Dynamic Real Time National Power Grid Control using Optical Fiber composite overhead Ground Wire (OPGW)

B. Ram
Rajasthan Rajya Vidyut Prasran Nigam Ltd.
Jodhpur (Raj.) India

M.K. Gaur
Rajasthan Rajya Vidyut Prasran Nigam Ltd.,
Merta City (Raj.) India

ABSTRACT
The power sector in India is expanding rapidly to achieve the goal of "Electricity for all by 2012". Due to additions of new generating plants, grid stations and sub-stations, the complexity of the power system has increased. A national power grid in any country is basically a high – voltage electric power transmission Network to connect power generating stations and major sub stations. Such grid ensure that electricity generated anywhere within the country can be used to satisfy demand elsewhere.

The saving of electric power is equal to the generation of electricity, this encourage use of advance technology for reducing transmission losses. Hierarchical load dispatching systems are employed to monitor, supervise and control the power grid in effective and efficient manner.

To perform the load dispatch function efficiently, on-line acquisition of power system data and its real time processing is required. A Computer Based Supervisory Control And Data Acquisition (SCADA) system with Intelligent Electronics Devices (IED) and OPGW as communication link associated with Energy Management System is a prime requirement of National Power Grid.

This paper presents the application of OPGW as a transmission media for modern SCADA in power sector to achieve dynamic real time control yielding power saving.

Keywords: IED,EMS,SCADA,OPGW

1. INTRODUCTION
India has a large complicated electric power system of generation having capacity about 170.2GW. Central Govt. undertakings generates 52.7 GW, while various states govt. undertaking generates 82.2GW. The private sector companies generate 35.3GW.

The Indian Power Grid is expanding at a fast pace to achieve its goal of "Electricity for all by 2012". There is an ambition of adding 78.7GW capacity during the 11th 5 year plan by the central and state utilities together. In order to achieve this goal, regional grids of Indian Power System are being connected synchronously to help in seamless transfer of power from one region to another.

India is thickly populated, tropically diversified and has heterogeneous geography. Power system of India has been divided in five regional grids namely North, West, East, North-east and South region. First four of the above five regional electricity grids are operating in a synchronous mode since 25th August 2006 and the interconnection is called the "NEW GRID". The southern Regional Grid is presently connected to the "NEW GRID" through several High Voltage Direct Current (HVDC) asynchronous ties and a few AC lines in radial mode [3].

In India such load dispatch has been divided in five regions of grids i.e. regional load dispatch centers (RLDC). They are currently owned, operated and maintained by central govt. owned company (Power Grid Corporation of India Ltd). It is the central transmission utility (CTU) of the country. State of Rajasthan falls under the North Region Load Dispatch Centre (NRLDC). The current overall generation capacity of NRLDC is 45.5 GW and state owned Rajasthan Rajya Vidyut Prasran Nigam Ltd. (RRVPNL) contributes 8.5GW to NRLDC.

Such a widely spread grid require wide area monitoring for efficient control. To meet this objective, a modern SCADA system employ a computerized SCADA master in which the remote information is either displayed on an operator's computer terminal or made available to a large Energy Management System (EMS) through network connections. The basis of monitoring is data collection from every sub-station under a grid.

Each such sub-station has a remote terminal unit (RTU) either hardwired to digital, analog and central points. It frequently acts as a sub-master or data concentrator. It connect various Intelligent Electronic Devices (IEDs) installed at the sub-station, and transfer their status/data using communication links.

Most of the existing interfaces in these systems are proprietary in nature, although in recent years standards-based communications protocols to the RTUs have also been incorporated to certain extent.

Till today, the power sector still relies upon Power Line Carrier Communication (PLCC) technology for transfer of data through the power transmission lines. The frequency spectrum allotted to the power sector for PLCC communication is already saturated and frequency crunch is being experienced in getting new/additional frequencies for new transmission lines. Besides PLCC equipment supports a very low data rate due to its narrow band of 4kHz [1,2]. Under this 4kHz all speech, data and protection control signals are to be accommodated. Thus it permits merely up to a maximum of 1200 baud in ideal case but only up to 200 baud in practical cases for data transmission. Transferring larger amount of data collected from ever increasing grid substations, has already stretched the PLCC channels to their full capacity. PLCC channels working merely @200 bauds require larger amount of time to make data reach the controlling computers, creating a bottle neck for effective control over the grid. It necessitates development of an alternative communication link for the Indian Power Sector. A composition of Optical fiber with power ground wire is able to fulfill this need. Such a technique is known as Optical Power Ground Wire (OPGW).

Using OPGW, the power grid controller can receive data @ Mb/Sec to Tb/Sec, achieving a speedup by a huge factor, for handling large data for supervisory and protection control requirement of modern SCADA.

2. INTELLIGENT ELECTRONIC DEVICE

An intelligent electronic device (IED) is a term used in the electric power industry/ utility to describe microprocessor-based controllers of power system equipment, such as circuit breakers, transformers and capacitors banks.

IED receive data from sensors and power equipment, and can issue control commands, such as tripping circuit breakers if they sense voltage, current, or frequency anomalies or raise/lower voltage levels in order to maintain the desired level, Common types of IED include protective relaying device, load tap changer controllers, circuit breaker controllers, capacitor bank switches, recloser controllers, voltage regulators, etc. Digital protective relays are primarily IEDs, using microprocessor to perform several protective, control, and similar functions. A typical IED can contain around 5-12 protection functions, 5-8 control functions controlling separate devices, an auto reclose function, self monitoring function, communication functions etc. Hence they are called Intelligent Electronic Devices. Some recent IEDs [8] are designed to support the IEC61850 standard for sub station automation, which provides interoperability and advanced communications capabilities.

3. SCADA & ENERGY MANAGEMENT SYSTEMS (EMS) FOR POWER SECTOR

For decades, traditional SCADA measurement [5] have been providing information on bus voltages, line, generator and transformer flows (MW, MVAR and Ampers), transformer taps and breaker status as well as other system parameters viz, frequency and weather data. These measurements are typically taken once every 4 or 10 seconds offering a steady state view of the power system behavior. However for monitoring and control of present times large grid, only steady state information may not be sufficient. Currently, a pilot project has been implemented in Northern Region (NR) based on a technique called synchrophasor measurement [4] to gain firsthand experience in use of this technology for monitoring and control of large power grids. Use of synchrophasor measurement, facilitates better supervisory controls, optimizes and managements of generation and transmission of larger complicated and ever increasing demand and supply of Indian Power System network. It will provide for better utilization of the power grid system, as the behavior of the system can be dynamically predicted and controlled. Such an implementation will facilitate achieving even better Energy Management System such that Transmission and Distribution (T&D) losses could be reduced. It has been initially estimated that such a reduction shall be of the order of almost 25% [8,9].

The back bone of a sound EMS is an efficient SCADA system. However it is the underlying communication system that makes a SCADA perform in real time.

For power sector, an efficient SCADA means quick collection of data from various field devices and other data processing units. The EMS on the basis of this information, system creates and provides various type of pre-defined, customized reports and user – friendly screen shots to the dispatcher for smooth and disciplined real time power system operation.

4. OPGW COMMUNICATION

The National Power Grid of India has been divided in five Regions to provide efficient Energy Management System in real-time. It can be achieved only with on-line data collection and processing. Thus an intelligent SCADA along with high speed telecommunication facilities at every state, becomes the strongest need for central EMS.
To handle large data with the adoption of IED and IT based SCADA/EMS for the Power System in India requires a switch over to the advance telecommunication technology such as optical fiber communication system.

Use of fiber optic based communication offers availability of phenomenal bandwidth. Not only this, it also offers low attenuation and capable of covering large distances with higher transmission rates. Currently the OPGW of single mode fiber type has experimentally established that almost 400 kms distance can be covered without repeater for transferring the status of various data measurements and protection control signals and other parameters to the SCADA. Such OPGW makes use of optical signals of 1310 to 1550 nanometer (nm) wave length in 6-12-24-...-144 core.

5. OPERATION OF AN OPGW BASED SYSTEM

OPGW is a composite type of cable, used for the construction of electric power transmission and distribution lines. Such cable performs two functions i.e. it provides a Ground wire and also a communication link for the transmission of voice, video or data by incorporating optic fibers within power cable. OPGW fiber cables shall replace conventional ground wire of old power lines with increase in the communication capacity due to optical fiber. Fig. 1 depicts the cross section view of an OPGW cable. It has a tubular structure with one or more single mode optical fiber inside surrounded by layers of steel and aluminum wire.

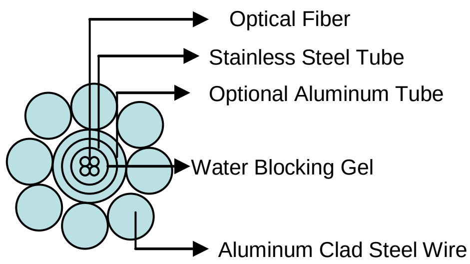

Fig. 1 : Central loose Tube Type OPGW

Overhead optical fiber systems shall be able to play the key role in telecommunication facility for power sector networks. In addition it offers a distinct advantage that no civil works are required for its installation. It can be installed along existing power transmission lines straight way. Thus it is possible to minimize costs and most importantly, the time required to begin network operation.

Since the various state electricity boards across the entire country have already dedicated transmission lines crossing the entire states i.e. interstate connectivity is also achieved.

The earth wire (a galvanized steel wire which is run on the peak of transmission lines) is replaced with a OPGW (composite optical power Ground Wire) which serves the purpose of acting as earth wire and has an embedded stainless steel tube which carry a bunch of fibers to serve or communications. The transmission line terminates at receiving stations or generating stations and these locations the OPGW is terminated and the fiber carried to special equipments called Optical Line Terminal Equipments (OLTE). These OLTE are similar as used in telecom companies and carry signals in the SDH format (An international telecom standard accepted across globe). The installation of OPGW is similar to earth wire, with the exception that mid-span compression joints are not possible with OPGW. Jointing /splicing are done usually at tension towers and with suitable modification at the suspension towers. Although some extra length is needed it is convenient to do the splicing at the ground level. The jointing box is normally placed on the tower above the anti-climbing device. As the OPGW cannot be subjected to any radial compression, performed type fittings are used in tension towers and armoured grip suspension clamps are used in suspension towers. The special core is necessary during installation as the twisting/rotation of cable may strain the fibers.

The signals from telephone exchanges or computer network such as Ethernet or data from RTU (Remote Terminal Unit) or connected to the SDH gate way through specialized equipment called primary multiplexer at the sending end. At the receiving end these are again "dropped" out of SDH gateway through another set of similar equipment and connected to the exchange or ethernet. Providing this OPGW over existing comparable communication links of Electricity board achieve increase band width at a low investment with increased automation being taken in terms of computerization of billing and collection, accessing their main load center points.

6. FUTURE TRENDS

It is envisaged that Remote Terminal Units (RTUs) installed at different generating stations, EHV sub stations acquire analog (MW, MVR etc) and digital (Breaker & Isolator) data from field devices and send it to SCADA system as and when interrogated by SCADA. The digital data collected shall be given highest priority and its information transmitted to the SCADA system in immediate next cycle of interrogation in a short span of time. All RTUs are equipped with dual redundant communication ports to avoid data interruption and are connected with SCADA system through PLCC/OPGW network.

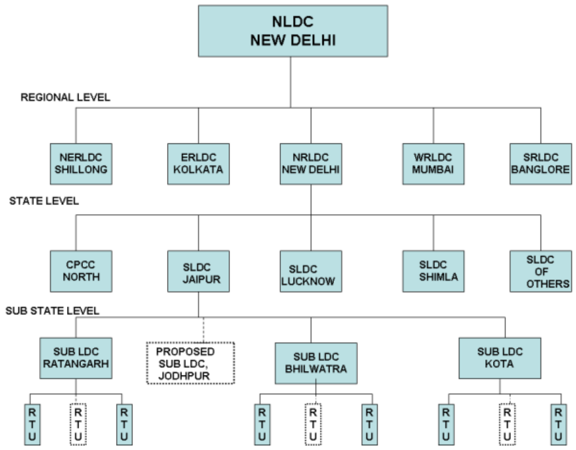

Fig. 2 : Projected OPGW system across Power Grid in India

Technological progress is expected to increase the requirement of power sector to include more services to be utilized along with the OPGW as communication. The internet facilities may be through this network can be utilized by the Indian Power Sector for their IMIS utilities.

7. CONCLUSION

With the advent of OPGW, the power sector SCADA can focus on gathering and circulating the right amount of system information to the right person or computer within the right amount of time. It will create solutions to fight or avoid blackouts. It will provide an information highway for power sector to achieve surplus electricity utilization quickly and orderly. An intelligent EMS shall be able to function well only when it makes use of combination of technologies i.e. IEDs, IT based SCADA along with the optical fiber communication for the transfer of data at fast rate. By use of OPGW, the power utilities can manage the operation of the large power grid more efficiently and save power losses. OPGW can also earn extra revenue by leasing out spare capacity to other agencies for their communication purposes. It can be concluded clearly that OPGW technique is best suited for the Indian Power Sector to achieve dynamic real time control over the grid.

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