Name: ______________________________ (please print)

Signature: ___________________________

ECE 2300 – Midterm Exam
July 2, 2015

Keep this exam closed and face up until you are told to begin.

1. This exam is closed book, closed notes. You may use one 8.5" x 11" crib sheet, or its equivalent.
2. Show all work on these pages. Show all work necessary to complete the problem. A solution without the appropriate work shown will receive no credit. A solution which is not given in a reasonable order will lose credit.
3. Show all units in solutions, intermediate results, and figures. Units in the quiz will be included between square brackets.
4. If the grader has difficulty following your work because it is messy or disorganized, you will lose credit.
5. Do not use red ink. Do not use red pencil.
6. You will have 90 minutes to work on this exam.

1. ________________/20

2. ________________/25

3. ________________/30

4. ________________/25

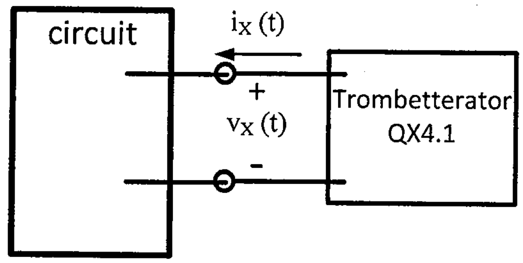
Room for extra work

1. (20 points) A new and improved version of the Trombetterator QX4 (the QX4.1) is found to have the following terminal voltage and current when connected to a particular circuit. The voltage and current, v_X and i_X, are defined in the figure.

$$v_x(t) = -12.4\,[V]e^{-2.20[ms]^{-1}t}$$

$$i_x(t) = 18.7[mA]e^{-1.15[ms]^{-1}t}$$

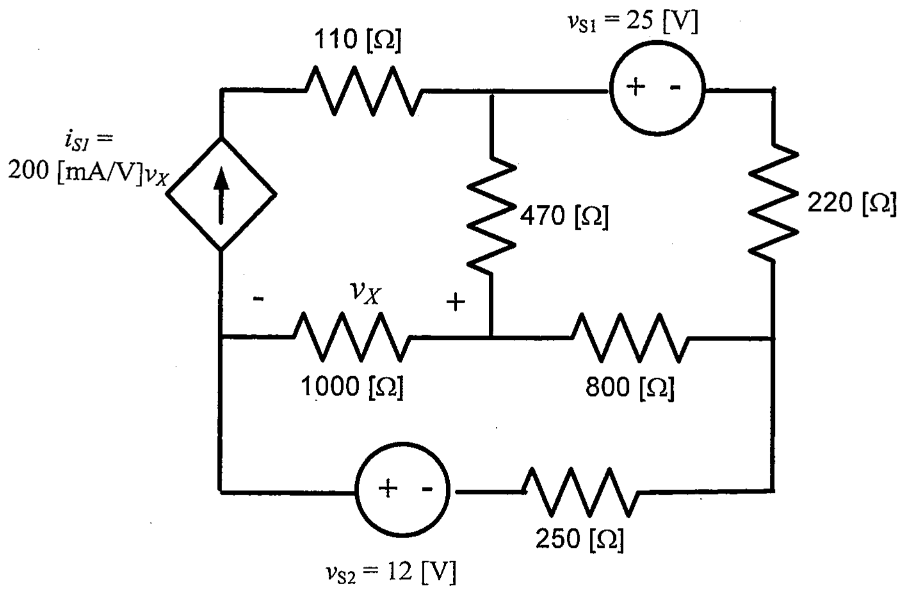
Find the energy delivered to the circuit by the Trombetterator QX4.1 in the time period 0.1 [ms] to 0.5 [ms].



2. (25 points) For the circuit below, find:

i) the power delivered by the current source i_{S1};

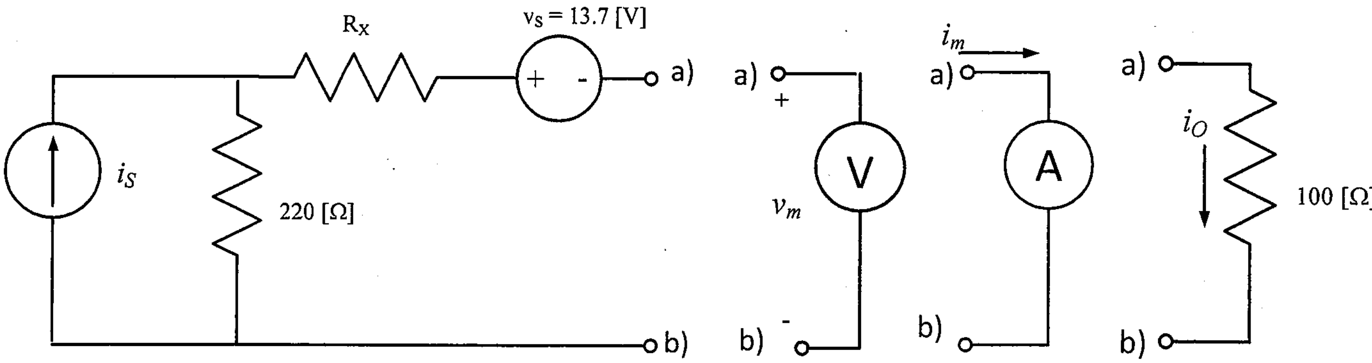
ii) the power delivered by the voltage source v_{S2}.



Room for extra work

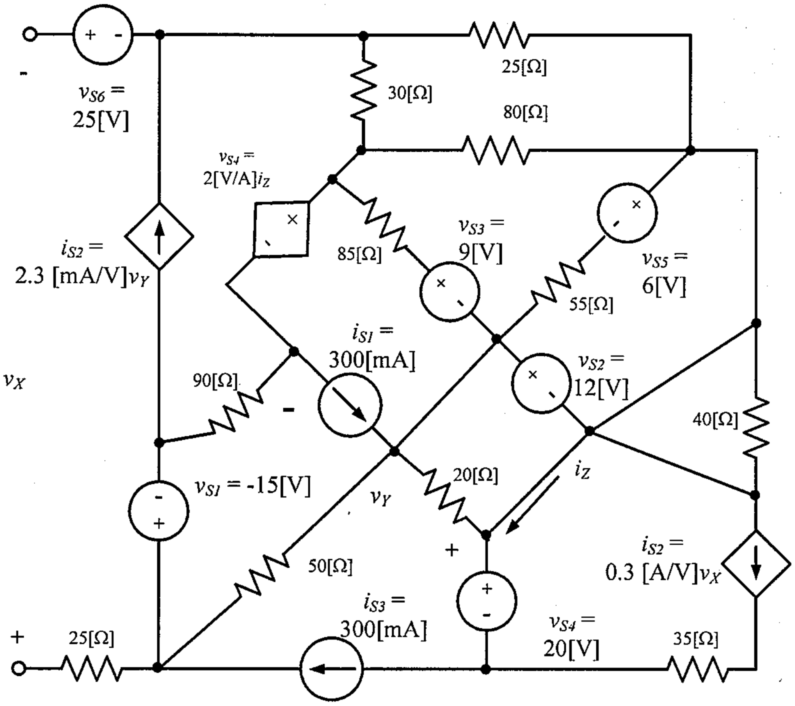
3. (30 points) When a voltmeter V with a resistance of 60 [kΩ] and a full scale reading of 100 [V] is connected to the terminals a), b) of the circuit below, the meter reads $v_m = 32.57$ [V]. The meter and the polarity of v_m are shown. If the voltmeter is disconnected, and an ammeter A with a resistance of 14 [Ω] and a full scale reading of 100 [mA] is connected to a), b), the ammeter reads $i_m = 46.80$ [mA]. The meter and the polarity of i_m are also shown. The current source i_S and resistance R_X are not given.

If the meters are removed and a 100 [Ω] resistor is placed across the terminals as shown, what is the value of i_O?



Room for extra work

4. (25 points) Use the Node Voltage Method to write a complete set of equations that could be used to solve the circuit below. Do not attempt to simplify the circuit. Do not attempt to solve the equations.



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1. ________________/20

2. ________________/25

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4. ________________/25

Room for extra work

(Prob 2 Con't)

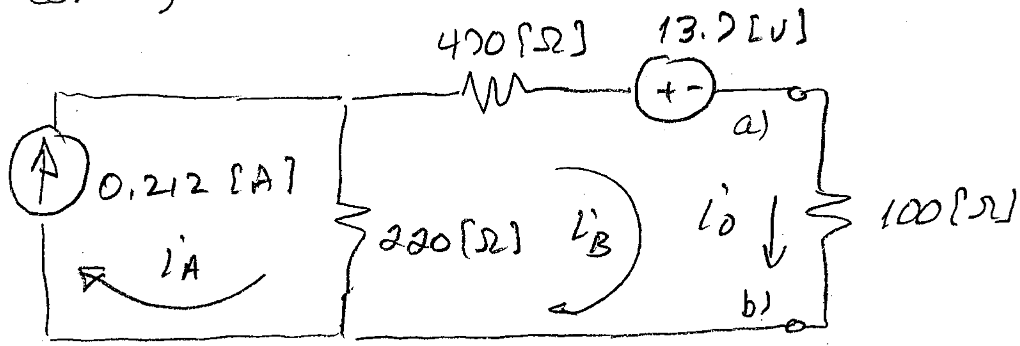
$$v_{is_1} + 110\, i_x + 470\,(i_x - i_y) + v_x = 0$$

$$v_{is_1} = -110\, i_x - 470\,(i_x - i_y) - v_x = -7.1522\ [v]$$

$$P_{del\ by\ is_1} = -v_{is_1} \cdot 0.2 v_x = -28.26\ [mW]$$

$$P_{del\ by\ v_{s2}} = v_{s2} \cdot i_3' = -47.18\ [mW]$$

(Prob 3 con't)



$$i_A' = 0.212\ [A]$$

$$470\, i_B' + 13.7 + 100\, i_B' + 220\,(i_B' - i_A') = 0$$

$$i_B' = i_o' = 41.696\ [mA]$$

V eqn	+ 10
A eqn	+ 10
solve	+ 3
R eqn	+ 7

1. (20 points) A new and improved version of the Trombetterator QX4 (the QX4.1) is found to have the following terminal voltage and current when connected to a particular circuit. The voltage and current, v_x and i_x, are defined in the figure.

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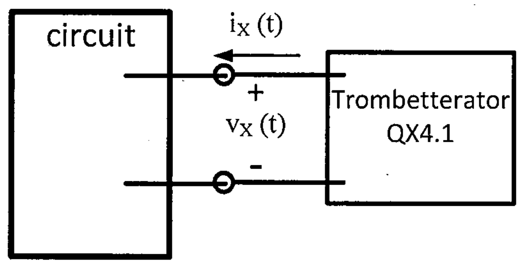


Power delivered by trombetterator (T) is

$$P_{del\ by\ T} = v_x(t) \cdot i_x(t) = -0.2319\,[W]\,e^{-3.35\,[ms]^{-1}t}$$ +5

$$W_{del\ by\ T} = \int_{0.1\,[ms]}^{0.5\,[ms]} v_x(t) \cdot i_x(t)\,dt = -0.2319 \int_{0.1[ms]}^{0.5[ms]} e^{-3.35[ms]^{-1}t}\,dt$$ +5

$$= -0.2319\,[W]\left(\frac{-1}{3.35\,[ms]^{-1}}\right) e^{-3.35\,[ms]^{-1}t}\Big|_{0.1\,[ms]}^{0.5\,[ms]}$$

$$= 0.06922\,[mJ]\,(0.1873 - 0.7153)$$

$$W_{del\ by\ T} = -0.03655\,[mJ] = -36.55\,[\mu J]$$

+5 units

+5 math

NVM (5) MC (4)

NVM/MCM eqns +3 eq +3eq

soln. +4 +3

2. (25 points) For the circuit below, find:

i) the power delivered by the current source i_{S1};

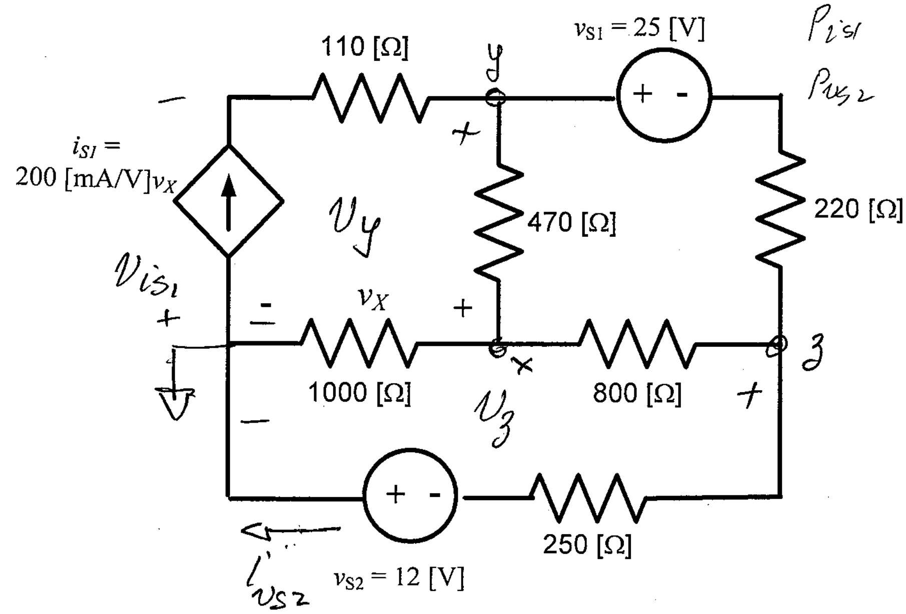
ii) the power delivered by the voltage source v_{S2}.

KVL i_{S1} +3 +3

KCL v_{S2} +3 +1

P_{is1} +2 +1

P_{vs2} +2 +1



If we choose NVM, and choose the reference as shown, v_x is one of the node voltages. Then:

x: $$\frac{v_x}{1000} + \frac{v_x - v_z}{800} + \frac{v_x - v_y}{470} = 0$$

y: $$\frac{v_y - v_x}{470} + \frac{v_y - v_z - 25}{220} - 0.2\,v_x = 0$$

z: $$\frac{v_z - v_x}{800} + \frac{v_z - v_y + 25}{220} + \frac{v_z + 12}{250} = 0$$

$v_x = -0.01976$ [V]

$v_y = 7.5869$ [V]

$v_z = -12.983$ [V]

Now, $v_{is1} + 110(0.2v_x) + v_y = 0 \Rightarrow v_{is1} = -7.1522$ [V]

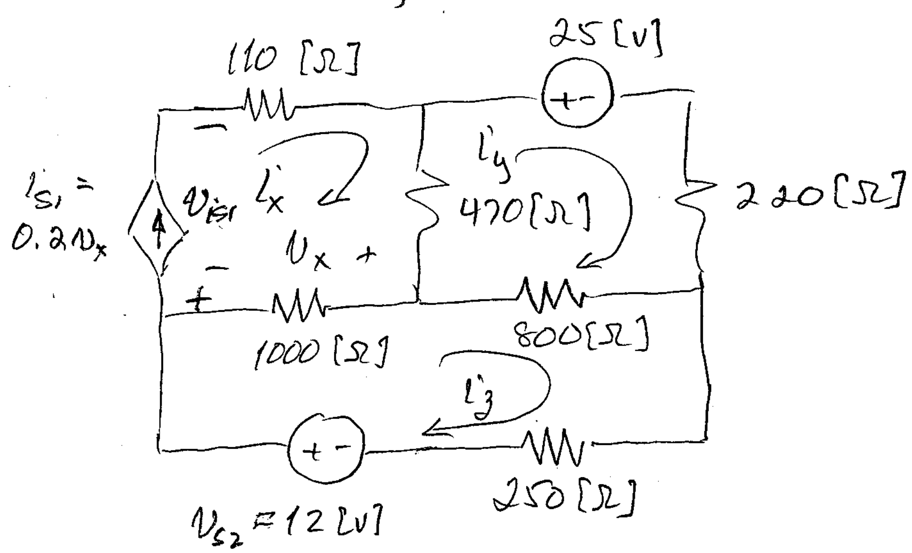
$P_{del\ by\ is1} = -v_{is1} \cdot (0.2\,v_x) = -28.26$ [mW]

Room for extra work

$$i_{vs2} = \frac{v_3 + 12}{250} = -3.932 \text{ [mA]}$$

$$P_{del\ by\ vs2} = v_{s2} \cdot i_{vs2} = 12(-3.932 \times 10^{-3}) = -47.18 \text{ [mW]}$$

Let's re-do using MCM:



x: $i_x = 0.2 v_x$ y: $25 + 220\, i_y + 800(i_y - i_3) + 470(i_y - i_x) = 0$

3: $1000(i_3 - i_x) + 800(i_3 - i_y) + 250\, i_3 - 12 = 0$

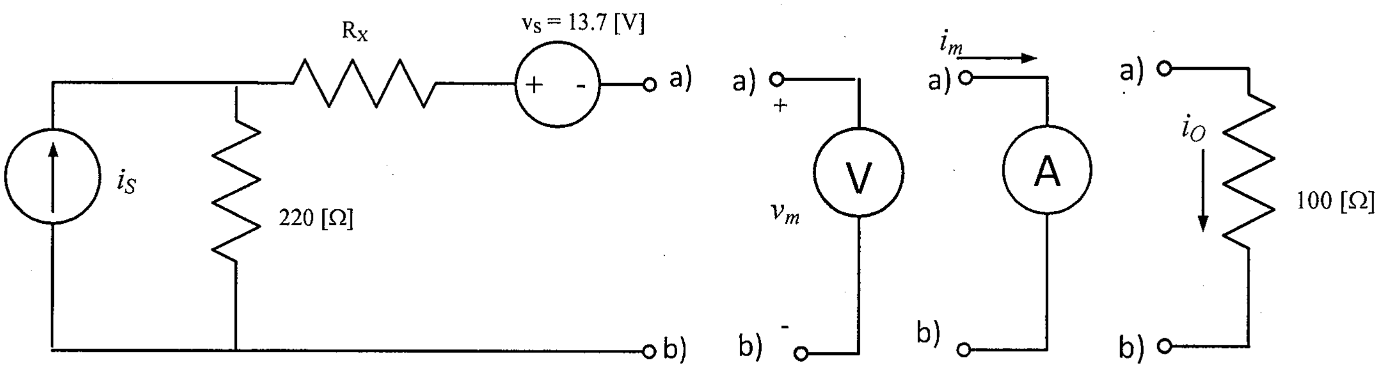
v_x: $v_x = 1000(i_x - i_3)$ $i_x = -3.952$ [mA] $i_3 = -3.932$ (mA)

$i_y = -20.136$ [mA] $v_x = -19.76$ [mV]

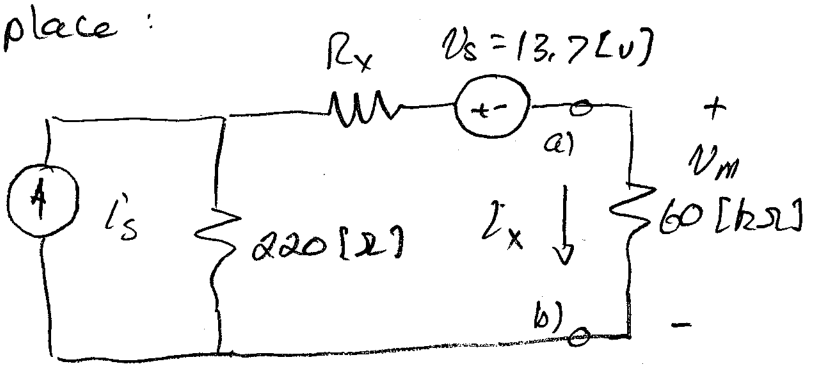
pg. 2

3. (30 points) When a voltmeter V with a resistance of 60 [kΩ] and a full scale reading of 100 [V] is connected to the terminals a), b) of the circuit below, the meter reads v_m = 32.57 [V]. The meter and the polarity of v_m are shown. If the voltmeter is disconnected, and an ammeter A with a resistance of 14 [Ω] and a full scale reading of 100 [mA] is connected to a), b), the ammeter reads i_m = 46.80 [mA]. The meter and the polarity of i_m are also shown. The current source i_S and resistance R_X are not given.

If the meters are removed and a 100 [Ω] resistor is placed across the terminals as shown, what is the value of i_O?



We start by drawing the circuit with the voltmeter in place:



$v_m = 32.57$ [V]

So we can set up an equation for i_s & R_x. We will have another equation from the circuit with the ammeter in place and we can solve for i_s & R_x:

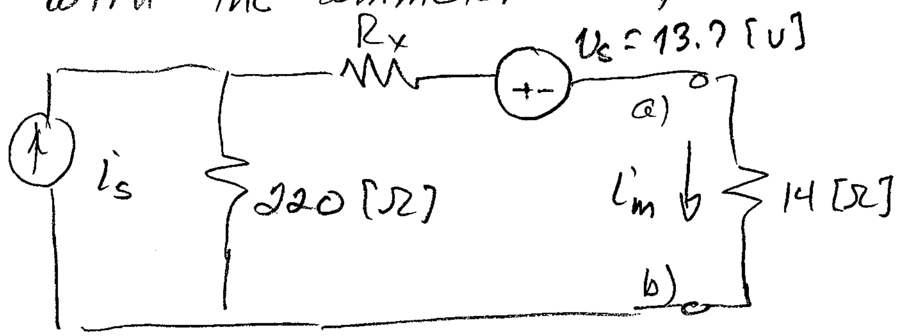
$$i_x = \frac{v_m}{60[k\Omega]} = 0.5428 \text{ [mA]}$$

Room for extra work

KVL: $i_x' R_x + 13.7 + V_m - 220(i_s' - i_x') = 0$ (1)

We need to be careful here: We need to write our equations in terms of R_x and i_s' because these remain constant no matter what is connected to a), b). If I were to define, say, the current in 220 [Ω] and solve for that, I would not get the right answer because this current changes depending on what is connected to the circuit.

Now with the ammeter in place...



$i_m = 46.80$ [mA]

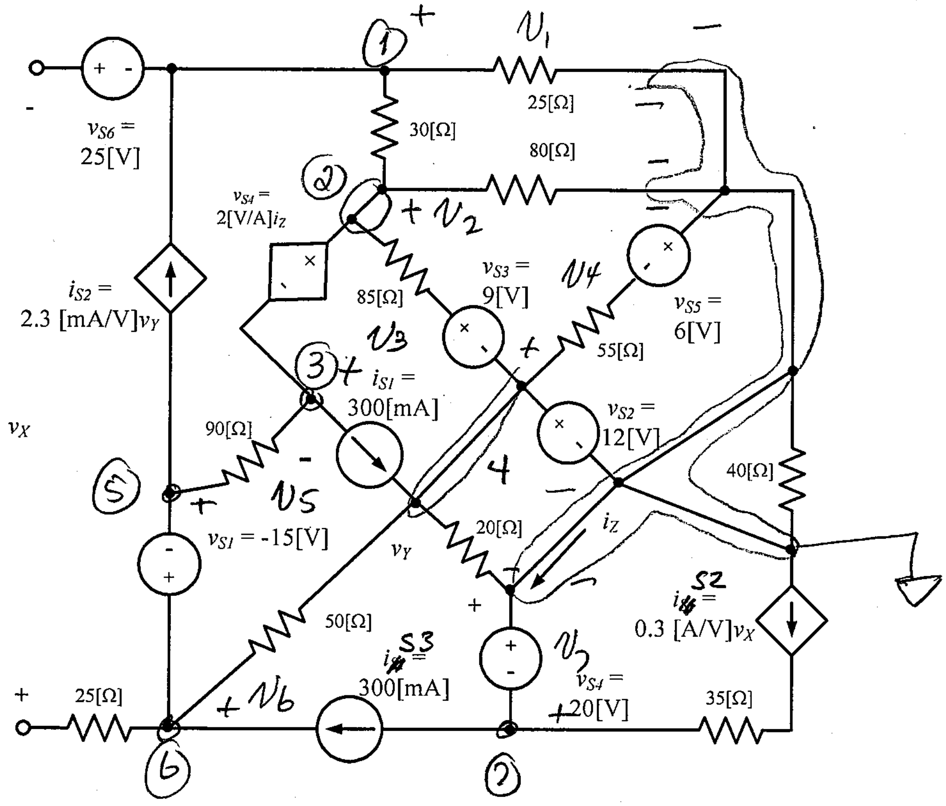
KVL: $i_m R_x + 13.7 + 14 i_m - 220(i_s - i_m) = 0$ (2)

Solving (1) and (2) gives $R_x = 470$ [Ω] $i_s' = 0.212$ [A]

Now we can connect 100 [Ω] ...

Pg 2 bottom

4. (25 points) Use the Node Voltage Method to write a complete set of equations that could be used to solve the circuit below. Do not attempt to simplify the circuit. Do not attempt to solve the equations.



+3 ① $\frac{v_1 - v_2}{30} + \frac{v_1}{25} - 2.3\times10^{-3} v_Y = 0$

+4 ② ③ $\frac{v_2}{80} + \frac{v_2 - v_1}{30} + \frac{v_2 - 9}{85} + \frac{v_3 - v_5}{90} + 0.3 = 0$

+2 $v_2 - v_3 = 2 i_3$

+3 v_X: $v_X + 25 + v_1 - v_6 = 0$

+3 i_3: $-i_3 + 0.3 - 0.3 v_X - \frac{v_4}{20} = 0$

+2 v_Y: $v_Y + v_3 = 0$

+1 ④ $v_4 = 12$ [v]

+4 ⑤ ⑥ $\frac{v_5 - v_3}{90} + 2.3\times10^{-3} v_Y + \frac{v_6 - v_4}{50} - 0.3 = 0$

+2 $v_5 - v_6 = +15$ [v]

+1 ⑦ $v_7 = -20$ [v]