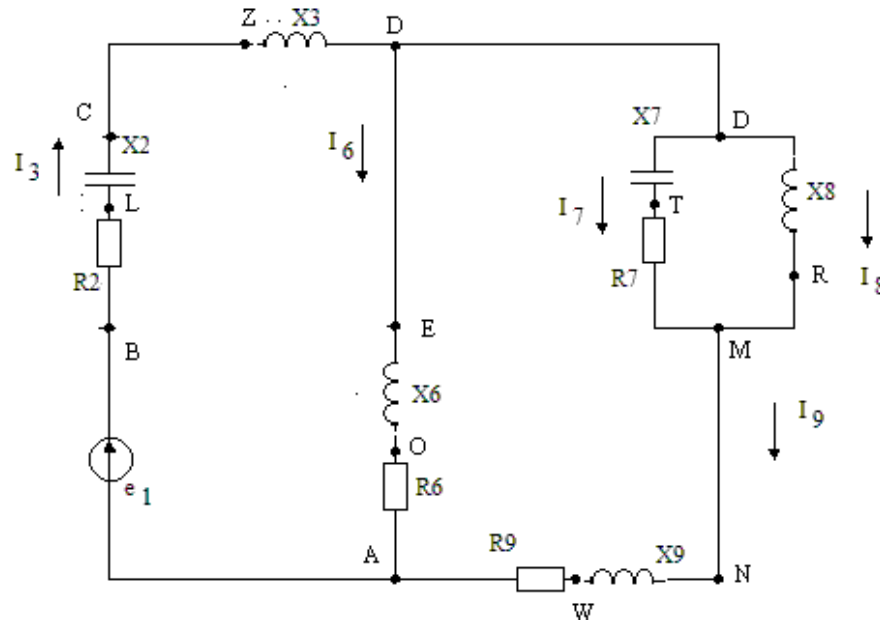


$$R1 := \infty \quad R2 := 10 \quad R3 := 0 \quad R4 := 0 \quad R5 := 10 \quad R6 := 10 \quad R7 := 25 \quad R8 := 0 \quad R9 := 5$$

$$X1 := \infty \quad X2 := -10 \quad X3 := 20 \quad X4 := 0 \quad X5 := 0 \quad X6 := 20 \quad X7 := -25 \quad X8 := 25 \quad X9 := 10$$

$$e_1 = 60 \cdot \sqrt{2} \cdot \sin(\omega t - 135^\circ) \quad \text{В комплексном виде} \quad E1 = 60 \cdot e^{-135^\circ i} \cdot B \quad E1 = -42.426 - 42.426i \cdot B$$

1. Изображаю схему в соответствии с заданием, ветвь DE закорачивается, т.к. $R4 = 0 \quad X4 = 0$
 Ветвь 1 ток не проводит, т.к. $X1 := \infty \quad R1 := \infty$



2. Комплексные сопротивления ветвей:

$$Z_7 := X7 \cdot i + R7 \rightarrow 25 - 25i \quad \text{Om}$$

$$Z_8 := X8 \cdot i \rightarrow 25i \quad \text{Om}$$

$$Z_{DM} := \frac{Z_7 \cdot Z_8}{Z_7 + Z_8} = \frac{(25 - 25i) \cdot 25i}{25 - 25i + 25i}$$

$$Z_{DM} = 25 + 25i \quad \text{Om}$$

$$Z_9 := X9 \cdot i + R9 \rightarrow 5 + 10i \quad \text{Om}$$

$$Z_{DMA} := Z_{DM} + Z_9 \rightarrow 30 + 35i \quad \text{Om}$$

$$Z_6 := X6 \cdot i + R6 \rightarrow 10 + 20i \quad \text{Om}$$

$$Z_{AD} := \frac{Z_{DMA} \cdot Z_6}{Z_{DMA} + Z_6} = \frac{(30 + 35i) \cdot (10 + 20i)}{(30 + 35i) + (10 + 20i)}$$

$$Z_{AD} = 7.838 + 12.973i \quad \text{Om}$$

$$Z_2 := X2 \cdot i + R2 \rightarrow 10 - 10i \quad \text{Om}$$

$$Z_3 := X3 \cdot i \rightarrow 20i \quad \text{Om}$$

$$Z_{BD} := Z_2 + Z_3 \quad Z_{BD} = 10 + 10i \quad \text{Om}$$

$$Z := Z_{BD} + Z_{AD} = 7.838 + 12.973i + (10 + 10i)$$

$$Z = 17.838 + 22.973i \quad \text{Om}$$

3. Токи в ветвях и напряжения на участках

$$I_3 := \frac{E1}{Z} = \frac{-42.426 - 42.426i}{17.838 + 22.973i} = -2.047 + 0.258i \text{ A} = 2.063 \cdot e^{172.8i} \quad i_3 = 2.063 \cdot \sqrt{2} \cdot \sin(\omega t + 172.8)$$

$$U_{R2} := I_3 \cdot R2 = (-2.047 + 0.258i) \cdot 10 = -20.47 + 2.58i = 20.63 \cdot e^{172.8i} \text{ B} \quad u_{R2} = 20.63 \cdot \sqrt{2} \cdot \sin(\omega t + 172.8)$$

$$U_{X2} := I_3 \cdot X2 \cdot i = (-2.047 + 0.258i) \cdot (-10 \cdot i) = 2.58 + 20.47i = 20.63 \cdot e^{82.8i} \text{ B} \quad u_{X2} = 20.63 \cdot \sqrt{2} \cdot \sin(\omega t + 82.8)$$

$$U_{X3} := I_3 \cdot X3 \cdot i = (-2.047 + 0.258i) \cdot (20 \cdot i) = -5.16 - 40.94i = 41.26 \cdot e^{-97.2i} \text{ B} \quad u_{X3} = 41.26 \cdot \sqrt{2} \cdot \sin(\omega t - 97.2)$$

$$U_{AD} := I_3 \cdot Z_{AD} = (-2.047 + 0.258i) \cdot (7.838 + 12.973i) = -19.391 - 24.534i = 31.27 \cdot e^{-128.3i} \text{ B}$$

$$u_{AD} = 31.27 \cdot \sqrt{2} \cdot \sin(\omega t - 128.3)$$

$$I_6 := \frac{U_{AD}}{Z_6} = \frac{-19.391 - 24.534i}{10 + 20i} = -1.369 + 0.285i = 1.398 \cdot e^{168.3i} \text{ A} \quad i_6 = 1.398 \cdot \sqrt{2} \cdot \sin(\omega t + 168.3)$$

$$U_{R6} := I_6 \cdot R6 = (-1.369 + 0.285i) \cdot 10 = -13.69 + 2.85i = 13.98 \cdot e^{168.3i} \text{ B} \quad u_{R6} = 13.98 \cdot \sqrt{2} \cdot \sin(\omega t + 168.3)$$

$$U_{X6} := I_6 \cdot X6 \cdot i = (-1.369 + 0.285i) \cdot 20 \cdot i = -5.7 - 27.38i = 27.97 \cdot e^{-101.7i} \text{ B} \quad u_{X6} = 27.97 \cdot \sqrt{2} \cdot \sin(\omega t - 101.7)$$

$$I_9 := \frac{U_{AD}}{Z_{DMA}} = \frac{-19.391 - 24.534i}{30 + 35i} = -0.678 - 0.027i = 0.678 \cdot e^{-177.7i} \text{ A} \quad i_9 = 0.678 \cdot \sqrt{2} \cdot \sin(\omega t - 177.7)$$

$$U_{R9} := I_9 \cdot R9 = (-0.678 - 0.027i) \cdot 5 = -3.39 - 0.135i = 3.39 \cdot e^{-177.7i} \text{ B} \quad u_{R9} = 3.39 \cdot \sqrt{2} \cdot \sin(\omega t - 177.7)$$

$$U_{X9} := I_9 \cdot X9 \cdot i = (-0.678 - 0.027i) \cdot (10 \cdot i) = 0.27 - 6.78i = 6.78 \cdot e^{-87.7i} \text{ B} \quad u_{X9} = 6.78 \cdot \sqrt{2} \cdot \sin(\omega t - 87.7)$$

$$U_{DM} := I_9 \cdot Z_{DM} = (-0.678 - 0.027i) \cdot (25 + 25i) = -16.275 - 17.625i = 23.98 \cdot e^{-132.7i} \text{ B}$$

$$u_{DM} = 23.98 \cdot \sqrt{2} \cdot \sin(\omega t - 132.7)$$

$$U_{X8} := U_{DM} \quad U_{X8} = -16.266 - 17.621i = 23.98 \cdot e^{-132.7i} \text{ B} \quad u_{X8} = 23.98 \cdot \sqrt{2} \cdot \sin(\omega t - 132.7)$$

$$I_8 := \frac{U_{DM}}{X8 \cdot i} = \frac{(-16.266 - 17.621i)}{25 \cdot i} = -0.705 + 0.651i = 0.959 \cdot e^{137.3i} \text{ A} \quad i_8 = 0.959 \cdot \sqrt{2} \cdot \sin(\omega t + 137.3)$$

$$I_7 := \frac{U_{DM}}{Z_7} = \frac{(-16.266 - 17.621i)}{25 - 25i} = 0.027 - 0.678i = 0.678 \cdot e^{-87.7i} \text{ A} \quad i_7 = 0.678 \cdot \sqrt{2} \cdot \sin(\omega t - 87.7)$$

$$U_{X7} := I_7 \cdot X7 \cdot i = (0.027 - 0.678i) \cdot (-25 \cdot i) = -16.95 - 0.675i = 16.96 \cdot e^{-177.7i} \text{ B}$$

$$u_{X7} = 16.96 \cdot \sqrt{2} \cdot \sin(\omega t - 177.7)$$

$$U_{R7} := I_7 \cdot R7 = (0.027 - 0.678i) \cdot 25 = 0.675 - 16.95i = 16.96 \cdot e^{-87.7i} \text{ B}$$

$$u_{R7} = 16.96 \cdot \sqrt{2} \cdot \sin(\omega t - 87.7)$$

3. Баланс мощностей

$$\text{Мощность источника : } S_1 := E1 \cdot \overline{I_3}$$

$$\text{где } \overline{I_3} = -2.047 - 0.258i \text{ A} \quad E1 = -42.426 - 42.426i \text{ В}$$

$$S = (-42.426 - 42.426i) \cdot (-2.047 - 0.258i) \quad S_1 = 75.911 + 97.764i$$

$$P_1 = 75.911 \text{ Вт} \quad Q_1 = 97.764 \text{ Вар}$$

Мощность потребляемая схемой :

$$P_2 := \langle I_3 \rangle^2 \cdot R_2 + \langle I_6 \rangle^2 \cdot R_6 + \langle I_7 \rangle^2 \cdot R_7 + \langle I_9 \rangle^2 \cdot R_9$$

$$P_2 = 75.911 \text{ Вт}$$

$$Q_2 := \langle I_3 \rangle^2 \cdot X_3 + \langle I_3 \rangle^2 \cdot X_2 + \langle I_6 \rangle^2 \cdot X_6 + \langle I_8 \rangle^2 \cdot X_8 + \langle I_9 \rangle^2 \cdot X_9 + \langle I_7 \rangle^2 \cdot X_7 \quad Q_2 = 97.764 \text{ Вар}$$

баланс выполнен

4. Проверим выполненные расчеты по законам Кирхгофа

$$I_3 \cdot (R_2 + X_2 \cdot i) + I_3 \cdot X_3 \cdot i + I_6 \cdot (R_6 + X_6 \cdot i) = E1 \quad \text{Левый контур}$$

$$-I_6 \cdot (R_6 + X_6 \cdot i) + I_9 \cdot (R_9 + X_9 \cdot i) + I_7 \cdot (R_7 + X_7 \cdot i) = 0 \quad \text{правый контур}$$

$$I_3 - I_6 - I_7 - I_8 = 0 \quad \text{узел "д"}$$

$$I_3 \cdot (R_2 + X_2 \cdot i) + I_3 \cdot X_3 \cdot i + I_6 \cdot (R_6 + X_6 \cdot i) = -42.426 - 42.426i \quad E1 = -42.426 - 42.426i \text{ В}$$

Токи найдены верно

Результаты заносим в таблицу

I_1 (A)	I_2 (A)	I_3 (A)	I_4 (A)	I_5 (A)	I_6 (A)	I_7 (A)	I_8 (A)
—	—	$2.063 \cdot e^{-172.8i}$	—	—	$1.398 \cdot e^{168.3i}$	$0.678 \cdot e^{-87.7i}$	$0.959 \cdot e^{137.3i}$

I_9 (A)	E_M (В)	P_1 Вт	Q_1 Вар	δ_P (%)	δ_Q (%)
$0.678 \cdot e^{-177.7i}$	60	75.911	97.764	0	0

Строим векторную диаграмму токов и напряжений в масштабе $\mu_i := 0.25 \frac{\text{A}}{\text{cm}}$ $\mu_u := 5 \frac{\text{В}}{\text{cm}}$
 Длина векторов на диаграмме

$$\frac{|I_9|}{\mu_i} = 2.71 \text{ cm} \quad \frac{|I_8|}{\mu_i} = 3.84 \text{ cm} \quad \frac{|I_3|}{\mu_i} = 8.25 \text{ cm} \quad \frac{|I_6|}{\mu_i} = 5.59 \text{ cm} \quad \frac{|I_7|}{\mu_i} = 2.71 \text{ cm}$$

$$\frac{|U_{R2}|}{\mu_u} = 4.13 \text{ cm} \quad \frac{|U_{X2}|}{\mu_u} = 4.13 \text{ cm} \quad \frac{|U_{X3}|}{\mu_u} = 8.25 \text{ cm} \quad \frac{|U_{X6}|}{\mu_u} = 5.59 \text{ cm}$$

$$\frac{|U_{R6}|}{\mu_u} = 2.8 \cdot \text{cm}$$

$$\frac{|U_{X8}|}{\mu_u} = 4.8 \cdot \text{cm}$$

$$\frac{|U_{X9}|}{\mu_u} = 1.36 \cdot \text{cm}$$

$$\frac{|U_{R9}|}{\mu_u} = 0.68 \cdot \text{cm}$$

$$\frac{|E1|}{\mu_u} = 12 \cdot \text{cm}$$

