Analog Electronic Circuits Lab (EC2.103, Spring 2025)

TAs:

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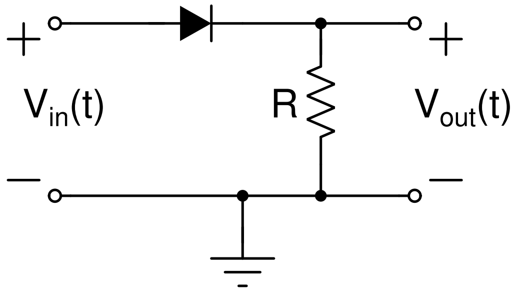
Instructions:

1. Systematically record all your observations in the lab book (mandatory)
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

Experiment-2
Diode characterization and applications

1. **Diode Characteristics**
   Connect the diode in forward bias as shown in Fig. 5 on the breadboard. (Refer to figure for biasing). Use R = 1 kΩ. Apply a sinusoidal signal as the input (V_{in}), with amplitude 1 V, using the function generator 'WavGen'. You can give a low frequency upto few 100's of Hz.



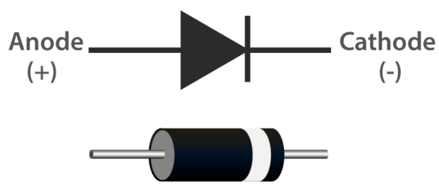


Figure 5: Forward Biased

   (a) Observe the output signal ($V_{out}(t)$). This circuit is an example of a simple half-wave rectifier.
   (b) Plot the voltage transfer 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 transfer characteristic plot using the cursor options.
   (d) Find the internal resistance (r_{on}) of the diode at the following values of V_{in}: 0.55 V, 1.8 V and 2V (hint: R and r_{on} are in series.)
   (e) Observe the transient response of the circuit while varying the frequency of the input signal to 500 Hz, 1 kHz, 10 kHz, 1 MHz and note down your observations.

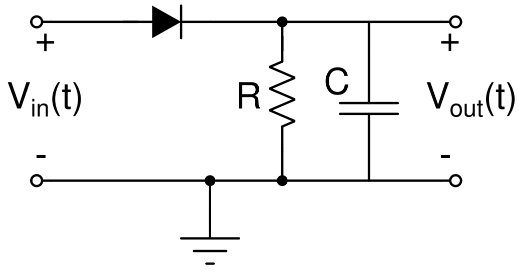


Figure 6: After adding capacitance

(f) Connect a capacitor across the resistor as shown in Fig. 6 and observe the output. (You can take 47 μF and 100 μF.)

2. **Clipper Circuits**

   (a) Now switch the resistor and the diode and connect the circuit as shown in Fig. 7. Use the DC power supply to give the bias voltage. Vary the bias voltage and observe its effects on the output and derive the expression for the output signal. (Hint: To give the bias voltage, use power supply as shown in Fig. 8. Make sure that the tracking ratio is at fixed. Press +20 or -20 in the 'METER' section to change the voltage to positive or negative, respectively, and adjust the $\pm$20 knob in the 'VOLTAGE ADJUST' section to change the voltage. Use COM as the reference voltage.)

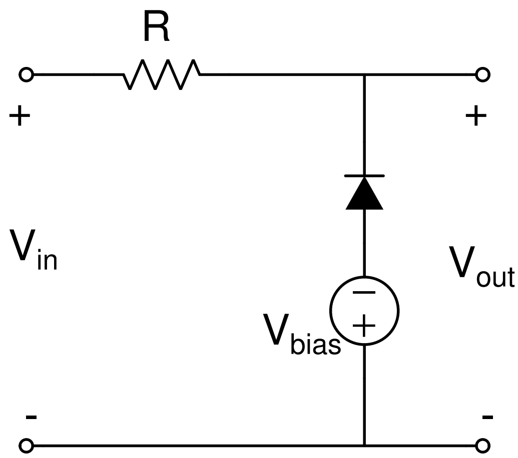


Figure 7: Negative Bias

Figure 8: Power Supply

   (b) Based on the output, plot the transfer characteristics and verify it using the XY mode on the oscilloscope. Vary the DC bias voltage and observe the effect on the output signal and transfer characteristics. Justify with respect to previously obtained expression

(c) Observe the waveform in Fig. 9 and derive the transfer characteristics. Design the circuit that exhibits the derived transfer characteristics by modifying the circuit in Fig. 7.

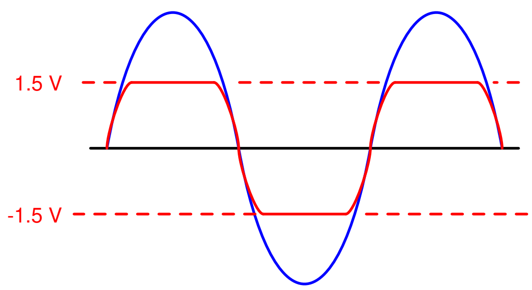


Figure 9: Clipping both half cycles

3. **Application of diode in Energy Harvesting**

   a) Meet the omnipresent - 50 Hz (noise) signal
   Electrical transmission in India uses 50 Hz causing electromagnetic radiations that are picked by almost all equipments and appears as a noise for the experiment under consideration. It is also known as *'mains-hum'* and is very disturbing for low frequency measurements, which commonly occur in biomedical domain (example: ECG, EMG, EEG). In this experiment, we will observe this 50 Hz hum.

   i. Connect a probe to your oscilloscope channel and leave it floating (it acts as an antenna for the 50 Hz signal)
   ii. Adjust time/amplitude scale and check if you can observe 50 Hz signal
   iii. Report the amplitude and frequency from your measurements
   iv. Coil the probe wire, stretch it and see the difference in amplitude (effectively EM radiations received is changed and hence change in amplitude)

   b) A simple energy harvester
   Energy harvesting is a technique, where energy present in the environment can be harvested and utilized for powering electronic circuits. Energy harvesters can lead to battery-less solutions and becoming very popular. Some examples from where energy can be harvested are - radiations from cell towers, vibration and heat.

   Can you think of building a simple energy harvester, which can convert the 50 Hz noise to generate DC voltage? Consider the scheme shown in Fig. 10(a), where a long wire is used as an antenna to capture the 50 Hz radiations present in the environment. Diode will allow

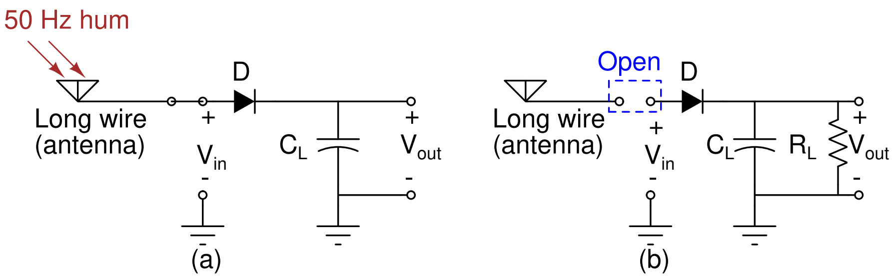


Figure 10

   to charge the load capacitor (C_L) in forward bias condition, which then can act as a voltage supply. You can follow these steps:

   i. As shown in Fig. 10(a), connect diode and $C_L = 100\ \mu$F first.
   ii. Discharge C_L (short both terminals to ground)
   iii. Connect oscillator probe at the output and measure voltage (you should see 0 V)

iv. Connect a big wire (You can use the BNC cable from the function generator.) and measure amplitude of 50 Hz signal using other channel of oscilloscope

v. As shown in Fig. 10(a), now connect the big wire (antenna) to the input of the circuit

vi. Keep observing V_{out} (it should rise **(why?)**), when it reaches to 400 mV, disconnect the long wire (antenna) from the input as shown in Fig. 10(b)

vii. C_L should hold this value for some time (wow, you have stored energy in capacitor from the environment) and will slowly start reducing (why?)

viii. Once voltage drops to 300 mV, connect $R_L = 1\ k\Omega$ resistance. How does V_{out} change now and to what final value

ix. Is it a good/useful harvester. Can you come up with a better harvester (exploratory problem - need not to be submitted)
