Solar fed Smart Irrigation System using Zeta Converter

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Abstract - This project proposes a simple and efficient for Solar Photovoltaic (SPV) array fed water pumping system. A zeta converter is proposed to extract the maximum available power from the SPV array. The Global system for mobile communication *(*GSM) transmission system is used to transmit the information obtained from the moisture sensor and the soil humidity sensor to make the microcontroller to perform the pumping operation for the required irrigation land. The proposed water pumping system is designed and modeled such that the performance is not affected under dynamic conditions.

The aim of this project is to provide an efficient solution for automatic control of irrigation motor for illiterates. Here the automation process is done through the micro controller based technology. The suitability of proposed system at practical operating conditions is demonstrated through simulation results using proteus simulation software followed by an experimental validation.

Index terms*– Zeta converter, Moisture sensor, Global system for mobile communication (GSM), DC pump, Float Sensor, Microcontroller.*

I. INTRODUCTION

In our project we make use of one microcontroller, which is dedicated at the water pump. The microcontroller forms the heart of the device. A relay switch to which irrigation motor is connected which is operated through microcontroller. To operate the system initially we should make a call to the mobile phone which is present at the soil moisture sensor in the fields. That mobile phone will be automatically will be answered after one or two rings then the control of the sensor is in our hands by using keypad buttons of our mobile phone the motor will be ON/OFF through Relay switch. The design of this system is very much sensitive and should be handled with utmost care because the microcontroller is a 5 volts device. So every small parameter should be given high importance while designing the interfacing circuit between the controller and the water motor. The major objectives of the present work are,

The system supports water management decision, which determines the controlling time for the process and monitoring the whole system through GSM module. The system continuously monitors the water level in the tank and provide accurate amount of water required to the land. Low cost and effective with less power consumption using sensors for remote monitoring and controlling devices which are controlled via SMS using a GSM using android mobile. The proposed work is organised into six sections.

II. STRUCTURE OF PROPOSED SYSTEM

Output power of the solar panels is effectively utilized by the proposed high power Zeta converter configurations. The zeta converter boosts the voltage from the solar panels and its output is fed to the dc pump which is used to pump the water from the reservoir tank to the main tank. A float sensor is present in the main tank to indicate the level of water in the tank whether it is low or high. Driver circuit 4 operates the solenoid valve 1 whether to open or close the valves to land 1. Driver circuit 3 operates the solenoid valve 2 to turn open or close the valves to land 2. Based upon the moisture content in

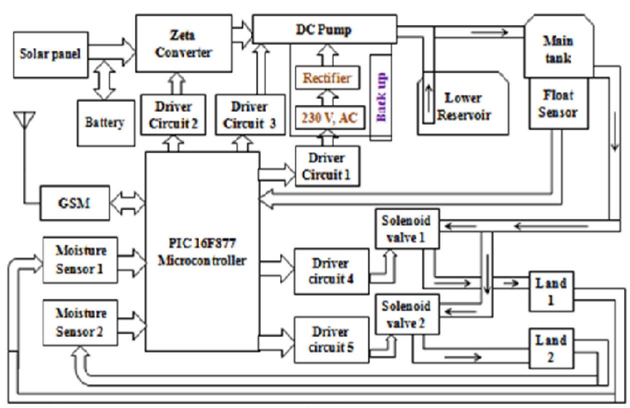

Fig.1. Structure of proposed system

the land, the moisture level of various land(land 1 and land 2) can be measured and monitored using moisture sensor. Global System for Mobile communication(GSM) is used to send information to the farmer based upon the land requirements. The output of the moisture sensors are given to the driver circuit(3 and 4) to open or close the valves. Driver circuit 2 is used to turn ON/OFF of the MOSFET switch. If the water level in the reservoir is low,then the DC pump is turned OFF through driver circuit 3.

III. ZETA CONVERTER

A zeta converter is a fourth order DC-DC is made up of two inductors and three capacitors. Zeta converter is capable of operating in continuous conduction mode. The ZETA converter is another option for regulating an unregulated input-power supply, like a low-cost wall wart. To minimize board space, a coupled inductor can be used. ZETA converter, consisting of an input capacitor, C_{IN} an output capacitor, C_{OUT},coupled inductors L_{1a} and L_{1b}, an AC coupling capacitor C_C, a power PMOSFET, Q_1 and a diode, D_1. Capacitor C_C will be in parallel with C_{OUT}, so C_C is charged to the output voltage, V_{OUT}, during steady-state CCM. Figure 2 shows the voltages across L_{1a} and L_{1b} during Continuous Conduction Mode operation.

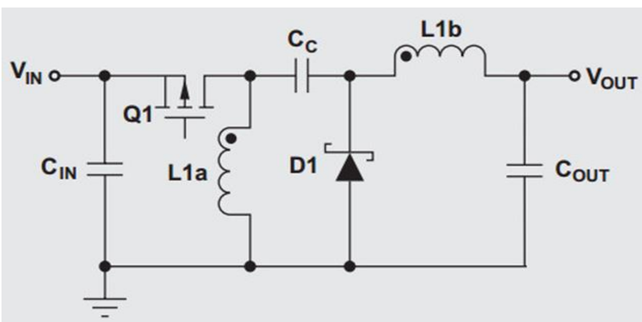

Fig.2. Zeta converter circuit

MODES OF OPERATION:

Mode 1 (Q_1 is ON): Capacitor C_C will be in parallel with C_{OUT}, so C_C is charged to the output voltage, V_{OUT}, during steady-state Continuous Conduction Mode (CCM).

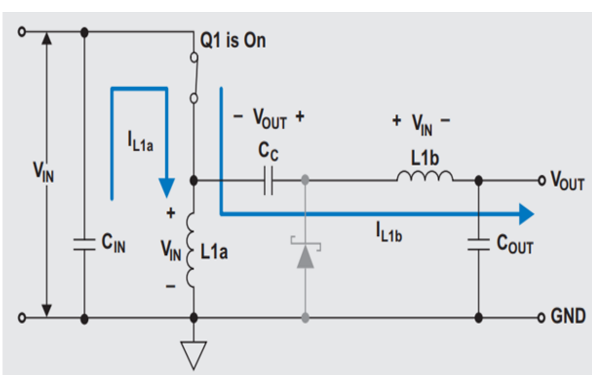

Fig.3. Mode 1 (Q1 is ON)

Mode 2 (Q_1 is OFF): The voltage across L_{1b} must be V_{OUT} since it is in parallel with C_{OUT}. Since C_{OUT} is charged to V_{OUT}, the voltage across Q_1 when Q_1 is off is V_{IN} + V_{OUT}; therefore the voltage across L_{1a} is $-V_{OUT}$ relative to the drain of Q_1. When Q_1 is on, capacitor C_C, charged to V_{OUT}, is connected in series with L_{1b}; so the voltage across L1b is $+V_{IN}$, and diode D_1 sees V_{IN} + V_{OUT}.

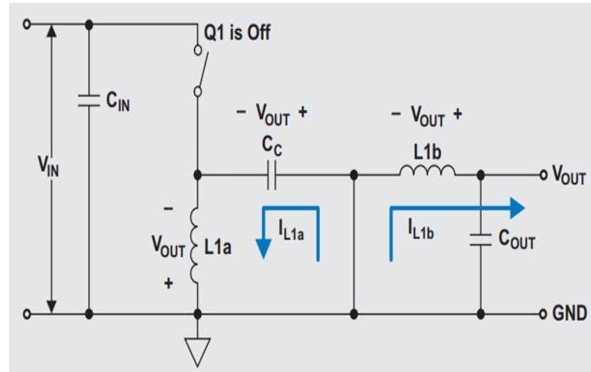

Fig.4. Mode 2 (Q1 is OFF)

Mathematical modelling:

Assuming 100% efficiency, the duty cycle, D, for a ZETA converter operating in CCM is given by equation(1)

$$\text{Duty cycle, } D = \frac{V_{OUT}}{V_{IN}+V_{OUT}} \quad ....(1)$$

One of the first steps in designing any PWM switching regulator is to decide how much inductor ripple current, $\Delta I_{L(PP)}$, to allow. Too much increases EMI, while too little may result in unstable PWM operation. A rule of thumb is to assign a value for K between 0.2 and 0.4 of the average input current. A desired ripple current can be calculated using equation(2)

$$\text{Inductor Ripple Current, } I_{L(PP)} = K \times I_{OUT} \times \frac{D}{1-D} \quad .....(2)$$

The value for K between 0.2 and 0.4 of the average input current.

The inductance required in a coupled inductor is estimated to be half of what would be needed if there were two separate inductors. The minimum value of inductance is given by equation(3)

$$L1a_{min} = L1b_{min} = \frac{1}{2} \times \frac{V_{IN} \times D}{\Delta I_{(PP)} \times f_{SW(min)}} \quad ....(3)$$

To account for load transients, the coupled inductor's saturation current rating needs to be at least 1.2 times the steady-state peak current in the high-side inductor. The steady state peak current is calculated using equation(4)

$$I_{L1aPK} = I_{OUT} \times \frac{D}{1-D} + \frac{\Delta I_L}{2} \quad ....(4)$$

IV. SIMULATION RESULTS AND DISCUSSION

The simulation result shows the automatic tap changes through proteus simulation software. The controller will control the entire simulation. The moisture level at various lands are displayed through Liquid Crystal Display(LCD). The moisture level adjustment can be done through potentiometer. The ON/OFF of Light Emitted Diode(LED) determines valve whether to be closed or opened. The GSM messages can be viewed through the virtual display.

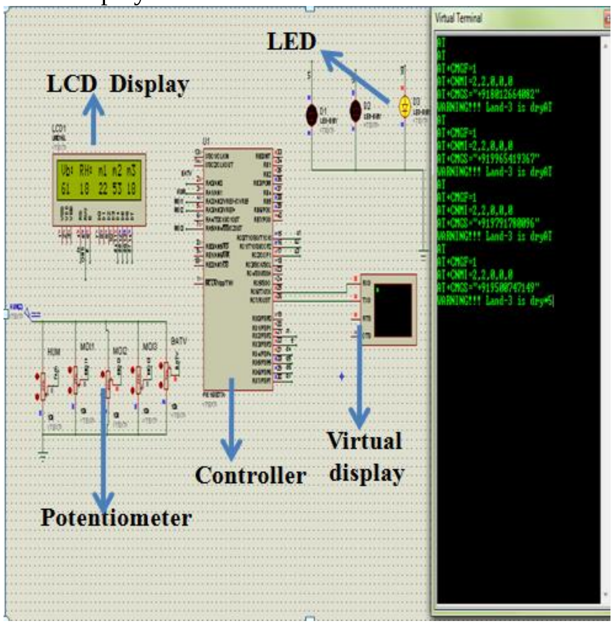

Fig.6. Simulation result

V. EXPERIMENTAL RESULTS AND DISCUSSION

The output results of various hardware units are obtained through Digital Storage Oscilloscope(DSO). The obtained results were compared with the simulated results and they are validated.

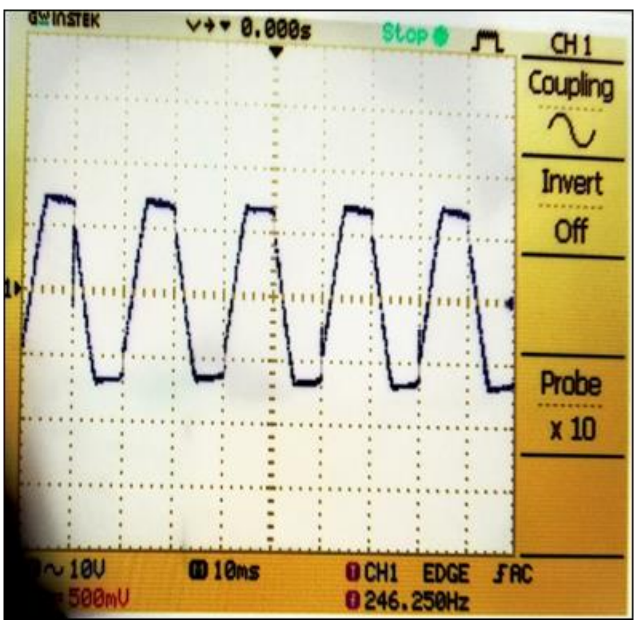

Fig.7. Transformer output 12 V (AC)

Fig.7 shows the voltage of stepdown transformer. The obtained output has the voltage magnitude of 12 V and frequency of 50 Hz.

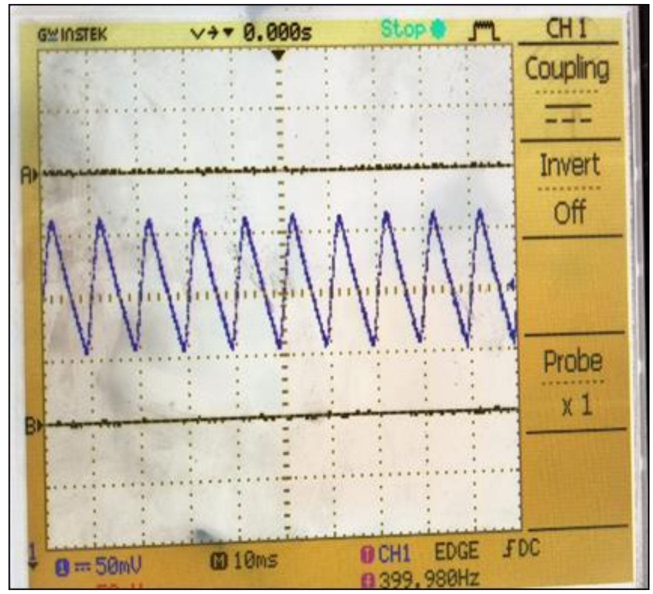

Fig.8 Rectifier output 12V, DC

Fig.8. shows the DC output voltage of rectifier unit with the magnitude of V.

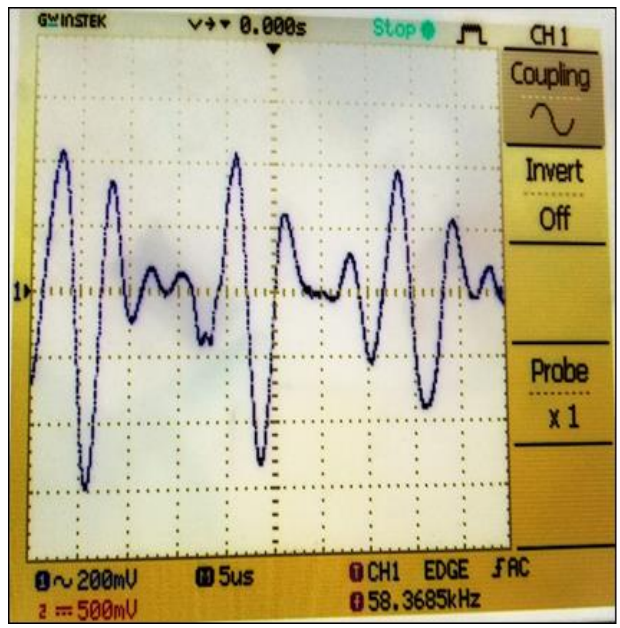

Fig.9. Tripping signal to the backup circuit

Fig.9 shows the output waveform of the driver circuit 1 which is used to operate the backup circuit based on the output of the battery unit.

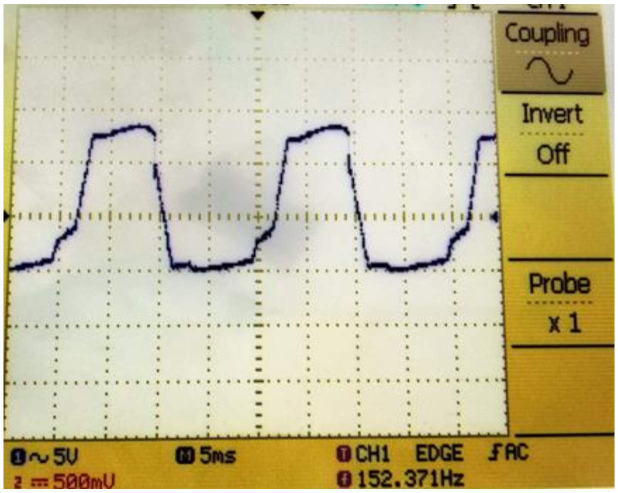

Fig.10. Driver circuit 2 output signal to the Converter

Fig.10 shows the output of driver circuit 2. The obtained pulses are provided to trigger the ZETA converter.

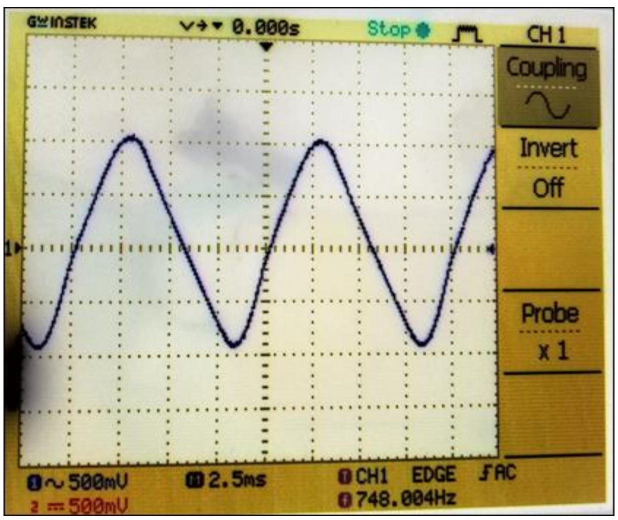

Fig.11. Driver circuit 4 output to the solenoid valve 1

Fig.11 shows the output of driver circuit to make the solenoid valve 1 open or close based on the moisture level in land 1.

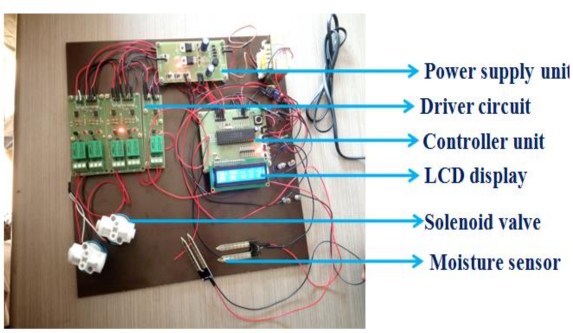

Fig.12.Hardware result

VI. CONCLUSION

The smart SPV array ZETA converter fed pump has been proposed and its suitability has been demonstrated through simulated results and experimental validation. The proposed system has been designed and modelled appropriately to accomplish the desired objectives and validated to examine various performances under various conditions. The performance evaluation has justified the combination of ZETA converter and DC pump for SPV array based water pumping.

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