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Design and Implementation of Audio Detection System

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Abstract: Environmental noise monitoring is an important link in improving the quality of life and strengthening environmental protection. In the bustling neighborhoods and residential areas of major cities, large-scale of environmental noise pollution have erected the streets. The design is mainly based on MCS89C5 1 microcontroller, which is the core of the audio detection system design. Capacitive electret microphone work by the principle of the sensor, the sound signal converts into electrical signal output when the microphone receiving noise, and then through the hardware circuit: amplify the signal, filtering A / D conversion circuit and software program control to complete the sound frequency detection function. Detection of the sound frequency display through the LED digital display, this design of the audio detection system is low cost, portable, can display environment noise digitally and so on. This can be widely used in industrial and mining enterprises, institutions and schools that need to measure and control the environment noise.

Keywords: Audio Detection; Microcontroller; Sensor; A / D Conversion; Digital Tube

1. Overview

At present, the domestic portable noise tester are mostly imported special equipment and very expensive, it cannot be popular as civilian products, only professional sector such as health, measurement and other environmental protection sector can own it. This paper describes an 89C51 microcontroller as the core, using A / D conversion technology constitutes a low-cost, portable digital display environment noise frequency measurement system diagram. The system is stable, good performance, meet the general civilian needs after calibration, and can be widely used in industrial and mining enterprises, institutions and other schools that need to measure and control the environment noise. Audio detection can also be used to effectively detect and test various industrial parts and products, and to evaluate its integrity, safety and reliability performance indicators, it is to test the quality, improve the process to ensure the safety of equipment. There are many kinds of detection technology using audio principle, according to the way the sound source occurs active and passive; according to the parameter identification method is divided into two kinds of amplitude and spectrum. Fault information can be extract from the audio detection of the various sound parameters, including the workpiece defect type, size, location and trends and other characteristics of the information, the reflection of the defect is authentic and real-time, and therefore applicable for rapid detection in finished and semi-finished products line, the other environmental conditions are not demanding except noise. Just as longitudinal vibration, bending vibration and torsional vibration of the vibration frequency are different, because of the different vibration modes even the same object have several different vibration frequency, but under certain conditions, the fundamental frequency and harmonic frequency fixed, the sound path is mainly in the form of air and solid sound, air

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sound is transmitted from the air to the audio detection system noise, solid sound is the audio detection system or other equipment and audio detection system vibration through the mechanical transmission to the Instrument, and noise generated by mechanical thin-wall vibration.

2. Course Design Purpose Tasks and Requirements

2.1.Design Purpose

After learning process detection and instrumentation technology course, we has a preliminary understanding of the commonly used process detection instrument working principle, characteristics and other theoretical knowledge, but lack of practical design and application capabilities. This audio detection system design course is a simple identification of audio parameters of the resonant frequency and internal friction value of the two-in-one system, suitable for hotels, shopping malls and other public places and noisy street to measure noise, especially suitable for detection of internal cracks in steel and steel content.

Through this design course, we can learn to think from the engineering point of view, familiar with the field of professional instrumentation system design, learn the process of testing the combination of all aspects of the system, learn the correct interface of the instrument, signal conditioning, linearization, calibration and commonly used alarm method.

2.2 Design Tasks

(1) Design an audio detection system that can detect changes in the surrounding sound.
(2) Detection of audio information from two audio parameters and output format: Resonance frequency (× ×. × × kHz), the internal friction value: (× ×. × 10-4)
(3) Audio detection effective distance: 10mm or so will be able to work properly.
(4) The design of the system should be low price, popular and easy for mass production.
(5) If can replace the recordable voice circuit, or other circuit combinations can be achieved for other purposes.
(6) Using PROTEUS and other software simulation, the waveform of the main signal input and output points is obtained, and the feasibility of the design function and the rationality of the parameter design are verifi ed according to the simulation results. The circuit diagram of the system is given (using the PROTEL software to make the schematics SCH file And the PCB file).
(7) Complete the course design report.

2.3 Design Requirements

1) Consult the sensor data as required by the mission statement.
2) Focus on learning the internal structure and principle of a sound sensor (recommended electret microphone), consider how to use ordinary SPEAKER imitation and PROTEUS simulation.
3) The use of LED digital tube (preferably LCD).

3. Audio Detection System Design

3.1 Design Ideas

The design of the audio detection system is shown in **Figure 3-3**. First, when the signal is activated, the microphone receives the audio signal conversion of the output voltage changes, the voltage signal is improved through the amplifier, the internal processing circuit obtain a stable and reliable voltage through the filter circuit, and then by the display of driver digital processing, the last LED or LCD achieve digital display.

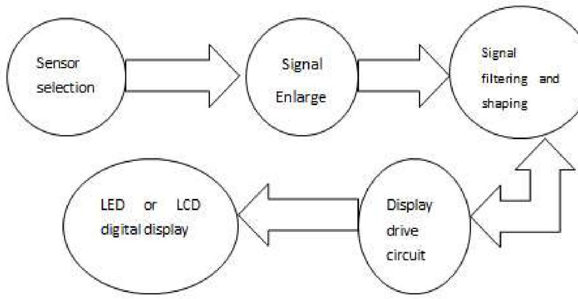


Figure 3-1; Audio Detection System Design Ideas**.**

3.2 Overall Structure Design

The overall design of the audio detection system is shown in **Figure 3-2**. The principle of this circuit is as follows:

Audio detection system consists of six parts, which are excitation source, sensor, frequency measurement circuit, data processing circuit and LED display output.

The whole system use AT89C51 microcontroller as the core, divided into two modules according to analog and digital circuits.

When the electromagnetic excitation system vibrates the projectile, the vibration of the sound waves is in the missile body. The sensor receives the audio carrier signal and converts it into a voltage signal. After one stage of amplification, the sensor is fed into the filter circuit for bandpass filtering.

Filter amplified audio signal is divided into two-way transmission, all the way through the two-stage voltage amplifier to filter a great attenuation after the signal control at 5.5V, and then put into the data processing system for data processing; another way to the audio carrier signal is put into internal friction circuit to measure. The internal circuit is mainly composed of the detection circuit and the voltage comparator. The detection circuit detects the envelope of the audio signal, and then compares the upper and lower voltage comparison circuits, controls the strobe by the exclusive-OR circuit, enters the computer for data processing, and finally print LED digital display output.

3.3 System Unit Module Design

Sensor Selection Scheme

Audio detection system sensor selection has two kinds of programs, one is the electret condenser microphone, and the other is the electromagnetic induction microphone. Filter circuit recommended the use of second-order band-pass filter program to design the system.

1) Electret Condenser Microphone

Electret microphone referred as ECM, known as MIC (Microphone), is a commonly used to convert the sound signal into electrical sound signals- electric conversion device. Its outstanding features are small size, light weight, simple structure, easy to use, long life, wide frequency response, high sensitivity, and the price is relatively low. It is widely used in cassette recorders, wireless microphones and voice switches and other electronic circuits.

The core device of the electret microphone is an electret diaphragm. It is actually a permanent polarized treatment of the dielectric. Its production principle is that, a very thin plastic film put on one side of the evaporation of a layer of pure gold film, and then placed in the high voltage electric field under the queen, so that both sides can be maintained in the long-term retention of the opposite sex charge. The vapor of the diaphragm is outwardly connected to the metal shell, and the other side of the diaphragm is separated from the metal plate by a thin insulating lining. In this way, a capacitance will be formed between the gold film and the metal plate. When the electret diaphragm vibrates, it caused the electric field capacitor changes at both ends, resulting in changes in the acoustic wave with the alternating voltage signal.

The output impedance of the electret is very high, about several tens of megahertz. Therefore, it cannot be use directly with the audio amplifier, in fact we need to add a level of impedance converter, it convert the high impedance into a few hundred oh or several thousand ohms low impedance. Usually installed the low noise junction type FET within the electret microphone product, composed of impedance converter, and become three-terminal microphone. **Figure 3-4** is the physical structure of the electret microphone decomposition, wiring, shape and circuit symbols.

Three-terminal electret microphone application circuit has two kinds of connection respectively, can be connected to the source output or drain output.

Many electret microphone products are not installed within the field effect tube, the two output contacts can be arbitrary access to the circuit, but it is best to take the shell of a little ground, another point take from the field eﬀ ect of high impedance input front amplifier.

In the selection of electret microphone, the focus should pay attention to the level of its sensitivity. Electret microphone sensitivity is usually white, blue (green), yellow, red and other color points to block, white point has highest sensitivity, and the lowest is red. Some of the microphone uses the dust cover color to indicate the sensitivity, and some with the model has a significant difference between the A, B, C and other letters. A is the lowest sensitivity, and in ascending order.

Typical products of the domestic electret microphone are CRZ2-9, CBZ2-11 and ZCH-12 and other models. CRZ2-9 with dimensions of Φ1.5 × 19 (mm), the use of the lead wire is shielded, two ends leaded, the shield is the cathode. Its voltage sensitivity is 0.5mV / mPa, frequency response range of 50 ~ 10

000Hz, the output impedance is 1kΩ.

The electret microphone detection includes resistance measurement and sensitivity measurement.

Resistance measurement, the multimeter placed in the R × 100 or R × 1k block, the red pen connected to the electret microphone core or signal output point, black pen lead wire to metal cover or microphone metal shell. Generally measured resistance should be 500Ω ~ 3kΩ. If the measured resistance is ∞, then the microphone is open circuit, if the measured resistance close to 0, then the microphone has a short circuit fault. If the resistance is much smaller or much larger than the normal value, it indicates that the measured microphone performance deteriorated may be damaged.

Sensitivity detection method is: the multimeter placed in the R × 100 block, the red pen connected to the microphone negative (usually the microphone lead wire), black pen connected to the microphone positive (usually the microphone lead wire shield). At this time, the multimeter should indicate a resistance (for example, 1kΩ), and then blow a breath against the microphone, and carefully observe the pointer, there should be a more substantial swing. The greater the amplitude, the higher the sensitivity of the microphone, if the pointer swing is very small, indicating that the microphone sensitivity is very low, the use will be poor. If the gas is found when the pointer does not move, you can exchange the pen position, and blow again, if the pointer is still not swing, then the microphone has been damaged. In addition, if the gas is not blowing, the pointer indicates the resistance with drift indefinite phenomenon, then the microphone stability is poor, such a microphone is not appropriate to use.

For the three-terminal electret microphone, as long as the correct distinction between the three lead wire polarity, the black pen connected to the positive power supply side, the red pen connected to the output, the ground side of the floating, it can still detect the performance of the identification of the merits of the microphone using the above method.

2) Electromagnetic Induction Microphone

Figure 3-5 is a moving coil microphone structure schematic diagram, which is made using electromagnetic induction phenomenon, when the sound wave make the metal diaphragm vibration, connected to the coil on the coil (called voice coil) with the vibration, the voice coil in the permanent magnet of the magnetic field vibrate, which produces the induced current (electrical signal), the size of the induced current and direction changes, changes in the amplitude and frequency determined by the sound wave, the current is amplified by the loudspeaker and passed to the speaker, and the amplified sound is emitted from the speaker.

Electromagnetic induction law is due to changes in magnetic flux generated by the phenomenon of induced electromotive force. When a part of the closed circuit conductor in the magnetic field do the movement of the magnetic induction line, the conductor will produce current, this phenomenon is called electromagnetic induction. The resulting current is called the induced current.

Secondary Amplifier Circuit

As the audio pulse exciter to stimulate the workpiece after the sensor signal is a weak signal, usually millivolt level or even micro-level weak signal cannot be directly measured, and thus need these signals to amplify and standard the processing, so that become 0-5V voltage or 4-20mA current. The current signal amplification circuit can be integrated with the op amp circuit, but with the development of electronic technology, there are more and more high-performance operational amplifiers to choose from, we can also require higher instrumentation amplifier, composite amplifier and high performance operational amplifier.

Amplifier circuit according to the selected integrated operational amplifier can be divided into instrumentation amplifier circuit, composite amplifier circuit and high-performance operational amplifier circuit. The most useful and most commonly used of amplifier circuit is instrument amplification circuit, which is divided into basic differential input instrument with amplification circuit, buffer differential input instrument with amplification circuit, variable gain differential input amplifier circuit, and with differential input to place in front place of the magnifying circuit of the instrument.

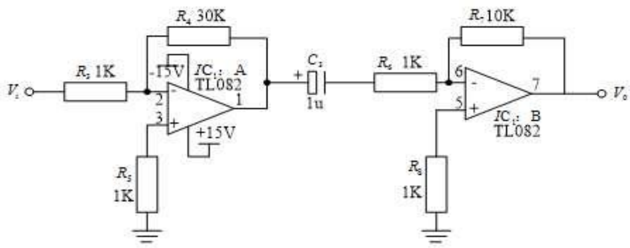


Figure 3-6; Secondary Amplifier Circuit**.**

Amplifier circuit shown in **Figure 1.2** shows the secondary amplifier circuit, the first level magnification is 30 times, the second level of magnification is 10 times, there is a total of 300 times, go through two magnification because the sensor through the audio signal is quite weak (mv Level).

Typical Second-Order Band-Pass Filter Circuit

The circuit is shown in **Figure 3**-7. This is a second-order band-pass filter consisting of a single-supply amplifier 8FC7. The circuit uses a single power supply, power supply voltage 3 ~ 30V.

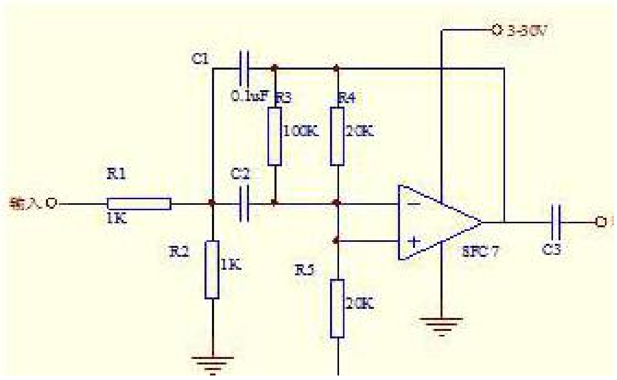


Figure 3-7; Single-Supply Low-Voltage Bandpass Filter**.**

Circuit components of the parameters of choice:

Capacitor C (C = C1 = C2) Select according to **Table 3-1** according to center frequency f_0:

F0 (Hz)	1-10	10-102	102-103	103-104	104-105	105-106
C (μF)	20-1	1-0.1	0.1-0.01	10-2-10-3	10-3-10-4	10-4-10-5

Table 3-1. Relationship between Capacitance and Frequency

Q value is a parameter that represents the frequency selection characteristic. The higher the Q value, the narrower the bandpass. When Q = 10, a frequency response characteristic of -40 dB per 10 octave is obtained. Q value is large, the circuit stability is poor. The general choice of Q is less than 10.

Closed-loop gain GF generally choose a value that less than 1.

Resistors R1, R2, R3 formula is as follows:

$$R_1 = Q/(G_F \omega_0 C) \qquad (1\text{-}1)$$

$$R_2 = Q/[(2Q^3 - G_F)\omega_0 C] \qquad (1\text{-}2)$$

$$R_3 = 2Q/(\omega_0 C) \qquad (1\text{-}3)$$

Among them, $\omega_0 = 2\pi f_0$

R4, R5 for the op amp inverting input bias resistor. Resistance is 20kΩ. The component parameter values in this circuit diagram are calculated at f_0 = 10KHz, Q = 5, GF = 0.6.

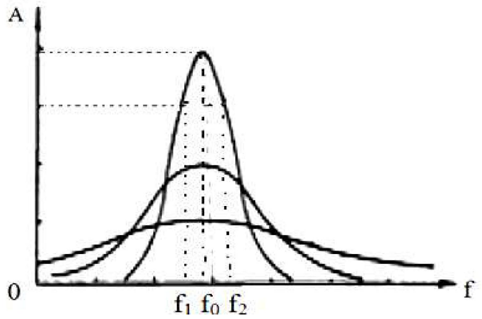


Figure 3-8; Amplitude and Frequency Distribution**.**

Select the center frequency f_0 = 10KHz, f_1 and f_2 is the center frequency, f_0 attenuation 3dB C = C1 = C2 = 10-3μF can be found from table above, calculated by:

B = f2-f1

Ω0 = 62.83 k

R1 = 133 kΩ

R2 = 319Ω

R3 = 159 kΩ

Display Circuit Selection and Design

Liquid crystal display or digital display are usually use in digital display circuit. For the general section of the LCD screen, there is a need for a special drive circuit, and liquid crystal display as a passive display, poor visibility, not suitable for long-distance viewing; for the drive circuit and microcontroller interface LCD module, the general use of parallel interface, the requirements of the microcontroller is higher, take up more resources; In addition, AT89S52 microcontroller itself does not have a dedicated LCD driver interface. The digital tube as an active display device, with high brightness, fast response, cheap, easy to buy, and other advantages, and also long-range visual effects, it is suitable for night or long-distance operation. Therefore, in this design, we use 7 digital tubes as a display medium. Digital tube display the overall block diagram is as follows:

Digital tube display can be divided into static display and dynamic display. For the static display, the frequency measurement results after decoding, and send output through the 89C51 serial port. The serial port operates in mode 0, the synchronous shift to register mode. At this time, from the 89C51 RXD (P3. 0) output data, sent to the serial input and output register 74164 data input port A and B; from TXD (P3. 1) output clock, sent to 74164 clock input CP, the 74164 converts serial data into parallel data for latching. 74164 output 8-bit parallel data sent to 8-segment ED, to achieve the display data measurement. Using this method, the main program does not have to scan the display, so that the microcontroller can make the next measurement.

Dynamic drive is all the digital tube of the eight show strokes 'a, b, c, d, e, f, g, dp' of the same name together, and each digital tube in the public increase the public COM through the control circuit, bit by the independent control of the I / O line, through the time-sharing control of the various digital control of the COM side, so that each digital tube turns the control display. P0 port plus pull the resistance, in order output '0' and '1' level normally, must ensure that P1 port LED digital tube connected to the normal display of digital, and software is match with the digital display. The internal structure of the digital tube is shown in **Figure 3-10**:

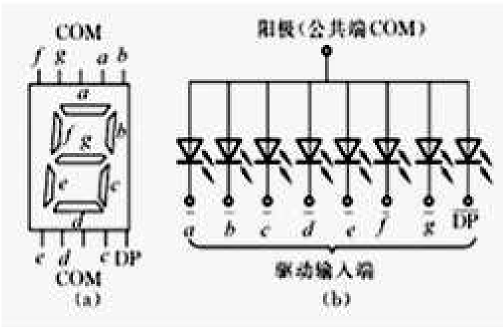
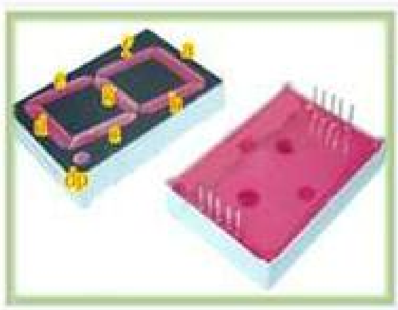


Figure 3-10; Digital Tube Internal Structure and Pin Diagram**.**

The external structure of the digital tube is shown in **Figure 3**-11 below.



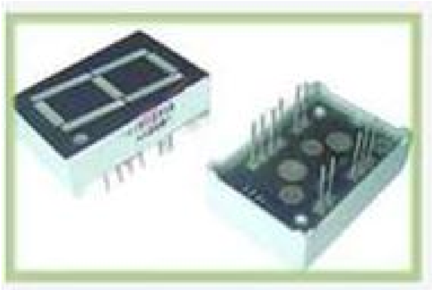


Figure 3-11; External structure of the digital tube**.**

3.4 System Overall Circuit Diagram

The hardware structure of the ambient noise and the display circuit are as follows:

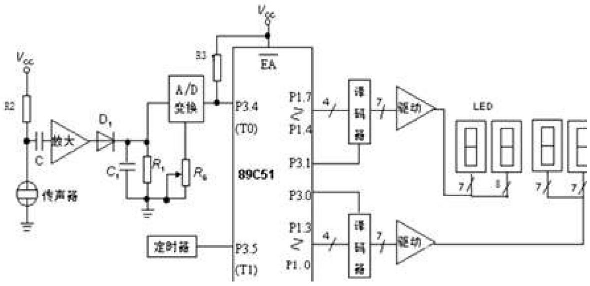


Figure 3-12; Hardware Structure of Noise**.**

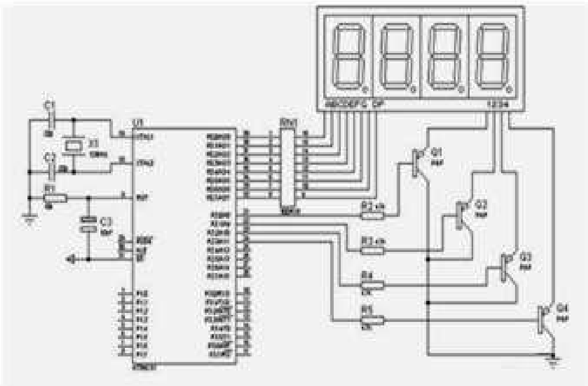


Figure 3-13; Frequency Display Circuit Diagram**.**

4. Software Design

4.1 Single-Chip Frequency Measurement Principle

Microcontroller is the main control chip of system with MCS89C51. The software design flow chart is shown in **Figure 4-1**. See appendix for procedures. Pulse number frequency measurement method is recorded in the determination of time, Tc signal to be measured, the number of pulses Mx, and the frequency to be measured:

F = Mx / Tc

4.2 Programming Analysis

T0 to achieve 50ms timing:

With a 12 MHz crystal oscillator, the timing of one second has exceeded the maximum timing that the timer can provide. A combination of timing and counting method is used to achieve a second of the timing. Select the timer / counter T0 as a timer, work in mode 1 to produce 50 ms timing, the timing of the completion of the count value multiplied by 20 is the measured signal frequency.

T1 count part:

The timer / counter mode register TMOD, with software initial value 51H, that is, 01010001B. At this time the timer / counter 1 uses the working mode 1, the mode selection bit C / T is set to 1, that is, set T1 to 16-bit counter. Timer / Counter O uses mode 1, C / T is set to 0, that is, set TO to 16-bit timer.

Calculate count initial value:

The initial value of the design is m, the design uses 12 MHz crystal. Machine cycle = 12 × (1 / crystal frequency). So the initial count m = 15536.

When the timer / counter T1 is set to count mode, its count pulse is an external event of source of T1 port. When a negative transition pulse from '1' (high) to '0' (low) appears on the T1 port, the counter is incremented by one. The computer samples the T1 port at the S5P2 state of each machine cycle. When the current machine cycle is sampled 1 and the next machine cycle is sampled as 0, the counter is incremented by one. The computer uses two machine cycles to identify the first count, so the maximum count rate is 1/24 of the oscillation frequency. In addition, there is no special requirement for the duty cycle of the external event count pulse (i.e., the continuous width of the pulse), but it must be ensured that the given high level is sampled at least once before its change, i.e., at least one complete of the machine cycle. Thus, from the T1 port input pulse signal, T1 can achieve the number of pulses counted.

5. System Simulation and Debugging

The use of simulation is the only way to debug the circuit from the modern electronic system design and development. The working point of the circuit can be check through the simulation, you can calibrate the instrument, measure the error, get all the data needed for the design report, and you can also see the actual output of the human sensor switch effect. Through simulation practice, we can learn the use of commonly used electronic equipment and learn to design a variety of circuit maintenance methods.

5.1 Keil C51 Software Debugging

Keil C51 simulator is a use of a cheap simulator Keil C51 IDE with integrated development environment as a simulation environment, it can be downloaded through the serial port to the user program, and can be downloaded through the serial port on the microcontroller.

The main method of debugging:

1) Start Keil C51
2) Create a new project. Project menu -New project, select the file we want to save, type First to save. Then pop up the CPU type selection box, we select AT89C51, and then click OK.
3) Add a document to the project. Create a new file, File menu File-New, then we select: File menu File-Save As? (Save As) pop-up dialog box, the file name box, type First.c and save. C file is built, then add the file to the project, click the front of the + +, right click on the Source Group1 and then select Add Files to Group, Source Group1, select Add. Compile and run, check the program. Keil software debugging diagram shown in **Figure 5**-1:

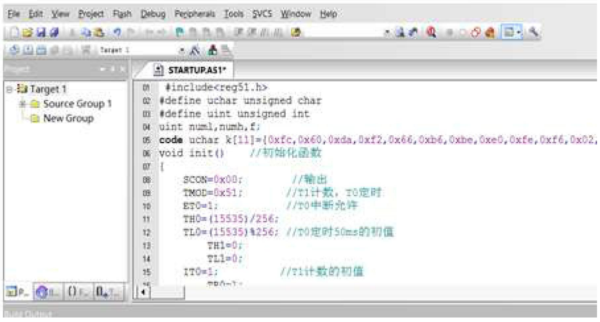


Figure 5-1; Keil Software Debugging Chart**.**

5.2 Proteus Software Simulation

In the use of Proteus simulation, we should pay attention to the combination of simulation and practice. In Proteus, need to pay attention to the settings of the photosensitive resistor and the actual resistance of the same resistance, the transistor 8050,954 need to use the corresponding transistor, voice chip and speaker with SPEAKER. Simulation should have real value.

Proteus is EDA software with simulation of system simulation, RS-232 dynamic simulation, I2C debugger, SPI debugger, keyboard and LCD system simulation with analog circuit simulation, digital circuit simulation, microcontroller and peripheral circuits. Virtual instruments such as oscilloscopes, subgrade analyzers, signal generators, and so on.

Debugging method: first use Keil software to compile C into the HEX file, open the Keil software, create a new document, enter the C program, save the C format file, and then create a new project, connect the microcontroller for the AT89C51, select options for target, select OUTPUT from Menu, in the Creat HEX, tick DeBug submenu, Select Settings ProteusVSM Simulator, USE before the hook, run the file again, after that the success of the directory will generate HEX file, open Proteus software, or directly click DSN file, double-click the microcontroller template, click the folder icon to select the corresponding HEX driver file, and then click Start to debug. The frequency output by the oscilloscope is shown in **Figure 5-2**:

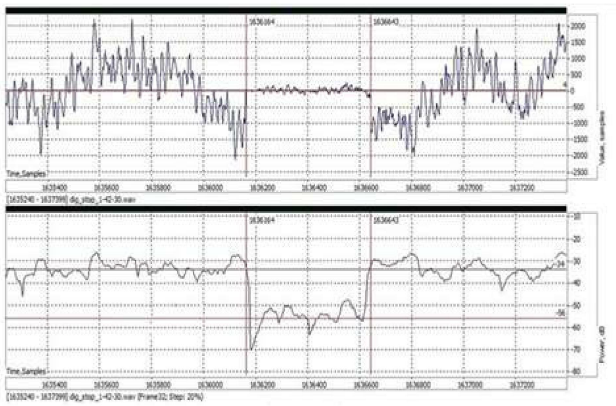


Figure 5-2; Output Frequency Waveform**.**

6. Conclusions

This course design is the actual validation of the process detection based on theory knowledge learned in this semester. Before the design, I read a lot of audio detection related information. The experimental design is very helpful. In the experiment, I find the solution carefully and teachers and students help me a lot to solve the problem. Besides, I learned a lot from this experiment:

1) Learned how the electret microphone and inductive microphone work and their usage.
2) To understand the design of audio detection ideas, and learned to design the performance of the audio detection system, perform analysis to find out the shortcomings of its existence.
3) The Keil C51 simulator and Proteus simulation software can be used to simulate the designed software and hardware circuits so that the designed system can work properly.
4) Know the measured analog signal need to add an A / D converter to the microcontroller, a microcontroller can identify the digital signal.

This lesson design has deepened my understanding of the audio detection system design, my software simulation capabilities have been improved for future design experiments to lay the foundation, and then cultivate the design of this aspect of interest. Design is focused on the process, must find out problems from the design, think positively, access to relevant information and ask other people to a greater extent to improve their ability. Specially thanks to patience guidance of teacher Bo in this design.

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