Measurement of reverse-bias capacitance of p-n junction diode

Objective: To measure the reverse-bias capacitance of p-n junction diode.

Background: Under reverse bias, the small signal model of a p-n junction is essentially a capacitance given by $C = A\varepsilon / W$, A being the depletion layer area of the diode and W being the depletion layer width. As the reverse bias Vr increases, W increases, thus causing a decrease in C. Measurement of C as a function of Vr can be used to identify the type of junction and to calculate the doping density (ND) in a p+n junction.

Purpose and method: The purpose of this experiment is to measure the small-signal capacitance C of a p-n junction at different values of the dc reverse bias Vr. We will do this by generating a voltage v (t) = Vdc + Vac (t) from a dc voltage (Vdc) and an ac voltage (Vac), and then measuring the ac current through the diode when this v(t) is applied across its terminals. For the first part, we will use a "summer" circuit, and for the second, we will use a current-to-voltage converter. Both of these circuits can be implemented using op-amps.

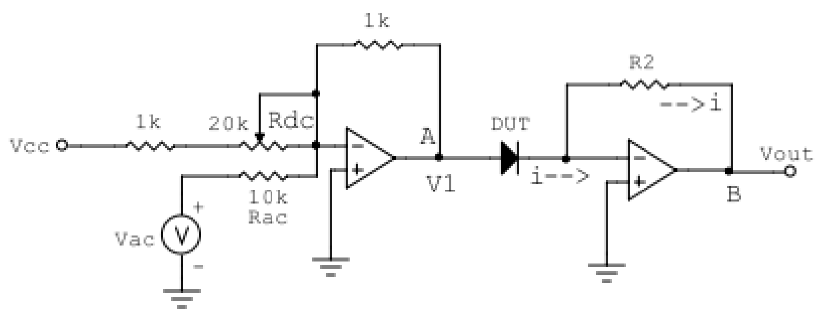

Figure 1

The complete circuit is shown in Fig.1. Show that the voltage V1 is given by, V1 = -Vcc (1kΩ / Rdc) – Vac (1/10). The cathode (the 'n' side) of the diode is at 0V (why?) .Thus V1 is also the voltage across the diode. This voltage causes a current i (which consists of a small dc "leakage" current and an accurrent) to flow through the diode as well as R2 resulting in Vout = -R2 i. By measuring the ac part of Vout and V1, we can calculate the small signal capacitance of the diode.

Experiment:

Use ±15V for the Op-Amp supplies. Note that +Vcc also serves to generate the dc bias for the diode (or else use a separate supply).

A) Testing:

B) Use R2 = 22K. Disconnect Rdc as we want only the ac voltage for testing.

1) Use a resistor (R = 10K) as the "device under test" (DUT) instead of a diode. Apply a 1 KHz, 1V peak-to-peak sinusoidal signal (note that this is scaled down by a factor of 10, as seen earlier) and measure Vout. Calculate R from this measurement. It should be equal to 10 K.

2) Use a capacitor (C = 1nF) as DUT. Apply a 1V peak-to-peak sinusoidal voltage. Vary the frequency and observe its effect on Vout. Calculate C. It should be equal to 1nF.

B) Diode capacitance:

Use the base-collector junction of the n-p-n (BJT SL100) as the DUT (make sure the Junction is reverse biased). Connect Rdc as shown in Fig.1. Use R2 = $1M\Omega$, frequency = 25 to 60 KHz. Choose an appropriate frequency so that the output voltage is easily observable, but ensure that there is a 90◦ phase shift between input and output (why?). Apply a 2V peak-to-peak sinusoidal signal as input, which will result in a 200 mV p-p ac signal at V1. Observe Vout and verify that its amplitude varies as the dc bias across the diode is varied.

Measure the dc level and ac amplitude at nodes A and B respectively for Vr = 1 to 10V (in steps of 1V). Repeat for the base-emitter junction of BJT SL100, for Vr = 1 to 5V, in steps of 1V. (Again, make sure the junction is reverse-biased).