

Module: Electricity

Tutorial Worksheet No. 4: Single-Phase Power

Duration: 1 weeks

Exercises to do in class: 1, 3

Assignment to submit: 2, 4

Exercise 1:

Part A

A workshop is supplied from a single-phase network of 380 V, through a line composed of two cables. Each cable has a resistance r_c of 0.06Ω and a reactance x_c of 0.08Ω .

The workshop consists of:

- A set of machines consuming a total current of 100 A with a power factor of 0.8 under a voltage of 380V.
 - A set of lamps for lighting consuming a total power of 1400 W at a voltage of 380 V ($\cos \varphi = 1$).
1. Establish the active, reactive, and apparent power balance of the workshop. Deduce the total absorbed current as well as the overall power factor of the workshop.
 2. What voltage must the network supply in order to maintain the voltage at 380 V at the terminals of the workshop? Deduce the voltage drop caused by the line. Is it acceptable if we desire to have a percentage voltage drop less than 6.5%? Determine the line efficiency under these conditions. Conclusion.

Part B

It is decided to proceed with the expansion of the workshop. For this purpose, several additional machines are installed as well as a network of lamps for lighting. The machines absorb a power of 19 kW with a power factor of 0.8 at 380 V, while the lamps consume a power of 1 kW at a voltage of 380 V.

1. Establish the new power balance. Is the voltage drop acceptable in this case? What does the line efficiency become?
2. In order to reduce the voltage drop, the workshop manager is asked to raise the power factor to 0.95. What capacitance must be installed to obtain this result? What do the voltage drop and efficiency become under these conditions? Give your conclusions.

Exercise 2:

An industrial bakery is supplied by a 500 V, 50 Hz network and includes the following receivers:

- 5 identical kneading machines, each driven by a motor whose nameplate bears the indications: 500V, $\cos \varphi = 0.7$, $P_u = 6.5 \text{ kW}$, $\eta = 0.8$.
 - A resistive oven whose nominal voltage is 500 V
 - 5 capacitors of $250 \mu\text{F}$ each and whose nominal voltage is 500 V
 - 10 fluorescent lamps, each lamp bearing the indications: 500 W, 250 V, $\cos \varphi = 0.5$ (inductive)
1. Show by a clear diagram the connection that must be made to correctly supply all the receivers.
 2. What is the power of the oven if the measurements of V and I recorded at the terminals of the ammeter and voltmeter (see figure) are: $V = 500 \text{ V}$ and $I = 278 \text{ A}$
 3. What is the voltage drop if the impedance of each supply cable is given by: $z_c = 0.08 + j0.1 \Omega$. Comments.
 4. Evaluate this same voltage drop if the capacitors are disconnected. Comments and conclusions.

Exercise 3:

An electrical installation is supplied from a single-phase network of 220 V and includes the following receivers:

- 3 lamps of 112 W each,
- A coil whose equivalent impedance is $Z_B = 66 + j88 \Omega$,
- A capacitor supplying a reactive power of 152 VAR,
- A motor which has the characteristics: $U = 220 \text{ V}$, $\tan \varphi_m = 0.5$ and $\eta_m = 0.85$.

We want to determine the characteristics of the motor. For this purpose, two measurements are made at the level of the overall installation. We find: $I = 25 \text{ A}$, $U = 220 \text{ V}$

1. Determine the active power absorbed by the motor. Deduce the useful power supplied by the motor and then the overall power factor of the installation.
2. What voltage must the network supply in order to maintain the voltage at 220 V at the terminals of the installation if the characteristic of each supply cable is given by: $z_c = 0.35 + j0.75 \Omega$. Deduce the voltage drop caused by the line. Is it acceptable if we desire to have a percentage voltage drop less than 6%?

Exercise 4

Use the diagram of the installation from Exercise 3: this time it is a workshop supplied from a single-phase network of 200 V and which includes the following receivers:

- 4 lamps with impedances of 400Ω each,
- A coil which absorbs a reactive power of 400 VAR and an active power of 100 W,
- A capacitor having the value: $C = (50/\pi) \mu\text{F}$,
- A motor which has the characteristics: $U = 200 \text{ V}$, $|\tan \varphi_m| = 0.5$ and $\eta_m = 0.85$.

We want to determine the characteristics of the motor. For this purpose, two measurements are made at the level of the overall installation (see diagram). We find: $I = 25 \text{ A}$, $U = 200 \text{ V}$

1. Determine the active power absorbed by the motor. Deduce the useful power supplied by the motor and then the overall power factor of the installation.
2. Determine the equivalent impedance $Z = R + jX$ of the workshop as well as the currents \bar{I}_b , \bar{I}_m , \bar{I}_l and \bar{I}_c of each receiver. Verify that we indeed have $\bar{I}_b + \bar{I}_m + \bar{I}_l + \bar{I}_c = 25 \text{ A}$.
3. We wish to raise the power factor to 0.95. Propose a solution to achieve this result.