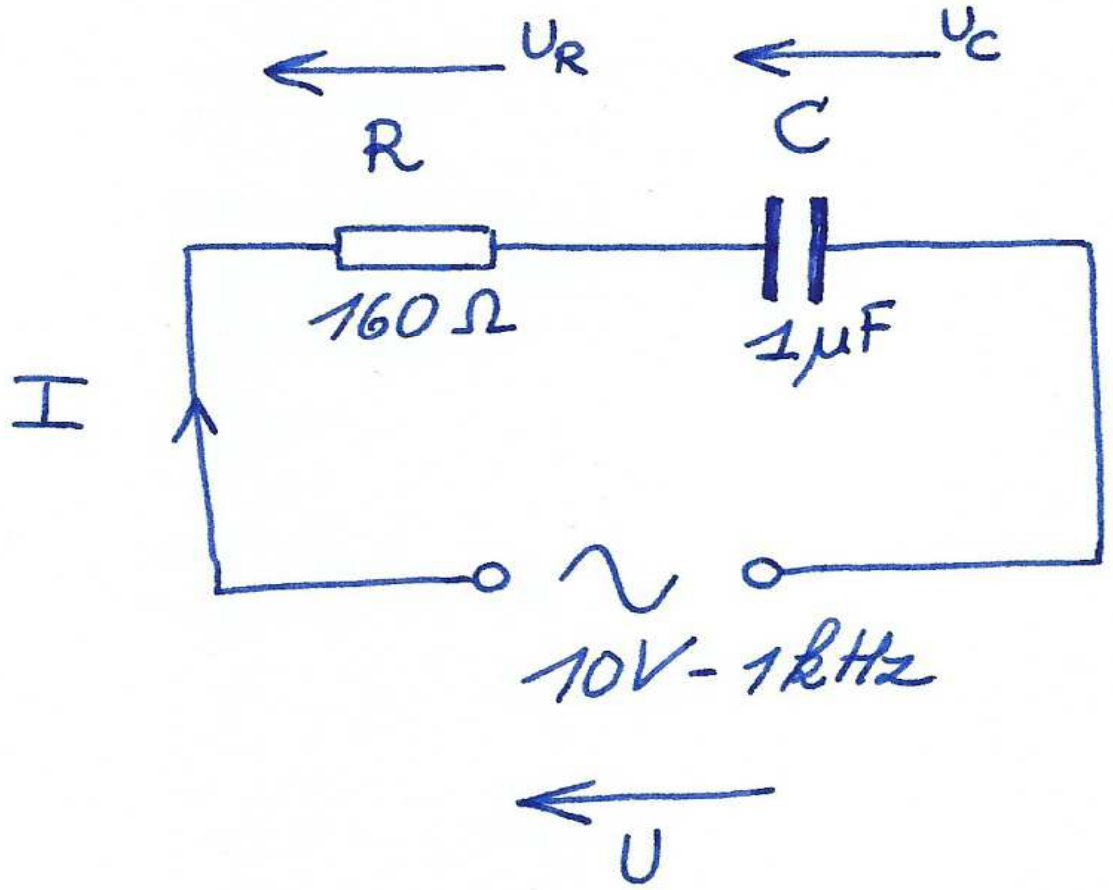


Elektriciteit tutorial

Seriekring R + C
Complexe uitwerking

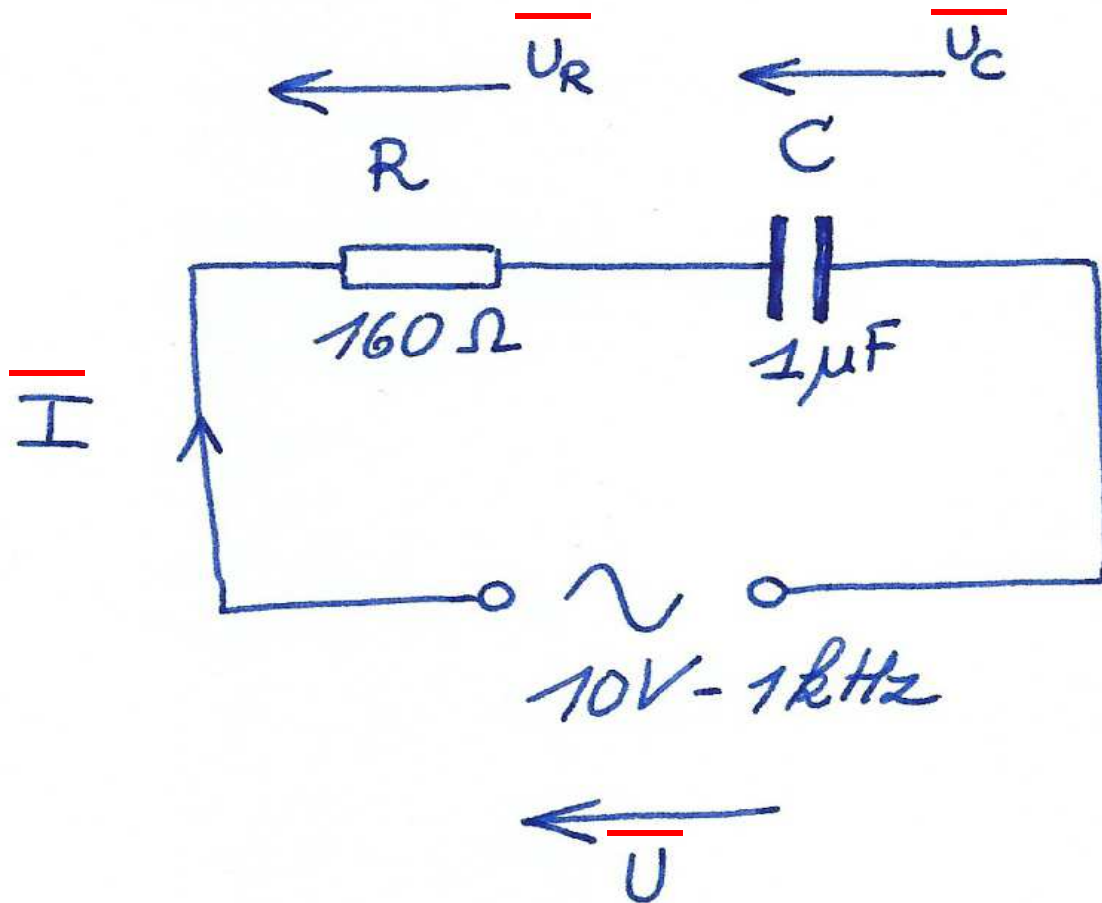
W. Van Wichelen

R + C seriekring



(amplitudes)

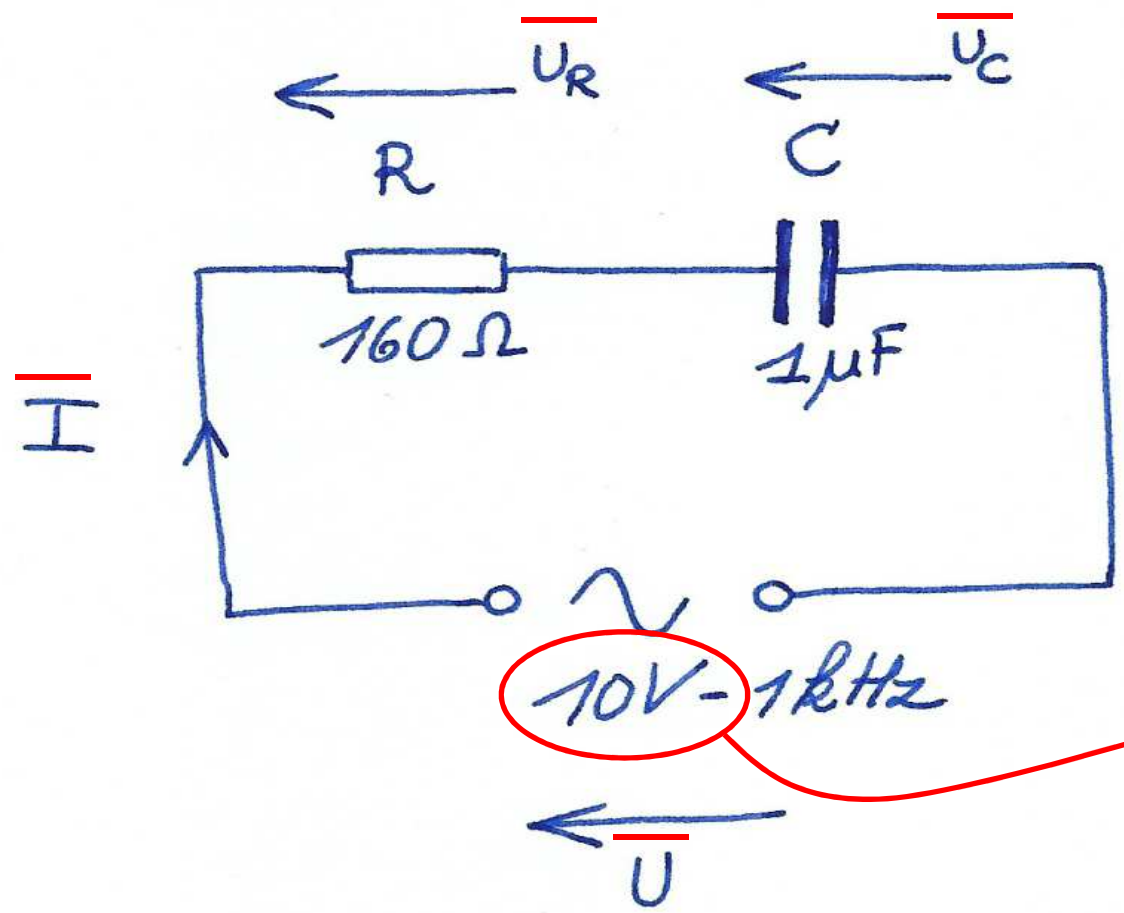
R + C seriekring



(amplitudes)

Complexe
uitwerking

R + C seriebinding



(amplitudes)

10V-1kHz → 10 volt piek

Impedantie

1. $\bar{Z} = \bar{R} + \bar{X}_C$

Zuiver **ohmse** component

Zuiver **reactieve** component

The diagram shows the equation $\bar{Z} = \bar{R} + \bar{X}_C$ where \bar{R} and \bar{X}_C are circled in red. Red arrows point from these circles to the text 'Zuiver ohmse component' and 'Zuiver reactieve component' respectively.

Impedantie

$$\begin{aligned} 1. \quad \bar{Z} &= \bar{R} + \bar{X}_C \\ &= 160 + \frac{1}{j\omega C} \end{aligned}$$

Impedantie

$$\begin{aligned} 1. \quad \bar{Z} &= \bar{R} + \bar{X}_C \\ &= 160 + \frac{1}{j\omega C} \cdot j \end{aligned}$$

Impedantie

$$1. \quad \bar{Z} = \bar{R} + \bar{X}_C$$

$$= 160 + \frac{1}{\cancel{j} \omega C \cdot j}$$

$$= 160 - \frac{1}{\omega C} j$$

$$j * j = -1$$

Impedantie

$$\begin{aligned} 1. \quad \bar{Z} &= \bar{R} + \bar{X}_C \\ &= 160 + \frac{1}{\cancel{j} \omega C \cdot j} \\ &= 160 - \frac{1}{\omega C} j \\ &= 160 - \frac{1}{2\pi \cdot 1 \cdot 10^3 \cdot 1 \cdot 10^{-6}} j \end{aligned}$$

\swarrow
1kHz \swarrow
1μF

Impedantie

$$1. \quad \bar{Z} = \bar{R} + \bar{X}_C$$

$$= 160 + \frac{1}{\cancel{j} \omega C \cdot j}$$

$$= 160 - \frac{1}{\omega C} j$$

$$= 160 - \frac{1}{2\pi \cdot 1 \cdot 10^3 \cdot 1 \cdot 10^{-6}} j$$

$$= 160 - 159,15 j$$

$$= (160 - 159,15 j) \Omega$$

Eenheid impedantie: 'ohm'

Stroom

$$2. \quad \bar{I} = \frac{\bar{U}}{\bar{Z}} = \frac{10}{160 - 159,15j}$$

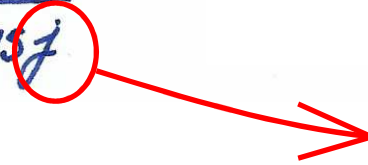
Stroom

$$2. \quad \bar{I} = \frac{\bar{U}}{\bar{Z}} = \frac{10}{160 - 159,15j}$$

Complexe schrijfwijze
voor de impedantie

Stroom

$$2. \quad \bar{I} = \frac{\bar{U}}{\bar{Z}} = \frac{10}{160 - 159,15j}$$



“Ik haat *j* in de noemer”

Stroom

$$2. \quad \bar{I} = \frac{\bar{U}}{\bar{Z}} = \frac{10}{160 - 159,15j}$$

Teller & noemer vermenigvuldigen met
complex toegevoegde

Stroom

$$2. \quad \bar{I} = \frac{\bar{U}}{\bar{Z}} = \frac{10}{160 - 159,15j}$$

$$[(a + bj)(a - bj) = a^2 + b^2]$$

Imaginaireel deel verdwijnt uit noemer
en noemer wordt zuiver reëel

Stroom

$$2. \quad \bar{I} = \frac{\bar{U}}{\bar{Z}} = \frac{10}{160 - 159,15j}$$

$$= \frac{10 (160 + 159,15j)}{160^2 + 159,15^2}$$

$$\left[(a + bj)(a - bj) = a^2 + b^2 \right]$$

Stroom

$$2. \quad \bar{I} = \frac{\bar{U}}{\bar{Z}} = \frac{10}{160 - 159,15j}$$

$$= \frac{10 (160 + 159,15j)}{160^2 + 159,15^2}$$

$$\left[(a + bj)(a - bj) = a^2 + b^2 \right]$$

Haakjes uitwerken

Stroom

$$2. \quad \bar{I} = \frac{\bar{U}}{\bar{Z}} = \frac{10}{160 - 159,15j}$$

$$\left[(a + bj)(a - bj) = a^2 + b^2 \right]$$

$$= \frac{10 (160 + 159,15j)}{160^2 + 159,15^2}$$

$$= \frac{1600 + 1591,5j}{50,93 \cdot 10^3}$$

Stroom

$$2. \quad \bar{I} = \frac{\bar{U}}{\bar{Z}} = \frac{10}{160 - 159,15j} \quad \left[(a + bj)(a - bj) = a^2 + b^2 \right]$$

$$= \frac{10 (160 + 159,15j)}{160^2 + 159,15^2}$$

$$= \frac{1600 + 1591,5j}{50,93 \cdot 10^3}$$

factor 10^3 buiten haken
brengen

Stroom

$$2. \quad \bar{I} = \frac{\bar{U}}{\bar{Z}} = \frac{10}{160 - 159,15j}$$

$$\left[(a + bj)(a - bj) = a^2 + b^2 \right]$$

$$= \frac{10 (160 + 159,15j)}{160^2 + 159,15^2}$$

$$= \frac{1600 + 1591,5j}{50,93 \cdot 10^3}$$

$$= \frac{10^3 (1,6 + 1,5915j)}{50,93 \cdot 10^3}$$

Stroom

$$2. \quad \bar{I} = \frac{\bar{U}}{\bar{Z}} = \frac{10}{160 - 159,15j} \quad \left[(a + bj)(a - bj) = a^2 + b^2 \right]$$

$$= \frac{10 (160 + 159,15j)}{160^2 + 159,15^2}$$

$$= \frac{1600 + 1591,5j}{50,93 \cdot 10^3}$$

$$= \frac{10^3 (1,6 + 1,5915j)}{50,93 \cdot 10^3}$$

$$= \frac{\cancel{10^3} (1,6 + 1,5915j)}{50,93 \cdot \cancel{10^3}}$$

teller & noemer
delen door factor 10^3

Stroom

$$= \frac{10^3 (1,6 + 1,5915j)}{50,93 \cdot 10^3}$$

$$= \frac{\cancel{10^3} (1,6 + 1,5915j)}{50,93 \cdot \cancel{10^3}}$$

$$= 31,41 \cdot 10^{-3} + 31,25 \cdot 10^{-3} j$$

Stroom

$$= \frac{10^3 (1,6 + 1,5915j)}{50,93 \cdot 10^3}$$

$$= \frac{\cancel{10^3} (1,6 + 1,5915j)}{50,93 \cdot \cancel{10^3}}$$

$$= 31,41 \cdot 10^{-3} + 31,25 \cdot 10^{-3}j$$

factor buiten haken brengen

Stroom

$$= \frac{10^3 (1,6 + 1,5915j)}{50,93 \cdot 10^3}$$

$$= \frac{\cancel{10^3} (1,6 + 1,5915j)}{50,93 \cdot \cancel{10^3}}$$

$$= 31,41 \cdot 10^{-3} + 31,25 \cdot 10^{-3} j$$

$$= (31,41 + 31,25j) \cdot 10^{-3} \text{ A}$$

eenheid stroom:
ampère

factor 'milli'

Stroom

$$= \frac{10^3 (1,6 + 1,5915j)}{50,93 \cdot 10^3}$$

$$= \frac{\cancel{10^3} (1,6 + 1,5915j)}{50,93 \cdot \cancel{10^3}}$$

$$= 31,41 \cdot 10^{-3} + 31,25 \cdot 10^{-3} j$$

$$= (31,41 + 31,25j) \cdot 10^{-3} \text{ A}$$

$$= (31,41 + 31,25j) \text{ mA}$$

complexe schrijfwijze
voor de stroom

Grootte stroom

$$\bar{I} = (31,41 + 31,25j) \text{ mA}$$

$$3. \quad |\bar{I}| = \sqrt{\text{Re}^2 + \text{Im}^2}$$

Grootte stroom

$$\bar{I} = (31,41 + 31,25j) \text{ mA}$$

$$\begin{aligned} 3. \quad |\bar{I}| &= \sqrt{\text{Re}^2 + \text{Im}^2} \\ &= \sqrt{31,41^2 + 31,25^2} \end{aligned}$$

Grootte stroom

$$\bar{I} = (31,41 + 31,25j) \text{ mA}$$

$$3. \quad |\bar{I}| = \sqrt{\text{Re}^2 + \text{Im}^2}$$

$$= \sqrt{31,41^2 + 31,25^2}$$

$$= \boxed{44,3 \text{ mA}}$$

ampèremeter duidt
deze waarde aan

Fasehoek

$$\bar{I} = (31,41 + 31,25j) \text{ mA}$$

$$4. \quad \varphi = \arctan\left(\frac{I_m}{R_c}\right)$$

Fasehoek

$$\bar{I} = (31,41 + 31,25j) \text{ mA}$$

$$4. \quad \varphi = \arctan\left(\frac{I_m}{I_r}\right)$$
$$= \arctan\left(\frac{31,25}{31,41}\right)$$

Let op!
rekenmachine in **graden**

Fasehoek

$$\bar{I} = (31,41 + 31,25j) \text{ mA}$$

$$4. \quad \varphi = \text{Bgtg} \left(\frac{I_m}{R_c} \right)$$

$$= \text{Bgtg} \left(\frac{31,25}{31,41} \right)$$

$$= +44,85^\circ \approx \boxed{+45^\circ}$$

[stroom ijlt 45° voor φ]
de bronspanning

Deelspanning U_R

$$\bar{I} = (31,41 + 31,25j) \text{ mA}$$

$$5. \quad \bar{U}_R = \bar{I} \cdot R$$

Deelspanning U_R

$$\bar{I} = (31,41 + 31,25j) \text{ mA}$$

$$5. \quad \bar{U}_R = \bar{I} \cdot R$$

$$= (31,41 + 31,25j) \text{ mA} \cdot 160 \Omega$$

Deelspanning U_R

$$\bar{I} = (31,41 + 31,25j) \text{ mA}$$

$$5. \quad \bar{U}_R = \bar{I} \cdot R$$

$$= (31,41 + 31,25j) \text{ mA} \cdot 160 \Omega$$

$$= (5025 + 5000j) \text{ mV}$$

Deelspanning U_R

$$\bar{I} = (31,41 + 31,25j) \text{ mA}$$

$$5. \quad \bar{U}_R = \bar{I} \cdot R$$

$$= (31,41 + 31,25j) \text{ mA} \cdot 160 \Omega$$

$$= (5025 + 5000j) \text{ mV}$$

$$= (5,025 + 5j) \text{ V}$$

complexe schrijfwijze
voor deelspanning U_R

Grootte U_R

$$\bar{U}_R = (5,025 + 5j) \text{ V}$$

$$6. \quad |\bar{U}_R| = \sqrt{\text{Re}^2 + \text{Im}^2}$$

Grootte U_R

$$\bar{U}_R = (5,025 + 5j) \text{ V}$$

$$\begin{aligned} 6. \quad |\bar{U}_R| &= \sqrt{\text{Re}^2 + \text{Im}^2} \\ &= \sqrt{5,025^2 + 5^2} \end{aligned}$$

Grootte U_R

$$\bar{U}_R = (5,025 + 5j) \text{ V}$$

$$\begin{aligned} 6. \quad |\bar{U}_R| &= \sqrt{\text{Re}^2 + \text{Im}^2} \\ &= \sqrt{5,025^2 + 5^2} \\ &= \boxed{7,09 \text{ V}} \end{aligned}$$

voltmeter duidt deze waarde aan

Deelspanning U_c

$$\bar{I} = (31,41 + 31,25j) \text{ mA}$$

$$7. \quad \bar{U}_c = \bar{I} \cdot \bar{X}_c$$

Deelspanning U_c

$$\bar{I} = (31,41 + 31,25j) \text{ mA}$$

$$\begin{aligned} 7. \quad \bar{U}_c &= \bar{I} \cdot \bar{X}_c \\ &= (31,41 + 31,25j) \text{ mA} \cdot (-159,15j) \Omega \quad [j \cdot j = -1] \end{aligned}$$

Deelspanning U_c

$$\bar{I} = (31,41 + 31,25j) \text{ mA}$$

$$7. \quad \bar{U}_c = \bar{I} \cdot \bar{X}_c$$

$$= (31,41 + 31,25j) \text{ mA} \cdot (-159,15j) \Omega \quad [j \cdot j = -1]$$

$$= (-5j + 4,97) \text{ V}$$

Deelspanning U_c

$$\bar{I} = (31,41 + 31,25j) \text{ mA}$$

$$7. \quad \bar{U}_c = \bar{I} \cdot \bar{X}_c$$

$$= (31,41 + 31,25j) \text{ mA} \cdot (-159,15j) \Omega \quad [j \cdot j = -1]$$

$$= (-5j \oplus 4,97) \text{ V}$$

$$= (4,97 - 5j) \text{ V}$$

complexe schrijfwijze
voor deelspanning U_c

Grootte U_c

$$\bar{U}_c = (4,97 - 5j) \text{ V}$$

$$8. |\bar{U}_c| = \sqrt{\text{Re}^2 + \text{Im}^2}$$

Grootte U_c

$$\bar{U}_c = (4,97 - 5j) \text{ V}$$

$$\begin{aligned} 8. \quad |\bar{U}_c| &= \sqrt{\text{Re}^2 + \text{Im}^2} \\ &= \sqrt{4,97^2 + 5^2} \end{aligned}$$

Grootte U_c

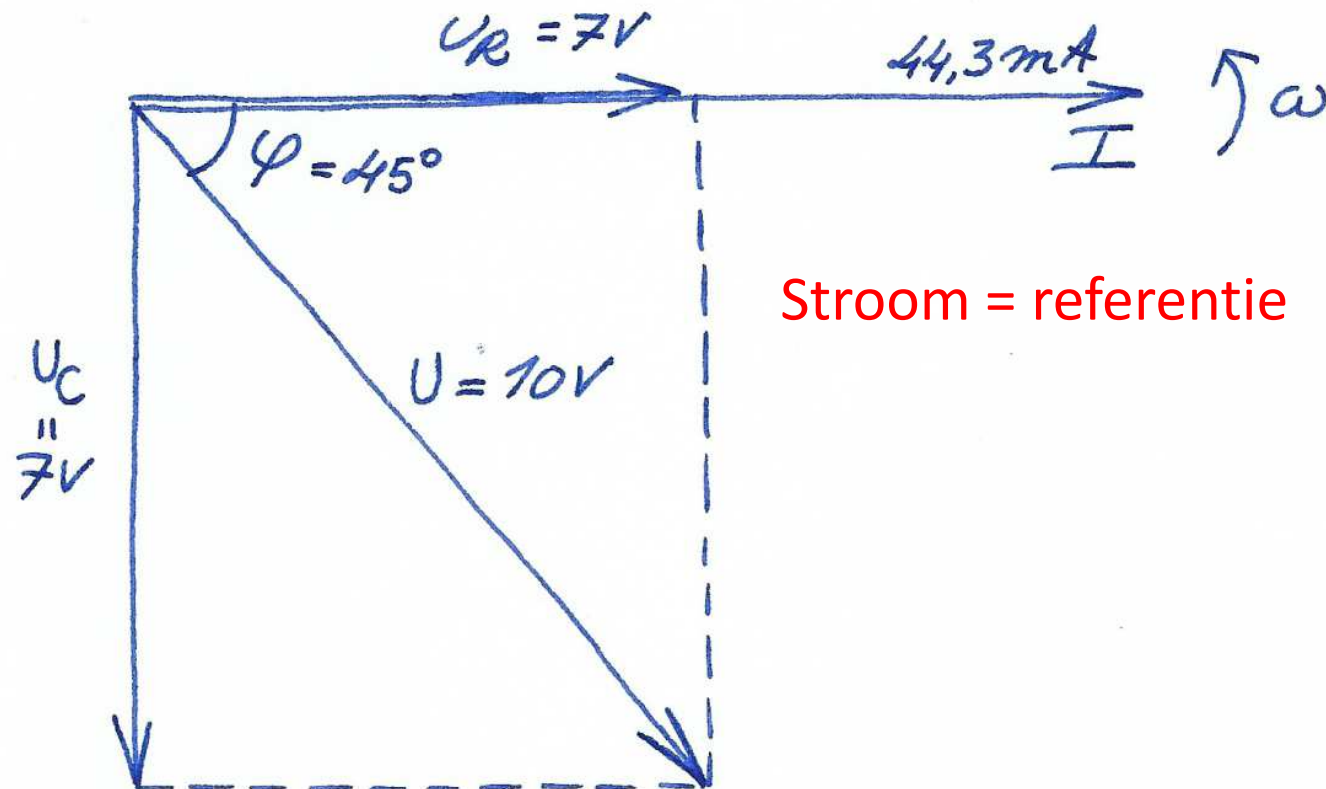
$$\bar{U}_c = (4,97 - 5j) \text{ V}$$

$$\begin{aligned} 8. \quad |\bar{U}_c| &= \sqrt{\text{Re}^2 + \text{Im}^2} \\ &= \sqrt{4,97^2 + 5^2} \\ &= \boxed{7,05 \text{ V}} \end{aligned}$$

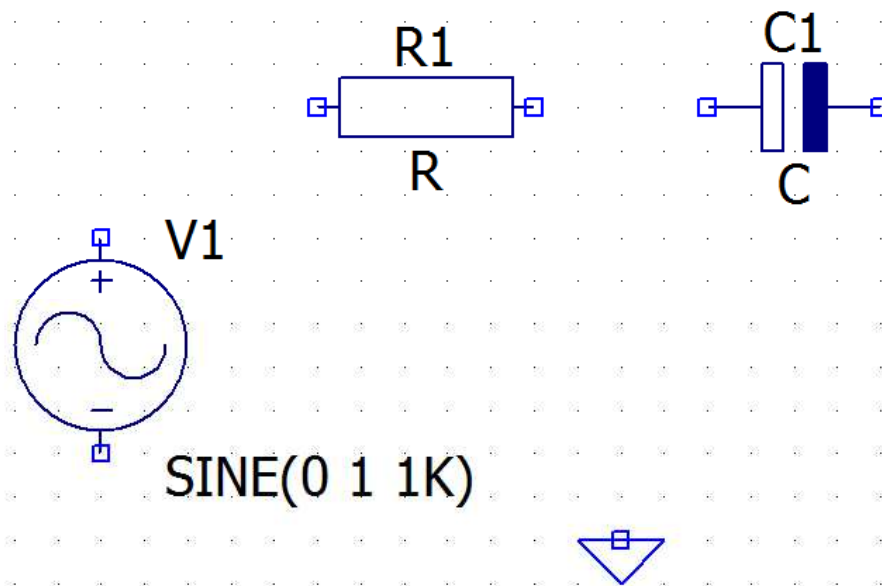
voltmeter duidt deze waarde aan

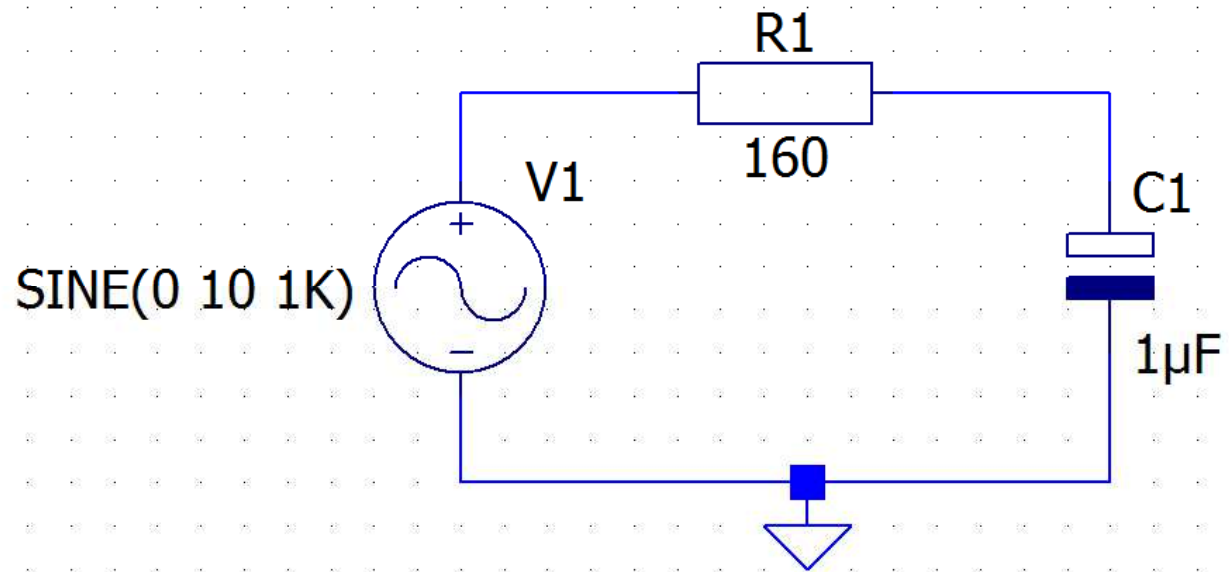
Vectordiagram

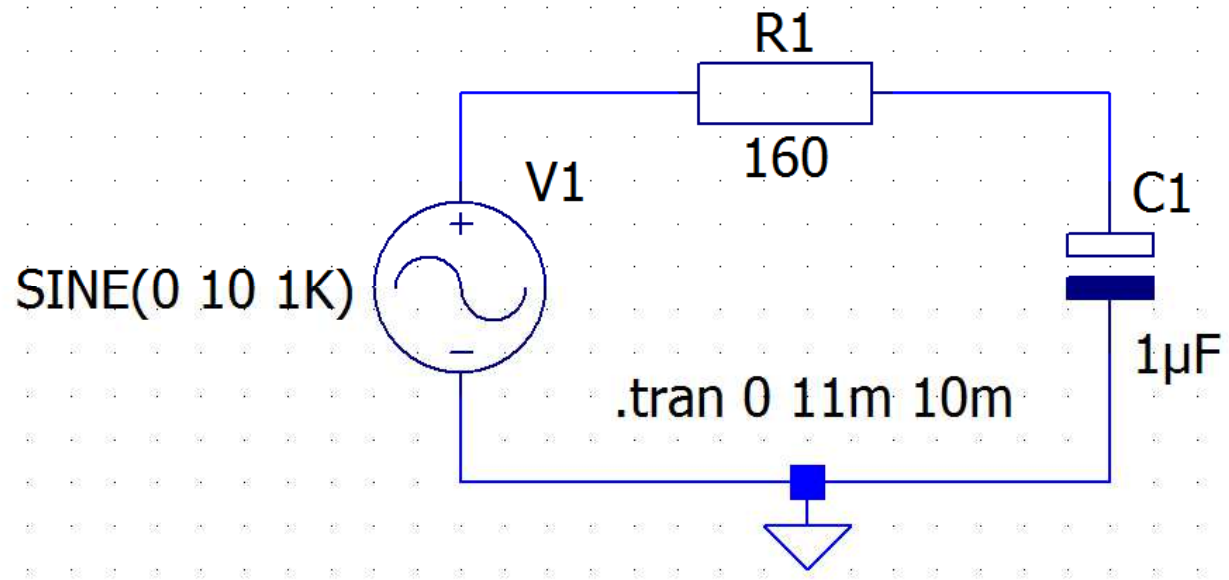
9. Vectordiagram

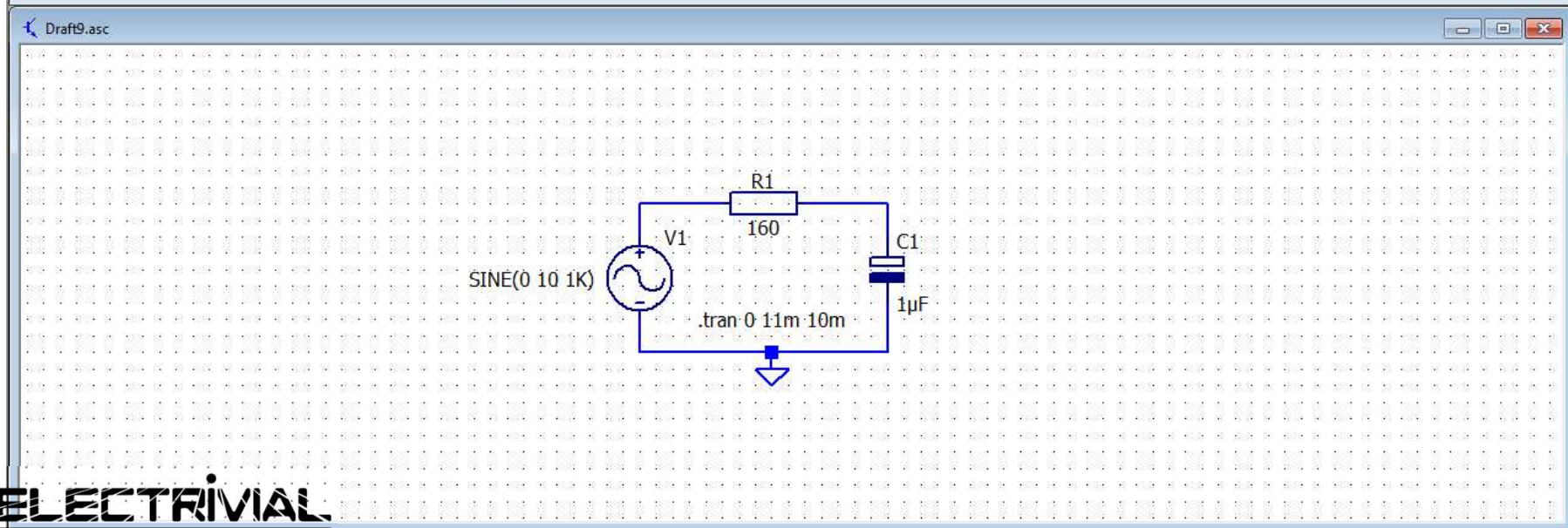
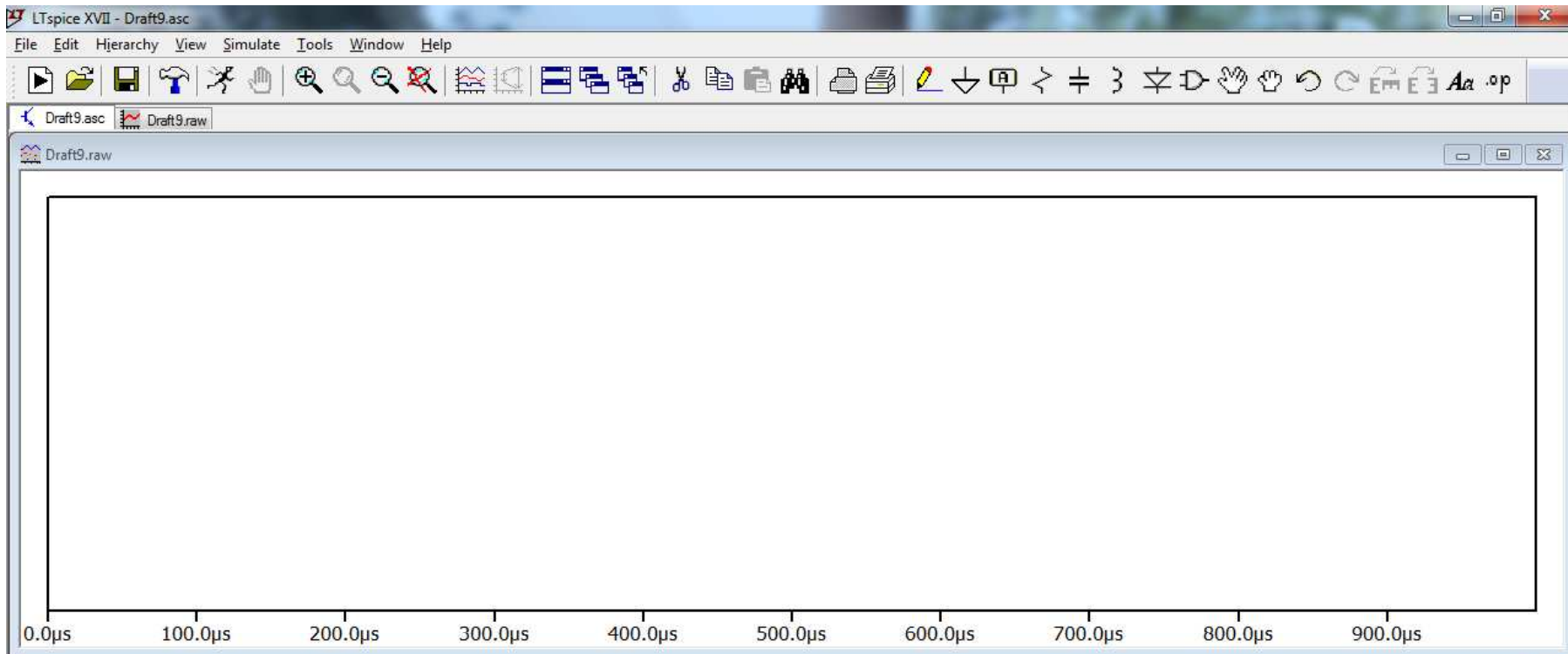


LTspice



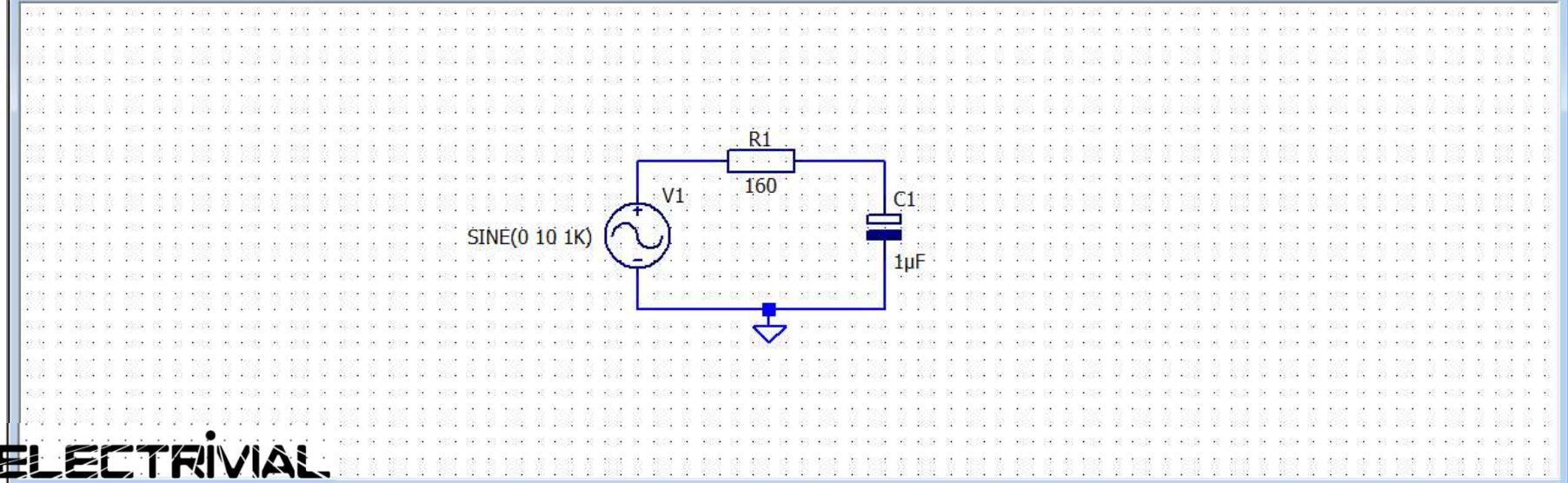
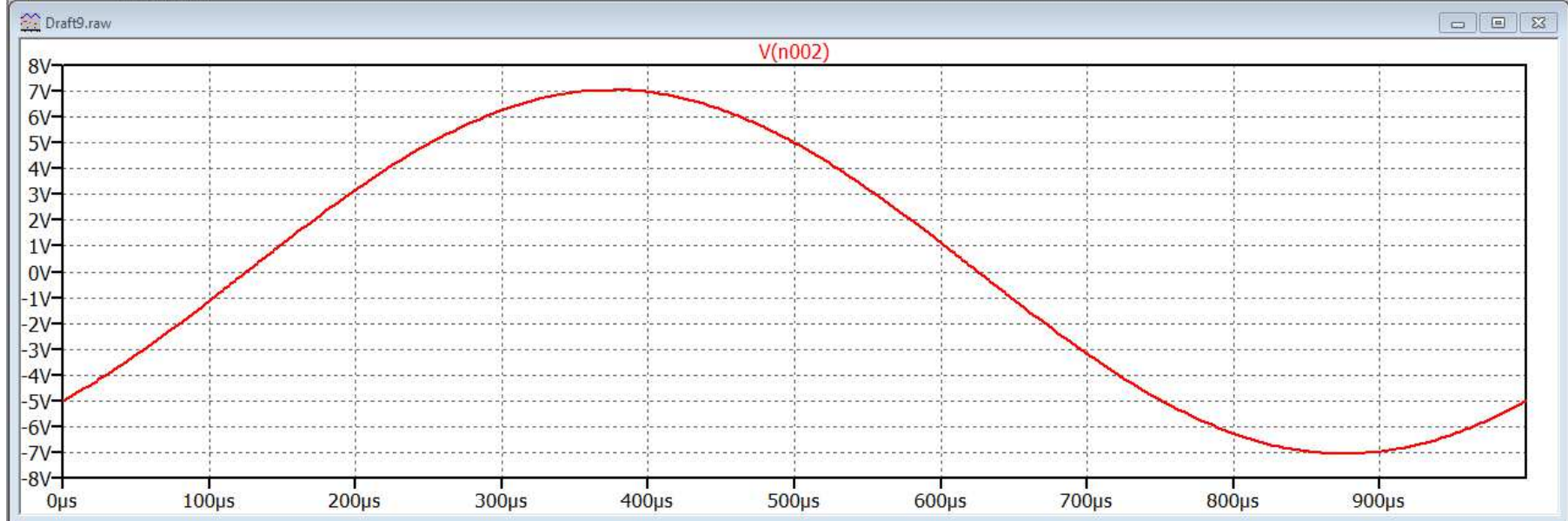


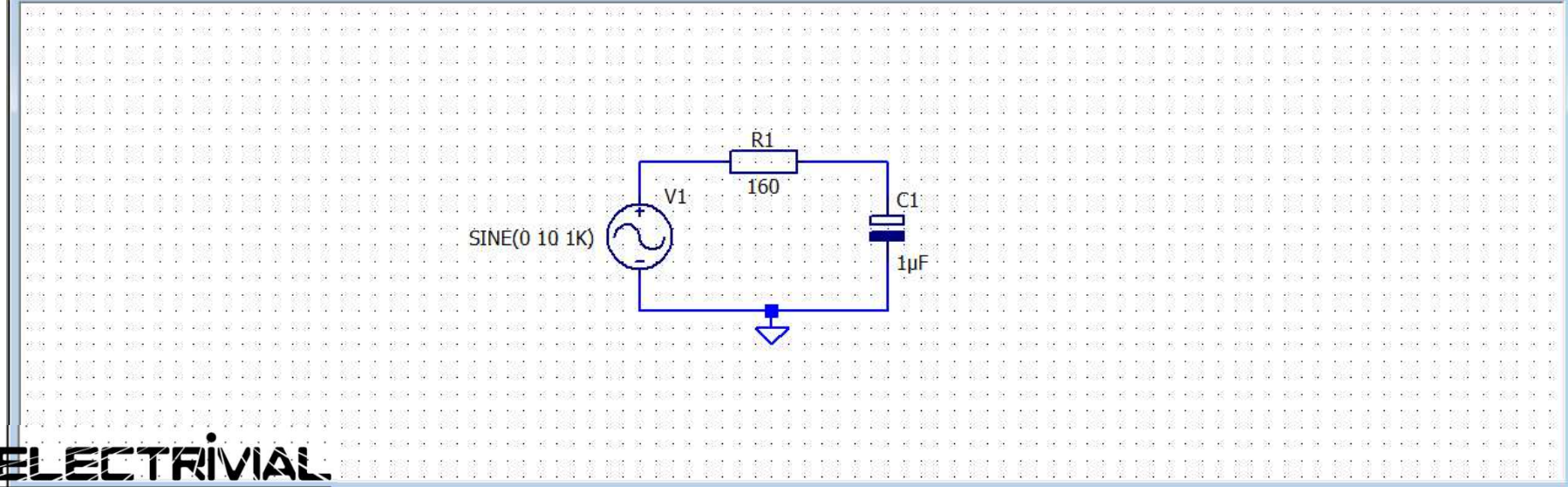
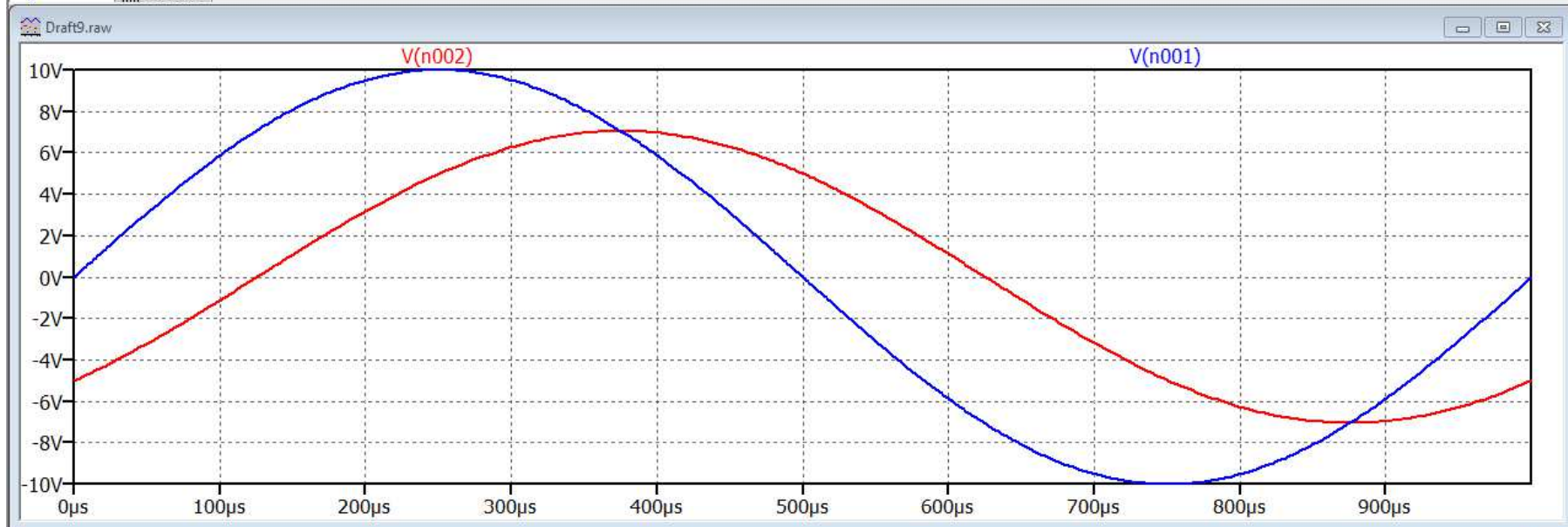


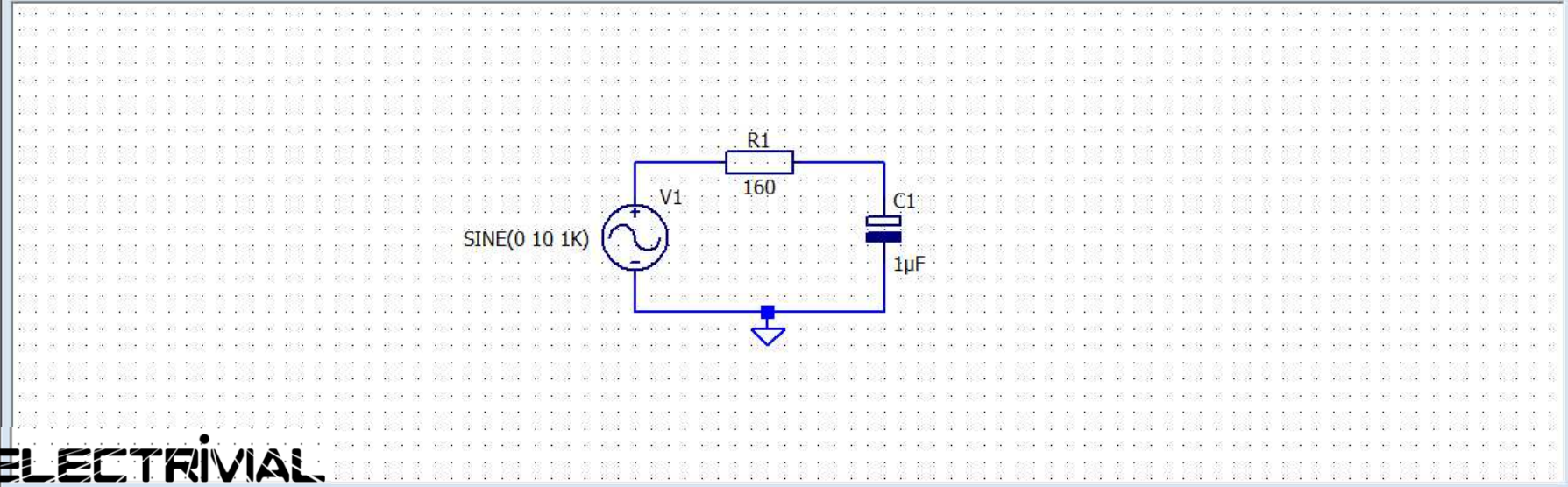
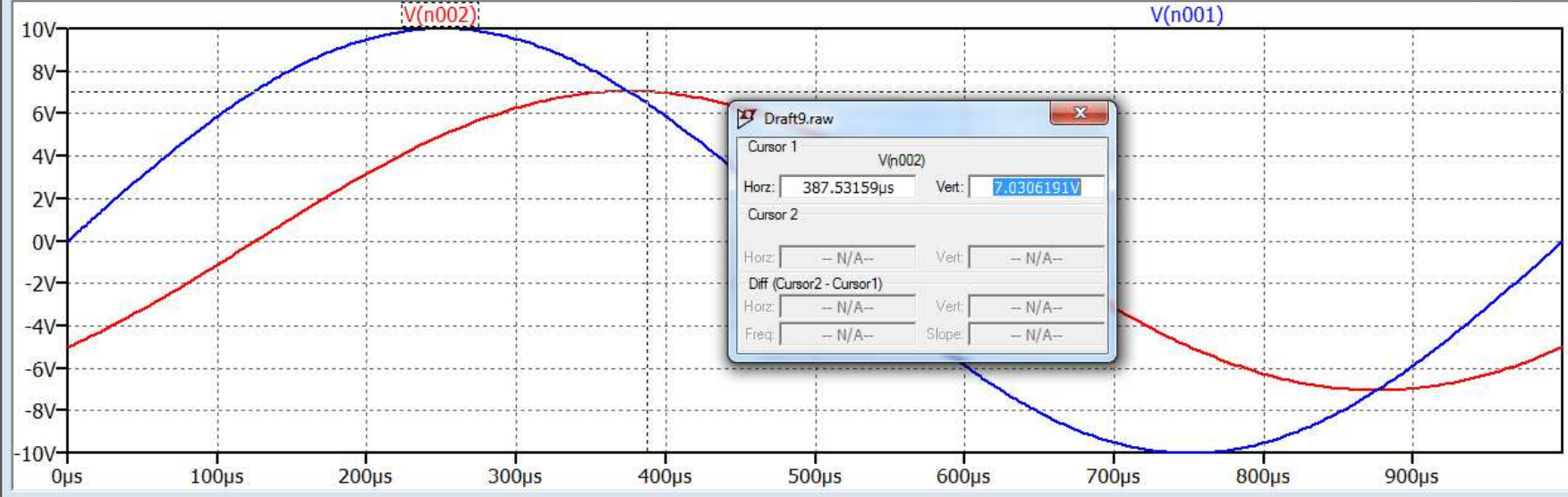


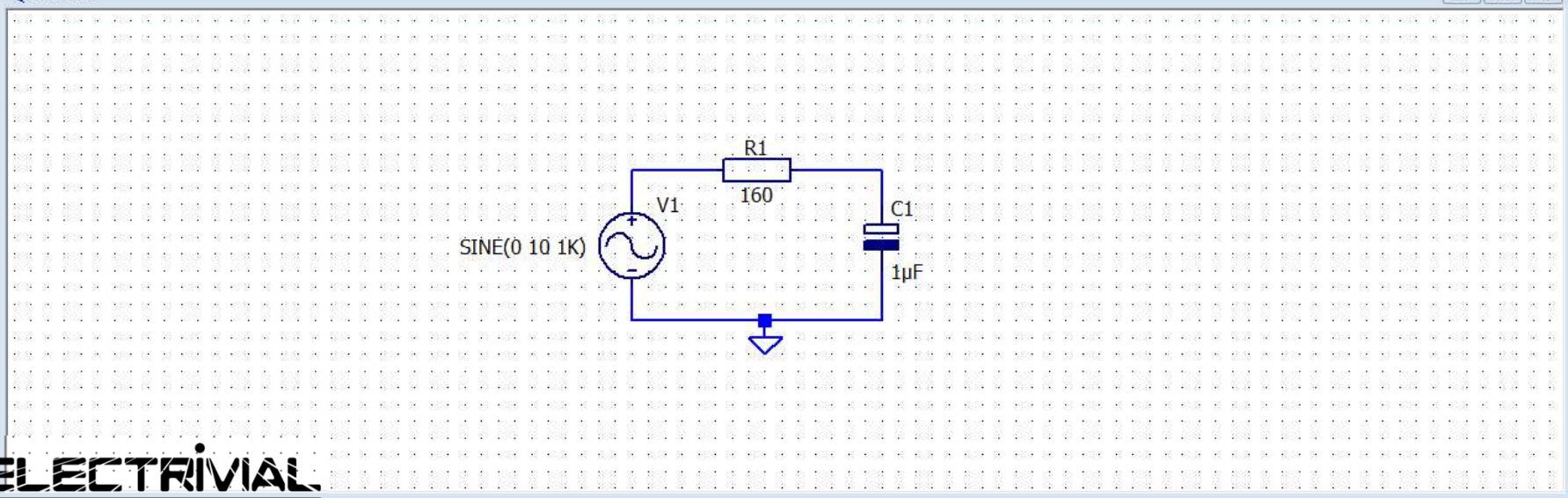
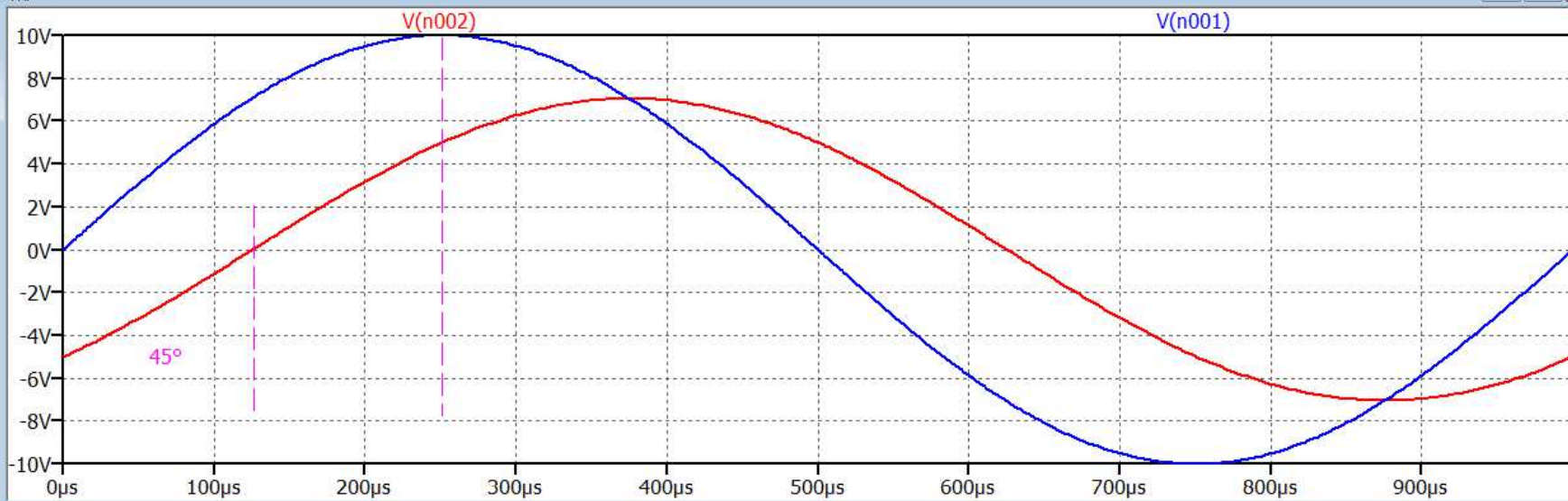
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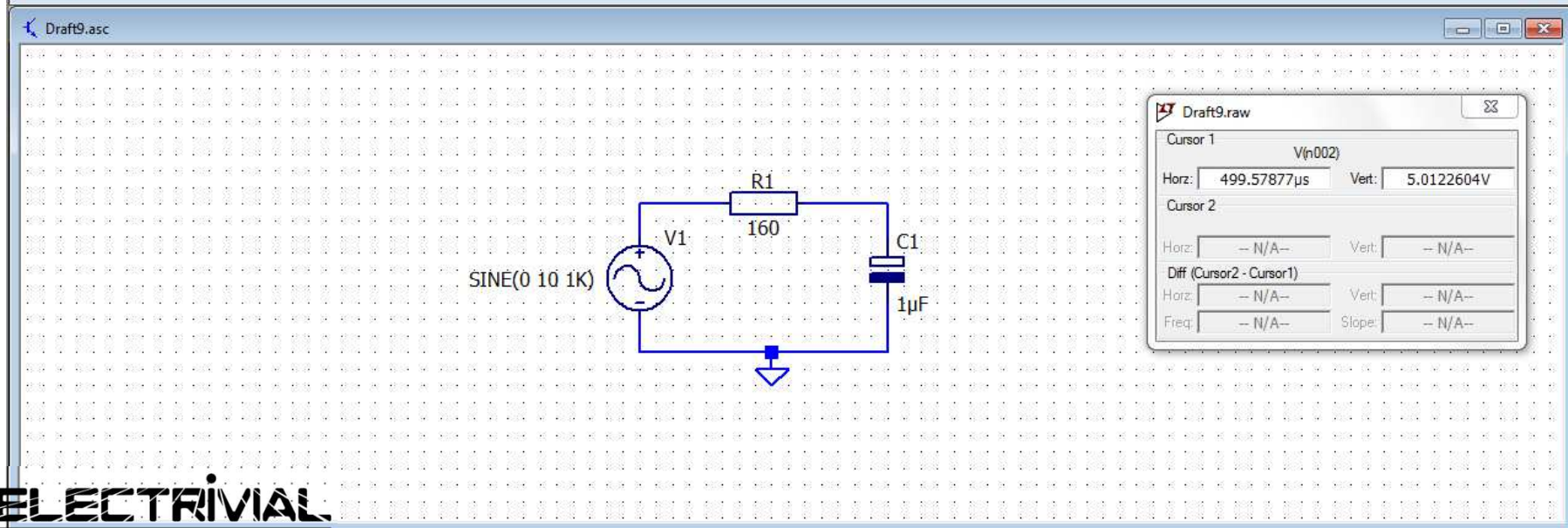
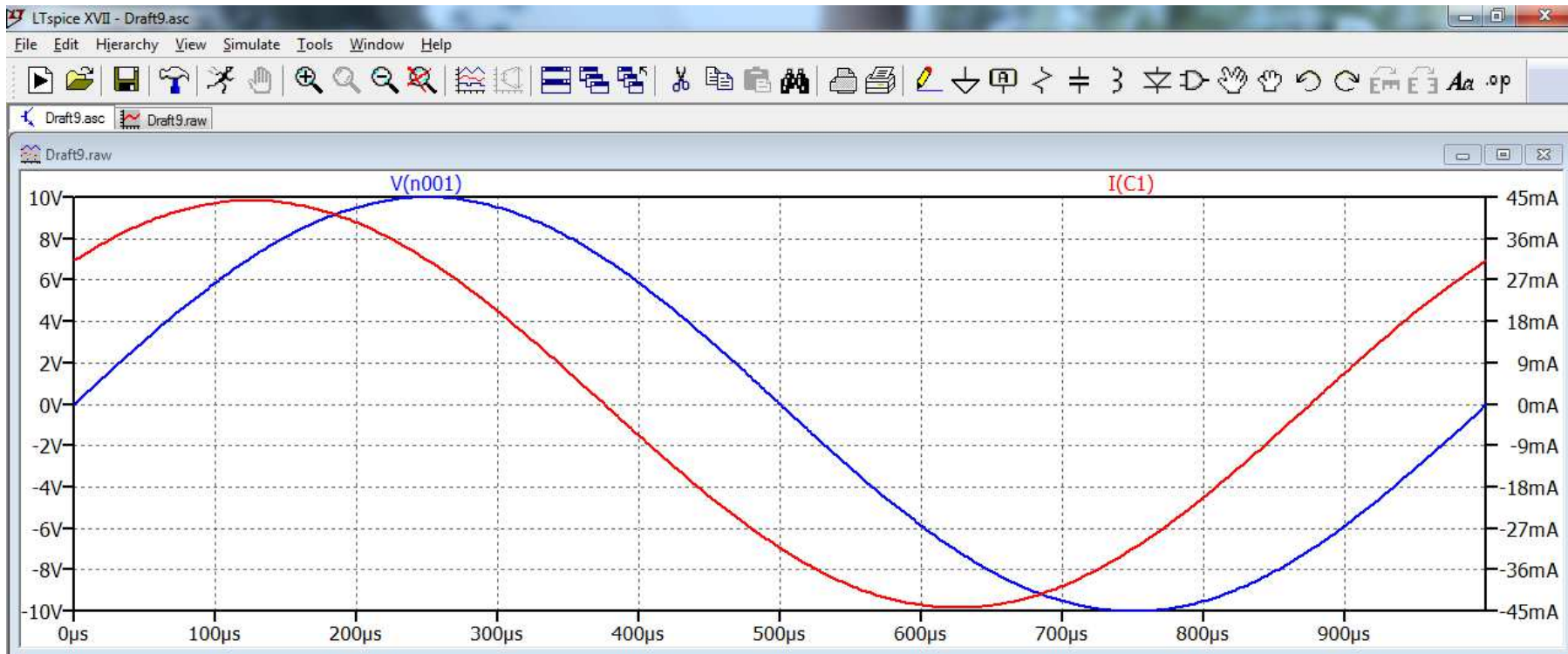


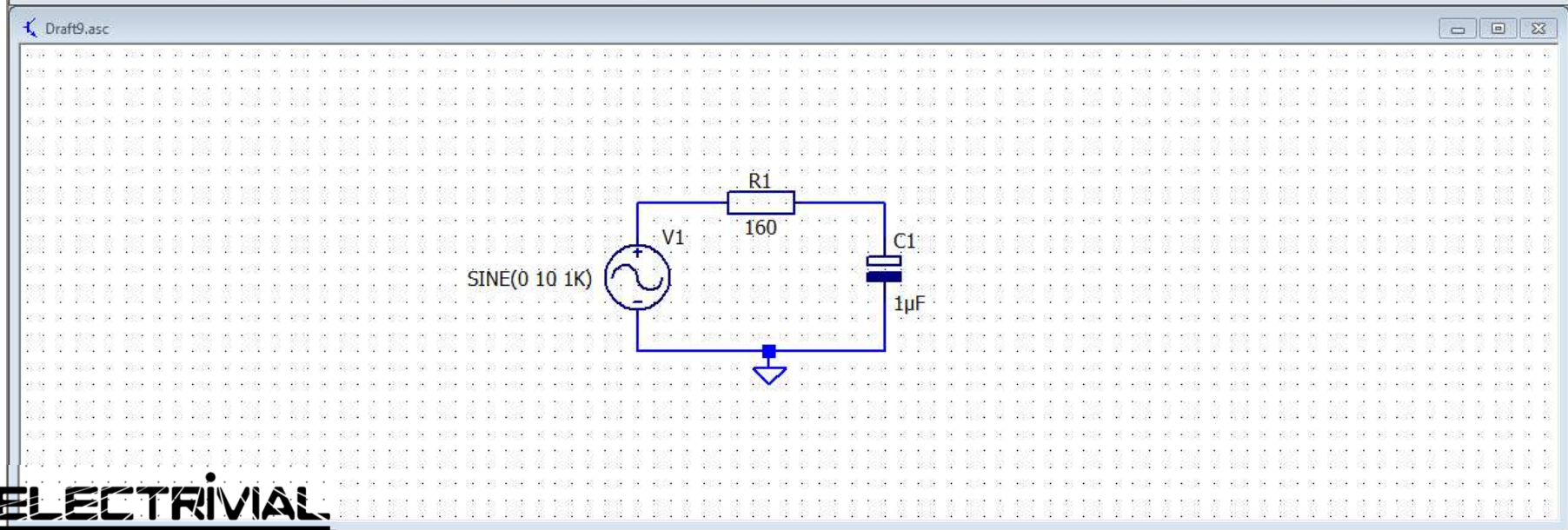
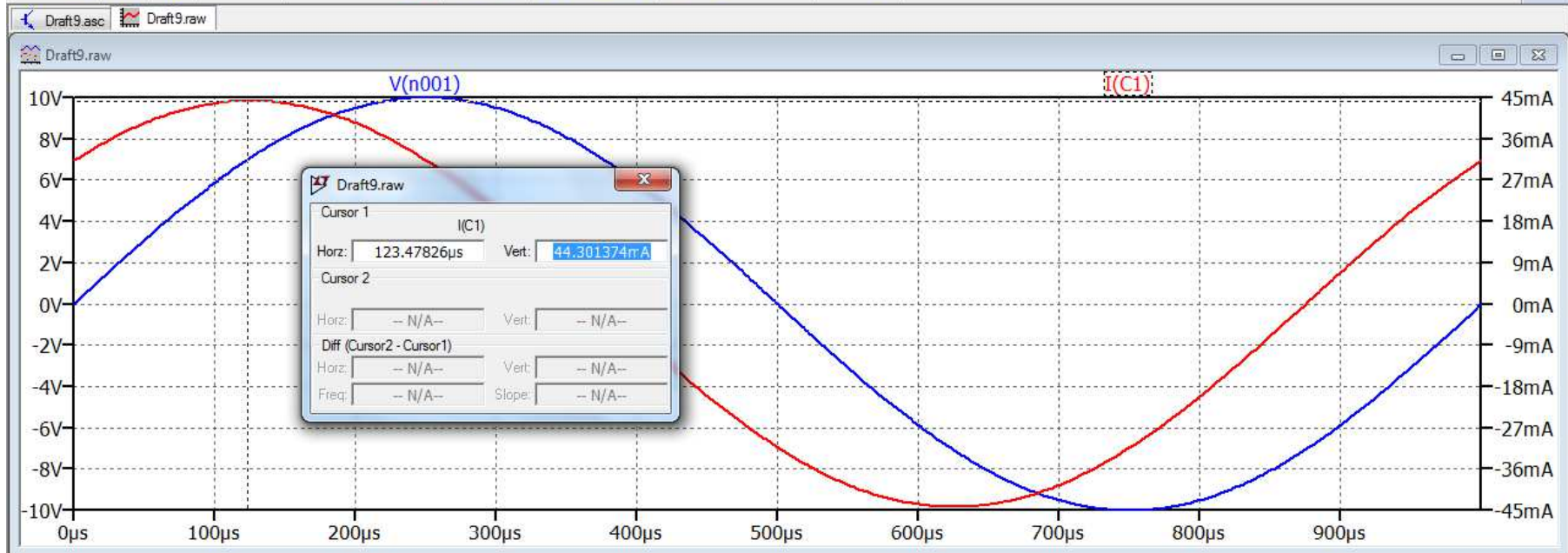


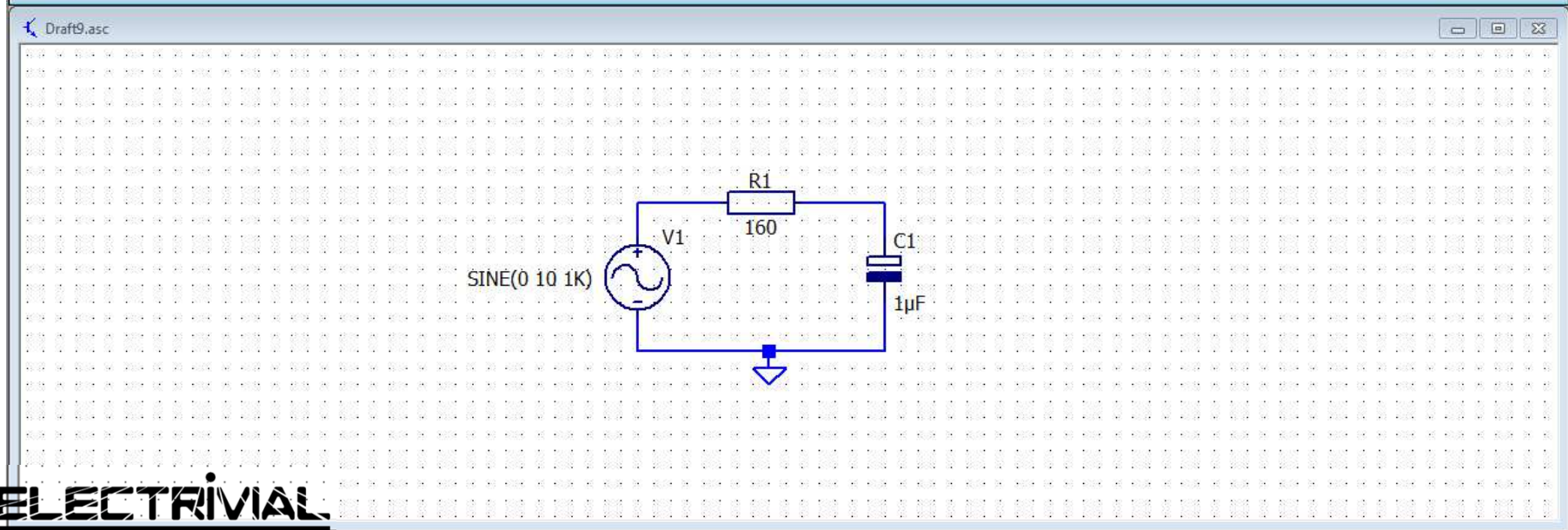
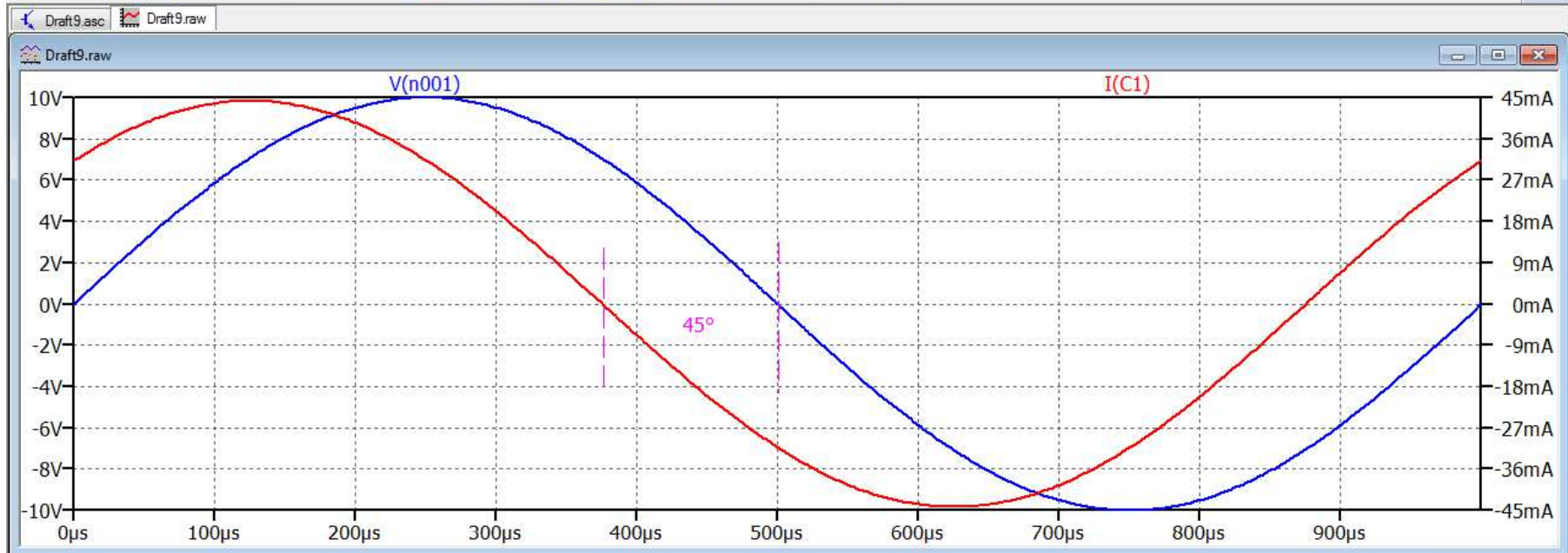


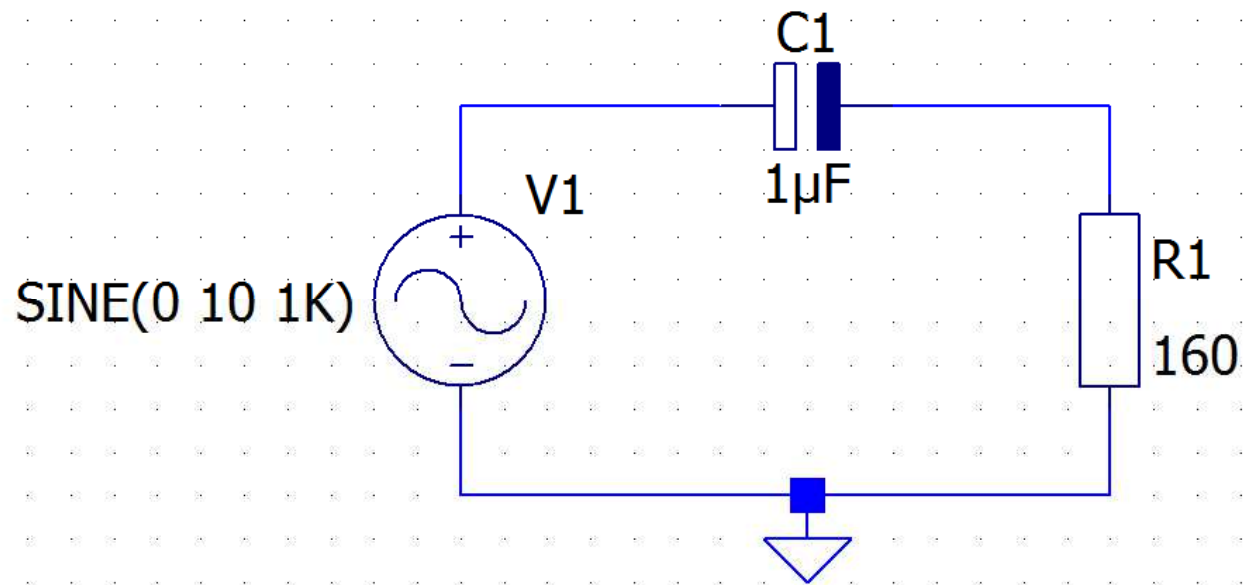


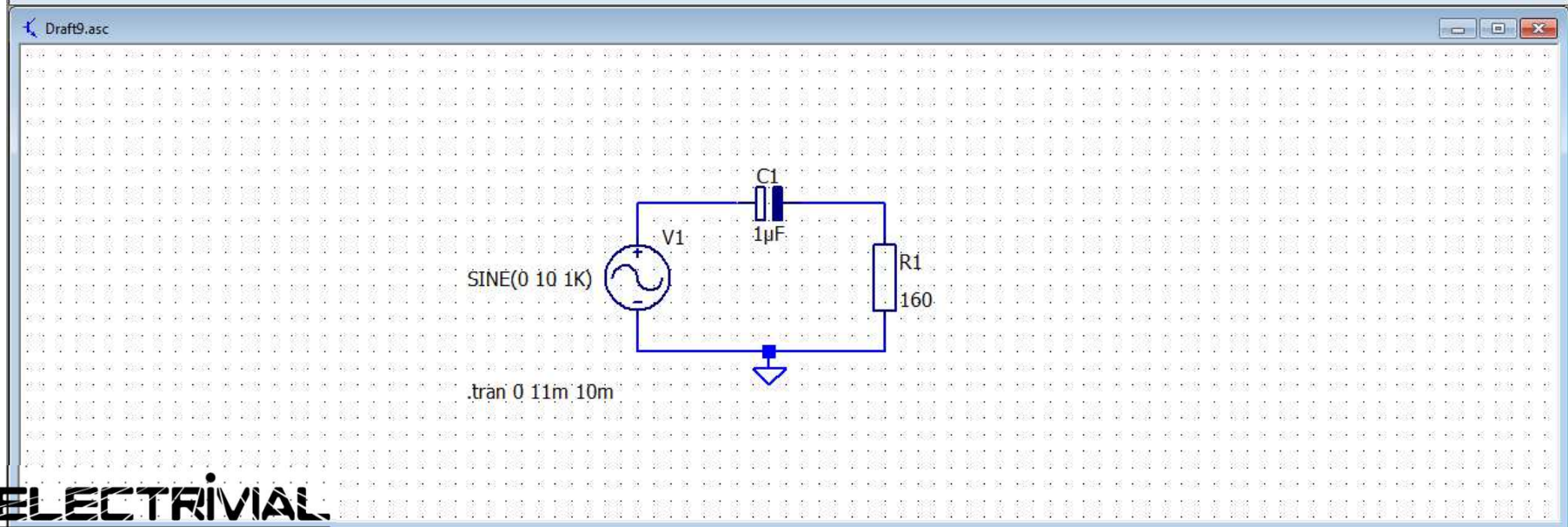
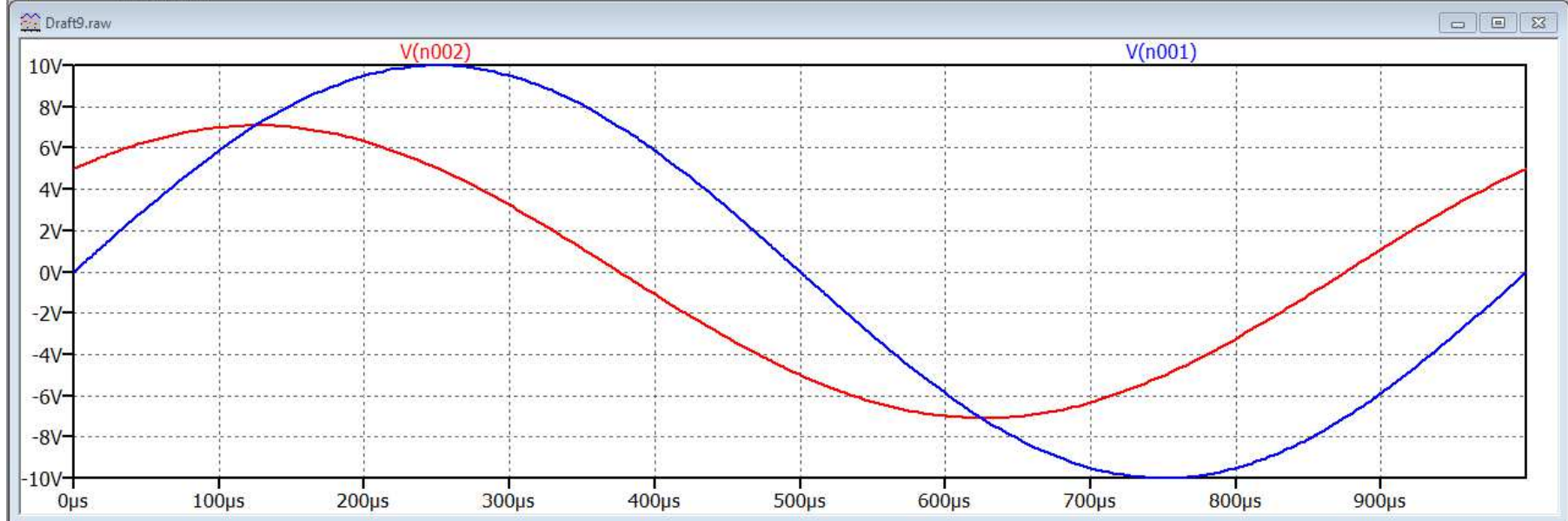




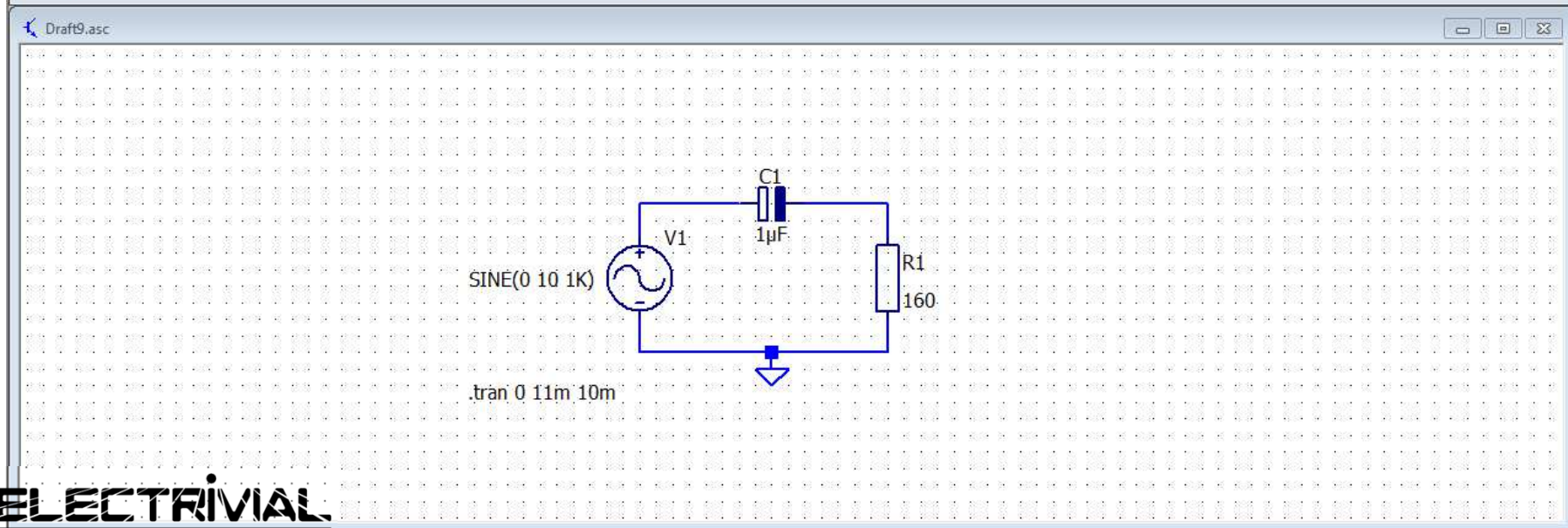
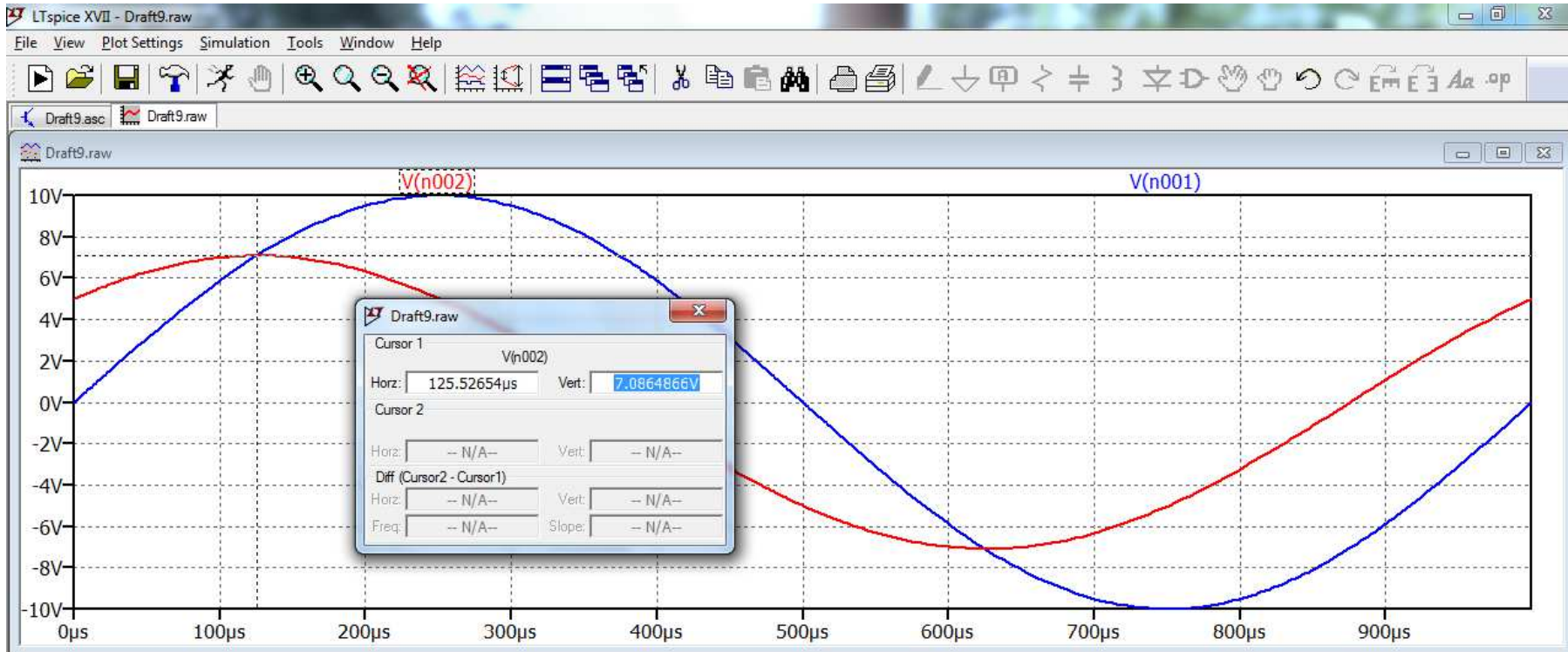


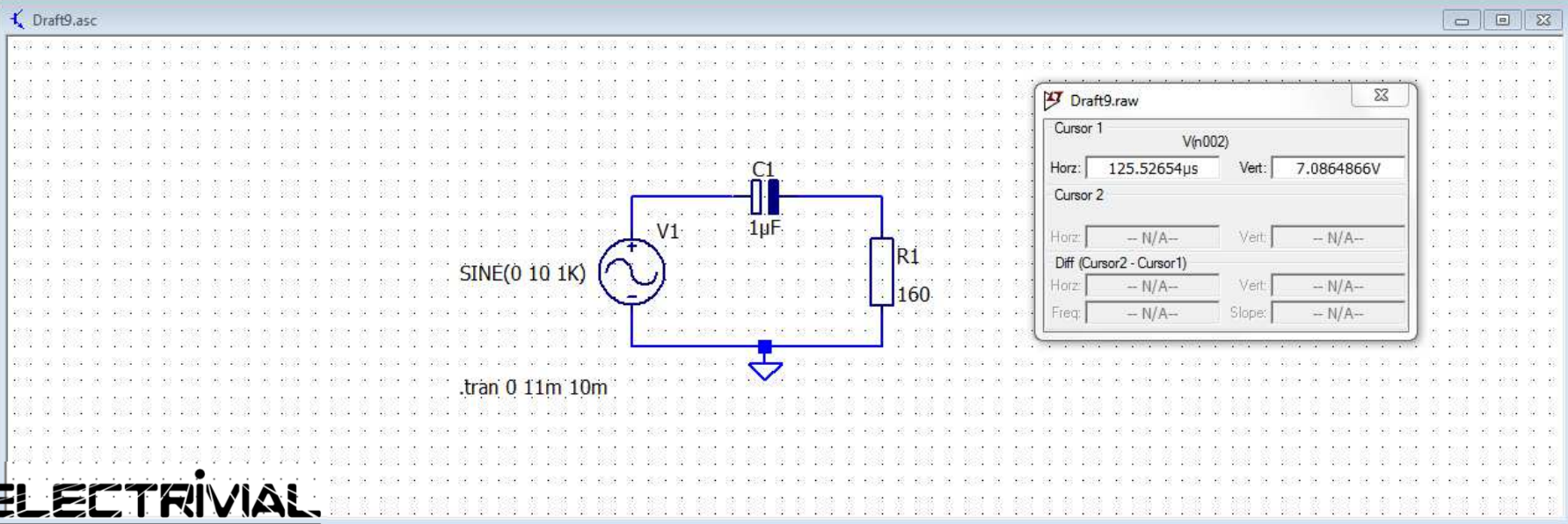
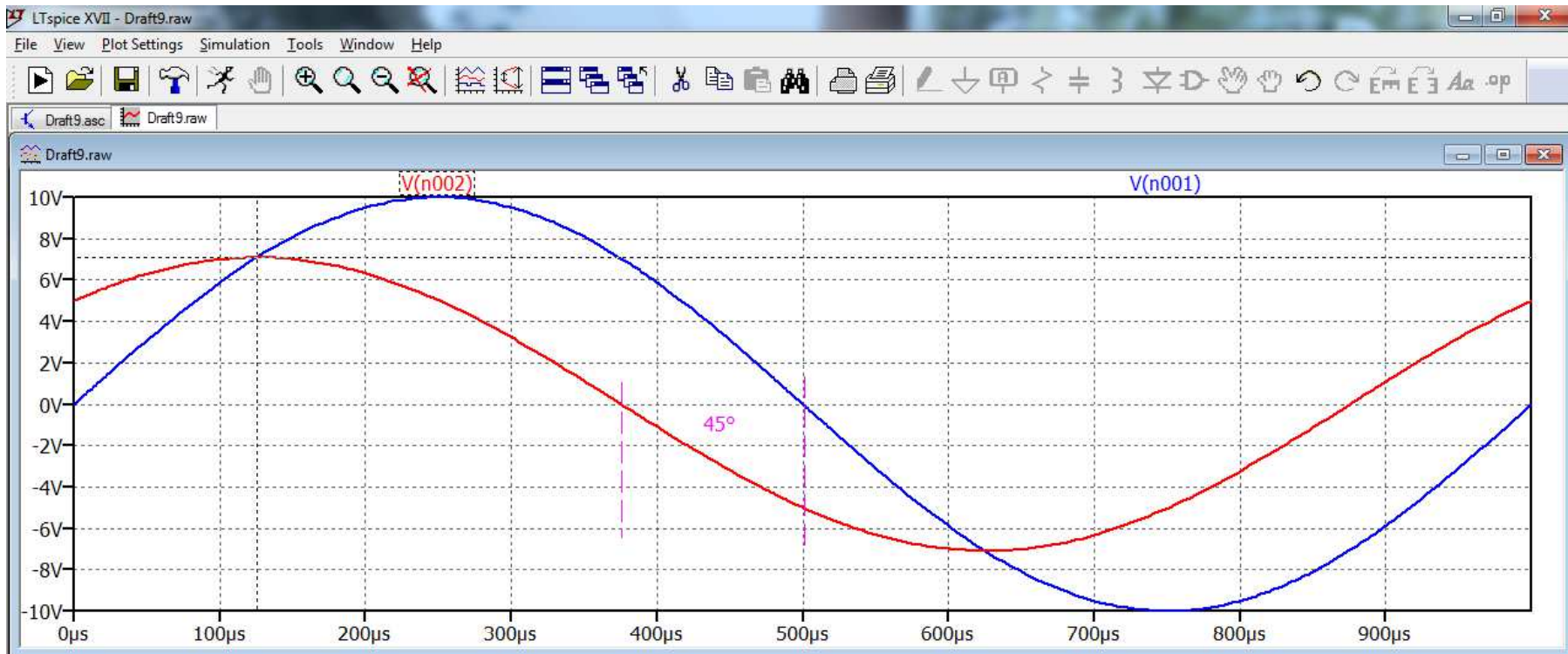






Click to plot (N001). VC operating point (n002) = 0V





Einde tutorial