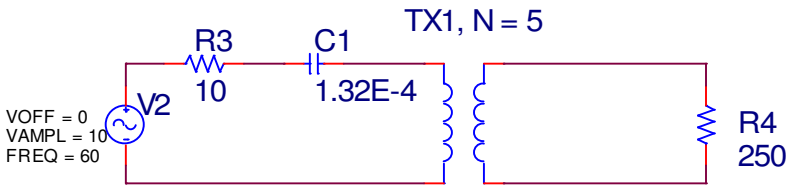
Lecture 22
questions

How does the orientation of the inductors affect transformer characteristics?
What is mutual inductance?
What is the coupling coefficient, k?
What is the Tee model of mutual inductance?
How do real transformers behave?

Review 2)



Determine IR4.

V.s has a 10 V amplitude, and 60 Hz frequency

$\omega = 2\pi 60 = 377 \frac{rad}{s}$ $N_2 := 5$

$\frac{1}{377 \cdot 1.3 \cdot 10^{-4}} = 20.404$

$Z_C = -j20$

Refer primary to secondary

$V_{SEQ} := N_2 \cdot 10$

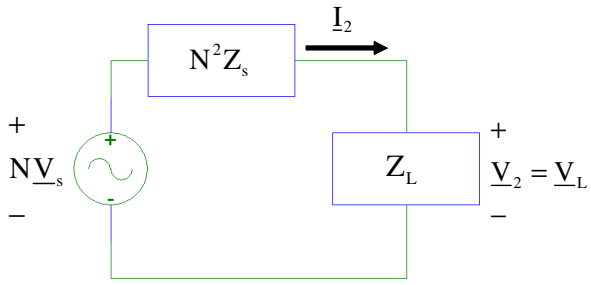
$V_{SEQ} = 50$

$Z_{SR} := N_2^{\,2} \cdot 10$

$Z_{SR} = 250$

$Z_{SC} := 20j \cdot N_2^{\,2}$

$Z_{SC} = 500i$ $Z_L = 250\Omega$



To find I2 get ZEQ for the entire circuit which is the Resistor Capacitor and Load Resistor in series

$500 - 500j$

$\sqrt{500^2 + (-500)^2} = 707.107$ also by inspection $500\sqrt{2} < -45\text{deg}$

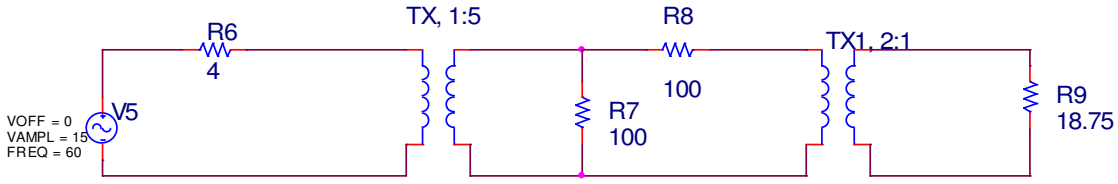
$\text{atan}\left(\frac{-500}{500}\right) = -45 \cdot \text{deg}$

$Z_{EQ} = 707.1 < -45\text{deg}$

So I2 or IR4 is $\frac{50 < 0}{707.1 < -45} = 0.071 < 45\text{deg}$ $\frac{50}{707.1} = 0.071$ $\frac{1}{10 \cdot \sqrt{2}} = 0.071$

In the time domain: $I_{R4} = 0.071 \cdot \cos(377t + 45\text{deg})$

Problem 1)



Find VR9

step up
$N_{3a} := 5$

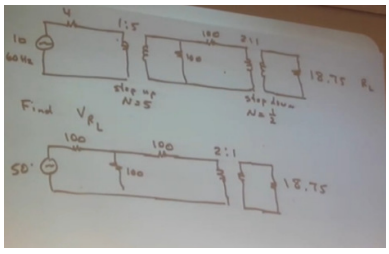
step down
$N_{3b} := 0.5$

Refer primary to secondary

Note: The middle is the secondary for the first part and the primary for the second part.

$V_{SEQ2} := N_{3a} \cdot 15$

$V_{SEQ2} = 75$



$Z_{SR} := N_{3a}^2 \cdot 4$

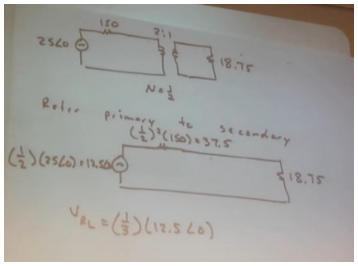
$Z_{SR} = 100$

Can do Thevenin equivalent, make the load the inductor, so take it out and measure vout..

$$V_{Th} := \frac{75 \cdot 100}{200} = 37.5$$

$$V_{Th} = 37.5 < 0$$

$$R_{th} = 150\Omega$$



Refer to primary to secondary with thevenin equivalent attached to a step down transformer

$$V_{SEQ3} := N_{3b} \cdot 37.5$$

$$V_{SEQ3} = 18.75$$

$$Z_{SR2} := N_{3b}^{2} \cdot 150 = 37.5$$

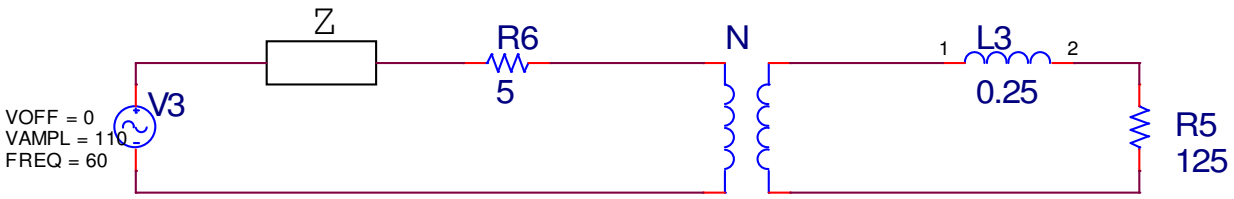
Using the voltage divider

$$\frac{18.75}{37.5 + 18.75} = 0.333$$

$$V_{R9} := 18.75 \cdot \frac{18.75}{37.5 + 18.75}$$

$$V_{R9} = 6.25 \angle 0\text{deg}$$

Problem 2) Impedance Matching



a. Determine the winding ratio and the impedance Z such that the power delivered to the load is maximized relative to the source power.

$\omega := 2 \cdot \pi \cdot 60$

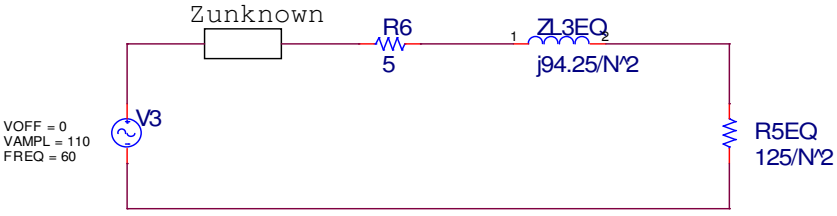
$\omega = 376.991$

$Z_{L3} = 377 \cdot 0.25 \cdot j$

$Z_{L3} = 94.25j$

Referring the secondary to the primary, the equivalent circuit is

$$Z_L = \frac{125 + 94.25j}{N^2}$$



$Z_S = 5 + Z_{unknown}$

The power is maximized when ZS=ZL* where Zunknow is imaginary

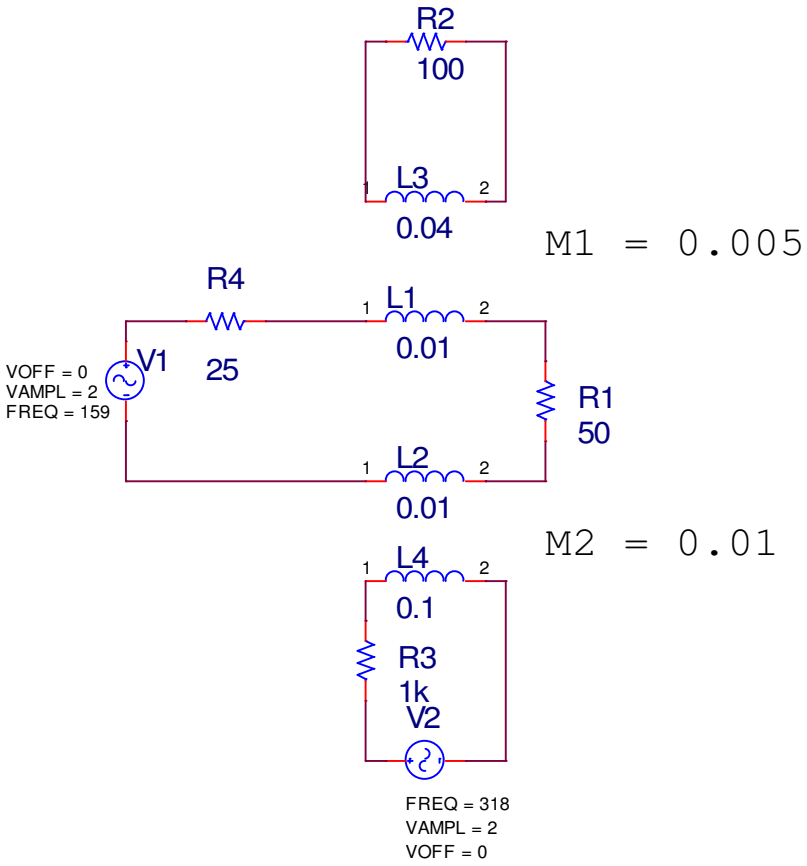
Considering the real parts of Zs and ZL

$\frac{125}{N^2} = 5$ $\qquad$ $N = 5$

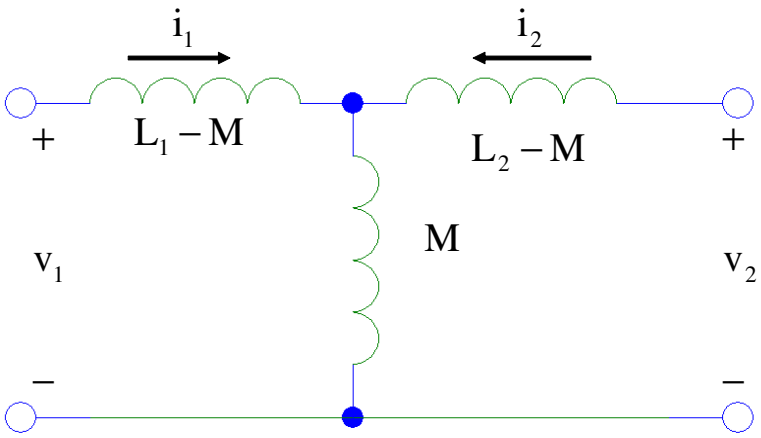
Considering the imaginary parts of ZS and Zl and the winding ratio

$\frac{-94.25j}{N^2} = Z_{unknown}$ $\qquad$ $Z_{unknown} = -3.77j\Omega$

Problem 3) Tee Model



Draw the tee model equivalent for the circuit above.



$M_1 := 0.005$

$M_2 := 0.01$

$L_3 := 0.04$

$L_2 := 0.01$

$L_1 := 0.01$

$L_4 := 0.1$

$L_3 - M_1 = 0.035$

$L_2 - M_2 = 0$

$L_1 - M_1 = 5 \times 10^{-3}$

$L_4 - M_2 = 0.09$