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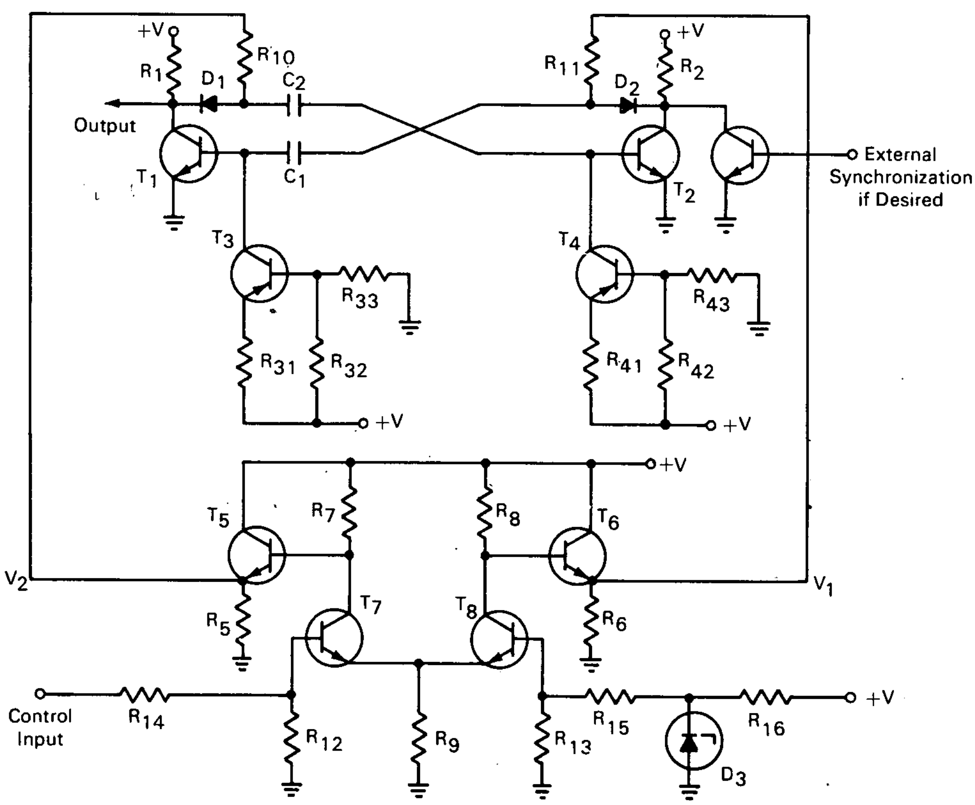
NASA TECH BRIEF

Constant-Frequency, Variable-Duty-Cycle Multivibrator



The problem:

To provide a pulse source of constant frequency with a duty cycle that is adjustable by an external input signal. Such a circuit would be most useful as a switching mode voltage regulator and could also find use as a switching source for a variety of control systems.

The solution:

A circuit in which the above requirements are met and which may easily be synchronized by an external signal without interfering with the operation of the duty cycle control.

How it's done:

Assume transistor T_2 is on. The capacitor C_1 has previously charged to potential V_1. With T_2 on, capacitor C_1 supplies a voltage $-V_1$ to the base of T_1, thus holding it off. The current source formed by transistor T_3 and its bias resistors R_{31}, R_{32}, R_{33}, causes this potential to increase linearly with time according to:

$$v_{beT_1} = -v_1 + \frac{It}{c_1}$$

where V_{beT1} is the base-emitter voltage of T_1, I the current produced by T_3, and t time. When V_{beT1} equals the "on potential" (i.e. forward bias potential)

(continued overleaf)

of T_1, T_1 turns on and T_2 turns off due to cross coupling. Thus, the duration of the off time of T_1 is given by $t_1 = (V_{be} + V_1)\frac{C_1}{I}$ where V_{be} is the forward bias voltage drop of T_1. Similarly, the duration of the off time of T_2 is given by $t_2 = (V_{be} + V_2)\frac{C_2}{I}$. The total duration of a cycle of the oscillator is then $T = t_1 + t_2 = \frac{C_2}{I}(V_1 + V_{be}) + \frac{C_2}{I}(V_2 + V_{be})$. If $C_1 = C_2$, we have $T = \frac{C}{I}(V_1 + V_2 + 2V_{be})$. Since V_1 and V_2 are derived from the differential amplifier T_5, T_6, T_7, T_8, R_5, R_6, R_7, R_8, R_9, the sum $V_1 + V_2$ is constant. Thus, the frequency of operation is constant, but the duty cycle, or equivalently, the off time of T_1, is a linear function of V_1 (see previous equation for t_1). V_1 is in turn a linear function of the control input signal. The duty cycle is thus controllable at constant frequency. The diodes D_1 and D_2 serve to decouple the charging of capacitors C_1 and C_2 from the power supply +V. Resistor R_{16} and Zener diode D_3 provide a reference input so that the duty cycle is a function of the difference between the control input and the reference voltage of D_3. The circuit may, therefore, also be used as a pulse duration modulator.

Notes:

1. The operation of the circuit is unchanged if a more complex differential amplifier is used instead of T_5, T_6, T_7, and T_8. Resistor R_9 may be replaced by a transistor current source network similar to transistor T_3, R_{31}, R_{32}, and R_{33}. Any other constant voltage source may be used in place of D_3 or it may be replaced by a resistor voltage divider network.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B69-10512

Patent status:

No patent action is contemplated by NASA.

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