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Control Scheme for Solar PV System under Asymmetrical Fault Condition

Mohini W. Badwaik[1], Prashant P. Jagtap[2]

[1]M.Tech. (IPS) Student, Department of Electrical Engineering, G. H. Raisoni College of Engg., Nagpur, India
[2]Assistant Professor, Department of Electrical Engineering, G. H. Raisoni College of Engg., Nagpur, India

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Abstract - *In the present scenario there is a rapid increase in demand of energy and will be double in future but still the use of Renewable energy sources is comparatively very low over Non-renewable energy sources. But now the various awareness programs of various organisations leads to the increase in use of Renewable energy sources like solar, winds etc. talking on solar power plant say micro-grid (MG) connected there are number of various faults occurs such as open circuit, short circuit, diode failures, shadowing etc. which are responsible for low power quality, number of interruptions in the system and may lead to the grid collapse, to avoid such conditions it is mandatory to go through the fault analysis and control in such case the behaviour of solar PV array is different compared to generators. This paper focuses on one of the above fault which is Asymmetrical fault or short circuit fault condition and its low voltage ride through control scheme for solar Photo-Voltaic array system with microcontroller is used to reach appropriate output reckless and competently in which the positive sequence voltage is recovered through microcontroller based inverter.*

Keywords: Solar PV system, Inverter, Microcontroller, LVRT, Pulse Width Modulation.

1. INTRODUCTION

The increasing demand electrical energy nowadays, it is essential to find the new efficient innovative ideas to reduce and control the various faults occurring in the PV system to maintain the quality and reliability of the solar PV system so that the most cleanest solar energy will became the biggest alternate source for electrical energy generation leads to reduce the pollution and protect the nature.

The photovoltaic name comes after the Greek word Photo for light and Greek physicist Alexandra Volta. In photovoltaic cell there is conversion of solar radiation directly into electrical energy which is in pure DC form. Mostly the electrical energy is consumed in the alternating current (AC) form to convert the DC into AC inverter is used. Which are electronic devices and can convert low voltage DC generated from Solar panel into AC and then step up the voltage level of converted AC by using power transformer [2].

Solar PV cells are influenced to various symmetrical and Asymmetrical faults and there are various control strategies are prepared to cover these faults but most of the control strategies focus to control the power of grid connected inverters but there is one more effective method which is not properly get the limelight yet is recovery of positive sequence voltage and reduction of negative sequence voltage by voltage support control [1].

The inverter has a characteristics of less heat generation, less voltage regulation along with high efficiency it also has less harmonics to get quality AC power output, the solar panel PV system followed by inverter having low cost microcontroller is best suitable to achieve above desirable characteristics as the modified sine wave generated by microcontroller contains less harmonics and voltage regulation can be easily controlled [2].

With the day by day adding up of solar PV arrays in the grid there is increase in the chances of the grid failure by low voltage and number of faults to avoid the grid failure when there is shadow condition or low DC voltage generation that is Low Voltage Ride Through (LVRT) condition, the DC output of inverter connected to Solar PV cell is controlled by adjusting the boost circuit duty cycle so that the generated DC voltage level controlled within limit, if required then reactive power also injected at the output side[3]

By connecting the Solar panel directly to the grid the cost and area required for energy storing device such as batteries is subtracted which is possible with solid state power inverter in addition to this the transformer less solar PV system is one of the best idea to reduce the cost as well as setup area[4].

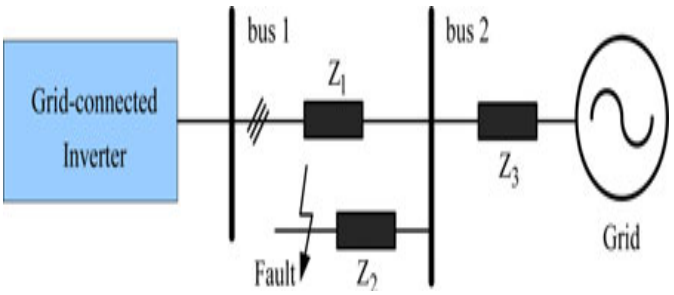

Fig.-1.1: Block diagram of grid-connected inverter.

2. SOLAR PV SYSTEM

A Solar PV system is an array of series parallel connection of solar photovoltaic cell, which converts the solar radiation into DC electrical energy form directly. When the sunrays incident on the silicon the electrical charges are generated and thus the solar energy converted into electrical energy.

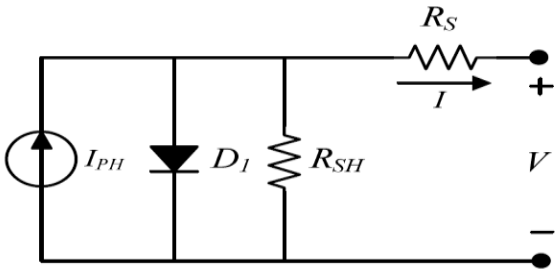

Fig-2.1: The equivalent circuit of a PV cell.

3. INVERTER

The small DC load can be easily fed on the solar panel directly but for the large loads or to connect the solar panel to the grid the inverter is must which converts the DC output of solar panel into AC. In this paper three level inverter is explained in which six IGBTs are used in three legs as switches which convert the input dc voltage into respective three phase ac voltage. To make the on/off operations of the switches in proper sequence at particular interval of time the Microcontroller 89c52 is used. The modified boost PWM signal is fed to the gate terminal of IGBTs with the help of gate driver circuit. To interrupt the microcontroller from sending the PWM signal and to setup the input voltage and time control the input keys are interfaced to the port pins.

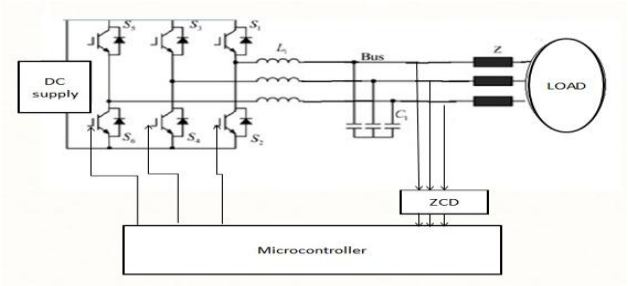

Fig.-3.1: Microcontroller based Inverter

The simulation results of inverter are shown below:

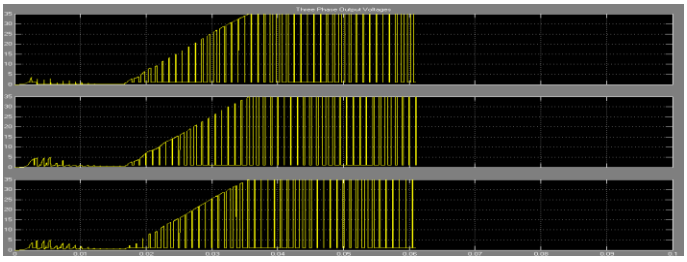

Fig.-3.2: Three Phase output voltage without LC Filter

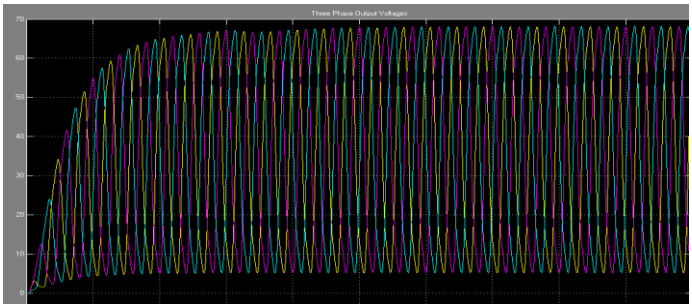

Fig.-3.3: Three Phase output voltage with LC Filter

4. CONTROL CIRCUIT FOR MICROCONTROLLER

The proteus software is used for simulation and draws the controller circuit for the generation of PWM signal through microcontroller 89c52. The five push buttons with led are provided at port 3 for interrupting microcontroller, switching the mode, increment and decrement of shoot through time and input voltage, to enhance the user interface the LCD also interfaced with the microcontroller at port 0 so that it can show the various values and message regarding the project. The gate driver circuit is interfaced at port 2. The microcontroller is able to generate two types of edge aligned waveforms through two modes of operation that is traditional and boost mode.

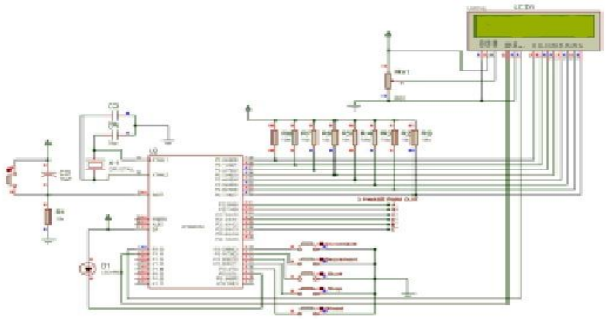

Fig.-4.1: Diagram for Interface of Microcontroller

5. BOOST PWM WAVEFORM

Mostly the traditional method is used to generate the PWM signal for controlling the microcontroller but it can be best controlled by generating the PWM waveforms through boost mode in which the shoot through state is obtained by converting the some part of traditional zero state.

6. GATE DRIVE CIRCUIT

To drive the power transistors like IGBT the gate drive circuit must have high current sink and source capability along with Opto-isolation, IC TLP250 from Toshiba company is best for IGBTs drive circuit due to its following features;

- Input threshold current Max.: IF=5mA

- Supply current (ICC) Max.: 11mA
- Supply voltage (VCC) Max.: 10–35V
- Output current (IO) Max.: ±1.5A
- Switching time (tpLH/tpHL) Max.: 0.5µs
- Isolation voltage rms Min.: 2500 V
- Operating Insulation Voltage Max,: 890 Vpp
- Permissible Over Voltage Max.: 4000 Vpp
- Creepage distance Min.: 0.64cm
- Clearance Min.: 0,64cm

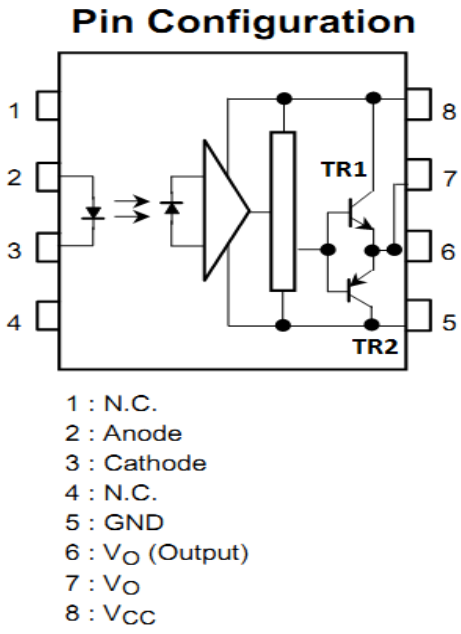

Fig.-6.1: Pin diagram of gate drive circuit

7. DC POWER SUPPLY

DC power of 5V for microcontroller operation and 12V for IGBT gate driver circuit operation can be obtained from IC7805 and IC7812.Rectifier is used to convert ac supply voltage to fixed dc voltage. In the following figure the full wave diode bridge rectifier is shown.

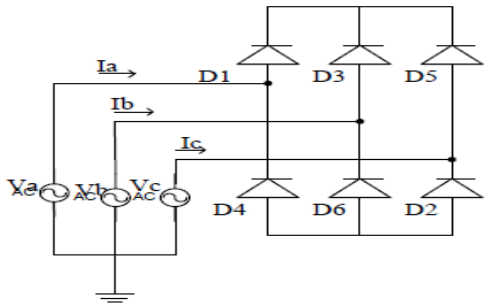

Fig.7.1: Diode Bridge Rectifier 3Φ

8. VOLTAGE SUPPORT CONTROL METHOD

When the grid fault occurs there is drastic reduction in the network node voltage profile. To maintain the voltage level there is necessity to add up the voltage in terms of power in the network, in other words simply we can say to control the power either controlling current or by controlling voltage. As the network has different impedance the level of voltage control also differs and only possible by controlling the power with varying voltage by proposing the new strategy control [1].

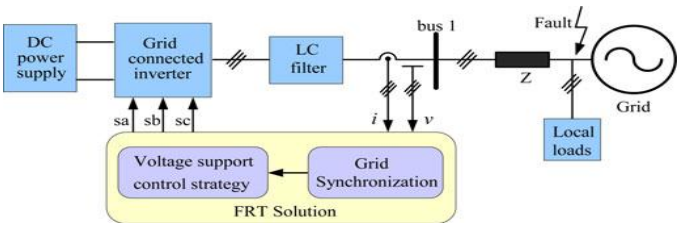

Fig.-8.1: Diagram for Conventional Control FRT solution for grid-connected inverter.

Mostly the low voltage network has resistive impedance, due to this the FRT control method is not that much effective for low voltage grid. When the fault occurs there is the reduction in the voltage value which results into the oscillation of power and same the oscillations in voltage of DC link, in such condition it is best to increase the positive sequence voltage and reduce the negative sequence voltage in the asymmetrical fault through voltage support control method.

This makes the FRT control more effective for low voltage grid during asymmetrical fault condition. Practically the asymmetrical fault i.e. L-G fault will be created for demonstration purpose and its result will be discussed in the future papers.

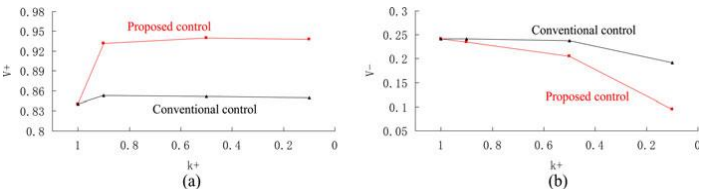

Fig.-8.2: Performance comparison between conventional and proposed solution. (a) Positive sequence voltage recovery. (b) Negative sequence voltage reduction.

9. CONCLUSION

The new strategy for the microcontroller based inverter is proposed in this paper to maintain the reliability of the renewable source fed system for low voltage grid under Asymmetrical fault condition theoretically. The positive sequence voltage recovery and negative sequence voltage reduction is the very effective method to increase the effectiveness of the FRT control through voltage support control method.

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