**Name of Student** ________Li Xianzhe ____________ **Score** ________________

**Student Number** ________2022214880___________ **Date** _________________

# EE 188L Lab 4: Node-Voltage & Mesh-Current Analysis

## EE 188L Electrical Engineering I

NAU + CQUPT (Fall 2021)


**Summary**

The purpose of this lab is first to show with measurements that **Kirchhoff's Current Law** (**KCL**) and **Kirchhoff's Voltage Law (KVL**) can be used to analyze a circuit by writing **Nodal & Mesh Equations**. The measurements of currents **leaving** each node will add to **zero** as required by **KCL**. The student will then treat the measured voltages (with respect to the reference node) as unknowns, and solve for those voltages by Node-Voltage or (Nodal Analysis) Method. Measured and calculated voltages will be compared.

Also, mesh-current equations will be written around the 3 meshes in the circuit using the measured resistances. The simultaneous equations formed will be solved in **Excel or Matlab** to derive individual mesh currents. These will then be compared to actual measured branch currents.


## I. Test bench equipment

**Dual DC Power Supply:**
The **Dual DC PS** has **two independent** ideal voltage sources that can provide voltages at the same time: 0 to+15VDC and 0 to -15VDC. For this experiment, **both** power supplies are used at the same time. The method to produce a **+5VDC** will be explained by the **Instructor**.

**Digital Multimeter (DMM):** The DMM is capable of **measuring resistances**, **voltages** and **currents**. The **DMM** measurement procedures will be discussed by the **Instructor**.

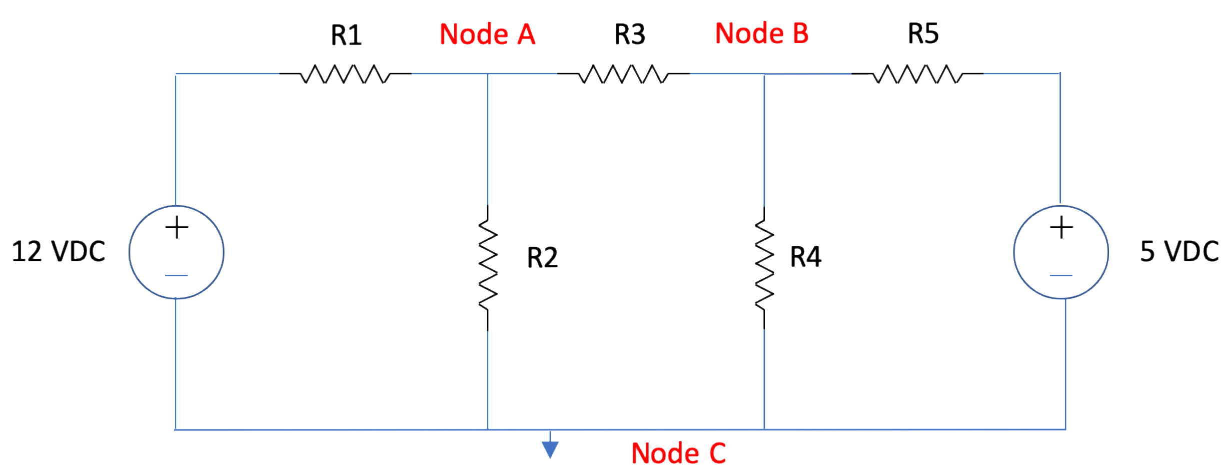
## II. Measuring Resistance

Locate 5 resistors with the values given below; **measure** the **actual resistance** with the **DMM** in **Resistance mode**. Record the **actual values** to 2 decimal places (for example if $R_2$ measures=> 2.7132k, use 2.71k):

**$R_1$ = 3.9k =>** ____3.858kΩ____________**(measured)**
**$R_2$ = 6.8k =>** ____6.788kΩ____________**(measured)**
**$R_3$ = 1.3k =>** ____1.304kΩ____________**(measured)**
**$R_4$ = 2.7k =>** ____2.701kΩ____________**(measured)**
**$R_5$ = 1.8k =>** ____1.778kΩ____________**(measured)**

## III. Circuit

On the **BB** put resistors **$R_1$, $R_2$, $R_3$, $R_4$, $R_5$** and the **two Power Supplies (PS)** as shown in the schematic below. **Note: Make the two PS independent as explained by the Instructor.**




Adjust the PS **voltage**, **$V_1$**, of the **PS** to **$V_1$ = +12V** with respect to its own reference. **→ Measure with the DMM to be sure!**

Adjust the PS **voltage**, **$V_2$**, of the **PS** to **$V_2$ = +5V** with respect to its own **reversed reference**, by **using the black as the + reference** and the **red as the – reference. → Measure with the DMM to be sure!**

## IV. KCL and Node-Voltage Analysis

Choose node C for nodal voltages' reference zero.

Measure and record voltages $V_A$ (at node A) and $V_B$ (at node B) with respect to reference zero at node C.

**$V_A$ =** ___________5.292V_______________(measured)
**$V_B$ =** ___________4.038V_________________(measured**)**

At **node A measure and record** the **currents leaving the node**.

➔ **Listen to the Instructor's explanation on how to connect the DMM in series in a circuit to measure current.**

**$I_{LeftA}$** = ________-1.740mA_________________
**$I_{RightA}$** = _______0.960mA__________________
**$I_{DownA}$** = _______0.780mA__________________
**$I_{TotalNodeA}$ = $I_{Left}$ + $I_{Right}$ + $I_{Down}$** = _____0mA_____ (Should be close to 0)

At **node B measure and record** the **currents leaving the node**.

**$I_{LeftB}$** = ______-0.959mA____________________
**$I_{RightB}$** = _____-0.535mA____________________
**$I_{DownB}$** = _____1.495mA_____________________
**$I_{TotalNodeB}$ = $I_{Left}$ + $I_{Right}$ + $I_{Down}$** = __0.001mA__ (Should be close to 0)

**Nodal Analysis:**

Set-up the **Nodal Equations** by treating **$V_A$, $V_B$** as **unknowns** and applying **KCL** at **nodes A, B**.

Node-voltage equations:

Node A

$(12-V_A)/R_1=V_A/R_2+(V_A-V_B)/R_3$

$(12-V_A)/3858= V_A/6788+(V_A-V_B)/1304$

(1/6788+1/1304+1/3858)VA-1/1304VB=12/3858

0.001173392VA-0.000766871VB=0.00311042

Node B

$(V_A-V_B)/R_3=(V_B-5)/R_5+V_B/R_4$

$(V_A-V_B)/1304=(V_B-5)/1778+V_B/2701$

1/1304VA-(1/1304+1/1778+1/2701)VB=-5/1778

0.000766871VA-0.001699534VB=-0.002812148

**NOTE: Use the measured values of $R_1$, $R_2$, $R_3$, $R_4$, $R_5$, NOT the listed values when setting up the equations!**

**$V_A$ =** ___________**5.29V**____________________(calculated)
**$V_B$ =** ___________**4.04V**____________________(calculated)

**Compare** the **calculated values** to the **measured values**.
(They should be pretty close!)

## V. Questions and Mesh-current analysis

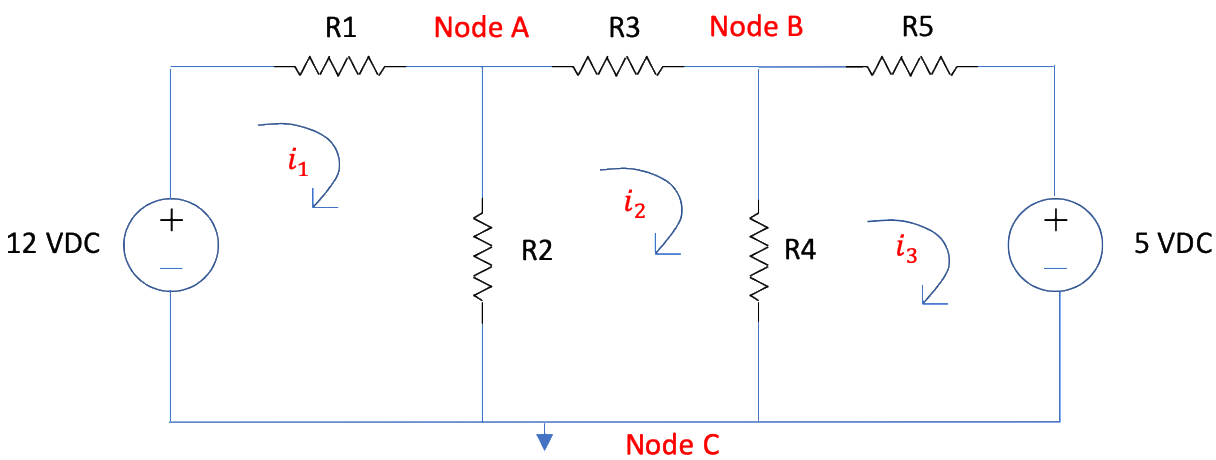
**A. Node-Voltage analysis** is a very powerful method to analyze circuits by generating **independent** equations. The **measured currents** leaving each node must add up to zero. **Why?**

Due to KCL, the current flowing into the node is the same as the current flowing out of the node.

**B.** We also have learned in class how to solve circuits with **Mesh Current analysis** by generating **independent** equations using **KVL**. Next, solve this circuit by **mesh analysis**.

➔ First, Form 3 meshes & generate equations for $\boldsymbol{i_1}$, $\boldsymbol{i_2}$, & $\boldsymbol{i_3}$.

➔ **<u>NOTE</u>: Use the <u>measured</u> values of $R_1$, $R_2$, $R_3$, $R_4$, $R_5$ <u>NOT</u> the listed values when setting up the equations!**




<u>Mesh-current equations:</u>

Mesh 1:

$12=R_1i_1+R_2(i_1-i_2)$

$12=3858i_1+6788(i_1-i_2)$

10646i1-6788i2=12

Mesh 2:

$R_2(i_1-i_2)=R_3i_2+R_4(i_2-i_3)$

$6788(i_1-i_2)=1304i_2+2701(i_2-i_3)$

6788i1-10793i2+2701i3=0

Mesh 3:

$(i_2-i_3)R_4=R_5i_3+5$

$(i_2-i_3)2701=1778i_3+5$

2701i2-4479i3=5

- ➔ **Solve for *$i_1$*, *$i_2$*, & *$i_3$* using Excel or Matlab**
- ➔ Use Excel's MMULT & MINVERSE formulas, or Matlab, to solve the simultaneous equations.
- ➔ **Attach** your Excel or Matlab printout!

- ➔ Write ***$i_1$*** = 0.001738A    *$i_2$* = 0.000959    *$i_3$* = -0.000538
- ➔ **Does (*$i_1 - i_2$*) *$R_2$** = 5.289V **= $V_A$** from the **Nodal Analysis?**  Yes.
- ➔ **Does (*$i_2 - i_3$*) *$R_4$** = 4.043V **= $V_B$** from the **Nodal Analysis?**  Yes.

*Solving simultaneous equations*

**Mesh current equations - coefficients**

| | | | | | |
|---|---|---|---|---|---|
| | 10646 | -6788 | 0 | | 12 |
| A | 6788 | -10793 | 2701 | B | 0.000 |
| | 0 | 2701 | -4479 | | 5 |

| | | | |
|---|---|---|---|
| | 0.001738 | i1 | I1 |
| | 0.000959 | i2 | I2 |
| Amps | -0.000538 | i3 | I3 |

**Branch currents**

| | At node 1 | At node 2 |
|---|---|---|
| Current In | 0.001738 | 0.000959 |
| | (I1) | (I2) |
| Currents Out | 0.001738 | 0.000959 |
| | (I2+I4) | (I3+I5) |

| | |
|---|---|
| 0.00078 | I4 |
| 0.00150 | I5 |

**Node voltage equations - coefficients**

| | | |
|---|---|---|
| 0.00117339 | -0.0007669 | 0.00311042 |
| 0.00076687 | -0.0016995 | -0.0028121 |

| | | |
|---|---|---|
| | 5.29 | v1 |
| Volts | 4.04 | v2 |

Note how the MMULT formulas are written!

**Important: Get the lab instructor's signature & date below, no signature means no marks!**

Signature of instructor ______________________  Date: _____________

Name of student ______________________  Date: _____________

Name of Student Li Xianshe Score ______

Student Number 20222148880. Date ______

due 23/10

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