

# The Data Analysis of the Subway Noise Signal Based on MATLAB

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**Abstract.** As subway noise affected psychological, physiological and normal life of passengers and people along the track seriously, it becomes an important indicator of urban construction. In this paper, subway noise is analyzed by MATLAB for its efficient data analysis capabilities. The measured data is taken time domain and frequency domain analysis by Fourier function, and the noise intensity and frequency components can be calculated. The results can provide the recommendations and data base for future subway construction.

## 1 Introduction

With the development of urban rail transit, subway travel brought great convenience. However the subway noise generated by subway running can also bring great troubles to people. As early as 1979, Robert LOTZ and others published the paper about subway tunnel and station noise in the United States, and the mechanism of subway noise, sound level and noise control were analyzed briefly. In 2006, RobynR.M. and others made a preliminary study on the platform and the carriage of the New York subway [1, 2, 3]. Relatively speaking, the research on the subway noise was late in China [4, 5, 6]. Labor Health Research Institute of Ministry of Railway and the Beijing Underground Railway Technology Research Science took the subway platform in Beijing and Tianjin as the object of the research and made the measurements on the noise of the platform. Tan Shuying did a survey on platform noise and carriage interior of Guangzhou subway. The survey results show that metro's high-speed is the main source of environmental noise, and the subway platform noise is related to the radio frequency, radio volume, traffic and other factors.

Shenyang subway is the first metro plan in the northeast China. Currently, the research of Shenyang subway noise pollution has not been reported. For analyzing the impact of the early stages of Shenyang subway on passengers and people along the rail, time-domain and frequency domain analysis method are applied in this design to calculate the noise frequency and intensity. On this basis, the reasonable and effective proposal can be proposed.

## 2 Subway noise

### 2.1 Noise generated in the process of subway

Subway noise is generated by all kinds of noise, and affected by train running status and track device status. Among the many factors that produce noise, the proportion is different. The noise test data analysis of Japanese subway shows that: in the case of not taking any measures, the wheel-rail noise accounted for 78%, the collector system noise accounted for 16%, mechanical movement noise accounted for 4%, and the airborne noise accounted for 2%. As urban rail transit operation is intermittent, the run interval of subway or light rail trains is usually 2-6 minutes, driving in the morning 5:00 to night 11:00, and the noise level is proportional to the speed of the train. Studies have shown that when the train speed is less than 250kmPh, railway noise is mainly to wheel-rail noise, and when the train speed is greater than 250 kmPh, railway noise is dominated by aerodynamic noise [7, 8].

### 2.2 Subway noise factors

The noise level of urban rail transit is related to system characteristics, and the location of the track is the determining factor affecting noise levels. The roadside noise level generated by the elevated railroad tracks is higher than the noise level of ground track. In addition, the speed of the train, the use of track types, the abrasions of wheel tread, the rough condition of track surface and

other factors are all affecting the strength of the noise level. At the same time, soil and rock type, density, shear coefficient and loss factor, propagation distance, terrain condition, tunnel structure size and cross-sectional shape, thickness of the tunnel structure, tunnel depth, building type and structure, natural frequency of the floor, room size, etc. also have an impact on rail traffic noise.

### 3 Subway noise analysis method

#### 3.1 Time-domain analysis of noise

Time-domain analysis method is the most common method used to analyze sound signal. Sound signal itself is time-domain signal, which directly use time domain waveforms of sound signal. Time-domain analysis is usually used for the basic parameters analysis, sound segmentation, preprocessing and large classification. The characteristic of time-domain analysis method are as follows: First, the sound signal is relatively intuitive and the physical meaning is clear. Second, it is simple to implement and the operational is less. Third, you can get some important parameters of sound. Fourth, it is simple by using general equipment such as oscilloscope [9, 10].

#### 3.2 Frequency-domain analysis of noise

In frequency-domain analysis section, the Fast Fourier Transform function (FFT) is used to convert the signal from the time domain to the frequency domain. After that, apply the appropriate function to achieve the multi-angle frequency-domain analysis in MATLAB according to the amplitude, phase, power and power spectral density of signal, and the analysis results are displayed in form of multiple spectrum. Then the user can visually analyze the signal characteristics through the spectrum graph. The essence of the Fourier transform is that,  $f(x)$  is decomposed into a superposition of a number of frequencies of sine waves, so that the signal can be converted from the time domain to the frequency domain [11, 12].

### 4 Analysis of shenyang subway noise based on MATLAB

In China, the sound frequency range of low-frequency noise is defined as 20-200Hz. The more obvious influence on the human body is mainly distributed in 3-50Hz. Medical experts found that low-frequency noise on the human body may not only cause functional impairment, but also cause device quality damage and mental damage. In addition, four types of noise standards stipulate subway station noise standard is 70dB. On the basis of this, the noise of subway station and carriage is analyzed so as to find the main source of noise.

#### 4.1 Analysis of station noise signal with or without broadcast

The station without train is analyzed, and it is divided into two cases such as the station with broadcast and without broadcast. Take FFT to transform the noise signals. The spectrum figure and decibel figure of station noise without broadcast are shown in fig. 1 and fig. 2 respectively.

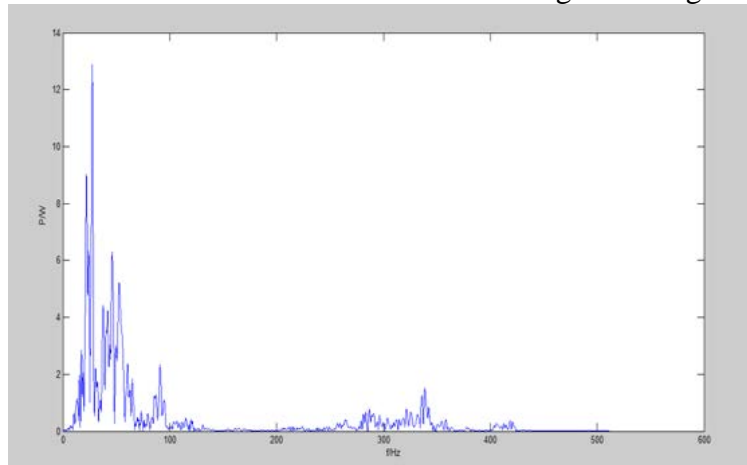


Figure 1: Noise spectrum of noise without broadcast

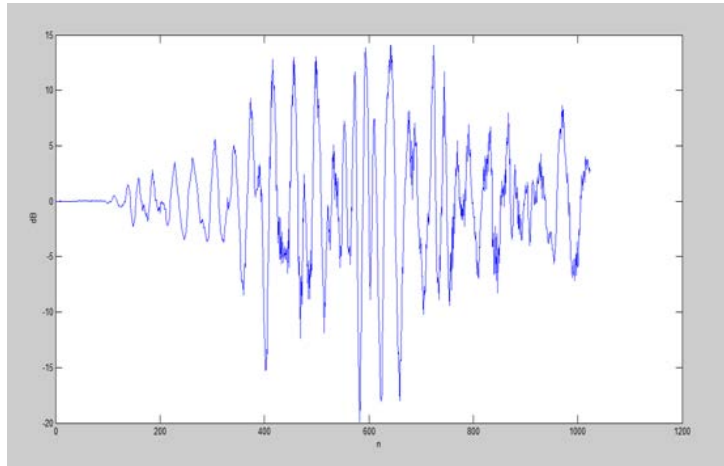


Figure 2: Noise decibel of noise without broadcast

From fig. 1 we can see that, the signal frequency is mainly in the range of 0-100Hz, and the most widespread is 27.5Hz. Fig. 2 shows that the noise is mainly around 15dB, and the maximum value is 14.035dB. The spectrum figure and decibel figure of station noise with broadcast are shown in fig. 3 and fig. 4 respectively.

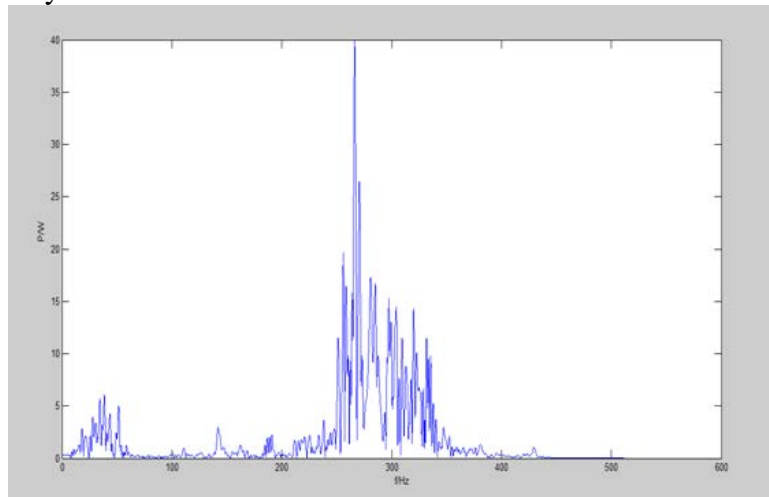


Figure 3: Noise spectrum of noise with broadcast

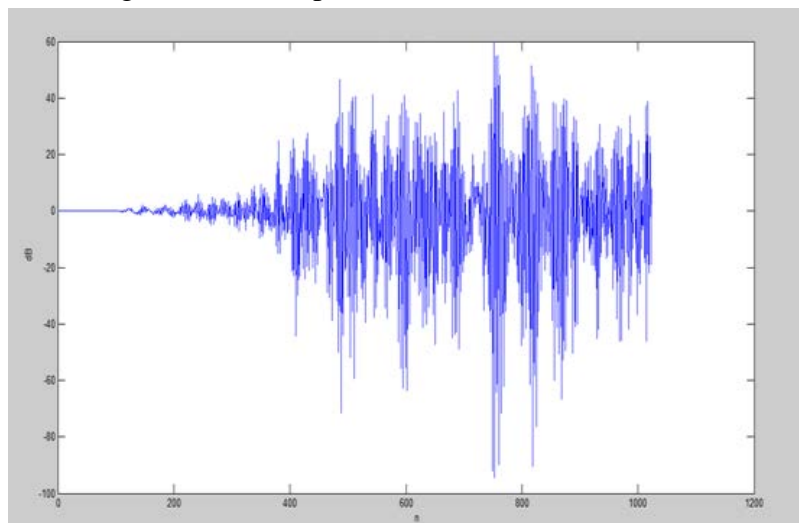


Figure 4: Noise decibel of noise with broadcast

Seen from fig. 3, the signal frequency is mainly in the range of 250-300 Hz, and the most widespread is 266Hz. Fig. 4 shows that the noise is mainly around 40 dB, and the maximum value is 59 dB. The maximum values and the standard deviation values are shown in Table 1. Can be analyzed, sound broadcasting is one of the sources of noise, and radio frequency and volume impact

on human health is greater. It is a slight discomfort noise value. Moreover, the number and the time of broadcast have become more numerous. How to reconcile the contradictions of two areas will also need the efforts of to manage personnel and vehicle maintenance staff.

The most widespread frequency value of noise with broadcast	27.5000Hz	The most widespread frequency value of noise without broadcast	266.4000H z
The maximum decibel value of noise with broadcast	14.0350dB	The maximum decibel value of noise without broadcast	59.8700dB
The deviation value compared with standard value (70dB)	-55.9650dB	The deviation value compared with standard value (70dB)	-10.1300d B

Table 1: The maximum and standard deviation values

#### 4.2 Analysis of station noise signal with or without train

The station is continued to be analyzed, and it is divided into two cases such as the station with train and without train. The most widespread frequency values and the standard deviation values are shown in Table 2. From the study, we can see that, the signal frequency is mainly in the range of 0-100Hz and 300-400Hz. Sound intensity is generally more than 50 dB, and the maximum value is 90.3 dB. The subway station noise standard is 70 dB, and the noise generated by a train has exceeded the national standard. Compare with no train, it can be inferred that the main source of noise is the wheel-rail system noise, traction power system noise, brake system noise, aerodynamic noise and track structure noise.

The most widespread frequency value of noise with train	27.5000H z	The most widespread frequency value of noise without train	333.8000Hz
The maximum decibel value of noise with train	14.0350d B	The maximum decibel value of noise without train	90.3070dB
The deviation value compared with standard value (70dB)	-55.9650d B	The deviation value compared with standard value (70dB)	20.3070dB

Table 2: The maximum and standard deviation values

#### 4.3 Analysis of carriage noise signal when train stillness or running

The carriage is analyzed, and it is divided into two cases such as the train stillness and running. The most widespread frequency values and the standard deviation values are shown in Table 3. When the train is still, the most widespread frequency is 13.6Hz, and the maximum sound intensity is 2.18 dB. When the train is running, the signal frequency is mainly in the range of 100-200Hz and 300-500Hz, and the sound intensity is in the range of 2-8 dB. From the above, the noise level of running noise is slightly higher than the noise level of stationary. The main reason is that the running noise is generated by wheel-rail noise, machine noise, aerodynamic noise and arc noise.

## 5 Conclusion

Subway noise had a significant impact on passengers and residents along the railroad. The noise sources are mainly stations broadcast, the wheel-rail noise, the noise generated by the mechanical movement, air conditioning noise and exhaust systems. In order to study the influence degree of these noise, time-domain and frequency-domain analysis are used for the subway station and subway carriage noise analysis in this paper. The processing function for powerful sound based on MATLAB can be inferred that subway noise sources are mainly broadcast noise or wheel-rail noise. This can provide the basis for subway noise prevention and control in the future, and will have huge social and economic benefits.

The most widespread frequency value of noise when stillness	13.6000Hz	The most widespread frequency value of noise when running	382.8000H z
The maximum decibel value of noise when stillness	2.1804dB	The maximum decibel value of noise when running	6.5218dB
The deviation value compared with standard value (70dB)	-67.8196d B	The deviation value compared with standard value (70dB)	-63.4782d B

Table 3: The maximum and standard deviation values

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