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Maximizing the Usage of Renewable Energy Resources using Adaptive Power Flow Control Strategy

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Abstract:- The increase in electricity demand has made us to use the renewable energy sources which are naturally available. The migration touse the renewable energy sources reduces the high peak load demand and the most commonly used sources are solar and wind energy. This paper presents a control of the grid tied system using DSTATCOM along with the maximum power point tracking (MPPT) technique and an adaptive power flow control strategy (APFC). The DSTATCOM technique is used to improve the power quality by selecting the power source with high efficiency and to provide a multi directional power flow ie. From source to grid and load or from source to load. The adaptive power flow control is used to manage the loads at the distribution side and a battery storage system to reduce the peak energy demand and energy imbalance between the load and the supply and also to increase the self consumption of renewable energy storage. The simulation model has been developed using Proteus software and the results are provided.

Keywords:- *DSTATCOM, demand side management, energy storage systems, peak power demand, adaptive power flow control method.*

I. INTRODUCTION

The world electricity demand has been almost doubled from the last two decades. The power generated from the fossil fuels will never balance this demand so in order to respond to this growth, a promising alternative energy sources which is renewable, pollution free, sustainable, free from greenhouse emission, etc, acts as a substitute energy sources. Moreover the power generation through the fossil fuels includes various disadvantages such as toxic gas emission, etc. To reduce the conventional generation through fossil fuels and to aid in shifting towards the generation through renewable energy sources, many countries were encouraging by providing the incentives. This has been resulted in a large scale installation of PV panels at domestic level in UK and on average it increases the power from 7MWp to 2373MWp. However, by connecting the renewable energy sources with the grid improves the system power quality, multidirectional power flow at a point of common coupling, etc. The widely adopted renewable energy sources are solar and wind energy because it is one of the free and readily available renewable energy sources.

During consumption, the power from these intermittent renewable energy sources does not always help in reducing the peak demand and the generation mismatch. This may also result in a serious issue at the distribution side which includes system losses, voltage regulation, etc. To overcome the above issues and energy storage problems, the combination of demand side management and energy storage features has to be encouraged. The opportunity for shifting the load from peak to off-peak periods and controlling the loads during high PV generation is achieved through demand side management and the energy storage system stores the excess energy from the grid which can be used during demands by reducing the peak. Some control techniques has to be followed to maximize the system benefit. Inconstant power flow control method, the target power point is set initially based on the predicted power demand and the instantaneous power generated is compared to the set value. The decision for the energy storage system such as either it should be charged or discharged and the load to be turned on or delayed is made by comparing the power at instantaneous and the predicted power set.

To improve the power quality with reduced harmonic distortions, to compensate reactive power and to balance three phase power in distribution system, the converter with PV array and an active filter known as PV-DSTATCOM is used. The system is able to work automatically in two modes namely, PV-DSTATCOM and DSTATCOM, by sensing the power from the PV panel. If the power generated is excess, the power is fed to both the grid and the load ie PV-DSTATCOM and if the solar is not available the grid and the converter system supplies the load. The proposed system consists of two or more renewable and a non renewable energy sources generating the power with

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different efficiencies which are connected to the grid and the load. The issues in generating the power through the non-renewable energy sources can be overcome by giving priority to the renewable energy sources. The system is made to prefer automatically anyone of the renewable energy sources generating the power with higher efficiency, to connect with the grid and the load. And only if the power from all the renewable energy sources were null, the grid and the load are connected to the non renewable energy sources. This is done by using the DSTATCOM concept.Thus both the DSTATCOM and the energy storage concepts are used for implementing this system.

II. ADAPTIVE POWER FLOW CONTROL STRATEGY

The APFC is a control method which is used to reduce the peak demand and electricity bills by directly controlling the load and the energy storage system. The predetermined target power is set from the average power demand. The controller is used to shift the load and the battery gets charged if the demand is below the predetermined value and discharges when the demand is at peak. This method also eliminates the energy imbalance by calculating the error using the following formula.

$$O_{t+1}^{Si} = O_t^{Si} + \frac{\sum_{i=1}^{6}(Error,i)}{6}$$

Where,

O_{t+1}^{Si} is the offset for next 3 hours,

O_t^{Si} is the offset used the same in the last week

$Error_i$ is the error from previous week

III. SYSTEM TOPOLOGY

The block diagram of the proposed system in fig-1 explains that the power generated from the renewable and non renewable energy sources are sensed by using the microcontroller unit. The microcontroller is associated with the crystal oscillator, power supply and an LCD. The efficiencies of the power generated from the sources are made to display in 16*2 display unit. The microcontroller unit makes the relay to operate depending upon the comparative values of the predicted power set and the power generated using solar and wind energies. If any one of the renewable energy source generation power is greater than the predicted values, then the corresponding relay operates to switch the grid to connect with the corresponding source from the other sources. The renewable energy sources are given priority by uding DSTATCOM and energy storage control methods. Thus the excess power is supplied to grid and the load efficiently.

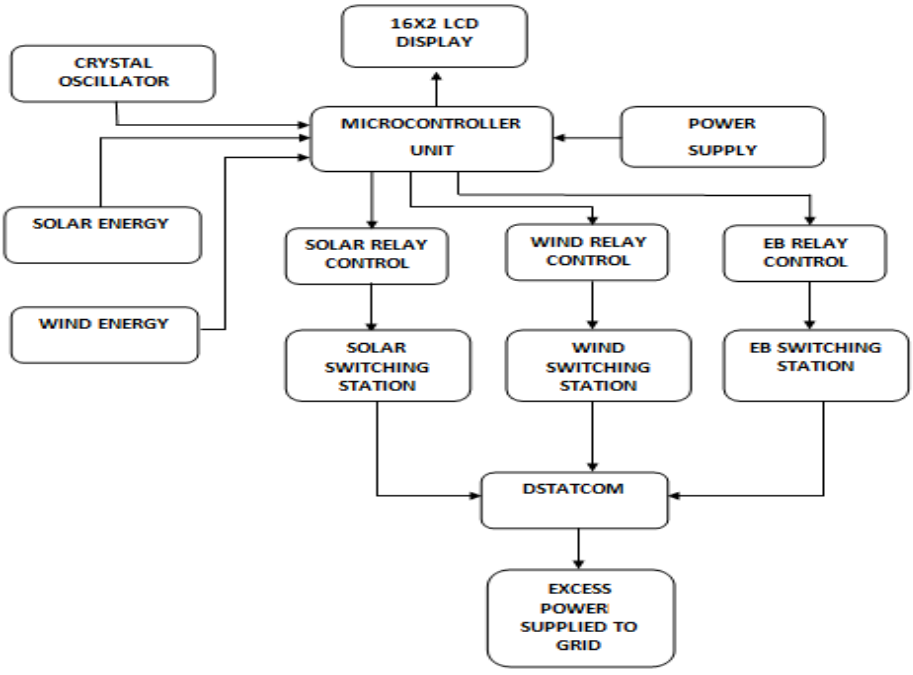

Fig 1:- Block diagram of the proposed system

The energy sources required in this proposed system includes solar energy, wind energy and an EB source ie a source from non renewable energy. Here the solar energy is obtained from the solar panel. The solar panels collect the sunlight and covert it to the electrical energy. The solar panels consists of many solar cells and its composed layers of silicon, phosphorous and boron to provide positive and negative charges. The wind energy is received using wind

mill. The EB source may be from any non renewable energy sources such as nuclear, etc.

IV. SIMULATION AND RESULTS

The simulation of the proposed system is done using the Proteus software tool along with the ARDUINO board.The simulation model consists of LDR as a solar source, a wind source and the power from the non renewable energy sources as the power sources, ARDUINO controller, relay switches, loads and an LCD to display the output of the proposed system. When the simulation is made to run,the power is generated from the renewable energy sourcesie solar or wind energy. The ARDUINO is an open source microcontroller and the serial number is ATMEGA 328 with the operating voltage as 5V. It has 14 digital input and output pins and 6 analog input pins.The ARDUINO is to control all the devices, and it is called as the brain of these all components.

The power generated by solar depends upon the intensity of the LDR. The intensity of the LDR can be varied to vary the power generation through solar which in turn meets the demand power. The wind power depends upon the speed of the rotation. The power from the renewable energy sources are connected through relay switch to the grid and the load correspondingly.Only if both the renewable energy sources are made null, the proposed system is made to draw power from the non renewable energy source (EB) which is supplied to the grid and the load. The loads are connected separately using relay switches and glows when the corresponding relay switch turns ON and the values of power generated are displayed using LCD. The excess energy generated will be stored in the battery. The power generated from different sources at any instant is displayed using LCD.Thus the program is made to give priority to renewable energy sources for distribution of the power.

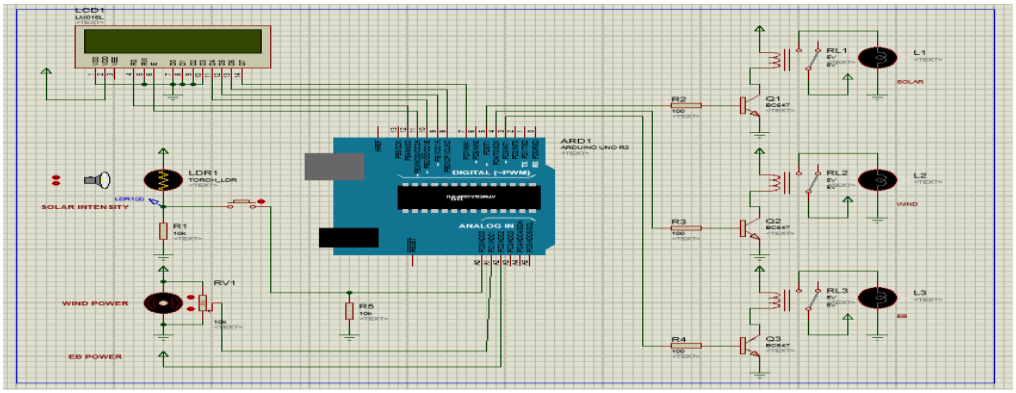

Fig 2:- Simulink model of the proposed system

The simulink model of the proposed system is shown in Fig2. It comprises of both renewable and non renewable energy resources which generates efficient power supply. Here the power generation from renewable energy is considered as solar and wind. The solar energy is provided using LDR and wind energy is from a rotating model. Now all the sources of energy are made null ie before starting and no loads are connected to the supply through grid.

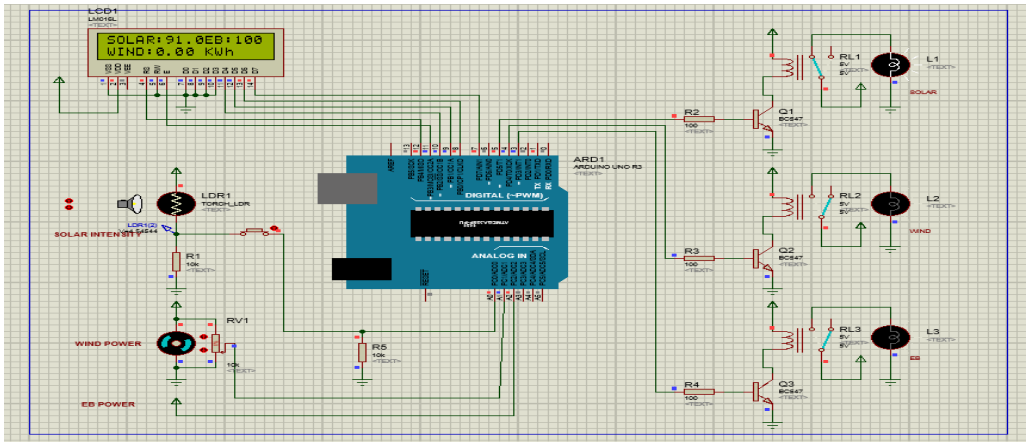

Fig 3:- Power supplied from Solar energy sources

The fig-3 shows that in the proposed system, when the generation of power from solar energy is high on comparison with the rest of the renewable energy source powers, the load and grid or load through grid is connected

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to the solar energy. Using the microcontroller, the comparison of powers is made and the commands are provided to the relay to switch the supply. The instantaneous powers generated are displayed in the LCD instantly. As soon as the relay switch of the solar power is turned ON, the load (lamp) connected gets power supply from solar. The solar energy source is connected to the grid and the load through a relay switch when the power generated through them is comparatively higher than the wind power and the lamp glows as shown in the above figure.

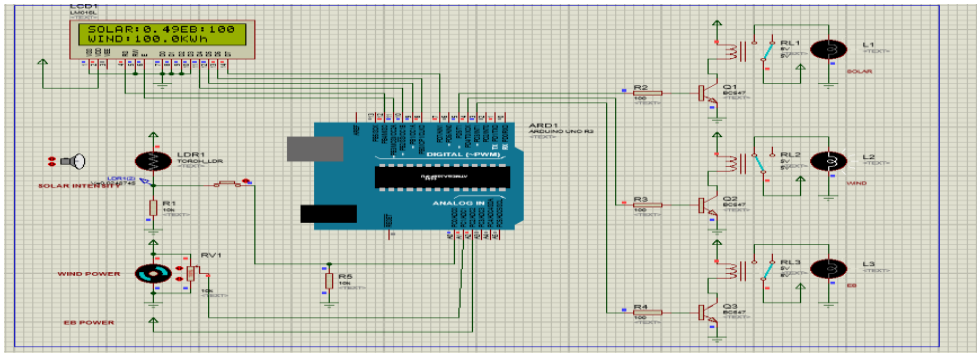

Fig 4:- Power supplied from wind energy sources

The power generation from the wind energy source of the proposed system which is shown in fig-4 is also similar to the solar power generated in this proposed system. Thus, the power generated by the wind can also be supplied to the grid and load when it leads the solar power generated or any other power generated from renewable energy sources if it is connected to generate the power. The power generation through wind energy here depends upon the rotation. The speed of the rotation can be varied and the load is connected to the wind energy source by using the relay switch through grid is shown clearly in fig-3.

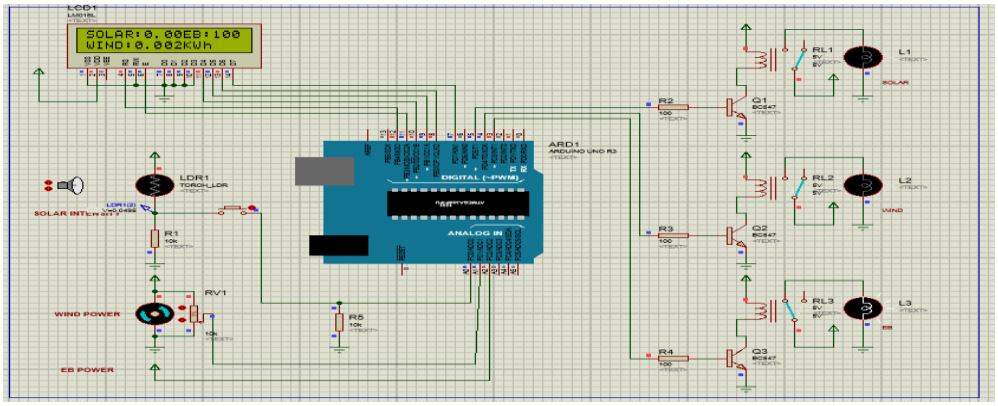

Fig 5:- Power supplied from EB (non renewable energy sources)

The fig-5 explains that when the power from all the renewable energy sources are made zero, the power from EB ie the power from the non renewable energy resources are supplied to the load. During this operation only the relay switch corresponding to EB source is made to turn ON while the remaining are turned OFF. This condition is preferred only when the renewable energy source generation is absent in the proposed system.

V. FUTURE ENHANCEMENT

The proposed grid tied renewable energy system has been simulated using Proteus software to which increases the power quality and reduces the energy imbalance. This system is used to track the maximum power at all instants and it can be implemented in future to reduce the peak demand and electricity billing cost.

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