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Design of Solar Energy Billboards that can Stand Typhoon

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Abstract: In order to solve the problem of typhoon or strong wind destroy billboards and common billboards now in use are too bulky and money-consuming and also electric energy-consuming, we disclosed in this paper a new kind of solar energy billboards that can stand typhoon or strong wind. The display screen or display board will be rolled up automatically when the wind becomes strong enough. The display screen or display board is controlled by electric motor powered by solar energy. There is a three cups style wind sensor that detect wind speed, the detected signal is sent to single chip microcomputer MSP430 SCM made by the National Semiconductor. When the detected wind speed exceeds the setting threshold, the microcomputer will send signal to motor to roll up the display screen, so there will be hardly any wind pressure on the billboards, so that it can stand firmly in whatever strong wind without being destroyed. The working power of these control system is supplied by solar energy collecting system mounted under the billboards. The billboard is both simple and elegant, it's money-saving, energy-saving, what's more, it can stand any strong wind without harming people.

Key words: Solar energy, billboard, typhoon, automatic control

INTRODUCTION

Every year, especially in summer, it's common to see strong wind destroy many fixed outdoor billboards, causing billions of property losses and often causing casualties, power accident and so on. The situation is especially serious in the coastal areas. These years, with the rapidly development of serious environmental pollution, there are more and more typhoon and strong wind than ever. There nearly ten typhoon landed China coastal areas just within two month and caused great losses (Gai, 2011).

In order to enhance the wind resistant ability of billboards, at present, the designed wind resistance billboards are very heavy, not only waste a lot of steel, occupy a lot of land, but also seriously affect the city or the natural landscape.

The common stand wind billboards were powered by national electric network source, not only consume a lot of power energy, but also need lain specially even if it stand along in suburban district or open field (Gai, 2011). This not only causes a large sum of investment, but also affects the city's appearance or the natural scenery and the wire connection and maintain are also need high cost and large workload (Gai, 2011).

Since the turn of this century, green and low carbon has become an urgently needed way of life to be set up by human. Almost all countries and regions worldwide will use solar energy resources as a country's or region's important strategy for sustainable development.

Usage of abundant solar energy resources is the effective way to improve living conditions, promote economic prosperity and social stability and ecological environment for coordinated development.

According to the above mentioned reasons, to solve the problem of typhoon or strong wind destroy billboards and common billboards now in use are too bulky and money-consuming and also electric energy-consuming, we designed a new kind of solar energy billboards that can stand typhoon or strong wind.

WORKING PRINCIPLE OF SOLAR ENERGY BILLBOARDS THAT CAN STAND TYPHOON OR STRONG WIND

The billboards is especially designed so it's both simple and elegant, as show in Fig. 1a and c but it can stand any strong wind. In Fig. 1a and c, the display screen is spread out, while in Fig. 1b and d, the display screen is rolled up and left the pillar and border there to stand strong wind (Gai, 2011).

In Fig. 1a, the display screen of the billboards spreads horizontally, In Fig. 1c, the display screen of the billboards spreads vertically.

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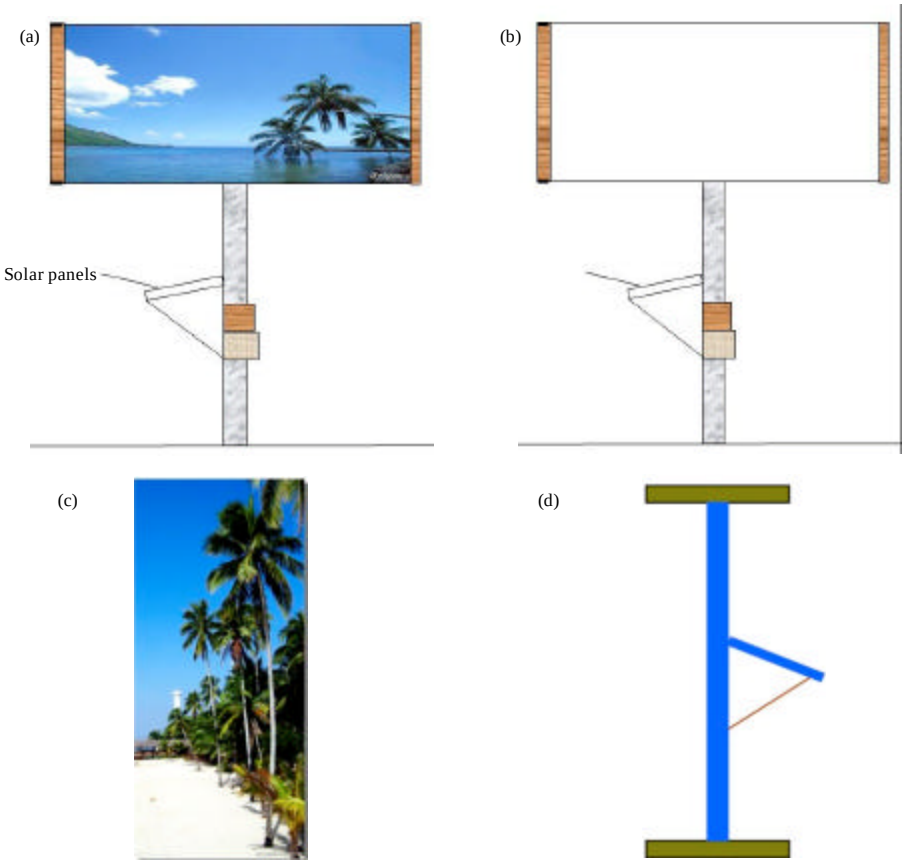

Fig. 1(a-d): Working principle of solar energy billboards

Its display screen or display board is controlled by electric motor powered by solar energy. The display screen or display board will roll up automatically when the wind becomes strong enough. There is a wind sensor that detect wind speed, the detected signal is sent to single chip microcomputer to process. When the detected wind speed exceeds the setting threshold, the microcomputer will sent signal to motors controlling axes at right and left sides of the screen to rolled up the display screen, so there will be hardly any wind pressure on the billboards, so that it can stand firmly in whatever strong wind without being destroyed. When the wind speed is less than threshold, the display screen will spread out again. The display screen is made of soft plastic material, so it can be rolled up and spread out (Gai, 2011).

The working power of these control system is supplied by solar energy collecting system mounted under the billboards. The billboards is both money-saving and energy-saving, what's more, it can stand any strong wind.

Figure 2 is a real picture of common billboards, it can often be seen along expressway or at road side in city.

Fig. 2: Picture of common billboards

In the picture, we can see how large and bulky the billboards is, especially compared with street lamp and light pole. The light pole supporting the street lamp is much thin.

The solar energy billboards that can stand typhoon we designed can also as thin as light pole. Besides, we can integrate the billboards with lamp and light pole.

Control system design of solar energy billboards that can stand typhoon or strong wind the functional block diagram of control system of solar energy billboards that can stand typhoon or strong wind is shown as Fig. 3.

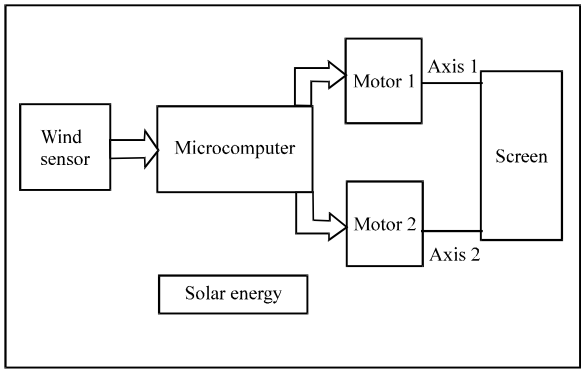

Fig. 3: Functional block diagram of control system of solar energy billboards

The wind sensor send signal to microcomputer to process, the microcomputer send signal to motor1 and motor2 to rotate the corresponding axis1 and axis2, so that the screen can be rolled up or spread out.

Solar energy source supply power for all the control system so that they can work properly. There is a battery that can store solar energy to insure power supply even in cloudy days.

Figure 4 shows the basic single chip microcomputer MSP430f149 system. Integration of MSP430f149 is very high, so the minimum system is easy to build.

Circuit design reference the TI official minimum system mainly, XTAL2 is external 32768 Hz crystal oscillator, XTAL1 is external 8 MHz passive crystal

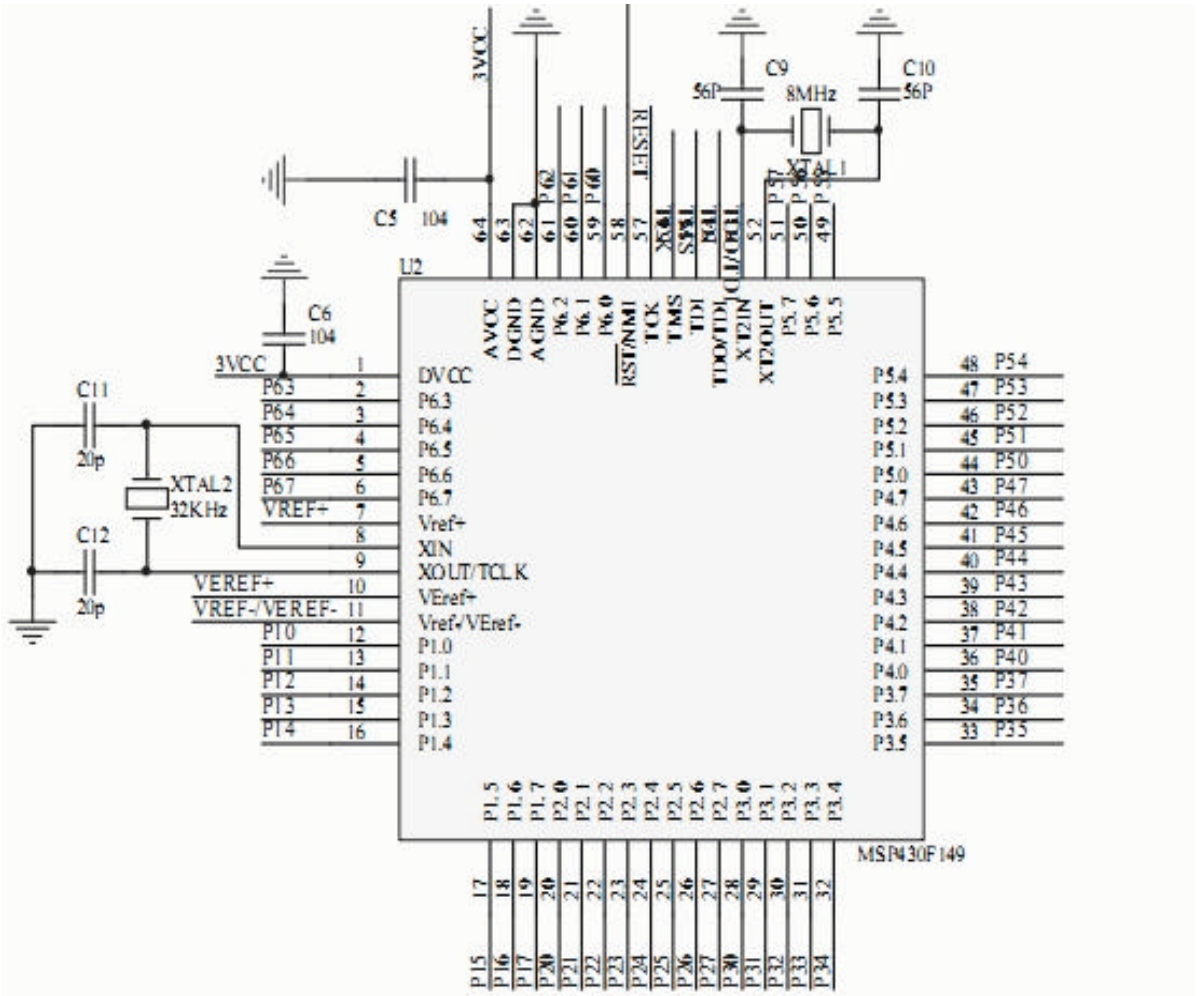

Fig. 4: Single chip microcomputer system

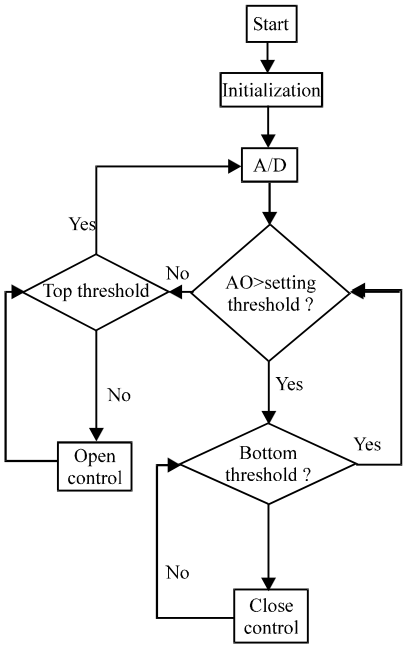

Fig. 5: Program flow chart of single chip microcomputer control system

oscillator, for XTAL1 the initial capacitance can be adjust to 58 p and oscilloscope observation of crystal oscillator of shock wave is standardized.

Program flow chart of single chip microcomputer control system is shown as in Fig. 5.

DESIGN OF RESET MONITOR CIRCUIT

In this system, IMP811S is used as reset monitor circuit. This chip is produced by IMP company as a CMOS monitoring and control circuit. It can monitor the voltage supplied to the system and can also provide manual reset input for debouncing.

This chip can Lead to the circuit more simple and reduce the amount of the elements and bring about the performance of the system more stable. The circuit is shown in Fig. 6.

DESIGN OF BUTTONS, ALARMS AND DISPLAY CIRCUIT

The HJ1602 Liquid Crystal Display is used as the displayer for buttons, alarms and display circuit. It's used mainly to display the speed of the wind as well as the opening and closing state of the system display screen. This LCD can work normally provided you connect a 10KÙ contrast adjustment potentiometer externally as shown in Fig. 7.

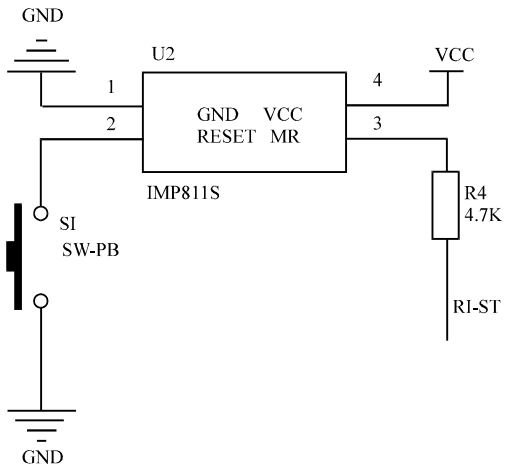

Fig.6: Reset monitor circuit

Its button is designed as the controller of the state of the display screen. While the monitoring part of the system is getting in trouble the button can be used as an alternate. Because IO pin of msp430f1 series microcontroller has no internal pull-up resistor, we connect each key with a 1 KÙ external pull up resistor. We use NPN transistor to drive active buzzer and also acts as its alarm circuit. The circuit is shown in Fig. 7.

The logical level of HJ1602 LCD is a TTL level which content is 5V. Because we write only to LCD, we didn't do the level exchange of the 3V system and 5V system. But the work of the LCD is stable. In order to ensure the accuracy and comfort of the operating. We use the light touch button produced by the Panasonic. The alarm circuit has also the function of indicating whether keys accept correctly. Whenever the button was pressed and SCM received this signal successfully, the buzzer will send out notification sound.

DESIGN OF THE POWER SUPPLY CIRCUIT FOR THE CONTROL SYSTEM

It is simple to design the power supply circuit of the control system. In backward stage, we choose linear voltage regulator IC act as power supply circuit for the system motherboard to prevent voltage fluctuations from impacting system. The maximum input voltage of AMS1117-3.3 is 12V. In order to adapting to wider voltage range better and reducing the maximum voltage drop on 7805, we add a 9V linear voltage regulator circuit before the 5V and 3.3V terminals of system power supply. And the chip has been used is an adjustable and low dropout linear regulator LM2941CT as voltage source and its maximum input voltage is 45 V, which can ensure that the

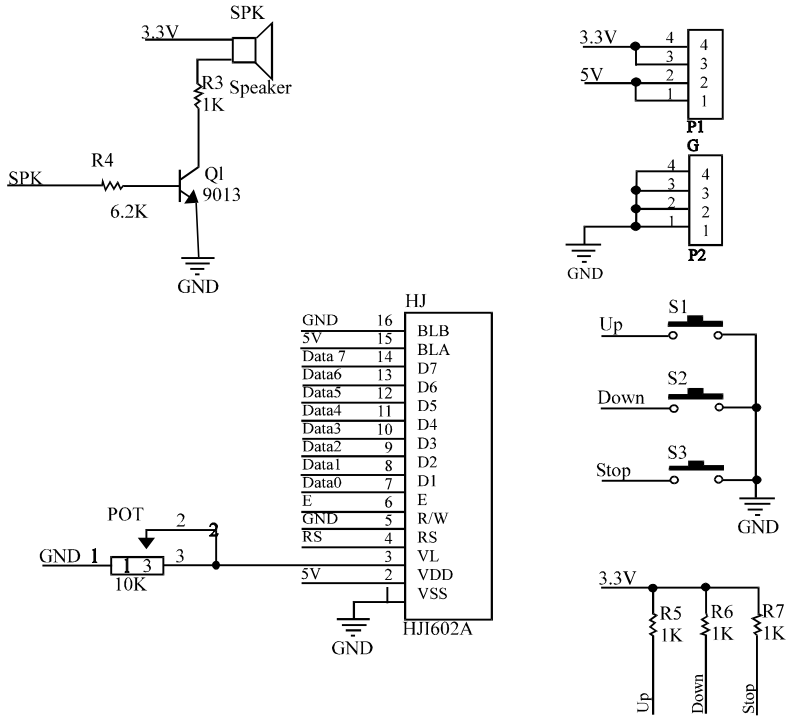

Fig. 7: Reset monitor circuit

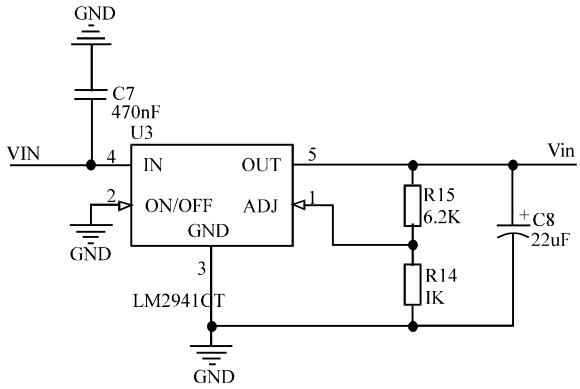

Fig. 8: Power supply circuit for the control system

system can adapt to wide voltage fluctuation and make it convenient to develop the subsequent product for the second time. The detailed circuit is shown in Fig. 8.

Because the system motherboard have the 5 V and 3.3 V power supply voltage at the same time, so we used a piece of 7805 and a piece of AMS1117-3.3 to supply power for the system main board, the performance to price ratio of the two chips are very high and are also very commonly used.

THE DESIGN OF MOTOR DRIVE CIRCUIT

We thought a lot about the design of motor drive circuit. If only in my model, as long as an integrated full-bridge chip is sufficient, such as the full-bridge chip MC33886, produced by free scale with the maximum output current of 5 A, is enough for the small motor design. But considering the actual situation, driving large billboards to open and close needs the motor have more power. Consider various factors, we decided to use four pieces N-channel FET to form the H-bridge driving circuit. Common H-bridge drive circuit consists of two N-channel FET and two P-channel FET, respectively, constitute the upper and under half-bridge. But the two FET parameters can not match, then the serious condition which the half-bridge runs hot is prone to be caused and P-channel FETs value of permissible current and voltage is generally smaller than the N-channel FET, so the heated half-bridge is usually composed by P-channel FET. In addition, because of the differences in manufacturing process, the prices of P-channel FET are generally higher than N-channel FET. In summary, the final selection of four N-channel FET to form the H-bridge drive circuit, is to use the specialized gate drive chip IR2104 to control the on-off of the field effect. IR2104 comes with a dead zone interval which can prevent the same FET arm from conducting. The circuit is shown in Fig. 9 and 10.

In figure 10, when the input of IR2104 is at high level, its output of HO is at high level, its output of LO is at low level. Vice versa, its output of HO is at low level, its output of LO is at high level. Thus, the on-off control of the field effect transistor is realized.

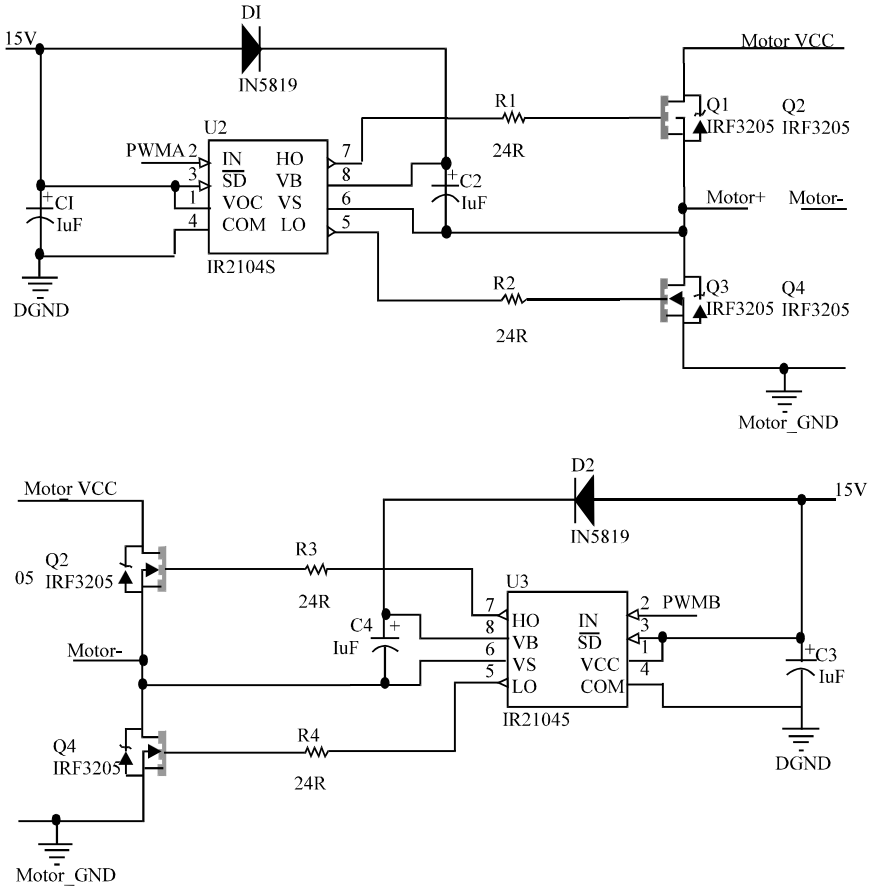

Fig. 9: H-bridge drive circuit

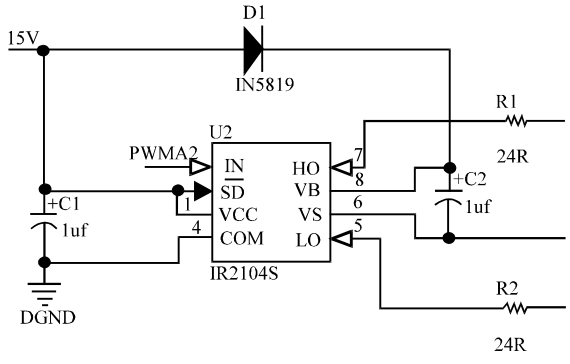

Fig. 10: Transistor on-off control circuit

The motor will produce larger surge currents during start and stop period, in order to prevent the surge current flow into the control circuit, it is necessary for us to isolate it. The driving circuit conducts reliable photoelectric isolation by using the optical coupling. The circuit is shown in Fig. 11.

The type of the field effect transistor is a voltage controlled device, its switch speed and degree of

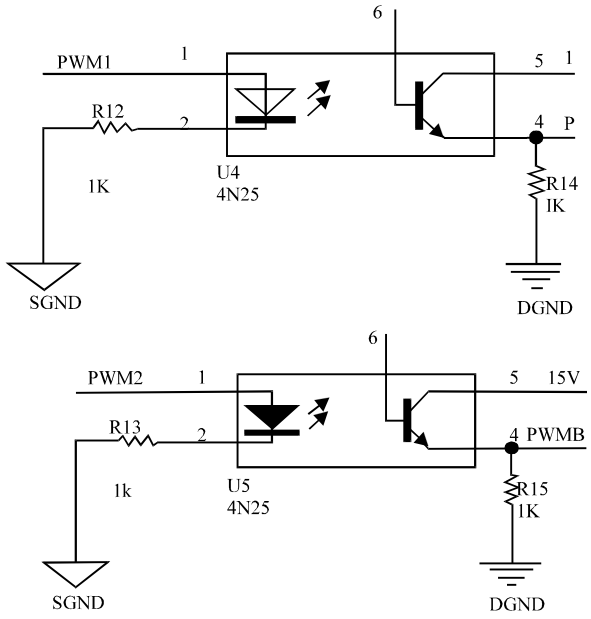

Fig. 11: Photoelectric isolation circuit

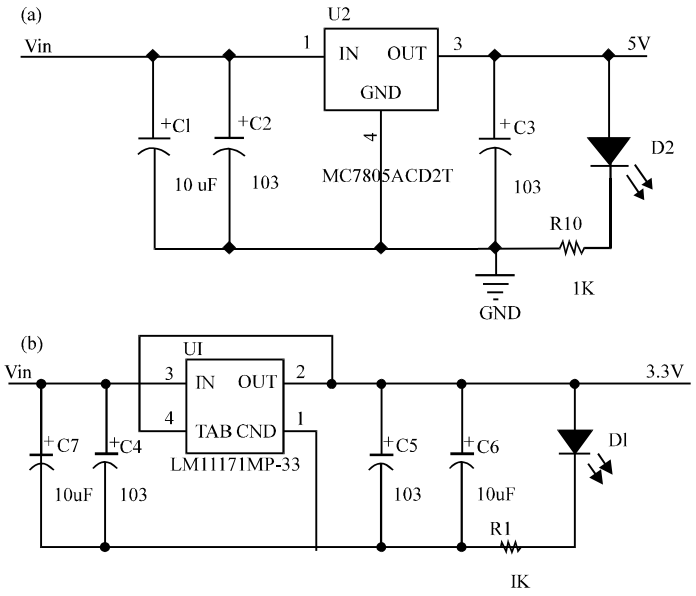

Fig. 12: Transistor power supply circuit

conduction is directly related to the input voltage of the grid electrode. In theory, the field effect transistor's conduction voltage is 2-4 V, but generally the 8 V is applied to ensure that the field effect transistor is completely conducted. The power voltage of control system is 5 V, so if the field effect transistor conduction is not complete, there will be a more voltage dropping on the drain-source electrode, which makes the transistor hot. In order to make the field effect transistor conduct rapidly and thoroughly and reduce the conduction resistance. We did boosted circuit in the drive circuit, bring about the voltage rise to 15 V. The circuit is shown in Fig. 12.

CONCLUSION

The new solar energy billboards that can stand typhoon or strong wind has been tested in lab, it's feasible and will be widely used in field, cities, tourist attractions, the park, the commercial plaza and other places, function as advertising, view and admire, even temporary electricity supply or night illumination and other functions, to provide a pure, fresh and natural, green and low carbon environmental protection magical landscape.

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