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EXPERIMENTAL AND MATHEMATICAL VALIDATION OF POWER QUALITY MONITORING IN SMART CITIES USING P/O LUO CONVERTER FED SOLAR PV ARRAY

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ABSTRACT. This paper aims at managing the power consumption in smart cities, especially in urban areas. With constant and tremendous increase in the rate of urbanization in the recent few decades, it has become highly inevitable to prevent the increase in power consumption. This problem can be harnessed in outdoor unit by using positive output Luo converter which consists of three levels of voltage lifting technique to manage energy consumption in street lights by using solar energy. This device periodically activates and disconnects street lamp during the day and night, by detecting the intensity of light via the LDR sensor. This aids in converting low voltage to high voltage of 200-250 Volts using Voltage Lifting Technique and power is supplied to street lights. The usage of three levels of lifting technique makes it possible to supply power even during rainy and cloudy periods. People being callous do not take care to turn off the indoor electrical gadgets after use. Sensors such as PIR sensor and DHT11 can automatically control their usage by switching off the loads when no person is detected in the room. This work reduces power consumption and thereby energy can be saved in the future.

Keyword; Smart Cities, Luo Converter, Lifting Technique, Temperature Sensor, Power quality, Power Management, Solar PV Array.

1. INTRODUCTION

That most of the population of the world resides of metropolitan regions, and over the next few years more citizens are projected to migrate to the cities. A convergence of initiatives aimed at improving quality of life and public infrastructure is correlated with the word smart cities. [11]. Street lighting is one of the city's main electricity expenses. In the environment of today, street light absorbs up to 60 % of the total energy in a city. This is attributable to the constant illumination activity throughout the night [12]. A smart street lighting system has been suggested in our paper without using external power supply in order to minimize the energy usage and waste, as energy demanded in street lights is obtained through the provision of solar energy[13]. Our paper is designed to efficiently manage energy consumption both inside and outside of a smart city. Throughout the external panel, the P / O Luo transfer system increases the voltage by utilizing the voltage shifting procedure from low voltage to high voltage. Closed-loop converter is designed to achieve the optimal performance range [4]. In this article, a P / O Luo converter system driven by solar lights with energy saving technologies is provided. The road lights are turned on / off automatically with the LDR system. The Solar PV consumes the very low light intensity tension. Through multiple voltage elevation methods this low voltage can be transformed to a high voltage, based on light strength occurring on the Solar PV. This high voltage can be subdivided into different street light systems mounted on the ground.

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2. LITERATURE SURVEY

Intelligent systems utilizing Luo converters in intelligent cities were surveyed in Literature. For the new method, the following articles are regarded as reference sources.

1. M. Wazed et al. "Remote Streets Light Control Using Microcontroller" This paper advances automated street control circuit architecture and development. The two key conditions in the operation of the circuit are LDR sensors and photoelectric sensors. No DC-DC converters in the circuit are required to make the voltage unreliable.
2. Khattab H. A. et al. [2016] addressed DC-DC Boost Converter for Stand-Alone PV Configuration system architecture, control and performance analysis. They find the electricity from a solar energy network to be one of the most efficient, regularly accessible and environmentally sustainable clean energy sources. The voltage is not raised up as the traditional boost converter is used.
3.ParkashTambare et al.[2016] discussed the innovative architecture and deployment of integrated energy management systems. It is done by detecting and entering a vehicle with an IR and IR detector pairs. The project has a sophisticated, automated network that regulates street lights on the basis of vehicle detection or some other hazard on the route.
4. Andrea Zanella, et al. Inspired Cognitive Internet Of Things
Street Lighting System"The aim of this paper is to track street lights anywhere and anywhere utilizing the internet. The creativity of this device can only be tracked using IOT.
5. D. Gacio, et al. DC-DC Luo Converter Dependent Smart Street Lighting Utilizing Arduino Uno"This paper switches on street light with low nocturnal visibility and strong nighttime visibility.
6. F. J. Perez-Pinal,et al"Microcontroller-controlled automated lights and fan settings" This device regulates lamp with LDR dependent on light strength. Temperature monitor powers the ventilator.
7. S. Escolar,et al. The paper introduces an intelligent street lighting control system which makes it possible to adjust multi-phase light sources in their intensity to the environment. The study of saving energy in Smart Street lighting utilizing adaptive control systems.From the existing systems the problems are defined as follows.

1. One solar panel and one DC - DC converter is implanted for each street light.
2. Installation cost is high.
3. Only one level of voltage lifting technique is used
4. Output voltage depends on the intensity of light falling on the Solar PV.
5. No assurance for constant high power during cloudy or winter seasons.

3. PROPOSED SYSTEM DESCRIPTION

The system proposed here is to mainly overcome the drawbacks of the existing system and it also has some added features. External power supply is not required since power is taken from solar energy[18]. High power can be obtained using super lifting technique of positive output DC-DC Luo converter. It deploys three levels of voltage lifting technique through which constant high output can be obtained irrespective of the intensity of light falling on the Solar PVarray [20].

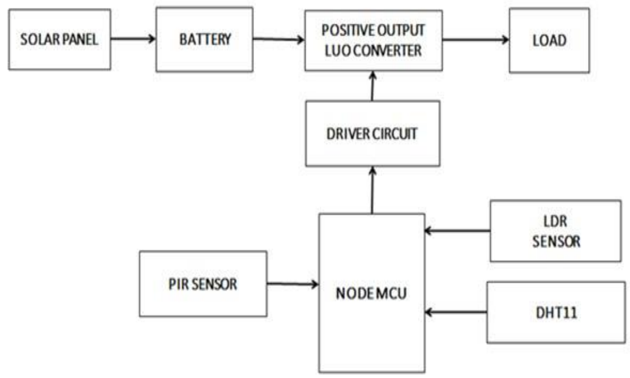

Figure.1. Proposed System Block Diagram

The three levels used are,
(i) Simple lift or elementary
(ii) Re-lift and
(iii) Triple lift or multiple lift by which persistent high output is acquired even during cloudy and rainy seasons.

The overall building block of the suggestedmethod is exposed in figure 1. There are two units in the block diagram such as outdoor unit and indoor unit. In the outdoor part, the solar panel absorbs the intensity of light falling upon it and it is stored in a battery. This low input from the Solar PV is boosted to high voltage using positive output DC-DC Luo converter and supplied to many street lights. Adriver circuit is used to increase current to the required levels and sends the required PWM signals to the MOSFET of Luo converter. All these operations are controlled by the NodeMCU.

The Indoor part focuses on reducing the unwanted usage of power by using sensors such as PIR, LDR, and DHT11.The lights and fans are switched off automatically when no person is detected in the room. The LDR sensor senses the intensity of the room light and when the intensity of light is high the lights are turned off. The DHT11 monitors the temperature in the room and when the temperature is below certain threshold level set, then fan is switched off automatically.

4. PROPOSED CONVERTER CIRCUIT OPERATION

P / O Luo-converters are a state-of-the-art DC-DC converter that utilizes the voltage lifting method to convert positive to positive voltages. [2] The first quadrant is fitted for an intensification of high voltage. This Luo converter proposes three stages of voltage elevation technology

- ✓ Elementary circuit
- ✓ Circuit Re-lift
- ✓ Triple-lift circuit

A. Elementary Circuit

The basic circuit of the voltage elevators is the Elementary circuit and their switching function is seen respectively in Fig.2 and Fig.3. The capacitor C serves as the major element of the collection and transfer of power from source to load by pumping inductor L_1. [2]Based on the constant-state case, the difference in voltage through condenser C from its mean value V_C may be ignored by believing that the condenser value C is fairly high , i.e., $V_C(t) \approx V_C$

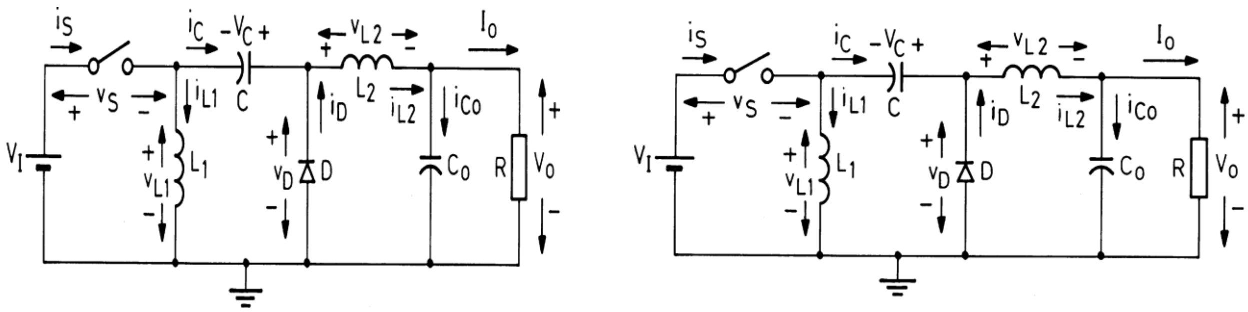

Figure.2. Elementary Circuit Diagram

Circuit Description

The input current moves through the circuit while switch S is turned on is the number of inductive currents $i_I = i_{L1} + i_{L2}$. Therefore the energy is derived from the power supply by the inductor L_1. Meanwhile, the L_2 inductor consumes energy from the source and the C condenser, hence the i_{L1} and i_{L2} inductor currents maximize.

The input current is 0 if the S function is set to OFF, i.e. $i_I = 0$. The current induction i_{L1} will therefore runs through the free-ride diode D and charges the condenser C. The inductor current i_{L2}, meanwhile, flows through the circuit (C_O – R), and the freewheeling diode D holds it going in continuous mode.

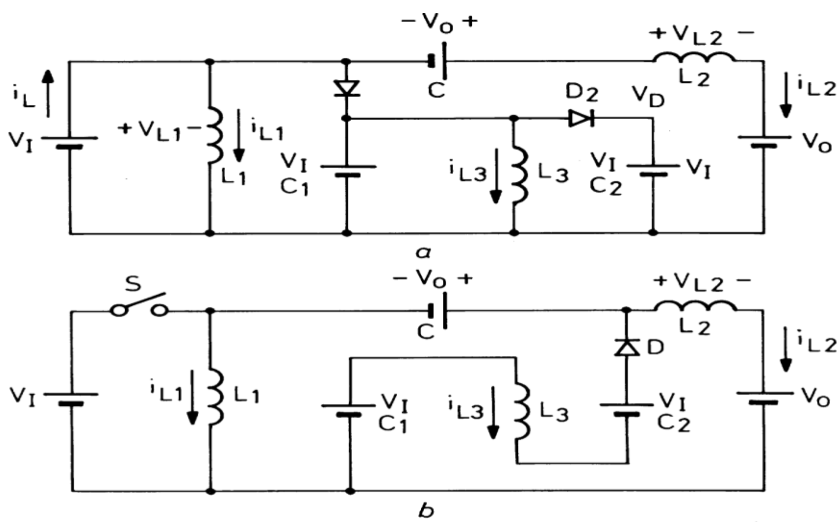

Figure.3. Switching Circuits a) ON condition b) OFF condition

Therefore i_{L1} and i_{L2} reduce inductor currents. [5]The alternating circuits are seen in Fig.3 to analyze the operating circuit. The inductor present variants i_{L1} and i_{L2} are therefore constrained such that iL1 is able to operate in i_{L1} and i_{L2} is able to operate in i_{L2}. [2]so capacitor C charge rises when OFF ground.

Circuit Re-lift

This is a circuit adapted from the self-lift circuit which increases the voltage twice as high as the original circuit.

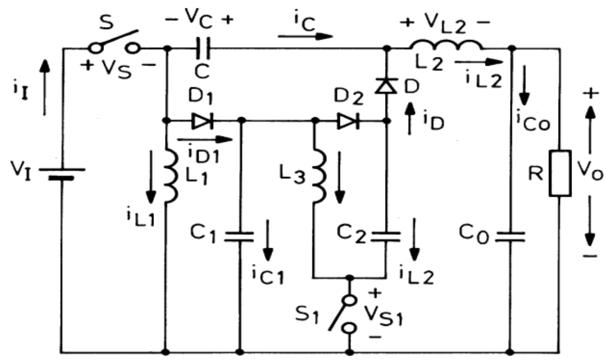

Figure.4. Re-lift Circuit Diagram

This comprises of two S and S_1 static controls, three D, D_1, and D_2, L_1, L_2 and L_3pumping inductors, C, C_1, C_2, and C_O. [2] Here the C_1 and C_2 act, with the VC voltage capacitor rising twice as far as the VI voltage infeed. The L3 inducer acts as a junction to link C_1 and C_2 capacitors and increase V_C capacitor stress. The present capacitor i_{C1} (t) = δ_1 (t) and $i_{C2}(t) = \delta_2(t)$ are also functions that are exponential[5]. The input voltage of the capacitor in a steady state of $v_{C1} = v_{C2} = V_{I.}$ The function of the switching mechanism of the re-lift as seen in Fig.5.

Circuit Description

The current flowing through the circuit with switches S and S1 is the sum of inductive currents (i.e., $i_I = i_{L1} + i_{L2} + i_{C1} + i_{L3} + i_{C2}$) The L_1 and L_3 inductors then remove the power from the source. The L_2 inducer consumes the energy from source to condenser C at the same time. So i_{L1}, i_{L3}, and i_{L2} get raise inductor currents. [2]

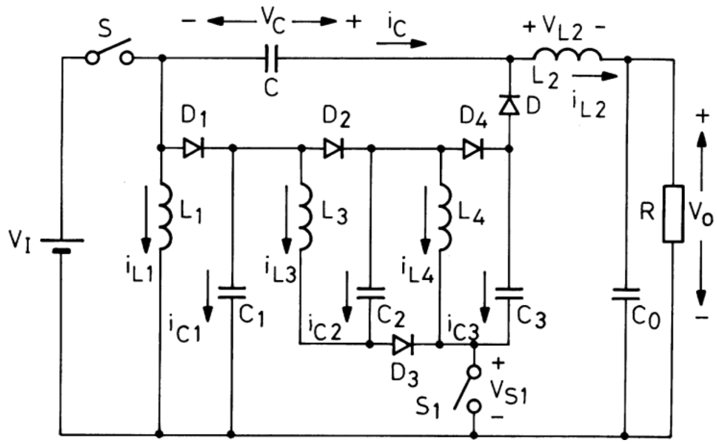

Figure.5. Equivalent Circuits a) Switch ON b) Switch OFF

As S and S1are are disabled, the input current is zero, i.e. $i_I = 0$. This means that the induction current i_{L1} must travel via the condenser C_1, inductor L_3, condenser C_2 and D, which loads the condenser C. Thus, the IL2 transmits the accumulated energy through the C condenser. At the same time, the iL2 inductor current passes the (CO – R) circuit via the condenser C1, L3 inducers, C_2 condensers and D diodes, which enables the circuit to work continuously. This rising i_{L1} and i_{L2} get inductor currents[2]. The circuits are shown in Fig.5 for the study of the operating cycle.

Hence in the steady-statethe capacitor voltages V_{C1} and V_{C2} across them are similar to $V_I$by assuming the capacitor C_1 and C_2 are sufficiently large [2].

B. Triple Lift Circuit

This is the circuit obtained from the self-lifting circuit which raises three times the voltage of the primary circuit. The condenser comprises two static switches S and S1, four pumping inductors L_1, L_2, L_3, and L_4 five switching condensers C, C_1, C2, C_3 and $C_O$and five freewheeling diodes, as seen in Fig.6. Here the condenser C_1, C_2 and C_3 switchovers work by raising the condenser voltage VC three times over by the Input voltage V_I [2].

The L3 and L4act inductors bind the three C_1, C_2, and C_3 and raise the capacitor voltage from the V_C[2] as an interconnection point. So, the capacitor currents iC1(t), iC2(t) and iC3(t) are the exponential equation i_{C1} (t) = δ_1 (t) $i_{C2}(t) = \delta_2(t)$ andi_{C3} (t) = δ_3 (t) [5].The condenser voltages in the steady-state is equivalent to input voltage $v_{C1} = v_{C2} = v_{C3} = V_I$.

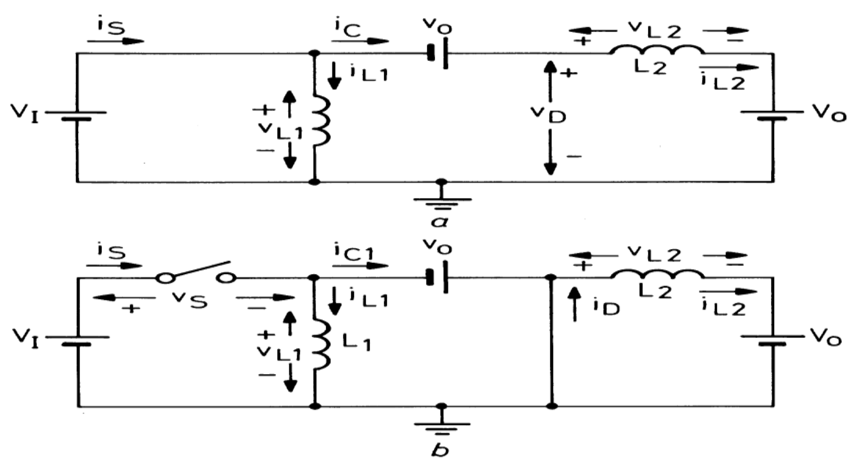

Figure.6. Triple Lift Circuit Diagram

V. HARDWARE RESULTS & DISCUSSIONS

Our proposed system has two units namely,

1. Outdoor unit
2. Indoor unit

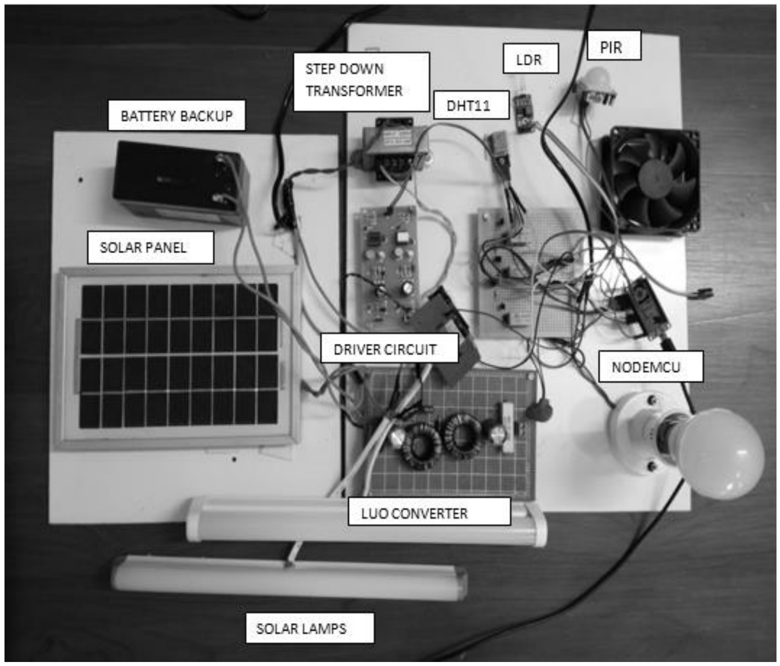

Figure.7. Indoor and Outdoor Unit

Outdoor Unit:

The outside unit consists of a solar panel that absorbs light intensity and is supplied with Luo converters with a high voltage. Step down Transformer transforms 230v to 12v supplied to the high-voltage driver circuit. The high voltage produced by the conversion system is subdivided into the lamps (street lighting). Street light is disabled during the day and triggered by measuring the light level in the surroundings using an LDR sensor during the night. The LDR system detects that light strength is strong in the atmosphere (day time) and the street light is turned off during daytime. Fig.8 displays the performance of the outdoor unit.

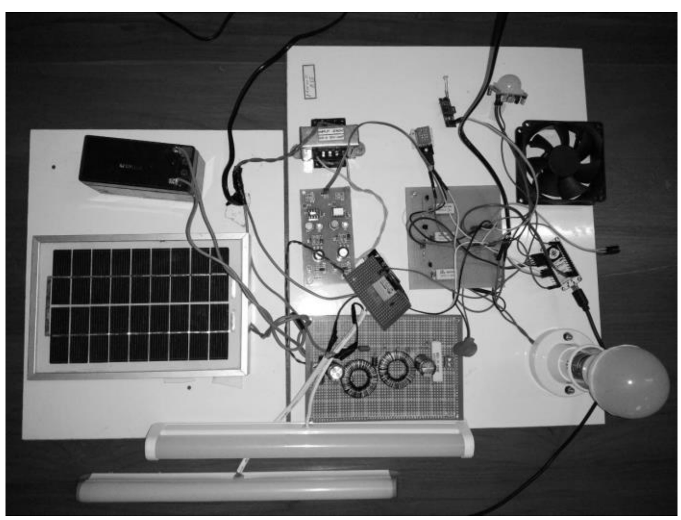

Figure.8. Street lights – Off condition during day time

The solar panel absorbs the intensity of light falling on it and the Luo converter converts into a constant high voltage by using any of the three voltage lifting techniques such as elementary re-lift or triple lift according to the intensity of the input to the solar panel is depicted in Fig.9

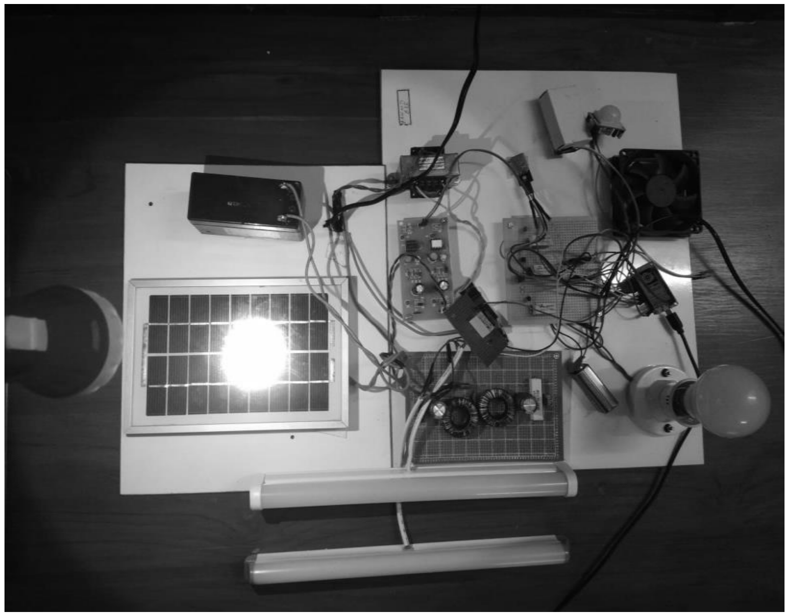

Figure.9. Input to Solar PV through torch light

The voltage boosted by the converter (from 3v to 30v) is sub divided and supplied to the street lights each of 15v during night time (i.e.) LDR sensor is closed which implies that the intensity of light in environment is less during night time which is depicted in Fig.10. When the LDR is activated the street lights are turned ON during night condition. During morning time the LDR is turned OFF so that the street lights are turned off automatically. The automatic operation of the outdoor units makes less energy consumption and saving the energy for future. Here the Luo converter plays a major role of lifting the voltages at higher levels.

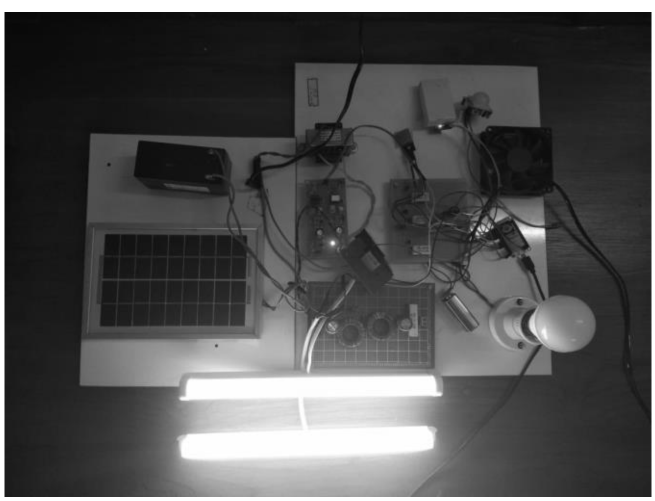

Figure.10. Street light-ON condition during night time

***Indoor Unit*:**

Indoor unit comprises of PIR sensor and DHT11 sensor. When there is no human detection the lights and fan are switched off using PIR sensor. When temperature inside the room goes below 25°C the fan is turned off automatically. The temperature is sensed using DHT11.

The PIR sensor detects human radiation so the light and fan are switched on automatically when a person is detected in a room is depicted in Fig.11.

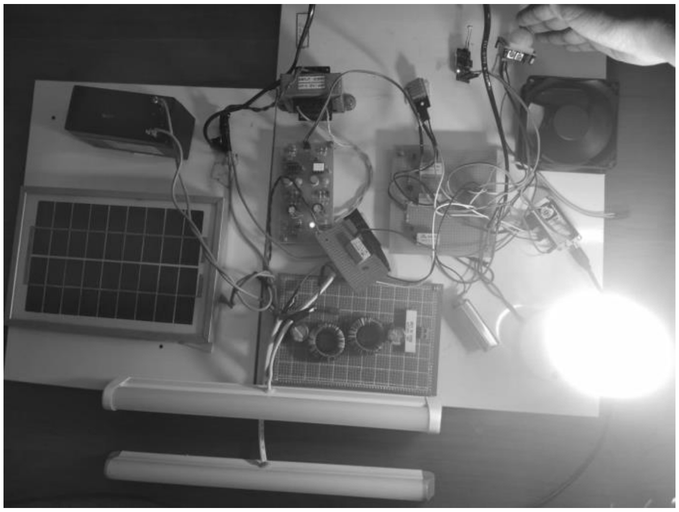

Figure.11. Human detected-Fan, Light ON condition

When no person is detected in the room (no human detection near PIIR sensor) the fan and light is turned of automatically.

Ice cube is placed near DHT11 sensor which senses the temperature. When the temperature is equal to or falls below 25°C then the fan is turned off automatically is depicted in Fig.12.

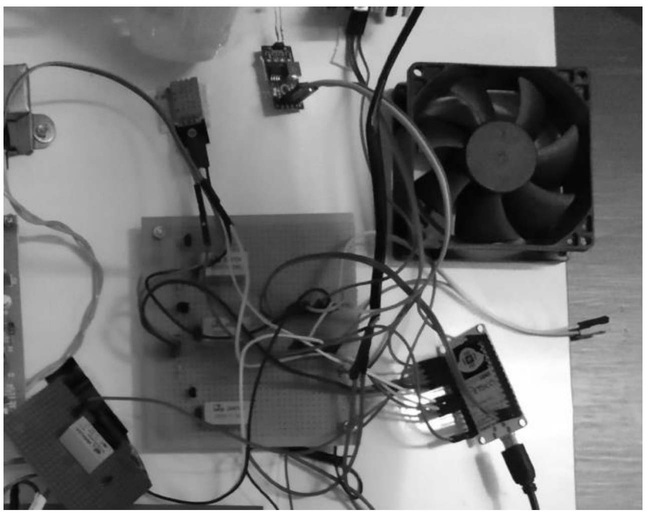

Figure.12. Temperature detection using DHT11 sensor

5. Conclusion

The key aim of the proposed study is to limit and control electricity use, use renewable energy without the use of artificial power sources, both indoors and outdoors in an successful community. So theelectricity bills are reduced with ease of maintenance and provide an eco-friendly environment in the outdoor unit. Since three levels of voltage lifting technique (super lift) is employed through positive output Luo converter, constant powercan be supplied in every seasons (i.e.) even during cloudy and rainy weather and moreover battery backup is also provided. The high power generated by theconverter is sub divided and provided to many street lights so the implantationcost is also reduced. The unwanted usage of power is reduced by switching offthe commonly used loads in indoor units such as fans and lights automatically when no person is detected and fan can be turned off when the temperature in the room goes below a certain threshold level and thereby reduce the wastage of energy. The disadvantages in the existing system are eradicated with some added features and the module has been implemented successfully.

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