

Control and Review of Micro-Grid Frequency Droop with Fuzzy Based WECS with Electric Vehicle

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Abstract— This paper presents an imaginative strategy in current force matrices that is to work the mix of wind generators and module half breed electric vehicles (PHEVs) for reducing the challenges. Notwithstanding the entirety of their advantages, these two sorts of sources are confined by some actual limitations in this manner, both of these sources are unfit to turn out effectively for directing the essential recurrence in frameworks with reduced idleness. By and by, the blend of wind generator and PHEVs are ensuring the recurrence during different situation over individual source. In this work, little sign framework with fluffy has proposed to analyze the recurrence guideline approach. Besides, the concentrated and dispersed control plans are examined within the sight of participation sources and doesn't happen any infringement. The recommended approach shown the better presentation over other traditional control strategies.

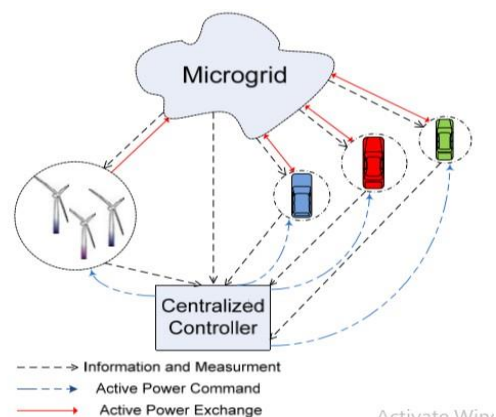
Keywords— wind generator, plug-in hybrid electric vehicles, Fuzzy, Small signal, Sources, Centralized control.

1. INTRODUCTION

In 2015, according to figures released by Energinet.dk, Danish wind turbines generated what corresponds to 42% of

Danish electricity consumption. In Jutland and on Funen, in fact, wind power supplied more electricity than the total load for 1460 hours of the year. This is the highest figure ever, and the highest proportion for any country. In 2014, the figure was 39% - also a world record, and in 2013, 32.7%. These figures illustrate that the Danish and European energy systems are undergoing huge changes, and that renewable energy will change the way the electricity systems are operated. "Hours with wind power production exceeding consumption is not in itself unusual, but the fact that we are now generating surplus power 16 % of the time in the Western Danish power grid illustrates that increasingly fluctuating electricity generation means that we can benefit from imports and exports across borders to an even greater extent.

Fig.1 The structure of the centralized control



2. Cenral Controller

The PHEVs are fast power sources; however, their available energy for frequency regulation is limited on the other hand, wind generators are rich sources of energy, but fast interactions can result in their fatigue. These characteristics make these two sources

great choices to complement each other. Therefore, the droop or the virtual inertia can be used by a centralized controller to decide how much power is needed to regulate the power system frequency, and then, the same control center can divide the power between these two sources based on their individual characteristics. The structure of the centralized controller is depicted in Fig.1. The controller gathers information from the microgrid, PHEVs and wind generator and sends back commands to the sources. As discussed, a low-pass filter (LPF) can be employed to share the power, but the coordination in practice is not straightforward because the energy storages units of the PHEVs are distributed and dispersed.

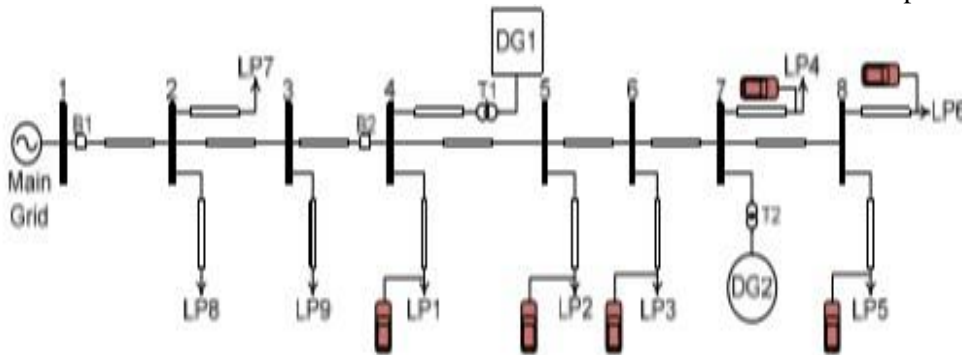


Fig.2 Studied system.

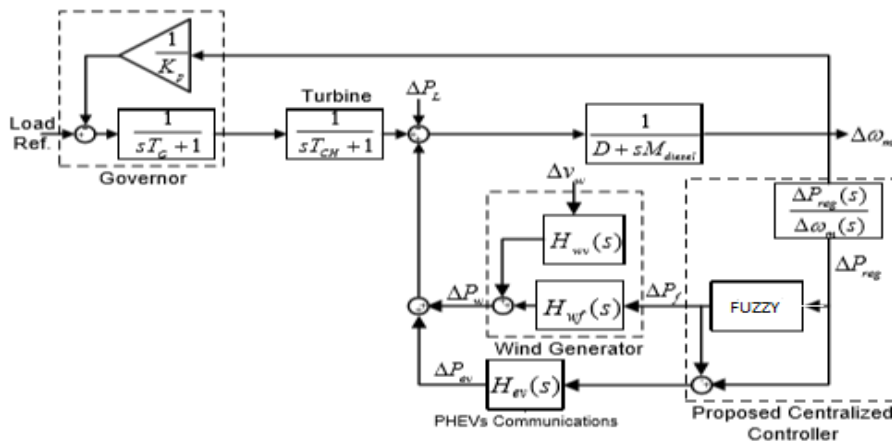


Fig.3 Proposed centralized controller.

For a meaningful analysis, a detailed model is needed. The system depicted in Fig. 2 is adopted in this paper. The system is a typical medium-voltage rural distribution system, a real system in

Ontario, Canada. The segment after the circuit breaker B2 can operate in the islanded mode and constitute a microgrid. It contains two DG units. DG1 is a variable-speed wind turbine

connected to a 2.5 MVA PMSG with a full-scale converter. DG2 is a 2.5 MVA synchronous generator with droop and excitation control systems. The stability analysis can be extended to either larger microgrids or weak grids.

$$\begin{aligned}\Delta \dot{x}_w &= A_w \Delta x_w + B_{wv} \Delta v_w + B_{wf} \Delta P_f, \\ \Delta P_w &= C_w \Delta x_w + D_{wv} \Delta v_w + D_{wf} \Delta P_f, \\ \Delta H_{wv} &= C_w (sI - A_w)^{-1} B_{wv} + D_{wv}, \\ \Delta H_{wf} &= C_w (sI - A_w)^{-1} B_{wf} + D_{wf}.\end{aligned}$$

2. DISTRIBUTED CO-OPERATIVE CONTROL

The generated reference power needed for the frequency regulation goes through a fuzzy or a high-pass filter (HPF) before reaching the wind and the PHEVs parking lots, respectively. Ideally, the system acts exactly like the perfect centralized controller. However, achieving such an ideal situation in reality is, if not impossible, rare. First of all, a delay could still exist. However, thanks to the distributed controller, the delays can be reduced dramatically with local measurements. Our studies showed that delays of less than 20 ms had no significant impact even in the case of high contributions from the wind generator and PHEVs. Smart parking lots or aggregators in dense areas can easily communicate with their vehicles with such small delays via low-cost local networks, which already exist for billing and monitoring. However, as discussed in the following subsection, the distributed coordination scheme is subject to some other unique threats and opportunities. Because the power system is subject to continuous changes and no immediate direct communication occurs between the PHEVs and the wind generator, the proposed controller must be robust against miss coordination and provide accessible control leverages. These concerns are discussed in the following subsections.

WIND SPEED:

Anemometers are often attached to wind turbines to control the start-up mechanism of wind turbines in low wind speeds, and also the shutting down of wind turbines in dangerously strong winds. Wind speed is a contributing factor to the energy output potential of a wind turbine. The greater the wind speed, the greater the energy output, assuming everything else is kept unchanged. Wind speed has an approximately cubic relationship with energy output. So, for example, if you were to double the wind speed, you would increase the power output by 8 times, it is easy to see this relationship in the graph provided below. Notice from the graph that at very low wind speeds the power output is near zero. This is because all wind turbines have a distinct start-up speed and a cut-in speed.

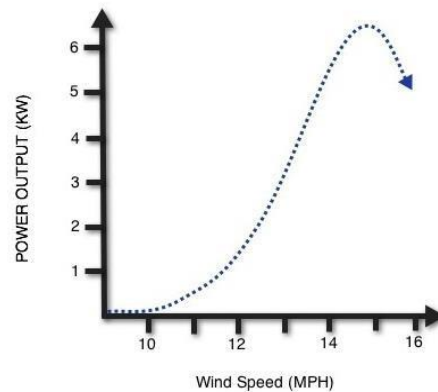


Fig.4 Power output based on wind speed.

The **start-up speed** is the minimum wind speed needed for the rotor and the blades to begin spinning, this low rotational speed will not provide any usable electric power. The more important, **cut-in speed**, is the wind speed at which the turbine generator will begin to produce electricity. This is a crucial piece of information to understand about wind turbine

generators. Just because the rotor and the blades are spinning, it does not mean that the generator is producing power. At low wind and rotational speeds, the turbine generator will produce no power until the wind speeds reach the required cut-in speed for that particular wind turbine.

we may come across a situation where

VARIOUS CUT-OFF FREQUENCIES

The energy injected by PHEVs may be increased by reducing the LPF cut-off frequency in some cases, flpf has no significant influence on the PHEVs power injection, as shown Maximum allowable HPF cutoff frequency, (b) The maximum frequency deviation at different LPF cut-off frequency. Impact of LPF cutoff frequency on (a) the maximum torque, (b) the maximum derivative of the torque of the shaft of the wind generator. Impact of LPF cutoff frequency on (a) the maximum energy, (b) the maximum power injected by PHEVs for the frequency regulation has shown. Because the PHEVs are used as the power sources, not energy, this almost constant power contribution means that the same number of the PHEVs is needed. In fact, separating the HPF and LPF in distributed coordination has resulted in this desired feature. In the centralized droop, the power injection of the PHEVs is highly dependent on the LPF cutoff frequency. In addition, the wind generator, and consequently the LPF, is more accessible to the system operator than the dispersed PHEVs HPF parameters. Without any need to change the control parameters of the dispersed vehicles, the mechanical tensions of the wind generator can be controlled without either significant changing in the system frequency behavior or involving more PHEVs in frequency regulation.

3. FUZZY DESIGN

The term fuzzy mean things which are not very clear or vague. In real life,

we can't decide whether the statement is true or false. At that time, fuzzy logic offers very valuable flexibility for reasoning. We can also consider the uncertainties of any situation. Fuzzy logic algorithm helps to solve a problem after considering all available data. Then it takes the best possible decision for the given the input. The FL method imitates the way of decision making in a human which consider all the possibilities between digital values Tand F.

into a crisp value. There are many types of techniques available, so you need to

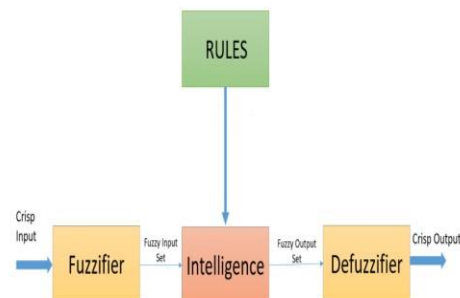


Fig.5 Schematic diagram of fuzzy.

It contains all the rules and the if-then conditions offered by the experts to control the decision-making system. The recent update in fuzzy theory provides various methods for the design and tuning of fuzzy controllers. This updates significantly reduce the number of the fuzzy set of rules.

Fuzzification:

Fuzzification step helps to convert inputs. It allows you to convert, crisp numbers into fuzzy sets. Crisp inputs measured by sensors and passed into the control system for further processing. Like Room temperature, pressure, etc.

Inference Engine:

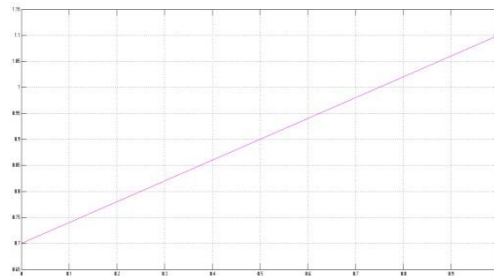
It helps you to determines the degree of match between fuzzy input and the rules. Based on the % match, it determines which rules need implement according to the given input field. After this, the applied rules are combined to develop the control actions.

Defuzzification:

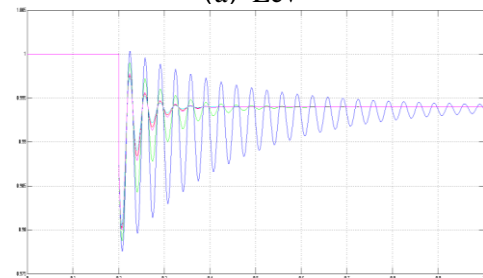
At last the Defuzzification process is performed to convert the fuzzy sets

select it which is best suited when it is used with an expert system.

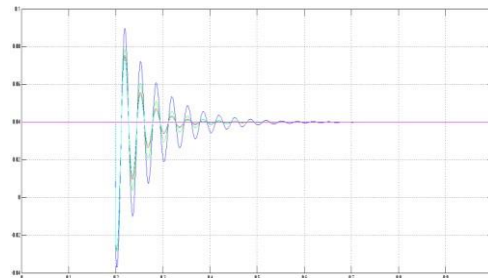
4. SIMULATION OUTCOMES



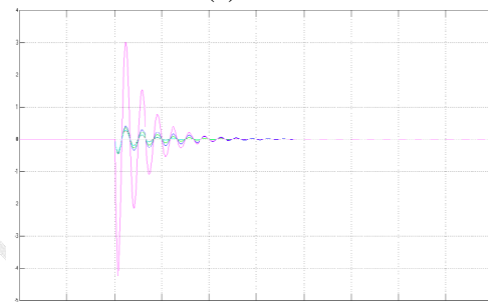
(a) Eev



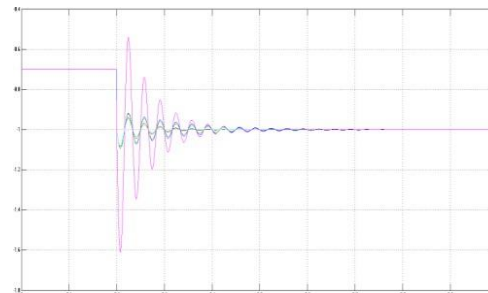
(b) Frequency



(c) Pev

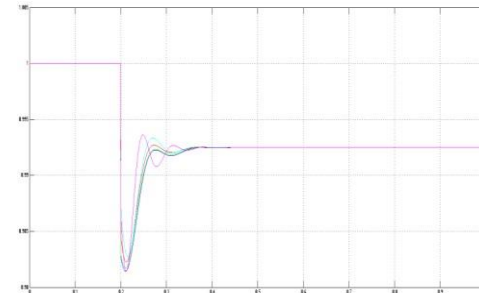


(d) ROCOTs

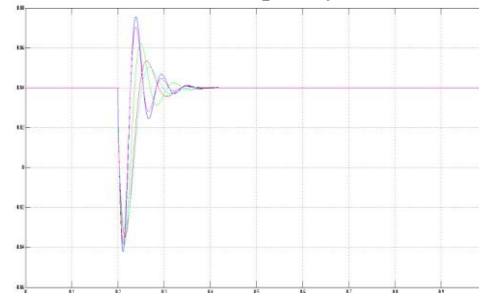


(e) Ts

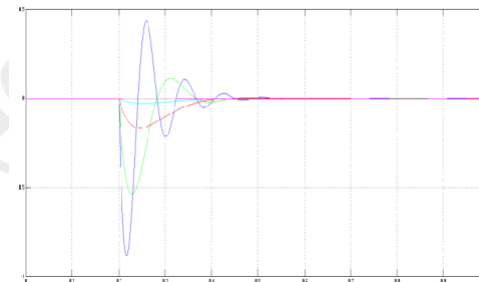
Fig. 20. Centralized control performance with $mp=80$ pu and $flpf=0.25$ Hz.



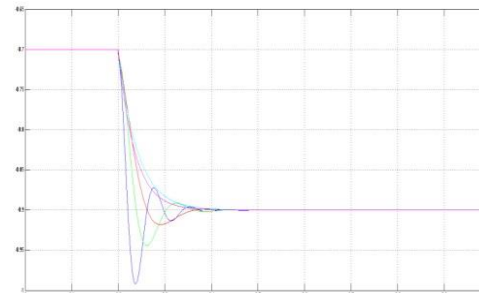
(a) Frequency



(b) Pev



(c) ROCOTs

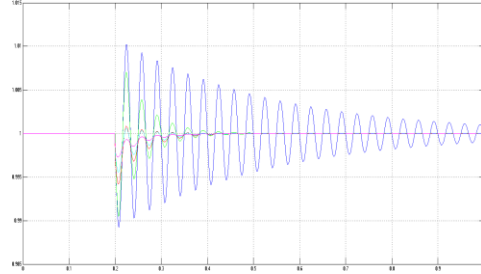


(e) Ts

(d) T_s

Fig. 22. Impact of the LPF cutoff frequency in distributed coordination.

(a) Frequency



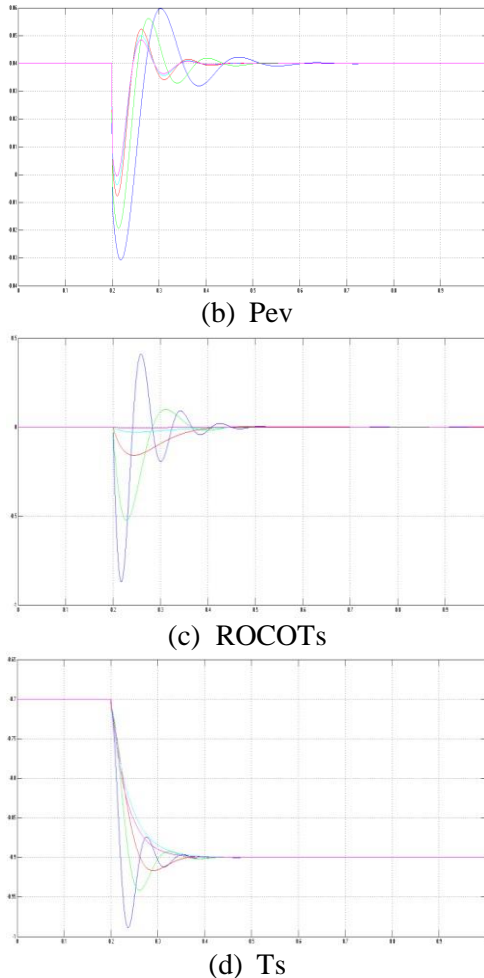


Fig. 23. Impact of unequal droop gains when $m_{p,wind}=40pu$, $flpf=0.25Hz$.

6. CONCLUSION

The coordination control of wind generator and PHEVs can compensate for each other's drawbacks and effectively participate in the primary frequency regulation of microgrids. The combination of both sources is coordinated each other at every perturbation and enhanced the system dynamic performance. As per the simulation outcomes, the virtual inertia does not appropriate to the frequency regulation tool for coordinated control. Furthermore, centralized coordinate control approach is rather suitable for a small contribution of wind and PHEVs in the presence of rapid communication system. The suggested approach shown the better performance over other conventional control techniques.

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