



PW AVANCED POWER ELECTRONIC

PW N°3

Power factor improvement

Objective :

The objective of this practical work is to remind the student of the interest in improving the power factor, which is related to reactive energy compensation, analyzing its impact and seeing how to size the compensation capacitors using MATLAB/SIMULINK.

1- Reminder:

Improving the power factor of an installation has multiple economic and technical advantages and makes it possible to reduce the electricity bill. In addition, improving the power factor allows reduced sizing of transformers, equipment, conductors, etc. as well as a reduction in line losses and voltage drops in the installation.

• But first why focus on improving power factor?

Because a poor power factor of an installation ($\cos(\varphi) \longrightarrow 0$) results in:

- Penalties (in tariff) by the electrical energy supplier.
- Increase in power subscribed by the energy supplier electric.
- Increase in Joule losses and voltage drop.
- Increased overloads at the transformer and cables.
- On sizing of conductors and cables.
- Tripping of circuit breakers.

What is the power factor?

The power factor $\cos\varphi$ is the ratio of active power to apparent power, so it has a numerical value between 0 and 1.

$$\cos(\varphi) = \frac{P}{S}$$

So, the power factor of an installation will be low when the power reactive will be high ($\cos\varphi$ will move away from 1 and approach 0).



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• How to improve the PF?

To increase the power factor ($\cos\phi$), it is necessary to compensate for the reactive power consumed by the inductive receivers.

Improving the power factor can be done in two ways:

- Global by placing a bank of capacitors at the head of the installation (factory).
- Individual or localized by placing the capacitors as close as possible inductive receiver.

• How to size the compensation of an installation?

To improve the power factor, a capacitor (capacitor bank) must be installed. The latter will produce the reactive power Q_C making it possible to reduce the initial reactive power Q_{R_1} supplied by the network into a reactive power Q_{R_2} (desired reduced value)

$$Q_C = Q_{R_1} - Q_{R_2}$$

Because the electrical energy supplier has set a penalty threshold beyond which it charges for over-consumed reactive power.

This threshold is calculated from the $\tan \phi$:

$$\tan(\phi) = \frac{Q}{P}$$

For example :

- If $\tan \phi \leq 0.4$: No billing for the reactive energy consumed.
- If $\tan \phi > 0.4$: Billing for additional reactive energy.

Then, the value of the capacitor to install is given by:

$$C = \frac{Q_C}{V^2 \omega}$$

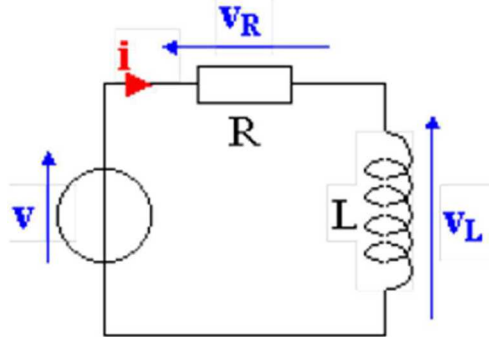
Such that, C Capacity of the capacitor in Farads. Q_C Compensation reactive power. V Voltage across the capacitor in Volts. $\omega=2.\pi.f$ Pulsation in rad/s.

2- Handling:

We use the electrical circuit simulation software MATLAB/ SIMULINK to analyze the current absorbed by an alternating motor and to measure the active and reactive powers absorbed (The motor is mobilized by a resistance in series with a coil). We then study the influence of a reactive power compensation capacitor. Carry out the assembly shown in the figure below as follows:

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$$V(t) = 220.\cos(\omega t) \quad f = 50\text{hz} \quad R = 1 \quad L\omega = 20$$



- 1- Visualize 0.5s of the source voltage V and the current i .
- 2- Calculate the phase shift of the current in relation to the voltage V .
- 3- Calculate the effective value of current i numerically then verify by Matlab/Simulink.
- 4- Calculate the active and reactive power supplied by the network using Matlab/Simulink and check the phase shift calculated previously.
- 5- If the electrical energy supplier has set the penalty threshold at 0.4, should we improve the PF to reduce billing.
- 6- Make a reactive power compensation so that the $\tan \varphi$ is equal to 0.1.