EEE270
Reactive Power Compensation (Power Factor Correction) Study Questions

Prepared by Prof. Dr. A. Mete VURAL

Q1. A single-phase 250 V (rms), 50 Hz supply feeds an inductive load drawing 13.46 A of current at a power factor of 0.73 lagging.

a) Calculate the apparent power (S), real power (P), and reactive power (Q) consumed by the load.
b) Determine the reactive power (Qc) that must be supplied by a capacitor connected in parallel with the load to improve the power factor to 0.95 lagging.
c) Calculate the capacitance value (C) in microfarads (μF) required for the capacitor that provides the compensation found in part (b)
d) Calculate the new total current drawn from the supply after power factor correction.
e) Compare the original and improved conditions in terms of Power factor, Supply current, and Overall efficiency of power delivery

Q2. A 230 V (rms), 60 Hz single-phase AC supply feeds two inductive loads connected in parallel:

- Load 1: Draws 18 A at a power factor of 0.65 lagging
- Load 2: Consumes 1345 W at a power factor of 0.8 lagging

a) Calculate the apparent power (S1), real power (P1), and reactive power (Q1) for Load-1.
b) Calculate the apparent power (S2), reactive power (Q2), and the current drawn by Load-2.
c) Determine the total real power (P_total), total reactive power (Q_total), and total apparent power (S_total) of the system before compensation.
d) A capacitor is added in parallel to the combined load to improve the overall power factor to 0.98 lagging. Calculate the reactive power (Qc) that must be supplied by the capacitor.
e) Determine the required capacitance value (C) in microfarads (μF) for the compensating capacitor.
f) Calculate the total current drawn from the source after power factor correction.

Q3. A 600 V (rms), 50 Hz single-phase AC supply feeds two different loads connected in parallel:

- Load 1: Draws 15 kW at a power factor of 0.9 lagging
- Load 2: Draws 25 kW at a power factor of 0.95 leading

a) Calculate the apparent power, reactive power, and current for each load.
b) Determine the total real power (P_total), total reactive power (Q_total), and total apparent power (S_total) of the system before compensation.
c) Calculate the overall power factor of the system before compensation. State whether it is lagging, leading, or unity.
d) An inductor is connected in parallel with the system to reduce the power factor to 0.85 lagging (i.e., to intentionally add inductive reactive power). Calculate the inductive reactive power (Q_L) that must be added.
e) Determine the required inductance (L) in millihenrys (mH) for the inductor that provides this compensation.
f) Calculate the new total current drawn from the supply after compensation.

Q4. A 440 V (rms), 60 Hz single-phase AC supply feeds three loads connected in parallel:

- Load 1: Draws 15000 W at a power factor of 0.70 lagging
- Load 2: Draws 10000 W at a power factor of 0.95 leading
- Load 3: A passive impedance load given as $Z=20+j15\ \Omega$.

a) For Load 1, calculate apparent power, complex power, and reactive power.
b) Repeat part (a) for Load 2.
c) Repeat part (a) for Load 3.
d) Calculate the current drawn by the impedance.
e) Calculate the supply current.
f) Determine the total real power, total reactive power, and total apparent power of the entire system (3 loads) before any compensation.
g) Calculate the overall power factor of the system before compensation. State whether it is lagging, leading, or unity.
h) What must be done to make the power factor be UNITY. Design a compensation system. Use either a capacitor or an inductor connected parallel to the loads.
i) Calculate the required amount of reactive power (inductive or capacitive).
j) Determine the total current drawn from the supply after compensation.

Q5. A three-phase, 400 V (line-to-line), 50 Hz power supply feeds a large induction motor. The motor delivers 100 hp of mechanical output power and operates at a power factor of 0.75 lagging with an efficiency of 92%. (1 hp = 746 W).

a) Calculate the input real power (in kW) drawn by the motor from the supply.

b) Calculate the apparent power (S) and reactive power (Q) consumed by the motor.

c) Determine the line current drawn by the motor from the 400 V three-phase supply.

d) To improve the power factor to 0.95 lagging, a bank of capacitors is connected in parallel with the motor. Calculate the required reactive power (Qc) that must be supplied by the capacitor bank.

e) Determine the required capacitance per phase (in microfarads, μF) for delta connection of capacitors to supply the required reactive power.

f) Determine the required capacitance per phase (in microfarads, μF) for star connection of capacitors to supply the required reactive power.

Q6. A three-phase, 1 kV (line-to-line), 50 Hz supply feeds:

- A large induction motor delivering 400 hp mechanical output power with an efficiency of 93% and operating at a power factor of 0.764 lagging. (1 hp = 746 W).
- An additional balanced resistive load that draws 300 kW of real power

a) Calculate the real input power (in kW) consumed by the motor.

b) Calculate the apparent power (S_motor) and reactive power (Q_motor) of the motor.

c) Determine the total real power (P_total), total reactive power (Q_total), and total apparent power (S_total) of the entire load (motor + resistor).

d) Calculate the overall power factor of the combined load. Indicate whether it is lagging or leading.

e) Determine the line current drawn by the combined load from the 400 V, 3-phase supply.

f) Determine the required capacitance per phase (in microfarads, μF) for delta connection of capacitors to raise the power factor to 0.98 lagging.

Q7. A 460 V (line-to-line), 50 Hz, three-phase balanced supply feeds the following three loads:

- Load 1 (*Induction Motor*): Delivers 250 hp of mechanical power at 0.75 lagging power factor and 92% efficiency. (1 hp = 746 W).
- Load 2 (*Resistive Load*): Draws 30 kW of real power
- Load 3 (*Capacitive Load*): A power electronics-based system draws 15 kVAR of leading reactive power

All three loads are connected in parallel.

a) Calculate the input real power (P_motor) consumed by the motor.

b) Calculate the apparent power (S_motor) and reactive power (Q_motor) of the motor.

c) Determine the total real power from all three loads.

d) Determine the total reactive power by accounting for all loads (pay attention to leading vs. lagging sign conventions).

e) Calculate the total apparent power and the overall power factor of the system. State whether it is lagging, leading, or unity.

f) Determine the total line current drawn by the system from the three-phase source.

g) Is additional power factor correction required if the goal is to achieve a power factor of 0.95 lagging? Justify your answer using total reactive power.

- If yes:
  - Calculate the additional reactive power that must be supplied or absorbed.
  - Determine the required capacitance per phase in μF for a delta-connected capacitor bank.
- If no:
  - Determine the existing power factor and discuss why compensation is not needed.

Prepared by Prof. Dr. A. Mete VURAL