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ADVANCED ANALOG

Model A-730/530-731/531 Log Amplifiers

DESCRIPTION

Models A-730/530 and A-731/531 provide an output proportional to the log or antilog (pin selectable) of a positive or negative input signal, either voltage or current. Log sensitivities of 2/3 V/Decade, 1 V/Decade and 2 V/Decade are available via pin connections. These units are complete log/antilog modules consisting of operational amplifiers, a precision log/antilog element, an internal reference network, and a temperature compensation network. Additionally, the wide dynamic range and the versatility of operation makes the A-730/530 and the A-731/531 an excellent choice for all logarithmic applications.

OPERATION

In the log mode, current inputs are taken directly at the op amp summing junction (see Figure 1), while voltage inputs are referred through R_{IN} , a $10K\Omega$ resistor. The feedback element is half of a matched transistor pair, the other half of which automatically compensates for temperature drift by use of the series-opposing technique of subtraction. Due to the transdiode effect of the feedback, the output is proportional to the log of the input signal according to:

$$E_{OUT} = A \log_{10} \left[\frac{E_{IN}}{E_{REF}} \right] \text{ or } E_{OUT} = A \log_{10} \left[\frac{I_{IN}}{I_{REF}} \right];$$

FEATURES

- Current or Voltage Inputs
- Three Sensitivities
- Internal Protection Against Shorts to Ground or Supplies
- Wide Dynamic Range, 120dB

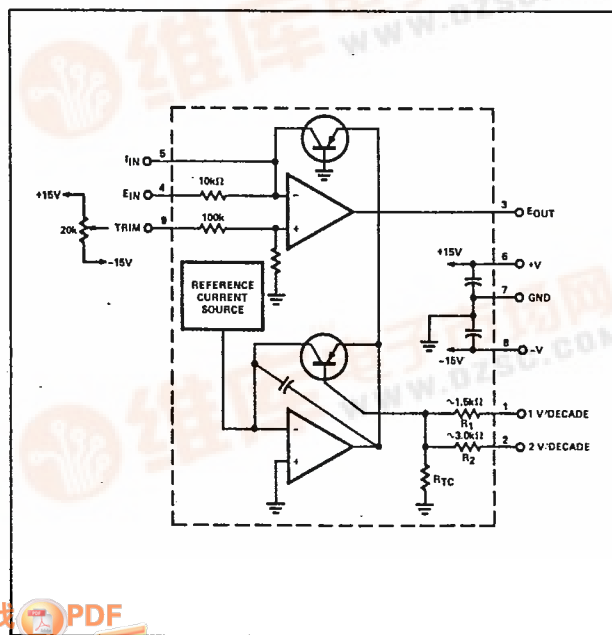


Figure 1. Functional Block Diagram

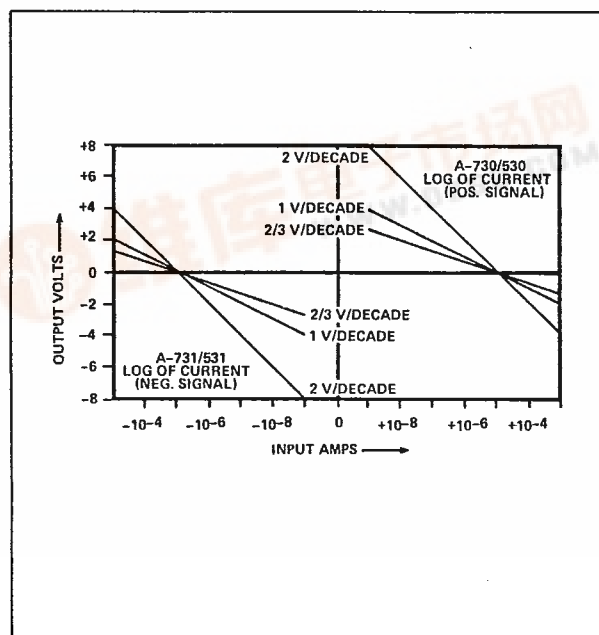


Figure 2. Voltage Output vs Current Input

SPECIFICATIONS (TYP. @ +25°C and ±15V Supplies)

Parameter	Limits	A-730/731	530/531	Units
TRANSFER FUNCTION Log of Current $E_{OUT} = A \left \log_{10} \left(\frac{I_{IN} - I_{OS}}{I_{REF}} \right) - E_{OOS} \right $ Log of Voltage $E_{OUT} = A \left \log_{10} \left(\frac{E_{IN} - E_{OS} - I_{OS} R_{IN}}{R_{REF}} \right) - E_{OOS} \right $ Antilog of Voltage $E_{OUT} = E_{REF} 10^{-[(E_{IN}/A) - E_{OS}]}$		Dynamic Range: $1\text{nA} \leq I_{IN} \leq 1\text{mA}$ $1\text{nA} \leq I_{IN} \leq 1\text{mA}$ $1\text{mV} \leq E_{IN} \leq 10\text{V}$ $-1\text{mV} \leq E_{IN} \leq -10\text{V}$ $1\text{mV} \leq E_{OUT} \leq 10\text{V}$ $-1\text{mV} \leq E_{OUT} \leq -10\text{V}$	Dynamic Range: $0.01\text{nA} \leq I_{IN} \leq 1\text{mA}$ $-0.01\text{nA} \leq I_{IN} \leq -1\text{mA}$ $1\text{mV} \leq E_{IN} \leq 10\text{V}$ $-1\text{mV} \leq E_{IN} \leq -10\text{V}$ $1\text{mV} \leq E_{OUT} \leq 10\text{V}$ $-1\text{mV} \leq E_{OUT} \leq -10\text{V}$	A-730/530 A-731/531 A-730/530 A-731/531 A-730/530 A-731/531
TRANSFER FUNCTION PARAMETERS Scale Factor (A) $A = 1 \text{ V/Decade (Pin 1)}^1$ $A = 2 \text{ V/Decade (Pin 2)}^1$ $A = 2/3 \text{ V/Decade (Pins 1 and 2)}^1$ Reference Current (I_{REF}) Temperature Coefficient Reference Voltage (E_{REF}) Temperature Coefficient Input Offset Current (I_{OS}) ² Temperature Coefficient Input Offset Voltage (E_{OS}) ² Temperature Coefficient Output Offset Voltage (E_{OOS}) ² Temperature Coefficient	max max max nom max nom max max max max max max	$\pm 1\%, \pm 0.04\%/^{\circ}\text{C}$ $\pm 2\%, \pm 0.04\%/^{\circ}\text{C}$ $\pm 1\%, \pm 0.04\%/^{\circ}\text{C}$ $10 \pm 3\%$ ± 0.03 $100 \pm 4\%$ ± 0.03 10 Doubles every $+10^{\circ}\text{C}$ ± 1.0 ± 15 ± 10 over 0°C to 70°C times A	$\pm 1\%, \pm 0.04\%/^{\circ}\text{C}$ $\pm 1\%, \pm 0.04\%/^{\circ}\text{C}$ $\pm 1\%, \pm 0.04\%/^{\circ}\text{C}$ $10 \pm 2\%$ ± 0.05 $100 \pm 2\%$ ± 0.05 3 Doubles every $+10^{\circ}\text{C}$ ± 0.4 ± 10 ± 1 over 0°C to 70°C times A	 μA $\%/^{\circ}\text{C}$ mV $\%/^{\circ}\text{C}$ pA mV $\mu\text{V}/^{\circ}\text{C}$ mV
LOG CONFORMITY (Referred to input) Input Current Input Voltage	max max max max max	1nA to 10nA : ± 1.0 10nA to $100\mu\text{A}$: ± 0.5 $100\mu\text{A}$ to 1mA : ± 1.0 1mV to 1V : ± 0.5 1V to 10V : ± 1.0	0.01nA to 10nA : $\pm 0.5\%$ for each decade below 10nA 10nA to 1mA : $\pm 0.5\%$	% % % % %
RATED OUTPUT Voltage Current Impedance	max max max	± 10 ± 10 < 1	± 10 ± 5 < 1	V mA Ω
FREQUENCY RESPONSE Small Signal (-3dB) Input Current 1nA^1 $1\mu\text{A}^1$ $10\mu\text{A}^1$ 1mA^1	min min min min	80 70 180 200	80 3 25 200	Hz KHz KHz KHz
RESPONSE TIME I_{IN} Increasing 1nA to 10nA^1 10nA to 100nA^1 100nA to $1\mu\text{A}^1$ $1\mu\text{A}$ to 1mA I_{IN} Decreasing 10nA to 1nA^1 100nA to 10nA^1 $1\mu\text{A}$ to 100nA^1 1mA to $1\mu\text{A}^1$	min min min min min min min min	1.0 100 10 10 4.0 200 50 10	1.0 100 7 4 4.5 400 30 7	ms μs μs μs ms μs μs μs
NOISE REFERRED TO INPUT 10 KHz Bandwidth Noise Voltage Noise Current	max max	2 2	2 2	μV , rms pA , rms
TEMPERATURE RANGE Rated Operating Storage		0 to $+70$ -25 to $+85$ -55 to $+125$	0 to $+70$ -25 to $+85$ -55 to $+125$	$^{\circ}\text{C}$ $^{\circ}\text{C}$ $^{\circ}\text{C}$
POWER SUPPLY^{3,4} Voltage Current		$\pm 15 \pm 2\%$ ± 8	$\pm 15 \pm 2\%$ ± 8	V mA

NOTES:

1. Positive for A-730/530 and negative for A-731/531.
2. Externally trimmable to zero error.
3. No damage from shorting any pin to ground indefinitely or to supply for less than 30 seconds.

where "A" is a scale factor described by:

$$A = \left[1 + \frac{R_1}{R_{TC}} \right] \frac{kT}{q} \ln 10 = 1 \text{ V/Decade}$$

$$A = \left[1 + \frac{R_2}{R_{TC}} \right] \frac{kT}{q} \ln 10 = 2 \text{ V/Decade}$$

$$A = \left[1 + \frac{R_1 R_2}{(R_1 + R_2) R_{TC}} \right] \frac{kT}{q} \ln 10 = 2/3 \text{ V/Decade}$$

$$\text{and } E_{REF} = I_{REF} R_{IN}$$

For log current operation, the input signal is fed into the summing junction (pin 5). Depending upon the scale factor desired, E_{OUT} (pin 3) is connected to (pin 1) for 1 V/Decade, (pin 2) for 2 V/Decade, or (pins 1 and 2) for 2/3 V/Decade as shown in Figure 4. A plot of output voltage versus input current is shown in Figure 2.

For log of voltage operation, the input signal is fed to the summing junction through R_{IN} (pin 4). The scale factor is determined as before and is shown in Figure 5, while Figure 3 shows the output voltage versus the input voltage.

In the antilog mode, the input signal is applied at the scale determining resistors which puts half the matched transistor pair in the input path to the op amp summing junction. E_{IN} (pin 4) is connected to E_{OUT} (pin 3) so that R_{IN} is now the feedback element and develops an output according to:

$$E_{OUT} = E_{REF} 10^{-(E_{IN}/A)};$$

where "A" is defined as above. Depending upon the scale factor desired, the input signal is applied to (pin 1) for 1 Decade/V, (pin 2) for 2 Decades/V or (pins 1 and 2) for 2/3 Decade/V as shown in Figure 6.

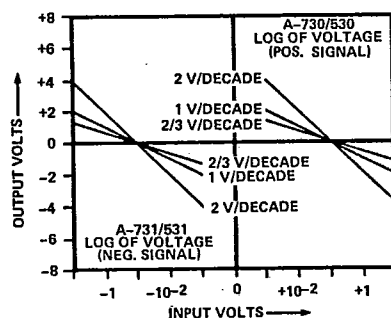


Figure 3. Voltage Output vs. Voltage Input

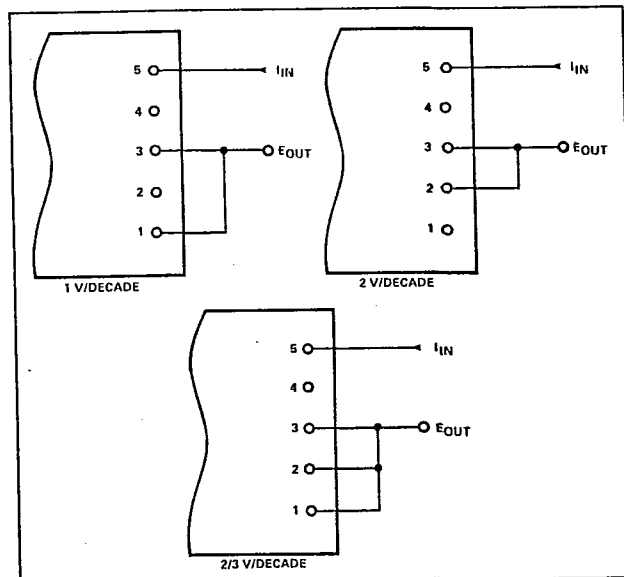


Figure 4. Log of Current Connections

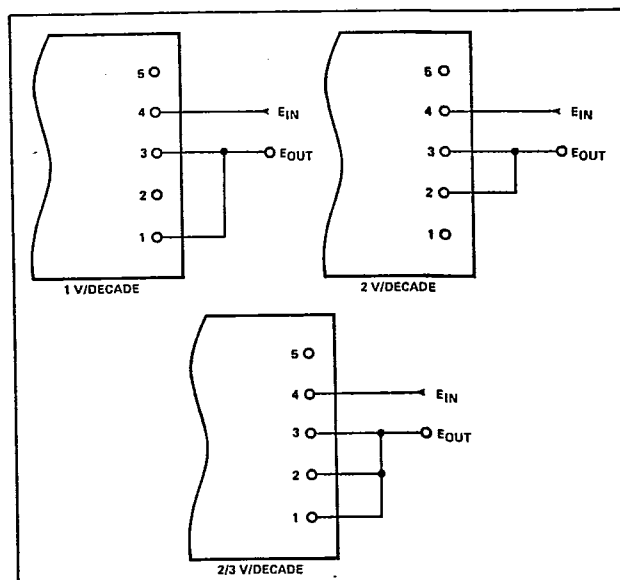


Figure 5. Log of Voltage Connections

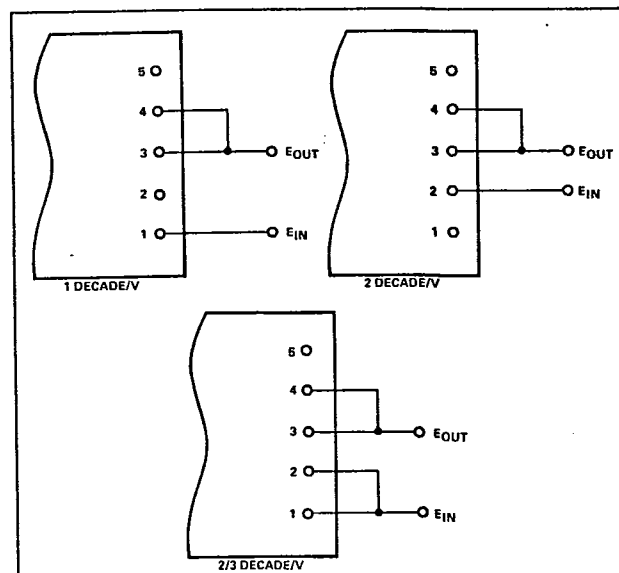


Figure 6. Antilog of Voltage Connections

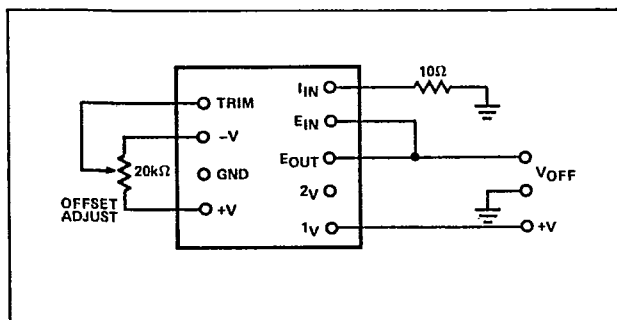
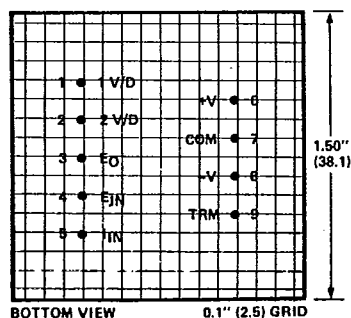
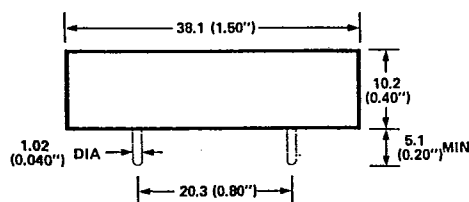


Figure 7. Offset Adjust Configuration

OUTLINE DIMENSIONS



Dimensions in millimeters (inches)

Case: Red epoxy
 Pins: Gold flashed over silver plated, 1/2 hard brass
 Weight: 1.5 oz.

OFFSET ADJUST

The offset voltage, V_{OFF} , is nulled by trimming the offset adjustment potentiometer until the output, V_{OFF} , equals zero as shown in Figure 7. This procedure adjusts the voltage offset of the input op amp to zero. The configuration in Figure 7 is in the antilog mode and sets the op amp gain at 1000, therefore V_{OFF} is divided by 1000 as referred to the input. For example, where $V_{OFF} = 1\text{V}$, then the offset equals 1mV.

OPTIONAL REFERENCES

For a reference current other than 10^{-5}A or a reference voltage other than 0.1 V, insert a constant current into pin 1 or pin 2 (whichever is not in use). Each $580\mu\text{A}$ of current changes the reference by one decade, where a positive current increases the algebraic value of the reference. This method can change the reference by ± 6 decades or more, providing the output is not required to exceed its $\pm 10\text{V}$ limit. The input impedance at pin 1 is approximately $1.5\text{K}\Omega$, at pin 2 it is approximately $3\text{K}\Omega$.

When computing the log of a voltage, an external resistance may be connected to pin 5 in place of the internal $10\text{K}\Omega$ resistor at pin 4. This provides a different reference value by changing the gain of the amplifier. Select the external resistance from the formula:

$$R = \frac{\text{Desired Reference Voltage}}{10^{-5}\text{A}}$$

Ensure the current through pin 5 does not exceed 1mA. For example, with an external value of $1\text{M}\Omega$ in the log of voltage mode, the useful dynamic range will increase to 10^6 (1mV to 1kV).

For other sensitivities, the slope of the curves shown in Figures 2 and 3 can be altered by connecting an external resistor in series with the leads to pins 1 and 2.

The information in this data sheet has been carefully checked and is believed to be accurate, however, no responsibility is assumed for possible errors. The specifications are subject to change without notice.

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