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Implementation of Bidirectional DC to DC Converter and Inverter for Vehicle to Grid System by using Sliding Mode and Fuzzy Logic Controller

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Abstract: ***In this paper a bidirectional DC to DC converter is designed by using sliding mode controller and fuzzy logic controller for vehicle to grid system. The vehicle to grid technique is intended to work in both grid to a vehicle battery and vehicle battery to grid applications in vehicle-to-grid scenarios. The two methodologies is verified using MATLAB software. Hardware is made by using a LAUNCHXL-F28377S microcontroller.***

Keywords: Electric vehicle, Fuzzy logic controller, sliding Mode controller, LAUNCHXL-F28377S, Gate driver circuit.

I. INTRODUCTION

EV's provide us with stability that fuel operation vehicles were unable to deliver. Electric cars are becoming more popular, and they provide economic benefits to society and reduce pollution[1]. Electric vehicles emit almost no carbon emissions if they are charged with renewable energy sources [3]. V2G technique provides the electric power stored in electric car batteries to be somehow driven power to the grid at full load [4]. A bi-directional power converter is used to charge and discharge the battery of an electric car battery.[5] Whenever charging of battery takes place that time, dc-dc power converter operates as buck dc to dc converter and at the time of discharging it serves as a boost converter. Since the charging/discharging cycle's impact battery life, it's critical to look after your battery to extend its life and make your device more effective [3][4]. Vehicle to grid and other intelligent energy management features make it possible to charge vehicles' batteries anywhere.[4] This technology assists in balancing energy demand and avoiding excessive costs associated with the construction of an electricity grid[5].

V2G promotes a low-carbon future and opens up the possibility of financial benefits for consumers by providing frequency control and energy storage to the grid. The car's stored energy can avoid peak tariffs and reduce home power usage and bills during periods of high demand. They are taking into account the present situation[5].

The vehicle to grid technique is intended to work in both grid to a car battery and vehicle battery to grid applications in vehicle-to-grid scenarios. This service is gaining popularity due to its benefits, including reducing our reliance on fossil fuels, reducing carbon emissions to zero per cent, and supplying power back to the system during the highest load time[4].The diagram below depicts the system's ability to use bidirectional converters. It is possible to execute in both car battery to grid modes and grid to the car battery[5].

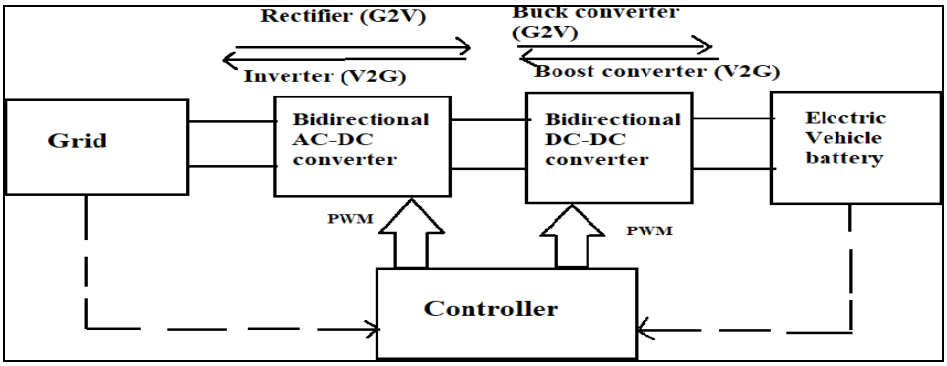


Fig. 1 Block diagram of a system operating in both vehicle battery to grid and grid to the battery of a vehicle.[5]

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II. METHODOLOGY

A. Fuzzy Logic Controller

A fuzzy control system, in turn, leads to an increase in digital logic, which deals with discrete values. It is a numerical technique that assesses analogue input data in judgmental with fixed values ranging from 0 to 1. The number and variety of fuzzy logic applications have grown dramatically in recent years. Applications include market items such as cam software developers and microwave ovens etc., industrial process automation, medical devices, provisions dealing, and inventory collecting. A fuzzy controller is used to control the pulses of a dc to dc converter. The following fuzzy rules are used in the MATLAB Simulink.

Fuzzy Rule

△ e \ e	PB	PS	ZZ	NS	NB
NB	50	45	40	40	40
NS	55	50	45	40	40
ZZ	60	55	50	45	40
PS	60	60	55	50	45
PB	60	60	60	55	50

Table 1 Fuzzy logic rule

B. Sliding Mode Controller

SMC controller methodology is widely regarded as one of the most effective methods for designing reliable controllers for complicated high-order nonlinear dynamic plants working in unpredictable environments. System state fulfils the model equation that regulates the sliding mode for all time does an ideal sliding mode exist. The capacity of sliding mode control to steady the platform in the face of unknown modelling mistakes was chosen. The control system works by directing an error vector forward towards a spatial domain sliding surface. The surface system describes this control scheme once it is on the sliding surface. The error vector converges as a result of these movements. SMC has long been a significant theoretical study subject, and it is now emerging as a valuable source of solutions. Its ability is only constrained by the individuals who work in production control's creativity. As a result, the potential for SMC use in industrial activities is enormous. In this paper, a sliding mode controller is used to control the pulse of dc to dc bidirectional chopper. For that, here used an SMC block of MATLAB and done the simulation.

III. MATLAB SIMULATION AND RESULTS

A. MATLAB Simulation of V2G System

In the MATLAB simulation, v2g and g2v operation incorporated. For this purpose, by using a PID controller, a switch is designed to control the system's operation. Bidirectional dc to dc converter and inverter is also designed in the simulation. Battery management is done by using a dc to dc converter by controlling the battery's SOC (state of charge).

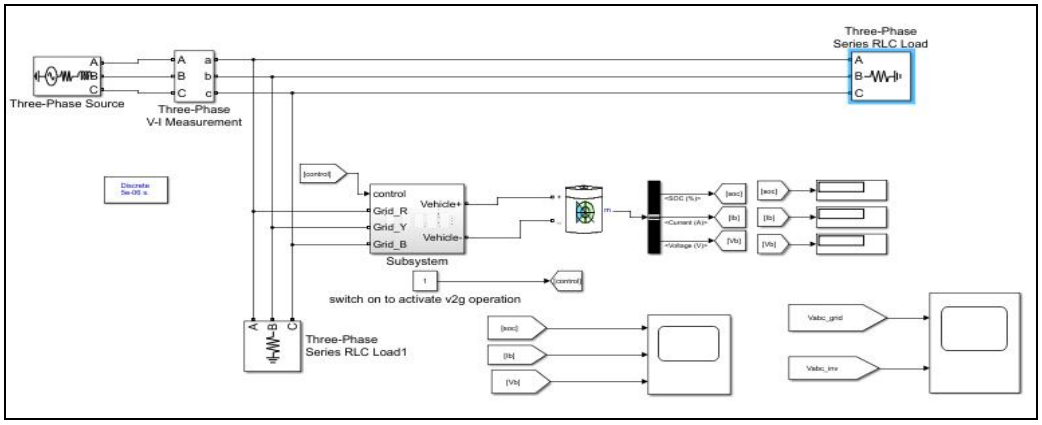


Fig.2 MATLAB simulation of v2g system.

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1) Result: Below results is obtained when switch is on at that time V2G operation takes place.

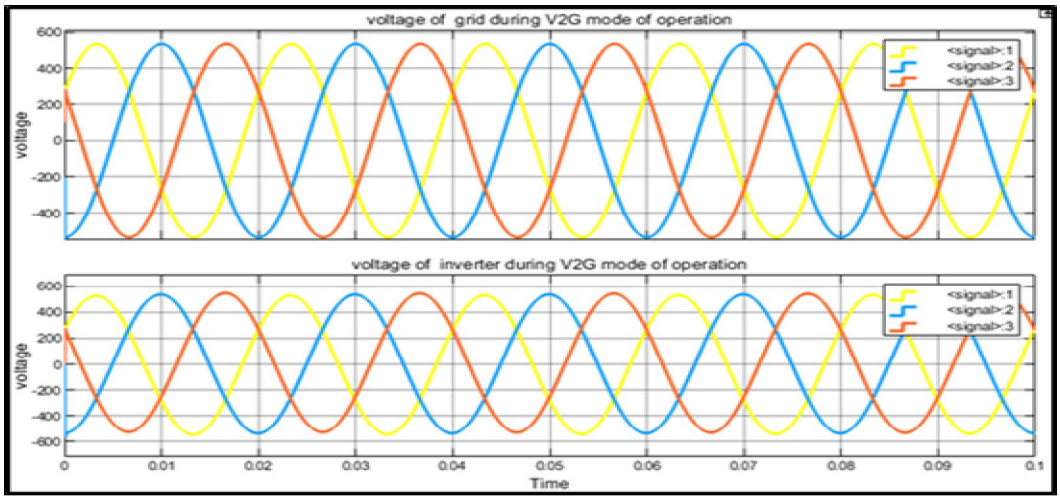


Fig.3 Waveform of the vehicle to grid mode of operation.

Below results is obtained when switch is at 0 that time G2V operation takes place. Here, there is no inverter voltage.

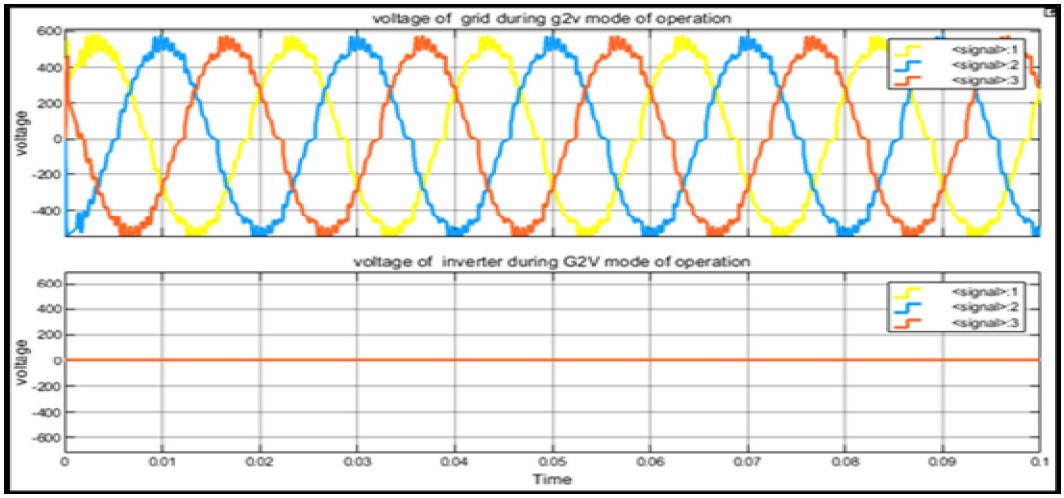


Fig.4 Waveform of grid to vehicle mode of operation**.**

During V2G operation, SOC will decrease and battery current and battery voltage will be positive this is shown from below results.

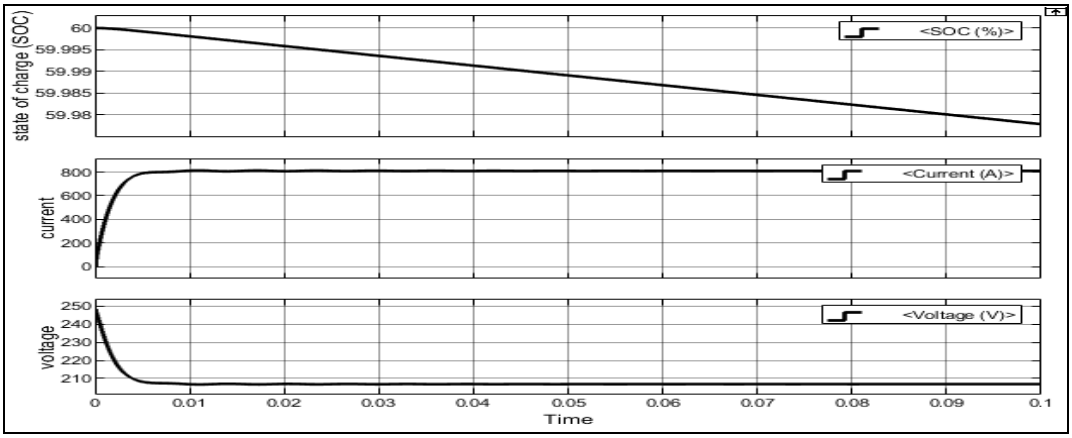


Fig.5 Waveform of voltage, SOC and current of a vehicle to grid mode of operation.

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During G2V operation, SOC will increase and battery current will be negative and battery voltage will be positive this is shown from below results.

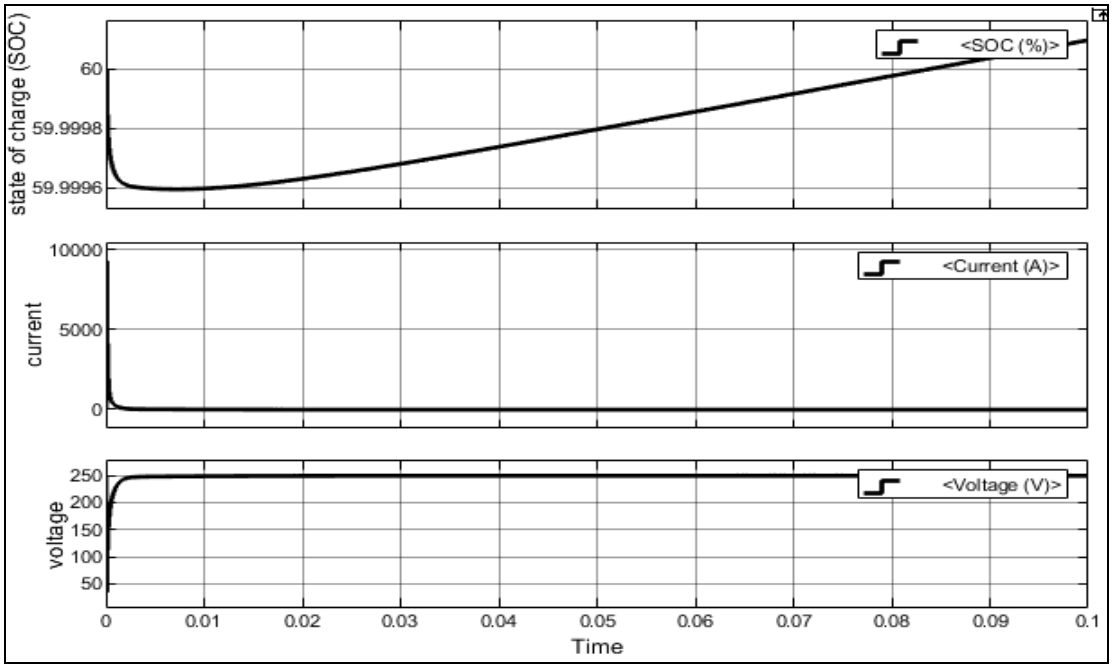


Fig.6 Waveform of voltage, SOC and current of grid to vehicle (G2V) mode of operation**.**

B. MATLAB Simulation of the Bidirectional Converter by using SMC (sliding mode controller).

Fig 7 is the MATLAB model of bidirectional buck boost converter. In this simulation, two MOSFET's are used. One MOSFET is act as buck and another act as a boost converter. Two batteries are used as voltage source .SMC is used to control the operation of the buck-boost converter.

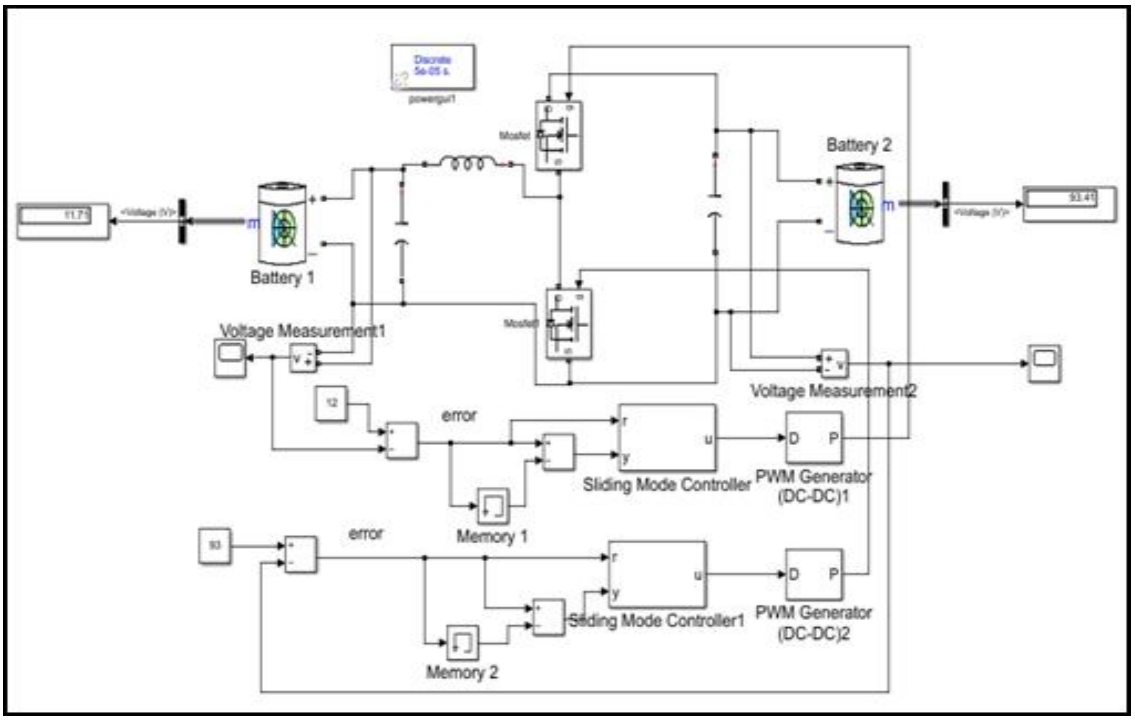


Fig.7 Simulink diagram of the bidirectional buck-boost converter by using sliding mode controller.

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1) *Result:* Below results is the output voltage of bidirectional converter using sliding mode controller. Here, a 12 v is given as a reference voltage and we got here an 11.71v as an output voltage.

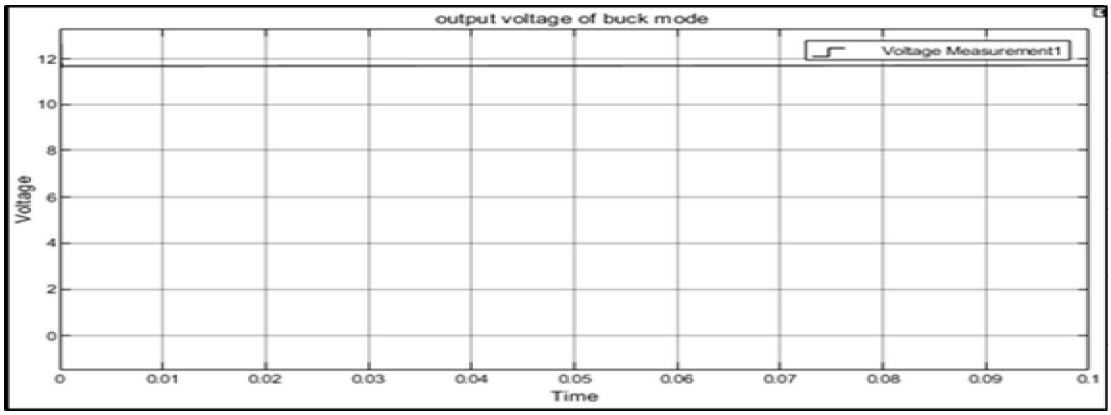


Fig. 8.The waveform of the output voltage of the converter in buck mode of operation.

Below results is the output voltage of bidirectional dc to dc converter using sliding mode controller. Here, a 93 v is given as a reference voltage and we got here a 93.41v as an output voltage.

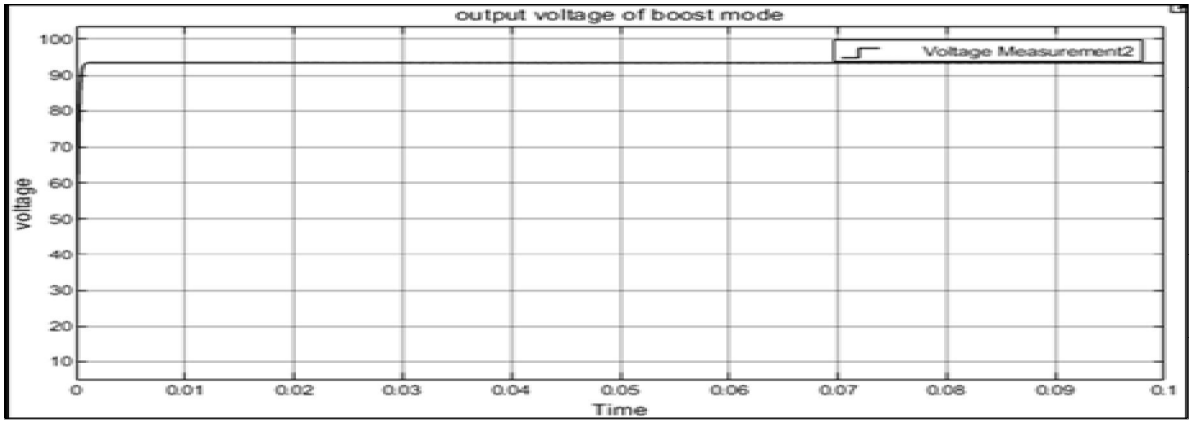


Fig. 9 Waveform of the output voltage of boost mode of operation.

C. *MATLAB Simulation of the Bidirectional Converter by using fuzzy Logic Controller*

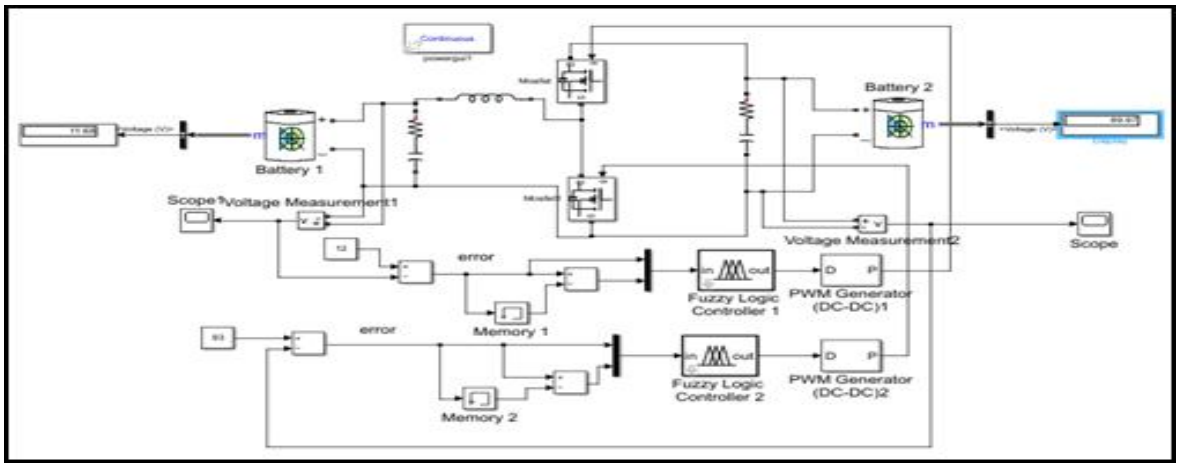


Fig.10 Simulink diagram of the bidirectional buck-boost converter by using fuzzy logic controller.

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Below results is the output voltage of bidirectional converter using FLC. Here, a 93 v is given as a reference voltage and we got here a 93.21v as an output voltage.

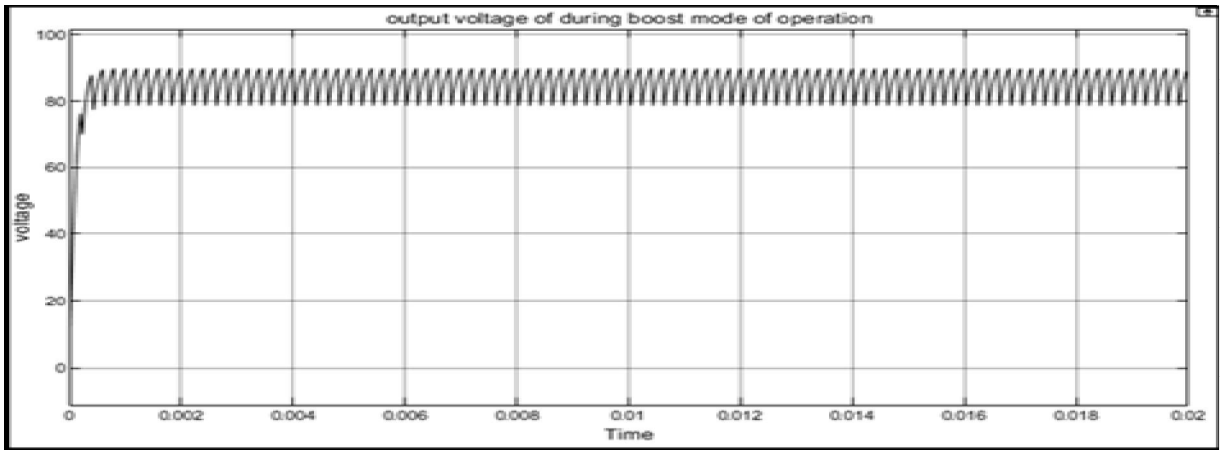


Fig. 11 Waveform of bidirectional dc to dc converter boosts service mode by using a FLC.

Below results is the output voltage of bidirectional dc to dc converter using fuzzy logic controller. Here, a 12 v is given as a reference voltage and we got here an 11.86 as an output voltage.

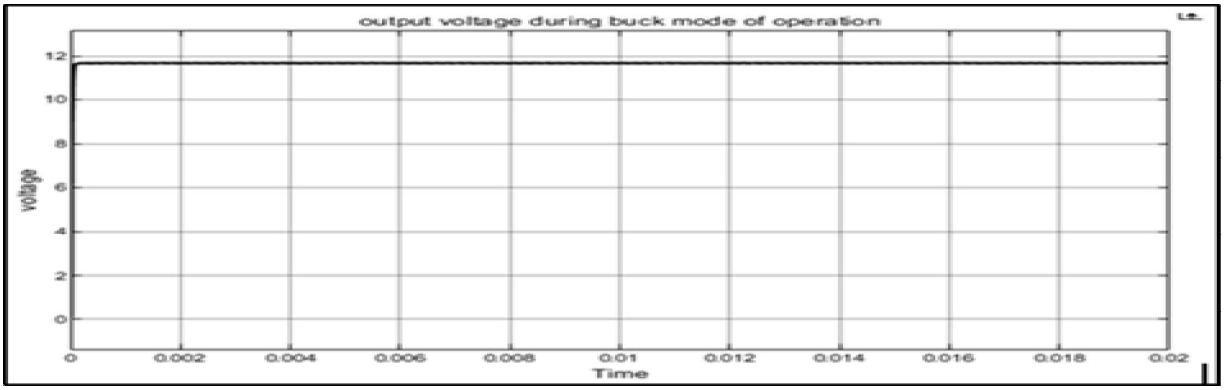


Fig.12 Waveform of bidirectional dc to dc converter in buck mode of service by using the FLC

D. PSIM Simulation and Result

In this paper, 3-phase VSI is designed by using the sinusoidal PWM technique. In this PSIM simulation, three voltage sources have 120-degree phase shift and a reference voltage, i.e.carriar voltage, to generate pulses. The same simulation is used for the hardware implementation .code is developed using PSIM software and code deployed in the LAUNCHXL-F28377S and checked the pulses.

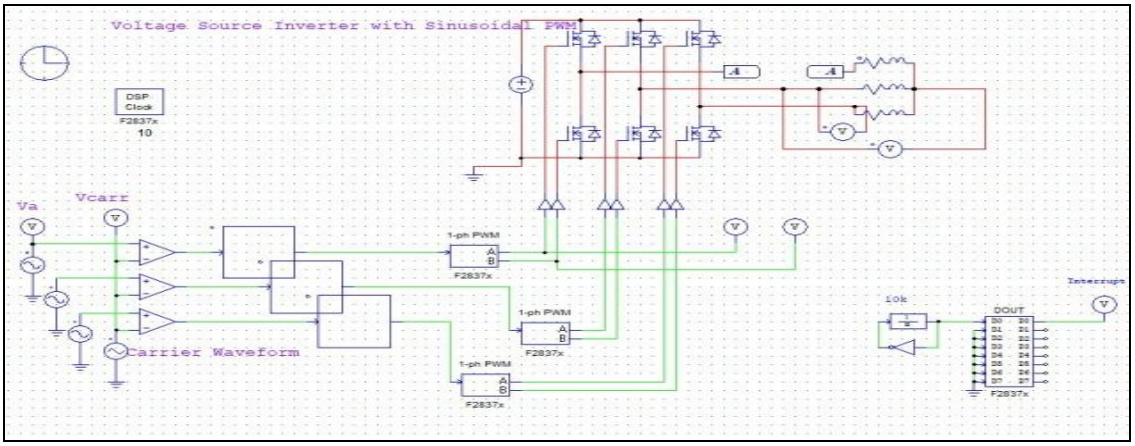


Fig. 13 PSIM Simulink diagram of VSI with sinusoidal PWM

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1) *Result:* The below result is the PWM generated by using Launchxl – F28377S with 1.5 kHz

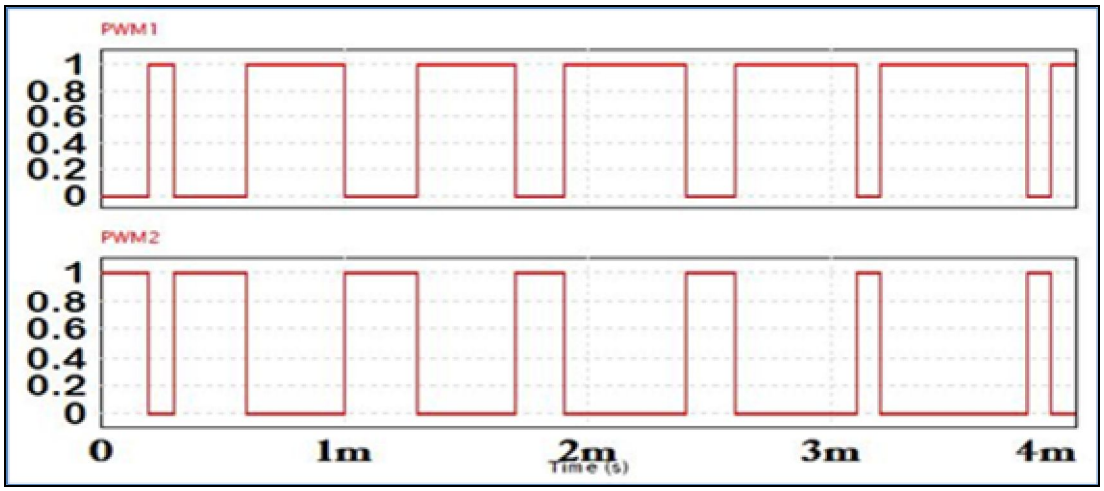


Fig.14 Waveform of PWM generated by using Launchxl – F28377S with 1.5 kHz

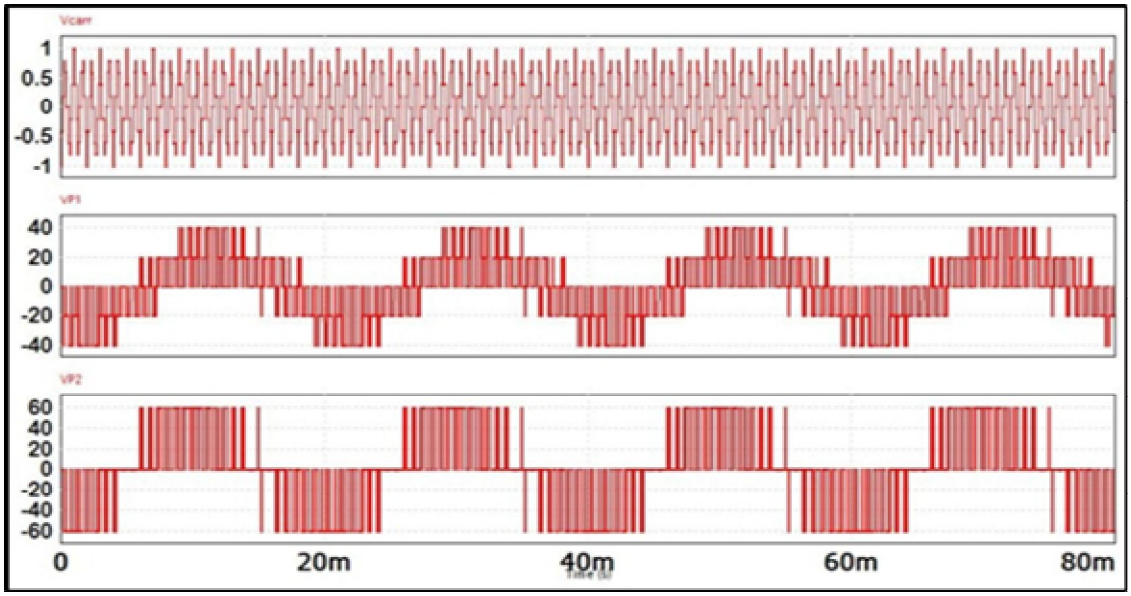


Fig. 15 Waveform of phase voltageVP1=40V, VP2=60 , Vcarr=2V.

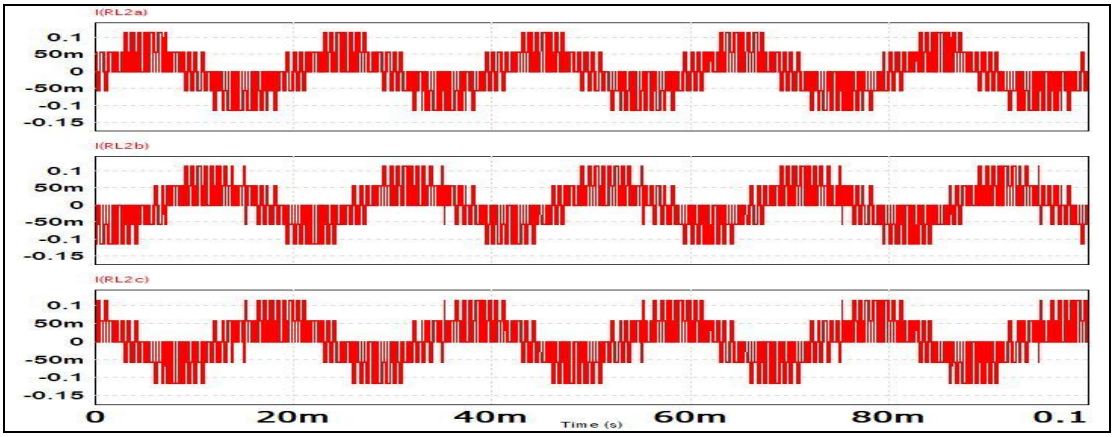


Fig.16 Waveform of current of R, Y, B phase of VSI.

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IV. HARDWARE SETUP AND RESULTS

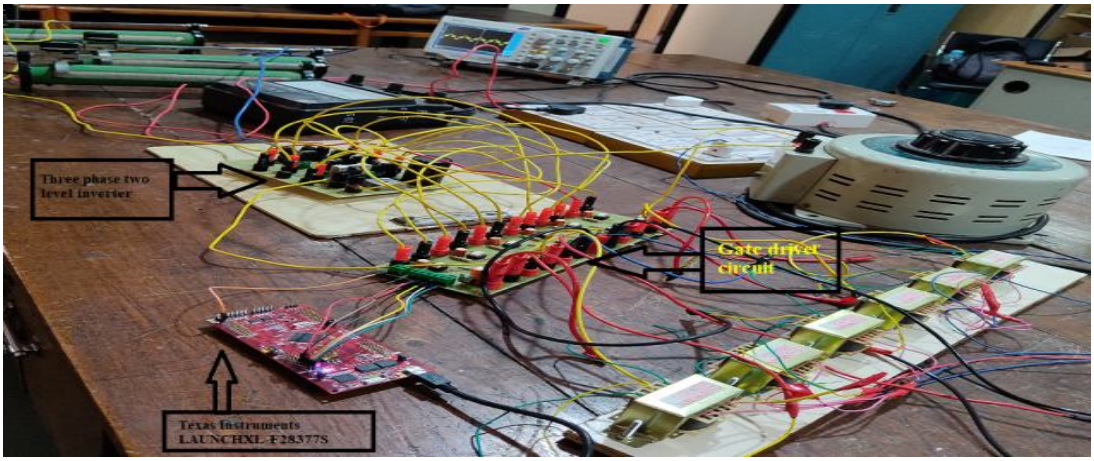


Fig. 17 Hardware set up of project

The above image is of the hardware setup of a project. The hardware part consists of a 3-phase inverter. Star connected load with 360 ohms each phase, dimmer stat, Texas Launchpad, driver board. In this hardware, we first checked the pulses by using a Texas Launchpad by deploying PSIM code generated by using PSIM simulation and that pulses are given to the inverter. The output voltage of the Texas board is not sufficient to drive the inverter gate terminal, so we have used the gate driver circuit. Then increase the ac voltage of dimmer stat across the rectifier, and the rectifier converts ac to dc. First of all, it is imperative to check the pulses generated using a microcontroller, i.e. Launchxl-F28377S. The below results show the vibrations caused by using a microcontroller.

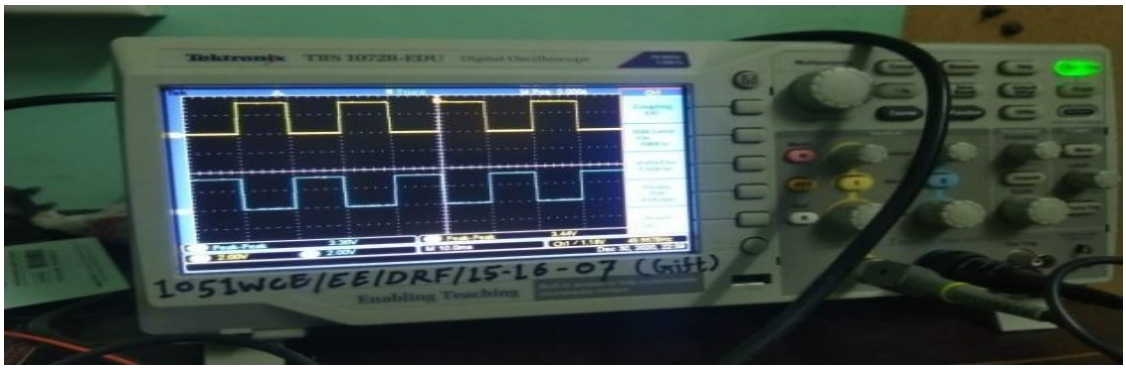


Fig.18 Pulses generated by using LAUNCHXL-F28377S with 50 Hz frequency

In the below image is the results of the phase voltage of the inverter.

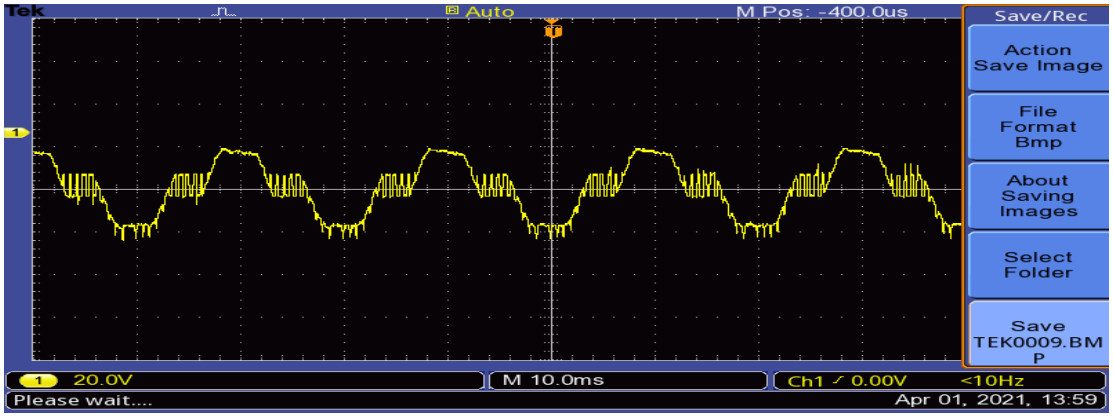


Fig.19 Waveform of phase voltage using PSIM software of VSI with sinusoidal PWM with 1.5 kHz frequency

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V. CONCLUSION

From above all results we can conclude that sliding mode controller is better than the FLC. The result obtained from sliding mode controller has fast response as compared to FLC. In the hardware part we have tested a 3 phase inverter and we are getting good results. We are trying to do the V2G and G2V hardware setup.

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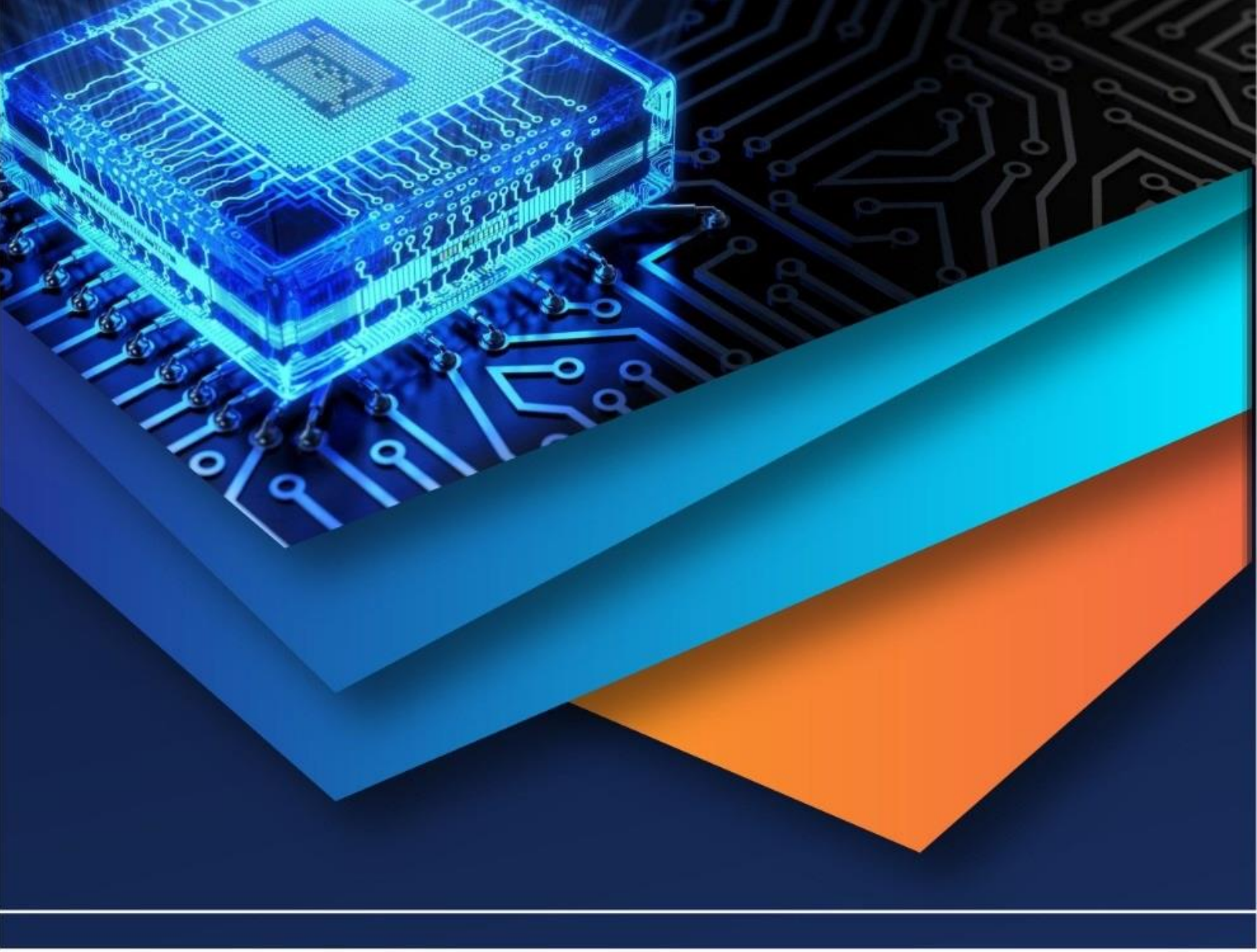
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