EE 230 - Analog Lab
Wadhwani Electronics Laboratory
Electrical Engineering IIT Bombay

Lab:1

Instructions:

- Write down all your observations in notebook.
- Verify your calculations with your respective TA.

Objectives:

- Familiarization with Lab Equipment's and basics of probing the circuit.
- Plot the time and frequency responses of the RC circuit.
- Familiarizing with diode-based circuit.
- Familiarizing with Operational Amplifier-based circuit.

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1. **Time response of the RC circuits**
   Fig.[1] is a simple RC low pass filter. $R_1 = 1K\Omega$ and $C_1 = 100nF$.

   (a) Find the transient response of this RC circuit by applying a square wave (V_{in1}) of 5 V_{pp} with a period of 2 milliseconds and 2.5 V DC offset. Determine the time constant (Using Cursor). Time constant is defined as the time taken by output voltage to rise by 63.2% of the maximum output voltage. Explain your observations (waveforms).

   Note: While measuring using cursor ensure that the part of waveform which is to be observed/measured is adequately zoomed-in in DSO to get accurate readings.

   (b) Determine the bandwidth (in Hz) of the circuit. Bandwidth (in rad/s) is defined as the reciprocal of the time constant. Compare the calculated and measured bandwidth. what is the reason behind the difference between theoretical and practical values?

   The difference is typically due to component tolerances, parasitic capacitance, and real-world circuit behavior.

   ?

   (c) Determine the rise time and the fall time using 'Cursor' on DSO. Rise(Fall) time is defined as the time taken for the signal to reach from 10-90% (90-10%) of its peak-to-peak value (Zoom in and measure). Repeat the same measurements using the 'Measure' functionality on DSO. Compare the results got from cursor and measure utility.

2. **Frequency response of the RC circuits**

   (a) Determine amplitude-frequency response (magnitude Bode plot) of the Fig.[1] RC Network by applying sinusoidal input (1 V_{pp}) and measuring $Vout_{pp}$ at different input frequencies(start from 5 Hz and take more readings until 3 kHz and go to 1 MHz in a step of decades). Note-down readings in tabular format in your notebook. Draw a rough frequency respone plot in your notebook.

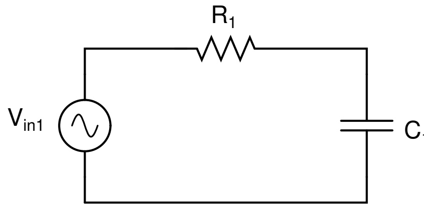

Figure 1: RC Low Pass Filter

(b) Determine the bandwidth of the circuit from amplitude-frequency response. Bandwidth is the frequency range in which the output of a circuit reaches $\frac{1}{\sqrt{2}}$ times the amplitude of the input signal, often corresponding to a -3 dB reduction in output amplitude.

(c) Compare measured bandwidth with the bandwidth calculated from time domain response. Explain your observations.

Probe loading effects, circuit non-idealities, or measurement inaccuracies could lead to variations.

3. **Basics of probing the circuit**

Fig.[2] is a simple potential divider circuit. Probing the circuit means measuring/acquiring electrical signals on oscilloscope. Below are the experiments to demonstrate correct way of probing the circuit

(a) Take V_{dd} = +15 V, V_{ss} = -15 V from DC Power Supply and all resistors of $10K\Omega$. Measure the voltage across R3 resistor using channel 1 of DSO. Compare with the expected value.

(b) Measure the voltage across the R2 resistor using channel 2 of DSO (without removing channel-1 connected across R3 resistor). Compare measured results with the expected result. Explain the cause of error. The DSO can introduce errors due to shared ground connections and impedance mismatches.

(c) To avoid the above cause of the error, which instrument will you use to probe the circuit?

An isolated oscilloscope to minimize measurement errors caused by ground loops and loading effects.

(d) Remove both DSO channels from the circuit and instead of taking VDD and VSS from dc power supply, apply sinusoidal input of 5 V_{pp}, 4.7 KHz from AFG across the potential divider. Measure the voltage waveform across R2. Compare the results with the expected waveform. Explain your observation.

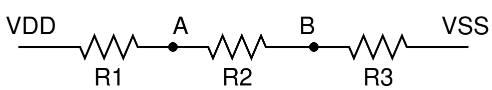

Figure 2: Potential divider circuit

4. **Half wave Rectifier**

(a) The half wave rectifier circuit shown in the figure [3] with $R = 22k\Omega$ and 1N4007 diodes. Apply a sinusoidal input with $4Vpp$ and frequency $1kHz$. Plot V_i and V_o with respect to time on DSO.

(b) Explain the reason behind the reduction in the peak amplitude between the input and the output voltage.

(c) Now, change the polarity of the diode and Explain your observations. Draw the V_i and V_o waveform in your notebook.

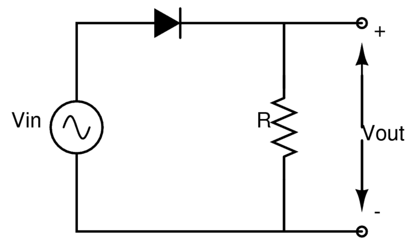

Figure 3: Half wave rectifier

5. **OpAmp based Negative feedback circuits - Non Inverting Amplifier**

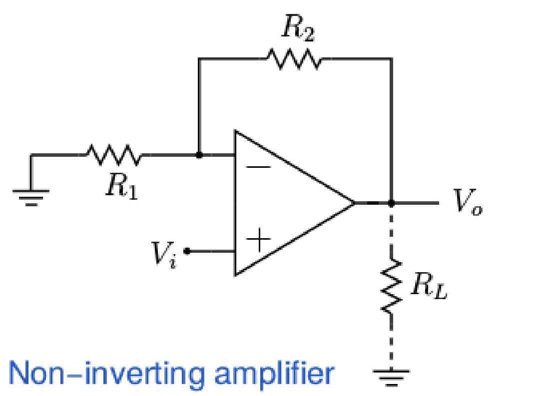

Figure 4: Non-Inverting amplifier

(a) The inverting amplifier circuit shown in the figure [4] with $R_1 = 1k\Omega$, $R_2 = 10k\Omega$. Apply a sinusoidal input with a peak of $0.1V$ and frequency $1kHz$. Apply the supply voltage of $\pm 15V$. Plot V_i and V_o with respect to time. Don't connect R_L explicitly, DSO itself will act as a load while measuring the output.

(b) Now, change the input amplitude from 0.1 V to 2 V and observe the output waveform. Explain what happens to output voltage after a particular value of input voltage.