Experiment 02: Verification of Percentage biased Differential Relay Characteristic for Transformer Protection

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Discussion:

A graph between I_{op} and I_{RES} for unit values was plotted. We can observe the behaviour by comparing the theoretical model of dual slope differential relay with the experimental data points.

For Case I, the theoretical model follows the path of experimental data points for the lower values of Ires and the difference (error) is very small which is under experimental permissible error margin. As the Ires value increases, the difference between the two curves widens considerably as the experimental plot assumes a near exponential form which can be attributed to the saturation of magnetic core.

Similarly for Case II, for lower values of I_{RES}, the theoretical model approximates the experimental data and the difference becomes considerable (significant) for high values of I_{RES}.

Relay performance can be improved by designing the relay as per specification of transformer, operating environment and proper testing. Current limit can be set for improving life expectancy. The operating timing & voltage must be mentioned with sufficient margin under permissible amount.

Percentage Biased Differential & Reference Characteristics

Case - II

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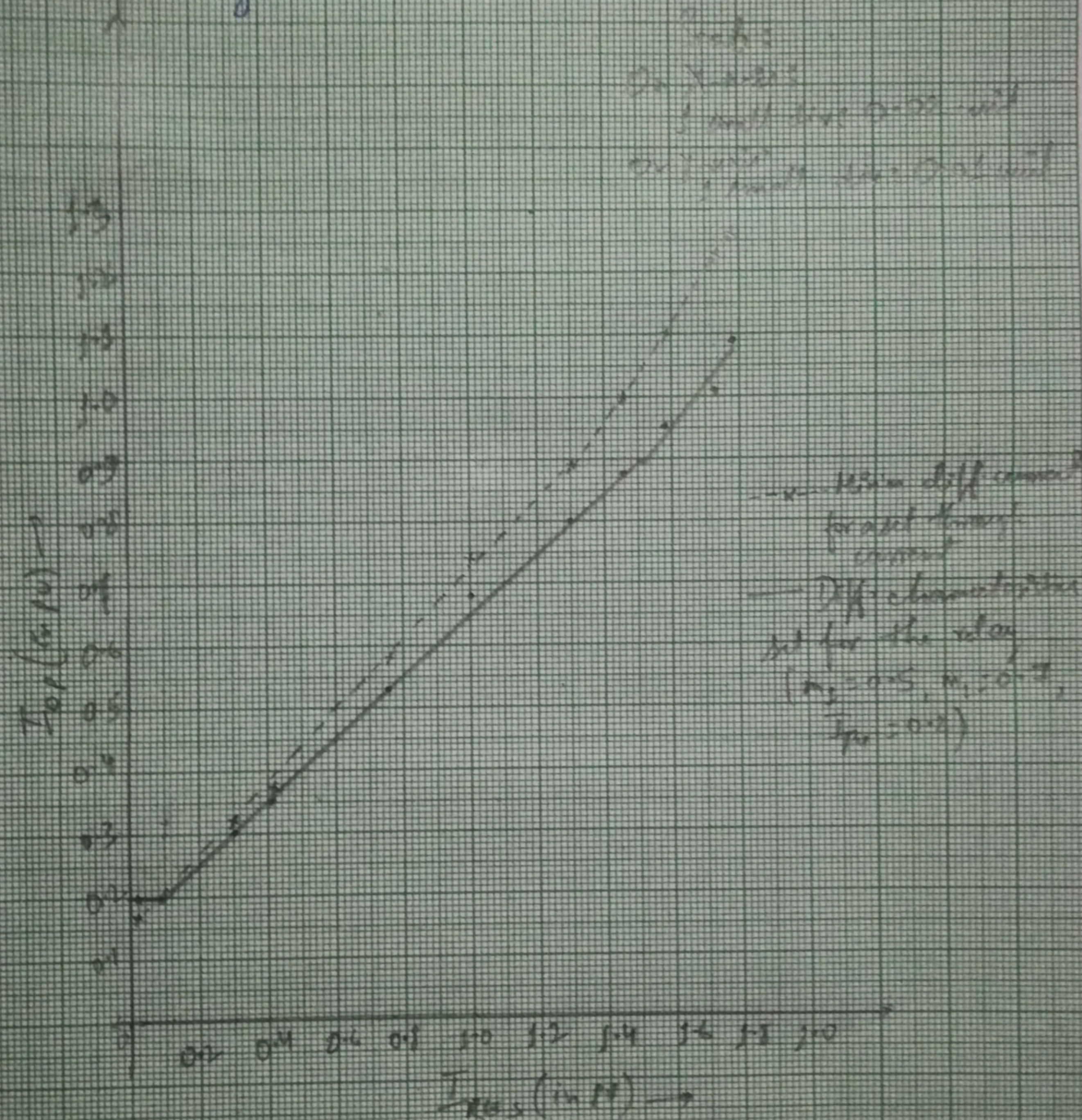

Percentage Biased Differential & Reference Characteristics

Case-II

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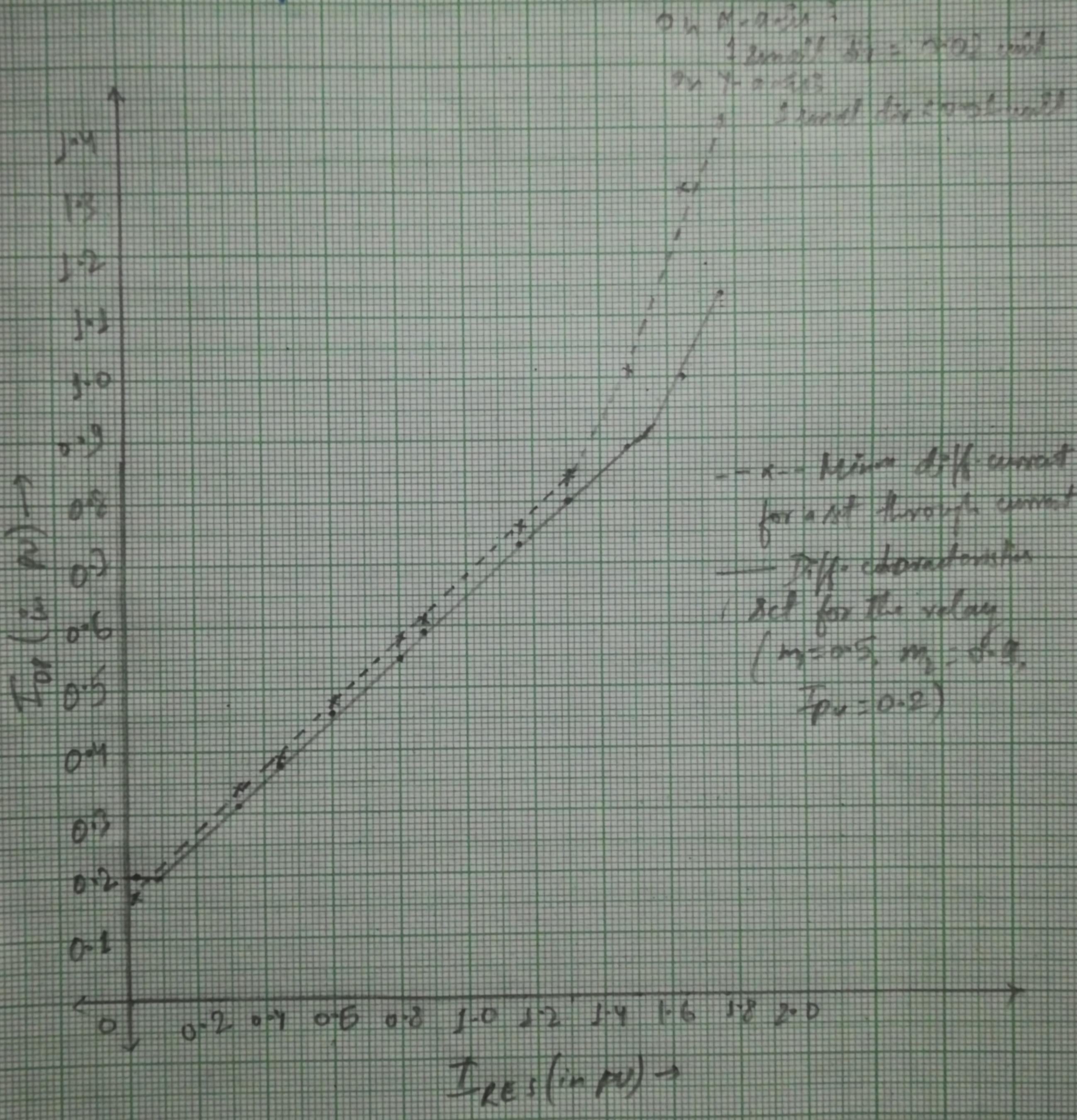

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5. Before deciding on the situation, let us first see the characteristics of them.

Inrush:

Magnetizing inrush current in transformers results from any abrupt change of the magnetizing voltage. Since the magnetizing branch representing the core appears as a shunt element in the transformer eq. circuit, the magnetizing current upsets the balance between the currents at the transformer terminals, and is therefore experienced by the differential relay as a false differential current. The characteristics of inrush current summarise that second-harmonic content starts with a low value and increases as inrush current increases.

Overexcitation:

Overexcitation of a transformer means that the magnetic flux in the core is increased above the normal design level. This will cause an increase of the magnetizing current and the transformer can be damaged. The current during overexcitation has a lot of fifth harmonic.

High loading:

In this situation, the current in the CT, may increase to very high levels causing saturation which would give a sine wave with a flat peak value giving the input the behaviour of a square wave. From the fourier transform we know that 1st & 2nd component is much more than 5th component.

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CT Saturation:

for internal faults, the harmonics resulting from CT saturation could delay the operation of diff. relays having harmonic restraint. This situation has the same harmonic characteristics as of the overloading.

So, from seeing all the situation characteristics, we can say that fifth harmonic component is dominant in the overexcitation situation. So, the situation is overexcitation.

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6. Given:

T/o : 25 MVA, 220kV/33kV, 50Hz

CT Ratio :- 100/5 HV
600/5 LV.

Normalised & Scaled

$$\boxed{I_i = (CT) \times \frac{I}{I_{rated}}}$$

finding Rated Currents

$$I_{LV}^{Rated} = \frac{25 \times 10^6}{\sqrt{3} \times 33 \times 10^3} A = 437.4 A$$

$$I_{HV}^{rated} = \frac{25 \times 10^6}{220 \times 10^6 \times \sqrt{3}} = 65.6 A$$

finding normalised & scaled currents,

$$|I_{Hf}| = \frac{5}{100} \times \frac{440}{65.6} A = 0.335 A$$

$$|I_{Lf}| = \frac{5}{600} \times \frac{1800}{437.4} A = 0.0343 A.$$

{both will be having opposite direction}.

finding I^{op} & I^{res}

$$I^{op} = |I_{Hf} + I_{Lf}| = |0.335 - 0.0343| A$$
$$= 0.301 A.$$

$$I^{res} = |I_{HV} - I_{LV}| = (0.335 + 0.0343) A$$
$$= 0.37 A$$

So, $m_{max} = \frac{0.301}{0.37} = 0.81$

$$\boxed{m_{max} = 0.8}$$