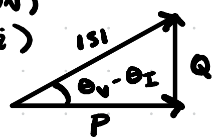
Complex Power

$v(t) = V_p \cos(\omega t + \theta_V)$
$i(t) = I_p \cos(\omega t + \theta_i)$
$\bar{V} = V_{Rms} \angle \theta_V$
$\bar{I} = I_{Rms} \angle \theta_I$



S: Complex power (VA, kVA, MVA)
|S|: Apparent Power (VA, kVA, MVA) = $V_{Rms} \cdot I_{Rms}$
P: Real Power (W, kW, MW)
Q: Reactive Power (Var, kVar, MVar)

$P = \frac{V_p I_p}{2} \cos(\phi)$ $\quad V_{Rms} = V_p / \sqrt{2}$
$Q = \frac{V_p I_p}{2} \sin(\phi)$ $\quad I_{Rms} = I_p / \sqrt{2}$
$\phi = \theta_V - \theta_I$

Power Triangle

$S = \bar{V}\bar{I}^* = V_{Rms} I_{Rms} \angle(\theta_V - \theta_I)$
$S = \bar{V}\bar{I}^* = P + jQ$
$P = V_{Rms} I_{Rms} \cos(\phi)$ [By Load]
$Q = V_{Rms} I_{Rms} \sin(\phi)$

Power Factor / Rms

$I = V/Z \qquad PF = \cos(\phi)$

$$PF = \frac{\text{Real Power}}{\text{Apparent Power}} = \frac{P}{V_{Rms} \cdot I_{Rms}} = \frac{P}{|S|}$$

$$THD = \frac{\sqrt{I_3^2 + I_5^2}}{I_1} = \frac{\sqrt{I_{Rms}^2 - I_1^2}}{I_1} = \sqrt{\frac{1}{DF^2} - 1}$$

$DF = I_1 / I_{Rms}$, $DPF = \cos(\theta_1)$

Given $v(t) = \sqrt{2}V \cdot \cos(\omega t)$ V
$i(t) = \sqrt{2}I_1 \cos(\omega t - \theta_1) + \sqrt{2}I_3 \cos(\omega t + \theta_3)$

$V_{Rms} = \sqrt{\left(\frac{V_1}{\sqrt{2}}\right) + \left(\frac{V_1}{\sqrt{2}}\right)} \qquad I_{Rms} = \sqrt{I_1^2 + I_2^2 + I_3^2}$

$P = VI_1 \cos(\theta_1)$, $|S| = V \cdot I_{Rms}$

$PF = \frac{I_1}{I_{Rms}} \cdot \cos(\theta_1)$

Single Phase PF Correction

$$i_c = \frac{E \cdot I_s}{V_d} \cos 2\omega t$$

$$C_d = \frac{P_{in}}{V_d^2 \cdot 2\omega \cdot \left(\frac{\Delta V_d}{V_d}\right)} \qquad E_d = \frac{P_{in}}{4\omega \cdot (\Delta V_d / V_d)}$$

$$E_d = (1/2)\, C_d V_d^2$$

$$L = \frac{V_d}{4 \cdot f \cdot RF_L \cdot I_s} \qquad RF_L = \Delta I_{L,max} / I_s$$

w/ Transistor
$V_d = \sqrt{2} \cdot E \sin \omega t$ $\quad P_{in} = EI_s(1 - \cos 2\omega t)$
$i_s = \sqrt{2} I_s \sin \omega t$ $\quad P_{out} = V_d \cdot I_d$

Two-Winding Transformer

$I_m = \frac{V_1}{\omega L_m} \qquad L_m = \frac{\mu V_1^2 A_m}{l_m}$

$I_{PEAK} = \sqrt{i_1^2 + I_m^2}$

Magnetic Circuit Concepts

Flux Density - $B = \phi / A$ $\quad$ Magnetic Field Strength - $H = N \cdot i / l$

$\phi = N \cdot i / (l / \mu \cdot A)$ $\quad B = \mu H \quad \mu = \mu_0 \mu_r$, $\mu_r = 1$ For Air

With an Air Gap

$[\mu_0 = 4\pi \cdot 10^{-7}]$

$$\phi = \frac{Ni}{\frac{l_m}{\mu_0 \mu_r A} + \frac{l_g}{\mu_0 A}}$$

l_m - core
l_g - gap

flux linkage - $\lambda_m = N \cdot \phi_m = L_m \cdot i$

$L_m = \lambda_m / i = N^2 / \left(\frac{l_m}{\mu_0 \mu_r A} + \frac{l_g}{\mu_0 A}\right)$

$$i = \frac{H_m l_m}{N}$$

Energy Stored in Core - $W_{core} = 1/2 \cdot B^2 / \mu_0 \mu_r$
in Airgap - $W_{airgap} = 1/2 \cdot B^2 / \mu_0$

Flyback DC-DC Converter

$V_d = V_{in}\, N_2/N_1 + V_o \qquad V_{sw} = V_{in} + V_o\, N_1/N_2$

$P_i = \frac{1}{2} \frac{V_i^2 D^2}{f L_m}$

$V_{in} \cdot I_{in} = V_o \cdot I_o$

$I_{in} = \frac{V_o}{V_{in}} I_o = \frac{D}{1-D} \cdot \frac{N_2}{N_1} I_o$

$\frac{V_o}{V_{in}} = \frac{D}{1-D} \cdot \frac{N_2}{N_1} \qquad L_m = \frac{V_{in} \cdot D}{\Delta i_{Lm} \cdot f} \qquad C = \frac{D}{R \cdot f \cdot (\Delta V_o / V_o)}$

$D = \frac{V_o}{V_o + V_{in}(N_2/N_1)}$

$I_{Diode} = I_o = V_o / R$

$I_{offset} = \frac{I_o (N_2/N_1)}{1-D}$, $I_{Lm,peak} = I_{offset} + \frac{\Delta I_L}{2}$

$\frac{i_1}{i_2} = \frac{N_2}{N_1}$