Winking LED notes null for IC-timer resistance bridge

by James A. Blackburn
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A resistance bridge that makes use of the popular 555-type IC timer operates without requiring the usual combination of a meter and an amplifier. Moreover, the circuit's sensitivity does not depend on the unknown resistance. And since a light-emitting diode is used for visual indication, there's no need to worry about shock-isolation for a meter movement. Two possible applications for the bridge are as a thermometer (where the unknown could be a thermistor) or as a photometer (where the unknown could be a photoresistor).

The color block in the diagram shows where unknown resistor R_X is inserted in the bridge. When the resistance of the dual potentiometer is increased, the brightness of the LED also steadily increases. Then, at a particular setting of the potentiometer (R_{POT}), the LED's brightness is suddenly halved. The ratio of R_{POT}:R_X at which this winking occurs is determined solely by the properties of the two IC timers.

The first timer ($TIMER_1$) operates in its astable mode and, therefore, is free-running. Its output (signal A) is low for a period of $T_1 = 0.693R_XC$ seconds and high for a period of $T_2 = 0.693(R_X+R_{POT})C$ seconds. The output from $TIMER_1$ is differentiated and then used to trigger the second timer ($TIMER_2$), which is operating in its monostable mode.

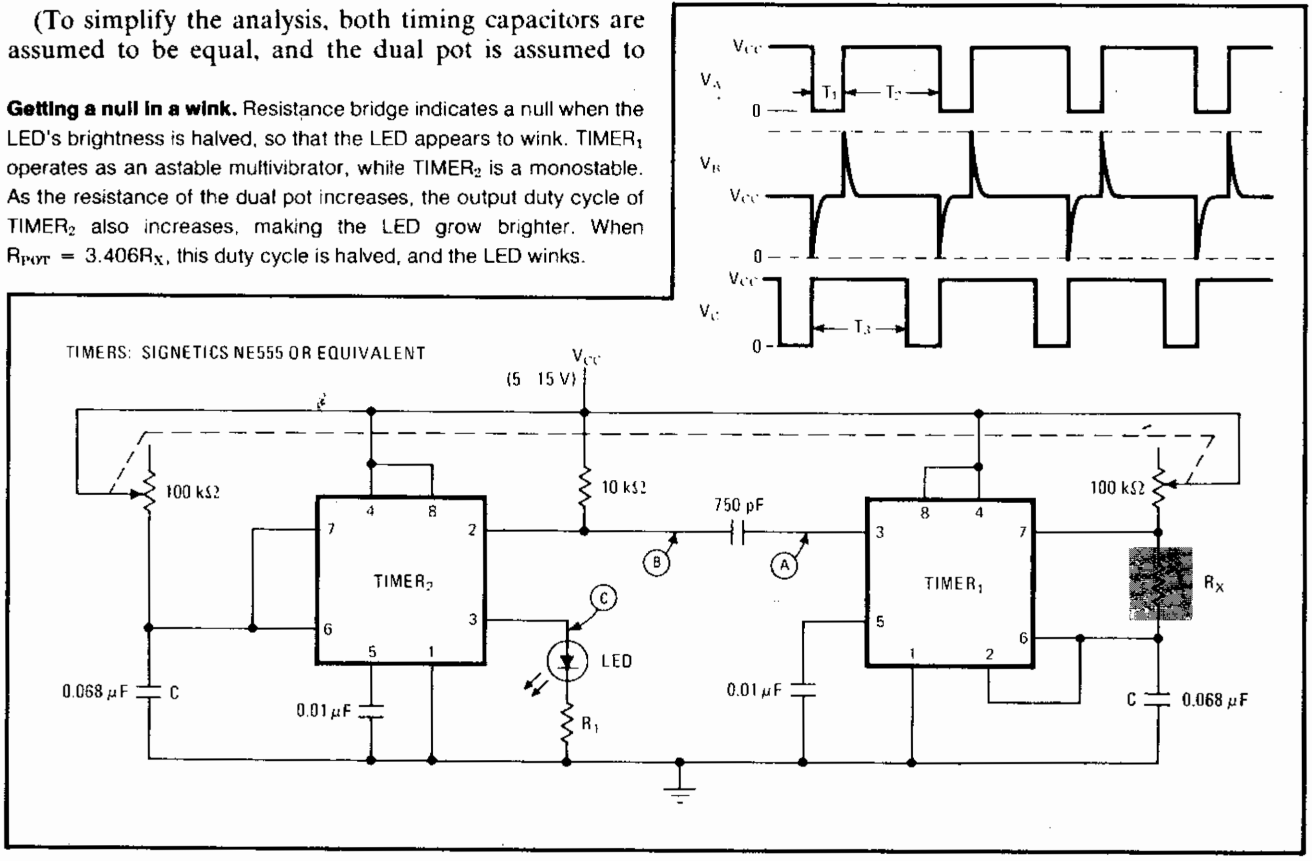
(To simplify the analysis, both timing capacitors are assumed to be equal, and the dual pot is assumed to track without error. In addition, the triggering spikes are considered to be of negligible width compared to period T_1.)

As R_{POT} is increased, the periods of signals A and B become longer, and the on-time of $TIMER_2$ ($T_3 = 1.1R_{POT}C$) starts to increase at a slightly faster rate. This means that the duty cycle of signal C is getting larger, and the LED will appear to grow brighter.

A closer look at the waveforms reveals that when period T_3 is just slightly less that T_1+T_2, the duty cycle of signal C is nearly 100%. But when T_3 is slightly greater than T_1+T_2, the duty cycle of the signal C drops to 50% and, at the same time, the frequency of this signal decreases to half the frequency of signal A. This happens because $TIMER_2$ locks out trigger pulses while its output is still high and, therefore, ignores all alternate negative-going spikes.

Further increases in R_{POT} cause the duty cycle of signal C to rise again slowly from 50% to a limiting value of 79.4%. The abrupt transition from 100% to 50% occurs when $R_{POT} = 3.406R_X$, making the calibration of this resistance bridge intrinsically linear. Circuit performance is limited by the desired upper and lower operating frequencies and the width of the triggering pulses.

For the component values shown, the circuit can operate over a fairly wide range of unknown resistance values—from 1 kilohm to 100 kilohms. The value selected for the LED's current-limiting resistor, R_1, depends on the supply voltage used. ☐



Getting a null in a wink. Resistance bridge indicates a null when the LED's brightness is halved, so that the LED appears to wink. $TIMER_1$ operates as an astable multivibrator, while $TIMER_2$ is a monostable. As the resistance of the dual pot increases, the output duty cycle of $TIMER_2$ also increases, making the LED grow brighter. When $R_{POT} = 3.406R_X$, this duty cycle is halved, and the LED winks.

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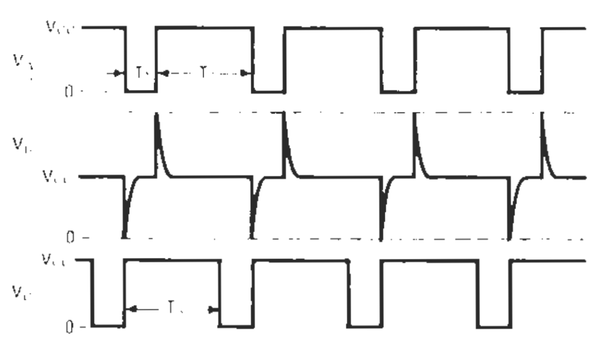

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