INTEGRATED PHOTOVOLTAIC AND DYNAMIC VOLTAGE RESTORER SYSTEM CONFIGURATION

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***ABSTRACT*—** this paper presents a new system configuration for integrating a Photovoltaic (PV) with a Dynamic Voltage Restorer (DVR). This configuration explains about the compensation of voltage sag (decrease in voltage) and voltage swell (increase in voltage) by using DVR. Whenever a natural fault or manual fault occurs on the Transmission line, the voltage gets decreased or increased in that particular line. To defeat this problem, DVR, one of the Flexible Alternating Current Transmission System (FACTS) devices is used for mitigating voltage sag and swell. By the time, the voltage gets compensated with occurred fault voltage with the use of DVR. The proposed system was developed by MATLAB simulink. An appropriate control algorithm is developed and the validity of proposed configuration is verified through extensive simulation as well as experimental studies.

***Keywords*:** PV, DVR, FACTS, MPPT

I.INTRODUCTION

The fast exhaustion of conventional energy resources and increasing environmental conditions has made renewable energy resources, such as Photovoltaic (PV) and wind, progressive sources of electric power generation. Since the power generated by PV source is generally DC.The components present in this system are PV source, Voltage Source Inverter(VSI), Converter, dc-link capacitor, capacitors, inductor, resistors, transformers, load. VSI contains six MOSFET switches in total. Its main function is to boost the active power which is injected through Maximum Power Point Tracking [MPPT]. Most severe disturbances in grid voltage are sags, swells and faults. To defeat these problems, DVR is the most potent and comprehensive solution.

DVR is one of the FACTS devices which are used to mitigate voltage sags, swells and faults. The active power is initially produced by PV panel. To maximize the power, P&O algorithm is employed. Then the produced power is being stored in battery. In proposed system, only one inverter is used. The stored DC power is inverted to AC and boosted. Finally the voltage gets compensated and given to load.

It also reduces switch count from twelve to nine. The advantages of reducing the switch count are to minimize the loss, improve efficiency and reduce cost.

II.LITERATURE SURVEY

In this paper [1], the six-port converter is replaced by the traditional back to back converters for dual motor drives, rectifier–inverter systems, and uninterrupted power supplies and also for micro grid applications. Fault is identified and the power is taken based on wind energy conversion system using nine switch-based converters is also reported recently. The proposed configuration essentially reduces the use of two dissimilar VSIs with one integrated converter while reducing the overall semiconductor count, gate drive, and control circuitry (by 25%). Also, this system allows bidirectional active power flow between six-port converter, PV plant, and utility grid, a feature that provides seamless sag compensation to protect sensitive loads during severe voltage dips at PCC. The proposed work is evaluated by detailed simulation study and finally, validated experimentally.

In the paper [2], the voltage sag occurs due to occurrence of substandard voltage and current, and frequency which contain harmonics which may damage the power system equipments. DVR is power electronics based device that can easily compensate these power quality issues like voltage sag in the system. DVR uses the error signal to adjust the triggering of the control of an inverter using Sinusoidal Pulse Width Modulation (SPWM) technique.

In the paper [3], the Voltage sags and swells in the industrial distribution system are the most severe disturbance at electrical grid because of the sufficient clearing time of the faults which create voltage sag and propagation of sags from the transmission and distribution system to the loads. Voltage sags are decrease of the normal voltage level between 10 to 90% of rms voltage, for durations of 0.5 cycles to 1 min. Voltage swells are increase of the voltage beyond the normal voltage level with duration of more than 3 cycles. This is eliminated by the DVR system.

In the paper [4], the compensation of voltage sag is studied in various faults and minimizes the total harmonic distortion in the transmission line. To maintain a proper voltage profile by mitigation of sag due to faults in power system occurred due to several reasons like energizing of heavy loads, transformers, induction motors, bad weather, insulation breakdown, closing & reclosing of circuit breakers.

In the paper [5], the in-phase voltage injection scheme for DVR is employed with a Photovoltaic system. Dynamic Voltage Restorer (DVR)'s performance is a better and cost is less. The control of compensation voltage in Dynamic Voltage Restorer (DVR) has been proposed using synchronous reference frame (dq0) technique and reduced the rating of DVR with compensate the voltage sag and voltage swell and harmonics in the system fed by Photovoltaic technique.

PROPOSED SYSTEM

The block diagram of the proposed system is shown below

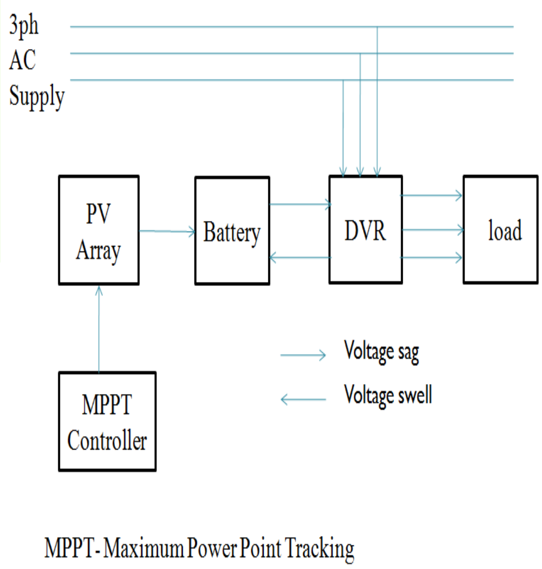

Fig., Block diagram of Diagram of proposed system

a) PV panel:

Photovoltaic solar panels absorb sunlight as a source of energy to generate electricity. A photovoltaic (PV) module is a packaged; connect assembly of typically 6x10 photovoltaic solar cells. A photovoltaic system typically includes an array of photovoltaic modules, an inverter and a battery pack for storage, interconnection wiring, and optionally a solar tracking mechanism. Here, a 3W panel is used for generating power which is DC. The power generated by the panel is different at all times. To extract maximum power from the panel, MPPT algorithm is used. The generated power is given to battery and is stored in it.

b) Battery:

An electric battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices such as flashlights, smart phones, and electric cars. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode. The terminal marked negative is the source of electrons that when connected to an external circuit will flow and deliver energy to an external device. Here, a 12V battery is used and it gets power from the solar panel. A PN junction diode is placed between panel and battery in order to restrict the flow of current in reverse direction. The output from the battery is given to DVR system. If voltage sag occurs, the stored power in the battery is given to the load. If voltage swell occurs, the extra power is return back to the battery and gets stored.

c) DVR:

A DVR is a series-connected solid-state device that injects voltage into the system in order to regulate the load side voltage. It is normally installed in a distribution system between the supply and a critical load feeder. Its primary function is to rapidly boost up the load -side voltage in the event of voltage sag in order to avoid any power disruption to that load. There are various circuit topologies and control schemes that can be used to implement a DVR. Together with voltage sag and swell compensation, DVR features are line voltage harmonics compensation, reduction of transients in voltage and fault current limitations. The DVR gets input from the battery which is DC. It consists of voltage source inverter and filter. The nine MOSFET switches have been employed in the VSI. MOSFET switches have an advantage of fast switching as well as good amplification process. The gating pulses are given to MOSFET switches by PIC microcontroller. The DC voltage is converted into AC by means of VSI. The output from the DVR gets boosted by step up transformer and is given to the load.

d) Microcontroller:

The PIC16F877A CMOS FLASH-based 8-bit microcontroller is upward compatible with the PIC16C5x, PIC12Cxxx and PIC16C7x devices. It features are 200 ns instruction execution, 256 bytes of EEPROM data memory, high-Performance RISC CPU, Operating speed is 20 MHz, and Operating voltage is 4.0-5.5V. The necessary gating signal requires to turn on the MOSFET is received from PIC controller which is coded with the help of MP lab. The input is taken from the regulator which gives constant output as 5V.

e) MPPT algorithm:

Maximum power point tracking (MPPT or otherwise just PPT) is a technique used commonly with wind turbines and Photovoltaic (PV) solar systems to maximize power extraction under all conditions. As the amount of sunlight varies, the load characteristic that gives the highest power transfer efficiency changes, so that the efficiency of the system is optimized when the load characteristic changes to keep the power transfer at highest efficiency. Here, Perturb and Observe algorithm is used. In this method the controller adjusts the voltage by a small amount from the array and measures power. If the power increases, further adjustments in that direction are tried until power no longer increases. It is referred to as a hill climbing method, because it depends on the rise of the curve of power against voltage below the maximum power point, and fall above that point. It is the most commonly used MPPT method due to its ease of implementation. This method may result in top-level efficiency, provided that a proper predictive and adaptive hill climbing strategy is adopted.

IV. METHODOLOGY

The proposed system configuration involves the integration of PV with DVR system. This system uses nine semiconductor switches to realize PV and DVR operations simultaneously. This eliminates the requirement of two separate inverters for PV and DVR applications reduce the switch count of conventional system by

25%. Initially the direct supply is given to the load. Whenever the fault occurs in the transmission line, the supply is taken from the PV panel. In order to maximize the power generated by PV systems, MPPT algorithm is used. Here, the Perturb and Observe (P&O) algorithm is employed. The power generated by PV is principally DC and it is stored in a battery. A PN junction diode is placed between panel and battery in order to restrict the flow of current in reverse direction. The DVR gets input from the battery which is DC. The DVR system consists of voltage source inverter and filter. The nine MOSFET switches have been employed in the VSI. MOSFET switches have an advantage of fast switching as well as good amplification process. The necessary gating signal requires to turn on the MOSFET is received from PIC controller which is coded with the help of MP lab. The voltage drop and rise is being measured by the use of controller in the circuit i.e., it gives the information about the voltage measurement. Then the voltage gets boosted and inverted into AC voltage. The produced AC voltage contains some ripples. The ripple content in the AC voltage is removed by means of filter and pure AC is given out. The voltage gets stepped up by step up transformer. Finally, the voltage sag is compensated and is given to the load. If voltage swell occurs in the line, the voltage will fed back to the battery through DVR system.

Software Used:

The proposed system uses two software. One is MATLAB which is used for simulation with integrated Photovoltaic and DVR system. The pulses to the semiconductor switches are coded in the PIC microcontroller by MP lab.

V. RESULT

SIMULATION

The proposed system configuration for integrating Photovoltaic and DVR system is shown below

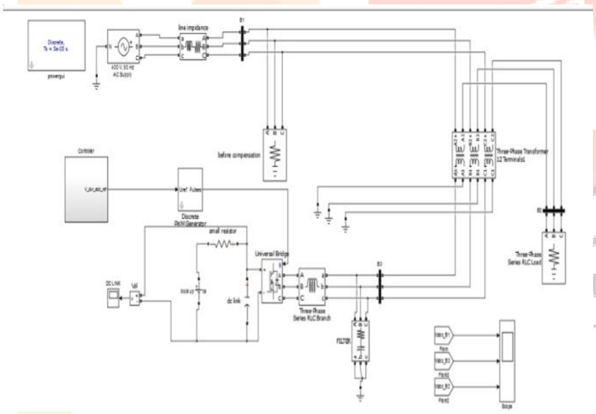

Fig: overall simulation of proposed system

Three phase AC supply is given to the circuit.

PIC controller is employed for generating Pulse Width Modulation (PWM) pulses which is further given to MOSFET as input.

DVR consist of Converter and Inverter. Converter is used to produce standard output which is given as input to inverter.

Inverter inverts to AC and boost the voltages.

Filter is used for removing ripples and produces a pure AC voltage.

Transformer is employed before the load in order to step up or step down the voltages based on the capacity of load.

Here 100W 3 phase induction motor is used as load.

SIMULATION RESULT

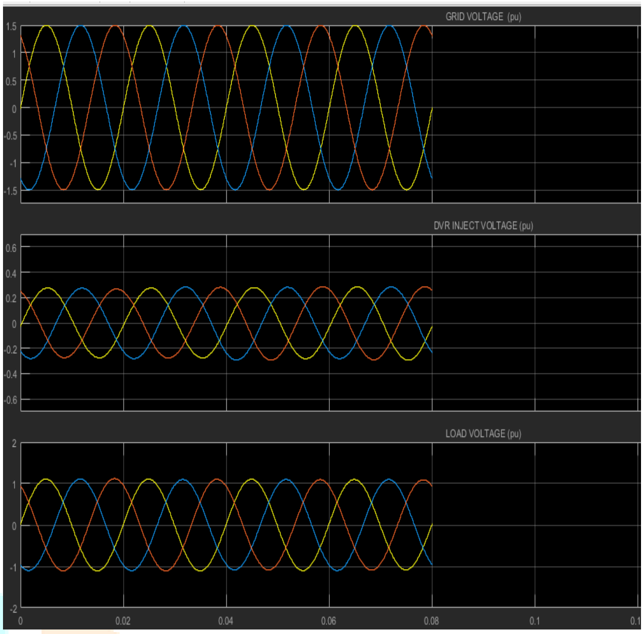

Fig. Simulation Output

The graph shown above is between time and voltage.
Initially 3 phase AC supply is given to the circuit as input voltage.
In next step, Voltage is injected to DVR based on running capacity of load.
Finally the compensated output voltage which is given to load is shown.

HARDWARE

The hardware implementation of this project is given below

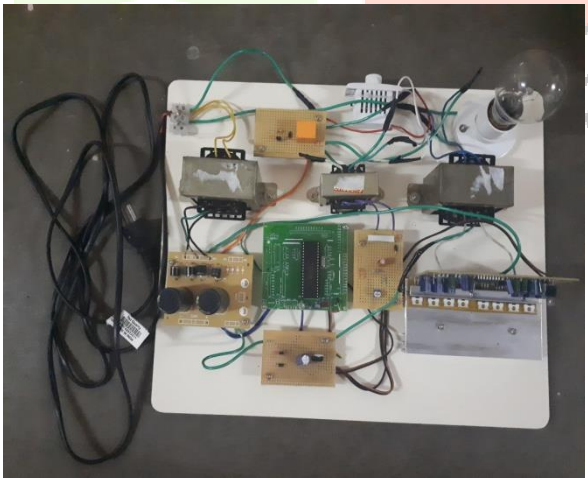

Fig: Snapshot of Hardware

Initially, Single phase AC supply is directly given to the load. If voltage sag occurs in the particular transmission line, an additional voltage is taken using another supply given. Then a 230V AC supply is stepped down into 12V AC supply using step down transformer. A bridge rectifier circuit converts 12VAC into DC and it contains some ripples. The capacitor is used to remove those ripples and a pure DC is produced. 12V DC is regulated into 5V by means of voltage regulator and is given to PIC microcontroller. The PIC microcontroller is being dumped with coding. The particular coding is developed using MP lab. Then, 12V DC is taken from bridge rectifier and is given to the converter- inverter circuit. To drive MOSFET switches present in the circuit, gate pulses must be given which are generated by controller. The converter converts 12V DC into standard 12V which is given to the inverter. The inverter inverts DC into

AC and also boost up the voltage upto 40V. The produced 40V AC is added with pulses generated and is given to step up transformer. The voltage drop that occurs on the load is measured by current transformer. The voltage drop is shown by the use of regulator placed before the load. Whenever the voltage drop occurs, the relay circuit is in ON position. The time delay on the relay circuit is coded in microcontroller. The transistor which is placed next to relay generates magnetic field which is given to relay circuit. The coil energizes and switch contact moves to ON position. At that time, the required voltage gets stepped up by means of step up transformer. Finally, the voltage gets compensated and is given to the load.

VI. RESULT

In this paper, a new process configuration for integrating Photovoltaic and Dynamic Voltage Restorer system is proposed. The proposed system not only reveals with the entire function of PV and DVR method, but also enhances the DVR working range. It allows DVR to take power from PV plant and for that reason improves the process robustness towards heavy faults in the grid. This system could be practically implemented in the Power plant where the frequent occurrence of faults is identified.

VII. REFERENCES

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