

#### DESCRIPTION

The TL431/TL431A/TL431B series precision adjustable three terminal shunt voltage regulators are pin-to-pin compatible with the industry standard TL431. The output voltage of this reference is programmable by using two external resistors from 2.5V to 36V.

These devices offer low output

impedance for improved load regulation. The typical output impedance of these devices is 200mΩ. These devices find application in the feedback path of switching power supplies, OVP crowbar circuits, reference for A/D, D/A, and as zener diodes with improved turn-on characteristics.

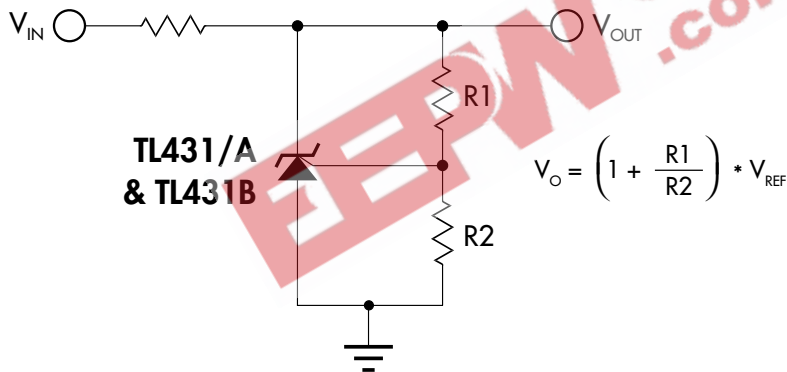
**NOTE:** For current data & package dimensions, visit our web site: <http://www.linfinity.com>.

#### KEY FEATURES

- ❑ INITIAL VOLTAGE REFERENCE ACCURACY OF 0.4% (TL431B)
- ❑ SINK CURRENT CAPABILITY 1mA to 100mA
- ❑ TYPICAL OUTPUT DYNAMIC IMPEDANCE LESS THAN 200mΩ;
- ❑ TYPICAL OUTPUT IMPEDANCE OF THE TL431B LESS THAN 100mΩ
- ❑ ADJUSTABLE OUTPUT VOLTAGE FROM 2.5V TO 36V
- ❑ AVAILABLE IN SURFACE-MOUNT PACKAGES
- ❑ LOW OUTPUT NOISE
- ❑ TYPICAL EQUIVALENT FULL RANGE TEMPERATURE COEFFICIENT OF 30ppm/°C
- ❑ DIRECT PIN-TO-PIN REPLACEMENT FOR INDUSTRY STANDARD TL431 AND TL1431

#### PRODUCT HIGHLIGHT

##### PRECISION PROGRAMMABLE REFERENCES



#### PACKAGE ORDER INFORMATION

T <sub>A</sub> (°C)	Initial Tolerance	DM	LP
		Plastic SOIC 8-pin	Plastic TO-92 3-pin
0 to 70	2%	TL431CDM	TL431CLP
	1%	TL431ACDM	TL431ACL P
	0.4%	TL431BCDM	TL431BCLP
-40 to 85	2%	TL431IDM	TL431ILP
	1%	TL431AIDM	TL431AILP
	0.4%	TL431BIDM	TL431BILP

Note: All surface-mount packages are available in Tape & Reel. Append the letter "T" to part number. (i.e. TL431CDMT) TO-92 (LP) package also available in ammo-pack.

# TL431/TL431A/TL431B

## PRECISION PROGRAMMABLE REFERENCES PRODUCTION DATA SHEET

### ABSOLUTE MAXIMUM RATINGS (Note 1)

Cathode to Anode Voltage ( $V_{KA}$ ) (Note 2) .....	-0.3V to 37V
Reference Input Current ( $I_{REF}$ ) .....	-50 $\mu$ A to 10mA
Continuous Cathode Current ( $I_K$ ) .....	-100mA to 150mA
Operating Junction Temperature	
Plastic (DM, LP Packages) .....	150°C
Storage Temperature Range .....	-65°C to 150°C
Lead Temperature .....	300°C

Note 1. Exceeding these ratings could cause damage to the device. All voltages are with respect to Ground. Currents are positive into, negative out of the specified terminal. Pin numbers refer to DIL packages only.

Note 2. Voltage values are with respect to the anode terminal unless otherwise noted.

### THERMAL DATA

#### DM PACKAGE:

THERMAL RESISTANCE-JUNCTION TO AMBIENT, $\theta_{JA}$	165°C/W
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#### LP PACKAGE:

THERMAL RESISTANCE-JUNCTION TO AMBIENT, $\theta_{JA}$	156°C/W
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Junction Temperature Calculation:  $T_J = T_A + (P_D \times \theta_{JA})$ .

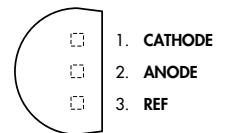
The  $\theta_{JA}$  numbers are guidelines for the thermal performance of the device/pc-board system.

All of the above assume no ambient airflow

### PACKAGE PIN OUTS

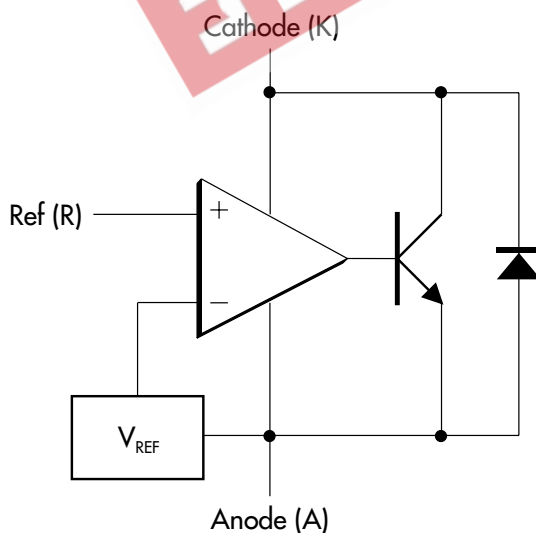
CATHODE	1	8	REF
N.C.	2	7	ANODE
ANODE	3	6	ANODE
N.C.	4	5	N.C.

DM PACKAGE  
(Top View)



LP PACKAGE  
(Top View)

### BLOCK DIAGRAM



# TL431/TL431A/TL431B

## PRECISION PROGRAMMABLE REFERENCES

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#### ELECTRICAL CHARACTERISTICS (Note 3)

(Unless otherwise specified, these specifications apply over the operating ambient temperatures for TL431C/TL431AC/TL431BC with  $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$ , TL431I/TL431AI/TL431BI with  $-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$ .)

Parameter	Symbol	Test Conditions	TL431/431A/431B			Units
			Min.	Typ.	Max.	
Reference Input Voltage	TL431	$V_{REF}$ $I_K = 10\text{mA}, V_{KA} = V_{REF}, T_A = 25^{\circ}\text{C}$	2440	2495	2550	mV
	TL431A	$I_K = 10\text{mA}, V_{KA} = V_{REF}, T_A = 25^{\circ}\text{C}$	2470	2495	2520	mV
	TL431B	$I_K = 10\text{mA}, V_{KA} = V_{REF}, T_A = 25^{\circ}\text{C}$	2490	2500	2510	mV
Reference Drift	TL431C	$\Delta V_{REF}$ $I_K = 10\text{mA}, V_{KA} = V_{REF}$		4	17	mV
	TL431I			5	30	mV
	TL431AC	$\Delta V_{KA}$ $I_K = 10\text{mA}, V_{KA} = V_{REF}$		4	17	mV
	TL431AI			5	30	mV
	TL431BC			4	15	mV
	TL431BI			5	20	mV
Voltage Ratio, Ref to Cathode (Note 4)	TL431, TL431A	$I_K = 10\text{mA}, V_{KA} = 2.5\text{V to } 36\text{V}$	-1.4	-2.7		mV/V
	TL431B	$I_K = 10\text{mA}, V_{KA} = 2.5\text{V to } 36\text{V}$	-1.1	-2		mV/V
Reference Input Current	TL431, TL431A	$I_{REF}$ $V_{KA} = V_{REF}, T_A = 25^{\circ}\text{C}$		2	4	$\mu\text{A}$
	TL431B	$V_{KA} = V_{REF}, T_A = 25^{\circ}\text{C}$		1.5	1.9	$\mu\text{A}$
		$V_{KA} = V_{REF}, T_A = \text{Operating Range}$				2.3
Minimum Operating Current	$I_{MIN}$	$V_{KA} = V_{REF}$ to 36V		0.4	1	mA
Off-State Cathode Current	TL431	$I_{OFF}$ $V_{KA} = V_{REF}$ to 36V, $T_A = 25^{\circ}\text{C}$		0.1	1	$\mu\text{A}$
	TL431A			0.1	1	$\mu\text{A}$
	TL431B	$V_{KA} = V_{REF}$ to 36V, $T_A = \text{Operating Range}$			2	$\mu\text{A}$
		$V_{KA} = 36\text{V}, V_{REF} = 0\text{V}, T_A = 25^{\circ}\text{C}$		0.18	0.5	$\mu\text{A}$
Dynamic Impedance	TL431	$ Z_{KA} $ $V_{KA} = V_{REF}, I_K = 1\text{mA to } 100\text{mA}, f \leq 1\text{kHz}, T_A = 25^{\circ}\text{C}$		0.2	0.5	$\Omega$
	TL431B		$V_{KA} = V_{REF}, I_K = 1\text{mA to } 100\text{mA}, f \leq 1\text{kHz}, T_A = 25^{\circ}\text{C}$		0.1	0.2

Note 3. These parameters are guaranteed by design.

Note 4.  $\frac{\Delta V_{REF}}{\Delta V_{KA}}$  Ratio of change in reference input voltage to the change in cathode voltage.

# TL431/TL431A/TL431B

## PRECISION PROGRAMMABLE REFERENCES

### PRODUCTION DATA SHEET

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##### Characteristic Curves

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2. REFERENCE INPUT CURRENT vs. FREE-AIR TEMPERATURE
3. CATHODE CURRENT vs. CATHODE VOLTAGE
4. CATHODE CURRENT vs. CATHODE VOLTAGE
5. OFF-STATE CATHODE CURRENT vs. FREE-AIR TEMPERATURE
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9. TEST CIRCUIT FOR  $V_{KA} > V_{REF}$
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###### FIGURE #

11. EQUIVALENT INPUT NOISE VOLTAGE OVER A 10-SECOND PERIOD
12. SMALL-SIGNAL VOLTAGE AMPLIFICATION vs. FREQUENCY
13. REFERENCE IMPEDANCE vs. FREQUENCY
14. PULSE RESPONSE
15. STABILITY BOUNDARY CONDITIONS

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16. SHUNT REGULATOR
17. SINGLE-SUPPLY COMPARATOR WITH TEMPERATURE-COMPENSATED THRESHOLD
18. HIGH CURRENT SHUNT REGULATOR
19. CROWBAR CIRCUIT
20. VOLTAGE MONITOR
21. PRECISION CONSTANT-CURRENT SINK

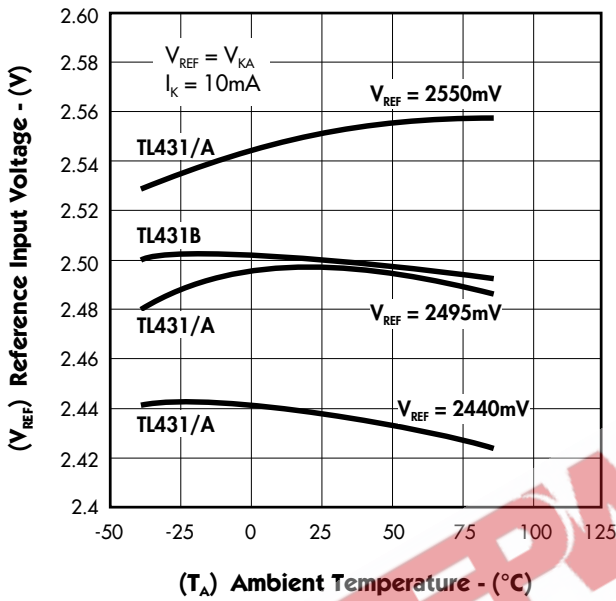
# TL431/TL431A/TL431B

## PRECISION PROGRAMMABLE REFERENCES

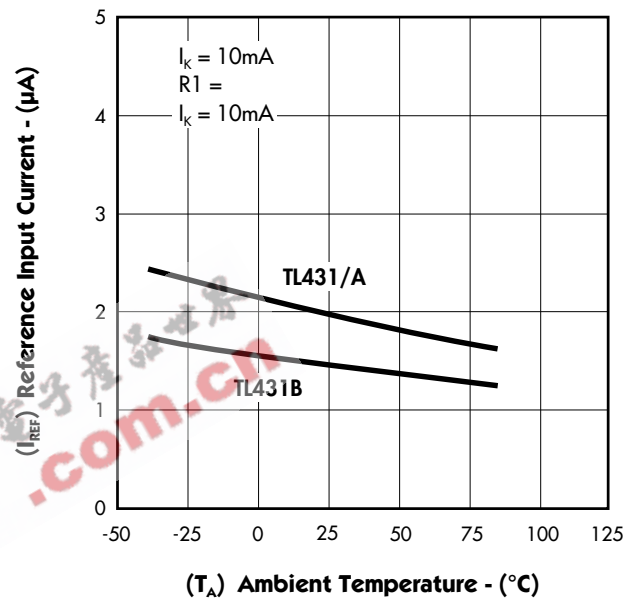
### PRODUCTION DATA SHEET

#### CHARACTERISTIC CURVES

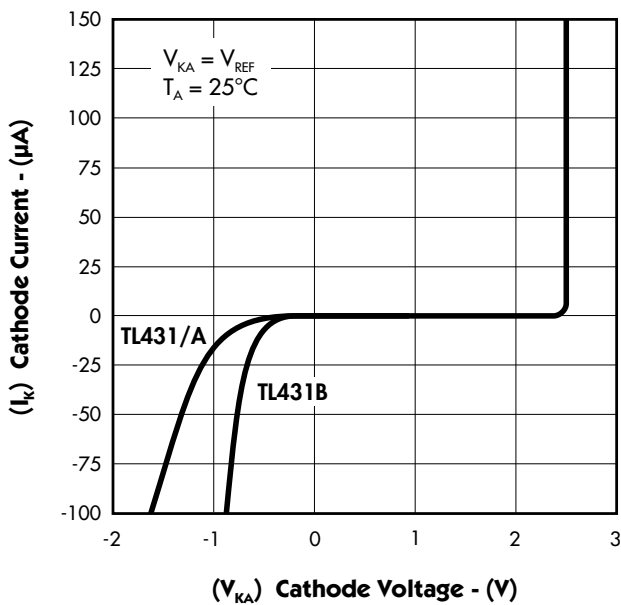
**FIGURE 1.** — REFERENCE VOLTAGE vs. FREE-AIR TEMPERATURE



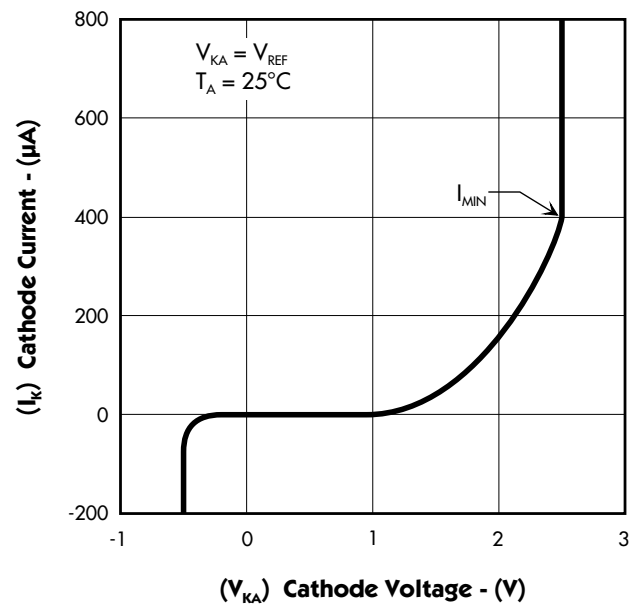
**FIGURE 2.** — REFERENCE CURRENT vs. FREE-AIR TEMPERATURE



**FIGURE 3.** — CATHODE CURRENT vs. CATHODE VOLTAGE



**FIGURE 4.** — CATHODE CURRENT vs. CATHODE VOLTAGE



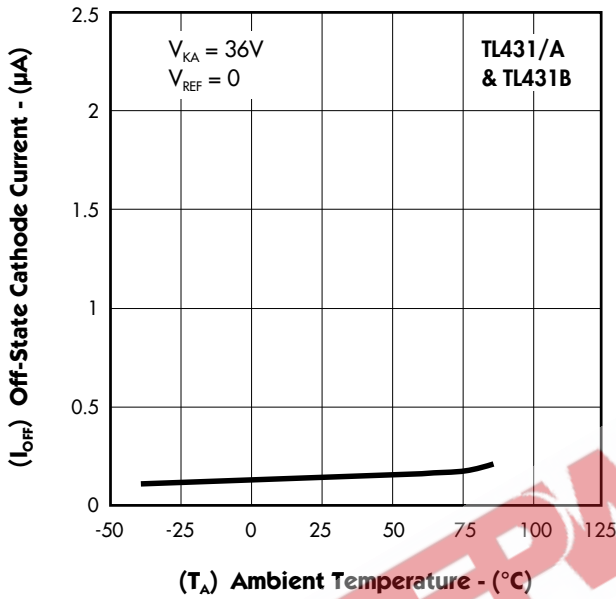
# TL431/TL431A/TL431B

## PRECISION PROGRAMMABLE REFERENCES

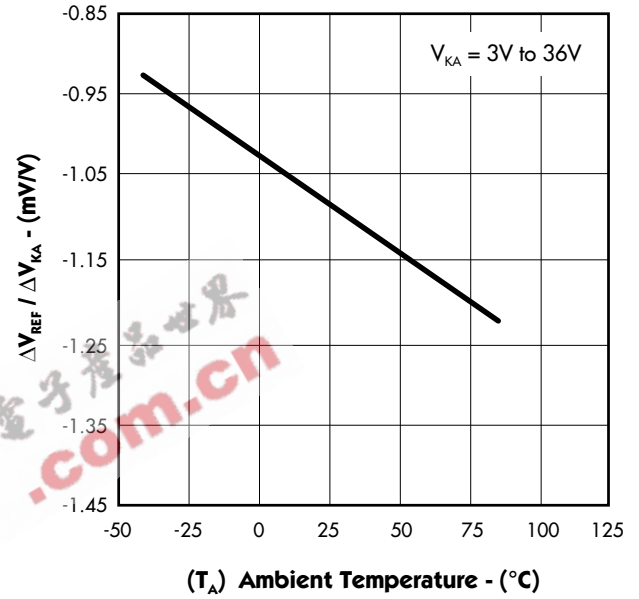
### PRODUCTION DATA SHEET

#### CHARACTERISTIC CURVES

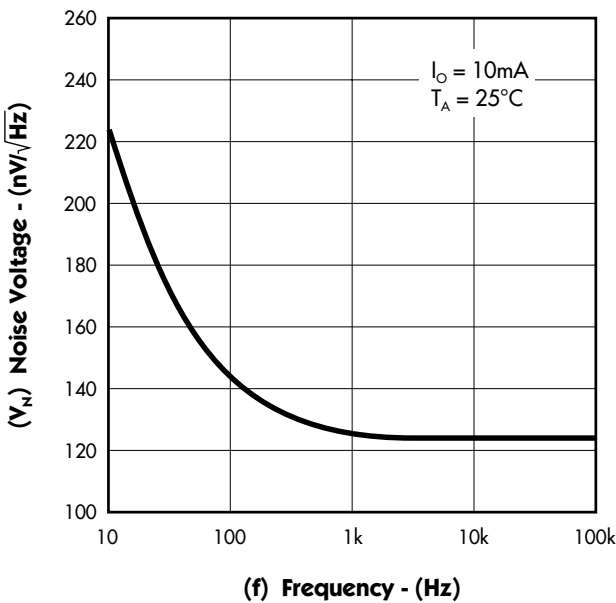
**FIGURE 5.** — OFF-STATE CATHODE CURRENT vs. FREE-AIR TEMPERATURE



**FIGURE 6.** — RATIO OF DELTA REFERENCE VOLTAGE TO DELTA CATHODE VOLTAGE vs. FREE-AIR TEMPERATURE



**FIGURE 7.** — EQUIVALENT INPUT NOISE VOLTAGE vs. FREQUENCY



# TL431/TL431A/TL431B

## PRECISION PROGRAMMABLE REFERENCES

### PRODUCTION DATA SHEET

#### PARAMETER MEASUREMENT INFORMATION

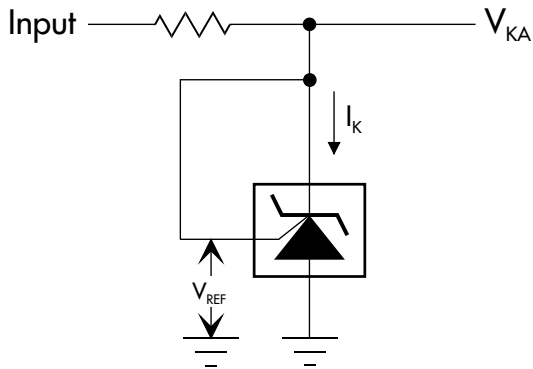


FIGURE 8 — TEST CIRCUIT FOR  $V_{KA} = V_{REF}$

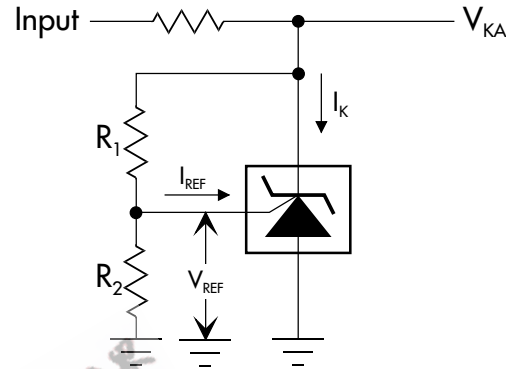


FIGURE 9 — TEST CIRCUIT FOR  $V_{KA} > V_{REF}$

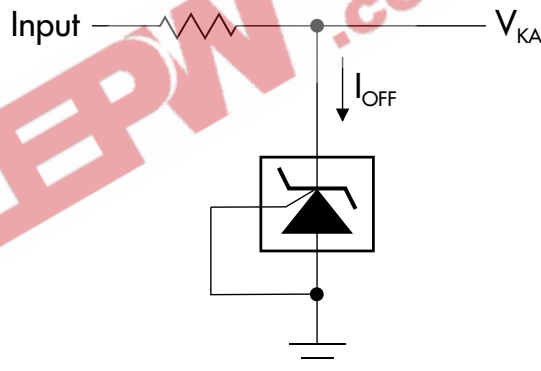


FIGURE 10 — TEST CIRCUIT FOR  $I_{OFF}$

# TL431/TL431A/TL431B

## PRECISION PROGRAMMABLE REFERENCES PRODUCTION DATA SHEET

### TYPICAL CHARACTERISTICS

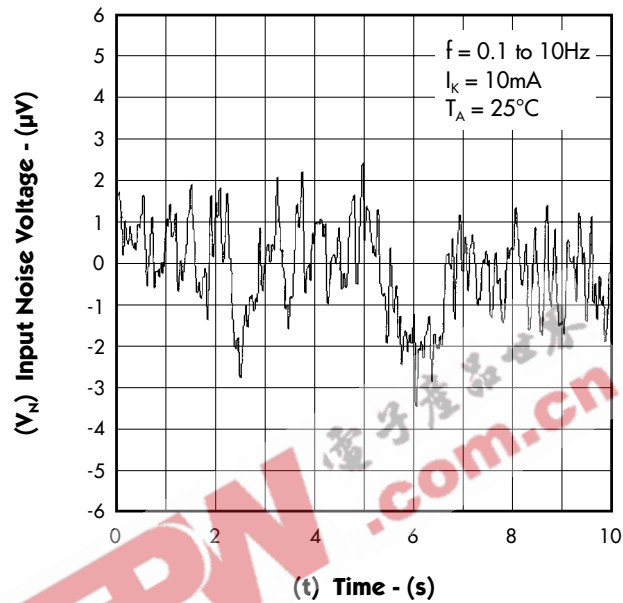
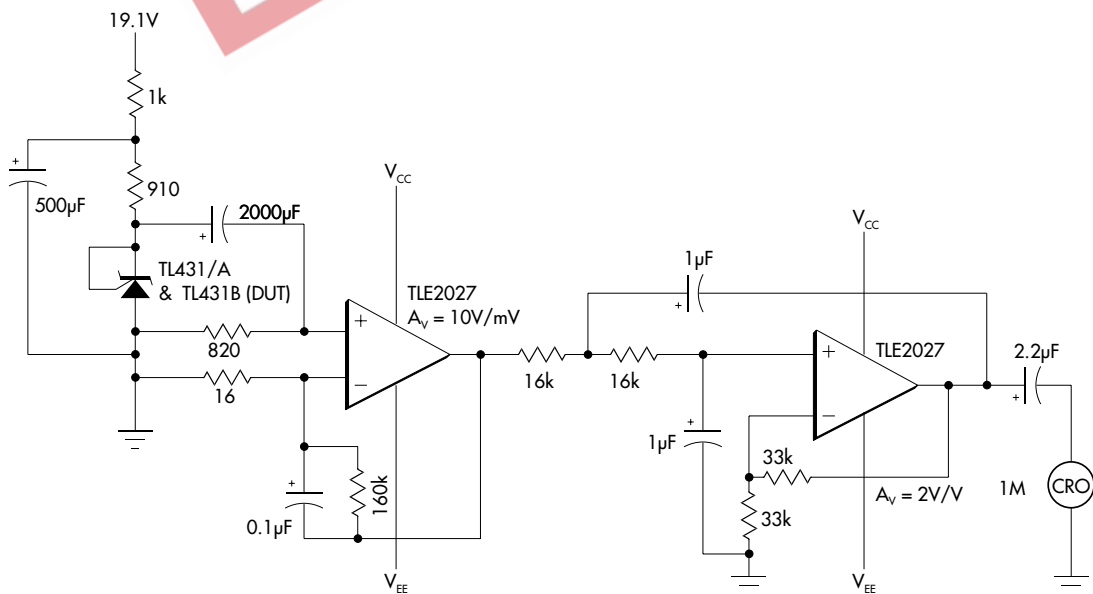


FIGURE 11. — EQUIVALENT INPUT NOISE VOLTAGE OVER A 10-SECOND PERIOD



Test Circuit for 0.1Hz to 10Hz Equivalent Input Noise Voltage

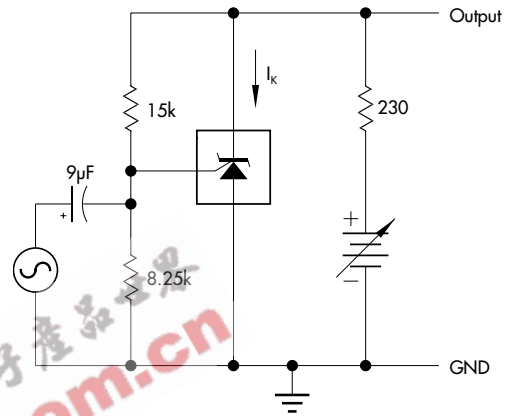
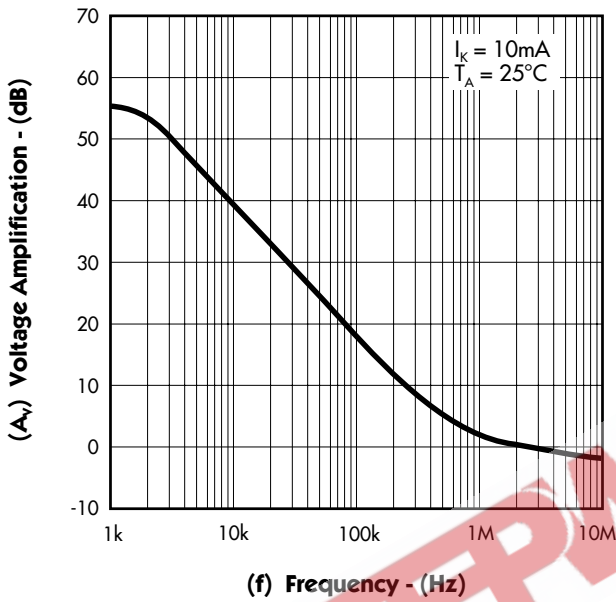


# TL431/TL431A/TL431B

## PRECISION PROGRAMMABLE REFERENCES PRODUCTION DATA SHEET

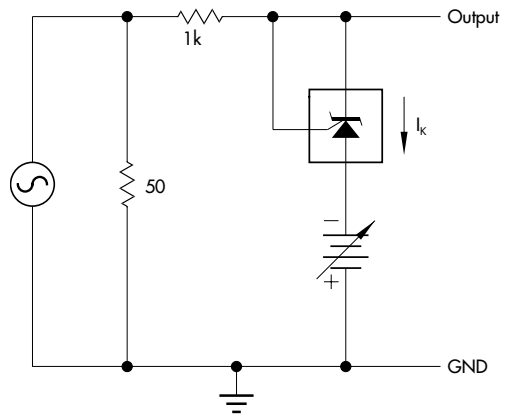
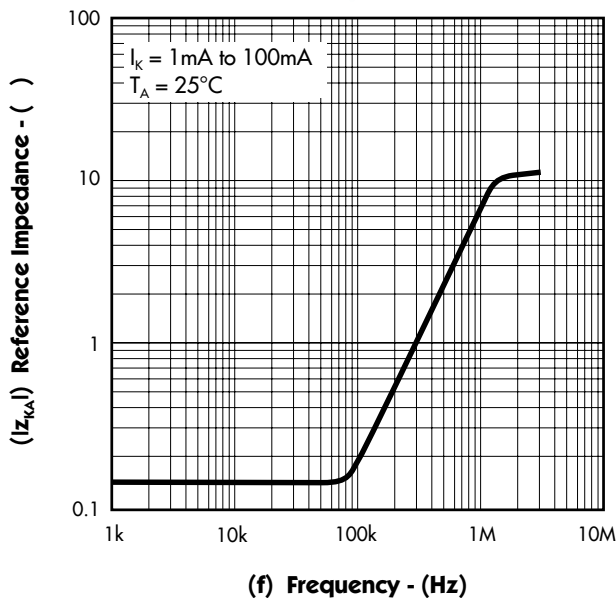
### TYPICAL CHARACTERISTICS

**FIGURE 12.** — SMALL-SIGNAL VOLTAGE AMPLIFICATION vs. FREQUENCY



Test Circuit for Voltage Amplification

**FIGURE 13.** — REFERENCE IMPEDANCE vs. FREQUENCY



Test Circuit for Reference Impedance

# TL431/TL431A/TL431B

## PRECISION PROGRAMMABLE REFERENCES PRODUCTION DATA SHEET

### TYPICAL CHARACTERISTICS

FIGURE 14. — PULSE RESPONSE

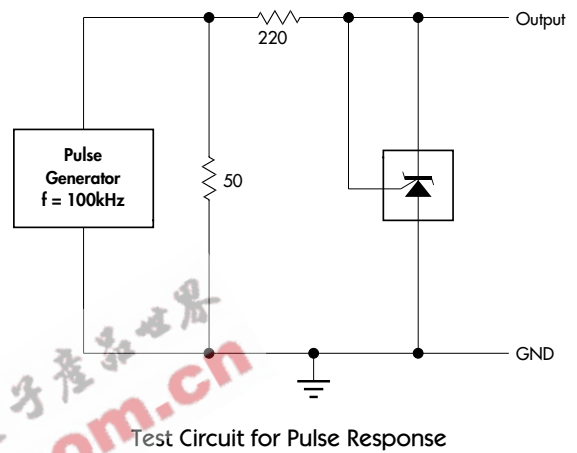
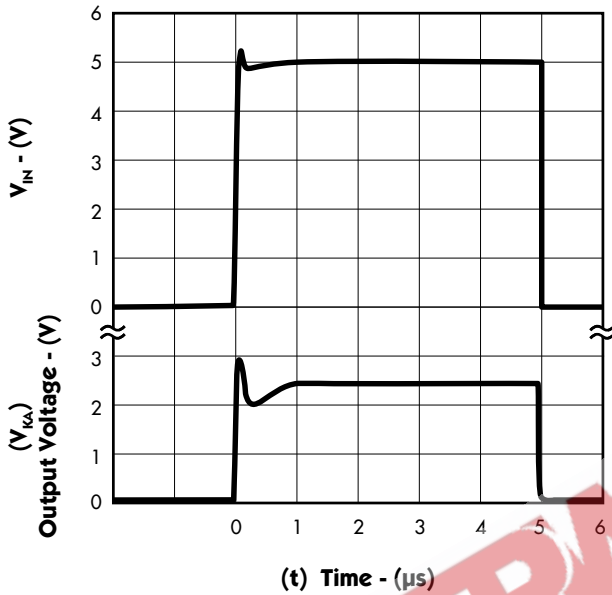
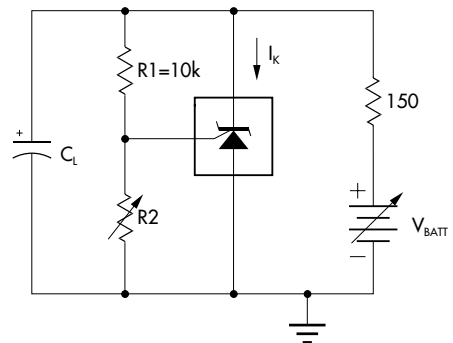
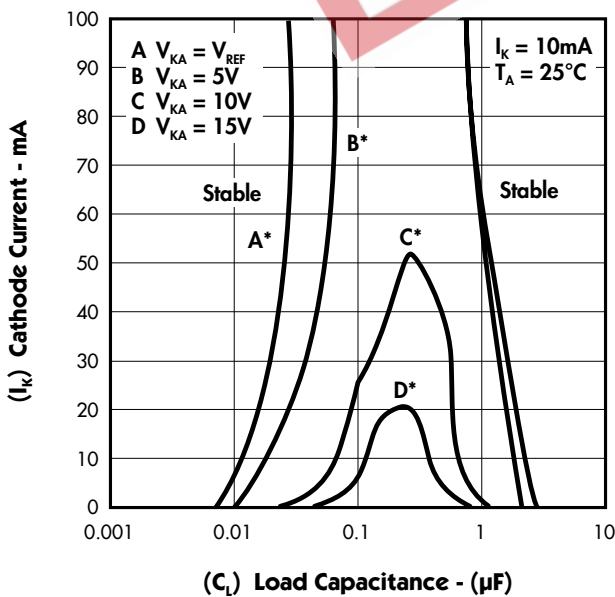
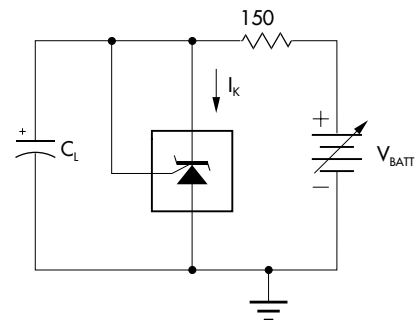


FIGURE 15. — STABILITY BOUNDARY CONDITIONS



Test Circuit for Curve A



Test Circuit for Curves B, C, and D

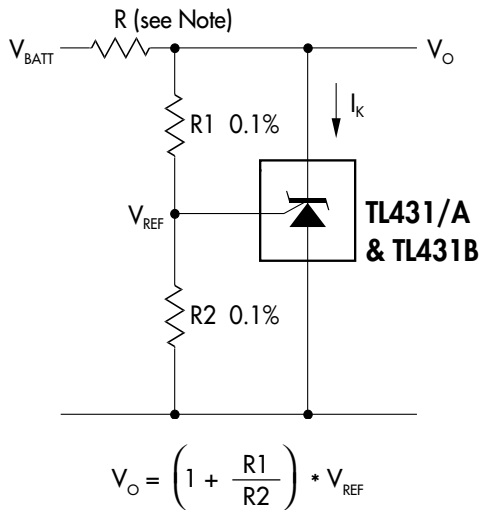
\* The areas under the curves represent conditions that may cause the device to oscillate. For curves B, C, and D, R2 and V+ were adjusted to establish the initial  $V_{KA}$  and  $I_K$  conditions with  $C_L = 0$ .  $V_{BATT}$  and  $C_L$  were then adjusted to determine the ranges of stability.

# TL431/TL431A/TL431B

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#### APPLICATION INFORMATION



Note: R should provide  $\geq 1$  mA cathode current to the TL431/A & TL431B at minimum  $V_{BATT}$ .

FIGURE 16 — SHUNT REGULATOR

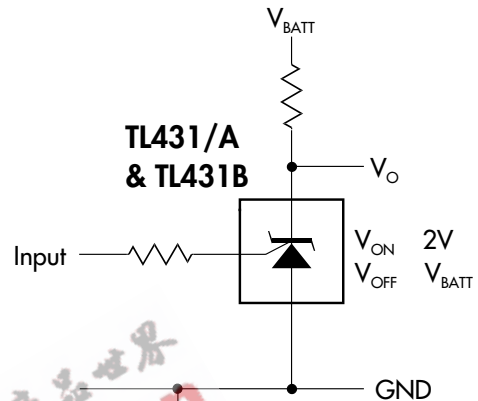


FIGURE 17 — SINGLE-SUPPLY COMPARATOR WITH TEMPERATURE-COMPENSATED THRESHOLD

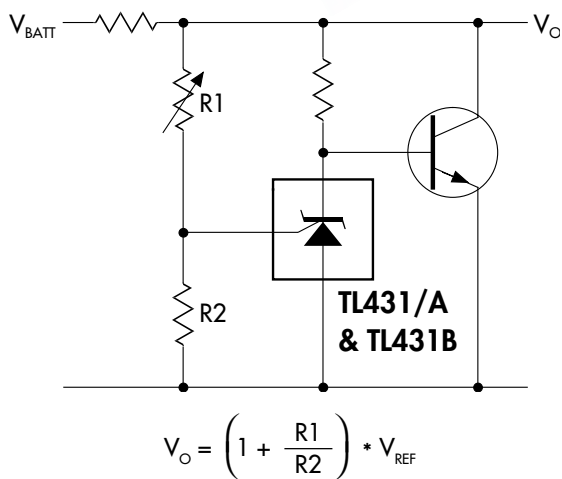
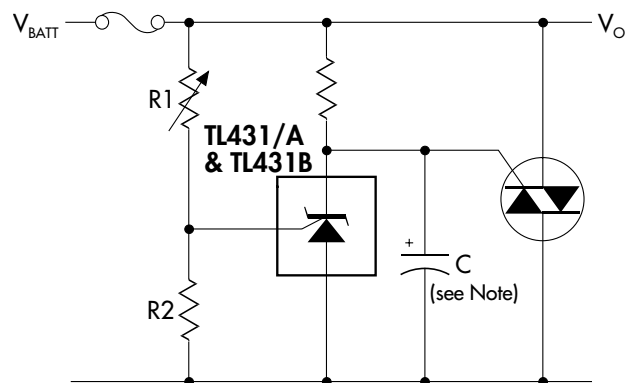


FIGURE 18 — HIGH CURRENT SHUNT REGULATOR



Note: Refer to the stability boundary conditions in Figure 15 to determine allowable values for C.

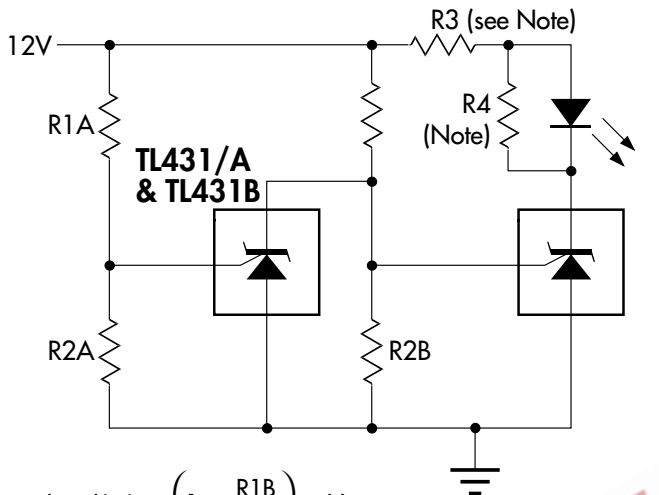
FIGURE 19 — CROWBAR CIRCUIT

# TL431/TL431A/TL431B

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#### APPLICATION INFORMATION



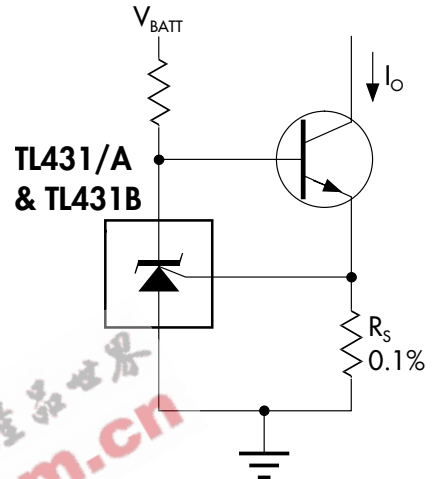
$$\text{Low Limit} = \left( 1 + \frac{R1B}{R2B} \right) * V_{REF}$$

$$\text{High Limit} = \left( 1 + \frac{R1B}{R2B} \right) * V_{REF}$$

LED On when  
Low Limit < V<sub>BATT</sub> < High Limit

Note: R3 and R4 are selected to provide the desired LED intensity and ≥ 1 mA cathode current to the TL431/A & TL431B at the available V<sub>+</sub>.

FIGURE 20 — VOLTAGE MONITOR



$$I_o = \left( \frac{V_{REF}}{R_s} \right)$$

FIGURE 21 — PRECISION CONSTANT-CURRENT SINK

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