Fast frequency oscillations detection in low inertia power systems with excessive demand-side response for frequency regulation

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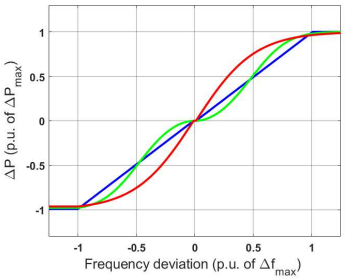
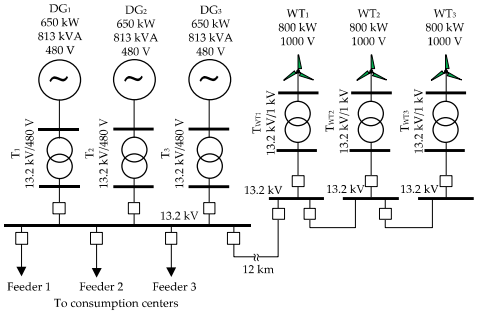
1.Introduction

Inertia reduction in electric power systems due to the increase in renewable generation interfaced with power converters **challenges conventional frequency control** strategies [1]. **Demand side response** is one possible way of mitigating this effect, but may lead to **fast frequency oscillations** when the load response is excessive.



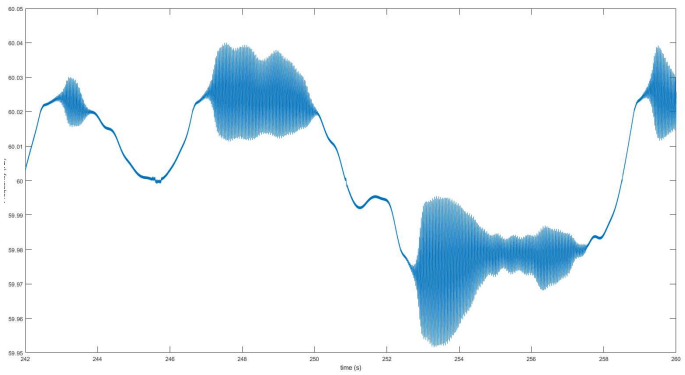
The electric power system of the island of San Cristóbal, in Galapagos (Ecuador) is modelled [2] and the impact of wind speed variation on system frequency is studied under various scenarios and demand side response strategies as shown in the figure.

The system consists of three **diesel generators** and three **wind turbines** that feed a maximum demand of 2,9 MW [3], with up to 50 kW of frequency sensitive demand contributing to **frequency control**.



2.Observations

Under some circumstances, specifically when the demand is low and a single diesel generator is running along with a 50% share of wind generation, the **frequency behaviour** in the system becomes unacceptable because of an **excessive response of the demand** to frequency deviations, as shown in the figure below.

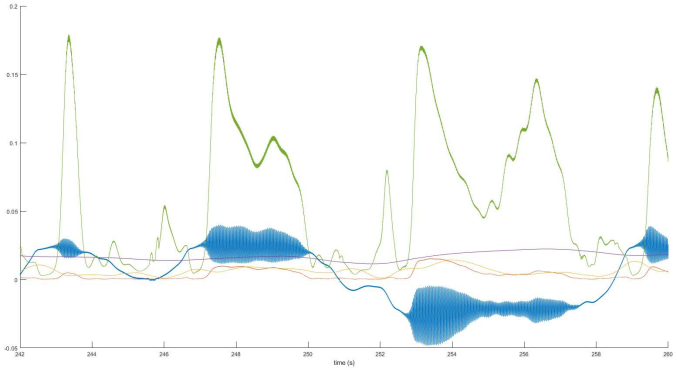


3.Detection

The **detection method** proposed for detecting these fast oscillations without using derivative calculations is based on the standard deviation over two different time periods: 0.1s and 1s:

$$ratio = \frac{f_{SD}^{0,1s}}{f_{SD}^{1s}}$$

The ration between these magnitudes allows the detection of these oscillations, as shown in the next figure



4.Conclusions

In **weak electric power systems** with **demand side participation in frequency regulation**, an excess in load response can lead to severe **frequency oscillations**.

We propose a method of **detecting** these **fluctuations** without using derivative calculations and apply it to a case study. Further analysis shall be carried out to detect excessive contribution of the demand to the frequency regulation and develop strategies to adjust accordingly.

Main references

[1] F. Milano, F. Dörfler, G. Hug, D. J. Hill and G. Verbič, "Foundations and Challenges of Low-Inertia Systems (Invited Paper)," *2018 Power Systems Computation Conference (PSCC)*, Dublin, Ireland, 2018, pp. 1-25, doi: 10.23919 / PSCC.2018.8450880.
[2] L. Casasola-Aignesberger and S. Martinez, "Electric vehicle recharge strategies for frequency control in electrical power systems with high wind power generation", 2020 IEEE International Conference on Environment and Electrical Engineering and 2020 IEEE Industrial and Commercial Power Systems Europe (EEEIC / I&CPS Europe), Madrid, Spain, 2020, pp. 1-5, doi: 10.1109/EEEIC/ICPSEurope49358.2020.9160577.
[3] D. Ochoa and S. Martinez, "Proposals for Enhancing Frequency Control in Weak and Isolated Power Systems: Application to the Wind-Diesel Power System of San Cristobal Island-Ecuador", Energies, vol. 11, 910, pp. 1-25, Apr. 2018.

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