APPENDIX
WATTMETERS USED IN EXPERIMENTS

A.1. The Ideal Wattmeter:

A wattmeter is an instrument for measuring power flowing into or out of the terminals of an electric circuit. An ideal wattmeter is the combination of an ideal ampermeter and an ideal voltmeter. As power is proportional to the product of current and voltage, the wattmeter output is produced by the combination of the ampermeter and voltmeter measurements.

The schematic representation of a wattmeter can be seen in Figure A.1.a. Its schematic connection to a circuit is shown in Figure A.1.b.
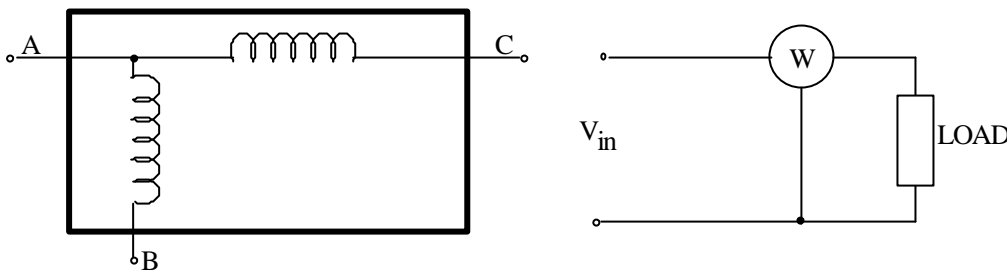

Figure A.1 a) Schematic representation of a wattmeter b) connection of a wattmeter.

A.2. The Electrodynamic Wattmeter:

An electrodynamic wattmeter shown in Figure A.2 consists of two coils. The field coils can carry large amounts of currents; hence they are used for detecting the current. It can be assumed that the field current i_f is approximately equal to the load current i_L as it acts as an ideal ampermeter. The moving coil and control springs are used for voltage detecting. They can carry small currents; i_p is very small compared to i_f; thus the current drawn by the wattmeter is negligible.
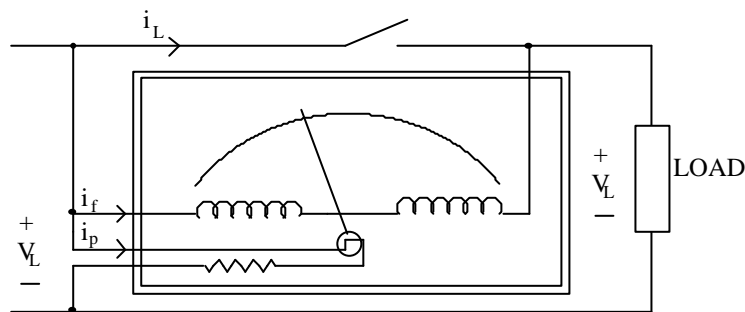

Figure A.2 An electrodynamic wattmeter.

The flux formed on the field coils together with the current in moving coils produce a torque on the moving coil. As the flux is dependent on i_f and the current in moving coils $i_p = V_L/R$, the torque is proportional to the product of the current and the voltage on the load. If v and i vary with time, torque also varies. The moving coil cannot follow these rapid changes; but instead stays in a steady

position corresponding to the average value of torque on the terminal. This holds true regardless of the frequency and the waveform of the source signals.

For sinusoidal voltage and current signals with a natural frequency of ω and phase difference ϕ

$$v(t) = V_m \cdot \sin(\omega t)$$

$$i(t) = I_m \cdot \sin(\omega t \pm \phi)$$

the average power is given by

$$P_{av} = \frac{1}{2} \cdot V_m \cdot I_m \cdot \cos(\phi) = V_{rms} \cdot I_{rms} \cdot \cos(\phi)$$

A.3. Wattmeters:

Wattmeters are devices used to measure the power flowing into a load or power drawn from a source. A wattmeter measures the power flowing by getting load current and voltage.

Figure A.3. shows a wattmeter which measures power flowing into the load.

Wattmeters used in the experiment are of two kinds which are analog and digital wattmeters.
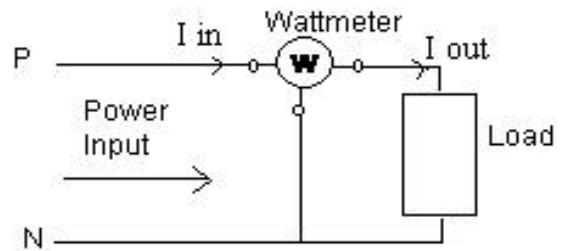

Figure A.3 Wattmeter in circuit.

A.3.1 Analog Wattmeters:

Analog wattmeters used in our laboratory experiments have an analog output to show the power value.

The wattmeter has been designed to measure three phase values as well as single phase, but In the experiments there are only single phase measurements so just phase A of the device is used.The
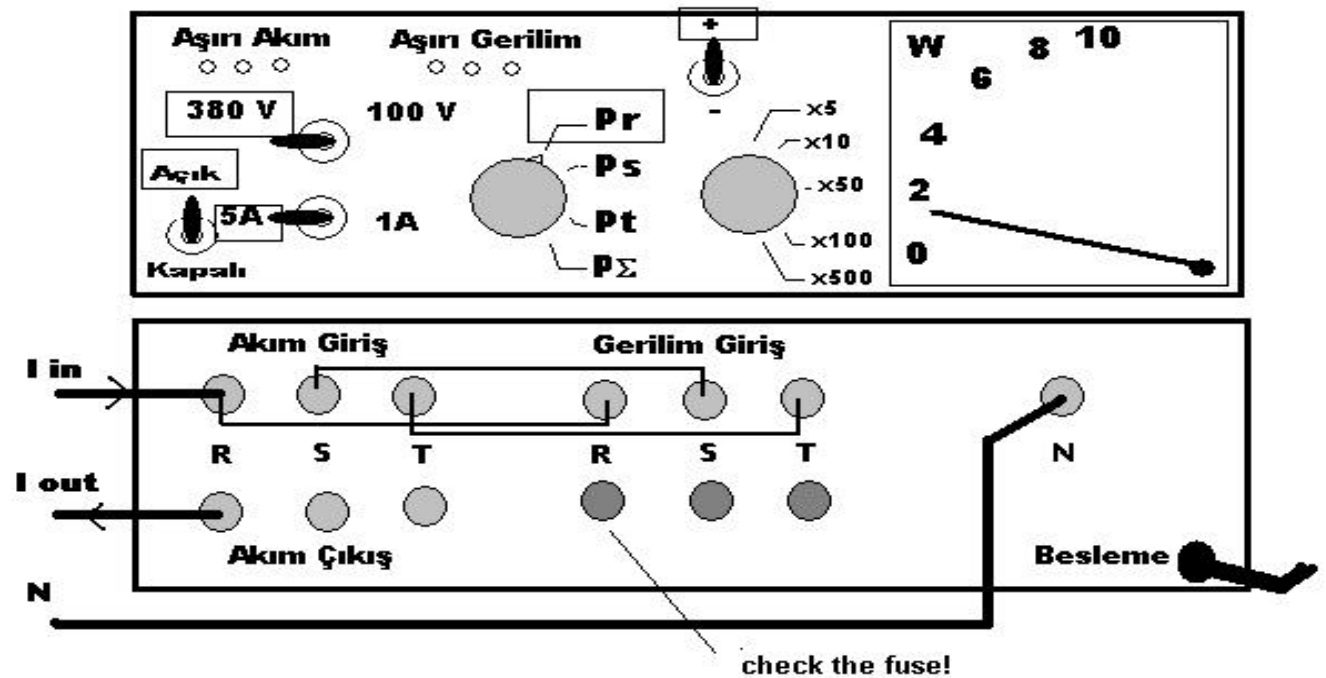

Figure A.4 Analog Wattmeter front and rear views.

connections below shows the appropriate way for single phase measurements. During experiments the parts highlighted with rectangles must be carefully checked .

A.3.2 Digital Wattmeters:

Digital Wattmeters output the measured power on a digital display . They are also able to measure three phase values but in experiments single phase measurements are made The connections shown below are useful to measure the values needed in the experiments. Again, care must be taken to the points highlighted by rectangles.
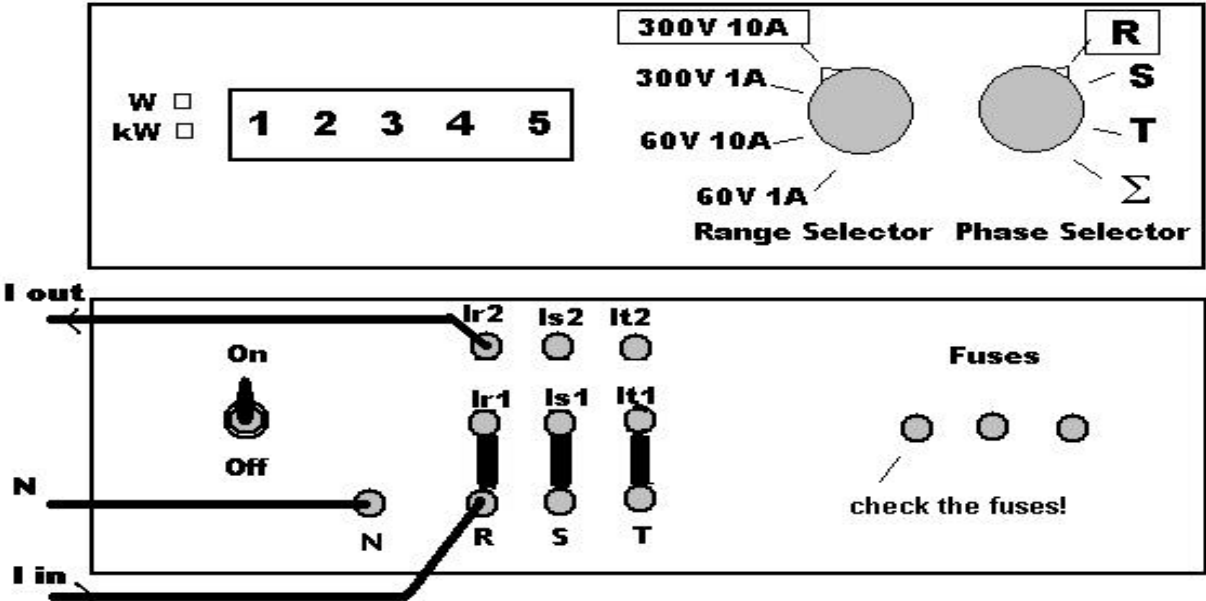

Figure A.5 Digital Wattmeter front and rear views.