DIODES AND TRANSISTORS
Experiment 2 – Diodes

This experiment will introduce the students to one of the most important inventions of the XX century, diodes. Unlike passive electronic components explored in the previous laboratory experiment, diodes no longer obey a linear current-voltage relationship. The elements considered in this experiment are composed of crystalline semi-conducting materials such as impurity doped Si and Ge arranged as a p-n junction. We will explore diodes ability to pass current in only one direction and to practically block the current propagation in the other direction.

Diode Circuits

**Diode Characteristics**

Start by figuring out which end of the diode is the anode and which is the cathode. Use one of the DMMs as an ohmmeter, and change the polarities of the leads connecting the diode. In one direction you will read a finite resistance, and in the other it will read infinite resistance. That is due to the ohmmeter applying bias in order to measure the resistance. You can use another DMM so see which lead is positive and which is negative.

Set up the circuit shown in Fig. 1 using a common germanium diode 1N995. Make sure that the two oscilloscope channels have their black leads in common. The signal generator must be isolated from ground for this experiment using the gray transformer. Plug the generator into the transformer and the transformer into the power outlet. The transformer has no direct connection to from one side to the other. It uses a magnetic field to transfer power. Take extra care to completely unplug the transformer when the experiment is complete. Since the leads on the resistor are reversed with respect to the positive direction for the diode, set channel two on inverted. The voltage on the resistor is used as a measure of the current through the circuit. This is a common technique. Use a frequency of about 1kHz to avoid distortions. Examine the traces on the scope for $V_D$ and $V_R$. Record the traces and discuss what you see in detail.

Next set the oscilloscope for X-Y scanning. This will give you a plot of $V_D$ versus $I$ as the generator runs up and down the voltage range. Start with both scales on two volts. Sketch the $I-V$ curve for the diode you observe (you should expect “ideal” diode behavior - “unlimited” current for positive voltage and no current when the voltage is negative; such approximation is often used in the circuit analysis).

Now increase the horizontal sensitivity to 0.1 V, plot the results. With increased
sensitivity one should expect a more accurate representation of a realistic diode $I-V$
curve.

From your graph determine the forward voltage drop $V_f$ for your diode (the voltage, at
which the current begins to take off from the X-axis). The value of forward voltage drop
is unique to the diode material (germanium in case of 1N995). Cross check your result
with the table value.

Make a X-Y scan at 0.05 $V$ intervals along the X axis. Compare the results of your scan
with the Shockley model:

$$I = I_0(e^{V_{f} / \eta V_T} - 1), \quad \text{Equation 1}$$

Where $V_T = kT / e =25mV$ at room temperature. Check, if instead one can use a
Shockley approximation for this case ($V \gg V_T$):

$$I \approx I_0(e^{V_{f} / \eta V_T}), \quad \text{Equation 2}$$

Plot your $I-V$ data on a semi-log scale and compare with this Shockley approximation.
Determine the value of the emission coefficient $\eta$ for germanium by fitting the data-
points.

Replace the germanium diode with a silicon diode 1N914. Repeat the X-Y scan to get
the V-I characteristic for the diode. Make a graph, corresponding to your measurements
at 0.1V sensitivity. Determine the forward voltage drop and the emission coefficient for
the silicon diode.

Finally, replace the silicon diode with the zener diode 1N749 provided, and do the X-Y
scan. Determine the material of the zener diode. Estimate the reverse voltage for which
this diode is designed.
**Diode Rectifier**

Using four $1N914$ diodes assemble the bridge rectifier pictured in Figure 2.

First examine the output on your oscilloscope without the capacitor. Sketch what you see carefully; check if there are “flat regions” near zero, explain your observations.

Add the capacitor to the circuit and examine the output on your oscilloscope. Explain the differences. Measure the ripple and compare with the value expected for these components.

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**Diode Limiter**

Construct the diode limiter circuit as shown in Figure 3. Apply several types of input signals to this circuit at low and high amplitudes. Record the output and describe carefully what you see. Explain how the circuit works and what it can be used for.