Design and Analyze Active Filter for Ferroresonance Suppression Circuit (FSC)

NORAZMAN BIN ROSLI

اونيورسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

A report submitted in partial fulfillment of the requirement for the degree of Bachelor of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

"I declare that report is entitle 'Design and Analyze Active Filter for Ferroresonance Suppression Circuit (FSC)' is the result of own research except as cited in the reference. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree"

Signature : ....

Student's Name : NORAZMAN BIN ROSLI

Date : 20/06/2016

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

" I hereby declare that I have read through this report entitle '**Design and Analyze Active Filter for Ferroresonance suppression Circuit (FSC)**' and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power) "

Signature : ....

Supervisor's Name : EN. ALIAS BIN KHAMIS

Date : 20/06/2016

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Dedicated to my beloved father and mother,

my siblings, Lecturers and to all my friends.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ACKNOWLEDGEMENT

First and foremost, I would like to express my thankfulness and gratitude to Allah S.W.T who has given me all the strength that I need to complete this project. Without His Permission, I will not be able to complete this project.

With this opportunity, I would like to express my gratitude to the UNIVERSITI TEKNIKAL MALAYSIA MELAKA (UTeM), Faculty of Electrical Engineering and especially to my supervisor, En Alias Bin Khamis for helping me in completing this project.

I also would like to express my sincere gratitude to my family who has been always supporting me especially when I encountered difficulties while doing this project. My thanks and appreciation also go to my friends in developing the project and people who have willingly help me out with their abilities throughout the whole progress.

Lastly, I have to appreciate the guidance given by other supervisor as well as panel especially to improve my report final year project to be better.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ABSTRACT

Ferroresonance is type of resonance in electric circuit happens when a nonlinear inductance from the source is connected in series with capacitor, and the circuit is subjected to a disturbance such as opening of switch or lightning. The occurrence will result in damaging the component connected with the system and hence reduce the quality of the power transmission. In order to prevent this from happened and affected the power quality of electrical equipment. The ferroresonance suppression circuit (FSC) will be applied. FSC that installed on secondary transformer used for prevent the severely damage to electrical equipment in voltage transformer. The circuit design for FSC using active filter to eliminate the harmonic disturbance from nonlinear load. Most of the disturbance is produced by ferroresonance phenomenon. The main purpose of this project is to design and analyze active filter for FSC which can be used to mitigate the ferroresonance phenomenon. The design and simulation of this project will use Power System Computer Aided Design (PSCAD). The simulation analyze based on the voltage reading of the transformer. Active shunt filter is used as the mitigation method in solving the ferroresonance phenomenon.

اونيورسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ABSTRAK

Ferroresonanceadalahjenisresonansdalamlitarelektrik yang berlakuapabilakearuhantak linear daripadasumber yang disambungsecarasiridengankapasitordanlitaradalahtertaklukkepadagangguansepertimembukasuis ataukilat. kejadianiniakanmengakibatkankerosakkankomponen yang berkaitandengansistemdanmengurangkankualitipenghantarankuasa. Untukmengelakkaninidaripadaberlakudanmenjejaskankuasakualitiperalatanelektrik.Litarferroresonancepenindasan (FSC) akandigunakan. FSC yang dipasangpadapengubahmenengahdigunakanuntukmencegahkerosakanterukperalatanelektrikpada pengubahvoltan.Rekabentuklitaruntuk FSC menggunakanpenapisaktifuntukmenghapuskangangguanharmonikdaripadabeban linear.Kebanyakangangguan yang dihasilkanolehfenomenaferroresonance.Tujuanutamaprojekiniadalahuntukmerekabentukdanmenganalisispenapisaktifuntuk FSC yang bolehdigunakanuntukmengurangkanfenomenaferroresonanceitu.Rekabentukdansimulasiprojekini akanmenggunakan Aided Design SistemKuasaKomputer (perisian PSCAD). simulasimenganalisisberdasarkanbacaanvoltanpengubah. Penapisaktifpiraudigunakansebagaikaedahmitigasidalammenyelesaikanfenomenaferroresonanceitu.

TABLE OF CONTENTS

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LISTOF FIGURE

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF SYMBOL AND ABBREAVIATIONS

FSC	**-**	**Ferroresonance Suppression Circuit**
AFSC	**-**	**Active Ferroresonance Suppression Circuit**
PFSC	**-**	**Passive Ferroresonance Suppression Circuit**
VT	**-**	**Voltage Transformer**
PSCAD	**-**	**Power System Computer Aided System**

اونيورسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHAPTER 1

INTRODUCTION

1.1 Overview

The main purpose for this project is to design and analysis active shunt filter of how it affect for ferroresonance suppression circuit (FSC) to reduce ferroresonance phenomenon in voltage transformer. The project background and problem statement of this project will be described briefly in this chapter. Furthermore, the scope of work and objectives of this project will be investigated to build on this project. Last but not least, in this chapter also the expected project outcome and motivation will be discussed. The design and analysis of this project will be done by using Power System Computer Aided System (PSCAD) to simulate the occurrence of Ferroresonance.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

1.2 Project background

Ferroresonance suppression circuit (FSC) is installed on secondary transformer to reduce the ferroresonance phenomenon. The fault which happens at substation may lead to Ferroresonance phenomenon. In this project, active shunt filter will be applied for FSC voltage transformer to mitigate the effect of ferroresonance. Ferroresonance is a special case phenomenon of disturbance that involves sudden increase of voltage and current that can cause severely damage to electrical component such as the transformer in substation [1]. Beside, this phenomenon will affect power quality that can cause the performance of the whole system. Other than that, switching operation and lightning strike also factor this ferroresonance phenomenon happened.

1.3 Problem statement

In power network nowadays when there is any disturbance in frequency waveform for current or voltage it that can lead damage to the electrical equipment. One of the example disturbances is ferroresonance. This power network contains capacitance and inductive that can saturate each other that may lead to ferroresonance phenomenon. Most of ferromagnetic equipment such as capacitance and inductor are non-linear which can resonance each other and sudden produce higher value of voltage and current [2]. Electrical equipment will have overstress thermal problem that effected by this phenomenon. Besides that, the performance quality of the power generation system also affected. The damage such as malfunction of voltage transformer, abnormal neutral-point voltage arises, incorrect earth-fault indication and etc. This phenomenon will cause the protection device failed to operate as usually. In order to mitigate and protect whole system from this phenomenon ferroresonance suppression circuit(FSC) are installed on secondary transformer. The occurrence of ferroresonance is unpredictable and consequently mitigation method of this phenomenon is needed to protect the whole power system.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

1.4 Objective

The objective of design and analyze active filter for ferroresonance suppression circuit (FSC) involtage transformer are:

- To study the characteristic of ferroresonance phenomenon.
- To design and analyze the effect active shunt filter for ferroresonance suppression circuit (FSC).
- To identify the solution in purpose of mitigate ferroresonance phenomenon.

1.5 Scope of Work

This project main focuses on design and analyze active shunt filter for ferroresonance suppression circuit (FSC) for the purpose to mitigate occurrences of ferroresonance in voltage transformer. There are two type of ferroresonance suppression circuit (FSC) that can reduce ferroresonance phenomenon which are active ferroresonance suppression circuit (AFSC) and passive ferroresonance suppression circuit (PFSC). But for this project it will use APFC as main circuit to design in order to mitigate the ferroresonance phenomenon.Many previous researches relate on this project most focus on ferroresonance, transient response and protection system that can used in this project. The simulation is set by using the parameter of 30 MVA, 230kV/13.2kV, delta-wye three phase voltage transformers.The capacitance set with 2.6uF while the inductance is 0.1H. The mitigation method is implementing active shunt filter to three-phase voltage transformer. The simulation is set by using Power System Computer Aided Design (PSCAD) software.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

1.6 Motivation of Project

This project designed for protection system in voltage transformer. This design will protect the equipment when ferroresonance phenomenon happened in voltage transformer. The usage of active filter that can control harmonic will eliminate the nonlinear disturbance. It also can save the loss of cost because when disturbance happened, the equipment of electrical device will protected.

1.7 Expected Project Outcome

At the end of the project, the occurrences of ferroresonance can be reducing by applying active shunt filter for ferroresonance suppression circuit (FSC) in voltage transformer. The analysis from this project must contained data of voltage in voltage transformer by using PSCAD software. The waveforms that obtained are used to analyze how the active shunt filter can affect in reduce ferroresonance phenomenon. The simulation of Power System Computer Aided Design (PSCAD) with proper parameter should be designed.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHAPTER 2

LITERATURE RIVIEW

2.1 Overview

In this chapter, all the related terms such as ferroresonance phenomenon, voltage transformer, ferroresonance suppression circuit (FSC) and active filter will be investigated and discussed.

2.2Ferroresonance phenomenon

Ferroresonance is a type natural phenomenon which occurred when a series of non-linear inductive reactance is connected in series with capacitive reactance [3]. This phenomenon effect were first discovered in a 1907 by JoseptBethenod. Then in 1920 the name of ferroresonance was created by French engineer, Paul Baucherot. This phenomenon involves high levels of overvoltage and overcurrent distortion oscillating in the electrical circuit.Ferroresonance and linear resonance is two different type of resonance. Linear resonance occurs when inductive and capacitive reactance is equal while ferroresonance is sudden increase of voltage and current from stable state to unstable state of resonance [4]

The occurrence of this phenomenon happens when interruption occur on one of the unloaded phase of the three phase system which consist of mainly inductive and capacitive load without or little resistive load. As a result overvoltage may occur if the other two phases were not interrupted quickly. Ferroresonance can occur in electrical circuit that must contain at least four elements which are non-linear inductor, a capacitor, voltage source and low losses [5]. Ferroresonance will appear after the transient disturbance such as transient overvoltage or fault happen.

There are factors that can contribute in ferroresonance. First, direct lightning strike that unpredicted happened. This phenomenon can causes many of damage to the equipment in electrical, electronic and even mechanical. The discharge of lightning which happened within few second of time will cause the transient overvoltage to occur. Secondly, switching in operation commonly happens caused by arching fault and static discharged.Other causes of ferroresonance may due to underground cable in primary circuit, single phase operation and low loss transformer

From this research of ferroresonance,manyprevious research had been investigated ferroresonance overvoltage reducing method. There are some recommended ways to solve ferroresonance phenomenon includes reduce capacitance reactance system, reduce the non-linear reactance by designing to operate in linear part and make sure the operation of transformer in no load condition by disconnect the supply with the primary transformer [6].

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

The consequences of the occurrence of ferroresonance such as the overcurrent and overvoltage can cause severely damages to the equipment connected with the voltage transformer. The damage mentioned will be as such of the malfunction of voltage transformer, abnormal neutral-point,voltage arise, incorrect earth fault indication and etc. subsequently, the whole power system will be facing transmission and distribution failure which will then lead to blackout in the vicinity.

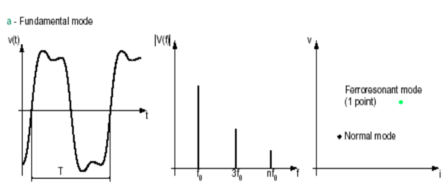
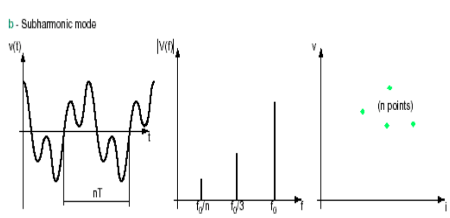
The mitigation method of ferroresonance is important so as to reduce the impact of the phenomenon which can cause power losses in the distribution system. For the past decades many research has been investigating many mitigation solutions to solve the problem. There are many referred to further study on the matter.

2.2.1 Ferroresonance symptoms

Ferroresonance phenomenon has many factors that random and unpredicted that can causes severely damage the equipment. So, there are some of sign that can used to recognize this phenomenon which are high sustained overvoltage, power quality problem due to current and voltage distortion, transformer heating and loud noise apparent power of protective device and Electrical equipment damage [7].

2.2.2 Ferroresonance modes

Ferroresonance modes can divide into four basic of steady-state which is fundamental mode,sub harmonic mode, quasi-periodic mode and chaotic mode [8].

Ferroresonance mode	Characteristic
I. Fundamental 	➢ The signal are distorted but periodic waveform are same. ➢ Have discontinuous spectrum
II. Sub harmonic 	➢ The signal are periodic ➢ The spectrum equal to f_0/n (where f_0 is the source frequency and n is integers)

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

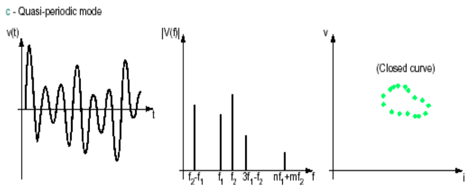
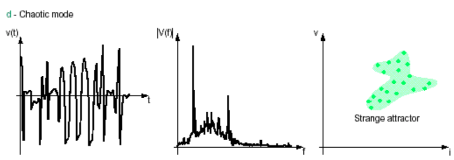
III. Quasi-periodic 	➢ The signal is not periodic(pseudo-periodic) ➢ Have discontinuous spectrum
IV. Chaotic 	➢ The signal are irregular and random ➢ Have non-periodic spectrum and continuous

Table 2.2: Types of ferroresonance modes

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2.3 Voltage Transformer

For three phases in power distribution system, it need voltage transformer to step down the high voltage to low voltage. The main purpose of voltage transformer is to step down the voltage to use the safe value of voltage for meter, relay or other load in distribution system. There are two main parts in voltage transformer which are protection and measurement. For protection it protects the equipment that connected to it from damage. Voltage transformer has same function like step down transformer. Besides, it also has lower secondary winding. In Malaysia, three phase system is used instead of single phase or two phase system is mainly due to the economical consideration. In this research project, a step down three phase voltage transformer with 132kV/33kV/22kV/11kV in transmission substation is being used to analyze the ferroresonance with mitigation solution.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 2.3: Voltage transformer

2.4Ferroresonance Suppression Circuit (FSC)

The main purpose of FSC is to prevent overvoltage that can severely damage for equipment that located in voltage transformer. FSC have two types of model which are active FSC and passive FSC [9]. In voltage transformer FSC will be placed in secondary transformer.

Active FSC is type of filter that contained inductance and capacitance characteristic, when the value of frequency change in AFCS, the ferroresonance phenomenon effects also reduced. There are three types of AFSC which are series AFSC, parallel AFSC and switching electronic AFSC.This project will use switching electronic AFSC as a main circuit. The circuit contains thyristor and diode. While passive FSC consist inductor that connected in parallel with resistor.

اونيورسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

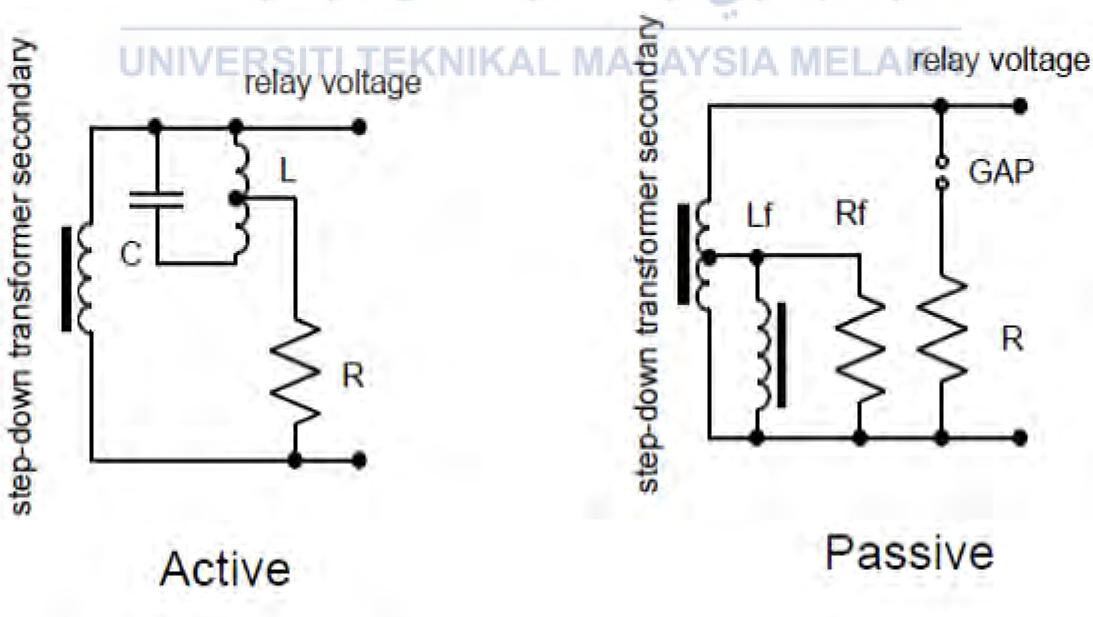


Figure 2.4.1: Active FSC Figure 2.4.2: Passive FSC

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2.5 Active filter

The presence of harmonic in distribution and transmission system that can cause severely damage to the equipment and effect the power quality of the system. To handle this problem active filter should be installed. Active filter is an electronic filter that can help to control harmonic, unbalance load current and reactive power [10]. There are two types of active filter which are shunt active filter and series active filter [11].

Active filter have some of advantages compared to passive filter are compensation is automatic which there no resonance happened, unity power factor can obtained without disturbance and active filter can function in unbalance phase. Beside, active filter and passive filter types cannot combine each other [12].

2.5.1 Shunt active filter

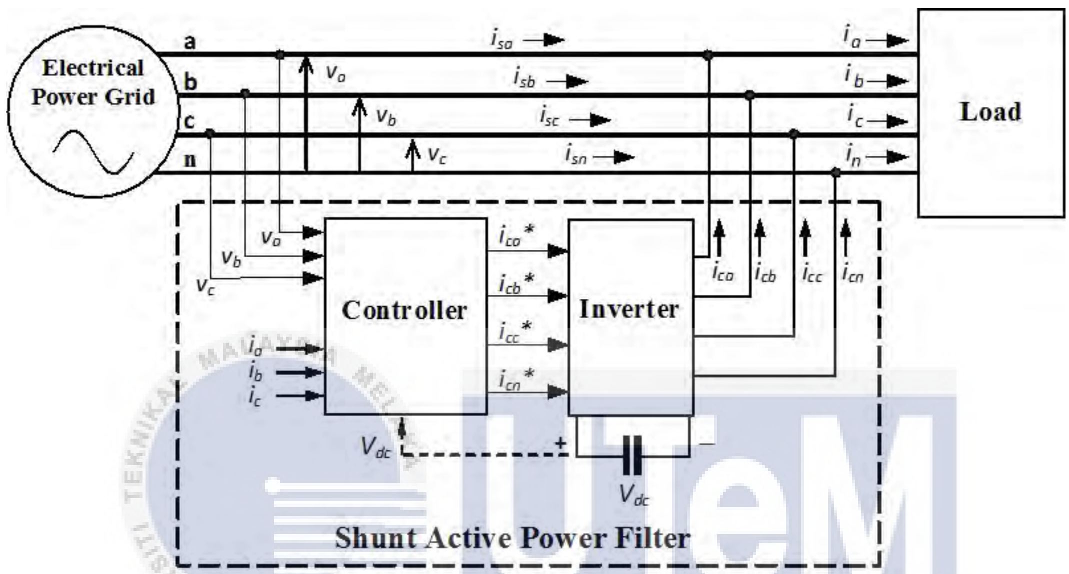


Figure 2.5.1: Shunt active filter

اونيورسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 2.5.1 show the schematic diagram for active shunt filter that have neutral line which can deals with harmonic current and power factor. It allows load balancing and eliminates current in neutral line. Other than that, it also operates as a current source that produce harmonic current which having the opposite phase with those produce by non-linear load. For instance, the one produced during ferroresonance. The phase harmonic current produce are 180 degrees. The active shunt filter connects with non-linear load in parallel to compensate the harmonic current and leave almost fundamental current in the network.

2.5.2 Series active filter

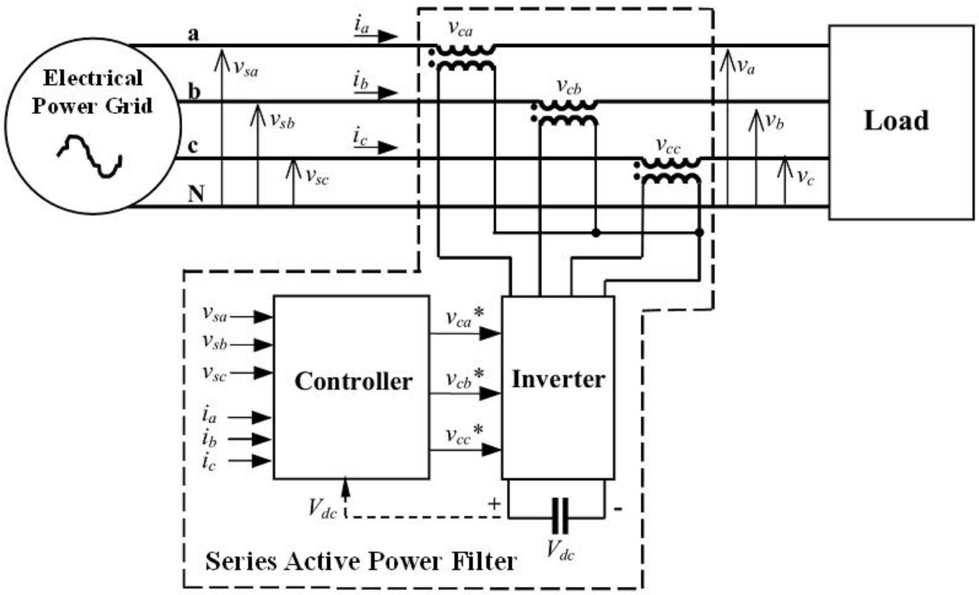


Figure 2.5.2: Series active filter

Figure 2.5.2 show the series active filter, it also can compensate harmonic distortion that produced by non-linear load. The shunt active filter will produce high value of impedance that created by generated voltage with the same frequency of the harmonic current that need to eliminate [13]. Beside, series active filter also known as a dual shunt active filter.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHAPTER 3

METHODOLOGY

3.1 Overview

The main purposed on this chapter is to simulate the active filter for ferroresonance suppression circuit (FSC) from the ferroresonance effect in three phase voltage transformer. In this chapter also the mitigation solution from design of active filter will be discussed briefly. The design and simulation of the circuit use Power Computer System Aided Design (PSCAD) software version 4.2.

3.2 Introduction to PSCAD software.

PSCAD software are used to design the schematic diagram, run a simulation and model the system with ease and providing limitless possibilities in power system simulation. It is very handy and professional software using in power system analysis to study the transient response of the electrical network. Beside that, this software is commonly used in planning, designing, developing new concept, testing idea, understanding what happen when equipment failed, commissioning, teaching and research. There are many of component of electrical that can used to design the schematic diagram in PSCAD [14].

Basic components in the master library of PSCAD software:

- Passive element (resistor, inductor, capacitor)
- Mutually coupled windings such as Transformer
- Current source and voltage source
- Switch
- Breaker
- Meter
- AC machine, exciters,governors,stabilizers and inertial models
- Meter and measuring function
- Diode, thyristors and GTO's
- HVDC, SVC, and other FACTS device
- Analogue and digital control function

UTeM
اونيۏرسيتي تيکنيکل مليسيا ملاک
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Application can conduct in PSCAD software [14]:

- Power lines and cables
- Asymmetrical fault
- Distribution system generation

- Industrial load system
- Power quality analysis improvement
- Insulation of AC and DC equipment
- Power electronic system and drives
- Incorporate the capabilities of MATLAB directly to PSCAD
- Power system studies, including fault, reclosure, and ferroresonance

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

3.3 Methodology of project

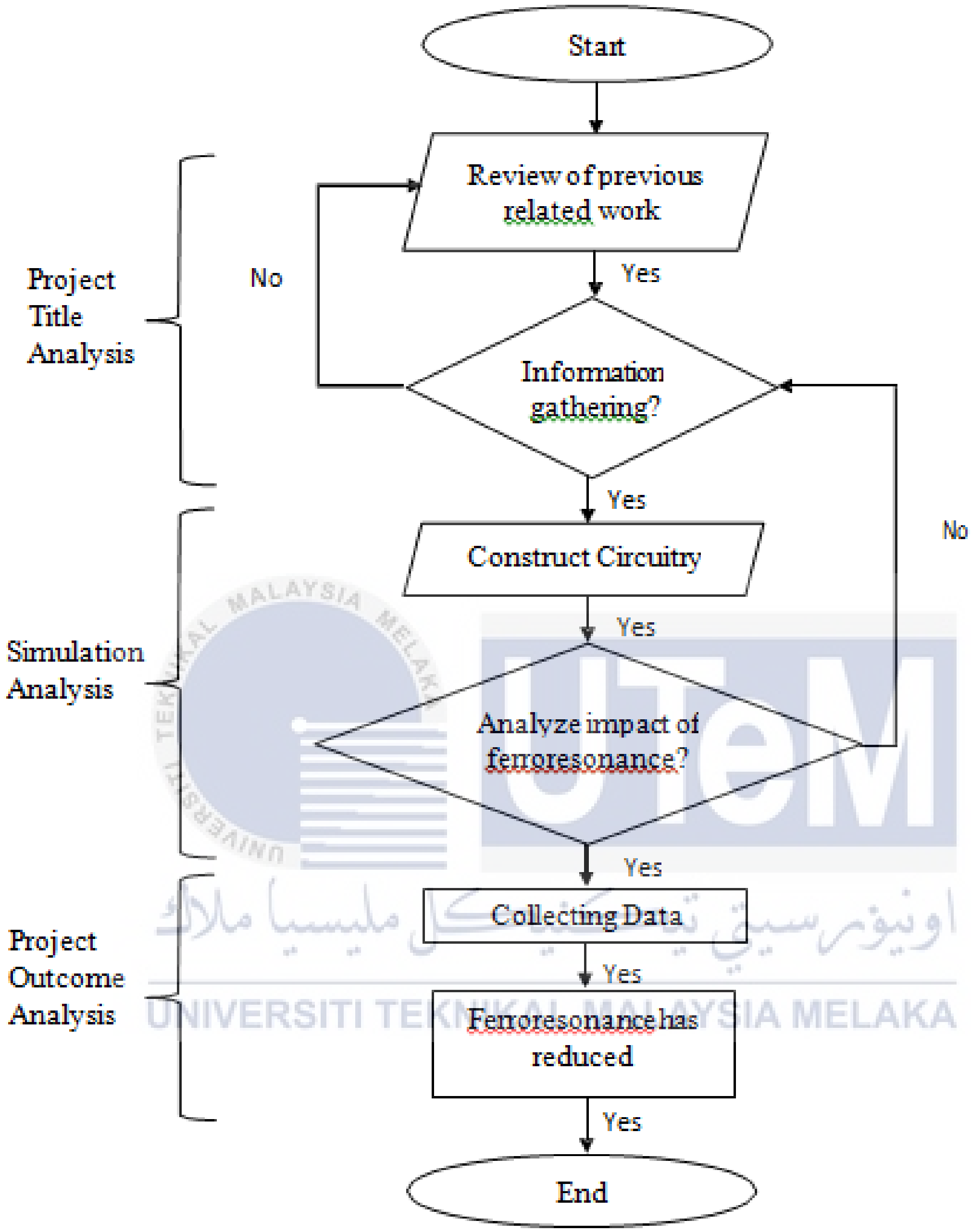


Figure 3.3: Methodology of project

3.3.1 Project Title Analysis

The first step in this project is to study and investigated any journal or previous research that related to active filter, ferroresonance phenomenon, ferroresonance suppression circuit (FSC) and voltage transformer that can used for design the active filter in order to mitigate the ferroresonance phenomenon. The information that related to ferroresonance phenomenon and active filter are always referring for help in this project. If the information gathering of project not success, the step will be reversed back to find the previous project that related.

3.3.2 Simulation Analysis

All the simulation will be carried out by PSCAD software. The circuit is obtained by previous research that related to this project. The main objective of using active filter is to mitigate ferroresonance phenomenon in voltage transformer. The voltage transformer is design with the exact real step-down three phase voltage transformer of 132kV/33kV/22kV/11kV in transmission substation.

Figure 3.4.1 shows the simulation circuit of transmission substation consisting of two substation and transmission line with buses while figure 3.4.2 shows the simulation of three phase voltage transformer. In this circuitry is where the ferroresonance effect been demonstrated using the ferroresonance equivalent source connected to timed breakers. The phase B timed breaker has being opened after 100msec to disconnect the current flow so as to generate the interruption of unloaded phase which is one of the condition for the occurrence of this phenomenon. The ferroresonance effect is then being induced through the three phase voltage transformer to the secondary winding of the system. The voltage waveforms of the primary and secondary winding have been recorded to illustrate the ferroresonance phenomenon. Lastly in figure 3.4.3 it shows the simulation circuit of active shunt filter. The circuitry consists of powers electronic which are thyristors and diode. The thyristors served as voltage regulator and reduced the overvoltage caused by ferroresonance effect while the diodes prevent the back flowing of current to occur.

3.3.3 Project Outcome Analysis

The project outcome obtained is by comparing the ferroresonance with and without implementation of active shunt filter. The measuring meter is placed to observe the waveform of voltage of voltage transformer. This section consists of data and justification whether ferroresonance effect has been successfully be reduced.

3.4 Circuit design

The figure below show the circuit design for whole system from design circuit of transmission distribution system, design circuit for voltage transformer and design circuit of active filter.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

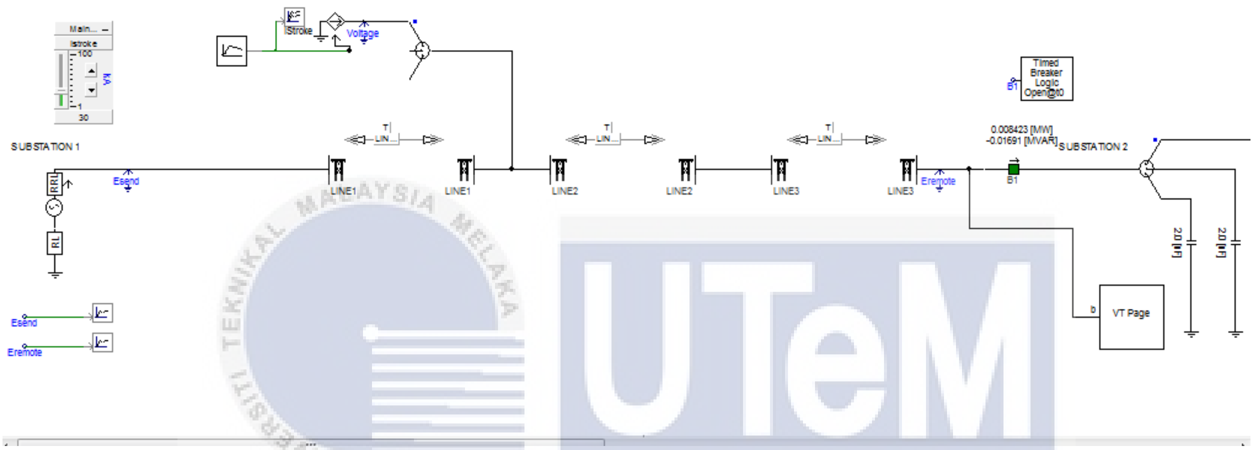


Figure 3.4.1: Simulation of transmission substation

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

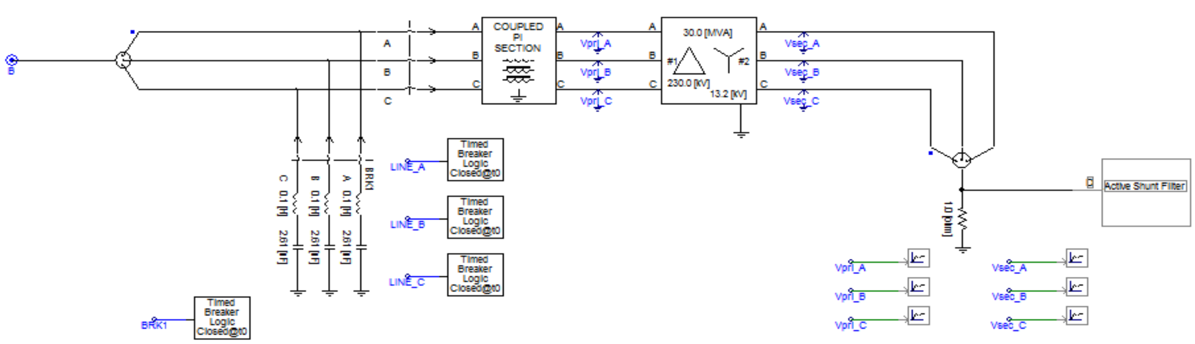


Figure 3.4.2: Simulation of voltage transformer

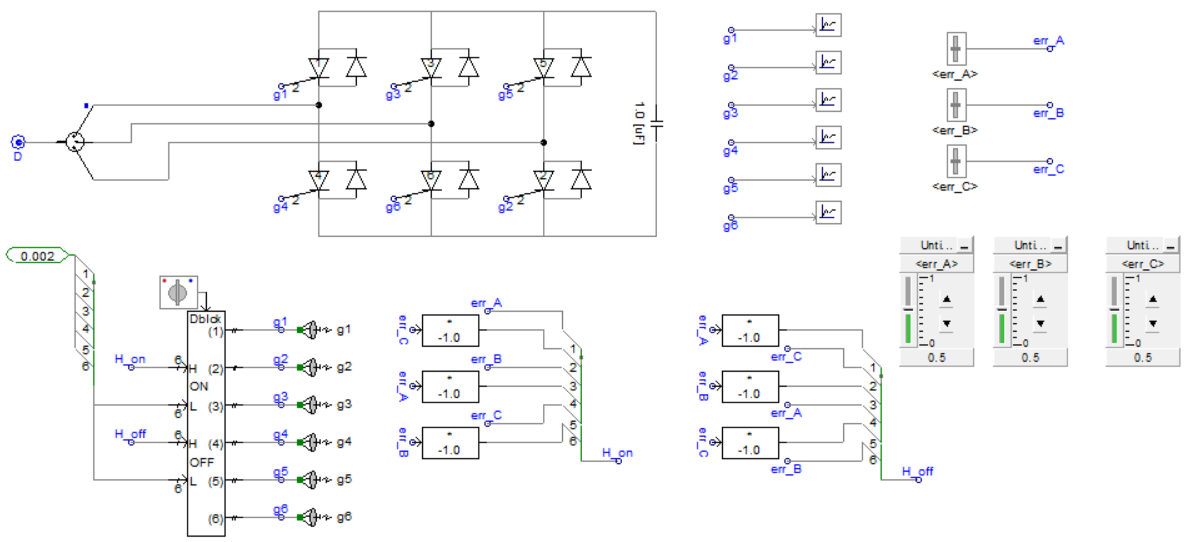


Figure 3.4.3: Simulation of active shunt filter

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

3.5 Gantt chart

Table 3.4.1 and 3.4.2 shows the project of Gantt chart for Final year Project 1 and 2. The Gantt chart is the most important for this project. This project planning shows the process which easily to follow smoothly and ensure it more organized.

Weeks/ Planning	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Determine PSM 1 title and registered title.	■	■												
Determine project overview, objective and scope.			■	■										
Obtain data and information relate to the project through previous study research.			■	■	■	■	■	■						
Prepared draft proposal report.							■	■	■	■	■	■		
Submit draft proposal report.												■	■	
Presentation PSM 1.														■
Repair & submit finalized report.														■
Continue the project according to future plan														■

Table 3.5.1: Gantt chart for FYP 1

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Weeks/ Planning	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Analysis on designing the circuit	■	■	■	■	■	■	■	■						
Analysis on simulation			■	■	■	■	■	■	■	■				
Simulation and the result study										■	■	■	■	
Report writing and preparation for the presentation								■	■	■	■	■	■	■

Table 3.5.2: Gantt chart for FYP 2

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHAPTER 4

RESULT

4.1 Overview

This chapter describes the result obtained from the simulation using the simulation Power System Computer Aided System (PSCAD). The voltage waveform for primary and secondary winding of three phase voltage transformer will be taken. The voltage output obtained after the active shunt filter is implemented has been taken and analyze. Furthermore, the waveform are being analyzed and justified whether the active shunt filter is workable of reducing the ferroresonance effects.

UTeM
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

4.2 Simulation result

The simulation results started with taking the voltage waveform at the primary and secondary sides of each three phases. Comparison is made between the both winding. The voltage output obtained after the active shunt filter is being applied has been taken with three phases of waveform in a single graph.

Phase A

The figure below show the simulation result at the primary and secondary winding for phase A in voltage transformer. Figure 4.1.1 show the voltage waveform at the primary side while figure 4.2.2 shows the voltage waveform at the secondary side of the voltage transformer.

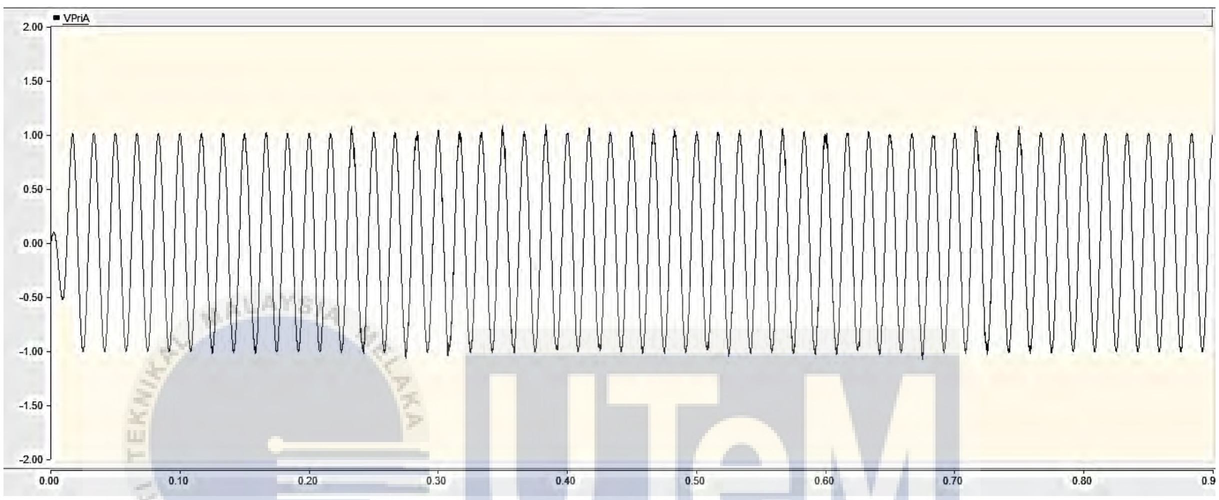


Figure 4.2.1: voltage waveform of phase A at primary winding

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

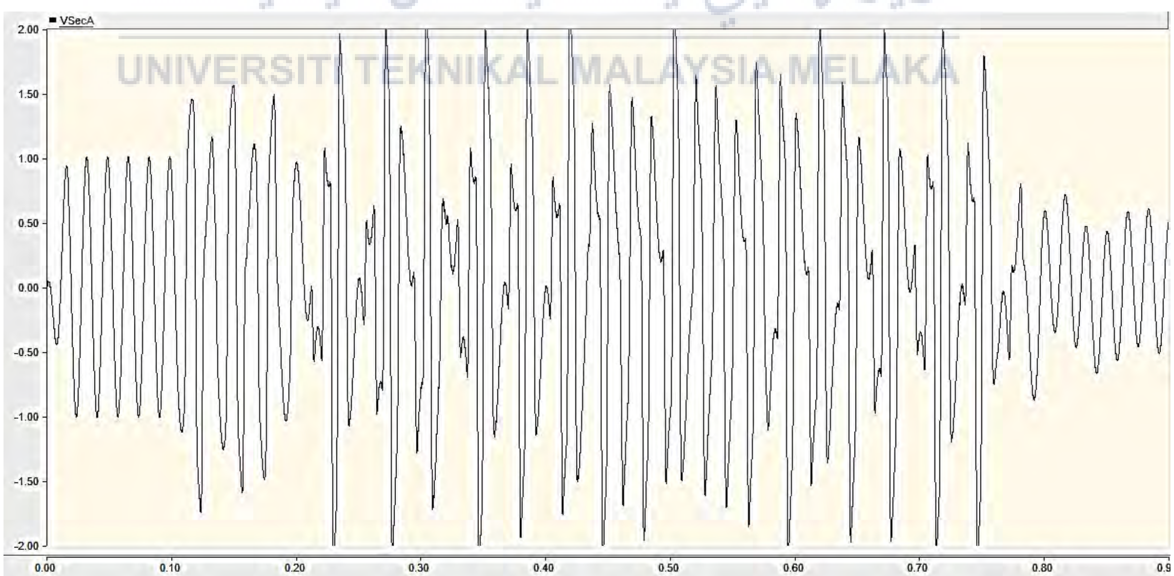


Figure 4.2.2: voltage waveform of phase A at secondary winding.

Phase B

The figure below show the simulation result at the primary and secondary winding in phase B in voltage transformer. Figure 4.2.3 show the voltage waveform at the primary side while figure 4.2.4 shows the voltage waveform at the secondary side of the voltage transformer

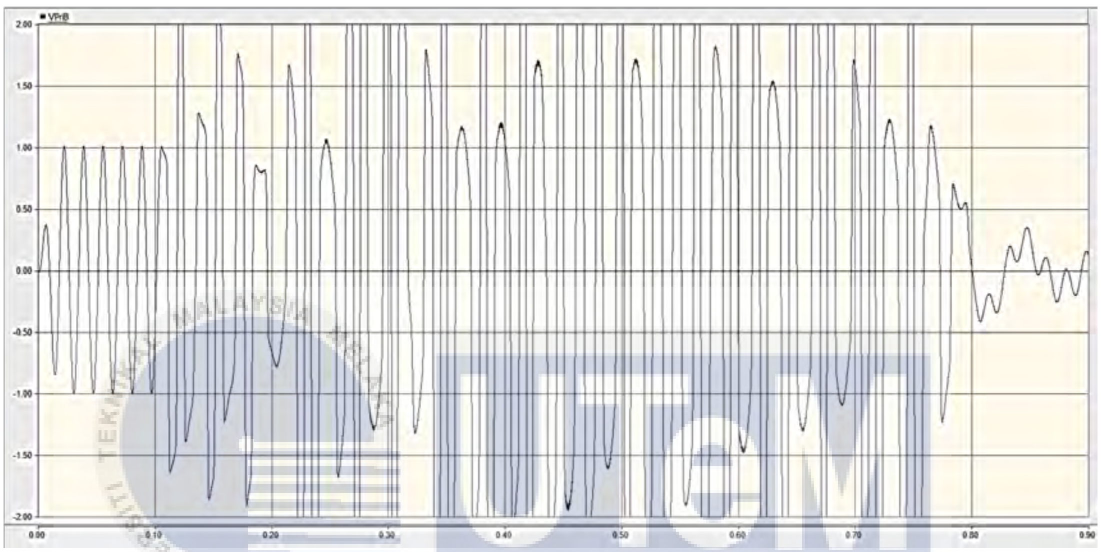


Figure 4.2.3: voltage waveform of phase B at primary winding

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

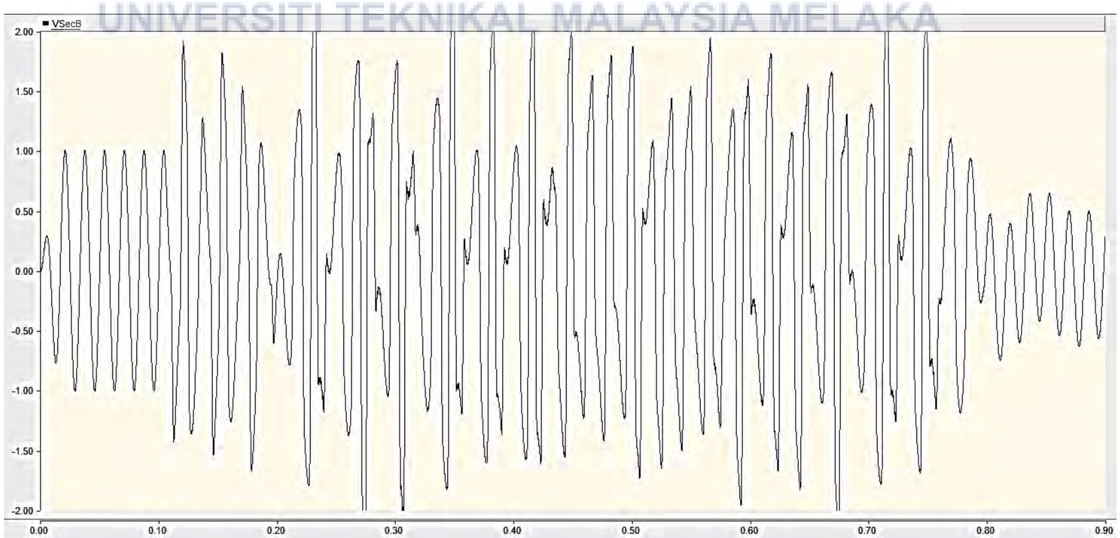


Figure 4.2.4: voltage waveform of phase B at secondary winding

Phase C

The figure below show the simulation result at primary and secondary winding in phase in voltage transformer. Figure 4.2.5 show the voltage waveform at the primary side while figure 4.2.6 shows the voltage waveform at the secondary side of the voltage transformer

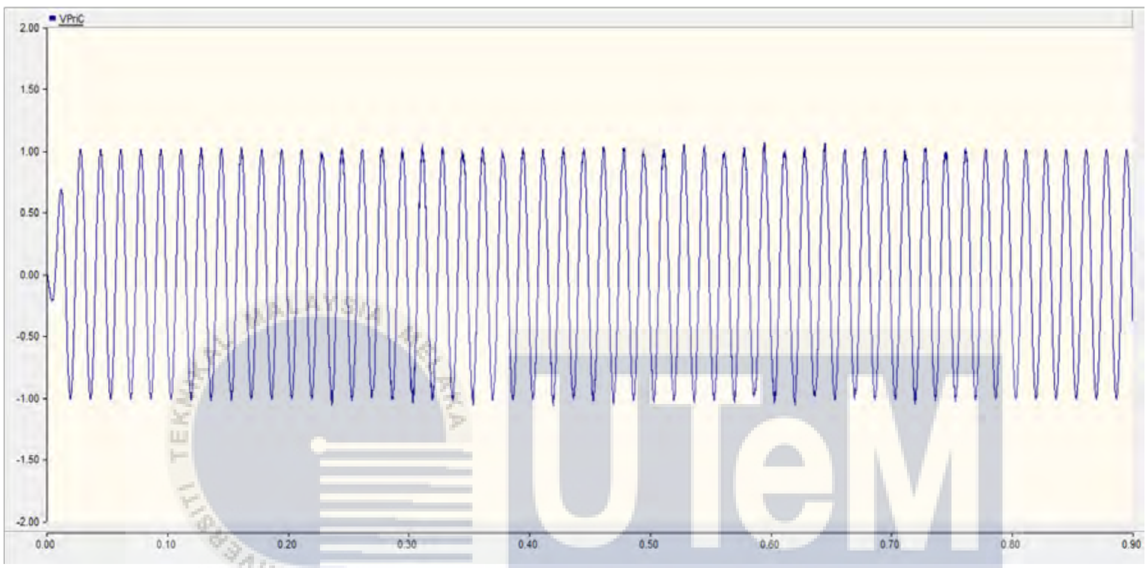


Figure 4.2.5: voltage waveform of phase C at primary winding

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

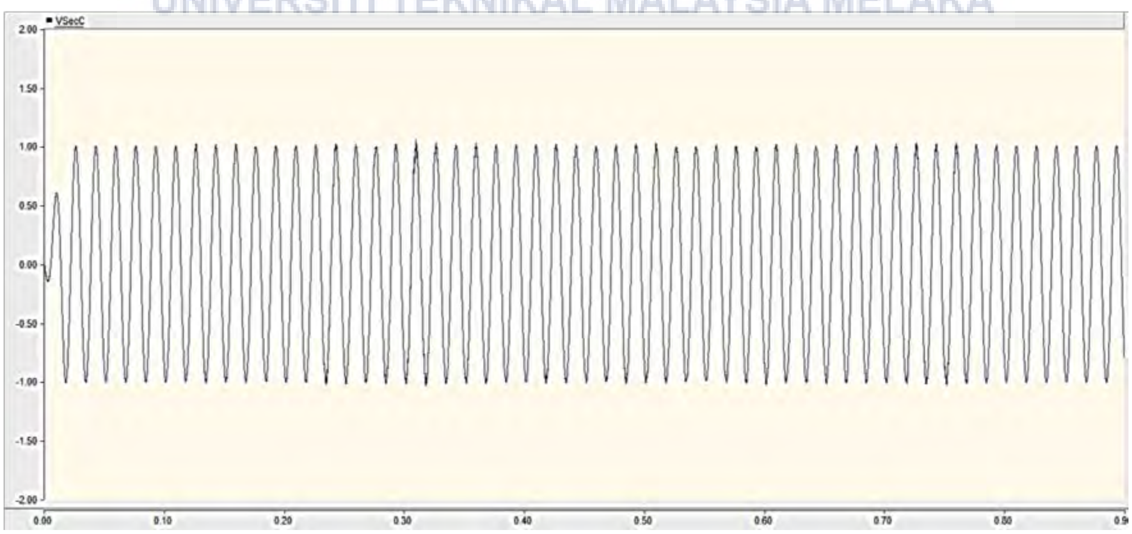


Figure 4.2.6: voltage waveform of phase C at secondary winding.

Voltage Output

Figure4.2.7belowshowsthesimulationresultofthevoltageoutputaftertheactiveshun tfilterisbeingappliedandthevoltagewaveformwiththreephase'swaveforms in a singlediagram.

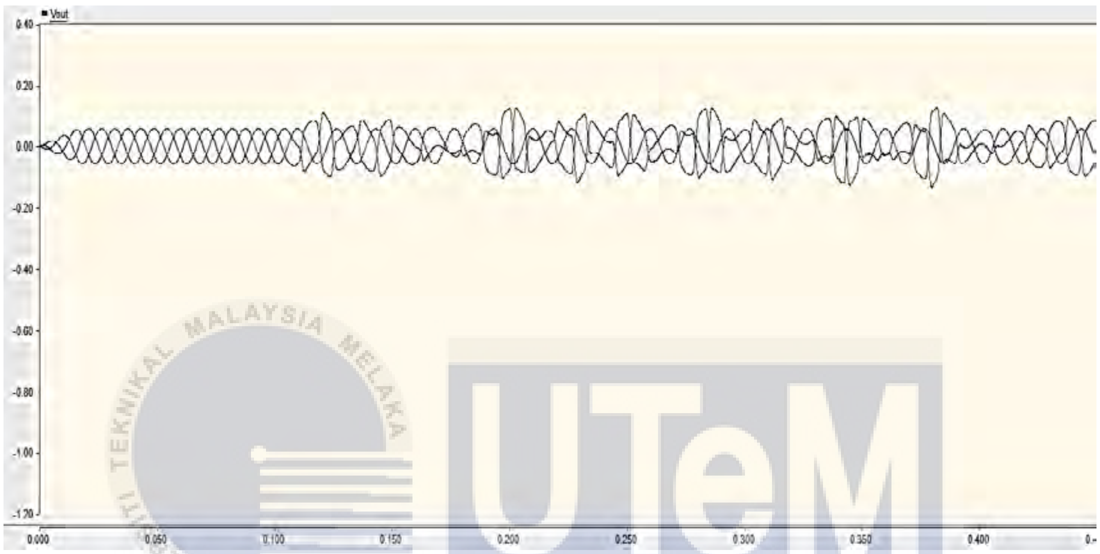


Figure 4.2.7: Voltage WaveformsafterActive Shunt Filteris BeingApplied

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

4.3 Simulation Analysis

In order to simulate the ferroresonance phenomenon, phase B is being open circuited and controlled by the timed circuit breaker. The operation at phase B has triggered the power system making the system to experience sudden voltage transformation. This step is done to demonstrate a ferroresonance phenomenon. Figure 4.3.1 shows the power loss during the transient voltage during the transient period between normal operating and ferroresonance condition. The analysis will be focused on phase B since the ferroresonance effect is apparent at the primary and secondary winding of transformer.

The secondary winding of phase B has experience the ferroresonance impact and all the three phases has being wired into the active shunt filter compartment. After being filtered, all the overvoltage waveform has been reduced to the almost same amplitude voltage values. This shows that active shunt filter is capable of reducing the overvoltage brought by ferroresonance effect. However, the voltage after being filtered is not the same as without ferroresonance effect. It has reduced to a much lower values.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

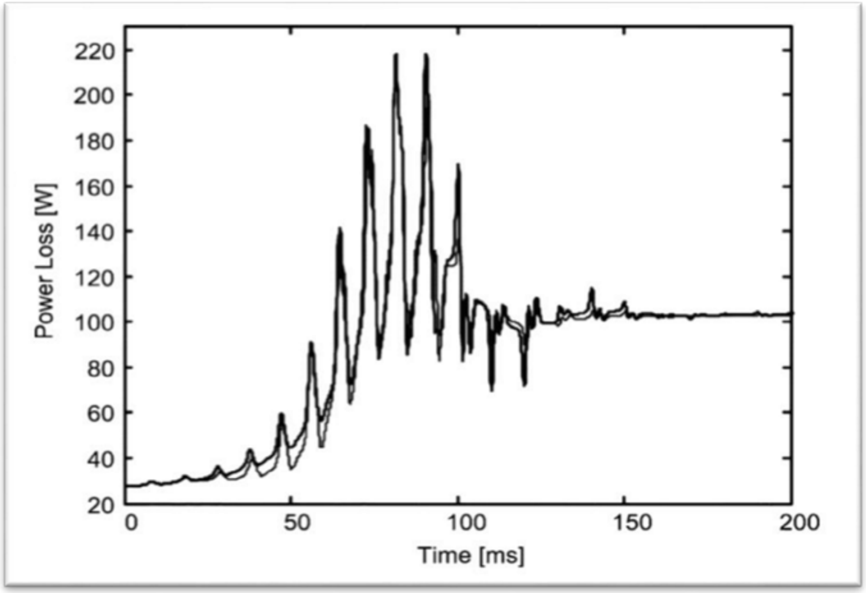


Figure 4.3.1: power loss during ferroresonance phenomenon

UTeM
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

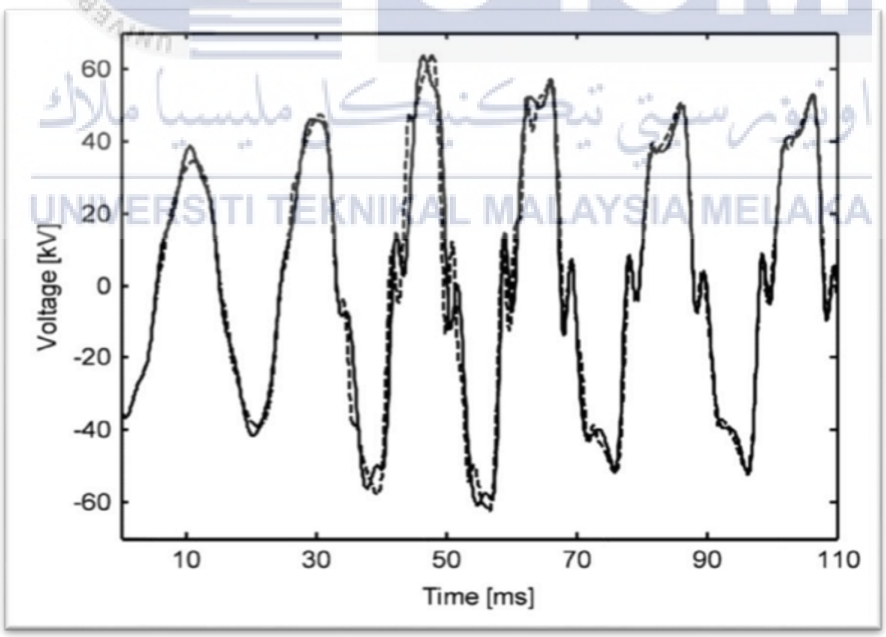


Figure 4.3.2: transient voltage of ferroresonance phenomenon

CHAPTER 5

CONCLUSION

5.1Conclusion

As a conclusion, ferroresonancephenomenon which happened at substation transmission systems can causes many problems such as power quality, severely damage to electrical equipment and etc. So, themitigatingmethodofusingactiveshuntfilteriscapableofreducingtheimpactofferroresonanceonthree-phasevoltagetransformer.Theeffectivenessisshownbytheeliminationofthesuddenincreaseonvoltage waveform.Theaimofthisresearchprojecthasachievedwheretheoccurrenceofferroresonancehasbeeninvestigated.Althoughthephenomenonisregardedasunpredictable,therearesymptomsofoccurrenceforcaution.FurthermorethemitigationmethodofferroresonancehasbeensimulatedusingsimulationsoftwarePowerSystemComputerAidedSystem(PSCAD).

اونيۏرسيتي تيكنيكل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

5.2 Recommendation

Itisrecommendedthatthemethodofmitigatingtheferroresonanceusingactiveshuntfiltercouldbesimulatedusingothersimulationsoftwaretoprovetheeffectivenessasfutureworkorresearchpurposes.TheothersimulationsoftwaresuggestedwouldbeMATLAB.Moreovertheactiveshuntfilterdesign'sparameterscouldbealteredtoobtainahighervoltagevaluesorasmootherwaveforms.Thisisbecauseafterthevoltagewhichhasbeensuccessfullyreduced,ithasneverachievedthevoltagevaluewithouttheoccurrenceofferroresonancephenomenon.Asaresult,thereducedvoltagemightbecausingpowerlossandotherconsequencestothe distributionsystemandusers.Subsequently,thecontrolsystemusedtocontroltheactiveshuntfiltercouldbefurtherimprovedusingadvancedmechanismtobettercontroltheperformance.Furthermore,theparametersforinductiveandcapacitanceinthethree-phasevoltagetransformeraresuggestedtobealteredtobetterdemonstratetheeffectofferroresonancephenomenon.This is becausetheferroresonanceeffectcouldnottheseenatbothwindingofphaseCandprimarywindingofphaseA.Eventhiscouldbeexplainedasnotallthetransmissionlinesareaffectedbytheferroresonanceeffect,butforthesakeofbetterunderstandingusingactiveshuntfiltertomitigatethephenomenon,itisrecommendedthatallthephaseshave to haveshown theferroresonanceimpact.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

REFRENCES

[1] V.Valverde, J.Mazon, G.Bugues, “Ferroresonance suppression in voltage transformer”

[2] A.H.A Bakar, N.A Rahim. M.K.M Zambri, “Analysis of lightning caused ferroresonance in CVT”

[3] AB. Halim S.A khan, Tan Chia Kwang, N AB. Rahman “A riview of ferroresonance in CVT”

[4] Project Gutenberg, “ferroresonance”

[5] D. Jacobso, “example of ferroresonance in high voltage”

[6] A.S Abdallah, M.A EL-KADY, “Ferroresonance phenomenon in power transformer” 2005

[7] V.Valverde, J.Mazon, G.Bugues, S.martin “ferroresonance in three phase power distribution transformer” may 2007

[8] Electrical engineering tutorial, “ferroresonance intro- classification and charecteristics”

[9] Study electrical “capacitor voltage transformer”

[10]Ahmet TEKE1, Lutfu SARIBULUT1, M. Emin MERAL2, Mehmet TUMAY, “Active Power Filter: Review of Converter Topologies and Control Strategies”

[11] Prof. Mrs.R.S.Udgave 1, Prof. Y. R. Atre, “ACTIVE FILTERS WITH CONTROL BASED ON THE P-Q THEORY”

[12] JL. AAFONSO.H.J Ribeiro da silva, J.S Martin “Active filter for power quality improvement” 2001

[13] L.Moran, I.Pastorini, J.Dixon, R. Wallace “Series active power filter compensate current harmonics and voltage unbalance simultaneously”

[14] Real time digital simulation facility, “PSCAD”

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

APPENDICES

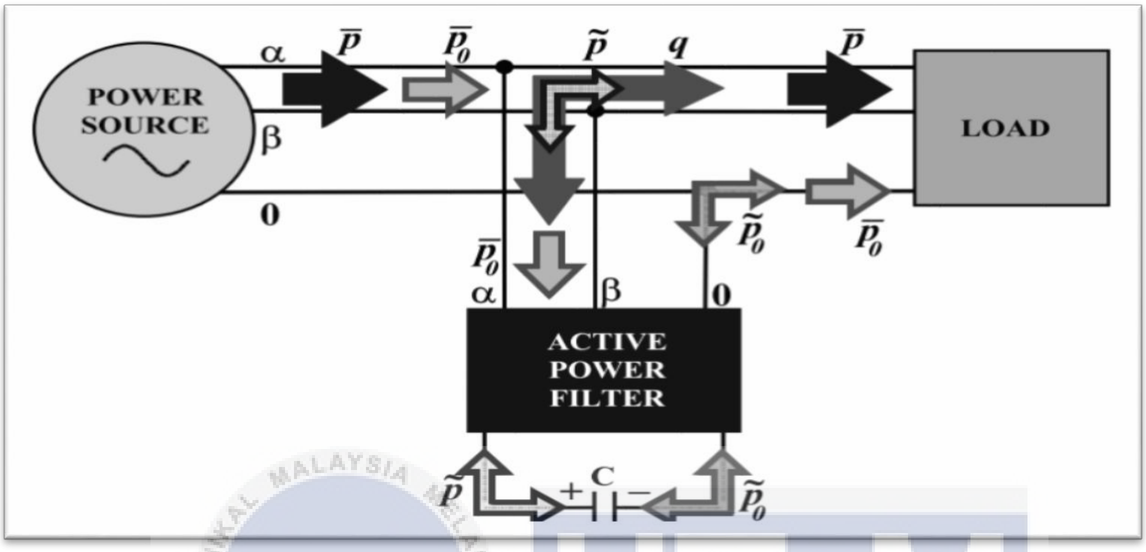
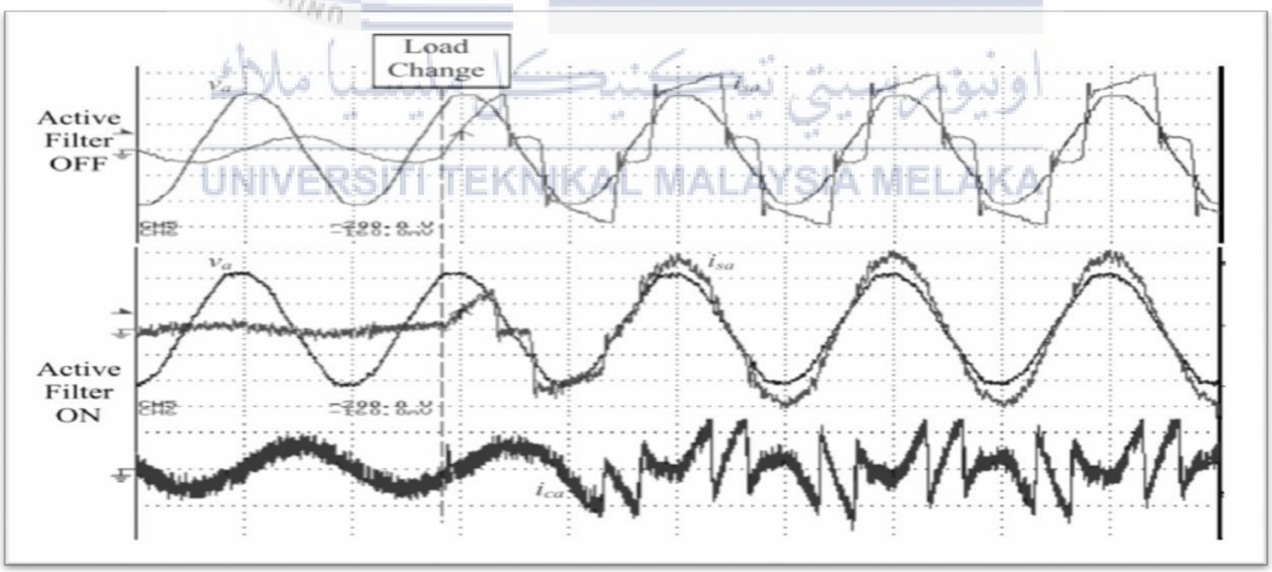
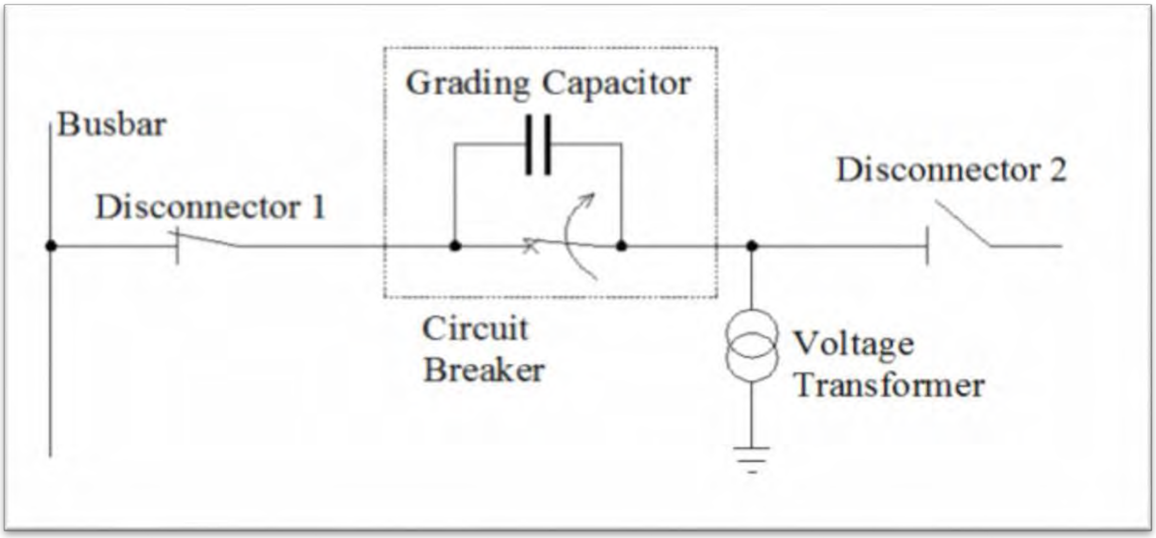


Figure aboveshows thecompensation of powercomponents.



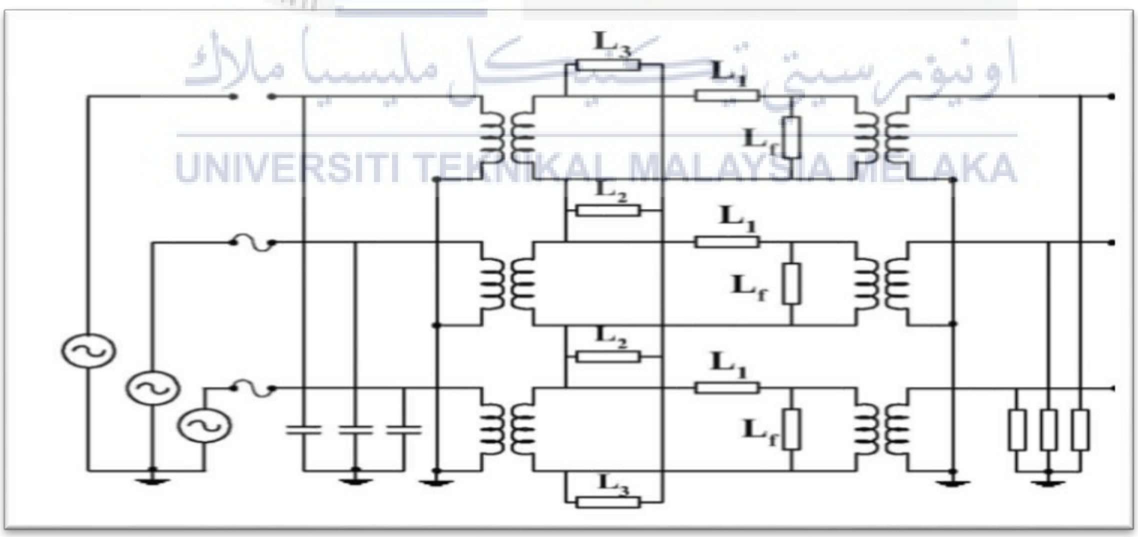
Figureaboveshows the response to aload change,with theshunt active filteroffand on.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA



Figureaboveshows the seriesferroresonancecircuit consistingof grading capacitorand Voltage transformer(VT)

UTeM
UNIVERSITI TEKNIKAL MALAYSIA MELAKA



Figureaboveshows the simulation circuit of mitigation method usinginductiveload.