CIRCUIT: The pulse generator circuit in Fig. 1 produces one pulse each time the input, at v_M, goes high. A comparator, as shown in Fig. 1, or a logic gate can provide the input signal to start the output pulse.

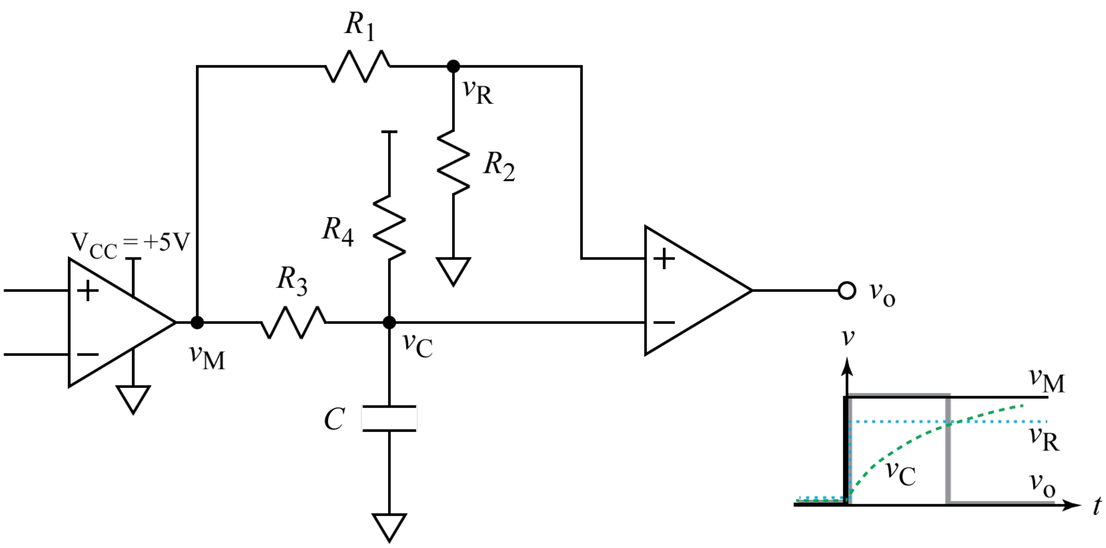

Fig. 1. Pulse generator circuit.

The duration of the output pulse at v_o is controlled by the R_3C time constant and the voltage divider formed by R_1 and R_2. When the signal at v_M goes high at $t = 0$, the signal at v_R immediately goes high, whereas the voltage at v_C starts to rise according to the general solution of an RC circuit:

$$v_C(t > 0) = e^{-t/\tau}[v_C(0) - v_C(t \to \infty)] + v_C(t \to \infty)$$

where $\tau = R_3C$.

If v_M has been low for several time constants, the C will discharge. For an LM324 quad op-amp with supplies of +5 V and 0 V, the output-low voltage is close to 0 V.

Thus, the initial voltage on the C is he output of the voltage divider formed by R_3 and R_4 with $v_M \approx 0$ V.

$$v_C(0) = \frac{v_M R_4 + V_{CC} R_3}{R_3 + R_4} \approx \frac{V_{CC} R_3}{R_3 + R_4}$$

For an LM324 quad op-amp with supplies of +5 V and 0 V, the output-high voltage is approximately $v_{+\text{Rail}} \approx 3.6$ V. Thus, the final voltage the C is charging toward is

$$v_C(t \to \infty) = \frac{v_{+Rail}R_4 + V_{CC}R_3}{R_3 + R_4}.$$

Substituting the values above and performing a few steps of algebra, we have

$$v_C(t > 0) = e^{-t/\tau}[v_C(0) - v_C(t \to \infty)] + v_C(t \to \infty)$$

or

$$v_C(t > 0) = e^{-t/(R_3C)}\left(\frac{V_{CC}R_3}{R_3 + R_4} - \frac{v_M R_4 + V_{CC}R_3}{R_3 + R_4}\right) + \frac{v_M R_4 + V_{CC}R_3}{R_3 + R_4}.$$

or

$$v_C(t > 0) = e^{-t/(R_3C)}\left(-\frac{v_M R_4}{R_3 + R_4}\right) + \frac{v_M R_4 + V_{CC}R_3}{R_3 + R_4}.$$

or

$$v_C(t > 0) = \left[1 - e^{-t/(R_3C)}\right]\left(\frac{v_M R_4}{R_3 + R_4}\right) + \frac{V_{CC}R_3}{R_3 + R_4}.$$

The extra term on the right ensures that the comparator's – input will be more positive than the + input when the circuit, so the output of the comparator will be low.

Once v_M goes high, the output of the circuit, v_o, goes high and stays high until $v_C = v_R$. If $R_4 >> R_3$, the last term on the right in the preceding equation is small, and the timing of the circuit is nearly independent of the exact value of v_M. From here on, we will assume that R_4 is quite large, and we use a simpler formula for $v_C(t > 0)$:

$$v_C(t > 0) \approx v_M\left[1 - e^{-t/(R_3C)}\right].$$

The value of v_R is given by the voltage-divider formula:

$$v_R = v_M \frac{R_2}{R_1 + R_2}$$

We solve for the duration, Δt, of the output pulse by solving for $v_C = v_R$.

$$v_R = v_M \frac{R_2}{R_1 + R_2} = v_C(\Delta t) \doteq v_M[1 - e^{-\Delta t/\tau}]$$

or

$$v_M \frac{R_2}{R_1 + R_2} \doteq v_M[1 - e^{-\Delta t/\tau}]$$

or

$$\frac{R_2}{R_1 + R_2} \doteq 1 - e^{-\Delta t/\tau}$$

or

$$\frac{R_2}{R_1 + R_2} - 1 \doteq -e^{-\Delta t/\tau}$$

or

$$-\frac{R_1}{R_1 + R_2} \doteq -e^{-\Delta t/\tau}$$

or

$$\frac{R_1}{R_1 + R_2} \doteq e^{-\Delta t/\tau}$$

or

$$\ln \frac{R_1 + R_2}{R_1} \doteq \Delta t / \tau$$

or

$$\Delta t \doteq \tau \ln \frac{R_1 + R_2}{R_1} \doteq R_3 C \ln \frac{R_1 + R_2}{R_1} .$$

Suppose, for example, $R1 = R2$.

$$\Delta t \doteq R_3 C \ln 2 \approx \tau(0.693)$$

Thus, the time constant we use is $\tau = R_3 C \approx \frac{\Delta t}{0.693} \approx (1.44)\Delta t \approx (1.5)\Delta t$.