Indian Institute of Technology, Bombay
Department of Electrical Engineering
Electronic Devices Lab(EE-236)
Quiz 1, Date: Feb 02, 2022

Timing: 2:00 PM to 4:00 PM | Spring 2022 | Max marks: 10

1 Instructions

- You are allowed to use only those models that have been provided. You can download by clicking the name.
- You need not edit any model file.
- You can use previous lab report, netlist.

2 Problem Statements

1. You have been given a full wave precision rectifier circuit (see Figure 1) and a subcircuit model, let's call it black_box. Your task is as follows,
   - Understand the given model (i.e. black_box). Use it to write the netlist of the given circuit (see Figure 1). ***(1.5 Marks)***
   - Plot the output response (Vout) of the circuit for sine input of **1 Vpeak** and frequency **1 kHz**. ***(0.5 Marks)***
   - Plot the transfer characteristics (Vout vs Vin) of this circuit and comment how transfer characteristics different from that of a full wave rectifier made using **1N4007 (Si diode).** ***(0.5 + 0.5 Marks)***

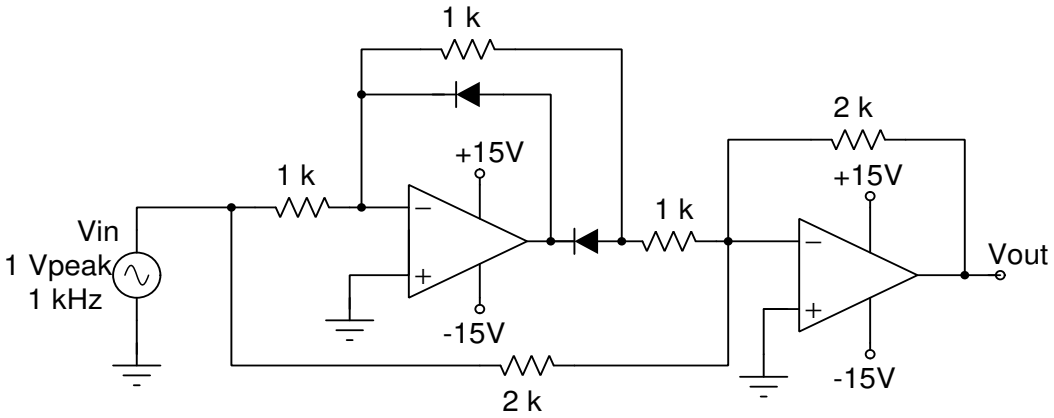

Figure 1: Circuit Diagram

The following models are given to you (Click on the names)
- OpAmp_UA741.
- Black Box

2.
- In this particular part, we want you to plot I-V characteristics of two different diodes. These are fabricated from different materials, let's call them **X** and **Y**. ***(0.5 Marks)***
- You are expected to tabulate **Forward Voltage, Reverse Saturation Current, Peak Inverse Voltage(PIV) and Ideality factor** of each diode. Note your observations and comment. ***(2 Marks)***
- Bandgap of Silicon is **1.14eV** and bandgap of Germanium is **0.67eV**.
- Suggest an application where one can use diode **X**, instead of diode **Y**. ***(0.5 Marks)***

The following models are given to you (Click on the names)
- Diode X.
- Diode Y.

3.
- Plot and comment on C_{DUT} vs $|V_{DUT}|$ characteristics of a **Schottky diode**, where C_{DUT} is junction capacitance and $|V_{DUT}|$ is reverse voltage. ***(2 Marks)***
- Similarly, plot $1/C^2$ **vs** V_{DUT} of a Schottky diode. Find doping density (N_D in $atoms/cm^3$) and diode's built in potential (V_{bi} in volts) from the plot. **You may refer equations mentioned in page 3.** ***(2 Marks)***

NOTE:

- Here C is normalized junction capacitance=C_{DUT}/Area
consider Area=1μm x 1μm (Hypothetical value)

Purpose of small sinusoidal input signal:

- The capacitance at any given DC reverse bias is obtained by varying the charge around that corresponding depletion region edge by adding a small sinusoidal ac signal (1 Vpp, 100 kHz).
- Here TL071 is a high-speed JFET based operational amplifier (**use** $\pm 15V$ **supply voltage**) and design under test (DUT) is a Schottky diode.

The following models are given to you (Click on the names)
- Schottky diode: BAT85
- Op-Amp: TL071

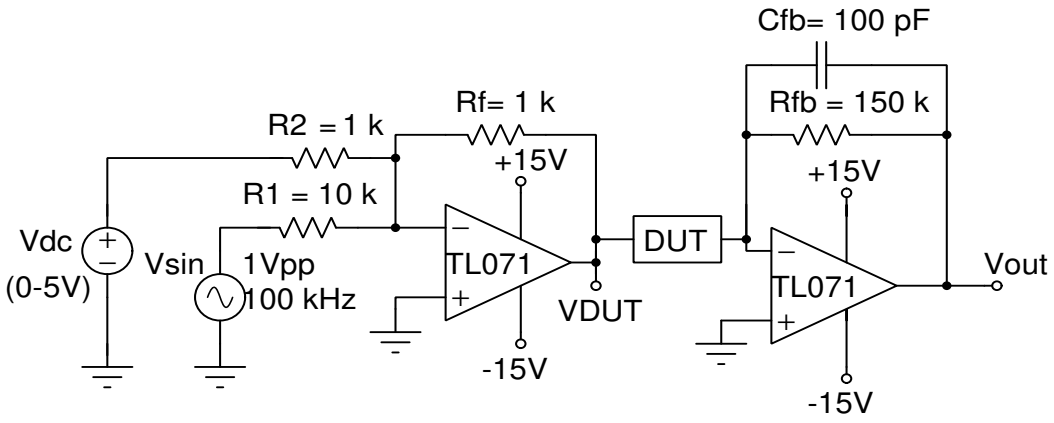

Figure 2: Circuit for measurement of C-V characteristics of a Schottky diode.

Formulas

- Transfer function : $|V_{out}/V_{DUT}| = (C_{DUT}/C_{fb})(1/\sqrt{1 + 1/(\omega.R_{fb}.C_{fb})^2})$
- $1/C^2 = (2/q\varepsilon N_D)(V_{bi} - V_R)$ where V_{bi} is diode built in potential
- V_R is diode reverse voltage $= V_{DUT}$
- $\varepsilon = \epsilon_0 \, . \, \epsilon_{silicon} = 8.85 * 10^{-12} F/m * 11.7 = 1.03 * 10^{-10} F/m$
- q is charge of electron $= 1.602 * 10^{-19}$ coulombs
- N_D is doping density, C is diode junction capacitance per unit area$= C_{DUT}/Area$