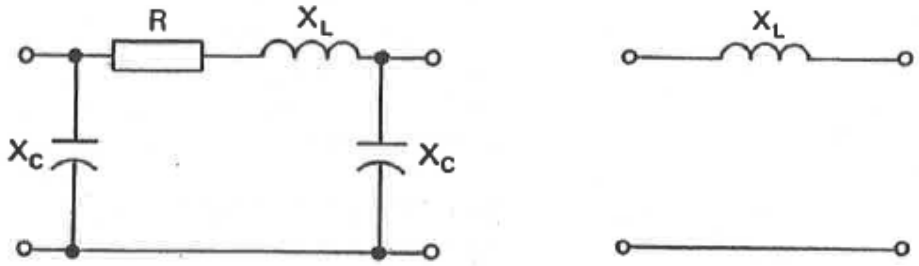
Lab 4- Power Flow and Voltage Regulation

- Transmission Line Representation (“Model”)



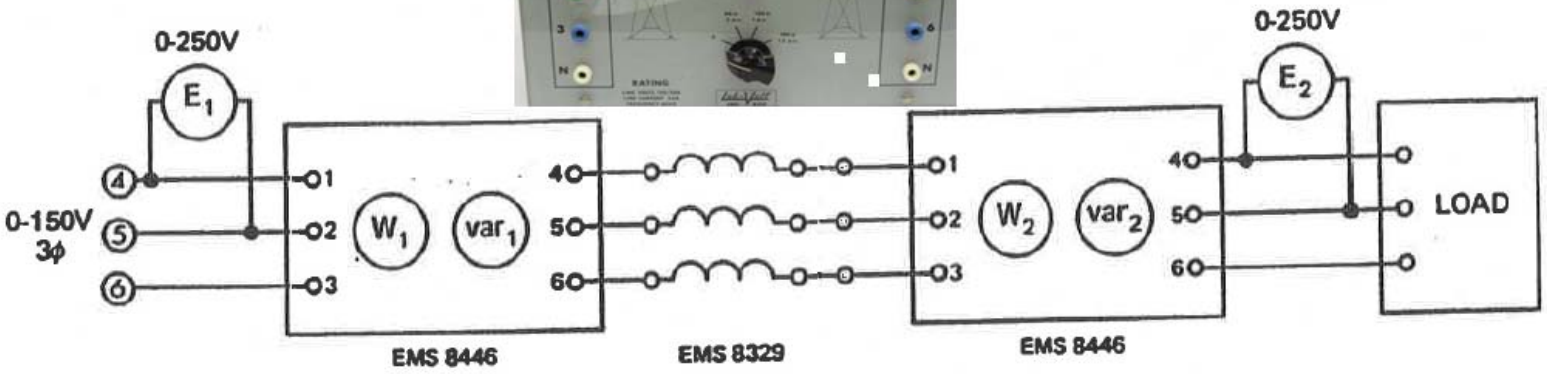
- Voltage Regulation:

  Load Voltage Difference Between

  V (open, no-load) and V (with Load)

$$\% \text{ regulation} = \frac{(E_O - E_L) \times 100}{E_O}$$

Transmission Line Loss (Q) + Load (P and Q)

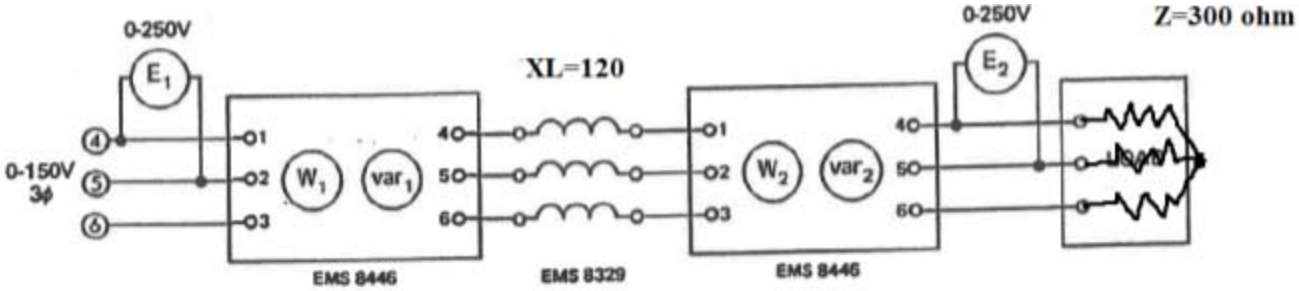


Total P = W1
Total Q = Var 1

Transmission
P = W1 - W2
Q = Var1 - Var 2

Load
P = W2
Q = Var 2

Example



$VL := 150 \qquad VP := \frac{VL}{\sqrt{3}} = 86.60254 \qquad Ztr := 0 + i \cdot 120 \qquad Zload := 300 + i \cdot 0 = 300$

$Z := Ztr + Zload$

$Z = 300 + 120 \cdot i$

$IL := \frac{VP}{Z} = 0.248858 - 0.099543 \cdot i$

$\theta v := \arg(VP) = 0 \qquad \theta i := \arg(IL) = -0.380506 \qquad \theta := \theta v - \theta i = 0.380506$

$Ptot := 3 \cdot |VP| \cdot |IL| \cdot \cos(\theta) = 64.655172$

$Qtot := 3 \cdot |VP| \cdot |IL| \cdot \sin(\theta) = 25.862069$

$Str := 3 \cdot \|IL\|^2 \cdot Ztr = 25.862069 \cdot i \qquad Ptr := Re(Str) = 0 \qquad Qtr := Im(Str) = 25.862069$

$Sload := 3 \cdot \|IL\|^2 \cdot Zload = 64.655172 \qquad Pload := Re(Sload) = 64.655172$

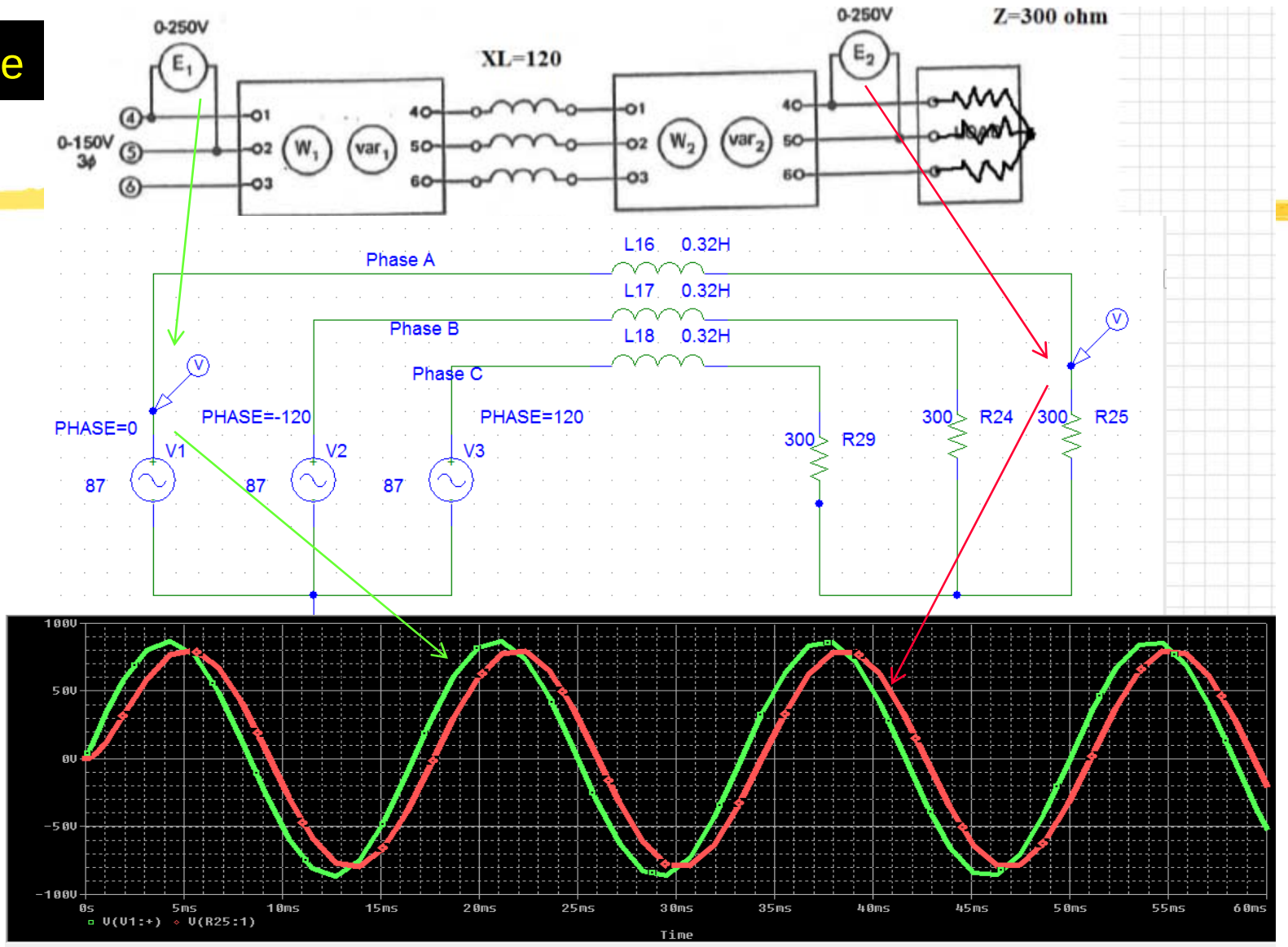
$Qload := Im(Sload) = 0$

Voltage Regulation

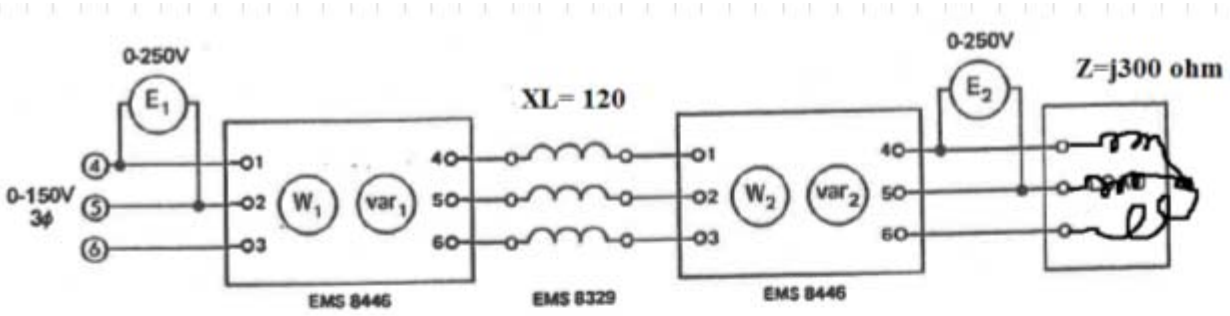
$Vload := IL \cdot Zload = 74.657362 - 29.862945 \cdot i \qquad |Vload| = 80.40844$

$\frac{|VP| - |Vload|}{|VP|} \cdot 100 = 7.152331$ percent

Example


0-250V
E1
0-150V
3ϕ
W1
var1
XL=120
W2
var2
0-250V
E2
Z=300 ohm
Phase A
Phase B
Phase C
L16 0.32H
L17 0.32H
L18 0.32H
PHASE=0
PHASE=-120
PHASE=120
V1
V2
V3
87
87
87
300 R29
300 R24
300 R25
100V
50V
0V
-50V
-100V
0s
5ms
10ms
15ms
20ms
25ms
30ms
35ms
40ms
45ms
50ms
55ms
60ms
V(V1:+)
V(R25:1)
Time

Example C



$VL := 150 \qquad VP := \frac{VL}{\sqrt{3}} = 86.60254 \qquad Ztr := 0 + i \cdot 120 \qquad Zload := i \cdot 300 - 300 \cdot i$

$Z := Ztr + Zload \qquad Z = 420 \cdot i$

$IL := \frac{VP}{Z} = -0.206197 \cdot i$

$\theta v := \arg(VP) = 0$

$\theta i := \arg(IL) = -1.570796 \qquad \theta := \theta v - \theta i = 1.570796$

$Ptot := 3 \cdot |VP| \cdot |IL| \cdot \cos(\theta) = -1.870438 \cdot 10^{-13}$

$Qtot := 3 \cdot |VP| \cdot |IL| \cdot \sin(\theta) = 53.571429$

$Str := 3 \cdot |IL|^2 \cdot Ztr = 15.306122 \cdot i \qquad Ptr := Re(Str) = 0 \qquad Qtr := Im(Str) = 15.306122$

$Sload := 3 \cdot |IL|^2 \cdot Zload = 38.265306 \cdot i \qquad Pload := Re(Sload) = 0$

$Qload := Im(Sload) = 38.265306$

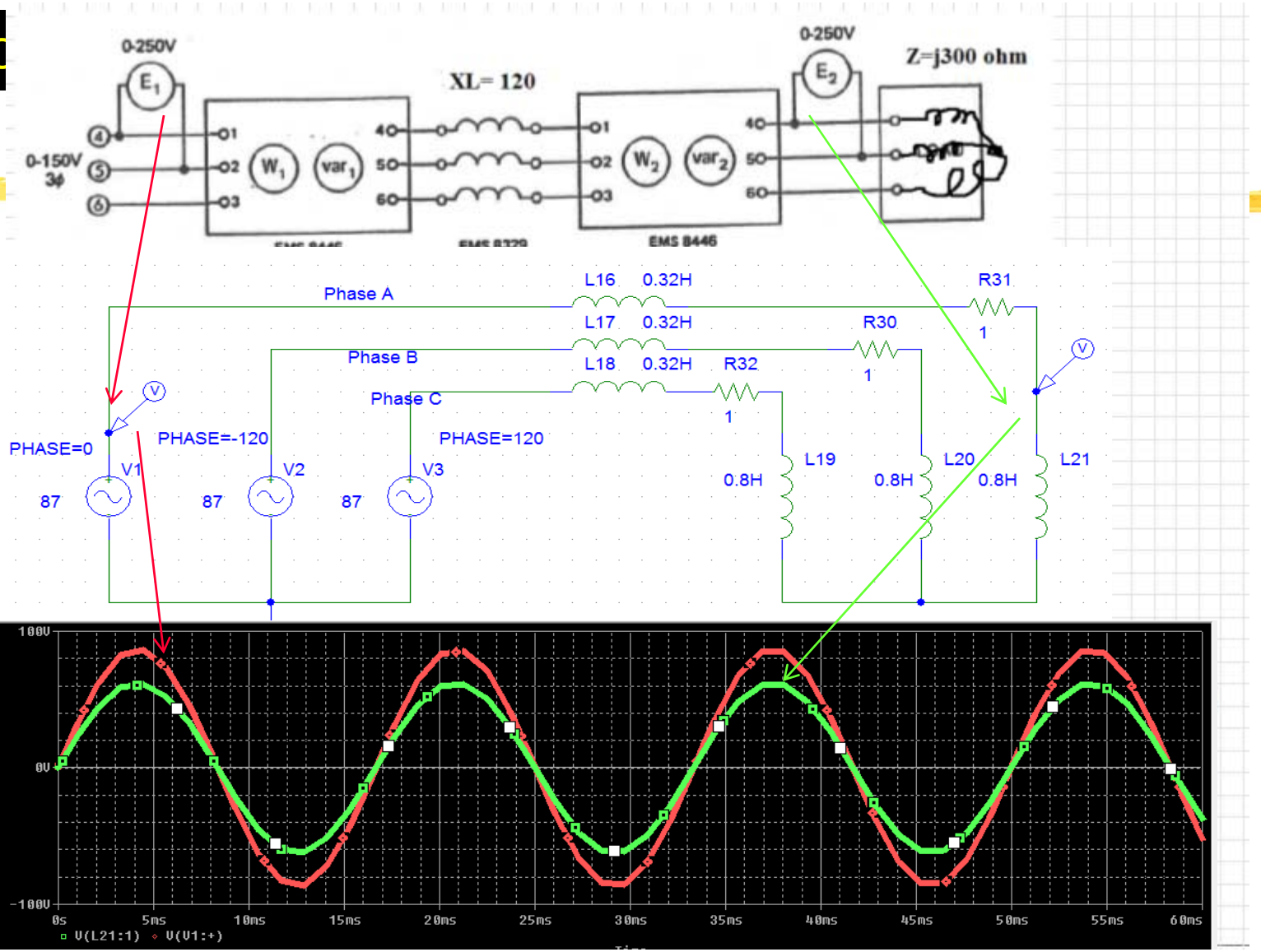
Voltage Regulation

$Vload := IL \cdot Zload = 61.858957$

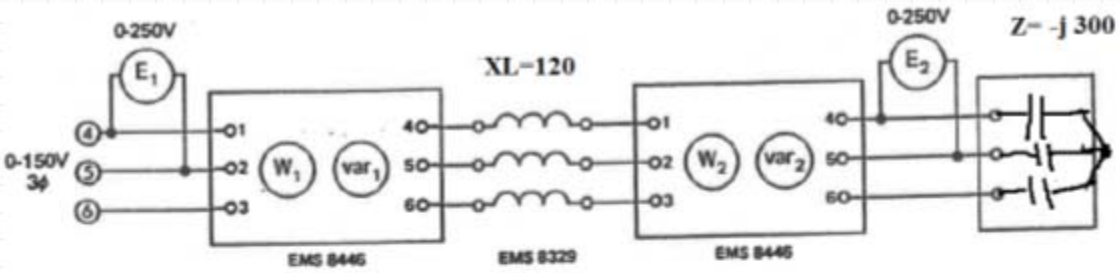
$|Vload| = 61.858957$

$\frac{|VP| - |Vload|}{|VP|} \cdot 100 = 28.571429$ percent

Example C


0-250V
E1
0-150V
3φ
XL= 120
W1
var1
W2
var2
0-250V
E2
Z=j300 ohm
EMS 8446
Phase A
Phase B
Phase C
L16 0.32H
L17 0.32H
L18 0.32H
R31
1
R30
1
R32
1
L19
0.8H
L20
0.8H
L21
0.8H
PHASE=0
PHASE=-120
PHASE=120
V1
V2
V3
87
87
87
100V
0V
-100V
0s
5ms
10ms
15ms
20ms
25ms
30ms
35ms
40ms
45ms
50ms
55ms
60ms
V(L21:1)
V(V1:+)

Example



$VL := 150 \qquad VP := \frac{VL}{\sqrt{3}} = 86.60254 \qquad Ztr := 0 + i \cdot 120 \qquad Zload := (-i) \cdot 300 = -300 \cdot i$

$Z := Ztr + Zload \qquad Z = -180 \cdot i$

$IL := \frac{VP}{Z} = 0.481125 \cdot i$

$\theta v := \arg(VP) = 0$

$\theta i := \arg(IL) = 1.570796 \qquad \theta := \theta v - \theta i = -1.570796$

$Ptot := 3 \cdot |VP| \cdot |IL| \cdot \cos(\theta) = -4.364354 \cdot 10^{-13}$

$Qtot := 3 \cdot |VP| \cdot |IL| \cdot \sin(\theta) = -125$

$Str := 3 \cdot |IL|^2 \cdot Ztr = 83.333333 \cdot i \qquad Ptr := Re(Str) = 0 \qquad Qtr := Im(Str) = 83.333333$

$Sload := 3 \cdot |IL|^2 \cdot Zload = -208.333333 \cdot i \qquad Pload := Re(Sload) = 0$

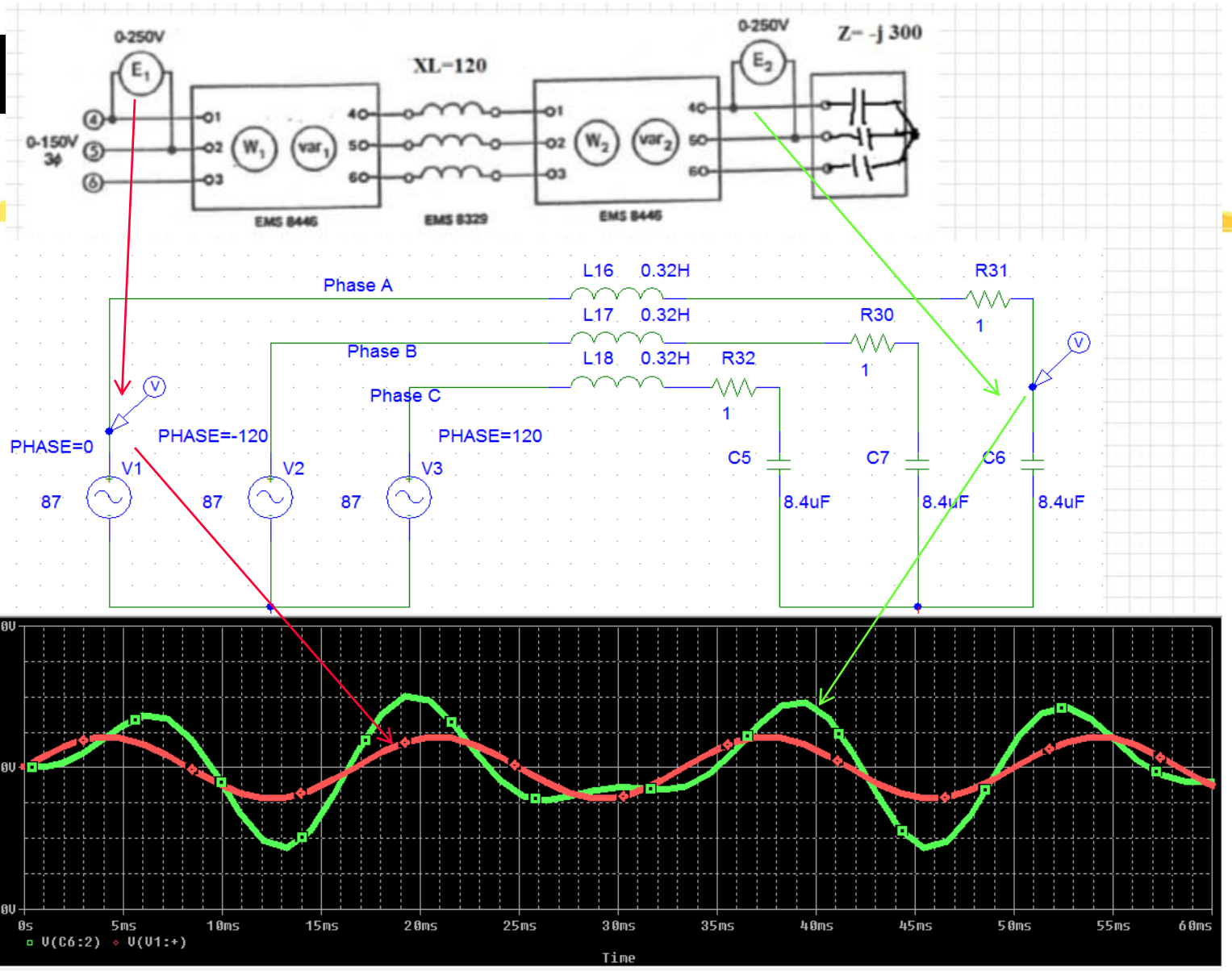
$Qload := Im(Sload) = -208.333333$

Voltage Regulation

$Vload := IL \cdot Zload = 144.337567 \qquad |Vload| = 144.337567$

$\frac{|VP| - |Vload|}{|VP|} \cdot 100 = -66.666667$ percent

Example


0-250V
E1
0-150V
3φ
W1
var1
XL=120
EMS 8446
EMS 8329
W2
var2
0-250V
E2
Z= -j 300
Phase A
Phase B
Phase C
L16 0.32H
L17 0.32H
L18 0.32H
R31
R30
R32
1
PHASE=0
PHASE=-120
PHASE=120
V1
V2
V3
87
C5
C7
C6
8.4uF
400V
0V
-400V
0s
5ms
10ms
15ms
20ms
25ms
30ms
35ms
40ms
45ms
50ms
55ms
60ms
V(C6:2)
V(V1:+)
Time

Experimentation Setup