Online unbalanced vibration suppression of a flexible rotor supported by active magnetic bearing

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OUTLINE

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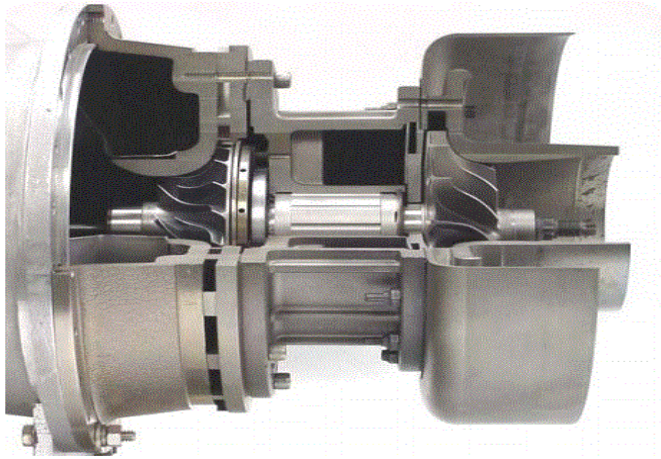
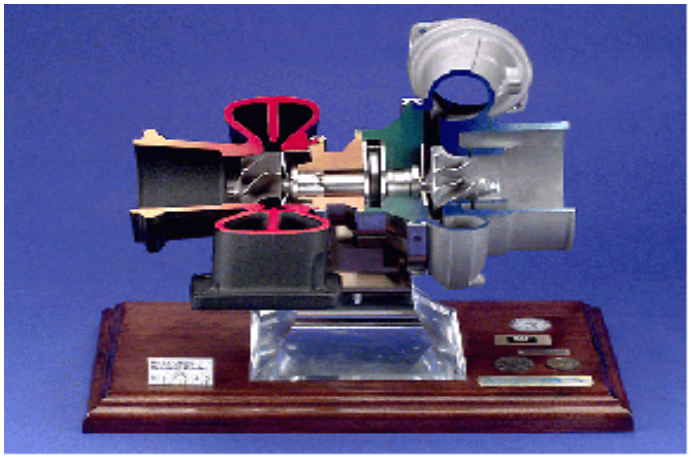
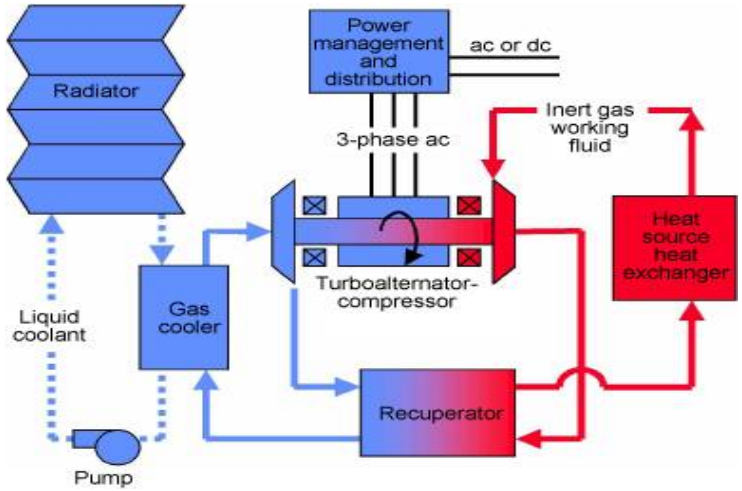
Introduction



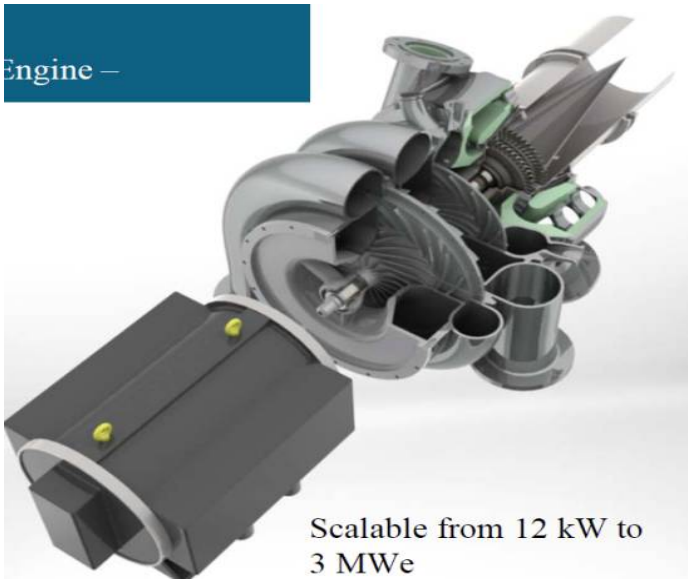
Capstone 30kW Gas Turbine



NASA Oil free turbocharger for vehicle



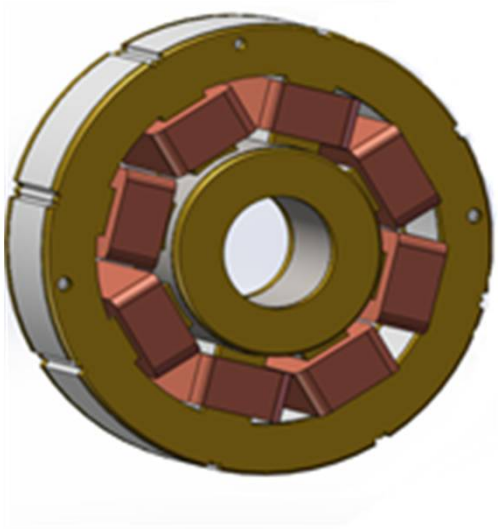
Closed Brayton Power System Prototype Developed for Future Space Nuclear Power Applications @ NASA

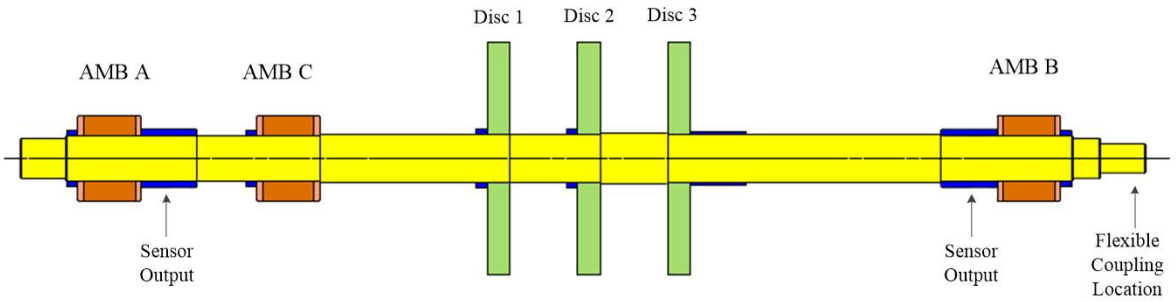


Causes of rotor unbalance

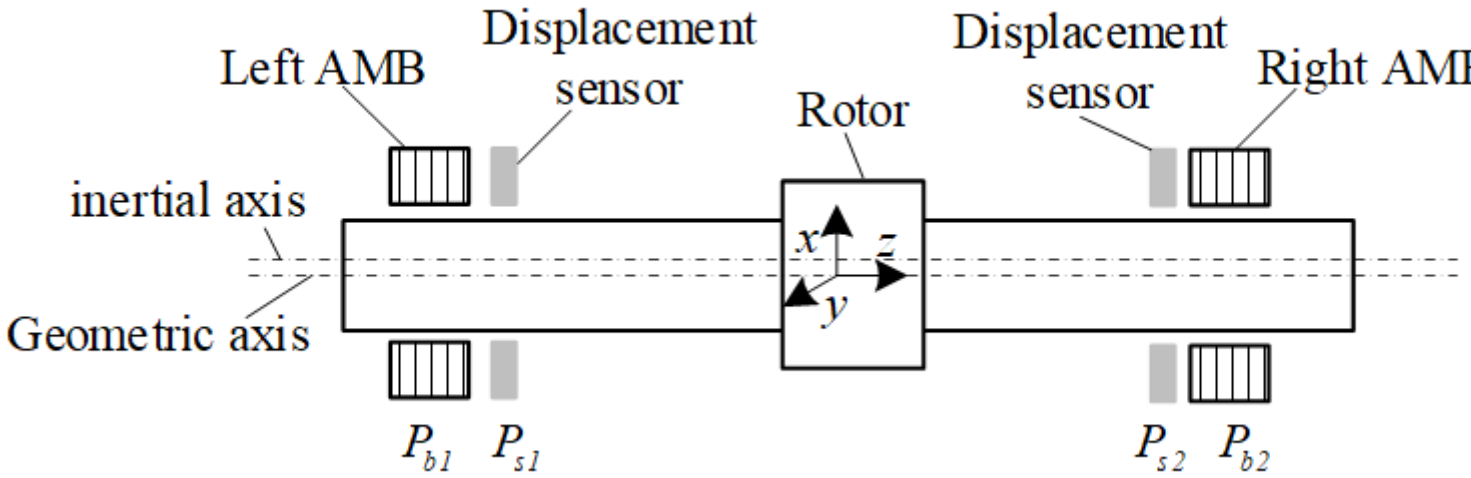
Introduction

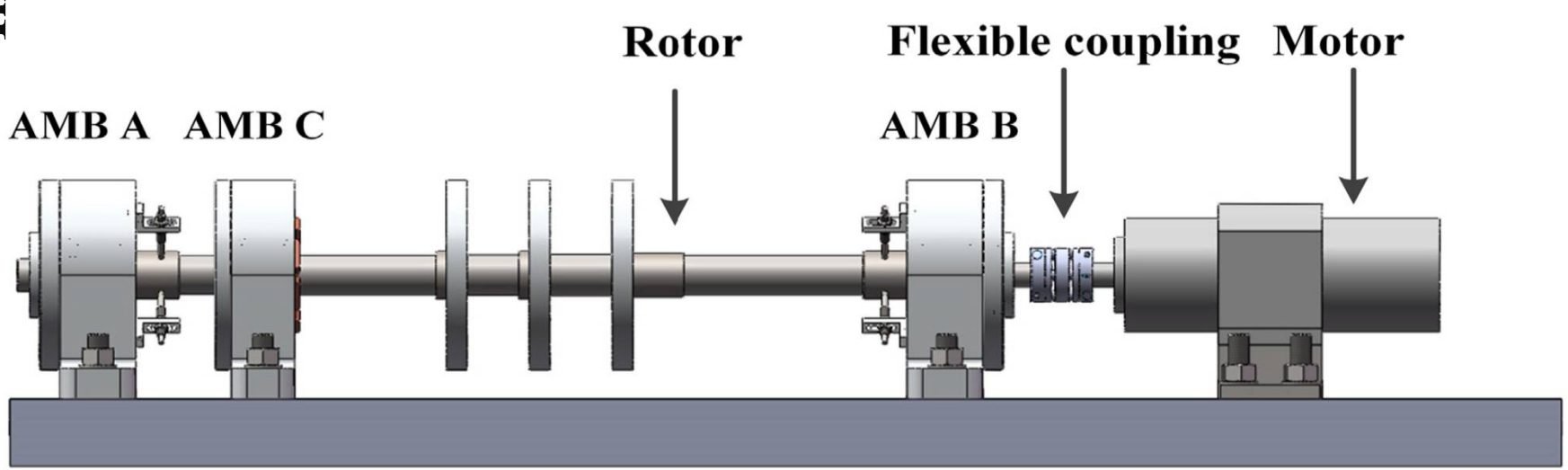
- uneven materials
- processing accuracy
- assembly errors
- other reasons



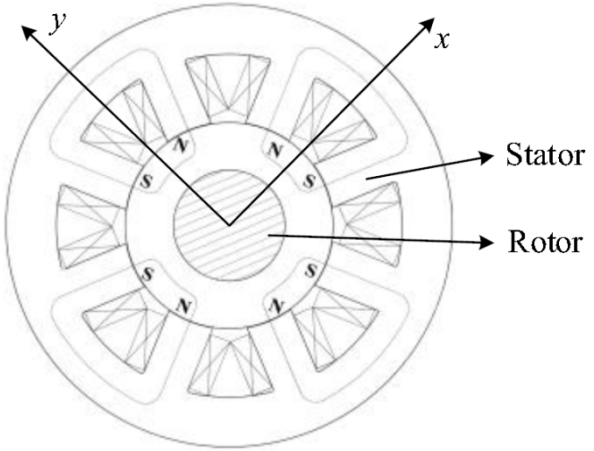


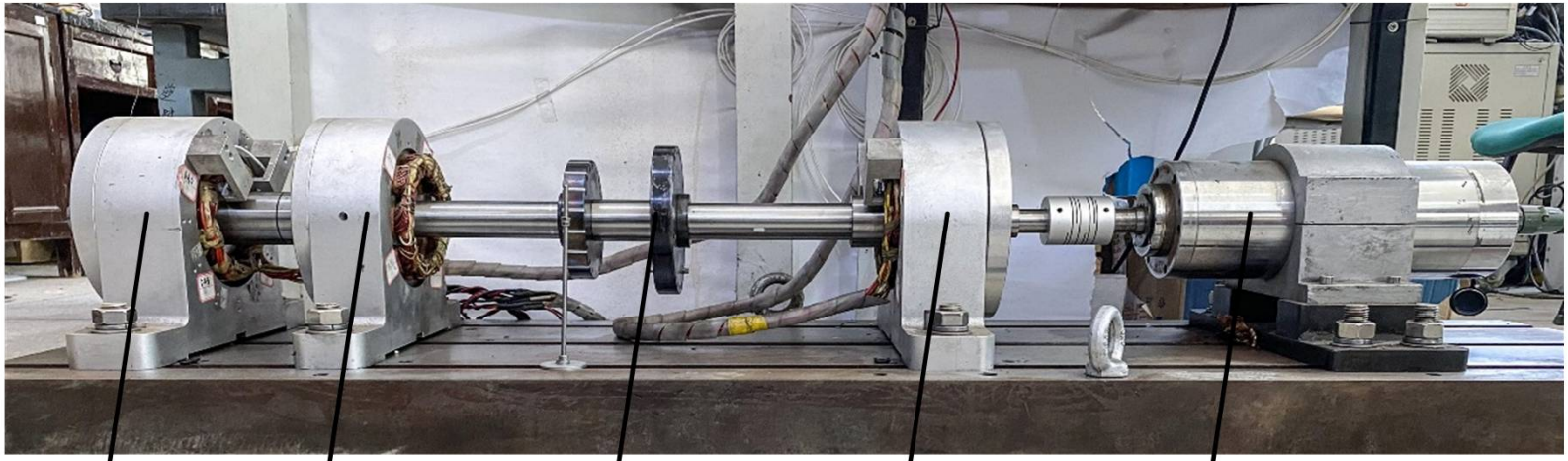
Introduction





Experimental setup

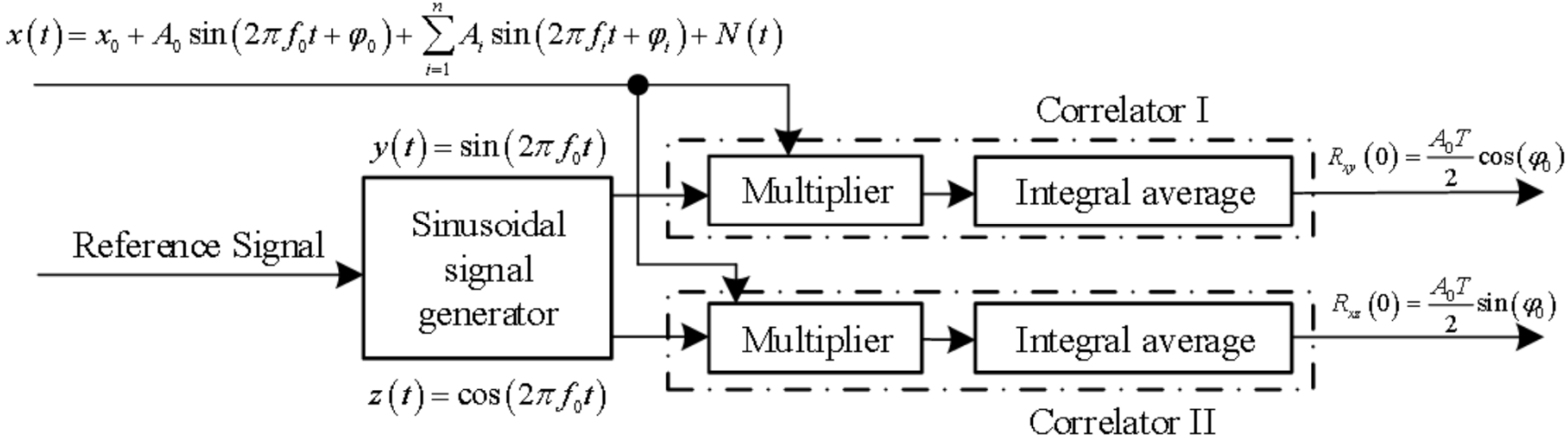




Principle of the cross-correlation method

Theory and solution approach

$$x(t) = x_0 + A_0 \sin(2\pi f_0 t + \varphi_0) + \sum_{i=1}^{n} A_i \sin(2\pi f_i t + \varphi_i) + N(t)$$

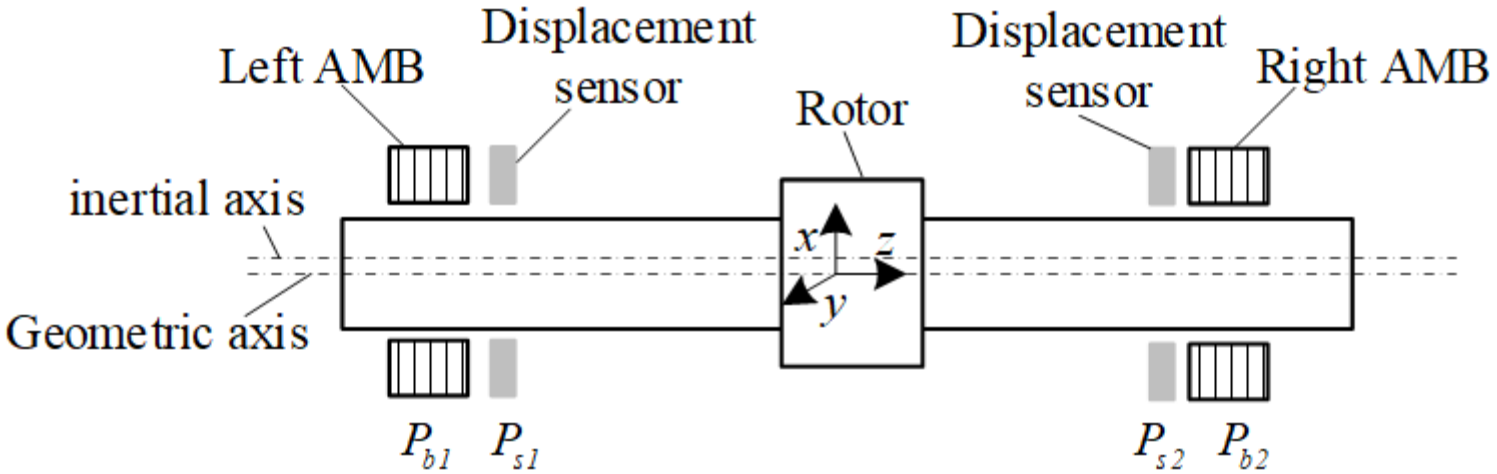


$$\begin{cases} A_0 = \dfrac{2\sqrt{R_{xy}^2(0) + R_{xz}^2(0)}}{T} \\ \varphi_0 = \arctan\dfrac{R_{xz}(0)}{R_{xy}(0)} \end{cases}$$

When $R_{xy}(0)<0$, $\varphi = \pi + \varphi_0$; when $R_{xy}(0)>0$ and $R_{xz}(0)<0$, $\varphi = \pi + \varphi_0$.

Principle of the influence coefficient method

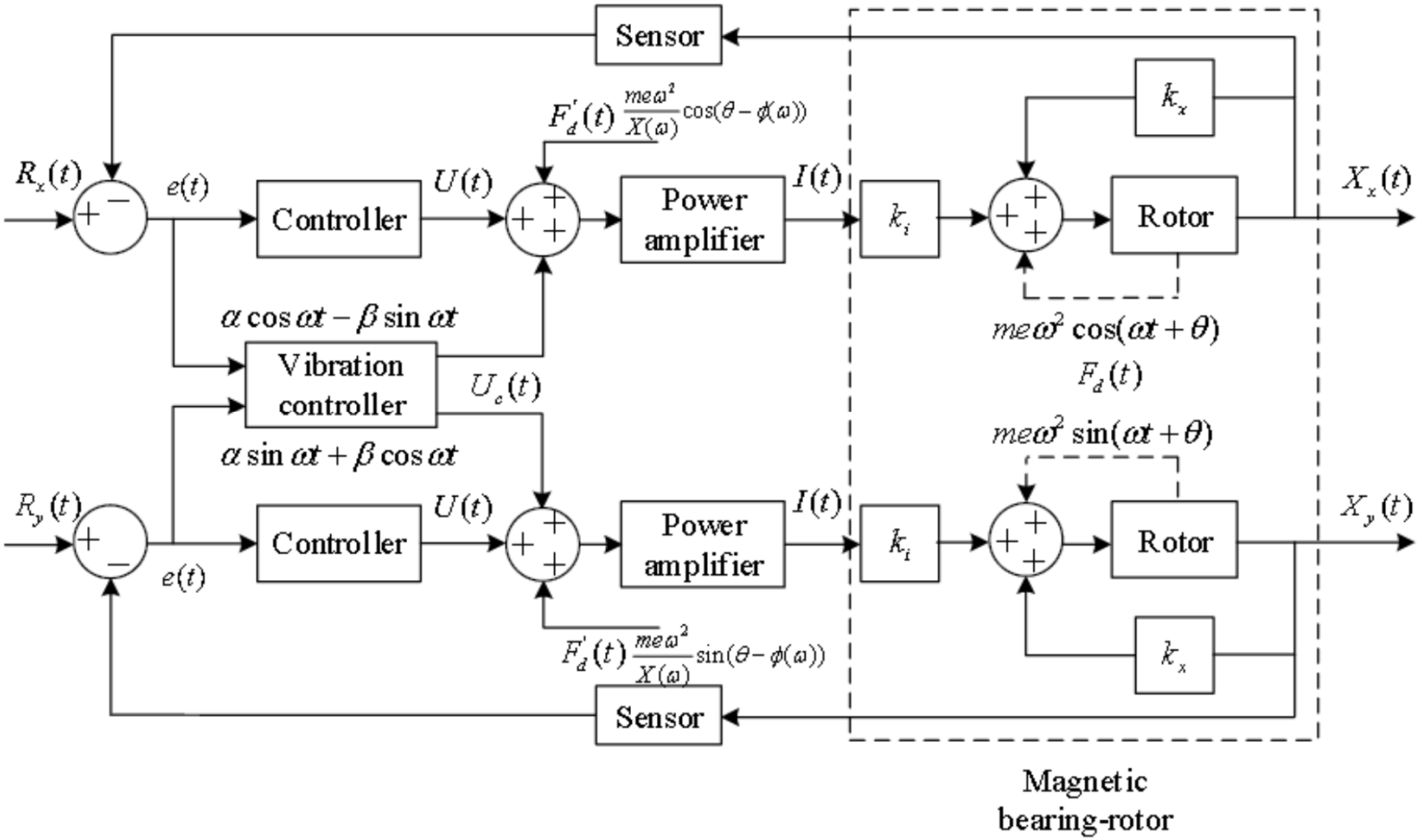
Theory and solution approach



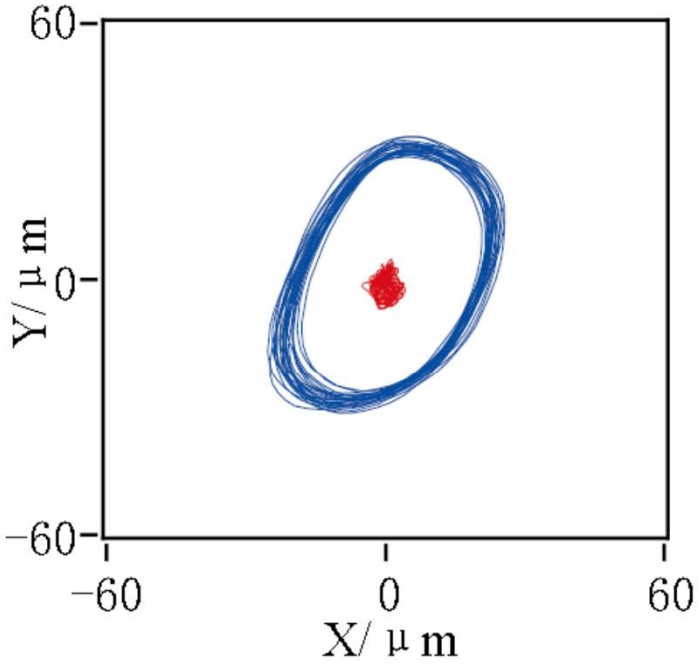
$$\vec{U}_1 = U_1 e^{j(\omega_0 t+\varphi_1)} = \frac{\begin{vmatrix} -\vec{P}_{s10} & \vec{a}_2 \\ -\vec{P}_{s20} & \vec{b}_2 \end{vmatrix}}{\begin{vmatrix} \vec{a}_1 & \vec{a}_2 \\ \vec{b}_1 & \vec{b}_2 \end{vmatrix}} \qquad \vec{U}_2 = U_2 e^{j(\omega_0 t+\varphi_2)} = \frac{\begin{vmatrix} \vec{a}_1 & -\vec{P}_{s10} \\ \vec{b}_1 & -\vec{P}_{s20} \end{vmatrix}}{\begin{vmatrix} \vec{a}_1 & \vec{a}_2 \\ \vec{b}_1 & \vec{b}_2 \end{vmatrix}}$$

Principle of online unbalanced vibration suppression

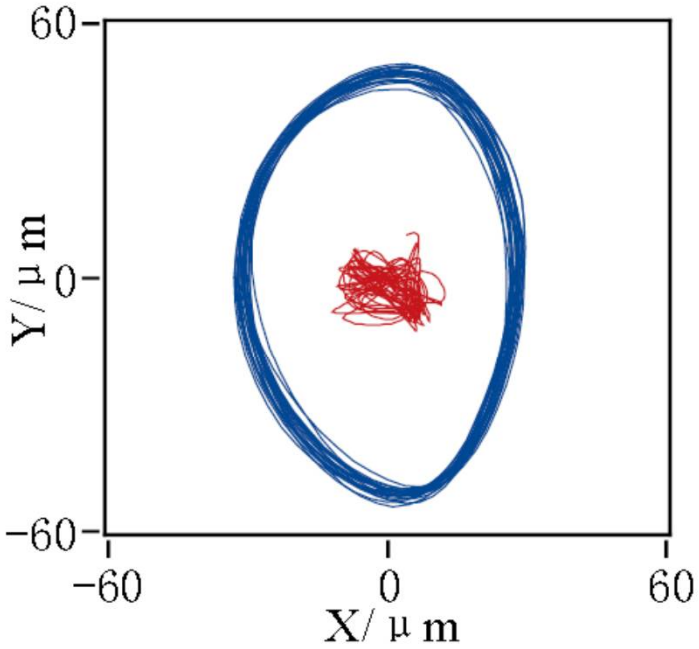
Theory and solution approach



Results and discussions



(a) Left active magnetic bearing



(b) Right active magnetic bearing

Conclusions

- Uses electromagnetic force to try to apply control voltage, instead of the traditional shutdown test and phase sensor measure.
- Use the influence coefficient method to detect the unbalanced quality information of the rotor with the mass unbalance, and obtain the magnitude of the compensation voltage.
- The cross-correlation method and feedback tracking control method in steady state is used to extract the fundamental frequency vibration signal of the rotor to obtain the phase information of the unbalanced vibration.

THANK YOU