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Testing of a power take-off system for an OWC spar-buoy wave energy converter

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Abstract

The paper concerns the development of the power take-off (PTO) control of an OWC oscillating-water-column (OWC) spar buoy wave energy converter. The OWC spar buoy is an axisymmetric device consisting basically of a submerged vertical tail tube open at both ends, fixed to a floater that moves essentially in heave. The oscillating motion of the internal free surface relative to the buoy, produced by the incident waves, makes the air flow through a new type of self-rectifying air turbine, the biradial turbine. The patented OWC spar-buoy and turbine are under development at Instituto Superior Técnico. The turbine drives an electrical generator. The control of this set was the object of tests performed at Tecnalia Electrical PTO Laboratory, in Bilbao, Spain. To reduce the overall costs of the PTO system, an electrical generator was adopted with a rated power twice the maximum expected average power output of the buoy. This level of generator rated power poses great challenges for the PTO control due to the irregular characteristics of the sea waves. In the present hardware-in-the-loop configuration, the hydrodynamics of the OWC spar buoy and the aerodynamics of the air turbine were numerically simulated in real time and coupled to the physical model of the turbine/electrical generator set. The instantaneous air turbine torque is emulated through the use of the electrical motor. In the reported implementation, only irregular wave conditions were considered. The experimental results allowed the dynamic behaviour of the PTO to be characterized, in order to ensure the practical applicability of the proposed control algorithms and provide a basis for the validation of the numerical models.