Scientific Journal of Impact Factor (SJIF): 4.14
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 3, Issue 7, July -2016

SMART GRID DISTRIBUTION AUTOMATION

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Abstract - *A smart grid is a system that incorporates a multitude of technological equipments and operational procedures like smart meter, intelligent control of the transmission and distribution of electricity so as to improve the operational and technological efficacy of the traditional electricity grid. These technologies are an extension of the traditional method of electronic control & monitoring. This also offers an information infrastructure to provide numerous advantages for providers & consumers of electricity*

Keywords –AMI(Advanced Metering Infrastructure)*, Data Concentrator Unit, Transformer Monitoring Unit, Data Logger and GPRS*

I. INTRODUCTION

Smart Grid refers to a two way communication technology and a computer processing employed to deliver the utility electricity. Earlier, Electricity companies had to send workers out to congregate the data required to supply electricity. The workers took note of measuring device data, looked for conked out equipment and quantified the needed electrical parameters like Voltage, current and Power for instance. Through the advent of the smart grid technology there is an elemental re-engineering of the utility electricity industries with reference to technical infrastructure by taking advantage of the advancement in electronic communication technology.

II. SYSTEM COMPONENTS

The entire system can be grouped under three headings. They are as follows
1. Field Devices
2. Communication Network
3. Control Centre

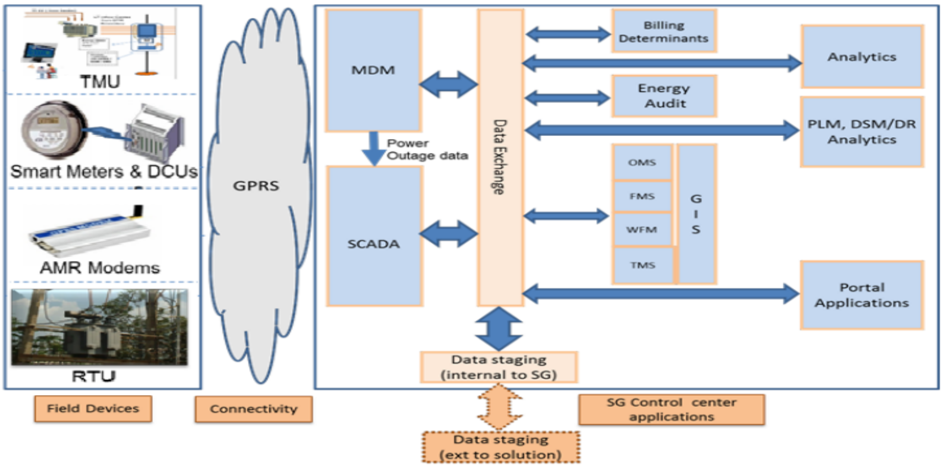

Figure 1. Block Diagram of the System

1. Field Devices:
These are the devices which are used to extract the ground level data from the field. Data obtained from the field devices will be in the raw format and hence needs further processing at the control centre. The field devices employed are

A. Smart meters
B. Data Concentrator Units
C. Transformer Monitoring Unit
D. Data Logger or GPRS AMR Modems

2. Communication Network:
The present electric power grid has grown to be an intricate network of networks, constituting both power and communication infrastructures and hundreds of Field Devices. Communication networks offer essential infrastructure

allowing a utility to control these devices from a central location. In the smart grid milieu, assorted communication technologies and architectures are employed. The communication networks used in the smart grid are Radio Frequency Communication; Between the Field Devices, GPRS and Wide Area Network; Between the Field devices and the control Centre.

3. Control Centre:
The Control Centre is the heart of the smart grid where, the data gathered from the field devices is processed to obtain the needed information. The information is stored, analyzed and used in various applications which in turn increases the operational efficacy of the grid.

III. IMPLEMENTATION METHODOLOGY

3.1 Implementation Approach for Advanced Metering Infrastructure

Advanced metering infrastructure (AMI) is an integrated arrangement of smart meters, communications networks, and data management systems which facilitates two-way communication between a smart meter and utility company. The figure shows how the smart meters are communicating with the Data Concentrator Units which in turn relays the data to the control centre.

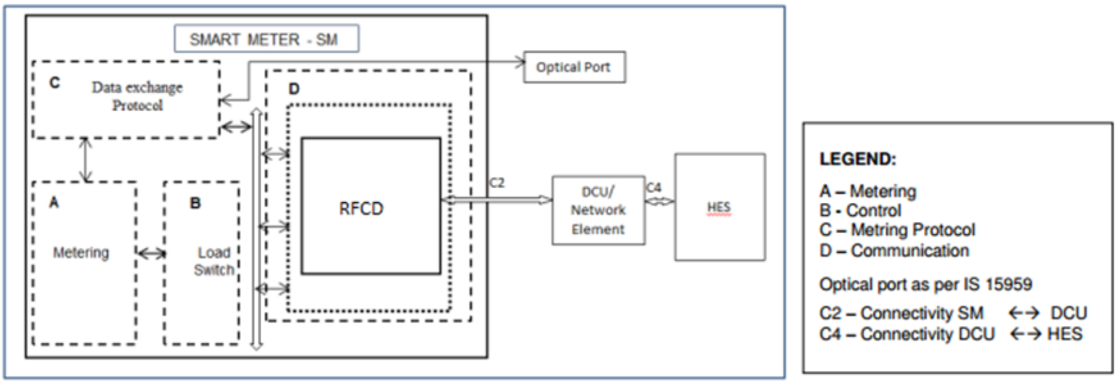

Figure 2. Advanced Metering Infrastructure

As shown in the figure the smart meter has a metering device to measure the energy consumption, Load switch which acts as an ON/OFF Relay, and a Radio frequency communication device [RFCD] operating at the frequency of 865-867MHz. Using the load switch the meter can be turned on and off from the control centre through the RF network, thus enabling the two way control and communication. The RF modules of the meters are connected to the DCUs . The DCUs are configured to the Head End servers in the control center. The communication between the DCU and the control centre is through the GPRS technology. The proprietary protocol is used for the data exchange between the Meter and the RFCD.

3.2 Interfacing the Substation SCADA RTU to the data logger/AMR Modem to obtain 11kv distribution feeder data

RTU is a solid state electronic device which connects sensory field units to a distributed control system or SCADA by means of an appropriate communication system. It monitors the field parameters and transmits the same to the Central Monitoring Station. The Data logger is connected to the SCADA RTUs through the ETHERNET Cable. For this purpose an additional Ethernet port has to be configured. As four Ethernet ports have been already configured for SCADA purposes, the Fifth port is used for Smart grid project.

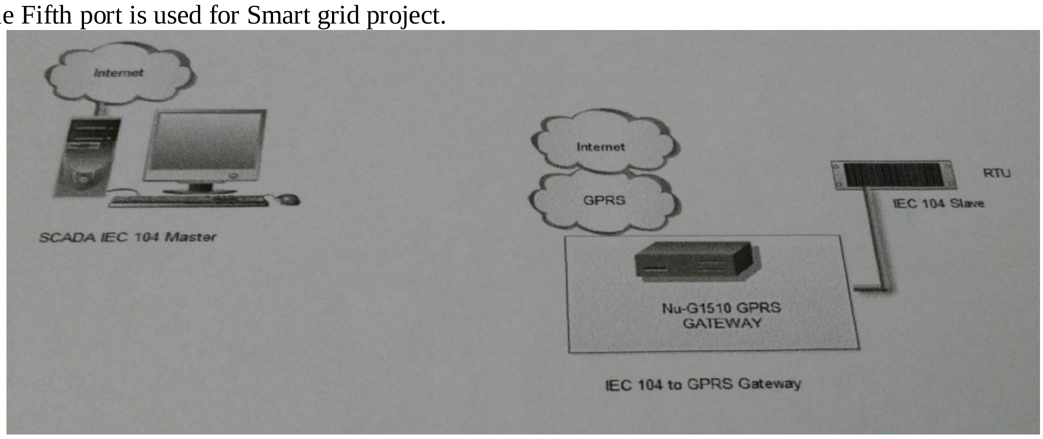

Figure 3. Connection Diagram

Data obtained from the RTU is transferred to the SGPP Control centre by the GPRS Modem through Edge Modulation and Coding scheme. The schematic Diagram of the same is shown.

3.3 Implementation approach for Transformer Monitoring Unit

The system architecture defines the way in which the different components of the system are organized to perform a required operation. The entire system is controlled by the ARM Microcontroller. The three sensors are used to monitor the ambient temperature, surface temperature and the enclosure door. The meter is connected to the Microcontroller by the RS 232 connector. The microcontroller is powered by the Switching mode power supply [SMPS]. The GPRS module is also connected to the microcontroller. The energy meter measures energy parameters of the transformer. The three sensors used measure the temperature of the transformer.

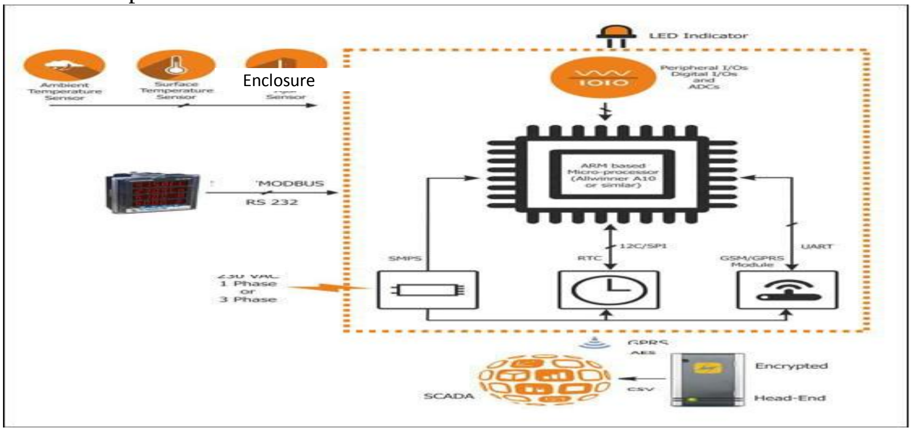

Figure 4. System architecture of the TMU

The microcontroller process the data from these connected devices and then sends it to the GPRS module which then transmits the same over the GPRS network to the Head end server at the control centre. The Advanced Encryption Standard is used to secure the data transmission.

3.4 Control Centre Operations Algorithm

Step 1: Obtain the Configured data of 11KV distribution feeders from the substation SCADA RTU through the Data logger by means of GPRS technology.
Step 2: Obtain the Configured Distribution Transformer parameters and Energy parameters from the Smart meters at the consumer end through GPRS technology.
Step 3: Concatenate all the inputs to the customized software applications designed for the power system operation analysis.
Step 4: Perform the needed data analytics and generate the required reports, event triggering and alarm modules using different functional applications deployed at the control centre.
Step 5: Take the counteractive measures in case of any faults and repeat the steps.

IV RESULTS AND DISCUSSIONS

The three core components of any distribution network are:
1 Distribution Transformer for voltage level conversion
2 Energy Meters for measuring the Power consumed over a period of time.
3 Consumers
The present grid infrastructure has many disadvantages in relation to these *three core components* of the distribution system.
1. Disadvantages with reference to distribution transformers:

a) Absence of two way Communication
b) Unbalanced loading
c) Improper temperature monitoring and control
d) Winding damage due to excessive load
e) Insulation loss due to excessive heating
f) Repair and response time is more in case of any breakdown
g) Reduced transformer life

2. Disadvantages with reference to Energy meters:

a) Unable to detect power theft
b) No duplex communication
c) Absence of remote relaying of the measured parameters

d) Meter readers have to be physically present to quantify the measurands.
e) Absence of prepaid metering.

3. Disadvantages with reference to Consumers:

a) No active participation of the consumers
b) Absence of consumer portals
c) No alerts to the consumers during the peak load times
d) More Blackouts and voltage surges
e) Cost of power will be high

From the above listed disadvantages with reference to distribution transformers, energy meters and consumers it is prudent to incorporate a technology to circumvent these shortcomings. The following section describes how Smart Grid effectively overcomes these short comings with the screen shots.

4.1 *Screenshots of the results obtained*

Figure 5. LIVE TMU Data

Figure 5 shows the live data obtained from the SLV GANAPATI 500KVA Distribution transformer. The KVA, Line voltage and transformer temperature are monitored and displayed continuously. This helps us to monitor the above parameters from the control centre itself.

In the event of any abnormal rise in the temperature of the transformer, the control centre gets the immediate notification with the exact location and the O and M teams from the distribution companies will be tipped off to take the necessary action thereby preventing the permanent damage to the transformer. This will prevent many damages that would have occurred like loss of insulation from excessive heating, burning of transformer etc.

4.2 *Smart Meter Screenshots*

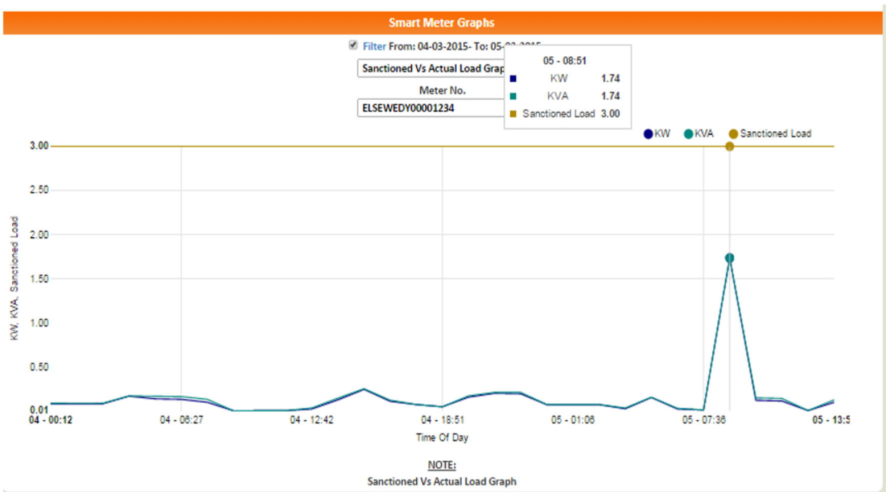

Figure 6. Smart meter Graphs

Figure 6 shows the Sanctioned verses the Actual load graph for Meter NO: ELSEWEDY00001234. This feature helps to manage load from the consumer premises. The individual consumer can be penalized if they exceed the allocated load limit at any point of time.

4.3 11KV Feeder data

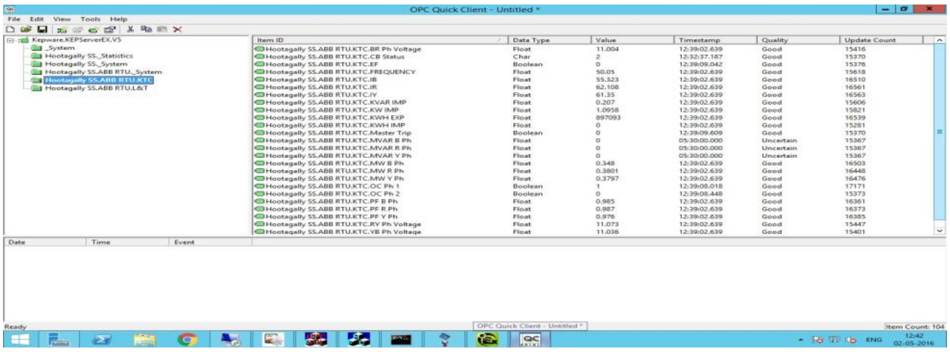

Figure 7. Feeder Data

Figure 7 shows the 11KV feeder data. The individual phase voltages, currents, Circuit breaker status, KW and kvar Export import, frequency and the master trip relay status are made known.

4.4 Advantages Envisaged

The advantages obtained from the above work are listed below;

- ***Facilitates Greater Accessibility;***
  Allows consumers to have access to greater levels of information on their electricity use, and assist them in managing electricity more proficiently.
- ***Decrease in Costs of Electricity;***
  Helps the companies that own the grid infrastructure to use their equipment more efficiently and thus reduce the costs involved which are ultimately passed onto consumers
- ***Expedites real-time troubleshooting;***
  Smart grid improvements shorten the problem solving period.
- ***Accouters the grid to meet up the increasing demand;***
  The demand for power is growing rapidly. Devoid of smart grid improvements, the traditional system, already stressed to near-capacity, will not meet the challenges of the future
- ***Optimizes asset utilization and operates efficiently;***
  Preferred performance at minimum cost of operations by sufficient utilization of assets through well-organized grid maintenance programs ensuing fewer equipment failures.

V CONCLUSIONS

The traditional grid has many inherent drawbacks. It has one way connectivity, meaning it can only carry the power to the consumer premises but it fails to record the actual consumption information at the consumer site and deliver the same to the grid. This leads to various disadvantages which will prove to be pricey both for the electric utility companies and the consumers. There is a call for better equipped technology which helps to circumvent the problems of the traditional grid. Smart grid helps to solve these problems efficiently by employing the cutting edge computing and the communication technologies to the existing grid. The Advanced metering infrastructure deployed helps to record and transmit the consumer consumption details to the utility companies, thus enabling the two way communication between the companies and the consumers.. The data loggers installed at the substations helps to monitor and control the field parameters of the 11KV distribution feeders. In totality the smart grid brings robustness, transparency, reliability, secured operation and optimization of the resource utilization.

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