PROBLEM SHEET 8

Frequency effects

1. Determine the gain in decibels if the output voltage is larger than the input voltage:
   a) 2 times; b) 3.16 times; c) 15 times; d) 20 times; e) 31.6 times; f) 80 times; g) 100 times;
   h) 316 times; i) 1000 times; j) 2000 times; k) 3162 times; l) 10000 times.
2. Determine the gain in decibels if the output voltage is smaller than the input voltage:
   a) 2 times; b) 3.1 times; c) 15 times; d) 20 times; e) 31 times; f) 80 times; g) 100 times;
   h) 310 times; i) 1000 times; j) 2000 times; k) 3100 times; l) 10000 times.
3. Determine the cut-off frequency for a *CR* low-pass filter if:
   a) $C = 0.01$ μF, $R = 1$ kΩ;
   b) $C = 0.1$ μF, $R = 1$ kΩ;
   c) $C = 0.2$ μF, $R = 20$ kΩ;
4. Determine the cut-off frequency for a *LR* high-pass filter if:
   d) $L = 0.01$ H, $R = 1$ kΩ;
   e) $L = 0.1$ H, $R = 1$ kΩ;
   f) $L = 0.5$ H, $R = 20$ kΩ;
5. **ASSIGNMENT.** In an *LCR* band-pass filter, $L = 40$ mH, $C = 0.02$ μF and $R = 150$ Ω. Determine the resonant frequency, the Q-factor and the band width for this filter. The filter is connected to a 1 V a.c. voltage source at the resonant frequency. Find the voltage across the coil, across the capacitor and across the resistor in this case.
6. **ASSIGNMENT.** Show that both for a *CR* low-pass filter and for *LR* high-pass filter, the cut-off frequency $f_c = \dfrac{1}{2\pi\tau}$ where τ is the time constant of a *CR* or *LR* circuit respectively.
7. Using MATLAB, obtain a plot of the response as a function of frequency for an *LCR* band-pass filter with $L = 25$ mH and $C = 0.01$ μF. Use the frequency range from 1 to 20000 Hz and the resistance values of 100, 200, 500 and 1000 Ω.
8. Using MATLAB, obtain a plot of the response as a function of frequency for a *CR* low-pass filter with $R = 500$ Ω and $C = 1$ μF. Use the frequency range from 1 to 100000 Hz. Make the plot in a) a semilog scale (frequency - logarithmic, response - linear) and b) loglog scale (both frequency and response - logarithmic).

9. (*) Determine the phase difference between the input and output voltages:
   1) For a *CR* low-pass filter at frequencies: a) cut-off frequency f_c; b) $100\times f_c$; c) $0.01\times f_c$.
   2) For a *LR* high-pass filter at frequencies: a) cut-off frequency f_c; b) $100\times f_c$; c) $0.01\times f_c$.
   3) For a *LCR* band-pass filter at frequencies: a) resonant frequency; b) cut-off frequencies f_1 and f_2; b) $100\times f_2$; c) $0.01\times f_1$.

   You may choose any values of *C*, *L* and *R*

10. (*) Using MATLAB, obtain a plot of the phase difference between the input and output voltages as a function of frequency
    1) For a *CR* low-pass filter
    2) For a *LR* high-pass filter
    3) For a *LCR* band-pass filter
    4) For a *LCR* band-stop filter

    You may choose any values of *C*, *L* and *R*