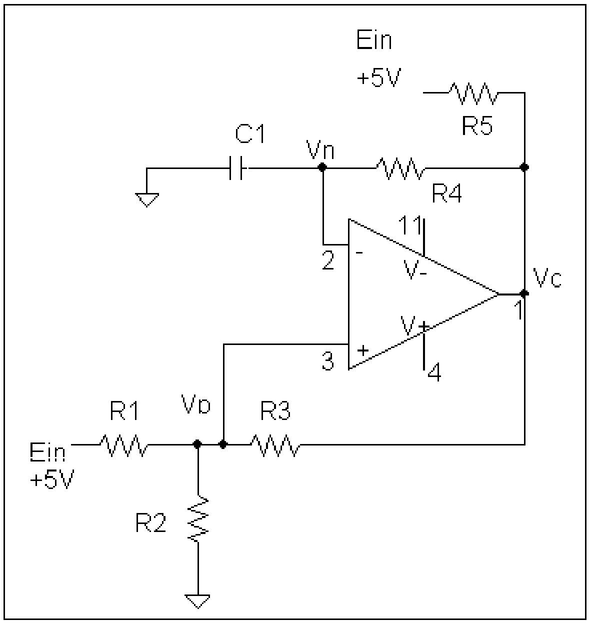
100 Hz Comparator Clock Generator



The analysis of this open-collector comparator (e.g., LM339) clock generator is given by the following equations: (The component values are given below and in the M-file comp100.m)

Run the following MATLAB M-file: comp100.m

Associated function M-files: c100.m

Some definitions are:

Vhi is the final stead-state charge voltage of C6 at node Va

Vlo is the final steady-state discharge voltage of C6 = 0.25V (Vce(sat) of LM339)

Vu is the upper trigger level at node Vb

Vx is the lower trigger level at node Vb

The arrays for the nodes Va and Vb are

$$A = \begin{bmatrix} \frac{1}{R2} + \frac{1}{R1} + \frac{1}{R3} & \frac{-1}{R3} \\ \frac{-1}{R3} & \frac{1}{R3} + \frac{1}{R5} \end{bmatrix}, \quad B = \begin{bmatrix} \frac{E1}{R1} \\ \frac{E1}{R5} \end{bmatrix}$$

where R1 = R2= R3 = 100K, R4 = 5.75K, R5 = 3.3K, C6 = 1uF, and E1 = +5V

The solution is C = inv(A)B = $[3.315 \quad 4.946]^T = [Vu \quad Vhi]^T$

When the comparator output is low (Vce(sat))

$$Vx = \frac{E1}{1 + R1\left(\frac{1}{R2} + \frac{1}{R3}\right)} + \frac{Vlo}{1 + R3\left(\frac{1}{R1} + \frac{1}{R2}\right)} = 1.75\ V$$

Defining a parallel impedance function $Rp(a,b) = \frac{ab}{a+b}$

For the charging time constant τa:

$$Rth = R4 + Rp\left(R5, Rp\left(R3, Rp\left(R1, R2\right)\right)\right), \quad \tau a = Rth \cdot C6$$

The discharge time constant $\tau b = R4 \cdot C6$

Time of 1st half-cycle

$$T1 = \tau a \cdot \ln\left(\frac{Vhi - Vx}{Vhi - Vu}\right) = 5.89\ ms$$

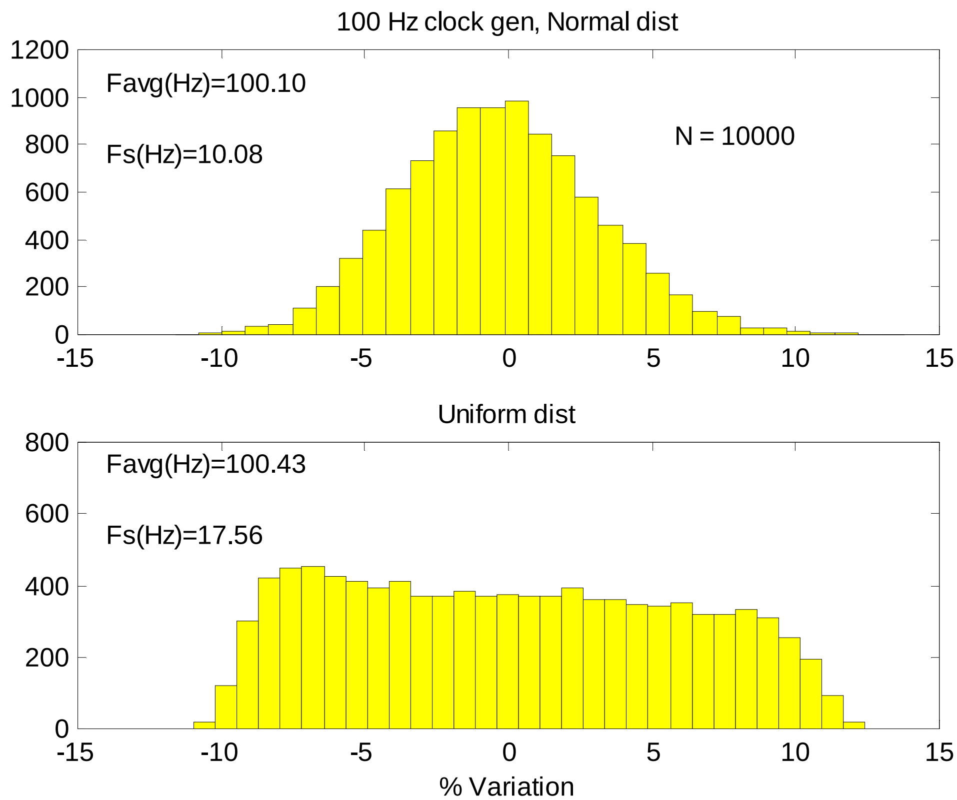
Time of 2nd half-cycle:

$$T2 = \tau b \cdot \ln\left(\frac{Vlo - Vx}{Vlo - Vu}\right) = 4.11\ ms$$

$$Freq = \frac{1}{T1 + T2} = 100.01\ Hz$$

The first two histograms of frequency (normal and uniform distribution inputs) are with N = 10000 samples. Note that the bottom plot has a different vertical scale and somewhat of a sloped uniform shape, in that the bars are longer at the left end of the histogram. Change N to 400 (Spice Monte Carlo maximum) and rerun; note that the definition of the histograms is not as clear as with N = 10000.

The output is given in terms of percent deviation from nominal, which might be more suitable for reports intended for management.



See M-File comp100.m