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Design of MPPT Charge Controller Using Zeta Converter for Photovoltaic System

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Abstract-— **This project is aimed at the implementation of a Fuzzy logic algorithm Based Maximum Power Point Tracking in Transformer less Grid Connected PV System along with Reactive Power Compensation. A zeta converter based charge controller for PV system is designed and implemented. P&O algorithm is implemented using Fuzzy logic. The mathematical model for PV panel and zeta converter is done. The simulation is done by MATLAB simulation software and the results are compared with the hardware. A DC-DC ZETA Converter is used for maintaining DC input to the inverter at various conditions of irradiation and temperature. This converter is used in power supply modules for electronic circuits. Adapted Zeta converter types with galvanic isolation are used in switched-mode power supplies for active reactive power compensation . Results show the effectiveness of the proposed method in utilizing the PV system. This project is implemented using DSPIC30F2010 controller.**

I. INTRODUCTION

Solar energy has great attention because of its abundance and pollution-free conversion to electricity through photovoltaic (PV) process. Increasing interest in PV systems such as Maximum Power Point Tracking (MPPT) requires more number of PV arrays installation and power electronic circuits to improve protection level, stability, reliability and power quality. Also for safety purpose, most of the PV systems requires galvanic isolation, Galvanic isolation in transformer windings increase the cost and size of the whole system, and decrease the overall efficiency (Kerekes, T., et al., 2009).

The constant current source is obtained by connecting big inductors in series to the DC source; both VSI and CSI are affected by EMI noise. It damages the devices connected. Therefore, the inverter efficiency is required to be improved further to mitigate the effects of the self-power consumption losses, unbalanced load on inverter output voltage, nonlinearity, PV low efficiency and output fluctuation, EMI and THD. One is nonisolated (transformer less) grid-connected inverter PV system and is shown in figure 1

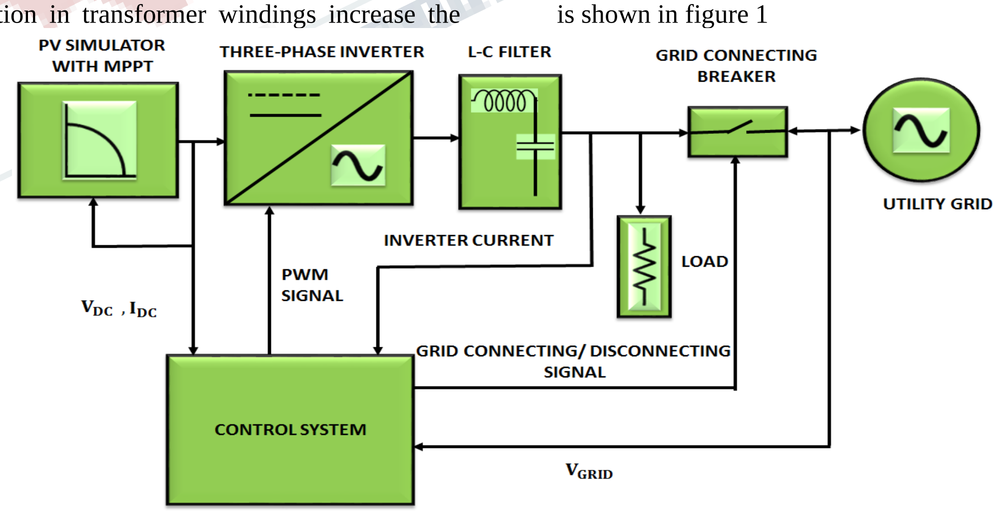

Figure 1. Block diagram of the transformer less grid-connected inverter PV system

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2.PROBLEM STATEMENT

The above statements demonstrate the result of current research for PV system. In this way, the issues accompanying the subject still require further examination: most extreme power point tracker of the PV, the PV framework topology, the power electronic interface, the voltage and current control in island and grid associated modes. The single platform PV framework is a modest topology since it utilizes fewer segments, cost effective and less weight.

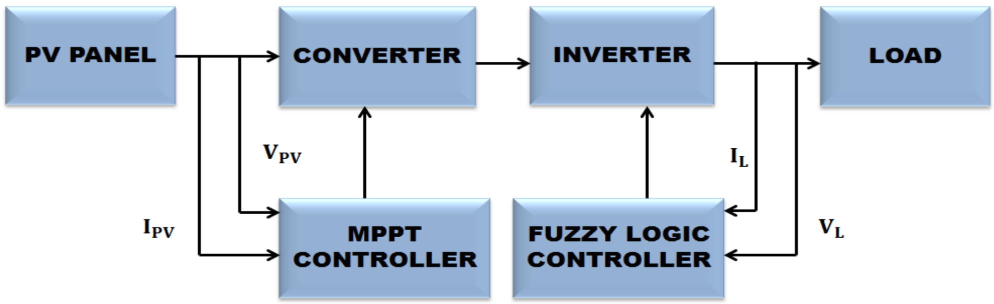

Figure 2.Block diagram of proposed PV system

The DC/AC inverter can handle optimum power and alters the DC current into AC current. The objective is to drive the PV panel at the greatest power point and simultaneously to deliver current with less symphonious contortion. The Perturb and Observe method is broadly utilized in most extreme power point calculation. Nonetheless, this technique wavers around MPPT. The incremental conductance is progressively steady, yet it isn't proficient with a boost converter. With a stable control of greatest power point, effective and quick tracking is possible. Since the distinctive locale of the PV panel requires more examination, a recreation model is needed for investigating and dissects the various converter topology, current symphonious, strength and control of the PV framework.

In this thesis, the investigation of the PV system is carried out. It will break down and build up the demonstration and recreation model of the PV panel, the most extreme power point control and the DC/DC converter. The modeling progression of MATLAB and Simulink of the photovoltaic framework are demonstrated individually and reenactment results are given. The Simulink model of the PV could be utilized further for extending the study with various DC/DC converter topologies. Optimized MPPT estimation can be executed using the current Photovoltaic and DC/DC converter.

3.PV MODULE

PV cells are manufactured from different materials. Mono-crystalline and polycrystalline are the popular techniques of silicon. Conventional solar cell gives less than 2W near to 0.5V hence to obtain a required voltage as output a number of cells are linked in series to make a solar panel. Hence the panels are integrated into an array. The series connection of an array results in high output voltage. During the process if PV cell have no solar radiation it functions as a p-n junction diode. When solar radiation falls on the PV cell due to the interaction between incident photons and cell atom, pairs of electron holes are produced. The electric field produced by the junction of cell divides the photo generated electron-hole pair with electrons and holes drifting to n region and p region of the cell. This movement causes a photo current which rely mainly on intensity and wavelength of solar irradiation (Messenger et al 1999). As mentioned above if solar radiation is not falling on PV cell it becomes inactive and functions as a p-n junction diode. In this condition PV cell does not generate current or voltage. However, when cell is linked with an external large supply than cell voltage it produces a current I_D which is called dark current.

The PV panel should be selected as per the rating of the load. The electrical equivalent diode model of PV cell is given below

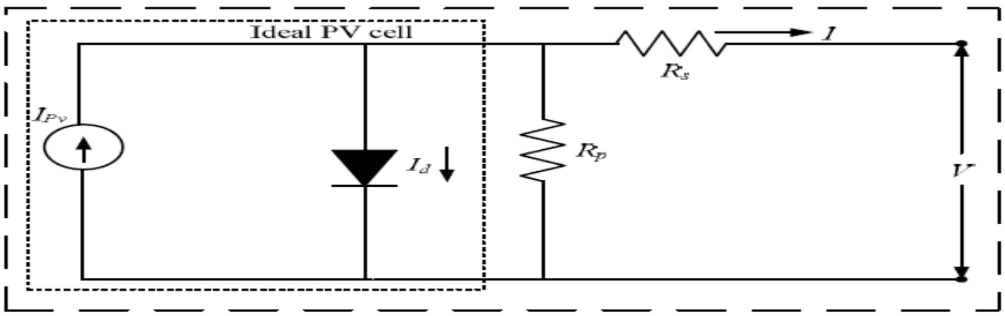

Figure 3. Equivalent circuit of PV cell

The PV model constitutes current sources, diode Shunt resistanceR_{sh}, Series ResistanceR_s. Shunt Resistance R_{sh} represent the cell surface leakage through the edges (manwell et al 1998).

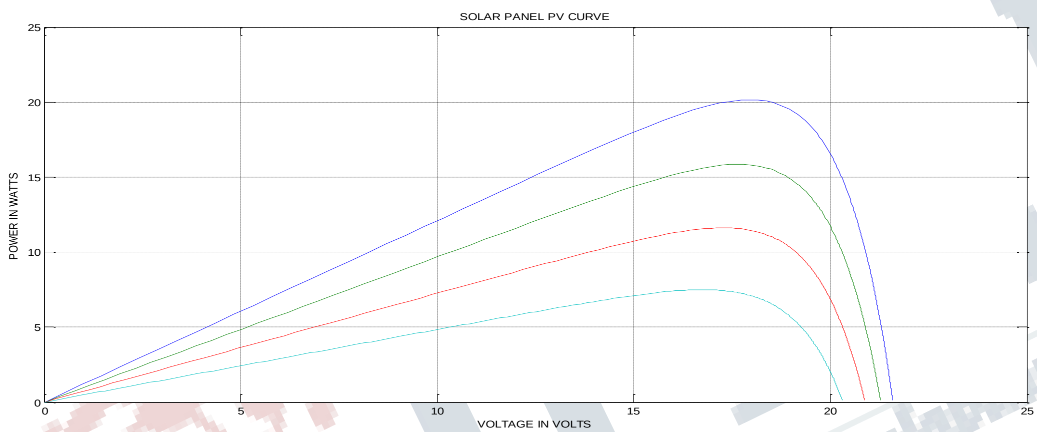

Figure 4. Single Solar panel PV curve

4.FIXED PERTURB BASED P&O ALGORITHM

The fixed perturb based P&O method is the most commonly practiced MPPT scheme. Here a constant value for perturb is used to produce a reference signal for the external control loop. The perturb signal is the reference voltage or current for the panel. The perturb step of fixed size is calculated by the system designer from their previous experience. Hence the solution given by this method is non-generic and not dependent on system. The tracking was slow with minimum power and voltage oscillations for low step size of perturb. With increased oscillations faster tracking is obtained in case of large perturb step. Therefore P&O algorithm with fixed perturb suffer from the problem of tracking and oscillations. To have a control over the power converter, following the MPPT a PI controller or hysteresis Controller is utilized.

5.FUZZY BASED MPPT ALGORITHM

The output efficiency of PV module is nonlinear as the relationship between the solar irradiance, temperature of cell and total resistance of PV cells are nonlinear. Hence to extract maximum power MPPT is utilized. In MPPT the PV output is sampled and fed to the appropriate load resistance to get maximum power at any climatic condition. Maximization of output power and transferring it to load is called MPPT system (Saikat Banerjee et al 2010). The output of PV is altering owing to changes in solar irradiation. Hence for reliability a controller is necessary for the system, so fuzzy based MPPT technique is developed (Mohammed et al 2012). The fuzzy based MPPT is utilized to produce reference voltage by modulating the duty cycle of the PV module.

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COMPARISON OF P & O, FUZZY AND FUZZY MPPT SCHEMES

PARAMETERS	MPPT ALGORITHMS	
	P & O	FUZZY LOGIC
Efficiency	88–89.9 %	96.78%
Response time	High	Better
Complexity	Low	Medium
Input parameters required	V_{pv} and I_{pv}	V_{pv} and I_{pv}

Zeta Converter

Zeta Converter is the type of buck boost converter that can increase or decrease the input voltage. The design of elementary Zeta converter fed PV application is discussed. The components such as input inductor and capacitor L_1 and C_1,output inductor L_2 and output dc link capacitor C_2 helps to work in continuous conduction mode with reduced stress on its devices and its components. Depends on the duty cycle the operation of mode can be changing.

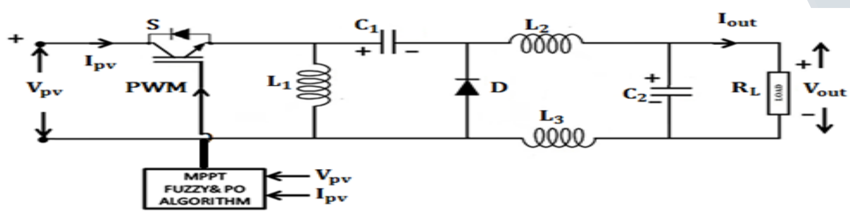

Figure 5.Proposed high gain DC-DC Zeta Converter

6.SIMULATION AND HARDWARE RESULTS

The procedure of the proposed work is verified through MATLAB/ SIMULINK software platform. The same is also experimentally verified by using DSPIC30F2010 controller. The prototype model of the work was implemented and shown in figure. The results taken from both simulation and hardware setup are highlighted and discussed in the following subsection.

Figure 5. Hardware Setup

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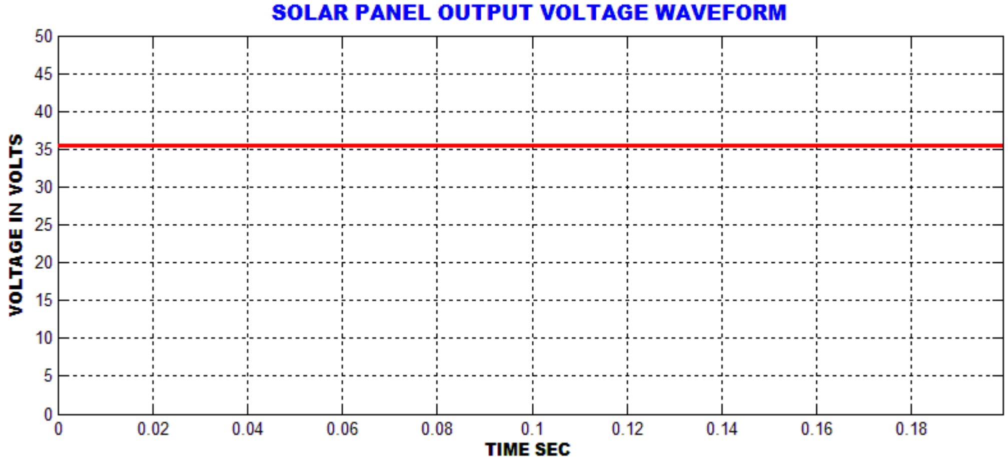


Figure.6. Simulation results of solar panel output voltage waveform (35.6 V)

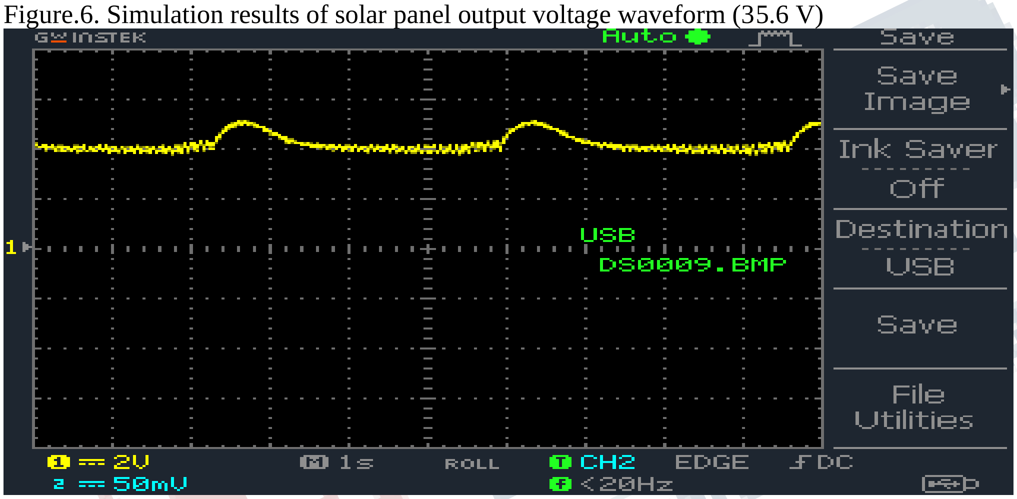
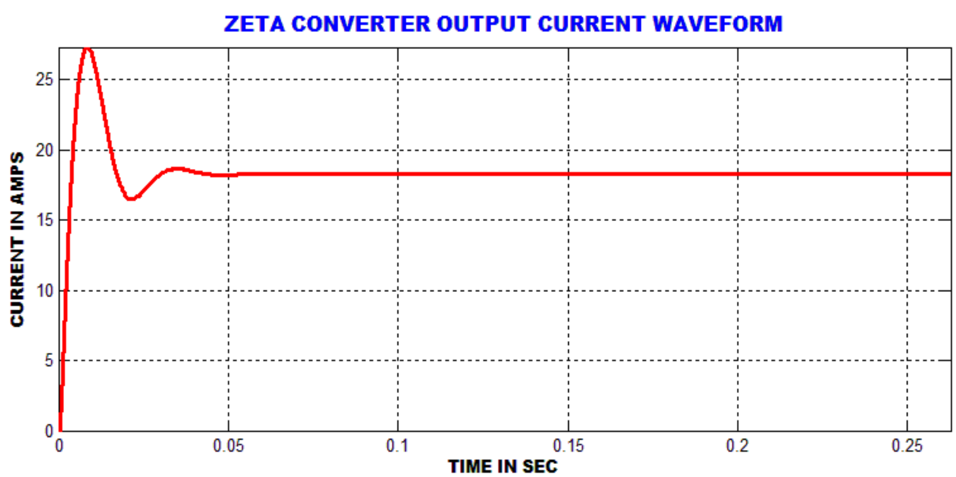


Figure 7.Hardware results of solar panel output voltage waveform

The figure 6 and 7 shows the Solar voltage to the Zeta converter, due to solar panel input variation, solar output voltage has higher order ripples. This voltage is given to the Zeta converter.



Simulation results of Input current waveform from the Zeta converter

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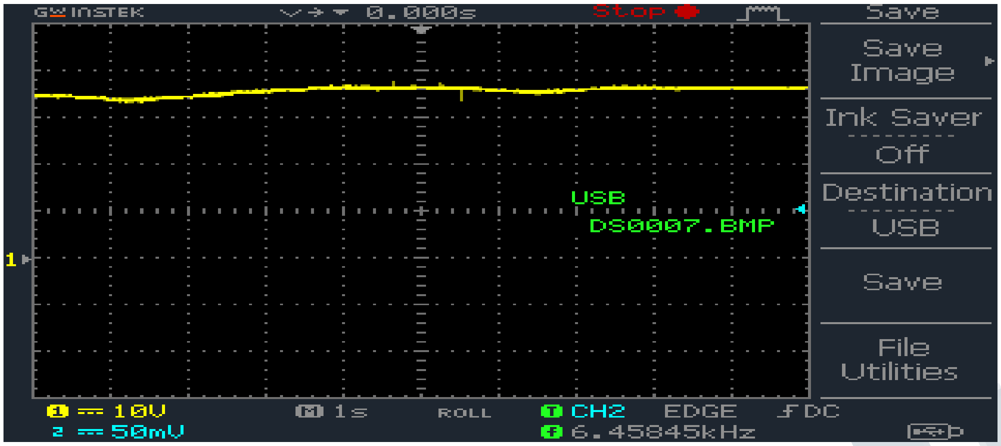
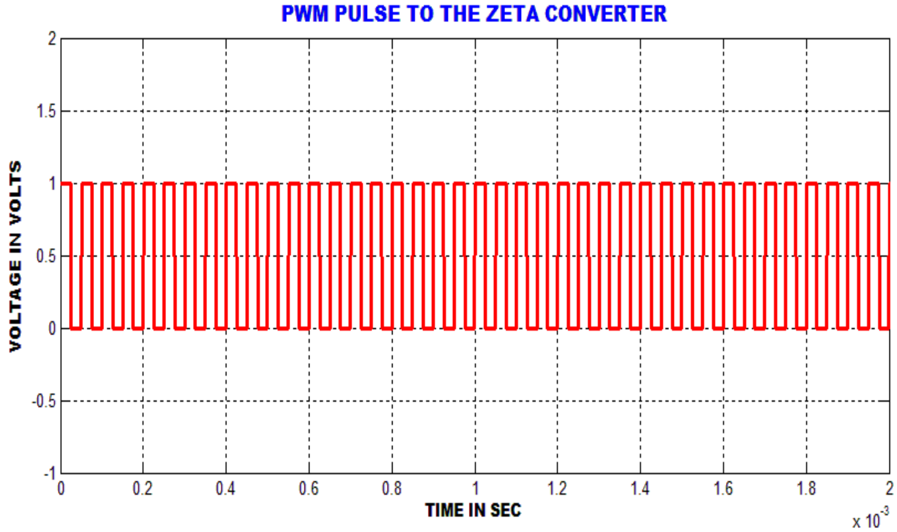
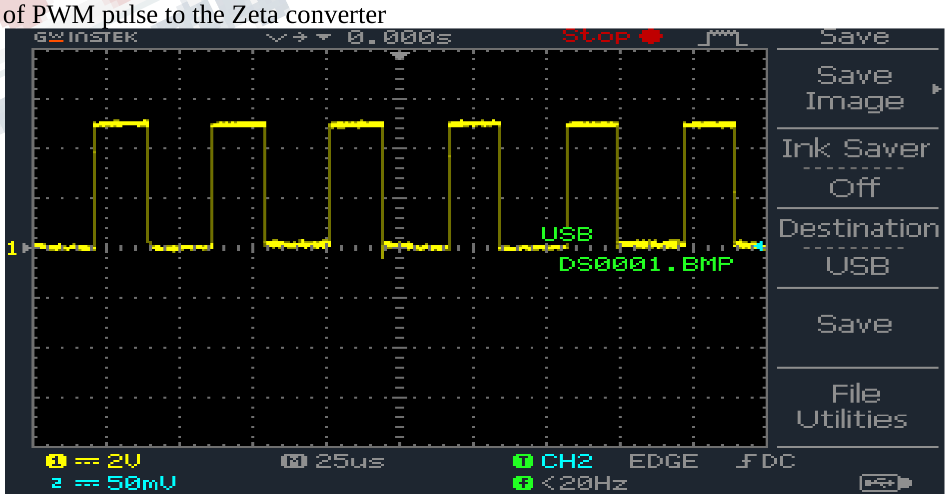


Hardware results of Input current waveform from the Zeta converter

The figures 4.5(a) and (b) show the Zeta converter input inductor current waveform, the inductor L1 present in Zeta converter maintains the input current continuously.



Simulation results of PWM pulse to the Zeta converter



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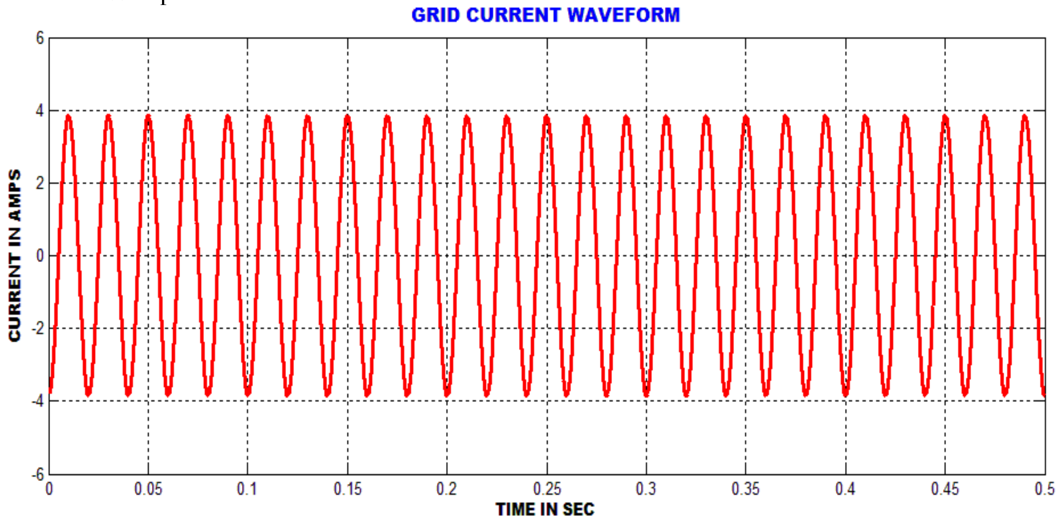
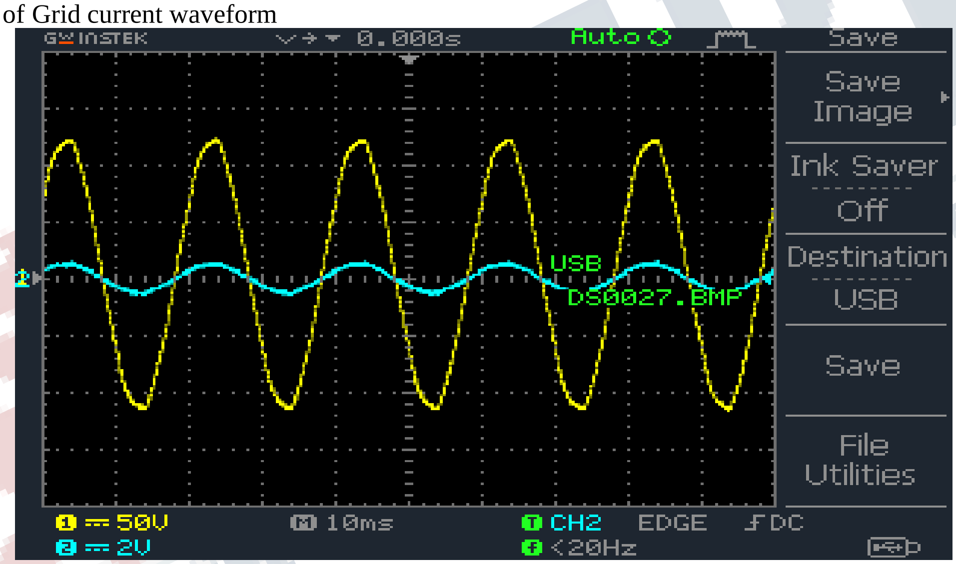
Hardware results of PWM pulse waveform to the Zeta converter



Simulation result of Grid current waveform



Hardware results of Grid voltage and current waveform

The figure 4.9 (c) shows grid voltage and current waveform, it indicates both are in phase. This achieves near unity power factor operation. This system looks likes STATCOM device.

7.CONCLUSION

A zeta converter based charge controller for PV system is designed and implemented. P&O algorithm is implemented using Fuzzy logic. The mathematical model for PV panel and zeta converter is done. The simulation is done by MATLAB simulation software and the results are compared with the hardware. The grid voltage and current both are in phase to each other. This provides a unity power factor operation hence the system looks like reactive power compensator(STATCOM). The steady state waveforms captured at grid-side show that power generated by the DG system is fed to the grid at unity power factor. The voltage THD and the current THD of the generator meet the required power quality norms recommended by IEEE. The proposed scheme easily finds application for erection at domestic consumer sites in a smart grid scenario.

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