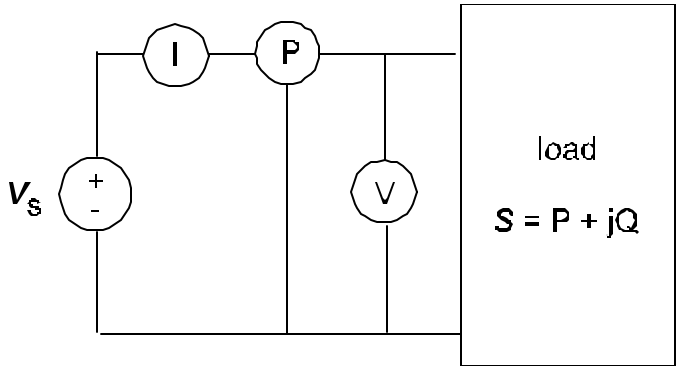
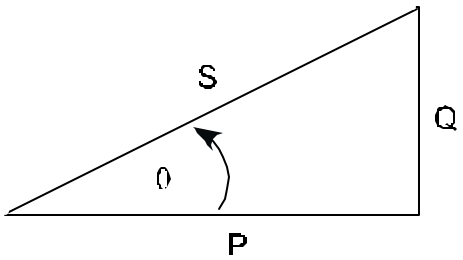
Power factor correction, voltage regulation, and efficiency



P, the average power delivered to load, is measured by the wattmeter.

S, the apparent power delivered to load, is determined by the product of the ammeter reading and the voltmeter reading.

Remember: ammeters and voltmeters give amps and volts in rms unless otherwise specified. The default is rms.



pf, the power factor, is the ratio of P to S. pf = P/S. Note that the magnitude of the pf does not, in itself, indicate whether the load is leading or lagging.

For most industrial loads, the power factor will be lagging. If this cannot be safely assumed to be the case, some means of measuring phase must be in place..

S, the complex power delivered to the load. $\boldsymbol{S} = S\angle\theta$

Q, the reactive power delivered to the load. $Q = S \sin\theta$

Example

Suppose in the circuit above, that the voltmeter reads 200V, the ammeter reads 10A, and the wattmeter reads 1.5kW. The load is a resistor and inductor in series. Determine:

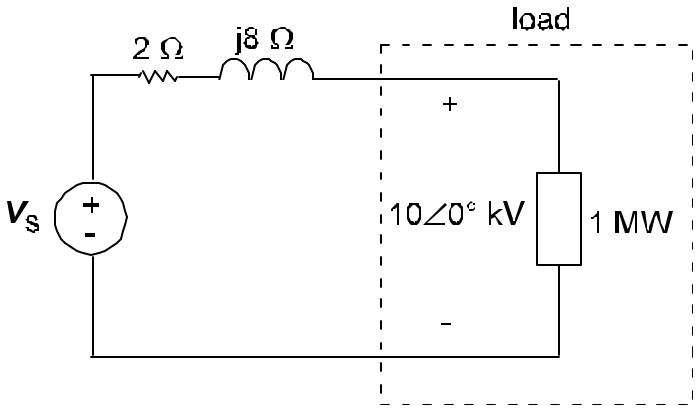
i) real power
ii) apparent power
iii) reactive power
iv) power factor
v) load component values (Ω for R, H for L) if f = 60 Hz

Power Factor

Example

A power source has 2 + j8Ω impedance in its leads. It supplies a load of 1MW at 10kV, 60Hz. Determine the magnitude of the supply voltage and the average power drawn from the supply when:

i) the load power factor is 0.5 lag, and
ii) the load power factor is 0.95 lag.



To determine the supply voltage, we first need to find the current so that we can determine the voltage across the feeder impedance.

To find the current, we need to determine the load complex power.

Notice the load power is specified in terms of average power, P, and pf. From this information, we can determine the load's complex power.

Voltage regulation, VR

Voltage regulation is a measure of how the load voltage varies with current.

$$\%VR = \frac{V_{\text{no load (I=0)}} - V_{\text{full load}}}{V_{\text{full load}}} 100\%$$

Find the VR at 0.5 lag and the VR at 0.95 lag

Efficiency

Efficiency is the ratio between power in and power out.

Here, P_{in} is provided by the source, $\boldsymbol{V}_s$; P_{out} is absorbed by the load.

$$\%\text{eff} = \frac{P_{load}}{P_{source}} 100\% = \frac{P_{load}}{P_{load} + P_{losses}} 100\%$$

Find the efficiency at 0.5 lag and 0.95 lag.

Power factor correcting capacitance

Find the capacitance necessary to correct the pf from 0.5 lag to 0.95 lag in the example above