EXPERIMENT 5
RESONANT CIRCUITS

PRELIMINARY WORK

The response of a circuit containing both inductors and capacitors in series or in parallel depends on the frequency of the driving voltage or current. This laboratory will explore one of the more dramatic e ects of the interplay of capacitance and inductance, namely, resonance, when the inductive and capacitive reactances cancel each other. Resonance is the fundamental principle upon which most lters are based lters that allow us to tune radios, televisions, cell phones, and a myriad of other devices deemed essential for modern living.

P1 Consider the series resonant circuit shown in Figure 1. Find **resonant frequency** f_0 and and the half power frequencies (f_1, f_2) of the circuit in kHz. Calculate the bandwidth (BW) and quality factor(Q) of the circuit. Find the expressions for Z(jw), V(jw), I(jw) and plot their magnitudes on scale against f=/2π. Indicate f_0, f_1 and f_2 on the plot for $|I(jw)|$.

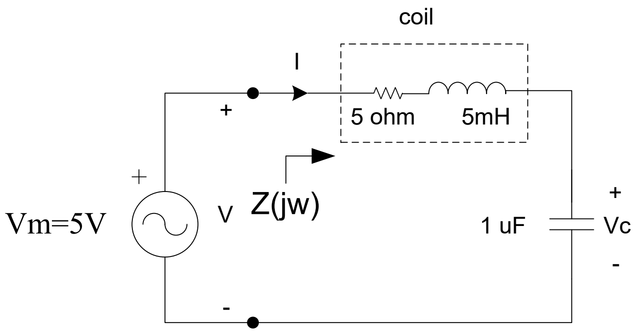

Figure 1 Series Resonant Circuit

P2 Consider the parallel resonant circuit shown in Figure 2. Find **resonant frequency** f_0 and and the half power frequencies (f_1, f_2) of the circuit in kHz. Calculate the bandwidth (BW) and quality factor(Q) of the circuit. Find the expressions for Z(jw), V(jw), I(jw) and plot their magnitudes on scale against f=/2π. Indicate f_0, f_1 and f_2 on the plot for |Z(jw)|.

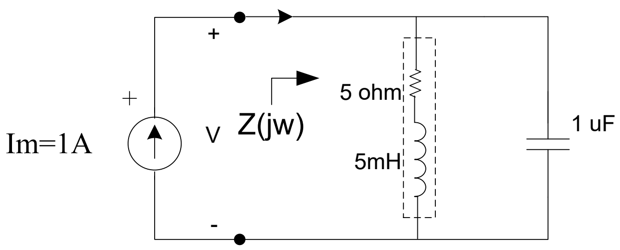

Figure 2 Parallel Resonant circuit

EXPERIMENTAL WORK

E1 Build the series resonant circuit as shown in **Figure 1.** Set the signal generator to a sine wave output with an amplitude of $\boldsymbol{V_m}$ = 5V. Vary the frequency of the source to find the **center frequency (f_0,)** where the current is at its maximum. Identify the **lower and upper cut-off frequencies (**f_1 and f_2**)** where the magnitude of the response drops to $1/\sqrt{2}$ (approximately 70.7%) of its maximum value. Using these values, calculate the **Bandwidth (*BW*)** and the **Quality Factor (*Q*)** using the following formulas:

$$BW = f_2 - f_1$$

$$Q = \frac{f_0}{BW}$$

Record the values of **Voltage (*V*)** and **Current (*I*)** for at least **15 different frequencies** starting from 100 Hz up to 10 kHz. For each frequency point, calculate the **Impedance Magnitude (|Z|)** using Ohm's Law: $|Z| = \frac{V}{I}$.

Using the obtained data, plot the following curves on linear scales:

- **Impedance Magnitude vs. Frequency** (|Z| vs. f)
- **Current Magnitude vs. Frequency** (|I| vs. f)

E2 Build the parallel resonant circuit as shown in Figure 3. Note that the current source is simulated by using a voltage source in series with a high resistance (10 kΩ). Set the signal generator to a sine wave output with an amplitude of V_m = 10V. Vary the frequency of the source to find the **center frequency (f_0,)** where the voltage V across the parallel network is at its **maximum**. Identify the **lower and upper cut-off frequencies (**f_1 and f_2**)** where the magnitude of the response drops to $1/\sqrt{2}$ (approximately 70.7%) of its maximum value. Using these values, calculate the **Bandwidth (*BW*)** and the **Quality Factor (*Q*)** using the following formulas:

$$BW = f_2 - f_1$$

$$Q = \frac{f_0}{BW}$$

Record the values of **Voltage (*V*)** and **Current (*I*)** for at least **15 different frequencies** starting from 100 Hz up to 10 kHz. For each frequency point, calculate the **Impedance Magnitude (|Z|)** using Ohm's Law: $|Z| = \frac{V}{I}$.

Using the obtained data, plot the following curves on linear scales:

- **Impedance Magnitude vs. Frequency** (|Z| vs. f)
- **Current Magnitude vs. Frequency** (|I| vs. f)

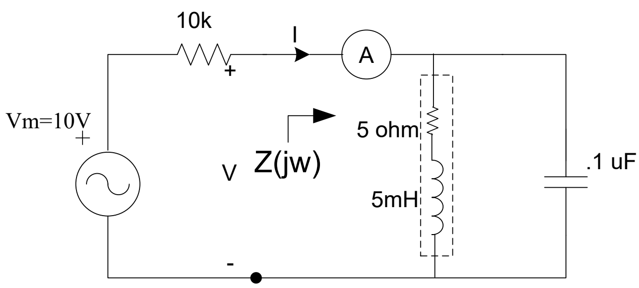

Figure 3 Experimental setup for the test of the parallel resonant circuit

CONCLUSION

C1 Compare the behavior of the series resonant circuit (E1) and the parallel resonant circuit (E2) based on your experimental data. Discuss why the impedance (*Z*) reaches a minimum in series resonance while the voltage (*V*) reaches a maximum in parallel resonance. Do your experimental observations align with the theoretical phasor analysis?

C2 The coil used in the experiment has an internal resistance of 5Ω. How does this resistance affect the Quality Factor (Q) and the Bandwidth (BW) of the circuits? Predict how the shape of your magnitude plot would change if the internal resistance were increased to 50Ω.