Low voltage ride-through capability control for single-stage inverter-based grid-connected photovoltaic power plant

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1. Introduction

Over the recent years, photovoltaic system has become one of the most promising renewable energy in the world and is expected to develop rapidly in the future. With high level of photovoltaic power plants (PVPPs) penetration in the electric power grids, disconnections of these plants during faults are no longer possible as it may cause problems concerning stability, reliability, and operation of the power system (Hasanien, 2016). Due to that, many countries have established new grid codes (GCs) requirements for grid-connected PV system that should be met. These requirements impose that the PVPPs should avoid a high loss of power and stay connected to the grid in case of voltage sag, which is usually caused by grid faults. This ability is known as low voltage ride-through (LVRT) capability CEI - Comitato Elettrotecnico Italiano, 2014; Kobayashi, 2012; Garcia-Sanchez et al., 2012; Troester, 2009; E.ON Netz GmbH; Al-Shetwi et al., 2015. Recent studies have compared LVRT requirements for grid-connected PV power plants (GCPPPs) in different GCs were done in Al-Shetwi et al. (2015), Cabrera-Tobar et al. (2016). Many countries have proposed and implemented grid code connection requirements for LVRT, such as German, Spain, Japan (Kobayashi, 2012; Al-Shetwi et al., 2015; Cabrera-Tobar et al., 2015, 2016; Obi and Bass, 2016; Neumann and Erlich, 2012). In Malaysia, the LVRT requirements for large-scale GCPPPs have been recently imposed by Malaysian GC as shown in Fig. 1 (Commission Malaysia (ECM), 2017). These requirements stipulate that when voltage sag happens, the PVPP should stay connected to the grid in case it operates in the connection area above the blue curve in order to avoid power loss and grid frequency decreasing. The PVPP must not be disconnected from the grid for 150 ms when the line voltage (V) drops to 0% of the nominal voltage (V_n). Additionally, the voltage should recover 90% from its pre-fault value within 1.5 s from the occurrence of voltage sag. Besides keeping the inverter connected, the PV power stations are required to support grid voltage recovery through the injection of reactive power according to the standard requirements (Al-Shetwi et al., 2015; Commission Malaysia (ECM), 2017; Ding et al., 2016; Shah et al., 2015). Based on these requirements, the amount of injected reactive power is represented according to the ratio of injected reactive current and rated current (Neumann and Erlich, 2012; Ding et al., 2016).

During grid faults, there-are-two-major-issues-that-should be