OVERVIEW
The Oil and Gas industry is continuously evolving in the rapid growth of Indian economy. These facilities are very energy intensive. A power disruption in a refinery could result in several days of lost production, which could translate into million dollars of lost revenue. These factors along with technical difficulties of manual control and distributed nature of the electrical network, attracts the need for automated systems to monitor and control electrical networks of this energy intensive industries to ensure reliable and stable energy supply. This case study is illustrative of the implementation of our integrated electrical control system for one of India's largest Public Sector Undertaking companies, involved in the refining and retailing of petroleum products.

Implementation Details
- **Country**: India
- **Year of Execution**: 2008 - 2009
- **Business Situation**: To provide Integrated Electrical Control System
- **Key platform**: SIEMENS S7-400H Controller
  - SIEMENS SIMATIC WinCC

Key Benefit
- *Balance energy requirements with available energy supply.*
- *Prevents blackouts and increases electrical stability of the plant.*
- *Response time of < 100ms.*
- *Ensures cost efficient and reliable power management.*
- *Integration into single application portfolio.*
- *Flexible and well organized single window interface.*
- *Reduce operator interventions.*
- *Reduce incorrect interventions.*
- *Integration with protection relays.*
INTRODUCTION
The client is one of India’s leading energy companies which produces a wide range of petroleum products with global presence through sustained aggressive growth and high profitability. This refinery has a crude oil refining capacity of 7.5 Million Metric Tones per Annum (MMTPA); with capacity expansion and modernization project it is now poised to enhance refining capacity to 9.5MMTPA. To supply the power requirements the following enhancements is done in the electrical network:

• Upgraded the state electricity board incomer voltage level to 220kV.
• New Captive Power Plant (CPP) with new Gas Turbine Generators.
• Three new distribution substations.
• Integrated existing CPP (with one STG and one GTG) and two substations to new electrical network.

As per production and process requirements the electrical system is distributed over a large area and operates at different voltage levels – 220kV, 33kV, 11kV, 6.6kV and 0.433kV. Figure-1 shows the overview of the complete electrical network.

SYSTEM REQUIREMENTS
Existing SCADA system covered the existing power sources viz., two grid incomers, Steam Turbine Generators, Gas Turbine Generators and all 11kV switchboards of three existing substations. This SCADA had three main functions viz., (a) Remote data acquisition and display,(b) Manual synchronization, grid transformer OLTC & CB control, (c) Manual electrical load shedding. Numerical relays and meters are integrated to gateways at individual locations over IEC103 and Profibus. These gateways communicate to SICAM PCC (Power Control Centre) based central SCADA over IEC 101 for data exchange. A standalone controller (lower version) was provided for load shedding application.

New system integrated the existing substations and five new substations. New system is built on SIEMENS S7-400H controller and SIMATIC WinCC. Existing functionalities along with new functionalities are provided as follows:

• Electrical plants data acquisition and display
• Routine log report generation and energy balance reports
• Detection and reporting of alarms
• ON/OFF control of circuit breakers
• RAISE/LOWER control of transformer OLTC
• Excitation RAISE/LOWER control of all generators
• Frequency RAISE/LOWER control of all generators
• Monitoring and Control with electrical diagrams
• Sequence of event recording
• Fast Acting Dynamic Load Shedding
• Slow Load Shedding
• Load Sharing
• Maximum Demand Control
• Automatic Breaker Synchronization

Figure-1 Single line diagram shows power plant and load centres for the plant.
• Capacitor Feeder switching for reactive power compensation

SOLUTION
The Electrical Control System (ECS) monitors and controls electrical power networks and the critical safety interlocks thereby avoiding blackout conditions. ECS is a functionally and geographically distributed system.

System Architecture
The system is built around SIMATIC S7-400H controller, SIMATIC WinCC and KALKI KSGL16R2 protocol gateways. Architecture comprises of two centrally located controllers; Load Management System (LMS) and non critical functionalities. Integration with protection relays and analog data acquisition for LMS is achieved through KALKI KSGL16R2. ECS HMI is implemented in SIMATIC WinCC platform. Figure- 2 shows the system architecture for the ECS.

- **SIEMENS S7-400H Controller**
  - Master decision making device of the ECS.
  - All critical logic/algorithm execution performed by this module.

- **Functions according to the principle of active redundancy in 'hot standby' mode.**
- **Remotely located ET200M (Data Acquisition Units) at all substations with hardwired interface to the field.**

- **KALKI Protocol Gateway KSGL16R2**
  - Offers scalable and standards based interface.
  - Main analog data acquisition device for LMS application.
  - Integration between field devices supporting various protocols.

- **SIMATIC WinCC**
  - Powerful HMI system for use under Microsoft Windows 2003 and Windows XP.
  - Project development and configuration environment.
  - HMI run-time software.
  - Powerful Client/Server System.
  - Increased system availability by means of redundancy.
  - Scalable SQL server for data archiving.

- **SIMATIC MANAGER**
  - Used to program S7-400H controller.
  - Administrating all tools and data of the project.
  - Configuration and parameterization of hardware.
  - Creating and testing user programs.
  - Complete Network Overview
  - Single line diagram of complete electrical network.
  - Status of breakers displayed.
  - Different voltage levels represented using different colours.
  - Figure-3 shows the Complete network overview
• Substation Overview display
  - Individual substation displays.
  - Status of circuit breakers and isolators displayed.
  - Control of equipments.
  - Analog measurements are displayed.
  - Figure-4 shows the Substation overview display

• Measurement Display
  - Feeder information like voltage current, active power, reactive power etc are displayed.

Figure- 3 complete network overview

Figure- 4 Substation Overview display

Figure- 5 Measurements Display

• Load Shed Information Display
  - Displays information of total load, generation and deficit network wise.
  - Substation wise feeder name, group, priority, inhibition details, load shed command details and active power displayed.
  - The source details, reason for load shedding, highest priority tripped etc are displayed.
  - Network wise under frequency load shed details are displayed.
  - Figure-6 shows the Load shed information display

Figure- 6 Load Shed Information Display
• **Load Shed Configuration Display**
  - Displays substation wise feeder list.
  - Feeder wise active power information displayed.
  - Interface to configure priority, group and inhibit for feeders.
  - Figure-7 shows the Load shedding configuration display

![Figure-7 Load Shed Configuration Display](image)

• **Load Sharing Display**
  - Sub-network number, governor mode, and active power, participation factor, spinning reserve, AVR mode and reactive power of each generator displayed.
  - Sub-network wise spinning reserve, number of generators in fixed MW mode, number of generators in control mode, frequency set point, high limit and low limits are displayed.
  - Figure-8 shows the Load sharing display

![Figure-8 Load Sharing Display](image)

• **Maximum Demand Control Display**
  - Sliding and Fixed window selection.
  - Operator entry for grid import limit, window time period and sub interval.
  - Enable / Disable MD Control.
  - Information like predicted value, target and average demand displayed.
  - Figure-9 shows the Maximum Demand control display

![Figure-9 Maximum Demand Control Display](image)
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- **Generator Capability Curve**
  - Generator inputs, Inputs from the field, Stability inputs etc displayed.
  - Theoretical steady state stability, steady state stability, Operating point, PF axis, Pmax line, Pmin line, Turbine limit, No load curve, Rotor end heat limit and Stator end heat limit are displayed.
  - Figure-10 shows the Generator capability curve

- **Capacitor Bank Switching Display**
  - Displays the power factor indication for the incomers.
  - Displays the limit values for the incomer power factor.
  - Advises the operator to switch ON / OFF the capacitor Bank.
  - Ensures that no other circuit breaker in the network is subjected to leading power factor interruption duty.
  - Changes in power flow arising out of automatic bus transfers in the network are taken into account.
  - Figure 11 shows capacitor bank switching display

Figure- 9 Maximum Demand Control Display

Figure- 10 Generator Capability Curve

Figure- 11 Capacitor Bank Switching Display
• Trend Display
  - Provides graphical representation for analog parameters.
  - Real time and historical trend provided.
  - Trending inputs are displayed in separate colours for easy identification.
  - Figure 12 shows the trend display

![Figure-12 Trend Display](image)

• Alarm / Event Display
  - Displayed visually, audibly and/or on printer
  - Filters to control display
  - Archiving facility
  - Acknowledging of alarms
  - Appearance in chronological order
  - Dynamic colour representation

![Figure-13 Alarm Display](image)

![Figure-14 Event Display](image)
• **Circuit Breaker Control Face Plate**
  - Displays the analog values, interlocks and status.
  - Displays the alarms.
  - Open and close command buttons.
  - Maintenance tag button and the reset button.
  - Figure 14 shows a CB face plate and the confirmation window for a breaker open command.
  - Figure 15 shows the circuit breaker control face plate.

• **Synchronization Face Plate**
  - Different types of synchronization – Dead Bus Sync, Check Sync, Active Sync.
  - Alarms displayed – Critical interlock active, Process interlock active, IO Error, load shed active and communication failure.
  - Active sync – Device selection and generator selection
  - Option for manual sync.
  - Indication of sync completed, sync canceled and sync time out are displayed.
  - Figure 16, 17, 18, and 19 shows the synchronization face plate.
ACHIEVEMENTS

- Less than 100ms response time for load shedding application.
- Automatic and Manual Synchronization of breakers based on software and hardware solution.
- Scalable Architecture – This enabled us to get new order for expansion of the system in the same industry.
- Single interface for customer for entire solution.
- Best solution that is different from standard products and solutions.

• OLTC Control Face
  - Tap Position, Primary Voltage, Secondary Voltage, Point of Control and Operation mode displayed.
  - Command windows for automatic and manual OLTC Control.
  - Status and Alarm sections.
  - Figure-20 shows the OLTC Control face plate