Dynamic Design of Bi-stable Oscillators with Synchronized Switching

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Project Description

Development of analytical and numerical models describing the dynamical performance envelope for bi-stable oscillators coupled with nonlinear electrical circuits for vibration control and vibration energy harvesting.

Applications – Energy harvesting and vibration control for wind turbines, jet engines, automotive chassis, turbomachinery, wearable electronics.

Approach

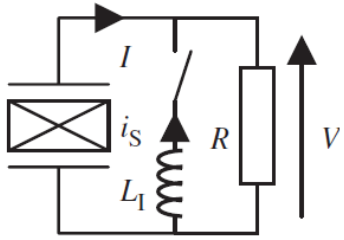
A synchronized switch on inductor (SSHI) circuit is coupled to the bi-stable oscillator.

Develop electromechanical models outlining the stability of the mechanical response as a function of the external forcing and electrical parameters.

Weak electromechanical coupling
- Analytical models based on harmonic balance

Strong electromechanical coupling
- Numerical co-simulation models

Develop control algorithms for sustaining desired mechanical response in the presence of noise and disturbance



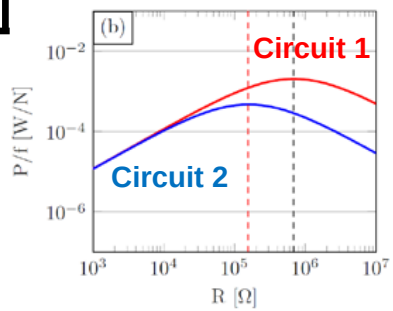
Discussion

Analytical model - weak coupling → Trends on optimal electrical parameters for harvesting or control

Numerical model - strong coupling → Margins indicating high performance zones of using coupled electromechanical nonlinearities

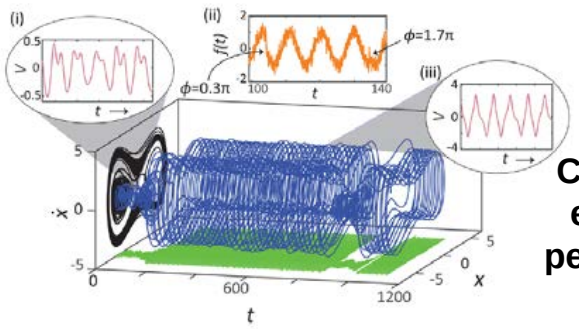
Control algorithm → Robust performance in the presence of noise and disturbances

Results

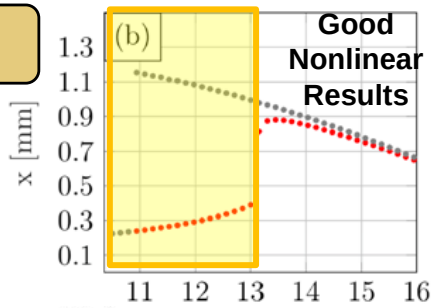


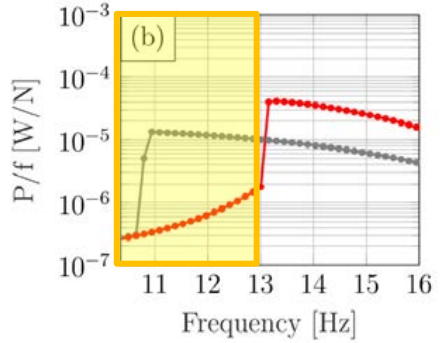
Margins on performance augmentation due to coupled nonlinearities

Electrical circuit parameters affect performance



Control algorithm ensuring robust performance under noise





The developed dynamical modeling schemes support the design of a nonlinear electromechanically coupled device for energy harvesting and vibration control