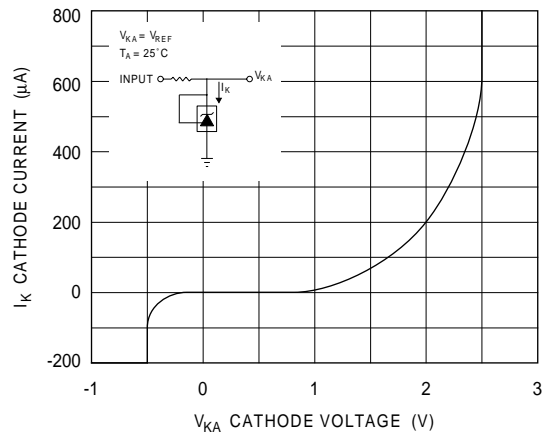
R <sub>θJA</sub>	Thermal Resistance, Junction – Ambient	D Package	178°C/W
		N Package	114°C/W
		J Package	100°C/W
R <sub>θJC</sub>	Thermal Resistance, Junction – Case	D Package	83°C/W
		N Package	41°C/W
		J Package	38°C/W

TYPICAL PERFORMANCE CHARACTERISTICS

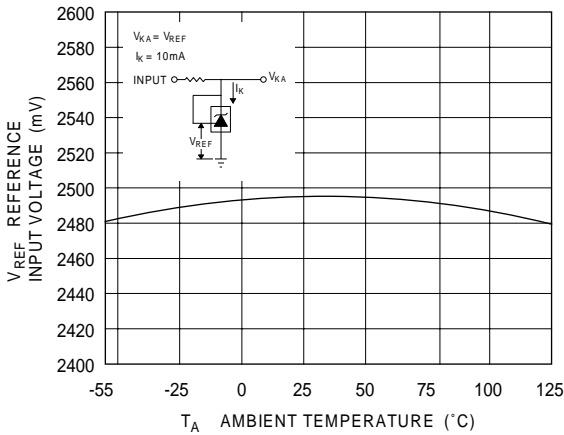
CATHODE CURRENT vs CATHODE VOLTAGE



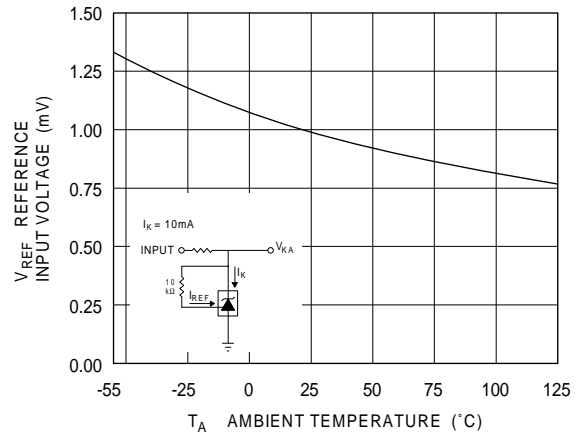
CATHODE CURRENT vs CATHODE VOLTAGE



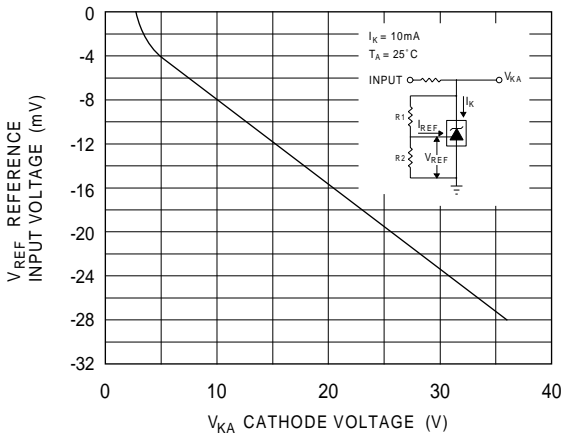
REFERENCE INPUT VOLTAGE vs AMBIENT TEMPERATURE



REFERENCE INPUT CURRENT vs AMBIENT TEMPERATURE



CHANGE IN REFERENCE INPUT VOLTAGE vs AMBIENT TEMPERATURE



OFF-STATE CATHODE CURRENT vs AMBIENT TEMPERATURE

