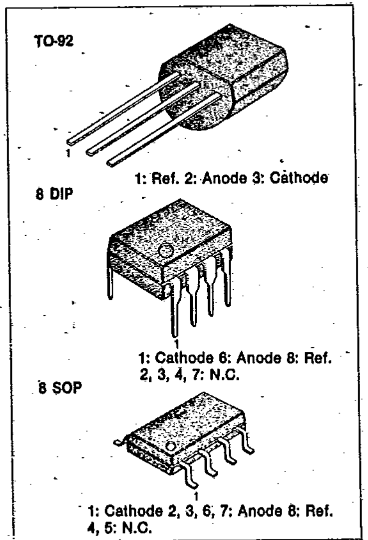
KA431 **LINEAR INTEGRATED CIRCUIT**

PROGRAMMABLE PRECISION REFERENCES

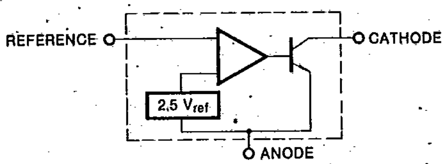
The KA431 is a three-terminal adjustable regulator series with guaranteed thermal stability over applicable temperature ranges. The output voltage may be set to any value between V_{ref} (approximately 2.5 volts) and 36 volts with two external resistors. These devices have a typical dynamic output impedance of 0.2Ω. Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replancement for zener diodes in many applications.

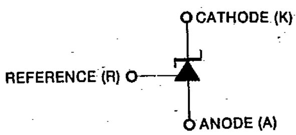


FEATURES

- Programmable output voltage to 36 volts
- Low dynamic output impedance 0.2Ω typical
- Sink current capability of 1.0 to 100mA
- Equivalent full-range temperature coefficient of 50ppm/°C typical
- Temperature compensated for operation over full rated operating temperature range
- Low output noise voltage

BLOCK DIAGRAM



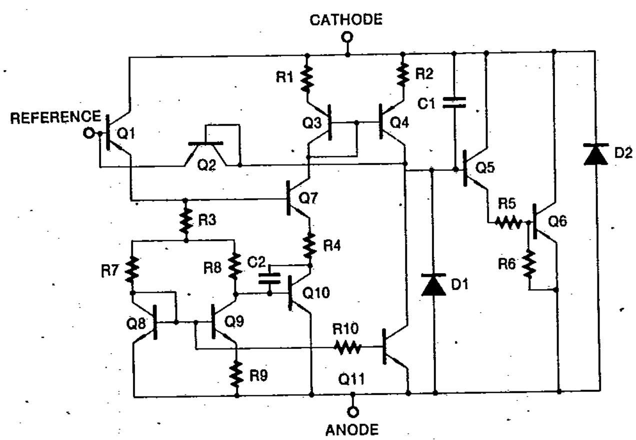


ORDERING INFORMATION

Device	Operating Temperature	Package
KA431CZ	0 ~ +70°C	TO-92
**KA431CN	0 ~ +70°C	8 DIP
KA431CD	0 ~ +70°C	8 SOP
**KA431IZ	−40 ~ +85°C	TO-92
**KA431IN	−40 ~ +85°C	8 DIP

** Under Development.

SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

(Operating temperature range applies unless otherwise specified.)

Characteristic	Symbol	Value	Unit
Cathode Voltage	V_{KA}	37	V
Cathode Current Range (Continuous)	I_K	−100 ~ +150	mA
Reference Input Current Range	I_{ref}	0.05 ~ +10	mA
Power Dissipation	P_D		
D, Z Suffix Package		770	mW
N Suffix Package		1000	mW
Operating Temperature	T_{opr}		
KA431CZ, KA431CN, KA431CD		0 ~ +70	°C
KA431IZ, KA431IN		−40 ~ +85	°C
Operating Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	−65 ~ +150	°C

RECOMMENDED OPERATING CONDITIONS

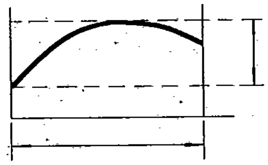
Characteristic	Symbol	Min	Typ	Max	Unit
Cathode Voltage	V_{KA}	V_{ref}		36	V
Cathode Current	I_K	1.0		100	mA

ELECTRICAL CHARACTERISTICS (Ta = 25°C, unless otherwise specified)

Characteristic	Symbol	Test Conditions		Min	Typ	Max	Unit	*T/C
Reference Input Voltage	V_{ref}	$V_{KA} = V_{ref}$, $I_K = 10mA$	Ta = 25°C	2.440	2.495	2.550	V	1
			Ta = 0°C to 70°C	2.423		2.567		
Deviation of Reference Input Voltage Over Temperature 1	$V_{ref(dev)}$	$V_{KA} = V_{ref}$, $I_K = 10mA$ Ta = 0°C to 70°C			8	17	mV	1
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	$\frac{V_{ref}}{V_{KA}}$	$I_K = 10mA$	$V_{KA} = V_{ref}$ to 10V		−1.4	−2.7	mV/V	2
			$V_{KA} = 10V$ to 36V		−1.0	−2.0		
Reference Input Current	I_{ref}	$I_K = 10mA$ R1 = 10KΩ R2 = ∞	Ta = 25°C		1.8	4.0	μA	2
			Ta = 0°C to 70°C			5.2		
Reference Input Current Deviation Over Temperature Range	I_{ref}	$I_K = 10mA$, R1 = 10KΩ R2 = ∞ Ta = 0°C to 70°C			0.4	1.2	μA	2
Minimum Cathode Current for Regulation	I_{Kmin}	$V_{KA} = V_{ref}$			0.5	1.0	mA	1
Off-State Cathode Current	I_{Koff}	$V_{KA} = 36V$, $V_{ref} = 0V$			2.6	1000	nA	3
Dynamic Impedance 2	Z_{KA}	$V_{KA} = V_{ref}$ $I_K = 1.0$ to 100mA f ≤ 1.0KHz			0.22	0.5	Ω	1

* Test Circuit

Note: 1. 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 equivalent full-range temperature coefficient of the reference input voltage, aV_{ref}, is defined as:



Max V_{ref} Min V_{ref} ΔT_A $V_{ref(dev)}$

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

where ΔT_A is the rated operating free-air temperature range of the device.
aV_{ref} can be positive or negative depending on whether minimum V_{ref} or maximum V_{ref}, respectively, occurs at the lower temperature

Example: Max V_{ref} = 2500mV@30°C, Min V_{ref} = 2492mV@0°C, V_{ref} = 2495mV@25°C, ΔT_A = 70°C for KA431C

$$aV_{ref} = \frac{\left(\frac{8mV}{2495mV}\right) \times 10^6}{70°C} = 46ppm/°C$$

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

2. The dynamic impedance is defined as:

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

When the device is operated with two external resistors (see Figure 2), the total dynamic impedance of the circuit is given by:

$$Z' = \frac{\Delta V}{\Delta I} = Z_{KA}\ \left(1 + \frac{R1}{R2}\right)$$

TEST CIRCUIT

Fig. 1 Test Circuit for $V_{KA} = V_{ref}$

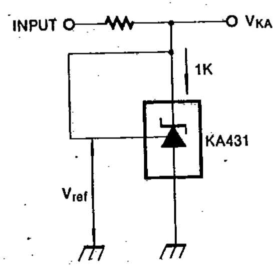
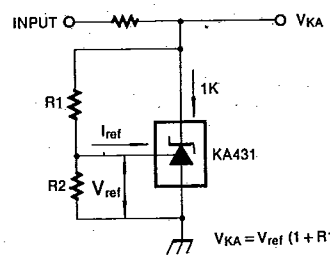
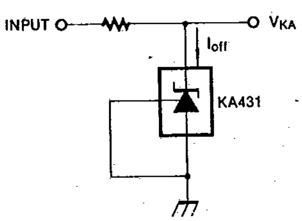


Fig. 2 Test Circuit for $V_{KA} \geq V_{ref}$



$V_{KA} = V_{ref}\ (1 + R1/R2) + I_{ref} \cdot R1$

Fig. 3 Test Circuit for I_{off}



TYPICAL PERFORMANCE CHARACTERISTICS

CATHODE CURRENT VS CATHODE VOLTAGE

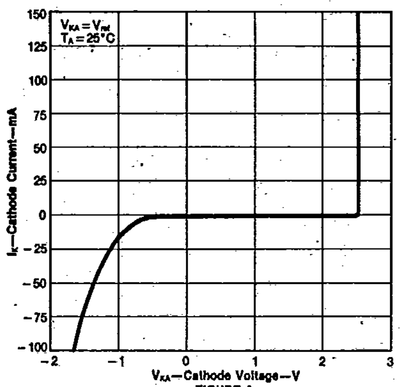


FIGURE 4

CATHODE CURRENT VS CATHODE VOLTAGE

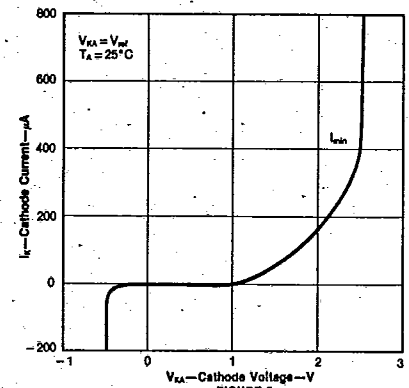


FIGURE 5

CHANGE IN REFERENCE INPUT VOLTAGE VS CATHODE VOLTAGE

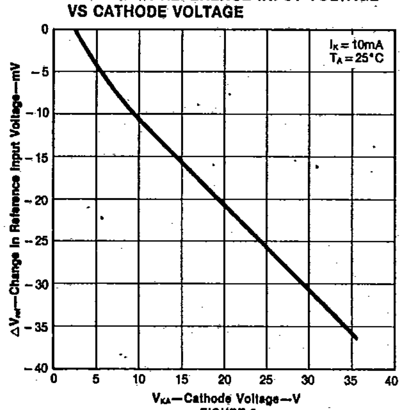


FIGURE 6

NOISE VOLTAGE VS FREQUENCY

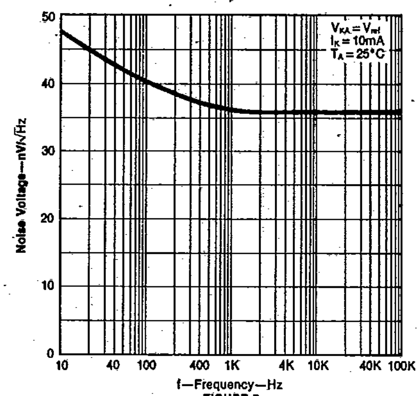


FIGURE 7

DYNAMIC IMPEDANCE VS FREQUENCY

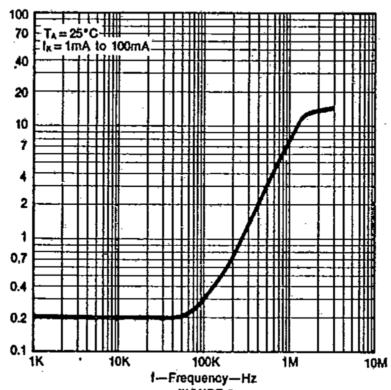


FIGURE 8

SMALL SIGNAL VOLTAGE AMPLIFICATION VS FREQUENCY

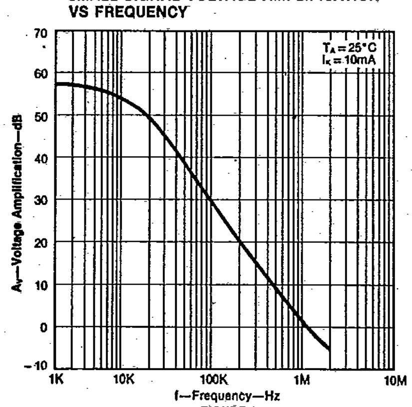


FIGURE 9

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

PULSE RESPONSE

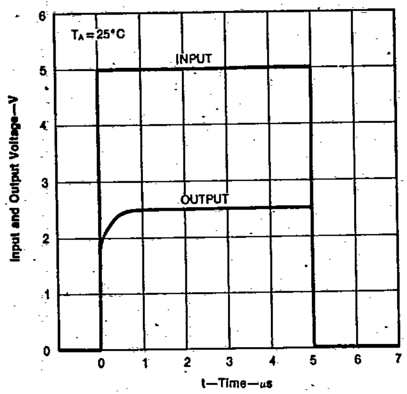
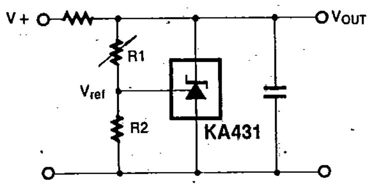


FIGURE 10

TYPICAL APPLICATIONS

FIGURE 11—SHUNT REGULATOR



$V_{out} = (1 + \frac{R1}{R2})V_{ref}$

FIGURE 12—SINGLE-SUPPLY COMPARATOR WITH TEMPERATURE-COMPENSATED THRESHOLD

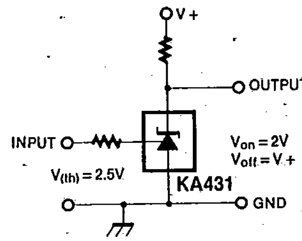
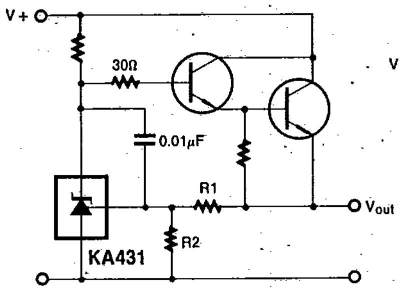
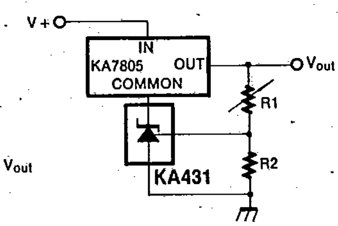


FIGURE 13—SERIES REGULATOR



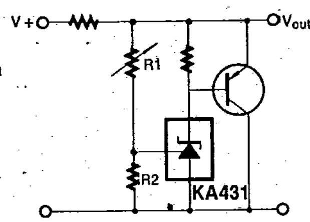
$V_{out} = (1 + \frac{R1}{R2})V_{ref}$

FIGURE 14—OUTPUT CONTROL OF A THREE-TERMINAL FIXED REGULATOR



$V_{out} = V_{ref}(1 + \frac{R1}{R2})$

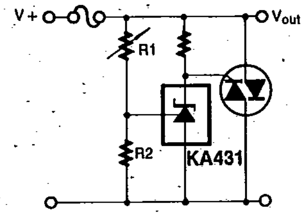
FIGURE 15—HIGHER-CURRENT SHUNT REGULATOR



$V_{out} = (1 + \frac{R1}{R2})V_{ref}$

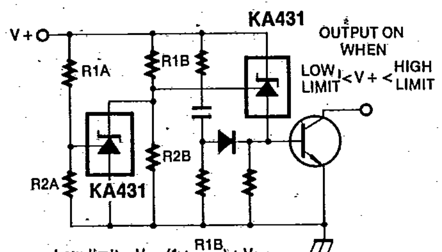
TYPICAL APPLICATIONS (Continued)

FIGURE 16—CROW BAR



$V_{limit} = (1 + \frac{R1}{R2})V_{ref}$

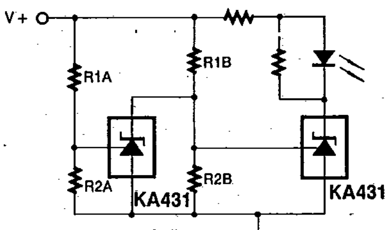
FIGURE 17—OVER-VOLTAGE/UNDER-VOLTAGE PROTECTION CIRCUIT



Low limit $= V_{ref}(1 + \frac{R1B}{R2B}) + V_{BE}$

High limit $= V_{ref}(1 + \frac{R1A}{R2A})$

FIGURE 18—VOLTAGE MONITOR

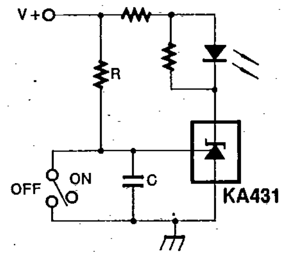


Low limit $= V_{ref}(1 + \frac{R1B}{R2B})$

High limit $= V_{ref}(1 + \frac{R1A}{R2A})$

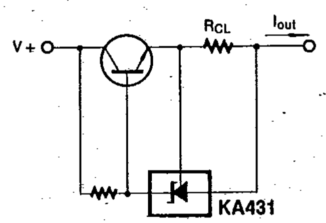
LOW LIMIT < V+ < HIGH LIMIT

FIGURE 19—DELAY TIMER



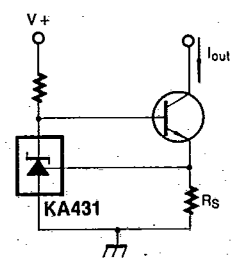
$\text{Delay} = R \cdot C \cdot \ln \frac{V+}{(V+) - V_{ref}}$

FIGURE 20—CURRENT LIMITER OR CURRENT SOURCE



$I_{out} = \frac{V_{ref}}{R_{CL}}$

FIGURE 21—CONSTANT-CURRENT SINK



$I_{out} = \frac{V_{ref}}{R_S}$