SWITCHING CIRCUITS FOR THE NIGHT LIGHT SYSTEM

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ABSTRACT The current work reports the design and study of the switching circuits needed for the night light system. The switching circuits control the night light systems to be on/off. These switching circuits are the main parts of the night light systems. Different circuits are designed and tested in this study. All circuits are feasible in theory.

INTRODUCTION

The night night system has five core units : renewable energy unit, power manager unit, energy storage unit, control unit, and electric energy consuming unit. The fig. 1 shows the configuration of the night light system. Explanations of the fig. 1 are as the followings. The first unit is the renewable energy unit. This unit can be solar pannel, windmill , or other renewable energy harvest units. The second unit is the power manager unit. In this unit, charger IC or power manger IC is the main element. The IC is in charge of storing electrical energy and protecting the battery. The third unit is the energy storage unit. In this unit, rechargeable battery is the main element. The task of the battery is to store the electrical energy from the solar energy, windpower energy, or other renewable energy. The fourth unit is the control unit. It contains the switching circuit and sensor circuit. The last unit is the electric energy consuming unit. Usually, LED modules and WiFi modules are the main components in this unit.

This report focuses on the control unit in the night light system. Each figure represents different design and has proved feasible in the lab. Diodes, NMOS, PMOS, resistor, BJT, 555 timer, OPAMP, photocell, phototransistor, relay, and Darlington relay are used in these designs. Finally, MCU will be the main element in the control unit, because AI(Artificial Intelligence) is the trend in all areas including renewable energy harvest and electric grid.
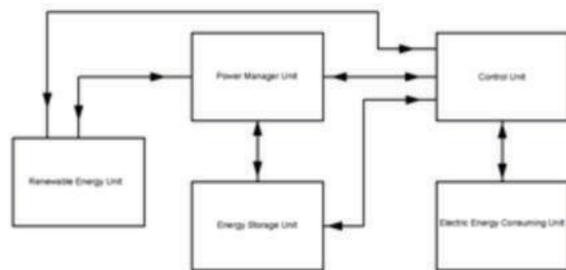

Fig. 1. Night light system

EXPERIMENTAL RESULTS

A. Night Light System using NAND logic circuits

From fig. 2 to fig. 4, NAND logic circuits are the control circuits of the night light systems. The fig. 2 shows the NAND logic gate using diodes. The advantages of diode logic gate circuits are simple, broad operating voltage, and fast response speed. The shortcomings of diode logic gate circuit are dissipation power, low input impedance, weak driving ability, and the restriction of diode logic gate.

The fig. 3 shows the NAND logic gate using PMOS and NMOS. The shortcomings of the CMOS logic gate are more complicated than the diode logic gate. Besides, the operating voltage is narrower than the diode logic gate. The advantages of the CMOS logic gate are fast response speed, strong driving ability, and high input impedance.

The fig. 4 shows the NAND logic gate using PMOS and BJT transistor. The response speed of the PMOS is slower than the NMOS, because holes are the roles for conduction in the PMOS. The BJT transistor combining with capacitor can accelerate the respose speed. Generally speaking, the performances of the BJT logic gate circuits are between the performances of the diode logic circuits and CMOS logic gate circuits.
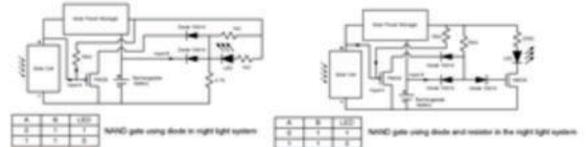

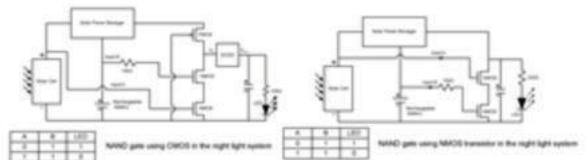Fig. 2. NAND gate using diode in the night light system

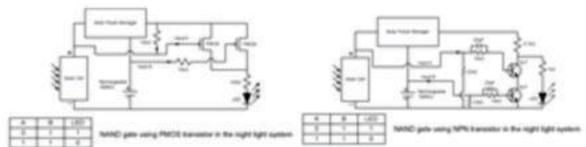Fig. 3. NAND gate using MOS transistor in the night light system

Fig. 4. NAND gate using NPN and MOS transistor in the night light system

B. Night Light System Using Schmitter Trigger Switch
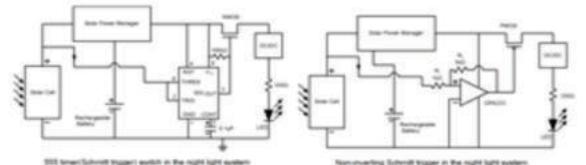

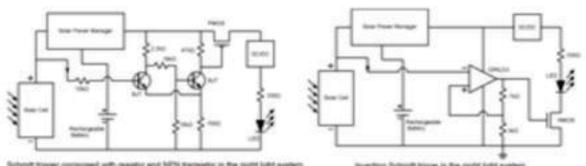Fig. 5.1 Schmitt trigger switch in the night light system

Fig. 5-2 Schmitt trigger switch in the night light system

The fig. 5.1 and 5.2 show the night light system using Schmitter trigger switch. The Schmitter trigger switch utilize the character of Hysteresis. This character can transform the analog signals to digital signals. Besides, these circuits can filter out the noise from the solar cell. This design can enhance the stability of the night light system. In fig. 5.1 and 5.2, timer 555, OPAMP, BJT transistor, and MOS transistor are the main parts for different circuits designs.

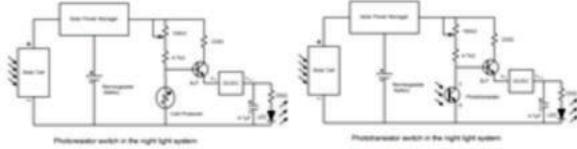### C. Night Light System Using Photocell And Phototransistor As The Switch

Fig. 6. Light activation switch in the night light system

The light activation switch uses two electric parts. The first is the photocell. The left hand side of the fig. 6 shows the design. The photocell will reduce the resistance when the surroundings is bright. Then the current will pass the photocell. The LED is in the off state. Batteries will be charged. If the surroundings is dark, the resistance of the photocell will be very high. Then the current will go into the NPN transistor. The LED is in the on state.

The second is the phototransistor. The right hand side of the fig. 6 shows the design using phototransistor. When the surroundings of the system is bright, the light will let the base of the phototransistor produce electrons. Then the current will flow from the collector to emitter. The LED in in the off state. Otherwise, the current will flow into the BJT. The LED is in the on state.

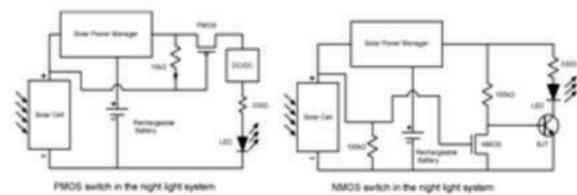### D. Night light system using PMOS and NMOS transistor

Fig. 7. MOS switch in the night light system

The left hand side of the fig. 7 shows the control circuits using only one PMOS. When the surroundings are bright, the PMOS turns off. The battery will be charged. When the surroundings are dark, the PMOS and LED will turn on. The right hand side of the fig. 7 shows the circuit using one NMOS and one NPN transistor as the core of the control circuit. When the surroundings are bright, the NMOS turns on. The battery will be charged. When the surroundings are dark, the NMOS turns off. The LED turns on.

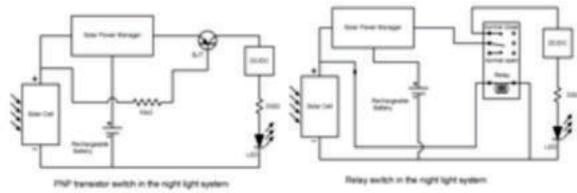### E. Night light system using PNP transistor and relay switch

Fig. 8. PNP transistor and relay switch in the night light system

The left hand side of the fig. 8 shows the control circuit using PNP transistor. When the surroundings are bright, the PNP transistor turns off. The battery will be charged. When the surroundings are dark, the PNP transistor and the LED turns on. The right hand side of the fig. 8 shows the control circuit using relay. Durning day time, coil will attract the armature when the current passes the coil. The battery will be charged. But durning night time, no current will go through the coil. The relay will let the LED be in the on state.

F. Night light system using OPAMP and Darlington pair switch

The left hand side of figure 9 shows the control circuit using OPAMP. OPAMP compares two signals. One is from solar cell, the other is from solar power manager. If the signal intensity from the solar cell reach the prescribed level, output signal from the output port of OPAMP will let PMOS turn off. Then the current will charge the battery. If the signal intensity from the solar cell doesn't reach the prescribed level, the PMOS and LED will turns on. The right hand side of figure 9 shows the control circuit using Darlington pair and relay. This design has very high input impedance and current gain. The relay is the switch and the photocell is the sensor of the night light system.
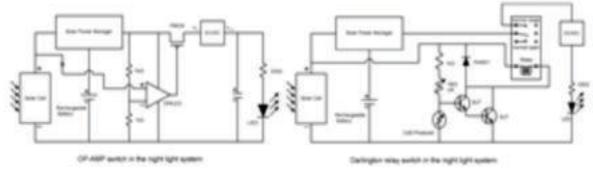

Fig. 9. OP-AMP and Darlington relay switch in the night light system

G. Night light system using Micro-controller(coding not finish)
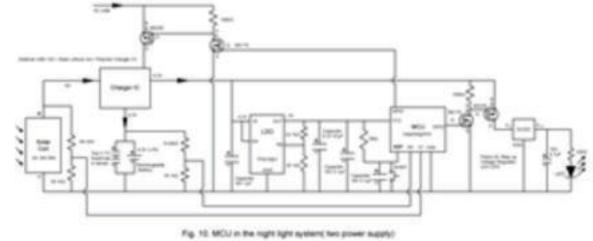

Fig. 10. MCU in the night light system(two power supply)
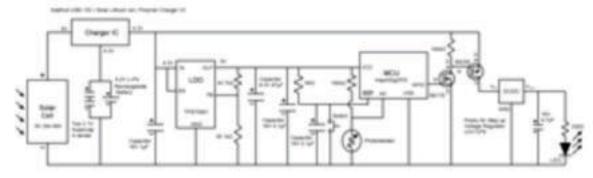

Fig. 11. MCU using in the night light system

Figure 10 and Figure 11 are the circuit designs using MCU. MCU is the core part for the robotics and AI technology. In the future, AI will be the trend for every area. Figure 10 shows the control circuit using MCU. There are two power supplie for the night system. One is the solar cell. Another is the power station. When the surroundings are dark and the battery has run out, MCU will let the electric energy from the power station go into the night light system. Then the night light system continues working. Because the MCU has many GPIO ports, these ports can control more than two power supplies. Besides, WIFI modules, GPS modules, LED, and other electronic parts can be incorporated into this system. Every night light system using MCU is the point (power station) for the smart electric grid.

Figure 11 shows the control circuit using MCU. The circuit is almost same with the circuit in figure 10. Automation is the trend in the future. So MCU is the main component inside the control unit in the night light system in the future. But the algorithm for programing the MCU will be more complicated.

CONCLUSION

The goal of this report is to study, design, assemble, and test different switching circuits of the night light system. By experiment, the switching circuits in this report are verified. Researchers and hobbyists can learn the principles of different electric components and how to use the components in the switching circuits of the night light system. Following this report, the switching circuits using MCU are the leading role in the next report. So the next report will focus on the night light systems using MCUs. We can consider the night light system using MCUs as the points (power stations) of the small smart grids. The night light system becomes the green energy harvest system. If the systems are set up along road and inside the community, electric cords connect all the small energy harvest systems. Every community has its own electric grid. The smart grid fundamentally completes. Finally, all the small smart grids connect with big power stations together and form a big electric grids. The electric grids can be manipulated efficiently by the control center. Carbon emission can be reduced. Besides, Wifi, GPS, smart meter, smart meter, and AI technology are incorporated into the small smart grids. Autonomous cars, smart city, and smart home can achieve in the future.

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