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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.

FEATURES

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

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 10KΩ 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 proportionalto the log of the input signal according to:

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

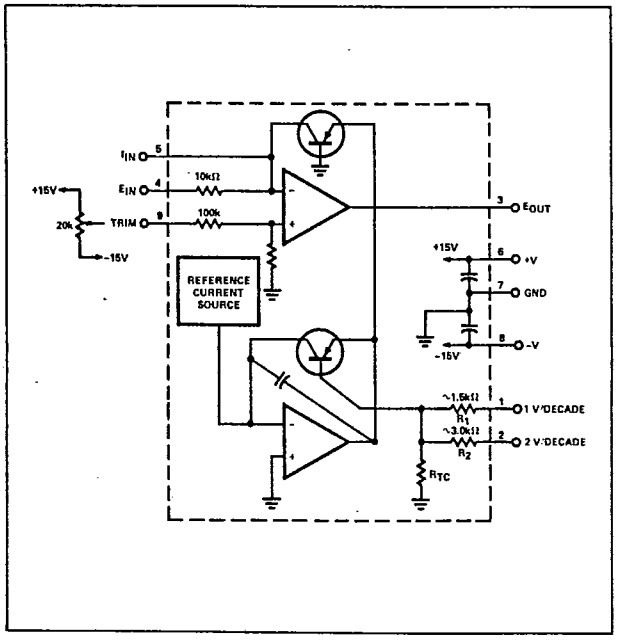


Figure 1. Functional Block Diagram

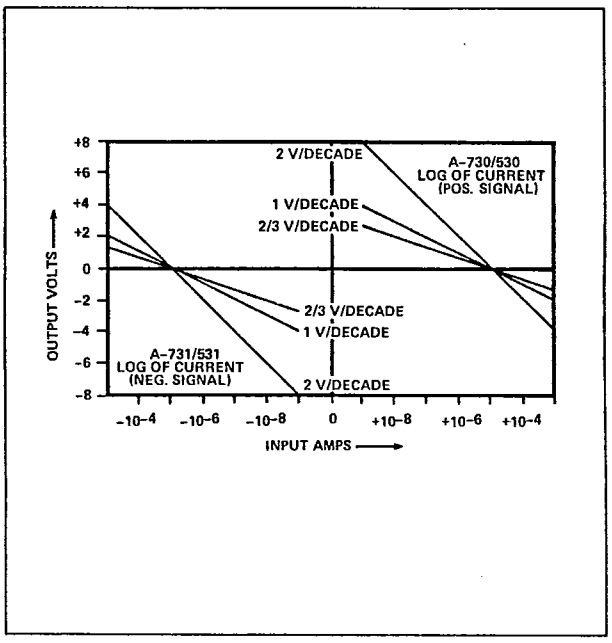


Figure 2. Voltage Output vs Current Input

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

Parameter	Limits	A-730/731	530/531	Units
TRANSFER FUNCTION				
Log of Current $E_{OUT} = A\left[\log_{10}\left(\frac{I_{IN}-I_{OS}}{I_{REF}}\right)-E_{OOS}\right]$		Dynamic Range: 1nA ≤ I_{IN} ≤ 1mA 1nA ≤ I_{IN} ≤ 1mA	Dynamic Range: 0.01nA ≤ I_{IN} ≤ 1mA −0.01nA ≤ I_{IN} ≤ −1mA	A-730/530 A-731/531
Log of Voltage $E_{OUT} = A\left[\log_{10}\left(\frac{E_{IN}-E_{OS}-I_{OS}R_{IN}}{R_{REF}}\right)-E_{OOS}\right]$		1mV ≤ E_{IN} ≤ 10V -1mV ≤ E_{IN} ≤ -10V	1mV ≤ E_{IN} ≤ 10V −1mV ≤ E_{IN} ≤ 10V	A-730/530 A-731/531
Antilog of Voltage $E_{OUT} = E_{REF}10^{-\left[(E_{IN}/A)-E_{OS}\right]}$		1mV ≤ E_{OUT} ≤ 10V -1mV ≤ E_{OUT} ≤ 10V	1mV ≤ E_{OUT} ≤ 10V −1mV ≤ E_{OUT} ≤ 10V	A-730/530 A-731/531
TRANSFER FUNCTION PARAMETERS				
Scale Factor (A)				
A = 1 V/Decade (Pin 1)[1]	max	±1%, ±0.04%/°C	±1%, ±0.04%/°C	
A = 2 V/Decade (Pin 2)[1]	max	±2%, ±0.04%/°C	±1%, ±0.04%/°C	
A = 2/3 v/Decade (Pins 1 and 2)[1]	max	±1%, ±0.04%/°C	±1%, ±0.04%/°C	
Reference Current (I_{REF})	nom	10±3%	10±2%	μA
Temperature Coefficient	max	±0.03	±0.05	%/°C
Reference Voltage (E_{REF})	nom	100±4%	100±2%	mV
Temperature Coefficient	max	±0.03	±0.05	%/°C
Input Offset Current (I_{OS})[2]	max	10	3	pA
Temperature Coefficient	max	Doubles every +10°C	Doubles every +10°C	
Input Offset Voltage (E_{OS})[2]	max	±1.0	±0.4	mV
Temperature Coefficient	max	±15	±10	μV/°C
Output Offset Voltage (E_{OOS})[2]	max	±10	±1	mV
Temperature Coefficient	max	over 0°C to 70°C times A	over 0°C to 70°C times A	
LOG CONFORMITY (Referred to input)				
Input Current				
	max	1nA to 10nA: ±1.0	0.01nA to 10nA:	%
	max	10nA to 100μA: ±0.5	±0.5% for each	%
	max	100μA to 1mA: ±1.0	decade below 10nA	%
Input Voltage				
	max	1mV to 1V: ±0.5	10nA to 1mA:	%
	max	1V to 10V: ±1.0	±0.5%	%
RATED OUTPUT				
Voltage	max	±10	±10	V
Current	max	±10	±5	mA
Impedance	max	<1	<1	Ω
FREQUENCY RESPONSE				
Small Signal (−3dB)				
Input Current				
1nA[1]	min	80	80	Hz
1μA[1]	min	70	3	KHz
10μA[1]	min	180	25	KHz
1mA[1]	min	200	200	KHz
RESPONSE TIME				
I_{IN} Increasing				
1nA to 10nA[1]	min	1.0	1.0	ms
10nA to 100nA[1]	min	100	100	μs
100nA to 1μA[1]	min	10	7	μs
1μA to 1mA	min	10	4	μs
I_{IN} Decreasing				
10nA to 1nA[1]	min	4.0	4.5	ms
100nA to 10nA[1]	min	200	400	μs
1μA to 100nA[1]	min	50	30	μs
1mA to 1μA[1]	min	10	7	μs
NOISE REFERRED TO INPUT				
10 KHz Bandwidth				
Noise Voltage	max	2	2	μV, rms
Noise Current	max	2	2	pA, rms
TEMPERATURE RANGE				
Rated		0 to +70	0 to +70	°C
Operating		−25 to +85	−25 to +85	°C
Storage		−55 to +125	−55 to +125	°C
POWER SUPPLY[3,4]				
Voltage		±15±2%	±15±2%	V
Current		±8	±8	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.
4. DO NOT REVERSE POWER SUPPLIES.

where "A" is a scale factor described by:

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

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

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

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.

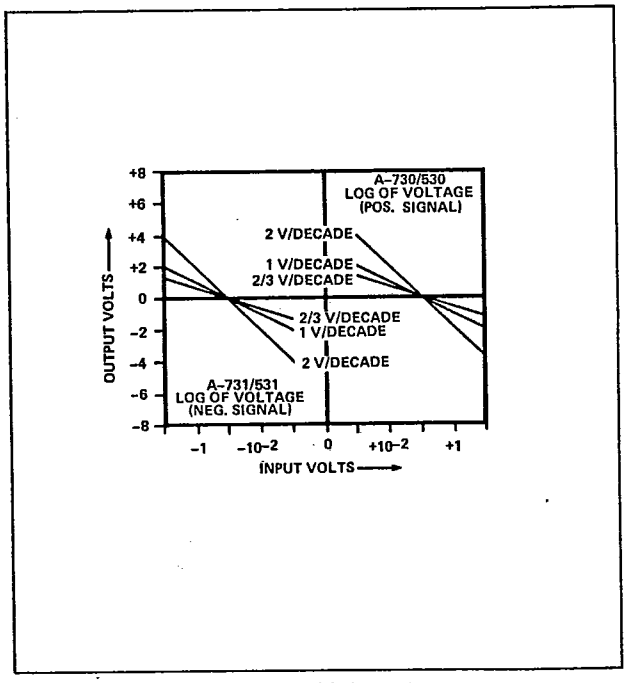


Figure 3. Voltage Output vs Voltage Input

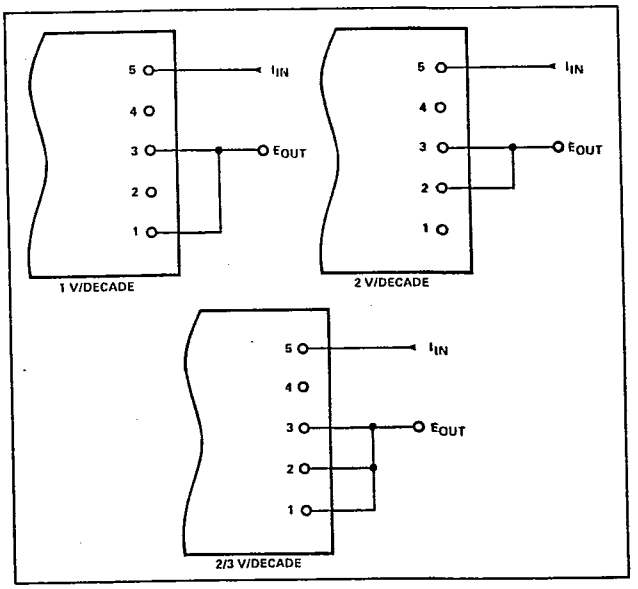


Figure 4. Log of Current Connections

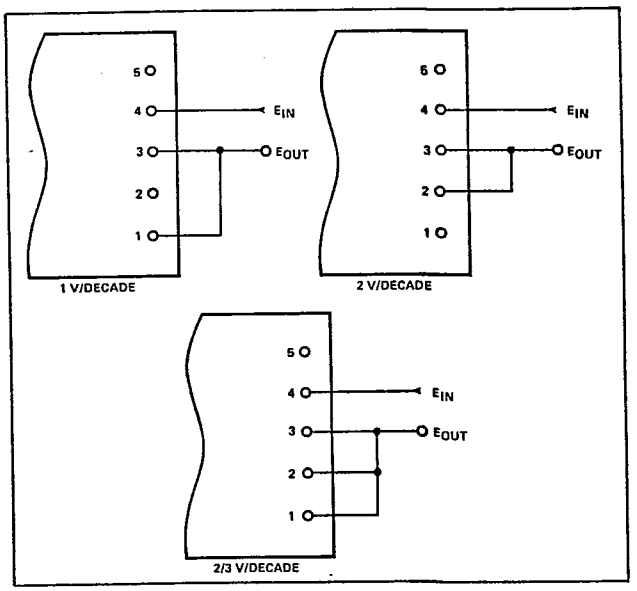


Figure 5. Log of Voltage Connections

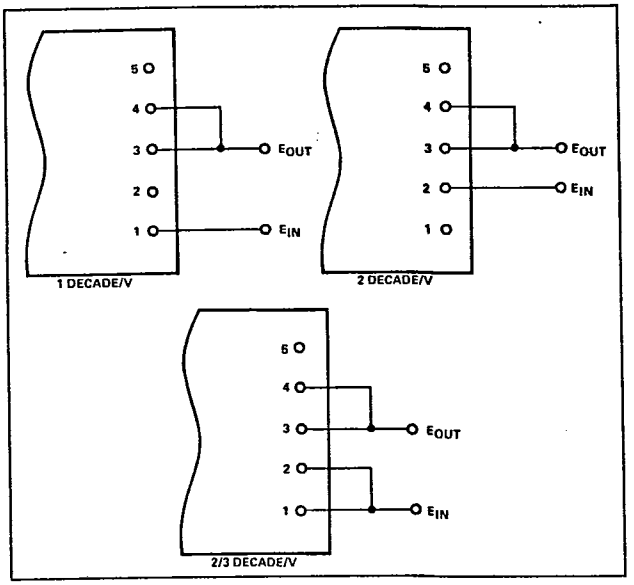


Figure 6. Antilog of Voltage Connections

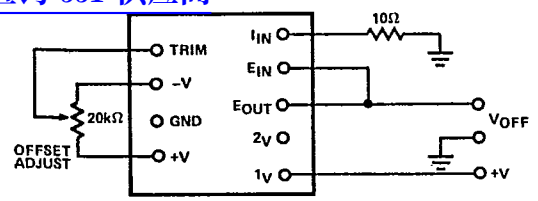
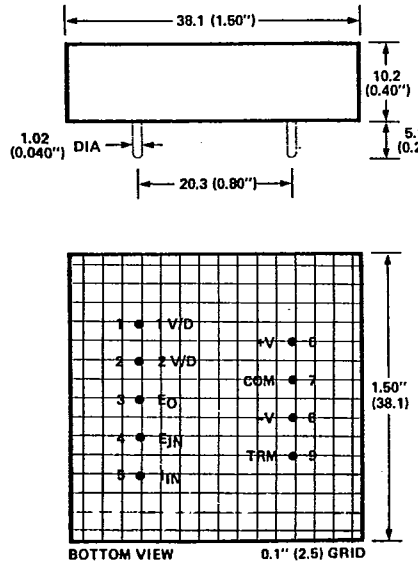


Figure 7. Offset Adjust Configuration

OUTLINE DIMENSIONS



Dimensions in millimeters (inches)

Case: Red epoxy
Pins: Gold flashed over silver plated, ½ 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} = 1v, 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 580μA 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 ±10V limit. The input impedance at pin 1 is approximately 1.5 KΩ, at pin 2 it is approximately 3 KΩ.

When computing the log of a voltage, an external resistance may be connected to pin 5 in place of the internal 10 KΩ 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 1MΩ 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.

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