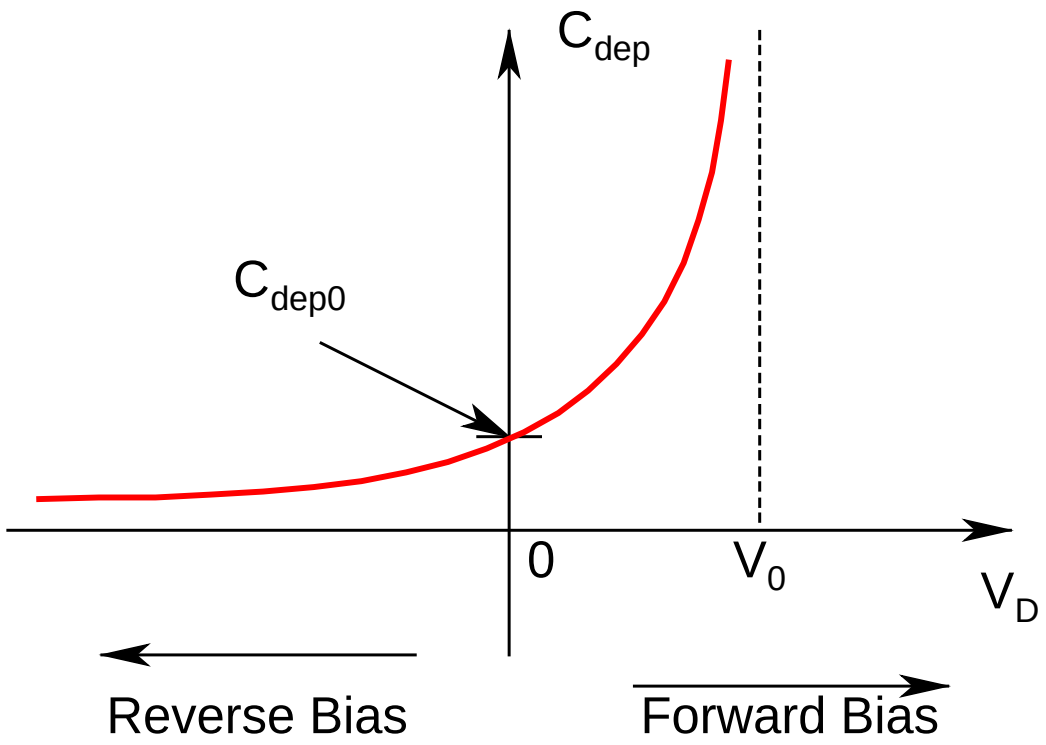
Series Resistance Effect

- The two ***quasi-neutral regions*** (p and n) have their own ***bulk resistances***
- ***Denoted as r_p and r_n***
- ***For small I_D***, their ***effects are negligible***
- However, ***for large I_D***, the ***potential dropped*** across them ***reduces*** the ***actual voltage*** appearing across the ***junction*** of the diode
- Known as the ***Series Resistance Effect***

- The ***actual voltage*** appearing across the ***junction***:
  - $V_{D,eff} = V_D - I_D(r_p + r_n)$
  - V_D: ***Diode terminal voltage***
- The ***new diode I-V relation***:
  - $I_D = I_0 \exp(V_{D,eff}/V_T)$
- ***Simultaneous solution*** of the above ***two equations*** would yield the ***Q-point***
- ***In presence of r_p and r_n, V_D may exceed V_0,*** but ***$V_{D,eff}$ would always be less than V_0***

Diode Capacitances

- ***Two components***:
  - ***Depletion Capacitance*** C_{dep}
  - ***Diffusion Capacitance*** C_{diff}
- ***Depletion Capacitance***:
  - Due to ***depletion charge dipole*** across the ***junction***
  - ***Expressed by***: $C_{dep} = C_{dep0}/(1 - V_D/V_0)^{1/2}$
    - $C_{dep0} = C_{dep}$ for $V_D = 0$
  - ***Present under both forward and reverse bias***



* C_{dep} diverges as $V_D \rightarrow V_0$

* C_{dep} in reverse bias < C_{dep} in forward bias

* **Rule of Thumb**: C_{dep} in forward bias $\approx 2C_{dep0}$

- ***Diffusion Capacitance***:
  - Due to ***charge injection*** in ***both sides of the junction*** (in the ***quasi-neutral regions***)
  - ***Expressed by***: $C_{diff} = I_D\tau/V_T$
    - τ: ***Injected carrier lifetime***
  - ***Present only in forward bias***, ***negligible in reverse bias***
  - ***Much larger than C_{dep}***
- ***Total Diode Capacitance*** C_D:
  - $C_D = C_{dep} + C_{diff}$

Small-Signal Model

- ***Needed for ac analysis***
- ***Electrical equivalent*** at the ***DC bias point***
- Represented as a ***network***, having various ***circuit components*** (***resistors***, ***capacitors***, ***current sources***, etc.)
- Also known as ***incremental model***
- ***Evaluated at (I_{DQ},V_{DQ})***
- Appropriate for ***small variations*** of the ***ac signal*** around the ***Q-point***