

SIMULATION AND PERFORMANCE ANALYSIS OF DC-DC CONVERTER

Submitted in fulfillment of the requirement for the award of
Bachelor of Engineering Degree in
Electrical and Electronics Engineering

By

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SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade “A” by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of **SUBBULAKSHMI M** (Register No. **37140085**) & **VARSHA S** (Register No. **37140092**) who carried out the project entitled **"SIMULATION AND PERFORMANCE ANALYSIS OF DC-DC CONVERTER"** under our supervision from December 2020 to April 2021.

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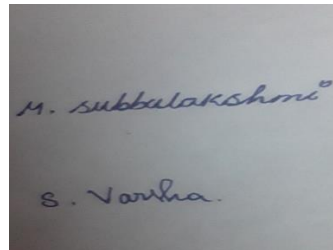
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DECLARATION

We **SUBBULAKSHMI M** (Register No. **37140085**) and **VARSHA S** (Register No. **37140092**) hereby declare that Project Report entitled “SIMULATION AND PERFORMANCE ANALYSIS OF DC-DC CONVERTER” done by us under the guidance of **Mr. J. BARNABAS PAUL GLADY** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering Degree in Electrical and Electronics Engineering.



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ABSTRACT

The project titled “SIMULATION AND PERFORMANCE ANALYSIS OF DC-DC CONVERTER” geared toward coming up with the high gain dc-dc convertor. High gain technique has been with success utilized in style of dc/dc converters. However, the output voltage will increase in progression. This paper introduces a high gain technique that implements the output voltage increasing in patterned advance. It effectively enhances the voltage transfer gain in Stevens' law. Nowadays, the employment of renewable energy sources is swollen additional and additional because of their clean and cost-efficient. However, renewable energy sources like electrical phenomenon panels, fuel cell, etc. offer an occasional DC voltage generally less than fifty so as to attach these sources to associate AC load or network, the output voltage ought to be enhanced to a better voltage level (typically 300V- 400V). The standard boost convertor cannot offer such a high conversion magnitude relation because of the high voltage stress on the switch and extreme in operation duty cycle issues. Thus, DC/DC high intensity converters area unit needed. These converters area unit applied in different applications like high-intensity discharge lamps (HID) for automobile headlamps, battery backup systems for uninterrupted power provides (UPS) and power provides within the telecommunication trade.

TABLE OF CONTENTS

CHAPTER NO	TITLE	PAGE NO
	Abstract	v
	List of Figures	x
	List of tables	xiv
1	INTRODUCTION	
	1.1 Power Electronics	1
	1.2 Types of Power Converter	1
	1.2.1 AC to DC Converter	1
	1.2.2 AC to AC Converter	2
	1.2.3 Cyclo-Converter	3
	1.2.4 AC to AC Converter with DC link	6
	1.2.5 Matrix Converter	6
	1.2.6 Hybrid Matrix Converter	7
	1.2.7 DC to AC converter	7
	1.2.8 DC to DC Converter	7
	1.2.9 Buck Converter	8
	1.2.10 Buck-Boost Converter	9
	1.3 Literature survey	11
	1.4 Objectives	13

2	CIRCUIT OPERATION OF EXISTING AND PROPOSED SYSTEM	
	2.1 Existing work	14
	2.2 Boost Converter	
	2.2.1 What is Boost Converter	14
	2.2.2 Operation of Boost Converter	15
	2.2.3 Boost Converter Design	15
	2.2.4 Advantages	17
	2.2.5 Applications	17
	2.2.6 Disadvantage of existing system	17
	2.3 Circuit operation of Existing system	17
	2.4 Components of Existing system	18
	2.5 Drawbacks of Existing system	18
	2.6 Circuit operation proposed system	18

3	SIMULATION RESULTS	
	3.1 Introduction to MATLAB	22
	3.2 The MATLAB System	23
	3.3 Simulation Results	
	3.3.1 Results of Existing System	24
	3.3.2 Results of Proposed System	25
	a) Open loop simulation Results	25
	b) Closed loop simulation Results	31
	3.4 Proposed system Advantages	38
	3.5 Applications	39

4	HARDWARE RESULTS	
	4.1 General	40
	4.2 Power Supply Circuit	40
	4.3 PIC Microcontroller	41
	4.3.1 Features of PIC-Controller "Pic16F84A"	42
	4.3.2 Memory Organization	44
	4.3.3 Special features of PIC16F84A	46
	4.3.4 Oscillator types	46
	4.4 Driver	48
	4.4.1 Opto-coupler	48
	4.4.2 IR2110-Highand Lowside driver	49
	4.4.3 Applications	51
	4.5 MOSFET	51
	4.5.1 Introduction	51
	4.5.2 IRF840-Power MOSFET	52
	4.5.3 Experimental Results	53
5	CONCLUSION	
	5.1 Conclusion	56
	5.2 Description	56

LIST OF FIGURES

S.NO	TITLE	PAGE NO
1.1	Single phase full wave uncontrolled Rectifier Circuit	2
1.2	Single phase to single phase cyclo-converter	4
1.3	Three phase to single phase cyclo-converter	5
1.4	Three phase to three phase Cyclo-converter	6
1.5	A typical Buck converter	8
1.6	A typical Buck-Boost converter	9
2.1	Equivalent circuit diagram of Existing system	18
2.2	Proposed Circuit Diagram of High Gain DC-DC converter open loop system	19
2.3	Circuit Diagram of High Gain Converter with Closed loop PI/FOPID Controller	20
3.1	Block diagram of Existing simulation Result	24
3.2	Output current of existing system	24

3.3	Output voltage of existing system	25
3.4	Circuit diagram of conventional boost converter	25
3.5	Input Voltage	26
3.6	Switching pulse of Boost converter M1 & Vds	26
3.7	Voltage Ripple across R load	26
3.8	Current through R load	27
3.9	Output power	27
3.10	Circuit diagram of proportional bi-directional DC-DC converter	27
3.11	Input voltage	28
3.12	Switching pulse of Bi-directional DC-DC converter M1&Vds	28
3.13	Voltage across R load	28
3.14	Voltage ripple across R load	29
3.15	Current through R load	29
3.16	Output power	29
3.17	Comparison of output voltage, Ripple voltage & output power	30

3.18	Circuit diagram of Proposed bi-directional DC-DC converter with Source disturbance	32
3.19	Input voltage	33
3.20	Voltage across R load	33
3.21	Current through R load	33
3.22	Output power	34
3.23	Circuit diagram of proposed bi-directional DC-DC Converter with closed loop PI controller	34
3.24	Input voltage	35
3.25	Voltage across R load	35
3.26	Current through R load	35
3.27	Output power	35
3.28	Circuit diagram of proposed bi-directional DC-DC Converter with closed loop FOPID Controller	36
3.29	Input voltage	36
3.30	Voltage across R load	37
3.31	Current through R load	37
3.32	Output Power	37

3.33	Output voltage with PI and FOPID controller	38
3.34	Barchart of PI and FOPID controller	38
4.1	Power circuit	40
4.2	Block diagram of “PIC16F84A”	43
4.3	Pin diagram of “ PIC16F84A”	43
4.4	Optocoupler	48
4.5	Pin diagram of IR2110	50
4.6	Simple model of an N-channel enhancement type MOSFET	52
4.7	Hardware snapshot of MBC	53
4.8	Input voltage	54
4.9	Switching pulse of M1 & Vds	54
4.10	Output Voltage across R load	55

LIST OF TABLES

S.NO	TITLE	PAGE NO
4.1	Lead Definitions	50

CHAPTER 1

INTRODUCTION

1.1 POWER ELECTRONICS

Electronics Engineering deals with distortion less production, transmission and reception of data and signals of very low power of the order of few milliwatts without much consideration of efficiency. Power Engineering is mainly concerned with generation, transmission, distribution and utilization of power at high efficiency. Basically, Power electronics is the area of study, which is combining of power, electronics and control. Power can be defined as it is dealing with static or rotating equipment's for transmission, generation and distribution of electrical energy. Power electronics is a subject that concerns the application of electronic principle in power engineering to improve the efficiency of the system. Hence, Power Electronics is used to optimize or improve the efficiency of existing power system. Power electronics involves study of switching semiconductor devices and corresponding circuits used for power control. The semiconductor devices such as SCR, IGBT, MOSFET, DIAC, TRIAC, etc. are used to control the power in AC or DC circuits/network.

1.2 TYPE OF POWER CONVERTERS

Power Electronic circuits converts one sort or level of voltage or current undulation to a different and are thence referred to as converters. The power converter is classified into six varieties. These are

- AC to DC device
- DC to DC device
- AC to AC device
- DC to AC device
- Static Switches
- Diode Rectifier

1.2.1 AC TO DC CONVERTER

These square measure AC to DC converters or controlled converters. the road commutated converters are AC to DC power converters. the road commutated

converters square wave want to convert a high frequency AC power provide to get a variable DC output voltage. they're used natural or AC line commutation of the Thyristors. differing kinds of line commutated AC to DC converters circuits square wave

- Diode rectifiers-Uncontrolled rectifiers
- Controlled rectifier victimisation SCR's
- Single part controlled rectifier
- Three part controlled rectifier

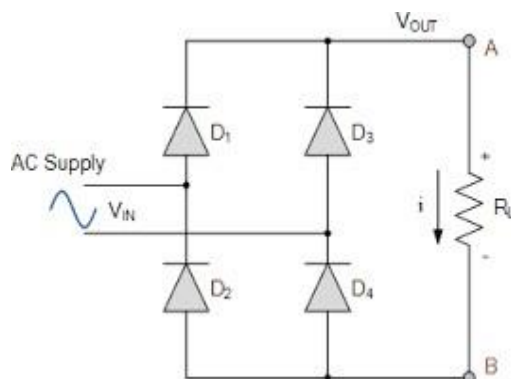


Fig:1.1 : Single phase full wave uncontrolled Rectifier Circuit

Figure 1.1 represents the circuit association for Single section full wave uncontrolled Rectifier with resistive load. it's conjointly referred because the full wave bridge rectifier. For this configuration, 2 diodes are forever conducting throughout a similar interval to offers closed-loop system for the present. D1 and D2 conducting whenever the provision voltage is positive. Diodes D3 and D4 conducting whenever the provision voltage is negative. Since the load is resistive load.

Applications of AC to DC Converters:

- Speed management of DC motor in DC drives.
- HVDC transmission.
- Battery charges.

1.2.2 AC TO AC CONVERTER

The AC voltage controllers convert the constant frequency, mounted voltage AC

offer into variable AC voltage at identical frequency victimization line commutation. AC regulators (RMS voltage controllers) area unit primarily used for

- Speed management of AC motor.
- Speed management of fans (domestic and industrial fans)
- AC pumps.

The AC-AC converters area unit classified into completely different types:

- Cyclo converters
- AC-AC converters with DC link
- Matrix converters
- Hybrid Matrix convertor

1.2.3 CYCLO-CONVERTER

Cyclo convertors also are known as as frequency charges that is AC to AC converter while not victimization DC link. It converts AC signal of mounted frequency to AC signal with variable frequency. This conversion is completed by victimization switches like thyristor and dominant mechanism of it.

NEED OF CYCLO CONVERTER:

- To management the speed of motor.
- Frequency are often reduced to drive significant load.
- Frequency are often raised to drive light-weight load.
- Extensively used for driving giant motors like cement, water pump, rolling mills, industries etc.

Classification of Cyclo converter:

Based on output frequency

- Step up cyclo convertor
- Step down cyclo convertor

Based on section input and section output:

- Single section to single section cyclo convertor

- Three section to single section cyclo convertor
- Three section to 3 section cyclo convertor

Besides the frequency management, cyclo-converter output voltage are often varied by applying section management technique. These are often accustomed give either mounted frequency output from variable frequency input worth or variable frequency output from mounted frequency input.

Step up Cyclo converter:

In accelerate Cyclo-converter, output frequency is above input frequency. It doesn't used wide because it doesn't have abundant sensible applications. In India and USA, most applications area unit there with but 60Hz frequency. accelerate cyclo-converter need forced commutation, that will increase the complexness of the circuit.

In step down Cyclo-converter, output frequency is not up to input frequency. it's most typically used cyclo convertor, because it has several sensible applications. Step down cyclo-converter need natural commutation, that is straightforward to make and straightforward to control. several step down cyclo convertor is obtainable with completely different applications.

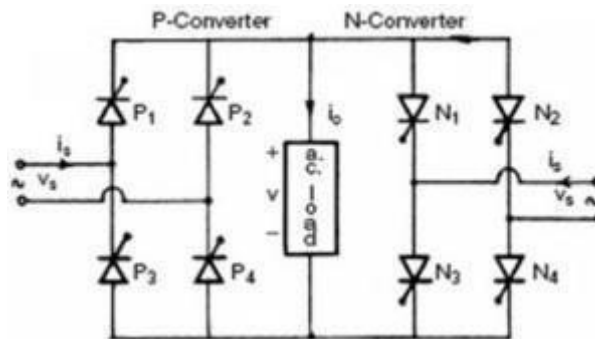


Fig: 1.2 :Single phase to single phase cyclo-converter

This type of Cyclo-converter converts single section AC wave shape with input frequency and magnitude to output AC wave shape with a unique frequency and magnitude.

Three section to single section cyclo-converter:

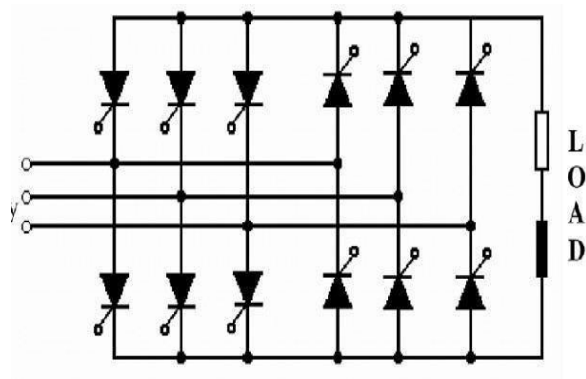


Fig:1.3 : Three phase to single phase cyclo-converter

This type of Cyclo-converter has a three phase AC supply with an input frequency and magnitude and produces output as a single phase AC waveform with a different output frequency or magnitude.

Three phase to three phase cyclo-converter:

This type of Cyclo-Converter has three phase AC supply with an input frequency and magnitude and produces output as a three phase AC waveform with a different output frequency or magnitude.

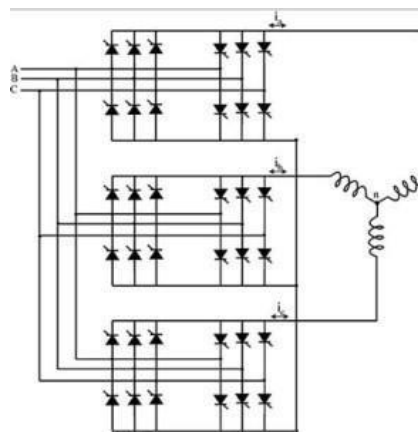


Fig: 1.4 : Three phase to three phase Cyclo-converter

1.2.4 AC TO AC CONVERTER WITH DC LINK

In this type of converter consists of DC link, rectifier and inverter as in this process the AC is converted into DC by using the rectifier. After the conversion the DC link is used to store DC power and again it is converted into AC power by using the inverter.

AC to AC converters with DC link is classified into two types:

- Current source inverter converter
- Voltage source inverter converter

1.2.5 MATRIX CONVERTER

Matrix converters are used for changing AC to AC directly while not

victimization any DC link for increasing the responsibility and potency of the system by reducing the price and losses of the DC link storage component. Matrix device consists of the bidirectional switches that much don't exist nowadays however is accomplished by victimization the switched devices like IGBTs and these are capable of conducting current and interference voltage of each polarities.

1.2.6 HYBRID MATRIX CONVERTER

The matrix converters that convert AC/DC/AC are termed as Hybrid matrix converters, and almost like the matrix converters, these hybrid converters conjointly don't use any electrical condenser or inductance or DC link. These are once more classified into 2 sorts supported the quantity of stages they deem conversion, if the voltage and current each are regenerate in an exceedingly single stage, then that convertor will be known as a Hybrid Direct Matrix convertor.

1.2.7 DC TO AC CONVERTER

Reasons to convert DC to AC:

Transformers work on AC however not at DC. If you wish to use electrical device to raise a voltage, we'd like AN AC signal. AC motors square measure smaller and additional economical than DC motors BLDC (Brushless DC motors or quad-Copter motors) would like 3-part AC. DC-AC device is especially designed for ever-changing a DC power offer into AN AC power offer.

Limitations of DC-AC converter:

- The semiconductor usage will scale back the circuit potency.
- The usage of switch semiconductor will cause cross over distortion inside the output signal.
- However, this limit can be reduced to some level by exploitation biasing diodes.

Applications of DC-AC converter:

- It's utilized in a vehicle to charge their batteries.
- These circuits square measure chiefly used for driving low power AC motors and utilized in alternative energy system.

1.2.8 DC TO DC CONVERTER

A DC-DC converter is designed to convert one direct current voltage into a different direct current voltage. A step up converter is called Boost converter and a step down converter is called Buck converter. They both work using the same principle and involve the use of inductors, capacitors and a switching circuit (usually a pulse with modulation circuit that switches on and off at a certain frequency).

A DC-DC converters are divided into several parts:

- Boost converter
- Buck converter
- Buck Boost converter
- Bcuk converter

1.2.9 BUCK CONVERTER

Buck converter is also known as step down chopper which reduces the input DC voltage to a specified DC output voltage.

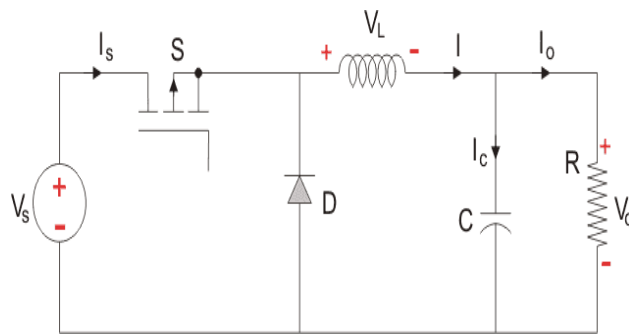


Fig: 1.5 : A typical Buck converter

Figure 1.5 represents a typical buck device. The input voltage supply is connected to a manageable solid state device that operates as a switch. The solid state device may be an influence MOSFET or IGBT. Thyristors aren't used usually for DC-DC converters as a result of to show off a thyristor hostelry a DC-DC circuit needs another commutation that involves victimisation another

thyristor, whereas power MOSFET and IGBT may be turned off by merely having the voltage between the gate and supply terminals of an influence MOSFET or the gate and supply terminals of a

power MOSFET, or the gate and collector terminals of the IGBT head to zero. Time based mostly modulation is usually used for DC-DC converters. it's easy to contruct and use. The frequency remains constant during this variety of PWM modulation. The buck device has 2 modes of operation.

1.2.10 BUCK-BOOST CONVERTER

Buck Boost convertor which might operates as a DC-DC change of magnitude convertor or a DC-DC increase convertor relying upon the duty cycle, D. The buck boost convertor that has associate output voltage magnitude that's either bigger than or but the input voltage magnitude. it's reminiscent of a flyback convertor employing a single inductance rather than a electrical device. 2 completely different topologies square measure known as Buck-Boost convertor.

In figure 1.19 represents a typical buck-boost converter is shown below.

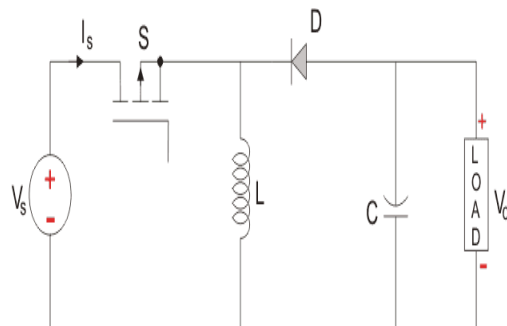


Fig: 1.6 : A typical Buck-Boost converter

The input voltage supply is connected to a solid state device. The second switch used as a diode. The diode is connected, in reverse to the direction of power ensue supply, to a electrical condenser and therefore the load and therefore the 2 square measure connected in parallel as shown in figure on top of.

The controlled switch is turned on and off by victimisation PWM modulation. PWM are often time based mostly modulation is generally used for DC-DC converters. it's straightforward to construct and use. The frequency remains constant during this sort

of PWM modulation. The Buck-Boost convertor. The Buck –Boost convertor additionally has 2 modes of operation. the primary mode is once switch is on and conducting.

The electrical device current is continuous and this is often created attainable by choosing an acceptable value of L .

The electrical device current in steady state rises from $\{V_{in} - V_{out}\}$ with a positive slope to a maximum value throughout the ON state then drops back off to the initial value with a negative slope. Thus the average change of the electrical device current over any complete cycle is zero.

Advantages and Disadvantages of Buck, Boost, Buck-Boost converters:

Buck converter:

- Output voltage is independent of load, thus potential unit regulation is great.
- Output is coupled with input voltage, therefore the line regulation is poor.
- Output voltage is a smaller amount than input voltage, depends on one another.
- No isolation between high and low voltage section and may have potential safety drawback.
- The output current is unidirectional

Boost converter:

- It has only 1 switch
- Its efficiency is high because of the employment of single electronic transistor
- The output current is unidirectional
- It will step-up the output voltage while not employing an electrical device
- It provides one polarity output voltage
- Low cost
- Easy to analyze

- Complicated in design
- Switching noise and ripple exist
- Cost factor
- The main disadvantage is large filter capacitor and a large inductor is required to be used.

Buck-Boost converter:

- It performs increase or change of magnitude of voltage exploitation minimum elements.
- It offers lower operational duty cycle
- It offers high potency across wide input and output voltage ranges.
- It is a smaller amount high-priced compare to most of the converters.
- Input current and charging current of output condenser is discontinuous because it end in massive filter size and a lot of EMI problems.
- High gain can not be achieved with this kind of device sorts as potency is poor for top gain (i.e. terribly tiny duty cycle or massive duty cycle).

1.3 LITERATURE SURVEY

Neeti Dubaj et al., (2019) presented a review of analyze bidirectional dc-dc buck booster quadratic converter for energy storage devices. In this review the author has covered from the analysis it has been evident that bi directional dc-dc buck boost converter which make the system more compatible for energy storage system.

M.Sheng,D.Zhai,X.Wang et al., (2016) presented a review of intelligent energy and traffic coordination for green cellular network switch hybrid energy supply. In this paper he has said that energy-harvesting-enabled networks, the intermitted and randomly distributed renewable energy impose severe challenges in reliably supplying the time- varying mobile traffic. the objective of minimizing the grid energy expenditure of cellular networks powered by both grid and renewable energy. We formulate this problem as a mixed -integer nonlinear programming, which was proved to be NP-

hard.

E.Jimenez,M.J.Carrizosa,A.Benchaib et al., (2016) presented a review of a new generalized power flow method for multi connected DC grids. In this review the author has covered from this work introduce a mathematical proof for this new power flow algorithm,which guarantees the existence of unique solution when voltages were close to nominal value.This new algorithm had in addition the advantage of being easily adapted for ACsystems.

J.Y.Yong,V.K.Ramachandaramurthy et al., (2015) presented a review of Bi-directionalelectric vehicle fast charging station with novel reactive power compensation for voltage regulation. In this review author has covered this work examined the voltage impact due to electric vehicle fast charging in low voltage distribution network during the peak load condition.Simulation results show that fast charging of only six electric vehicles had driven the network to go beyond the safe operational voltage level.

Viter farno pires,Danier foito,Armando cordiro et al., (2017) presented a review of Dc-Dc converter with quadratic gain and bi-directional capability for battries. In this paper author has covered the bidirectional quadratic converter is indicated for applications that require the existence of energy storaged devices bank,electrical such as batteriesor super capacitors.

Tusn-Anchnng,Chun-choko,Kuo-kuang jen et al., (2013) presented a review of cascade cockroft walton voltage multiplier applied to transformer has high step-up dc-dc converter. In this review author has covered by futurework the influenceof loading on the output voltage of the proposed converter will be driven for completing the steady state analysis.

Seyed hossein,Rezq ghazi,Hamad-heydari et al., (2019) presented a review of an extendable quadratic bidirectional dc-dc converter. In this review author has covered by this is complicated circuit daigram .complicated small signal highly sensitive voltage gain versus duty cycle.

Jiuchum juang,Yan bao,Leyiwang et al., (2014) presented a review of topology of bidirectional converter for energyinteractions between electric vehicles and the grid.In this review author has covered by it's operational

principles and control the charging and discharging modes on presented.

1.4 OBJECTIVES

- 1 To increase the voltage gain of the converter.
- 2 To regulate the output voltage of the converter.
- 3 To simulate a open loop high gain DC-DC converter with proposed system.
- 4 To simulate a closed loop high gain DC-DC converter with PI controlled system.

CHAPTER 2

CIRCUIT OPERATIONS OF EXISTING AND PROPOSED SYSTEM

2.1 EXISTING METHOD

Single phase on-board EV charger coupled inductor (CI) converter in interleaved CI converter suffered from high number of elements. Since the remarkable problem of isolation for isolated converters such as in can put the performance of the battery in jeopardy, so a non-isolated structure circuit would be a compromise to be utilized. Hence, this work only focuses on the bidirectional DC-DC converter of the G2V and V2G. A non-isolated extendable bidirectional DC-Dc is engaged to a lithium-ion battery.

2.2 BOOST CONVERTER:

2.2.1 WHAT IS BOOST CONVERTER:

A boost device could be a simplest form of change mode device. It takes input voltage and boosts or will increase. It include is AN inductance a semiconductor switch a diode and a condenser. this may be one thing as straightforward as a 555 timer or maybe an ardent SMPS IC just like the illustrious MC34063A IC. There area unit needed to create a lift device. it's less cumbersome than AN AC electrical device or inductance. They were originally developed by Nineteen Sixties to power the natural philosophy systems on craft. it had been a demand that these converters be as compact and as economical as potential. Switched systems like SMPS area unit a challenge to style since their models depend upon whether or not a switch is opened or closed. The models for DC to DC converters used nowadays. Middle brook averaged the circuit configurations

for every switch state in a very technique referred to as state-space averaging. This simplification reduced 2 systems into one. The new model led to perceptive style equations that helped the expansion of SMPS

2.2.2 OPERATION OF BOOST CONVERTER

There is yet one more method of pondering the operation of a lift device. we all know that the energy kept in an electrical device is given by $\frac{1}{2} \times L \times I^2$. Where L is that the inductance of the coil and that i is that the most peak current. So we tend to store some energy within the electrical device from the input and transfer that very same energy to the output though at the next voltage (power is preserved, obviously). This happens several thousands of times a second (depending on the generator frequency) and then the energy adds up in each cycle so you get a pleasant measurable and helpful energy output, as an example ten Joules each second, i.e. 10 watts. because the equation tells U.S., the energy kept within the electrical device is proportional to the inductance and conjointly to the sq. of the peak current. To increase output power our 1st thoughts could be to extend the scale of the electrical device. Of course, this can facilitate, however not the maximum amount /as we tend to think! If we tend to create the inductance larger, the utmost peak current that may be achieved in a very given time decreases, or the time taken to succeed in that current will increase (remember the fundamental equation $V/L = di/dt$), therefore the overall output energy doesn't increase by a big amount! However, since energy is proportional to the sq. of the utmost current, increasing this can cause a bigger increase in output energy So we tend to perceive that selecting the electrical device may be a fine balance between inductance and peak current. With this data we will begin to know the formal methodology of planning a lift device.

BOOST CONVERTER DESIGN

STEP – 1

- To begin with, we want a radical understanding of what our load needs. it's extremely suggested (from experience) that if you plan to build a lift

convertor at the start it's vital to understand the output voltage and current severally, the merchandise of that is our output power.

STEP – 2

- Once we've got the output power, we will divide that by the input voltage (which ought to even be decided) to urge the typical input current required.
- We increase the input current by four-hundredth to account for ripple. This new worth is that the peak input current.
- Also the minimum input current is zero.8 times the typical input current, therefore multiply the typical input current by zero.8.
- Now that we've got peak and minimum current, we will calculate the whole modification in current by subtracting the height and minimum current.

STEP – 3

- Now we tend to calculate the duty cycle of the convertor, i.e. the quantitative relation of the on and off times of the generator.
- Duty cycle is given by this textbook formula:
- $D.C. = (V_{out} - V_{in}) / (V_{out})$
- This should provide United States an inexpensive decimal worth, higher than zero however below zero.999.

STEP – 4

- Now it's time to come to a decision upon the frequency of the generator. This has been enclosed as a separate step as a result of the signal supply is something from a 555 timer (where the frequency and duty cycle ar utterly below your control) or a hard and fast frequency PWM controller.
- Once the frequency is decided, we will determine the whole fundamental measure by taking AN inverse. currently the fundamental measure is increased by the duty cycle worth to urge the on time.

STEP – 5

- Since we've got determined the on time, input voltage and alter in current, we will plug those values into the inductance formula that has been rearranged a little:
- $L = (V \cdot dt) / dI$
- Where V is that the input voltage, dt is that the on time and dI is that the modification in current. Don't worry if the inductance worth isn't a usually accessible one, use the nearest commonplace worth accessible. With a touch tweaking, the system ought to work simply fine.

2.2.3 ADVANTAGES:

- provides the high output voltage
- Low operative duty cycles
- Lower voltage on MOSFET

2.2.4 APPLICATION

- Automotive applications
- Power electronic equipment applications
- adaptative management applications
- Battery power systems
- shopper natural philosophy
- Communication applications

2.2.6 DISADVANTAGES OF EXSISTING METHOD

- More shift loss thanks to the presence of additional switches.
- Due to convention PI management strategy, it's not get sleek Performance.
- High shift loss.
- Less efficiency.

2.3 OPERATION OF EXISTING SYSTEM:

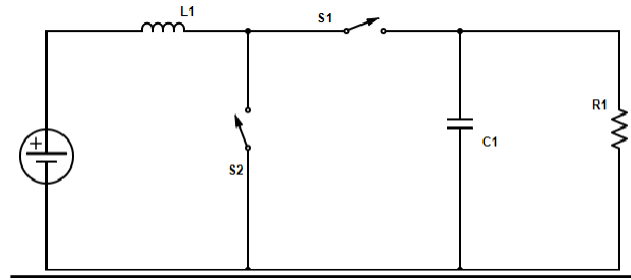


Fig: 2.1 : Equivalent circuit diagram of Existing system

Figure 2.1 represents an equivalent circuit diagram of existing system. It consists of input voltage source, inductor. S1 and S2 represent switches. MOSFET acts as a switch for existing system. Here, capacitor acts as a filter. It removes unwanted components. Finally, R1 acts as an external load.

2.4 COMPONENTS OF EXISTING SYSTEM:

Input voltage	42-48V
Capacitors (C1-C6)	470uF
Inductor	1.5mH
Switching frequency (f _{sc})	1KHZ
Switching frequency (f _{sm})	60KHZ
Switching Devices	IGBTs
Diodes	PN-junction
Output Power	200W
Output Voltage	450V
Output Current	0.45A

2.5 DRAWBACKS OF EXISTING SYSTEM

- More conduction loss
- High switching loss
- Less efficiency

2.6 CIRCUIT DIAGRAM OF PROPOSED SYSTEM

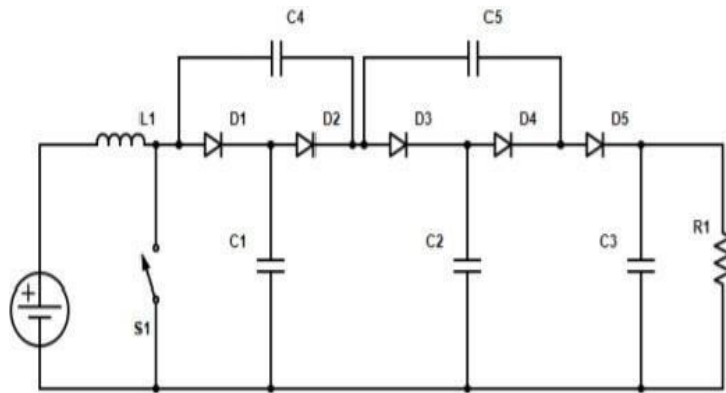


Fig:2.2 : Proposed Circuit Diagram of High Gain DC-DC converter open loop system

The Figure 2.2 shows the schematic diagram of the planned Circuit Diagram of High Gain DC- DC device Open Loop System. This device consists of 1 power switch, one coupled inductance, 5 capacitors and 5 diodes. The magnetizing inductance luminous flux unit, the discharge inductance L_k and a perfect

transformer model the coupled inductance. during this device, the second winding of the coupled inductance is placed within the electrical condenser charging/discharging loops of the high gain circuit. This changed super-lift module contains the second winding of the coupled inductance. Hence, it creates no inpour current and transfers a high voltage to the output with a correct variety of parts and an occasional flip quantitative relation of the coupled

inductance.

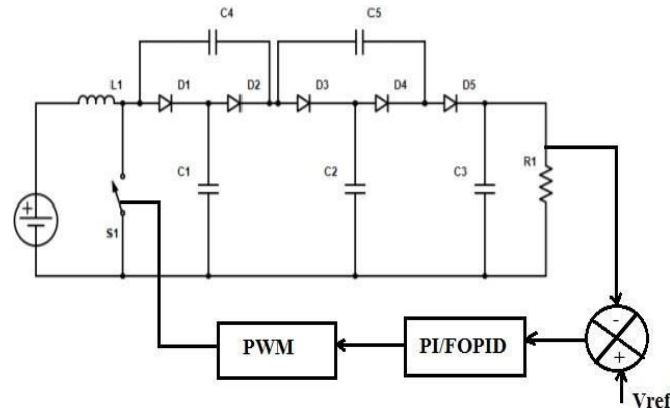


Fig:2.3: schematic Circuit Diagram of High Gain convertor with closed-loop system of PI/FOPID controller

A schematic Circuit Diagram of High Gain convertor with closed-loop system PI/FOPID Controller is shown in Fig. 2.3. This convertor consists of 1 power switch, one coupled electrical device, 5 capacitors and 5 diodes. The magnetizing inductance luminous flux unit, the discharge inductance Lk and a perfect electrical device model the coupled electrical device. during this convertor, the second winding of the coupled electrical device is placed within the electrical condenser charging/discharging loops of the high gain circuit. Figure 2.3 Circuit Diagram of High Gain Converter with Closed Loop PI/FOPID controller.

- The magnetizing electrical device lumen is giant enough to own a relentless current throughout a switch period.
- The capacitors square measure giant enough to own a relentless voltage throughout a switch amount.
- K and n square measure the coupling constant of the coupled electrical device and also the flip magnitude relation of the second winding to the first winding, where: $K \approx L_m / (L_m + L_{lk})$ and $n =$ This changed super-lift module elements and a coffee contains the second winding of the coupled electrical device. Hence, it creates no inpouring current and transfers a high voltage to the output with a correct range of flip magnitude relation of the coupled

electrical device. Since the coupled electrical device is connected to the drain of the switch, a clamp circuit is needed to clamp the off-state voltage of the switch and to scale back the voltage stress of the switch. The clamp circuit is additionally effective in terms of the voltage gain improvement.

- A passive clamp circuit is employed, that consists of 1 condenser C_c and one diode D_c . so as to discharge the clamp condenser, the charging of the condenser C_1 within the super-lift stage is down via clamp condenser discharging whereas the switch is on. once the switch is within the on-state, D_1 and D_3 square measure conducting and C_1 and C_3 square measure charged via C_c and C_2 , severally. The N_s leak inductance makes a resonance with the capacitors within the charging/discharging loops. Thus, no inpouring current is formed.
- The magnetizing inductance of the coupled inductors is far larger than the leak inductance. To alter the analysis, the secondary facet leak inductance is transferred to the first facet and modelled with L_{lk} . once the switch is within the off-state D_2 , D_o and D_c conduct. Therefore, the leak energy and also the energy hold on in C_1 and C_3 square measure transferred to C_2 and C_o , severally. additionally, the clamp condenser is charged and clamps the strain voltage of the switch to a correct voltage.
- To alter the analysis, the subsequent assumptions square measure created.
- The switch is right however its parasitic condenser is taken into account.
- The ESR of the capacitors and inductors and also the conductivity voltage of the diodes and switch square measure neglected.

CHAPTER 3

SIMULATION RESULTS

3.1 INTRODUCTION TO MATLAB:

Simulation has become a really powerful tool on the business application also as in lecturers, nowadays. it's currently essential for associate applied scientist to know the thought of simulation and learn its use in varied applications. Simulation is one in every of the simplest ways that to check the system gate behavior while not damaging it. The tools for doing the simulation in varied fields area unit accessible within the marketplace for engineering professionals. several industries area unit outlay it's quiet not possible to proceed any. It ought to be noted that in power physical science, theoretical account and a symbol of thought hardware epitome within the laboratory area unit complimentary to every alternative. but theoretical account should not be thought of as a substitute for hardware epitome. the target of this chapter is to explain simulation of resistivity supply electrical converter with R, R-L and RLE masses victimization MATLAB tool.

MATLAB may be a superior language for technical computing. It integrates computation, mental image, associated programming in an easy-to-use atmosphere wherever issues and solutions area unit expressed in acquainted notation.

Typical uses include Math and computation

- Data acquisition
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics

MATLAB is associate interactive system whose basic knowledge part is associate array that doesn't need orientating. this enables you to unravel several technical computing issues, particularly those with matrix and vector formulations, during a fraction of the time it might go for write a program during

a scalar non interactive language like C or algebraic language.

The name MATLAB stands for matrix laboratory. MATLAB was originally written to supply easy accessibility to matrix code developed by the LINPACK and EISPACK comes. Today, MATLAB engines incorporate the LAPACK and BLAS libraries, embedding the state of the art in code for matrix computation. MATLAB has evolved over a amount of years with input from several users. In university environments, it's the quality educational tool for introductory and advanced courses in arithmetic, engineering, and science. In trade, MATLAB is that the tool of alternative for high-productivity analysis, development, and analysis. MATLAB options a family of add-on application-specific solutions known as toolboxes. important to most users of MATLAB, toolboxes enable you to find out and apply specialized technology. (M-files) that stretch the MATLAB surroundings to resolve explicit categories of issues. Areas during which toolboxes square measure accessible embrace signal process, management systems, neural networks, symbolic logic, wavelets, simulation, and lots of others.

3.2 THE MATLAB SYSTEM:

a) Desktop Tools and Development Environment

This is the set of tools and facilities that assist you use MATLAB functions and files. several of those tools ar graphical user interfaces. It includes the MATLAB desktop and Command Window, a command history, Associate in Nursing editor and computer programme, a code instrument and alternative reports, and browsers for viewing facilitate, the space, files, and also the search path.

b) The MATLAB Mathematical function library

This is an enormous assortment of machine algorithms starting from elementary functions, like sum, sine, cosine, and sophisticated arithmetic, to additional subtle functions like matrix inverse, matrix chemist values, Bessel functions, and quick Fourier transforms.

3.1 SIMULATION RESULTS

3.3.1 RESULTS OF EXISTING SYSTEM:

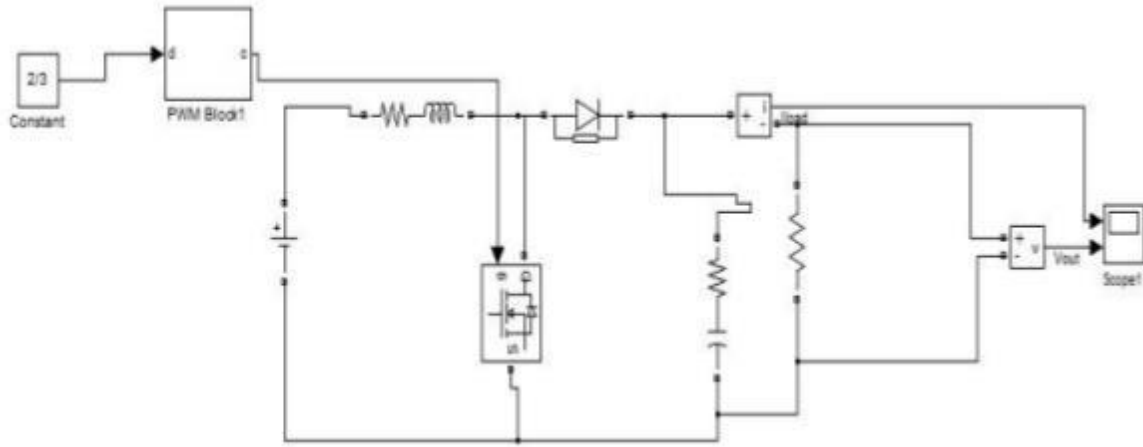


Fig: 3.1 : Block diagram of Existing simulation Result

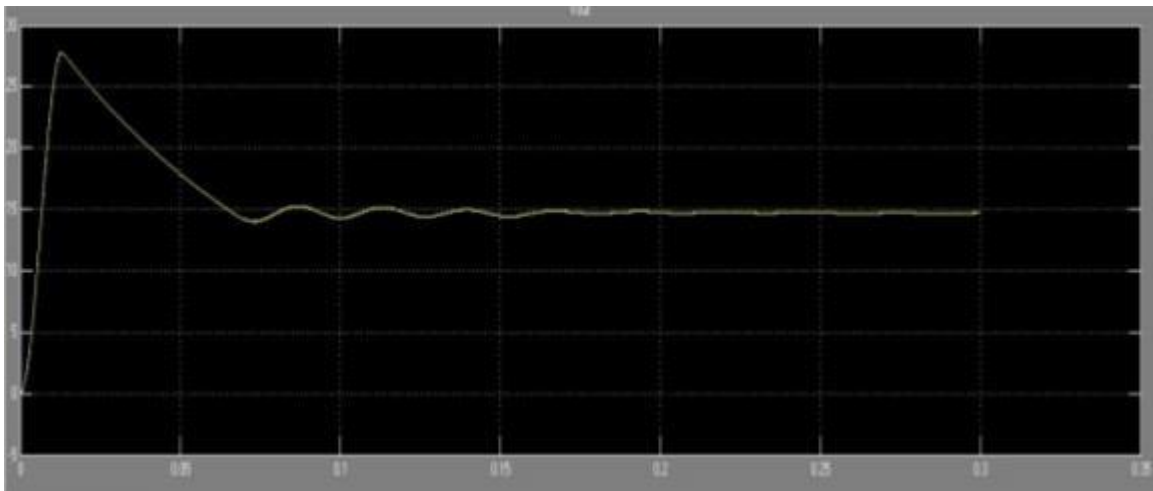


Fig:3.2 : output voltage of existing system

The frequency of operation is 50kHz. The output voltage obtained from simulation, which is 15 V. Duty Cycle is maintained above 50%. The output current obtained from simulation which is 0.4 A is shown in Fig 3.3.

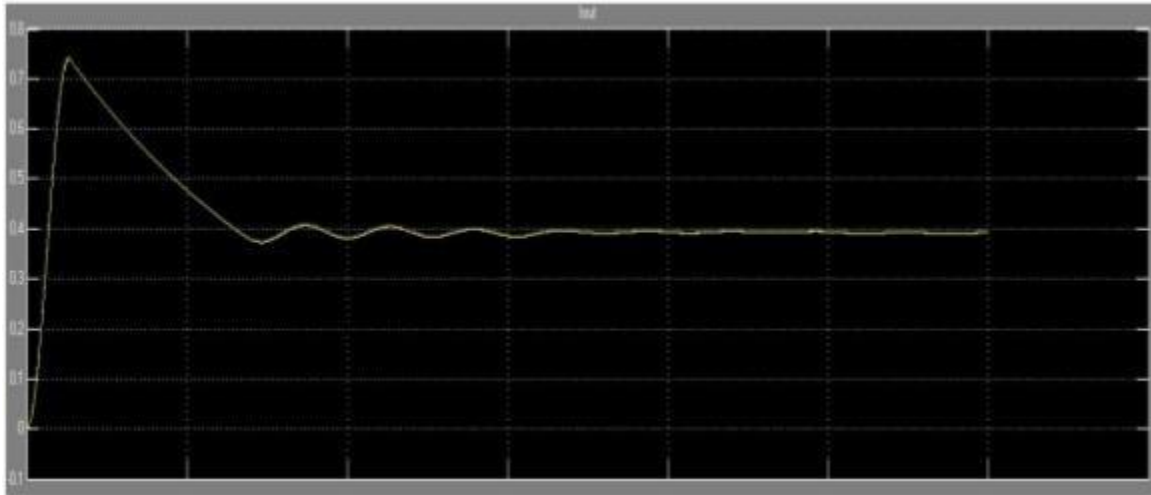


Fig: 3.3 : Output current waveforms

3.3.2 RESULTS OF PROPOSED SYSTEM:

a) OPEN LOOP SIMULATION RESULTS:

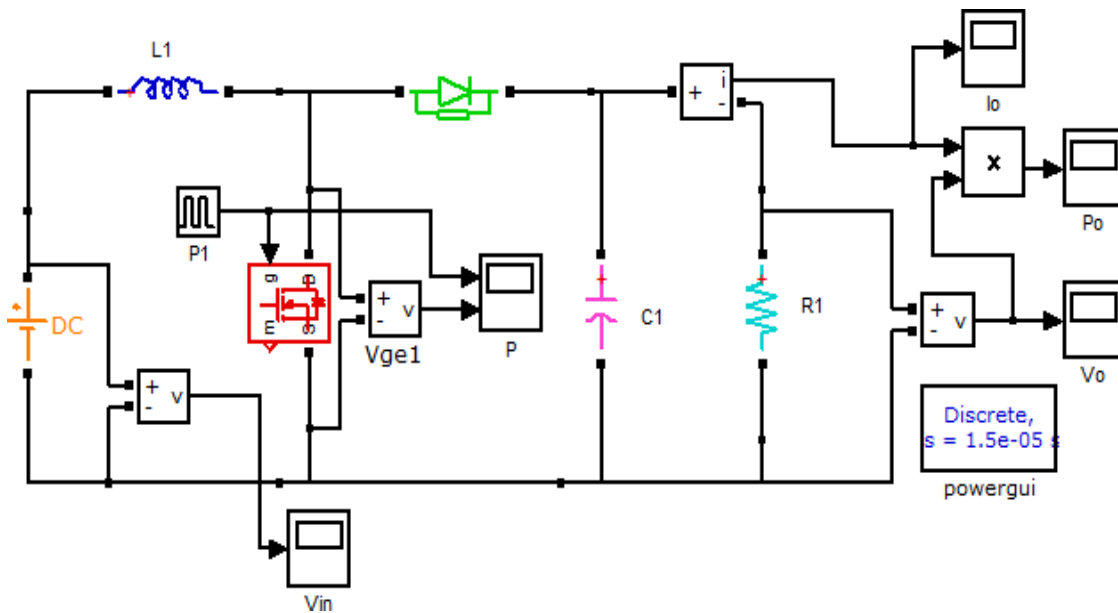


Fig: 3.4 : Circuit diagram of conventional boost converter.

The circuit diagram of conventional boost converter is shown in the Fig 3.4. The

input voltage is given in the Fig 3.5 and its value is 24V. The switching pulse for the boost converter M1 & V_{ds} is given in the Fig 3.6. The voltage across drain to source is 80V and the gate voltage is 1V.

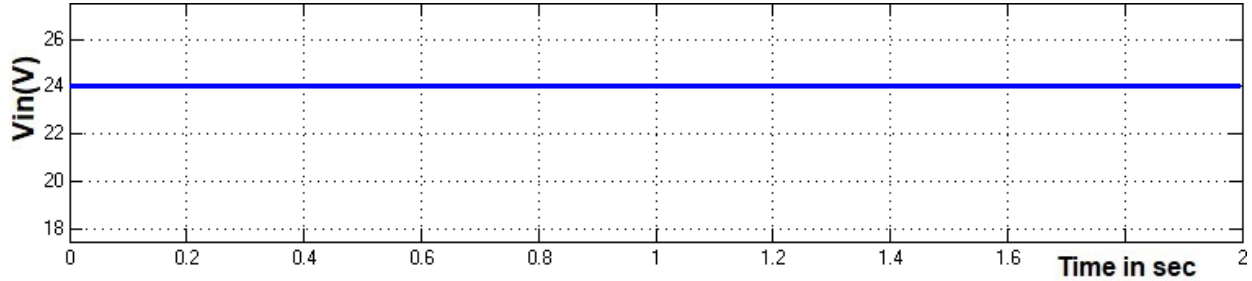


Fig: 3.5: Input Voltage

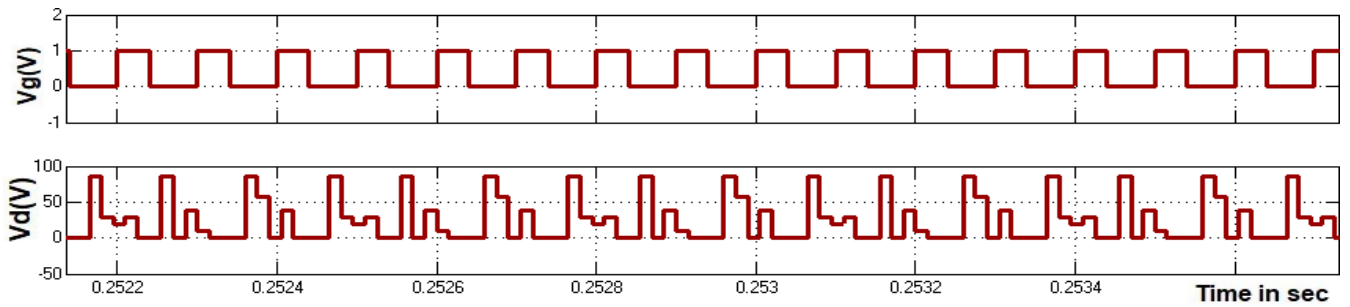


Fig: 3.6 : Switching pulse of boost converter M1 & V_{ds}

The voltage across R-load is given in the Fig 3.6 and its value is 85V. The ripple voltage across R-load is given in the Fig 3.7 and its value is 88V. The current through the R-load is given in the Fig 3.8 and its value is 0.9A. The output power is given in the Fig 3.9 and its value is 74W.

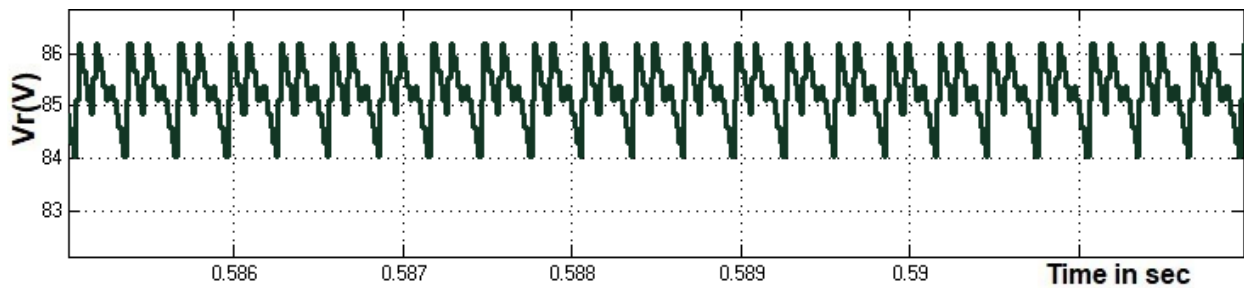


Fig: 3.7 : Voltage Ripple across R-load

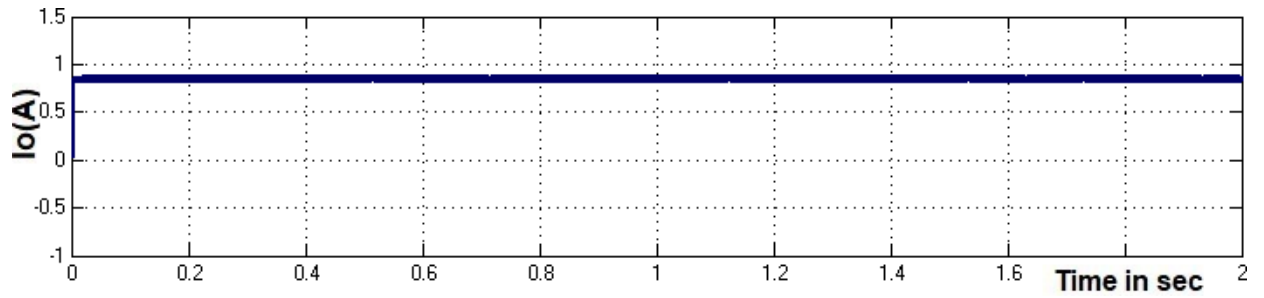


Fig: 3.8 : Current through R load

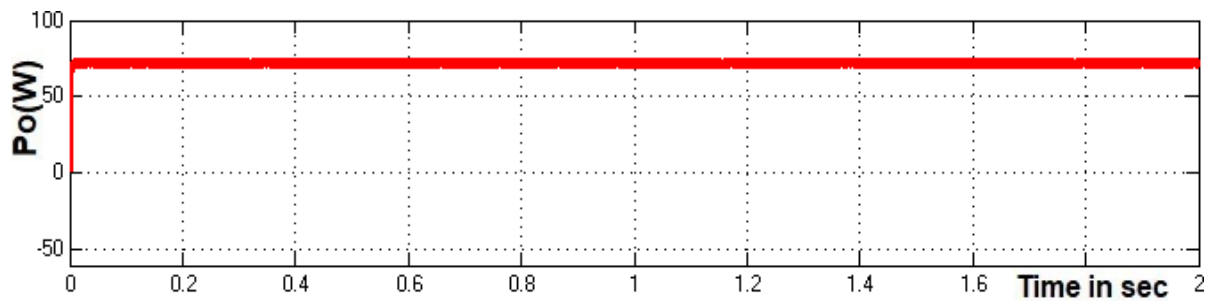


Fig:3.9 : Output power

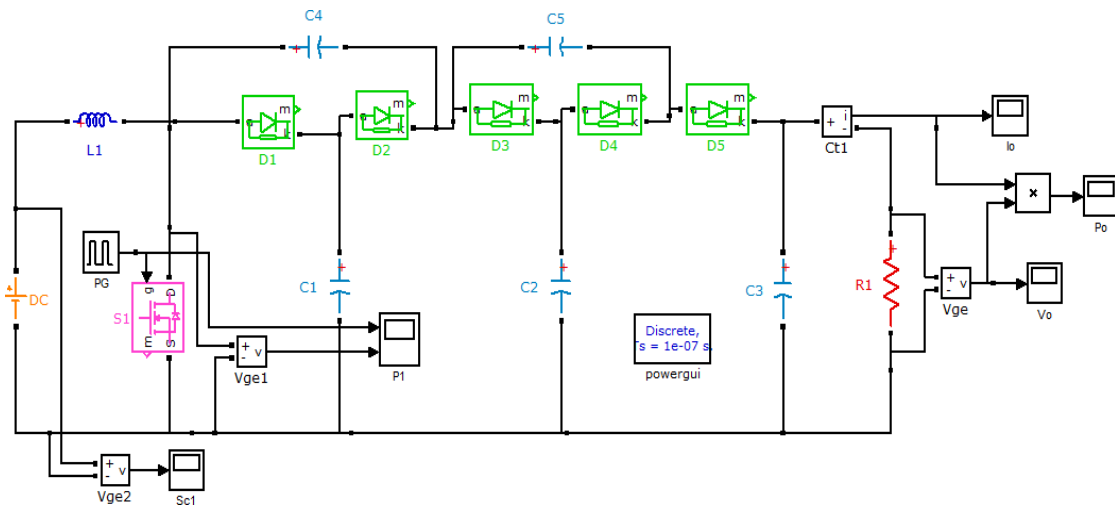


Fig: 3.10 : Circuit diagram of propotional bi-directional DC-DC converter

The circuit diagram of propotional bi-directional DC-DC converter is shown in the Fig 3.10. The input voltage is given in the Fig 3.11 and its value is 24V. The switching pulse for the boost converter M1 & V_{ds} is given in the Fig 3.12. The

voltage across drain to source is 40V and the gate voltage is 1V.

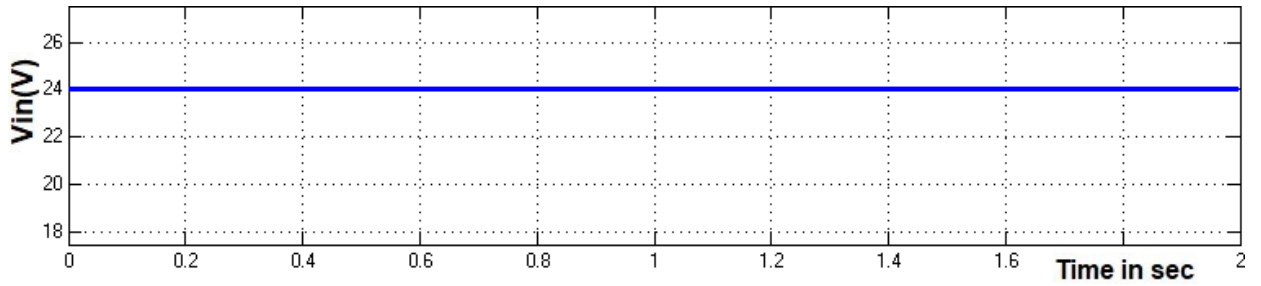


Fig: 3.11: Input voltage

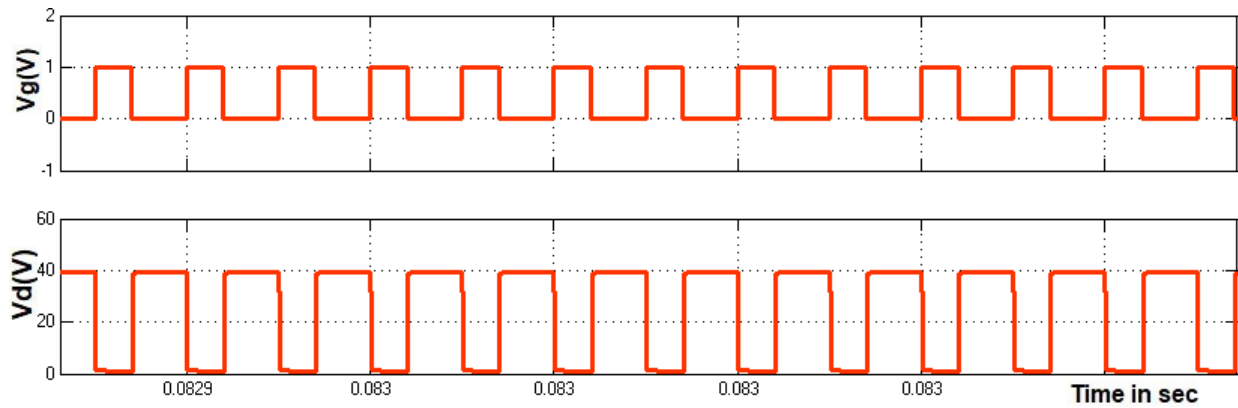


Fig 3.12 : Switching pulse of bi-directional DC-DC converter M1 & V_{ds}

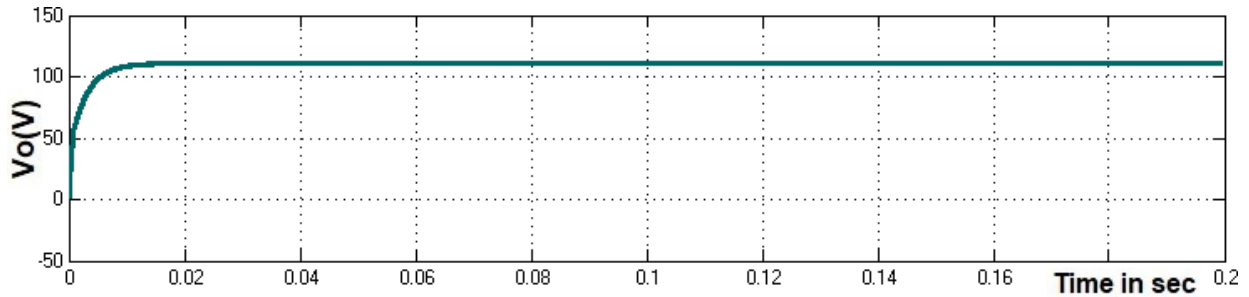


Fig 3.13 : Voltage across R-load

The voltage across R-load is given in the Fig 3.13 and its value is 110V. The ripple voltage across R-load is given in the Fig 3.14 and its value is 111.35V. The current through the R-load is given in the Fig 3.15 and its value is 1.1A. The output power is given in the Fig 3.16 and its value is 124W.

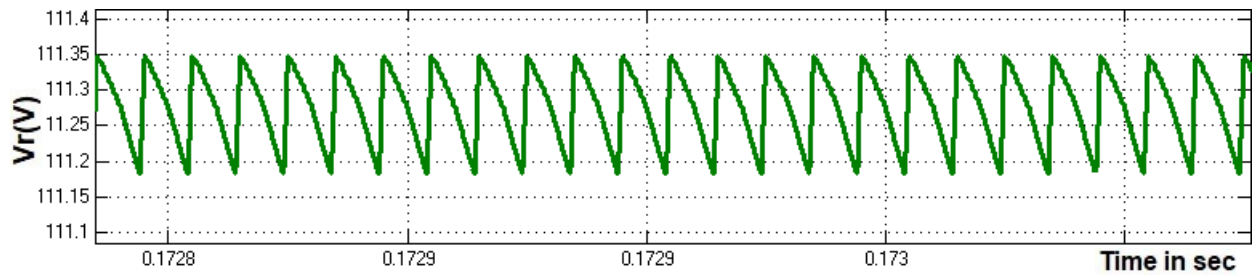


Fig: 3.14 : Voltage Ripple across R-load

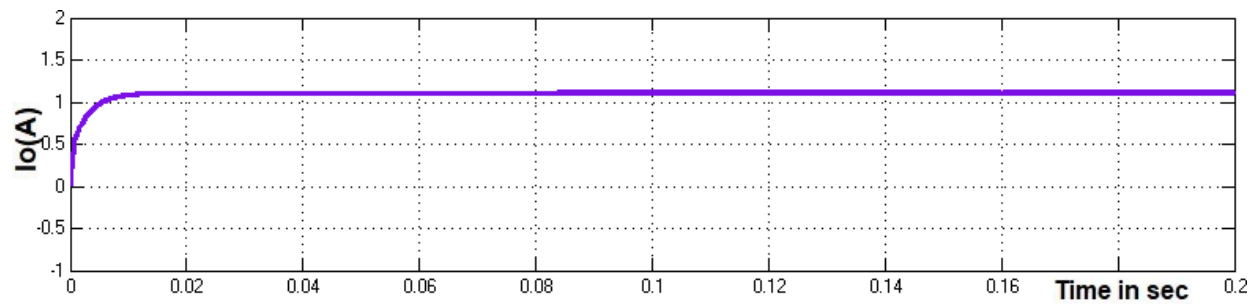


Fig: 3.15 : Current through R load

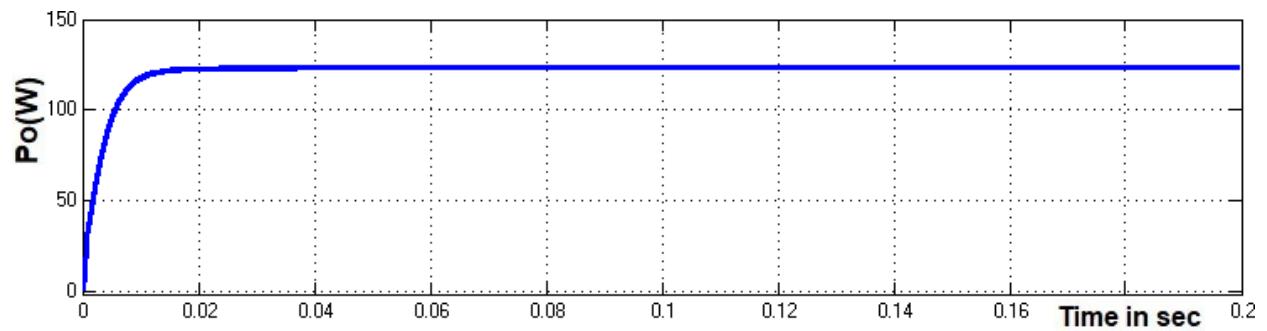


Fig: 3.16 : Output power

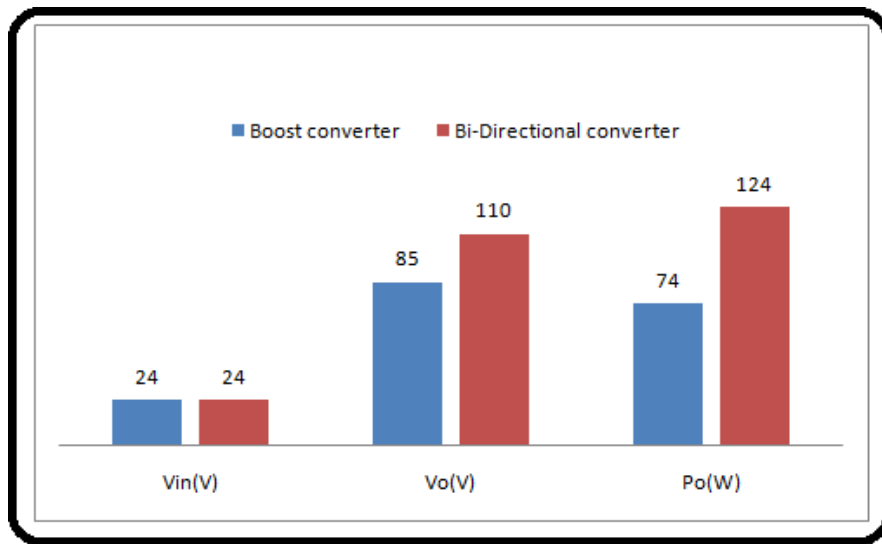


Fig: 3.17 : Bar chart of Output Voltage, Ripple Voltage & Output Power

The Comparison of Output Voltage, Ripple Voltage & Output Power with boost converter and bi-directional DC-DC converter is given in the table 3.1. The bar chart diagram of boost converter and bi-directional converter with input voltage and output voltage and power is given in the Figure 3.17.

b) CLOSED LOOP SIMULATION RESULTS:

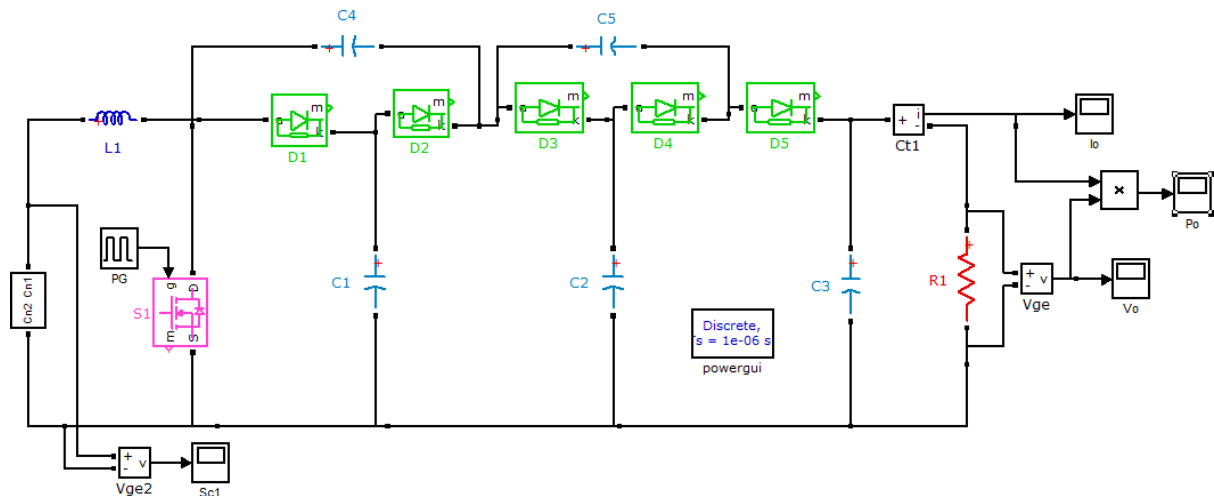


Fig. 3.18: Circuit diagram of proposed bi-directional DC-DC converter with source disturbance

The circuit diagram of proposed bi-directional DC-DC converter with source disturbance is shown in the Fig 3.18. The input voltage is given in the Fig 3.19 and its value is 30V. The voltage across R-load is given in the Fig 3.20 and its value is 165V. The current through the R-load is given in the Fig 3.21 and its value is 1.7A. The output power is given in the Figure 3.22 and its value is 280W.

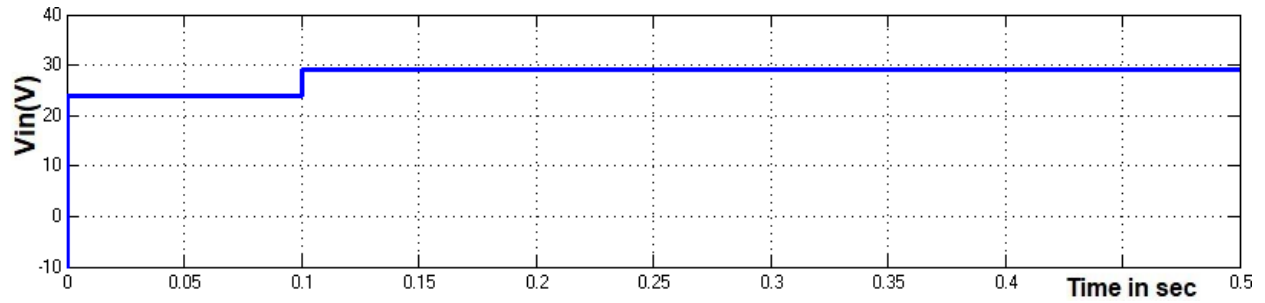


Fig: 3.19 : Input voltage

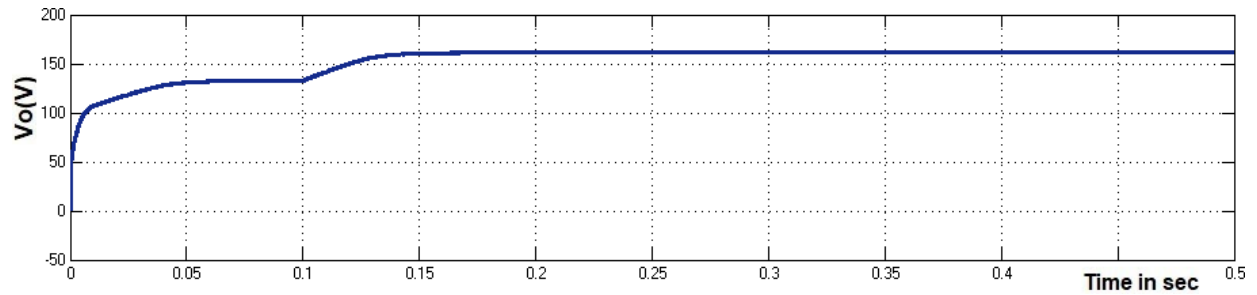


Fig: 3.20 : Voltage across R-load

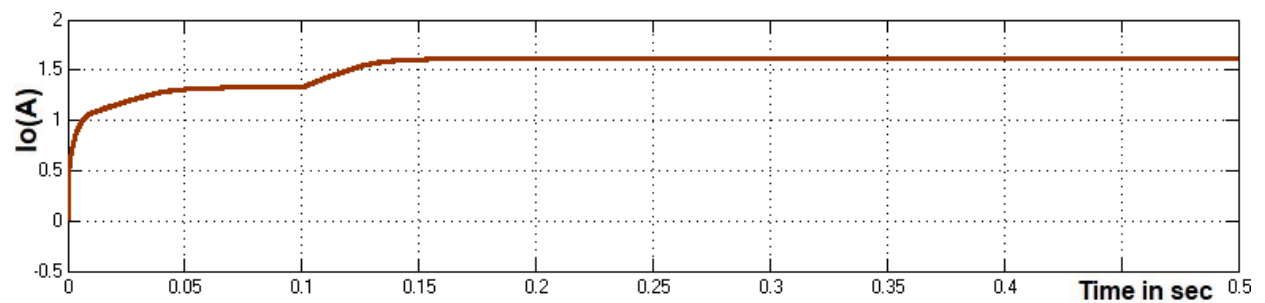


Fig: 3.21 : Current through R-load

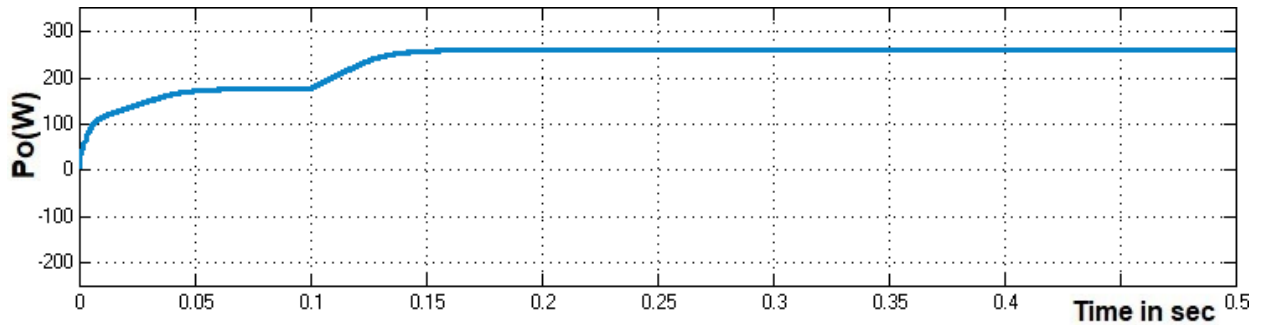


Fig:3.22 : Output power

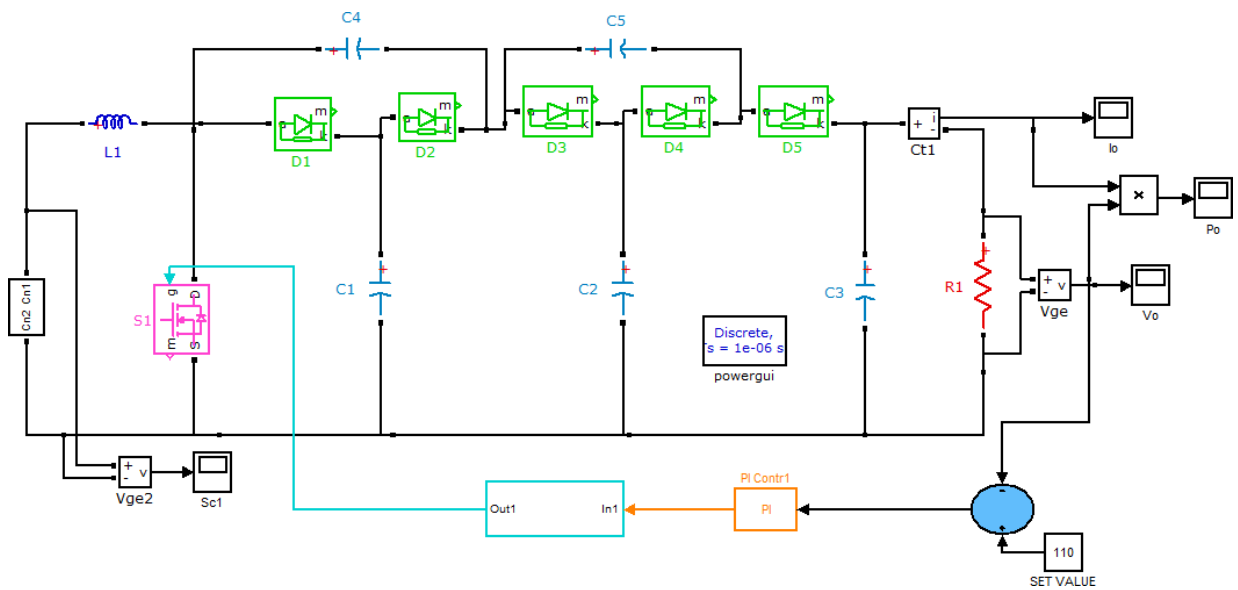


Fig: 3.23 : Circuit diagram of proposed bi-directional DC-DC converter with closed loop PI controller

The circuit diagram of proposed bi-directional DC-DC converter with closed loop PI controller is shown in the Fig 3.23. The input voltage is given in the Fig 3.24 and its value is 30V. The voltage across R-load is given in the Figure 3.25 and its value is 110V. The current through the R-load is given in the Figure 3.26 and its value is 1.1A. The output power is given in the Fig 3.27 and its value is 124W.

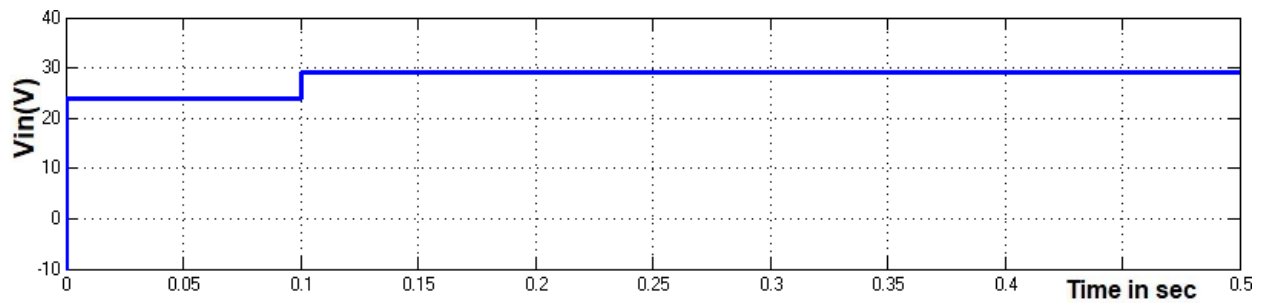


Fig: 3.24 : Input voltage

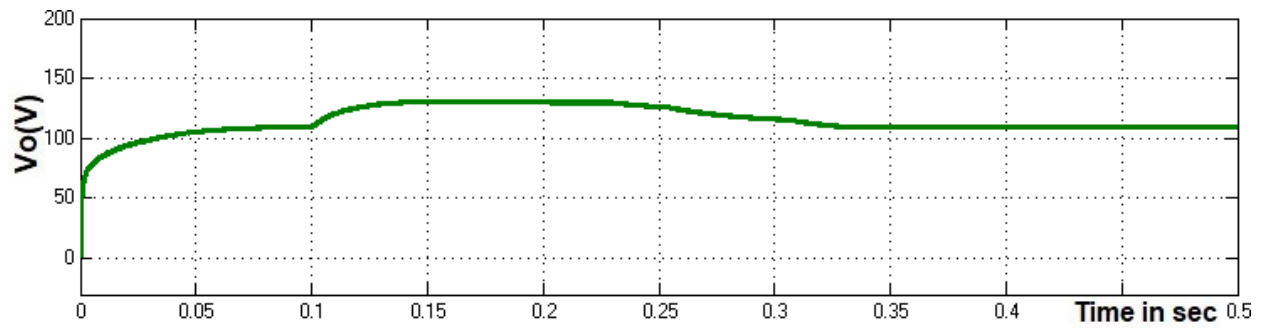


Fig:3.25 : Voltage across R-load

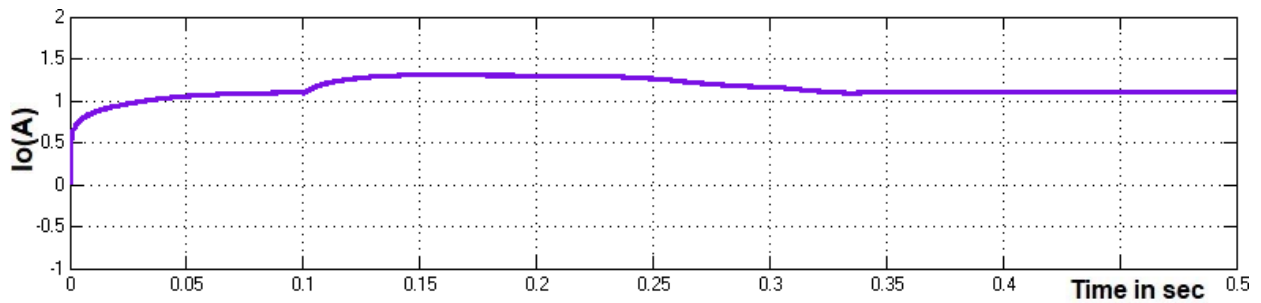


Fig: 3.26: Current through R-load

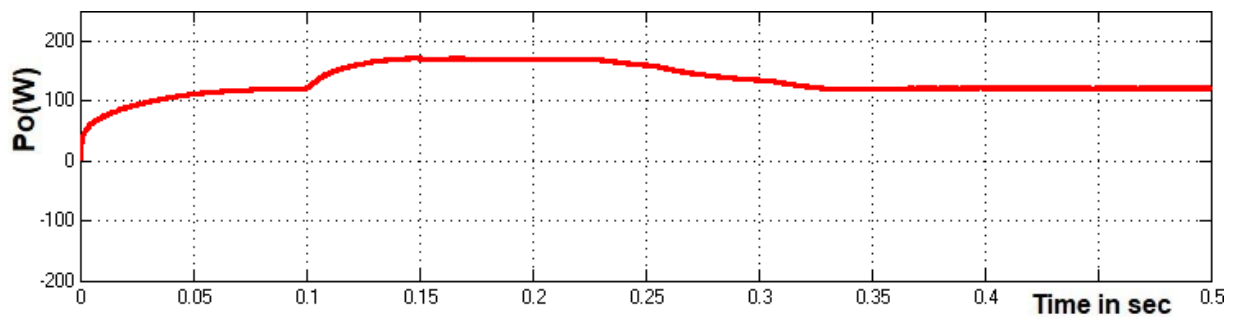


Fig: 3.27 : Output power

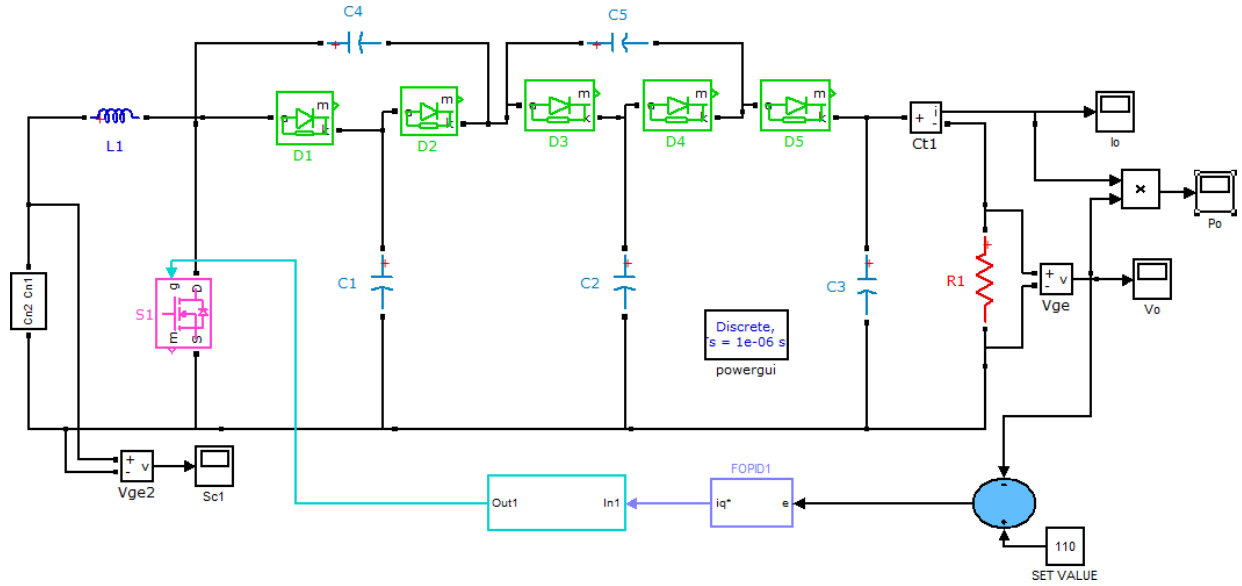


Fig: 3.28 : Circuit diagram of proposed bi-directional DC-DC converter with closed loop FOPIDcontroller

The circuit diagram of proposed bi-directional DC-DC converter with closed loop FOPID controller is shown in the Fig 3.28. The input voltage is given in the Fig 3.29 and its value is 30V. The voltage across R-load is given in the Fig 3.30 and its value is 110V. The current through the R- load is given in the Figure 3.31 and its value is 1.1A. The output power is given in the Fig 3.32 and its value is 124W.

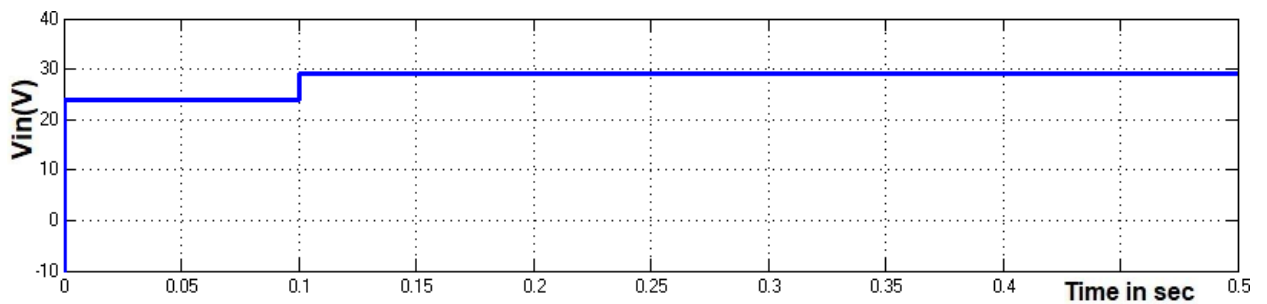


Fig: 3.29 : Input voltage

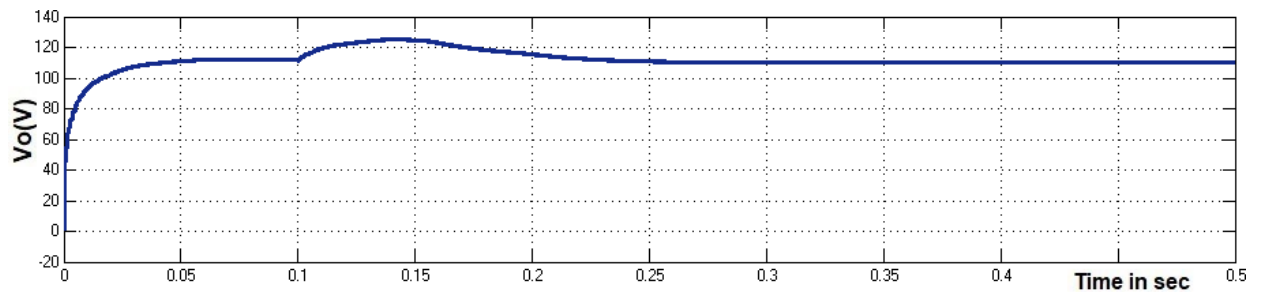


Fig: 3.30 : Voltage across R-load

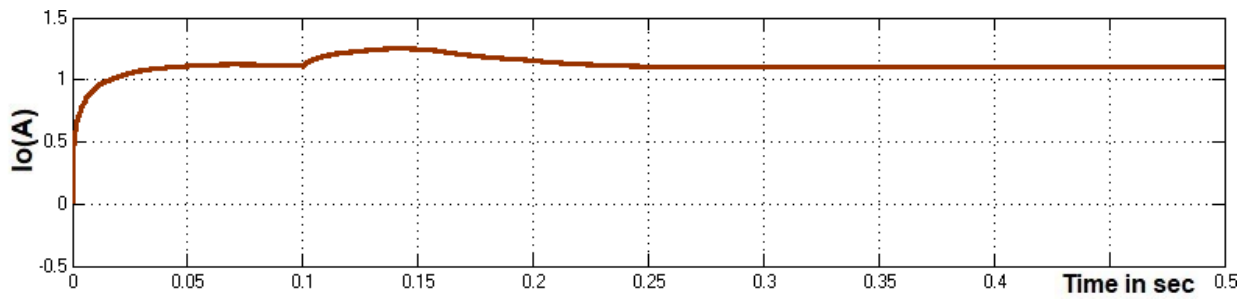


Fig: 3.31 : Current through R-load

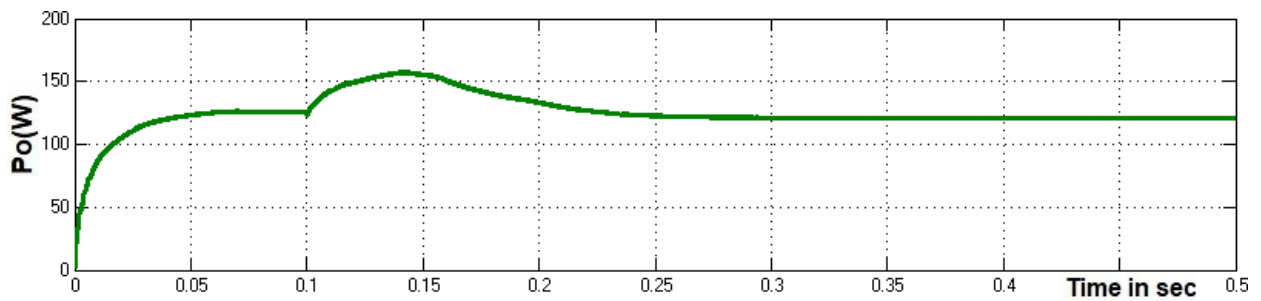


Fig: 3.32 : Output power

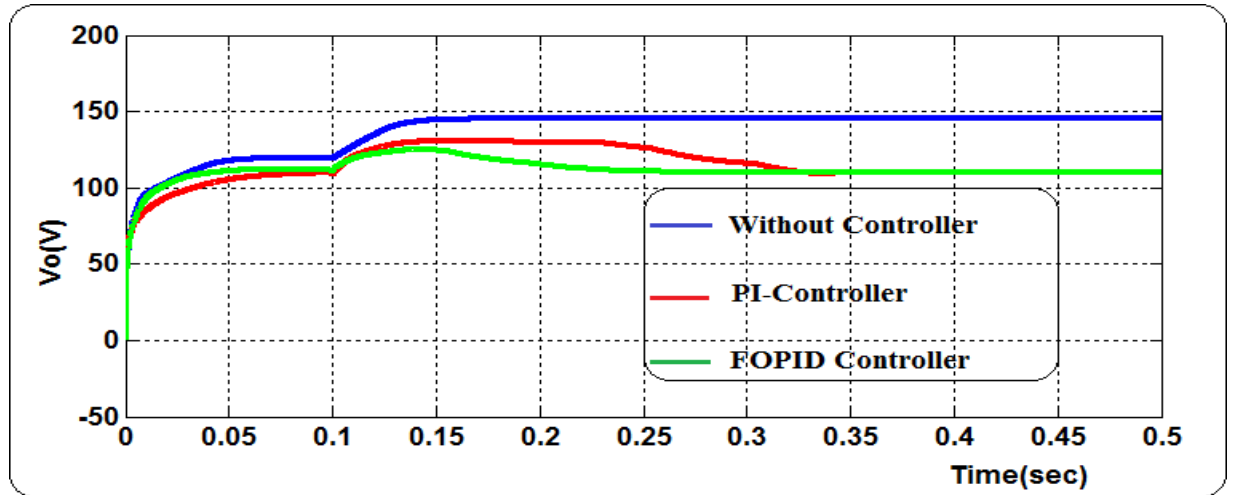


Fig. 3.33 : Output voltage with PI and FOPID controller

The Output voltage of without controller and with PI and FOPID controller is shown in the Fig 3.33. The bar chart diagram of time domain response of PI and FOPID controllers are given in the Fig 3.34.

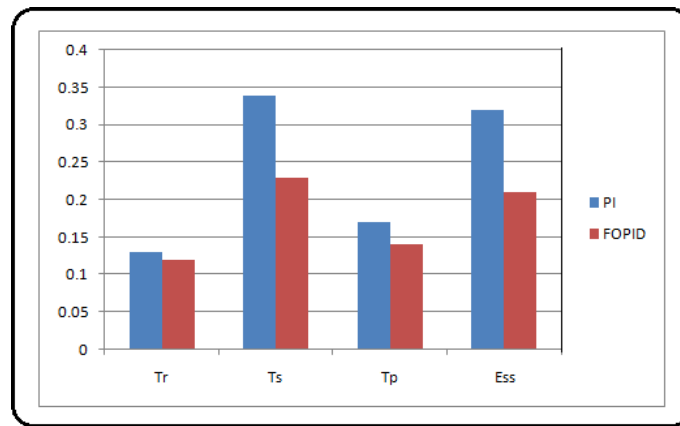


Fig. 3.34 : Bar chart of PI and FOPID controller

3.4 PROPOSED SYSTEM ADVANTAGES

- High efficiency
- Less switching losses due to ZVS
- Less voltage ripples in the output.

- High output voltage

3.5 APPLICATIONS

- Battery charging
- Motor Drive
- Aerospace

CHAPTER 4

HARDWARE RESULTS

4.1 GENERAL

For the hardware implementation we tend to use completely different elements. they're listed below as

- PIC Microcontroller 16F84A.
- Voltage Regulators
 - 7812 transformers
 - 7805 transformers
- IC IR2110 for the amplification of the pulses given by PIC16F84A

4.2 POWER SUPPLY CIRCUIT

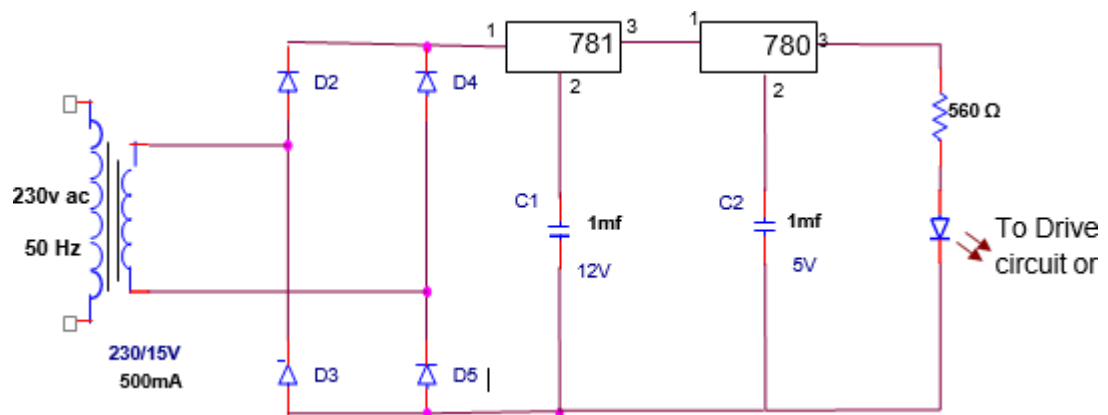


Fig: 4.1 : Power circuit

FEW SIGNIFICANT POINTS REGARDING THE POWER CIRCUIT:

- A transformer (230/15) V is employed to allow input offer to the ability circuit.
- The 15V AC input is corrected into 15V pulsing DC with the assistance of full bridge rectifier circuit.
- The ripples within the pulsing DC ar removed and pure DC is obtained by employing a electrical device filter.
- The positive terminal of the electrical device is connected to the input pin of the

7812 regulator for voltage regulation.

- An output voltage of 12V obtained from the output pin of 7812 is fed because the offer to the heartbeat electronic equipment.
- An output voltage of 5V obtained from the output pin of 7805 is fed because the offer to the small controller.
- From identical output pin of the 7805, a crystal rectifier is connected nonparallel with the electrical device to point that the ability is ON.

4.3 PIC CONTROLLER

In this project the hardware is enforced exploitation the Pic- Microcontroller “Pic 16F84A”. the benefits of the Pic- microcontroller is that the instruction set of this controller square measure fewer than the same old microcontroller. not like typical processors, that square measure typically advanced, instruction set pc (CISC) sort, Pic microcontroller could be a architecture processor. The advantages of RISC processor against CISC processor are:

- 1.RISC directions area unit less complicated and consequently operate quicker.
- 2.A RISC processor takes one cycle for every instruction, whereas CISC processor needs multiple clocks per instruction (usually, a minimum of 3 cycles of output execution time for the only instruction and twelve to twenty-four clock cycles for a lot of advanced instruction), that makes coding a troublesome task.
- 3.The management unit during a CISC is often enforced by a micro-code, that is way slower than the hardware enforced in RISC.
- The idea of victimization the Pic microcontroller is because:
- 1.to use the oftentimes used directions because the instruction set whereas employing a few directions to attain identical perform performed by a far a lot of advanced instruction during a CISC.
- 2.The RISC itself features a sizable number of general-purpose registers, for the most part reduced the frequency of the foremost long access.

- 3. In terms of clock rate, the RISC with its abundant less complicated circuits will have the next clock rate that once more will increase the performance of a processor.
- Overall, the RISC processor will offer process power quite thrice of a CISC processor during a specific field of application.

4.3..1 FEATURES OF PIC CONTROLLER

- “Pic16F84A” Only 35 single word instructions to learn
- All directions single-cycle apart from program branches that square measure two cycle
- Operating speed: DC - twenty megacycle clock input DC - two hundred ns instruction cycle
- 1024 words of program memory
- 68 bytes of information RAM
- 64 bytes of information EEPROM
- 14-bit wide instruction words
- 8-bit wide knowledge bytes
- 15 Special perform Hardware registers
- Eight-level deep hardware stack
- Direct, indirect and relative addressing modes
- Four interrupt sources:
- External RB0/INT pin
- TMR0 timer overflow
- PORTB<7:4> interrupt-on-change
- Data EEPROM write complete

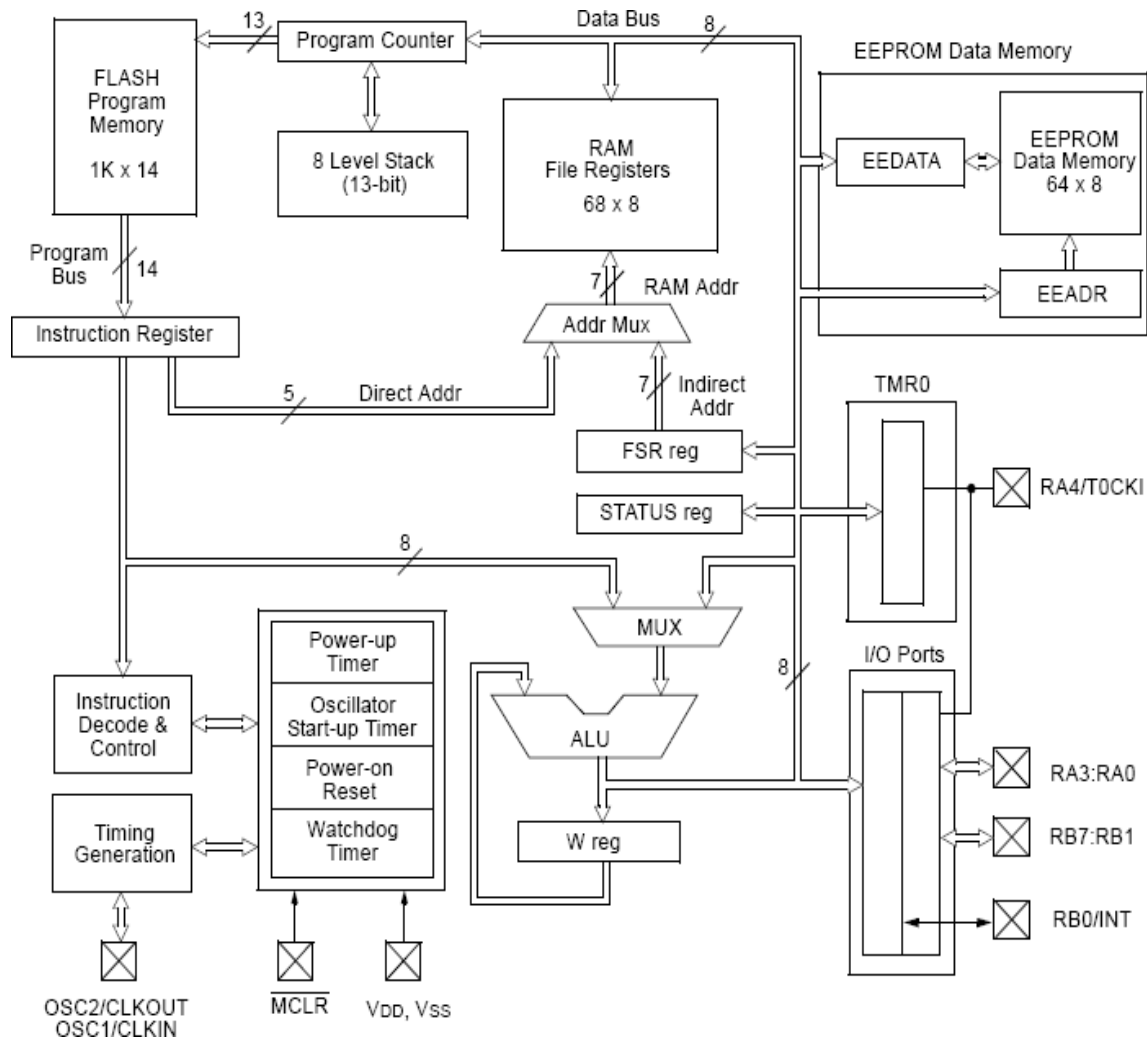


Fig: 4.2 : Block Diagram of "PIC16F84A"

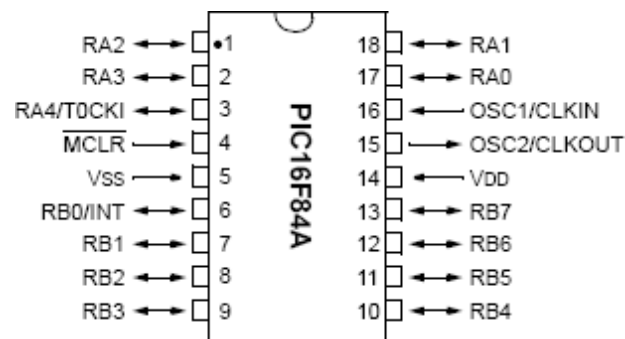


Fig: 4.3 : Pin Diagram of PIC16F84A

The PIC16F84A belongs to the mid-range family of the PIC microcontroller devices. A

diagram of the device is shown in Figure four.2

The program memory contains 1K words, that interprets to 1024 directions, since every 14-bit program memory word is that the same breath as every device instruction. the info memory (RAM) contains sixty-eight bytes. information EEPROM is sixty-four bytes. There square measure are} thirteen I/O pins that are user-configured on a pin-to-pin basis. Some pins square measure multiplexed with alternative device functions. These functions include:

- External interrupt
- Change on PORTB interrupts
- Timer0 clock input

4.3..2 MEMORY ORGANISATION

There area unit 2 memory blocks within the PIC16F84A. These area unit the program memory and also the information memory. every block has its own bus, so access to every block will occur throughout constant generator cycle.

The data memory will any be attenuated into the final purpose RAM and also the Special perform Registers (SFRs). The operations of the SFRs that management the “core” area unit delineated here. The SFRs accustomed management the peripheral modules area unit delineated within the section discussing every individual peripheral module.

The data memory space conjointly contains the info EEPROM memory. This memory isn't directly mapped into the info memory, however is indirectly mapped. That is, associate degree indirect address pointer specifies the address of the info EEPROM memory to read/write. The sixty-four bytes of information EEPROM memory have the address vary 0h-3Fh.

Data EEPROM Memory

The EEPROM information memory is decipherable and writable throughout traditional operation (full VDD range). This memory isn't directly mapped within the register file

house. Instead, it's indirectly addressed through the Special perform Registers. There are four SFRs that can scan and write this memory.

These registers are:

- EECON1
- EECON2 (not a physically enforced register)
- EEDATA
- EEADR

EEDATA holds the 8-bit knowledge for read/write, and EEADR holds the address of the EEPROM location being accessed. PIC16F84A devices have sixty-four bytes of information EEPROM with Associate in Nursing address vary from 0h to 3Fh. The EEPROM knowledge memory permits bytes scan and write. A computer memory unit write mechanically erases the situation and writes the new knowledge (erase before write). The EEPROM knowledge memory is rated for top erase/write cycles. The write time is controlled by Associate in Nursing on-chip timer. The write time can vary with voltage and temperature still as from chip to chip. Please confer with AC specifications for precise limits.

When the device is code protected, the CPU might still scan and write the information EEPROM memory. The device applied scientist will now not access this memory.

I/O Ports

Some pins for these I/O ports area unit multiplexed with associate alternate operate for the peripheral options on the device. In general, once a peripheral is enabled, that pin might not be used as a general purpose I/O pin.

Timer0 Module

The Timer0 module timer/counter has the following features

- 8-bit timer/counter
- Readable and writable

- Internal or external clock select
- Edge selects for external clock
- 8-bit software programmable pre-scaler

4.3..3 SPECIAL FEATURE OF PIC 16F84A

What sets a microcontroller except for different processors square measure special circuits to trot out the wants of real time applications. The PIC16F84A includes a host of such options meant to maximize system responsibleness, minimize value through elimination of external parts, give power saving in operation modes and provide code protection. These options are:

- OSC choice
- RESET
- Power-on Reset (POR)
- Power-up Timer (PWRT)
- Oscillator Start-up Timer (OST)
- Interrupts
- Watchdog Timer (WDT)
- SLEEP
- Code Protection
- ID Locations

In-Circuit Serial Programming (ICSP) The PIC16F84A encompasses a Watchdog Timer which may be shut-off solely through configuration bits. It runs off its own RC generator for value-added responsibleness. There area unit 2 timers that provide necessary delays on power- up. One is that the generator Start-up Timer (OST), meant to stay the kick in RESET till the quartz oscillator is stable.

4.3..4 OSCILATOR TYPE

The PIC16F84A are often operated in four completely different generator modes. The user will program 2 configuration bits (FOSC1 and FOSC0) to pick one among these four modes:

- LP Low Power Crystal
- XT Crystal/Resonator
- HS High Speed Crystal/Resonator
- RC Resistor/Capacitor

The PIC16F84A differentiates between numerous varieties of RESET:

- Power-on Reset (POR)
- MCLR throughout traditional operation
- MCLR throughout SLEEP
- WDT Reset (during traditional operation)

Power on Reset (POR)

A Power-on Reset pulse is generated on-chip once VDD rise is detected (in the vary of one.2V - 1.7V). to require advantage of the POR, simply tie the MCLR pin directly (or through a resistor) to VDD. this can eliminate external RC elements typically required to form Power-on Reset. A minimum rise time for VDD should be met for this to control properly.

Power-up Timer (PWRT)

The Power-up Timer (PWRT) provides a hard and fast seventy-two ms nominal time-out (TPWRT) from POR. The Power-up Timer operates on an interior RC generator. The chip is unbroken in RESET as long because the PWRT is active. The PWRT delay permits the VDD to rise to a suitable level.

A configuration bit, PWRTTE, will enable/disable the PWRT. The operation of the PWRTTE bit for a specific device. The power-up time delay TPWRT can vary from chip to chip thanks to VDD, temperature, and method variation. Interrupts

The PIC16F84A has four sources of interrupt:

- External interrupt RB0/INT pin
- TMR0 overflow interrupt

- PORTB amendment interrupts (pins RB7:RB4)
- Data EEPROM write complete interrupt

4.4 DRIVER:

4.4..1 OPTOCOUPLERS

There are several things wherever signals and information got to be transferred from one system to a different at intervals a chunk of natural philosophy instrumentality, or from one piece of kit to a different, while not creating a right away ohmic electrical association. typically this is often as a result of the supply and destination area unit (or is also at times) at terribly completely different voltage levels, sort of a chip that is working from 5V DC however being employed to manage a triac that is shift 240V AC. In such things the link between the 2 should be associate degree isolated one, to safeguard the chip from over voltage injury.

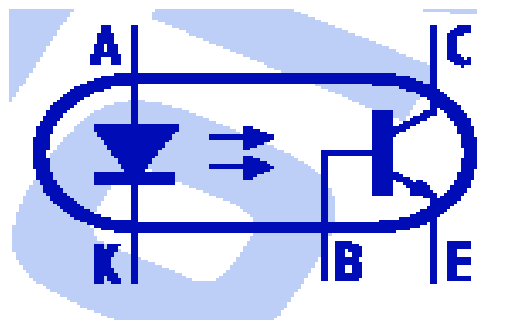


Fig:4.4 : Optocoupler

- Relays will after all offer this type of isolation, however even tiny relays tend to be fairly large compared with ICs and plenty of of today's alternative miniature circuit elements. as a result of their electro-mechanical, relays also are not as reliable and solely capable of comparatively low speed operation. wherever tiny size, higher speed and bigger dependability area unit necessary, a far higher various is to use AN optocoupler. These use a beam of sunshine to transmit the signals or information across AN electrical barrier, and deliver the goods glorious isolation.

- Optocouplers generally are available in a little 6-pin or 8-pin IC package, however area unit basically a mix of 2 distinct devices: AN optical transmitter, generally a atomic number 31 compound light-emitting diode (light- emitting diode) and an optical receiver like a phototransistor or light-triggered disc. the 2-area unit separated by a clear barrier that blocks any electrical current flow between the 2, however will permit the passage of sunshine. the essential plan is shown in Fig.1, beside the same old circuit image for AN optocoupler.

4.4.2 R 2110 – HIGH AND LOW aspect DRIVER

Some of the features of IR 2110 are:

Separate logic provides vary from three.3V power ground + 5V and ground + 5V offset CMOS Schmitt-triggered inputs with pull Floating channel designed for bootstrap operation

- Gate drive provide vary from ten to 20V
- Under voltage opposition for each channel
- 3.3V logic compatible down
- Cycle by cycle edge-triggered termination logic
- Matched propagation delay for each channel
- Outputs in part with inputs

The IR2110 may be a high voltage, high speed power MOSFET driver with freewheeling high and low side output channels. It's absolutely operational to +500V or +600V and tolerant to negative transient voltage dV/dt immune. Logic inputs square wave compatible with customary CMOS or LSTTL output, down to 3.3V logic. The output drivers feature a high pulse current buffer stage designed for minimum driver cross-conduction. Propagation delays are matched to modify use in high frequency applications. The floating channel may be accustomed drive Associate in Nursing N-channel power MOSFET or IGBT within the high side configuration that operates up to five hundred or 600

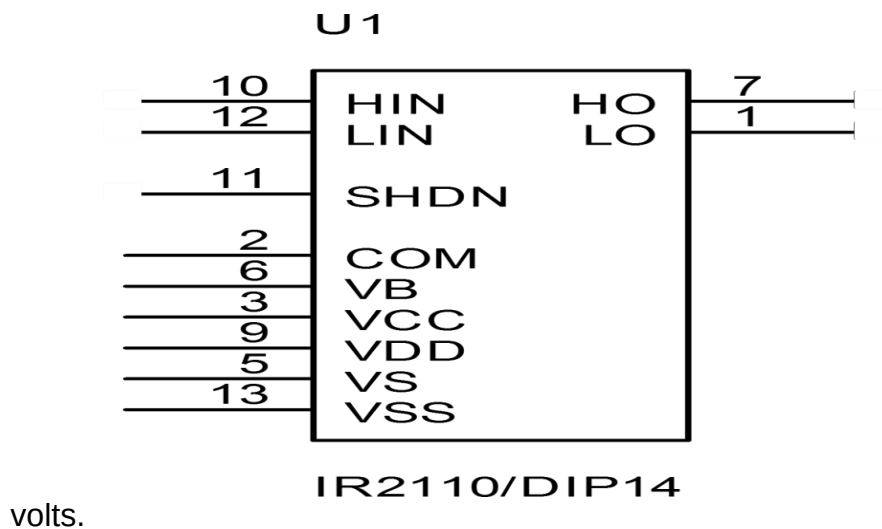


Fig:4.5 : Pin Diagram of IR 2110

LEAD DEFINITIONS:

Symbol	Description
VDD	Logic Supply
HIN	Logic input for high side gate drive output (HO), in phase
SD	Logic input for shut down

LIN	Logic input for low side gate driver output (LO), in phase
VSS	Logic ground
VB	High side floating supply
HO	High side gate drive output
VCC	Low side supply
LO	Low side gate drive output
COM	Low side return

4.4.2 APPLICATIONS

- Power supply regulator
- Digital Logic input

4.5 MOSFET

4.5.1 INTRODUCTION

The MOSFET consists of a channel of n-type or semiconductor unit material, and is consequently referred to as as NMOSFET or a PMOSFET. sadly, several semiconductors with higher electrical properties than atomic number 14 like Ga compound don't kind smart gate oxides and therefore don't seem to be appropriate for MOSFETS.

A simplified diagram of the N-channel improvement MOSFETS is shown in figure. Drain and supply connections square measure created to higher conductivity high doped regions. The metal gate is electrically isolated from the P-type substrate by a layer of non-conducting oxide (SiO_2).

When a positive voltage is applied to the gate with relation to the supply an electrical field are going to be created inform far from the bottom and across the

P-region directly below the bottom. the electrical field can cause positive charges within the P-region to maneuver far from the bottom inducement or enhancing associate N-region in its place.

Conduction will then happen between the N+ (drain) N (enhanced region) N+(source) .Increasing or decreasing in size thus controlling conduction. Varying the voltage between the gate and body modulates the conductivity of this layer and makes it possible to control the current flow between drain and source.

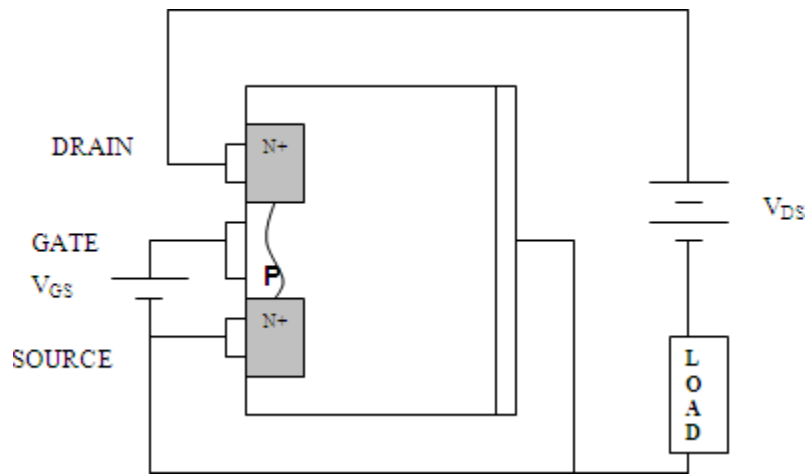


Fig: 4.6 : Simple model of an N-channel enhancement type MOSFET

Power MOSFET has lower switch losses however its on-resistance and physical phenomenon losses square measure more. MOSFET may be a voltage-controlled device. it's positive temperature co-efficient for resistance. This makes simultaneous operation of MOSFET simple. If a MOSFET shares exaggerated current at the start, it heats up quicker its resistance rises and this exaggerated resistance causes this current to shift to alternative devices in parallel In MOSFET secondary break down doesn't occur, as a result of it's positive temperature co- economical. Power MOSFETS in higher voltage ratings have additional physical phenomenon losses.

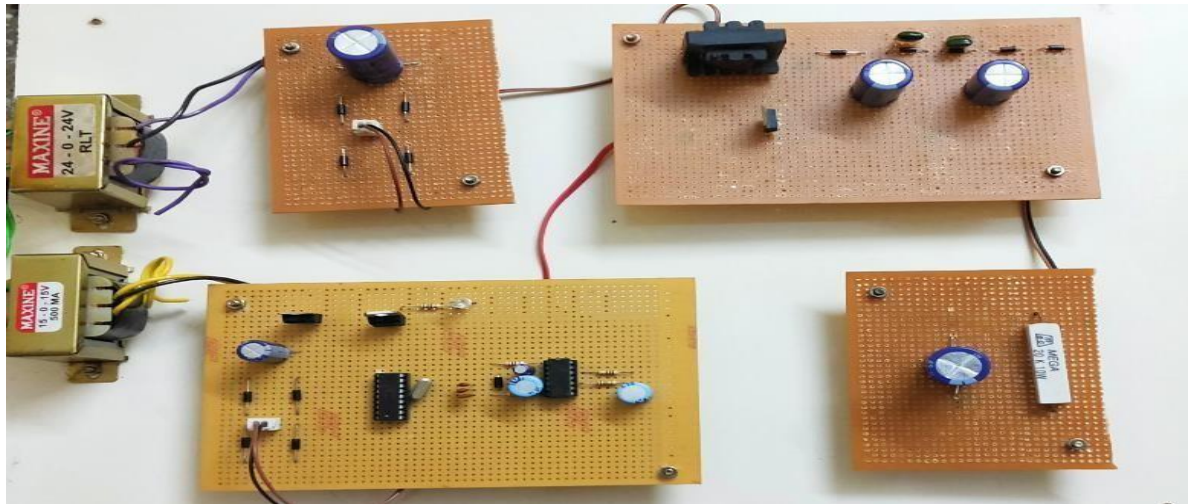
4.5.2 IRF 840- POWER MOSFET

- Dynamic dv/dt Rating

- Repetitive Avalanche Rated
- Fast switching
- Ease of paralleling
- Simple Drive requirements

4.2 EXPERIMENTAL RESULTS:

To verify the performance and functionality of the Modified high gain converter prototype is developed in the laboratory using power MOSFET IRF840 and microcontroller PIC 16F84A with a switching frequency and the hardware consists of control circuit, rectifier circuit, MBC- board and the load. The Hardware snap shot of MBC is shown-in-Figu.5.7.



**Fig: 4.7 : Hardware snap shot of
MBC**

Input voltage is shown in Figure 4.8. Another method for switching pulse for M1 and Vds is appeared in Figure 4.9. The output voltage is shown in Figure 4.10.

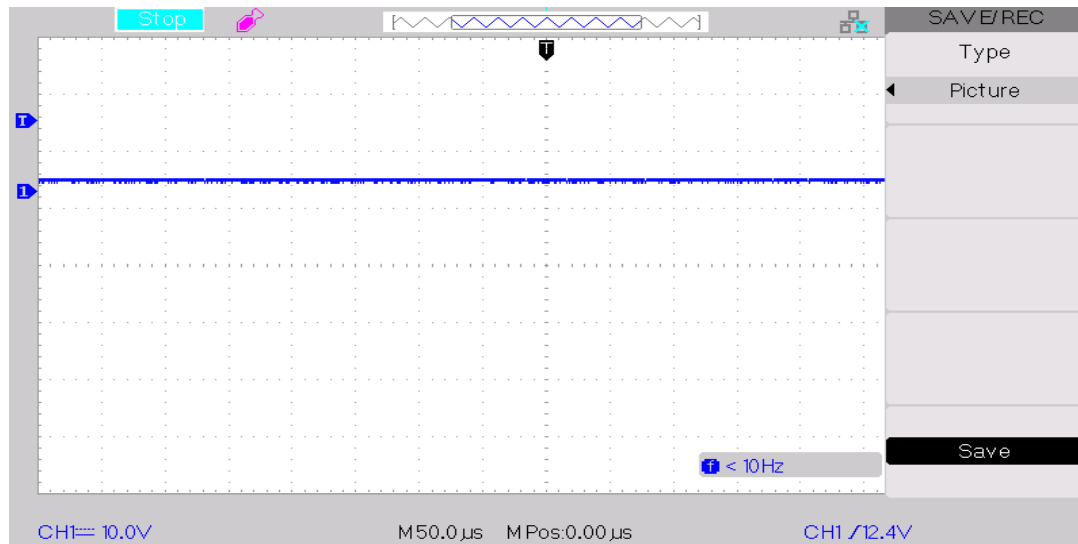


Fig: 4.8 : Input voltage

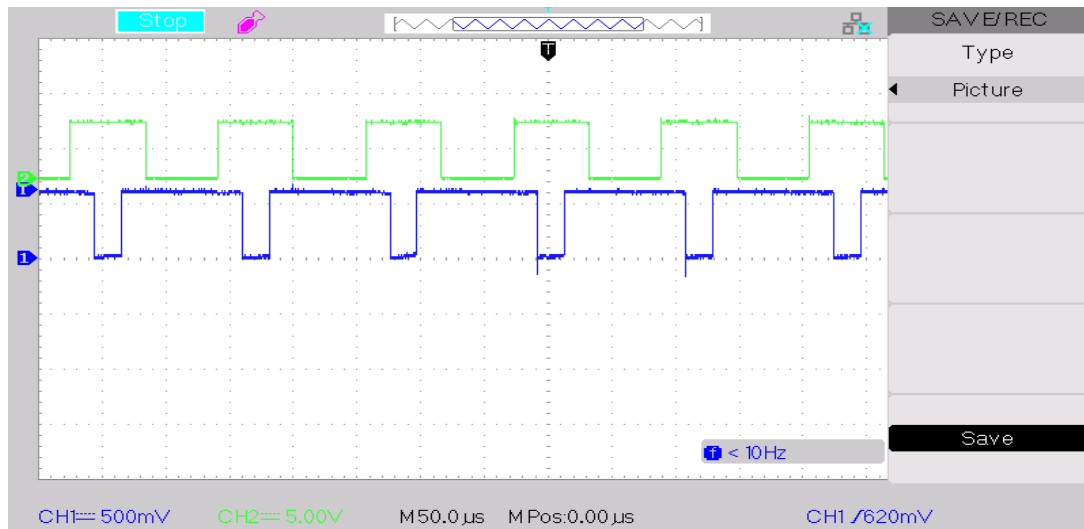


Fig:4.9 : Switching pulse of M1&Vds

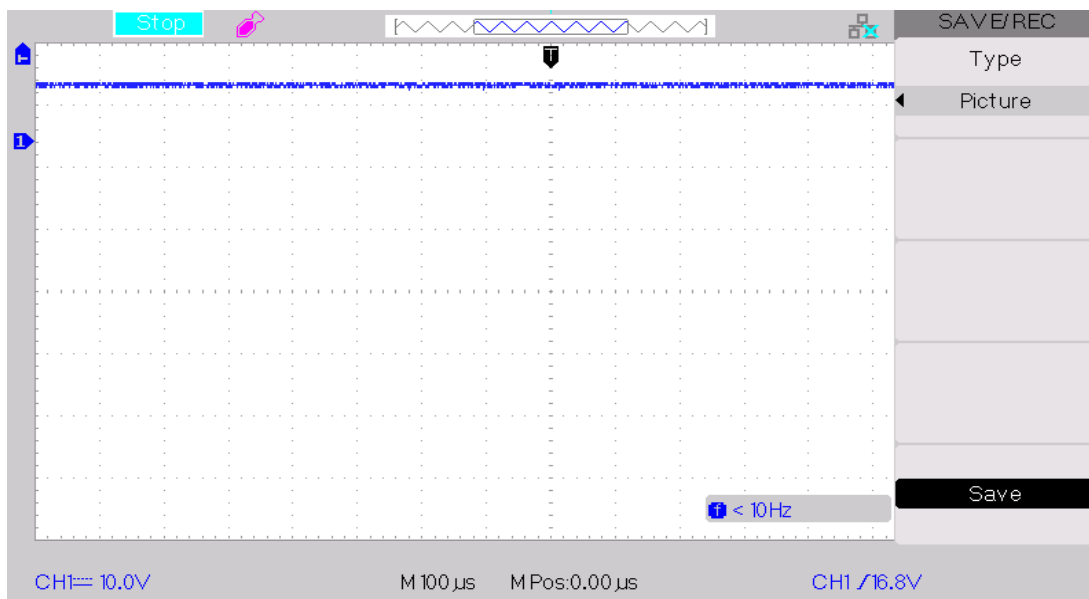


Fig:4.10 : Output voltage across R load

CHAPTER 5

CONCLUSION

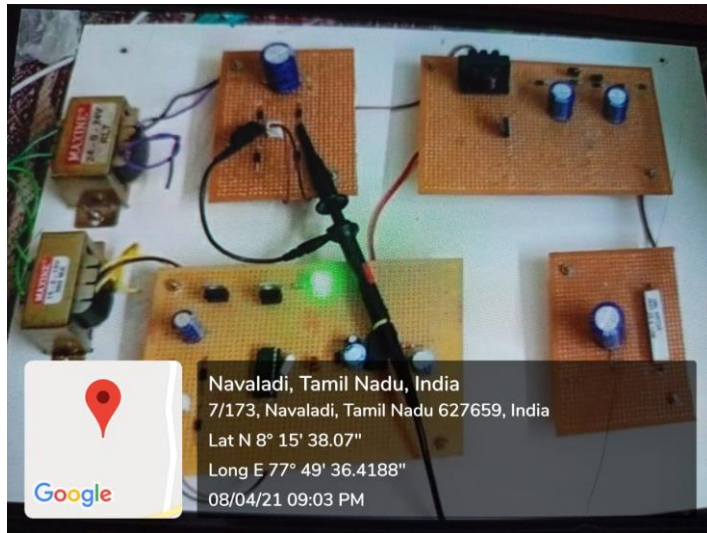
4.1 CONCLUSION

Existing circuit diagram of boost DC-DC converter system is simulated. Proposed circuit diagram of high gain bidirectional DC-DC converter with open loop is simulated. High gain bidirectional DC-DC converter with closed loop PI controller is simulated. High gain bidirectional DC-DC converter with closed loop FOPID controller is simulated. Output voltage is increased from 85V to 110V. Voltage ripple is reduced from 2.0V to 0.15V. Output Power is increased from 74W to 124W. Rise time is reduced from 0.13s to 0.12s. Peak time is reduced from 0.17s to 0.14s. Settling time is reduced from 0.34s to 0.23s. Steady state error voltage is reduced from 0.32V to 0.21V.

4.2 DESCRIPTION

The IRF-840 provides quick change, ruggedized device style, low on-resistance and value effectiveness. The TO-220 package is universally most well-liked for all commercial-industrial applications at power dissipation levels to some fifty watts. The low thermal resistance and low package price of the TO-220 contribute to its wide acceptance throughout the trade.

GEOTAG PICTURES





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