Devre Teorisi

→ 23 mart 1. kısa sınav

→ 25 mayıs 2. kısa sınav

hamza Osman ilhan
hoilhan@yildiz.edu.tr

Subject :   Date :....../....../......

Units of measurement - Basic Terminologies in Circuits - circuit components - Ohm's law

Units of measurement :

- Length — meter — m
- mass — kilogram — kg
- Time — second — s
- Electric current — ampere — A
- Thermodynamic temperature — kelvin — K
- Luminous intensity — candela — cd
- charge — coulomb — C

10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

*** Scientific notation** : tek decimal

- $\frac{1}{16} = 6.25E-2 = 6.25 \times 10^{-2}$
- $1/3 = 3.33E-1$

*** Engineering notation** : 1, 2 veya 3 decimal olabilir

- $\frac{1}{16} = 62.5E-3$
- $1/3 = 333.33E-3$

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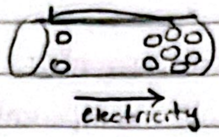
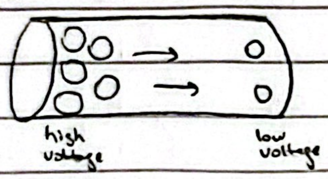


Electricity

→ Electricity is a result from the flow of electrons

→ Electricity flows in the opposite direction of electron flow

⊛ Electricity is similar to water flow :
- water flows from high level to low level
- Electricity flows from high voltage to low voltage



⊛ akımın olması için güç farklılığı olması lazım

⊛ Potansiyel fark arttıkça akım hızı artar veya yüksek akım oluşur

Circuit Components

- Active elements
  - independent power sources
    voltage , current (akım)
  - dependent power sources
    voltage , current

- Passive Elements
  - Resistors
  - Capacitors
  - inductors

- Protective Devices
  - Fuse (sigorta)

- Measurement Devices
  - Ampermeters
    measure current
  - Voltmeters
    measure voltage

- Ground
  - Reference point

- Electric wire (electric tel)

- Switches

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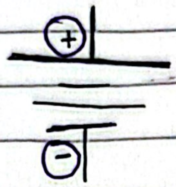
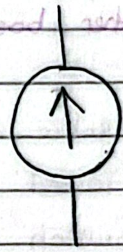
independent Power Sources

1- independent Voltage Source outputs a Voltage to the circuit no matter how much current is required



2- independent current Source outputs a dc or ac current to the circuit no matter how much voltage is required



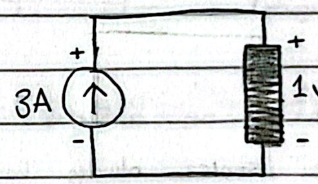
example 1

the current source is generated

$1V(3A) = 3W \quad (P = V \cdot i)$

$P = -3A(1V) = -3W$ ← üreten olduğu için

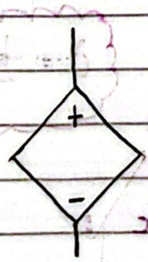
$$\boxed{\sum P = P_{current\ source} + P_{red\ element} = 0}$$

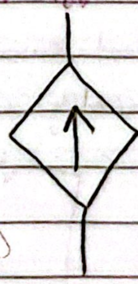


* artıdan akım çıkarsa üretendir.
artıdan akım girerse tüketicidir

Dependent Power Sources

- Voltage controlled voltage Source (VCVS)
- Current Controlled voltage source (CCVS)
- Voltage controlled current source (VCCS)
- Current controlled current Source (CCCS)





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Passive Elements

Resistor		ohm Ω
inductor		henry H
Capacitor		Farad F

enerji depolar

other basic circuit elements

Electric wire
Ground
Switch
Fuse (sigorta)

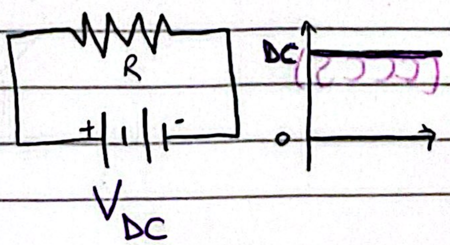
* All points on a same electric wire have the same voltage
* A voltage source always have volt difference of its pins equal to its value
* Ground always has zero voltage (0 volts)

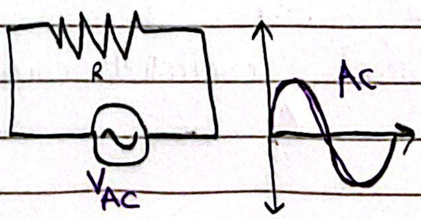
Current : the flow of charge through a cross-sectional area as a function of time or the time rate of change of charge. Symbol used is I or i

$$i = \frac{dq}{dt}$$ q = yük t = time i = akım

Dc vs. Vc :

- Direct current → current remains constant with time (yenilenme özelliği)
- Alternating current → there isn't an acronym defined for them (daha kullanışlı)





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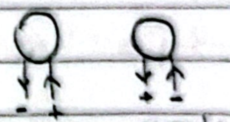
Voltage (Potential Difference) the electromotive force that causes charge to move. (bir yükü hareket ettirmek için gereken enerji)

1 volt = 1 Joule / 1 coulomb

$$V = \frac{dw}{dq}$$ w = enerji = work

Power the change in energy as a function of time is power. (watts)

$$P = \frac{dw}{dq} \times \frac{dq}{dt} = V \times i = \frac{dw}{dt}$$ $$P = \frac{dw}{dt}$$



absorb (+) generate (-)

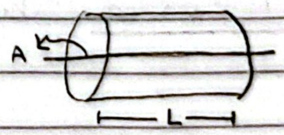
OHM's Law voltage = current x resistance

$$\boxed{V = I \cdot R}$$ volts = Amperes x Ohms

Resistivity : is a material property (ρ) dependent on the mobility of the charges. (akımın (q) hareketini sönümlendirir)

→ Resistance takes into account the physical dimensions of the material

$$\uparrow R = \rho \frac{\ell \uparrow}{A \downarrow}$$ ℓ = length A = sectional area



⊛ Short Circuit

if the Resistor is equal to zero

$R = 0\ \Omega$

then :

$V = iR = i \cdot 0 = 0$

$V = 0$

⊛ akım kaç olursa olsun gerilim sıfırdır

⊛ Open Circuit

If the Resistor is a perfect insulator

$R = \infty\ \Omega$

then:

$$i = \lim_{R \to \infty} \frac{V}{R} = 0$$

$i = 0$

⊛ gerilim oluşabilir ama akım oluşmaz

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Conductance (iletkenlik) is a reciprocal of resistance (tersi)

$G = R^{-1} = i/V$ $G = A \cdot \frac{\sigma}{L}$ σ is conductivity which is the inverse of resistivity (ρ)

unit for conductance is S (siemens)

→ $P = iV = i(iR) = i^2 R$

→ $P = V/R \cdot V = V^2/R$

→ $P = V/G \cdot V = V^2/G$

→ $P = i \cdot i/G = i^2/G$

Power

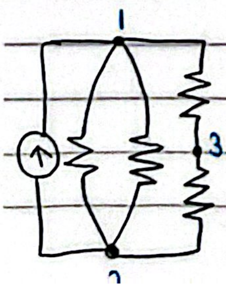
Power dissipated (sömürmek) by a resistor is always positive

üretici → ⊕ tüketici → ⊖

+ yönünden akım çıkarsa üretici, akım girerse tüketici olur

Circuit terminology

NODE : point at which +2 elements have a common connection. (node 1)



PATH : a route through a network, through nodes that never repeat

1 → 3 → 2

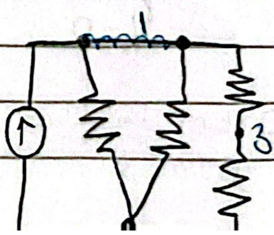
1 → 2 → 3

LOOP: a path that starts and ends on the same node

3 → 1 → 2 → 3

BRANCH: a single path in a network contains one element and the nodes at the 2 end

1 → 2 , 1 → 3 , 3 → 2



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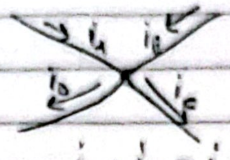
Kirchhoff's Current Law (KCL)

Based upon conservation of charge, the algebric sum of the charge within a system can not change.

$$\sum_{n=1}^{N} i_n = 0 \qquad \sum i_{enter} = \sum i_{leave}$$



$$i_A + i_B - i_C - i_D = 0$$

Kirchhoff's Voltage Law (KVL)

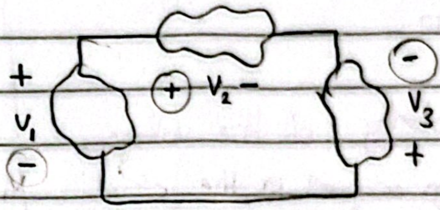
Based upon conservation of energy, the algebraic sum of voltages dropped across components around a loop is zero.

$$\sum_{m=1}^{M} V = 0$$

The energy required to move a charge from point A to B must have a value independent of the path chosen

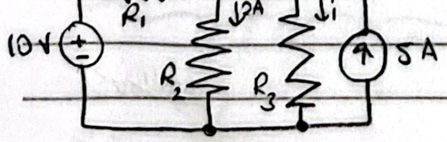
$$V_{drops} = V_{rises}$$

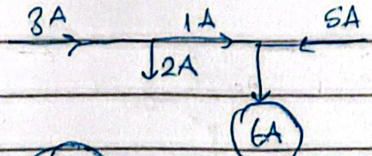
$$V_1 + V_3 = V_2$$



Example:

For the circuit, compute the current through R_3 if it is known that the voltage source supplies a current of 3A.



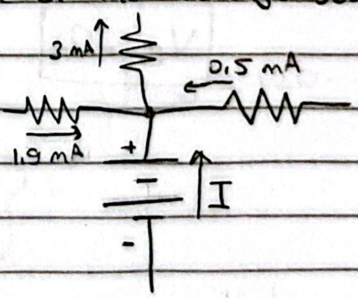


6A

KCL

Example:

Determine I the current flowing out of the voltage source.



1,9 mA + 0,5 mA + I → entering

3 mA leaving

2,4 + I = 3

I = 0,6 mA

KCL

↳ I is generating

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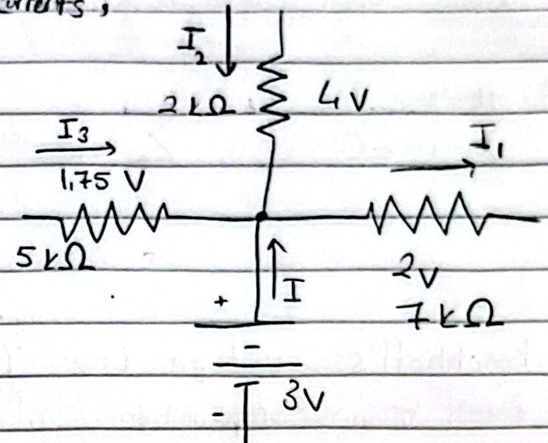
Example:

if voltage drops are given instead of currents,

$\boxed{V = IR}$ you need to apply Ohm's low



$I_1 = 2v / 7k\Omega = 0{,}286$

$I_2 = 4V / 2k\Omega = 2\ mA$

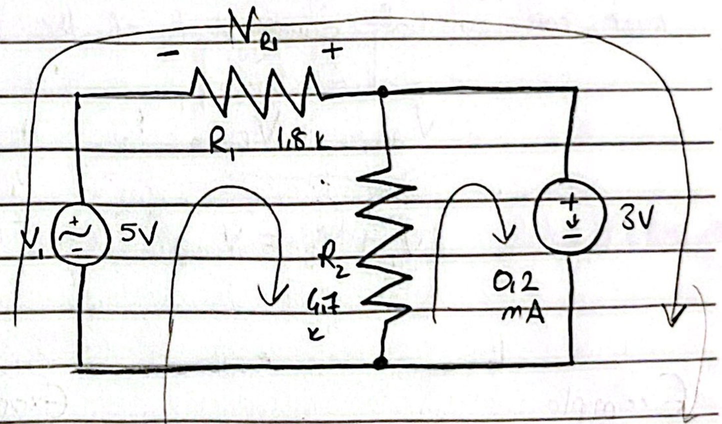
$I_3 = 1{,}75V / 5k\Omega = 0{,}35\ mA$

$2 + 0{,}35 + I = 0{,}286$

$\boxed{I = -2{,}06}$

Example:

note: the polarity of the voltage has been asigned in the circuit schematic.



find the voltage across R1

$\boxed{V_{R1} = 2}$

$5V + V_{R1} = 3V \rightarrow V_{R1} = 2$

veya

$-5V - V_{R1} + 3V = 0 \rightarrow V_{R1} = 2$

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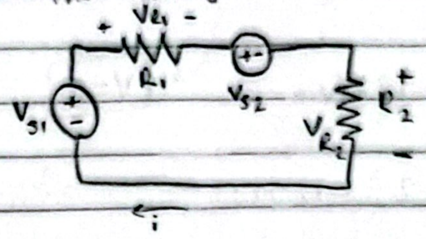
The single-loop circuit (Her yeri vardır ve herhangi akım eşit)

1- First step in the analysis is the assumption of reference Directions for the unknown currents (yön belirleme)
2- Second step is a choice of the voltage Reference.
3- third step is KVL



$$-V_{S1} + V_{R_1} + V_{S2} + V_{R_2} = 0$$

$$i = \frac{V_{S1} - V_{S2}}{R_1 + R_2}$$

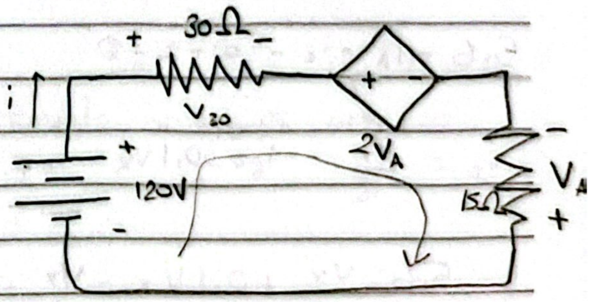
Conservation of Energy

$$\sum_{\text{all elements}} P_{absorbed} = 0$$

$P_{absorbed} = P_{supplied}$

Example

compute the power absorbed in each element for the circuit shown



$120 - 30i - 2V_A + V_A = 0$

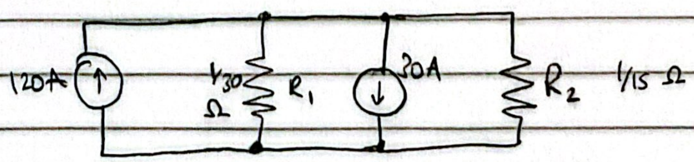
$V_A = -15i$

$120 - 15i = 0 \rightarrow i = 8$

$P_{120V} = 120 \cdot -8 = -960W$

The Single-node-Pair Circuit

the voltage across each branch is the same as that across any other branch



Elemanlar Paralel olduğu için gerilimleri eşit olmak zorunda.

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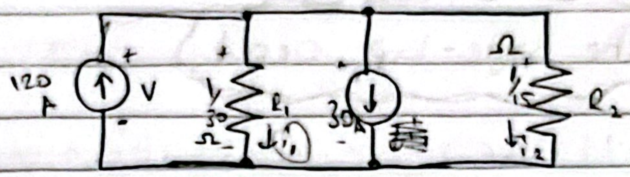
* Example:

find the voltge, current and Power associated with each element



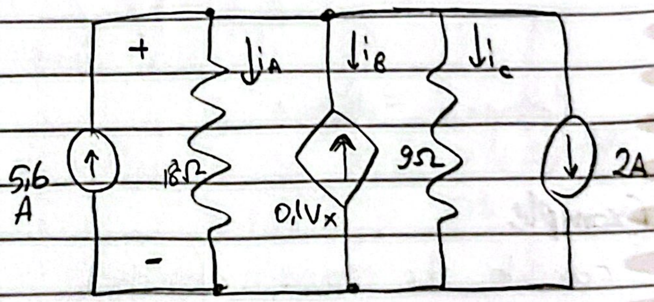
$-120 + i_1 + 30 + i_2 = 0$

$i_1 = 30v$ $\quad i_2 = 15v$ $\quad \boxed{V = 2} \rightarrow i_1 = 60 \quad i_2 = 30$

$P_{R_1} = 30 \cdot 2^2 = 120\ W$

* Example

find i_A, i_B and i_c



$5.6 - i_A - i_B - i_C - 2 = 0$

$i_A = \frac{V_x}{18} \quad i_B = -0.1 V_x \quad i_C = \frac{V_x}{9}$

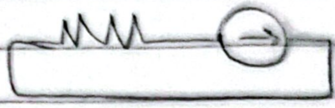
$5.6 - \frac{V_x}{18} + 0.1 V_x - \frac{V_x}{9} = 0 \rightarrow V_x = 54\ V$

Subject :   Date :

Series Circuits

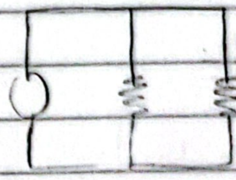
all elements in a circuit (loop) that carry the same current

(ortak düğüme sahip elemanlar seri bağlıdır)



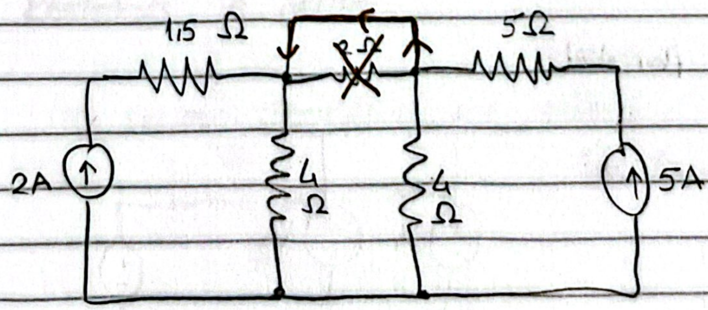
Parallel Circuits

all elements in a circuit that have a common voltage across them.



example:

in the following circuit whic individual elements or groups are in series / parallel ?



+ → seri bağlı

// → paralel bağ

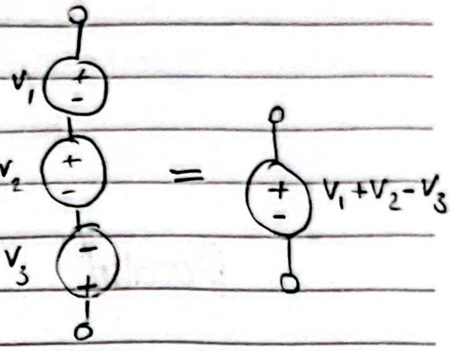
$$((5+5)\,//\,4)\,//\,((1{,}5+2)\,//\,4)$$

Voltage Sources in Series

→ we can replace Voltage sources in series with a single equivalent source.

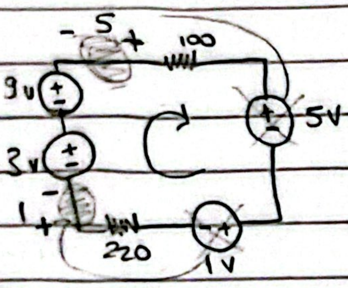
→ the connection of batteries in series is common.

→ the voltage has increased, but the maximum current for each AAA battery and for the V supply is SAME



Example:

what is the sum of V ? (-16)

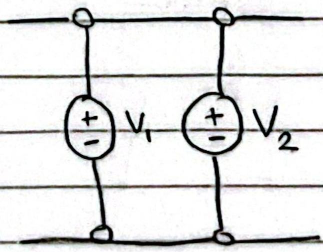


$1-(9+3+5) = -16$

$320\,i = 16 \rightarrow \boxed{i = 50\,mA}$

⊛ Voltage Sources in Parallel

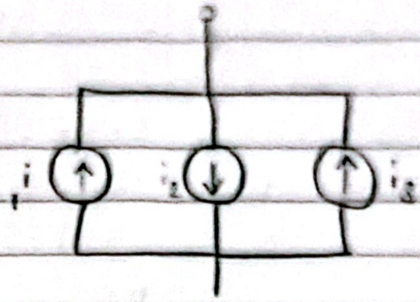
unless $V_1 = V_2$ this circuit isn't valid for ideal sources.



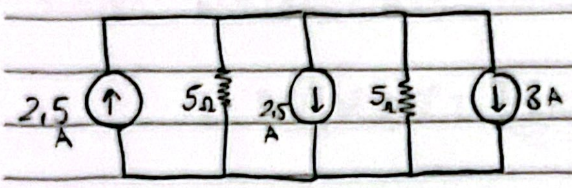
Current will flow from the higher source to the lower source until equilibrium is reached.

Current Sources in Parallel

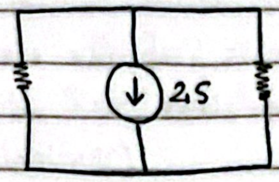
- Can replace current sources in Parallel with a single equivalent source



example:



kaynakları birleştir.



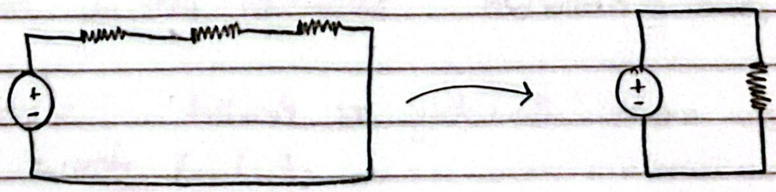
$2{,}5 + 3 - 2{,}5 = 3 \downarrow$

$2{,}5 - 3 - 2{,}5 = -3 \uparrow$

$3 - V/5 - V/5 \Rightarrow 3 = \frac{2V}{5} \rightarrow$ $V = 7{,}5\ V$

Resistors in Series

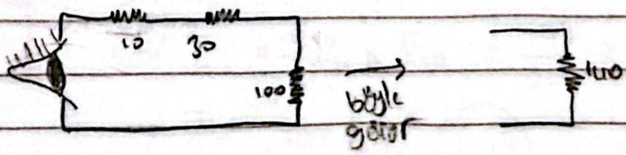
in series, resistances are added... $R_{eq} = \sum_{n=1}^{N} R_n$ $\quad R_1 + R_2 + R_3 = R_{eq}$



$V = i \cdot R_{eq}$

$R_{eq} = V/i$

it is important to realize that when a dc supply is connected it see the total resistance seen at the connection terminals.



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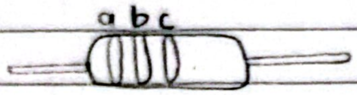
(*) Direnaları fiziksel özellikleri :

3 renklendirmesi olur.

siyah = 0 turuncu = 3 mavi = 6 beyaz = 9

kahverengi = 1 sarı = 4 mor = 7

kırmızı = 2 yeşil = 5 gri = 8



Renkler (ab) x 10^c ohm şeklinde okunur

(*) $P_E = P_{R_1} + P_{R_2} + P_{R_3}$ $\boxed{P = V.I} = I^2R = V^2/R$

Resistors in Parallel :

→ for resistors in parallel, the reciprocals of the resistances sum to 1/ the equivalent

$(R_{es})^{-1} = 1/R_1 + 1/R_2 + 1/R_3$ $i_s = i_1 + i_2 + i_3 + \dots + i_n$

- Always keep in mind that ohmmetters can never be applied to a live circuit

- in parallel resistive network, the larger the resistor, the less the power absorbed

- $R_1 \parallel R_2 \parallel R_3$ means that they are parallel

- iletkenlikte paralellik = Dirençteki Seri

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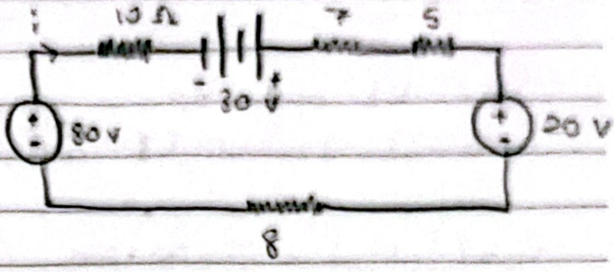
Example :

Use resistance and source combinations to determine the current i and the power delivered by the 80 V source



$20 - 80 - 30 = -90 \rightarrow$ Volt $\qquad V = I \cdot R \qquad P = I \cdot V$

$10 + 7 + 5 + 8 = 30 \rightarrow R \qquad -90 + 30i = 0 \qquad -240 = 3 \cdot -80$

$i = 3A \qquad P = 240\ W$

Voltage Division :

- All resistors in series share the same current
- the Source voltage V is divided among the resistors in direct proportion to their resistances. (Potansiyel fark oranlı bir şekilde dirençlere bölünür).

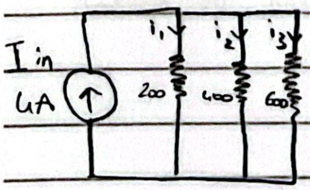
Sadece DC (direct current) için değil AC (alternating current) için de geçerlidir. (Gerilim bölücü özelliği hep geçerli)

Current Division :

- All resistors in parallel share the same voltage
- The total current I is shared by the resistors in inverse proportion to their resistances

example :

Find currents I_1, I_2, I_3 in the circuit. 2,18 1,09 0,727

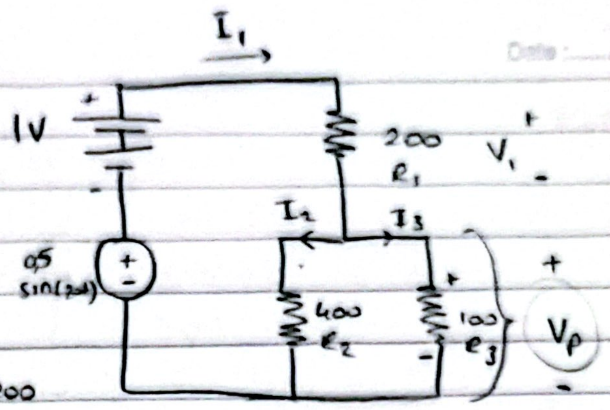


$$R_{eş} = \frac{1}{\frac{1}{200} + \frac{1}{400} + \frac{1}{600}} = \frac{1}{11/1200} = 109\ \Omega$$

$$I_1 = \frac{R_{eş}}{R_1} \times I_{in} = \frac{109}{200} \times 4 = 2{,}18$$

$$I_2 = \frac{109}{400} \times 4 = 1{,}09 \qquad I_3 = \frac{109}{600} \times 4 = 0{,}727$$

Example:



find V1 and Vp
find I1, I2 and I3

$$R_{eş} = \left(\frac{1}{400} + \frac{1}{100}\right)^{-1} = \frac{400}{5} = 80 + 200$$

$R_{eş} = 280\ \Omega$ $\qquad V_{top} = 1\text{v} + 0{,}5\sin(20t)$

$$I_1 = \frac{V_{top}}{R_{eş}} = \frac{1\text{V}}{280} + \frac{0{,}5\sin(20t)}{280} = 3{,}57\ \text{mA} + 1{,}79\ \text{mA}\sin(20t)$$

$$V_1 = R_1 \cdot I_1 = 200 \cdot (3{,}57 + 1{,}79\ \text{mA}) = 0{,}714\ \text{V} + 0{,}357\ \text{V}\sin(20t)$$

$$V_p = R_{eş1} \cdot I_1 \rightarrow 80 \cdot I_1 = 0{,}287\text{V} + 0{,}143\ \text{V}\sin(20t)$$

$$I_2 = \frac{R_{eş}}{R_2} \cdot I_1 = \frac{280}{400} \cdot I_1 = 0{,}7 \cdot I_1 = 0{,}714\ \text{mA} + 0.357\ \text{mA}\sin(20t)$$

$$I_3 = R_{eş}/R_3 \cdot I_1 = 280/100 \cdot I_1 = 2{,}86\ \text{mA} + 1{,}43\ \text{mA}\sin(20t)$$

Önemli formüller

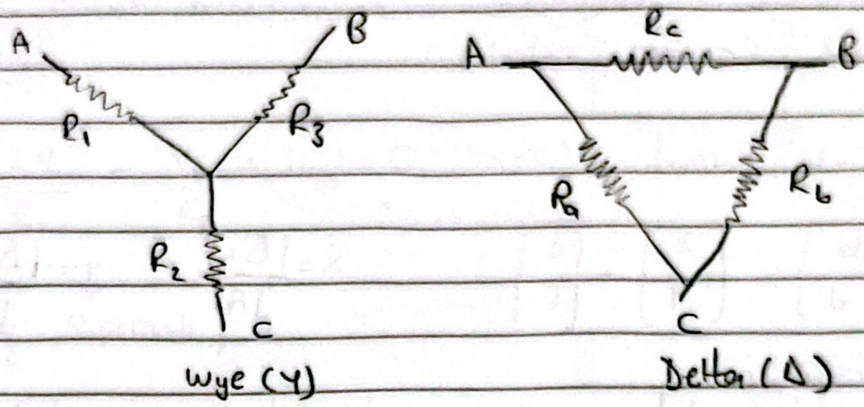
$$V_n = \frac{R_n}{R_{eş}} \cdot V_{total} \qquad i_m = \frac{R_{eş}}{R_m} \cdot i_{total}$$

7v 9
15

Subject : Date : / /

Wye and Delta Networks

→ 3 terminal arrangments - commonly used in Power systems



* it must be ;

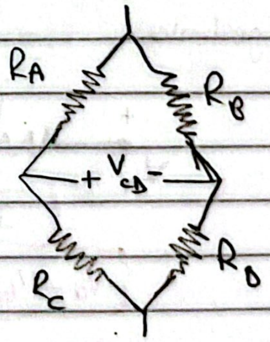
→ $R_1 + R_2 = R_a$
→ $R_1 + R_3 = R_c$
→ $R_2 + R_3 = R_b$

* wye windings Provides better torque at low rpm

* delta windings generates better torque at high rpm

Bridge Circuits

→ Measurement of the voltage V_{CD} is used in sensing and full-wave rectifier circuits



* if $R_A = R_B = R_C = R_D$, $V_{CD} = 0V$

** Sesör oluşturursak bu şekilde ortamdaki şartlardan minimum etkilenir hassas bir ölçüm elde ederiz...

Nodal and Mesh Analysis
düğüm   çevre

~ mathematical Preliminaries ~

→ basit eşitsizlik ve denklemler

→ Determinant (cramer metodu) :

$A \cdot x = b$ format

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix} \cdot \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} e \\ f \end{bmatrix} \qquad x = \frac{|\Delta x|}{|A|} \qquad y = \frac{|\Delta y|}{|A|}$$

$$|\Delta x| = \begin{vmatrix} e & b \\ f & d \end{vmatrix} \qquad |\Delta y| = \begin{vmatrix} a & e \\ c & f \end{vmatrix} \qquad |A| = \begin{vmatrix} a & c \\ b & d \end{vmatrix}$$

✱ Nodal Analysis :

. Technique to find currents at a node using Ohm's Law and the Potential differences between nodes.

→ first, determine the node voltages (referenced to ground)

→ Second, calculate the currents

✱✱ düğüm gerilimleri üzerinden gideriz (akım (KCL) denklemleri ile)

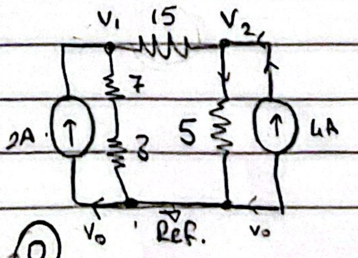
$$\overset{+}{V_a} \bullet \!\!-\!\!\overset{R}{\text{WWW}}\!\!-\!\! \bullet \overset{-}{V_b} \qquad \xrightarrow{I}$$

$\boxed{V_a - V_b = I \cdot R}$ and $\boxed{I = (V_a - V_b) / R}$

→ Current flows from a higher Potential to a lower Potential in a resistor

example:

Determine the current flowing left to right through the 15 ohms resistor



$$2 = \frac{V_1 - 0}{10} + \frac{V_1 - V_2}{15} \qquad \boxed{V_1 = 20}$$

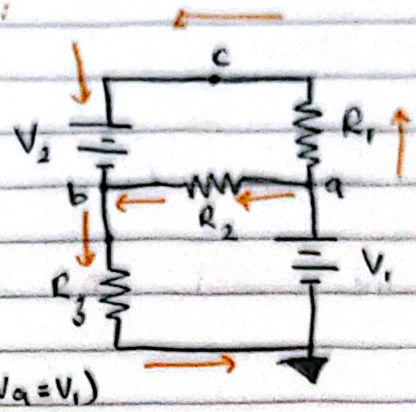
$$4 = \frac{V_2 - V_0}{5} + \frac{V_2 - V_1}{15} \qquad 18V_2 = 360 \qquad \boxed{V_2 = 20}$$

$$4V_2 - V_1 = 60 \qquad 5V_1 - 2V_2 = 60$$

$$\frac{V_2 - V_1}{15} = \frac{0}{15} = 0$$

nodal analysis with supernodes :

A floating source is a problem for the Nodal Analysis. in this circuit, battery V_2 is floating.



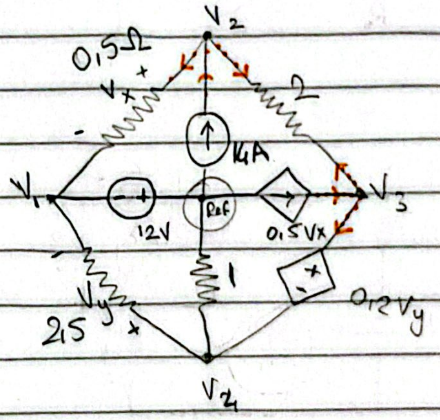
$$\frac{V_a - V_b}{R_2} - \frac{V_b}{R_3} + i_{V_2} = 0 \quad (V_a = V_1)$$

? it's not a resistance ?!

using Supernode ;

$$\frac{V_1 - V_b}{R_2} - \frac{V_b}{R_3} + \frac{V_1 - (V_b + V_2)}{R_1} = 0$$ yani $V_c = V_b + V_2$

example



$$14A = \frac{V_2 - V_1}{0,5} + \frac{V_2 - V_3}{2}$$

$$0,5V_x = \frac{V_3 - V_2}{2} + i_{vy}$$ Super node

$$\boxed{\frac{V_4 - 0}{1} + \frac{V_4 - V_1}{2,5}}$$

$V_1 = -12V$ $\quad V_3 - V_4 = 0,2V_y$ $\quad 0,5V_x = (V_2 - V_1) \cdot 0,5$, $\quad V_y = V_1 - V_4 \cdot 2,5$

$5V_2 - 4V_1 - V_3 = 28A$ $\quad (7V_4 - V_1) \cdot 2 + 5V_3 - 5V_2 = V_2 - V_1 \cdot \frac{1}{2}$

$28V_4 - 4V_1 + 10V_3 - 10V_2 = V_2 - V_1$

$\boxed{28V_4 - 3V_1 + 10V_3 - 11V_2 = 0}$

$V_3 - V_4 = (V_1 - V_4)\frac{5}{2}$

$2V_3 - 2V_4 = 5V_1 - 5V_4$

$3V_4 + 2V_3 = 5V_1$

$3V_4 = -60 - 2V_3$ $\quad -60$

$V_4 = \frac{-60 - 2V_3}{3}$

$28V_4 + 10V_3 = 3V_1 + 11V_2$

-36

$V_2 = -4$ $\quad V_3 = 0$ $\quad V_4 = -2$

$9I_1 - 3I_2 = 42V$
$-9I_1 + 21I_2 = 30V$
$18 I_2 = 72$
$I_2 = 4$
$I_1 = 6$

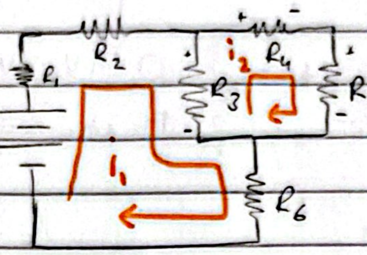
Subject :   Date :......./......./.......

Mesh Analysis :

• to find voltage drops within a loop using currents that flow within the circuit and Ohm's Law.

• Mesh: the smallest loop around a subset of components in circuit

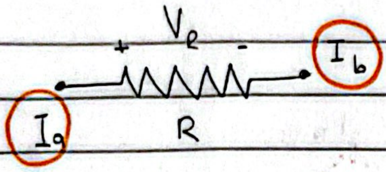
$\boxed{-V_{in} + V_1 + V_2 + V_3 + V_6 = 0}$
KVL



$V_1 = i_1 R_1$
$V_2 = i_1 \cdot R_2$
$\boxed{V_3 (i_1 - i_2) \cdot R_3}$
$V_4 = i_2 R_4$
$V_5 = i_2 R_5$
$V_6 = i_2 R_6$

$\boxed{-V_3 + V_4 + V_5 = 0}$
KVL

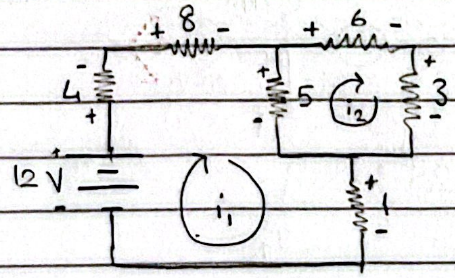
** R_3 = uretes



$\boxed{V_R = (I_a - I_b) \cdot R}$.

example :

$\boxed{\text{find } I_1 , I_2}$



$12V = 4 \cdot I_1 + 8 I_1 + 5(I_1 - I_2)$
$1 I_1$
$\boxed{12V = 18 I_1 - 5 I_2}$

$5(I_1 - I_2) = 6 I_2 + 3 I_2$
$5 I_1 = 14 I_2$

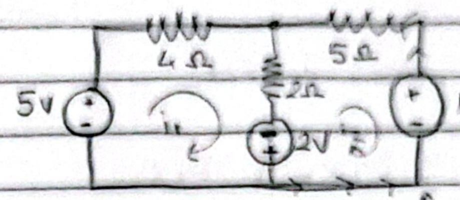
$12V = 18 I_1 - 5.5 \frac{I_1}{14}$

$\boxed{740 = I_1 \quad 264 = I_2}$

Subject : Date : ..../..../....

Example :

Determine the Power supplied by the 2 V source



$P = I \cdot V$

$5V = 4i_1 + 2i_1 - 2i_2 + 2V$

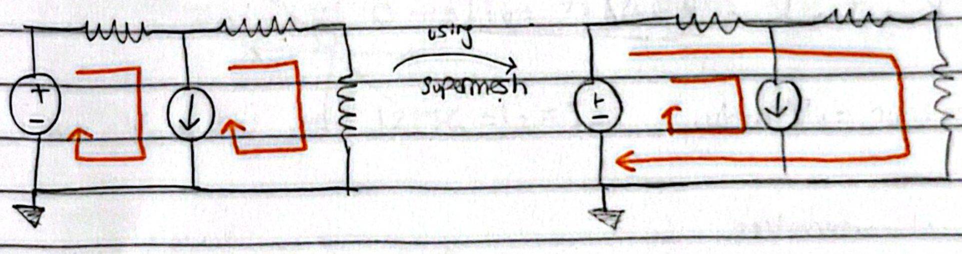
$-3V = 5i_2 - 2(i_1 - i_2)$

akım yönü ters

$$\left.\begin{aligned} 7V &= 6i_1 - 2i_2 \\ (-3V &= 7i_2 - \cancel{2i_1}) \cdot 3 \end{aligned}\right\} \quad -2V = 19i_2 \quad \begin{aligned} &\rightarrow \boxed{I_2 = -0{,}1053} \\ &\rightarrow \boxed{i_1 = 1{,}132} \end{aligned}$$

$P = -2 \cdot 1{,}237 = \boxed{-2{,}474 \text{ W}}$

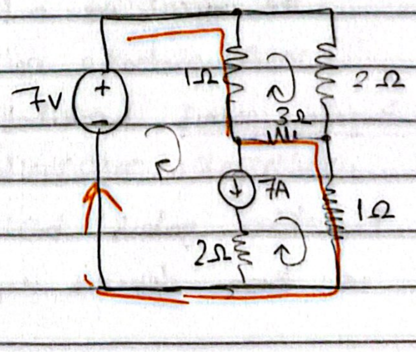
Mesh Analysis with Supermeshes :



Supermesh : a mesh that contains multiple meshes with a Shared Current Source

Exmple :

Determine the current i as labled in the circuit



$7V = 1(i_1 - i_2) + 3(i_3 - i_2) + 1 i_3$

$i_1 - i_2 = 2i_2 + 3(i_2 - i_3)$

$-i_1 + 6i_2 - 3i_3 = 0$

$\boxed{i - i_3 = 7}$

Subject : Date : ....../....../......

Linearity

→ if x is doubled,

$$y = f(2 \times x) = 2f(x)$$

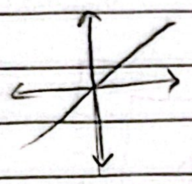
→ if x is multiplied by any constant, a

$$y = f(ax) = af(x)$$

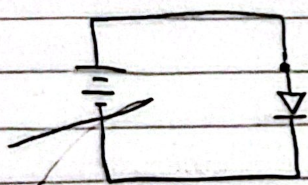
* then the system is linear

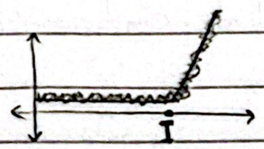
(*) if the current is increased by a constant k, then the voltage increases correspondingly by k;

$$\boxed{k} \times I \times R = \boxed{k} \times V$$



→ Diode characteristics





→ Nonlinear

an equation for a line can not be used to repsent the current as a function of voltage

\- Süperpozisyon -

* Gerilim kaynağı yalnız bırakılırken, akım kaynakları açık devre yapılır.

* Akım kaynakları yalnız bırakılırken, gerilim kaynakları devreden çıkartılır ve kısa devre yapılır.

Subject :

Summary : The property is used to seperate contributions of several sources in a circuit to the voltages across and the currents through components in the circuit.

→ ⊛ superposition

example

For the circuit, find I_o when $V_s = 12V$ and $V_s = 24V$.

$$V_s = 6i_1 + 2i_1 + 4i_1 - 4i_2 = 12i_1 - 4i_2$$

$$V_s + 3(2i_1) = 4i_2 - 4i_1 + 8i_2 + 4i_2$$

$$V_s = 16i_2 - 10i_1 = 12i_1 - 4i_2$$

$$12i_1 - 4i_2 = -V_s$$

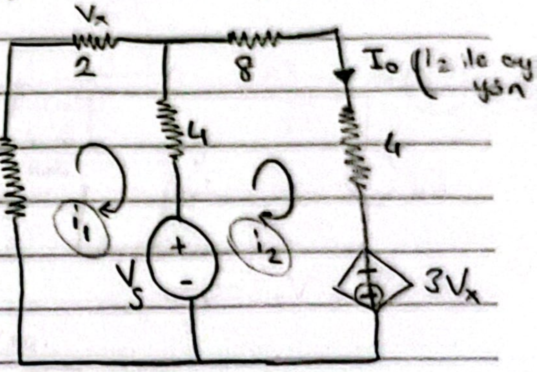
$$+\ 16i_2 - 10i_1 = \cancel{V_s}$$

$$2i_1 + 12i_2 = 0$$

$$\boxed{i_1 = -6i_2}$$

$$16i_2 - 10\cdot(-6i_2) = V_s$$

$$76i_2 - V_s = 0 \rightarrow \boxed{i_2 = V_s/76}$$



when $V_s = 12V \rightarrow 12/76 = i_2 = I_o$ when $V_s = 24V \rightarrow 24/76 = i_2 = I_o$

Superposition

⊛ voltage sources should be replaced with short circuits

⊛ Current Sources should be replaced with Open Circuits

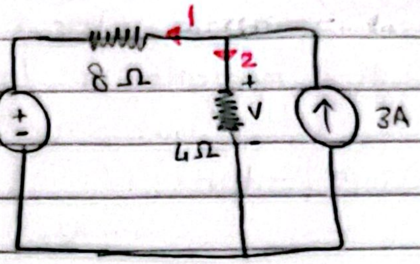
* bağımlı kaynak varsa bunları çıkartamayız *

→ Kaynakları çıkarsak da dirençler üzerindeki ilk tayin edilen polarizasyon değişmez

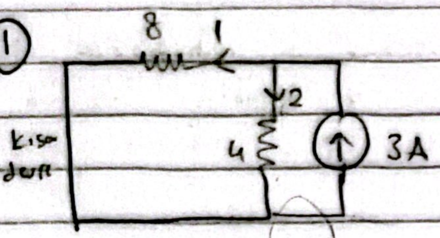
Subject: Date: ..../..../....

example

Use the superposition theorem to find v in the circuit.



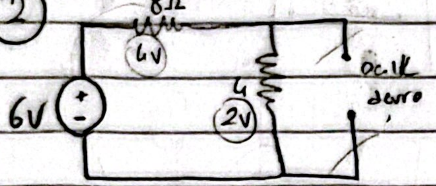
(1)



$V_1 = 2.4 = 8V$

$V = V_1 + V_2$

(2)

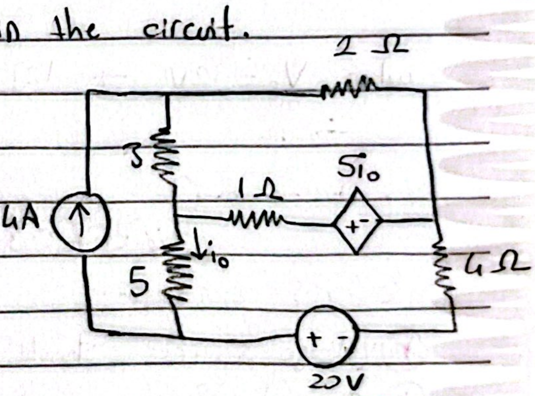


$V = 2 + 8 = 10\,V$

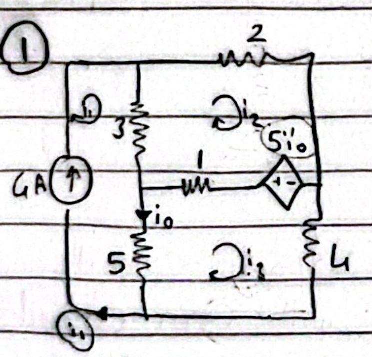
$V_2 = 2V$

example

using the superposition theorem, find i_o in the circuit.



(1)



$i_1 = 4A$

$-3i_1 + 6i_2 - 1i_3 + 5i'_o = 0$

$-5i_1 - 1i_2 + 10i_3 + 5i'_o = 0$

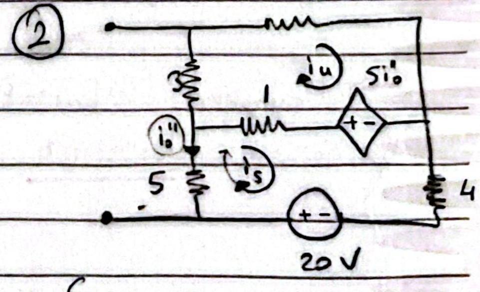
$i_3 = i_1 - i'_o = 4 - i'_o$

$3i_2 - 2i'_o = 8 \qquad 2i_2 + 5i'_o = 20$

$\rightarrow i'_o = 52/17\,A$

$\boxed{i_o = i''_o + i'_o}$

(2)



$i_o = \frac{52}{17} + \left(\frac{-60}{17}\right)$

$i_o = -8/17$

$i''_o = \frac{-60}{17} =$

$0 = 6i_4 - 4i''_o$

$-20 = i_4 + 5i''_o$

$6i_4 - i_5 - 5i''_o = 0$

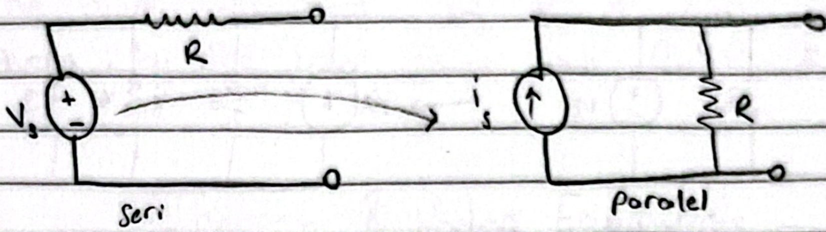
$-20V + 10i_5 + 5i''_o - i_4 = 0$

$\boxed{i_5 = -i''_o}$

Subject : Date : ..../..../....

Source transformation : Devreyi daha sade bir sekilde göstermek için kaynaklar arasında dönüşüm yapmaktır.

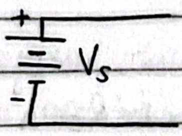
A source transformation is the process of replacing a voltage source V_s in series with a resistor R by a current source I_s in parallel with a resistor R



*** Voltage Sources :**

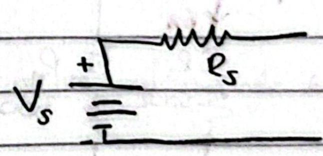
• **ideal**

• an ideal voltage source has no internal (iç direnç) resistance
→ no limit (Producing current)



• **Real**

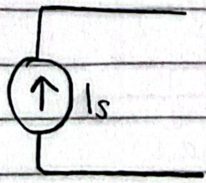
• is modeled as an ideal voltage source in series with a resistor.
→ there are limits



*** Current Sources :**

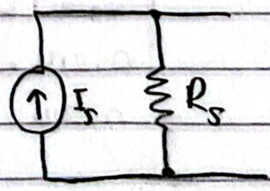
• **Ideal**

* no internal resistance
→ no limit (Power



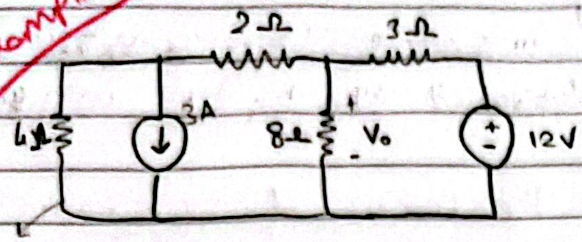
• **Real**

* ideal current source + Parallel with resistor.
→ have limits (volt and current)



Subject:

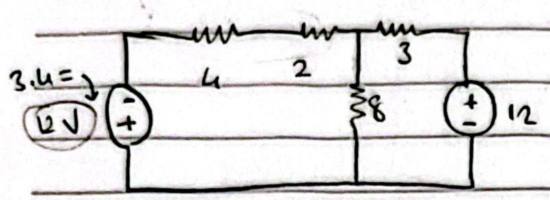
example

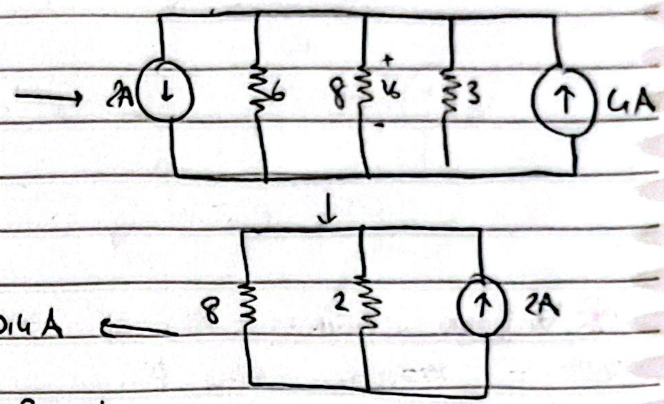


Use Source transformation to find V_o in the circuit.

akıma paralel direnç var (VJ)

$\frac{1}{6}+\frac{1}{8}+\frac{1}{3}$





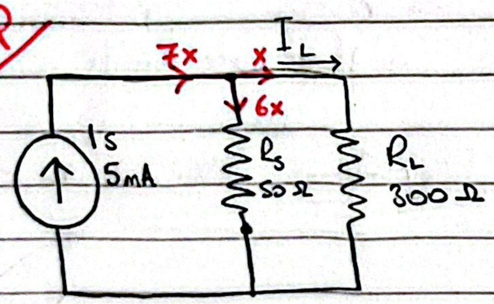
$$i = \frac{2}{2+8}(2) = 0{,}4\ A$$

$V_o = 8i = 8 \cdot 0{,}4 = 3{,}2\ V$

or

$$V_o = \frac{8 \times 2}{10} \cdot 2 = 3{,}2\ V$$

exmp



Find an equivalent voltage source to replace I_s and R_s in the circuit below

$$I_L = \frac{50}{300+50} \cdot I_s = 0{,}714 = 5/7$$

$$V_L = I_L \cdot R_L = 0{,}714 \cdot 300 = 0{,}214\ V$$

$P_{Vs} = P_L + P_{Rs}$

$0{,}214 \cdot 0{,}714 = P_L$

$0{,}214 \cdot (5 - 0{,}714) = P_{Rs}$

$+$

$P_{Vs} = 1{,}07\ mW$

Subject: Date: ..../..../....

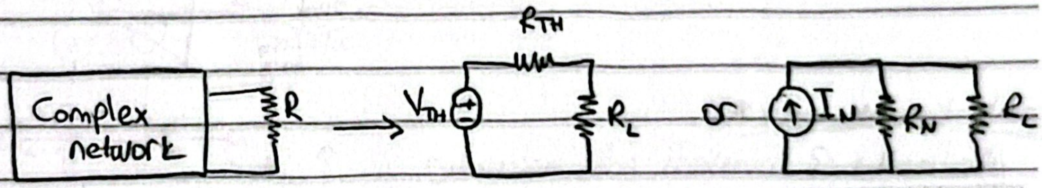
Summary on equivalent circuit is a circuit where the voltage across and the current flowing through a load R_L are identical

- if the shunt resistor decreases → current increase. (Real current)
- if the series resistor increases → voltage increase (Real voltage)

The Power dissipated by R_L is %50 of the Power Produced by the ideal source when $R_L = R_S$

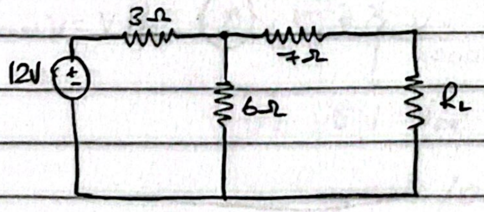
- Thevenin & Norton Equivalents -

Any linear circuit network at two terminals may be replaced with a thevenin (V_{TH}, R_{TH}) or a Norton (I_N, R_N)

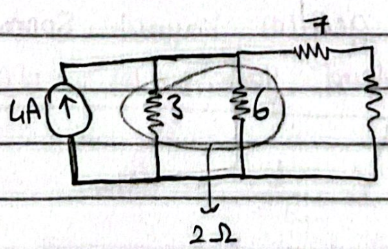


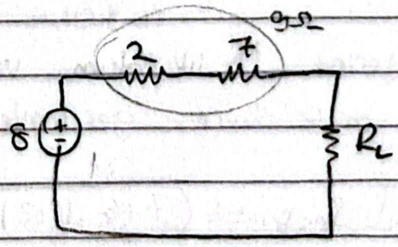
1- thevenin equivalent:

use repeated source transformations to arrive at a single voltage source in series with a single series Resistance



compute the power delivered to the R_L (use thevenin)



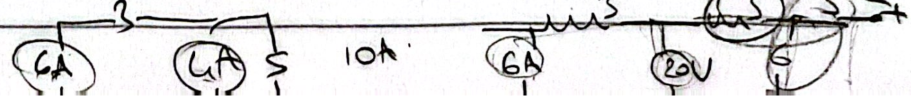


20 - 5;

20V = 3;

$$P_L = \left(\frac{8}{9 + R_L}\right)^2 R_L \qquad V_{TH} = 8\text{ V} \qquad R_{TH} = 9\ \Omega$$

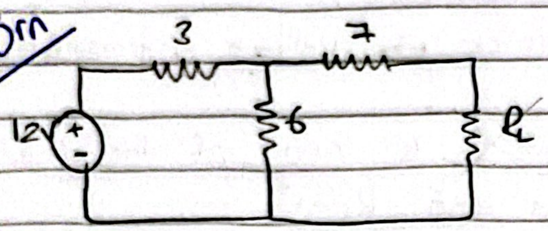
50



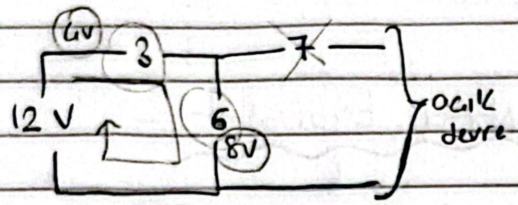
Subject : Date : ...../...../.....

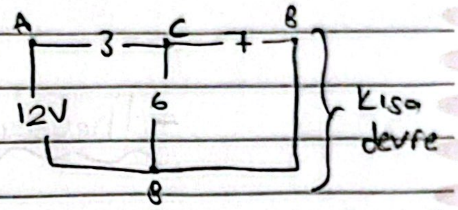
Method -2- : Open the load and determine the open-circuit voltage, then short the load and determine the short-circuit current.

örn



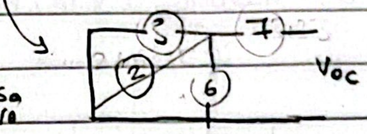
Determine the thevenin eq. using method 2.





$V_{TH} = 8V$

anlamadım $R_{TH} = ?$



2yol vol = kısa devre

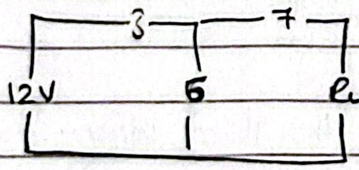
$9\,\Omega = R_{TH}$

* bağımlı kaynak varsa *

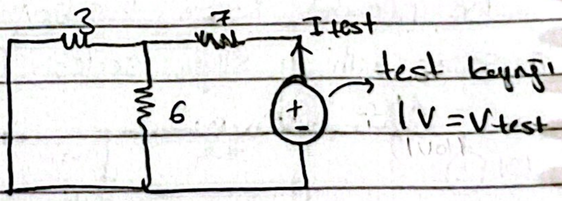
Method - 3 :

→ when the circuit includes dependent sources.

→ open the load and deactivate all independent sources



→



$V_{oc} = 8V$

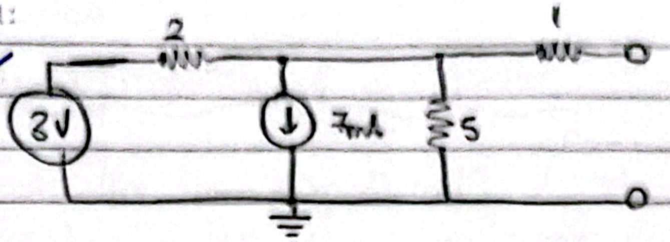
R_L yerine 1A lik akım veya 1v luk gerilim koyarız. Sonra eski akımları açık devre, gerilimleri kısa devre yaparız.

$$I_{test} = \frac{1}{(7+6 \parallel 3)} = 0{,}111\,A$$

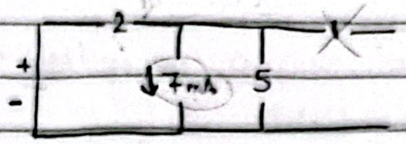
$$R_{test} = V_{test} / I_{test} = 1 / 0{,}111 = 9\,\Omega$$

Subject : Date

Örn.

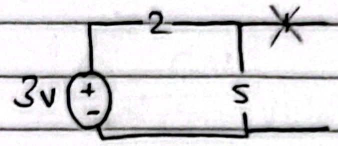


Determine the thevenin and northon equivalents of the circuits.

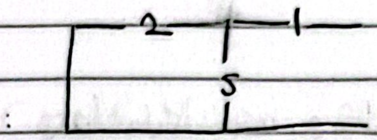


$-\left(\frac{2.7}{7}\right)\times 5 = -10$

$2.14 - 10 = -7.86 \quad V_{TH}$

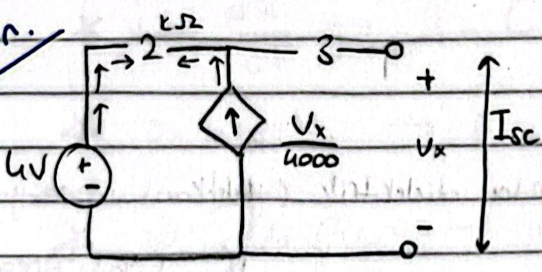


$\frac{3.5}{7} = 2.14\ V$



$\frac{1}{2}+\frac{1}{5} = 10/7 = 1.4 + 1 = 2.4 \quad R_{TH}$

Örn.



Determine the thevenin equivalent of this network at the open-circuit terminals.

$-4 + 2\cdot 10^3\left(-\frac{Vx}{4000}\right) + 3\times 10^3\cdot 0 + Vx = 0$

$Vx = 8\,V = V_{oc} \qquad I_{sc} = 4/5\cdot 10^3 = 0.8\ mA$

$R_{TH} = 8/0.8\cdot 10^{-3} = 10\ k\Omega$

Maximum Power Transfer

max val. $\rightarrow \frac{d}{dR_L} P_L = 0$ if $R_L = R_S \rightarrow d/dR_L\, P_L = 0$ (max)

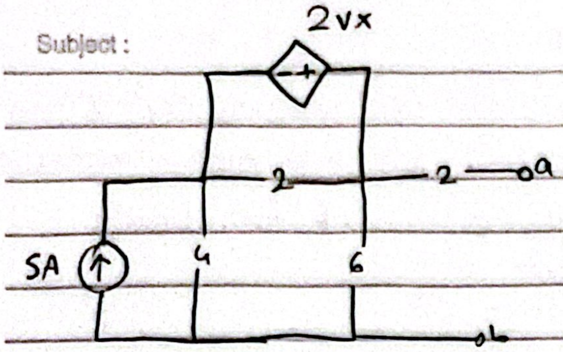
max powers delivered to the load when the load resistance = thevenin resistance

$P_L = \frac{V_S^2 R_L}{(R_S+R_L)^2}$

$\boxed{R_L = R_S}$

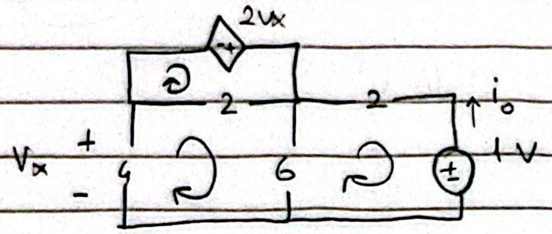
YSO

Subject : Date : ...../...../.....



find the thevenin equivalent

bağımlı kaynak var → akım testi :



: Energy Storage Devices ~ Capacitors and inductors :

1- Capacitors : gerilim saklar

yapısı : iki iletken plaka arasında dielektrik (yalıtkan) malzemeden oluşur

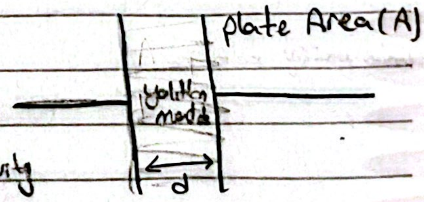
$$\boxed{C = \varepsilon \cdot \frac{A}{d}}$$

yüklenebilme kapasitesi.

$\varepsilon = \varepsilon_r \varepsilon_o$

ε_r = relative constant

ε_o = vacuum permittivity

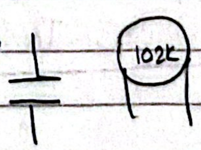


yüzey alanı, epsilon ile doğru, d ile ters orantılı.

a - Nonpolarized (kutupsuz) capacitors :

Paper, ceramic

Tolerance on capacitence values is very large

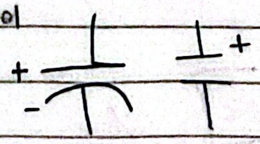


102K → tolerance (10, 10^2)

1000 pF @ 10%

b - Electrolytic (kutuplu) capacitors : the negative terminal must always be at a lower voltage the the positive terminal

Aluminum



Subject :   Date : ..../..../....

Electrical properties of a Capacitor

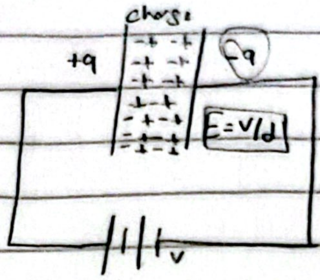
→ Acts like an open circuit at steady State (Doyum) when connected to a d.c. voltage or current source

→ Voltage on a capacitor must be continuous (sürekli gerilim gerekli)

Energy Storage

$\boxed{Q = CV}$

coulomb = farad · Voltage



$C = \frac{Q}{V}$ yük

$V = Ed$ net yük, mesafe

→ Current - Voltage Relationships

* $i_c = \frac{dq}{dt} \rightarrow q = C v_c \rightarrow \boxed{i_c = C\frac{dv_c}{dt}} \rightarrow V_c = \frac{1}{C}\int_{t_0}^{t} i_c\,dt$ denklem verilirse

* $p_c = i_c \cdot V_c \rightarrow p_c = C V_c \cdot \frac{dv_c}{dt}$

* $W_c = 1/2\, C V_c^2 \rightarrow \boxed{W_c = q^2/2C}$ enerji $U = 1/2\, CV^2$

Time Constant

→ charging

- $V(t) = V_c\,(1 - e^{-t/\tau})$

→ Discharging

- $V(t) = V_c\, e^{-t/\tau}$

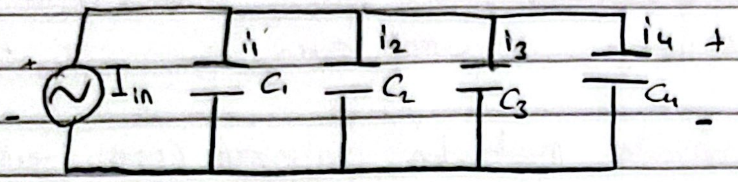
* $\tau = RC$

$Q = 5 \cdot 10 = 4C$

$Q = C \cdot V$ 16, 6, 18, 96, $V = 1/6$

Subject : Date :....../....../......

→ Capacitors in parallel :



paralelken normal toplama yapılır.

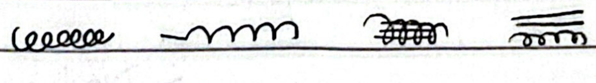
- $C_{eq} = C_1 + C_2 + C_3 + C_4$

→ in Series :

- $C_{eq} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_4}\right)^{-1}$

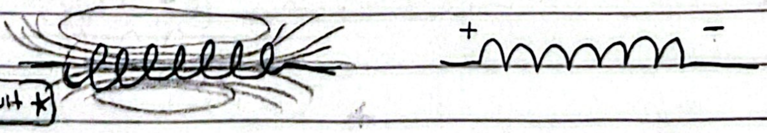
Summary

- An ideal capacitor act like open circuit when a DC volt. or current has been applied for at least 5τ
- Must be continous.

2 - inductors :  (akım) depolama

the flow of current through an inductor creates a magnetic field (right hand rule)

- akım sürekli olmalı -
* Eşit olduğunda short circuit *



L, inductance, has the units of Henries (H) $1H = 1V\text{-}s/A$

$$V_L = L \frac{di}{dt} \qquad i_L = \frac{1}{L} \int_{t_0}^{t_1} V_L \, dt$$

Subject : Date : ..../..../....

→ inductors in Series → In Parallel

• $L_1+L_2+L_3+L_4$ • $\left(1/L_1+1/L_2+1/L_3+1/L_4\right)^{-1}$

Power and Energy

→ $P_L = V_L \cdot i_L = L\, i_L \int_{t_0}^{t_1} i_L\, dt$ → $W = \int L \frac{di_L}{dt}\, dt = L \int i_L\, di_L$

$\boxed{\text{Calculations of } L}$

→ $L = \frac{N^2 \mu A}{l} = \frac{N^2 \mu_r \mu_0 A}{l}$

$L = N^2 - i \int dt$

N: the number of turns of wire
A: sectional area
μ: mobilite
l: length

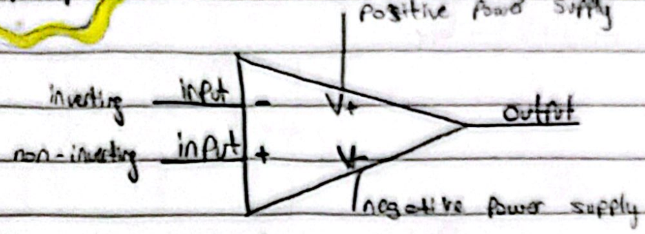
$\boxed{\text{wire}}$

unfortunately, even bare wire has inductance

$L = l\left[\ln\left[4\frac{l}{d}\right]-1\right](2\cdot10^{-7})\,H$ d: diameter of the wire

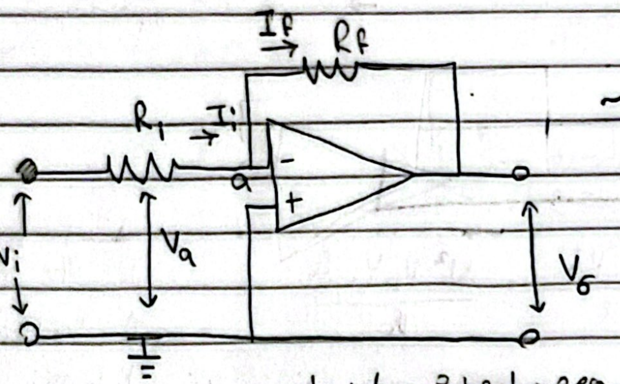
Subject : Date : ....../....../......

Operational Amp



the potential difference between the 2 inputs is → zero
the currents at the 2 inputs is → zero

example



eviren giriş

~ INVERTING - Amp ~

$V_i = 2V \sin 20\pi t$

$R_i = 800\ \Omega$

$R_f = 1200\ \Omega$

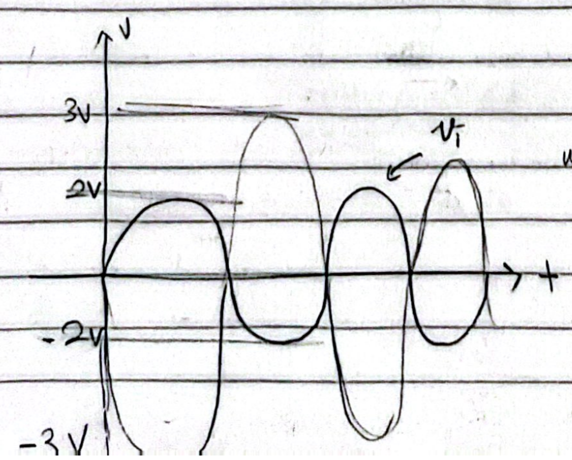
currents between 2 input → zero

$I_i = I_f + 0$

$\dfrac{V_a - V_i}{R_i} = \dfrac{V_o - V_a}{R_f} \rightarrow V_a = 0 \rightarrow$ ground

$\dfrac{-V_i}{R_i} = \dfrac{V_o}{R_f} \rightarrow \boxed{-V_i = V_o\left(\dfrac{R_i}{R_f}\right)}$ $\boxed{V_o = -V_i\left(\dfrac{R_f}{R_i}\right)}$

$\boxed{V_o = -2V \sin(20\pi t)} \cdot \dfrac{1200}{800} = -2 \cdot \dfrac{3}{2} \sin(20\pi t) = \boxed{-3V \sin(20\pi t)}$



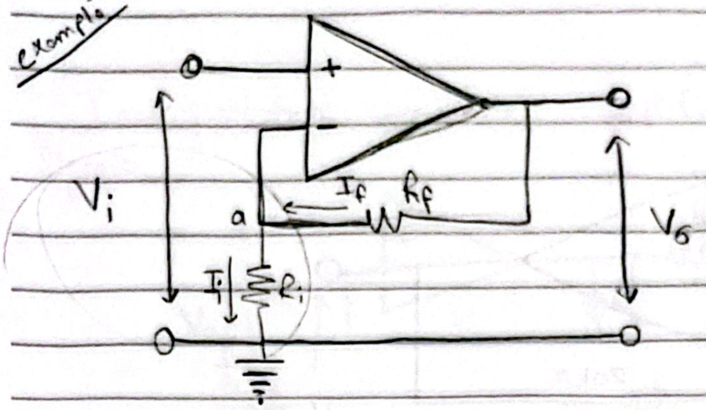
$w = 20\pi$

$f = \dfrac{w}{2\pi} = \dfrac{20\pi}{2\pi} = 10\ Hz$

Sena ♥ Sara

[redacted]

example



Non-inverting amp

$I_f + 0 = I_i$

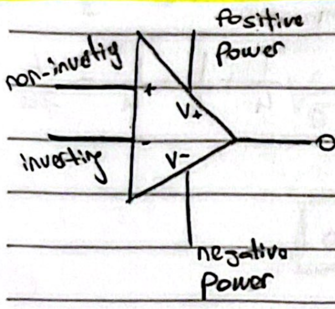
$$\frac{V_6 - V_a}{R_f} = \frac{V_a - 0}{R_i}$$

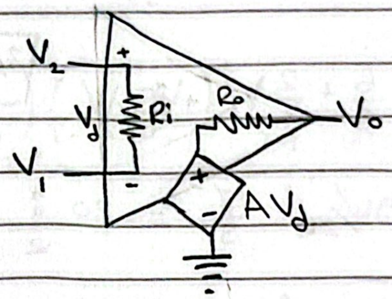
$V_i = V_a \longrightarrow$

$$\frac{V_6 - V_i}{R_f} = \frac{V_i}{R_i}$$

$$\boxed{V_6 = V_i\left(1 + \frac{R_f}{R_i}\right)}$$

Non-ideal OP-AMP





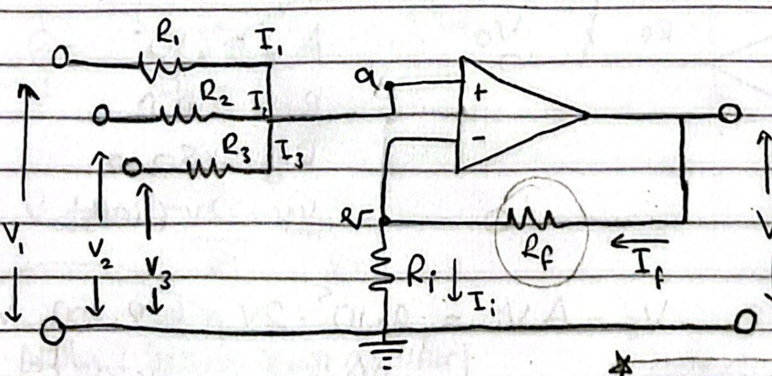
A is the open-loop voltage gain.

$R_i = \infty$
↳ so $V_d = 0$
$V_1 = V_2$

$$V_6 = A V_d = A(V_2 - V_2)$$

$$\boxed{V_d = V_2 - V_1}$$

Summing amplifier - non-inverting



$I_f + 0 = I_i$

$$\frac{V_o - V_v}{R_f} = \frac{V_v - 0}{R_i}$$

$$\boxed{V_o = V_v\left(1 + \frac{R_f}{R_i}\right)}$$

$$\boxed{V_a \cong V_v}$$

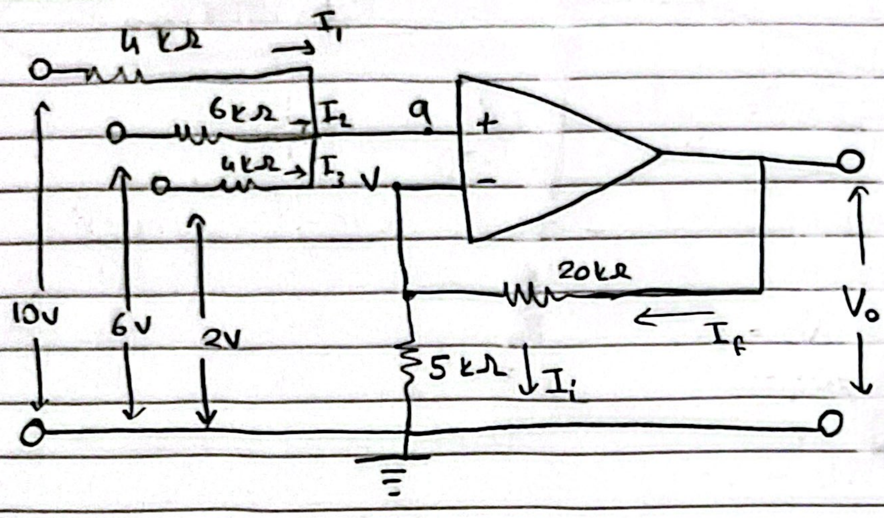
$$V_o = R_T\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)\left(1 + \frac{R_f}{R_i}\right)$$

$I_1 + I_2 + I_3 = 0$

$$\frac{V_1 - V_a}{R_1} + \frac{V_2 - V_a}{R_2} + \frac{V_3 - V_a}{R_3} = 0 \qquad \frac{1}{R_T}$$

$$\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} = V_a\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right) \longrightarrow V_a = R_T\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right) = V_v$$

example:



$$V_o = R_T\left(\frac{V_1}{R_1}+\frac{V_2}{R_2}+\frac{V_3}{R_3}\right)\left(1+\frac{R_f}{R_i}\right) \qquad \frac{1}{R_T} = \frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$$

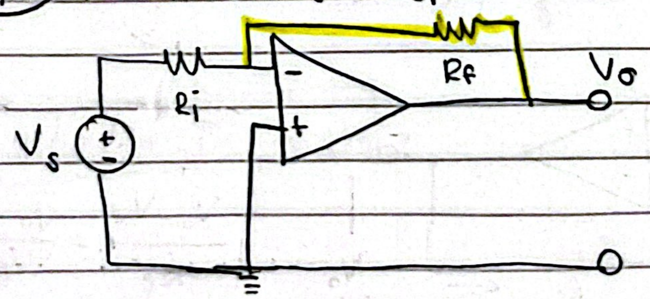
$$\boxed{3/2 = R_T} \leftarrow \frac{2}{3} = \frac{1}{4}+\frac{1}{6}+\frac{1}{4} = \frac{16}{24}$$

$$V_o = 3/2\left(\frac{10}{4}+\frac{6}{6}+\frac{2}{4}\right)\left(1+\frac{20}{5}\right)$$

$$V_o = 3/2 \cdot 96/24 \cdot \frac{25}{5} = \frac{20.3}{2} = \boxed{30\ V = V_o}$$

Gain = $\left(1+\frac{R_f}{R_i}\right) = 5$ = kazanç

Example - open loop vs closed loop -



$A = 2 \times 10^5$

$R_i = 2\,M\Omega$

$R_6 = 50\,\Omega$

$V_s = 2V$ (input

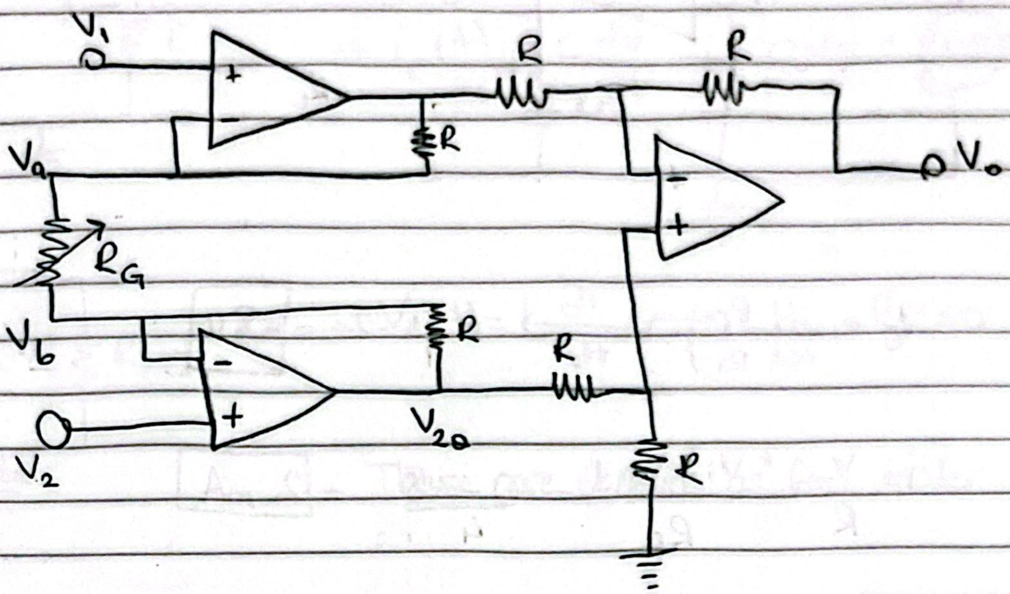
open loop gain = ? $V_6 = A V_i = 2 \times 10^5 \cdot 2V = 400.000\ V$

$V_6 = V_{cc}$ Saturated

closed loop gain = ? ($R_f = 20\,k\Omega$)

$$V_6 = -\frac{R_f}{R_i} \cdot V_i = \frac{-20}{10} \cdot 2V = -4V$$

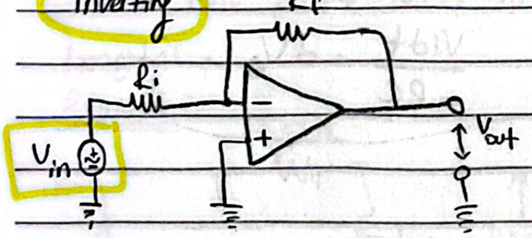
Instrumentation amplifier amplifies small differences in the input signals.



$$V_o = \underbrace{\left(1 + \frac{2R}{R_G}\right)}_{\text{gain}}(V_2 - V_1)$$

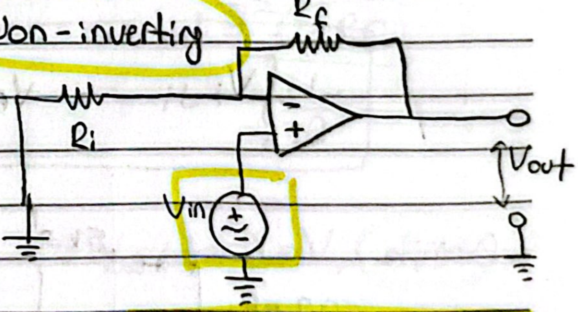
Summary

Inverting



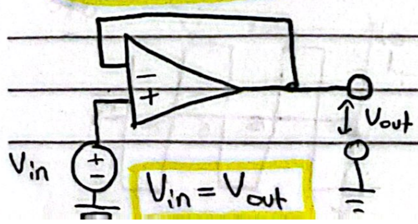
$$\boxed{V_{out} = -\frac{R_f}{R_i} V_{in}}$$

Non-inverting



$$\boxed{V_{out} = \left(1 + \frac{R_f}{R_i}\right) V_{in}}$$

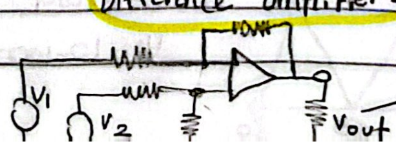
Voltage follower (Gain amplifier)



$\boxed{V_{in} = V_{out}}$

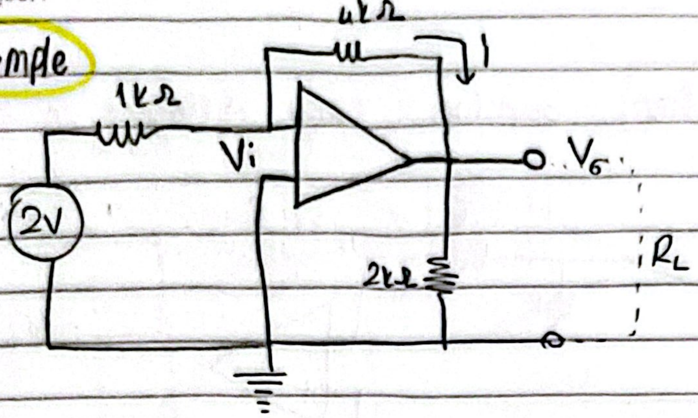
Summing amplifier → $\boxed{V_{out} = \frac{-R_f}{R}(V_1 + V_2 +}$

Difference amplifier → $\boxed{V_{out} = V_2 - V_1}$



Subject : Date : ...../...../.....

example



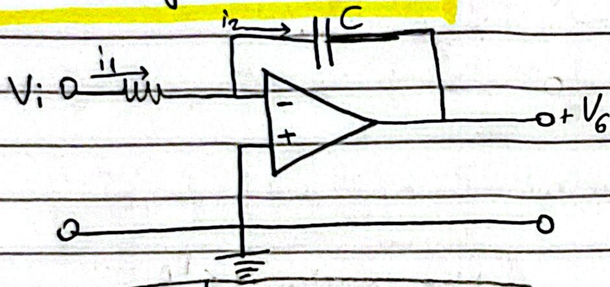
$i = ?$

$V_o = ?$

$$V_o = -\left(\frac{R_f}{R_i}\right) \cdot V_{in} \rightarrow -\frac{4}{1} \cdot 2 = \boxed{-8V}$$

$$i = \frac{V}{R} = \frac{V_i - V_o}{R_f} = \frac{0 - -8}{4} = \boxed{2\ mA}$$

the integrator Curcuit



$$i_1 = \frac{V_i}{R} \qquad i_2 = -C\frac{dV_o}{dt}$$

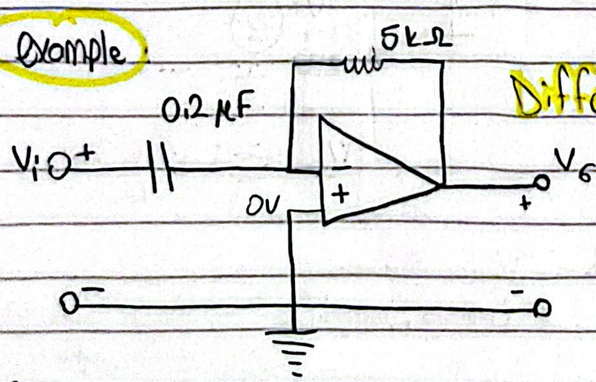
$$i_1 = i_2$$

$$\frac{V_i}{R} = -C\frac{dV_o}{dt}$$

$$\frac{V_i dt}{-RC} = dV_o \rightarrow \text{integral}$$

$$\boxed{\frac{-1}{RC}\int_0^t V_i\,dt = V_o(0)}$$

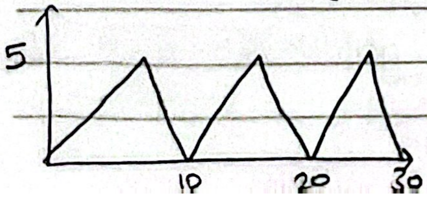
example



Differantiator $V_o = -RC\dfrac{dv_i}{dt}$

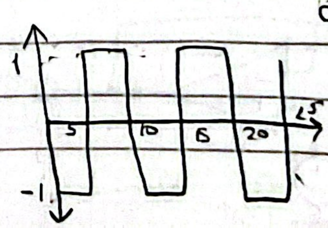
$$V_o = -5000 \cdot 0.2 \cdot 10^{-6} \cdot \frac{d(1000)}{dt} = (-1)$$

$$V_o = -5000 \cdot 0.2 \cdot 10^{-6} \cdot \frac{d(10-1000)}{dt} = (1)$$

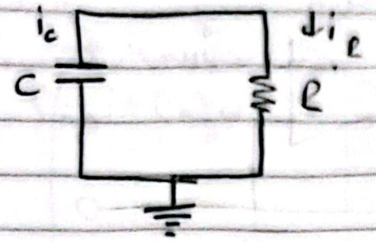


$V_i = 1000t \quad 0<t<5$

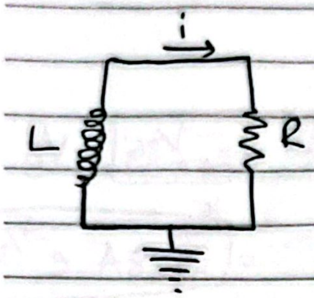
$V_i = 10-1000t \quad 5<t<10$



RC and RL Circuits



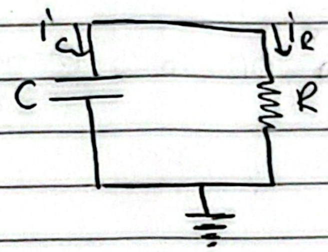
$\rightarrow i_c(t) = C\frac{dv}{dt} \longrightarrow C\frac{dv}{dt} + \frac{V}{R} = 0$



$\rightarrow V_L(t) = L\frac{di}{dt} \longrightarrow L\frac{di}{dt} + Ri = 0$

These are known as "first order circuits"

RC circuit



$i_c + i_R = 0$

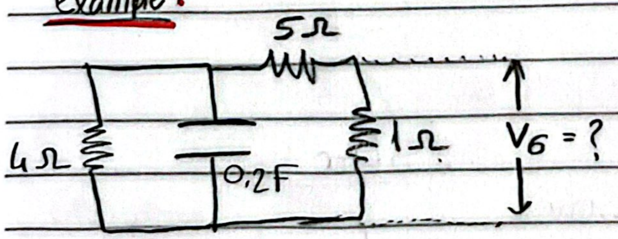
$C\frac{dv}{dt} = \frac{V}{R}$

$\boxed{v(t) = V_0 e^{-t/RC}}$

when time $0 \rightarrow v(t) = V_0$

time constant $= \boxed{\tau = RC}$

example:



$V_c(t=0) = V_0$

$\tau = RC = 2{,}4 \cdot 0{,}2 = 0{,}48$

$R_{eq} = \frac{4 \cdot 6}{4+6} = \frac{1}{4} + \frac{1}{6} = 2{,}4\,\Omega$

$V_c(t) = V_0 e^{-t/\tau} = \frac{1}{1+5} \cdot e^{-t/0{,}48} = \boxed{\frac{1}{6}e^{-t/0{,}48}}$

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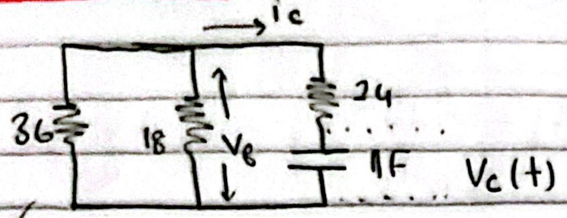
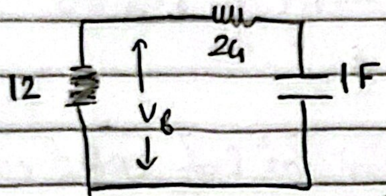
example -2-:



$V_z(t=0) = 10V$

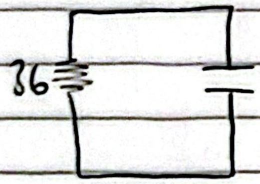
$V_c = ?$ $V_B = ?$ $i_c = ?$

$\frac{36 \cdot 18}{36+18} = \frac{1}{36} + \frac{1}{\underset{(2)}{18}} = \frac{3}{36} = 12$



$\frac{12}{12+24} \cdot 10V \cdot e^{-t/36} = \boxed{3.33\,Ve^{-t/36}} = V_B$

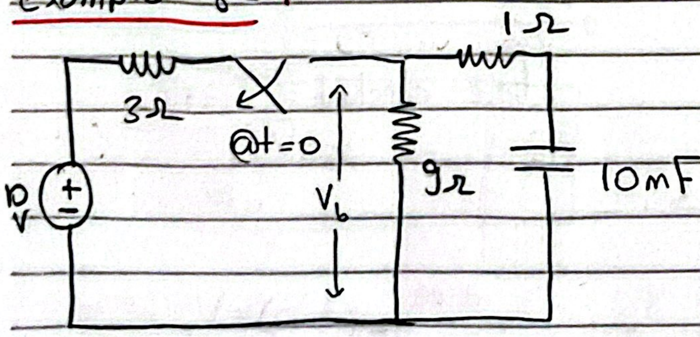
$i_c = \frac{V_B}{R_B} = \frac{3.33\,Ve^{-t/36}}{12} = \boxed{0{,}28A \cdot e^{-t/36}}$



$36 \cdot 1 = 36 \text{ sec} = \tau \rightarrow \boxed{V_c(t) = 10V \cdot e^{-t/36}} = V_c$

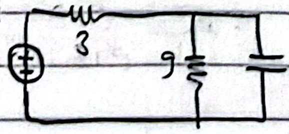
or $i_c = C \frac{dv}{dt}$

example -3-:



$V_c(t) = ?$ $U_c(t) = ?$

before:

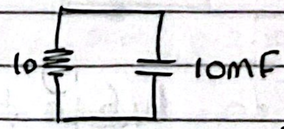


$V_b = \frac{9}{9+3} \cdot 10V$

$\boxed{V_b = 7{,}5} = V_{oc}$

$U = \frac{1}{2} C V_0^2 = \frac{1}{2} \cdot 10 \cdot (7{,}5)^2 = \boxed{0{,}28\,J}$

after:



$V_c(t) = V_0 e^{-t/\tau}$

$\tau = 10 \cdot 0{,}001 = 0{,}01$

$\boxed{V_c(t) = 7{,}5 \cdot e^{-t/0{,}01}}$

$U_c(t) = \frac{1}{2} C \left[V_c(t)\right]^2$

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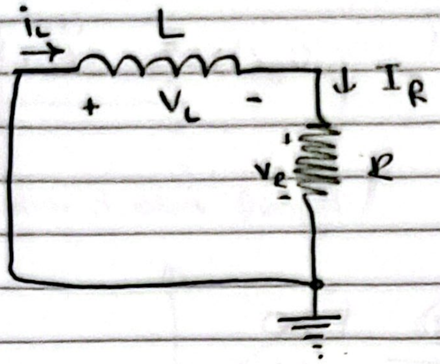
RL circuit :



$$V_L = L\frac{di}{dt} \qquad u(t=0) = \frac{1}{2}LI^2$$

KVL :

$$V_L + V_R = 0$$

$$L\frac{di}{dt} + i_R R = 0$$

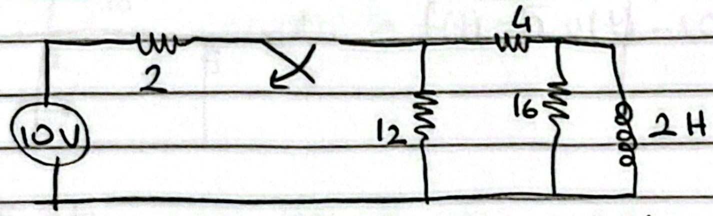
$$i(t) = B\,e^{-t/L/R} \qquad \tau = \frac{L}{R}$$

$$i(t=0) = I_0 = B\,e^0$$

$$I_0 = B$$

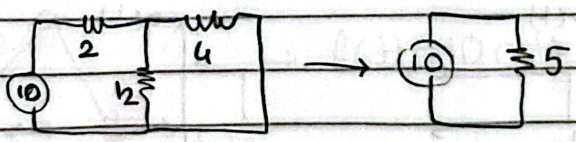
Sooo $\boxed{i(t) = I_0\,e^{-t/\tau}}$

example :



$i(t) = ?$

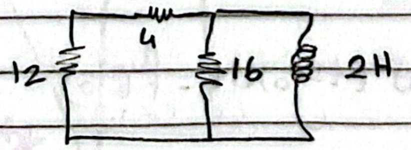
(*) when $t<0$ (the inductor → short circuit)



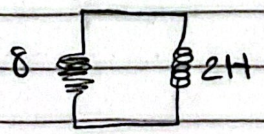
$$I = \frac{V}{R} = \frac{10}{5} = 2 = I$$

$$I_a = I\left(\frac{12}{4+12}\right) = 2A \cdot \frac{12}{16} = 1{,}5\,A$$

(*) when $t>0$



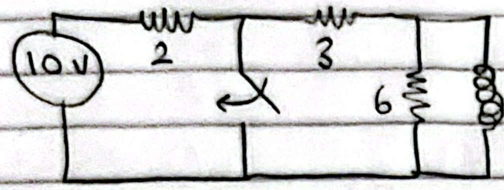
$$I(t) = 1{,}5 \cdot e^{-t/0{,}25} = \boxed{1{,}5e^{-4t}}$$



$$\tau = \frac{L}{R} = \frac{2H}{8\Omega} = 0{,}25\,sec$$

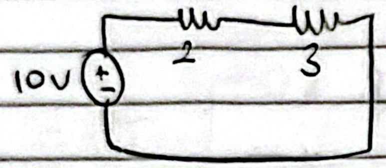
Subject : Date

example -2-



$i(t) = ?$ $V_L(t) = ?$ $i_6(t) = ?$

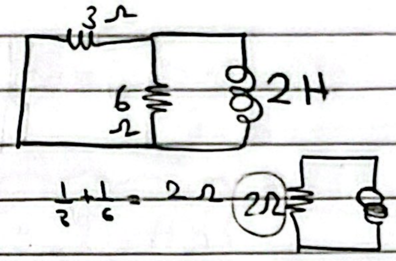
* $t < 0$



$= 10V = 5 \cdot i$

$\boxed{i = 2A}$

* $t > 0$



$\frac{1}{3} + \frac{1}{6} = 2\Omega$

$\tau = \frac{L}{R} = \frac{2H}{2\Omega} = \boxed{1 \text{ sec}}$

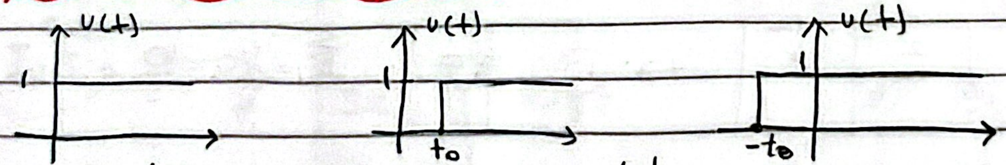
$i_6(t) = \frac{-4ve^{-t}}{6\Omega} = \boxed{-\frac{3}{4} A e^{-t}}$

$V_L = L\frac{di}{dt} = 2H \cdot \frac{d(2e^{-t})}{dt}$

$\boxed{V_L = -4v e^{-t}}$

$\boxed{2 \cdot e^{-t}} \leftarrow i(t) = i_L(t=0) \cdot e^{-t}$

the unit step Functions



$u(t) = 0 \quad t < 0$
$u(t) = 1 \quad t > 0$

$u(t - t_0) = 0 \quad t < t_0$
$u(t - t_0) = 1 \quad t > t_0$

$u(t + t_0) = 0 \quad t < -t_0$
$u(t + t_0) = 1 \quad t > -t_0$

* Delta function $\delta(t)$

$$\delta(t) \begin{cases} 0 & t < 0 \\ \infty & t = 0 \\ 0 & t > 0 \end{cases}$$

$$\int_a^b f(t)\delta(t - t_0)dt = f(t_0)$$

$$\int_{-\infty}^{+\infty} \delta(t)dt = \int_{-0}^{+0} \delta(t)dt = 1$$

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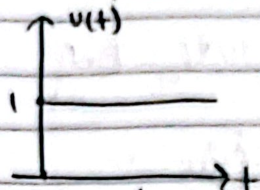
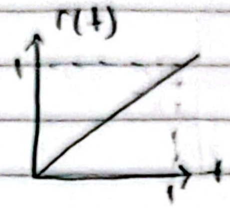
the Ramp function :

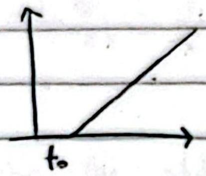


assuming it start from '1'

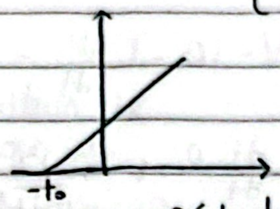


$$r(t) = \int_{-\infty}^{t} u(t)\,dt = t\,u(t)$$

$$r(t) = \begin{cases} 0 & t<0 \\ t & t>0 \end{cases}$$



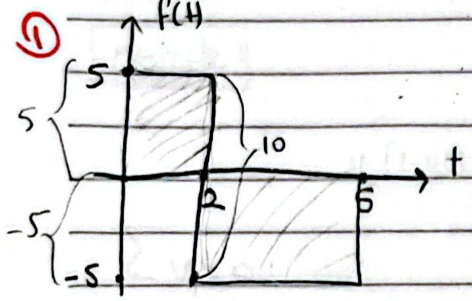
$$r(t-t_0) = \underbrace{\begin{matrix} 0 & t-t_0 \\ t<t_0 & t>t_0 \end{matrix}}$$



$$r(t+t_0) = \begin{cases} 0 & t<-t_0 \\ t+t_0 & t>-t_0 \end{cases}$$

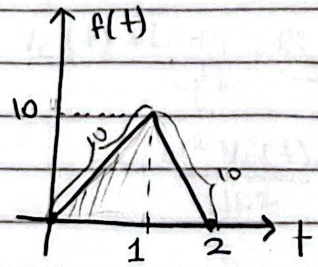
examples

①



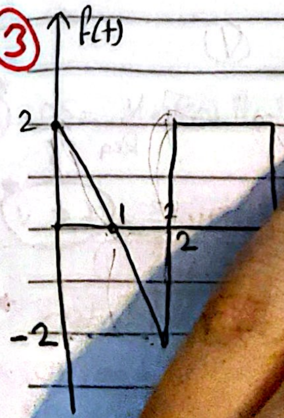
$\rightarrow f(t) = 5\,u(t) - 10\,u(t-2) + 5\,u(t-5)$

②



$\rightarrow f(t) = 10\,r(t) - 20\,r(t-1) + 10\,r(t-2)$

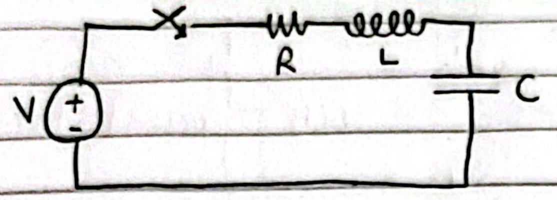
③



[illegible]$) = 2$ [illegible] $2\,r(t) + 2\,r(t-2) + 4\,u(t-2)$

[illegible]$-3)$

Second Order Circuit :



$V_R = iR \qquad V_L = L\frac{di}{dt}$

$V_C = \frac{1}{C}\int_0^t i\,dt$

KVL :

$$V - iR - L\frac{di}{dt} - \frac{1}{C}\int_0^t i\,dt = 0$$

derivative

$$\frac{di}{dt}R + L\frac{d^2i}{dt^2} + \frac{i}{C} = 0$$ divide by L

$$\frac{R}{L}\frac{di}{dt} + \frac{d^2i}{dt^2} + \frac{1}{LC}i = 0$$

Çözüm aşamaları :

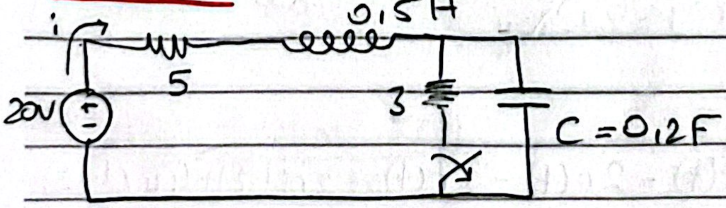
① $i(t=0^-)$ $\qquad V(t=0^-)$

② $i(t=0^+)$ $\qquad V(t=0^+)$

③ $\frac{di}{dt}(t=0^+)$ $\qquad \frac{dV}{dt}(t=0^+)$

④ $i_L(t\to\infty)$ $\qquad V_C(t\to\infty)$

Example :



① $t<0$ ✓

$i(0^-) = i_L(0^-) = \frac{V}{R_{eq}} = \frac{20}{8} = 2{,}5$ *

$V_C(0^-) = 20V \cdot \frac{3}{8} = 7{,}5\,V$ *

② $t>0$ ✓

will still some cause the inductor is right there

$i(0^+) = 2{,}5$ * $\quad V(0^+) = 7{,}5$ *

$20V - (2{,}5)(5) - V_L - 7{,}5V = 0$

$V_L = 0$

④ $t\to\infty$ ✓

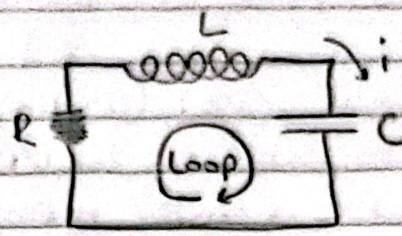
$i_L(t\to\infty) = 0$ *

$V_C(t\to\infty) = 20V$ *

③ $\left(i_C/C = \frac{dV_C}{} = \frac{2{,}5}{} = \boxed{12{,}5V} \right)$ * $\frac{di}{dt} = \frac{V_L}{L}$ = to find V_L → $\frac{di}{dt} = \frac{V_L}{L} = \boxed{0}$ A *

Subject :	Date : ..../..../....

Source free RCL circuit



Using KVL :

$-V_R - V_L - V_C = 0$

$$-iR - L\frac{di}{dt} - \frac{1}{C}\int i\,dt = 0$$

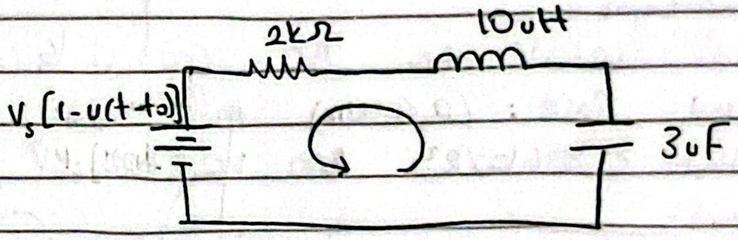
Describe the solution when the condition is

1- Overdamped → $a > w_0$

2- Critically damped → $w_0 = a$

3- underdamped → $w_0 > a$

example:



$\sum V = 0$

$$V_c(t) + L\frac{di_L}{dt} + Ri_L = 0 \qquad i_c(t) = C\frac{dv_c(t)}{dt} \qquad i_L(t) = i_c(t)$$

$$LC\frac{d^2V_c(t)}{dt^2} + RC\frac{dv_c(t)}{dt} + V_c(t) = 0 \qquad \text{(LC'ye böl)}$$

$$\frac{d^2V_c(t)}{dt^2} + \frac{R}{L}\frac{dV_c(t)}{dt} + \frac{V_c(t)}{LC} = 0$$

Let $V_c(t) = Ae^{s\Delta t}$

$$As^2e^{s\Delta t} + \frac{AR}{L}se^{s\Delta t} + \frac{A}{LC}e^{s\Delta t} = 0$$

$a = R/2L$ $\qquad Ae^{s\Delta t}\left(s^2 + \frac{R}{L}s + \frac{1}{LC}\right) = 0$

$w = \frac{1}{\sqrt{LC}}$ $\qquad \boxed{S^2 + \frac{R}{L}S + \frac{1}{LC} = 0}$ $\qquad \Delta = b^2 - \sqrt{4ac}$

$s^2 + 2as + w^2 = 0$ $\qquad s_1\, s_2 = \frac{b^2 \pm \sqrt{\Delta}}{}$

$s_1 = \ldots$

$C > \frac{4L}{R^2}$ $\frac{CR^2}{4}$

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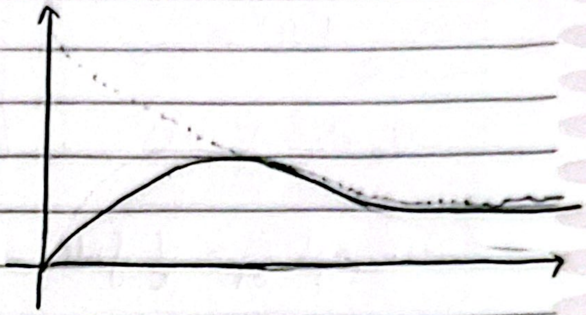
* three types of Solutions :

1- Overdamped Case : ($a > w_0$)

implies that $C > 4L/R^2$

S_1 and S_2 → negative + Real



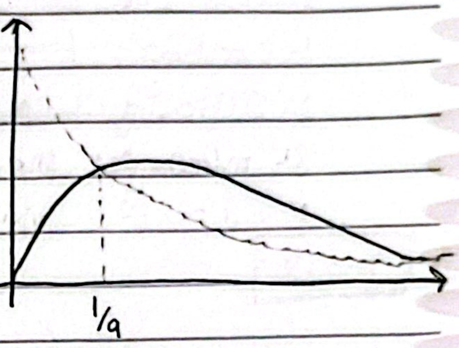
→ $V_c(t) = A_1 e^{s_1 \Delta t} + A_2 e^{s_2 \Delta t}$

en hızlı inen

2- Critically damped Case : ($a = w_0$)

implies that $C = 4L/R^2$

$S_1 = S_2 = -a = -R/2L$



→ $V_c(t) = A_1 e^{-a\Delta t} + A_2 \Delta t e^{-a\Delta t}$

en erken yakınsayan

3- Underdamped Case : ($a < w_0$)

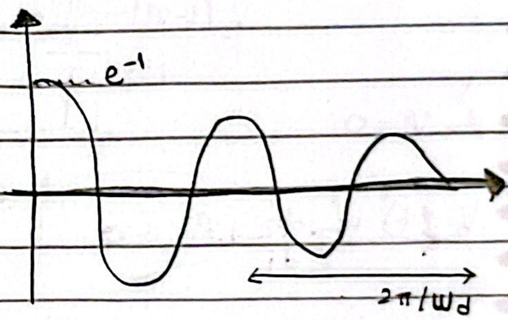
implies that $C < 4L/R^2$

- en çok salınım -

$S_1 = -a + \sqrt{a^2 - w^2} = -a + jw_d$

$S_2 = -a - \sqrt{a^2 - w^2} = -a - jw_d$

$\boxed{w_d = \sqrt{w^2 - a^2}}$ $j = \sqrt{-1} \rightarrow (i)$



$V_c(t) = e^{-a\Delta t}(A_1 e^{jw_d \Delta t} + A_2 e^{-jw_d \Delta t})$ → for ($w_d \Delta t = \theta$)

$V_c(t) = e^{-a\Delta t}[(A_1 + A_2)\cos w_d \Delta t + j(A_1 - A_2)\sin w_d \Delta t]$

(*) Sadece Paralel veya Seri olduğu zaman a değişir

Parallel → $a = \frac{1}{2RC}$ Series → $a = \frac{R}{2L}$

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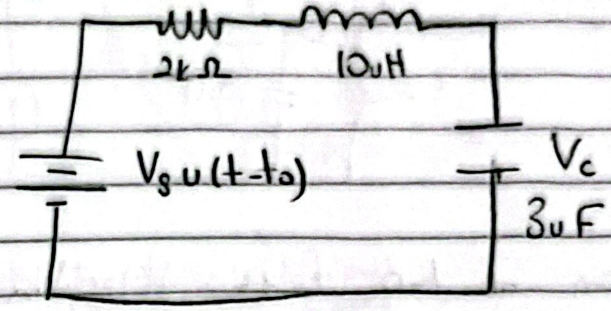
Series RLC Network (with Source)



$i(t_o) = i_L(t_o) = 0A$ and $V_C(t_o) = 0V$ – initially –

$V_L(t_o) = 0V$ $\quad i_C(t_o) = 0A$

→ when V_s at $t > t_o$, Replace the capacitor with open circuit and the inductor with a short circuit.

$i(\infty) = i_L(\infty) = 0A$ and $V_C(\infty) = V_s$

$V_L(\infty) = 0V$ and $i_C(\infty) = 0A$

for k

$$\frac{d^2 V_C(t)}{dt^2} + \frac{R}{L}\frac{dV_C(t)}{dt} + \frac{1}{LC} V_C(t) = \boxed{V_s}/LC$$

* hep Sabit olon formoller *

- $i_C(t) = C\dfrac{dV_C(t)}{dt}$ $\quad$ - $i(t) = i_C(t) = i_L(t) = i_R(t)$
- $V_L(t) = L\dfrac{di_L(t)}{dt}$ $\quad$ - $V_R(t) = R\,i_R(t)$

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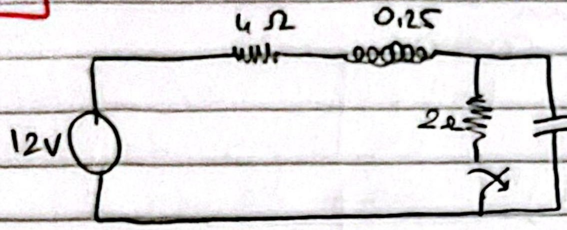
example :



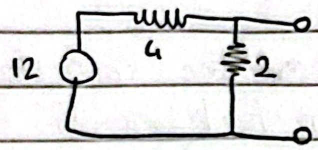
the switch open at $t=0$. find: $i(t=0^+)$, $v(t=0^+) = ?$

$\frac{di(t=0)}{dt}$, $\frac{dv(t=0^+)}{dt} = ?$

steady state → inductor = short $i(\infty)$, $V(\infty) = ?$

capacitor = open

$(t=0^-)$

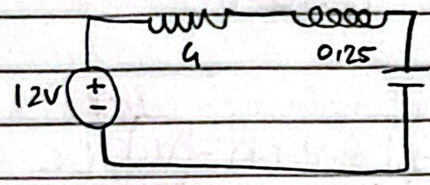


→ $12 = 6i \rightarrow \boxed{i = 2A} = i(0^-)$

$4V = 2 \cdot i(0^-) = V(0^-)$

$(t=0^+)$

$i_L(0^+) = i(0^-) = 2A$ $V(0^+) = V(0^-) = 4V$

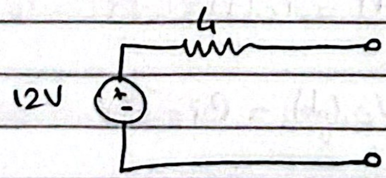


$i_C = C\frac{dv(0^+)}{dt} \rightarrow \frac{2}{0.1} = 20V/s$

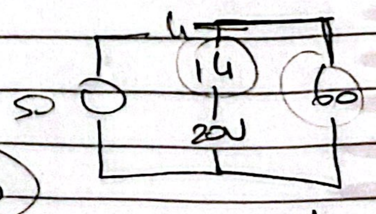
$-12 + 4\underbrace{i(0^+)}_{2} + V_L(0^+) + \underbrace{V_C(0^+)}_{4} = 0$

$\frac{di}{dt} = \boxed{V_L(0^+) = 0 \ A/S}$

$(t = \infty^+)$ steady state → L → short, C → open



$i(\infty) = 0$ $V(\infty) = 12V$

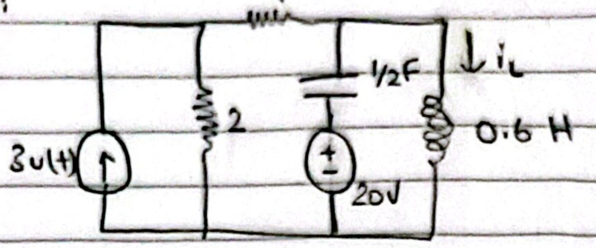


$t = 0$

$\frac{1}{...} + \frac{1}{14}$

Subject : Date ..../..../....

example :



$i_L(0^+) = ?$ $V_C(0^+) = ?$

$V_R(0^+) = ?$

$\frac{dV_C(0^+)}{dt} = ?$ $\frac{di_L(0^+)}{dt} = ?$

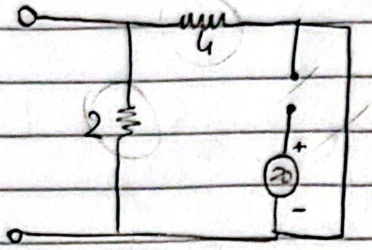
$\frac{dV_R(0^+)}{dt} = ?$

$3u(t) = 0$

$(t < 0)$ steady state . L → short, C → open

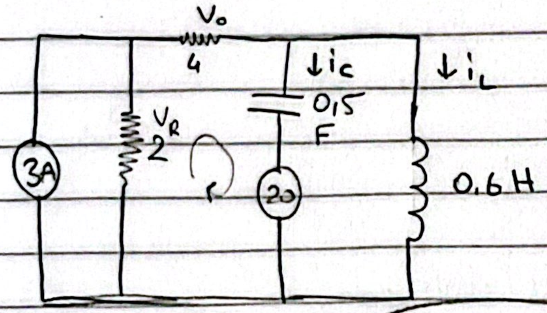
$i_L(\infty) = ?$ $V_C(\infty) = ?$

$V_R(\infty) = ?$



$i_L(0^-) = 0$ $V_R(0^-) = 0$ $V_C(0^-) = -20$ V

$(t = 0^+)$ $(3u(t) = 3)$



$i_L(0^+) = V_R(0^+) = 0$ $V_C(0^+) = -20$ V

$3 = \frac{V_R(0^+)}{2} + \frac{V_o(0^+)}{4}$ → $2V_R + V_o = 12$

$-V_R(0^+) + V_o(0^+) + V_C(0^+) + 20 = 0$

$12 - 2V_R$ -20

$-3V_R = -12$ → $\boxed{V_R = 4}$

$\boxed{V_o = 4}$

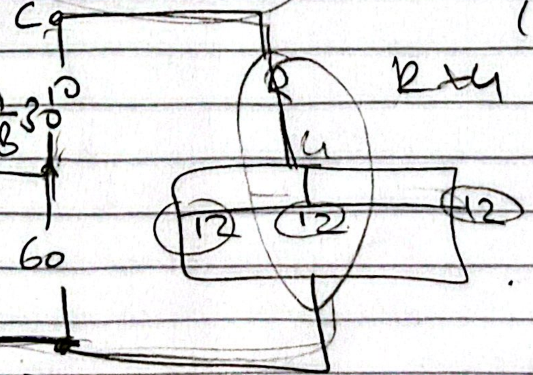
A 30 B 10 C R+4 D

60

$\frac{4}{60} = \frac{1}{R+14} + \frac{1}{60}$

(3)

t<0



$\left(\frac{1}{R+14} + \frac{1}{60}\right)^{-1} + 30 = 45$

$= 15$

$R+4$

$\frac{3}{3R+52} + \frac{1}{60} = \frac{4}{60} \frac{1}{15}$

$3R + 52 = 60$ -52

$\frac{3}{12} = \frac{1}{4}$

8/3

$\frac{1}{15} = \frac{1}{60} + \frac{1}{R+14}$ D

(3) R+4

A 30 — B — 10 C 10 $3R = 8$ R+4

$\frac{4}{60} = \frac{1}{15}$ 60

$3R + 52 = 60$ $+10$ $R+14$