Palestine Technical University - Kadoorie
جامعة فلسطين التقنية - خضوري

Electrical Engineering Department

Electronics Lab

Exp (1):

Effect of the P-N Junction in Diodes / Characteristic Curves for Diodes of Different Semiconductor Materials

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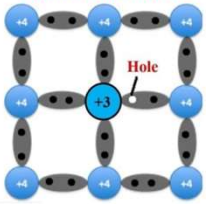
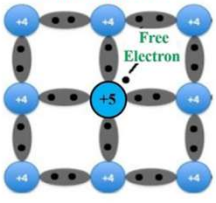
PN Junction – Diode creation

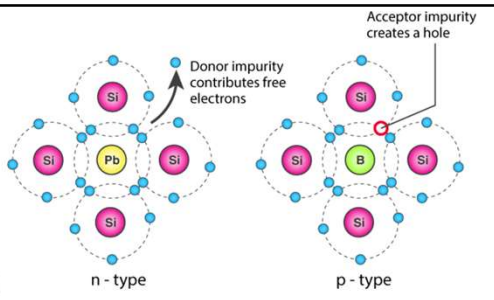
P-Type Semiconductor

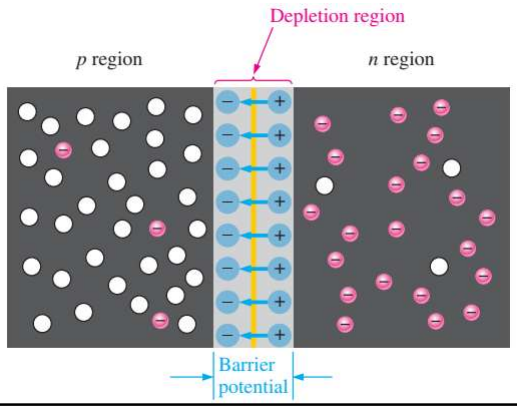


N-Type Semiconductor

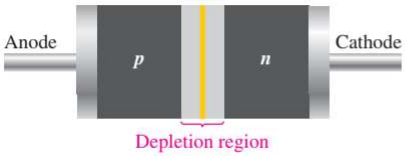


If a piece of intrinsic silicon is doped so that part is *n*-type and the other part is *p*-type, a **pn junction** forms at the boundary between the two regions and a diode is created





PN Junction – Diode creation



(a) Basic structure

(b) Symbol

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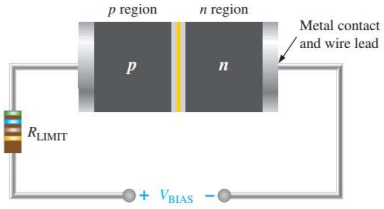
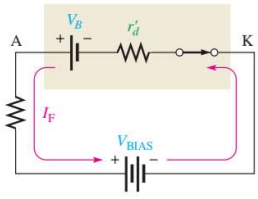
Diode Biasing

To **bias** a diode, you apply a dc voltage across it.

- **Forward bias** is the condition that allows current through the *pn* junction.





(a) Forward bias

Requirements for the forward bias:

- The negative side of *V*BIAS is connected to the *n* region of the diode and the positive side is connected to the *p* region.
- The bias voltage, *V*BIAS, must be greater than the **barrier potential**.

- voltage drop across the *pn* junction equal to the barrier potential (0.7 V),
- An additional small voltage drop occurs across the *p* and *n* regions due to the internal resistance of the material. For doped semiconductive material, this resistance, called the **dynamic resistance,** is very small

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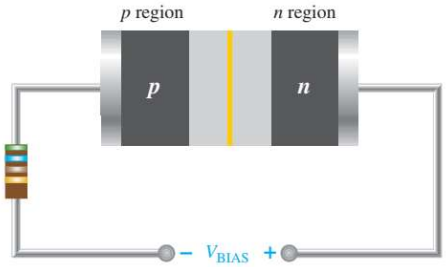
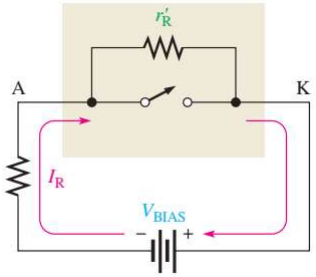
Diode Biasing

- **Reverse bias** is the condition that essentially prevents current through the diode.





(b) Reverse bias

- Reverse current: small number of free minority electrons in the *p* region are "pushed" toward the *pn* junction by the negative bias voltage.
- If the external reverse-bias voltage is increased to a value called the breakdown voltage, the reverse current will drastically increase.

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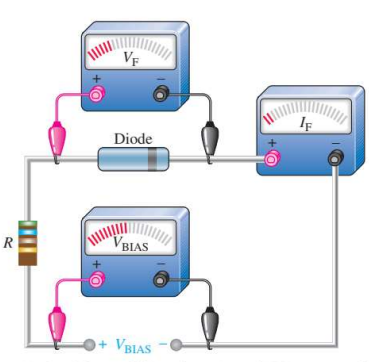
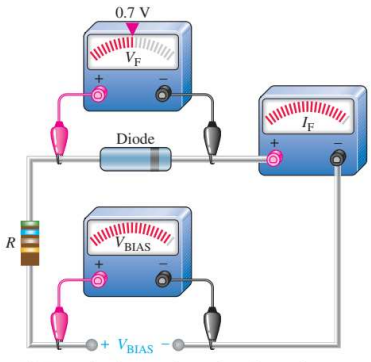
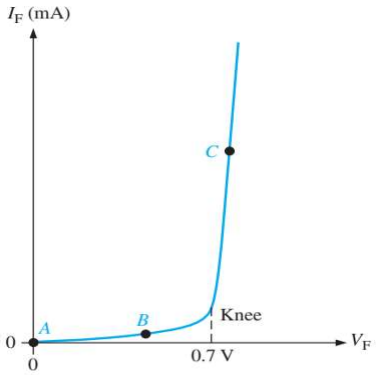
V-I Characteristic for Diode



(a) Small forward-bias voltage ($V_F < 0.7$ V), very small forward current.

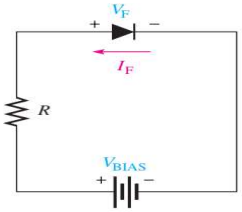


(b) Forward voltage reaches and remains nearly constant at approximately 0.7 V. Forward current continues to increase as the bias voltage is increased.



(a) *V-I* characteristic curve for forward bias.

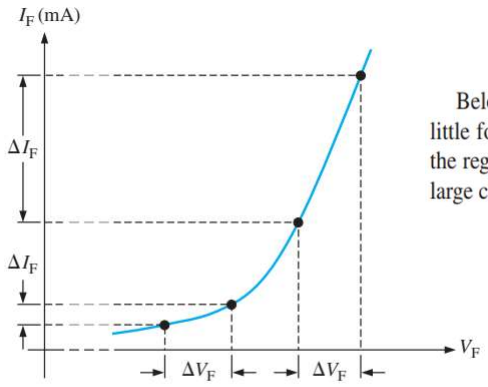
Point *A* corresponds to a zero-bias condition.
Point *B* corresponds to where the forward voltage is less than the barrier potential of 0.7 V.
Point *C* corresponds to where the forward voltage *approximately* equals the barrier potential.



(a) Forward bias

V-I Characteristic for Diode

Dynamic resistance



(b) Expanded view of a portion of the curve in part (a). The dynamic resistance r'_d decreases as you move up the curve, as indicated by the decrease in the value of $\Delta V_F/\Delta I_F$.

Below the knee of the curve the resistance is greatest because the current increases very little for a given change in voltage ($r'_d = \Delta V_F/\Delta I_F$). The resistance begins to decrease in the region of the knee of the curve and becomes smallest above the knee where there is a large change in current for a given change in voltage.

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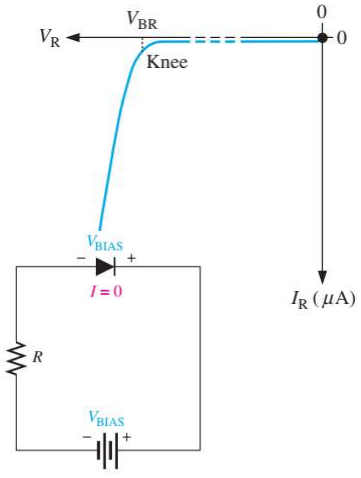
V-I Characteristic for Diode



(b) Reverse bias

- With 0 V across the diode, there is no reverse current. As you gradually increase the reverse-bias voltage, there is a very small reverse current and the voltage across the diode increases. When the applied bias voltage is increased to a value where the reverse voltage across the diode (V_R) reaches the breakdown value (V_{BR}), the reverse current begins to increase rapidly. As you continue to increase the bias voltage, the current continues to increase very rapidly, but the voltage across the diode increases very little above V_{BR}. Breakdown, with exceptions, is not a normal mode of operation for most *pn* junction devices.
- The diode will be damaged if current is not limited to a safe level.

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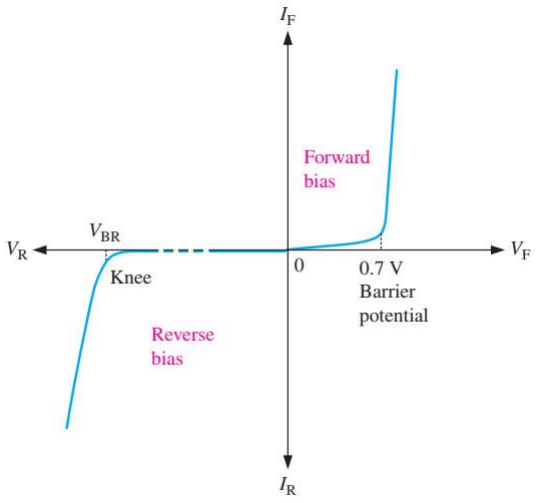
V-I Characteristic for Diode



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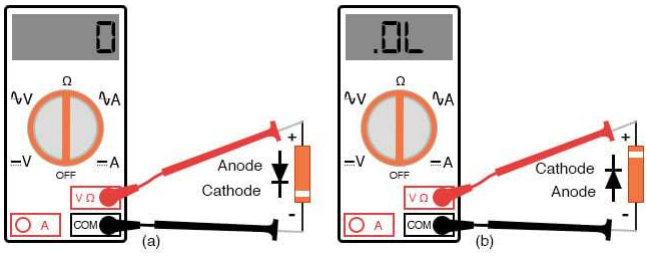
Practical Part:

Part 1: Testing Diodes

1: Testing diodes using DMM – Ohm method



Forward bias:
Low Resistance

Reverse bias:
Very high Resistance

Practical Part:

Part 1: Testing Diodes

2: Testing diodes using DMM – Diode method

(a) Forward-bias test

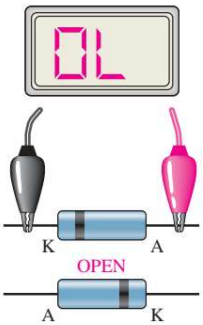
(b) Reverse-bias test

- **Forward bias:** If the diode is good, you will get a reading of between approximately 0.5 V and 0.9 V, with 0.7 V.
- **Reverse bias:** If the diode is working properly, you will typically get a reading of "OL".

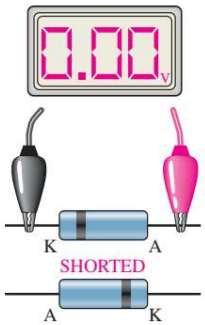
Practical Part:

Part 1: Testing Diodes

When the Diode Is Defective



(c) Forward- and reverse-bias tests for an open diode give the same indication.



(d) Forward- and reverse-bias tests for a shorted diode give the same 0 V reading.

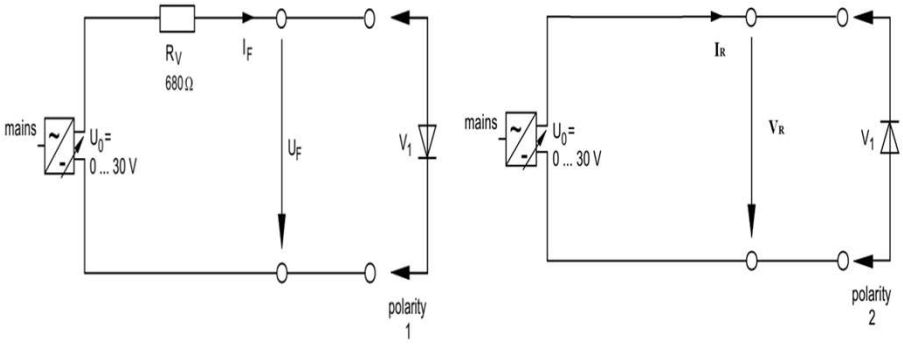
- When a diode has failed open, you get an out-of-range "OL" indication for both the forward-bias and the reverse-bias conditions,
- If a diode is shorted, the meter reads 0 V in both forward- and reverse-bias tests.

Practical Part:

Part 2: Investigate the effect of the p-n junction of a diode on the current flowing through in dependence on the applied voltage and its polarity

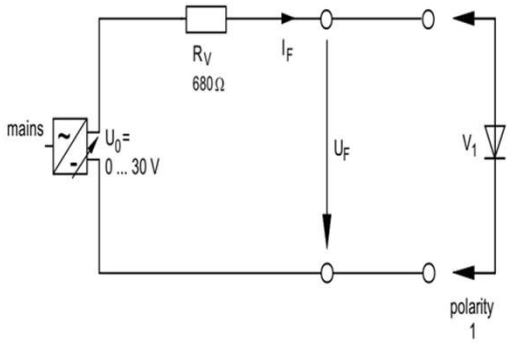
Equipment:

- **Breadboard**
- **DC power supply**
- **Digital multimeter**
- **Resistor (680)**
- **Diode (9114.3)**



Practical Part:

Part 2: Investigate the effect of the p-n junction of a diode on the current flowing through in dependence on the applied voltage and its polarity

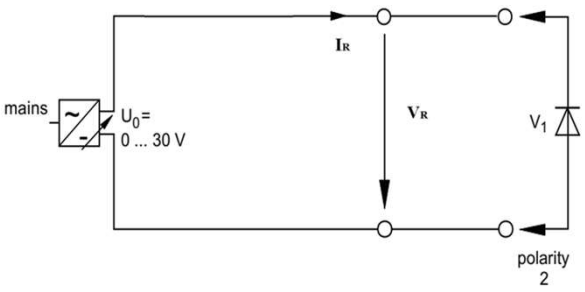


1. Apply the DC voltages UF listed in the Table to the diode as shown in the Figure (polarity 1), measure the corresponding current IF and enter the values in the Table.

U_F [V]	0	0.1	0.2	0.3	0.4	0.5	0.6	0.65	0.7	0.75
I_F [mA]										

Practical Part:

Part 2: Investigate the effect of the p-n junction of a diode on the current flowing through in dependence on the applied voltage and its polarity



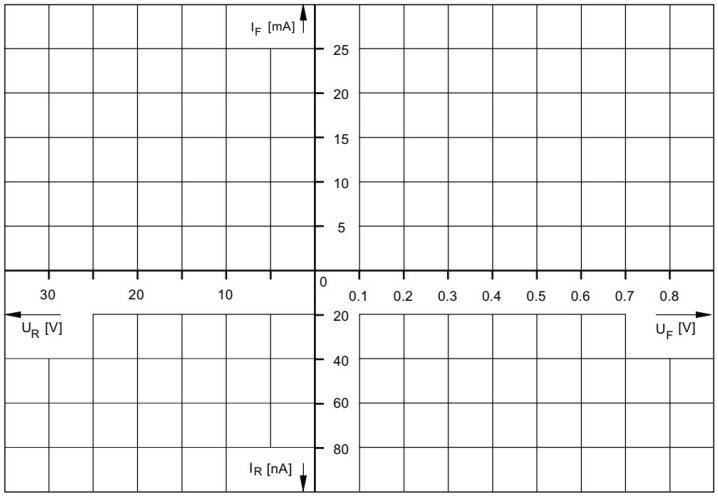
2. Then reverse the polarity of the diode (polarity 2) and repeat the experiment with the voltage values given in the Table.

U_R [V]	0	2.5	5	10	15	20	25	30
I_R [nA]								

Practical Part:

Part 2: Investigate the effect of the p-n junction of a diode on the current flowing through in dependence on the applied voltage and its polarity

Plot the diode characteristics



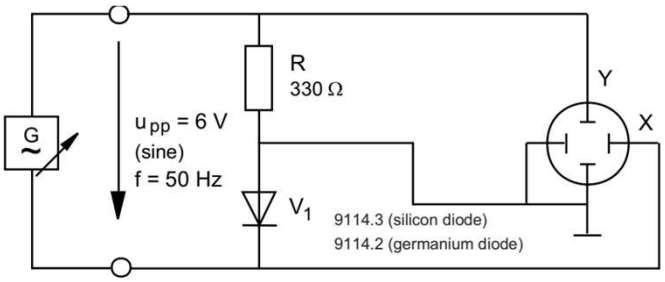
Practical Part:

Part 3: Characteristic Curves for Diodes of Different Semiconductor Materials

Observe the characteristics of a silicon and germanium diodes with the oscilloscope.

Equipment:

- **Breadboard**
- **Function generator**
- **Oscilloscope and DMM**
- **Resistor 330**
- **Diodes (Si & Ge)**



Set up the circuit as shown in the Figure and record the voltage signal at the silicon and germanium diodes with the oscilloscope (X/Y representation).

One of the channels must be inverted.

Practical Part:

Part 3: Characteristic Curves for Diodes of Different Semiconductor Materials

Observe the characteristics of a silicon and germanium diodes with the oscilloscope.

Threshold voltage

$$R_{diff} = \frac{\Delta U_F}{\Delta I_F} =$$

ΔU_F = change of on-state potential in V

ΔI_F = change of on-state current in A