Bruce Trump *Oct 23, 2012*

Have you ever tried to use a linear potentiometer (pot) as a volume control? Yikes! The volume jumps up much too rapidly. It requires a safe-cracker's touch to adjust the volume to quiet listening levels. Thus the *logarithmic potentiometer*.

Our senses have extremely wide dynamic ranges. Our ears (actually, younger ones, not mine) have a useful range of 120dB or more, a 1,000,000-to-1 ratio. The origin of the decibel owes to our sense of hearing with 1dB approximating the smallest perceivable change in volume. A logarithmic potentiometer adjustment is approximately linear in decibels so incremental changes in position make relatively uniform changes in perceived volume.

Figure 1 shows the attenuation when used as a voltage divider for a linear pot and a mathematically perfect logarithmic pot. This one has an output of 0.1Vin (-20dB) at 50% rotation, a common target value for audio pots. Each 10% of rotation changes the output by 4dB. But this "ideal" log pot only provides 40dB attenuation (1% output) at zero rotation (see the expanded graph). Listeners want their volume controls to go to zero output (infinite attenuation) so log pots have a "walk-off" that fades to zero output at zero position.

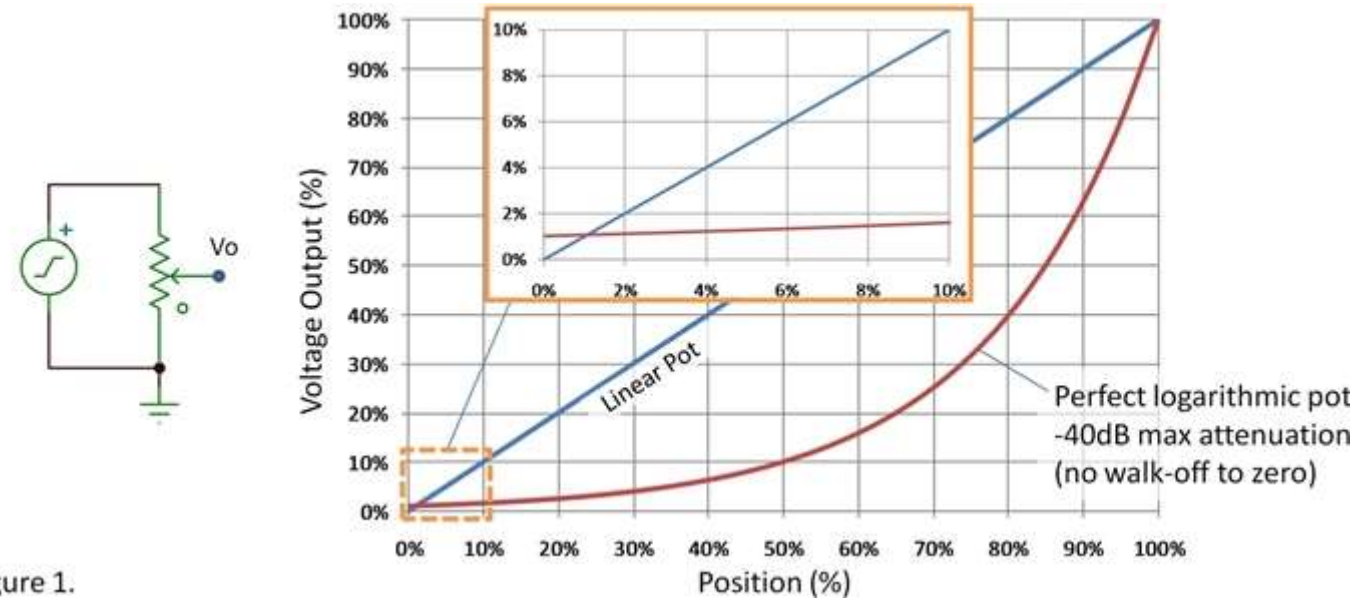

Figure 1.

There are several semi-standard logarithmic characteristic curves or *tapers* as they are called. They are generally specified by the attenuation factor at 50% rotation. Naming conventions are not well-standardized so I will not add to any confusion by naming them. If you have specific needs, consult a supplier. There are also special "*reverse log tapers*" that may be required in some applications. They bow in the opposite direction.

- Log pots are generally fabricated by making two (maybe more?) piecewise approximations to a desired taper (figure2). Two different resistivity “inks” are printed to form the resistive element. A critical factor for stereo volume controls is the tracking accuracy of the two ganged pots. Note that the output goes to zero at the zero position.

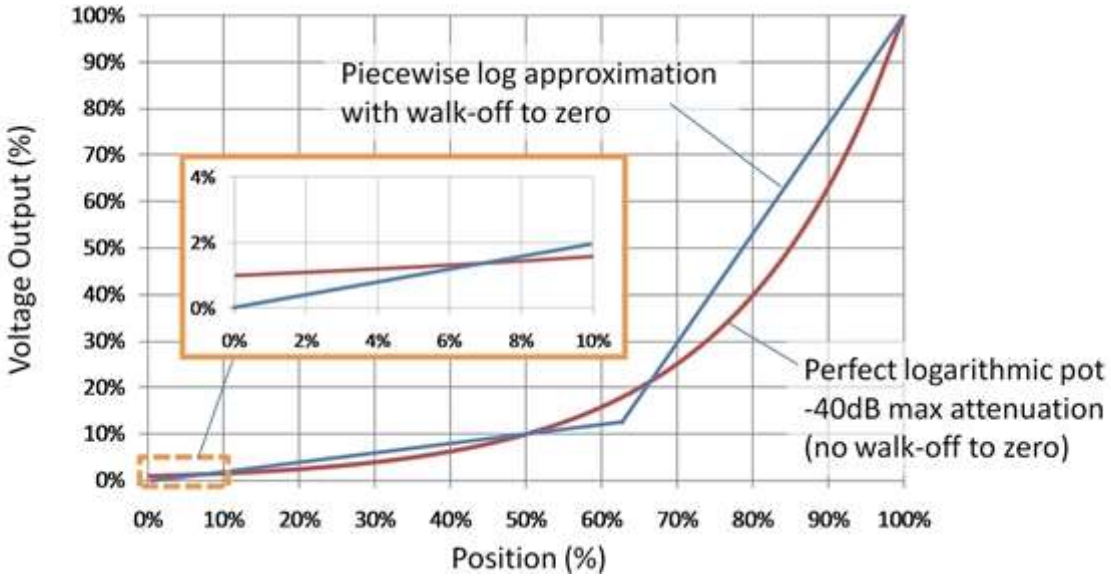

Figure 2.

You can create an approximation of a log pot with a linear pot and a fixed resistor loading the output (figure 3). Used as a volume control, this circuit still suffer from the behavior of a linear pot—it “jumps up” too quickly in volume at the bottom of rotation. It’s better than a linear pot alone but not as good as a log taper. The same output resistor circuit can also be used on a log pot to change its taper curve. Beware that the input signal must be able to drive R1 at 100% output and this can be a low resistance depending on the value chosen for Rp.

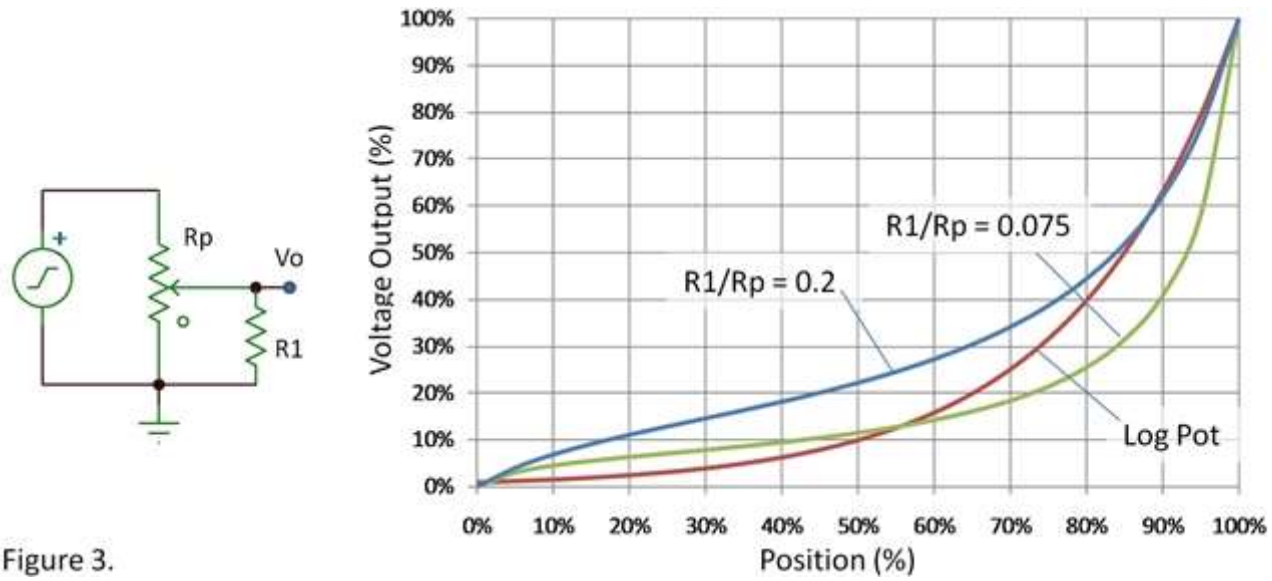

Figure 3.

Electronic volume controls have largely replaced conventional log pots in high volume consumer applications. All this is done with digital control in natural-sounding logarithmic increments, with a walk-

- off to zero at the bottom. Conventional looking home and automotive audio gear replicate the feel of a volume control with knob that generates the control signals for the digitally controlled signal path. Some of these devices may also be useful in signal paths other than audio. Here is a sampling:

  - PGA2500 Professional microphone preamp with digital gain trim
  - PGA2320 Professional Stereo, line-level audio console level control
  - LM1971 Single channel volume control, 0dB to -62dB with mute to -100dB
  - LM1972 Stereo volume control, 0dB to -78dB with mute to -104dB
  - LM1973 Three-channel volume control, 0dB to -76dB with mute to -104dB
  - TPA6130A2 138mW Stereo headphone driver with I2C volume control
  - TPA6140A2 Stereo headphone driver, 25mW, with I2C volume control
  - TPA2054D4A 2.4W Class-D Stereo Driver, 32-step volume control
  - TLV320AIC3262 Stereo Codec with miniDSP and integrated Class-D Speaker/Earphone Drive

Still, there are many uses for conventional volume controls and logarithmic pots so an analog designer should know the basics. As always with my blogs, there's more to know if you have critical needs and some of you know more than I do. I welcome you to share your knowledge in your comments.

Thanks for reading,

Bruce email: thesignal@list.ti.com (Email for direct communications. Comments below.)

Index to all *The Signal* blogs.

Jens-Michael Gross *over 12 years ago*

If you ever tried the volume control of the Windows Media Player, then you know that linear volume regulation isn't limited to the use of pots.

When designing volume ocntrols, it should be considered that +3dB are twice the power, +6dB are twice the voltage but +10dB are required for twice the 'loudness'. Also, most people prefer a finer control for lower volumes, so a perfect logarithmic pot isn't the best solution.

Eric Fletcher *over 12 years ago*

Ever heard of Analog Devices AD 7110, AD 7111, AD 7112 & AD 7115 Multiplying Log DAC's ?