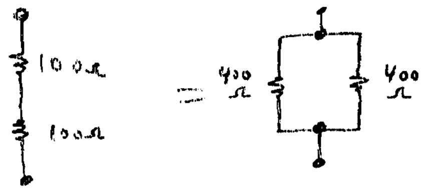
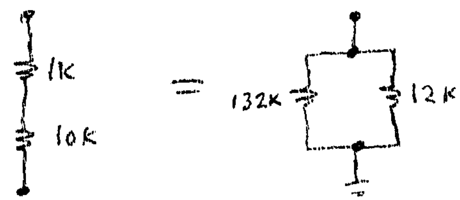
Series — parallel equivalent circuits --

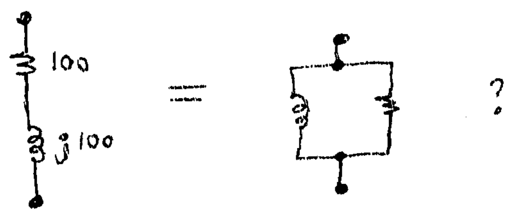
At *any one frequency*, For every series circuit there is an equivalent parallel circuit:



⟵ Actually, there are many — anything that results in 200Ω

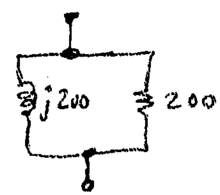


How about ---



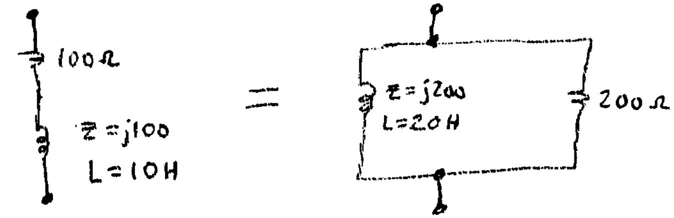
$$100 + j100 = \frac{1}{.005 - j.005} = \frac{1}{\frac{1}{200} + \frac{1}{j200}}$$

→

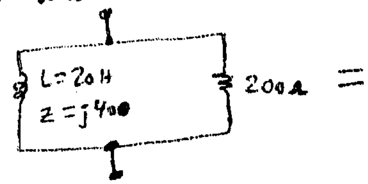


But it really is at *only one frequency*

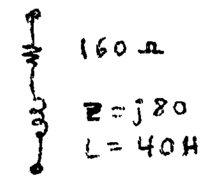
Suppose $\omega = 10$



But when $\omega = 20$: .



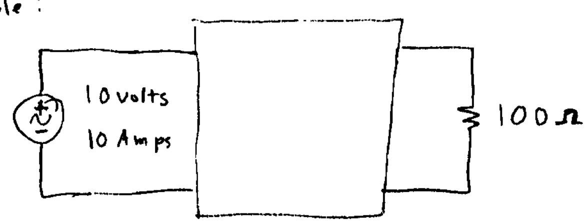
$$\frac{1}{\frac{1}{200} + \frac{1}{j400}} = \frac{1}{.005 - j.0025} = 160 + j80$$



Impedance matching

Suppose we have a power source that doesn't match the load ---
What can we do?

Example:



The source (10 volts) can supply 10 Amps - (100 watts)

The optimum load is $R = \frac{V}{I} = \frac{10V}{10A} = 1\Omega$

We want to deliver 100 watts to 100Ω
That's 100 volts at 1 Amp.

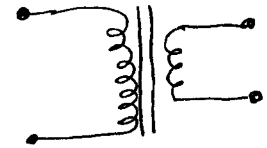
How? What goes in the box?

Two approaches:

① Transformer

② LC Matching network

Approach #1 -- Transformer --



Two inductors wound on the same core — so they are coupled.

We refer to "turns ratio" ---

1:10 means there are 10 times as many turns in the primary as in the secondary

Example: 50 turns to 500 turns.

→ This will "transform" the voltage according to the turns ratio --

10 volts on primary gives you 100 volts on secondary

and the current according to the inverse of the turns ratio

10 Amps on the secondary gives you 1 Amp on the primary

power ---

primary: $P = VI = (10)(10) = 100$ Watts

secondary: $P = VI = (100)(1) = 100$ watts

Impedance ---

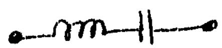
primary $Z = \frac{V}{I} = \frac{10}{10} = 1\Omega$

Secondary $Z = \frac{V}{I} = \frac{100}{1} = 100\Omega$

→ impedance ratio is turns ratio squared.

Approach # 2 -- LC network --

Recall:

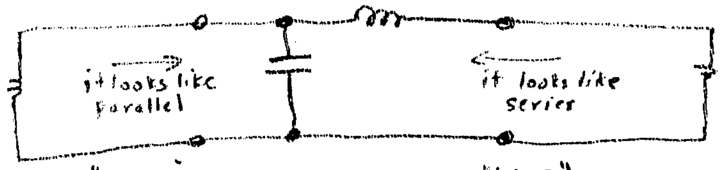


series → 0 Ω at resonance "Lo-Z"

parallel → ∞ Ω at resonance. "Hi-Z"

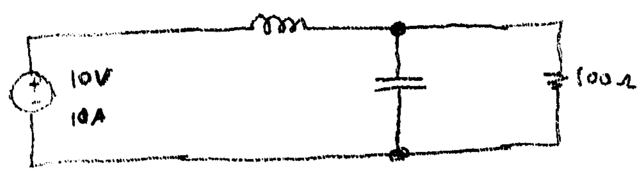
Consider these:

(A)



Idea: put this L-C between our generator and load.

which way? Look at "Hi-Z" and "Lo-Z" ends.



Lo Z (1 Ω)

Hi-Z put cap on this end

Pick value of cap for $X = \sqrt{Z_1 Z_2}$

$= \sqrt{(1)(100)}$

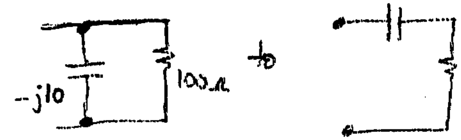
$= \sqrt{100}$

$= 10\,\Omega$

$X_C = -j\,10\,\Omega$

Now pick L to tune it, but the combination of series-parallel is hard to tune.

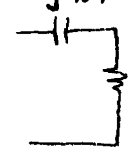
Convert



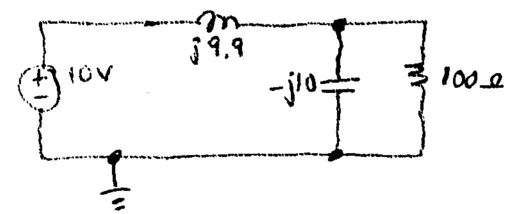
$Z = \dfrac{1}{\frac{1}{100} + \frac{1}{-j10}}$

$= \dfrac{1}{.01 + j.1}$

$= .99 - j9.9$ →



So choose inductor $+j\,9.9$



The 10 V source sees a 1 Ω resistive load!

Try some real values --

suppose F = 60 Hz ω = 376.99

$X_L = j\omega L \;\rightarrow\; L = \frac{X_L}{j\omega} = \frac{j9.9}{j376.99} = .026261\ H$

$X_C = \frac{1}{j\omega C} \;\rightarrow\; C = \frac{1}{j\omega X_C} = \frac{1}{j(376.99)(-j10)} = .00026526\ F$

$= 265.26\ \mu F$