Coordinated Control and Network Integration of an Array of Wave Energy Converters

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Work stream 7: Advanced Control and Network Interaction

Introduction

The unpredictable and random nature of the wave energy resource causes voltage fluctuations when wave energy converters (WECs) are connected to the electricity network. The power quality problem is compounded by the weak, rural grids to which most wave farms will be connected. Hence, some control means are required which would ensure that the voltage remains within statutory limits for as long as possible.

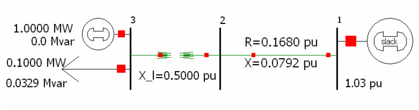


Fig. 1. Radial test network.

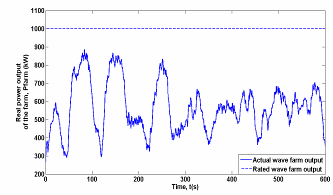


Fig. 2. Real power production of a 1 MW wave farm.

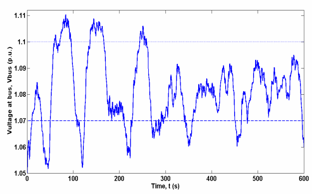


Fig. 3. Voltage variation at the bus where the wave farm is connected.

Control of the wave farm

Generators have been conventionally operated either at a constant power factor or at a constant voltage. In Automatic Voltage and Power Factor Control (AVPFC) method the control modes are switched depending on the energy content of the seas. A Fuzzy Logic Power Factor Controller (FLPFC) has also been developed to control the operating power factor of the wave farm, which again ensures that the voltage lies within limits.

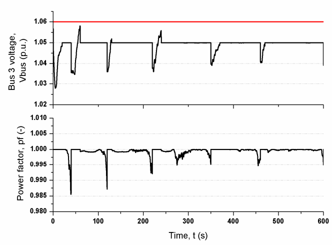


Fig. 4. Voltage and power factor when the wave farm operates with the AVPFC controller.

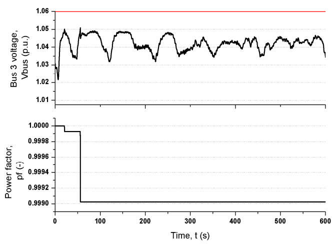


Fig. 5. Voltage and power factor when the wave farm operates with the FLPFC controller.

Requirement for coordination

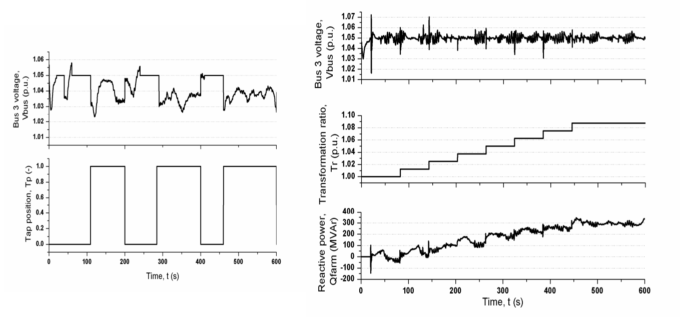


Fig. 6. Unnecessary tap operations due to uncoordinated control.

The control of the substation On-Load Tap Changing (OLTC) transformer and the intelligent control of the wave farm will need to be coordinated to avoid unnecessary tap operations and runaways.

Methodology and results

A procedure using which the substation OLTC transformer can sense the voltage at the bus where the wave farm is connected has been developed. It only requires archives of load data, normally collected at substations and does not have any communication requirements.

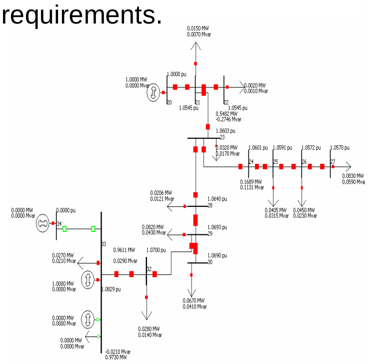


Fig. 7. Radial test network.

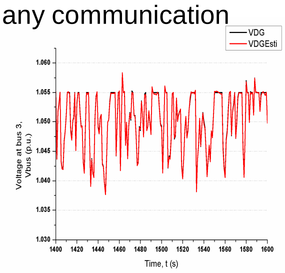
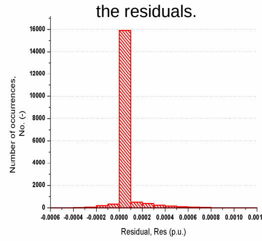


Fig. 8.The estimated and measured voltage time series and the histogram of the residuals.



References

[1] A. E. Kiprakis and A. R. Wallace, "Time Domain Modelling of Wave Energy Converter Arrays in 3-Dimensional, Non-Stationary Seas," Proc. 1st UKERC SuperGen Conference, Oxford, UK, 2008.

[2] A. J. Nambiar et al, "Quantification of voltage fluctuations caused by a wave farm connected to weak, rural electricity networks," Proc. 14th Intl. Conf. on Harmonics and Quality of Power, Bergamo, Italy, 2010.

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