Experiment 4:

RC and RLC Circuits

Post-Lab Report

A. Phase Shift Measurements

- Fill the table below and then comment on the results

Phase Shift	
Calculated	57.858
Y-T Format	57.6
Lissajous Figure	57.004

%errors are equal to 0.45% and 1.47% respectively for the Y-T format and the Lissajous Figure.
Thus, there is only a slight difference between the calculated and the observed values for the phase shift. These differences are due to some error reading on the oscilloscope that cannot be observed clearly by naked eyes. (The luminous line on the oscilloscope is bold that one cannot read the value clearly).

B. Lead and Lag Networks

- Explain the shape of the output waveforms of the lag and lead networks to square wave inputs of various frequencies, with particular reference to the fundamental property of a capacitor not changing its voltage instantaneously.

The output voltage differs for the lag and the lead network. For the lead network, as frequency decreases, the waveform (representing Vout) tends to deviate more from its square shape. For the lag network, as frequency increases, the waveform (representing Vout) tends to deviate more from its square shape. This is due to the fundamental property of a capacitor not changing its voltage instantaneously Vc=Vo(exp(-t/RC)) and V(0-)=V(0+)

- What should be the relationship between the RC time constant and the frequency of the square wave so that:
  - The lag network does not appreciably distort the square wave.
  - The lag network acts as an integrator.
  - The lead network does not appreciably distort the square wave.
  - The lead-network acts as a differentiator.

*The lag network does not appreciably distort the square wave implying that the lead network is a differentiator, then 1/F >> RC where RC is very small.
*The lead network does not appreciably distort the square wave implying that the lag network is an integrator, then 1/F << RC where RC is very large.

- What should be the relationship between the RC time constant and the frequency of the sinusoidal input so that:
  - The lag network does not introduce appreciable attenuation.
  - The lead network does not introduce appreciable attenuation.
  - How do these relationships compare with those for the square wave?
  - What is the relationship between a periodic waveform (such as the square wave) and sinusoids? (Refer to Fourier's Theorem).

The lag network does not introduce appreciable attenuation,then RC and F are both small
The lead network does not introduce appreciable attenuation,then RC and F are both large
These relationships also hold for the square wave input functions.
Fourier theorem states that any periodic function can be expressed as the sum of sine and cosine terms, each of which has specific amplitude and phase coefficients.

- The lag and lead networks are also referred to as Lowpass and Highpass filters respectively. Explain what these terms mean and indicate the cutoff frequency in each case.The cutoff frequency is defined as the frequency at which the output amplitude is 0.7071 of its maximum value

The low-pass filter is a filter that passes low frequencies but attenuates frequencies higher than the cutoff frequency (often called the break frequency).
The high-pass filter is a filter that passes high frequencies but attenuates frequencies less than the break frequency.
In case of RC circuit, no matter low-pass or high-pass frequency,
Fb=(1/2T*R*C)

- Considering one of the RC elements to be a source impedance, and the other to be a load impedance, explain the integrating and differentiating action of these networks on the basis of the relationship between source and load impedances in the *s* domain.

In Integrator we consider only high frequencies, so that the
capacitor has not enough time to charge up, so the input voltage approximately equals the voltage across the resistor.
The formula of the integrating low pass lag filter where R is the source impedance and C is the load impedance is H(s)=wc/(wc+s)=(1/RC)/[s+(1/RC)]
In Differentiator, we consider only low frequencies, so that the capacitor has time to charge up until its voltage almost equals that of the source.
The formula of the differentiating high pass lead filter where C is the source impedance and R is the load impedance is: H(s)=s/(wc+s)=s/[s+(1/RC)]

- If the input voltage to either network has an average value of VDC, what will be the average value of the voltage across the resistor and the capacitor? What will be the relationship between these three voltage values?

The sum of the average voltages across the capacitor and that across the resistor will be equal to the average value of the input voltage:
VDC= VCDC + VRDC

C. Series RLC circuits

- Comment on the results obtained and compare the measured resonant frequency to the calculated one.

The resonant frequency measured is 10 KHz slightly smaller than the resonant frequency calculated which is 10.730224 KHz. The %error is 6.805% which is small. However, this difference is due to the reading error on the oscilloscope where reading becomes hard as our eyes cannot determine precisely whether the two waveforms coincide 100%.