Noise test system of auto alternator based on LabVIEW

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ABSTRACT

In the instant of start-up, idle or stop, sounds that with high frequency and particularly harsh, will be heard by the passengers inside the car. According to the mechanism of noise, it can be divided into three categories: electromagnetic noise, mechanical noise and aerodynamic noise. This paper creates a noise test system based on LabVIEW, for more in-depth analysis of the noise. Through the analysis of the test data, error of this system is less than 1%, in line with the general design requirements. In addition, it has a superior function than the traditional sound level meter. Specific functions are as follows: (a) cheaper; (b) display of noise waveform; (c) data preservation; (d) capture amplitudes beyond the rated point; (e) frequency spectrum analysis.

Keywords: Auto alternator, noise test system, frequency spectrum analysis, LabVIEW

1. INTRODUCTION

With the increasing requirements for car riding comfort, fuel economy, and environmental protection of emissions, the trend of automobile electronization continues to develop, and electricity consumption continues to increase. According to statistics, the current average power consumption demand of each vehicle has developed from below 500 W in the 1970s to more than 950 W today, with an average increase of 10% to 15% every 10 years[1].

Therefore, the generator is very important to the car, without the generator, the advanced nature and comfort of the car are out of the question. However, at the moment when the car starts, idles or stops, the occupants of the compartment can hear a very high frequency and particularly harsh shushing sound from the alternator. For drivers, if the noise in the car is relatively large, the mood will inevitably be affected by it, which will lead to decreased comfort, easy to produce tension and irritability, and may cause safety accidents. Therefore, it is very necessary to detect and evaluate the generator noise, which can provide data support for the next step to improve the generator's shortcomings.

At present, the commonly used generator noise measurement tool is the sound level meter[2], which can measure the generator noise level, but the whole measurement system is expensive. The development of virtual instrument technology makes it possible to conduct complex tests on generator noise and to process generator noise signals by modern signal processing methods without spending a lot of money to purchase special equipment[3,4]. In this paper, LabVIEW is used as the development platform and modern signal processing methods are combined to establish a generator noise test system, and the generator noise mechanism and generator noise source based on noise signal are studied[4].

Through the experiment, the main source of the noise of automobile generator is studied, so as to provide data support for the next improvement of the generator.

2. SYSTEM PRINCIPLE AND HARDWARE COMPOSITION

2.1 System principles

Figure 1 shows the operating principle of the system[5,6].

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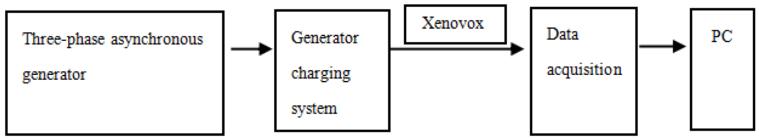

Figure 1. System principles.

2.2 Functions of each component unit

2.2.1 Data Acquisition card. The system NI 9234 data acquisition card, it is 4 channel C.

Series dynamic signal acquisition module, dynamic range 102 dB, 4 pieces.

The input channel is aided by built-in anti-aliasing filters that automatically adjust the sampling rate.

The signal is simultaneously matched at a rate of up to 51.2 kHz per channel.

Go digital.

2.2.2 Test bench. The experimental bench is the Honda Accord charging and discharging system bench.

2.2.3 Microphone. The MPA416 microphone has a frequency response range of 20-20 kHZ, sensitivity up to 502 dB and dynamic range between 29 and 127 dBA.

2.2.4 PC. Lenovo G550, the CPU is Intel Core 2 Duo T650, the main frequency is 2.1 GHz.

3. TEST SYSTEM SOFTWARE COMPOSITION

3.1 User interface

The graphical virtual software LabVIEW is used to design the user interface. After running the main program, the data collection (this is shown in Figure 2), processing (this is shown in Figure 3) and display (this is shown in Figure 4) can be realized.

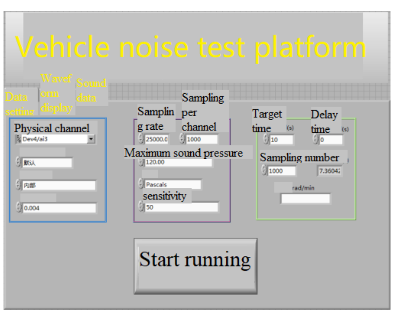

Figure 2. Settings.

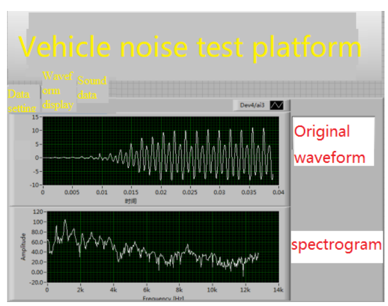

Figure 3. Oscilloscope.

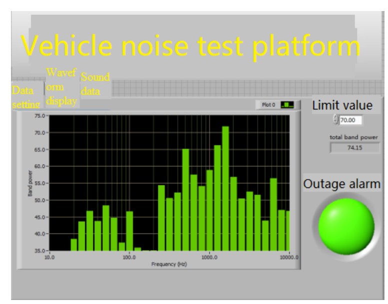

Figure 4. Noise level panel.

3.2 System program block diagram

The system program block diagram is shown in Figure 5.

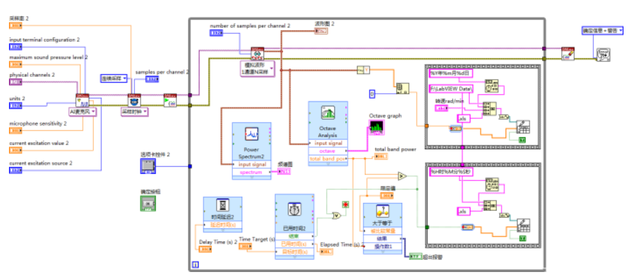

Figure 5. Application source code.

4. DATA ANALYSIS

4.1 Comparison between system sound level data and sound level meter

The reading rate of the system is changed to read once per second, and the sound level data of the system test generator noise is obtained. At each speed, complete 5 experiments, record and compare the noise level data of the alternator measured by the sound level meter every second, through the comparison, we can judge whether the system can be used as a test noise detection system.

Table 1. Data analysis in different RPM.

Rotational speed n/r·min^{-1}	**System tests average sound level/dB**	**Sound level meter average sound level/dB**	**Absolute error**	**Absolute value of the relative error%**
1000	62.931	62.892	0.039	0.392
2000	72.307	71.976	0.331	0.596
3000	73.681	73.612	0.069	0.666
4000	76.024	76.004	0.02	0.326

As can be seen from Table 1, at 1000 r/min, the average value of the absolute relative error between the sound level data measured by the system and that measured by the sound level meter is only 0.392%. Therefore, it is certain that at a speed of 1000 r/min, the system can accurately test the noise emitted by the alternator.

At 2000 r/min, the average value of the absolute relative error between the sound level data measured by the system and the data measured by the sound level meter is only 0.596%. Therefore, it is certain that at a speed of 2000 r/min, the system can also accurately test the noise emitted by the alternator.

At 3000 r/min, the average absolute value of the relative error between the sound level data measured by the system and the data measured by the sound level meter is only 0.666%. Therefore, it can be judged that at a speed of 2000 r/min, the system can also accurately test the noise emitted by the alternator.

At 4000 r/min, the average value of the absolute relative error between the sound level data measured by the system and the data measured by the sound level meter is only 0.326%. Therefore, it is certain that at a speed of 4000 r/min, the system can also accurately test the noise emitted by the alternator.

From the data comparison of the above four different speeds, it can be seen that the average value of the absolute relative error under the four different speeds is only between 0.326% and 0.666%, which is far less than 5%. Therefore, it can be confirmed that the noise test system designed in this subject can be used as a detection instrument for testing noise.

From the data of the chart, the accuracy of the system is higher than that of the sound level meter. In addition, since the data reading speed of the system can be adjusted according to personal or experimental needs, reading more than 100 or 1000 data per second can be, but the sound level meter is only limited to reading one data per second, so it can be seen that the system can better reflect the change of noise in a period of time. This is where virtual instruments have an advantage over traditional instruments.

4.2 Spectrum analysis

Spectrum analysis is to expand the signal intensity issued by the signal source according to the frequency order, make it a function of frequency, and investigate the change law. The study of the noise spectrum is to deeply understand the characteristics of noise sources, help find the main noise pollution sources, and provide a basis for noise control[7,8].

Below is the noise spectrum diagram at each speed.

According to the data read from the noise spectrum charts in Figures 6-9, it can be concluded that the noise density of the alternator at 1000 r/min is significantly lower than that at 2000-4000 r/min. In addition, it can be seen that the noise density gradually increases from 1000 r/min to 4000 r/min.

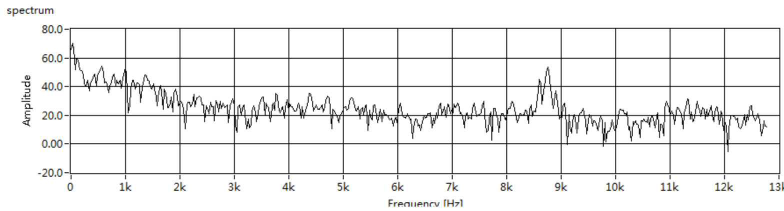

Figure 6. Noise pattern in 1000 r/min.

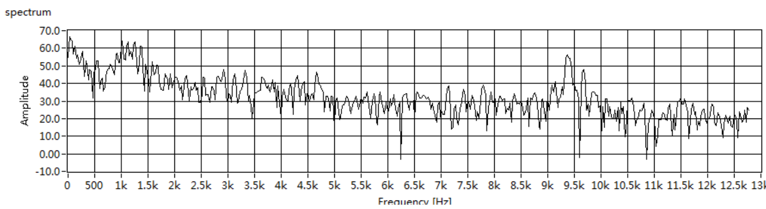

Figure 7. Noise pattern in 2000 r/min.

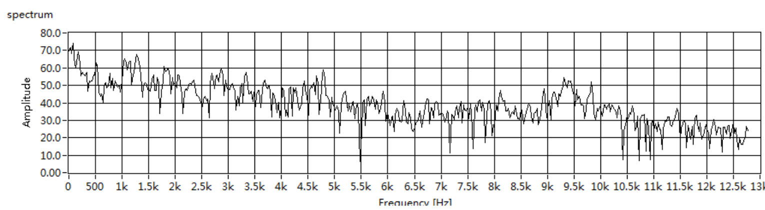

Figure 8. Noise pattern in 3000 r/min.

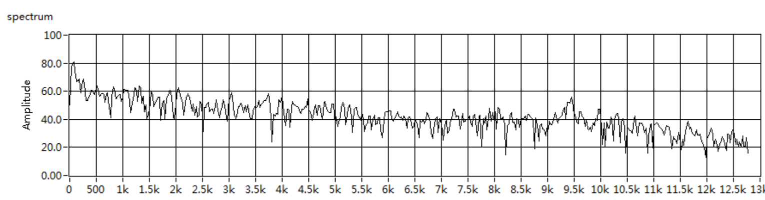

Figure 9. Noise pattern in 4000 r/min.

From another point of view, in the noise change from 1000 r/min to 4000 r/min, the amplitude of each frequency has a trend of slowly approaching. At 1000 r/min, there is a significant difference between the frequency amplitudes, and at 4000 r/min, this difference becomes significantly smaller. From this point of view, in the process of increasing the noise of the alternator with the increasing speed, the noise amplitude of different frequencies emitted by the generator will slowly become similar.

Next, the main source of noise emitted by the alternator when it changes between 1000 r/min and 4000 r/min is analyzed.

According to the formula[9]:

$$f=pn/60$$

The pole number p=2 of the alternator is known, and the results are shown in Table 2.

From the waveform data of Figures 6-9, it can be seen that the frequency amplitude between 0 and 200 Hz is within the maximum range of the entire spectrum diagram. Therefore, it can be known that the main noise of the alternator between 1000 r/min and 4000 r/min is related to the power supply frequency of the generator.

According to the formula[9]:

$$f=kn/60$$

The brush noise at different speeds can be calculated, where k is the number of commutating pieces and k=2. The results are shown in Table 2.

For this alternator, because the number of commutators of the brush and the number of magnetic poles of the generator are the same in number, the frequency of the brush noise is the same as the frequency of the power supply of the alternator. It can be seen that in this generator, brush noise is also the main noise source.

According to the formula[10]:

$$f = n/60$$

The rotor unbalance noise at different speeds can be calculated.

The results are shown in Table 2.

Table 2. Different noises' frequency in different RPM.

Rotational speed $n/r \cdot min^{-1}$	**Power supply frequency/Hz**	**Brush noise frequency/Hz**	**Rotor unbalance noise frequency/Hz**
1000	33.33	33.33	16.67
2000	66.67	66.67	33.33
3000	100.00	100.00	50.00
4000	133.33	133.33	66.67

From the waveform data of Figures 6-8, it can be seen that the frequency amplitude between 0 and 100 Hz is also within the maximum range of the entire spectrum diagram. Therefore, it can be known that the main noise of the alternator between 1000 r/min and 4000 r/min is also related to the rotor unbalance noise of the generator.

From Table 2, comparing the frequency of power supply frequency, brush noise and rotor unbalance noise, it can be seen that rotor unbalance noise still accounts for a relatively important part of the noise of the alternator. As can be seen from the overall data, the main noise source of the alternator comes from low-frequency noise, which is mainly mechanical noise, that is, the main noise source of the alternator is mechanical noise.

5. CONCLUSION

This paper summarizes and classifies the noise types of automobile alternator, which provides a theoretical basis for noise analysis. Then the software and hardware involved in this system are described, and the reasons for choosing these software and hardware. Through the program design, debugging, experiment, and finally the analysis of experimental data, the following conclusions are drawn: The absolute error between the system and the data tested by the sound level meter is only 0.326%-0.666%. Through the spectrum analysis of noise, it can be known that the main noise source of the alternator comes from low frequency (0-200 Hz) noise, which is mainly mechanical noise, that is to say, the main noise source of the alternator is mechanical noise. However, this design has not been able to analyze the noise of automobile alternator more deeply, and can only test the generator noise. When the spectrum analysis of noise is performed, the system cannot automatically analyze the main noise types, which is inconvenient to quickly determine the noise source. In addition, the system does not have a program to connect with the generator under test. If a generator control program can be added to the program, it will bring more convenience to the operation of the experiment.

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