University of Technology, Sydney
Faculty of Engineering

Subject:	**48572 Power Circuit Theory**
Assignment Number:	**1**
Assignment Title:	**Lab 1 – Power and Phase**
Tutorial Group:	

Students Name(s) and Number(s)

Student Number	Family Name	First Name

Declaration of Originality:

The work contained in this assignment, other than that specifically attributed to another source, is that of the author(s). It is recognised that, should this declaration be found to be false, disciplinary action could be taken and the assignments of all students involved will be given zero marks. In the statement below, I have indicated the extent to which I have collaborated with other students, whom I have named.

Statement of Collaboration:

Signature(s)

Marks

Office use only ☺

key

Assignment Submission Receipt

Assignment Title:	**Lab 1 – Power and Phase**
Student's Name:	
Date Submitted:	
Tutor Signature:	

Lab 1 – Power and Phase

Power. Phase.

Introduction

The measurement of power and phase is of fundamental importance in electrical engineering. Modern electric power systems almost universally use AC voltages and currents to deliver real power to end-users. The delivery of this power needs to be predicted, measured and controlled to create an efficient and manageable system. Power is also very important in communication systems, where we can trade-off power with communication performance. Power also naturally plays a role in the conversion of one form of energy to another (e.g. from electrical energy to acoustic energy in a home entertainment system) and it is important to understand the conditions for maximum power transfer to take place. Real power depends not only on the magnitudes of the sinusoidal voltage and current, but on the phase difference between them.

Objectives

1. To become familiar with locus diagrams of admittance, impedance, current and voltage in one-ports with a single variable element.

2. To use locus diagrams for prediction and interpretation of current and voltage behaviour.

3. To observe and analyse the resonant or unity power factor condition.

4. To measure average power entering a single-phase network using a wattmeter.

5. To observe experimentally the relationship between power entering a one-port and the phase angle between the port voltage and current.

L1.2

Equipment

- 1 single-phase 240 V, 8A autotransformer – Warburton Franki Variac,
- 1 single-phase 240 V : 120 V, 1.5 kVA, 50 Hz isolating transformer – Standard Waygood
- 1 rheostat (410 Ω or 235 Ω)
- 1 inductor – Oliver coil
- 2 capacitors (20 μF and 30 μF)
- 2 AC voltmeter / ammeters – YEW
- 2 digital multimeters
- 1 clip-on wattmeter – Fluke

Safety

Cat. B lab

This is a Category B laboratory experiment. Please adhere to the Category B safety guidelines (issued separately).

Warning!

Remember:

1. **Choose suitable METER SCALES and <u>WIND DOWN</u> and <u>SWITCH OFF</u> the supply VARIAC when making circuit connections.**
2. **<u>Ensure equipment is earthed.</u>**

Pre-work

1. Consider the one-port network shown below:

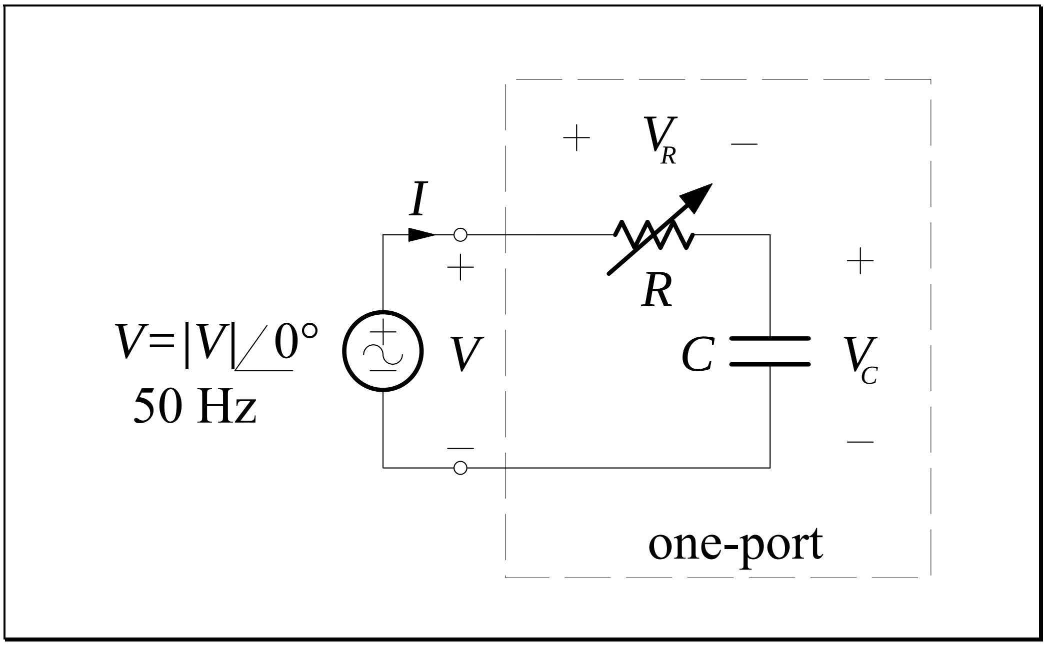


Figure L1.1

1.1 Show that the graph of the loci of the port impedance, *Z*, and port admittance, *Y*, as the resistance *R* is varied from 0 to $\infty\,\Omega$, are as shown:

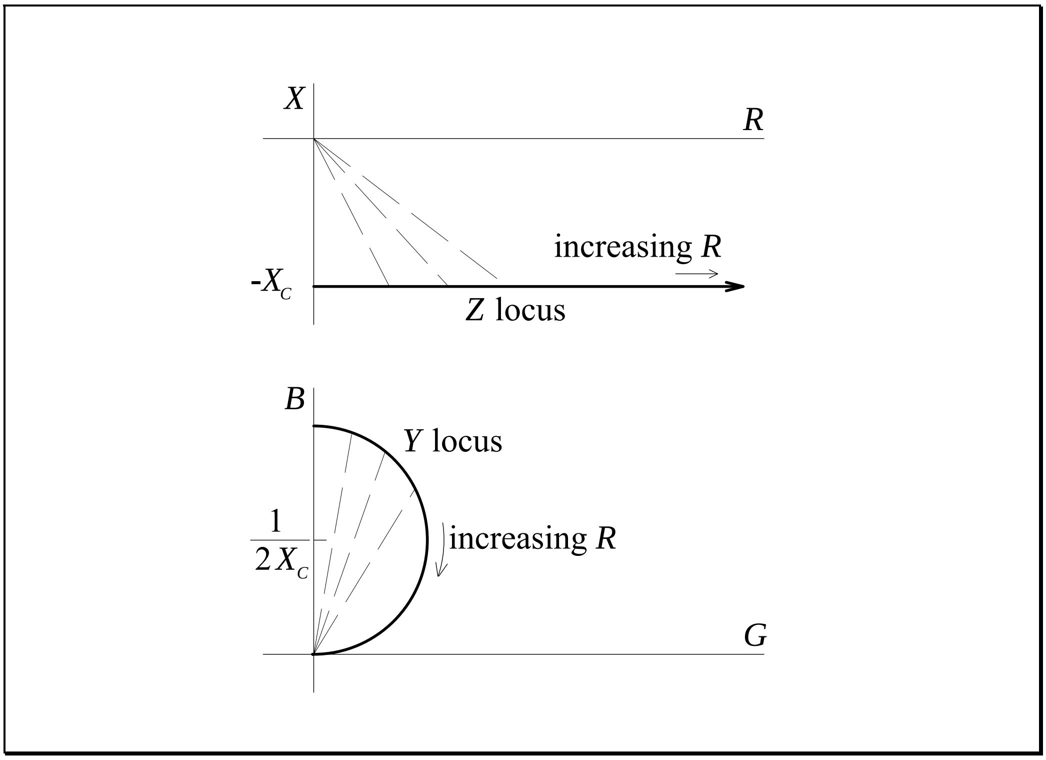


Figure L1.2

L1.4

1.2 Show that the graph of the loci of *I*, V_C and V_R as the resistance *R* is varied from 0 to $\infty\,\Omega$, are as shown:

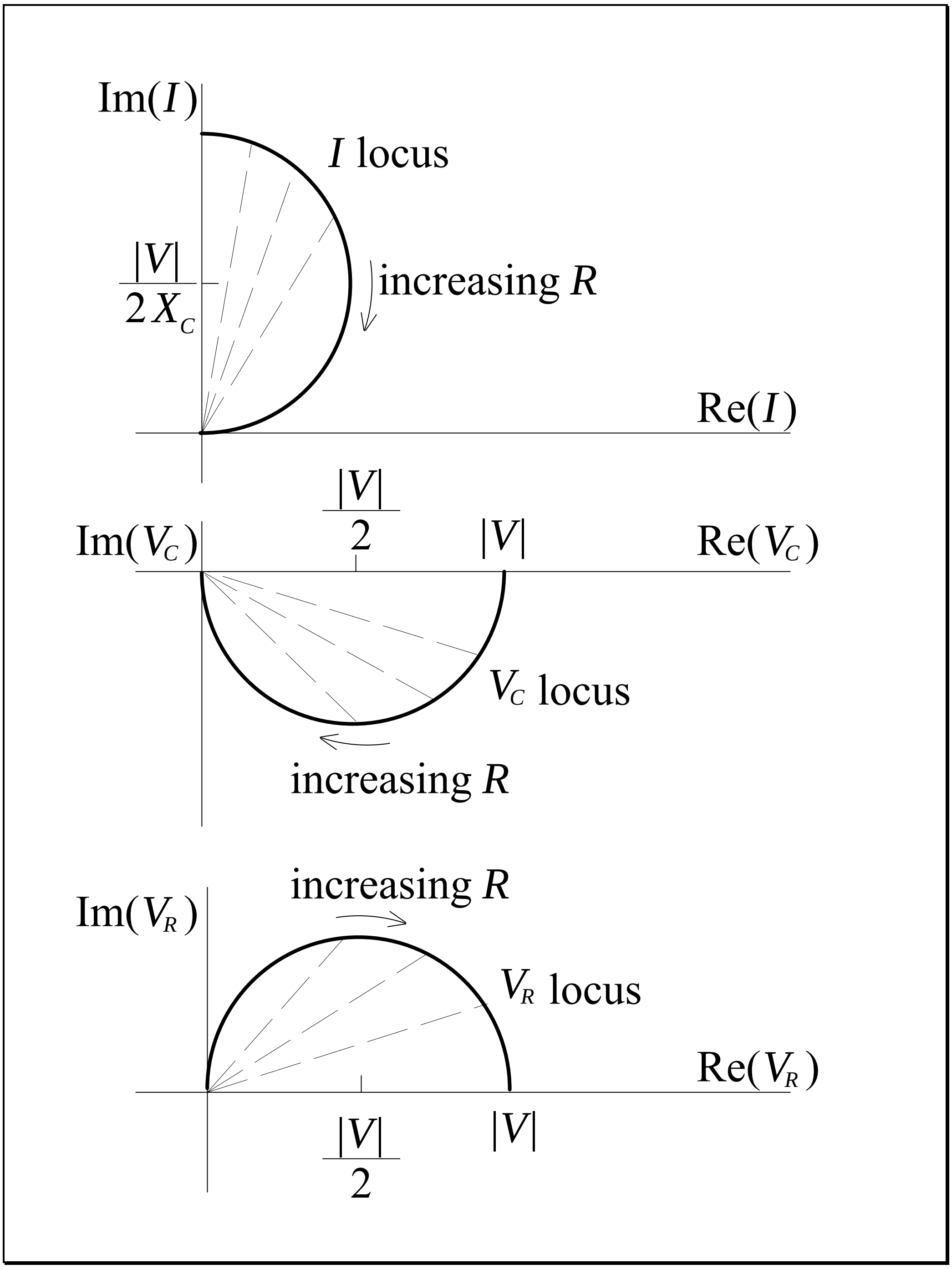


Figure L1.3

2. Consider the one-port network shown below:

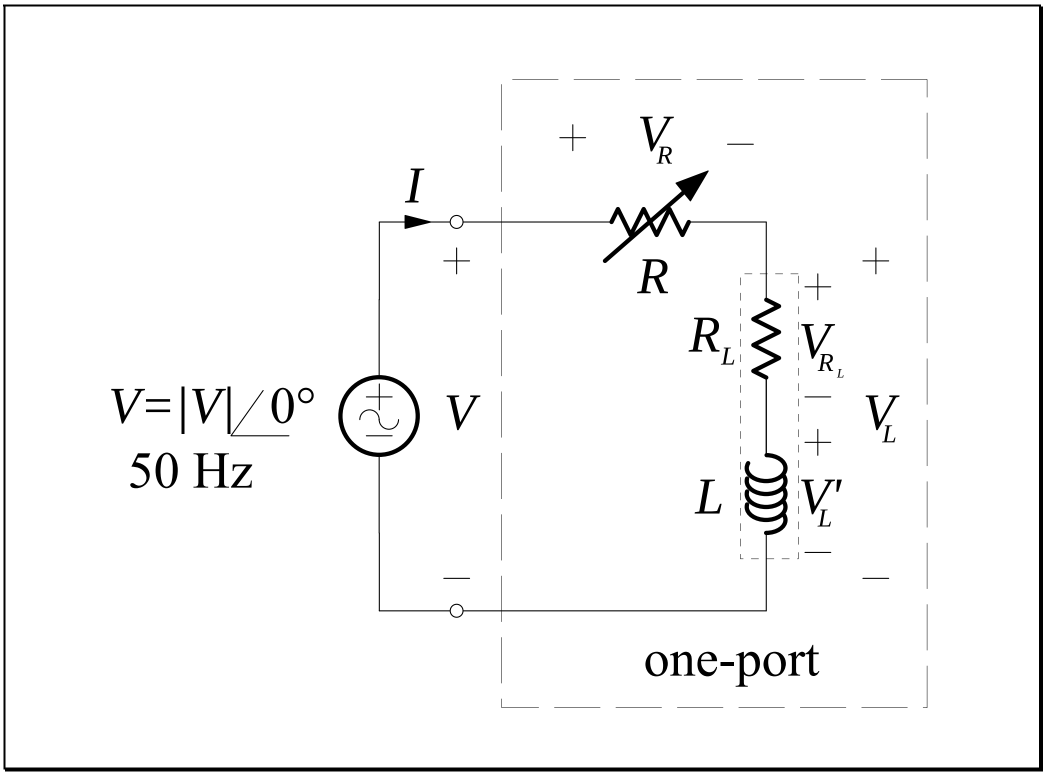


Figure L1.4

L1.6

2.1 Show that the graph of the loci of V_{R_L} , V_L', V_R and V_L as the resistance R is varied from 0 to $\infty\,\Omega$, are as shown:

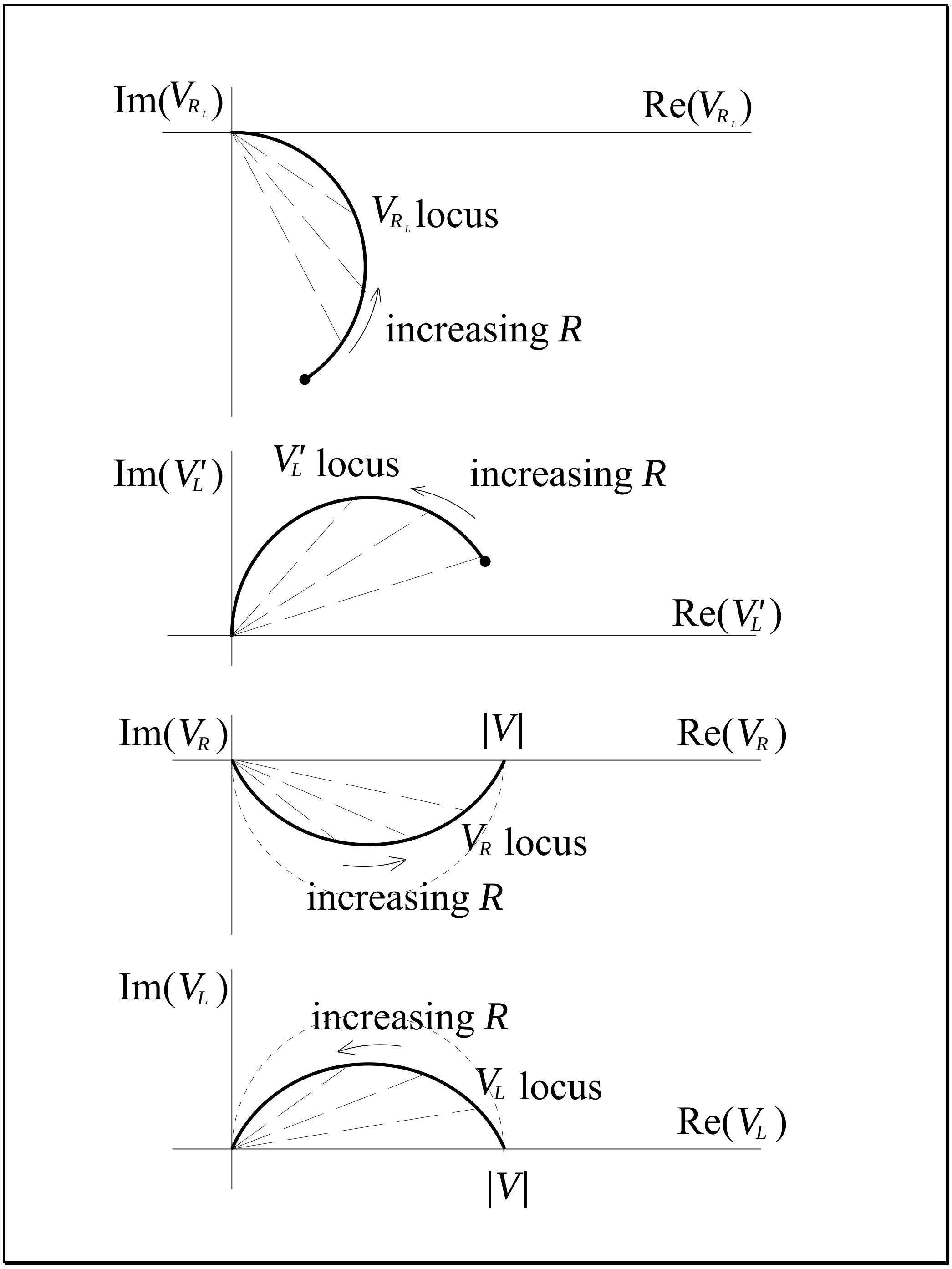


Figure L1.5

3. Show that the expression for the average power entering the one-port shown below is $P = |V||I|\cos\phi$, where $|V|$ and $|I|$ are the RMS magnitudes of the voltage and current respectively, and ϕ is the angle by which the voltage *leads* the current.

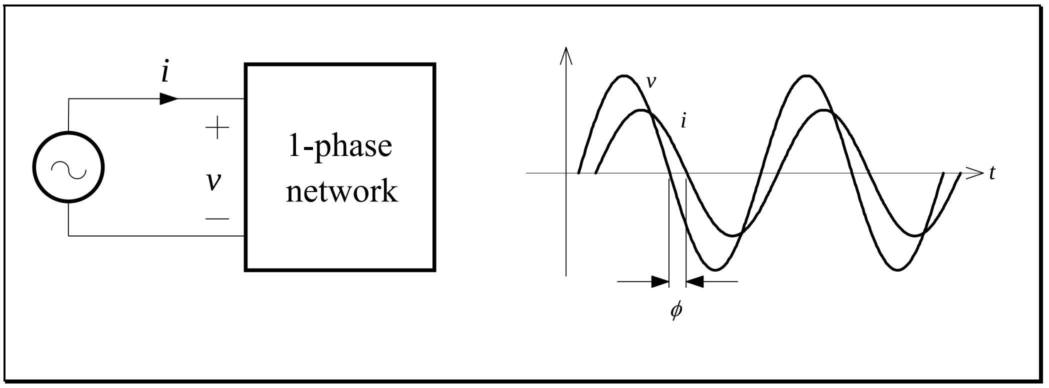


Figure L1. 6

L1.8

Lab Work

Note the use of coloured leads

$|V_P|$ and $|I_P|$ are measured using the analog YEW meters

$|V_R|$ and $|V_C|$ are measured using digital multimeters

Power factor (pf) is measured on the clip-on wattmeter

Remember to connect the earth!

1. **<u>Do not connect the supply or turn on the power until circuit connections are checked by a lab tutor.</u>**

2. Wire up the circuit shown below:

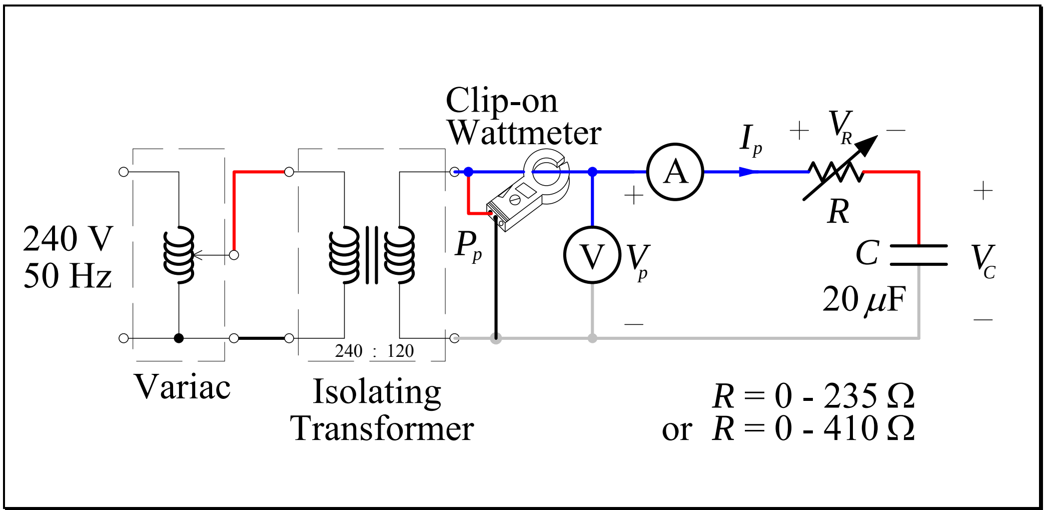


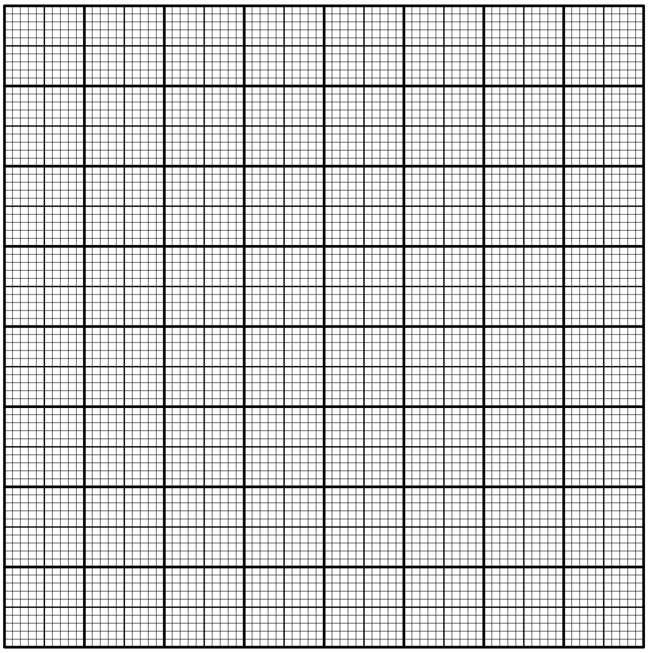
Figure L1.7

3. Maintain the port voltage RMS magnitude $|V_p|$ constant at 110 V (adjustment will be necessary for each reading) and vary R to give values of $|V_R|$ from 0 – 100 V in 10 V steps. Tabulate readings below.

$\lvert V_R\rvert$ (V)	$\lvert V_C\rvert$ (V)	$\lvert I_p\rvert$ (A)	$R = \lvert V_R\rvert / \lvert I_p\rvert$ (Ω)	$\phi = \tan^{-1}\left(\frac{X_C}{R}\right)$ (°)	pf	$\phi = \cos^{-1}(\text{pf})$ (°)
0						
10						
20						
30						
40						
50						
60						
70						
80						
90						
100						

4. Construct loci for V_R, V_C and I from your experimental values.

L1.10



5. Wire up the circuit shown below:

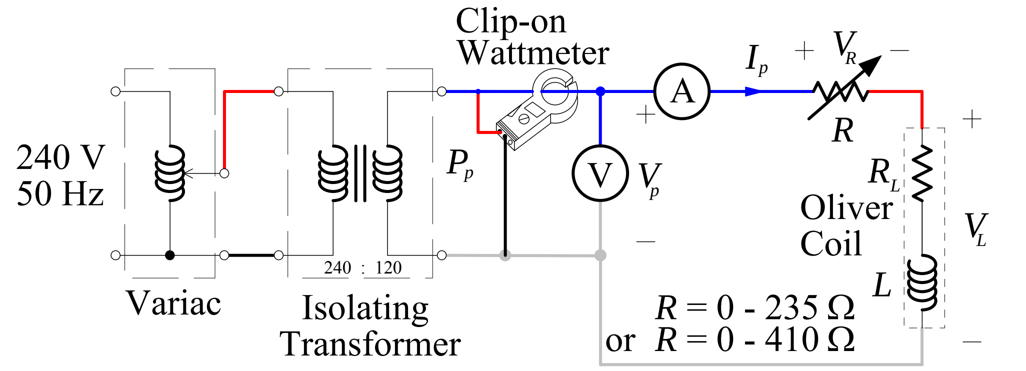


Figure L1.8

Note the use of coloured leads

$|V_P|$ and $|I_P|$ are measured using the analog YEW meters

$|V_R|$ and $|V_C|$ are measured using digital multimeters

Power factor (pf) is measured on the clip-on wattmeter

Remember to connect the earth!

6. Maintain the port voltage RMS magnitude $|V_p|$ constant at 110 V (adjustment will be necessary for each reading) and vary R to give values of $|V_R|$ from 0 – 70 V in 10 V steps. Tabulate readings below.

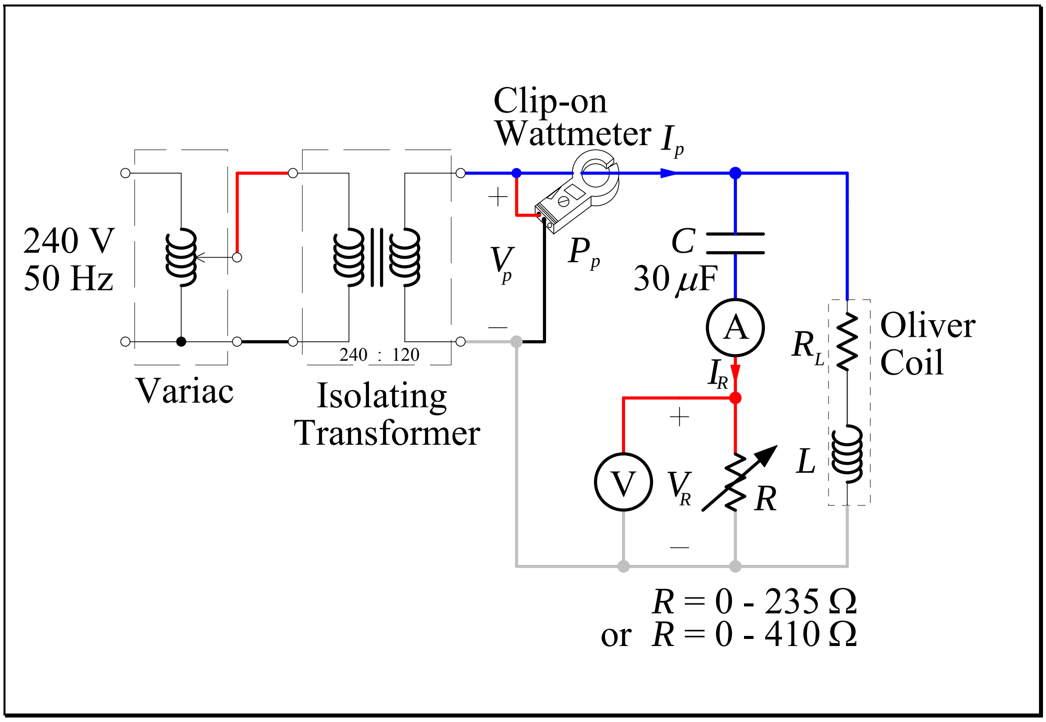
$\|V_R\|$ (V)	$\|V_L\|$ (V)	$\|I_p\|$ (A)	$R = \|V_R\|/\|I_p\|$ (Ω)	$\phi = \tan^{-1}\left(\frac{X_L}{R+R_L}\right)$ (°)	pf	$\phi = \cos^{-1}(pf)$
0						
10						
20						
30						
40						
50						
60						
70						

7. Construct loci for V_R and V_L from your experimental values.

8. From two or three points on the locus, obtain values for R_L and L.

$R_L =$	$L =$

9. Wire up the circuit shown below:



Note the use of coloured leads

$|V_P|$ and $|I_P|$ are measured using the clip-on wattmeter

$|V_R|$ is measured using a digital multimeter

$|I_R|$ is measured using an analog YEW meter

Remember to connect the earth!

Figure L1.9

<u>Note:</u> The wattmeter needs to have assumed positive current pass through the clamp in the direction of the arrow.

10. Set the port voltage to 110V and the clip-on wattmeter to display the voltage and current waveforms graphically. Vary the resistance over the entire range and observe the changing phase relationship between the voltage and current.

11. With the port voltage maintained at 110 V, obtain a series of readings of input power and port current as a function of R (R is determined from V_R and I_R). When you are satisfied you are getting sensible results, enter the readings directly into the table below, calculating the corresponding phase angle ϕ. As each reading is taken, plot the corresponding point on the current locus.

No:	$\lvert V_R \rvert$ (V)	$\lvert I_R \rvert$ (A)	$R = \lvert V_R \rvert / \lvert I_R \rvert$ (Ω)	$\lvert V_P \rvert$ (V)	$\lvert I_P \rvert$ (A)	P_p (W)	$\cos\phi = \frac{P_p}{\lvert V_p \rvert \lvert I_p \rvert}$ (W)	ϕ (°)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

12. Calculate a value for the variable resistance R required to produce resonance and compare with the experimentally obtained value.

$R_{\text{theoretical}} =$	$R_{\text{experimental}} =$