SOLAR POWERED SMART IRRIGATION SYSTEM WITH AN AUTOMATIC TANKER FILLING MOTOR PUMP AND DUAL AXIS SUN TRACKING SOLAR PANEL

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Abstract: ***Agriculture in Ethiopia is one of the main sources of living and it has also a tremendous impact in the economy for majority of the peoples. Due to the lack of rains and scarcity of land reservoir water in the field of agriculture, use of proper method of irrigation is very much important. Another very important reason of this is due to unplanned use of water due to which a significant amount of water goes waste. For this purpose; this automatic plant irrigation system is used. Since the farmers working in the farm lands are only dependent on the rains and bore wells for irrigation of the land. It also improves the traditional irrigation system in Ethiopia enabling to have high efficiency and low water usage of the existing irrigation system being tedious, time consuming and very wasteful in water usage. The system derives power from solar energy through photo-voltaic cells to operate the Self-controlled tanker filling and water feeding irrigation system with a microcontroller-based photovoltaic maximum power point tracking control system. Hence, dependency on erratic commercial power is not required. The main objective of the project is to develop an irrigation plan based on Indigenous, low cost, time-based microcontroller-based irrigation scheduler. The study, therefore, focuses on improving agricultural, soil conservation and harvesting periods, water utilization and water management. To achieve this, it needs to measure the different temperatures, the amount of water and soil moisture it has. This system provides design and development of irrigation control systems using the PIC16f877A type control unit. The system includes controller, LDR, temperature meter, water sensor, LCD, and circuit relay to turn (on/off) a motor and different control valves. Generally, the system has three independent regulators: the sun's energy to the electrical system, the flow of water, and tanker filling and water feeding system. Here it uses the highest power point monitoring system to improve the effectiveness of the solar panels and to utilize the power of the pulses. Then, with the help of the pump, water is conveyed under pressure through a pipe system to the tanker or to the field where it drips or sprinkled onto the soil through sprinklers or drippers. Tanker filling system is controlled automatically from the feedback of the sensors installed in the tanker and water feeding to the field will be controlled with a similar way using humidity level sensor located in the soil of the field.***

Keywords - Solar Tracking, Microcontrollers, Stepper motors, Sensors, Simulation, Automatic Irrigation

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INTRODUCTION

Like many other countries the energy situation in Ethiopia is becoming critical. In order to solve this problem, the government has taken initiatives for utilization of renewable energy sources for electricity generation. One of these renewable energy sources is the photovoltaic systems because of the high daily average of solar radiation (about 6.5 $KWh/m^2/day$) [5],[13,[16]. Photovoltaic systems have different applications. One of these applications is irrigation and pumping water in remote areas and far from electrical grid using PV DC water pumps [2]. DC pumps can be run by the electricity generated by PV systems while AC pumps need an inverter [10], [13].

Solar tracking keeps PV panels in an optimum position perpendicularly to the solar radiation during daylight hours so as to increase the collected energy [3]. Efficient collection of maximum solar radiation on a flat panel requires adjustment of two parameters of the energy collecting surface namely the angle of the azimuth and the angle of tilt [1],[9],[11].This paper deals with a dual axis sun tracking solar powered smart irrigation system with an automatic tanker filling motor pump. Figure 1 shows the block diagram of the proposed system. It consists of Humidity sensor in the soil and temperature sensors in the air are used to control the DC water pump operation. Four light dependent resistances (LDRs) sensors are used to detect the sun position, this information is read and processed by a 16F877A PIC microcontroller to move two stepper motors, used as actuators for the two axes PV solar tracking system, in order to control the azimuth and tilt angles. The system has been simulated using PROTEUS-ISIS simulation software first as shown in figure 2, and then it is constructed as shown in figure 3.

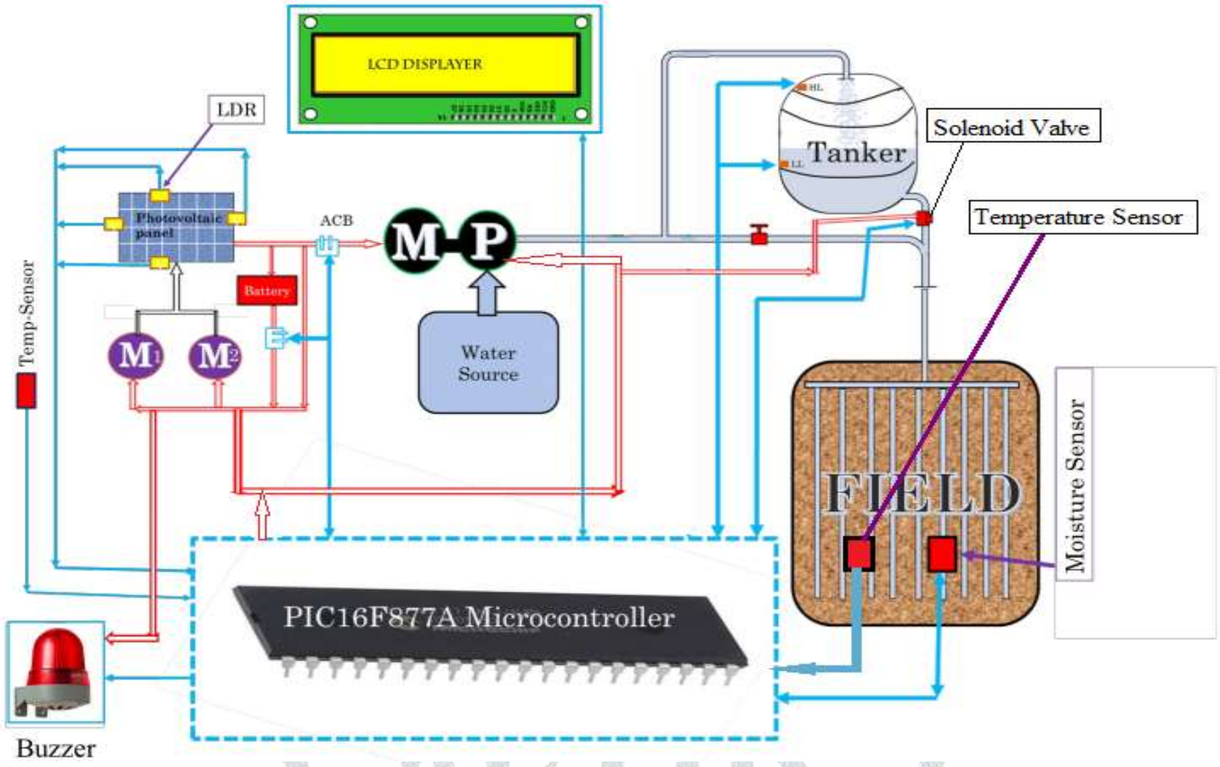


Figure 1: Overall system component and their operation.

SIMULATION OF THE SYSTEM

The complete system has been simulated by using Proteus ISIS professional package in order to verify the validity of the control algorithm of the irrigation system before its construction. The simulation includes the microcontroller PIC 16F877A, LDR sensors, temperature sensor LM35, humidity sensor, LEDs, relays, UNL2003 ICs, L298 ICs and stepper motors all connected as the block diagram in figure 2 [8]. Different situations have been simulated with very good results for solar tracking and for the pump function.

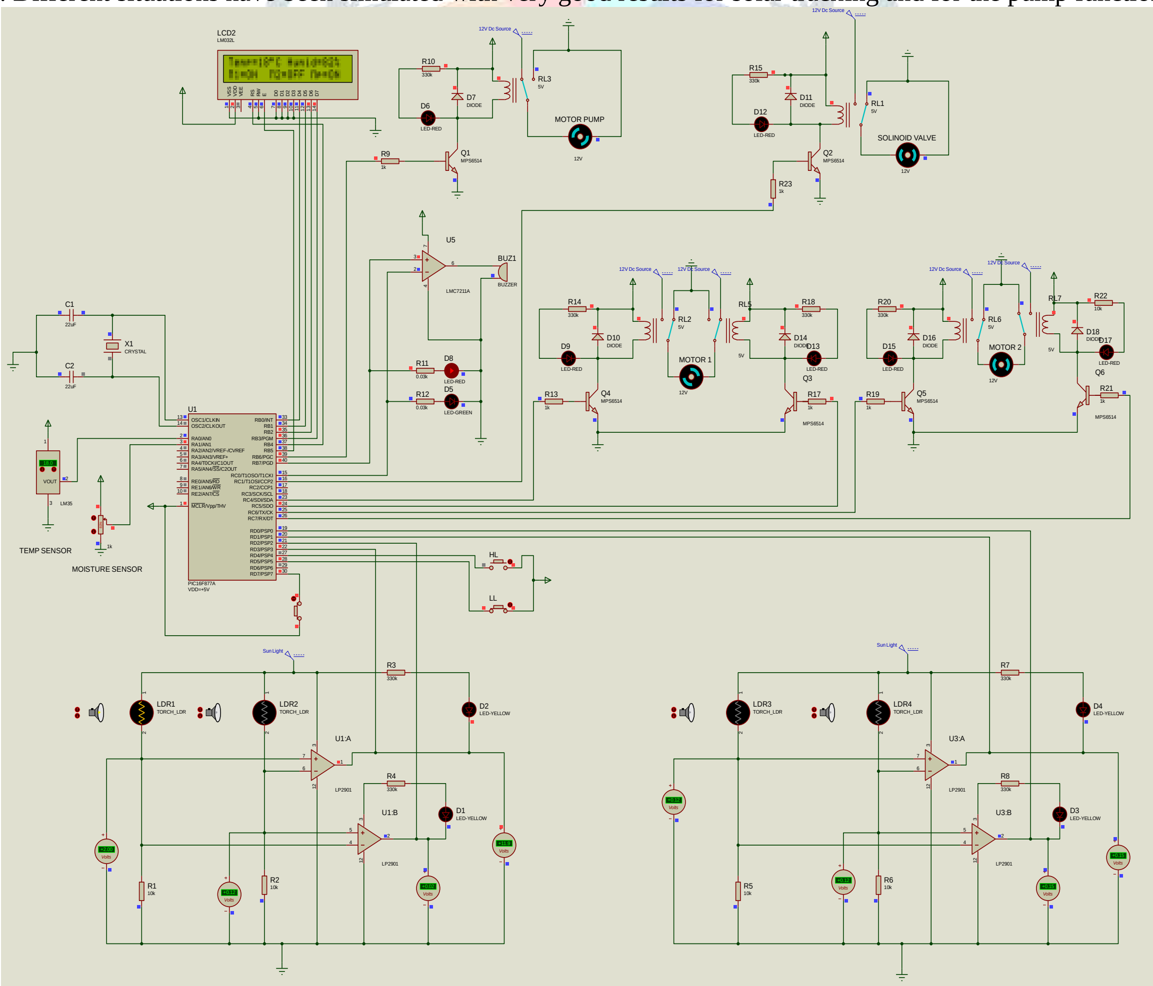


Figure2. Simulation of the system by PROTEUSISIS simulation software

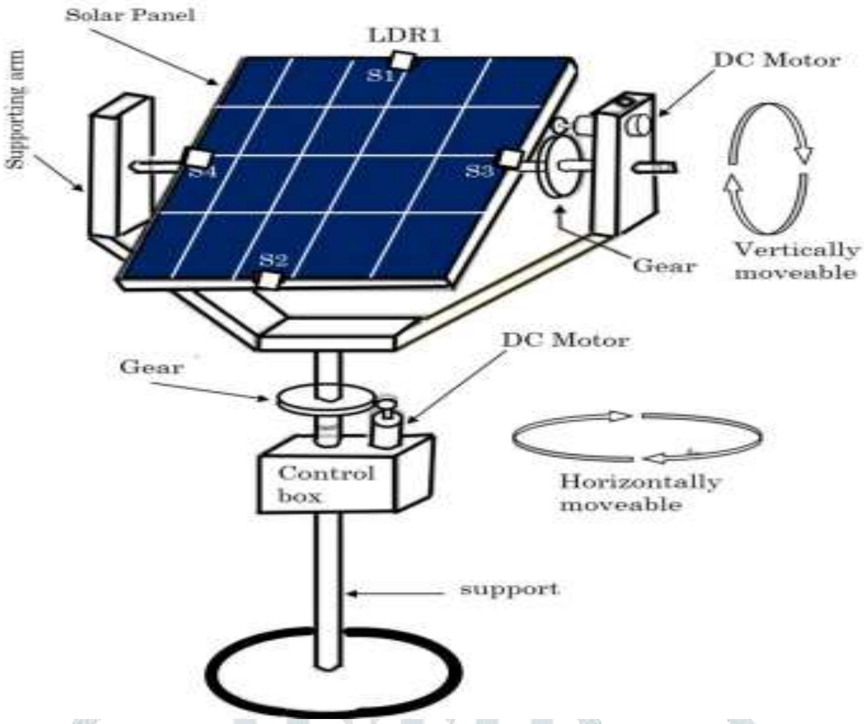


Figure3: The constructed system

CIRCUITS AND COMPONENTS

Solar Tracking System Circuits

Solar tracking is the most appropriate technology to enhance the electricity production of a PV system. To achieve a high degree of tracking accuracy, several approaches have been widely investigated. Generally, they can be classified as either open-loop tracking types based on solar movement mathematical models or closed-loop tracking types using sensor-based feedback controllers. In the open-loop tracking approach, a tracking formula or control algorithm is used. Referring to the literature, the azimuth and the elevation angles of the Sun were determined by solar movement models or algorithms at the given date, time and geographical information. The control algorithms were executed in a microprocessor or a microcontroller. In the closed-loop tracking approach, various active sensor devices, such as light dependent resistors (LDRs) are utilized to sense the Sun's position and a feedback error signal was then generated to the control system to continuously receive the maximum solar radiation on the PV panel. [7][12],[14]. Solar tracking can be achieved by using single-axis structure dual-axis structures for higher accuracy systems. In general, the single-axis tracker follows the Sun's movement from the east to west during a day while a dual-axis tracker also follows the elevation angle of the Sun. [7], [15].

Light Dependent Resistor (LDR)

The LDR sensor is a resistor whose resistance decreases with the increase of light intensity. It can also be referred to as a photo conductor. A photo resistor is made of high resistance semiconductor. If light, falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump to the conduction band. The resulting free electron and its hole partner conducts electricity, thereby lowering resistance. The reverse is the case when darkness falls on the LDR, for this will increase its resistance. This characteristic of the LDR is used to vary the input voltage as the sun moves over it. There are many different symbols used to indicate LDR, one of the most commonly used symbol is shown in the figure below. The arrow indicates light falling on it.

Figure 4: LDR with its characteristics curve

Stepper Motor Circuits

Stepper motors are commonly used in precision position control applications. This is because of the different advantages they have such as they are brushless, load independent, has open loop position control capability, good holding torque and excellent response characteristics. For these reasons two identical bipolar, permanent magnet 2 phase, 12V, 1.50 step stepper motors shown in figure 5 are used in this application in order to control the azimuth and tilt angle. Motor 1 is used to control the azimuth angle and motor 2 is used to control the tilt angle.

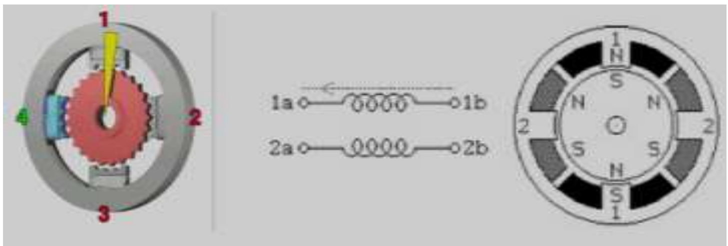
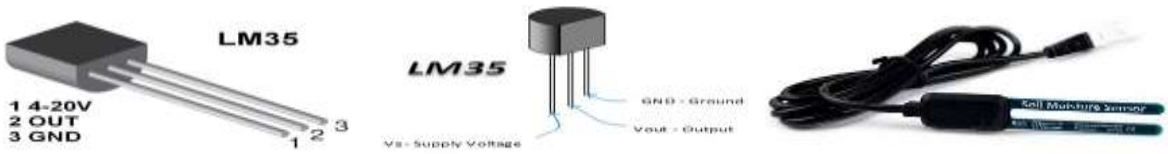


Figure5: Stepper motors

Humidity and Temperature Sensors Circuits

Humidity and temperature sensors have been used to decide the operation of the pump. The main idea is when the humidity is low (less than 4V) there is a need for irrigation, we measure the temperature so as to make the pump operate and so irrigate during low temperature (less than 20C^{o}) so as to avoid water evaporation. The temperature sensor used is the LM35 shown in figure 8 with its connection circuit. The analog output of this sensor is linearly proportional to the Celsius (Centigrade) temperature, 10 mV/C^{o}. The output of this sensor is connected to the analog input (AN7) of the microcontroller.



a) Temperature sensor b) Soil moisture sensor

Figure6: Schematic diagram of temperature and soil moisture sensor

PV and Pump Circuits

The PV module used has an output voltage of 12V dc capable of supplying a dc current of 300mA which is enough to switch on the pump. The connection circuit of the pump with the microcontroller is shown in figure 2. Here the control signal of the microcontroller to switch on the pump is sent from RC0 output to driver UNL2003 IC to drive the coil of the relay.

LCD Circuit

The LCD used is shown in figure 7. The connections of the pins with the microcontroller are shown in fig. 2. The LCD is used to show the values of the LDRs, temperature sensor, humidity sensor, state of motor1, motor2 and the pump.

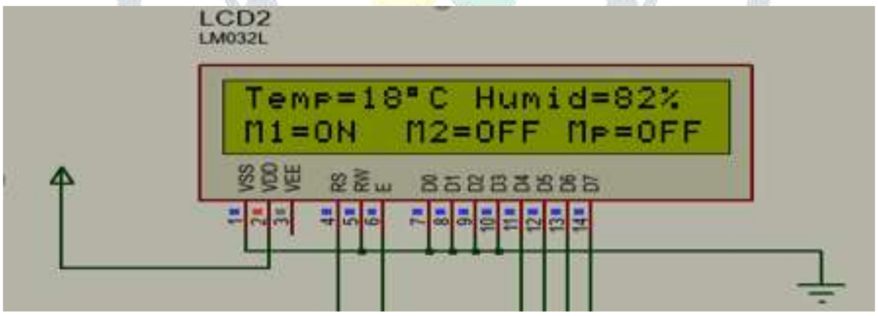


Figure7: LCD

FLOW CHART OF THE CONTROL SYSTEM

In figure 8 the flow chart of the control system is shown. When the humidity is less than 4V and the temperature is more than 20 C^{0}, the pump operates. In figure 9 the flow chart of the control system is shown. When the humidity is less than 4V and the temperature is more than 20 C^{0}, the pump operates. As shown in the figure below LDR1, LDR2, LDR3 and LDR4 represented in terms of S1, S2, S3, S4 respectively mounted on the solar panel and placed in an enclosure. If the difference between the value of LDR1 and LDR4 is less than a certain value (e), the microcontroller generates no control signals because that means that the PV panels are perpendicular to the source light. When the difference between LDR1 and LDR4 is more than (e), the microcontroller generates control signals to drive stepper motor 1 to the left. When the difference between LDR4 and LDR1 is more than e, the microcontroller generates control signals to drive stepper motor 1 to the right [1][4]. The same test is done for LDR2 and LDR3 in order to control stepper motor 2 up and down. The system is programmed so that after sunset the PV panels are directed to east waiting the sunrise. The microcontroller has been programmed using Flow code software.

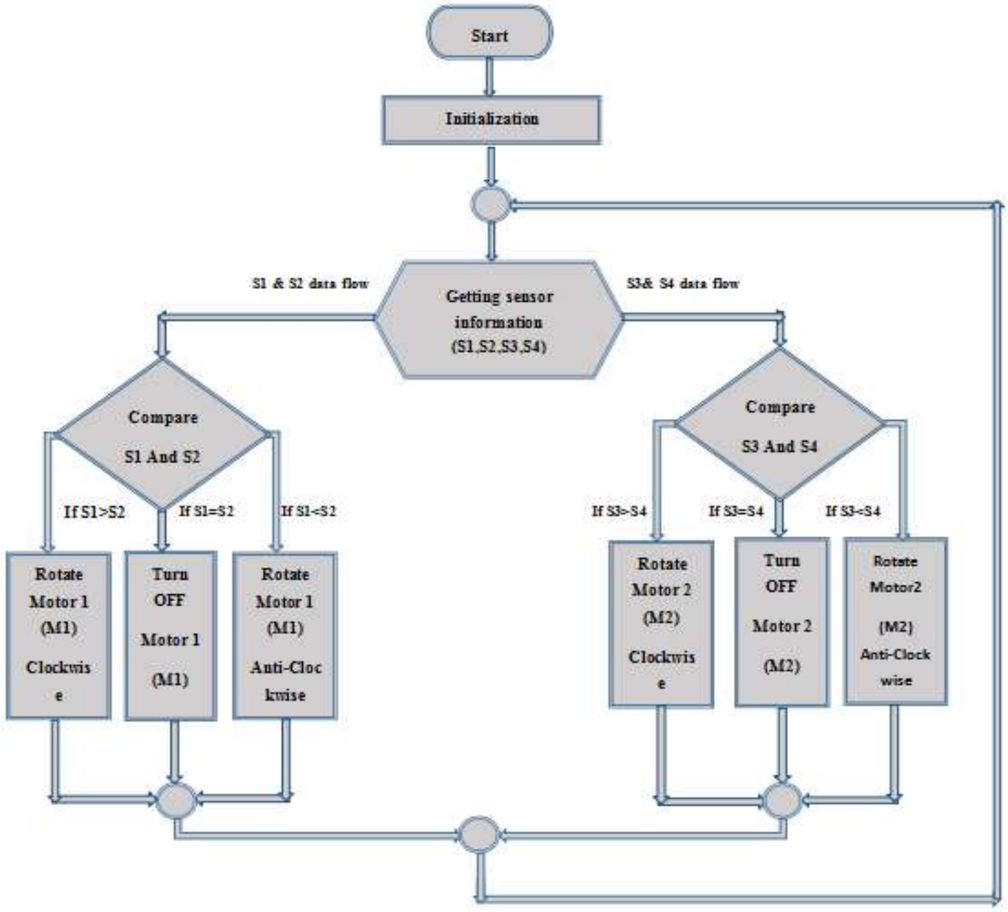


Figure8: Flow chart of the control system

CONCLUSION

A dual axis sun tracking solar powered smart irrigation system with an automatic tanker filling motor pump is simulated. The simulation result shows it is very beneficial for government as well as farmers. This is one of the best solutions for energy crisis and water consumption. The smart irrigation system reduces the human intervention during the irrigation of field and also optimizes the water usages.

RECOMMENDATION

The current population of Ethiopia is increasing in an increasing rate and agriculture remaining as the primary source of livelihood in rural areas, the focus should be on increasing the productivity. At the same time Ethiopia has huge untapped solar off-grid opportunities that can enhance the current energy concern and also receives enough rainfall. But nothing is done on generation of energy from the solar source. This shows that most of the farmers are using regular farming and irrigation system. Hence it is recommend that the government, public and private companies participating on agricultural activities and individual farmers to do and concern on the irrigation system by introducing new agricultural technologies that can double and triple the product of the individuals and the country. Automatic solar tracker microcontroller based irrigation system is among the best technologies done for agriculture.

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