© IJCIRAS | ISSN (O) - 2581-5334
August 2019 | Vol. 2 Issue. 3

AUTOMATIC LIGHT SWITCH BY USING SOLAR POWER SYSTEM

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Abstract

This paper describes the automatic light switch by using solar power system. Nowadays, solar technology is very useful in industrial process and saving conventional energy sources. Solar photovoltaic (PV) system enables the generating of electricity directly from sunlight. PV system is quiet, clean, no pollution and it requires no fossil fuel and less maintenance. This solar cell is used as the input power source. But it cannot store energy. In this paper, 12V lead-acid battery is selected as a storage device to reproduce the required DC voltage. When the charging is reached to 12V, the battery over charge cut out circuit portion is cut off charging to the battery. After charging the battery, it can be used in lamp. The lamp is automatically turned ON and turned OFF depending on the light. The inverter is used to gain AC power which is connected to that battery. This paper intends to save power losses, cost effect, high efficiency of battery.

Keyword: Photovoltaic effect, Charge controller, Battery, Inverter, Electricity generation

1.INTRODUCTION

Solar power is produced by photovoltaic. The word "photovoltaic" is a marriage of two words "photo" meaning light and "voltaic" meaning electricity. So, photovoltaic technology, the scientific form used to describe solar energy, involves the generation of electricity from light. Solar technology is the most significant this solar technology is used for providing power to a lamp.

A solar PV panel delivers certain DC current at certain DC voltage for certain intensity of incident solar energy. The DC output power depends upon total number of cells and power per cell. The current and voltage are influenced by the circuit connection and external resistance.

The circuit may be used to charge rechargeable battery cells from sunlight. This is an unregulated charger, proper charging if achieved by placing the unit in the sun for a known amount of time, and the time varies according to the battery types. Each of solar cells develops about 0.5V across itself when in full sunlight. The string of eight solar cells puts out around 4V with no load.

The solar cells are connected to a battery. Then, the battery is connected to the lamp. When the solar cells are connected to the battery, a current flows and the battery charges. When the charging is reached to 12V, the battery over charge cutout circuit portion is cut off charging to the battery. And then,

when the environment is darked, the lamp is automatically turned on. The lamp is bright by using power from the battery. When the environment is bright, the lamp is automatically turned OFF. For operation in cloudy weather, it is useful to add one or two additional solar panel.That battery is also connected to an inverter to get AC output.

2.SYSTEM BLOCK DIAGRAM

The block diagram of automatic light switch by using solar power as shown in Fig.1. Solar panel is used to charge the battery. It is connected to the battery. This battery is connected to the DC load with LDR. Then, the battery is connected to the inverter. The inverter is used to produce AC power.

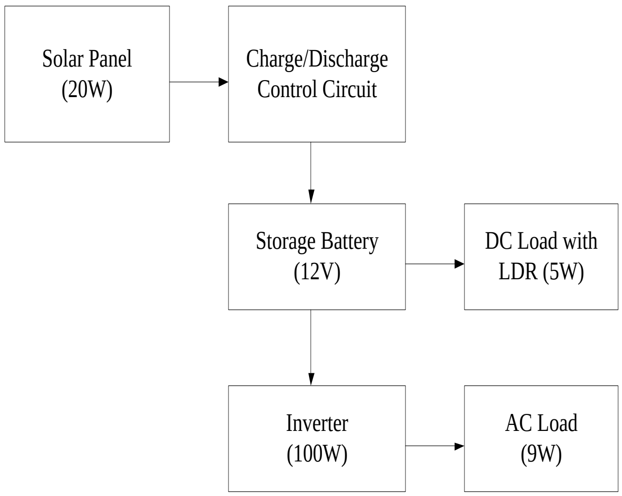

Fig1: System Block Diagram of Automatic Light Switch by using Solar Power

3.DESIGN AND CONSTRUCTION

The overall circuit operates with the main three sections. The first section is battery over charge cut out circuit by using solar power system. And then, the second section is inverter. Finally, the third section is automatic light switch circuit. The overall circuit diagram shows in Fig 5.

3.1. Operation of Battery over Charge Cut Out Circuit by using Solar Power System

In this circuit, 12V battery is charged by using 7812 regulated IC to store the voltage coming from the solar. The positive pin of the solar is connected to the point C of the relay. The battery is charged by connecting the input pin of 7812 IC and the relay point NC. When the battery is full, the relay is pulled and then the charging of the battery is cut out. In the output pin and ground pin of IC, the diode is used because the diode is permitted uni-directional flowing the current and is prevented the voltage come from the battery not to flow through IC. The voltage come from the battery (12V) is varied the uncontrolled DC voltage depending on the variation of the input voltage. Vin is the uncontrolled DC voltage at the middle pin of present VR1. The magnitude of Vin can adjust by rotating the present VR1. The DC voltage Vin through the zener diode and resistor R3is applied to the base of transistor Q1.

This circuit is combined the characteristics of the zener diode and transistor switch. If the reverse bias voltage applied to the zener diode is over the zener voltage, the current flows across the zener diode. When enough the forward bias voltage (eg. about 0.7V) is given to a silicon transistor, the transistor is saturated. Then the high collector current is followed. At the applied voltage is the regular voltage (eg.12V), the uncontrolled input DC voltage (Vin) to have below the zener voltage is adjusted by the preset VR1.

When the uncontrolled input DC voltage Vin is less than the zener diode voltage, the current doesn't flow through the zener diode. So, the base current is zero where the collector current doesn't flow and the relay becomes OFF. If the applied voltage rises, the uncontrolled DC voltage is also proportionally to rise. If Vin is higher than the zener voltage Vz, the base current flows through the zener diode. When the base current flows, the relay is pulled by flow the higher collector to the relay coil. By the way, the applied voltage is over the defined magnitude where the relay is pulled. By connecting the relay point, the automatic over charge cut out is used. The resistor R3 is prevented the transistor not to decay at saturated condition by limiting the magnitude of the base current.

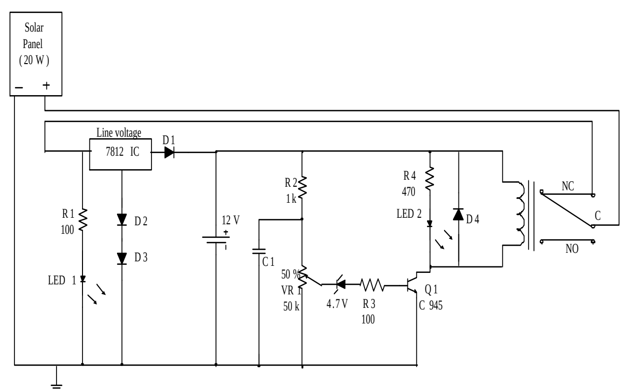

Fig 2: Battery over Charge Cut Out Circuit by using Solar Power System

3.2. Operation of Inverter

This circuit is very simple to build DC to AC converter. The principle of this circuit is generating 50Hz frequency by using IC CD4047 and the output complement pin 10 and pin 11 of IC CD4047 to drive MOSFET IRF Z44. So induction to primary transformer is worked and got high voltage at out of secondary transformer about 220AC. CD4047 has 14 pins. It has 3 pins. And pin 13 is not used.

Pin 10 and pin 11 are used as the output pins because they generate two reverse face rectangular waves. These two waves are the same voltage and frequency. So, this IC can be used as an astable oscillator.

Power amplifier is the main part of the inverter. It amplifies the input signal to get the required power. Input signals are the rectangular waves. Therefore, transistors work as the switch. When the transistor is the cut off, it becomes the open switch. When the transistor is the saturate, it becomes the closed switch. In the first half wave of the input rectangular wave, the base of TR1 receives positive half wave and the base of TR2 receives negative half wave. When the input signal becomes negative half wave TR1 becomes cut off and TR2 becomes saturate. According to the transformer, those half waves are moved to the copper wire S. 220V AC voltage is received because these copper wires become full wave rectangular.

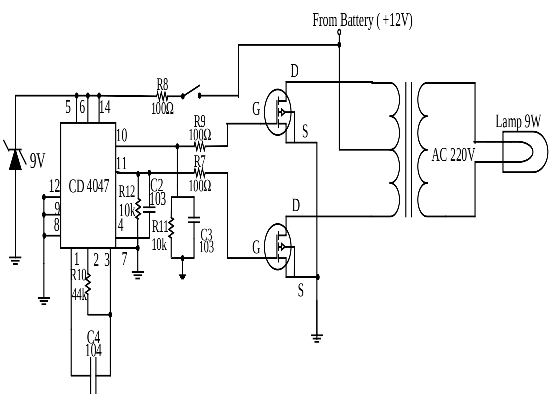

Fig 3: Circuit Diagram of Inverter

3.3. Operation of Automatic Light Switch

This circuit is automatically turned on when dark and turned off when bright. LDR is used as sensitive light equipment. If the environment darks, the resistance of LDR is very large (about 1MΩ) while the resistance of LDR is down to very small value. In this circuit, base voltage of a transistor darlington pair is proportionally divided by VR2, R5 and LDR. When having day-light, the resistance of LDR is very low. As the voltage drop appearing on LDR is very small, the voltage coming to the base of darlington pair is very low (below 1.2V). Therefore, the darlington pair is cut off. At that time, the current is not flowed to the collector and then the relay is not pulled. Because of the relay point C is not connected to NO, the light is turned OFF.

After the sunset, the light is faded and the resistance of LDR will rise. Then the voltage drop appearing on LDR rises. When the resistance of LDR is high, the voltage coming to the base is above 1.2V and the darlington pair is saturated. Therefore, the collector current is flowed and the relay coil is pulled. As the relay point C is connected to NO, the light is turned ON.

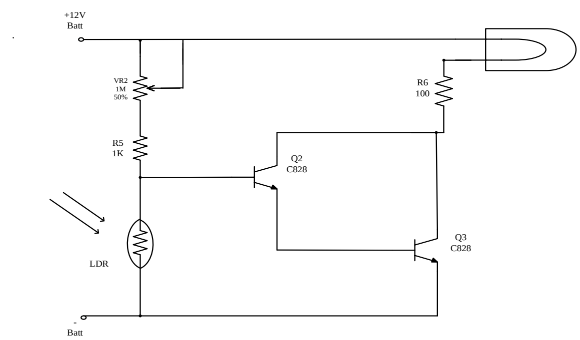

Fig 4: Automatic Light Switch Circuit

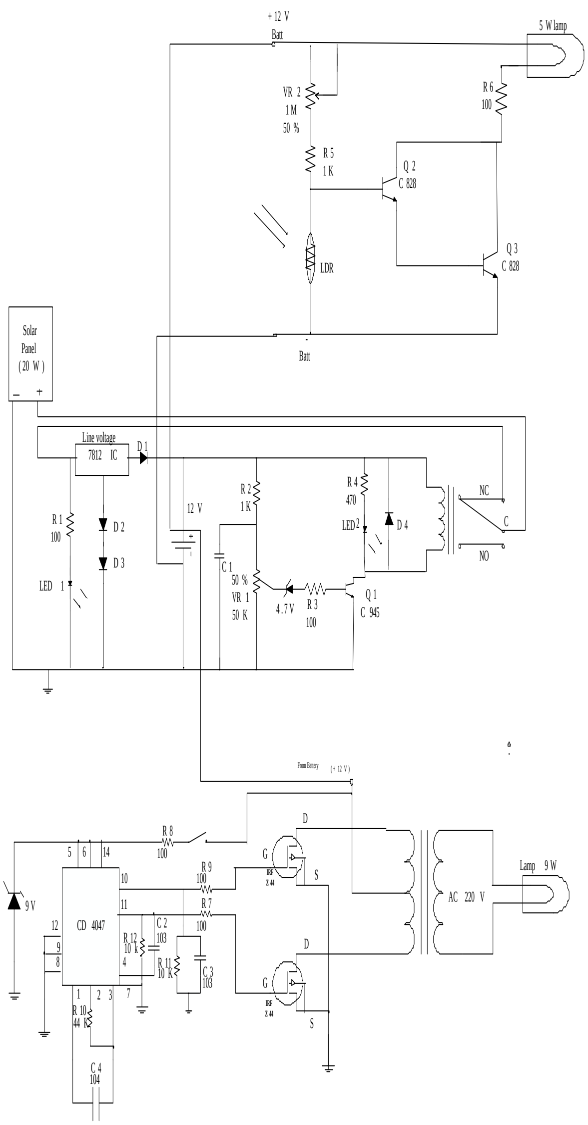

Fig 5: Overall Circuit Diagram

Table 1. Components List of Automatic Light Switch by using Solar Power System

Name	Types	Value	Number
Q_1	C945NPN Transistor	-	1
Q_1, Q_2	C828NPN Transistor	-	2
R_1, R_3, R_6, R_7, R_8, R_9	Resistor	100Ω	6
R_4	Resistor	470Ω	1
R_2, R_5	Resistor	1kΩ	2
R_{11}, R_{12}	Resistor	10kΩ	2
R_{10}	Resistor	22kΩ	2
VR1	Variable resistor	50kΩ	1
VR2	Variable resistor	1MΩ	1
C_1	Capacitor	100µF	1
C_2, C_3	Capacitor	103pF	2
C_4	Capacitor	104pF	1
D_1, D_2, D_3, D_4	Diode (1N 4007)	1A	4
V_{z1}	Zener diode	4.7V	1
V_{z2}	Zener diode	9V	1
-	Relay	12V	2
7812	Regulated IC	12V	1
IRF Z44	MOSFET	-	2
Switch	Toggle switch	12V	1
CD 4047	CMOS IC	12V	1

4.RESULTS

The indicator light emitting diode has less current capacity. Therefore, to used the LED, it is always required a series resistor to prevent the supply current. The value of series resistor can be calculated the following Equation.

$$R_4 = \frac{V_{CC} - V_{LED}}{I_R} \quad (1)$$

where,

V_s = Supply voltage

V_{LED}= Voltage of LED

I_R = LED resistance current

Depending on the color of LED, the green LED voltage is 3.2V. Moreover, the LED current is about 20mA. All of data is contained in the data of LED.

From Equation 1,

$$R_4 = \frac{12-3.2}{20\times10^{-3}}$$

$$= 440\Omega$$

So, the series resistance for LED is selected to 470Ω.

For darlington pair,

VR2 = 0.5MΩ

R_5= 1kΩ

R_X= VR2 + R_5

= 0.5M + 1k

= 500kΩ

R_Y = LDR = 1MΩ (when dark)

$R_B = R_X // R_Y$

= 500k // 1M

= 333.33kΩ

$V_{BE1} = V_{BE2} = 0.6V$

$V_{BE} = V_{BE1} + V_{BE2}$

= 0.6 + 0.6 = 1.2V

$$I_{B1} = \frac{V_{CC}-V_{BE}}{R_B} \quad (2)$$

$$= \frac{12-1.2}{333.33k}$$

= 32.4μA

$$h_{fe1} = \frac{I_{C1}}{I_{B1}} \quad (3)$$

h_{fe} = 130 (from data sheet)

$I_{C1} = h_{fe1} \times I_{B1}$

= 130 × 32.4μ

= 4.212mA

$h_{fe1} = h_{fe2} = h_{fe}$= 130

$$h_{fe2} = \frac{I_{C2}}{I_{B2}}$$
(4)

$$= \frac{I_{C2}}{I_{B2}} \ (I_{B2} = I_{C1})$$

$I_{C2} = h_{fe2} \times I_{C1}$

= 130 × 4.212 × 10^{-3}

= 0.548A

$$P = V_{CC} I_{C2} \quad (5)$$
= 12 × 0.548

= 6.57W

$$V_B = \frac{R_2}{R_1+R_2} \times V_{CC} \quad (6)$$

$$= \frac{1M}{1M+501k} \times V_{CC}$$

= 7.99V

For step-up transformer,

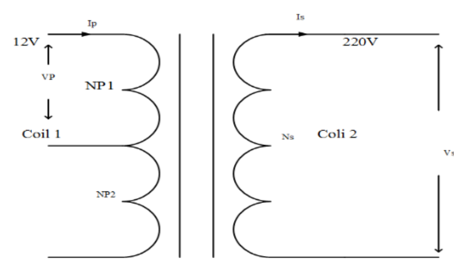

Fig 6: Transformer

Let P_o = 100W, V_o = 220V, V_{in} = 24V

$$I_o = \frac{P_o}{V_o} \quad (7)$$
$$= \frac{100W}{220V} = 0.45A \ (27SWG)$$

In practical, input power must be 10% greater than output power to resist losses. So, the following equation is used.

$$P_{in} = 110 \times \frac{P_o}{100} \quad (8)$$
$$=110 \times \frac{100W}{100}$$

=110W

$I_{in} = \frac{P_{in}}{V_{in}}$ (9)

$= \frac{110W}{24V}$ = 4.54A (17SWG)

Number of turns per volt,

N =100000000×E /4.44 × f ×H × A (10)

E = Voltage at copper wire

f = frequency

B= flux density

A = core area

B = magnetic flux line in one unit

Let E = 1V, f =50Hz, B=60000H

A = 1.6in×1.25in = $2in^2$

N = 3.75 ≈ 4turns

Voltage rating = $\frac{110V}{220V}$ = 0.5 (11)

N_p = 4 × 110 = 440turns

N_s = 4 × 220= 880turns

$\frac{Np}{Ns} = \frac{440turns}{880turns}$ = 0.5 (12)

$\frac{Vp}{Vs} = \frac{Np}{Ns}$, (13)

So, the step-up transformer is designed by 440turns in primary coil and 880turns in secondary coil.

For rectangular pulse width for CD4047,

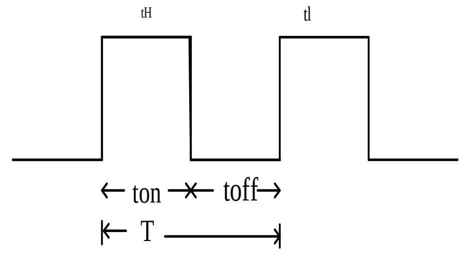

Fig 7: Rectangular Wave of CD4047

R = 44kΩ

C = 104pF

C = 10 × 10^4pF

= 1 × 10^{-7}

f = $\frac{0.23}{RC}$ = 52.27Hz

(14) T = $\frac{1}{f}$ (15)

= $\frac{1}{52.27}$ = 0.02s

Assume:

R = 1MΩ

C = 1µF

From Equation 14,

f = 0.23Hz

From Equation 15,

T = $\frac{1}{0.23}$ = 4.35s

Assume:

R = 1kΩ

C = 100µF

From Equation 14,

f = 2.3Hz

From Equation 15,

T = $\frac{1}{2.3}$ = 0.43s

For solar battery charging time,

In shinning day,

Solar voltage = 15V

Battery capacity = 7Ah (from specification)

Charging rate = $\frac{\text{Battery capacity}}{\text{Voltage}}$
(16)

= $\frac{7\text{Ah}}{15\text{V}}$ = 0.47A

Charging time = $\frac{\text{Battery capacity}}{\text{Current}}$
(17)

= $\frac{7\text{Ah}}{0.47\text{A}}$ = 14h

From Equation 5,

P = V I

= 15 × 0.47

= 7.05W

In clouding day,

Solar voltage = 12V

Battery capacity = 7Ah

From Equation 16,

Charging rate = $\frac{\text{Ah}}{12\text{V}} = \frac{7}{12}$ = 0.583A

From Equation 17,

Charging time = $\frac{\text{Ah}}{\text{I}} = \frac{7}{0.583}$ = 12h

From Equation 5,

P = V I

= 12 × 0.583

= 6.996W

For power consumption of full charged battery,

From specifications,

DC lamp = 5W, 12V

Battery capacity = 7Ah

From Equation 5,

P =VI

I = $\frac{\text{P}}{\text{V}} = \frac{5}{12}$ = 0.42A

$\frac{\text{Battery capacity}}{\text{current}} = \frac{7\text{Ah}}{0.42}$ = 17h

AC lamp = 9W, 12V

Battery capacity = 7Ah

From Equation 5,

P =VI

I = $\frac{\text{P}}{\text{V}} = \frac{9}{12}$ = 0.75A

$\frac{\text{Battery capacity}}{\text{current}} = \frac{7\text{Ah}}{0.75}$ = 9h

The 12V battery is charged by using 7812 regulated IC to store the voltage coming from the solar. The positive pin of the solar is connected to the point C of the relay. The battery is charged by connecting the input pin of 7812 IC and the relay point NC. In the charging condition, red LED turns on until the battery reach the full charge state.

When the battery is full, the relay is pulled and then the charging of the battery is cut out. When the full charge condition is reached, green LED turns ON. But red LED turns OFF.

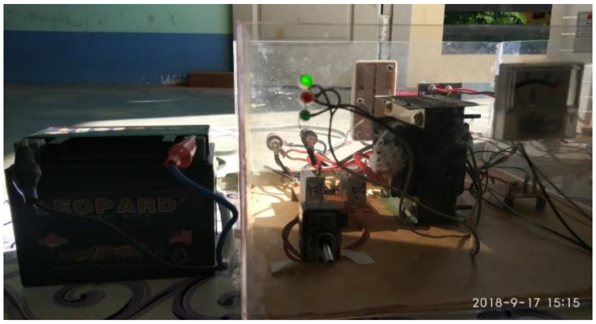

Fig 8: Full Charge Condition

The inverter is connected to the battery to get AC power. When the toggle switch is opened, the inverter is ON. When the inverter is ON, yellow LED turns ON. And, green LED continuous to turns ON.

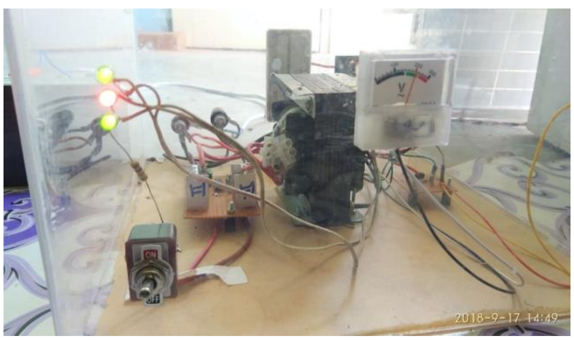

Fig 9: Inverter ON Condition

When the inverter is ON, the AC load is used. The AC lamp is 9W.

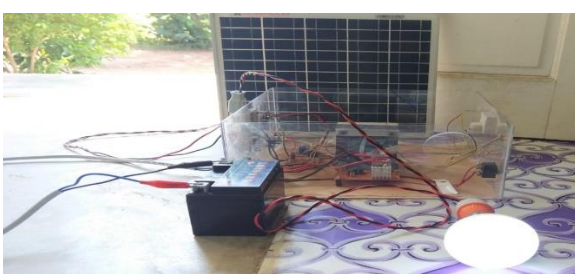

Fig 10: AC Load ON Condition

LDR is used as sensitive light equipment. This circuit is automatically turned ON when dark and turned OFF when bright.

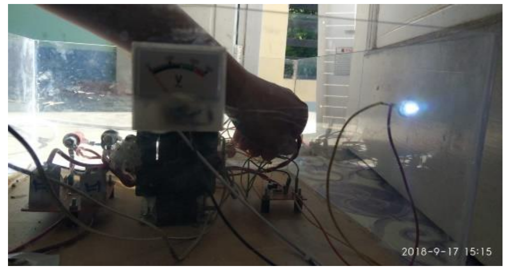

Fig 11: Automatic Light Switch ON Condition

5.DISCUSSION

This paper is discussed about the automatic light switch by using solar power system. The use of PV system becomes attractive because of high reliability, low maintenance requirement as they have no moving parts for generating electricity, low running cost, suited to most location and long life expectancy for main components. However, the presence of some disadvantages such as high capital cost, as vulnerable to damage as they are not physically robust and availability for specialized battery, i.e. deep cycle battery which is most suitable for PV system, discourage the use of PV system.

The system was also built to conserve energy with the use of a light emitting diode lamp (LED lamp) to replace other lamps such as the fluorescent lamp which reduce the efficiency of the battery. Also, the use of an inverter was eliminated since the solar panel supply direct current (DC) necessary to charge the battery without the need for a conversion to an alternating current (AC). It is difficult to adjust the variable resistor VR1 to get the voltage greater than the zener voltage. When the transformer is constructed, it is little difficult to achieve the required current amperes. The automatic light switch circuit has a little difficult to adjust variable resistor VR2 for turning of 5W DC lamp. It is needed to get good bright level of environment for turning off 5W DC lamp.

6.CONCLUSION

This circuit is designed for automatic light switch by using solar power system. When the charging is reached to 12V, the battery overcharge cut out portion is cut off charging to the battery. The charging time is dependent in the type and size of battery. Then, the lamp is automatically, turned on and turned off depending on the light and dark of the environment. The lighting time of the lamp is depending on the watt power of battery and charging voltage. The inverter is used to get AC power (220W). It is good efficient and reduced the manpower, maintenance and complexity. This circuit is suitable for village because of the cost construction is cheap.

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