DESIGN AND CONSTRUCTION OF AN AUTOMATIC SOLAR POWERED IRRIGATION FARMING SYSTEM

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Abstract

This project presents the design and construction of Automatic solar powered irrigation farming system using NE555 Timer, 7404 HEX inverter, Transistor SK100 and Relay, the system will work when two probes which are connected to the circuit are placed/inserted into the soil, they will conduct only when the soil is wet (resistance is low) and cannot conduct when the soil is dry due to high resistance. The voltage is generated from the Solar Panel connected to the circuit. When the soil is dry it will produce large voltage drop due to high resistance. This is sensed by 7404 Hex Inverter and makes the first NE555 Timer trigger which is configured as Monostable Multivibrator with the help of an electrical signal. When the first NE555 Timer is triggered at Pin 2, it will generate the output at pin 3 which is given to the input of second NE555 timer. The second NE555 Timer is configured as Astable Multivibrator which got triggered by the first NE555 timer and will generate output and drive the Relay which is connected to the electrically operated valve through the Transistor SK100. The output of second NE555 timer will switch on the transistor SK100 which in turn derives the relay; the relay which is connected to the input of electrical valve. When the transistor turns on the relay, it will then open the valve and water is poured on to the land. When the water content in the soil is increased, the resistance in the soil will be decreased and conduction of the probes will get started which make the 7404 Inverter to stop triggering of the first NE555 timer. The Design System was simulated using Proteus Software and the System was found to be working successfully.

Keywords: *Solar panel, probe, 555 timer, hex inverter, transistor, electronic valve.*

I. INTRODUCTION

Automatic control has played a vital role in advancing Engineering and Science, as it provides means of attaining optimal performance of dynamic systems, improving productivity, relieving the drudgery of many routing repetitive manual operations, etc. Therefore, Engineers and Scientists must have a good understanding of this concept. This control system is made up of electronic components together with some industrial solid devices designed to control a water pump for irrigation farming system which is powered by solar energy. Automatic irrigation farming system contains an electronic and power system that gives control to water the plants [1].

The aim of this project is to design and construct a control part of an Automatic Solar Powered Irrigation Farming system that will be able to control the watering of Plants in an Irrigation Farming System.

The considerations made in the design are;
(a). To use the Solar Panel 6V 3W as a Source of Power Supply

(b). To use the basic concept of Soil resistance (i.e. Soil has high resistance when it is dry and has low resistance when it is wet)

(c). To use the HEX Inverter 7404 IC

(d). To use the NE555 Timer as Monostable Multivibrator

(e). To use the NE555 Timer as Astable Multivibrator

(f). To apply the use of Transistor SK100

(g). To apply the use of relay

The system is designed to operate in a normal atmospheric condition during the dry season. Scope constructed a working system which will enable the plants to be automatically watered during irrigation farming system. It can be made to operate under period of time depending on the moisture condition of the soil. The system can take care of small sizes of farm or garden such as 3m x 3m (1oft & 10ft).

The system is designed to cover a small area of farm. It is powered by an external power source which may not be constant. A bad or abnormal weather can temper the smooth operation of the system.

II. MATERIAL AND METHOD

(a). POWER SUPPLY UNIT

A photovoltaic system is a power system designed to supply usable solar power by means of photovoltaic. PV system converts sunlight directly into electricity.

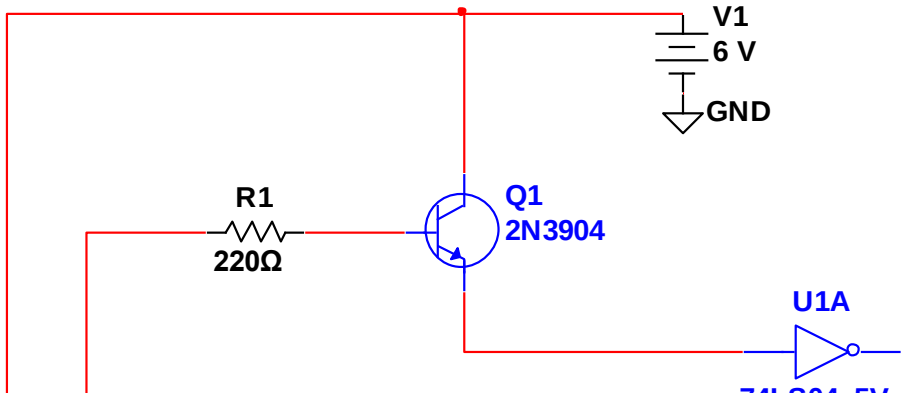
The Power Supply unit is a Solar Panel of 6V 3W that can be used to supply enough power required for the system to operate effectively and efficiently

Model	6V 3W
Solar cell	Polycrystalline silicon
Dimension	23.8 X 14 X 1.7 CM
Output wire	10FT
Application range	Charge 3V-5V batteries
Water	IPX6
VMP(Optimum operating Voltage)	6V
IMP(Optimum operating Current)	500mA
VOC(Open-circuit Voltage)	7.2V
ISC(Short-circuit current)	575mA
STC	Irradiance 1000W/m^2,module temperature 25^0 C, solar spectrum AM=1.5

(b). SOIL MOISTURE SENSOR

In the Soil Moisture Sensor, the transistor was configured as a switch (Sinking Current). When the soil is dried there will be a very high resistance in the soil as well as high voltage drop, so no current will pass through the base terminal of transistor and the transistor will be in off-state (i.e. there will be open-circuit between the collector and emitter terminal) in which there's no signal to the input of an inverter then the inverter will sense low logic input signal and the output logic signal will be high.

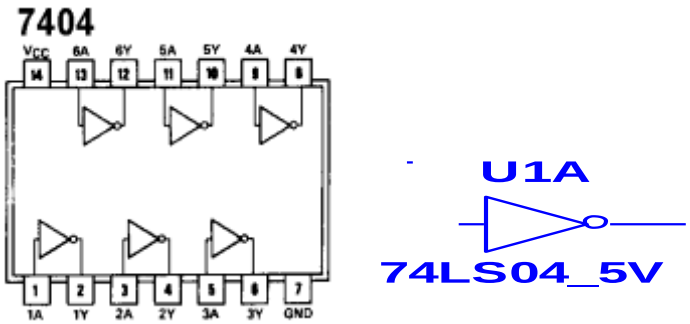
When the soil is wet there will be a decrease in resistance which will allow the current to pass through resistor to the base terminal of the transistor and will be open (i.e. there's short-circuit between the collector and emitter of the transistor and Vcc will be allowed to pass to the 7404 Hex inverter).



(c). HEX INVERTER 7404

The main function of the inverter is to give the complemented output for its input i.e. it will give output which is opposite to input. For example, if the input is low to the inverter, then the output will be high. Just like the normal inverter which gives high output when the input is low and gives low output when the input is high.

The Hex inverter 7404 IC will be having six independent inverters, in this project only one inverter was used to trigger first NE555 timer that has been configured as Monostble Multivibrator with the help of electrical signal. Also, four (4) pins were used: pin1=input, pin2=ouput, pin7=ground and pin14=Vcc with the operating supply voltage around 4.75V minimum to 5.5V maximum, normal supply voltage is 5V.



(d). NE555 TIMER AS MONOSTABLE MODE

The first 555 timer configured on Monostable multivibrator was used in order to obtain an approximate operating period of 3 seconds which will be sent to the second NE555 timer using a conventional formula below:

Time period (T) = In (3) R_1 C or 1.10 R_1 C
The capacitor C was selected to be 47µF while the value of the Resistor R_1 was calculated;
C = 47µF
T = 3 s

Now from the formula $T = 1.10\ R_1\ C$
Making R_1 the subject of the formula, we have;
$R_1 = \frac{T}{1.10\ C} = \frac{3}{1.10}\ x\ 47\ x\ 10^{-6}$
$R_1 = 58K\Omega$

(e). NE555 TIMER AS ASTABLE MODE

The second NE555 timer was configured as Astable Multivibrator that got triggered by the first NE555 timer and will generate output to switch ON the Transisitor SK100 in order to drive the relay and calculated values where obtained below;

Data:
$R_3 = R_4 = 27K\Omega$
C4 = 10µF
$T_{high} = In\ (2)\ [\ R_3 + R_4]\ C$
$T_{high} = 0.693[27x10^3 + 27x10^3]\ x\ 10x10^{-6}$
$T_{high} = 0.37\ s$
$T_{low} = In\ (2)\ C\ R_4$
$T_{low} = 0.693[27x10^3]\ x\ 10x10^{-6}$
$T_{low} = 0.19\ s$
Period (T) = $T_{high} + T_{low}$
Period (T) = 0.37 + 0.19 = 0.56 s
Frequency (F) = $\frac{1}{T} = \frac{1}{0.56} = 1.786$ Hz
Duty cycle = $\frac{Thigh}{Thigh\ +Tlow} = \frac{0.37}{0.37+0.19}$
$= \frac{0.37}{0.56} = 0.66$

(f). NE555 TIMER AS ASTABLE MODE

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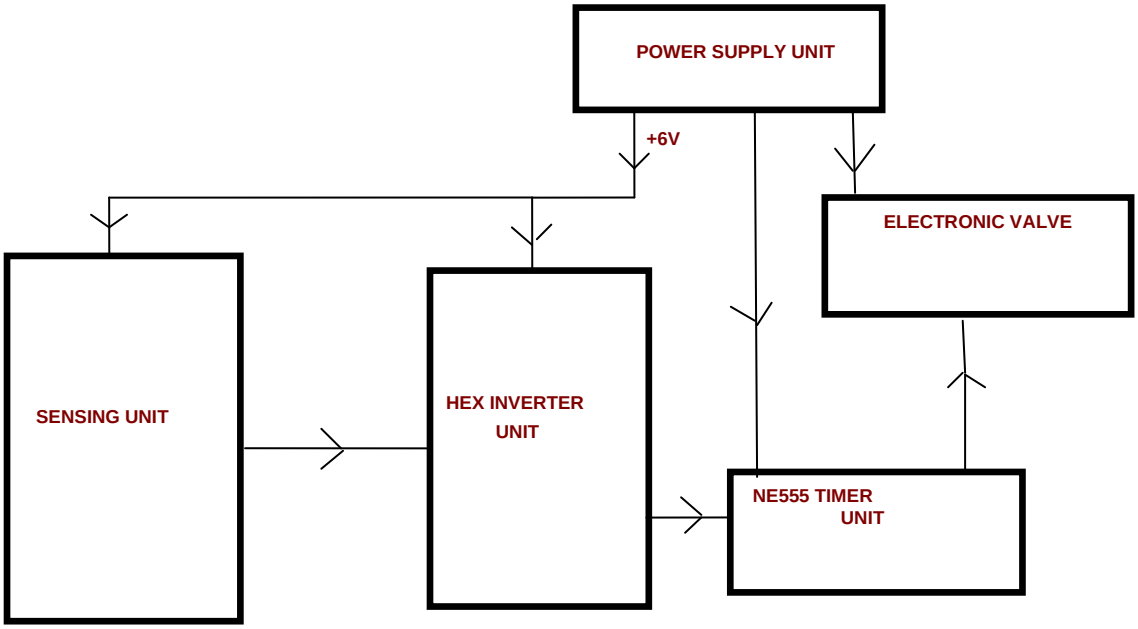
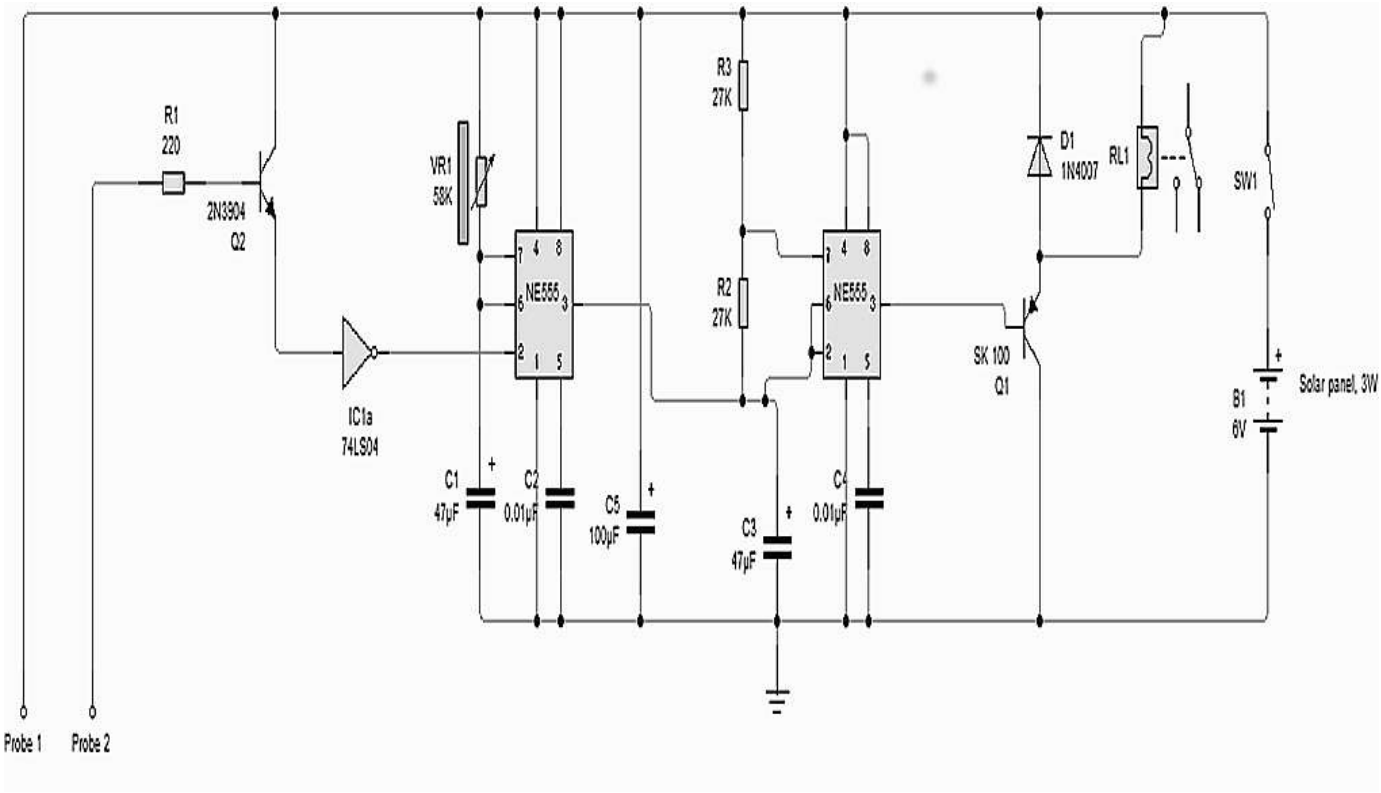
$T_{high} = 0.693[27x10^3 + 27x10^3]\ x\ 10x10^{-6}$

(g). RELAY
The relay's switch connections are usually labelled COM (POLE), NC and NO:

COM/POLE= Common, NC and NO always connect to this, it is the moving part of the switch.
NC = Normally Closed, COM/POLE is connected to this when the relay coil is not magnetized.
NO = Normally Open, COM/POLE is connected to this when the relay coil is MAGNETIZED and vice versa.

There are 5 Pins in a relay. Two pins A and B are two ends of a coil that are kept inside the relay. The coil is wound on a small rod that gets magnetized whenever current passes through it. COM/POLE is always connected to NC (Normally connected) pin. As current is passed through the coil A, B, the pole gets connected to NO (Normally Open) pin of the relay





III. PERFORMANCE EVALUATION AND TESTING

After construction, tests were carried from table 4.1 to ensure that the circuit operates as designed. In the first stage of the test, output voltage of the power to the circuit was measured to make sure it was 6V DC power supply which was obtained from the solar photovoltaic or solar panel connected to the circuit, after which the sensor unit was tested separately to know if the automatic solar powered circuit will display on the led. The principle of testing equipment for the components is the MULTIMETER. This is used in order to know that good equipment and exact ones are used. This is necessary in order to prevent malfunctioning of the equipment.

Table 4.1 Table of Rated Voltages

Name	Hex inverter	NE555 Timer	Relay
Voltages	5V – 5.5V	5V – 18V	6V – 9V

IV. CONCLUSION

All the circuits were designed, constructed and tested, they were found to be working according to the designed specifications.

This system can be used for domestic garden as well as small scale irrigations, therefore it can be produced in commercial quantities looking at complete circuit diagram, it is relatively

cheap to construct. This low cost of production and high efficiency should therefore encourage the production of the system in commercial quantities.

V. RECOMMENDATION

Despite that the circuit design and construction were successful, modification of the circuit can be made to improve its efficiency and performance.

In order to reduce the complexity of the circuit, the units involved can be reduce by employing a cheap microcontroller into the system.

Also, the motor controller can be set to carry heavy motors by approximately re-designing the circuit for a large span of garden or irrigation farm, where large amount of water is needed to be pumped.

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