

Solar Driven Automatic Water Level Controller with Dry Run Protection

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ABSTRACT

This paper presents solar driven automatic water level controller with dry run protection (SDWLC). The main purpose of SDWLC is to reduce wastage of water, to stop dry running of motor and to use solar energy effectively by using PV system. Generally water is pumped to overhead tank (OHT) from underground tank (UGT). People will switch on pump when taps go dry, switch off pump when water over flows and they do not check dry running of motor during this. Also pumping of water to OHT during power cuts is a major problem in most of villages and in some of cities. However these problems can be solved by SDWLC. By using inverter the DC generated from PV system is converted into AC and given to the motor. The operation of water level controller works upon the fact that water conducts electricity. So water can be used to open or close a circuit. As the water level rises or falls, different circuits in the controller send different signals. These signals are used to switch ON or switch OFF the motor pump as per our requirements.

Keywords: Dry run protection, Inverter, OHT, PV system, UGT.

I. INTRODUCTION

The total amount of water available on Earth has been estimated at 1.4 billion cubic Kilometres, enough to cover the planet with a layer of about 3 km. About 95% of the Earth's water is in the oceans, which is unfit for human consumption. About 4% is locked in the polar ice caps, and the rest 1% constitutes all fresh water found in rivers, streams and lakes which is suitable for our consumption. A study estimated that a person in India consumes an average of 135 litres per day. This consumption would rise by 40% by the year 2025. This signifies the need to preserve our fresh water resources.

Solar photovoltaicity is being widely used in different applications. Despite of various limitations of several energy sources, one of the most appropriate and simplest use of photovoltaicity is water pumping [1]. The major advantage of this water pumping system is storing water when sun is shining thus eliminating the need of batteries. It enhances the simplicity and reduces the overall cost of the system.

Solar photovoltaicity uses a solar inverter, or PV inverter, or Solar converter, converts the variable direct current (DC) output of a

photovoltaic (PV) solar panel into a utility frequency alternating current (AC) that can be fed in to a commercial electrical grid or used by a local, off-grid electrical network. It is a critical balance of system (BOS) component in a photovoltaic system, allowing the use of ordinary AC powered equipment

In this paper the most cost-effective and reliable water level controller with dry run protection is made and PV system with inverter is used as a resource. Water level controller with dry run protection is made of 555 timer and 74F00 IC'S. PV inverter is made of HF4047 IC, IRFZ44 power MOSFETS and 12-0-12V/220V, 5A transformer. The working of controller along with inverter is tested by taking 30 litres can as OHT, bucket as sump and cooler pump as a motor using battery as a resource.

The remainder of this paper is organised as follows: section 2 explains components used, section 3 explains circuit diagrams and logic used. Section 4 presents snapshots of circuits, tested system and results. Finally conclusion is summarized in section 5.

II. COMPONENTS USED

2.1 Components used for water level controller

Water level controller uses following components.

- Metallic Contacts
- Voltage Regulator IC
- Centrifugal Submersible Pump
- Relay

- NAND gate
- 555 Timer IC
- Transistor
- Diode

2.1.1. Metallic contacts

The water level controller I propose to make in my project depends on two detection points in the OHT and one detection point in the sump. The water level must be controlled at these points. To facilitate this, we use sensors. In our case, these sensors are non corrosive metallic contacts with space between them present at each detection point.

2.1.2. Diodes

IN4001 diodes are used. Two diodes at starting rectifies ac signal if input used is available ac voltage. For this 220/12 V step down transformer has to use. If input used is 12V DC diode acts as short circuit.

2.1.3. Voltage Regulator IC

IC7805, IC 7812 are connected in parallel across rectifier output. The output of IC 7805 provides VCC to the NAND gate and is also used to supply the DC voltage to support current flow between the metallic wires. The output of IC 7812 is used to give VCC to 555 Timer IC and BJT.

2.1.4. Centrifugal Submersible Pump

The centrifugal pump is commonly found inside a submersible fountain pump and some air conditioning units. As the impeller inside it turns, water is drawn in one side of the pump. It is then expelled out the other end. The power and size of the impeller decide the amount of water flow. More water can be pumped if we have a larger impeller. As the impeller rotates, it moves water from the inlet (which is located near the centre of rotation of the impeller) along the surfaces of the impeller to the outer portions of the volute by means of centrifugal force (thus, its name centrifugal pump). As this water collects in the outer regions of the volute, it is directed to the outlet. The water leaving the outlet causes the water pressure to drop at the inlet. To match the rate with which water is leaving the outlet, the pump sucks in new water at the inlet. These pumps must be primed before starting, which in this case is already done because of its underwater application. Rating: Voltage: 165-240V/ 50 Hz; Power: 18W; Output: 1200L/hr.

2.1.5 .Relay

Relays are defined as remote controlled electrical switches that are controlled by another switch e.g. - a horn switch [2]. Relays allow a small current flow in a circuit to control a higher current circuit. The relay used here is a Single Pole Double Throw (SPDT) relay whose magnetizing coil terminals operate on 12V DC supply.

2.1.6. NAND gate

A NAND gate (Negated AND or NOT AND) is a logic gate which produces an output that is false only if all its inputs are true [3]. A LOW (0) output results only if both the inputs to the gate are HIGH (1); if one or both inputs are LOW (0), a HIGH (1) output results. If water falls below the bottom contacts, the pump must switch on. If water fills above the upper contacts, the pump must switch off.

2.1.7. 555Timer IC

Here, 555timer used as a flip-flop element i.e. in bi-stable mode.

Bi-stable mode

In bi-stable mode, the timer has two stable states, high and low. By making the Trigger input low the output of the circuit goes into the high state. By making the Reset input low we cause the output to go into the low state. Using this mode avoids unnecessary switching of relay [4].

2.1.8. Transistor

Transistors are semiconductor devices used to amplify and switch electronic signals and electrical power [5]. At least three terminals for connection to external circuit are present. By applying voltage or current to one pair of the transistor the current through other pair of terminal changes. Because the controlled (output) power can be higher than the controlling (input) power, transistors can amplify a signal. In this circuit, the output from the NOT gate is not strong enough to activate the relay. Hence, I used transistor C547B to amplify it. IC 7812 provided the 12 volts VCC to the BJT which was connected in common base configuration.

2.2 .Components used for PV Inverter

PV inverter uses the following components.

- HCF4047IC.
- IRFZ44 MOSFET.
- Transformer.
- Light Emitting Diode.
- Capacitor and Resistors.

2.2.1. HCF4047 IC

The 12V DC supply from the battery is given to the input of the inverter circuit through a Voltage regulator to have constant Voltage of 12V. The IC 4047 is a Monostable/astable multivibrator [6]. The use of IC is to generate 100 Hz pulses. HCF4047 IC in astable multivibrator mode generates two signals out of phase at pin 10 and 11.

2.2.2 .IRFZ44 MOSFET

IRFZ44 is a power MOSFET [7]. It is to amplify the signals generated at pin 10 and 11 of 4047 IC so as to drive the load.

2.2.3. Transformer

The inverter transformer has centre tapped primary winding and secondary winding. The rating of the inverter transformer is 10A, 100W. The primary winding has 12-0-12V and 230V in the secondary.

2.2.4 .Light Emitting Diode

LED is used to indicate the ON/OFF of the power inverter. A resistance of 1 KΩ should be connected in series with the LED to protect it from high voltages.

2.2.5. Capacitor and Resistors

Capacitor and Resistor are connected across pin 1&2. They decide pulse width generated at pin 10, 11&13. Also a resistor in series with the HCF4047 output is required to limit the current, since the MOSFET gate is highly capacitive and can draw a big instantaneous current when we try to turn it on. Around 220 ohms is a good value.

III. DESIGN AND IMPLEMENTATION

3.1 water level controller with dry run protection circuit and operation

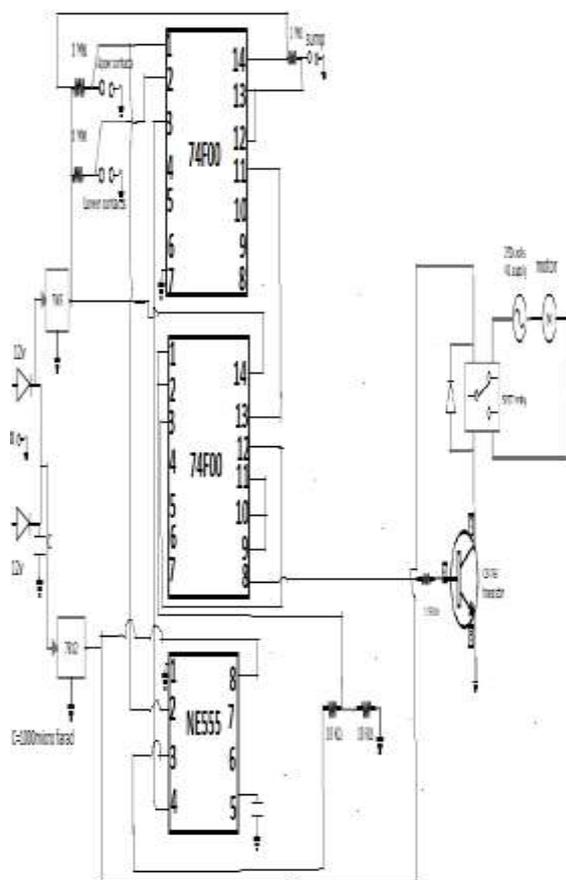


Fig -1: Water level controller with dry run protection

The circuit used for controller is shown in fig-1. The Metallic contacts are placed at the lower area, upper area of the OHT and in Sump. When water

filled the gap between them, the adjoining circuit closed and a signal (current) flowed. These signals were given to a first NAND gate which produced an output signal Q. This signal Q was used to provide Reset signal to the 555 timer IC. Also signal A was fed as the Trigger input to the 555 timer IC. The output of the timer is compared with sump level at second NAND gate and output signal was then passed through a BJT to amplify it and make it strong enough to activate the relay. The pump was started through the relay and water was provided to the OHT. The truth tables are tabulated in table 1 and table 2.

Table-1: Truth table of OHT & 555 timer output

Water Level	Input Signal A	Input Signal B	NAND Output	555 timer output
A: [empty] B: [empty]	1	1	0	0
A: [filled] B: [empty]	1	0	1	0
A: [empty] B: [filled]	0	0	1	1
A: [filled] B: [filled]	1	0	1	1
A: [empty] B: [empty]	1	1	0	0

Table-2: Truth table of WLC with dry run protection

555 timer output [A]	Sump [0-water, 1-no water] [B]	Pump state
0	0	1
0	1	0
1	0	0
1	1	0

Logic used for the water level controller with dry run protection is \overline{AB}

The advantages of proposed water level controller with dry run protection is

- 1) Low cost
- 2) Maintenance free
- 3) Easy construction
- 4) No skill required

3.2. PV Inverter Circuit Operation:

The circuit diagram for inverter is shown in figure2. The IC requires an external capacitor (between pins 1 and 3) and an external resistor (between pins 2 and 3) to determine the output pulse width in the monostable mode, and the output pulse

width in the astable mode. Here the IC is wired as “astable multivibrator” producing two pulse trains of 0.01s which are 180 degree out of phase at the pins 10 and 11 of the IC. Pin 10 is connected to the gate of Q1 and pin 11 is connected to the gate of Q2. The output pulses are amplified by power MOSFETS Q1 and Q2.

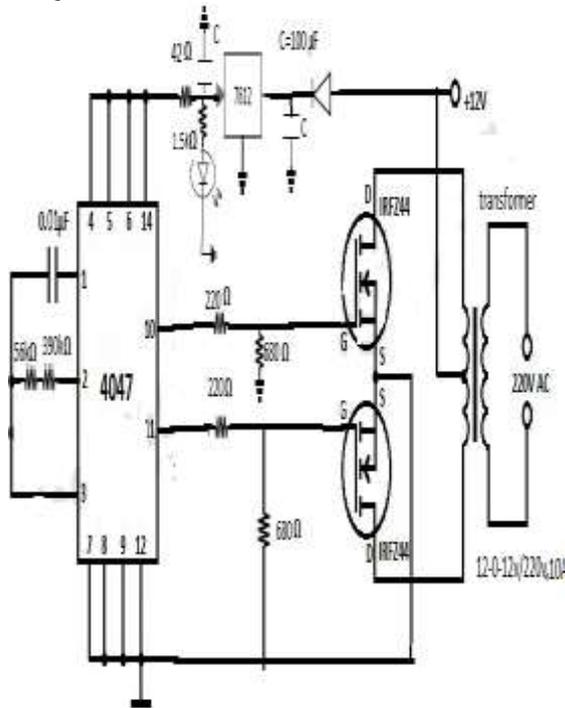


Fig -2: PV inverter

When pin 10 is high Q1 conducts and current flows through the upper half of the transformer primary which accounts for the positive half of the output AC voltage. When pin 11 is high Q2 conducts and current flows through the lower half of the transformer primary in the opposite direction and it accounts for the negative half of the output AC Voltage

IV. CIRCUIT LAYOUT, HARDWARE SETUP & RESULT

Water level controller with dry run protection is assembled on silicon board as per circuit diagram and soldered with soldering material.

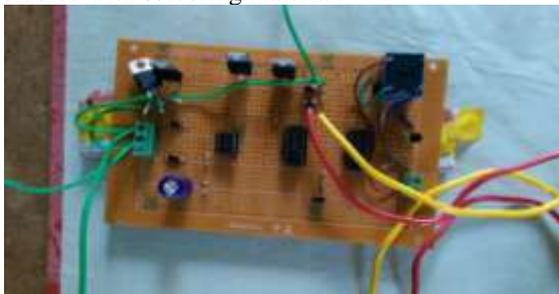


Fig-3: Circuit layout for controller

PV inverter is assembled on silicon board as per circuit diagram and soldered with soldering material.

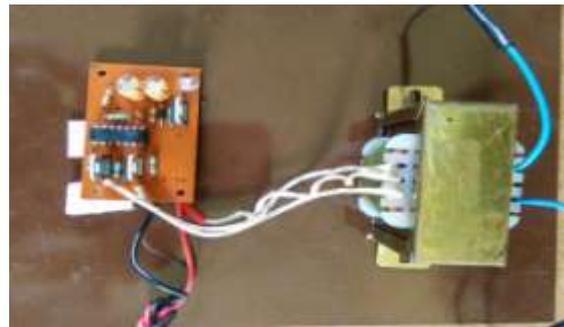


Fig-4: Circuit layout for inverter



Fig-5: Total hard ware setup

Experiment is conducted with 30 Litres bucket as sump, 30 litres watercan as over head tank, 18 watt cooler pump as motor and the set up is shown in figure

4.1. RESULT:

Thus a 100 watt inverter circuit capable of inverting 12V direct current (DC) from a battery charged by solar energy to 230V AC is designed using HCF4047 and power MOSFET IRFZ44. This is given as input to controller and motor. The motor pump switched ON when the OHT was about to go dry and switched OFF when the OHT was about to overflow or sump is empty.

V. CONCLUSION

The circuits are fabricated and tested successfully. This system is very beneficial in rural as well as urban areas. It helps in the efficient utilization of available water sources along with dry run protection and renewable energy like solar energy. If used on a large scale, it can provide a major contribution in the conservation of water and fuels which was excess in use in power generation for us

and the future generations. In these days, Earth's reserve of consumable water and fuels is decreasing every moment. Solar driven Water level controller with dry run protection is a simple yet effective way to prevent wastage of water. Its simplicity in design and low cost components make it an ideal piece of technology for the common man.

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