Low-frequency VCO gives exponential response

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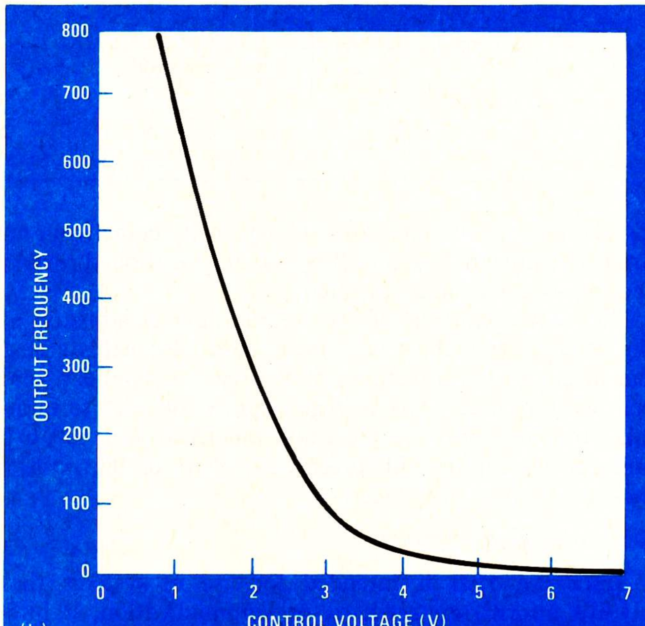
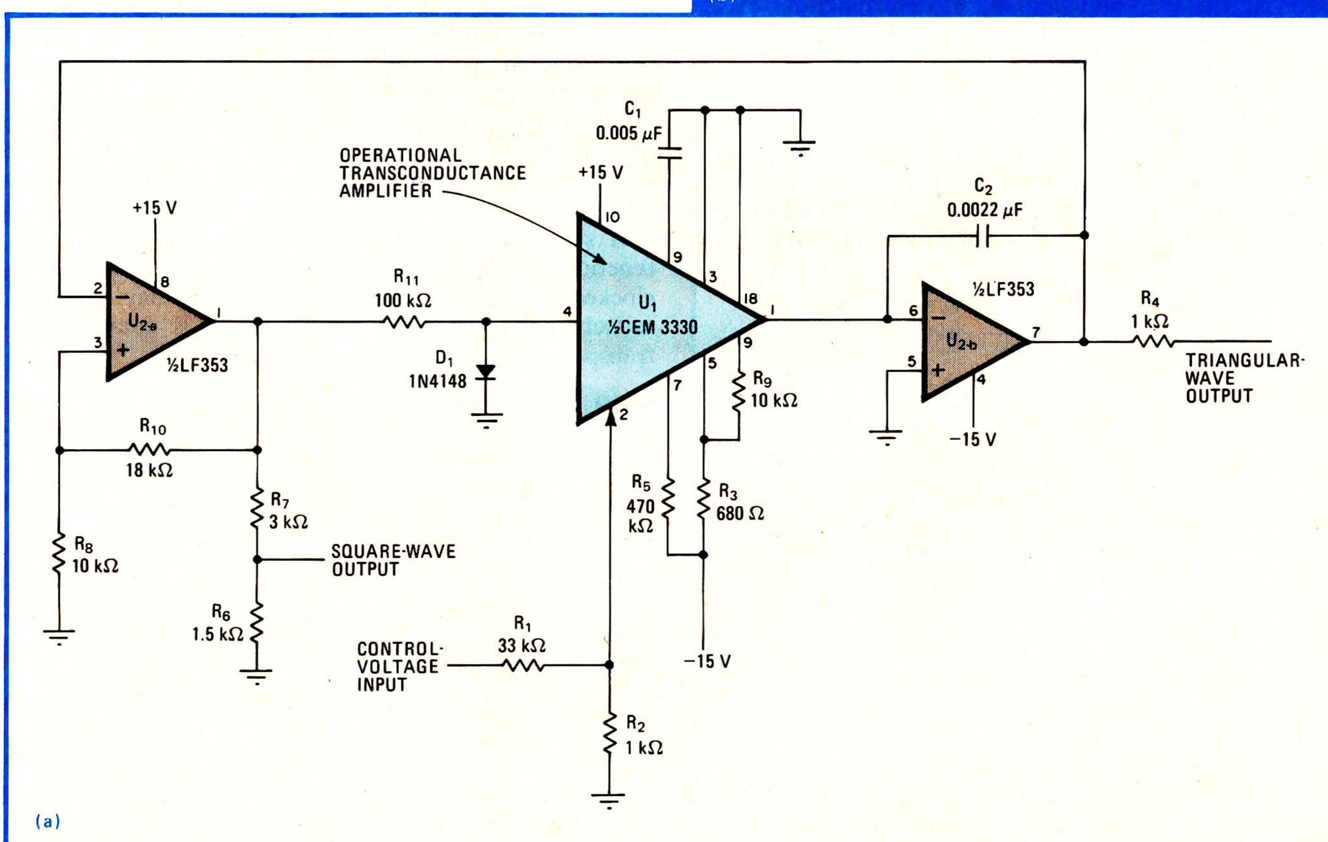
Low-frequency oscillators, commonly used instruments, are often controlled by external voltages. But to obtain a design that has an exponential relationship between voltage and output frequency is both expensive and difficult. However, this low-frequency voltage-controlled oscillator, which uses just two integrated circuits and a handful of passive components, does just that.

The heart of the oscillator is operational transconductance amplifier U_1 (a) whose gain is set by the external control voltage. U_1 controls the amount of current flowing from the output of Schmitt trigger $U_{2\text{-}a}$ to the integrator comprising U_1 and $U_{2\text{-}b}$, and the current determines the oscillation frequency. If the control voltage is varied linearly, the amount of current flowing through operational transconductance amplifier U_1 changes exponen-



(b)



(a)

Exponential. Using operational transconductance amplifier CEM3330 and operational amplifier LF353, this low-frequency voltage-controlled oscillator produces an output frequency that changes exponentially for a linear change in the input control voltage. For the components shown (a), the amplitude of the triangular and square wave is 10 volts peak to peak, while the exponential frequency range is 0.5 to 800 Hz for a control voltage of 1 to 7 V (b).

tially; an exponential frequency response results.

When the output of $U_{2\text{-a}}$ is high, U_1 charges capacitor C_2 at a rate that is determined by the control voltage input. Because the integrator output is fed back to $U_{2\text{-a}}$, the Schmitt trigger is reset when the output of $U_{2\text{-b}}$ equals the reference voltage, which is determined by resistors R_8 and R_{10}. As a result, the output of $U_{2\text{-a}}$ reverses its polarity and goes to the opposite rail. This change causes current to be drawn from U_1, and current is discharged from C_2 through U_1. As before, the Schmitt trigger is set when C_2 discharges to the level set by resistors R_8 and R_{10}. This sequence gives a continuous set of oscillations.

For the components shown, the oscillator has a frequency range extending from 0.5 to 2,000 hertz. The curve (b) shows that the output frequency varies exponentially with respect to the input control voltage. For applications that require precise measurements, 0.1% resistors and polystyrene capacitors may be used. In addition, R_2 may be replaced with a 3,300-part-per-million thermistor for reliable operation under varying temperature conditions. □

RC oscillator linearizes thermistor output

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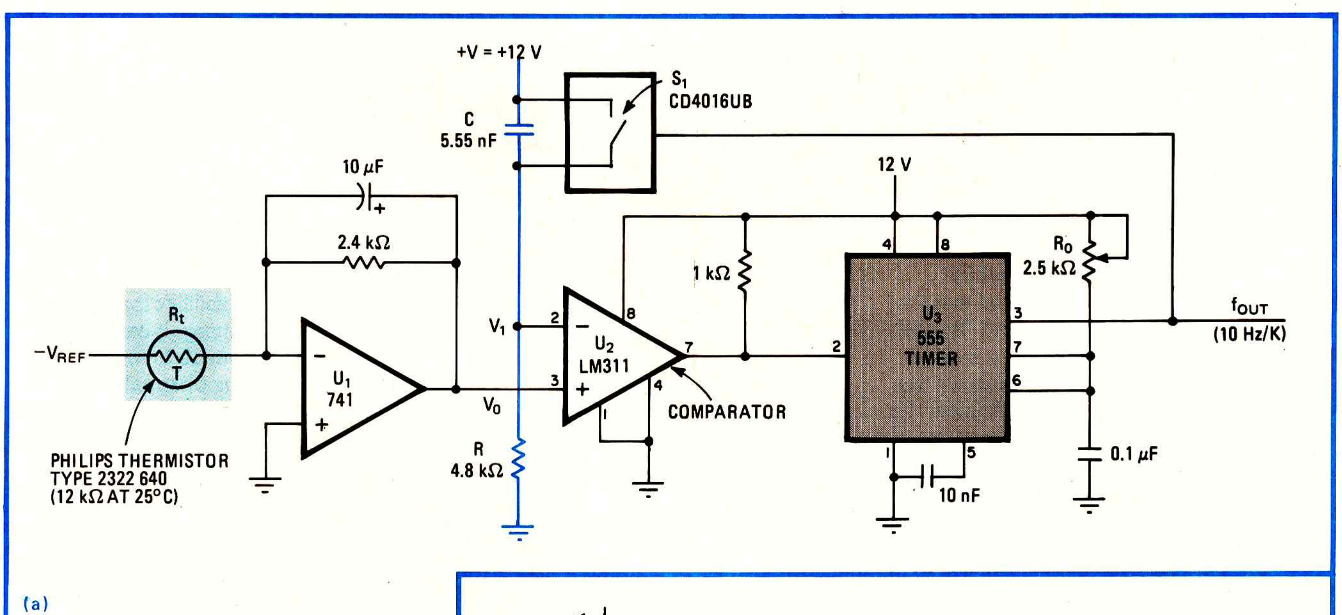
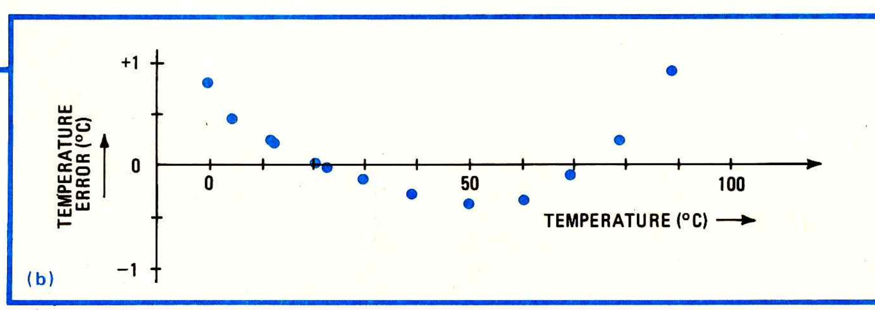
Standard thermistors are seldom employed as temperature sensors because of the exponential relationship that exists between temperature and their resistance. However, a thermistor in conjunction with a simple RC oscillator will generate an output frequency that is proportional to absolute temperature. The linearity error is determined by the thermistor's resistance R_t, which may be derived from the exponential relationship $R_t = Ae^{(B/T)}$, where B is a constant of the circuit and T is the absolute temperature in Kelvin.

Initially, switch S_1 is closed and voltage $V_1 = V$. When S_1 is opened, the value of V_1 decreases according to the relation $V_1 = Ve^{-t/RC}$, where V is the supply voltage, and reaches V_0 when $t = t_0 = RC \ln(V/V_0) = RC(B/T) + k$, where k is a time constant. When V_0 is reached, the comparator output goes high and triggers monostable U_3 (a). This output has a duration of t_1 and





Linearizing. This RC oscillator (a) helps to linearize a standard thermistor and enables it to function as a temperature sensor over a wide temperature range. The circuit is calibrated with the relationship $f_{out} = T/RCB$, where T is the absolute temperature and RCB is the circuit constant. The trace (b) shows the error over the range 0° to −100°C.