Electronic keyboard design report

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Summary

This experiment introduces the design method of the electronic organ with RC parallel as the main vibration circuit, and gives the design method of the parameters of the eight-scale electronic organ circuit and a set of parameter values. Multisim is used to design and simulate the RC series parallel sine wave oscillation circuit. The results show that the analog circuit method is used to make an electronic organ with a simple structure and low cost, which meets the C-tone reference standard.

Key words: electronic organ, RC oscillation circuit, circuit parameter design, Multisim simulation.

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1. Motivation, Aims and objectives

Music plays an important role in human society. Traditional musical instruments are difficult and expensive to learn, while some simple electronic instruments are relatively cheap and can meet the needs of ordinary enthusiasts. With the development of contemporary scientific design, electronic products occupy an increasingly important position in people's daily life. Therefore, the development of electronic musical instruments has certain social significance. As one of the typical representatives, the electronic organ leads many children into the hall of music. Therefore, I chose the topic of simple electronic organ to make it, because it can not only improve practical ability, but also have a close relationship with real life.

2. Introduction and background theory

The electronic organ can play a variety of wonderful music. These music are composed of notes. Different notes are generated by the sound electrical signals of different frequencies after being pronounced by the speaker. The tone is mainly determined by the frequency of the sound. In the octave scale with the C as the reference tone, the corresponding frequency is shown in Table 1.

Scale	1	2	3	4	5	6	7	1
Frequency/Hz	264	297	330	352	396	440	495	528

In the design and production of this simple electronic organ, NE555 and triode power amplifier are used to complete the design requirements. The oscillation frequency of the 555 timer forming a multi-resonant oscillator can be adjusted by changing the value of the RC original in the oscillation circuit. Different RC FM networks are realized through the button switch, so as to control the waveform output of different frequencies of the 555 multi-resonant oscillator; and then the audio power amplifier is amplified to output full and beautiful music. The specific design of the system is carried out according to the functional module, and the whole circuit is composed of the main oscillator, the trill oscillator, the speaker and the key button. The main oscillator is composed of 555 timer, eight key buttons S1~S8, external capacitor C1, C2, resistance and other components. The resistance of different resistance values and the 555 timing oscillator produce different frequency notes. After connecting the speaker, eight notes can be obtained. The key part is the input control system of the system, which realizes the input of do, re, mi, fa, so, la, si, do; the frequency modulation circuit and the oscillator together generate signals of different frequencies; the power amplifier amplifies the output of the oscillator to drive the loudspeaker to emit different scales.

3.Methods and procedures

3.1 Circuit components

3.1.1 Timer 555

NE555 (Timer IC) is an 8-foot time-based integrated circuit, released by Signaletics Corporation around 1971. At that time, it was the only very fast and commercial Timer IC, which was widely used in the next 40 years, and Many application circuits have been extended. Later, the Timer IC based on CMOS technology version, such as MOTOROLA's MC1455, has been widely used, but the original NE555 is still normally available in the market. Although the new version of IC has some functional improvements, its foot function The ability has not changed, so it can be used directly so far.

3.1.2 NE555

NE555 is one of the models of the 555 series timing IC. The foot function and application of the 555 series IC are compatible, but the different models have different prices, their stability, power saving, and oscillation frequencies are not the same; while 555 is a widely used and quite common one. The timing IC can generate a variety of pulse signals of different frequencies required by digital circuits with only a few resistors and capacitors.

Main features

1. A specific oscillation delay can be completed with simple resistors and capacitors.

Its delay range is extremely wide, ranging from a few microseconds to a few hours.

2. Its operating power supply range is extremely large, which can be matched with TTL, CMOS and other logic circuits, that is, its output level and input trigger level, which can match the high and low levels of these series of logic circuits.

3. The supply current at the output end is large, which can directly promote a variety of automatically controlled loads.

4. It has high timing accuracy, good temperature stability, and cheap price.

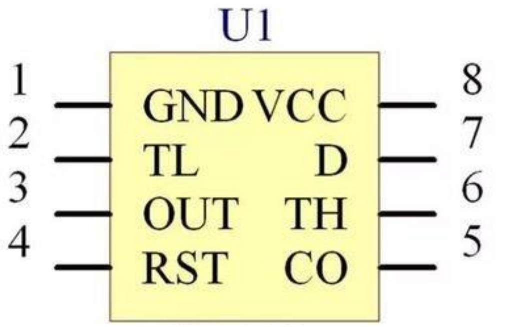


Figure 1: NE555 Pins

Pin 1 (ground) - ground wire (or co-ground), usually connected to the circuit co-ground.

Pin 2 (trigger point) - This foot is the time period to trigger NE555 to start it. The voltage of the upper edge of the trigger signal must be greater than 2/3 VCC, and the lower edge must be less than 1/3 VCC.

Pin 3 (output) - When the time cycle begins, the output foot of 555 is moved to a high potential of 1.7 volts less than the power supply voltage. The output at the end of the cycle returns to the low potential of about Ovolts. The maximum output current at high potential is about 200 mA.

Pin 4 (reset) - When a low logic potential is sent to this foot, it will reset the timer and bring the output back to a low potential. It is usually connected to a positive power supply or ignored.

Pin 5 (Control) - This pin allows the external voltage to change the trigger and gate limit voltage. When the timer operates in a stable or oscillating mode, the input can be used to change or adjust the output frequency.

Pin 6 (reset lock) - Pin 6 resets the lock and makes the output low. Start this action when the voltage of this pin is moved from below 1/3 VCC to above 2/3 VCC.

Pin 7 (decharge) - This pin and the main output pin have the same current output ability. When Pin3 is low, Pin7 is low resistance to the ground (ground conduction), when Pin3 is high, Pin7 is high resistance.

Pin 8 (V +) - This is the positive power supply voltage end of the 555 timer IC. The supply voltage ranges from +4.5 volts (minimum) to +16 volts (maximum).

3.1.3 555 multi-harmonic oscillator

The frequency generation is composed of 555 chips to form a 555 multi-harmonic oscillator. The 555 multi-harmonic oscillator single-channel standard circuit is as follows: a multi-harmonic oscillator is a self-exciting oscillator circuit that can generate rectangular waves. Because the rectangular wave is rich in high-order harmonics in addition to the base wave, it is called a multi-harmonic oscillator. The multi-resonant oscillator has no steady state, only two transient states. Under the action of its own factors, the circuit converts back and forth between the two transient states, so it is also called an unsteady state circuit. The multi-resonant oscillator composed of 555 timer is shown in the figure. R1, R2 and C are external timing elements. In the circuit, the high-level trigger end (6 pins) and the low-level trigger end (2 pins) are connected to the connection of R2 and C, and the discharge end (7 pins) are connected to the Because the capacitor C is not enough to charge at the moment of power, the voltage uc at both ends of the capacitor is low level, less than (1/3) Vcc, so the high level trigger end and the low level trigger end are both low level, the output uo is high level, and the discharge tube VT is cut off. At this time, the power supply is charged by R1 and R2 to the capacitor C, so that the voltage uc rises exponentially. When uc rises to (2/3) Vcc, the output uo is low level, the discharge tube VT is turned on, and the uc is raised from (1/3) Vcc to (2/3) Vcc. As the first transient steady state, the length of its maintenance time TPH is related to the charging time of the capacitor. Charging time constant T charge =

(R1+R2) C. It is not difficult to understand that after the power is turned on, the circuit flips back and forth between the two transient states, and the output can obtain a rectangular wave. Once the circuit start to oscillate, the uc voltage always changes between (1/3 to 2/3) Vcc.

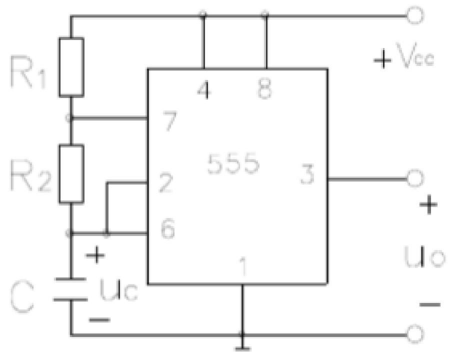


Figure 2: Multi-resonant oscillator composed of 555

The charging time and discharge time of capacitance C passing through the wave sphere T_1 of Vc T_2 are calculated as follows:

Charging time T_1 calculation formula: $T_1 = (R_1 + R_2) C \ln \frac{V_{CC} - V_{T-}}{V_{CC} - V_{T+}}$

Discharge time T_2 calculation formula: $T_2 = R_2 C \ln \frac{0 - V_{T+}}{0 - V_{T-}} = R_2 C \ln \frac{V_{T+}}{V_{T-}}$

Therefore, the oscillation period of the circuit is:

$$T = T_1 + T_2 = (R_1 + R_2) C \ln \frac{V_{CC} - V_{T-}}{V_{CC} - V_{T+}} + R_2 C \ln \frac{V_{T+}}{V_{T-}}$$

When Vco V_{T+} is suspended (ground after connecting the capacitor), ⅔ =V CC

V_{T-}= ⅓ VCC

$T_1 = (R_1 + R_2) C \ln 2$ $\quad$ $T_2 = R_2 C \ln 2$

Oscillation period: $T = (R_1 + 2R_2) C \ln 2$

Oscillation frequency: $f = 1/T = \frac{1}{(R_1 + 2R_2) C \ln 2}$

where is the time required t_{w1} from Vc rise to $\frac{2}{3}Vcc$ the required time $\frac{1}{3}Vcc$, which is the time required t_{w2} for capacitor C to be discharged. The 5 55 circuit requirements and R_1 R_2 both should not be less than $1K\Omega$, but the su m of the two should not be greater than $3.3M\Omega$.

where R2 is R2 in the corresponding general figure, R1 corresponds to R 1 1~R18 in the total figure, and C is 100n F , the resistance value of the adj ustable resistor is calculated.

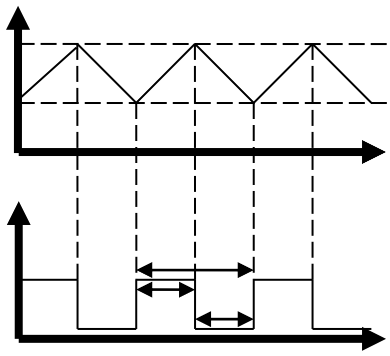


Figure 3: Waveform diagram of multi-resonant oscillator

3.1.4 LM324

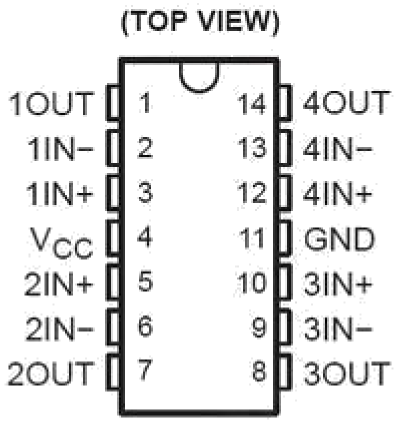


Figure 4: LM324 pins

LM324 series devices have four operational amplifiers with true differentia l input, with real differential input. Compared with standard operational amplifi ers for single-power applications, they have some significant advantages. The f our amplifiers can work in a power supply as low as 3.0 volts or as high as 32 volts, and the quiescent current is one-fifth of the quiescent current of MC 1741. The common-mode input range includes a negative power supply, thus el iminating the need to use external bias components in many applications.

3.1.5 Key circuit design

The key switch module takes into account both the power switch and the change of the resistance in the oscillator RC combination. That is, when different switches are pressed, the power supply will be turned on, and different resistance values will be connected at the same time to generate signals of different frequencies in the oscillator module.

3.2 Simulation realization

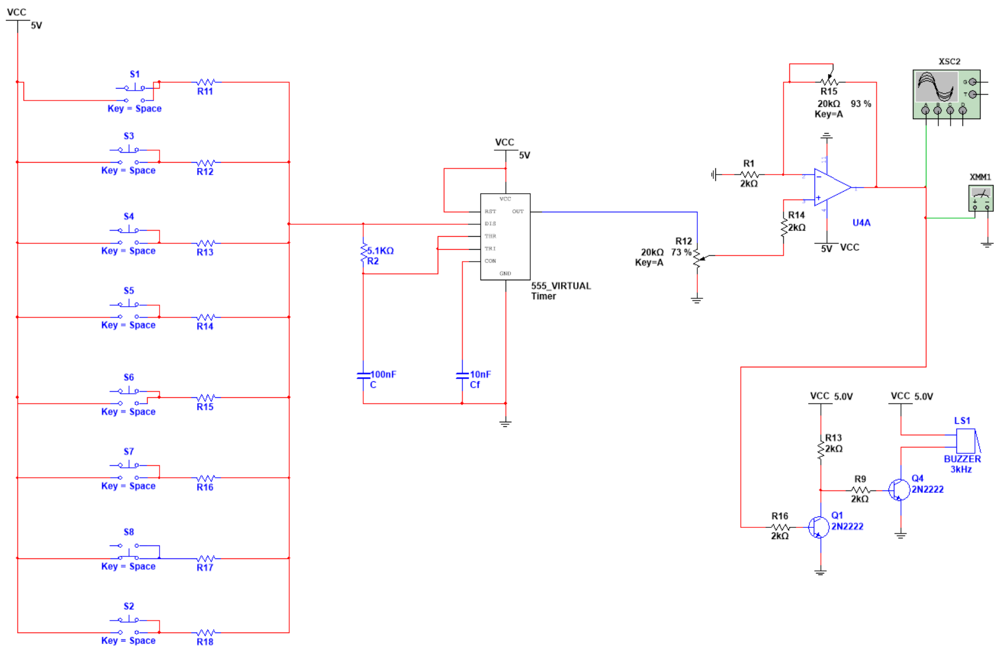


Figure 5: Simulation circuit diagram

When the button is pressed, the oscillation frequency is as follows:

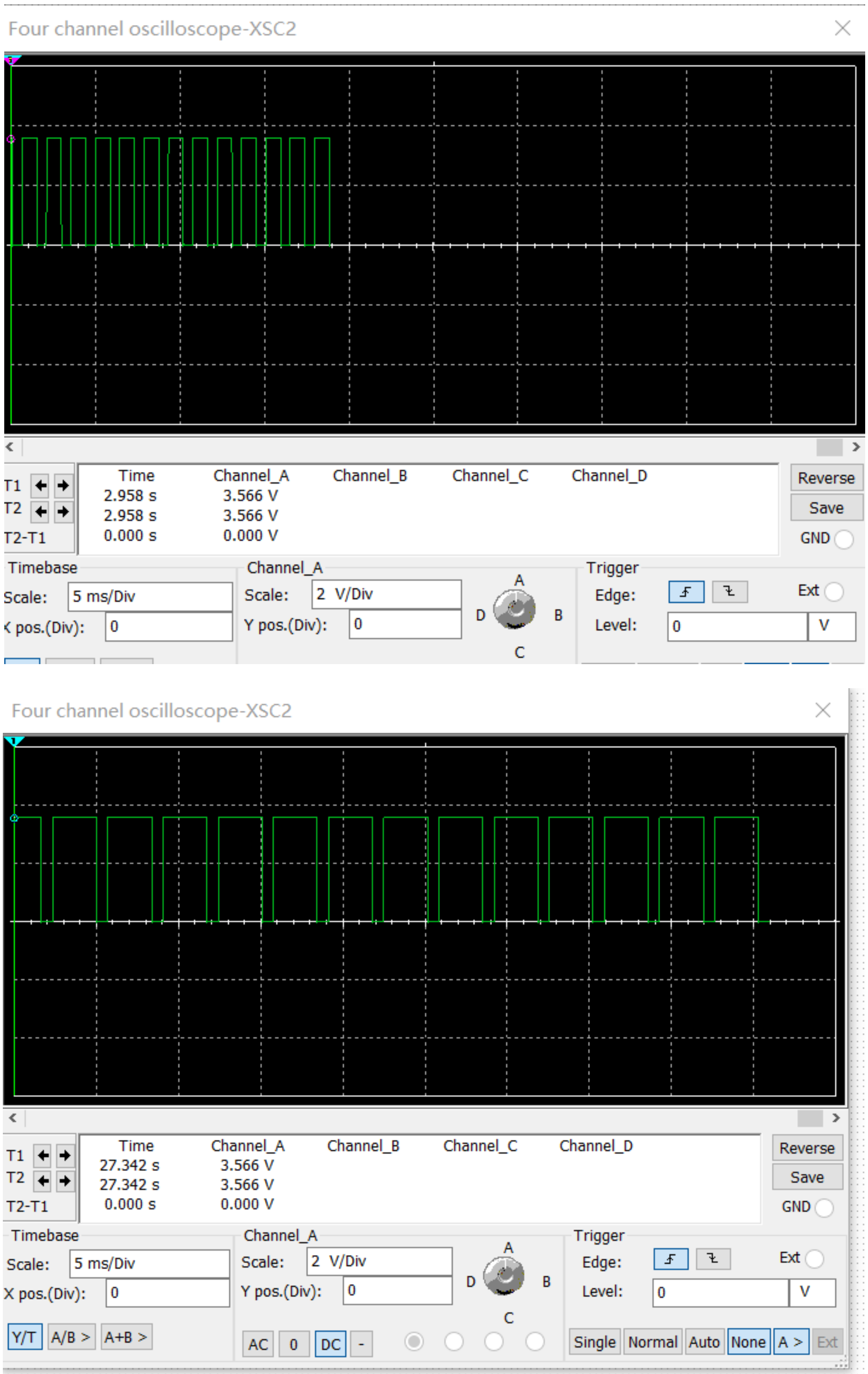


Figure 6&7: Waveform is generated

3.3 Proto-board

3.3.1 Equipment used

A DC power supply

A dual channel oscilloscope

A digital multi-meter

10cm*15cm stripboard

17.33kΩ,14.33kΩ,11.65kΩ,10.43kΩ,8.17kΩ,6.17kΩ,4.37kΩ,3.57kΩ resistances

5.1kΩ resistances

5*2kΩ resistances

100nF、10nF capacitors

LM324

NE555N

2*20kΩ potentiometer

2*audion

buzzer

Some wires

3.3.2 Work process record

(1) Construct the circuits use the single strand wire for the links, keep the circuits neat by cutting the links to the correct length.

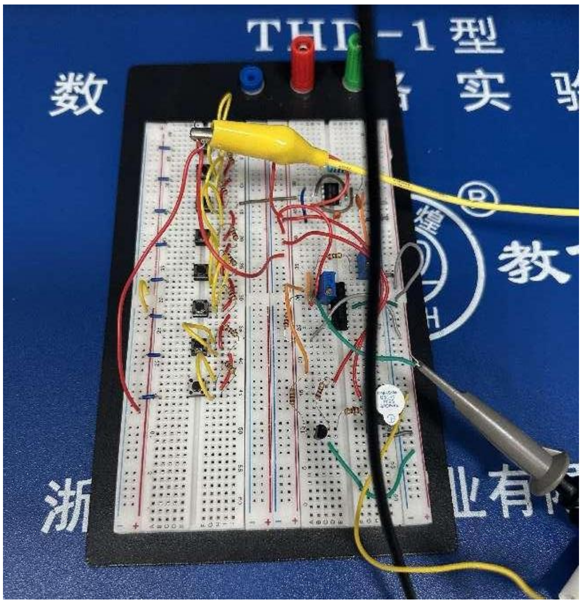


Figure 8 : proto-board

(2)Prepare the power supply (15V)

According to the experimental requirement, connect the power supply to the positive deal paver supply, and detected the output voltage of forward power supply.

Figure 9: The power supply outputs 5V voltage

We use the multimeter to detect the voltage connected to the proto-board, adjust the range of the multimeter to 20 V firstly, then connect the black metre pen of the multimeter to the greenen terminal (grounding end), and connected the red metre pen of the multimeter to the red terminal column with the proto-board. The multimeter indicates 5.25V(Figure 6)

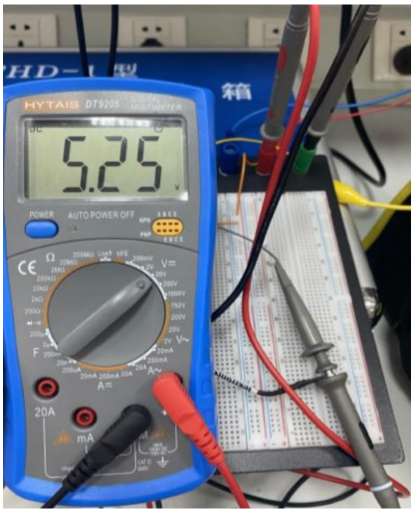


Figure 10 : Measure the voltage by using the multimeter

(3)Test and record the result for electronic keyboard on the proto-board

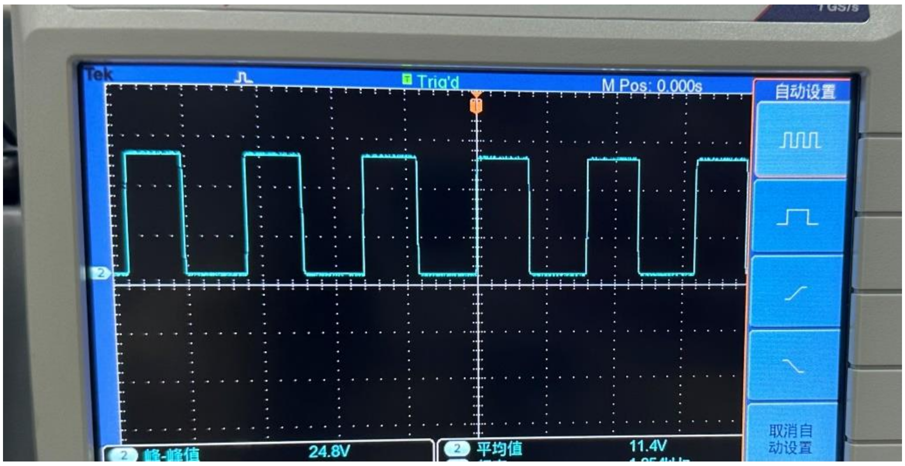


Figure 11: Waveform is generated

3.4 Stripboard

3.4.1 Equipment used

A DC power supply
A dual channel oscilloscope
A digital multi-meter

10cm*15cm stripboard

17.33kΩ,14.33kΩ,11.65kΩ,10.43kΩ,8.17kΩ,6.17kΩ,4.37kΩ,3.57kΩ resistances

5.1kΩ resistances

5*2kΩ resistances

100nF、10nF capacitors

LM324

NE555N

2*20kΩ potentiometer

2*audion

buzzer

Some wires

3.4.2 Work process record

Prepare the power supply. (+5V)

(1) According to the experimental requirements, connect the power supply to the positive and negative dual power supply.

(2) Detected the output voltage of forward and reverse power supply

Figure 12: +5V power

(3)Test and record result on stripboard.

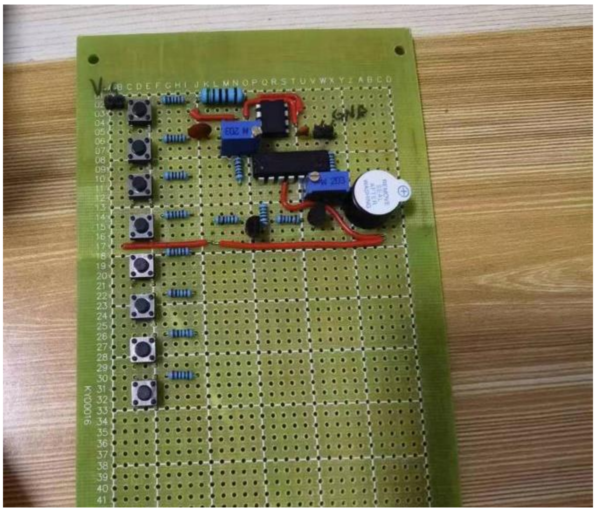


Figure 13: Circuit in stripboard.

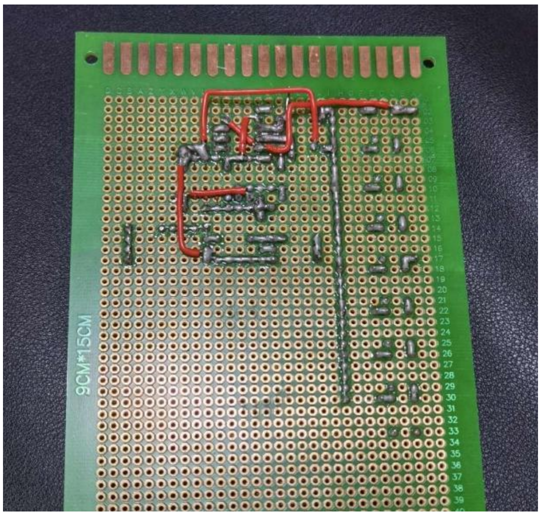


Figure 14: stripboard welding

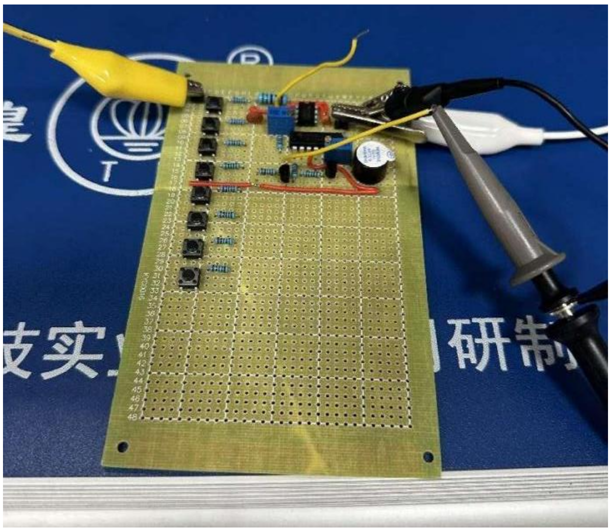


Figure 15: Test on stripboard.

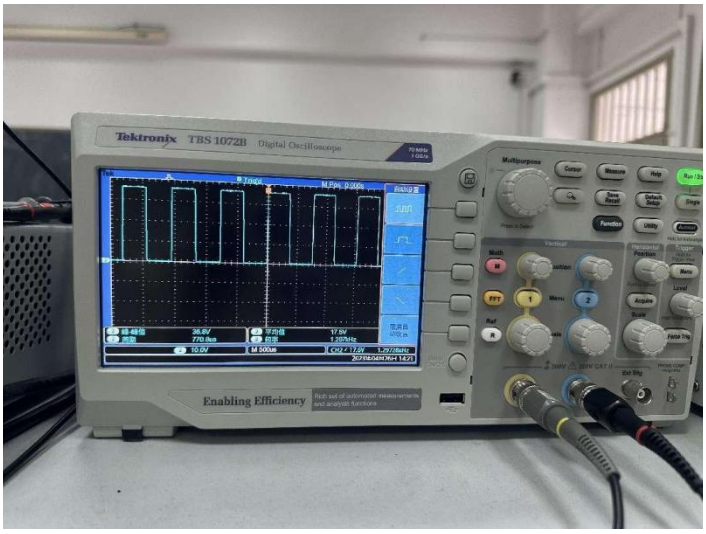


Figure 16: Result for the circuit in stripboard

3.5 PCB board

3.5.1 Fabrication PCB

（1）Used the AD 20 software so to draw the schematic and transform into PCB.

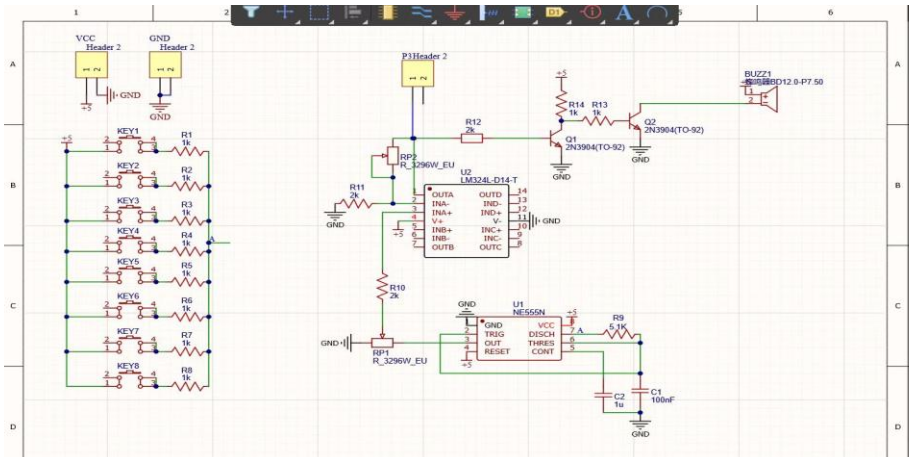
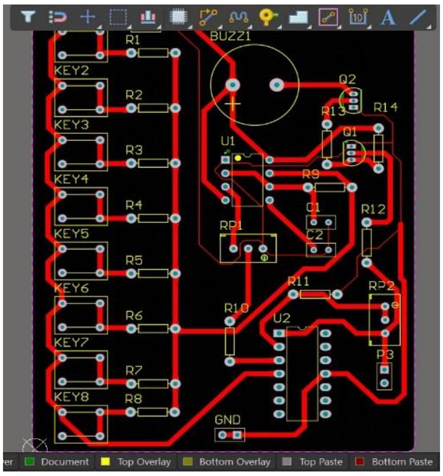


Figure 17



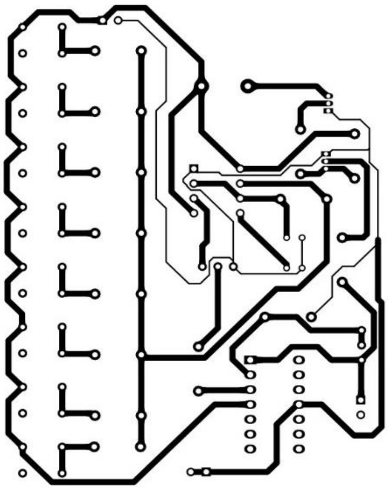


Figure 18 Figure 19

(2)The converted PDF was printed on the sulfuric acid paper. The sulfuric acid paper was vacuum and exposed to the photosensitive circuit board for 210 seconds. The developing circuit board was then developed for about 40 seconds. When the images were clear, it was removed from the developer, rinsed with clean water, and then placed into the etch solution for about 7 minutes. After corrosion completion, boreholes shall be drilled. Welding construction after drilling, as shown in Figure 15.

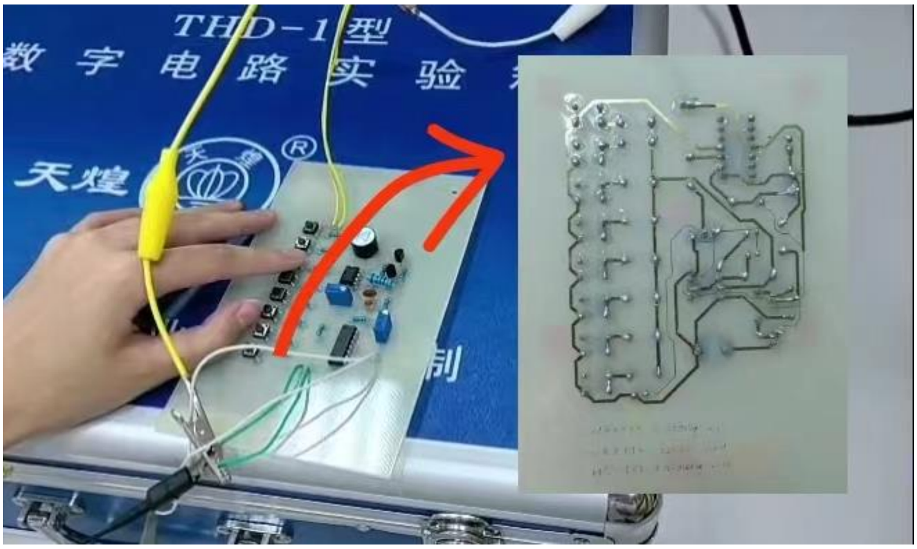


Figure 20

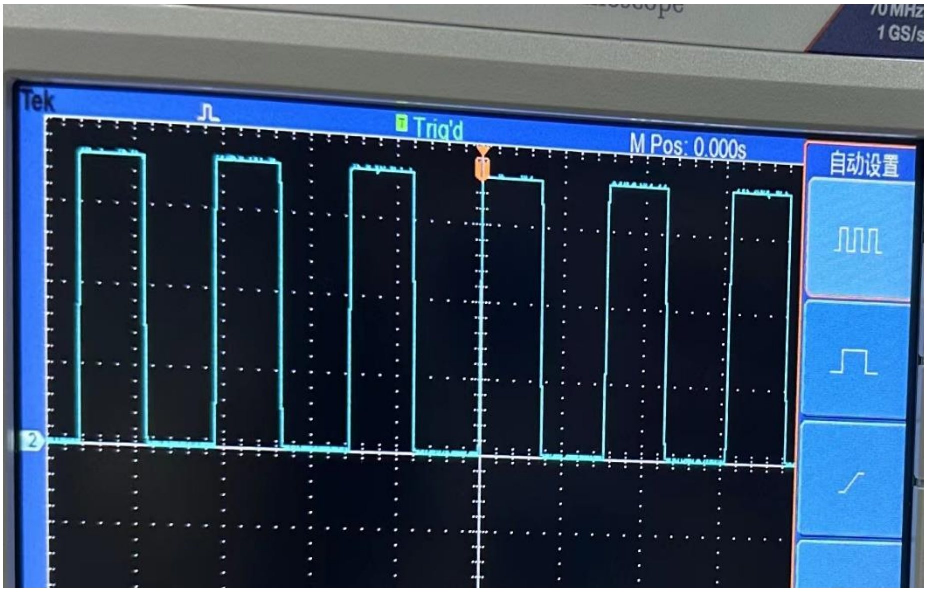


Figure 21

(2) Connect the welded PCB to the power supply and oscilloscope and measure the image as shown in Figure 16.

4.Result

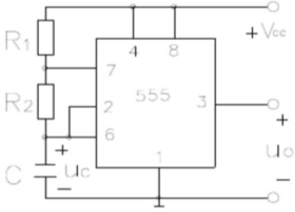


Figure 22

oscillating period: $T = (R_1 + 2R_2)C\ln 2$

oscillation frequency ： f=1/T

Tone	Do	Re	Mi	Fa	So	La	Si	Do
R / kΩ	26	24	22	20	18	16	14	13
F	262HZ	294HZ	330HZ	349HZ	392HZ	440HZ	494HZ	523HZ

The electronic principle of using NE 555 to make an electronic organ is to use the corresponding keys of different resistance to make NE 555 emit square waves of different frequencies, thus producing different tones.

We varied the frequency by changing the resistance, and then we produced different tones.

The waves formed are as follows:

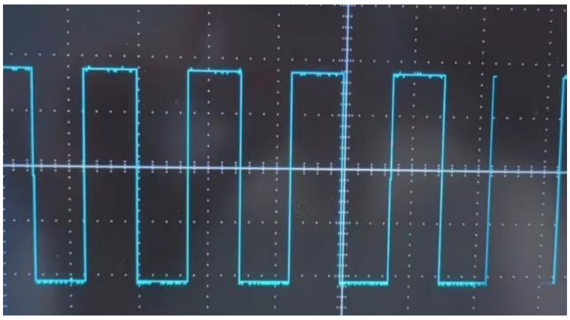


Figure 23

5.Dicussion

When the simulation was done on Multisim before the experiment, the LM324 power amplifier required for the experiment was not provided, resulting in the failure of the early simulation. Later, the problem was solved by searching for data, and the simulation was successful. After analysis, when you know that the problem is caused by the tool problem or cannot be solved, you should collect more information through the network and other means, and then use the existing conditions to solve the problem.
In the process of making the circuit according to the simulation diagram, the circuit error was caused by unfamiliar with the integrated chip pin. After searching the pin diagram on the Internet and checking the circuit, the circuit was concisely modified and made the circuit work normally. Therefore, it must be accurate when setting up the circuit. Where there is any uncertainty, it should be verified by checking the data. The simplicity of the circuit can effectively reduce the wiring error. After setting up, you should check it carefully. After confirming that it is correct, add the power supply to carry out the experiment, otherwise there is a risk of burning the components.
When designing the keys, due to the limited resistance value, the resistance close to the calculation value is used, resulting in a large frequency error of some sounds, which cannot meet the requirements of the experiment. After calculation, the resistance of the appropriate resistance value was re-selected, which greatly reduced the frequency error, so that the tone was accurate and the experiment was completed. From this, it is concluded that the experiment should not only have the approximate idea of engineering, but also be careful in the handling of errors. It is necessary to use existing materials flexibly to meet the experimental requirements and reduce the error as much as possible. In the next experiment, you can also choose adjustable resistance, which will be more convenient.
There are fewer faults in the overall experimental process, and finally it was solved through carefulness, which made me understand the idea design and lap of the experiment and the selection of components. We should be careful to reduce the error and complete the experiment perfectly.

6.Conclusion

The 555 timer is used to form a multi-harmonic oscillator, which controls different RC combinations with 8 keys to generate pulse signal waves of eight basic scales at different frequencies. Through the power amplifier driving the speaker, eight levels of music can be emitted. The 555 timer is a medium-sized integrated circuit with a double in-line 8-foot structure, which is small in size and easy to use. As long as a few appropriate resistance capacitance elements are equipped externally, it can form pulse signal generation and conversion circuits such as Schmidt triggers, monostable triggers and multi-resonant oscillators. It is widely used in the generation and transformation of waveforms, measurement and control, timing circuits, household appliances, electronic toys, electronic musical instruments, etc. Multi-harmonic oscillator composed of 555 timer circuit, its oscillation frequency can be changed by changing the value of the RC original in the oscillation circuit. According to this principle, by setting some different RC values and connecting different RC components to the oscillation circuit at a certain speed through the control circuit, the oscillation circuit can rhythmically transmit the set audio signal and music according to the set requirements.

7. Reference

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