World Scientific Research Journal (WSRJ) ISSN: 2472-3703
www.wsr-j.org

Design of shower nozzle with water prompting function

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Abstract: "Shower" is the highest daily activity of household water consumption, accounting for 40% of the monthly household water consumption. In order to save water in the shower process, this paper designed the device which built the water-saving prompting circuit on the shower nozzle. The device uses a low power single chip STC12C5204AD as the main control core, the main power supply is the current generation sensor, and the LM7805 three terminal voltage regulator is used as the whole system power. The pulse signal generated by the water power generation sensor is taken as a detection signal and combined with square wave shaping circuit to transform the square wave signal that can be recognized by single-chip microcomputer. Through the jump of LED lamp as output, we use Bluetooth module to transmit data to achieve system testing and debugging. The device designed in this paper is stable, highly efficient, and meets the application requirements in real life. It has wide market prospects.

Keywords: shower nozzle, sensor, Bluetooth, circuits.

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1. INTRODUCTION

Shower is one of the most frequent daily activities. Currently, the market is full of shower products. After many years of development of shower facilities, there are pressurized shower nozzle, water-saving shower nozzle, automatic temperature regulating shower nozzle and so on. Although shower heads have been widely applied, there is no relevant equipment to measure the water consumption of shower heads. Therefore, a shower nozzle system with water volume prompts is designed in this paper. Although many current products have the function of flow statistics, but the city electricity is used, which induce a great hidden danger, the circuit fault may lead to the danger of electric shock and thus endangering life. At the same time, considering the environmental conservation, the design in this paper does not use batteries, so that it can avoid the tedious battery replacement and battery contamination. Based on safety and environmental protection, using water flow generation sensor to generate electricity, the

most commonly used three end voltage regulator LM7805 is applied for the whole system to provide DC power supply, combined with low power MCU STC12C5204AD as the central processor, the circuit is simple and stable. Since the system has selected small chips with small weight, small volume and low power consumption, thus improving the reliability of the system. Therefore, the products designed in this paper are innovative and practical.

The overall design objectives of the system are as follows:

1. For safety considerations, the electric power supply and battery power supply are not allowed in the circuit power supply, but the kinetic energy is converted into electric energy by the current generator, and the required DC voltage is generated by the switching power supply circuit.
2. The alternating current signal of the water generator should be converted to the square wave pulse signal, so that the water flow would be calculated after entering the single chip microcomputer.
3. Using single chip microcomputer to control the LED light emitting tube. When it shows blue, it means that 7.3 liters, green represent less than 11 liters of water. Once more than 11 liters, the sprinkler becomes red and prompts users to pay attention to water saving.

2. OVERALL DESIGN

The system mainly contains water power generation sensor, AC-DC power converting circuit, Bluetooth module, waveform converting circuit and single-chip microcomputer control circuit. When the water flows through the generation sensor, the alternating current signal is generated. After the signal is sent to the AC-DC power supply system, the signal is converted into a 5V DC power supply with a waveform converting circuit and the single-chip microcomputer. The other signal is sent to the waveform conversion circuit. Through the LM358 comparison circuit, the alternating current signal of the flow generation sensor is converted into a square wave signal. The square wave pulse signal is supplied to the single chip microcomputer and the number of the pulse is detected by opening the external interruption, and the water consumption is understood through the number of pulses. According to the experimental results, it is calculated that when the microcontroller detects 2728 pulses, it is probably 1L water. Therefore, we set up a blue LED lamp when the water is less than 7.3L, which mean that the single chip microcomputer detects less than 20000 square wave pulses. When the water is between 7.3L and 11L, a green light is turned on, which indicate that 20000 to 30000 square-wave pulses are detected by the microcontroller. When the water reaches 11L, the red light is on, which imply that the microcontroller detects more than 30000 square wave pulses. At the same time, Bluetooth module is designed to connect the mobile phone APP, the amount of water can be sent to mobile phone APP, so that users can understand the amount of water every day.

The specific design is provided in Fig. 1.

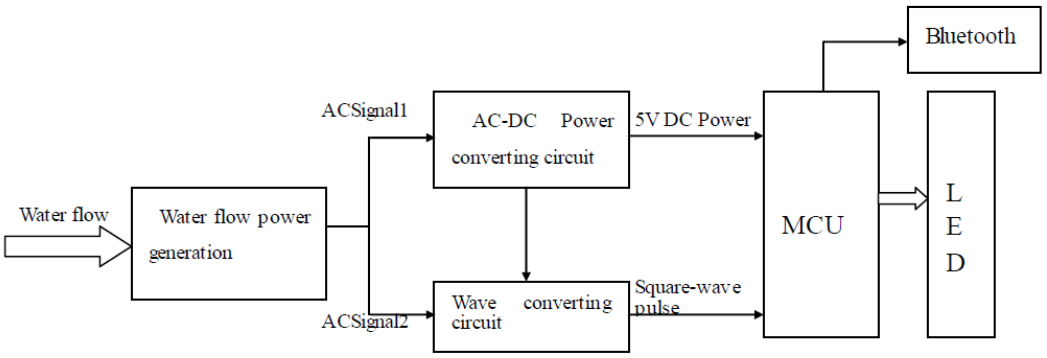

Fig. 1 System structure diagram

3. HARDWARE STRUCTURE DESIGN

3.1 AC-DC power supply converting circuit

In this system, single-chip microcomputer and shaping circuit need to connect 5V DC power supply. The output voltage of the generator is an alternating current with the change of the rotation rate, so we must design the power converting circuit. The three terminal voltage regulator IC LM7805 is used in the system. The LM7805 three terminal voltage regulator IC has three pins, which include the input terminal, the grounding terminal and the output terminal. The encapsulation is very like the transistor TO-220. The output voltage is 5V, and it can be adjusted slightly. LM7805 output signal ripple is very small and easy to build a DC regulated power supply with a simple circuit. The output voltage of LM7805 is just 5V, which is the voltage of most single chip computers. However, the three terminal voltage regulator IC LM7805 needs to install large heat sink. When the temperature of regulator tube is too high, the voltage stability of LM7805 will be worse, or even lead to damage. Because the input voltage of the LM7805 three end integrated circuit is between 7V and 30V, and the maximum output voltage of the flow generation sensor is only 20V, so there is no limit voltage protection circuit in this design.

In this paper, the alternating current generated by the water power sensor is rectified into a pulsed DC signal. The clutter is filtered through capacitor C1 and C2 in the circuit, and smooth DC signal is produced, which is transformed to 5V DC through LM7805 three terminal voltage regulator IC. The DC power can be supplied to MCU and waveform converting circuit after filtering by C3. AC-DC power supply converting circuit is showed in Fig. 2.

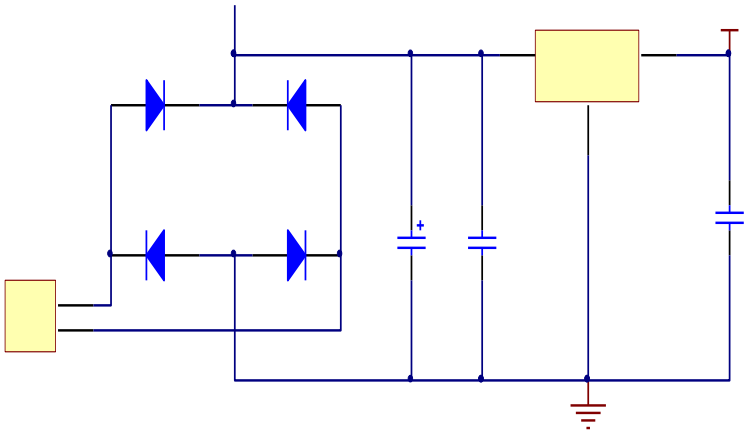

Fig. 2 AC-DC power supply converting circuit

3.2 Generator sensor

The parameters of the flow generation sensor used in this paper are as follows:

(1) maximum output voltage: AC20V

(2) maximum output current: 100mA (12V)

(3) maximum pressurization of closed unidirectional at the outlet: 0.6Mpa

(4) maximum pressurization at the outlet: 1.2Mpa

(5) minimum starting water pressure: 0.05Mpa

3.3 Waveform converting circuit

LM358 is widely used in the comparison circuit. The operational amplifier inside LM358 can be used as a comparator. When the reference voltage is input to the IN- foot, the comparison signal is input to the IN+ foot input, and the output is OUT, the comparison circuit formed. When the input signal is greater than the reference voltage, the output voltage is high level through comparing by comparator. When the input signal is less than the reference voltage, the output voltage is low level through comparing by comparator. When we input a sinusoidal signal and a suitable reference voltage, we can get a square wave pulse signal.

Since the impeller rotates around the axle under the water flow, the generator will send out a sinusoidal alternating current signal. When the impeller rotates, it will generate a periodic AC signal, which can calculate the water volume by calculating the number of cycles of the AC signal. Because the timer of single-chip can only sample the number of external pulse signal, so the external waveform converting circuit is needed. As shown in Fig. 3, the AC signal is input from the LM3583, and the clutter in the signal is filtered by a 0.1uF capacitor. A suitable input reference voltage of feet2 in LM3583 is obtained by adjusting the adjustable resistance RP2. After comparing the LM358 internal comparison circuit, the square wave signal is sent from feet1 to the single chip P3.4 port.

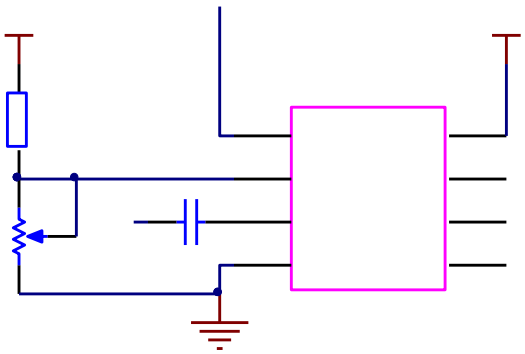

Fig. 3 Waveform converting circuit

3.4 The state indicator circuit

The state indicator circuit uses the counter function of the microcontroller to calculate the number of pulses from the P3.4 port. When the counter is counted, it will trigger counting by calculating the number of external signals and the falling edge of external pulses through pins T0 and T1. The single chip computer calculates the square wave pulse. According to the experimental data of 2728 pulses for a water lift, we calculate the amount of water used. We set up a blue LED light when water is less than 7.3L. When water is between 7.3L and 11L, the green light is lit, and the red light rises when the water reaches 11L. At the same time, we set up a power indicator to know whether the water power generation sensor is generating electricity. As long as the sensor starts working and the LM7805 three terminal stabilizer works normally, the power indicator will light up.

3.5 Bluetooth module

The power supply of HC-06 Bluetooth module is 3.1V to 6V, 2.4G antenna is built, Bluetooth 2 standard is used, and the data transceiver is transmitted through UART serial port. At the same time, HC-06 Bluetooth module supports Android, WINXP and WIN7 systems.

First we need to download a debug Bluetooth serial phone App, and then turn on the Bluetooth function of the phone. In the mobile phone APP, the nearby Bluetooth and the HC-06 Bluetooth module are scanned. Then we select the start pairing. The initial password of general HC-06 Bluetooth serial module is "1234". If pairing was successful, HC-06 Bluetooth serial module can be used.

3.6 LCD display

The LCD1602 interface is shown in Fig. 4.

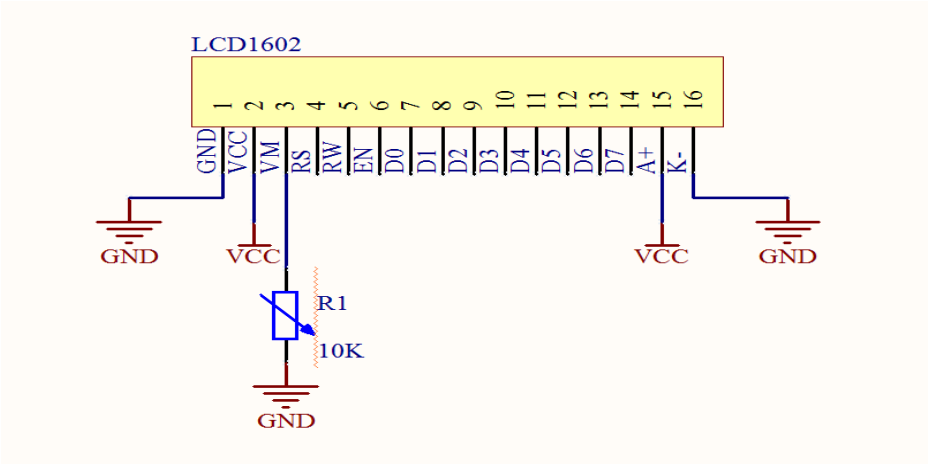

Fig. 4 LCD connection

3.7 STC12C5204AD minimum system

As shown in Fig. 5, the smallest system of STC12C5204AD microcontroller includes crystal oscillator circuit and reset circuit.

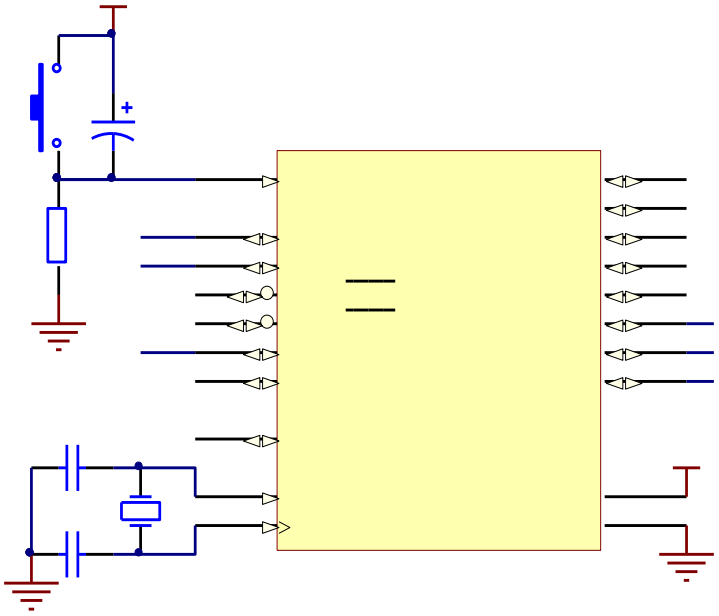

Fig. 5 STC12C5204AD minimum system

4. SOFTWARE DESIGN

The functions of the main program are as follows: when a certain pulse is detected by the single chip computer, the light can be converted, and the number of pulses can be displayed on the LCD1602 and communication with the Bluetooth. The macro definition part is run first when the program runs. The macro definition part includes the definition of function header file, the definition of IO port, and the definition of variables, the declaration of subroutine and delay program. Then the program initializes LCD1602 display, external interrupt and serial port. Subsequently the program will enter the while (1) cycle. The purpose of the cycle is to

constantly detect the number of external pulses to determine the amount of the water. When the water is less than 7.3L, the blue light is bright， the green light is bright when the water is more than 7.3L and less than 11L, the red light is bright when water is more than 11L. After that, the program will transform the number of external pulses into LCD1602 display and Bluetooth serial port.

5. SYSTEM DEBUGGING

5.1 Experimental data

According to the test data, it can be calculated that when the square wave pulse is 2728, there is a 1L current passing through the water power generation sensor. As shown in Table 1.

Table 1. Experimental data

	Number of pulses	Amount of water/L	Color of LED
Data 1	491	0.18	Blue
Data 2	20432	7.49	Green
Data 3	31372	11.5	Red
Data 4	19641	7.2	Blue
Data 5	29462	10.8	Green

5.2 Hardware debugging

When the water consumption is below 7.3L, the single chip microcomputer controls the blue LED lamp to light up, and displays the water consumption on the LCD1602. For example, Fig. 6 is an experimental scene of normal water consumption in the daytime, Fig. 7 is an experimental scene of normal water consumption at night when the light is turned off. Fig. 8 is LCD1602, and the value is about 0.18L at this time.

Fig. 6 Normal amount of water (daytime)

Fig. 7 Turn off the lights

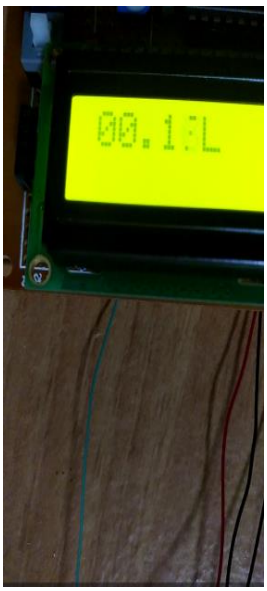

Fig. 8 The display

5.3 Debug of mobile APP

Using App inventor to make the mobile App, the functions including Bluetooth client, timer, text output and so on.

6. CONCLUSION

A water-saving prompting circuit on the shower nozzle is designed. The device uses a low power single chip STC12C5204AD as the main control core, the main power supply is the current generation sensor, and the LM7805 three terminal voltage regulator is used as the whole system power. The pulse signal generated by the water power generation sensor is taken as a detection signal and combined with square wave shaping circuit to transform the square wave signal that can be recognized by single-chip microcomputer. Through the jump of LED lamp as output, we use Bluetooth module to transmit data to achieve system testing and debugging. The device designed in this paper is stable, highly efficient, and meets the application requirements in real life. It has wide market prospects.

ACKNOWLEDGEMENTS

This study was supported by Jiangsu Innovation and entrepreneurship project of college students No. 201712686002Y.

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