TL431 / TL432 Precision Programmable Reference

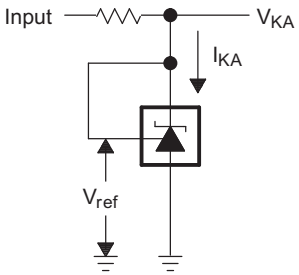
1 Features

- Reference Voltage Tolerance at 25°C
  - 0.5% (B Grade)
  - 1% (A Grade)
  - 2% (Standard Grade)
- Adjustable Output Voltage: V_{ref} to 36 V
- Operation From −40°C to 125°C
- Typical Temperature Drift (TL43xB)
  - 6 mV (C Temp)
  - 14 mV (I Temp, Q Temp)
- Low Output Noise
- 0.2-Ω Typical Output Impedance
- Sink-Current Capability: 1 mA to 100 mA

2 Applications

- Adjustable Voltage and Current Referencing
- Secondary Side Regulation in Flyback SMPSs
- Zener Replacement
- Voltage Monitoring
- Comparator with Integrated Reference

Simplified Schematic



3 Description

The TL431LI / TL432LI are pin-to-pin alternatives to TL431 / TL432. TL43xLI offers better stability, lower temperature drift ($V_{I(dev)}$), and lower reference current (I_{ref}) for improved system accuracy.

The TL431 and TL432 devices are three-terminal adjustable shunt regulators, with specified thermal stability over applicable automotive, commercial, and military temperature ranges. The output voltage can be set to any value between V_{ref} (approximately 2.5 V) and 36 V, with two external resistors. These devices have a typical output impedance of 0.2 Ω. Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replacements for Zener diodes in many applications, such as onboard regulation, adjustable power supplies, and switching power supplies. The TL432 device has exactly the same functionality and electrical specifications as the TL431 device, but has different pinouts for the DBV, DBZ, and PK packages.

Both the TL431 and TL432 devices are offered in three grades, with initial tolerances (at 25°C) of 0.5%, 1%, and 2%, for the B, A, and standard grade, respectively. In addition, low output drift versus temperature ensures good stability over the entire temperature range.

The TL43xxC devices are characterized for operation from 0°C to 70°C, the TL43xxI devices are characterized for operation from –40°C to 85°C, and the TL43xxQ devices are characterized for operation from –40°C to 125°C.

Device Information(1)

PART NUMBER	PACKAGE (PIN)	BODY SIZE (NOM)
TL43x	SOT-23-3 (3)	2.90 mm × 1.30 mm
	SOT-23-5 (5)	2.90 mm × 1.60 mm
	SOIC (8)	4.90 mm × 3.90 mm
	PDIP (8)	9.50 mm × 6.35 mm
	SOP (8)	6.20 mm × 5.30 mm

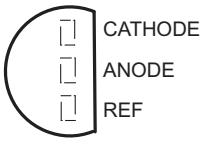
(1) For all available packages, see the orderable addendum at the end of the data sheet.

5 Device Comparison Table

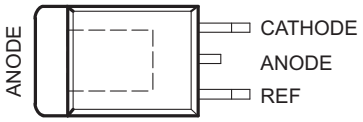
DEVICE PINOUT	INITIAL ACCURACY	OPERATING FREE-AIR TEMPERATURE (T_A)
TL431 TL432	B: 0.5% A: 1% (Blank): 2%	C: 0°C to 70°C I: -40°C to 85°C Q: -40°C to 125°C

6 Pin Configuration and Functions

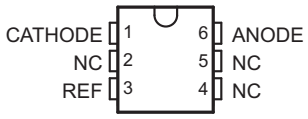
TL431, TL431A, TL431B . . . LP (TO-92/TO-226) PACKAGE
(TOP VIEW)



TL431 . . . KTP (PowerFLEX /TO-252) PACKAGE
(TOP VIEW)

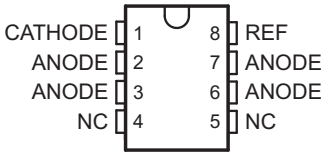


TL431A, TL431B . . . DCK (SC-70) PACKAGE
(TOP VIEW)



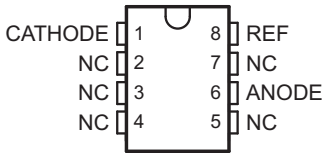
NC − No internal connection

TL431, TL431A, TL431B . . . D (SOIC) PACKAGE
(TOP VIEW)



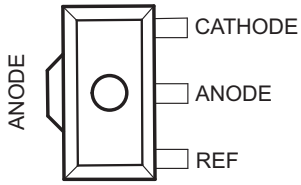
NC − No internal connection

TL431, TL431A, TL431B . . . P (PDIP), PS (SOP),
OR PW (TSSOP) PACKAGE
(TOP VIEW)

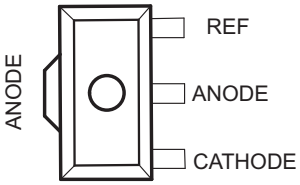


NC − No internal connection

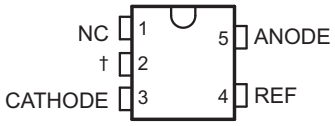
TL431, TL431A, TL431B . . . PK (SOT-89) PACKAGE
(TOP VIEW)



TL432, TL432A, TL432B . . . PK (SOT-89) PACKAGE
(TOP VIEW)

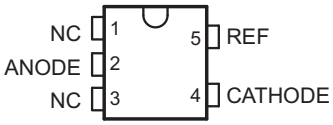


TL431, TL431A, TL431B . . . DBV (SOT-23-5) PACKAGE
(TOP VIEW)



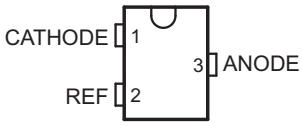
NC − No internal connection
† Pin 2 is attached to Substrate and must be connected to ANODE or left open.

TL432, TL432A, TL432B . . . DBV (SOT-23-5) PACKAGE
(TOP VIEW)

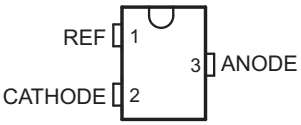


NC − No internal connection

TL431, TL431A, TL431B . . . DBZ (SOT-23-3) PACKAGE
(TOP VIEW)



TL432, TL432A, TL432B . . . DBZ (SOT-23-3) PACKAGE
(TOP VIEW)



Pin Functions

PIN												TYPE	DESCRIPTION
NAME	TLV431x								TLV432x				
	DBZ	DBV	PK	D	P, PS PW	LP	KTP	DCK	DBZ	DBV	PK		
CATHODE	1	3	3	1	1	1	1	1	2	4	1	I/O	Shunt Current/Voltage input
REF	2	4	1	8	8	3	3	3	1	5	3	I	Threshold relative to common anode
ANODE	3	5	2	2, 3, 6, 7	6	2	2	6	3	2	2	O	Common pin, normally connected to ground

7 Specifications

7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

		MIN	MAX	UNIT
V_{KA}	Cathode voltage(2)		37	V
I_{KA}	Continuous cathode current range	–100	150	mA
$I_{I(ref)}$	Reference input current range	–0.05	10	mA
T_J	Operating virtual junction temperature		150	°C
T_{stg}	Storage temperature range	–65	150	°C

(1) 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.
(2) All voltage values are with respect to ANODE, unless otherwise noted.

7.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)	±1000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process. Manufacturing with less than 500-V HBM is possible with the necessary precautions.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process. Manufacturing with less than 250-V CDM is possible with the necessary precautions.

7.3 Thermal Information

THERMAL METRIC(1)		TL43xx									UNIT
		P	PW	D	PS	DCK	DBV	DBZ	LP	PK	
		8 PINS				6 PINS	5 PINS	3 PINS			
$R_{\theta JA}$	Junction-to-ambient thermal resistance	85	149	97	95	259	206	206	140	52	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	57	65	39	46	87	131	76	55	9	

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report (SPRA953).

7.4 Recommended Operating Conditions

See(1)

			MIN	MAX	UNIT
V_{KA}	Cathode voltage		V_{ref}	36	V
I_{KA}	Cathode current		1	100	mA
T_A	Operating free-air temperature	TL43xxC	0	70	°C
		TL43xxI	–40	85	
		TL43xxQ	–40	125	

(1) 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 affect reliability.

7.5 Electrical Characteristics, TL431C, TL432C

over recommended operating conditions, T_A = 25°C (unless otherwise noted)

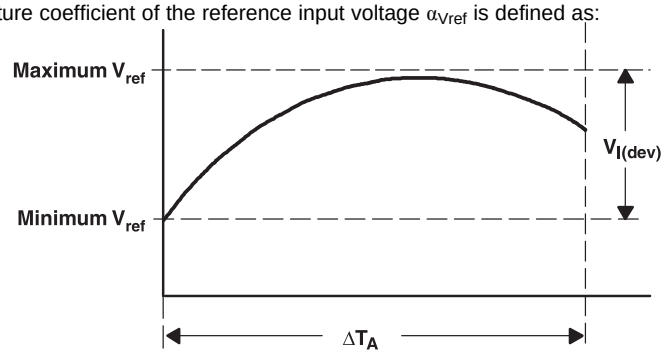
PARAMETER		TEST CIRCUIT	TEST CONDITIONS		TL431C, TL432C			UNIT
					MIN	TYP	MAX	
V_{ref}	Reference voltage	See Figure 20	V_{KA} = V_{ref}, I_{KA} = 10 mA		2440	2495	2550	mV
$V_{I(dev)}$	Deviation of reference input voltage over full temperature range(1)	See Figure 20	V_{KA} = V_{ref}, I_{KA} = 10 mA,	SOT23-3 and TL432 devices		6	16	mV
				All other devices		4	25	
ΔV_{ref} / ΔV_{KA}	Ratio of change in reference voltage to the change in cathode voltage	See Figure 21	I_{KA} = 10 mA	ΔV_{KA} = 10 V – V_{ref}		–1.4	–2.7	mV/V
				ΔV_{KA} = 36 V – 10 V		–1	–2	
I_{ref}	Reference input current	See Figure 21	I_{KA} = 10 mA, R1 = 10 kΩ, R2 = ∞			2	4	µA
$I_{I(dev)}$	Deviation of reference input current over full temperature range(1)	See Figure 21	I_{KA} = 10 mA, R1 = 10 kΩ, R2 = ∞			0.4	1.2	µA
I_{min}	Minimum cathode current for regulation	See Figure 20	V_{KA} = V_{ref}			0.4	1	mA
I_{off}	Off-state cathode current	See Figure 22	V_{KA} = 36 V, V_{ref} = 0			0.1	1	µA
$\lvert z_{KA} \rvert$	Dynamic impedance(2)	See Figure 20	V_{KA} = V_{ref}, f ≤ 1 kHz, I_{KA} = 1 mA to 100 mA			0.2	0.5	Ω

(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 average full-range temperature coefficient of the reference input voltage α_{Vref} is defined as:

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

where:

ΔT_A is the rated operating temperature range of the device.



α_{Vref} is positive or negative, depending on whether minimum V_{ref} or maximum V_{ref}, respectively, occurs at the lower temperature.

(2) The dynamic impedance is defined as: $\lvert z_{KA} \rvert = \frac{\Delta V_{KA}}{\Delta I_{KA}}$

When the device is operating with two external resistors (see Figure 21), the total dynamic impedance of the circuit is given by: $\lvert z' \rvert = \frac{\Delta V}{\Delta I}$ which is approximately equal to $\lvert z_{KA} \rvert \left(1 + \frac{R1}{R2}\right)$.