Available online at www.ijapie.org

INTERNATIONAL JOURNAL OF ADVANCED PRODUCTION AND INDUSTRIAL ENGINEERING

IJAPIE-2018-01-127, Vol 3 (1), 27-32

IJAPIE
Connecting Science & Technology with Management.

A Journal for all Products & Processes.

# Design & Simulation of Transformerless Power Convertors for Solar Application

Soumya Sourav,Vikas Sharma,Vinayak Nadir, Siddharth Verma, J N Rai
*(Department of Electrical Engineering, Delhi Technological University,New Delhi, India)*
*Email: vinayak_nadir@yahoo.co.in*

*Abstract : This paper presents simulation and design results for Transformerless Power Convertors which are to be used in conjunction with a PV array for solar applications. The set of converters consists of a boost converter as well as a single phase inverter for conversion of DC supply from the array to a usable AC voltage. The power extraction from the array is done by using the Maximum Power Point tracking (MPPT) algorithm. Simulation is done on Proteus and PSIM.*

*Keywords: PV converter; transformer-less inverter; boost converter MPPT illumination.*

## I. INTRODUCTION

The dependency on the traditional non-renewable sources energy generation has not only led to fast depletion of the resources but also contributed to the degradation of our environment. There has been a growing consensus around the world to curb the use of these polluting resources and switch to more dependable and clean energy sources. A lot of renewable options are available like wind, hydro, geothermal and probably the most popular of them all solar.

There has been a boom in the renewable energy market all around the world. This growing interest is quite visible by the exponential growth in the demand for Photo-Voltaic (PV) power. In general a PV inverter, converts the variable direct current (DC) output of a photovoltaic solar panel[3] into alternating current (AC) with the desired frequency that can be fed into a commercial electrical grid or used by a local, off-grid electrical network.

The photo voltaic converters used presently generally employ a transformer. This leads to transformer losses. To combat these losses which present mainly in the form of heat a more efficient converter system is designed that does not use transformers for its functioning. Apart from high efficiency the transformer-less PV power convertors has several benefits which are low cost, small leakage current, low harmonic distortion and constant high frequency common mode voltage. Due to nonlinear *i-v* characteristics of a photo voltaic array, the Maximum Power Point tracking (MPPT) algorithm is used as it derives power by tracking the Maximum Power Point, which is the point where the product of current and voltage is maximum.
The system designed is used as a standalone system and is not fed into the grid.

## II. DESIGN OF POWER CONVERTERS

### *A. PV Array and MPPT Algorithm*

The photovoltaic array is a complete power-generating unit, consisting of any number of PV modules and panels. The output current and open circuit voltages are given by the following equations:

$$I = I_L - I_O \{exp\,[\frac{V+IR_S}{nV_T}] - 1\} - \frac{V+IR_S}{R_{SH}} \quad (1)$$

$$V_C = \frac{nK_T}{q}\{ln\,[\frac{I_L}{I_O}] + 1\} \quad (2)$$

The MPPT algorithm allows a PV array to deliver the maximum amount of energy to the desired system is known as *maximum power point tracking* (MPPT)[1]. These are highly reliable and accurate versions that allow us to maximize the charging ability of our PV array and, in some cases, reduce the required PV array size.

MPPT controllers take the power from a PV array at the Maximum Power Point, regardless of the required voltage, and deliver that same amount of power (minus losses) to the boost converter (DC/DC) because they're able to reduce the voltage from the array to the required level.

### *B. DC to DC Boost and DC to AC Converters*

A DC to DC convertor (as shown in Fig. 1) is used to boost the voltage output from the MPPT Controller to a desired level. This voltage is the fed into the inverter. The key principle that drives the boost converter is the tendency of an inductor to resist changes in current by creating and destroying a magnetic field. In a boost converter, the output voltage is always higher than the input voltage. When the switch is closed, current flows through the inductor in clockwise direction and the inductor stores some energy by generating a magnetic field. Polarity of the left side of the inductor is positive[2].

When the switch is opened, current will be reduced as the impedance is higher. The magnetic field previously created will be destroyed to maintain the current towards the load. Thus the polarity will be reversed (means left side of inductor will be negative now). As a result, two sources will be in series causing a higher voltage to charge the capacitor through the diode.

The ratio of the input and output voltage and current is shown below:

$$\frac{V_o}{V_d} = \frac{T}{t_{off}} = \frac{1}{1-D} \quad (3)$$

$$\frac{I_o}{I_d} = 1-D \quad (4)$$

Where D is the duty ratio.

The DC voltage from the boost converter is converted to a square 50 Hz AC voltage via a full H bridge DC to AC Converter[9][4] (as shown in Fig. 4). This is then smoothed to a sinusoidal 50 Hz AC voltage via chokes (two inductors).

To drive the Convertor circuit to enable fast switching we require a driver circuit:

The driver circuit for an H-Bridge is basically the circuit that sits between the PWM digital control inputs and the MOSFET gates. It is used to translate the input voltages to suitable levels to drive the gates and provide enough current to charge and discharge the gates fast enough. We use an optocoupler driver circuit in our power convertor.

## III. SIMULATION RESULT

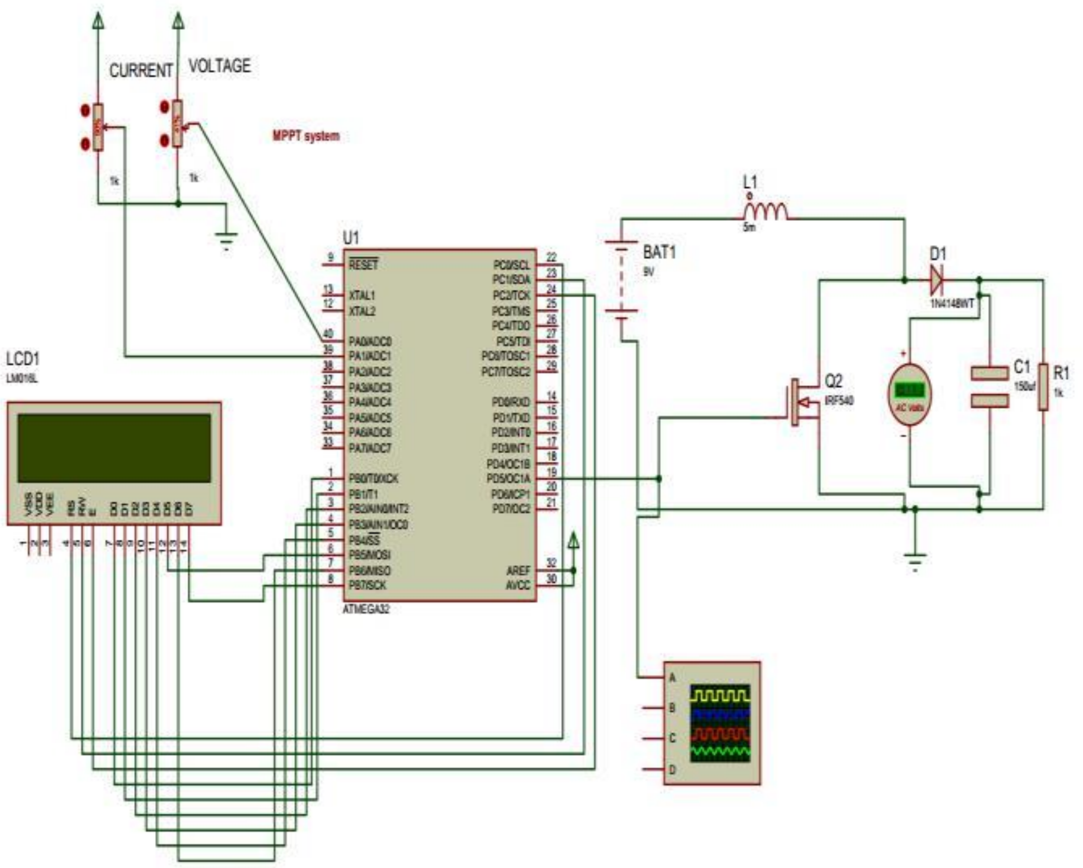


Fig. 1 DC to DC Booster Converter

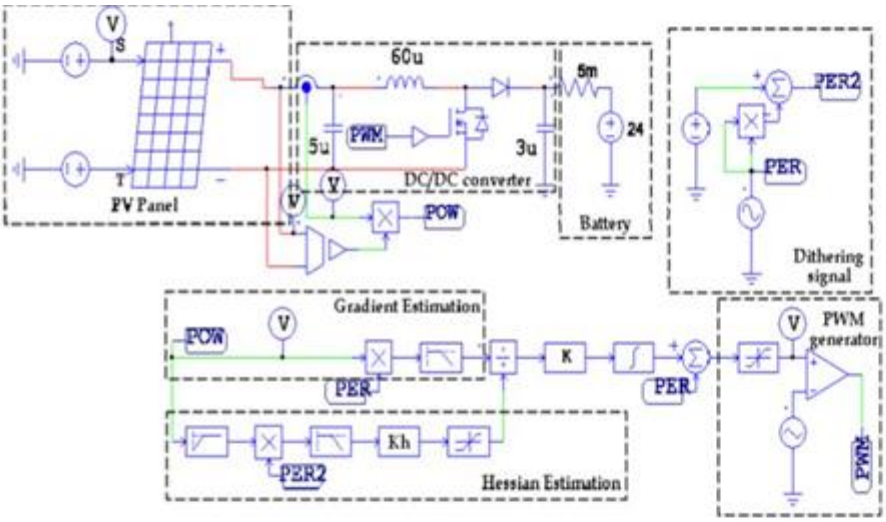


Fig. 2 DC to DC Booster Converter with MPPT system

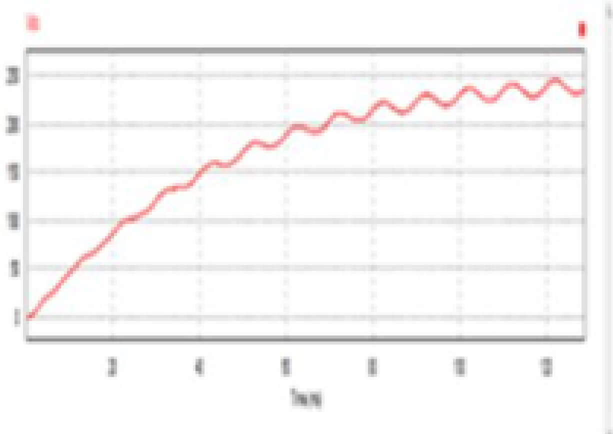

Fig 3(a) Simulation results of DC to DC boost convertor with MPPT algorithm

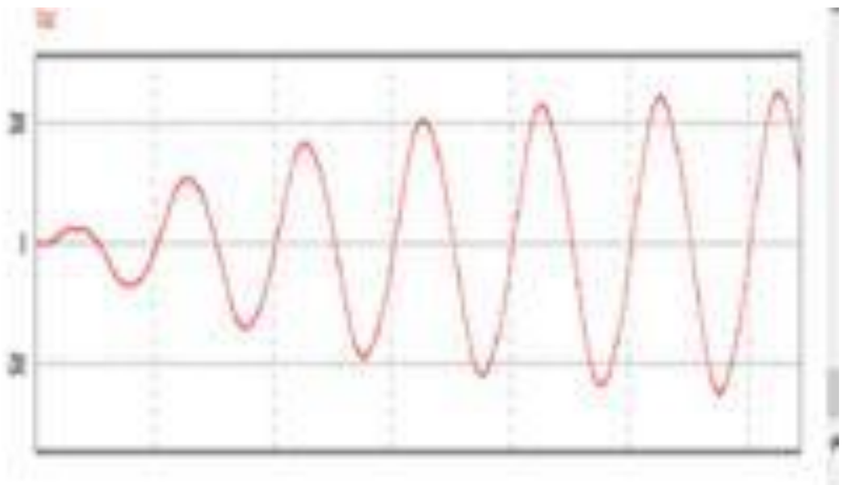

Fig 3(b) Simulation results of DC to AC convertor

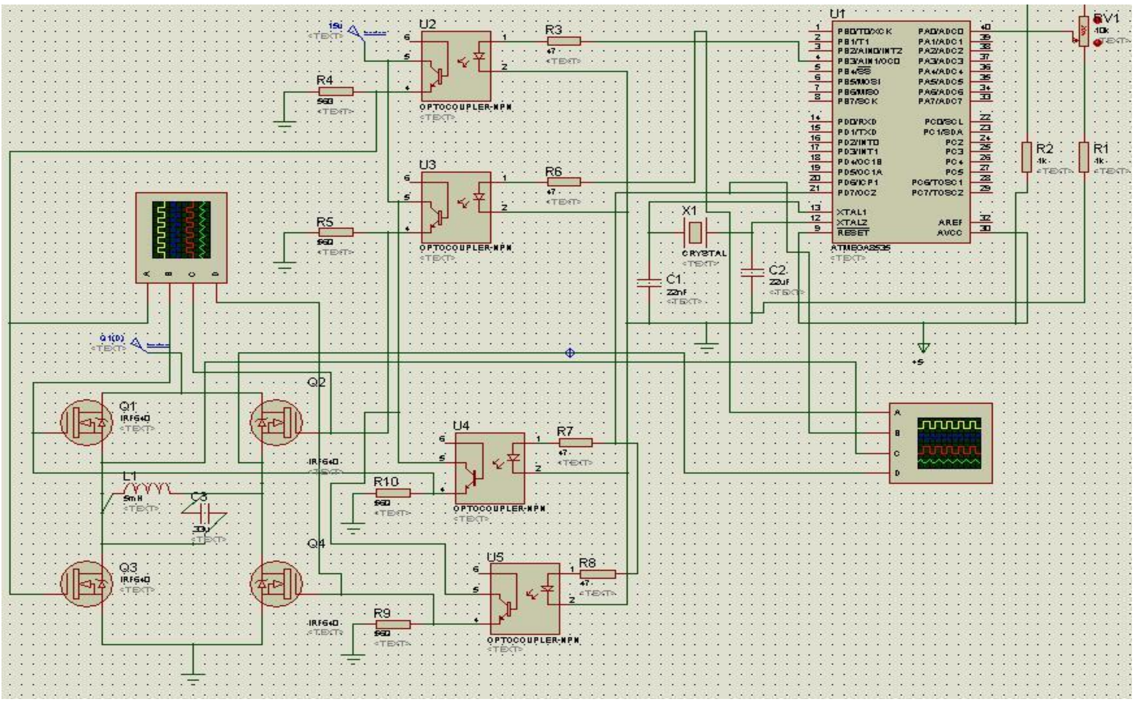


Fig. 4 DC to AC Inverter with Optocoupler Driver Circuit

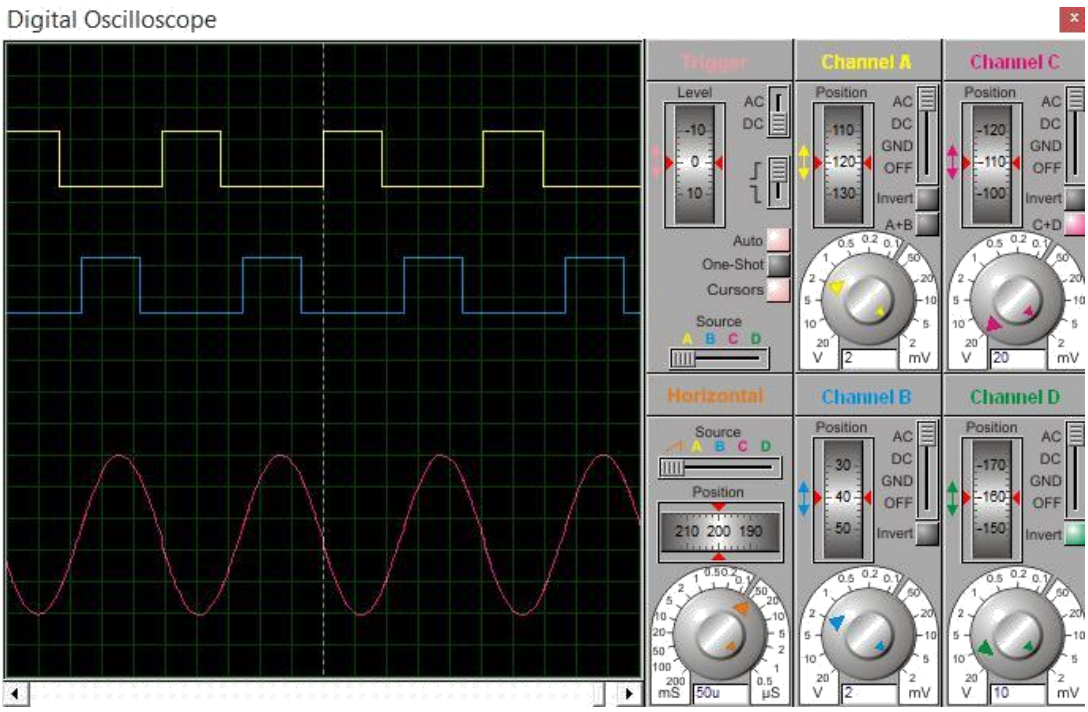


Fig. 5 Simulation of DC to AC Convertor in Proteas

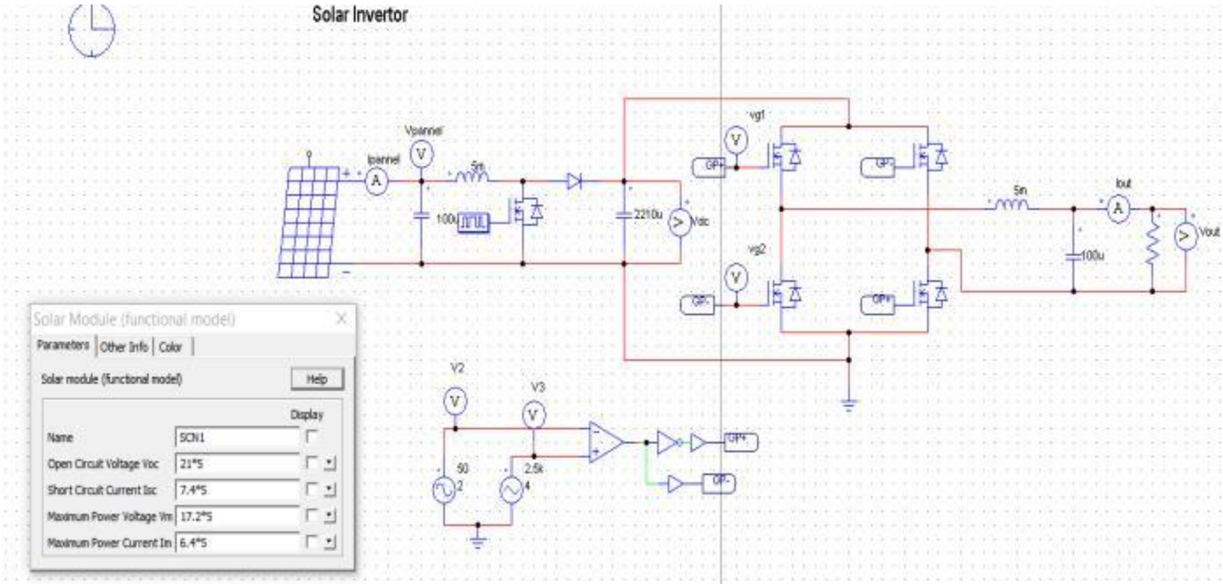


Fig. 6 Complete Circuit Model in PSIM

## IV. HARDWARE MODEL SETUP

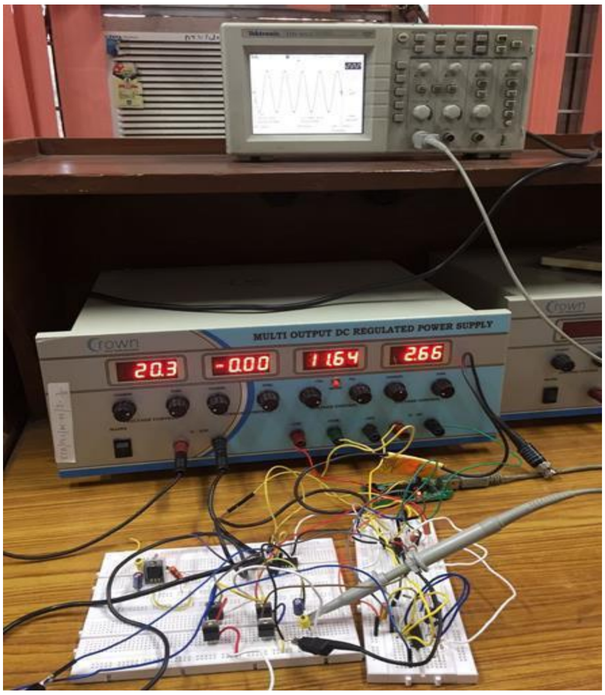


Figure7.Effect of shunt resistance on I-V and P-V characteristics

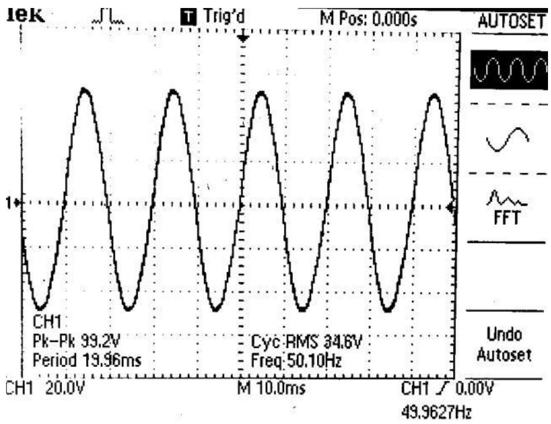


Fig. 8 Hardware model Output

## V. RESULTS AND CONCLUSION

Result has been shown in Fig. 3(a) indicating increasing DC output. The delay in the output voltage is on account of inductor storing energy which does not increases suddenly.

Fig. 3(b) shows the inverter output voltage increasing with increasing DC output. Steady state sinusoidal voltage is achieved with rated DC output voltage of DC-DC boost converter.

## VI. CONCLUSION AND FUTURE WORK

Design & Simulation of Transformerless Power Convertors for Solar Application is concluded. The system can be used for landscape lighting, power tools application, Power pump etc. which makes it quite useful.

The system has an added benefit of being safe due to its low voltage.
The systems construction is done to ensure that heat dissipation is kept at minimum to make sure that the components used don't get damaged. Individual parts of the systems are designed and constructed by making a trade-off between the efficiency and practicality of construction. Several improvements can be made such as:

1. Harmonics cause distortion in the final sine ac output tha can be removed by designing specified harmonic filters[8].
2. We can create a standalone system that has a 230V, 50Hz output that can be used for general household use.

## VII. ACKNOWLEDGMENT

We would like to thank Ajendra Singh for his continued support and encouragement that made this paper possible. We would also like to thank our Department for providing us with the testing equipment for testing our project and the laboratory staff for their help.

## REFERENCES

[1] S. Jain, V. Aggarwal "A single-stage grid connected inverter topology for solar pv systems with maximum power point tracking" , ieee transactions on power electronics, vol. 22, no. 5, september 2007
[2] Voltage Fed Full Bridge DC-DC and DC-AC Converter for High-Frequency Inverter Using C2000, TEXAS INTRUMENTS application report, May 2014
[3] H. Tian, F. Mancilla David, K. Ellis, E. Muljadi and P. Jenkins "A Detailed Performance Model for Photovoltaic Systems", NREL Journal JA-5500-54601 July 2012.
[4] U.A. Kshirsagar, S.B.Chavan and M.S.Chavan, "Design and Simulation of transformer less Single Phase Photovoltaic Inverter without battery for Domestic Application", p-ISSN: 2320-3331, Volume 10, Issue 1 Ver. I (Jan – Feb. 2015), PP 88-93.
[5] V. Suryawanshi, S. Pawar, "Transformer-less grid connected PV inverter for single phase", IJESRT, ISSN: 2277-9655, June 2014.
[6] R. Mayfield, Photovoltaic Design & Installation For Dummies, 1st ed. John Wiley and Son's Inc., 2010.
[7] C. Julian Chen, Physics of Solar Energy, 1st ed. John Wiley and Son's Inc., 2001.
[8] Mohan, Undeland and Robbins Power Electronic, 2nd ed. John Wiley and Son's Inc., 1995
[9] Power Electronics and Control in Grid Connected PV Systems, ECEN 2060.

.