“Fundamentals on Voltage and Current”

1.1 Ohm’s Law

\[ V = IR \quad I = \frac{V}{R} \quad R = \frac{V}{I} \]

1.2 KCL, KVL

KCL

\[ \text{sum of current is “0”} \]

KVL

\[ V_1 = V_2 \]

1.3 Mesh Analysis, Node Analysis

Mesh Analysis

\[ \Sigma V = 0 \]

Node Analysis

\[ \Sigma I = 0 \]

1.4 Volt Meter, Current Meter

Measurement accuracy of volt/current meter decides their require impedance.

Volt Meter

High-Z

* Z : Impedance

Volt Meter

Low-Z
1.5  **Ideal Voltage / Current Source**

- Ideal Voltage Source
- Ideal Current Source

**Q.1** What is the value of $V_1$ and $V_2$?

(a) $V_1 = 1V$

(b) $V_2 = 1V$

**Q.2** What is the value of $I_1$ and $I_2$?

(a) $I_1 = 1mA$

(b) $I_2 = 100A$

Holds CONSTANT voltage (no matter what the current is.) $\rightarrow$ Ideal Voltage Source

Emits CONSTANT current (no matter what the voltage is.) $\rightarrow$ Ideal Current Source

**Then, what is the " Non-Ideal Voltage/Current sources " ?**

Voltage varies (a little bit) depending on the current going through $\cdots \cdots$ Actual Voltage Source.

Current varies (a little bit) depending on the voltage drop across it $\cdots \cdots$ Actual Current Source

“A little bit” is not always true.

Sometimes we can not tell voltage source from current source. ( $\rightarrow$ Norton / Thevenin Equivalent Ckt )

we can classify them by their impedance.
Q. 3 What are the V1-2 and I1-2?

(a)  

\[ V_1 \]
\[ 1k\Omega \]
\[ V \]
\[ 1V \]
\[ 1k\Omega \]
\[ 1mA \]
\[ 100\Omega \]

(b)  

\[ V_2 \]
\[ 100\Omega \]
\[ V \]
\[ 1V \]
\[ 1k\Omega \]
\[ 1k\Omega \]

(c)  

\[ I_1 \]
\[ 1k\Omega \]
\[ I \]
\[ 1mA \]
\[ 100\Omega \]
\[ 100\Omega \]

(d)  

\[ I_2 \]
\[ 100\Omega \]
\[ I \]
\[ 1mA \]
\[ 1k\Omega \]

Q. 4 What are the V3 and I3?

(a)  

\[ V_3 \]
\[ 0.90909\Omega \]
\[ V \]
\[ 1V \]
\[ 1k\Omega \]
\[ 1k\Omega \]

(b)  

\[ V_3 \]
\[ 1.3333k\Omega \]
\[ 1.3333k\Omega \]

Q. 5 Calculate open voltage, short currents, and source impedance.

1.6 Norton, Thevenin Equivalent Circuits

Any independent voltage source, independent current source, and linear resistor can be uniformly expressed as Norton/Thevenin equivalent circuit.

V (open voltage): Max Voltage which the source can output
I (short current): Max Current which the source can output
R (source impedance): Impedance which can be seen from the output.

\[ V = RI \]

This needs to be true under any circumstances. Think about extreme cases, e.g. open/short output.
Q.6 Calculate $V_{10}$, $V_{11}$, $I_{10}$, $I_{11}$.

(a) \[\begin{align*}
&\text{1V} \\
&\quad \quad \quad \quad 1k\Omega \\
&\quad \quad \quad \quad V_{10} \\
&\quad \quad \quad \quad 100\mu A
\end{align*}\]

(b) \[\begin{align*}
&\text{1V} \\
&\quad \quad \quad \quad 1k\Omega \\
&\quad \quad \quad \quad V_{11} \\
&\quad \quad \quad \quad 500\mu A
\end{align*}\]

(c) \[\begin{align*}
&\text{1mA} \\
&\quad \quad \quad \quad 1k\Omega \\
&\quad \quad \quad \quad 0.1V
\end{align*}\]

(d) \[\begin{align*}
&\text{1mA} \\
&\quad \quad \quad \quad 1k\Omega \\
&\quad \quad \quad \quad 0.5V
\end{align*}\]

Q.7 Calculate $V_{\text{out}} / I_{\text{out}}$ (Impedance)

Q.8 Calculate $I_{\text{out}} / V_{\text{out}}$ (Conductance)

The ratio of loading impedance $R_2$ and source impedance $R_1$ decides whether the source is voltage source or current source.

<table>
<thead>
<tr>
<th>$R_2/R_1$</th>
<th>$V_{\text{out}}$</th>
<th>$I_{\text{out}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_2 &gt;&gt; R_1$</td>
<td>$V_{\text{out}} \propto R_2$</td>
<td>$I_{\text{out}} \propto 1/R_2$</td>
</tr>
<tr>
<td>$R_2 &lt;&lt; R_1$</td>
<td>$V_{\text{out}} \propto V$</td>
<td>$I_{\text{out}} = I$</td>
</tr>
</tbody>
</table>

↑ ↓ Assume $V = RI$, and they are same circuit !!!

Loading decides voltage
Loading decides current
Q. 8 Suppose that you are given a circuit which consists of ideal voltage sources and resistances.
- You measured voltage without any loading, the volt meter pointed to 2V.
- You inserted 1kOhm of resistance, and measured voltage drop across the resistance. Volt meter pointed to 1.8V
Guess the structure of the circuit.

Q. 9 Calculate open voltage V1.

Q. 10 Calculate short current I1

Q.11 Calculate V1

Solution: “Apply Norton/Thevin idea!”