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BIFURCATIONS OF AN ELECTRO-VIBROIMPACT SYSTEM WITH FRICTION

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ABSTRACT

This paper presents a flavour of bifurcation phenomena from numerical analysis of a new electro-vibroimpact system. The system involves the use of a solenoid driven by a RLC circuit, coupled with a solid state relay (SSRL), to generate large electro-magnetic forces acting on a metal bar, which oscillates within the solenoid. Impacts are generated by placing a stop in the path of bar oscillations. The forward progression of the device can then be generated. A schematic of the system is shown in Figure 1.

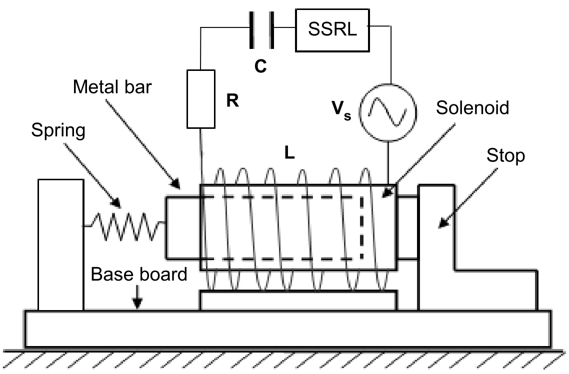

Figure 1: Schematic diagram of the prototype of electro-vibroimpact device.

A variety of nonlinear dynamic responses of the system has been observed through both experimental studies and numerical analysis [1] by varying the control frequency of the solid state relay. The control frequency appears to be one of the important system parameters that affects the system stability. To further confirm the qualitative responses of the system, a bifurcation diagram needs to be constructed, especially to compare with an experimental bifurcation diagram previously observed by Nguyen and Woo [2].

A bifurcation diagram has been constructed by numerical integration of the system mathematical model. The control frequency is allowed to vary in a range of 4.62 Hz to 7.96 Hz. It has been observed that when the frequency increases from 4.62 Hz to 5.25 Hz, the system dynamic response changes from chaotic motion to period-2 motion before settling to a period-1 motion. This synchronous trajectory becomes more apparent for higher frequencies ranging from 5.25 Hz to 7.96 Hz. 10 phase portraits have been constructed to further confirm the system qualitative responses.

By inspecting the overall progression rate achieved by the device, it has been found that period-1 motion is the optimal operating regime. The experimental results revealed that the achieved progression gradually increases when the control frequency changes from 3.4 Hz to 8.3 Hz and peaks at 8.3 Hz before dropping significantly. Numerical analysis has shown a similar trend with a slight difference in the frequency range (from 4 Hz to 8.1 Hz).

On gaining more insight to the system bifurcation phenomena, coupled with an approximate analytical solution, an optimal feedback control system can then be designed to achieve better forward progression rate.

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