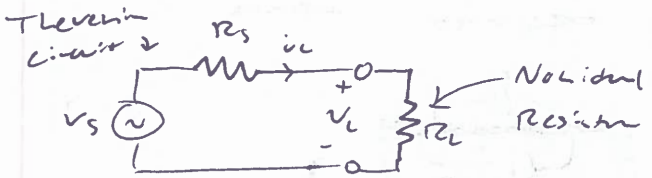
We can understand component parasitics and their effects with a simple power transfer circuit



We'll take a look at

- Tolerance
- Power handling
- Parasitic capacitance

Quick check-your-circuit-knowledge: What should R_L value be (in ohms) to maximize power transfer from v_S to R_L?

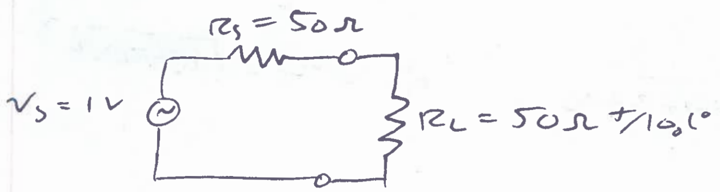
Answer: $R_S = R_L$ maximizes $\Rightarrow v_L = \frac{1}{2} v_S$, $P_L = \frac{v_S^2}{4R_L}$

Tolerance

Tolerances will typically be provided as a percentage range that the component value can vary (1%, 5%, 10%). Typically applies to passive components like

If the value of a component is very small, often the tolerance will be provided in absolute units. Ex. a 0 ohm resistor will often have a 0.1 ohm tolerance

Ex. Given a well matched 50 ohm system, how much power transfer degradation can we expect from a 10% resistor tolerance.



Ideal case: $P_L = \frac{1}{200} W = 5mW$

Worst case: $R_L = 55\Omega \to P_L = \left(\frac{R_L}{R_S+R_L} v_S\right)^2 \frac{1}{R_L}$

Difference of 0.23% ← $P_L = 4.98mW$

↳ 10% is a fine tolerance to use

Power Handling

All passives will have a power handling rating in some form → due to the thermal destruction of the part due to heating, especially for resistors

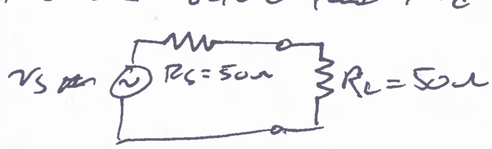
For chip resistors

Heating will cause destruction of ~~film~~ resistive film or resistor. Can be reduced by

- Thermally conductive substrate
- Larger device area
- Larger/conductive solder connection

* Value will change with temperature also!

For an 0402 part → $P_d^{max} = 100mW$



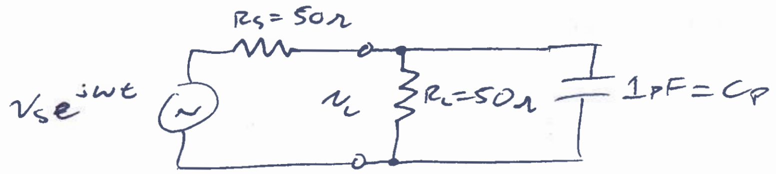
$v_S = 1V \to P_d = 5mW$

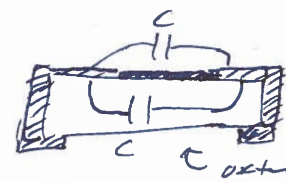
$v_S = 2V \to P_d = 20mW$

$v_S = 10V \to P_d = 500mW \Rightarrow$ Resistor destroyed

Parasitic capacitance

Parasitic capacitance is often a significant limiting factor for high-frequency devices since capacitors have lower impedances as frequency increases.





$$v_L = \frac{(R_L \| C_P)}{R_S + (R_L \| C_P)} v_s e^{j\omega t} = \frac{(R_L/j\omega C_P)/(R_L + \frac{1}{j\omega C_P})}{R_S + (R_L/j\omega C_P)/(R_L + \frac{1}{j\omega C_P})} v_s e^{j\omega t} = \frac{(R_L/j\omega C_P)}{R_S R_L + \frac{R_S}{j\omega C_P} + \frac{R_L}{j\omega C_P}} v_s e^{j\omega t}$$

$$\cancel{v_L = \frac{R_L}{R_S R_L j\omega C_P + R_S + R_L} v_s e^{j\omega t}} \qquad v_L = \frac{R_L}{R_S R_L j\omega C_P + R_S + R_L} v_s e^{j\omega t}$$

$$\cancel{P_L = \frac{|v_L|^2}{R_L} = \frac{R_L^2}{R_L(R_S R_L j\omega C_P + R_S + R_L)^2} = \frac{R_L}{(R_S R_L j\omega C_P + R_S + R_L)^2}}$$

$$\cancel{P_L \propto \frac{R_L}{(R_S R_L \omega C_P)^2} = \frac{1}{R_S^2 R_L \omega C_P} = \frac{1}{2\pi R_S^2 R_L C_P}}$$

Now we calculate the power dissipation

$$P_L = \frac{|v_L|^2}{R_L} = \frac{v_L v_L^*}{R_L} = \frac{R_L}{R_S R_L j\omega C_P + R_S + R_L} \cdot \frac{R_L}{-R_S R_L j\omega C_P + R_S + R_L} v_s^2 = \frac{R_L^2}{R_S^2 R_L^2 \omega^2 C_P^2 + (R_S + R_L)^2} v_s^2$$

$$P_L = \frac{R_L^2 v_s^2}{R_S^2 R_L^2 \omega^2 C_P^2 + (R_S + R_L)^2}$$

We expect that 1/2 power should not be dissipated by resistor at resonant frequency

$$\omega_0 = \frac{1}{RC} = \frac{1}{(R_S \| R_L) C_P}$$

$\omega_0 \sim 2\pi \cdot 6\,GHz$

therefore, use of this ~~resonance~~ resistor past 1 GHz is not great since much of the power will not get dissipated and will be reflected away.