Effects of Interacting Dynamic Demand Controlled Appliances on the Frequency Grid Stabilization

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The stable operation of the electric power grid depends on several control protocols and management actions including demand forecasting, technical maintenance, generation and transmission planning, etc. The control of the grid frequency is one of the most important tasks of the power system operator, which has to ensure the global stability, reliability and efficiency of the grid operation. The frequency control is strongly related to the balance of supply (power generation) and load (demand/power consumption). If at any moment supply surpasses load, then the frequency rises. While if load exceeds supply, the frequency falls. Thus the power system operator has to maintain the frequency within a tolerable range, for instance [49.8;50.2] in most of European countries. Control is typically applied on the supply side. Power plants modify their outputs according to the load, i.e. supply follows demand. The increase of electric demand and the integration of renewable energy sources have increased the difficulty of controlling frequency fluctuations, and have shown the weakness of traditional frequency control protocols, which need very large and expensive power plants as spinning reserve. This issue has encouraged the proposal of a new control methods applied on the demand side, such as demand response programs, demand side management direct load control, and recently Dynamic Demand Control (DDC). Basically DDC, which is used in this work, is a distributed demand side control where consumers/appliances modify their consumption according to the grid frequency. In other methods appliances may modify their consumption according to either the electricity prices (price-based programs) or to some incentives (incensitive-based programs). In [2] a generic algorithm of DDC was analyzed and we found that, although DDC can substantialy reduce small or medium frequency fluctuations, the probability of extreme events(large frequency peak) is actually increased as it is shown in Fig.1.

In this work we show how introduicing communication among devices can improve DDC efficiency, eliminating completely large frequency fluctuations and reducing as well the total pending energy of the devices illustrated in Fig.2.

[1] J.A. Short, D.G.Infield and L.L. Freris, Stabilization of grid frequency through dynamic demand control, IEEE Trans.Power Syst.**22**,1284 (2007).

[2] E.B.Tchawou Tchuisseu, D.Gomila, D. Brunner and P. Colet, Effects of dynamic-demand-control appliances on the power grid frequency, submitted (2017)

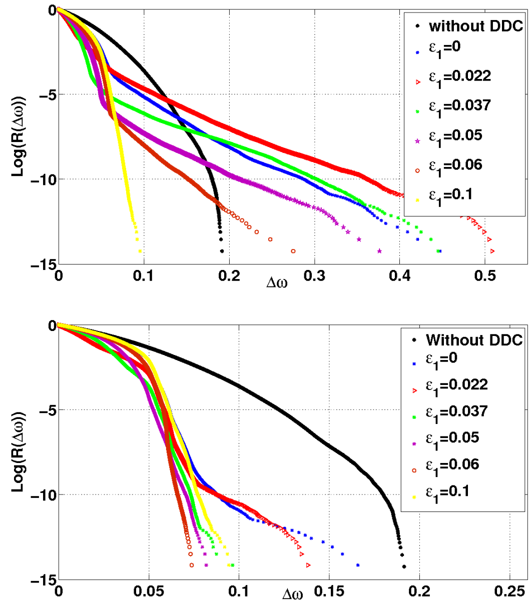

Figure 1: cumulative probability for different value of ϵ_1 for $\gamma = 1, 2.10^{-3}$ and P_0=132 MW. We consider n=1 household and l=1000 non interacting(top) and interacting(bottom) appliances

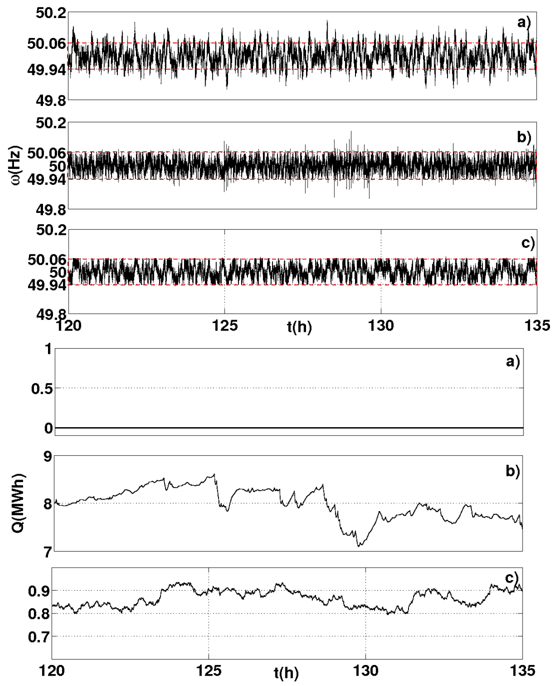

Figure 2: Illustration of the time evolution of the frequency fluctuation(top) and the pending energy(bottom): without DDC (a), with DDC and without interaction(b) and with DDC and with interaction(c).