

## The Research of Noise Power Generation

Siqi Zhu <sup>a</sup>, Zhiyuan Dong <sup>b</sup>

School of Mechatronic Engineering, Southwest Petroleum University, Chengdu, 610500, China

<sup>a</sup>352321768@qq.com, <sup>b</sup>1392915507@163.com

### Abstract

Currently, noise pollution is one of the four major pollution in the world, which has seriously affected people's normal work and life. Noise control technology usually only meet the emission requirements. It is focusing on prevention for the traditional method of noise control, that is isolating or protectecting the source of the noise, noise propagation path and receiver, noise energy is denied or absorpted. Although it is some extent to decrease the noise hazard to humans, it can not effectively make full use of the noise energy. Aiming at the disadvantages of the traditional method of noise management, a new device using noise power generation for the comprehensive management of noise is designed. a new device using noise power generation for the comprehensive management of noise pollution is designed. It elaborates the principle of noise power generation device, system structure and software design. Noise power generation device has the advantages of convenient operation, safety, high sensitivity, environmentally friendly, zero emissions,and can effectively absorb noise.

### Keywords

Noise pollution; Energy; Power generation.

### 1. Introduction

Due to the increasing of the energy consumption, the energy shortage and environmental pollution are increasingly serious, and the development of new energy has been paid more and more attention. The noise in the environment is a considerable potential energy, noise pollution is also a great harm to the health of human life. It is focusing on prevention for the method of noise control, that is isolating or protectecting the source of the noise, noise propagation path and receiver, noise energy is denied or absorpted. For example, the noise source is covered, the installation of spring device is to absorb shock etc[1]. Although it is some extent to decrease the noise hazard to humans, it can not effectively make full use of the noise energy.

In recent years, a large number of noise power generation technology has been explored and researched, and many achievements have been made. For instance,noise weeding, noise power generation, noise dust, noise cooling, noise diagnosis etc[2]. As early as 1896, Lord Rayleigh explained the problem of sound and vibration caused by heat sources. Nineteen seventies, the Swiss scientist N.Rott proposed thermoacoustic oscillation quantitative theory, laid the theoretical basis for the sound power. Iranian researchers have invented sound wave power generation technology[3]. Utah University scientists invented a micro-thermoacoustic power generator, which can turn heat into sound waves, and then become available power. Recently, South Korean researchers have invented a "thunder" noise generator, in the effective elimination of noise at the same time, and can also use these noise to generate electricity. In the 1980s, researches in this area were started, the wave equation of the isothermal thermoacoustic effect and the adiabatic thermoacoustic effect of the traveling wave field was established by Professor Xiao Jiahua of the Chinese Academy of Sciences; The nature of thermoacoustic conversion process is discussed by Deng Xiaohui in Huazhong University of Science and Technology, and a regenerator active network model is established; A traveling wave thermoacoustic generator was developed by Luo Ercang researchers in Technical Institute of Physics and Chemistry,CAS[4]. However, these noise generators are relatively complex, large in size, not easy to carry, and have a low noise utilization rate.

Aiming at the disadvantages of the existing noise power generation device and the traditional method of noise management, a new noise generating device based on DSP is designed. The device has several parts, including acoustic receivers, acoustoelectric converters, rectifier circuits, electrical equipment, batteries, DSP and peripheral control circuits, PC. DSP is a core for the noise power generation device, it is particularly suitable for signal processing operations, and has the advantages of data processing speed, high precision etc. A drum type acoustic receiver is used for the noise generation device, and the resonator increasing the acoustic agglomeration energy is connected with the receiver, then the electricity can be generated by the sound energy from the resonator effected on acoustic transducer. It uses a piezoelectric acoustic transducer and the piezoelectric effect of polarized material to turn the sound energy into electricity. It is the ideal choice for noise power transducer, because there is no need for additional power supply, voice coil and other ancillary structures. Noise power generation device has the advantages of convenient operation, safety, high sensitivity, environmentally friendly, zero emissions, and the goal of environmental improvement and energy saving is realized.

## **2. The Basic Principle of Noise Power Generation**

### **2.1 The Present Situation of Noise Control**

With the development of society and the continuous improvement of people's living standards, a large increasing in energy consumption leads to energy shortages and environmental pollution problem becoming increasingly serious. At present, the four major pollution in the world is noise pollution, water pollution, air pollution and solid waste pollution. In most countries, the three major pollutants have been the attention of government departments and have a very considerable improvement, but the noise pollution has become an important issue of environmental governance in the 21st century. Noise is composed of different frequency and different intensity of sound, there are five categories: traffic noise, industrial noise, construction noise, social noise, family noise. Noise pollution has seriously affected people's normal work and life, so noise must be controlled. There are two types of governing measures:

(1) Traditional noise control methods: It is focusing on noise control and noise absorption, that is isolating or protecting the source of the noise, noise propagation path and receiver, noise energy is denied or absorbed. For example, the noise source is covered, the installation of spring device is to absorb shock etc; the sound barriers is built on the propagation path; the protection of the receiver is generally sound insulation window, sound insulation earphone etc. Install the acoustic wave emitter around the noise source and the noise is eliminated by canceling the wave crest of the same wavelength. Although it is some extent to decrease the noise hazard to humans, it cannot effectively make full use of the noise energy.

(2) The latest noise control methods: In recent years, the use of noise has been further researched in the world. Such as noise dust, noise enemy, noise hypnosis, noise weeding, noise diagnosis, noise temperature measurement, noise cooling, noise power generation etc.[5]. Noise can be effectively used for the new method of noise control, not only it is a major breakthrough in noise control, but also it is a supplement on increasingly scarce energy in the human society.

In this paper, the main method of noise control is noise power generation, the mechanical structure of the system is simple. It has the advantages of convenient operation safety, environmentally friendly, zero emissions, energy saving etc. So it has an important practical significance and broad application prospects.

### **2.2 The Principle of Noise Power Generation**

Noise power generation device uses a tympanic membrane acoustic receiver, the resonator capable of increasing the energy of the acoustic energy accumulation is connected to the receiver. When the sound energy from the resonator acts with the acoustic transducer, producing the force acts on the piezoelectric element, a certain amount of charge can be produced by the piezoelectric element

surface , after the rectifier circuit processing, then the device accessing to electricity circuits can be achieved by the power supply equipment.

**2.3 The Possibility of Noise Power Generation**

Noise is a sound energy, but not any sound is noise, in accordance with national standards, residential noise cannot exceed 50dB during the day and should be less than 45dB at night. Everything has a double-sided nature, when it reaches a certain strength, it is a considerable energy. The reference sound power  $W_0$  may be taken as  $10^{-12}W$ , the sound power level of any noise is P, W is the noise power, then

$$W = W_0 \times 10^{\frac{P}{10}} \tag{1-1}$$

According to the above equation, a jet aircraft with a noise of 160 dB has the noise power within 20m reaching 10000W;A large blower with 140dB noise, it has the noise power up to 100W;KTV music is usually played by high-power subwoofer speaker, it releases the volume up to 120dB or so, the calculation of the noise power should be 1W[6-7]. If the noise is turned into treasure, it can be turned into electricity by the noise power generation device, and it is important for environmental improvement and energy savings [8].

**2.4 Analysis of the Relationship between Sound Energy and Sound Pressure Level**

When the object encounters a sound, it is vibrated to produce a mechanical wave, mechanical energy is a way of external radiation, so the sound wave is energy. According to the classical theoretical formula of acoustic deduction, we can find, in the same frequency band, the sound pressure level is higher, and the sound energy is stronger. Sound pressure level is increased by 1 times, the sound energy can be enhanced to the original 10 million times. Therefore, in the noise power generation design, we should choose a relatively high sound pressure level of noise source or noise environment.

**3. The System Structure Design of the Noise Power Generation Device**

**3.1 The System Structure of the Noise Power Generation Device**

Figure 1 shows the structure of the noise power generation device, it includes an acoustic wave receiver, an acoustoelectric converter, rectifier circuits, electrical equipments, a battery, DSP and peripheral control circuits, and PC.

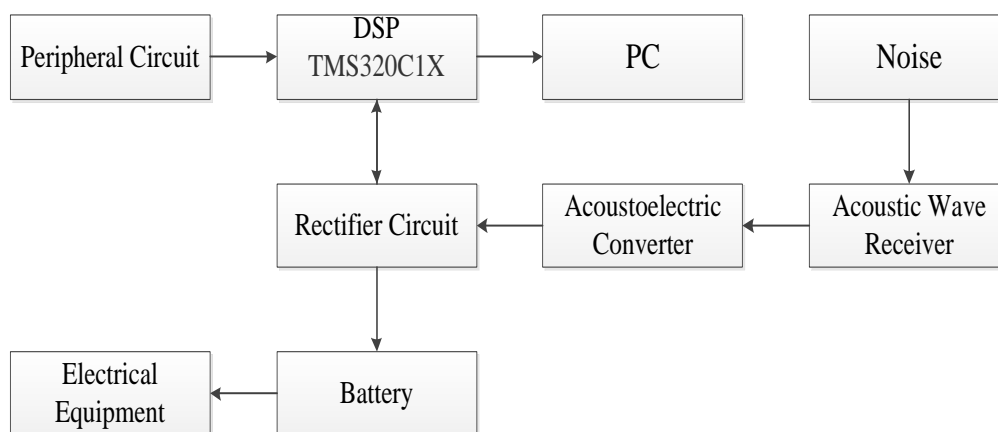


Figure 1. The system structure of the noise power generation device

The noise power generation device takes DSP as the core, it is controlled by DSP and peripheral circuit, it uses tympanic membrane acoustic receiver to absorb noise, and the resonator increasing the acoustic agglomeration energy is connected with the receiver. When the acoustic energy from the resonator acts with the acoustic energy converter, it produces a force on the piezoelectric element, then the piezoelectric element surface produces a certain amount of charge, after the rectifier circuit processing, then the device accesses to electricity circuit, it can supply the power for the battery and the electrical appliances. Finally, the DSP processing results are displayed on the PC.

### 3.2 Data Processing Module (DSP)

TMS320C1X minimum system is used for data processing module. It is one of the most cost-effective DSP chip, and has a strong digital signal processing capabilities. It is widely used in industrial control, especially in the application requiring high processing speed and processing accuracy. It supports the new CCS environment C Compiler, and provides the direct C language embedded in the assembly language development interface, it can be in the C language environment with the assembly language to write programs. It uses C language to program, the programming is simple, C language has the assembly language, and it can improve the operating efficiency of the program. DSP has the merits of high performance, flexible programming, good stability, high precision and embedding etc, and it is widely used in military, communication and medical fields etc.

### 3.3 The Type Of Acoustoelectric Converter and Transducer Material

#### 3.3.1 The Type of Acoustoelectric Converter

Acoustoelectric transducer is used to convert acoustic energy into electrical energy. At present there are three types of acoustoelectric transducer: moving coil, capacitive, piezoelectric etc. Moving coil type acoustoelectric transducer is based on electromagnetic conversion principle, when the voice coil in the magnetic field of a ring magnet does cutting magnetic field line movement, it produces the induced voltage. The diaphragm is integrated with the voice coil in the transducer, vibration diaphragm brings voice coil vibration in under the action of sound wave, and it produces the corresponding electric signal. Due to the vibrating membrane of moving coil type acoustoelectric transducer is loaded with its a few hundred times the weight of the voice coil, so it is very complicated to make the noise power generation device. Generally speaking, the moving coil type acoustoelectric transducer is common used in the production of microphones and high-fidelity headphones. Capacitive acoustoelectric transducer has a fixed rear plate and an active diaphragm as the front plate, they are close to each other, and it is equivalent to a small variable capacitor. This acoustoelectric transducer is the most common application, because it is inexpensive and compact. It is used for the common mobile phone built-in microphone and noise statistical analyzer. But it needs the additional power supply for the capacitor plate, because of its high sensitivity and wide frequency response, and can be used as auxiliary acoustoelectric transducer. Piezoelectric acoustoelectric transducer uses the piezoelectric effect of polarized material to turn the sound energy into electricity. It is the ideal choice for noise power transducer, because there is no need for additional power supply, voice coil and other ancillary structures.

### 3.4 The Collection And Treatment Of Electricity

#### 3.4.1 The Collection of Electricity

Due to the piezoelectric material itself with charge, so it can produce alternating current. When the force acting on the piezoelectric element disappears, the electric charge generated by the piezoelectric element immediately disappears, so that a large capacity capacitor C is required to store the electric charge generated by the piezoelectric element. It is shown in Figure 2.

When the piezoelectric ceramic surface is acted by the role of force F, it produces the electric charge.

$$Q = gFS \quad (2-1)$$

In the equation is the generated charge, F is the force, g is the electric field stress constant, S is the piezo ceramic pressure area. It is the output voltage.

$$U = \frac{gFS}{C} = \frac{gPS^2}{C} \quad (2-2)$$

In the equation: C is the capacitance of the piezoelectric material, P is the effective sound pressure, Pa.

Through the experiment, we can draw the following conclusions:

When the external load resistor  $R$  and the equivalent impedance of piezoelectric element are same, the energy absorption of load is the largest; when the external capacitor  $C_0$  and the piezoelectric element are equal capacitance, the energy transmission efficiency is maximum.

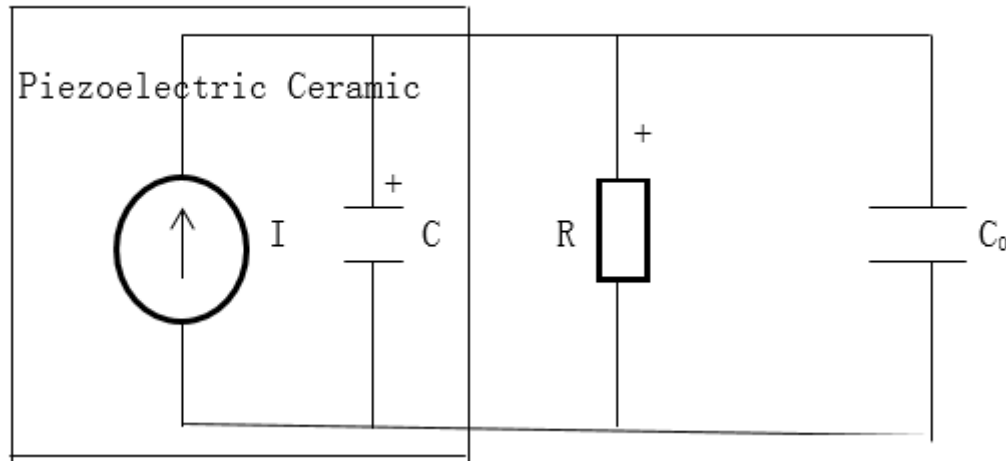


Figure 2. Piezoelectric ceramic electricity storage circuit

### 3.4.2 The Treatment of Electricity

In general, the energy generated by noise is not large. According to the above analysis, assuming that PZT is used as the diaphragm material, the inter-electrode capacitance is  $1\text{F}$ , the electric field stress constant  $g$  is  $0.15$ , and the pressure receiving area is  $1\text{m}^2$ . When the sound pressure level of noise is  $80\text{dB}$ , the theoretical calculation of the open-circuit voltage is  $0.03\text{V}$ ; at  $100\text{dB}$ , the open-circuit voltage is  $0.3\text{V}$ ; At  $120\text{dB}$ , the open-circuit voltage can only reach  $3\text{V}$ . In actual conditions, the voltage is even smaller. It is not enough to charge a large capacitance of the capacitor, so our first work is to increase the voltage. Because the resonant fundamental frequency of each piezoelectric element in the spherical array is the same, so the formation of the voltage waveform after acoustoelectric converter is almost the same. It can be connected the same array of acoustoelectric converter units, they are equivalent to a number of AC batteries connected to form the AC voltage power supply. But in the case of some uncertain factors, due to space constraints, it is impossible to make the diaphragm area of each unit  $1\text{m}^2$ , so we can consider the voltage doubler rectifier circuit to amplify the voltage  $N$  times and charge the capacitor. So that the capacitor voltage reaches a certain value, then the charge control chip drives to work and charge the battery.

### 3.5 The Installation Of The Noise Power Generation Device

In order to obtain a higher sound pressure, noise power generation device can be installed on both sides of the highway, railway, wharf etc. It is close to the noise source and uses whistle, friction noise generated by locomotive, eddy current noise, impulse noise to generate electricity.

In addition, the noise power generation device corresponds to a function of the noise screen. But the noise screen produces infrasound to damage the human body, the installation of noise power generation device can absorb noise and generate energy. It can be installed under the surface of the aircraft runway in the airport. When the aircraft takes off and lands, it can use a variety of noise generated by airplane to produce electricity. The stored electrical energy can be used for lighting and sensing, monitoring equipment. It not only eliminates the noise impact on people's normal life and the environment, but also produces clean energy and achieves the purpose of energy saving.

## 4. Software Design of the Noise Power Generation Device

Noise power generation device software includes five parts: DSP initialization, noise signal reception, acoustoelectric converter, data processing, human-computer interaction. The software flow of the noise power generation device is shown in Figure 3.

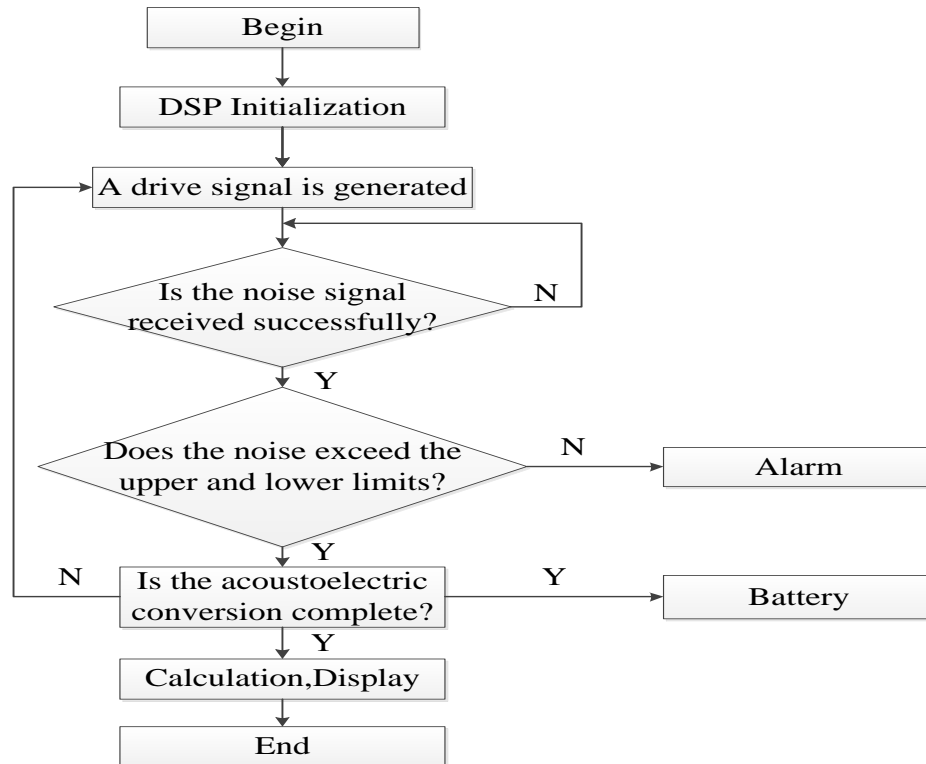


Figure 3. Software flow chart

In figure 3, DSP initialization is the main initialization process automatically called by the power system. DSP program consists of initialization module, data acquisition and AD conversion module, communication module, logic control and alarm module etc. Data acquisition uses timer interrupt, timer T generates the timer interrupt, then starts the AD conversion after interrupt generation, reads vibration and noise data, the data is sent to display and save by the PC, data is expressed in fixed-point numbers. And it is the purpose for DSP to speed up the processing speed.

The data collected in real time is compared with the alarm value set by the system, when the vibration amplitude and noise intensity exceeds the set alarm value, PC monitoring interface alarm area alarms, then the logic control circuit action cuts off the circuit, and it is the purpose of protecting the noise power generation device. When the noise pressure is in the normal range, the noise signal receiver sends the received signal to the acoustoelectric converter, then the acoustic signal is converted into current. After rectification, filtering, amplification and other treatment, one current is sent to the DSP, after the DSP receives the signal, then stops the timer T and completes the current measurement. Another current is sent to the battery storage. Continue to repeat the above process, after completing the three data measurements, calculate the average current, and finally the result is displayed by the LCD.

## 5. Conclusion

Chinese current highway is total length of more than 170 million kilometers, railway is total length of more than 80,000 km, and airports are more than 220. The noise energy generated in these places is huge, the current method of comprehensive noise control has been unable to meet the requirement of noise reduction. Aiming at the shortcomings of traditional noise control methods, a new noise power generation device is designed. It has the advantages of convenient operation safety, high sensitivity environmentally friendly, zero emissions, and can indirectly reduce thermal power factories CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub>, soot emissions, it has high environmental and social benefits.

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