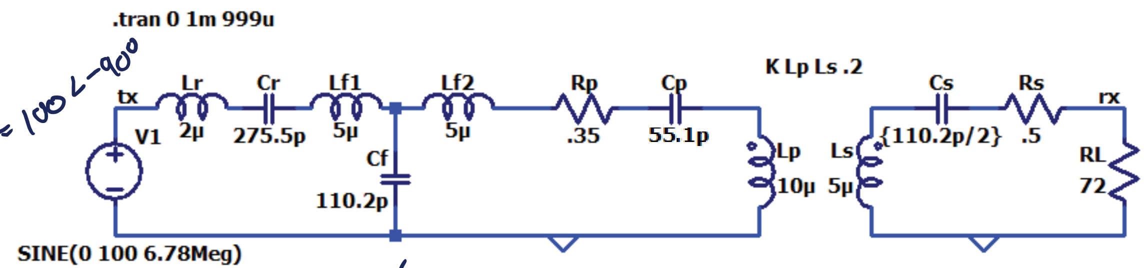
Circuit Simulation 2

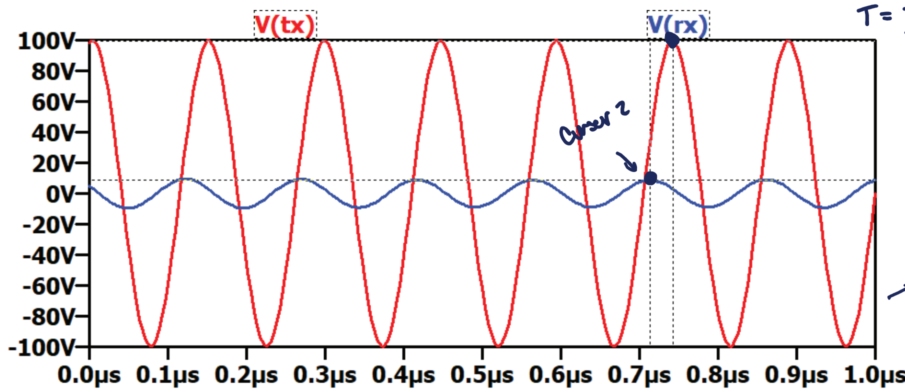
$V_{TX} = 100\angle -90^\circ$

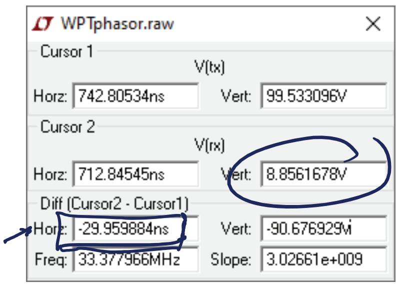


$\varphi_{rx} = -18^\circ$ ✓

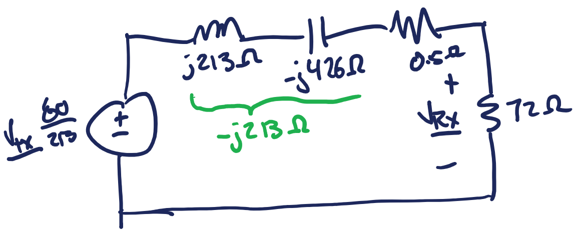
$\frac{29\,ns}{T} 2\pi = \Delta\varphi = 72^\circ$

$T = \frac{1}{f} \Rightarrow \frac{1}{6.78\,MHz}$





from last class analysis



$$V_{RX} = V_{TX} \frac{60}{213} \frac{72}{72.5 + (-j213)}$$

where $V_{TX} = 100\angle -90^\circ = 100 e^{j(-\frac{\pi}{2})} = -j100$

(1) $$V_{RX} = (-j100)\frac{60}{213}\frac{72}{72.5 - j213}\cdot\frac{(72.5 + j213)}{(72.5 + j213)} = -j\frac{6000}{213}\frac{72(72.5) + j72(213)}{72.5^2 + 213^2}$$

$$= \left(\frac{6000}{213}\frac{72(213)}{72.5^2 + 213^2}\right) - j\left(\frac{6000}{213}\frac{72(72.5)}{72.5^2 + 213^2}\right) = 8.53 - j2.905$$

$$V_{RX} = \sqrt{8.53^2 + 2.905^2}\, e^{j\tan^{-1}\left(\frac{-2.905}{8.53}\right)} = \boxed{9 \angle -18.8^\circ}$$

$V_{RX}(t) = 9\cos(\omega t - 18.8^\circ)$

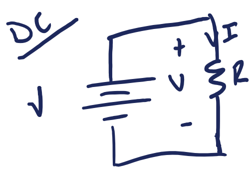
(2) $$V_{RX} = 100 e^{j(-\frac{\pi}{2})}\frac{60}{213}\cdot 72\left[\sqrt{72.5^2 + 213^2}\, e^{j\tan^{-1}\left(\frac{-213}{72.5}\right)}\right]^{-1}$$

$$V_{RX} = \left(100\,\frac{60}{213}\cdot\frac{72}{\sqrt{72.5^2 + 213^2}}\right) e^{j\left(-\frac{\pi}{2} - \tan^{-1}\left(\frac{-213}{72.5}\right)\right)} = \boxed{9 \angle -18.8^\circ}$$

Chapter 11

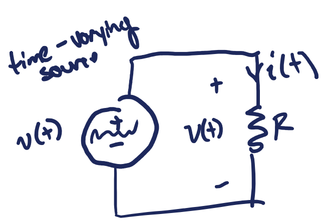
AC CIRCUIT POWER ANALYSIS

Average Power



$P = V \cdot I$, $V = IR$

for resistors $P = \frac{V^2}{R} = I^2 R$



$p(t) = v(t) \cdot i(t) \longrightarrow p(t) = i(t)^2 R = \frac{v(t)^2}{R}$

↳ instantaneous power

Average power over some time interval $[t_1, t_1 + T]$

$$P = \frac{1}{T} \int_{t_1}^{t_1+T} p(t)\, dt$$

Average power over all time

$$P = \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} p(t)\, dt$$

For any periodic signals, the average over a positive integer number of periods is the averge for all time.

Power in a Resistor

Assume time-varying bias to a resistor w/ periodic voltage/current with period T

$$P_R = \frac{1}{T}\int_0^T p(t)dt = \frac{1}{T}\int_0^T i(t)^2 R\, dt = R\frac{1}{T}\int_0^T i(t)^2 dt$$

Let's make this expression look like $P = I^2 R$

$$P_R = \left[\sqrt{\frac{1}{T}\int_0^T i(t)^2 dt}\right]^2 R$$

↳ square root of the average of $i(t)^2$

↓

root-mean-squared (rms) current

Define: $\boxed{I_{rms} = \sqrt{\frac{1}{T}\int_0^T i(t)^2 dt}}$ $\qquad \underline{P = I_{rms}^2 R}$

↳ Book calls this "effective" current I_{eff}

RMS of a sinusoid

$$i(t) = I_A\cos(\omega t + \phi_I) \qquad T = \frac{2\pi}{\omega} = \frac{1}{f}$$

Trig identity

$\cos^2\theta = \frac{1}{2}[1 + \cos 2\theta]$

$$i_{rms} = \sqrt{\frac{1}{T}\int_0^T [I_A\cos(\omega t + \phi_I)]^2 dt}$$

$$i_{rms}^2 = I_A^2\frac{1}{T}\int_0^T\left[\frac{1}{2} + \frac{1}{2}\cos(2\omega t + 2\phi_I)\right]dt$$

$$= I_A^2\frac{1}{T}\left[\frac{1}{2}t - \frac{1}{4\omega}\sin(2\omega t + 2\phi_I)\right]\Bigg|_0^{\frac{2\pi}{\omega}}$$

$$= I_A^2\frac{\cancel{\omega}}{2\cancel{\pi}}\left[\frac{\cancel{\pi}}{\cancel{\omega}} - \emptyset\right]$$

$$i_{rms}^2 = \frac{I_A^2}{2} \longrightarrow \boxed{i_{rms} = \frac{I_A}{\sqrt{2}}}$$