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Output Power of Linear Generators under Reactive Control in Regular Waves

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Abstract. Direct drive wave energy converters couple a linear generator directly to a reciprocating wave energy device. This way, the performances showed by hydraulic and pneumatic based systems are improved. After linear generator, full-scale back-to-back Voltage Source Converters are used to adequate the electric energy before delivering to the grid. This stage is made up of two parts: the generator side converter stage consists of rectifying the electricity generated by the linear generator; the other one turns it in alternating current with suitable voltage and frequency parameters. The first one allows control over the instantaneous power flow possible, and in turn enables both power flow directions; this capability allows implementing reactive control. This control strategy is used to maximize the energy extraction from waves by the power take-off (PTO) based on reaction force control. This paper shows how to determine and quantify, not the power extracted from waves, but the one transferred to the electronic converter.

Key words

Wave energy converters, linear generators, WEC control, renewable energy.

1. Introduction

Ocean energy conversion systems have seen renewed interest, stimulated mostly by the increasing energy discussions. Several commercial ocean wave energy projects have already been undertaken. Sea waves are a very promising energy carrier among renewable power sources, since they are able to manifest an enormous amount of energy resources in almost all geographical regions.

A diversity of prototypes has been developed during the last decades. This paper focuses on oscillating buoy systems, which are a kind of oscillating point absorber [1]. In these systems, waves exert forces on these devices, and the vertical axis movement can be exploited. The oscillating system consists of a buoy on the ocean surface connected to a Permanent Magnet Linear Generator (PMLG) with a rope set on the seabed. Permanent magnets are mounted on the traslator and the varying magnetic field acts on stator windings. Here the generator can have different number of sides and the stator ones are fixed to the foundation on the seabed. Springs are connected to the alternator. The generator is placed in a watertight enclosure.

Device survival possibilities are increased because of the direct drive PTO system. It highlights simplicity and robustness, and also reduces the maintenance costs and probably those incurred because of extracting energy from waves. The available primary power features are pulsing and thus, the electric energy should be set up to be properly injected into the grid. Linear generators and full-scale back-to-back Voltage Source Converters (VSC), implemented together, are one of the most promising choices used to connect the electricity generated by buoy oscillating systems to the power grid. The buoy oscillating motion can be directly transformed into electricity applying linear generators, without conversion to rotative motion. This way, mechanical linkages are avoided and efficiency increases. DC link capacitor can also be used as an intermediate stage of storage through electronics power, and thus, electric power can be tuned to grid connection parameters. Figure 1 shows the general scheme.

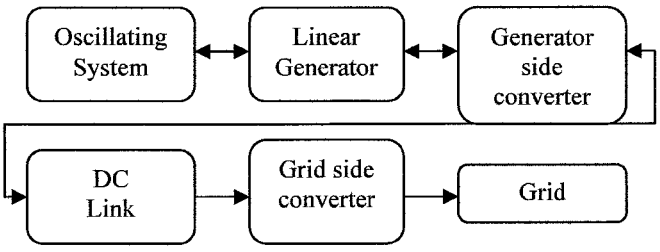

Fig. 1: General WEC system scheme.