Setting up Power Systems SCADA Lab for Academic Institutes

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Introduction

Rapid developments taking place in the power industry require more resources, possessing state of art technology to manage the substations. Academic institutions today, need to work in tandem with the industry to provide resources with sound knowledge about the current industry scenarios to meet these requirements. The hands-on experience supported with systematic training & experiments will enable the resource to place him/her with added value in the industry.

Along this line, Kalkitech has set up a power systems laboratory at National Institute of Technology (NIT), Calicut with the view of providing students and practicing engineers with hands on learning experience on Substation SCADA system, and its applications to the monitoring, supervision and control of an electric power Transmission & Distribution system. It is a scaled down model of 220KV substation and transmission line module with capability of inducing all types fault simulation. Lab also included distribution model with variable load models and load shedding functions. The entire system is connected with Kalkitech's SMART STATION SCADA system with monitoring and configuration capability. A variety of experiments has been done by the Power Systems faculty as well as integrated power system M Tech students. This article will explain in detail the setting up of the lab including the system architecture, experiments, hardware & software components and communication protocols/interfaces.

System Overview

The Laboratory setup consists of three main Units:

- 400/220kV substation and 220kV transmission line model with SCADA
- 11kV Distribution station model with SCADA
- Control center Software Model

Electrical process of HT transmission system is modeled in the first unit. The model consists of 400/220 kV receiving substation with 220kV out going lines. One typical 220kV transmission line also is modeled for a distance of 200 KM. The system consists of protection, control and measurement equipments communicating to a SCADA system. The communication system is built on the newest Substation Communication Architecture of IEC 61850.

Figure 1: Transmission System

Power distribution system is modeled as 33/11kV substation with related protection, metering and control. Various types of loads can be connected to the system. SCADA system is provided for monitoring and control of the distribution panel.

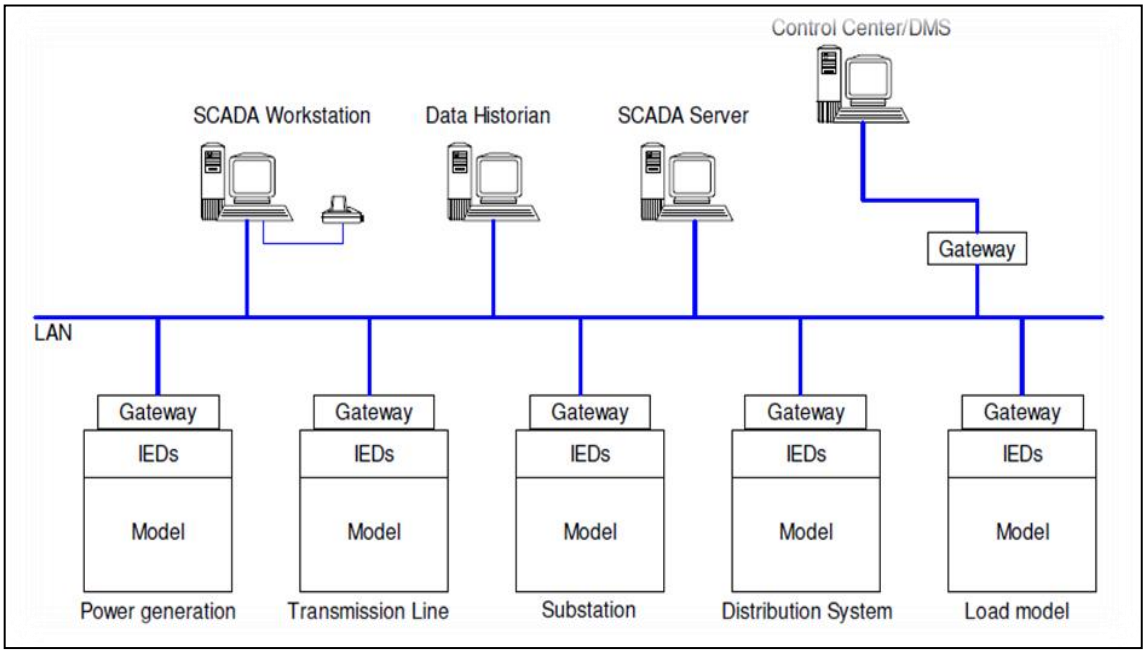

Figure 2: System Architecture

Control Center Unit is a SCADA system communicating with the two substations over serial communication links. Dynamic information from the stations is displayed for remote monitoring functions. Control of remote station equipment can be done from the control center. The Control center consists of remote SCADA system for operation, training, monitoring and control of the electrical network. The control center SCADA system communicates with the substations (400/220kV and 33/11kV) in IEC 870-5-101 standard protocol. Substation communication gateway is installed at both the stations for the data transfer. The SCADA/HMI system acquires all relevant data from the stations and provides dynamic displays like Single Line Diagrams (SLD), trending, alarming and Sequence of Events.

Key Experiments

Transmission Model

i. Simulation of Faults (in transmission line)

   L-G Fault –Relay sensing and tripping and observe the fault current

   L-L Fault - Relay sensing and tripping and observe the fault current

   L-L-G Fault - Relay sensing and tripping and observe the fault current

   L-L-L Fault - Relay sensing and tripping and observe the fault current

ii. Ferranti Effect – Observe the voltage profile at sending and receiving end

iii. Loading of Transmission line

   - Resistive Load –Observe Voltage and current profile
   - Inductive Load - Observe Voltage and current profile
   - R & L Load -Observe Voltage and current profile

iv. VAR Compensation

   - Series Compensation - Observe the bus voltage profile
   - Shunt Compensation
   - Regulation of bus voltage – Observe the bus voltage profile
   - Automatic voltage regulation - Observe the bus voltage profile

v. Loading of transformer - Observe the current profile and relay sensing, tripping

vi. Operation of OLTC transformer – Voltage regulation at sending end

vii. Impact of sudden load Rejection on transmission line. – Observe the voltage profile

viii. Simulation of Lightning effect on transmission line – Observe the voltage and current profile.

ix. Performance of Double circuit line.

Distribution Model

i. Simulation of Fault (in any feeders) – Observe the fault current

ii. Relay co-ordination – Relay sensing and tripping and observe the fault current

iii. Voltage Regulation (Automatic / Manual) – Regulation of voltage at substation feeders

iv. Demand side management (DSM) – Integrated logic for automatic load management for specified system constraints involves a DSM tool for monitoring and controlling

v. Load shedding (Automatic / Manual) – Logic development for automatic load shedding during non-availability of demand.

vi. Power factor control (Automatic / Manual) – Logic development for manual & automatic power factor control

vii. Loading of the sub-station transformer – Observe the overload current and relay tripping

Apart from these, Kalkitech also supports **power generation modules** that will help to simulate and learn: AGC (Automatic Generation Control), Governor Modes (Droop, KW, Auto), AVR control Modes (Droop KVar, P.F), Generator Capability curve and Droop Characteristics.

Communication interfaces and protocols

The smart lab set up by Kalkitech uses open standard based interfaces and protocols for data interface between various modules and devices in the lab. The complete system is designed based on IEC 61850.

IEC 61850 is the new international standard for information exchange and interoperability between intelligent devices within a substation. The other protocol

standards followed are IEC 870-5-101, IEC 870-5-104 and Modbus. The system is flexible enough to add any new protocols.

Communication links: RS232, RS485, Ethernet, Dial-up

Panel enclosures: NEMA, IP

Major Hardware Components	Major Software Components	Control & Software functions
Circuit Breakers	SCADA/HMI application software	Equipment control
Isolators	Power generation module	Dynamic SLD
Capacitor banks	Substation Monitoring and Control	Alarms and Events
Transformer with on load tap changer (OLTC) Circuit Breakers	Energy Management	Trending
Bus bar	Load Management	Reporting
3 Phase resistive and inductive variable loads	RTU Configuration and Programming Tool	Historian
CT, PT and Transducers	IED Configuration Tool	Fault analysis
Numerical Protection Relays for various types of protections	Disturbance analysis Software	Disturbance Monitoring
Multi Function Meters		Automatic Load shedding
Remote Terminal Unit (RTU)		Metering
IEC61850 Communication Gateway		Energy management
		Distribution management

Figure 3 Distribution Module

Figure 4: SCADA Simulation

About Kalkitech

KALKI Communication Technologies Limited (Kalkitech) was founded in 1998, with the vision of becoming the leading provider of standard-based Control, Communication and Computing solutions to OEMs, System Integrators and End–Users in the energy industry. Kalkitech solutions are successfully deployed in over 25 countries in 4 continents, across the full spectrum of the energy value chain. Kalkitech has also been empanelled as a SCADA/DMS consultant under the R-APDRP scheme of Government of India and is currently the State Government consultants for Rajastan, Gujarat, Kerala, Uttarakhand and West Bengal. Continuous innovation through research and development is at the core of Kalkitech's corporate philosophy aimed at creating a Whole New World of Intelligent Energy Systems. For more information, please visit our website: www.kalkitech.com