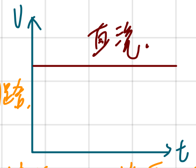
1. (10) Compare DC power system with AC power system.

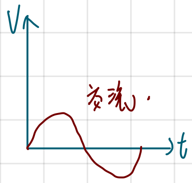
直流電力系統

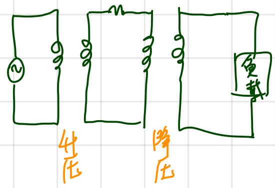


①∵電感短路,電容開路,
∴沒有虛功.

②傳統的無法升降壓轉換;近代靠電力電子

交流電力系統





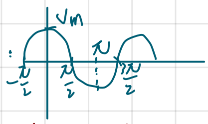
①分:單相&三相

②電感、電容不能忽略.
⇒發生虛功.

③利用變壓器升壓⇒減少傳輸線損失再降壓提供負載使用.

2. (10) Compare AC single phase voltage with three phase voltage.

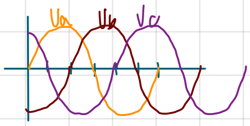
單相:



缺點: Power脈動.
電功是擾動的

$v(t) = V_m \cdot \sin\omega t$

三相:



優點: Power是常數 $= 3 \cdot V_{相} \cdot I_{相} \cos\theta = \sqrt{3}\, V_{line\text{-}to\text{-}line} \cdot I_{line\text{-}to\text{-}line} \cos\theta$
(線對線)

$V_a(t) = V_m \cdot \sin\omega t$

$V_b(t) = V_m \cdot \sin(\omega t - 120^\circ) = V_m \sin(\omega t - \frac{2}{3}\pi)$

$V_c(t) = V_m \cdot \sin(\omega t - 240^\circ)$

3. (10) A generator will be paralleled with a running AC power system. Which conditions are required for paralleling?

併網條件: ①頻率 (f(頻率), $\omega = 2\pi f$ (角速度)) 一樣.

②角度一樣

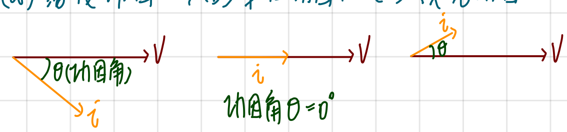
③相序一樣

④V_m(振幅)一樣.

4. (10) Plotting the generator phasor diagrams under (a) lagging power factor; (b) unity power factor; (c) leading power factor.

相量圖在同步座標.

(a)落後功因 , (b)單位功因. (c)領先功因.



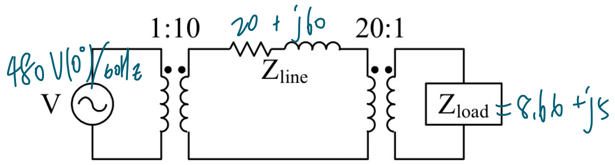
5.(20) A simple power system is shown in figure. This system contains a 480V(0^0)/60Hz generator connected to an ideal 1:10 step-up transformer, a transmission line, an ideal 20:1 step-down transformer, and a load. The impedance of the transmission line is Z_{line} =20+j60Ω, and Z_{load} =8.66+j5Ω. The base values for this system are chosen to be 480V and 10kVA at the generator.

(a) Find the base voltage, current, impedance, and apparent power at every point in the power system.

(b) Convert this system to its per-unit equivalent circuit.

(c) Find the power supplied to the load in this system.

(d) Find the power lost in the transmission line



(a) I. In the generator region:

$V_{base1} = 480\,V;\ S_{base} = 10kVA = 10000\,VA.$

$I_{base1} = \frac{S_{base}}{V_{base1}} = \frac{10000\,VA}{480\,V} = 20.83\,A.$

$Z_{base1} = \frac{V_{base1}}{I_{base1}} = \frac{480\,V}{20.83\,A} = 23.04\,\Omega.$

II. In the transmission line region:

$V_{base2} = 10 \cdot V_{base1} = 10 \times 480 = 4800\,V;\ S_{base} = 10000\,VA.$

$I_{base2} = \frac{S_{base}}{V_{base2}} = \frac{10000\,VA}{4800\,V} = 2.083\,A$

$Z_{base2} = \frac{V_{base2}}{I_{base2}} = \frac{4800\,V}{2.083\,A} = 2304\,\Omega.$

III. In the load region:

$V_{base3} = \frac{1}{20} V_{base2} = \frac{1}{20} \times 4800 = 240\,V;\ S_{base} = 10000\,VA.$

$I_{base3} = \frac{S_{base}}{V_{base3}} = \frac{10000\,VA}{240\,V} = 41.67\,A.$

$Z_{base3} = \frac{V_{base3}}{I_{base3}} = \frac{240\,V}{41.67\,A} = 5.76\,\Omega.$

(b) I. In the generator region:

$V_{G,pu} = \frac{V_G}{V_{base1}} = \frac{480 \angle 0^\circ\,V}{480\,V} = 1.0 \angle 0^\circ\,pu.$

II. In the transmission line region:

$Z_{line,pu} = \frac{Z_{line}}{Z_{base2}} = \frac{20 + j60\,\Omega}{2304\,\Omega} = 0.0087 + j0.026\,pu.$

III. In the load region:

$Z_{load,pu} = \frac{Z_{load}}{Z_{base3}} = \frac{8.66 + j5\,\Omega}{5.76\,\Omega} = 1.503 + j0.868\,pu$

按 shift + 2，选 3.

(c) $I_{pu} = \frac{V_{pu}}{Z_{tot,pu}} = \frac{1\angle 0^\circ}{0.0087 + j0.026 + 1.503 + j0.868\,pu} = 0.4901 - j0.2898\,pu = 0.569 \angle -30.6^\circ\,pu.$

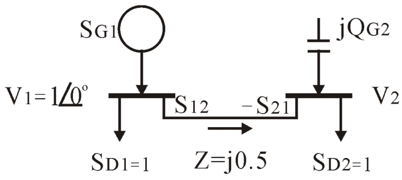
$P_{load,pu} = I_{pu}^2 \cdot R_{load,pu} = (0.569)^2 \cdot 1.503 = 0.487.$

$P_{load} = P_{load,pu} \cdot S_{base} = 0.487 \times 10000\,VA = 4870\,W.$

(d) $P_{line,pu} = I_{pu}^2 R_{line,pu} = (0.569)^2 (0.0087) = 0.00282$

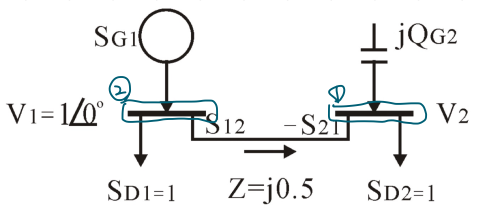
$P_{line} = P_{line,pu} S_{base} = 0.00282 \times 10000 VA = 28.2W$

6.(20) S_{G1}:$V_1=1\angle 0°$，$S_{D1}=1$，jQ_{G2} :V_2=? ，$S_{D2}=1$，Z=j0.5, (a)Find Q_{G2} for $|V_2|=1$ (b) and $\angle V_2$?(c) If $Q_{G2}=0$, could be supplied load S_{D2} ?(d) and $\angle V_2$?



$$\boxed{* \ S = P + jQ.}$$

$$\begin{cases} P_{12} = -P_{21} = \dfrac{|V_1||V_2|}{X}\sin\theta_{12} \\ Q_{12} = \dfrac{|V_1|^2}{X} - \dfrac{|V_1||V_2|}{X}\cos\theta_{12} \\ Q_{21} = \dfrac{|V_2|^2}{X} - \dfrac{|V_1||V_2|}{X}\cos\theta_{12} \end{cases}$$



① $jQ_{G2} - S_{21} = 1.$ $\Rightarrow P_{21} = -1$; $Q_{21} = Q_{G2}$.

$\Rightarrow P_{12} = 1.$

② $S_{G1} = 1 + S_{12}$

(a)(b) $|V_2| = 1$. Find Q_{G2}, $\angle V_2$

$$P_{12} = \frac{|V_1||V_2|}{X}\sin\theta_{12} = 1.$$

$$\Rightarrow \frac{1\times 1}{0.5}\sin\theta_{12} = 1$$

$$\Rightarrow \sin\theta_{12} = \frac{1}{2} \Rightarrow \theta_{12} = 30°.$$

$$\Rightarrow \theta_{12} = \theta_1 - \theta_2 = 30°$$

$$\theta_2 = \theta_1 - 30° = -30°. \ \therefore \angle V_2 = -30°. \ \#$$

$$Q_{G2} = Q_{21} = \frac{|V_2|^2}{X} - \frac{|V_1||V_2|}{X}\cos\theta_{12}$$

$$= \frac{1}{0.5} - \frac{1}{0.5}\cos 30°$$

$$= 2 - 2\cos 30° = 0.2679. \ \#$$

$\sim S_{21} = -1.$

(c)(d) $Q_{G2} = 0$, 求 S_{D2} & $\angle V_2$.

法I.

$$Q_{G2} = 0 \Rightarrow Q_{21} = \frac{|V_2|^2}{X} - \frac{|V_1||V_2|}{X}\cos\theta_{12} = 0.$$

$$\Rightarrow |V_2| = |V_1|\cos\theta_{12}$$

$$\Rightarrow |V_2| = \cos\theta_{12} \ —①$$

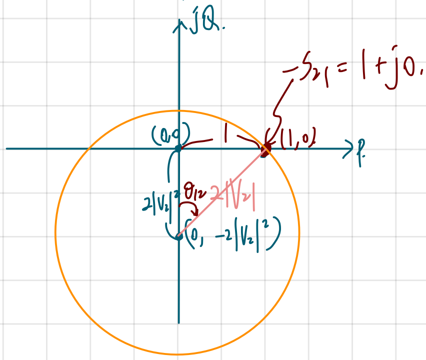
$$P_{12} = \frac{|V_1||V_2|}{X}\sin\theta_{12} = 1.$$

$$\Rightarrow |V_2|\sin\theta_{12} = \frac{1}{2} \ —②.$$

法II.

圓心: $C_2 = -\dfrac{|V_2|^2}{|Z|}e^{j\angle Z} = -2|V_2|^2 j$

半徑: $|B| = \dfrac{|V_1||V_2|}{|Z|} = 2|V_2|$



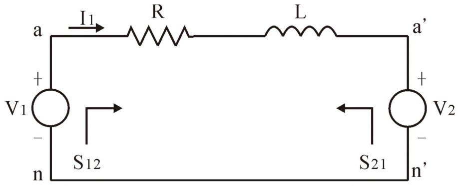
$$1^2 + (2|V_2|^2)^2 = 4|V_2|^2.$$

$$4(|V_2|^2)^2 - 4|V_2|^2 + 1 = 0$$

$$\Rightarrow |V_2|^2 = \frac{1}{2}. \ \Rightarrow |V_2| = \frac{1}{\sqrt{2}}.$$

$$\Rightarrow \theta_{12} = 45°. \ \Rightarrow \angle V_2 = -45°.$$

7. (20) Find (a) S12 and S21; (b) P12 and –P21; (c) Q12 and Q21.
($Z=R+j\omega L$, $V_1=|V_1|e^{j\theta 1}$，$V_2=|V_2|e^{j\theta 2}$，$Z=|Z|\, e^{j\angle Z}$，$\theta_{12}=\theta_1-\theta_2$)



功率圓(短程) Complex power Circle

短程輸電線，用串聯的RL電路來表示電線$Z=R+j\omega L$

(2.25)$V_1=|V_1|e^{j\theta 1}$，$V_2=|V_2|e^{j\theta 2}$，$Z=|Z|\, e^{j\angle Z}$，$\theta_{12}=\theta_1-\theta_2$

(2.26)$S_{12}=V_1I_1^*=V_1[(V_1-V_2)/Z]^*= |V_1|^2/(Z)^*-V_1V_2^*/(Z)^*$

$= |V_1|^2\, e^{j\angle Z}/|Z|-|V_1||V_2|\, e^{j\angle Z}e^{j\theta 12}/|Z|$

(2.27)$S_{21}=|V_2|^2\, e^{j\angle Z}/|Z|-|V_1||V_2|\, e^{j\angle Z}e^{-j\theta 12}/|Z|$

(2.28) $-S_{21}= -|V_2|^2\, e^{j\angle Z}/|Z| + |V_1||V_2|\, e^{j\angle Z}e^{-j\theta 12}/|Z|$

(2.29) $S_{12} = C_1 - B\, e^{j\theta 12}$, →以C為圓心，B為半徑

(2.30) $-S_{21} = C_2 + B\, e^{-j\theta 12}$,

$C_1 = |V_1|^2\, e^{j\angle Z}/|Z|$, $C_2 = -|V_2|^2\, e^{j\angle Z}/|Z|$,

$B = |V_1||V_2|\, e^{j\angle Z}/|Z|$,

Assume R=0，$Z=jX \Rightarrow \angle Z=90^\circ$ ，$e^{j\angle Z}=j$

So(2.31) $P_{12}= -P_{21}=(|V_1||V_2|/X)\sin\theta_{12}$

(2.32)$Q_{12}=|V_1|^2/X - (|V_1||V_2|/X)\cos\theta_{12}$

(2.33)$Q_{21}=|V_2|^2/X - (|V_1||V_2|/X)\cos\theta_{12}$