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Ocean energy harvesting device for long-term monitoring applications

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ABSTRACT

This work reports the development and test of an energy harvester (few centimetres sized) designed to power the miliwatts required in submersible monitoring systems, that uses water movements as energy source. The device was fabricated with moulded materials (epoxy resin and silicone), using additive manufacturing for mould fabrication. The device was characterized with movements from 0.1 Hz to 0.4 Hz, and the maximum power of 7 Mw WAS measured in emulated environment. Power was used to charge a lithium rechargeable battery (for levelling energy sourcing and demanding) and tested to power turbidity sensors.

Keywords: Energy, harvesting, generator, waves, currents, monitoring, autonomous.

INTRODUCTION

The monitoring of ocean variables requires long-time deployments, in extreme environments, able to be alive for long periods. For this reason, the use of energy storage devices (batteries) represent a drawback in the installation and cost operation of these system, due to large capacity needed, or costly maintenance to replace them. At ocean surface buoys, photovoltaic harvesting can overcome this limitation. However, in submersed systems, solar energy becomes unavailable a few meters below surface, where the most abundant energy is derived from water movements (waves, currents or upwellings). This device (figure 1) was designed to operate 10-20m bellow surface to avoid vandalism and collision with maritime traffic. It is based in a linear electromagnetic generator (LEG), composed of an acrylic tube with 100 mm of length with 31 mm of interior diameter and thickness of 2 mm. The top and bottom ends of the tube include a silicone disk to damp the final movement of the magnets. Two N45 magnets discs of Neodymium Iron Boron (NdFeB), with 30 mm of diameter and 1,32 T residual magnetism (Br) are placed inside the acrylic tube. The mass of each magnet is 53,7 gr. Two coils are placed outside of acrylic tube, fabricated with isolated copper wire 0.2 mm of diameter, with 1500 turns, as fully described in [1].

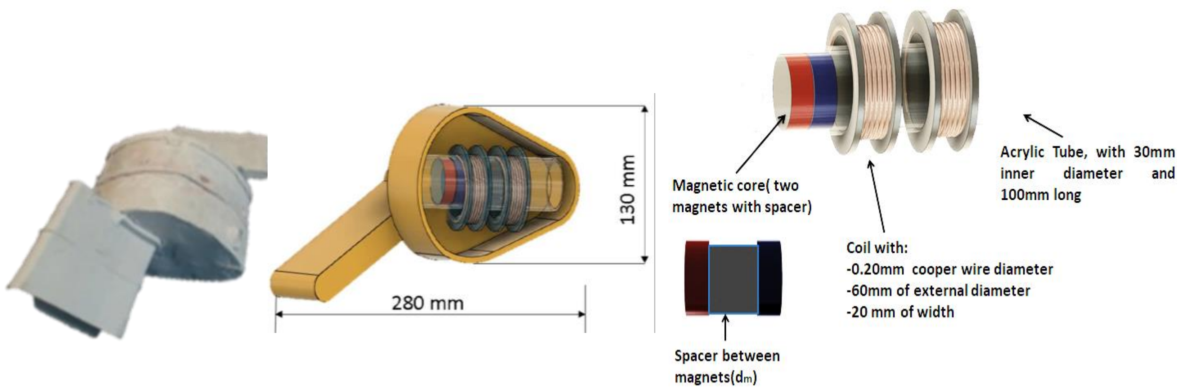

Fig. 1 – Energy harvesting device. Left: photo of fabricated device. Centre: Artwork of device section. Right: details of the linear electromagnetic generator.

RESULTS AND CONCLUSIONS

The generator was characterized in a controlled environment [2], to extract its characteristics. A repetitive sinusoidal movement was mechanical imposed, to emulate ocean waves, with frequencies ranging from 0.1 Hz to 0.4 Hz, representing wave periods from 10 s to 2.5 s. Voltage from each coil was rectified, with two full wave bridges (figure 2), using low dropout (0.2V) schottky diodes, and connected to a power management circuit and an energy storage device (LiPo battery) [2]. Figure 2 represents the typical voltage obtained before battery connection.

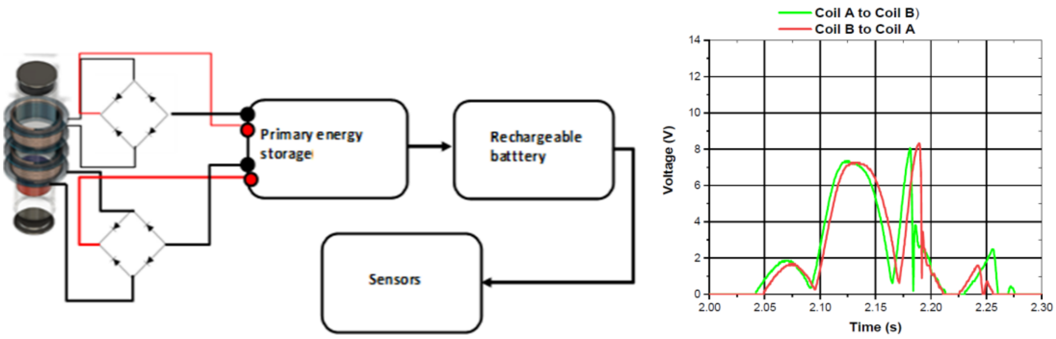

Fig. 2 – Connection diagram and typical output voltage

The average measured output power, for several load resistances (left) and for several movement frequencies are presented in figure 3. The measured output power was sufficient to power up to eight turbidity sensors as in reference [3] with a 0.4 Hz movement, and a to power one sensor with 0.1Hz movements.

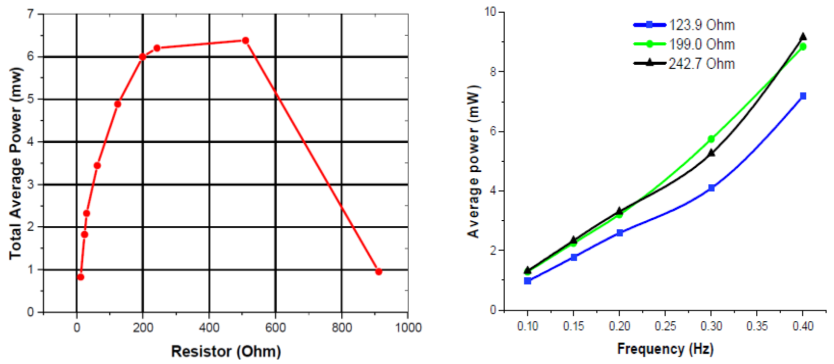

Fig. 3 – Measured output power as function of load resistance (left) for several movement frequencies (right)

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