University of JorDan

Electrical Engineering Department

Power lab

Experiment No. 1

17/20

8.5/10

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الاربعاء ٢١١٥

(A) : Voltage Distribution Over a String of Sufension Insulators

* Objectives :-

- to study the voltage distribution over a string of suspension insulators.
- to determine the string efficiency.
- to find out how the voltages distribution can be equalized.

* Theory :

Introduction

-3

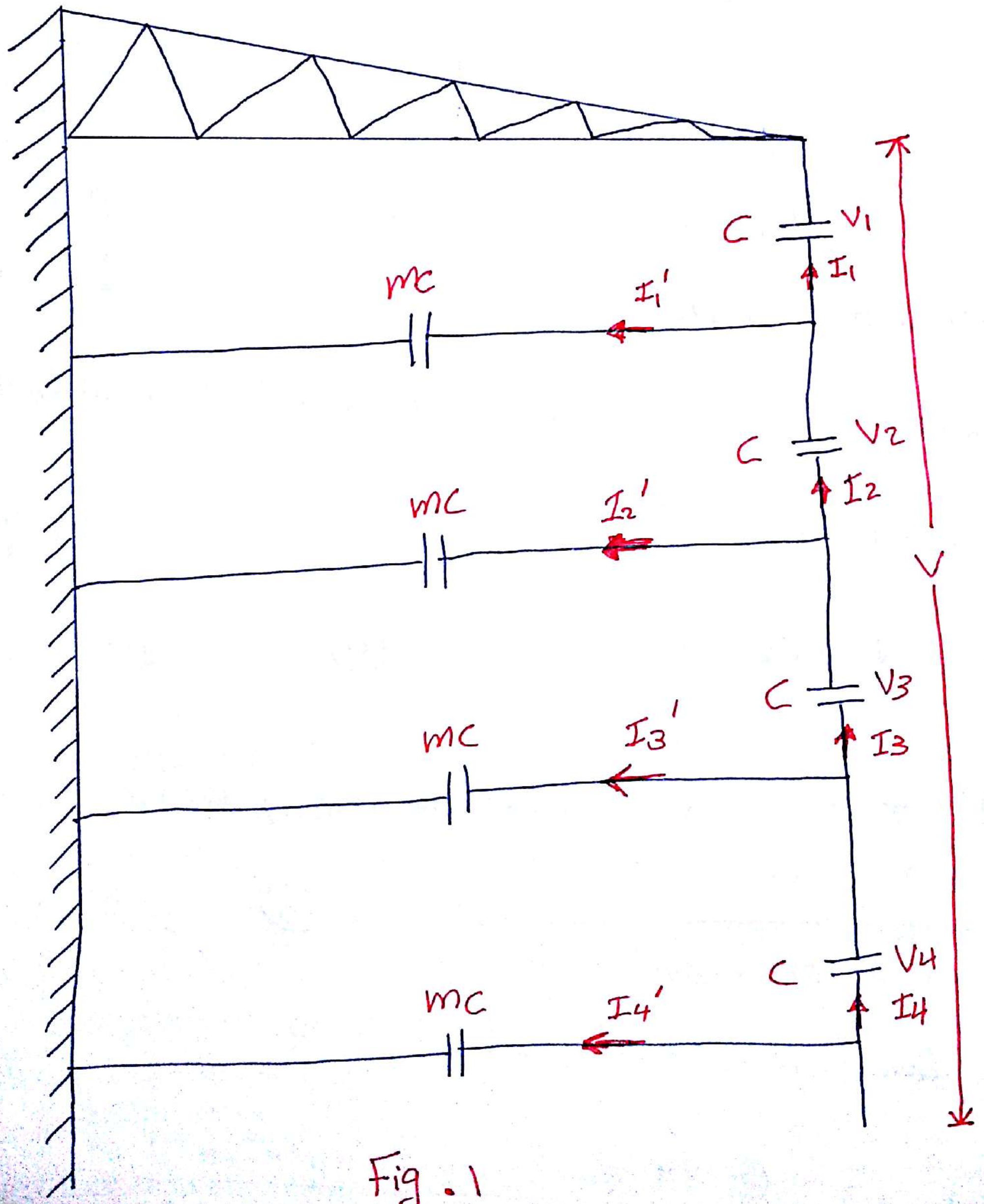

Fig. 1

* the relations between voltages in Fig. 1 are as follows :

* $I_2 = I_1 + I_1'$

$jwC V_2 = jwC V_1 + jwCm V_1$

$V_2 = V_1(1+m)$ ——— ①

* $I_3 = I_2 + I_2'$

$jwCV_3 = jwC V_2 + jwCm(V_1+V_2)$

$V_3 = V_1(1+m) + mV_1 + m(m+1)V_1$

$V_3 = V_1(1+3m+m^2)$ ——— ②

* $I_4 = I_3 + I_3'$

$jwCV_4 = jwC\cancel{V}_3 + jwCm(V_1+V_2+V_3)$

$V_4 = V_3 + mV_1 + mV_2 + mV_3$

$V_4 = V_1(1+3m+m^2) + mV_1 + mV_1(1+m) + m(V_1)(1+3m+m^2)$

$V_4 = V_1(1+6m+5m^2+m^3)$ ——— ③

* Knowing that : $V = V_1 + V_2 + V_3 + V_4$ ——— ④

Then $V = V_1 + (m+1)V_1 + (m^2+3m+1)V_1 + (m^3+5m^2+6m+1)V_1$

* So : $V_1 = \dfrac{V}{4+10m+6m^2+m^3}$ ——— ⑤

* in the same way we can find V_3 & V_2 & V_4 :

⑥ $V_2 = \dfrac{V(1+m)}{4+10m+6m^2+m^3}$

⑧ $V_4 = \dfrac{V(1+6m+5m^2+m^3)}{4+10m+6m^2+m^3}$

⑦ $V_3 = \dfrac{V(1+3m+m^2)}{4+10m+6m^2+m^3}$

η efficiency $= \dfrac{\text{Voltage across the string}}{N * \text{Voltage across the unit adjacent the live}}$

$$\eta = \frac{V_1 + V_2 + V_3 + V_4}{4 * V_4} = \frac{4 + 10m + 6m^2 + m^3}{4(1 + 6m + 5m^2 + m^3)} \quad \text{--- (9)}$$

* the voltages are distributed in not uniform way, but there's two way to controll the voltage distribution :

$\boxed{1}$ Grading of the units :

- In this method we take different values of capacitors, $C_4 > C_3 > C_2 > C_1$
- The voltage across lower units will be reduced while the voltage on the top units will be increased.
- For perfect grading $V_1 = V_2 = V_3 = V_4$

* Fing the value of the capacitor to staistify the perfect grading :

* $V_1 = V_2$

$$\frac{I_1}{jwC_1} = \frac{I_2}{jwC_2} = \frac{I_1 + I_1'}{jwC_2} = \frac{I_1}{jwC_2} + \frac{jwCm\, V_1}{jwC_2}$$

- but: $V_1 = \dfrac{I_1}{jwC_1}$ then : $\dfrac{I_1}{jwC_1} = \dfrac{I_1}{jwC_2} + \dfrac{mC\, I_1}{jw\, C_1 C_2}$

- So : $\boxed{C_2 = C_1 + mC}$

* $V_2 = V_3$

$$\frac{I_2}{jwC_2} = \frac{I_3}{jwC_3} = \frac{I_2 + I_2'}{jwC_2} = \frac{I_3}{jwC_3} + \frac{jwC m (\overset{2V_2}{\overbrace{V_1+V_2}})}{jwC_3}$$

- but: $V_2 = \frac{I_2}{jwC_2}$ then : $\frac{I_2}{jwC_2} = \frac{I_2}{jwC_3} + \frac{2mC I_2}{jw C_3 C_2}$

- So : $\boxed{C_3 = C_2 + 2mC}$

* $V_3 = V_4$

$$\frac{I_3}{jwC_3} = \frac{I_4}{jwC_4} = \frac{I_3 + I_3'}{jwC_4} = \frac{I_3}{jwC_4} + \frac{jwC m (\overset{3V_3}{\overbrace{V_1+V_2+V_3}})}{jwC_4}$$

- but $V_3 = \frac{I_3}{jwC_3}$ then $\frac{I_3}{jwC_3} = \frac{I_3}{jwC_3} + \frac{3mC I_3}{jwC_3 C_4}$

- So : $\boxed{C_4 = C_3 + 3mC}$

* from all this we find that :

$$C_n = C_{n-1} + (n-1) mC$$

10

where : $C_n \equiv$ the capacitance of the n^{th} unit

$C_{n-1} \equiv$ the capacitance of the lower unit

$mC \equiv$ capacitance of the ground

* using diferent type of capacitor is complex and hard to mantinance so we need another method.

Arc Shielding :

Here we controll the voltages by emboying a gaurd ring which usually takes the form of large metal ring sarrounding the bottom unit & connected to the line as shown in Fig. 2

- this ring increases the capacitance between the line & the metal work .

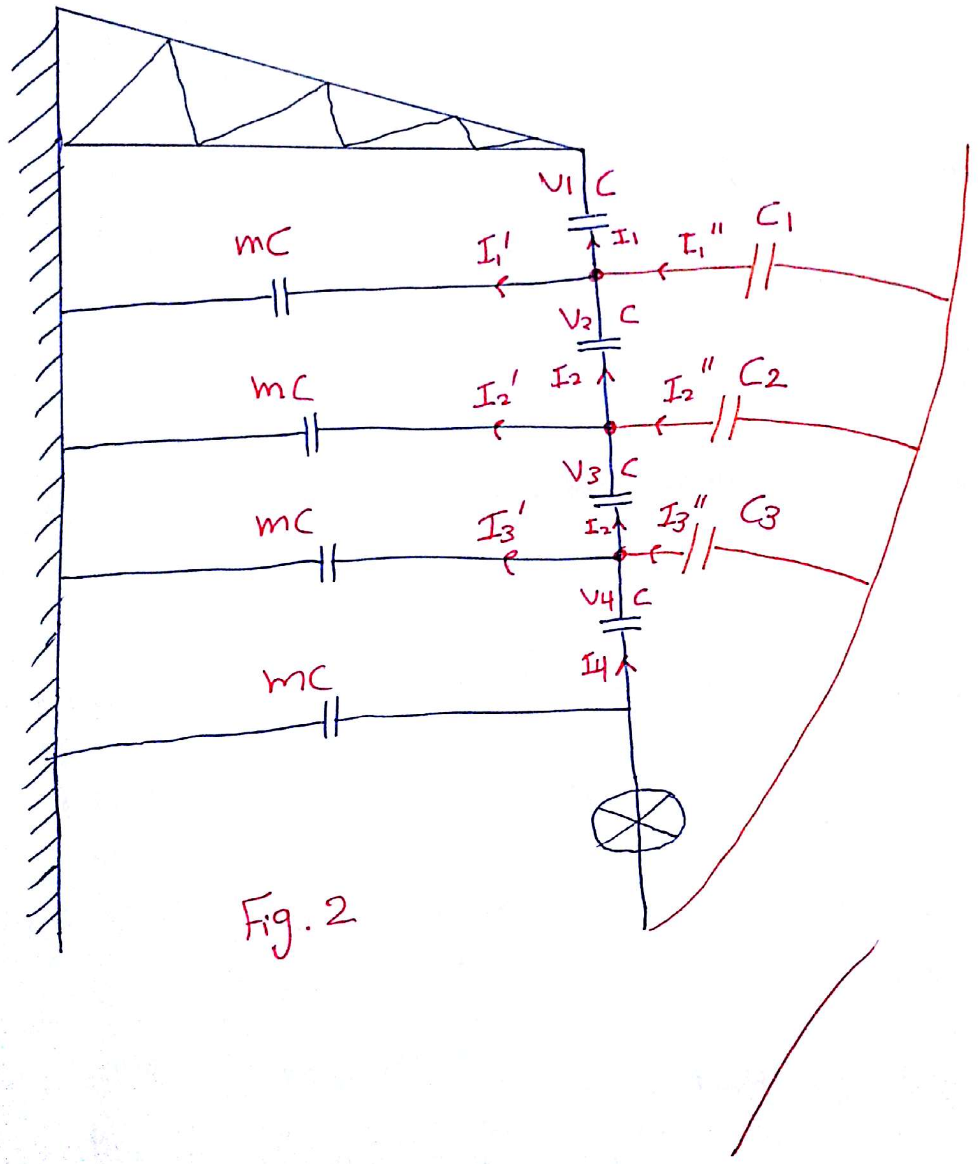

Fig. 2

* finding the value of the capacitor to statisfy $V_1 = V_2 = V_3 = V_4$

* $I_2 = I_1 + I_1' + -I_1''$

$j\omega C V_2 = j\omega C V_1 + mj\omega C V_1 - j\omega C_1 V$

$V = V_1 + V_2 + V_3 + V_4$, then : $\cancel{C} = \cancel{C} + mC - 3C_1$

$$\boxed{C_1 = \frac{mC}{3}} \text{ — (a)}$$

* $I_3 = I_2 + I_2' + -I_2''$

$j\omega C V_3 = j\omega C V_2 + j\omega m C (V_1 + V_2) - j\omega C_2 V$

$V = V_2 + V_3$, then : $\cancel{C} = \cancel{C} + 2mC - 2C_1$

$$\boxed{C_2 = 2mC/2} \text{ — (b)}$$

* $I_4 = I_3 + I_3' + -I_3''$

$j\omega C V_4 = j\omega C V_3 + j\omega C m (V_1 + V_2 + V_3) - j\omega C_3 V$

$V = V_3$, then : $\cancel{C} = \cancel{C} + 3mC - C_3$

$$\boxed{C_3 = 3mC} \text{ — (c)}$$

* from all above we can find that :

where $N \equiv$ number of units

$$\left.\begin{aligned} C_1 &= mC/(N-1) \\ C_2 &= 2mC/(N-2) \\ C_3 &= 3mC/(N-3) \end{aligned}\right\} \text{ — (11)}$$

...re (1) : Determination of Voltage Distribution :

V \ mc	0	0.22 μF	0.47 μF	0.69 μF
V_1	25.61 V	20.32 V	16.13 V	14.55 V
V_2	25.35 V	22.8 V	19.31 V	18.8 V
V_3	25.29 V	26 V	26.5 V	28.8 V
V_4	26.6 V	33 V	39.5 V	48.1 V

Table. 1 measured value

* using equations number 5, 6, 7 & 8 to calculate the voltage Distribution theoritecally :

for mc = 0	for mc = 0.22 μF	for mc = 0.47 μF	for mc = 0.69 μF
$V_1 = 27.5$	$V_1 = 21.72$	$V_1 = 17.12$	$V_1 = 14.17$
$V_2 = 27.5$	$V_2 = 23.81$	$V_2 = 20.4$	$V_2 = 18.63$
$V_3 = 27.5$	$V_3 = 28.46$	$V_3 = 28.8$	$V_3 = 28.91$
$V_4 = 27.6$	$V_4 = 36.87$	$V_4 = 43.17$	$V_4 = 48.27$

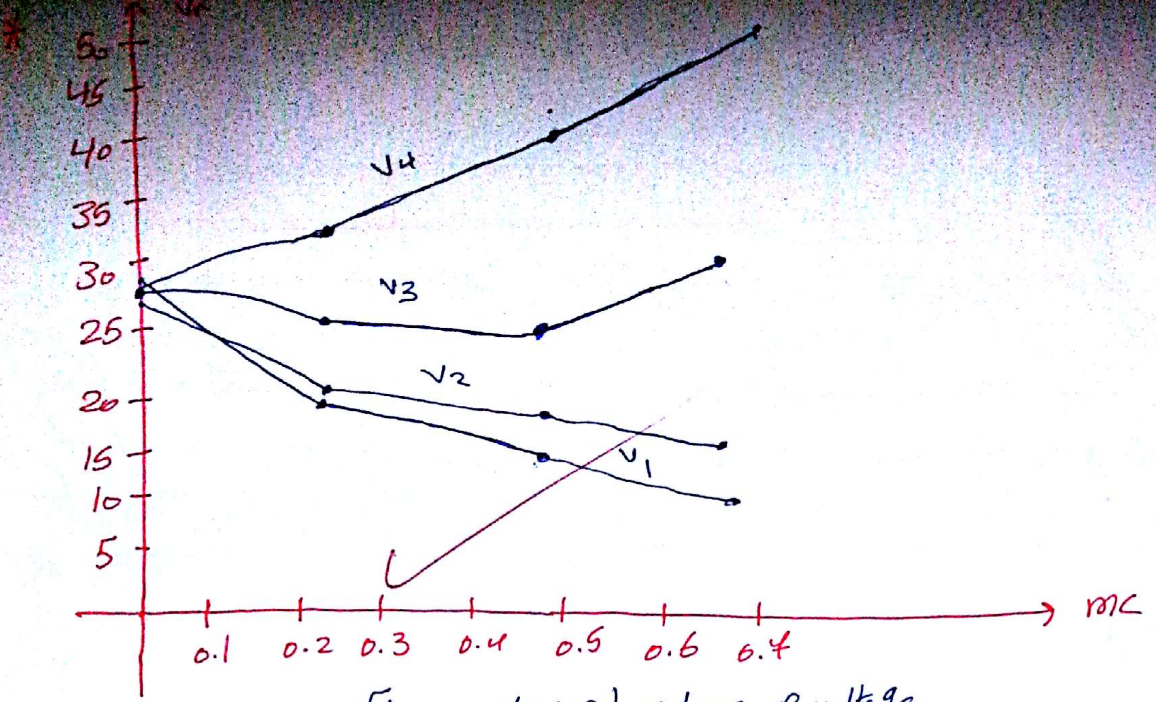

Fig. 3 Measurd values of voltage due to differant mc value

* String efficiency : using equtin number (9)

for mc = 0	for mc = 0.22 μF	for mc = 0.47 μF	for mc = 0.69 μF
η = 100%	η = 76.63%	η = 63.95%	η = 56.95%

* Procedure (2) :- Voltage control using static shelding

- taking mc = 0.47 μF & N = 4
- calculating C_1, C_2 & C_3 by eqution (11)

C_1 = 0.157 μF

C_2 = 0.47 μF

C_3 = 1.41 μF

- then we connect the capacitors C_1 & C_2 & C_3 as gaird Ring

ring the Voltage Distribution we get :

$V_1 = 27.86$ V
$V_2 = 27.7$ V
$V_3 = 27.7$ V
$V_4 = 27.7$ V

→ that show that the static shielding helps the voltage Distribution to be almost uniform

* trying the grading Method :

- take $mc = 0.22$ & $C_1 = 2.2\ \mu F$

- $C_1 = 2.2\ \mu F$
$C_2 = C_1 + mc = 2.42\ \mu F$
$C_3 = C_2 + 2mc = 2.86\ \mu F$
$C_4 = C_3 + 3mc = 3.52\ \mu F$

- $V_1 = 27.92$ V
$V_2 = 27.23$ V
$V_3 = 26.83$ V
$V_4 = 28.74$ V

* It's show that grading Method give an un-uniform Destribution becouse of the imprefection deviations.

* PART (B) : I-t charachteristcs of wire fuse in the over current zone

* objectives :

- to find the relitionship between current in the Fuse and the time needed by the Fuse

* Procedure :

Measurement No	input voltage (V)	Primary current Fuse 1/25 (A)	Time (sec)
1	130	0.28	> 200
2	135	0.3	> 200
3	140	0.31	> 160
4	150	0.33	67.12
5	160	0.36	2.24
6	170	0.4	2.06
7	180	0.42	1.56
8	190	0.46	1.46
9	200	0.46	1.26
10	210	0.49	106

Table . 3

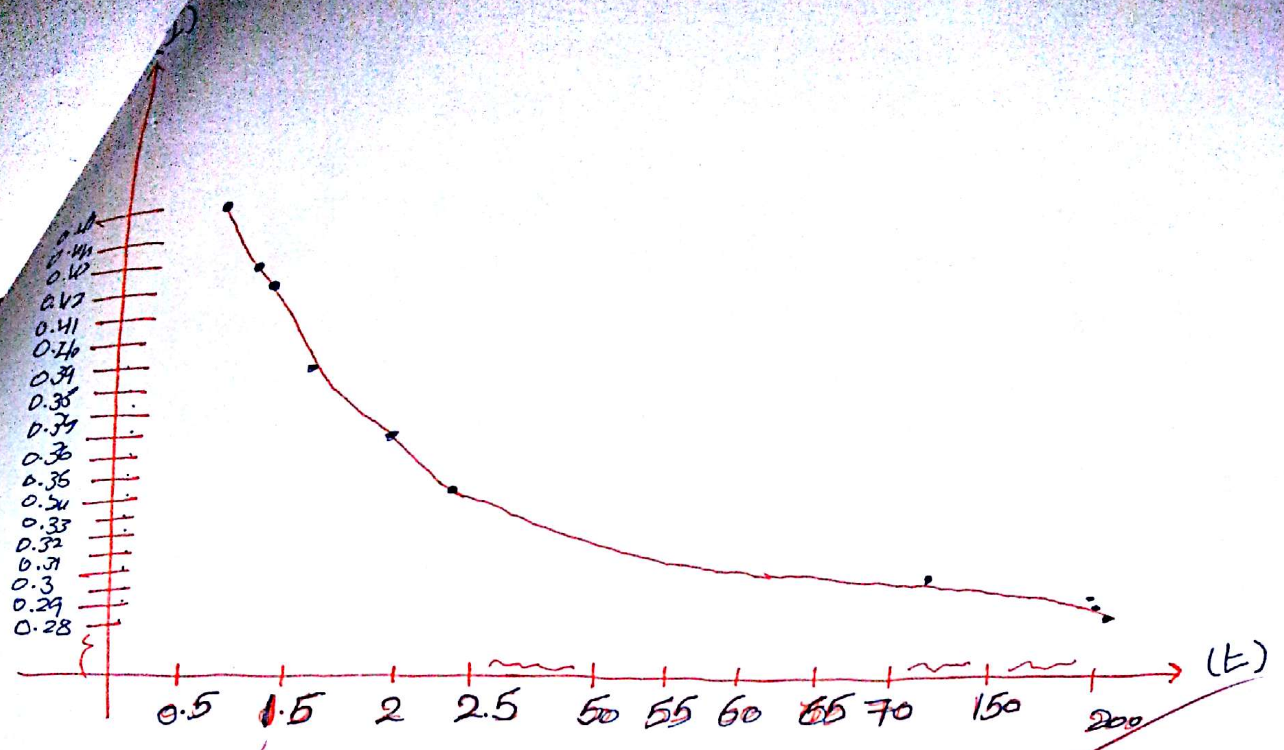

Fig No. 4

* from the table.3 and Fig No. 4 we find that the time needed by the Fuse to interrupt the Circuit is Inversely proportional that is as the fault increase the operating time decreases, which is the fundemental property in the fuse which lead to it's use in protection the circuit from the Fault.

* rating Current is the Maximum Current the Fuse can stand & still work for it, in our procuder rating current Calculated as follow :

$$I_{rating} = I_{sec} * I_{rely} = 0.3 * 25 = 7.5\,A$$

— The END —

Exp (2)

Measure of the +ve and zero seq current

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done by the group

6/10

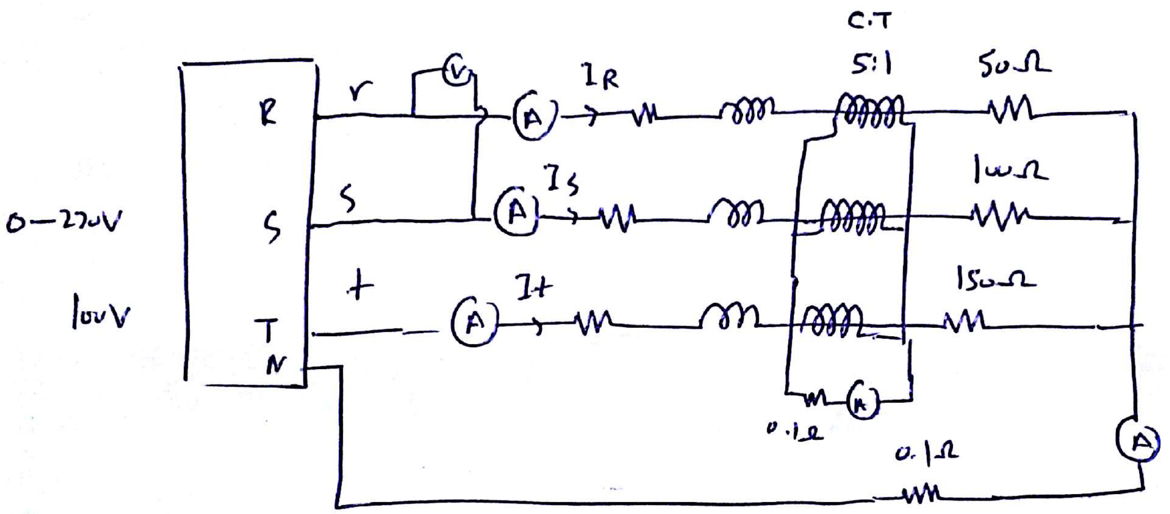
Exp(2)

Measurement of symmetrical component of Curr in unbalance system.

*** objective.**

To measure the zero, positive and negative current for 3-phase unbalanced system.

PART (A) : Measurement of zero sequence current :



$I_r = 1.05 \angle 0$ Inphase with V_{rn} $\qquad I_{CT} = \cancel{0.13}\ 0.11$

$I_s = 0.55 \angle 120$ with V_{rn}

$I_R = 0.4 \angle 240$ with V_{rn}

⇒ ~~Now disconnect N n~~ :

$I_n = 0.62$

$V_{Nn} = 0.1 \times I_n = 0.062V = 3I^{(0)} R_N$

$I_{CT} = \frac{1}{5} I_N = \frac{0.62}{5} = 0.11$

$I^{(0)} = \frac{I_N}{3} = \frac{0.62}{3} = 0.2$, $I^{(0)} = 2 \times I_{CT} = 0.2$

⇒ No

* Now disconnect Nn :

$I_R = 0.7 \angle 0$

$I_S = 0.59 \angle 135°$

$I_T = 0.4 \angle 225°$

$I_n = 0$

$I_{CT} = 0$

$V_{Nn} = V^{(0)} = \cancel{6.063 V}$ 18V

* Conculusion from frist part :

[1] we find the The Relation betwn I_{CT} & I_{NN} & $I^{(0)}$ is:

[1] $I^{(0)} = \frac{I_N}{3} = 0.4$

[2] $I_{CT} = \frac{1}{5} I_N = 0.11$

[3] $I^{(0)} = 2 * I_{CT} = 0.2$ X

$\Rightarrow I^{(0)} = \frac{1}{3} I_N = \frac{1}{3} (I_R + I_S + I_T)$

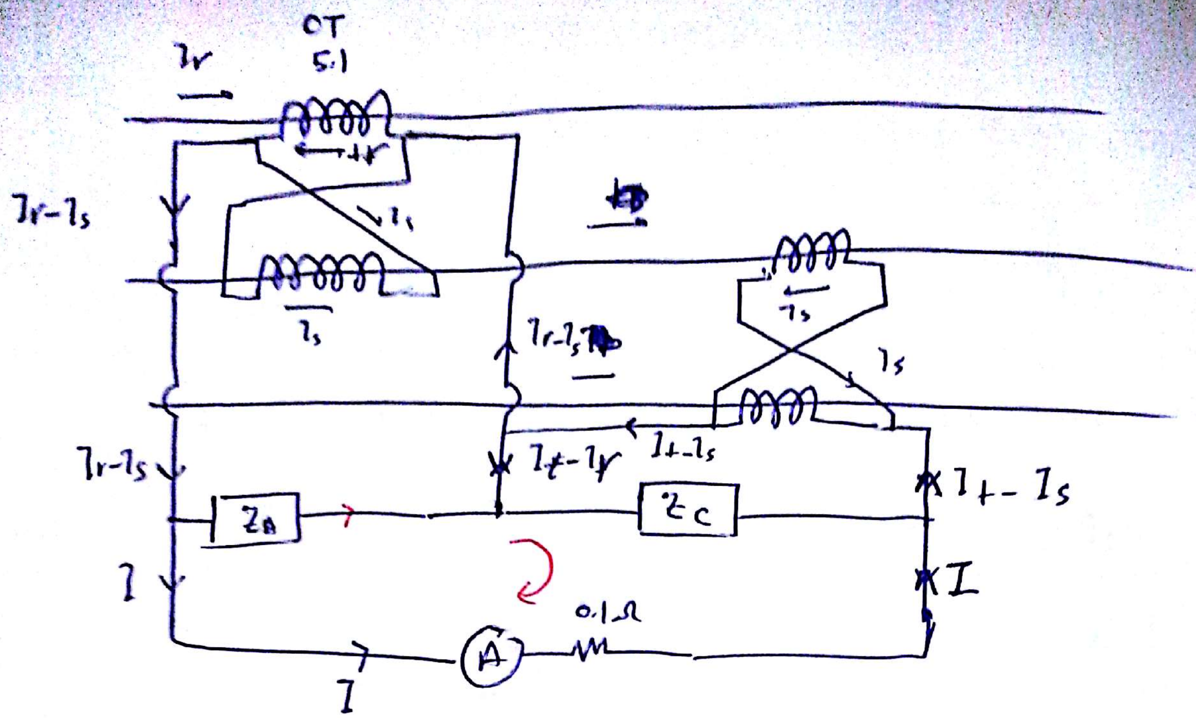
[2] when we disconnect Nn

$V_{Nn} = V^{(0)} = 18$ The V_{Nn} equal to zero seq voltage.

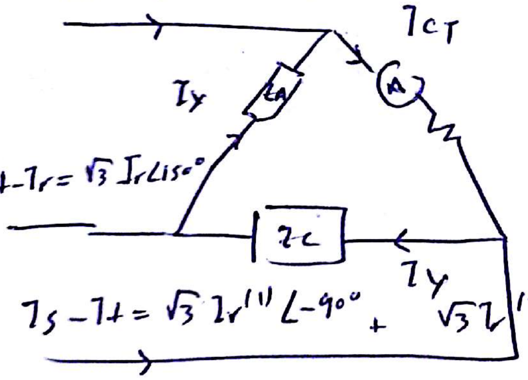
[3] $V^{(0)} = \frac{1}{3} (V_a + V_b + V_c)$

$[V_{012}] = [A]^{-1} [V_{abc}]$

* Part B : Measure of positive & negative seq current :



$\Rightarrow$ $I_r - I_s = \sqrt{3}\, I_r^{(1)} \angle 30^\circ + \sqrt{3}\, I_r^{(2)} \angle -30^\circ$



$I_s - I_t = \sqrt{3}\, I_r^{(1)} \angle -90^\circ + \sqrt{3}\, I_r^{(2)} \angle +90^\circ$

$$I_x\, Z\angle 30^\circ + I_y\, Z\angle -90^\circ + 0.1\, I_{CT} = 0$$

$$\left(-\sqrt{3}\, I_r^{(1)} \angle 30 \quad + I_{CT}\right) Z\angle 30^\circ + \left(I_{CT} + \sqrt{3}\, I_r^{(1)} \angle 90^\circ \quad\right) Z\angle 90^\circ$$

$$+ 0.1\, I_{CT} = 0$$

$$\Rightarrow -\sqrt{3}\, Z\, I_r^{(1)} \angle 60^\circ + Z\, I_{CT} \angle 30^\circ + Z\, I_{CT} \angle -90^\circ + \sqrt{3}\, Z^{(1)} \angle -180^\circ + 0.1\, I_{CT} = 0$$

$$\Rightarrow -\sqrt{3}\, Z\, I_r^{(1)} \angle 60^\circ + \sqrt{3}\, Z\, I_r^{(1)} \angle -180^\circ = \left(-Z\angle 30 - Z\angle 90^\circ\right) I_{CT}$$

$$\Rightarrow 3\, Z\, I_r^{(1)} \angle 210 = -Z\angle -30^\circ\, I_{CT} = +Z\angle +150\; I_{CT}$$

$$\Rightarrow I_{CT} = 3\, I_r^{(1)} \angle 60^\circ$$

\# First phase

The second prove if we Interchange Z_A & Z_C

$$I_x\, Z\angle -90 + I_y\, Z\angle 30 + 0.1 I_{CT} = 0$$

$$(-\sqrt{3} I_r^{(2)} \angle -30 - I_{CT})(Z\angle -90) + (I_{CT} + \sqrt{3} I_r^{(2)} \angle 90^\circ) * Z\angle 30 + 0.1 I_{CT} = 0$$

$$-\sqrt{3}\, Z I_r^{(2)} \angle -120 + Z I_{CT} \angle -90^\circ + Z I_{CT}\angle 30 + Z\sqrt{3} I_r^{(2)} \angle 120 + 0.1 I_{CT} = 0$$

$$-\sqrt{3}\, Z I_r^{(2)} \angle -120 + \sqrt{3} Z I_r^{(2)} \angle 120^\circ = (-Z\angle -90 - Z\angle 30) I_{CT}$$

$$3 I_r^{(2)} Z \angle 90^\circ = Z \angle 150\ I_{CT}$$

$$I_{CT} = 3 I_r^{(2)} \angle -60^\circ$$

* Some conclusion :

1) The value of I_{CT} before and After Interchange Z_a & Z_c and phased by 180°

2) If N-n is Removed Then The value of zero seq. current will be zero

⇒ The CT on R will measure the value of +ve seq current

⇒ & The CT on T will measure the -ve seq

⇒ & The CT on S phase is not Required to measure +ve & -ve seq.

4) $I_{CT} = 0.28\angle 30^\circ$ After Interchange $\quad I_{CT} = 0.2\angle -172^\circ$ After Interchange

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Experement 3

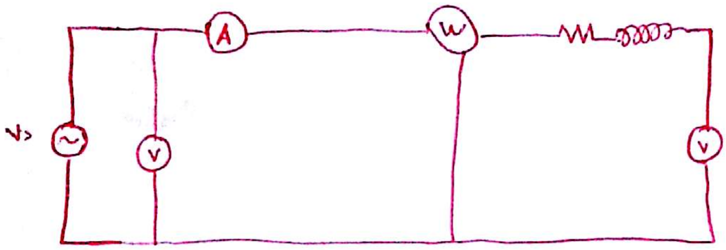
Current Voltage and Power Relations Across A Transmission Line

Disscussion:- To determine The parameters of the short and medium Length Lines And to investig voltage, current and Power relations at Both ends Under no Load and Load conditions.

11/20

Procedure:-

1:- open circuit test



S.S/10

1) set Vs To 25, 50, 75, 100
2) take The readings of Vs and V_R and I_s, W and find the phase shift
3) Find A, C constants.

$$V_s = AV_R + BI_R$$
$$I_s = CV_R + DI_R$$

$A = \frac{V_s}{V_R}$ ... $\boxed{1}$

$C = \frac{I_s}{V_R}$ ... $\boxed{2}$

Vs	25	50	75	100
Vs	25.92	50.61	75.38	99.77
I_s	0	0	0	0
Power	0	0	0	0
VR	25.91	50.62	75.37	99.76
phase shift	0	0	0	0
A	1.0003	1.001	1.0001	1.0001
C	0	0	0	0

* since I am working on an open Circuit Then The current will be Zero

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Circuit test :-

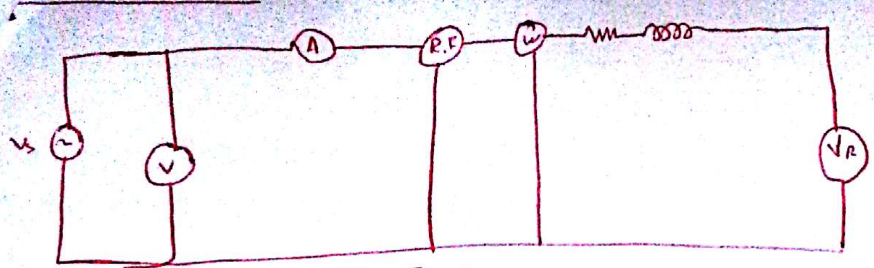


Fig. 2.

1) increace V_s after slowly Adjusting I_R to 1A And take the readings V_s, I_s, W, I_R, phase shift and $I_R(I_s)$

2) Repeat For I_R = 2, 3, 4

3) Calculate B, D

$V_s = AV_R + BI_R$

$I_s = CV_R + DI_R$

$\boxed{V_R = 0}$

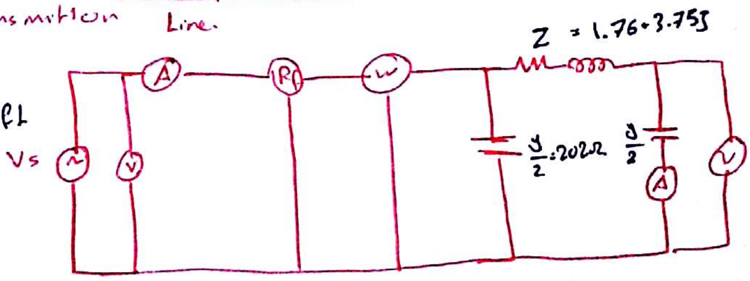
$B = \frac{V_s}{I_R}$

$D = \frac{I_s}{I_R}$

I_R	0.5	1	1.5	2
V_s	13.3	28.2	41	60.9
I_s	0.479	0.99	1.443	1.96
W	0.463	1.03	3.58	6.273
I_R	0.479	1.08	1.463	1.96
Phase shift	62.5	54.7	51.5	51.8
B	27.76	27.38	28.02	31.07
D	1	0.961	1.02	1

B.1 ~~short~~ open Circuit test For medium Transmition Line.

1) Adjust Vs to 25, 50, 75, 100V and measure V_s, I_s, W, I_a, I_{c2}, V_R and the phase shift



$A = \left(\frac{y}{2}Z + 1\right)$

$B = Z\Omega$

$C = Y\left(\frac{y}{4}Z + 1\right)$

$D = \left(\frac{y}{2}Z + 1\right)$

* Calculate A, C Parameters.

at the open cct test

$A = \frac{V_s}{V_R}$

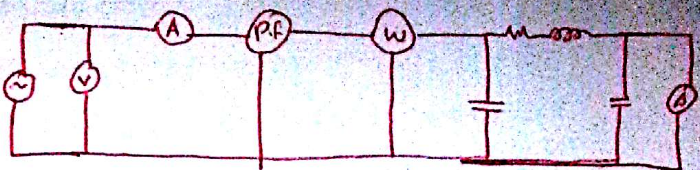
$C = \frac{I_s}{V_R}$

V_s	25	50	75	100
V_s	24.77	50.7	74.6	100.4
I_s	0.196	0.325	0.478	0.644
W	7.161	7.204	7.075	7
V_R	26.37	54.17	79.8	107.4
I_{c1}	0.07	0.15	0.22	0.29
I_{c2}	0.07	0.15	0.22	0.29
A	0.94	0.936	0.934	0.935
C	7.421 ms	6×10^{-3}	6×10^{-3}	6×10^{-3}

as we see Here V_R is Larger than V_s

This is due to the capacitor C_1.

...t test for medium Transmition Line :-



1) ...crease V_s slowly to set I_R to ...1, 1.5, 2 A

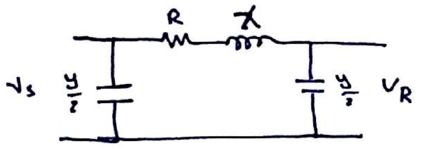
2) take the readings of V_s, I_s, W, V_R, I_{c1}, I_{c2}

3) calculate B, D constants

$$B = \frac{V_s}{I_R} \quad / \quad D = \frac{I_s}{I_r}$$

I_s	0.5	1	1.5	2
Vs	15.4	33	46.1	61.3
Is	0.505	1.08	1.508	1.9
W	0.715	2	4.8	6.9
Ir	0.541	1.17	1.639	2.134
Ic1	0.03	0.04	0.13	0.17
Ic2	0.01	0.01	0.01	0.02
B	28.46	28.2	28.1	28
D	0.933	0.923	0.92	0.89

The equivalent cct of the medium transmition line is:-



$B = Z = 28.2\,\Omega$

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$D = \left(\frac{y}{2} Z + 1\right) \Rightarrow \frac{y}{2} = 2.836 \times 10^{-3}$

Operating at No Load :-

1) adjust Vs to 100 V (L-N)

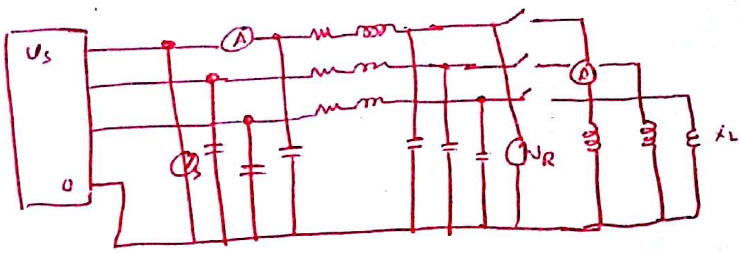
2) Take the readings of V_s, I_s, V_R

3) adjust X_L to the max

4) Keep Vs const and Adjust X_L until $V_L = V_s = 100\,V$

5) take I_L and calculate X_L

6) comment on I_L value



Vs	Is	VR	IL	XL
100	0.668	107	0.26	166.6

(1)

* note that I_L Here (0.26) is the current value that flows through the inductor. ~~because the SCADA can't reason [illegible]~~

This current exists due to the Line risistance and inductance.

I to 2A and the pf to 0.8 by adjusting I_1, I_2 while V_R is 100v

continously Adjusting Vs

2) Take the readings of V_s, I_R, P_R, I_s, V_R, Pf.

3) Draw The circle diagram

4) Ensure Xc is kept at max and close the switch

5) increace Ic to Achieve $V_s = V_R = 100v$

6) Calculate the VAR injected by Xc

7) Explain why Is increases after shunt compensation.

Before	Compensating					after			
Vs	I_R	P_R	I_s	VR	pf	Xc	I_C	Pf	I_L
99.5	0.442	20.5	0.5	94%	0.813	100 VAR	0.37	0.98	0.43

(2)

VAR injected By Xc = 100 VAR

?.

Conclusion of this part:- we preformed compensating with and without load

We are doing the compensation because at no load or Light loads the out volt is smaller than the input and to maintain it we use compensating

* in the no load The load is capacitive so we use an inductive compensating ... as it's shown in the First and secound table VR was bigger than Vs at no load and after the compencting it's closer to each other

* we can use capacitors to compensate if The power factor isn't high enough
* also we can use Compensation to increace V_R when it isn't equall to VR

* I_s increaces after the shaunt compensation Because we are aiming to achive The resonanee, at the resonance I_s is max.

circle diagrame −4

Conclusion −1

R, L, C −2

EXP 4

Done by : إحسان العبادي 0134069

7

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الأربعاء

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Five Apple

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reading $\boxed{S_1 = S_2 = 0 , S_3 = 1}$

- $V_{st} = 225$, - $V_{rs} = 225$ $V_{rt} = 223$
- $V_s = 220$, - $V_o = 122.7$ $V_r = 95.9$
- $V_f = 95.5$, $I_r = 0.72$ $I_s = 1.15$
- $I_t = 1.62$ $I_{rj} = 0$ $I_j = 1.64$

$\boxed{2-}$ reading at $\boxed{S_2 = S_3 = 1 , S_1 = 0}$

- $V_{st} = 225$, $V_{rs} = 225$ $V_{rt} = 223$
- $V_o = 127$, $V_r = 99.6$ $V_f = 0.13$
- $I_r = 1.1$, $I_s = 1.14$, $I_t = 0.25$

$I_{ej} = 2$, $I_{rj} = 2$ $I_j = 0.29$

$\boxed{3-}$ with $R_J = 50$ $\boxed{S_2 = 2\ S_1 = 0\ S_3 = 1}$

- $V_{st} = 225$, $V_{rs} = 225$, $V_{rt} = 223$
- $V_o = 126.2$, $V_r = 99$, $V_f = 0.15$
- $I_r = 1.1$ $I_s = 1.12$ $I_t = 0.42$
- $I_{ej} = 1.98$ $I_{rj} = 2.25$ $I_j = 0.37$

Part B reading : Power system with neutral earthed through a resistance:

$\boxed{1-}$ $\boxed{S_1 = 1\ \#\ S_2 = S_3 = 1}$

- $V_{rs} = 225$, $V_{rt} = 225$ $V_{st} = 223$
- $V_i = 99.8$, $I_t = 2.8$, $I_s = 1.14$
- $I_r = 1.08$, $I_{rj} = 2.53$ $I_{cj} = 1.87$
- $I_j = 2.75$

$\boxed{2-}$ $\boxed{S_1 = 1\ \ S_2 = 2\ \ S_3 = 1}$

$V_{st} = 225$ $V_{rt} = 225$ $V_{rs} = 223$

$V_o = 122.8$ $V_r = 96.1$ $V_f = 95.5$

$I_r = 0.83$ $I_s = 1.17$ $I_t = 1.65$

$I_{cj} = 1.66$ $I_j = 1.65$

Part (C) Power system with neutral earthed through a reactor:-

$\boxed{1.}$ $\boxed{S_1 = 2\ \ S_2 = S_3 = 1}$ $\boxed{L_o\ max}$

- $V_{st} = 225$ - $V_{rt} = 225$ $V_{rs} = 223$
- $V_o = 122.8$ - $V_r = 96.1$ $V_f = 45.5$
- $I_r = 0.73$ - $I_s = 1.17$ $I_f = 1.65$
- $I_{ej} = 1.66$ - $I_j = 1.65$

$\boxed{2.}$ $\boxed{L_o\ min}$ $I_{Lmi} = 0.35$

- $V_{st} = 225$ $V_{rs} = 225$ $V_{rt} = 223$

$V_o = 126.2$ $V_r = 99$ $V_f = 0.15$

$I_r = 1.1$ $I_s = 1.12$ $I_t = 0.42$

$I_{ej} = 1.98$ $I_{rj} = 2.25$ $I_j = 0.37$

ussion and Conclusion :-

he relation between I_{cJ} for all position of S_2 :-

1) when $S_2 = 0$, $S_1 = 0$, $S_3 = 1$ $I_{cj} = 0$; No current will flow because a sum of currents equal = 0.

2) when $S_3 = 1$ $S_2 = 1$ → $I_{cj} = 2.26$, In this while $S_1 = 0$
$I_{cJ} = I_J = 2.6$

3) when $S_3 = 1$, $S_2 = 2$ $S_1 = 1$
$I_{cJ} = 0.99$ A while $I_j = 1,42$ A there are almost equal

4) when $S_3 = 1$ $S_2 = 1$ $S_1 = 1$
$I_J = 2.72$, $I_{cj} = 1.87$, $I_{rj} = 2.53$
so $I_J = I_{cj} = I_{rj}$

B) - $V_r = 1.4$ in $S_1 = 0$, $S_2 = 0$ $S_3 = 1$ with Isolated neatural.
- $V_r = 50$ with $R_3 = 50$, $S_1 = 0$ $S_2 = 1$ $S_3 = 1$
- $V_r = 105.5$ $S_1 = 1$ $S_2 = 1$ $S_3 = 1$ with reactor.

- from all number above we can say that the voltage with neatural is small too because $\Sigma = 0$
- for Resistance + Inductuance · Grounding V_r is bigger because summation of voltages not equal to ZERO

C) when we add maximum L we reduce the fault current
I_{rj} = Pure Inductive + I_{cj} = is Pure capacitive
; becuse they are subtract each other + they not equal exactly

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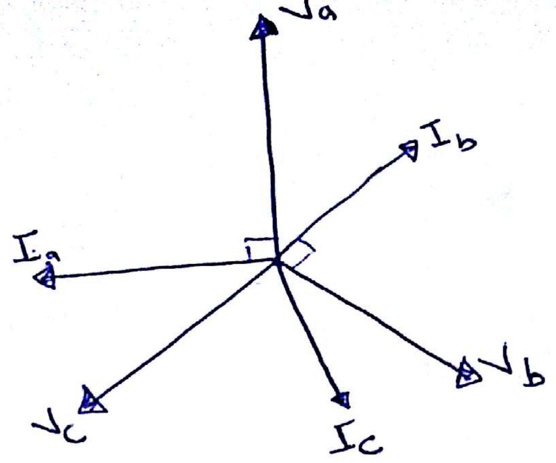
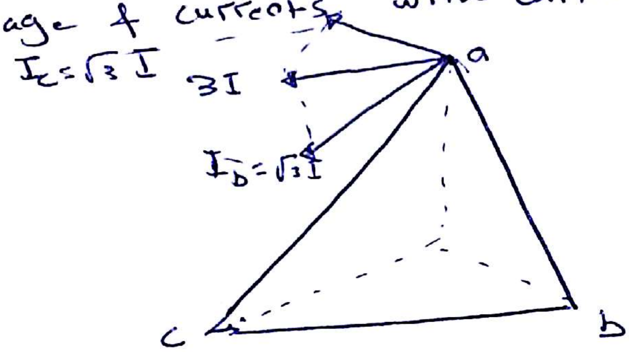
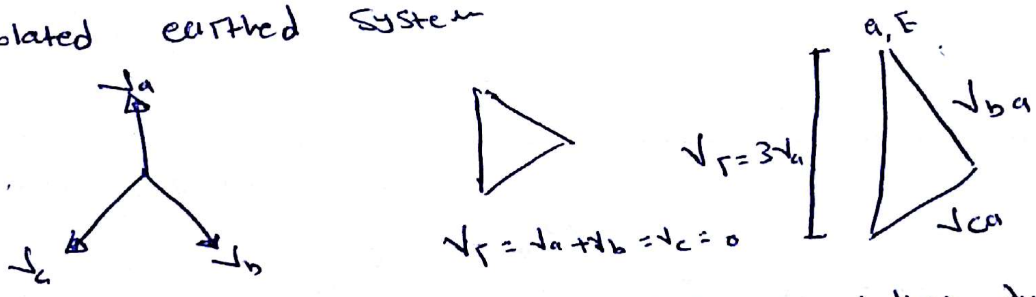
balance load conditions the currents and voltages shown in Fig 1-b & $V_n = V_E$ n: neatural E: earth



* The voltage & currents with earth fault on phase a



* Figures during healthy and faulted conditions for an Isolated earthed system



— normal condition

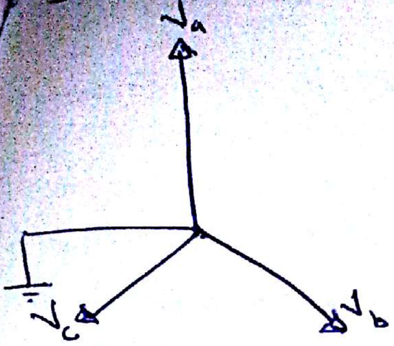
$V_r = V_a + V_b + V_c = 0$

- normal condition

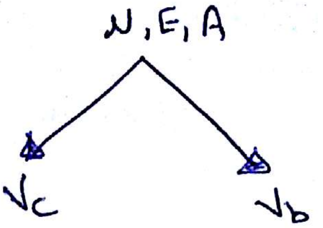
Voltage during fault condition

$V_r = V_a + V_b + V_c = 3V_a$

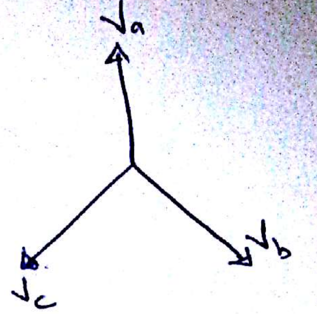
... solidly earthed system.



- Voltage during healthy condition



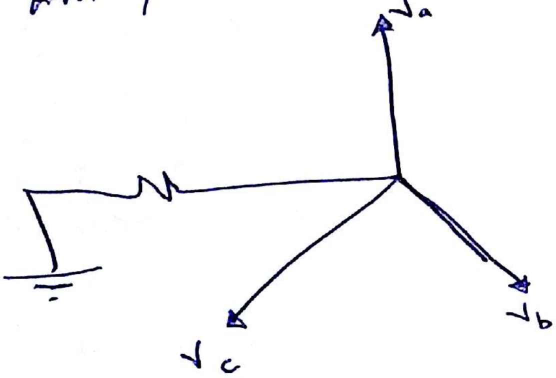
+ Voltage during a zero resistance fault on phase a



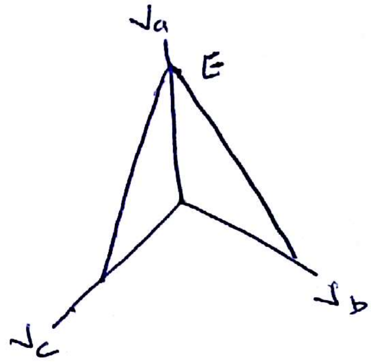
- Voltage during a high R fault on phase a

---

* Voltage during healthy + fault condition on a system earthed through resistance

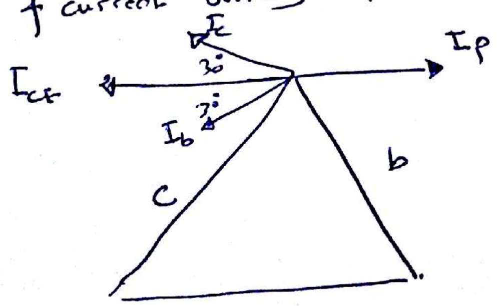


* Voltage during healthy condition



+ during a high R fault in phase "a"

Voltage + current during fault in phase a



$I_f + I_{CF} + I_P = 0$

Since $I_{CF} + I_P = 0$

then $I_F = 0$

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+ Conclusion :-

...ice following things during exp :-

... is connected to an open delta Transformer to get rid of an residual voltages

(2) when a switches is set to ZERO position it's means that point left is unconnected.

(3) In the final part when we have a minimum fault current, this mean that the cct will act as reasonanse circuit

(4) when a fault occurs in part II we notice that the values of the currents, are no longer balanced but instead value will rise however, the increased, current is small enough for the system to work satisfactorily and so the fault does not have to be clear Immediatly

(5) In the 2nd part we first ground the neatural through a reactance + so it's value excussive, this lead to high value of fault current

(6) In the last part, the value of Lo is adjusted until we obtain a minimum fault current that is the cct becomes a reasonace cct.

Experiment no. 5

Instantaneous Measuring Relays
for ac type RXIG, RXEG

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65/10

OBJECTIVES

- Recording the operating and resetting values for RXEG 2, RXIG 2 relays.
- Determining the power consumption of the measuring circuit
- Recording the pickup times of RXEG2 relay

THEORY

Description of The Relays :

An auxiliary dc supply is needed because both relays are designed to work for both 50-60 HZ alternating current supply. They are also calibrated for operation at both max & min values. The output is an auxiliary electromagnetic relay.

Current Relay RXIG2:

It can be used as a short cct protection for direct-on-line-started induction motor since it's insensitive to the dc component of the short cct current.

Providing an air gap in the input transformer achieve the above mentioned characteristic, and also makes the relay suitable for measuring ac current superimposed on dc current.

There's another type of this relay that is sensitive to the dc component. It could have a higher operating value at frequencies above the rated one, high overload capacity and a very high resetting ratio.

Voltage Relay RXEG2:

It can be used at frequencies up to 400 HZ with no variation in the operating Value. It's useful for monitoring ac voltage levels because of the high resetting ratio.

PROCEDURE

a) Operating Characteristics of The Current Relay RXIG2

a.1) Use a screwdriver to put the max marking to 1.
a.2) Connect the cct and ~~change~~ increase the voltage until the indicator flag drops. [cct in Fig 1]
a.3) Enter the ammeter reading in Table 1.
a.4) Repeat for relay settings to 1.5 & 2.
a.5) The indicator flag must be reset by hand

TABLE 1

Scale Factor X 2.5 A	Operating Value (A) Measured	Relay Data
1.0	2.48	2.5
1.5	3.78	3.75
2	4.98	5.0

b) Operating & Resetting Values of The Voltage Relay RXEG2

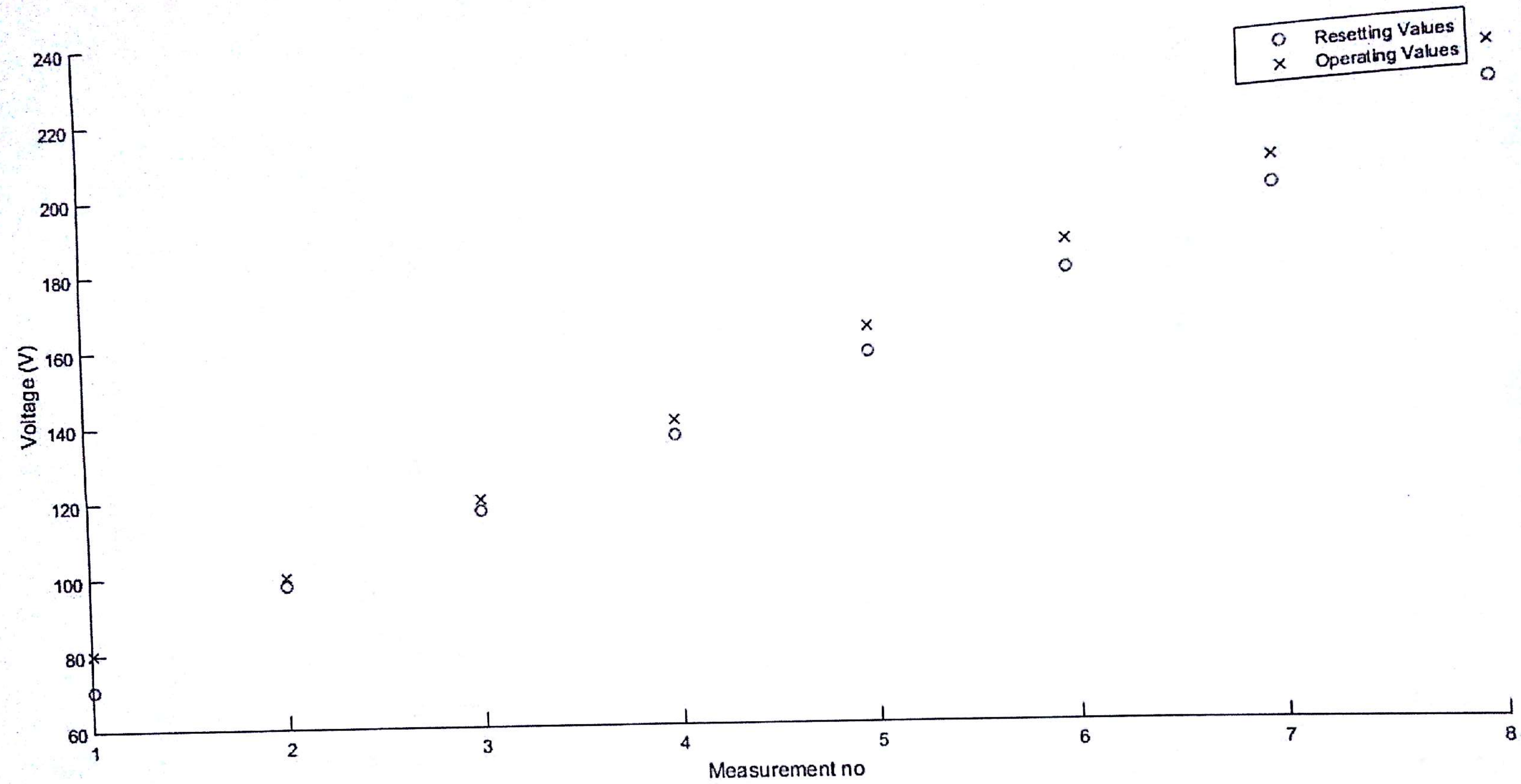
It's recommended to use a digital voltmeter since a voltmeter of extremely high quality should be used for a measurement to be worthwh[ile]

The signaling cct RXSF is supplied with dc auxiliary voltage from suitable terminals of the front panel of the relay unit.

b.1.) set up the cct in Fig 2.
b.2) Set scale factor to 1 on relay RXEG2.
b.3) Increase the voltage (using the rotary transformer) until signal relay RXSF indicates
b.4) Enter the operating Value in Table 2.
b.5) Reduce the voltage until the signal relay resets.
b.6) Enter the resetting value in the table.
b.7) Repeat steps 1.3 to 1.6 twice.
b.8) change the scale factor to 1.25 and perform all subsequent measurements as shown in the table.

Measurement no.	Set Value (V)	operating Value (V)	Resetting Value (V)	resetting ratio
1	1.0X80	80.1	70.3	0.878
2	1.25X80	100.2	98	0.978
3	1.5X80	120.1	117.1	0.975
4	1.75X80	140.2	136.1	0.971
5	2.0X80	163.6	157.2	0.961
6	2.25X80	184.9	177.6	0.961
7	2.5X80	203.4	196.4	0.966
8	2.75X80	227.5	218.4	0.96

* where Resetting Ratio = Resetting Value/Operating Value



Resetting Values
Operating Values
Voltage (V)
240
220
200
180
160
140
120
100
80
60
1
2
3
4
5
6
7
8
Measurement no

Copy?)

. Power Consumption ...

Use the same set up as for step b1. A digital voltmeter must be used connected directtly across the relay input

In this part we repeated steps b.2 & b.3 then measured current and voltage when scale factor (1 & 2 & 2.75)

Scale factor	V	I	S
1.0	78.9	0.08	6.312
2.0	161.6	0.16	25.856
2.75	227.2	0.22	49.98

TABLE (3)

d. Pick-up times

The pickup-time of RXEG is the time from the instant when the measuring input detects a voltage until completion of the contact movement of the output relay.

To measure pick-up time it is necessary to include an intermediate relay (RXME)

Operating times for RXME ...

TWo contacts one make and one break contact are connected the Parallel and to the input of the timer as shown in fig (3)

RXME is energized with switch s and the operating time on the timer is recorder

After repeated the measurement twice and read the value of time (ms) we calculated the mean value

Measurement	Time (ms)
1	9
2	7
3	11
Mean value	9

TABLE (4)

d.1 set up the circuit shown in fig (4)
d.2 Ensure that the rotary transformer in the Power supply unit is set to zero and close the main switch

d.3 Set the scale factor (1)
d.4 Increase the voltage from the rotary transformer to 88V
d.5 open the main switch, and reset the timer to zero

d.7 Repeat Points (d.5) and (d.6) twice

d.8 Increase the voltage to 120 and 200 V repeating the measurements

Measurement	Set voltage	test voltage	time (ms) read	corrected	Mea value (ms)
1	1.00 X 80	88	~~44~~ 41	32	32
2	1.00 X 80	120	39	30	30
3	1.00 X 80	200	32	23	23

Discussion & Conclusion

Part a)

Our measured & the actual relay data are very close with only a small error. Increasing the scale factor increases the current that the relay is set to, and hence the relay trips at higher currents.

Part b)

looking at the resetting ratios, we notice that they are very close to 1 (around 0.97 or so), which means that the relay operating & resetting value are close which leads to a sensitive relay. Also it's noticed that the resetting value is less than the operating value.

Part c)

We investigated the power consumed by the relay, this ~~depends~~ increases as the scale factor increases.

Part d)

The operating times of both RXME & RXEG2 is studied. The measured time is the operating time of both RXEG & RXME, ~~thus~~ therefor, to measure RXEG time we must include RXME and measure the time for both relays, and measure the operating time of RXME, then we can subtract the two values to find the operating time of RXEG.

The operating time of RXME is measured 3 times to reduce errors.

The operating time of the relay is in the order of 30 ms or less, and this number decreases as the test voltage increases (fault current increases). However, this is an instantaneous voltage relay, so this delay is not intended, and is due to mechanical issues.

Sources of Errors.

We notice a slight deviation between our measured and actual readings, and this is due to the following:

1. Human errors in performing the procedure and in reading the data.
2. Resistances of wires and other components, which causes voltage drops.
3. Errors in the measuring devices themselves
4. Wear in moving mechanical parts (like switches)

University of Jordan
Eelctrical Engineering DepartMent
Power Lap expermant # 6

* Done by : محمد رشاد قدومي

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8/10

18/1 الاربعاء

Introduction :

- our goal is to compare between electromechanical relay & Static Relay.
- operation of electromechanical relay based on Force between electromagnet & armature parts to open & close the circuit as shown in Fig.1

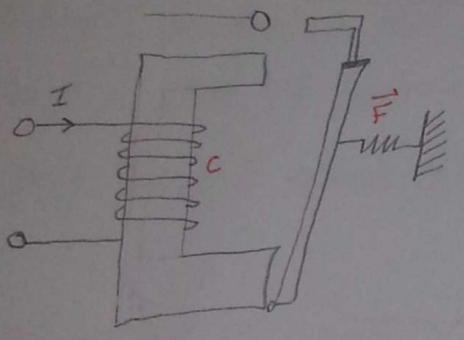


Fig.1

- we have 2 forces the spring force F & the electromagnetic force & the electromagnetic force depend on the amount of current I in the winding C, if the electromagnetic force exceedes the spring force then the contactes will open.

- electromechanical Relay have setting knob which adjust the tention of armuter spring the scale is graduated for operation with slowly increasing current

- the operating value depends on the rate of change of the current or voltage or whatever the Relay designed to work with, if the short circuit current have a dc componant the relay pick-up at the value of the a.c compont which is 50% approximetly.

* RXIG1 : The static Relay which block the dc component of short circuit current.

* RXIC : The electro Mechanical Relay.

* First we test the operating & Ressting value for booth Relay whithout any d.c component.

* RXIG2 :
static

No	Set value (A)	operating value (A)	Ressting value (A)	reseting Ratio
1	1.0 * 2.5	2.66	2.56	1.039 / or 0.962
2	2.0 * 2.5	5.2	5.11	1.017 / or 0.982

* RXIC1 :
electro Mechanical

No	Set value (A)	operating value (A)	Reseting value (A)	Reseting Ratio
1	1.25*2	2.2	1.2	1.83 / or 0.546
2	2.5*2	4.8	1.63	2.94 / or 0.339

In this part we Notic that the reseting ratio of the static Relay is larger than the electro Mechanical Relay.

* that Means thet the static Relay will be reday faster than the electro Mechanical Relay if another fault is happened.

* The resoen why the electroMechanical have a huge differeance between the operating & Reseting values that we need the spring to go bact to it's Normal possition & that Mean we have to remove the force that going a ginst it's tention so we need lower current so that the spring force f exceeds the electro Magnatic force.

*2_ power Consumption :

set value	operating value	voltag before operating	voltage after operating	before (VA)	After (VA)
1.0*2.0	1.81	0.36	0.54	0.652	0.9774

Table. 2 for RXIC1

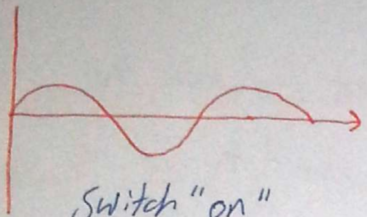
set value	operating value	voltage before operating	voltage after operating	before (VA)	after (VA)
1.0*2.5	2.69	0.56	0.6	1.5064	1.614

Table. 3 for RXIG2

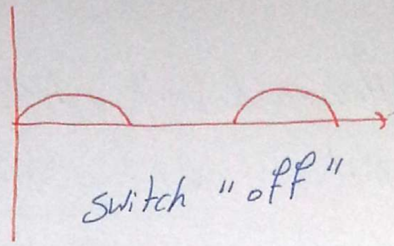
* electro Mechanical Relay Need (consume) power Mor than static Relay becouse we Need large current to generate force to exceed the spring force.

* The effect of Dc componant :

* we introdue the Dc componant by other Source connected in Series with a Switch so that



Switch "on"



Switch "off"

* we use 3 Ammeter (Ac, Dc & RMs) to get better indecation of what the different between the two Relays.

Set	Ac operating	Dc operating	RMs operating	Ac Resiting	Dc Reseting	RMS Reseting
1.25*2	1.09	0.93	1.5	0.12	0.06	0.02

Table. 4 the RXIG1 "electroMagnatic".

Set	AC operating	Dc operating	RMs operating	Ac Resuting	Dc Reseting	RMS Reseting
1.0*25	2.6	2.36	3.5	2.6	2.2	3.4

Table. 5 the RXIG2 "static".

$$I_{e\,RMS} = \sqrt{I_{Ac_{RMS}}^{2} + I_{d_{Rms}}^{2}}$$

* For RXIC2 :

$$\text{AC Reseting ratio} = \frac{0.12}{1.0.93} = 0.109$$

$$\text{Dc Reseting ratio} = \frac{0.06}{0.93} = 0.064$$

* For RXIG11 :

$$\text{Ac Reseting ratio} = \frac{2.59}{2.62} = 098$$

$$\text{Dc Reseting ratio} = \frac{2.2}{2.36} = 0.932$$

* So the static Relay effected by the Dc componant but the electro Mechanical Relay see the fault & the Dc componat So it's Not effected by the Dc.

Conclusion

Introduction

Experiment No#7

Time-lag Over-Current Relay

RXIDE-41

students:

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- Muath
- Ala' Awwad
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6/10

المهندس

Objective

To explore the inverse & instantaneous operation of a relay, and its current & time settings.

Procedure

1) Operating and Resetting Values for starting function without tripping function.

Measurement no.	set Value (A)	operating value(A)	Resetting value(A)	resetting Ratio(%)
1	0.5X4	1.95	1.82	93.3
2	0.75X4	2.93	2.75	93.86
3	1.25X4	4.89	4.56	93.25

where Resetting Ratio = Resetting Value / operating Value

The resetting ratio is about 93.3%.

-) Inverse Time Curves

TABLE2: set current 0.5x4 = 2 A set time factor K = 1.)

Measurement No.	Measuring Current(A) I	I_R	I/I_s	Measured Time (m Sec)
1	4	0.4	2	14.68
2	8	0.8	4	4.88
3	12	0.8	6	2.73
4	16	0.8	8	1.92
5	20	1	10	1.49

TABLE4: Set current 0.5 x 4 = 2 A , set time factor K=0.5
when K was reduced, the measured time decreased.
So K is directly proportional to K

Measurement No.	Measuring Current(A) I	I_R	I/I_s	Measured Time (msec)
1	4	0.4	2	6.3
2	8	0.8	4	2.18
3	12	0.8	6	1.34
4	16	0.8	8	0.97
5	20	1	10	0.75

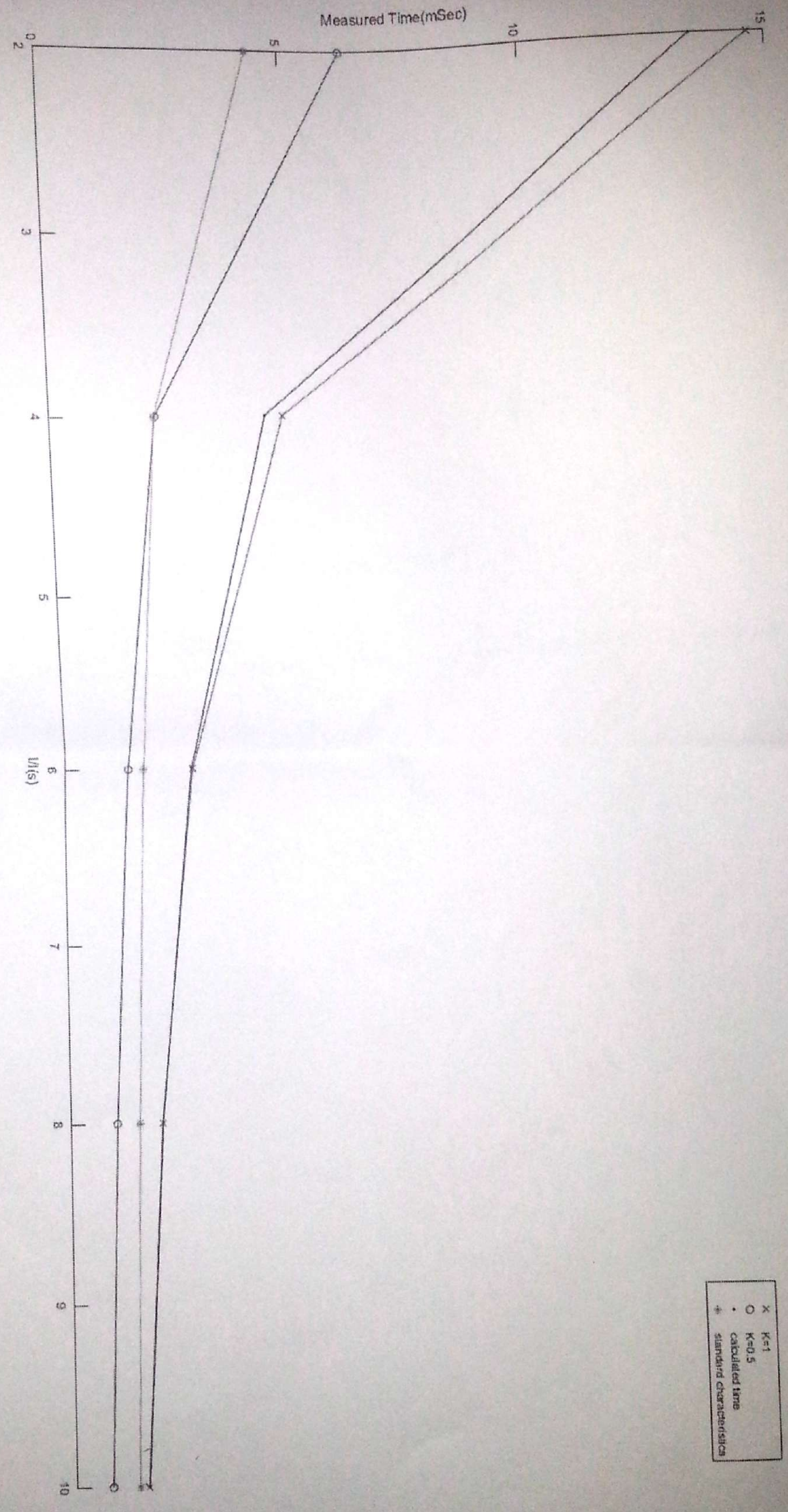
The following operating times were calculated from

$$t = \frac{13.5}{\frac{I}{I_s} - 1}$$

I/I_s	T (calculated time)
2	13.5
4	4.5
6	2.7
8	1.93
10	1.5

Time calculated from the above equation and the standard characteristics ($t = \frac{3}{\log PSM}$) are plotted as well as the measured data.

From the graph we can see that the time calculated using standard characteristics is less than that of $t = \frac{13.5}{\frac{I}{I_s} - 1}$


Measured Time(mSec)
0
5
10
15
2
3
4
5
6
7
8
9
10
I/I(s)
K=1
K=0.5
calculated time
standard characterisitcs

...stantaneous Operation.

Instantaneous Setting B

current instantaneous operation (A)

$2 \times I_s$

$(2)(0.5)(1.1) = 1.1$

$3 \times I_s$

$3(0.5)(1.1) = 1.65$

$4 \times I_s$

$4(0.5)(1.1) = 2.2$

$8 \times I_s$

$8(0.5)(1.1) = 4.4$

we noticed that both flags operated together, which means that increasing the current setting increase the instantaneous operation current.

Conclusion?