Wide Range Timer

National Semiconductor
Linear Brief 38

One of the problems encountered in potentiometer controlled circuits is dynamic range. With a linear pot, about a 100:1 range is the limit. Although the pot resolution may be better than 1%, the angular displacement for good control becomes too small. Usually, range switching is then used.

A logarithmic control is a possible solution. With log controls, the resolution is the same anywhere within the operating range. For example, if 40° rotation is equal to a change from 10% to 100% of full scale, then 40° rotation is also equal to a change from 0.01% to 0.1% of full scale. It is easy to control a function over a 1,000,000:1 range with good control anywhere within the range.

The exponential relationship between the emitter-base voltage of a transistor and its collector current is well known. This relationship holds true within a few percent over extremely wide ranges. Using a transistor pair, and an op amp, it is easy to make a current source controllable over a 6 decade range.

Figure 1 shows a timer which can be adjusted from 2 ms to 2000 seconds with a single control. An LM122 is used for the timing function in conjunction with a current source that is logarithmically controlled from a pot. The operation is as follows:

Transistors Q1 and Q2 are a matched PNP pair. Resistor R1 and the op amp set up a constant current of 1 mA through Q1 using the internal 3V reference from the timer. With R2 at the most positive end of its range, the non-inverting input of the op amp is a V_{REF}. This forces the emitter-base voltage of Q2 to equal Q1 and since the transistors are matched, the collector current of Q2 is also 1 mA. A timeout period of 2 ms results.

Rotating R2 subtracts the voltage between the arm of the pot and V_{REF} from the emitter-base voltage of Q2—lowering its collector current. The current is decreased by a factor of 10 for every 60 mV developed. A total of 360 mV is dropped across the pot, allowing a reduction in Q2 collector current by a factor of 1,000,000 or from 1 mA to 1 nA. A 1 nA charging current gives a 2000 second time out. (At maximum time, there is about a 30% error due to the 0.3 nA input current of the comparator). Finally, diodes D1 and D2 temperature compensate the voltage across the pot.

Calibrating the circuit is relatively easy (except for obtaining a log dial for the pot). Resistor R1 is adjusted for the minimum operating time removing for mismatch in the transistors, capacitor tolerance, and the offset of the op amp. R3 is used to calibrate the full scale time by adjusting the drop across R2 to 360 mV.

This type of log control is not limited to timers. If used in oscillator or function generator circuits, an ultra wide range VCO can be made. Also, in power supply circuitry, it is possible for a reguator to have as much resolution when adjusted for 0.001V output as when the output is 10V. Finally, a log current generator makes an easily adjusted low value current source without high value resistors.

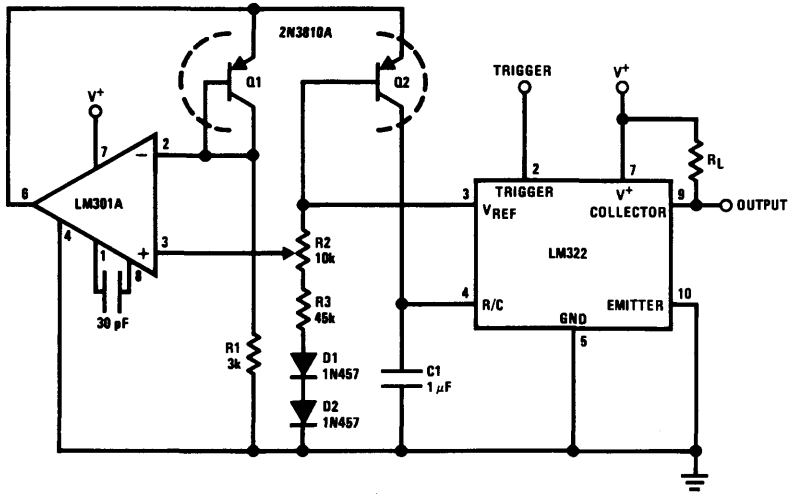

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FIGURE 1. 2 ms to 2000 Second Timer