

## Experiment 32: NO-LOAD OPERATION OF THE ASYNCHRONOUS MOTOR

**Purpose :** Finding the stationary losses (Pfe), frictional losses of the asynchronous motor; Analyzing the starting current at no-load for  $\lambda$ ,  $\Delta$  connections.

**Equipments :** -Experiment board with energy unit  
 -Railed motor table  
 -Three phase asynchronous motor  
 -Jagged cable ,cable with IEC plug  
 -Tachometer

Y-036/001  
 Y-036/003  
 Y-036/015

**Connection diagram for the experiment :**

Y-036/001

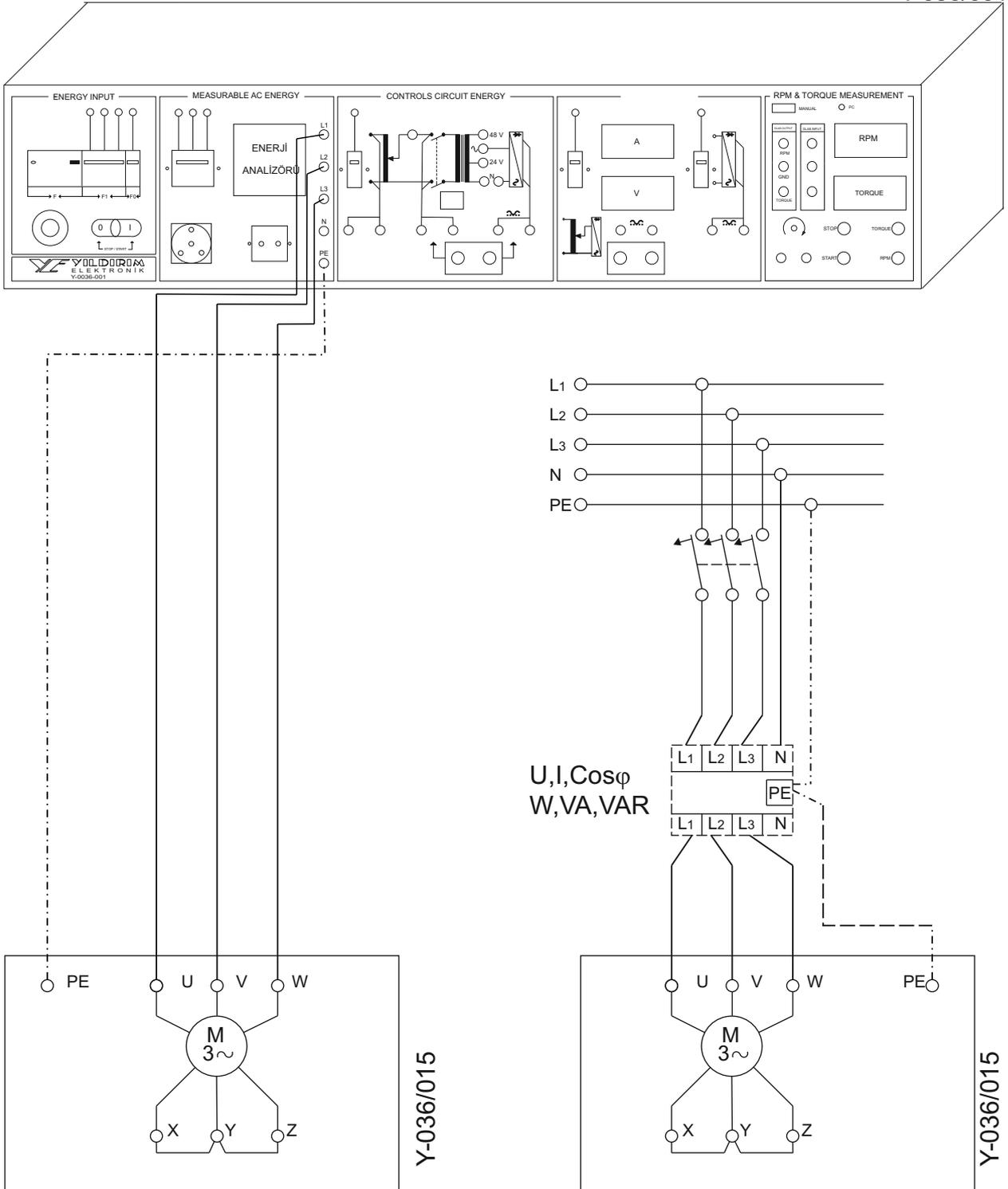


Figure 32.1: The connection diagram for the no-load operation of the 3-phase asynchronous motor.

Information: The asynchronous motors are supplied with little current and power by the network. This small power meets the constant losses of the motor.

These losses are;

Iron Losses  $P_{fe}$

Friction and wind losses  $P_s$

In no-load operation motor operates with nominal voltage and the slip of the asynchronous motor is too small. Asynchronous motors in no-load operation pull 15-50 % of the nominal current from the supply according to the structure of motor. The elements of this current are magnetic field current ( $I_m$ ), and ( $I_w$ ) current for meeting the losses. The power factor of the motor is 0.1-0.3 initially.

**Power at no-load operation:**

$$P_{no-load} = \sqrt{3} \cdot U_n \cdot I_n \cdot \cos \phi_b$$

**Losses at no-load operation:**

$$P_{cub} + P_{fe} + P_{sü}$$

$$P_{no-load} = P_{cub} + P_{fe} + P_{fri.}$$

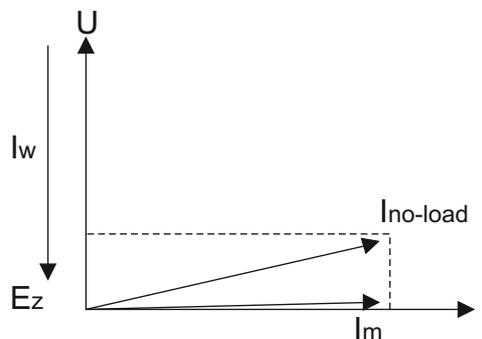


Figure 2 :The components of the current at no-load operation of the asynchronous motor

The asynchronous motor rotating field does not change at no-load or full-load. The speed varies too little at no-load and full load. In that operation there are copper losses. That loss must be very small such as the current.

**Procedure :**

Note: The reason of using 4kw asynchronous motor (y-036/016) in the experiment is due to see the big measurement values in measurement units.

- Connect the circuit shown in the figure: 32.1.
- Apply nominal voltage to the Y-connected motor clemence.
- Observe and take note of the starting parameters ( $I$ ) of the motor.
- At normal operation of the motor, take note of the values  $U, I, \cos \phi, W, VA, VAR$  from the energy analyzer.
- Measure and take note of the motor speed ( $n_r$ ) from the motor shaft with tachometer.
- Turn of the energy and finish the experiment.
- Repeat the same procedure above after connecting the clemence of the motor in  $\Delta$  form.
- Turn of the energy and finish the experiment.

**Values recorded in the experiment:**

(λ connected) Energy analyzer							(Δ connected) Energy analyzer							EXPLANATION	
U	I	Cosφ	W	VA	VAR	starting	U	I	Cosφ	W	VA	VAR	starting		

**Evaluation :**

Question 1: Why did we perform the no-load operation experiment for the asynchronous motor?

Question 2: Why is the value of  $\text{Cos}\phi$  small at no-load?

Question 3: Find the copper ( $P_{cu}$ ), iron ( $P_{fe}$ ) and frictional ( $P_{fri}$ ) losses at no-load operation. What happens to copper loss? Explain.

Question 4: Is the calculated value of the  $\text{Cos}\phi$  same with the measured value of  $\text{Cos}\phi$ ? Explain the reason if not.

Question 5: Are the starting currents different for Y and  $\Delta$  connections? Explain.

Question 6: State your final observations about the experiment.

## Experiment 34: LOADED OPERATION OF THE TRI-PHASE ASYNCHRONOUS MOTOR

**Purpose :** Operating the asynchronous motor with load. Analyzing the parameters power-torque, speed, current,  $\text{Cos}\phi$ , voltage and relations in between.

**Equipments :**

- Experiment board with energy unit Y-036/001
- Railed motor table Y-036/003
- Three phase asynchronous motor Y-036/015
- Magnetic powder brake Y-036/024-A
- Tachometer
- Jagged cable , cable with IEC plug

**Connection diagram for the experiment :**

Y-036/001

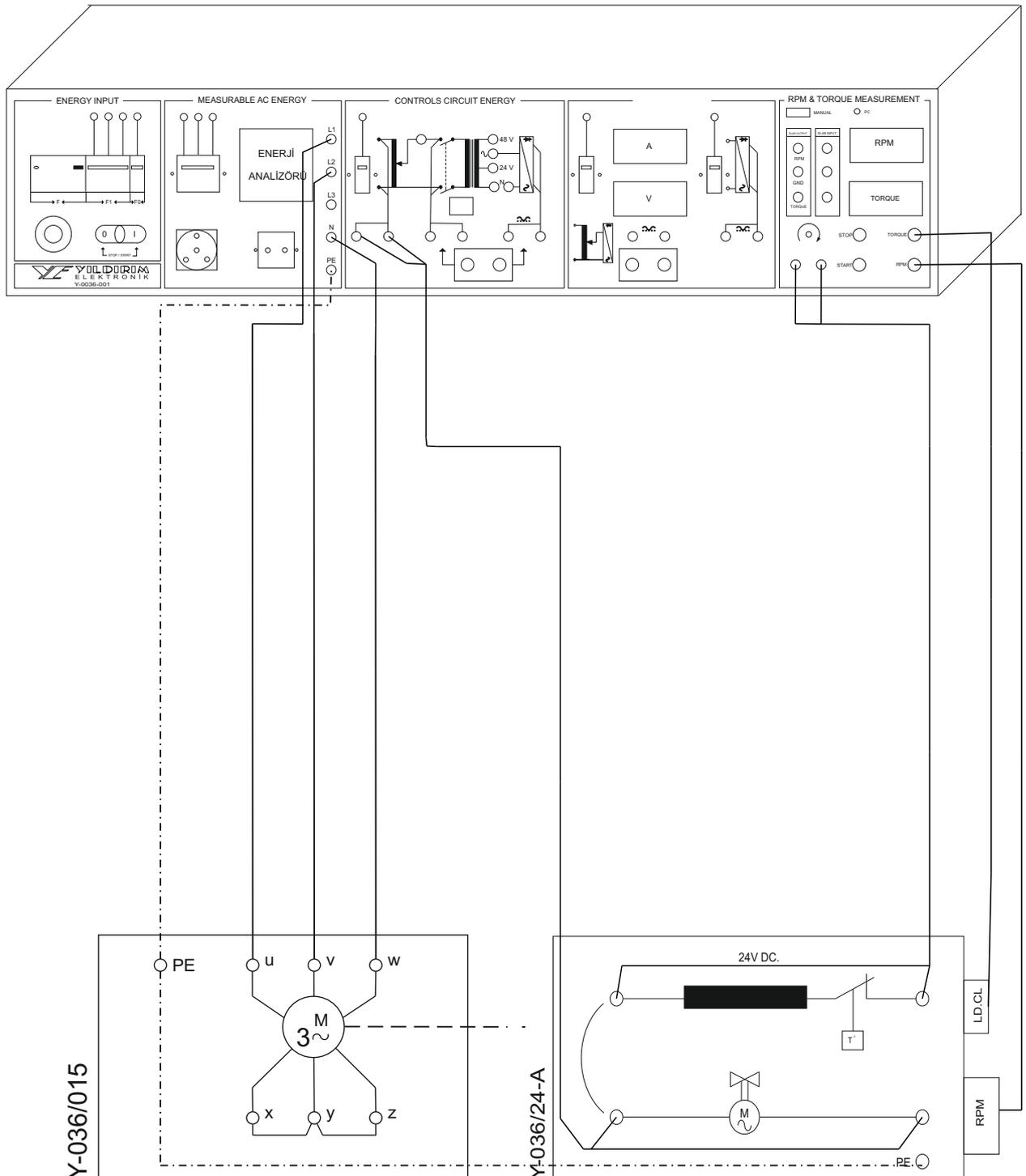


Figure 34.1: Connection diagram for the loaded operation of the tri-phase asynchronous motor

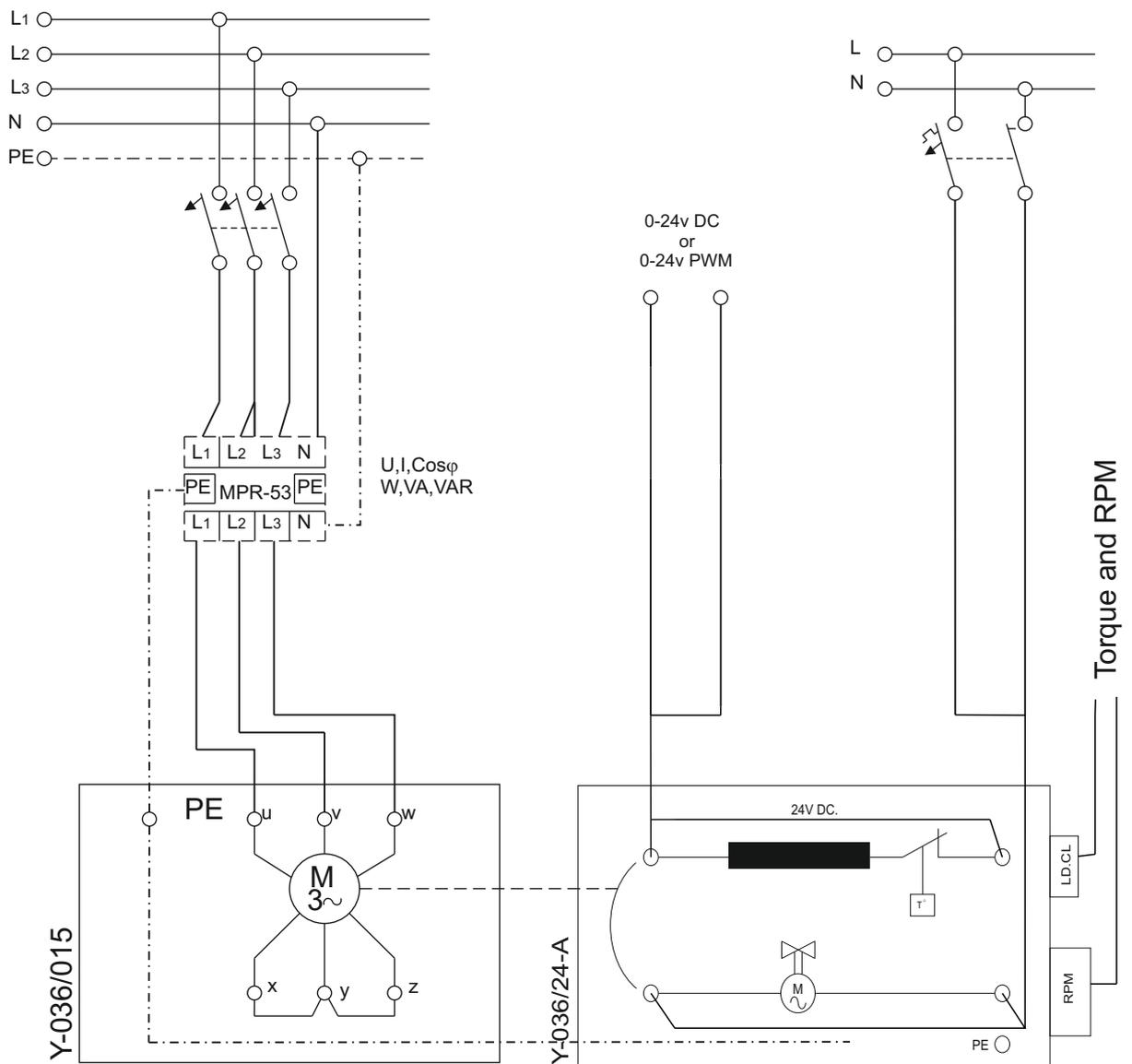


Figure 34.2: Connection diagram for the loaded operation of the tri-phase asynchronous motor

#### Information :

In loaded operation of the asynchronous motor, we can observe the parameters, Power (P), Torque (T), Speed (n), efficiency ( $\eta$ ), slip (S) power factor ( $\text{Cos}\phi$ ), and relations like current-torque, slip-torque.

The speed of the asynchronous motor decreases with the increasing load. The speed decreases linearly at full-load and no-load. But this is not the case at high values. The power factor of the asynchronous motor is small at no-load and it increases with the increasing load. The slip of the motor also increases up to some value with the increasing load.

The efficiency of the asynchronous motor increases with the increasing load. From 1/3 load to full load, the increase in the efficiency is high.

The torque produced by asynchronous motor increases proportional with the output power of the motor. This increase continues up to the motor is overturn. Some equations for some asynchronous motor parameters.

$$S = \frac{n_s \cdot n_r}{n_s} \cdot 100$$

The rated power of the motor is output power.

$$\eta = \frac{\text{Output power}}{\text{Input power}}$$

$$M = \frac{P_{kv} \cdot 975}{n_r} \text{ kgm.}$$

$$P = \sqrt{3} \cdot U \cdot \text{Cos}\phi \cdot \text{input power}$$

The speed is measured by tachometer, the power factor is measured by  $\text{Cos}\phi$  meter, and the motor losses  $P_l = P_{cu} + P_{fe} + P_f$  are measured by braking systems.

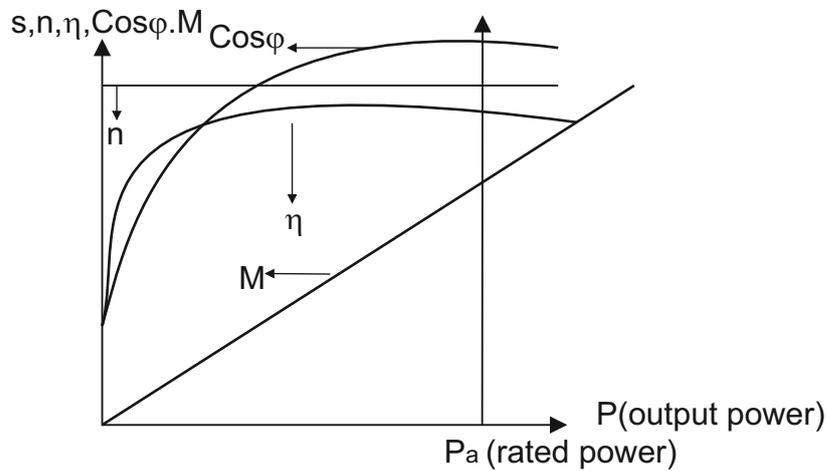


Figure 34.3 Load characteristics of the asynchronous motor

**Procedure :**

Note:\* Magnetic powder brake (Y-036/024-A) is used to load the asynchronous motor in the experiment. DC shunt, compound generator and load group can also be used.  
 \*The tri-phase asynchronous motor in the figure is Y-connected. Be careful about the values in the label of the motor since the motor is directly connected to the network.

- Connect the circuit shown in the figure 34.1, 34.2
- Operate the tri-phase asynchronous motor by applying nominal voltage to it.
- Take note of the parameters (U,I,Cosφ,W,VA,VAR) in the energy analyzer at this condition.
- Operate the fan motor of the magnetic powder brake (220V AC).
- Apply voltage to the magnetic powder brake from the RPM and Torque unit with press the start button, starting from zero, step by step.
- Continue until the asynchronous motor reaches nominal power. Observe and take note of the parameters in the energy analyzer and the values Nm, n in each step.
- Set the power of the tri-phase asynchronous motor to 1.5 times the nominal power by increasing the DC voltage applied to themagnetic powder brake. Observe and take note of the parameters in the energy analyzer and the values If, Uf, n in that case.
- Repeat the procedure above step by step after connecting the motor in  $\Delta$  form considering the rated values of the asynchronous motor. Compare the Y and  $\Delta$  connections for loaded operation of the motor. If the motor doesn't appropriate running star/delta connection, connect delta with using AC motor driver (Y-0036/026 or Y-0036/026-A.)
- Turn of the energy and finish the experiment.

**Values recorded in the experiment :**

Energy analyzer						n rpm	S Calculate	M Calculate	$\eta$	Torque Nm	EXPLANATION
U	I	Cosφ	W	VA	VAR						

**Evaluation :**

- Question 1: What is the relation between the speed (n) and load (Po) of the asynchronous motor?
- Question 2: What is the relation between the slip (S) and load (Po) of the asynchronous motor?
- Question 3: Analyze the torque value of the asynchronous motor.
- Question 4:What is turnover torque and when does it occur?
- Question 5:Analyze the efficiency value ( $\eta$ ) in loaded operation of the asynchronous motor.
- Question 6:State your final observations about the experiment.

## Experiment 37 :STARTING THE TRI-PHASE ASYNCHRONOUS MOTOR DIRECTLY

**Purpose :** Observing the current-power torque relation at starting of the tri-phase asynchronous motor, analyzing the relations in no-load/loaded starting.

**Equipments :**

- Experiment board with energy unit Y-036/001
- Railed motor table Y-036/003
- Tri-phase asynchronous motor Y-036/016 (Y-036/015)
- Magnetic powder brake Y-036/024-A
- Tachometer
- Jagged cable ,cable with IEC plug

**Connection diagram for the experiment :**

Y-036/001

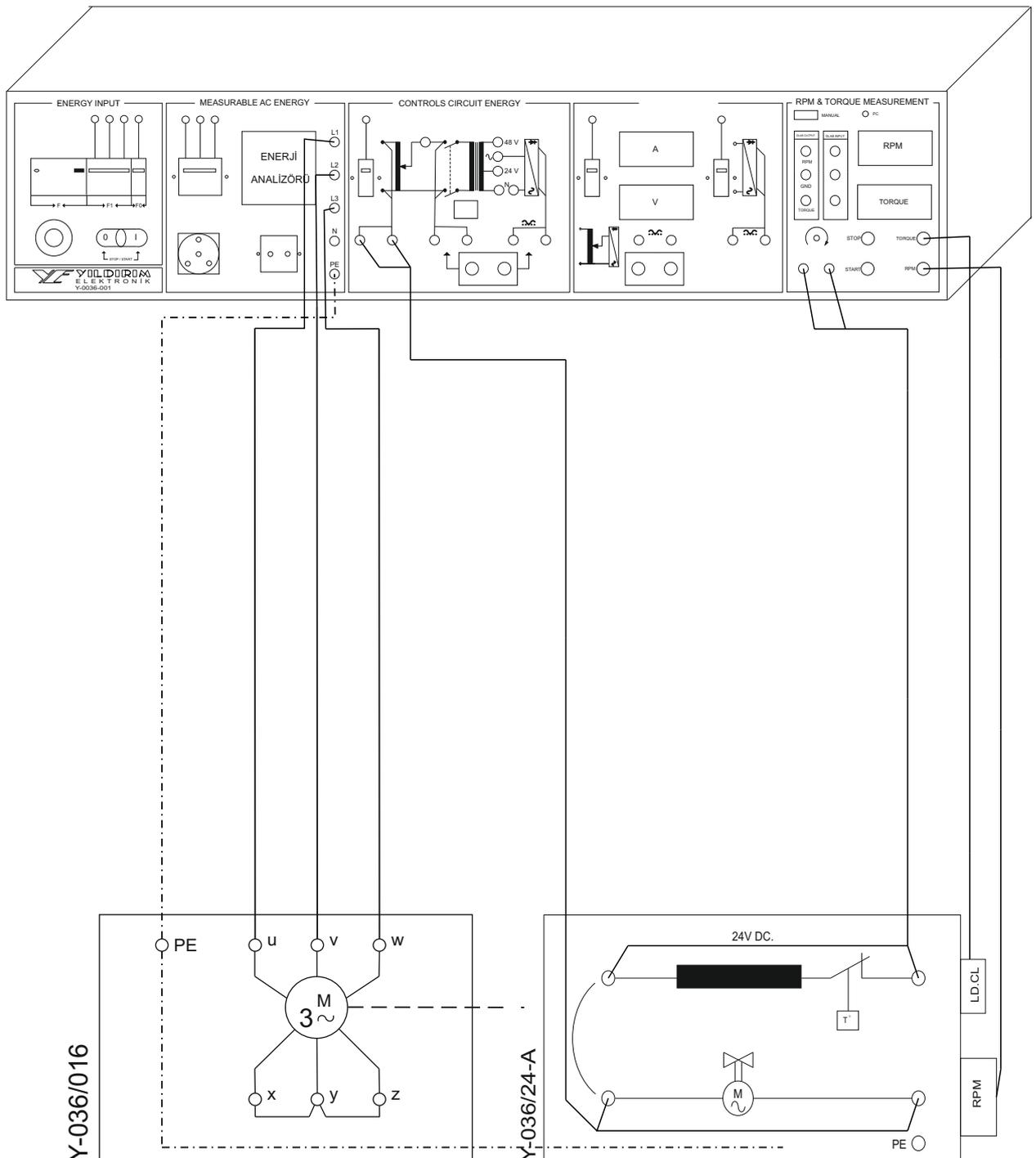


Figure 37.1:Connection diagram for direct start of the tri-phase asynchronous motor.

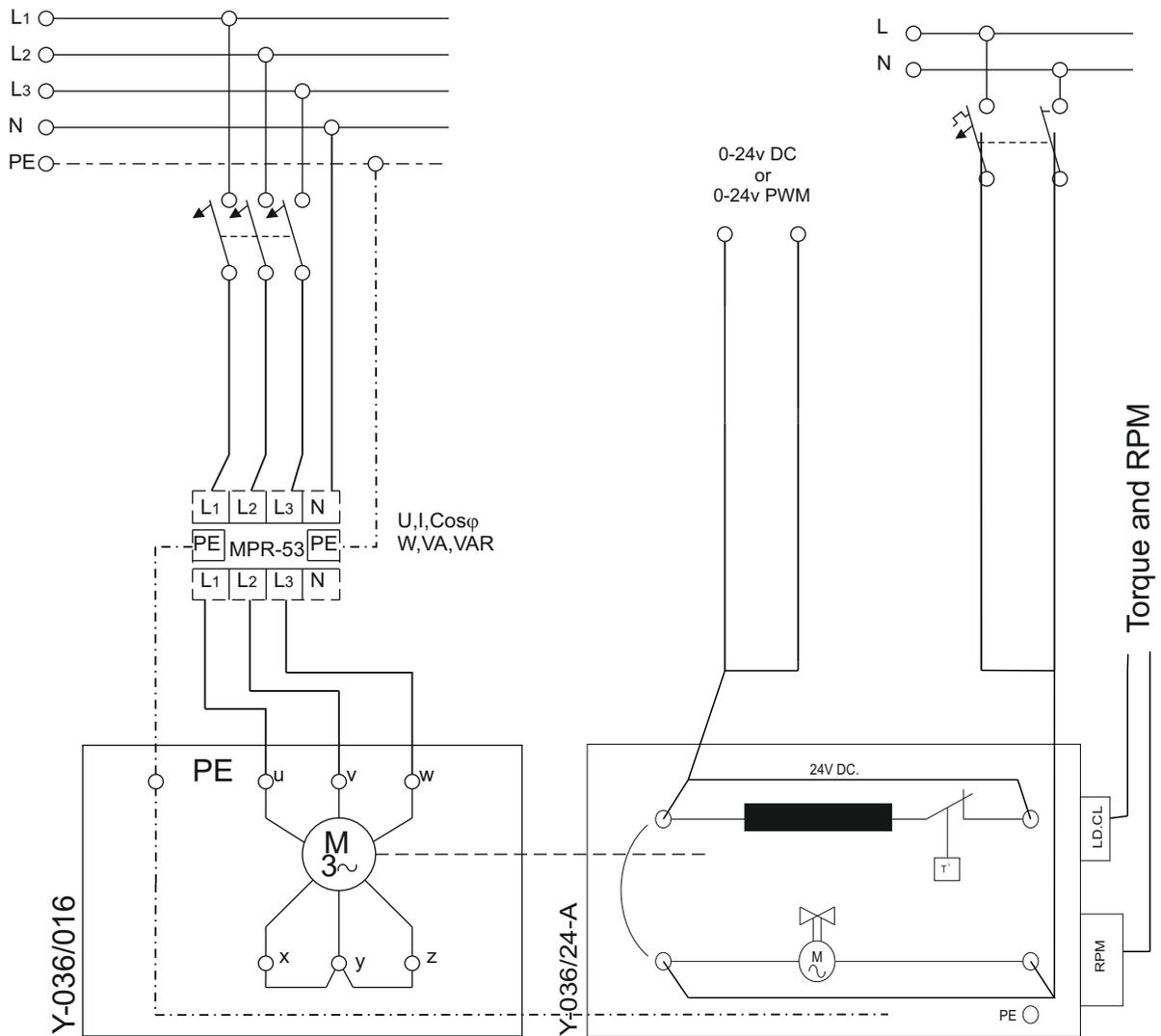


Figure 37.2: Connection diagram for direct start of the tri-phase asynchronous motor.

Information :

In direct start of the asynchronous motor, the motor is directly connected to the circuit via a switch or conductor-thermic controller system. That starting system is applicable for motors with power less than 5 HP-4 KW. The asynchronous motors pull very high currents from the network when starting. This situation continues until the motor reaches 75-80 % of the nominal speed. Starting takes more time when the motor is loaded, also the high current takes more time. Therefore, the motor is started without load. The high current at starting instant do not damage the windings of the motor since it continues for a short time. However, motor protection systems are suggested to be used in asynchronous motors.

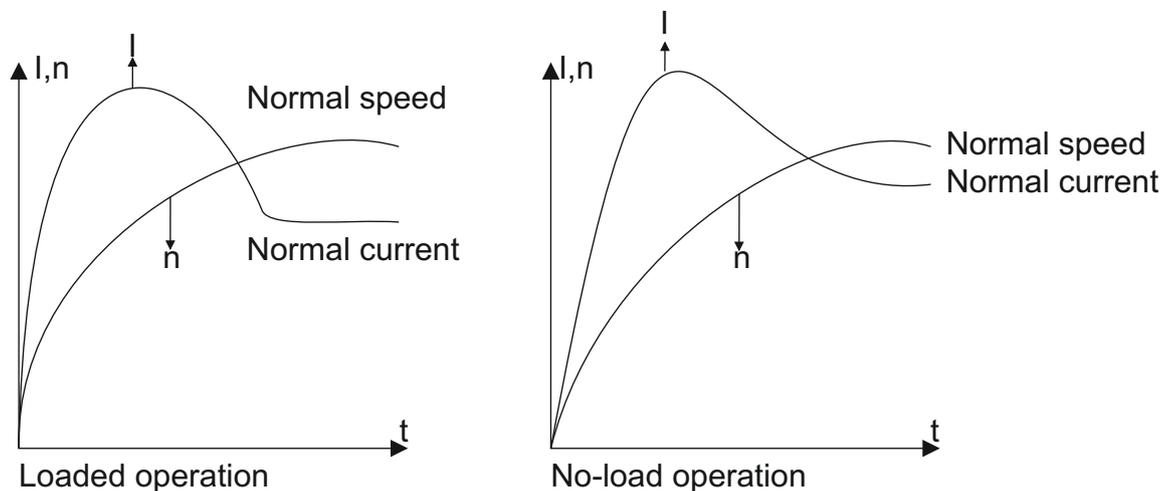


Figure 35.3 The speed curve of the asynchronous motor.

**Procedure :**

△

Note: Be careful about the label of the asynchronous motor used in the experiment. It should be connected Y and △ form if the conditions are suitable.

- Connect the circuit shown in the figure 37.1, 37.2.
- Start the motor while no-load is connected to it and the motor clemence is Y-connected. Take note of the parameters U,I,Cosφ,W,VA,VAR and n (speed) in the energy analyzer at starting and normal operation times.
- Provide starting and normal operation by loading the motor with the nominal power using the magnetic powder brake.Start with magnetic powder brake %50 and %100 load seperately
- Take note of the parameters U,I,Cosφ,W,VA,VAR and n (speed) in the energy analyzer at starting and normal operation times with load.
- It maybe necessary to repeat the previous step to observe the parameters since the starting duration is very short.
- Repeat the same procedure after connecting the motor in △ form (if possible).
- Observe and take note of the required parameters in any condition.
- Turn of the energy and finish the experiment.

**Values recorded in the experiment :**

Energy Analyser (road-making)								(normal operation)								Explanation
U	I	Cosφ	W	VA	VAR	n	Nm	U	I	Cosφ	W	VA	VAR	n	Nm	

**Evaluation :**

- Question 1:In which condition, we start the asynchronous motor directly?
- Question 2:What are the reasons of the high current at starting of the asynchronous motor? Explain.
- Question 3:Analyze the loaded and no-load starting of the asynchronous motor considering the values recorded in the experiment.
- Question 4:What are the results of Y-△ connection of the asynchronous motor at starting? Explain.
- Question 5:Explain the starting conditions and requirements of the asynchronous motor.
- Question 6:State your final observations about the experiment.

## Experiment 54 :THE NO-LOAD OPERATION OF THE TRI-PHASE SYNCHRONOUS MACHINE AS ASYNCHRONOUS GENERATOR

**Purpose :** Analyzing the no-load operation of the synchronous motor, analyzing the relation between the speed and voltage-frequency; the excitation current-voltage and generator voltage and sketching the related graphs.

**Equipments :**

-Experiment board with energy unit	Y-036/001
-Railed motor table	Y-036/003
-Energy analyzer	Y-036/004
-Tr-phase asynchronous motor	Y-036/015
-A.C motor driver	Y-036/026
-3 phase synchronous machine	Y-036/021
-Tachometer, Jagged cable ,cable with IEC plug	

**Connection diagram for the experiment :**

Y-036/001

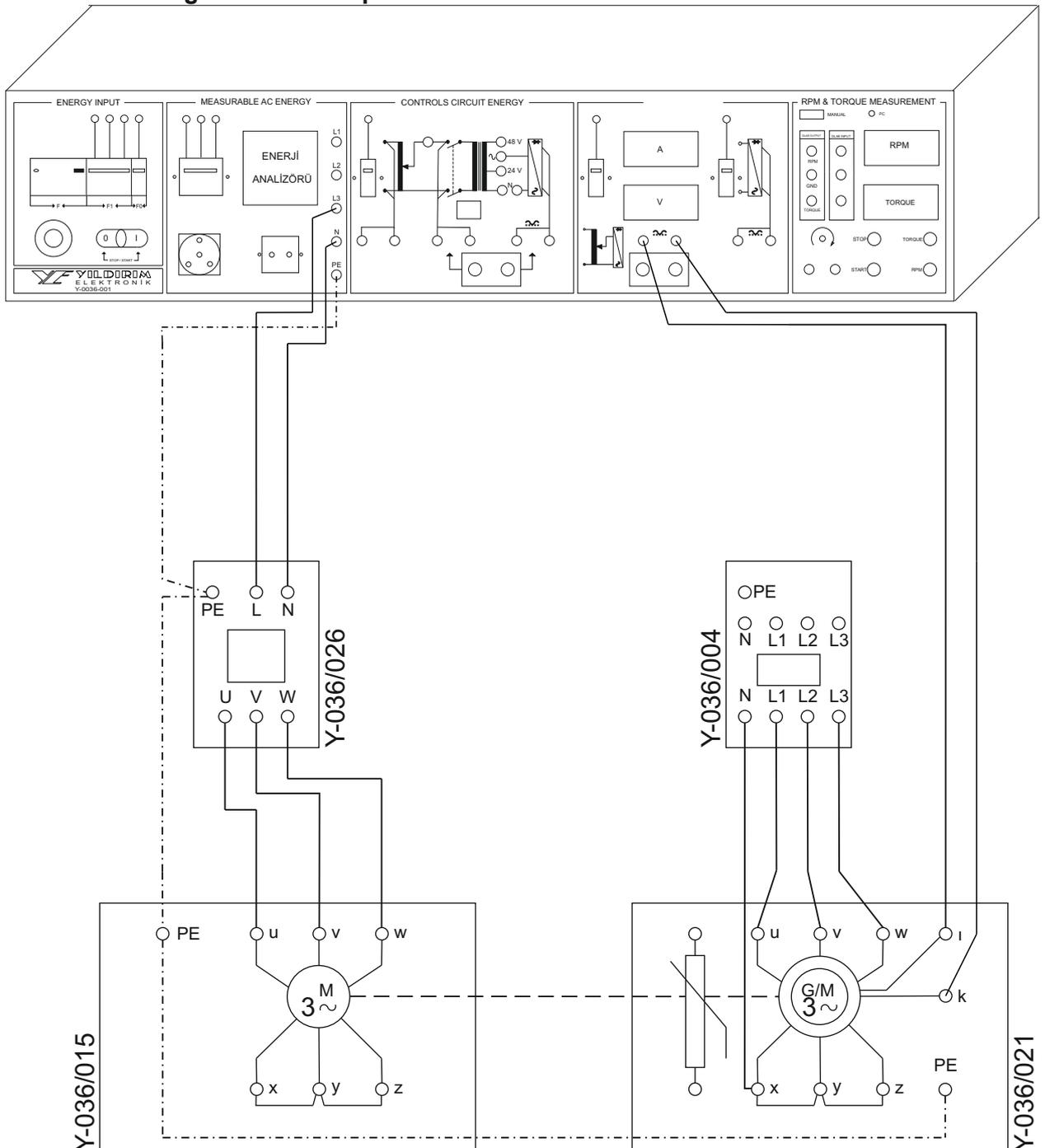


Figure 54.1:Connection diagram for the experiment of tri-phase synchronous generator

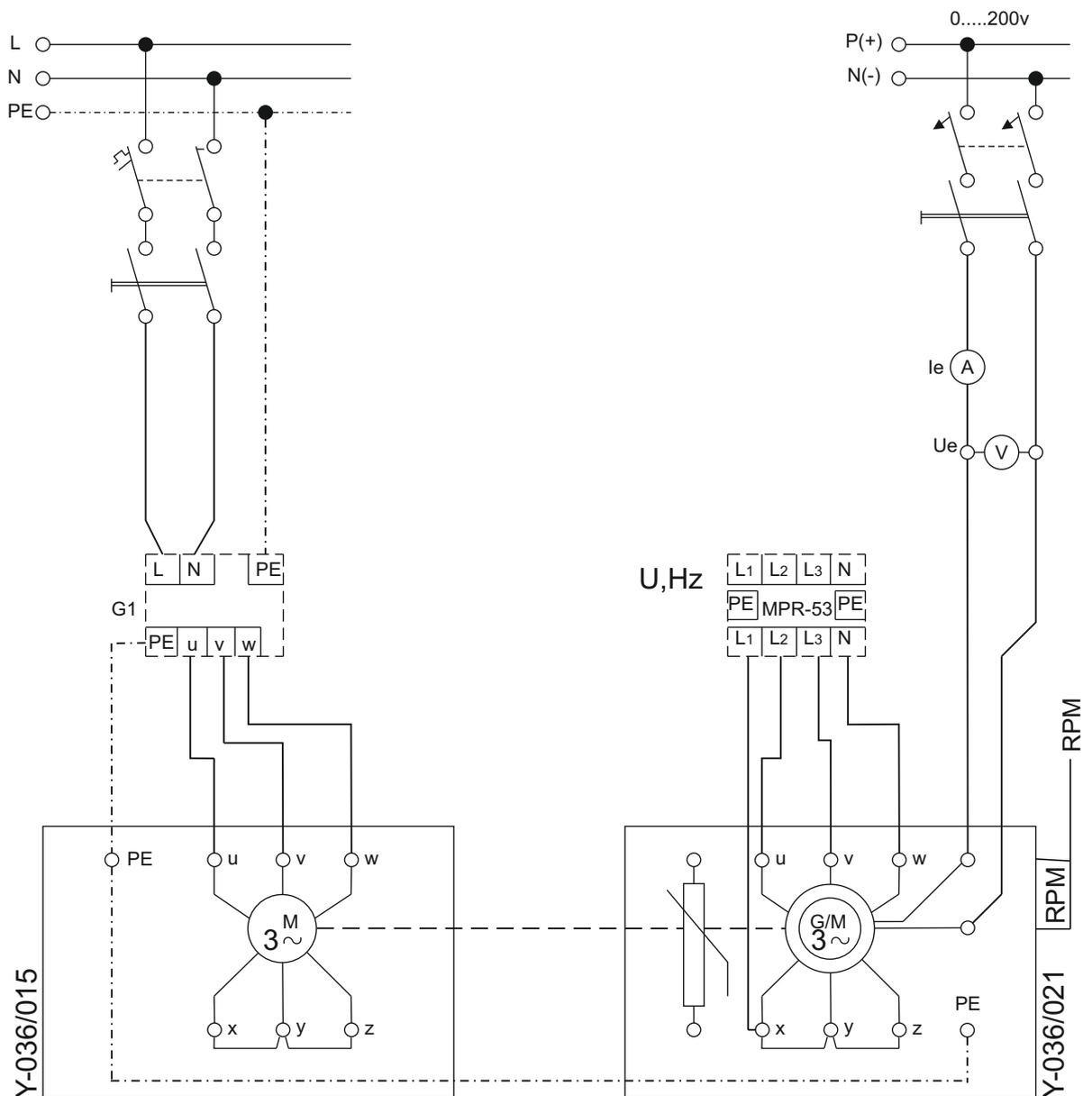


Figure 54.2: Connection diagram for the experiment of tri-phase synchronous generator

**Procedure :**

Note: Be careful about the nominal values of the synchronous machine.

- Connect the circuit shown in the figure 51.1, 51.2.
  - Set the speed of the synchronous generator to its nominal value (1500 rpm) using the asynchronous motor and the driver and keep that speed during the experiment.
  - Increase the excitation current starting from zero until it takes 1.2 times the nominal value step by step. Take note of the parameters  $U(L-N, L-L)$  in the energy analyzer and the frequency in each step.
  - Set the terminal voltages L-N to 220V, L-L to 380V at frequency=50 Hz. using the excitation current  $I_e$  and the excitation voltage  $U_e$ . Observe and take note of the values speed (n),  $I_e$ ,  $U_e$  at that case.
- Analyze the relation between the excitation currents ( $I_e$ )-speed (n) and terminal voltage using the measured values and your observations in the experiment.
- Turn of the energy and finish the experiment.

**Values recorded in the experiment :**

Speed n= rpm	Excitation		Energy analyzer		EXPLANATION
	I <sub>e</sub>	U <sub>e</sub>	U	f	

**Evaluation :**

Question 1: Why do we keep the speed of the synchronous generator constant at no-load? What happens if the speed varies? Explain your observations.

Question 2: Why does not the generator voltage increase when the excitation current (I<sub>e</sub>) increases over the nominal value?

Question 3: Explain the voltage at the terminals of the generator when the speed is at rated value (1500 rpm) but the excitation current is zero (I<sub>e</sub>=0). What happens if we touch the terminals of the generator at this instance?

Question 4: Do we observe a voltage at the output if we reverse the direction of the excitation current? Why? Explain.

Question 5: Sketch and analyze the no-load operation curve of the generator using the values recorded in the experiment.

Question 6: State your final observations about the experiment.