Real, Apparent and Reactive Power

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Real Power (P)

- Real Power (P) measured in Watts is required to do useful work
  - Boil kettles, turn motors, power light bulbs.
  - Single phase $P = |V|.|I|.\cos(\phi)$
  - Three phase $P = 3.|V_{LN}|.|I|.\cos(\phi)$

    or $P = \sqrt{3}.|V_{LL}|.|I|.\cos(\phi)$

- Note: Real power is actually the average of instantaneous power.

Apparent Power (S)

- The apparent power (S) measured in VA is just the product of (rms) Volts and (rms) Amps
  - The apparent power (S) is a useful figure for determining the size of electrical equipment.
  - Single phase $S = |V|.|I|$
  - Three phase $S = 3.|V_{LN}|.|I|$

    or $S = \sqrt{3}.|V_{LL}|.|I|$

Reactive Power (Q)

- You should know by now that inductors and capacitors don’t dissipate any power ($\cos(\phi) = 0$) but they still draw current.
- Reactive power (Q) measured in vars is an indication of how much current is being drawn by inductors and capacitors.
  - Single phase $Q = |V|.|I|.\sin(\phi)$
  - Three phase $Q = 3.|V_{LN}|.|I|.\sin(\phi)$

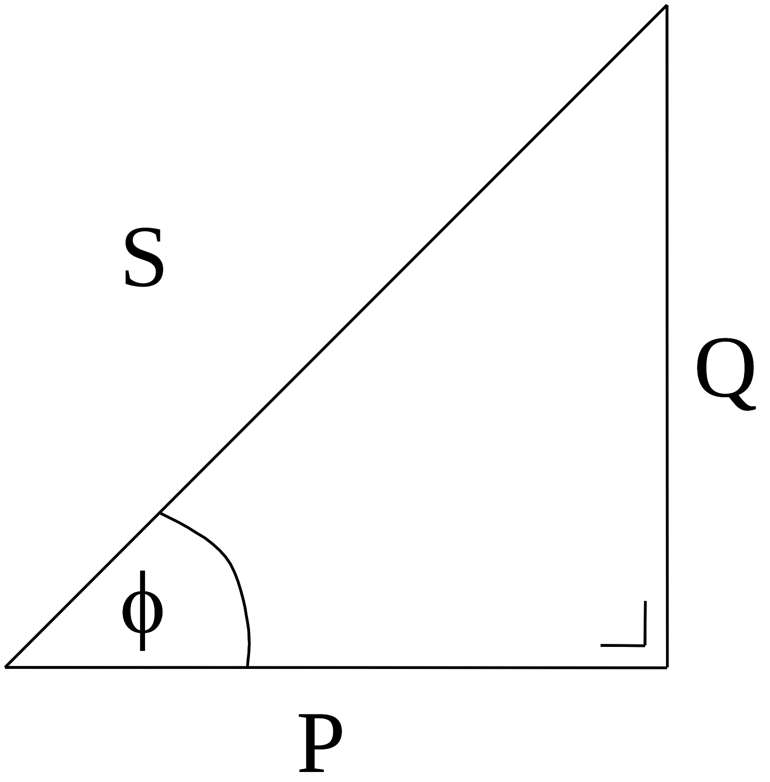
    or $Q = \sqrt{3}.|V_{LL}|.|I|.\sin(\phi)$
- By convention
  - Inductors draw positive vars (Q positive)
  - Capacitors draw negative vars (Q negative)

Examples

- Resistor: $\phi = 0^o$
    - $P = |V|.|I|$
    - $S = |V|.|I|$
    - $Q = 0$
- Inductor: $\phi = 90^o$ Lagging
    - $P = 0$
    - $S = |V|.|I|$
    - $Q = +|V|.|I|$
- Capacitor: $\phi = 90^o$ Leading
    - $P = 0$
    - $S = |V|.|I|$
    - $Q = -|V|.|I|$

Relationships

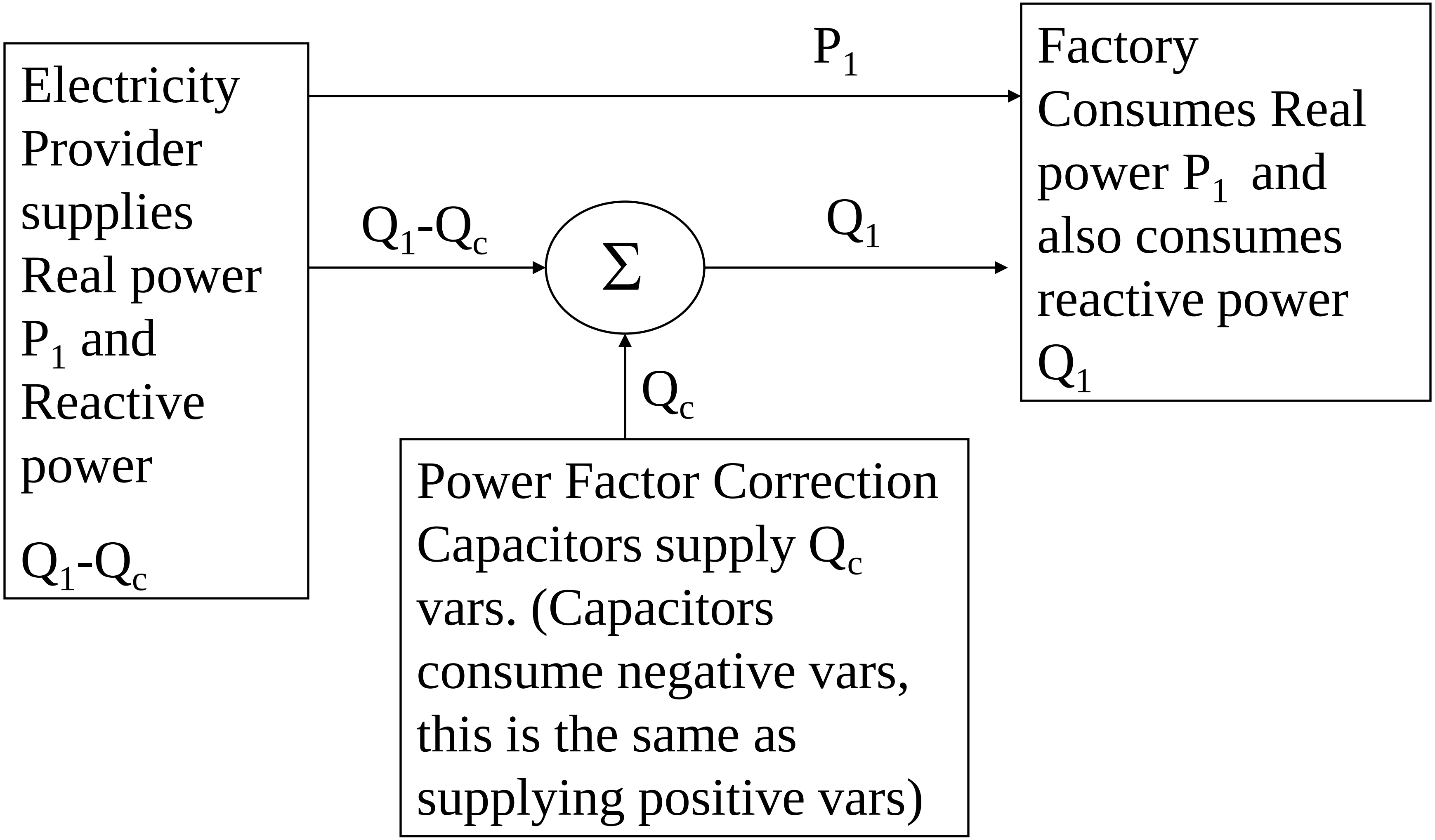
- $P = S.\cos(\phi)$
  $Q = S.\sin(\phi)$
  $S^2=P^2+Q^2$
- See the power triangle:
- **NB: $\cos(\phi)$ is usually called the Power Factor or PF for short.**



Power factor correction

- High Q (lots of inductors or capacitors) is a bad thing.
  - High Q => low power factor
  - For a given level of useful work a high Q will require higher S and higher current => higher losses in transmission.
- Utilities (ESB) penalise industrial users if their power factor falls below 0.95
  - Unfortunately most industrial loads (e.g.motors and transformers) have high inductance => low power factor
  - Luckily you can add capacitors (negative Q) to cancel out the positive Q of inductors.

Power Factor Correction



Question

- A factory draws 1MVA at a power factor of 0.8 lagging from a 10kV 3 phase supply.
- What is the current drawn from the supply?
- How many vars of power factor correction capacitance are required to bring the power factor up to 0.95?
- What will the new current be after the capacitors are fitted?