Hyperbolic clock inverts time

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Instruments designed to measure speed must contain circuits for converting a time function, t, to units of 1/t in order to calculate rate. This circuit aids in plotting the hyperbolic curve (1/t) using relatively few parts and, notably, having no need for logarithmic dividers.

As shown in the figure, a start pulse triggers transmission gate S_1, initiating the measurement cycle. At that time, A_1 and A_2 are reset. Current I_1 thereupon charges C_1 linearly, and thus a ramp voltage is applied at the noninverting input of A_3.

When the ramp voltage reaches $\frac{1}{16}$ volt, the potential at the lowermost tap on the resistor voltage divider A_3 moves high and advances counter A_1. At this instant, the total elapsed time is $\frac{1}{16}(C_1/I_1)$ V.

Switch S_2 is then activated, so that the second resistor in the ladder is shorted. Thus the voltage at the inverting port of A_3 increases to $\frac{1}{15}$ V. When the ramp voltage reaches this value, A_3 again moves high and fires A_2. This action occurs at an elapsed time of $\frac{1}{15}(C_1/I_1)$ V. The process continues as A_1 counts to 15 in a binary sequence and either all combinations of the resistor ladder are shorted or the measurement cycle ends (start pulse held at logic 1). It is assumed the data will be stored in a latch prior to the start pulse, because A_2 will be reset. At that time, A_2 will have counted down with each clock from A_3 to provide an output corresponding to an elapsed time of $1/t\ (C_1/I_1)$ V, where t may assume integer values from 1 to 15. Note that comparable circuit action cannot be realized easily with an astable multivibrator operating as a fixed-frequency source for stepping A_2; that is, the circuit is not performing a time-to-frequency conversion.

The contents of A_2 at the termination of the measurement cycle provide a direct indication of an object's speed. The factor $(C_1/I_1)V$ may be adjusted to 1 by suitable choice of component values or set to a multiplicative constant as required. Also, to reduce the voltage divider increment, the resistor ladder may be expanded by cascading counters and their appropriate circuitry. □

Time twist. Circuit inverts time function, t, to 1/t in order to measure speed. Note that unit does not perform a standard time-to-frequency conversion. Ramp voltage derived from current generator is compared with resistive-ladder voltage at A_3, and A_1–A_2 are clocked each time the ramp exceeds changing ladder potential. Output of down counter, A_2, yields rate.