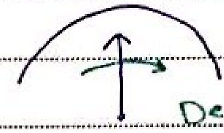
Subject 6 / 21 / MON

* Instrument: → device collect data.
  → Display
  → optional (analysis)

* Instrument
  → analogue
  → Digital → A/D, D/A
    → store data

Ammeter $I \propto i$



Deflection

EN50160

~~EN50160~~ ↑ standard → (code)

Distribution code

1week. 95% within voltage limit.

10 min.

$-6\% \leq \Delta V \leq 10\%$

voltage drop.

* Does this instrument provide True value?!

true value $\triangleq$ theoritical value based on models

* Charateristics of measurment instruments:-

(1) Accuracy: How close is the reading from the true value.

Ex: measured value = 10 V, voltmetter

(close to the true value) accuracy = 10%, range 0-15V, Find the true value?

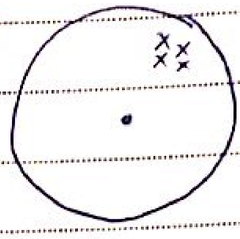
sol: $10 \pm (10\% * 15) = 8.5V$ (-)

$= 11.5V$ (+)

1

2 precision ⇒ Reproducibility

Ex:



• → true value

X → measurement value

- high precise
- low accuracy.

* لما اعمل التجربة اكثر من مرة بيطلعلي قراءات قريبة، مالها علاقة ب true value

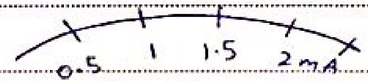
3 Sensitivity :- the ability to respond to the changes in the measured quantity (inputs)

$$S = \frac{\Delta output}{\Delta input}.$$

4 threshold: minmum input that could be measured

5 Resolution :-

قديش ال Step Change بقدر اشوفها



* Accuracy (expressed inaccuracy)

accuracy ($\pm 0.1\%$)

↳ tolerance.

* Precision

Metric

$\sigma \triangleq$ Standard deviation

$\sigma^2 = \underline{\underline{E}}\left[(x-\underline{\underline{\bar{x}}})^2\right]$

$\bar{x}$ → mean.

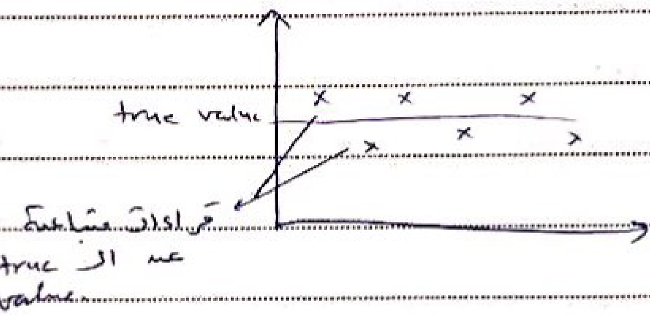
E → expectation

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N}(x_i-\bar{x})^2}{N}}$$

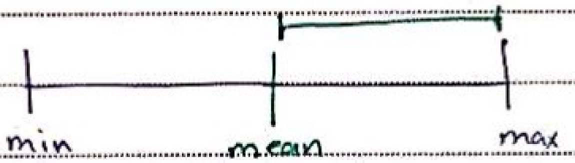
$N \equiv$ sample size

$\bar{X} \equiv$ mean ((average).

$X_i \equiv$ reading



* اذا اجت قراءات كثير بعيدة
يعني انه ال precision سيئ



|max - mean| → Precision

$\boxed{Ex}$ A voltmeter is used to read voltage of 5V [DC loa

((Snap shot))

reading A ⇒ " 5.03 , 4.97 , 5 , 5.02 , 4.99 , 4.89 , 5.03
5.02 , 5.01 , 4.97 "

reading B ⇒ " 5.2 , 5.2 , 5.2 , 5.2 "

compare accuracy , Precision ?

Subject .... / /

Note: * reading 10 8 20 → mean = average

reading	10	8	20
freq	100	20	80

$$\bar{x} = E[x] = 10 * \left(\frac{100}{200}\right) + 8 * \frac{100}{200} + 20 * \frac{100}{200}.$$

mean
average.

Sol: accuracy 84

A: true value = 5V

$$\underset{A}{\text{mean}} = \frac{5.03 + 4.97 + \cdots + 4.97.}{10} = 5 = \text{average}.$$

B: $$\underset{B}{\text{mean}} = \frac{5.2 + \cdots + 5.2}{4} = 5.2 = \text{average}.$$

true value = 5 V

⇨ A more accurate than B.

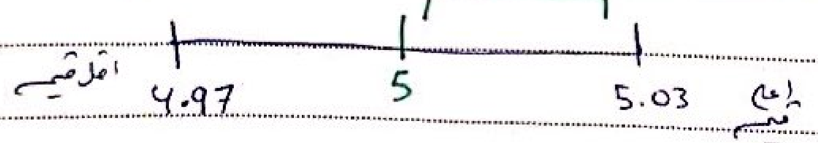
Precision

⇨ the precision in B is higher than in A

Sensitive

Jump = |max − mean| = 0.03.

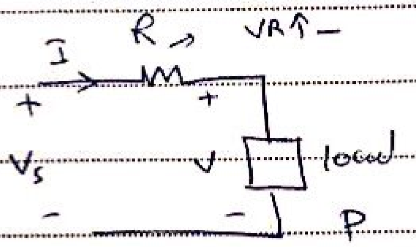
A:



B: 5.2 |max − ~~mea~~| = 0
mean.

4

Subject .... / /



↑P → I↑ → V↓

V بيوصل البيت مش ثابت

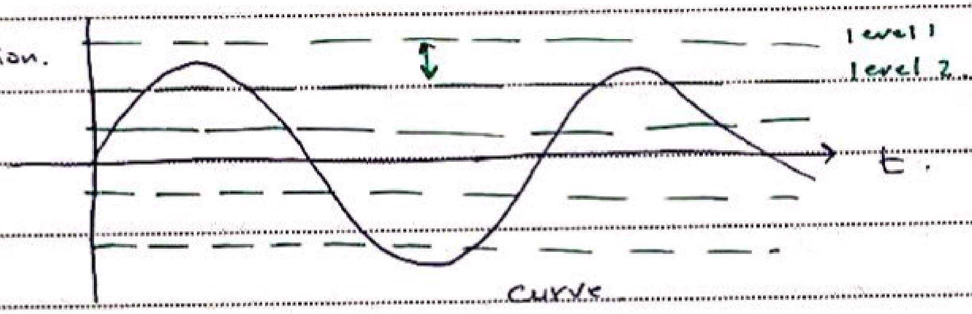
* الـ V في الصبح بعد مش نفس الـ V في وقت كل الناس بتكزمو.

* Resolution:-

$\boxed{\text{Ex}}$ A digitial system (A/D) uses a specific # of bit (12 bits)

How much is the resolution ?!

① Sample
② Quantization.



3 bit ⟶ 8 level (2^3) ((resolution = مسافة من level لـ level تانية))

0 0 0
0 1 0
⋮
1 1 1

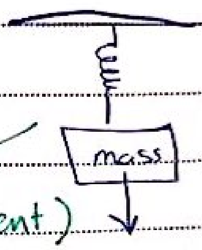
Full Scale = 5V

$\boxed{\text{Sol:}}$ 12 bit ⟹ # level = ~~12~~ 2^{12}

resolution = Step size = $\frac{5}{2^{12}}$ = 1.22 m

* Sensetives:

Ex: measurment system aims to measure mass

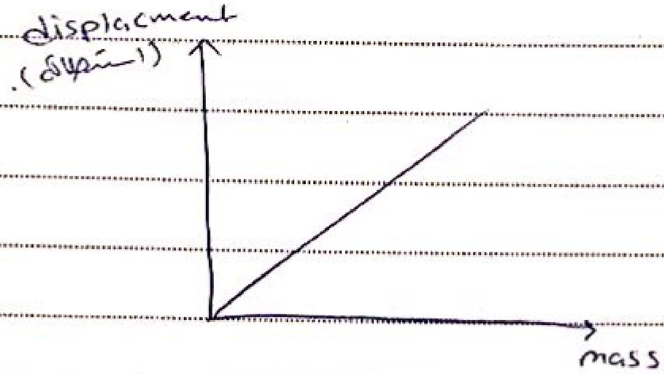


(mass ∝ displacement)

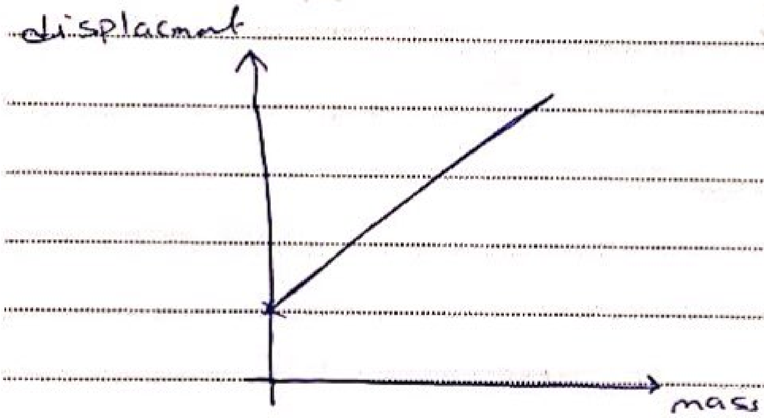
Subject / /

input (Kg)	0	50	100
output (Cm)	0	10	20

$\Rightarrow$ operating condition



sensitivity $\triangleq$ slope $= \dfrac{10}{50}\ \dfrac{Cm}{Kg} = 0.2\ Cm/Kg$

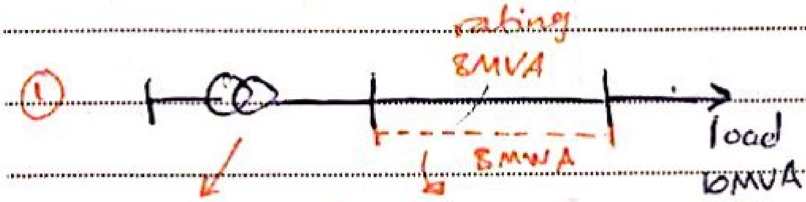


$\Rightarrow$ error $\Rightarrow$ بصير ازاحة

Subject   13 / 2 / MON

Slides: error of measurment

- Systematic error "~~[illegible]~~ معروف السبب"
- Random error "مابعرف السبب"



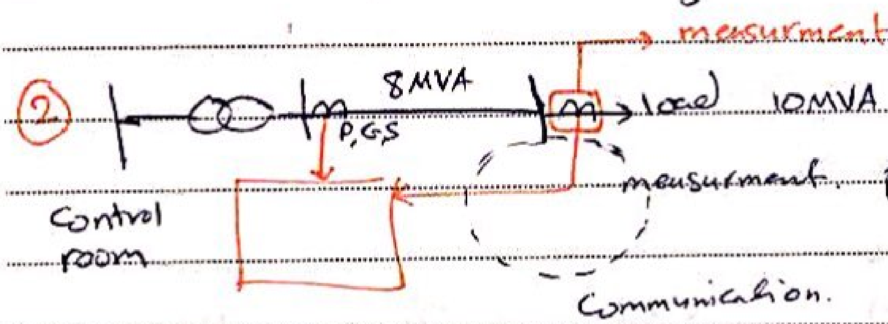
"Power System"

Single line diagram

transformer [install new line] cost ↑ ← T.L بغير الحل اول -

Control load

active network managemant

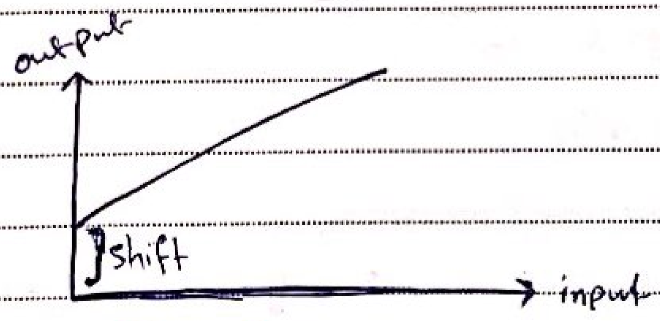


7MW ⟶ 8 MW ⟶ 9MW

slide 2:

redpoint = mean of measurmant value + Gaussian noise

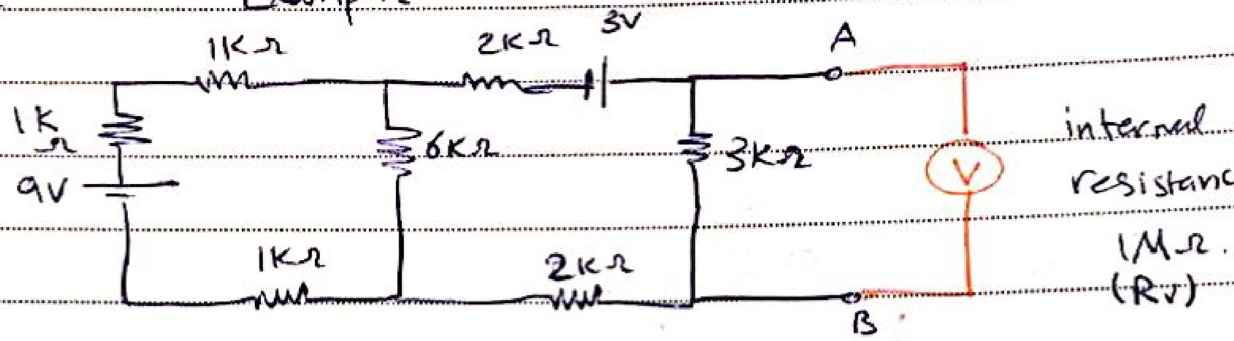
slide 3:



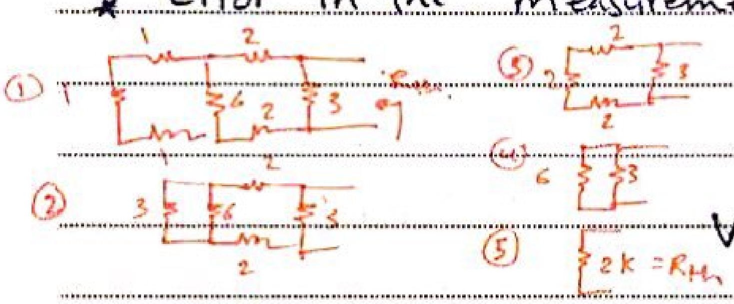
~~Slide 8 - Example~~

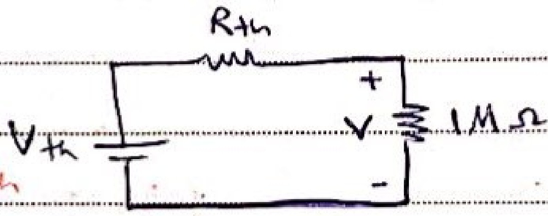
Subject .... / /

Slide Example



* Error in the measurement ?!





$V_{\text{real value}} = \underline{V_{th}}$ $(R_v \rightarrow \infty)$

$V_{\text{measured value}} = \dfrac{1M}{1M + 2K} * V_{th} = 0.998\ V_{th}$

$\text{Error} = \dfrac{V_{real} - V_{measured}}{V_{\cancel{measured}}\ real} * 100\%$

$= \dfrac{V_{th} - 0.998\ V_{th}}{V_{th}} * 100\%$

$= \cancel{0.1996\%}$

$= 0.2\%$

?. – $R_v > 198K\Omega$ to achieve ↓1% error.

⇒ $0.01 = \dfrac{V_{th} - \cancel{0.99V_{th}}\ V_{measured}}{V_{th}}$

$0.01\ V_{th} = V_{th} - V_{measured}$

$V_{measured} = 0.99\ V_{th}$

less than ② $\dfrac{R}{R + 2K}\ \cancel{V_{th}} = 0.99\cancel{V_{th}}$

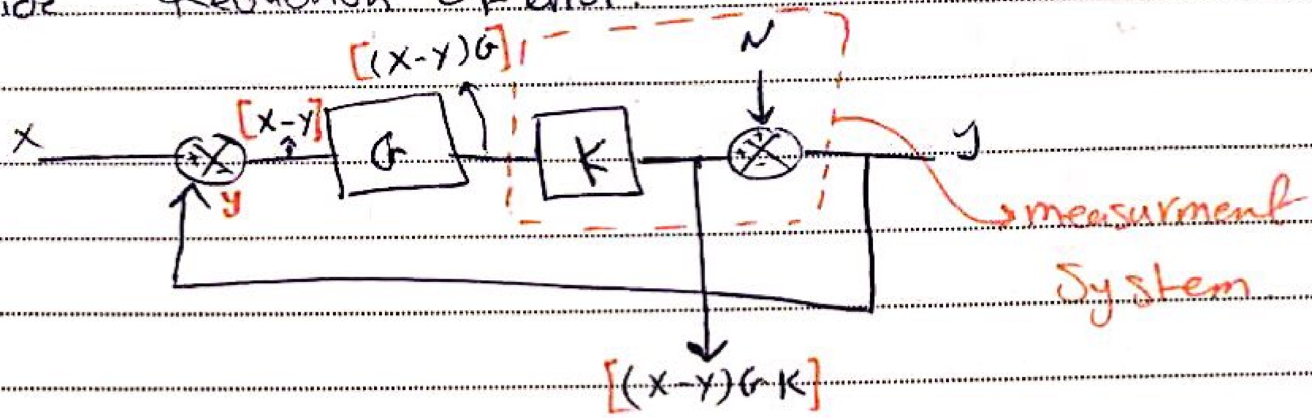
$R = 0.99R + 1.98K$

$0.01R = 1.98K$

$\boxed{R = 198K}$

Subject ....   /   /

Slide   Reduction of error.



$y = (X - y)GK + N$

~~y = GKX - yGK + N~~

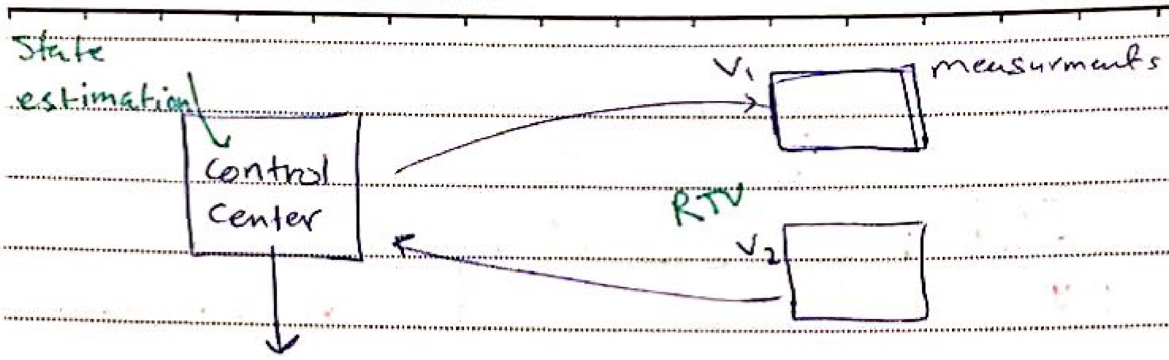
"without feed back
$y = XKG + N$
open loop"

$$y = X\frac{GK}{1+GK} + \frac{N}{1+GK}.$$

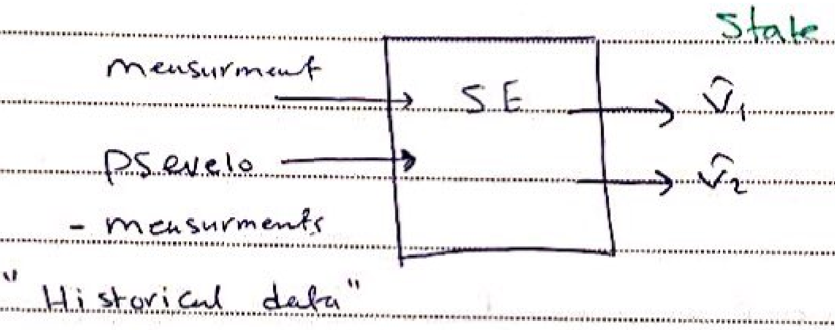
① G is very large ⇒ eleminate noise
② $y \approx X$

Scanned by CamScanner

Subject 15/2/Wed



1) monitoring.
2) decision - making
algorithm



RTV = remate terminal unit.

slide: statical Analysis ...
13+14.

1 4 7 11 15

median = 7

$$\sigma^2 = \frac{1}{n}\sum (x - \bar{x})^2$$

variance. sample measurment mean

$\sigma \triangleq$ standar variation.

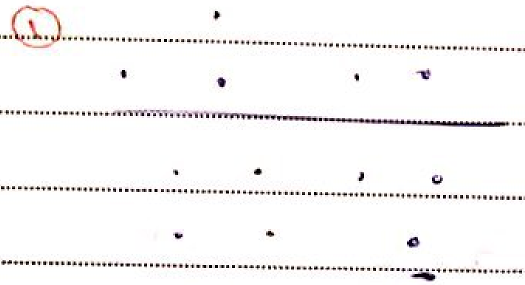
n

$n-1$ (Sample size) $n \leq 30 \Rightarrow$

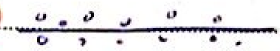
نقسم ع $n-1$

$\sigma \downarrow \rightarrow \downarrow$ error

1



2



$\downarrow$ error $\downarrow \sigma$

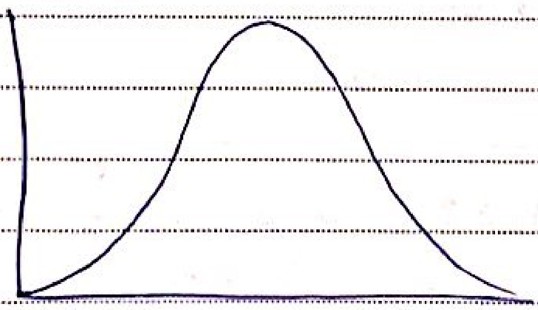
$\uparrow$ error $\rightarrow \uparrow \sigma$

Slide "Histogram"

$$\text{mean} = \frac{1}{N} \sum x$$

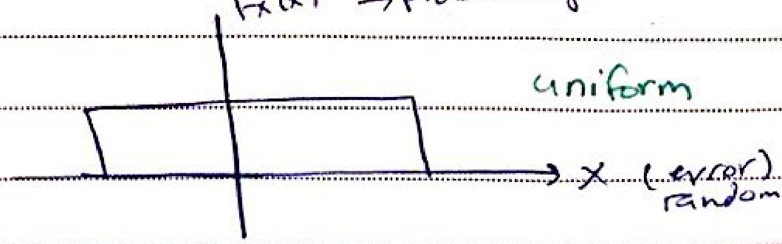
$$\text{mean} = \sum x_i \, P_r(x)$$

slide Histogram $\rightarrow$ pdf

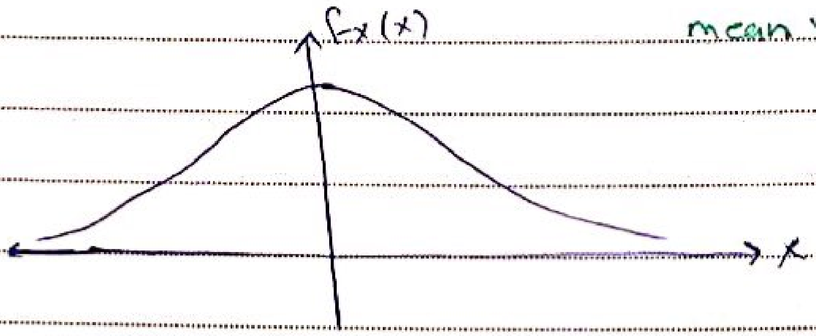


$f_x(x) \rightarrow$ probability.

uniform



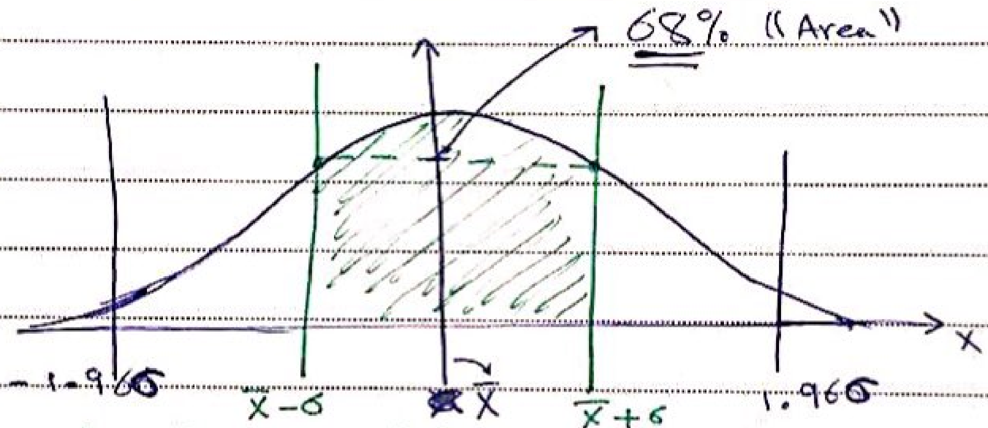
Subject .... / /



mean variance

Wein Ball "Wind"

slide Gaussian Curve.



median = 0 ⇒ Symmetric

$$f_x(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{(x-\bar{x})^2}{2\sigma^2}}$$

σ^2 ↳ variance

$\bar{x}$ = mean

at 1.96σ → Area = 95%

$Pr(-1.96\sigma \le X \le 1.96\sigma) = 95\%$

$Pr(\bar{x} - \sigma \le X \le \bar{x} + \sigma) = 68\%$

$Pr(\bar{x} - 1.96\sigma \le X \le \bar{x} + 1.96\sigma) = 95\%$

Subject .... / /

pdf "prob. density function"

$f_X(x)$

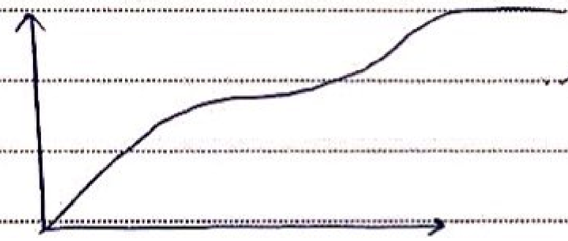
$$Pr(x_1 \leqslant X \leq x_2) = \int_{x_1}^{x_2} f_X(x)\,dx$$

slide (CDF)

CDF $\Rightarrow$

$$F_X(x_0) = Pr(X \leqslant x_0)$$

non - decreasing



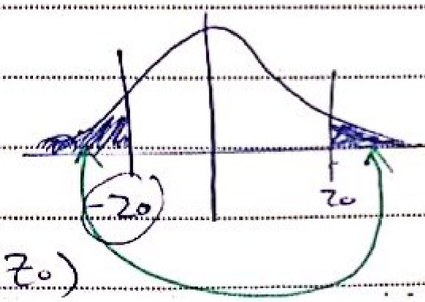
$$F_X(x_0) = \int_{-\infty}^{x_0} f_X(x)\,dx$$

slide Standard Gaussian :

$$F_X(X_0) = pr(X \leq x_0)$$

$$Z_0 = \frac{x_0 - \text{mean}}{\sigma}$$

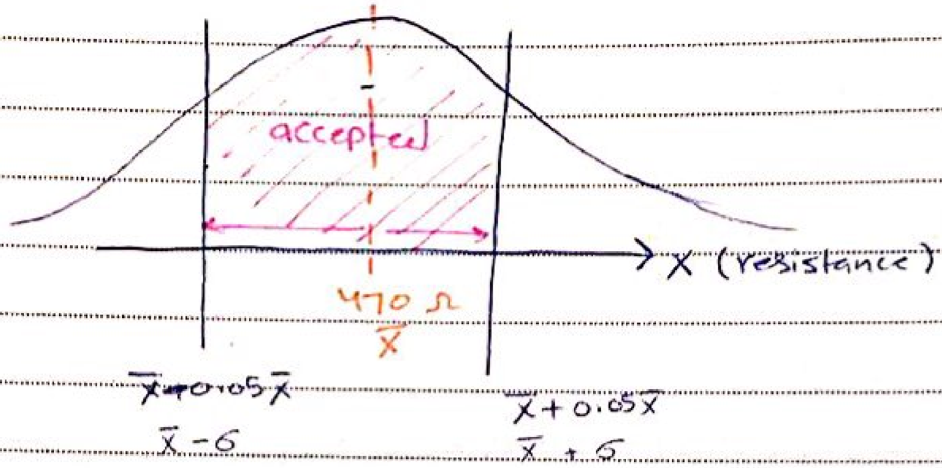
$\searrow$ table



$$F(-Z_0) = 1 - F(Z_0)$$

نفس المساحة.

Slide 21 Gaussian Curve - Example



①

$\sigma = 23.5\ \Omega$, $\bar{x} = 470\ \Omega$.

$Pr(\bar{x} - 0.05\bar{x} \leq X \leq \bar{x} + 0.05)$

$= Pr(X \leq \bar{x} + 0.05\bar{x}) - Pr(X \leq \bar{x} - 0.05\bar{x})$

$= F_x(\bar{x} + 0.05\bar{x}) - F_x(\bar{x} - 0.05\bar{x})$.

$F(z) = Pr(Z \leq z_0)$

table $z = \dfrac{x - \text{mean}}{\sigma}$

$F_z\left(\dfrac{\cancel{\bar{x}} + 0.05\bar{x} - \cancel{\bar{x}}}{\sigma = 0.05\bar{x}}\right) - F_z\left(\dfrac{\bar{x} - 0.05\bar{x} - \bar{x}}{\sigma}\right)$

$= F_z(1) - F_z(-1)$

$= 68\ \%$

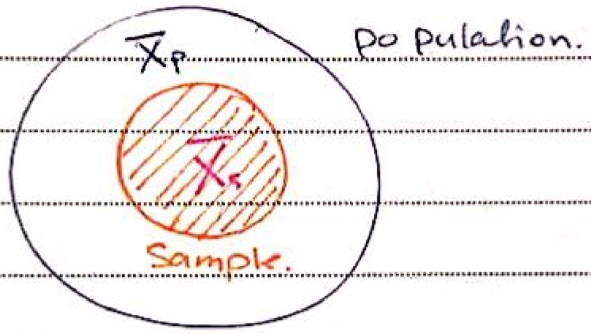
Pr(rejection) = 32%.

32% * 10,000 = 3174 will be rejected.

"random error"

② $\sigma^2 = \frac{1}{N}\sum(\underset{+5}{x} - \underset{+5}{\bar{x}})^2$

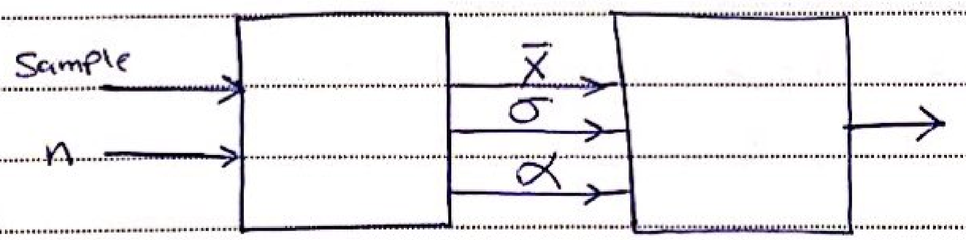
Slid 22 Standard Error of the Mean.



Confidance level.

α (Standard error of the mean)

$$\alpha = \frac{\sigma}{\sqrt{n}}$$



confidance level

$\bar{X} \pm \alpha$ (68%)

$\bar{X} \pm 2\alpha$ (95.4%)

$\bar{X} \pm 1.96\alpha$ (95%)

- Confidance level ← بيزيد ال data كما زدت ال

Subject .... / /

$\boxed{\text{slide 26}}$ Example:

A voltmeter was ...

(sample) $\bar{X} = \dfrac{36.1 + 36.3 + \cdots + 35.8}{10}$

$= 35.93\ \Omega$

$$\sigma_{n-1} = \sqrt{\frac{1}{N-1}\left[\sum_{i=1}^{N}(X_i - \bar{X})^2\right]}$$

$= 0.365$

نقسم على N-1 ← 30 <

$\alpha = \dfrac{\sigma}{\sqrt{n}}_{\rightarrow 10} = 0.115$

Confidance ~~limit~~ level $\cong$ 95.4 %

$\bar{X} \pm 2\alpha$

- mean true value

$35.93 \pm 2(0.115)$

$\boxed{\text{slide 27}}$ aggregation of error.

تجميع

$u = V + W$

tolarance $\pm m\%$ ← V, W → tolarance $\pm n\%$

$W = 5\text{ volt} \pm 10\%$

$V = 10\text{ V} \pm 10\%$

Subject .... / /

$U = 15V$ (No error).

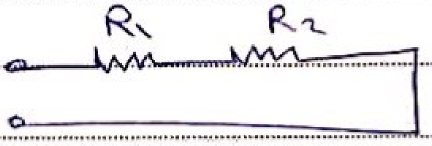
$U_{max} = (10 * 1.1) + (5 * 1.1)$ $(1 + 0.1)$ $1 + \frac{10}{100}$

$= 11 + 5.5$

$= 16.5\ V$

$U_{min} = (10 * 0.9) + (5 * 0.9)$ $(1 - 0.1)$

$= 13.5\ V$



* $R_{eq} = R_1 + R_2$

5% 10%

$\boxed{\text{Slide 32}}$ Example.

when a steel rod ...

constant

$F = \frac{E \cdot A \cdot d}{L}$

- $\Delta F = \Delta A \frac{\partial F}{\partial A} + \Delta d \frac{\partial F}{\partial d} + \Delta L \frac{\partial F}{\partial L}$

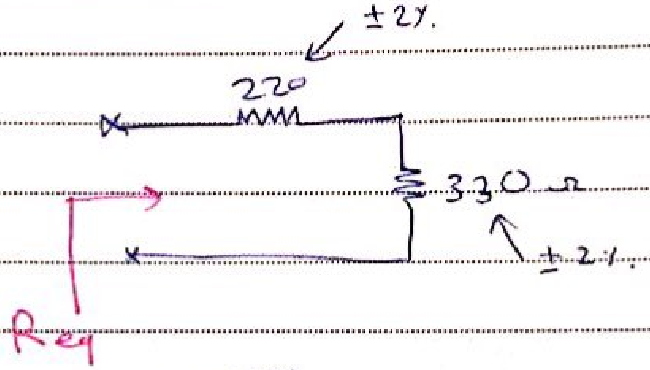
$\left|\frac{\Delta F}{F}\right|_{min} = \frac{\Delta A}{A} + \frac{\Delta d}{d} + \frac{\Delta L}{\ell}$

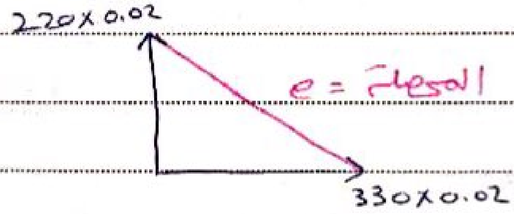
$\left|\frac{\Delta F}{F}\right|_{max} = -\frac{\Delta A}{A} - \frac{\Delta d}{d} - \frac{\Delta \ell}{\ell}$

Slide: probable value - ~~[illegible]~~ Multiplication

$e = \sqrt{(m)^2 + (n)^2}$

Slide: 37 aggregation of error:





((probable error))

$$e = \sqrt{(220 * 0.02)^2 + (330 * 0.02)^2}$$

$$e = 7.93\ \Omega$$

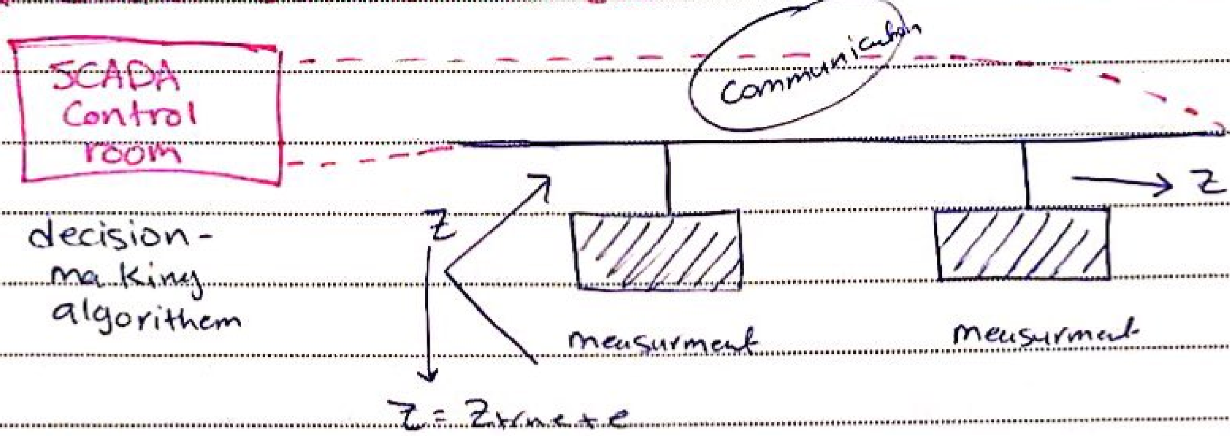
$$R_{series} = 220 + 330 = 550\ \Omega$$

$\frac{7.93}{550} = 1.44\%$: * نسبة error كبيرة للصغيرة
تقسم على قيمة الاصلية

$$R = 550 \pm (1.44\% * 550)$$

$$error = \frac{true - meas}{true}$$

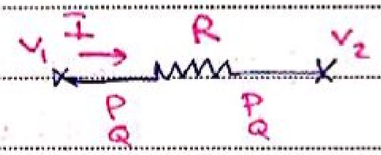
* State estimation 84



$Z = Z_{true} + \underline{e}$

e = error → Systematic
→ random

⇒ Know value of State ((voltages and angels at each node))



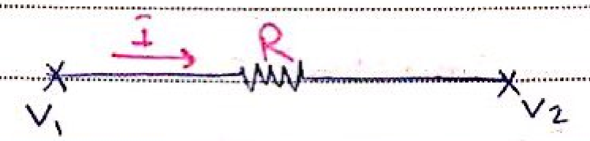
$\boxed{1}$ error in measurment
in measurment / Communication / SCADA.

$\boxed{2}$ Not enough real measurments

$$Z_i = h_i(X) + e$$

- Z_i → measurment "Known"
- h_i → math model
- X → State "unknown"
- e → error "unknown"

Subject .... / /



* Random error: assumptions 8⊲

- Gaussion
- measurments are independent

↑ measurment → " state ال بيقل الخطأ "

* Weighted lease square error ((WLS))

$$\underset{J}{\underline{\underline{Min}}} \sum_{i=1}^{m} \frac{(Z_i - h(x))^2}{\underline{\underline{\sigma_i}}^2}$$

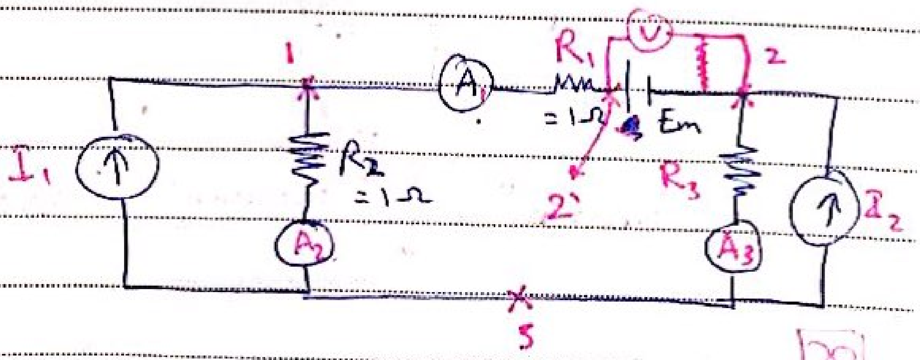
minimization
for error.

$\sigma_i \equiv$ ~~emphasis~~ trust measurment.
emphasis

- Pseudo measurment :
  ↳ historical data

* linear least square estimation 8⊲

$\boxed{Ex}$



I_{V}, I_{2}, e are all unknown

$R_1 = R_2 = R_3 = 1\Omega$

meusurment :

$A_1 : i_{12} = 1A$

$A_2 : i_{31} = 3.2A$

$A_3 : i_{23} = 0.8A$

$V : E_m = 1.1\,V$

State

$$\begin{bmatrix} V_1 \\ V_2 \\ e \end{bmatrix}$$

!?

$Z_i = h(x)$

$$i_{12} = \frac{V_1 - V_2'}{R_1}$$

$V_2' = E_m + V_2$

$$i_{12} = \frac{V_1 - E_m - V_2}{R_1} = V_1 - E_m - V_2$$

$\underline{i_{12}} = \underline{1}(V_1) - \underline{1}(E_m) - \underline{1}(V_2) = 1A \quad \ldots \; 1$

$$i_{31} = \frac{V_3 - V_1}{R} \Rightarrow -3.2 = \frac{0 - V_1}{1}$$

$$\boxed{-V_1 = -3.2} \quad \ldots \; 2$$

$$i_{23} = \frac{V_2 - V_3}{1} = \frac{V_2 - 0}{1} = 0.8$$

$V_2 = 0.8 \quad \ldots \; 3$

$\Rightarrow$ coefficent $E_m, V_1 = 0$

Subject .... / /

$e = 1.1\ v \quad \dots (4)$

$$\begin{array}{ccc} v_1 & v_2 & e_m \end{array}$$

$$\begin{bmatrix} 1 & -1 & -1 \\ -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ e_m \end{bmatrix} = \begin{bmatrix} 1 \\ -3.2 \\ 0.8 \\ 1.1 \end{bmatrix}$$

$$\underset{A}{} \quad \underset{X}{} = Z$$

$A\ X = Z$

$X = ?!$

$A_1 = 1A + e$

$e = 1A - (\underbrace{F(x)}_{model})$

" Unique Solution عدد معادلات أكبر من عدد المجاهيل ما في "

$Z - Ax = error$

Minimize ((WLSE))

" over determined "

- pseudo measurment
(distorinal data)

$Ax = b = z$ ↳ best estimate

b → real measurment
↳ A_x

Minimize error between measurment that value resulting from the model.

$$\begin{bmatrix} Error \end{bmatrix}_{WLSE} = \underset{z}{\begin{bmatrix} 1 \\ -3.2 \\ 0.8 \\ 1.1 \end{bmatrix}} - \left[\underset{A}{\begin{bmatrix} 1 & -1 & -1 \\ -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}} \underset{x}{\begin{bmatrix} v_1 \\ v_2 \\ e \end{bmatrix}} \right] = \begin{bmatrix} 1 - v_1 - v_2 + e_m \\ -3.2 + v_1 \\ 0.8 - v_2 \\ 1.1 - e_m \end{bmatrix}$$

$$\text{Min} \Rightarrow (1 - V_1 - V_2 + e_m)^2 + (-3.2 + V_1)^2 + (0.8 - V_2)^2 + (1.1 - e_m)^2$$

$$X = G^{-1} A^T b \qquad b = z$$

Gain matrix

$$G = A^T A$$

$$X = \begin{bmatrix} 3.125 \\ 0.875 \\ 1.175 \end{bmatrix} \begin{matrix} V_1 \\ V_2 \\ e_m \end{matrix}$$

residual

$$r = b - AX$$

$$= \begin{bmatrix} 1 \\ -3.2 \\ 0.8 \\ 1.1 \end{bmatrix} - \begin{bmatrix} 1 & -1 & -1 \\ -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 3.175 \\ 0.875 \\ 1.175 \end{bmatrix}$$

$$= \begin{bmatrix} -0.075 \\ -0.075 \\ -0.075 \end{bmatrix}$$

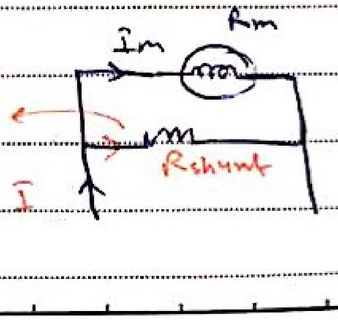
$\boxed{\text{Slide Meters :-}}$

Dc meters. — Analoge.

P.MMC
- → Ammeter
- → voltmeter

$\boxed{\text{Slide 43}}$ Basic DC ammeter.

$\downarrow R_{shunt} \rightarrow I \uparrow$



Subject

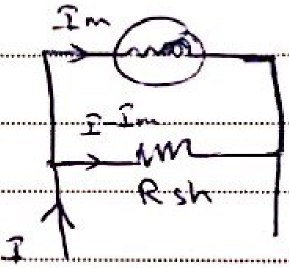
$$I_m R_m = R_{sh}\,(I - I_m)$$

$$R_{sh} = \frac{I_m R_m}{I - I_m} = \frac{R_m}{\left(\frac{I}{I_m}\right) - 1}$$

$$\boxed{R_{sh} = \frac{R_m}{n-1}} \qquad \boxed{\frac{I}{I_m} = n}$$

Slide 45 Basic DC Ammeter:

Ex 1:



$I_m = 1mA$, $I = (0 - 10mA)$

$R_m = 100\ \Omega$

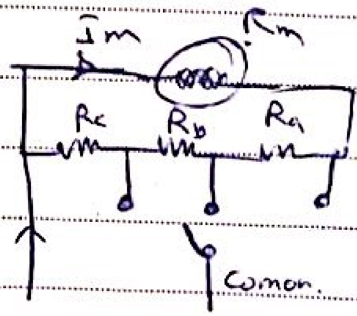
Sol:

$$R_{sh} = \frac{100}{\left(\frac{10m}{1m}\right) - 1} = 11.11\ \Omega$$

Ex 2 ↑ Range → ↓ R_{sh} $\left[R_{sh} = \frac{800}{\left(\frac{100m}{100\mu}\right) - 1} = 0.8\ \Omega \right]$

Slide 46 7 Multiple Range Ammeter.

Ex



$I_m = 50\mu A$

$R_m = 2400\ \Omega$

3 ranges → 5mA
→ 50mA
→ 500mA

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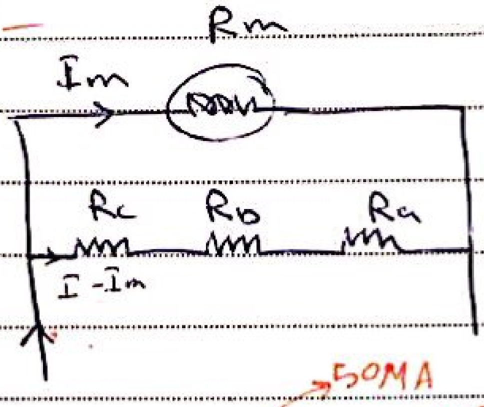
Subject .... / /

5mA :-

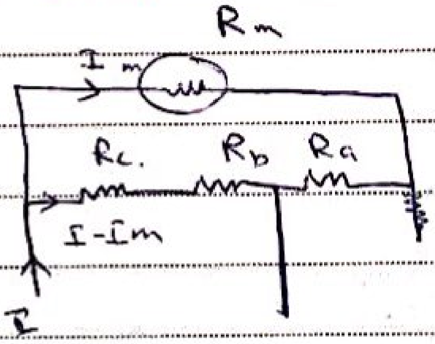


50MA 2400

$$R_c + R_b + R_a = \frac{I_m R_m}{I - I_m} \quad \dots (1)$$

5mA 50 MA

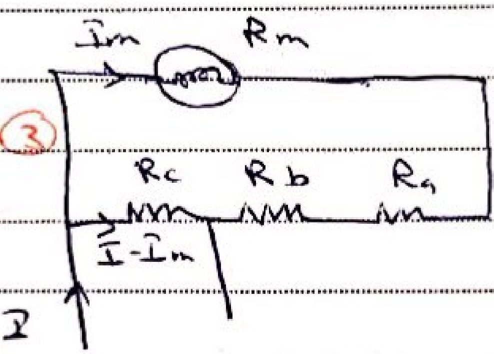
50 mA :-



$$\frac{I_m (R_m + R_a)}{I - I_m} = R_c + R_b \quad \dots (2)$$

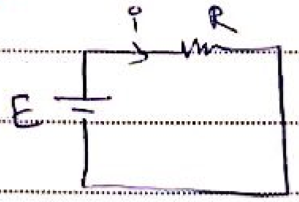
500 mA :-

$$\frac{I_m (R_a + R_b + R_m)}{I - I_m} = R_c \quad \dots (3)$$

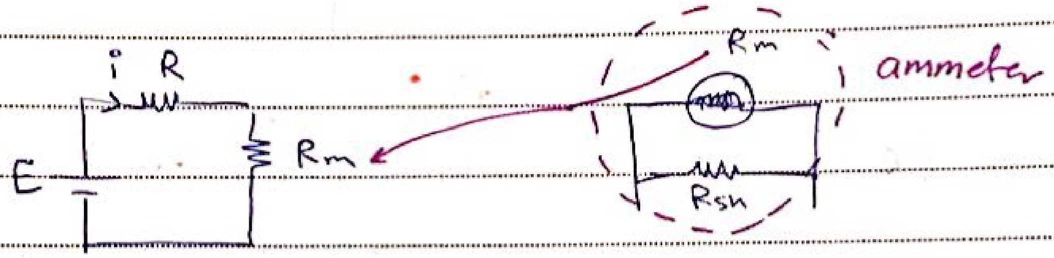


- $R_c = 2.18\ \Omega$
- $R_b = 9\ \Omega$
- $R_c = 21.81\ \Omega$

slide 49 Ammeter loading effect



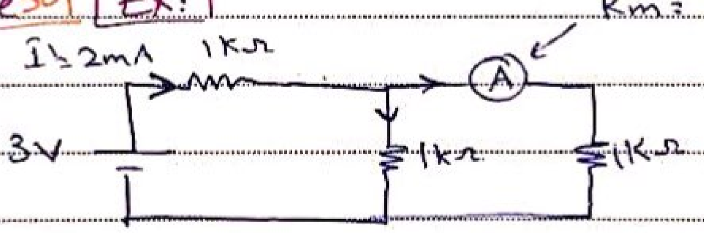
$$I_{applied} = \frac{E}{R}$$



$$i_{measured} = \frac{E}{R + \underbrace{R_m}_{\text{ammeter resistance.}}}$$

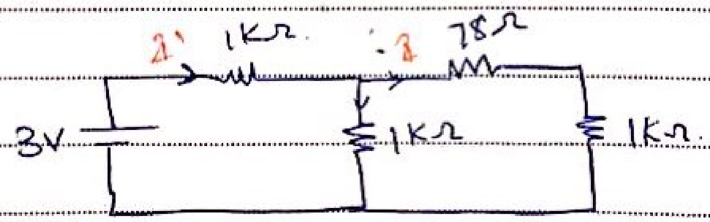
$$\text{Insurtion error} = \frac{I_{exp} - I_m}{I_{exp}}$$

slide 50 Ex:



$$I'_{expected} = \frac{3}{1.5K} = 2mA$$

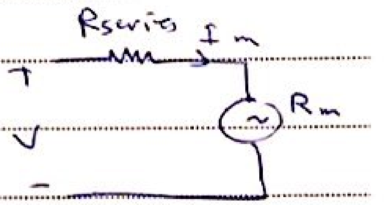
$$I_{expected} = \cancel{2mA}\ \cancel{1mA}\ 1mA$$



$$I' = \frac{3}{1K + (1K\Omega + 78) \,//\, 1K\Omega} = 1.97\,mA$$

$I_{measured} = I' * \frac{1K}{1K + 1K + 78} = 0.95\,mA$

$error = \frac{1 - 0.95}{1} * 100 = 5\%$

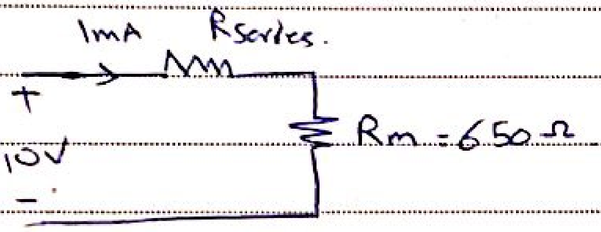


$R_1 \rightarrow V_1$

$R_1 + R_2 \rightarrow V_2$

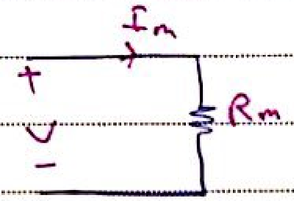
slide 51 Basic DC voltmeter.

Ex A ~~Param~~ Permanent:



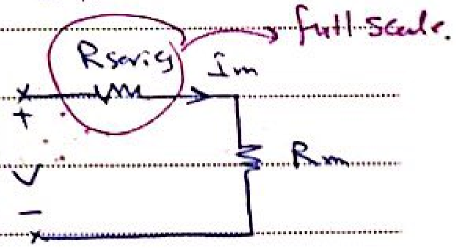
$-10 + 1mA(R_S + R_m) = 0$

$\boxed{R_{series} = 9.35\,K\Omega}$



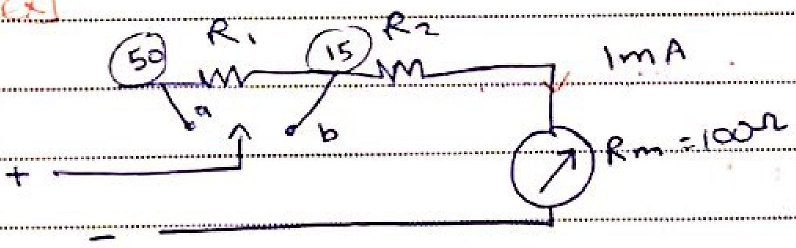
ال V لما تكون 20 V is full scale

$V_{Full scale\ deflection} = I_m R_m$



Slide 53 Multi Range Voltmeter:

Ex



range: (0−15)V , (0−50)V

Design (R_1, R_2)

$\uparrow \Omega \rightarrow \uparrow$ scale

بدي اياه عند ال 15 ← عند نقطة b

$b \Rightarrow 15 = I_m (R_2 + R_m) \quad \ldots (1)$

$a \Rightarrow 50 = I_m (R + R_2 + R_m) \quad \ldots (2)$

$R_2 = 14.9\,k\Omega$

$R_1 = 35\,K\Omega$.

Subject .... / /

Slide Sensetivity

$$\text{Sensetivity} = \frac{1}{I \text{ full scale deflection}} \quad \frac{\Omega}{V}$$

$$S = \frac{1}{I_m}$$ 50 MA . 500 MA

50 MA more sensetive.

Slide Multi range ⇒ حلها بطريقة S

$$S = \frac{1}{1mA} = 1000 \ \Omega / V.$$

total Series resistance = $15 \times 1K = 15000 \ \Omega$	15 V
" " " = $50 \times 1K = 50 K\Omega$	50 V

$$15K = R_2 + R_m$$

$$50K = R_1 + R_2 + R_m$$

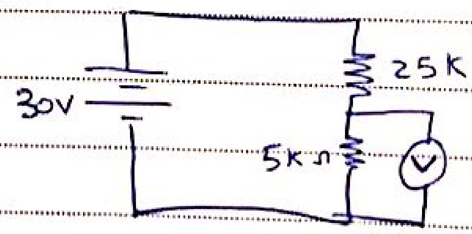
Slide Voltmeter loading effect:-

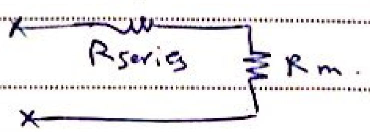
meter A ⇒

$$R_{\text{voltmeter}} = 10 \times \frac{1 K\Omega}{V}$$ (V × S)

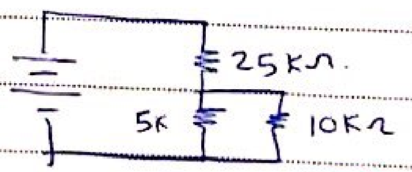
$$= 10 \ K\Omega.$$

⇓



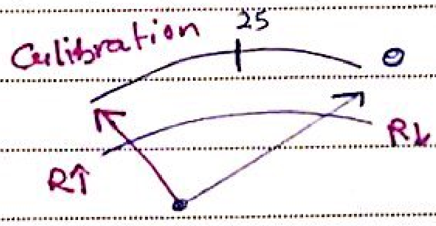


meter B ⇒ $R_V = 10 \times \frac{20 K\Omega}{V} = 200 K\Omega$

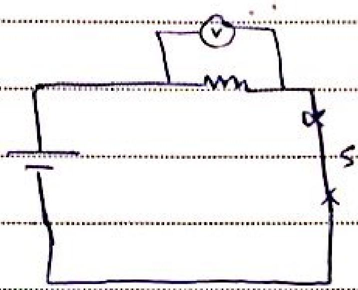


Subject ________ / /

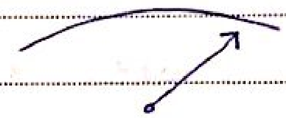
Slide ohmmeter → Reverse
→ Nonlinear

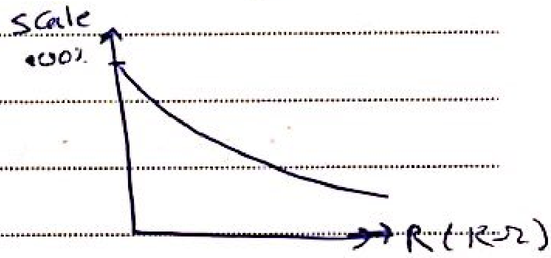


linear: اذا راح ع النص يقرأ 50% ← بس بالواقع ما يقرأ 50% non linear.



↑R → ↓V

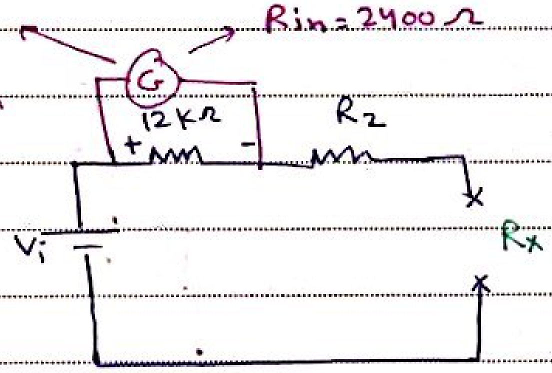




- Reverse
- Not linear.

Slide 62:

Ex.:

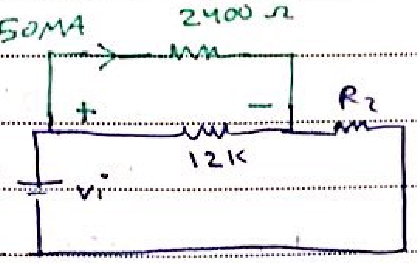


V_i, R_2 ?!

→ full scale deflection, $R_x = 0$?!

→ 20% full scale deflection $R_x = 200K\Omega$

Sol:



full scale deflection voltage

50MA * 2400 = 120 mV

$$120\,mV = V_i * \frac{(12K // 2400)}{(12K // 2400) + R_2}$$

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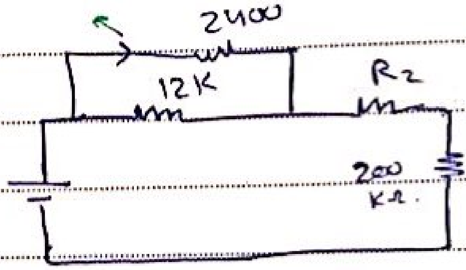
Subject .... 6 / 3 / MON

$$\boxed{240 + 0.12 R_2 = 2000\ V_i} \quad \cdots \ (1)$$

20% full scale deflection.

(2) $20\% (2400 * 50 mA)$

$= 0.024\ V.$

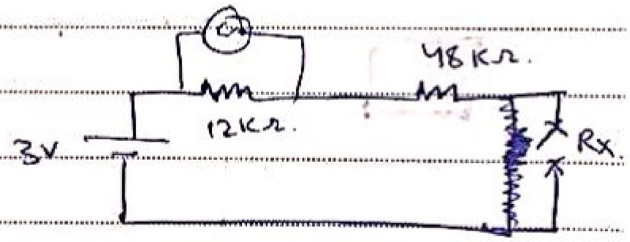


$$0.024 = V_i \frac{(12K // 2400)}{(12K // 2400) + R_2 + 200K}.$$

$$\boxed{4848 + 0.024 R_2 = 2000\ V_i} \quad \cdots (2)$$

$$\boxed{\begin{matrix} R_2 = 48 K\Omega \\ V_i = 3V \end{matrix}}$$

(3)



$$\%d * 120mK\ \ 3 * \frac{(2400 // 12K)}{(2400 // 12K) + 48K + 450K}$$

!?

75 K

50 K

Rx = 450 K Ω.

Rx ↓

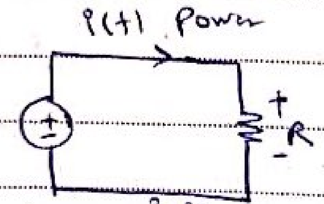
(full scale deflection ال ...)

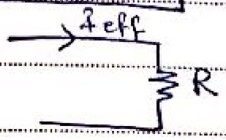
450 K → 10%.

75 K → 40%

50 K → 50%.

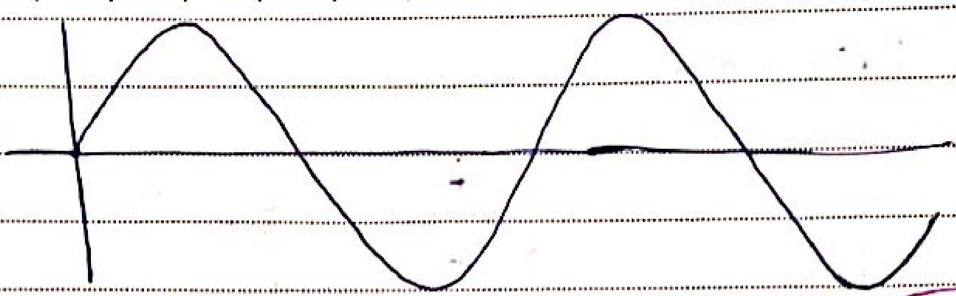
Slide AC volt.





rms

Subject .... / /

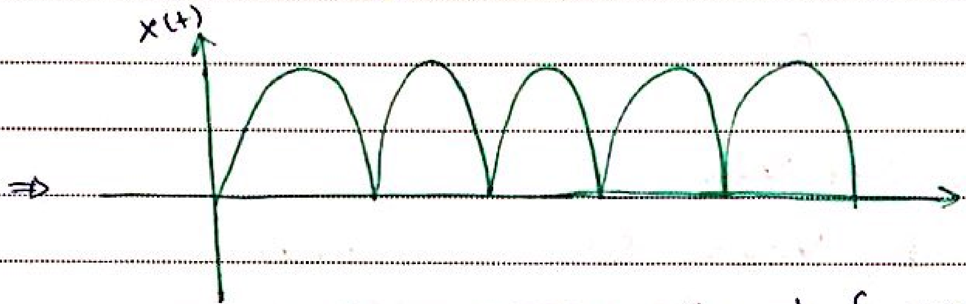


⇒ Rectifier.

average = 0.

$$I_{rms} = \sqrt{\frac{1}{T}\int i(t)^2\,dt}$$

$$\boxed{V_{rms} = \frac{V_m}{\sqrt{2}} \qquad \therefore V_{rms} = 0.707\,V_m}$$



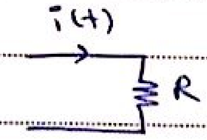
(FWR)

average ✓ $= \frac{1}{T}\int x(t)\,dt$

$= 0.636\,V_m$ ⇒ عندي error
تختلف عن 0.707

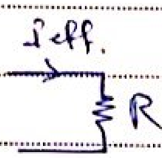
~~safty~~ safe factor. ⇐ كل ال error نعدله ب Scaling

$$P_{av} = \frac{1}{T}\int i^2(t)\,\partial t = \frac{1}{2} I^2_{max} R.$$



$$P_{av} = I^2_{rms} * R$$

$$= I_{eff}^2 * R$$

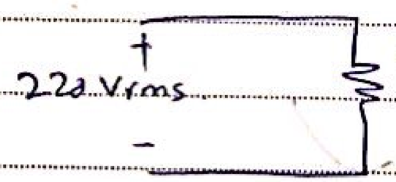


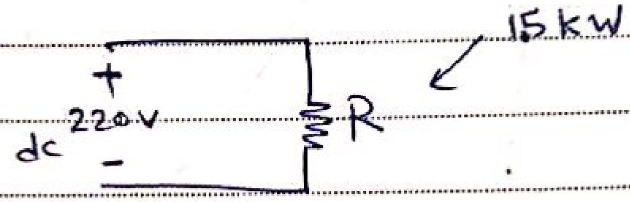
$$\frac{1}{2} I^2_{max} R = I^2_{rms} * R$$

$$I_{eff} * R$$

$$\boxed{I_{rms} = \frac{I_m}{\sqrt{2}}}$$

Slide 66 True RMS.





AC rms dc

~~(FWR)s~~

AC Signal 84

$V_{rms} = 0.707\ V_m$

HWR $\Rightarrow$ $V_{av} = 0.5 V_m$ " Half wave rectifier "

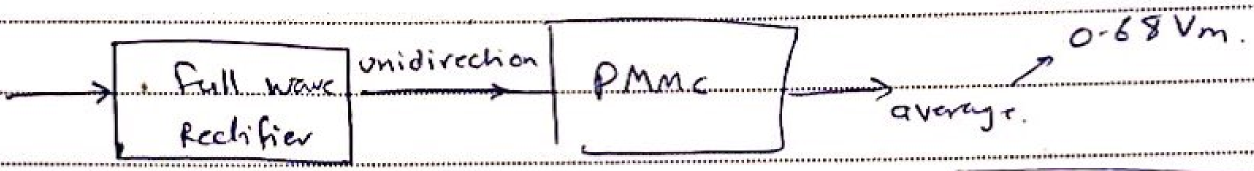
FWR $\Rightarrow$ $V_{av} = 0.636 V_m$ " Full wave " "

$$\boxed{V_{av} = \frac{1}{T}\int_0^T x(t)\, dt}$$

$$SF = \frac{V_{rms}}{V_{avg}} = \frac{0.707\ V_m}{0.636\ V_m} = \boxed{1.1}$$

Subject 8 / 3 / Wed

Slide AC voltmeter.



true rms
0.707Vm

Slide 72

* correction factor

$$CF = \frac{SF_{\text{waveform}}}{SF_{\text{sinusoidal}}}$$

(ohmmeter) => Accuracy = 3% full scale. ~~(analog ...)~~

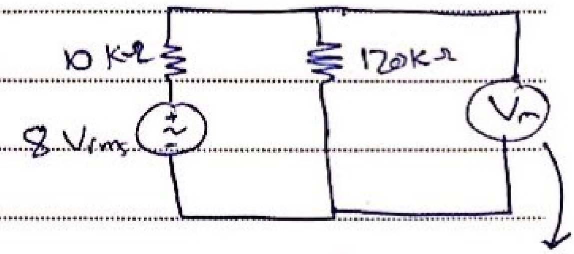
if Full scale = 10 V. => Accuracy = 3% x 10 = 0.3V

reading = 9V => 9 ± 0.3 V

reading = 1V. => 1 ± 0.3 V

[analog meter]

slide 73 : Ex: A PMMC ...



V_{true} voltage (ideaL)

$$= 8 * \frac{120}{120K + 10K}$$

$$= 7.38 V$$

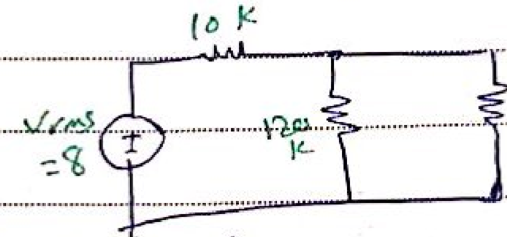
~~measured value 8Δ~~

Analoge
(0-10V)
Sensitivity = $10 \frac{K\Omega}{V}$

Vm = Calibrated to read Vrms for sinusoidal

Subject .... / /

measured value:



$\frac{10\,K\Omega}{V} * 10V$

$= 100\,K\Omega$

$$V_{measured} = 8 * \frac{(120K // 100K)}{(120K // 100K) + 10K}$$

$$= 6.76\ V.$$

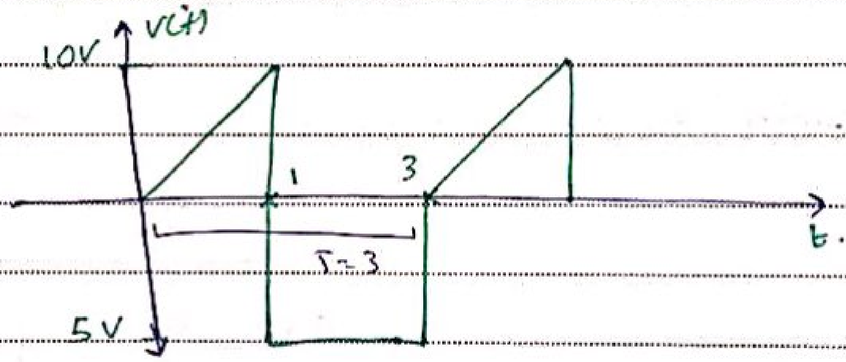
$$\% \text{ error} = \frac{6.76 - 7.38}{7.38} * 100\%$$

error = $\frac{V_m - V_{true}}{V_{true}}$

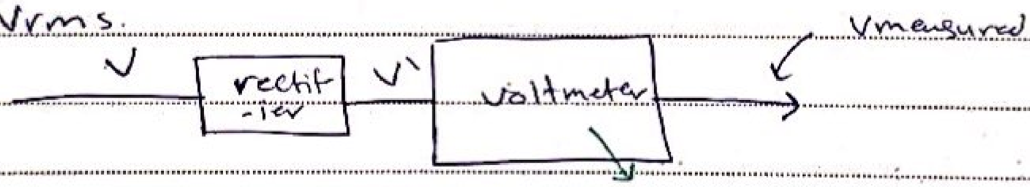
$$= -8.4\%.$$

slide 73

Ex2



① Vrms.

② 

Calibrated to ~~read~~ measure Sinuisodial signal.

③ error in the rms reading?

Sol:

$\boxed{1}$ $V_{rms} = \sqrt{\frac{1}{3}\left[\int_0^1 (10t)^2\,dt + \int_1^3 (-5)^2\right.} = 5.27\ V.$

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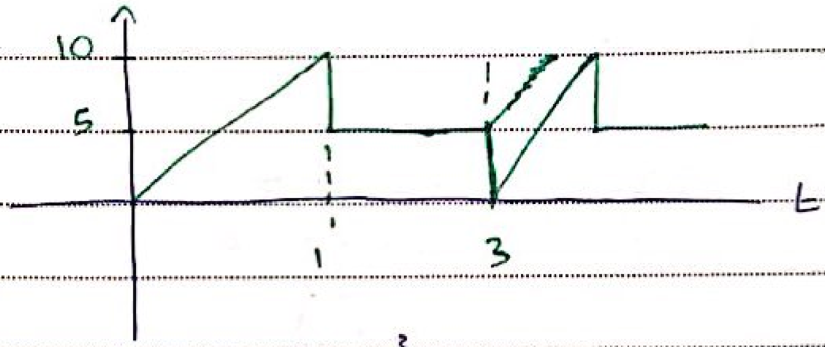
Subject .... / /

2



$$V_{average} = \frac{1}{3}\left[\int_0^1 10t\,dt + \int_1^3 5\,dt\right] = 5\,V.$$

V_{ind} ~~measured~~ $= 5 \times 1.11 = 5.5\,V$

~~error = (Vi - Vrms) / Vrms = (5.5 - 5.27) / 5.27~~

(لو كانت sinusoidal لازم تطلع نفس قيم rms وبتطلع ال error = 0)

$error = \frac{5.5 - 5}{5} = 5.3\%$

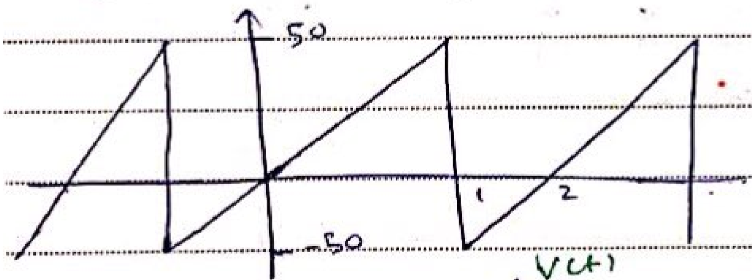
V_{sinn}

$0.636 = V_{average}$

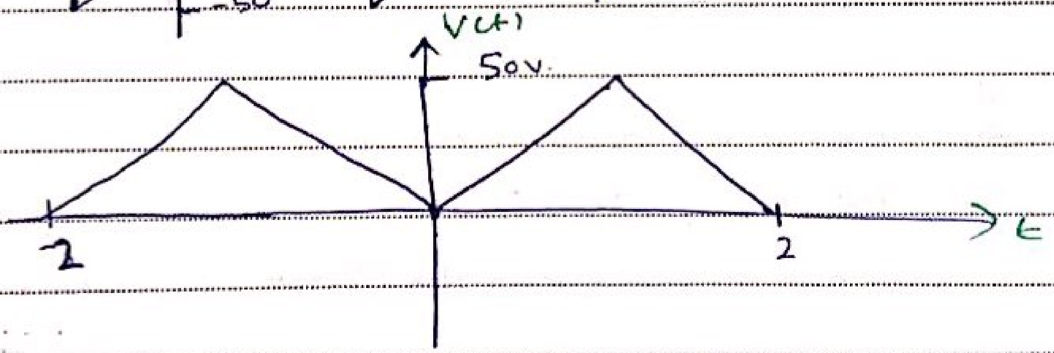
$V_{rms} = 0.707\,V_m$

$\frac{0.707}{0.636} = 1.1$

Ex A voltage wave forme ....



after rectifier ⇒



Correction factor ?!

$V_{rms} = 28.87\,V$
(true)

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Subject

Vavg (rectified Signal) = 25V ,

$28.87 = 25V * 1.11 *$ Correction Factor.
Vrms = average * calibrated * CF.

$\boxed{CF = 1.04}$

* ((اللي بكون Calibrated ← بيضرب ب 1.11))

OR CF = $\frac{\text{SF waveform}}{\text{SF sinusoidal}}$ ⇒ (rms / average = SF)

Digital multimeter.

عدد الـ digit إلو علاقة بالـ resolution

Ex 1. If ⇒ 4 1/2 digit multimeter

((اعلى قراءة بقدر أقراها))

0 / 1 > اعلى قراءة ↓ . 9 9 9 9

19 999

≈ 20,000 count

* Quantization مفهوم الـ

↳ Quantization

((عدد الـ level , بحدده عدد الـ bit))

accuracy ⇒ percentage from reading

Accuracy = ± 0.1% ± 1

↳ least significant digit (LSd)

↑ Range → ↓ resolution

—— —— . —— —— ⇒ 0.01

—— . —— —— . —— —— → 0.0001 (↑ resolution)

Subject 13 / 3 / MON

* max voltage < 2 ⇒ 1.9999 (max display.

resolution ⇒ 0.0001 ⇒ 100 MV

to display 2V

02.000

resolution → 0.001 ⇒ 1mV

$\boxed{\text{slide 81}}$ Example:-

4 1/2 digit.

_ _ _ _ _

0,1   0,9

reading 1.8000

accuracy (± 0.05% ∓ 1)

$1.8000 * \frac{1.05}{100} = 1.8009\ V.$

$1.8000 * \frac{0.95}{100} = 1.7991\ V$

1 ⇒ 1 digit ⇒ LSD

1.8000 ⟶ 0.0001

1.8009 V ⟶ 1.8009 + 0.0001 = 1.8010

1.7991 V ⟶ 1.7991 - 0.0001 = 1.7990

4 digit ⇒ (9 ← 0) ... digit ... [illegible]

Subject

Ex in ~~83~~ slide 82|84

reading. 1 . 8 0 0 → least significant

وزنها 1mV

5 * 1m = ± 5mV

(* بروح عـ least significant. بيغير نعداد 5)

1 absolute error. ⇐ ~~[illegible]~~

((بالنسبه مع القراءة .)) ← 0.01 %.

error = |0.01 * reading|

Slide 83{

Ex 84 4 digit. accuracy = 0.1% ∓ 5 digit

~~[illegible]~~ 9 9 9 9

$\boxed{\text{range} < 1000 V}$

اعلى قراءة ممكن اقرأها 999.9

resolution => 0.1

~~0 ± 0.1*5~~

0 ± 0.1*5

± 0.5 V

the maximum display = 999.9 ⇐ Slide نعدل عـ الـ

Ex: A 20V ⇒ ...

tolarance = Voltage error = 0.5 V

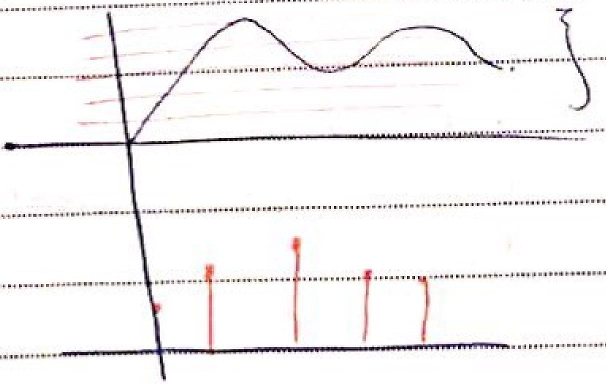
3/1/2 digit

* بدي اقرأ 20V

0 2 0 . ● عشان اعرف شو

0 0.9 0.1 وزن الـ least significant اللازم

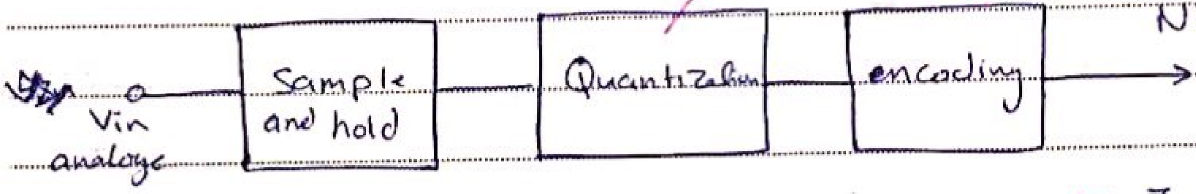
لعرف مكان الـ dicimal point.

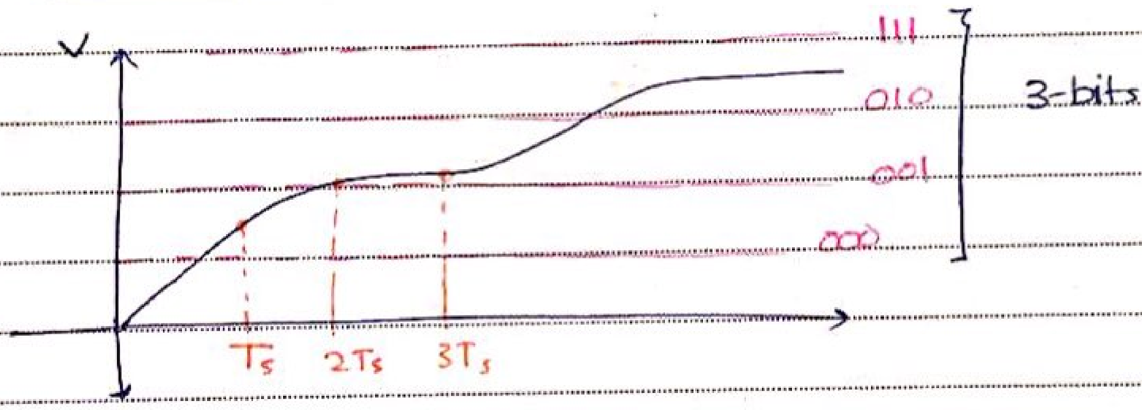


000 → L1
001
011
100
101
110
111 → L8

Slide Analouge to Digital Converter. (ADC)

defined # of level





$T_s \triangleq$ Sampling time

$f_s \triangleq$ Sampling frequency $\Rightarrow f_s = \frac{1}{T_s}$ Hz

# of levels $= 2^N$

Step size $= \frac{V_{max} - V_{min}}{2^N}$

Quantization error $= \frac{\Delta}{2}$

* ADC 8

0V

$V_{ref} = 5V$

3 bits ⇒ 8 level

$V_{in} = ?!$

V_{ref} !!!

Δ = Step size $= \dfrac{V_{ref}}{2^N}$

→ Resolution

3Δ 010

2Δ 001

Δ 000

Step size

$V_{in} = \dfrac{V_{ref}}{2^N} * (R)$

Digital Code.

Slide : Digital Multimeter :-

$\boxed{\text{Ex1}}$ Signal from ...

max Quantization $= \dfrac{\Delta}{2}$

Quantization error % $= \dfrac{\Delta/2}{V_{Full\ Scale}} * 100\%$

$= \dfrac{(V_{Full\,scale}/2^N)/2}{V_{Full\ Scale}} * 100\%$

$$\boxed{\text{Quantization error} = \frac{1}{2^{N+1}} * 100\%}$$

Subject

/ /

Sol Ex :- 800 mV ⟶ 1500 mV

$$800\,mV \xrightarrow{ADC} \text{Code} \Rightarrow 80 \qquad 1500\,mV \rightarrow 150$$

$\Delta \equiv$ Step Size ?! or Find resolution ?!

$800\,mV = \Delta\, 80$

$$\boxed{\Delta = 10\,mV}$$

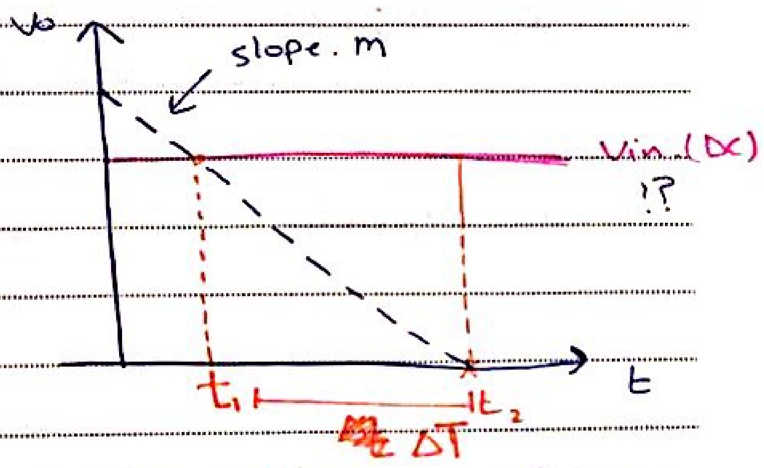
Slide : Accuracy

↑ accuracy ↑ # o bits (level

* sampling rate ⇒ differant btween the 2 figure.

Slide : Ramp - Type Digital Voltmeter

" Voltage to time conversion "



$V(t) = V_o - mt$

at $t_1 \Rightarrow$

$V_{in} = V_o - mt_1$ ... (1)

at $t_2 \Rightarrow$

$V_{in} = V_o - m_2 t_2$

$0 = V_o - mt_2$ ... (2)

* حول قيم الـ Volt ⟸ time

$V_{in} = m (t_2 - t_1)$

Subject .... / /

$$\boxed{\Delta T = \frac{V_{in}}{m}}$$

* "اذا كان عندي error ~~[illegible]~~ في الدائرة بنتقل حطّه للـ Vin"

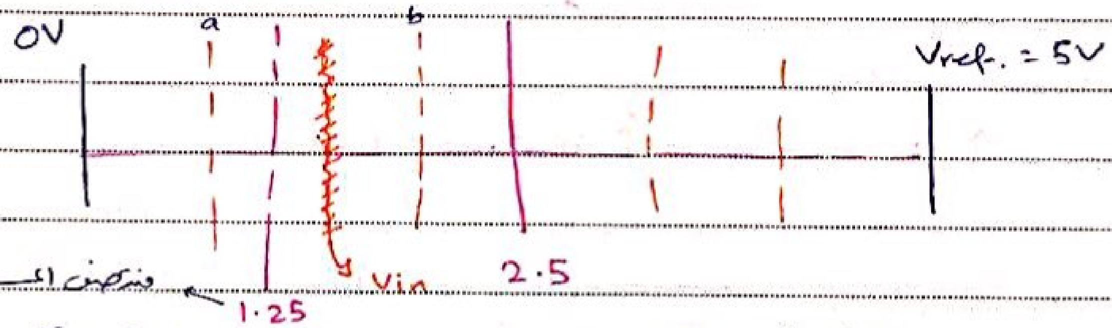
disadvantage

* بتعتمد على قيمة الـ Slope للـ ramp.

$\Delta T = n T_s$

$V_{in} = m\, n T_s$

Slide: Successive Approximation ...



3 bits
8 level

بنحصر المسافة بين (a,b)

Suppose Vin between 0 and 2.5

* Compare with 2.5V ⇒ 0 bit

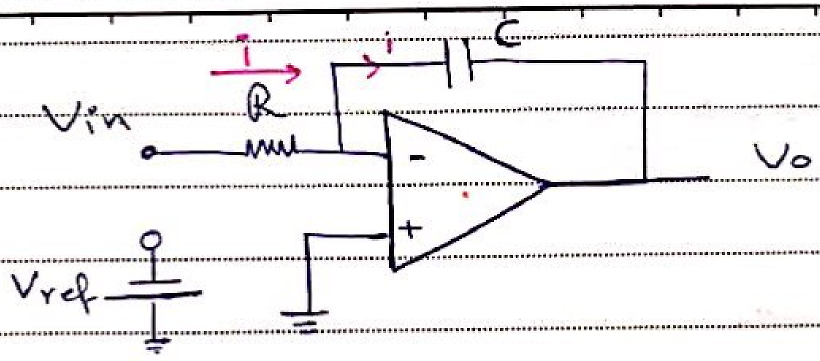
* Compare with 1.25V ⇒ 1 bit

" Vin اكبر من الـ 1.25 "

* Compare with ____ ⇒ 0 bit

MSD ⇒ 010

Slide: Dual-slope digital voltmeter :-



Charging ➡ voltage output ↑

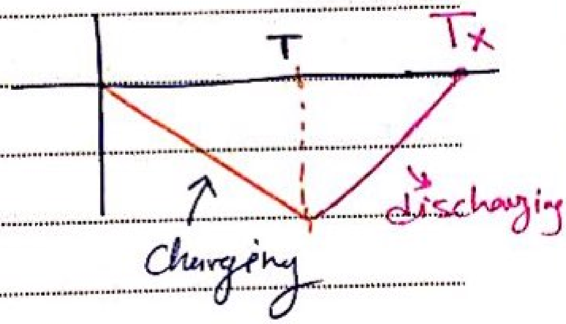
$$i_c = C\frac{dv}{dt} \quad , \quad V = \frac{1}{C}\int C \cdot dt = \frac{1}{C}\int \frac{V_{in}}{R}\, dt$$

$$V_c = \frac{1}{RC}\int V_{in}\, dt$$

$$V_c + V_o = 0$$

$$V_o = \frac{-1}{RC}\int_{T} V_{in}\, dt$$

$T \rightarrow$ "defined"



$$V_o = \frac{-1}{RC}\int -V_{ref}\, dt + V_{initial} = 0$$

$$0 = \frac{V_{ref}}{RC}\underbrace{T_x}_{\text{قيم ما بعرفها}} - \frac{V_{in}}{RC} * T$$

$$T_x = \frac{V_{in}\, T}{V_{ref}}$$

Subject .... / /

$$\boxed{V_{in} = \frac{T_x * V_{ref}}{T}}$$

Slide: Dual-Slope ...

$\boxed{\text{Ex}}$ A digital slope ....

$V_{ref} = 10V$, $T = 10ms$

$T_{conversion} = T + T_x$

$$T_x = \frac{V_{in} T}{V_{ref}} = \frac{6.8 * 10ms}{10} = 6.8\ ms$$

$T_{conversion} = 10ms + 6.8ms$

$= 16.8ms$

$\boxed{\text{Ex}}$ A dual slope ---

$V_{in} = ?!$

$$V_{in} = \frac{T_x * V_{ref}}{T}$$

Slide Meter Types:-

شركة كهرباء
تحاسب

* Residential Energy KWh
* power ⇒ Industrial , capacitive charge P
* penalty PF → PF = 0.88 "Industrial"

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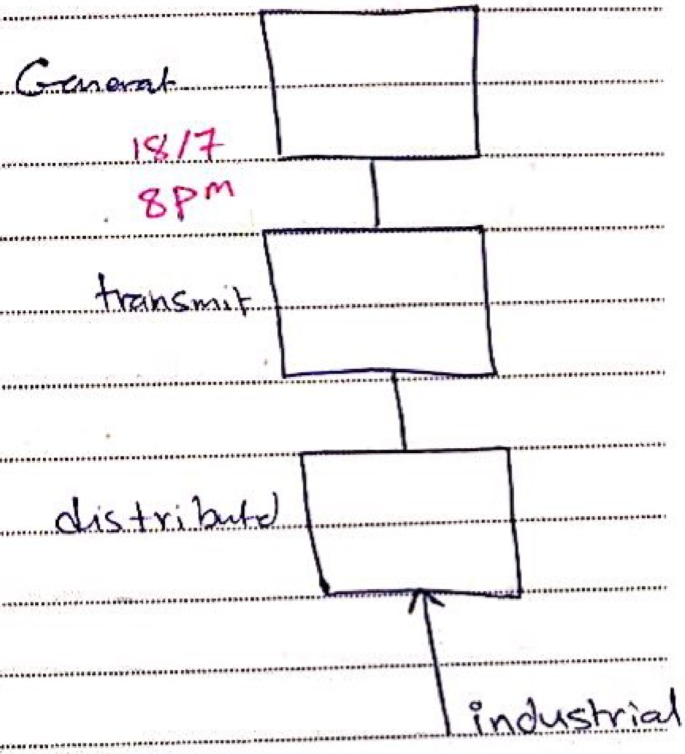
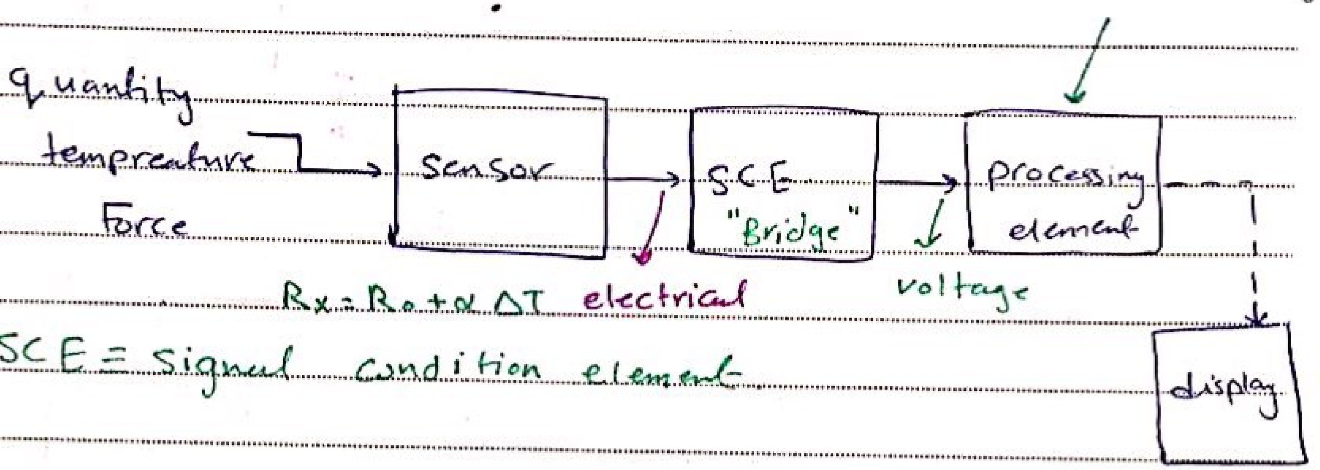


* Energy → Day [35 pince/Kwh]
  بيحسبوا > نهار , ليل
  → Night [7 pince/ ~~kwh~~ kwh]

Subject .... 27 / 3 / 2016.

Bridge:-



SCE = signal condition element

- Reactance
- inductive.
- Capacitor

- frequency
- phase.

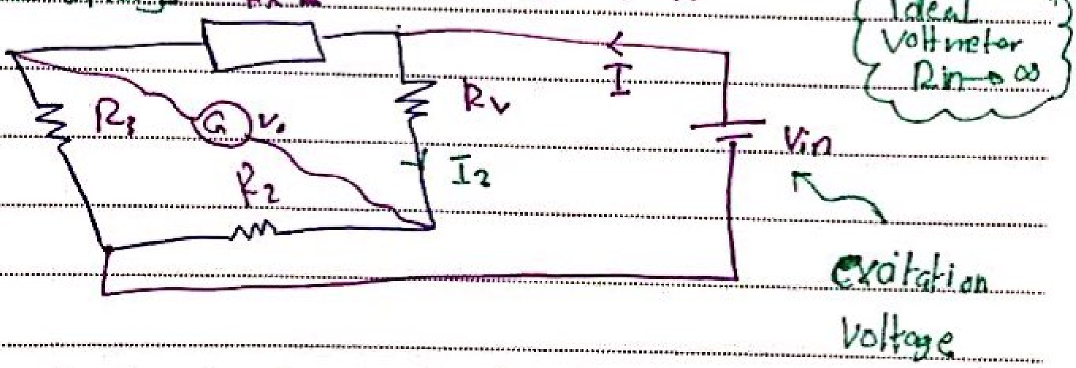
Bridge → Dc bridge → R ⇒ "Wheatstone bridge"

Bridge → AC brige → L, C, f

~~Rx~~ " Rx بيدي أثرها بدلالة ال voltage. "

"Wheatstone bridge" → balanced, → un balanced.

Wheat Stone bridge R_x ← sensor R_x??



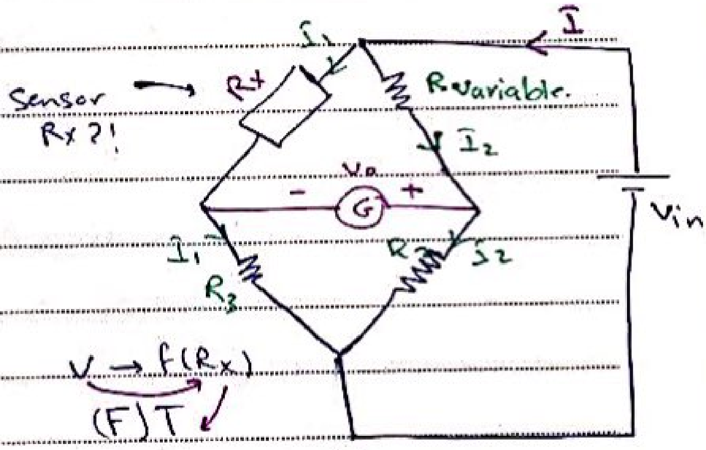
Subject 27/3/2017 / /

$V \to f(R_x) \to F(T)$

- Null method (balanced)
- Deflection method (unbalanced)

$$V_o = V_{in}\left(\frac{R_x}{R_x+R_3}\right) - V_{in}\left(\frac{R_v}{R_v+R_2}\right)$$

$$V_o = V_{in}\left(\frac{R_x}{R_x+R_3} - \frac{R_v}{R_v+R_2}\right)$$



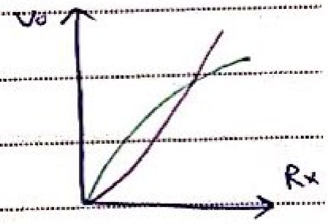
Null method: $(R_v \nearrow \Rightarrow V_o = 0)$ "balanced"

$$V_o = 0 \to V_{in}\left(\frac{R_x}{R_x+R_3} - \frac{R_v}{R_v+R_2}\right) = 0$$

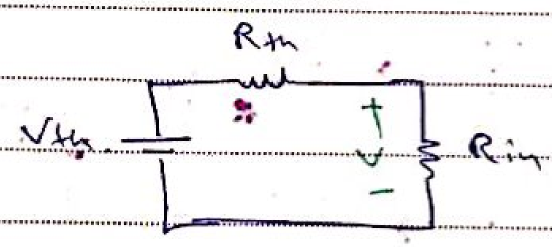
$$\frac{R_x}{R_x+R_3} = \frac{R_v}{R_v+R_2} \Rightarrow \cancel{R_x R_v} + R_x R_2 = \cancel{R_v R_x} + R_v R_3$$

$$\boxed{R_x R_2 = R_v R_3}$$

$$\boxed{R_x = \frac{R_v R_3}{R_2}}$$



Subject .... / /



* Deflection method :-

تقيس الـ Voltage مش لازم اجل الـ control الـ resistance .

$R_V \xrightarrow{\text{replaced}} R_1$ (~~[illegible]~~ Nominal R_x)

$$V_o = V_{in}\left(\frac{R_x}{R_x+R_3} - \frac{R_1}{R_1+R_2}\right)$$

C

$C = f(f)$.

R_x ($f(T)$)

Case 8 $R_2 = R_3$

$R_x = R_1$ (Nominal) $\Rightarrow V_o = 0$

$\hookrightarrow R_x = R_1 \pm \Delta R_x$ < V_o (+ve) / V_o (−ve)

الـ R_x في بتغير عن nominal وبتعطي تغيرات ((عم البعد عن الـ nominal))

$\boxed{\text{Ex}}$ pressure sensor measure pressure (0–10 bar)

$R_x = \underbrace{120}_{\text{nominal.}} + \frac{338 \text{ m}\Omega}{\text{bar.}}$, $R_V = \infty$ (voltmeter) .

maximum current sensor $\leq$ 30 mA
((R_x))

Find V_o when pressure is 10 bar and max V_{in} is used ?

- Deflection method.

$R_1 = R_2 = R_3 = 120 \ \Omega$

Subject .... / /

$I_1 \leq 300\,mA$

$\dfrac{V_{in}}{R_x + R_3} \leq 300\,mA.$

$\dfrac{V_{in}}{120 + 120} \leq 300\,mA.$

$$\boxed{V_{in} \leq 7.2\,V}$$

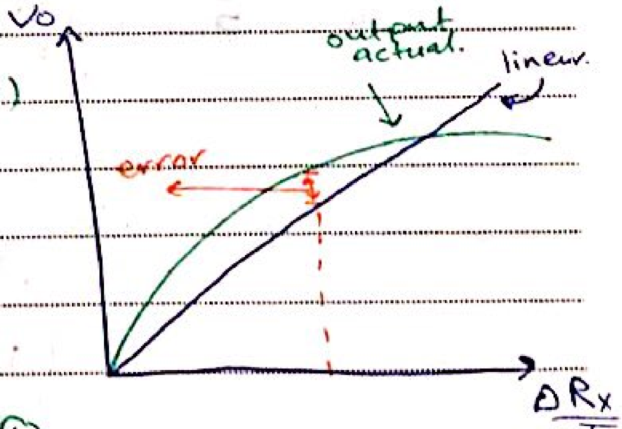
10 bar

$R_x = 120 + 0.338 \times 10$

$= 120 + 3.38 = 123.38\ \Omega.$

$$V_o = V_{in}\left(\frac{R_x}{R_x+R_3} - \frac{R_1}{R_1+R_2}\right)$$

$\boxed{V_o = 50\,mV}$ at 0 bar $\rightarrow V_o = 0\,V$



* output actual (بين تغيرات Vo مع ΔRx)

Case 8 ΔR_x is small compared nominal

$$V_o = V_{in}\left(\frac{R_x}{R_x+R_3} - \frac{R_1}{R_1+R_2}\right) \quad \text{.....}(1)$$

تغيرات ال Rx مع ال nominal

$$V_o' = V_{in}\left(\frac{R_x + \delta R_x}{R_x + \delta R_x + R_3} - \frac{R_1}{R_1+R_2}\right) \quad \text{.....}(2)$$

$\delta V_o = f(\delta R_x)$ $\qquad R_x + \underbrace{\delta R_x}_{\text{small}} \approx R_x$

$\delta V_o = V_o' - V_o \qquad (① - ②)$

$$\boxed{\delta V_o = \frac{\delta R_x}{R_x + R_3} V_{in}}$$

هي العلاقة بتربط بين [illegible]
التغيرات قليلة .

$$\frac{\delta V_o}{\delta R_x} = \frac{V_{in}}{R_x + R_3} \Rightarrow \text{sensitivity bridge.}$$

$\boxed{\text{Ex}}$ A resistance thermometer $(0c^\circ \longrightarrow 50^\circ c$

$R_{nominal} = 500\ \Omega$ at $0c^\circ$

$$\Delta R = \frac{4\ \Omega}{1 C^\circ}$$

$R_1 = R_2 = R_3 = 500\ \Omega$, $V_{in} = 10V$

$R_x = \underbrace{500 + 4T}$ ↳ temprature.

$$V_o = V_{in}\left(\frac{R_x}{R_x + R_3} - \frac{R_1}{R_1 + R_2}\right)$$

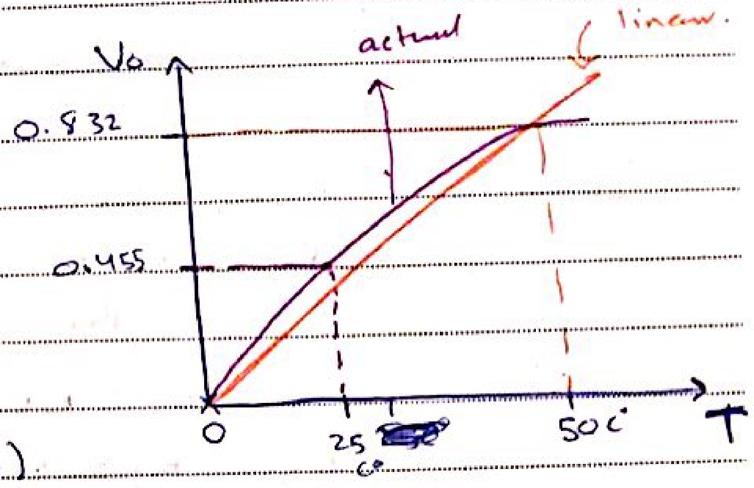
$$V_o = 10\left(\frac{125 + T}{250 + T} - 0.5\right). \quad ((V_o \propto T \text{ non linear}))$$

at $T = 0 \longrightarrow V_o = 0$

at $T = 25C^\circ \longrightarrow V_o = 0.455V$

at $T = 50C^\circ \longrightarrow V_o = 0.833V$

Subject



$V_o = 0.016T$

$V_o = 10\left(\frac{125+T}{250+T} - 0.5\right)$

بدي اطلع ال max ← بشتق وبساوي $=0$.

DC Bridge

measurment error

Balanced $R_2 R_3 = R_x R_1$

$$R_x = \frac{R_2 R_3}{R_1}$$

- tolarance $R_2 = R_2 \pm \Delta R_2$

$$R_3 = R_3 \pm \Delta R_3$$

$$R_1 = R_1 \pm \Delta R_1$$

* limiting error :-

$$R_x = \frac{(R_2 \pm \Delta R_2)(R_3 \pm \Delta R_3)}{(R_1 + \Delta R_1)}$$

approximation $(\Delta R_2 \times \Delta R_3 \approx 0)$

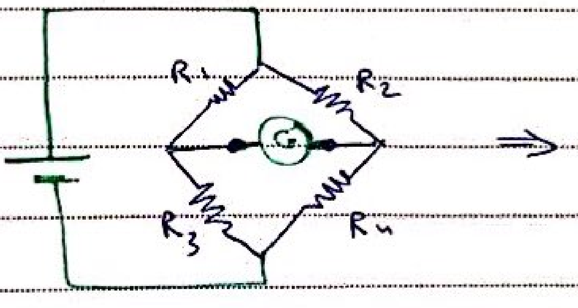
$$R_x = \frac{R_3 R_2}{R_1}\left(1 \pm \frac{\Delta R_1}{R_1} \pm \frac{\Delta R_2}{R_2} \pm \frac{\Delta R_3}{R_3}\right)$$

* بنوجد ق $R_{x\,max}$ اذا كانوا كلهم ((+ve))
" " $R_{x\,min}$ " " " ((−ve))

for that it's called limitting error

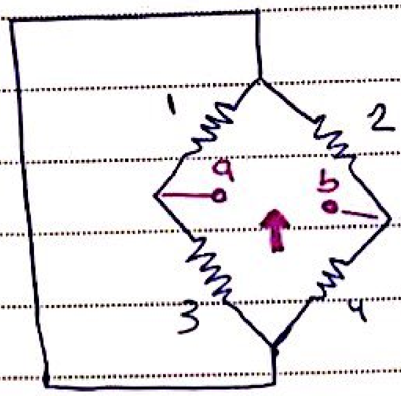
Example : study !!

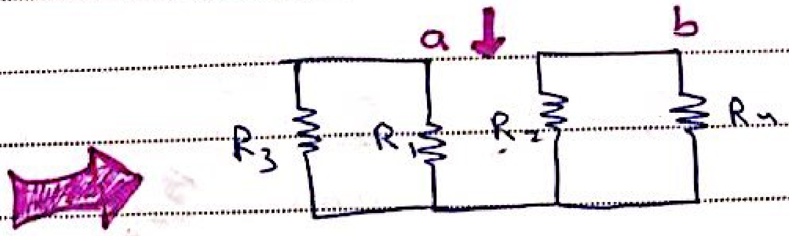
* Sensitivity for Galvanometer :-



⟹ thevinin → R_{th}, → V_{th}

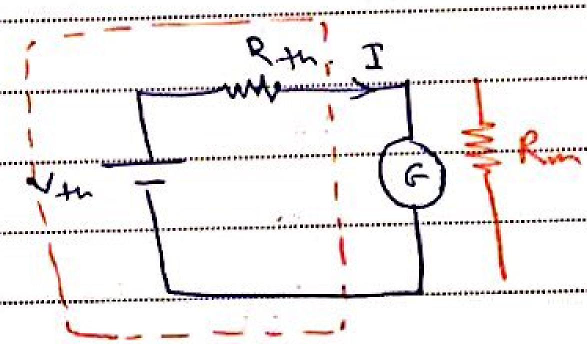
Subject .... / /



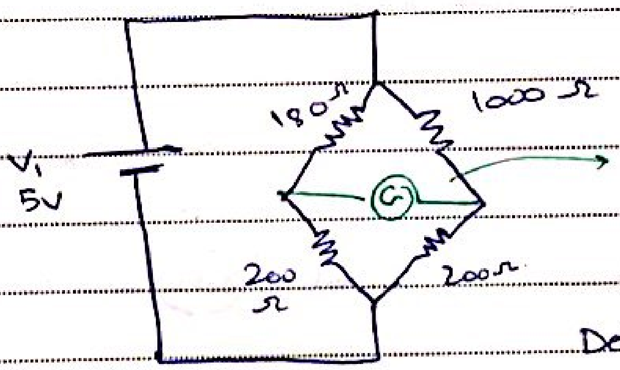


$R_{th} = (R_1 // R_3) + (R_2 // R_4)$

$V_{th} = V_1 \left(\frac{R_1}{R_1+R_3} - \frac{R_2}{R_2+R_4} \right)$



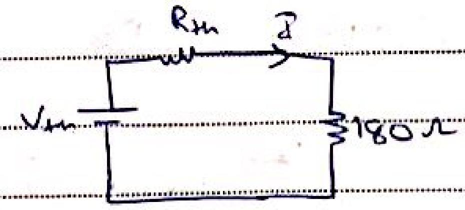
Example1:-



sensitivity $= \frac{10\,MM}{1\,MA}$

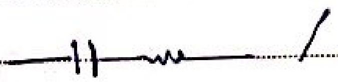
Deflection by the Galvanometer ?

Example 2:-



Capacitor:

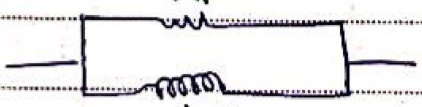
(AC bridge) E. σ dielectric material.



* Quality factor

$$\text{Quality} = \frac{\text{energy stored}}{\text{average energy dissipated}}$$

$$\text{dissipation factor} = \frac{\text{energy lost}}{\text{energy stored}} = \frac{1}{QF}$$

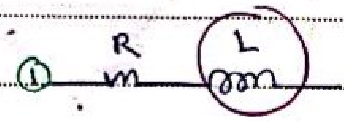


$$Z_{eq} = R_p \,//\, jX_p$$

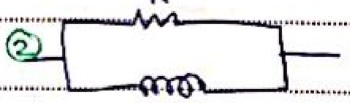
$$Z_q = \frac{\overbrace{R_p X_p^2}^{R_s} + j \overbrace{X_p R_p}^{X_s}}{R_p^2 + X_p^2}$$

$R_s + jX_s$

Quality factor. ①



① ∴ $Q = \frac{|I|^2 * X_L}{|I|^2 * R} = \frac{\omega L}{R}$



② $Q = \frac{V^2 / X_L}{V^2 / R}$

$$\boxed{Q = R / X_L}$$

Balanced $Z_1 Z_4 = Z_2 Z_3$ → magnitude
→ phase

* Slide oscilloscope :

Signal → oscillscope → Graphical → picture for signal

→ voltage

ADC اهم اشي فيه

* CRO Analoge oscill

10 : 1

down Scale for Signal

* وكأنك 10 بمقاطع 1 مساحل ⇐ (voltage division)

* وين اقيس تيار, حط مقاومة وبقيس عليها Volt.

↓ f : c —— (V division)

" Attinuation بعمل prob "

↑ input impden ↓ error

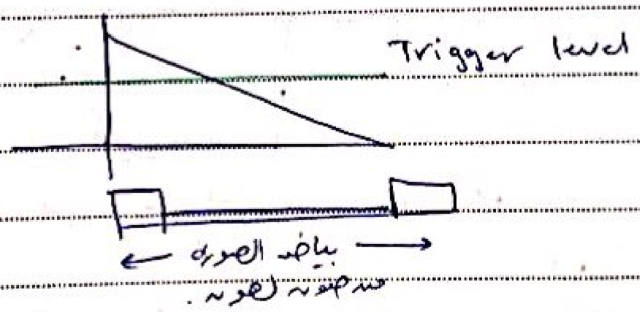
scale → V division

* 1 cycle → Time division

up / down → Volt division

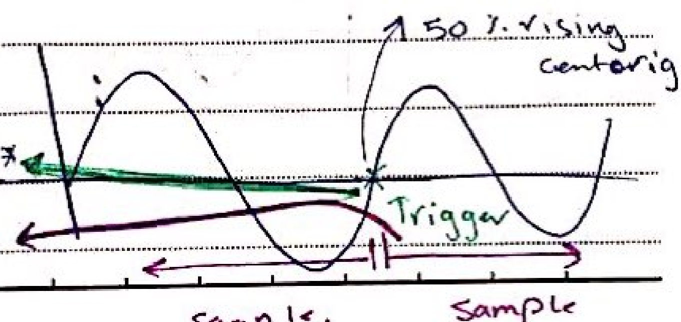
* 8 vertical division ⇒ Max peak to peak = 8

* trigger :



(Trigger > Peak to Peak)

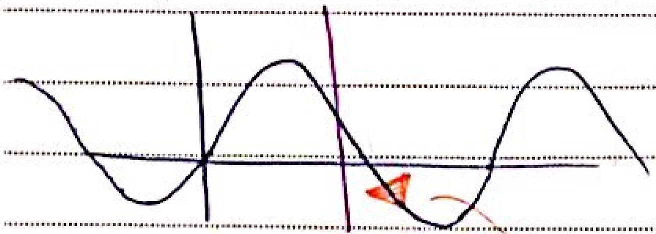
Trig = Rising and 50%



* عالنص يعني بوخذ عينة قبل ومن اللحظة.

Centoring is Trigger كذلك بصير عند

Subject .... / /



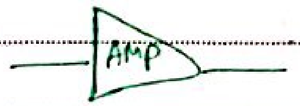
* بداية عرض ~~السيجنل~~ السيجنال ⇐ Trigger level ← حطه ع الصفر مثلاً.

* ملاحظات: ① في digital osc. انت بتحدد مكان الـ trigger

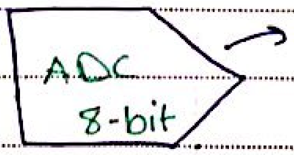
② في analog osc. دائماً بكون الـ trigger ع الشمال

③ بحدد الـ trigger time ← ① بحدد trigger level
← بحدد rising edge
falling edge

④ pre tigger and post trigger. ⇐ بس موجود في Digital osc.

* 

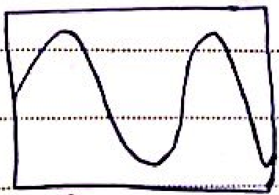
أهم جزء في osc.

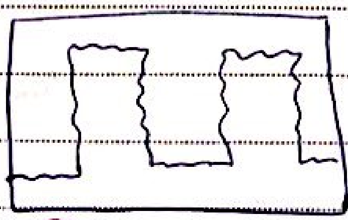


بحول sampling.

* عدد الـ samples بتعتمد على حجم الـ Memory.

LPF بشبه OSC


①


②

* ~~[illegible]~~

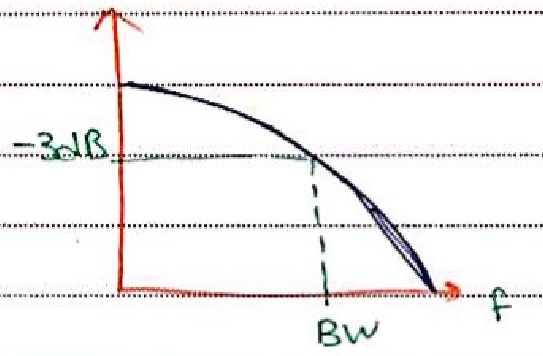
Subject .... / /

* في حالة (2) ⇐ في عندي ~~distortion~~ distition ⇐ يعني بيطلع قيم وهمية للـ Signal

for figure (2) $\Rightarrow$ $x(t) = A\cos(w_1 t) + A_2\cos(w_2 t)$

(1) $\Rightarrow$ $x(t) = A\cos(w_1 t)$

لغاها للـ $A_2\cos(w_2 t)$



XYZ of oscillescope. Z : intensite (شدة الضوء)

CAThode $\Rightarrow$ عندي 2 deflection موجب → vertical → Horizontal

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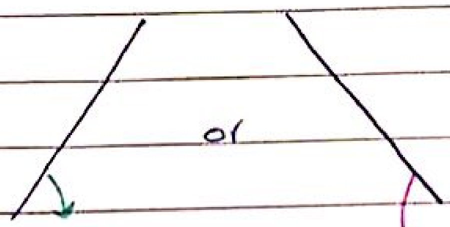
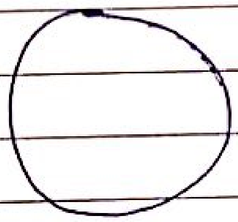
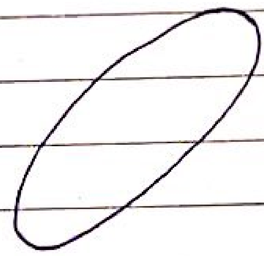
Oscilloscope (X-Y mode) :-

if we insert a sinusiodal signal . 3 possible cases in the x-y mode 8A

① 

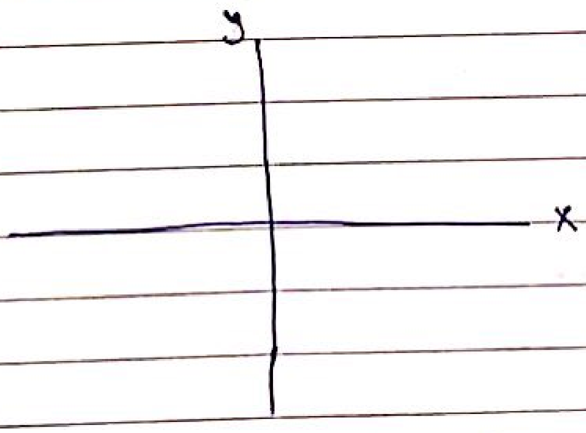
② 

③ 

Ex

$x = \sin \omega t$

$y = \cos \omega t.$



⇒ Zero crossing (x = 0) :-

$x = \sin \omega t = 0 \qquad \omega t = 0, \pi$

$y(\omega t = 0) = 1 \Rightarrow (\overset{x}{0}, \overset{y}{1})$

$y(\omega t = \pi) = -1 \Rightarrow (0, -1)$

* ~~xx~~ $(y=0)$ 8Δ

$\cos \omega t = 0 \longrightarrow \omega t = \frac{\pi}{2}, \frac{3\pi}{2}$

$x(\omega t = \frac{\pi}{2}) = 1 \Longrightarrow (1, 0)$

$x(\omega t = \frac{3\pi}{2}) = -1 \Longrightarrow (-1, 0)$

Max y :

max $\cos(\omega t) \Rightarrow \omega t = 0$

$x(0) = 0 \Rightarrow (0, 1)$

$y(0) = 1$

Max x :

max $\sin \omega t \Rightarrow \omega t = \frac{\pi}{2}$

$x(\frac{\pi}{2}) = 1$

$\Rightarrow (1, 0)$

$y(\frac{\pi}{2}) = 0$

Min x :-

min $\sin \omega t \Rightarrow \omega t = \frac{3\pi}{2}$

$y(\frac{3\pi}{2}) = 0$

$\Rightarrow (-1, 0)$

$x(3\frac{\pi}{2}) = -1$

Min y :-

min $\cos \omega t \Rightarrow \omega t = \pi$

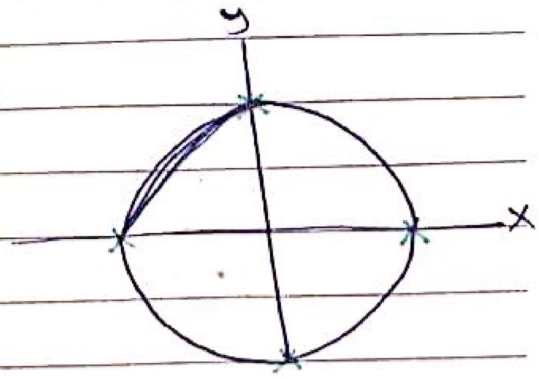
$x(\pi) = 0$

$y(\pi) = -1 \Rightarrow (0, -1)$

Scanned by CamScanner

So we have :

(0,1) , (1,0) , (0,-1) , (-1,0)

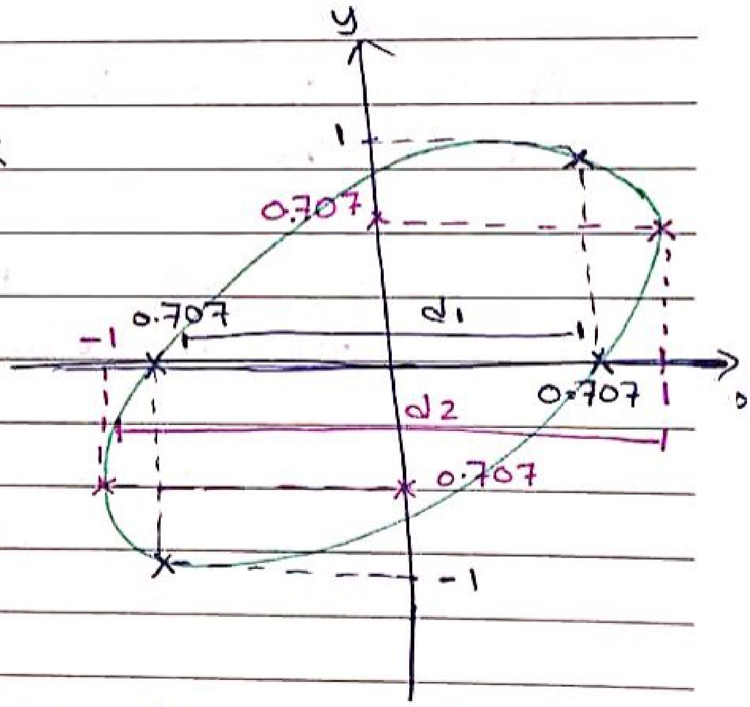


Ex

$x = \cos(\omega t)$

$y = \cos(\omega t - 45^\circ)$

Do the same steps as the previous example.



d_1 = zero crossing

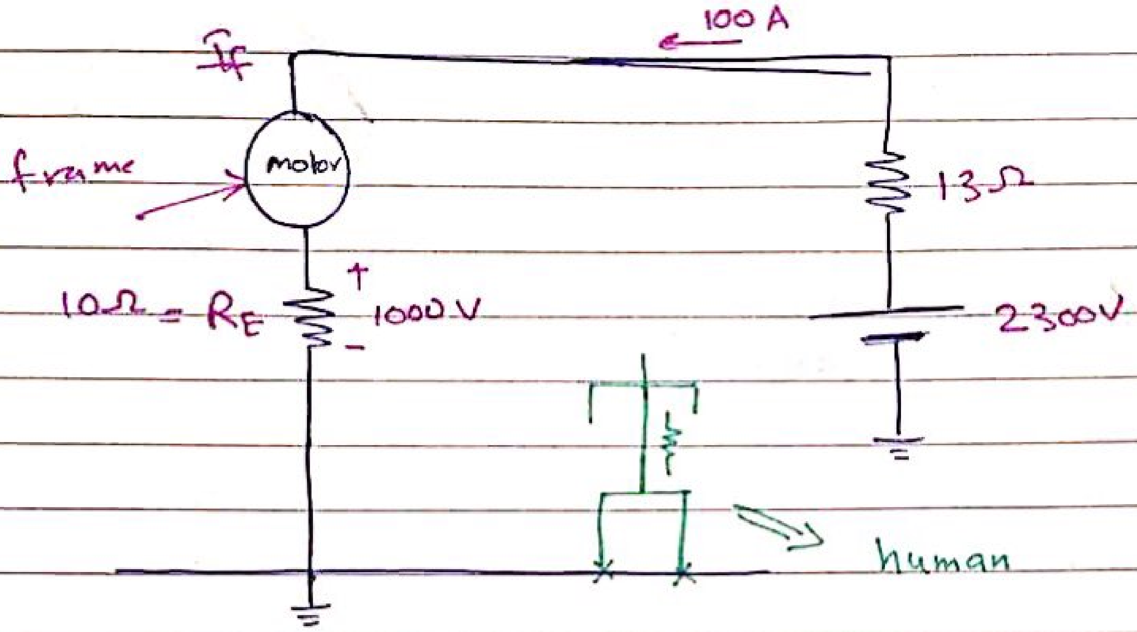
d_2 = peak to peak

from d_1 and d_2 we evaluate the phase shift.

$$\boxed{\theta = \sin^{-1}\left(\frac{d_1}{d_2}\right)}$$

Note: also we could use the y-axis to find the phase shift with the same way.

* Earthing :



if the human touch the motor after a fault happend we protect him:

1. by wearing asafty shoes.
2. by using Tire to clear fault.
3. by redusing R_E.

* The conductor btween motor and the earth.
  ⇒ must be able to carry the fault current.

0 ⟶ 10 mA (No Impact)
150 mA ⟶ 200 mA (dead).

* Electrical shock:-
difference in the voltage and will create a path of current.

The worst path for current passing through the human, that between humman hands (since it will pass through the heart).

current relation that related to human to has No impact from the current:-

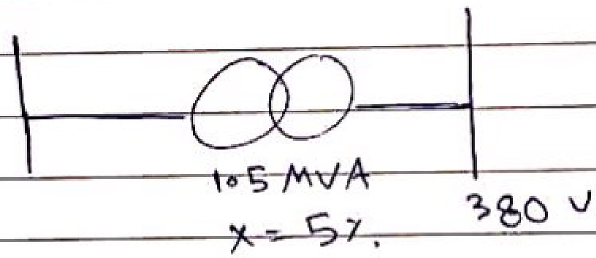
$$\boxed{I = \frac{116\ mA}{\sqrt{t}}}$$

time to clear fault

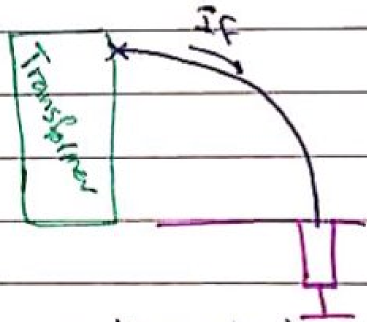
max safe current

Ex

3-phases transformer



Find I_f ?!
Find cross section ?!



with stand = fault current : cross section.

Sol:-

$$\boxed{I_f = \frac{1}{X\%} * \text{full load current}}$$

$$\text{full load current} = \frac{1.5\ M}{\sqrt{3} * 380}$$

$$I_f = 20 * \frac{1.5\ M}{\sqrt{3} * 380}$$

$$\boxed{I_f \simeq 45\ KA}$$

$$\boxed{\text{Cross section } (mm^2) = 9 * \sqrt{t} * I_f}$$

t = time to clear fault

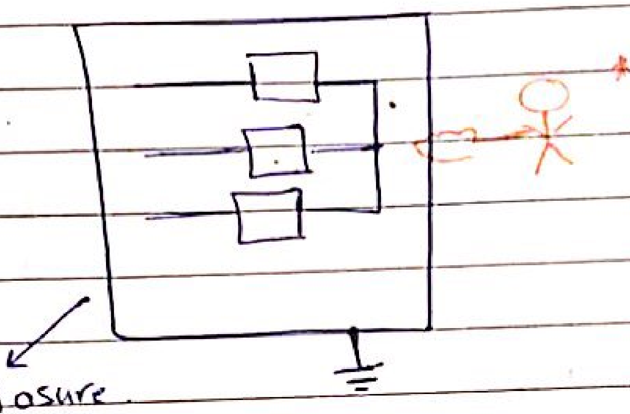
assume $t = 0.5$ sec

Cross section $(mm^2) = 9 * \sqrt{0.5} * 45K$.

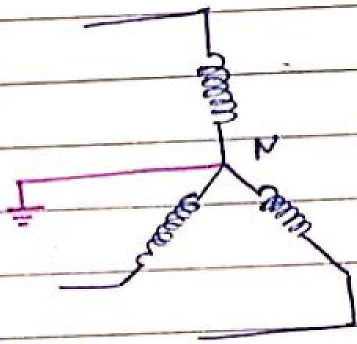
$$\boxed{\text{Cross section} = 286 \ mm^2}$$

Grounding :-

Connecting anet work point to the ground through as impedance.



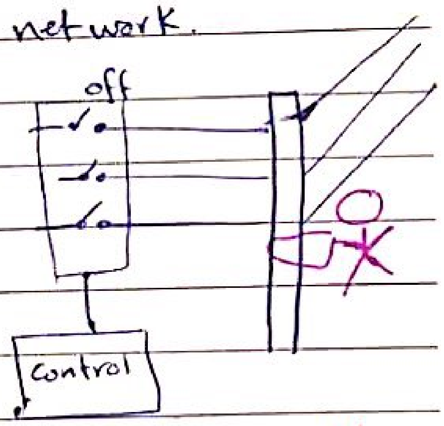
Enclosure.



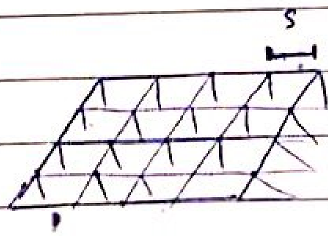
* توفر مسار آمن لل fault curr

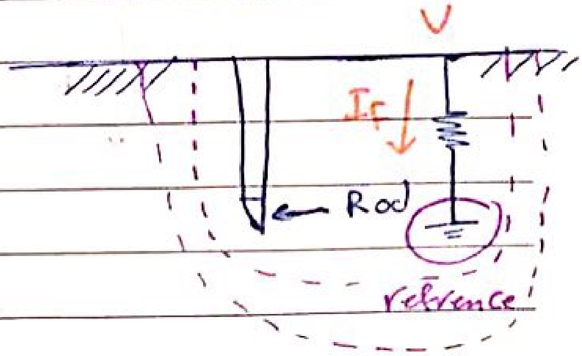
Grounding → Safety
unenergized element.
→ performance of the network.

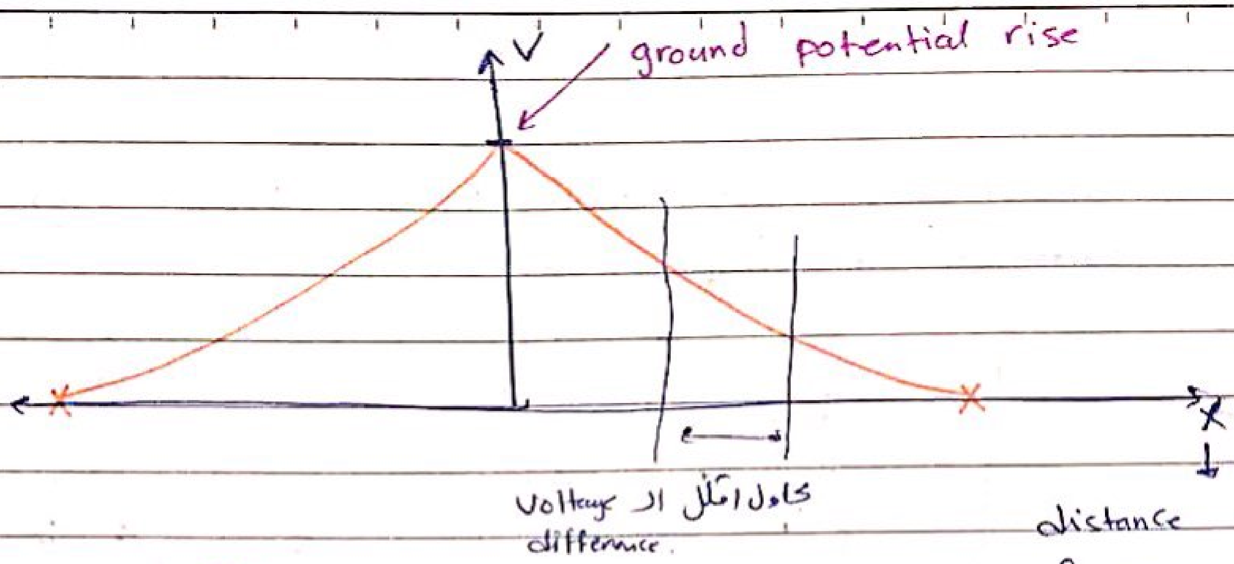
*"اذا صار fault ← بصير على الانسان
voltage difference ← بولد تيار ممكن يسبب صعق
اشارة قاتل. "اذا مسك الشخص الفاصلة"



*Safety :



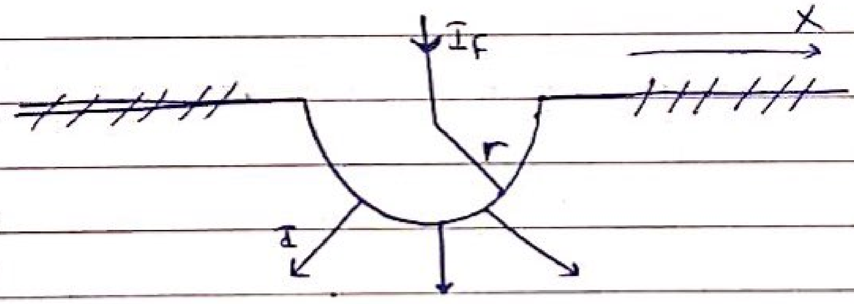


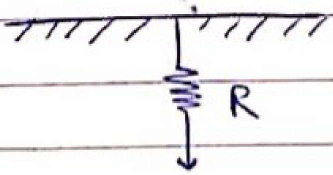


Saftey means :

- Insulation (Gloves , boots)
- Grounding $\Rightarrow$ reduce GPR "ground potential rise"
- equipotential rise $\Rightarrow$ reduce voltage difference in the site.

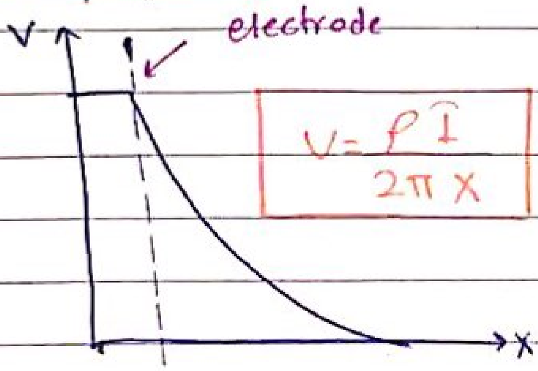
Hemispherical electrode :-



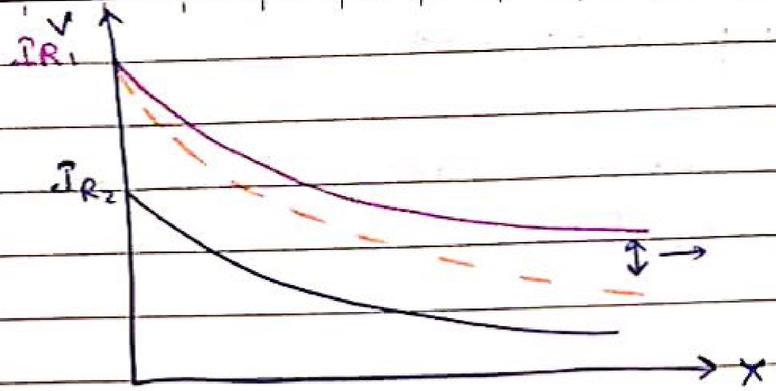


$$\boxed{R = \frac{\rho}{2\pi r} \ \Omega}$$

ρ = soil resistivity.



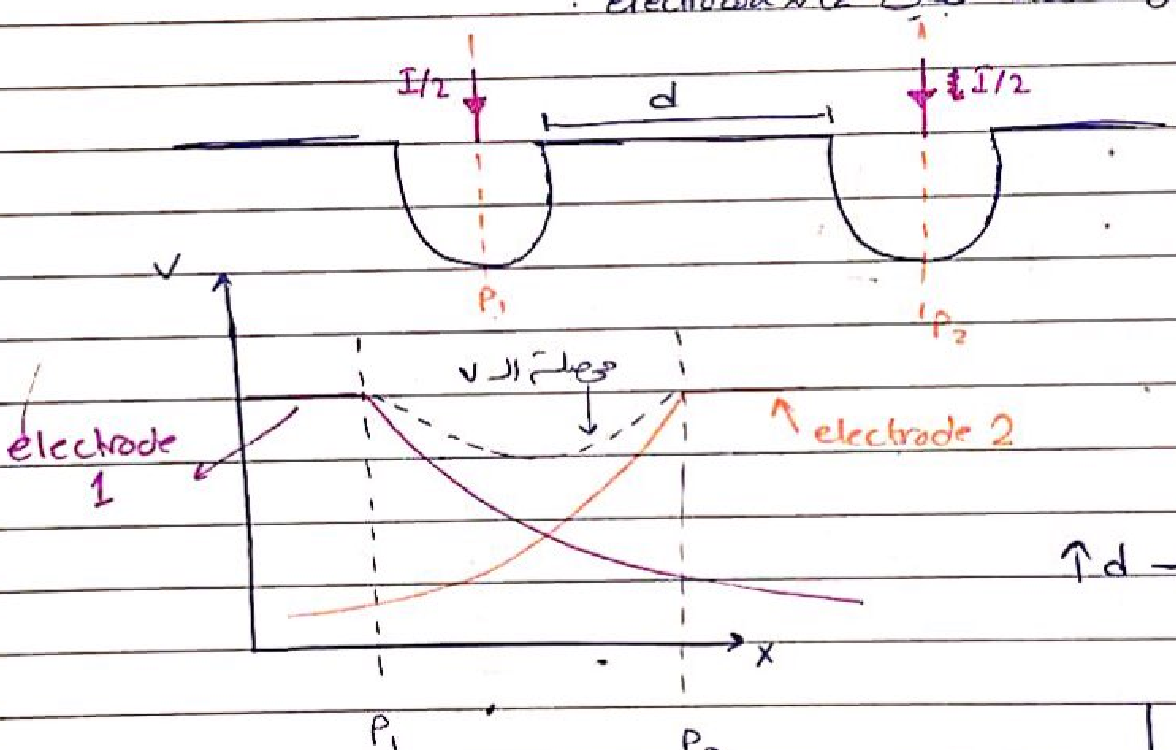
$$\boxed{V = \frac{\rho I}{2\pi X}}$$



الفرق بين — و - - - العمر نفس الـ R بس بتختلف بنوع الـ electrode.

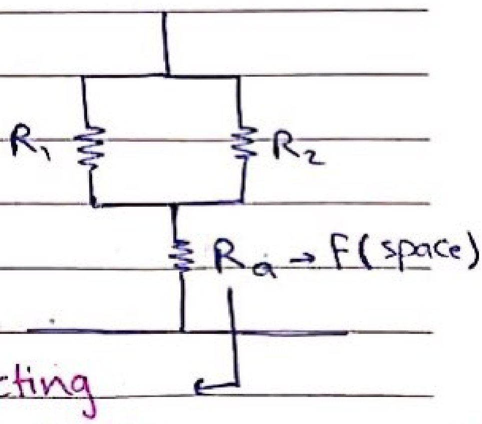
$\downarrow I_{R_2} \rightarrow \downarrow$ voltage difference.

بدي اقلل الـ Resi بضيف كم electrode.



$\uparrow d \rightarrow R \downarrow$

* R_1 و R_2 المسافة اصغر ما يمكن و هيك فخم نجيب
المفروض تقل الـ R بس انت رفعت الـ R.
فبضيف الـ R_a



$$R_{eq} = \frac{R}{N * \eta}$$

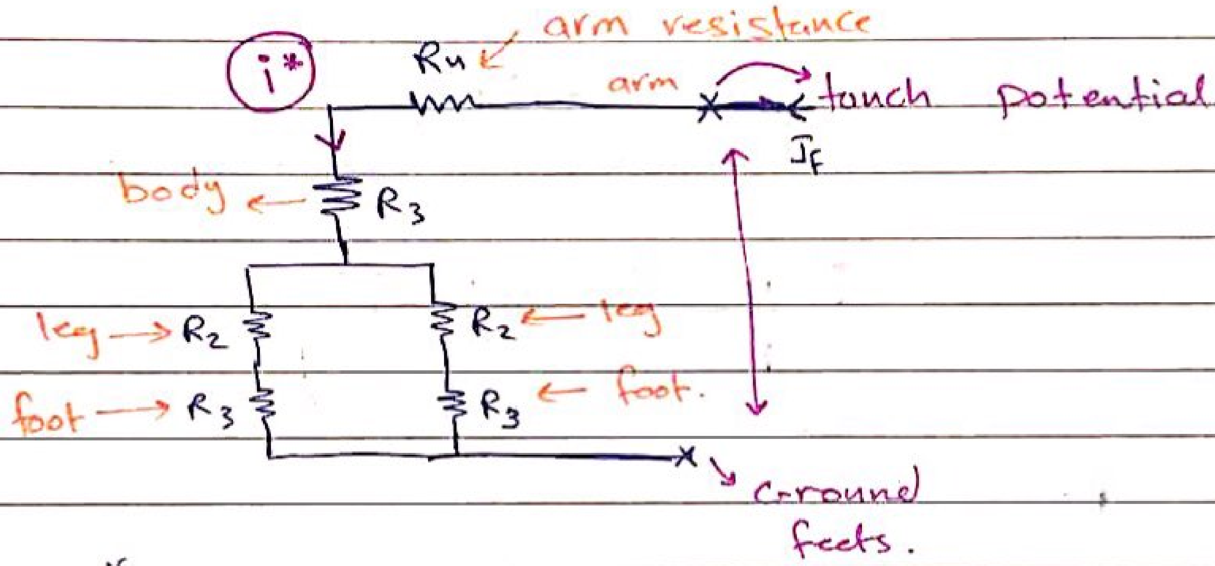
$\eta \Rightarrow$ efficiency $\rightarrow$ depend on space.

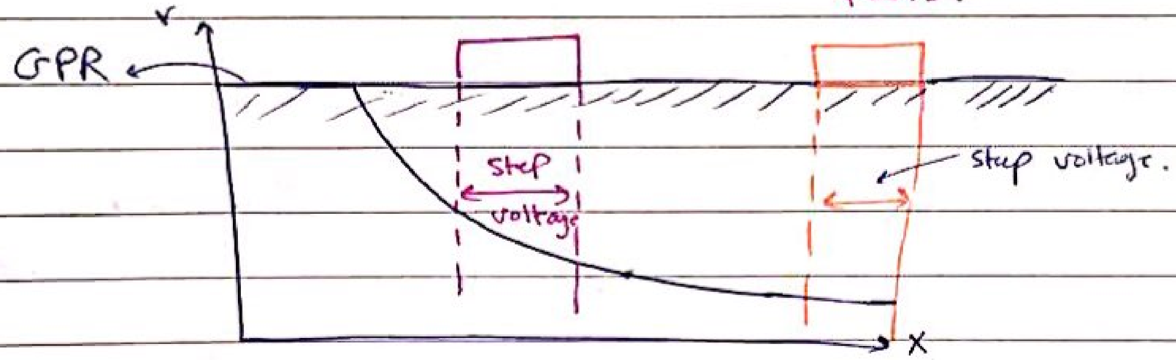
$\downarrow \eta \rightarrow R_{eq} \uparrow \quad (\downarrow \eta \rightarrow \text{space} \downarrow)$

* touch and step voltage :

- touch : voltage difference between your hand and your feats

voltage : voltage difference btween your feets.





كل ما بتبعد بيقل ال step voltage.

* IEEE :

< 1mA → No sensetion.

1- 8mA → sensation of "shack"

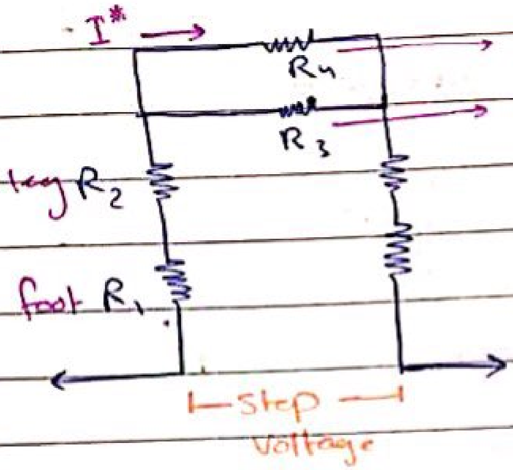
8-15 mA → painful shack.

15 - 20 mA → loss of muscle control

20 - 50mA → muscle failuer.

50 - 200 mA → heart failure.

> 200mA → death and burns.

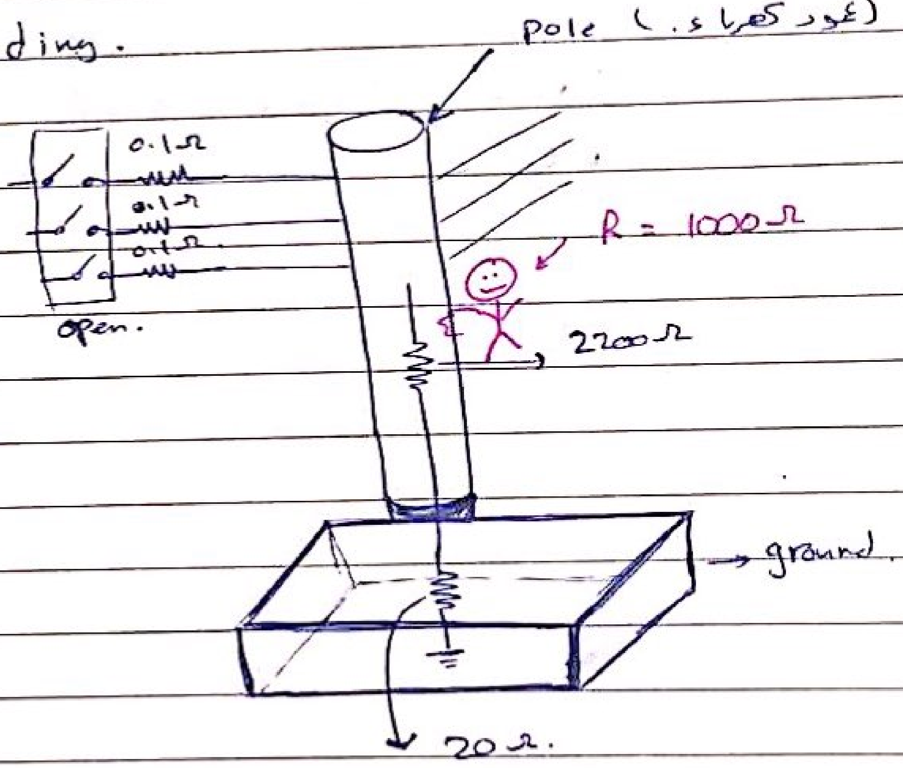


Grounding and Bonding.

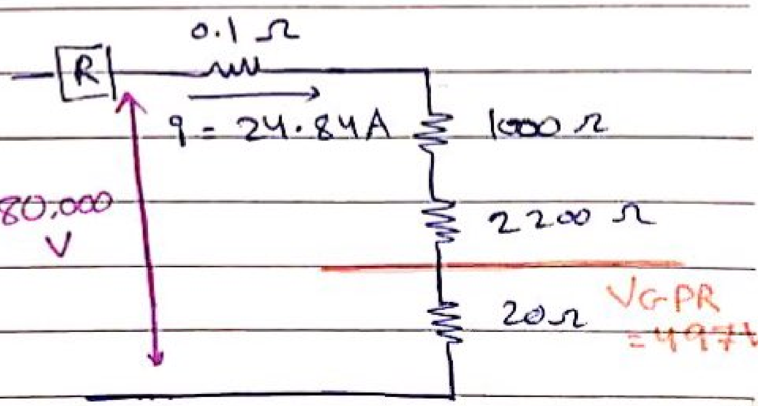
Ex:

* code of practice.

$V_{LG} = 80KV$.

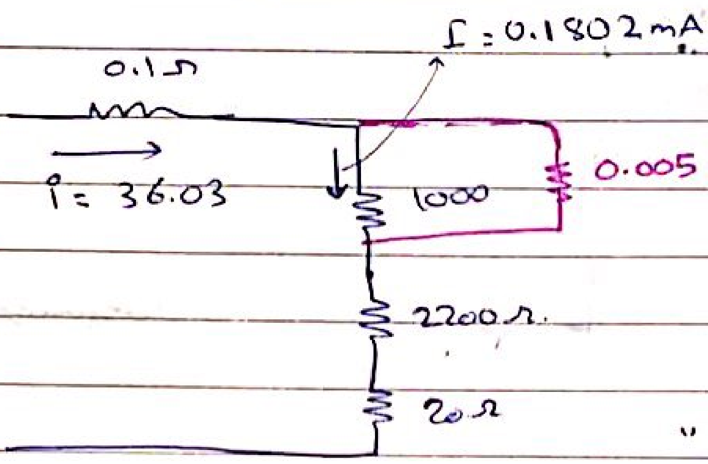


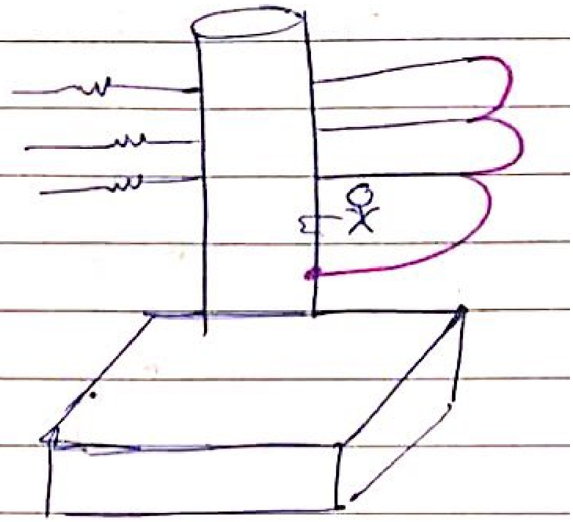
i ⇒ small compeared to the setting of the relay protection.



equipotential Bonding.

Solution ⟹





* ربطت حولين الشخص ⇐ الكل "
لـ نزلت الـ لا و نزلت الـ آ.

$$I = \frac{116\,mA}{\sqrt{t}}$$ "safe current"

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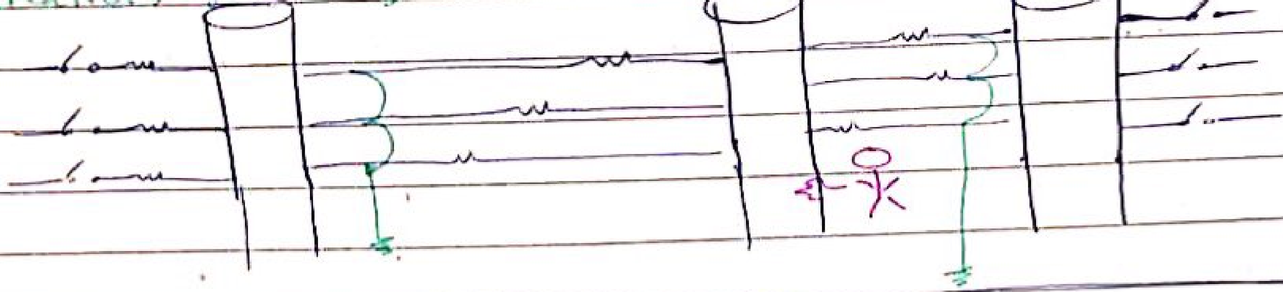
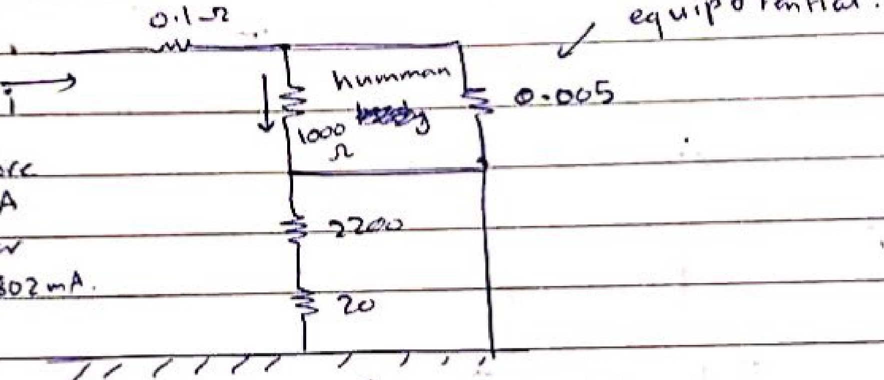
24/4
MON

breakets grounding





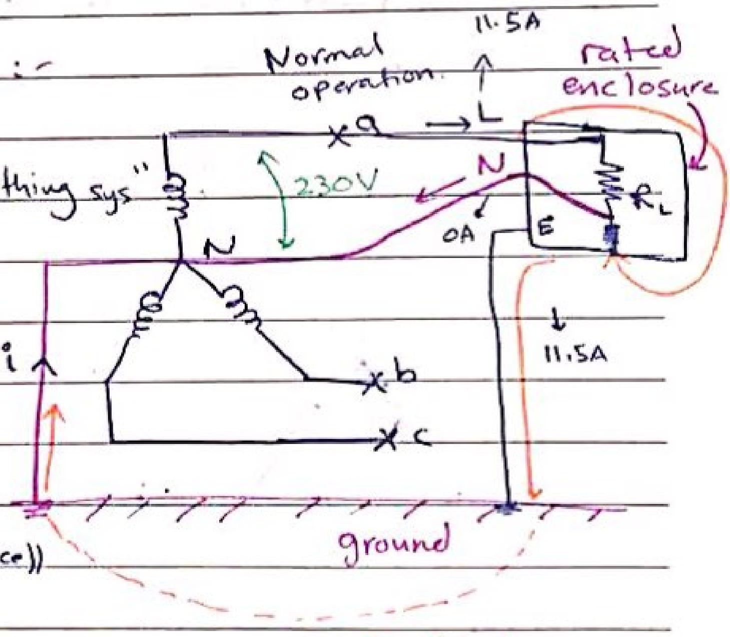
before
24A
after
0.1802 mA.

trip ground.

types of earthing system :-

TT "earthing sys"

TT → earthing in load and earthing => خاصة



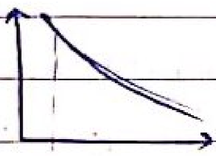
LG fault.

$$\hat{I}_{LG} = \frac{V}{R \text{ ((ground loop resistance))}}$$

$\hat{I}_{LG}$ small ⇒ Ground loop ≈ 20 Ω

$$\hat{I}_{LG} = \frac{230}{20\,\Omega} = 11.5\ A$$

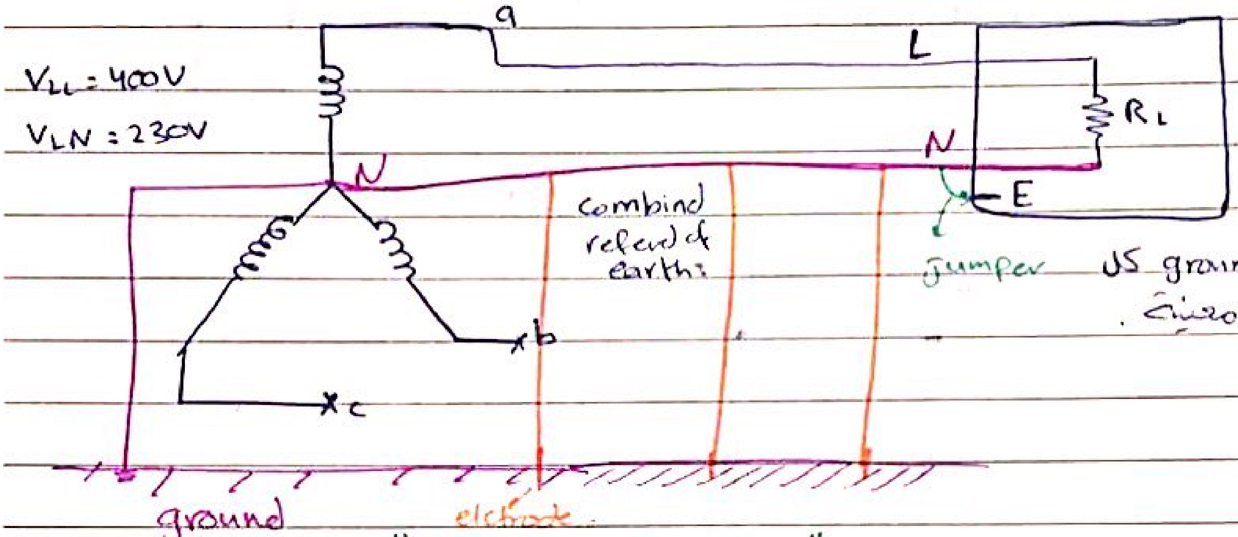
fues ⇒ ↑ current → يفصل اسرع



dis: TT → current قليل → بدو وقت ليفصل

* $I_{L_1} = 11.5A$, → $I_N = 0$ ⇐ بجيب جهاز بيقرأ ~~الفرق~~ قراءة التيار

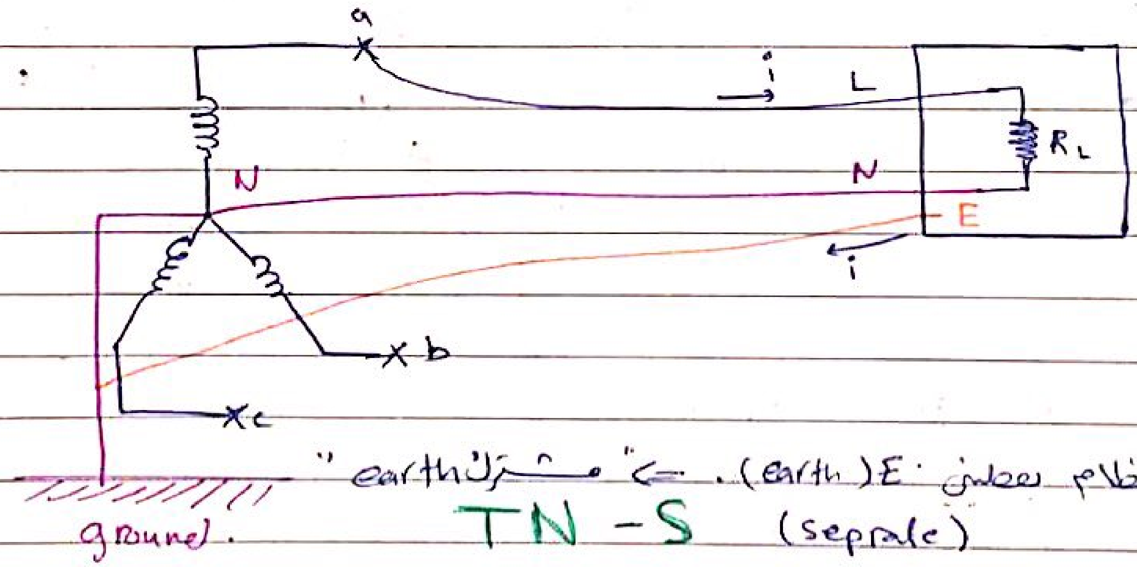
اذا وجد انو الفرق كبير بين I_N و I_{L_1} ← بعرف انو عندي fault وبفصل السيستم .



* بحط كل ground مسافة معينة .

"TN – C – S"   C ≡ combined

(PME) ≡ protective multiple earthing   S ≡ seprate

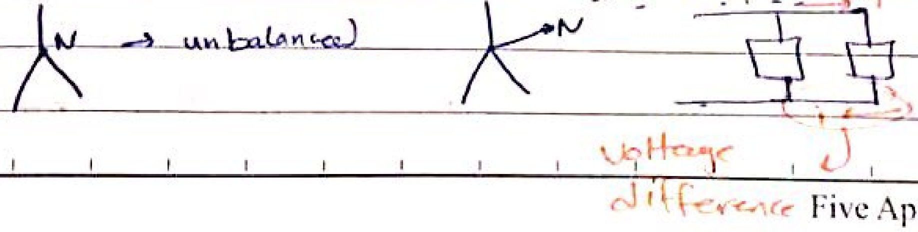


* هذا النظام بعطيني E (earth) . ← "earth مشترك"

TN – S (seprate)

* disadvantage : اذا صار fault على costumer1 و E مشترك بصير على costumer2 بصير عليه voltage . ← بخفف استخدام لـ one costumer.

* ~~N~~ N → unbalance ⇒ shifted. (يعني بطل يعطيني 230V)



ground loop :-

TNS $\approx 0.8\,\Omega \longrightarrow I_{LG} = \frac{230}{0.8} = 287\,A$

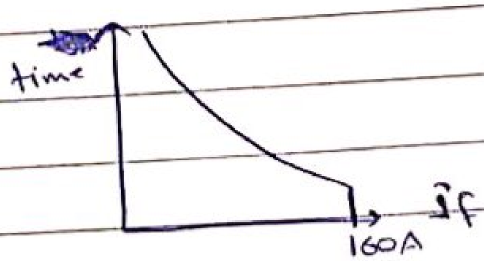
TN-C-S $\approx 0.35\,\Omega \longrightarrow I_{LG} = 657\,A$

TT $\rightarrow 21\,\Omega \longrightarrow I_{LG} = 11\,A$

$\hookrightarrow 100\,\Omega \longrightarrow I_{LG} = 2.3\,A$

MCB → 32 A type B

$32 * 5 = 160\,A$

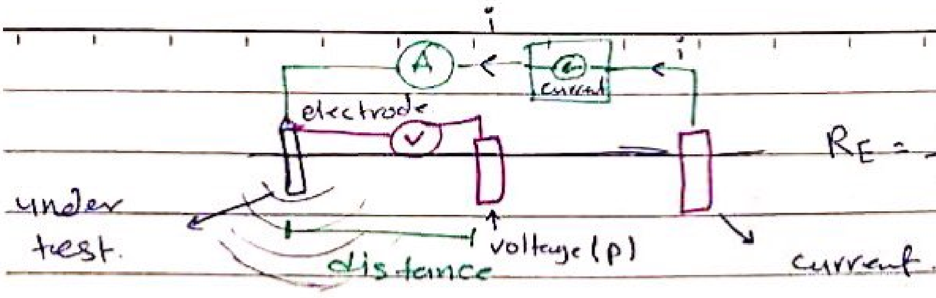


MCB 32 A - type C

$10 * 32\,A = 320\,A$ * عند 320 بفصل "

اكل عشان يلقطوا بستخدم جهاز RCD

RCD = residual current device.

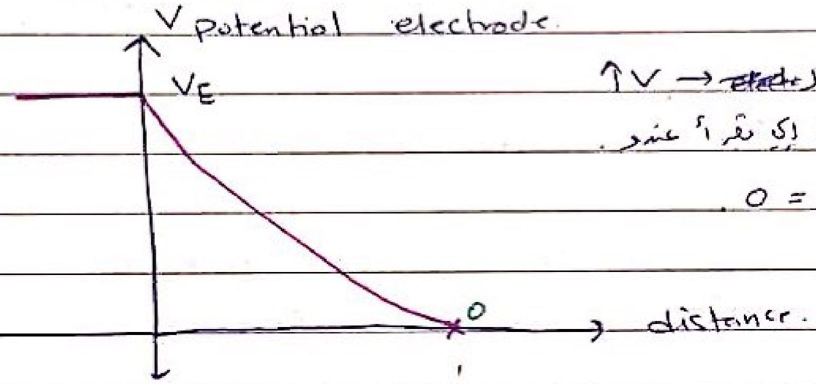


$$R_E = \frac{V_E}{I}$$

* اشكال بدي اقيس المقاومة ((2 terminal)) → first terminal (معروفة) / second terminal

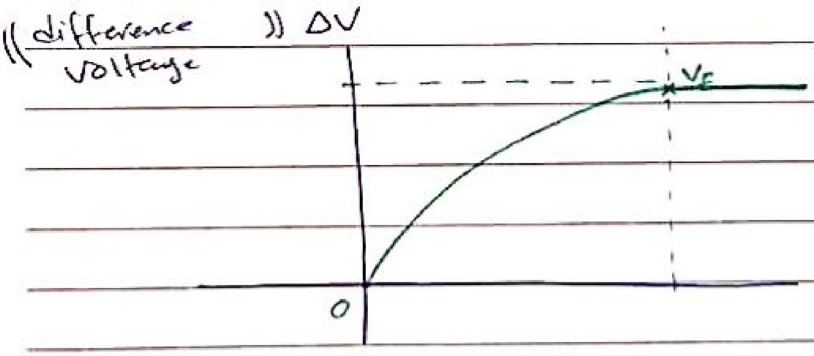
$R_E =$ مقاومة الارض

موجود في باطن الارض (ما بعرف).

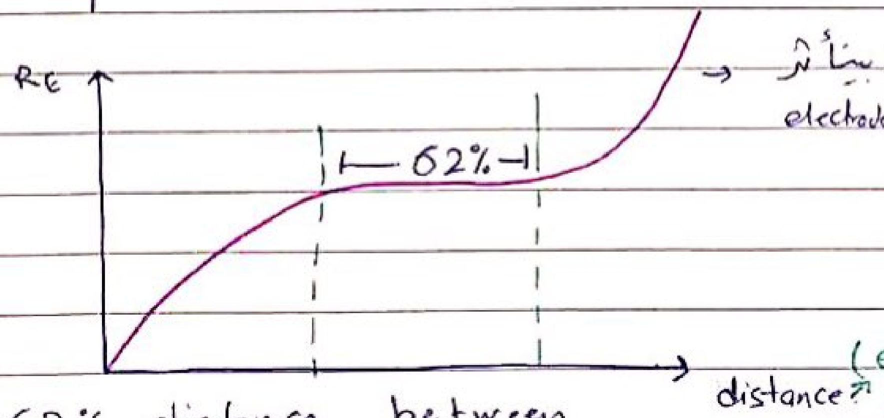


↑V → كلما قربت من ~~Elect~~ الـ electrode الـ اللي بقرأ عنده

وبصير $0 = \Delta V$.



صفر ← بعيد خارج المجال



→ بتزيد لانو بيأثر عليها electrode 3

(electrode under test and potential electrode)

74

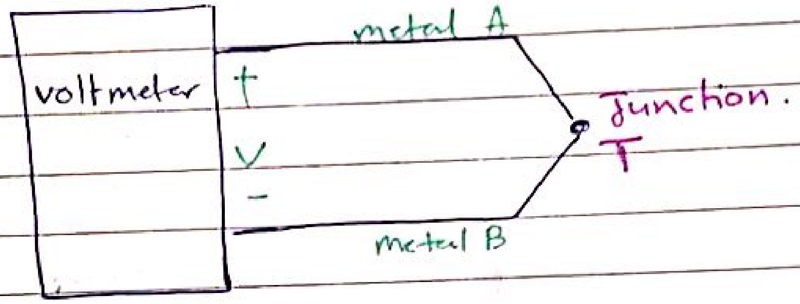
((62% distance between electrode under test and current electrode))

* اذا طلعت قيم ~~[illegible]~~ RE عالية

① بزيد العمق للارض (تقيس عليه)

② نضيف electrode ← parallel

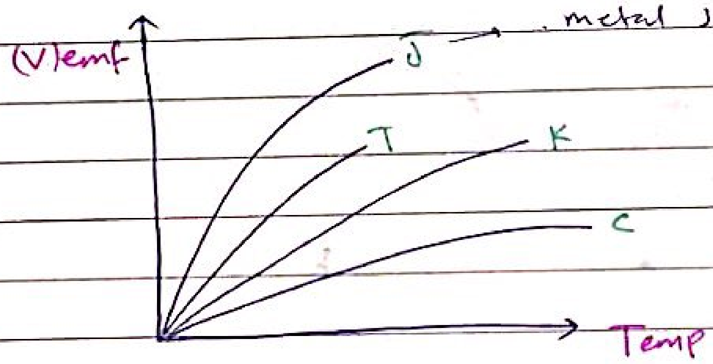
* Thermcouples 8△ "temprature → voltag"



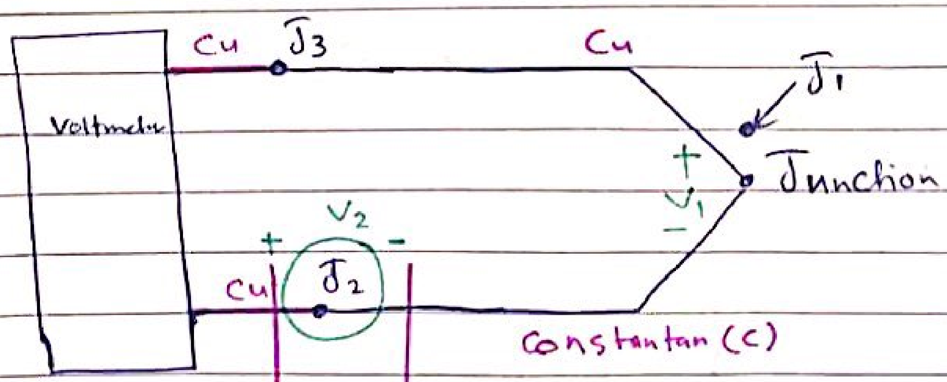
$V = \alpha T$

emf

* بختلف بنوع الـ metal



Type T: (Cu, constantan)



$J_2 \Rightarrow C - Cu$ (emf)

$V = V_1 - V_2$ → ice $\left\{ \begin{matrix} ref \Rightarrow T = 0 \\ V_2 = 0 \end{matrix} \right\}$

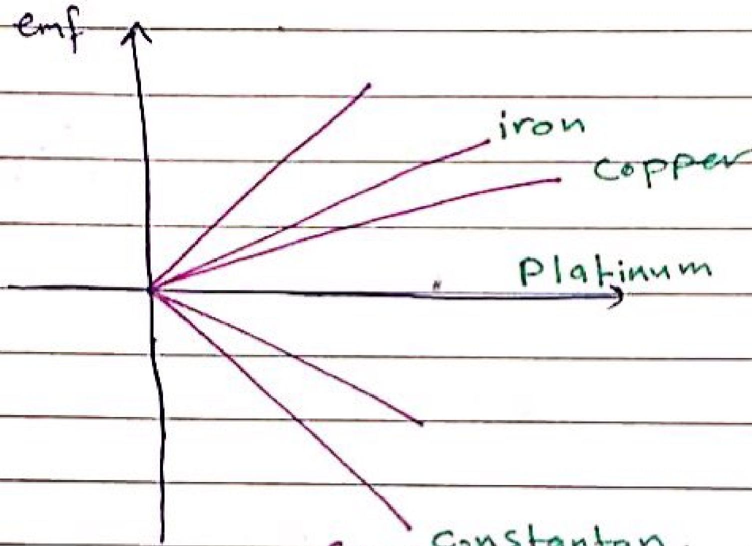
75

* Refernce Junction :-

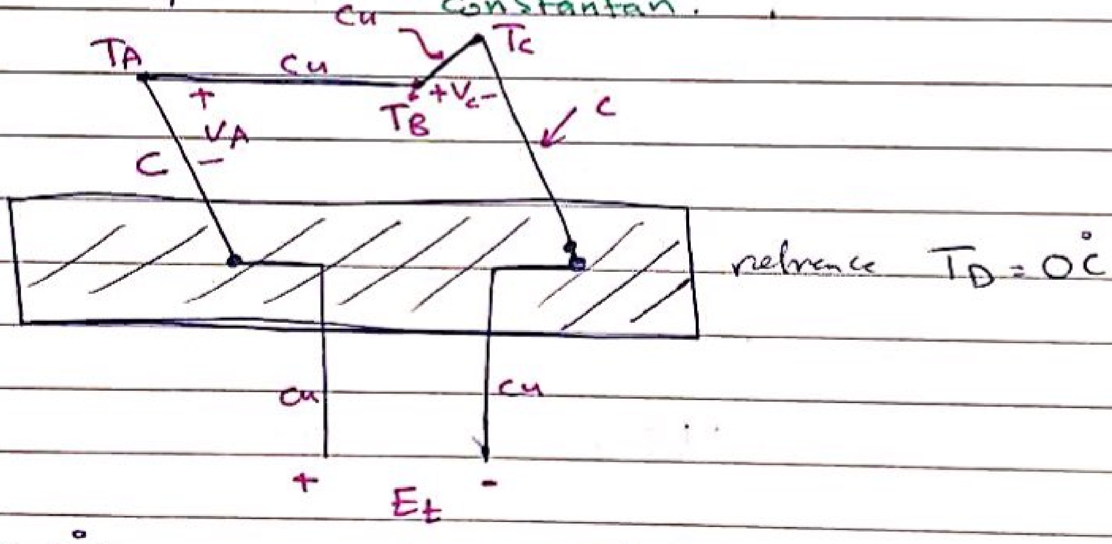
$J_2 \Rightarrow$ refrence (ice) $\Rightarrow 0^\circ C \rightarrow V_2 = \alpha T$

$V_2 = 0.$

$V = V_1 = \alpha T_{J_1}$



Ex



$T_B = 121.1^\circ C$, $E_t = 2.05\, mV.$

$V_A = +1.517\, mV$

① emf (B, C) ?!

② T_A, T_c ?!

sol: ① $V_B = 0$ (Cu − Cu Junction)

$V_c = ?!$ KVL

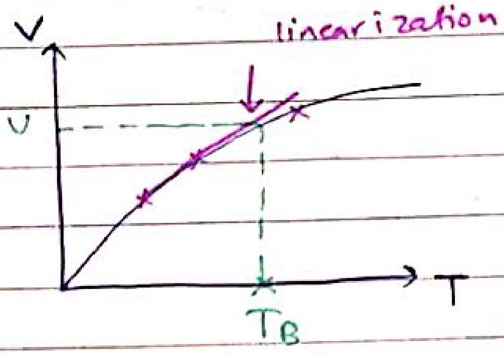
$-E_t - V_A + V_c = 0$

$V_c = E_t + V_A$

$V_c = 2.05\,mV + 1.517\,m = 3.567\,mV$

(2) $T_A \Rightarrow$ curve

بطلعه من ال curve



اذا اعطاني نقاط ← ~~[illegible]~~ ⇐ بعمل linearization

ما لقيت نقاط من tabel

T			
V			

Five Apple

3/5
Wed

time domain $\longrightarrow$ frequency domain

$\Downarrow$

fourier series

$$x(t) = a_0 + \sum_{n=1}^{N} a_n \cos w_0 t + \sum_{n=1}^{N} b_n \sin w_0 t$$

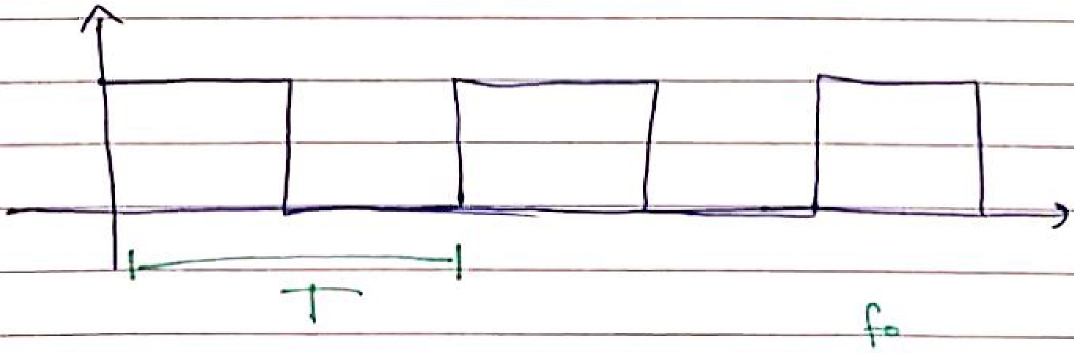
$\Rightarrow$ a_0 = dc signal.

$$= \text{average} = \frac{1}{T} \int x(t)\, dt$$

$$\Rightarrow a_n = \frac{2}{T} \int x(t) \cos n w_0 t \, dt$$

$$\Rightarrow b_n = \frac{2}{T} \int x(t) \sin n w_0 t \, dt$$

$\boxed{w_0 \triangleq \text{fundamental freq}}$



$f_0 = \dfrac{1}{T}$ HZ.

f_0

$1f_0$

$2f_0$ harmonic

$3f_0$

$\vdots$

* Distortion analyzers:
وظيفته يقيس كم نسبة الharmonic بالنسبة للـ fundamental.

* لو بدي اقيس الThird harmonic بس ⇐ pass band حوليني filter.

الـ Third harmonic.

* Wave:
هو selective بقيس ع frequency معينة.

* Hertodyne:
بتحول الـ Signal ع carrier وبشوف الـ BW.

$$dB = 20 \log \frac{V_2}{V_1}$$

$$dBm \longrightarrow mW$$