ECE121: Electronics (1) Lecture 3: The Varactor Diodes

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Basic Operation of Varactors.

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Introduction:

 In a reverse biased PN junction, the junction capacitance varies with the amount of reverse bias voltage V_R.

$$C' = \left\{ \frac{e \epsilon_s N_a N_d}{2(V_{bi} + V_R)(N_a + N_d)} \right\}^{1/2}$$

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- The depletion region acts as a capacitor dielectric.
- The *p* and *n* regions act as the capacitor plates.

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- A varactor operates in **reverse bias** and is doped to maximize the capacitance of the depletion region.



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• In general, the capacitance *C* of a capacitor is determined by:

$$C = \epsilon \frac{A}{d}$$

where,

A is the plate area.

d is the plate separation distance.

 ϵ is the dielectric constant.

- In the varactor diode, the **depletion region width** is varying to change the capacitance value.
- Changing the depletion region width is done by varying the **reverse biased voltage**.





If the reverse-bias voltage increases: The depletion region widens, effectively increasing the plate separation, thus decreasing the capacitance.



P n Dielectric narrows

If the reverse-bias voltage increases: The depletion region widens, effectively increasing the plate separation, thus decreasing the capacitance.

When the reverse-bias voltage decreases: The depletion region narrows, the separation distance decrease and thus increasing the capacitance.



Example of a diode capacitance versus reverse voltage graph:

Basic Operation of Varactors: Capacitance Ratio:

Varactor Capacitance Ratio:

The varactor capacitance ratio is the ratio of the diode capacitance at a minimum reverse voltage to the diode capacitance at a maximum reverse voltage.



Varactor diode symbol

Basic Operation of Varactors: Capacitance Ratio:

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Example

For Zetex832A Varactor, the capacitance at V_R of 2 V is 22 pF. And it is measured as 4.4 pF at a V_R of 20 V. The capacitance ratio is designated as:

$$CR = \frac{C_2}{C_{20}} = \frac{22}{4.4} = 5$$



Varactor diode symbol

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Principle of Operation

The two diodes will be driven **alternately** into high and low capacitance, and the net capacitance will remain constant and is unaffected by the rf signal amplitude.



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- C₁ prevents a dc path from the potentiometer back to the ac source.
- C_2 prevents a dc path from the potentiometer to
 - a load on the output.

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Example

- The capacitance ratio of a Zetex 832A varactor is 5.
 Its capacitance at a 2 V reverse bias is 22 pF, determine the capacitance at a reverse bias of 20 V.
- Calculate the resonant frequencies at the bias extremes for the circuit if L = 2 mH.

Solution: $C_{20} = \frac{C_2}{CP} = 4.4 \ pF$ 2 $f_{r1} = \frac{1}{2\pi\sqrt{LC_2}} = \frac{1}{2\pi\sqrt{2 \ mH \ 20 \ pF}} = 795 \ kHz$ 3 $f_{r2} = \frac{1}{2\pi\sqrt{LC_{20}}} = \frac{1}{2\pi\sqrt{2 \ mH \ 4.4 \ pF}} = 1.7 \ MHz$

End of Lecture

Best Wishes

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