



### PROGRAMMABLE PRECISION REFERENCES

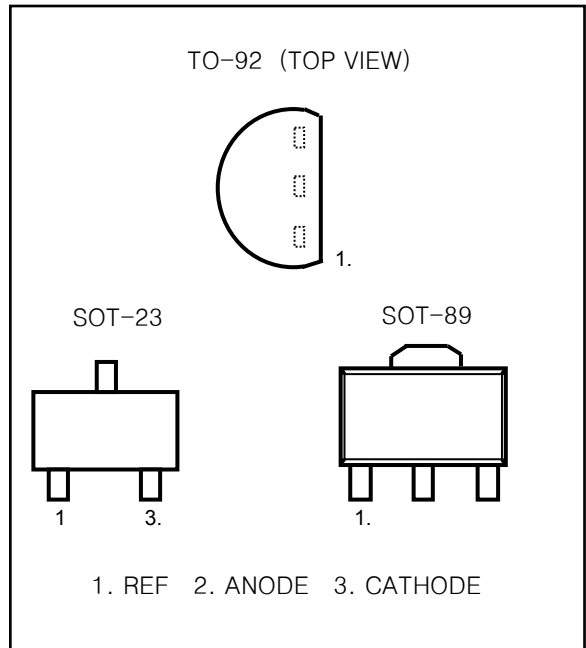
The TL431 is three-terminal adjustable shunt regulator with specified thermal stability.

The output voltage may be set to any value between  $V_{REF}$  (Approx. 2.5V) and 36V with two external resistors. This device has a typical output impedance of  $0.2\Omega$ .

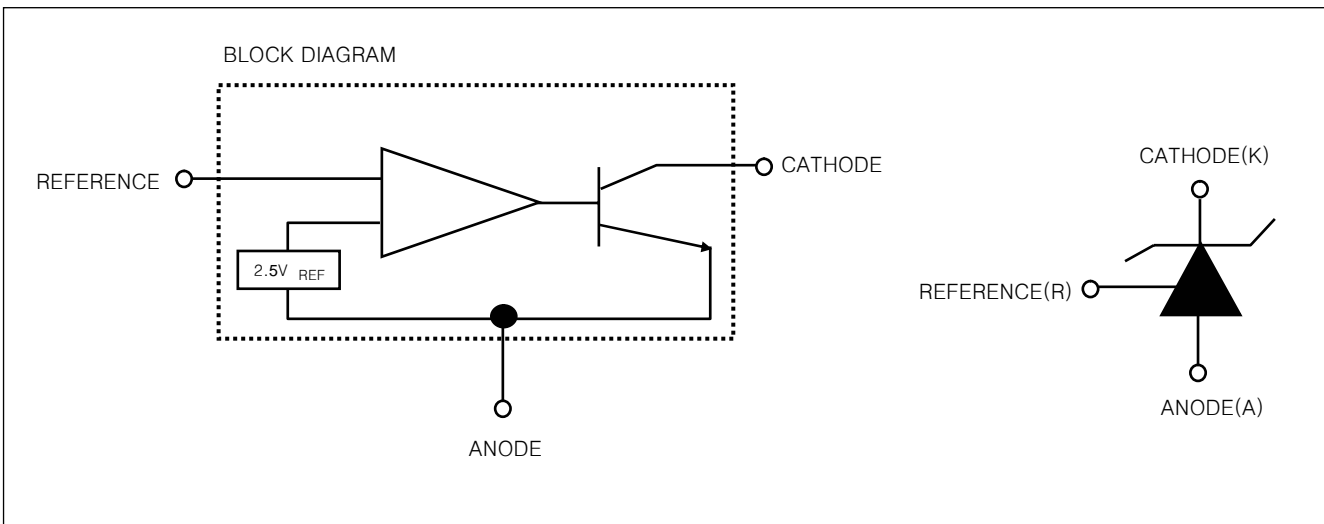
Active output circuitry provides a very sharp turn-on characteristic, making this device excellent replacement for zener diodes in many application.

### FEATURES

- Equivalent Full Range Temperature Coefficient 50PPM/°C
- Temperature Compensated For Operation Over Full Rate Operating Temperature Range
- Adjustable Output Voltage
- Fast Turn-on Response
- Sink Current Capability 1mA to 100mA
- Low ( $0.2\Omega$  Typ.) Dynamic Output Impedance
- Low Output Noise



### FUNCTION BLOCK DIAGRAM





**ABSOLUTE MAXIMUM RATINGS**

(Full Operating Ambient Temperature Range Applies Unless Otherwise Noted)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Cathode Voltage	$V_{KA}$	37	V
Continuous Cathode Current Range	$I_{KA}$	-100~+150	mA
Reference Input Current Range	$I_{REF}$	0.05~10	mA
Junction Temperature	$T_J$	150	°C
Operating Temperature	$T_{OPR}$	-20 ~ 85	°C
Storage Temperature	$T_{STG}$	-65 ~ 150	°C
Total Power Dissipation	$P_D$	700	mW

**TL431-0.3% ELECTRICAL CHARACTERISTIC** ( $T_A=25^\circ\text{C}$ , unless otherwise specified)

CHARACTERISTIC	SYMBOL	CIR-CUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Reference Input Voltage	$V_{REF}$	1	$V_{KA}=V_{REF}, I_K=10\text{mA}$	2.487V	2.495V	2.502V	
Deviation of Reference Input Voltage Over Full Temperature Range	$\Delta V_{REF}/\Delta T$	1	$V_{KA}=V_{REF}, I_K=10\text{mA}$ $T_A=\text{Full Range}$		3	17	mV
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	$\Delta V_{REF}/\Delta V_{KA}$	2	$I_K=10\text{mA}$ $\Delta V_{KA}=10\text{V}-V_{REF}$ $\Delta V_{KA}=36\text{V}-10\text{V}$		-1.4 -1	-2.7 -2	mV/V
Reference Input Current	$I_{REF}$	2	$I_{KA}=10\text{mA}, R1=10\text{k}\Omega, R2=\infty$		1.8	4	$\mu\text{A}$
Deviation of Reference Input Current Over Full Temperature Range	$\Delta I_{REF}/\Delta T$	2	$I_K=10\text{mA}, R1=10\text{k}\Omega, R2=\infty$ $T_A=\text{Full Range}$		0.4	1.2	$\mu\text{A}$
Minimum Cathode Current for Regulation	$I_{KA\text{MIN}}$	1	$\Delta V_{KA}=V_{REF}$		0.5	1	mA
Off-State Cathode Current	$I_{KA\text{OFF}}$	3	$V_{KA}=36\text{V}, V_{REF}=0$		0.2	1	$\mu\text{A}$
Dynamic Impedance	$Z_{KA}$	1	$V_{KA}=V_{REF}, I_K=1\text{mA}\sim 100\text{mA},$ $f\leq 1\text{kHz}$		0.2	0.5	$\Omega$



**TL431-0.5% ELECTRICAL CHARACTERISTIC** ( $T_A=25^{\circ}\text{C}$ , unless otherwise specified)

CHARACTERISTIC	SYMBOL	CIR-CUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Reference Input Voltage	$V_{REF}$	1	$V_{KA}=V_{REF}, I_K=10\text{mA}$	2.482V	2.495V	2.507V	
Deviation of Reference Input Voltage Over Full Temperature Range	$\Delta V_{REF}/\Delta T$	1	$V_{KA}=V_{REF}, I_K=10\text{mA}$ $T_A=\text{Full Range}$		3	17	mV
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	$\Delta V_{REF}/\Delta V_{KA}$	2	$I_K=10\text{mA}$	$\Delta V_{KA}=10\text{V}-V_{REF}$	-1.4	-2.7	mV/V
				$\Delta V_{KA}=36\text{V}-10\text{V}$	-1	-2	
Reference Input Current	$I_{REF}$	2	$I_{KA}=10\text{mA}, R1=10\text{k}\Omega, R2=\infty$		1.8	4	$\mu\text{A}$
Deviation of Reference Input Current Over Full Temperature Range	$\Delta I_{REF}/\Delta T$	2	$I_K=10\text{mA}, R1=10\text{k}\Omega, R2=\infty$ $T_A=\text{Full Range}$		0.4	1.2	$\mu\text{A}$
Minimum Cathode Current for Regulation	$I_{KA\text{MIN}}$	1	$\Delta V_{KA}=V_{REF}$		0.5	1	mA
Off-State Cathode Current	$I_{KA\text{OFF}}$	3	$V_{KA}=36\text{V}, V_{REF}=0$		0.2	1	$\mu\text{A}$
Dynamic Impedance	$Z_{KA}$	1	$V_{KA}=V_{REF}, I_K=1\text{mA}\sim 100\text{mA},$ $f\leq 1\text{kHz}$		0.2	0.5	$\Omega$

**TL431-1% ELECTRICAL CHARACTERISTIC** ( $T_A=25^{\circ}\text{C}$ , unless otherwise specified)

CHARACTERISTIC	SYMBOL	CIR-CUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Reference Input Voltage	$V_{REF}$	1	$V_{KA}=V_{REF}, I_K=10\text{mA}$	2.47V	2.495V	2.52V	
Deviation of Reference Input Voltage Over Full Temperature Range	$\Delta V_{REF}/\Delta T$	1	$V_{KA}=V_{REF}, I_K=10\text{mA}$ $T_A=\text{Full Range}$		3	17	mV
Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	$\Delta V_{REF}/\Delta V_{KA}$	2	$I_K=10\text{mA}$	$\Delta V_{KA}=10\text{V}-V_{REF}$	-1.4	-2.7	mV/V
				$\Delta V_{KA}=36\text{V}-10\text{V}$	-1	-2	
Reference Input Current	$I_{REF}$	2	$I_{KA}=10\text{mA}, R1=10\text{k}\Omega, R2=\infty$		1.8	4	$\mu\text{A}$
Deviation of Reference Input Current Over Full Temperature Range	$\Delta I_{REF}/\Delta T$	2	$I_K=10\text{mA}, R1=10\text{k}\Omega, R2=\infty$ $T_A=\text{Full Range}$		0.4	1.2	$\mu\text{A}$
Minimum Cathode Current for Regulation	$I_{KA\text{MIN}}$	1	$\Delta V_{KA}=V_{REF}$		0.5	1	mA
Off-State Cathode Current	$I_{KA\text{OFF}}$	3	$V_{KA}=36\text{V}, V_{REF}=0$		0.2	1	$\mu\text{A}$
Dynamic Impedance	$Z_{KA}$	1	$V_{KA}=V_{REF}, I_K=1\text{mA}\sim 100\text{mA},$ $f\leq 1\text{kHz}$		0.2	0.5	$\Omega$

Fig. 1 Test Circuit for  $V_{KA} = V_{REF}$

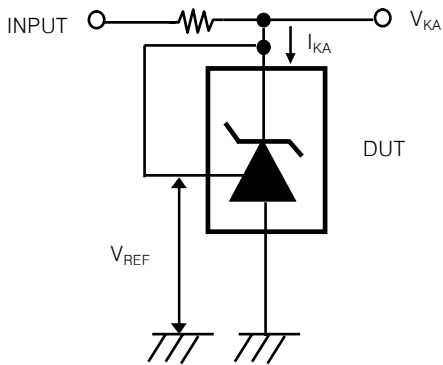


Fig. 2 Test Circuit for  $V_{KA} \geq V_{REF}$

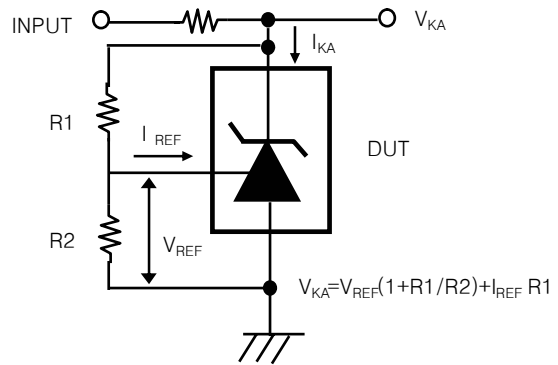
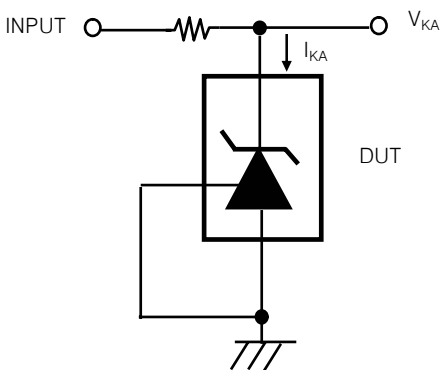
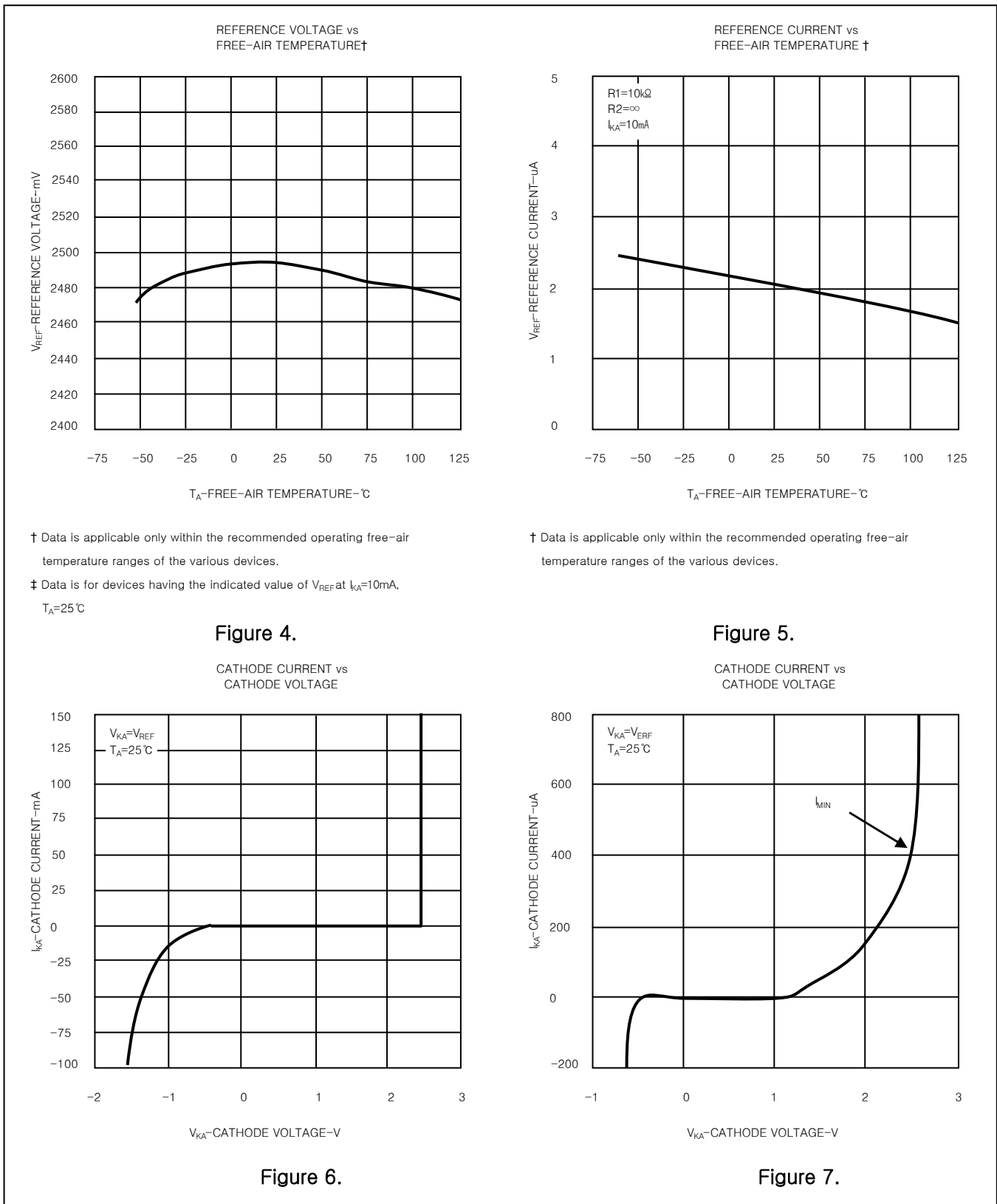


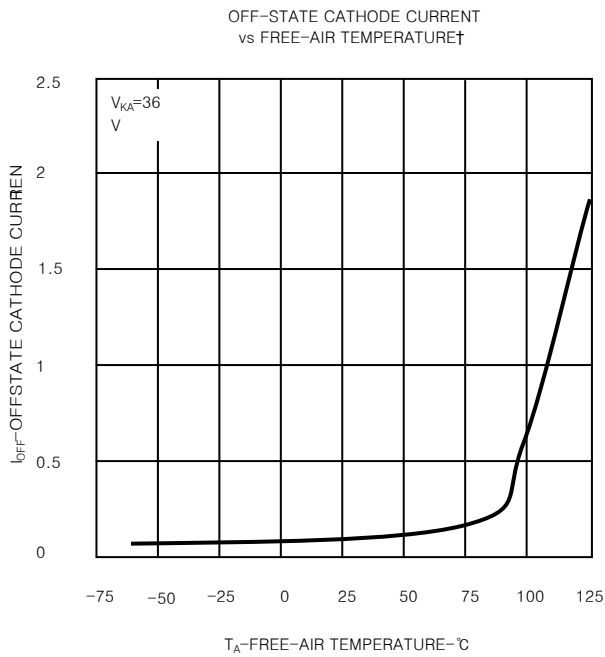
Fig. 3 Test Circuit for  $I_{KA}$  (off)



TYPICAL PERFORMANCE CHARACTERISTICS

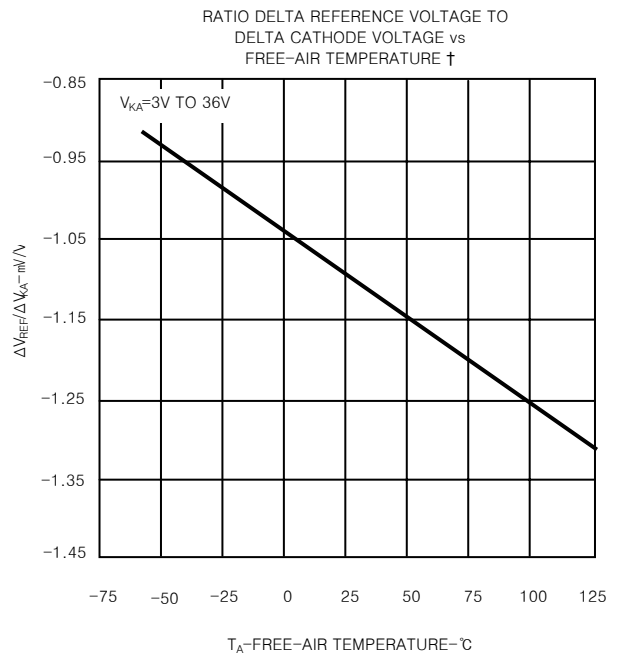


TYPICAL PERFORMANCE CHARACTERISTICS



† Data is applicable only within the recommended operating free-air temperature ranges of the various devices.

Figure 8.



† Data is applicable only within the recommended operating free-air temperature ranges of the various devices.

Figure 9.

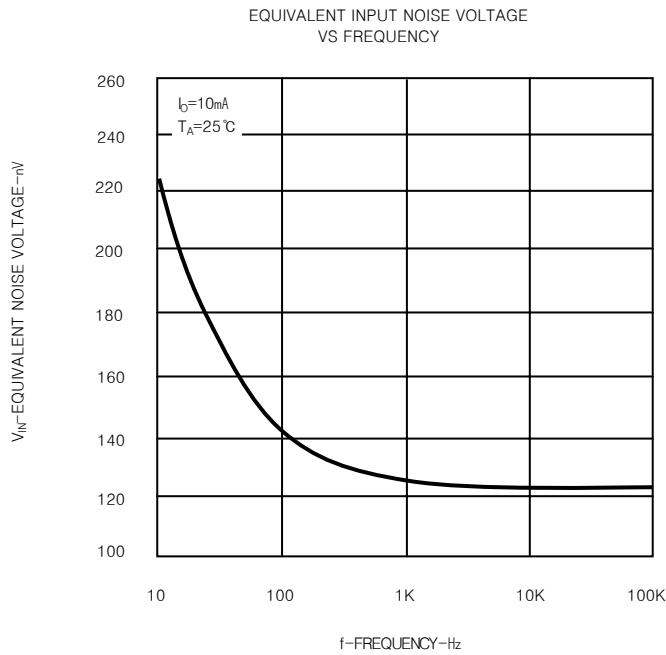


Figure 10.

TYPICAL PERFORMANCE CHARACTERISTICS

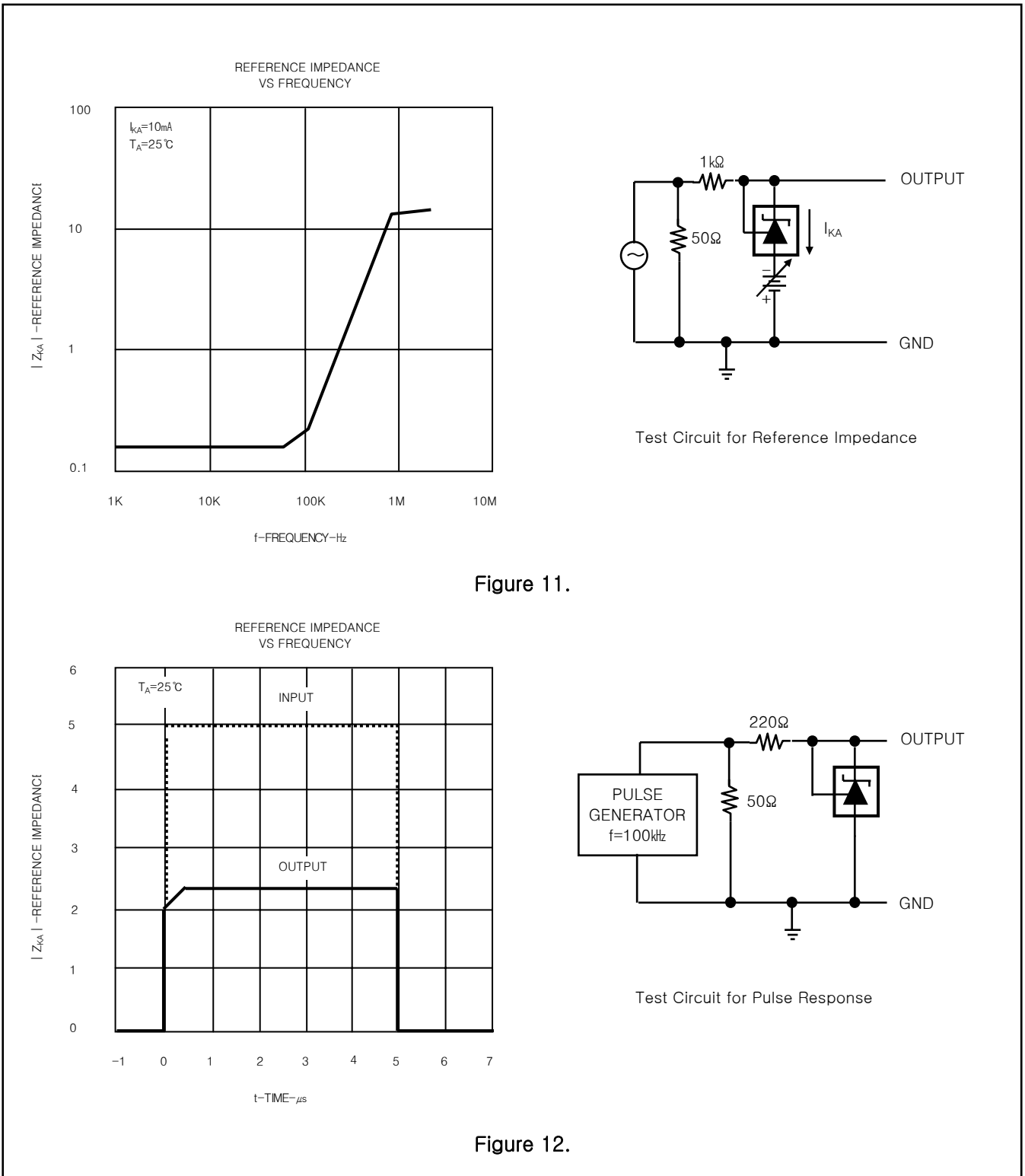
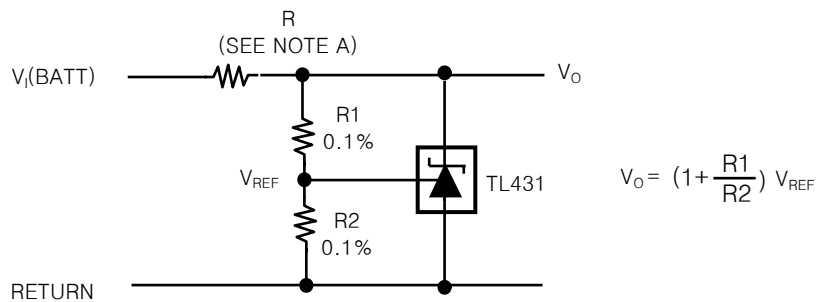


Figure 11.

Figure 12.

APPLICATION INFORMATION



NOTE A : R Should provide cathode current  $\geq 1\text{mA}$  to the TL431 at minimum  $V_{I}(\text{BATT})$

Figure 13. Shunt Regulator

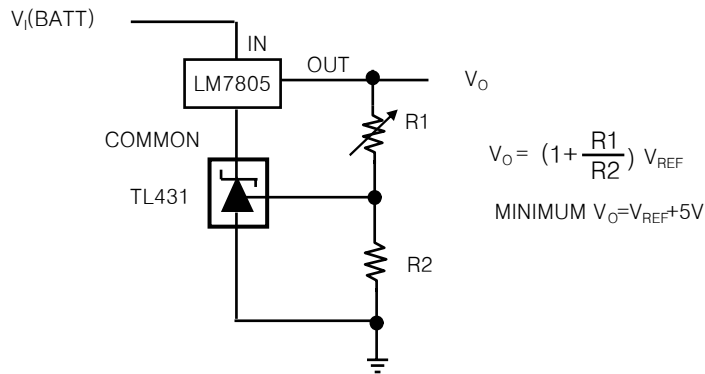


Figure 14. Output Control of a 3-Terminal Fixed Regulator

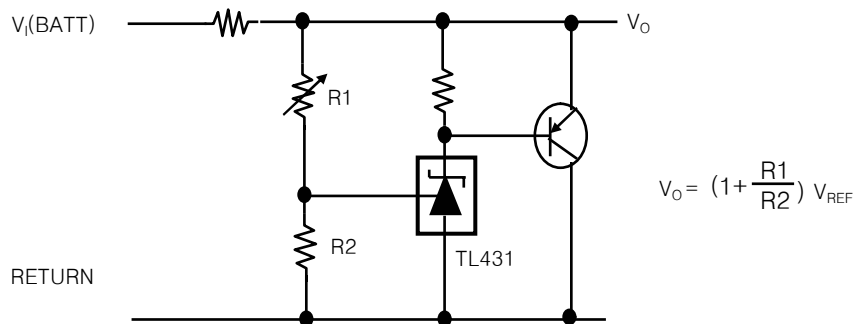


Figure 15. High-Current Shunt Regulator