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A Novel Fault Ride-Through Technique for Grid-Connected Large Scale Solar Photovoltaic Inverter

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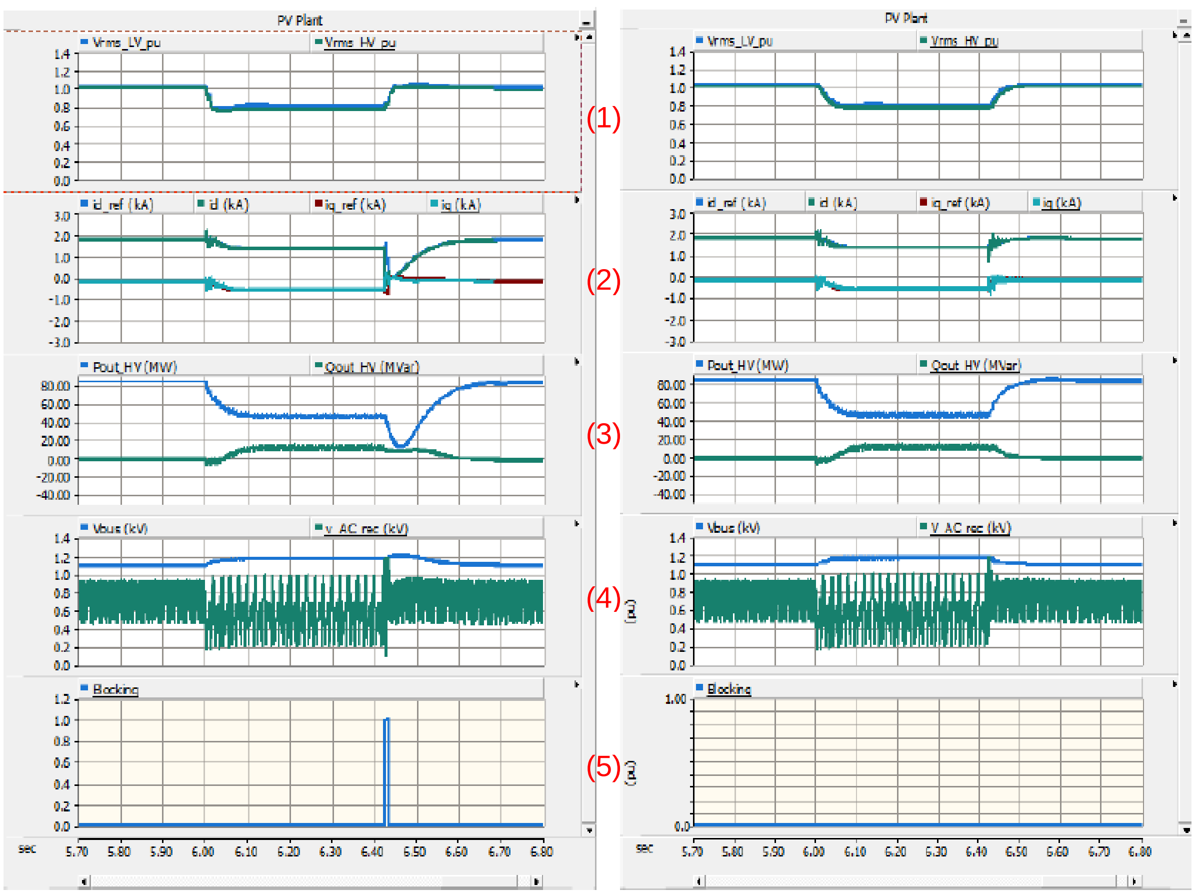
Abstract: Renewable power, particularly Solar photovoltaic (PV) will be one of the major sources of Australia's energy generation to meet energy demand while reducing the country's carbon emissions. The primary factor for site selection during the planning process of large-scale solar PV plant installation is usually favourable at remote locations where the public grid is not particularly strong due to high grid impedance levels. Integration of such power electronic based converter units equipped with complex fast-acting control systems into the weaker portion of the grid pose significant challenges for equipment manufacturers, grid planners and operators. These challenges stem from the fact that connecting this power electronic based converter to a weak grid may cause transient overvoltages, voltage oscillations and system instability. Integration of this power electronic based inverter into a weak grid requires comprehensive planning studies in order to evaluate the possible instability and reliability risks.

One of the key challenges of the PV inverter is to remain in continuous uninterrupted operation during voltage transients (over-voltages and voltage dips). Voltage dips are mainly caused by line faults in transmission and distribution systems and the condition of power system changes during these line faults. The voltage dip recovery after the fault clearance is always associated with an unpredictable increase in the grid voltage magnitude and phase angle jump. One major requisite for the grid-connected PV inverter is to be fast enough (within few milliseconds) to synchronize with the new grid conditions (such as voltage levels and phase angles) during and after the faults while reducing the overvoltage phenomena after the fault clearance irrespective of the weakness of the grid. Furthermore, multiple line faults occurring within very short periods of time (few seconds) can jeopardize the inverter's operation and can induce new fault characteristics. However, the current PV inverter control strategies are designed based on the assumption of a strong grid condition, where the short circuit ratio is high. It is quite difficult to adapt these control techniques to the transient processes of a weak grid as it requires more sensitive control and complex mechanisms compared to a strong grid. The inverter requires an effective control technique and robust fault ride-through (FRT) capability to remain connected and operated during the grid faults regardless of any grid conditions. The Australian Energy Market Operator (AEMO) has provided some standard guidelines (AEMO, 2018) to assess the performance of the large-scale grid-connected PV inverter prior to connecting to the grid to ensure that it can fulfill its obligations to operate the power system in accordance with the National Electricity Rules (NER).

Ingeteam Power Technology is one of the pioneers of PV inverter manufacture worldwide. One of the most noticeable achievements of Ingeteam is a new FRT technology developed in coordination with AEMO. This FRT algorithm introduces a novel control technique, which smooths the voltage variations during the fault clearance and reduces the overvoltage phenomena after the fault recovery as well as allowing prompt active and reactive power restoration regardless of any grid conditions. To demonstrate the benefits of this new approach an extensive analysis in different grid and fault conditions has been performed. Results up to now are more than promising and it is likely to become a standard of Ingeteam's PV products.

Figure 1 shows a comparison between the previous and the new proposed inverter control techniques. In this example, the solar park is working with a Short Circuit Ratio (SCR) = 3.5 and X/R = 10. It can be seen that after the voltage dip recovery at 6.43 seconds (as shown in graph (1)), the grid voltage increased significantly to 1.2 pu for a few milliseconds (as shown in graph (4)). To reduce the overvoltage phenomena and to synchronise with the new grid voltage angle after the fault recovery, the previous Low Voltage Ride Through (LVRT) control technique drops the active power injection into the grid to zero, which called a blocking technique (as shown in graphs (2) and (3)). Also, with this LVRT control technique, the restoration time required for active and reactive power recovery same as the pre-fault value is quite long. However, with the proposed new LVRT control technique, it offers clear improvements in overvoltage phenomena as well as fast restoration of active and reactive power without curtailing the active power injection to the grid.



(a) Previous technique (b) New technique

Figure 1. Comparison of LVRT with previous and new technique

References

AEMO, 2018, 'National electricity amendment (generator technical performance standards) Rule.' Available at: https://www.aemc.gov.au/sites/default/files/2018-09/Final%20Determination_0.pdf