# Energy transfer and dissipation in frictional systems with multiple contact interfaces

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**Abstract**. The vibration energy transmission and dissipation characteristics of a system with multiple frictional contacts modelled by Coulomb friction are investigated. The internal vibration transmission between masses and energy dissipation is studied quantitatively using the power flow analysis approach. The harmonic balance (HB) method with alternating frequency time (AFT) scheme and direct numerical integrations are used to obtain the dynamic responses and power flow variables. Results show that the level of vibrational dissipation within frictional system depends substantially on the interfacial contact properties and thus is tailorable by changing friction coefficients. Complex nonlinear dynamic phenomena of the system arising from frictional contacts are revealed and the primary energy dissipation source of the frictional system is identified. The findings are expected to some insights into the vibration suppression design for frictional systems.

## Introduction

An in-depth understanding of effects of the friction on vibrating systems is vital to achieve designs of superior dynamic performance. The strong non-smooth nonlinearity resulted from the contact frictional interface brings about challenges in the design and analysis of frictional structures. While work has been reported from the complex dynamic responses, such as stick-slip responses, associated with frictional systems, more work is needed to achieve enhanced dynamic design in terms of vibration suppression performance. The vibration power flow analysis approach offers a promising tool to reveal new nonlinear phenomena of systems with friction by taking a new viewpoint of vibration energy transfer and dissipation [1]. In this paper, a system with multiple frictional contacts as shown in Fig. 1(a) is studied taking into consideration of various frictional contact roughness. The vibration power flow analysis based on HB-AFT is carried out, with the time-averaged energy transfer between subsystems and dissipation at the contacts defined and evaluated.

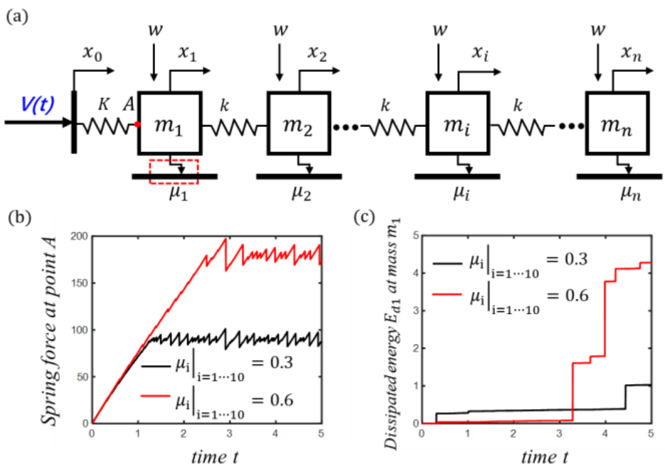


Figure 1: (a) 10-DOF system with various friction contact between masses and the ground; (b) time histories of spring force at point $A$ (i.e., the tangential force); (c) accumulated dissipated energy by friction at $m_1$.

## Results and discussion

Figure 1(a) shows a 10-DOF system with prescribed velocity $v(t)$ at its left-hand-side end and parameters set as stiffness $K = 0.8$ MN/m, normal force $w = 30\ N$, $m_i|_{i=1\cdots10} = 1.2$ g, and $k = 25$ MN/m. For Fig. 1(b) and (c), $v$ is set constant at 0.1 mm/ while other values can also be considered. The time histories of the spring force at point $A$, namely the tangential load, are obtained and shown in Fig. 1(b). The accumulated energy dissipation by friction at the interface of $m_1$ is depicted in Fig. 1(c). By varying the friction coefficient $\mu_i$, it is evident that both the maximum spring force at point $A$ (i.e., the tangential load) and the accumulated dissipated energy by the friction at $m_1$ can be modified. The results show that the dynamic response, energy dissipation and transfer can be achieved by tailor-designing the frictional contacts.

## Reference

[1] Dai W., Yang J., & Wiercigroch M. (2022) Vibration energy flow transmission in systems with Coulomb friction. *Int. J Mech Sci*, **214**:106932.