

## Experiment A.1 Measuring Inductance and Capacitance using A.C. Techniques

In this experiment, a cathode ray oscilloscope (CRO) is used as an a.c. voltmeter. The most accurate reading is given by measuring **peak-to-peak voltages**, i.e. measuring along the y-axis the distance from a trough to a crest.

Division by 2 gives the amplitude,  $V_o$ .

The rms (root mean square) voltage is given by  $V_{rms} = V_o/\sqrt{2}$ .

### PART 1: To measure the inductance, $L$ , and resistance, $r$ , of an inductor.

#### **Procedure**

Set up the apparatus as shown in Fig 1<sup>1</sup> with the a.c. voltage set at 6 V.

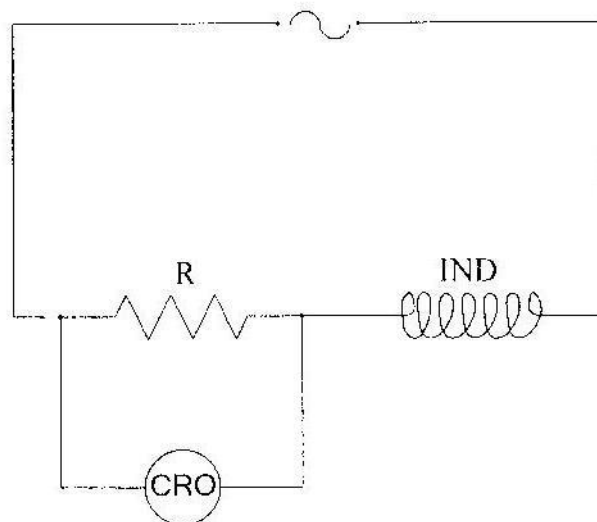


Figure 1: Experimental setup to measure inductance,  $L$ , and resistance,  $r$ , of an inductor.

Use the CRO to measure the:

- Voltage across the supply,  $V$
- Voltage across the inductor,  $V_{IND}$
- Voltage across the resistor,  $V_R$

Adjust the resistance,  $R$ , to ensure that  $V_R$  and  $V_{IND}$  are approximately equal.

<sup>1</sup> The inductor is traditionally given the symbol  $L$ . However, the voltage across the inductor is made up of two components: the resistive component ( $V_r$ ) and the inductive component ( $V_L$ ). To avoid confusion, the inductor will be given the symbol  $IND$  here.

**Data Analysis**

The quantities measured are the magnitudes of the various voltages but the phase relation between them is unknown. However, it is known that the voltages across the inductor and resistor must add vectorially to equal the supply voltage.

Draw the vector triangle (Fig. 2):

- Draw XY of magnitude  $V_R$
- Draw an arc of circle with centre Y and radius  $V_{IND}$
- Draw an intersecting arc with centre X and radius  $V$ .

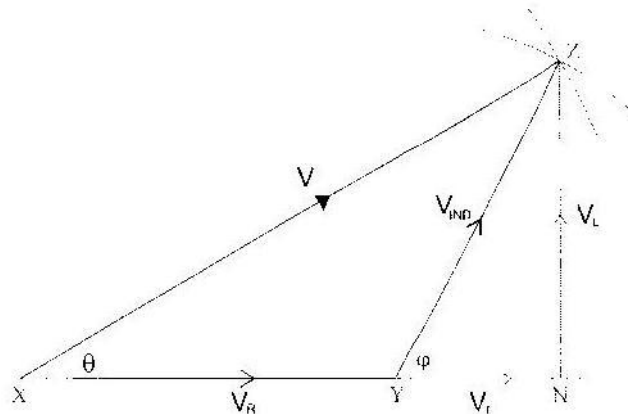


Figure 2: Vector triangle for Part 1.

$\theta$  is the phase difference between the supply voltage and the current,  $I$ , since  $V_R$  is in phase with the current.  $V_{IND}$  does NOT lead the current by  $90^\circ$  but by the angle  $\phi$  because of the finite resistance of the inductor.

Next, drop a perpendicular NZ from Z.

$V_r$  (YN) represents that voltage across the inductor which is in phase with the current.  $V_L$  (NZ) represents that voltage across the inductor which leads the current by  $90^\circ$ . Measure YN and NZ and, using the scale chosen, calculate the values of  $V_r$  and  $V_L$ . Hence, the inductance and resistance,  $L$  and  $r$ , may be determined assuming  $\omega = 2\pi f$ , where  $f = 50$  Hz, i.e. the a.c. mains frequency, since:

$$V_R = IR \quad \text{and} \quad V_r = Ir$$

$$\therefore r = \left( \frac{YN}{XY} \right) R$$

and

$$V_R = IR \quad \text{and} \quad V_L = I\omega L$$

$$\therefore L = \frac{R}{2\pi f} \left( \frac{NZ}{XY} \right)$$

**PART 2: To measure the capacitance of a capacitor*****Procedure***

Set up the apparatus as shown in Fig. 3. Replace the inductor in the previous experiment with a capacitor. Choose  $R$  so that  $V_R \approx V_C$  and measure  $V$ ,  $V_R$  and  $V_C$ .

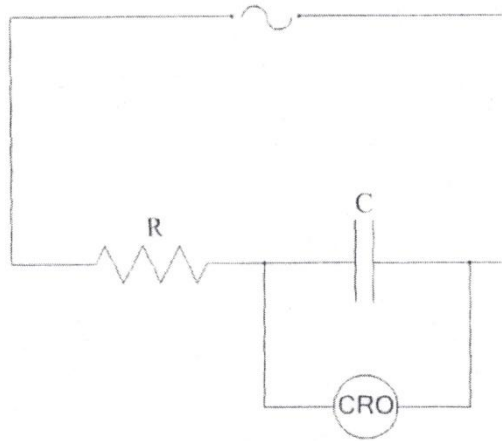


Figure 3: Experimental setup to measure the capacitance,  $C$ , of a capacitor.

***Data Analysis***

Plot the vector triangle as before (see Fig. 4).  $YZ$  should be perpendicular to  $XY$  this time as the resistance of the capacitor should be much greater than  $R$ .

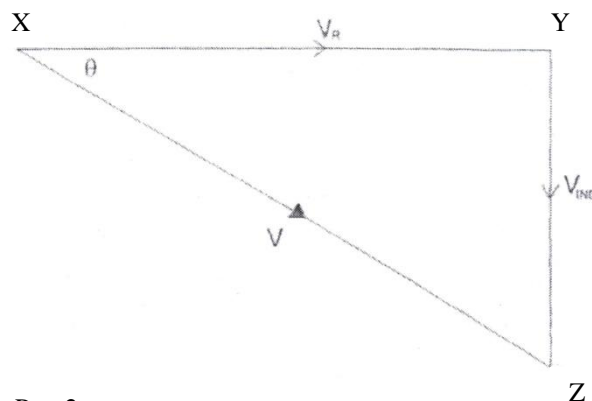


Figure 4: Vector triangle for Part 2.

Hence,  $C$  may be determined from:

$$V_R = IR \quad \text{and} \quad V_C = 1/\omega C$$

$$\therefore C = \frac{1}{2\pi f R} \left( \frac{XY}{YZ} \right).$$

**NOTE:** Your report must include a full error analysis on the values you obtain for  $r$ ,  $L$  and  $C$ .