IMPLEMENTATION OF AUTOMATIC SOLAR STREET LIGHT CONTROL CIRCUIT

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Abstract- An automatic control circuit for LED street lamp is designed. Solar power is utilized and electric energy is stored in battery. This circuit works in four mode control, (1) light control, (2) intensity adjustment, (3) under voltage and overvoltage control and (4) uninterrupted power in night. Under the light control mode, LED lamp turn off in daytime and lit in night automatically. PWM technique is used to adjust intensity according to darkness and under voltage and over voltage protection is provided so that battery life is improved. A special scheme of alternative supply is added for foggy areas where battery is not charged fully and due to this discharge in midnight.

1. INTRODUCTION

Solar energy is a renewable source of energy, which is long-lasting and no pollution type. It can be easily utilized and also a cost effective in long term. Solar street light do not need staff for management and control and it can easily stalled in public places like hospital, school, street etc. LED lamp is generally used because of long life and energy saving (low watt). LED street lamp is compact and shock resistive with energy efficient. In this paper control circuit for solar LED street lamp is designed and also discusses the work to improve further control.

2. CIRCUIT AND WORKING PRICIPALE

As shown in Fig. 1 , circuit composed of six control part such as over/under voltage control, on/off circuit, LED driving part, LDR dimmer and outside supply control part. Circuit is design using simple technique consist of OP-amp, 555 Timer and simple switching circuit.

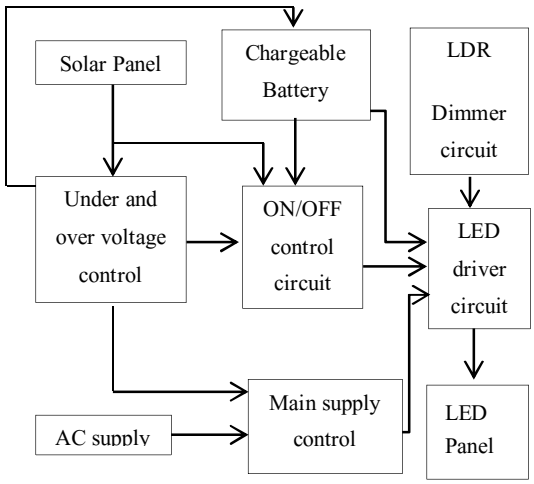


Fig.1 Block Diagram of solar street light control.

A. SOLAR CELL PANEL

Solar panel is made by connecting no of photovoltaic cell in plan manner, so that proper current and voltage rating is available at terminal in daytime. As one silicon photovoltaic cell producing about 0.5 Volt. A no. of cells is arranged in array to produce specific output. Circuit is design for 12 Volt solar panel and can be adjusted for different rating of panel.

B. BATTERY PROTECTION CIRCUIT

The charge protection circuit uses lead acid battery (12V, 12Ah) as a power supply. Sometime Battery is not fully charged due to foggy environment. Due to this reason, it

discharge in midnight with voltage drop from 12 V to 8 V. we generally want to avoid this condition, so under voltage circuit is employed to discontinue the supply from battery. R11 and R12 constitute a voltage division circuit, R13 and potentiometer RP14 constitute another. R1 and R2 connect directly to battery and another arm is connect to LM7808. The node 1 and 2 is use as comparator OP- amp input. When battery voltage is below 10.8 V, OP amp generates 12 V, otherwise -12 V. Now this voltage is reduced to 5V using transistor switching circuit. If there is 5 V signal at node 3, it mean that output of U3 is always low and LED driving circuit does not work and prevent further discharging

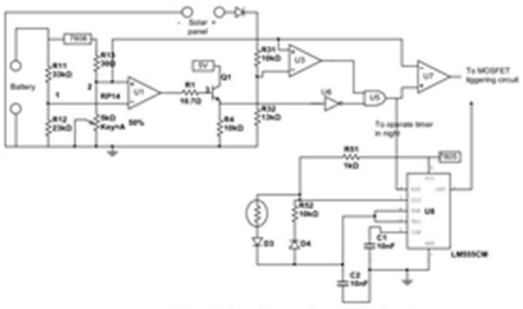


Fig.2 Under voltage and turn ON/OFF circuit

Sometime due to overcharging, battery terminal voltage rise up to 14V. Simpler bridge circuit as for under voltage condition consists of R21, R22, R23 and RP24. Whenever voltage of battery higher then 14V, the voltage of non-inverting terminal becomes higher than voltage of inverting terminal and cause there is high voltage on U4 output. This cause npn transistor operate, which operate the relay coil so that NC circuit activate and solar cell pin is disconnect.

C. LIGHT CONTROL CIRCUIT

It is found from experiment that in evening time, the output voltage of solar panel is less than 2.8V. Resistance R31 and R32 is used as

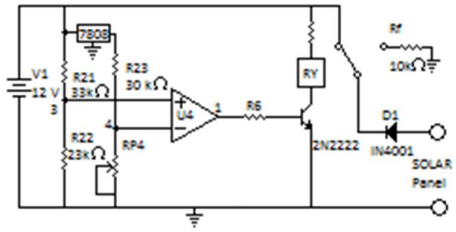


Fig.3 Over voltage control circuit.

one leg of bridge and other one is same R13, RP14. Now both of them compare and output of op amp is high only when panel voltage is below 2.3V. Output of U3 and U4 is provided to a input of AND gate U5. High signal at U5 mean there is a night and battery work normally. U5 output is amplifying using OP amp before using as a gate signal of power MOSFET. MOSFET IRF3205 work as a switch, when properly gate pulse is provided. It is used to connect Negative terminal of battery to LED lamp.

D. 555 TIMER BASED POWER REGULATING CIRCUIT

555 timer IC is one of the oldest and an effective way to control various electronic circuit. When 555 timer is used in astable mode it generate PWM wave. Resistance RA and RB is used to change the duty cycle and pulse width. From fig 4, capacitor C2 charges through external resistance Ra and Rb.

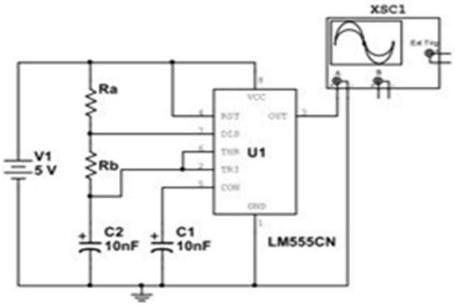


Fig. 4 555 Timer in Astable mode

As capacitor is charge up to threshold voltage which trigger the flip flop so that output at pin

3 goes low. Now the discharge transistor is driven and discharges the capacitor voltage through Rb. Now capacitor is discharge until it drops below the trigger level (5/3). The flip flop is triggered and output goes back high and discharged transistor is turned off.

$$t_{high} \approx 0.7 R_a C$$

$$t_{low} \approx 0.7 R_b C$$

If diode is connect across Rb so that capacitor charge through diode the equation is turned into even simpler form.

$$t_{high} \approx 0.7 R_a C$$

$$t_{low} \approx 0.7 R_b C$$

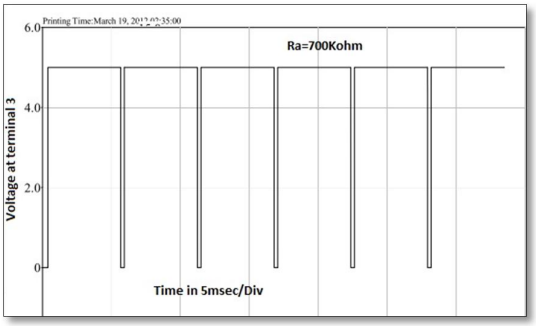
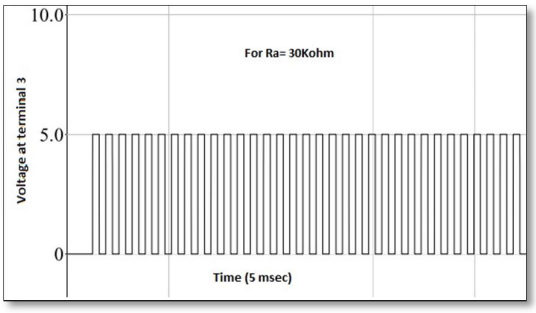


Fig.5 output of 555 timer for Ra=700kΩ

It is clear from equation when Ra and Rb is equal duty cycle is 50%. Now for increasing a value of Ra duty cycle increase upto 97%. In place of Ra , LDR is connect and Rb remain fix. LDR (Light Dependent Resistor) is a light sensitive and resistance is changed sharply from 1Kohm in daytime to 2Mohm in dark night.



LDR resistance is observed during evening and morning time. From the data it found that in evening resistance of LDR change sharply from few ohms to mega ohm.

LDR Resistance Table (18/03/12, New Delhi, India)			
Evening		Morning	
Time, PM	Res, KΩ	Time, AM	Res, KΩ
6:25	2.3	5:50	2000
6:30	5.1	5:55	1900
6:35	9.7	6:00	970
6:40	18.4	6:05	203
6:45	65.0	6:10	47.5
6:50	85.2	6:15	7.4
6:55	411	6:20	4.5

In the main circuit, RST switch of 555 timer is only allow to connect the main supply when there is a night and this is done by connecting relay which is control using U5 output. The effect of change in LED intensity is not observed by human eyes. But in practical there is a saving of energy.

E. ALTERNATIVE CONNECTION FOR MID NIGHT UNDER VOLTAGE CONDITION

Sometime due to foggy environment battery is not able to charge fully. And due to this reason, completely discharge by mid night. It is batter to provide power to LED from AC source which is available. It is just like an emergency situation and may be used for max 2-3 hour. A relay as shown in fig. 6 is used with normally open setting so, AC circuit is cut off in normal condition. If output of U1 and U3 is high, it indicates there is midnight under voltage condition. Both port is connect to input of AND gate and when output is high, relay operate and AC supply is feed into a circuit. So it confirms that street light glow in night continuously.

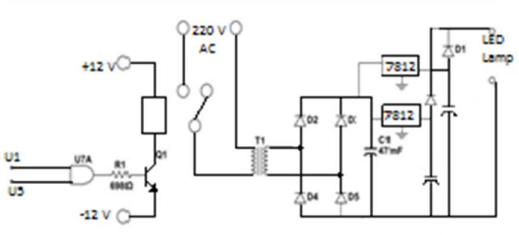


Fig. 6 Alternative supply for midnight under voltage

3. COMPONENT SELECTION AND PRACTICAL IMPLEMENTATION

LM324 IC is used for OP amp. Power MOSFET of rating above 6 A is used. For this purpose MOSFET is used. Value of under voltage is 10.8V. When voltage of battery is below 10.8V, MOSFET is not fired. In this case alternator source is supplied the circuit if needed. If battery voltage is above 13.2V, over voltage protection circuit activated and Battery is no more charge.

When OP amp is used as comparator circuit, it output is always equal to 12V, for using this circuit for Gate input it is necessary to properly transform it into 5V using simple transistor circuit otherwise IC may be damage. For driving IC and relay there is requirement of 12V and 5V control DC supply.

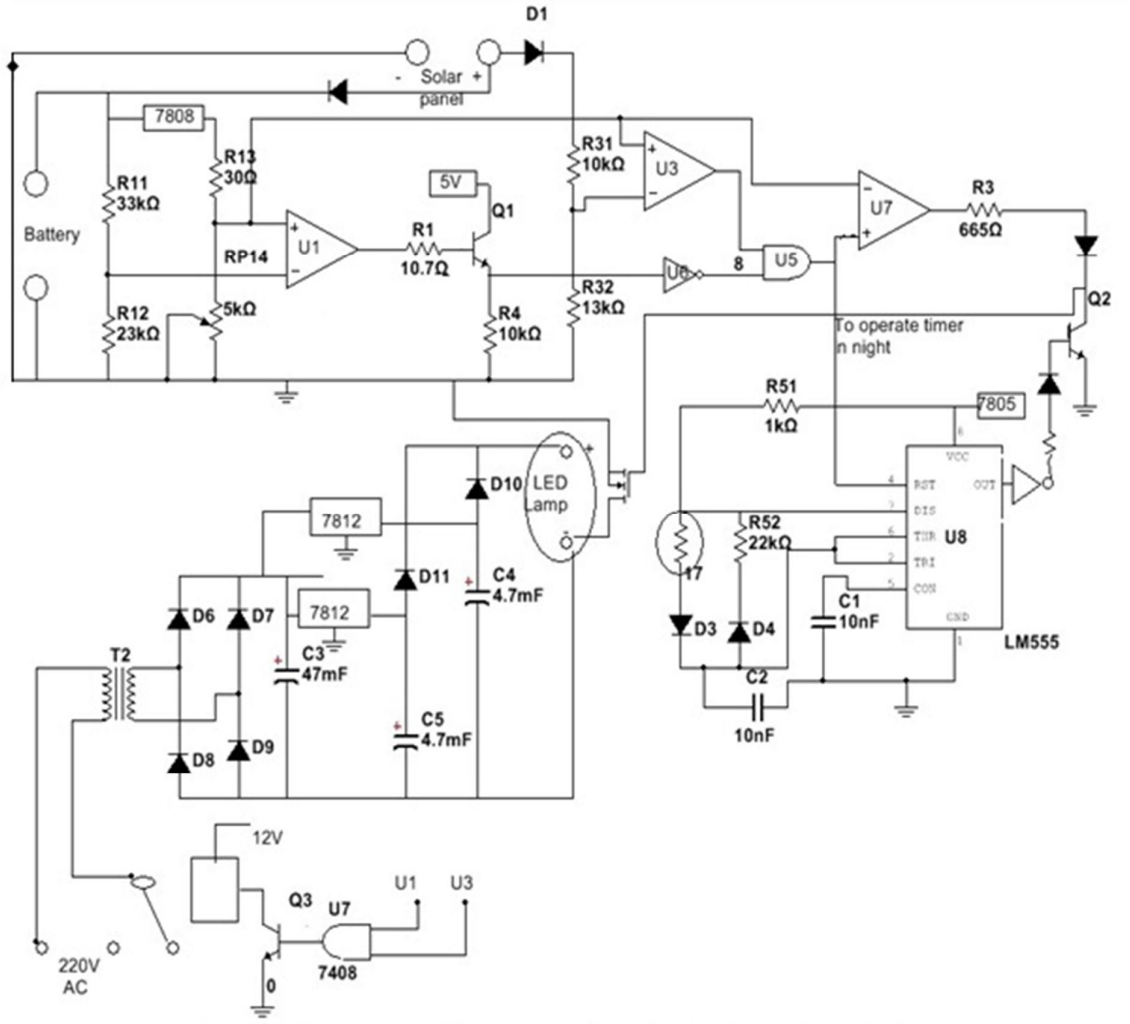


Fig. 7 schematic of design of automatic solar LED street light circuit

Simple low power circuit using LM7812 and 7806 is easily used. On/off time of circuit is depend on solar panel voltage. Setting is also easily changed to change the time period of operation. Heat sink must be used for driving more than 1amp current from IC LM7812. Now a day Digital transformer of 220/12V rating is available with high efficiency and low cost. It can be used in place of core type conventional transformer, to reduce bulkiness. This circuit is test only in lab without use of solar panel, so it is possible there is slightly modification in circuit is required for implement in practical circuit.

4. CONCLUSION AND FURTHER IMPROVEMENT

This paper elaborates the design and construction of automatic solar street control circuit. Circuit works properly to turn street lamp on/off. Under voltage and over voltage scheme is taken care which is an essential part of any solar street lamp. There is very small saving of energy using LDR dimmer. In future, slightly modification in circuit improve mode of control (Time based dimmer circuit). Counter can be used to turn off lamp after glowing 8 hour. This control circuit can be used in different place like street, shops and advertising board etc.

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