# Design and Analysis of Hybrid Energy System

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***Abstract***

*This paper presents a study on of hybrid solar and wind energy systems behaviour, which allows employing renewable and variable in time energy sources with a continuous supply. Solar energy is not a revolutionary technology by any means and has long been criticized for its inefficiency and other shortcomings. "What do we do when the sun goes away every night"? Well with batteries, of course! But it's not that simple, the battery currents and voltages need to be regulated to provide optimum power transfer to the client because efficiency reduces cost and high cost is the last major road block in making solar &wind feasible energy alternative. The heart of our product then is microprocessor control of the stored energy. The approach taken was essentially an embedded systems approach. We needed to interface the microprocessor, with some current/voltage limiting hardware, a voltage regulator, relay, and various other necessary components to effectively read the currents coming off the panels and entering the batteries, and those currents leaving the batteries to power some desired application.*

**Keywords—** *Solar, control, hybrid energy, renewable energy, wind*

## I. INTRODUCTION

Harnessing solar and wind energy research for some time now. Photovoltaic solar cells convert light energy to high voltage and low current, which can be manipulated to provide power to our modern electrical devices and homes [1, 2]. With the ever-rising costs of fossil fuels, the need for an efficient and affordable solar and wind energy system has never been greater. This is why our market of interest focuses on the residential community to help offset the cost of utilities while striving to be environmentally conscientious. One group, Energy evolution claims, "The sunlight which reaches the earth's surface is enough to provide 2850times as much energy as we can currently use. On a global average, each square meter of land is exposed to enough sunlight to produce 1,700 kWh of power every year."[3, 4] However, the energy from this foil would be useless if it could not be stored in some manner for use at another time when the sun may not be as readily available (i.e. batteries). The field of solar and wind energy engineering requires products to maximize this power storage and monitor the power levels. In addition, the optimal sizing of such systems is required to reduce the initial costs of the system and increase the reliability.

Therefore, recently, many studies have been done using artificial optimization for hybrid systems [5]. The artificial optimization results provide a set of optimal system combinations which gives the decision makers the freedom to select the best combination based on the site specifications. Our project is essentially all of the technology that must be in place in order to interface the power-generating solar cells and wind turbine to the power-storing batteries. In order to accomplish this we must choose a microprocessor, generate its necessary control signals, read in the voltages and currents corning off both the batteries and panels, and use a buck regulator to manipulate the voltages and currents according to an optimization scheme regulated by the microprocessor [6, 7].

Hybrid power systems consist on a combination of renewable energy sources such as: photovoltaic (PV), wind generators, hydro, etc., to charge batteries and provide power to meet the energy demand, considering the local geography and other details of the place of installation. These types of systems, which are not connected to the main utility grid, are also used in stand-alone applications and operate independently and reliably [8-10]. The best applications for these systems are on remote places, like as example, rural villages, telecommunications, etc. Nowadays renewable energy technologies offer important benefits compared to those of conventional energy source [11, 12].

In this paper, a savours wind turbine whose design and performance measurements are known, is integrated with PV system. A savours type wind turbine has been used for this study because the turbine has been planned for use with a gear. This kind of turbine is the best solution for this kind of applications to get the advantage of the wind that is created by the slow wind [13, 14]. An evaluation of the combined solar and wind system for light load energy requirements such as lighting, hand phone charger and its prototype was build. Experimental results of the savonius rotor shows that the system can be used effectively to obtain energy requirements on small wind .in order to support energy requirements continuously, the system should b used with PV panels. This project also will bring to light discussion on programming that used to program the PIC. The hybrid wind/solar systems are automatically switched to ensure constant current supply at the output without interruption. For overall safety of the system in case of over current, a regulator IC is used to prevent voltage spikes and over charging from damaging the circuit and battery and might present potential danger.

## II. SYSTEM DESIGN AND MODELLING

### *A. Control unit*

This powerful (200 nanosecond instruction exaction) yet easy-to-program (35signal word instruction) CMOS FLASH-based 8-bit microcontroller packs microchip's powerful PIC architecture into an 40- or 44-pin packages and is upwards compatible with other devices .the PIC16F877A features 256 bytes of 10-bit analog-to-digital (A/D) converter, all of this features make it ideal for more advances level A/D application in automotive, industrial, appliances and consumer applications [15].

PIC16F877A-I/P microcontroller is used to control the whole system. it is designed using flash technology. So the PIC can read/write program for more than 100,000times.the PIC can store up to 8Kbytes program. a program is download into PIC through PIC programmer .this program will used to operate the system.

OSC1 and OSC2 pins are connected to 20MHZ crystal to execute very single program line in the system. 20MHZ crystal is used because this is the maximum frequency that the PIC can support. If over frequency the PIC will burn. Else if crystal speed less than 20MHZ then PIC response sped will slower. The MCLR pin of the PIC is pull up to 5V through a 10K resister.

The PIC cans operate using 4.5V to 6.0V DC voltage. In the project is operating at 5.0V (by using 7805). It is DIP layout (dual in line package) and suitable for student project .it has 40 pins but only 33 I/O pins can be set as digital input or digital output. The digital output of PIC is 5V (for signal 1) and 0V (for signal 0) these signals will be directly connected to actuators for control purpose. When PIC pin is set as digital input. It will detect input voltage 5V as signal 1 and 0V as signal 0. Any voltage less than 0V or more than 5V will damage PIC.

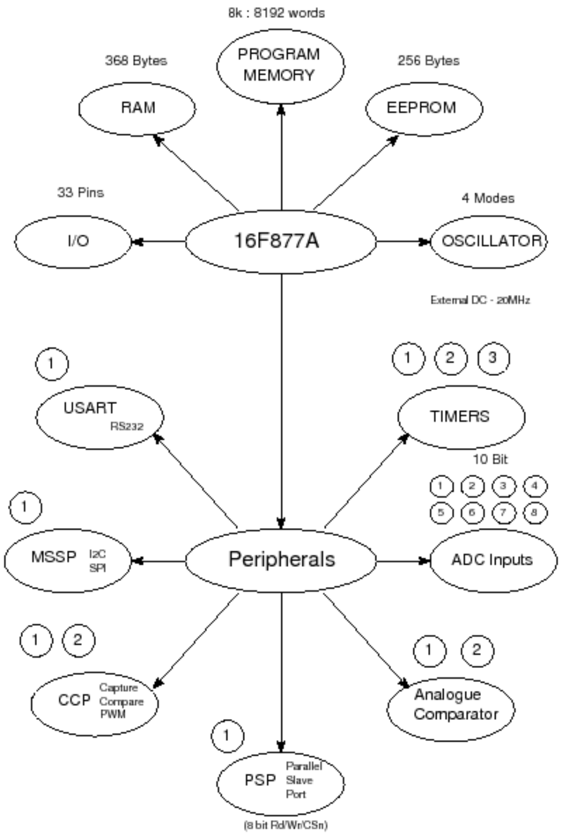


**Fig. 1. PIC16F877A bubble diagram**

### *B. Solar panel*

Solar panels convert sunlight directly into 12V electricity. These panels are used to charge a battery in sunny or cloudy conditions. The condition of solar panel is also an important factor in order to increase the amount of solar radiation harvested from sun. The surface dusts and damages can reduce the performance of the panel and effect the panel's chemical materials [16]. A 12v solar panel that is supplied by the energy lab in the faculty was used in testing and observing stage. It's common that 12v solar panel is probably one of the most popular solar panel products on the market, beside the 10watt solar panel.

For all practical purposes, how the three types work in application is very similar. It will all do the same thing; make electricity when the sun hits them. Thin film is often less efficient, but on the other hand they work better in hot climates due to not losing quite as much at high temperature.

In I/V curve, it has some parameters. Open-circuit voltage (VOC) is an operating point with shorted output; voltage and power equal zero. Maximum power (Vmp) is an operating voltage at peak power output. Maximum power (Pmp) is a peak output power point.

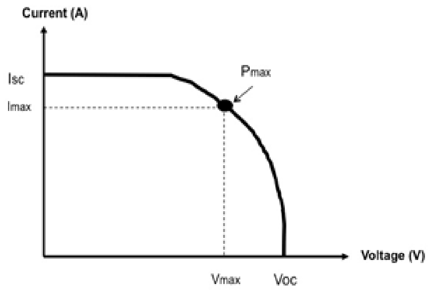


**Fig. 2. I/V Characteristics**

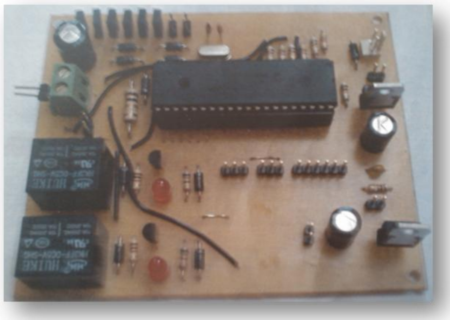

**Fig. 4. Overall physical layout of the wind and solar hybrid system**

### *C. Overall system block diagram*

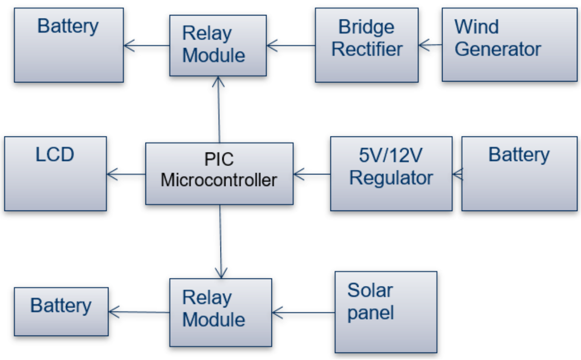


**Fig. 3. Overall system block diagram**

## III. RESULTS AND DISCUSSIONS

In this section, will deliver further to investigate and various outputs and effects of important functional block of portable hybrid wind and solar energy system. The result depicted will be accompanied with pictorial evidence for Ross-referencing. Some irregularities are highlighted and discrepancies discussed for analysis. outputs are discussed and analyzed independently to make it clearer for reader to understand the intricate working of this project. The wind and solar energy system is designed to work together to produce electricity.

Testing is made under hot sun with the solar panel and the turbine generator is connected to the circuit where PV terminal and its voltage is measured. The output of the PV and wind turbine generator where when the circuit is connected will light up red. This is turn show that the wind turbine and solar panel is connected to the board and ready to be connected to the rechargeable battery. The minimum voltage required for recharging is below 11V.by the results show that the solar panel successfully generates 13.78VDC.by the time data taken; there is no wind so that the LCD indicates 0.0V for wind generator. It's fulfils the requirement and the battery is recharged. CHg indicates 1 means solar panel is charging the battery.

**Table 1. Charging and discharging data**

| Voltage (V) | Current (A) | Status |
|---|---|---|
| 11.5 | 0.35 | Charging state |
| 12.0 | 0.35 | Charging state |
| 12.5 | 0.30 | Charging state |
| 13.0 | 0.25 | Charging state |
| 13.5 | 0.10 | Charging state |
| 14.0 | 0.08 | Discharging state |
| 13.6 | 0.05 | Discharging state |
| 13.0 | 0.03 | Discharging state |
| 12.6 | 0.30 | Charging state |

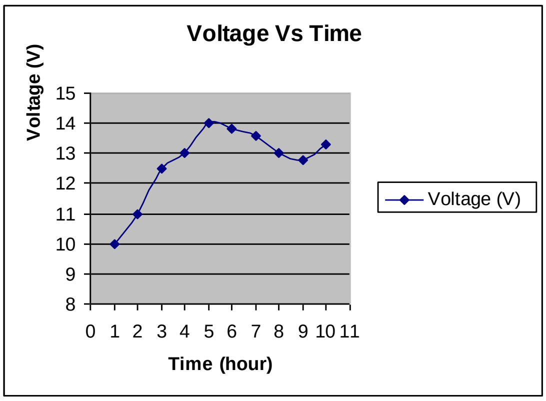


**Fig. 5. Charging and discharging of the battery**

Choosing the suitable number of diodes is essential to verify the lower threshold voltage rate chosen for "return to charging state tripping action". A quantity of two diodes is chosen in this design. As observed, a drop of around 1 volt in battery charge is not that critical so the voltage drop caused by two diodes is calculated as: 0.6+0.6 =1.2volts.

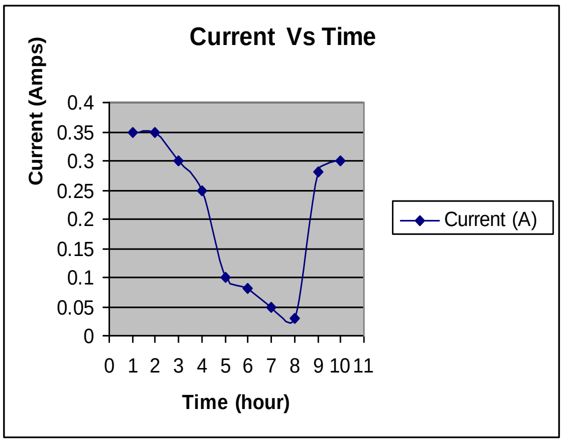


**Fig. 6. Current vs Time**

At the lower threshold level, the circuit will react sooner and switch back the relay to the charging mode. That means if the battery voltage drops approximately from 13.5 to 12.5 volts which is a fact that been observed experimentally. The Charging Behavior of Charge Controller circuit has been recorded in table 5.1 along with the corresponding status of battery. Figures 5.3 and 5.4 are charts displaying voltage and current behaviors during the charging and discharging modes in terms of time as recorded.

While the red LED is light up indicate that wind are charging the battery as from wind voltage 9.9V which is bigger than battery voltage and fulfil the requirement that battery voltage must less than11V in order to recharge

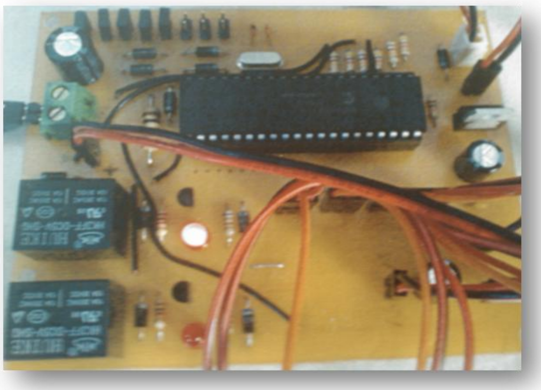

**Fig. 7. Wind charging**

Once the battery is connected to the renewable energy conversion circuit, the charging process takes place of charging depends on the intensity of solar energy from the sun and also the wind speed at that time. With this in mind, the charging process is allowed to continue until the battery is fully charged. This is where the LCD will show the battery level indicating full voltage.

## IV. CONCLUSIONS

This paper presents a study and analysis of a hybrid energy system was effectively conducted and done. The design concept consists of both solar and wind modules. Converting the AC current which is obtained from permanent magnet generator "car alternator" to DC current optimizes wind power. For solar power system, solar energy is absorbed by solar cells. The charge controller circuit designed charge the battery with DC current in order to maintain a continuous power supply at all times. The current is then converted into AC by the inverter circuit designed and stepped up to generate the desired voltage of 230 V AC at 50 Hz frequency.

The prototype device designed can be used as a power supply for light loads. It has several features and practical functions implemented within it. In fact, the device can be used as a portable power supply mean. It can be used for different types of batteries providing its charging voltage doesn't exceed approximately 14 volt, which is considered a bit of a drawback. The charge controller circuit has the ability to charge the battery again after discharging stage, but that enquires the battery voltage level to decrease by almost 1.2v to activate the replay as elaborated in the prior chapter. This means that it's not actually possible to charge the battery during this time. A buzzer and LED lights are fixed in the charge controller circuit to indicate the battery discharging stage.

The inverter circuit performs its duty in a likely good way and it's just suitable for the light loads "10 watt" proposed. However, the matter of harmonics and difficulties to achieve the full sinusoidal waveform is always an issue that has to be minimized and resolved to attain the most efficient power supply.

Overall, the prototype design is successfully designed and implemented on time. It can be said, that it effectively functions quite flawlessly as sketched. For the entire system's protection and safety a number of two "2 amps" fuses are used in the circuits in case if short circuit faults occur. The work, tasks, along with design have been done and materialized as per schedules and time line planned.

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