Lecture 9

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- Rectifiers
  - Simple Half-Wave Recitifers
    - Used for AC-to-DC conversion
    - Circuit representation when the diode is forward biased
      - $V_o = V_i$
      - $I_D = V_O/R_L$
    - Average output voltage: $V_{oAVG} = V_{oPK}/\pi$
    - RMS output voltage: $V_{oRMS} = V_{oPK}/2$
  - Half-Wave Rectifier with Smoothing Capacitor
    - Addition of a capacitor in parallel with the load resistor
      - Formation of a first-order low-pass filter
      - Impedance of R_L and C in parallel

$$Z_P = \frac{1}{(1/R_L) + sC} = \frac{R_L}{1 + j(\omega/\omega_B)}, \quad \text{where } \omega_B = (1/RC)$$

    - The capacitor charges to V_i when the diode is on ($I_D = I_C + I_L$)
      - $I_C > 0$ when $V_o = V_c < V_i$, $I_C = 0$ when $V_O = V_C = V_i$ (ideal model)
    - The capacitor holds (stores the output voltage when the diode is off)
      - V_o reduces gradually due to discharge of the capacitor: $I_C = -I_L 0$
    - Average output voltage: $V_{oAVG} \approx V_{iPK} - (V_r/2)$
      - V_r is the ripple voltage (design starting point: only for the half-wave rectifier)
      - Goal for a given input signal period (T): minimum $V_r \to$ maximum V_o
- Electrostatic Discharge (ESD) Protection
  - ESD event

    * Rapid discharge of charge between two bodies at different potentials
    * High voltage build-up $\rightarrow$ current flow (can destroy internal circuits)
    * Occurs during the manufacturing and lifetime of a chip (pins come into contact with equipment and sometimes people)
  - Simplified ESD protection concept with diodes

- Transformers
  - Convert voltage based on a turns ratio, $N_p : N_s$, or simplified $n : 1$, where:

$$V_s = \frac{V_p}{n}$$

- Full-Wave Rectifiers
  - Begins with a transformer, which isolates AC input to bridge from ground
  - Proceeds to a square arrangement of diodes, with one node grounded (current path for positive half-cycle)
  - Proceeds to a load resistance connected to ground