Analog Electronic Circuits Lab (EC2.103, Spring 2024)

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Instructions:

1. Systematically record your observations in the lab book
2. Save results in USB or take pictures
3. Make meaningful tables to summarize your findings and show it to the instructor(s) during the lab session only
4. Bring your calculators and DMM (if available)
5. Handle equipments carefully and report in case of any incidence
6. Enjoy your time in lab and strengthen your understanding about circuits

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Experiment-1
RC Circuits and diode characterization

1. Know your equipment

a) Bread-board/power-supply/multimeter
Familiarize yourself with these modules.

b) Oscilloscope and function generator
We will use *Keysight EDUX1052G Digital Storage Oscilloscope (DSO)* in our experiments. It has 2 oscilloscope channels and 1 waveform generator in built. For complete functionality refer to the User guide (shared on moodle): Keysight InfiniiVision 1200 X-Series and EDUX1052A/G Oscilloscopes.

i. Read the RC specifications of oscilloscope probes and channel on the equipment

ii. Plot Demo signal available on DSO in one of the channels and report signal parameters (shape, amplitude and frequency)

iii. Generate the signal of your choice (preferably sin wave or square wave so that you can Observe the effect). There will be a mode setting at two places, one in the oscilloscope and another one in the Probe tip. Take different combinations of them (1x and 10x) and plot the signal generated, Mentioning the specification of the signal (Peak to peak Amplitude, Frequency). Make sure you take the measurement using the Cursor function so that you get the proper scaled Values (Note: - Don't measure the parameters just by looking at the display and taking block size). Use the values that are separately shown in the display. Make sure you place the cursors appropriately for measurement. Report the details in table 1. Verify that amplitude of $V_{OSC} = \frac{OSCfactor}{Probefactor} \times V_{in}$.

iv. Generate Sine wave of 10 KHz and observe the spectrum using FFT. Make sure You set the span and the center appropriately. For example, if your fundamental frequency is 10 KHz make sure your center frequency is around that. Make sure your span of the FFT plot is reasonable value so that FFT plot look clear for understanding and taking readings. For this particular experiment, You can set the center at 50 KHz and span of 100 KHz.

Type of signal	Amplitude V_{in} (V_{pp}) (The amplitude which you set)	Frequency (Hz) (The frequency which you set)	Probe factor	OSC factor	V_{OSC} (Oscilloscope measured)	$V_{OSC} = \frac{OSCfactor}{Probefactor} \times V_{in}$

Table 1

v. Generate Square wave and observe the Frequency Spectrum. As mentioned above, set the appropriate Centre and Span according to the fundamental Frequency of your square wave. For example, if your fundamental Frequency is 10 kHz, keep your centre frequency around that value and to observe your plot clearly, you can give 100 KHz span. By this you can see up to 10 different harmonics. Play around with the Span and Centre to get comfortable with the FFT function. Also Make sure you set FFT dB offset to zero if you do not require to give an additional shift in the y-axis. Note down the signal strength for the first 5 harmonics in table 2. Choose a Reasonable Cut-off frequency for your low pass filter depending on your fundamental frequency of the signal ($f_c = \frac{1}{2\pi RC}$) and set the values of R and C accordingly. Note down the signal strength of first 5 harmonics after passing through RC low pass filter in table 2. Check if you observe any particular change in the values when compared to the previous case. Report the Values of R, C, input signal amplitude and the respective cut-off Frequency.

	1^{st} harmonic (strength / frequency)	2^{nd} harmonic (strength / frequency)	3^{rd} harmonic (strength / frequency)	4^{th} harmonic (strength / frequency)	5^{th} harmonic (strength / frequency)
Without filter					
With filter					

Table 2

2. Estimate the effective probe-capacitance

As shown in Fig. 1, You are given $R = 1M\Omega$ and $C = 10\ pF$. Plot input and output using

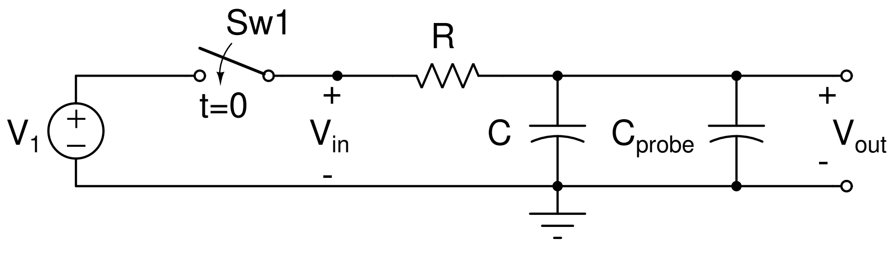

Figure 1

two channels of DSO and measure the time constant (τ_{meas}) of the circuit (use probes/DSO in **10x mode**). Does it match with the calculated (theoretical) value of the time constant (τ_{theo})? What could be the cause of mismatch (extra cap due to probe/wires/bread-board (C_{probe})). Estimate the value of C_{probe}. Fill the following table 3 for different values of capacitance and check the value of C_{probe}.

(Hint: You can either use switch or a pulse source, use cursor facility in DSO and clearly mark the values).

C_{load}	Probe factor	Calculated Time Constant	Measured Time Constant	C_{probe}
10pf	1x			
27pf	1x			
100pf	1x			
10pf	10x			
27pf	10x			
100pf	10x			

Table 3

3. **Two capacitor experiment**
In this experiment we will be observing the switching behaviour (charging and dis-charging) of capacitors for the two capacitor network discussed during lecture. For this we will use the circuit arrangement shown in Fig. 2.

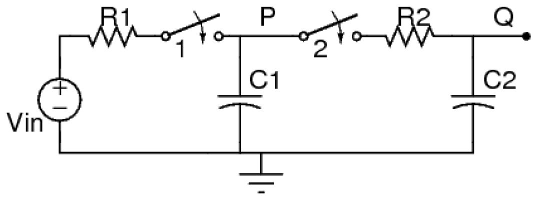

Figure 2

(a) Connect the circuit as shown in Fig. 2 (*Use push buttons*). Choose the values of R and C appropriately so that the time it takes for the capacitors to either charge or discharge($5{*}\tau$) is of the order of 100 ms to be able to observe it on the oscilloscope. For example, Set $C_1 = C_2 = 1\ \mu F$ and $R_1 = R_2 = 100$ KΩ.

(b) Apply a DC supply voltage of 1V with the help of the function generator integrated in the oscilloscope('Wave Gen').

(c) Initially, switch 1 is closed (*push button is kept pressed*) and switch 2 is opened, which allows the capacitor C_1 to charge to the supply voltage(1V). To observe that C_1 is charged/charging, at node P as shown in Figure 2, we place the probe and set the time scale in the order of 100 ms. Also report the initial value, the final value and time taken to reach the final steady state value for the chosen values of R_1 and C_1 in table 4.

Resistance (R_1)	Capacitance (C_1)	V_P (initial)	V_P (final)	Time taken to reach steady state

Table 4

(d) When C_1 is completely charged, open switch 1 and close switch 2, and observe the voltage across nodes P and Q using probes in the oscilloscope. (*Set the time scale in the order of 100 ms. Use Run/Stop button on DSO to capture your plot*)

(e) Note the observations on how the voltages change as time elapses and try to give intuitive explanations for the same.

(f) Now, change the values of $R_2 = 10$ KΩ and observe the changes in the plot on oscilloscope. Report the time it takes to reach V_P and V_Q to its final values for the two values of R_2 in table 5.

(*Note: Make sure that you discharge the capacitors C_1 and C_2 before each trial of experiment to get proper plots, as they tend to hold on to the charge.*)

Resistance (R_2)	Capacitance (C_2)	V_P (initial)	V_P (final)	V_Q(initial)	V_Q (final)	Time taken to reach steady state

Table 5

4. **Diode Characteristics**
Connect the diode in forward bias as shown in Fig. 3 on the breadboard. (Refer to figure 4 for biasing). Apply a sinusoidal signal as the input (V_{in}), with amplitude 1V, using the function generator 'WavGen'.

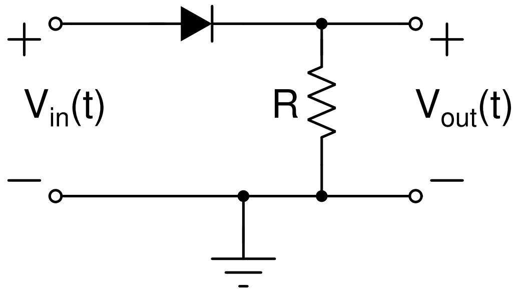

Figure 3: Forward Biased

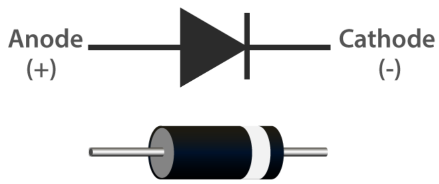

Figure 4

(a) Observe the output signal ($V_{out}(t)$). What can you infer from this? Note down your input output plots/observations.

(b) Plot the I-V characteristics on the oscilloscope using the X-Y mode by pressing the **'Aquire'** button (XY mode plots V_{out} vs V_{in}, where V_{out} is proportional to the current (I_D) through the diode.)

(c) Find the cut-in voltage from the I-V characteristic plot using the cursor options.

(d) Obtain the current at this position by dividing V_{out} with R.

(e) Connect the diode in reverse bias and observe the output. What do you infer from the output?

(f) Plot the I-V characteristics on the oscilloscope.

(g) Observe the I-V characteristics in both forward and backward bias configurations and note down your observations.