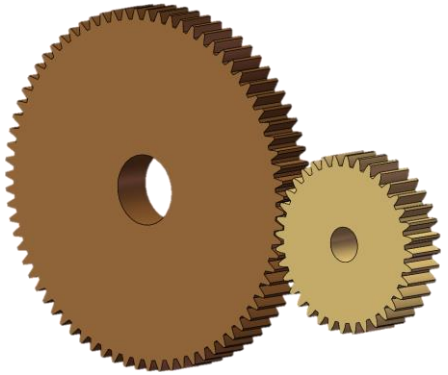
*Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*

Cite this as: Shuiguang TONG, Zilong FU, Zheming TONG, Junjie LI, Feiyun CONG, 2023. Fault diagnosis for gearboxes based on Fourier decomposition method and resonance demodulation. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 24(5):404-418.
https://doi.org/10.1631/jzus.A2200555

# Fault diagnosis for gearboxes based on Fourier decomposition method and resonance demodulation

**Key words:**
Fourier decomposition method
singular value ratio
resonance frequency
envelope demodulation
fault diagnosis



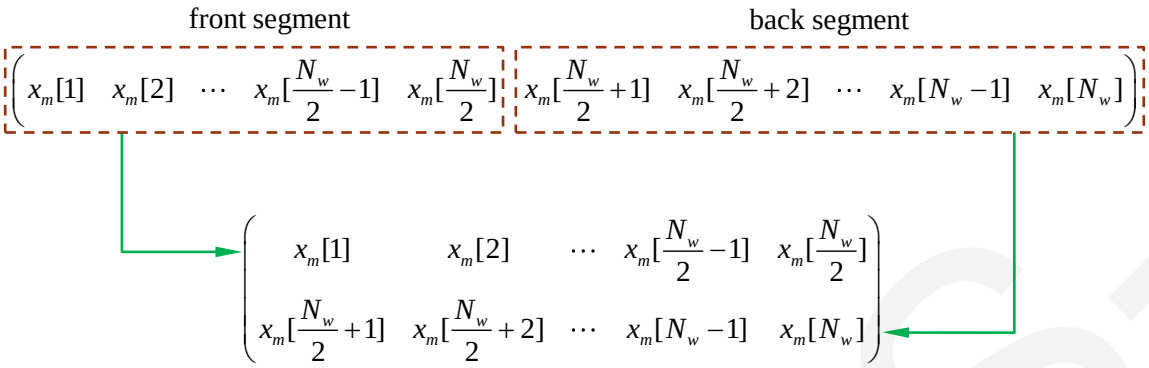
# The challenges in fault diagnosis

The vibration signal of gearboxes is characterized by complex spectral structure and strong time variability, which bring challenges to fault feature extraction.

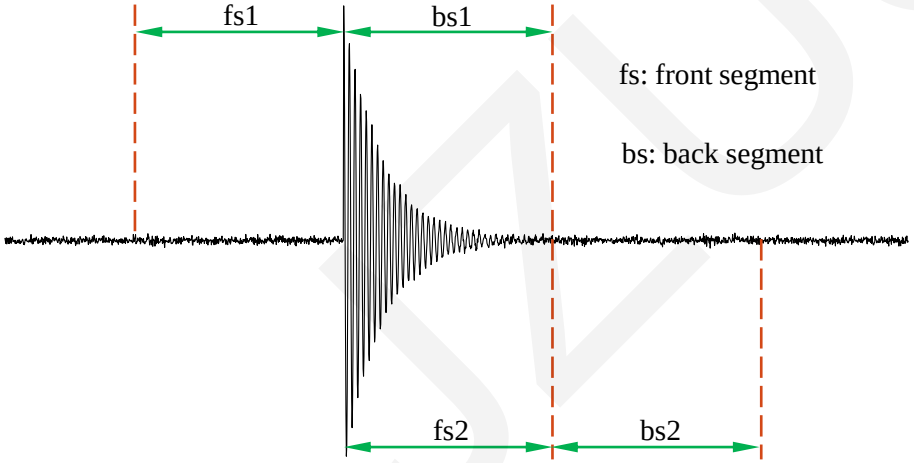
- The vibration signal is complicated. How to decompose the vibration signal into mono-components for further analysis is important.
- The resonance frequency can serve as a criterion for the selection of the optimal mono-component. But determining the resonance frequency effectively and accurately is a problem.

- ✓ The Fourier decomposition method (FDM) can decompose the vibration signal into mono-components adaptively in the frequency domain.
- ✓ The short-time singular value decomposition is sensitive to transient pulses. The maximum singular value ratio （MSVR） method based on short-time vectors is proposed to calculate the resonance frequency.

# The extraction of resonance decay signals




(*a*) The construction of double-row matrix



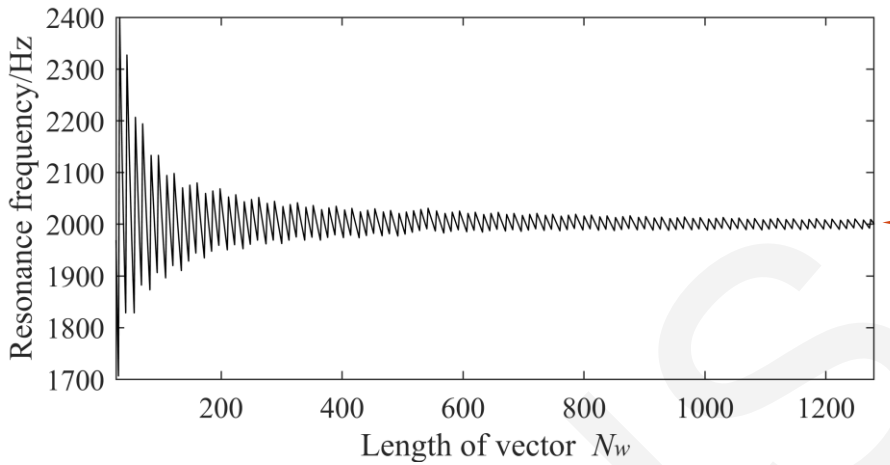

(*b*) Two ideal vectors with proper length

Calculate the singular value ratio (SVR) based on the double-row matrix and pick out the vector with the maximum SVR.

The optimal vector contains two parts: a resonance decay signal and a noise signal.

Fig.1 Calculate the maximum singular value ratio with different length of vectors.

# The calculation of the resonance frequency




The resonance frequency curve converges to the true value.

Fig.2 Resonance frequency curve

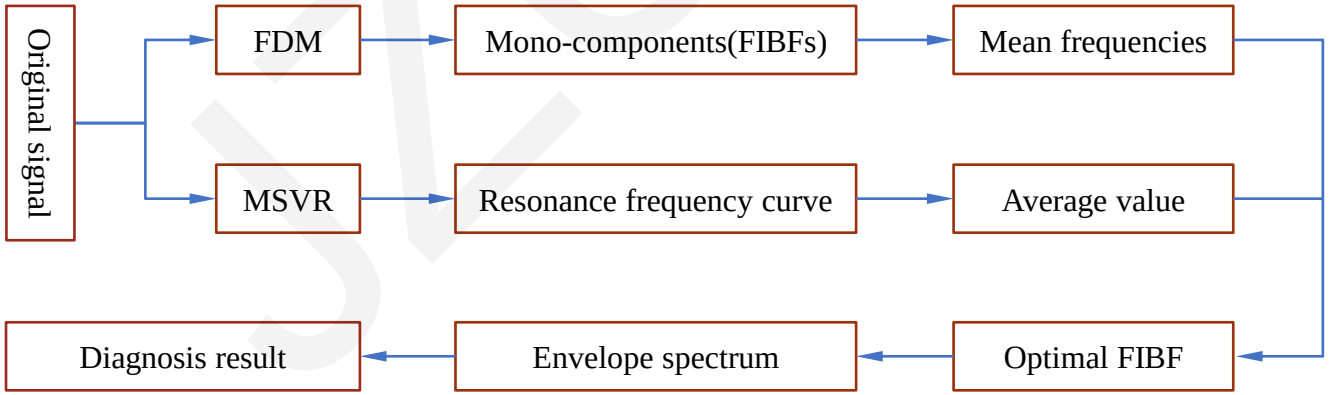
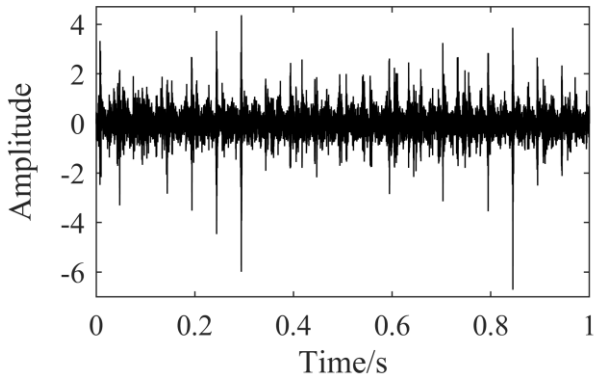
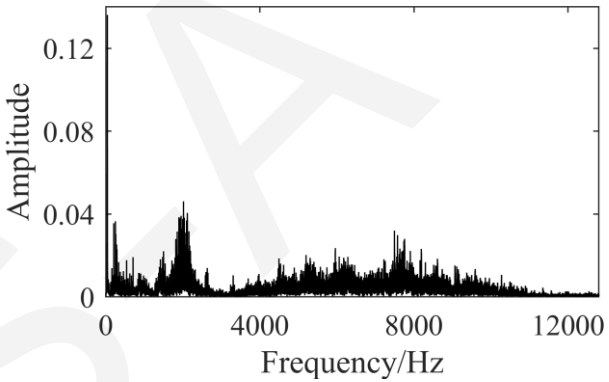



Fig.3 Demodulation method based on FDM-MSVR

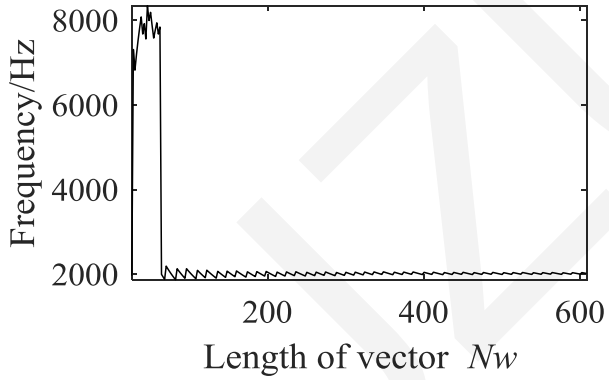
# Experimental signal analysis



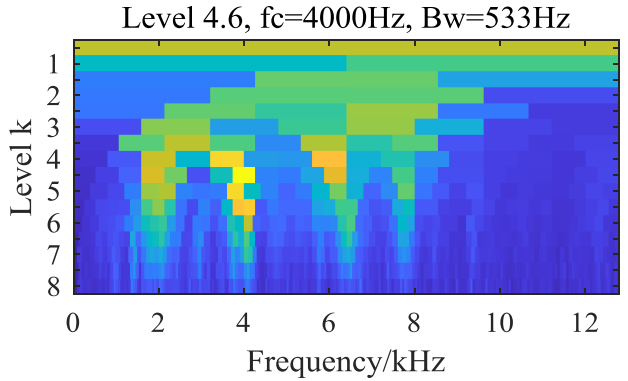

(*a*) Time domain signal




(*b*) Amplitude spectrum



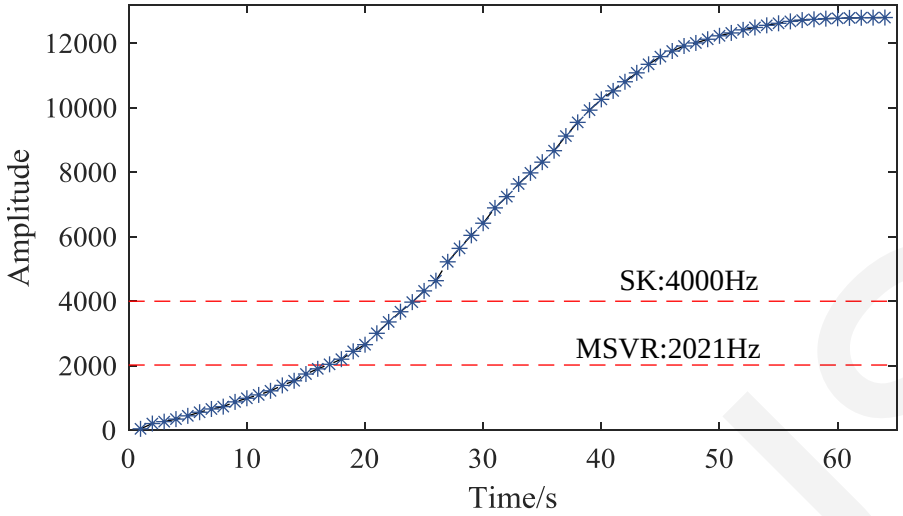

(*c*) Resonance frequency curve




(*d*) Kurtogram

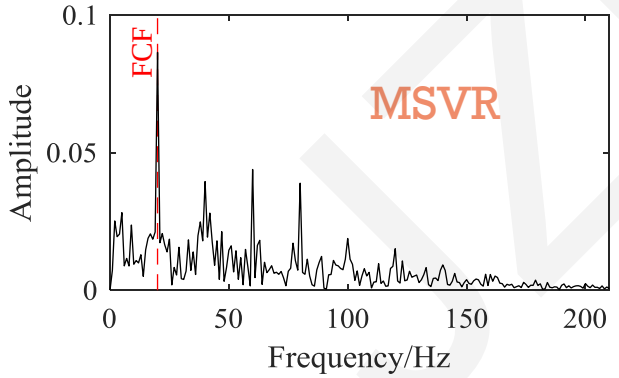
Fig.4 Estimate of resonance frequency using MSVR and spectral kurtosis

# Experimental signal analysis

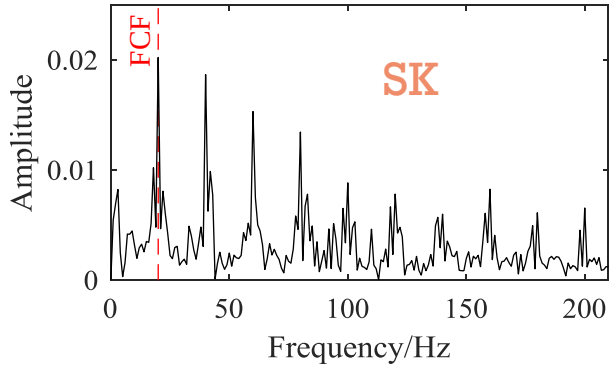



(*a*) Mean frequencies of mono-components

For comparison, spectral kurtosis (SK) is also utilized to estimate the resonance frequency and pick out the optimal component. Then, envelope demodulation is conducted to identify the fault characteristic frequency.




(*b*) Optimal component by MSVR




(*c*) Optimal component by SK

Fig.5 Fault diagnosis by the optimal components selected by MSVR and SK