International Journal of Trend in Scientific Research and Development (IJTSRD)
International Open Access Journal
ISSN No: 2456 - 6470 | www.ijtsrd.com | Volume - 2 | Issue – 3

A Review on Substation Monitoring and control technologies and Problems

Amba Lal Mathur
Associate Professor, Department of Electrical Engineering, Poornima College of Engineering, Sitapura, Jaipur, Rajasthan, India

Dr. Deepika Chauhan
Associate Professor, Department of Electrical Engineering, Poornima College of Engineering, Sitapura, Jaipur, Rajasthan, India

Yogendra Singh
Final Year Student, Department of Electrical Engineering, Poornima College of Engineering, Sitapura, Jaipur, Rajasthan, India

ABSTRACT

The paper present review on various substation monitoring and control technologies to convert conventional substations into smart substation, This includes automated monitoring and control using PLC and SCADA system , microcontrollers based monitoring and control system, cloud computing and Intelligent electronics devices(IEDs) monitoring ,control and protection system for substations. Further, this paper also includes the recent advancement in substation automation which includes the new standard proposed by International Electro-technical commission(IEC) which is IEC-61850 for communication system in substations which primarily used to eliminate the problem of interoperability between IEDs supplied by different vendors. It also describe various issues related with various monitoring and control technologies in substation. smart substation is the principal foundation and support of smart grid and hence this paper includes several technologies and issues of converting a conventional substation into smart substation.

Keywords: *Substation monitoring and control, Cloud computing, Microcontroller, PLC, SCADA, IEC 61850*

I. INTRODUCTION

Electrical power system is one of the most complex man-made networks in the world. In India, Power demand is increasing at very fast rate with increase in population, industrialization and technological advancements. The conventional sources of power generation are depleting day by day, there is scarcity of trained manpower as compared to demand , So to deal with this situation we have only one option- we have to operate our existing system with utmost security and optimization, and economically as much as possible. Hence, To do this, substation automation is the best way.

Substation automation is a technology by which we can monitor and control all the components and equipments installed in the substation from a remote place. Various technologies are used for automating the substations like we can use the programmable logical controllers for the control operation in the substation and we can easily locate the faults in the substations. SCADA software is used for the real time monitoring of the substation. So we can remotely supervise and control the substation without going into the field. Also we can use a new concept for monitoring of substations that is cloud computing. By using cloud computing consumer can enter to their applications at any time with the help of a connected device to the system. Cloud computing has vast application in the power system which increase reliability, efficiency and security of the system.

We also can use microcontroller based system for a distribution transformer which is installed in substation that is used for monitoring the voltage,

current, temperature of transformer and protect the system from rise in these mentioned parameters.

In this era of automation, Electric power utilities are facing problem of interoperability among Intelligent Electronic devices(IEDs) which are supplied by different companies during the expansion of an existing electric substation. In this context International Electro-technical commission (IEC) has proposed a new standard that is IEC-61850 . So this paper review all these technologies, their merits, functions and also comprises the implementation issues, cyber security of smart substation and various restrictions in substation automation.

II. TECHNOLOGIES

A. Substation monitoring and control using SCADA system

This system uses 'Supervisory control and data acquisition' (SCADA)software to monitor various electrical parameters of electrical substation .In Remote terminal unit(RTU) automated substation, the power equipment, their communication and computers are interdependent ,means they are dependent on each other. The data from substation equipment is communicated with the SCADA systems with the help of RTU. The main advantage of using SCADA system is that monitoring and controlling can be done easily and it reduce the human labor because we can monitor the whole substation on a single computer screen (in SCADA software). The real time parameters which are monitored through SCADA are currents, voltages, pressures, temperatures etc. This supervision done with the help of digital equipment and sensors which are installed in the substation. First the data is collected from the sensors and then processing is done at data acquisition and control unit. Then by using a suitable communication method , this data is send to the main computer which is at control center. After that this data is send to main head office from where remote supervision is done. [1]

Hence SCADA system is very advance technology in the field of industrial automation and it has vast application in the power system automation. At the substations , the complete overview of the field can be seen over SCADA system and we can monitor and control the various equipments from the control center itself. Thus it increases the reliability, efficiency of the grid and reduces the human labor.

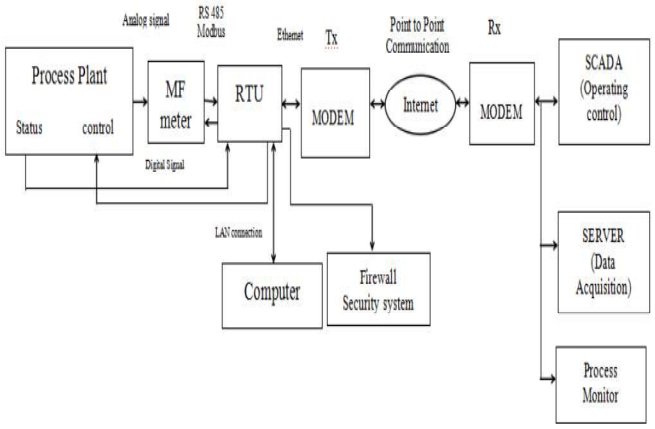

Fig.1: Block diagram of substation monitoring using SCADA System [1]

B. Substation monitoring using microcontroller based system

In the substations, Distribution transformers may subjected to damage due to the increase in the temperature of oil filled in its tank. Due to overloading or when high current flows through the transformer winding, high heat is generated which increase the oil temperature. Hence transformer may be highly damaged. As transformer is very costly unit, we should give high priority to transformer monitoring to avoid such situations. In the following scheme, a microcontroller based system is connected with the distribution transformer for monitoring. [2].

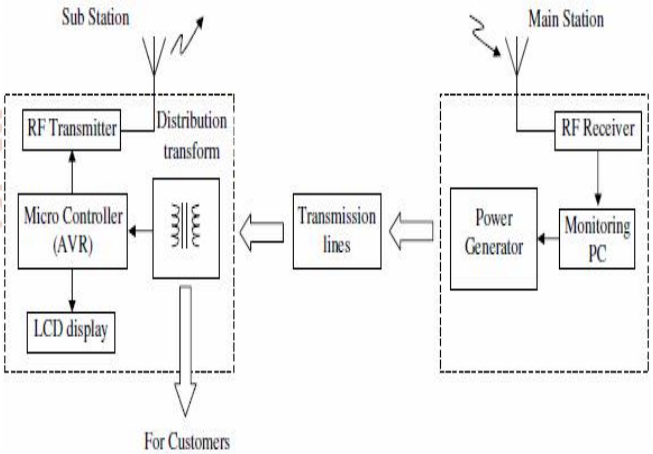

Fig. 2: Substation monitoring using microcontroller based system [2]

The monitoring and control system using microcontroller is shown in the fig-2. There are two stations are shown in the figure, one is power generating station and another one is distribution substation. Distribution substation contains the

monitoring unit. This monitoring unit consists of an AVR microcontroller which is interfaced with RF transmitter and other sensors installed in the substation. The various parameters like voltage, currents, temp. etc. are given to the input port of AVR (say port A). A LCD screen is connected to the second input port of AVR (say port B) for display operation. The RF transmitter is then connected to the output port of AVR (say port C). The computer which monitor all these parameters is situated in the main power generating station. At substation, AVR monitors all parameters and record them for a specific time period that is predefined in its programming. It stores the values in its register and display these on LCD screen.

Now, these monitored values are transmitted through RF transmitter module for every specific time period. We can use any antenna according to our application. At the receiving station , another receiver antenna converts these RF signals into electrical signals and obtain the information. On the basis of this, controlling operation is done. If the received values are largely deviated from the predefined levels, then immediately the unit is shutdown and hence protected. Also the power generation can be controlled through the data [2].

Thus the microcontroller based system used for monitoring as well as controlling of distribution transformer . Since distribution transformer is an crucial and costly part of the substation and this system is monitoring it, hence this system contributes to make the substation automated**.**

C. Monitoring of substation using cloud computing

Security is one of very important case to secure the privacy of any field. Cyber security, data outage, threat detection are various issues which are required to be prevented. For customer motivation proper privacy policy should need to keep secure at their end. For fulfillments of all the above mentioned terms, cloud computing is very useful technology in recent development of grid. It consists of following properties [3] :-

1) By actual time monitoring and controlling of various electrical parameters, it optimize the cost .

2) According to the energy usages at consumers end they can make payment by using some specific applications or software.

3) Most of the power is generated through the thermal power plants, so carbon emissions is very serious issue for our environment. So, cloud computing may lead to control this problem through inclusion of hydro, solar and wind power generating stations as cloud will be a better source to keep your data safe and observe your parameters if someone install any kind of renewable energy power plant. They will not depend on the conventional grid for their data.

4) There is a proper balance of power demand and supply. This is done by accessing the data to the customer utility side.

5) With the help of cloud computing, customers can view their daily consumption anytime. So they get motivated to save energy if they found they are wasting it.

Cloud computation is a cutting edge technology for grid which provides a computation model that will prevent on demand model and also store various records which can be seen anytime at the connecting device . Cloud use the data taken by the various smart meters in grid. Cloud computing includes following properties [3]:

(1) On-demand function

(2) Broad network access

(3) Rapid elasticity

(4) Resource pooling

(5) Measuring devise

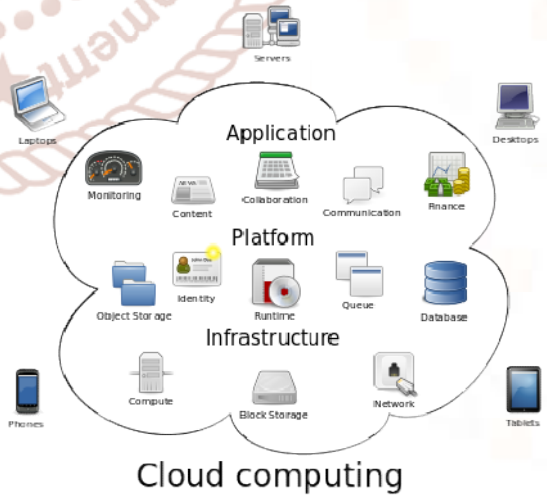

Fig.3: Cloud Computing [3]

D. *IED MONITORING*

Intelligent electronic devices are very important for monitoring and control purpose in substations.

IED performs various functions like they are used to monitor, control and protect operation. Various equipments in the substations are monitored and data is collected. So the important and costly devices essentially has IED. Some of the devices which are monitored are-

(1) Circuit Breaker

- Contact wear.
- Total number of operations
- Time in operation(mechanical)
- Time in operation(electrical)
- Inactivity time

(2). *DC Battery System*

- DC voltage level
- Leakage current

(3) *Power Transformer*

The Power transformer is the main unit of the substation. If we compare the cost of transformer with the other equipments in the substation then transformer is most costly unit. Also the maintenance and transportation of transformers is very costly. Hence proper monitoring must be done to protect these costly units.

The IEDs monitor the following parameters:

- It measure the winding temperature.
- It calculate the temp. of oil
- Accumulated loss-of-life rate.
- Monitor cooling system of transformer.

IEC -61850 STANDARD

Substation Automation (SA) is a system in which we can remotely monitor, control and coordinate the various electrical substation components. IED are used to automate and protect the substation equipments. Here, communication among various IEDs and between IED and control center is needed. Hence it becomes an important issue to realize the substation automation function. Because when we expend an existing substation or install a new one, then we have to order IEDs from IED manufacturers. So if these IEDs are supplied by different vendors, then communication between these becomes a serious problem. So this interoperability has to be resolved. Recently, a new standard is proposed by International Electro-technical commission(IEC) that is IEC-71850 Standard to eliminate the interoperability and hence flexible data communication between different IEDs.

Substation automation performs various functions like switch control, data monitoring, protection etc. In IEC-61850, these functions are divided into sub-functions. Each function is performed by the IED installed in the substation. A single IED can perform one or more sub-functions. A set of sub-functions is integrated together to realize a substation automation function. All the sub-functions communicate with each other through Local Area Network(LAN) in the substation. All the possible sub-functions have been standardized in IEC 61850. Information produced and required by each substation is given in the IEC-61850 standard. [4]

In the substation, there are basically two types of equipments :

(i) primary equipments(ex: Transformer, Switchgear)

(ii) secondary equipments (ex: Protection, control and communication equipments)

Now, the secondary equipments are further divided into three levels in IEC-61850 standards which are station level , bay level, and process level equipments.

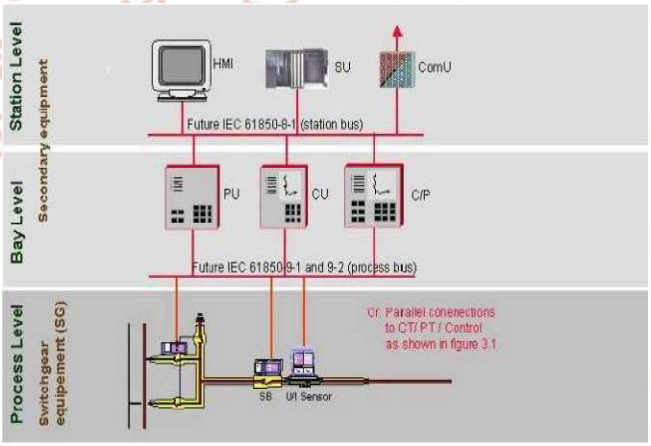

Fig. 4 Three level topology of substation equipment [4]

Process level function takes the information from

Various sensors/transducers installed in the substation and send them to upper level device, called bay level device.

Bay level functions acquire the data from the bay which is send by the process level device and then mainly act on the primary (power circuit) equipment of the bay.

Station level functions are of two types.

(i) ***Process related functions***

(ii) ***Interface related function***

III. Problems related with various technologies

A *Substation monitoring and control using SCADA system*

- Hijacking of SCADA control system and disruption of process is a serious threat. Attempts will be made to fiddle with control system parameters which will definitely adversely affect the whole control system of the substation and affect the reliability of power. Hence cyber security analysis must be done by experts to avoid such situations.
- If inadequate protection is provided to the SCADA system then it is likely to exploited through many ways. Viruses, Trojan horses and malware can also cause disruption. Hence ultimately the whole control process is affected.
- Since SCADA system applications are also accessed through the mobile devices. Hence this is really a big threat because hackers have a new domain to work on. So this side must be continuously monitored by the experts
- SCADA systems are getting open, unbounded and Interconnected. Restricted, authenticated access shall be one way to protect such systems. Protecting an open, unbounded and interconnected system is a challenging task. [12]
- SCADA system becomes complex due to addition of computers, operator stations, networks and other type of resources. Hence, due to this complexity SCADA systems becomes inflexible and cannot easily adept new changes to control process and monitoring of equipments. So we should try to design less complex systems by using proper number of devices which are essential in operation.
- The failure of SCADA system is mainly due to communication network failure. So the availability of the communication network should be increased for a more reliable SCADA system.[11]

B. Substation monitoring using microcontroller based system

- The range of RF modules is limited, hence this system is not applicable for the very long distances between generating station and substation. So we have to use long range modules.
- Only applicable for the real time monitoring of the substation as data cannot be stored for long period of time. Hence other methods of data storing are required.

C. Monitoring of substation using cloud computing

- The Major problem with the cloud computing is that we are accessing the data through internet , then if server is down or internet connection is unavailable by any reason, it also mean that cloud services will also unavailable. Hence we can't access the data and due to this the functionality of the substation will largely affected.
  So there should be an alternate to access the data.
- If cyber infrastructure is hacked or any other cyber attack take place on it then it would affect all the clients connected with it even if only one site is attacked. So Cloud service providers must pay attention to such frauds to protect large number of system connected with their servers
- Electrical power system is very complex network. At the substation large amount of data is required to stored and accessed through cloud computing. But for such high data applications, the companies have to spend a large amount because sufficient bandwidth is required to deliver huge and complex data over the network.

D. IED monitoring

- IEDs consist of all the electronic equipments present in the substation. So if any fault occur on the system, then total system will become

uncontrolled. Hence a backup control and monitoring is required.

- A single IED can perform multiple functions and it is programmable. Hence initial cost of IED based system increases as compared to the conventional system.
- As IED is a combination of hardware and software. Hence a programmer must have the hardware and programming knowledge.

IV. CONCLUSION

In this paper, we have reviewed various monitoring and control technologies of substation. The working and advantages of each technology, i.e. SCADA monitoring and control, microcontroller based monitoring, IEDs and cloud computing based monitoring system, are reviewed. We also discussed various problems related with each technology. The automation in substation monitoring and control operation is the best way to optimize the available resources efficiently and economically. Hence these monitoring and control technologies are very useful for electrical power system.

V. REFERENCES

1) Jogi Jose, Christy P Varghese, Akhil Jo Abraham,Justin Joy, A.Koilraj, "Substation Automation system for energy monitoring and control using SCADA", International Journal of Recent trends in Engineering and Research, 2017,ISSN:2455-1457, pp.32-38

2) Kaxil Patel, "A review on an efficient monitoring of substations using microcontroller based monitoring system" ,International Journal of Engineering and computer sciences, 5 May 2016, volume- 5,Issue- 5 , ISSN: 2319-7242, pp. 16548-16554

3) Hans Manoj R, Raut Ashwini, Dr. Vivekkant Jogi, "Real time monitoring of substation by using cloud computing", International Journal of Engineering Research and application, September 2017, Volume 7, ISSUE 9, pp.01-04

4) R.P. Gupta, "Substation automation using IEC61850 standard", Fifteenth National Power system conference, IIT Bombay,December 2008, pp.462-466

5) Tarlochan S. Sidhu, Mitalkumar g. Kanabar, Palak P. Parikh, "Implementation Issues with IEC 61850 based substation automation systems", Fifteenth National Power systems conference, IIT Bombay, December 2008,pp.473-478

6) Hongwei Li, Kixin Wang, " Research on technologies in smart substation", Technology college ,State grid corporation of China, Jinan, China, ICSGCE 2011,Energy Procedia 12 (113-119)

7) K.P Satheyamoorthy, "Role of controlling of substation using PLC and SCADA", Journal of Automation and system Engineering, 2015, pp. 194-201

8) Aarsha Unni J, Vinukumar A R, Shalu George K, "Cyber security analysis of substation automation system", International research journal of engineering and technology, July 2016, volume:03,Issue:07,pp.301-304

9) "cloud computing applications for smart grid: A survey"-Samaresh Bera, Sudip Misra, senior member, IEEE, Joel J. P. C. Rodrigues, senior member, IEEE

10) IEC-61850:Communication Network and system in substation, Part 2, August 2003.

11) Hosny A. Abbas, "Future SCADA challenges and the promising solution: the agent-based SCADA", Automatic Control Department,Qena paper company, Qena, Egypt

12) Suhas Rautmare, "SCADA system security :Challenges and Recommendations", Niche Technologies Delivery Group, Tata Consultancy Services, Mumbai, India