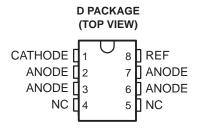
- 0.4% Initial Voltage Tolerance
- 0.2-Ω Typical Output Impedance
- Fast Turnon . . . 500 ns
- Sink Current Capability . . . 1 mA to 100 mA
- Low Reference Current (REF)
- Adjustable Output Voltage . . . V_{I(ref)} to 36 V

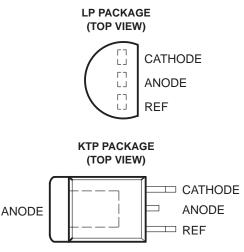
description

The TL1431 is a precision programmable reference with specified thermal stability over applicable automotive commercial and temperature ranges. The output voltage can be set to any value between V_{I(ref)} (approximately 2.5 V) and 36 V with two external resistors (see Figure 16). These devices have a typical output impedance of 0.2Ω . Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replacements for zener diodes and other types of references in applications such as on-board regulation, adjustable power supplies, and switching power supplies.

The TL1431C is characterized for operation over the commercial temperature range of 0°C to 70°C. The TL1431Q is characterized for operation over the automotive temperature range of -40°C to 125°C.



NC – No internal connection ANODE terminals are connected internally.



The ANODE terminal is in electrical contact with the mounting base.

AVAILABLE OPTIONS

	P			
TA	SMALL OUTLINE (D)	PLASTIC FLANGE MOUNTED (KTP)	TO-226AA (LP)	CHIP FORM (Y)
0°C to 70°C	TL1431CD	TL1431CKTPR	TL1431CLP	TL1431Y
–40°C to 125°C	TL1431QD	_	TL1431QLP	114311

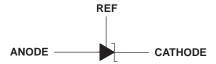
The D and LP packages are available taped and reeled. The KTP package is only available tape and reeled. Add the suffx R to the device type (e.g., TL1431CDR). Chip forms are tested at 25°C.



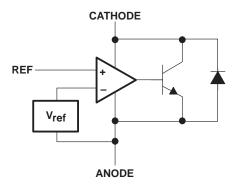
Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



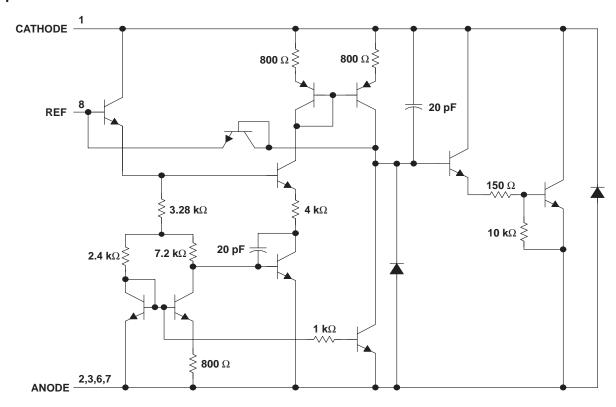
logic symbol



functional block diagram



equivalent schematic†



† All component values are nominal. Pin numbers shown are for the D package.



TL1431 PRECISION PROGRAMMABLE REFERENCES

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absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Cathode voltage, V _{KA} (see Note 1)		37 V
Continuous cathode current range, I _{KA}		
Reference input current range, I _{I(ref)}		–50 μA to 10 mA
Package thermal impedance, θ_{JA} (see Notes 2 and 3):		
	KTP package	28°C/W
	LP package	156°C/W
Lead temperature 1,6 mm (1/16 inch) from case for 10	seconds	260°C
Storage temperature range, T _{stq}		65°C to 150°C

[†] Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES: 1. All voltage values are with respect to ANODE unless otherwise noted.
 - 2. Maximum power dissipation is a function of $T_J(max)$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can impact reliability.
 - 3. The package thermal impedance is calculated in accordance with JESD 51, except for through-hole packages, which use a trace length of zero.

recommended operating conditions

		MIN	MAX	UNIT
Cathode voltage, V _{KA}		V _{I(ref)}	36	V
Cathode current, IKA		1	100	mA
One vesting free pir temperature T	TL1431C	0	70	°C
Operating free-air temperature, T _A	TL1431Q	-40	125	C

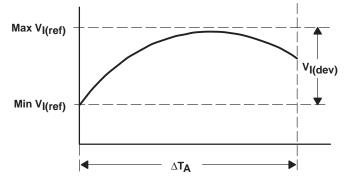
electrical characteristics at specified free-air temperature, I_{KA} = 10 mA (unless otherwise noted)

PARAMETER		TEST CONDITIONS	t	TA [†] TEST	TL1431C			TL1431Q			UNIT
	ARAWEIER	TEST CONDITIONS	'A'	CIRCUIT	MIN	TYP	MAX	MIN	TYP	MAX	UNIT
V _{I(ref)}	Reference input voltage	$V_{KA} = V_{I(ref)}$	25°C Full	1	2490 2480	2500	2510 2520	2490 2470	2500	2510 2530	mV
V _I (dev)	Deviation of reference input voltage over full temperature range‡	V _K A = V _I (ref)	Full range	1		4	20		17	55	mV
$\frac{\Delta V_{I(ref)}}{\Delta V_{KA}}$	Ratio of change in reference input voltage to the change in cathode voltage	$\Delta V_{KA} = 3 \text{ V to } 36 \text{ V}$	Full range	2		-1.1	-2		-1.1	-2	mV/V
	Reference		25°C			1.5	2.5		1.5	2.5	
I _{I(ref)}	input current	R1 = 10 k Ω , R2 = ∞	Full range	2			3			3	μΑ
II(dev)	Deviation of reference input current over full temperature range‡	R1 = 10 kΩ, R2 = ∞	Full range	2		0.2	1.2		0.5	1.2	μΑ
	Minimum cathode current for regulation	$V_{KA} = V_{I(ref)}$ to 36 V	25°C	1		0.45	1		0.45	1	mA
	Off-state		25°C			0.18	0.5		0.18	0.5	
IKoff =	cathode current (Vref - 1.2) / 3100	$V_{KA} = 36 \text{ V}, V_{I(ref)} = 0$	Full range	3			2			2	μΑ
z _{KA}	Output impedance§	$V_{KA} = V_{I(ref)}$, $f \le 1$ kHz, $I_{KA} = 1$ mA to 100 mA	25°C	1		0.2	0.4		0.2	0.4	Ω

[†] Full range is 0°C to 70°C for C-suffix devices and –40°C to 125°C for Q-suffix devices.

$$\left|\alpha_{V_{\text{I(ref)}}}\right|\left(\frac{ppm}{{}^{\circ}C}\right) = \frac{\left(\frac{V_{\text{I(dev)}}}{V_{\text{I(ref)}} \text{ at } 25{}^{\circ}C}\right) \times 10^{6}}{\Delta T_{\text{A}}}$$

 ΔT_A is the rated operating temperature range of the device.



 $\alpha_{V_{l(ref)}}$ is positive or negative depending on whether minimum $V_{l(ref)}$ or maximum $V_{l(ref)}$, respectively, occurs at the lower temperature.

§ The output impedance is defined as: $|z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_{KA}}$

When the device is operating with two external resistors (see Figure 2), the total dynamic impedance of the circuit is given by: $|z'| = \frac{\Delta V}{\Lambda I}$, which is approximately equal to $|z_{KA}| \left(1 + \frac{R1}{R2}\right)$.

[‡] The deviation parameters $V_{I(dev)}$ and $I_{I(dev)}$ are defined as the differences between the maximum and minimum values obtained over the rated temperature range. The average full-range temperature coefficient of the reference input voltage $\alpha_{V_{I(ref)}}$ is defined as:

electrical characteristics at I_{KA} = 10 mA, T_A = 25°C

PARAMETER		TEST CONDITIONS	TEST	TL1431Y			LINUT
	PARAINETER	TEST CONDITIONS	CIRCUIT	MIN	TYP	MAX	UNIT
V _{I(ref)}	Reference input voltage	V _K A = V _I (ref)	1	2490	2500	2510	mV
$\frac{\Delta V_{l(ref)}}{\Delta V_{KA}}$	Ratio of change in reference input voltage to the change in cathode voltage	$\Delta V_{KA} = 3 \text{ V to } 36 \text{ V}$	2		-1.1	-2	mV/V
I _I (ref)	Reference input current	R1 = 10 k Ω , R2 = ∞	2		1.44	2.5	μΑ
IKAmin	Minimum cathode current for regulation	$V_{KA} = V_{I(ref)}$ to 36 V	1		0.45	1	mA
l _{off}	Off-state cathode current	$V_{KA} = 36 \text{ V}, \qquad V_{ref} = 0$	3		0.18	0.5	μΑ
z _{KA}	Output impedance†	$V_{KA} = V_{I(ref)}$, $f \le 1$ kHz, $I_{KA} = 1$ mA to 100 mA	1		0.2	0.4	Ω

[†] The output impedance is defined as: $|z'| = \frac{\Delta V}{\Delta l}$

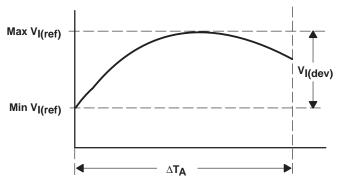
When the device is operating with two external resistors (see Figure 2), the total dynamic impedance of the circuit is given by: $|z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_{KA}}$, which is approximately equal to $|z_{KA}| \left(1 + \frac{R1}{R2}\right)$.

PARAMETER MEASUREMENT INFORMATION

$$\left|\alpha_{V_{\text{I(ref)}}}\right| \left(\frac{\text{ppm}}{^{\circ}\text{C}}\right) = \frac{\left(\frac{V_{\text{I(dev)}}}{V_{\text{I(ref)}} \text{ at } 25^{\circ}\text{C}}\right) \times 10^{6}}{\Delta T_{\text{A}}}$$

where:

 ΔT_A is the rated operating temperature range of the device.



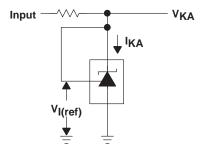


Figure 1. Test Circuit for $V_{(KA)} = V_{ref}$

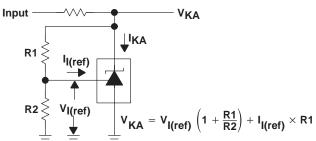


Figure 2. Test Circuit for $V_{(KA)} > V_{ref}$

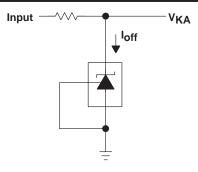


Figure 3. Test Circuit for Ioff

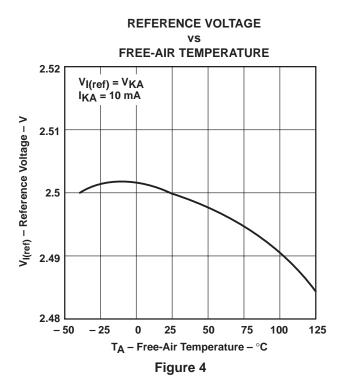
SLVS062D - DECEMBER 1991 - REVISED JULY 1999

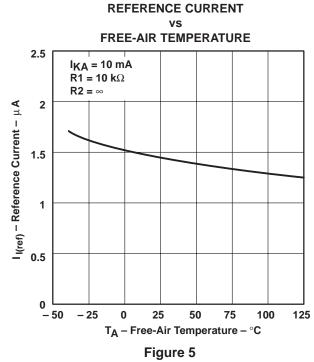
TYPICAL CHARACTERISTICS

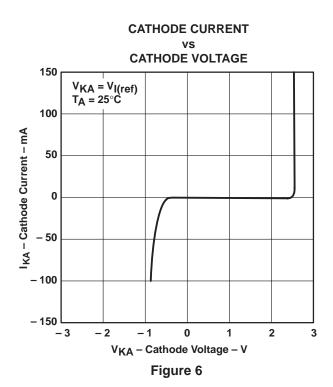
Table of Graphs

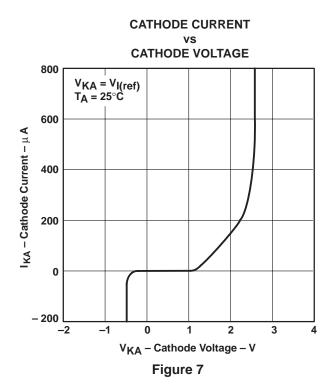
	FIGURE
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TYPICAL CHARACTERISTICS[†]





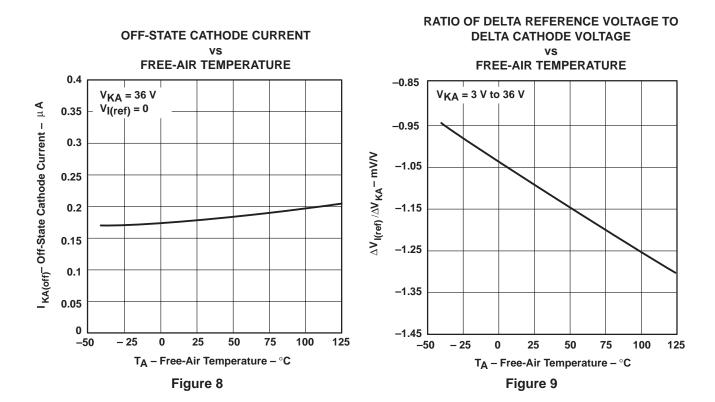




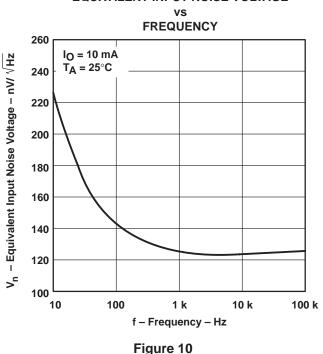
[†] Data at high and low temperatures are applicable only within the recommended operating free-air temperature ranges of the various devices.



TYPICAL CHARACTERISTICS[†]



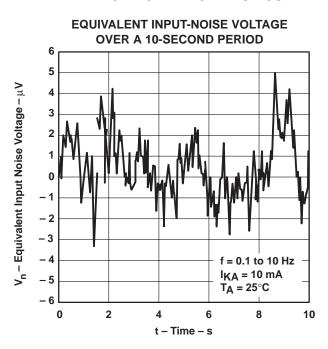
EQUIVALENT INPUT-NOISE VOLTAGE

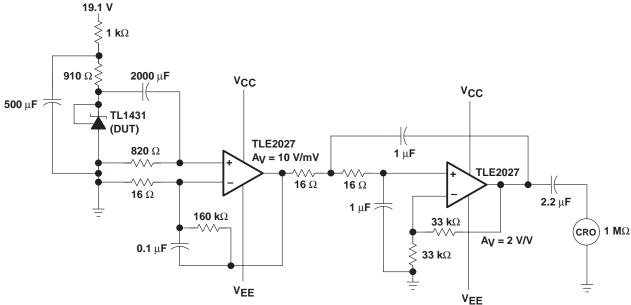


† Data at high and low temperatures are applicable only within the recommended operating free-air temperature ranges of the various devices.



TYPICAL CHARACTERISTICS





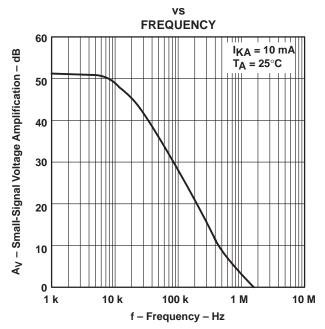
TEST CIRCUIT FOR 0.1-Hz TO 10-Hz EQUIVALENT INPUT-NOISE VOLTAGE

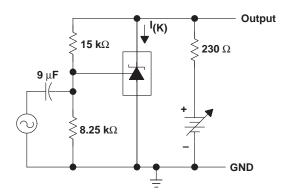
Figure 11



TYPICAL CHARACTERISTICS

SMALL-SIGNAL VOLTAGE AMPLIFICATION

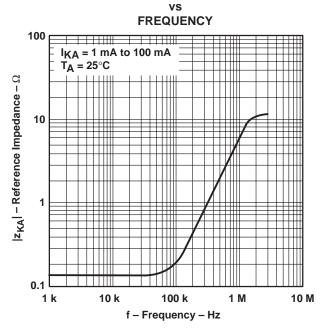


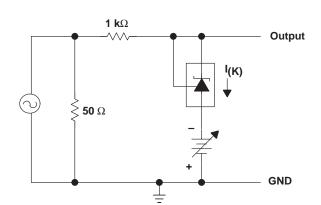


TEST CIRCUIT FOR VOLTAGE AMPLIFICATION

Figure 12

REFERENCE IMPEDANCE

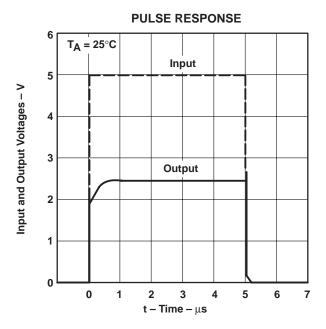




TEST CIRCUIT FOR REFERENCE IMPEDANCE

Figure 13

TYPICAL CHARACTERISTICS



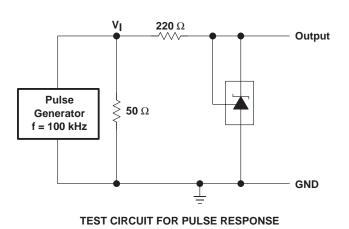
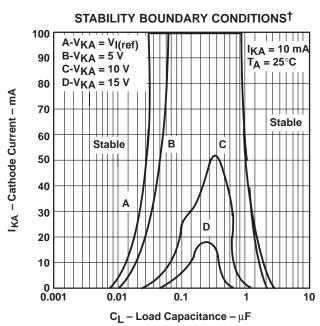
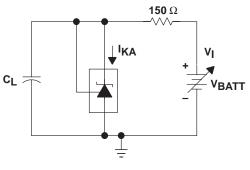


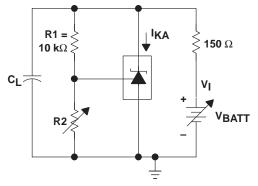
Figure 14



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



TEST CIRCUIT FOR CURVE A



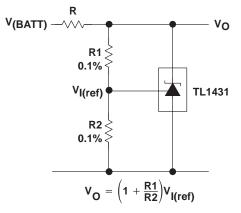
TEST CIRCUIT FOR CURVES B, C, AND D

Figure 15



Table of Application Circuits

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Precision current limiter	27
Precision constant-current sink	28



NOTE A: R should provide cathode current \geq 1 mA to the TL1431 at minimum V(BATT).

Figure 16. Shunt Regulator

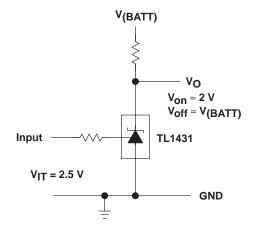
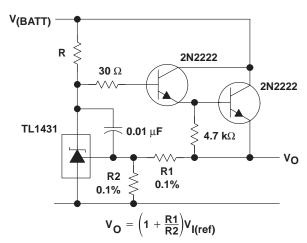


Figure 17. Single-Supply Comparator With Temperature-Compensated Threshold



NOTE A: R should provide cathode current \geq 1 mA to the TL1431 at minimum $V_{(BATT)}$.

Figure 18. Precision High-Current Series Regulator

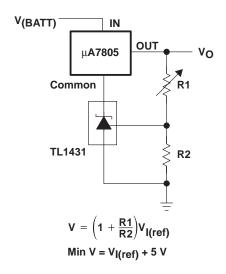


Figure 19. Output Control of a Three-Terminal Fixed Regulator

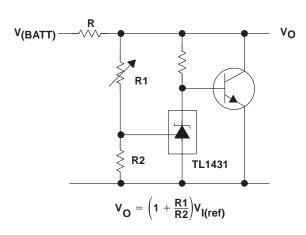
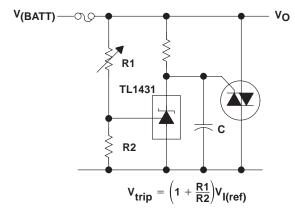
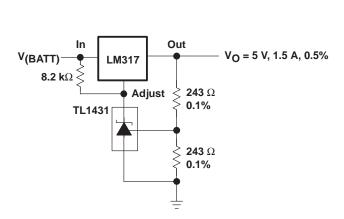


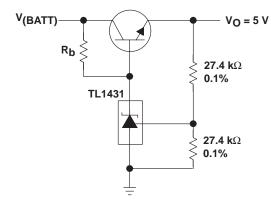
Figure 20. Higher-Current Shunt Regulator



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

Figure 21. Crowbar





NOTE A: R_b should provide cathode current ≥ 1 mA to the TL1431.

Figure 22. Precision 5-V, 1.5-A, 0.5% Regulator

Figure 23. 5-V Precision Regulator

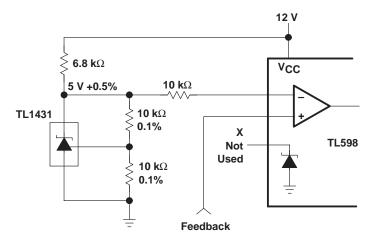
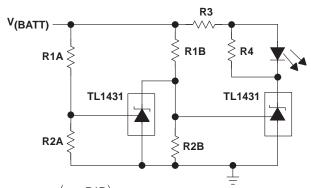


Figure 24. PWM Converter With 0.5% Reference



$$\begin{aligned} &\text{Low Limit} = \left(1 + \frac{R1B}{R2B}\right) V_{\text{I(ref)}} & & \\ &\text{High Limit} = \left(1 + \frac{R1A}{R2A}\right) V_{\text{I(ref)}} & & \\ &\text{Low Limit} < V_{\text{(BATT)}} < \text{High Limit} \end{aligned}$$

NOTE A: Select R3 and R4 to provide the desired LED intensity and cathode current ≥1 mA to the TL1431.

Figure 25. Voltage Monitor

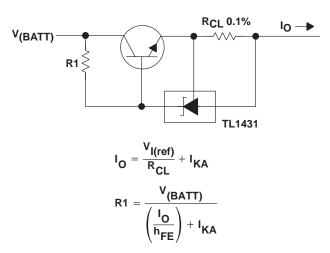


Figure 27. Precision Current Limiter

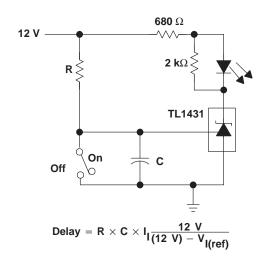


Figure 26. Delay Timer

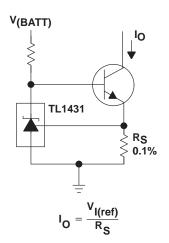


Figure 28. Precision Constant-Current Sink

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