Introduction to Time-Varying Electrical Networks : Week 7

Problem 1

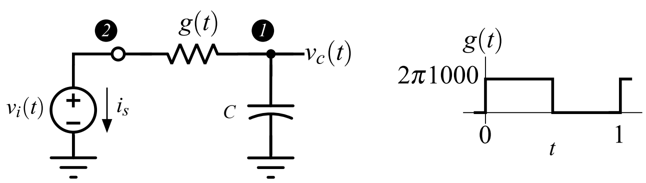

Figure 1: Time-varying RC filter for problem 1.

Fig. 1 shows an RC network with a periodically time-varying resistor. The capacitor $C = 1$ F. The conductance varies from 0 to $2\pi1000$ S as shown in the figure. Write a MATLAB program to determine the harmonic transfer functions of this network. Assume that $g(t)$ has a rise- and fall-times of 0.1 s and an average value that is half its peak value. Denoting the maximum number of harmonics at any node by K, so that there are $(2K + 1)$ sinusoids at any node, your code should be able to accommodate a user-specified K. Plot $|H_k(j2\pi f)|$ for $k = 0, \pm1$, for $K = 128, 256, 512$. For uniformity, the range of the y-axis must be 0-1, and the x-axis from -3 to 3 Hz, with increments in f chosen to be 0.05. What do you notice as you change K? Run sanity checks for the values of the harmonic transfer functions at frequencies $1, 2, 3$ Hz.

Suggestion : When you invert the **G** matrix in MATLAB to solve **GV = I**, do *not* use `V = inv(G)*I`. Turns out that matrix inversion is a very computationally intensive process – remember that you are inverting a 3000×3000 matrix. Rather, use `V = G\I`, which is much quicker. Since I told you not to do something, I am sure you will definitely do it. See for yourself how much quicker the `V = G\I` is with respect to explicitly computing the inverse.

Problem 5

Fig. 2 shows an RC network with a periodically-operated ideal switch. The switch is closed when $s(t)$ is high and open when it is low. $s(t)$ has a frequency of 1 Hz and a 25% duty cycle. The capacitor $C = 1$ F. $RC = 10$ s. The output is the voltage at the output of the capacitor $v_c(t)$. Analytically determine $H_{-k}(j2\pi k)$ for $1, 2$ (use the fact that $RC \gg T_s/4$ to advantage).

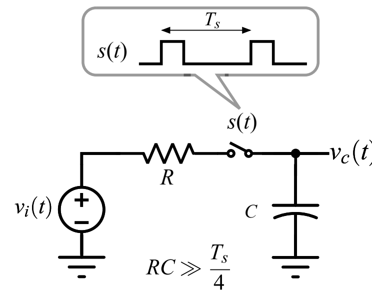

Figure 2: Switched RC filter for problem 2.

Next, use the code you developed in the previous problem to compute $H_{-k}(j2\pi k)$ for $1, 2$. Use $K = 512$, and a frequency resolution of 0.01 Hz. Plot $H_{-k}(j2\pi f)$ for $1, 2$ for f between 0 and 3 Hz at intervals of every 0.01 Hz. What do you notice? For ease of computation, assume that the rise- and fall-times of $s(t)$ are 1% of its period, and that the average of $s(t)$ is 25% of its peak value.