Programmable Precision Reference

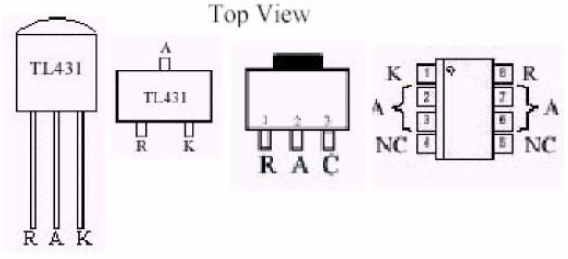
DESCRIPTION

The TL431, A, B is a three-terminal adjustable regulator with a guaranteed thermal stability over applicable temperature ranges. The output voltage may be set to any value between Vref (approximately 2.5 volts) and 40 volts with two external resistors. These devices have a typical dynamic output impedance of 0.2Ω. Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replacement for zener diodes in many applications.

The TL431, A, B is characterized for operation from −60 to +125 °C.

PIN CONNECTIONS

Top View



TO-92 SOT-23-3 SOT-89 SOP-8

FEATURES

- Programmable Output Voltage to 40V
- Low Dynamic Output Impedance 0.2Ω
- Sink Current Capability of 1.0mA to 100mA
- Equivalent Full-Range Temperature Coefficient of 50 ppm/°C
- Temperature Compensated for Operation over Full Rated Operating Temperature Range
- Low Output Noise Voltage
- Fast Turn on Response
- TO-92, SOT-23, SOP-89 packages
- Reference Voltage Tolerance at 25°C
  - 0.5%...B Grade
  - 1.0%...A Grade
  - 2.0%...Standard Grade

ORDERING INFORMATION

Temperature Range	Package		Orderable Device	Package Qty	Tolerance
0℃ to +70℃	SOT-23	Pb-Free	TL431ACDBZ	75 Units/Tube	0.5%
			TL431BCDBZ		1.0%
			TL431CDBZ		2.0%
	TO-92		TL431ACLP TL431ACLPR	50 Units/Tube	0.5%
			TL431BCLP TL431BCLPR		1.0%
			TL431CLP TL431CLPR		2.0%
	SOT-89		TL431ACPK	75 Units/Tube	0.5%
			TL431BCPK		1.0%
			TL431CPK		2.0%

DIAGRAM

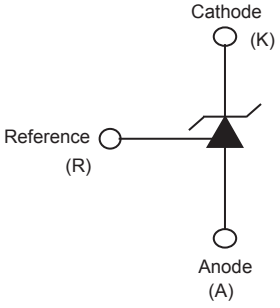


Figure 1. Symbol

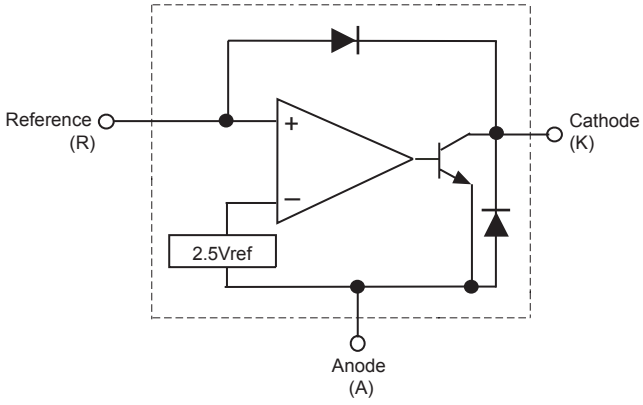
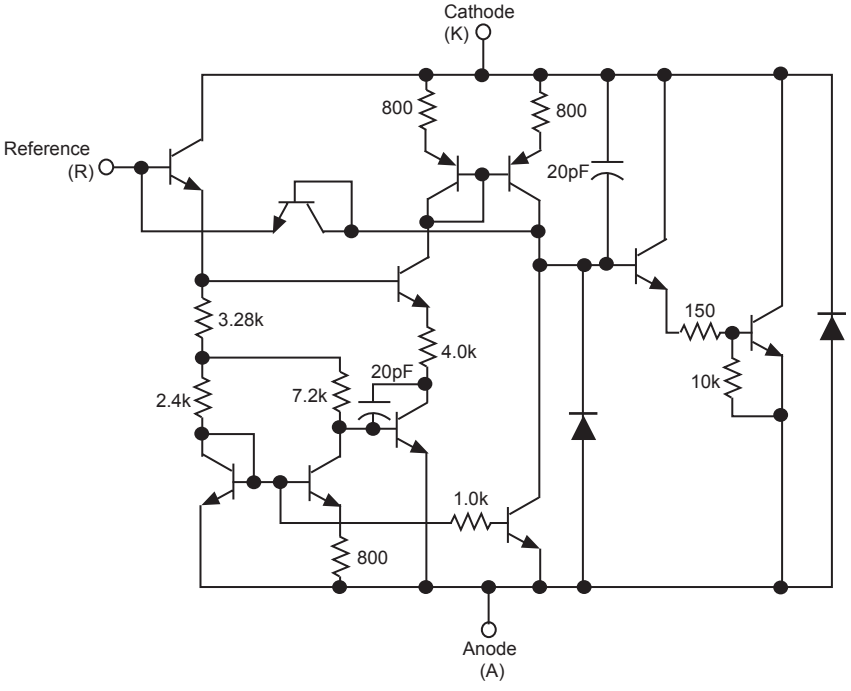


Figure 2. Block Diagram



Component values are nominal

Figure 3. Equivalent Schematic

ABSOLUTE MAXIMUM RATINGS

(Over Temperature Range, unless otherwise notes)

Parameter		Symbol	Value	Unit
Cathode Voltage		V_{KA}	42	V
Cathode Current Range (Continuous)		I_K	-100 to +150	mA
Reference Input Current Range		I_{REF}	+0.05 to +10	mA
Power Dissipation at 25°C	LP Suffix Package	P_D	700	mW
	DBZ Suffix Package		200	
Junction Temperature Range		T_J	0 to +150	°C
Operating Temperature Range		T_A	-60 to +125	°C
Storage Temperature Range		T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Parameter	Symbol	LP Package	DBZ Package	Unit
Thermal Resistance, Junction−to−Ambient	$R_{\theta JA}$	178	206	°C/W
Thermal Resistance, Junction−to−Case	$R_{\theta JC}$	55	76	°C/W

RECOMMENDED OPERATING CONDITIONS

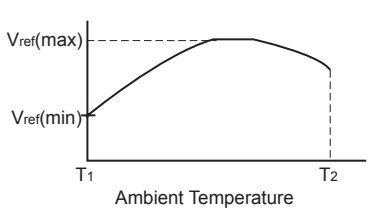
Parameter	Symbol	Min	Max	Unit
Cathode to Anode Voltage	V_{KA}	V_{ref}	40	V
Cathode Current	I_K	0.5	100	mA

ELECTRICAL CHARACTERISTICS

(T_A = 25 °C , unless otherwise notes)

Parameter	Symbol	Test Conditions		Min	Typ	Max	Unit
Reference Input Voltage $V_{KA}=V_{REF}$, I_K=10mA (Figure4)	V_{REF}	TL431(2.0%)		2.440	2.495	2.550	V
		TL431A(1%)		2.470	2.495	2.520	
		TL431B(0.5%)		2.482	2.495	2.508	
Deviation of Reference Input Voltage Over Full Temperature Range (Figure 4, Note 1)	ΔV_{REF}	$T_{MIN}\le T_A\le T_{MAX}$, $V_{KA}=V_{REF}$, I_K=10mA			3	17	mV
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage (Figure 5)	$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	I_K=10mA	ΔV_{KA}=10V-V_{REF}		-1.4	-2.7	mV/V
			ΔV_{KA}=36V-10V		-1.0	-2.0	
Reference Input Current (Figure 5)	I_{REF}	I_K=10mA, R1=10kΩ, R2=∞			1.8	4	μA
Deviation of Reference Input Current Over Full Temperature Range (Figure 5)	ΔI_{REF}	I_K=10mA, R1=10kΩ, R2=∞			0.4	1.2	μA
Minimum Cathode Current for Regulation (Figure4)	$I_{K(min)}$	$V_{KA}=V_{REF}$			0.5	1	mA
Off-State Cathode Current (Figure 6)	$I_{K(off)}$	V_{KA}=42V, V_{REF}=0			0.17	0.9	μA
Dynamic Impedance (Figure 6， Note2)	$\lvert Z_{KA}\rvert$	$V_{KA}=V_{REF}$, ΔI_K=1.0mA to100mA, f≤1.0kHz			0.27	0.5	Ω

Note 1:The deviation parameter ΔV_{REF} is defined as the difference between the maximum and minimum values obtained over the full operating ambient temperature range that applies.



$\Delta V_{ref}=V_{ref}(max)-V_{ref}(min)$
$\Delta T_A=T_2-T_1$

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

$$\alpha V_{ref}\left(\frac{ppm}{°C}\right)=\frac{\left(\frac{\Delta V_{ref}}{V_{ref}@25°C}\right)\times 10^6}{\Delta T_A}=\frac{\Delta V_{ref}\times 10^6}{\Delta T_A(V_{ref}@25°C)}$$

αV_{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: ΔV_{ref}=8.0mV and slope is positive, V_{ref}@25°C=2.495V,ΔT_A=70°C

$$\alpha V_{ref} = \frac{0.008\times 10^6}{70(2.495)} = 45.8 ppm/°C$$

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

When the device is programmed with two external resistors, R1 and R2, (refer to Figure 5) the total dynamic impedance of the circuit is defined as:

$$|Z_{KA}'|\approx|Z_{KA}|\left(1+\frac{R1}{R2}\right)$$

TYPICAL PERFORMANCE CHARACTERISTICS

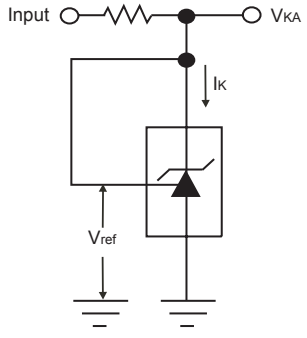


Figure 4. Test Circuit for $V_{KA}=V_{REF}$

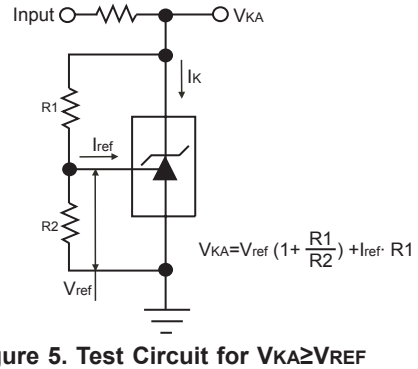


Figure 5. Test Circuit for $V_{KA}\geq V_{REF}$

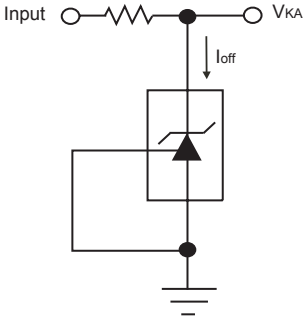


Figure 6. Test Circuit for I_{off}

TYPICAL PERFORMANCE CHARACTERISTICS(CONTINUED)

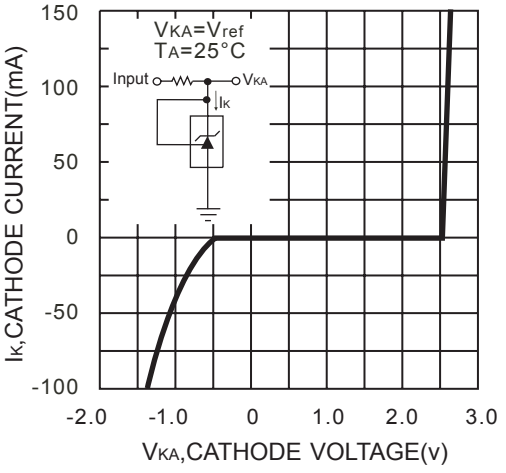


Figure 7. Cathode Current vs. Cathode Voltage

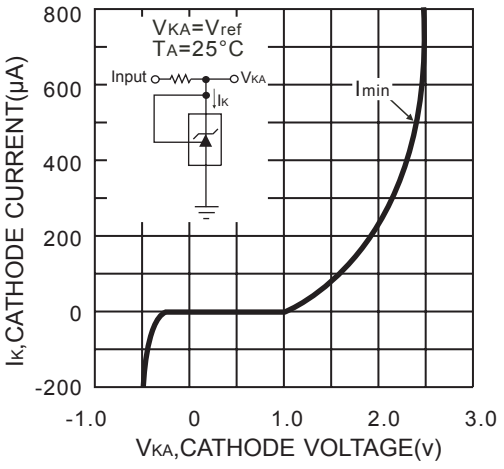


Figure 8. Cathode Current vs. Cathode Voltage

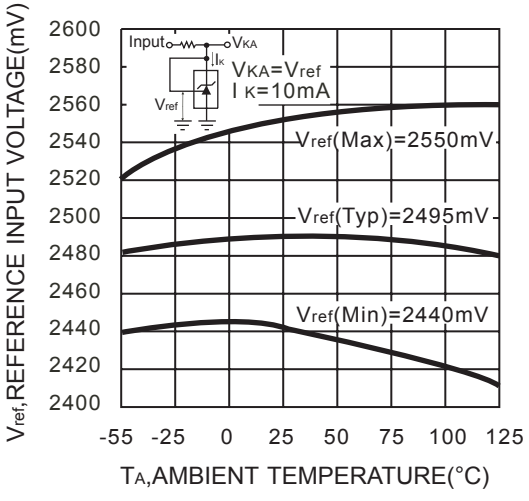


Figure 9. Reference Input Voltage vs. Ambient Temperature

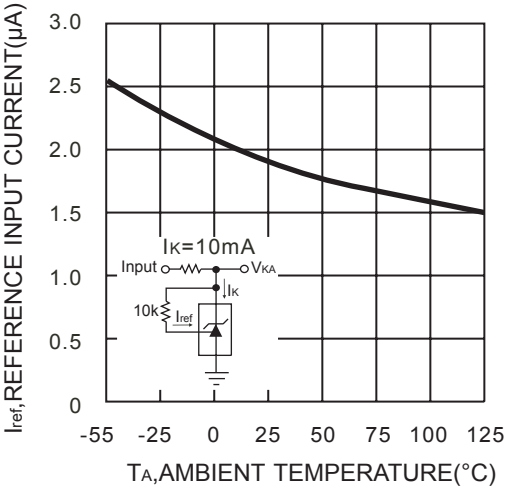


Figure 10. Reference Input Current vs. Ambient Temperature

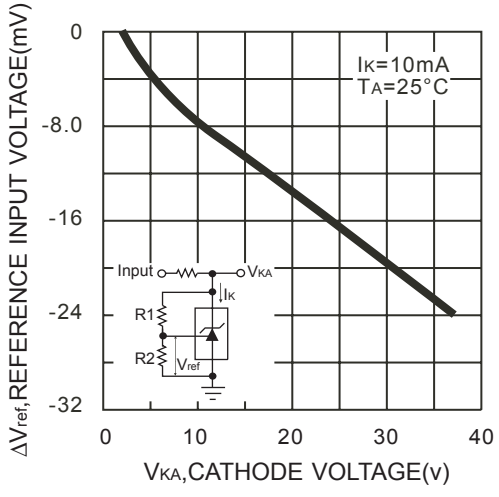


Figure 11. Change in Reference Input Voltage vs. Cathode Voltage

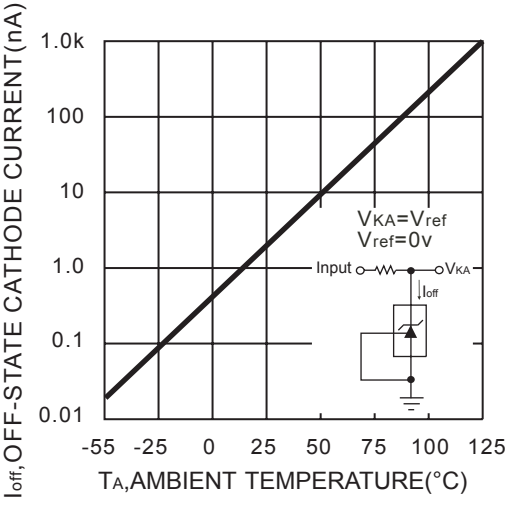


Figure 12 .Off−State Cathode Current vs. Ambient Temperature

TYPICAL PERFORMANCE CHARACTERISTICS(CONTINUED)

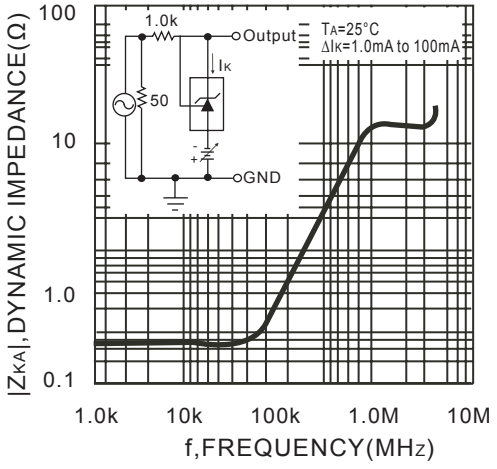


Figure 13. Dynamic Impedance vs. Frequency

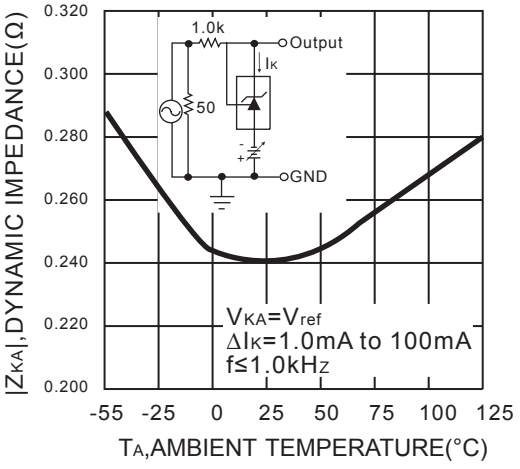


Figure 14. Dynamic Impedance vs. Ambient Temperature

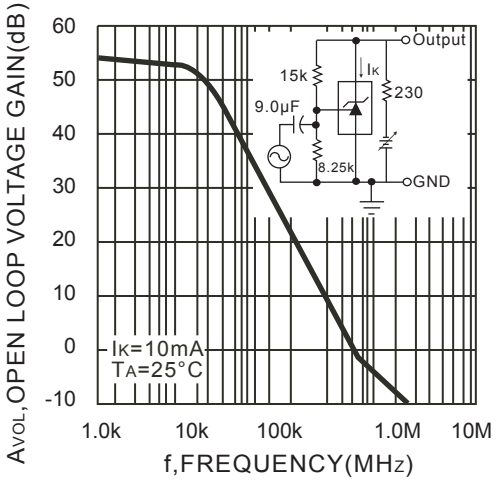


Figure 15. Open−Loop Voltage Gain vs. Frequency

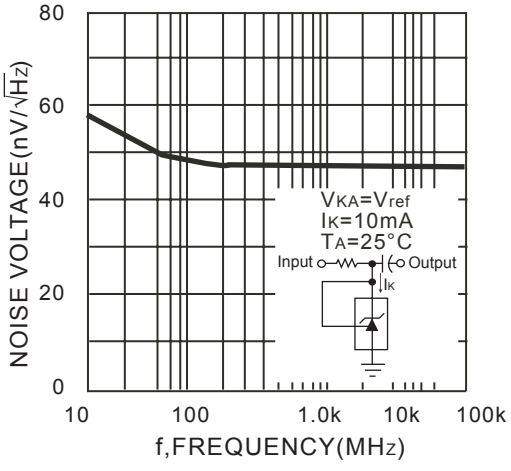


Figure 16. Spectral Noise Density

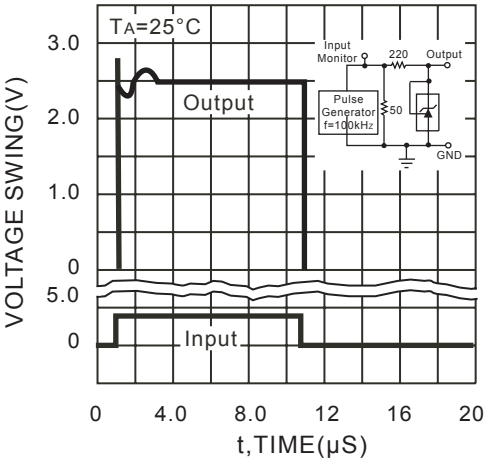


Figure 17. Pulse Response

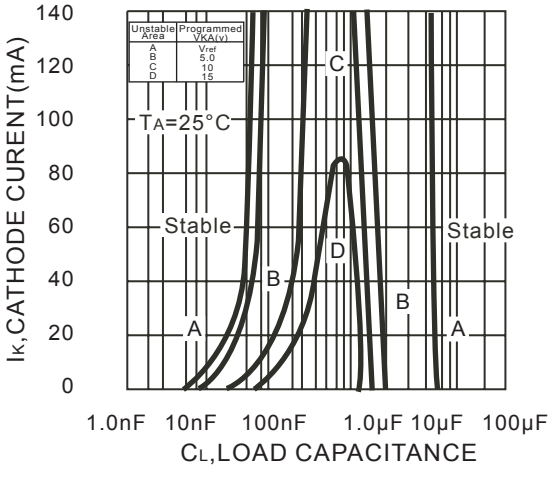


Figure 18. Stability Boundary conditions

TYPICAL PERFORMANCE CHARACTERISTICS(CONTINUED)

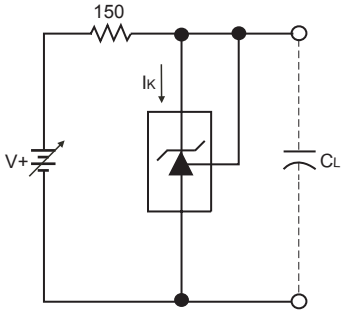


Figure 19. Test Circuit For Curve A of Stability Boundary Conditions

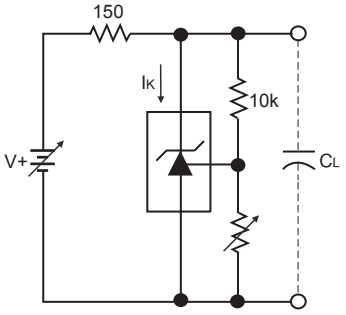
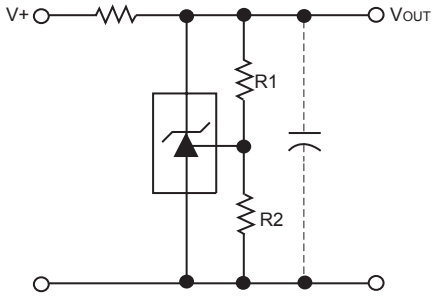


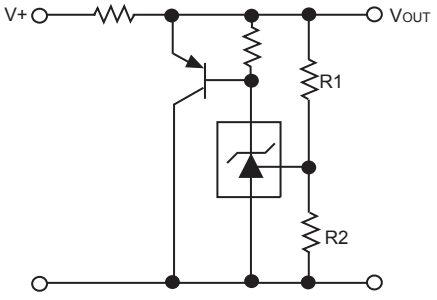
Figure 20. Test Circuit For Curves B, C, And D of Stability Boundary Conditions

TYPICAL APPLICATION CIRCUITS



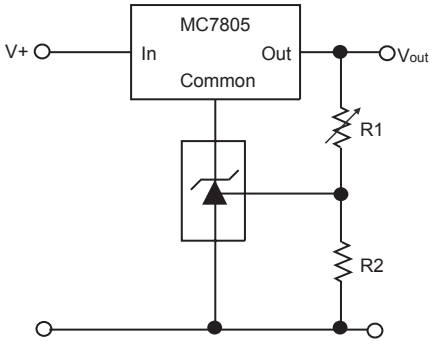
$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

Figure 21. Shunt Regulator



$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

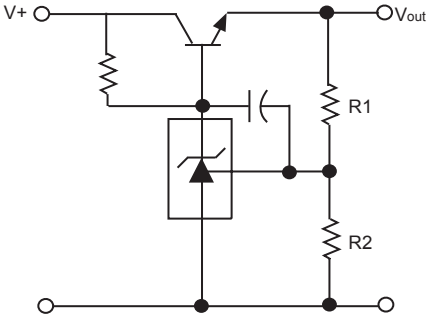
Figure 22. High Current Shunt Regulator



$$V_{out} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

$V_{out}(min) = V_{ref} + 5.0V$

Figure 23. Output Control for a Three−Terminal Fixed Regulator



$$V_{out} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

$V_{in}(min) = V_{out} + V_{be}$

$V_{out}(min) = V_{ref}$

Figure 24. Series Pass Regulator

TYPICAL APPLICATION CIRCUITS(CONTINUED)

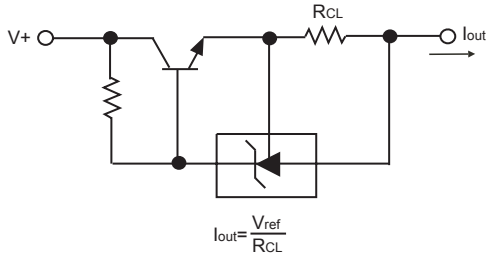


Figure 25. Constant Current Source

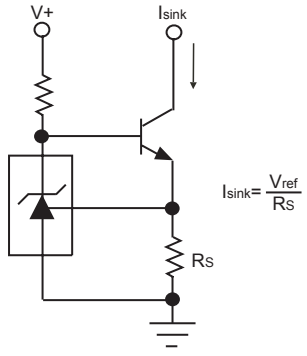


Figure 26. Constant Current Sink

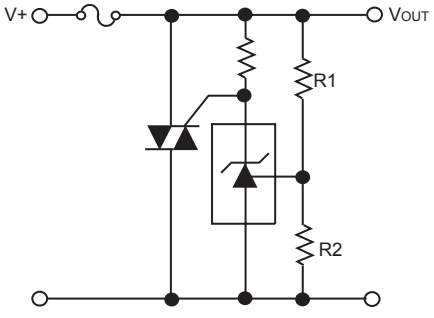


Figure 27. TRIAC Crowbar

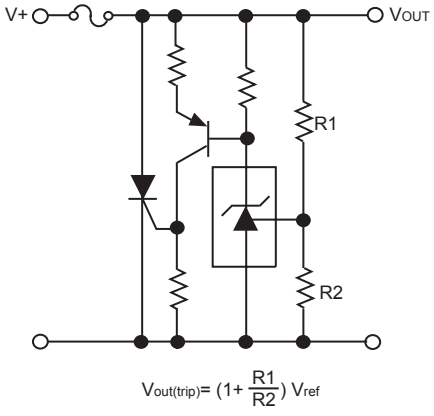


Figure 28. SRC Crowbar

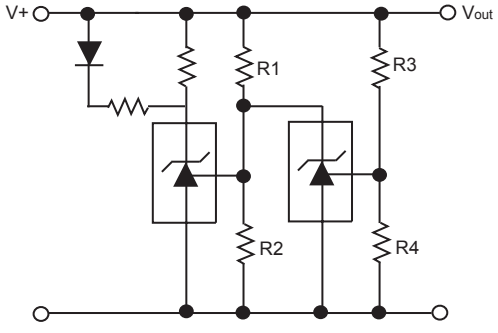
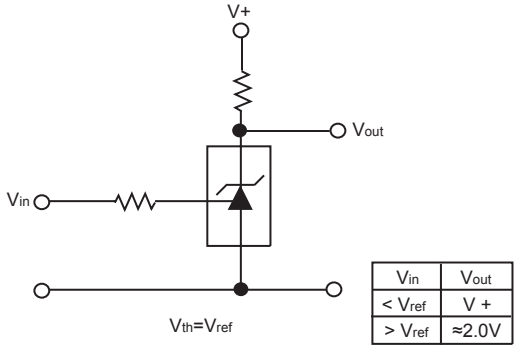


Figure 29. Voltage Monitor



Vin	Vout
< Vref	V +
> Vref	≈2.0V

Figure 30. Single−Supply Comparator with Temperature−Compensated Threshold

TYPICAL APPLICATION CIRCUITS(CONTINUED)

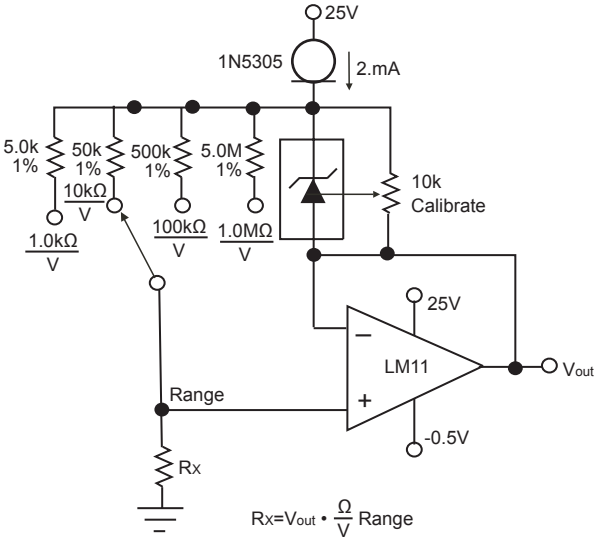


Figure 31. Linear Ohmmeter

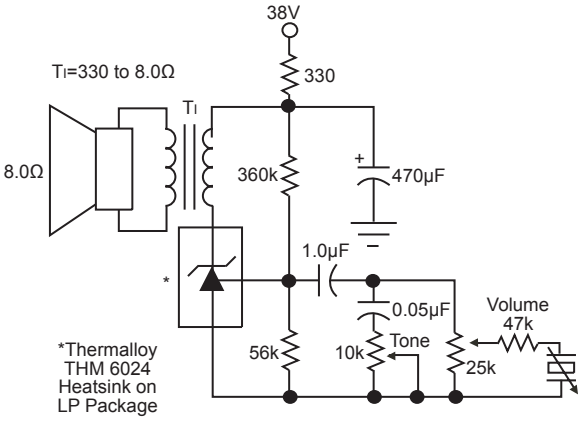


Figure 32. Simple 400 mW Phono Amplifier

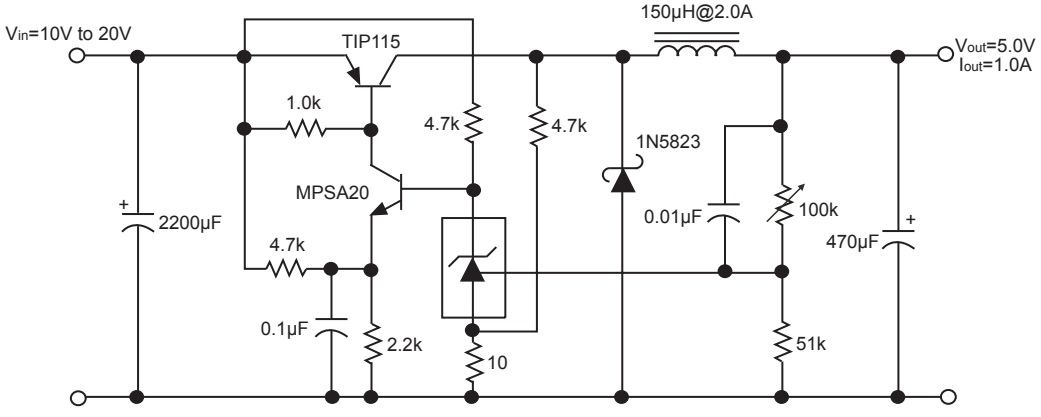
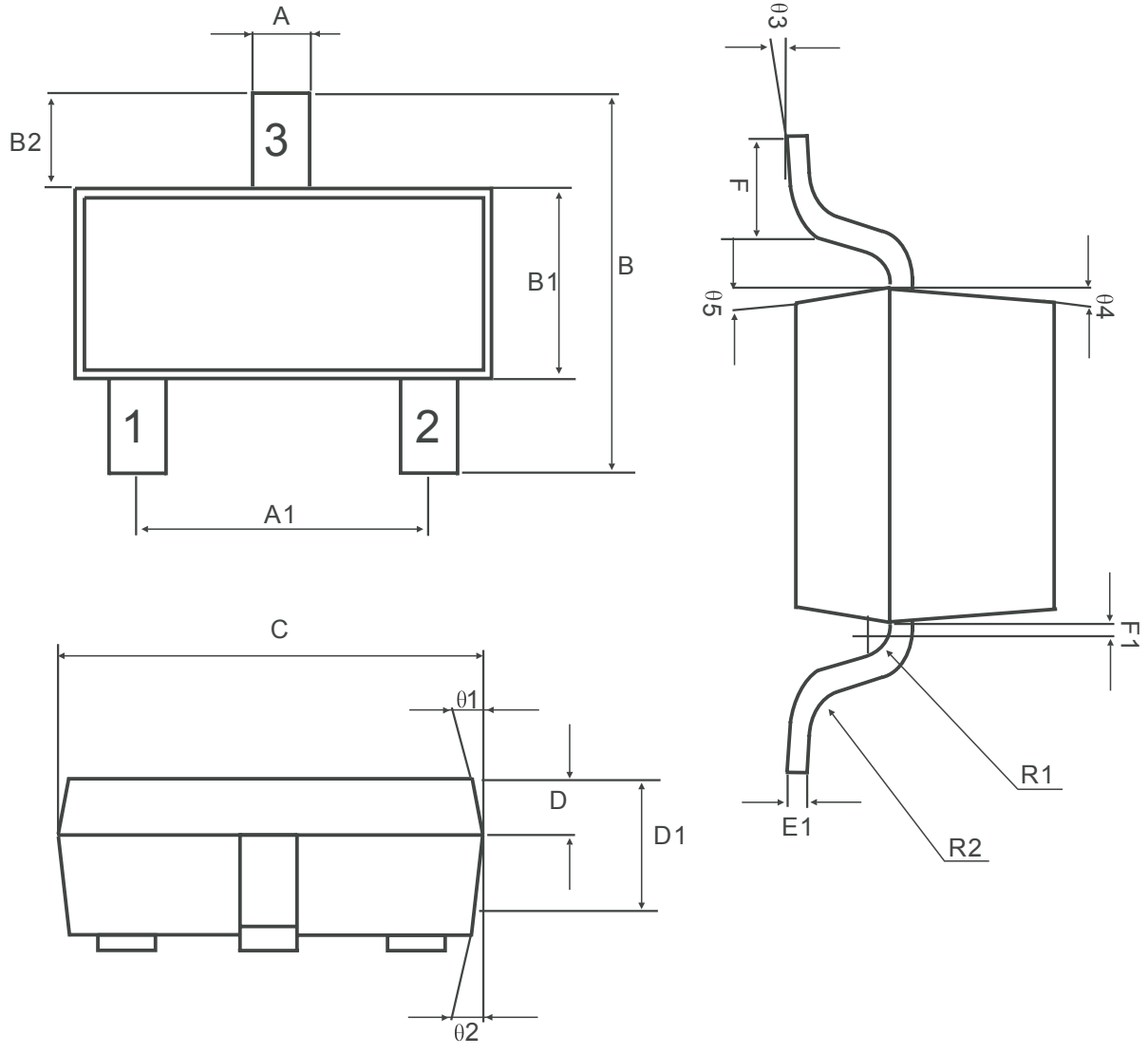


Figure 33. High Efficiency Step−Down Switching Converter

Parameter	Test Conditions	Results
Line Regulation	V_{in}=10V to 20V, I_O=1.0A	53mV (1.1%)
Load Regulation	V_{in}=15V, I_O=0 to 1.0A	25mV (0.5%)
Output Ripple	V_{in}=10V, I_O=1.0A	50mV_{pp} P.A.R.D.
Output Ripple	V_{in}=20V, I_O=1.0A	100mV_{pp} P.A.R.D.
Efficiency	V_{in}=15V, I_O=1.0A	82%

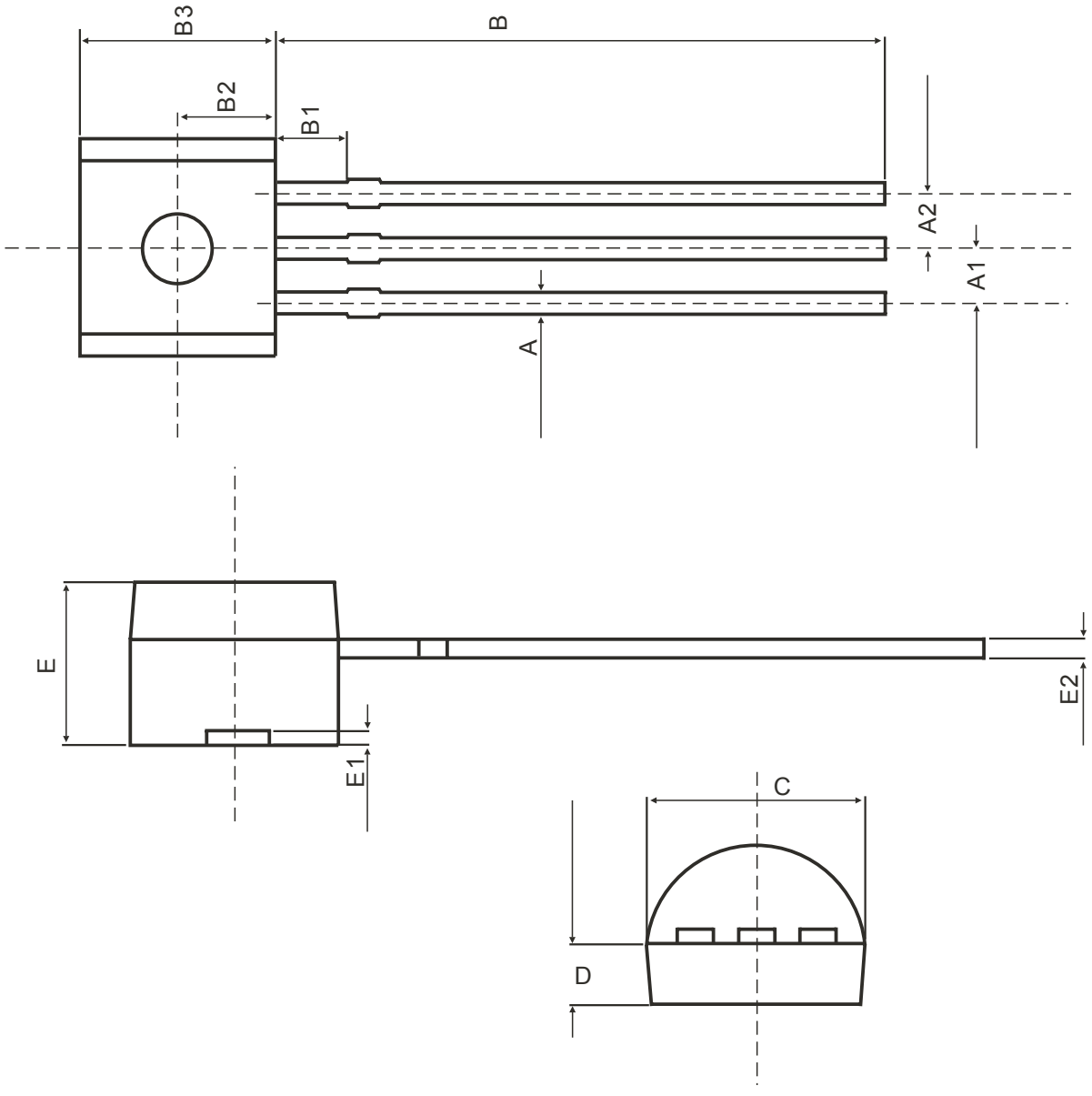
PHYSICAL DIMENSIONS

SOT-23



Symbol	Dimension(mm)		Symbol	Dimension(mm)	
	Min	Max		Min	Max
A	0.37	0.43	F	0.20	-
A1	1.85	1.95	F1	0.06	0.10
B	2.35	2.45	R1	0.08(TYP)	
B1	1.25	1.35	R2	0.08(TYP)	
B2	0.50	0.60	θ1	2X5º(TYP)	
C	2.85	2.95	θ2	2X5º(TYP)	
D	0.35	0.40	θ3	0º	5º
D1	0.95	1.00	θ4	2X7º(TYP)	
E1	0.09	0.15	θ5	2X7º(TYP)	

TO-92



Symbol	Dimension(mm)		Symbol	Dimension(mm)	
	Min	Max		Min	Max
A	2.55(TYP)		C	4.59	4.61
A1	1.25	1.30	D	1.27	1.28
A2	1.25	1.30	E	3.59	3.61
B	12.7	-	E1	0.25(TYP)	
B1	1.54(TYP)		E2	0.45(TYP)	
B2	2.29(TYP)				
B3	4.69	4.71			