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# LOW COST SMART SOLAR POWERED AUTOMATIC IRRIGATION SYSTEM

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## ABSTRACT

In developing countries Photovoltaic energy can find many applications in agriculture, providing electrical energy in various cases, particularly OFF grid and desert area. Today Modern irrigation methods in developing country are needed to fulfill the food demands. Although in these countries Ethiopia, there are many diesel engine operated and rare solar operated water pumps for irrigation; but due to the running cost of diesel and capital cost of photovoltaic irrigation system. So Photovoltaic water pumping system is one of the best alternative methods for irrigation .In this paper solar powered smart automatic irrigation systems are the solution to the farmers. This system consists of solar powered water pump along with a soil moisture sensors; solenoid valve along with automatic water level sensor and water sprinkler to clean the solar array. The system is implemented both practical and software simulation.

**KEYWORDS:** Automatic irrigation, solar power, photovoltaic systems.

## INTRODUCTION

Recently in the Ethiopia the water demand has been increased due to the increase in the population and the availability of water has become more crucial than ever before. A source of energy to pump water and controlling mechanisms are also a big problem in developing countries like Ethiopia [4]. In Developing countries like Ethiopia a grid system is often too expensive because rural villages are separately populated too far away from existing grid lines. Even if fuel is available within the country, transporting that fuel to remote rural villages can be difficult and the running cost also high. There are no roads or supporting infrastructure in many remote villages. The use of renewable energy is attractive for water pumping applications in desert remote areas of many developing countries [6]. Transportation of renewable energy systems, such as photovoltaic (PV) pumps, is much easier than the other types because they can be transported in pieces and reassembled on site. Photovoltaic (PV) energy production is recognized as an important part of the future energy generation for irrigation. Because it is non-polluting, free in its availability, and is of high reliability. Therefore, these facts make the PV energy resource attractive for irrigation, especially in rural and remote areas of most of the developing countries like Ethiopia. Solar photovoltaic (PV) water pumping has been recognized as suitable for grid-isolated rural locations in poor countries where there are high levels of solar radiation. Solar powered smart automatic irrigation system can provide water for irrigation without the need for any kind of fuel or the extensive maintenance required by diesel pumps and with optimal usage of water resources. They are easy to install and operate, highly reliable, durable and modular, which enables future expansion. This research is able to solve the irrigation system which is becoming major problem in our country with the following objectives.

- To control the flow of water so that it can be effectively used in the irrigation system this leads us to the term irrigation scheduling.
- To improve water usage efficiency by remotely measuring the humidity, temperature of farm land soil during irrigation.
- To control the distribution of optimum amount of water to various areas.
- To reduce the manpower required for monitoring and performing irrigation activities.

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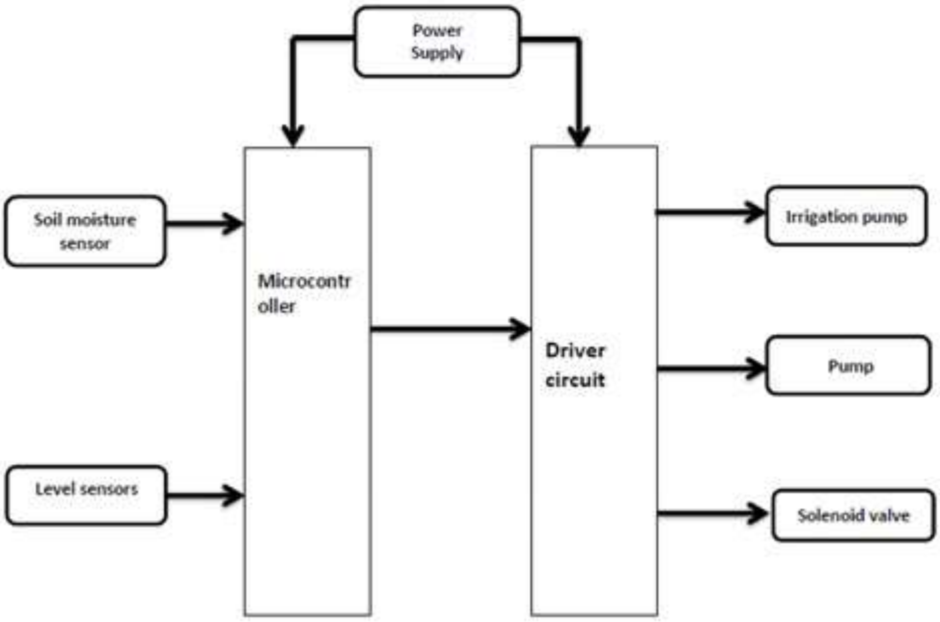


***Fig 1. Solar power automatic irrigation systems***

These blocks operate in conjunction with one another to make the flow diagram work properly as the function of each block is mentioned as follows. The input is the sensor and the output is the irrigation pump, LED, reservoir inlet solenoid valve and solenoid valve for array cleaner. The soil moisture sensor and level sensor gives input to the microcontroller and the output of the microcontroller will drive the relay to activate solenoid valves and pump motor, also the cleaner part of solenoid which is used to clean the panel from a defect to get proper radiation.

**Dam/lake:** The dam is expected to be capable of supplying the water to the reservoir based on the requirements sent to the deep well pump via the dipstick switch mounted on the reservoir to monitor the water level automatically. Here extraneous water is not required as it can cause damage to the water tanker (reservoir) and this over flow can come upon with flooding to the environment. The source of water to this dam can be the river (as this dam can be a barrier constructed across flowing water course in order to hold water).

**Pumping System** A deep well pump in this research is responsible to pump the water from the dam/lake to our systems water tank. This solar power based DC motor powered pump was controlled by the liquid level control float switch automatically. In this photo-irrigation research, the brushless DC motor (BLDC) is selected because of its high operating efficiency, brushless construction, maintenance frees operation than the others. But for my practical implementation I have used the solenoid valve and solar panels was selected according to calculated maximum power consumption.

**Soil moisture sensor:** soil humidity sensor was designed that would operate based on electric characteristics of water inside soil to measure the overall humidity level. These include the use of a locally made moisture sensor as shown figure below.

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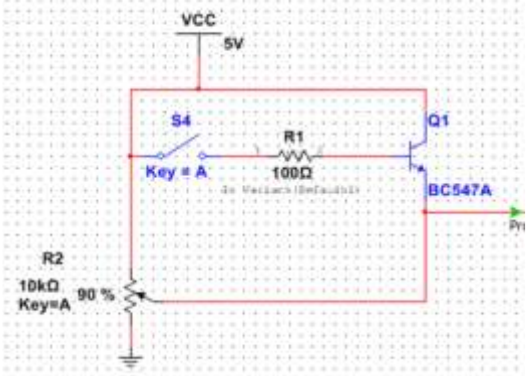


*Fig 2. Soil moisture sensor circuit.*

This sensor works on the principle of measuring soil conductivity which is proportional to the moisture content of the soil. The first half serves as the anode and the second half serves as the cathode, the soil conductivity forms a conductive path across the probe and the voltage across the probe is read off.

**Case#1: Dry condition**- The probes are placed in the soil under dry conditions and are inserted up to3.5cm depth of the soil. As there is no conduction path between the two copper leads the sensor circuit remains open as shown on figure below. The voltage output of the emitter in this case ranges from 0 to 0.5V.

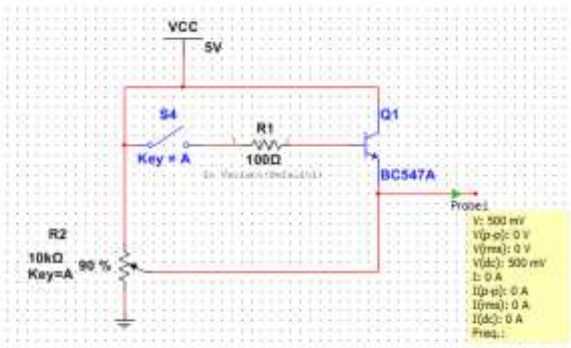


***Fig 4. Moisture sensors output in dry condition.***

**Case#2: wet condition**- With the increase in water content beyond the optimum level, the conductivity of the soil increases drastically and a steady conduction path is established between the two sensor leads as shown on the figure below and the voltage output from the sensor increases no further beyond a certain limit. The maximum possible value for it is not more than 4.2V.

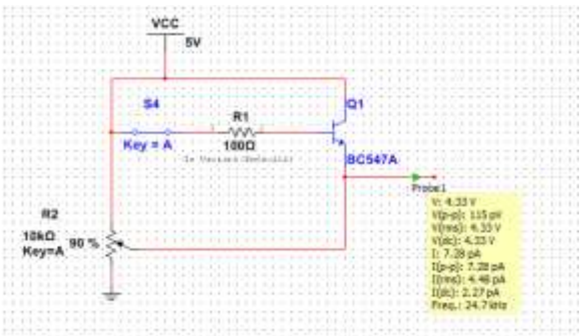


***Fig 5. Moisture sensor output in wet condition.***

**Water level sensor:** There are many types of water level sensors in this research, the simplest and the chipset one type of the dipstick water level sensor is used as shown figure 6. This sensor works on the principle of measuring voltage between the end point of the level sensor copper with respect to the ground and feeds this as an input to the BC547A transistor, the water conductivity forms a conductive path across the probe and the voltage across the probe are read off.

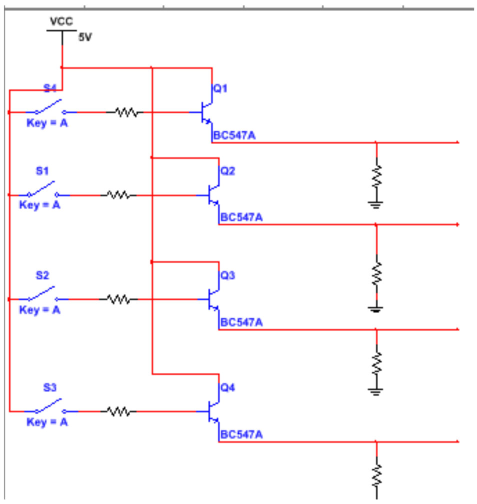


***Fig 6. Water level sensor circuit***

**Case#1: 25% condition-** The probes are placed in the water on 1/4 of the reservoir tank as shown below. As there is no conduction path between the two copper leads the sensor circuit remains open. The voltage output of the emitter in this case ranges from 0 to 0.5V.If there is a condition path between the two copper leads the sensor circuit become close. The voltage output of the emitter in this case is 4.2V.

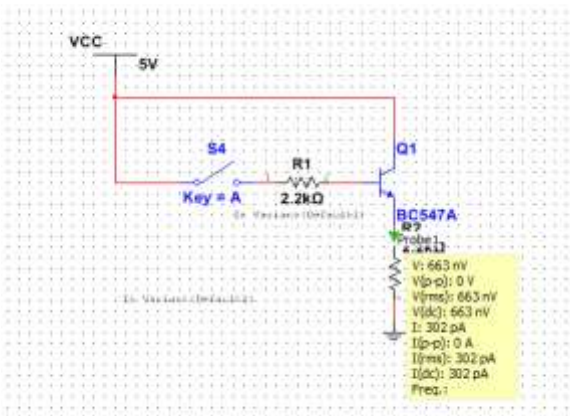


***Fig7. Below 25% condition***

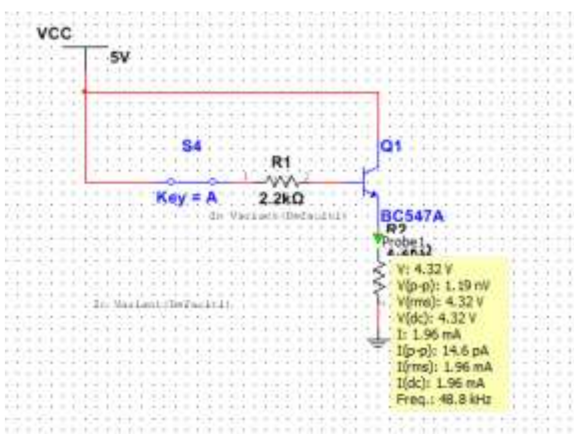


***Fig 8. Greater than 25%***

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**Case#2: 50% condition-** The probes are placed in the water on 1/2 of the reservoir tank as shown on figure below. As there is no conduction path between the two copper leads the sensor circuit remains open. The voltage output of the emitter in this case ranges from 0 to 0.5V. If there is a condition path between the two copper leads the sensor circuit become close. The voltage output of the emitter in this case is 4.2V.

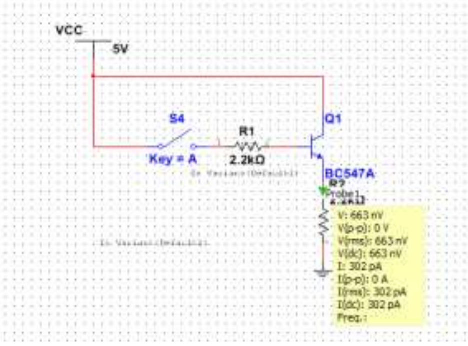


***Fig 9. Below 50% condition***

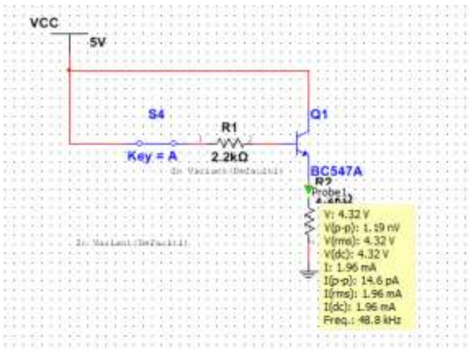


***Fig 10. Greater than 50%***

**Case#3: 75% condition** - The probes are placed in the water on 3/4 of the reservoir tank as shown figure 11. As there is no conduction path between the two copper leads the sensor circuit remains open. The voltage output of the emitter in this case ranges from 0 to 0.5V.If there is a condition path between the two copper leads the sensor circuit become close. The voltage output of the emitter in this case is 4.2V.

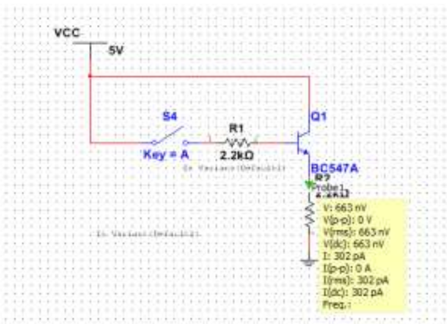


***Fig 11. Below 75% condition.***

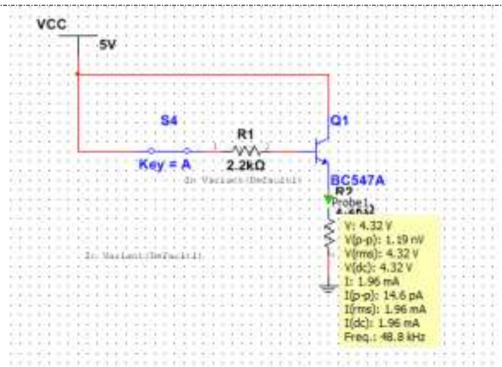


*Fig 12. Greater than 75%*

**Case#4: 100% conditions**- The probes are placed in the water on the top of the reservoir tank as shown figure below. As there is no conduction path between the two copper leads the sensor circuit remains open. The voltage output of the emitter in this case ranges from 0 to 0.5V.Iif there is a condition path between the two copper leads the sensor circuit become close. The voltage output of the emitter in this case is 4.2V.

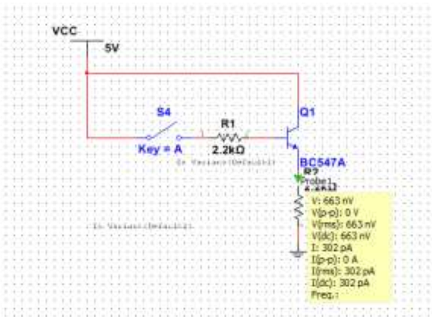


*Fig 13. Below 100% condition.*

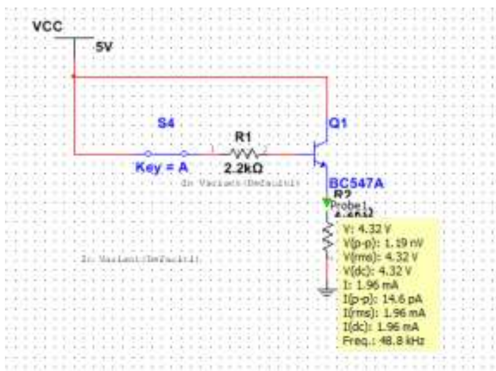


*Fig 14.level equal to 100%.*

## ANALYSIS AND RESULTS

### Sizing of solar system

**Total ac load:** For the prototype practical implementation the 8W solenoid valve is selected instead of brushless DC motors to control the flow of water from thank one T1 to thank two T2, In addition the single phase 0.37KW AC motor to pump farm land and five relays and power supply and this research applies to the system on 1.5$m^2$ area and the estimated watering time and pumping time based on try and error method. And finally from this data the calculated total AC load and total watt hour as follows:-

1. single phase 0.37KW AC motor.
2. one 220V 8W solenoid valve.
3. power supply for relay and microcontroller.
4. four relay for driver circuit.

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From this data we have a total load of 0.37kw + 8W + 2W + 4*0.43W = 381.7W .And as mentioned in the above the garden is small so it is enough for 20 minute watering, the solenoid valve energizes for 30 minutes and power supply is ON through all time. And we selected our system voltage 12V.

So the TOTAL Whr = 370w * 1/3 hr+( 2W + 1.7w) * 24hr + 8W * 1/2hr = 216 Whr .
Due to inverter loss the total watt hour is multiplied by 1.2. Thus total Whr = 216Whr*1.2 = 259Whr .TOTAL AHr = Total Whr/ System voltage.
Where TOTAL Whr = the amount of energy consumed by system in one hour = 259Whr/12V = 21Ahr.
From the above information the following are calculated;
1. Panel size,
2. Charge controller,
3. Battery size
4. Inverter size and
5. Cable size

**Panel sizing:** Panel sizing used to determine the number of solar panel 1.35*total Ahr .Where 1.35 is safety factor = 1.35*21Ahr = 29.2125Ahr 29.2125Ahr/4.6hr = 6.339A.
Watt of panel is= 6.339836A*17.2V = 109.033Wp .So 120 WP panel is enough.

**Charge controller sizing:** Charge controller rating is equal to = 1.1*1.2*ISc of panel. If the panel is polycrystalline ISc = 5.6A.
So it will be 1.1*1.2*5.6A = 7.392A.

**Battery size:** The capacity of a battery is usually expressed as a number of ampere-hours (Ah). One ampere-hour is the amount charge delivered when a current of one ampere is delivered for one hour. Since the capacity of lead-acid batteries depends on the rate at which they are discharged. Capacities are sometimes expressed in terms of kilowatt-hours (kWh) which can be calculated from the ampere-hour rate using the following equation. Battery capacity = Total Ahr* day of autonomy/depth of discharge = 21Ahr*3/0.5 = 126 Ahr. Two 65Ahr batteries are enough for solar systems.

**Cable size:** From the panel to charge controller is 3meter. From charge controller to battery fuse 0.5 meter. From charge the controller to inverter it is 0.5meter. The total is= 2(3m+0.5m+0.5m+0.5m) = 9m .The cable size will be = L*p/0.03*v2*CU cons = 9m*372W/0.03*144*56 = 13.83mm$^2$.

**Resistance Analysis**
**Resistance analysis for sensor circuit:** Resister analysis for sensor parts to limit the current flow through base of the transistors BC547A as a result voltage from sensor output, The calculated value of resistors connected to the base of these transistors as follows. The emitter current (IE) is the sum of the collector current (IC) and the base current (IB), expressed as follows: IE = IC + IB from ECG book of component, the IC & IB = 0.90909mA & 100mA in active region respectively .IE is = 0.90909mA +100mA = 100.90909mA .Then VBB forward-biases the base-emitter junction and VCC reverse bias the base-collector junction. When the base-emitter junction is forward-biased, it is like a forward-biased diode and has a nominal forward voltage drop of VBE = 0.7 V .Since the emitter is grounded by KVL ,the voltage across RB is VRB = VBB – VBE.

VRB = 4.72-0.7 = 4.02V. Also, by Ohm"s Law, VRB = IBRB. Substituting for VRB yields IBRB = VBB – VBE. RB=4.02V – 0.7V/0.90909mA = 3.2kohm. Therefore we connected 2.2k ohm resistor to all transistor bases since we used the same transistors (BC547A NPN transistors) in the level sensor because the water itself has resistance value.

**Resister analysis for driver circuit:** it is used to limit the current flow through base of the transistors BC547A as a result voltage from PIC output as shown figure shown below.

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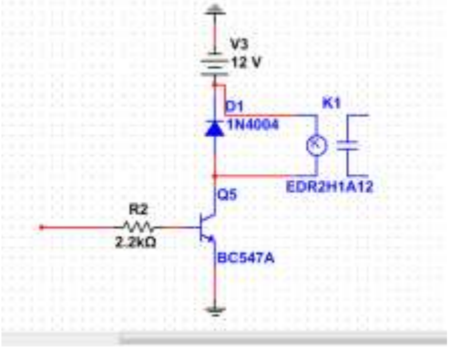


***Fig 15. Driver circuit***

From the figure above the calculated value of resistors connected to the base of these transistors and rating of fly wheeling diode as shown below. The emitter current (IE) is the sum of the collector current (IC) and the base current (IB), expressed as follows: From ohms low we have V=IR IC=V/R =12/432 =0.28A IB=IC/B =0.28/110.=2.54Ma RB= (VCC-VBE)/ IB = (5V-0.7V)/2.54Ma =1.69Ω .The VBE forward-biases the base-emitter junction and VCC reverse bias the base-collector junction. When the base-emitter junction is forward-biased, it is like a forward-biased diode and has a nominal forward voltage drop of VBE = 0.7V.

## CONCLUSION

In this research there are certain aims that this research tries to reach. First of all the actual motivation toward this research is water consumption, since recently it is becoming a global issue. The second is to make the irrigation automatic and more efficient in industrial agriculture to reduce the need for human resources and decrease the cost of production. The price of this research is estimated to be birr 6,500, which is not so expensive, that means it can be easily implemented for the Ethiopian farmers. Finally this system if flexible and cost effective.

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