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	55
Lissajous Figure	56.44

The phase shifts claculated are almost with only a minor differnce of 4.9% error(Y-T format) and a2. 45% for the Lissajous figure.

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 shape of the waveforms can be explained in that the lag and the lead networks differ in the output voltage.
In the lag network, as the frequency increases, the shape of Vout tends to deviate more from the square shape. In the lead network, as the frequency decreases, the shape of Vout tends to deviate more from the square shape. Since the fundamental property of a capacitor states that the voltage can't change instantaneously, it changes exponentially Vc = V0 * e (-t/RC)

- 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.

IF • The lag network does not appreciably distort the square wave.
• The lead network is a differentiator then 1/F >>RC where RC is a very small quantity.
IF:• The lead network does not appreciably distort the square wave.
• The lag network is an integrator then 1/F <<RC where RC is a very large quantity.

- 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).

In case the lag network does not introduce appreciable attenuation: RC and F should be both small
In case the lead network does not introduce appreciable attenuation: RC and F should be both large
These relationships are the same for the sinusoidal and square wave input functions.
Fourier theorem states that any periodic function can be expressed as the sum of a series 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

By definition a low-pass filter is a filter that passes low frequency signals but attenuates signals with frequencies higher than the cutoff frequency.
Cutoff frequency= $1/ (2\pi \times R \times C)$

However a high-pass filter is a filter that passes high frequencies well, but attenuates frequencies lower than the cutoff frequency. Cutoff frequency= $1/ (2\pi \times R \times C)$

- The cut-off frequency for the series RC circuit has the value $1/ (2\pi \times R \times C)$ whether the circuit is configured as a low-pass filter or a high pass filter.

- 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 measured and calculated frequenices are almost equal with minor differences due to errors in mathematical approximation or error done when reading the frequencies.