Determining the dynamic range of logarithmic amplifiers

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The dynamic range of a logarithmic amplifier can be easily determined by observing its response to an exponentially decaying input voltage. The test procedure is based upon the principle that when an exponential waveform, e^x, is operated upon by its inverse function, log(x), the product that appears at the amplifier's output is a linear function of x. Thus the dynamic range, not surprisingly, will be directly proportional to the time during which the amplifier generates a linear response.

The graph in Fig. 1 plots the input/output characteristic of a typical log amp. Its dynamic range is easily found by plotting its input-voltage values on a logarithmic scale, as shown. The response is linear over an input-signal range of 60 decibels for this amplifier. The output dynamic range is 12 dB.

Although the methods for testing linear amplifiers are not valid for logarithmic amps, the dynamic range may be found just as easily for these nonlinear devices. A response similar to the one in Fig. 1 can be simply constructed, and without the need for point-by-point plotting of the input-to-output relation, by using an oscilloscope and a periodic exponential waveform.

Figure 2 shows how it is done. Simply differentiate the output of a square-wave generator to generate Ae^{-x} and then introduce this signal to the input of the log amp. Trigger the scope on the rising edge of the square wave, and observe the output of the log amp. The dynamic range is defined by the equation:

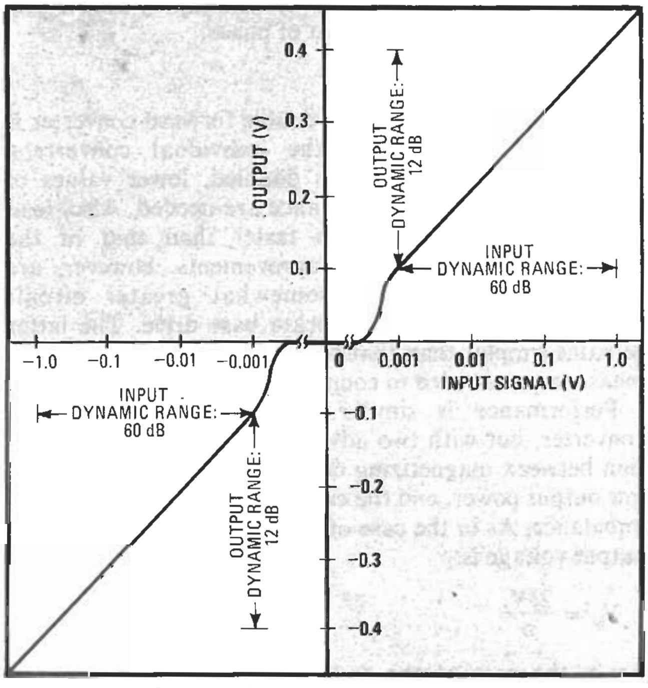
$$D\,(\mathrm{dB}) = 8.69\,t/RC$$

where RC is the time constant of the differentiator and t is the time, measured with the aid of the scope, during which the response is linear.

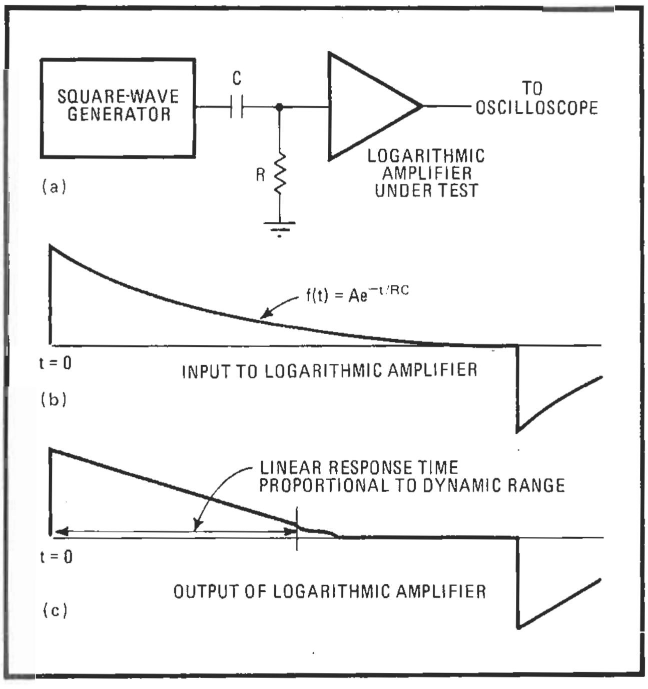
To serve as an effective differentiator, the actual time constant should be at most one tenth the value of the time, corresponding to the dynamic range measured over one period of the input square wave. For example, if the dynamic range is expected to lie in the region of 60 dB, and a square wave input frequency of 100 kilohertz is to be used (t = 10 microseconds), then:

$$RC_{max} = \frac{8.69}{60}\,\frac{(10)(10^{-6})}{10} = 0.145\ \mu s$$

In addition, the time constant should be selected so that the output impedance of RC is not so large that it will be loaded down by the log amp. Otherwise, a buffer amplifier may have to be inserted between the two. □



1. Characteristic. Input dynamic range of typical logarithmic amplifier is 60 decibels; the output range is 12 dB. Both of these ranges are easily measured if input-signal values are plotted on a logarithmic scale. Dynamic-range measurement circuit discussed in text can generate a response similar to the one shown here.



2. Measurement. Exponential waveform Ae^{-x} is processed by logarithmic amplifier (a), and the resulting output waveform proves to be linearly proportional to x. Dynamic range will vary directly with the time the amplifier's output is in the linear region, as described in the text. Typical input and output waveforms (b,c) are shown.