Performance Improvement in Photovoltaic Cell for Grid Connecting System Using Power Converters with Transformer less Techniques

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Abstract—A regulated, constant output voltage from the photovoltaic cell input voltage source is need for many grids connecting system applications. By considering a tradeoff amount cost, efficiency and output noise or disturbed pulse. The step-up chopper with intermediate Proportional Integral control can be a best choice to replace the conventional method of step up chopper to regulate the constant output voltage. In conventional control method of step up chopper with transformer, by applying normal pulses from pulse generator it produces unwanted spikes in the output voltage. A proposed method modifier less converter is implemented to overcome the problem. As it is a transformer less converter it contains leakage electrons. To suppress this leakage electrons Neutral grounding technique is implemented. The same transformer less step up chopper is designed in closed loop by using proportional integral controller to analyze the performance and same results are verified with existing system. The hardware circuit is fabricated based on the above simulation models and results are verified against the theoretical values.

Index Terms— Step up chopper, photovoltaic cell with negative grounding, Proportional integral controller.

1. INTRODUCTION

The need for large-scale gathering of non-conventional energy source, such as sun energy or PV energy, has newly been entirely fixed for dipping green-house gas productions and safeguarding the handiness of energy in the forthcoming. Universal movements have been planned and initiated for developing technologies capable of fulfilling the recognized needs. Sun energy can be used as hot power or as electrical power by means of photovoltaic change. PV cell that has been used widely in many filed and presently with a detachment transformer [2]. Thus, by using the isolation transformer in the circuit can be done mainly in two ways. Using a segregation transformer in the grid related inverter can solve the problem of the escape electrons began by the earth freeloading capacitance in inductive coil.

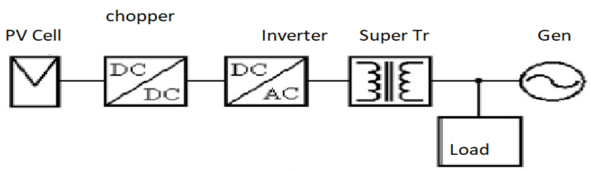

Figure 1(a): PV cell liked to main line normal frequency

One is a normal frequency static device, and the other is a high-oscillation device. Figure 1(a) shows a main line photovoltaic group system with a normal frequency transformer. The cell units can be stranded directly and there is no electrons path for escape electrons because the normal frequency static devices are isolated [1-3]. This system supplies empty direct electrons to the grid and has the benefit of a simple switch circuit. However, the normal frequency transformer's disadvantages are great volume, high bulk, and high cost.

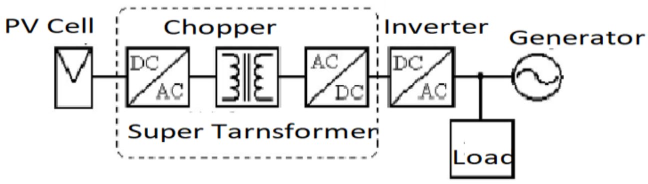

Figure 1(b): PV cell liked to main line with a super transformer.

Fig. 1(b) shows a PV cell liked to main line with a high-oscillation device. The transformer is incorporated in a dc–dc converter and is operated at high frequency to reduce volume and cost [4]. However, the control circuit of this PV cell liked to main line is complicated due to the practice of a protected transformer dc–dc converter. Also, the high-oscillation devices transformer is not placed at the output of the PV cell liked to main line, so it cannot stop the direct electrons from inoculating the main line [3].

The usage of this type of modifier raises the price and scope of the circuit. In order to overawe this problem a new classical is future that reduces these problems that is deprived of using transformer [5-7]. But the drawback of using modifier less converter gives high leakage electrons and increases the erosion [4-6]. This works proposes a modifier less main line power converter with Neutral grounding for a photovoltaic generation system[10-11]. The planned modifier less main line power converter simultaneously solves the problems of escape electrons and Neutral grounding as the topologies. The Neutral grounding of the sun cell array in the planned work is attained by a boost dc–dc converter and select switches [8-9]. Therefore, the problem of erosion in metal or Metal Si thin-film cell units is also cracked.

2. GRID CONNECTING PV SYSTEM WITH POWER CONVERTER

2.1 SOLAR CELL MODELLING

The operational attitude of solar module is based on the PV effect, i.e. the generation of a potential difference at the junction of two dissimilar resources in reply to electromagnetic energy. The photovoltaic effect is meticulously related to the photoelectric effect, where electrons are emitted from a material that has engrossed light with a frequency overhead a material-dependent verge frequency.

The energy of such a photon is given by $E = h\nu$,

where h is Planck's constant and ν is the frequency of the light., is shown in Figure 2 of solar model

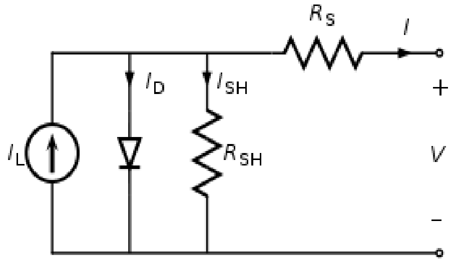

Figure 2: Equivalent circuit of solar model

In an actual semiconductor, the valence and conduction bands are not smooth, but vary depending on the so-called K-vector that designates the crystal impetus of the semiconductor. If the maximum of the valence band and the minimum of the conduction band occur at the same k-vector, an electron can be motivated from the valence to the conduction band without a modification in the crystal momentum. Such a semiconductor is called a direct bandgap material

$$I = I_p - I_i\,[\exp\,(q\,(v + ir_S) / kh_C A) - 1] - (v + ir_S) / r_{SH} \quad (1)$$

Where, I_p is a light-generated electrons or photoelectrons, I_i is the cell saturation of dark electrons,

Table 1: Solar Module

Variable	Parameter	Value
PV	Model	F-MSN-75W-R-02
Pmax	Maximum power	75W
Vin	Open voltage	21.7V
Isc	Short electrons	5.0A

2.2 STEP UP CHOPPER

A step-up chopper (low to high converter) is a power converter with an output DC voltage. It is a class of switching-mode power supply – regulator containing at least two power switches (a diode and a transistor) and at minimum one energy storage element. Filters made of charging devices which is in combination with inductive coil may also be generally added to the output of the converter in order to reduce output voltage disturbed pulse.

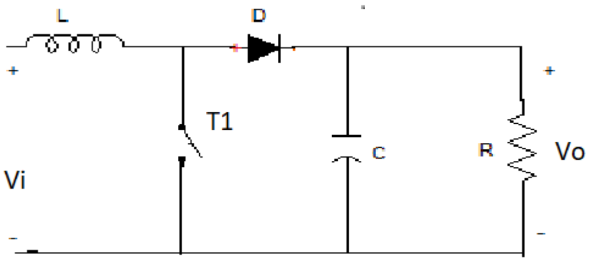

Figure 2a: Basic Step up chopper

The network shows the simple operation of the step-up chopper is shown in figure 2a. The input voltage which is in series with the inductive coil acts as an electrons source. The energy that is deposited in the inductive coil gets augmented when the switch is normally closed. When the switch is in open condition, electrons continue to flow through the inductive coil side and to the load. Since both the source and the discharging inductive coil are providing energy with the switch in open condition, the main consequence is to boost the voltage crossways the load. The load consists of a resistor in parallel with a filter capacitor. The capacitor voltage is advanced than the input voltage. The capacitor is also retained large value in order to keep a constant output voltage and it acts to decrease the swell in the output voltage.

There are two types operation mode: Normal operation mode. Disrupted operation mode

The solar modules output will be variable in order to get the constant output voltage the output is directly given to the step up chopper. From the output of the phase up converter the output voltage disturbed pulse can be found out.

2.3 PROPORTIONAL INTEGRAL

K_{PI} controller gives the control signal in the following way:

$$u(t) = K\left[e(t) + \frac{1}{T_i}\int_0^t e(\tau)\,d\tau\right] \quad (3)$$

where:

Tin – integral time constant of PI controller assuming K = 1 and Tin = 1. Constant $K_i = \frac{K}{T_i}$ (4)

K = is called "reset mode". Integral control is also occasionally called reset control.

1. *Kp*: Proportional Gain - Larger *Kp* typically means earlier response since the greater the error, the greater the feedback to reward.

2. *Ki*: Essential Gain - Larger *Ki* implies steady state errors are eliminated faster. The trade-off is superior overshoot: any negative error integrated during transient response must be integrated away by positive error before we reach steady state.

3. PROPOSED SYSTEM OF PV- GRID

3.1 Exisisting System Circuit Diagram of Pv Grid

The main line power converter is with transformer. Both the problems of TCO corrosion and leakage electrons in Cadmium or arsenic electrode thin-film solar cell array can be avoided. The dc–dc power converter is a step-up chopper. The dc–dc power converter consists of three dc capacitors *Ca*1, *Ca*2, and *Ca*3, an inductive coil *La*1, two diodes *Da*1 and *Da*2, and four power electronic switches *Ga*1, *Ga*2, *Ga*3, and *Ga*5 show in figure 3.

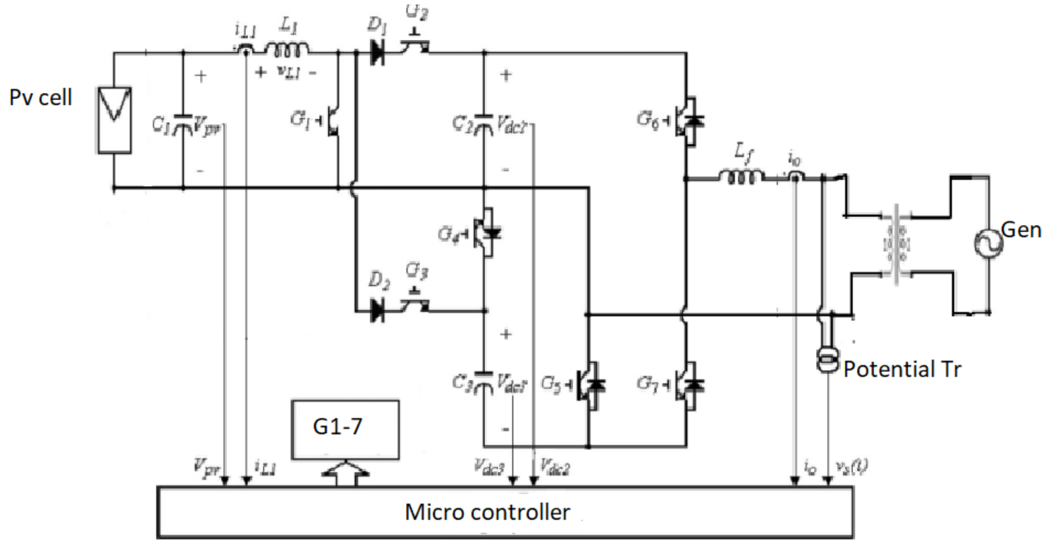

Figure 3: Exisisting System Circuit Diagram

The dc–dc power converter converts the dc voltage of the solar cell array to a stabilized dc voltage. The dc–ac inverter consists of two dc capacitors *Ca*2 and *Ca*3, an ac inductive coil L_f, and four power electronic switches *Ga*4, *Ga*5, *Ga*6, and *Ga*7. The dc–ac inverter further converts the output dc voltage of the dc–dc power converter into ac power and injects into the grid shows proposed transformer less main line power converter. As can be seen, (*Ga*2, *Ga*7) and (*Ga*3, *Ga*5) are switched in opposition and synchronous with the utility voltage.

3.2 PROPOSED SYSTEM

The configuration of the proposed PV generation system. As can be note, the main line power converter is transformer minus, and its neutral terminal is related right to the ground. Both the problems of switch corrosion and leakage electrons in Cadmium or arsenic electrode thin-film solar cell array can be evaded.

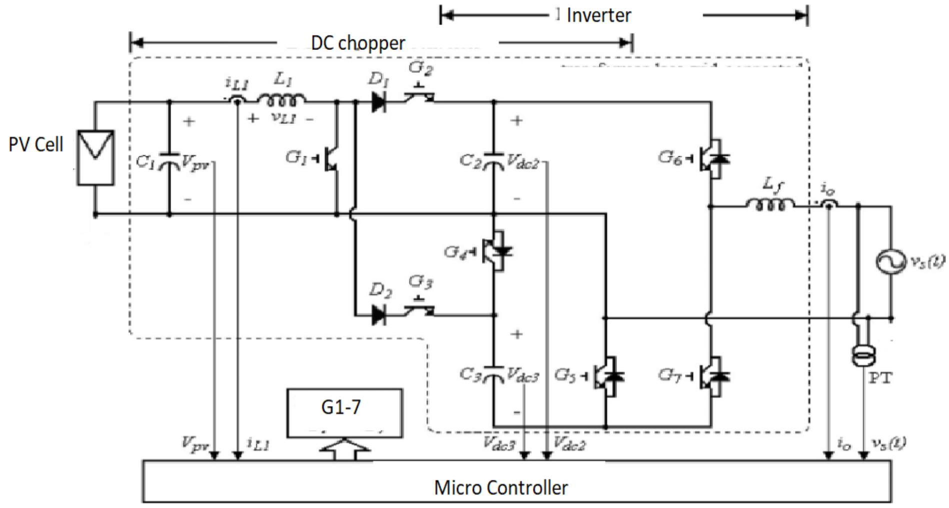

Figure 4 circuit configuration of photovoltaic cell with Neutral grounding technique

Table 2: Parameters for the Proposed Network

Utility voltage	12V, 50Hz
Switch oscillation	18 kHz
DC capacitor(C_1)	470 µF
DC bus capacitor(C_2)	1,680 µF
DC bus capacitor(C_3)	1,680 µF
DC inductive coil(L_1)	2.8 mH
AC inductive coil(L_f)	2.8 mH

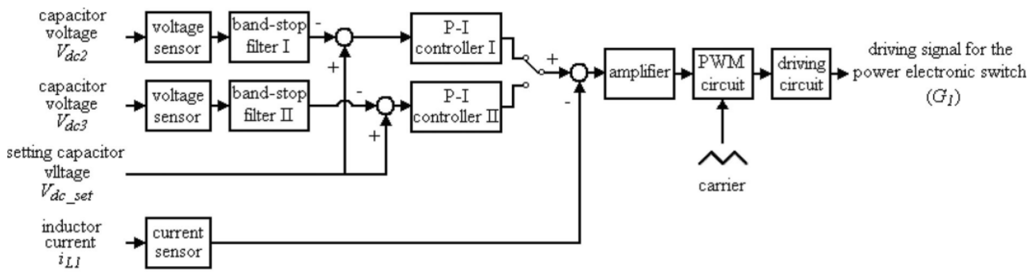

Figure 5: Gate pulse for switch 1

Figure.4 is the control block diagram for the Dc–Dc power converter. *Ga*1 of the dc–dc power converter controls the dc voltages of *Ca*2 and *Ca*3. As previously mentioned, the positive and the negative half-cycles of the Ac electrons are alternately complete from the dc capacitors *Ca*2 and *Ca*3, and the dc capacitors *Ca*2 and *Ca*3 are individually charged during different half-cycles. Therefore, the DC voltages of *Ca*2 and *Ca*3 will contain a voltage disturbed pulse with a frequency equalling the utility frequency shown in figure 5. The generating power of the solar cell array will decrease if their output voltage contains a voltage disturbed pulse. Table 2 shows that design parameter of proposed model of PV grid system without static devices.

3.3 Hardware Configuration of Proposed System

The hardware of step up chopper is intended based on the factors listed in the Table 2. The circuit operates at 99 kHz switching frequency.

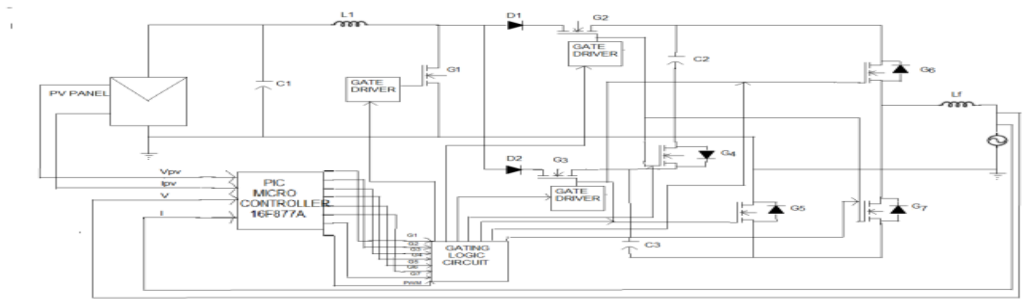

Figure 6: Hardware block diagram

Seven MOSFET switches and fast recovery diodes are used for this configuration. The MOSFET switch and diodes are IRFx840 and INx4007 respectively shown in figure 6. Controller has been implemented using a microchip peripheral interface controller (PIC) micro controller 16Fx877A. The output voltage reference is set to 12.199V and input voltage varies from 1 to 5 V. Seven gate drivers are designed for IRF540.The gating driver logic circuit is applied for the proper operation of the circuit.

3.4 Operation of Hardware Kit

The circuit configuration of the proposed photovoltaic generation system. The main line power converter is modifier less , and its negative terminal is connected directly to the ground. Both the problems of TCO corrosion and leakage electrons in Cadmium or arsenic electrode thin-film solar cell array can be avoided. The proposed modifier less main line power converter is composed of a dc–dc power converter and a dc–ac inverter. The dc–dc power converter is a step-up chopper. The dc–dc power converter consists of three dc capacitors *Ca*1, *Ca*2, and *Ca*3, an inductive coil *L*1 , two diodes *Da*1 and *Da*2 and four power electronic switches *Ga*1,*Ga*2 , *Ga*3 , and *Ga*5 .

The figure 7 below shows the experimental setup that is composed of PIC micro controller, gate driver, gating logic and converter with various parts.

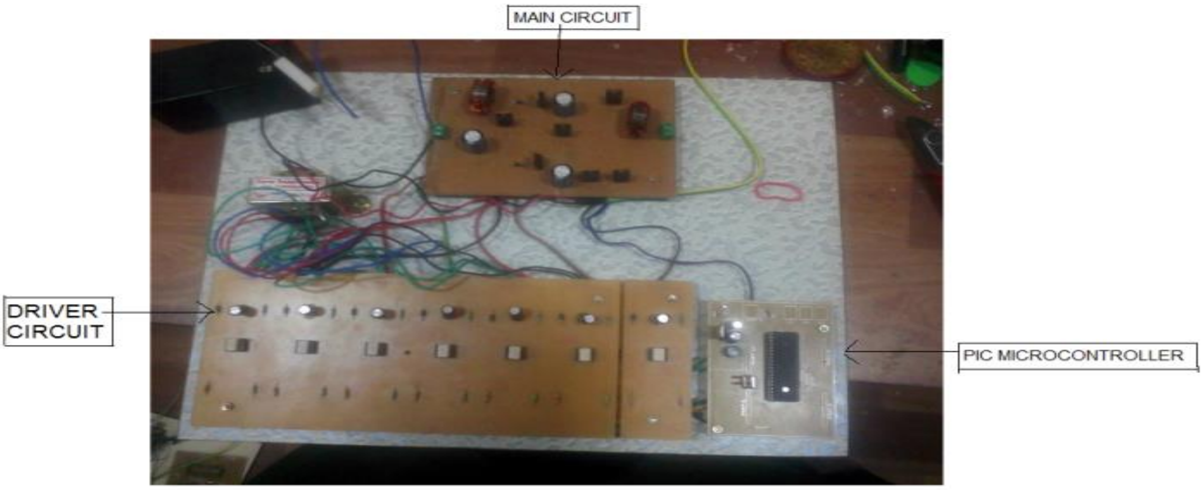

Figure 7: Hardware kit

The dc–dc power converter converts the dc voltage of the solar cell array to a stabilized dc voltage. The dc–ac inverter consists of two dc capacitors *Ca*2 and *Ca*3, an ac inductive coil *Lf* , and four power electronic switches *Ga*4 , *Ga*5 , *Ga*6 , and *Ga*7 . The dc–ac inverter further converts the output dc voltage of the dc–dc power converter into ac power and injects into the grid.

4. SIMULATION AND HARDWARE RESULTS ANALYSIS AND DISCUSSION

The Matlab for the step-up chopper with photovoltaic cell using Neutral grounding technique is designed and output waveforms obtained while applying a photovoltaic cell and applying the normal pulses. The waveforms obtained from this circuit is shown in figure 8(a), (b).

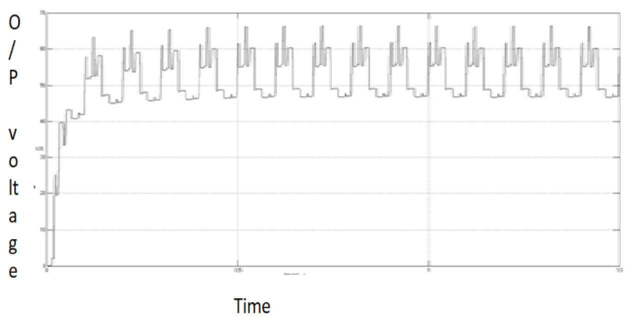

Figure 8(a) Voltage across Vcx3

From figure 8(a) the output voltage obtained in converter side across capacitor Ca3 gets maximum voltage of 8.199V with disturbed pulse factor of 1.79

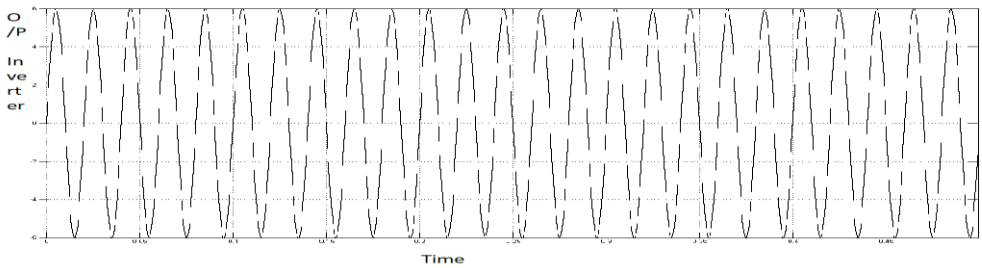

Figure 8(b) Voltage across Inverter

From figure 8(b) the output voltage obtained in inverter side gets maximum voltage of 8.199V. The result obtained after applying the PI controller to the step-up chopper circuit is shown in figure 8(a) and (b) for the existing system of PV grid model.

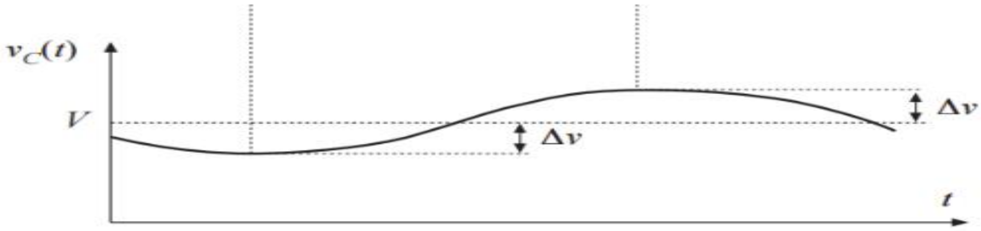

Figure 9(a) Output across V_{cx2}

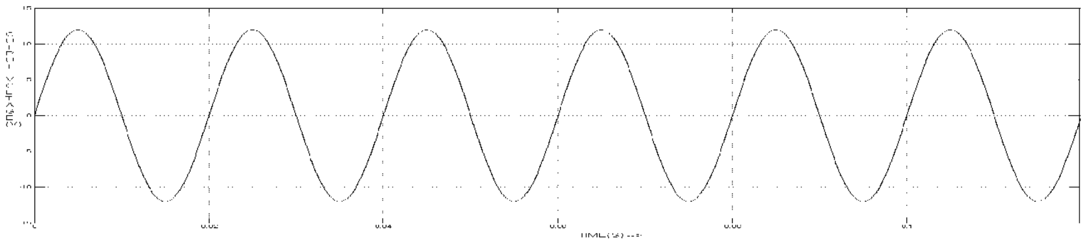

Figure 9(b) Output voltage across inverter.

The output voltage and electrons waveforms of ordinary step up chopper plotted above shows that the output voltage is get increased with the input voltage as that it works for step up chopper by proposed system shown figure 9(a), (b). During this step-up chopper operation, input of 1.419 V is boosted into 8.199 V in converter side and 12.119 V obtained in inverter side. As it is a closed circuit, the results obtained are accurate than the result obtained in open loop.

Table 3: Comparison Table of Simulation Result In Existing And Proposed Model

Existing System	Proposed System
In existing system the circuit is designed using transformer and the corresponding output is obtained.	In proposed system the circuit is designed without transformer and using PI controller the pulses are given to the circuit and the output is obtained.
Input voltage 1-5V	Input voltage 1-5V
output voltage 8.199V	Output voltage 12.119V
Disturbed pulse factor (Vo)= 1.57V	Disturbed pulse factor (Vo)= 0.9V
THD = 6.7 %	THD = 4.6 %

The input and output of the circuit obtained from the hardware model is given below Figure 10 shows the input waveform of the hardware circuit diagram for the proposed system whose input voltage value is 1.409 V. Figure 10 shows the output waveform of the proposed system which is displayed in the digital storage oscilloscope.

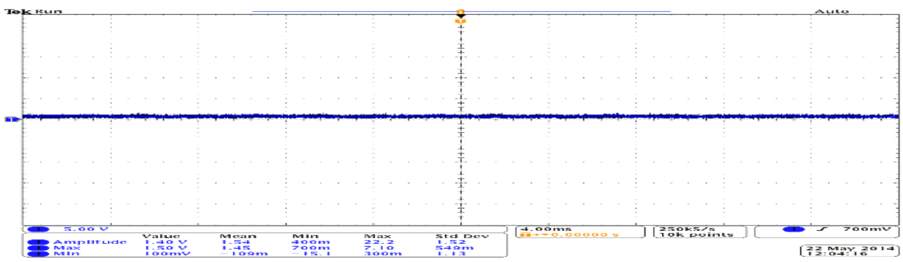

Figure 10: Input waveform of hardware

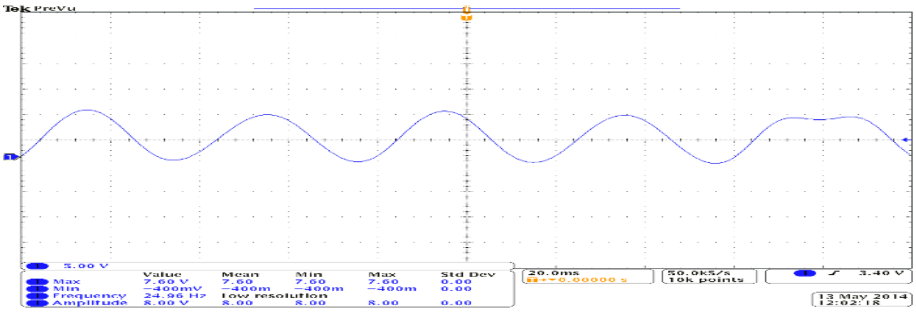

Figure 11: Output waveform from Hardware

From figure 11 the input value of 1.40 V gets boosted to 8.10 V in the output side. The output obtained across the inverter is the AC signal with 10.29 volts.

Table 4: Comparison of Simulation and Hardware

Simulation Value	Hardware Result
Input voltage=1-5 V	Input voltage= 1.4V
Output voltage = 12.9 V	Output voltage= 10.2 V
Disturbed pulse factor (Vo)= 0.9	Disturbed pulse factor (Vo)= 12.2
THD = 4.6 %	THD =5.9 %

Table 4 shows the comparison of proposed system of PV grid model in two categories, the first row is explaining the input and output of various parameter and total harmonics distraction is 4.6 and pulse factor is 0.9 same way the hardware result shows that pulse factor is 12.2 and THD 5.9 %.

5. CONCLUSION

In this article DC-DC step up chopper has been illustrated with a highly enabling control strategy of pulse width modulation. The proposed transformer less technique and PI control scheme can regulate the output voltage for an input voltage, which changes based on the utility grid. The method introduced in this work is unique of its kind in improving the output voltage and reduce disturbed pulse content of the output voltage for a step-up chopper whenever smooth transition is needed. The transformer less method has been utilized to improve the output voltage transients with the use of ground technique. The overall harmonics analysis shows that proposed system has been reduced 79.1 % compare to existing model and 67.01 % power quality has been improved compared to existing system. This is an efficient method to improve the voltage transients in any applications that mainly uses step up chopper technology, for PV application. The required output voltage is obtained across the grid with less disturbed ripple content.

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