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REVIEW OF FAULT RIDE THROUGH CAPABILITY OFGRID TIED PV PLANT

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ABSTRACT:

Over the recent years, the photovoltaic (PV) and its integration with the grid is penetrating steeply worldwide. Thereon, the integration of PV power plants (PVPs) needs to analyse thoroughly with their dynamics during grid faults and grid codes requirements. In line with this, the fault ride through (FRT) capability control of grid-tied PV plants (GTPPs) became the most important issue related to grid codes. This paper intends to an overview andcomparison of several FRT capability to improve the system dynamics during grid fault conditions. This paper intends to present an overview for control method to enhance fault ride-through (FRT) capability of grid integrated photovoltaic (PV) plants. The above method effectively regulates the voltage and active-reactive powerat the point of common coupling when a low voltage fault occurs. The grid connected inverter overcurrent and itsDC-link overvoltage can be effectively suppressed by tuning the PV system and the grid.

KEYWORDS: *Fault Ride Through, Photo Voltaic Plant (PVP), Phase Lock Loop, and Maximum Power PointTracking.*

1. INTRODUCTION

Earlier, Photo Voltaic Plant (PVP) required to be disconnect from the grid as soon as a fault occurred. However in the present scenario of rapid increase of photovoltaic (PV) generation systems needs more study for its influence on the power system operation [1]. At the time of voltage sags PV could boost the grid voltage and can regulate the grid profile. Considering such scenario, the grid connection requirements have been updated [2–4]. The disruption of these plants at the same time of grid disturbances may cause operational and stability problems to the grid and customers. [5]. Hence one of the most promising solution is the low voltage ride through (LVRT) or fault ride through (FRT) capability that should be met by Grid tied PVPs (GTPVP) via the PV inverters [6]. Thus, it is importantto analyze PV power's impacts on power grid and impacts of grid disturbances such as grid faults on PV farm generators [7]. As a result, for PV system-grid integration, the FRT capability control becomesan important aspect regarding the control system design and manufacturing technology [8] The FRT capability indicates that the PV inverter need to behave like traditional synchronous generators to tolerate voltage sags resulting from grid faults or disturbances, stay connected to the power grid, and deliver the specified amount of reactive current at the time of grid faults, respectively [9]. In the recentliterature, various studies have been documented in terms of FRTrequirements in modern grid code [10].

Low Voltage Ride Through (LVRT), is the capability of PV system to stay connected in short periods of lower electric network voltage (voltage dip) as shown in figure 1. It is needed at distribution level (wind parks, PV systems, distributed cogeneration, etc.) to prevent a short circuit at HV or EHV level

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from causing a widespread loss of generation. Similar requirements for critical loads such as computer systems and industrial processes are often handled through the use of an uninterruptible power supply (UPS) or capacitor bank to supply make-up power during these events. Along with the updates of grid codes, the control techniques of grid-tied PV inverters are required to be upgraded as well because the operation under the low voltage faults is much different from that under the normal conditions. To be specific, the main issues need to be considered include the over current caused by the abrupt voltage drop, the sudden surge of dc-link voltage as a result of the difference between input and output power, the fault detection and the phase-locked loop (PLL) under the low voltage faults. In order to successfully complete the LVRT operation, several control methods have been proposed. The most important task of the control to stabilize the operation under the condition of LVRT is to inject the required amount of reactive power in order to maintain the voltage sag due to fault. Under such conditions strategies must be designed so that PV system must be capable of ride-through under the condition of fault.

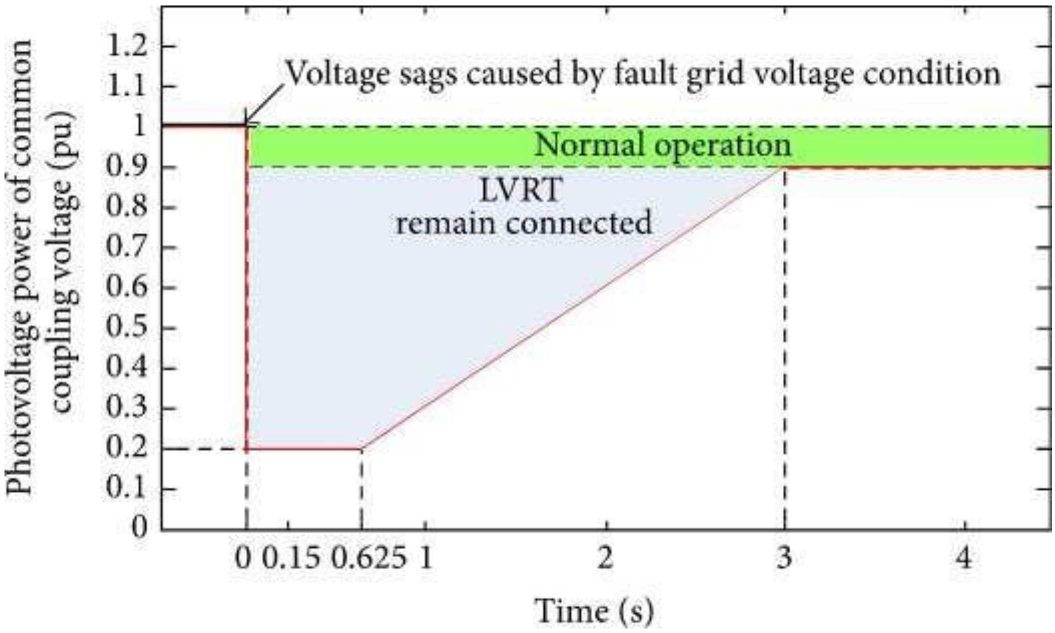

Fig. 1 FRT ability requirement of PV power stations.

2. FAULT RIDE THROUGH REQUIREMENTS IN MODERN GRID CODES

The FRT requirements for large-scale GTPVPs have been recently imposed by the utility system. As per the grid code whenever voltage sag happens, the PVP should stay connected to thegrid in the prescribed range of voltage and frequency in order to avoid power loss and grid frequency decreasing. This is required to make sure there is no loss of power generated due to commonly voltage sags. In some grid codes, the PVPP is expected to perform like the conventional synchronous generators in which reactive currents must be fed into the power grid in order to maintain the power system stability and to assist the voltage recovery. Besides keeping the inverter connected, the PVPare required to support grid voltage recovery through the injection of reactive power according to the standard requirements. Hence, the amount of injected reactive power is represented according to the ratio of injected reactive current and rated current. During grid faults, there-are-two-major-issues-that-should be addressed by the PVPs to achieve the FRT requirements mentioned above. The first one is the dc-link over-voltage in the dc-side of the PV inverter as well as the over-current that may occur in

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the ac side. The second one is the injection of reactive current, which is considered as an effective solution for voltage recovery and to support the grid in order to overcome the voltage dip. Most publications in the past focused only on ride-through of the fault for either single or two stages grid-connected PV power plants. However, always not sufficiently deal with the reactive current injection during voltage dip under all types of the grid faults along with the fault-ride-through capability and inverter protection.

3. METHODS FOR IMPROVING FRT

The major strategies proposed in the literature that have addressed the FRT capability of PVPPs connected to the power grid are illustrated in Fig. 2. The two fundamental approaches of FRT capability control can be divided into the FRT control using external devices and modified controller approaches. Energy storage systems (ESSs) including energy storage system (ESS) and super- capacitor energy storage system (SCESS), brake chopper circuits (BCC), flexible alternating current transmission system (FACTS) devices, in addition to some other methods such as fault current limiters (FCLs) and series dynamic breaking resistor (SDBR), are the FRT capability control strategies using external devices. The modified inverter controllers (MIC) and Computational are the improved controller strategies without additional devices.

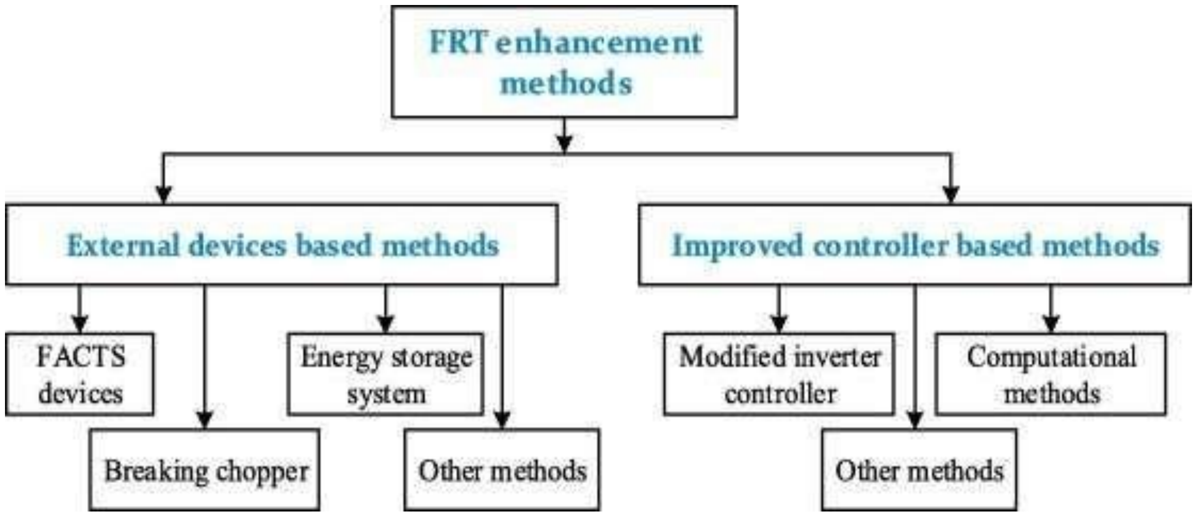

Fig. 2 Methods for FRT enhancement.

The typical ESSs can be connected to the DC-link through a DC-DC converter as shown in figure 3. Once a grid fault occurs, the ESSs will absorb extra energy from the DC-link at the inverter DC side to overcome the overvoltage incident. During this period, the duty cycle of the DC-DC converter is adjusted to reduce the output power of the PV battery in order to restrain the DC side voltage. After the grid fault, the energy stored is injected to the grid.
This BCC is effective for the protection of inverter against over-voltage which may be the consequence of the increase in the DC-link voltage during faults. It will be activated when the fault is detected, as shown in fig. 4. Therefore, the gate pulse of the IGBT will be switched on, whereby the excess energy generated by PV generators will be absorbed by the high-power resistor. Another worthy method to improve FRT capability of GTPVPs is the use of FACTS devices like STATCOM, SVC and SDBR which are presented in figure 5, 6, 7 respectively.

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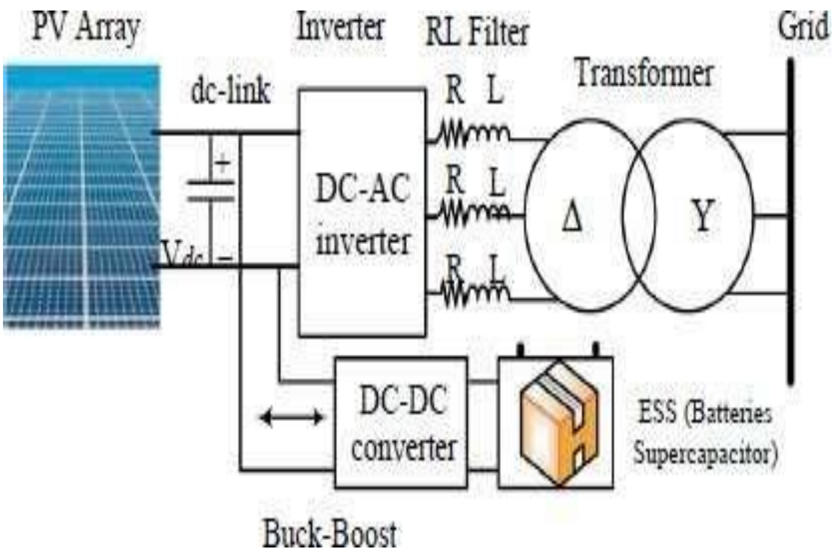

Fig.3 Fault ride-through improvement of grid-connected PV systems using energy storages.

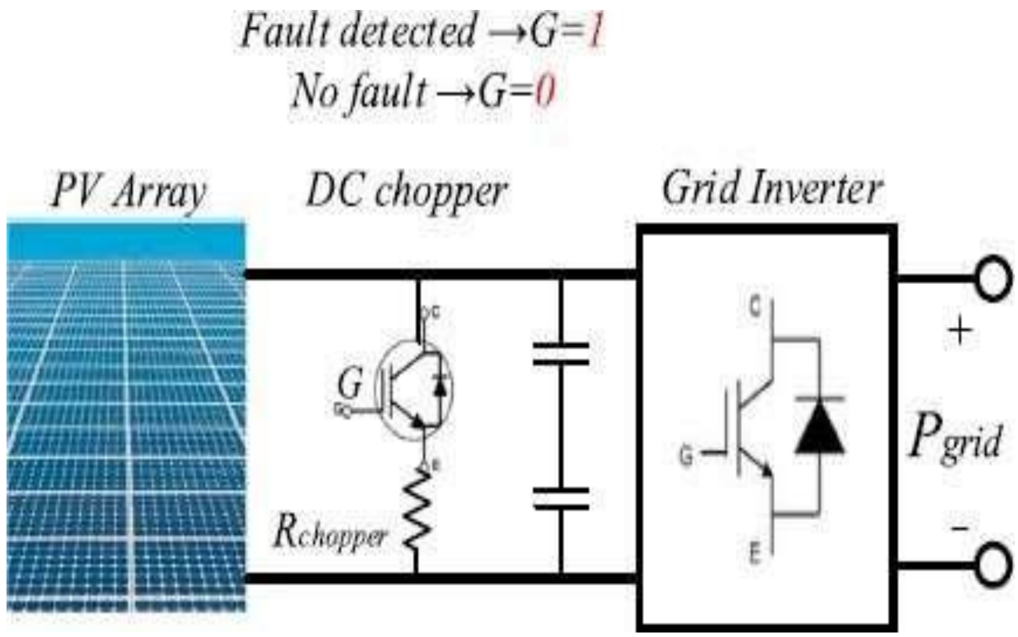

Fig. 4 Brake chopper protection in the case of the FRT operation.

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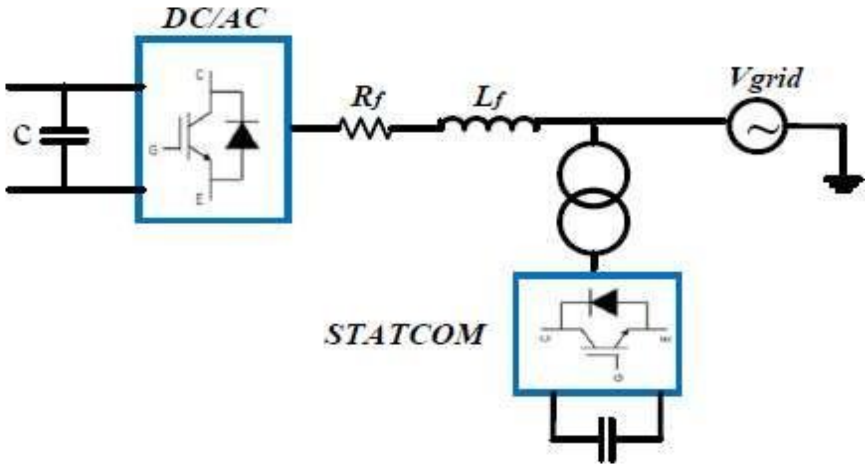

Fig. 5 Typical configuration of the STATCOM to improve the FRT performance for grid-connected PV system.

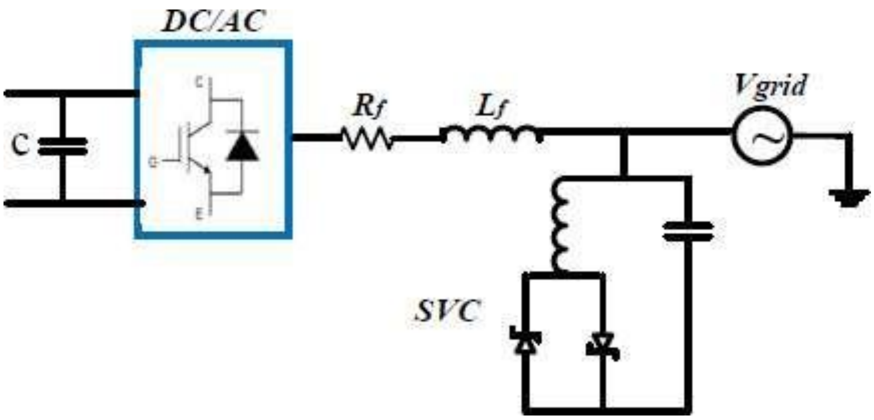

Fig. 6 Typical structure of the SVC to enhance the FRT performance for grid connected PV systems.

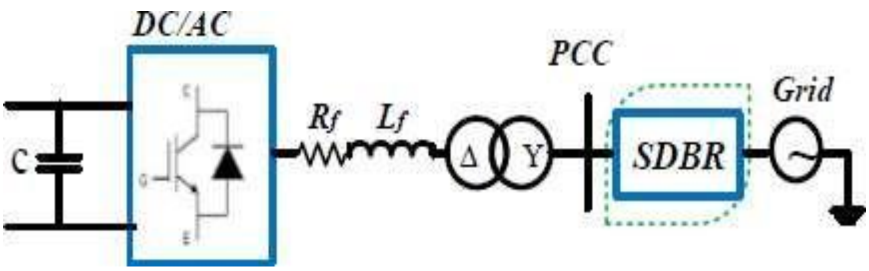

Fig. 7 Dynamic breaking resistor protection for the FRT operation.

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4. COMPARISON OF VARIOUS FRT TECHNIQUES

The controller is so designed so as to maintain the constant PV as well as DC boost voltage when the system is undergoing fault grid side. The methods mentioned in the literature have their own consequences and limitations which has been summarized in table 1 below

Table 3.1 The technical comparisons among all the above mentioned methods.

METHODS	ADVANTAGES	LIMITATIONS
Storage of energy system [14]	Excessive energy can be stored and can reduce the AC current	It reduces the system life and leads to the Dc parameters fluctuations
Brake chopper protection [15,16]	Efficient in protecting the inverter against overvoltage	Efficiency of the system reduces
STATCOM [17]	Fast response and efficient reactive current control	Effective active power measurement is reduced and required coupling transformers also switching action is increased
Static voltage compensator (SVC) [18]	Affective reactive power management and stability improvement of weak grid	Fast response causes unstable voltage oscillations
Static breaking resistor (SDBR) [19,20]	- High ability to restrict the excessive AC- current - Enhance the grid transient stability	Should mixed with other techniques to enhance the overall FRT performance

5. CONCLUSION

As the need of time demands to impose a robust FRT feature in a grid tied PVPs, a brief overview is presented in paper explaining the codes and requirement of FRT. Numerous techniques particularly external device based has been overviewed mentioning its limitation advantages and disadvantages.

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