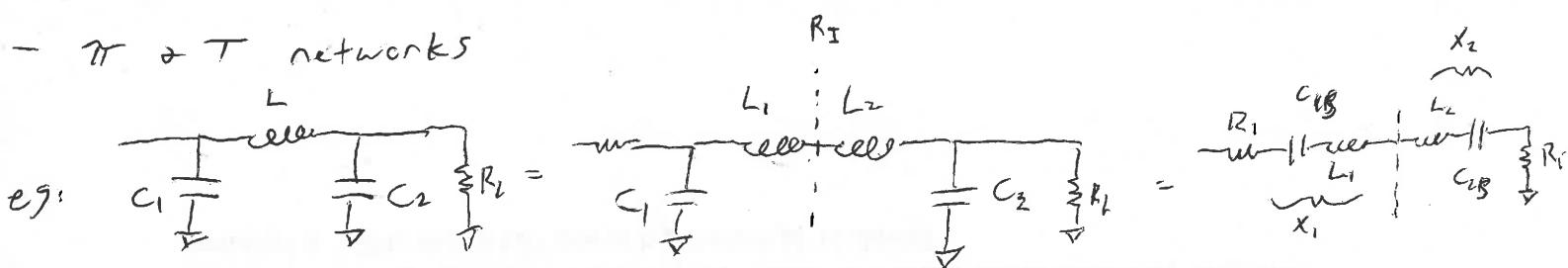


Π & T matchesComponent Q,
Loaded Q
Insertion LossTapped Inductor
or capacitorAntenna Intro
↳ why radiation?
↳ Path loss
↳ Gain & Link Budget

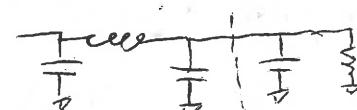
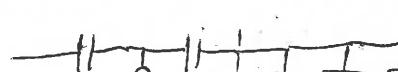
- We are finishing matching networks & starting antennas

- A few matching topics that I need to finish on schedule

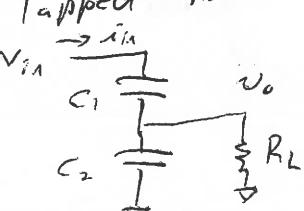
- Π & T networks↳ use them to set Q separately from R_{in}/R_L ← linked in L-match↳ Analyze w/ series-parallel transform $R_P = (Q^2 + 1)R_S$

$$X_P = \frac{Q^2 + 1}{Q^2} X_S$$

- parallel R bigger than series always → step-up L & step-down T

- In Π step down & then up resistance to intermediate "image resistance"- can evaluate $Q_{total} = \frac{X_1 + X_2}{2R_I} = \frac{1}{2}(Q_1 + Q_2)$ - $Q_1 = \sqrt{\frac{R_L}{R_I} - 1}$ & $Q_2 = \sqrt{\frac{R_I}{R_S} - 1}$ → Q_{total} is $f(R_I)$ - pick total Q, then design 2x L-match for $Q_1 + C_0$ & $Q_2 + C_0$ - Merge parasitics into matches - e.g.: - Or ring them out - e.g.: - Narrow vs. broad match

- Tapped inductor/capacitor



$$Z_{in} \approx \frac{V_{in}}{I_{av}(C_1, C_2)} \cdot \frac{C_1 + C_2}{C_1 C_2}$$

$$\text{so } V_o = V_{in} \cdot \frac{C_1}{C_1 + C_2} \approx k V_{in}$$

$$P_{in} = i_{in}^2 V_{in} \quad \text{so} \quad P_{out} = \frac{V_o^2}{R_L} = \frac{V_{in}^2}{R_L}$$

$$\rightarrow R_{in} = R_L / k^2 \quad (k < 1 \text{ so boost } R_L \text{ value})$$

Antennas!

- 1st topic in comm. systems ~ concerned w/ on board for 1st 1/2 class

- Why do wires decide to radiate?

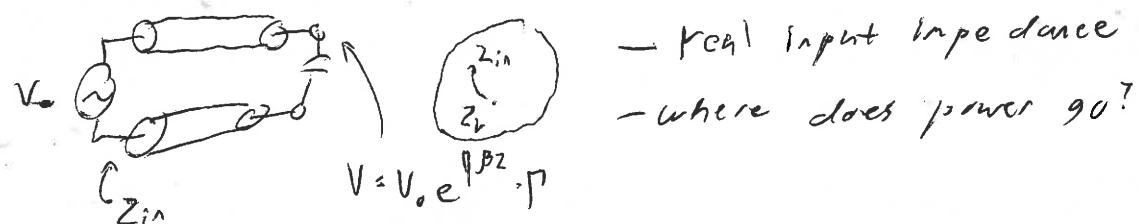
- related example: V_o $kV_o e^{j\phi}$ $i = V_o(1 - ke^{j\phi})$

$$\text{constant } Z_{eq} = \frac{1}{j\omega C(1 - ke^{j\phi})}$$

~ How much power drawn from V_o ?

↳ real Z_{eq} implies real power } depends on large ϕ
 ↳ can get from $\frac{1}{2} \operatorname{Re}\{V_i I_i^*\}$ too } (at $\phi=0, 180^\circ$ Z is just $\operatorname{Im}.$)
 ↳ shunt by kV_o source

- Can see same effect w/t. line ~ delay picture or smith picture



~ resistive component of Z called radiation resistance

~ power dissipated in fields surrounding wire (does work on field at other end)

~ Poynting Thm $P = \frac{1}{2} \operatorname{Re}\{\mathbf{E} \times \mathbf{H}^*\}$

- Aside: how much power in ideal conductor?

$P=0$ b/c $\vec{E}=0$ ~ carried in fields around conductor

- only see radiation for $l \approx \lambda$ % that causes sizable ϕ

↳ antennas come in $\lambda/2$, $\lambda/4$, $\lambda/8$ dimensions

- what happens to power after it leaves wire
 - Antenna w/ 2 spheres
 - $I_1 A_1 = I_2 A_2$ or power buildup / creation
 - $\frac{I_1}{I_2} = \frac{A_2}{A_1} = \frac{4\pi r_2^2}{4\pi r_1^2} = \left(\frac{r_2}{r_1}\right)^2$ - intensity falls as r^2
 - $I \propto |E|^2 / Z_0 \rightarrow |E| \propto \frac{1}{r}$ - field falls off as $\frac{1}{r}$
 - Field must fall off as $\frac{1}{r}$, components w/ other fall off must be reactive ... can't be real power flow - $E \propto \frac{1}{r^2}$ & $H \propto \frac{1}{r^3}$ in near field
 - consider fields around stationary charge
 - I_n far field if $r > \frac{2D^2}{\lambda}$ & $r \gg D$ & $r \gg \lambda$
 - Reactive near field until $r > 0.62 \sqrt{\frac{P^3}{\lambda}}$, reactive in between
- Antennas aren't isotropic - represent w/ directivity
 - ~ imagine 2 antennas
 - $P_{RX} = \frac{P_{TX}}{4\pi r^2} \cdot A_{RX} \cdot D_{TX}(\theta) \cdot \frac{G_{TX}}{G_{RX}}$
 - Equivalent isotropic power density (EIPD)
 - receive aperture
 - directivity
 - $\frac{P_{TX}(\theta)}{EIPD}$
 - loss in antenna
- ~ RX antenna aperture trickier $A_e = \frac{\lambda^2}{4\pi} G$

~ combine $P_{RX} = \frac{P_{TX}}{4\pi r^2} G_{TX} G_{RX} \frac{\lambda^2}{4\pi} \rightarrow P_{RX} = \frac{P_{TX} G_{TX} G_{RX} \lambda^2}{(4\pi r^2)}$ $\frac{\lambda^2}{4\pi r^2}$ called path loss