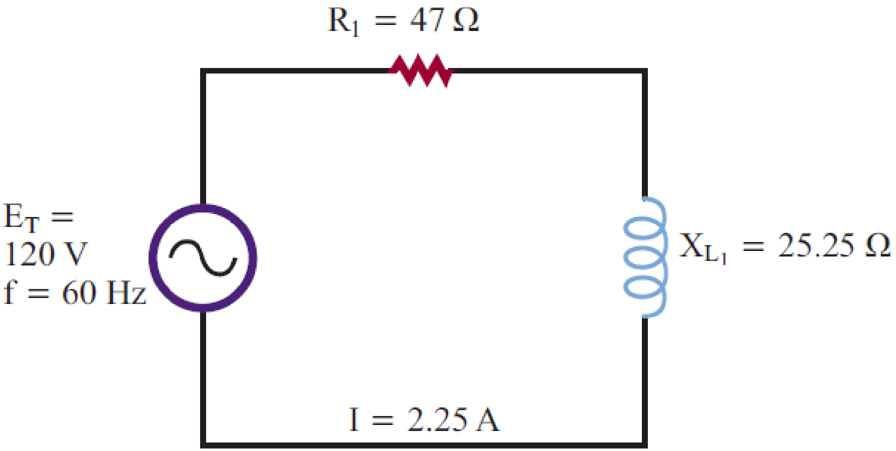
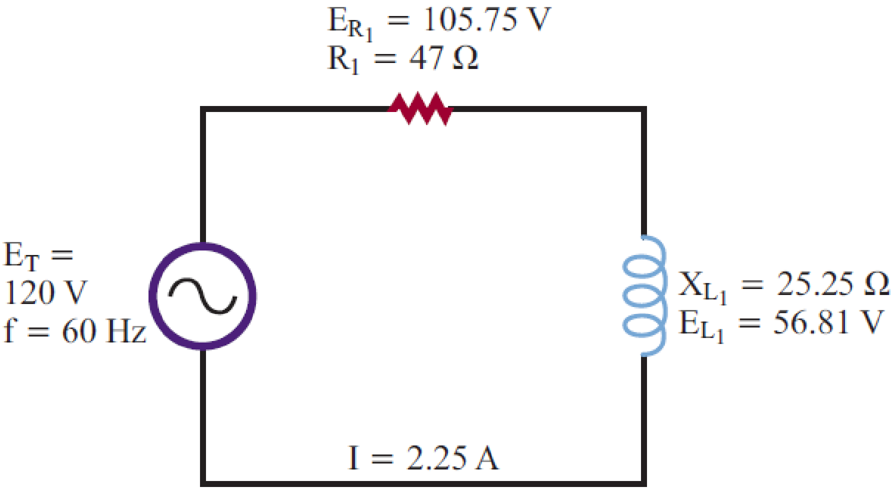
13장 리액턴스와 공진 회로

13-1 직렬 회로

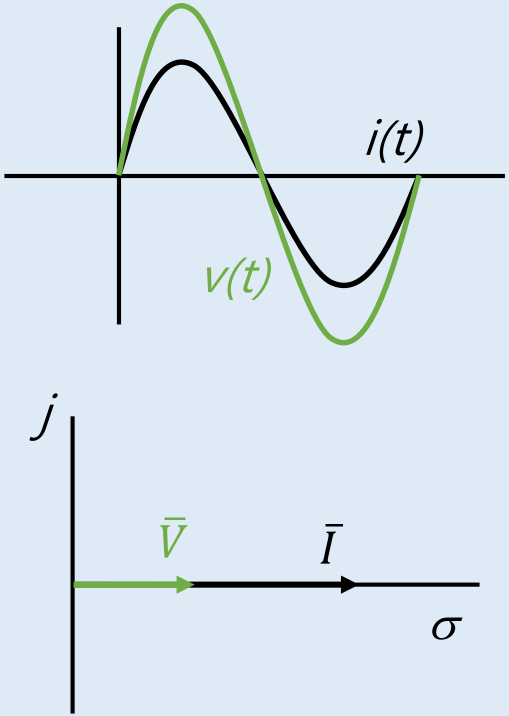




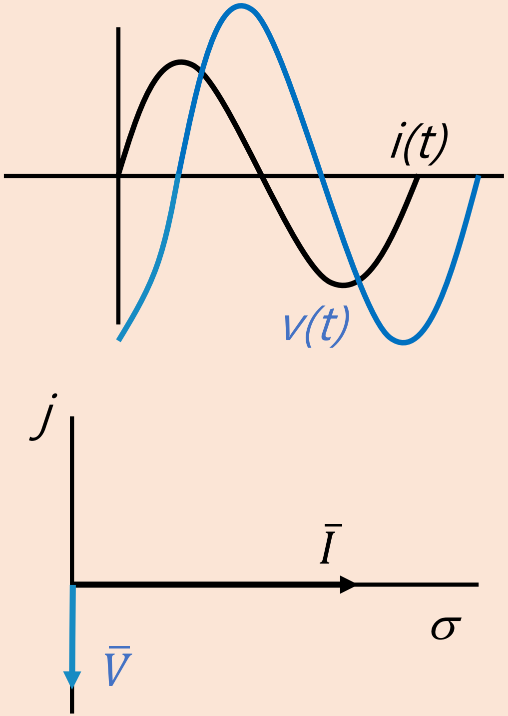
RL 회로 또는 RC 회로의 전압의 위상은 동상이 아니므로 직접 더할 수 없다. (키르히호프 법칙에 위배: $E_T \neq E_R + E_L$)

13-1 직렬 회로

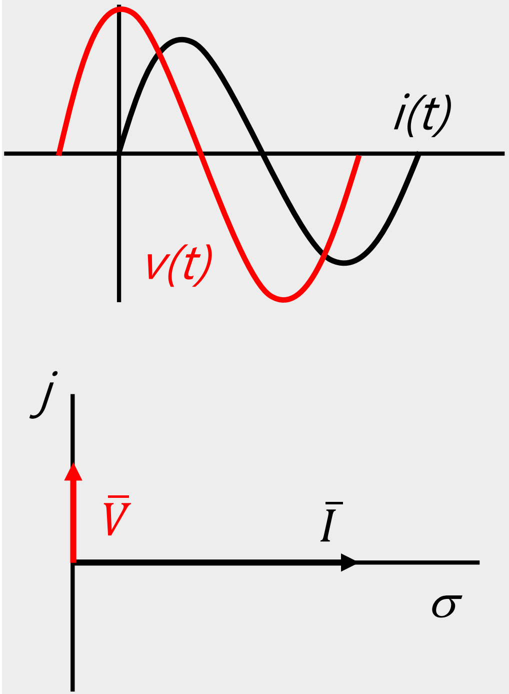
R의 회로



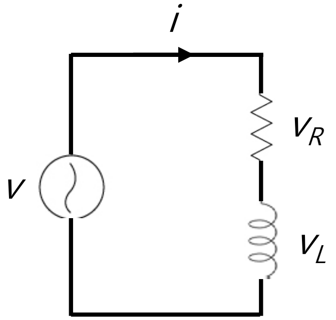
C의 회로

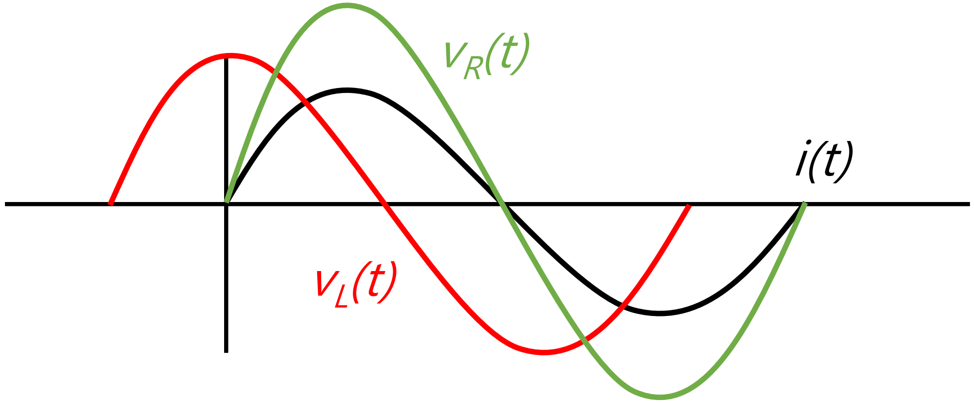


L의 회로



13-1 RL 직렬 회로





- 키르히호프의 전압법칙

$$v = v_R + v_L$$

인가전압의 합　　전압강하의 합

$$\bar{V} = \overline{V_R} + \overline{V_L}$$

$$= IR + jIX_L$$

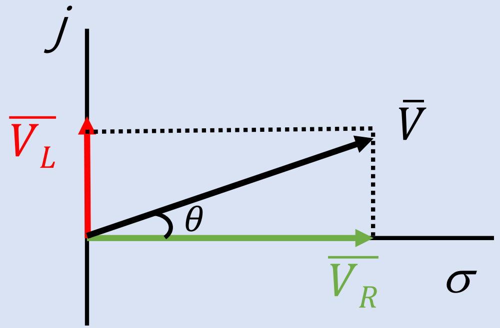
$$= \bar{I}(R + j\omega L)$$

$$\bar{Z} = R + jX_L$$

$$= R + j\omega L$$

임피던스

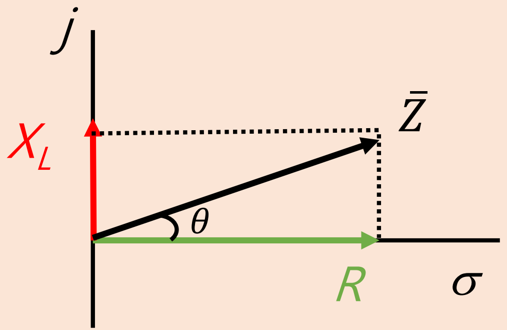
13-1 RL 직렬 회로



$$\overline{V_R} = IR \quad and \ \overline{V_L} = jIX_L$$

$$\theta = tan^{-1}\left(\frac{\overline{V_L}}{\overline{V_R}}\right) = tan^{-1}\left(\frac{\omega L}{R}\right)$$

Phase difference

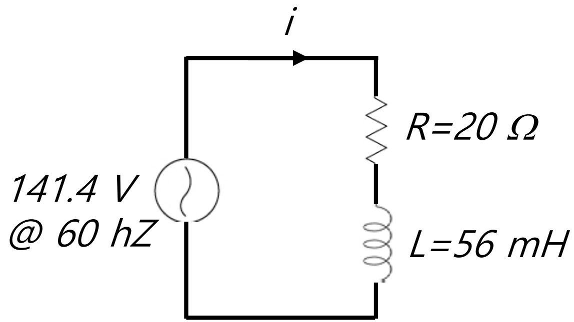


$$\bar{Z} = R + jX_L(\omega L)$$

$$\theta = tan^{-1}\left(\frac{X_L}{R}\right) = tan^{-1}\left(\frac{\omega L}{R}\right)$$

13-1 RL 직렬 회로

- Example *Find the current flow*



$$\bar{Z} = R + jX_L$$

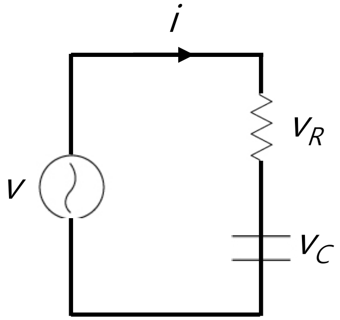
$$|Z| = \sqrt{(20)^2 + (2\pi \times 60 \times (56 \times 10^{-3}))^2} = 29\ \Omega$$

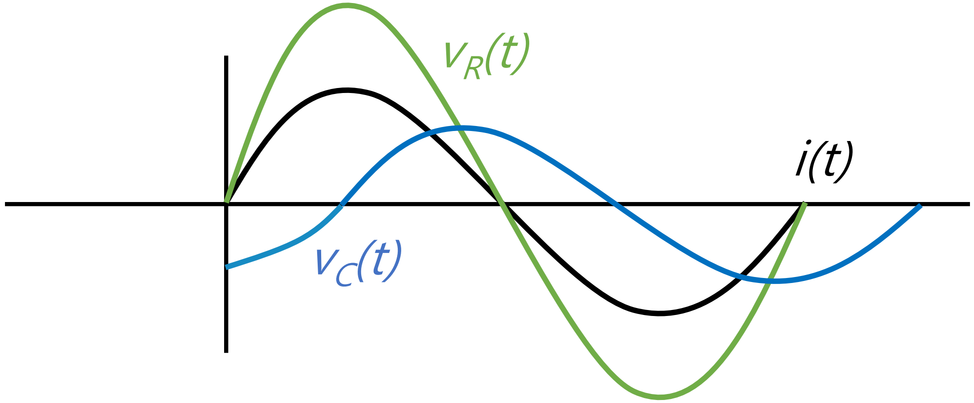
$$\therefore\ \theta = tan^{-1}\left(\frac{\omega L}{R}\right) = 46.5°$$

$$\therefore\ i(t) = \sqrt{2}\,\frac{141.4}{29}\sin(2\pi \times 60t - 46.5°)$$

$$= 6.88\sin(377t - 46.5°)$$

13-1 RC 직렬 회로





- 키르히호프의 전압법칙

$$v = v_R + v_C$$

인가전압의 합 전압강하의 합

$$\bar{V} = \overline{V_R} + \overline{V_C}$$

$$= IR\text{-}j\,IX_C$$

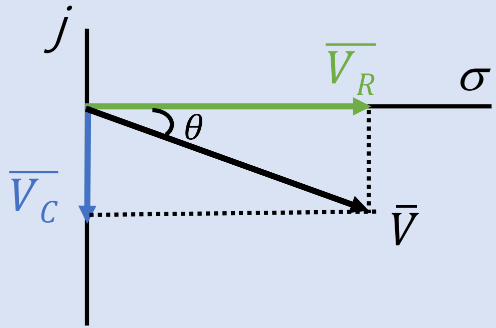
$$= I\left(R - j\frac{1}{\omega C}\right)$$

$$\bar{Z} = R - jX_C$$

$$= R - j\frac{1}{\omega C}$$

임피던스

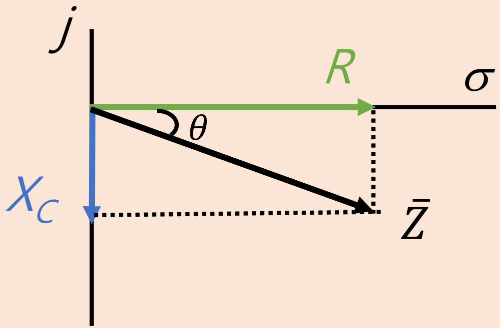
13-1 RC 직렬 회로



$$\overline{V_R} = IR \;\; and \; \overline{V_C} = -jIX_C$$

$$\theta = tan^{-1}\left(\frac{\overline{V_C}}{\overline{V_R}}\right) = tan^{-1}\left(\frac{1/\omega C}{R}\right)$$

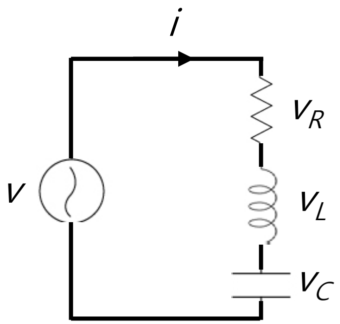
Phase difference

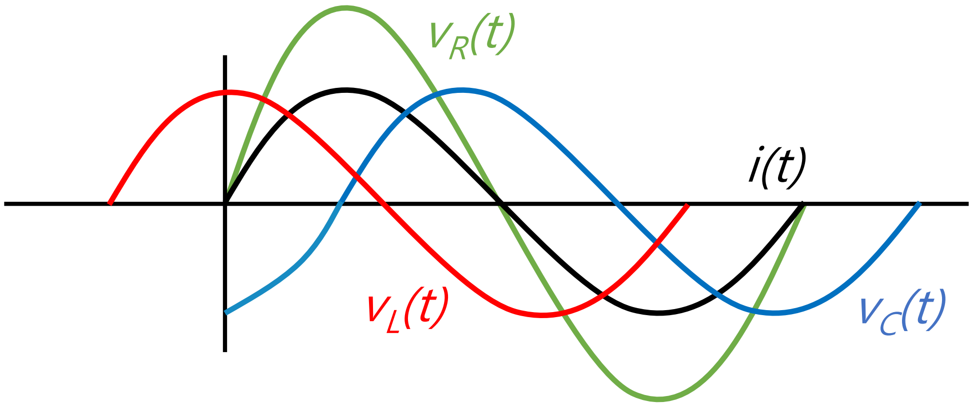


$$\bar{Z} = R\text{-}jX_C(1/\omega C)$$

$$\theta = tan^{-1}\left(\frac{X_L}{R}\right) = tan^{-1}\left(\frac{1/\omega C}{R}\right)$$

13-1 RLC 직렬 회로





- 키르히호프의 전압법칙

$$v = v_R + v_L + v_C$$

인가전압의 합   전압강하의 합

$$\bar{V} = \overline{V_R} + \overline{V_L} + \overline{V_C}$$

$$= IR + jIX_L - jIX_C$$

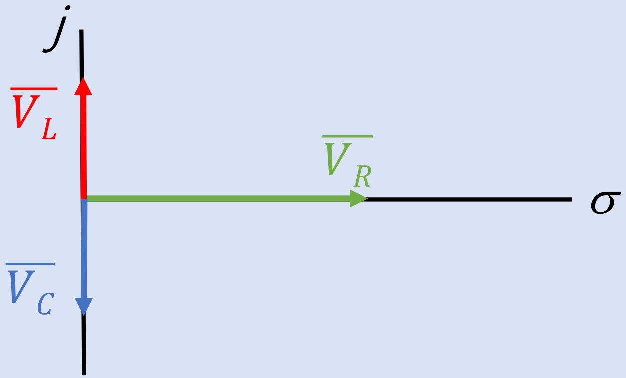
$$= \bar{I}\left(R + j\omega L - j\frac{1}{\omega C}\right)$$

$$Z = R + jX_L - jX_C$$

$$= R + j\omega L - j\frac{1}{\omega C}$$

임피던스

13-1 RLC 직렬 회로



$$\overline{V_R} = IR,\ \overline{V_L} = jIX_L,\ \overline{V_C} = -jIX_C$$

$$\theta = tan^{-1}\left(\frac{|\overline{V_L} - \overline{V_C}|}{\overline{V_R}}\right) = tan^{-1}\left(\frac{|\omega L - 1/\omega C|}{R}\right)$$

Phase difference

- For $\overline{V_L} > \overline{V_C}$

$$\bar{V} = \overline{V_R} + \overline{V_L} + \overline{V_C}$$

$$= IR + jIX_L - jIX_C$$

$$= I\left[R + j\left(\omega L - \frac{1}{\omega C}\right)\right]$$

$\bar{Z}$ (임피던스)

- For $\overline{V_L} < \overline{V_C}$

$$\bar{V} = \overline{V_R} + \overline{V_L} + \overline{V_C}$$

$$= IR + jIX_L - jIX_C$$

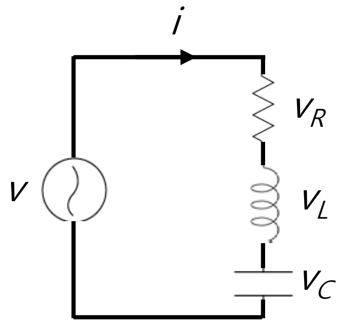
$$= I\left[R - j\left(\frac{1}{\omega C} - \omega L\right)\right]$$

$\bar{Z}$ (임피던스)

13-1 RLC 직렬 회로

- For $\overline{V_L}$ = $\overline{V_C}$ ($\because X_L = X_C$) : 직렬 공진회로
  - 임피던스 최소 ($\bar{Z} = R$)
  - 전류 최대
  - 전압과 전류 동상
  - 공진주파수$\left(f = \frac{1}{2\pi\sqrt{LC}}\ due\ to\ \omega L = \frac{1}{\omega C}\right)$
  - 전압확대비

<전압확대비>



$R = 10\ \Omega$

$X_L = 20\ \Omega$

$X_C = 20\ \Omega$

For I=V/Z=10 A

$V_R = IR = 10 \times 10 = 100\ V$

$V_L = IR = 10 \times 20 = 200\ V$

$V_C = IR = 10 \times 20 = 200\ V$

If $X_L = 200\ \Omega$ and $X_C = 20\ \Omega$

Then $V_L = V_C = 10 \times 200 = 2000\ V$

13-2 병렬 회로

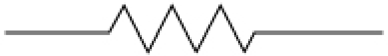
► 어드미턴스 (admittance)

- V=IR, I=GV (G=1/R, 컨덕턴스)
- V=I$\bar{Z}$, ($\bar{Z}$=R+jX)
- $\bar{Y} = \frac{1}{\bar{Z}} = \frac{1}{R+jX}$; Admninttance

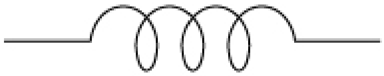
$$= \frac{1}{R+jX} \times \frac{R-jX}{R-jX}$$

$$= \frac{R}{R^2+X^2} + \frac{-jX}{R^2+X^2}$$

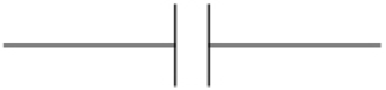
$$= G \pm jB$$



$\bar{Z} = R \;/\; \bar{Y} = \frac{1}{R}$

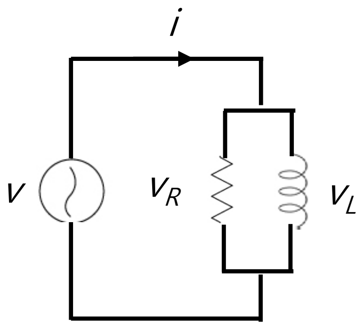


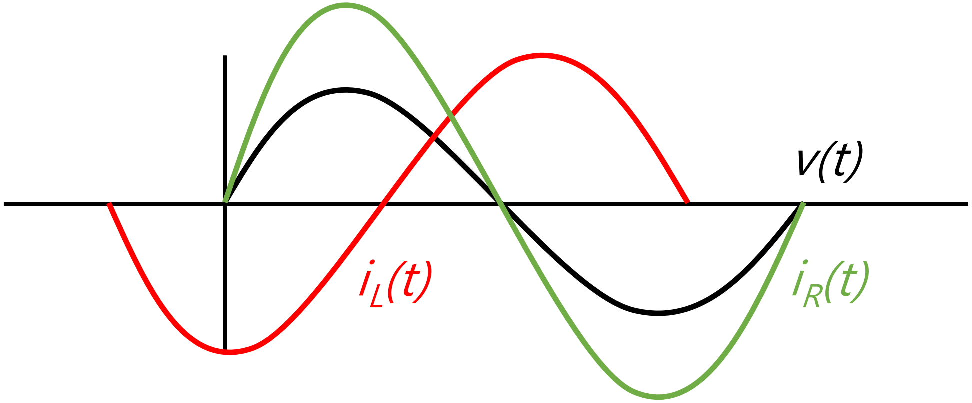
$\bar{Z} = j\omega L \;/\; \bar{Y} = -\frac{1}{\omega L}$



$\bar{Z} = \frac{1}{j\omega C} \;/\; \bar{Y} = j\omega C$

13-2 RL 병렬 회로





- 키르히호프의 전류법칙

$$i = i_R + i_L$$

$$\bar{I} = \bar{I}_R + \bar{I}_L$$

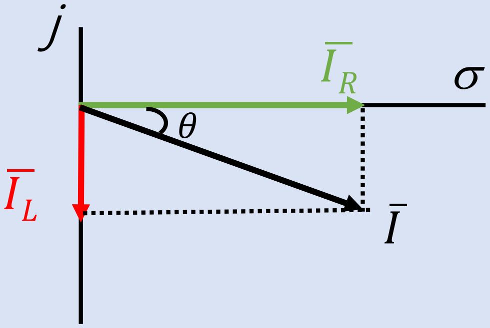
$$= \frac{V}{R} - jV/(X_L)$$

$$= V\left(\frac{1}{R} - j\frac{1}{\omega L}\right)$$

$$\bar{Y} = \frac{1}{R} - j\frac{1}{\omega L}$$

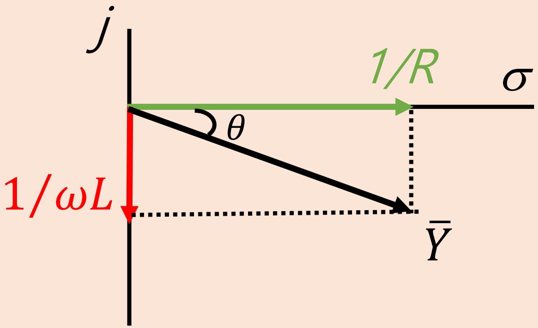
어드미턴스

13-2 RL 병렬 회로



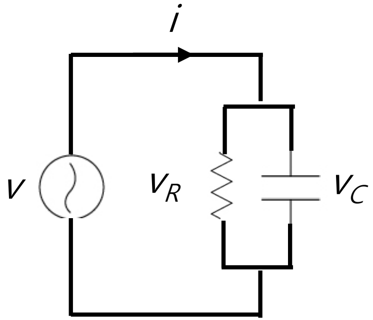
$$\theta = tan^{-1}\left(\frac{\bar{I}_L}{\bar{I}_R}\right) = tan^{-1}\left(\frac{1/\omega L}{1/R}\right)$$

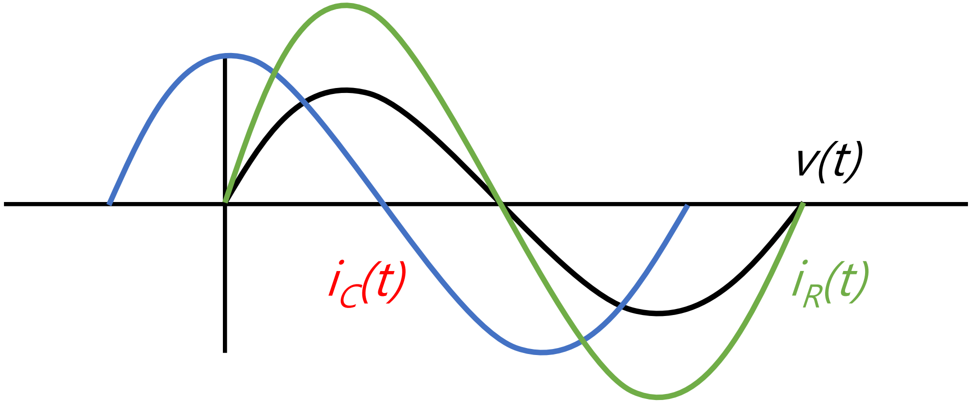
Phase difference



$$\bar{Y} = \frac{1}{R} - j\frac{1}{\omega L}$$

13-2 RC 병렬 회로





- 키르히호프의 전류법칙

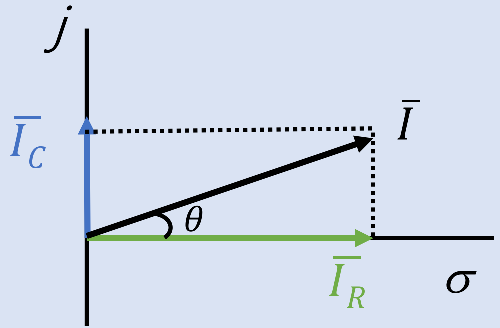
$$i = i_R + i_C$$

$$\bar{I} = \bar{I_R} + \bar{I_C}$$
$$= V/R + jV/(X_C)$$
$$= V\left(\frac{1}{R} + j\omega C\right)$$

$$\bar{Y} = \frac{1}{R} + j\omega C$$

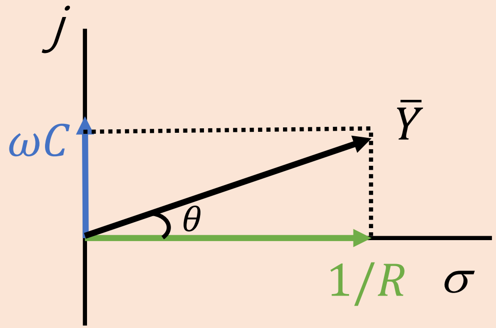
어드미턴스

13-2 RC 병렬 회로



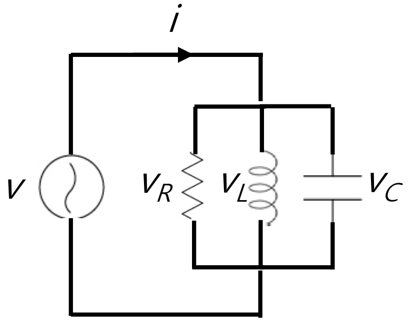
$$\theta = tan^{-1}\left(\frac{\bar{I}_C}{\bar{I}_R}\right) = tan^{-1}\left(\frac{\omega C}{1/R}\right)$$

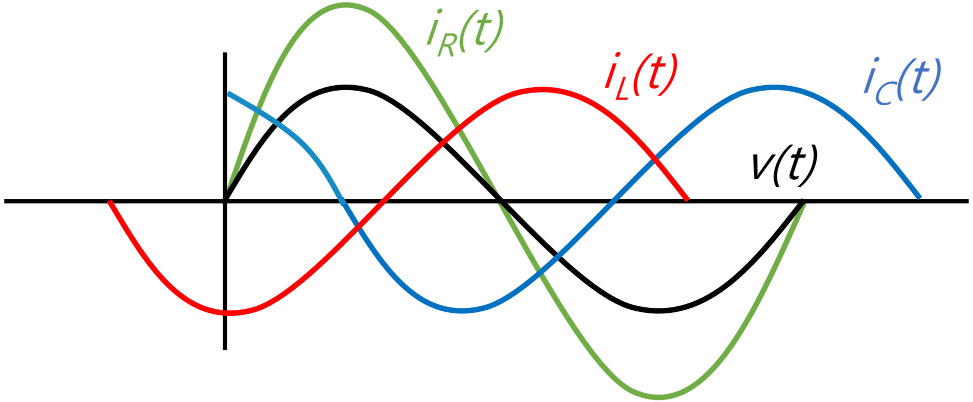
Phase difference



$$\bar{Y} = \frac{1}{R} + j\omega C$$

13-2 RLC 병렬 회로





- 키르히호프의 전류법칙

$$i = i_R + i_L + i_C$$

$$\bar{I} = \bar{I}_R + \bar{I}_L + \bar{I}_C$$

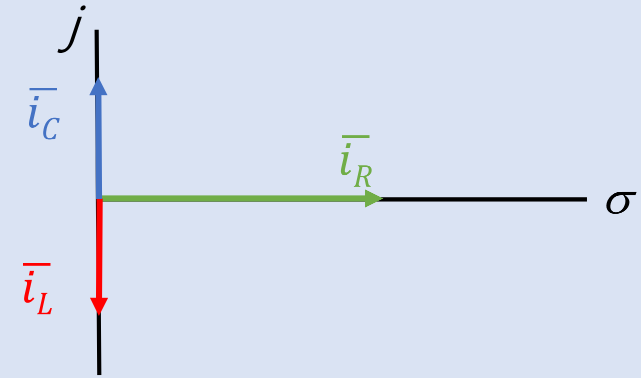
$$= V/R - jV/(X_L) + V/(jX_C)$$

$$= V\left[\frac{1}{R} - j\left(\frac{1}{\omega L} - \omega C\right)\right]$$

$$\bar{Y} = \frac{1}{R} - j\left(\frac{1}{\omega L} - \omega C\right)$$

어드미턴스

13-1 RLC 직렬 회로



$$\bar{I_R} = \frac{V}{R}, \bar{I_L} = -jV/(X_L), \bar{I_C} = jV/(X_C)$$

$$\theta = tan^{-1}\left(\frac{|\bar{I_L} - \bar{I_C}|}{\bar{I_R}}\right) = tan^{-1}\left(\frac{\left|\frac{1}{\omega L} - \omega C\right|}{R}\right)$$

Phase difference

- For $\bar{i_L} > \bar{i_C}$

$$\bar{i} = \bar{i_R} + \bar{i_L} + \bar{i_C}$$

$$= V/R - jV/(X_L) + V/(jX_C)$$

$$= V\underbrace{\left[\frac{1}{R} - j\left(\frac{1}{\omega L} - \omega C\right)\right]}_{\bar{Y}\ (\text{어드미턴스})}$$

- For $\bar{i_L} < \bar{i_C}$

$$\bar{V} = \bar{V_R} + \bar{V_L} + \bar{V_C}$$

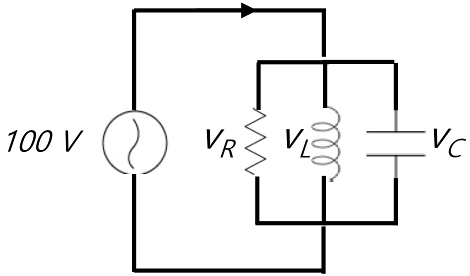
$$= V/R - jV/(X_L) + V/(jX_C)$$

$$= V\underbrace{\left[\frac{1}{R} + j\left(\omega C - \frac{1}{\omega L}\right)\right]}_{\bar{Y}\ (\text{어드미턴스})}$$

13-1 RLC 직렬 회로

- For $\overline{I_L} = \overline{I_C}$ ($\therefore X_L = X_C$) : 병렬 공진회로
  - 어드미턴스 최소 ($\bar{Y} = 1/R$)
  - 전류 최소
  - 전압과 전류 동상
  - 공진주파수$\left(f = \frac{1}{2\pi\sqrt{LC}}\ due\ to\ \omega L = \frac{1}{\omega C}\right)$
  - 전류확대비

<전류확대비>



R=10 Ω

X_L=5 Ω

X_C=5 Ω

For I=V/Z

I_R=V/R=100/10=10 V

I_L=V/R=100/5=20 V

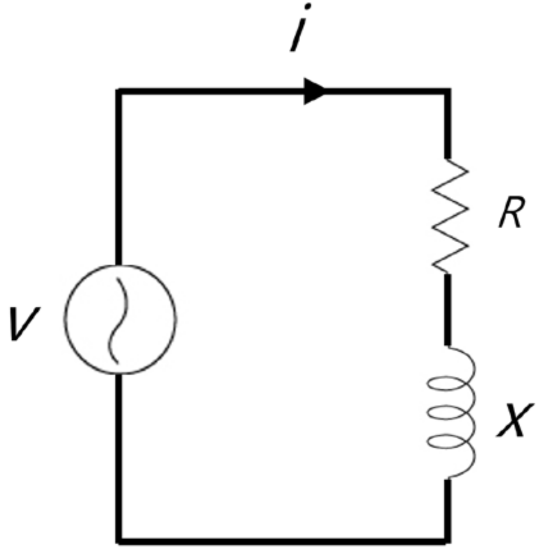
I_C=V/R=100/5=20 V

If X_L=1 Ω and X_C=1 Ω

Then I_L=I_C=100/1=100 V

13-3 교류 전력

micr systems



- 유효전력 (R만 고려)

$$P_R = I^2R$$

- 무효전력 (X만 고려)

$$P_R = I^2X$$

- 피상전력 (전체 임피던스 고려)

$$P_R = I^2Z$$