ENSC3021 Tutorial Problems 4A

Martin T. Hill, 23rd March 2019

Question 1.

The input impedance to an oscilloscope can be modelled as a resistor and a capacitor connected to the input terminals, Figure 1. Note in Figure 1 the resistor is represented here by its conductance G (G=1/R).

Often a probe is connected to the input terminals to measure a potential difference in a circuit. The probe typically consists of a resistor and variable capacitor (whose value C_1 can be adjusted manually) in parallel (G_1 and C_1 in figure 2). The potential difference in the circuit to be measured is shown as $v_1(t)$ in figure 2. Figure 2 shows a circuit diagram of the probe connected to the oscilloscope input.

A) Can the circuit of figure 2 provide a distortion less transfer of the circuit voltage $v_1(t)$ to the input voltage seen by the oscilloscope $v_2(t)$ for all frequencies? By distortion less we mean the voltage $v_2(t)$ is just a linearly scaled version of $v_1(t)$, with the scaling factor constant for all frequencies of $v_1(t)$.

B) If yes, what relationships between the values of the resistors and capacitors must there be?

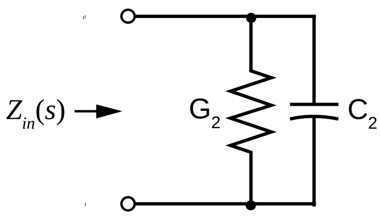

Figure 1.

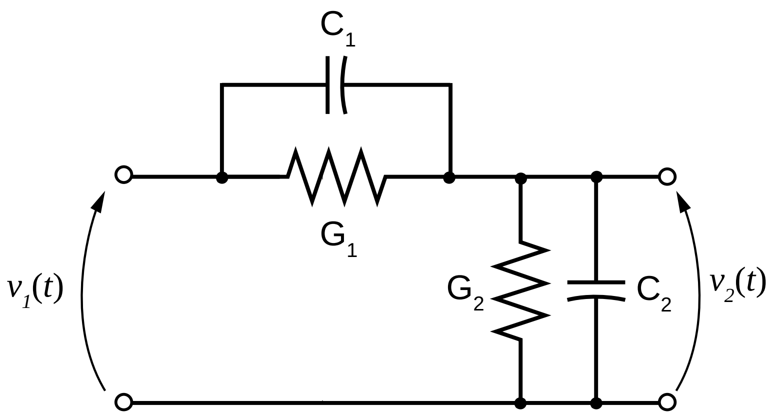

Figure 2.

Question 2.

With reference to the circuit of Figure 3: Apply impedance and frequency scaling so that the driving point impedance (Zin) is 1000 Ω at a new resonant frequency of 10^6 r/s. Give the new values for the resistor, inductor and capacitor. Note the resonant frequency ω_0 with the component values of Figure 3 is 1 r/s.

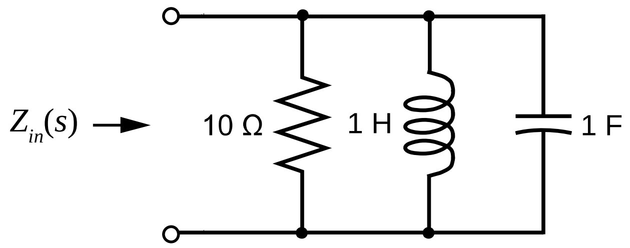

Figure 3.

Question 3.

With reference to the amplifier circuit of Figure 4:

A) Find the voltage transfer ratio $V_{out}(s)/V_{in}(s)$.

B) Make a rough sketch of the poles and zeros of $V_{out}(s)/V_{in}(s)$ on the s-plane.

C) What would be the approximate voltage gain for sinusoids in the middle of the pass band of the amplifier? (pass band in this case meaning frequencies between the upper and lower poles).

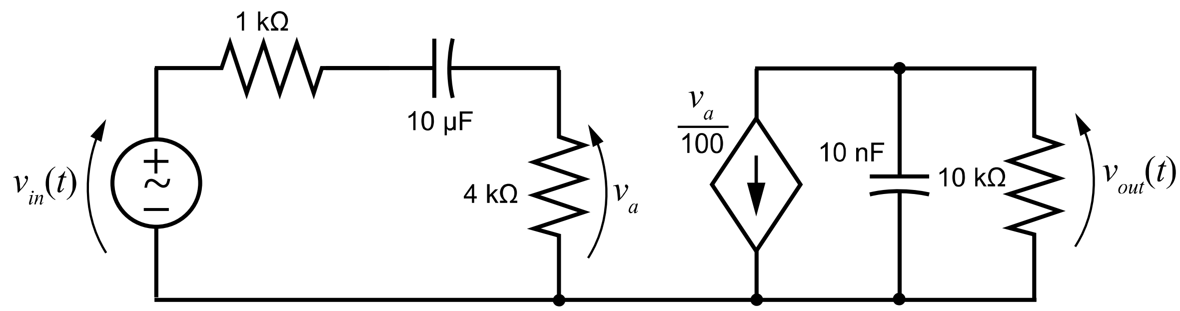

Figure 4.

Question 4.

With reference to the circuit of Figure 5:

A) Find the driving point impedance $Z_{in}(s)$.

B) The network is to be connected to a voltage source with a source impedance of 50 Ω. What value of L should be chosen to give a maximum power transfer to the resistor of 250 Ω for a sinusoidal source frequency of 10^9 r/s?

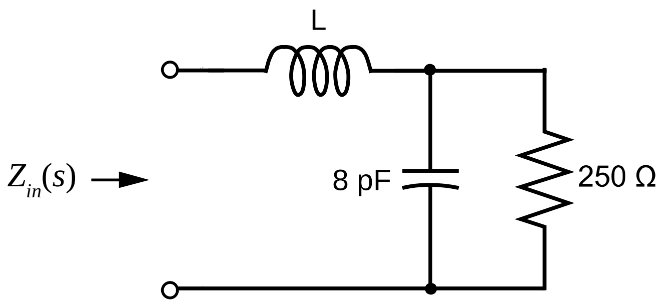

Figure 5.

Question 5.

With reference to the circuit of Figure 6: The switch has been closed for a long time before it is opened at t=0.

A) Find an expression for $v_c(t)$ in the Laplace domain (i.e. $V_c(s)$) for t>0.

B) What are the poles and zeros of $V_c(s)$.

C) Find $v_c(t)$ for t>0 from $V_c(s)$.

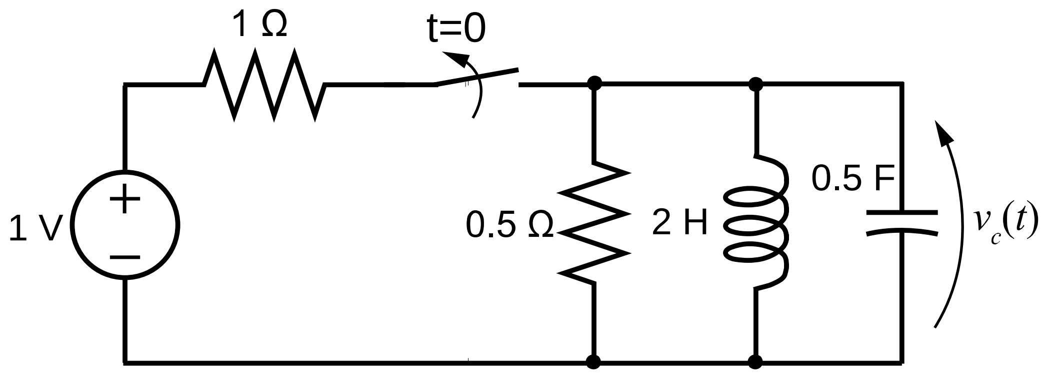

Figure 6.