CONDITION MONITORING OF ELECTRICAL EQUIPMENT

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ACADEMIC YEAR : 2022-23

SEMESTER : 7th

COURSE NUMBER : EED4010

DATE OF PRESENTATION : 18/11/2022

INTRODUCTION

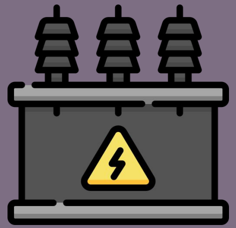
- Condition monitoring is necessary to avoid motor failure. Different fault monitoring for 3 phase transformer can be broadly categorized as model based, signal processing based and soft computing techniques give good analysis of a faulty system even if accurate models are unavailable.

- several fault identification methods have been developed and been effectively applied to detect machine faults at different stages by using different machine variables such as current, voltage, speed, temperature,efficiency etc.

- Thus considering safety and economic factors, it is essential to monitor the condition of machines of different sizes such as large and small

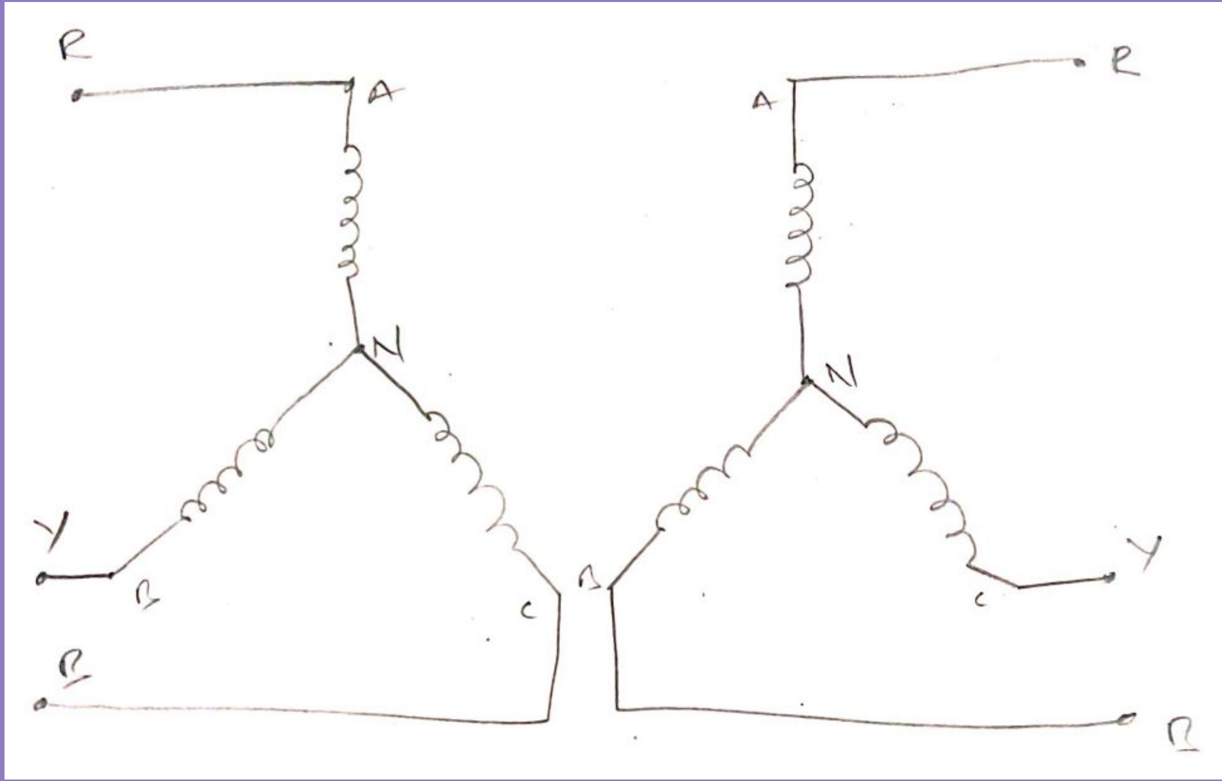
- An effective condition monitoring scheme is one that provides warning and predicts the faults at early stage.

THREE PHASE TRANSFORMER



- A three-phase transformer is composed of three sets of primary and secondary windings, each of which is wrapped around one leg of an iron core assembly.
- It appears to be three single-phase transformers sharing a common core.
- Three sets of windings are used in a three phase transformer core.

SCHEMATIC DIAGRAM OF 3 PHASE TRANSFORMER



INCIPIENT FAULT IN TRANSFORMERS

- incipient faults are those that slowly develop in time, leading ultimately to process failure or an emergency situation.

DATA ACQUISITION SYSTEM

- The hardware and software components of a data acquisition system allow for the measurement or control of physical attributes in the real environment.
- Greater process control and a quicker reaction to potential faults are two benefits of data collecting. The processes are fully optimised to provide high-quality goods and services that maximise the result of the company and increase its efficiency.

AIM

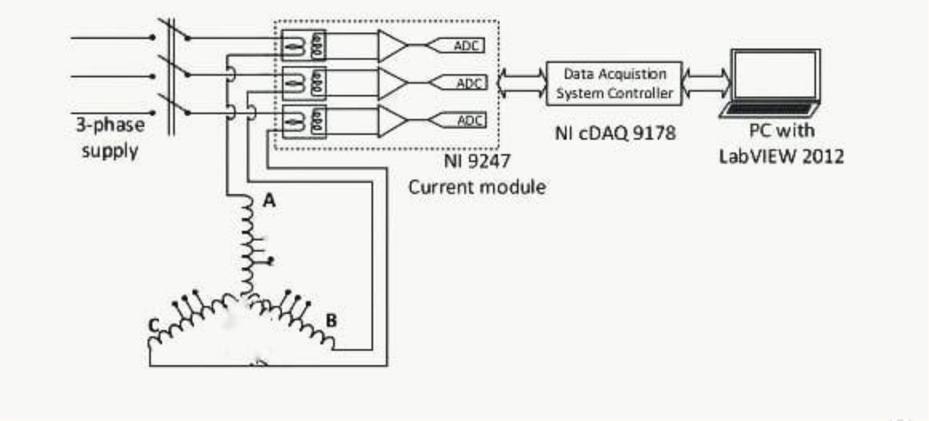
- Acquire current signals using a DAQ (data acquisition) through labview software
- Detecting the fault in the 3 phase transformer
- Identifying type of fault (phase to phase or ground fault)
- Locating the faulty phase(R Y)

WORK DONE

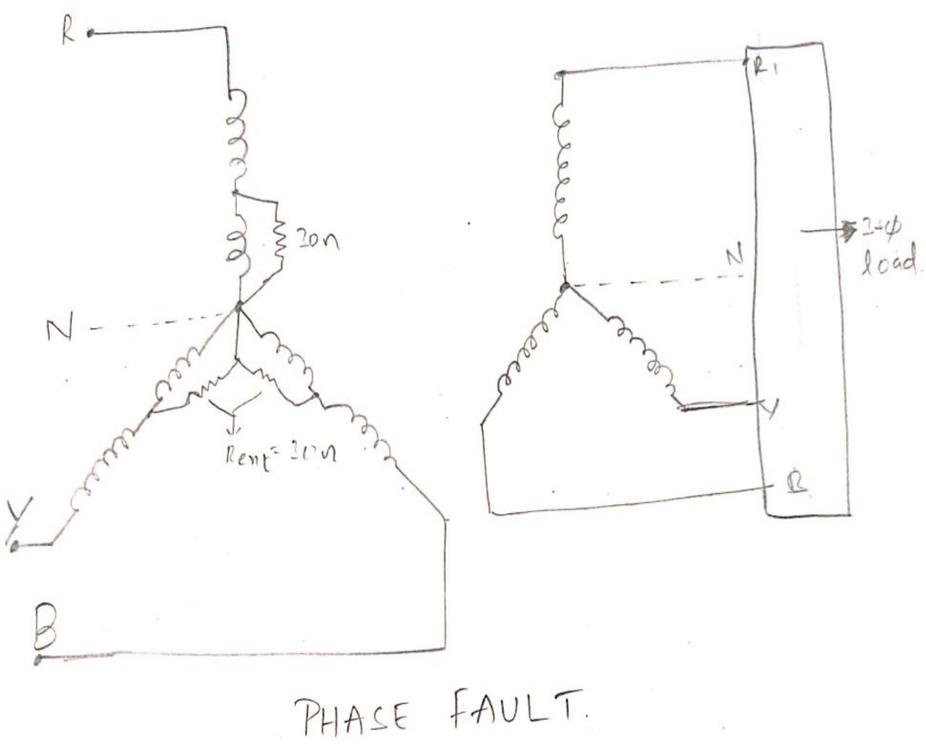
- created an interface in Labview to collect data from three channels, and produced simulations of current signals for the three phases (R, Y, and B) that are stated in the research paper.

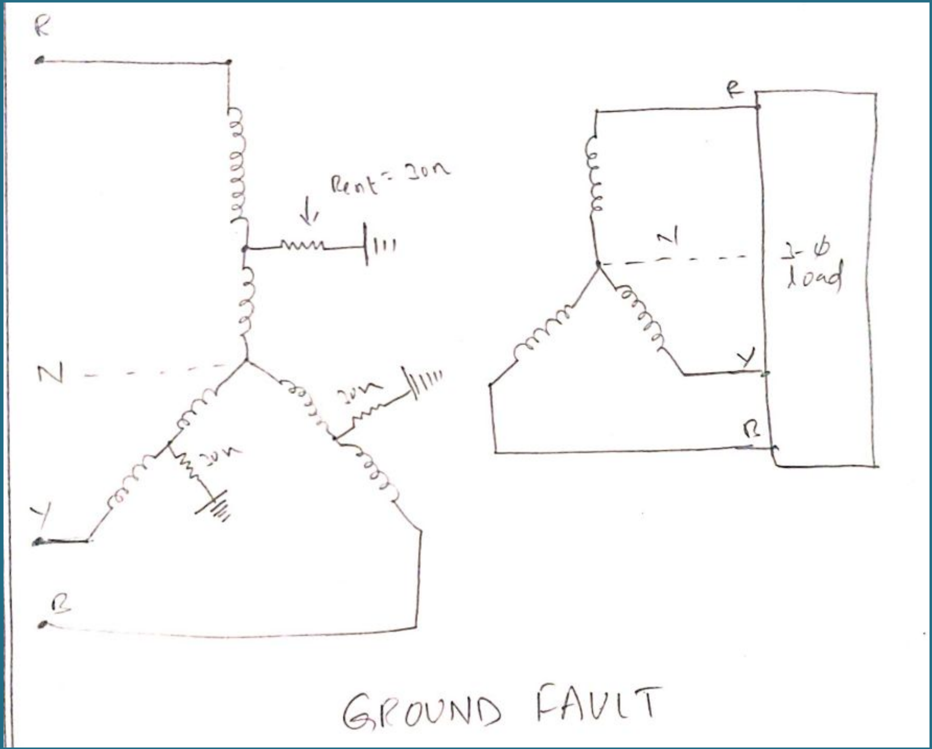
- Done fault analysis from the collected data using machine learning algorithms.

EXPERIMENTAL SETUP

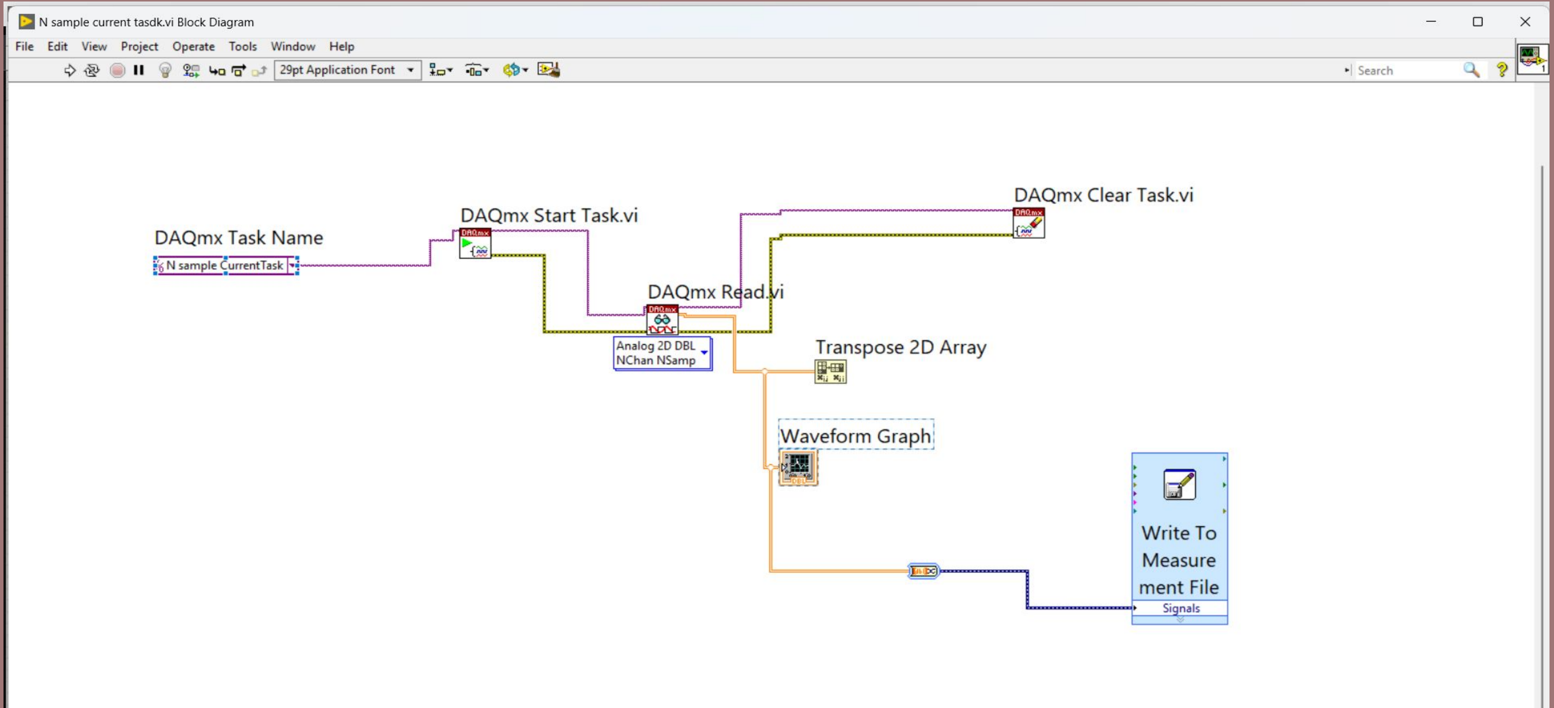


SCHEMATIC DIAGRAM FOR PHASE FAULT AND GROUND FAULT

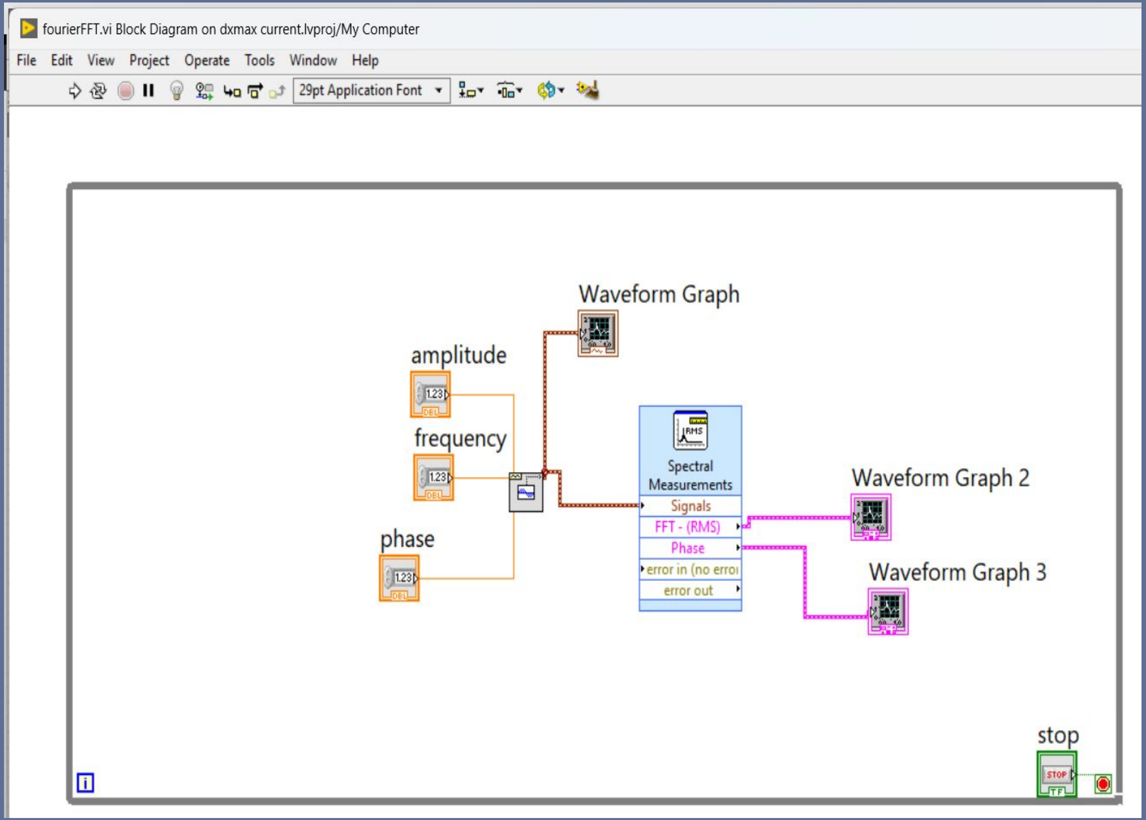




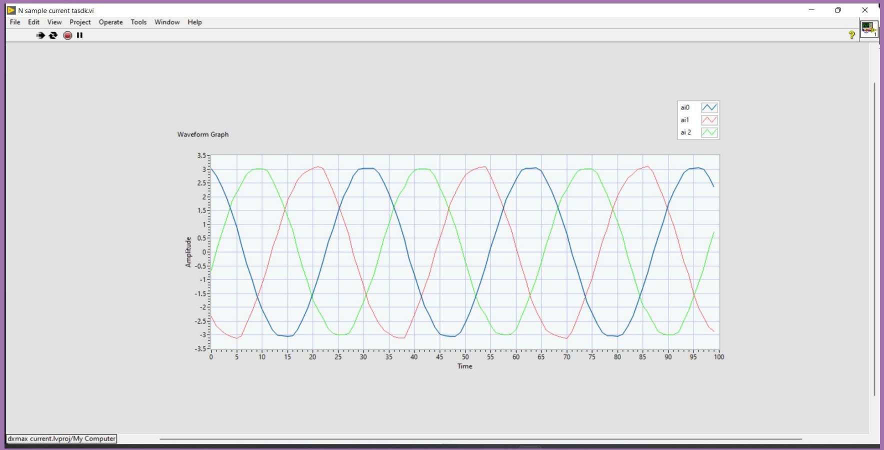
BLOCK DIAGRAM



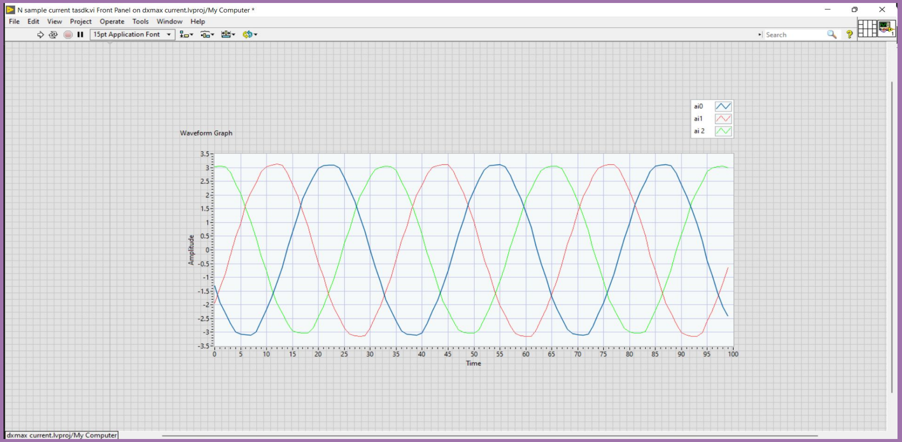
Block diagram for collecting current values in the excel file



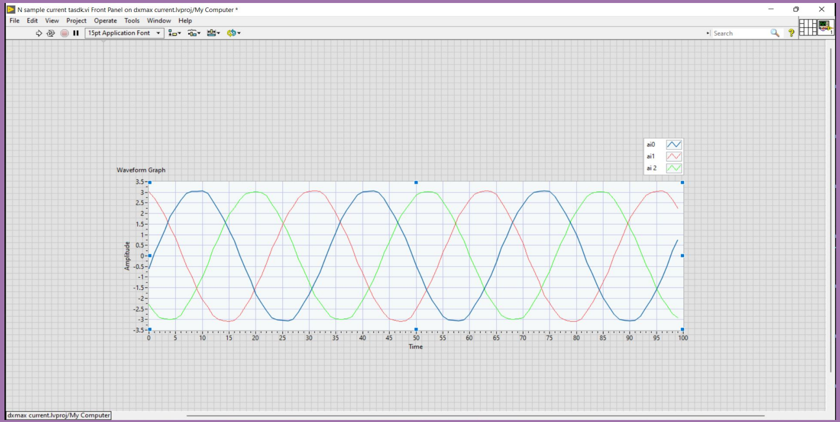
BLOCK DIAGRAM OF FAST FOURIER TRANSFORM(FFT)



FOR HEALTHY CURRENT SIGNAL



GROUND FAULT CURRENT SIGNAL



for a three-phase Transformer

PHASE TO PHASE FAULT CURRENT SIGNAL

HALFLOAD.lvm - Notepad

File Edit View

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	-0.673165	3.033507	-2.199022
```

Ln 1, Col 1   100%   Windows (CRLF)   UTF-8

FAULT DIAGNOSIS

Stage 1: Fault detection

- Standard deviation of each phase for the selected band of frequencies is determined

- Fault index of each phase is computed to detect the fault is present or not

$$FI_1 = \sum_{i=1}^{3} std(|S_i(\tau, f)|)_{F\sigma_1, F\sigma_2, F\sigma_3}$$

Where $S_i(\tau, f)$ is stock well transform matrix

$std(|S_i(\tau, f)|)$ is standard deviation of magnitude of ST matrix for ith phase and $i = 1, 2, 3$ represent all 3 phases.

- Using this Fault index 1, the fault (phase-phase-phase or ground fault) can be detected by comparing it to a threshold.

Stage 2: Identification of fault type

2

- the faults are classified into phase-to-phase-faults and ground faults with the help of zero sequence current (ZSC).

- A fault index based on ZSC is defined by

$$FI_2 = std(|I_0|)$$

where I_0 is ZSC and is given as $I_0 = \frac{(I_a + I_b + I_c)}{3}$

I_a, I_b, I_c are phase currents of windings A, B, C

It has been observed ground faults have much higher values when compared to phase-to-phase faults.

Thus, this difference can be utllized to identify the nature of the fault.

Stage 3: Detection of Faulty Phase

3

- The stockwell transform matrices' characteristics are used to determine the incorrect phase. Two different SVM models, one for ground faults and the other for phase-to-phase faults

<u>SVM classification:</u>
Step 1: set n = 2 and create the feature set using the first n features.

Step 2: Use SVM to calculate the classification accuracy.

Step 3: If the accuracy is less than 100% or all features have been used, repeat the previous steps with a fresh set of features.

In order to detect faulty phase in both types of defects, the features offering the maximum classification accuracy can be used.

- Chosen fault frequencies are 125, 175, and 225 Hz a subband of frequencies centred at about +-10 Hz

- The frequencies chosen have been chosen to cover the minor fluctuations.

- Fr1i and Fr2i are the lower and upper bounds of the ith frequency range, where i = 1,2, 3 and these bounds are Fr11 = 115 Hz, Fr21 = 135 Hz, Fr12 = 165 Hz, Fr22 = 185 Hz, Fr13 = 215 Hz, and Fr23 = 225 Hz, and fea1i, j is the feature of ith frequency range and jth phase. Thus, for all three phase current signals, there are nine features to represent the fault case.

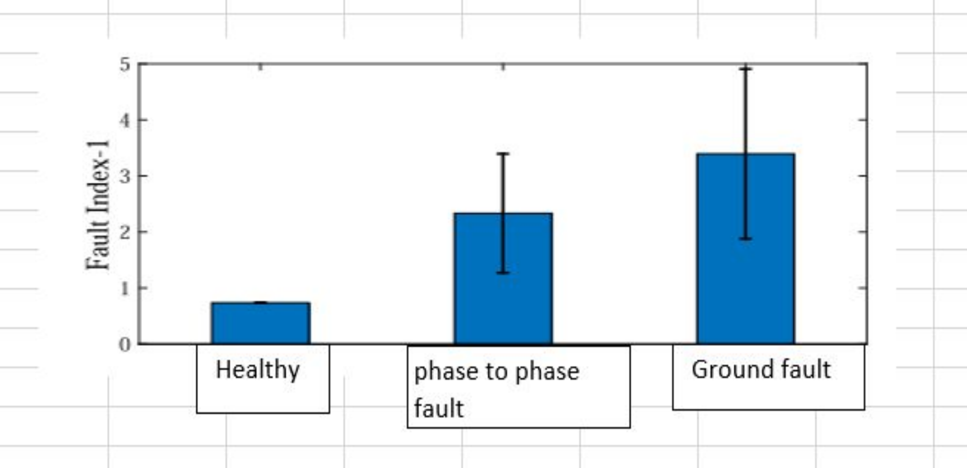
DATA SET USED FOR DIFFERENT STAGES OF DIAGNOSIS

Stages	Detection of fault	Healthy	Phase-to-phase-fault	Ground fault
stages-1	fault	Yes	Yes	Yes
stages-2	Type of fault	No	Yes	Yes
stages-3	Faulty phase	No	Yes	Yes

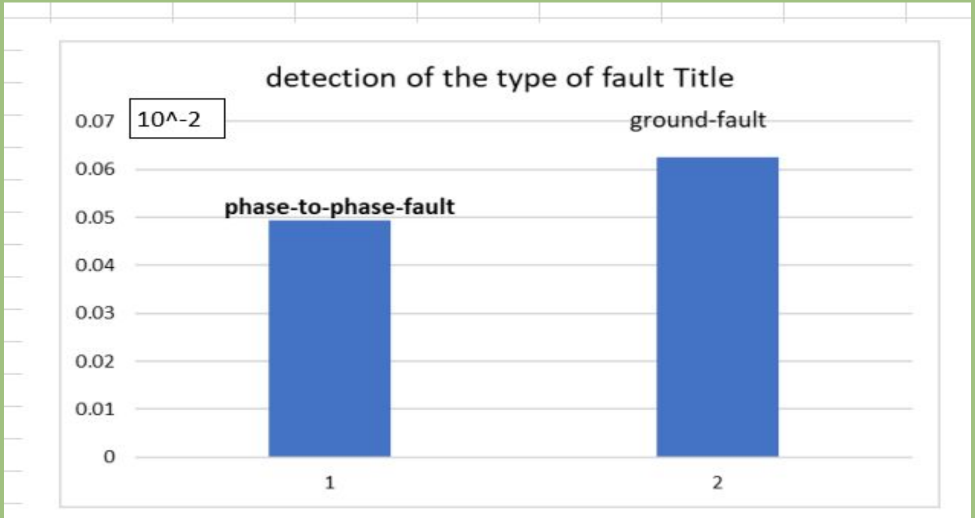
TOTAL CURRENT DATA SET RECORDED UNDER VARIOUS TRANSFORMER CONDITIONS

Condition	Phase-A	Phase B	Phase C	Total
Healthy	-	-	-	5
Phase-o-phase -faults	10	10	10	30
Ground faults	20	20	20	60

RESULTS



Fault index for detecting faults



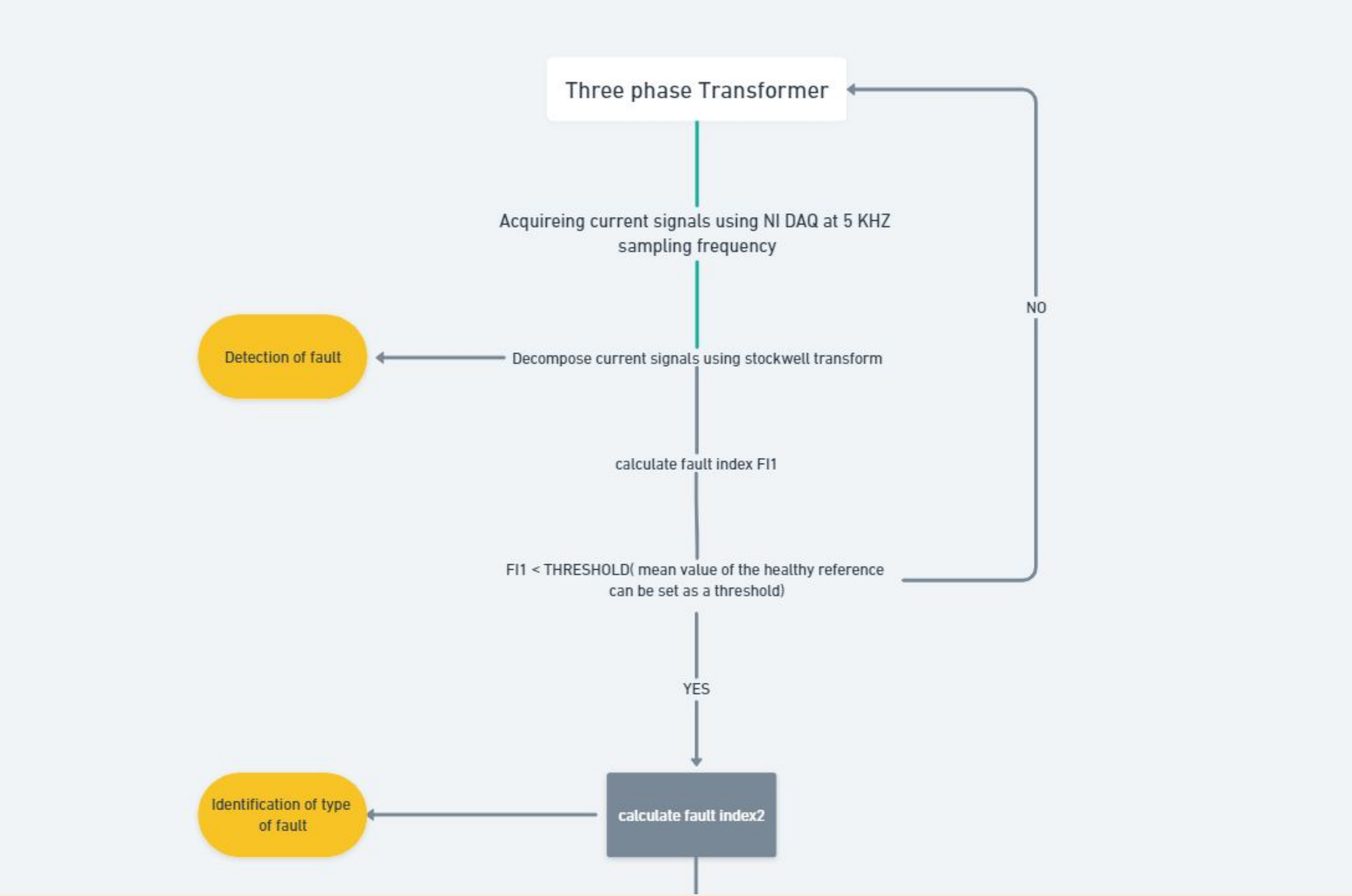
Fault index for discriminating phase-to-phase-faults and ground faults in stator windings.

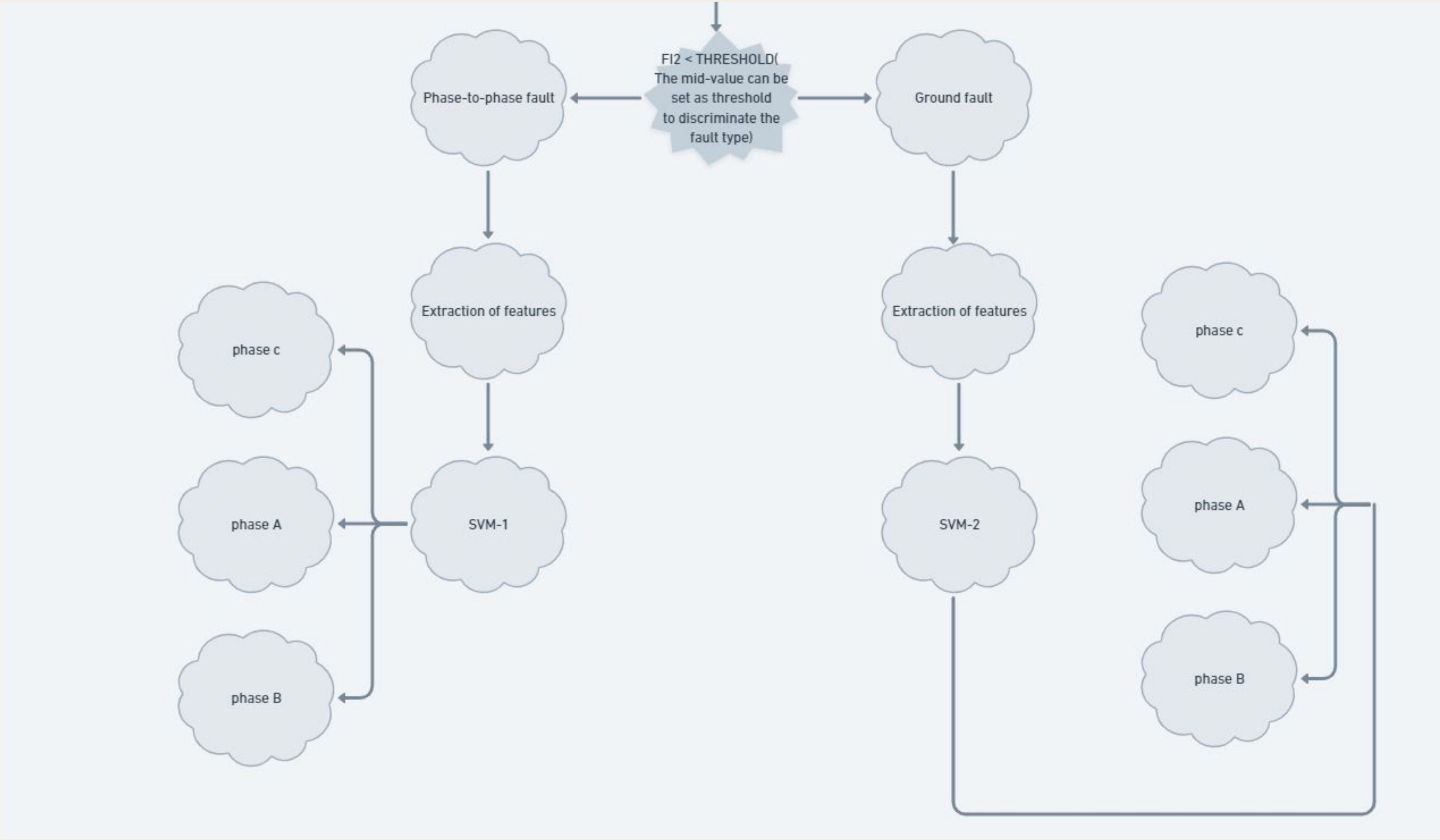
FEATURES SELECTED (WITH HIGHEST ACCURACY) FOR EACH SET OF COMBINATIONS FOR PHASE-TO-PHASE-FAULTS

Number of features (n)	Selected features	Accuracy (%)
6	f1,f2,f3,f4,f5,f6	100
4	f1,f3,f6,f9	87.4
2	f1,f4	60.77

FEATURES SELECTED (WITH HIGHEST ACCURACY) FOR EACH SET OF COMBINATIONS FOR GROUND FAULTS

Number of features (n)	Selected features	Accuracy (%)
9	f1,f2,f3,f4,f5,f6,f7,f8,f9	70.006
4	f2,f3,f5,f8	84.1
2	f1,f4	50.4


Three phase Transformer
Acquireing current signals using NI DAQ at 5 KHZ sampling frequency
Detection of fault
Decompose current signals using stockwell transform
NO
calculate fault index FI1
FI1 < THRESHOLD(mean value of the healthy reference can be set as a threshold)
YES
Identification of type of fault
calculate fault index2


FI2 < THRESHOLD(The mid-value can be set as threshold to discriminate the fault type)
Phase-to-phase fault
Ground fault
Extraction of features
Extraction of features
SVM-1
SVM-2
phase c
phase A
phase B
phase c
phase A
phase B

CONCLUSION

- we understood the serious practical experience of 3 phase transformer and how the incipient faults are identified and also learnt the theories behind this amazing concept .

- We successfully able to reproduce similar results compared to the given simulations in our research paper which will be helpful in our further studies and research in this domain

REFERENCES

1. https://ieeexplore.ieee.org/document/9117047?signout=success

2.https://www.sciencedirect.com/science/article/pii/S0263224118308418

3.D. G. Dorrell and K. Makhoba, “Detection of inter-turn stator faults in induction motors using short-term averaging of forward and backward rotating stator current phasors for fast prognostics,” IEEE Trans. Magn., vol. 53, no. 11, pp. 1–7, Nov. 2017.

THANKYOU