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DESIGN OF SCADA USING MICROSCADA FOR SUBSTATION AUTOMATION SYSTEM

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Abstract: This paper gives us the details about power system ie.. for Green and sustainable power is the need of the day. With widening supply and demand gap, power management has become one of the most critical areas of concern all over the world. India's energy consumption is increasing at one of the fastest rates in the world. Hence, we require Substation Automation Systems in the present day substations to efficiently control and deliver power. The main objective is to create a SCADA system for the 765/400kV substation of KANPUR PGCIL India Ltd. Power automation serving electric supply locations often require special protection against the effects of fault-produced. Protection relays need to function immediately when a faulty condition occurs. This is why Intelligent Electronic Devices (IED's) are brought in for safe operation of switchyard devices, which can prevent disasters to energy supply and help in human safety. With the introduction of IEC 61850, utility communication will be used for substation automation and also for protection purposes within a substation and between substations. Measured values and trip signals will be transmitted as digital signals over a communication network. A Substation Automation System (SAS) provides facility to control and monitor all the equipment in the substation locally as well as remotely. A Supervisory Control & Data Acquisition (SCADA) system provides users with a Human Machine Interface (HMI) which can be used for controlling, monitoring and protection of devices. This saves us cost and time when it is of utmost need by providing real time information about the substation devices status.
Keywords: SCADA, Supervisory control, Data Acquisition, Automatic control, IED, IEC.

I. INTRODUCTION

This chapter gives us information related to the introduction of the project work carried out in ABB India, Bangalore's Peenya Factory premises. It gives us an insight as to why this particular project work was taken up, the challenges faced in the earlier days, main objectives and the motivation to develop the SCADA application in a Substation Automation System (SAS).

A. Work Area Description

This project work was carried out inside the factory development and testing shopfloor area of ABB India Ltd, Bangalore. The project undertaken was development of a complete Substation Automation System for a 765/400kV substation of KANPUR PGCIL India Ltd. Generator manufacturing facility. This involved taking customer specifications, requirements and then designing the whole system for the given control room.

B. Motivation for the project

Instrument transformers pass on information about the primary current and voltages to the secondary equipment (protection, control and metering). In the earlier days, these transformers were large apparatuses composed of insulation materials, copper and iron. They were also used to power the electromechanical secondary equipment. Nowadays, the numerical type of secondary equipment gets its operating power from a separate power supply (i.e., battery). In addition, thanks to the emergence of fiber-optic technology, the old large instrument transformers can be replaced by fibre-optic sensors that give information about primary currents and voltages. These values are transformed into digital fiber-optic signals, which are fed to the secondary equipment which forms the entire Substation Automation System and can be controlled using a remote SCADA control system for all the switchyard devices. Replacing traditional instrument transformers with optical sensors has further reduced the switchgear footprint and lowered the costs, while at the same time provides secondary equipment that is more flexible and secure. To develop such a vast system, we have to adhere to a standard called IEC61850 which has been developed mainly for substation automation and protection. Introduction of this technology in the substation control has motivated me to take up this project, which complies with the present substation automation standards and is widely used by all major companies worldwide.

II. LITERATURE SURVEY

When the building of electricity systems started in earnest some 100 years ago, the network wasn't particularly reliable. The circuit breakers were mechanically and electrically very complicated and required frequent maintenance. Outages due to maintenance were the norm rather than the exception. The invention of the disconnector switch certainly helped to increase the availability of these electrical networks. The single-line configurations used were such as to surround the circuit breakers by many disconnector switches so that adjacent parts of the switchgear were kept in service while maintenance was carried out on the breakers. These ideas led to the double busbar and double plus transfer busbar schemes. In addition to maintenance considerations, single-line configurations were chosen to limit the consequences of primary faults in the power. To limit these faults while still retaining the maintenance aspects, 1½-breaker and 2-breaker single-line configurations were introduced. Today's breakers require less maintenance than their predecessors. [1] The complex interlocking and sequence control requirements that prevail in most substations of any significant size lend themselves naturally to the application of substation automation. Hence, computers have been applied to the control of electrical networks for many years, and examples of them being applied to substation control/automation were in use in the early 1970's. The first applications were naturally in the bulk power transmission field, as a natural extension of a trend to centralised control rooms for such systems. The large capital investment in such systems and the consequences of major system disruption made the cost of such schemes justifiable. In the last twenty years or so, continuing cost pressures on utilities and advances in digital hardware have led to the application of computers to substation control and automation as a first-choice solution. [8] In the earlier days, multiple protocols existed for substation automation, which include many proprietary protocols with custom communication links. Interoperation of devices from different vendors was not possible and was considered as an advantage to users of substation automation devices. An IEC project group of about 60 members from different countries worked in three IEC working groups from 1995. They responded to all the major concerns and objectives and created IEC 61850. The objectives set for the standard were:

1. A single protocol for complete substation considering modelling of different data required for substation.
2. Definition of basic services required to transfer data so that the entire mapping to communication protocol can be made future proof.
3. Promotion of high interoperability between different systems from different vendors.
4. A common method/format for storing complete data.
5. Define complete testing required for the equipments which conforms to the standard.

IEC 61850 is the present day standard for the design of electrical substation automation. IEC 61850 is a part of the International Electro technical Commission's(IEC) Techinical Committee 57 (TC57) reference architecture for electric power systems. The abstract data models defined in IEC 61850 can be mapped to a number of protocols. Current mappings in the standard are to MMS (Manufacturing Message Specification), Generic Object Oriented Substation Events (GOOSE), SMV (Sampled Measured Values), and to Web Services as well. These protocols can run over TCP/IP networks or substation LANs using high speed switched proprietary ethernet to obtain the necessary response times below four milliseconds for protective relaying. [4]

III. METHODOLOGY

In this chapter, we will be discussing in details about the methodology that was adopted during the execution of the project work. It involves engineering of various numerical relays, their specifications, internal design structures, SLD's and the software tools used for the entire SCADA engineering process and design.

A. OPC Server

OLE for Process Control, which stands for Object Linking and Embedding (OLE) for Process Control, is the original name for a standards specification developed in 1996 by an industrial automation industry task force. It has been officially renamed as "Open Platform Communications (OPC)". The standard specifies the communication of real-time substation data between control devices from different manufacturers. OPC includes data transportation technologies like XML, Microsoft's .NET Framework, and even the OPC Foundation's binary-encoded TCP format. OPC is a series of standards specifications consisting of seven current standards and two emerging standards. The first standard is called the Data Access Specification or "OPC Data Access". OPC was designed to provide a common bridge for Windows based software applications and process control hardware. An OPC Server for one hardware device provides the same methods for an OPC Client to access its data as any and every other OPC Server for that same and any other hardware device. The aim is to reduce the amount of duplicated effort required from hardware manufacturers and their software partners, and from the SCADA and other HMI producers in order to interface the two. Once a hardware manufacturer has developed their OPC Server for the new hardware device their work is done to allow any 'top end' to access their device, and once the SCADA producer had developed their OPC Client their work is done to allow access to any hardware, existing or yet to be created, with an OPC compliant server. OPC servers provide a method for many different software packages (as long as it is an OPC Client) to access data from a process control device. The purpose of OPC is to define a common interface that is written once and then reused by any business, SCADA, HMI, or custom software packages. There is nothing in the OPC specifications to restrict the server to providing access to a process control device. OPC Servers can be written for anything from getting the status of a circuit breaker to getting the current measurements of the line. Once an OPC Server is written for a particular device, it can be reused by any application that is able to act as an OPC client. OPC servers use Microsoft's OLE technology (also known as the Component Object Model, or COM) to communicate with clients. COM technology permits a standard for real-time information exchange between software applications and process hardware to be defined.

B. Protection & Control Manager (PCM600 2.5)

The Protection and Control IED Manager PCM600 tool provides versatile functionalities for the entire life-cycle of all Relion protection and control IED applications, at all voltage levels. PCM600 interacts with IEDs over the fast and reliable TCP/IP via corporate LAN or WAN, or alternatively directly through the communication port at the front of the IED. PCM600 tool is able to read and write all configuration and the settings data of an IED with a single command. The software is initialized by creating- New Project > Substation > Voltage Level > Bays > IED. Once all the IED configurations are over, then the OPC server is created to provide the linking of the signals and systems. All the components of a substation automation system are created in the same specific order and the online configuration of IED's and other components are initiated by giving them their individual IP addresses.

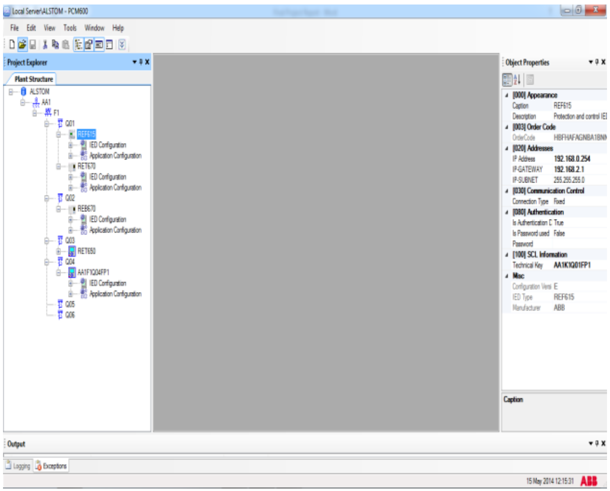

Fig. 3.1 PCM600 Initialization

C. IED Application Configuration

Inside the application settings we create the functional blocks consisting of the logics developed depending on the project requirements including the switches which are then linked up accordingly to get details like status, switch position, etc. We also configure logical blocks for the system measurements like current, voltage, power, frequency etc.

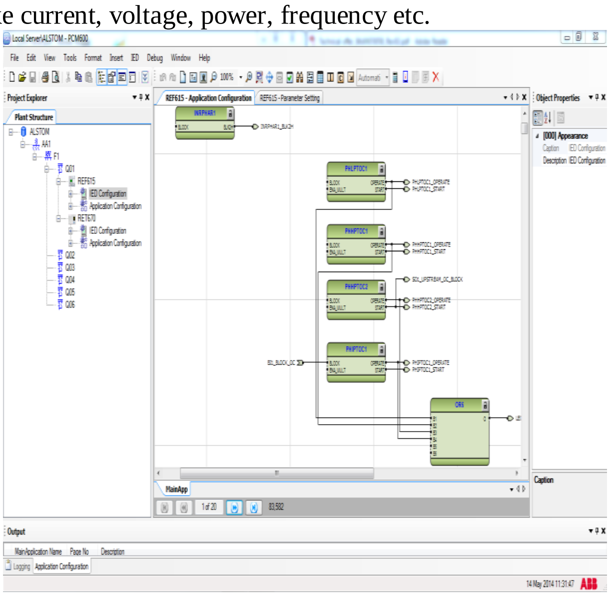

Fig. 3.2 Application Configuration

D. Graphical Display Editor

In this, the SLD is created which will be written to the REC670 (control IED) and will be displayed on the physical device. This can be used to control the device switches from the station locally if remote control is not required. This cannot be configured in REF615 as it is a feeder protection device and does not have an SLD viewer.

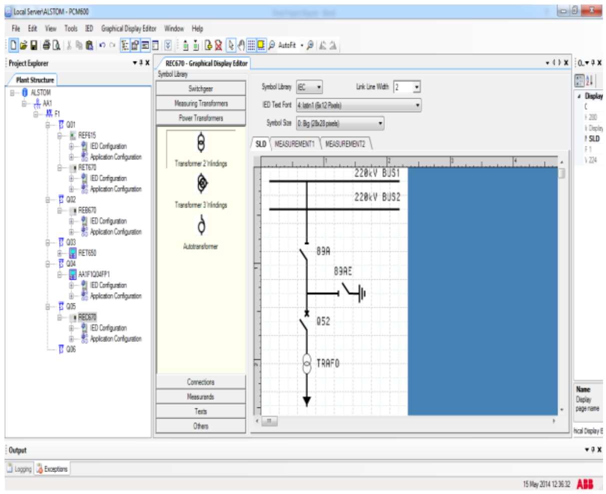

Fig. 3.3 REC670 Display Editor

E. IEC61850 Configuration

This is an international standard communication protocol at which the entire system communicates. This standard was developed for inter-operability with devices from various manufacturers. The data is taken from a signal list prepared depending on the inputs and measurements required for the IED's from the switchyard level. All the signals are mapped and both the Client-Server (Vertical) and Generic Object Oriented Substation Events (GOOSE/Horizontal) communications are configured and initiated.

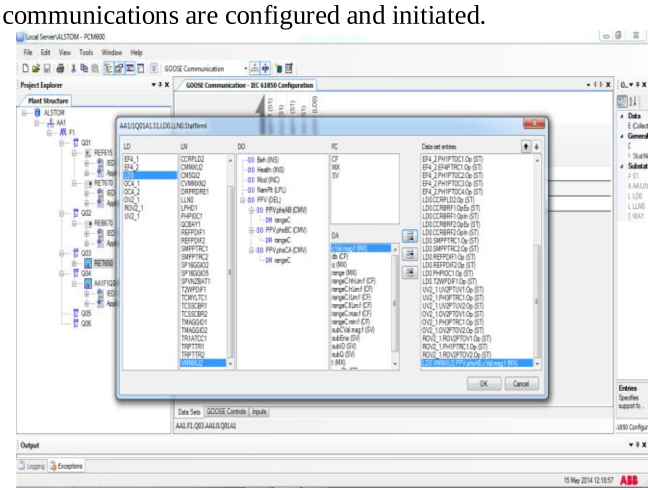

Fig. 3.4 IEC61850 Configuration

F. Signal Matrix

In this configuration, the GOOSE communication signals are mapped to individual switches and positions so that the channel card can read the different signals and their Status Validity (stVal) and Quality (q) information from the IED's and can have their internal data communication processed.

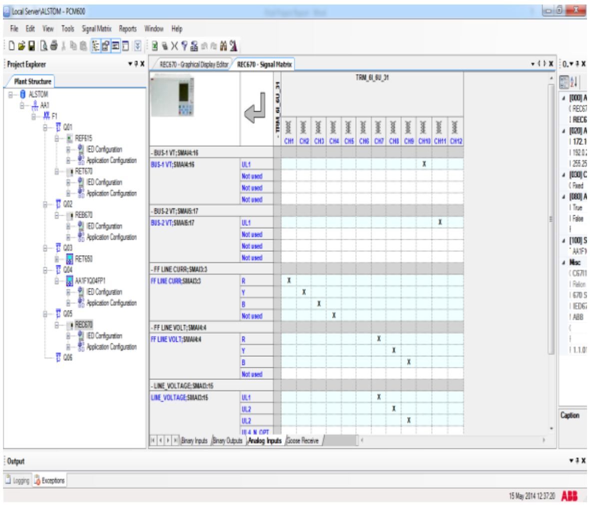

Fig. 3.5 Signal Matrix

After all these configurations in PCM600, a .SCD file, Substation Configuration Language(SCL) file format is generated and exported to be used in Micro SCADA Pro SYS600 engineering.

G. MicroSCADA Pro Control System SYS600 Engineering

MicroSCADA Pro is designed to communicate and connect to Control Centers. The system is started from SYS600 Control Panel. In this software, there are many steps involved and are executed in the following order:

H. Process Objects

SYS600 Monitor Pro > Tool Manager > Process Objects (PO): Standard functions are installed for station, bays, switches, IED, measurements and alarms etc. and we configure them to their individual addresses in the OPC Server Client Configuration. Each signal received from the IED has its own unique address.

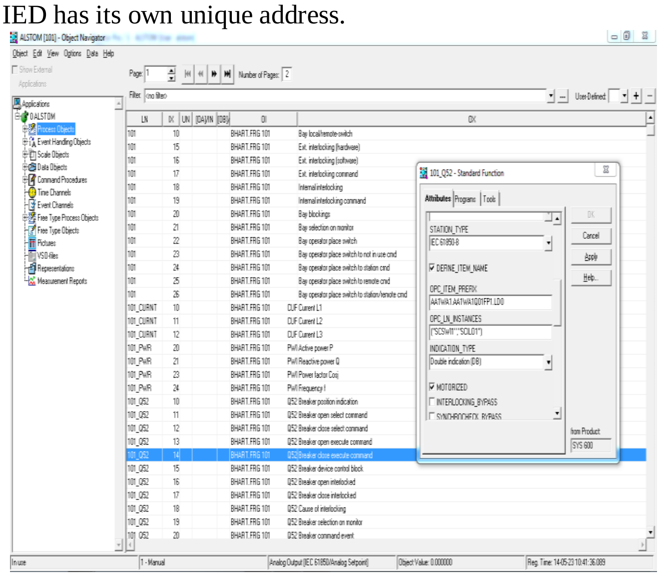

Fig. 3.6 Process Objects

I. Display Builder

SYS600 Monitor Pro > Display Builder: Here we design the entire system and SLD and the switches are imported and are mapped to their address as shown in the figures. The switches are named according to ANSI codes.

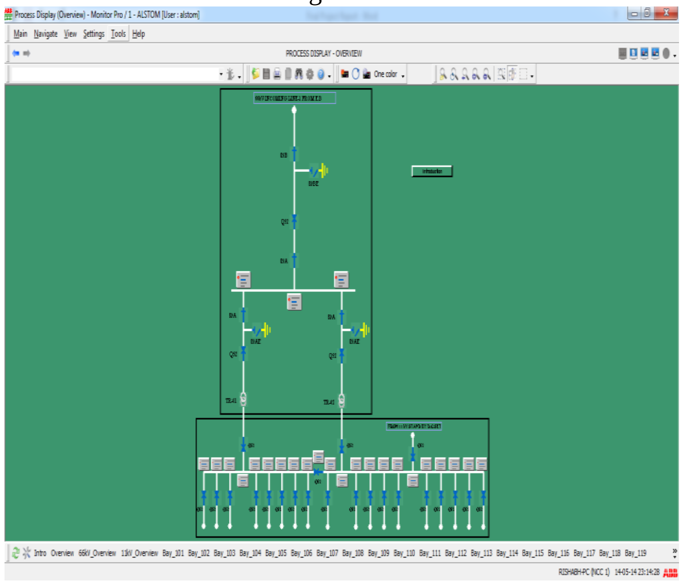

Fig. 3.7 System Design

J. OPC PO List

SYS600 Monitor Pro > Tool Manager > OPC PO List: This list is used to publish all the devices, switches and their mapped signals included in the network under the particular station. The Station Unit Number (UN) is assigned as 5.

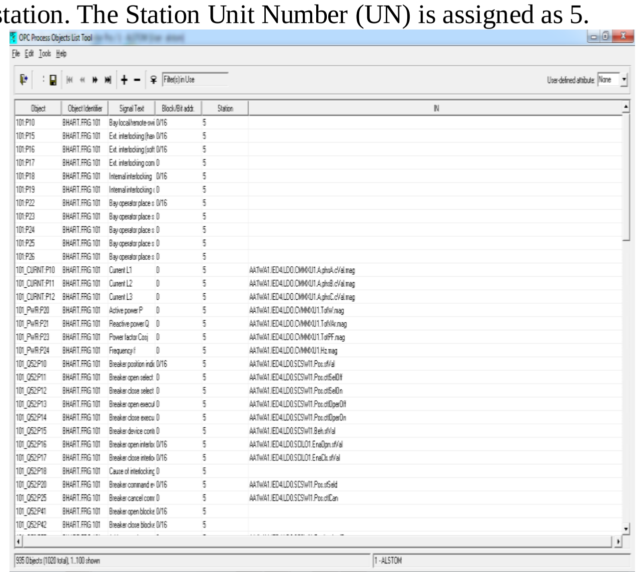

Fig. 3.8 OPC PO List

K. Communication Engineering Tool (CET)

In this engineering tool, we create- New Project > Computer Node > IEC61850 OPC Server. With the help of this software, we can import the .SCD file (via SCL Import) inside the OPC Server which consists of the Substation configurations having the IED files. From here we can establish the IEC61850 communication and an online test of the IED's is completed. This is done to check the connectivity of the computer system to the IED.

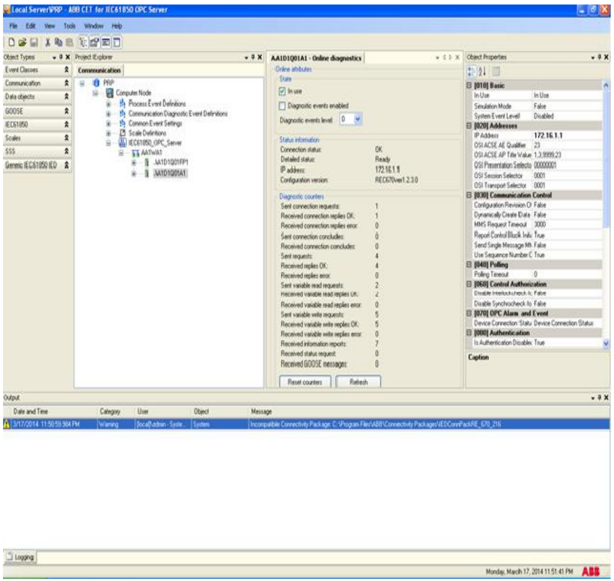

Fig. 3.9 REC670 Online Test

L. OPC DA Client Configuration

Browse for the active client instance in the software installation folder, which can be checked after importing and running the .SCD file in CET and create an IEC61850 computer station by giving the base address as 127.0.0.1 and import the OPC PO List into the station. This gives the signal list of all the equipments, measurements etc. This file is saved in the .INI format.

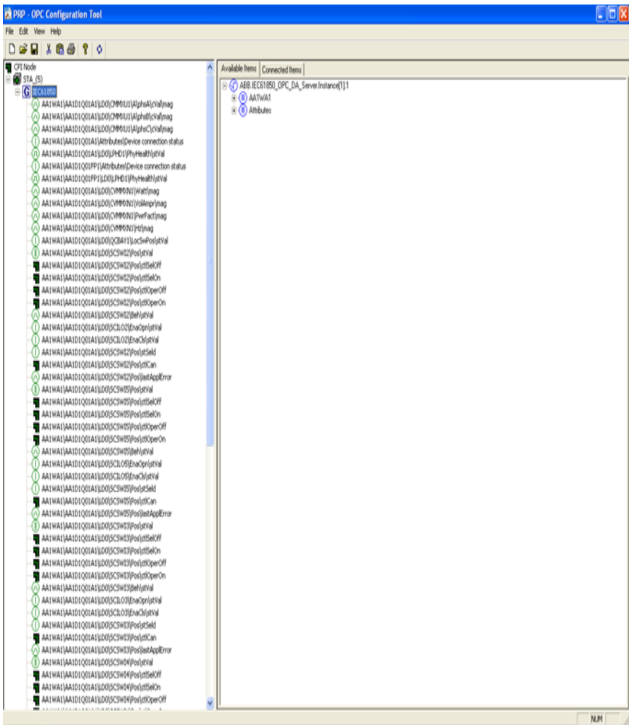

Fig. 3.10 OPC DA Configuration

M. OPC DA Client Control Panel

The .INI instance file is imported into this tool and the system is brought online for SCADA remote control.

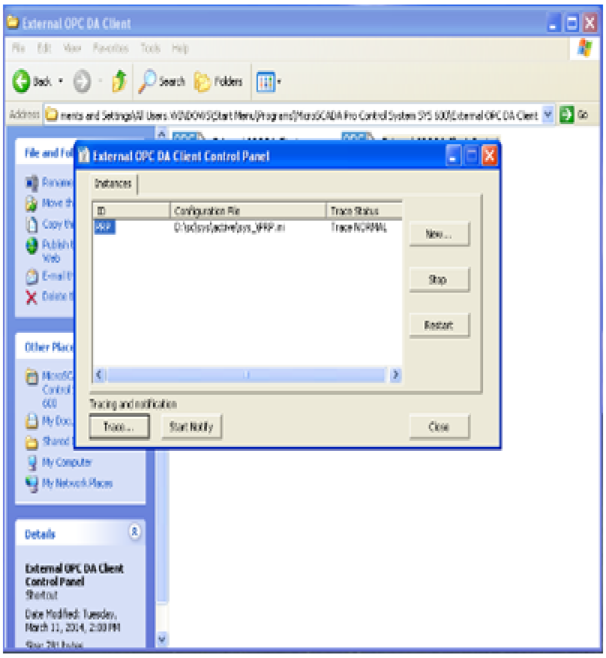

Fig. 3.11 OPC DA Client Control Panel

N. SYS600 Monitor Pro

Once the system is brought online for remote access, we can control and monitor all the parameters of the system like station control, switch positions, alarms, measurements etc.

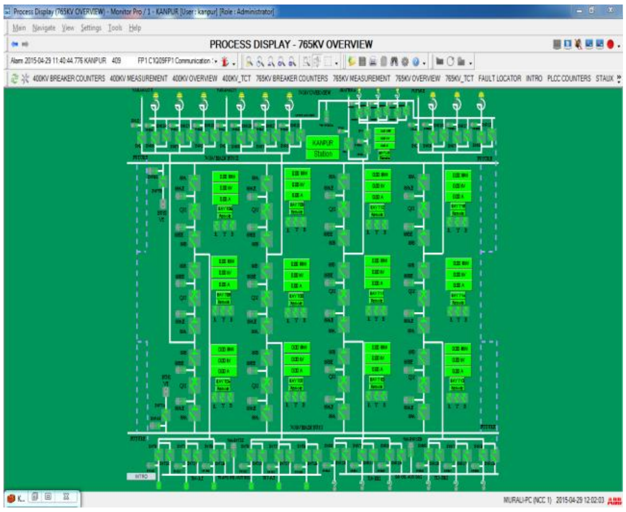

Fig. 3.12 System Control

IV. RESULTS

In this particular chapter, we will be discussing about the final test results, reports, graphs and the final system developed for the customer.

A. Measurement Reports

Measurement reports provide an interface for showing measured values for further data analysis in the application. It can be used for monitoring time related follow-ups of the process and measured, entered or calculated data. It shows the history of these values, the predicted future values and the entering values. The reports are for various types of time related reports, e.g. hourly, weekly, monthly etc.

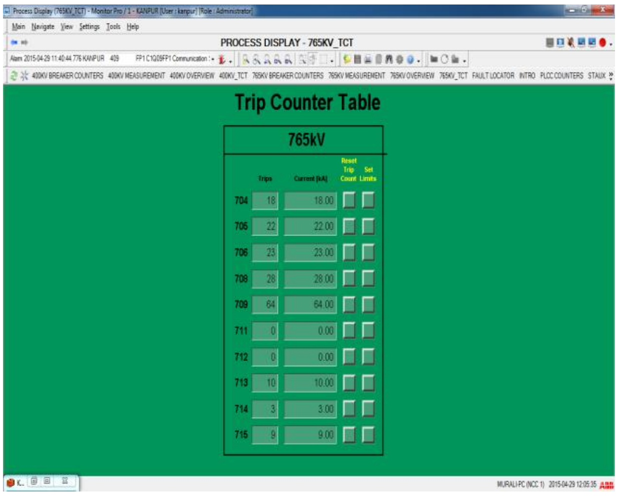

Fig. 4.1 Triping table

B. Events Display

With the Event Display you can monitor the information about events occurring in the system. Thus, you can make the right decisions and verify that taken measures have been successfully performed. You can also receive information about activities carried out by other users, operations of objects, acknowledging of alarms, editing of limit values, logging in, and so on.

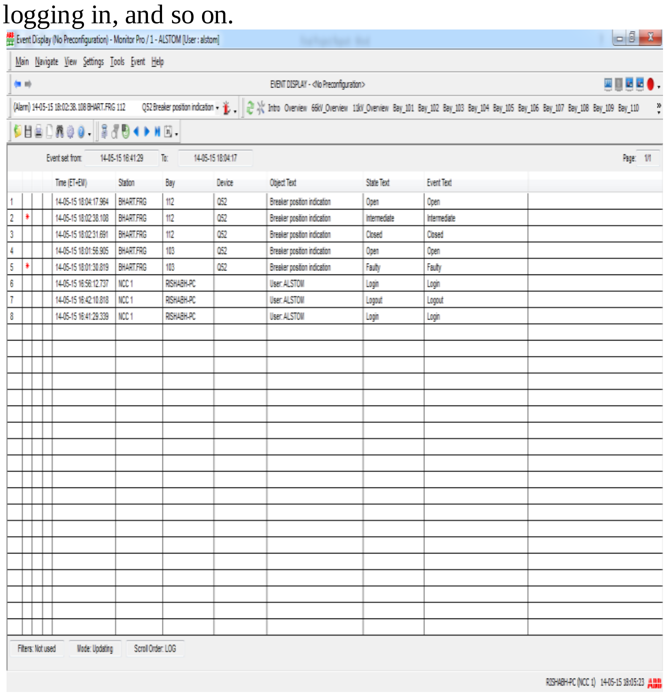

Fig. 4.2 Events

C. Alarm Display

This shows the summary of the present alarm situation of the supervised process. It shows the time stamp, object id, object text, text indicating alarm status and a number ranging from 1-7 indicating the alarm class.

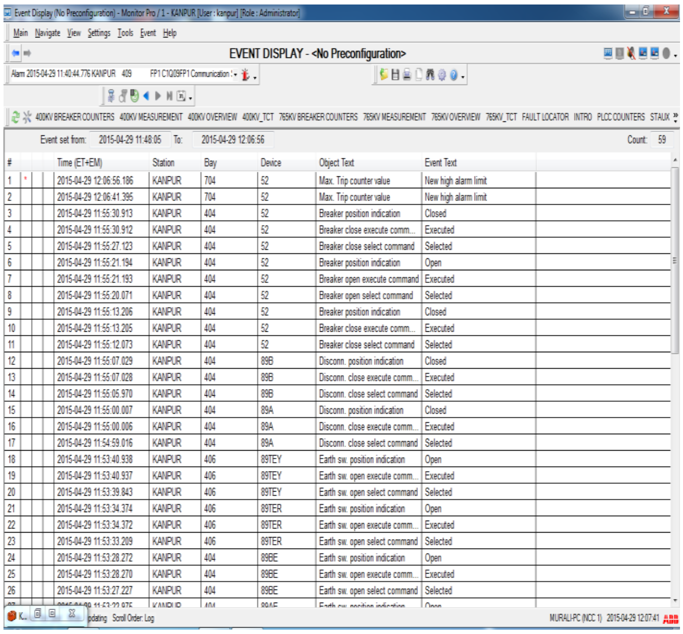

Fig. 4.3 Alarms

D. Final SAS Architecture

The figure on the next page shows the final Substation Automation System architecture which was developed for the 765/400kV substation.

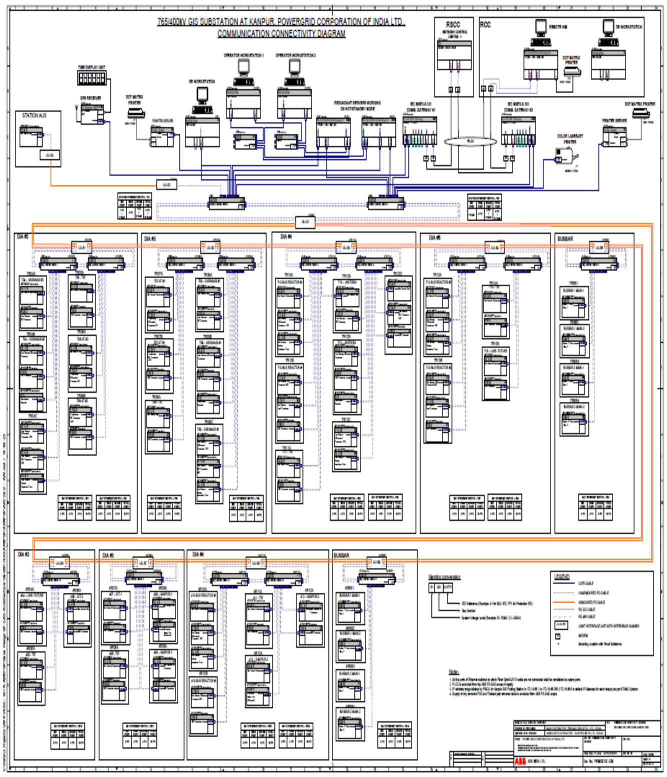

Fig. 4.4 SAS Architecture

E. Final Control Panel Setup

These panel figures depict the final setup done which were required to do the final testing before commissioning the SAS system for the customer.

Fig. 4.5 PC Panel


Fig. 4.6 REC670 Panel

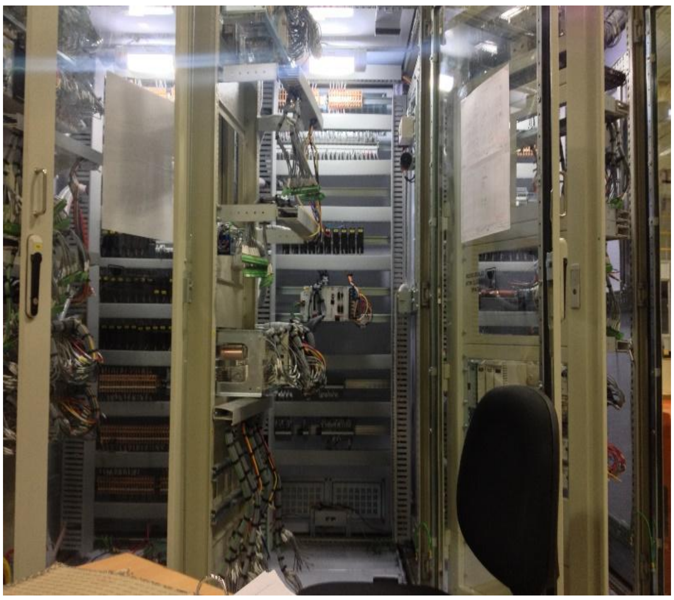
Fig. 4.7 IED Panel (Inside)

V. CONCLUSION

The new processes involved in Substation Automation System and the standard IEC61850 offer several benefits for the design of a substation. This reduces the number of copper wires significantly along with the reduced manual work involved in assembling and testing these wires. The number of non-supervised functions have reduced to almost zero. This reduces the time until an error will be detected and increases the availability of the system. With the introduction of the new technology, a true redundancy is possible at a reasonable cost for all the functions of the substation. Initially, on the path towards the intelligent switchgear, more physical devices were introduced in the system which affected the overall system reliability. However, with each step of functional integration, there is a reduction in the number of physical devices that consequently have improve the overall system reliability. The general principles of the substation operation have not changed, since the developing days. Therefore the control and protection tasks remain the same. The main objective of a modern Substation Automation System (SAS) is to solve these tasks in a more efficient and economical way by using state of the art information technologies and to provide more functionality to work substations and their systems harder. IEC61850 communication protocol has made it easy for interoperability of different IED’s from different manufacturers. This gives an open possibility to the customers and allows them to integrate various devices within a system for the remote control operations.

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