Voltmeter

↳ The internal resistance is very large

Ammeter

↳ has a very small internal resistance

DCV → DC: Direct (Voltage)
AC: Avg

DCA → DC: direct (current)
AC: Avg

---

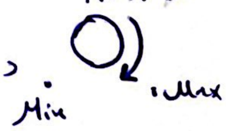
ACV → RMS value in AC (Voltage)

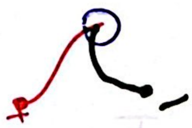
ACA → RMS value in AC (current)

---

Frequency , Shape

AMPL



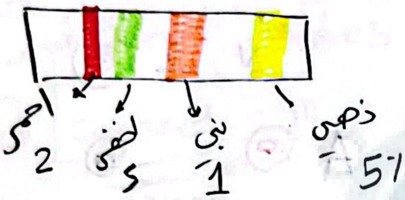



# Electrical lab

## (Exp 1)

### 1 Resistor

- → 4-colors: $a\,b \times 10^{c}$ $\pm d$ (Tolerance)
- → 5-colors: $a\,b\,c \times 10^{d}$ (Tolerance) $\pm e$



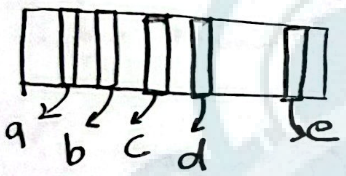

4-color-Code

$25 \times 10^{1} \pm 0.05$

$250 \pm (0.05 \times 250)$

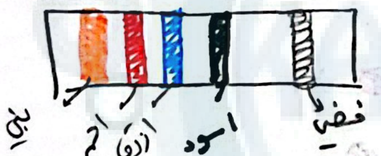
$250 \pm 12.5$

↳ Range (237.5 – 262.5)




5-color-code

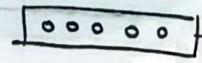
$abc \times 10^{d} \pm e$ ↳ tolerance




$126 \times 10^{0} \pm 10\%$

$126 \pm 12.6$ → Range

bread board



→ one node


$\Sigma I = zero$ (Intering)

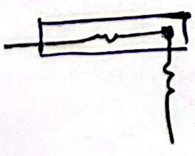

$V_1 = V_2$

short circuit

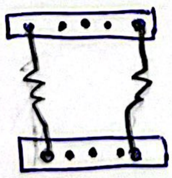
$\Delta V = zero$

$\Delta V = zero$

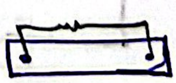
$I = zero$



series



Parallel



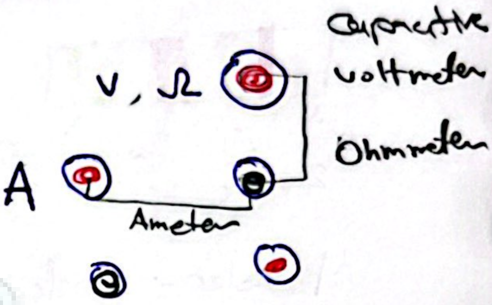
no Resistance

short circuit

## [2] Supply:-

(DC) constant with time

① digital multimeter




ACV → $V_{rms}$ (efficitive) voltage

DCV → Direct voltage

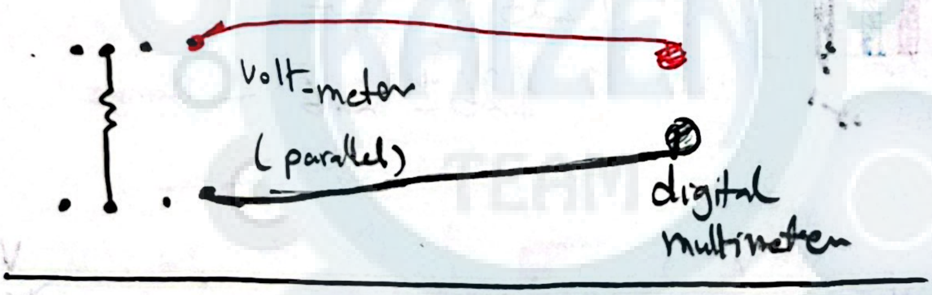
Ω → Resistance

DCA → direct current

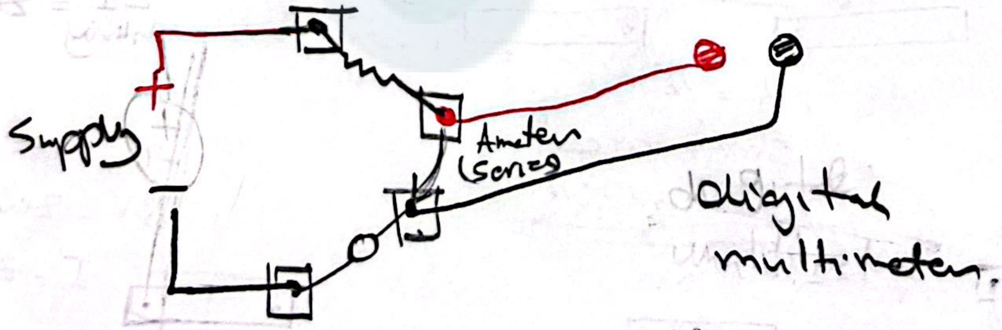
ACA → effictive current ($I_{rms}$)

diode → ① shift ② direct ⟹ diode

① V




② I



# 3 Resistance (R)

Can't be measured while it's connected to the circuit


1. you must remove all of the supplies
2. put the (resistance / resistor) at any tow different nodes, but alone (not connected to any supply)
3. connect the ohmmeter in parallel

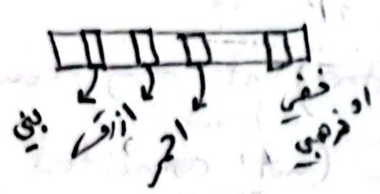

4. you can find its value by the color code.. (nominal value)

# Exp2

4 - color - code

**way 1 by the color code**

[1] 1600 Ω → 1 6 * $10^2$



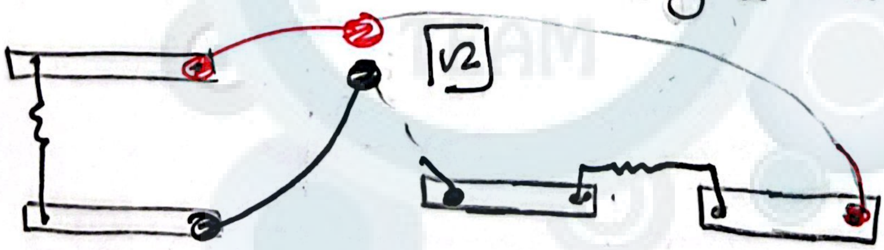

[2] 1200 Ω → 1 2 * $10^2$

بني احمر احمر

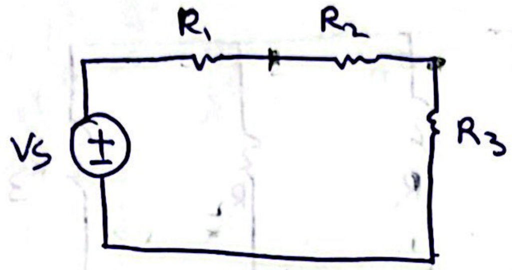
[3] 1000 → 1 0 * $10^2$

بني اسود احمر

Second way → by The ohmeter
digital multimeter

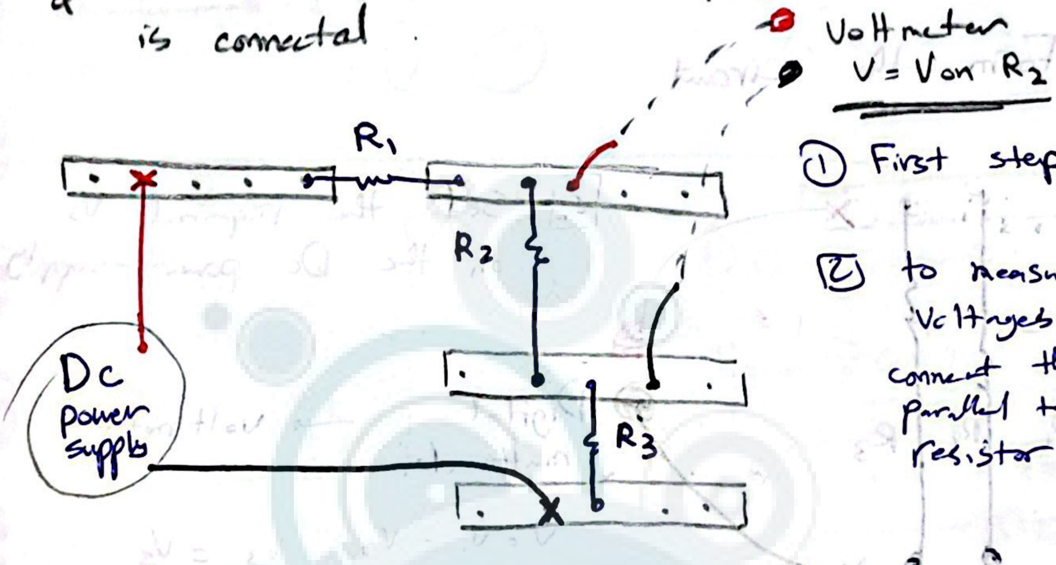


(1) Form the circuit




(2) Set Vs on the DC-power supply

* don't turn the power supply on unless your circuit is connected.

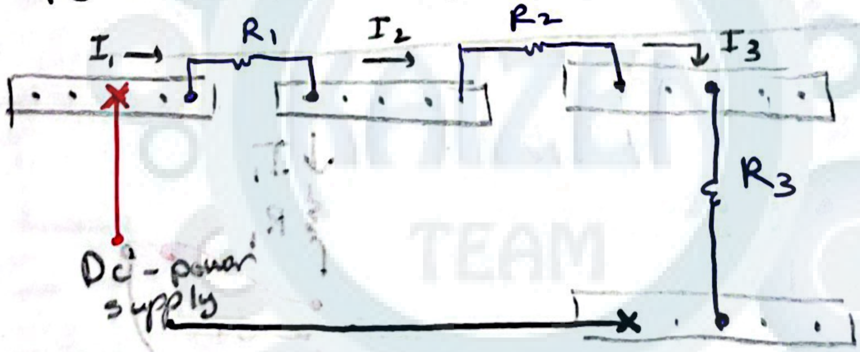



(1) First step

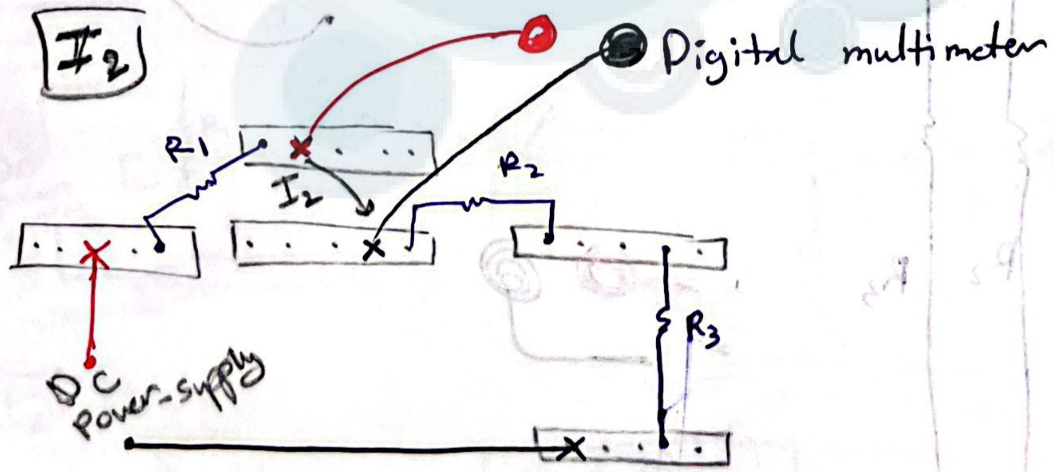
(2) to measure the Voltages.. connect the voltmeter parallel to the resistor..

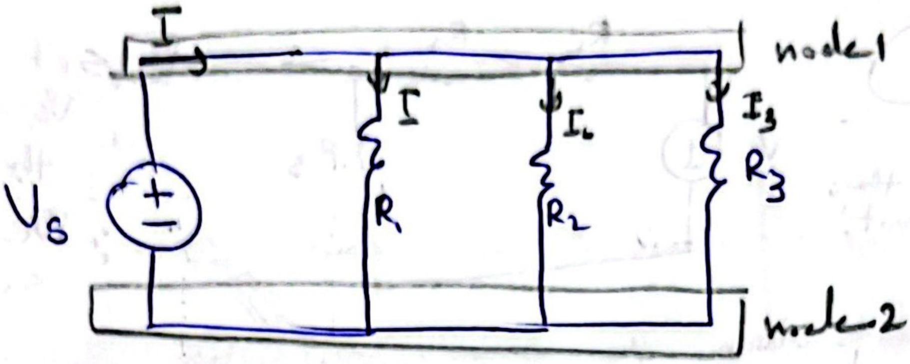
---

to find the currents



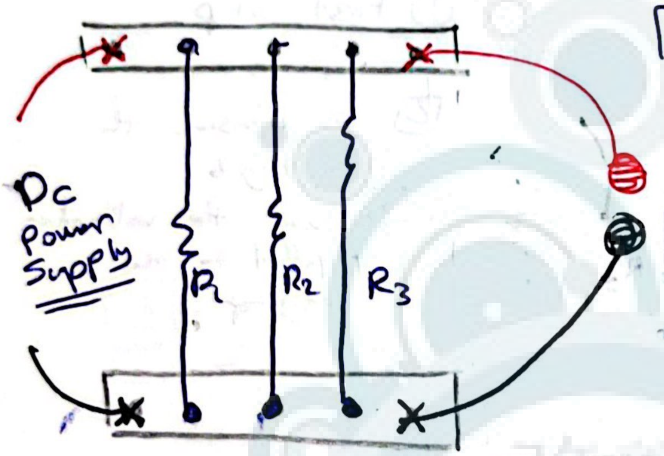

I2






① Form the circuit

① V :

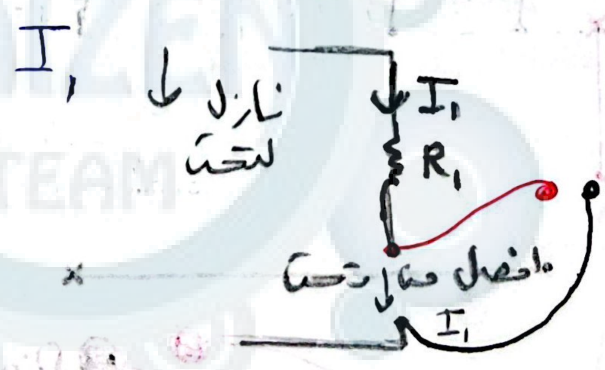


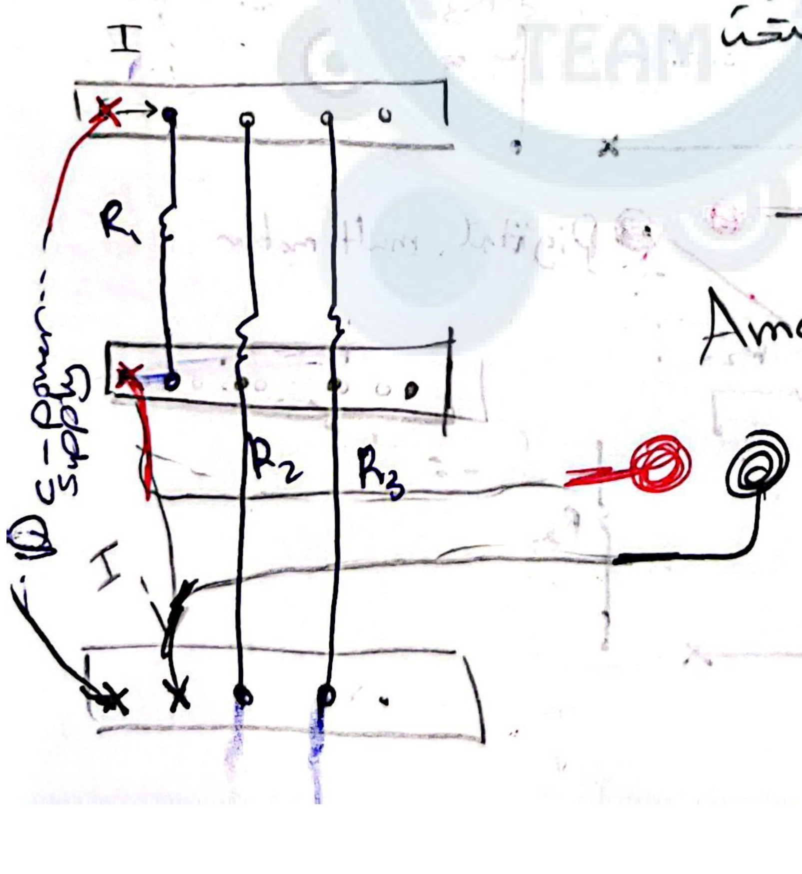

[2] Set the required $V_s$ on the Dc-power-supply

Digital multi-meter → Volt meter

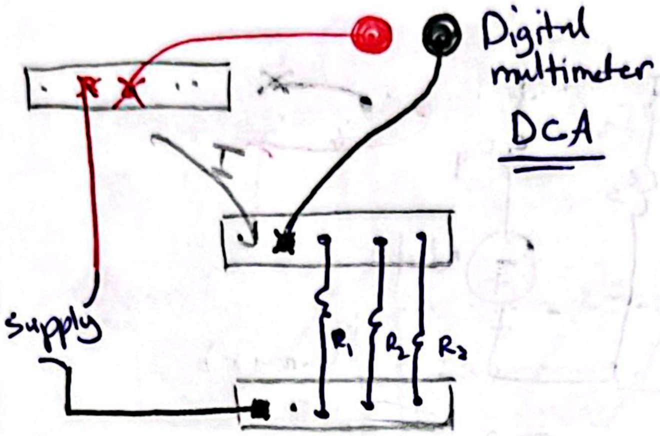
$V = V_1 = V_2 = V_3 = V_s$

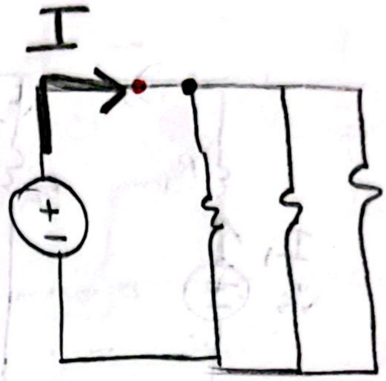
② I :

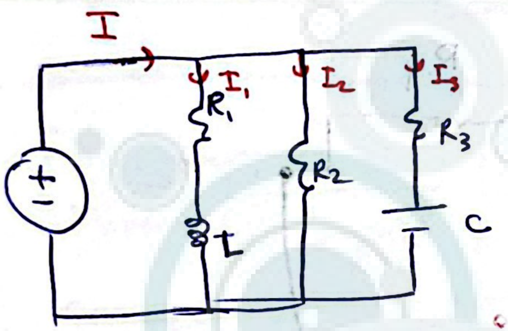



Ameter




DC- circuit

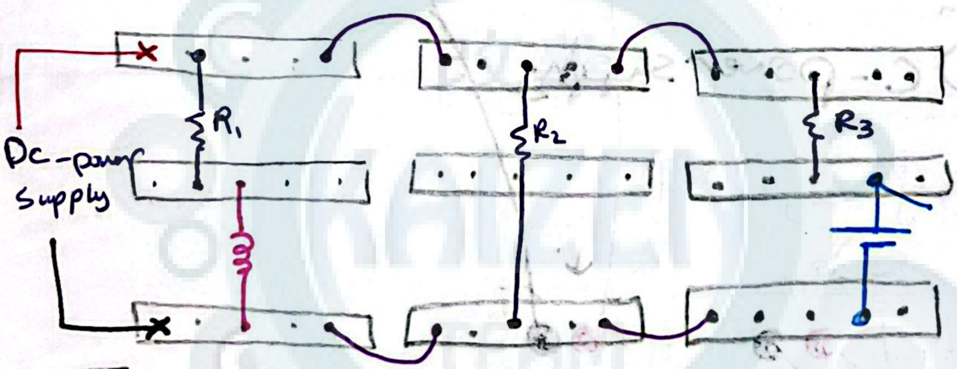
$I_3 = $ (zero)

$I_1 = (I_1$ without L)

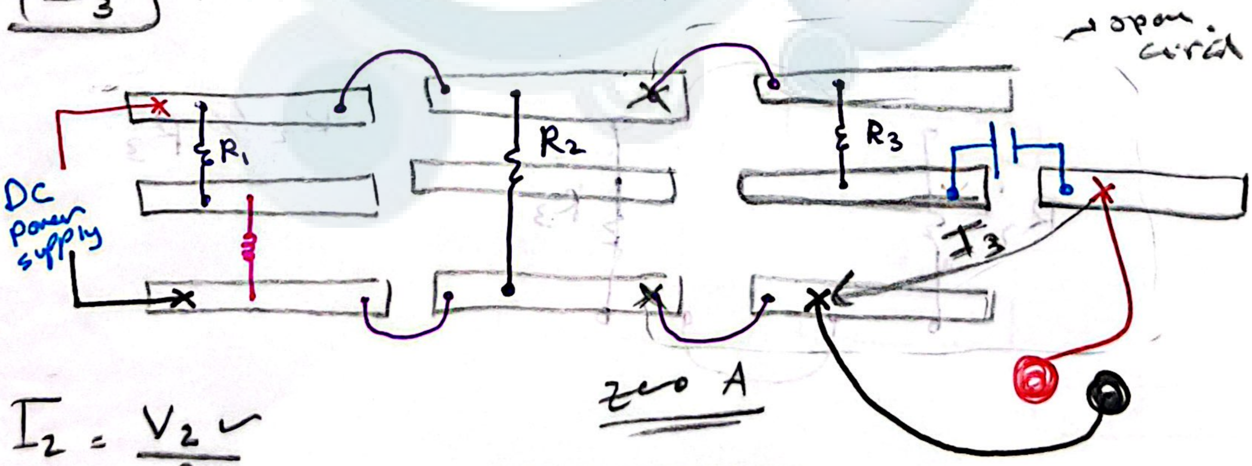
In DC-circuit :-

(1) Inductor
↓
short circuit

(2) capacitor
↓
open circuit




$I_3$



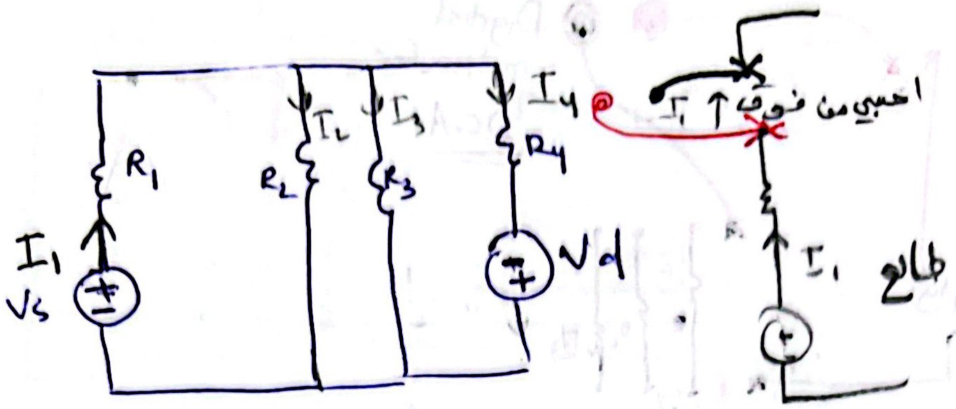

$I_2 = \frac{V_2}{R_2}$

↳ constant

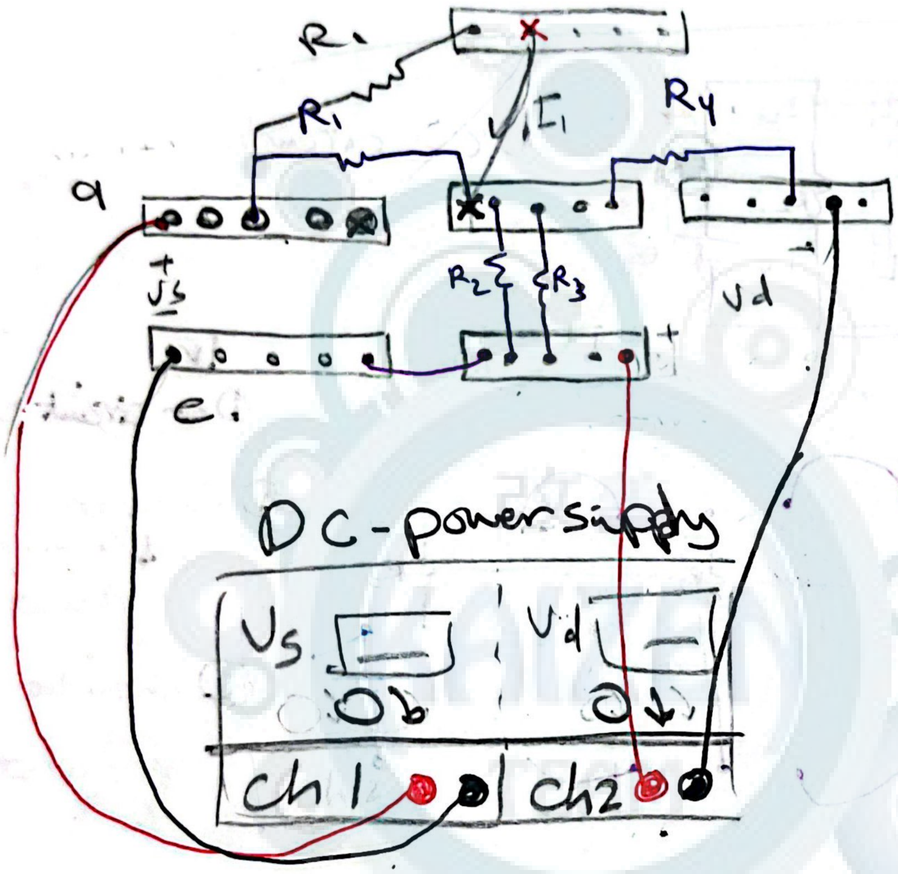
zero

Digital
multimeter

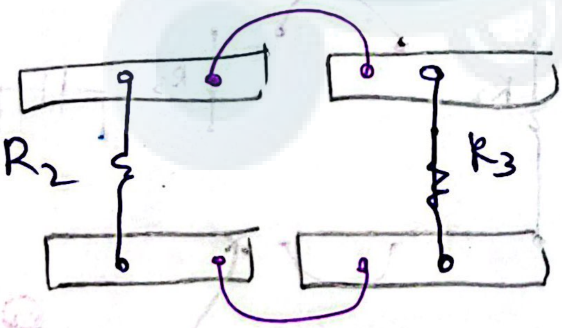
DCA



R1
R2
R3
R4
I1
I2
I3
I4
Vs
Vd
احسبي من فوق
طالع

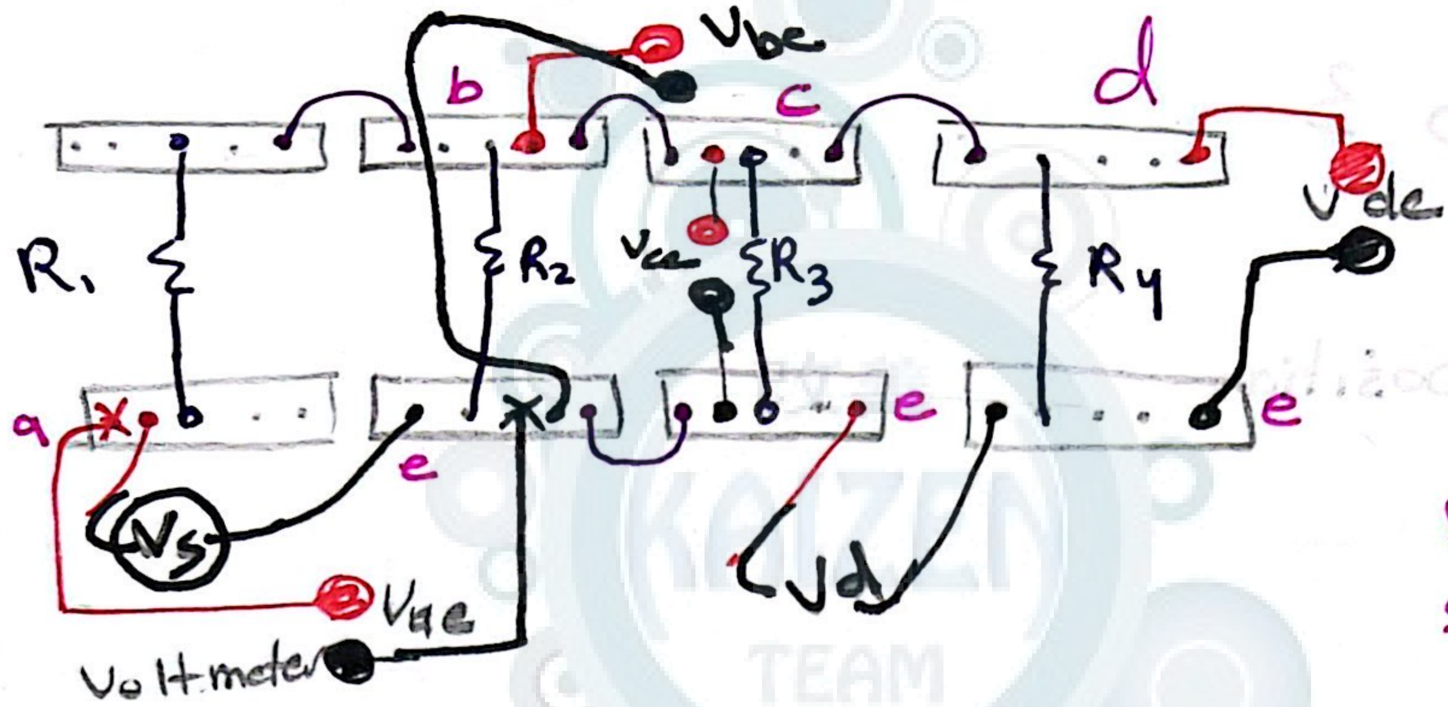



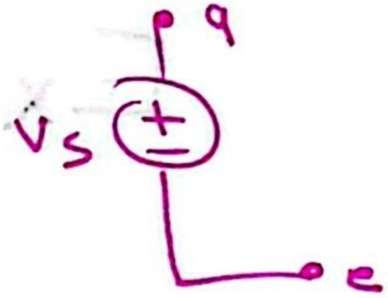
R1
R4
I1
a
e
Vs
Vd
R2
R3
DC-power supply
Vs
Vd
ch1
ch2

R2
R3


$R_2 // R_3$




$V_{ae} = V_s$

First letter +

Second letter -

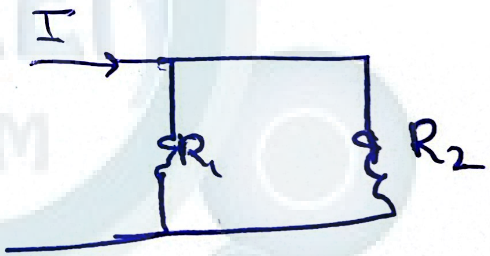
$V_{be} = V$ on $R_2$

$$\text{Deviation} = \frac{\text{Measured} - \text{Nominal}}{\text{Nominal}} * 100\%$$

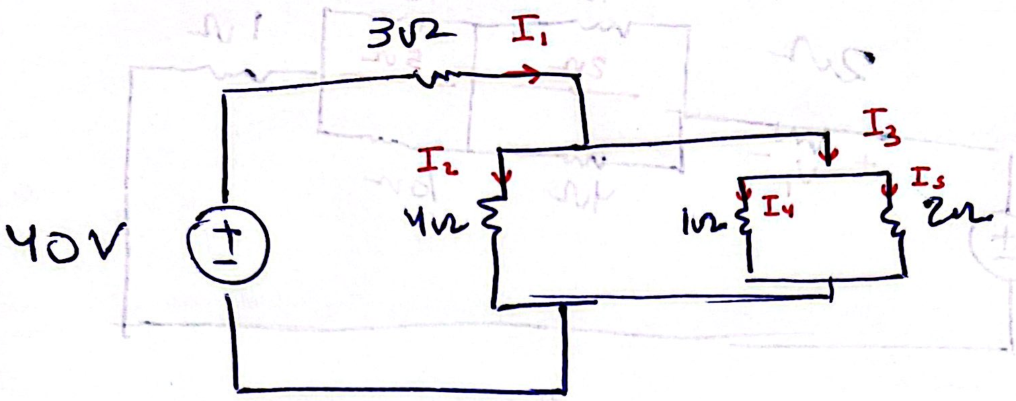
$$V_1 = V * \frac{R_1}{R_1 + R_2}$$


in series

$$I_2 = I * \frac{R_1}{R_1 + R_2}$$




Parallel




$$I_1 = \frac{40}{3.57} = 11.2 \text{ A}$$

$$I_2 = 11.2 * \frac{2/3}{4+(\frac{2}{3})} = 1.6 \text{ A}$$

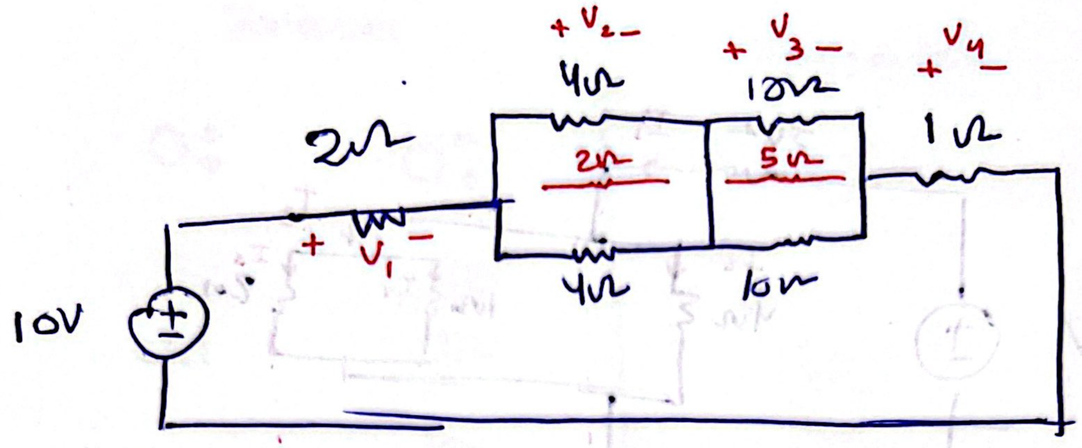
$$I_3 = I_1 - I_2 = 9.6 \text{ A}$$

$$I_3 = 11.2 * \frac{4}{4+\frac{2}{3}} = 9.6 \text{A}$$

$$I_4 = 9.6 * \frac{2}{2+1} = 6.4 \text{ A}$$

$$I_5 = I_3 - I_4 = 3.2 \text{A}$$

$$I_5 = 9.6 * \frac{1}{3} = 3.2 \text{A}$$




$$V_1 = 10 * \frac{2}{2+8} = 2V$$

$$V_2 = 10 * \frac{2}{10} = 2V$$

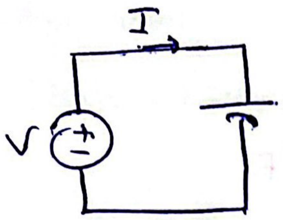
$$V_3 = 10 * \frac{5}{10} = 5V$$

$$V_4 = 10 * \frac{1}{10} = 1V$$

$$V_1 + V_2 + V_3 + V_4 = 10$$

$$2 + 2 + 5 + 1 = 10V \checkmark$$

## ① Capacitors




$V_{(t)} = \frac{Q_{(t)}}{C}$ , C: constant


↳ at t:

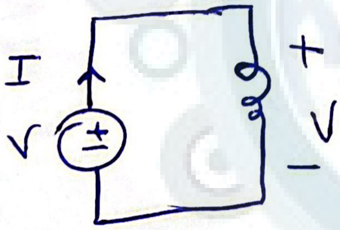
$\boxed{V_c = V}$

V becomes constant ←

$V_c = V = \frac{Q_t}{C}$ (constant) (constant)

$Q_t$ → should become constant too

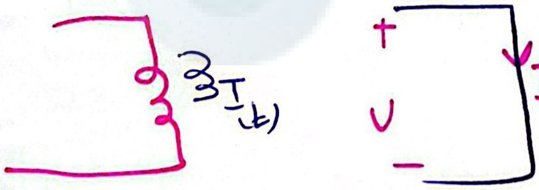

## ② Inductors



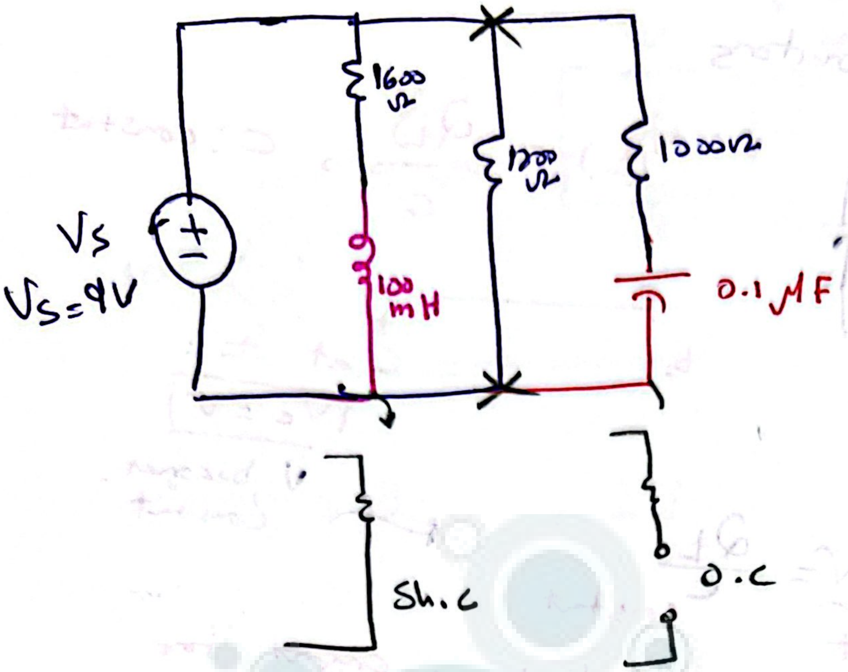

$V_L = L \frac{di}{dt}$ → $V_L = V$

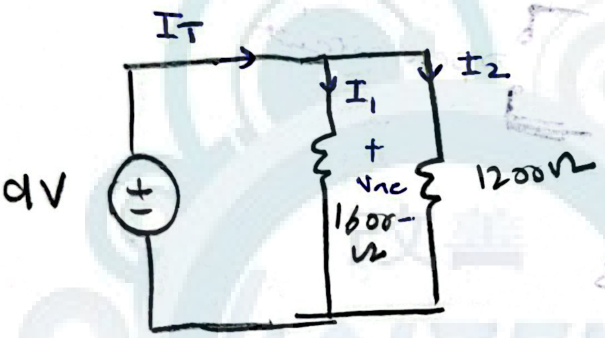
(L: constant) (I: alternating current)

when $(V_L = V)$ I → becomes constant



# DC -Circuit




Req = 685.7

$V_{ae} = 9V$

$I_T = 0.013125\,A$

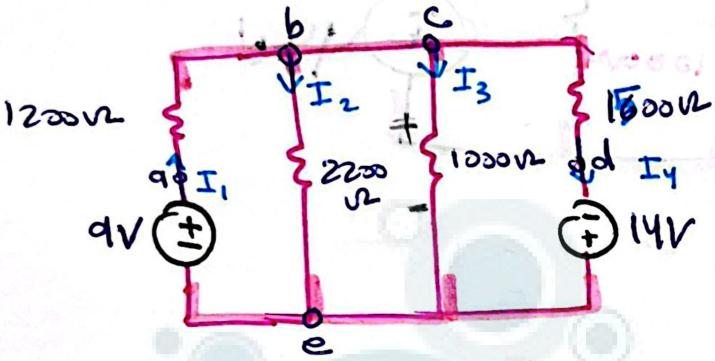
$I_1 = 5.625 \times 10^{-3}\,A = 5.625\,mA$

$I_2 = 7.5\,mA$

# Nodal & Mesh Analysis

Nodal → to find Node-Voltages

Mesh → to find Mesh-currents




$V_{R_3} = 1000 * I_3$

$-V_{R_3} = -1000(I_3)$

$I_1 - I_2 - I_2 - I_4 = 0$

$-9 + 1200(I_1) + 2200(I_2) = 0$

$-2200 I_2 + 1000 I_3 = 0$

$-14 + 1000 I_3 + 1500 I_4 = 0$

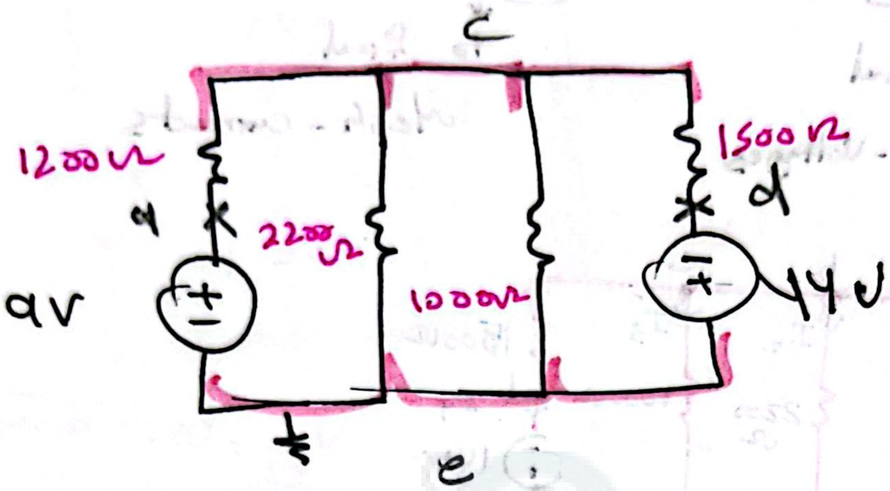
$I_1 = 8.0171$ mA

$I_2 = -2.82 * 10^{-4}$ A $= -0.282$ mA

$I_3 = -6.2 * 10^{-4}$ A $= -0.62$ mA

$I_4 = 8.92$ mA

Mesh analysis




$V_a = 9V$

$V_e = \text{Zero } V$

$V_d = -14V$

$$\frac{-14 - V_c}{1500} + \frac{9 - V_c}{1200} + \frac{-V_c}{2200} - \frac{V_c}{1000} = 0$$

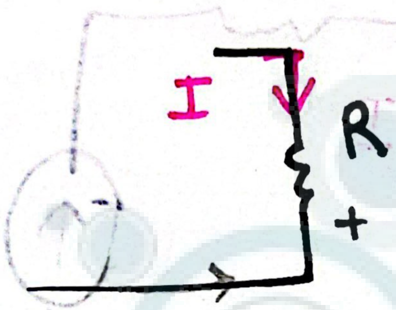
$$\frac{9 - V_c}{1200} + \frac{-V_c}{2200} + \frac{-V_c}{1000} + \frac{-14 - V_c}{1500} = 0$$

$$\frac{-V_c}{1200} - \frac{V_c}{2200} - \frac{V_c}{1000} - \frac{V_c}{1500} = \frac{14}{1500} + \frac{9}{1200}$$

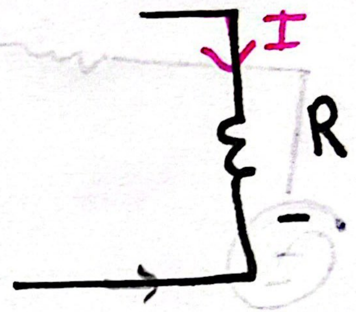
$$V_c\left(\frac{-1}{1200} - \frac{1}{2200} - \frac{1}{1000} - \frac{1}{1500}\right) = \frac{14}{1500} \cdot \frac{9}{1200}$$

$$\boxed{V_c = -0.62\,V}$$

(KUL)

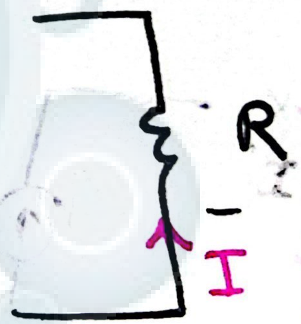



$+(R \alpha -I)$




$-(R \alpha I)$


$+(RI)$

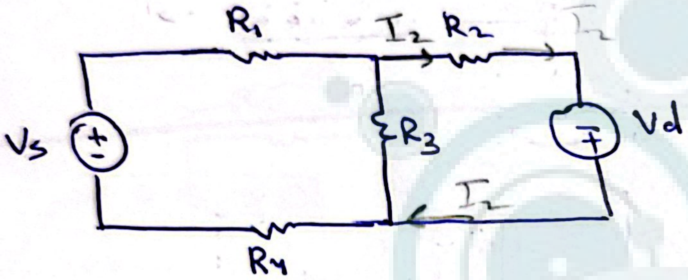


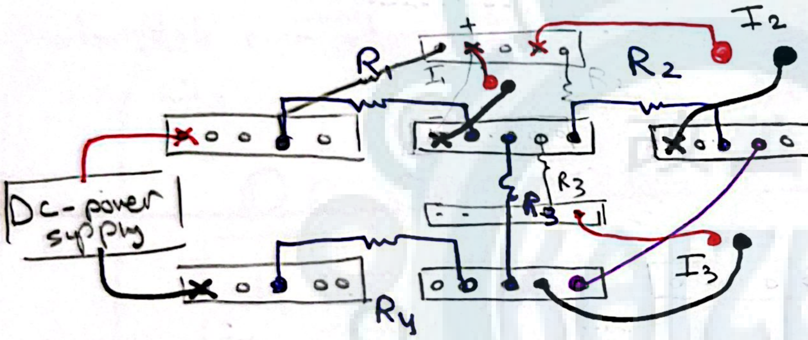

$-(R \alpha -I)$

# Exp 3

## a) Super position

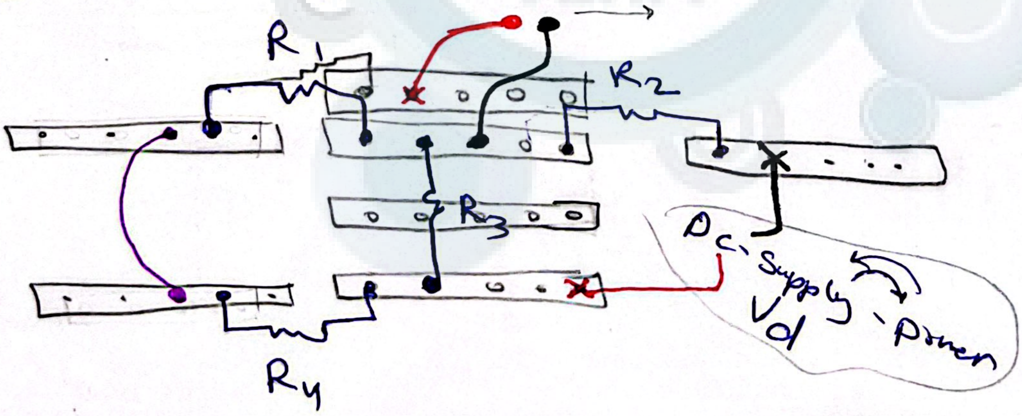
1. Kill voltage source ⟶ short circuit (jumper)
2. Kill current source ⟶ open circuit (gap)



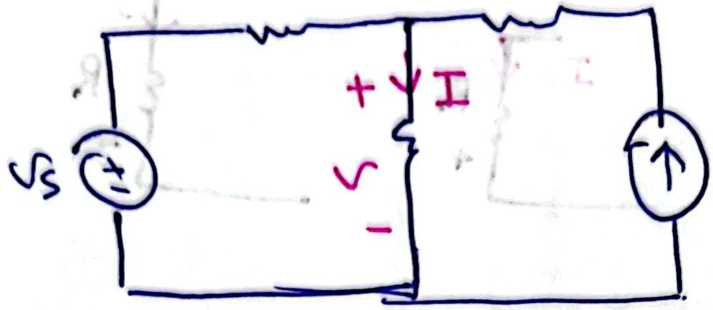




Values due to (Vs)
kill (Vd)

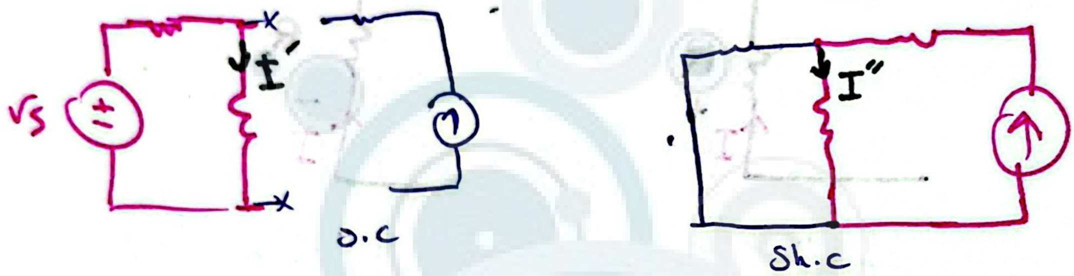
1. form the circuit
2. turn the supply on



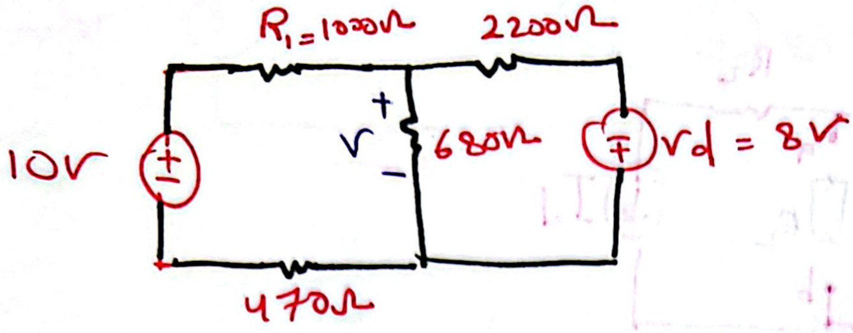

1. turn the DC-power-supply off
2. Form the circuit
3. turn the supply on

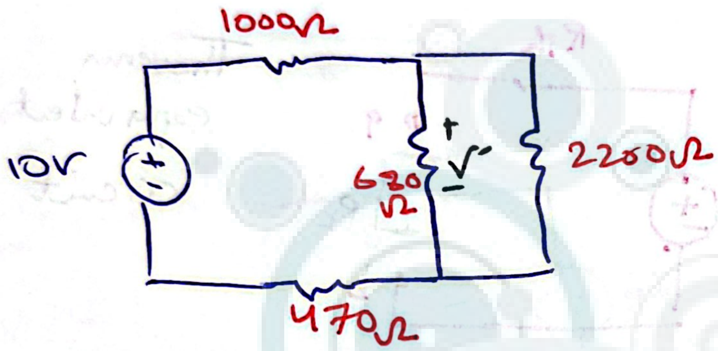



① $I = I' + I''$

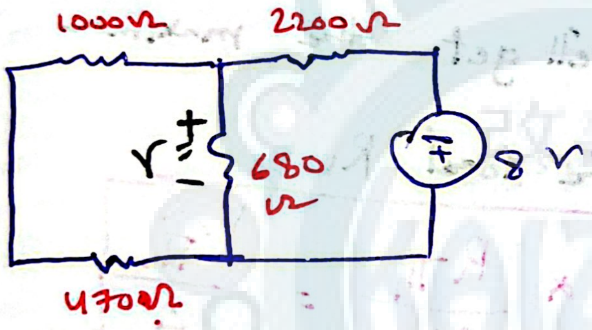



② $V = V' + V''$



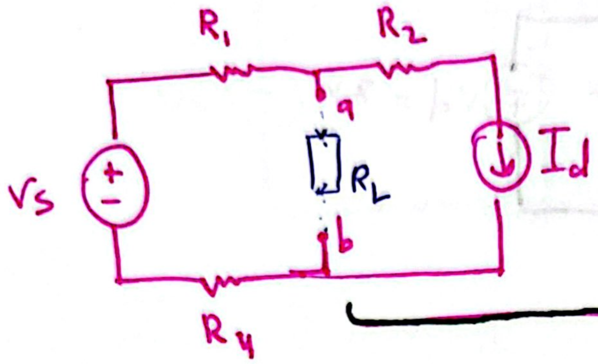

$v' = 2.611v$

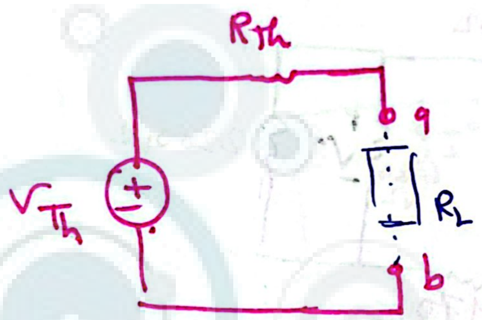



$v'' = 1.396\ v$

$\boxed{v = v' + v'' = 4.007V}$

# " Thevenin & Norton Theorems "

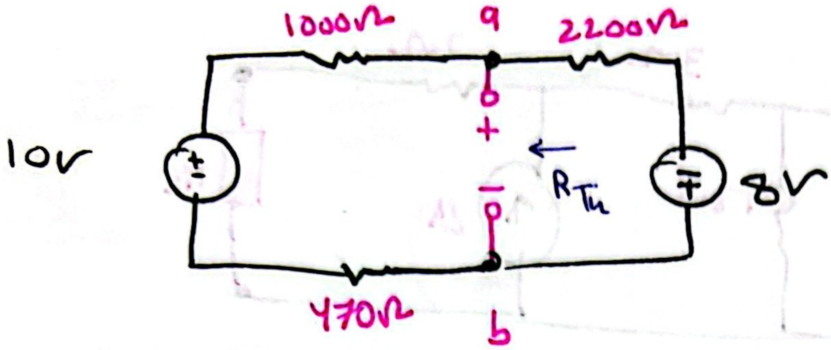


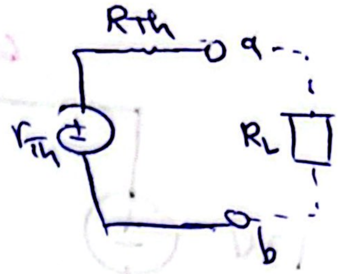



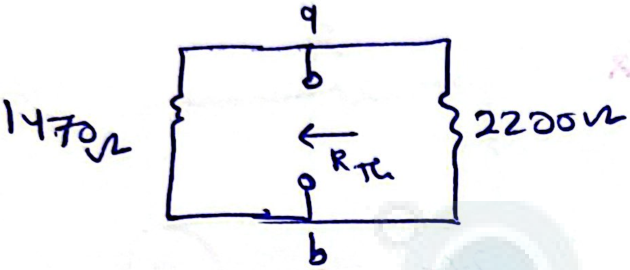

* when ($R_L = R_{Th}$) we'll get the maximum power transfered to the load $R_L$

$$R_L = R_{Th} \quad , \quad V_{R_L} = V_{Th} \times \frac{R_{Th}}{2R_{Th}} = \frac{V_{Th}}{2}$$

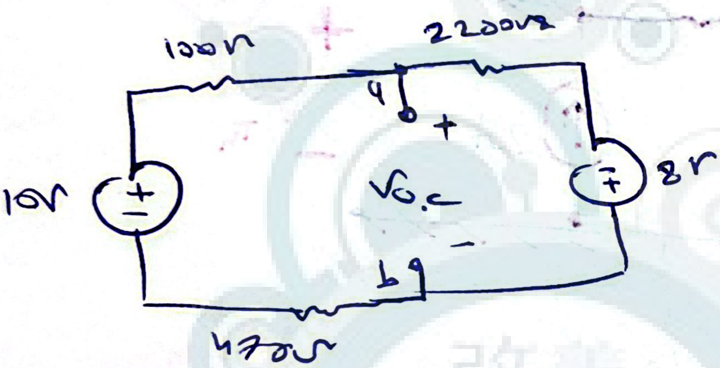
$$P_{(R_L)} = P_{max} = \frac{(V_{Th}/2)^2}{R_{Th}} = \frac{V_{Th}^2}{4R_{Th}}$$




$$R_{Th} = 881.2\ \Omega$$




$$-10 + 1000I + 2200I - 8 + 470I =$$

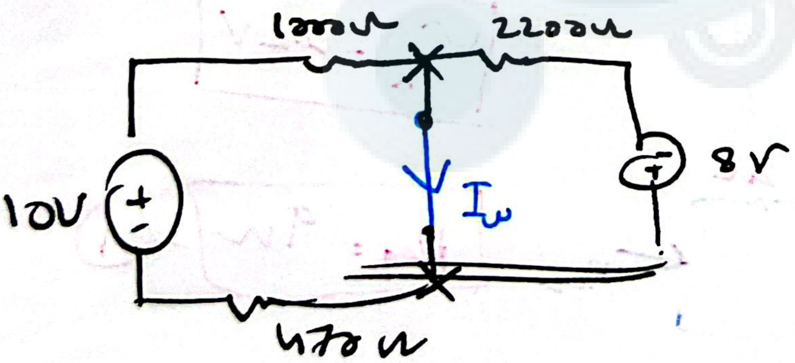
$$18 = I(3670)$$

$$I = 4.9\ mA$$

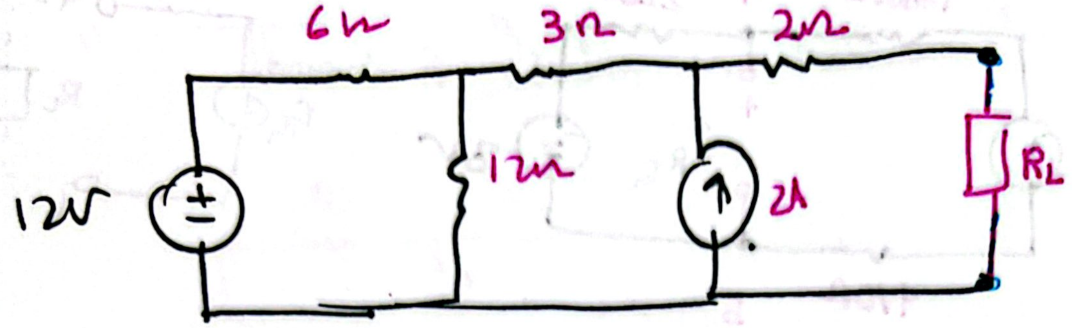
$$-10 + 1000(4.9\times10^{-3}) + V(o.c) + 470(4.9\times10^{-3}) =$$

$$V(o.c) = 2.79\ V$$

$$P_{max} = 2.2\ mW$$

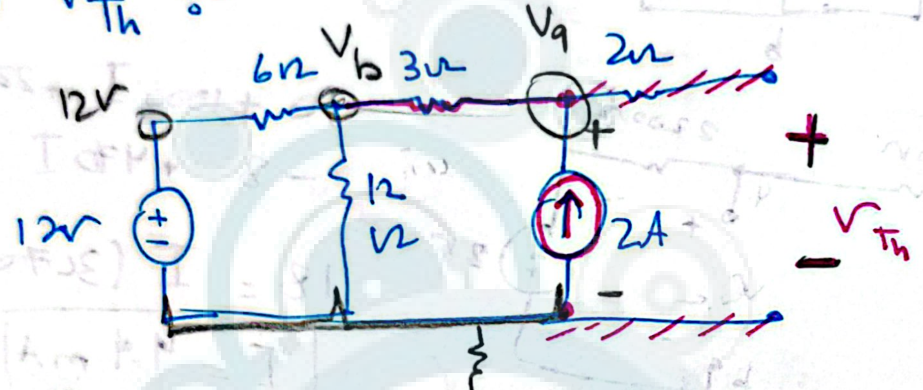



$$I_N = 3.166\ mA$$




Find $R_L$ & $P_{max}$

① $V_{Th}$ :-




$$\frac{12 - V_b}{6} + \frac{-V_b}{12} + \frac{V_a - V_b}{3} = 0$$

$$2 + \frac{V_b - V_a}{3} = 0$$

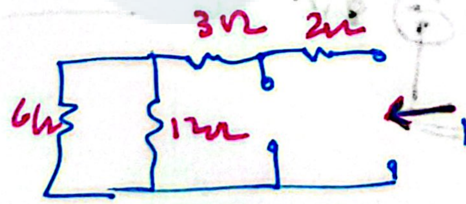
$$-\frac{1}{3} V_a + \frac{1}{3} V_b = -2 \quad —①$$

$$\frac{1}{3} V_a + \frac{-7}{12} V_b = \frac{-12}{6} \quad —②$$

$V_a = 22V$

$V_{Th} = 22V$

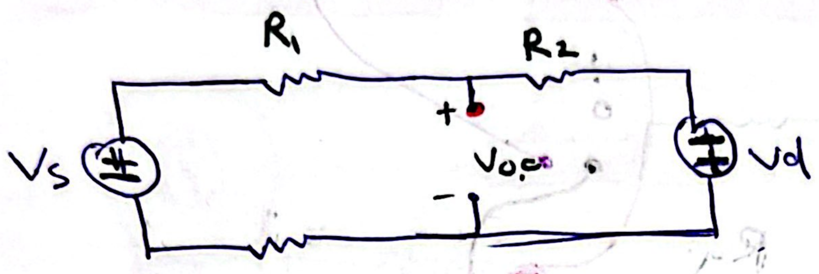
② $R_{Th}$ :-

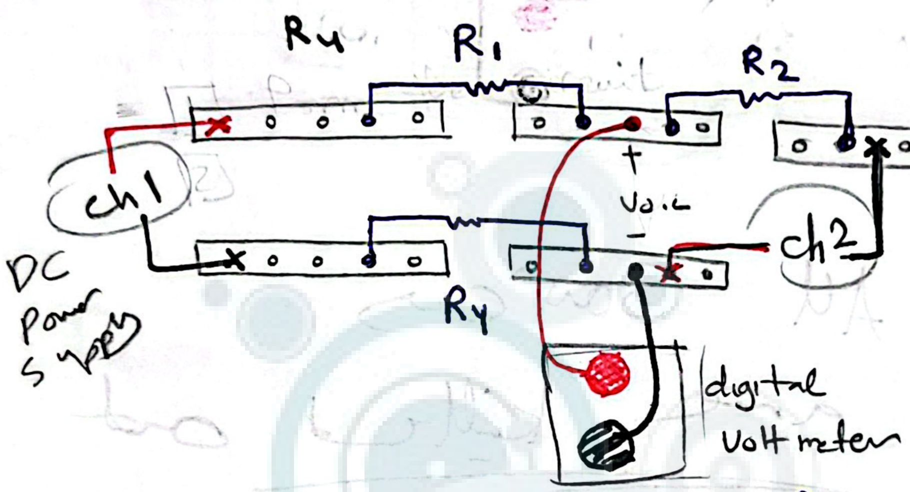



$R_{eq} = 9Ω$ —①

$P_{max} = 13.44 W$

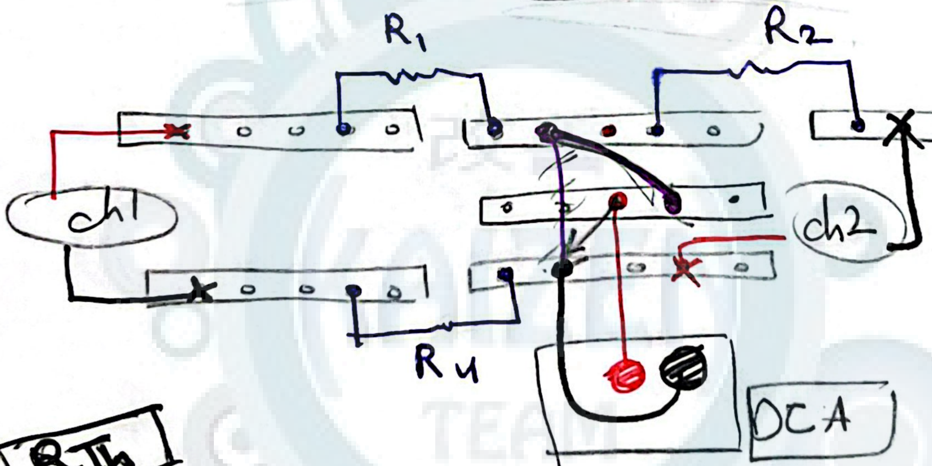
# (B) Thevenin & Norton




① Find $V_{Th}$

DC V



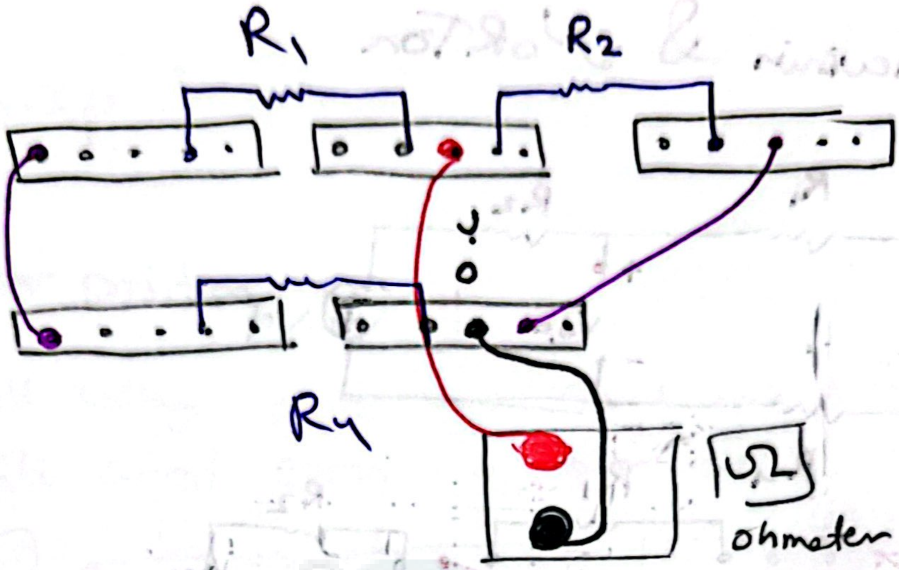

② Find $I_{Norton}$

DCA

## $R_{Th}$

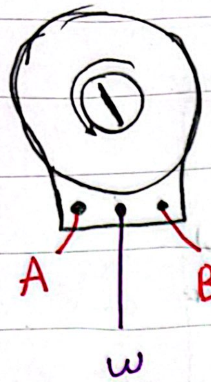
1. turn the supplies off (DC power supply)
2. Remove them from the Circuit
3. put short circuit at the voltages places
4. leave the place of current supplies as an (open circuit)

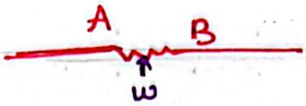
$R_{Th}$

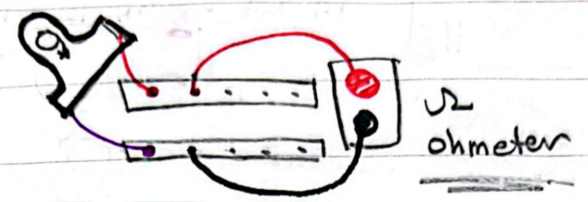



All Sources are killed out

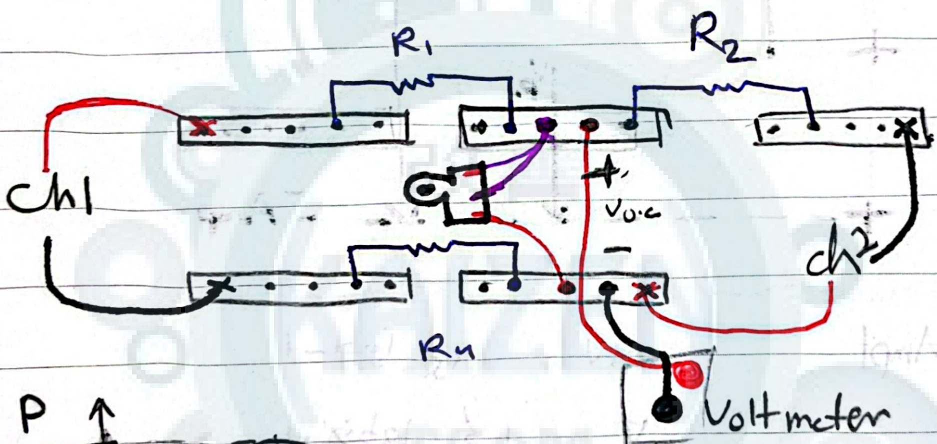
# C Maximum Power Transfer ((potentio-meter))

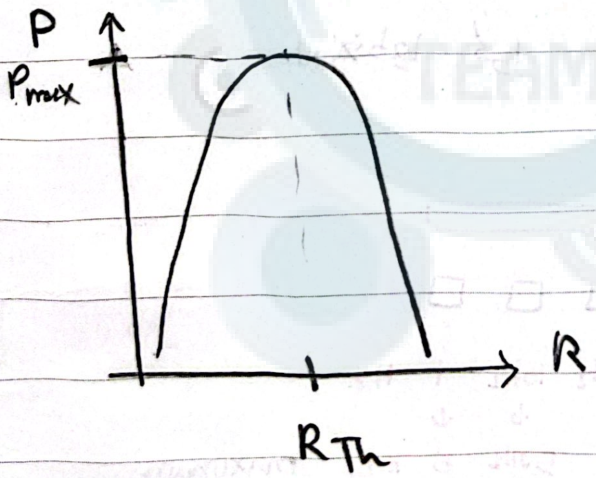


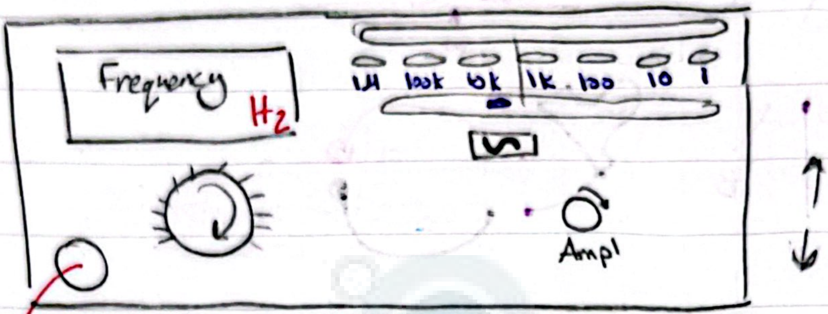

$$P_{max} = \frac{1}{4}\left(\frac{V_{Th}^2}{R_{Th}}\right)$$



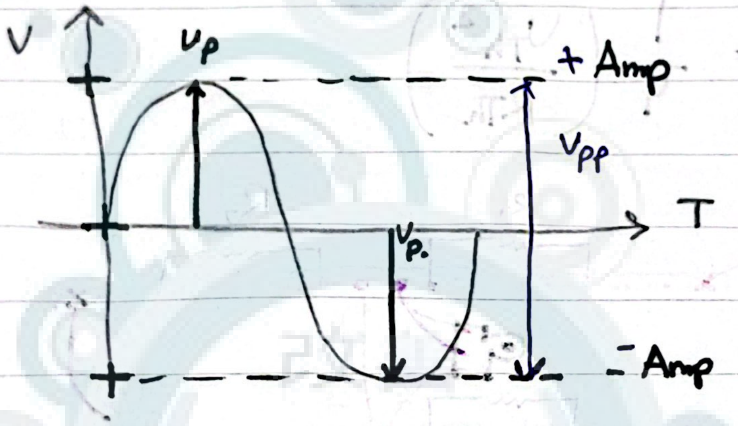



Shape ↰ Frequency ↑ ↱ Ampl (+ oscilloscope)

# Exp 4 — Function Generator (AC - Supply)

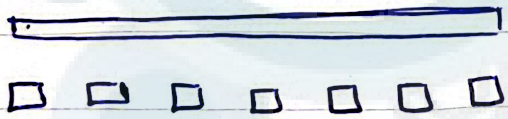



Power




○ Ampl — mV — اسحبها لبرا

V — اضغطها لجوا



| 1m | 100k | 10k | 1K | 100Hz | 10Hz | 1 Hz | |
|---|---|---|---|---|---|---|---|
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | |
| 5m | 500k | 50k | 5K | 500Hz | 50Hz | 5 Hz | maximum |

① 7 Hz → 10Hz

② ○ فتلها

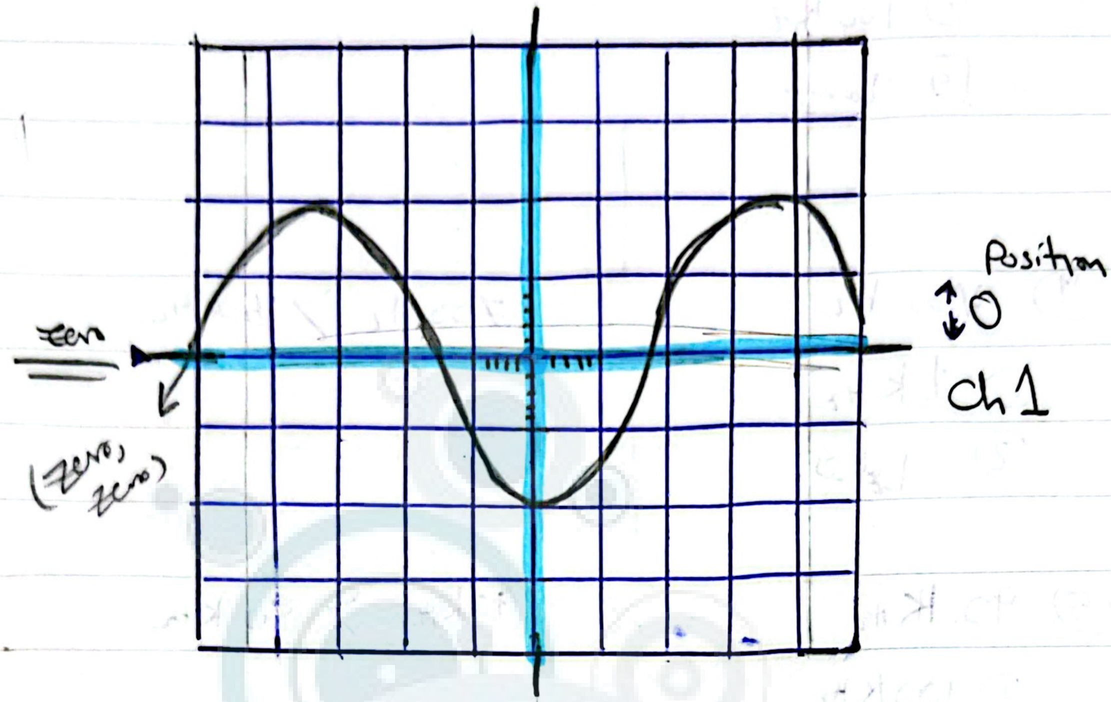
---

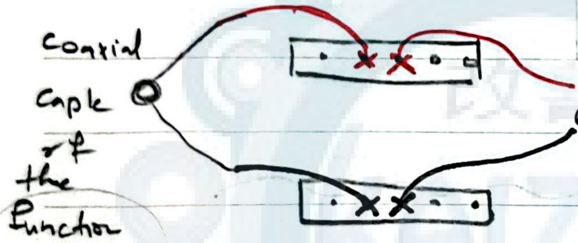
800Hz :-

① 1 K

② ○ فتلها

# { Oscilloscope }



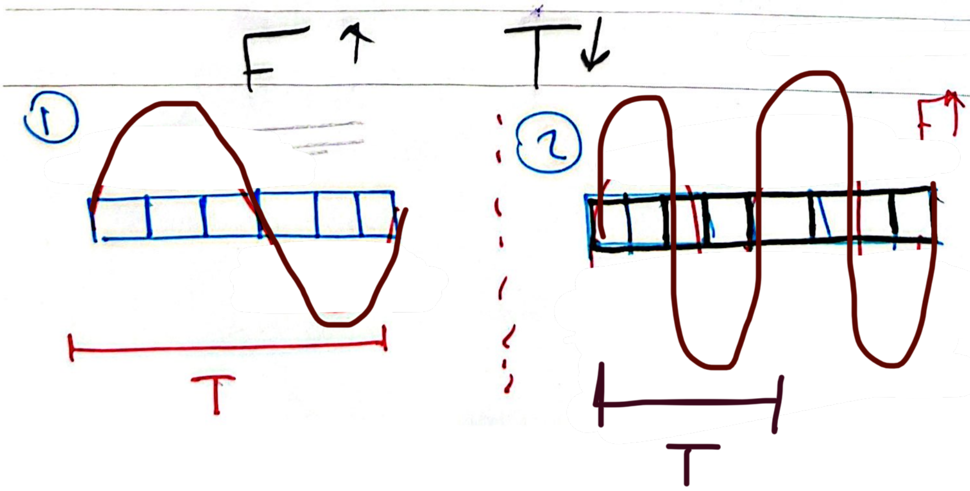




channel 1 on the oscilloscope → Signal viewer

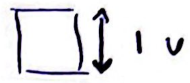
1. Frequency → ← ~~extension horizontally~~
2. Shape
3. Ampl → Vpp ↕ extension vertically

---

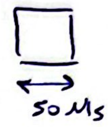
F ↑ T ↓



1. Connect the Oscilloscope parallel to the generator (A-C)
2. Set the position at Zero
3. Volt/division — ch1 = 1V/division




4. Time/division — 50 µs/division



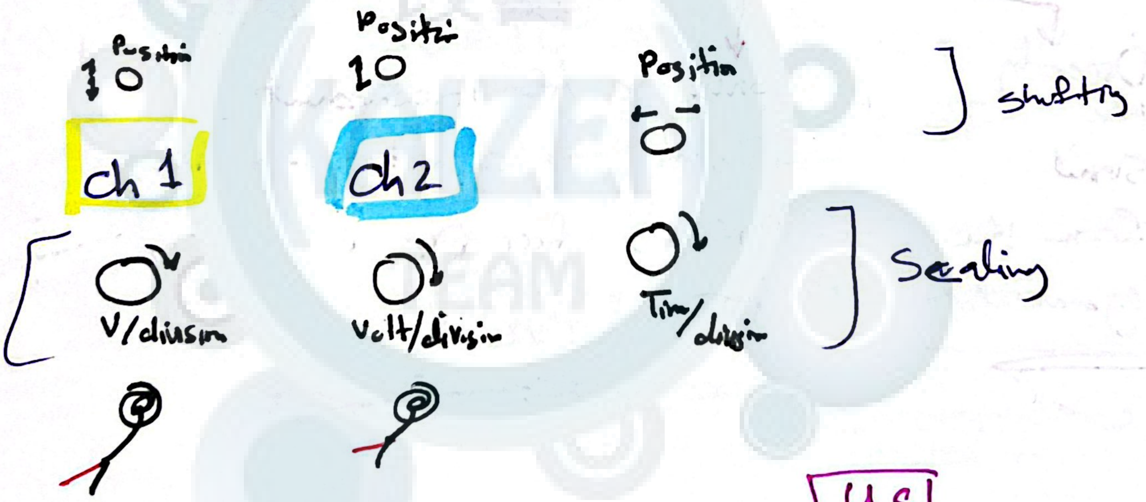

---

$V_{pp}$ = Scale (ch) * no of squares vertically

$T_{(period)}$ = Scale (T) * no of squares horizontally

$F = \frac{1}{T}$ or / from the Function generator /

---




us
↳ Micro-sec

$$V_p = \frac{V_{pp}}{2}$$

$$V_{rms} = \frac{V_p}{\sqrt{2}}$$

Vpp
1: ____
2: ____

measure

Vavg
1: ____
2: ____

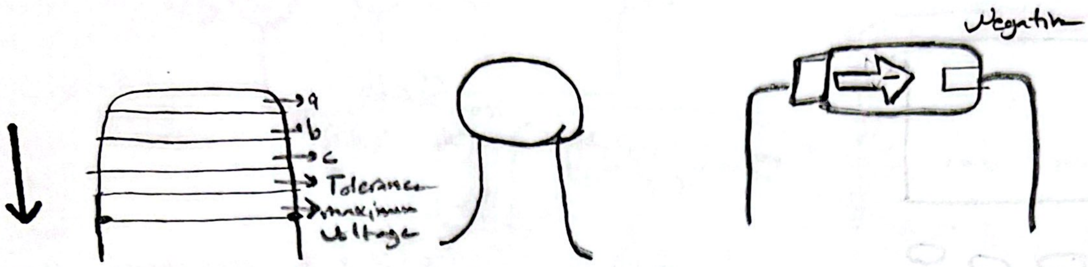
---

1. press Ch1
2. F1
3. choose the DC

Coupling

- DC (choose →) → Directly the signal from the generator ✓
- AC → only the AC-component → signal → capacitor → AC blocking for DC → Filtered
- Ground = Zero

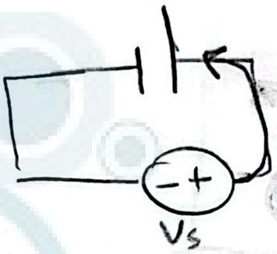
# I Capacitors (pF)



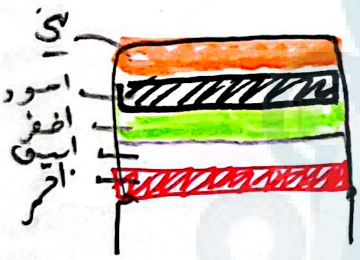

color-code    Ceramic

من فوق لتحت
بالأول ↓

$\boxed{a\,b \times 10^{c} \pm d}$ pF




Store charge 'till the $V_{capacitor} = V_s$ then the ⊣⊢ will be open circuit no current enters the capacitor.




$10 \times 10^{5}$ pF

$10 \times 10^{5} \times 10^{-12}$ F

$1 \times 10^{-6}$ F $= 1\ \mu F$

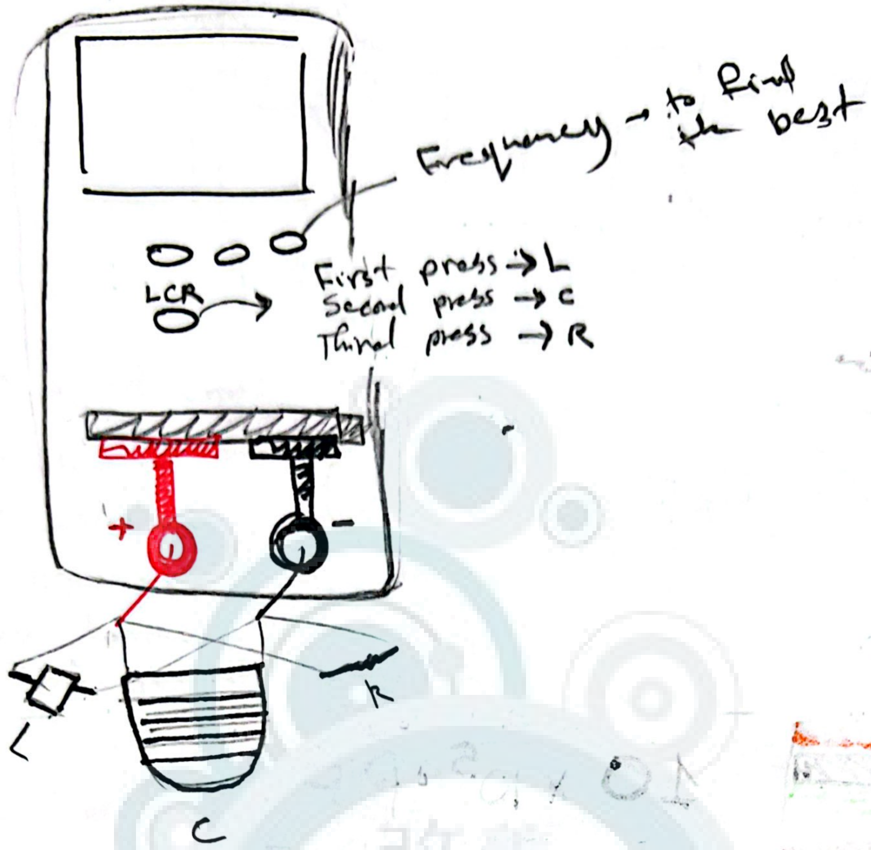
---

Tolerance $= 10\%$

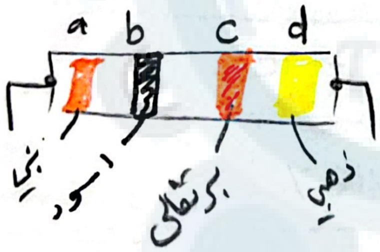
$C = \boxed{1\ \mu F \pm 10\%}$ Nominal

---

# RLC - Meter




## [2] Inductor :- (μH)




$ab \times 10^{c} \pm d$ μH

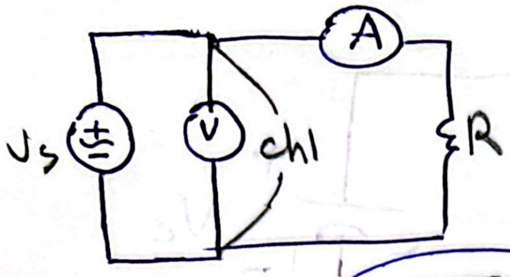
$10 \times 10^{3} \pm 5\%$ μH → $10^{-6}$ H

$10^{4} \times 10^{-6}$ H $\pm 5\%$

$$L = 10^{-2} \pm 5\% \text{ H}$$

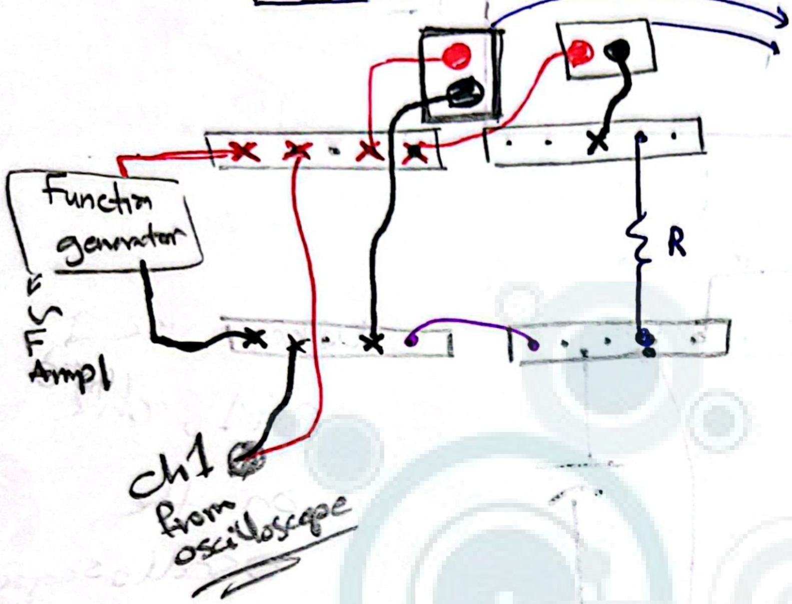
$$L = 10 \pm 5\% \text{ mH}$$

$$L = 10 \pm 0.5 \text{ mH}$$




$R = 3300\ \Omega$

ر. ثالث    ر. ثاني    صفر




→ digital multimeters

ACA , ACV → $V_{rms}$

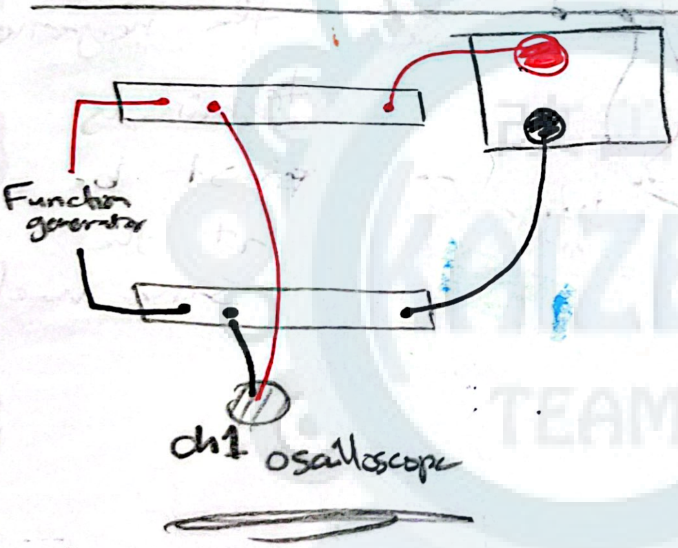
DCA , DCV → $V_{avg}$

F ↑ T ↓

R is constant, $V_{rms}$ , $I_{rms}$ → constant

C, L → variation ..

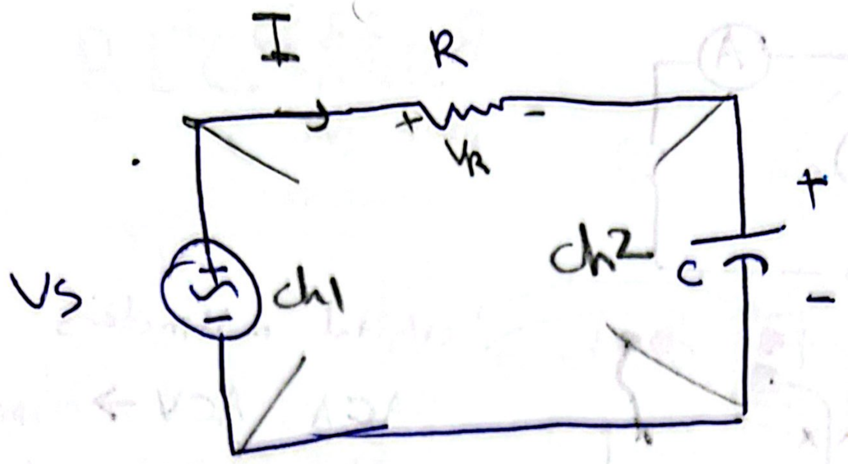
---

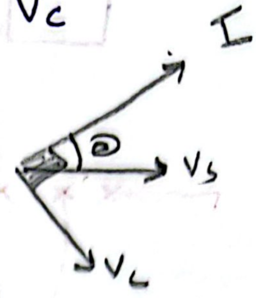


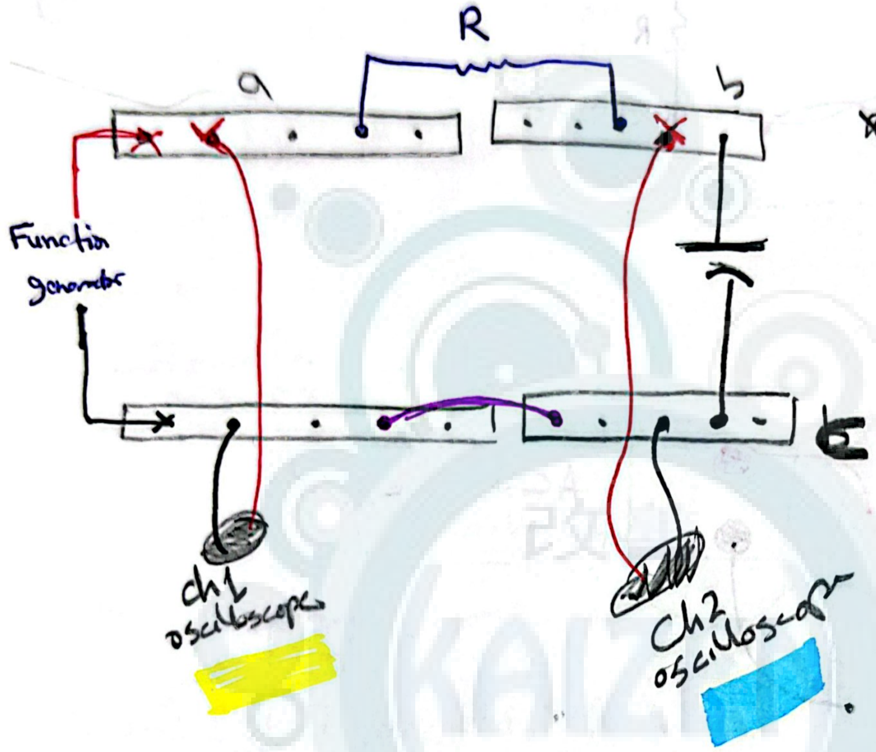

ACV → $V_{rms}$

F ↑

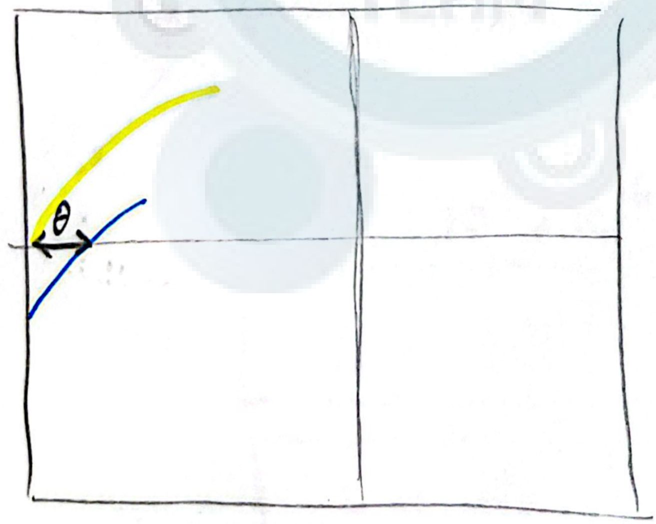
T ↓ انكماش



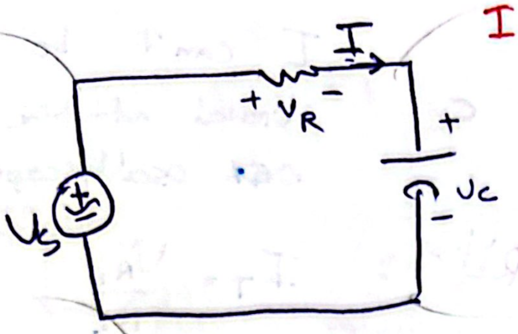



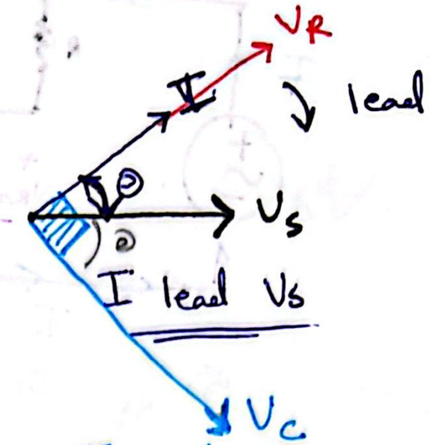

* When use **ch1, ch2** on the oscilloscope the negative terminals must be at the **same node**




Capacitor lags the supply -- by θ

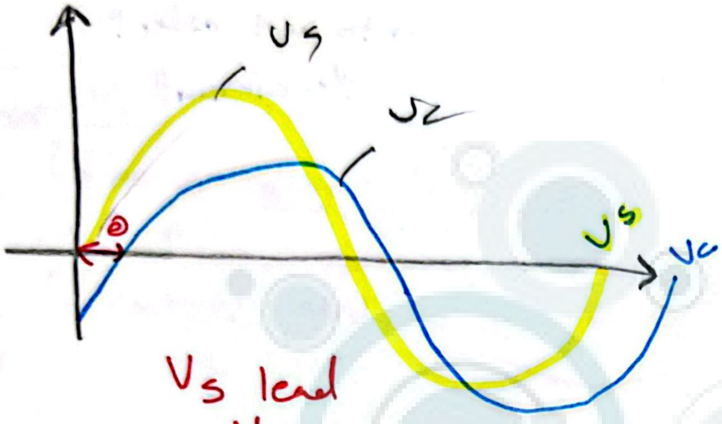
I & R in phase




I lead Vs

$Z_R$ =

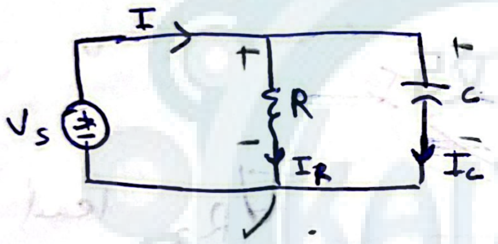



Vs lead Vc by θ ..

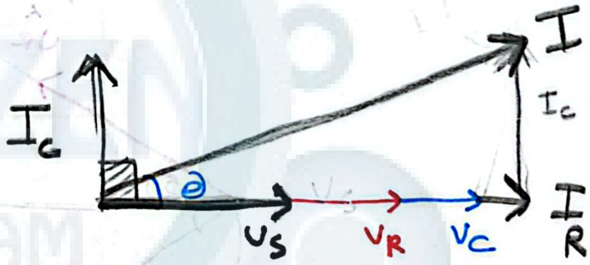
I lead Vc by 90°

I lead Vs by θ

I is in phase with R ..

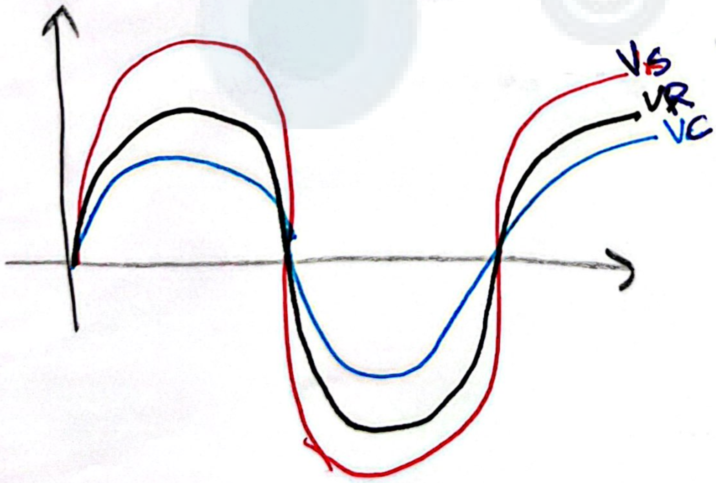



$|V_s = V_R = V_c|$

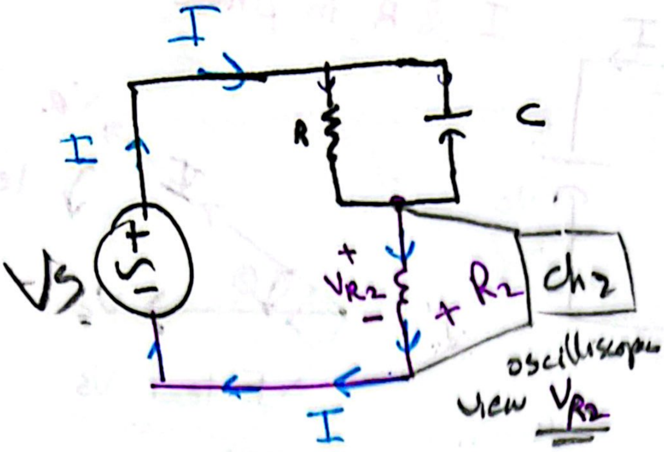



$I_R$ , $V_R$ in phase

$I = I_R + I_c$




in phase




I can't be viewed at the oscilloscope

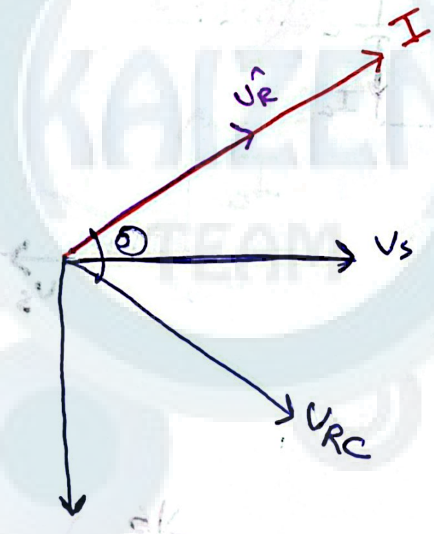
$I_T = \frac{V_{R_2}}{R_2}$

very small.. → to not affect the circuit

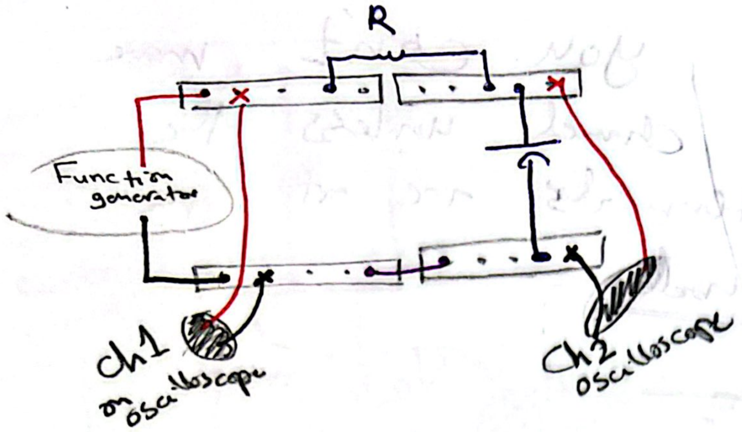
$\theta V_{R_2} = \theta I_T$

- In phase
- $\theta_R$ = zero

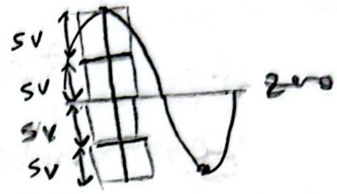
اي تيار يمر ا مقاومة
يكونه inphase مع فولتيتها
ف you can find $\theta_I$ by $\theta_{V_R}$




$V_{R_2}$ lead $V_S$



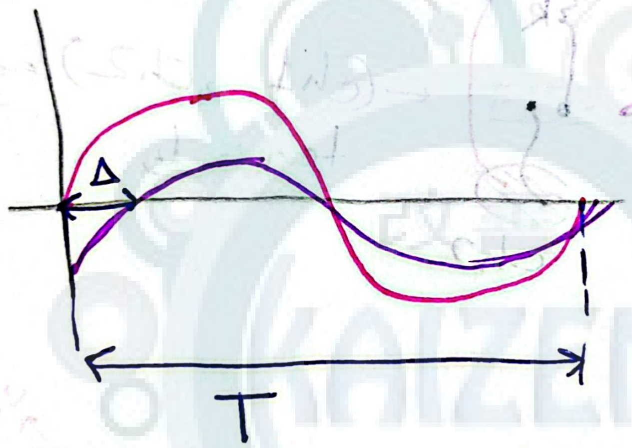

Vpp = 10




$V_{pp} = 10V$

↳ no of squares × $V_{ch1}$ = 10 V ← 2×5V
P — P

↳ control it by Ampl on the function generator




$$\theta = \frac{360^\circ \times (\Delta \text{ divisions})}{(T \text{ divisions})}$$

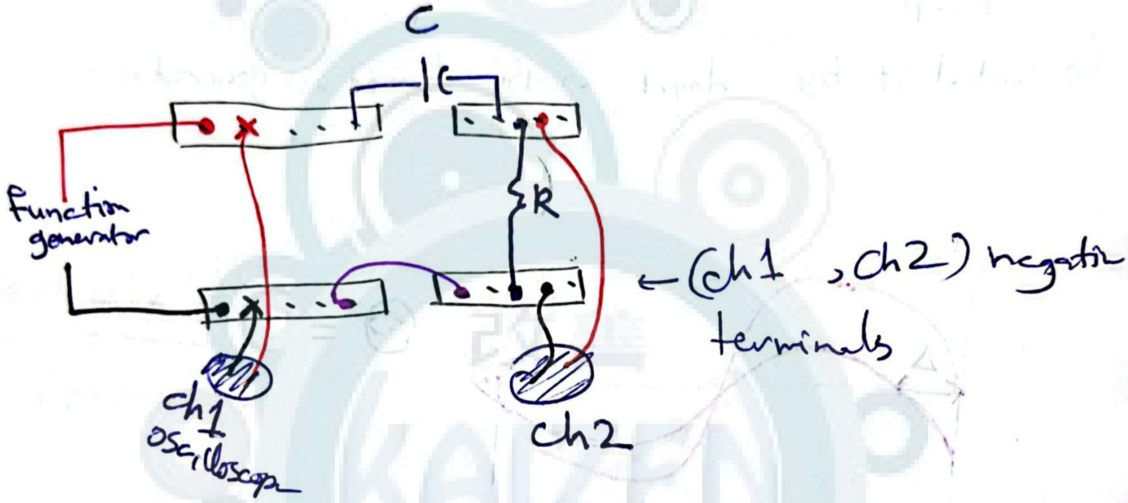
T (divisions) ⟶ 360°

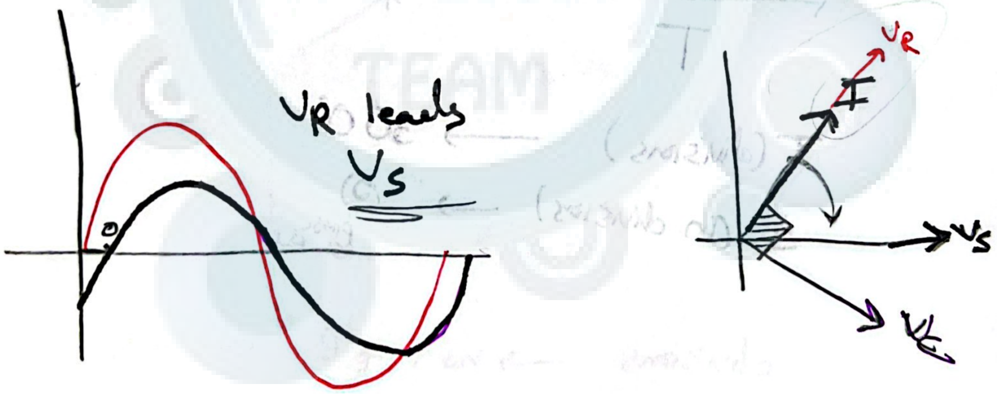
Δ (in divisions) ⟶ θ phase shift

divisions ⟶ no. of squares

* Remmeber you can't move The other chanel unless the negative terminals are at the Same node.

→ So to find $V_R$ move the Resistor not the channel terminals

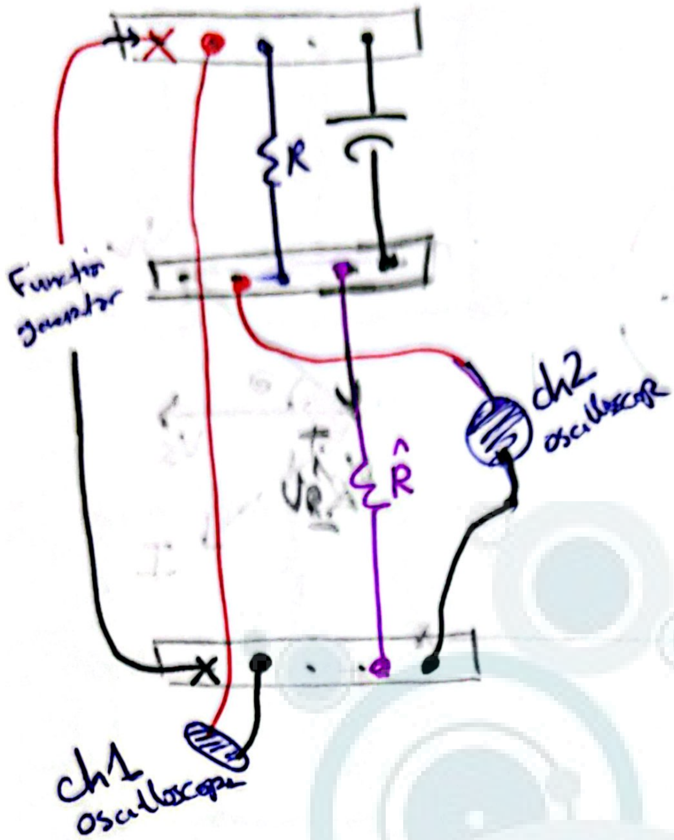



$$\theta = \frac{360^\circ \times T}{\Delta}$$

F ↓ T ↑ expansion

F ↑ T ↓ Compression




$V_{\hat{R}}$ In phase $I$

**ch2 // $\hat{R}$**

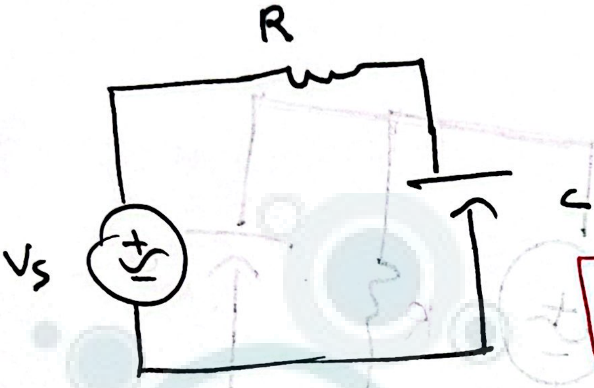
↳ to view $V_{\hat{R}}$

↳ determine $\theta_I$

↳ $\theta_I = \theta_{\hat{V}_R}$

* $Z_c = \frac{1}{\omega C} \angle -90^\circ$

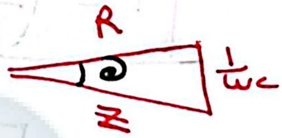
$$Z_c = -j\left(\frac{1}{\omega C}\right)$$



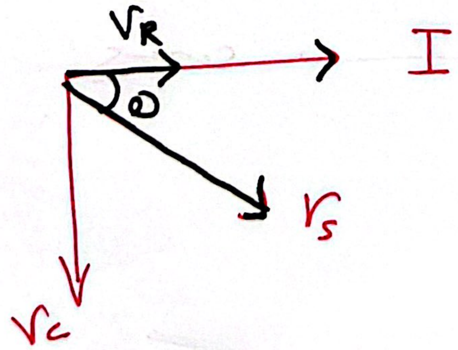

$Z = Z_R + Z_C$

$$Z = R - j\frac{1}{\omega C}$$

$|Z| = \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}$

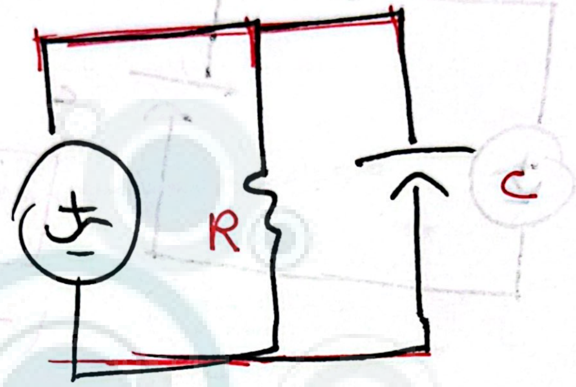

$\theta = \tan^{-1}\left(\frac{1}{\omega C R}\right)$



# Admittance $\left(\frac{1}{Z}\right)$

$R \rightarrow \frac{1}{R}$ (S)

$Z_C \rightarrow \omega c$

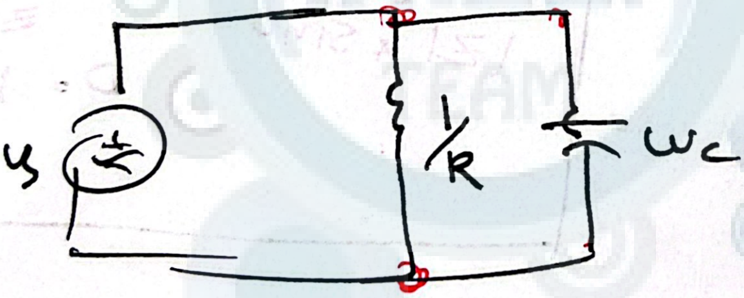



$(R \parallel C)$

$\hookrightarrow$ ($\frac{1}{R}$ series with $\omega c$)

$\rightarrow |Y| = \sqrt{\left(\frac{1}{R}\right)^2 + (\omega c)^2}$

$$Y = \frac{1}{R} + j\omega c$$




Series $\longrightarrow$ Parallel

Parall $\longrightarrow$ series

$P = V * I$ → in DC

$P(t) = V(t) * I(t)$ → AC

Real power :- ($P_{avg}$)

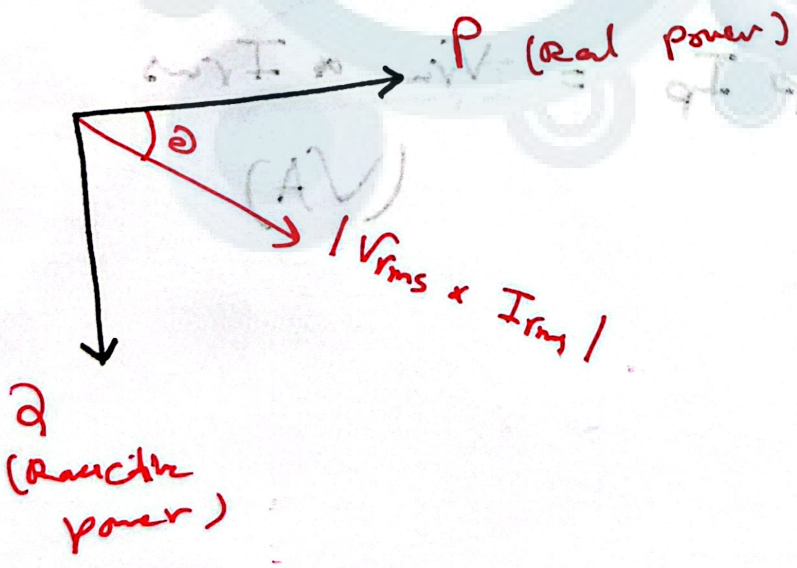
$$P = \frac{1}{2} V_p I_p \cos(\theta_v - \theta_i)$$

$$= V_{rms} * I_{rms} * \cos(\theta_v - \theta_i) \quad (\underline{W})$$

Reactive Power :- (Q)

$$Q = V_{rms} * I_{rms} * \sin(\theta_v - \theta_i) \quad (\underline{VAR})$$

$$= \frac{1}{2} V_p I_p \sin(\theta_v - \theta_i)$$



$$\vec{S} = P + j\,Q \quad (VA)$$

$$= V_{rms} \times I_{rms} \angle(\theta_v - \theta_i)$$

$$|\vec{S}| = S \text{ (Apparent power)}$$

$$\vec{S} = \frac{1}{2} V_p \times I_p \angle(\theta_v - \theta_i)$$

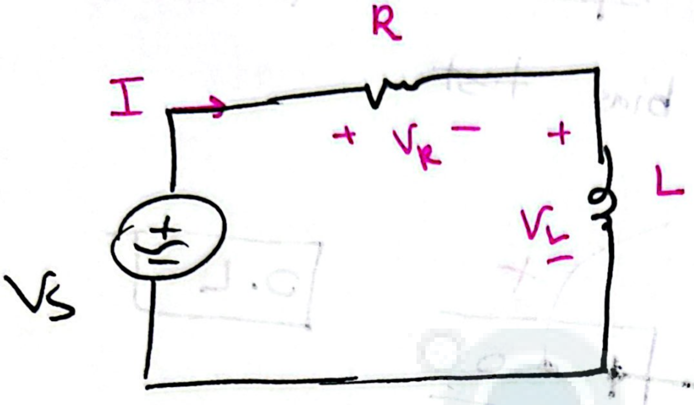
$$PF = \cos(\theta_v - \theta_i) \text{ (Power factor)}$$

- lagging (Inductive)
- leading (Capacitive)

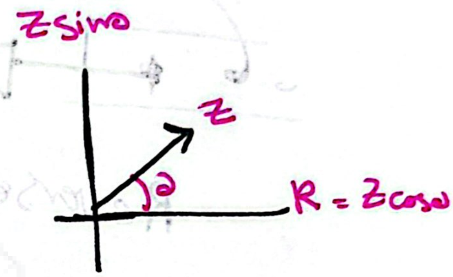
$$S = \frac{1}{2} V_p I_p = V_{rms} \times I_{rms}$$

(VA)

$$Z_L = \omega L \angle 90^\circ = j\omega L$$



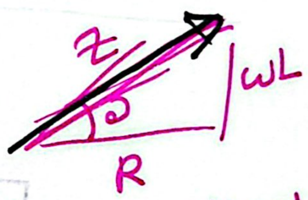

$$Z_L = j\omega L$$



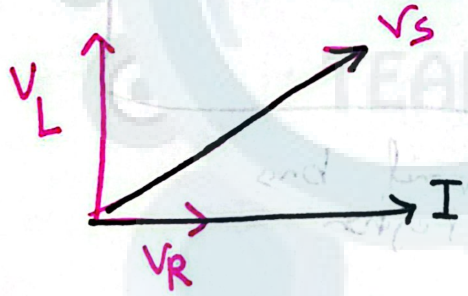

$$Z = Z_R + Z_L$$

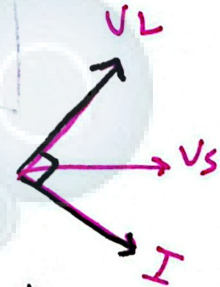
$$= R + j(\omega L)$$

$$Z = \sqrt{(\omega L)^2 + R^2} \angle \theta$$



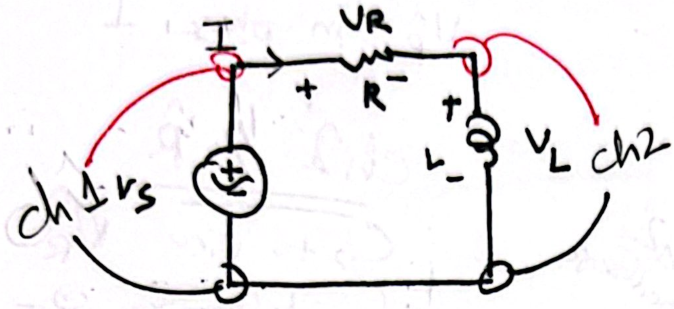

$$\theta = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

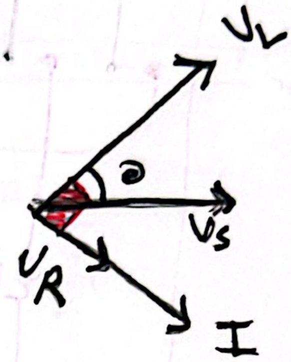


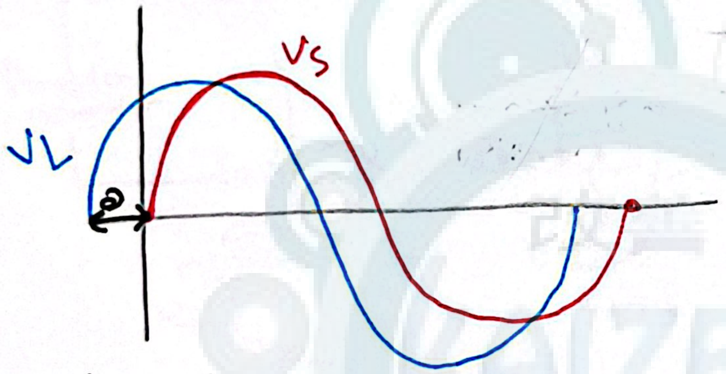




lagging load

# Exp 6



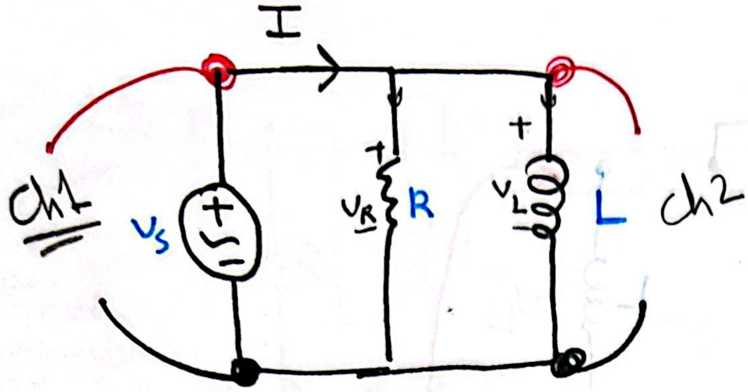




$V_L$ lead $V_s$

$V_s$ lags $V_L$

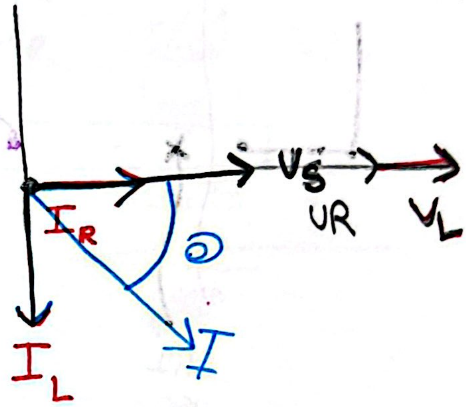
θ depends on the frequency of the supply..



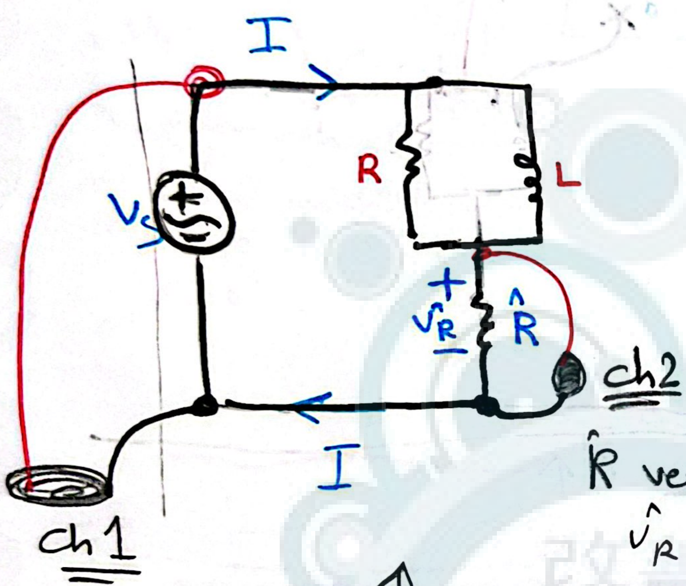

$I_R + I_L = I$

$V_s = V_R = V_L$

$I_R$ In phase $V_R$

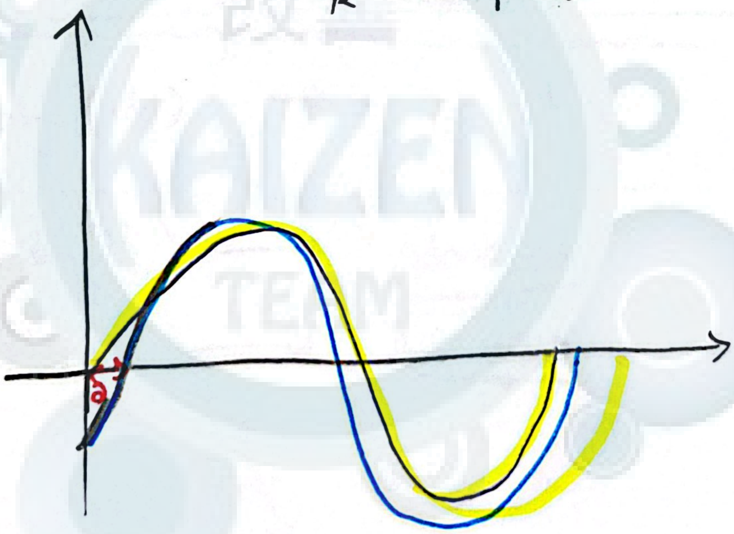



$V_s$ lead $I$ by θ



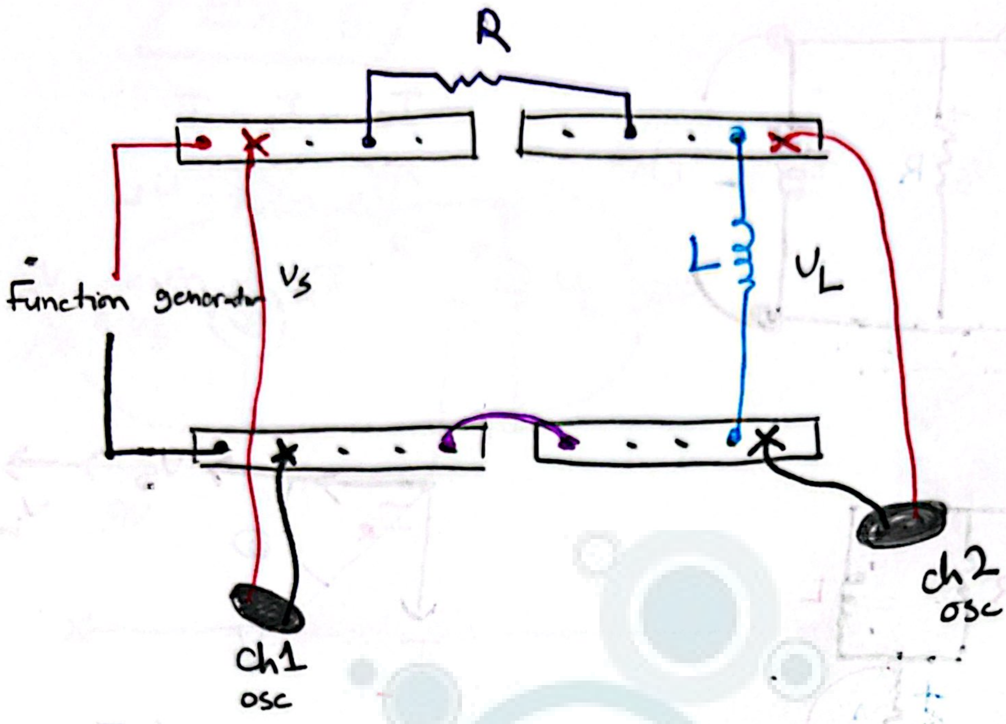

$\hat{R}$ very small..

$\hat{V}_R$ In phase with $I$

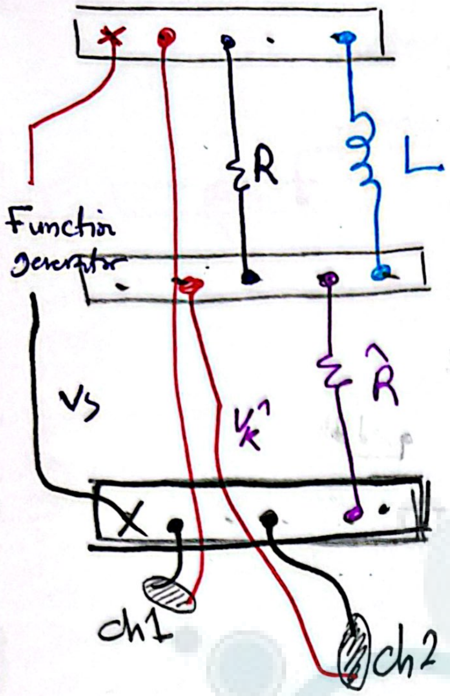



{ $\hat{V}_R$ lags $V_s$ by θ .. } Inductive load ..

($\hat{V}_R$ = I, $V_s$ = $V_s$)




F ↑ $V_{inductance}$ (VPP) ↑↑




$I$ · in phase $\hat{U}_R$

$\hat{U}_R$ ~~[illegible]~~ lags $U_s$

$U_s$ leads $I$

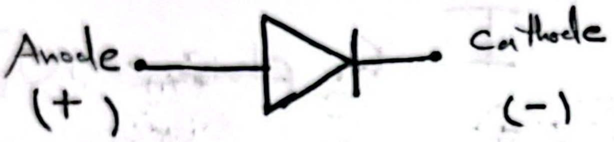

F ↑ T ↓ → ←

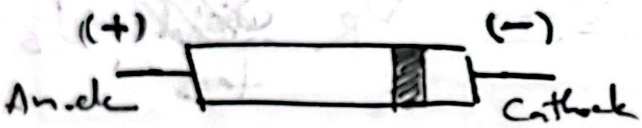
Ampl ($V_s$) → ثابت

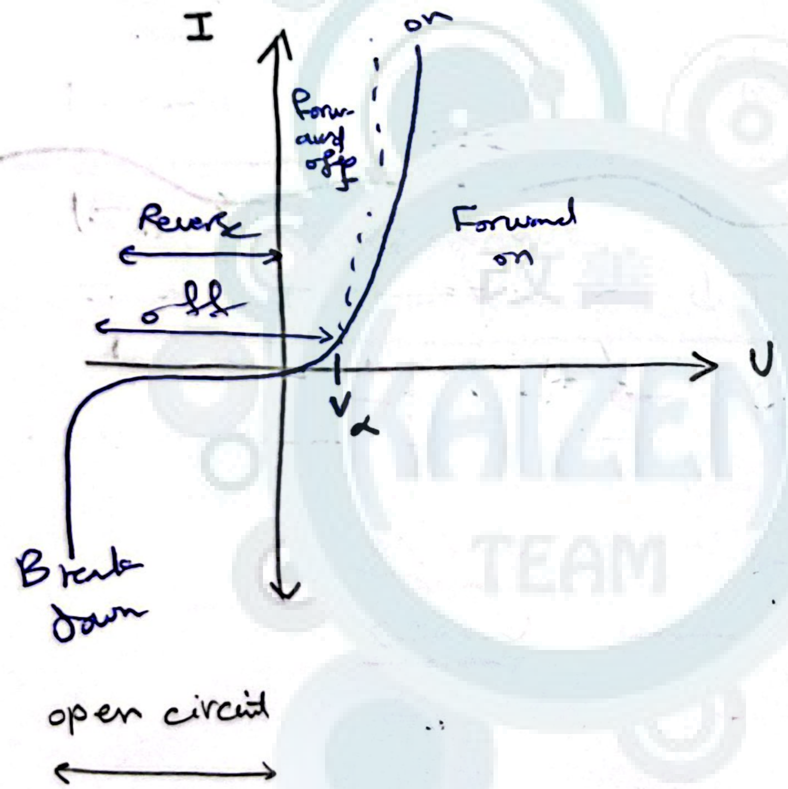
Ampl ($V_L$) → Varies

$\varphi_L$ → Varies

# Exp 8

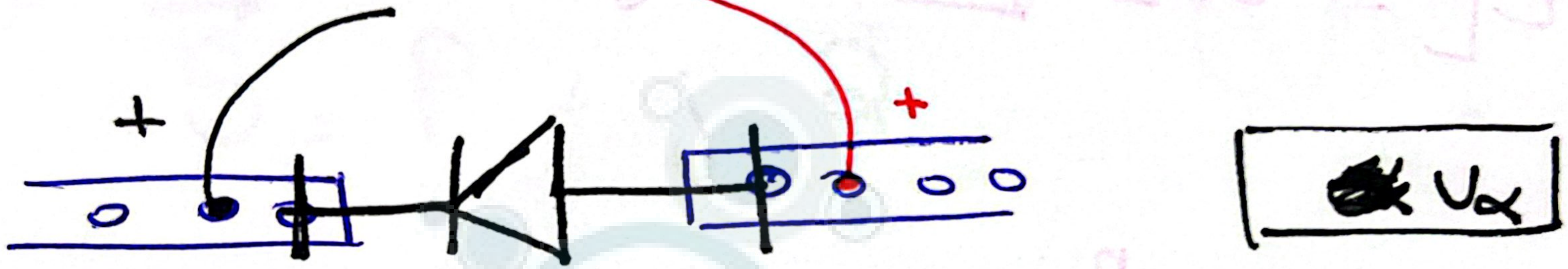


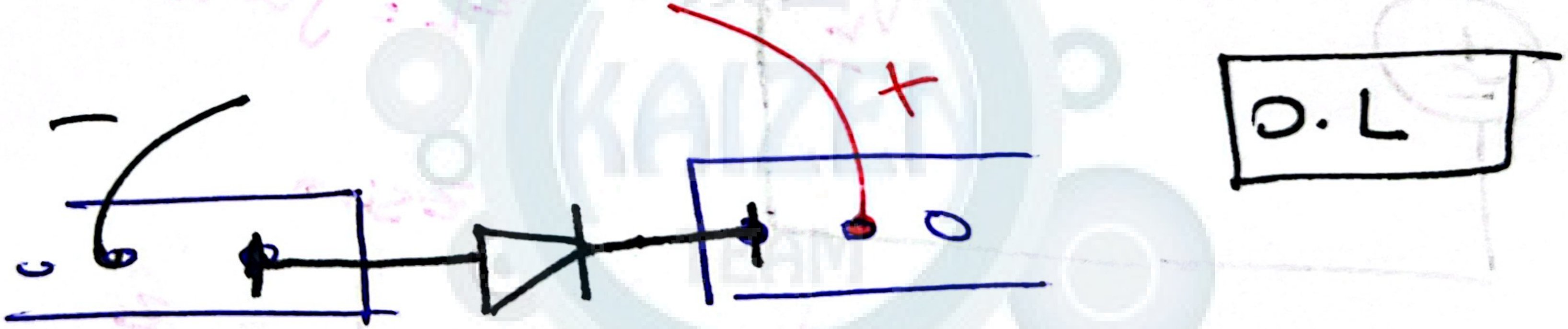




$V_\alpha \simeq 0.7$ → Sillicon $\quad V < V_\alpha$ off

$V_\alpha \simeq 0.2, 0.3$ → germanium $\quad V > V_\alpha$ on



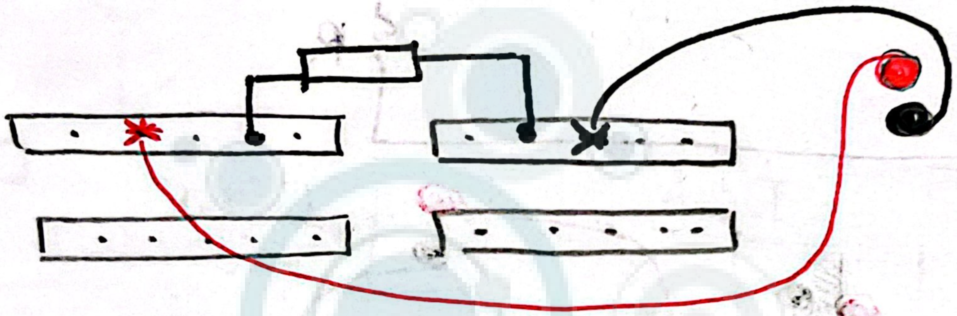
Forward bias test




Reverse bias test

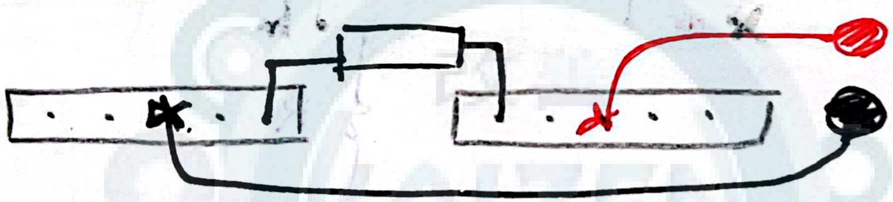
## 1 Diod test :-

To determine the cathode , anode

① 

Digital multimeter

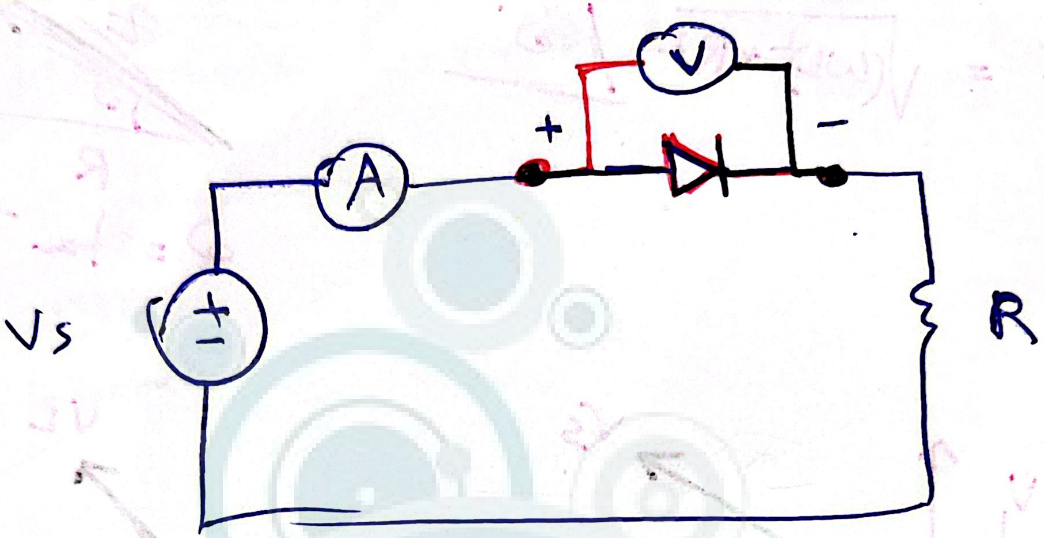
① shift
② diod

② 

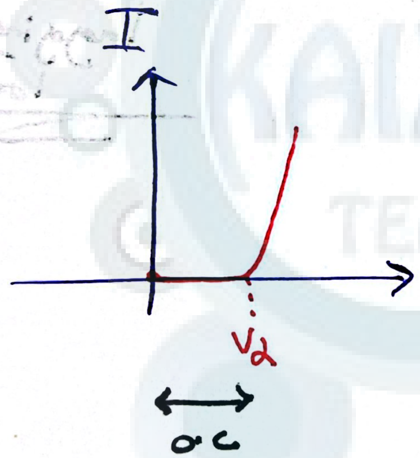
VK , O.L

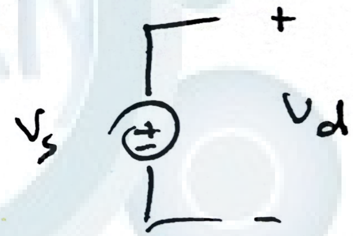
- one of them → O.L ( reversed )
- second one → real Value ( Forward )

اذا كانو ال 2 (قراءة / O.L) بكونو خربانة



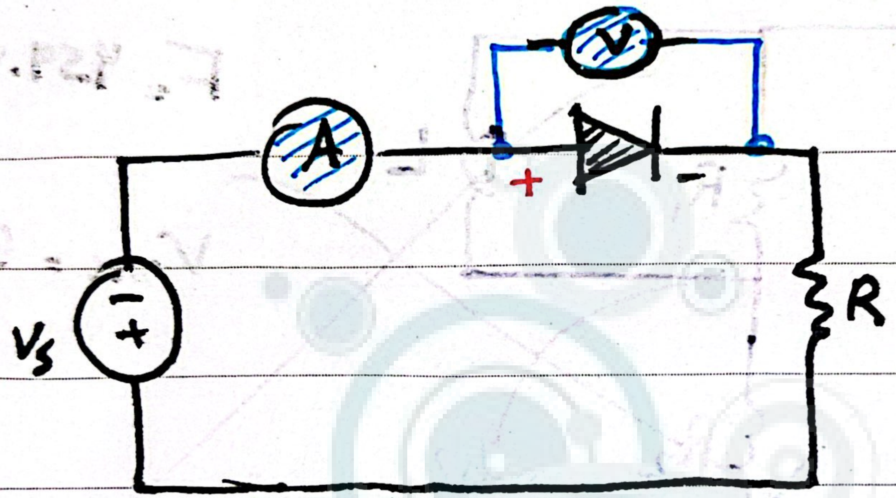

Forward bias region



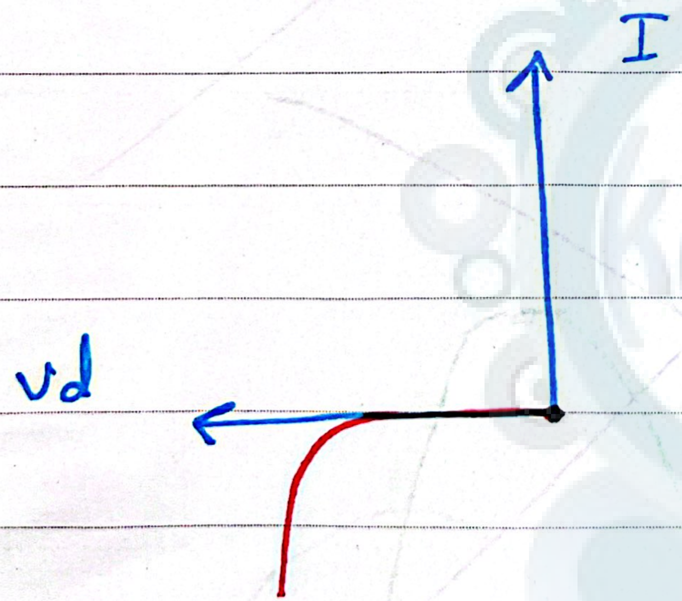




① $V_s \simeq V_d$

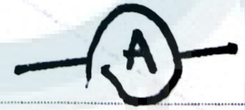
② $V_s \geq V_d$ , $V_d = V_s - V_R$




reverse bais region

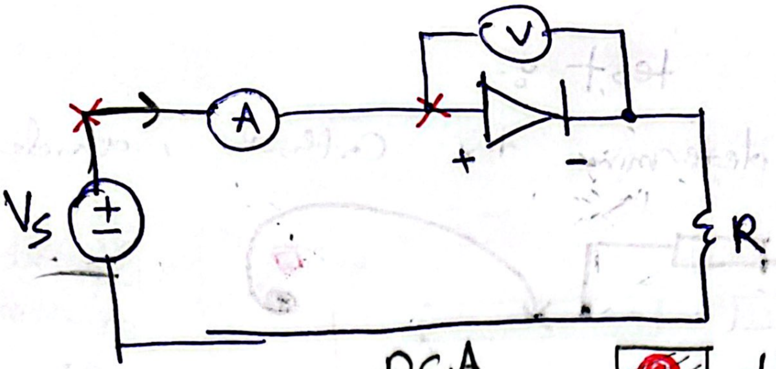


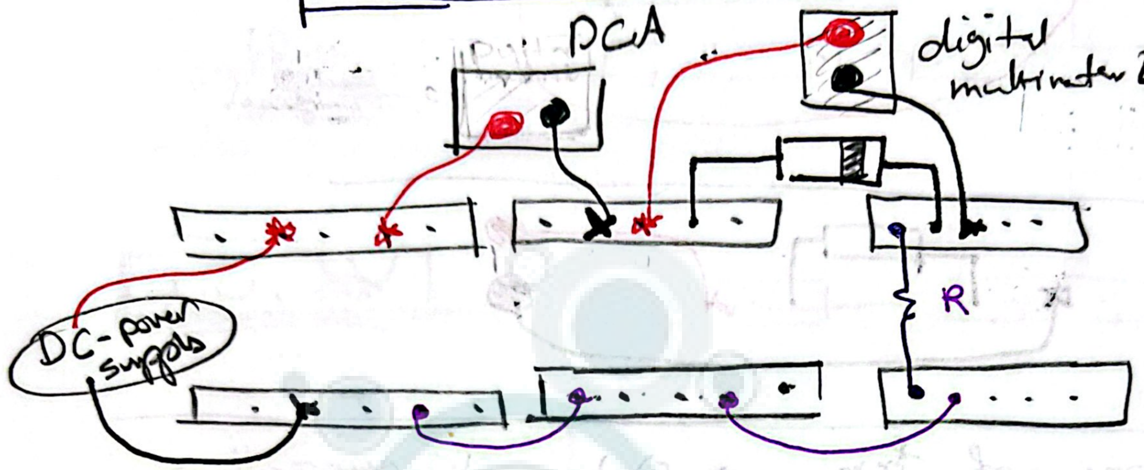

“open circuit”



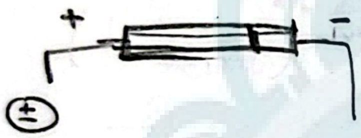

zero


negative value




Forward $U < V_d$ off → ($V_S = V_D$) open circuit

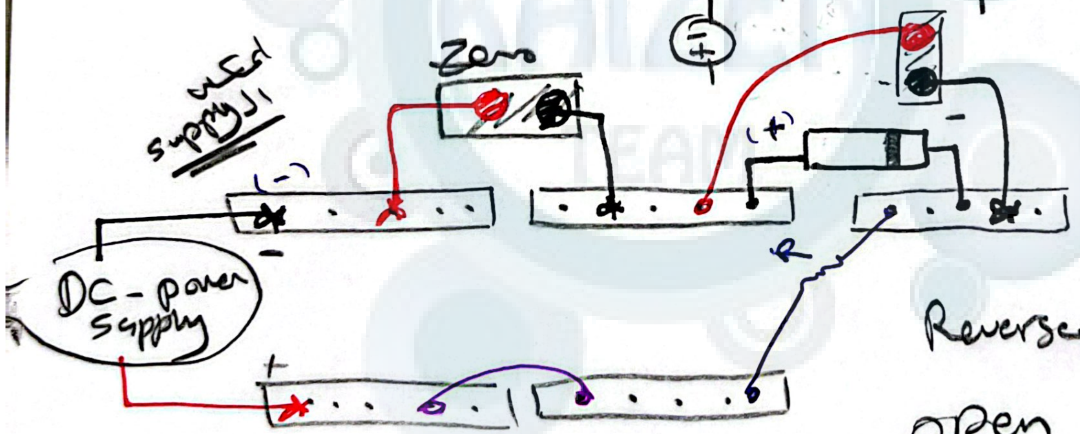



$U > V_d$ on

## 2 Reversed :

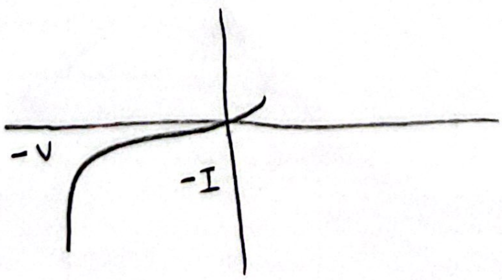

open circuit

I ≈ zero

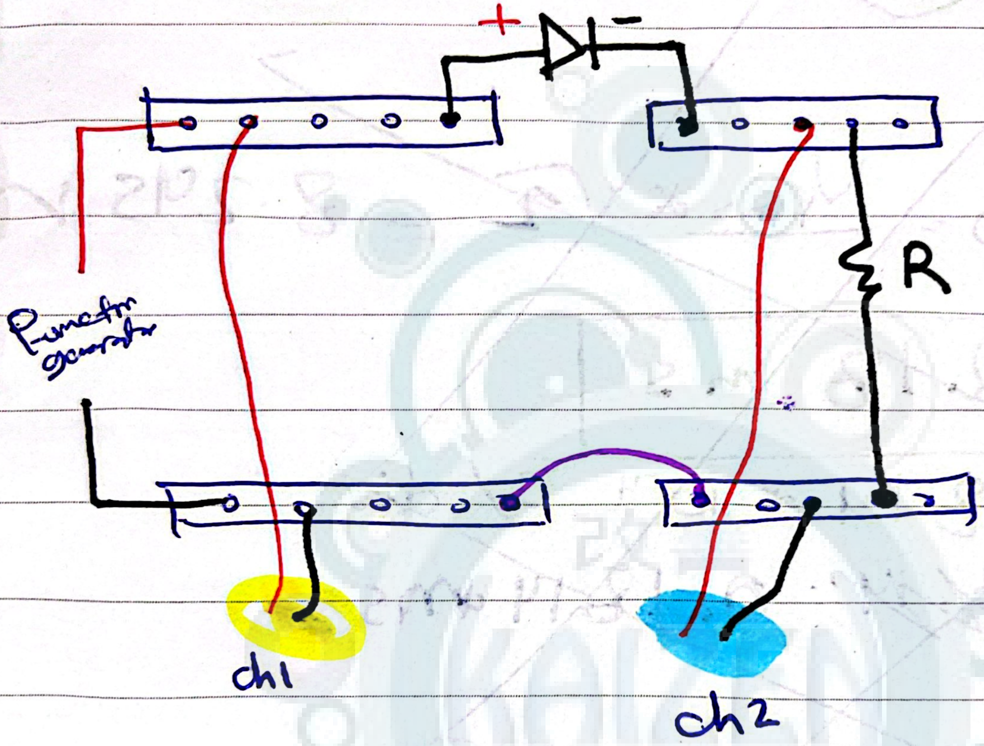


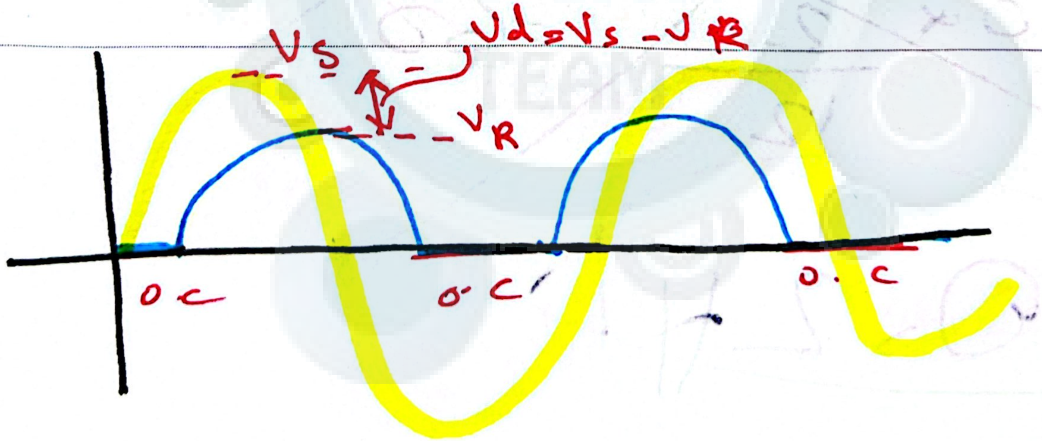

Reversed

open circuit

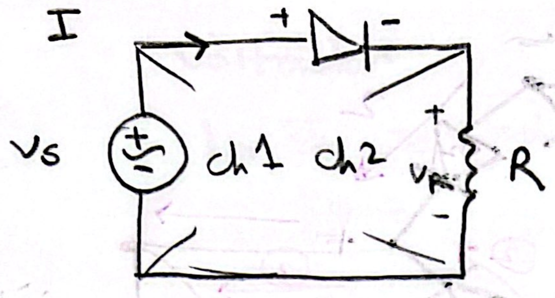


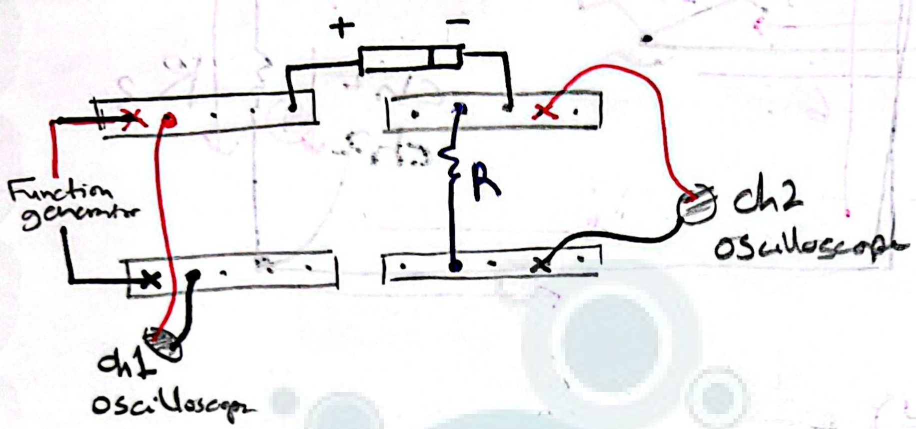
# Half wave Rectifier



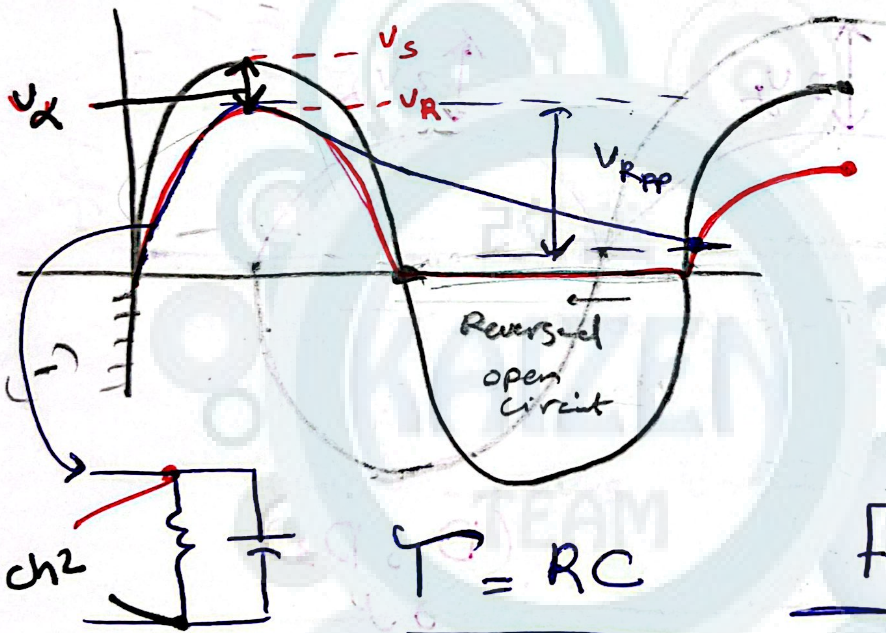
# "Half Wave" Rectifier

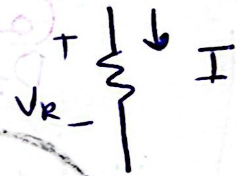



Forward

Un Filtered




I (In phase) $V_R$

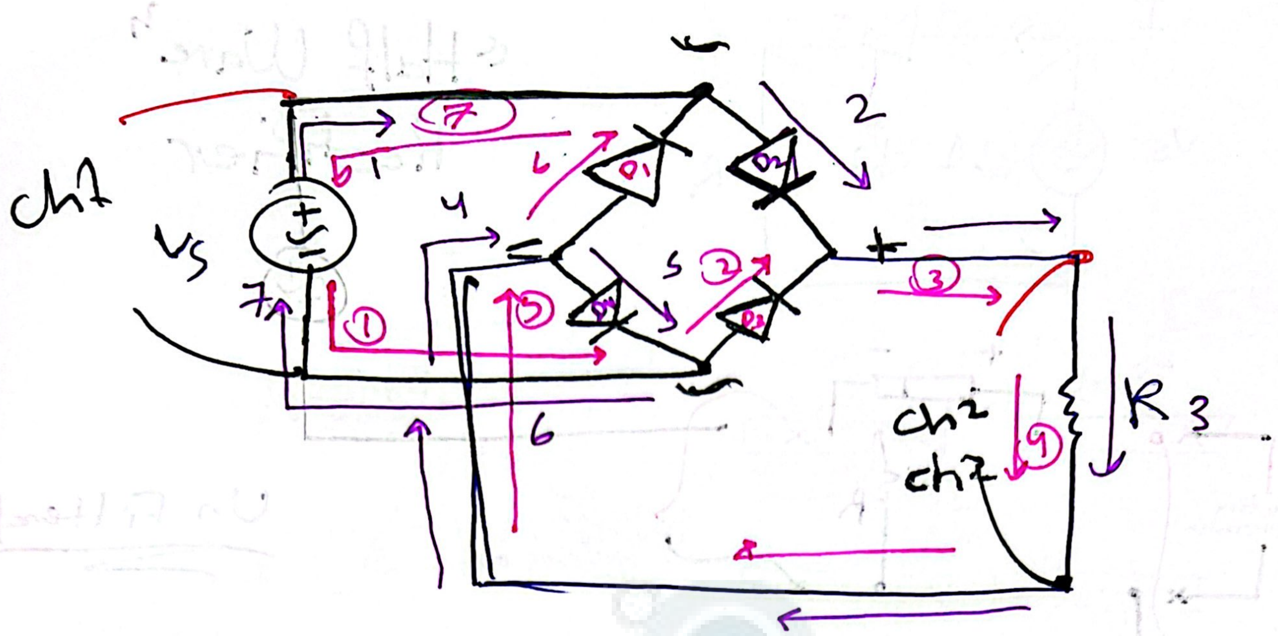
$V_R$ (In phase) $V_s$

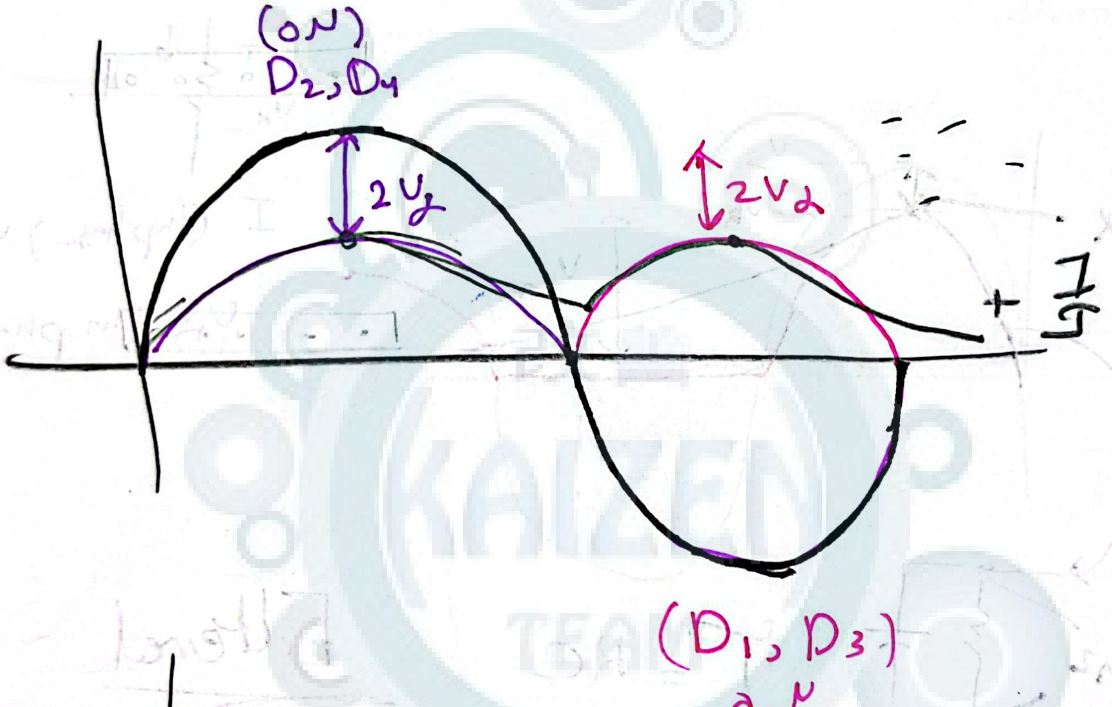
$\tau = RC$

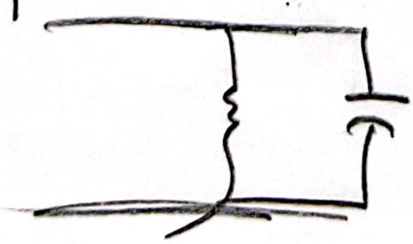
Filtered

$\tau \uparrow$ , $V_{Rpp} \downarrow$

↳ (DC) اشبه



T ↑

Vrpp ↓

Close to DC