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실효치 기반 동적 모의를 위한 HVDC UDM 모델 개발

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Development of HVDC user defined model for RMS-based dynamic simulation

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Abstract - This paper presents a new user defined modeling about HVDC system based on the PSS/E. The principles, methods and procedures of user defined modeling for dynamic simulation are expounded. Comparing beween the dynamic simulations results of a power system by CDC4T in the PSS/E library and a user defined model CDCKU1 respectively, we illustrate the general usage of custom features and verify the model accuracy. Future work about CDCKU series and practical models will be considered to enhance the power system stability in Korea.

1. INTRODUCTION

High voltage direct current (HVDC) technologies have rapidly developed due to numerous advantages.[1] PSS/E, namely power system simulation for engineering, is the premier software tool by electrical transmission participants world-wide. Since its introduction in 1976, PSS/E has become the most comprehensive, technically advanced, and widely used commercial program and also be recognized as the most fully featured, time-tested and best performing commercial program available.[2]

Comparing with electromagnetic transient program such as EMTP or EMTDC [3] [4] in which the study cases are simulated by the instantaneous values of power systems with time domain simulation, PSS/E could compensate their disadvantages: 1) the simulation speed is very low due to small time step of calculation; 2) the number of buses simulation is also limited so that they can not simulate a large and complex power system.

In dynamic simulation, PSS/E library already has wide variety of equipment models that users just call them in dynamic file to make study cases. However, due to the diversity of HVDC models, PSS/E library could not involve all types of HVDC models. For accurate simulation, the users should better to compose their own models in term of user defined model(UDM) which is readily modified totally according to the purpose of the user. In this paper, a simple HVDC system has been proposed. The proposed model is written of the UDM function in PSS/E (version 32) program.

In the new model CDCKU1, VDCOL was set at the inverter side. Future work about other new detailed HVDC control scheme will be considered and developed to support power system stability enhancement.

2. DYNAMIC SIMULATION AND USER DEFINED MODEL IN PSS/E

2.1 Dynamic Simulation Principle

The dynamic simulation can be used to calculate and simulate accurately the response of physical system to several events like a fault or line tripping. The model will be presented in term of differential equation describing the dynamic behavior.

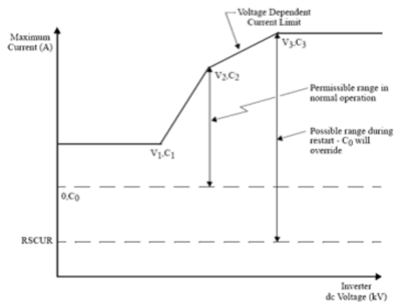
In PSS/E, the RMS value will be analysis in time domain. From ″T″ to ″T+t″, differential equations of the system should be solved and the moving forward by ″t″. Following the steps: 1) calculate time derivative of each state variable; 2) calculate constant & algebraic equations which describe the system at that instant in time; 3) update the state variables based on the present state and the time derivative.

The basic structure of dynamic simulation section shows in [5]. The main skeleton of PSS/E consists of logic for data input, output, numerical integration, and electric work solution while no logic to differential equations of specific. The differential equation intelligence on the equipment is included in a library of subroutines which contains logic to calculate time derivatives for one specific type of equipment. The model subroutines can be obtained by PSS/E program library or User Defined Model (*.dll file). The model subroutines are called when the main skeleton logic needs numerical values of time derivatives. Most models are called directly by PSS/E and others that may require user input are called via linking subroutines CONEC and CONET .[5]

2.2 Proposed HVDC user defined model in PSS/E

The modeling of DC transmission recognizes three distinct types of action by the controls: 1) normal regulation of dc converter operation to maintain specified constant current or constant power transfer; 2) temporary overriding of dc converter normal operating set points in response to disturbances of ac system voltages during faults; 3) modulation of dc power set point by supplementary control device for purpose such as assist the damping of rotor angle swings in ac system or keep the frequency under the acceptable range.

In HVDC system, power control and current control can be utilized, If in power control mode, the current set point will be acquired indirectly by divide power set point to filter value of the absolute value of DC voltage of the converter. If in current control, the current set point will be directly compared to a ″voltage dependent current order limit″ VDCOL [6], [7] to get the current order for the converter of HVDC station [8]. The VDCOL control shows in Fig.1.

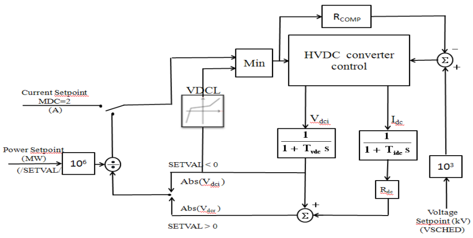


<Fig.1> Voltage-Dependent current limit for dc converters

2.3. New User Defined HVDC Model in PSS/E

By changing the firing angle of the thyristor the control system gets the desire current and can regulate the impedance in the large-scale smoothly. The block diagram for the master controller is shown in Fig.2.

In transient operation, all dc transmission should be secured against inverters commutation failure which causes one pair of diodes conducting permanently in the inverter bridge [9]. Because these are normally not on the same leg of the bridge, the dc current flows permanently through one phase-pair of the transformer. Protection and extinguishing of the two conducting diodes, is handled by bypassing the inverter bridge. CDCKU1 models a dc transmission in which the bypass is a fast operating vacuum switch. Two actions taken by the dc converters during ac system disturbances: 1) the rectifier and inverter are both shut down (blocked) if the ac voltage at the rectifier falls below the per unit value, VBLOCK; 2) The inverter bypass switch is closed if the inverter end dc voltage falls below the kilovolt value, VBYPAS. The rectifier continues to maintain dc current at scheduled value.



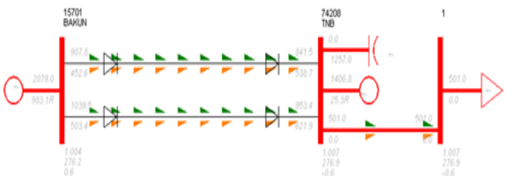
<Fig.2>Master Control of CDCKU1

3. CASE STUDY AND RESULTS

3.1 Case study description

In CDCKU1, normally the inverter sets dc voltage and the rectifier sets dc current during state operation.

To make it simple, we make use of a three bus power system shown in Fig.3. The power system consists of two generators connected with each other by two 500 kV HVDC transmission line supply to a 395 MW load. Nominal voltage of AC system is 275 kV. The purpose of case study is to check the validity of the proposed HVDC-UDM. Therefore, in dynamic simulation one of the HVDC line is modeled as CDCKU1 while the other is CDC4T in PSS/E library. 2 case studies have been performing: 1) fault on rectifier side of HVDC; 2) fault on inverter side of HVDC.



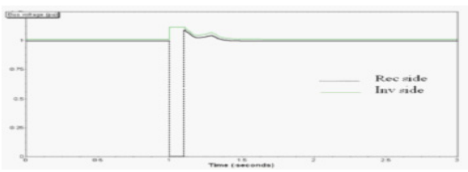
<Fig.3> Case Study Structures

3.2 Simulation Result

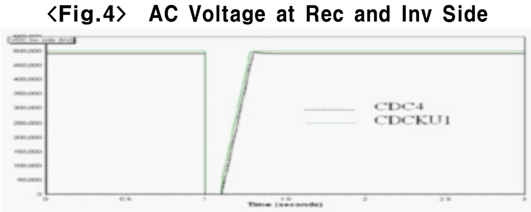
3.2.1 Case study1

At time=1.000 CDCKU1 blocked
At time=1.000 CDC4 blocked
At time=1.100 CDCKU1 unblocked
At time=1.100 CDC4 unblocked

The simulation results of case study 1 show in Fig.4. and Fig.5.



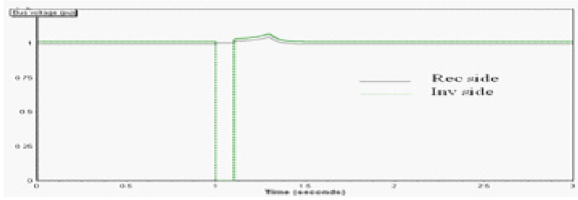
<Fig.4> AC Voltage at Rec and Inv Side



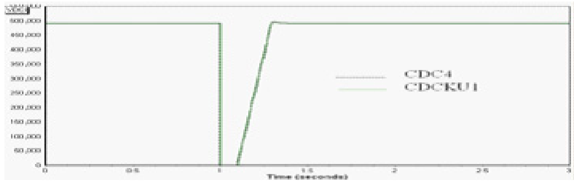
<Fig.5> DC Voltage at CDC4 and CDCKU1

3.2.2 Case study2

At time=1.000 CDCKU1 bypassed
At time=1.000 CDC4 bypassed
At time=1.100 CDCKU1 bypassing
At time=1.100 CDC4 bypassing
The simulation results of case study 2 show in Fig.6. and Fig.7.



<Fig.6> AC Voltage at Rec Side and Inv Side



<Fig.7> Inv DC Voltage at CDC4 and CDCKU1

4. CONCLUSION AND FUTURE WORK

This paper has presented user defined model in PSS/E in the term of HVDC. The new model design which based on dynamic simulation principle and HVDC user defined model principle shows the validity of the HVDC model. Some control models are applied to this model to protect HVDC in some severe situation from communication failure by using bypassed function or HVDC broken down by blocked function. VDCOL also take control in the case study when the current order higher than current from VDCOL. [10]Otherwise, According to the simulation results, the dynamic respond of UDM-CKCKU1 coincide with that of HVDC model from the PSS/E library. However, CDCKU1 is just a respond type model HVDC so the L/R dynamics of the dc links is not very accurate.

Future work: some other new detailed HVDC control scheme will be developed to support other functions of HVDC in power system stability enhancement like frequency damping control or rotor angle damping control and improve the dynamic response of the HVDC more accuracy. [11]

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