# AN OSCILLATOR USING THE NAND SCHMITT–TRIGGER

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A simple method to generate rectangular waves is with NAND Schmitt-trigger the gate.

The oscillator here presented uses only one of the four gates existent in the commercial integrated circuit CD4093 or its equivalent circuits.

The advantage of the circuit shown here is that it is possible to control the frequency and duty-cycle in an almost independent manner.

In the diagram we see that the capacitor charges by the 'high' output through the resistor **R2** and the part **Rd** of **R1** to the right of its center, as its left part is short-circuited by the left diode.

As the threshold of the IC is reached, this produces an output 'low' that discharges the capacitor through **R2** and the left part **Re** of **R1**, as its right part is short-circuited by the right diode. So, the charge time constant depends on **R2 + Rd** and the discharge time constant depends on **R2 + Re**. As the period of the oscillation is the sum of those two time constants, it depends don **R2 + Re + R2 + Rd**. But **Re + Rd = R1**, and the period depends only on **2 x R2 + R1**, that is, independent of the value of the control **R1**.

Thus, **R1** controls the ration between the charge and discharge times, that is, the duty-cycle, and the position of **R2** controls the frequency. The maximum frequency is given for **R2 = 0**, that is, it is limited by value of **R1** (of course, also by the characteristics of the IC).

The above calculi consider the diodes as ideal ones; therefore, germanium diodes are more suitable for greater independence of both controls.

The charge time **Tc** corresponds to the voltage increase from **Vmin** to **Vmax**. During the charge the capacitor voltage is given by:

$Vc = A + B \cdot \exp(-t/\tau c)$ where $\tau c$ = charge time constante; as, for $t = 0$, $Vc = Vmin$ and for $t \rightarrow \infty$, $Vc \rightarrow Vmax$, we have:

$Vc = Vcc + (Vm - Vcc) \cdot \exp(t/\tau c)$; as, for $t = Tc$, $Vc = Vmax$, we have:

$Vmax = Vcc + (Vmin - Vcc) \cdot \exp(Tc/\tau c)$ or $Tc = \tau c \cdot \ln [(Vcc - Vmin) / (Vcc - Vmax)]$

**ln** stands for the natural logarithm.

The threshold ‘up’ and ‘down’ voltages **Vmax** and **Vmin** for the used IC are respectively 60% and 40% (typical) of the supply voltage **Vcc** (this varies with temperature and with **Vcc** itself). So, we can write for the charge time:

$$Tc = 0.4 \cdot \tau c \quad (1)$$

The discharge time **Td** corresponds to the decrease from **Vmax** to **Vmin**. During the discharge the capacitor voltage is given by:

$Vc = a + b \cdot \exp(-t/\tau d)$, where $\tau d$ = discharge time constant; as, for $t = 0$, $Vc = Vmax$, and for $t \to \infty$, $Vc \to Vmin$, we have:

$Vc = Vmax \cdot \exp(-t/\tau d)$; as, for $t = Td$, $Vc = Vmin$, we have:

$Vmin = Vmax \cdot \exp(-Td/\tau d)$ or $Td = \tau d \cdot \ln(Vmax / Vmin)$. With their values, we can write for the discharge time:

$$Td = 0.4 \cdot \tau d \quad (2)$$

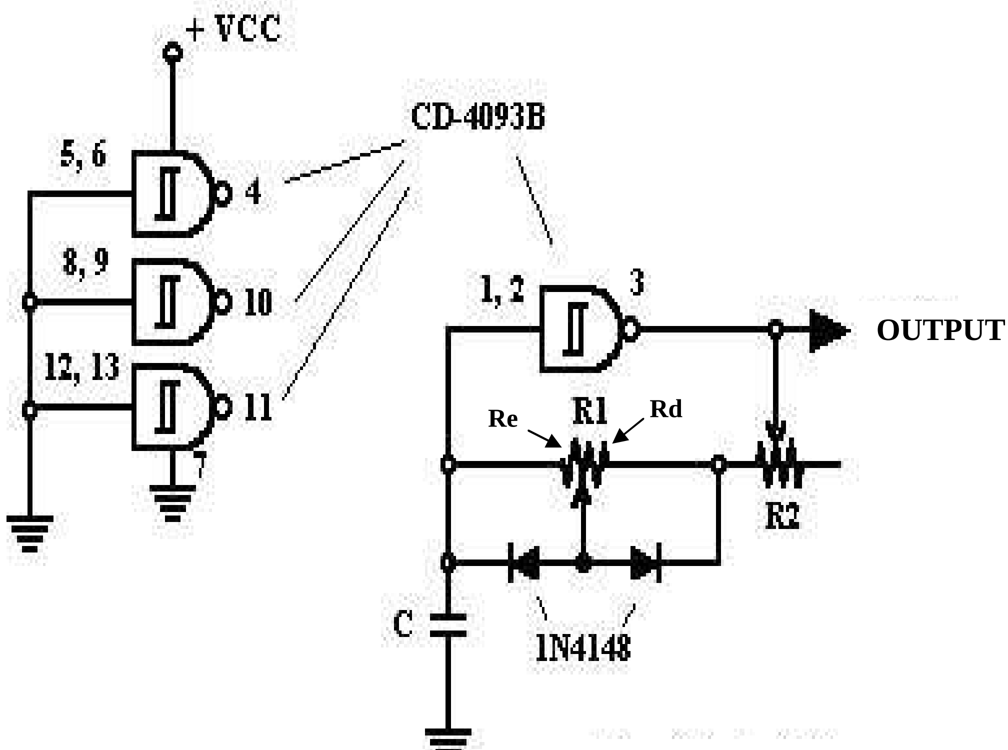
As **(1)** e **(2)** have the same constant 0.4, we have for the total period **T**:

$$T = 0.4 \cdot (\tau c + \tau d) \quad (3)$$

But $\tau c = R2 + Rd$ and $\tau d = R2 + Re$ and so we have, with $Rd + Re = R1$:

$T = 0.4 \cdot (2R2 = R1)$ or the frequency **F**:

$$F = 1 / [0.4 \cdot (2R2 + R1)]$$




The frequency is given approximately by:

$$F = \frac{1}{0{,}81 \times (R1 + R2) \times C}$$

The symmetry is controlled by R1
The frequency is controlled by R2