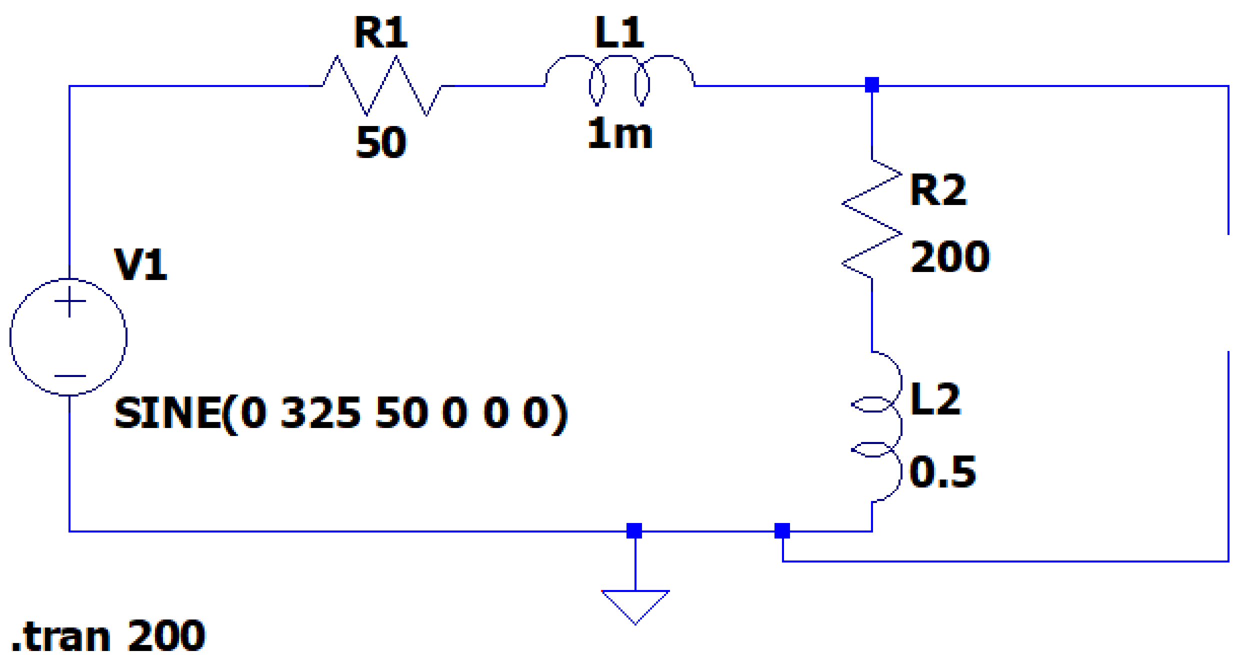
Experiment No.8 **Date:23/11/2021**

Power Factor Improvement

Objective:

- To study the effect on inductive load and power factor
- To improve the power factor and understand the advantages

Circuit:



Simulation Tool:

LTSpice – transient analysis

<u>Observation</u>

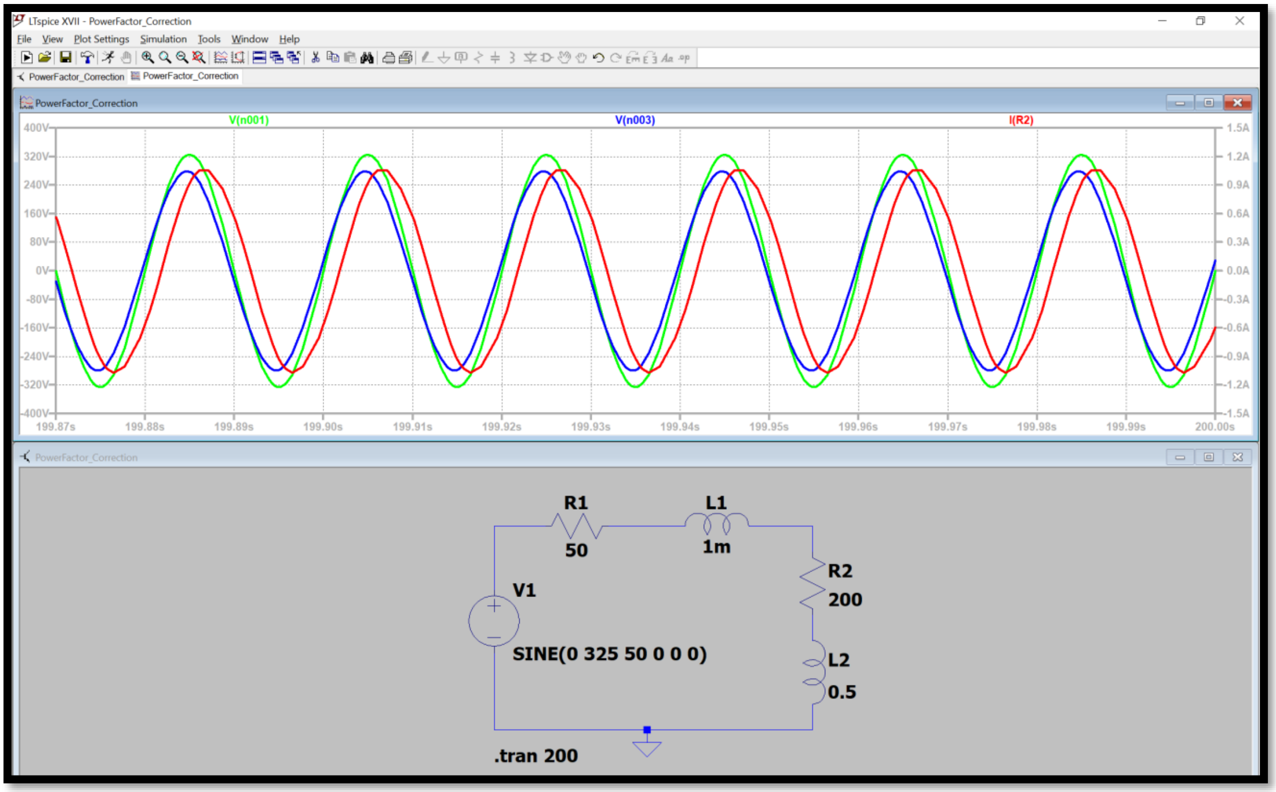
Source Voltage: vs(t) =325V, Vsrms= 230V

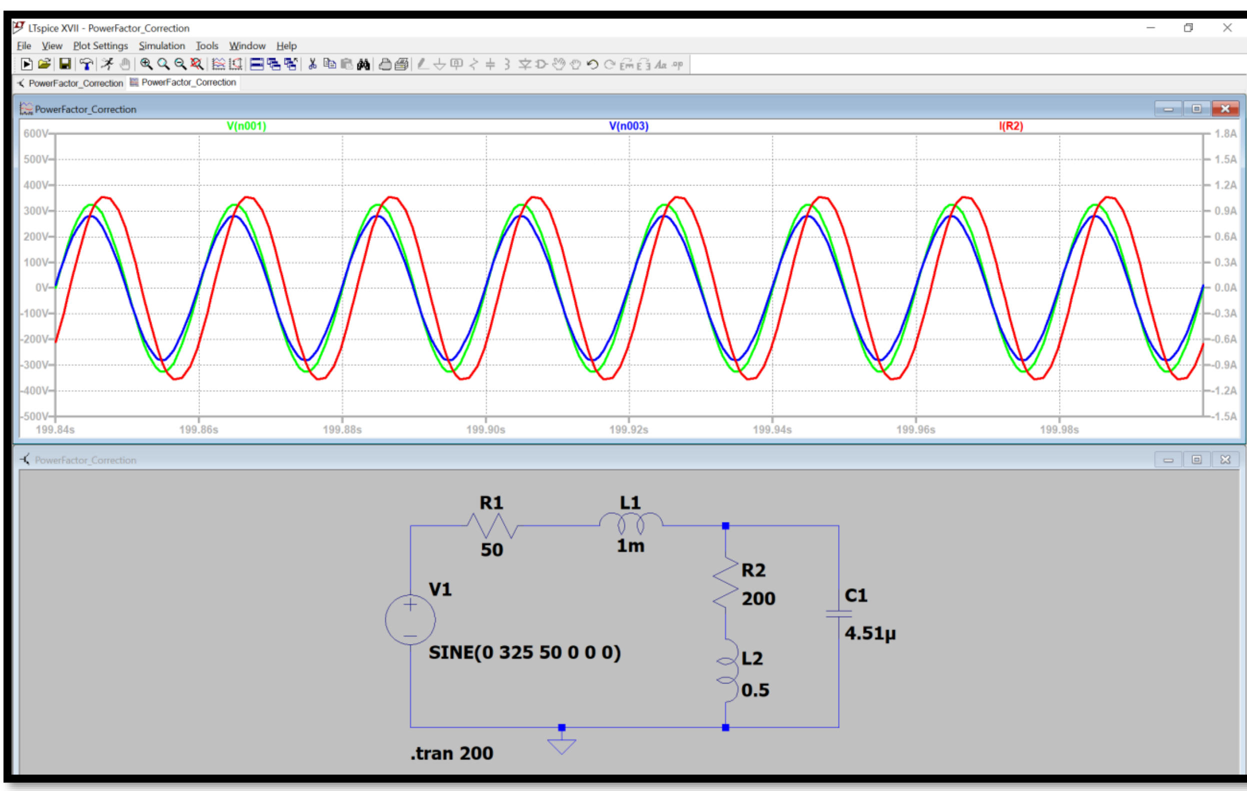
Load	Load Impedance $(\|Z\| < \emptyset)$	Line Current (Irms)	Load Terminal Voltage (Vrms)	Phase Angle Measured $(\Delta t/T) * 360$	Power Factor	Real Power P(W)	Reactive Power Q(VAR)	Line Losses (W)
($R+jX_L$) 200+j157	254.26	0.777A	197.7V	38.5	0.782(lag)	120.88	94.5	30.3
$R+jX_L$ with C1 200+j157 c = 4.51μF	335.18	0.65A	198.78V	18.9	0.95(lag)	122.81	40.16	21.15
$R+jX_L$ with C2 200+j157 c = 5μF	359.99	0.64A	199.35V	16.26	0.96(lag)	122.94	34.09	20.24
$R+jX_L$ with C3 200+j157 c = 4.51μF	370.20	0.62A	199.49A	7.69	0.99(lead)	122.67	-15.80	19.07

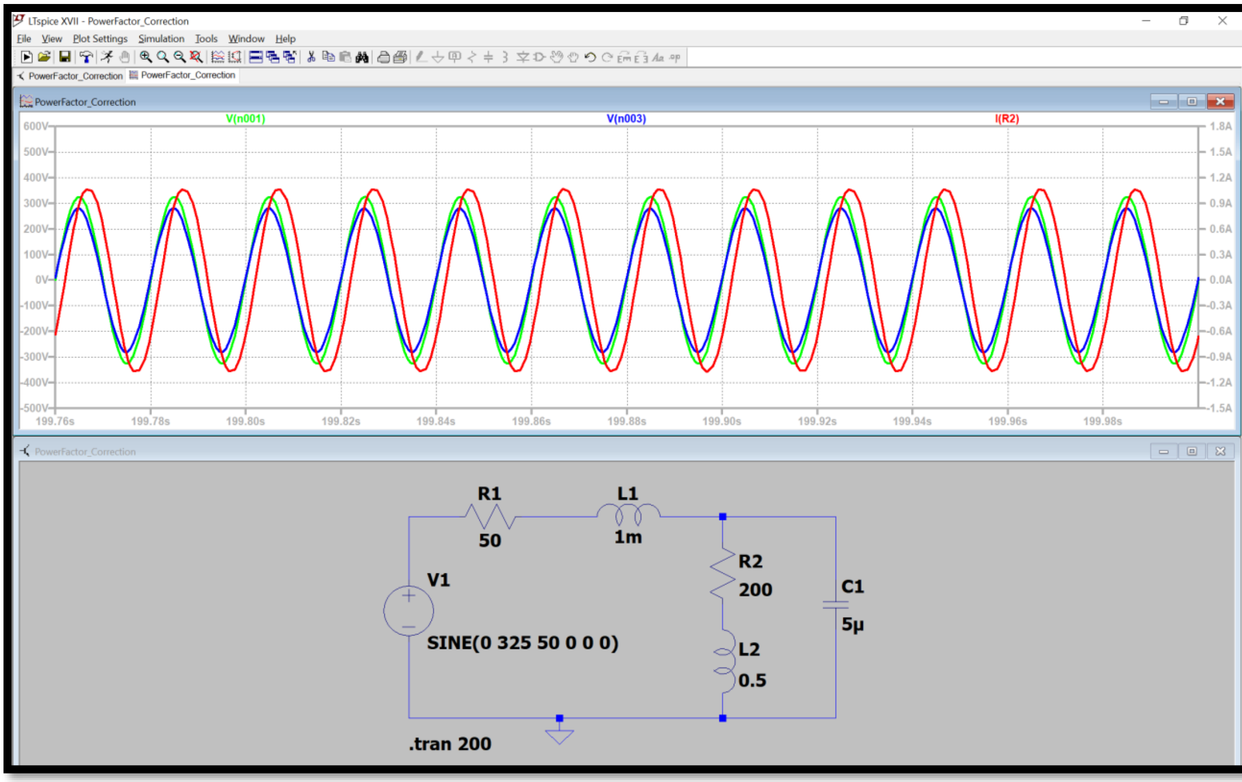
Observe the results and comment on the changes in the following parameters:

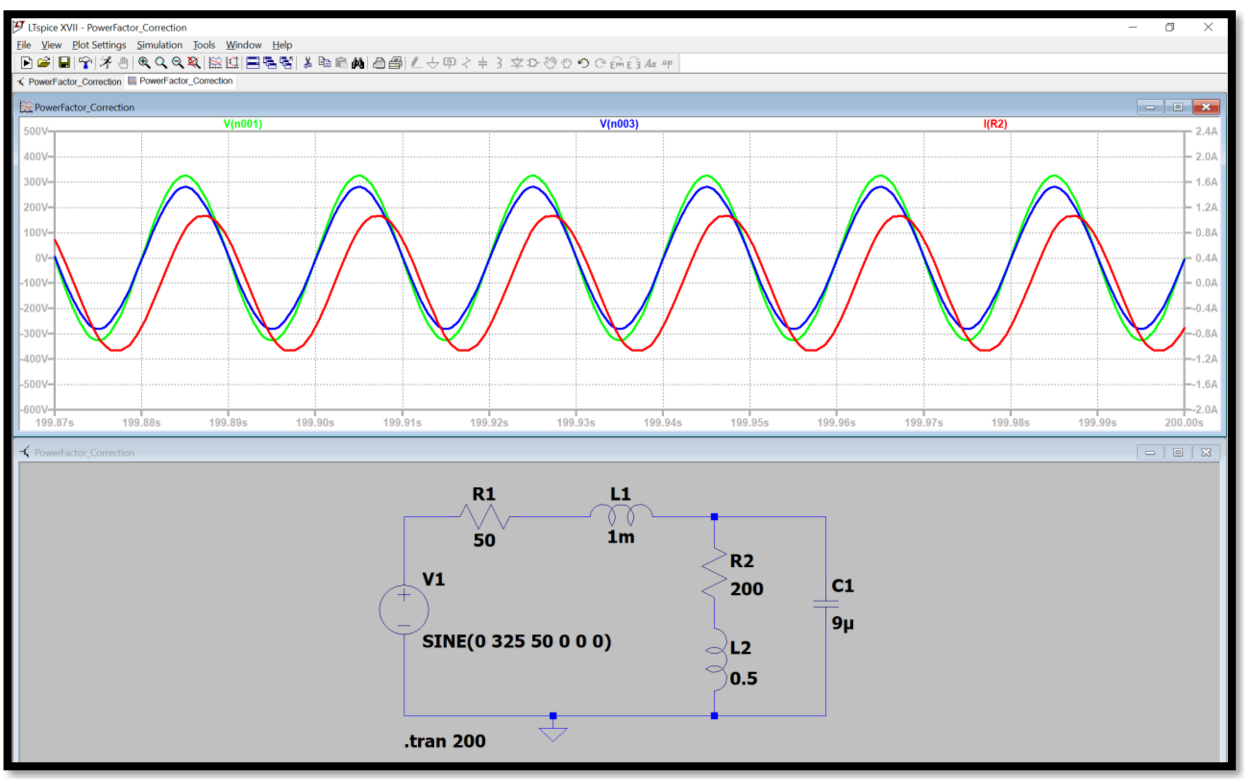
1. Power Factor
2. Line losses
3. Terminal Voltage
4. Real Power
5. Reactive Power

Verify with theoretical calculation for load 1 and load 2 in the table


LTspice XVII - PowerFactor_Correction
File View Plot Settings Simulation Tools Window Help
PowerFactor_Correction
V(n001)
V(n003)
I(R2)
400V 320V 240V 160V 80V 0V -80V -160V -240V -320V -400V
1.5A 1.2A 0.9A 0.6A 0.3A 0.0A -0.3A -0.6A -0.9A -1.2A -1.5A
199.87s 199.88s 199.89s 199.90s 199.91s 199.92s 199.93s 199.94s 199.95s 199.96s 199.97s 199.98s 199.99s 200.00s
R1
50
L1
1m
R2
200
V1
SINE(0 325 50 0 0 0)
L2
0.5
.tran 200

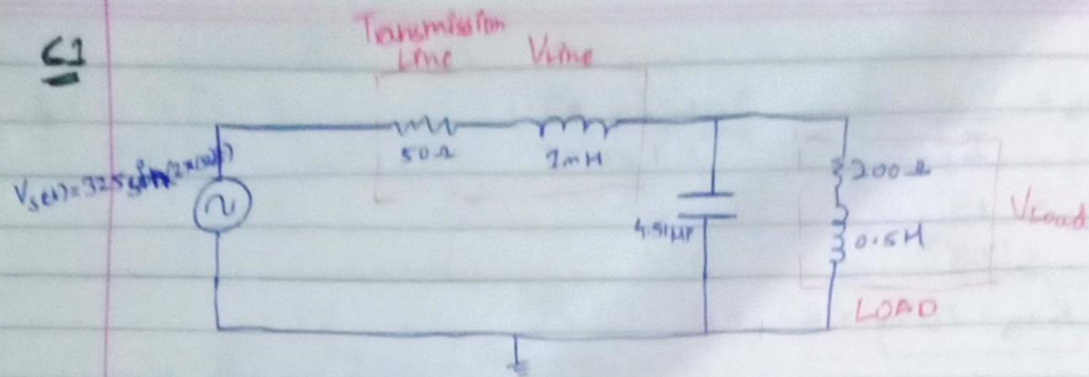

LTspice XVII - PowerFactor_Correction
File View Plot Settings Simulation Tools Window Help
PowerFactor_Correction
V(n001)
V(n003)
I(R2)
600V 500V 400V 300V 200V 100V 0V -100V -200V -300V -400V -500V
1.8A 1.5A 1.2A 0.9A 0.6A 0.3A 0.0A -0.3A -0.6A -0.9A -1.2A -1.5A
199.84s 199.86s 199.88s 199.90s 199.92s 199.94s 199.96s 199.98s
R1
50
L1
1m
R2
200
C1
4.51μ
V1
SINE(0 325 50 0 0 0)
L2
0.5
.tran 200


LTspice XVII - PowerFactor_Correction
File View Plot Settings Simulation Tools Window Help
V(n001)
V(n003)
I(R2)
R1
50
L1
1m
V1
SINE(0 325 50 0 0 0)
R2
200
L2
0.5
C1
5µ
.tran 200


LTspice XVII - PowerFactor_Correction
File View Plot Settings Simulation Tools Window Help
V(n001)
V(n003)
I(R2)
R1
50
L1
1m
V1
SINE(0 325 50 0 0 0)
R2
200
L2
0.5
C1
9µ
.tran 200

Calculations:

Q1



$$V_s = 325 \angle -90^\circ$$

$$V_{s_{RMS}} = \frac{325}{\sqrt{2}} \angle -90^\circ$$

$$= 230 \angle -90^\circ$$

$$Z_T = \left[(157j + 200)^{-1} + (-707.79j)^{-1}\right]^{-1}$$

$$= 292.02 + 95.49j$$

$$\therefore Z_{eff} = 50 + 0.314j + 292.02 + 95.49j$$

$$= 342.02 + 95.80j$$

$$I_s = \frac{325 \angle -90}{342.02 + 95.80j}$$

$$= 0.915 \angle -105.65 \text{ A}$$

$$I_{s_{RMS}} = 0.65 \angle -105.65 \text{ A}$$

$$S_s = (V_{RMS})(I_{s_{RMS}})^*$$

$$= (230 \angle -90)(0.65 \angle 105.65)$$

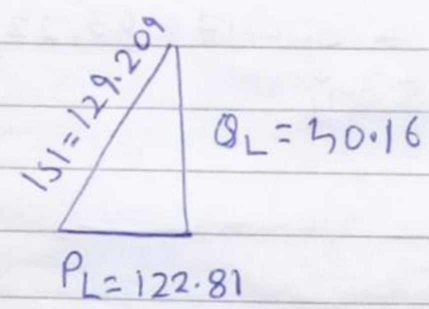
$$= (\underbrace{143.96}_{W} + \underbrace{40.33j}_{VAR}) \text{ VA}$$

$$V_{Load} = I_s \times Z_1$$
$$= (0.915 \angle -105.65)(292.02 + 95.49j)$$
$$= 281.12 \angle -87.54 \text{ V}$$

$$V_{Load_{RMS}} = 198.78 \angle -87.54 \text{ V}$$

$$S_{Load} = (V_{Load_{RMS}})(I_{s_{RMS}})^*$$

$$= (198.78 \angle -87.54)(0.65 \angle 105.65)$$
$$= (\underbrace{122.81}_{W} + \underbrace{40.16j}_{VAR}) \text{ VA}$$



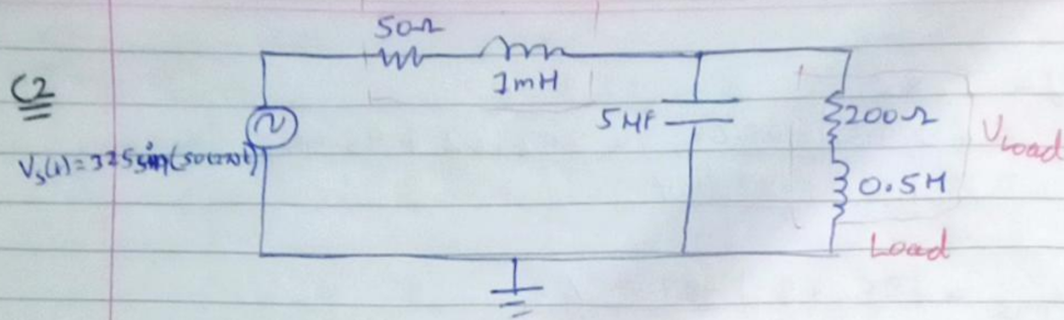
$$\therefore \cos\phi = \frac{122.81}{129.21}$$

$$\Rightarrow \boxed{\cos\phi = 0.95} \text{ (lag)}$$

$\therefore$ power loss in line = $\underline{\underline{21.15 \text{W}}}$

Transmission Line

Q2



$V_s = 325\angle{-90^\circ}$

$\therefore V_{s_{RMS}} = 230\angle{-90^\circ}$

$Z = \left[(157j + 200)^{-1} + (-636.62j)^{-1} \right]^{-1}$

$= 300.17 + 83.22j$

$\therefore Z_{eff} = 50 + 0.314j + 300.17 + 83.22j$

$= 350.17 + 83.534j$

$I_s = \dfrac{325\angle{-90^\circ}}{350.17 + 83.534j}$

$= 0.903\angle{-103.42}$ A

$\therefore I_{s_{RMS}} = 0.64\angle{-103.42}$ A

$\therefore S_s = (V_{s_{RMS}})(I_{s_{RMS}})^*$

$= (230\angle{-90})(0.64\angle{103.42})$

$= 143.18 + 34.16j)$ VA

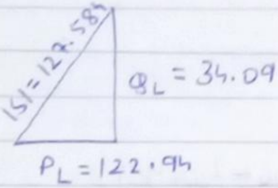
$V_{Load_{RMS}} = (0.64\angle{-103.42})(30.17 + 83.22j)$

$V_{Load_{RMS}} = 199.35\angle{-87.92}$ V

$S_{Load} = (V_{Load\,RMS})(I_{S\,RMS})^*$

$= (199.35 \angle -87.92)(0.64 \angle 103.42)$

$= (122.94 + 34.09j)\ VA$

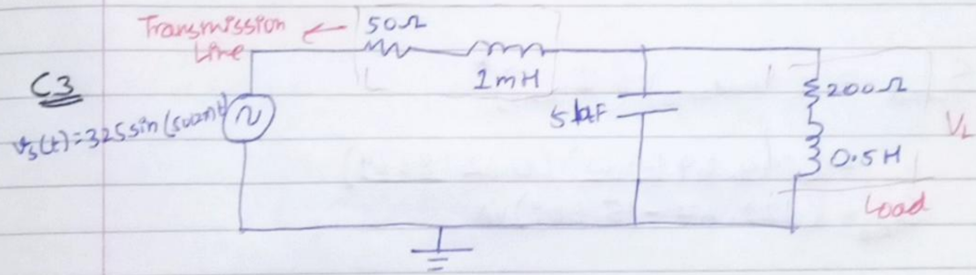


$\cos\phi = \dfrac{122.94}{127.584}$

$\Rightarrow \boxed{\cos\phi = 0.96 \text{ (lag)}}$

Power loss in line $= \underline{20.24\,W}$

C3



$V_S = 325 \angle -90°$

$V_{S\,RMS} = 230 \angle -90°$

$Z = \left[(157 + 200)^{-1} + (-353.68j)^{-1}\right]^{-1}$

$= 317.96 - 40.99j$

$\therefore Z_{eff} = 50 + 0.314j + 317.96 - 40.99j$

$= 367.96 - 40.676j$

$I_S = \dfrac{325 \angle -90}{367.96 - 40.676j} = 0.88 \angle 85.69\,A$

$I_{S\,RMS} = 0.62 \angle -83.69\,A$

$$\therefore S_s = (V_{s_{RMS}})(I_{s_{RMS}})^*$$

$$= (230 \angle -90)(0.62 \angle -83.69)$$

$$= (141.74 - 15.67j)\, VA$$

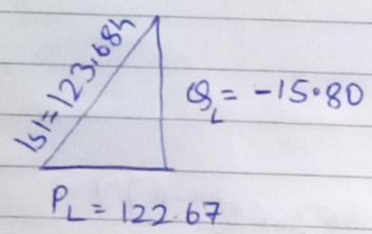
$$V_{Load_{RMS}} = (0.62 \angle -83.69)(317.96 - 40.99j)$$

$$V_{Load_{RMS}} = 199.49 \angle 91.03\, V$$

$$S_{Load} = (V_{Load_{RMS}})(I_{s_{RMS}})^*$$

$$= (199.49 \angle -91.03)(0.62 \angle 83.69)$$

$$S_{Load} = (122.67 - 15.80j)\, VA$$



$$\therefore \cos\phi = \frac{122.67}{123.684}$$

$$\boxed{\cos\phi = 0.99 \ (Lead)}$$

$\therefore$ Power loss in line = 19.07 W