Duty cycle evaluation of a linear gravitational energy harvester for AIOT application

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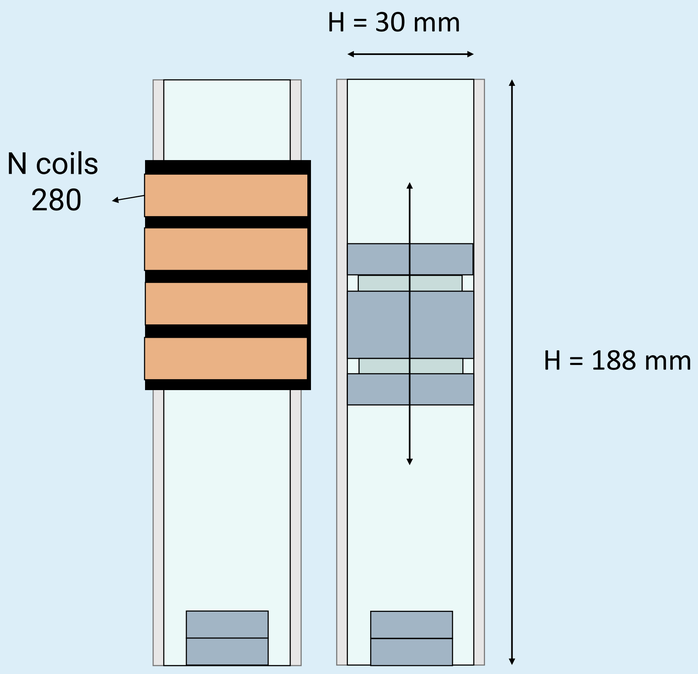
Introduction:

In the field of Autonomous Internet of Things (AIOT) systems, which combine wireless sensor nodes with energy harvester devices, a 1DoF inductive linear generator is presented. This EH is characterized by a non-symmetrical magnetic suspension. This type of harvester is properly designed considering the specific duty cycle for powering a node in a monitoring sensors network for railway application.

Method and Material

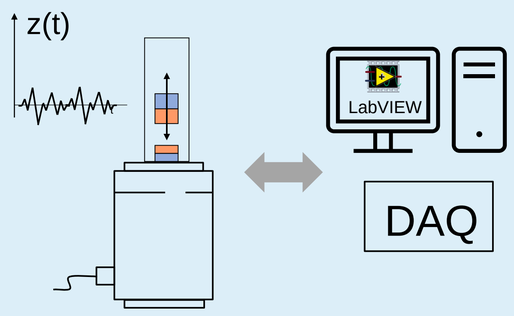


Max output power (@0.4g 3.5 Hz)	36 mW
Min output power (@0.1g 3.8 Hz)	4 mW
Resonant Frequency (softening)	3÷4 Hz
Acceleration input	0.1÷0.4 g
Optimal Rload	70 Ohm

Numerical model

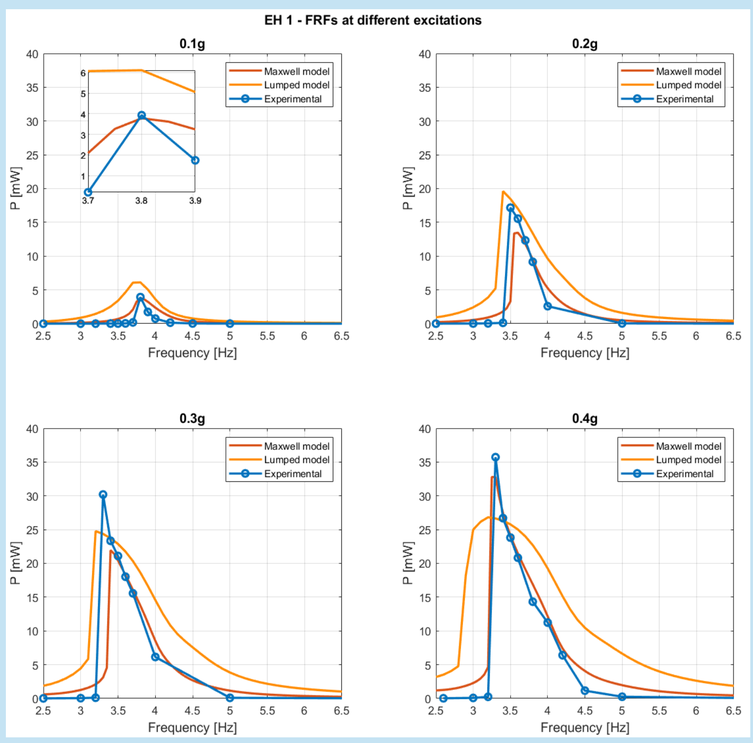
MATLAB
SIMULINK

Experimental test bench



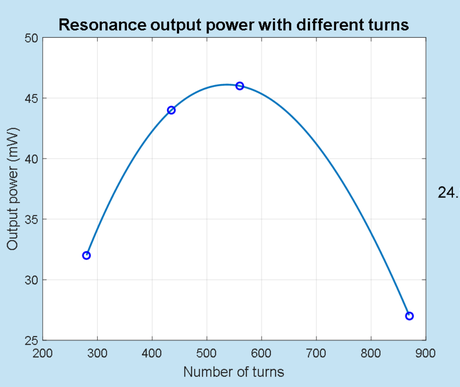
Results Obtained

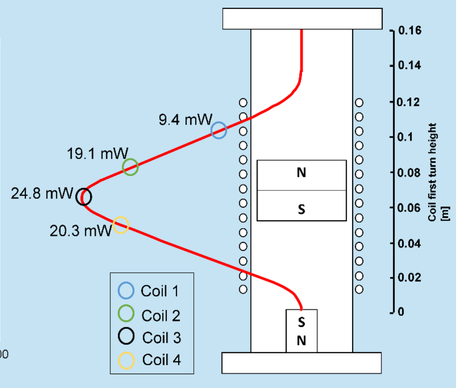
We compared the FRFs obtained by the numerical simulation with the experimental ones obtaining a good agreement in the overlap. We improved our model with an Ansys Maxwell simulation to compute the stiffness numerically.



Optimization parameters:

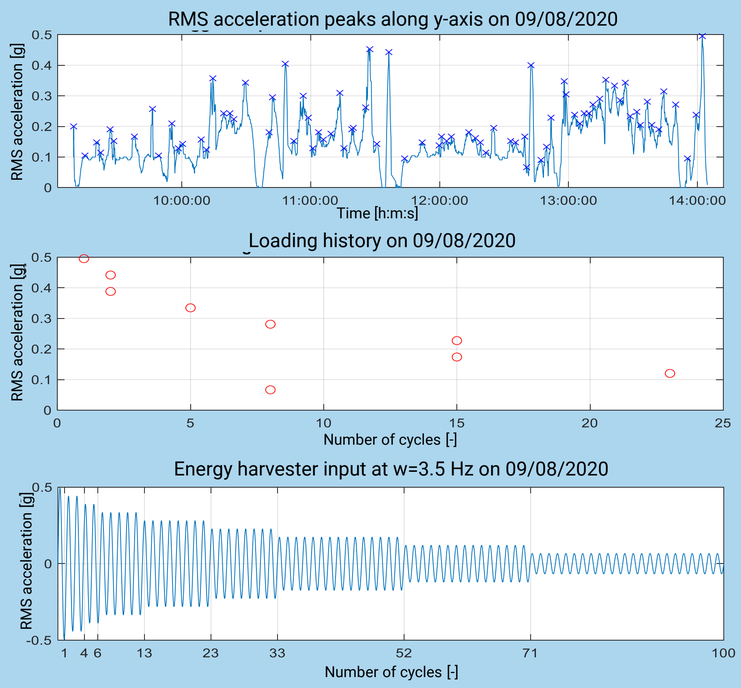
- The optimum value of coils
- The optimum position of the coil



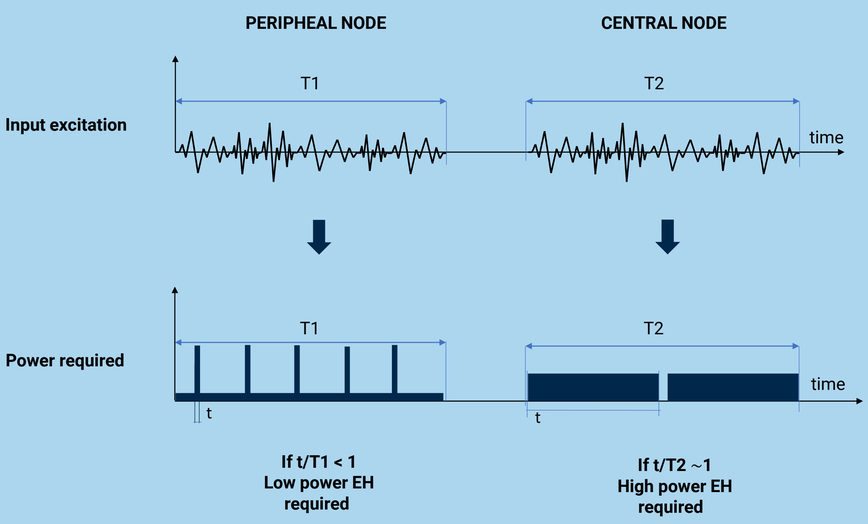


On-Board Unit Measures and Duty Cycle Evaluation

The real vertical acceleration of a freight vehicle was collected to understand how the device operates in a simulated real environment. Following the load diagram method, the real excitation was introduced in the model.



Simulating the EH efficiency allows us to understand if the duty cycle is suitable for the desired monitoring application.



Next steps:

- Design a more **compact EH** to be suitable for a railway application
- Evaluate methods to achieve a **wider range of high-power frequency**
- Introduce the **power management system** to complete the circuit and power the peripheral node

Reference:

[1] Magneto-inductive energy harvester device, having an internal guide magnetic suspension, Somà Aurelio [it]; Fraccarollo Federico [it];De Pasquale Giorgio [it], WO2013IT00167 20130612, 2015

[2] Aimar M, Soma` A, Study and results of an onboard brake monitoring system for freight wagons, *Proc. Inst. Mech. Eng. Part F J. Rail Rapid Transit.* , 2017

[3] Russo C, Lo Monaco M, Fraccarollo F, Soma` A , “Experimental and numerical characterization of a gravitational electromagnetic energy harvester”, *Energies*, 2021,