International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 06 | June 2021 www.irjet.net p-ISSN: 2395-0072

THREE-PHASE FOUR-LEG POWER SUPPLY SYSTEMS WITH NONLINEAR AND UNBALANCED LOADS

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Abstract – *In this paper three phase power supply with grid forming Four-Leg Voltage Source Inverters (FL-VSIs) with nonlinear and unbalanced load is designed. The Four-leg VSI is fast becoming a key instrument in three -wire Power system due to its superior performance characteristics in handling unbalanced and nonlinear load conditions. The key purpose of is to compensate for load and phase disturbances in order to improve voltage waveforms quality in standalone power supply systems. This adaptation mechanism can be easily expanded to other control techniques in order to increase their efficiency under disturbing load conditions.*

Key Words: Power Quality; Voltage Control; Standalone Power Supply; Four-Leg Voltage Source Inverters (FL-VSIs)

1.INTRODUCTION

The actual electrical energy orientation which leads to the definition of new directives and policies on performances and reliability of the electrical structures in the world focuses on the development of a new grid concept namely distributed generation (DG) especially those based on locally available natural resources (solar and wind). The integration of DG is very attractive and offers the possibility to support the electrical network in recent years in remotes areas through power electronics devices. The systems may display some weakness to handle substantial load transients and non-linear and unbalanced load conditions during off-grid operation, which leads to increase of the voltage harmonic contents and asymmetry at the point of common coupling, it may deteriorate the power quality. In order to maintaining balanced output voltage waveforms with required quality standards the use of a four-leg voltage-source inverter topology deserves a lot of attention even in transformer less applications and under various loading conditions. In fact, the additional fourth leg provides supports voltage balance in three-phase four-wire electrical networks in unbalanced load conditions a path for the resulting zero-sequence current. In comparison with three phase three leg voltage-source inverters the use of the added neutral connected fourth leg allows to increase the output voltage range and to reduce the DC-link capacitors.

In order to reduce the output current ripples and attenuate high-frequency voltage components due to the switching harmonics an output low-pass filter (LPF) is commonly connected to these power electronic structures. Many control techniques performances in DG and uninterruptible power supply applications with three-phase four-leg voltage-source inverters have been proposed to enhance load voltage control.

2. SYSTEM DESCRIPTION OF A FOUR LEG-VSI

Figure1 shows the four-leg inverter topology with an output inductor–capacitor (L-C) filter and constant voltage source as DC-link. To simplify the modeling, the inverter input voltages, the output voltages, the LC filter line currents, the neutral line current and the load currents. The midpoint of the fourth leg is connected to through a neutral inductor L_n , the output capacitor filter and the load in order to reduce the neutral current switching frequency ripple.

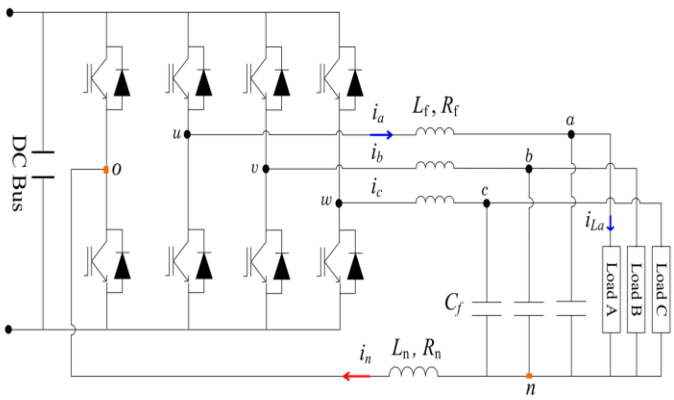

Figure1. Standalone power supply based FL-VSI

2.1 NEUTRAL LINE PROVISION IN MICROGRIDS

The presence of a combination of single- phase and three-phase loads/DGs has more intense the need for a neutral line to provide a current path for unbalanced loads in microgrids. Malfunctioning of protection devices and adjustable speed drives are the main challenges caused by unbalanced and nonlinear loads in microgrids.

2.2. SPLIT DC-LINK

Figure2 shows the configuration of the split DC-bus link into a pair of capacitors. The split DC-link topology is one of the more common ways of providing a neutral point for three-phase VSIs in three-phase four- wire systems and the neutral path connects to the midpoint of the capacitor. A large neutral current flows through the neutral path and cause a perturbation in the control scheme under severe unbalanced and nonlinear conditions.

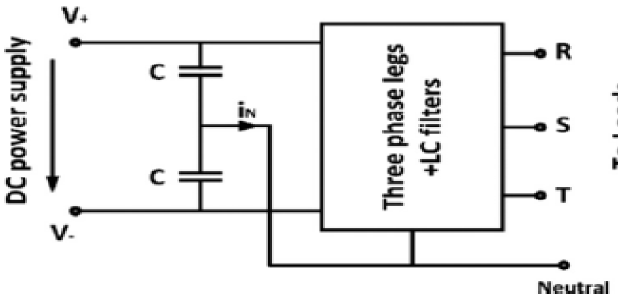

Figure 2 Split DC-link capacitor

2.3 Four-leg inverter

The three-phase four-leg inverters can capable have effectively handle the unbalanced loads in four-wire systems. This configuration does not need to utilize large and expensive capacitors and provides lower ripple on the DC-link voltage. Moreover, the four-leg inverter shaves the significant potential to handle unbalanced and nonlinear conditions.

Figure3 shows the structure of the differential negative feedback control loop. The hysteresis voltage regulator is one of the most well-known approaches to control the output voltages of power inverters in designed to improve the overall performance of the conventional hysteresis controller.

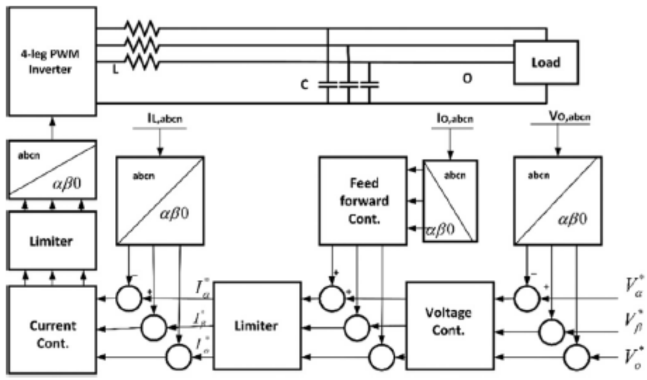

Figure 3 Block diagram of the control strategy

3. SIMULATIONS AND RESULTS

The software MATLAB was used in the simulations to obtain the results for the output voltage, current and powers that are supplied to the electric grid as shown in figure 4.

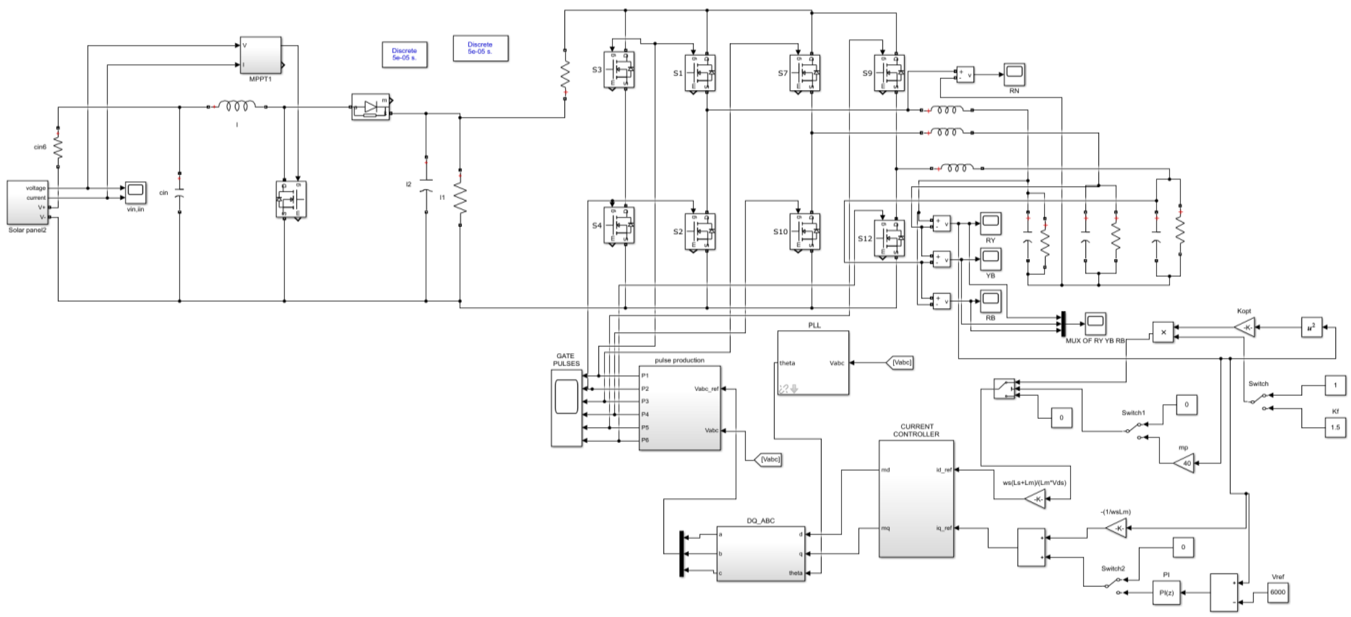

Figure 4 Proposed Circuit diagram- Three phase Four Leg configuration

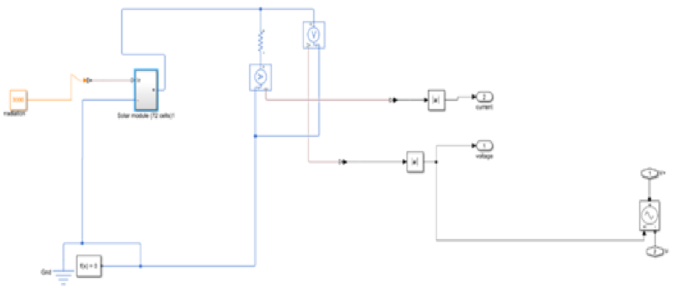

Figure 5 Solar Panel

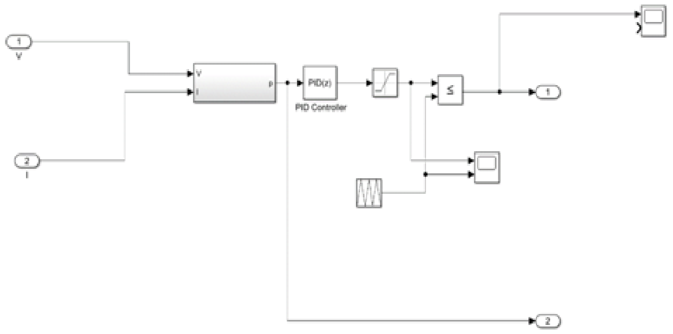

Figure 6 MPPT Controller

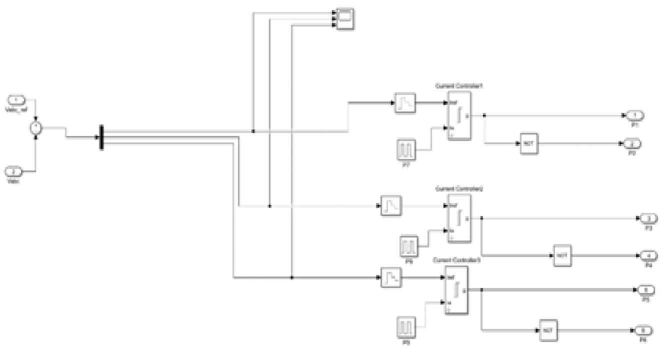

Figure 7 Pulse Generation

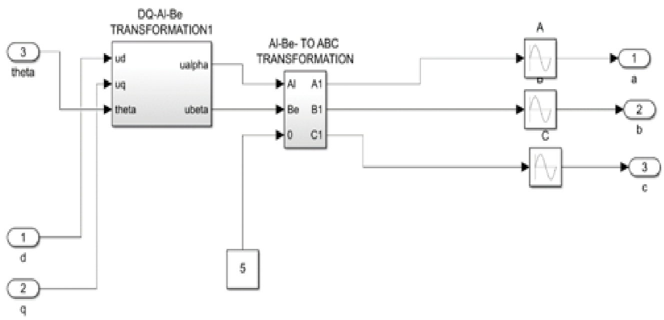

Figure 8 DQ Transformation

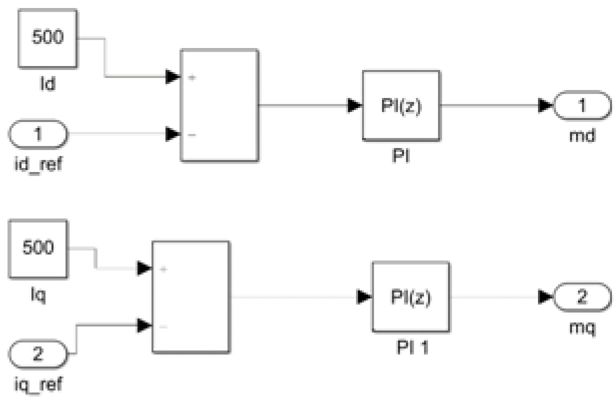

Figure 9 Current Controller

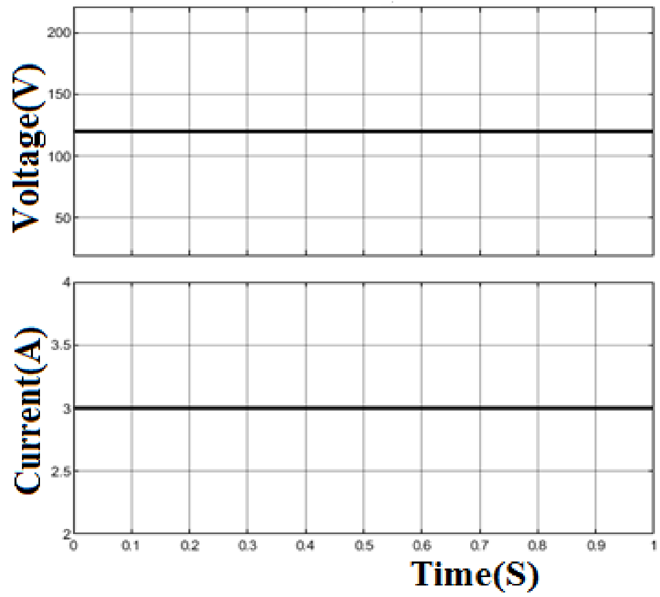

Figure 10 Input Voltage and Current

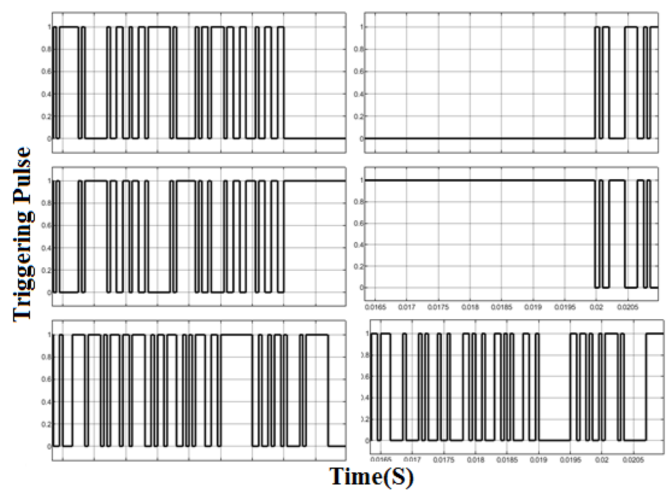

Figure 11 Triggering Pulse

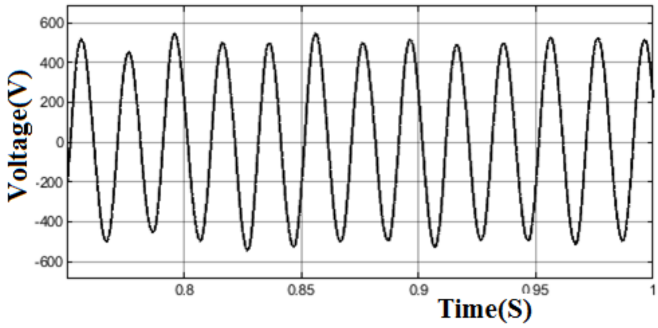

Figure 12 Output phase Voltage at RY

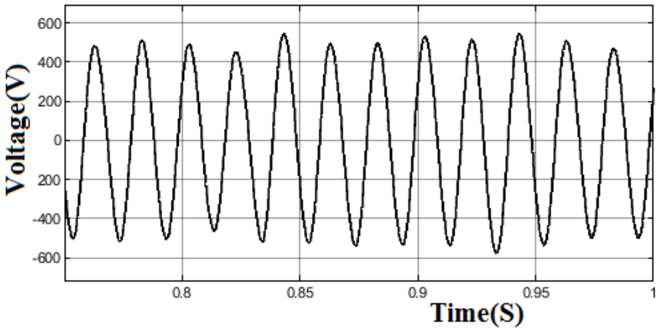

Figure 13 Output phase Voltage at YB

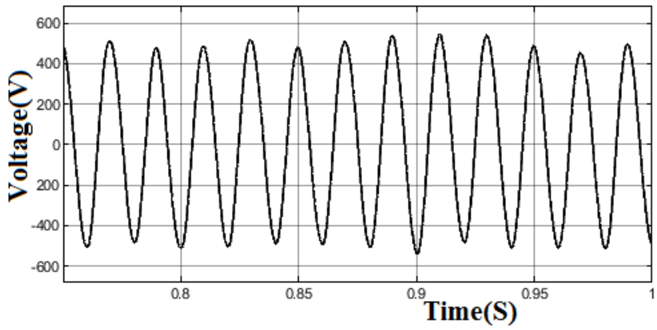

Figure 14 Output phase Voltage at RB

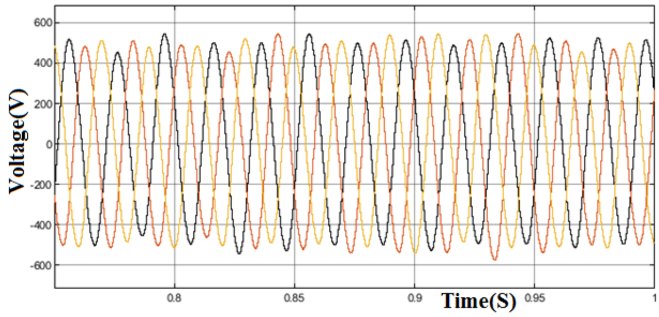

Figure 15 Three phase Output Voltage

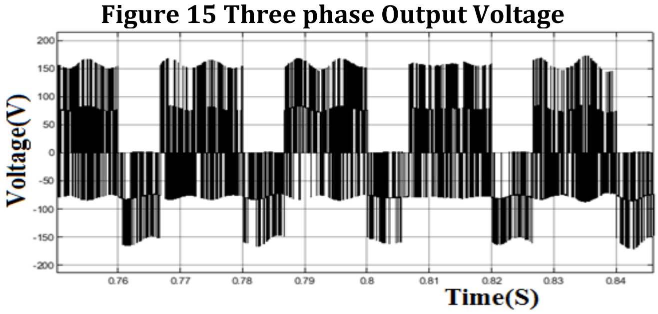

Figure 16 Output Voltage at RN

5. CONCLUSION

In this paper three phase power supply with grid forming Four-Leg Voltage Source Inverters (FL-VSIs) with nonlinear and unbalanced load was designed and simulated. The proposed system Four-leg VSI is fast three-wire Power system due to its superior performance characteristics in handling unbalanced and nonlinear load conditions. Simulation results reveal that the proposed method can provide meaningful improvement to voltage waveform quality in standalone power supply systems in order to increase their efficiency under disturbing load conditions.

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BIOGRAPHIES

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