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Modelling of Custom Power Devices in PSCAD/EMTDC

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The modeling of several different solid-state custom power devices is underway at the University of Manitoba as part of a project sponsored by the Manitoba HVDC Research Centre. The purpose of the work is to identify the salient control and implementation issues, develop a simple study system that can demonstrate these fundamental issues and finally to construct the actual model. The custom power devices considered initially fall into two categories. First, the semi-conductor device is used as a simple 'Solid State Breaker' (SSB). Devices in this class include the solid-state transfer switch (SSTS) [1] and the Solid State Fault Current Limiter (SSFCL). Another class of devices can be used for control of voltage and reactive power. Examples of these are the Dynamic Voltage Restorer (DVR) and the Distribution Static Synchronous Compensator (D-STAT-COM) which can be used to control voltage flicker. Each of the modeled cases include the device as well as a set of comprehensive controls and a suitable study network.

Solid State Transfer Switch (SSTS): As an example of a custom power device, consider the static transfer switch shown in Fig.1. The test system is based on one reported in literature [2]. While mechanical devices can take up to 2 seconds to transfer a load from a faulted bus over to a healthy one, this device can achieve the transfer in a fraction of a cycle. The need for such a rapid transfer is dictated by the proliferation of sensitive equipment such as computers, programmable drives and consumer electronics. These loads show perceptible performance interruptions when subjected to an extended period of poor voltage regulation. Indeed several industrial plants using sensitive controllers have reported hours of downtime due to voltage sags [2].

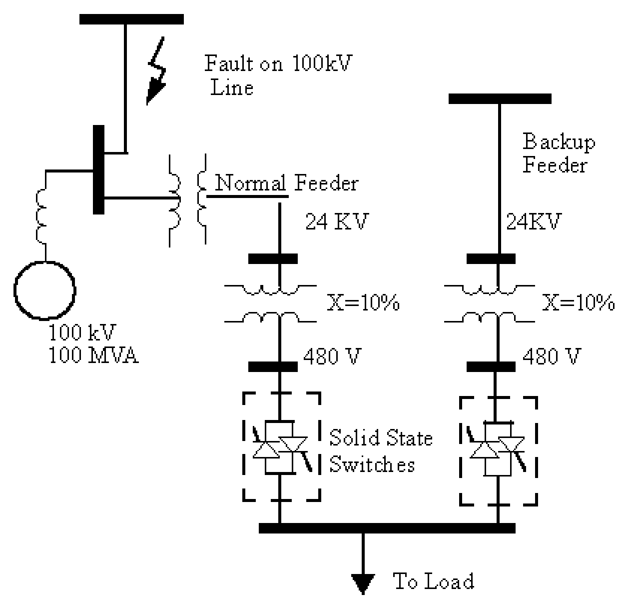


Figure 1: Test Circuit for Transfer Switch

A system application of the SSTS is shown in Fig 1. Each phase of the SSTS is a parallel back to back thyristor arrangement. The switch which is on has its thyristors pulsed continuously. On detection of a sag, these firing pulses are stopped. The thyristors which would have then stopped conducting at the first natural current zero in that phase, are now subjected to a high reverse voltage from the other feeder and are immediately turned off. Current interruption is thus achieved at sub-cycle intervals.

The control system designed for the simulations, which incorporates the above mentioned considerations is shown in Fig. 2. Instantaneous detection of a sag is obtained by constant comparison of the voltage waveform with an ideal sinusoid in phase with it and having a magnitude equal to the pre-sag value. This sinusoid is reconstructed using the fundamental frequency component of the Fast Fourier Trans-form of the voltage waveform from a previous cycle. If the actual waveform has a lower instantaneous value than the predicted waveform, a sag is detected. This allows for the instantaneous detection of large sags (V<85%). However, errors are possible due to voltage distortions, harmonics and so on. For the detection of smaller sags (85%<V<90%), additional time must be allowed. Further considerations include the inhibit of transfer for a large phase difference (say, exceeding 30°) between the two feeders, as well as controls for the protection of the semiconductor devices.

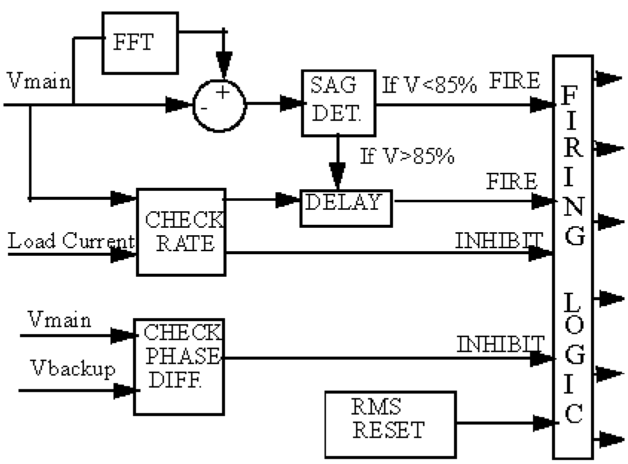


Figure 2: Control Circuit for Transfer Switch

Additional control features are required if the load consists largely of induction motors.

<u>PSCAD/EMTDC Simulations for the SSTS:</u> The waveforms from the simulation of the system in Fig. 1 are shown in Fig. 3. Evident from the results is the detection of the sag (to 0.85 pu voltage) and transfer of the load within 1/4th of a cycle with minimal transients. The dotted line shows the voltage that would have appeared at the load in the absence of a Transfer Switch.

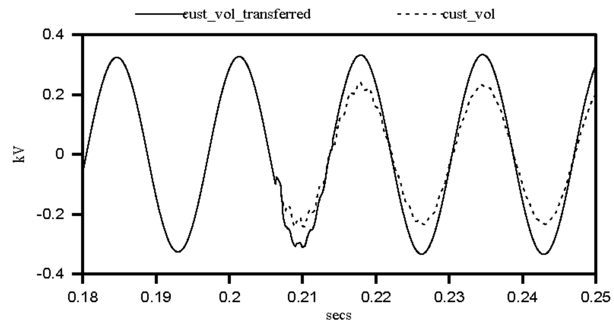


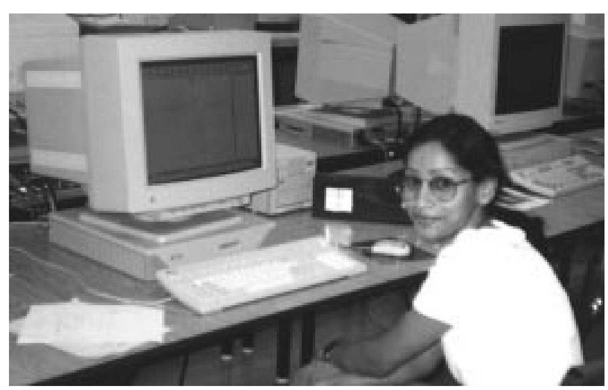
Figure 3: Transfer for 30% sag at 0.8 pf 3325 kVA load

References:

[1] Schwartzenberg, J.W.; De Donecker, R.W. “A 15kV Medium Voltage Transfer Switch.” Proceedings of the IEEE IAS Annual Meeting, 1995.

[2] Harshad Mehta , Le Tang et al, “ Distribution System Voltage Sags : Interaction with Motor and Drive Loads.” IEEE T & D Conference 1994.

[3] L. Palav and A.M. Gole, “On Using the Solid State Breaker in Distribution Systems”, Canadian Conference on Electrical and Computer Engineering, May 25-28, 1998.



Leena Palva hard at work

THE CONCEPT OF A POWER ELECTRONICS SYSTEM DATA BASE

Can an electric power transmission provider be confident that modern power electronic controllers such as HVDC and STATCOM will be successfully operated and maintained? When the operating and maintenance staff are rotated to other jobs or seek other employment, and new staff are brought onto the job, how are they adequately trained to ensure a high level of service is maintained? Clearly, the transmission provider needs policies and procedures to be in place to adequately deal with this problem.

The concept of a Power Electronics System Data Base is introduced as a means to preserve the complex technology of advanced power electronic controllers. **What is a "Power Electronics System Data Base?"** It is an exact simulation of every advanced power electronic controller of the transmission provider, together with its associated electric network. The term "exact" is precisely applied. The software code for controls and protections as well as the main power equipment are represented identically within the simulation model of the Power Electronics System Data Base. The equipment, controls and protections are assembled and identically labeled. The names of parameters, output and input signals, and any numbered pins, wires and connectors are also exactly labeled. If done with care, the Power Electronics System Data Base simulation will perform identically to the actual equipment connected on-line in the system. Overvoltages, voltage and current waveshapes, harmonics, control and protections signals and sequences will all be reproducible from simulations using the Power Electronics System Data Base.

There are two main advantages for a Power Electronics System Data Base. Firstly, all the information on the power electronic controller is contained in the simulation model and is therefore accessible as a knowledge base and for essential on-going training of staff. Secondly, because the data is resident in a form ready for simulation, the performance and operation of all power electronic controllers can be reviewed and inspected at any time. This is most important for a diagnostic analysis following a malfunction or a serious system disturbance. The event can be quickly recreated and studied to ensure its response is understood to a level not possible with regular load flow and stability program models. If adjustments to controls or protections have to be made, they can be done so only after thorough off-line investigations and tests.

PSCAD/EMTDC is ideal for a Power Electronics System Data Base. It is completely graphical, which aids in understanding of the equipment and knowledge transfer at the man-machine interface. Electric power utilities who rely very heavily on power electronic controllers have used this concept to their advantage. As the expert staff retire, are reassigned or leave, the Power Electronics System Data Base is retained and provides the essential means to pass the knowledge base on to new staff. Manitoba Hydro is one transmission provider who benefits from a Power Electronics System Data Base.

When a new SVC, STATCOM or HVDC link is being purchased, consider following the examples of some others. Require the successful supplier to submit an exact simulation model of the equipment on PSCAD/EMTDC. Ensure the simulation is available as soon as possible after the contract is let or at least before commissioning. This forms the basis for transfer of technology to the operating and maintenance staff or contractors.

By ensuring there is an up-to-date Power Electronics System Data Base for all complex power electronic controllers at every level of transmission and distribution, a useful means is provided to train the staff or contractors to operate and maintain the equipment at the management's desired level of performance and availability.

The Manitoba HVDC Research Centre is available to assist your staff in assembling a Power Electronics System Data Base right now. If not available from the equipment supplier, just the very act of assembling the information into an exact simulation has training benefits to your staff or contractors who will be, when the system is operational, the experts in a complex technology. This expertise has great value these days.

PSCAD EMTDC

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