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Investigating the Dependability of Synchronous Machine at the Generation Station

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ABSTRACT: This paper investigates and analyze the dependability of the synchronous machines at the power generation station. The electrical power in practicality is not stable due to the rapid change of three-phase loads. This research presents a method to improve power quality and grid stability for power generation. By introducing synchronous machines, either virtual or physical connected to wind turbine, solar, and hydropower generator enable seamless operation in all operation modes and guarantees maximum power point tracking in grid-connected operation. The synchronous machines are dependable at the generation station due to their ability of sustaining the instability of the power system to improve generation and to curb transmission losses by injecting reactive power to compensate losses.

KEYWORDS: synchronous machines, virtual synchronous machines, power stability, dependability, distributed generation.

I. INTRODUCTION

Research has proven that the electric power in real-life is not stable due the increase of load to the generation source. (Chen et al, 2011) explains that the instability in the power system is been caused by increase of loads to the grid system. Some technologies used to generate power also causes system instability. (Mohammed et al,2019) proposed that the extent to which distributed generation (DG) and renewable energy sources (RES) are intended to be incorporated into the traditional grid is now undergoing extensive exploration. The desire to "Go Green" as a result of worries about the depletion of non-renewable energy sources and the preservation of the environment has compelled several nations to develop ways to obtain renewable energy for the creation of electric power. Photovoltaic and wind power are the most widely utilized renewable energy; they are both plentiful and ecologically benign. Technology has advanced quickly, which has contributed to the rapid affordability of renewable energy. Their crucial assistance of the electrical network in the electrification of remote and rural regions is another benefit. The increase in worldwide investment in renewable energy in recent years is evidenced by the popularity of wind and solar energy sources.

(Fernández-Guillamón et al,2019) also proposed that the grid-connected synchronous machines are essential for the stability of the power system. When a sudden power imbalance occurs, they are synced with the grid, and their stored kinetic energy is instantly retrieved. For instance, a sudden increase in a big load or the removal of a major generating unit from the grid may cause the machines on the grid to slow down and lower grid frequency as a result. But when the renewable energy sources overtake conventional generating in the power systems generation fleet. The major drivers behind this change in electricity generation are the depletion of fossil fuel supplies and the necessity of lowering greenhouse gas emissions.

II. METHODOLOGY

(Tsegaye et al,2018) uses the third order differential equation model synchronous generator was used for the model and three-phase generator which is rate 1.3MVA, 415V; 112.5 rpm parameters were used and it was connected to a 230kV supply through a transformer which is rated 10MVA $\Delta - Y$. Simulation was done with Matlab simulink.

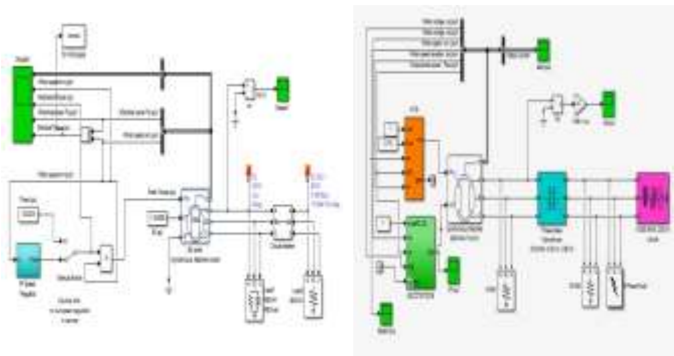

Figure 1. Hydropower with synchronous machine simulation blocks

(Mohammed et al,2019) suggested that dynamic responsiveness and power system stability would be greatly affected by the growing DG penetration level. Virtual synchronous generator (VSG) idea was presented to simulate the external characteristics of the SG using converter control method, in order to virtually give more inertia, in order to improve the frequency stability of the DG systems. However, A. Fernández-Guillamón et al. suggested that both wind and PV power plants are managed by power converters utilizing the maximum power point tracking (MPPT) approach in order to get the most power from the natural resource. This power converter is referred to as being decoupled from the grid since it prevents wind and solar power plants from directly adding to the system's inertia. Additionally, B. Muftau et al. suggested that the fundamental principle of the VSM is to replicate the Synchronous Generator's (SG) static and dynamic properties on the RES in order to derive the SG's ideal qualities. The VSM is anticipated to function without a hitch in grid and islanded modes and to offer reliable support for the grid under fault and steady state scenarios.

(Kabsha et al,2019) and (Cheema,2020) also conducted an experiment on virtual synchronous generator (VSG) and found out that, VSG is a blend of control algorithms, renewable energy sources, energy capacity frameworks, and power hardware that copies the inertia of an ordinary power system and furthermore VSG calculation is the essential piece of the framework which connected among various capacity units, age units and the utility network. Variable wind turbines are utilized in current grid system, and these turbines are associated with consecutive inverters which give total decoupling of inertia from the utility grid. Synchronverter is identical to a SG with a little capacitor bank associated in lined up with the stator. The unique conditions are something very similar; just the mechanical power traded with the central player is supplanted with the power traded with the dc transport. This geography doesn't need a critical underlying change in the plan and power framework to customarily play out its tasks.

(Noland et al,2019) also conducted research on the excitation of synchronous machines and proposed technologies to mitigate the excitation challenges of the synchronous machines. The proposed technology is modern WFSM, which will that will improve post-fault operation for reduced downtime and compensate cooling challenges of the synchronous machines.

(Chen et al,2011) experimented on the virtual synchronous machines and came out that, the main purpose of the virtual synchronous machine is to set up a static and dynamic presentation of electrochemical synchronous machine on the three-phase hysteresis control inverter with battery storage with the intent that a distributed generation with inverter connected to the grid will operate like normal synchronous machine. The virtual synchronous machine performance is strictly depended on the reference current which is been calculated by the help of the synchronous machine.

Properties of Virtual Synchronous Machine

The virtual synchronous machine has the ability to control both active and reactive power. The active power can be supplied by regulating the setting of the mechanical torque of the synchronous machine while the reactive power is by adjusting the setting in the excitation winding.

III. RESULTS AND DISCUSSION

(Chen et al,2011) To confirm the simulation results, a micro grid experiment was set up, which comprise of two asynchronous-synchronous machine sets (ASM-SM-set) with a nominal voltage of 15kw for each of the two machines

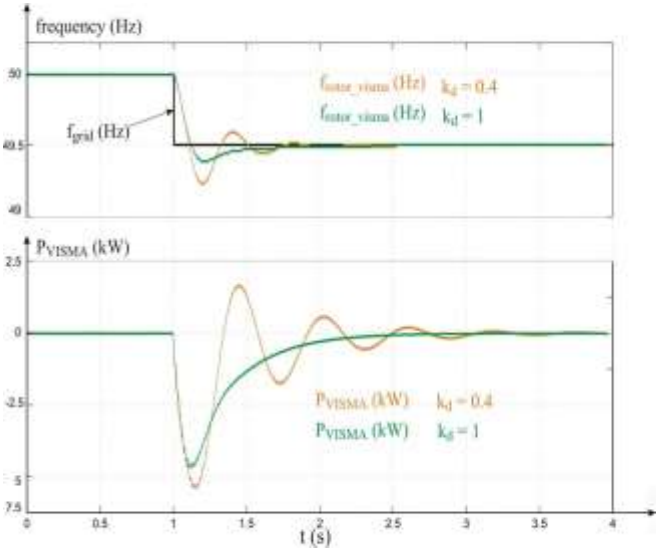

Figure 2. Effect of Virtual Damping

With one battery set for each of the system with 5kW power. The figure below shows the block diagram of the micro grid been experimented.

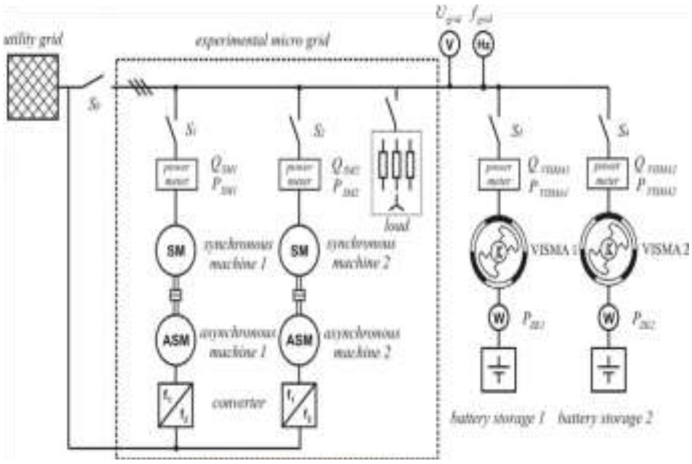

Figure 3. Block Diagram of The Micro Grid

The two ASM-SM-sets stands for the conventional controlled power plant is viable to supply the required frequency and the voltage changes in the grid caused by load activity. When the virtual synchronous machine is connected to the grid, it virtual torque and virtual excitation which is placed separately from each other help to eliminate oscillation that occurs in the grid (Chen et al,2011).

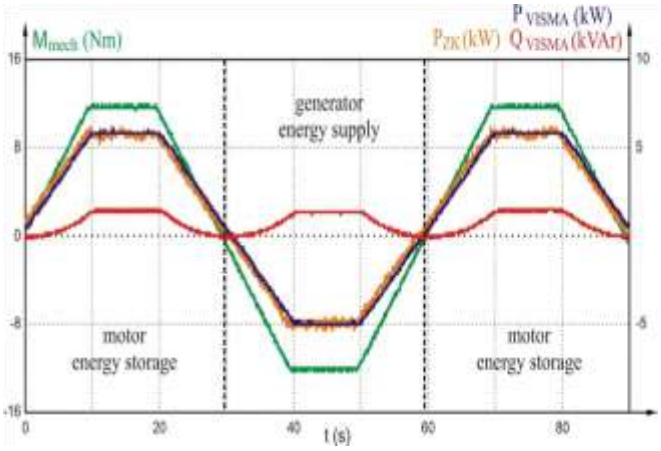

Figure 4. Investigation of the active, reactive and DC-link power in dependence of the virtual torque in VSMA

From the graph above shows the trace of VSMA active power (blue), corresponding to the power in the DC-link (light red) and reactive power (red), the active power follows the virtual torque M_{mech}. From the graph it is noticed that the active power follows the virtual torque straight. The reactive power changes significantly, because of the connection between the active and reactive power which can also be seen on conventional synchronous machines. The green curve represents the virtual excitation Ep. The results shows that the inductive and capacitive reactive power varies proportionally to the changes of the virtual excitation. (chen et al 2011).

IV. CONCLUSION

(Tsegaye et al,2018) concluded on their Matlab based research that the Matlab model has proven that the application of synchronous machine for hydro power plants with type 3 hydro governor and AC1A excitation system is precise that help the power plant to be stable to resist critical disruption that occurs in three-phase.

In order to maintain stability and sustainability, the integration of DGs into the power system network has continuously grown, which has led to an imbalance in the structure of the traditional power system, as this article gives important information on. The inertia of the entire system is reduced since the DGs systems lack the inertia and damping properties seen in conventional SGs. Accordingly, we evaluate conventional generation units, summing their inertia constant values for each kind of technology and rated power. Depending on the technology, wind turbines exhibit inertia values between 2 and 6 seconds, which is referred to as "emulated hidden inertia" in the industry. It was shown that in order to preserve stability and provide the best dynamic performance, a fast virtual Automatic Voltage Regulator (AVR) and a somewhat slow and well-damped virtual governor are required. Additionally, it accomplishes Low Voltage Ride Through (LVRT) during failures, Maximum Power Point Tracking (MPPT) during grid-connected operation, and Load Following Power Generation (LFPG) during islanded operation.

(Singh,2011) researched on six-phase synchronous generator and concluded that the synchronous generator has a great advantage as compared to other generators because when there is a fault on one three-phase, the other remaining three-phase is there to supply power to prevent total shutdown of system. Using the synchronous with hydro power plant there is no need to increase transformer kVA for phase shifting because it permits recombination of three phase power in step-up transformer bank.

(Cheema,2020) concluded on his experiment conducted on virtual synchronous generator and proceeded that the VSG solves the problem of low inertia and under damping up to some extends. The development of VSG provides a convenient and economical solution to utilize renewable power generation sources and widen their application prospects. Moreover, the growing integration of VSG into power system depicts that a large part of the future power system consists of a large number of VSGs along with conventional SGs.

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