ID2- EVALUATION OF TWO MPPT TECHNIQUES IN LOW-POWER PENDULUM-TYPE WAVE ENERGY CONVERTERS

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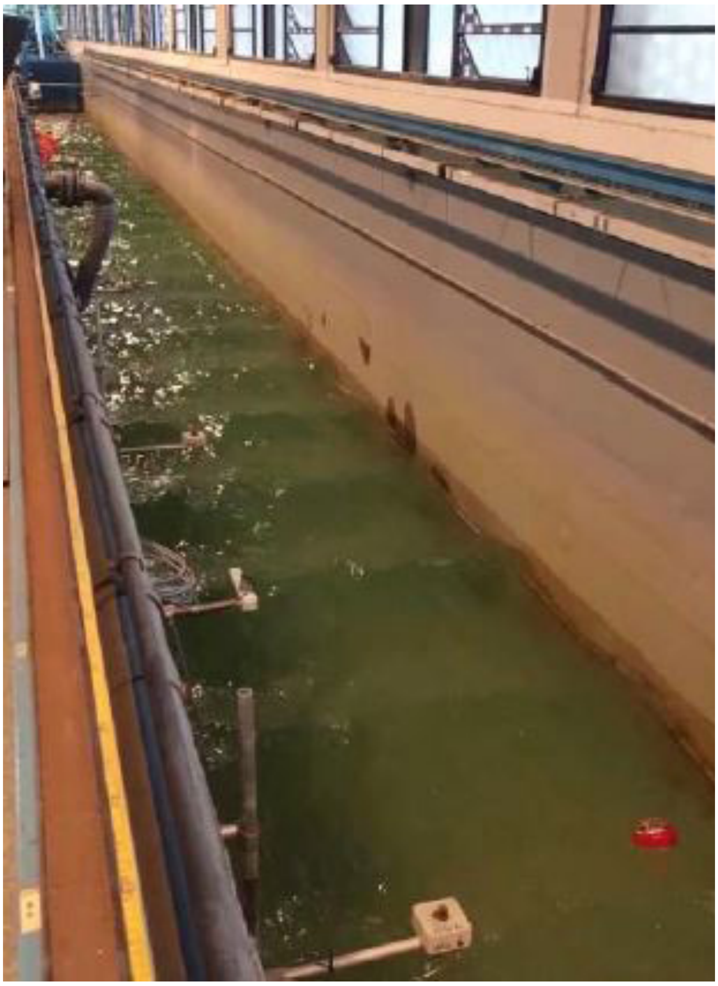
ABSTRACT
Lagrangian Drifters are autonomous floating passive devices that provide oceanographic surface data. They are low-cost, low-power and easy-deployable marine instrumentation used in climate research. One of the main challenges of drifters is energy autonomy. Wave Energy Converters (WEC) have proved their viability in high-power electric generation plants to work as Kinetic Energy Harvesters (KEH) [1] and now they are also showing up at smaller power rate applications in order to power devices such as ocean buoys and drifters [2]. In this latter case, a wise and efficient energy management is crucial to maximize the lifespan of the device. To achieve this goal, a Power Management Unit (PMU) is used, which can also include a Maximum Power Point Tracker (MPPT) to extract maximum energy from the KEH device.



At [3], we presented a novel pendulum-type KEH device that transforms the motion of the waves into rotation of a microgenerator to produce electrical energy. A PMU based on a commercial chip (ADP5092, TI) was used after the KEH device. Also, a test drifter was designed to embed the KEH system and perform real sea tests, where information is gathered about the motion of the drifter and the output power provided by the KEH system.

The micro-generator of the KEH device can be modeled by the electrical Thévenin equivalent, where VOC is the open circuit voltage and Vgen the output voltage. As for the MPPT, a dynamic tracking mode was used based on the fractional open circuit voltage (FOCV) technique. In this technique, VOC is periodically sampled and a fraction of it is used to dynamically fix its output voltage (Vgen) at its maximum power point (MPP). According to the Thévenin model of the KEH device, maximum power can be achieved for Vgen = 0.5VOC and this ratio was thus set at the PMU. On the other hand, the MPPT sampling period is preset to 16 s by the PMU chip, which can be too long. If the sampling instant happens when the generator is not spinning, the sampled data of VOC will be null, which will lead to gathering a null power from the KEH device during the next 16 s, until a new sample is collected. This will lower the collected energy. So, here we propose to use another MPPT technique, the constant voltage (CV), which is compared with the FOCV technique. The CV technique is simpler and can also be implemented by the same PMU chip. It consists on fixing a constant voltage for Vgen, which should be selected near the average MPP point expected during the actual deployment.

Tests have been carried out in a controlled environment, the water channel shown in Fig. 1, where wave height and period were set at 30 cm and 1.25 s, respectively. The tests for the two MPTTs were performed consecutively with the same test drifter. Based on previous results [3], the CV was fixed to 0.4 volts. Fig. 2 shows the results using the CV (left) and FOCV (right) MPPT techniques. From top to bottom, the following variables are shown: PMU input voltage (brown) and current (blue), PMU output voltage (purple) and current (green), PMU input (red) and output power (black). Mean power and current values are also shown. In both cases, the PMU samples VOC every 16 s, but then for the CV the input voltage (Vgen) is fixed to 0.4 V, whereas for the FOCV Vgen is placed at 0.5VOC.Output voltage was set in both cases by a Li-ion battery of 2.2 Ah at 4.1 V. On the other hand, during the first 35 seconds (almost two sampling periods), the input voltage was nearly null for the FOCV. The reason for that is that the PMU sampled two consecutive null voltages for VOC (generator not spinning). So, although the generator of the KEH device started to rotate and thus provide current to the PMU, the generator output voltage (Vgen) and thus power (input for the PMU) were null. Even so, in this case, the average power generated by the FOCV was higher than that generated by the CV (264 μW in front of 208 μW), probably due to the alignment of the KEH pendulum with the direction of the waves. Future work can include using different voltages for the CV technique and lowering the sampling period for the FOCV in order to achieve higher energy in both cases.

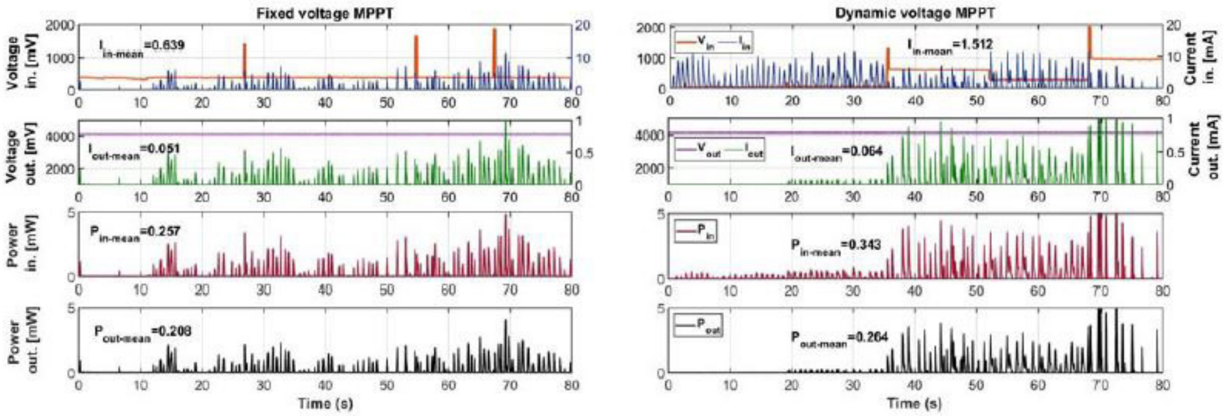


Fig. 2. Power Management Unit (PMU) input and output variables during the channel test of the drifter for the two MPPT techniques: CV (left) and FOCV (right). From top to bottom, PMU input voltage (brown) and current (blue), PMU output voltage (purple) and current (green), PMU input (red) and output power (black). Mean power and current values are also shown.

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