# Microcontroller Based Hybrid Renewable Energy System

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**Abstract: This paper presents the design and implementation of a hybrid renewable energy system. This system is composed of two subsystems sun tracking, and wind energy. The sun tracking system, tracks the sun locations from sun rise to sun set using a set of solar cells mounted on a movable mechanical system. A position control system is used to track the sun and trying to collect the largest amount of solar radiation and convert it into electrical energy. The wind energy system converts the wind energy into electrical energy by using a wind turbine and a DC generator. The solar cell and DC generator output are regulated, and fed to set of batteries. The batteries output is used to fed DC loads or AC loads through a three phase inverter circuit. The microcontroller is used in the design of the position control of the sun tracking system and in the control circuit of the three phase inverter. A powerful software package, called HOMER have been used.**

## I. Introduction

The use of renewable energy technology has been increased over the past years. However the drawback associated with renewable energy systems is the difficulty to guarantee reliable and uninterrupted output. With the growing concern about the ill-effects of using fossil fuels, their increasing costs and diminishing reserves, the use of clean and sustainable energy will have to increase in the future. Wind turbine generators are free from major environmental concerns and at the same time, cost competitive. Photovoltaic are still an expensive option. The maintenance required for these systems is very little compared with a diesel engine. A drawback, however, common to wind and solar options is their unpredictable nature and dependence on weather and climatic changes. Both these systems individually are not accurately predictable and to make them completely reliable these would have to oversize. This increase the total cost. An Option that could solve the problem is combining wind and solar energy into a hybrid generating system. The two random sources of energy, which individually have a low reliability, could as a whole have a higher reliability. It has been found that a hybrid wind-photovoltaic system is better than an individual wind or photovoltaic power system. Thereby an improvement in the system performance and dependability can be achieved without much increase in the cost. These options could be used wherever sufficient wind and solar resources are available.

Our system is a stand-alone hybrid system. Thus it does not interact with the grid at all. The load demand from the system has to be supplied solely by the system. The design of such a system therefore involves the determination of optimum values for the rated capacity of the wind turbine, the number of photovoltaic arrays and the number of batteries. These three parameters have to be chosen so that the system as a whole meets the required reliability conditions.

The paper is organized as follows: section II is devoted to get an overview of the system. A there phase inverter bridge and associated power electronics circuitry are presented in section III. In section IV the detailed experimental setup of the photovoltaic system is introduced. In section V the experimental setup of the wind energy system is introduced. Homer software package is described in section VI. Conclusions are found in section VII.

## II. Overview of the system

The design and implementation of a hybrid renewable energy system was done in the laboratory. This system is composed of two subsystems sun tracking, and wind energy. The position control of sun tracking system was implemented using microcontroller in order to track the sun locations from sun rise to sun set. The electrical DC output voltage from the photovoltaic and win energy systems was collected into a set of batteries through a shunt regulator charging circuit. The three phase power inverter of microcontroller based control circuit was designed and implemented in order to supply the electrical AC loads.

## III. Three Phase Inverter Bridge[8]

In this section the design and implementation of a three phase inverter circuit was carried out in the laboratory which consists primarily of an array of power transistors, Metal-Oxide-Semiconductor field effect transistors (MOSFET) devices. The architecture of such inverter circuits is designed to enable switching of the DC supply voltage supplied from the batteries across any pair of phases in either polarity, the implemented inverter power circuit is shown in fig(2). The microcontroller (pic16f877) is used in the design of the gate control circuit of the inverter power electronic switches. The photo of the inerter control circuit which was designed and implemented in the laboratory is shown in fig(3).

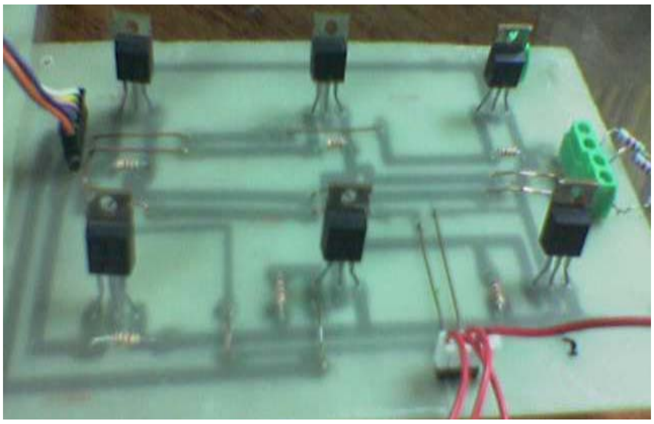


Fig.(2) three-phase inverter power circuit.

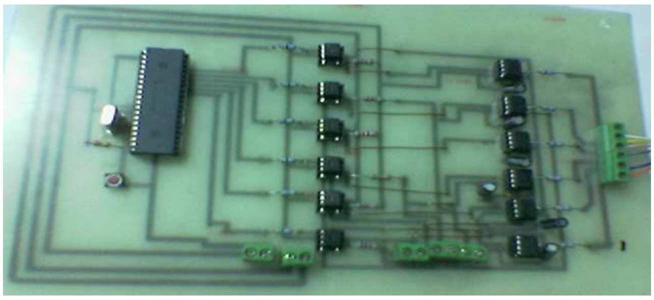
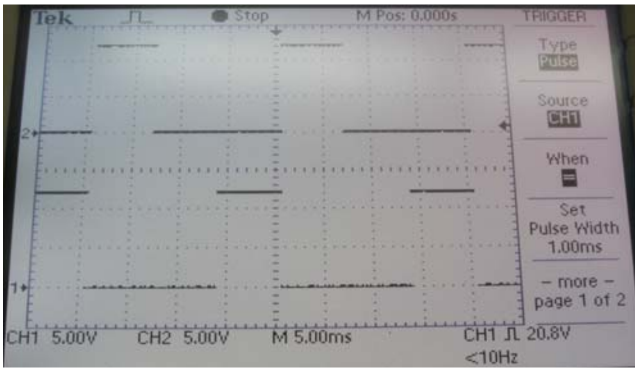


Fig.(3) three-phase inverter control circuit.

The output of the inverter control circuit is a 6-pulse square wave. Fig(4) shows a two gate pulses of the two transistors 2 and 4 on a digital oscilloscope.




Fig(4). Firing pulses of the transistors 2 and 4.

Phase voltages $V_{an}$ and $V_{bn}$ of the stare connected load, for the three phase inverter are shown in fig(5).

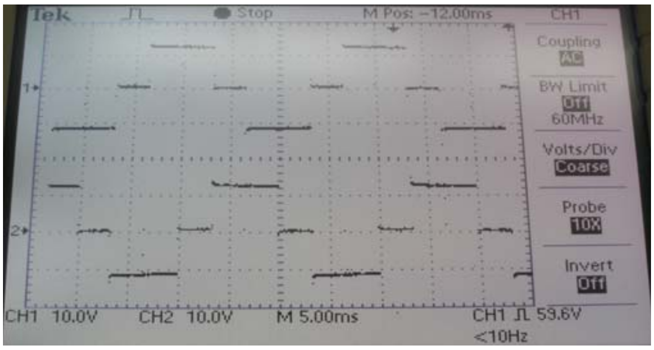



Fig.(5) $V_{an}$ and $V_{bn}$ of stare connected load.

Also the three phase inverter phase voltages $V_{an}$ and $V_{cn}$ of star connected load are shown in fig(6).

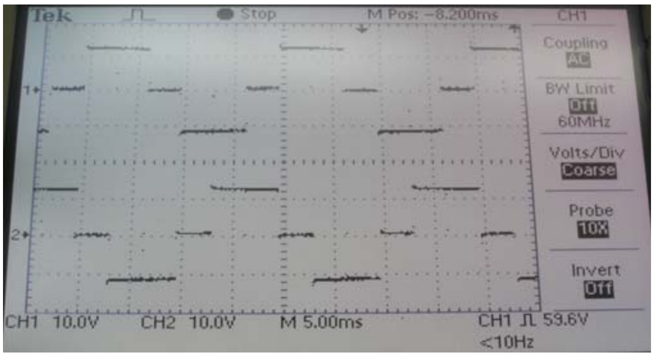



Fig.(6) $V_{an}$ and $V_{cn}$ of stare connected load.

The three phase inverter line voltages $V_{ab}$ and $V_{bc}$ of a star connected load are shown in fig(7).

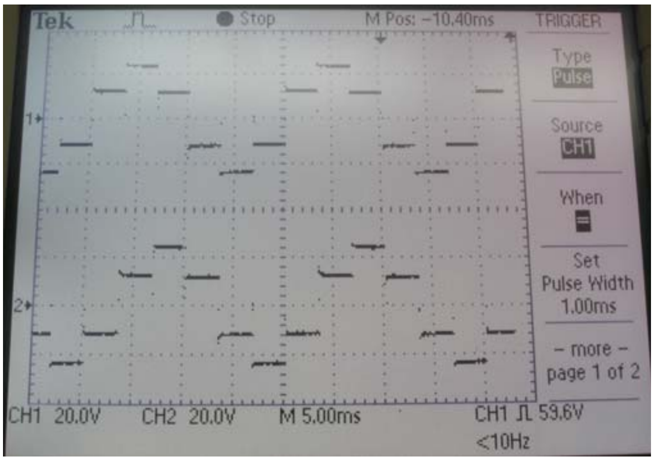



Fig.(7) $V_{ab}$ and $V_{bc}$ of stare connected load

Also the three phase inverter line voltages $V_{bc}$ and $V_{ca}$ of a star connected load are shown in fig(8).

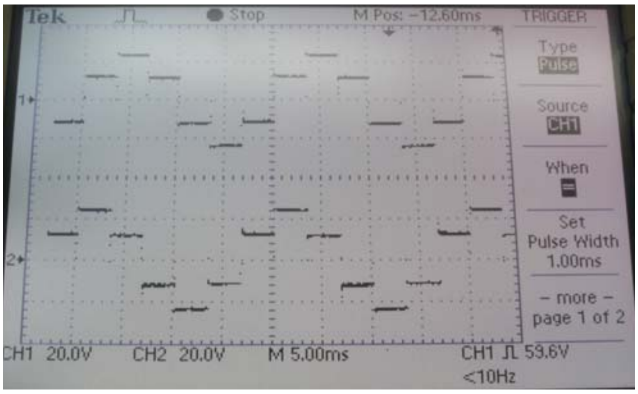



Fig.(8) $V_{bc}$ and $V_{ca}$ of stare connected load.

## IV. Photovoltaic System [1]- [6]

Solar cell technology dates to 1839 when French physicist Antoine-Cesar Becquerel observed that shining light on an electrode submerged in a conductive solution would create an electric current. In 1941, the scientist Russell invented a silicon solar cell. Improved solar cells became a reliable source of electricity for satellites, but their price horrified electric utilities, so they were only used when cheaper alternatives were unavailable. Sure, if you lived three miles down a dirt track or in the outback of Australia

PV could be cheaper than stringing a new power line. The design and implementation of a small sun tracking system was carried out in the lab. This system consists of light sensors, permanent magnet DC motor, microcontroller, relays and solar cell.The photocell with its mechanical setup which was designed and implemented in the laboratory is shown in fig.(9).

Fig.(9) Mechanical setup of the sun tracking system.

Fig.(10) shows the microcontroller based position control circuit of the sun tracking system.

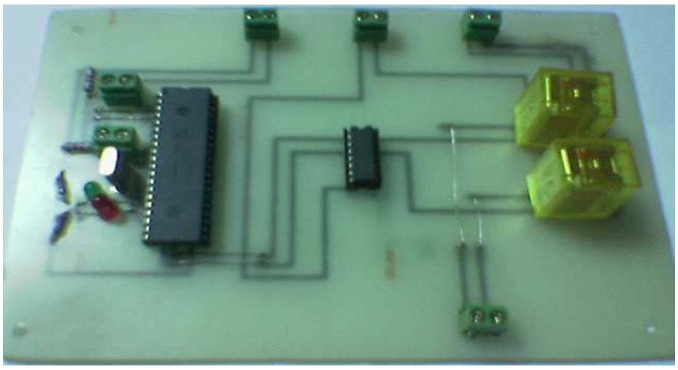


Fig.(10) control circuit of sun tracking system.

One of the most important components in our configuration for the sun tracking purpose, is the light sensors which convert the intensity of light to resistance, its main job is to take a signal from sun light and transmits it to the controller (microcontroller), the controller output is used to control the operation of the relay which drive the motor to the appropriate direction.The microcontroller program compare two voltage signals comes from the two photo-sensors by reading the analog magnitude and convert theses voltages into digital form. Those two digital voltages are compared using status register and depending on this comparison pin one or zero of PORT C in the microcontroller will operate and give a signal to one of the two relays in order to operate it and then run the motor in the desired direction. The flowchart of the microcontroller program is shown in fig.(11).

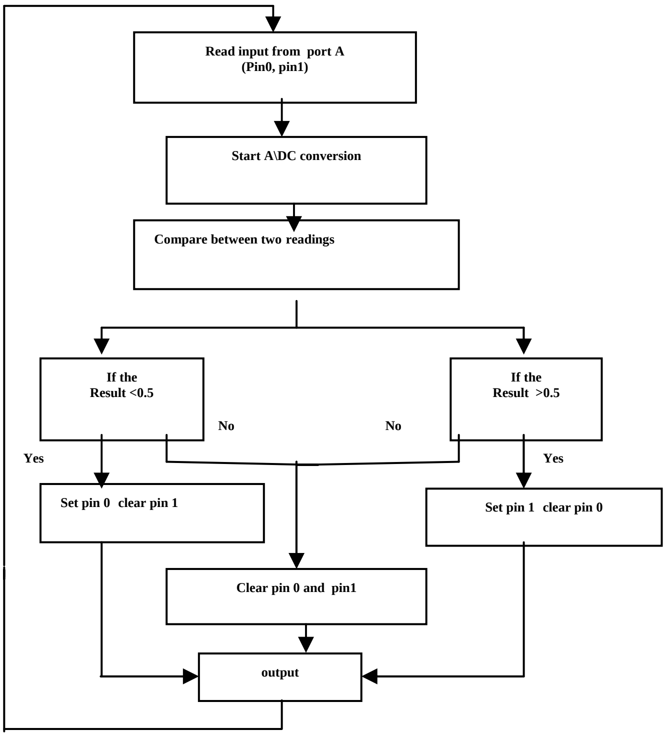



Fig.(11) position control flow chart.

Also the position control system consists of two relays to reverse the direction of the motor depending on the signal fed from the microprocessor. Reverse direction of the motor was done by changing the connection of two relays as shown in fig(12).

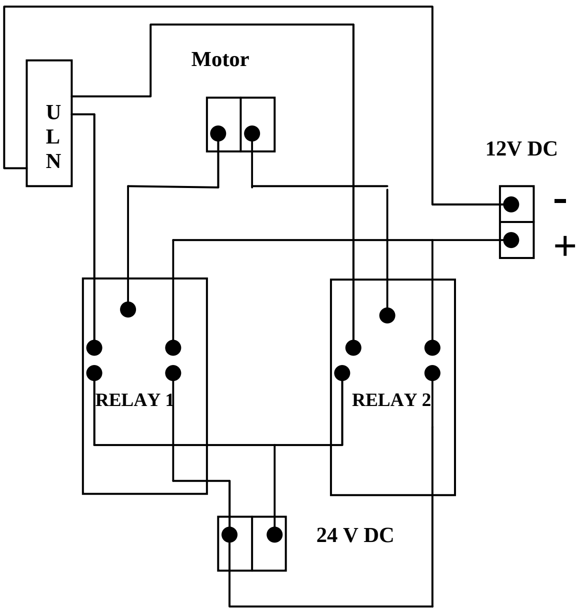



Fig.(12) relay control circuit of sun tracking system

The ULN2001A, ULN2002A, ULN2003A and ULN2004A are high voltage, high current Darlington arrays each containing seven open collector Darlington pairs with common emitters. Each channel rated at

500mA and can withstand peak currents of 600mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite the outputs to simplify board layout as shown in fig.(13).

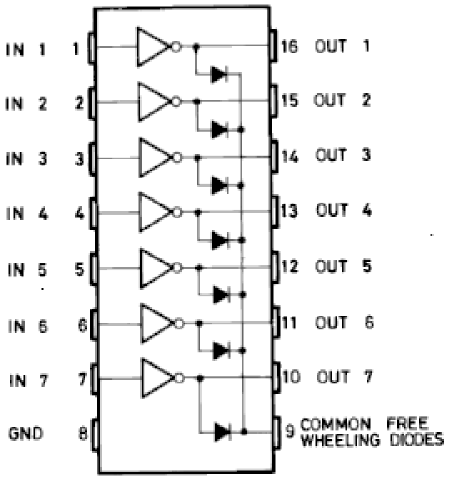



Fig.(13) ULN Pin assignment.

## IV. Wind Energy System [7]

The design and implementation of wind energy system was done in the laboratory as shown in fig.(14). In the experimental setup shown in fig.(14) we use a propeller of 108cm diameter. A chrome-plated iron rod with length 55cm then adding two supports with bearings to decrease the friction. All this set was fixed on a board of dimensions 40*15*5.5cm. The furling tail also fixed on the board at a distance 30 cm away from its end. This part always makes sure the propeller is facing the wind direction and operating at maximum Speed.

Fig.(14 )Experimental setup of wind energy system**.**

A permanent magnet DC generator was used to convert the mechanical energy comes from wind to electrical energy. A shunt regulator charging circuit was the first circuit to meet the output terminals of the generator as shown in fig.(15). It is simply used to adjust the output voltage from the generator and from the photovoltaic system to the batteries.

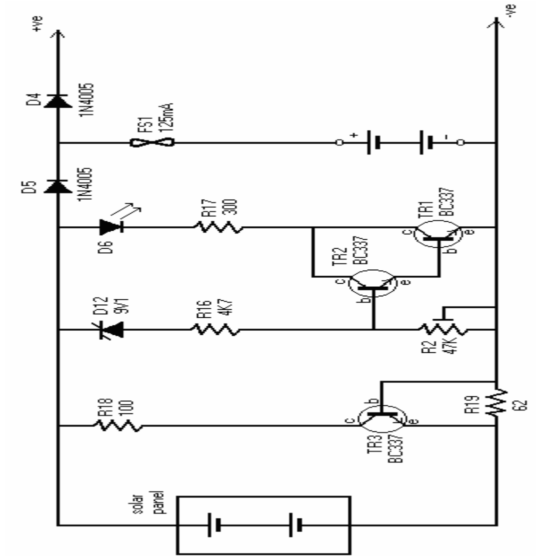



Fig.(15) Shunt regulator battery charging circuit.

## V. Homer Software Package [ 9]

HOMER, is the micro power optimization model, simplifies the task of evaluating designs of both off-grid and grid-connected power systems for a variety of applications. When you design a power system, you must make many decisions about the configuration of the system: What components does it make sense to include in the system design? How many and what size of each component should you use? The large number of technology options and the variation in technology costs and availability of energy resources make these decisions difficult. Homer's optimization and sensitivity analysis algorithms make it easier to evaluate many possible system configurations.

To use HOMER, you provide the model with inputs, which describe technology options, component costs, and resource availability. HOMER uses these inputs to simulate different system configurations, or combinations of components, and generates results that you can view as a list of feasible configurations sorted by net present cost. HOMER also displays simulation results in a wide variety of tables and graphs that help you compare configurations and evaluate them on their economic and technical merits. You can export the tables and graphs for use in reports and presentations.

HOMER simulates the operation of a system by making energy balance calculations for each of the 8,760 hours in a year. For each hour, HOMER compares the electric and thermal demand in the hour to the energy that the system can supply in that hour, and calculates the flows of energy to and from each component of the system. For systems that include batteries or fuel-powered generators, HOMER also decides for each hour how to operate the generators and whether to charge or discharge the batteries.

HOMER performs these energy balance calculations for each system configuration that you want to consider. It then determines whether a configuration is feasible, i.e., whether it can meet the electric demand under the conditions that you specify, and estimates the cost of installing and operating the system over the lifetime of the project. The system cost calculations account for costs such as capital, replacement, operation and maintenance, fuel, and interest.

After simulating all of the possible system configurations, HOMER displays a list of configurations, sorted by net present cost (sometimes called lifecycle cost), that you can use to compare system design options. When you define sensitivity variables as inputs, HOMER repeats the optimization process for each sensitivity variable that you specify. For example, if you define wind speed as a sensitivity variable, HOMER will simulate system configurations for the range of wind speeds that you specify.

## VI. Conclusions

In this paper a hybrid wind/ photovoltaic system was implemented and tested. The output of each system was regulated and fed to set of batteries through a shunt regulator charging circuit. The DC output voltage from the batteries is fed to a three-phase voltage fed inverter circuit such that the output of the inverter is a three-phase which is used to feed a three-phase load or infinite grid.

## X. References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