Design and Implementation of PV Inverters for Transient and Voltage Stability Enhancement

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Abstract-This paper presents on developing efficient inverter for solarbased power system. Inverters place crucial role in electric grid system. By ensuring stable voltage and addressing transient events, such as sudden changes contributed to the over all stability and reliability of the power system. The hybrid system consists the solar PV systems with synchronous generator system and are fed to grid. The new proposes consist of SVPWM band technique to develop the gate signals for PV inverter. It leads improve the inverter performances. The PV inverts improves the transient stability of synchronous generator and that can be connected to grid and in the scheme makes the PV inverter's dc link capacitor absorb some of the kinetic energy in this synchronous machine. It is able to improve voltage ability of grid system. This proposed technologies are validate in MATLAB-SIMULINK environment.

Keywords- Photovoltaic generation, synchronous machine, transient stability, voltage stability

1. Introduction

In recent years, power systems have experienced a significant increase in the penetration of RE sources, which are usually connected to the power grid through power converters (such as inverters). The increase of PV generation implies some new technical challenges, such as transient stability, which makes the operation of power systems under severe disturbances an important issue. The overall system inertia and governor response are reduced for this new system configuration, which may negatively impact the transientresponse of the rotor angle of SMs. However, the inverters used in PV generation provide new opportunities, such as ancillary services to SMs. For instance, PV inverters may help maintain stability after a system disturbance, such as a short circuit caused by a lightning strike on a transmission line, which may trigger a FD signal that is responsible for opening the faulted line's circuit breakers . The GCs of the past two decades did not anticipate the significant changes in the power system configuration regarding the operation of power inverters. Even today, it is difficult to comprehend and estimate future scenarios of RE generation. Because of that, during the last decade, GCs have required the RE sources to be disconnected as soon as a disturbance is detected. This requirement is acceptable as long as the RE penetration level is not significant, which is done to prevent the loss of synchronism.

2. Proposed Scheme of the PV Inverter

The power system configuration shown in Fig. 1 is used for the transient stability analysis presented below. This hybrid power system consists of an SM operating in parallel with a PV system, both power plants are connected to the grid through two transmission lines. The PV system is composed of n PV units , these units are controlled according to a MPPT strategy under normal operation. However, during a fault in one of the transmission lines, the PV inverters can enable FRT in MC mode and perform the proposed control action to minimize the SM load angle (δr). It is well known that in an APF the grid currents can be indirectly controlled by making the APF inject the harmonic

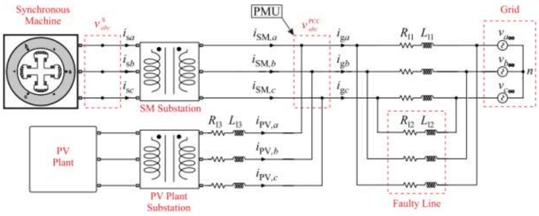

FIG.1 Three-phase diagram of a utility-scale hybrid power system.

components and reactive parts of the load currents. Similarly, the SM current components responsible for regulating the torque (or active power) and magnetic flux (or reactive power) can be imposed by controlling the currents injected into the grid by the PV inverters. This can be done because these inverters can act within the fault time frame, whereas the SM governor usually acts after the fault has ended. The disequilibrium caused by a disturbance can be reduced by maintaining the active power output of the SM as close as possible to its pre-fault condition. This means that, during the fault, the exceeding active power, that cannot be absorbed by the faulty grid must be delivered to the dc link capacitors of the PV units. Therefore, it should be noted that this strategy depends on the operational limits of the inverter, which must be considered.

$$P_{\mathrm{PV}}^{*} = \bar{P}_{\mathrm{g}}^{\mathrm{f}} - P_{\mathrm{SM}}^{\text{pre-f}},$$

where P¯f g is the average active power injected into the grid during the fault.
As determined by (1), the PV plant will require real-time measurements of the SM and of the grid. For this, as shown in Fig. 1, a PMU is installed in the SM substation to measure the voltage phasor at the PCC and the current phasors of the transmission lines. Current PMU technology
can transmit synchro phasor data at up to 120 samples per second to a PDC, which is located at the PV plant substation for the following analysis

3. Limitations Of The Proposed Control Scheme

The criteria for choosing the limit on the maximum dc link voltage is described in Section II. According to this criteria, the v max dc is 1500 V . The PV unit's inverter maximum absorbed power, calculated based on, is P inv max = 0.32 MW. This means that the PV plant will be limited to absorb a total active power of 16 MW, thus, the reactive power support will be limited to not exceeding the maximum apparent power of each PV unit.

4. Simulation Results

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The simulation results in correspond to the comparative analysis between the transient response of the following FRT schemes: the FLC with a VR-FCL installed between the PCC and the transmission grid through an isolation transformer , with a resistance having a nominal value of 1.6 p.u.; the PV plant in compliance with the German GC requirements; and the proposed control scheme.
The SM active power transient response is shown in Fig. 8a. The FLC and the German GC results show a significant decrease during the fault, which causes a disequilibrium between electrical and mechanical power. The proposed control shows a better performance during the fault, increasing the SM active power close to its pre-fault value only except during the PMU communication delay.

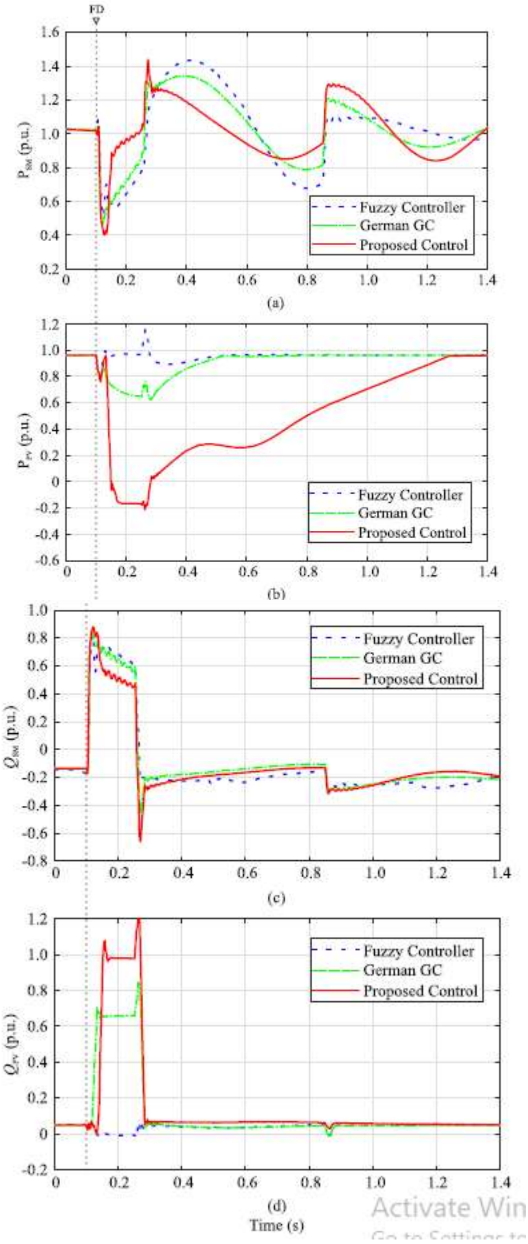

Fig 2: Comparative responses of the hybrid system subjected to a 2LG fault. (a) SM active power output. (b) PV system active power output. (c) SM reactive power output. (d) PV system reactive power output.

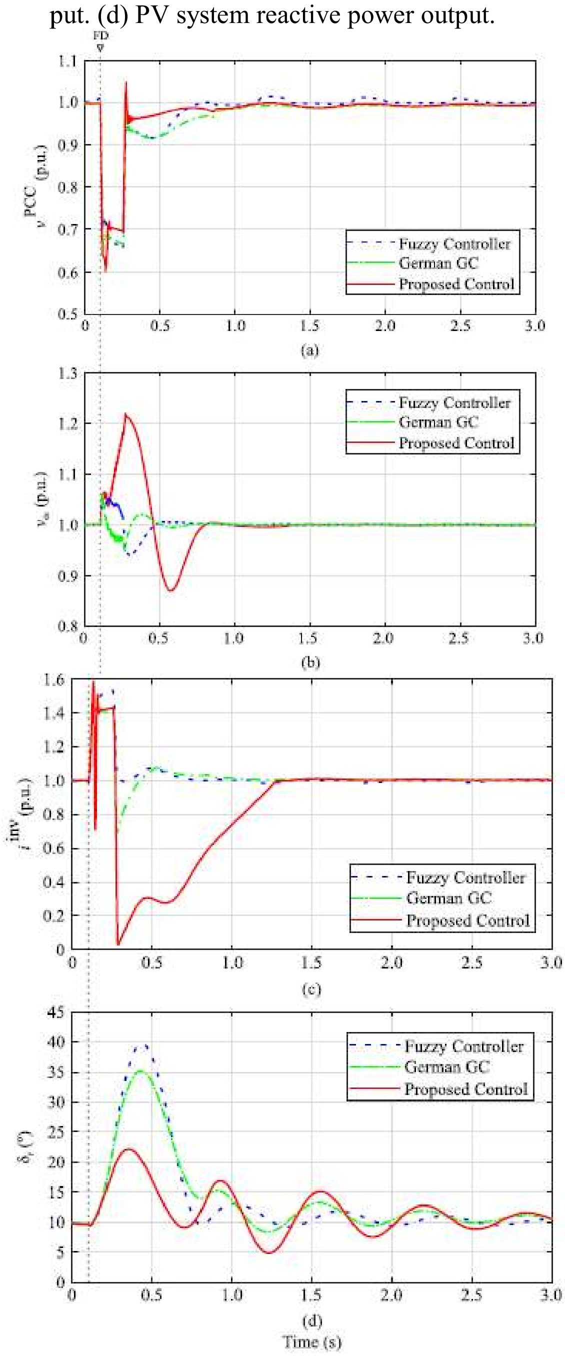

Fig 3: Comparative responses of the hybrid system subjected to a 2LG fault. (a) PCC voltage. (b) dc link voltage. (c) PV unit's inverter current output. (d) SM rotor angle.

5. Conclusion

In this work, a control scheme for PV inverters is proposed to act during faults that could compromise the transient and voltage stability of a hybrid power system. The analysis simulated that the proposed control scheme can act while the PV system is in MC operation, supporting the grid to recover stability during and after a disturbance on the transmission grid. The proposed control scheme makes the SM kinetic energy to be absorbed into the dc link capacitors to ensure transient stability. Besides that, it also enables the injection of reactive power into the grid to support voltage stability.
Simulation results have shown that the proposed control scheme can reduce the rotor angle oscillations within the first few cycles of the fault, effectively ensuring the SM's transient stability. It has also shown improvements in the grid voltages during the fault period and a very fast post-fault voltage recovery in comparison with other FRT control schemes.

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