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Substation Automation System for Energy Monitoring and Control using SCADA

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Abstract: ***Inherent scarcity of thermal sources with a time varying temperature profile is the reason why the Thermo electric-based energy harvesting is not as prominent as its counter-part, thermoelectric generators, in the thermal energy harvesting domain. The main focus of the work is to modulate the concentrated solar radiation using a vertical axis wind turbine for producing higher rate of change of temperature on the Thermo electric material. In a typical demonstration of thermoelectricity, one part of the device is kept at one temperature and the other part at a different temperature and the result is a permanent voltage across the device as long as there is a temperature difference.***
Keywords: ***Inherent scarcity, wind energy, temporary voltage, Piezoelectricity.***

I. INTRODUCTION

mart substations form the key building block of a smart grid. Smart substation implies, the creation of highly reliable power system, which rapidly responds to real time events, with appropriate action to ensure uninterrupted power services to end users. Substation automation lead to smart substations and Supervisory control and data acquisition (SCADA) forms the entry towards substation automation. SCADA was introduced in Indian substations in the year 2000. It followed the GE Harris Extended architecture for the 21st century (XA/21). Kerala started with 30 Remote Terminal Units (RTU's) and has at present 32 RTU's. Information is gathered from a series of RTU's, which are wired to substation equipment's, such as isolators, CT's, PT's, transformers, etc. The communication protocols used is IEC 60870-5-101. The State Load Dispatch Centre is located at Kalamassery and is supported by three Sub Load Dispatch Centers at Thiruvananthapuram, Kalamassery and Kannur. The system operation activities of the State are coordinated from the State Load Dispatch Centre. The Load Dispatch Control room is equipped with a full-fledged SCADA system acquiring real time data from all Generating Stations, 400kV, 220kV and major grid 110kV stations. The RTU Stations connects the generating stations, 400kV, 220kV substations and major 110kV substations to the SLDC via optical fiber, microwave and the PLCC Communication Network System. The data from these stations are made available on a real time basis through Data Networking. The GE Energy XA/21 software package is used for the SCADA/EMS system in all the control centers.

II. SYSTEM ARCHITECTURE

The substation structure can be divided into four levels: process level, bay level and a station level and network level. The process level forms the base, where the switchgear equipment is located. These are wired to the Bay Control Units(BUC) which form the bay level. The bay control unit performs (a) control in accordance with control commands from station level control equipment and (b) monitoring for the bay. The data transferred consists either an analog or binary input or output. Human Machine Interface (HMI) device, a monitoring and maintenance tool for bay control unit and data communication unit during commissioning or maintenance is placed at the bay level. At the station level, which forms the brain of the system, is located the Station Control Unit (SCU). Between the bay level and station level is present a Data Communication Unit (DCU), which serves as a communication interface between station level and bay level units. At present, the process level is equipped with RTU's. Communication between the bay level and station level is through Power Line Carrier Communication (PLCC), Optical fiber communication or microwave communication following the IEC 60870-5-101protocol (defines protocols for SCADA).Communication between control centers is through inter control center communication protocol.

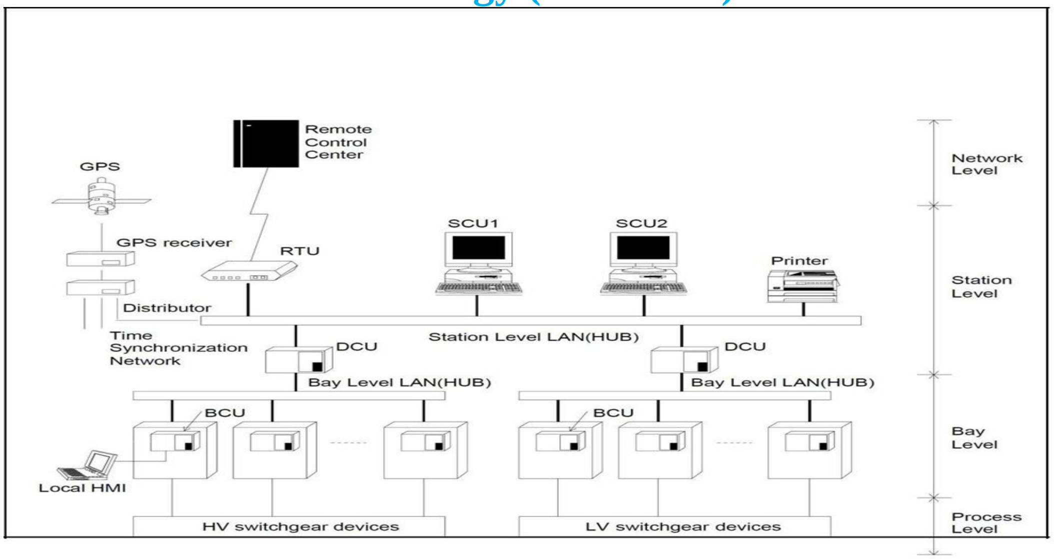

Fig 1: System Architecture

To make the system reliable and intelligent, either the present RTU's are upgraded or replaced with IED's. As communication protocol defined for substation automation is IEC 61850 and IED's communicate following IEC 61850, communication takes place following IEC 61850 protocols. Time Synchronization is done through a global positioning satellite (GPS). At present only the remote control center is equipped with GPS. As time synchronization is an important element while establishing IEC61850, it is crucial that a GPS antenna is located both at the remote control center and the substation

III. PROPOSED SYSTEM

Communication plays an important role in the real time operation of a power system. In the beginning, telephone was used to communicate line loadings back to the control center as well as to dispatch operators to perform switching operations at substations. With the entry into a digital age, we needed the technology to cater to the hot requirements, which are;

A. High-speed IED to IED communication
B. Multi-vendor interoperability
C. Support for File Transfer
D. Auto-configurable / configuration support
E. Support for security

Given these requirements, work on next generation communication architecture began with the development of the Utility Communication Architecture (UCA) in 1988. The result of this work was a profile of "recommended" protocols for the various layers of the International Standards Organization (ISO) Open System Interconnect (OSI) communication system model. The concepts and fundamental work done in UCA became the foundation for the work done in the IEC Technical Committee Number 57 (TC57) Working Group 10 (WG10), which resulted in the International Standard–IEC 61850– communication Networks and Systems in Substations.

F. Features of IEC 61850

1) *Data Modeling*: Primary process objects as well as protection and control functionality in the substation is modeled into different standard logical nodes which can be grouped under different logical devices
2) *Reporting Schemes*: There are various reporting schemes (BRCB & URCB) for reporting data from server through a server-client relationship which can be triggered based on pre-defined trigger conditions.
3) *Fast Transfer of Events:* Generic Substation Events (GSE) are defined for fast transfer of event data for a peer-to-peer communication mode. This is again subdivided into GOOSE & GSSE.

4) *Setting Groups:* The setting group control Blocks (SGCB) is defined to handle the setting groups so that user can switch to any active group according to the requirement.
5) *Sampled Data Transfer:* Schemes are also defined to handle transfer of sampled values using Sampled Value Control blocks (SVCB)
6) *Commands:* Various command types are also supported by IEC 61850 which include direct & select before operate (SBO) commands with normal and enhanced securities.
7) *Data Storage:* Substation Configuration Language (SCL) is defined for complete storage of configured data of the substation in a specific format.

IV. COMPONENTS DESCRIPTION

Communication involves exchange of information, and it takes places through one of the following ways

A. Power Line Carrier Communication (PLCC)
B. Microwave Communication
C. Fiber Optic Communication

For various functions, which include voice communication, teleportation, telemetering and telecontrol, PLCC is an approach to utilize the existing power lines for the transmission of information.

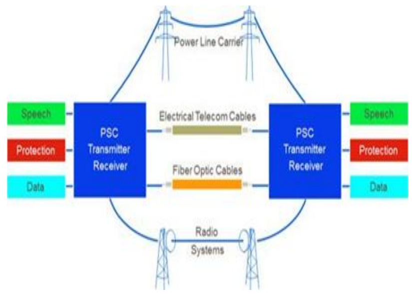

Fig2: Forms of communication

A Powerline modem is used for communications over power lines. It works as both transmitter and receiver, i.e., it transmits and receives data over the power lines. There are two different ways by which we can connect a PLC unit with the power lines– capacitive coupling and inductive coupling. In capacitive coupling, a capacitor is used to superimpose the modulated signal on to the network's voltage waveform. Another way is inductive coupling which employs an inductor to couple the signal with the network's waveform. To overcome this crisis, Unified Load Dispatch and Communication (ULDC) project commissioned in 2002 by PGCIL with the participation of EBs. It Forms the Communication Systems for carrying required Real time data and voice for LD operations.

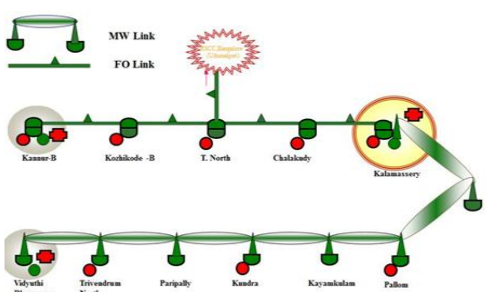

Fig3: Communication between various substations in Kerala

Microwave communication is the transmission of signals via radio using a series of microwave towers. They have an operating range of 50 Kms to 100 Kms and frequency range 300 Mhz to 30 Ghz Their advantages include

D. Reliable

E. Multiple voice and data channel capabilitiy
F. Last Mile Access
G. Right of way
H. Enables communication where wired networks are difficult to install.
I. Wider bandwidth

With the development of satellite and cellular technologies, microwave has become less widely used in the telecommunications industry. Fiber optic communication is now the dominant data transmission method. Depending upon applications, the choices of cables are

OPGW (Optical ground wire): During initial construction of new transmission lines. Techniques have also been developed to install OPGW by substituting theconventional Ground wire on existing lines.

ADSS (All Dielectric Self Supporting cable): To be erected on existing Towers by stringing the cable at electromagnetic null points on the power lines.

Wrap Around: Specially suited for existing transmission lines where installation of ADSS cable is not possible due to inadequate ground clearance or excessive wind loading.

J. *Advantages of using Fibre Optic Communication*
1) High quality transmission
2) Not susceptible to noise, ground potential or EMI
3) Very high bandwidt
4) Immune to cross-talk (light radiated from neighbor cable do not Interfere
5) Secure (cannot be tapped)
6) Long life span

V. SOFTWARE

KSEB uses XA/21 version4.3.2 for its SCADA/EMS applications. XA/21 was chosen as GE quoted the lowest tender among the rest of its competitors in the tendering process. Some of its competitors are Toshiba's-TOSCAN-3500, Siemens'-WIN CC.

XA/21 is a field proven, scalable and feature-rich Supervisory Control and Data Acquisition (SCADA) / Energy Management System (EMS) solution that is specifically designed to meet the needs of electric utilities.

XA/21 has several features and advantages, which include

A. Presenting a consistent real-time view of the entire electrical network to operators.

Simultaneously the doctors can view the result in his pc with the help of web publishing tool in lab view. Similarly this feature can be enhanced with the additional GSM module so that patients can receive messages with the help of this module.

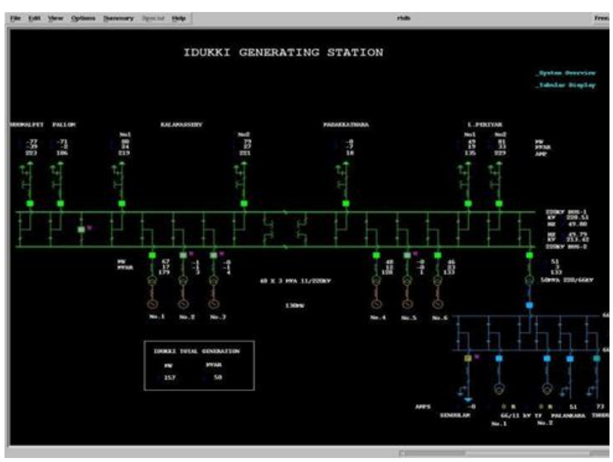

Fig4: Real time view Nance costs

B. Reducing costs of ownership, operating and maintenance.
C. Next generation Java™-based, full graphic user interface.
D. Facility add, modify or delete database entries online, without interruption of online operations.

User authentication, data/communication encryption, and file tampering detection.XA/21(ver 4.3.2), was no doubt, the best when introduced. But with the advancement in technology, i.e with the change in protocol, ver 4.3.2 becomes incapable. Some drawbacks are,

E. IEC 61850 communications have a refreshing rate of 2ms, while XA/21 refreshes in 4ms.
F. Serial communications become obsolete, as IEC 61850 would require faster packet data communication.
G. Modern peripheral equipment's become incompatible.
H. With the passage of time, the system becomes matured, making service and updating troublesome.

The improved versions of XA/21 are updated and fixed ones, that overcomes the mentioned drawbacks.GE has now introduced the 7th version of XA/21.

VI. SERVER

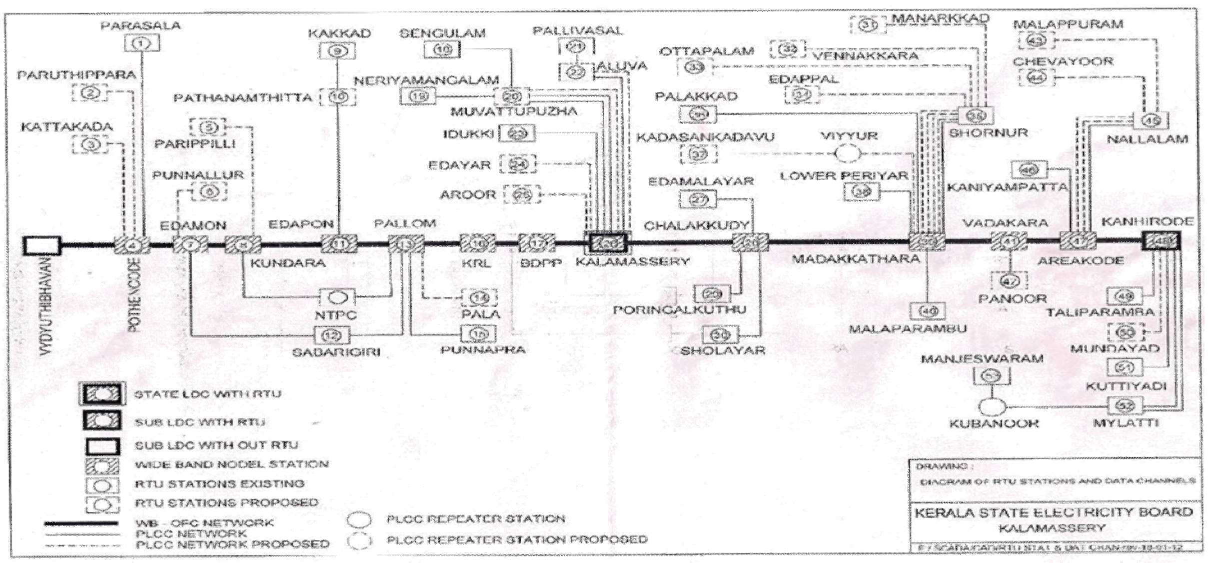

Fig5: Data Channel Routing of the EB

OPC Servers from Matrikon OPC provides connectivity to any IEC 61850 compliant RTU, IED (Intelligent Electronic Device), PLC, meter, transducer, relay, etc.

A. The OPC Server for IEC 61850 Supports

1) The ability to control remote device operations by performing Structured Writes to Control Blocks.XML technology for saving configuration files
2) Channel redundancy with multiple devices.
3) Multiple communication channels at the same time for IEC 61850 Ethernet access (TCP/IP).
4) Client-Server Architecture using MMS over TCP/IP.

RTUs are intelligent microprocessor based units which are used to monitor and control the operation of equipment at a remote site.

B. Certain essential requirements of an RTU are

1) Rugged construction to withstand extreme environmental condition
2) Multiple communication ports to keep the RTU online even whenever the primary communication fails
3) Watchdog timer to ensure equipment is back online after a power failure is resolved.

4) Provides accurate date/time stamping of COS alarms.

C. The Various Components of an RTU are

1) D20 processor
2) Status card
3) Control card
4) Analog card

Analog Input Card: This card is used to output analog data in form of electrical signals. The CPU communicates 12/16 bit digital values per AO channel to the AO card. The AO card then outputs these values as electrical signals after conversion using D/A converter. Digital Input card: This card is used to output analog data in form of electrical signals. The CPU communicates 12/16 bit digital values per AO channel to the AO card. The AO card then outputs these values as electrical signals after conversion using D/A converter. RTU communicates in the vertical direction, as per the communication protocol IEC 60870. But with the need for advanced reliability, there arises a need that RTU's communicate with each other. Thus in order to enhance reliability and intelligence, an IED is used. IED's are capable of communicating in the horizontal direction thus enabling exchange of data from one IED directly to another. This feature is useful for example for station interlocking' between different bays or for complex distributed functions that demand a coordinated action of different IEDs.

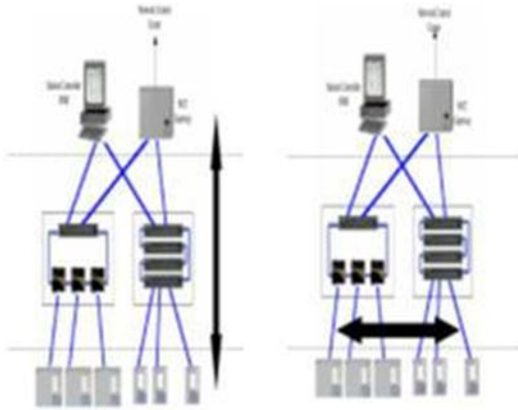

Fig 6: Horizontal & Vertical communication

VII. CONCLUSION

The introduction of the standard IEC 61850 to the SA systems is a positive measure. The standard does not impose restrictive rules over many aspects because of which there is still a large functional freedom for each vendor to explore. It's a future-proof solution as it takes into consideration the progress of technology and is able to follow it. As it implements interoperability advantage, it is no doubt the technology to substation automation. Thus SCADA systems built with the latest RTU technologies can deliver the optimal reliability, efficiency, and cost-effectiveness that today's complex infrastructure and industrial processes require.

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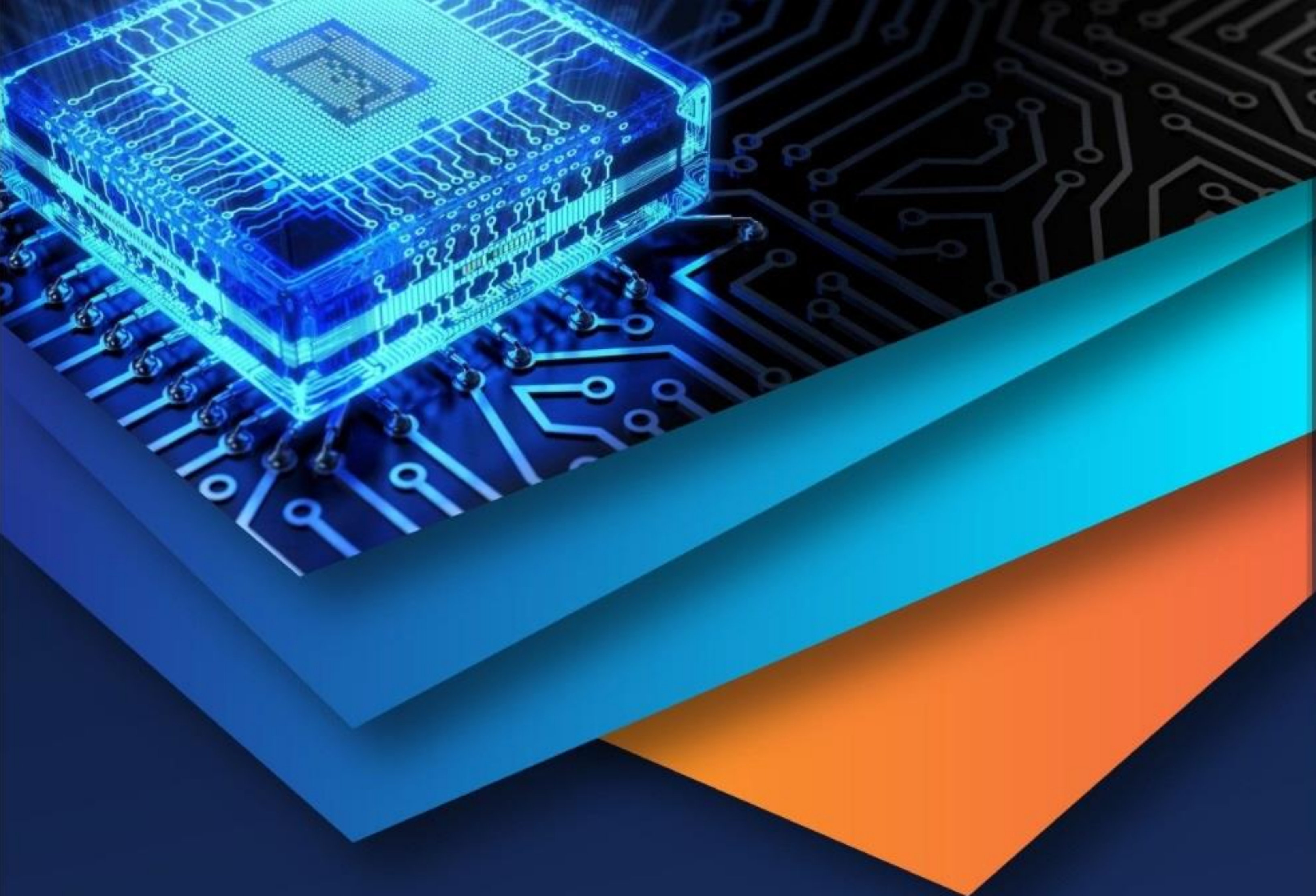

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