West Virginia University

EE 224 Section 03

Electrical Circuits Lab
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Lab 3: Power Factor Correction

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Procedure

The objective of this lab is to learn power factor correction in power systems. This lab focuses on correcting the power factor of a RL circuit. The inefficient circuit is to be simulated in LTSpice . The complex power is also to be calculated for this circuit. The magnitude and current is to be obtained through the Trigger Sweep Method. This is done by using cursors to zero in on both voltage and current graphs from which delta T is given. After this is done, the value of the capacitor needed to cancel reactive power caused by the inductor is to be calculated. This new capacitor is then added in parallel to the load to correct the power factor. The new circuit is also similarly simulated in LTSpice with current and complex power measurements to be taken.

Calculations

The following calculations are for the circuit without the capacitor

```
f = 60;
w = 2*pi*f;
R_1 = 1e03;
R_2 = 5e03;
L_1 = 10.5;
X_L1 = w*L_1;
V_in = 2.5 * (cosd(-90) + sind(-90) * 1j);
V_inrms = V_in/sqrt(2);
Z_F = R_1;
Z_L = R_2 + X_L1 * 1j;
Z_T = Z_F + Z_L;
I_inrms = V_inrms / Z_T
S_in = V_inrms * conj(I_inrms)
S_inmag = abs(S_in)
S_inangle = angle (S_in)
P_in = real (S_in)
Q_in = imag(S_in)
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pf_in = cos(S_inangle)
P_line = abs(I_inrms)^2 * R_1

Output Values:

I_inrms = -1.3543e-04 - 2.0528e-04i
S_in = 3.6289e-04 + 2.3941e-04i
S_inmag = 4.3475e-04
S_inangle = 0.5832
P_in = 3.6289e-04
Q_in = 2.3941e-04
pf_in = 0.8347
P_line = 6.0481e-05

The following calculations are for the circuit with the capacitor

Q_c = Q_in
V_L = V_inrms - I_inrms * R_1
%Value of required capacitance to achieve pf=1
C = Q_c/(w * (abs(V_L))^2)
Z_c =(1/(w*C)*-1j)
Z_Tnew = Z_F + (Z_L * Z_c) / (Z_L + Z_c)
I_inrmsnew = V_inrms / (Z_Tnew)
S_innew = V_inrms * conj(I_inrmsnew)
P_innew = real (S_innew)
Q_innew = imag(S_innew)
S_innewangle = angle(S_innew)
pf_innew = cos(S_innewangle)
P_linenew = abs(I_inrmsnew)^2 * R_1
1.7774 * 247.4e-06

Output Values:
Q_c =2.3941e-04
V_L = 0.1354 - 1.5625i
C =2.5818e-07
Z_c = 0.0000e+00 - 1.0274e+04i
Z_Tnew = 9.1338e+03
I_inrmsnew = 0.0000e+00 - 1.9354e-04i
S_innew = 3.4214e-04
P_innew = 3.4214e-04
Q_innew = 0

S_innewangle = 0
pf_innew = 1
P_linenew = 6.0481e-05

Result Tables

	Calculated	Simulated
Sin (VA)	3.6289e-04 + 2.3941e-04i	3.42E-04
pfin	0.8437	0.81
Pline (W)	6.05E-05	6.12E-05

Table 1: Circuit without Capacitor

	Calculated	Simulated
Sin (VA)	3.42E-04	3.40E-04
pfin	1	1
Pline (W)	6.05E-05	6.09E-04

Table 2: Circuit without Capacitor

Figures and Circuit Diagram

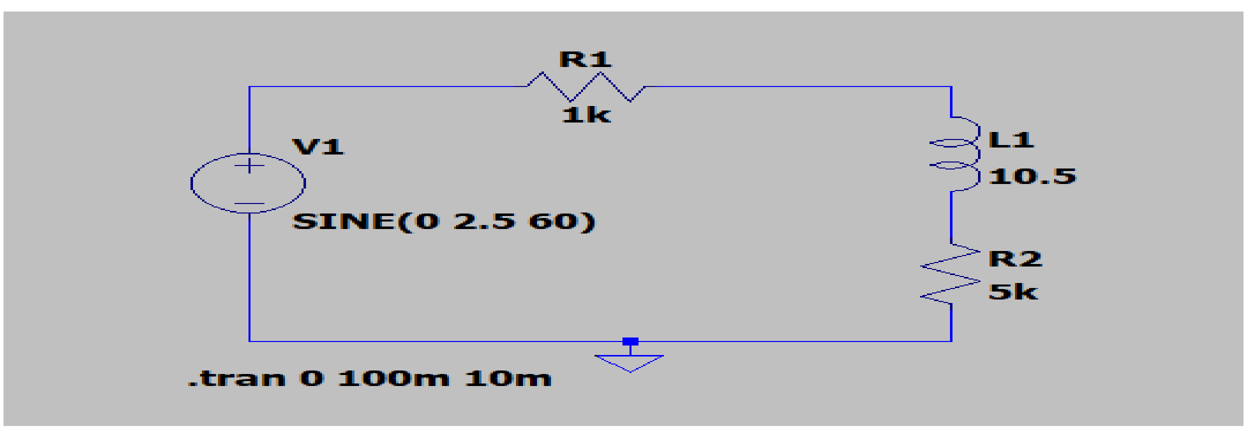

Figure 1: RL Circuit

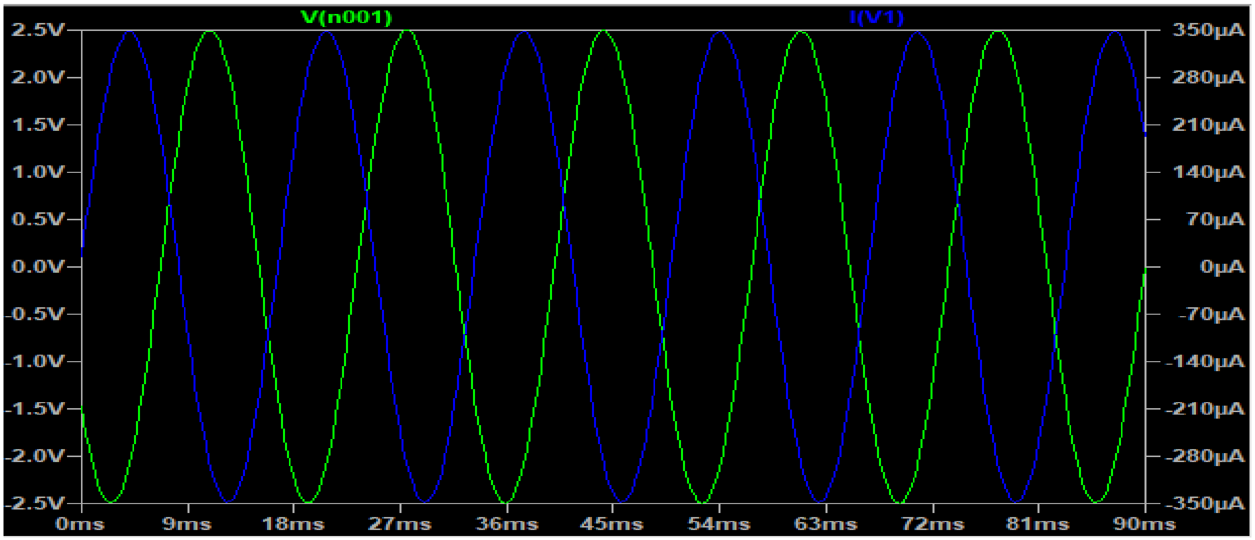

Figure 2: Input Voltage and Current

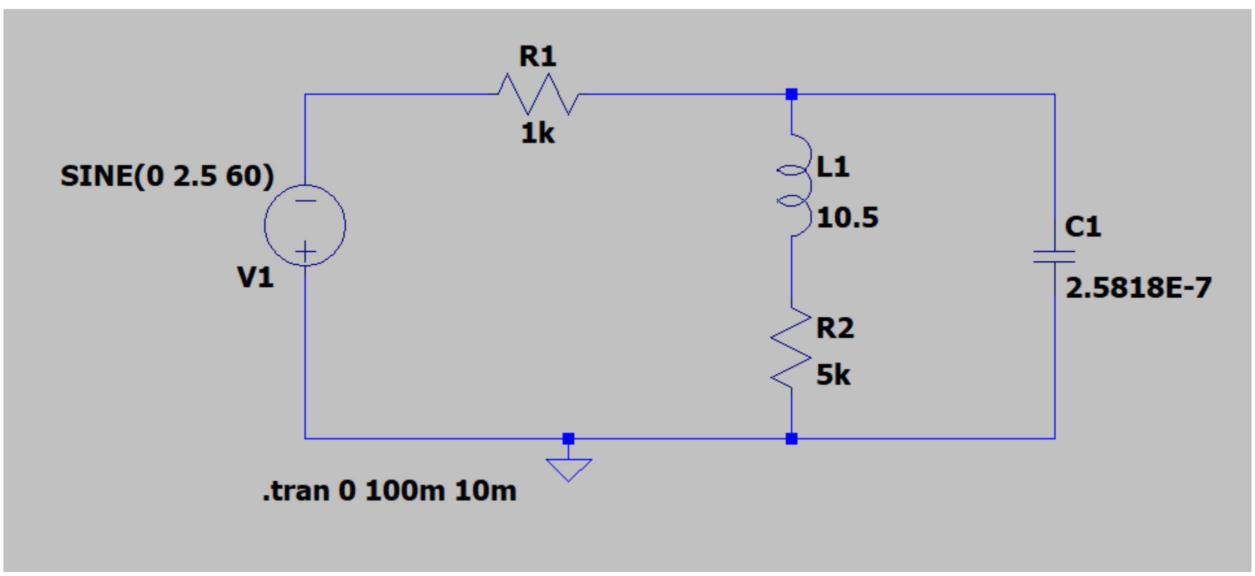

Figure 3: Circuit with Capacitor

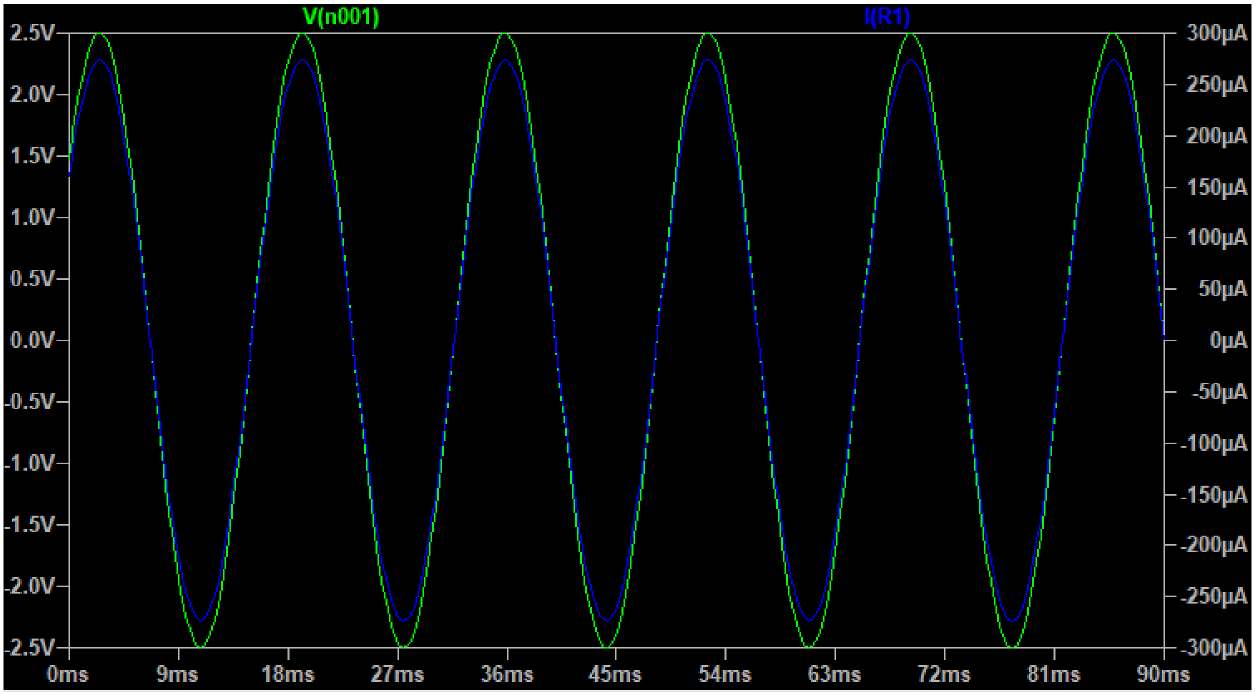

Figure 4: Input Voltage and Current after power factor correction

Inferences

Before the capacitor was added, there was too much reactive power in the circuit. Since in complex power, the reactive power and real power are added, reactive and real power have an inversely proportional relationship. The higher the reactive power the worse it is as there is less real power. To correct this successfully, a capacitor is added. The reactance of this capacitor is efficient in canceling the reactance of the inductor. It was seen that after this capacitor with a calculated value of 2.58158 E -7 farads was added the reactive power of the circuit is removed resulting in purely real power, power which we can use.

The other critical inference to take away from this lab is the ability of the added capacitor to sync the voltage and current in phase with each other. One perspective to look at this is through the formula of the power factor. The power factor is the cosine of the voltage angle - current angle. Knowing that cos(0) is 1, it is logical for the most ideal power factor the phase difference between voltage and current must be minimal.