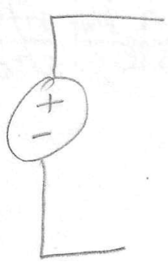
Review Notes for Stream

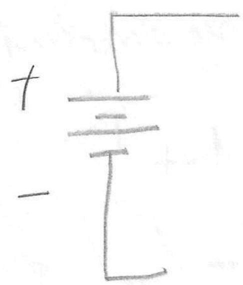
Make Lecture Notes After Reviewing

→ Use Mystery Persuasion while writing Notes

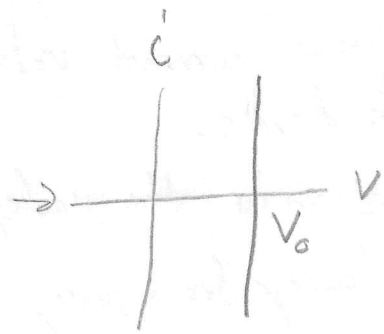
Chapter 2 Ideal Sources



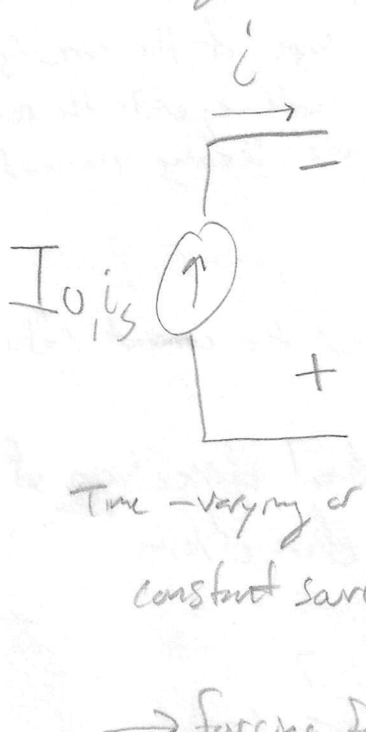
Time varying



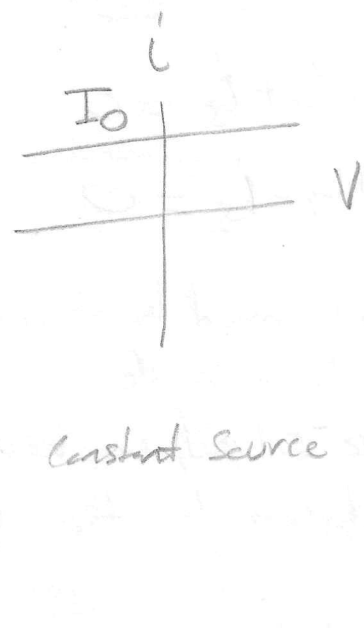
Constant



i-v-plot for constant



Time-varying or constant source



Constant source i-v characteristics

→ forcing function, driving function

→ represents an input that causes a circuit response

For Analysis & Design of Linear circuits → DC: V, AC: V(t)

for Circuit Analysis and Design → DC: V, AC: v

②

Kirchhoff's current Law (KCL)

→ the algebraic sum of the currents entering a node is zero at every instant

node → an equipotential

$$\sum_{n=1}^{N} i_n = 0 \quad \text{(KCL)}$$

N = total # of branches connected to the node

i_n is the nth current

- we must know current reference direction associated with each device.
- if current is into the node, '+'
  " away from node, '−'

$$A: -i_1 - i_2 = 0$$
$$i_1 - i_3 - i_4 + i_5 = 0$$
$$i_2 + i_3 + i_4 - i_5 = 0$$

The sum of the currents entering a node equals the sum of the currents leaving the node

→ '+' or '−' determined by the orientation of the current reference direction relative to a node

→ when equations are solved, we have the actual direction of the current relative to the reference direction

for $i_1 = 4\,A$, $i_3 = 1\,A$, $i_4 = 2\,A$ $\quad i_2?\ i_5?$

$-i_1 - i_2 = 0 \rightarrow i_2 = -4\,A$ $\quad i_2$ is actually going into A

$i_1 - i_3 - i_4 + i_5 = 0 \rightarrow i_5 = i_4 + i_3 - i_1$
$= 2 + 1 - 4$
$= -1 \rightarrow i_5 = -1A$, comes out of B

Note

$i_2 + i_3 + i_4 - i_5 = 0$ is from

$$-i_1 - i_2$$

$$+$$

$$i_1 \quad -i_3 - i_4 + i_5$$

$$\underline{-i_2 - i_3 - i_4 + i_5 = 0}$$

$-(A+B) = C$

C is not independent of A, B

→ In a circuit containing a total of N nodes, there are only N − 1 independent KCL connection equations

→ So select one Node as ground (reference) the get KCL equations from (N − 1) nodes

[Self Q, does Ulaby mention this?]

[Does nilsson mention this?]

Kirchoffs' Voltage Law

based on conservation of Energy

The algebraic sum of all the voltages around a Loop is zero at every instant

$$\sum_{n=1}^{N} V_n = 0$$

N = Total number of branches in the Loop

V_n is nth voltage across the nth branch

p 24, Figure 2-13 – In writing the algebraic sum of voltages, we must account for the assigned reference marks

→ Positive for + → −

→ Negative for − → +

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eq 2-10

L1: $V_2 + V_3 - V_1 = 0$

L2: $V_4 + V_5 - V_3 = 0$

L3: $V_2 + V_4 + V_5 - V_1 = 0$

If a Voltage is positive, Then it agrees with the reference. Polarity wise

Solve KVL for $V_1 = 5V$, $V_2 = -3V$, $V_4 = 10V$

V_3?, V_5?

$$V_3 = V_1 - V_2 = 8V$$

$$V_5 = V_3 - V_4 = -2V$$

We found using KVL constraints

Loop 3 is valid eq but has no new info cuz $L1 + L2 = L3$

L3 is not independent of L1 or L2

In a circuit containing a total of $\mathcal{E}$ two-terminal elements and N nodes, there are only $\mathcal{E} - N + 1$ independent KVL connection equations

→ A sufficient condition for a Loop to be different is that each contains at least one element that is not contained in any other Loop

nodes

$$\mathcal{E} - N + 1 = 2$$

$$\mathcal{E} - N = 1 \quad N = 4 \quad \mathcal{E} = 5$$

for 2-13 devices

p26 Parallel and Series Connections

p28 Combined constraints

We want to know V and I at various places in the circuit

element constraints are based on the models of the specific devices connected in the circuit

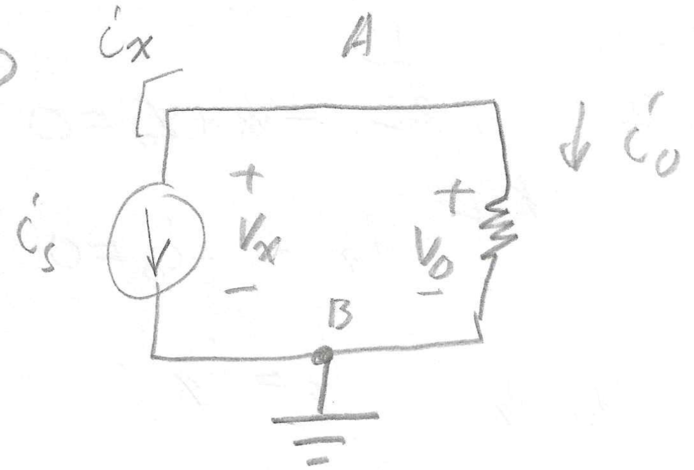
- based on Kirchhoff's Laws and circuit connection

So we know:

$i_x = i_s$

$V_0 = R i_0$

2-20



combined restraint circuit

$\mathcal{E} = 2$ element

$N = 2$ nodes

So $\mathcal{E} - N + 1 = 1$ KVL

$N - 1 = 1$ KCL

(at A) KCL: $-i_x - i_0 = 0$

KVL $-V_x + V_0 = 0$

$i_0 = -i_x = -i_s \rightarrow V_0 = -R i_s$

[if i_s is '+' then V_0 is '−']

Not i-v relationship

→ input-output relationship

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$i_s = +2mA \quad R = 2k\Omega$

$i_x, v_x, i_o, V_o?$

$V_o = V_x = -(2\times10^3)(2\times10^{-3}) = -4\ V$

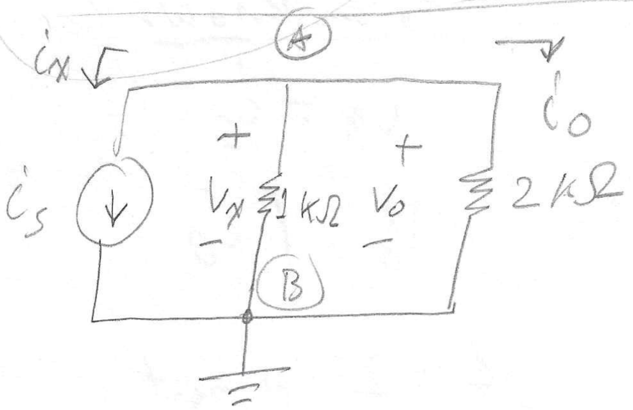
$i_o = -2mA$

$i_s = -2mA$

$i_x = -2mA$

$V_o = V_x = 4\ V$

$i_o = -i_x = 2mA$



KVL $3 - \cancel{2} + 1 = 2$

1L

2L: $-V_x + V_o = 0$

KCL $-i_x - i - i_o = 0$

$i_s = i_x$

i_x, V_x, i_o, V_o

$V_o = V_x$

$V_o = 2\times10^3 (i_o)$

$$-\frac{V_x}{1k\Omega} - \frac{V_o}{2k\Omega} = i_x$$

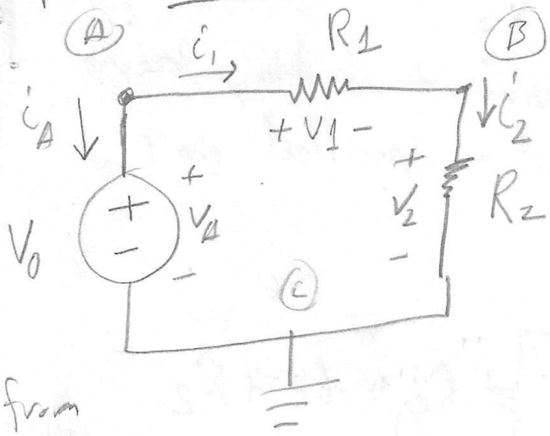
$-2i_o - i_o = -3i_o = i_x$

$V = IR \qquad V_x = 2k\Omega\, i_o$

$\frac{V}{R} \qquad I = \frac{2k\Omega}{1k\Omega} i_o = 2i_o \rightarrow -i_x - i - i_o = 0$

$3i_o - 2i_o - i_o$

p30 2-21



$V_A = V_0$
$V_1 = i_1 R_1$
$V_2 = i_2 R_2$

KCL
A: $-i_A - i_1 = 0$
B: $-i_2 + i_1 = 0$

KVL
L1: $V_1 + V_2 - V_A = 0$

from ohms Law

Elemental equations	$\mathcal{E}$	$\mathcal{E}$ = # of Element
KCL equations	$N-1$	N = # of nodes (incl. GND)
KVL equations	$\mathcal{E}-N+1$	
	$2\mathcal{E}$ ← Total Equations	

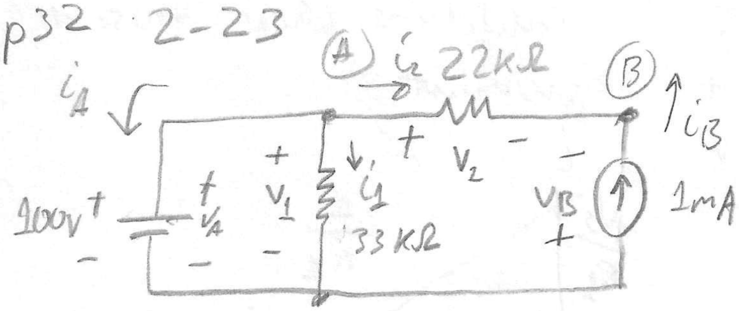
$i_1R_1 + i_2R_2 - V_0 = 0$

$i_1R_1 + i_1R_2 - V_0 = 0 \rightarrow V_0 = i_1(R_1+R_2)$

$i_1 = \frac{V_0}{R_1+R_2} = \frac{10}{2K\Omega + 3K\Omega} = \frac{1}{500} = 2mA = i_2 = i_1$

$-i_A = i_1 = -2mA$

p32 2-23



A: $-i_A - i_2 - i_1 = 0$
B: $i_2 + i_B = 0$

$V_1 - V_A = 0$
$V_2 - V_B - V_1 = 0$

ohm's Law assumes that the passive sign convention is used to assign the voltage and current reference marks to a device p34, 35

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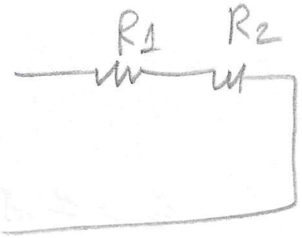
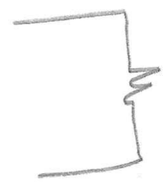
Equivalent circuits p36

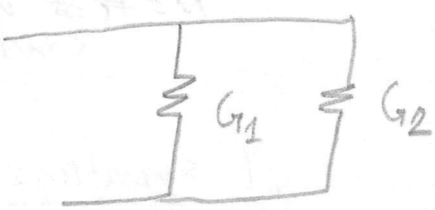
→ Two circuits are said to be equivalent if they have identical i-v characteristics at a specified pair of terminals



→



$R_{eq} = R_1 + R_2$



→

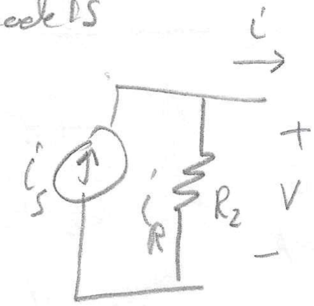
$G_{eq} = G_1 + G_2$

$$R_1 \| R_2 = R_{eq} = \frac{1}{G_{eq}} = \frac{1}{G_1 + G_2} = \frac{1}{R_1^{-1} + R_2^{-1}} = \frac{R_1 R_2}{R_1 + R_2}$$

Equivalent sources p39

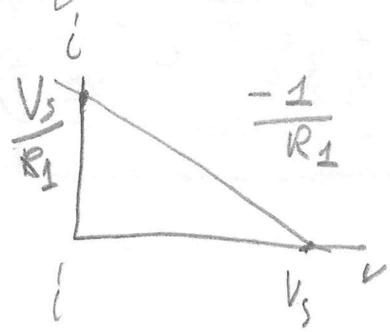
Practical source models

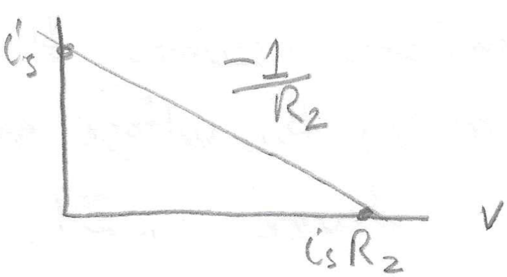
A



B

conditions where these are equivalent





KVL

$V_R = V_s - V$ | $V_s = V_R + V$

$V_R = R_1 i$

$i = \frac{V_R}{R_1}$

$i = \frac{V_s}{R_1} - \frac{V}{R_1}$

KCL

$i_s = i_R + i$

$i_R = \frac{V}{R_2}$

$i = i_s - \frac{V}{R_2}$

we need

$$V_s = i_s R_2 \quad , \quad i_s = \frac{V_s}{R_1}$$

So $R_1 = R_2 = R \rightarrow V_s = i_s R$

A

$$i = -\frac{V}{R} + \frac{V_s}{R}$$

B

$$i = -\frac{V}{R} + \frac{V_s}{R}$$

i_s

Exchanging one practical source model for an equivalent model is called source transformation

→ Either models will deliver the same voltage and current to the rest of the circuit

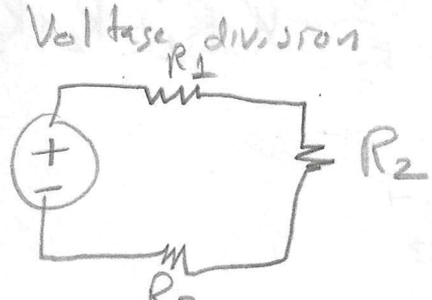
→ Do not have same internal power loss (p 40)

Summary p 42

Voltage and Current Division

p 44

Voltage division



2-38

$$V_s = V_1 + V_2 + V_3$$
$$= R_1 i + R_2 i + R_3 i$$
$$\rightarrow i = \frac{V_s}{R_1 + R_2 + R_3}$$

Voltage across each resistor

$$V_1 = R_1 i = \left(\frac{R_1}{R_1 + R_2 + R_3}\right) V_s$$

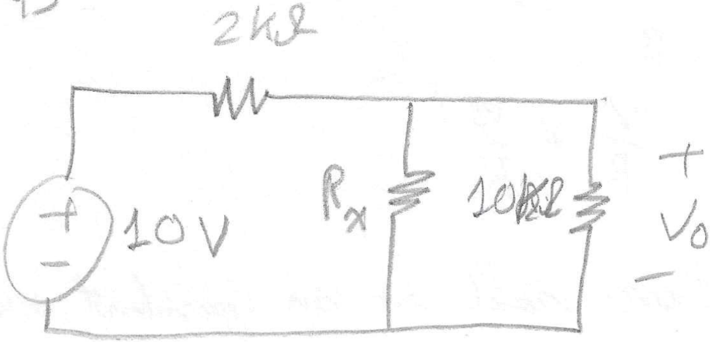
$$V_2 = R_2 i = \left(\frac{R_2}{R_1 + R_2 + R_3}\right) V_s$$

$$V_3 = R_3 i = \left(\frac{R_3}{R_1 + R_2 + R_3}\right) V_s$$

so write voltage division rule

$$V_K = \left(\frac{R_K}{R_{eq}}\right) V_{Total} \qquad (2-31)$$

ex) p 45



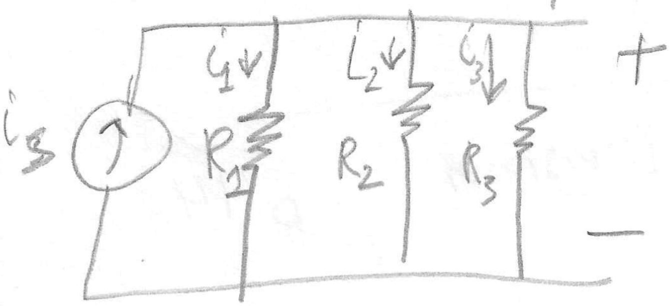
$V_o = 8V$

$$\rightarrow V_o = \left(\frac{R_{eq}}{R_{eq} + 2k}\right) 10V$$

$R_{eq} = 8k\Omega$

$$R_{eq} = \frac{R_x(10k)}{R_x + (10k)} \rightarrow R_x = 40k\Omega$$

Current Division p 47-48



KCL

$$i_s = i_1 + i_2 + i_3$$

$$i_s = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} = V(R_1^{-1} + R_2^{-1} + R_3^{-1})$$

$$V = \frac{i_s}{R_1^{-1} + R_2^{-1} + R_3^{-1}}$$

$$i_1 = V/R_1 = \frac{i_s}{R_1(R_1^{-} + R_2^{-} + R_3^{-})}$$

$$i_2 = V/R_2 = \frac{i_s}{R_2(R_1^{-} + R_2^{-} + R_3^{-})}$$

$$i_3 = \frac{i_s}{R_3(R_1^{-} + R_2^{-} + R_3^{-})}$$

so $$i_K = \left(\frac{G_K}{G_{eq}}\right) i_{Total}$$