

# ECE 451

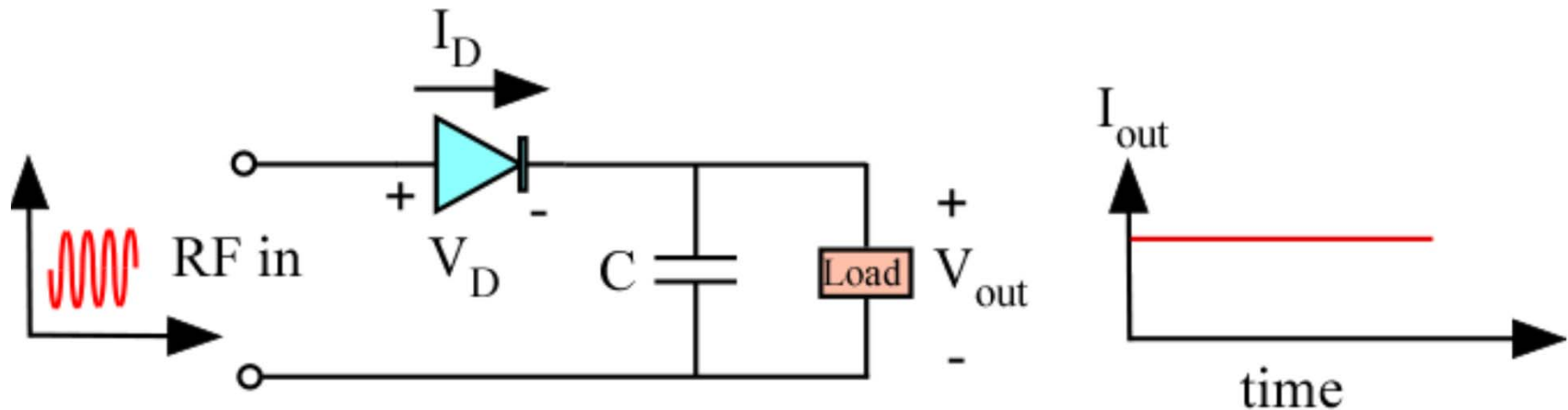
# Advanced Microwave Measurements

## 1. Square-Law Detector

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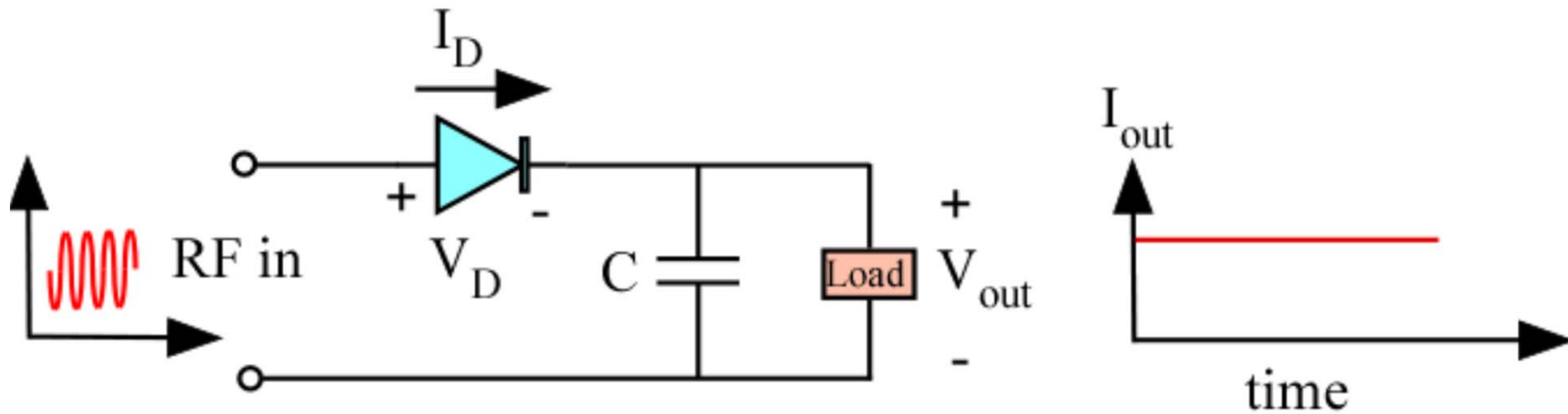
# Square-Law Detector

- Detector will receive RF at input and will produce a DC voltage proportional to the magnitude of the RF input



In order to operate properly, diode must remain in the square-law region

# Square-Law Detector

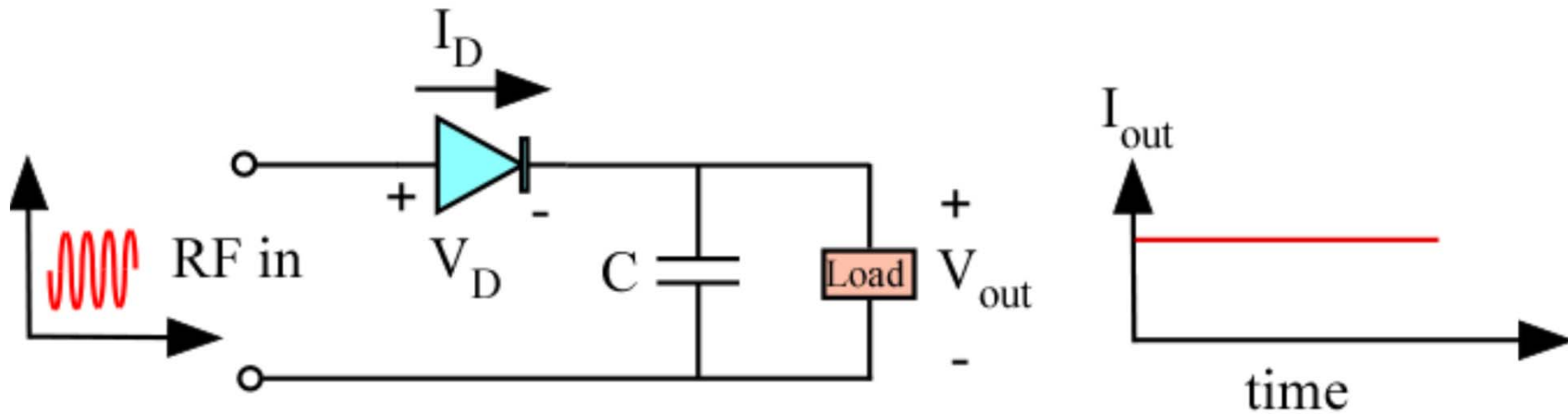


$$I_D = I_S \left( e^{\frac{qV_D}{kT}} - 1 \right) = I_S \left( e^{\frac{V_D}{V_T}} - 1 \right)$$

## Expanding

$$I_D \approx I_S \left[ \frac{V_D}{V_T} + \frac{1}{2} \left( \frac{V_D}{V_T} \right)^2 + \frac{1}{6} \left( \frac{V_D}{V_T} \right)^3 + \dots \right]$$

# Square-Law Detector



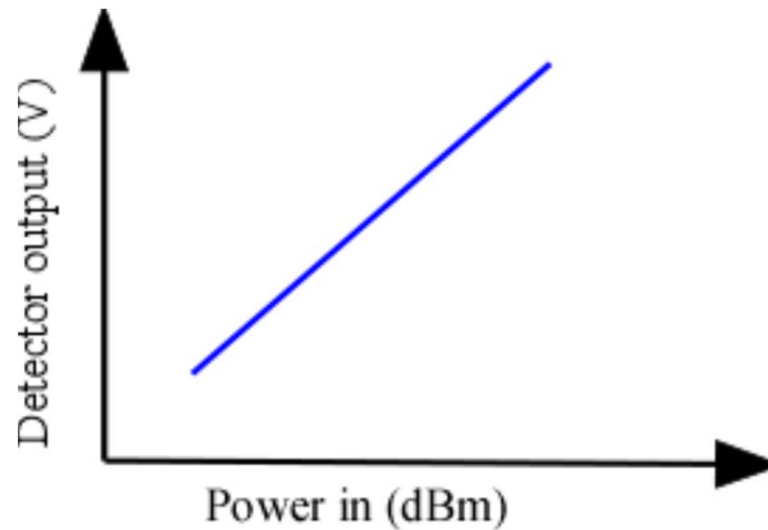
If  $V_D$  is small  $I_D \approx I_S \left[ \frac{V_D}{V_T} + \frac{1}{2} \left( \frac{V_D}{V_T} \right)^2 + \frac{1}{6} \left( \frac{V_D}{V_T} \right)^3 + \dots \right]$   $I_{out} = a V_D$  where  $a$  is some constant

If  $V_D$  is larger  $I_D \approx I_S \left[ \frac{V_D}{V_T} + \frac{1}{2} \left( \frac{V_D}{V_T} \right)^2 + \frac{1}{6} \left( \frac{V_D}{V_T} \right)^3 + \dots \right]$   $I_{out} = b V_D^2$  where  $b$  is some constant

If  $V_D$  is even larger  $I_D \approx I_S \left[ \frac{V_D}{V_T} + \frac{1}{2} \left( \frac{V_D}{V_T} \right)^2 + \frac{1}{6} \left( \frac{V_D}{V_T} \right)^3 + \dots \right]$   $I_{out} = c V_D^3$  where  $c$  is some constant

# Square-Law Detector

**GOAL:** Keep detector operating in square-law range. Then,  $I_{out}$  is proportional to  $V_D^2$  and thus proportional to the power input.



**Experiment:** Perform several measurements of detector output voltage for various levels of RF power input.