Experiment 1

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Verification of Overcurrent Relay characteristics.

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3.) Assessment and Observations:

IEEE MI (Moderately Inverse) and VI (very Inverse). curves

→ TMS = 1.25 → less deviation between observed and calculated data comparison.

→ TMS = 0.7, at high PSM, → larger deviation.

→ If there is increment in PSM then time of operation even increases.

- For both cases, operating time at particular PSM is higher when TSM = 1.25 than 0.7.
  {Increase in TMS increases operation time.}
- TMS = 1.25 at lower PSM, operation time for MI is smaller than VI. But as PSM increases, difference becomes smaller.
- Similar observation in TMS = 0.7 But smaller dimension.
- All are inverse initially and approach definite minimum operation time with PSM increasing.

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4.>
To improve Relay's performance:

- Numerical relay protection shares common function, may lead to common failure. Thus, use backup relays

- Use externally-sourced transient interferences such that they don't affect conventional technology of numerical relay.

- Provide cyber security to relays to avoid hacking risk.

1.> IEEE VI curve.

(i) $K = 19.61$, $\alpha = 2$, $L = 0.491$

$I_{pickup} = 1A$ (primary side).

$TMS = 1.25$

operating time $\Rightarrow t = TMS\left(\frac{K}{\left(\frac{I}{I_{pickup}}\right)^2 - 1} + L\right)$

$$t = 1.25\left(\frac{19.61}{I^2 - 1} + 0.491\right)$$

Verify: $I_a = 4.5205A$

$t_{on} = 1.707s$ (tripping time)

$t_{cal} = 1.875s$

$t_{on} \approx t_{cal}$ thus, verified.

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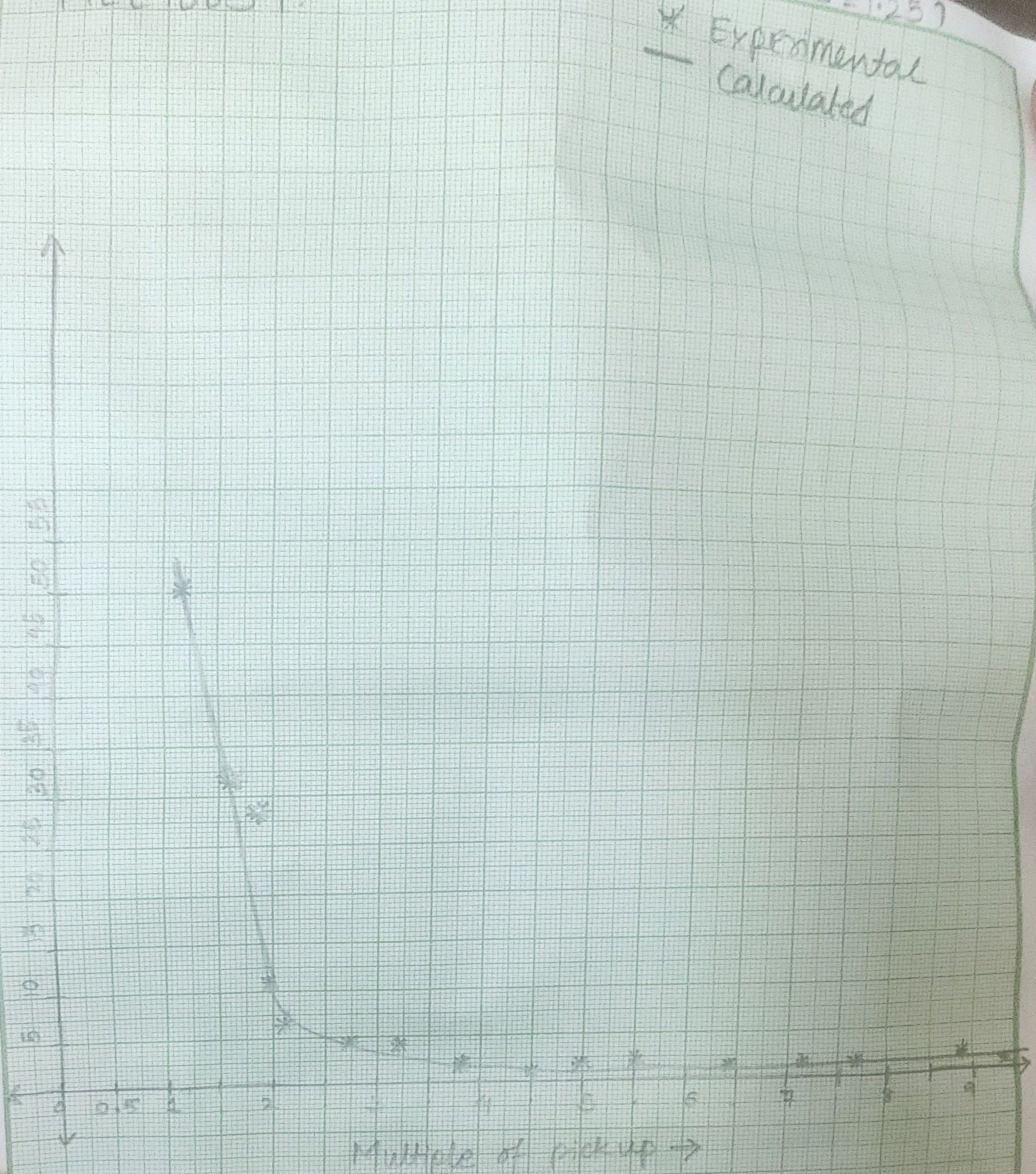

Gopal outline Map & Graph
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1.> IEEE VI curve.

(ii) $K = 19.61$, $\alpha = 2$, $L = 0.491$

$I_{pickup} = 1A$, $TMS = 0.7$

$$t = 0.7\left(\frac{19.61}{I^2 - 1} + 0.491\right).$$

Verify: $I_a = 3.2063A$.

t_obs = 1.8229 s
t_cal = 1.8228 s. } almost same.

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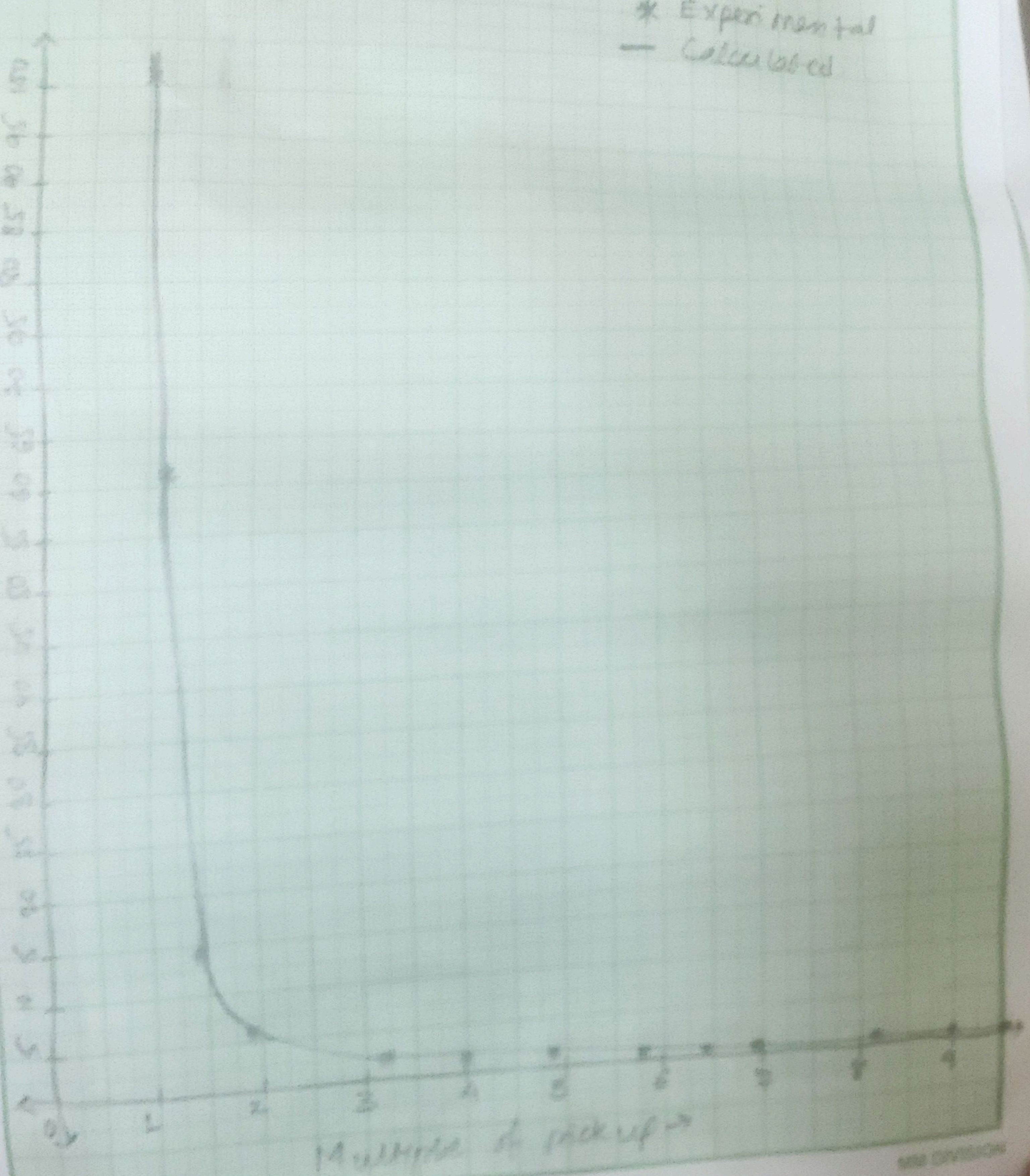
IEEE VI (TMS=0.7)



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1.)
(iii) IEEE MI curve.

$K = 0.0515$, $\alpha = 0.02$, $L = 0.114$

$I_{pickup} = 1 A$ (primary side)

$TMS = 1.25$

$$t = 1.25\left(\frac{0.0515}{I^{0.02} - 1} + 0.114\right)$$

Verify: $I_a = 2.0538\ A$

$t\_obs = 4.7783\ s$

$t\_calc = 4.5828\ s.$ } almost same.

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IEEE MI curve TMS 1.25

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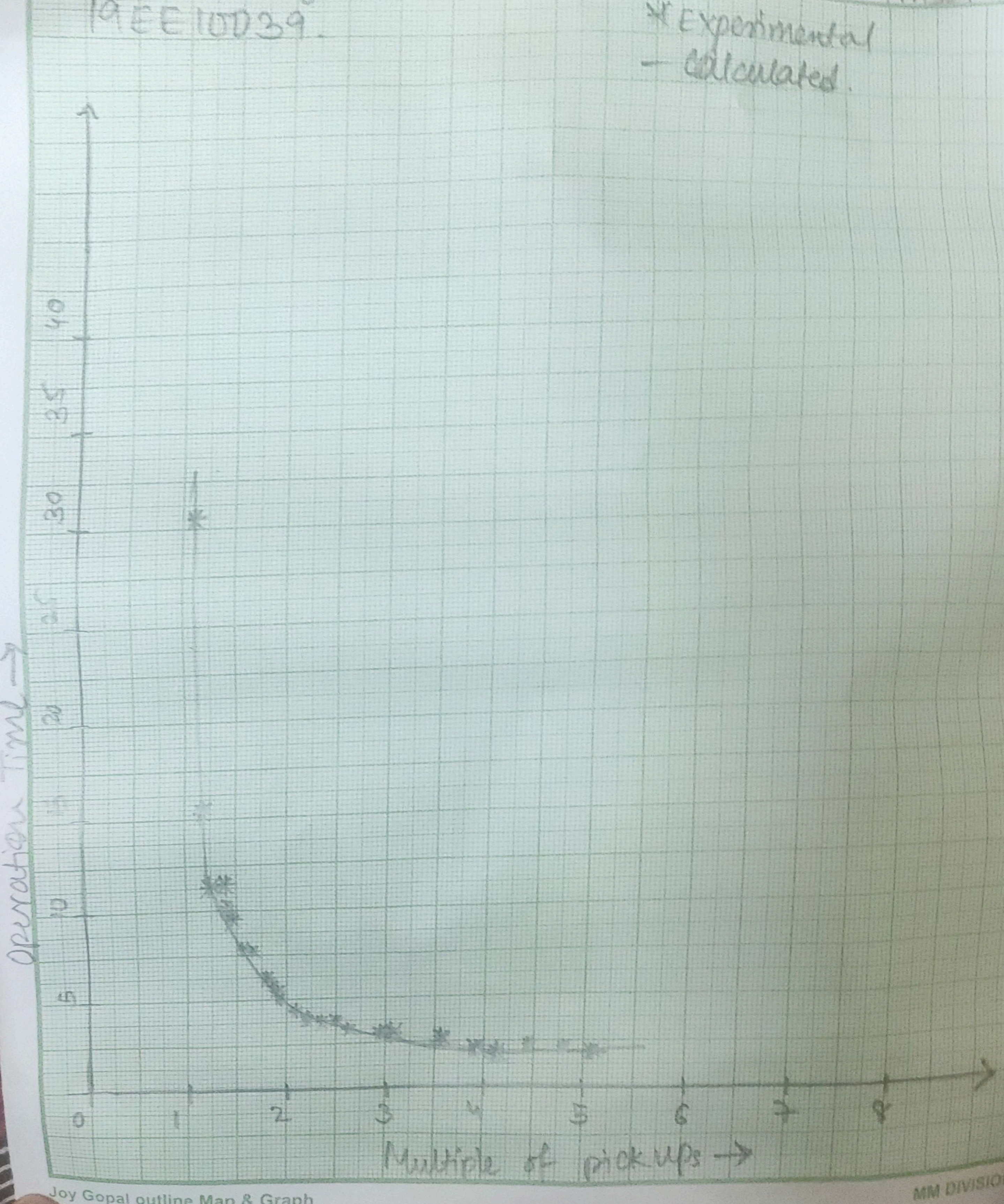

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1.)
(iv) IEEE MI curve.

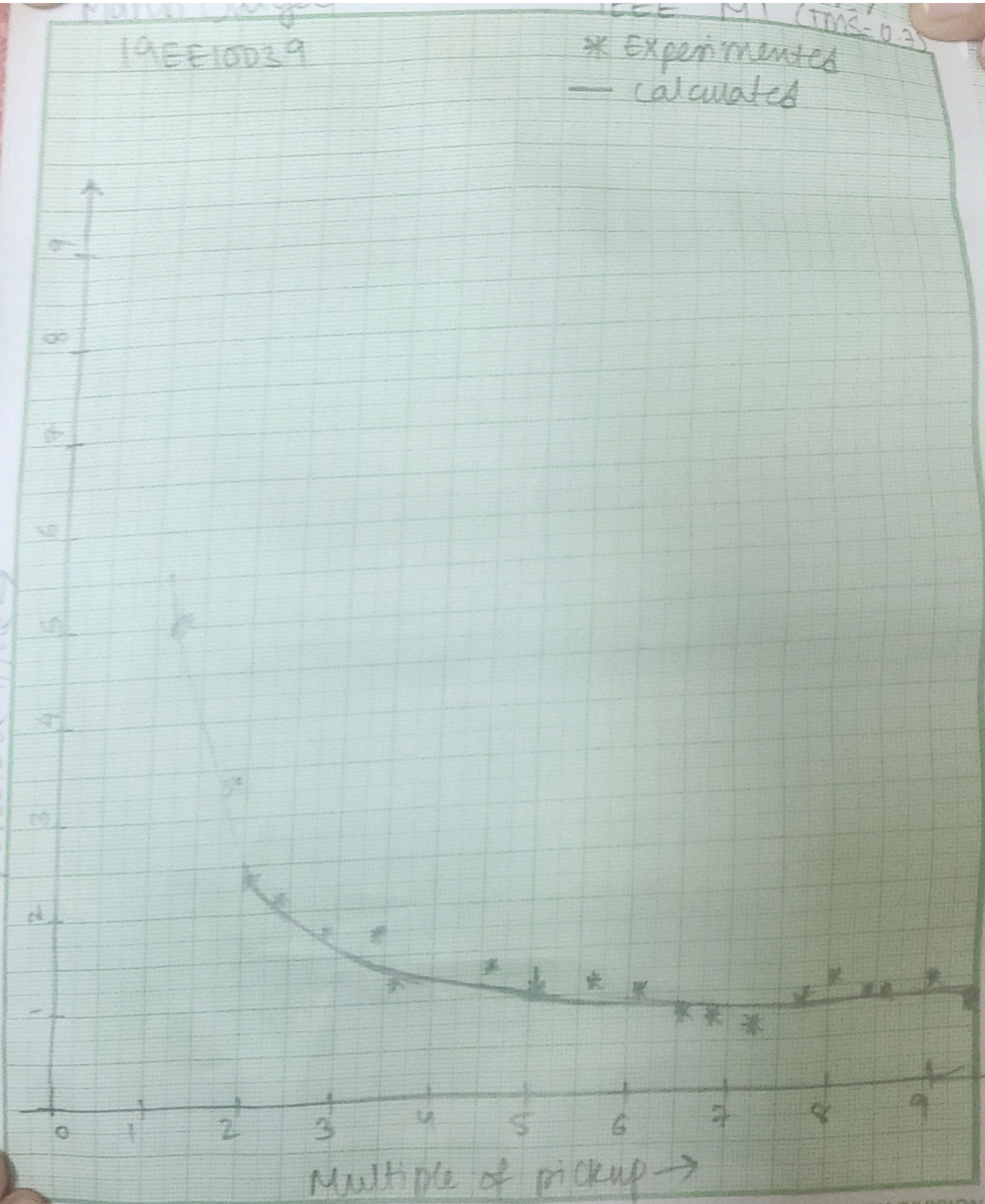
$K = 0.0515$, $\alpha = 0.02$, $L = 0.114$.

$I_{pickup} = 1A$, TMS = 0.7.

$$t = 0.7\left(\frac{0.0515}{I^{0.02} - 1} + 0.114\right).$$

Verify: $I_a = 4.6637$ A

$\left.\begin{array}{l} t\_obs = 1.3339 \text{ s} \\ t\_calc = 1.2325 \text{ s} \end{array}\right\}$ almost same.



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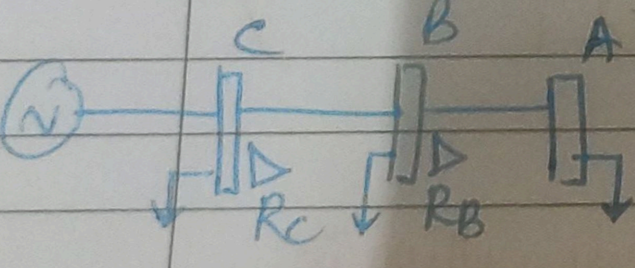
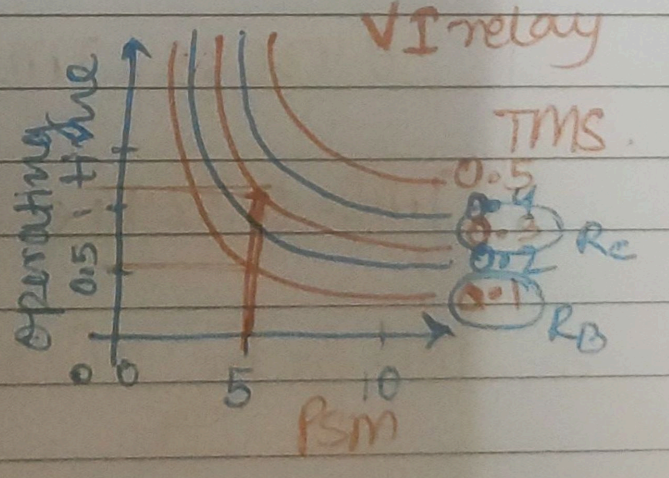
5.)

R_B and R_C have CTs of 100:5. Max fault current at bus B = 800 A. I_{pickup} = 8A for both relays. R_B is set with TMS = 0.1 and R_C has TMS = 0.3. if time of coordination = 0.3 s.





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for R_B;

max. fault current $= \frac{800}{(100/5)} = 40A$.

$TMS = 0.1$

$PSM = \frac{I}{I_{pickup}} = 40/8 = 5$.

trip time.

$t = \left(\frac{19.61}{5^2-1} + 0.491\right) * 0.1 = 0.13085s$.

$t_{coordination} = 0.3$.

for R_C;

trip time

$t = 0.13085 + 0.3 = 0.43085s$.

If R_B fails to break,

then I_{fault} at $C = 40A$.

$PSM = 40/8 = 5$.

$0.43085 = TMS\left(\frac{19.61}{5^2-1} + 0.491\right)$

$\therefore TMS = 0.3294s$

$\therefore$ TMS for R_C $= 0.3294$ > 0.3, thus Setting is Wrong!

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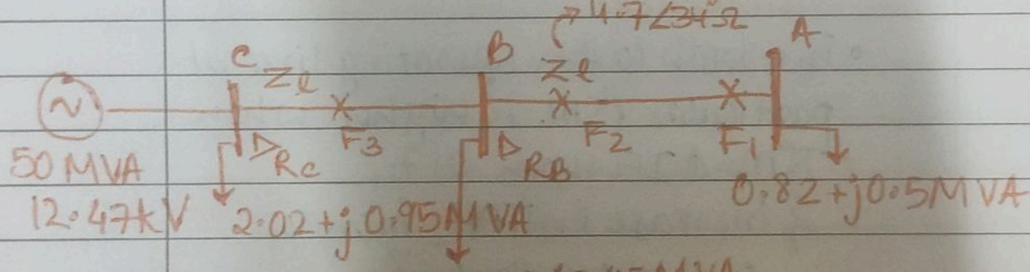
6.) 12.47kV distribution system, with Relay R_B and R_C as IEEE Very Inverse (VI) curve and coordinated with time interval 0.3s. CTs for R_B and R_C are of 100:5 and 200:5 respectively. Phase A to ground faults at F_1, F_2, F_3, with fault resistance of 9Ω.

Relays	I_{pickup} (A)	TMS
R_B	79	0.1
R_C	162	0.4



$$t = \left\{ \frac{19.61}{(I/I_{pickup})^2 - 1} + 0.491 \right\} TMS$$

Roll number: 19EE10039

$\boxed{R_f : 9\Omega}$

Fault at	F_1		F_2		F_3	
Relays	R_B	R_C	R_B	R_C	R_B	R_C
I (A)	151.9	179.1	170.8	197.1	39.92	224.6
t(s) stimulation	0.7766	35.4	0.583	16.54	$I<I_{pickup}$	8.707
t_{ref} (s) Std curve	0.7762	35.489	0.5828	16.529	-	8.7025