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AUTOMATIC PHOTOVOLTAIC WATER PUMPING SYSTEM

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Abstract— In India, some of the houses use overhead tanks without controller which causes overflow of water resulting in wastage of water as well as electricity. In this paper, we proposed and developed an Arduino based automatic water level controller to overcome the limitations of existing AC pump. This water pumping system consists of a Solar panel, DC Source, DC pump, controller, sensor and a relay. When water waves are sensed by the floating switch, the sensor produces the signal to the controller and the motor pump is automatically turned on and which is in turn driven by a DC source. The water level is measured with the help of sensors. If the water level in the sump goes below the floating switch then the motor is switched off assuming the water is empty.If the water level in the tank goes above the floating switch then the sensor switches off the pump assuming the water is full. The device automatically monitors the water level and hence triggers the relay which in turn controls the motor operation. A prototype is developed under laboratory test bench condition and it was observed that the water pumped using a DC source was able to suffice the daily requirement of a rural household.The DC pump is able to pump 5 liters per minute under laboratory test conditions.
Index Terms — controller, Sensors, Relay, Photovoltaic panel, Pump, Voltage regulator

I. INTRODUCTION

A solar water pumping system is the ideal solution for fulfilling the needs in renewable resource technology. With the use of microcontroller we control the operation of the solar power and pump.The amount and the rate at which the water is pumped by a solar water pumping sytem depends on solar radition duration in day ,the pumping capacity of the pump and also height or distance .The rate of the water pumped is determined by the intensity of the solar energy and the size of the photovoltaic array which is used to convert the solar energy into electricity. Photovoltaic water pumping systems meets are simple, reliable, cost competitive, and low maintenance.The water powered through water pump can be used for all household activities. This save more time and allows the people to concentrate on productive activities. Photovoltaic water pumping system is a modern, well-designed, and simple to maintain.

II.LITERATURE SURVEY

The main objective of using the photovoltaic water pumping system is to prevent wastage of time, water and power. In the PV module the solar cells are made from semiconductor material called silicon. When packets of light energy called photons strikes the solar cell, electrons are knocked loose from the material's atoms and these electrons passes through the p-n junction to produce electricity. The conductorswhich are consisting of the positive and negative sides of the material allow the charges to be captured in the form of a direct current. This current can then be used to power a load, such as a water pump, or it can also be stored in a battery [1]. A pump only need a some amount of power to produce a some amount of pressure and some amount of water flow.From this we can save money by using only required PV array.We should also overcome the friction created when water passes along the insides of the pipe, the longer the distance it runs at greater flow rates it requires large diameter pipe to minimize the amount of the pressure lost due to friction[2].

The components used in the solar-powered water pump system are the photo voltaic panel, microcontroller, and an dc pump. Solar irradiance also plays a prominent role in proper functioning of the PVWS. Solar irradiance is defined as the amount of solar energy received in a particular area or a surface . Solar irradiance is expressed in term of kilo watts per meter square .Here it is nothing but the solar panel surface.The intensity of sunlight also varies from one region to another and also the angle in which the solar beams are incident.The intensity of light is very high when there is not disturbances in the atmosphere and when the sun is straight above our head . Conversely,the intensity of the sun is least during the dawn and the dusk as there is more disturbances in the atmosphere. [3].

III. PROPOSED WORK

In this the main constituents are microcontroller and the heart of the system that is the solar module. The solar powered water pumping system also consists of components that include pump, controller, Arduino and sensor. In our proposed

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work we have used a DC source at a laboratory setup in place of Solar panel.

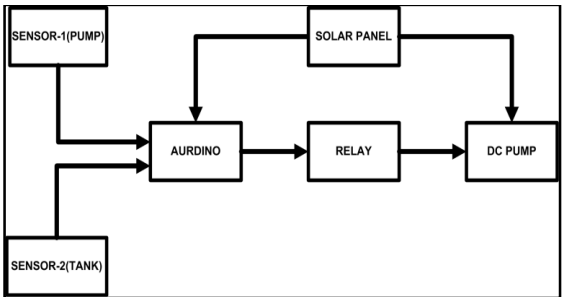

Figure1. Proposed Block diagram

The proposed block diagram as described in Fig. 1 is explained below

A. Solar module

The smallest unit of PV panel is a cell. Solar panels or module generates direct current which is given to the DC motor through an arduino controller. A group of modules constitute an array. Photovoltaic are solar cells that convert sunlight to D.C electricity. The solar array is chosen considering availability of yearly solar radiation on location and power required to operate water pump. The solar module is as shown below in the Figure 2.Here we have used a regulated DC source instead of solar panel. The voltage was given in a range of 12V to 14V and the current drawn by the pump was 3A.

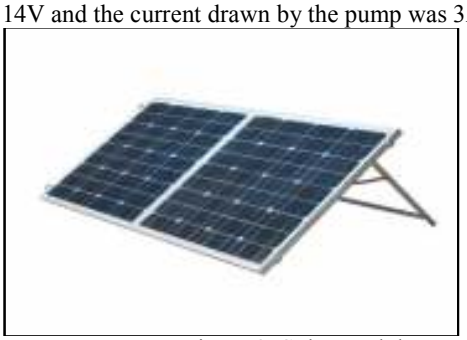

Figure 2. Solar module

B. Pumps

DC motor pumps uses very less energy when compared of AC pump. Water pumping capability of pump is expressed in gallons per minute (gpm) or gallons per hours (gph).DC pumps are classified as displacement pumps or centrifugal or submersible or surface types . Displacement pumps use diaphragms, vanes to seal water in a chamber and force it through a discharge outlet. Centrifugal pumps use a spinning impeller that adds energy to the water and pushes into the system, similar to a water wheel. Submersible pumps, placed down in a well or sump are highly reliable because they are not exposed to freezing temperatures and do not need special protection from the elements. Surface pumps, located near the water surface, are used primarily for moving water through a pipeline. Some surface pumps can develop high-heads and are suitable for moving water long distances or to high elevations. In this project we are using a dc submersible pump rather than ac pump. We have used a submersible DC water pump as it is more advantageous than any other pumps and safety of the pump can be ensured since it will be a submersible.

C. Controller

The controller protects the pump from high voltage and high current conditions and maximizes the amount of water pumped even under less irradiation. The damage to the pump can be prevented by the use of this controller. The controller increases the durability and efficiency of the pump and hence it can also be maintained for longer duration.

D. Arduino

Arduinois an open-source computer hardware and software tool and user community that designs, manufactures microcontroller-based kits for building digital devices and interactive objects which can sense and control objects in the physical world. We have chosen arduino because it is user friendly application which uses simple instructions. Arduino used in our prototype was ATmega328 which has an operating voltage of 5V.The clock speed of Arduino is 16MHz. Arduino is also cheaper when compared to other microcontrollers.The pin configuration of the Arduino is shown in Fig.3.

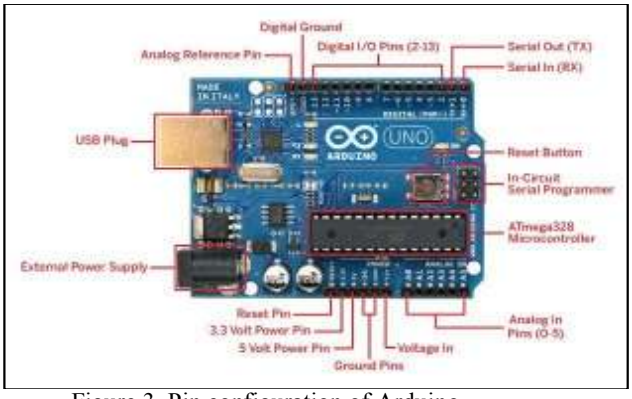

Figure 3. Pin configuration of Arduino.

E. Sensors

A float switch which acts as sensors turns the pump ON and OFF when filing the overhead tank . It is similar to the float in a toilet tank but it is connected to the pump controller. Here we use two sensors one is kept at the overhead tank which indicates the status of the tank whether it is empty or full and other sensor is kept inside the sump which indicated whether the sump is full or empty.When water level in the sump is low controller cuts off electrodes and protect the pump from low water level.Another sensor is used in the storage where it indicates the presence of ample

amount of water ensuring the quantity of water does not go below the required limits .This is monitored by the use of the above Arduino represented in Fig. 3.

IV. CIRCUIT DIAGRAM DESCRIPTION

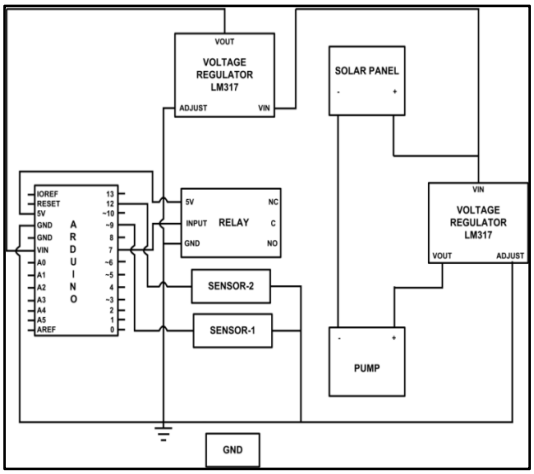

Figure 4. Circuit diagram

This circuit consists of Arduino, solar panel/DC source, voltage regulator, relay and dc pump.The solar panel is the centre for generation of dc power in our system. This power is distributed to controller and pump as inputs. The controller part consists of voltage regulator, relay and Arduino. The voltage regulator limits the excess voltage and supply the required amount of power to pump and Arduino respectively.The Arduino has two more inputs from the sensors, one from reservoir of water which is sump and another from the overhead tank.The relay is triggered based on the inputs received from the two sensors. The relayy acts like an intermediate switch between the Arduino and the pump.The relay has input, normally closed, normally open and common pins.The power for the relay is derived from Arduino.The relay receives the commands from any one of the digital input/output pins of Arduino, which in turn acts like a switch and activates the pumping mechanism of water .The main aim of using controller is to monitor the input voltage from the solar panel/dc source and to control the pump.

V. FACTORS AFFECTING WATER PUMP

A. Pressure

In the design of a solar pumping system , pressure plays a major role, as the pump must overcome and move a certain amount of water . Any deviation between the source of water and the destination will affect the flow of water and the pressure needed to be created in order to elevate the water. Pressure is expressed in terms of pounds per square inch (psi). The flow of the water decreases as the pressure increases.

$$\text{Pressure} \sim (1/\text{Flow})$$

B. Pump power

Solar water pump produces a range of flow and pressure. Solar water pump draws a certain amount of power according to the amount of pressure that is required to pump the water .Power is expressed in terms of watts likewise photovoltaic panels are also rated in terms of watts .While choosing certain photovoltaic panel array it necessary to consider the specifications.Addition of photovoltaic panel may enable the pump to turn ON faster and later in the day or under low light conditions, but adding extra photovoltaic power will not at all increase the rate of flow when the radiations of the sun are high[2].

C. Flow rate of pump

The flow rate of the pump must be determined in order to avoid losses. The flow rate for the pump is calculated by taking the ratio of regular water needs to that of the number of maximum number of availability of the sun in terms of hours per day.

$$Flow = \frac{Dailyneeds\left(\frac{Gallons}{Day}\right)}{NumberofPeakHours\left(\frac{Hours}{Day}\right)} \qquad (1)$$

D. Friction loss

Friction loss is nothing but the loss of the pressure that occurs due to the friction of the water as it flows through the pipe. the pressure loss is due to the valves and fittings. Friction loss due to the can be determined by the following factors. Firstly the size of the pipe that is the inside diameter of the pipe , next is the flow rate of the water inside the pipe, the roughness of the pipeand the length of the pipe. We mainly use pipes of thermoplastics that are of polyvinyl chloride because they are flexible,tough and light and provide corrosion resistance. Friction losses also occur in valves and fittings. The resistance in the valves and fittings also contributes to the overall loss. The system has to be well designed system so the resistance inside the fittings and valves must be minimised as much as possible.

VI. ADVANTAGES

A. Saves power

It can be used in places where there is problem of load Shedding or where there is no electricity access. It limits the amount of electricity, as it is automatically controlled. Today energy conservation is the utmost need and it our duty to save energy for future.

B. Saves Money

Automatic water level controller saves power, it saves money as well. Regulation of water is optimized using this systemwhich means that the

wastage of electricity and wastage of water are minimised.This also saves a huge amount of investment along without any manpower involved.

C. Works Automatically

The most advantage of water level controller is that it can work on its own. It is because of relay and timer used in the controller switches the On and Off operation automatically.

D. Minimises Water wastage

The water usage can be minimized with a water level controller. Water pumps are only used more during the day time . A water controller is helpful because it automatically provides more water during the day and less water at night. As a result, water remains at its appropriate level at all times.

VII. RESULTS AND DISCUSSIONS

The existing project consists of PIC microcontroller, where as in our project we have used Arduino as the microcontroller .The existing project have used two solar panels of each rating 37Wp .When the solar irradiation is 100W/m^2 it is pumping upto two liters per minute which would approximately takes 4 and a half hour to fill 500 liters overhead tank which is at a height of 35 feet including sump depth. In our project we have used a DC source in place of solar panel with a total power of 40W (I=3A, V=14V) which can pump upto four liters per minute approximately. This has increased the overall efficiency of the system by twice.

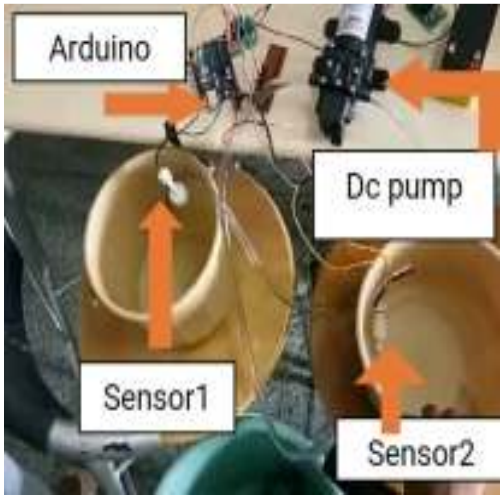

Figure5:Demonstration of prototype

CONCLUSION

This project has achieved its main objectives. Moreover, this project includes the designing and development of automatic water pumping system which is uses in easier and the best way of software and hardware thatmatches together for the interfacing purposes. This system uses the advance of the sensing technology to detect the water level. This system is very beneficial and useful in urban as well as rural areas. It helps in the efficient utilization of available water and energy resourses. If it is used on a large scale, it can provide a vast contribution in the conservation of water for us and the future generations.

FUTURE WORK

Automatic water level monitoring system has a good scope in future especially for agriculture sector and rural household.This prototype will be installed for a house using solar panel to evaluate the performance of the system under different irradiation. There are many areas where there is a need for water level controller. We can make this project wireless using transmitters and receivers. We can also add Ethernet shield so that we can get all the information using mobile phones and control it accordingly.

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