http:d2cigre.org

CONSEIL INTERNATIONAL DES GRANDS RÉSEAUX ÉLECTRIQUES
INTERNATIONAL COUNCIL ON LARGE ELECTRIC SYSTEMS

STUDY COMMITTEE D2
INFORMATION SYSTEMS AND TELECOMMUNICATION

2013 Colloquium
November 13-15, 2013
Mysore – KARNATAKA - INDIA

D2-01_01

Communication System for Smart Transmission

by

N.S.Sodha, H.H.Sharan, Sheela Rani*

Power Grid Corporation of India Limited

(IN)

SUMMARY

Indian Power System is expanding at a very fast pace and with increased number of inter-connections between Regions, many new technologies are being implemented. In addition, Indian Grid is characterized by wide variation of Power flow due to variation in demand / generation during day / seasons. Further, consumer aspiration for quality and reliable power supply is increasing. The increasing complexity of Grid operation manifold, necessitates dynamic monitoring of Grid parameters / conditions on real-time basis. To meet the same, emerging technologies like Phasor Measurement Unit (PMU), Wide Area Measurement System (WAMS) which provides dynamic monitoring of network on real time basis are being implemented. Such monitoring shall facilitate development of various control, regulation and preventive features like Remedial Action Schemes (RAS), System Integrated Protection Scheme (SIPS), Adaptive islanding, Self-healing Grid etc. As Indian Economy pushes targets a 10 percent annual GDP growth rate, unprecedented growth of Indian Power System is being witnessed with commissioning of advanced technologies like UHVAC, HVDC, WAMS, FACTS etc. System Operator is now equipped with numerous controls for better Grid Management. Such phenomenal transformation in the Indian Power Sector requires robust communication system. These emerging technologies are all bandwidth intensive and would require communication system having reliability, availability and security of the highest order and least latency.

It may be mentioned that under POWERGRID's Unified Load Dispatch & Communication (ULDC) projects, approximately 9500kms of overhead fibre optic cable network mainly OPGW was established on regional basis for providing advanced EMS/SCADA and Communication System for Management of Regional Power Grids. These ULDC Projects were commissioned progressively from July 2002 to February 2006 in Southern, Northern, North-Eastern, Eastern & Western regions. It is worth mentioning here that these OPGW based fibre optic links are working satisfactorily till date and no disruption of wideband communication connectivity has been reported so far. Communication equipment based on SDH & PDH technology was commissioned as part of Fibre Optic Communication connectivity. Our past experience shows

* LD&C Department, Corporate Centre
Saudamini, Plot No. 2, Sector-29
Gurgaon 122001 (HARYANA)
Fax: + 91 11 0124 2571981 e-mail: sheela@powergridindia.com

that OPGW based wideband communication network is most reliable form of communication media due to least amount of down time and would be most suitable for such applications.

Subsequent to commissioning of ULDC Schemes, several EHV substations have been added or planned to be added in the network due to government emphasis for accelerated development of the power sector and addition of generating capacity through Ultra Mega Power Projects (UMPP), IPPs and Public Sector companies. The new substations shall be integrated to the SCADA system of regional ULDC project. Therefore, in order to provide reliable and efficient communication network to the fast growing power system network, existing FO Communication Network is being expanded to cater for providing wideband connectivity. Therefore, an expansion of OPGW based Communication System is being considered essential to meet the power system communication requirements. POWERGRID is installing more than 50,000kms of OPGW in next 2-3 years on EHV transmission lines spread through out the country for meeting the growing communication bandwidth demand.

This paper shall aim to discuss the need of robust communication network for the smart transmission. It shall also discuss, POWERGRID's plan, its experience with OPGW based communication network, and suitability of communication network based on SDH & PDH technology for meeting communication bandwidth requirement for the emerging technologies and other power system need.

KEYWORDS

Power Line Carrier Communication(PLCC), Optical Ground Wire (OPGW), Synchronous Digital Hierarchy (SDH), Supervisory Control & Data Acquisition System(SCADA), Energy Management System (EMS), Phasor Measurement Unit(PMU), Wide Area Monitoring System(WAMS), Unified Load Despatch & Communication(ULDC), Electric Power Utility(EPU). RLDC, Central Transmission Utility (CTU), State Transmission Utilities (STUs), Independent Power Producers(IPPs), Load Dispatch & Communication (LDC);

BACKGROUND

POWERGRID, the CTU in India, owns & operates a large EHV transmission network of about 71,500 circuit kms of EHVAC & HVDC system and wheels about 45% of total power generated in the country. STUs, CTUs, Central/State Generation utilities and IPPs; all combined together form the Regional Power System. There are five regions namely Northern, Southern, Eastern, Western and North- Eastern Regions covering PAN Indian Power System with diverse geographical, environmental & demographic conditions.

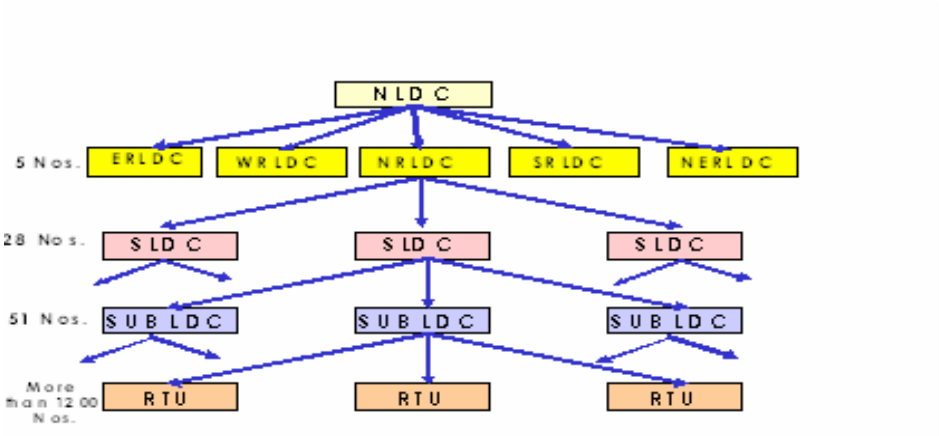
To meet the challenging task of operating such a large power system with security, economy and reliability, POWERGRID has established state of the art Load Dispatch & Communication (LDC) facilities using the concept of ULDC Schemes. The implementation of these Schemes

has considerably improved the operational reliability and reduced the number and impact of Grid disturbances.

Prior to implementation of the ULDC schemes, the EPU were mostly dependent on PLCC & leased lines due to which power utilities were finding it difficult to manage the grid in proper manner.

ULDC schemes were established on regional basis for providing advanced EMS/SCADA and Communication System for Management of Regional Power Grids. These ULDC Projects were commissioned progressively from July 2002 to February 2006 in Southern, Northern, North-Eastern, Eastern & Western regions.

The ULDC Schemes involved implementation of SCADA/EMS Systems and dedicated communication at all three levels of hierarchy of Regional System as shown below. The ULDC project established hierarchical telemetry/SCADA/EMS system which includes Regional Load Despatch centers (RLDC), State Load Despatch Centers(SLDCs), Sub Load Despatch Centers(Sub-LDC) & Remote Terminal Units (RTUs). The RTUs were installed for capturing the power system parameters i.e. voltage, frequency, MW, MVAR etc. and data from these RTU stations to Sub-LDC/SLDC/RLDC were transmitted in a real time manner using the dedicated communication system.



COMMUNICATION SYSTEM IMPLEMENTED UNDER ULDC PROJECT

Wide Band Communication systems consisting of Digital Microwave Radio and Fibre Optic System were established under the ULDC scheme. The Microwaves system provides maximum of 8mbps band width whereas fiber based communication network can provide any amount of bandwidth depending upon the terminal equipment installed on the substation and power plants. Presently, SDH system with STM-1 bit rate was installed. Power Line Carrier Communication (PLCC) is being used to transfer data from RTU locations to the nearest wideband/control centre locations. This is first time that the wide Band communication for operation of power system was established on large scale in a planned way.

It may be mentioned that at the time ULDC scheme was conceived, the cost of establishing Fibre Optic and Microwave Communication was exorbitant therefore, wideband connectivity was planned mainly between Centre Centres and only few substations under central sector have been provided with wide band connectivity.

The SCADA/EMS system and wideband communication system established under ULDC Projects are as detailed below:

Sl. No.	ULDC Scheme	Control Centres	Fibre Optics (in Kms)	MW Hops (in Kms)
1	NR	33	2142	78
2	SR	15	2324	35
3	NER	8	903	12
4	ER	11	1453	40
5	WR	11	2561	0

The communication channels from all these systems have been integrated/interconnected to make a hybrid communication system.

A brief overview of various communication system deployed under ULDC is described below:

PLCC SYSTEM

Under ULDC scheme, PLCC system has been implemented for providing communication connectivity from RTUs up to Sub-LDCs. The main considerations for using PLCC were low data requirement between RTU & Sub-LDC, low cost, availability of systems in India and extensive experience on the system with in the EPU. Single channel PLCC equipment where data is superimposed over speech channel is used.

However, these system have limitation which include low capacity, low performance in long connections consisting of several hops and limited frequencies. Inspite of these problems, PLCC system are still the most preferred means where data traffic is low. Further, PLCC system has been extensively used by the EPUs for several decades and has gained reputation for its robustness and reliability for communication purposes. PLC system satisfies the EPU needs on Telecommunication facilities for speech and data such as telemetering, telecontrol and protection signalling.

DIGITAL MICROWAVE (DMW) COMMUNICATION SYSTEM

In order to provide a techno economical solution, a mix of DMW and Fibre Optic links were planned between control centres under ULDC scheme.

Digital Microwave Communication Systems were implemented for providing connectivity between control centres where data traffic is high. Microwave links were designed using frequency band between 2.3 GHz to 2.5 GHz allocated to Power Sector. This frequency band has been withdrawn by Ministry of Communication now.

As the system requires clear 'line-of-sight' for design of communication system, the antennas are mounted on high towers so that even trees should not obstruct path of microwaves. Tower heights at microwave stations ranged from 30 to 110 meters. These digital microwave systems were designed on hot standby mode with or without space diversity. Some links, which are suspected for excessive fading during propagation of signal, have been provided with additional antennas for 'space diversity'.

These systems has centralised management system which has got many useful features for easy maintenance. The 'Network Management System' (NMS) helps in remote diagnosis, operation and maintenance from a centralized location.

Radio links are widely used to provide power system communication services. The merits of these systems include independence from power line and low cost compare to cable system. However, there are fundamental problems in initial planning of radio links. These include obtaining suitable frequency assignment, line of sight requirement, susceptible to fading.

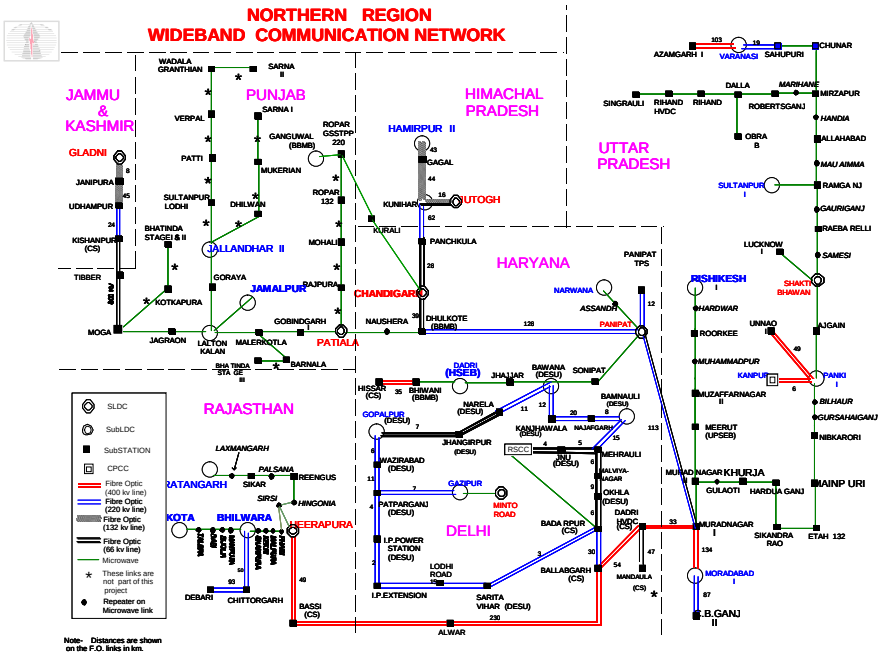
FIBRE OPTIC COMMUNICATION SYSTEM

Mostly OPGW based Fibre Optic communication Systems was implemented under ULDC scheme. The fibre optic cable was installed mostly in live line condition. Terminal Equipment based on SDH (STM-1, 155mbps bit rate) technology was installed. In general, repeater less Fibre Optic Links was designed for distances up to 150kms.

POWERGRID has installed approximately 10000 kms of OPGW under the ULDC scheme. Protected links using 4 fibres has been implemented in linear sections of the network. In case of ring network, protection has been implemented with two fibres.

A Centralised NMS system feature provide (1) Configuration Management (2) Fault Management (3Performance Management (4) Security Management.

These features of the NMS help the maintenance staff in immediate identification of faults and isolate the failed element down to the card level. It also does the event based analysis based upon the alarms generated. Configuration management helps in establishing and changing topologies and providing alternate routes for important services. While the performance permits monitoring the health of equipment, setting of alarm threshold.



Aerial Fibre optic cables are most suitable in Power Sector applications, since the ROW is readily available. Among aerial fibre optic cables, OPGW is best suited as it is a composite wire which serves as a conventional overhead ground wire, with the added benefit of providing safety to the fibres & free from EMI & RFI and no additional load on the towers.

COMMUNICATION REQUIREMENT DUE TO ADOPTION OF NEW TECHNOLOGIES IN POWER SECTOR

Power System in the country is expanding very fast and with increased number of interconnections between Regions, many new technologies are being implemented. The new requirement necessitates real time monitoring of grid parameter/condition as the grid is characterized by wide variation of power flow due to variation in demand / generation during day / seasons. Further, consumer aspiration for quality and reliable power supply is increasing. The existing SCADA/EMS provides the data which are steady state in nature and not suitable for dynamic monitoring and control for the Grid due to high degree of latency of tele-metered data and also non-synchronization of sampling of data.

Emerging technologies like Phasor Measurement Unit (PMU), Wide Area Measurement (WAM) system which provide dynamic monitoring of network on real time basis are being implemented. Dynamic Monitoring through the said measurements shall facilitate development of various control, regulation and preventive features like Remedial Action Schemes (RAS), System Integrated Protection Scheme (SIPS), Adaptive islanding, Self-healing Grid etc. These emerging technologies would require communication system with least latency & more reliability. POWERGRID has taken initiatives for implementation of Smart Grid projects using WAMS (Wide Area Measurement System) and PMUs in transmission level on a pilot basis. Such two projects have been implemented in the Northern & Western Region of India. In these projects, Under these project, PDCs has been installed at Regional Control Centre and the data

from a number of PMUs shall be utilised for better visualisation and situational awareness. The PMU data shall be further used for Analytical functions such as State Estimator based on PMU data.

Getting real time data of various power system elements i.e. substations, generating plants, HVDC links, Interstate transmission lines etc. has become an essential prerequisite for successful operation of modern power system.

With the restructuring & liberalization of power sector and the advent of new regulations, open access, power exchange etc reliable voice & data communication has become critically important. There is a need for a comprehensive institutional mechanism regarding planning, implementation, up-gradation, operation & maintenance, resource & cost sharing of a high capacity, fast & reliable communication system for power sector.

The development of new technology has provided the opportunity to deploy more and more IT based automation tools for operation of the power system in more efficient manner. All this requires very large band width and least possible transmission time between the nodes exchanging the information. These stringent requirements cannot be accommodated in the PLCC because of the limitations elaborated above.

POWERGRID PLAN TO MEET COMMUNICATION SYSTEM NEEDS

To meet the need of effective & efficient communication system, POWERGRID is implementing OPGW based Communication System under various project such as Microwave Replacement Project (MRP), Fibre Optic Expansion Projects (FEP) and other projects namely HVDC & Consultancy assignments. Around 33500 Kms OPGW network is envisaged for implementation under these projects which have been already awarded. Further, around 62500 Kms OPGW network is envisaged for implementation under different projects involving various Consultancy Projects and Grid Management Projects namely Unified Real Time Dynamic State Measurement (URTDSM) and Grid Security Expert System (GSES). In total, around 96000 Kms OPGW network shall be implemented to meet the requirement.

The existing communication network is based on traditional time-division multiplexing (TDM) with STM-1 (155mbps) bit rate. As part of expansion, the network with minimum bit rate 622mbps is under implementation. The OLTE equipment shall have provision for both E1 & Ethernet interfaces. These equipments shall have equipment protection as well as path protection.

POWERGRID EXPERIENCE ON VARIOUS COMMUNICATION MEDIA

Past experience shows that Fibre optics installed on overhead power lines is the most reliable form of communication medium due to least amount of down time. Hence, POWERGRID is expanding its existing Fibre Optic Communication System to meet the power system communication requirements. OPGW based communication system would be most suitable for

the meeting the communication system requirement of Power Utility. The proposed FO network would be used for such upcoming advanced technologies also.

NETWORK FOR FUTURE

Communications for Smart Grid & SCADA data transport require that utilities address both the backbone and the spur links. Most of the communications network established is generally based on traditional time-division multiplexing (TDM) digital architectures. TDM technology, being highly reliable, was originally developed for the transport of point-to-point constant bit-rate voice communications and is not necessarily suited to cost-effective transport of point-to-multipoint "bursty" data traffic required in an IP environment. The Smart Grid will require that these backbones be upgraded to backhaul Ethernet/IP data traffic at speeds ranging from one to 10 gigabits per second in a highly reliable manner.

CONCLUSION

The introduction of "smart grid" solutions and other application imposes that cyber security and power system communication systems must be dealt with extensively. These parts together are essential for proper electricity transmission, where the information infrastructure is critical. Based on the previous experience, OPGW based communication network is best suited for meeting the communication requirement of Power System. However, in spite of the growing significance of digital communication systems, PLCC will remain in many cases as it is the most cost effective solution to cover the operational needs of a power system. This applies particularly when only low volumes of data have to be transmitted over long distances. Under National Optical Fibre Network (NOFN)project which aim to connect all 250,000 Gram Panchayats (GP) in the country to form a seamless network providing broadband bandwidth pipe of 100 Mbps to a nodal GP location (GP NODE), utilizing the existing optical fibre network of various Telcos and incrementally providing additional optical fibre cable to each GP NODE tapped off from the nearest available Junction Optical Joint Manhole (JMH) or Point Of Presence (POP), POWERGRID is implementing around 75000kms of OFC network which can further be utilised for smart grid implementation purpose.