Harmonic Mitigation Methods in Large Wind Farms

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Abstracts

This poster presents various sources of harmonic problems in large wind farms and shows optimized harmonic mitigation methods. The harmonic problems (see Figure 1) such as harmonic emission and amplification sources as well as harmonic stability are identified. Also modern preventive and remedial harmonic mitigation methods (see Figure 2) in terms of passive and active filtering are described. It is shown that wind farm components such as long HVAC cables and park transformers can introduce significant low-frequency resonances which can affect wind turbine control system operation and overall wind farm stability as well as amplification of harmonic distortion. It is underlined that there is a potential in terms of active filtering in modern grid-side converters in e.g. wind turbines, STATCOMS or HVDC stations utilized in modern large wind farms. It is also emphasized that the grid-side converter controller should be characterized by sufficient harmonic/noise rejection and adjusted depending on wind farms to which it is connected.

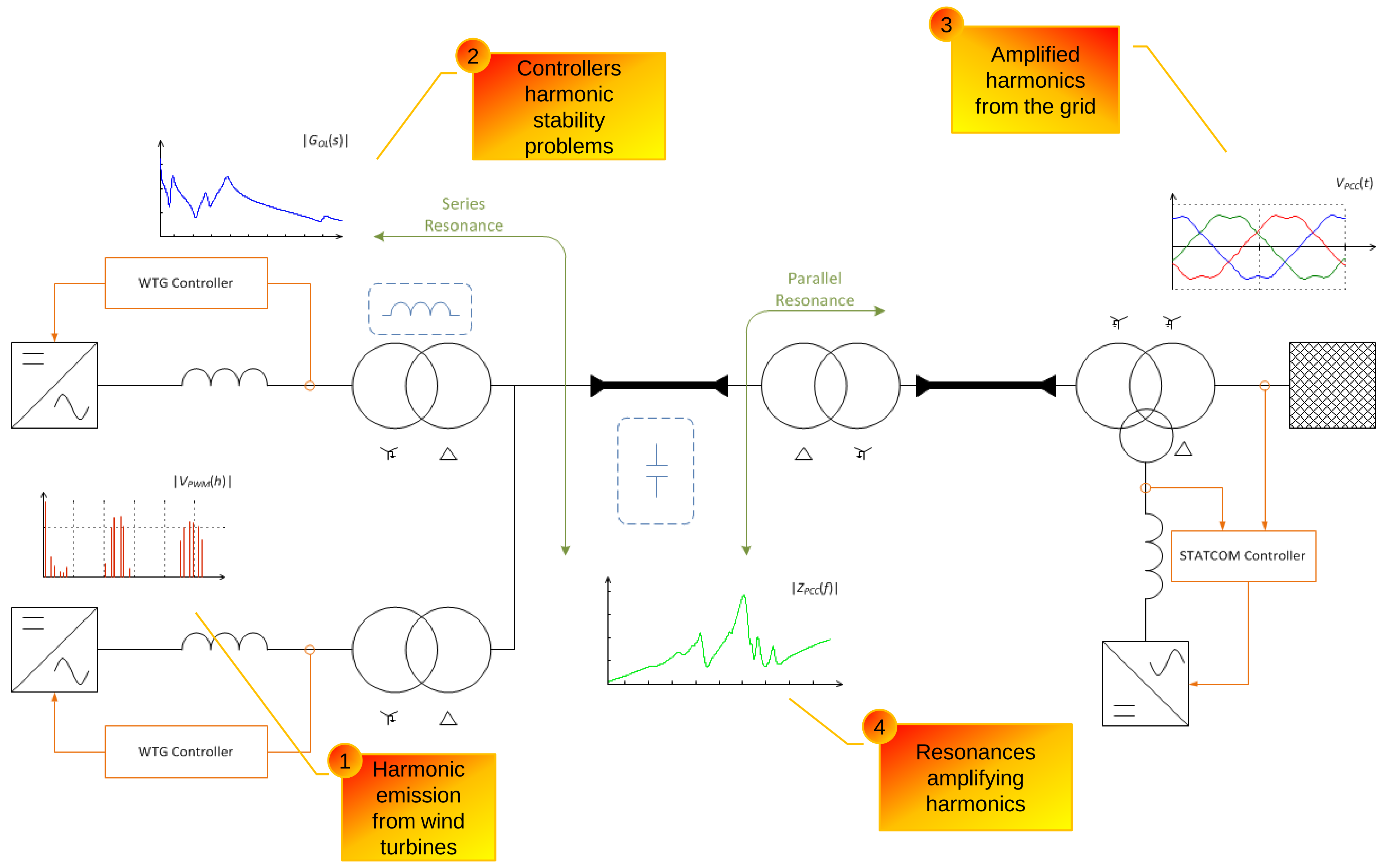

Figure 1 Harmonic problems in large wind farms.

Objectives

Wind turbines with full-scale back-to-back converters are more and more used in large offshore wind farms. This affects the significant increase of complexity in wind farm structures . The wind turbines are nowadays mainly connected through a widespread MV subsea cable network and long HV cables to the HVAC or HVDC transmission system. Such configuration is still being challenging to the industry from harmonic generation, propagation and stability perspective.

Therefore it is of great importance to investigate how a certain wind turbine or a group of wind turbines can interact with various wind farm structures including MV cable network, park transformer, HVAC export cable, shunt components (e.g. capacitor bank, shunt reactor, SVC, etc.).

Methods

Due to the fact that large offshore wind farms are characterised by complex structures including wide application of power electronic devices in wind turbines, FACTS devices or transmission devices such as HVDC links as well as passive components such as filters, array cables, transformers, transmission cables, and shunt compensation there are many ways of dealing with harmonic problems.

There are two main branches of harmonic mitigation methods: passive filtering and active filtering. It is recognised that passive filtering is state-of-the-art technology nowadays however requires extensive knowledge of the system during the wind farm design phase. In many cases this is of uncertainty and related additional risk as well unnecessary oversizing of the passive filters.

Due to the fact that more and more power electronic equipment (e.g. wind turbines with grid connected converter, STATCOMS, HVDC, etc.) is being utilised in wind farms, active filtering starts to be an interesting solution. Thanks to active filtering which is implemented on the converter control level there is no need to install additional expensive equipment in order to perform filtering. On the other hand by means of active filtering possible uncertainties faced during the wind farm design phase can be reduced even during the execution or evaluation phase by simply tuning the controller.

Due to the fact that on the market are available various harmonic mitigation solutions the wind farm design can be optimized in order to reduce the cost of energy by means of reducing the risk, providing flexible solutions applicable for various project and depended on applications, reducing the size as well as shortening the wind farm execution phase.

Taking many aspects into consideration probably hybrid solutions involving both passive and active filtering in various locations as shown in Figure 2 would be the most beneficial simultaneously providing hybrid harmonic mitigation solutions. In order to optimise the wind farm design from harmonic emission and stability perspective some more studies and research is required.

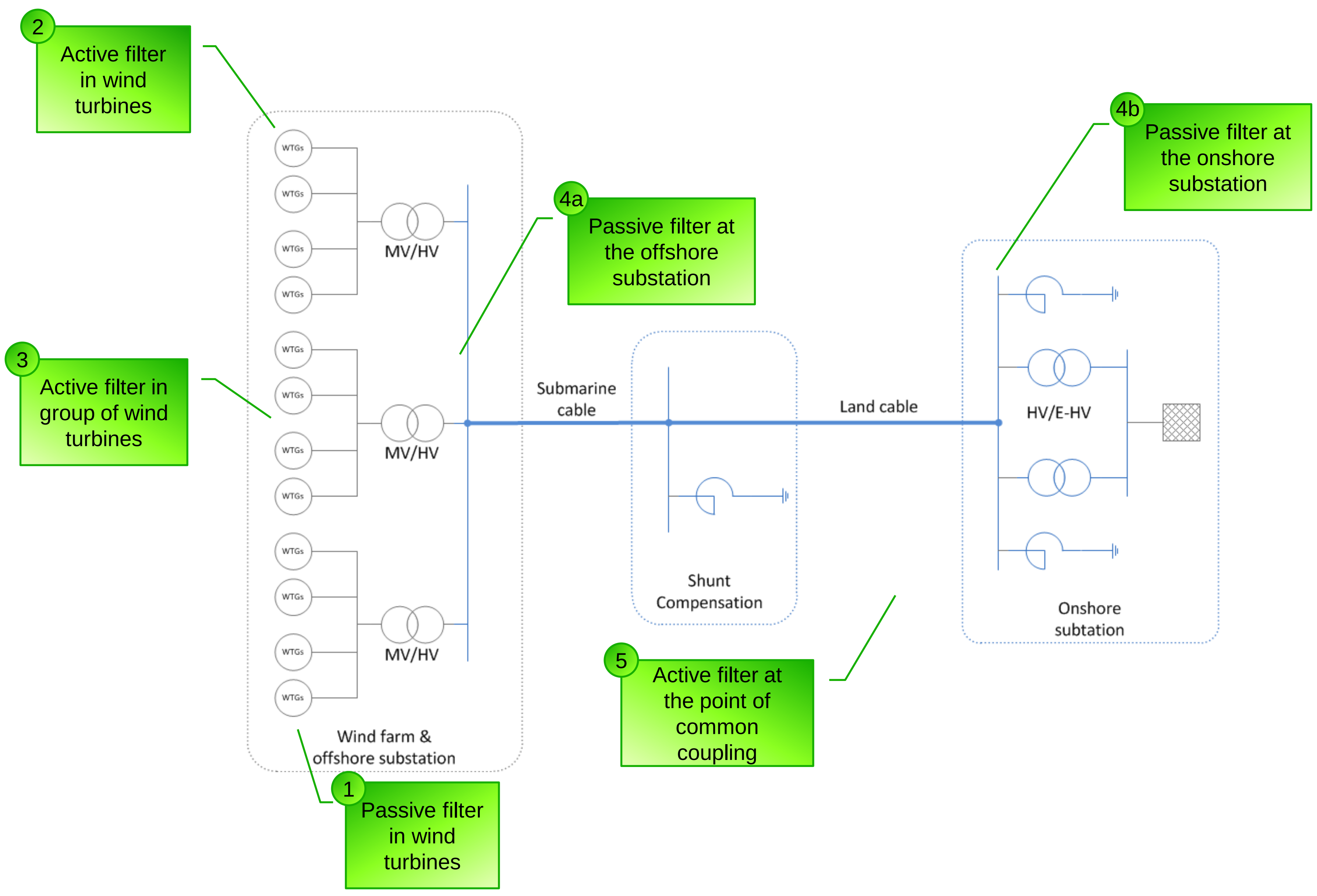

Figure 2 Harmonic mitigation methods in large wind farms.

Conclusions

It was shown that harmonic problems are being more and more significant while bigger and bigger wind farms are being developed. Therefore there is a need to provide optimized harmonic mitigation methods based on passive and active filtering solutions.

Optimised solutions can be recognised by application of active filtering in various grid-connected converters (e.g. wind turbines, STATCOMS, etc.) connected together with passive filtering in different locations of wind farms which introduces significant potential in reducing the cost of energy.

Also by applying adjusted advanced control strategies according to locally specified grid-code requirements brings completely new sight to the large wind farm development process.

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