Log amplifier fundamentals

Log amplifiers are a very useful component in RF/wireless and analog signal processing. They are typically used to extract the *envelope* of a modulated signal and compress the envelope logarithmically as shown in figure 1.0 below. They *do not* extract the log of the *instantaneous* signal. This should be made clear from the outset.

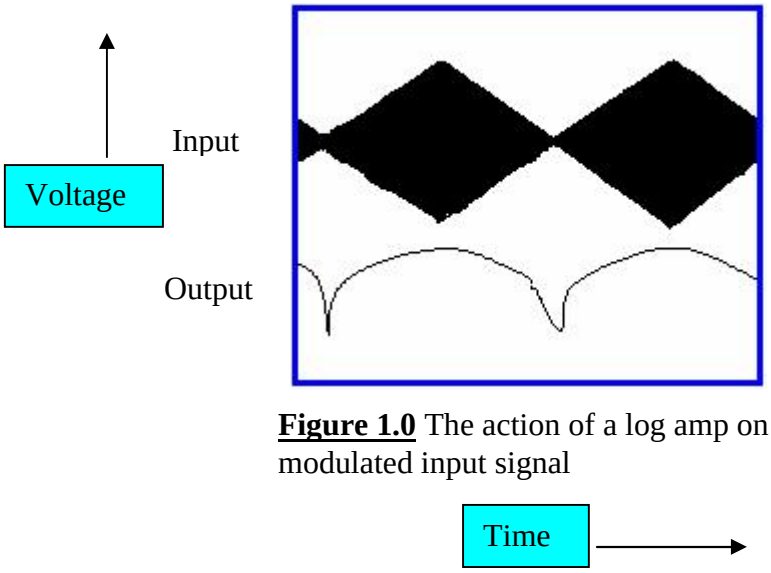

Figure 1.0 The action of a log amp on a modulated input signal

Generally, a log amp measures signal *strength*. The output signal, can represent a very large dynamic range of input signal amplitudes by a relatively narrow range. i.e *compression* takes place. For instance using a log amp in an automatic gain control loop.

Cellular base stations, for example, can use the output from a log amp to control the receiver gain. Log amps can also measure and control transmitted power. The figures below present simplified diagrams and explanations of how log amps work.

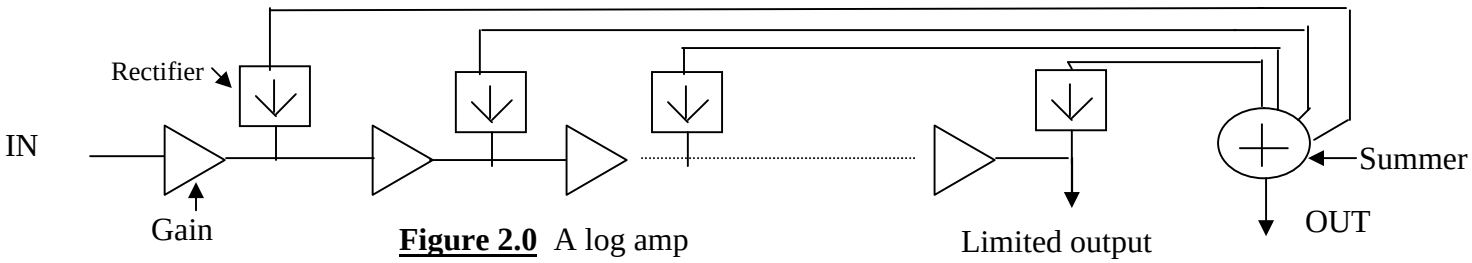

Figure 2.0 A log amp

The basis of the logamp is a chain of amplifiers in tandem. These amplifiers have linear gain, (typically 10 dB to 20 dB). For instance, assume a chain of 5 amplifiers, each with a gain of 20 dB, or 10×. The input is a sine wave with a small amplitude. The signal is amplified 20 dB/amplifier as it traverses the chain.

At some point the signal becomes so large it will start *clipping or limiting*. Assume that the clipping level is set to 1.0 V peak. All amplifiers are designed to limit at this level. The limited signal moves through the chain, and maintains its limiting level of 1.0V peak.

The output of each amplifier is also applied to a full wave rectifier. The outputs of all the rectifiers are summed and connected to a low-pass filter. The LPF reduces the ripple to an acceptable level. The contributions of the early stages are very small and can be neglected. The output ("video"output), will be a steady-state quasi-logarithmic dc output for a steady-state ac input signal.

The limiter output sum can be called the *characteristic*, and the output of the linear limited terms the *mantissa.*

The logarithmic transformation:

To understand how the amplifier produces a logarithmic output, let us assume that in the chain of amplifiers, 3 amplifiers (the last three) are limiting, the second amplifier is about to limit and the first one is still in its small linear range. Let us say this produces an output of 4.0V at the output of the summer. Let us also assume that the gain of each amplifier is 10X or 20dB.

If the input signal is now reduced by 10 times (or 20dB) one of the input amplifier stages will produce negligible output. As a result of this loss the summer output (unfiltered) will drop by 1.0V to 3.0V total. If the input signal is further reduced by 20dB, another stage will drop its contribution to the summer output and the summer output voltage will drop an additional 1.0V.

So what is happening here is that a 10X decrease in the input signal causes a 1.0V drop in the summer output. So the summer output has a 1(V)/20(dB) change. This then leads to the compression characteristic of 50mV/dB. The amplifier has transformed the input signal range into a logarithmic output. As mentioned above, a large input dynamic range can be accommodated by a narrow range in the log output.

Conclusions:
A logamp is a very useful component in RF/wireless and analog signal processing. The design is somewhat complicated owing to the requirements of the accuracies and

tolerances involved. However once these are overcome, the device becomes a great tool for a large number of applications. Among these applications is the received signal strength indicator or RSSI. The design and implementation of a RSSI circuit is explored in detail in a companion paper to be published in the SPG website.