Flexible AC Power Flow Control in Distribution Systems by Coordinated Control of Distributed Solar-PV and Battery Energy Storage Units

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Abstract – *In this paper the flexible AC power flow control in the distribution system by coordinated control of distributed renewable energy resource such as solar photovoltaic and battery energy storage systems is designed .The flexible AC transmission systems (FACTS) have been used for controlling power flows and the outputs of the proposed flexible AC power flow control system can be used to help the distribution network operator to optimize the use of renewable energy resource and battery energy storage systems. To validate the proposed system simulation has been carried out using MATLAB/SIMULINK.*

Keywords: Battery Energy Storage, coordinated control, flexible AC distribution systems, solar PV units

1. INTRODUCTION

The Flexible AC Transmission System (FACTS) is an evolving technology controls to enhance the controllability and power transfer capability in the transmission corridors based on power electronic applications. Significant penetrations of power electronics equipment, control center technologies and associated automation are the benefits of FACTS technologies. FACTS technology can increase the reliability and reducing the power delivery costs. Improve the power quality and power transfer efficiency by FACTS devices appropriately injecting the reactive power to the grid. The use of flexible AC distribution system (FACDS) devices has emerged with the increasing applications of FACTS devices in power systems. By intermittent power output from multiple solar-PV units is applying FACTS in distribution systems for mitigating power quality issues and controlling power flows in distribution systems the adverse effects of voltage sags.

The advantages of FACTS device are

(a) In most of the distribution lines compared to that of the transmission lines can lead to divergence in the load flow analysis by High *R/X* ratio.

(b) There is more distribution lines connected to a node.

(c) Many small distributed renewable resources connected to the distribution system while only large wind or solar farms are connected in the transmission system.

The utilization of both active and reactive power flows BESS inverter systems for controlling are examined. The operational flexibility by controlling power flow paths can enhance the proposed multiple input-multiple output inverter interfaced controls. The concepts of flexible DC distribution systems by utilizing BESS converters and control devices act as stand-alone controllers are subjected to distribution system operation inherently varying constraints associated with it. Smoothing power fluctuations experienced between the DC distribution system and the AC grid with co-operative controls among BESS and renewable DG units.

2. GRID-CONNECTED PHOTOVOLTAIC & BESS SYSTEM

Figure1 shows the grid-connected photovoltaic systems includes power conditioning unit and are designed to operate in parallel with the electric utility grid with PV arrays connected to the grid. The power conditioning unit may include control system needed for efficient system performance and has the MPPT, the inverter, the grid interface. There are two general types of electrical designs for PV power systems: systems that interact with the power grid utility with no capability of battery backup and systems that interact with power grid utility include battery backup as shown in Figure 1.

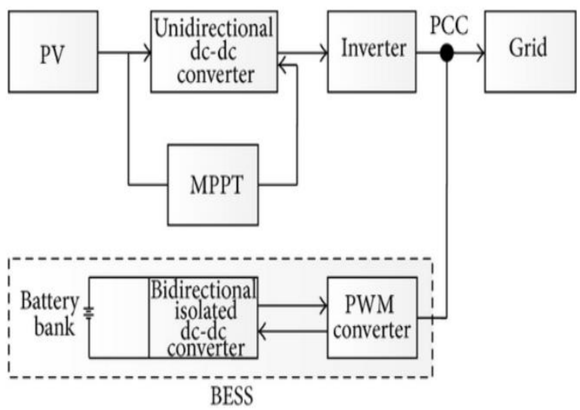

Figure 1 Battery energy storage and PV systems connected to the utility grid

Other specifications are imposed by the grid requirements to make grid-connected PV systems more capacity to recover quickly from difficulties and grid-friendly: (1) secure/reliable the power supply (2) flexible control of active and reactive power (3) dynamic grid support per demands (4) system protection, communication and condition monitoring (5) low cost ,high efficiency and high reliability.

Two basic storage architectures commonly found with grid-connected PV systems a shown in figure2 (a) Shows architecture that consists of separate battery charge control many older systems have used where a device controls power collected from the PV array. This arrangement does not allow efficient extraction of excess PV power for supply to the grid when the batteries are fully charged leaves the inverter to provide backup battery charge control from the utility power grid when insufficient PV power is available. Figure 2 (b) shows an architecture that is PV array power to be directed optimally by the inverter to batteries or the utility power grid as appropriate more common in modern grid-connected PV power systems. During a utility outage storage provides the opportunity to supply power to critical loads in both cases and is not available without storage.

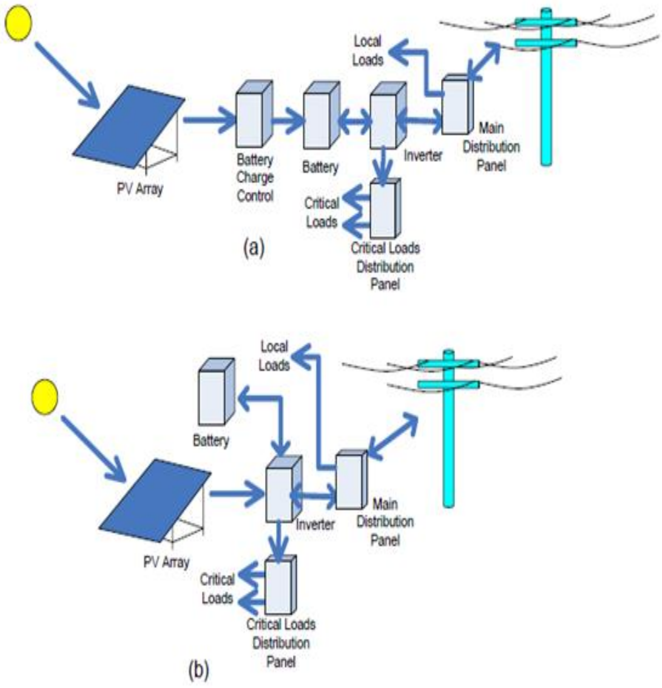

Figure 2 Grid-connected PV systems with storage by (a) separate PV charge control and inverter charge control (b) integrated charge control

3. SIMULATION AND DISCUSSION

The proposed strategy on the operation of the test distribution system model have been carried out connected to grid system is simulated using MATLAB/SIMULINK software as shown in figure3 .

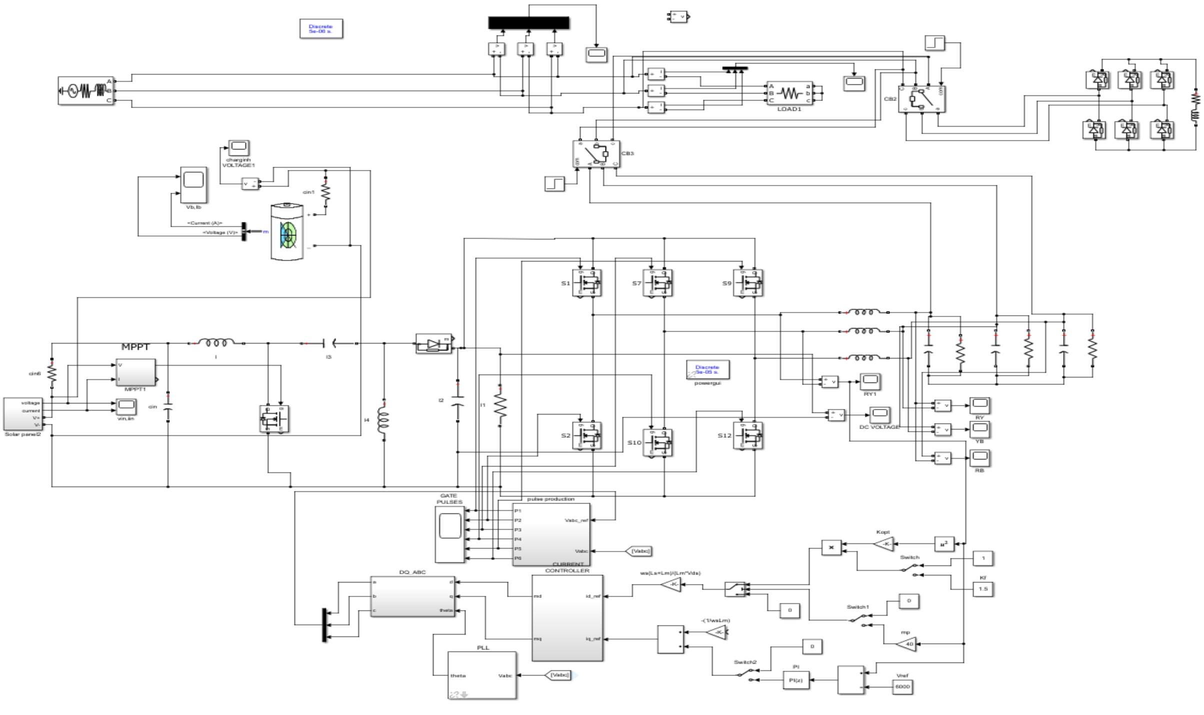

Figure 3 Simulation Circuit with solar PV array & BESS

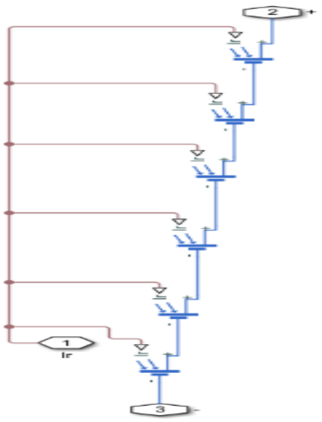

Figure 4 Solar Array Arrangement(6 cell)

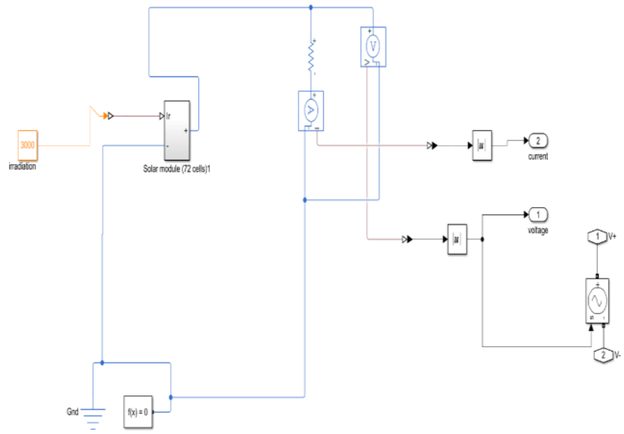

Figure 7 Solar PV arrary

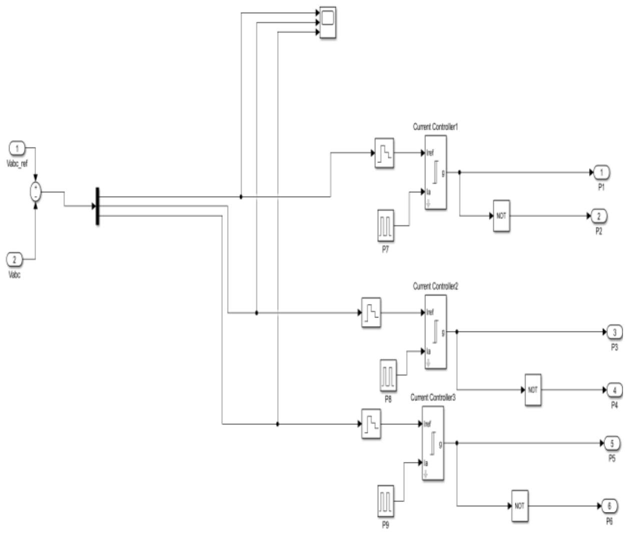

Figure 5 Pulse production

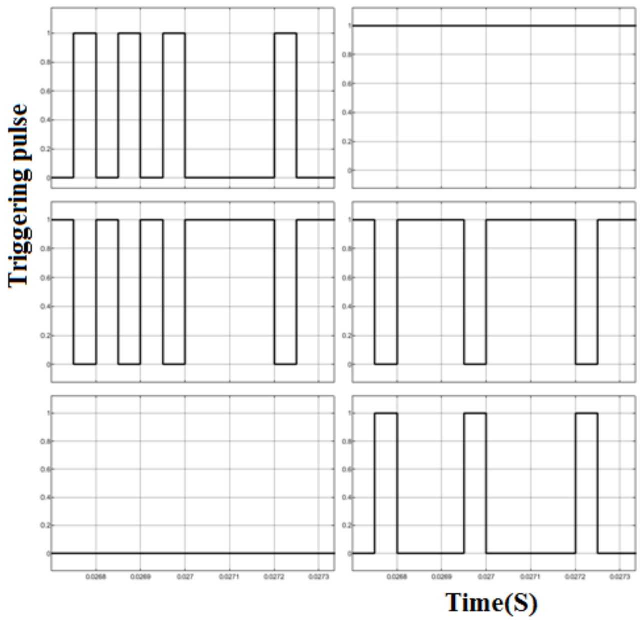

Figure 8 Gate Pulse

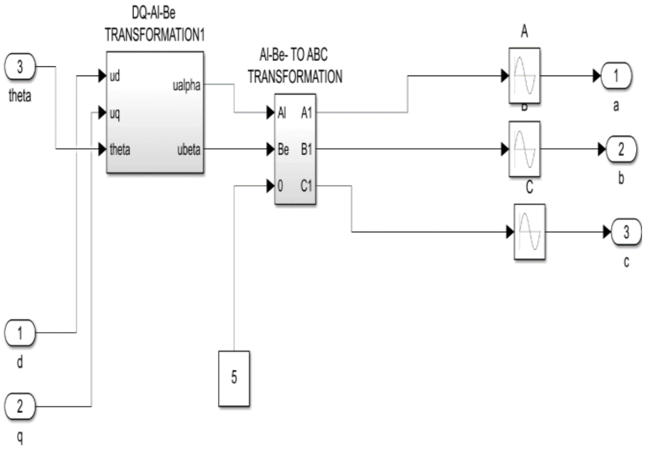

Figure 6 DQ Transformation circuit

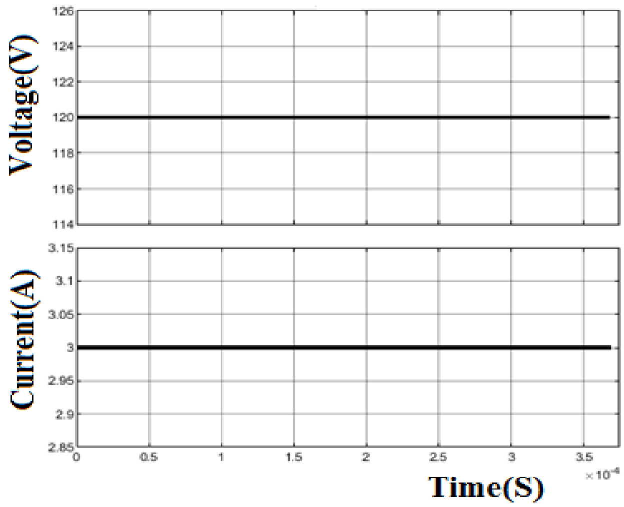

Figure 9 Input voltage and Current

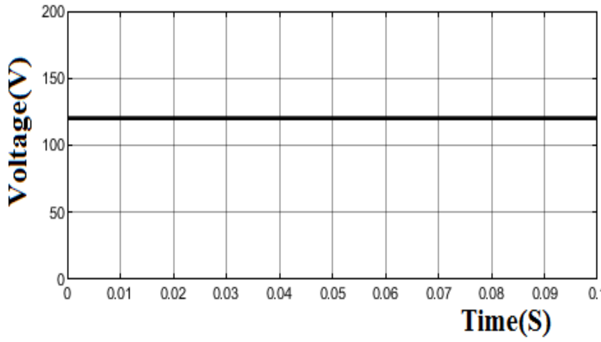

Figure 10 Charging voltage

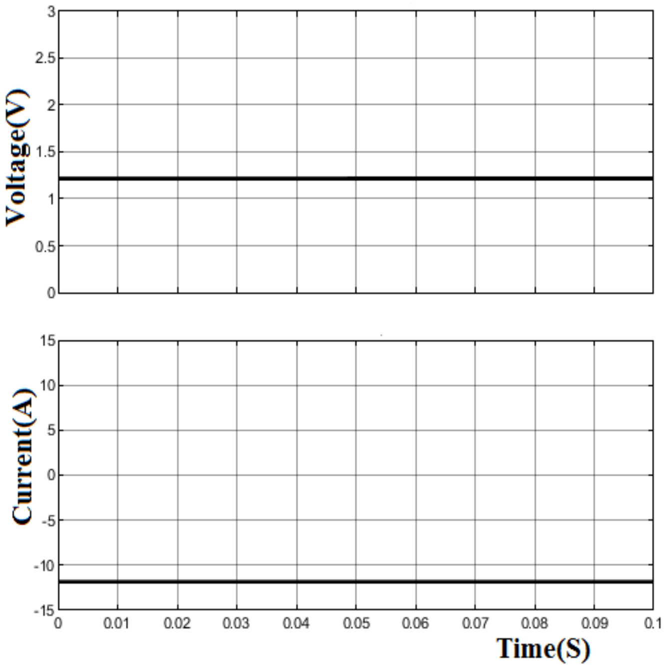

Figure 11 Battery Voltage and Current

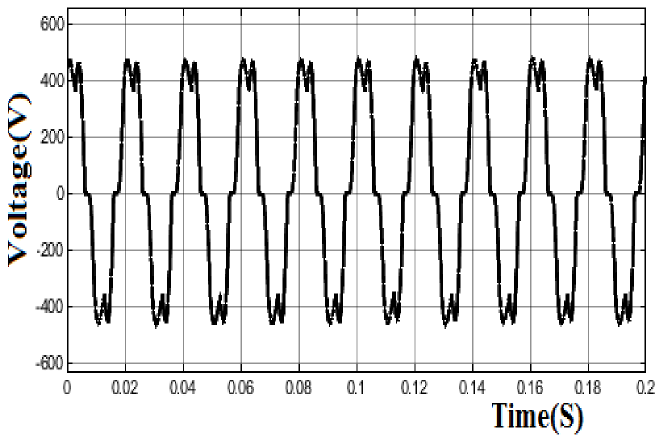

Figure 12 voltage at RY phase

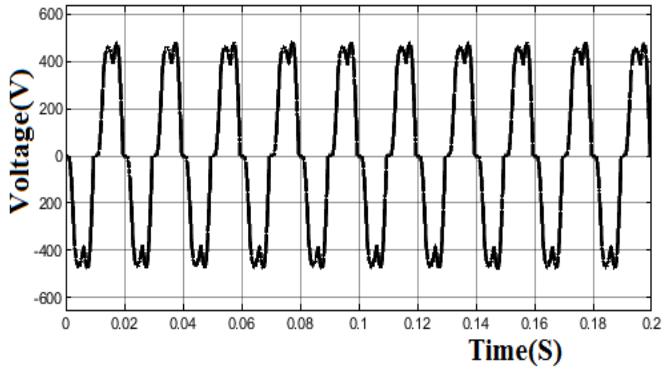

Figure 13 voltage at YB phase

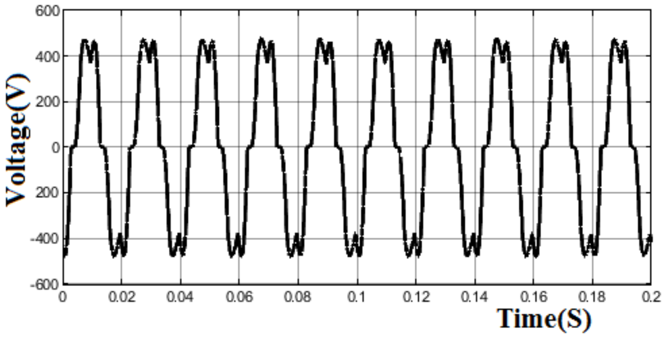

Figure 14 voltage at YB phase

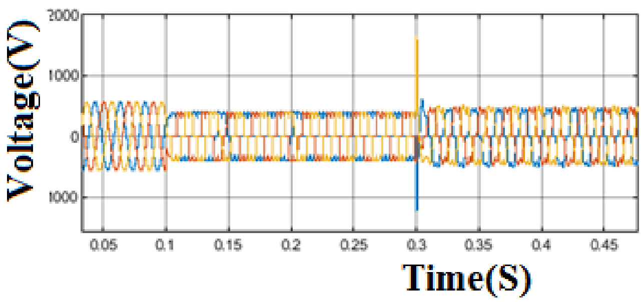

Figure 15 Three phase Output load voltage

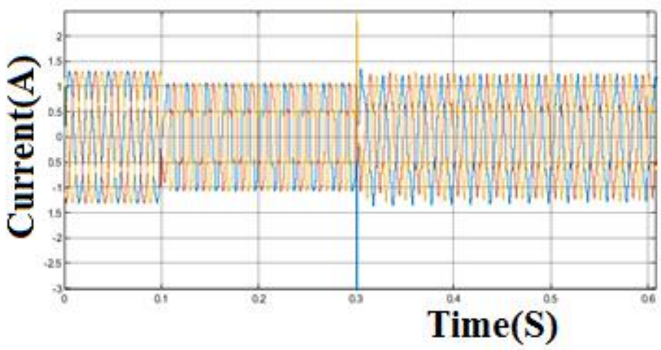

Figure 16 Three phase output load Current

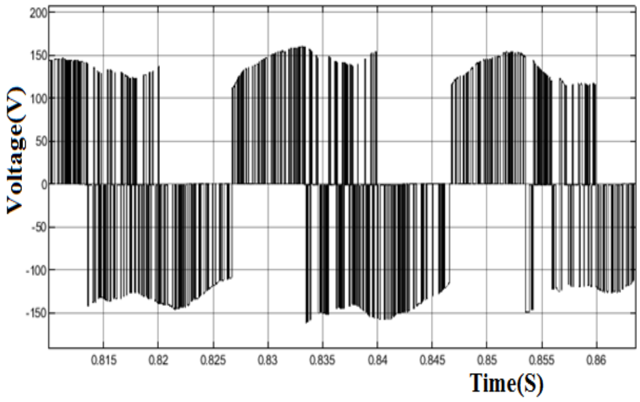

Figure 17 Converter voltage

5. CONCLUSION

In this paper, control renewable energy resources (RERs) and battery energy storage systems (BESSs) to provide a flexible AC power flow control in the distribution corridors of a voltage distribution system was designed and simulated. The simulation results demonstrate an effective coordinated control of BESS and solar-PV units in the distribution systems to provide the mentioned benefits by controlling the power flows in the distribution lines.

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BIOGRAPHIES

J.ABIRAMI received the Engineering degree in April-2013 from Anna University, Panruty, Tamilnadu. Worked as Assistant Engineer (Electrical) in Tamilnadu Generation and Distribution Corporation Limited from March – 2014. Her specialization in TANGEDCO special maintenance wing maintenance and calibration of Sub Station equipments / Power transformer up to 25 MVA and Distribution Transformers.