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A Review and Case Study on Improvements in Substation Automation Systems for Better Performance of Indian Power Distribution System

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Abstract: Substation is a vital part of power system where all electrical equipments are installed for transformation of electrical power from one circuit to another circuit without changing its frequency. Now a day due to economical as well as technological growth the power transferring system is totally automatically. Yet it is not applied to almost all places but most of the substations in India are automated. Power utilities adopt SCADA system for maintenance development and operation. It provides an application program for acquiring real time data from IED/RTU using open process control technology for substation monitoring. Now a day modified substation is installed with LAN system and Ethernet, such substation is design for task which uses communication system. Due to increasing combined distributed energy resources such as small photovoltaic plants or micro-cogeneration system grid leads to new competition to distribution system operation (DSO'S). TEC has developed a global communication standard. IEC 61850 is to facilitate substation automation. Communication security and reliability become important and it should be considered to ensure correct operation of substation automation system. Hence to make all automated we are trying really hard from our project. Since Substation is manually operated. It required lots of skill manpower for successful operation and it also leads to many human errors. Hence we need to automate the substation. Risk and reliability analysis of substation auto system are the most important and desirable design considered.
Keywords: Smart Grid, SCADA, PLC, LAN, Ethernet, SAU-Substation Automation Unit, Remote Terminal Unit (RTU), Substation Automation, Reliability.

I. INTRODUCTION

Substation plays an important role in transmission and distribution system, its main function is to gain energy transmitted at HV from generating station to required level at distribution hence automation is a process of controlling system by some automation device (PLC SCADA) is called substation automation. Automation of 11 KV Substation using Raspberry pi. Mrs. Asha John, Richu Varghese, Sai Krishna [7]. SCADA is real time process control system which monitors and control local and remote devices. It is considered as secured and utilizes dedicated communication line. Authentication and Authorization Mechanisms for Substation Automation in Smart Grid Network. Binod Vaidya, Dimimtrios Makrakis[11].

A large amount of work is done in the field of substation automation using matlab. Substation Automation Ujjawal Deep Dahal, Dhendup Cheten [1] Gives complete idea of development which includes a prototype with results of a user configurable SCADA system. Engineering your Substation Network For Protective Relaying, Automation and SCADA, James Bougie, ABB [2] Gives information about substation engineering of designing network to meet the needs of substation. Design and Implementation of a Substation Automation Unit, Andrea Anioni, Anna Kulmala, Anttti Mutanen [3] Gives information about an adequate quality of power system. An automation system leads to decentralized monitoring and control capabilities within network; it includes DER's, reactive power compensators, and controllable loads, on load tap changer transformer. System automation controller cause power flow more efficient way in grid system. This paper gives automation architecture capable of allocating the intelligence at each voltage level, by reducing communication burden.

The implementation of substation automation, as the existing substation network is telephonic it requires large amount of human participation for control communication purpose, as it is simple now by using IED control and monitoring and all protection function done by a single device (IED). Implementation Aspects of Substation Automation System based on IEC 61850. Biswajit Adhikary, Sudhakar Rao [4]. Risk, security and reliability weakness and their proper solution are proposed in Security and Reliability Analysis of a use case in Smart Grid Substation Automation Systems Peyman Jafary, Sami Repo [5], Risk and Reliability Analysis of Substation Automation Systems using Importance Measures Koteswara Rao Alla, G.L. Pahuja[6] by using IP, and RAW.

The distributor and MV substation are most common and important The Centralized System of Relay Protection and Automation for Substation of Medium Voltage. Lizunov I.N., Misbakhov R.Sh.,[8]. Power facilities they are deprived due to high cost within smart grid, and its requirement of IFC 31850 construction of digital substation of MV distribution network. An overview of intelligent substation automation system form point of view of services this this kind of system can offer which in future in well cause the active participation in market. Overview of Intelligent Substation Automation in Distribution Systems. Juan Diego, Daniel Remon, Antoni M. Cantrarellas[9]. Smart grid substation full fill the requirement induced reliability, flexibility, efficiency and smootion operation and it also reduce the problems of SCADA for PS communication. On the Utilization of system-on-chip platforms to Achieve Nanosecond Synchronization Accuracies in Substation Automation Systems Naiara Moreira, Jesus Lazaro [10]. Substation Automation by using upgraded system i.e raspberry Pi [7].

II. NEED FOR SUBSTATION AUTOMATION

Substation automation systems are used in control, protection and monitoring of substation. Hence power system reliability and fault clearing ability will be increased for supplying continues power to consumer [4]. As existing system is manually operated hence it leads to many errors and many consumers face lots of fluctuation crises. Hence to reduce such errors, substation automation has to be in practice. Automation makes system more reliable even in critical information for the operation of substation [2]. Substation automation cause monitoring function that includes SAU and IEDs and control functions by using cascaded OLTCs [3]. The requirement of substation LAN causes high data availability, integrity in substation LAN [5]. SAS introduced which includes DCP, BCU, ESW, EI, IED, HMI, IPC, and NCE. Raspberry pi automation substation by using IEC 61131-3 CONDESYS turned into a soft PLC [7]. Substation automation gives solution of problem of cost and relay protection in industry as well as MV distribution networks. Automation makes substation active, upgraded and allows bidirectional power flow through it. SAS require for analyzing globally the response of system in cause of fault take place. Substation automation control threats and security requirement. Improve PQ by using power devices in automating the substation. Power Quality Improvement using Custom Power Devices in Squirrel Cage Induction Generator Wind Farm to Weak-Grid connection by using Neuro-fuzzy control. Kopella Sai Teja, R.B.R.Prakash[12

III.DESIGN AND IMPLEMENTATION METHODS FOR SUBSTATION AUTOMATION

1. OPC DA it make available the data i.e real time data form IED, it also exchange data with IED [1]. OPC servers consist of RTU to collect data and provide to signal i.e signal and double status point. Hence OPC get configured as RTU and provide simple output.

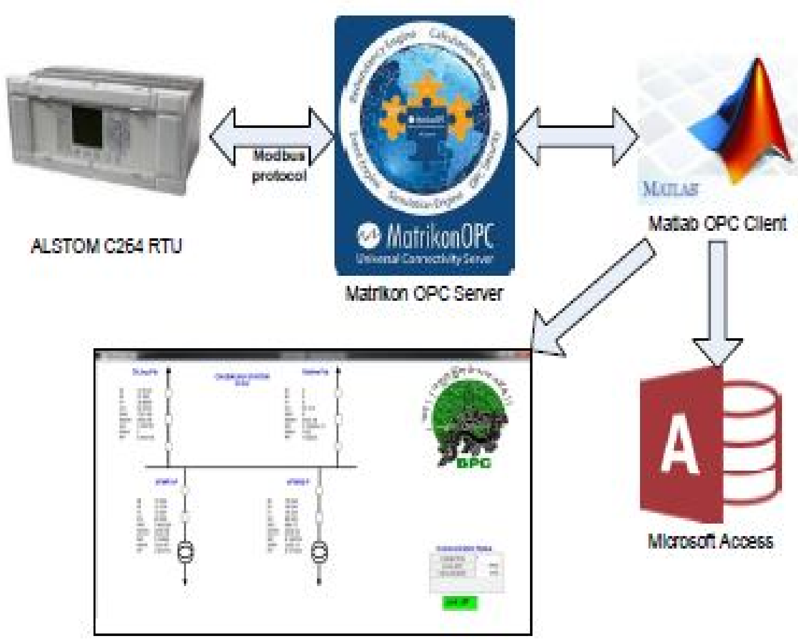

Figure 3.1 Architecture for SCADA system

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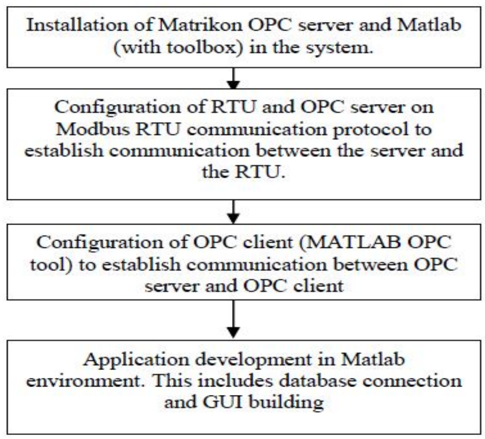
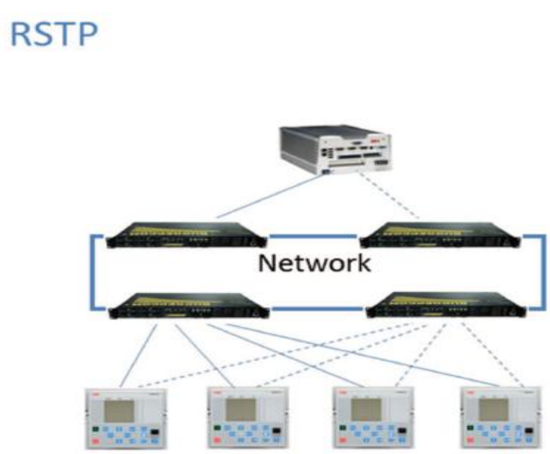


Figure 3.2 System Design and Implementation process

There are two network standard network and network reliability hence standard network have only one point of failure, this can switch and cable at time of failure, anyone of the component within it is interrupted. Where reliable network more than one point of failure and they are high expensive and difficult for troubleshoot.

Fig.3.3 Ethernet Chain

RSPT cause reconfiguration of network automatically anyone node in the network.



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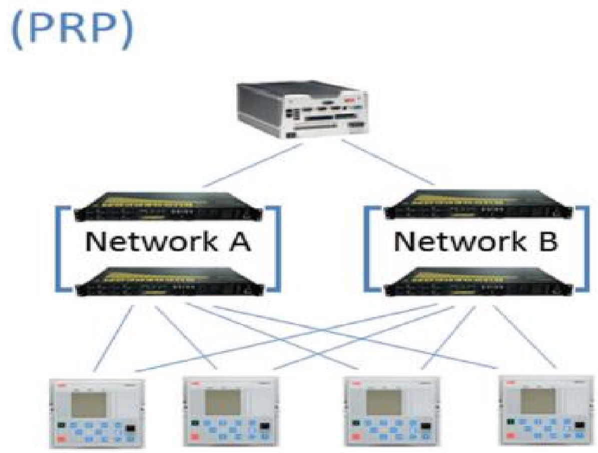


Figure 3.4. RSTP AND PRP

PRP similar configuration. HSR have the ring type setup[2].

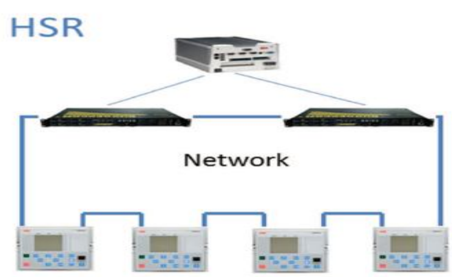
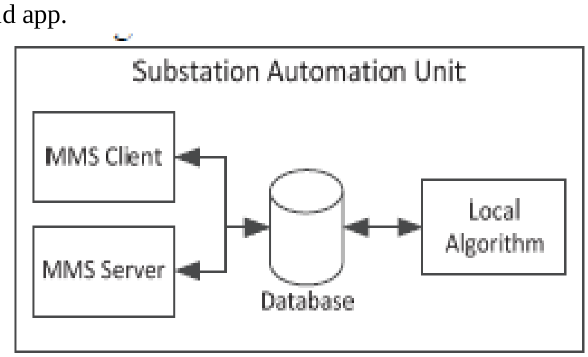


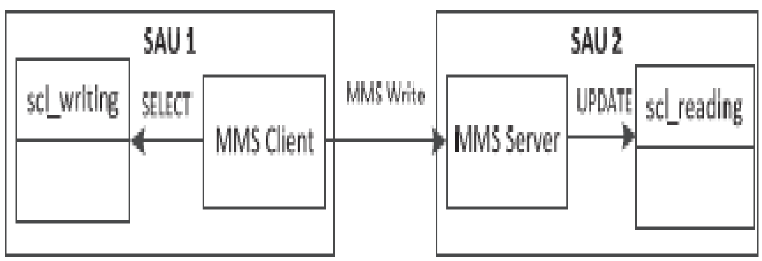
Figure3.5 HSR

A. SAV interfacing method with MMS and DB[3]

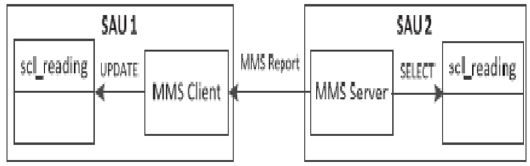
1) MMS interface coordination with DB and app.



2) MMS write variable feature.



3) Reporting features



B. The GOOSE message are exchange for interlocking mechanism which are form feeder circuit to command the coupler is closed. GOOSE message tripping of CB [4].

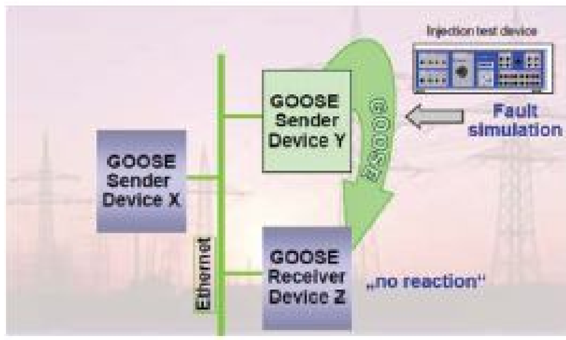


Figure 3.6.GOOSE message tripping of CB

C. Without security and with solution substation LAN.

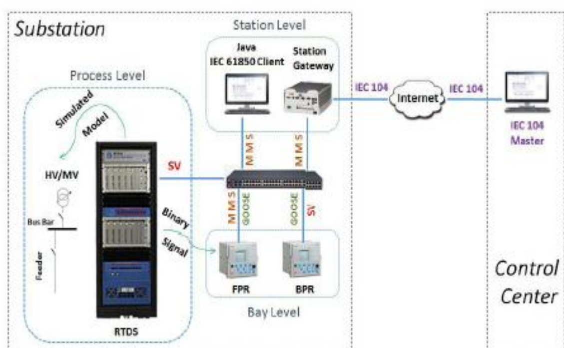


Figure 3.7 Lab setup without security

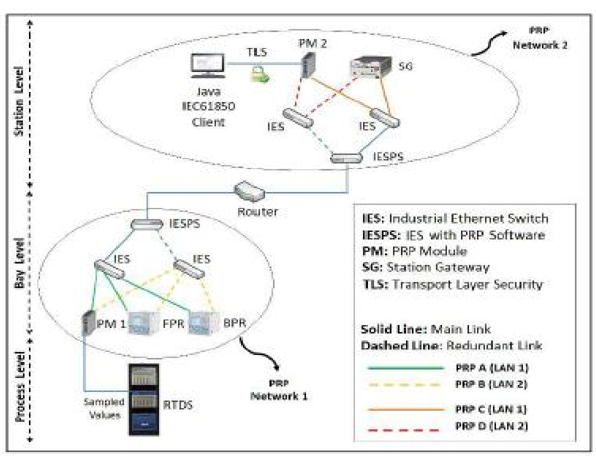


Figure 3.8. Lab setup with security and relaibility solution

This method use for controlling security and reliability [5]

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D. To increase reliability of system following RBD is used connected in series and parallel configuration [6].

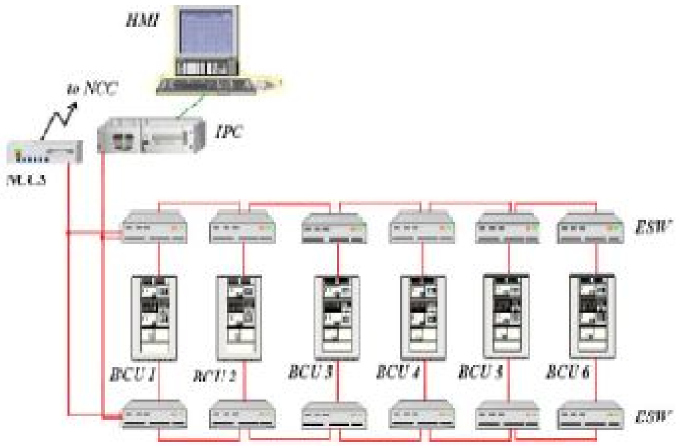

Figure 3.9. Cascaded architecture

E. FEC is a two controller system (1 for working and one for backup), it is a hear of automation system connected to peripheral bus[8].

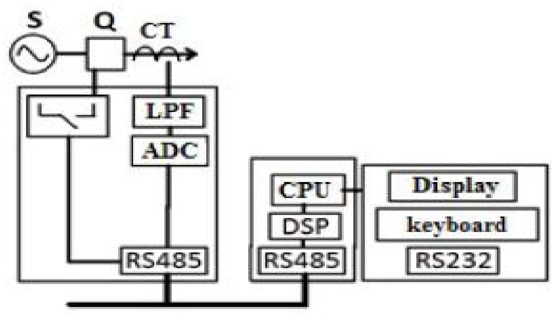

Figure 3.10 Front End Controller (FEC)

F. ISAS using IT, IED, ESS, SCADA, multi-agens reliability is maintained in ISAS[9].

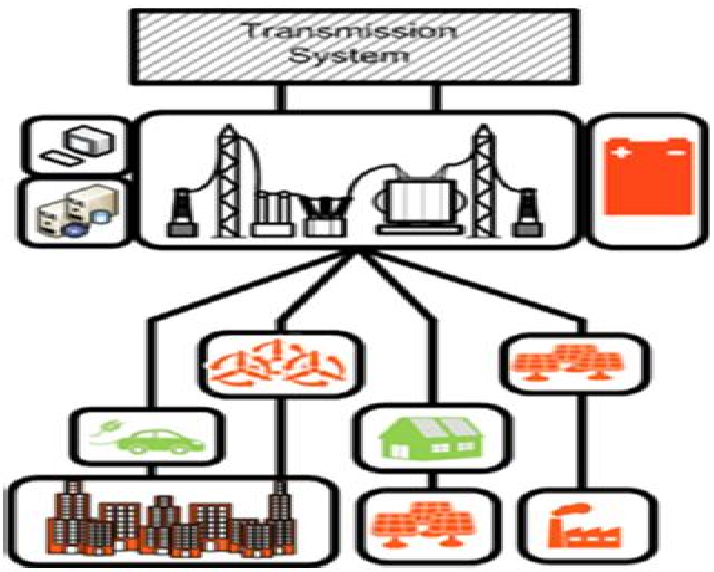

Figure 3.11 (ISAS) Intelligent Substation Automation System

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G. For power quality maintenances UPQC method is used where injecting voltage change takes in MVC busbar[12].

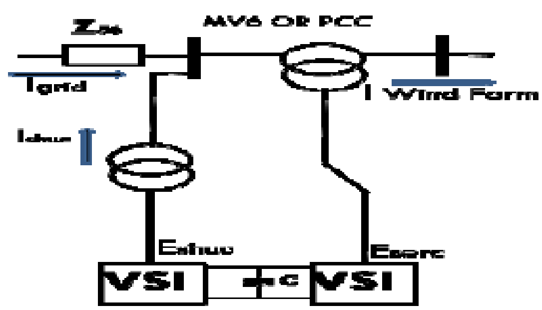

Figure 3.12 UPQC

IV. CASE STUDY

A 33/11 KV Substation located at Hatkanangale, Kolhapur in western Maharashtra is considered for case study analysis. It feeds power to seven villages. The incoming of this substation is 12MW. This is given to three distribution transformer, where each feeds to two villages. The capacity of transformer is 4MW each, namely T1, T2 and T3. Each feed to feeder village T1 feed to Hatkalangle and Atigre T2 fed to Alate and Nimshirgaon and T3 only feed to Jathar i.e domestic and agriculture feeder.

The incoming busbars are three namely 220KV Tilwani, choundeshwari (Jaysingpur) and Kumbhoj 33KV. In case if 220KV main line Tilwani fails the supply continuity is maintained by rest three. In faulty conditions, test charge are done at the interval of 5 minutes. If after test charge fails again supply trips then and that particular faulty feeder is disconnected from healthy line.

This Substation is modeled in Power Word Simulator (PWS) and it is simulated to understand the variation in generation and load switching for different feeders connected.

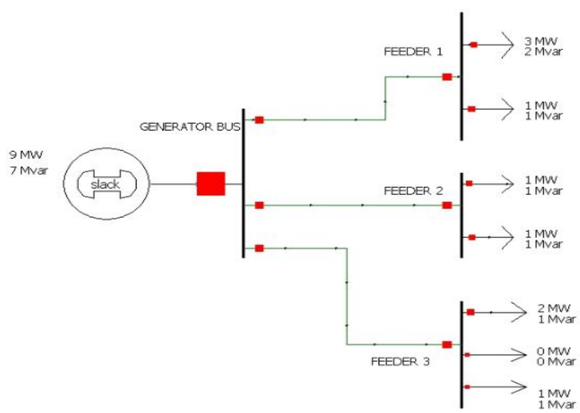

Figure 4.1. Simulation Diagram

Above figure 14 shows the simulation of an hatkanangale substation. From this simulation we obtain the generation and load data. Figure 15 shows the generator bus data.

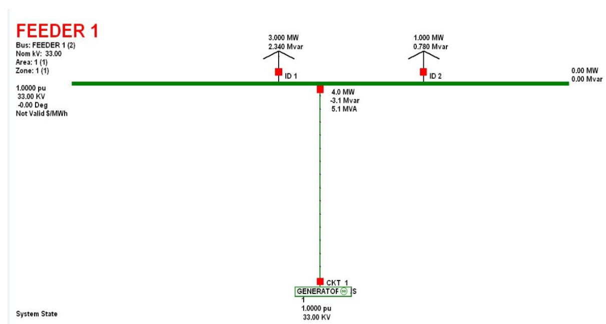

Figure 4.2 Data of Ist feeder

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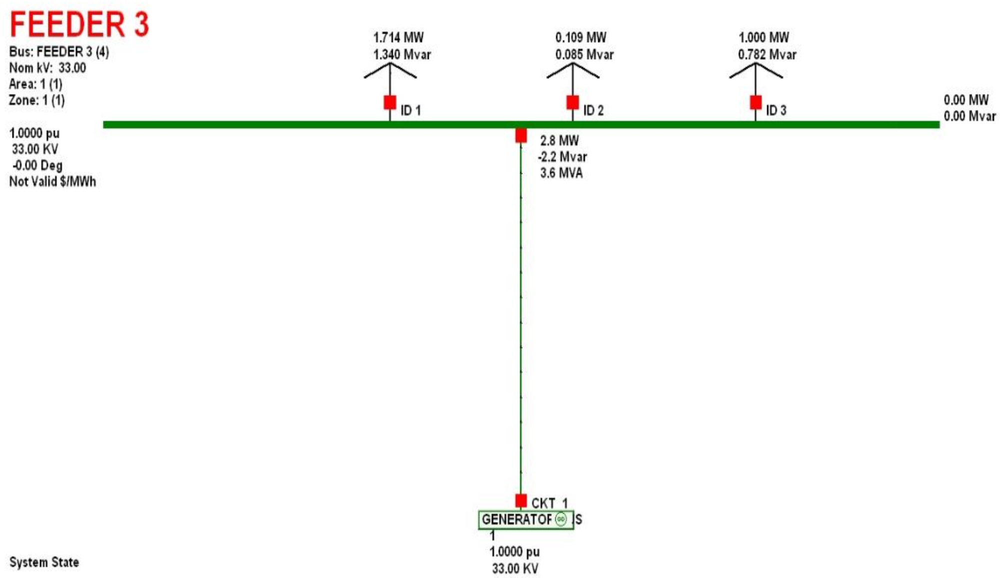

Figure 4.3 Data of IInd feeder

Name	Nom KV	PU Volt	Load MW	Load Mvar	Gen MW	Gen Mvar
Generator Bus	33.00	1.0000	-	-	9.40	7.34
Feeder 1	33.00	0.9997	4.00	3.12	-	-
Feeder 2	33.00	0.9998	2.58	2.02	-	-
Feeder 3	33.00	0.9998	2.82	2.21	-	-

Table 4.1 Results of simulation

V. RESULTS AND DISCUSSION

By using Power World Simulator software, considered substation is modelled and Newton Raphson method based Load flow study has been carried out to understand the violation of limits of feeder voltage as well system frequency on increasing load and by reducing generation capacities.

The obtained outputs are helpful to tabulate time schedule of Load shedding to maintain system parameters with in standard limits. This data is taken as reference and work is in progress to develop Automatic system that can monitor load fluctuations and take intelligent decisions on critical conditions using DCS controller interfaced with SCADA system.

This paper is an attempt to understand the present advancements in the fields of substation automation and results obtained on case study clearly demands a huge scope on improvements to be done in Substation automation systems to upgrade system performances. We are currently working with development of Intelligent and smart system that can manage substations in better way with reduced human efforts and updates of work carried will be explained in our upcoming papers with successful experimentation and validation of results with real time systems.

VI. ACKNOWLEDGEMENT

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