"I hereby declare that I have read through this report entitle "Self Organizing Map Technique for Transformers Condition Monitoring from SFRA Result" and found that it has comply the partial fulfillment for awarding the degree of bachelor of electrical Engineering Power Electronic and Drive

Signature :…….

Name :…….

Date :…….

SELF ORGANIZING MAP TECHNIQUE FOR TRANSFORMERS CONDITION MONITORING FROM SFRA RESULT

AHMAD NOR SYAHID BIN HASSAN

A report submitted in partial fulfillment of the requirements for the degree of Power Electronic and Drive

Faculty of Electrical Engineering
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2013

I declare that this report entitle "Self Organizing Map Technique for Transformers Condition Monitoring from SFRA Result" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :…….

Name :…….

Date :…….

To my beloved mother and father

ACKNOWLADGEMENT

The preparing of this report, I was in contact with many person either individual or grouping people, researchers, academicians especially to my supervisor Encik Sharin Bin Ab. Ghani and also Encik Zulhasrizal and last but not least to my friends. This person who give commitment towards my understanding and thought. Here my supervisor is the most that I want to express my sincere appreciation where he give full support to my project which is him give their critic and idea to help me for give the best performance and result of this project. The guidance for conducting the Matlab toolbox, I'm also very thankful to the lecturer Encik Zulhasrizal where he gives their knowledge and gives me a advice and also motivation.

Universiti Teknikal Malaysia Melaka (UTeM), I am also appreciate and indebt for give me an opportunity to show my skill and apply my knowledge in this project and also give assistance in literature and funding.

Last but not least, my fellow friend who is give me their moral support to make me continue this project even though it tough. I am sincerely give my obligation to my friend because of their support and also to my family members especially my mother and father.

ABSTRACT

Self organizing map (SOM) is the main method proposed for this project where the purpose was using it to determine and also diagnosing the data taken from various condition monitoring tests in the real distribution transformers application. SOM is the tool that uses to decide and collect data by give a train, where the sum of data will give as a reference to the SOM and then it will explore the data and also give a conclusion result about the data. This tool is an unsupervised neural network where it has their own algorithm which is consist vector quantization and vector projection. When have a lot of data using SOM it will make it their decision using a reference before where it supervise the new data and conclude it in what the value as reference decided before. In this project, by applying a data from Frequency Response Analysis (FRA) apply it to SOM tools to obtain the result in topographic map. This project had focus on using toolbox in Matlab with perform with their algorithm and create the data set to put as input using m file. This research work had achieved their objective and successfully gives the good result according the Self Organizing Map technique.

ABSTRAK

"Self Organizing Map" (SOM) adalah kaedah utama yang dicadangkan untuk projek ini di mana tujuan penggunaanya adalah untuk menentukan dan juga mendiagnosis data diambil dari pelbagai ujian pemantauan keadaan di transformer pengagihan sebenar . SOM adalah alat yang menggunakan untuk membuat keputusan dan mengumpul data dengan memberikan latihan, di mana jumlah data akan memberikan sebagai rujukan kepada SOM dan kemudian ia akan meneroka data dan juga memberikan hasil kesimpulan tentang data. Alat ini adalah satu rangkaian neural tanpa pengawasan di mana ia mempunyai algoritma mereka sendiri yang terdiri pengkuantuman vektor dan unjuran vektor. Apabila telah banyak data dikumpul SOM ia akan membuat ia keputusan mereka menggunakan rujukan sebelum ia menyelia data baru dan membuat kesimpulan dalam apa nilai sebagai rujukan keputusan sebelum ini. Dalam projek ini, dengan menggunakan data dari Kekerapan Analisis Response (FRA) dipraktikkan kepada alat SOM untuk mendapatkan hasil dalam peta topografi. Projek ini telah memberi tumpuan kepada penggunaan toolbox dalam Matlab dengan melaksanakan dengan algoritma mereka sendiri dan mewujudkan set data untuk dimasukkan sebagai input dengan menggunakan m fail sebagai pengantara. kerja-kerja penyelidikan telah mencapai matlamat mereka dan berjaya memberikan hasil yang baik mengikut teknik "Self Organizing Map".

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

FIGURE **TITLE** **PAGE**

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 General Background

The transformer breakdown is common in the industry where the transformer is continuously used and it makes deterioration performance of transformer. Here the main problem where it need to define the characteristic of the transformer for their lifetime use. Using a data from Sweep Frequency Response Analysis (SFRA) then record it and analyze it manually, here it use a Self Organizing Map to solve the problem where it can explore the data and make the decision by provide the output result. SOM is a method that uses to simplify data where it auto clustering the data, this method also can show result in visualize using their topographic map. The data from SFRA is used and apply it to SOM where all the data will be trained in SOM and it will learn the pattern of the data. The data will train using their techniques and in major the data will be learned by SOM and cluster it and it will show the result by using color in their topographic map.

1.2 Problem Statement

Previously, the data will collected from SFRA and will record it manually and analyze it using human consideration where when we use human the error always can be happened. In this project it focus on three frequency sub-bands where their range between 20 Hz and 1 MHz of the SFRA measurement results for evaluating the transformer core and winding conditions was proposed. This proposed is used for detection on core and also their failure in mechanical movement. The problem in this project being investigated base on collecting data of SFRA

and to record it and also make a conclusion for the data. At the first time it will be easier but when it have a lot of data using same problem to justified and conclude the result is hard using manually observe and justified it. Here in this project, the data get from the transformer condition have a lot of data to record and classified it into the state of the transformer condition. Using Self Organizing Map (SOM) it can explore the data and make conclude to justified each transformer using the data record, where it need to give a reference data to train to make a decision for a latest data give.

1.2 Objective

1. To obtain Sweep Frequency Response Analysis (SFRA) measurement results from five TNB distribution transformers.
2. To perform the transformer condition monitoring using Self-Organizing Map (SOM) toolbox.
3. To verify results from the SOM toolbox with the condition of the five TNB distribution transformers.

1.3 Scope

1. Using five of TNB distribution transformers as data sets, with two of them are confirm in defective condition.
2. Using input data Sweep Frequency Response Analysis SFRA from cross-correlation function (CCF) data.
3. Using a Self-Organizing Map (SOM), Matlab as tools to obtain the result. Neural Cluster tool and SOM toolbox are two methods that had been focus in research work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Literature Review

In this chapter, the related of previous information about the Self Organizing Map are provided and it is also include of the example from the Matlab that had been try to give some explanation to use SOM technique for the clustering and to diagnosis monitoring of transformers.

2.2 Self Organizing Map

Distribution transformer is the transformer that steps down the voltage from primary voltage of the electric distribution to the customer. Here, the transformer is provide alternating current power by electronic magnetic induction using a primary to secondary winding where it in the same frequency [3]. From this transformer the FRA and DGA method will used to measure the condition of the transformer. The data from both measurements will apply to Self Organizing map where this software can read the data, explore it and make a decision for the data given.

SOM is the tools in Matlab software that can explore the data and give the conclusion all the data given as table 2.1 by train it with the reference data. Here this SOM have two type of training one is supervising where it has a output target from the input data pattern and it learn to produce the desired result. The other one is unsupervised train where here we need to determine class for each input data by sharing a common feature and after that it will explore the data given by follow the common featured decide [2]. The algorithm for this SOM is

cooperative and also competitive where it will select the winner from the matching of neuron. The result will produce in a form of map where called as a topographic map.

Table 2.1: Data SFRA from transformers

Frequency Band (Hz)	Winding	Phases Comparison	Non - defect Transformers			Defect Transformers	
			PPU JLN PUDU	PPU MBF Spring Crest, Puchong	PPU KL EAST	PPU Seksyen 23 T2	PPU Kelibang T2
20 Hz to 10 kHz	HV	H1H2 to H2H3	0.999	0.995	0.949	0.922	0.974
		H1H2 to H3H1	0.999	1.000	0.999	1.000	0.999
		H2H3 to H3H1	0.998	0.995	0.962	0.922	0.984
	LV	x0x1 to x0x2	0.992	0.999	1.000	0.999	0.976
		x0x1 to x0x3	0.997	0.975	0.995	0.768	0.997
		x0x2 to x0x3	0.982	0.981	0.994	0.779	0.990
5 kHz to 500 kHz	HV	H1H2 to H2H3	0.992	0.958	0.989	0.942	0.951
		H1H2 to H3H1	0.993	0.937	0.999	0.901	0.993
		H2H3 to H3H1	0.989	0.962	0.997	0.981	0.972
	LV	x0x1 to x0x2	0.958	0.989	0.997	0.992	0.974
		x0x1 to x0x3	0.995	0.988	0.997	0.983	0.995
		x0x2 to x0x3	0.948	0.989	1.000	0.991	0.984
400 kHz to 1 MHz	HV	H1H2 to H2H3	0.994	0.971	1.000	0.940	0.992
		H1H2 to H3H1	0.995	0.962	0.999	0.653	0.943
		H2H3 to H3H1	0.992	0.995	0.999	0.713	0.953
	LV	x0x1 to x0x2	0.998	0.967	1.000	0.977	0.780
		x0x1 to x0x3	0.997	0.929	1.000	0.976	0.990
		x0x2 to x0x3	0.999	0.821	1.000	0.988	0.780

This tool Self Organizing Map using Euclidean distance formula to calculate distance for each neurons that to be train by the SOM where the distance between two point in the grid with their coordinate estimate (X,Y) and (A,B) as:

$$dist\big((X,Y),(A,B)\big) = \sqrt{(\mathrm{X}-\mathrm{A})^2 + (\mathrm{Y}-\mathrm{B})^2}$$

Very often, especially when measuring the distance in the plane, we use the formula for the Euclidean distance. According to the Euclidean distance formula, the distance between two points in the plane with coordinates (x, y) and (a, b) is given as illustrated in figure 2.1.

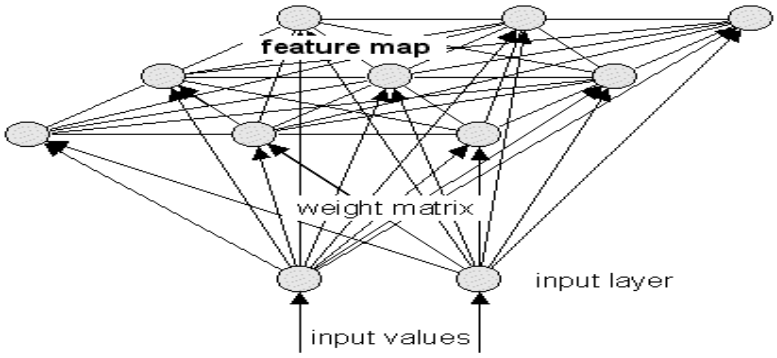

Figure 2.1: Result from SOM.

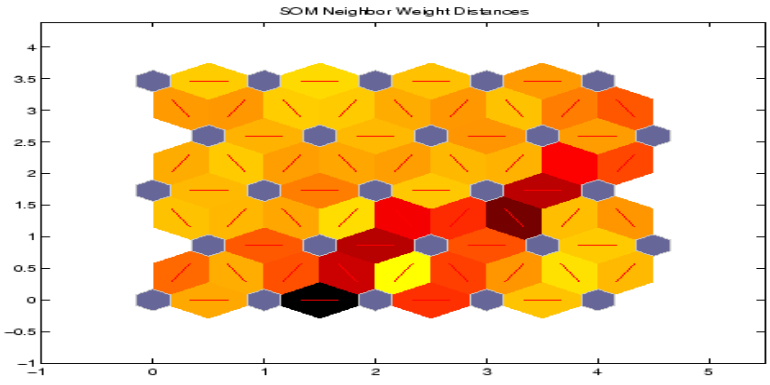

Figure 2.2: Result from SOM1.

From the result stated in figure 2.2, it can be seen a different color where it represent each part that had been decided before. This topographic map is determine by using a color

what had been decide in this case the yellow color is the perfect condition but the red color is a bad condition. Each part in this topographic map it called as node, this node each will map to neuron where it will repeatedly map to train. On the other hand, weight where the data that contain variable value will present to neuron and it make neuron attempt to become like input data.

The neuron that receives data will adjust their weights along data value where it called as training. This neuron will train data several time and each time data input to neuron it call epoch. This process will continuously loop and the data input given will change the neuron and it will train again to get a pattern and it will give result as a topographic map.

The neuron have a connection between them with the relation by neighborhood where it response each other by weight and distance. These topology structures have two type of factor which is local lattice structure and global map where in this project it uses local lattice structure as figure 2.3 below.

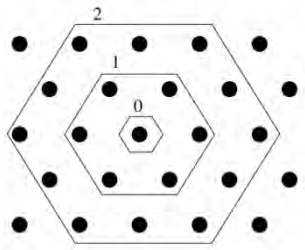

Figure 2.3: Hexagonal lattice.

Using hexagonal lattice is better than others in this project because it have the most plot of weight in their neighbor, this characteristic of structure can produce an accurate data to perform the diagnosis.

The data that provided need to be brought in Matlab by using standard M file , this will be perform by calling the data using command which it can be seen in appendix. In this project, the node or each neuron is representative a data from FRA. Every time data change it will affect the output at SOM and it will follow the data input given.

Data from m file will train by using SOM toolbox in Matlab where it had been sampling and mapping the data. All data that had been train by SOM may be normalized where it shifted and been scaled to have a standard variance where it normally equal to one.

This normalizing is important because it can protect the data from overwhelming and hold the data to repeat the normalization or denormalize. The simple instruct command can be seen in appendix. The data had been normalize and it need to initialization and been train, there are two type of initialization which is random and linear algorithm. This initialization can be perform in simple command which is it can be seen in appendix.

2.3 Summary of Literature Review

SOM, Self Organizing Map consists organized of neuron on the grid where it may be having varied of the value of neurons. The value of neurons is important to determine how much could be train the data ser given by input, the more value of neurons the more precise and accurate data will have and the more better resolution of topographic map will have. Using the algorithm in SOM toolbox the result will produce the topology map and the map will analyze the neighbor and distance between neurons. The neighbor and the distance of neurons will determine by clustering in SOM and also using Euclidean distance.

CHAPTER 3

METHODOLOGY

3.1 Introduction of Methodology

In this chapter, it stated the process on finishing this final year project. The flow chart illustrated in Figure 3.1 shown that the activities or tasks to be done in each stage of the project's planning. This shown the step that to clear a view of flow of this project and try to manage the project according time given. The flow is to apply Self Organizing Map techniques in Matlab to produce result by visualisation of topographic map. In next sub chapter it will discuss more detail phase by phase of the methodology.

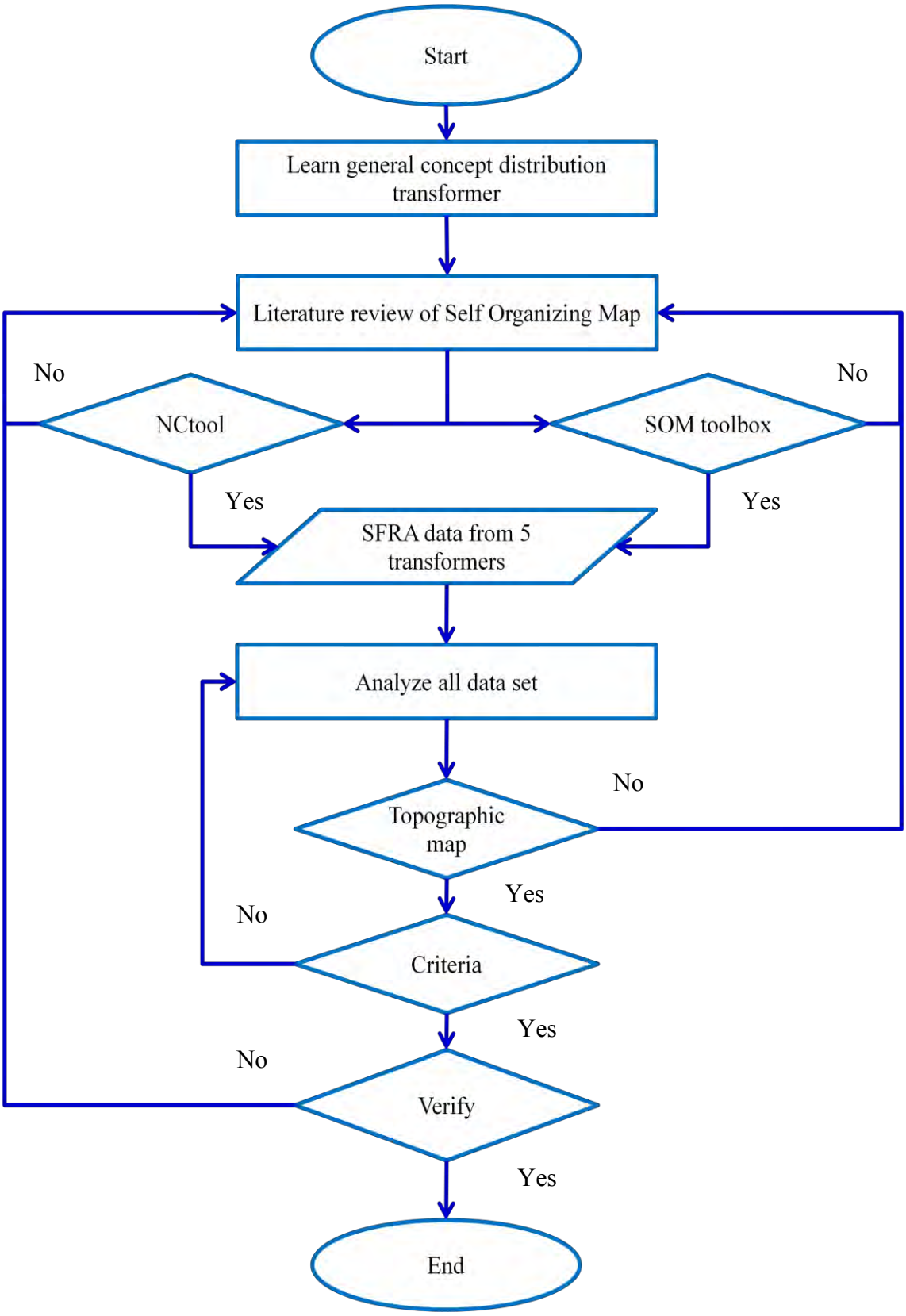

Figure 3.1: Flow chart of methodology.

3.2 Phase 1: Learn the general concept of distribution transformer and SFRA

The characteristic of distribution transformer and also the breakdown behavior of distribution transformer had been learning. In this research it focuses on the data from SFRA where the data is important to determine the good or bad transformer. This research work using five TNB transformers specification data as the input data for Self Organizing Map method to analyze and intemperate the data in visual mode using topographic map. In table 3.1 represent details transformers of the distribution transformers that being used in this research work.

Table 3.1: Transformers detail

No.	Transformers Location	Voltage Rating (kV)	MVA Rating (MVA)	Year	Phase	Manufacturer
1	PPU JlnPudu T2	33/11	30	1996	3	MTM SDN BHD
2	MBF Spring Crest,Puchong T1	33/11	30	1994	3	WILSON
3	PPU KL East T2	33/11	30	1986	3	HYUNDAI ELECTRICAL
4	PPU Seksyen 23 T2	33/11	30	1993	3	HEFEI TRANSFORMERS
5	PPU Kelibang T2	33/11	7.5	1995	3	MTM

The data get from SFRA is in dB unit where it has been tested using omicron board and will provide result as a figure 3.2. In this figure it can be seen that it have three sub band where the low frequency sub band is below 10 kHz, middle frequency sub band is from 10 kHz until 500 kHz, and last but not least is high frequency sub band is 400 kHz until 1 MHz each of this sub band have their own characteristic to be determine where the low sub band it sensitive to element transformer core problem, middle sub band is sensitive to element Transformer winding deformation due to radial movements, and lastly is high sub band sensitive to element Transformer winding deformation due to axial movements.