Power Electronics Notes - D. Perreault

★ (Passive) Power Factor Compensation — chap KSV 3.4.1

Lets focus on the displacement factor component of power factor. For simplicity, lets assume a linear load (e.g. R-L) so that voltages + currents are sinusoidal.

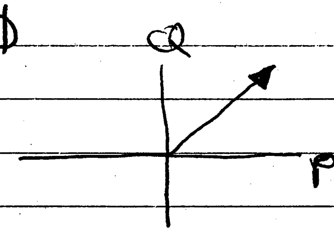
For sinusoidal v, i: $\quad P.F = \dfrac{\langle p \rangle}{V_{rms} I_{rms}} = \cos\phi$

ϕ is the <u>power factor angle</u> $\begin{cases} \text{leading} & \phi < 0 \quad \text{capacitive} \\ \text{lagging} & \phi > 0 \quad \text{inductive} \end{cases}$

Real Power $P = V_{rms} I_{rms} \cos\phi$

★ Define reactive power as

$$Q \triangleq V_{rms} I_{rms} \sin\phi$$



In vector form $\vec{S} = P + jQ$

In phasor form $\vec{V}, \vec{I} \rightarrow \vec{S} = \langle V I^* \rangle$

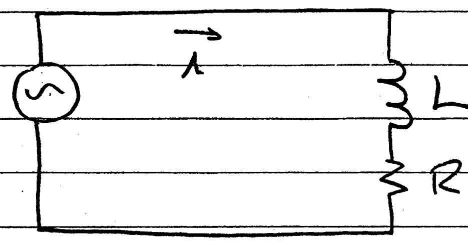
		Units
apparent power	$S = \lVert \vec{S} \rVert = V_{rms} I_{rms}$	VA
average power	$Re\{S\} = P = V_{rms} I_{rms} \cos\phi$	W
reactive power	$Im\{S\} = Q = V_{rms} I_{rms} \sin\phi$	VAR

We can use these results to help adjust the displacement factor of a system! (make $Q_{net} \rightarrow 0$)

Power Electronics Notes ~ D. Perreault

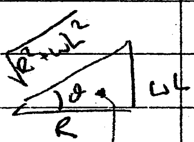
Suppose we have an R-L load (e.g. an induction machine)

$V_s \cos \omega t$



$$i(t) = \frac{V_s}{\sqrt{\omega^2 L^2 + R^2}} \sin\left(\omega t - \text{ATAN}\left(\frac{\omega L}{R}\right)\right)$$

voltage-current phase $\phi = \text{ATAN}\left(\frac{\omega L}{R}\right)$



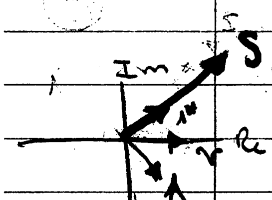
flip for neg.

$$P.F. = \cos\left(\text{ATAN}\left(\frac{\omega L}{R}\right)\right) = \frac{R}{\sqrt{R^2 + \omega L^2}} < 1$$

Voltage-Current phase because $S \triangleq V i^*$

we can add some additional reactive load to balance out + give net unity power factor.

$$S = V_{rms} I_{rms} = \frac{1}{2} \frac{V_s^2}{\sqrt{\omega^2 L^2 + R^2}}$$



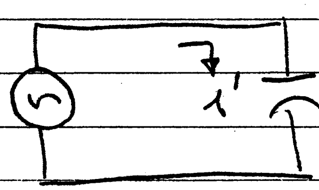
$$P = S \cos \phi = V_{rms} I_{rms} \cos \phi = \frac{V_s^2 R}{2(\omega^2 L^2 + R^2)}$$

$$jQ = jS \sin \phi = jV_{rms} I_{rms} \sin \phi = j\frac{\omega L V_s^2}{2(\omega^2 L^2 + R^2)}$$

so we have real + Reactive power

Suppose we add a <u>Capacitor</u> in parallel

$V_s \sin(\omega t)$



$$Z_c = \frac{1}{j\omega C} = \frac{1}{\omega C} e^{-j\pi/2}$$

$$\frac{1}{Z_c} = \omega C e^{j\pi/2}$$

$V_{phase} - I_{phase} = -90^\circ$

$$i' = V_s \omega C \sin(\omega t + \pi/2)$$

$$S' = V_{rms} I_{RMS} = \tfrac{1}{2} V_s^2 \omega C \qquad P' = 0$$

$$Q' = -j \tfrac{1}{2} V_s^2 \omega C$$