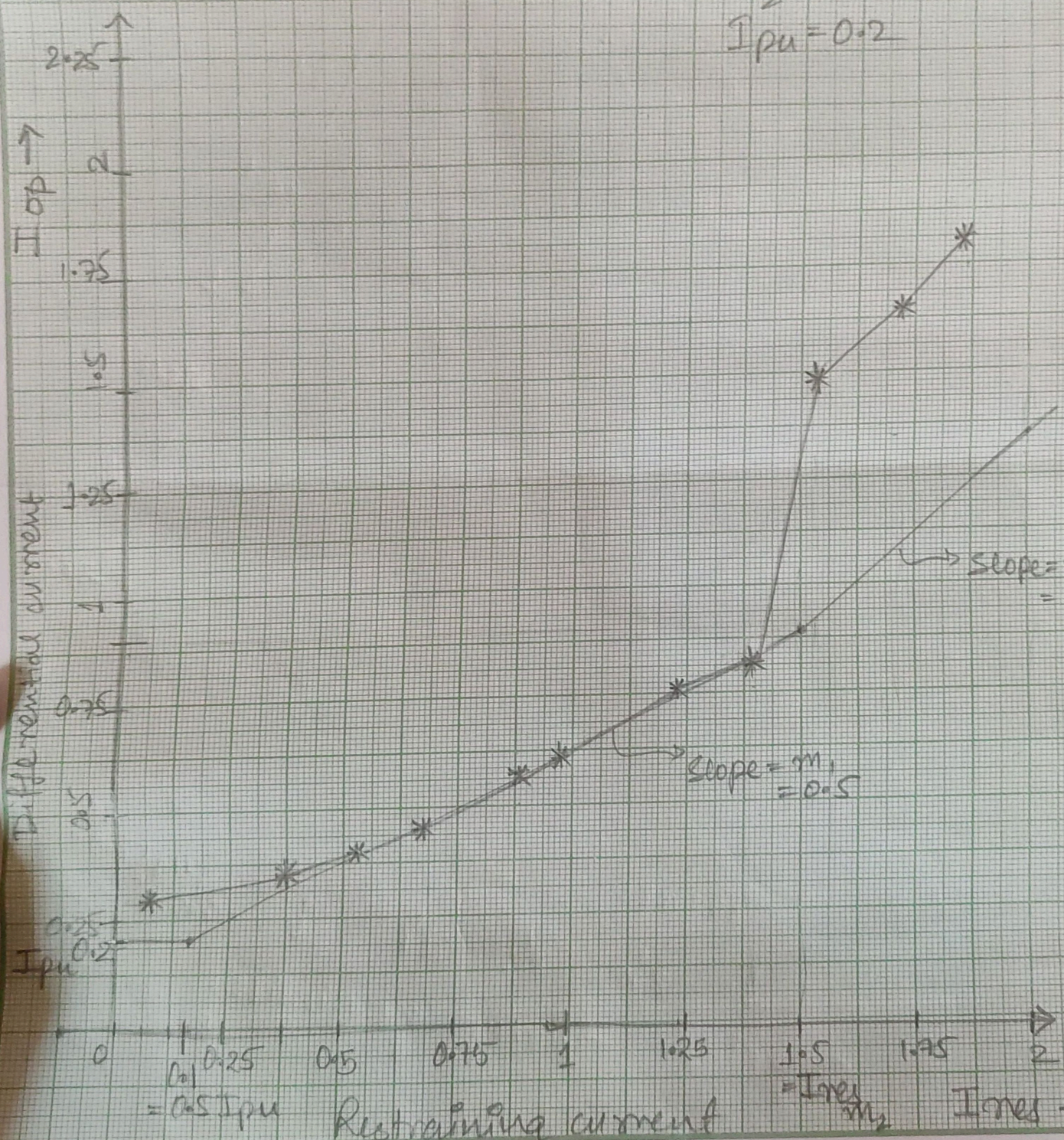
Mansi Uniyal. Dataset 1.

19EE10039.

* Experimental
— Calculated.

Scale
X axis: 1 unit = 0.125 Apu
Y axis: 1 unit = 0.125 pu

$m_1 = 0.5$
$m_2 = 0.9$
$I_{pu} = 0.2$

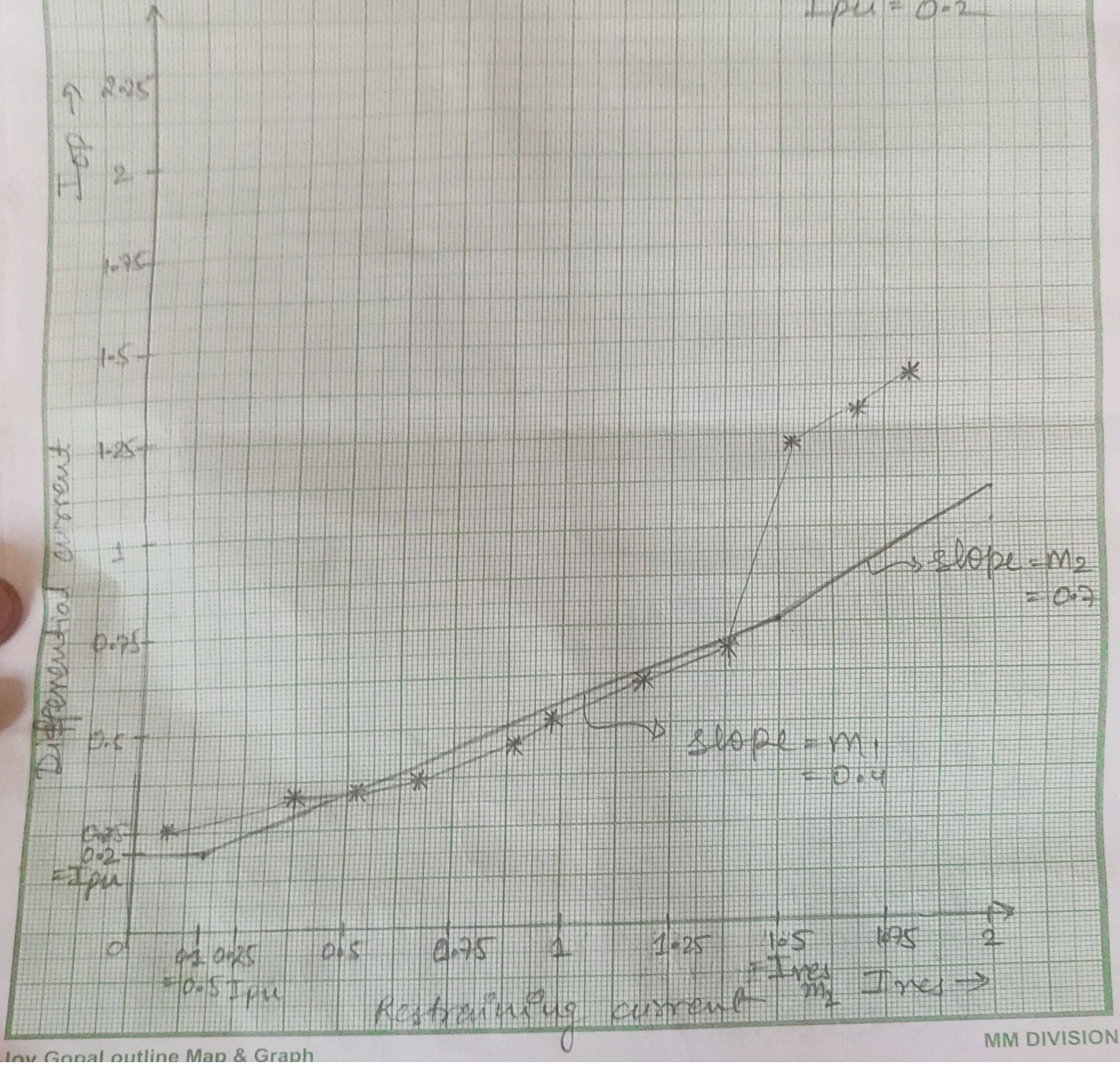


Manit Uniyal
19EE10059

Dataset 2:
* experimental
— calculated.

Scale
x axis: 1 unit = 0.125 pu
y axis: 1 unit = 0.125 pu

$m_1 = 0.4$
$m_2 = 0.7$
$I_{pu} = 0.2$



Experiment

Mansi Uniyal
19EE10034

__/__/____

Verification of percentage biased differential relay characteristics for Transformer Protection.

3. Assessment:

Dataset 1 ($m_1=0.5, m_2=0.9, I_{pu}=0.2$)

For low I_{res}, datapoints are above reference characteristic ie in trip zone. For $I_{res} \in (0.5-1.5A)$, they are just below reference curve, making normal operation condition. For high I_{res}, they are well above curve ie. in trip zone.

Dataset 2 ($m_1=0.4, m_2=0.7, I_{pu}=0.2$)

For low I_{res}, datapoints are just above reference characteristics ie trip zone. For $I_{res} \in (0.5-1.5)$, they are just below the curve, operating at normal condition. For high I_{res}; they are well above curve in trip command.

Comparison: For dataset 1 slope m_1 is higher, which means more points in block region. Thus more points at normal condition are allowed: high security but low reliability of dataset 1 over dataset 2. Experimental dataset 1 are closer to reference curve.

Mansi Uniyal
19EE10039

__/__/____

4. Improve performance

Relay will perform FFT analysis of differential current. It will compare different harmonics to fundamental component to prevent unnecessary tripping due to inrush or over-fluxing.

For example, if differential current is higher than reference current, but ratio of second harmonic to the fundament component of differential current is greater than 17%, then the relay should consider this as an inrush and thus should not trip unnecessarily.

5. For given transformer relay

$$\frac{5^{th} \text{ harmonic component}}{\text{fundamental differential current}}$$

$$= \frac{I_5}{I_1} = 41\% > 30\%.$$

6. Case of overfluxing or overexcitation.

(C)

Mansi Uniyal
19EE10039

6. Transformer rating:
37.5 MVA, 220 kV/11 kV.
Relay setting:
$I_{pu} = 0.2$, $m_1 = 0.5$, $m_2 = 0.9$

$$I_{ref\,HV} = \frac{S_{ref}}{\sqrt{3}\,V_{nom\,HV}} = \frac{37.5 \times 10^6}{\sqrt{3} \times 220 \times 10^3}$$

$I_{ref\,HV} = 98.41\,A$
$I_{ref\,LV} = 1968.24\,A$

Case 1: $I_1 = 76.84 \angle -17.92°$
$I_2 = 420.02 \angle 145.5°$

$$I_{op} = \left| \frac{I_1}{I_{ref\,HV}} + \frac{I_2}{I_{ref\,LV}} \right| = 0.5795\,A$$

$$I_{res} = 0.5\left(\left| \frac{I_1}{I_{ref\,HV}} \right| + \left| \frac{I_2}{I_{ref\,LV}} \right| \right)$$

$= 0.4971\,A.$

$I_{op}' = 0.15 + 0.5 \times 0.4971$
$= 0.39855\,A.$

$I_{op} > I_{op}' \Rightarrow$ Internal fault.

Monis Uwiyed
19EE1D039.

Case 2 $I_1 = 48.35 \angle -20.66°$

$I_2 = 955.78 \angle 160.9°$

$$I_{op} = \left| \frac{I_1}{I_{ref\,HV}} + \frac{I_2}{I_{ref\,LV}} \right| = 8.306\ mA$$

$$I_{res} = 0.5 \left(\left| \frac{I_1}{I_{ref\,HV}} \right| + \left| \frac{I_2}{I_{ref\,LV}} \right| \right)$$

$= 0.4882\ A$

$I_{op}' = 0.15 + 0.5 \times 0.4882$

$= 0.3941\ A$

$I_{op} < I_{op}' \Rightarrow$ not internal fault
external fault

Case 3. $I_1 = 49.51 \angle -17.9°$

$I_2 = 426.12 \angle 148.5°$

$$I_{op} = \left(\left| \frac{I_1}{I_{ref\,HV}} + \frac{I_2}{I_{ref\,LV}} \right| \right) = 0.2969A$$

$$I_{res} = \left(\left| \frac{I_1}{I_{ref\,HV}} \right| + \left| \frac{I_2}{I_{ref\,LV}} \right| \right)$$

$= 0.3598\ A.$

$I_{op}' = 0.15 + 0.5 \times 0.3598$

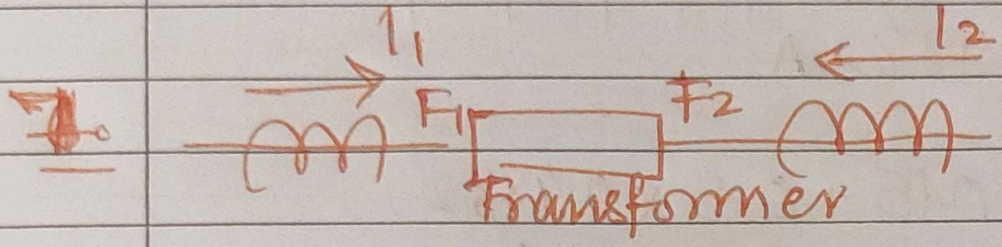
$= 0.3299\ A.$

$I_{op} < I_{op}' \Rightarrow$ no fault / external fault
not negligible

Mansi Uniyal
19EE10039

__/__/____

	I_1(A)	I_2(A)	Fault	Justify
Case 1	$76.84\angle -17.92^\circ$	$420.02\angle 145.5^\circ$	Internal	$I_{op} > I_{op}^{\circ}$
Case 2	$48.30\angle -20.66^\circ$	$955.78\angle 160.1^\circ$	External	$I_{op} < I_{op}^{\circ}$
Case 3	$49.51\angle -17.99^\circ$	$426.12\angle 148.5^\circ$	External	$I_{op} < I_{op}^{\circ}$



Fault Resistance = 9Ω.

Current (pu)	F_1	F_2	F_3
I_1	129.8	0.6908	0.6908
I_2	0.2068	0.2093	0.5085
I_{op}	129.6	0.4915	0.3549
I_{res}	65	0.4473	0.58
Remarks fault	Internal	Internal	External