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ANALYSIS FOR THE PERFORMANCE OF CASCADED H-BRIDGE MULTILEVEL INVERTER FOR HARMONICS MINIMIZATION GRID CONNECTED PV SYSTEM

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ABSTRACT

In the current senerio the demand for renewable energy generated by solar system is increasing day by day. PV systems transform energy obtained from sunlight into electrical energy and produce DC power output which need to be controlled accurately and converted into AC power output by use of inverters. For reference current generation and proper control of switches of the CHB-MLI here synchronous reference frame (SRF) theory and level shifted PWM scheme have been used as these techniques have good performance for harmonics reduction in the signal obtained as output from inverter. PV array with MPPT is modeled and analyzed in Matlab Simulink. For the accurate control of MPPT here in this work Incremental Conductance with Integral Regulator Control Algorithm is used. The designed PV system with enhanced control has good performance that can supply maximum power of 100 kW when the solar irradiance is at the maximum value of $1000\ W/m^2$.

Keywords: PV, MPPT, PWM, Harmonics.

I. INTRODUCTION

In the todays time electricity is our basic and improtand need. In this modern life electricity can be considered as one of the important factors for economic and social development of a country. In order to meet the customer demands a reliable and sustainable source of renewable electrical energy is required to provide electrical power to the power system according to the requirements. But the most vital issue in case of injection of renewable electrical energy to grid is it produce power quality issues and cause the grid parameters to fall down from their standard values which is undesirable [1]. From literature survey in [2] it is clear that the environment is badly affected those producers of energy which results in the production of greenhouse gases such as carbon dioxide etc. It has also been observed that in recent years the need for clean and green energy i.e. renewable energy is increasing day by day in order to produce less environmental impacts. It has been observed that in the last ten years the application of Photovoltaic (PV) cell connected to the Grids, for the production of electrical energy have been increasing exponentially. PV cells which convert sun light energy into electrical energy, has lower efficiency in the range of 9 % to 17 %. In order to handle this problem linked with PV cells MPPT device is employed with PV system which are coupled to the grid. Its basic function is to extract maximum amount of power for grid connected PV panel under all environmental conditions and to ensure consistent and continuous supply of energy [4] There are several control algorithms for the MPPT but amongst them the two important schemes are “Perturb & Observe (P&O)” and “Incremental Conductance Control Scheme” [5], [6]. CHB-MLI is a single stage power processing inverter because of which it has low switching losses. Using CHB-MLIs for grid tied PV systems offer quite a lot of benefits for example reduced mismatch losses and THD value, higher efficiencies, small size of filter, less voltage stress in switching components and fractional shading. In CHB-MLIs several H Bridges are linked in series connection and require separated DC sources and that can be easily provided by PV strings or PV modules. Because of these landscapes, the CHB-MLIs schemes are appropriate for grid tied PV systems [8]-[9].

II. MODELLING AND ANALYSIS

This research work proposes an enhance control method of CHB-MLI for grid tied PV inverters using SRF theory control in order to make sure the accurate operation of MPP for power transfer from each PV strings or PV modules as discussed.

A) MODELING OF THE GRID

The Matlab Simulink block model of the proposed grid coupled PV Array is presented in fig.1. The Simulink PV block diagram consists of PV Array, 5–Level CHB–MLI and MPPT. For extraction of maximum amount of power MPPT is installed. The blue block diagram represents the line impedance. The PV Array generates 260 volts output voltage that is joined to the grid through 100 kVA 260/25kV step–up transformer.

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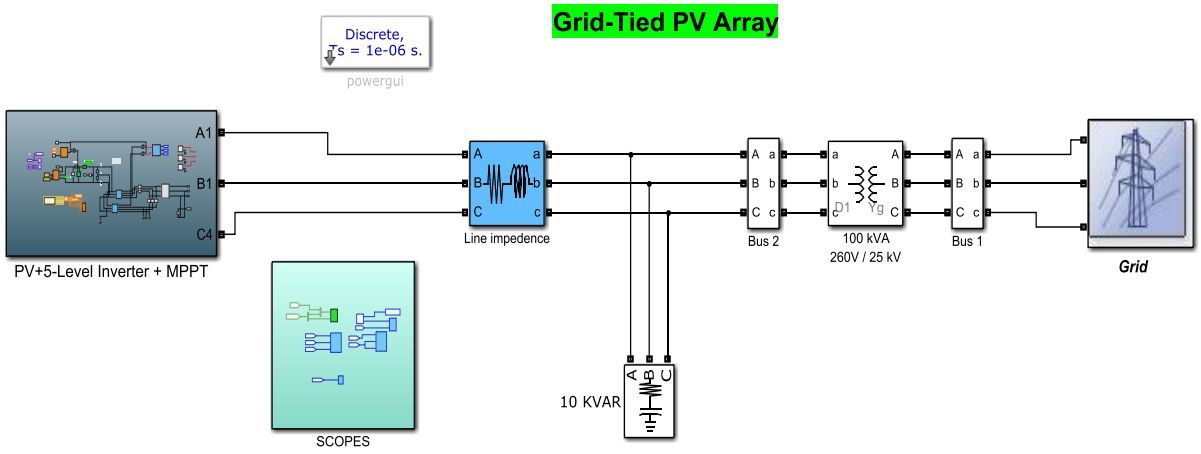

Figure 1: Simulink Model of Proposed Grid Tied PV System

B) CASCADED H–BRIDGE MULTI–LEVEL INVERTER TOPOLOGY

The Simulink diagram of 5-Level CHB inverter topology for PV Array is shown in fig. 2. It can be seen form the figure that there are two CHB connected in series connection. The output of the two H-Bridges are combined and synthesized at certain state of the switching components. When there are "M" number of H-Bridges that are linked in series combination the output waveform generated will be such that it will contain $(2 * M + 1)$.

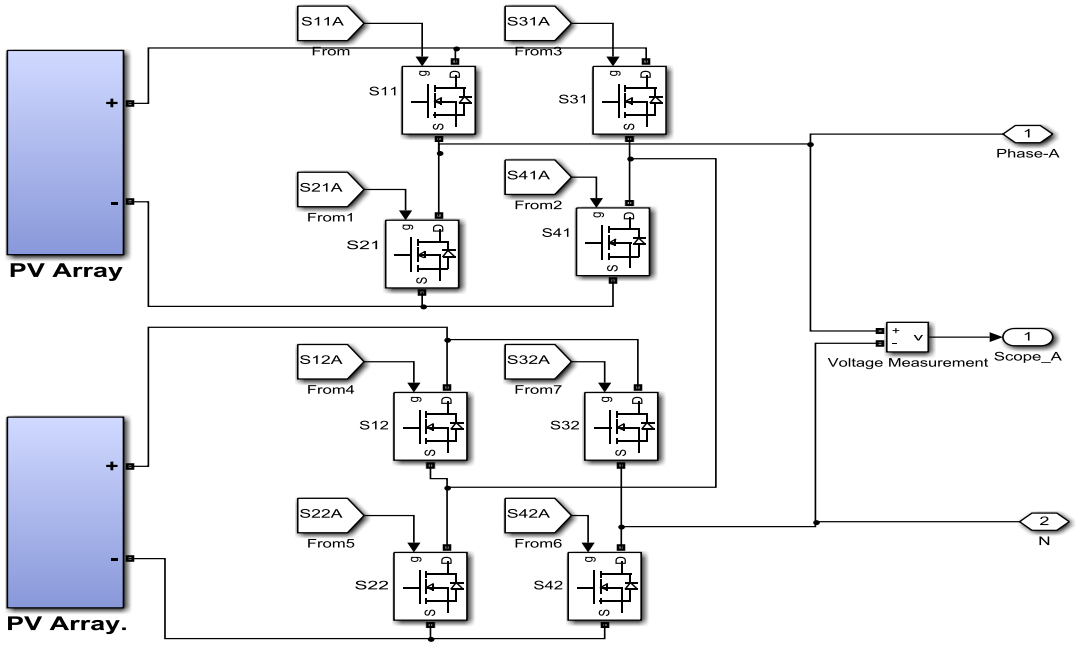

Figure 2: PV Array with CHB-MLI Topology

C) CONTROL SCHEME

The control scheme basically comprised of DC Voltage regulator, Current-Regulator, PLL block and generation of reference signals. The reference signals are then given to the PWM signal generator to generate gat pulses for the operation of switching components of CHB-MLI in order to produce the desired output signal. In order to synchronize the CHB-MLI output to the utility grid a three phase, phase locked loop (PLL) circuitry is used. For generation of the control reference signals in this work rotating synchronous reference frame theory (SRF) is used as it is a superior control scheme and have good performance for harmonic contents reduction. The SRF control scheme comprised of two regulators. The current regulatory controller regulates the grid currents through PI controller. The control signals produced V_d and V_q are transformed back to abc frame using *dq to abc* transformation and finally we get the reference signals represented by the name *Vabc _ref.*

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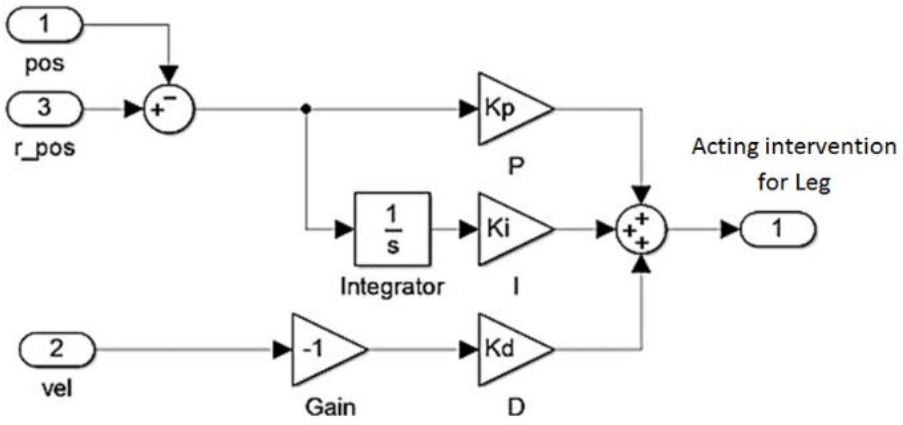

Figure 3: Simulink Model of the Controller

The output control signal ($V_d V_{q\_con}$) of the DC Voltage regulator is given to reference signal generator and also the phase angle sensed by PLL block for synchronization purpose is given as input to reference generator. Using *dq–to–abc* transformation the control signals $V_d V_{q\_con}$ are converted back to abc–frame and lastly reference signal *Vabc_ref* is obtained.

The reference voltage signals *Vabc_ref* are then provided to the PWM signal generator. In the PWM Generator *Vabc_ref* and a high frequency carrier signal are compared to get the PWM switching signals for the operation of the switching components (IGBTs) of the CHB-MLI VSI. In this work level shifted PWM (LS–PWM) method is used for switching signal generation of the CHB-MLI VSI due to the reason that this technique has superior performance for harmonic reduction in the output signal.

III. RESULTS AND DISCUSSION

The simulation results of the Grid Tied PV system implemented with CHB-MLI topology are discussed here; 5-level CHB–MLI based VSI is implemented in Matlab Simulink which acts as interface between PV array and grid. The PV array is designed in such a manner that there are five (5) modules connected in a single string in parallel connection and such sixty six (66) are then connected in series connection.

The power rating of the designed module can be find as:

PV array power output $= (66) * (5) * (305.2Watt) = 100.7kW$

The P–V and I–V Characterization curves of the designed PV array under varying solar irradiance is presented in the fig. 5–2. Under STC (T°=25°*C & S=Irradiance=1000W/*$\boldsymbol{m^2}$) the maximum power generated by PV array is 100.7 kW respectively.

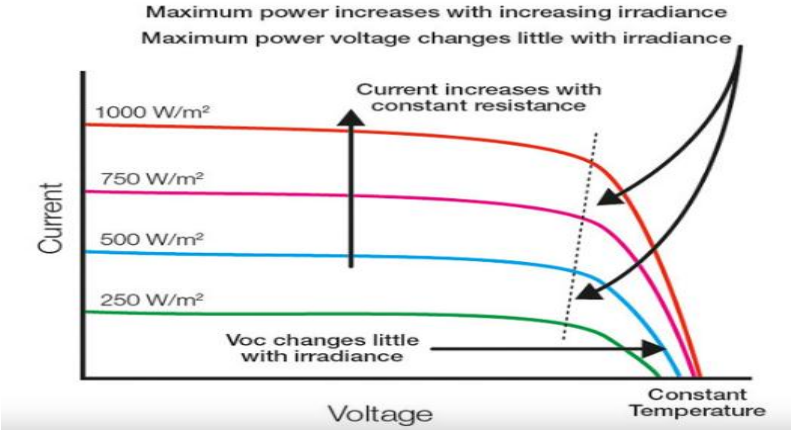

Figure 4: P-V and I-V Characterization curves of the designed PV Array

A) Grid Connected 5-Level CHB-MLI Output

Output voltage of the phase-A of Grid tied 5-level CHB inverter is displayed in fig. 5. In this research work two CHBs are joined in cascaded connection therefore their output waveform consists of 5-levels as shown below.

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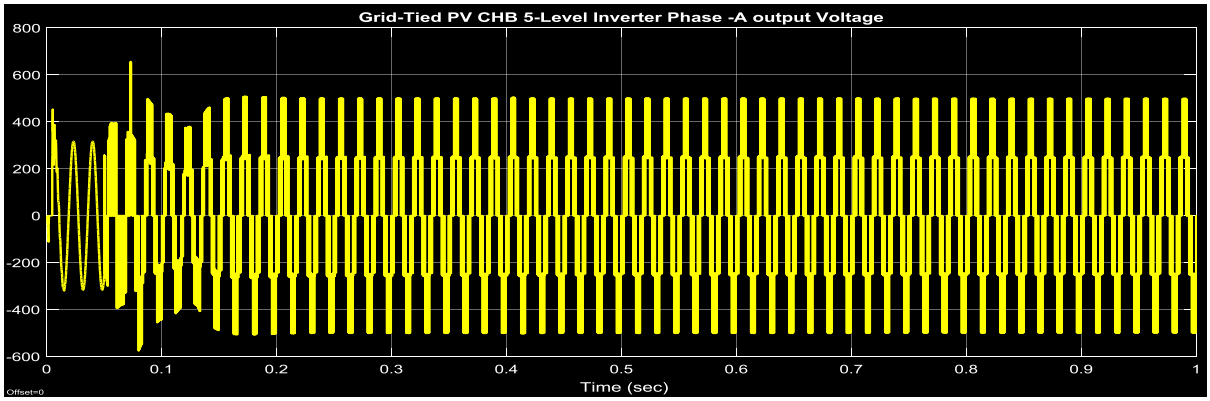

Figure 5: Grid Tied PV 5-Level CHB inverter Phase A output

B) Grid Voltage and Injected Current

Figure 6 illustrates the grid voltage and the current injected into the grid. After 0.7 seconds as the sun irradiance falls down the grid injected current also goes on decreasing as shown in the figure below. As the injected current decreases the injected active power by PV Panel to the grid also decreases.

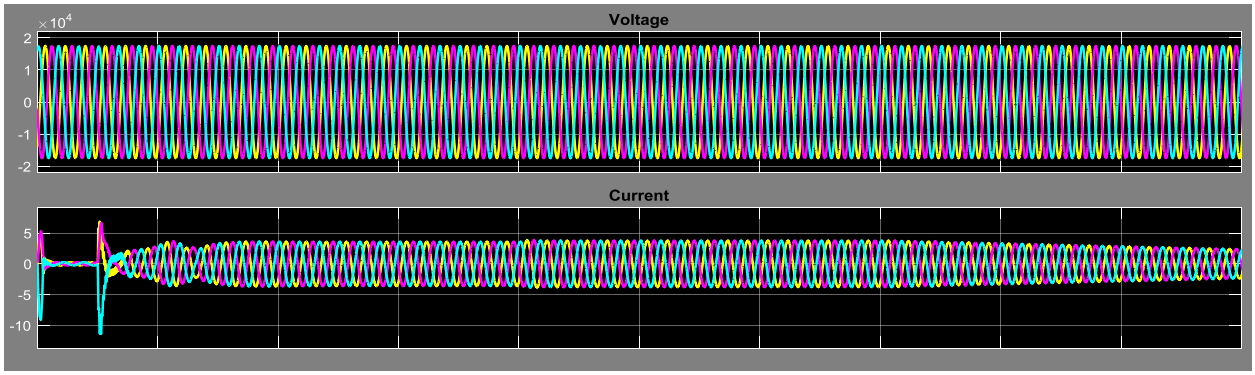

Figure 6: Grid Voltage and Injected–Current

C) Harmonics in the Grid Voltage and Injected Current

Grid tied PV inverters which supply power to the grid must produce a high quality and sinusoidal waveform output so as to get enhanced performance and to accomplish the inter connection requirements and standards of the main grid. The standards may be power factor, notching of voltage and magnitude of voltage, frequency and harmonic distortion (THD). The last one is the most important requisite and also hard to achieve this constraint.

i. Grid Voltage Harmonics

The harmonics content that are existent in the grid voltage are shown in fig. 7. According to the IEC or IEEE standard limits THD value in voltage should not be greater than 5 percent. From the figure it is clear that this limit is successfully achieved that is 0.26 percent which is less than 5%.

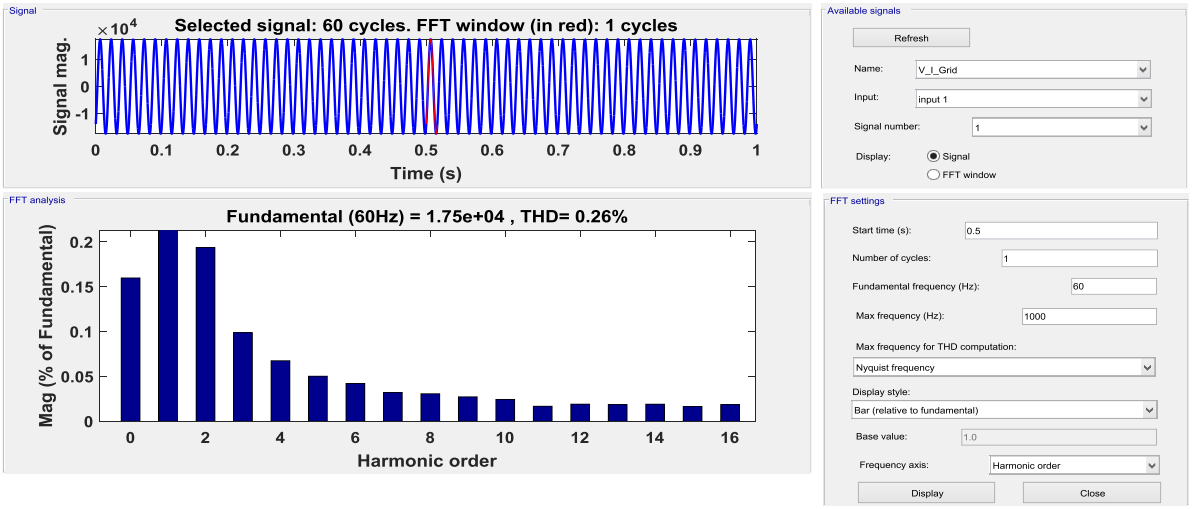

Figure 7: Grid Voltage Harmonics

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ii. Grid Injected Current Harmonics

The harmonics that are present in the grid injected current are shown in fig. 8. According to the IEC or IEEE standard limits THD value in currents should not be greater than 3 percent. From the figure it is clear that this limit is effectively accomplished that is 1.31 percent which is less than 3%.

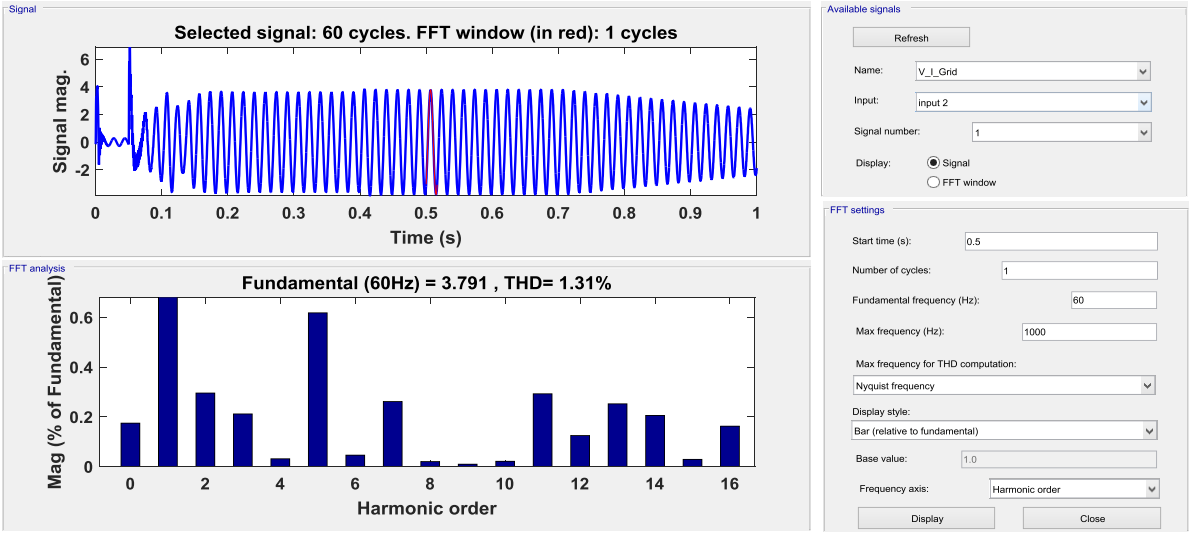

Figure C-1: Grid Injected Current Harmonics

Simulation results portray that the standard limits for voltage & current harmonics have been efficaciously attained that is in voltage THD% value is 0.26% and in injected current THD% value is 1.31%

IV. CONCLUSION

The sunlight which is the primary and utmost major source of renewable energy in the world. PV systems transform energy obtained from sunlight into electrical energy/electricity. PV panels produce DC power output which need to be controlled accurately and converted into electrical energy or other usable forms of energy. But the main problem is that the output of these inverters contains harmonics due to staircase output. Therefore, in this research work the main focus is to minimize the harmonics in the inverter output signal by means of multilevel inverter. Also, for maximum power abstraction from the PV system an accurate control scheme is required for MPPT to continuously track the MPP.

V. REFERENCES

[1] F. Liu, et al., "Variable Step Size INC MPPT Method for PV Sytems," IEEE Transactions on Industrial Electronics, vol/issue: 55(7), 2008.

[2] IEA-PVPS, "Trends in Photovoltaic Applications. Survey report of selected IEA countries between 1995 and 2011," International Energy Agency – Photovoltaic Power Systems Programme, Tech. Rep. IEA PVPS T1-21:2012, August 2012

[3] Singh Mukhtiyar, KhadkikarVinod, Chandra Ambrish, and Varma K. Rajiv. Grid Interconnection of Renewable Energy Sources at the Distribution Level with Power –Quality Improvement Features. IEEE transactions on Power Delivery, vol.26, no.1, pp 307 –315, January 2011.

[4] NeginHeidari& Joshua M. Pearce. A Review of Greenhouse Gas Emission Liabilities as the Value of Renewable Energy for Mitigating Lawsuits for Climate Change Related Damages. Renewable and Sustainable Energy Reviews 55C (2016) pp. 899-908.

[5] M. C. Mira, et al., "Boost Converter With Combined Control Loop for a Stand-Alone Photovolainc Battery Charge System," IEEE 14th Workshop On Control and Modeling Power electronics, 2013.

[6] "Photovoltaic Cell Conversion Efficiency," U.S. Department of Energy, Retrieved, 19 May 2012.

[7] D. Sera, et al., "On the Perturb-and-Observe and Incremental Conductance MPPT Methods for PV Systems," IEEE Journal of Photovoltaics, vol/issue: 3(3), pp. 1070-1078, 2013. .