PIN Diode I-V Characteristics & usage as RF Switch

Electronic Devices Lab : Experiment 3

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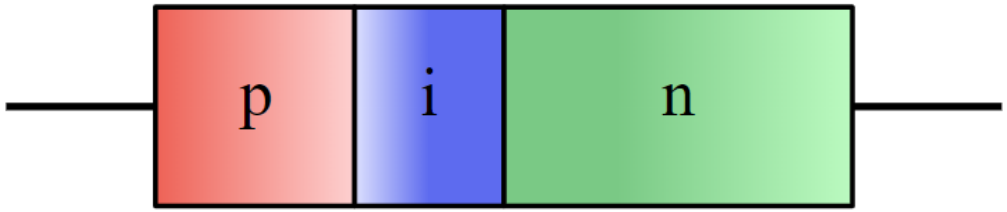
Background Theory

- PIN diode has a wide, un-doped intrinsic semiconductor region between 'p' and 'n' regions. The p-type and n-type regions are typically heavily doped.



- PIN diode obeys the standard diode equation for low-frequency signals. At higher frequencies, the diode looks like an almost perfect resistor.
- Under zero- or reverse-bias, a PIN diode has a low capacitance. The low capacitance will not pass much of an RF signal. Under a forward bias, a PIN diode will have a low RF resistance, making it a good conductor of RF. Consequently, the PIN diode makes a good RF switch.

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Aim of the experiment

- To find forward voltage, reverse saturation current and ideality factor of the given PIN diode (Infineon BAR 15-1) and compare with normal PN junction Diode (1N4007).
- To find reverse recovery time of the given PIN diode at various frequencies and compare with the reverse recovery time of normal PN junction Diode.
- To observe how the PIN diode works as an RF switch at different DC bias voltages.
- To find the relation between bias current and RF resistance (dynamic resistance) of the PIN diode at different frequencies [simulation].

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Components required

- PIN diode Infineon BAR 15-1, PN junction diode 1N4007.
- Resistors - 500Ω $(\times 2), 50\Omega, 1k\Omega$
- Potentiometer - $1k\Omega$
- Capacitors - $100nF$ $(\times 2)$
- Breadboard, connecting wires
- Multi-meters, variable power supply, signal generator and oscilloscope

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Experiment-Part 1

1. Make the connections as per the circuit diagram. Notice the role of the $1k\Omega$ pot, that can be used to vary the voltage to be applied to the diode.
2. Vary V_D in suitably small steps (from 0 V to 1 V only), and measure and tabulate I_D and V_D for each step.

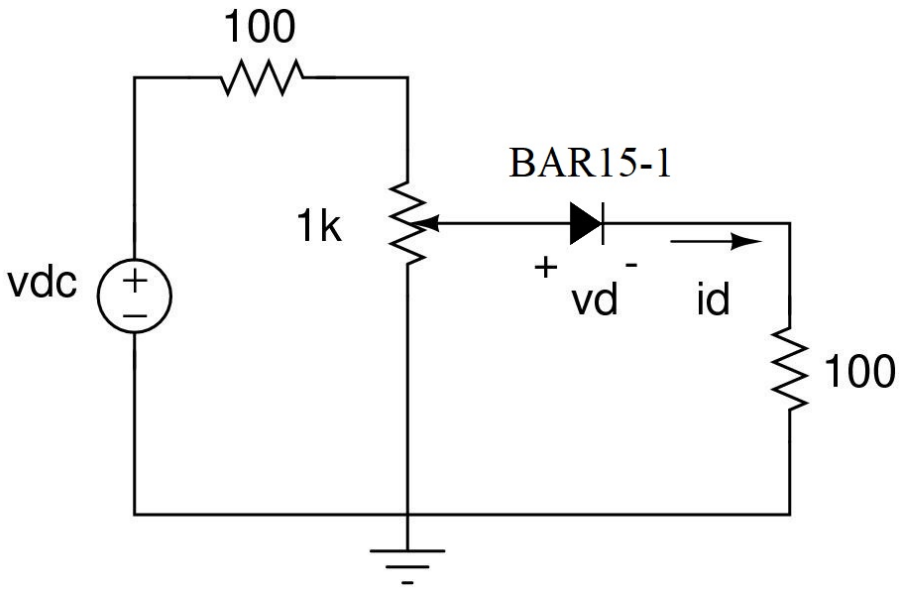

Figure: Circuit to measure I/V characteristics of a semiconductor diode

You are advised to simultaneously plot I-V in the lab, to quickly identify if the measurement is as expected.

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Experiment-Part 2

Apply sinusoidal signals of different frequencies (10 *KHz*, 100 *kHz*, 1 *MHz*, 10 *MHz*) to the given circuit (for both PIN diode and PN diode) and note down the reverse recovery times.

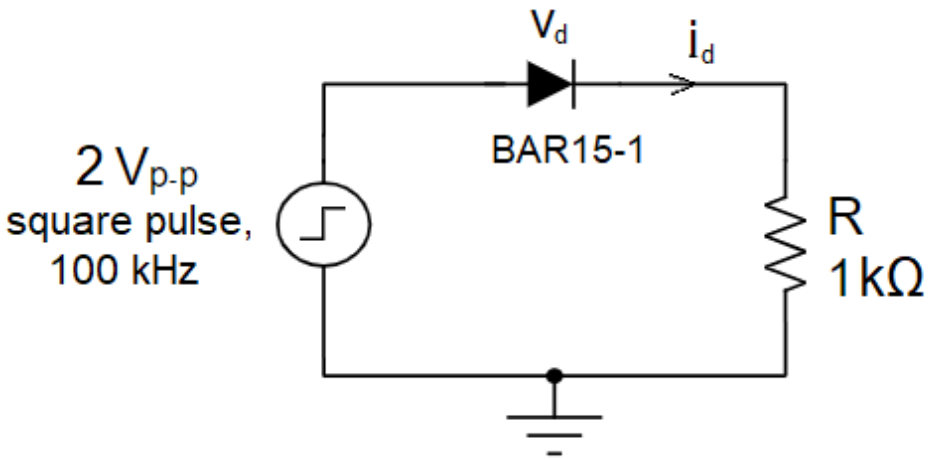

Figure: Circuit to measure reverse recovery time

Which diode has the potential of passing major portion of the input signal to the output at 10 *MHz*?

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Experiment-Part 3

Make the circuit as shown and find sinusoidal output voltage and diode DC current for different DC bias voltages ($-5\ V$, $0\ V$, $1\ V$, $3\ V$, $5\ V$).

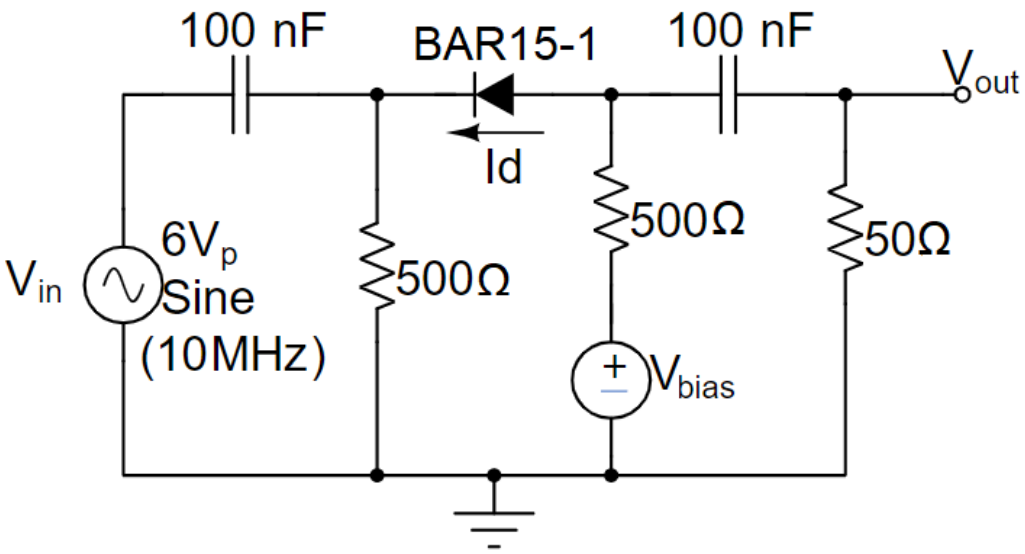
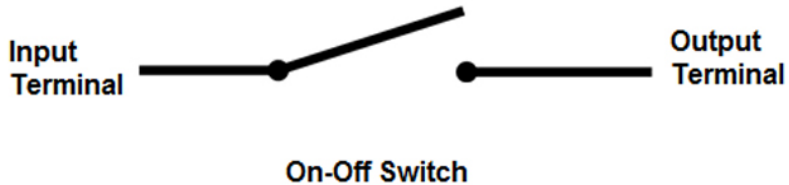


Figure: Circuit to characterize PIN diode as RF switch

Repeat the experiment using regular PN junction diode and note down the results. Relate the PIN diode circuit with an SPST switch.



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Documenting Results

Table format for reverse recovery time comparison (part 2).

Frequency	RRT of PIN	RRT of PN
10 *kHz*		
100 *kHz*		
1 *MHz*		
10 *MHz*		

Table format for RF switch (part 3).

V_{bias}	I_D	v_d
-5V		
0V		
1V		
3V		
5V		

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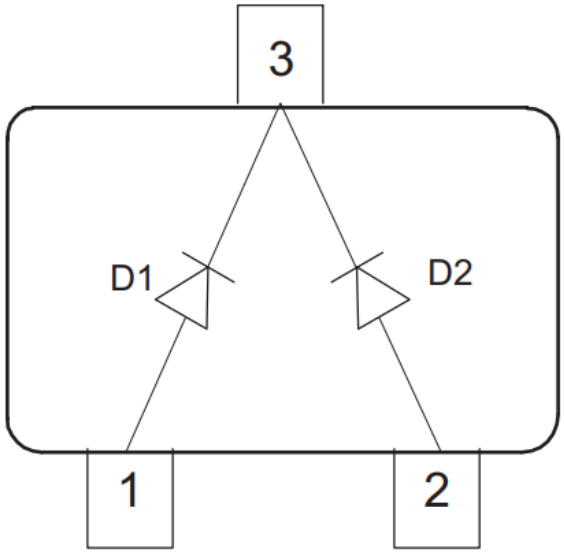
BAR15-1 Device

The Infineon BAR15-1 PIN Diode has a common cathode structure.



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Simulation Exercise-Part 4

Note that for simulation, RN142S PIN diode model file is used.

- In order to find the relation between RF resistance and bias current of the PIN diode at different frequencies, write NGPSICE netlist for the following circuit.

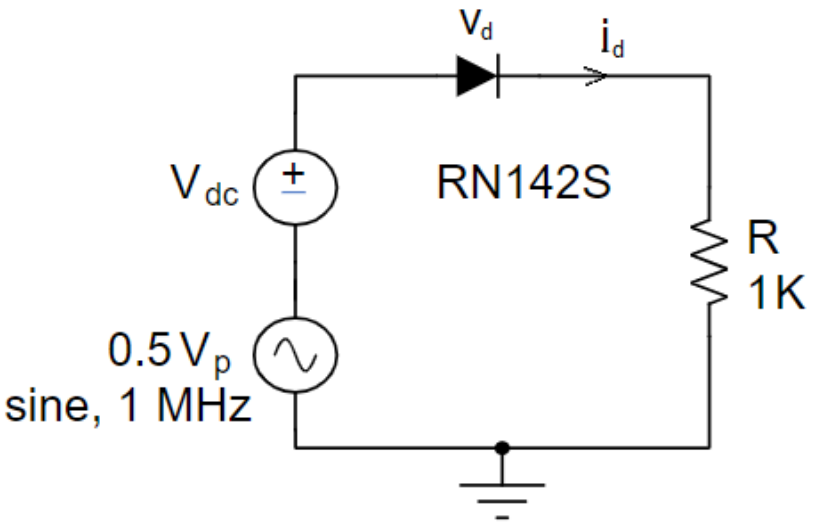

Figure: Circuit to find dynamic resistance

- RF resistance of the diode is obtained by fixing a DC operating point (of 1 V) and superimposing a small RF sinusoidal signal (of 250 mV peak-to-peak) on it and then finding the ratio of peak-to-peak diode voltage to peak-to-peak diode current.
- Find the RF resistance at two frequencies i.e 1 MHz and 10 MHz.

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