C-MOS oscillator has 50% duty cycle

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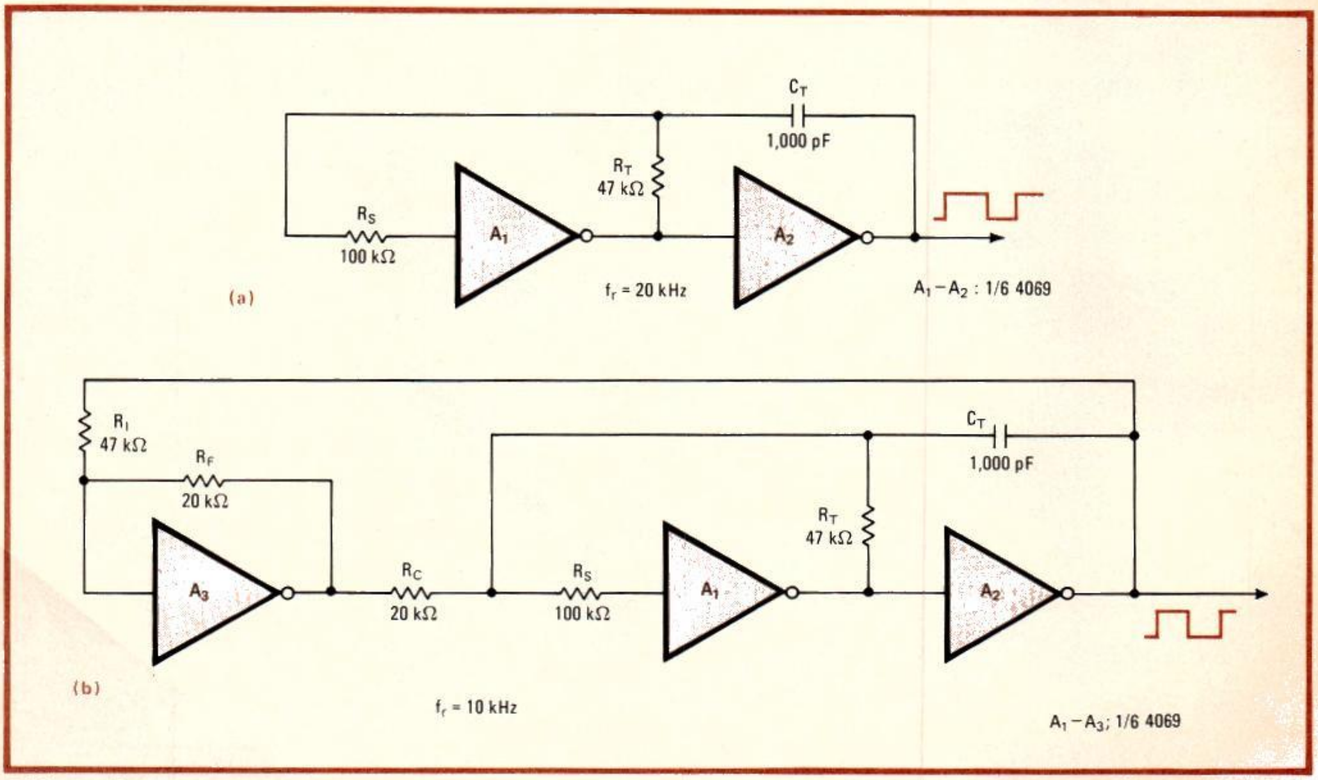
Astable multivibrators built with complementary-metal-oxide-semiconductor gates suffer one major drawback—their duty cycle may vary from 25% to 75% because of the variations of each gate's switching-threshold voltage (V_{TH}). Variations in the V_{TH} can be canceled and the desired square-wave output therefore attained by adding a C-MOS inverter and three resistors to the basic circuit. The gate-resistor combination uses negative feedback to perform the compensation.

The standard astable multivibrator is shown in (a) of the figure. Running at a frequency ($f = ½R_TC_T$) that is almost independent of the individual gate used, the circuit nevertheless has an unpredictable duty cycle because of a V_{TH} that can vary by up to 40% on either side of $V_{DD}/2$, where V_{DD} is the supply voltage. If a 50% duty cycle is required, either this circuit must be followed by an edge-triggered flip-flop, or each circuit must be individually adjusted using two trimpots and a diode (see RCA application note ICAN-6267).

The circuit in (b) eliminates these drawbacks. Inverter A_3 creates a second negative-feedback path around A_1 (the signal flow through R_T constitutes the prime path). A_3 is operated at a low closed-loop gain, much like an operational amplifier working in the linear portion of its characteristic. As a result, A_3's inverted threshold voltage can be combined with the negative feedback voltage and injected into A_1. If the ratio R_F/R_I equals the ratio R_C/R_T, complete cancellation of threshold errors between A_1 and A_3 can be obtained. It is assumed that A_1 and A_3 are contained in the same package along with A_2 and that their V_{TH}s are essentially equal.

Since A_3's gain must be set so that its output will not saturate with a ±40% variation of V_{TH}, resistor values must be selected so that $R_I/R_F = 2.33$. At the same time, the correct gain for A_3 is set when $R_CR_I = R_FR_T$. In these circumstances, and ignoring stray and input capacitances, the multivibrator's operating frequency will be $f = 1/R_TC_T$ and the duty cycle will be 50%.

Note that the operating frequency, in this case 20 kHz, is twice that of the standard astable circuit using the same values of C_T, R_T, and R_S because of the second feedback path. □



Right on. Standard astable multivibrator using C-MOS gates (a) has unpredictable duty cycle because of variable switching-threshold voltages. Adding inverter and three resistors (b) creates second negative feedback path around A_1, forcing A_1 and A_2's switching point to half the supply voltage, so that 50% duty cycle is attained and square waves are produced.