CASE STUDY : Transient Stability Simulation Package

CLIENT NAME : **A major T&D solutions provider in the world**

END CUSTOMER : **A public T&D utility in one of the SAARC nations**

PROJECT TITLE : **Customized Transient Stability Simulation Package for integration with existing EMS/SCADA system at a Load Dispatch Center**

ABSTRACT

A major Multi-National T&D solutions provider in the world had secured an order for an EMS/SCADA system for the public T&D utility in one of the SAARC nations. The transmission network is a three phase balanced network system which is interconnected with another SAARC nation grid. The proposed EMS/SCADA system performs real time load flow solutions and dumps the results of the same as a text file in standard IEEE format. The project required a transient stability program in three phase systems for evaluation of electro-mechanical transient stability analysis of the system. The client wanted the transient stability program to fetch the data from EMS/SCADA and perform analysis at specified interval of time and also to add specific types of events to the transient stability simulation that can cause transients [or disturbances or events] in the network.

Kalkitech proposed a solution with its PowerApps – A Suite of Power System Analysis Software which is based on Windows platform. PowerApps is an integrated Power Systems Analysis Software & Simulation package with Electrical Equipment Parameter Estimation for creating the Network Single-line diagram and associated database system. It also includes the Graphic User Interface and a Database Management. PowerApps had to be customized to handle the specific requirements of this project like scheduler, importing of data from EMS/SCADA system, custom reports and graphs.

INTRODUCTION

The Client, a major T&D solutions provider in the world required a transient stability simulation package to be integrated with their EMS/SCADA system installed at the national LDC (Load Dispatch Center) of a SAARC country whose grid is interconnected to another large SAARC nation grid. The existing EMS/SCADA system was capable of performing load flow studies but there was a specialized requirement for transient stability module with specific event simulation requirements. The client also wanted a facility to schedule the running of transient stability simulation and graphs for the simulation to displayed while performing the analysis [real time graphical display during simulation]. Text reports generation was also one of the requirements.

The National LDC (Load Dispatch Center) located in the SAARC nation is entrusted with the responsibilities of grid operations, maintenance of grid discipline, management, monitoring, control and regulation of power flow on real time on a round the clock basis within the country and its transactions with neighboring countries. Also generation of all hydro projects including Mini & Micro situated in the country are being monitored and regulated at national LDC.

Brief Background of Transient Stability:

The recovery of a power system which is subjected to a severe large disturbance is of interest to system planners and operators. Typically the system must be designed and operated in such a way that a specified number of credible contingencies do not result in the failure of quality and continuity of power supply to the loads. This calls for accurate calculation of the system dynamic behavior, which includes the electro-mechanical dynamic characteristics of the rotating machines, generator controls, static var compensators, loads, protective systems and other controls. Transient stability analysis can be used for dynamic analysis over time periods from few seconds to few minutes depending on the time constants of the dynamic phenomenon modeled.

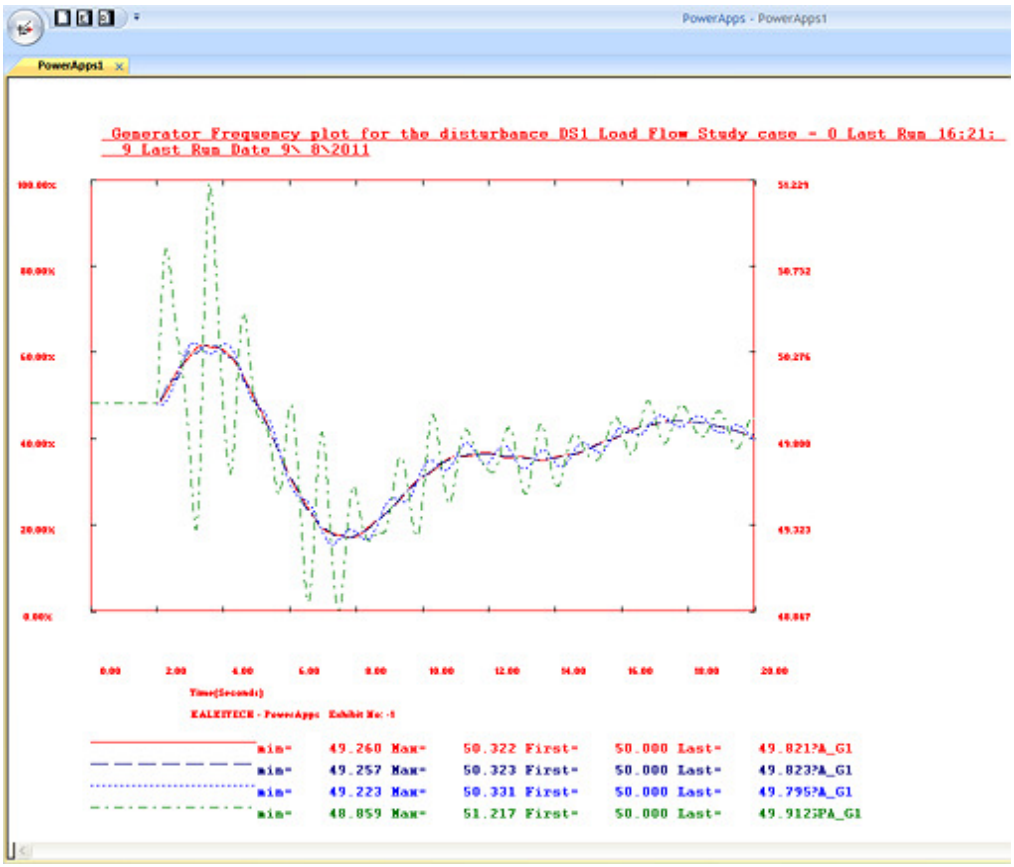
Kalkitech proposed a MS Windows operating system based solution. The module was developed under MS Visual Studio 2010, VC++ environment and further customized to meet the specialized project requirements. Kalkitech provided all the necessary interfaces to import the IEEE format data provided from EMS/SCADA system to Kalkitech's Transient Stability Simulation Module. Since the load flow solution is directly provided by EMS/SCADA system, the same was used by Kalkitech's transient stability module. Apart from load flow data additional dynamic data was also needed and this additional dynamic data was stored in a separate file, database etc. For this purpose, Kalkitech provided necessary additional Windows based GUI. Further it was ensured that the additional data stored in the Kalkitech's database was prepared by the user in such a way that the data was compatible with the IEEE load flow data without any ambiguity. This was essential to relate the data stored in Kalkitech's database with the IEEE format load flow text file. The Transient Stability module also had facilities to do error checks to ensure that the IEEE.RAW data and the dynamic data were compatible with each other and were as required by Transient Stability Simulation module data format. If errors were found the module provided print/display error message and stopped the execution. The user could then investigate the data based on the error messages and correct the data either in IEEE.RAW or in GUI database so that there was no ambiguity between the two data sources. Apart from the real time interface provided, an offline module was also provided for Transient Stability Simulation with protected executable, which the operator could Execute periodically with built in load flow depending on their requirements.

SOLUTIONS

The following technical features were provided in Kalkitech's transient stability analysis module:

- Transient Stability models of excitation systems, turbine governors, static-var compensators, power system stabilizers and HVDC controllers.
- Load shedding / islanded operation.
- Transient stability analysis of multiple-islanded systems with solution for each of the islands.
- Choice of generator models. From, simple classical generators with constant voltage behind transient reactance to modeling detailed synchronous machines with variable voltages behind sub-transient reactances.
- Standard IEEE excitation system models and turbine and governor models. [standard IEEE models for power system equipments]
- Commercial excitation models and governor models.
- Models for power system stabilizers and different stabilizing signals.
- Modeling load characteristics similar to that in the load flow analysis.
- Modeling load characteristics as function of frequency.
- Dynamic models of Induction motor and its load.[Static and Dynamic Load models]
- Motor starting studies. Motor modeling by their equivalent circuits or by the measured response during starting along with mathematical model for load torque as function of speed.
- Under frequency/Under Voltage relay operation simulation along with Load shedding and islanded operation.
- Element opening/closing. [Disconnection of Lines, cables and transformers], Line Switching and Line re-closing. These are simulated in the transient stability module to capture the dynamics of the generator rotor swings, frequencies, generator control system responses and system behavior.
- Relay models for overcurrent, instantaneous, distance relays
- Loss of generators. Generation Reduction, via Prime Mover Setting Control
- Multiple transient stability disturbance scenarios for each base case load flow study.
- Plots of selected bus frequencies and bus voltages. Note: Bus frequencies are different from generator frequencies.
- Symmetrical and Asymmetrical faults(such as LLL, L-G, LL and LL-G) application and removal at buses or on transmission lines
- Able to work for frequency range between 45 to 53 hertz.
- Initialization: Periodic [from SCADA/EMS outputs], Operator demand [through relevant text files] and Event driven Input/output. Note: PowerApps runs continuously and periodically access IEEE raw text files and run transient stability with pre-scheduled list of events. The time interval for this periodic initialization can be specified by the user.
- Calculation of voltages, currents, power flows, rotor angles and rotor frequencies
- Separate Violation listing of variables
- Real time Plotting of variables
- Storage of the transient stability results in a file/save case.

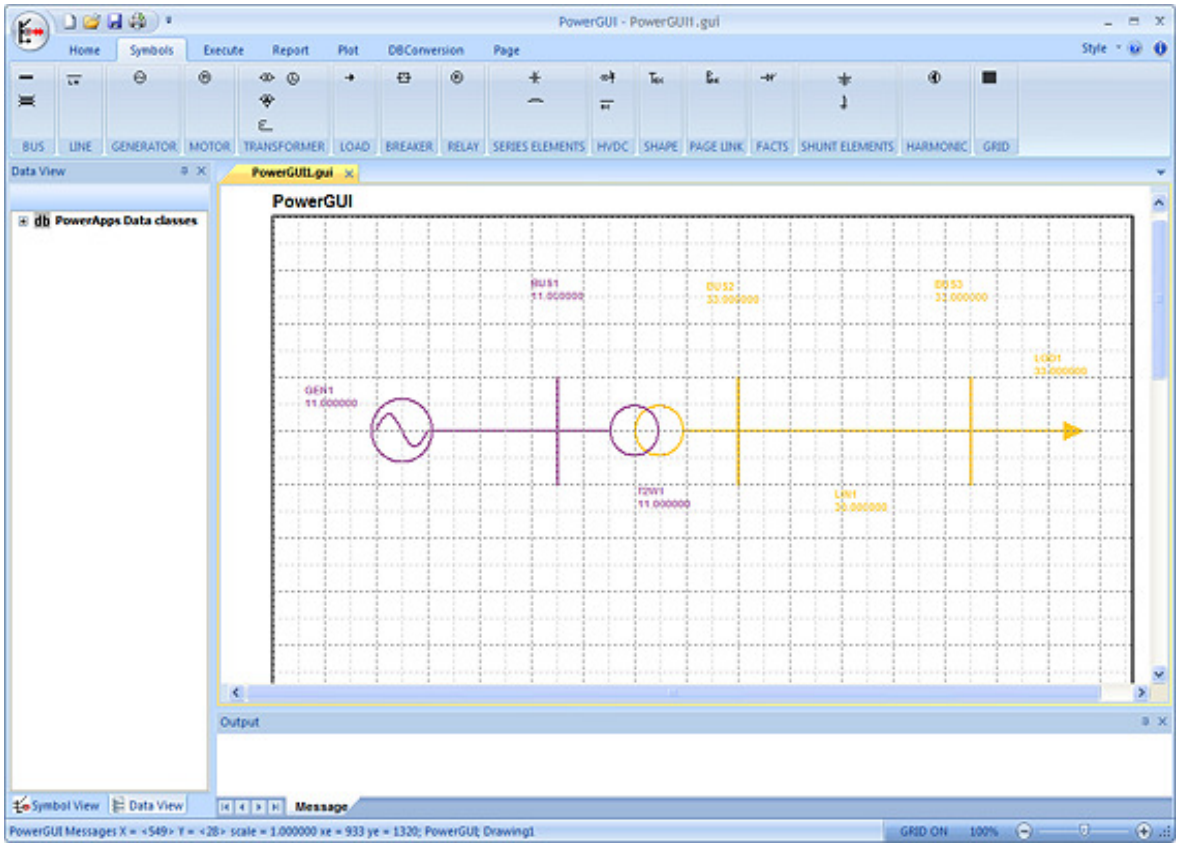
- Capability to compare results from two or more simulations
- Control systems and load model definitions (Only standard power system control models available Kalkitech will provide necessary control system libraries to the end user during the warranty period and subsequent AMC period.)
- Possibility to monitor specific equipment during simulation. This is done by monitoring state variables associated with the equipment such as voltage, current, frequency, power etc.
- Possibility to vary the integration step during simulation. However the chosen step size of time will have to be smaller than the smallest time constant in dynamic simulation; else the module will reset the same internally to the smallest time constant.
- Possibility to interrupt the simulation temporarily and restart.
- Real Time input data will be provided periodically in the form of IEEE data. Software has capability to import IEEE data.
- The software was configured to meet the sizing requirement of the Transmission network.
- Single Pole Open, Re-close simulation facilities was provided.

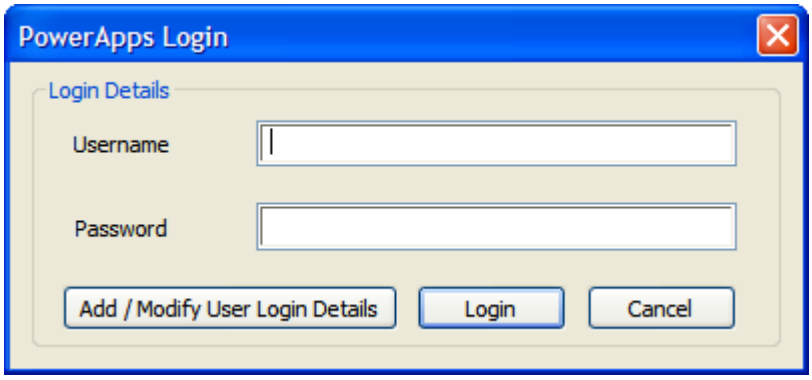


Features of PowerApps Graphical User Interface (GUI) for drawing SLD with integrated Power System Analysis:

- Highly interactive and user friendly GUI for single line diagram creation
- Standard library and Symbol facilities for all common power system elements.
- Opening/Closing of power system elements.
- Power system analysis and simulation reports and graphs.
- Time current characteristics graphs relay coordination
- Facilities for reporting, plotting the simulation reports
- OLE support.
- Power system data conversion facility in CSV, MS Excel, MDB, XML, CIM formats.
- No built in restriction on system size or components.
- SLD zooming with selective zooming facility
- Real time integration with SCADA/DCS

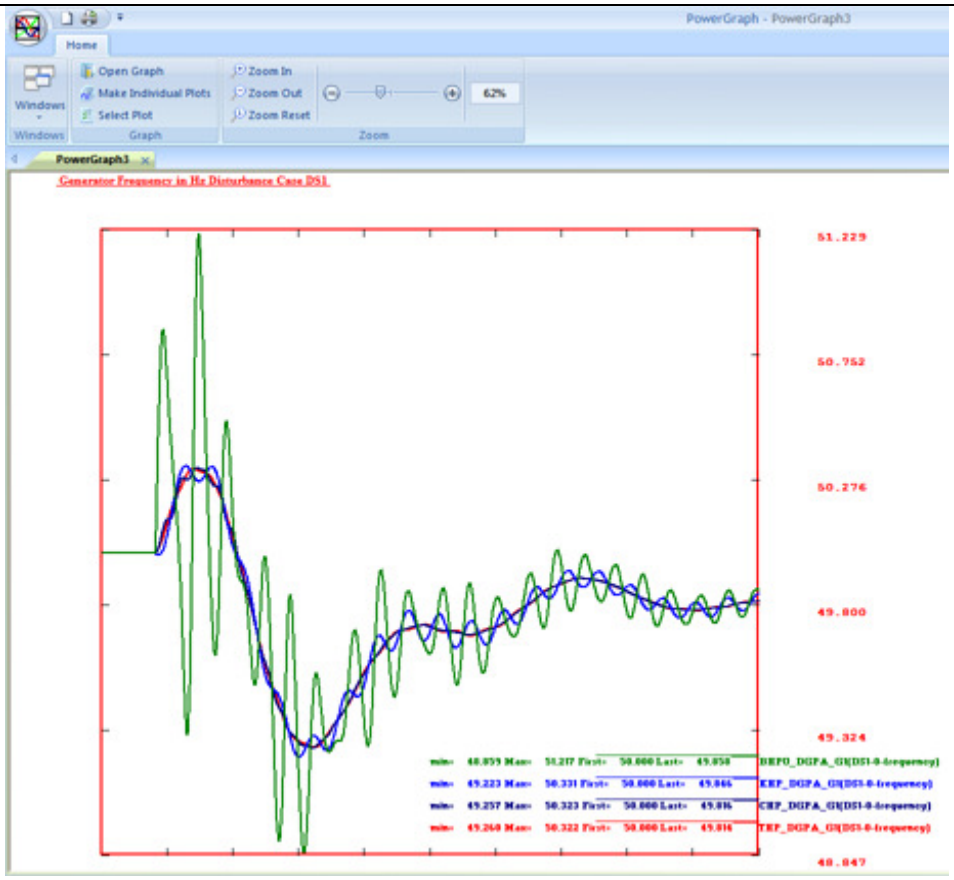
- PowerApps simulation mode with real time plots.
- Measurement value plotting with real time trends.
- Display the reports in tabular format for easy interpretation.
- Secured login feature to avoid unauthorized access.





A graphical tool PowerGraph was provided to view and analyze the transient stability plot. Its features include:

- Zoom-In and Zoom-Out options have provided to scale the graphs as user needs them to be.
- Print option is also provided.
- Option to compare two the same variable in to two different graphs.
- Plot selected variables in the graph.



KEY BENEFITS

Transient Stability simulation module in PowerApps is dedicated to simulating electromechanical transients in three phase electric power systems. It features an extensive library of equipment and controller models, the capability to include user-defined controls, a very flexible user-interface and powerful graphics. Transient Stability Analysis module utilizes the simultaneous implicit trapezoidal integration solution technique for network, machine and controller equations. The program supports the capability to test the step response of controllers and User Defined Modeling for system equipment and controllers.

List of Reports and Recommendations that can be obtained from Transient Stability simulation Package:

- Plots of Dynamic response of Generator rotor angles, frequencies, power outputs, voltages, excitation system outputs, governor-prime mover outputs
- Plots of Line Flows, transformer flows, bus voltages, bus frequencies
- Plots of Motor dynamic variables where required
- Plots of the system variables that are of interest from protection point of view [example frequencies, distances seen from distance relays, fault currents seen from overcurrent relays etc]
- Recommendation related to protection and control, operating strategy, Control settings of equipments [for example power system stabilizer, relay settings, load shedding schemes etc], based on various study cases considered

REFERENCES

1. www.kalkitech.com/offerings/solutions-powerapps
2. www.powerapps.org/PAES_TStability.aspx