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APPARATUS NOTES

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Light-operated millisecond timers

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We describe two simple and economical timers which are suitable for measuring time intervals with fractional millisecond resolution in physics experiments. For example, in a Fletcher's trolley experiment, a timer could be located at various points along the trolley's path, thus providing values of Δt at each of these points. In conjunction with a measurement of a Δx at each of these points (e.g., the length of the trolley itself, or the length of a small "flag" riding on the trolley), it is then possible to compute values of the trolley speed at these various points, and eventually to compute the acceleration. Evidently, fairly small values of Δx should be chosen. The value of the time interval Δt is read directly from the frequency counter. For example, assuming that the 555 integrated circuit (IC) is oscillating at 100 kHz, then a display of, say, 2.78K counts implies that Δt is 27.8 msec. Two versions of a timer are given: one is "light activated" (supplies pulses when the phototransistor is illuminated) and the other is "dark activated" (supplies pulses when the phototransistor is not illuminated). For applications such as the Fletcher's trolley experiment, the "dark-activated" version would be the more appropriate in conjunction with an electronic counter, whereas the "light-activated" unit would be appropriate for measuring camera shutter speeds.

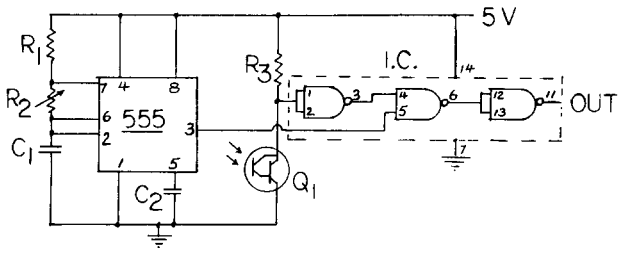

Fig. 1. Schematic of the "light-activated" timer: 100-kHz pulses appear at OUT for the duration of illumination on Q_1. $R_1 = 3$ kΩ, 0.25 W; $R_2 = 10$-kΩ trim pot; $R_3 = 5$ kΩ, 0.25 W; $C_1 = 0.001$ μF; $C_2 = 0.01$ μF; Q_1 = phototransistor (see text); IC = Fairchild 7400 (or equivalent).

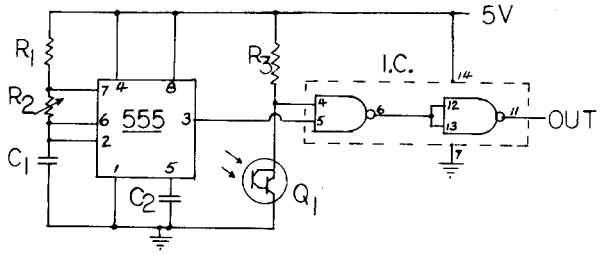

Fig. 2. Schematic of the "dark-activated" timer: 100-kHz pulses appear at OUT for the duration of no illumination on Q_1. Parts are the same as for the circuit in Fig. 1.

With reference to the circuit diagrams, the operation of the timer is as follows: The 555 IC[1] is adjusted to oscillate at 100 kHz (incidentally, the oscillation frequency is sufficiently independent of power supply variations for the proposed applications) and this pulse train is fed to one input of a TTL NAND gate. The phototransistor[2] (a photo-Darlington assembly in our circuit) is suitably connected to the other input of the NAND gate so that the output of the gate is controlled by the conduction state of the phototransistor. Hence, to implement the "light-activated" operation, the suitable connections are as shown in Fig. 1, and to implement the "dark-activated" operation, the suitable connections are as shown in Fig. 2. Experience has shown that this arrangement is much better than one in which the phototransistor gates or controls the 555 IC. The pulse output is then fed to any available electronic digital counter. Finally, the spectral sensitivity of the phototransistor should be taken into account when choosing the associated light source.

[1]Available for approximately $1 from Poly Paks, Box 942, South Lynnfield, MA 01940.

[2]Available from Poly Paks for $1 under Catalog No. 92CU1314. Presumably, any photo-Darlington would work in this circuit.