

## Energy extraction circuits for piezoelectric vibration energy harvesting

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Piezoelectric generators are among the most promising vibration energy harvesters due to their high power density and technological maturity. They generate alternating voltage that must be rectified and regulated to power, for example, IoT wireless sensor nodes. The usual method of using a diode-based rectifier followed by a voltage regulator is, however, sub-optimal, especially in the case of piezoelectric generators with weak electromechanical coupling.

Advanced energy harvesting strategies have been proposed to improve energy extraction. Non-linear circuits based on electronic switches driven synchronously with vibrations have attracted much attention. This talk will present the operating principle of these techniques and how they can improve the power density, and also the bandwidth, of piezoelectric generators.

For piezoelectric generator with low electromechanical coefficient or driven in such a way that the magnitude of their inertial mass's vibration remains constant, non-linear energy extraction circuit can drastically enhance their power density.

For strongly coupled piezoelectric generator, such as the one shown in Fig.1 ( $k^2 = 32\%$ ), non-linear energy extraction techniques, such as the SC-SECE circuit schematized in Fig. 2, makes it possible to drastically increase the frequency bandwidth for which the harvester can generate its maximal power, as shown in Fig. 3. This frequency tuning mechanism is possible through the tuning of control parameters of the energy harvesting circuit ( $\phi_s$  and  $\Delta\phi$  for the SC-SECE circuit) which impact the dynamic of the piezoelectric generator through the piezoelectric inverse effect.

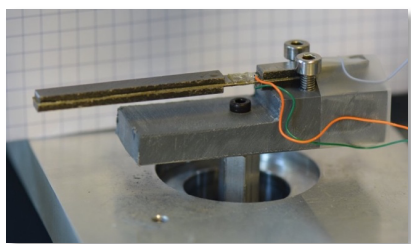


Fig. 1. Piezoelectric vibration energy harvester

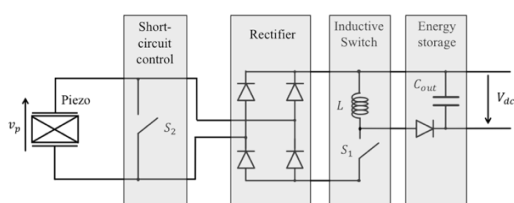


Fig. 2. SC-SECE energy extraction circuit

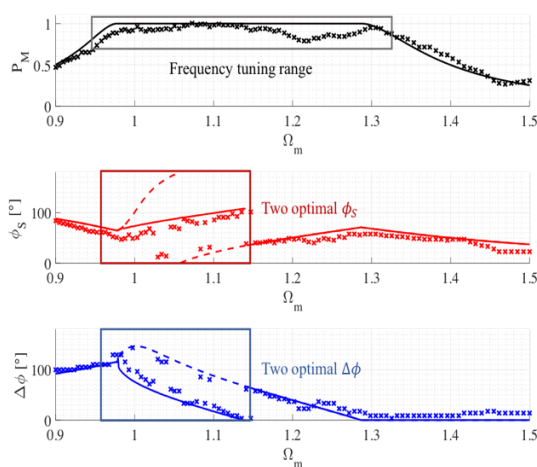


Fig. 3. Harvested power as well as optimal control parameters as a function of frequency using the SC-SECE energy extraction circuit