International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 04, April-2019

LOW VOLTAGE RIDE THROUGH CAPABILITY ENHANCEMENT OF PV POWER PLANT BASED ON BATTERY ENERGY STORAGE SYSTEM

Samira Sadat [1], Jatinkumar [2]

[1] *Electrical Engineering Department& Gujarat Technological University,samirasadat100@gmail.com*
[2] *Electrical Engineering Department& Gujarat Technological University, jatinpatel@gcet.ac.in*

Abstract*— By increasing the electricity demand, the need for the application of renewable energy sources in the traditional transmission and distribution systems feels more than before. This paper presents Low Voltage Ride Through Capability enhancement of photovoltaic (PV) power plants based on battery energy storage system. This system consists of PV arrays connected to the point of common coupling (PCC), a grid tied inverter, battery energy storage system (BESS). The LVRT Capability based battery energy storage system is verified by the simulation results, which are carried out using MATLAB/SIMULINK software. So the proposed model improves the LVRT capability of the PV Power Plants in such a way that the DG power conversion unit remains connected to the grid even during fault conditions.

***Keywords*— low voltage ride through (LVRT), photovoltaic (PV) power system, power system control, power system dynamic stability, BESS.**

I. INTRODUCTION

The development and installation of photovoltaic (PV) system in the distribution grid shows the importance of renewable energy sources during last decades. The growing usage of renewable energy sources specially (solar and wind) shows a way to solve many problems against global warming and finally such sustainable sources may effect on the development of power system. In this paper, Battery Energy Storage System (BESS) is considered as LVRT Capability Enhancement. And PV system that is synchronized with the grid and supply power to the load as well to the grid. The (BESS) is used as a backup source during emergency times and fault conditions. This paper proceeds with the modelling of the PV power system, control algorithm, voltage source converter (VSC), BESS, grid tied Inverter. The simulation results presented in this paper, strongly shows the LVRT Capability Enhancement. [1][2][3]

II. LVRT

Low Voltage Ride Through (LVRT) is short for Low Voltage Ride Through and describes the requirements that generating plants must continue to operate through short periods of low grid voltage and not disconnect from the grid. LVRT is the capability of electric generators to stay connected in short periods of lower electric network voltage (voltage dip). It is needed at distribution level (wind parks, PV systems, distributed cogeneration, etc.) to prevent a short circuit at HV or EHV level from causing a widespread loss of generation. [3]

III. PROPOSED SYSTEM

THE PROPOSED SYSTEM IMPROVES LOW VOLTAGE RIDE THROUGH CAPABILITY USING BATTERY ENERGY STORAGE SYSTEM AND CIRCUIT BREAKER CONTROL. [1], [2]

A. *Grid Tied Inverter*

This paper presents three phase grid connected inverter design based dq0 transformation theory. The basic transformation equations are as follows. [1], [2]

$$\begin{bmatrix} u_d \\ u_q \\ u_0 \end{bmatrix} = \begin{bmatrix} \cos(\omega t) & \cos\left(\omega t - \frac{2\pi}{3}\right) & cos\left(\omega t + \frac{2\pi}{3}\right) \\ -\sin(\omega t) & -\sin\left(\omega t - \frac{2\pi}{3}\right) & -\sin\left(\omega t + \frac{2\pi}{3}\right) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix} \begin{bmatrix} u_a \\ u_b \\ u_c \end{bmatrix} \quad (1)$$

Synchronous reference frame theory is suggested due to its good performance for control applications, dc quantities are easily controllable without having steady state errors. The current control loop based on PI controller is implemented as inner control loop. The transformation makes it easy to synchronize the inverted signal with grid by obtaining phase-

Angle signals from Phase Locked Loop (PLL). The output of analysed signals is given as input to the sinusoidal PWM gate pulse generator. The pulse width modulated signals fire the IGBT switches as per the input signals. [4]Fig.1 shows the inverter controller in Simulink.

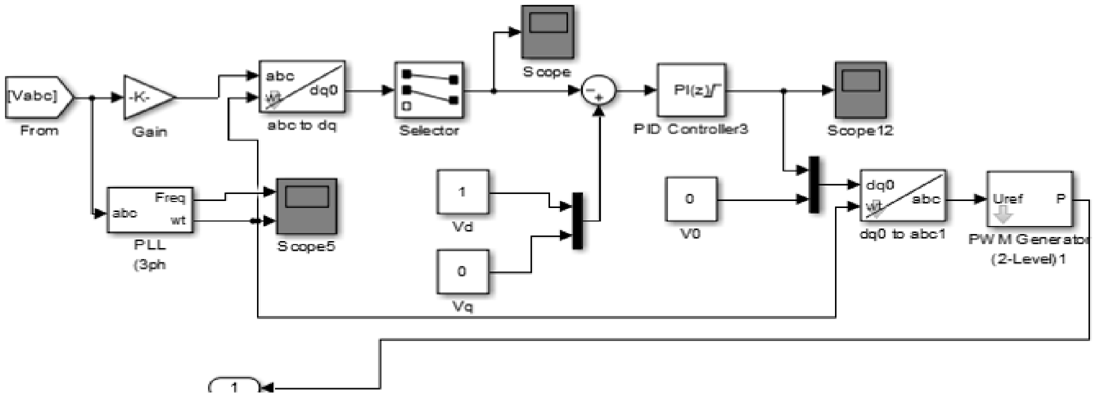

Fig.1 Matlab/Simulation of grid tied Inverter controller

B. LCL Filter

LCL Filter is selected over L and LC filters as it gives better reduction in switching harmonics. The current control strategy however becomes complex from the stability point of view. The filter is connected after the inverter and before the utility grid. In operation of grid connected inverter the filter performs 2 main functions. First; its inductive behavior limits the effect of current surge and second, it reduces the effect of side band voltage harmonics generated by PWM [5].

Where Li = 38.4mH, Lg = 35.4 mH, Nominal power= 10kW, Grid frequency=50 Hz, Switching frequency=4 kHz, Line to line RMS Voltage = 380 V, DC-Link voltage= 1000V,

The block diagram of the proposed system to implement LVRT is shown in Figure 2. [3].

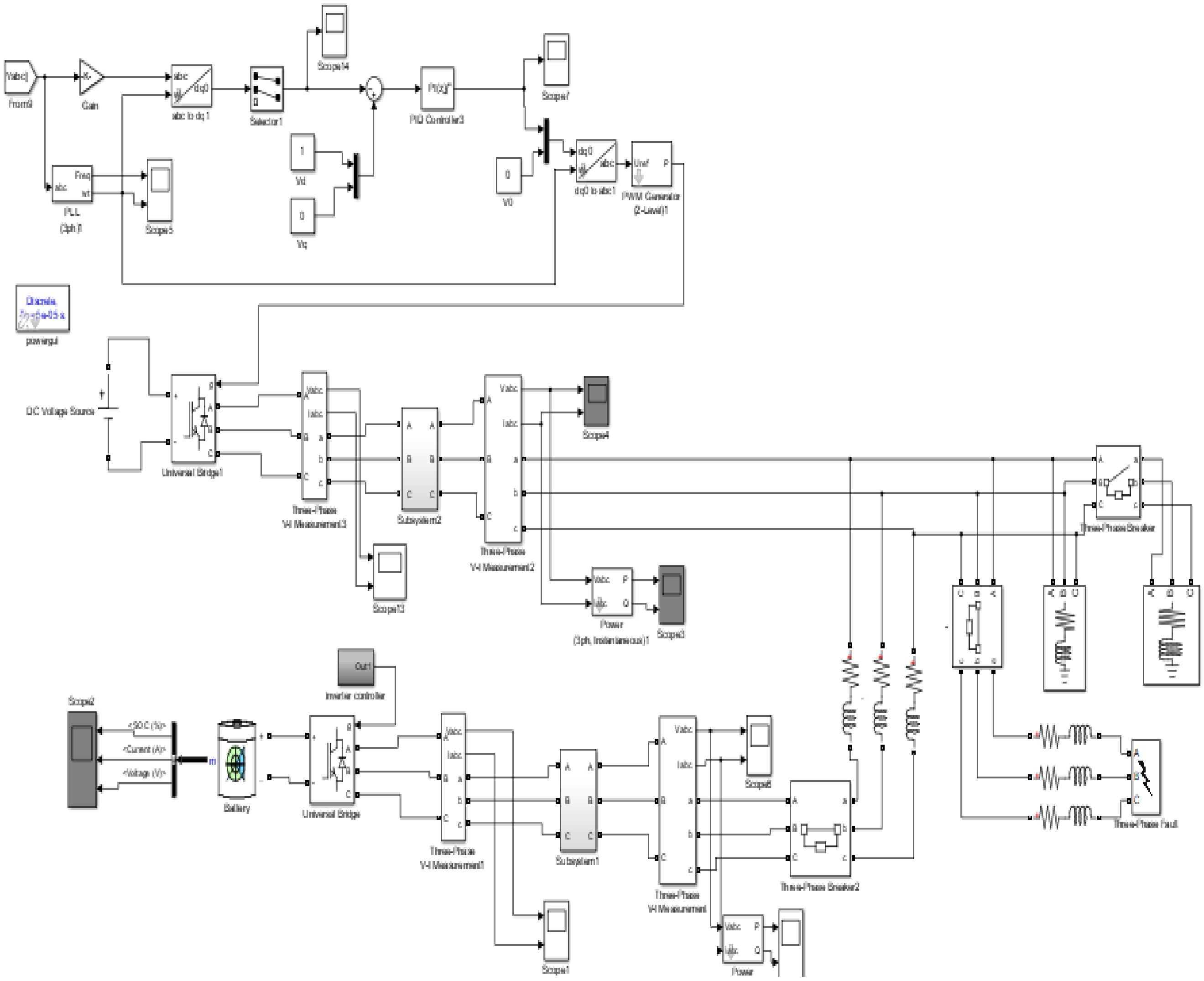

Fig.2 Matlab/Simulation of proposed system

C. SIMULATION RESULTS

The control of the grid-connected inverter and BESS which supplies the system with active and reactive power improvement is performed. BESS is considered as a backup to improve LVRT Capability during fault condition that in this paper is considered for 0.3-0.4 sec. thus system by adding BESS to the grid connected system is able to continue transferring

Power to the load even during fault conditions. By occurring fault in the system, voltage profile and active power is decreased while reactive power and current value is increased. So by using the proposed system, grid connected system is able to go back easily to the healthy condition. The MATLAB simulation results of proposed system have been shown in figures below.

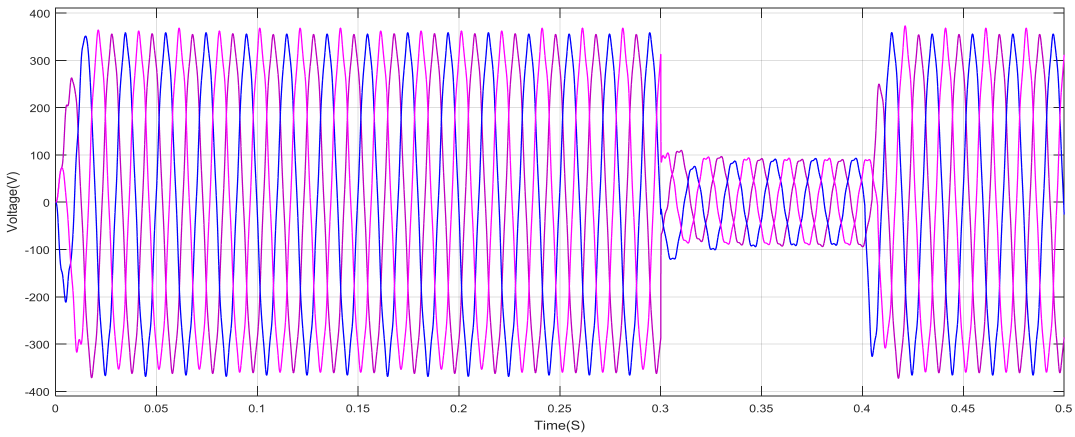

Fig.3 Voltage profile in fault condition

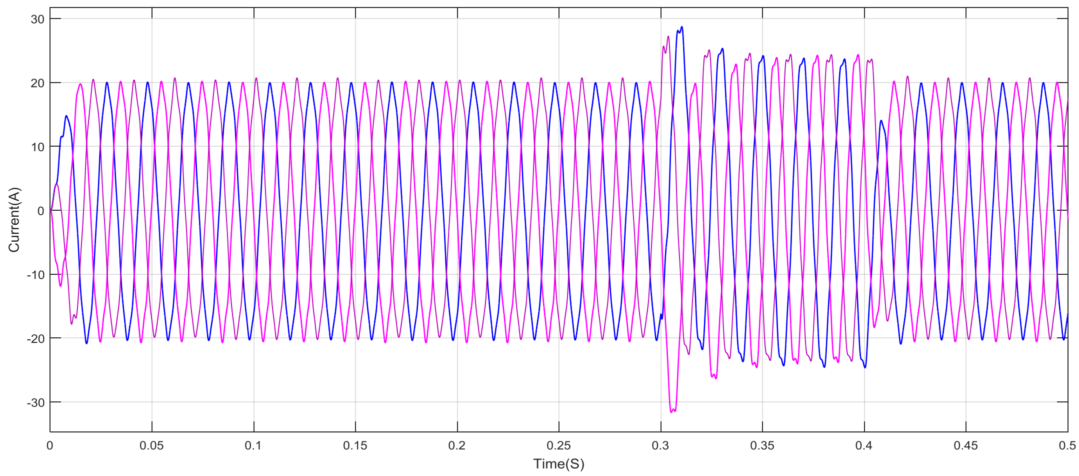

Fig.4 Current profile in fault condition

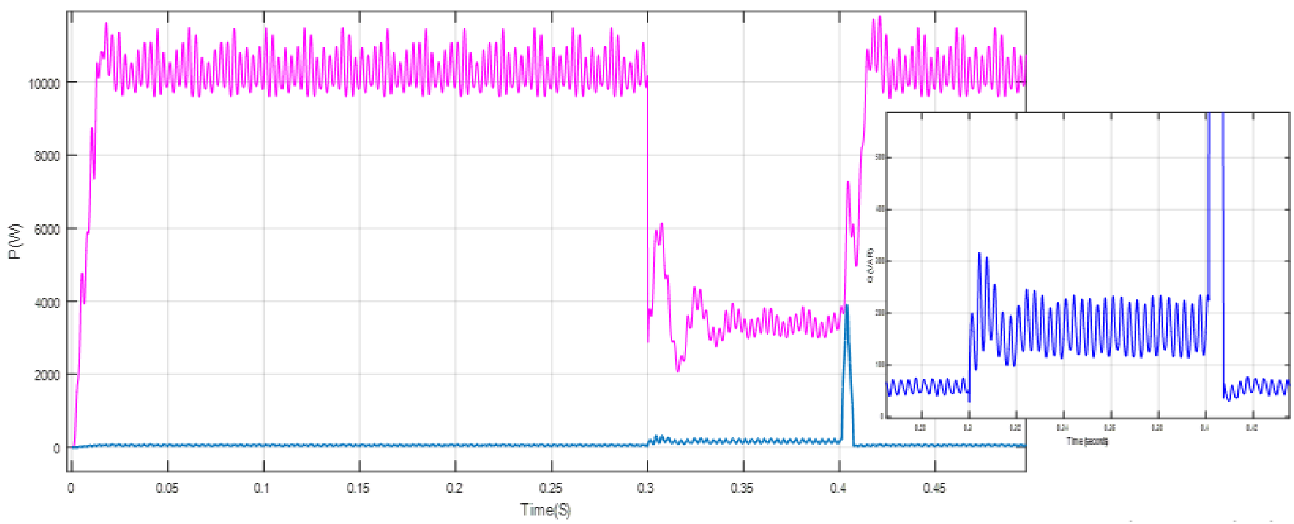

Fig.5 Active and Reactive Power in fault condition

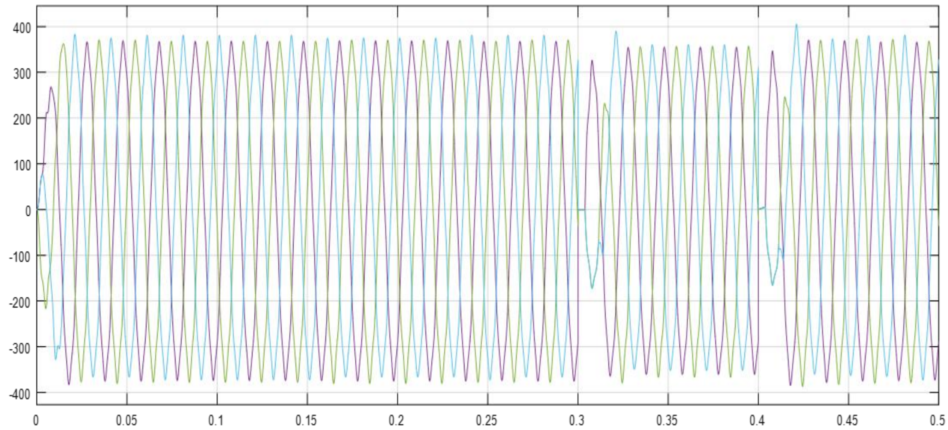

Fig.6 Voltage profile after fault

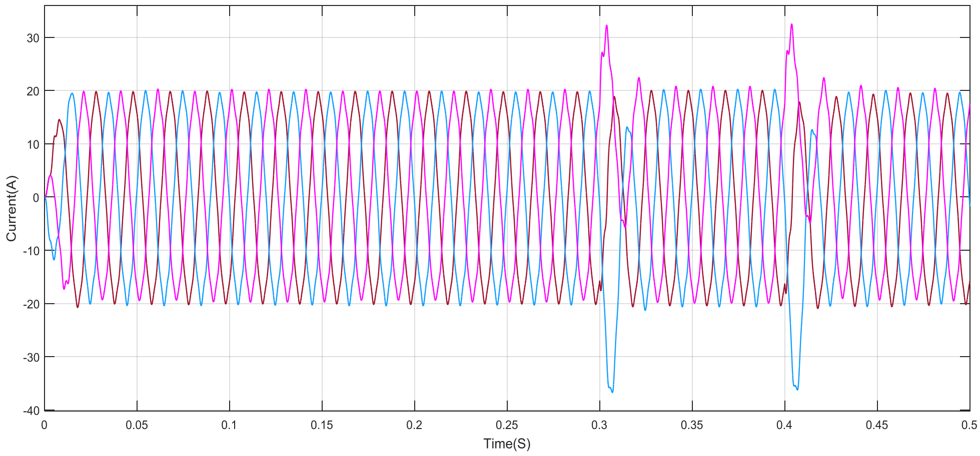

Fig.7 Current profile after Fault

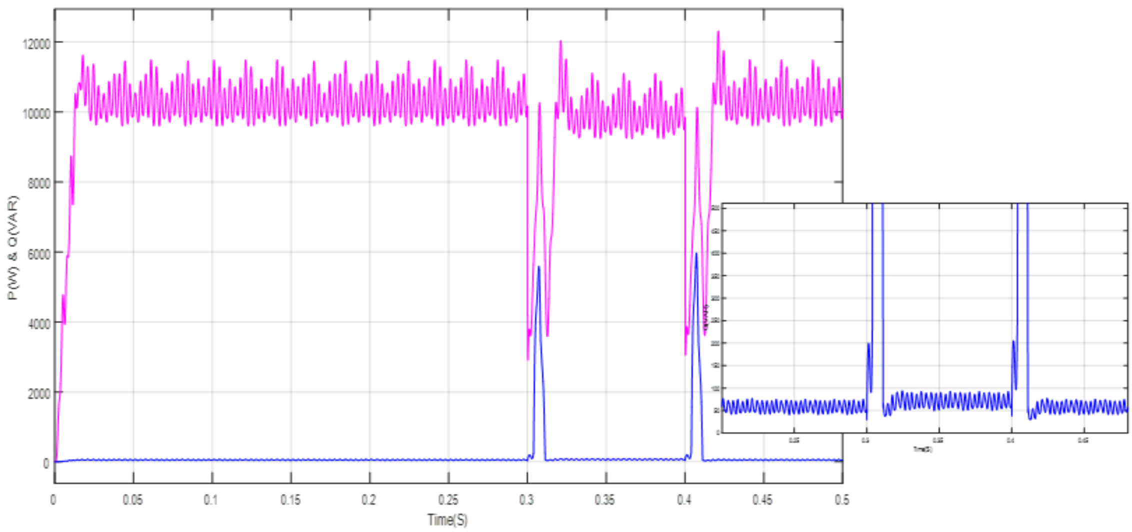

Fig.8 Current profile after Fault

IV. CONCLUSION

The simulation results of the proposed system successfully proves the enhancement of LVRT capability of Photovoltaic(PV) systems based on BESS by increasing voltage profile and reactive power during fault conditions therefore is able to keep the system transferring power to the load even for very short time of fault occurrence in the system.

V. REFERENCES

[1] Mr. Pratik Nagesh Joshi "Improving Low Voltage Ride Through Capabilities of Grid Connected Residential Solar PV System Using Reactive Power Injection Strategies", IEEE International Conference 2017

[2] Yongheng Yang, "Reactive power injection strategies for single phase PV system considering grid requirement," IEEE Trans. pp. 2014.

[3] Sasmita JenaPerformance Analysis of Solar PV Based Microgrid With and Without BESS Estimating the Expected Battery Life", IEEE International Conference March 2018.

[4] Katiraei, F, & Aguero "Solar PV integration challenges", IEEE Power transaction, 2011

[5] Huang, B. J., L in "Performance evaluation of solar photovoltaic/thermal systems", Solar Power, 2001.

[6] M. Kazmierkowski and L. Malesani, "Current control techniques for three-phase voltage-source pwm converters: a survey,"Industrial Electronics, IEEE Transactions on, vol. 45, no. 5, pp.691 - 703, Oct. 1998.

[7] Xiangdong Zong, and Peter W. Lehn, "Reactive Power Control of Single Phase Grid Tied Voltage Sourced Inverters for Residential PV Application" IEEE University of Toronto 2012.

[8] Yongheng Yang, F. Blaabjerg, and H.Wang,"Low voltage ride through of single phase transformer less PV inverter," IEEE Trans. Ind. Appl.. vol. 50 no.3.pp. 1942-1952, May/Jun. 2014.

[9] Ramakant A. Gayakwad, "Op-amps and linear integrated circuits" Reference book PHI publication New Delhi, 2011.

[10] Dr Ak Raji "Design And Development Of A Smart Inverter System" Cape Peninsula University of Technology, December,2015.

[11] Twining, E. & Holmes, D.G., 2003"Grid current regulation of a three-phase voltage souinverter with an LCL input filter". IEEE Transactions on Power Electronics.