ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Transformer less MCPWM Controlled 2-Stage IsolatedGrid Connected PV System

Mr.P.Shekar
M.Tech (Power Electronics)
Dhruva Institute and Technology
Nalgonda, Telangana 508252

Mr.V.Balu
Assistant Professor
Dhruva Institute and Technology
Nalgonda, Telangana 508252

Abstract: In this proposed study, Transformerless MCPWMControlled 2-Stage PV System is proposed for 3-phase electricalpower generation. In this present scheme, to get AC power, powerconditioning has been proposed in two stages; namely in first stagemaximum power will be extracted and in second stage DC powerwill be converted into AC power. In this research paperconversion topology has been proposed for transformer less PVsystem and verified its results in MATLAB Simulink which isinterfaced with Xilinx system generator. To extract optimum DCpower from solar PV modules MPPT charge controller isdesigned. In this study, constant voltage MPPT charge controlleris designed based on small signal analysis of converter withPM=57° and GM=14.7dB. After this charge controller output fedto Multi level inverter for the conversion of dc to ac. Proposedmultilevel inverter is offering very low line voltage THDscompared with conventional inverter and observed that they arevery low, hence required less size and cost of the filter.

I. INTRODUCTION

Renewable energy as the name suggests the energy availableagain and again for the utilization. Interest of using renewableenergy has boost up in past few years in order to decrease theburden on fossil fuels to generate electrical energy [1]

Most renewable energy comes in - directly or directly fromthe sun. Sunlight can be used directly for lightning homes andlarge buildings and also used for heating purpose and solarenergy for the generation of electricity, for heating of water anda variety of industrial and commercial use. Solar cells convertsunlight into electricity, which can be used in rural areas as asource of electricity. Solar cells are in used calculators as apower source and it is also used in watches.

Solar cells are madeup of semiconducting material which is similar to those used incomputer chips. When sunlight is absorbed by these materials, the solar energy energizes electrons loose from atoms andallowing the electrons to flow through the cell to produceelectricity. This process of converting light (Photon) toelectricity (voltage) is called photovoitaic (PV) effect.. Solar cells are combined together into modules that holdabout a number of cells. Modules created by joining the solarcells forming a array, that are placed in the photovoltaic arraythat trap sunlight on all sides. Several united photovoitaic arraysgenerate enough electricity for a residential load, for largeelectricity utility or industrial applications, a large number ofarrays can be united to form a single large photovoltaic system.

Photovoltaic systems particularly single phase systems arebecoming more important worldwide. They are usually privatesystem where the owner tries to get the maximum systemprofitability. Issues such as reliability, high efficiency, smallsize and weight and low price are of great importance to theconversion stage of the photovoitaic system. Often, these PVsystems include a line transformer in the power conversionstage, which guarantees galvanic isolation between the load andthe PV system thus providing protection. As it strongly reducethe leakage current between the photovoltaic system and theground.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

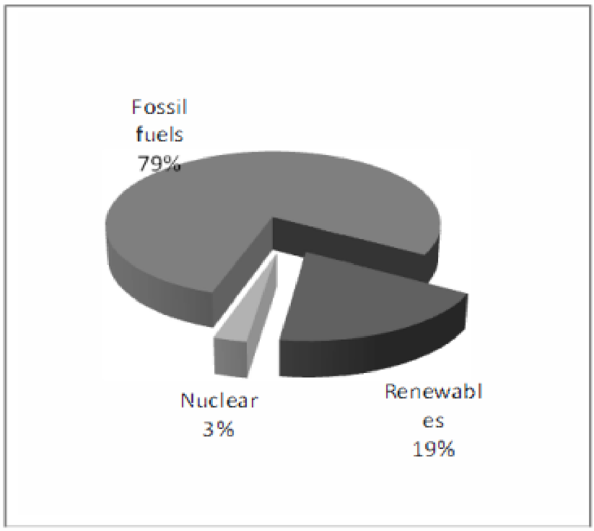


Fig.1 Worldwide electricity energy consumption

From the Fig. 1 we can observe that the energy production fromsolar photovoitaic is low. But there is reduction in the energyproduction by fossil fuels. The two main topologies have beenstated in the photovoltaic system i.e. with and without thegalvanic isolation. The main aim of the galvanic isolation is tooffer safety for the user, but this decreases the overallefficiency of the system. In the case of the Transformer lesssystem the efficiency of the system raises up. The mostimportant advantage of the Transformer less system is that itoffers higher efficiency, smaller in size and petite in weight ascompared to system with transformer. [2]

The differences between standard or conventional inverters andTransformer less inverters are:

Conventional inverters are built with an internal transformerthat synchronizes the DC voltage with the AC output.

Transfonnerless (TL) inverters use a computerized multi-stepprocess and electronic components to convert DC to highfrequency AC, back to DC, and ultimately to standardfrequencyAC.

Comparison between Transfonner and [1, 3, 4]Transformer less inverter:-

Table I comparison between transormer an d tans ormerless

Parameters	Transformer	Transformerless
Sensitivity	Lower	Higher
Distortion	Higher	Lower
Low frequency reproduction	Less precise	Good
Noise immunity	Higher	Lower
Cable drive	Longer	Shorter

II.PROPOSED TOPOLOGY

Fig.2 shows the block diagram of the proposed transformerlesssystem which consists of two stages. In this system a solararray has been constructed in Matlab by combining it into seriesand parallel combinations. As we now the output of solar cell isvariable so we have deployed a DC-DC converter whichconverts variable DC into fixed DC, this is done in first stage.In second stage DC is converted into AC which will be utilizedby the appliances.

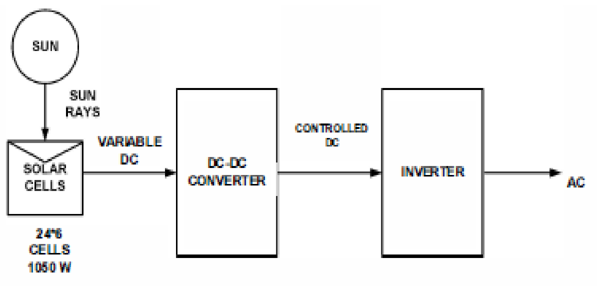


Fig. 2 Block diagram of the proposed system

A. PV Module

The heart of every PV system is the array of photo voltaicmodules. Today, the overwhelming maiority of PV modules(more than 95%) are crystalline silicon, made from the secondmost abundant element on earth. A PV module converting lightinto electricity can be modeled as a single diode model.Relationship among the different current and voltages of theequivalents circuit model of PV module. [5

$$I_{LG}- I_D-(V_D/R_{SH}) - I_{PV} = 0 \quad (1)$$

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

$$V_{PV} - V_D + I_{PV} R_s = 0 \quad (2)$$

I_{LG} = Light Generated current.
I_D = Diode current.
V_D = Diode voltage.
R_{SH} (Ω) = Shunt Resistance.
R_s (Ω) = Series Resistance.

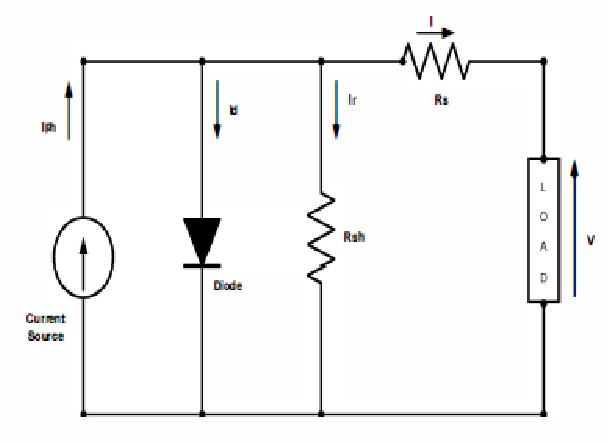


Fig. 3 Equivalent circuit of a solar cell

I_{PV} (Amp) & V_{PV} (V)are the module output current and voltage.Operating equation of the PV module

$$I_{PV} = I_{LG} - I_{sat}\{e^{\frac{q}{AKT}(V_{PV}+I_{PV}R_s)} - 1\} - (V_{PV}+I_{PV}R_s)/R_{SH} \quad (3)$$

I_{sat} t(Amp) is the PV module saturation current. Temperature(T) in Kelvin is the temperature of the PV module. The panel isoperated usually or near maximum power point for optimumperfonnance of the system.

B. Boost Converter based MPPT Charge controller

DC-DC Boost converter is used to magnify the voltage fromPV to a suitable form of energy accepted by the load. Boostconverter is a second order system consists of an inductor, acapacitor, a diode, and with the load resistance connected inparallel with the capacitor. As the output from PV is notconstant due to the ambient temperature and environmentalcondition, the modeling of such converter is crucial. [6]

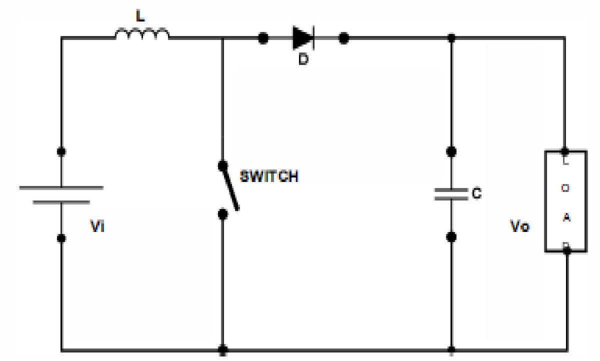


Fig. 4 Boost converter

A DC-DC boost converter can be modeled based on theknowledge about PV voltage. DC-DC converters are dynamicalsystems with highly nonlinear behavior. [7] The use ofsemiconductor devices as a switch makes the system nonlinear.Moreover, the parasitic capacitances and inductances ofthe switches produce nonlinear phenomena of the converterbuilt up by these power electronic components. In DC-DCconverters, load fluctuation behaves as disturbances to thesystem. As such, the system is non-linear in nature and cannotbe easily solved analytically using Laplace transform.Therefore, the utilization of powerful computer aided designpackage is required. Boost converter steps up the voltage[8].The basic ethic of a DC-DC converter consists of 2categories

• First the On-state, when the switch S is closed, itresults in the increase in the current flowing through the inductor.

• Second the Off-state, when the switch S is open and the path offered to the current flowing through theinductor is through the diode D, the resistance R andthe capacitor C. Which results in transferring theenergy acquire during the On-state into the capacitor.

$$V_d * t_{on}/L = \Delta i \quad (4)$$

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

$V_d - V_i * t_{off} / L = \Delta i$ (5)

i is the current flowing through the inductor.

$V_{in} t_{on} + (V_{in} - V_o) t_{off} = 0$ (6)

This can be rearranged as

$\frac{V_o}{V_{in}} = \frac{T}{t_{off}} = \frac{1}{(1-D)}$ (7)

And for a loss less circuit the power balance ensures

$\frac{I_o}{I_{in}} = (1-D)$ (8)

Maximum power point tracking (MPPT) is a technique that isused to get the maximum power from one or more photovoltaic(PV) devices, typically solar panel. Solar cells have a typicalrelation between solar irradiation, temperature and totalresistance that produces a non-linear output efficiency whichcan be analyzed by the I-V curve. The purpose of the MPPTsystem is to sample the output of the cells and apply properresistance to obtain maximum power for any givenenvironmental conditions. [9]

C. Neutral Point Clamped Inverter

The most commonly used multilevel topology is the diodeclamped inverter, in which the diode is used as the clampeddevice to grip the dc bus voltage so as to attain steps in theoutput voltage. Fig. 2 shows the proposed topology i.e. neutralpoint clamped inverter with the boost converter[10].A neutralpoint clamped (NPC) inverter system has a DC power and anNPC inverter having a neutral point connected to the positiveand negative poles of the DC power source to convert the DCvoltage into AC voltage characterized in that first and secondbranch means having a switching element provided between thepositive and negative poles sides of the DC power source andthe neutral point of the NPC inverter, and control means forturning the switching elements of the second and first branchon when short-circuit current of the NPC inverter flow throughthe neutral point of the NPC inverter. [11]

As the size of the fIlter is large it makes the system bulky andheavy. Leading to high cost. To reduce the size of the fIlter aneutral point clamped inverter topology is used[12]. The uppertwo semiconductors are switched on simultaneously giving apositive voltage at the output of the inverter terminal. In thesame way a negative voltage will be developed by at the outputof the inverter by switching on the lower two semiconductor,and a zero voltage is developed by switching the switches. Toincrease the level of the proposed topology transistors, diodesand DC source are to be added [13-14].

The main advantage of this inverter topology is that the Centreof the DC link is connected to the neutral of the load. Thisresults in the decrement of the ground leakage current.

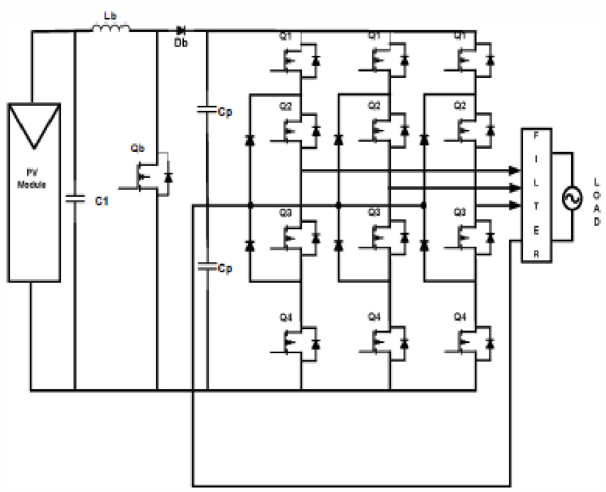


Fig. 5 Boost converter and neutral point clamped inverter

III.SIMULATION

In this section simulation results of the proposed system areshown. The output of the solar photovoltaic module depends onthe irradiation of sunlight and the temperature of the sunlightwhich affects the generated output voltage and current.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

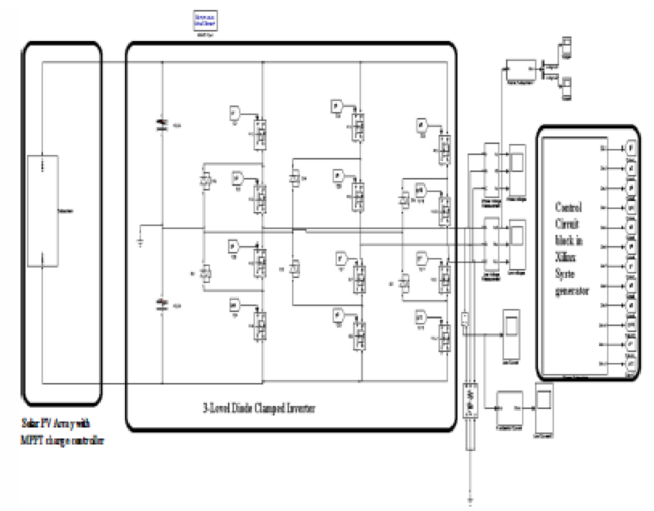
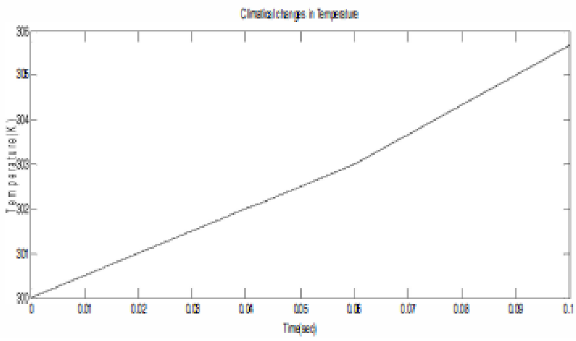


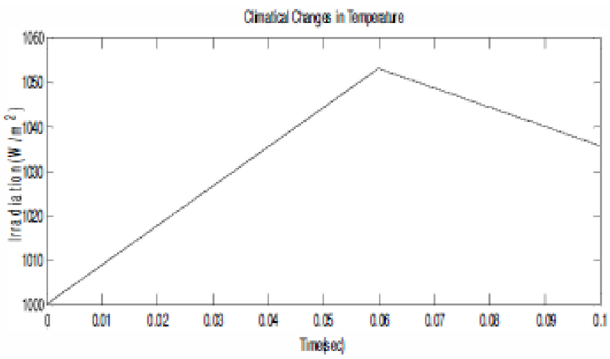
Fig. 6 Simulink block diagram of proposed system

In Fig.7(a) the graph represents the change in the ambienttemperature at the input of the solar PV module. In Fig. 7(b) thegraph represents the change in irradiation at the input of thesolar PV module.

From these input the corresponding output voltage and currentin solar PV module are shown in Fig.8(a)&Fig.8(b)respectively.

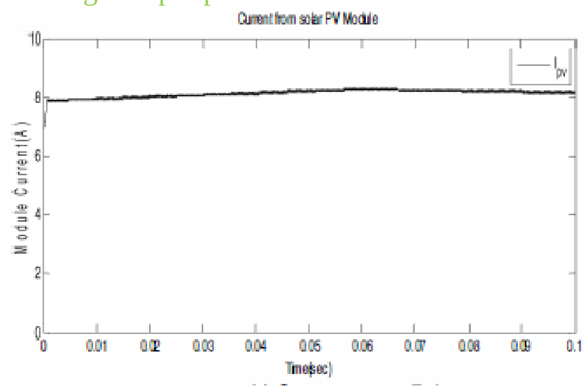


(a) Temperature

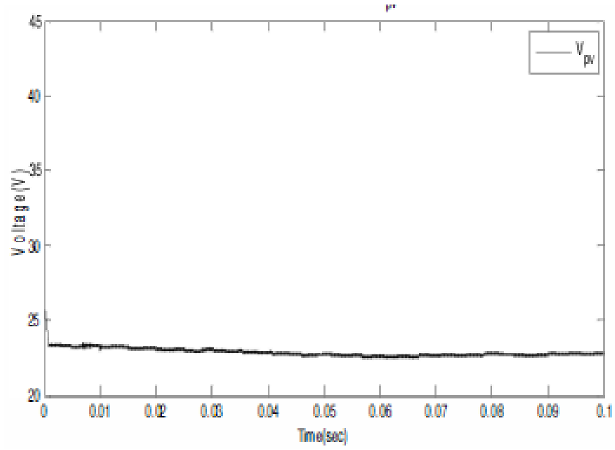


(b) Irradiance

Fig. 7 Input parameters of SPY module



(a) Output current (Ipv)



(b) Output voltage (Ypv)

Fig.8 Output voltage and current of SPY module

The converter proposed in this research paper is boostconverter. Fig.9 depicts the frequency response of the closedloop boost converter.

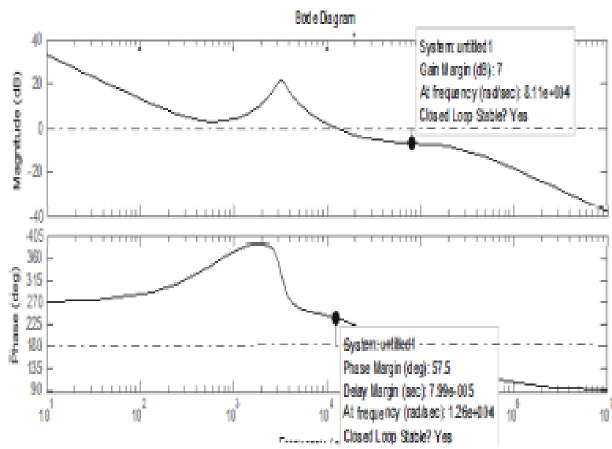


Fig. 9 Frequency response of closed loop boost converter

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Charge Controller 0 utput Voltage

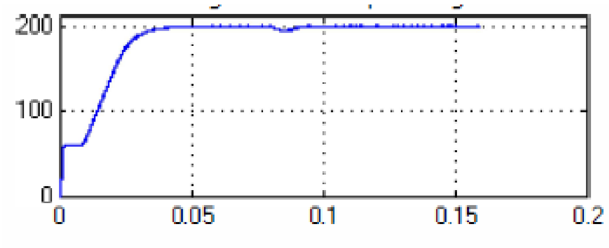


Fig. 10 Charge controller output voltage waveform

Inverter Input Voltage

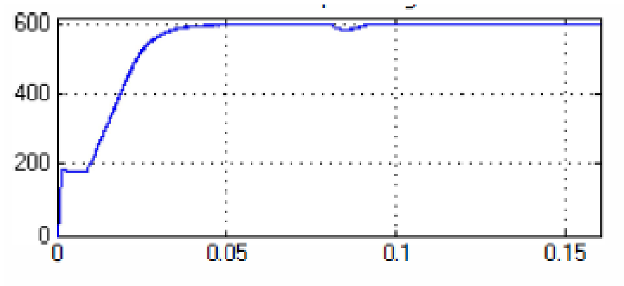


Fig. II Inverter input voltage waveform

Fig.II shows the input voltage which is fed to thethree level inverter.

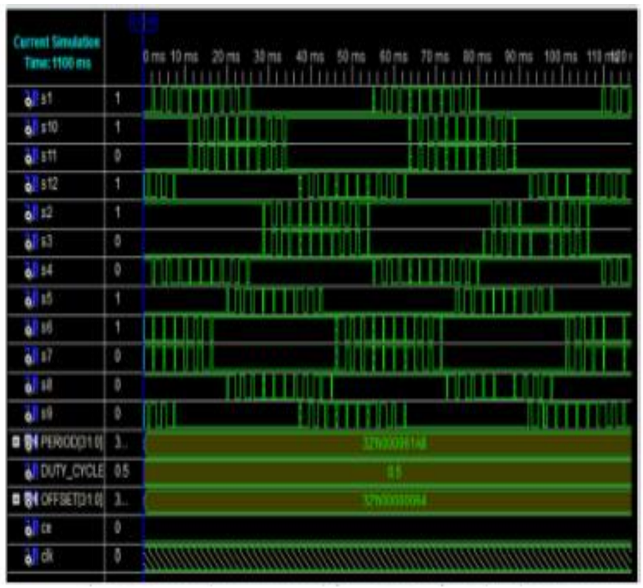


Fig 12 great pulses generated from MCPWM for 3-level MLI

Fig.12 shows the gate pulses waveform which is generated byMCPWM for solar PV system fed three level inverter. Sinusoidalpulse width modulation technique was used to generate pulsesin MCPWM.

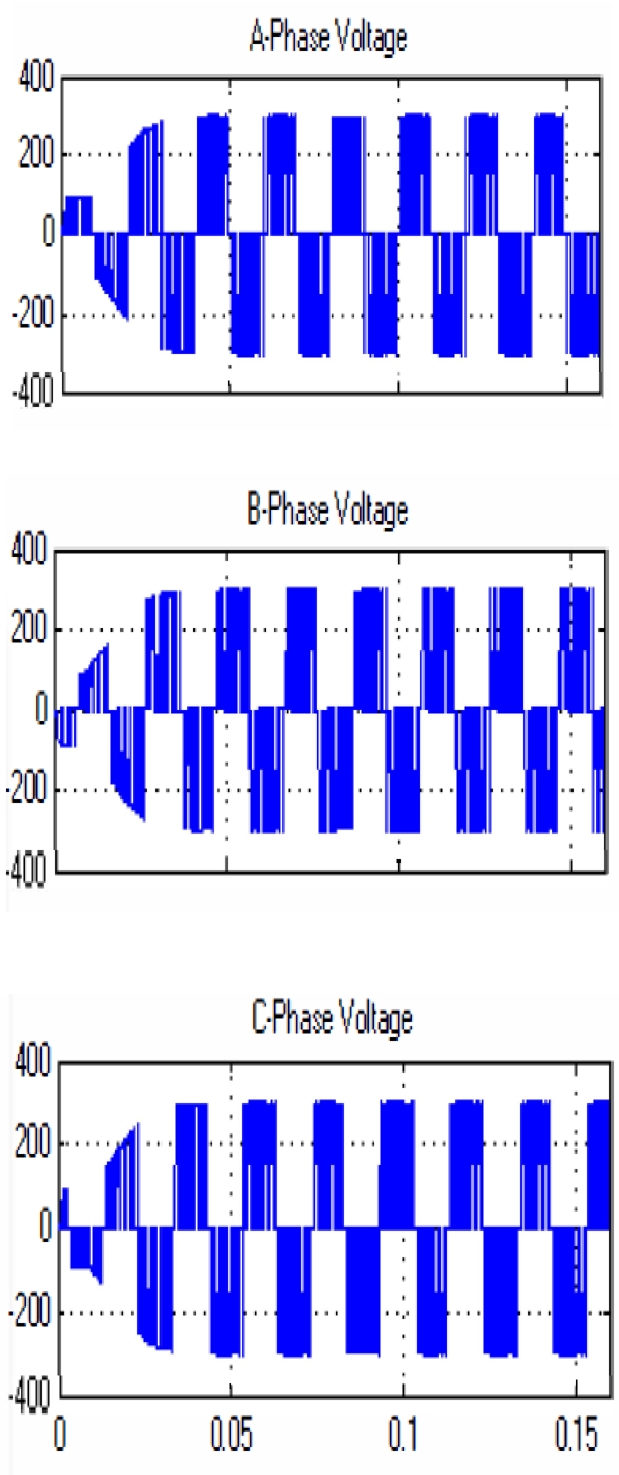


Fig. 13 Phase voltage waveforms

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

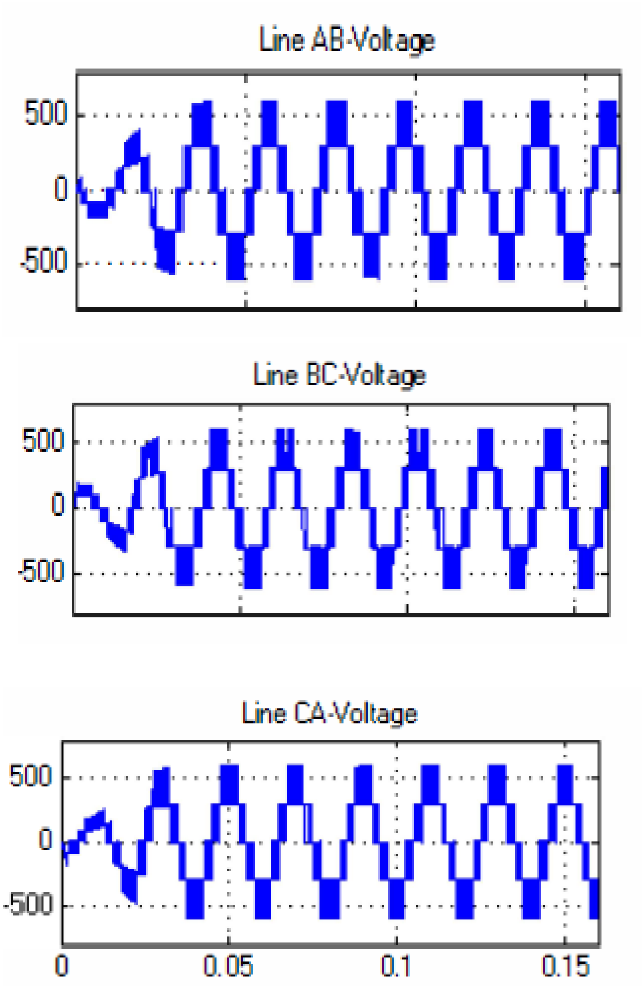


Fig.14 Line voltage waveforms

Phase voltages, line to line voltages, line current are shown inFig. 13,Fig. 14, and Fig. 15.

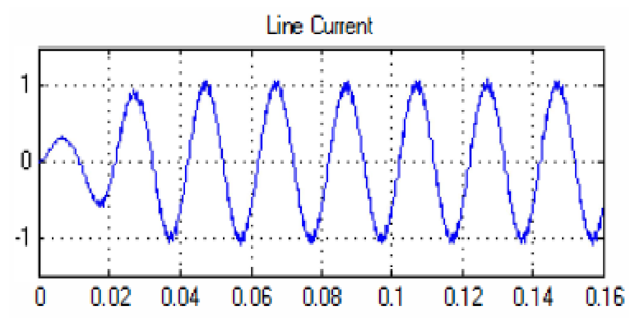


Fig.IS Line current wavefonns

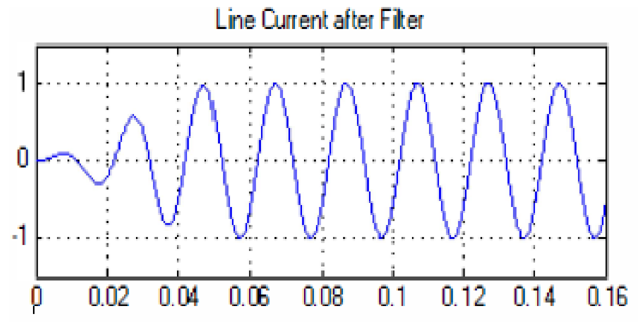


Fig.16 Line current after filtering waveform

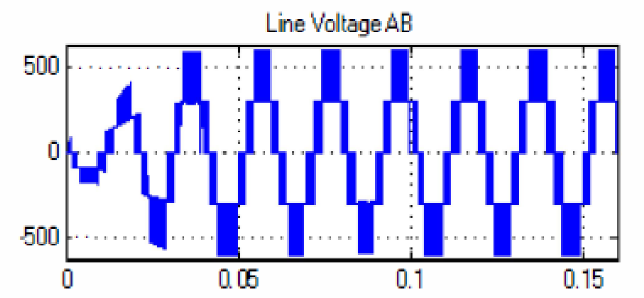


Fig.17 Line voltageAB waveform

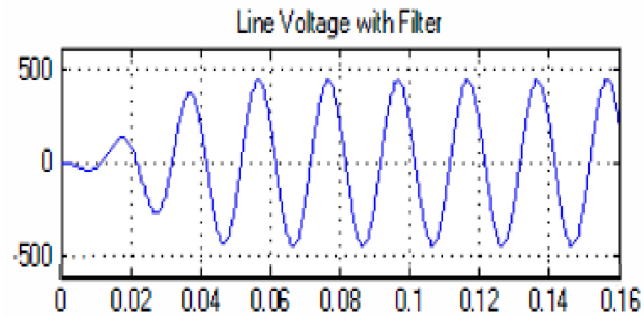


Fig.18 Line voltage with filter waveform

Line voltages and Currents of proposed system THD valuescalculated from MA TLAB are shown in Table. 1

T ab le .1 THD's of voltage an d current 0 f proposed system

Waveform	THD
Line Voltage	21.96%
Line Current	1.51%

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

IV.CONCLUSION

Transformer less inverters offers a better efficiency, comparedto those inverters that have a galvanic isolation. In this researchpaper conversion topology has been proposed withouttransformer in PV system and verified its results in MA TLABSimulink which is interfaced with Xilinx system generator. Inthis topology no common mode voltage is generated, thus Changes in the behavior of the inverter in terms of highefficiency and insures that no DC will be injected into the load.Constant voltage MPPT charge controller is designed based onsmall signal analysis of converter with PM-57 andGM=14.7dB. After this charge controller output fed to Multilevel inverter for the conversion of dc to ac. Proposedmultilevel inverter is offering very low line voltage THDscompared with conventional inverter; offered less size and costof the filter.

REFERENCES

[1] Y. Xue, K. e. Divya, G. Griepentrog, M. Liviu, S. Suresh, and M.Manjrekar, "Towards next generation photovoltaic inverters," in Froc.IEEEEnergy Converso Congr. Expo., 2011, pp. 2467-2474.

[2] Kerekes, T.; Teodorescu, R.; Rodriguez, P.; Vazquez, G.; AJdabas, E.,"A New High-Efficiency Single-Phase Transformerless PV InverterTopology," industrial Electronics, iEEE Transactions on , vo1.58,no.l, pp.184,191, Jan. 2011

[31 Raveendhra, D.; Pathak, M.K.; Panda, A, "Power conditioning systemfor solar power applications: Closed loop DC-DC convertor fed MCPWMcontrolled diode clamped multilevel inverter," Electrical, Electronicsand Computer Science (SCEECS), 2012 iEEE Students' Conferenceon, vol., no., pp.l,4, 1-2 March 2012

[41 Gonzalez, Roberto; Lopez, Jesus; Sanchis, P.; Gubia, Eugenio; Ursua,A; Marroyo, L., "High-Efficiency Transformerless Single-phasePhotovoltaic Inverter," Power Electronics and Motion ControlConference, 2006. EFE-FEMC 2006.i 2th international , vol., no.,pp.1895,l900, Aug. 30 2006-Sept. I 2006

[51 Cavalcanti, M.e.; de Oliveira, K.C.; de Farias, AM.; Neves, F.AS.;Azevedo, G.M.S.; Camboim, F.e., "Modulation Techniques toEliminate Leakage Currents in Transformerless Three-PhasePhotovoltaic Systems," industrial Electronics, iEEE Transactions on ,vo1.57, no.4, pp.1360, 1368, April 2010

[6] L. Ma, T. Kerekes, R. Teodorescu, X. Jin, D. Floricau, and M. Liserre,"The high efficiency transformer-less PV inverter topologies derivedfrom NPC topology," in Proc. Eur. Conf Power Electron. Appl., 2009,pp. 1-10.

[7] W. Li and X. He, "Review of non-isolated high-step-up DC/DCconverters in photovoltaic grid-connected applications," iEEE Trans.ind. Electron., vol. 58, no. 4, pp. 1239-1250, Apr. 2011

[81 Gonzalez, Roberto; Lopez, J.; Sanchis, P.; Marroyo, L.,"Transformerless Inverter for Single-Phase Photovoltaic Systems,"Power Electronics, iEEE Transactions on, vo1.22, no.2, pp.693,697,March 2007

[91 Saini, T.; Raveendhra, D.; Thakur, P., "Stability analysis of MCPWMbased perturb and observe method MPPT charge controller for solarPV system," Engineering and Systems (SCES), 2013 StudentsConference on, vol., no., pp.I,5, 12-14 April 2013

[10] Meneses, D.; Blaabjerg, F.; Garcia, 0. Cobos, J.A., "Review andComparison of Step-Up Transformerless Topologies for PhotovoltaicAC-Module Application," Power Electronics, iEEE Transactions on ,vo1.28, no.6, pp.2649,2663, June 2013

[11] Lopez, 0. Teodorescu, R.; Doval-Gandoy, J., "Multileveltransformerless topologies for single-phase load-connected converters,"IEEE industrial Electronics, iECON 2006 - 32nd Annual Conference

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

on, vol., no., pp.5191,5196, 6-10 Nov. 2006

[12] Oliveira, K.e.; Cavalcanti, M.e.; Afonso, 1.L.; Farias, A.M.; Neves,F.AS., "Transformerless photovoltaic systems using neutral pointclamped multilevel inverters," industrial Electronics (ISiE), 20iOiEEE international Symposium on , vol., no., pp.II3I,1136, 4-7 July2010

[13] Raveendhra, D.; Pathak, M.K.; Panda, A, "Power conditioning systemfor solar power applications: Closed loop DC-DC convertor fed MCPWMcontrolled diode clamped multilevel inverter," Electrical, Electronicsand Computer Science (SCEECS), 2012 IEEE Students' Conference on, vol., no., pp.I,4, 1-2 March 2012

[14] Raveendhra, D.; Prakash, P.; Saini, P., "Simulation based analysis ofMCPWM controlled Cascaded H-Bridge Multilevel inverter fed solar PVsystem," Energy Efficient Technologies for Sustainability (lCEETS),2013 International Conference on , vol., no., pp.568,572, 10-\2 April2013

Mr.P.SHEKAR. He is pursuing M.Tech (Power Electronics) at Dhruva institute of engineering and technology . Completed her B.Tech(EEE) from SRI CHAITANYA institute of Engineering and technology collage sheriguda, rangareddy, TELANGANA STATE,INDIA

Mr.V.BALU he received M.E (Power Systems) from University College of Engineering, Osmania University, Hyderabad in 2008 A.P. Graduated from JNTU University, Hyderabad in the year 2002. Presently he is working as Assistant Professor in Dhruva Institute of Engineering & Technology, Hyderabad in the Department of Electrical & Electronics Engineering. He had total 9 years of experience in teaching. His fields of interest include power quality and Power Systems Optimization.