Simulation # 4

<u>Effect of R on Q factor</u>

Electrical and Electronic circuit simulation laboratory (EE2701)
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Aim of the Expt.:

1. Determine the effect of value of 'R' on the selectivity/Q-factor of the circuit

Theory:

Quality Factor:

The quality factor or Q factor is a dimensionless parameter that describes how under-damped an oscillator or resonator is, as well as characterizes a resonator's bandwidth relative to its centre frequency. Higher *Q* indicates a lower rate of energy loss relative to the stored energy of the resonator; the oscillations die out more slowly. For a series RLC circuit it can be given as

$$\boldsymbol{Q = \frac{1}{R}\sqrt{\frac{L}{C}}}$$

Table 1 Defining the nature of the system based on the value of Q-factor

Value of Quality factor	Condition	Nature of circuit
low	Q < 0.5	Over-damped
High	Q > 0.5	Under-damped
Intermediate	Q = 0.5	Critically

Sinusoidally driven resonators having higher Q factors resonate with greater amplitudes (at the resonant frequency) but have a smaller range of frequencies around that frequency for which they resonate; the range of frequencies for which the oscillator resonates is called the **bandwidth**.

Thus, a high-Q tuned circuit in a radio receiver would be more difficult to tune, but would have more **selectivity**; it would do a better job of filtering out signals from other stations that lie nearby on the spectrum. High-Q oscillators oscillate with a smaller range of frequencies and are more stable. *Q* can alternatively be defined as the ratio of the energy stored in the oscillating resonator to the energy dissipated per cycle by damping processes.

Comparison of series and parallel resonance circuit:

item	*series circuit (R–L–C)*	*parallel circuit (R–L and C)*
Impedance at resonance	Minimum	Maximum
Current at resonance	Maximum = V/R	Minimum = $V/(L/CR)$
Effective impedance	R	L/CR
Power factor at resonance	Unity	Unity
Resonant frequency	$1/2\pi\sqrt{(LC)}$	$\frac{1}{2\pi}\sqrt{\left(\frac{1}{LC}-\frac{R^2}{L^2}\right)}$
It magnifies	Voltage	Current
Magnification is	$\omega L/R$	$\omega L/R$

Figure 1 Comparison of series and parallel resonance circuit

Simulation:

1. Simulate circuit 'A' to find the how the circuit behaves for various values of Q by changing the values of R.
2. Method called as parametric sweep is used to simulate such cases, the procedure is as follows:
3. Go to Simulate -> Analyses -> Parametric Sweep
4. Adjust the parameters for parameter sweep as shown in Figure 2, Figure 3, and Figure 4.

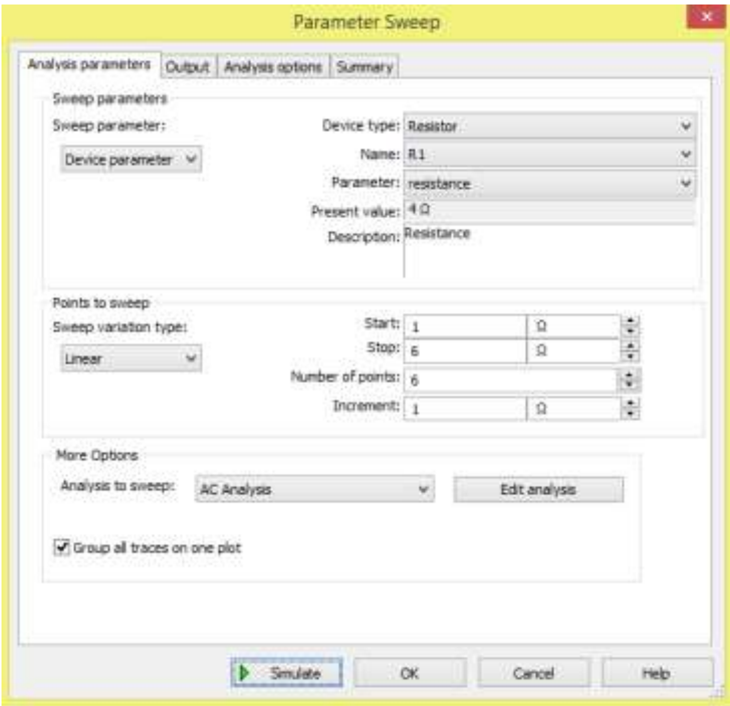

Figure 2 Parameter Sweep for Part II

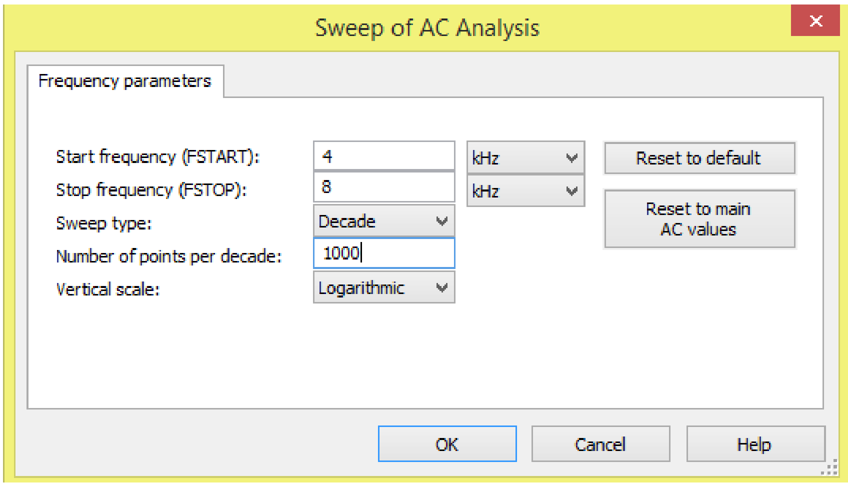

Figure 3 AC analysis for parameter sweep of part II

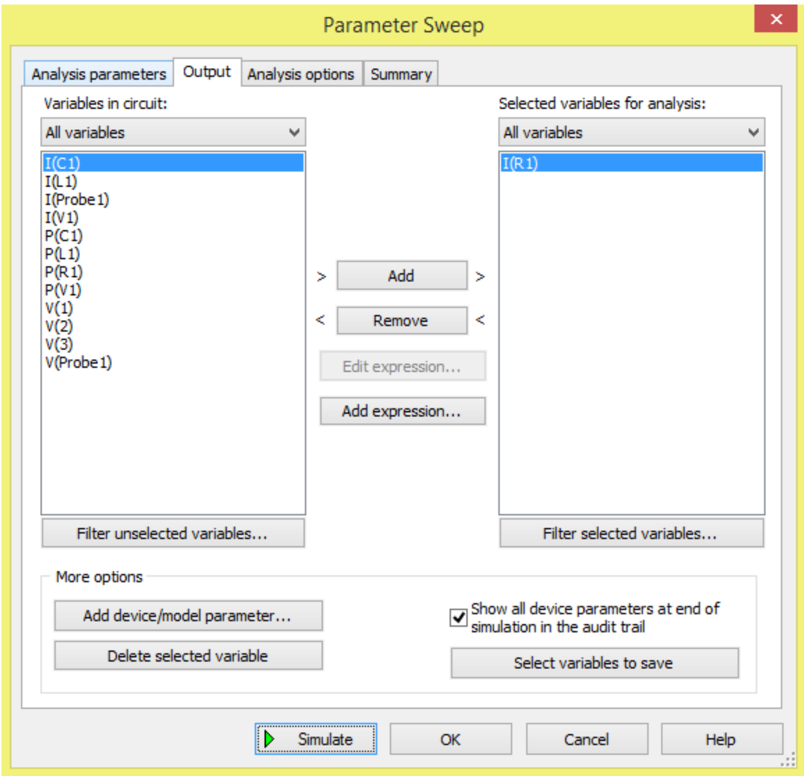

Figure 4 Probable output values for the graph of part II

5. Plot the graph, sample is shown by Figure 5.
6. Repeat the exercise for circuit B.

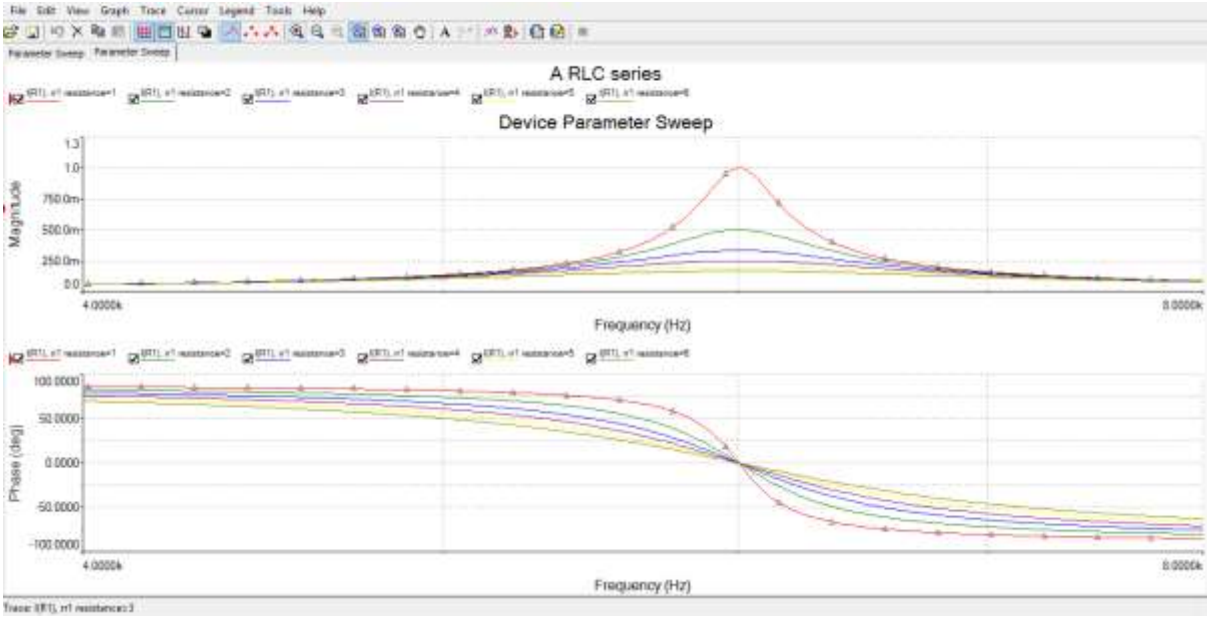

Figure 5 Parameter sweep analysis for part for a series RLC circuit

Questions:

1. What is the impact of R on the Bandwidth, quality factor and selectivity?
2. Is it possible to use an RLC circuit as a filter? Illustrate with reason.