TL431, A, B Series, NCV431A

Programmable Precision References

The TL431, A, B integrated circuits are three−terminal programmable shunt regulator diodes. These monolithic IC voltage references operate as a low temperature coefficient zener which is programmable from V_{ref} to 36 V with two external resistors. These devices exhibit a wide operating current range of 1.0 mA to 100 mA with a typical dynamic impedance of 0.22 . The characteristics of these references make them excellent replacements for zener diodes in many applications such as digital voltmeters, power supplies, and op amp circuitry. The 2.5 V reference makes it convenient to obtain a stable reference from 5.0 V logic supplies, and since the TL431, A, B operates as a shunt regulator, it can be used as either a positive or negative voltage reference.

Features

- Programmable Output Voltage to 36 V
- Voltage Reference Tolerance: ±0.4%, Typ @ 25°C (TL431B)
- Low Dynamic Output Impedance, 0.22 Typical
- Sink Current Capability of 1.0 mA to 100 mA
- Equivalent Full−Range Temperature Coefficient of 50 ppm/°C Typical
- Temperature Compensated for Operation over Full Rated Operating Temperature Range
- Low Output Noise Voltage
- Pb−Free Packages are Available

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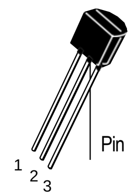
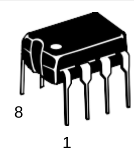
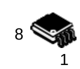


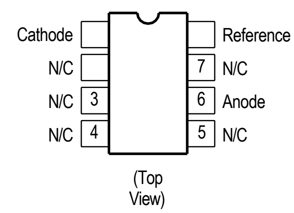
TO−92 (TO−226)
LP SUFFIX
CASE 29

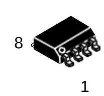


PDIP−8
P SUFFIX
CASE 626

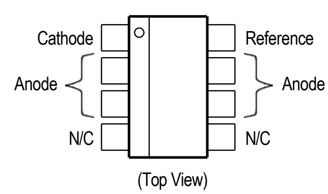


Micro8
DM SUFFIX
CASE 846A





SOIC−8
D SUFFIX
CASE 751



This is an internally modified SOIC−8 package. Pins 2, 3, 6 and 7 are electrically common to the die attach flag. This internal lead frame modification increases power dissipation capability when appropriately mounted on a printed circuit board. This modified package conforms to all external dimensions of the standard SOIC−8 package.

ORDERING INFORMATION

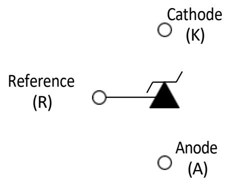
See detailed ordering and shipping information in the package dimensions section on page 13 of this data sheet.

DEVICE MARKING INFORMATION

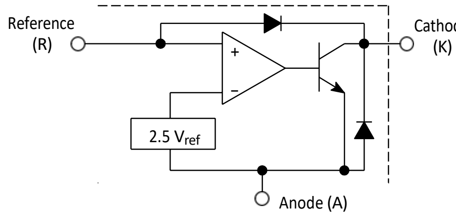
See general marking information in the device marking section on page 15 of this data sheet.

July, 2005 − Rev. 22
Publication Order Number:
TL431/D

Symbol

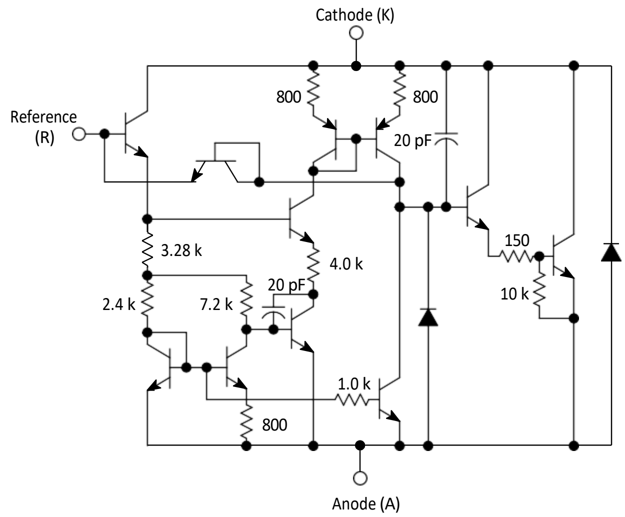


Representative Block Diagram



Representative Schematic Diagram

Component values are nominal



This device contains 12 active transistors.

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

Rating	Symbol	Value	Unit
Cathode to Anode Voltage	V_{KA}	37	V
Cathode Current Range, Continuous	I_K	−100 to +150	mA
Reference Input Current Range, Continuous	I_{ref}	−0.05 to +10	mA
Operating Junction Temperature	T_J	150	°C
Operating Ambient Temperature Range TL431I, TL431AI, TL431BI TL431C, TL431AC, TL431BC NCV431AI, TL431BV	T_A	 −40 to +85 0 to +70 −40 to +125	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Total Power Dissipation @ T_A = 25°C Derate above 25°C Ambient Temperature D, LP Suffix Plastic Package P Suffix Plastic Package DM Suffix Plastic Package	P_D	 0.70 1.10 0.52	W
Total Power Dissipation @ T_C = 25°C Derate above 25°C Case Temperature D, LP Suffix Plastic Package P Suffix Plastic Package	P_D	 1.5 3.0	W

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

NOTE: ESD data available upon request.

RECOMMENDED OPERATING CONDITIONS

Condition	Symbol	Min	Max	Unit
Cathode to Anode Voltage	V_{KA}	V_{ref}	36	V
Cathode Current	I_K	1.0	100	mA

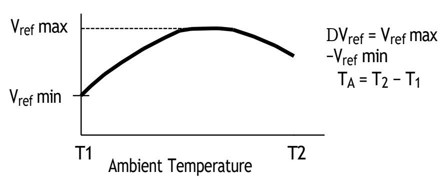
THERMAL CHARACTERISTICS

Characteristic	Symbol	D, LP Suffix Package	P Suffix Package	DM Suffix Package	Unit
Thermal Resistance, Junction−to−Ambient	$R_{\theta JA}$	178	114	240	°C/W
Thermal Resistance, Junction−to−Case	$R_{\theta JC}$	83	41	−	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C, unless otherwise noted.)

Characteristic	Symbol	TL431I			TL431C			Unit
		Min	Typ	Max	Min	Typ	Max	
Reference Input Voltage (Figure 1) $V_{KA} = V_{ref}$, I_K = 10 mA T_A = 25°C $T_A = T_{low}$ to T_{high} (Note 1)	V_{ref}	 2.44 2.41	 2.495 −	 2.55 2.58	 2.44 2.423	 2.495 −	 2.55 2.567	V
Reference Input Voltage Deviation Over Temperature Range (Figure 1, Notes 1, 2) $V_{KA} = V_{ref}$, I_K = 10 mA	V_{ref}	−	7.0	30	−	3.0	17	mV
Ratio of Change in Reference Input Voltage to Change in Cathode to Anode Voltage I_K = 10 mA (Figure 2), V_{KA} = 10 V to V_{ref} V_{KA} = 36 V to 10 V	$\frac{V_{ref}}{V_{KA}}$	 − −	 −1.4 −1.0	 −2.7 −2.0	 − −	 −1.4 −1.0	 −2.7 −2.0	mV/V
Reference Input Current (Figure 2) I_K = 10 mA, R1 = 10 k, R2 = ∞ T_A = 25°C $T_A = T_{low}$ to T_{high} (Note 1)	I_{ref}	 − −	 1.8 −	 4.0 6.5	 − −	 1.8 −	 4.0 5.2	A
Reference Input Current Deviation Over Temperature Range (Figure 2, Note 1, 4) I_K = 10 mA, R1 = 10 k, R2 = ∞	I_{ref}	−	0.8	2.5	−	0.4	1.2	A
Minimum Cathode Current For Regulation $V_{KA} = V_{ref}$ (Figure 1)	I_{min}	−	0.5	1.0	−	0.5	1.0	mA
Off−State Cathode Current (Figure 3) V_{KA} = 36 V, V_{ref} = 0 V	I_{off}	−	20	1000	−	20	1000	nA
Dynamic Impedance (Figure 1, Note 3) $V_{KA} = V_{ref}$, I_K = 1.0 mA to 100 mA f ≤ 1.0 kHz	$\lvert Z_{KA}\rvert$	−	0.22	0.5	−	0.22	0.5	

1. T_{low} = −40°C for TL431AIP TL431AILP, TL431IP, TL431ILP, TL431BID, TL431BIP, TL431BILP, TL431AIDM, TL431IDM, TL431BIDM;
   = 0°C for TL431ACP, TL431ACLP, TL431CP, TL431CLP, TL431CD, TL431ACD, TL431BCD, TL431BCP, TL431BCLP, TL431CDM, TL431ACDM, TL431BCDM
   T_{high} = +85°C for TL431AIP, TL431AILP, TL431IP, TL431ILP, TL431BID, TL431BIP, TL431BILP, TL431IDM, TL431AIDM, TL431BIDM
   = +70°C for TL431ACP, TL431ACLP, TL431CP, TL431ACD, TL431BCD, TL431BCP, TL431BCLP, TL431CDM, TL431ACDM, TL431BCDM
2. The deviation parameter V_{ref} is defined as the difference between the maximum and minimum values obtained over the full operating ambient temperature range that applies.



The average temperature coefficient of the reference input voltage, V_{ref} is defined as:

$$V_{ref}\ \frac{ppm}{C}\quad \frac{\left(\frac{V_{ref}}{V_{ref}\ @\ 25\ C}\right) \times 10^6}{T_A}\quad \frac{V_{ref} \times 10^6}{T_A\,(V_{ref}\ @\ 25\ C)}$$

V_{ref} can be positive or negative depending on whether V_{ref} Min or V_{ref} Max occurs at the lower ambient temperature. (Refer to Figure 6.)

Example : V_{ref} 8.0 mV and slope is positive,

V_{ref} @ 25 C 2.495 V, T_A 70 C

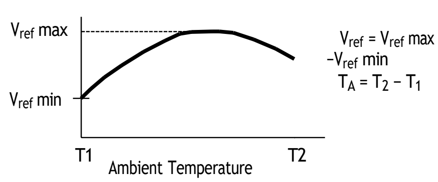
$$V_{ref}\quad \frac{0.008 \times 10^6}{70\,(2.495)}\quad 45.8\ ppm\ \ C$$

3. The dynamic impedance Z_{KA} is defined as: $|Z_{KA}|\ \ \frac{V_{KA}}{I_K}$. When the device is programmed with two external resistors, R1 and R2, (refer to Figure 2) the total dynamic impedance of the circuit is defined as: $|Z_{KA}|\ \ |Z_{KA}|\ \ 1\ \ \frac{R1}{R2}$

ELECTRICAL CHARACTERISTICS (T_A = 25°C, unless otherwise noted.)

Characteristic	Symbol	TL431AI / NCV431AI			TL431AC			TL431BI / TL431BV			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Reference Input Voltage (Figure 1) $V_{KA} = V_{ref}$, I_K = 10 mA T_A = 25°C $T_A = T_{low}$ to T_{high}	V_{ref}	 2.47 2.44	 2.495 −	 2.52 2.55	 2.47 2.453	 2.495 −	 2.52 2.537	 2.483 2.475	 2.495 2.495	 2.507 2.515	V
Reference Input Voltage Deviation Over Temperature Range (Figure 1, Notes 4, 5) $V_{KA} = V_{ref}$, I_K = 10 mA	V_{ref}	−	7.0	30	−	3.0	17	−	3.0	17	mV
Ratio of Change in Reference Input Voltage to Change in Cathode to Anode Voltage I_K = 10 mA (Figure 2), V_{KA} = 10 V to V_{ref} V_{KA} = 36 V to 10 V	$\frac{V_{ref}}{V_{KA}}$	 − −	 −1.4 −1.0	 −2.7 −2.0	 − −	 −1.4 −1.0	 −2.7 −2.0	 − −	 −1.4 −1.0	 −2.7 −2.0	mV/V
Reference Input Current (Figure 2) I_K = 10 mA, R1 = 10 k, R2 = ∞ T_A = 25°C $T_A = T_{low}$ to T_{high} (Note 4)	I_{ref}	 − −	 1.8 −	 4.0 6.5	 − −	 1.8 −	 4.0 5.2	 − −	 1.1 −	 2.0 4.0	A
Reference Input Current Deviation Over Temperature Range (Figure 2, Note 4) I_K = 10 mA, R1 = 10 k, R2 = ∞	I_{ref}	−	0.8	2.5	−	0.4	1.2	−	0.8	2.5	A
Minimum Cathode Current For Regulation $V_{KA} = V_{ref}$ (Figure 1)	I_{min}	−	0.5	1.0	−	0.5	1.0	−	0.5	1.0	mA
Off−State Cathode Current (Figure 3) V_{KA} = 36 V, V_{ref} = 0 V	I_{off}	−	20	1000	−	20	1000	−	0.23	500	nA
Dynamic Impedance (Figure 1, Note 6) $V_{KA} = V_{ref}$, I_K = 1.0 mA to 100 mA f ≤ 1.0 kHz	$\lvert Z_{KA}\rvert$	−	0.22	0.5	−	0.22	0.5	−	0.14	0.3	

4. T_{low} = −40°C for TL431AIP TL431AILP, TL431IP, TL431ILP, TL431BID, TL431BIP, TL431BILP, TL431BV, TL431AIDM, TL431IDM, TL431BIDM, NCV431AIDMR2, NCV431AIDR2
   = 0°C for TL431ACP, TL431ACLP, TL431CP, TL431CLP, TL431CD, TL431ACD, TL431BCD, TL431BCP, TL431BCLP, TL431CDM, TL431ACDM, TL431BCDM
   T_{high} = +85°C for TL431AIP, TL431AILP, TL431IP, TL431ILP, TL431BID, TL431BIP, TL431BILP, TL431IDM, TL431AIDM, TL431BIDM
   = +70°C for TL431ACP, TL431ACLP, TL431CP, TL431ACD, TL431BCD, TL431BCP, TL431BCLP, TL431CDM, TL431ACDM, TL431BCDM
   = +125°C TL431BV, NCV431AIDMR2, NCV431AIDR2
5. The deviation parameter V_{ref} is defined as the difference between the maximum and minimum values obtained over the full operating ambient temperature range that applies.



The average temperature coefficient of the reference input voltage, V_{ref} is defined as: $V_{ref}\ \frac{ppm}{C}\ \frac{\left(\frac{V_{ref}}{V_{ref}\ @\ 25\ C}\right) \times 10^6}{T_A}\ \frac{V_{ref} \times 10^6}{T_A\ (V_{ref}\ @\ 25\ C)}$

V_{ref} can be positive or negative depending on whether V_{ref} Min or V_{ref} Max occurs at the lower ambient temperature. (Refer to Figure 6.)

Example : V_{ref} 8.0 mV and slope is positive,

V_{ref} @ 25 C 2.495 V, T_A 70 C $V_{ref}\ \frac{0.008 \times 10^6}{70\ (2.495)}$ 45.8 ppm C

6. The dynamic impedance Z_{KA} is defined as $\lvert Z_{KA}\rvert\ \frac{V_{KA}}{I_K}$ When the device is programmed with two external resistors, R1 and R2, (refer to Figure 2) the total dynamic impedance of the circuit is defined as: $\lvert Z_{KA}\rvert\ \lvert Z_{KA}\rvert\ 1\ \frac{R1}{R2}$
7. NCV431AIDMR2, NCV431AIDR2 T_{low} = −40°C, T_{high} = +125°C. Guaranteed by design. NCV prefix is for automotive and other applications requiring site and change control.

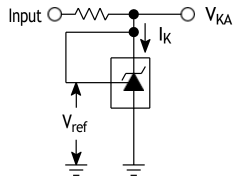


Figure 1. Test Circuit for $V_{KA} = V_{ref}$

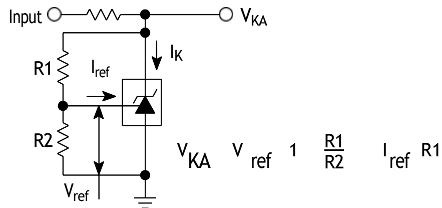


Figure 2. Test Circuit for $V_{KA} > V_{ref}$

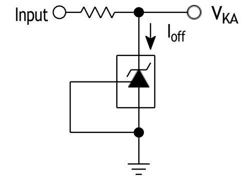


Figure 3. Test Circuit for I_{off}

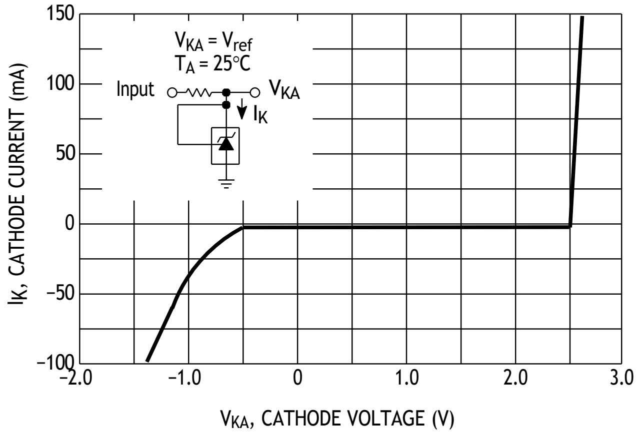


Figure 4. Cathode Current versus Cathode Voltage

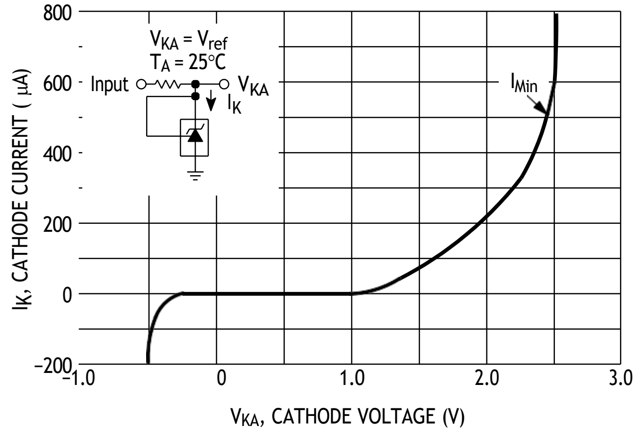


Figure 5. Cathode Current versus Cathode Voltage

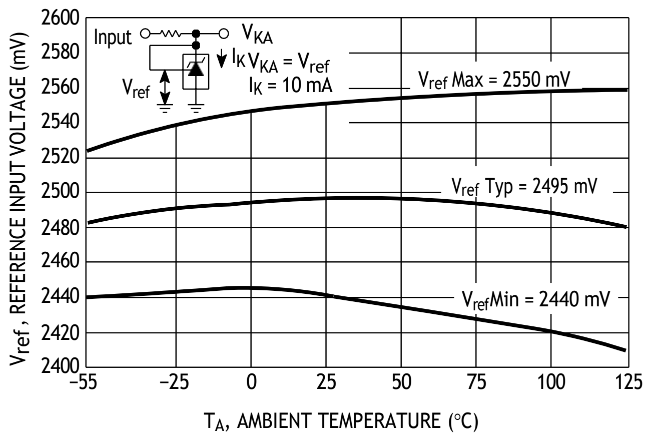


Figure 6. Reference Input Voltage versus Ambient Temperature

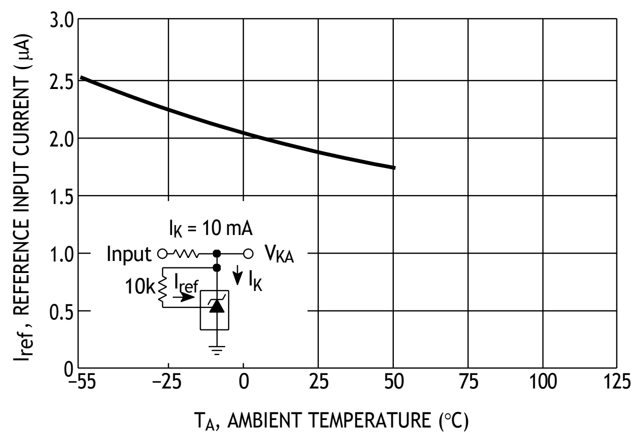


Figure 7. Reference Input Current versus Ambient Temperature

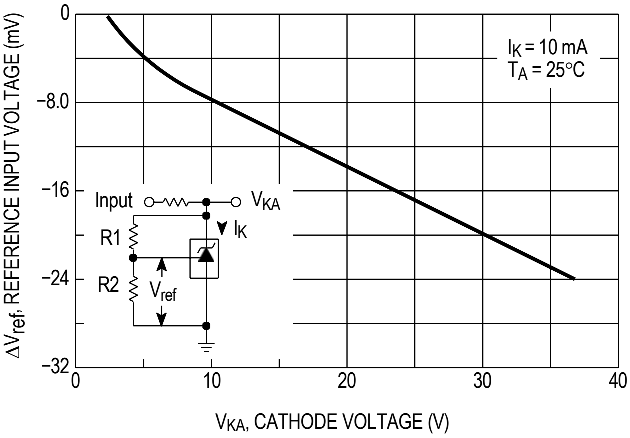


Figure 8. Change in Reference Input Voltage versus Cathode Voltage

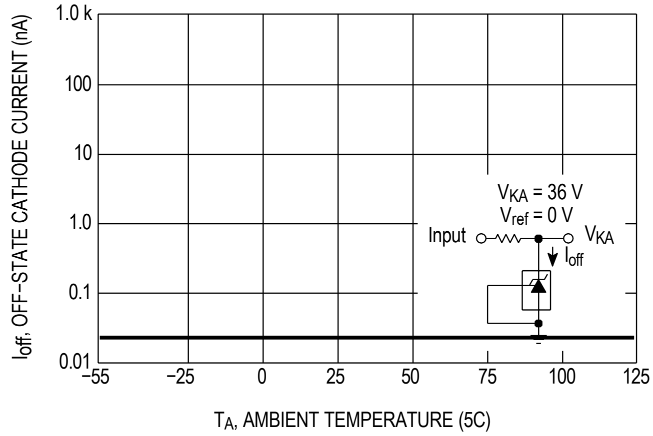


Figure 9. Off−State Cathode Current versus Ambient Temperature

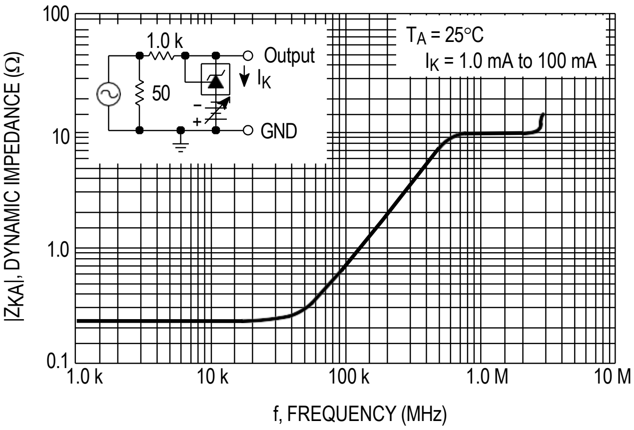


Figure 10. Dynamic Impedance versus Frequency

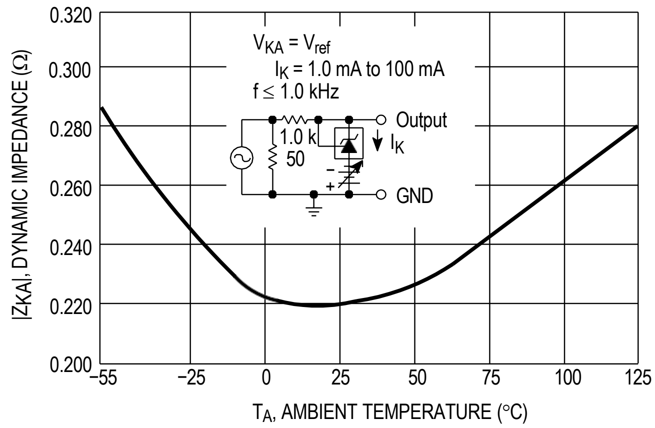


Figure 11. Dynamic Impedance versus Ambient Temperature

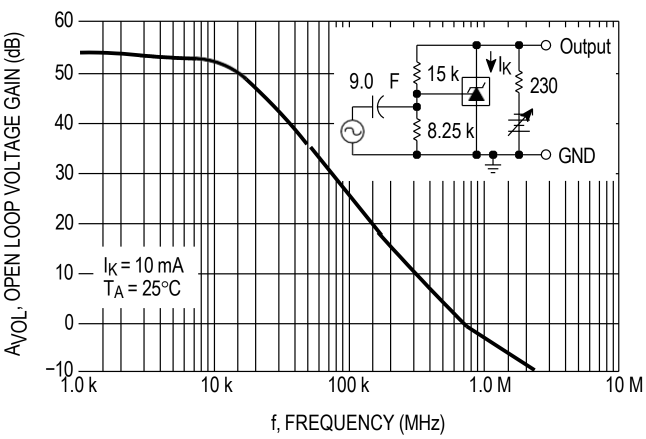


Figure 12. Open−Loop Voltage Gain versus Frequency

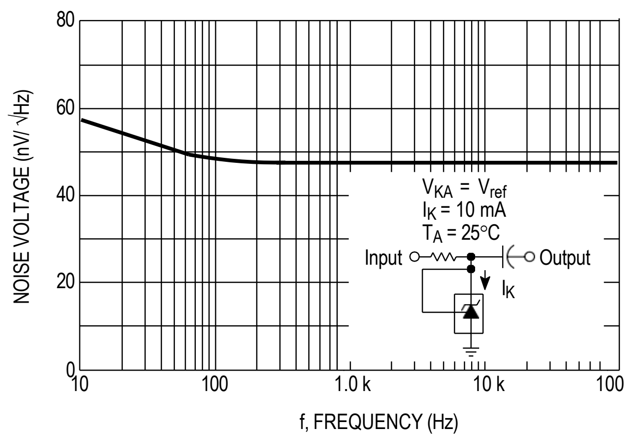


Figure 13. Spectral Noise Density

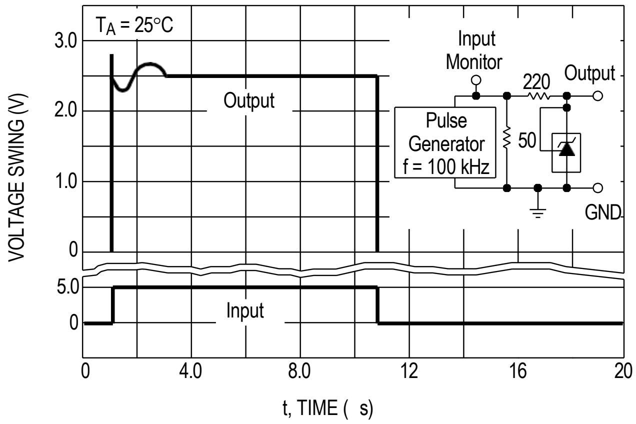


Figure 14. Pulse Response

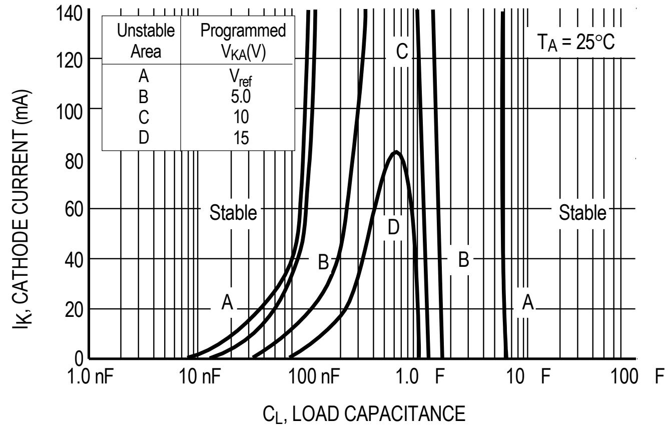


Figure 15. Stability Boundary Conditions

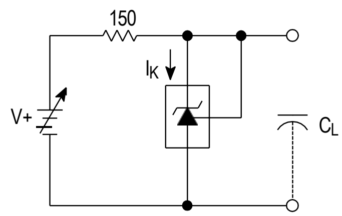


Figure 16. Test Circuit For Curve A of Stability Boundary Conditions

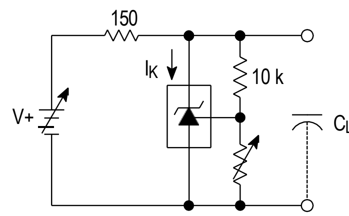


Figure 17. Test Circuit For Curves B, C, And D of Stability Boundary Conditions

TYPICAL APPLICATIONS

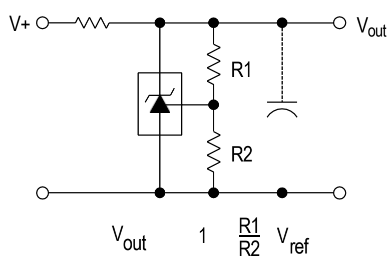


Figure 18. Shunt Regulator

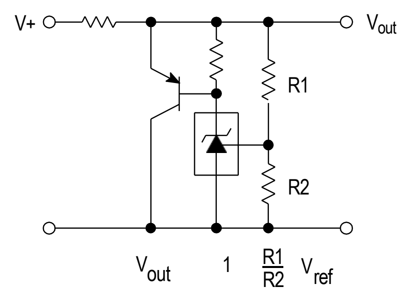


Figure 19. High Current Shunt Regulator