GL431

2.5V ADJUSTABLE SHUNT REGULATOR

Description

The GL431 is a three terminal adjustable shunt regulator with thermal stability guaranteed over temperature. Output voltage can be adjusted to any value between 2.5V (V_{ref}) and 36V by using two external resistors. The GL431 has a typical dynamic output impedance of 0.2 ohm. Active output circuitry provides a very unique turn on characteristic, making the GL431 an excellent replacement for zener diodes in many applications such as on-board regulation and adjustable power supplies. The GL431 is an ideal voltage reference for 3.0 to 3.3V switching power supplies.

The GL431 shunt regulator is available with 3 voltage tolerances 0.5% and 1.0% over T_A=0°C to +70°C , and four package options (SOT-23 and TO-92) .Whatever your application is , the GL431 offers the optimum combination of performance, reliability, and economy.

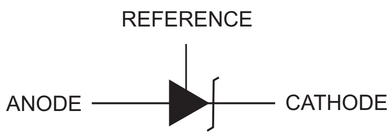
Features

- Sink Current Capability 1 mA to 100mA
- Low dynamic output impedance , 0.2 ohm typ.
- Low output noise
- 0.5% or 1% reference voltage tolerance
- Alternate for TL431, TL431, LM431 & AS431
- Temperature range 0°C to +70°C
- Available in SOT-23 and TO-92 packages

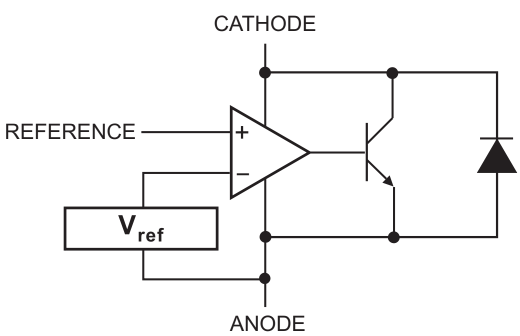
Application

Switching power supplies
Linear regulators
Adjustable supplies
Battery-operated computers
Computer disk drives
Instrumentation

LOGIC SYMBOL

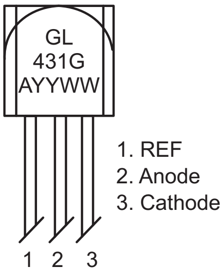


BLOCK DIAGRAM (POSITIVE LOGIC)

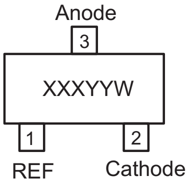


MARKING INFORMATION & PIN CONFIGURATIONS (TOP VIEW)

TO- 92



SOT-23



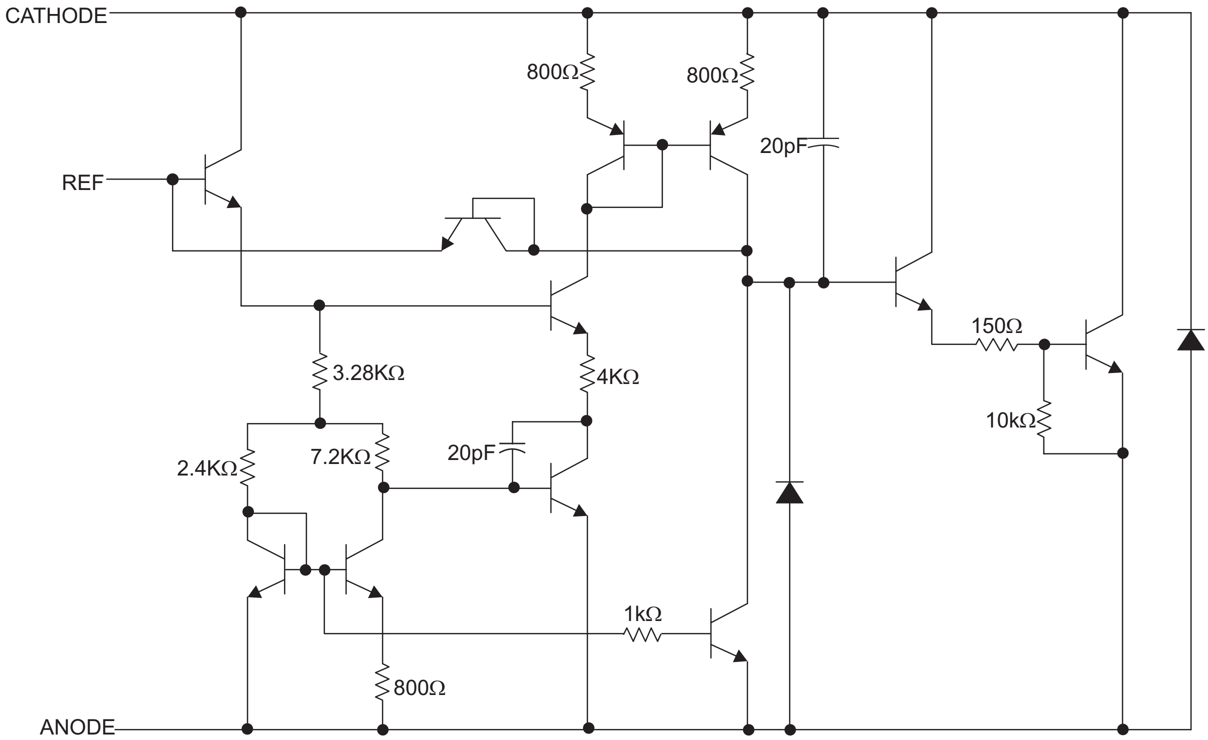
XXX = Marking Code
G** = Grade
A = Assembly Location
YY = Year
WW, W = Weekly

ORDERING INFORMATION (Green Package Products are available now!)

Ordering Number	Precision	Device code	Grade	Package	Shipping
GL431AT92B	0.5%		A	TO-92	1,000 Units/ ESD Bag
GL431AT92RL	0.5%		A	TO-92	2,000 Units/ Ammo Pack(Tape)
GL431AST23R	0.5%	AAA		SOT-23	3,000 Units/ Tape &Reel
GL431BT92B	1%		B	TO-92	1,000 Units/ ESD Bag
GL431BT92RL	1%		B	TO-92	2,000 Units/ Ammo Pack(Tape)
GL431BST23R	1%	AAB		SOT-23	3,000 Units/ Tape &Reel

* For detail ordering number identification, please see last page.
** Grade A: indicates Precision of 0.5%, B: indicates Precision of 1%

◆ EQUIVALENT SCHEMATIC



* All component values are nominal.
Pin numbers shown are for the D package.

◆ ABSOLUTE MAXIMUM RATINGS (over free-air temperature range except as noted)

PARAMETER	SYMBOL	Value	UNIT
Cathode Voltage [1]	V_{KA}	37	V
Continuous cathode current range	I_K	-100 to 150	mA
Reference input current range	I_{ref}	-50 µA to 10mA	mA
Power dissipation at T_A=25°C SOT-23 TO-92	P_D	 0.23 0.78	W
Package thermal impedance [2, 3] SOT-23 TO-92	θ_{JA}	 336 132	°C/W
Operating ambient temperature range	T_A	0 to + 70	°C
Lead temperature (soldering) 10 seconds	T_{LEAD}	260	°C

These are stress ratings only. Functional operation of the device at these or any conditions beyond the "recommended operating conditions" is not implied. Exposure to absolute maximum rated conditions may affect device reliability.

NOTES:
1. Voltage values are with respect to the anode except as noted.
2. Maximum power dissipation is a function of $T_{J(max)}$, θ_{JA} and T_A. Maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_{J(max)} - T_A)/ \theta_{JA}$.
3. Package thermal impedance is calculated per JESD 51.

◆ RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	MINIMUM	MAXIMUM	UNIT
Cathode Voltage	V_{KA}	V_{ref}	36	V
Cathode Current	I_K	1.0	100	mA

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

GL431A (0.5%)

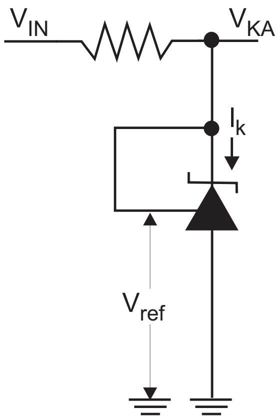
PARAMETER		CONDITION			MIN	TYP	MAX	UNIT
Reference Voltage	V_{ref}	$V_{KA}=V_{ref}$, I_K = 10 mA, T_A= 25°C (1) $V_{KA}=V_{ref}$, I_K = 10 mA, T_A= 0 to 70°C(1)			2.487	2.500	2.512	V
V_{ref} temp deviation	V_{dev}	$V_{KA}=V_{ref}$, I_K = 10 mA (1), T_A = full range				4	17	mV
Ratio of change in V_{ref} to change in V_{KA}	$\frac{\Delta V_{ref}}{\Delta V_{KA}}$	I_K = 10mA	ΔV_{KA} = 10V to V_{ref}		-2.7	-1.0		mV/V
			ΔV_{KA} = 36V to 10V		-2.0	-0.4		
Reference input current	I_{ref}	I_K= 10mA, R1 = 10KΩ, R2 =∞ (2)				0.7	4.0	μA
Deviation of reference input current over full temperature range	$I_{ref(dev)}$	I_K = 10mA, R1 = 10KΩ, R2 =∞ (2) **T_A = full range**				0.4	1.2	μA
Minimum operating current	$I_{K(min)}$	$V_{KA}=V_{ref}$ (1)				0.4	1.0	mA
Off-state cathode current	$I_{K(off)}$	V_{KA}= 36V, V_{ref} = 0V (3) V_{KA} = 16V, V_{ref} = 0V (3)				0.1	1	μA
Dynamic impedance	$\lvert Z_{KA}\rvert$	f≤1kHz,$V_{KA}=V_{ref}$, I_K=1mA to 100mA (1)				0.2	0.50	Ω

GL431B (1.0%)

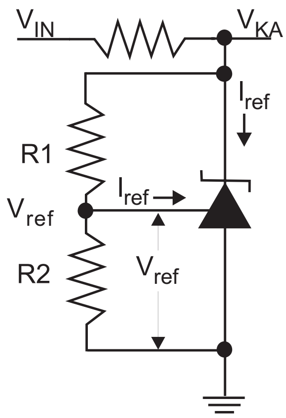
PARAMETER		CONDITION			MIN	TYP	MAX	UNIT
Reference Voltage	V_{ref}	$V_{KA}=V_{ref}$, I_K = 10 mA, T_A= 25°C (1) $V_{KA}=V_{ref}$, I_K = 10 mA, T_A= 0 to 70°C(1)			2.475	2.500	2.525	V
V_{ref} temp deviation	V_{dev}	$V_{KA}=V_{ref}$, I_K = 10 mA (1), T_A = full range				4	17	mV
Ratio of change in V_{ref} to change in V_{KA}	$\frac{\Delta V_{ref}}{\Delta V_{KA}}$	I_K = 10mA	ΔV_{KA} = 10V to V_{ref}		-2.7	-1.0		mV/V
			ΔV_{KA} = 36V to 10V		-2.0	-0.4		
Reference input current	I_{ref}	I_K= 10mA, R1 = 10KΩ, R2 =∞ (2)				0.7	4.0	μA
Deviation of reference input current over full temperature range	$I_{ref(dev)}$	I_K = 10mA, R1 = 10KΩ, R2 =∞ (2) **T_A = full range**				0.4	1.2	μA
Minimum operating current	$I_{K(min)}$	$V_{KA}=V_{ref}$ (1)				0.4	1.0	mA
Off-state cathode current	$I_{K(off)}$	V_{KA}= 36V, V_{ref} = 0V (3) V_{KA} = 16V, V_{ref} = 0V (3)				0.1	1	μA
Dynamic impedance	$\lvert Z_{KA}\rvert$	f≤1kHz,$V_{KA}=V_{ref}$, I_K=1mA to 100mA (1)				0.2	0.50	Ω

NOTES:
(1) See test circuit 1 on page 6.
(2) See test circuit 2 on page 6.
(3) See test circuit 3 on page 6.

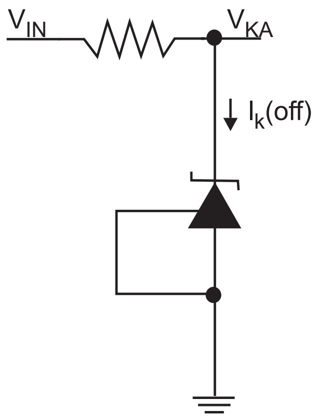
◆ TEST CIRCUITS



Test Circuit 1
$V_{KA} = V_{ref}$

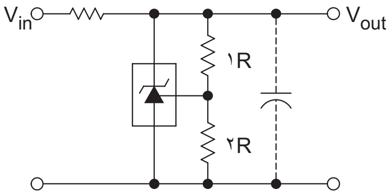


Test Circuit 2
$V_{KA} > V_{ref}$



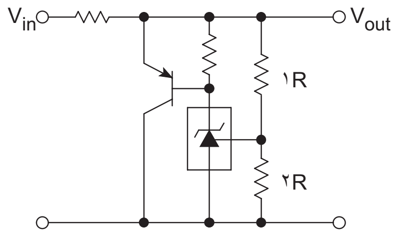
Test Circuit 3
Off-State

◆ TYPICAL APPLICATIONS
GL431A, GL431B



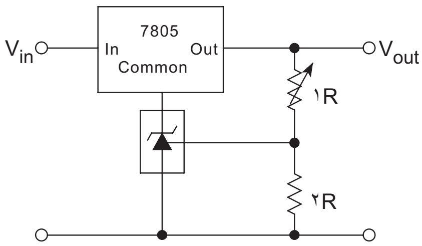
$V_{out}=(١+\frac{١R}{٢R})V_{ref}$

Figure 1. Shunt Regulator



$V_{out}=(١+\frac{١R}{٢R})V_{ref}$

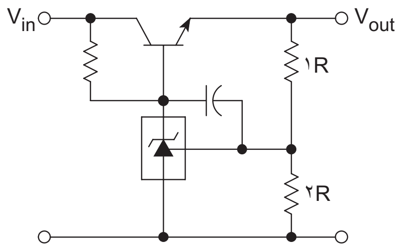
Figure 2. High Current Shunt Regulator



$V_{out}=(١+\frac{١R}{٢R})V_{ref}$

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

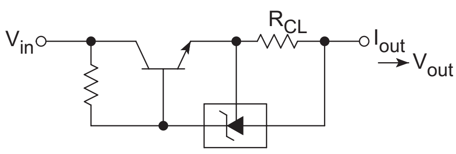
Figure 3. Output Control for a Three Terminal Fixed Regulator



$V_{out}=(١+\frac{١R}{٢R})V_{ref}$

$V_{out(min)} = V_{ref} + V_{be} \approx 2.0V$

Figure 4. Series Pass Regulator



$I_{out}=\frac{V_{ref}}{R_{CL}}$

Figure 5. Constant Current Source

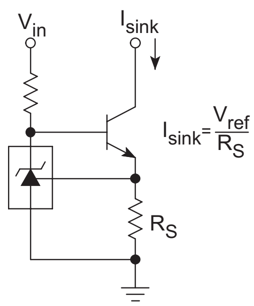
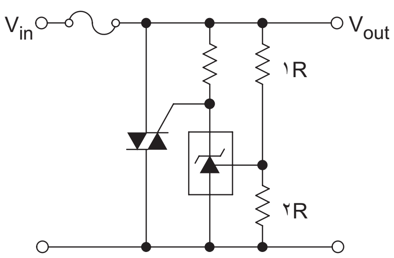
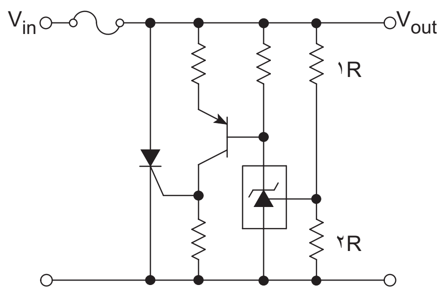


Figure 6. Constant Current Sink



$V_{out(trip)}=(١+\frac{١R}{٢R})V_{ref}$

Figure 7. TRIAC Crowbar



$V_{out(trip)}=(١+\frac{١R}{٢R})V_{ref}$

Figure 8. SCR Crowbar

◆ Typical Performance Characteristics

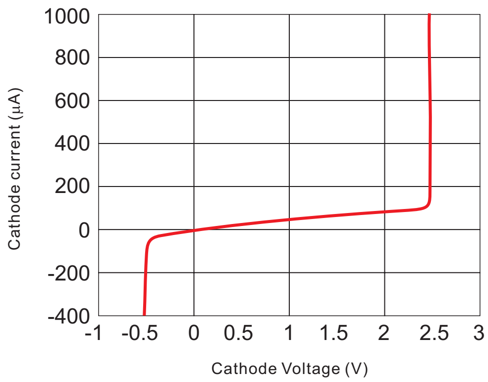


Figure 9. Cathode Current vs. Cathode Voltage

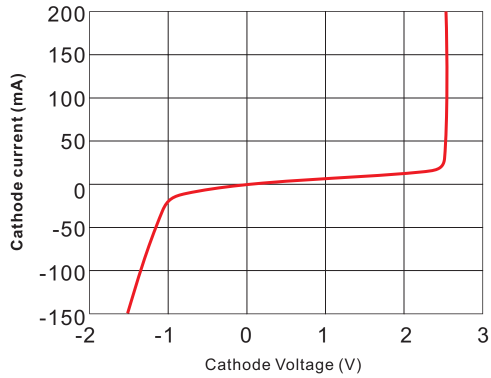


Figure 10. Cathode Current vs. Cathode Voltage

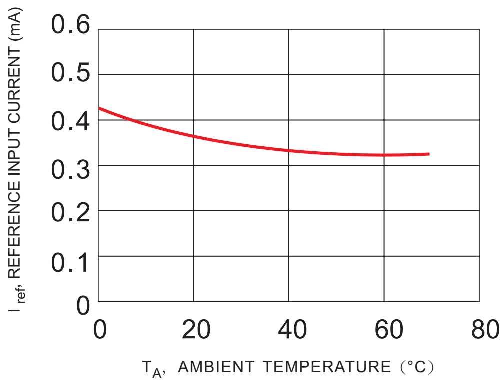


Figure 11. Reference Input Current versus Ambient Temperature

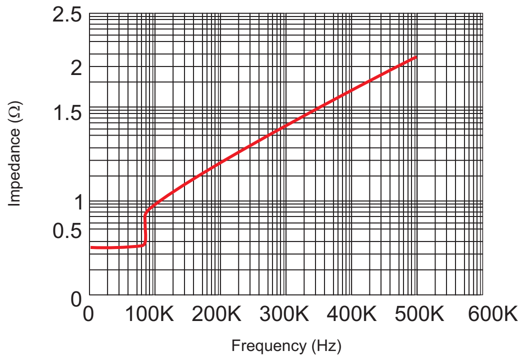


Figure 12. Dynamic Impedance Frequency

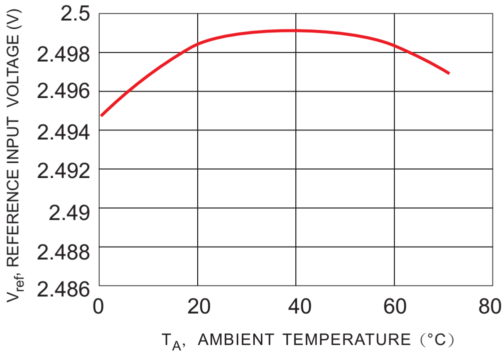


Figure 13. Reference Input Voltage versus Ambient Temperature

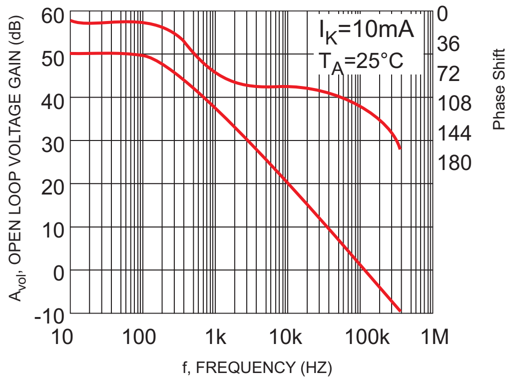


Figure 14. Open-Loop Voltage Gain vs. Frequency

Design Guide for AC-DCSMPS (Switching Mode Power Supply)

Use of Shunt Regulator in Transformer Secondary side Control

This example is applicable to both forward transformers and flyback transformers. A shunt regulator is used on the secondary side as an error amplifier, and feedback to the primary side is provided via a photocoupler.

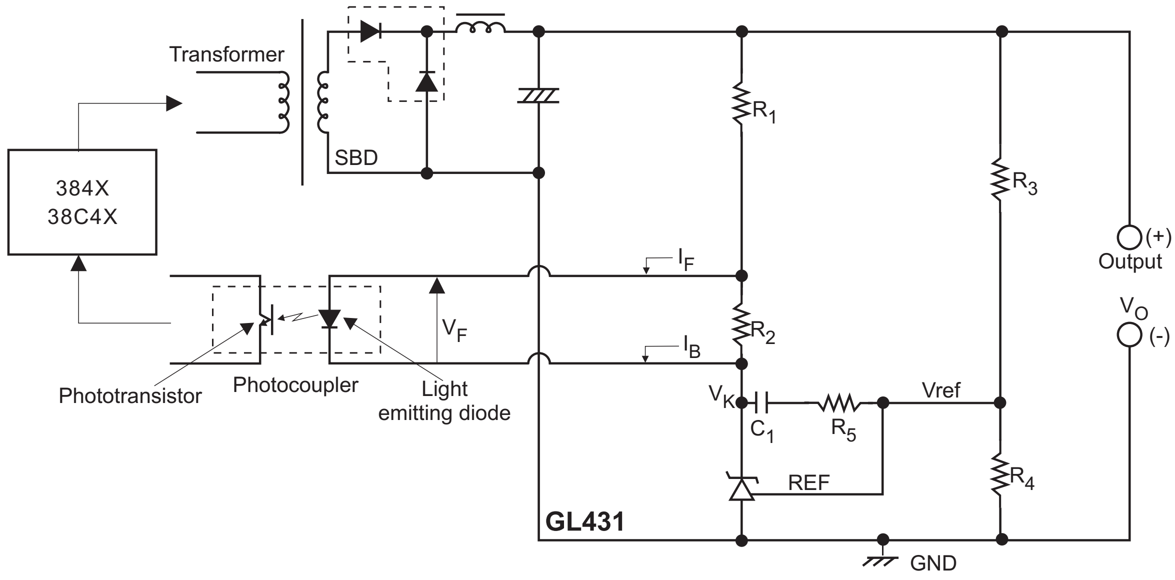


Figure 16. Typical Shunt Regulator/ Error Amplifier

Determination of External Costants for the Shunt Regulator

Dc characteristic determination:

In figure 16, R_1 and R_2 are protection resistor for the light emitting diode in the photocoupler, and R_2 is a bypass resistor to feed I_K Minimum, and these are determined as shown below. The photocoupler specification should be obtained separately from the manufacturer. Using the parameters in figure 16, the following formulas are obtained:

$$R1 = \frac{V_O - V_F - V_K}{I_F + I_B},\ R2 = \frac{V_F}{I_B}$$

V_K Is the GL431 operating voltage, and is set at around 3V, taking into account a margin for fluctuation. R_2 is the current shunt resistance for the light emitting diode, in which a bias current I_B of around 1/5 I_F flows.

Next, the output voltage can be determined by R_3 and R_4, and the following formula is obtained:

$$V_O = \frac{R3 + R4}{R4} \text{ X } V_{ref},\ V_{erf} = 2.5V \text{ Typ}$$

The absolute values of R3 and R4 are determined by the GL431 reference input current I_{ref} and the AC characteristics described in the next section. The I_{ref} value is around 0.7A Typ.

AC Characteristic Determination:

This refers to the determination of the gain frequency characteristic of the shunt regulator as an error amplifier. Taking the configuration in figure 16, the error amplifier characteristic is as shown in figure 17.

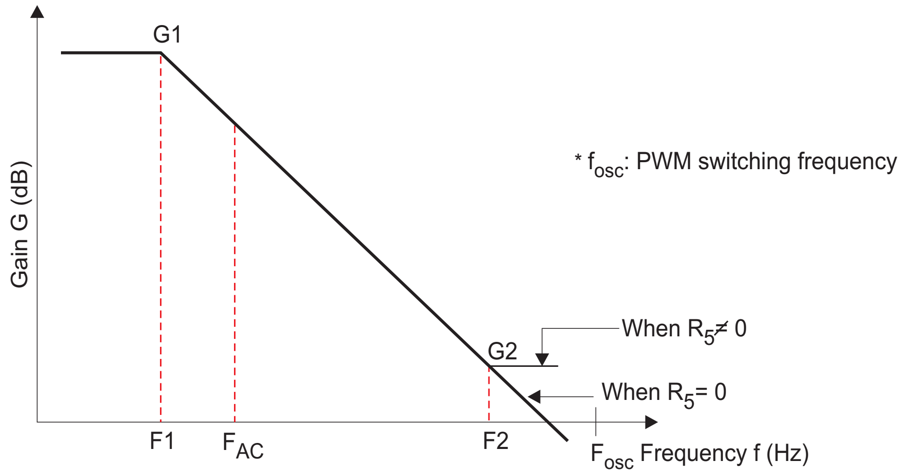


Figure 17. GL431 Error Amplification Characteristic

In Figure 17, the following formulas are obtained:

Gain

$$G_1 = G_0 \approx 50 \text{ dB to } 60 \text{ dB (determined by shunt regulator)}$$

$$G_2 = \frac{R_5}{R_3}$$

Corner frequencies

$f_1 = 1/(2\pi\ C_1\ G_0\ R_3)$

$f_2 = 1/(2\pi\ C_1\ R_5)$

G_0 is the shunt regulator open-loop gain; this is given by the reciprocal of the reference voltage fluctuation $\Delta Vref/\Delta V_{KA}$, and is approximately 50 dB.

Practical Example

Consider the example of a photocoupler, with an internal light emitting diode V_F == 1.05 V and I_F = 2.5 mA, power supply output voltage V_2 = 5 V, and bias resistance R_2 current of approximately 1/5 I_F at 0.5 mA. If the shunt regulator V_K = 3 V, the following values are found.

$$R_1 = \frac{5V - 1.05V - 3V}{2.5mA + 0.5mA} = 316\Omega$$

$$R_2 = \frac{1.05V}{0.5mA} = 2.1\ k\Omega$$

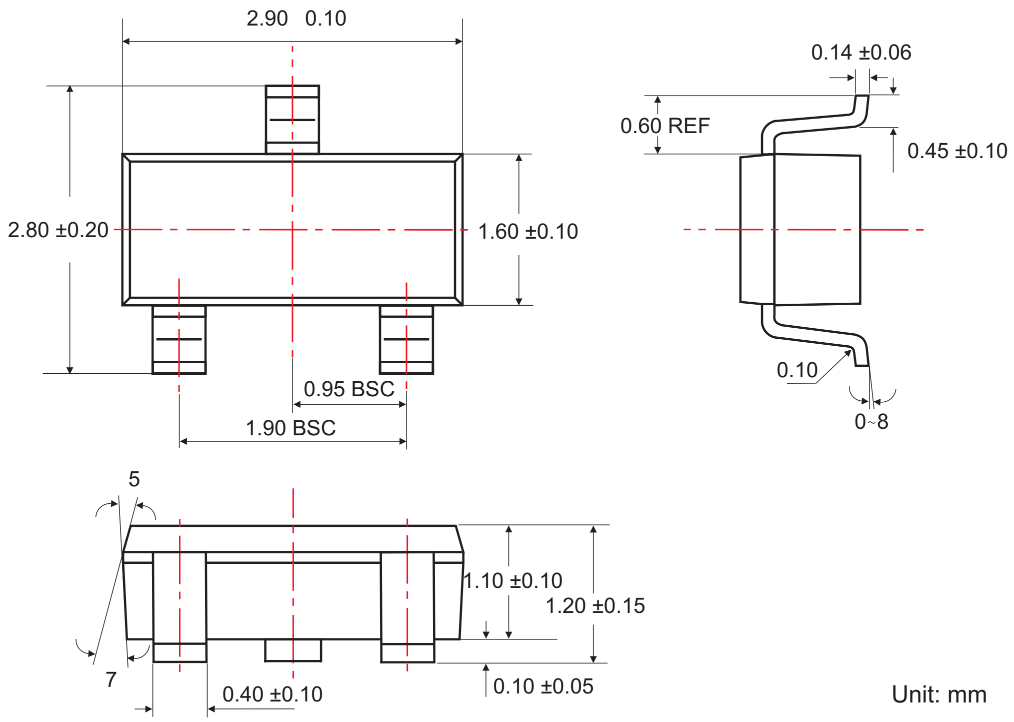
Next, assume that R_3 = R_4 = 10 kΩ. This gives a 5 V output. If R_5 = 3.3 kΩ and C_1 = 0.022 μF, the following values are found.

G_2 = 3.3 kΩ / 10 kΩ = 0.33 times (–10 dB)

f_1 = 1 / (2 x π x 0.022 μF x 316 x 10 kΩ) = 2.3 (Hz)

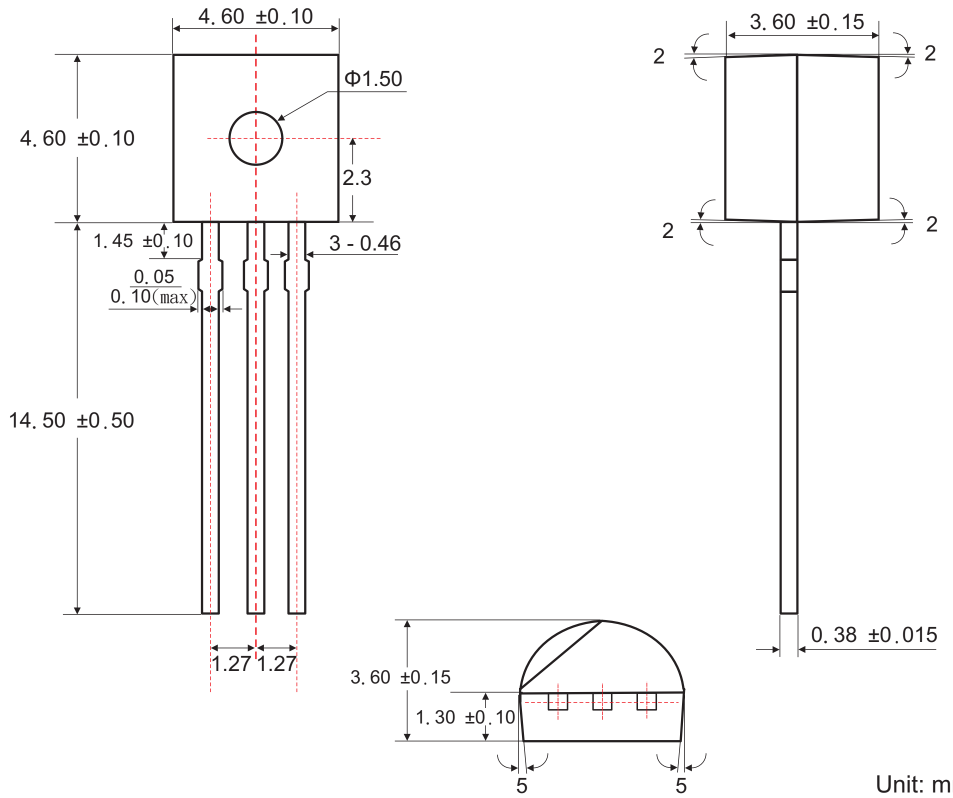
f_2 = 1 / (2 x π x 0.022 μF x 3.3 kΩ) = 2.2 (kHz)

SOT-23 PACKAGE OUTLINE DIMENSIONS



Unit: mm

TO-92 PACKAGE OUTLINE DIMENSIONS



Unit: mm

ORDERING NUMBER