Programmable Precision Shunt Regulator TL431

FEATURES

- Programmable Output Voltage to 40V
- Guaranteed 0.5% Reference Voltage Tolerance
- Low (0.2Ω Typ.) Dynamic Output Impedance
- Cathode Current Range (Continuous) – 100 ~ 150 mA
- Equivalent Full Range Temperature Coefficient of 50PPM/°C
- Temperature Compensated For Operation Over Full Rate Operating Temperature Range
- Low Output Noise Voltage
- Fast Turn-on Response
- Available in TO-92, SOT-89 and SOT-23-3L Packages

APPLICATIONS

- Shunt Regulator
- Precision High-Current Series Regulator
- High-Current Shunt Regulator
- Crowbar Circuit
- PWM Converter With Reference
- Voltage Monitor
- Precision Current Limiter

DESCRIPTION

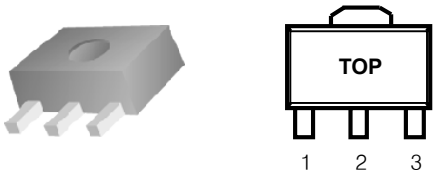
The TL431 is a three-terminal adjustable shunt regulator with specified thermal stability over applicable temperature V_{REF} (2.495V) and 40V with two external resistors. This device has a typical dynamic output impedance of 0.2Ω. Active output circuitry provides a very sharp turn-on characteristic, making this device excellent replacement for Zener diodes in many applications. The TL431 is characterized for operation from -40°C to +125°C.

TO-92 PKG

(Straight) (Bent)

SOT-23 PKG

SOT-89 PKG



Pin 1. REFERENCE 2. ANODE 3. CATHODE

ORDERING INFORMATION

Device	Package
TL431x	TO-92 (Bulk, Straight)
TL431xTA	TO-92 (Tape, Bent)
TL431xSF	SOT-23-3L
TL431xF	SOT-89-3L

* Refer to the ordering information for the details.

ABSOLUTE MAXIMUM RATINGS

(Full operating ambient temperature range applies unless otherwise noted.)

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Cathode Voltage	V_{KA}	-	42	V
Cathode Current Range	I_{KA}	-100	150	mA
Reference Input Current Range	I_{REF}	-0.05	10	mA
Junction Temperature Range	T_J	-40	150	°C
Storage Temperature Range	T_{STG}	-65	150	°C

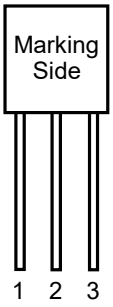
RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Cathode Voltage	V_{KA}	V_{REF}	40	V
Cathode Current	I_{KA}	0.5	100	mA
Operating Temperature Range	T_{OPR}	-40	125	°C

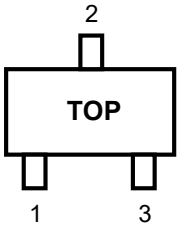
ORDERING INFORMATION

VREF	Package	Tolerance	Order No.	Marking	Supplied As
2.495V	TO-92	0.5%	TL431C	TL431-C	Bulk (Straight Lead)
			TL431CTA	TL431-C	Tape & Ammo Pack
		1%	TL431A	TL431-A	Bulk (Straight Lead)
			TL431ATA	TL431-A	Tape & Ammo Pack
		2%	TL431	TL431	Bulk (Straight Lead)
			TL431TA	TL431	Tape & Ammo Pack
	SOT-23	0.5%	TL431CSF	431	Tape & Reel
		1%	TL431ASF	431	Tape & Reel
		2%	TL431SF	431	Tape & Reel
	SOT-89	0.5%	TL431CF	431	Tape & Reel
		1%	TL431AF	431	Tape & Reel
		2%	TL431F	431	Tape & Reel

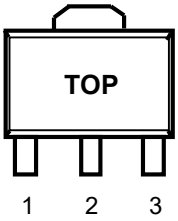
PIN CONFIGURATION



TO-92 PKG



SOT-23 PKG

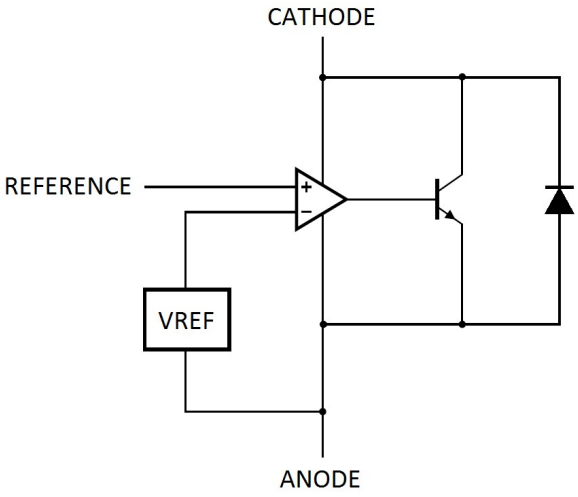


SOT-89 PKG

PIN DESCRIPTION

Pin No.	TO-92 / SOT-23 / SOT-89	
	Pin Name	Pin Description
1	REFERENCE	Reference Voltage
2	ANODE	Ground
3	CATHODE	Input Supply Voltage

BLOCK DIAGRAM



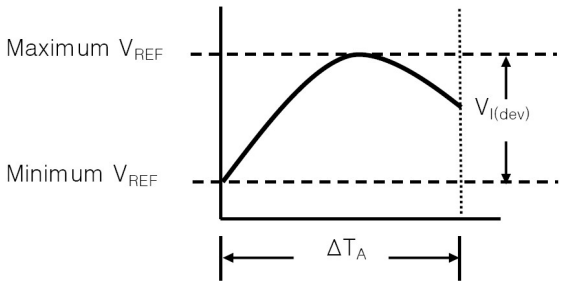
ELECTRICAL CHARACTERISTICS

(T_A=25°C, unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
Reference Input Voltage	V_{REF}	$V_{KA}=V_{REF}$, I_K=10mA	TL431C	2.483	2.495	2.507	V
			TL431A	2.470	2.495	2.520	
			TL431	2.440	2.495	2.550	
Deviation of Reference Input Voltage (Note 1)	$\Delta V_{REF}/\Delta T$	V_{KA} = V_{REF}, I_K =10mA T_A =Full Range			15	30	mV
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	$\Delta V_{REF}/\Delta V_{KA}$	I_K =10mA	ΔV_{KA}=10V to V_{REF}		-1.4	-2.7	mV/V
			ΔV_{KA}=36V to 10V		-1.0	-2.0	
Reference Input Current	I_{REF}	I_{KA}=10mA, R_1=10kΩ, R_2=∞			1.8	4.0	μA
Deviation of Reference Input Current (Note 1)	$\Delta I_{REF}/\Delta T$	I_K =10mA, R_1=10kΩ, R_2=∞ T_A =Full Range			0.4	1.2	μA
Minimum Cathode Current for Regulation	$I_{K(MIN)}$	V_{KA}= V_{REF}				0.5	mA
Off-State Cathode Current	$I_{K(OFF)}$	V_{KA}=36V, V_{REF}=0			0.17	0.90	μA
Dynamic Impedance (Note 2)	Z_{KA}	V_{KA}= V_{REF}, I_K =1mA~100mA f ≤ 1kHz			0.27	0.50	Ω

(Note 1) The deviation parameters $\Delta V_{REF}/\Delta T_A$ and $\Delta I_{REF}/\Delta T_A$ are defined as the differences between the maximum and minimum values obtained over the recommended temperature range. The average full-range temperature coefficient of the reference voltage, αV_{REF}, is defined as:

$$|\alpha V_{REF}|\ (ppm/°C)=\frac{\left(\frac{V_{I(dev)}}{V_{REF}\ at\ 25°C}\right)\times 10^6}{\Delta T_A}$$



Where:

ΔT_A is the recommended operating free-air temperature range of the device.

αV_{REF} can be positive or negative, depending on whether minimum V_{REF} or maximum V_{REF}, respectively, occurs at the lower temperature.

Example : Maximum V_{REF}=2496mV at 30°C, maximum V_{REF}=2492mV at 0°C, V_{REF}=2495mV at 25°C, ΔT_A=70°C for TL431C.

$$|\alpha V_{REF}| =\frac{\left(\frac{4mv}{2495mV}\right)\times 10^6}{70°C} \approx 23ppm/°C$$

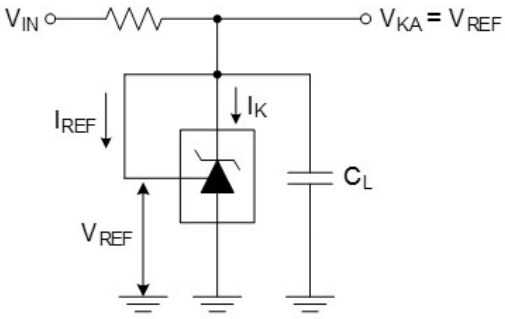
Because minimum V_{REF} occurs at the lower temperature, the coefficient is positive.

(Note 2) The dynamic impedance is defined as: $|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_{KA}}$

When the device is operating with two external resistors, the total dynamic impedance of the circuit is given by:

$$|Z'| = \frac{\Delta V}{\Delta I} \approx |Z_{KA}|(1+R1/R2)$$

TEST CIRCUITS



< Fig 1. Test circuit for $V_{KA} = V_{REF}$ >

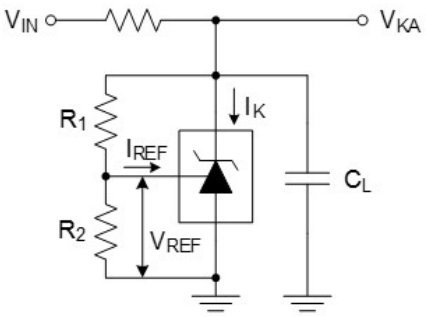
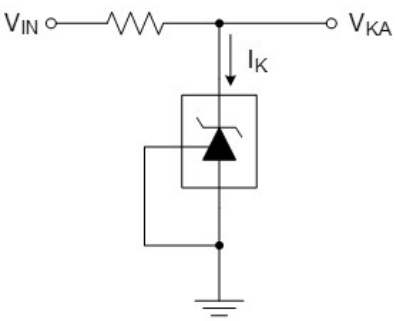


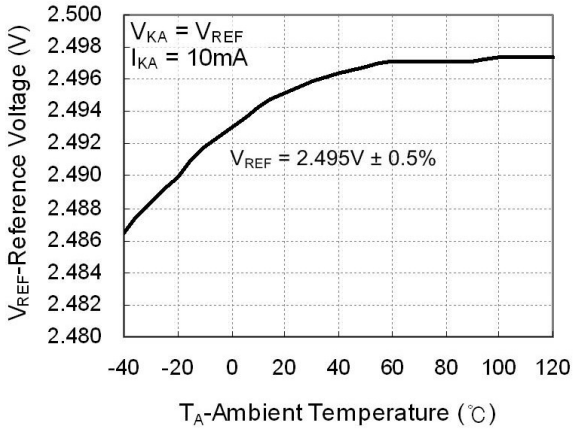
Fig 2. Test circuit for $V_{KA} \geq V_{REF}$ >



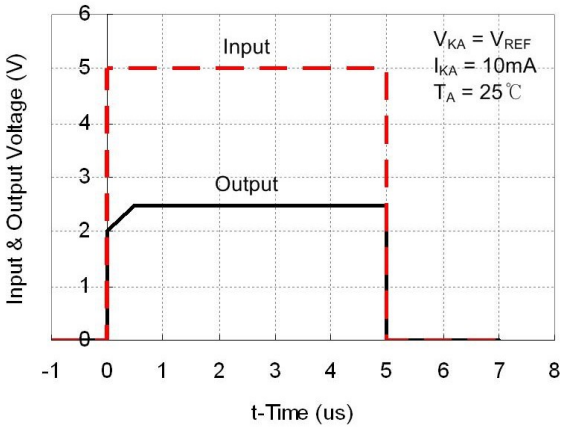
< Fig 3. Test circuit for $I_{KA(OFF)}$ >

TYPICAL OPERATING CHARACTERISTICS

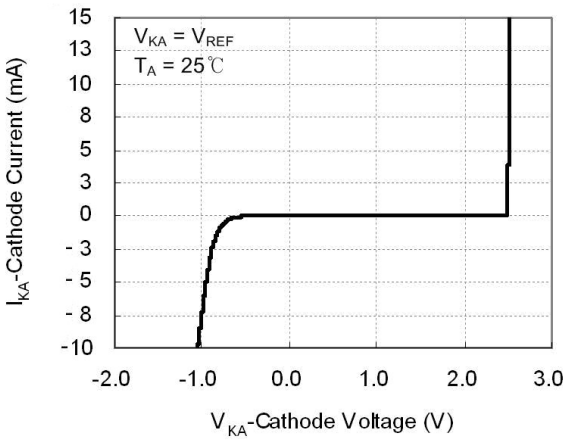
Reference Voltage vs. Ambient Temperature



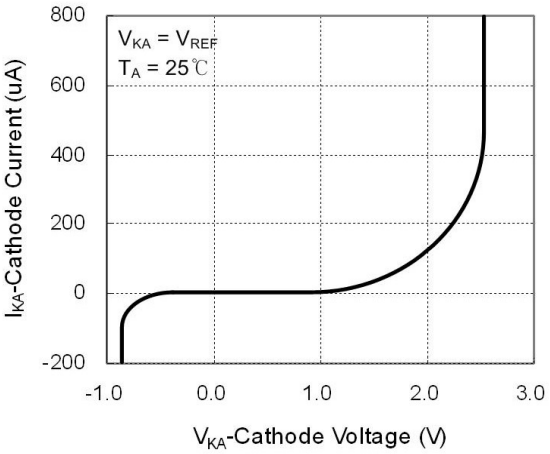
Pulse Response



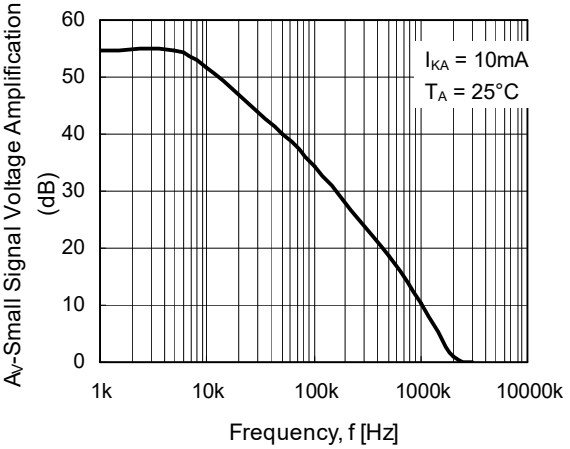
Cathode Current vs. Cathode Voltage

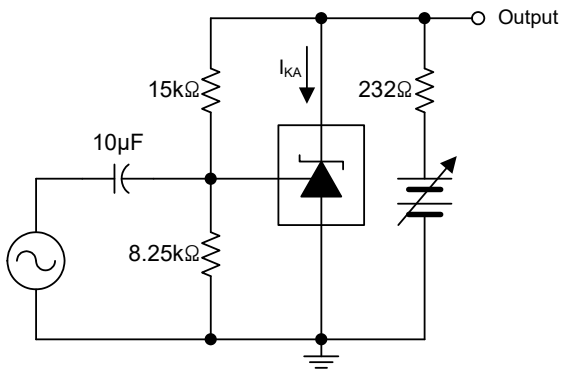


Cathode Current vs. Cathode Voltage



Small Signal Voltage Amplification vs. Frequency

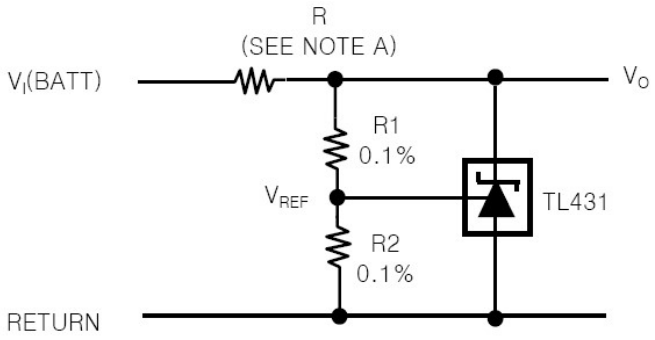




< Fig 4. TEST Circuit for Voltage Amplification >

APPLICATION INFORMATION

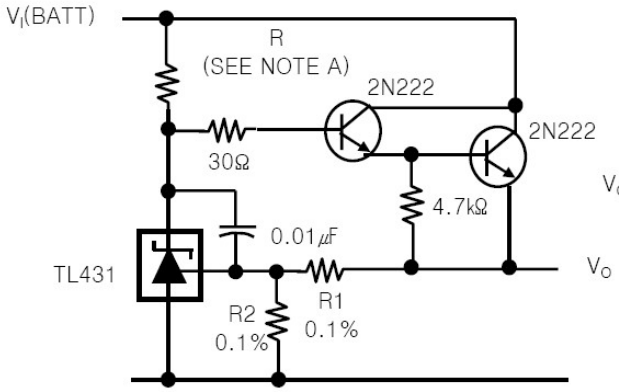
1. Shunt Regulator



$$V_O = (1+\frac{R1}{R2})\ V_{REF}$$

Note: R Should provide cathode current 1mA to the TL431 at minimum $V_{I(BATT)}$

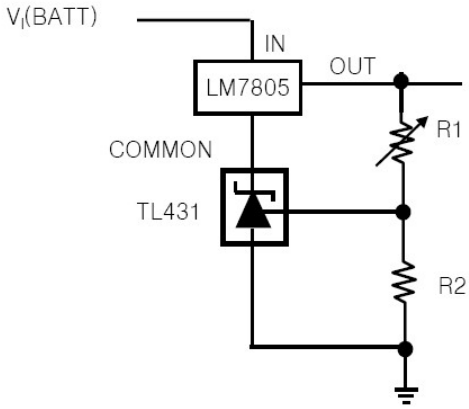
2. Precision High-Current Series Regulator



$$V_O = (1+\frac{R1}{R2})\ V_{REF}$$

Note: R Should provide cathode current≥1mA to the TL431 at minimum $V_{I(BATT)}$

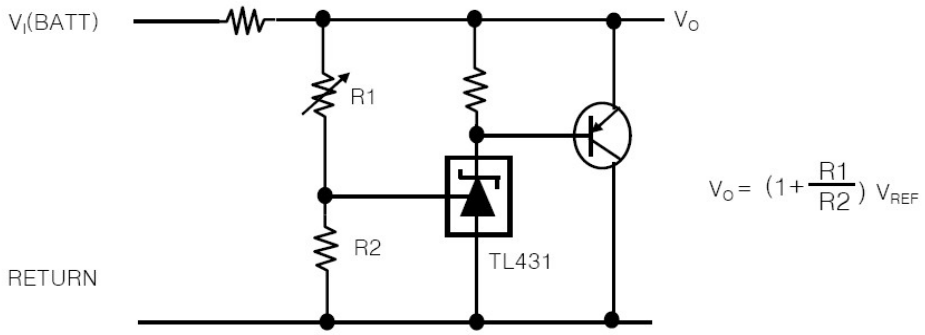
3. Output Control of a Three-Terminal Fixed Regulator



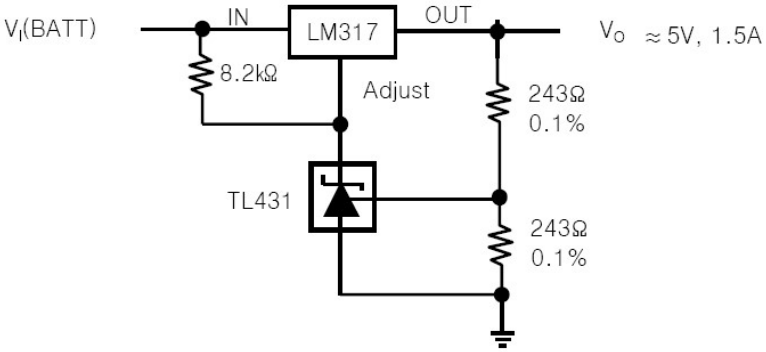
$$V_O = (1+\frac{R1}{R2})\ V_{REF}$$

MINIMUM V_O=V_{REF}+5V

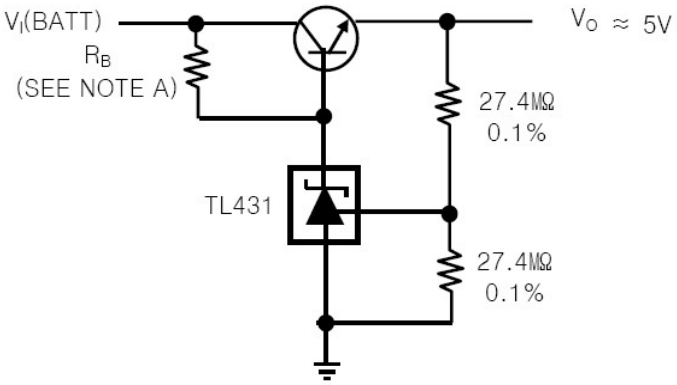
4. High-Current Shunt Regulator



5. Precision 5-V 1.5A Regulator

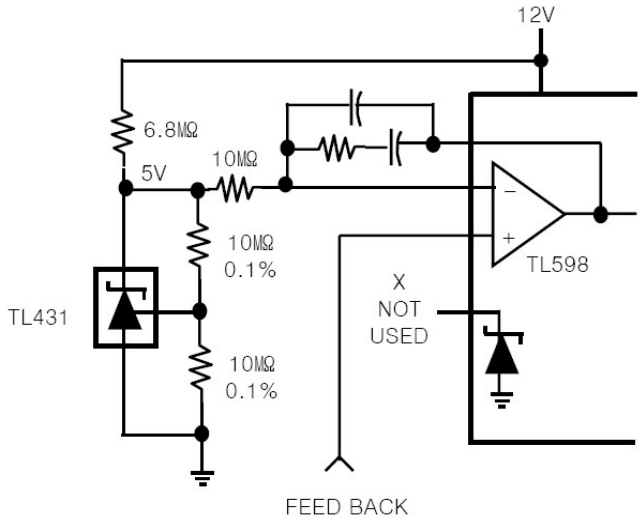


6. Efficient 5-V Precision Regulator

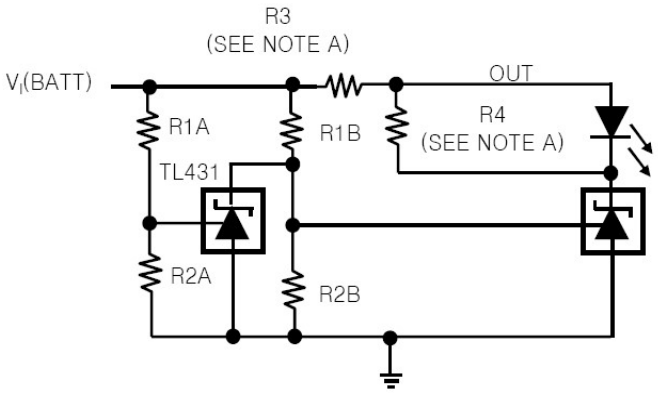


NOTE: R_B Should provide cathode current≥1mA to the TL431.

7. PWM Converter With Reference



8. Voltage Monitor



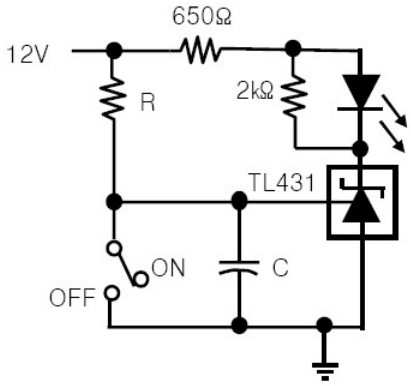
$$\text{LOW LIMIT} = \left(1+\frac{R1B}{R2B}\right) V_{REF}$$

$$\text{HIGH LIMIT} = \left(1+\frac{R1A}{R2A}\right) V_{REF}$$

LED ON WHEN LOW LIMIT < $V_{I(BATT)}$ < HIGH LIMIT

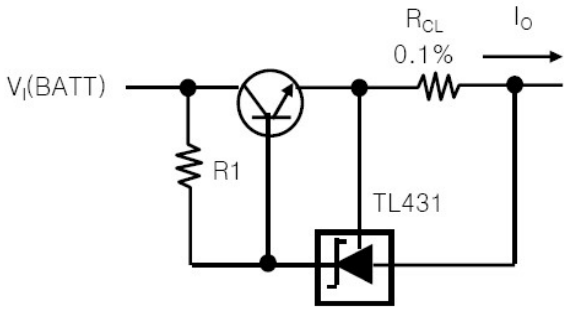
NOTE: R3 and R4 are selected to provide the desired LED intensity and cathode current ≥1mA to the TL431 at the available $V_{I(BATT)}$.

9. Delay Timer



$$DELAY = RxCxI_N \left(\frac{12V}{12V - V_{REF}} \right)$$

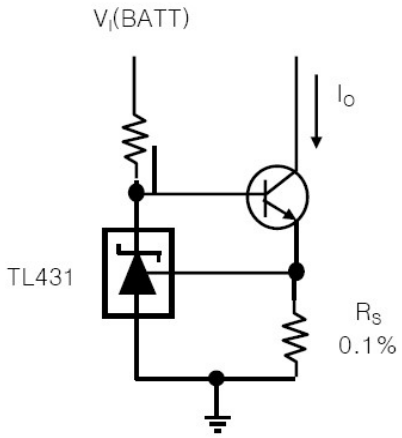
10. Precision Current Limiter



$$I_{OUT} = \frac{V_{REF}}{R_{CL}} + I_{KA}$$

$$R1 = \frac{V_{I(BATT)}}{\frac{I_O}{H_{FE}}} + I_{KA}$$

11. Precision Constant-Current Sink



$$I_O = \frac{V_{REF}}{R_S}$$

REVISION NOTICE

The description in this datasheet is subject to change without any notice to describe its electrical characteristics properly.

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Programmable Precision Shunt Regulator TL432

FEATURES

- Programmable Output Voltage to 18V
- Low Voltage Operation from 1.24 V
- Sink Current Capability of 1mA to 100mA
- Equivalent Full Range Temperature Coefficient of 50ppm/°C
- Temperature Compensated for Operation over Full Rated Operating Temperature Range
- Low Output Noise Voltage
- Available in TO-92, SOT-89 and SOT-23-3L Packages

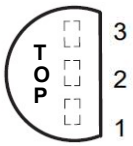
APPLICATIONS

- Shunt Regulator
- Voltage Monitoring
- Current Source and Sink Circuits
- Analog & Digital Circuits Requiring Precision References
- Low Out Voltage (3.0V to 3.3V) Switching Power Supply Error Amplifier

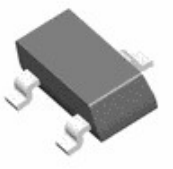
DESCRIPTION

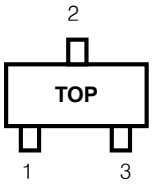
The TL432 is a three-terminal Shunt Voltage Reference providing a highly accuracy 1.24V bandgap reference with 0.5% and 1.0% tolerance. The TL432 thermal stability and wide operating current (100mA) makes is suitable for all variety of applications that are looking for a low cost solution with high performance. The TL432 is an ideal voltage reference in an isolated feed circuit for 3.0V to 3.3V switching mode power supplies.

TO-92 PKG (Bent)

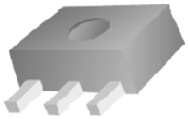


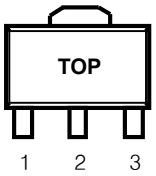
SOT-23 PKG





SOT-89 PKG





Pin 1. REFERENCE 2. ANODE 3. CATHODE

ORDERING INFORMATION

Device	Package
TL432xTA	TO-92 (Tape, Bent)
TL432xSF	SOT-23-3L
TL432xF	SOT-89-3L

* Refer to the ordering information for the details.

ABSOLUTE MAXIMUM RATINGS

(Full operating ambient temperature range applies unless otherwise noted.)

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Cathode Voltage	V_{KA}	-	20	V
Cathode Current Range	I_{KA}	-	100	mA
Reference Input Current Range	I_{REF}	-	3	mA
Junction Temperature Range	T_J	-40	150	°C
Storage Temperature Range	T_{STG}	-65	150	°C

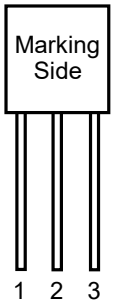
RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Cathode Voltage	V_{KA}	V_{REF}	18	V
Cathode Current	I_{KA}	0.1	100	mA
Operating Temperature Range	T_{OPR}	-40	125	°C

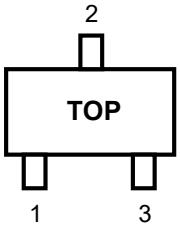
ORDERING INFORMATION

VREF	Package	Tolerance	Order No.	Marking	Supplied As
1.24V	TO-92	0.5%	TL432CTA	TL432-C	Tape & Ammo Pack
		1%	TL432ATA	TL432-A	Tape & Ammo Pack
	SOT-23	0.5%	TL432CSF	432	Tape & Reel
		1%	TL432ASF	432	Tape & Reel
	SOT-89	0.5%	TL432CF	432	Tape & Reel
		1%	TL432AF	432	Tape & Reel

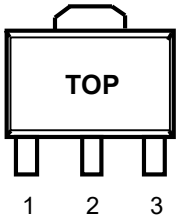
PIN CONFIGURATION



TO-92 PKG



SOT-23 PKG

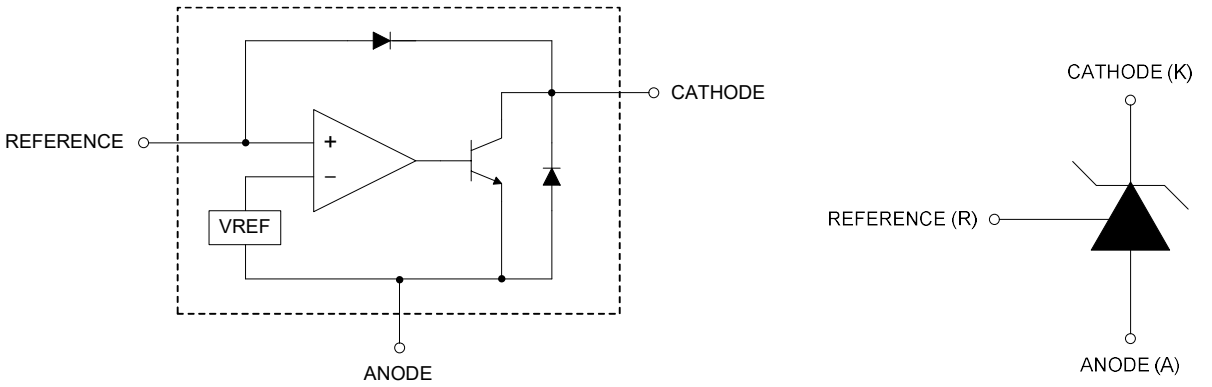


SOT-89 PKG

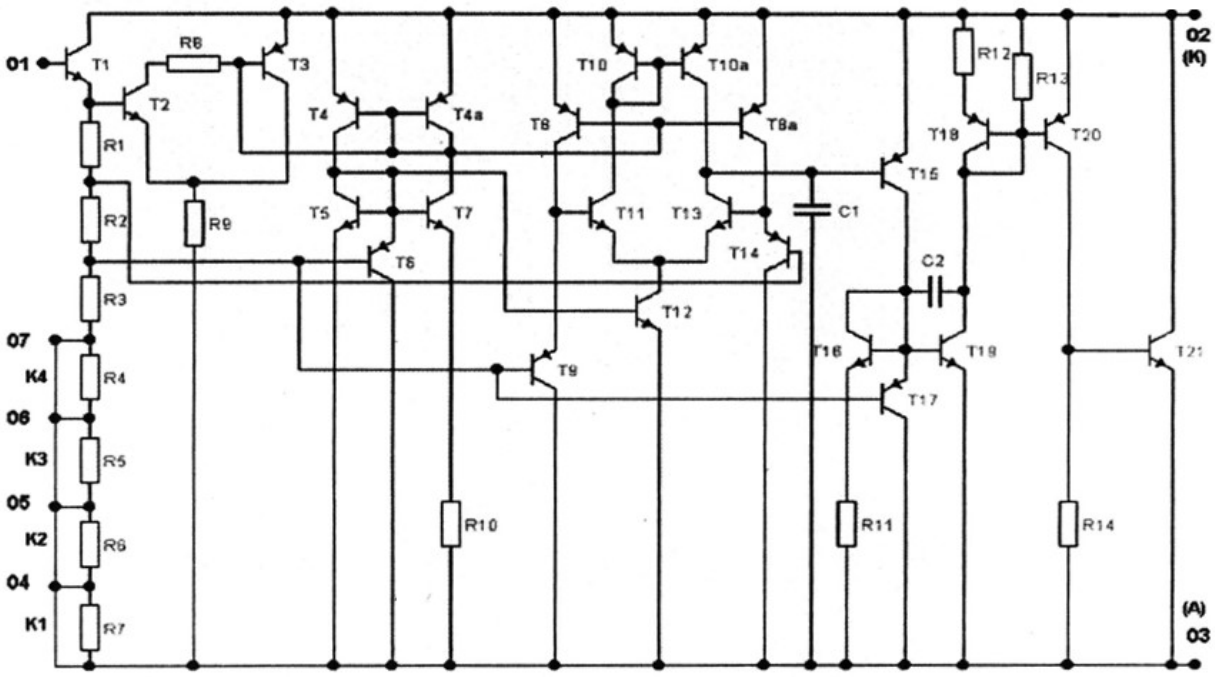
PIN DESCRIPTION

Pin No.	TO-92 / SOT-23 / SOT-89	
	Pin Name	Pin Description
1	REFERENCE	Reference Voltage
2	ANODE	Ground
3	CATHODE	Input Supply Voltage

BLOCK DIAGRAM



EQUIVALENT SCHEMATIC



* All component values are nominal.

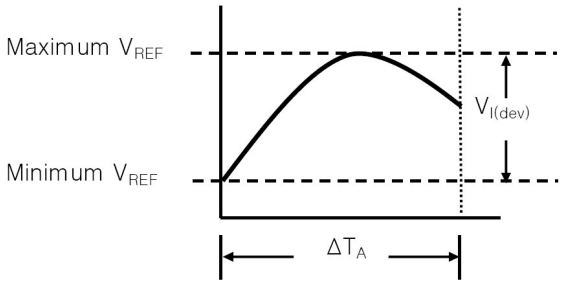
ELECTRICAL CHARACTERISTICS

(T_A=25°C, unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
Reference Input Voltage	V_{REF}	$V_{KA}=V_{REF}$, I_K=10mA	TL432C	1.234	1.240	1.246	V
			TL432A	1.228	1.240	1.252	
Deviation of Reference Input Voltage (Note 1)	$\Delta V_{REF}/\Delta T$	$V_{KA}=V_{REF}$, I_K=10mA, T_A=Full Range			15	25	mV
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	$\Delta V_{REF}/\Delta V_{KA}$	V_{KA} = 1.25V to 14.5V			1.0	2.7	mV/V
Reference Input Current	I_{REF}	R1=10kΩ, R2=∞			0.25	0.5	μA
Deviation of Reference Input Current (Note 1)	$\Delta I_{REF}/\Delta T$	R1=10kΩ, R2=∞, T_A = Full Range			0.05	0.3	μA
Minimum Cathode Current for Regulation	$I_{K(MIN)}$	$V_{KA}=V_{REF}$			60	80	μA
Off-State Cathode Current	$I_{K(OFF)}$	V_{KA}=16V, V_{REF}=0			0.04	0.5	μA
Dynamic Impedance (Note 2)	Z_{KA}	$V_{KA}=V_{REF}$, I_K=0.1mA~100mA, f ≤ 1kHz			0.2	0.4	Ω

(Note 1) The deviation parameters $\Delta V_{REF}/\Delta T_A$ and $\Delta I_{REF}/\Delta T_A$ are defined as the differences between the maximum and minimum values obtained over the recommended temperature range. The average full-range temperature coefficient of the reference voltage, αV_{REF}, is defined as:

$$|\alpha V_{REF}|\ (ppm/°C)=\frac{\left(\frac{V_{I(dev)}}{V_{REF}\ at\ 25°C}\right)\times 10^6}{\Delta T_A}$$



Where:

ΔT_A is the recommended operating free-air temperature range of the device.

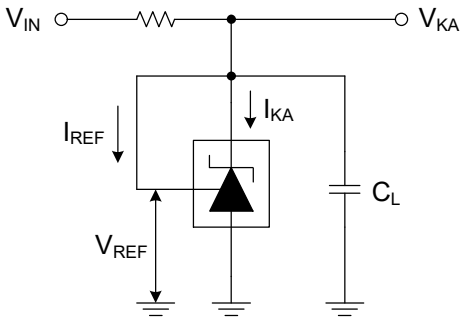
αV_{REF} can be positive or negative, depending on whether minimum V_{REF} or maximum V_{REF}, respectively, occurs at the lower temperature.

(Note 2) The dynamic impedance is defined as: $|Z_{KA}|=\frac{\Delta V_{KA}}{\Delta I_{KA}}$

When the device is operating with two external resistors, the total dynamic impedance of the circuit is given by:

$$|Z'|=\frac{\Delta V}{\Delta I}\approx |Z_{KA}|(1+R1/R2)$$

TEST CIRCUITS



< Fig 1. Test circuit for $V_{KA} = V_{REF}$ >

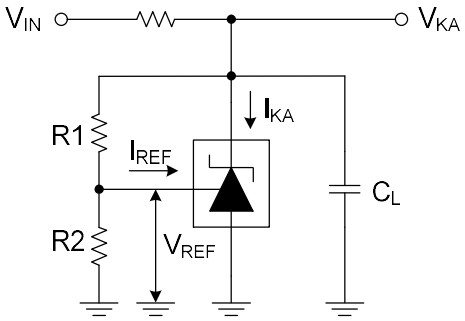
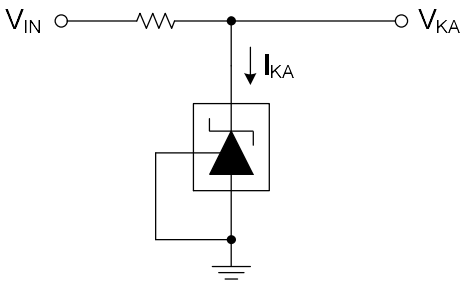


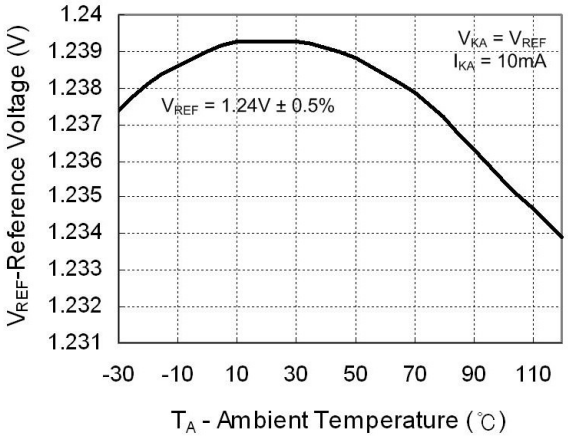
Fig 2. Test circuit for $V_{KA} \geq V_{REF}$ >



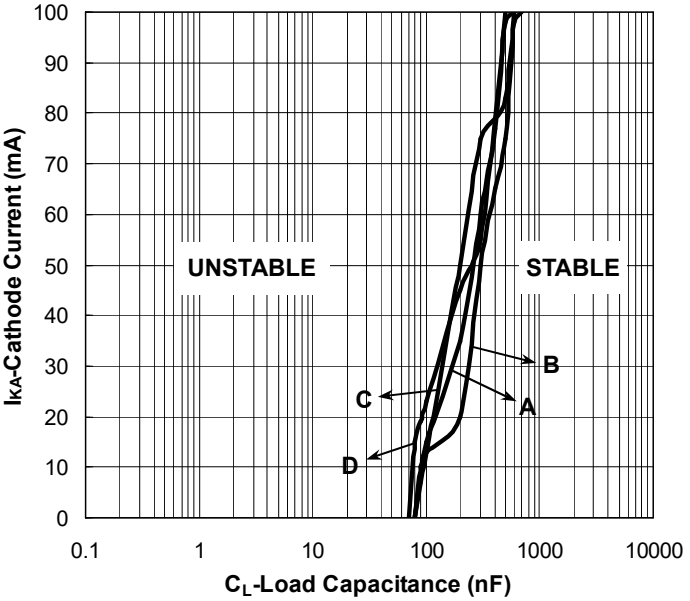
< Fig 3. Test circuit for $I_{KA(OFF)}$ >

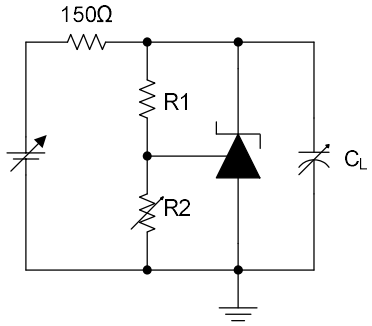
TYPICAL OPERATING CHARACTERISTICS

Reference Voltage vs. Junction Temperature



Stability Boundary Conditions





< Fig 4. Test Circuit >

A $V_{KA}=V_{REF}$ R1= 0Ω, R2 = ∞
B V_{KA}=5.0V, R1=10kΩ, R2 = 3.3kΩ
C V_{KA}=10.0V R1=10kΩ, R2 = 1.42kΩ
D V_{KA}=15.0V R1=10kΩ, R2 = 900Ω

REVISION NOTICE

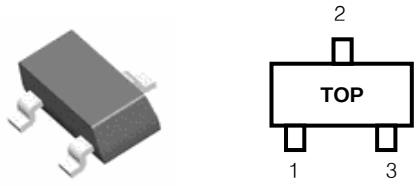
The description in this datasheet is subject to change without any notice to describe its electrical characteristics properly.

Programmable Precision Shunt Regulator LP431

FEATURES

- Programmable Output Voltage to 36V
- Extended Cathode Current Range 80μA to 100mA
- Low (Typ. 0.08Ω) Dynamic Output Impedance
- Adjustable Output Voltage
- Fast Turn-on Response
- Low Output Noise
- Excellent Temperature Coefficient 25ppm/°C
- Available in SOT-23-3L Package

SOT-23 PKG



Pin 1. REFERENCE 2. ANODE 3. CATHODE

ORDERING INFORMATION

Device	Package
LP431GxSF	SOT-23-3L

* Refer to the ordering information for the details.

APPLICATIONS

- Secondary Side Regulation in Flyback SMPS
- Industrial, Computing, Consumer and Portables
- Adjustable Voltage and Current Referencing
- Power Management
- Power Isolation
- Zener Replacement

DESCRIPTION

The LP431 is a three-terminal adjustable shunt regulator with a specified thermal stability. The output voltage may be set to any value between V_{REF} and 36V with two external resistors. The active output circuitry provides a very sharp turn-on characteristic making these devices an excellent replacement for Zener diodes in many applications, such as on board regulation, adjustable power supplies, and switching power supplies.

ABSOLUTE MAXIMUM RATINGS

(Full operating ambient temperature range applies unless otherwise noted.)

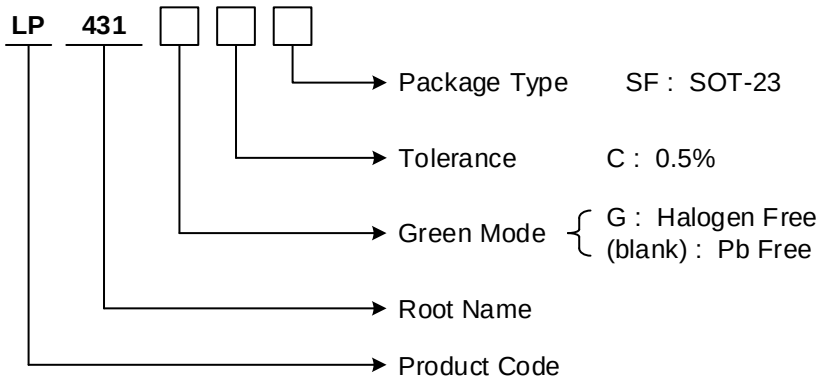
PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Cathode Voltage	V_{KA}	-	40	V
Cathode Current Range	I_{KA}	-	150	mA
Reference Input Current Range	I_{REF}	-	10	mA
Junction Temperature Range	T_J	-40	150	°C
Operating Temperature Range	T_{OPR}	-40	125	°C
Storage Temperature Range	T_{STG}	-65	150	°C

RECOMMENDED OPERATING CONDITIONS

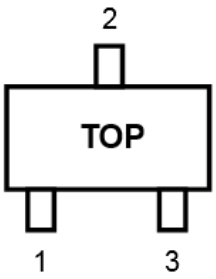
PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Cathode Voltage	V_{KA}	V_{REF}	36	V
Cathode Current	I_{KA}	0.08	100	mA
Operating Temperature range	T_A	-40	85	°C

ORDERING INFORMATION

VREF	Package	Tolerance	Order No.	Supplied As	Status
2.5 V	SOT-23-3L	0.5%	LP431GCSF	Reel	Active



PIN CONFIGURATION

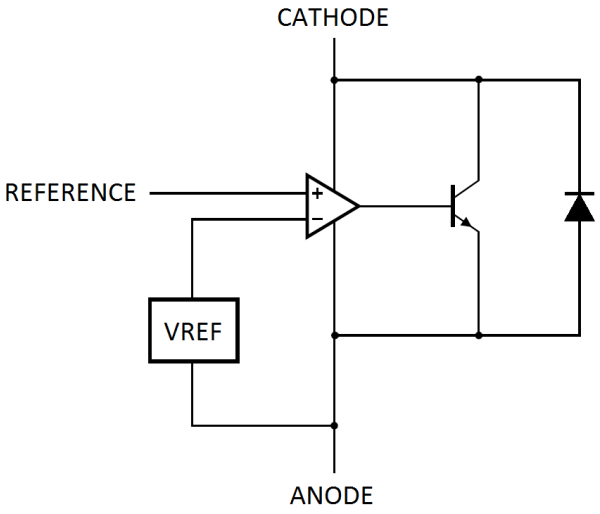


SOT-23-3L

PIN DESCRIPTION

Pin No.	Pin Name	Pin Description
1	REFERENCE	Reference Voltage
2	ANODE	Ground
3	CATHODE	Input Supply Voltage

BLOCK DIAGRAM



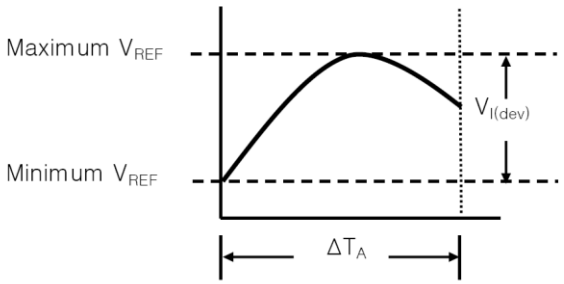
ELECTRICAL CHARACTERISTICS

(T_A=25°C, unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
Reference Input Voltage	V_{REF}	$V_{KA}=V_{REF}$, I_K=1mA	LP431GC	2.487	2.500	2.512	V
Deviation of Reference Input Voltage (Note 1)	$\Delta V_{REF}/\Delta T_A$	$V_{KA}=V_{REF}$, I_K=1mA, T_A =Full range		-	35	50	mV
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	$\Delta V_{REF}/\Delta V_{KA}$	I_K=1mA	ΔV_{KA}=10V to V_{REF}	-	-1.0	-2.7	mV/V
			ΔV_{KA}=36V to 10V	-	-0.4	-2.0	
Reference Input Current	I_{REF}	I_K=1mA, R1=10kΩ, R2=∞		-	180	500	nA
Deviation of Reference Input Current (Note 1)	$\Delta I_{REF}/\Delta T_A$	I_K=1mA, R1=10kΩ, R2=∞, T_A=Full range		-	100	300	nA
Minimum Cathode Current for Regulation	$I_{K(MIN)}$	V_{KA} = V_{REF}		-	30	80	μA
Off-State Cathode Current	$I_{K(OFF)}$	V_{KA} =36V, V_{REF} =0		-	0.01	1	μA
Dynamic Impedance (Note 2)	$\lvert Z_{KA}\rvert$	V_{KA}= V_{REF}, I_K =0.2mA~100mA, f ≤ 1kHz			0.08	0.3	Ω

(Note 1) The deviation parameters $\Delta V_{REF}/\Delta T_A$ and $\Delta I_{REF}/\Delta T_A$ are defined as the differences between the maximum and minimum values obtained over the recommended temperature range. The average full-range temperature coefficient of the reference voltage, αV_{REF}, is defined as:

$$|\alpha V_{REF}|\ (ppm/°C)=\frac{\left(\frac{V_{I(dev)}}{V_{REF}\ \text{at}\ 25°C}\right)\times 10^6}{\Delta T_A}$$



Where:

ΔT_A is the recommended operating free-air temperature range of the device.

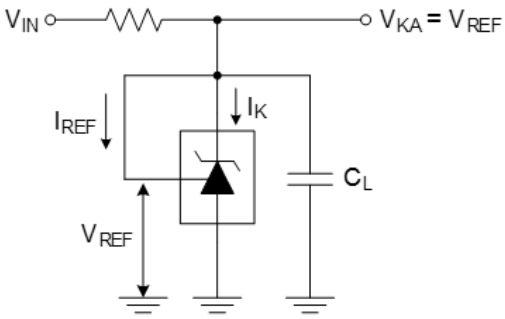
αV_{REF} can be positive or negative, depending on whether minimum V_{REF} or maximum V_{REF}, respectively, occurs at the lower temperature.

(Note 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, the total dynamic impedance of the circuit is given by:

$$\lvert Z'\rvert = \frac{\Delta V}{\Delta I} \approx \lvert Z_{KA}\rvert (1+R1/R2)$$

TEST CIRCUITS



< Fig 1. Test circuit for $V_{KA} = V_{REF}$ >

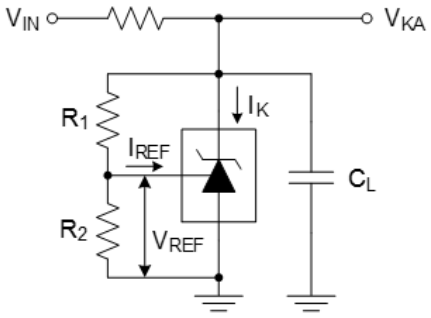
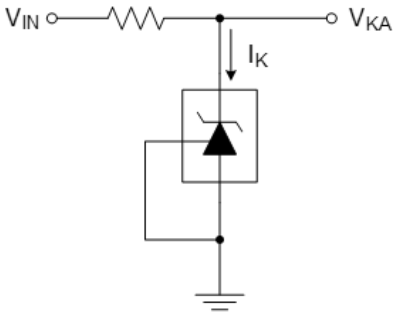


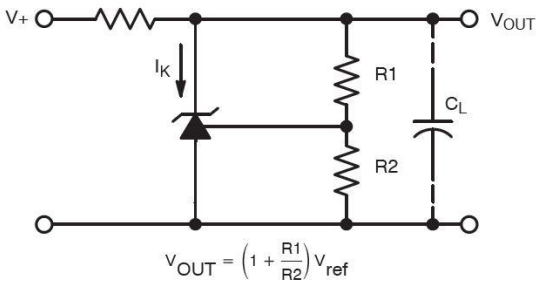
Fig 2. Test circuit for $V_{KA} \geq V_{REF}$ >



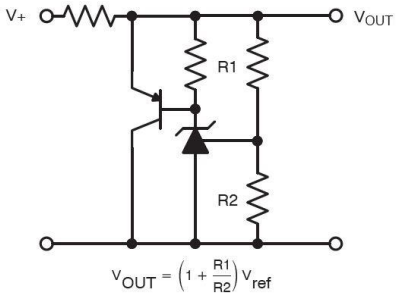
< Fig 3. Test circuit for $I_{KA(OFF)}$ >

TYPICAL APPLICATION CIRCUIT

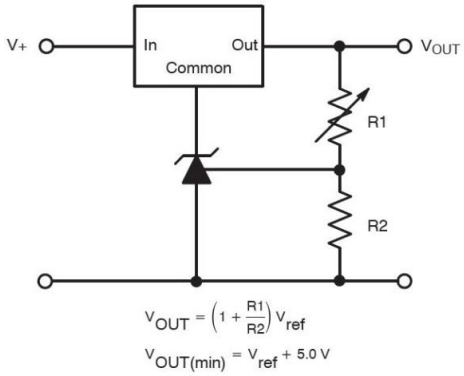
1. Shunt Regulator



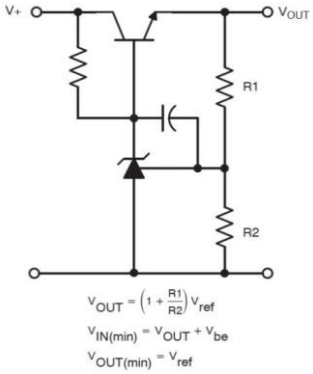
2. High Current Shunt Regulator



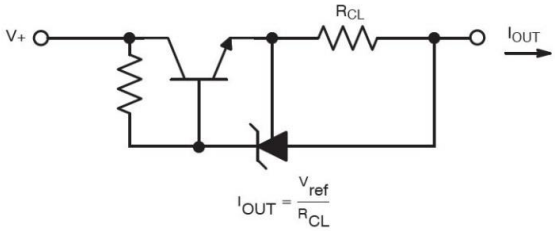
3. Output Control for a Three-Terminal Fixed Regulator



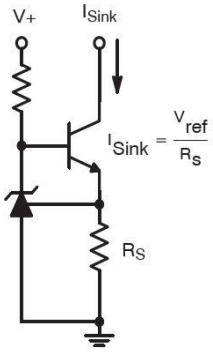
4. Series Pass Regulator



5. Constant Current Source



6. Constant Current Sink



REVISION NOTICE

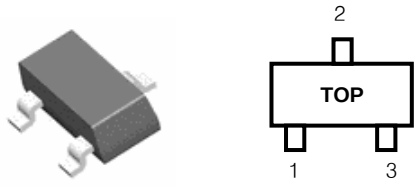
The description in this datasheet is subject to change without any notice to describe its electrical characteristics properly.

Programmable Precision Shunt Regulator TJR431

FEATURES

- Programmable Output Voltage to 28V
- Guaranteed 0.5% Reference Voltage Tolerance
- Cathode Current Range (Continuous) 100 mA
- Temperature Compensated For Operation Over Full Rate Operating Temperature Range
- Low Output Noise Voltage
- Fast Turn-on Response
- Available in SOT-23-3L Package

SOT-23 PKG



Pin 1. CATHODE 2. ANODE 3. REFERENCE

APPLICATIONS

- Shunt Regulator
- Precision High-Current Series Regulator
- High-Current Shunt Regulator
- Crowbar Circuit
- PWM Converter With Reference
- Voltage Monitor
- Precision Current Limiter

ORDERING INFORMATION

Device	Package
TJR431xSF	SOT-23-3L
TJR431GxSF	SOT-23-3L

* Refer to the ordering information for the details.

DESCRIPTION

The TJR431 is a three-terminal adjustable shunt regulator with specified thermal stability over applicable temperature V_{REF} (2.495V) and 28V with two external resistors. This device has a typical dynamic output impedance of 0.25Ω. Active output circuitry provides a very sharp turn-on characteristic, making this device excellent replacement for Zener diodes in many applications. The TJR431 is characterized for operation from -40°C to +125°C.

ABSOLUTE MAXIMUM RATINGS

(Full operating ambient temperature range applies unless otherwise noted.)

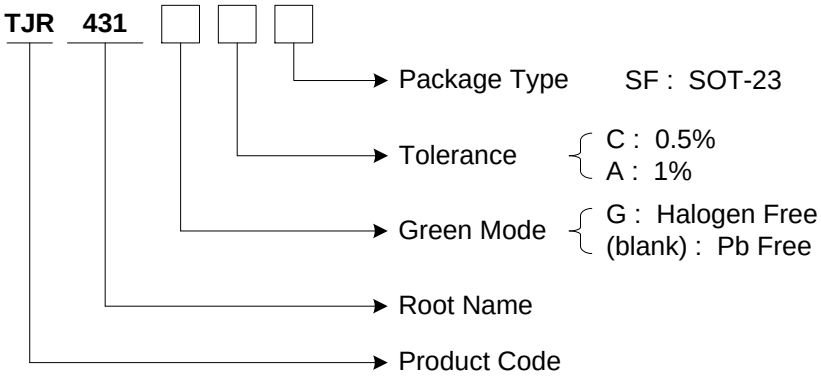
PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Cathode Voltage	V_{KA}	-	37	V
Cathode Current Range	I_{KA}	-100	150	mA
Reference Input Current Range	I_{REF}	-0.05	10	mA
Junction Temperature Range	T_J	-40	150	°C
Storage Temperature Range	T_{STG}	-65	150	°C

RECOMMENDED OPERATING CONDITIONS

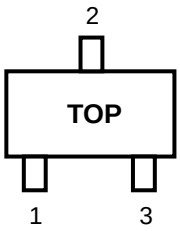
PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Cathode Voltage	V_{KA}	V_{REF}	28	V
Cathode Current	I_{KA}	1.0	100	mA
Operating Temperature Range	T_{OPR}	-40	125	°C

ORDERING INFORMATION

V_{REF}	Package	Tolerance	Order No.	Package Marking	Supplied As
2.495V	SOT-23	0.5%	TJR431CSF	-	Reel
			TJR431GCSF	-	
		1%	TJR431ASF	-	Reel
			TJR431GASF	-	



PIN CONFIGURATION

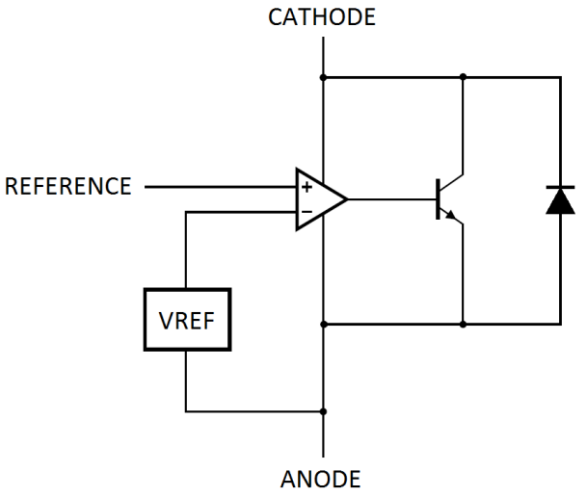


SOT-23 PKG

PIN DESCRIPTION

Pin No.	Pin Name	Pin Description
1	CATHODE	Input Supply Voltage
2	ANODE	Ground
3	REFERENCE	Reference Voltage

BLOCK DIAGRAM



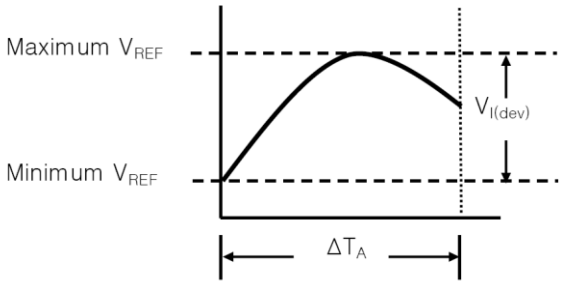
ELECTRICAL CHARACTERISTICS

(T_A=25°C, unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
Reference Input Voltage	V_{REF}	$V_{KA}=V_{REF}$, I_K=10mA	TJR431C	2.483	2.495	2.507	V
			TJR431A	2.470	2.495	2.520	
Deviation of Reference Input Voltage (Note 1)	$\Delta V_{REF}/\Delta T$	$V_{KA}=V_{REF}$, I_K=10mA T_A=Full Range			35	50	mV
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	$\Delta V_{REF}/\Delta V_{KA}$	I_K=10mA	ΔV_{KA}=10V to V_{REF}		-1.0	-2.7	mV/V
			ΔV_{KA}=28V to 10V		-0.4	-2.0	
Reference Input Current	I_{REF}	I_{KA}=10mA, R_1=10kΩ, R_2=∞			0.5	1.2	µA
Deviation of Reference Input Current (Note 1)	$\Delta I_{REF}/\Delta T$	I_K=10mA, R_1=10kΩ, R_2=∞ T_A=Full Range			0.4	1.2	µA
Minimum Cathode Current for Regulation	$I_{K(MIN)}$	$V_{KA}=V_{REF}$			0.4	1.0	mA
Off-State Cathode Current	$I_{K(OFF)}$	V_{KA}=28V, V_{REF}=0			0.1	1.0	µA
Dynamic Impedance (Note 2)	Z_{KA}	$V_{KA}=V_{REF}$, I_K=1mA~100mA f ≤ 1kHz			0.25	0.50	Ω

(Note 1) The deviation parameters $\Delta V_{REF}/\Delta T_A$ and $\Delta I_{REF}/\Delta T_A$ are defined as the differences between the maximum and minimum values obtained over the recommended temperature range. The average full-range temperature coefficient of the reference voltage, αV_{REF}, is defined as:

$$|\alpha V_{REF}|\ (ppm/°C)=\frac{\left(\frac{V_{I(dev)}}{V_{REF}\ at\ 25°C}\right)\times 10^6}{\Delta T_A}$$



Where:

ΔT_A is the recommended operating free-air temperature range of the device.

αV_{REF} can be positive or negative, depending on whether minimum V_{REF} or maximum V_{REF}, respectively, occurs at the lower temperature.

Example : Maximum V_{REF}=2496mV at 30°C, maximum V_{REF}=2492mV at 0°C, V_{REF}=2495mV at 25°C, ΔT_A=70°C for TJR431C.

$$|\alpha V_{REF}|=\frac{\left(\frac{4mv}{2495mV}\right)\times 10^6}{70°C}\approx 23ppm/°C$$

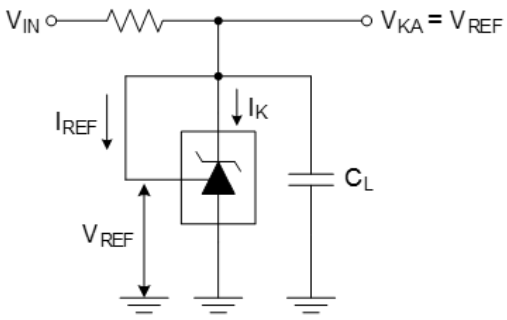
Because minimum V_{REF} occurs at the lower temperature, the coefficient is positive.

(Note 2) The dynamic impedance is defined as: $|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_{KA}}$

When the device is operating with two external resistors, the total dynamic impedance of the circuit is given by:

$$|Z'| = \frac{\Delta V}{\Delta I} \approx |Z_{KA}|(1+R1/R2)$$

TEST CIRCUITS



< Fig 1. Test circuit for $V_{KA} = V_{REF}$ >

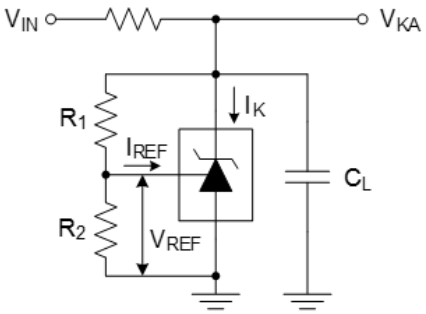
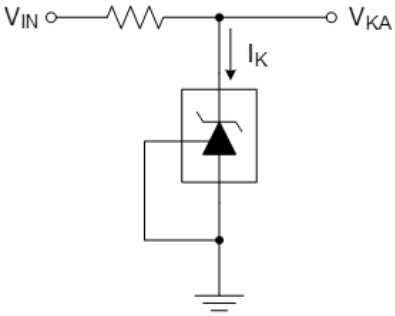
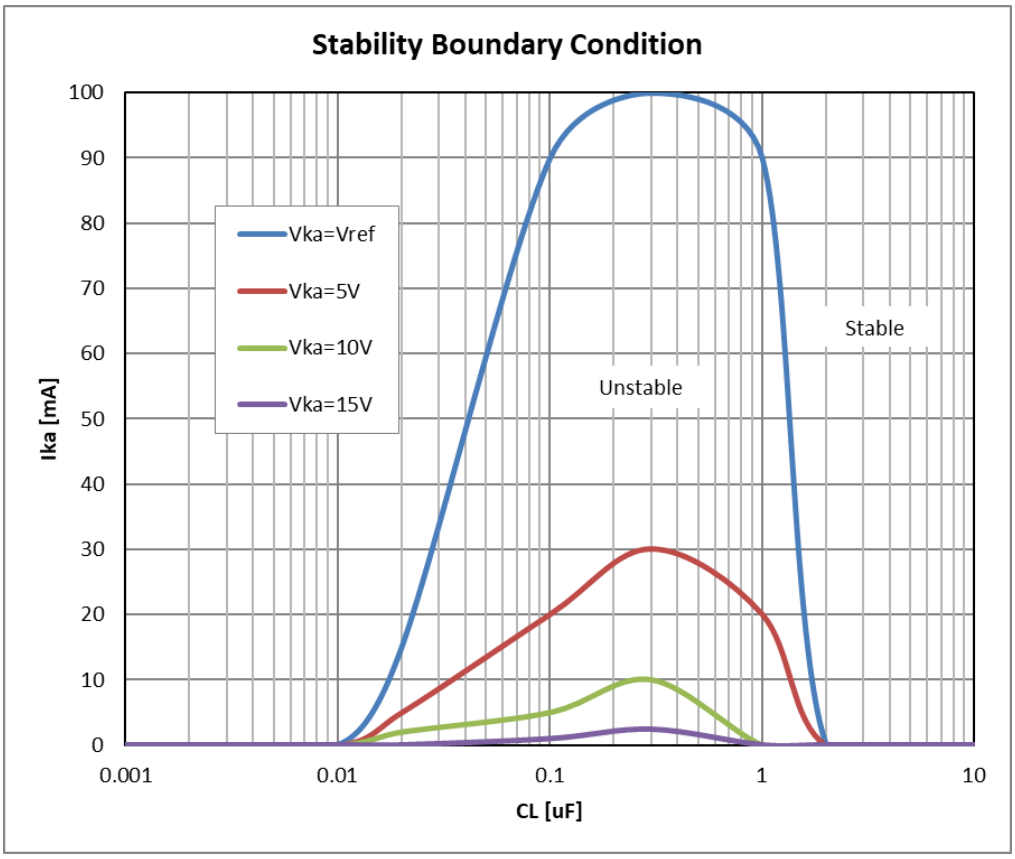


Fig 2. Test circuit for $V_{KA} \geq V_{REF}$ >



< Fig 3. Test circuit for $I_{KA(OFF)}$ >

TYPICAL OPERATING CHARACTERISTICS



Stable Region CL < 5nF or CL > 10uF

< Stability Boundary Conditions >

REVISION NOTICE

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Programmable Precision Shunt Regulator TL432

FEATURES

- Programmable Output Voltage to 18V
- Low Voltage Operation from 1.24 V
- Sink Current Capability of 1mA to 100mA
- Equivalent Full Range Temperature Coefficient of 50ppm/°C
- Temperature Compensated for Operation over Full Rated Operating Temperature Range
- Low Output Noise Voltage
- Available in TO-92, SOT-89 and SOT-23-3L Packages

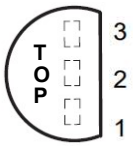
APPLICATIONS

- Shunt Regulator
- Voltage Monitoring
- Current Source and Sink Circuits
- Analog & Digital Circuits Requiring Precision References
- Low Out Voltage (3.0V to 3.3V) Switching Power Supply Error Amplifier

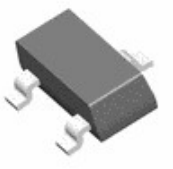
DESCRIPTION

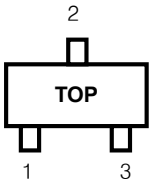
The TL432 is a three-terminal Shunt Voltage Reference providing a highly accuracy 1.24V bandgap reference with 0.5% and 1.0% tolerance. The TL432 thermal stability and wide operating current (100mA) makes is suitable for all variety of applications that are looking for a low cost solution with high performance. The TL432 is an ideal voltage reference in an isolated feed circuit for 3.0V to 3.3V switching mode power supplies.

TO-92 PKG (Bent)

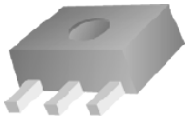


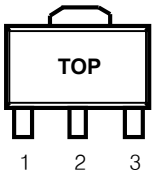
SOT-23 PKG





SOT-89 PKG





Pin 1. REFERENCE 2. ANODE 3. CATHODE

ORDERING INFORMATION

Device	Package
TL432xTA	TO-92 (Tape, Bent)
TL432xSF	SOT-23-3L
TL432xF	SOT-89-3L

* Refer to the ordering information for the details.

ABSOLUTE MAXIMUM RATINGS

(Full operating ambient temperature range applies unless otherwise noted.)

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Cathode Voltage	V_{KA}	-	20	V
Cathode Current Range	I_{KA}	-	100	mA
Reference Input Current Range	I_{REF}	-	3	mA
Junction Temperature Range	T_J	-40	150	°C
Storage Temperature Range	T_{STG}	-65	150	°C

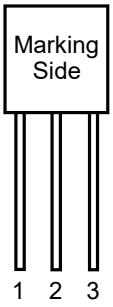
RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	MIN.	MAX.	UNIT
Cathode Voltage	V_{KA}	V_{REF}	18	V
Cathode Current	I_{KA}	0.1	100	mA
Operating Temperature Range	T_{OPR}	-40	125	°C

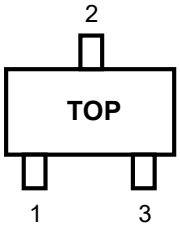
ORDERING INFORMATION

VREF	Package	Tolerance	Order No.	Marking	Supplied As
1.24V	TO-92	0.5%	TL432CTA	TL432-C	Tape & Ammo Pack
		1%	TL432ATA	TL432-A	Tape & Ammo Pack
	SOT-23	0.5%	TL432CSF	432	Tape & Reel
		1%	TL432ASF	432	Tape & Reel
	SOT-89	0.5%	TL432CF	432	Tape & Reel
		1%	TL432AF	432	Tape & Reel

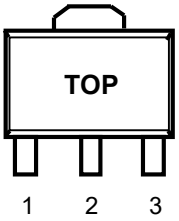
PIN CONFIGURATION



TO-92 PKG



SOT-23 PKG

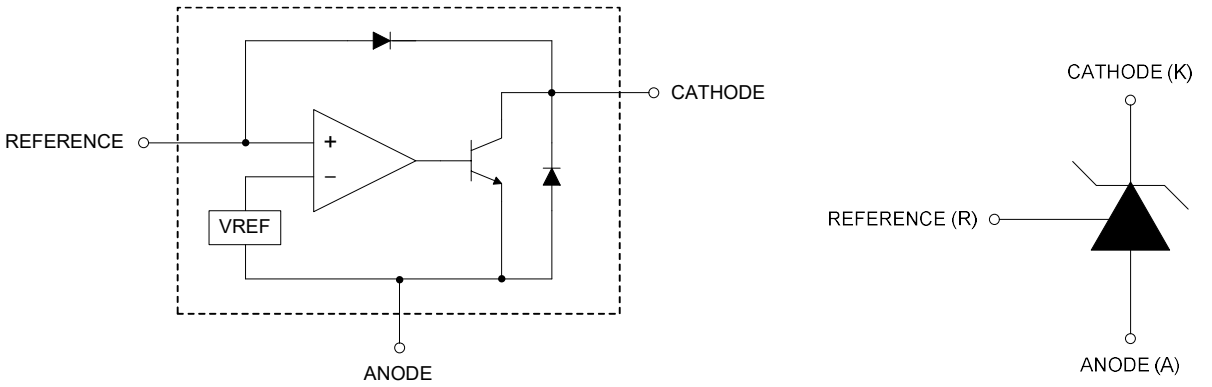


SOT-89 PKG

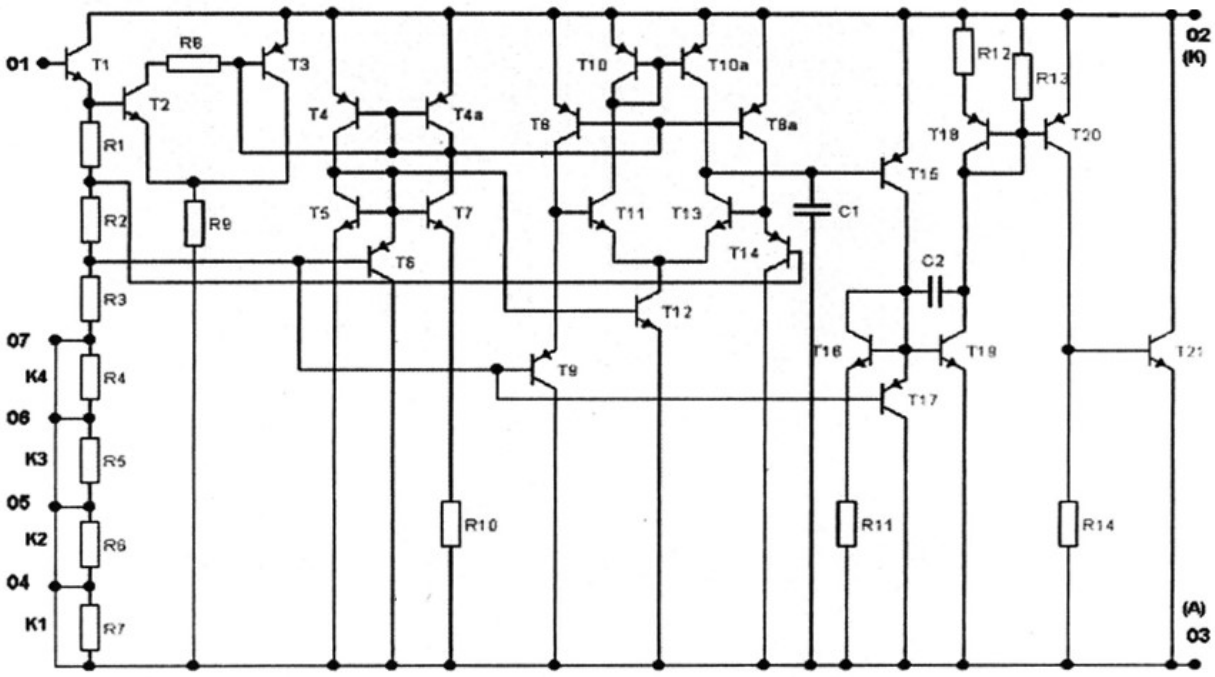
PIN DESCRIPTION

Pin No.	TO-92 / SOT-23 / SOT-89	
	Pin Name	Pin Description
1	REFERENCE	Reference Voltage
2	ANODE	Ground
3	CATHODE	Input Supply Voltage

BLOCK DIAGRAM



EQUIVALENT SCHEMATIC



* All component values are nominal.

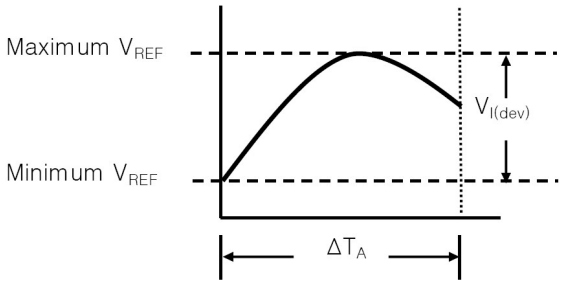
ELECTRICAL CHARACTERISTICS

(T_A=25°C, unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
Reference Input Voltage	V_{REF}	$V_{KA}=V_{REF}$, I_K=10mA	TL432C	1.234	1.240	1.246	V
			TL432A	1.228	1.240	1.252	
Deviation of Reference Input Voltage (Note 1)	$\Delta V_{REF}/\Delta T$	$V_{KA}=V_{REF}$, I_K=10mA, T_A=Full Range			15	25	mV
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	$\Delta V_{REF}/\Delta V_{KA}$	V_{KA} = 1.25V to 14.5V			1.0	2.7	mV/V
Reference Input Current	I_{REF}	R1=10kΩ, R2=∞			0.25	0.5	μA
Deviation of Reference Input Current (Note 1)	$\Delta I_{REF}/\Delta T$	R1=10kΩ, R2=∞, T_A = Full Range			0.05	0.3	μA
Minimum Cathode Current for Regulation	$I_{K(MIN)}$	$V_{KA}=V_{REF}$			60	80	μA
Off-State Cathode Current	$I_{K(OFF)}$	V_{KA}=16V, V_{REF}=0			0.04	0.5	μA
Dynamic Impedance (Note 2)	Z_{KA}	$V_{KA}=V_{REF}$, I_K=0.1mA~100mA, f ≤ 1kHz			0.2	0.4	Ω

(Note 1) The deviation parameters $\Delta V_{REF}/\Delta T_A$ and $\Delta I_{REF}/\Delta T_A$ are defined as the differences between the maximum and minimum values obtained over the recommended temperature range. The average full-range temperature coefficient of the reference voltage, αV_{REF}, is defined as:

$$|\alpha V_{REF}|\ (ppm/°C)=\frac{\left(\frac{V_{I(dev)}}{V_{REF}\ at\ 25°C}\right)\times 10^6}{\Delta T_A}$$



Where:

ΔT_A is the recommended operating free-air temperature range of the device.

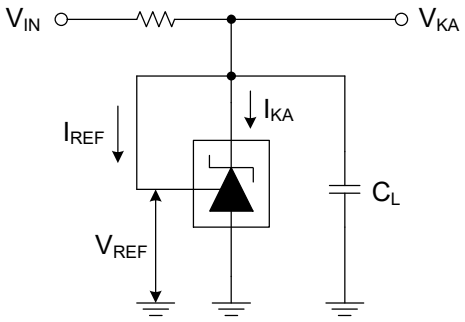
αV_{REF} can be positive or negative, depending on whether minimum V_{REF} or maximum V_{REF}, respectively, occurs at the lower temperature.

(Note 2) The dynamic impedance is defined as: $|Z_{KA}|=\frac{\Delta V_{KA}}{\Delta I_{KA}}$

When the device is operating with two external resistors, the total dynamic impedance of the circuit is given by:

$$|Z'|=\frac{\Delta V}{\Delta I}\approx |Z_{KA}|(1+R1/R2)$$

TEST CIRCUITS



< Fig 1. Test circuit for $V_{KA} = V_{REF}$ >

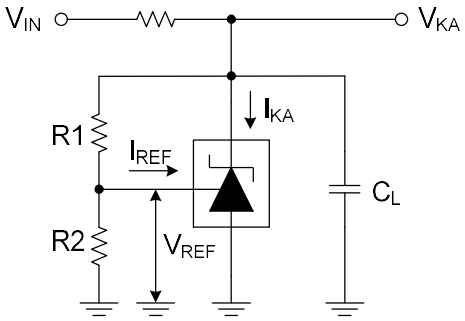
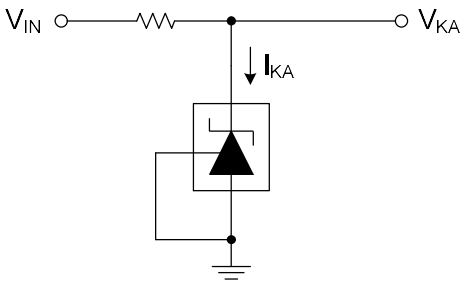


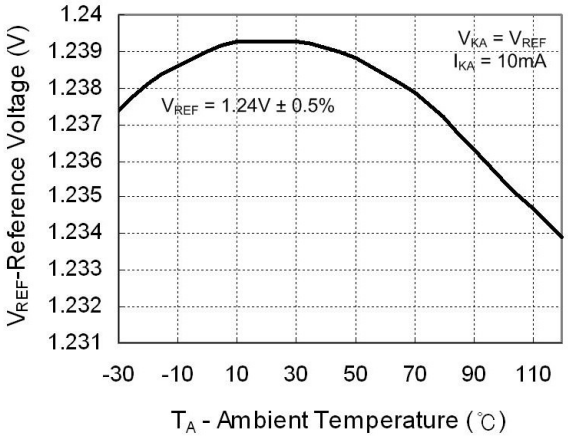
Fig 2. Test circuit for $V_{KA} \geq V_{REF}$ >



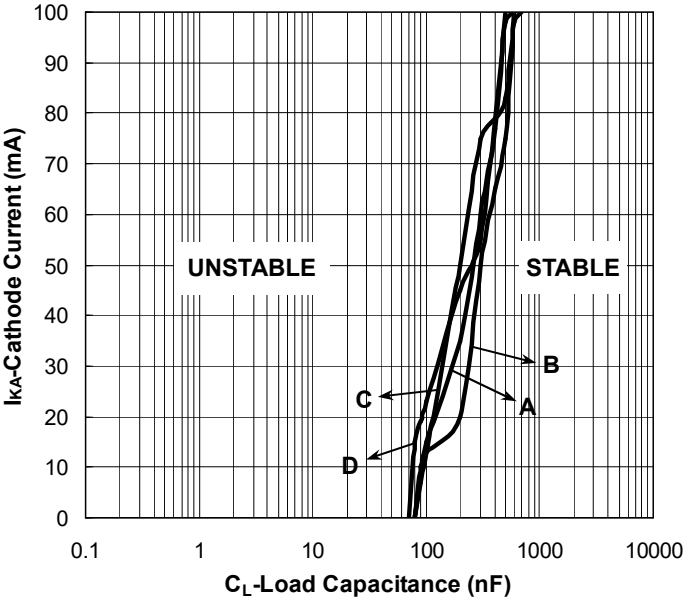
< Fig 3. Test circuit for $I_{KA(OFF)}$ >

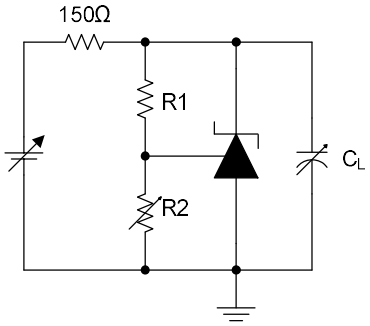
TYPICAL OPERATING CHARACTERISTICS

Reference Voltage vs. Junction Temperature



Stability Boundary Conditions





< Fig 4. Test Circuit >

A $V_{KA}=V_{REF}$ R1= 0Ω, R2 = ∞
B V_{KA}=5.0V, R1=10kΩ, R2 = 3.3kΩ
C V_{KA}=10.0V R1=10kΩ, R2 = 1.42kΩ
D V_{KA}=15.0V R1=10kΩ, R2 = 900Ω

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