STATIC AND DYNAMIC IMPACT OF HIGH VOLTAGE DIRECT CURRENT (HVDC) IN AC POWER TRANSMISSION SYSTEM

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This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Electrical Engineering (Power System)

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NOVEMBER, 2009

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Date : 23 NOVEMBER 2009

ACKNOWLEDGEMENT

First and foremost, I am very grateful to the almighty ALLAH S.W.T for letting me to finish my Final Year Project.

Here, I wish to express my sincere appreciation to my supervisor, En. Mohd Redzuan bin Ahmad for encouragement, guidance, suggestions, critics and friendship throughout finishing this project.

In particular, I wish to thank lecturers, staff and technicians, for their cooperation, indirect or directly contribution in finishing my project. My sincere appreciation also extends to all my friends who has involved and helped me in this project.

Most importantly, I wish my gratitude to my parents for their support, encouragement, understanding, sacrifice and love.

ABSTRACT

High voltage direct current(HVDC) is very suitable for AC transmitting power over very long distances.It is more economical for long distances of transmitting of transmitting power. Since the cost of an HVDC transmission line is less than that of an AC line with the same capacity, the additional cost of converters for DC transmission is offset when the line is long

enough. Studies show that it is advantageous to consider overhead HVDC transmission lines when the transmission distance is longer than 600 km. HVDC lines have no reactance and are capable of transferring more power for the same conductor size than AC lines. DC transmission is especially advantageous when two remotely located large systems are to be connected. The DC transmission tie line acts as an asynchronous link between the two rigid systems eliminating the instability problem inherent in the AC links.This project will determine or analysis the impact of load flow,fault and stability by using Power System Computer Added Design(PSCAD).So,the stability and load flow of the system can be determined.Load flow study are used to ensure that electrical power transfer from generator to consumer through the grid system is stable,reliable and economic.The result from this analysis can be used to make another research related to the power flow which familiar as power system stability analysis

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LIST OF ABBREVIATIONS

HVDC	–	High Voltage Direct Current
LCC	–	Line Commutated Converter
CCC	–	Capacitor Commutative Converter
PSCAD	–	Power System Computer Adapt Designing
Io	–	Output Current
PIC	–	Programmable Intelligent Computer
SSR	–	Solid State Relay
V	–	Voltage
V_{in}	–	Input Voltage
V_o	–	Output Voltage
ZCT	–	Zero phase Current Transformer
Ω	–	Ohm

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CHAPTER 1

INTRODUCTION

1.1 Project Background

The project is based on the Power System . In Power Transmission System, High Voltage Direct Current (HVDC) is used widely in most of modern countries. HVDC is used in transmission system for long distances. When HVDC is combined in AC power system, there are many impacts accurs inside the system like static and dynamic impacts.

This project will focus on the impact of using HVDC. Two types of effection that we want to determined are static impact and dynamic impact. By using the analysis in MATLAB and PSCAD system, the static impact like steady state voltage, load flow analysis and fault analysis can be determined. The dynamic impact of the system like transient stability also can be determined. The result from this project is very important to know why we use HVDC and not HVAC. What is the advantages of using HVDC over HVAC.

The problem of this project is to understand the HVDC system.The questions like what is HVDC,why use HVDC,when use HVDC,and how HVDC operate is the major problems for this analysis.I have to understand and try to get all informations related with power system to finish this psm project. I hope the result from this project can be used for TNB to upgrade their system in power transmission system. With all my work hard and support from my advisor,insyaALLAH this project can be finished on the time.

1.2 . Objectives :

The objective of this project are:

I. To know the stability of the system when using HVDC.
II. To conduct a load flow analysis.
III. To determine the impact of the HVDC system.
IV. To carry out fault that can be effected power system.

1.3. Scope of Project

The scope of this project are as follow:

I. Static impact of HVDC
I.I. Steady state voltage profile
I.II. Load flow analysis
I.III. Fault analysis
II. Dynamic impact of HVDC
II.I. Transient stability

1.4. Literature Review

For transmitting power over very long distances it may be more economical to convert the HVAC to HVDC, transmit the power over two lines and invert it back to ac at the other end. Studies show that it is advantageous to consider dc lines when the transmission distance is 500km or more. DC lines have no reactance and are capable of transferring more power for the same conductor size than ac lines. DC transmission is especially advantegous when two remotely located large system are to be connected. The dc transmission tie line act as an asynchronous link between the two rigid system eliminating the instability problem inherent in the ac link.The main disadvantage of the dc link is the production of harmonic which requires filtering, and a large amount of reactive power compensation required at both ends of the line.[1]

The first long-distance transmission of electric power was demonstrated using direct current in 1882 at the Miesbach-Munich Power Transmission, but only 2.5 kW was transmitted. An early method of high-voltage DC transmission was developed by the Swiss engineer Rene Thury and his method was put into practice by 1889 in Italy by the Acquedotto de Ferrari-Galliera company. This system used series-connected motor-generator sets to increase voltage. Each set was insulated from ground and driven by insulated shafts from a prime mover. The line was operated in constant current mode, with up to 5000 volts on each machine, some machines having double commutators to reduce the voltage on each commutator. This system transmitted 630 kW at 14 kV DC over a distance of 120 km. The Moutiers-Lyon system transmitted 8600 kW of hydroelectric power a distance of 124 miles, including 6 miles of underground cable. The system used eight series-connected generators with dual commutators for a total voltage of 150,000 volts between the poles, and ran from about 1906 until 1936. Fifteen Thury systems were in operation by 1913 Other Thury systems operating at up to 100 kV DC operated up to the 1930s, but the rotating machinery required high maintenance and had high energy loss. Various other electromechanical devices were tested during the first half of the 20th century with little commercial success.[2]

One conversion technique attempted for conversion of direct current from a high transmission voltage to lower utilization voltage was to charge series-connected batteries, then connect the batteries in parallel to serve distribution loads. While at least two commercial installations were tried around the turn of the 20th century, the technique was not generally useful owing to the limited capacity of batteries, difficulties in switching between series and parallel connections, and the inherent energy inefficiency of a battery charge/discharge cycle.

HVDC in 1971, this 150 KV mercury arc valve converted AC hydropower voltage for transmission to distant cities from Manitoba Hydro generators.

The grid controlled mercury arc valve became available for power transmission during the period 1920 to 1940. Starting in 1932, General Electric tested mercury-vapor valves and a 12 kV DC transmission line, which also served to convert 40 Hz generation to serve 60 Hz loads, at Mechanicville, New York. In 1941 a 60 MW, +/- 200 kV, 115 km buried cable link was designed for the city of Berlin using mercury arc valves (Elbe-Project), but owing to the collapse of the German government in 1945 the project was never completed.[8] The nominal justification for the project was that, during wartime, a buried cable would be less conspicuous as a bombing target. The equipment was moved to the Soviet Union and was put into service there.[3]

Introduction of the fully-static mercury arc valve to commercial service in 1954 marked the beginning of the modern era of HVDC transmission. A HVDC-connection was constructed by ASEA between the mainland of Sweden and the island Gotland. Mercury arc valves were common in systems designed up to 1975, but since then, HVDC systems use only solid-state devices.

From 1975 to 2000, line-commutated converters (LCC) using thyristor valves were relied on. According to experts such as Vijay Sood, the next 25 years may well be dominated by force commutated converters, beginning with capacitor commutative converters (CCC) followed by self commutating converters which have largely supplanted LCC use.[10] Since use of semiconductor commutators, hundreds of HVDC sea-cables have been laid and worked with high reliability, usually better than 96% of the time.[4]

1.5. Thesis Outline

This report have 6 chapters.For every chapter, there are subpoint under major point.In chapter 1, it is about project backgound. The explanation about title of the project, objective, scope of project and literature review. In chapter 2,explanation more detail about what is HVDC system like operation, advantages, and application. In chapter 3, discussion is about what is static and dynamic impact in theorcal and related for HVDC. In chapter 4, it is about analysis of HVDC system by uing MATLAB and PSCAD. Flow chart and project flow also discussed in this chapter. In chapter 5, explanation about result and discussion Last, in chapter 6 , explanation is focused at conclusion and recommendation for overall point of this project.

CHAPTER 2

HIGH VOLTAGE DIRECT CURRENT

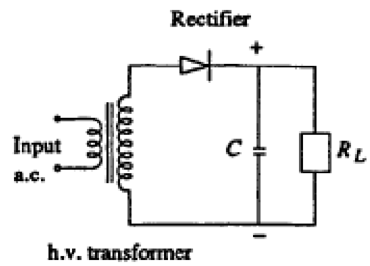
2.1. Introduction

High voltage is used for transmission to reduce the energy lost in the resistance of the wires. For a given quantity of power transmitted, higher voltage reduces the transmission power loss. Power in a circuit is proportional to the current, but the power lost as heat in the wires is proportional to the square of the current. However, power is also proportional to voltage, so for a given power level, higher voltage can be traded off for lower current. Thus, the higher the voltage, the lower the power loss. Power loss can also be reduced by reducing resistance, commonly achieved by increasing the diameter of the conductor; but larger conductors are heavier and more expensive.

High voltages cannot be easily used in lighting and motors, and so transmission-level voltage must be reduced to values compatible with end-use equipment. The transformer, which only works with alternating current, is an efficient way to change voltages.

A high-voltage, direct current (HVDC) electric power transmission system uses direct current for the bulk transmission of electrical power, in contrast with the more common alternating current systems. For long-distance distribution, HVDC systems are less expensive and suffer lower electrical losses. For shorter distances, the higher cost of DC conversion equipment compared to an AC system may be warranted where other benefits of direct current links are useful.

In the half wave rectifier, C (smoothing capacitor) is charged to V_{max}, (maximum a.c. voltage in the conducting half cycle).In the other half cycle, the capacitor C is discharged into the load, R_L. The value of the C is chosen such that the time constant CR_L is at least 10 times of the period of the ac supply.The input and output waveforms of half wave rectifiers.



(a) Half wave rectifier

Figure 2.1: Half wave rectifier

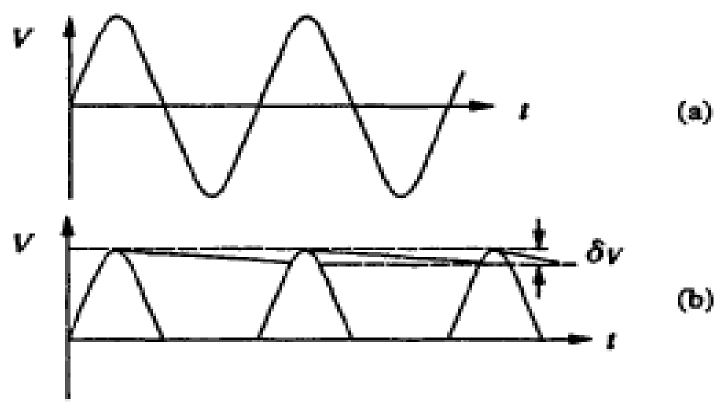


Figure 2.2:Half wave waveform

A full wave rectifier circuit is shown in Fig. 2.3.In the positive half cycle, rectifier A conducts and charges the capacitor C,In the negative half cycle rectifier B conducts and charges the capacitor. The source transformer requires a centre tapped secondary with a rating of 2V.The input and output waveforms of full wave rectifiers are shown in Fig. 2.3.Capacitor C is required as smoothing condenser. Without C, the output waveform will follow the ac waveforms (+ ve polarity)

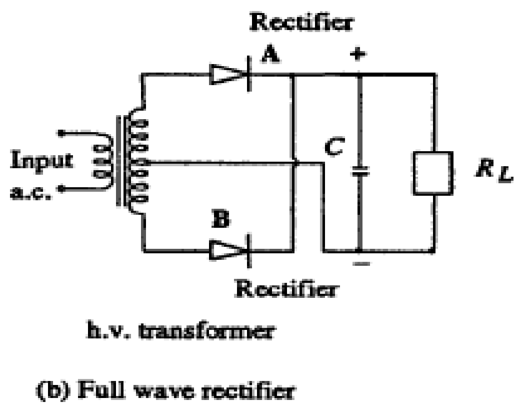


Figure2.3:Full wave rectifier

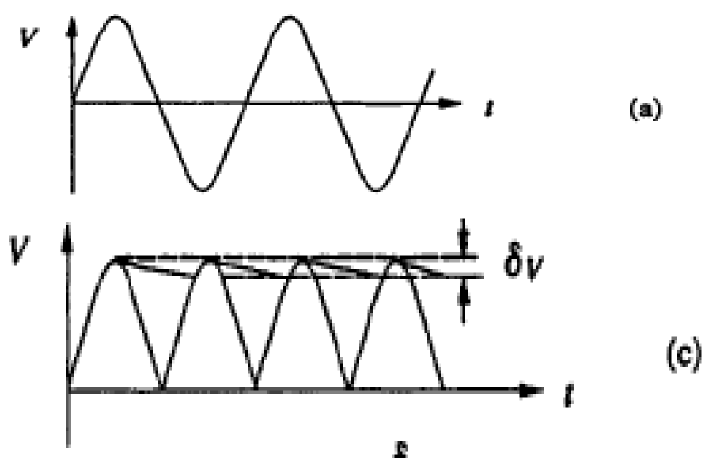


Figure 2.4:Full wave waveform

2.2. Operation of HVDC

The power system begins from power plant.Inside the power plant,electrical power is producing by generator.The generator can operate by using steam from many sources like nuclear,winding,coal and gases.F rom power plant,electrical power will transmit to transmission substation to step up by using transformer.From power plant to substation,the system operate in AC.HVDC is used at transmission line only.To convert AC to DC,rectifier is used.In the end of transmission line,inverter is used to convert DC to AC again .The next station is power substation.The electrical power will step down here and transmit to the load or user.The figure 2.1 shows the operation of power system and figure 2.5 show the HVDC system in power transmission system.

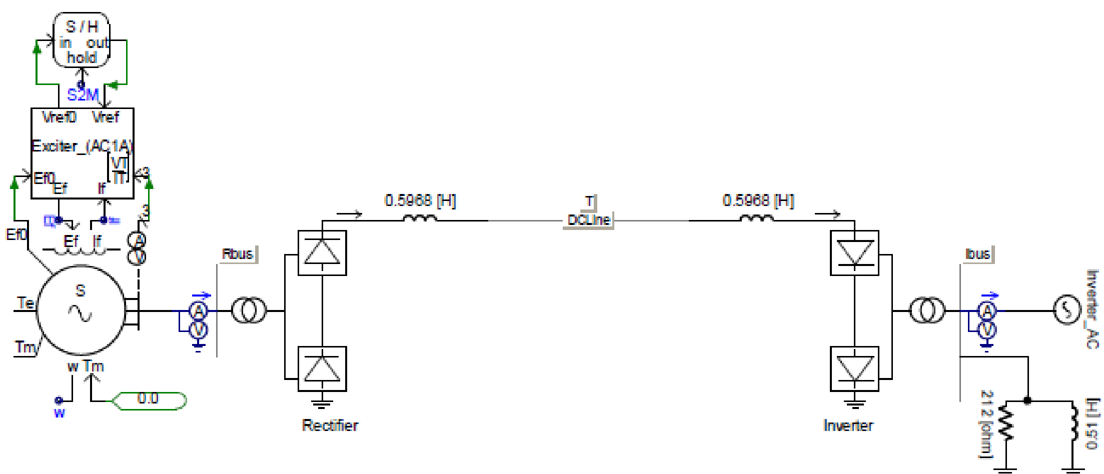


Figure 2.5: HVDC system.

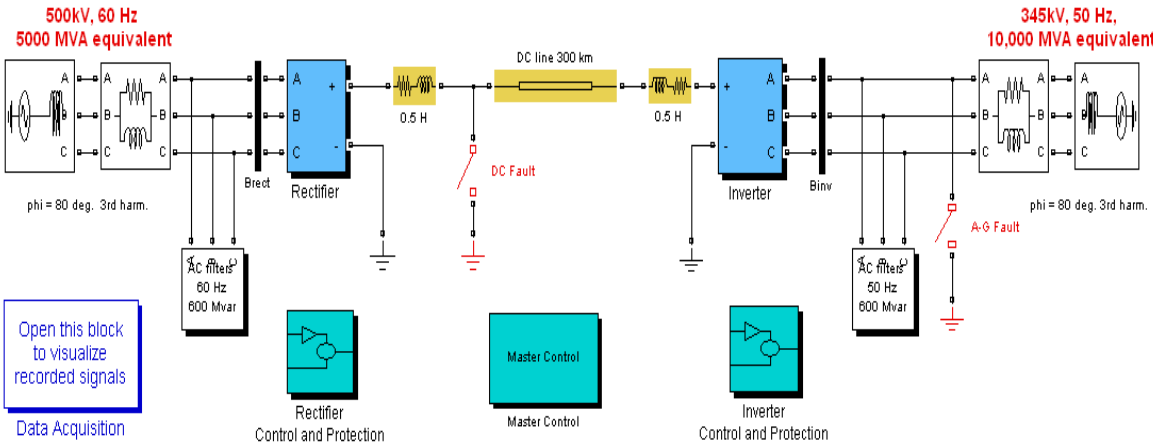


Figure 2.6:HVDC link system

Figure 2.6 show that how HVDC operate in two system. As we know, the DC have only real power (P) not reactive power(Q) and apparent power(S).in DC, the value of frequency is equal to zero. so, the unsynchronized of AC can be combined together when the system convert to DC. Figure 2.2 show that how two unsynchronized of AC that have different value of frequency(60Hz and 50Hz) can be connected when using the HVDC. To convert AC to DC, rectifier is used and to convert DC to AC, inverter is used. In DC, there are no reactive component like inductance and capacitance. capacitance is leading(+ve) and inductance is lagging(-ve).From the figure, after generation, transformer is used to step up the electrical power. transformer is used in AC only because transformer is component of inductance. Rectifier is used to convert AC to DC. component of rectifier are diod and filter. Component of inverter are power transmitter and SCR. After HVDC transmission, electrical power will convert to AC and step down by using transformer again.

2.3 HVDC System configurations

In its simplest form, an HVDC system consists of a rectifier, a DC link and an inverter. However, there are different system configurations which are used in different situations and sometimes for different purposes as it will be seen later. These configurations can be classified as follows:

I. Monopolar links
II.Bibolar links
III.Multiterminal links
III.Back to Back links

2.3.1 Monopolar link

Monopolar links are the simplest and least expensive for moderate power transmission. They use a single conductor, usually in negative polarity and two converters. The schematic of a monopolar link is shown in figure 2.7.

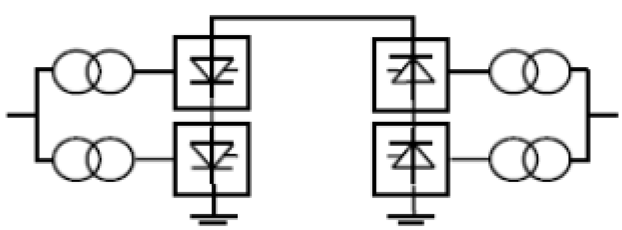


Figure 2.7:Monopolar link

Monopolar systems use the earth or sea water as the return conductor. This is however not always possible and is not generally accepted. If the earth's resistivity is too high, it becomes impossible to use the earth as the return path and a metallic conductor