NCPRE NEWS

August 2017

National Centre for Photovoltaic Research and Education
www.ncpre.iitb.ac.in
A Project of the Ministry of New and Renewable Energy at IIT Bombay

Smart PV Inverters with LVRT capability

Operation During Grid Abnormalities

NCPRE has been consistently working towards development of more efficient and reliable PV Inverters with advanced features so as to comply with the new standards. There is a need to shift paradigm from a ``fit it and forget it'' practice to the active integration of PVs. With more and more distributed PVs being connected to the utility, the ride-through operation during voltage disturbances and faults has gained attention. Hence, research in the domain of low-voltage ride-through (LVRT) technique for high PV penetration application is of wide interest.

According to IEEE Standard 1547, the DERs are supposed to disconnect from the utility whenever voltage at point-of-common-coupling (PCC) goes beyond overvoltage /undervoltage (OV/UV) limits. However, the tripping of large number of DERs connected to a common grid during an unintentional voltage disturbance can further degrade the system and can even lead to extreme voltage flickers or power outages. Many state grid codes, especially those by Germany, Italy and Japan demand low-voltage ride-through (LVRT) capability during faults in low-voltage (LV) grids as well, similar to the one stated for a medium- and high-voltage (MV-HV) grid. The new amendment of IEEE Std. 1547a suggests extended tripping time for DERs during abnormal voltage conditions as shown in Fig. 1, and demands active participation of DERs in voltage support for ride-through operation. These tripping times can be further adjusted by mutual agreement between the electric power system and the DER operators.

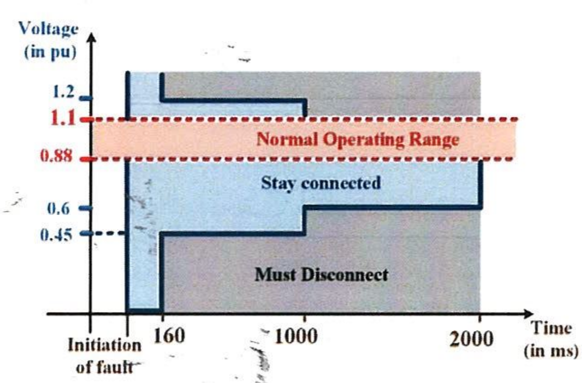

Fig. 1: Extended clearing time to abnormal voltages as mentioned in the amendment IEEE 1547a.

LVRT defines the requirement for DER to continue operating during short periods of low grid voltages and not get disconnected from the utility. Considering the new adjustable clearing times defined for operation during abnormal voltage events, there is a need to focus on providing better voltage support during LVRT operation rather than continuing to be connected to grid. Majority of the grid codes insist on injecting only reactive power from PV systems during grid faults to provide voltage support and stay connected to the grid. For LV grids with more resistive characteristic, the injection of only reactive power is not an effective way of voltage support. An integrated controller which can inject flexible active and reactive power according to local PCC parameters would help the cause.

In case of inverter-based PV systems, the injection of active and reactive power can be controlled independently using synchronous reference frame theory and instantaneous power theory. In the proposed smart PV inverters for enhanced voltage support, the active power injection is given higher priority than the reactive power injection during fault ride-through operation. A peak current limiter is imposed which controls the injection within inverter rated capacity. During an active power curtailment, the PV system shifts from the operation at maximum power point (MPPT) to non-MPPT mode. The anti-islanding OV/UV protection limits are modified and implemented based on the extended clearing times defined in LVRT curve to handle short duration grid abnormalities. The reliability of the system is improved by accurately distinguishing between an islanding event and a short duration voltage transients.

To handle an unbalanced grid condition, the power is injected in both positive and negative sequence component forms. This compensates the unbalance in grid voltages and improves the voltage profile. DDSRF-PLL is used to achieve accurate estimation of positive and negative sequence components of voltages and currents, and proper synchronisation even under unbalanced grid conditions. A multi-resonant current controller is implemented with improved frequency selective feature to tackle unbalanced current injections. Under all circumstances, the operation of the proposed LVRT controller is satisfactory, and hence can be considered as an integral part of the smart PV inverters.