

Assignment 1 - AC power

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Question 1

$$pf = 0.75, f = 50\text{Hz}, V_{rms} = 230\text{V}$$

$$S = \frac{511448}{100} = 5114.48\text{VA}$$

Calculate I_{rms}

$$I_{rms} = \frac{S}{V_{rms}} = \frac{5114.48}{230} \approx 22.2\text{A}$$

Calculate P and Q of the load

$$P = V_{rms} \times I_{rms} \times \cos(\varphi)$$

$$= 230 \times 22.2 \times 0.75$$

$$\approx 3829.5\text{W}$$

$$S^2 = P^2 + Q^2$$

$$\Rightarrow Q = \sqrt{S^2 - P^2}$$

$$= \sqrt{5114.48^2 - 3829.5^2}$$

$$\approx 3390.1\text{var}$$

Calculate R and L value of the load

$$R = \frac{V_{rms}}{I_{rms}} = \frac{230}{22.2} \approx 10.36\Omega$$

$$pf = \frac{R}{|Z|}$$

$$\Rightarrow |Z| = \frac{R}{pf}$$

$$= \frac{10.36}{0.75} \approx 13.81\Omega$$

$$X_L = \sqrt{|Z|^2 - R^2}$$

$$= \sqrt{13.81^2 - 10.36^2}$$

$$\approx 9.13\Omega$$

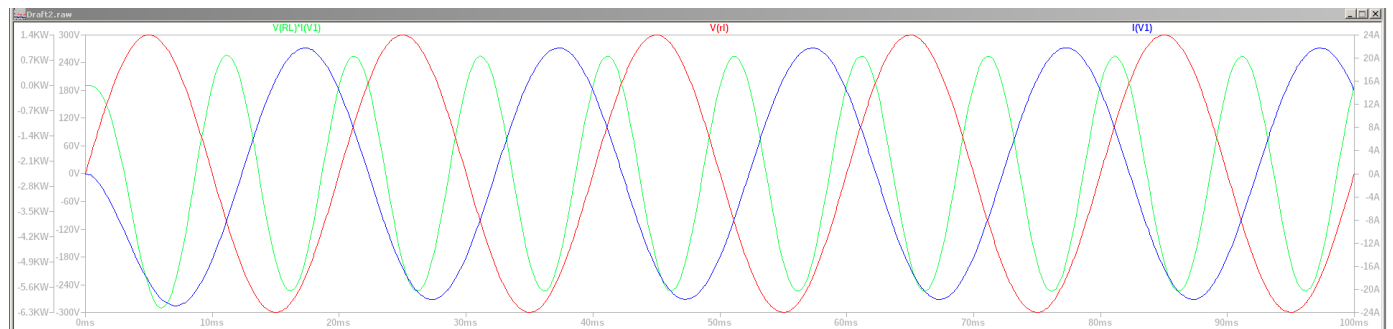
$$L = \frac{X_L}{2\pi \times f}$$

$$= \frac{9.13}{2\pi \times 50}$$

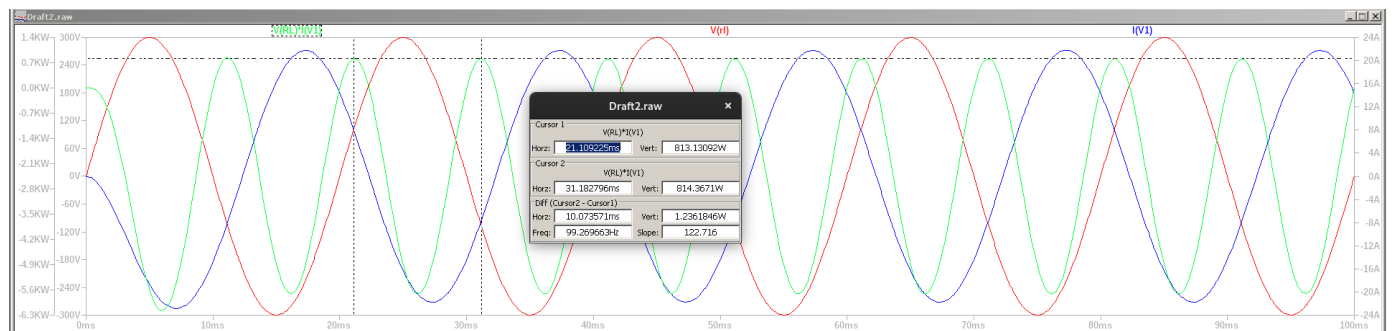
$$\approx 29.06\text{mH}$$

Question 2

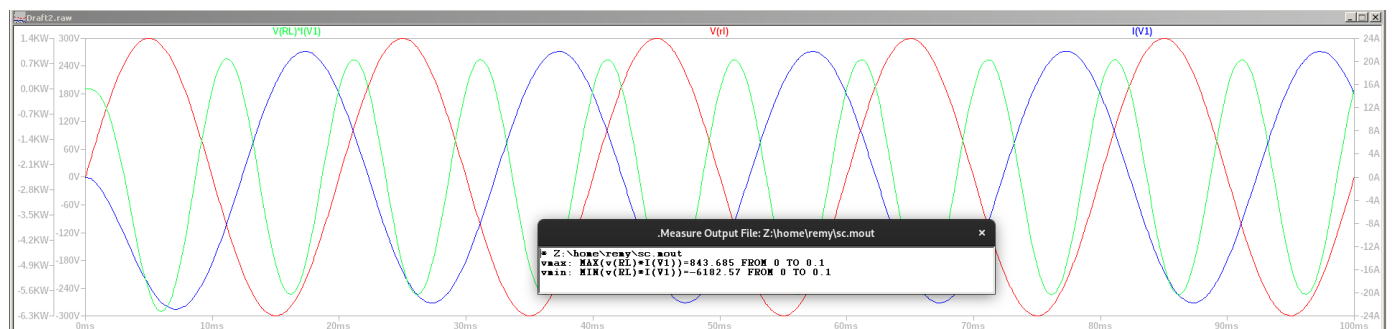
plot the voltage across RL , the source current and its instantaneous power



What is the frequency of the instantaneous power?

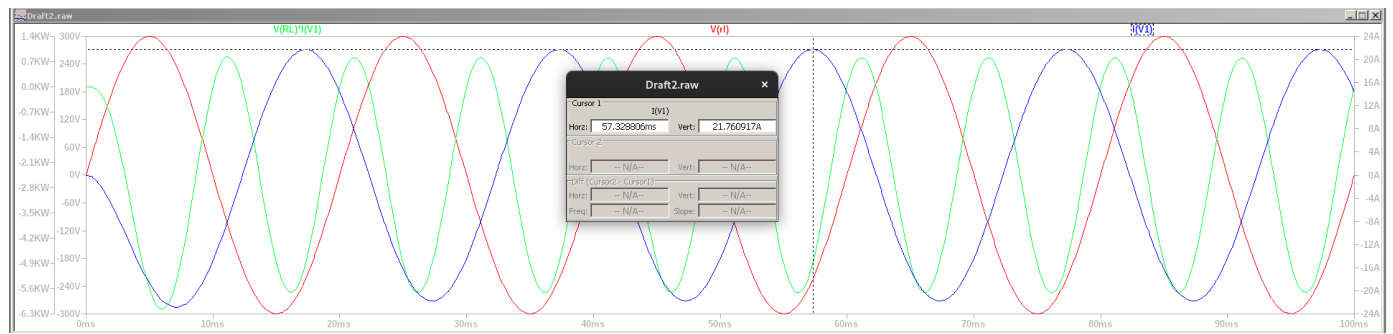


What is the minimum and maximum instantaneous power?



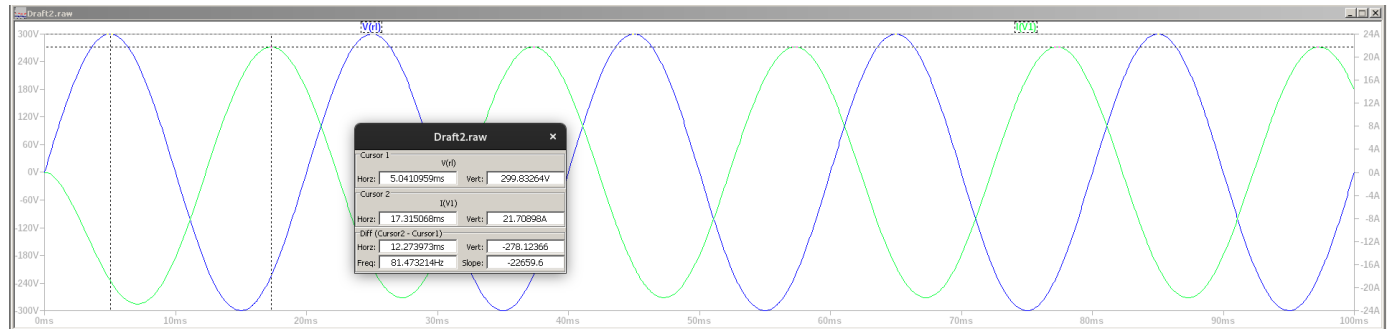
$f \approx 100\text{Hz}$

Also determine I_{rms} using the simulation plots



$$I_{rms} = \frac{I_{peak}}{\sqrt{2}} = \frac{21.76}{\sqrt{2}} \approx 15.38\text{A}$$

Verify by using the simulation plots, the power factor



$$\Delta t = 12.27\text{ms}$$

$$\varphi = 2\pi \times f \times \Delta t = 2\pi \times 50 \times 12.27 \times 10^{-3} \approx 3.85\text{rad}$$

$$pf = \cos(\varphi) = \cos(3.85) \approx 0.76$$

Question 3

Calculate C when $pf = 0.9$ lagging

$$pf = 0.9$$

$$\varphi = \cos^{-1}(0.9) = 0.451\text{rad}$$

$$Q = U_{rms} \cdot I_{rms} \cdot \sin(\varphi) = 2225$$

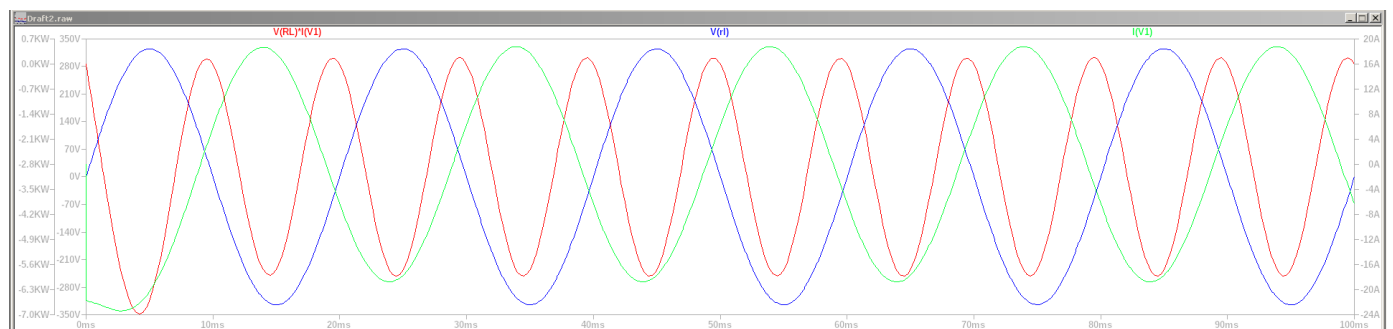
$$Q_L = \frac{U_L^2}{X_L} = 5794\text{var}$$

$$Q_C = Q - Q_L = 2225 - 5794 = -3569\text{var}$$

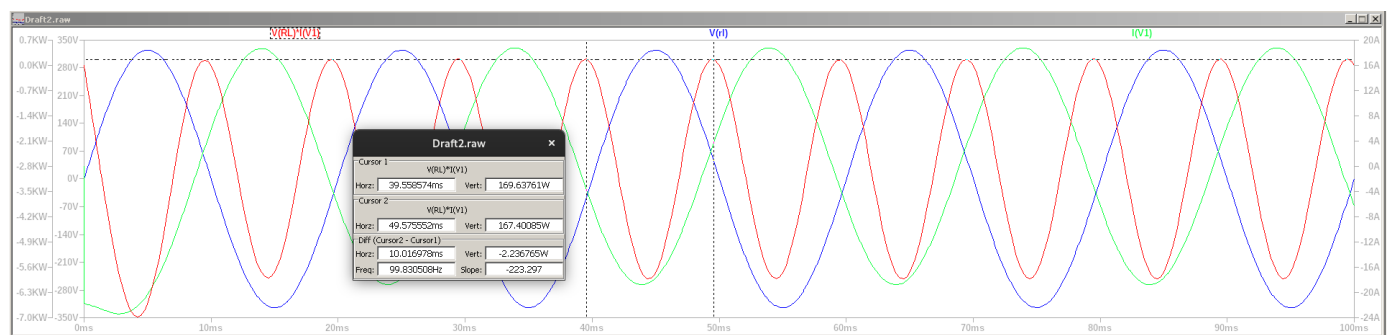
$$X_C = \frac{U_C^2}{Q_C} = 14.86\Omega$$

$$C = \frac{1}{X_C \cdot 100\pi} = \frac{1}{14.86 \cdot 100\pi} = 214.2\mu\text{F}$$

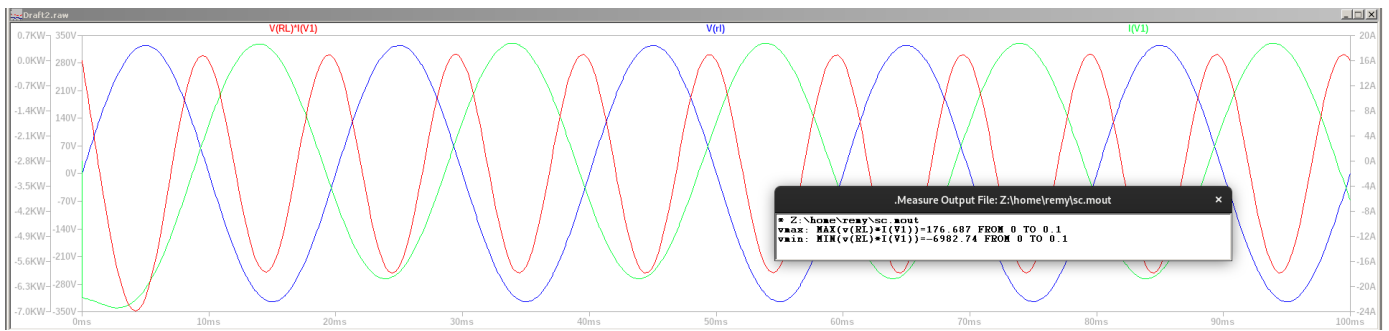
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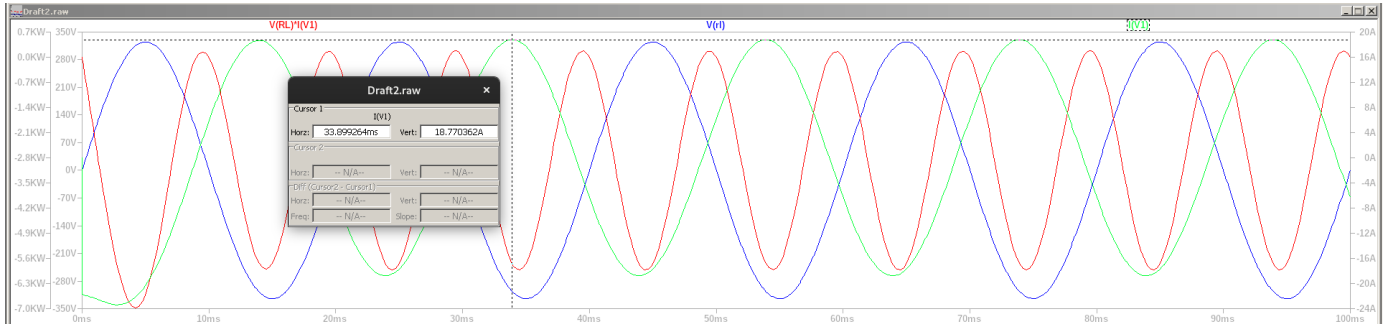


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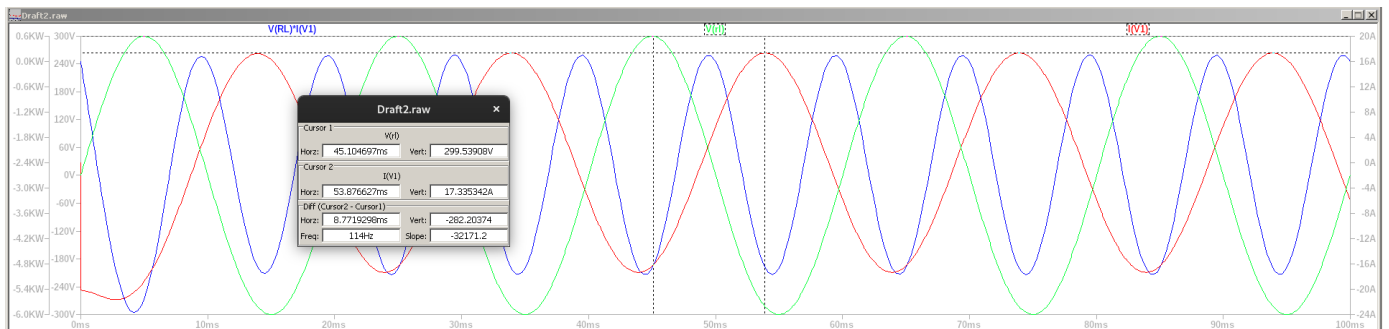
$f \approx 100\text{Hz}$

Also determine I_{rms} using the simulation plots



$$I_{rms} = \frac{I_{max}}{\sqrt{2}} = \frac{18.77}{\sqrt{2}} \approx 13.27\text{A}$$

Verify by using the simulation plots, the power factor



$$\Delta t = 8.77\text{ms}$$

$$\varphi = 2\pi \times f \times \Delta t = 2\pi \times 50 \times 8.77 \times 10^{-3} \approx 2.77\text{rad}$$

$$pf = \cos(\varphi) = \cos(2.77) \approx 0.93$$

Question 4

Calculate C when $pf = 0.9$ leading

$$\varphi = -\cos^{-1}(0.9) = -0.451$$

$$Q = U_{rms} * I_{rms} * \sin(\varphi) = -2225\text{var}$$

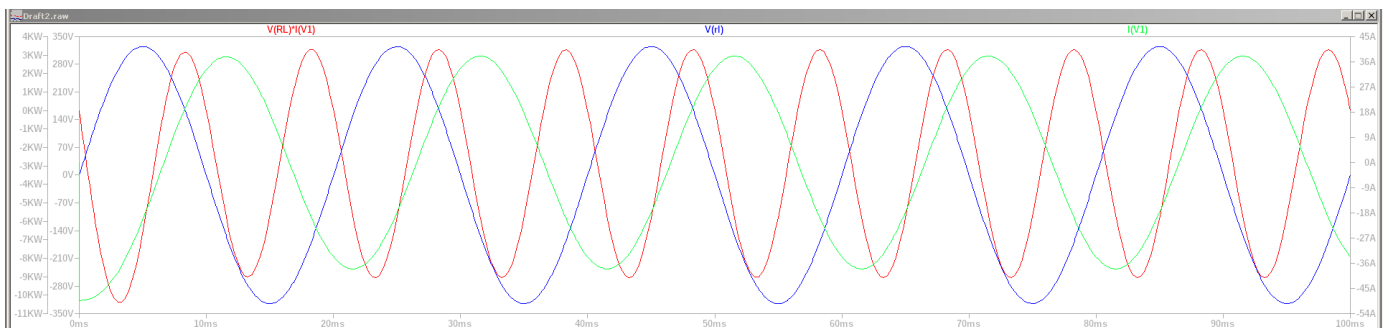
$$Q_L = \frac{U_{rms}^2}{X_L} = 5794\text{var}$$

$$Q_C = Q - Q_L = 2225 - 5794 = -3569\text{var}$$

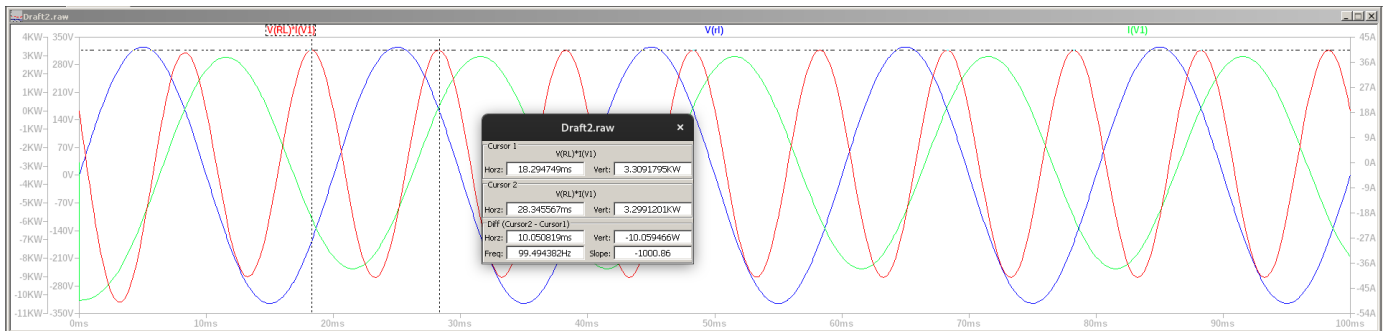
$$X_C = -\frac{U_{rms}^2}{Q_C} = 6.60\Omega$$

$$C = \frac{1}{X_C * 100\pi} = 482.5\mu\text{F}$$

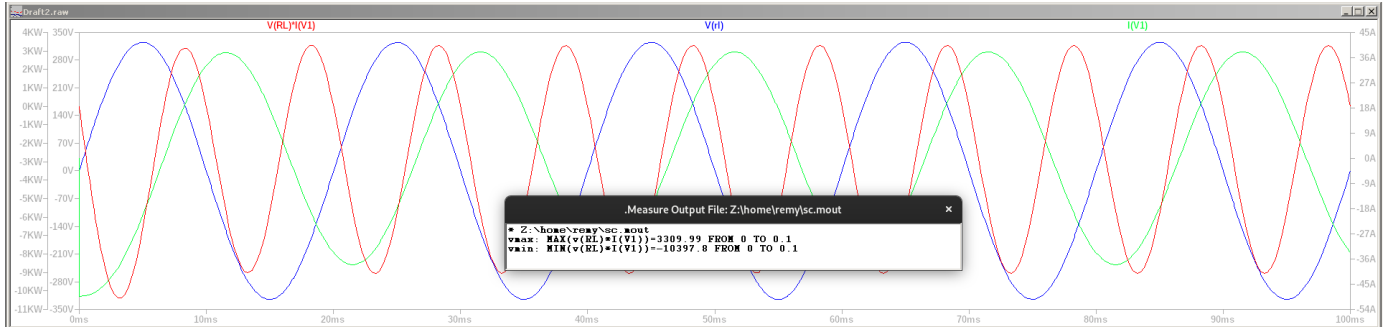
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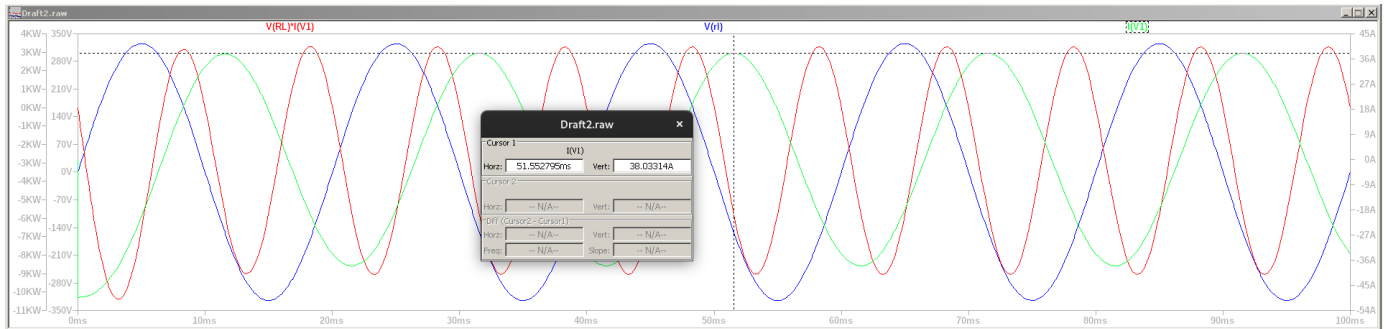


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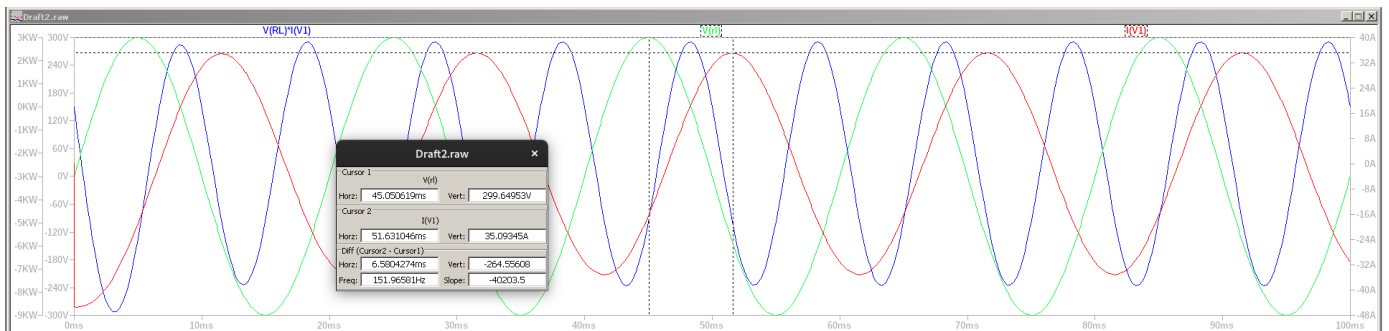
$f \approx 100\text{Hz}$

Also determine I_{rms} using the simulation plots



$$I_{rms} = \frac{I_{peak}}{\sqrt{2}} = \frac{38.03}{\sqrt{2}} \approx 26.89\text{A}$$

Verify by using the simulation plots, the power factor



$\Delta t = 6.58\text{ms}$

$$\varphi = 2\pi \times f \times \Delta t = 2\pi \times 50 \times 6.58 \times 10^{-3} \approx 2.07\text{rad}$$

$$pf = \cos(\varphi) = \cos(2.07) \approx 0.48$$