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# Smart Photovoltaic UPS system for domestic use

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***Abstract* — The world is facing problem to generate and use energy to drive different machines and circuits. In this scenario paper suggests a solution to overcome the problem through successful implementation of cost and maintenance effective system. This project aims to design and implement a low cost low maintenance and high/low voltage protection system for rural area. The Non-Conventional energy sources are cheaply and easily available. Effective and efficient harnessing of solar energy will play a crucial role in providing the environment friendly energy.**

***Index Terms* — DC-AC converter, Photovoltaic.**

## I. INTRODUCTION

During last 20 years the world is facing a biggest problem of GLOBAL WARMING. It has become essential to search for alternatives for power sources and the proper utilization of it. The source easily cheaply available is solar energy! This project deals with the NON CONVENTIONAL ENERGY sources. Environment-friendly energy used for domestic, industrial, agricultural, transport and other needs of mankind. Solar energy will be more relevant for the developing countries whose energy requirements are increasing rapidly as a result of large scale industrialization and growing population.

Solar energy systems have emerged as a viable source of RENEWABLE ENERGY. Such systems are based on a solar collector, designed to collect the sun's energy and to convert it into either electrical power or thermal energy. This project will control fetching the input from the sensor for reception of maximum intensity and gives command to arrange motors as per change in the position of the sun. This energy is further used to drive various applications.

Smart photovoltaic UPS system suitable for domestic applications is discussed by C.Cavallaro et. application of photovoltaic system for UPS using a novel single phase PWM voltage source inverter Sokutaro Nonaka et as The application of utility interactive photovoltaic power generation system for UPS.

This project aims to design a low cost photovoltaic UPS for home load (Like FL, CFL).Project is designed such that if troubleshooting is required then basic knowledge is also sufficient since no programming involved. A common man also can get system repaired in his\her hometown.

## II. BLOCK SCHEMATIC OF SYSTEM

### A. AC Mains

Sine, 230 Volts, 50Hz AC supply from electricity board (As per Asian country).

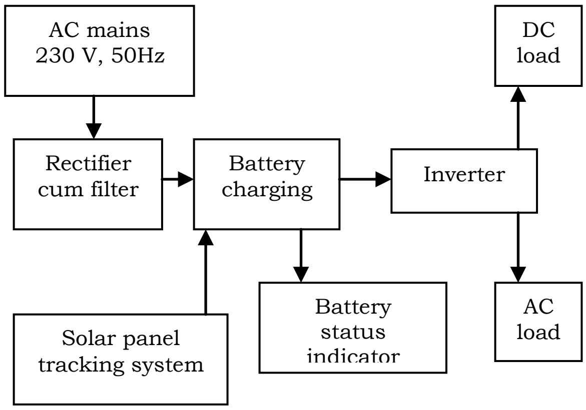



Fig.1. block diagram of system

### B. Rectifier cum charger

Bridge rectifier is used as it has PIV rating (Vm) and rectification efficiency (81.2%), Transformer utilization factor (TUF) is 0.812, a charger is a device used to put energy into a secondary cell or rechargeable battery by forcing an electric current to flow through it.

### C. PV or solar cell

Solar energy is the conversion of the sunlight into electricity and this can be done using the Photovoltaic Cell. The basic working principle of working of PV cell is that it generates electromotive force as a result of absorption of ionizing radiation. These are durable, Reliable and generally maintenance free.

### D. Battery

It is nothing but combination of the individual cells. A storage cell is one of that can be recharge after discharging by passing the DC current through the cell in the positive direction. For the continuous supply to the load it is directly connected to the battery.

### E. Load

Circuit is designed to have capacity of driving AC or DC load. Such Motor, Buzzer etc. AC load can also be drive using inverter.

### F. Solar panel tracking system

Four light sensors (such as LDR) are placed on solar panel edges. One motion: 180 ° rotations from east-west as shown in fig 2. (Solid line) and second motion: slightly E –NW (Uttarayana) and slightly E-SW (Dakshinayana) as shown in fig 2(dotted line).

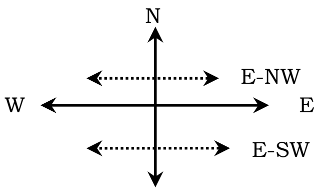



Fig.2 Direction to be followed

Latitudes are increasing till December 22nd and after that it's starting to decrease. These are in negative and hence it shows the sun is moving to south. When the latitude starting to decrease it means sun is moving up – Uttarayana (starts at approximately Dec 22 days are longer than nights).

Jun 23rd midnight at universal time sun's latitude is decreasing before that it was increasing and hence before reaching midnight of 23/Jun Sun already starting to descend in latitude – dakshinayana (Approximately starts at Jun 22; nights are longer and days are shorter). The motor 2 is required to set after every 6 months while motor one will require bring back every day.

Table 1: Motor movement as per Uttarayana and Dakshinayana

| Dire-ction | M-1 | M-2 | Comp-1 (V) | | Comp-2 (V) | |
|---|---|---|---|---|---|---|
| | | | Pin no 7 | Pin no 14 | Pin no 7 | Pin no 14 |
| E-W | CW | - | 10.6 | -0.44 | -0.44 | -0.44 |
| W-E | CCW | - | -0.44 | 10.56 | -0.44 | -0.44 |
| E-SW | CCW | CCW | -0.44 | 10.56 | -0.44 | 10.56 |
| SW-E | CW | CW | 10.56 | -0.44 | 10.56 | -0.44 |
| E-NW | CCW | CW | -0.44 | 10.56 | 10.56 | -0.44 |
| NW-E | CW | CCW | 10.56 | -0.44 | -0.44 | 10.56 |

## III. Working Of System

### A. DC Power supply

The circuit uses LM 317 H linear monolithic adjustable positive voltage regulator. The step down signal from transformer secondary (12-0) Vrms is faded to bridge rectifier (using 1N4007) to get pure DC 12V regulated voltage after capacitor filter (2200uF, 63V). The variable resistor is set to approximately 5.6KΩ.

Solar Panel gives 15-17V as per intensity .This level is faded to regulator to generate regulated 12V DC. Battery takes time to charge 02.30 Hrs with 1A and discharges 05.00Hrs with 9W Pl lamp.

### B. Battery protection circuits

#### i. Overcharge

LM 324A is Op- amp quad comparator inverting terminal is connected to 5.12 V and non-inverting terminal to battery when battery voltage exceeds 13V this switches transistor Q1 (BC 547A, NPN general audio power transistor) when collector current goes 80 mA to device is on and otherwise off. This energizes relay of 100Ω, 12V. This action causes buzzer of 200Hz and Red LED to glow to indicate the condition of overcharge. AS shown in fig. 4

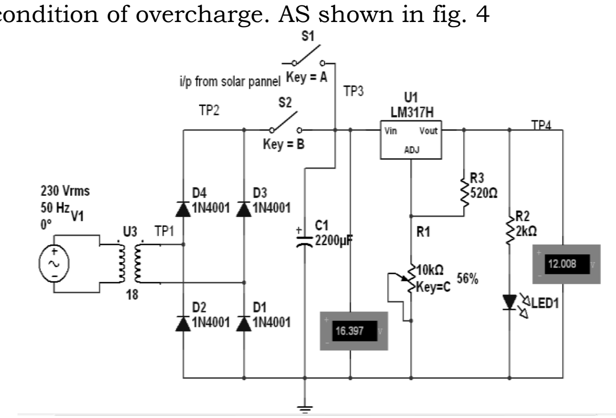



Fig.3. Power supply for control circuit drive

#### ii. Undercharge

LM 324 A is Op- amp Quad comparator inverting terminal is connected to 2.19 V and non-inverting terminal to battery when battery voltage reaches 10.5 V this switches transistor BC 547A and rest operation as per overcharge. Indication by green LED as shown in fig. 4.

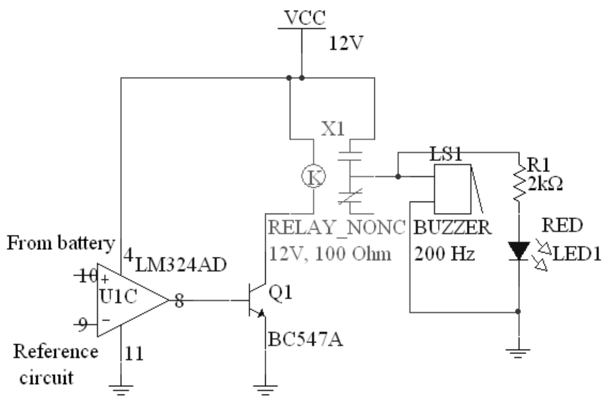



Fig.4. Battery status indication circuit showing overcharge condition

The following table gives different testing result, which gives idea of reference voltage available at comparator terminal, transistor status which drives relay and activate buzzer and LED. This is made induplicate to track undercharge condition too. The charging circuit will break if overcharge/ undercharge condition occurs. This will assure safety of battery.

Table 2: Table showing status and indication for safe

| Battery level (V) | Ref. Level (v) | Battery status | Trans-istor | Indicator |
|---|---|---|---|---|
| >10 | 10 | Under-charged | Q1 ON | RED |
| >11.05< | NA | Inter- | NA | NO |

| | | | | |
|---|---|---|---|---|
| | | mediate | | INDICATION |
| <13 | 13 | Over-charged | Q2 ON | GREEN |

The table shows battery status indicator output voltage levels

Table 3: battery status indicator comparison

| Pin No | Mains Supply | Solar Panel |
|---|---|---|
| pin no 09 | 5.12V | 5.12V |
| Pin no 10 | 3.86V | 3.17V |
| Pin no 12 | 2.14V | 2.15V |
| Pin no 13 | 2.21V | 2.19V |

*C. Tracking decision circuits*

This is LM 324A Quad Op am comparator are used drive 12V, 100 RPM, 0.5KG torque, DC motors as intensity sensed by four light sensors. The following table elaborates about the motor rotation direction.

Several factors must be considered when determining the use of trackers. Some of these include; the solar technology being used, the amount of direct solar irradiation, field-in-traffics in the region where the system is deployed, and the cost to install and maintain the trackers.

There are many types of solar trackers, of varying costs, sophistication and performances:

Single Axis.

Dual Axis.

Dual Axis Tracking system is much more advantages compared to Single Axis. In Dual Axis, solar trackers have both horizontal and a vertical axis, thus they can track the sun's apparent motion anywhere in the world. Many traditional solar PV applications employ two axis trackers to position the solar panel perpendicular to sun's rays. This maximizes the total power output by keeping the panels in the direct sunlight for the maximum number of Hours per day.

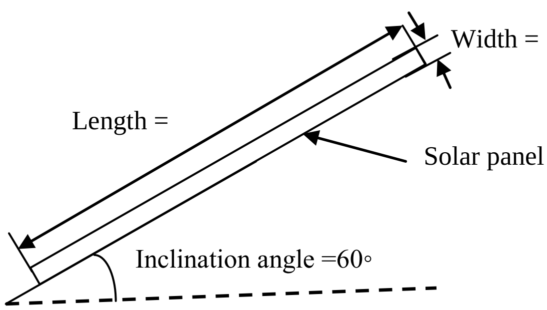



Fig .5.a. showing inclination

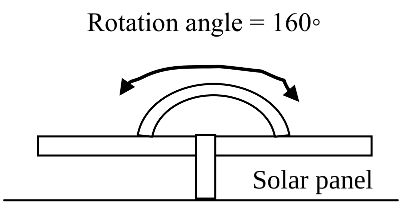



Fig .5.b. Showing rotation angle

The fig 5.a shows an inclination angle of panel with reference to earth's surface. This arrangement will help to travel from E to SW or NW. The angle of inclination is fixed.

Fig.5.b. shows rotation of solar panel along East-West. This rotation angle is 160◦.This arrangement will work every day starts at sunrise and ends at sunset.

*D. Sensor and signal conditioning circuit*

The resistance of the LDR is in the range of 800 Ω to 500Ω in sunlight. To process this data it is necessary to convert it into electric signal. For this a voltage divider is used. The output of this voltage divider should vary in the range of 0.5 to 8 volts. 0.5V corresponds to 800 Ω and 8V corresponds to 500 Ω. Keeping these parameters in mind, the voltage divider has been designed as shown in following fig.6.

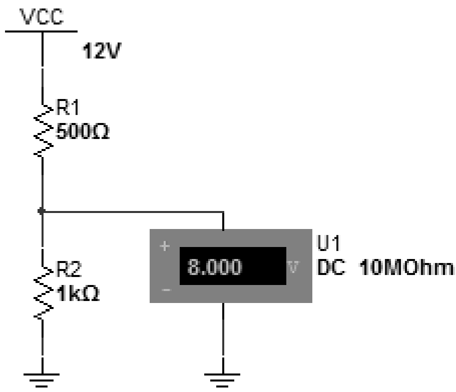



Fig.6. Voltage divider circuit (circuit created in Multisim 11)

$V_{ref}$ = $(R_2/(R_1+R_2))VCC$……………………(1)

$V_{ref}$ = 8 Volts

Sensors arrangement is as shown in following circuit diagram fig.7

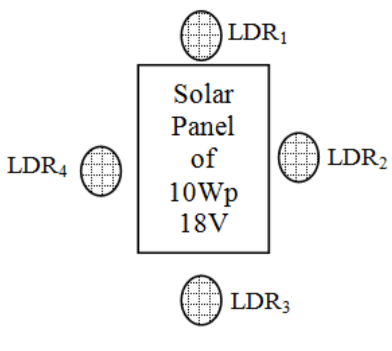



Fig.7.sows LDR arrangement for sunlight sensing

The following table shows voltage observed at every LDR as per incident sunlight intensity. LDR exposed to light and dark conditions are given in tabular format (L indicates light and D indicates Dark).

The difference amplifier is used to carry out the difference between the outputs of 2 LDR's. The lowest resistance for which the panel should move is taken as 500Ω. The gain of the difference amplifier comes out to be 27.

Table 4: Showing LDR light and dark condition voltage levels.

| Sr. No | Condition | Reference voltages (V) | | | |
|---|---|---|---|---|---|
| | | V1 | V2 | V3 | V4 |
| 1 | ALL LDR Exposed to sunlight | 0.58 | 1.08 | 1.39 | 0.92 |
| 2 | LDR1 L | 7.45 | 0.85 | 1.46 | 0.86 |
| 3 | LDR2 L | 0.82 | 7.31 | 1.49 | 0.98 |
| 4 | LDR3 L | 0.79 | 0.90 | 7.45 | 0.81 |
| 5 | LDR4 L | 0.84 | 1.07 | 1.44 | 5.68 |
| 6 | LDR1 D | 0.01 | 1.06 | 1.43 | 0.89 |
| 7 | LDR2 D | 0.88 | 0.02 | 1.52 | 1.05 |
| 8 | LDR3 D | 0.85 | 1.02 | 0.09 | 1.05 |
| 9 | LDR4 D | 0.85 | 1.16 | 1.52 | 0.42 |

$V_1$ and $V_2$ are the inputs from the voltage divider 1 and 2 respectively. The output equation of the difference amplifier is given by:

$$V_o = R2/R1\ (V1-V2) \qquad (2)$$

The comparator circuit compares the output of difference amplifier with the threshold voltage and gives the output to the motor driver. The threshold voltage is set to 7 Volts.

*E. Design of motor driving circuit*

The L293D is quadruple high current half-H drivers IC. The L293D is designed to provide bidirectional drive currents of up to 1A at voltages from 4.5V to 36V.

IC can drive the two DC Motor simultaneously by giving a enable signal. When the enable input is high, the associated drivers are enabled which makes their outputs active and in phase with their input. With proper data inputs, each pair of drivers forms a full-H (bridge) reversible drive suitable for motor applications.

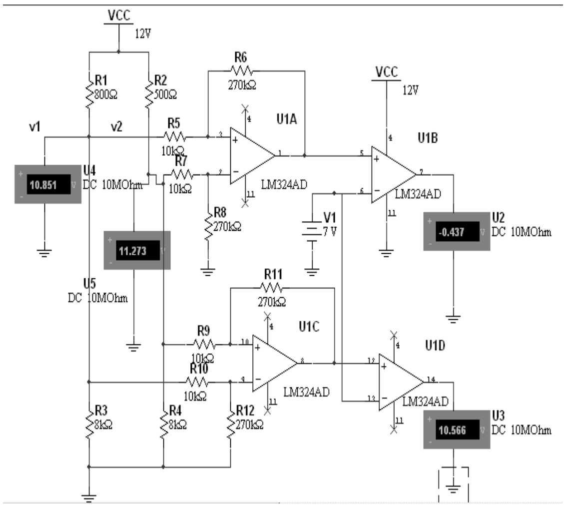



Figure .8 showing motor drive control circuit.

The output from the timer is given to the driver IC pin no 1 and 9, these pins enables driver IC. Output from the comparator IC 1 is given to the pin no.2 and 7. The DC motor is connected between the pin no.3 and 6 as in H-bridge fashion. The diode 1N4001 is used in H-bridge. If the voltage at pin no. 2 is greater than the voltage at pin no.7 then motor will rotate in forward direction and if voltage at pin no.2 is less than the voltage at pin no.7 then motor will rotate in reverse direction. Same way the other DC motor will rotate according to the input voltage.Fig.8 shows comparator LM324D arrangement and Multisim 11 simulation results. Input side voltmeter shows reference voltage generated 10.851V and 11.273 V which generate output voltage using LM324D U1D 10.566 V which will cause to rotate DC motor 1 counter clockwise. If Output of comparator U1B is 10.566 then DC motor 1 will rotate clockwise. The Resistor 800Ω and 500 Ω represents LDR in terms of resistor values since LDR is not available in Multisim 11 component library.

Table 5: Dual axis tracking system references

| R LDR 1 | R LDR 2 | Reference voltages in (V) | | Output of comparator IC LM324 | | DC motor direction |
|---|---|---|---|---|---|---|
| | | V1 | V2 | Pin 7 | Pin 14 | CW/CCW |
| 800 Ω | 500 Ω | 10.85 | 11.27 | -0.43 | 10.56 | CCW |
| 500 Ω | 800 Ω | 11.27 | 10.85 | 10.56 | -0.43 | CW |
| 500 Ω | 500 Ω | 11.25 | 11.25 | -0.53 | -0.53 | Stop |
| 800 Ω | 800 Ω | 10.85 | 10.85 | -0.53 | -0.53 | Stop |

## IV. Results

On powering of the system the solar panel aligns itself in the direction maximum light intensity.

The maximum power consumption of tracking system is given by.

Power = 12x (4x ILDR + Imotor1 + Imotor2) + 2 x PLM324A + PLM555 + PL293D
= Watts

Total Power consumption of the system
= PPOWERSUPPLY + PCOMPARATOR + PDRIVER + IINVERTER
= W

Battery usage

Charging time:
- By solar panel:
- By AC mains:

Discharging Time:
- DC load:
- AC load:

*A..Calculation for units charged by MSEB and Solar*

Appliance: PL (Lamp with ballast) 230V, 50Hz, 9W.

Average usage per day: 08 Hrs.

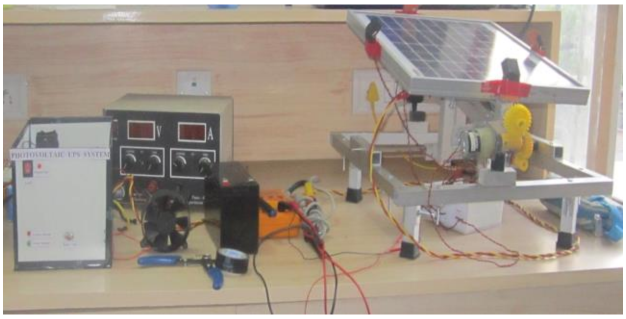
Approximate units/month: 8.64.

Maharashtra state electricity board charges: INR 04.50/-

Solar panel: INR 0.00/-

*B..Final look of product:*

*Traccking system*



## V. Conclusions

It has been found the cost of system excluding Solar panel comes to 1500.00/- INR. All components used to design are easily available to local (villages/towns) electrical market .Electricians at local places can easily troubleshoot system by the provided troubleshoot manual. Solar panel is little costly but it is better to have one time investment as it has huge life span. It can useful to the places where electric load shedding is the major problem but sunlight is available at the most (Temp 35-48 degree centigrade). The effective and efficient harnessing of solar energy takes place. This project is development of low cost and less (easy) maintenance technology can be used in rural areas where there is load shedding problem and light is the most important factor. Thus the proposed scheme is simple, cost effective and having fast response in terms of control stability under varying solar radiation.

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