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Design of Solar Powered Electric Fencing System for Low Resource Setting

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Abstract: ***Solar Powered Electric Fencing System is designed for low resource settings hence low cost components are utilized to construct the fencing system at a cost of less than 30USD. The system is designed to provide an electric fencing system with low initial as well as a low lifecycle costs. Such systems are necessary for rural and tribal areas as these communities have high level of threat from wildlife. The electric fence is used to protect agricultural products, pastures, sheep, cattle, poultry and honeybees from damage to wild animals. Such systems need a reliable source of power as these systems need to be active thought the day. In most remote areas electric supply from utility is not reliable and is available for not more than six hours in a day. Thus these systems need a supplementary power source. Photovoltaic Solar systems provide a low cost solution to the problem as these systems can be easily and reliably installed in most parts in the Indian subcontinent. Lithium Ion batteries are charged by solar PV systems throughout the day and whenever electric supply from utility is available. This ensures that a reliable, low maintenance and rugged electric fencing system can be implemented.***

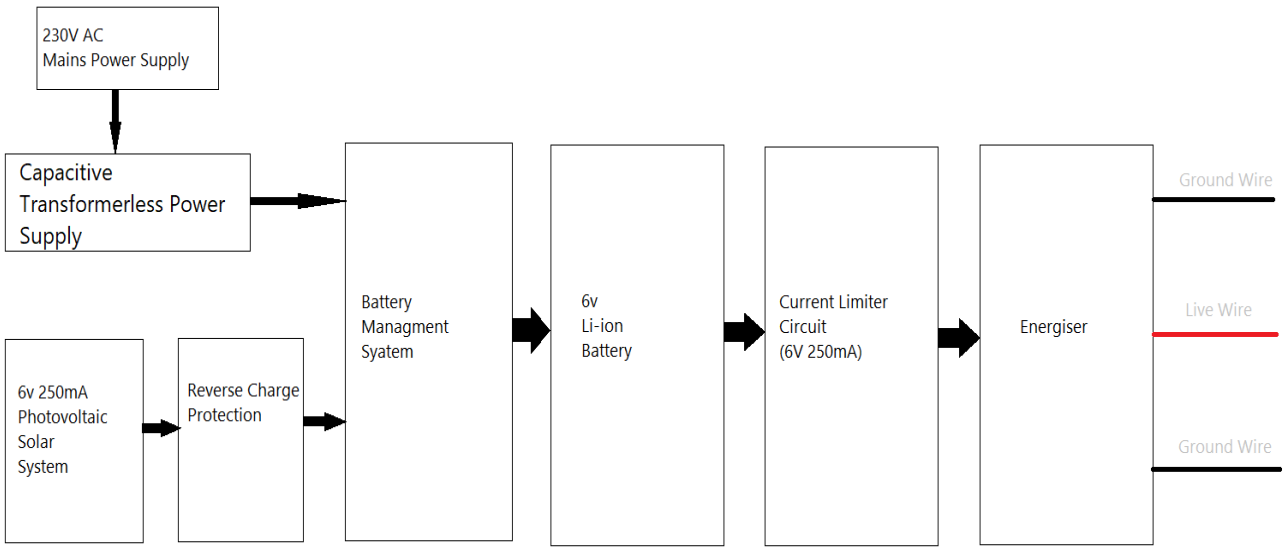
Keywords: Solar, photovoltiac, electric fence, low resource

I. INTRODUCTION

This system utilizes a low cost circuitry which is housed in PVC box and is hence easily transportable. Photovoltaic Solar panels and the fence wire are directly connected to the circuitry. Hence rapid installation is possible. The system is designed such that a non-lethal, high voltage, low current is induced in the fence. When a conducting body (animal) touches the fence, the body experiences a repellant shock. The current levels are maintained at safe levels such that it does not adversely affect wildlife.

II. METHODOLOGY

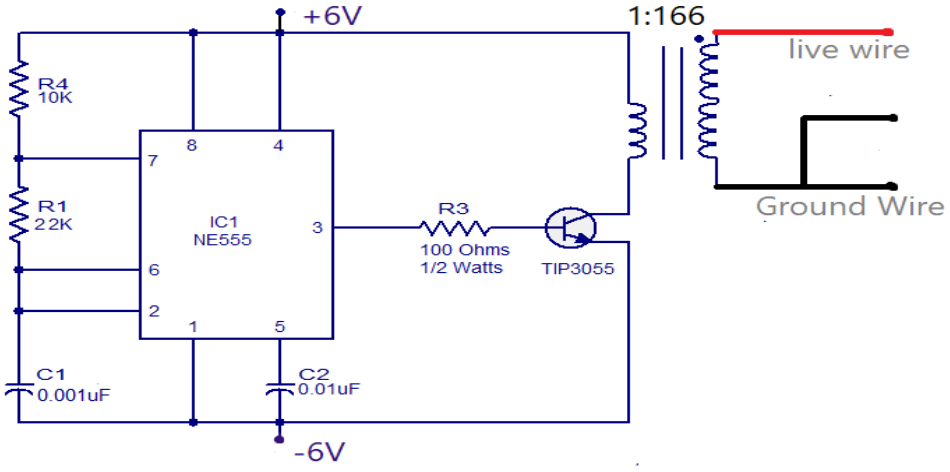
The total resistance of the fence (1km, 1mm thick Aluminum wire) is measured to be 2.2 ohms. The system is implemented using the components shown in the block diagram which are discussed here. The methods discussed are intended to induce a small but painful electric current in the fence wire. This can to be an effective restraining measure.



Electrical System Block Diagram

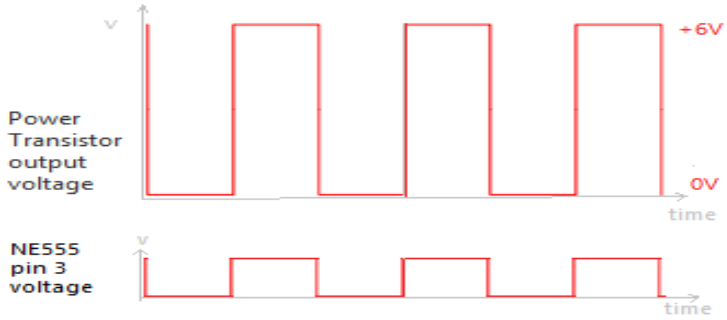
A. Energizer Circuit.

The energizer circuit is designed to step up voltage from 6Volts to 900Volts. The input current is stepped down to a safer level that is below 100mA. The Energizer is responsible for providing a painful electrical shock to anyone in contact with the live wire without permanent harm.

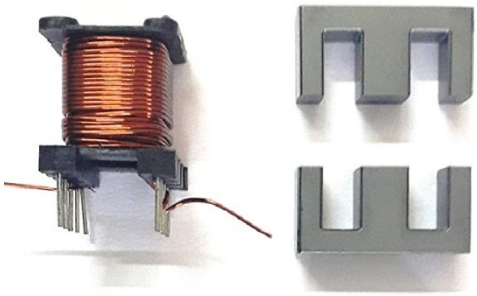


Circuit diagram of energizer circuit [1]

1) *Tigger Circuit:* A timer chip (NE555) is configured as astable multivibrator (oscillator), or square wave generator. This square wave generator is used as a trigger pulse for the switching device. The gate terminal of the static switching device is connected to pin3 of the NE555 which provides a square pulses at a frequency of 25 kHz. Passive components connected to NE555 are selected according to required output frequency (25Hz) and required duty cycle (50%). A series resistance is connected between pin3 and base terminal to dampen the amplitude of the square wave and make it suitable for triggering the static switch.
2) *Power Transistor as a Static Switch:* The TIP3055 NPN power transistor is designed for general purpose switching. The power transistor is connected to a heat sink to prevent overheating. It is used as a switching device for conversion of 6V DC supply into 6V 25kHz AC supply and drives primary winding of the step up transformer at 25 KHz and as a result a high voltage will be induced across its secondary winding



3) *Step up Transformer:* A transformer with the required turns ratio can be locally manufactured using a 10E type core. A PVC bobbin is used for housing the primary and secondary windings. The turn's ratio is 1:166 with five turns on the primary side. A 1mm thick copper wire is used on a primary side while a copper wire of 0.6mm is used on the secondary side.



B. Current Limiter Circuit

It is necessary to provide a reliable current limiter circuit for safety of the affected. The LTC3638 based circuit is used to regulate current supplied to the energizer circuit. This is very important as it regulates the output current of the energizer circuit at a safe level. Thermally Enhanced High Voltage MSOP Package is used.

C. Energy Storage System

Two 18650 Lithium Ion batteries are used in series configuration for energy storage. The output voltage of the battery pack varies between 5V and 8.4V. The series connected batteries are connected to linear voltage regulator circuit which utilizes IC7806. Hence a regulated voltage of 6V can be obtained. A switch is connected in series to this setup which can be toggled to switch the energy supplied to the fence.

D. Battery Management System (BMS)

"A battery management system is designed to monitor the status of batteries, control the process of charging/discharging the battery. Two batteries (18650) can be connected simultaneously to the HX-2S-D20 charge-discharge controller module. The module has protection against short circuit, overcharge and over-discharge. One of the functions of the charge controller is to turn off the power supply for the batteries when the maximum capacity of at least one battery is reached. This BMS controller is designed for more than 30,000 hours of operation. The maximum allowable current is 20 A." [2]

E. Transformer Less Capacitive Power Supply

Power Supply from utility is necessary on cloudy days or during monsoon when adequate energy from PV Solar system is not available. Transformer less power supplies can be effectively used in such low resource settings where a reliable power supply is needed. An output voltage of 6.2 Volts is selected to charge the 2S 18650 Battery pack.

"This Transformer-less power supply designed to produce 6.2V DC output supply, this circuit takes AC input 230V, ceramic capacitor C (474k/400V) is connected serially with AC mains phase line and R Resistor connected parallel to the C capacitor to discharge the energy when there is no AC supply, between fuse and C capacitor metal oxide varistor connected to protect the circuit from transient voltages." [3]

F. Photovoltaic Solar

Small Epoxy Solar Panels are used. Construction requires no frame or special modifications. For connection, just solder or crimp to the copper tape. Laser cut to proper size and encapsulated in special sun and weather resistant materials.

1) Max output power: 3.23W
2) Max working voltage: 6.6V
3) Max charging current: 300mA
4) Min output power: 2.7W
5) Min working voltage: 6V
6) Min charging current: 200mA

A blocking diode (IN4007) is used to prevent reverse charging. Diodes are placed in box with adequate degree of protection. This is done to prevent reverse charging and prevent loss of energy during times when adequate energy is not supplied by the photovoltaic system.

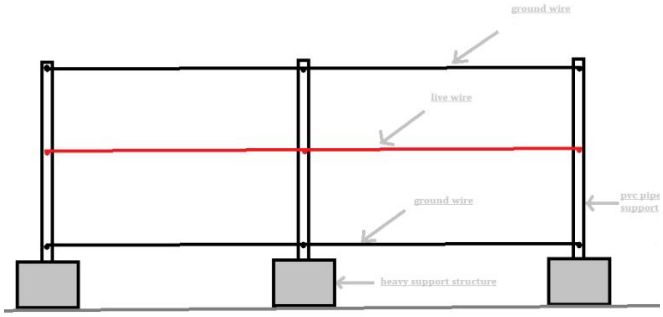
G. Electric Fence

The electric fence consists of three aluminum wires mounted on PVC pipe using polypropylene hooks. The PVC structure is supported by a heavy supporting structure placed at the bottom. The PVC pipes have a length of 300cm.

1) Height of support structure from Ground level = 50cm
2) Height of Ground Wire 1 from Ground Level = 100cm
3) Height of Live Wire from Ground Level = 200cm
4) Height of Ground Wire from Ground Level = 300cm
5) Maximum distance between consecutive structures supporting = 300m

Such a fence can be setup for a length of 1km. If the length of the live wire is increased further by 100m a decrease in voltage levels below rated levels is observed. Moreover a heating of the circuit driving the primary of the transformer is observed for distances greater than 1km.

The distance between the aluminum wires can be changed depending on the threat perception but a minimum distance of 5cm should be maintained to avoid electric stress on lines and avoid corona discharge between the wires.
Energizer unit is arranged to be connectable to fence by means of one single electric connection. In such a manner the electrical module can be connected metal fence in a very easy way.



III. COST ANALYSIS

The system utilizes low cost components which have a costing of 2900INR (30USD) as of April 2020. These components are rated for more than 10000 discharges or 12,000Hrs. Breakdown maintenance schedule may be followed to minimize operational costs.
The system has a modular design .Blocks can be replaced on site even by untrained technicians. Hence the system is highly maintainable.

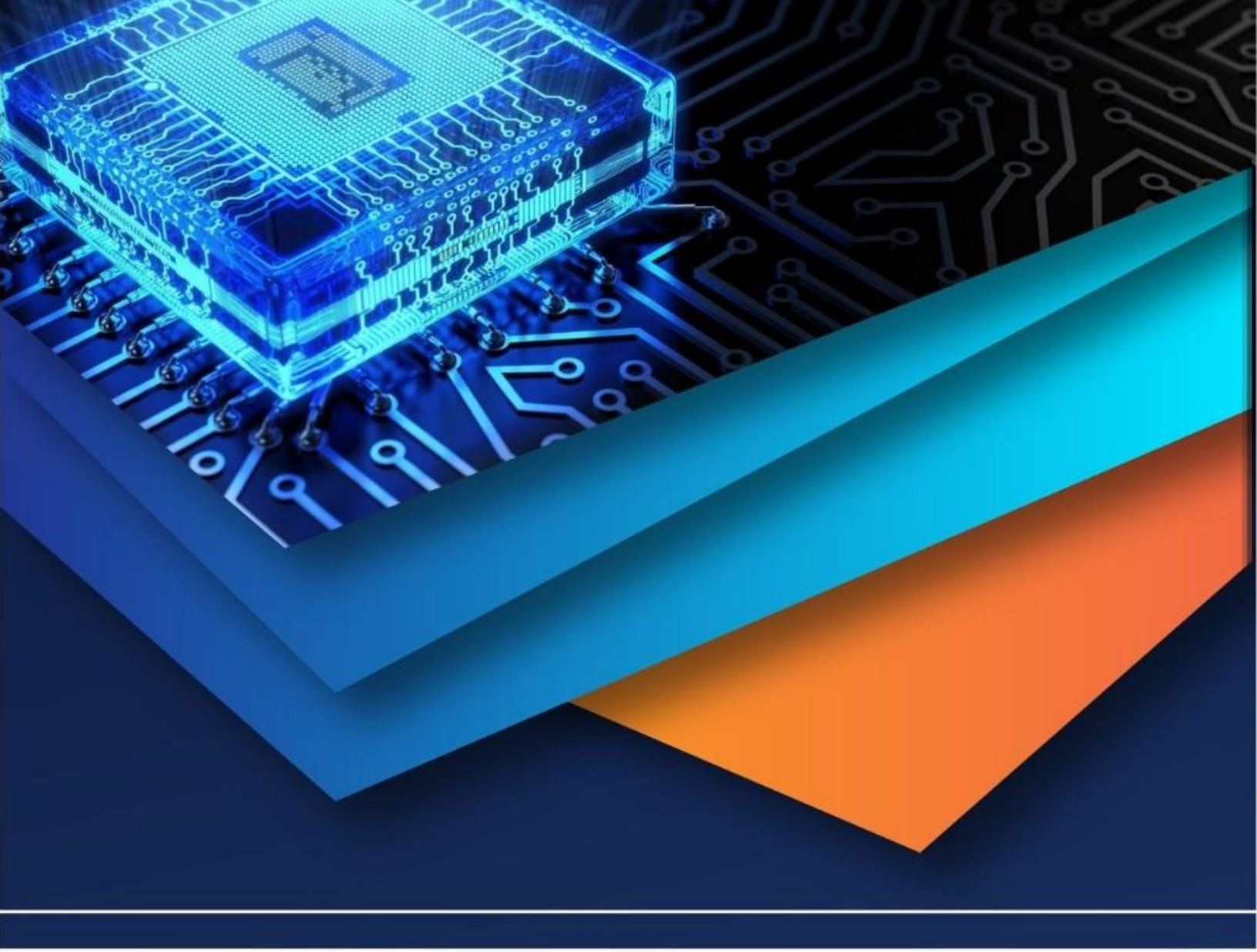
IV. CONCLUSION

In this way a transportable electric fence is designed for a low resource setting at a cost of less than 30USD. The system parameters are measured and found out to be as follows

A. Input Voltage from PV solar system = 6V DC
B. Input voltage from utility supply = 230V AC
C. Input Voltage to Energizer = 6V DC
D. Input Current to Energizer = 250 mA
E. Energizer output Voltage = 900V
F. Energizer output Current = 20mA

V. REFERENCES

[1] http://www.circuitstoday.com/high-voltage-generator-circuit.
[2] https://robu.in/
[3] http://www.theorycircuit.com/transformerless-power-supply-6v-dc/



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