Energy Management System in Smart Grid using Internet of Things

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Abstract—**Electricity is the basic need of the human being. Supply utilities always try to improve the performance through different technologies like SCADA, DMS, EMS etc. From grid point of view hierarchical control of the grid namely National Load Despatch Centre, Regional Load Despatch Centre, State Load Despatch Centre and Area Load Despatch Centre plays important role. The basic architecture of power system structure is generation, transmission, substation and distribution. Such system are required to be automatized and monitored regularly. Smart Grid concept plays the major role in grid management. In this concept things being visualize for better performance of the grid. In this paper monitoring and control of different system parameter is demonstrated through Internet of Things. System data has been analysed for decision making.**

Keywords—Smart Grid; Internet of Things; Energy Management

I. INTRODUCTION

Every day electricity plays important role in keeping home, businesses, public institution running smoothly. The transportation and industrial sectors, such as trains and electric vehicles use electricity directly. Power transportation take people from one place to another for work, school etc. Without electricity it would not be possible for human being to enjoy the modern conveniences. The conventional power system structure is divided into generation, transmission, substation and distribution. The characteristics of the conventional power system: Traditional electricity power flow is unidirectional in nature, Centralized electricity generation, Generation and transmission are only real time monitor and control, Present system is not flexible, so it is difficult to switch electricity from alternate source.

The traditional grid are required to build with additional system automation, communication and IT system to transfer to Smarter Grid. Losses in the transmission and distribution system of India is very high. Loss reduction in the distribution network is on top priority of utilities. Smart Grid implementation will help to monitor, measure and even control power flow in real time. That will help to identify losses, critical condition, manage assets [1].

Smart Grid is an electrical system with bidirectional flow of electricity, automation, communication technologies and IT system that can monitor power system flow right from generation end to consumer end. Smart Grid does not replace the existing power system but builds the additional functionality on the available infrastructure in order to increase the utilization of the existing assets [2].

Communication is a basic requirement of the modern age. Present infrastructure of power system is unidirectional in nature. By utilizing modern communication infrastructure Smart Grid is capable of delivering two way flow of electricity. Wired and wireless are the two different type of communication media. Based on the distance of transmission and amount of information the communication technology is divided into two categories: short range communication technology and wide area communication technology [3]. For the short range communications, IEEE 802.15.4 (ZigBee) is used. And for wide area communication IP based internet, optical fiber communication, satellite communication technology can be used [4].

Internet of Things is a network that connect physical objects or things that are embedded with electronics sensor to collect and exchange data. IoT is described as a self configuring network.

In 2012 India faced two severe power blackouts which affected most of northern and eastern part of India on 30 and 31 July 2012. The blackout has put in order to take measures in power system reliability. How the operator will be better able to understand both grid performance and customer behavior ? The IoT application in Smart Grid focuses on examines the real time data in order to make the system more reliable which leads to improve the energy efficiency.

The development of IoT application in Smart Grid will provide detailed real time data of the system. This information allows the utility operator to take the real time decision to improve the performance [5].

The paper describes how Internet of Things is apply to Smart Grid environment, access the data, monitor and control the system. Which improve the efficiency, reliability and performance of the system.

In this paper, Section II illustrate proposed system architecture.

A complete implantation of IoT architecture is described in Section III. Section IV shows Hardware and Simulation results.

II. SYSTEM ARCHITECTURE

The basic system architecture of the power system is shown in Figure 1. In this information flow from the substation to the distribution service operators on to the transmission service operators. Electricity is generated at different power plants using various method. The power plants are large and suited away from heavily populated area. The generated power are stepped up to a higher voltage for transmission. The transmission grid moves the power over long distance to distribution station. At distribution the power is stepped down from transmission level voltage to distribution level voltage. At substation the power is again stepped down from the distribution voltage to the required service voltage and feed to the feeder line [1].

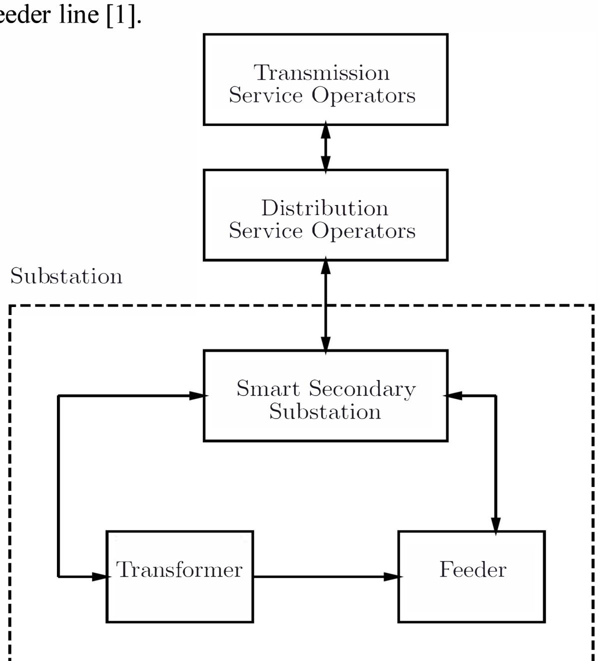

Fig. 1: System Architecture

III. IMPLANTATION OF IoT ARCHITECTURE

An proposed architecture of the Smart Grid on IoT platform from the Smart Secondary Sub-station end to the consumer end is shown in Figure 2. This system presents Energy Management System scheme for Smart Grid that is embedded with Internet of Things platform. The basic idea is to collect the information of power system right from substation to the end user.

In the proposed scheme every system is equipped with the sensor and actuator. The sensor and actuator are the part of network which are connected to the device which continuously collect the information and transfer the data through communication protocol using IoT platform [6]. The communication in this architecture is bidirectional. The communication follows the TCP/IP client server model. IP address of the board is access in order that the gateway required to know the network name and the IP address of the message dispatcher. Sensors send messages to the IoT server over a link through the gateway with the configured IP. The IoT server converts information from nodes, into a standard to be transmitted. Hence, data can be easily collected, represented, manipulated and aggregated wireless. It allows users to access real time data [7].

Smart Secondary Sub-station include digitalization, automatization, co-ordination and self healing. It receive the load information and analyse the data. At Smart Secondary Substation, one substation produces a data set: The current on primary and secondary of the feeder; the voltage on primary and secondary side of transformer; real and reactive power. The Smart Secondary Substation monitor and visualize the information to the operator which make the electrical grid more reliable. The operator at Smart Secondary Substation is able to identify the failure and diagnose, critical patterns can be anticipated before they happen. This transformed capability of Smart secondary sub-station will be able to respond the problem in near real time, improve the grid's health [8]. The bidirectional communication capability enable Smart Secondary Substation to analyse, configure and program the actuator according to the received data.

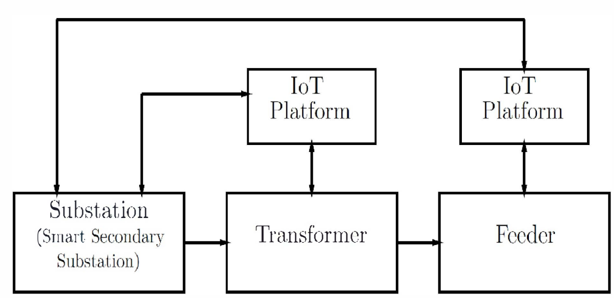

Fig. 2: Proposed System Architecture

IV. HARDWARE AND SIMULATION RESULTS

A. Simulation

We have simulated the three phase circuit along with RL section line in Matlab Simulink. Here for simulation we have used current and voltage measurement blocks to measure magnitude and phase of current and voltage. Collected the data of the three phase RLC load is shown in Figure. 3. We have store the data in the excel data base and monitor the circuit. The valuable data from every point of the physical infrastructure are capture and analysed in real time. We are being able to access the data of the load, also can predict the critical pattern of the load. In the database, the data are represented with unique format which help us to identify the data correspond to the load that make the decision making more reliable.

The database of the three phase load is shown in the Table I which contains different parameters of the load1.

TABLE 1: DATA COLLECTION OF THREE PHASE LOAD

Phase 1 Voltage	Phase 2 Voltage	Phase 3 Voltage	Phase 1 Angle	Phase 2 Angle	Phase 3 Angle	Phase 1 Current	Phase 2 Current	Phase 3 Current
167.527	167.527	167.527	-16.534	-136.534	103.465	4.944	4.944	4.944
167.527	167.527	167.527	-16.534	-136.534	103.465	4.944	4.944	4.944
167.527	167.527	167.527	-16.534	-136.534	103.465	4.944	4.944	4.944
167.527	167.527	167.527	-16.534	-136.534	103.465	4.944	4.944	4.944
167.527	167.527	167.527	-16.534	-136.534	103.465	4.944	4.944	4.944
167.527	167.527	167.527	-16.534	-136.534	103.465	4.944	4.944	4.944

B. Hardware Result

1) Domestic load smart grid implementation

We have designed the domestic load prototype on the IoT platform using Intel Galileo 2nd Generation processor [9] as shown in Figure. 4. The prototype include simple load lamp circuit connected to IoT server. The sensor and actuator attached to the network are able to collect the real time load information remotely as show in Table II.

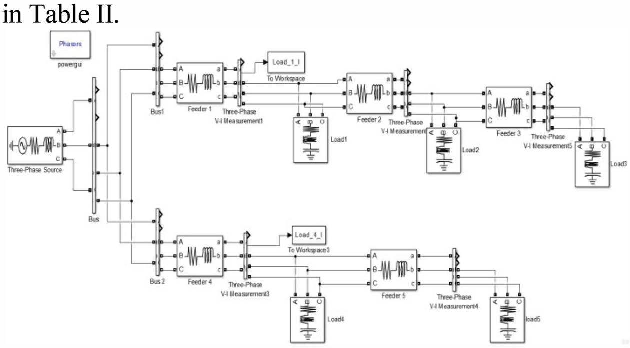

Fig. 3: Simulation of Three Phase Circuit

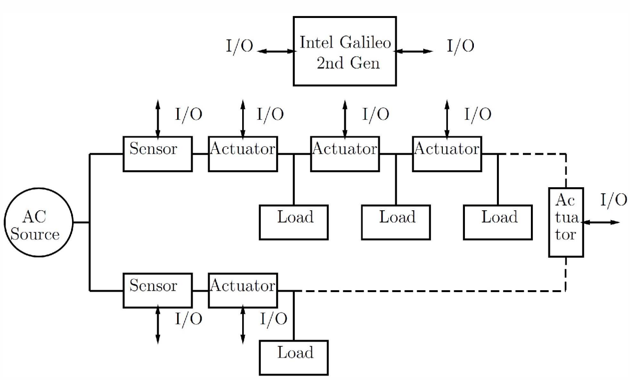

Fig. 4: IoT Hardware

The Intel Galileo processor collects the load information from the attached equipment. The information include single phase load current, voltage, rms current and voltage and on/off status. The circuit is equipped with the current sensor, potential transformer and actuator. The sensor and the potential transformer collects the load information. The actuator is used in order to remotely on/off the load and transfer the excess load feeder line to another feeder line.

2) Smart grid peak load management system

In the proposed scheme as shown in the Figure. 4, each feeder line is equipped with a switching circuit and a current sensor that communicates with a master controller Intel Galileo 2nd Generation processor. This processor is used as it is an effective medium for wireless technology for rural networks [10]. The current sensors located at each feeder line measures the local current and sends this information to the master controller continuously. The master controller processes this received information and send to the Smart Secondary Sub-station. The current readings at each feeder line is compared with the threshold limit. If the reading exceeds above the threshold limit, the processor will send a control signal to the specific switching circuit. The respective switching circuit will switch the load to another feeder line which has low load on it.

TABLE 2: REAL TIME DATA OF RESISTIVE LOAD

Load Watts	Voltage	Current	Rms Voltage	Rms Current	Power Factor
40	232	0.17	164.048	0.12	1
60	232	0.25	164.048	0.18	1
120	232	0.54	164.048	0.38	1
160	231	0.71	163.341	0.50	1

Table III shows data of two feeder line for different load. The load on line 1 is increased. As the line1 cross 0.5 ampere current the load of line 1 is switch to line 2.

This increases the reliability reducing the load on the network. The switching of the load from the network is implemented by synchronizing with other switches with lowest possible delay. This ensures that the consumer do not experience a drastic change in the outage during transfer. To initiate reconnection of the load to its respective line, the sensor, which continuously senses the current will send signal to master controller. Receiving this signal, the master controller will be reconnect the load to its respective feeder line. Signals to the controller are sent remotely from the Smart Secondary Substation to perform the action.

TABLE 3: REAL TIME DATA OF LOAD MANAGEMENT

		Line1				Line2	
Load1 Watts	Load2 Watts	Load3 Watts	Rms Voltage	Rms I	Load1 Watts	Rms Voltage	Rms I
60	-	-	164.048	0.18	40	164.048	0.12
60	60	-	164.048	0.38	40	164.048	0.12
60	60	40	163.341	0.50	40	164.048	0.12
60	60	40	0	0	40	164.048	0.62

V. CONCLUSION

In this paper the three phase circuit is simulated using MATLAB and SIMULINK, collected the load parameter of the data, analyzed the data and shifted the excess load to other feeder line which has comparatively lesser load on it. We have presented the complete implantation of IoT architecture, an implementation and an experimental demonstration on domestic load prototype of Smart Grid on the IoT platform. We have we have continuously access the load parameter through IoT architecture and being able to monitor the system remotely. Depending upon the data real time decision are made. The analysis and result have shown that, this scheme can be effectively used to control the network profile remotely using Eclipse software. Stable performance is observed that the reliability and the efficiency of the Smart Grid improved.

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