PreLab 6: Transient Response of a 1st Order RC Circuit

ECEN 214 - 517

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A. Design the circuit of Figure 6.3 to oscillate at a frequency as near to *fo* = 1 Hz as you can get it. Choose component values for *R*, *C*, *R*1, *R*2 that are available to you in your lab kit.

Also, try to choose the values of $R1$ and $R2$ so they sum to value as close as possible to $10k\Omega$. Note, the resistors (or the capacitor) do not necessarily have to be a single component. You can use parallel/series combinations to get the component values closer to where you would like them. Specify your chosen component values and then calculate your expected values for the following quantities related to the voltage $V2(t)$:

A) $R_1 = 5.1k\Omega$

$R_2 = 5.1k\Omega$

$$f_0 = \frac{1}{2 \cdot R \cdot C \cdot \ln\left(1 + \frac{2R_2}{R_1}\right)}$$

$$f_0 = 1 = \frac{1}{2 \cdot R \cdot C \cdot \ln(3)}$$

$2.197 = 1 / RC$

$RC = 0.455$

$R = 470k\Omega$

$C = 1\mu F$

a. Actual frequency of oscillation. This should be near 1Hz but probably not exactly 1Hz.

a) $$f_0 = \frac{1}{2 \cdot R \cdot C \cdot \ln\left(1 + \frac{2R_2}{R_1}\right)}$$

$$f_0 = \frac{1}{2(455000)(1\times10^{-6})\ln\left(1 + \frac{2(5100)}{(5100)}\right)}$$

$$f_0 = \frac{1}{2(455000)(1\times10^{-6})\ln(3)}$$

$f_0 = 1.000262888\ Hz$

$\boxed{f_0 = 1.000263\ Hz}$

b. Peak-to-peak voltage. For this, you will need to know the saturation voltage of the op-amp. Use your measured value from Lab 5.

b) the peak to peak is $\boxed{8V}$

c. Root-Mean-Square (RMS) Voltage. For a periodic signal $x(t)$ with period To, the RMS value is given by $Xrms = \sqrt{1\ To} \int x\ 2(t)dt\ To$, where the integral is taken over any interval of length To. Make sure to show all of your work.

c) $X_{rms} = \sqrt{\frac{1}{T_0}\int_{T_0}^{?} x^2(t)\,dt}$

$X_{rms} = \sqrt{f_0 \int_{1/f_0} (x_1)^2 \, dt}$

$V_2 = \pm V_{sat} + [V_2(0) - V_{sat}]e^{-t/\tau}$

$V_2 = \pm 4 + [-1 - 4]e^{-t}$

$V_2 = \pm 4 - 5e^{-t}$

$V_{rms} = \sqrt{0.999\left[\int_0^{.51}(4 - 5e^{-t})^2 dt + \int_{0.51}^{1.02}(-4 + 5e^{-t})^2 dt\right.}$

$V_{rms} = \sqrt{0.999\ (0.172386 + 1.45105)}$

$V_{rms} = 4.12\ V$

B. Simulate your design using SPICE or Multisim. Print out and hand in the transient waveforms at *V*1, *V*2, and *Vout*. Consult your TA if you need help setting up the transient response in SPICE. A few pointers are listed below.