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2531A

DATA AND SPECIFICATIONS
DESCRIPTION AND INSTRUCTIONS

Optical Electronics Incorporated

BIPOLAR LOGARITHMIC AMPLIFIER

FEATURES

- LOGARITHMIC FUNCTION
- 70dB DYNAMIC RANGE
- VOLTAGE INPUT ±10V to ±3mV
- OUTPUT, ±10V, ±200mA

APPLICATIONS

- AUDIO
- SONAR
- RADAR
- INFRARED DETECTION
- VIDEO LOG

DESCRIPTION

The 2531A bipolar logarithmic amplifier is designed to perform logarithmic functions to signals applied to its inputs. Square root functions can also be implemented. Its specifications make it most suitable to a variety of applications. This very successful design sports a dynamic range of 70dB at a frequency of 100kHz. Even at a full 3MHz, there is still 30 to 40dB dynamic range available. For a full 10V output at 1MHz, a 50dB dynamic range can be counted on.

The 2531A has been designed to fill the gap that exists for logarithmic amplifiers, where wide available bandwidth and wide dynamic range at high frequencies is concerned. Most amplifiers of this kind have wide bandwidth and good dynamic range at frequencies near DC. The dynamic range of the device covers a minimum of 3.5 decades (70dB). Over 75% of this range (60dB), a logarithmic error of ±0.7% is typical, with a maximum error of only ±3% in the lower portion of the dynamic range.

Power supply requirements are standard ±15 volts input, and range from±12 volts to ±18 volts.

The specified ranges follow OEI's conservative philosophy and more dynamic range can be squeezed out of the device. Operated as suggested, the bottom is somewhere between 10 and 20dB above the noise threshold. Therefore, if some noise is permissible in a given design, more than the specified 70dB can be made useful.

The 2531A is a true logarithmic device and the designer must be cautioned that the logarithm of zero is undefined, and signals that cross over this region are not defined. More on this can be found in the applications section.

The 2531A finds applications in video and audio compression circuits and any other place where a logarithmic function is required.

Even square root signal processing can easily be accomplished. The wide frequency range also makes it ideal for ultrasonic measurements, in sonar devices, and certain medical applications. The drive capability of ±10 volts into a 50 ohm load make the device useful, even for a cable driver.

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SPECIFICATIONS

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ELECTRICAL

Specifications at T_A = +25°C, V_{CC} = ±15VDC unless otherwise noted.

MODEL	2531A			
PARAMETER	**MIN**	**TYP**	**MAX**	**UNITS**
DYNAMIC RANGE	70			dB
RATED OUTPUT				
Voltage		±10		V
Current	±200			mA
Dynamic Resistance			5	Ω
Output Coefficient		±2		V
INPUT				
Dynamic Range	0.003		10	V
Resistance Voltage Input		1000		Ω
Polarity		Bipolar		
INPUT OFFSET VOLTAGE				
Initial Offset		±1		mV
Drift		±100		μV/°C
INPUT BIAS CURRENT				
Initial Bias			±10	μA
Drift			±100	nA/°C
MAXIMUM LOGARITHMIC ERROR				
70dB Dynamic Range		1	3	%
60dB Dynamic Range		0.7		%
FREQUENCY RESPONSE				
10KHz	70			dB
100KHz	70			dB
100KHz	70			dB
1MHz	50			dB
3MHz	30			dB
TEMPERATURE RANGE				
Thermal Resistance of Package			11	°C/W
Quiescent Temp Rise			21	°C
Operating	-25		+75	°C
Storage	-65		+100	°C
POWER SUPPLY				
Rated Voltage	±12	±15	±18	V
Current Quiescent		±65		mA

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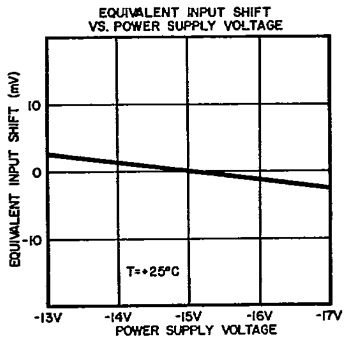
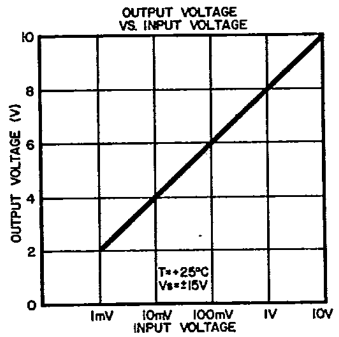
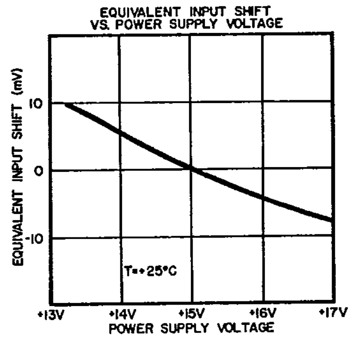
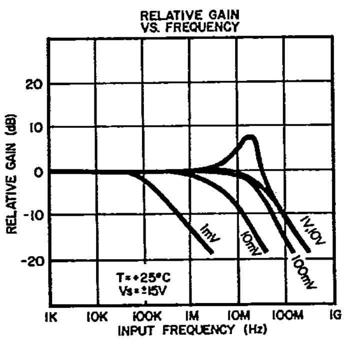
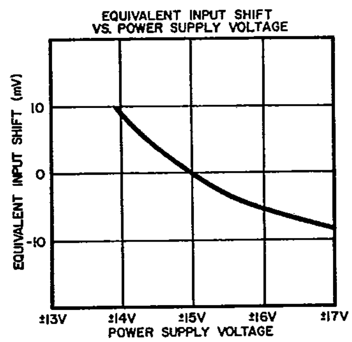
2531A
TYPICAL PERFORMANCE CURVES
(T_A = 25°C, V_{CC} = ±15VDC unless otherwise noted)

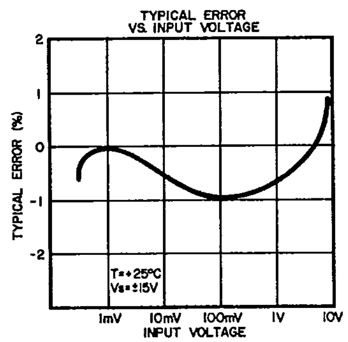






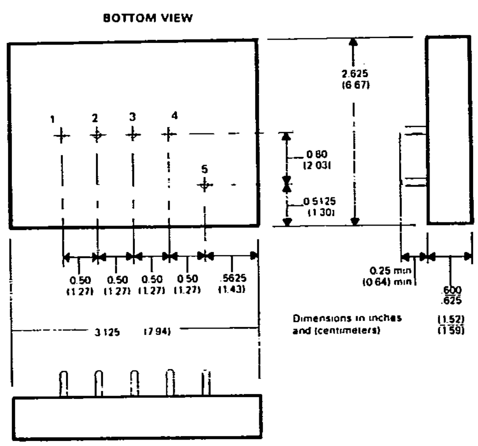






MECHANICAL DESCRIPTION: The 2531A uses an epoxy encapsulant and is enclosed in a glass-fiber-filled-phthalate case. Its pins are gold-plated per MIL-G-45204, Type 2, Class 2. They are 0.040 inches (0.102 cm) in diameter.

PIN CONNECTIONS	
1	INPUT
2	+V
3	COMMON
4	−V
5	OUTPUT



INTRODUCTION

The 2531A bipolar logarithmic amplifier can be employed whenever logarithmic functions are required. Input levels range from 3mV to 10 volts and, with a conversion factor of an even 2 volts per decade, output voltages can go from ±3mV to ±10 volts maximum. Because of the physical size, the 2531A is stable and very seldom will go into oscillations. Even when not too much attention is paid to layout configurations, little degradation is encountered. The offset voltage of ±1mV matches the small drift of only ±100mA/°C. The output characteristics are also impressive and the ±10V into a 50 ohm load allows the device to drive cables over fairly long distances.

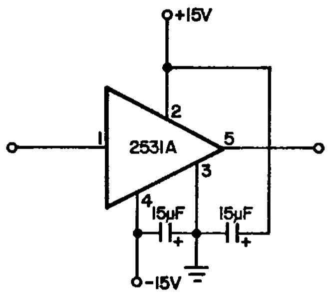


FIGURE 1. BASIC CONNECTIONS

THEORY OF OPERATION

The 2531A is basically an operational amplifier with diodes in its feedback loop, or at the device input. Thus, advantage is taken of the exponential relationship between current and voltage exhibited by a pn junction. Although not applicable with the 2531A, depending on the connection scheme used, logarithmic or antilogarithmic functions can be obtained with the same device. This is exemplified with the 2910 logarithmic amplifier from OEI.

The relationship of current through the diode and the voltage across it can be expressed by

$$i_f = I_o\,(e^{V_f/K} - 1)$$

where i_f current through diode
I_o reverse current
v_f voltage across diode
and where the factor K is dependent on junction material and temperature. If the diode is connected in the feedback-loop of an operational amplifier, the input current becomes i_f and the output voltage becomes V_f as shown in the diagram.

Since the input current i_f is equal to V_{in}/R, the equation for the diode becomes:

$$\frac{V_{in}}{R} = i_f = I_o\,(e^{V_o/K} - 1)$$

For large enough output voltages, the exponential expression becomes very much larger than 1 and the equation can be simplified. If the natural logarithm is taken on both sides and the equation is rearranged, it reads:

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$$V_o = -K\ln\frac{V_{in}}{R} + K\ln I_o$$

This shows that the output voltage is proportional to the logarithm of the input voltage, plus a constant. The constant K as well as the inverse current I_o are constant for a constant temperature. Additionally, an internal buffer amplifier is used in the 2531 A, which compensates for temperature and provides a voltage output.

GENERAL CONSIDERATIONS, APPLICATIONS

The 2531A is a bipolar device. This implies that positive and negative going signals can be processed. This is, however, not strictly true, because the logarithm of zero is undefined. Therefore, the device cannot respond correctly to a truly bipolar signal. A unipolar setup is always recommended. In this manner, a small dc offset can be established, which allows full use of the lower operational decades and, thus, affords a better high frequency response. As has been mentioned before, the dynamic range can be somewhat extended if some noise is tolerable in the system design. Unlike the other logarithmic amplifier offered by OEI (2910), this device is voltage driven and no scaling resistors are needed.

The output coefficient is 2V per decade. This means, that for an input change from 10 volts to 1 volt, the output reacts with a 2 volt change, i.e. if the output was originally at ±10 volts, a ±8 volts output would be registered.

The device contains two inverting stages which to the designer means, that a positive input step also results in a positive output step, and no additional inverter stage is needed. And, of course, the 200mA drive current into a 50 ohm load resistance is a welcome feature in many applications.

LOG MEASURE OF OPTICAL COUPLE

Many biological and other natural phenomena provide measurement ranges that need logarithmic conversion before they can be useful. Light intensity, for instance, behaves in a typical logarithmic manner, i.e. changes in light intensity, although perceived linearly, really will provide voltages over several decades. This can create a real challenge to a measurement system, unless a logarithmic conversion is planned.

In Figure 2, the 2531A is shown in such a case. There, the current from a light sensitive diode is, via the resistor and with the bias voltage, converted to a device friendly input.

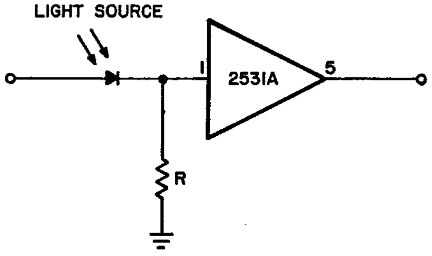

FIGURE 2. LOG MEASURE OF OPTIC COUPLE

This signal, then, is logarithmically compressed by the 2531A for use in further processing. The circuit is intended to provide isolation in noisy environments and can reduce its influence by suppressing the incidental noise. The dynamic range of this combination is excellent, even in the MHz frequency range.

An extension of this circuit could be conceived, where a photo multiplier tube, responding to a scanning laser beam, would provide the input in the form of a current. A transimpedance amplifier converts this current to a voltage which can be processed by the 2531A. Medical applications, such as the count of cells differentiated by some staining method, can benefit from this arrangement.

DRIVING A L.E.D. FOR OPTICAL COUPLE

The circuit shown in Figure 3 is, in a manner of speaking, the inverse of the one of Figure 2. Here the input voltage is translated and fed to a light emitting diode (LED). Because of the resistor in line with the output, the current is known. Therefore, the light intensity from the LED is voltage dependent, or more accurately, the light intensity is proportional to the logarithm of the input voltage. Again, this arrangement is most useful in a noise environment.

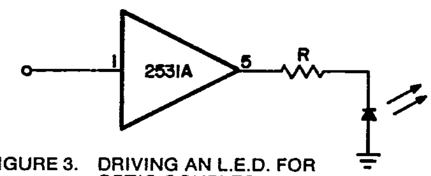

FIGURE 3. DRIVING AN L.E.D. FOR OPTIC COUPLES

An arrangement could be made, where this circuit would be used as the driver of a fiber-optics cable. The other end, the receiver, can then be connected, via optocoupler, to an antilog device to restore the voltage originally injected. This arrangement can be very successful in an environment that has shock and vibration. Electrical interference can be prevented from entering the electrical portions of this circuit by appropriate filtering and shielding.

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VIDEO SIGNAL MEASUREMENT

The next example stems from an application from the medical field. There, two almost identical images were scanned, and the difference needed to be detected. Because the dynamic range of photographic film can extend over several decades, the signal needs to be compressed. Both tasks, difference detection and compression, can be accomplished with only a few devices. Naturally, the transfer function of a photographic negative can be very steep, i.e. a transition from pure white to pure black can be instantaneous and, therefore, an excellent bandwidth characteristic is required.

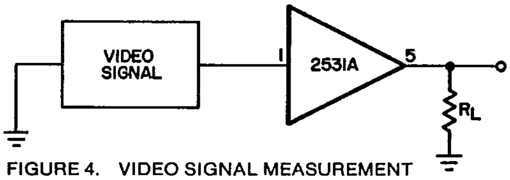

FIGURE 4. VIDEO SIGNAL MEASUREMENT

An operational amplifier, such as the AH0605 from OEI, can be used to obtain the difference signal. This, then, is compressed for further processing. Frequency limitations are only caused by the 2531A, and if the voltages are scaled properly, even that should be of little or no consequence.

TEST EQUIPMENT

The 2531A can be a real headache reliever in test equipment for a few very simple reasons. The device provides excellent frequency response from near DC to 3MHz. It can drive 50 ohm loads with ease at up to ±200mA and ±10 volts. Many video applications require only a 1 or 2 volts response capability. Thus, the device combines several components in one. This, then, will definitely improve reliability and, thus the Mean Time Between Failure (MTBF).

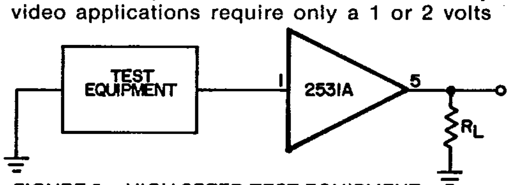

FIGURE 5. HIGH SPEED TEST EQUIPMENT

The designer must remember to operate the 2531A away from DC to avoid the undefined region. Also, unlike other devices that do not employ a diode in the feedback loop (such as successive approximation parts), the OEI device needs current drive on the input. Otherwise, the bandwidth capability will be severely limited.

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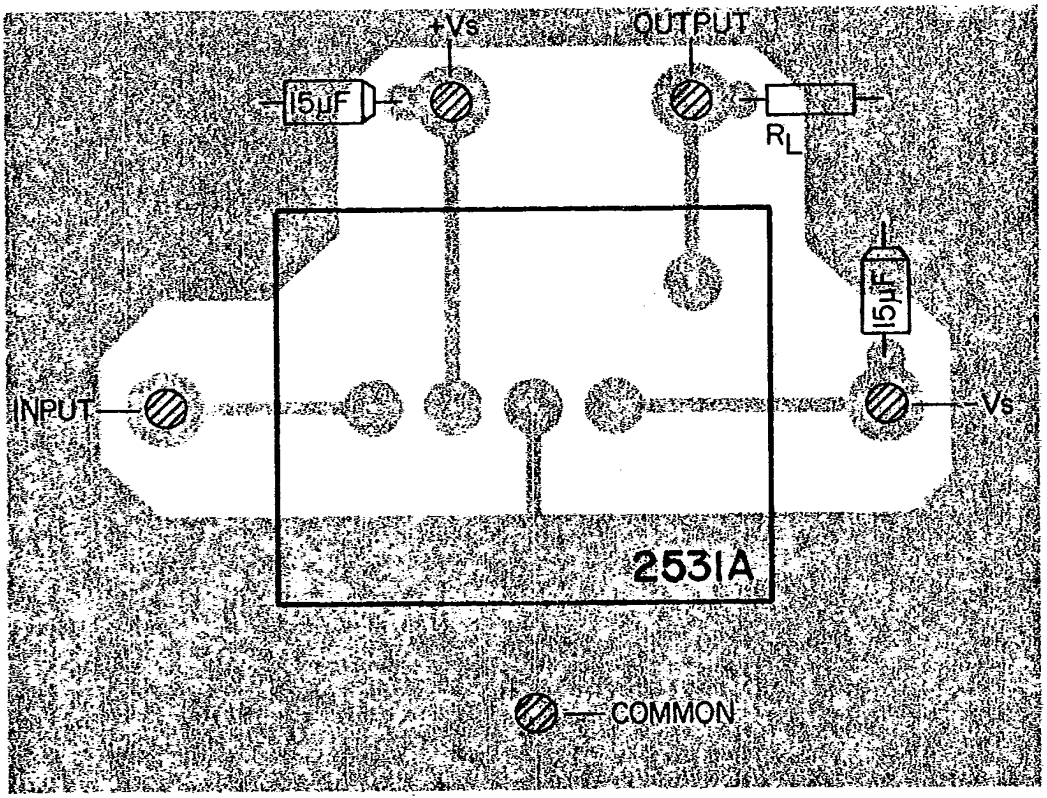

VIEW FROM COMPONENT SIDE

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