KALKI Communication Technologies Limited
Bangalore, India

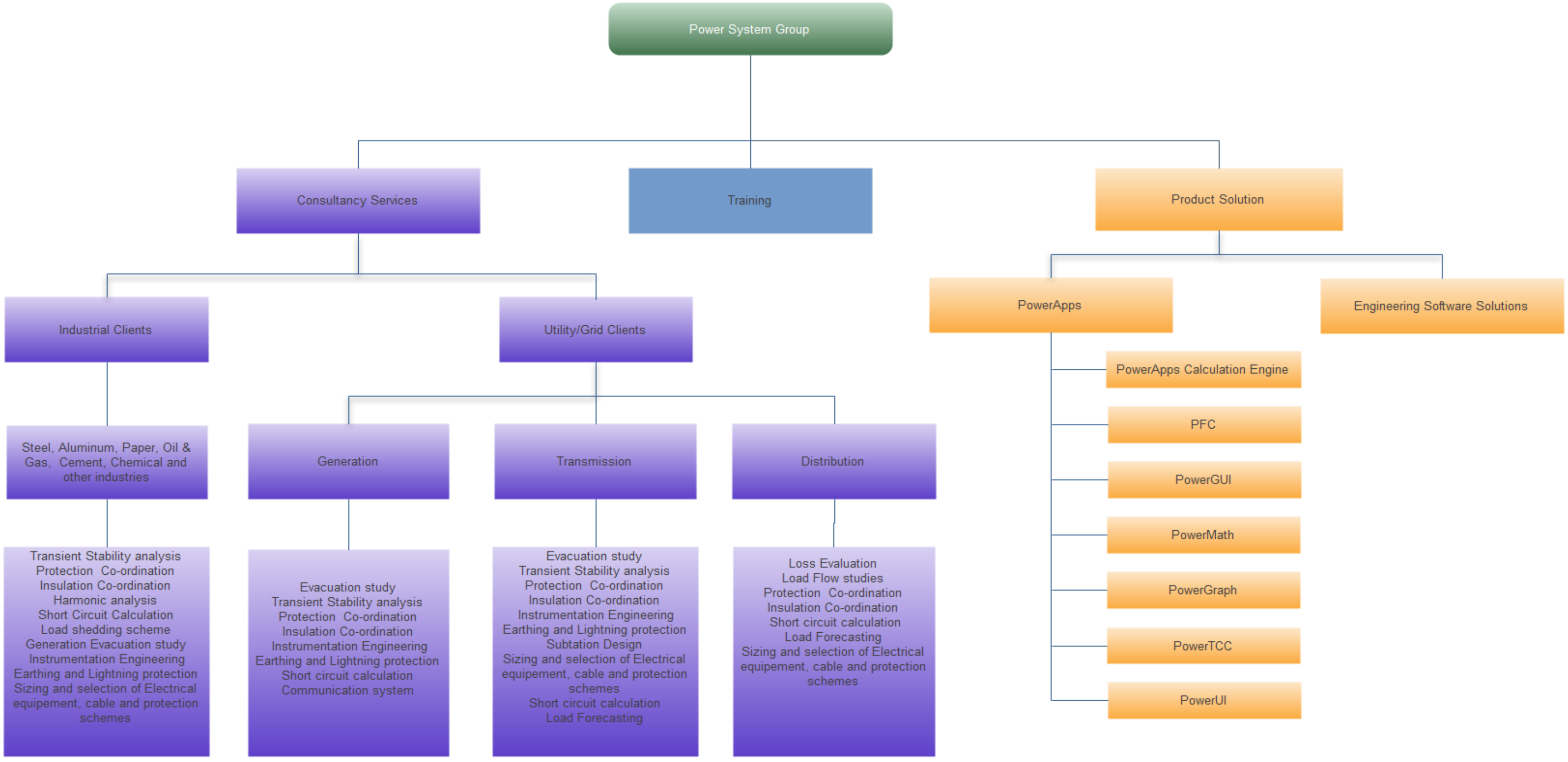
Power System Group Presentation

Overview

Main Areas – Power System Group

- Product Solutions [Power System Analysis Software Library]
- Consulting Solutions [Engineering Design & Power System Studies]
- Project Management [Substations]
- Training Solutions [O&M related, Engineering Related Training]
- Engineering Software Solutions[General, Graphics, Analytical, Database solutions]

Overview



Power System Group
Consultancy Services
Training
Product Solution
Industrial Clients
Utility/Grid Clients
PowerApps
Engineering Software Solutions
PowerApps Calculation Engine
PFC
PowerGUI
PowerMath
PowerGraph
PowerTCC
PowerUI
Steel, Aluminum, Paper, Oil & Gas, Cement, Chemical and other industries
Generation
Transmission
Distribution
Transient Stability analysis
Protection Co-ordination
Insulation Co-ordination
Harmonic analysis
Short Circuit Calculation
Load shedding scheme
Generation Evacuation study
Instrumentation Engineering
Earthing and Lightning protection
Sizing and selection of Electrical equipement, cable and protection schemes
Evacuation study
Transient Stability analysis
Protection Co-ordination
Insulation Co-ordination
Instrumentation Engineering
Earthing and Lightning protection
Short circuit calculation
Communication system
Evacuation study
Transient Stability analysis
Protection Co-ordination
Insulation Co-ordination
Instrumentation Engineering
Earthing and Lightning protection
Subtation Design
Sizing and selection of Electrical equipement, cable and protection schemes
Short circuit calculation
Load Forecasting
Loss Evaluation
Load Flow studies
Protection Co-ordination
Insulation Co-ordination
Short circuit calculation
Load Forecasting
Sizing and selection of Electrical equipement, cable and protection schemes

Kalkitech Product Solutions

BACK GROUND

- Available Standard Modules, Algorithms Developed Since 1986 – Collection of Modules – PowerApps
- Modules are Customized to Meet Specific Requirements of Clients
- Applications to Power System Analysis, Real Time Monitoring and Control, Training Simulators
- Any other Engineering Software Solutions

Kalkitech Product Solutions

- Standard Commercial Product – Power System Analysis – PowerApps
- Custom Solutions – Example Areva T&D, Transient Stability Program, with Real Time Database Interface – Bhutan Power Corporation
- Operators Training Simulator
- Customized solution for new Problems – for real time or off line applications

Consulting Solutions

Design, Planning, Operational Planning Studies for

- Transmission Systems
- Distribution Systems
- Industrial Distribution Network
- Regulatory Commission Related Studies
- Basic and Detailed Engineering of Network

Consulting Solutions – Analysis

- Load Flow Studies
- Short Circuit Studies [ANSI/IEEE/IEC 60909/Conventional methods]
- Relay Coordination [Overcurrent Phase/Earth Fault/Distance Relays]
- Unit Protection [Transformers/Generators/Motors/Bus]
- Energy Audit/Transmission Pricing
- Techno Commercial Evaluation of Proposals

Consulting Solutions –Analysis- Continued

- Harmonic Measurements, Analysis, Filter Design
- Reactive Power Compensation Studies
- Grid Paralleling Studies
- Transient and Dynamic Analysis [Large & Small Signal analysis]
- Static Voltage Stability Analysis
- Insulation Coordination Studies
- Motor Starting Studies
- Ground Mat Design

Training Solutions

- Training O&M Personnel on network operations, protection, Control, Safety, Testing and Commissioning

- Training Related to Power System Studies

- Training Related to Power System Protection and Relay Coordination

e.g. Schneider Electric Projects.

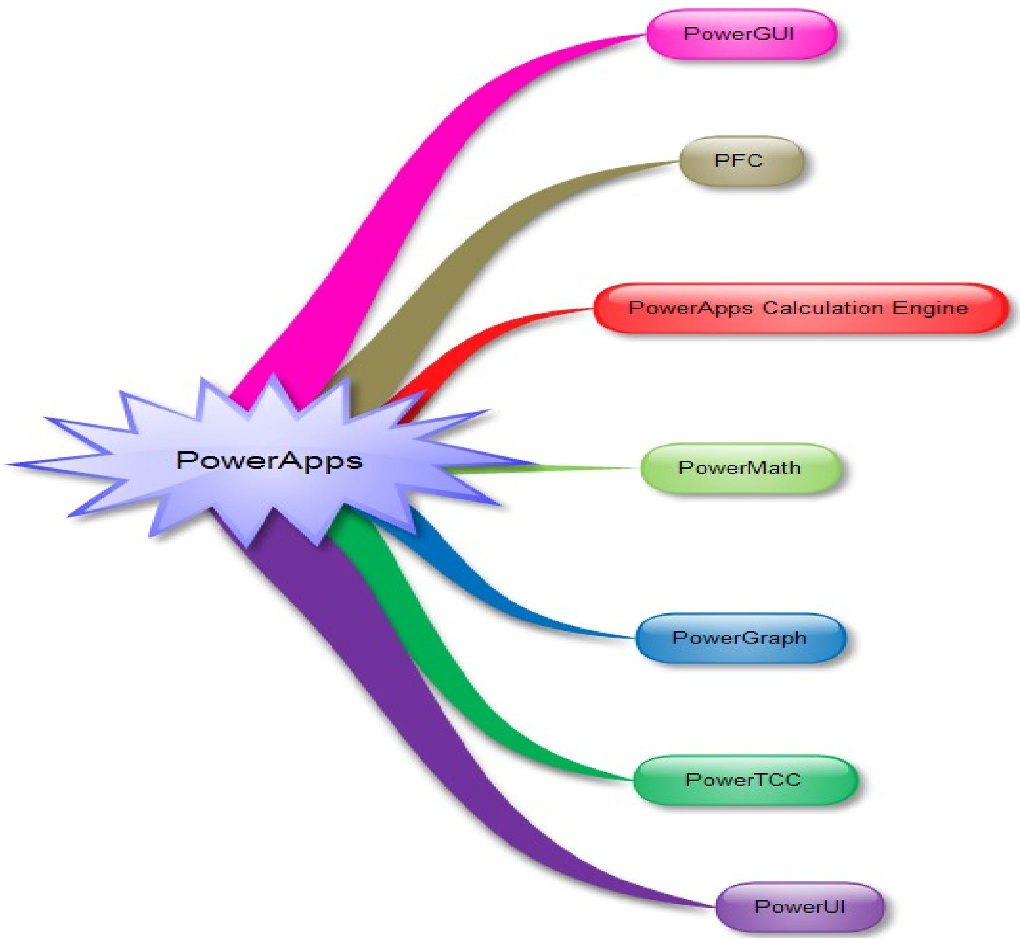
Kalkitech Advantage

- Source Codes for All Modules are Developed in House
- Customization, Addition , Modification of New Features are Possible
- In House Software Development Group for Various OS, Development Tools & Environments
- Applications to Web, Database, GUI, Real Time Interfaces, MMI etc.
- Well Defined Quality Procedures for Software Development, Testing and Commissioning
- Experts at Kalkitech Have a Rich Experience in Modeling and Simulation

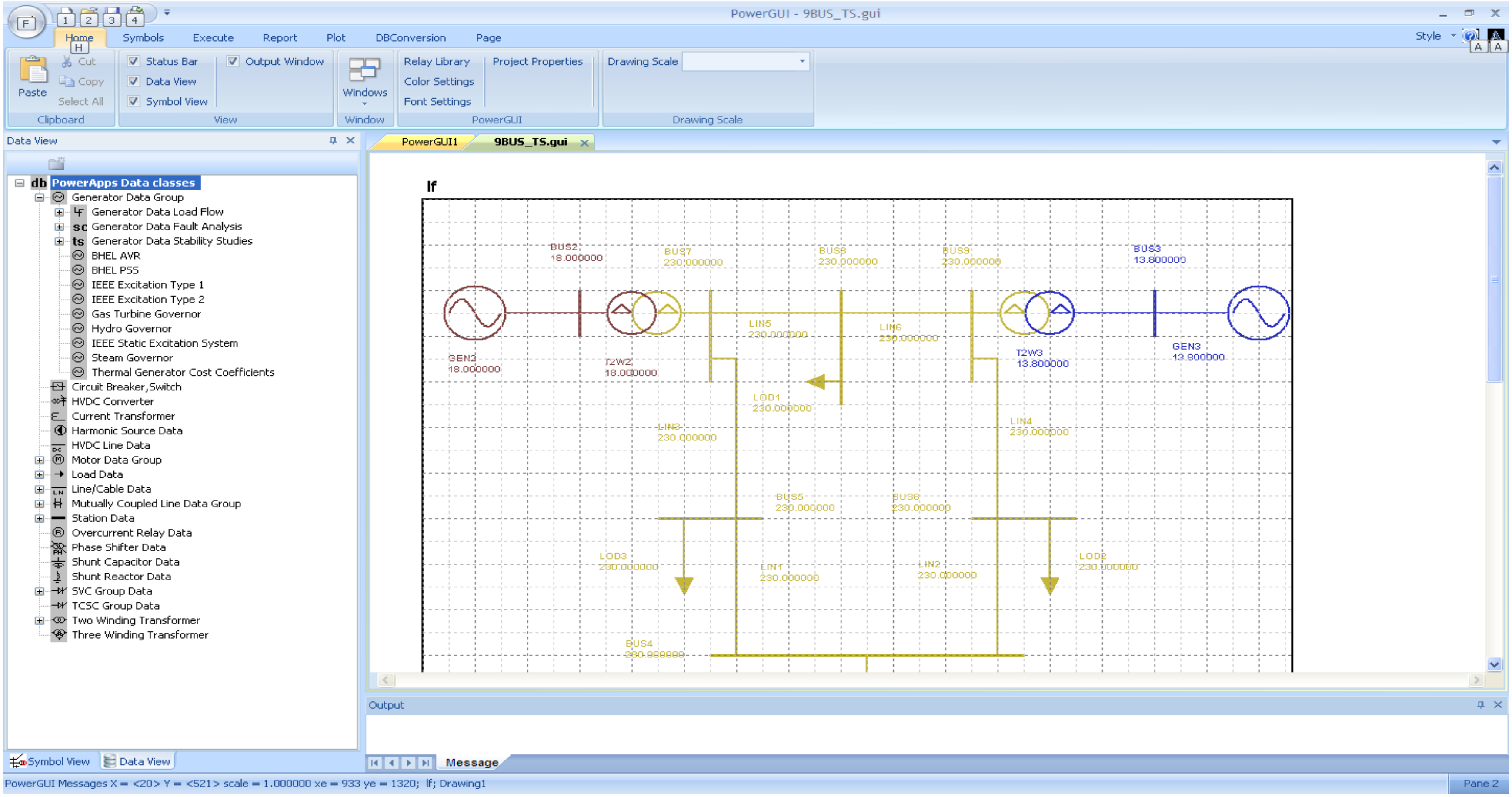
Certificate of Satisfactory Performance

- CPRI Bangalore (www.cpri.in)
- AEE-IDEA (www.aee-idea.in)
- POET Consultants Pvt. Limited (www.poetconsultants.in)
- Danway LLC (http://www.danwayllc.com/)
- Unofficially Indian Institute of Science, Bangalore for consulting works (No Certificate Available)
- Power Research & Development Consultants (P) Limited (PRDC) – Partial Modules Usage for consulting (http://www.prdcinfotech.com/)

PowerApps Overview



A Sample GUI Tool – SLD-PowerGUI



General Features of PowerApps

- Multiple study cases of load flow / short circuit / stability / protection / and other analytical procedures. Studies for all the network islands in one single execution
- A single master database for all the study cases and outputs for easier maintenance of project database
- Automatic one line diagram creation and presentation of results for all the study cases. The one-line diagrams are created for each network island. Further, single line diagrams for different user specified zones are automatically created
- Facilities for interactive single line diagram creation using a Windows based GUI - PowerGUI

General Features-Network Topology

- Automatic network model construction based on breaker statuses using an inbuilt Network topology processor
- The Network topology processor algorithm is suitable for real time applications
- Network topology considers elements in service or out of service (specified as 0 number of circuit elements)

General Features – Multiple Study Cases

Multiple study cases due to

- changes in breaker statuses
- changes in load power specifications
- changes in generator schedules
- changes in transformer taps
- changes in number circuits
- changes in compensation etc.

Are Handled in Single Program Execution

Analysis Requiring Load Flow for Initial Condition.

- Multiple Transient Stability Study Cases for Each Load Flow Base Case
- Small Signal Stability Studies
- Static Voltage Stability Analysis
- Short Circuit Studies Requiring Load Flow Initial Conditions

Above Calculations Follow Each Load Flow Study Case, without user intervention in batch mode

General Features – Contd.

- No in built restriction on system size or components. The size of the system can vary between the barest minimum to maximum permissible by the memory available in the computer. It is the opinion of this author the entire Indian grid network can be represented for the analysis
- Input data in the format of ASCII, Excel, Access databases
- Object oriented programming approach with Power Foundation Classes (PFC) to build analytical algorithms
- Standard library facilities for all common electrical elements
- Validated algorithms (documents) with standard bench mark examples.

Power Flow – General Features

- Gauss-Seidel.
- Newton-Raphson.
- Fast-Decoupled.
- AC/DC Load Flow.
- Load flow solution of multiple-islanded systems. The solution is available for each of the islands having a reference (slack) node. The reference node is automatically identified by the algorithm as the largest generator node in each island.

Power Flow – General Features

- Limit violation reports, summary reports
- Multiple Slack Bus in a single network Island. Multiple Reference buses in each network Islands
- Unbalalanced 3 phase load flow, including 1 and 2 phase load flow for lines drawn separately from a 3 phase supply point
- No limits on the number of study cases and related reports in a single execution of the program

Optimal Power Flow – General Features

- Choice of objectives for the OPF/RPO (Transmission loss minimization, Voltage Stability improvement, Removal of operating violations, Economic dispatch)

- OPF/RPO control options are – active power injections, reactive power injections, shunt compensations, series compensations, phase shifters, transformer taps

- OPF/RPO sensitivity calculations with respect to the performance objective provides information for suitable location of shunt reactive power compensation and also identifies most effective controllers for optimization

- Sequential LP based Algorithm

Power Flow - Validation

- IEEE 14 Bus
- IEEE 30 Bus
- IEEE 57 Bus
- IEEE 118 Bus
- IEEE 300 bus
- IEEE Std 399 – 1997
- Comparison with ETAP 5.5.6 (Commercial Software Tool)
- Comparison with DIgSilent Power Factory (Commercial Software Tool) Document Not Available)

Typical Power Flow Convergence Characteristics – 1043 Bus System

ITNO	NAME	MAX P MISM	NAME	MAX Q MISM	NAME	MAX ANG COR	NAME	MAX VMAG COR
1	153	2.2119	666	8.1539	850	29.6327	543	-.1496
2	216	.0895	807	.4716	847	-13.6900	543	-.1179
3	10	.0135	10	.0620	543	-1.5276	543	-.0275
Q/B LIMITS VIOLATED REPEATING LOAD FLOW WITH BUS TYPE SWITCHING								
4	382	.0003	10	.0003	543	.0000	543	.0000
5	382	.0003	540	.2569	415	-.7810	419	-.0383
6	540	.0031	540	.0104	444	-.0998	419	-.0019
Q/B LIMITS VIOLATED REPEATING LOAD FLOW WITH BUS TYPE SWITCHING								
7	540	.0000	540	.0000	444	.0000	419	.0000
8	540	.0000	320	.0003	444	.0000	419	.0000

OPF – Convergence Characteristics – 1043 Bus System

Optimal Power Flow Convergence Characteristics (A Module of PowerApps)
1043 bus southern grid system of India
S.No OPF iteration number (0 , base case, Uncoverged Load Flow Solution)
Nv Number of buses having voltage violations.
Sv Absolute sum of voltage violations in per unit
PLOSS MW loss in the transmission system

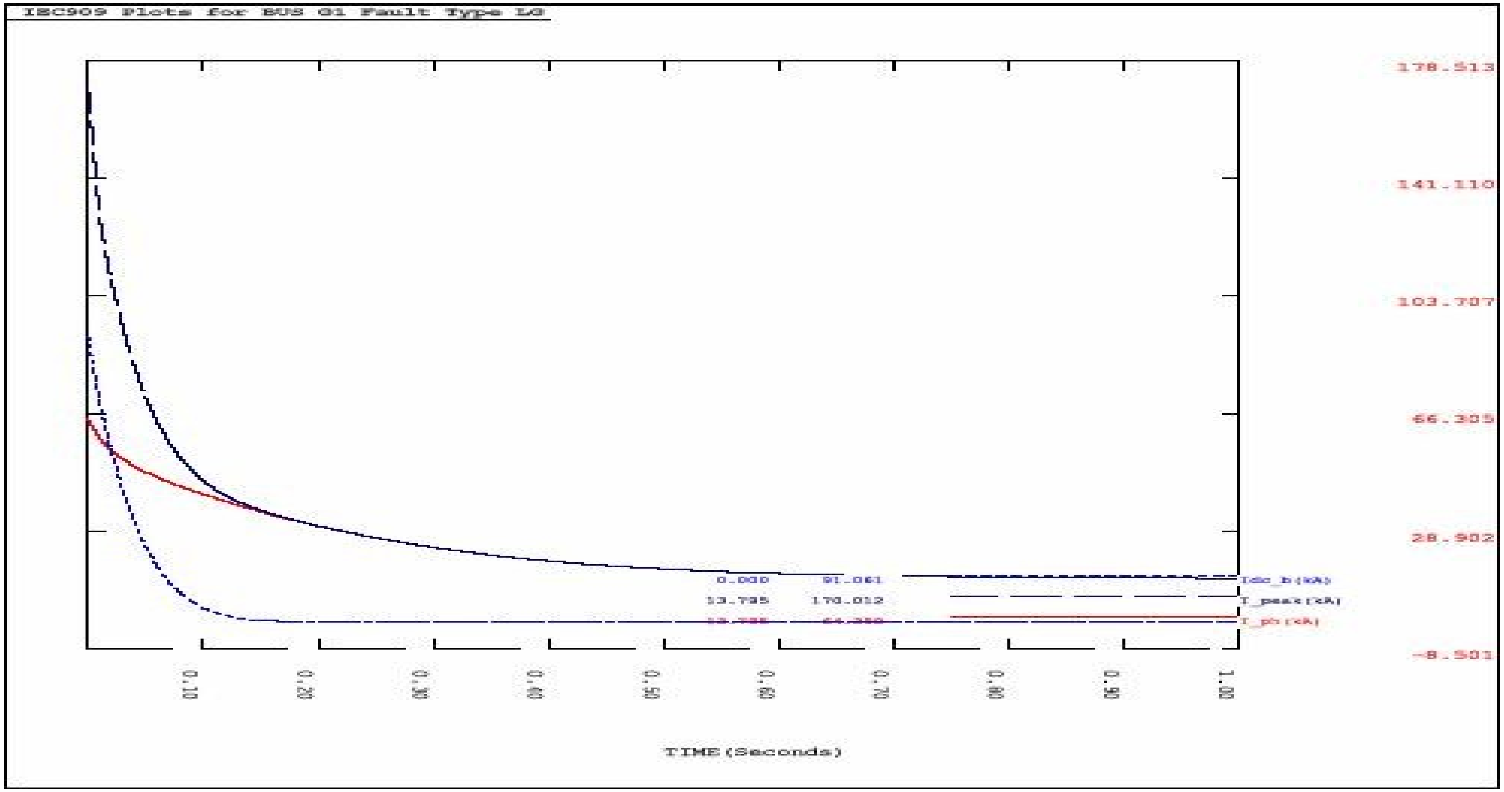
S.No	Nv	Sv	PLOSS
0	924	174.978919	1234.81981
1	131	4.590724	635.078662
2	47	1.814937	617.129999
3	41	1.559753	613.625515
4	45	1.513914	613.065429
5	45	1.475848	612.3624
6	47	1.479047	612.296658
7	46	1.483851	612.258983
8	42	1.4684	612.381906

"Conclusion: It is observed that the algorithm is stable , robust for a practical grid network achieving a significant loss reduction and voltage improvement"

General Features - Short Circuit

- Fault levels for asymmetrical and symmetrical faults including bolted faults.
- ANSI/IEEE standards.
- IEC standards including 363 and 909.
- G74 British standard, a computer algorithm based standard for IEC 909 standard.
- Short circuit analysis of multiple-islanded systems with solution for each of the islands.
- Default flat 1.0 pu positive sequence bus voltage based calculations.
- Option to consider pre-fault bus voltages from load flow along with the sequence impedances for loads.
- Results of fault calculations with mutual coupling matches perfectly with published examples

Short Circuit Studies – Plot (dc,ac,total)



Short Circuit - Validation

- Appendix Examples from Text Book "Analysis of Faulted Power Systems", Paul. M. Anderson (Wiley-IEEE Press, July 1995).
- Results are Matching with Mutual Coupling Between Parallel Circuits.
- Comparison with ETAP 5.5.6 For Sample System.
- Comparison with DIgSilent PF (Document not available)

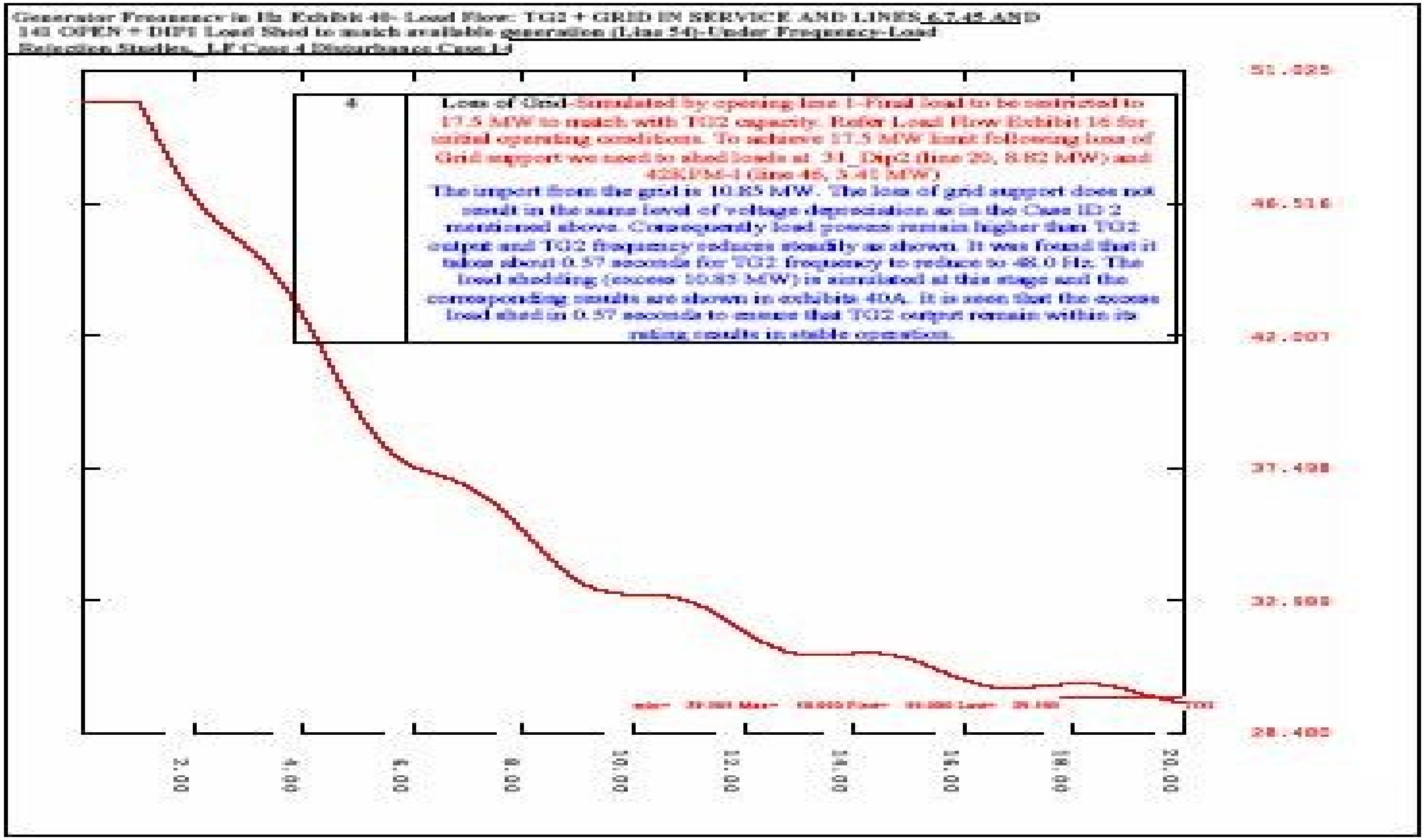
Transient Stability - Features

- Based on State of the art Simultaneous Implicit Algorithm – H.W.Dommel, N.Sato, IEEE Trans Vol, PAS-91, pp.1643-1650 July/Aug 1972.
- Class Notes of Prof H.W.Dommel Detailing Algorithm Available (UBC, Canada)
- Simple to Detail Models for Generators
- Generator and Other controller Models (E.G. SVC)
- Standard IEEE and Commercial Models of AVR/Prime Mover Governor
- Dynamic Model of Induction Motor and Its Mechanical Load
- All standard Disturbance/Event simulations

Transient Stability - Features

- Modelling load characteristics similar to that in the load flow analysis.
- Modelling load characteristics as function of frequency
- Motor starting studies. Motor modelling 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
- Load shedding
- Islanded operation
- Element opening/closing
- Loss of generators
- Multiple transient stability disturbance scenarios for each base case load flow study. Note that, multiple load flow case studies can be performed followed by multiple transient stability simulations for each load flow study case
- Plots of selected bus frequencies and bus voltages. Note bus frequencies are different from generator frequencies

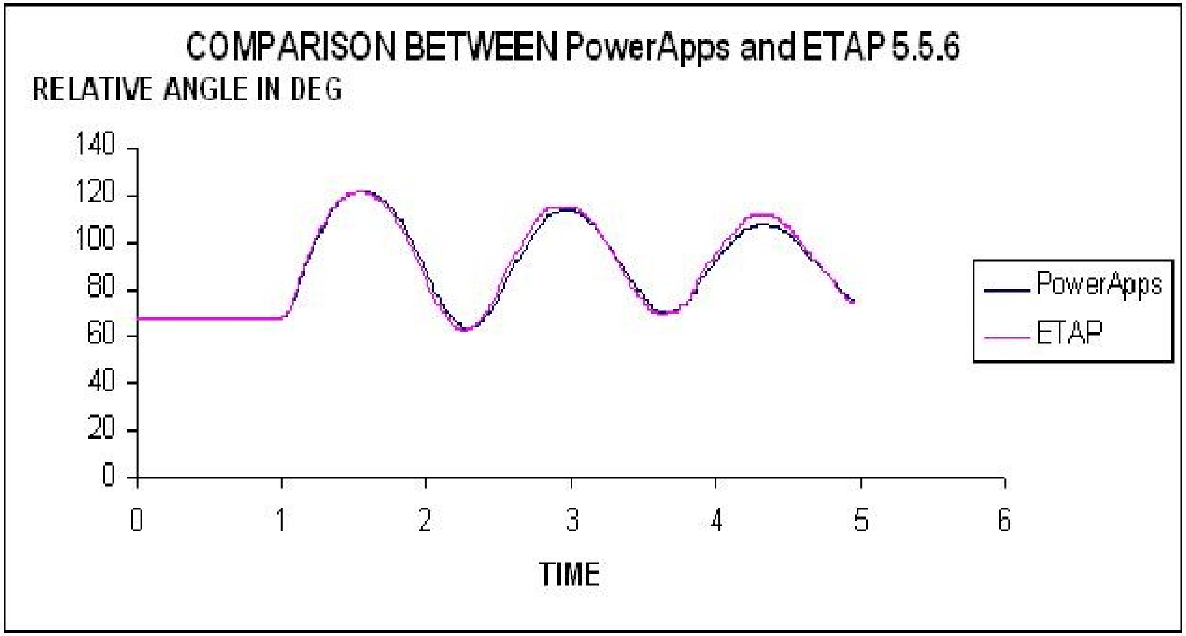
Transient Stability – Sample Plot



Transient Stability - Validation

- The transient stability simulation results of PowerApps are compared with those of the ETAP 5.5.6 for the reference example chosen from the text book P. Kundur. The details of the system considered are provided in the exhibits
- The chart (next slide) shows the relative angle response for a sample text book example 13.2, Page 864, Power System Stability and Control, Prabha Kundur
- The plots compare well with those of Figure E.13.7, on page 867 of the text book, (refer plot of Constant Efd)

Transient Stability - Validation



DEMO of PowerApps and PowerGUI

- Execution from ASCII Input Data File – GEB and 1043 Bus Southern Grid of India
- Automatic One Line Diagram Illustration From PowerApps [Feature from Earlier Version not used currently, However code is available]
- Creation of SLD from Database – PowerGUI Illustration
- Interactive Creation of SLD – PowerGUI Illustration
- PowerTCC, PowerGraph, Harmonic Plots
- Validation Documents

OPF - Illustration – Using Fortran Program

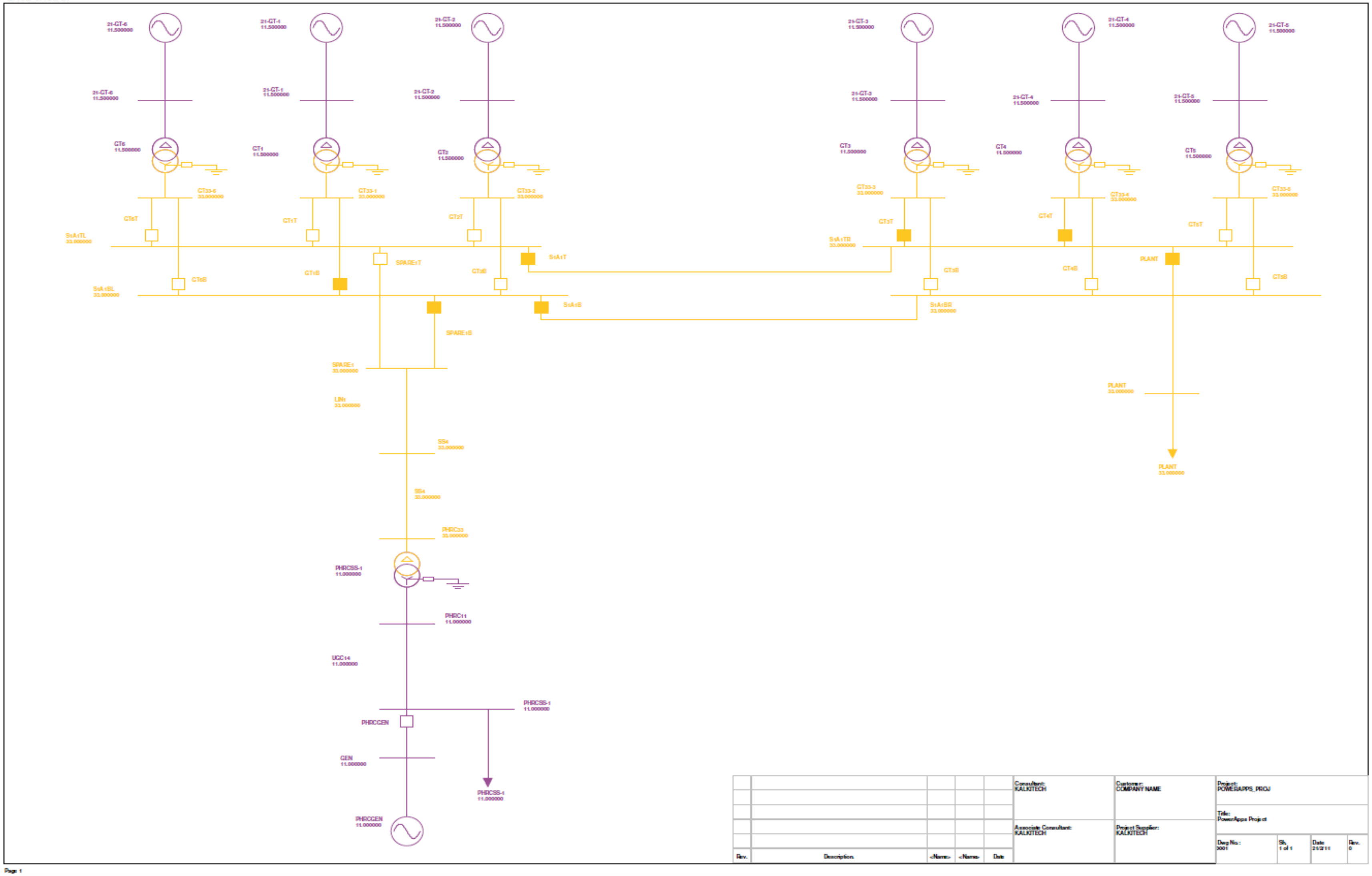
- GEB System
- 1043 Bus Southern Grid of India
- Illustration of Numerical Stability

Sample Case Studies for Consulting Projects

- EPCL Nigeria, Load flow, short circuit studies [Conventional/IEC 60909], Relay coordination, Transient Stability, Insulation Coordination, Power Export, Transmission Routing
- Motor City Project , DANWAY, Dubai: Load Flow Studies, Short Circuit Studies, Relay Coordination, Harmonic Analysis, Motor Starting Studies
- ABB Emirates Steel Plant Studies: Load Flow, Short Circuit, Relay Coordination, Harmonic Analysis, Motor Starting Studies

EPCL Nigeria -Study

BASE CASE LF



Motor City Project , DANWAY

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intelligent energy systems

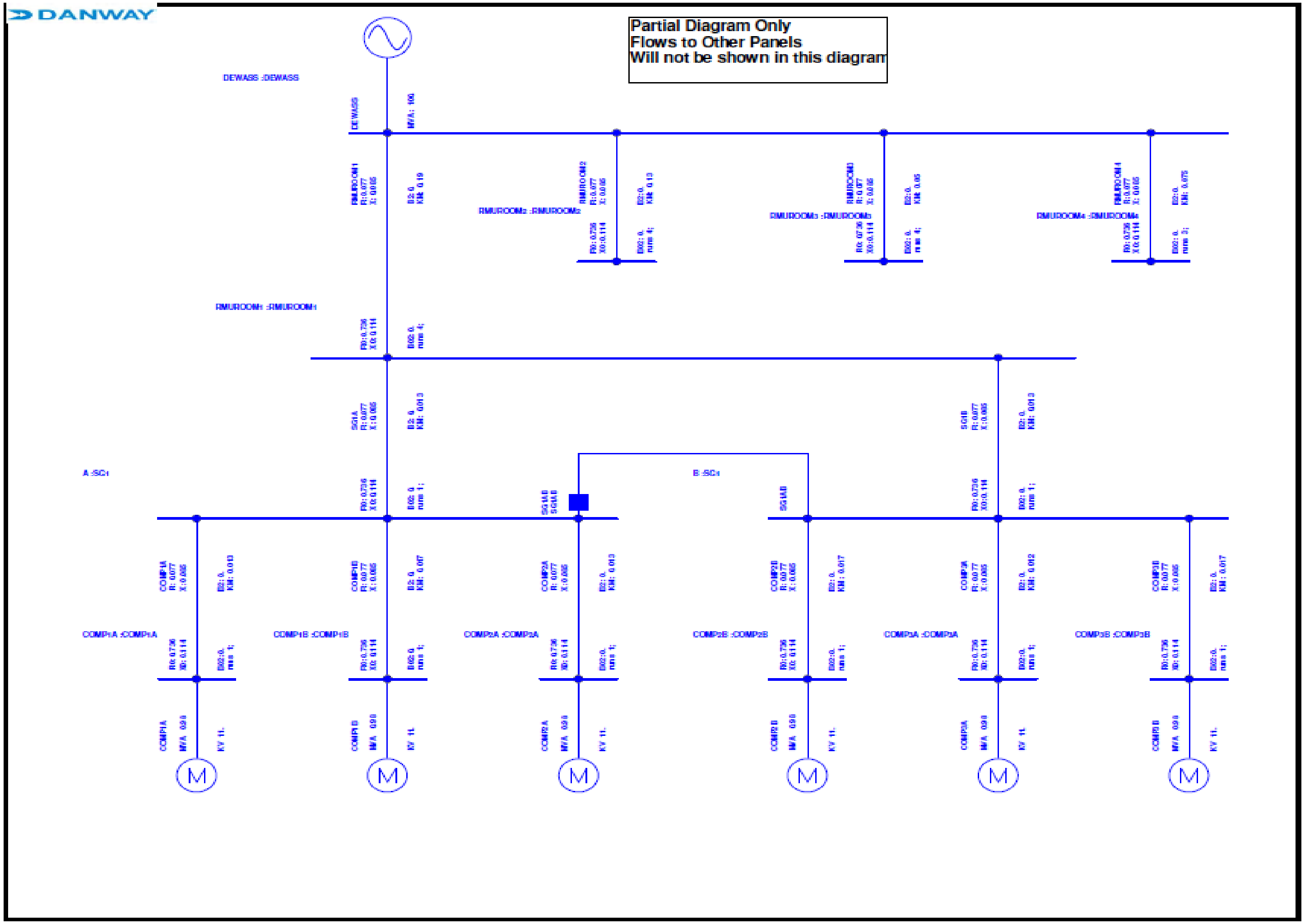
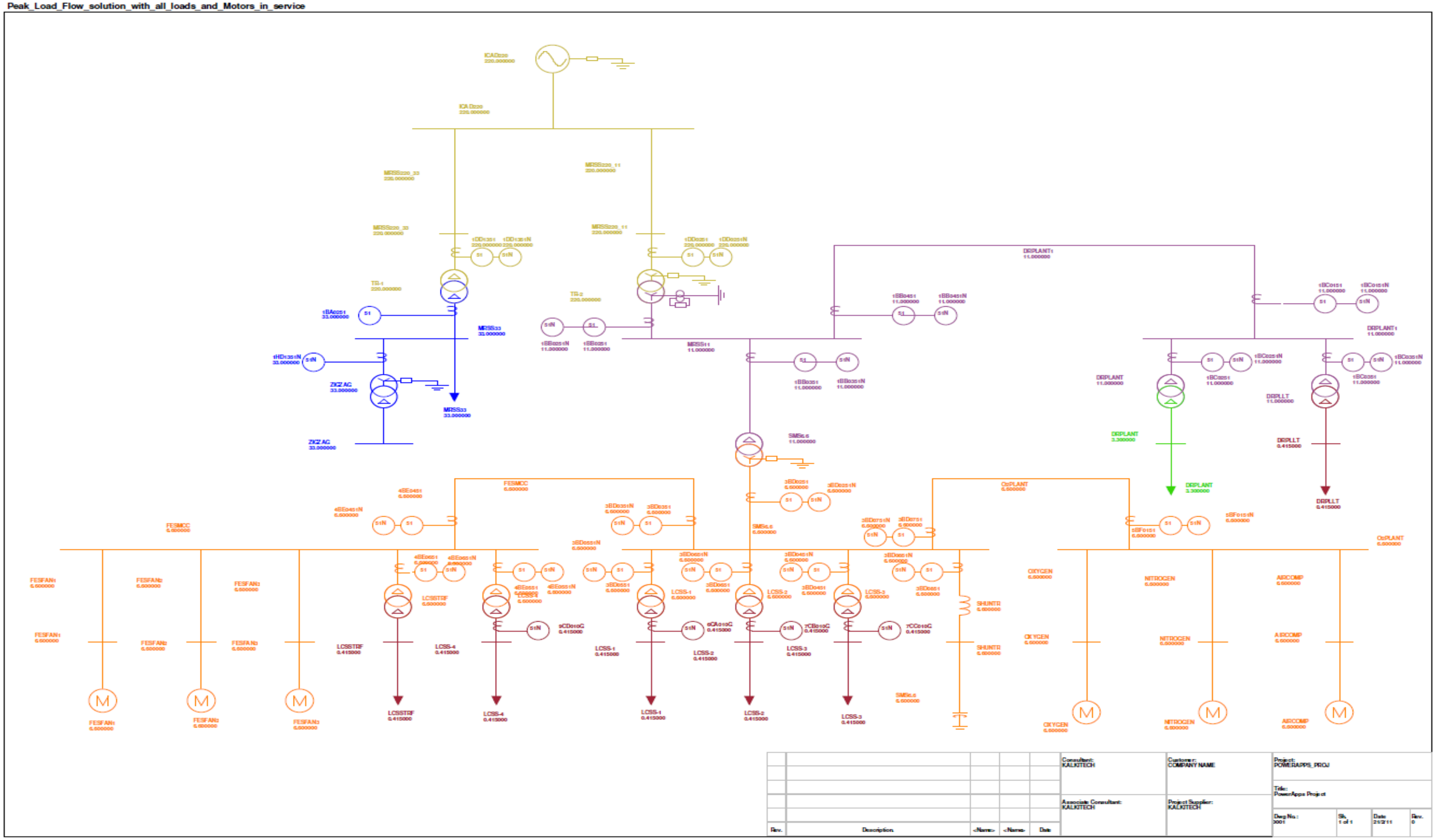
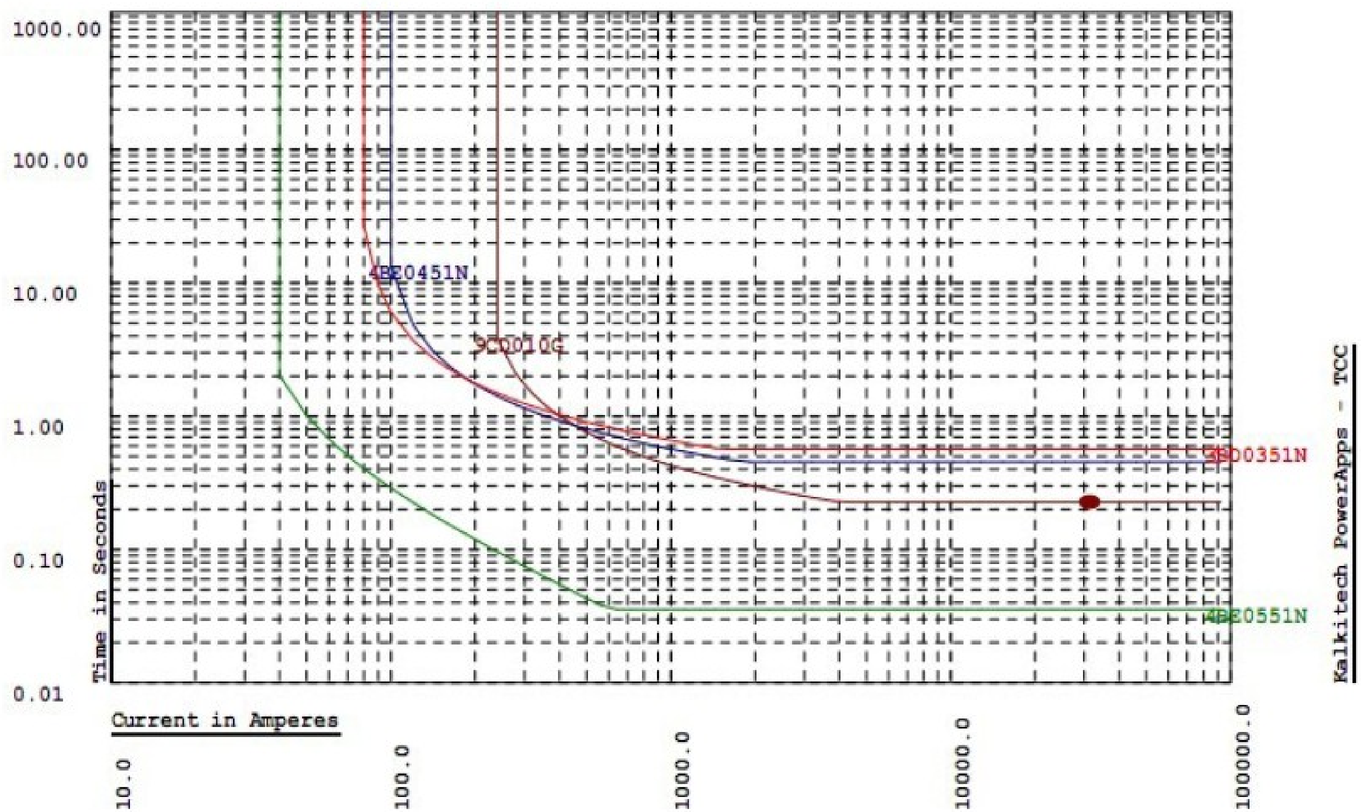


ABB Emirates Steel Plant Studies

Peak_Load_Flow_solution_with_all_loads_and_Motors_in_service



Sample TCC Plot



Case Studies: Sample Training Program

- Power System Protection:
- Client : Schneider Electric, UAE
- Participants: Engineers from O&M in UAE
- Theory, Demonstration of Secondary Injection Kits, Software Simulation Examples on Relay Coordination, Fault Calculations, ATP-EMTP Simulations.

Case Study: Sample Custom Software Solution

- Client Areva T&D, Noida
- Project: EMS Bhutan Power Corporation
- Modules: Network Topology Processor, Load Flow, Short Circuit Studies, Transient Stability Studies
- Special Requirements: Single Pole Open/Close, Unbalanced Fault simulations, Under Frequency/Under Voltage Load Shedding, Load /Generator reduction

Thank You

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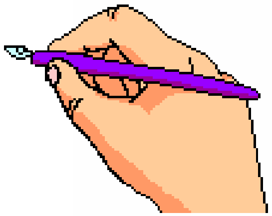

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