Design and Implementation of Efficient Energy Utilization and Distribution Management with Photovoltaic System

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Abstract

Due to increased interest for solar energy harvesting systems in recent years the number of developed system types is large. In order to choose the optimal one for future system development the analysis of common architectures being used for photovoltaic systems has been done. This paper proposes a high efficient maximum utilization and energy management system needs to consider both energy distribution and generation simultaneously to minimize the energy cost by requiring fewer solar panels. The reason of better performance is that distributed PV-systems have dual axis maximum power point tracking, therefore increase the harvest of energy by keeping the photovoltaic power generation process optimal and demand side energy management for a connected household to ensure efficient household energy management. Smart scheduling of electrical appliances has been presented.

Index Terms – Maximum power point tracking, Photovoltaic System, Appliance scheduling, household energy management,

NOMENCLATURE

Impp	Current of the PV panel at maximum power point.
Isc	Short circuit current.
Pbat	Power consumed by the battery during charging.
Pmax	Maximum power of a PV panel.
Ps	Power supplied by a PV panel.
Rint	Internal resistor of a battery.
t	Time for battery charging and discharging.
ton	Backup time for a battery.
Vcv	Battery cells voltage.
*V*MPP	Voltage of the PV panel at the maximum power point.
*V*oc	Open circuit voltage.
Vs	Supply voltage of the PV system.

I .INTRODUCTION

Energy plays a key role in achieving the desired economic growth. Energy is a pivotal prerequisite of developed economy and social structures. One of the major problems concerning its supply is the depleting nature of the extraction of fossil resources, combined with the need for transition to renewable energy supplies.

The system depends on a number of scientific and technological breakthrough. Meanwhile, energy conservation promises to fill the gap between supply and demand. Several measures for conservation of energy are very important for consideration. The conservation of energy is less more wisely than before. Saving a watt is nearly always cheaper than increasing the supply by a watt.

Now a days solar harvesting is more popular. As the popularity become higher the material quality and solar tracking methods are more improved. There are several factors affecting the solar system. Major influence on solar cell, intensity of source radiation and storage techniques. This makes it particularly difficult to make considerable improvements in the performance of the cell, and hence restricts the efficiency of the overall collection process.

Therefore, the most attainable dual maximum power point tracking method of improving the performance of solar power collection is to increase the mean intensity of radiation received from the source used. The first MPPT controller is an astronomical two-axis sun tracker, which is designed to track the sun over both the azimuth and elevation angles and obtain maximum solar radiation at all times. The second MPPT algorithm controls the power converter between the PV panel and the load, this implements a Perturb and Observe (P&O) scheme to keep the system power operating point at its maximum.

Many companies and research centers study this new sustainable energy, and various products have appeared to the public. However, this kind of researches concentrates on elemental technologies, and now a management system is needed to manage these technologies to maximize energy efficiency. This paper includes the system of Efficient Energy Distribution Management to monitor available energy from storage and manage loads flexibly, Use of energy efficient equipments to save energy is also proposed.

II.Maximization of solar Energy

Global warming and the drive to minimize Greenhouse gas emissions has put the focus on how to make the most of natural energy sources. The sun and the wind are freely available almost everywhere in the

world and electric actuators can help improve the exploitation and efficiency of these sustainable source of energy.

Solar tracking is an obvious way to improve the efficiency of solar power plants. As the sun moves across the sky an electric actuator system makes sure that the solar panels automatically follow and maintain the optimum angle in order to make the most of the sunbeams.

The proposed dual axis sun tracking system can tracked the sun in two axes- horizontal and vertical. The first motor will rotate the solar panel to track the sun in the horizontal axis. Once it has established the correct direction of the sun, it will start tracking in the vertical axis to get the best tilt angle. The working principle of the tracking system is based on the P & O MPPT of solar cell used under the correct conditions. In short, the system will take a step in unidirectional and sense the change in the voltage of the solar cell.

Solar system which utilizes a tracking unit can generate 20% to 30% more power than a fixed or stationary unit. When the sun first rises in the morning, the energy that can be harnessed from its rays is already almost equal to that of midday.

By using a tracking device, a solar cell can be oriented to take advantage of this early morning sunlight. The tracker then slowly moves the panel throughout the day, following the sun to gain maximum exposure to the sun. Tracking units work differently, depending on what type of power they are producing and on the type of tracker.

III. RELATED WORKS

Renewable energy is the major source available now for energy generation. In order to utilize these resources efficiently without depleting them soon an efficient power management system is in need. In this project a power management system with efficient utilization is proposed.

To maximize the efficiency, an intelligent management system is needed not only to monitor the whole system but also to perform optimal management according to ever-changing conditions such as weather, season, and power generation. Here the power management is bought into use with a control and generation block along with monitoring block.

The PIC controller used in the control block is responsible for collecting the generated power and distributing them when proper command is provided. The monitoring block is interfaced with keypad and display where display shows energy can be used ie available battery bank storage details. Keypad receives distribution time needed for the particular load, and when to distribute the load from user, these information will be transmitted to the controller. We designed Smart Energy utilization and Distribution Management system implemented it , and verified its performance on how efficiently it manages energy.

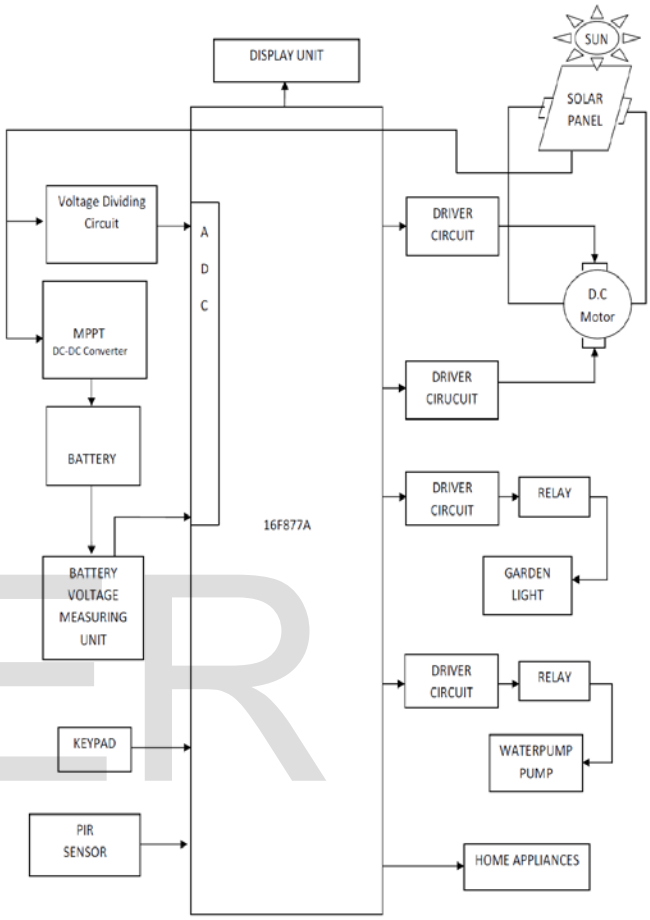

Fig 1. Overall Functional Block

The overall project is divided into four segments which includes:

a. EFFICIENT ENERGY UTILIZATION

i) To make solar energy more viable, the efficiency of solar array systems must be maximized. A feasible approach to maximizing the efficiency of solar array systems is sun tracking. Solar modules are devices that cleanly convert sunlight into electricity and offer a practical solution to the problem of power generation in remote areas. The solar tracker designed and constructed in this project offers a reliable and affordable method of aligning a solar module with the sun in order to maximize its energy output. Automatic Sun Tracking System is a hybrid

hardware/software prototype, which automatically provides best alignment of solar panel with the sun, to get maximum output (electricity).

Microcontroller is connected with two driver circuit to switch the motor. Depends on the voltage Vs sensing from the Solar panel, tracking is done with the help of DC motor. the project's focus is on embedded software control, the microcontroller is the heart of the system. The microcontroller selected for this project had to be able to convert the analog photocell voltage into digital values and also provide four output channels to control motor rotation.

In this sun tracking system, polycrystalline PV cells itself used as the sensors to determine the solar irradiance. The very important electrical characteristic of the solar panel used is the short circuit current, Isc. Isc increases with the increase in the irradiance. To put it more accurate, Isc is proportional to the irradiance in the cosine function of the angle between a normal to the collector face and the incoming solar beam radiation.

The analog-to-digital (A/D) converter module can have up to eight analog inputs for a device. The analog input charges a sample and hold capacitor. The output of the sample and hold capacitor is the input into the converter. The converter then generates a digital result of this analog level via successive approximation.

Fig 2. Photovoltaic Tracking System

This A/D conversion, of the analog input signal, results in a corresponding 10-bit digital number. The analog reference voltages (positive and negative supply) are software selectable to the device's supply voltage or the voltage level.

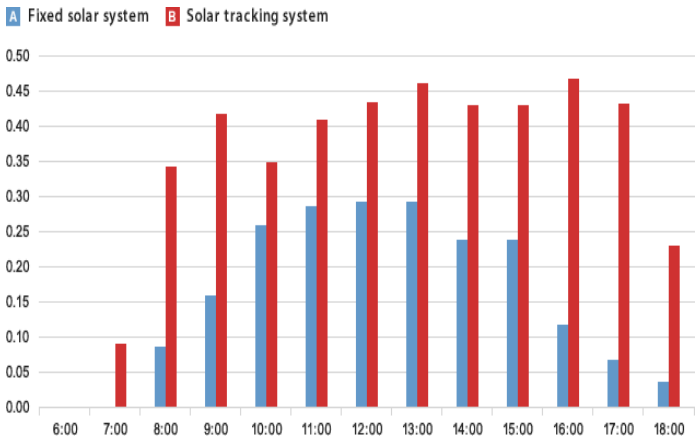

Fig 3.Efficiency of solar Tracking System

Rotate and Tilt structure is chosen for a smoother movement on dynamic search system to get Impp. This structure is friendly to the base motor. It does not stress the first level structure through unnecessary load torque from the structure above it. This design involves first rotating the PV panel to the desired direction and then tilting it to the desired tilt angle in order to get maximum irradiance. Rotate and tilt system has a rotational structure at the base platform and the tilting structure at the second level. To make sure the structure is stable and the load torque is constant for the rotational motor, the centre of gravity of tilting structure is aligned at the rotating centre.

Usually, the system measures Voc and calculate the operating voltage. This method has some disadvantages, temporary loss of power being an obvious one. An alternate method would be to use one or more monitoring cells, but they also need to be chosen and placed very carefully to reflect the true open circuit voltage of the system. To overcome the disadvantage, we can give time delay if the tracking happens often. So that this will significantly increase the top power drawn from the same PV installation.

If any fluctuation detect by ADC then motor step is taken and there is a delay set. so after some time motor start stepping as per ADC signal. Small minimum change in intensity is required before a further step is taken. Besides the algorithm, searching conditions need to be specified to anticipate the changing environment condition such as movement of cloud over the sun which causes a variation in the intensity of solar irradiance. Without these searching conditions, the sun tracking system will be searching nonstop to react to the changing intensity.

a) Condition for searching:

With the predetermined searching cycle, the system still needs another condition for starting the search. condition will be able to handle the current fluctuation in the solar intensity. The system will sample the solar intensity every second for a period of four seconds. The results are analyzed to check whether the peak to peak variation is less than a user predefined value. If the condition is satisfied, the system will start the search. This condition could increase the possibility of getting constant intensity during the search, To ease the concern over this matter, the search is made in the shortest time possible. Since the movement of the sun could be estimated about 15 degree is equal to an hour.

Sun tracking system will start tracking from sun rise. As the sun moves, the system will use the roll DC motor to track the movement in azimuth plane and tilt DC motor to track the movement in the altitude plane to get the best tilt angle.

b) MPPT

Power supplied from the panel is given to MPPT unit which has DC-DC Converter it coverts the supply voltage Vs from panel adequate to the Battery and increases the power consumption Pbat of battery.

A typical solar panel converts only 30 to 40 percent of the incident solar irradiation into electrical energy. Maximum power point tracking technique is used to improve the efficiency of the solar panel.

The maximum power point tracking is basically a load matching problem. In order to change the input resistance of the panel to match the load resistance Rint a buck converter is required.

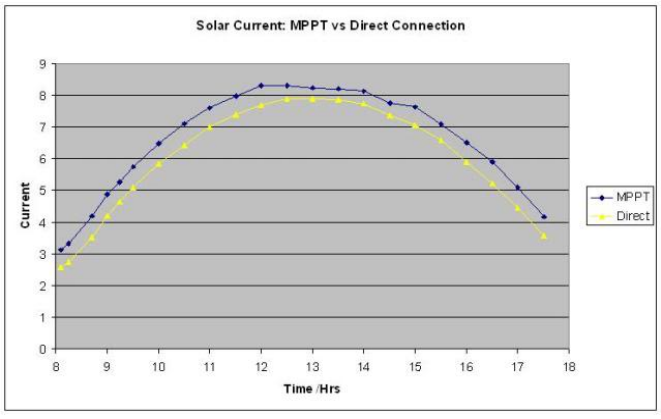

Fig. 4: Comparison between MPPT voltage and Fixed Voltage

ii) When the charging is full on batteries the load that is garden water pumping motor is operated to conserve energy instead of losing on clear sunny days.

b. INTELLIGENT ENERGY DISTRIBUTION MANAGEMENT

iii) Smart scheduler having keys to select appliances which should be operated with time scheduling, it has voltage measuring unit to calculate the available energy ton.

The most important purpose of the EDM- Energy Distribution System is to determine how efficiently generated power from solar panels can be used. For this purpose, EDM checks the status of a solar batteries charge and infers future power consumption by using specific methods to use solar power.

EDM decides the time to use stored energy in a battery by using power information, the residual amount of stored energy, and web information. For example, EDM considers weather, which affects the efficiency of photovoltaic panels, and power consumption, which is changing every hour, and decides the best time to use the stored energy.

Due to the intermittent nature of PV production, a display device has been installed in the household to provide expected hourly energy predictions. The consumers use this information to schedule their appliances and to anticipate the energy prices.

We assume that the energy supplier has different feed in tariff structures for different households depending on their energy production capacity. However customers pay the same tariff for each unit of grid imported power.

Manual participation by customers in demand response will not be possible. Some users may be unavailable or may not have the knowledge to appropriately respond to grid signals.

The success of the EDM therefore lies in its full automation. We propose an autonomous scheduling scheme by use of the smart scheduler. The smart scheduler is used here to refer to an intelligent device that control a household's energy consumption pattern to ensure that the aggregate demand does not exceed the pre-defined limit. Moreover, it ensures that the appliances are slotted in the time periods that would incur the least energy costs. It achieves this by generating optimal customer's appliances operating schedules without his/her direct involvement. It will show a warning to minimize or switch off the loads when ton is go beyond 50%.

The scheduler has a two way communication capability that enables it to send and receive signals to/from the consumer. Other than the "off" and "on" commands, the scheduler has additional "pause" and "resume" commands to enable it to manipulate the deferrable loads.

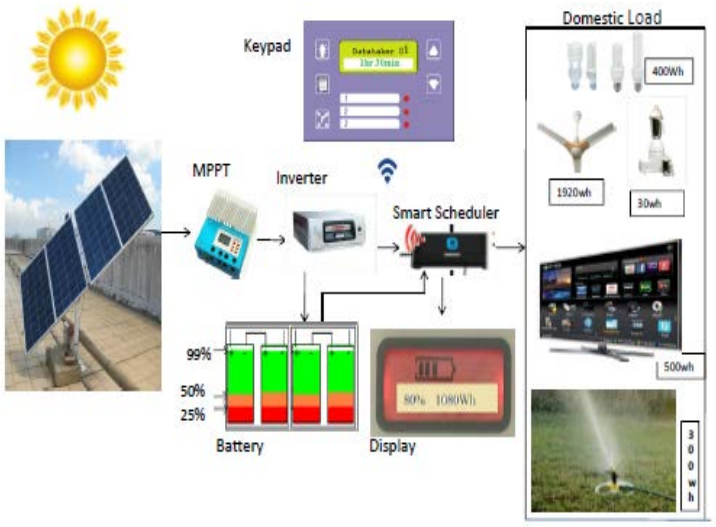

Fig 5.Architecture of Solar Efficient utilization and Distribution Management system.

Based on Scheduled pattern of the devices over the planning horizon, say a month, the scheduler calculates appliances' corresponding probability for each hour. This schedule can be cancelled if there is an emergency.

This computing information is computed for all the months in a year and stored. By monitoring these data over a given time span, the smart scheduler can estimate accurately the likelihood of a household using a certain device or a set of appliances. From these probabilities, the scheduler develops hourly profiles of each household device.

Numeric keypads usually operate in two modes: when Num Lock is off, keys 8, 6, 2, 4 act like an arrow keys and 7, 9, 3, 1 act like Home, PgUp, PgDn and End; when Num Lock is on, digits keys produce corresponding digits. These, however, differ from the numeric keys at the top of the keyboard in that, when combined with the Alt key on a PC, they are used to enter characters which may not be otherwise available: These are referred to as Alt codes. The numeric keypad always produces only numbers. The num lock key is replaced by the clear key.

iv) PIR sensor is used to save light load powers in garden and street lights as well as unnecessary loads in household. Time scheduler switch off the lamps after the scheduling period-particularly 10Pm for garden and street lights, after that there is any arrival of human it senses and switch on the lamp.

PIR sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensors range. They are small, inexpensive, low-power, easy to use and don't wear out. For that reason they are commonly found in appliances and gadgets used in homes or businesses. They are often referred to as PIR, "Passive Infrared", "Pyroelectric", or "IR motion" sensors.

PIRs are basically made of a pyroelectric sensor, which can detect levels of infrared radiation. Everything emits some low level radiation, and the hotter something is, the more radiation is emitted. The sensor in a motion detector is actually split in two halves. sensors use the This chip takes the output of the sensor and does some minor processing on it to emit a digital output pulse from the analog sensor.

V.EXPERIMENTAL RESULTS

Efficiency of solar Tracking System is shown in fig3. Comparison between MPPT voltage and Fixed Voltage is shown in fig 4.

To evaluate the performance of the proposed scheme, we simulated the daily energy use of a set of three household appliances using data obtained from The analysis considers energy costs under the three pricing scenarios discussed earlier.

Further, this study assumes that a household's PV generation must be able to meet at least 50% of its load demand.

Schedulable appliances requests were altered by systematically switching them off and on. MPLAB IDE is a Windows-based Integrated Development Environment for the Microchip Technology Incorporated PICmicrocontroller (MCU) and dsPIC digital signal controller (DSC) families.

PROTEUS VSM combines a superb mixed mode circuit simulator based on the industry standard SPICE3F5 with animated component models. And it provides an architecture in which additional animated models may be created by anyone, including end users.

Fig. 6 illustrates activation and deactivation of selected preemptive appliances. "1" represents "on" state and "0" the "off" state. Which is given by the keypad.

Fig. 7 illustrates activation and deactivation of selected preemptive appliances when battery voltage is at maximum level. Fig. 8 This simulation result illustrates activation and deactivation of selected garden lamp when PIR sences the human.

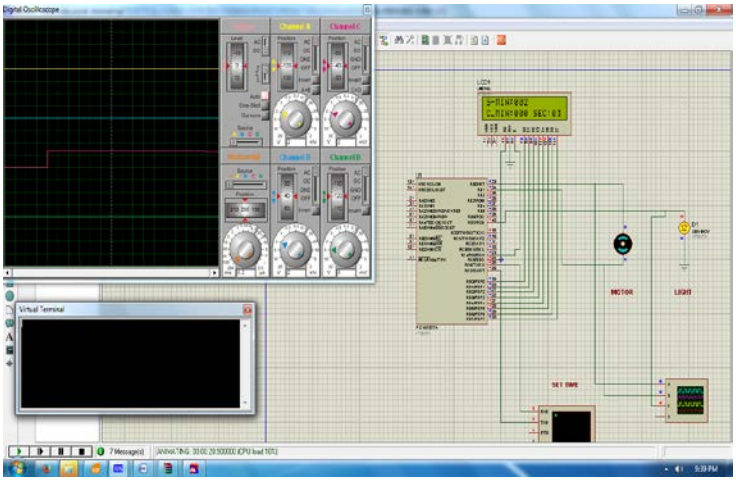

Fig6.Simulation Result of Energy Distribution Management System when selecting light load.

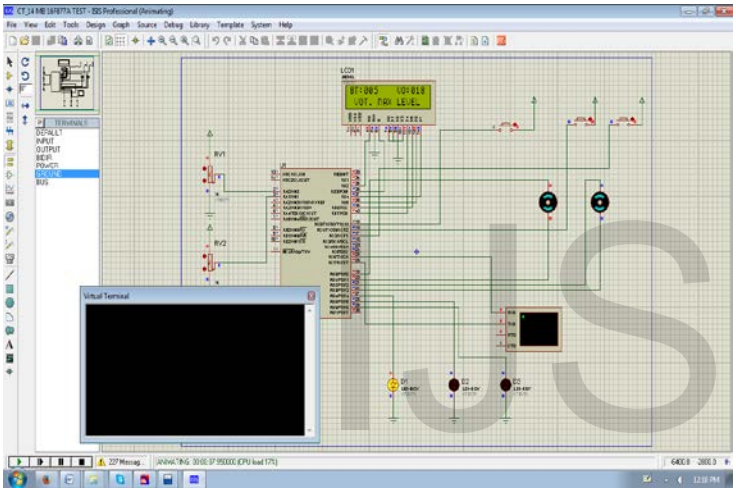

Fig7.Simulation Result of Energy Distribution Management System when Battery voltage is in maximum level.

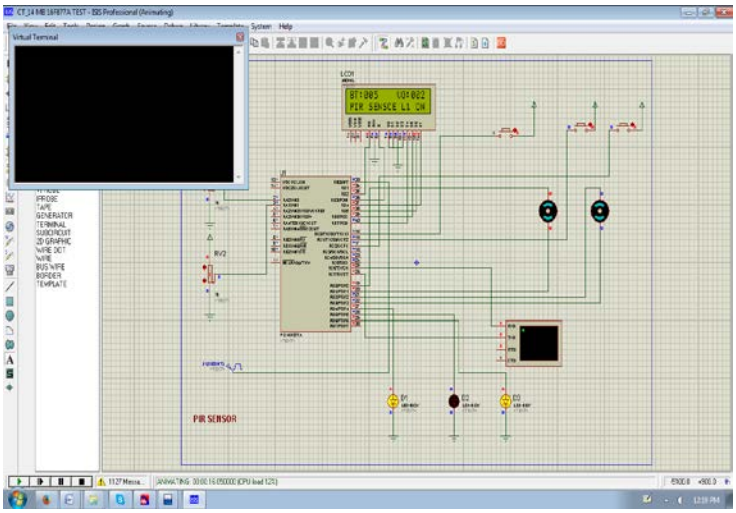

Fig8.Simulation Result of Energy Distribution Management System when PIR Sensor Operates.

VI. APPLICATIONS

- The cost of operation and maintenance of solar system is negligible
- Useful for supply power in remote areas without grid power.
- we can reduce the environmental impacts
- High subsidy results in early pay back
- Water pump can be operated frequntly because it is completely automized
- Efficient and effective use of electricity and water.
- Highly reliable, Durable
- Easy to remove, transport and store
- Simple to install

VII.CONCLUSION

In this paper, the proposed system gave improved energy efficiency compared with a normal utility interactive system. Dual MPPT Tracking provides 30-40% more efficiency then conventional system. The main idea is to encourage customers not only to participate in energy generation but also in efficient electricity consumption. The study also addresses the challenge of manual demand response where electricity users have to actively participate in Demand Side Management by submitting requests and responding to price notifications.

In our method, appliances time of use probabilities have been applied as a technique of learning the customers electricity demand pattern. These past power consumption behaviors are converted to device schedules that are then used to autonomously regulate energy use.

From the simulated results, we observed that considerable savings in energy costs could be realized by consumers as compared to the traditional energy users. More savings could further be achieved through appropriately utilizing and scheduling load consumption.

VIII. FUTURE WORK

In future, More savings could further be achieved through increasing utilization of energy with more advanced MPPT technique and scheduling load consumption. The results show that through a carefully designed energy billing model, appliance scheduling could offer a viable solution to optimal power management among energy users.

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