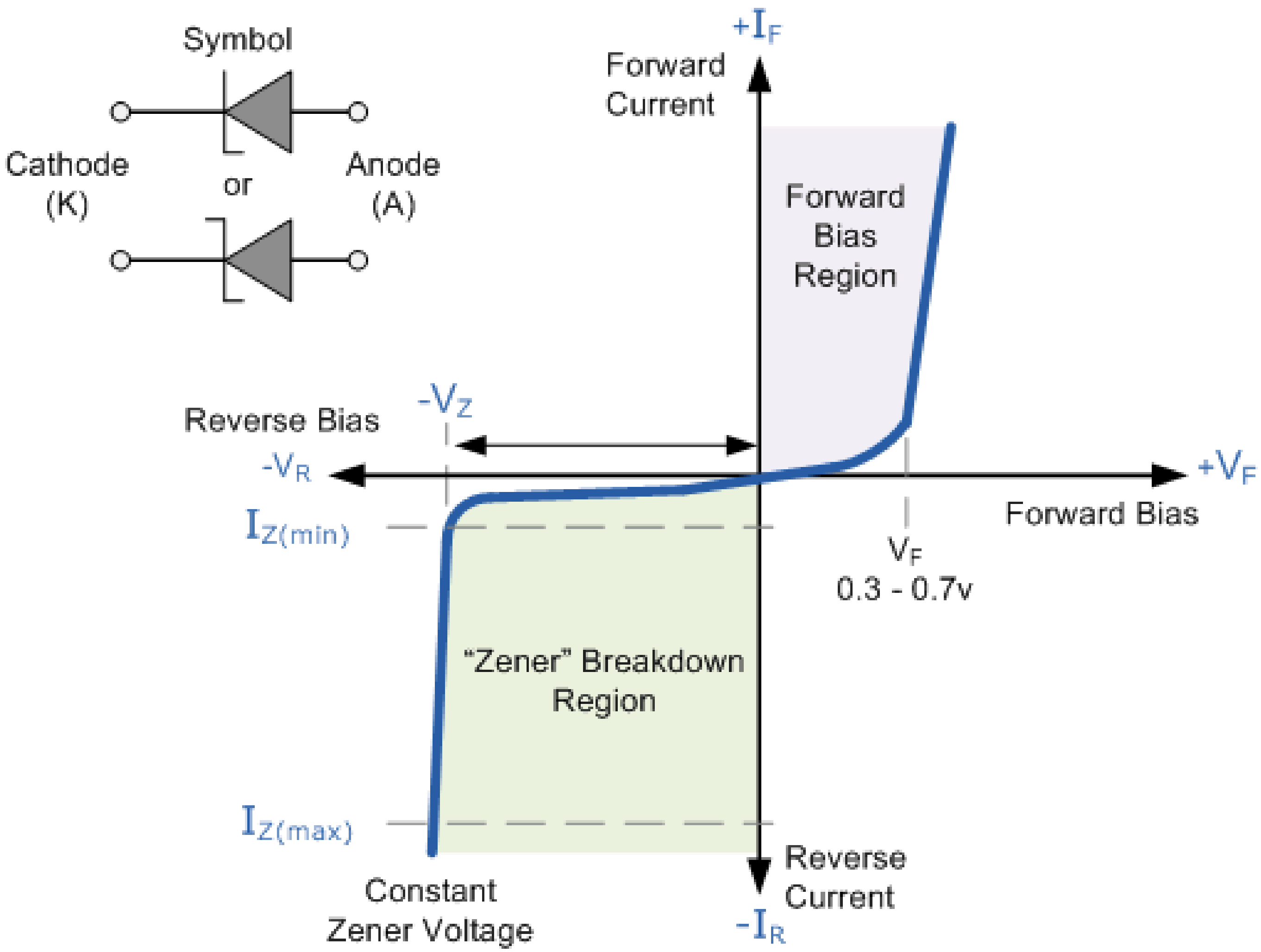
Lecture 4 – Power supply 2

Dr. Aftab M. Hussain,

Associate Professor, PATRIoT Lab, CVEST

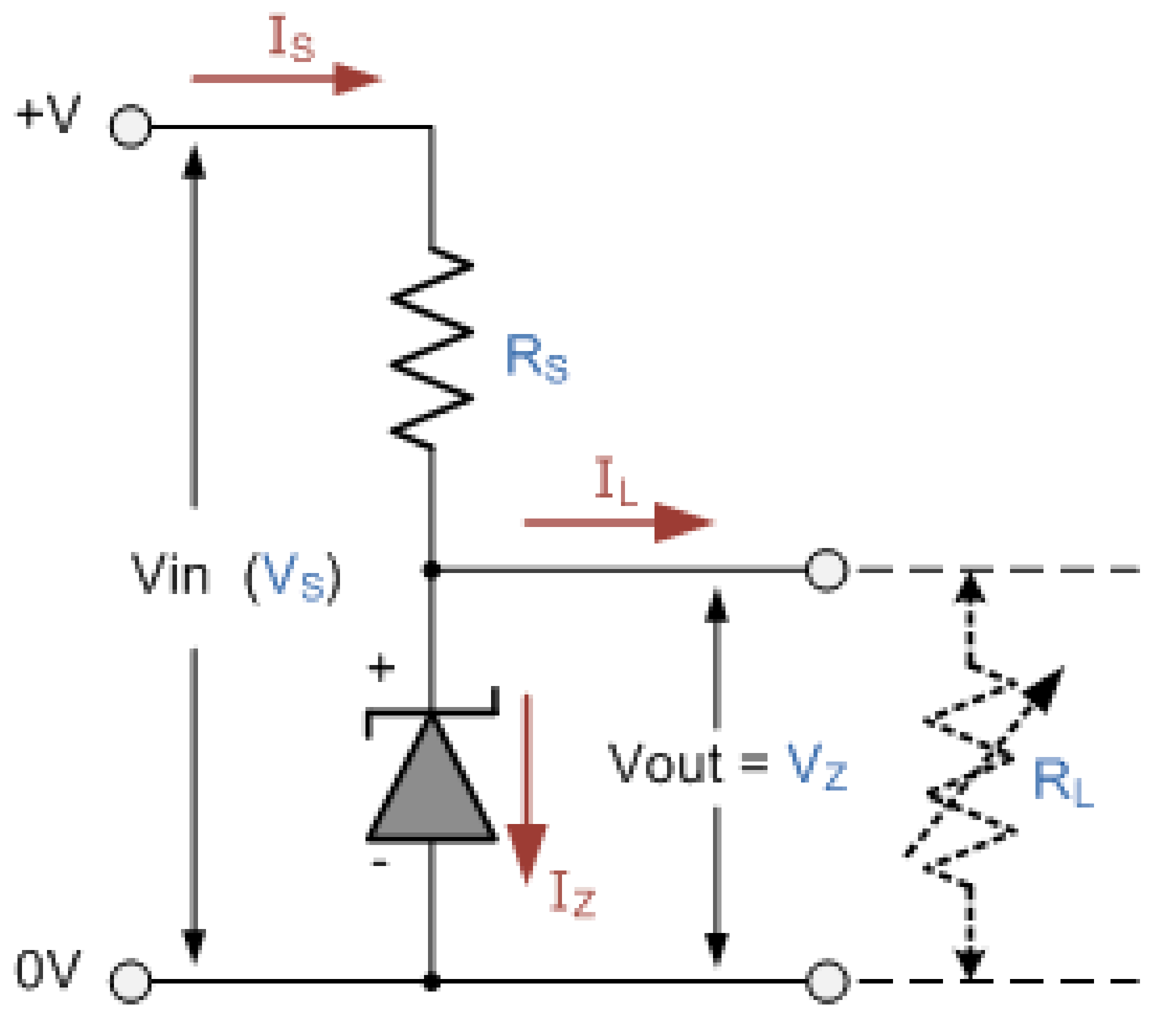
The problem with regulation

- Need a fixed voltage for any current
- Not allowed by Ohms Law!
- Enter, The Zener Diode
- Works because of quantum tunneling through the built-in potential in the depletion region



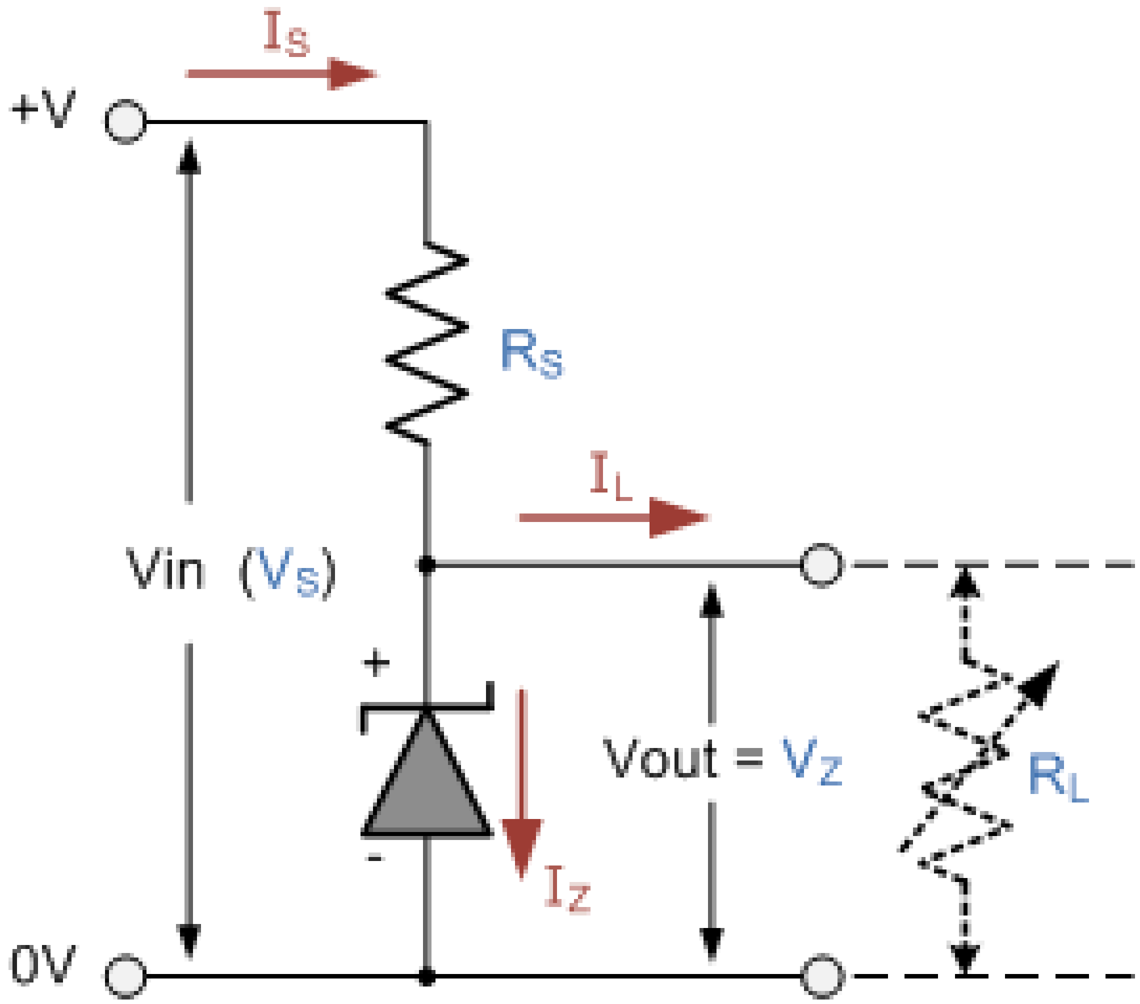
Regulated voltage source

- Voltage is truly (not approximately) independent of load
  - For a specific range of load
- Non-linear elements need to be used
- Zener diode maintains a constant voltage across its terminals for a range of currents through it
  - Needs a minimum current for Zener effect



Regulated voltage source

- When load current is zero ($I_L = 0$), all the current goes through the Zener (I_z), thus dissipating maximum power
  - This should be less than the power rating of the Zener (P_z)
- When a large load is drawn, the current through Zener goes down
  - However, it should be higher than a minimum current (I_{min}) through the Zener required to maintain Zener action
- These considerations determine the value of R_s and the maximum load $I_{L_{max}}$

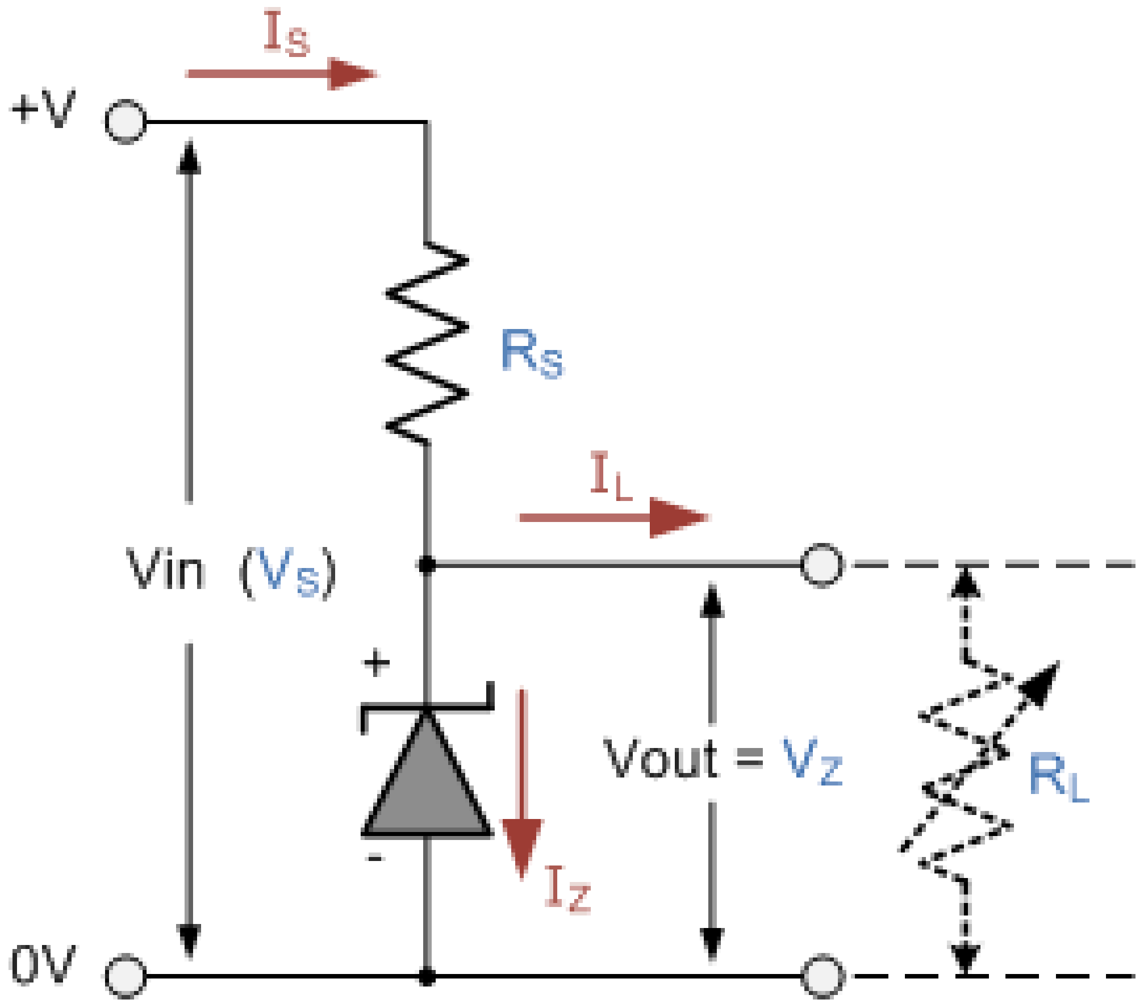


Regulated voltage source

- For example, A 5 V regulated power supply is required to be produced from a 12 V DC power supply input source. The maximum power rating P_Z of the Zener diode is 2 W. Minimum Zener current is 0.1 A.

- Thus, $R_s = 17.5\ \Omega$

- And, $I_{L_{max}} = 0.3\ A$

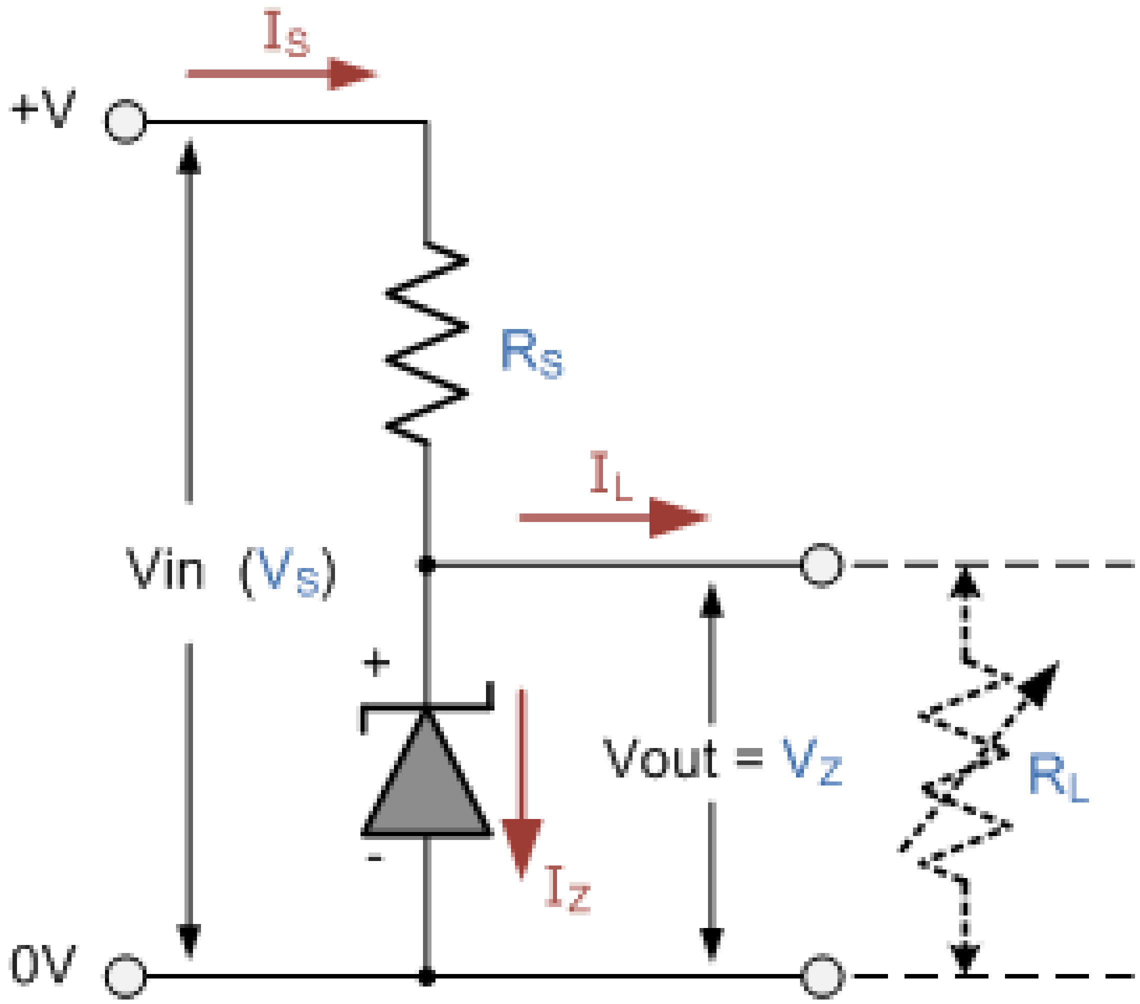


Loading!

- What happens if we ask for current more than $I_{L_{max}}$?

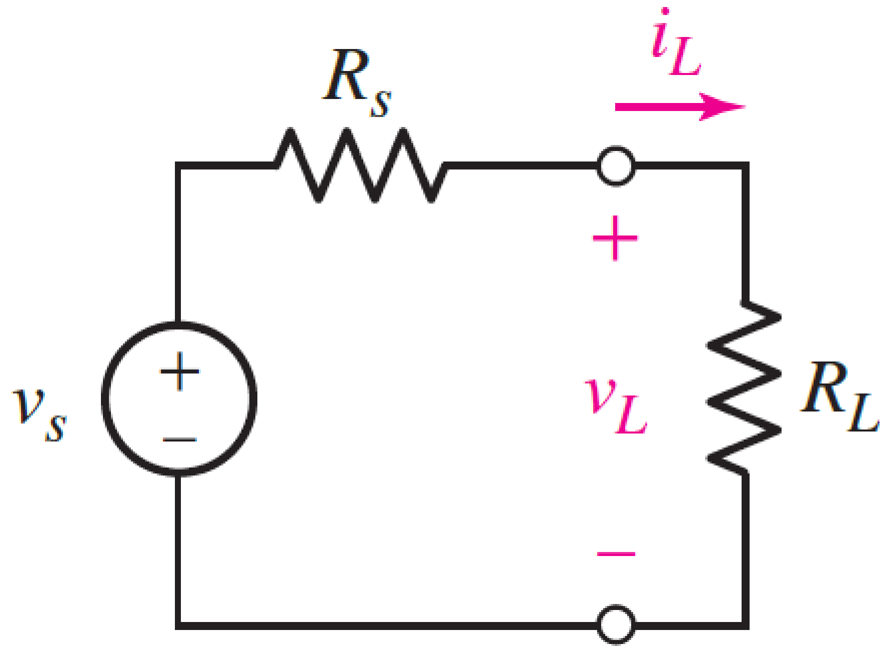
- The current across the Zener is not enough to maintain Zener action, leading to lowering of output voltage

- In this case, the supply is said to be “overloaded”, because it is being asked for more current (power) than it can provide



Power transfer to the load

- Consider a non-ideal voltage source connected to a load resistance
- If the load is very high ($R_L \approx 0$), then very high current flows through R_L, however, given that load resistance value is low, power transferred is small
- If load is very low ($R_L \approx \infty$), then current is very low, thus power transferred to the load resistance is small
- When do we get maximum power?



Power transfer to the load

- When do we get maximum power?

$$P_L = v_L i_L$$

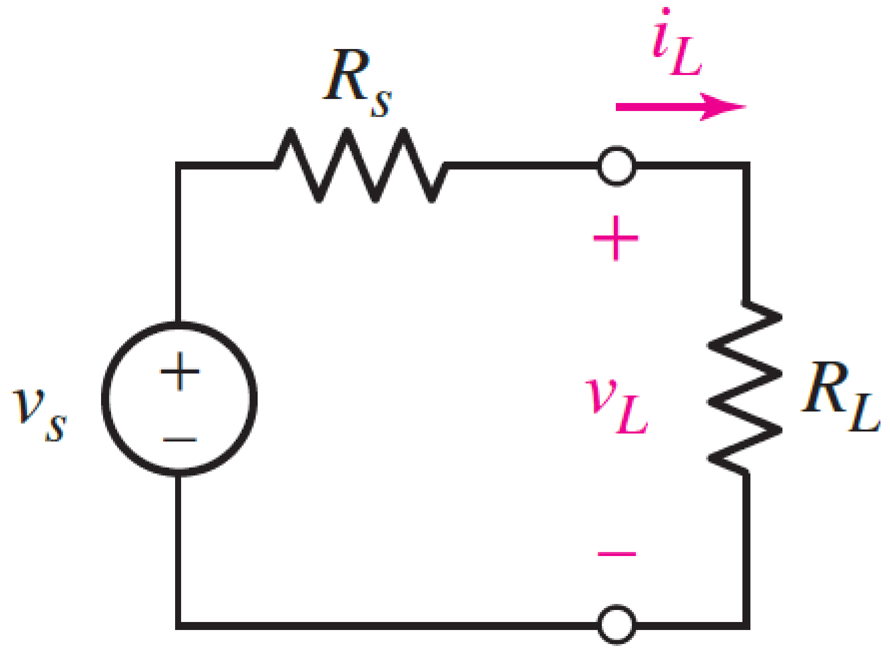
$$P_L = \frac{v_s R_L}{R_s + R_L} \times \frac{v_s}{R_s + R_L}$$

$$P_L = v_s^2 \, \frac{R_L}{(R_s + R_L)^2}$$

To find maximum, $dP_L/dR_L = 0$

$$\frac{dP_L}{dR_L} = v_s^2 \frac{R_s - R_L}{(R_s + R_L)^3} = 0$$

Thus, $R_L = R_s$



Maximum power transfer theorem

To transfer maximum power to a load,

the resistance of the load must be equal to the resistance of the source

- This concept is the basis for impedance "matching"
- When connecting, say an antenna and a transmitter, their impedances should match so that maximum power is transferred from the transmitter to the antenna

Very imp: There is a distinct difference between *drawing* maximum power from a source and *delivering* maximum power to a load