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SMART MICRO GRID IMPLEMENTATION

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Abstract – ***Smart Micro-Grid is a modern electric power grid infrastructure for improved efficiency, reliability and safety with smooth integration of renewable and alternative energy source through automated control and modern communication technology. This small automated grid is the vital part of the smart grid. Here real time information becomes the key factor for reliable delivery of power from the generating units to the end users. Embedded system can be found everywhere in day today life, from electrical appliances to nonlinear compensation, complex automation and adaptive control. The microcontrollers are the main part of the embedded system. The microcontrollers control the entire system based on the instruction given to it during the installation stage. In this thesis work a control system is designed and implemented which enables communication between different components of the micro-grid and also control the micro-grid is a reliable and efficient manner. Here the main aim is to implement a smart micro-grid that can serve the loads connected to each DG on the basis of cost i.e. each consumer can get power cost effectively.***

Key Words: *Smart micro-grid, Renewable energy resource, Distributed generation, Microcontroller, etc...*

1. INTRODUCTION

Natural or man-made disasters have a profound effect on the society as they affect critical infrastructures. Large portions of the centralized electricity grid are compromised during these events. Such events thus are followed by lowered electricity supply reliability. In addition to the immediate inconvenience caused due to these events and the outage cost, the rebuilding efforts are also affected. These issues can be overcome by the emerging paradigm know as smart micro-grid.

As the micro-grid technologies grew, so did the dependence on distributed renewable energy sources. From 2004 to 2008, the use of renewable energy resource in the world grew at a very faster rate. Fig 1 shows the status of renewable energy source usage around the world.

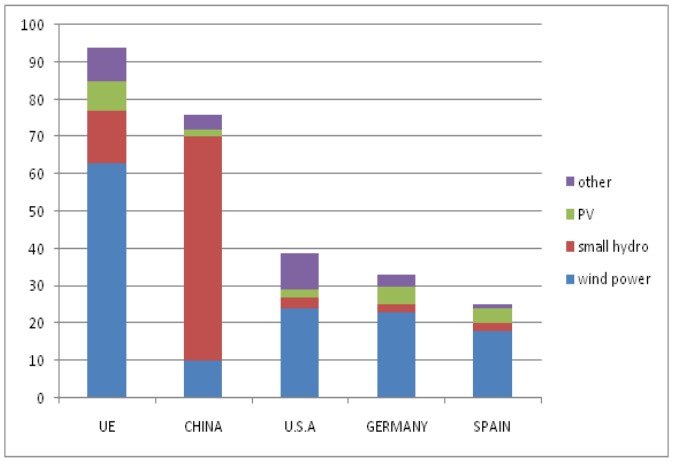

FIG – 1: Renewable energy capacity

With the growing emphasis on reliability and power quality, the distributed generation has emerged as a promising option [1]. The DER's are connected in a micro-grid and are controlled in intelligent and independent manner.

2. SMART MICROGRID

Micro-grids are small scale versions of large centralized conventional electric grid. These fulfill goals like higher reliability, lower carbon emission, diversification of energy resources and reduction in overall cost. Like as in large power grids the smart micro-grids generate, distribute and regulate the flow of electricity to customers, but they do so locally. The smart micro-grids are so far the best way to integrate distributed generation in community level and also allow consumer participation in electricity enterprise.

The smart micro-grid contains distributed renewable energy resource, advanced control system, load management system, energy storage system, and modern communication infrastructure to optimize the energy usage. These systems have the capability to work both in grid connected mode and islanded mode. Fig 2 shows a simple smart micro-grid system [2].

There are basically three modes of operation for the smart micro-grids, Grid tied normal mode, Grid tied emergency mode and Off grid mode.

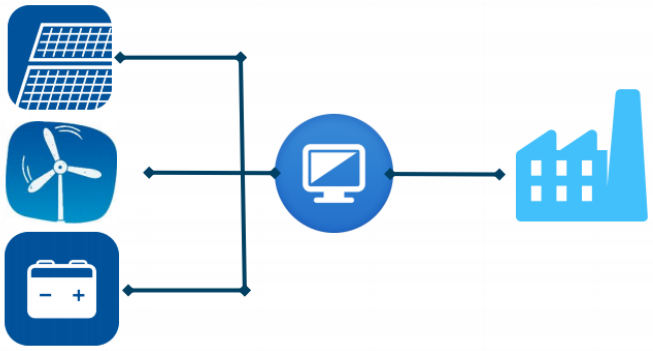

Fig – 2: Simple Smart micro-grid system

In the Grid tied normal mode of operation Economic optimization is taken into account. Here the control of the DERs, loads and storage is such that the cost of energy is considered and the best possible or economic energy source is considered to meet the load requirement. In the Grid tied emergency mode, No economic optimization is considered. This is the mode of operation during peak hours or during sudden grid fluctuation. During these hours the available source is considered to meet the load requirement rather than consider the energy cost during these hours. In the last mode of operation, i.e. the Off grid mode of operation, the micro-grid is disconnected from the centralized grid. This mode is considered during peak hours, hours of low power quality in grid, power cut, and during storm or worse environmental condition. Here the entire dependence of micro-grid loads is on the DERs and the energy storage devices.

3. MICRO-CONTROLLER

PIC Microcontroller is a product from the Microchip. It finds application is areas like control of different application in industry, machine control device, measurement device, etc, due to its low price, high quality and easy availability [4]. PIC indicates peripheral interface controller and its first ancestors were designed in 1975 by General Instruments.

PIC 16F877 microcontroller is available in different types of chip packages with different pin numbers. According to the type of application and usage, these packages can be differentiated. Here we use a 40 pin PIC controller chip. The pin diagram of the PIC microcontroller is shown in Fig 3.

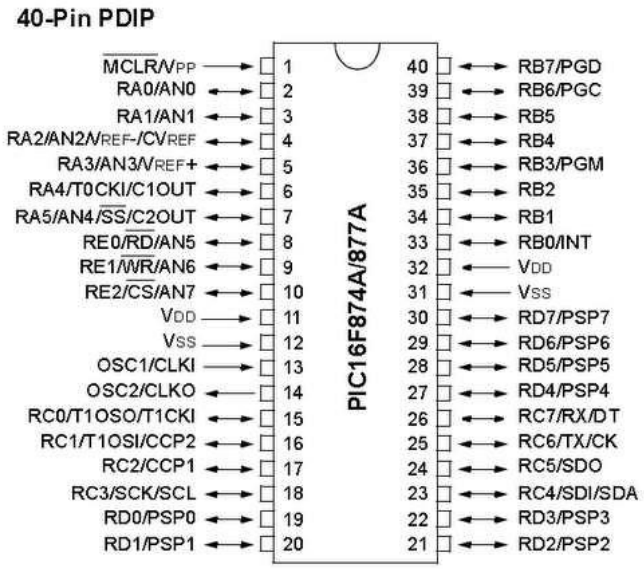

Fig – 3: Pin diagram of PIC Controller

Fig 4 gives the internal architecture of PIC microcontroller. Here there is no distinction between memory space and register space because the RAM serves the job of both memory and registers, and the RAM is usually just referred to as the register file or simply as the registers. The memory of PIC16F877 is divided into three sections; they are program memory, data memory and data EEPROM. The program memory has programs that are written by the user and this governs the operation of controller. The data memory has multiple register banks, which contain general purpose banks and special purpose register banks. The data EEPROM and FLASH memory are readable and writable during normal operation. This memory can't be directly addressed or mapped in register file space. But they can be accessed through special function or purpose register.

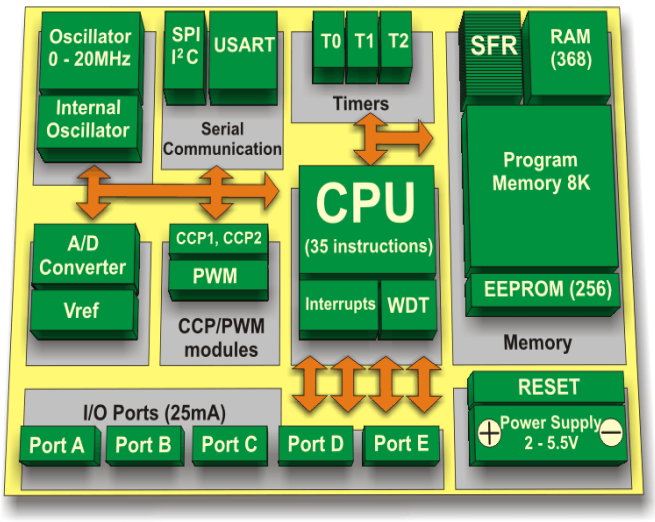

Fig – 4: Architecture of PIC Controller

4. SMART MICROGRID MODEL

The term Smart Grid has become an extensively used word in the operation of electric power systems and thus intermittent renewable energy sources will be massively integrated in electrical grids, it became mandatory to think about smarter communication methods to make the power grid more flexible and robust. In order to address this issue, this paper presents a simplified energy flow average models for hybrid Micro Grid.

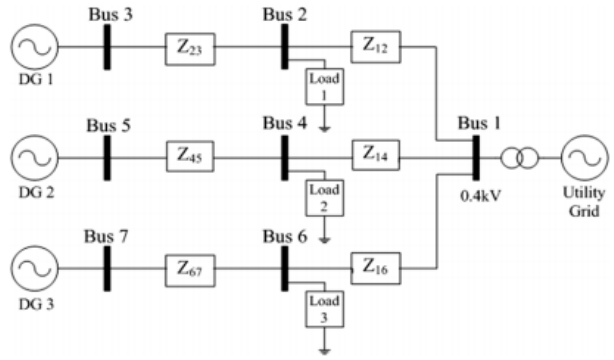

Fig – 5: System model considered in the paper

Fig 5 shows the micro-grid model that is considered in this paper. In this model there are three DG's and three loads. Each DG is assigned to serve its immediate load. These loads can also be served from the utility grid when the power generation from the DG is not sufficient to meet the load demand.
The objective here is to meet the power demand from the most economical power generation source. The system is modeled such that each load can either be served from the utility or the DG which it is connected.

5. SYSTEM SIMULATION

The smart micro-grid communication infrastructure provides efficient and consistent access to every grid component in diverse environment [5]. Communication technologies in smart micro-grid can be classified into two main categories: wired and wireless technologies. Wired technology include power line communication (PLC), digital subscriber lines (DSL) and optical power ground wire (OPGW). These have problems like attenuation and interference with signals from other appliances or electromagnetic sources. The wireless technology has low installation cost and rapid connectivity. Presently major researches are carried out to improve efficiency through mobile connected devices.

The Micro-grid system modeled has been implemented in the simulation tool PROTEUS 8 Professional and the program code for the system to work according to the requirement has been given in the tool MikroC.

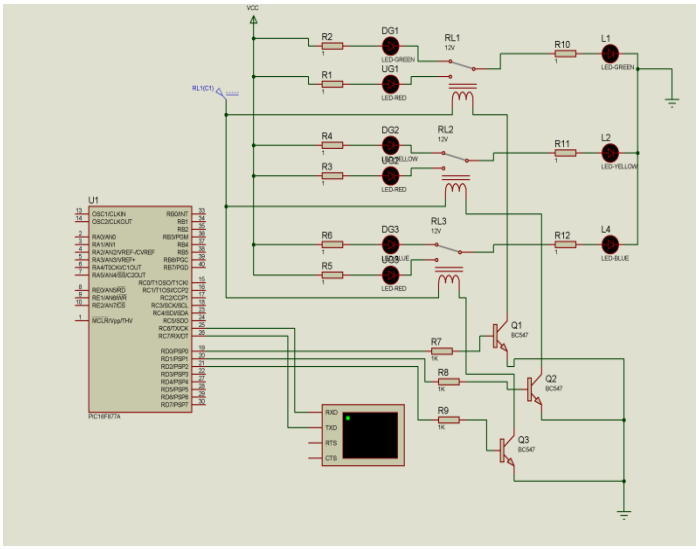

Fig – 6: System Simulation in Proteus

The basic simulation diagram of the micro-grid system has been shown in Fig 6. The system has three DG units, three immediate loads and utility grid. A PIC16F877 microcontroller acts as control operator and it coordinates the operation of the micro-grid. The controller has a program code encoded in it, thus the controller acts according to the requirement of the system.

Here, the requirement is to introduce a control into the micro-grid system such that the load can be served with the lowest energy cost. It can be seen from the figure that the provision for collecting the energy cost from each DG and utility is given through SMS. The USART module connected gives a virtual terminal where the user can provide the cost at any time of day.

6. RESULT ANALYSIS

The expected result for thesis phase 1 was to establish a control in the system such that the load can be served at the lowest possible energy cost. In short there are two possibilities of supplying the load, i.e. the load can either be served from the DG or from the utility grid. If the DG energy cost at a particular time of day is less than the Utility energy cost then the load is served from the DG units or else if the DG cost is higher, then the load is served from the utility grid.

The Fig 7 gives the basic result when the micro-grid is in initial state of operation. The result shows that each load is served from the DG generation. Here the LED at the side of DG indicates that the Load 1 (L1) is fed from DG1, the Load 2(L2) from DG2 and Load 3 (L3) from DG3. In this case the utility is not active.

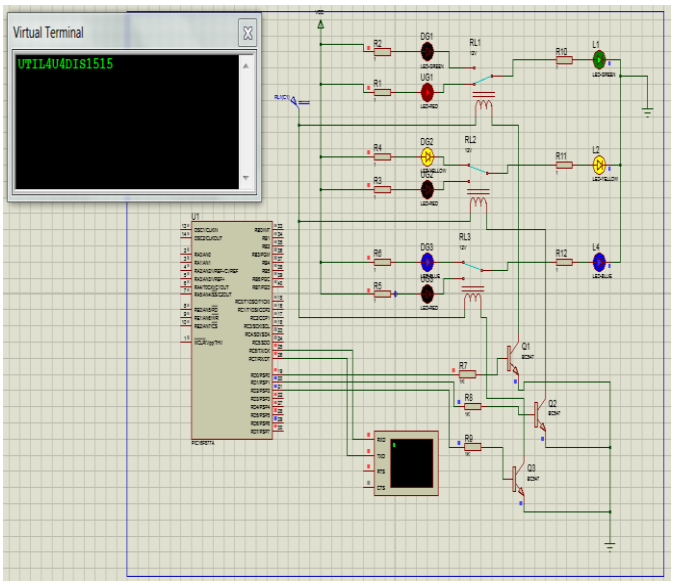

Fig – 7: Output at initial state

6.1 CASE 1

In this case 1, we are analyzing the case that the energy cost at a particular instant for DG1 is greater than the energy cost at utility side. Thus here the expected result is that the relay should operate and the load is to be shifted to the utility side without waiting for the knowledge about the cost from other DG.

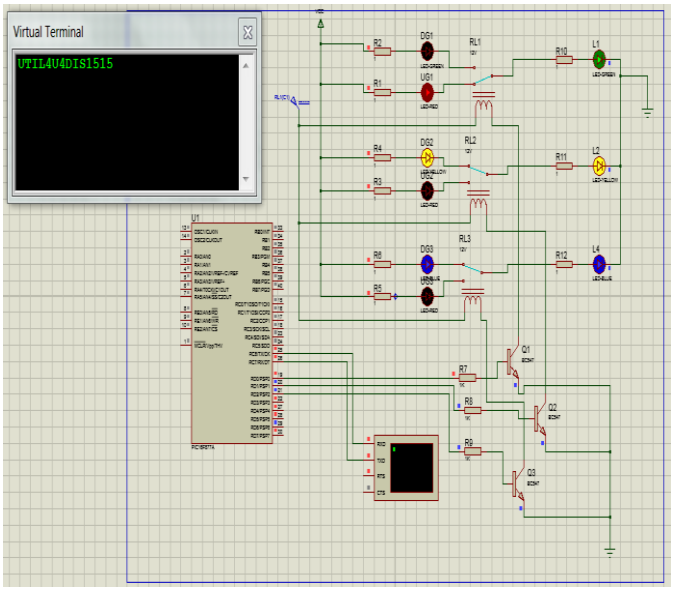

Fig – 8: Output of case 1

The Fig 8 shows the result that is obtained during simulation of the case 1. The result obtained shows that as the energy cost information about the utility and DG1 is obtained, it is compared in the controller. In this case DG energy cost is more and thus the controller operates the relay such that the load is connected to the utility side.

6.2 CASE 2

In this case we are analyzing the case when after the case 1 is executed, the energy cost information about the DG2 and DG3 is obtained and in each case the energy cost is less than that of the utility. Thus in this case the expected result is that the load 1 should be served from the utility side and the other loads (1 and 2) should be served from the DG side itself.

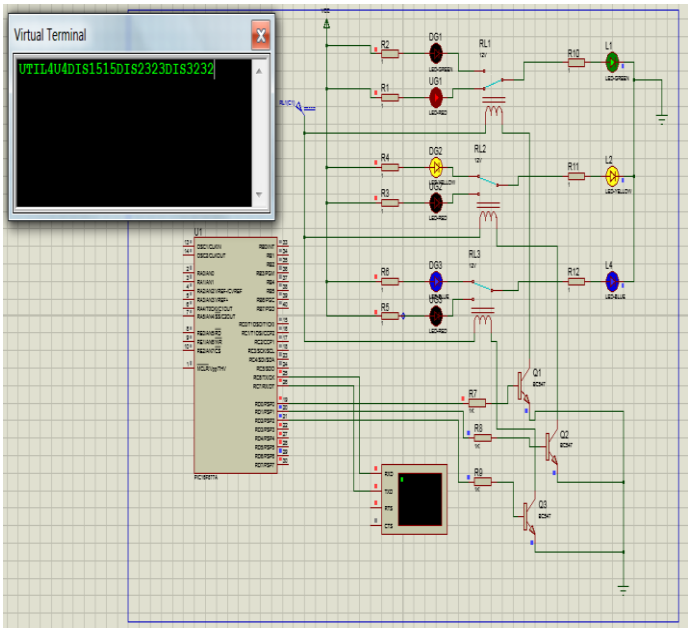

Fig – 9: Output of case 2

The Fig 9 shows the result for this case. From the figure it can be observed that the Load1 as in case 1 is served from the utility and the load 2 and load 3 are served from the DG2 and DG3 respectively.

6.3 CASE 3

In this case 3 we are analyzing the case when there is a sudden change in the energy cost of anyone of the DG. Here the expected result is that the if a DG energy cost is less than that of the utility energy cost then there should not be any switching of the load system from the DG side to the utility side. If the energy cost of DG is greater than that of the utility side then the load is to be switched to the utility side.

The Fig 10 shows the result of case 3. From the figure it can be seen that there was a sudden change in the energy cost of DG2, this information reached the controller via SMS and the controller compares the present DG2 cost with the utility cost. In this case it can be seen that the energy cost of DG2 is more than that for utility system.

Thus the Load 2 is switched to the utility side through the relay operation and there is no change in any other load systems.

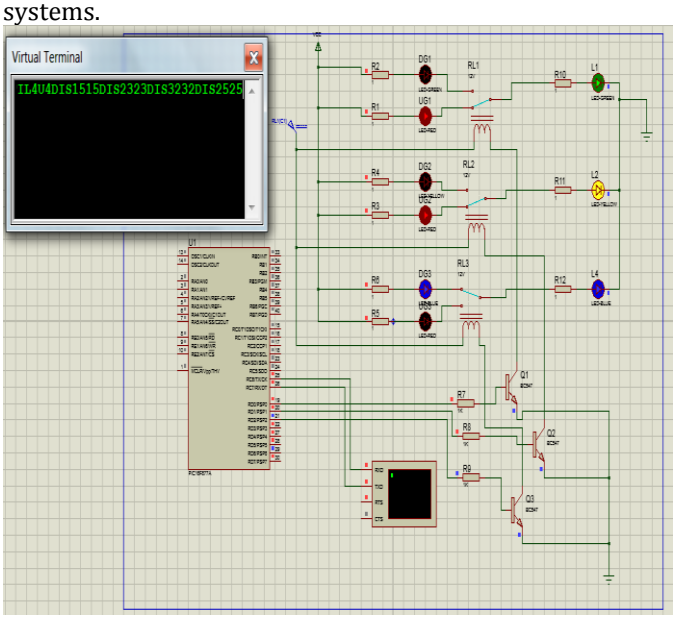

Fig – 10: Output of case 3

6.4 RESULT SUMMARY

From the results obtained we can reach a conclusion that the system operates as per required and the each load is switched by the controller according to the situation that occurs at any time of day.

Table 4.1 gives a brief summary of the overall thesis work done and the results obtained. Here the relay status is given as either OFF or ON. The relay status OFF indicates that the relay is not actuated and thus there is no change in the current system. The relay status ON indicates that the system in being controlled by the controller and the relay is actuated and thus there is change in the current state of the system.

Table -1: Summary of Results

CASE	ENERGY COST	RELAY STATUS	LOAD STATUS
GRID CONNECTED MODE			
1	DG < UG	OFF	FROM DG
2	DG > UG	ON	FROM UG
ISLANDED MODE			
1	DG > UG or DG < UG	OFF	FROM DG

7. CONCLUSIONS

This paper provides a cost based algorithm to control the micro-grid components in a way that each load in the micro-grid can be served with the lowest energy cost. The work was implemented in PROTEUS 8 Professional. In this work the communication between the components are through SMS from the DG operator and utility operator. It is observed that the demand is met from the generating source with lowest energy cost at each time of the day.

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BIOGRAPHIES

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