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HVDC Rectifier Station Modelling using PSCAD-EMTDC

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Abstract

In this paper we have presented HVDC Rectifier station Model using PSCAD-EMTDC. Here HVDC system is modelled using CIGRE Benchmark circuit. A Benchmark model provides a common base for trying out new concepts and to compare simulation results. It also provides a base to study the advantages of HVDC over AC systems. Here HVDC Rectifier Station is modelled and its results are also plotted, so that PG student can understand evaluation of software for simulation purposes.

Keywords

CIGRE, HVDC, Gratez Converter, PSCAD-EMTDC

Introduction

HVDC (High Voltage Direct Current) transmission has got lot of attention for possessing various advantages over AC transmission system. It is used for long distance transmission and higher power ratings. It is quite economical than ac system and possess environmental advantages. The first commercial project was started in Sweden in 1954 and after that it expanded all over the world and has achieved a fast pace by transmitting around 70,000 MW power.

Overview

The first CIGRE MODEL (The Conseil International des Grands Reseaux Electriques) was proposed in 1985. This benchmark model developed by CIGRE study group is an international association based in France. This benchmark has been used all over the world for testing and evaluating the performance. The CIGRE system shown in the figure is a monopolar 500-kv, 1000 MW HVDC link with 12-pulse converters on both rectifier and inverter side, and connected to AC system with a predefined SCR.

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The model which has been shown in the figure is elaborated for comparative studies of different HVDC control schemes. Each AC system has a pre-set Short Circuit Ratio (SCR), which represents the degree of strength of the system. The model also consists of AC filters of the damped-arm type and capacitor banks for reactive power compensation. The DC transmission line is considered as a long cable system and hence is represented by a T-section model with high shunt capacitance and low series inductance.

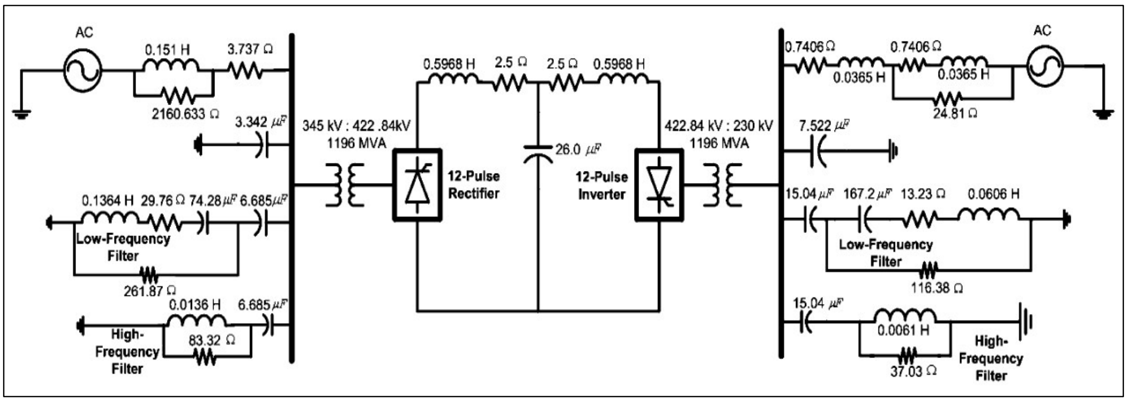

Figure 1: CIGRE Benchmark Model

Details of CIGRE benchmark system:

Parameters	Rectifier side	Inverter side
Base AC voltage	345 kv (line to line)	230 kv (line to line)
Base power	1000 MW	1000MW
Base impedence	119.03 ohm	52.9 ohm

In India also HVDC projects are in existence, one of the world largest multi-terminal HVDC system is under construction list of HVDC projects are as:

PROJECT NAME	TYPE	RATINGS	LENGTH (km)
Biswanath-Agra	Long distance transmission bipole	800 kV 6000MW	1825
Ballia-Bhiwadi	Long distance transmission	500kV 2500MW	780
Visakhapatnam-B2B-Vizag2	Back to back	176 kV 500MW	-
Vizag1	Back to back	176kV 500MW	-
Rihand-Delhi	Long distance transmission	500kV 1500MW	814
Sileru-barsoor	Long distance transmission	200kV 400MW	196

Talcher-Kolar	Long distance transmission	500kV 2500MW	1450
Vindhyachal	Back to back	176kV 500MW	-
Chandrapur-Padghe	Long distance transmission	500kV 1500MW	900
Chandrapur	Back to back	205kV 1000MW	-

Table: List of HVDC Projects in India

Implementation of HVDC Rectifier Using PSCAD

Benchmark model of a mono polar two terminal HVDC transmission system, which has been developed by CIGRE described in the foregoing section has been implemented using PSCAD/EMTDC. PSCAD is a powerful and flexible graphical user interface to the world renowned EMTDC solution engine. This application includes control system design and coordination of FACTS, HVDC and optimal design of controller parameters among many others. Several basics components of electrical networks can be found already modelled in extensive library supported by PSCAD. A brief description of those components used is described below.

Description of PSCAD Model

1. **Twelve Pulse Converter Model:** The converter of two area system has been modelled using PSCAD. The model consists of two components which are present in the library. The first one is 12-pulse bridge converter which is a compact representation of dc converter which includes built in 12-pulse GRAETZ Converter Bridge figure below, internal Phase locked oscillator (PLO), firing and valve blocking control which is used for firing angle and extinction angle measurement. It also consists of RC snubber circuit for protection of each thyristor. The bridges are connected in series. The other component is 3-phase 2-winding transformer. The leakage reactance of this transformer is assumed to be 18% which is sufficient to limit the fault current through the valves. No tap changers are used because only transient phenomenon is considered.

2. **DC System:** In this the DC system is represented by using a equivalent T-model as shown in the figure. DC line consists of DC cables, DC filters and smoothing reactors. The R, L, C values of DC line including the smoothing reactor is given below.

Parameters	DC side
Base voltage	500kV
Base current	2000A
Base impedance	250 ohm
Base power	1000MW

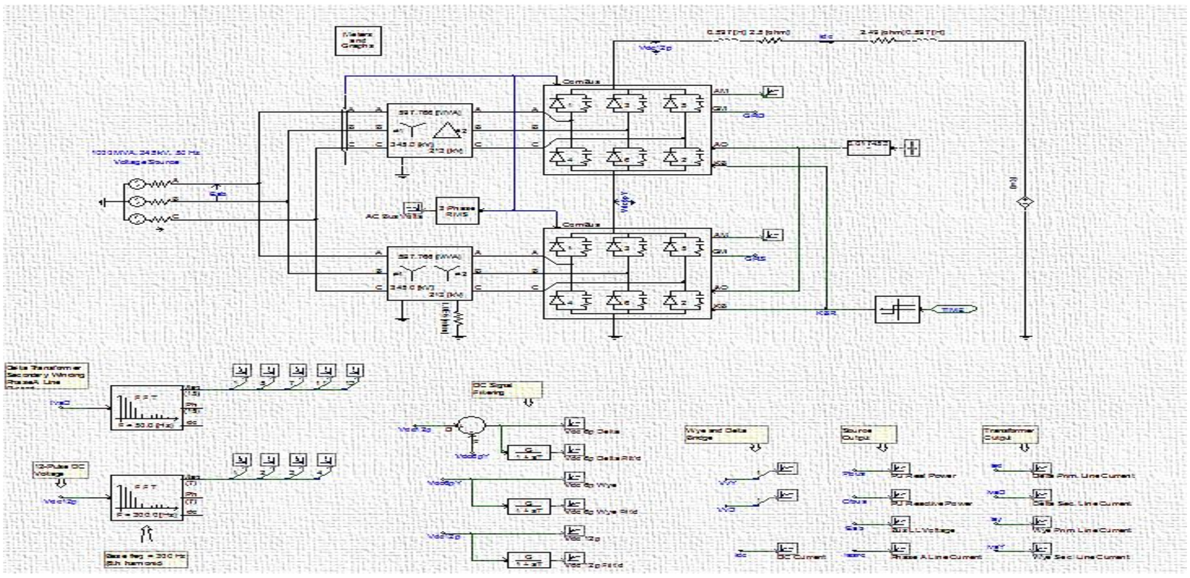

Figure 2: Converter model in PSCAD

3. **AC System:** The ac system is represented and modelled using a Thevenin's equivalent circuit. The HVDC system is connected to AC system of frequency 50 hertz. As shown in figure the model consists of a specified source and zero sequence impedance. In this model weak AC system is considered on both the sides.

4. **AC line:** The impedance angle at rectifier side is 84° and 75° at the inverter side. These values are chosen to provide necessary damping to the systems. Source parameters are selected such that both sending and receiving end AC systems have a peak impedance around 100Hz.

Applications of HVDC Converters

The first application for HVDC converters was to provide point to point electrical power interconnections between asynchronous A.C. power networks. There are other applications which can be met by HVDC converter transmission which include:

i. **Interconnections between asynchronous systems:** Some continental electric power systems consist of asynchronous networks such as the East, West, Texas and Quebec networks in North America and island loads such as the Island of Gotland in the Baltic Sea make good use of HVDC interconnections.

ii. **Deliver energy from remote energy sources:** Where generation has been developed at remote sites of available energy, HVDC transmission has been an economical means to bring the electricity to load canters. Gas fired thermal generation can be located close to load centers and may delay development of isolated energy sources in the near term.

iii. **Import electric energy into congested load areas:** In areas where new generation is impossible to bring into service to meet load growth or replace inefficient or decommissioned plant, underground d.c. cable transmission is a viable means to import electricity.

iv. **Increasing the capacity of existing A.C. transmission by conversion to D.C. transmission:** New transmission rights-of-way may be impossible to obtain. Existing overhead A.C. transmission lines if upgraded to or overbuilt with D.C. transmission can substantially increase the power transfer capability on the existing right-of-way.

v. **Power flow control:** A.C. networks do not easily accommodate desired power flow control. Power marketers and system operators may require the power flow control capability provided by HVDC transmission.

vi. **Stabilization of electric power networks:** Some wide spread AC power system networks operate at stability limits well below the thermal capacity of their transmission conductors. HVDC transmission is an option to consider increasing utilization of network conductors along with the various power electronic controllers which can be applied on AC transmission.

Control System Model of CIGRE Benchmark Model

The control structure of HVDC CIGRE Benchmark can be modelled in PSCAD. Modelling is done Using the fundamental blocks found in Control System Modelling Functions (CSMF) folder in the master library of this platform. For each converter control four main blocks are used, which are Generic current control block, generic gamma control block, voltage dependent current limit block and minimum gamma detector block. The complete configuration of the by trial and error using multi run characteristics available at PSCAD, while voltage dependent current order limit have been adjusted according to static characteristics.

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Results

The various waveforms of voltages have been shown in figure 3. The input voltage (single phase), output voltage.

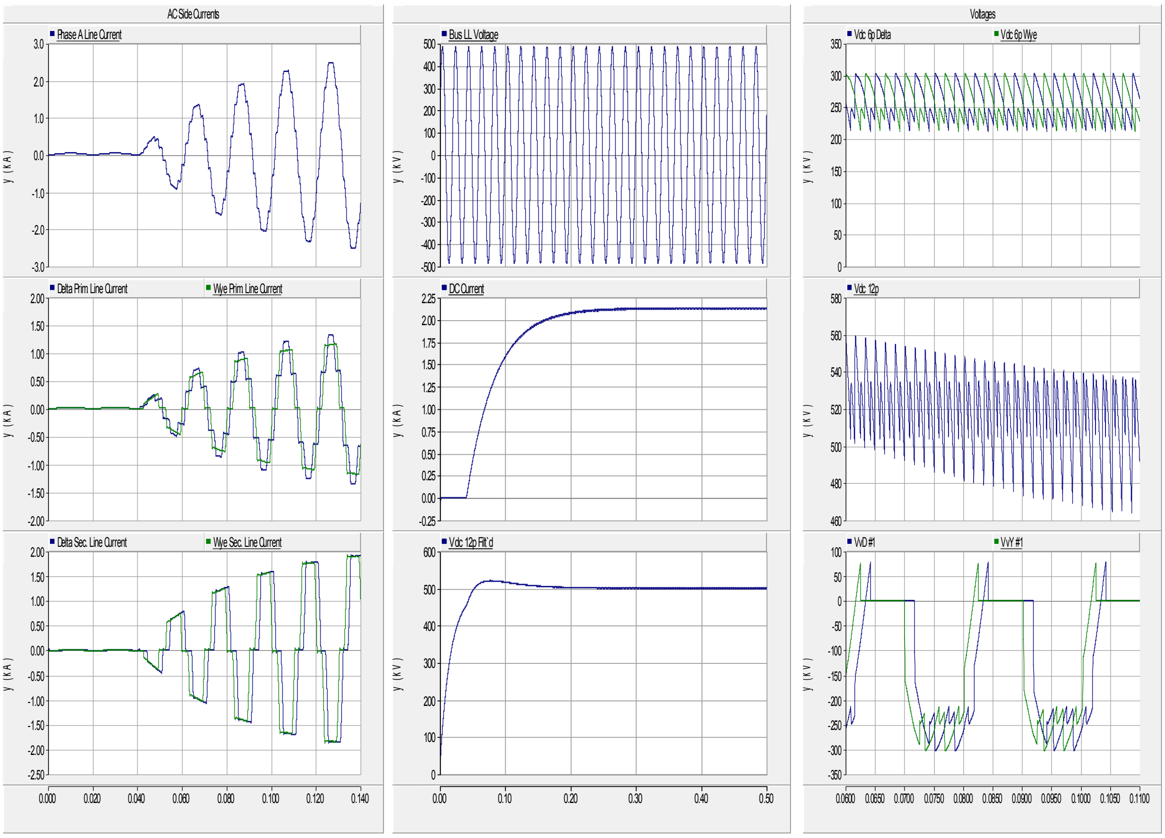

Figure 3: Various waveforms of voltages

Conclusion

In this report an HVDC system based on the CIGRE Benchmark model is presented. Modelling of each subsystem is performed using PSCAD simulation. The HVDC Rectifier Station modelling is done in PSCAD-EMTDC. The control system and its results waveform have been shown, by this PSCAD-EMTDC software simulation PG students should be able to know the working of HVDC system.

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