

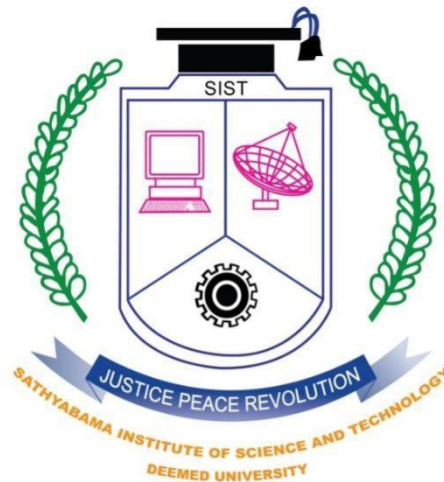
OPTIMIZED EVALUATION OF HVDC TRANSMISSION SYSTEM USING STATCOM

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

By

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**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING**

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 **AARTHI R**(Reg. No. 37140001) and **DHARSHINI D** (Reg. No. 37140025) who carried out the project entitled "**OPTIMIZED EVALUATION OF HVDC TRANSMISSION SYSTEM USING STATCOM**" under our supervision from December 2020 to April 2021.

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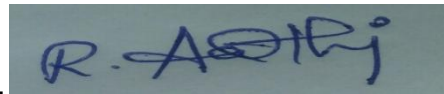
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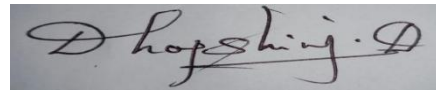
DECLARATION

We **AARTHI R** (Reg No.37140001) and **DHARSHINI D** (Reg No.37140025) hereby declare that the Project Report entitled “**OPTIMIZED EVALUATION OF HVDC TRANSMISSION SYSTEM USING STATCOM**” done by under the guidance of **Dr.D.GODWIN IMMANUEL** 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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DATE:

PLACE:

SIGNATURE OF THE CANDIDATES

ACKNOWLEDGEMENT

We are pleased to acknowledge our sincere thanks to Board of Management of **SATHYABAMA** for their kind encouragement in doing this project and for completing it successful. We are grateful to them.

We convey our thanks to **Dr.N.M.Nandhitha, Dean, School of Electrical and Electronics Engineering** and **Dr.V.Sivachidambaranathan, Head of the Department, Dept. Of Electrical and Electronics Engineering** for providing us necessary support and details at the right time during the progressive reviews.

We would like to express our sincere and deep sense of gratitude to our Project Guide **Dr. D. Godwin Immanuel** for his valuable guidance, suggestions and constant encouragement paved way for the successful completion of our project work.

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ABSTRACT

STATCOM may be a in style device to enhance voltage of weak buses in 2 bus systems. Small grids constitute a very essential part in today's power system installation for fulfilling the increasing power demand however once operating beneath isolated conditions small grids become very vulnerable thanks to the very fact that commonly small grids have tiny generation capacities and most of the generation sources square measure renewable / constant power sources, that reduces the transient also as voltage stability limits of a small grid once operating beneath isolated conditions. during this work one a synchronous generator based mostly isolated small grid system is studied. The small grid system feeds power to a focused time variable load. Fluctuation in load causes variation within the load bus voltage that reduces the soundness of the system. STATCOM may be a in style device to enhance voltage of weak buses in 2 bus systems

This work deals with modeling and simulation of closed-loop system controlled 3 section voltage supply electrical converter based mostly STATCOM in eight bus system. closed-loop system optimized FOPID & PR controlled STATCOM systems square measure investigated and their results square measure compared. The comparison is completed in term of your time domain response parameters like steady state error & sinking time. The STATCOM with optimized PR is discovered to be quicker than optimized FOPID controller. This work deals with modeling and simulation of closed-loop system controlled 3 section voltage supply electrical converter based mostly STATCOM in eight bus system. closed-loop system optimized FOPID & PR controlled STATCOM systems square measure investigated and their results square measure compared. The comparison is completed in term of your time domain response parameters like steady state error & sinking time. The STATCOM with optimized PR is discovered to be quicker than optimized FOPID controlled system.

TABLE OF CONTENTS

CHAPTER NO.	TITLE	PAGE NO.
	ABSTRACT	v
	LIST OF FIGURES	ix
	LIST OF TABLES	xii
	LIST OF ABBREVIATION	xiii
1	INTRODUCTION	1
	1.1 General	1
	1.2 STATCOM	1
2	LITERATURE SURVEY	2
	2.1 Scope of the project	6
	2.2 Advantages	6
3	PROJECT DESCRIPTION	7
	3.1 Static synchronous compensator	7
	3.2 Operating principle of STATCOM	7
	3.2.1 Power Transfer Limit	9
	3.2.2 Power System Constraints	9
	3.2.3 Controllability of Power System	10
	3.3 Benefits of Control of Power System	13
	3.3.1 Conventional Devices for Enhancing Power System	14
	3.4 FACTS Controllers for Enhancing Power System Control	15
	3.4.1 Advantages of FACTS	15
	3.4.2 Real Power Coordination Controller	15

3.5	Operating Modes	17
3.6	Major Advantages of STATCOM Over SVC	17
3.7	Characteristics of STATOM	17
3.8	Design of STATCOM	18
3.9	STATCOM Operation	19
3.9.1	Basic Principle of Operation	19
3.9.2	Modes of Operation	19
3.10	STATCOM versus SVC	20
3.11	Applications	20
4	SIMULATION RESULTS	21
4.1	Open Loop Simulation Results	21
4.2	Closed Loop Simulation Results	30
4.2.1	Closed Loop Result for FOPID Controller	34
4.2.2	Closed Loop Result for PR Controller	38
4.2.3	Results	43
5	HARDWARE IMPLEMENTATION	45
5.1	General	45
5.2	Power Supply Circuit	46
5.3	PIC Controller	47
5.3.1	Features of PIC Microcontroller	48
5.3.2	Oscillator Types	53
5.4	Driver Unit	55
5.4.1	Optocouplers	55
5.4.2	Applications	56
5.5	MOSFET	57
5.5.1	Introduction	57
5.5.2	Features of Power MOSFETs	59

	5.5.3 IRF840 Power MOSFETs	60
	5.6 Experimental Results	60
6	CONCLUSION	63
	REFERENCES	64

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE NO.
3.1	Functional model of STATCOM	8
3.2	Controllability of power system	11
3.3	Block diagram of the FOPID Controller	11
3.4	Operation mode of STATCOM	17
3.5	VI characteristics of STATCOM	18
4.1	Circuit diagram of without STATCOM	21
4.2	Voltage across RL load	22
4.3	Output voltage THD	22
4.4	Current through RL load	23
4.5	Output current THD	23
4.6	Real power	24
4.7	Reactive power	24
4.8	Circuit diagram of with STATCOM	24
4.9	Voltage across RL load	25
4.10	Output voltage THD	25
4.11	Current through RL load	26
4.12	Output current THD	26
4.13	Real power	27
4.14	Reactive power	27
4.15	Bar chart of real and reactive power	28

4.16	Bar chart of output voltage	28
4.17	Bar chart of voltage THD and current THD	29
4.18	Circuit diagram of STATCOM with load disturbance	30
4.19	Voltage across RL load	30
4.20	RMS voltage across RL load	31
4.21	Output voltage THD	31
4.22	Current through RL load	32
4.23	Output Current THD	32
4.24	Real power	33
4.25	Reactive power	33
4.26	Circuit diagram of STATCOM with closed loop optimized FOPID controller	34
4.27	Voltage across RL load	34
4.28	RMS voltage across RL load	35
4.29	Output voltage THD	35
4.30	Current through RL load	36
4.31	Output current THD	36
4.32	Real power	37
4.33	Reactive power	37
4.34	STATCOM with closed loop optimized PR controller	38
4.35	Voltage across RL load	38
4.36	RMS voltage across RL load	39
4.37	Output voltage THD	39

4.38	Current through RL load	40
4.39	Output current THD	40
4.40	Real power	41
4.41	Reactive power	41
4.42	Bar chart of time domain parameters	42
4.43	Bar chart of voltage THD and current THD	43
5.1	Block diagram of hardware implementation	45
5.2	Power circuit	46
5.3	Block diagram of PIC16F84A	49
5.4	Pin diagram of PIC16F84A	49
5.5	Optocoupler	55
5.6	Controller circuit	57
5.7	Simple model of N channel enhancement type	59
5.8	Hardware set up	60
5.9	Input Voltage	61
5.10	Voltage across rectifier	61
5.11	Switching pulse for inverter M1,M3	62
5.12	Switching pulse for inverter M2,M6	62
5.13	Voltage across RL load	62

LIST OF TABLES

TABLE NO.	TITLE	PAGE NO
4.1	Comparison of output voltage, real & reactive power	27
4.2	Comparison of output voltage and current THD	29
4.3	Time domain parameters	41
4.4	Output voltage and current THD	42
4.5	Result for open loop system	43
4.6	Result for closed loop system	44

LIST OF ABBREVIATIONS

K_p	-	Proportional gain
K_r	-	Resonant constant
ω	-	System oscillating frequency
T_{is}	-	Double integral times
δ	-	Damping factor
V_{dc}	-	Condenser voltage
I_{se}	-	Series current
P_{se}	-	Real power demand of series device
iD_{se}	-	D-axis current
STATCOM	-	Static Synchronous Compensator
SVC	-	Static Var Compensator
IGBT	-	Insulated Gate Bipolar Transistor
FOPID	-	Fractional Order Proportional Integral Derivative
PRC	-	Proportional Resonant Controller
P	-	Real Power
Q	-	Reactive Power
THD	-	Total Harmonic Distortion
RPS	-	Regulated Power Supply
RISC	-	Reduced Instruction Set Computer
CISC	-	Complex Instruction Set Computer
MOSFET	-	Metal Oxide Semiconductor Field Effect Transistor

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Modern power system is facing several challenges thanks to day-by-day increasing complexity in their operation and structure. within the recent past, one among the issues that got wide attention is that the installation instability. With the dearth of recent generation and transmission facilities and over exploitation of the prevailing facilities meshed by increase in load demand build these sorts of issues a lot of at hand in trendy power systems

Demand of power is incessantly rising at a really high rate thanks to fast industrial development thanks to ever increasing energy consumption and heavy environmental pollution, interest in alternative energy has been increasing. However, a high penetration of alternative energy raises a retardant of system instability, caused by the character of wind uncertainty. the combination of Associate in Nursing energy storage system (ESS) is one among the simplest solutions to confirm the soundness and power quality of an influence system with facilitating penetration of distributed wind resources.

1.2 STATCOM

A Static synchronous compensator could be a shunt-connected static power unit compensator whose electrical phenomenon or inductive output current is controlled freelance of the ac system voltage.

STATCOM is created of a coupling electrical device, a VSC and a dc energy device. STATCOM is capable of exchanging reactive power with the conductor attributable to its little energy device i.e. little dc electrical device, if this dc electrical device is replaced with dc accumulator or alternative dc voltage supply, the controller will exchange real and reactive power with the transmission, extending its region of operation from 2 to four quadrants.

CHAPTER 2

LITERATURE SURVEY

Abbey C and Joos G planned a two-stage random optimum formula for size the ESS in Associate in Nursing isolated wind-diesel installation. The author thought of the wind penetration, ESS potency, and diesel operational strategy to attenuate the price of equipped energy.

Abdallah T, Bhavaraju V, Fu Q, Montoya L.F, Nasiri A, Solnaki A and Yu D.C designed the simplest locations Associate in Nursing sizes of an ESS in installation are able to do vital edges as follows: enhance installation responsibility and power quality; cut back the ability system value and management high-cost energy imbalance charges; minimize the ability loss and improve the voltage profiles; serve the demand for peak load and proper the ability issue. With the fast development of technology in Associate in Nursing ESS, large-scale energy storage systems have attracted a lot of attention. In big apple, Beacon Power, LLC developed a 20-MW frequency regulation plant, that consists of flywheels. The Golden natural depression electrical Association in Fairbanks, AK, USA, put in a large-scale Ni-Cd battery energy storage system to produce twenty seven MW of electricity to serve the native facility. thanks to the wide application of huge ESS, it's vital to optimally confirm the situation and capability of ESS.

Aman Behal and Amit K Jain, STATCOM management supported Hamiltonian control theory planned by Liu Q.J, for multi-machine grid stability improvement and located by mistreatment this controller the non-linearity and interconnection of the general system will simply be resolved.

Anderson M and Lo C associate in Nursing economic dispatch and optimum capability of ESSs has been mentioned. This formula combining multi-pass dynamic programming was planned to maximize fuel-cost savings and edges thanks to energy rating variations between peak-load and light-load periods.

Bastard P, Chacra F.A, Clavreul R and Fleury G, genetic formula (GA) improvement technique supported a multiple objective perform was employed to gauge the eons, impact of the energy storage specific prices on cyber web gift price of energy storage installations in distribution substations.

Bazmohammadi N, Bazmohanmmadi S and Karimpour, MOPSO approach that adopts differential evolution formula was given to optimize the operation of AN interconnected micro-grid that contains a spread of distributed energy resources and storage devices so as to attenuate each price and emission resulted from supply native demands. The standard inevitable state consistent quality investigations and transient hardiness take into account the dynamic power stream and power edge and usually expect relentless obtaining and causation finish transport voltage. The receptive power stream and voltage fall amid overwhelming current stream square measure unnoticed. This approach couldn't make a case for the many blackouts in USA, Europe, and Japan etc. throughout the half-moon of the 20 the century. The blackouts were because of voltage collapse. throughout voltage collapses, the bus-voltage starts falling and as a result, power transfer through the cable starts reducing leading to final voltage collapse and loss of system stability of the whole network. that's the explanation voltage security ponders have gotten additional thought and have obtained a elementary place in power framework. Voltage fall happens wherever receptive power administration is lacking.

Cai T, Chen C, Duan S, Liu B and Hu G, FACTS devices square measure proving to be terribly effective in victimization the complete transmission capability whereas increasing grid stability, transmission potency and maintaining power quality and reliableness of grid. These devices square measure primarily supported either Voltage supply converter (VSC) or Current supply converter (CSC) and have quick reaction time. As a vital member of FACTS devices family, STATCOM has been at the middle of attention and also the subject of active analysis for several years. STATCOM may be a shunt-associated widget that's utilized to administer reactive power remuneration to a cable. The analysis bestowed a strategy to optimize the allocation and economic operation of energy storage devices in an exceedingly low-tension micro-grid system.

Chang Y, planned a MOPSO methodology to work out AN optimum SVC installation theme for the desired loading margin with the SVC installation locations and capacities derived from the union of the SVC installations for all thought of contingencies.

Cherkaoui R, Hohmann M, Nick M and Paolone M, centered on the optimum ESS for increasing the support to the network voltage management in an exceedingly distributed system. It was found that satisfactory dynamic responses is reached by the

planned self calibration controller below numerous loading conditions. Vitaaly Spitsa, etal introduced zero set ideas for planning feedback controller for STATCOM.

Chia-Tien and Li-Wang etal. planned a damping management of the STATCOM mistreatment model control theory to contribute effective damping characteristics to the studied system below completely different operative conditions in [10] and it had been found that planned STATCOM controller joined with the designed FOPID damping controller is capable of rising performance of studied system.

Chun Li Ohrang Jiang and Manfred Eigen price Associate in Nursing analysis mistreatment literalized model was dispensed to style a compensator in cascade with an integral controller to beat this drawback. style of a nonlinear controller for STATCOM supported the differential pure mathematics theory is conferred.

Cong L, Wang Y and Farsangi M.M, etal. designed STATCOM controller supported Hinf loop shaping methodology and located that it's more practical as compared to ancient controller.

Ekanayake J.B and Jenkins N,MOPSO has become AN economical tool for determination the nonlinear, non-differentiable, multi-model also as separate variables optimization issues because of its versatile applications and higher hardiness in dominant parameters.

El-Sharkawi and Sortomme E, It's already been wide utilized to unravel the multi-objective optimization issues on grid by finding out an appropriate Pareto-optimal set. The fundamental operation of STATCOM and also the useful management theme to manage the STATCOM used for each reactive and real power compensation square measure given during this paper. Study of construction topologies of STATCOM has been conferred.

Ghafouri A created the utilization of particle swarm improvement to attain optimum dispatch of manageable hundreds and generators also as effectively utilizing the battery storage of every micro-grid. mercantilism hold on energy at high costs and shave peak hundreds from the larger system reduces the price of the micro-grid.

Gole A.M and Keyou Wang etal, planned a replacement internal STATCOM management supported feedback linearization. Simulation results show that the planned management exhibits more practical performance despite operative condition

together with little load modification, giant load modification and 3 section short circuits, when put next with ancient FOPID controls.

Gonzalez S.A and Puleston P.F, The controller designed by this methodology permits linearizing the compensator and dominant directly the electrical condenser voltage and output reactive power of the STATCOM. Such an impact allows to stabilize the compensation system and therefore helps to boost for the most part the transient performance of the world system. A rule based mostly contrives the synchronize for STATCOM was planned. The paper analyzing and damping torsion elicited on the shaft of the generator by STATCOM in a very single machine infinite bus (SMIB) system. It had been found that the elicited damping torsion forever decreases with the strengthening of the voltage management. Moreover, a set parameter PI damping controller is invalid or maybe give the system with negative damping sure system parameters and cargo conditions.

Gyugyi L, This controller will either absorb or inject reactive power whose electrical phenomenon or inductive current is controlled severally by the AC line voltage. Thus, STATCOM will enhance the cable load ability by extending the MW margin and improves the oscillation of voltage transients through effective regulation of the cable voltage at the purpose of association.

Iravani M.R and Lehn P W, The device is connected to a load bus with a converter electrical device. the airing of shunt controller and testing is reproduced within the MATLAB/ Simulink condition. The controller is spoken to as piece chart that presents right down to earth electronic model of shunt controller. PID controller is employed in dominant the present injection at the association purpose by variable the required parameters, one is Modulation Index (AM) and another is power angle (δ). primarily there square measure four loop standardization strategies for a PID controller; those square measure Manual standardization, Ziegler-Nichols, package tools and Cohen con methodology.

2.1 SCOPE OF THE PROJECT

- To simulate without STATCOM system.

- To simulate with STATCOM system.
- To simulate closed loop optimized FOPID controlled STATCOM system.
- To simulate closed loop optimized PR controlled STATCOM system.

2.2 ADVANTAGES

- Improve the power quality.
- High level of output voltage.
- Less Harmonics.
- Power flow control.

CHAPTER 3

PROJECT DESCRIPTION

3.1 STATIC SYNCHRONOUS COMPENSATOR (STATCOM)

“A Static synchronous compensator could be a shunt-connected static power unit compensator whose electrical phenomenon or inductive output current is controlled freelance of the ac system voltage”.

The conception of STATCOM was planned by Gyugyi in 1976. Power device used within the STATCOM primarily of 2 varieties i.e. is Voltage supply device and Current supply device. In Current supply device electricity forever has one polarity and also the power reversal takes place through reversal of dc voltage polarity whereas In Voltage supply device dc voltage forever has one polarity, and also the power reversal takes place through reversal of dc current polarity. The ability semiconductor devices utilized in current supply device needs on top of reasons Voltage supply device is most popular over Current supply device and currently currently it act as a basic electronic block of a STATCOM that converts a dc voltage at its input terminals into a three-phase set of ac voltages at fundamental with governable magnitude and point in time.

In STATCOM completely different technologies used dependent upon the ability ratings of STATCOM. For higher power STATCOMs GTO technologies square measure used whereas for lower power STATCOMs IGBT based technologies used

3.2 OPERATING PRINCIPLE OF STATCOM

STATCOM is created of a coupling electrical device, a VSC and a dc energy device. STATCOM is capable of exchanging reactive power with the conductor attributable to its little energy device i.e. little dc electrical device, if this dc electrical device is replaced with dc accumulator or alternative dc voltage supply, the controller will exchange real and reactive power with the transmission, extending its region of operation from 2 to four quadrants. A purposeful model of a STATCOM is shown in Figure 3.1

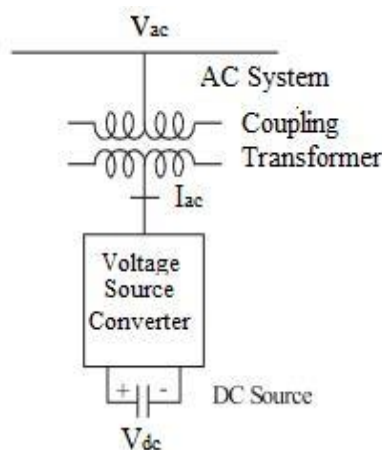


Fig.3.1 Functional model of STATCOM

The fundamental element of the device output voltage i.e. V_{out} will be controlled by varied the dc voltage across electrical device which may be done by dynamic the point in time point in time the operation of the device switches relative to the part of the ac system bus voltage.

The direction of flow of reactive power whether or not it's from coupling electrical device to the system or from system to the coupling electrical device depends upon the distinction between the device output voltage and also the ac system bus voltage. the \$64000 power flowing into the device provides the device losses thanks to change and charges the dc electrical device to a satisfactory dc voltage level. The electrical device is charged and discharged throughout the course of every change cycle however in steady state, the typical electrical device voltage remains constant. If that weren't the case, there would be real power flowing into or out of the device, and also the electrical device would gain or lose charge every cycle. In steady state, all of the ability from the ac system is employed to fill again the losses thanks to change.

The STATCOMs ability to absorb/supply real power depends on the dimensions of dc electrical device and also the real power losses thanks to change. Whenever the DC electrical device and also the losses are comparatively little. the number of real power transfer is additionally comparatively little. this means that the STATCOMs output ac current I_{ac} , needs to be about + 900 with relevancy ac system voltage at its line terminals. varied the amplitude of the device three-phase output voltage V_{out} controls the reactive power generation/absorption of the STATCOM. If the amplitude of the device output voltage V_{out} is increased on top of the amplitude of the ac system bus voltage holiday then the ac current I_{ac} , flows through the electrical device electrical phenomenon from the device to the ac system generating reactive power.

In this case, the ac system attracts electrical phenomenon current that leads by associate angle of 900 the ac system voltage, forward that the device losses are

capable zero. The ac current flows from the ac system to the voltage-sourced device if the amplitude of the device output voltage is bated below that of the ac system, and consequently the device absorbs reactive power. For associate inductive operation, the present lags the ac voltage by associate angle of 900. forward once more that the device losses are neglected. If the amplitudes of the ac system and device output voltages are equal, there'll be no ac current flow in/out of the device and thence there'll be no reactive power generation/absorption the ac current.

3.2.1 POWER TRANSFER LIMIT

One or more of the following network characteristics limits power flow over a transmission system.

- Stability limit
- Thermal limit
- Voltage limit
- Loop flow

Technically limitations on power transfer will invariably be removed by adding new transmission and/or generator capability. FACTS are designed to get rid of such limitations and meet operator's goals while not having to grasp major system additions.

3.2.2 POWER SYSTEM CONSTRAINTS

As noted within the introduction, transmission systems are being pushed nearer to their stability and thermal limits whereas the main target on the standard of power delivered is bigger than ever. the restrictions of the transmission will take several forms and should involve power transfer between spaces (referred to here as transmission bottlenecks) or at intervals one area or region (referred to here as a regional constraint) and should embody one or additional of the subsequent characteristics:

- Steady-State Power Transfer Limit
- Voltage Stability Limit
- Dynamic Voltage Limit
- Transient Stability Limit

- Power System Oscillation Damping Limit
- Inadvertent Loop Flow Limit
- Thermal Limit
- Short-Circuit Current Limit
- Others

Each transmission bottleneck or regional constraint might have one or additional of those system-level issues. The key to finding these issues within the most cost efficient and coordinated manner is by thorough systems engineering analysis.

3.2.3 CONTROLLABILITY OF POWER SYSTEM

Let's say that the ability system solely has bound variables that may be compact by management, contemplate the essential and well-known power-angle curve, shown in figure1 though this is often a steady-state curve and also the implementation of FACTS is primarily for dynamic problems, this illustration demonstrates the purpose that there are primarily 3 main variables that may be directly controlled within the grid to impact its performance. These are:

- Voltage (V)
- Angle (δ)
- Impedance (Z)

One may additionally create the purpose that direct management of power may be a fourth variable of controllability in power systems. Figure 3.2 below Illustrates of the controllability of grids with the institution of “what” variables will be controlled in an exceedingly power system, following question is “how” these variables will be controlled. the solution is given in 2 parts particularly typical instrumentation and FACTS controllers.

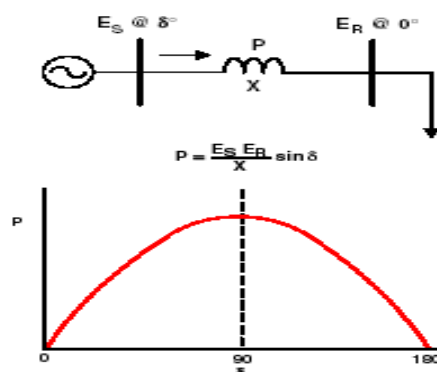


Fig.3.2 Controllability of power system

Fractional order proportional integral derivative (FOPID)

The illustration of FOPID was developed from halfway differentiation. The response with FOPID is quicker than that of the corresponding PI controlled system. A block-diagram that signifies the FOPID management structure is displayed in Fig.3.2. The transfer operate of AN FOPID controller takes the shape of

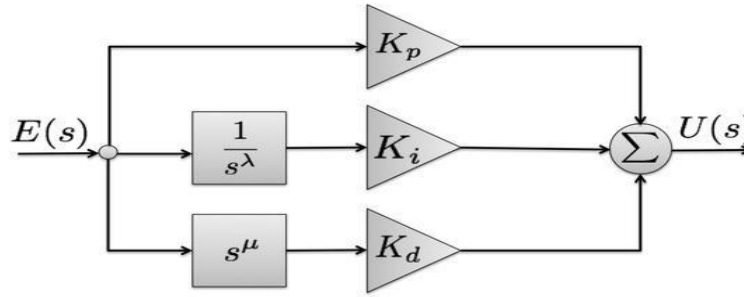


Fig.3.3 Block diagram of the FOPID controller

$$CF.O.P.I.D(s)=K_P+K_I/s^\lambda+K_D s^\mu \quad (1)$$

Where λ is that the order of the integral half, μ is that the order of the by product half, while K_P , K_I , and K_D square measure the controller as in an exceedingly typical PID controller.

Non Linear Fractional Order pelvic inflammatory disease Controller of the form

$$u(t)=f(e(t))*(K_p e(t)+T_i D^{-\lambda} e(t)+T_d D^{\delta} e(t)),$$

where $f(e(t))$ is nonlinear function $f(e(t))=K_0+(1-K_0)*|e(t)|$

The dc yield voltage is detected & evaluated with reference yield voltage, that provides the error signal. This error signal is coursed by the PI to sustain the output voltage

constant and diminish the steady state error. The set current is compared with actual current. The FOPID parameters, proportional gain (K_p) & double integral times (T_{is}), square measure assessed using Ziegler Nichols tuning method.

Proportional Resonant Controller (PRC)

PR controller may be a combination of proportional & resonant controller. The negative aspects of PI controller square measure conquered using PR controller. The resonant term PR controller provides elevated gain. The proportional term determines information measure, phase margin and gain margin. The PR controller is employed to regulate voltage or current. PR controller is more practical than PI controller with nearly zero steady state error. The transfer function of PR controller is as follows,

$$G(s) = K_p + K_r \frac{s}{s^2 + \omega^2} \quad (2)$$

' K_p ' – proportional-constant

' K_r ' – resonant-constant

' ω ' – system-oscillating-frequency, rad/sec

As 'space vector hypothesis' cannot be connected to the single phase VSI, the controller structure & modelling of the framework is not possible in dc outline. Consequently controller need to have the choice to follow single phase sinusoidal Current reference lawfully. The 'transfer function' of the LCL channel is largely spoken to by plant $G_f(s)$, that is given as pursues.

$$G_{f1}(s) = \frac{s C_f R_d + 1}{s^3 L_l L_g C_f + s^2 C_f R_d (L_l + L_g) + s(L_l + L_g)} \quad (3)$$

There is perpetually 'consistent state-magnitude & phase blunder exists whereas following a sinusoidal signal utilizing PI control'. variously a PR control that is stay on "inward model rule" planned by Francis & Won ham has AN never ending addition at reference signal wavering return. This may expel steady state error whereas following a sinusoidal signal. The PR controller $G_i(s)$ is within the blueprint.

$$G_{i1}(s) = K_p + \frac{K_i s}{s^2 + 2\delta\omega_0 s + \omega_0^2} \quad (4)$$

Here 'Kp and Ki' square measure the proportional & integral gain individually δ is the damping factor, ω is power frequency of the grid voltage. The 'infinite gain of PR control' is lessened by damping factor ' δ ' to reinforce the bandwidth & thus dynamics of the framework stays steady.

3.3 BENEFITS OF CONTROL OF POWER SYSTEM

Once power grid constraints square measure known and thru system studies viable solutions choices square measure known, the advantages of the additional power grid management should be determined. the subsequent offers an inventory of such benefits.

- Added Power Flow Control
- Improved Power System Stability
- Increased System Security
- Increased System Reliability
- Added Flexibility in siting New Generation

The advantages during this list square measure vital to realize within the overall designing and operation of power systems. However, for justifying the prices of implementing additional power grid management and for scrutiny typical solutions to FACTS controllers, a lot of specific metrics of the advantages to the ability system square measure typically needed. Such edges will sometimes be tied back to a vicinity or region for a particular season and year at an outlined dispatch (usually given by an ISO or equivalent) whereas meeting the subsequent criteria, as an example

- Voltage Stability Criteria
e.g., P-V voltage
- Dynamic Voltage Criteria
e.g., Avoiding voltage collapse
- Transient Stability Criteria
- Power System Oscillation Damping

e.g., Minimum damping ratio

Each of the above listed things will sometimes be measured in terms of a physical amount like power transfer through a crucial transmission interface, station output space or region load level. this enables for an immediate quantification of adding power grid management and provides a way to match such benefits by the assorted answer choices thought-about, whether or not they be typical or FACTS based mostly.

3.3.1 CONVENTIONAL DEVICES FOR ENHANCING POWER SYSTEM CONTROL

- Series Capacitor
 - Controls impedance
- Switched Shunt-Capacitor and Reactor
 - Controls voltage
- Transformer LTC
 - Controls voltage
- Phase Shifting Transformer
 - Controls angle
- Synchronous Condenser
 - Controls voltage
- Special Stability Controls
 - Typically focuses on voltage control but can often include direct control of power
- Others (When Thermal Limits are Involved)
 - Can include re conduct ring, raising conductors, dynamic line monitoring, adding new lines, etc.

3.4 FACTS CONTROLLERS FOR ENHANCING POWER SYSTEM CONTROL

- Static Synchronous Compensator (STATCOM) - Controls voltage
- Static VAR Compensator (SVC) - Controls voltage

- Unified Power Flow Controller (UPFC)
- Convertible Series Compensator (CSC)
- Inter-line Power Flow Controller (IPFC)
- Static Synchronous Series Controller (SSSC) - Each of the aforementioned (and similar) controllers' impact voltage, impedance, and/or angle (and power)
- Thyristor Controlled Series Compensator (TCSC) - Controls impedance
- Thyristor Controlled Phase Shifting Transformer (TCPST)
- □ Super Conducting Magnetic Energy Storage (SMES) - Controls voltage and power

3.4.1 ADVANTAGES OF FACTS

- Rapid response
- Frequent variation in output
- Smoothly adjustable output

3.4.2 REAL POWER COORDINATION CONTROLLER

To understand the planning of a true power coordination controller for a UPFC, take into account a UPFC connected to a line. The interaction between the series injected voltage (V_{se}) and conjointly the line current (I_{se}) lands up in exchange of real power between the series device and conjointly the line. the $\$64000$ power (P_{se}) demand of the series device (P_{se}) causes the dc link electrical condenser voltage (V_{dc}) to either increase or decrease counting on the direction of the $\$64000$ power result the series device.

This decrease/increase in dc link electrical condenser voltage (V_{dc}) is detected by the shunt device controller that controls the dc link electrical condenser voltage (V_{dc}) and acts to increase/decrease the shunt device real power flow to bring the dc link electrical condenser voltage (V_{dc}) back to its scheduled worth. as an alternative, the $\$64000$ power demand of the series device is recognized by the shunt device controller solely by the decrease/increase of the dc link electrical condenser voltage (V_{dc}). Thus, the shunt and also the series device operation square measure in an exceedingly

method separated from one another. to supply for correct coordination between the shunt and also the series device system, a feedback from the series device is provided to the shunt device system. The feedback signal used is that the real power demand of the series device (P_{se}). The P_{se} power demand of the series device (P_{se}) is reborn into constant D-axis current for the shunt device (i_{Dse}). By doing therefore, the shunt device responds directly to a modification in its D-axis current and provides the required series device real power demand. The equivalent D-axis current (i_{Dse}) is an extra input to the D-axis shunt device system. Equation (1) shows the connection between the series device real power demand (P_{se}) and also the shunt device D-axis current $i_{Dse} = P_{se} / |V_{upfc\ bus}|$

The real power demand of the series device (P_{se}) is that the real a part of product of the series device injected voltage (V_{se}) and also the line current (I_{se}). $V_{upfc\ bus}$, i_{Dse} represent the voltage of the bus to that the shunt device is connected and also the equivalent further D-axis current that ought to flow through the shunt device to produce the P_{se} power demand of the series device. The equivalent D-axis further current signal (i_{Dse}) is fed to the inner system, thereby increasing the effectiveness of the coordination controller. Further, the inner system loops square measure quick acting PI controllers and guarantee quick offer of the series device real power demand (P_{se}) by the shunt device.

3.5 OPERATING MODES

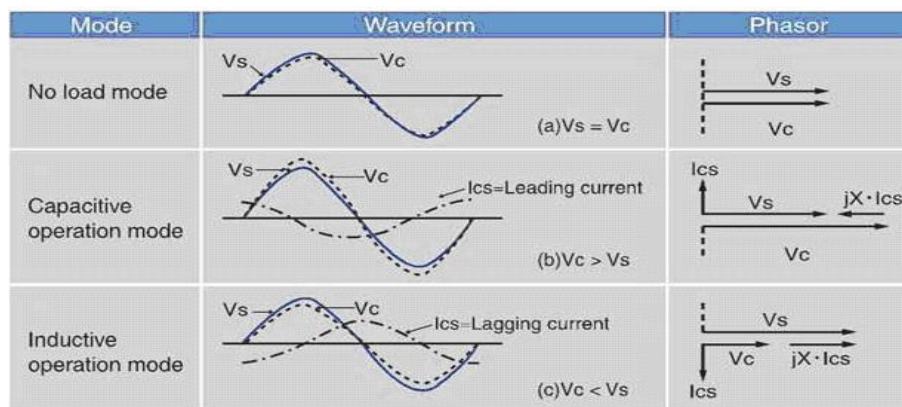


Fig.3.4 Operation mode of STATCOM

3.6 MAJOR ADVANTAGES OF STATCOM OVER SVC

- 1) In STATCOM, maximum inductive or capacitive current can be maintained independently of the ac system voltage and the maximum var generation or absorption changes linearly with ac system voltage while in SVC maximum inductive or capacitive current decreases linearly with system ac voltage and maximum var output decreases with the square of voltage. I.e. why STATCOM is better than SVC in providing voltage support under large disturbances.
- 2) STATCOM is more effective than SVC in improving transient stability of system because of its ability to maintain full capacitive output current at low system voltage.
- 3) Response time is better than SVC.
- 4) Active power control is possible in STATCOM
- 5) Installation space requirement of STATCOM is lesser as compared to SVC

3.7 CHARACTERISTICS OF STATCOM

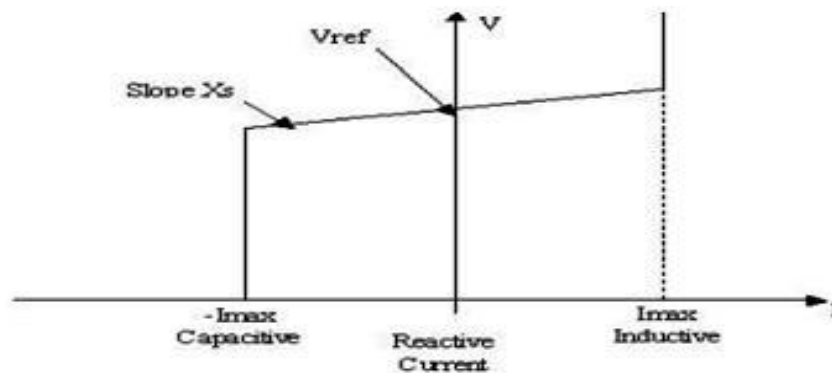


Fig.3.5 V-I Characteristics of STATCOM

STATCOM or Static Synchronous Compensator may be a shunt device, that uses force commutated power natural philosophy (i.e. GTO, IGBT) to manage power flow and improve transient stability on power networks. it's additionally a member of the questionable versatile AC gear (FACTS) devices. The STATCOM primarily performs

constant perform because the static power unit compensators however with some benefits.

The term Static Synchronous Compensator springs from its capabilities and in operation principle, that are kind of like those of rotating synchronous compensators (i.e. generators), however with comparatively quicker operation.

3.8 DESIGN OF STATCOM

A STATCOM consists of the subsequent components

A. Voltage supply device (VSC)

The voltage source device transforms the DC input voltage to associate degree AC output voltage. Two of the foremost common VSC sorts are delineate below. Square wave Inverters using Gate Turn off Thyristors.

Generally, four three-level inverters square measure accustomed type a 48 step voltage wave. After, it controls reactive power flow by dynamical the DC capacitance input voltage, just because the elemental element of the device output voltage is proportional to the DC voltage.

In addition, special interconnection transformers are used to neutralize harmonics contained within the sq waves created by individual inverters.

PWM Inverters mistreatment Insulated Gate Bipolar Transistors (IGBT).

B. DC capacitance

This element provides the DC voltage for the electrical converter.

C. Inductive electrical phenomenon (X)

It connects the electrical converter output to the ability system. this can be sometimes the leak inductance of a coupling electrical device.

D. Harmonic Filters

Mitigate harmonics and alternative high frequency elements thanks to the inverters.

3.9 STATCOM OPERATION

3.9.1 BASIC PRINCIPLE OF OPERATION

In the case of 2 AC sources, that have constant frequency and are connected through a series electrical phenomenon, the ability flows can be

- Active or Real Power flows from the leading supply to the insulant supply.
- Reactive Power flows from the upper to the lower voltage magnitude supply.

Consequently, the phase distinction between the sources decides the active power flow, whereas the voltage magnitude distinction between the sources determines the reactive power flow. Supported this principle, a STATCOM will be wont to regulate the reactive power flow by dynamical the output voltage of the voltage-source device with relation to the system voltage

3.9.2 MODES OF OPERATION

The STATCOM will be operated in 2 completely different modes

The static synchronous compensator regulates voltage at its affiliation purpose by dominant the quantity of reactive power that's absorbed from or injected into the ability system through a voltage-source device. In steady-state operation, the voltage V_2 generated by the VSC through the DC capacitance is in part with the system voltage V_1 ($\delta=0$), so solely reactive power (Q) is flowing ($P=0$).

1. once system voltage is high, the STATCOM can absorb reactive power (inductive behavior)
2. once system voltage is low, the STATCOM will generate and inject reactive power into the system (capacitive).

Subsequently, the quantity of reactive power flow is given by the equation:

$$Q = [V_1(V_1 - V_2)] / X$$

In this mode, the STATCOM reactive power output is unbroken constant freelance of different system parameter.

3.10 STATCOM VERSUS SVC

The STATCOM has the flexibility to produce a lot of electrical phenomenon reactive power throughout faults, or once the system voltage drops abnormally, compared to standard static power unit compensator. this can be as a result of the most electrical phenomenon reactive power generated by a STATCOM decreases linearly with system voltage, whereas that of the SVC is proportional to the sq. of the voltage. Also, the STATCOM incorporates a quicker response because it has no time delay related to thyristor firing. Yet, these benefits come back at the next worth (about 20% more).

3.11 APPLICATIONS

STATCOMs area unit generally applied in long distance transmission systems, power substations and serious industries wherever voltage stability is that the primary concern.

- ❖ In addition, static synchronous compensators area unit put in choose points within the installation to perform the following:
- ❖ Voltage support and control
- ❖ Voltage fluctuation and flicker mitigation
- ❖ Unsymmetrical load balancing
- ❖ Power factor correction
- ❖ Active harmonics cancellation
- ❖ Improve transient stability of the power system

CHAPTER 4

SIMULATION RESULTS

4.1 OPEN LOOP SIMULATION RESULTS

The Fig.4.2 shows the Voltage across RL load and its value is 3000V. The Fig.4.3 shows the Output voltage THD and its value is 27.79%.

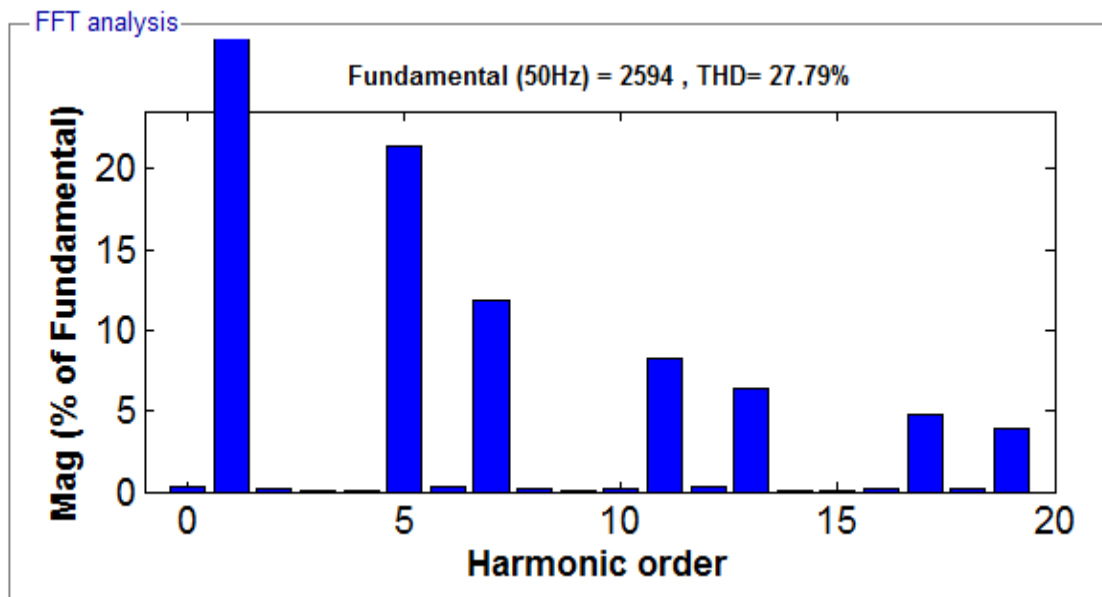


Fig. 4.3 Output voltage THD

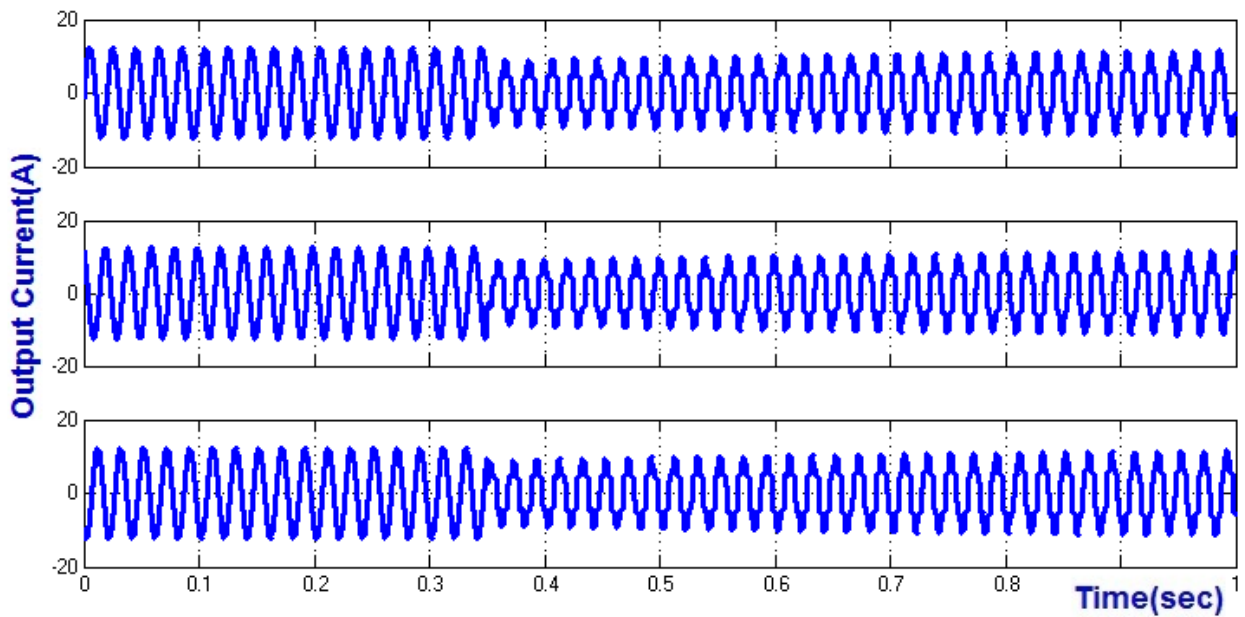


Fig. 4.4 Current through RL load

The Fig.4.4 shows the Current through RL load and its value is 17A

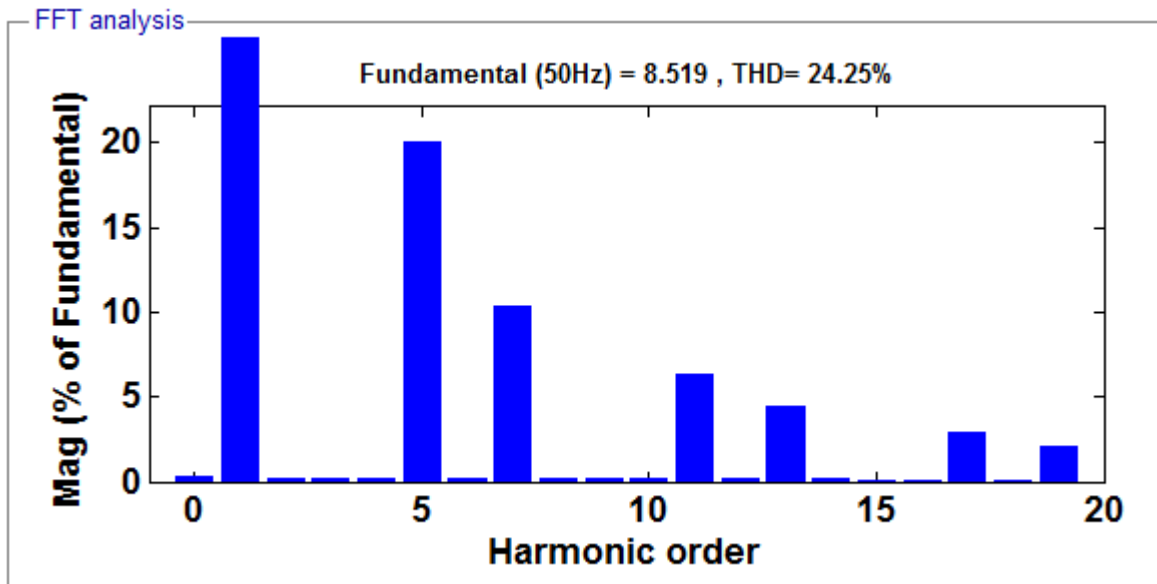


Fig. 4.5 Output Current THD

The Fig.4.5 shows the Output current THD and its value is 24.25%.

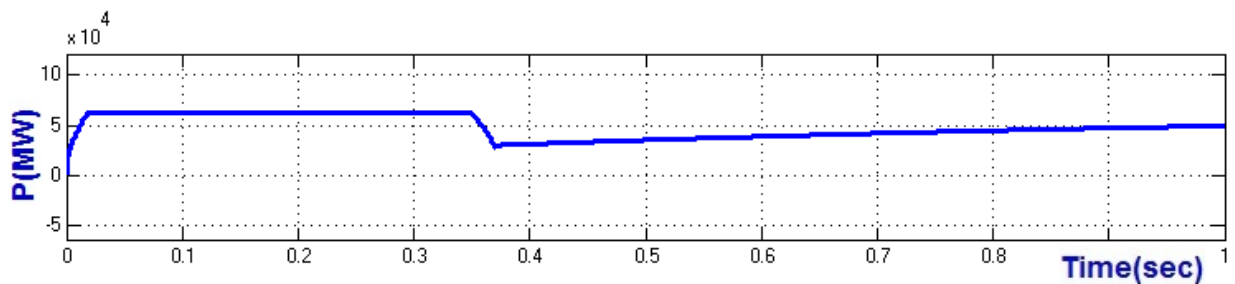


Fig. 4.6 Real Power

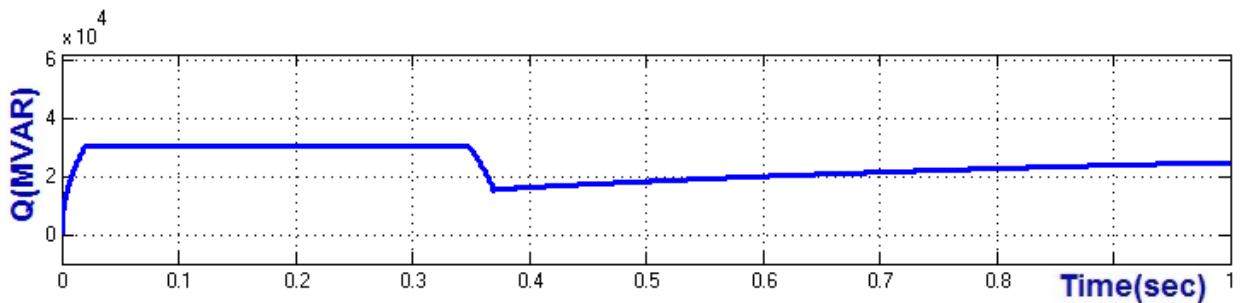


Fig. 4.7 Reactive Power

The Fig.4.6 shows the real power and its value is 0.046MW. The Fig.4.7 shows the reactive power and its value is 0.024MVAR.

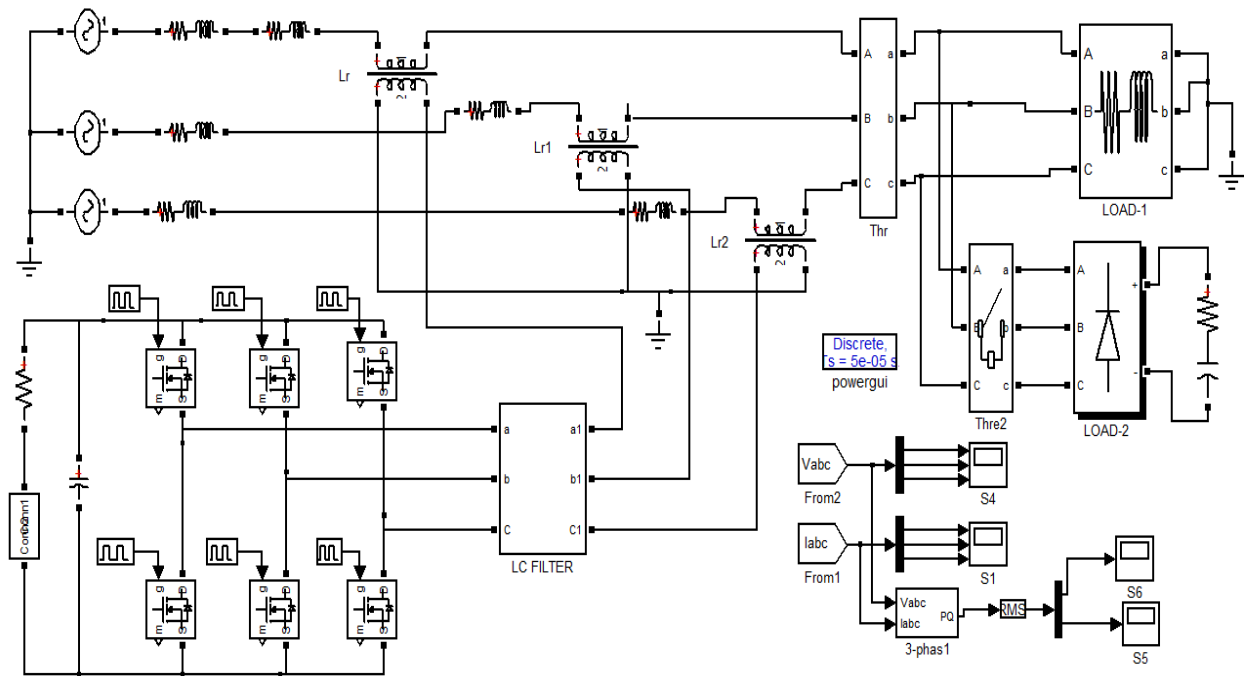


Fig. 4.8 Circuit diagram of with STATCOM

The Fig 4.8 shows the circuit diagram of with STATCOM

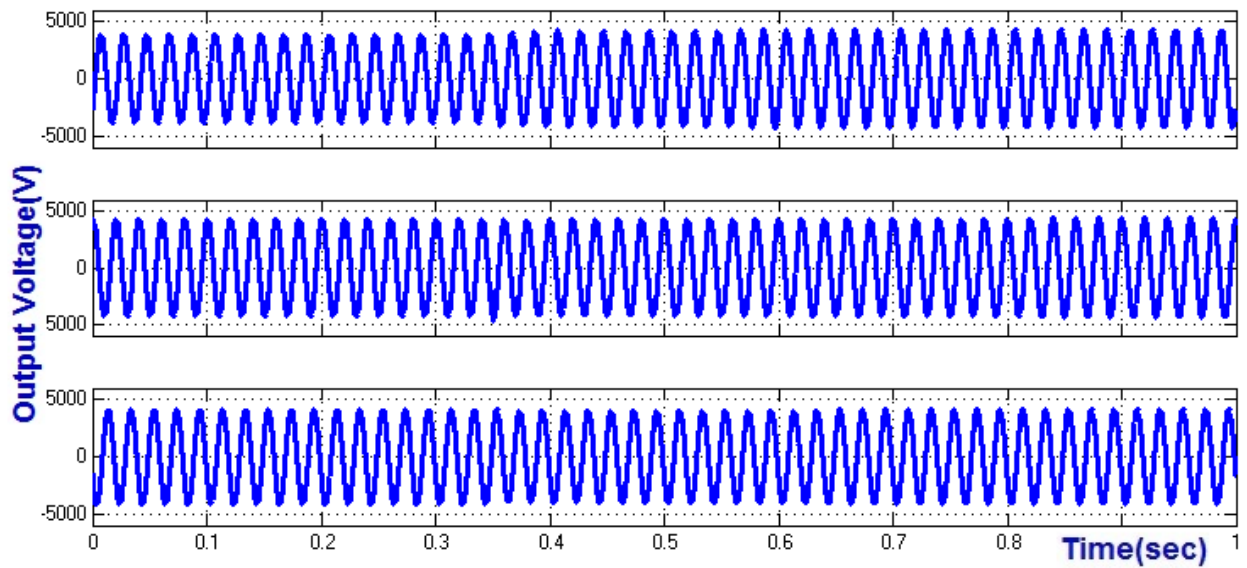


Fig. 4.9 Voltage across RL load

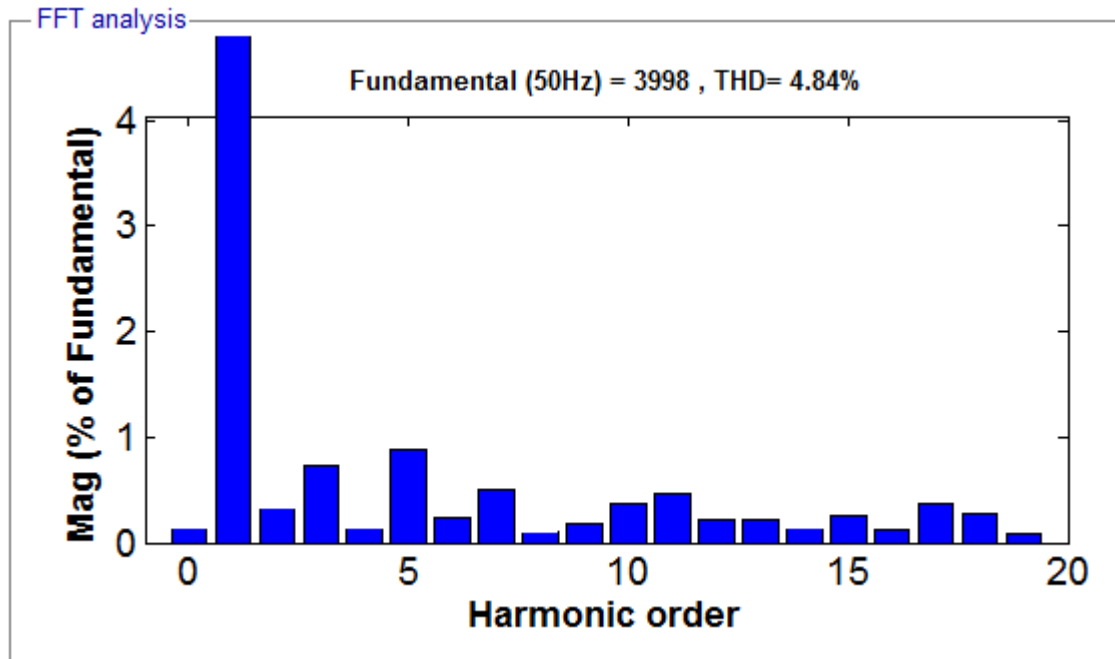


Fig. 4.10 Output voltage THD

The Fig.4.9 shows the Voltage across RL load and its value is 4200V. The Fig.4.10 shows the Output voltage THD and its value is 4.84%.

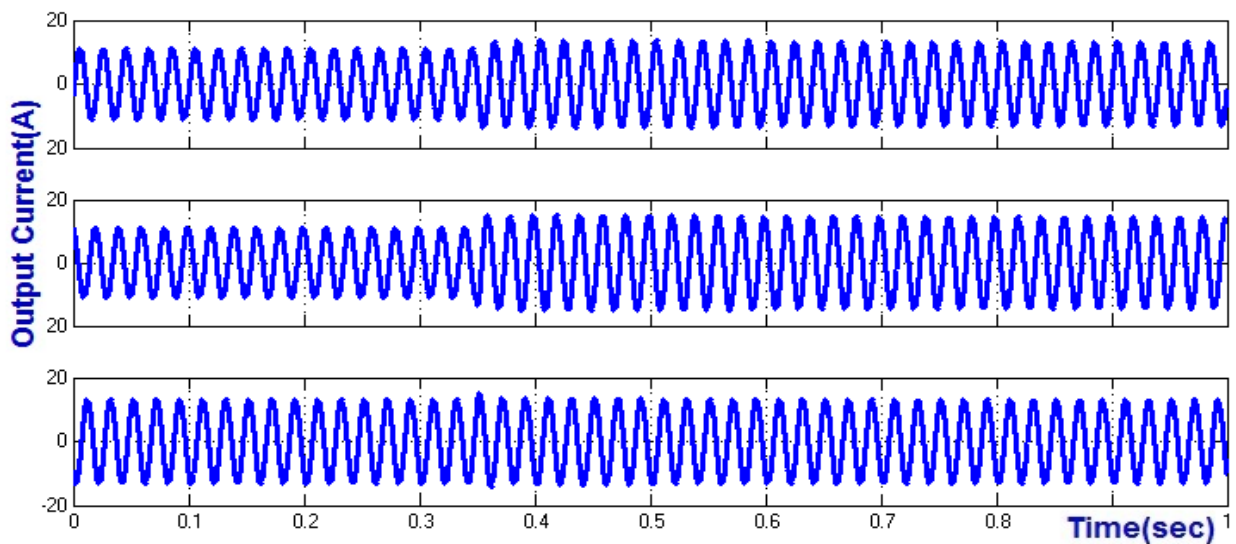


Fig. 4.11 Current through RL load

The Fig.4.11 shows the Current through RL load and its value is 19A. The Fig.4.12 shows the Output current THD and its value is 4.59%.

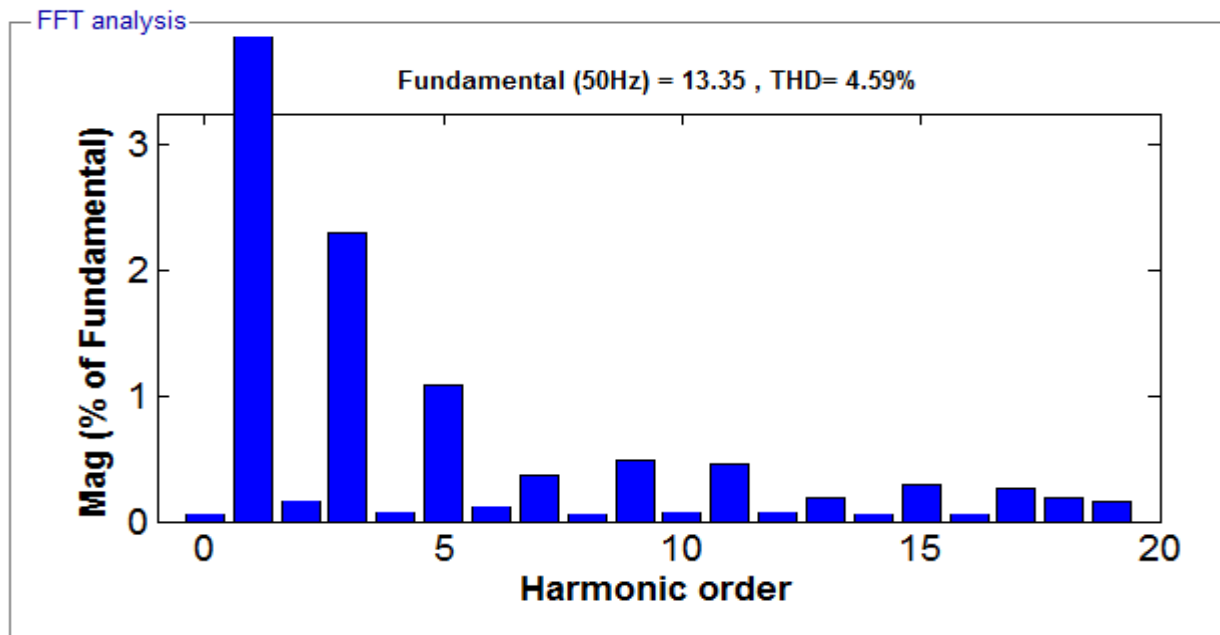


Fig. 4.12 Output Current THD

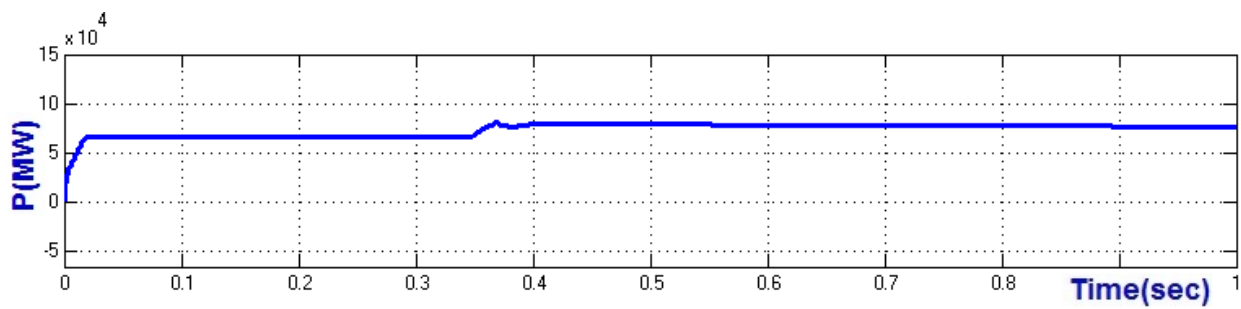


Fig. 4.13 Real Power

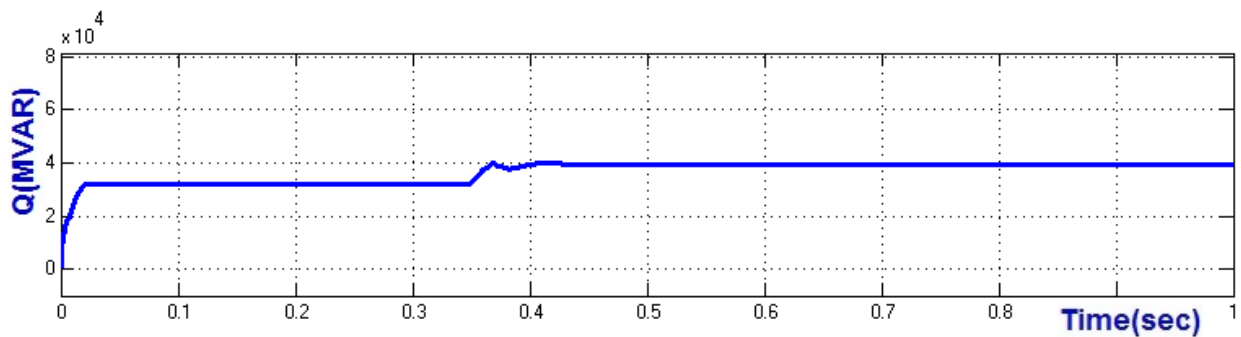


Fig. 4.14 Reactive Power

The Fig.4.13 shows the real power and its value is 0.075MW. The Fig.4.14 shows the reactive power and its value is 0.040MVAR.

Table 4.1 Comparison of output voltage, Real & Reactive Power

Facts Device	Vo(V)	P(MW)	Q(MVAR)
Without STATCOM	3000	0.046	0.024
With STATCOM	4200	0.075	0.040

The table 4.1 shows the comparison of output voltage, Real & Reactive Power for without and with STATCOM.

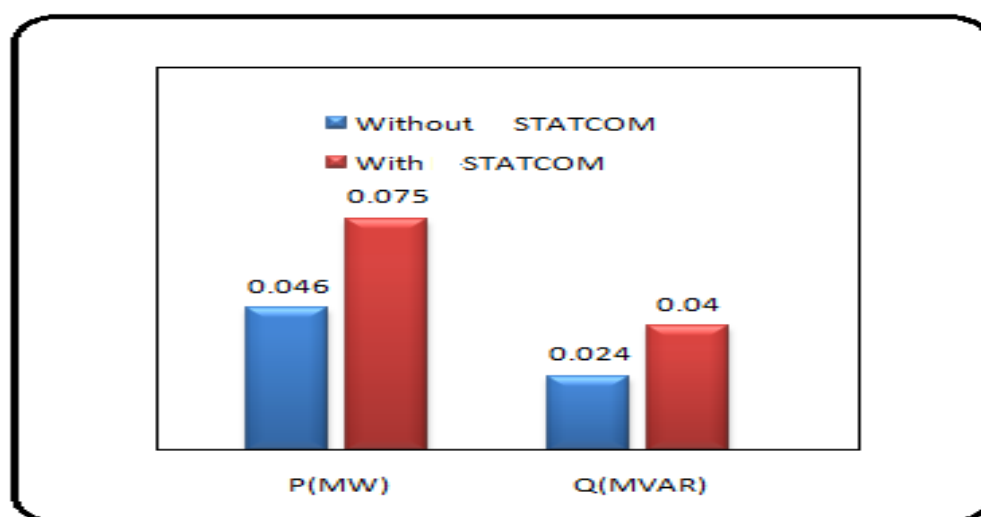


Fig. 4.15 Bar chart of real and reactive power

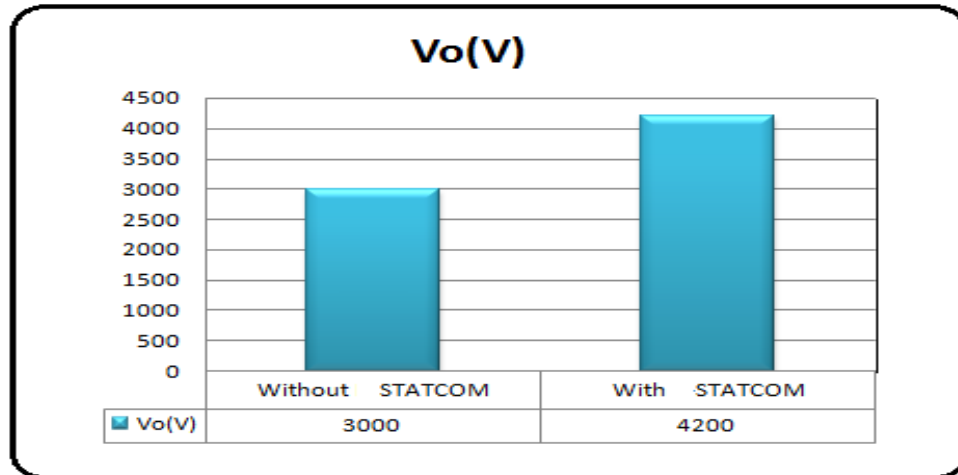


Fig. 4.16 Bar chart of output voltage

The Fig.4.15 shows the Bar chart of real and reactive power for without STATCOM and with STATCOM. The Fig.4.16 shows the Bar chart of output voltage for without STATCOM and with STATCOM.

Table 4.2 Comparison of output voltage and current THD

Facts Device	Voltage THD (%)	Current THD (%)
Without STATCOM	27.79	24.25
With STATCOM	4.84	4.59

The table 4.2 shows the Comparison of output voltage and current THD for without STATCOM and with STATCOM.

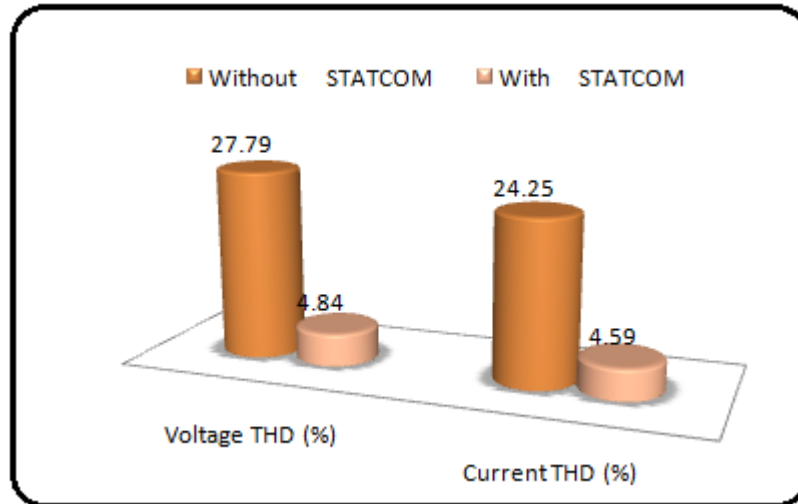


Fig. 4.17 Bar chart of voltage THD and current THD

The Fig.4.17 shows the Bar chart of voltage THD and current THD for without STATCOM and with STATCOM.

4.2 CLOSED LOOP SIMULATION RESULTS

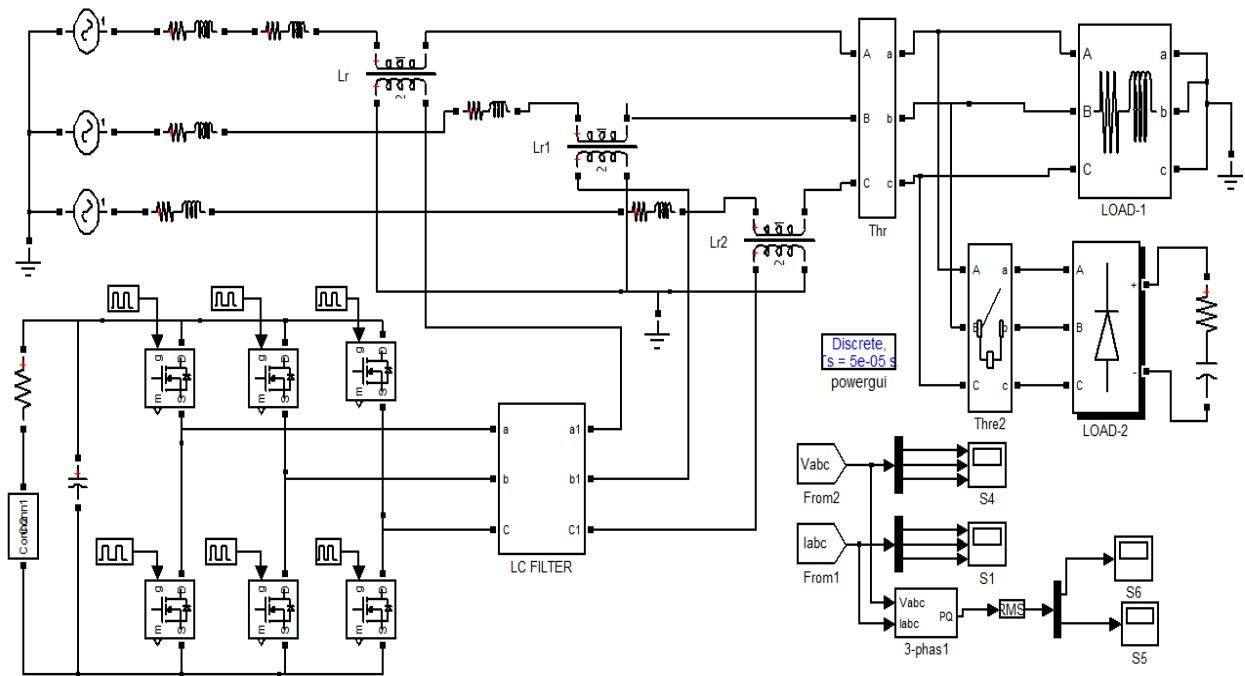


Fig.4.18 Circuit diagram of STATCOM with load disturbance

The Fig.4.18 shows the circuit diagram of STATCOM with load disturbance

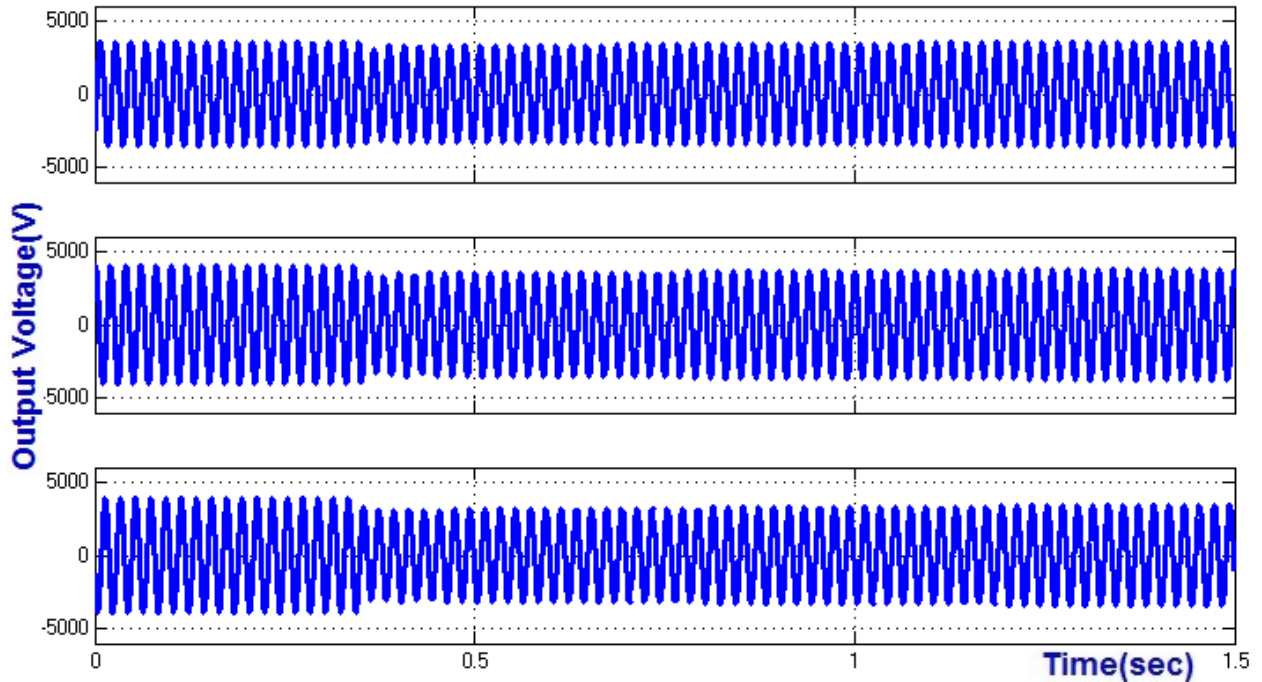


Fig.4.19 Voltage across RL load

The Fig.4.19 shows the Voltage across RL load and its value is 4200V.

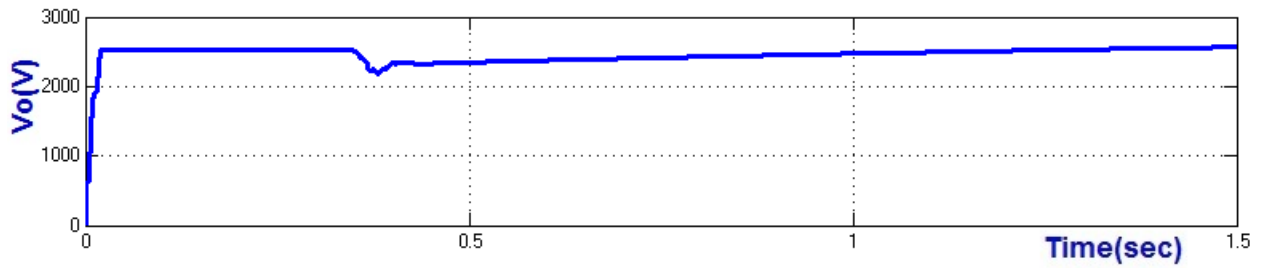


Fig. 4.20 RMS Voltage across RL load

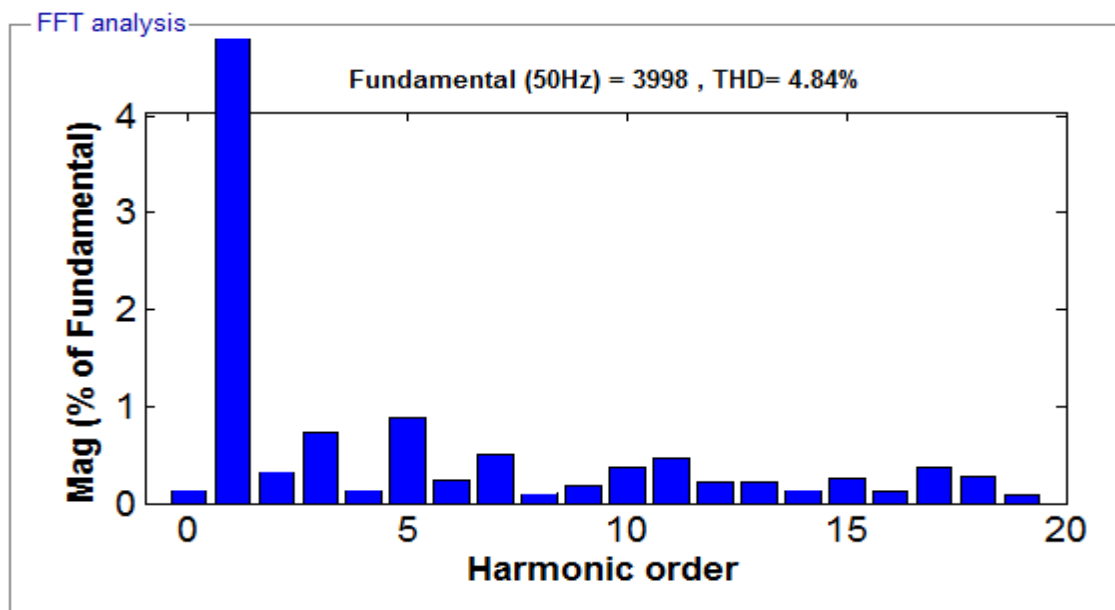


Fig. 4.21 Output voltage THD

The Fig.4.20 shows the RMS Voltage across RL load and its value is 2500V. The Fig.4.21 shows the Output voltage THD and its value is 4.84%.

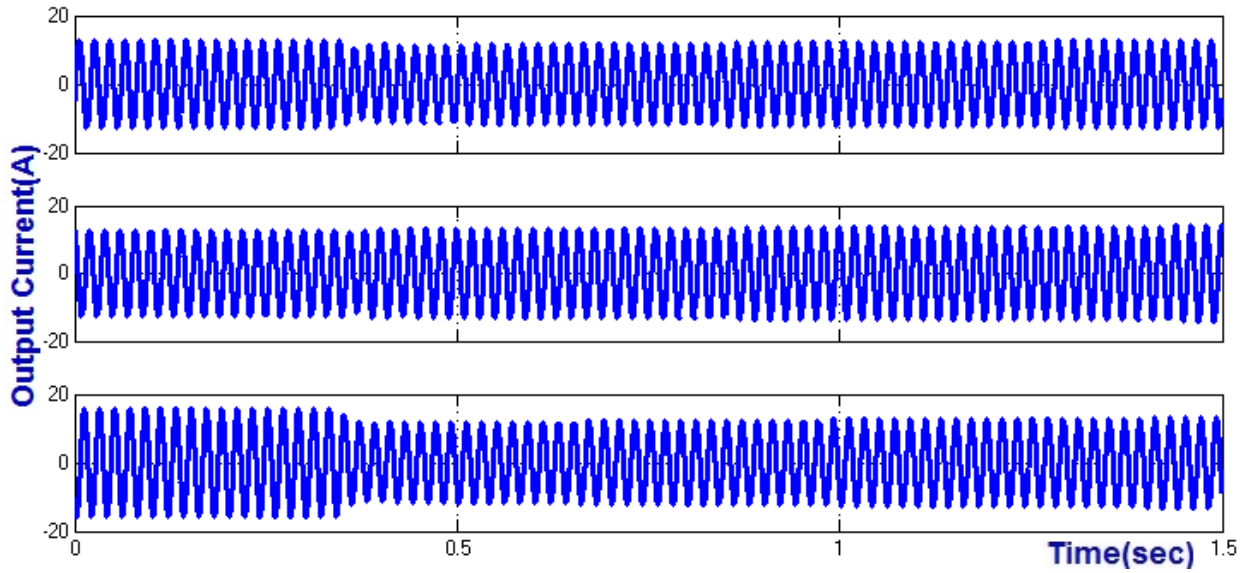


Fig. 4.22 Current through RL load

The Fig.4.22 shows the Current through RL load and its value is 19A.

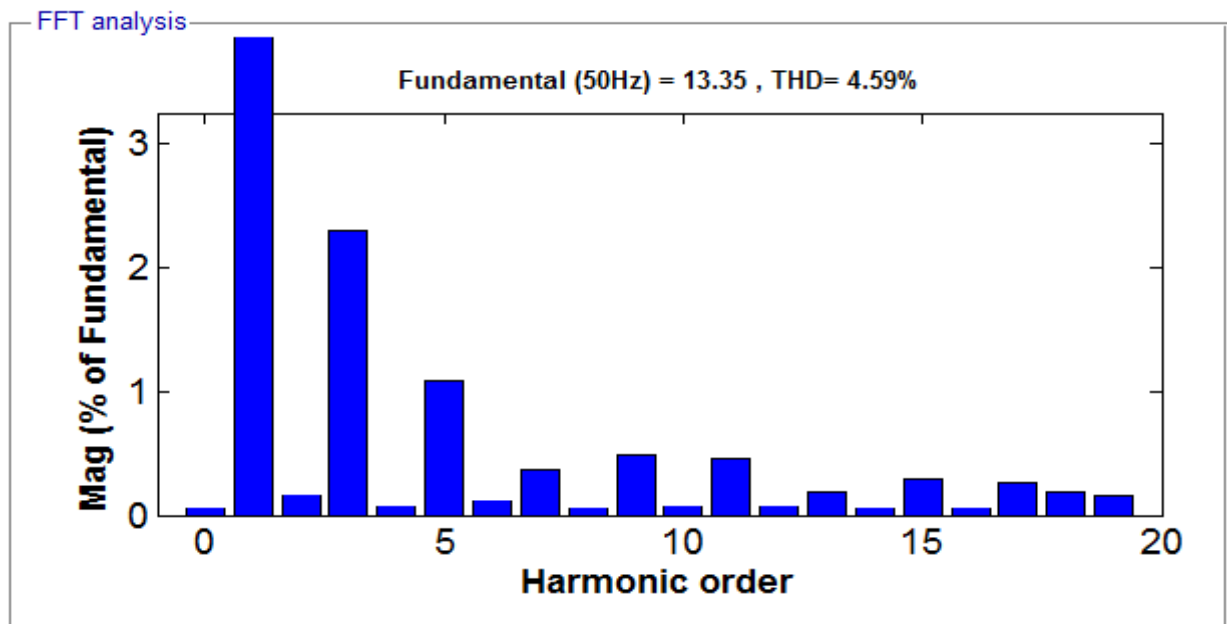


Fig. 4.23 Output Current THD

The Fig.4.23 shows the Output current THD and its value is 4.59%.

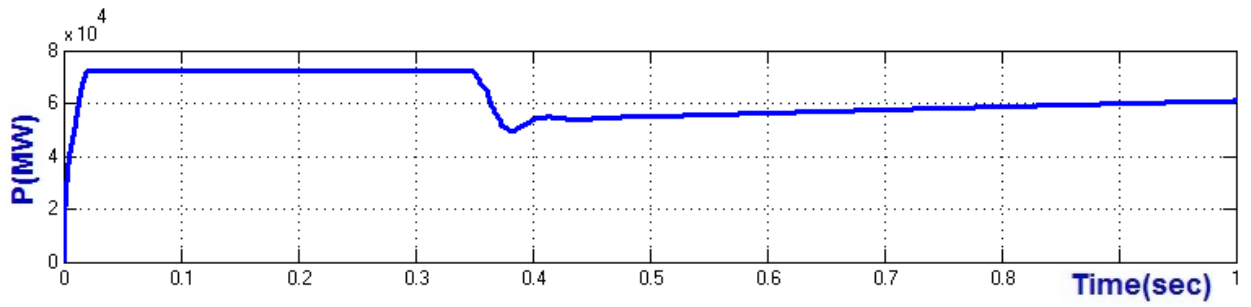


Fig. 4.24 Real Power

The Fig.4.24 shows the real power and its value is 0.06MW.

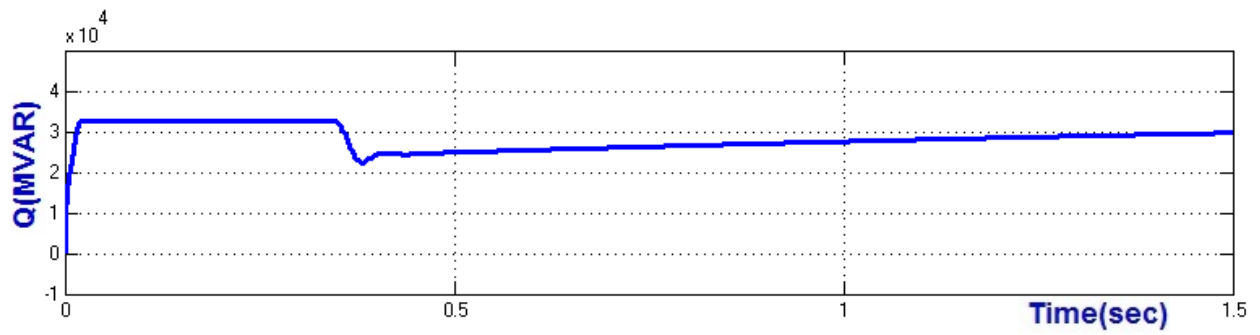


Fig. 4.25 Reactive Power.

The Fig.4.25 shows the reactive power and its value is 0.030MVAR.

4.2.1 CLOSED LOOP RESULT FOR FOPID CONTROLLER

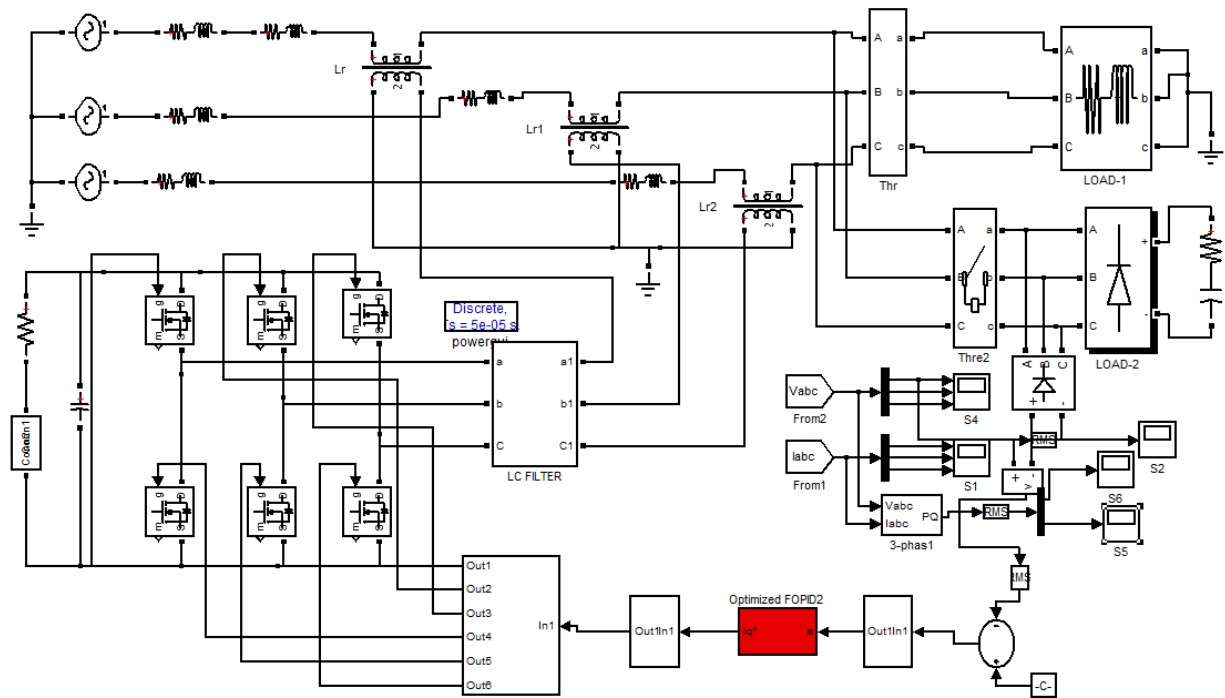


Fig. 4.26 Circuit diagram of STATCOM with closed loop optimized FOPID controller

The Fig 4.26 shows the circuit diagram of STATCOM with closed loop optimized FOPID controller.

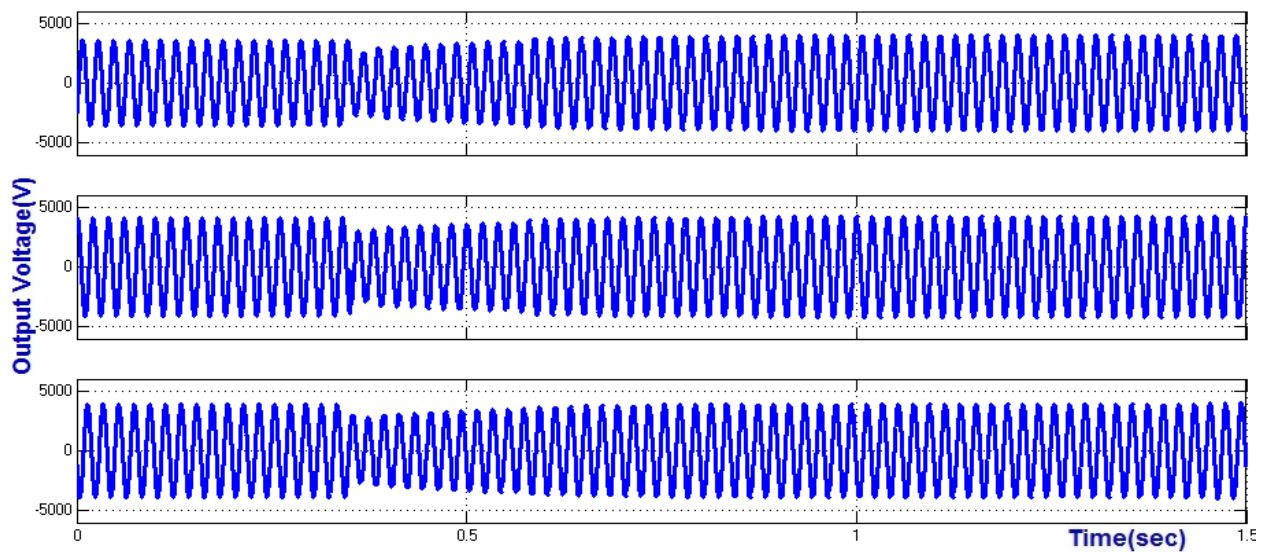


Fig. 4.27 Voltage across RL load

The Fig.4.27 shows the Voltage across RL load and its value is 4200V.

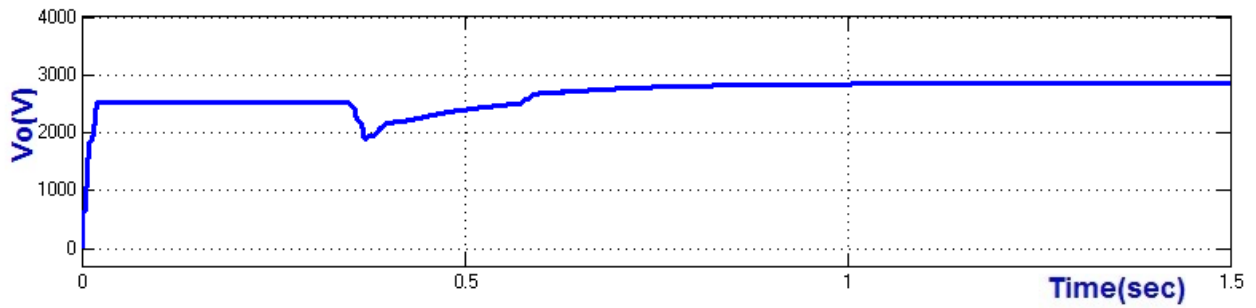


Fig. 4.28 RMS Voltage across RL load

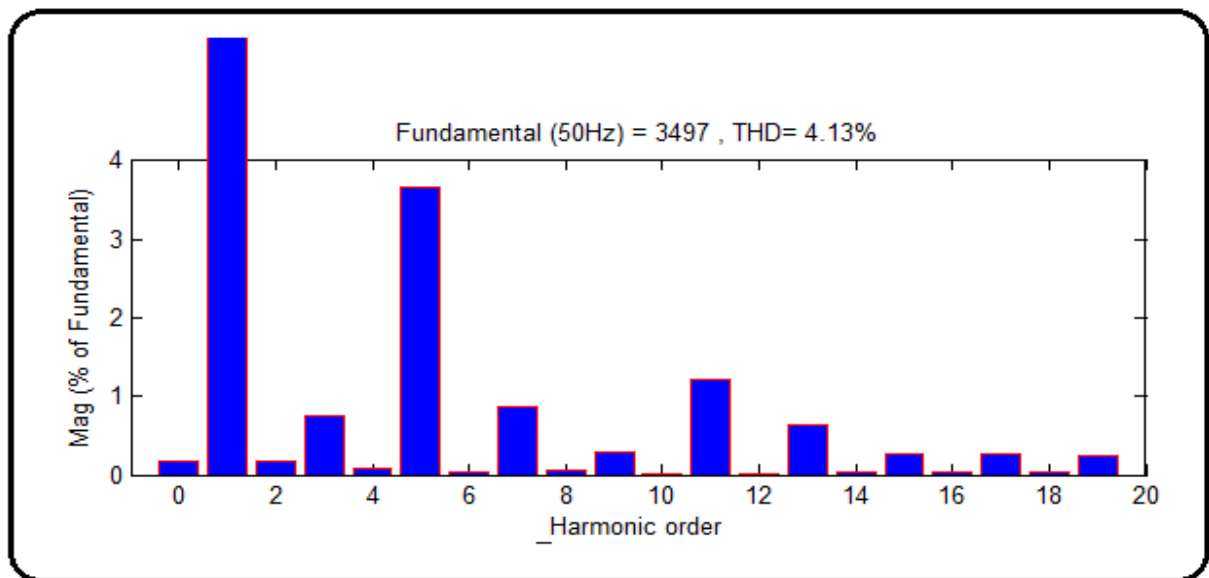


Fig. 4.29 Output voltage THD

The Fig.4.28 shows the RMS Voltage across RL load and its value is 2900V.
The Fig.4.29 shows the Output voltage THD and its value is 4.13%.

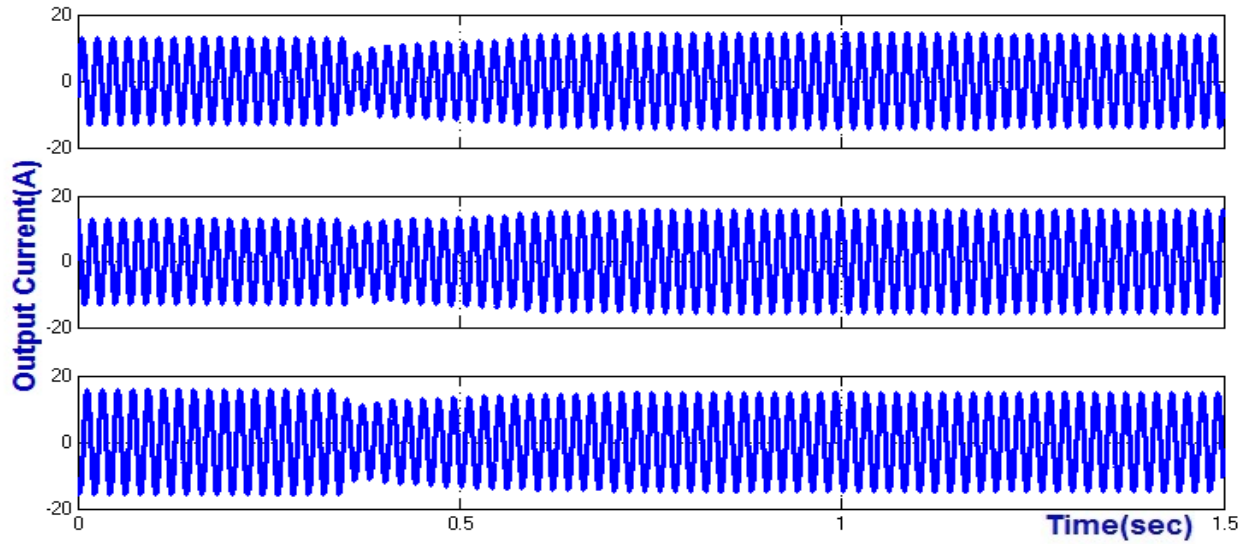


Fig. 4.30 Current through RL load

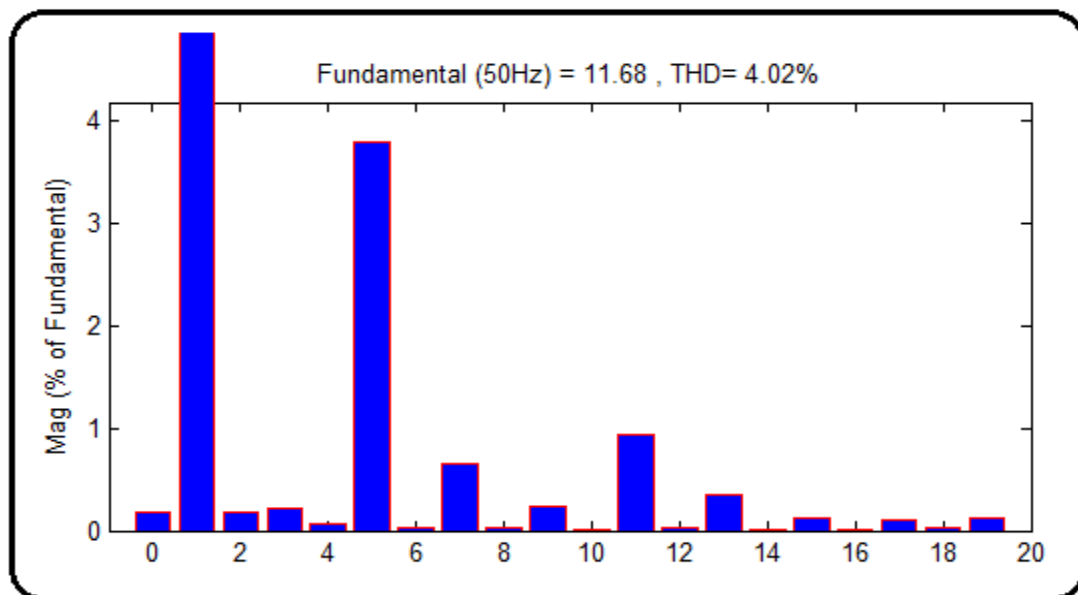


Fig. 4.31 Output Current THD

The Fig.4.30 shows the Current through RL load and its value is 19A. The Fig.4.31 shows the Output current THD and its value is 4.02%.

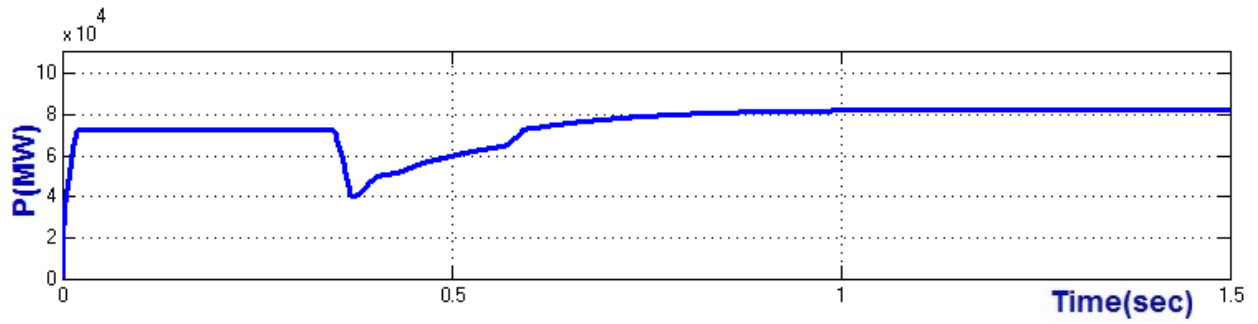


Fig. 4.32 Real Power

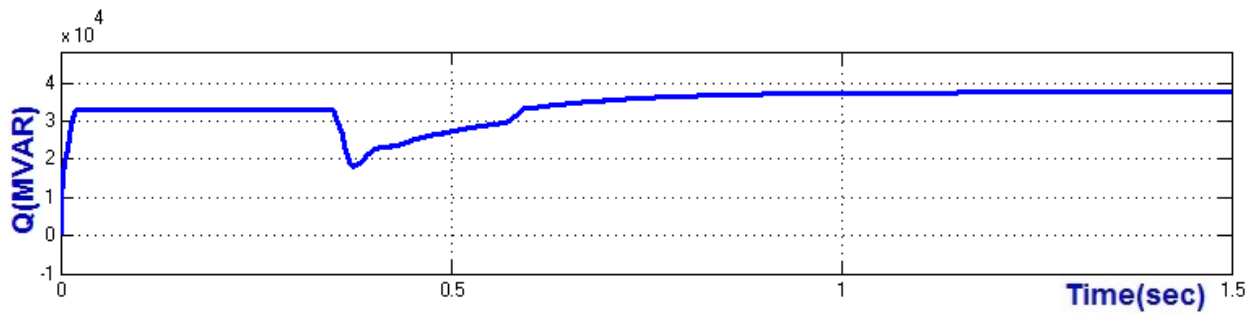


Fig. 4.33 Reactive Power

The Fig.4.32 shows the real power and its value is 0.81MW. The Fig.4.33 shows the reactive power and its value is 0.039MVAR.

4.2.2 CLOSED LOOP RESULT FOR PR CONTROLLER

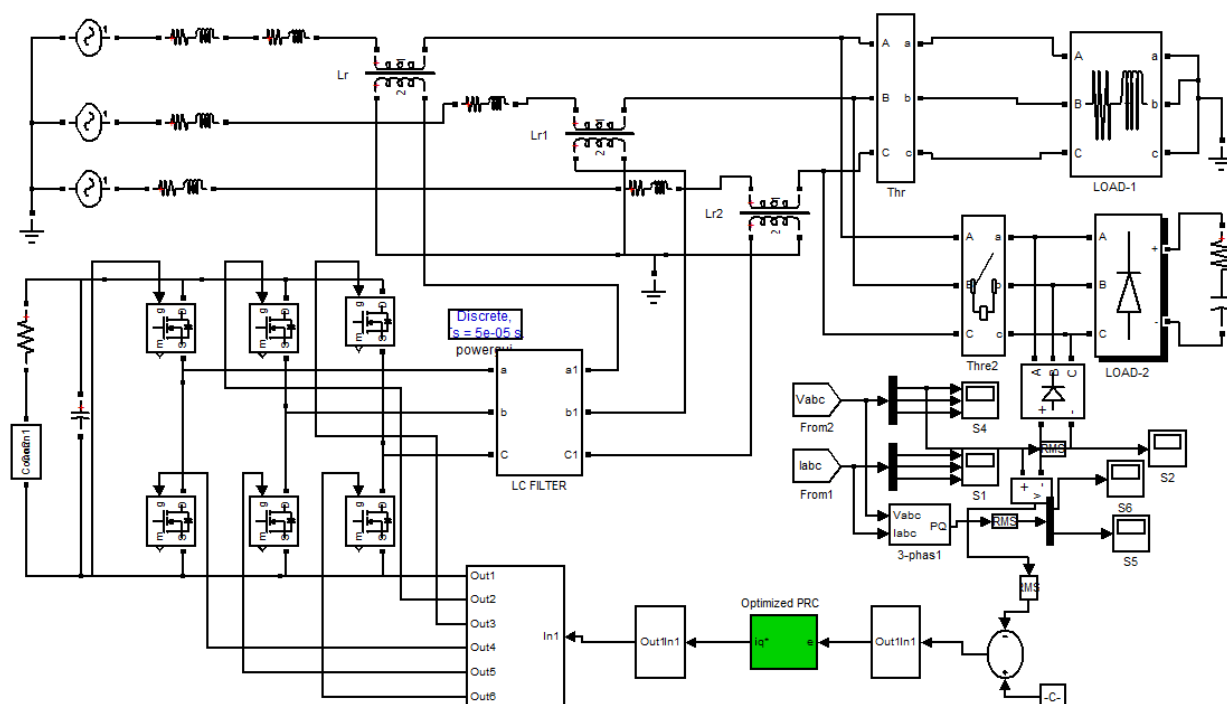


Fig. 4.34 Circuit diagram of STATCOM with closed loop optimized PR controller

The Fig 4.34 shows the circuit diagram of STATCOM with closed loop optimized PR controller.

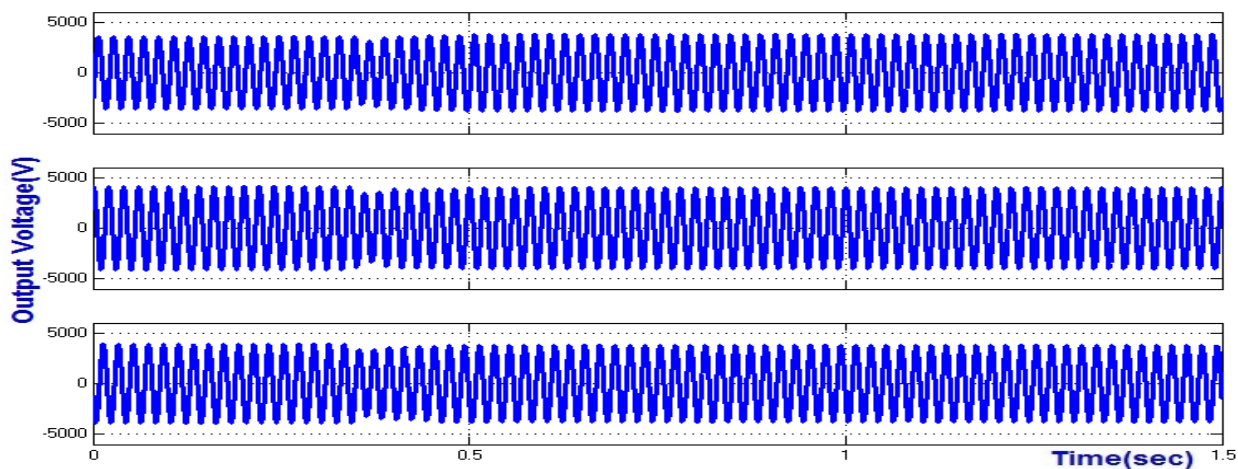


Fig. 4.35 Voltage across RL load

The Fig.4.35 shows the Voltage across RL load and its value is 4200V.

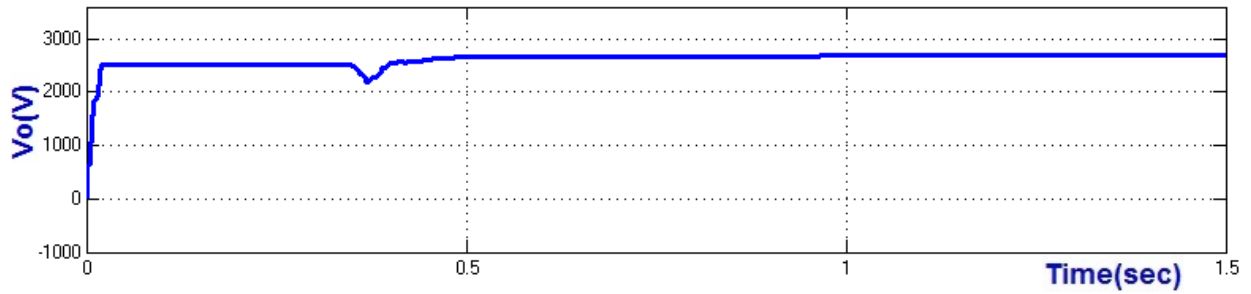


Fig. 4.36 RMS Voltage across RL load

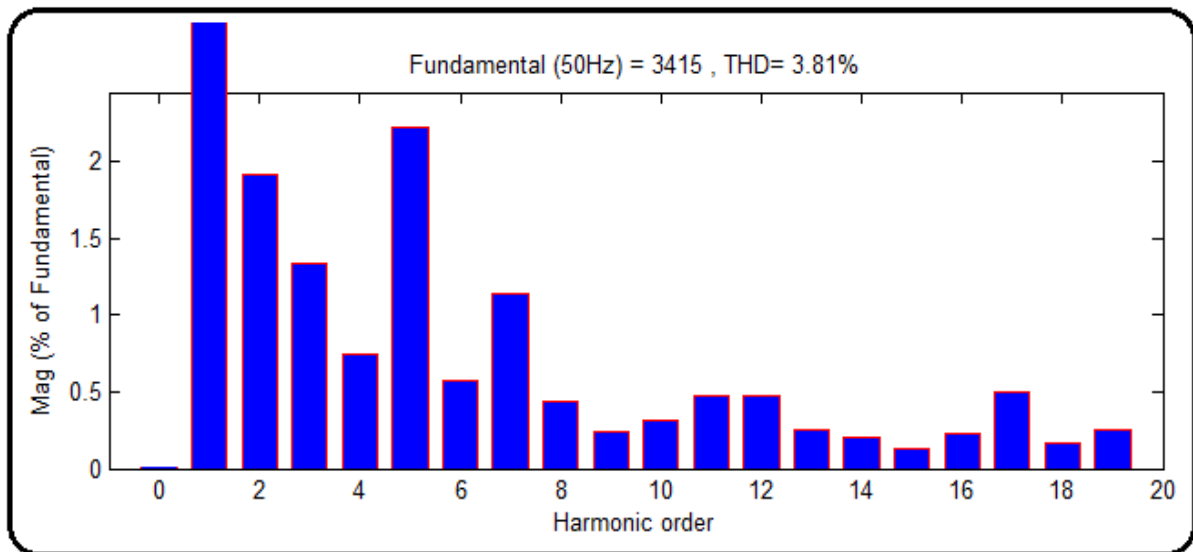


Fig. 4.37 Output voltage THD

The Fig.4.36 shows the RMS Voltage across RL load and its value is 2900V. The Fig.4.37 shows the Output voltage THD and its value is 3.81%.

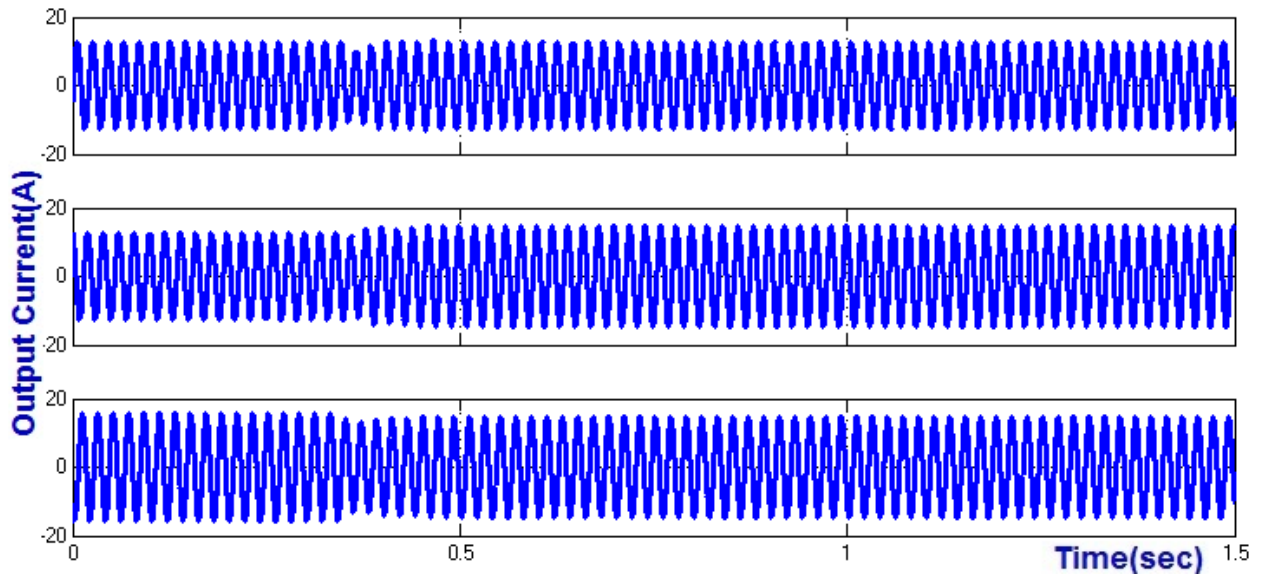


Fig. 4.38 Current through RL load

The Fig.4.38 shows the Current through RL load and its value is 19A.

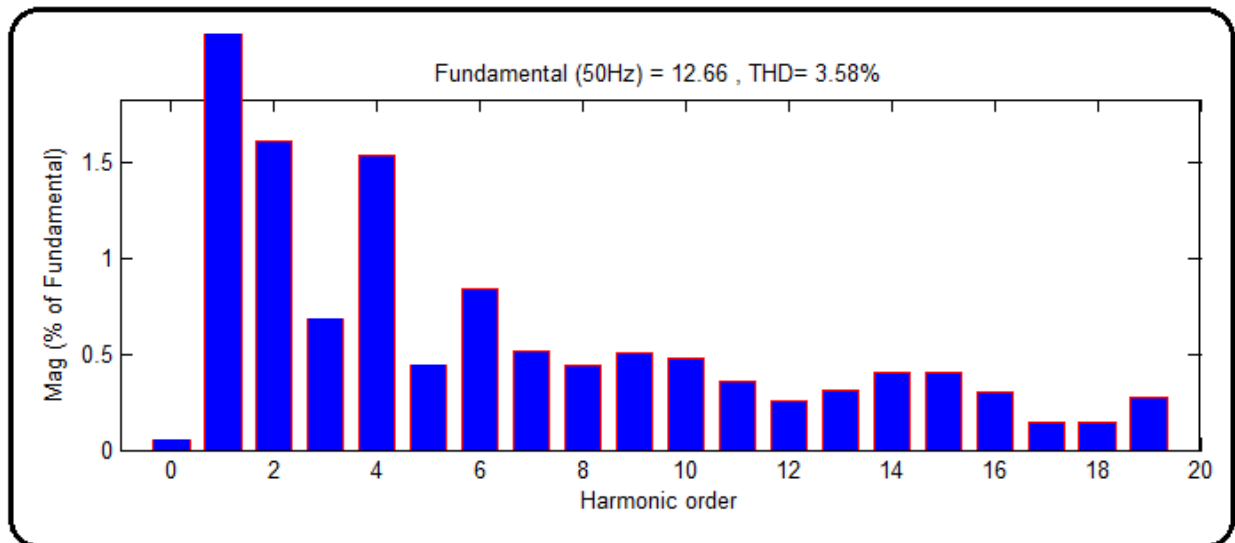


Fig. 4.39 Output Current THD

The Fig.4.39 shows the Output current THD and its value is 3.58%.

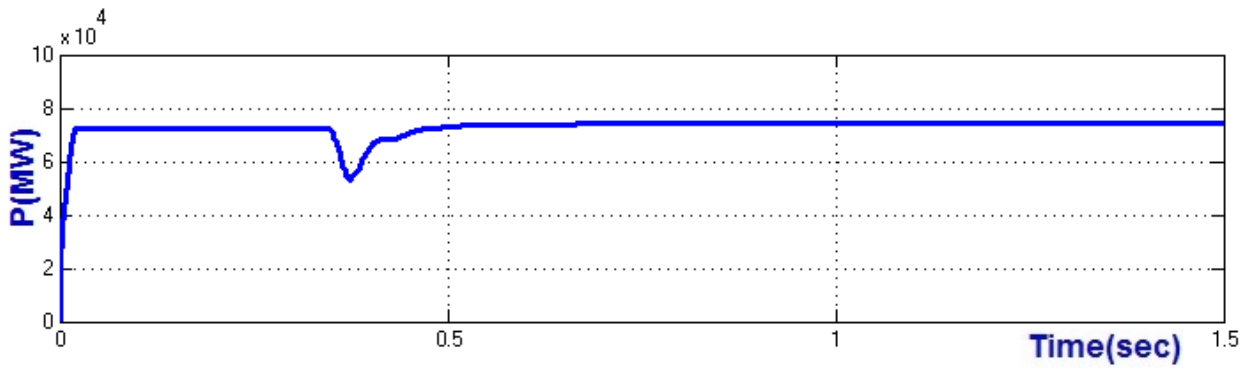


Fig. 4.40 Real Power

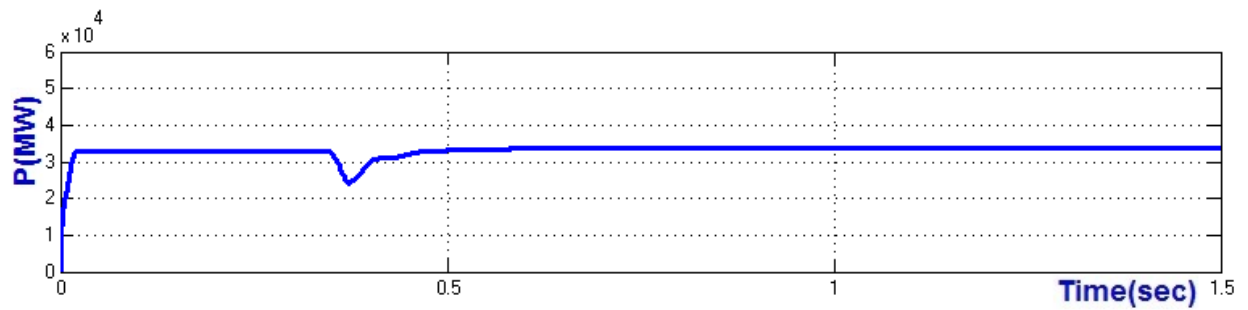


Fig. 4.41 Reactive Power

The Fig.4.40 shows the real power and its value is 0.78MW. The Fig.4.41 shows the reactive power and its value is 0.031MVAR.

Table 4.3 Summary of time domain parameters

Controller	Rise time	Peak time	Settling time	Steady state error
Optimized FOPID	0.38	0.39	0.73	1.89
Optimized PR	0.37	0.38	0.50	1.42

The Table 4.3 shows the summary of time domain parameters.

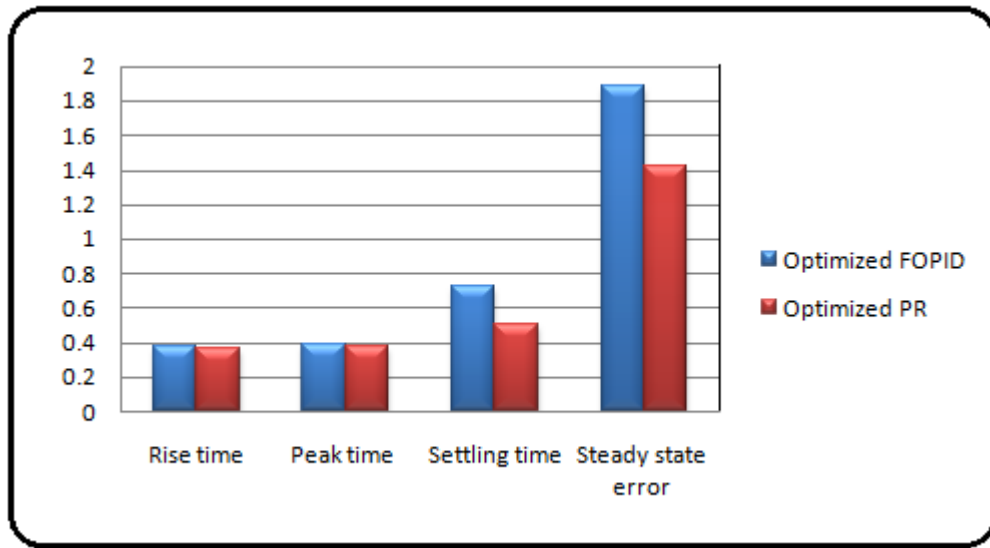


Fig. 4.42 Bar chart of time domain parameters

The Fig.4.42 shows the Bar chart of time domain parameters for optimized FOPID and optimized PR controller.

Table 4.4 Comparison of output voltage and current THD

Controllers	Voltage THD (%)	Current THD (%)
Optimized FOPID	4.13	4.02
Optimized PR	3.81	3.58

The Table 4.4 shows the comparison of output voltage and current THD.

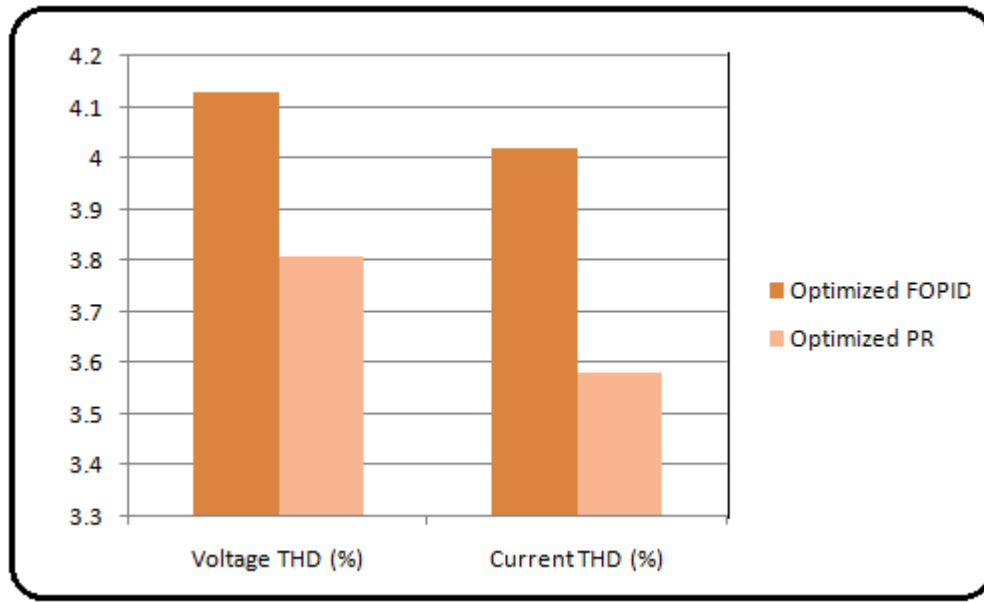


Fig. 4.43 Bar chart of voltage THD and current THD

The Fig.4.43 shows the Bar chart of voltage THD and current THD for optimized FOPID and optimized PR controller.

4.2.3 RESULTS

Table 4.5 Results for open loop system

Open loop system	Output voltage (V)	Voltage THD %	Current THD %	Real power (P)	Reactive power (Q)
Without STATCOM	3000	27.79	24.25	0.046	0.024
With STATCOM	4200	4.84	4.84	0.075	0.040

The Table 4.5 shows the results for open loop system.

Table 4.6 Results for closed loop system

Closed loop system	Rise time (s)	Peak time (s)	Settling time (s)	Steady state error (V)	Voltage THD %	Current THD %
FOPID controller	0.38	0.39	0.73	1.89	4.13	4.02
PR controller	0.37	0.38	0.50	1.42	3.81	3.58

The Table 4.6 results for closed loop system.

CHAPTER 5

HARDWARE IMPLEMENTATION

5.1 GENERAL

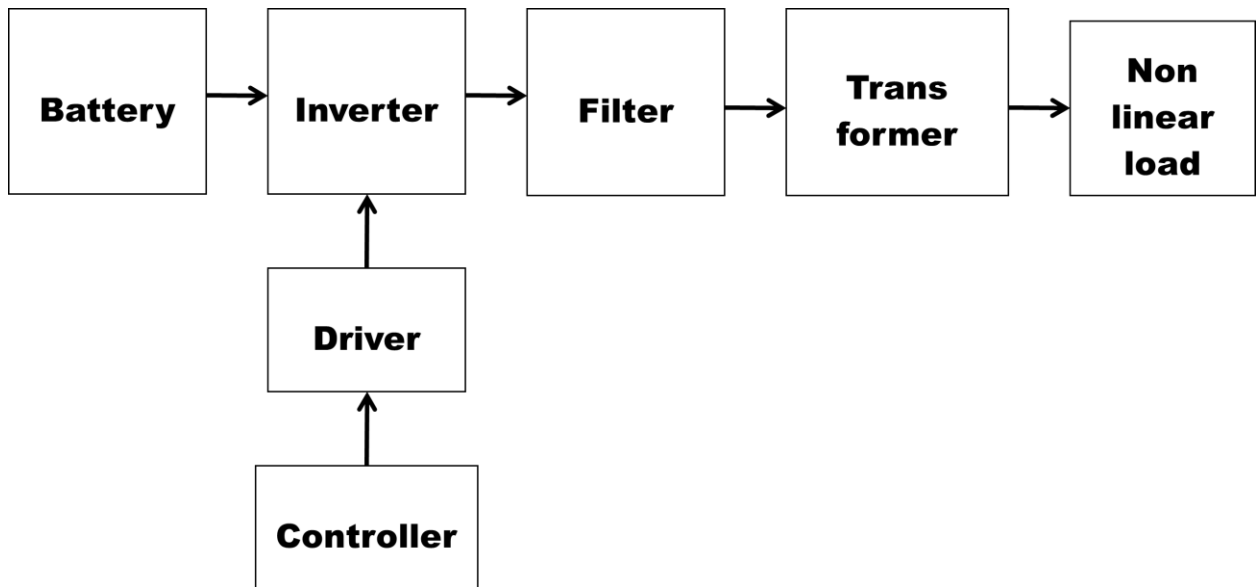


Fig.5.1 Block diagram of hardware implementation

It is the primary stage of this project. Therefore it's provide the DC offer to electrical converter. The DC supply could also be Battery or electric cell or corrected from AC supply.

It is accustomed convert dc to 3 part ac voltage. It operates one hundred twenty and a hundred and eighty modes of operation. It is used for step up/ down purpose. It's additionally used for isolation purpose.

Micro controller is employed to come up with triggering pulse for mosfets. It's accustomed management the outputs. small controller have a lot of advantage compare then analog circuits and small processor like quick response, low cost, tiny size and etc.

It is additionally known as as power electronic equipment as a result of it's wont to amplify the heartbeat output from small controller. It's additionally known as as opto mechanical device IC.

RPS offer 5V offer for small controller and 12V offer for driver. it's regenerate from AC offer. AC offer is step down mistreatment step down electrical device. For the hardware implementation we have a tendency to use completely different elements. they're listed below as

1. PIC Micro controller 16F84A
2. Voltage Regulators
 - a.7812 transformer
 - b.7805 transformer
3. IC IR2110

5.2 POWER SUPPLY CIRCUIT

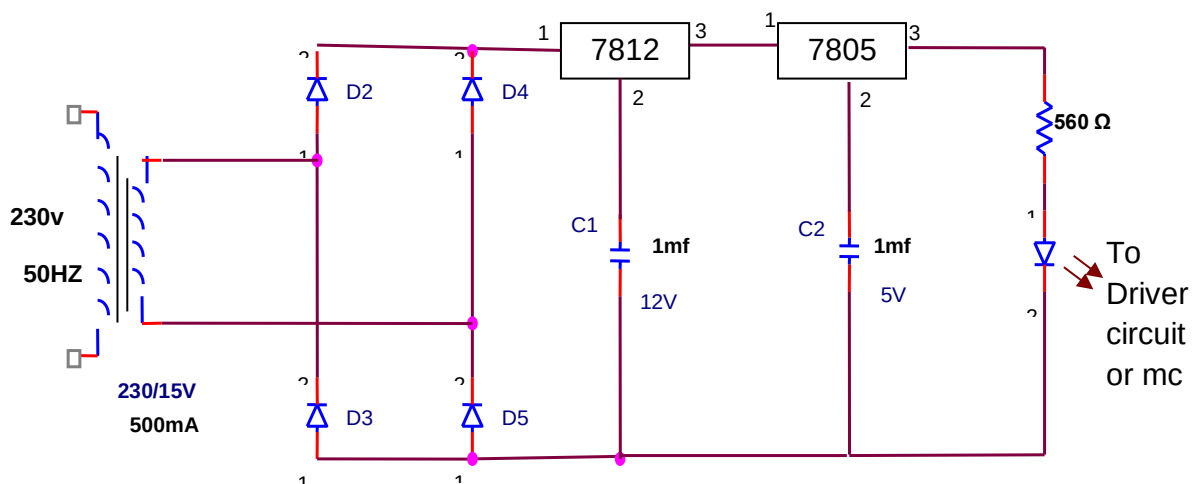


Fig.5.2 Power circuit

A step down transformer (230/15) V is employed to offer input supply to the power circuit. The 15V AC input is corrected into 15V rhythmic DC with the assistance of full bridge rectifier circuit. The ripples within the rhythmic DC are removed and

pure DC is obtained by employing a capacitor filter. The positive terminal of the condenser 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 as the supply to the pulse amplifier. An output voltage of 5V obtained from the output pin of 7805 is because the offer to the heartbeat electronic equipment (micro controller). From constant output pin of the 7805, a semiconductor diode(LED) is connected in nonparallel with the resistor to point that the power is ON.

5.3 PIC CONTROLLER

In this project the hardware is enforced mistreatment the PIC Micro controller "Pic 16F84A". The benefits of the Pic- microcontroller is that the instruction set of this controller square measure fewer than the same old microcontroller. In contrast to standard processors, that square measure usually complicated, instruction set laptop (CISC) kind, Pic microcontroller could be a reduced instruction set computing processor.

Advantages of Reduced Instruction Set Computer processor against CISC are

1. Reduced instruction set computing directions square measure easier and consequently operate quicker.
2. A reduced instruction set computing processor takes one cycle for every instruction, whereas CISC processor needs multiple clocks per instruction (generally, a minimum of 3 cycles of out turn execution time for the best instruction and twelve to twenty four clock cycles for a lot of complicated instruction), that makes cryptography a tricky task.
3. The management unit during a CISC is often enforced by a micro code, that is far slower than the hardware enforced in reduced instruction set computing.

The plan of mistreatment the Pic microcontroller is because

1. To use the often used directions because the instruction set whereas employing a few directions to attain a similar perform performed by a way a lot of complicated instruction during a CISC.

2. The reduced instruction set computing itself incorporates a sizable amount of general purpose registers, mostly reduced the frequency of the foremost long access.

3. In terms of clock rate, the reduced instruction set computing with its abundant easier circuits will have the next clock rate that once more will increase the performance of a processor.

Overall the reduced instruction set computing processor will give process power quite thrice of a CISC processor during a explicit field of application.

5.3.1 FEATURES OF PIC MICROCONTRLLER “PIC16F84A”

- Only 35 single word instructions to learn
- All instructions single cycle except for program branches which are two cycle
- Operating irradiation DC twenty megahertz clock input DC two hundred ns instruction cycle
- 1024 words of program memory
- 68 bytes of Data RAM
- 64 bytes of Data EEPROM
- 14-bit wide instruction words
- 8-bit wide data bytes
- 15 Special Function 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

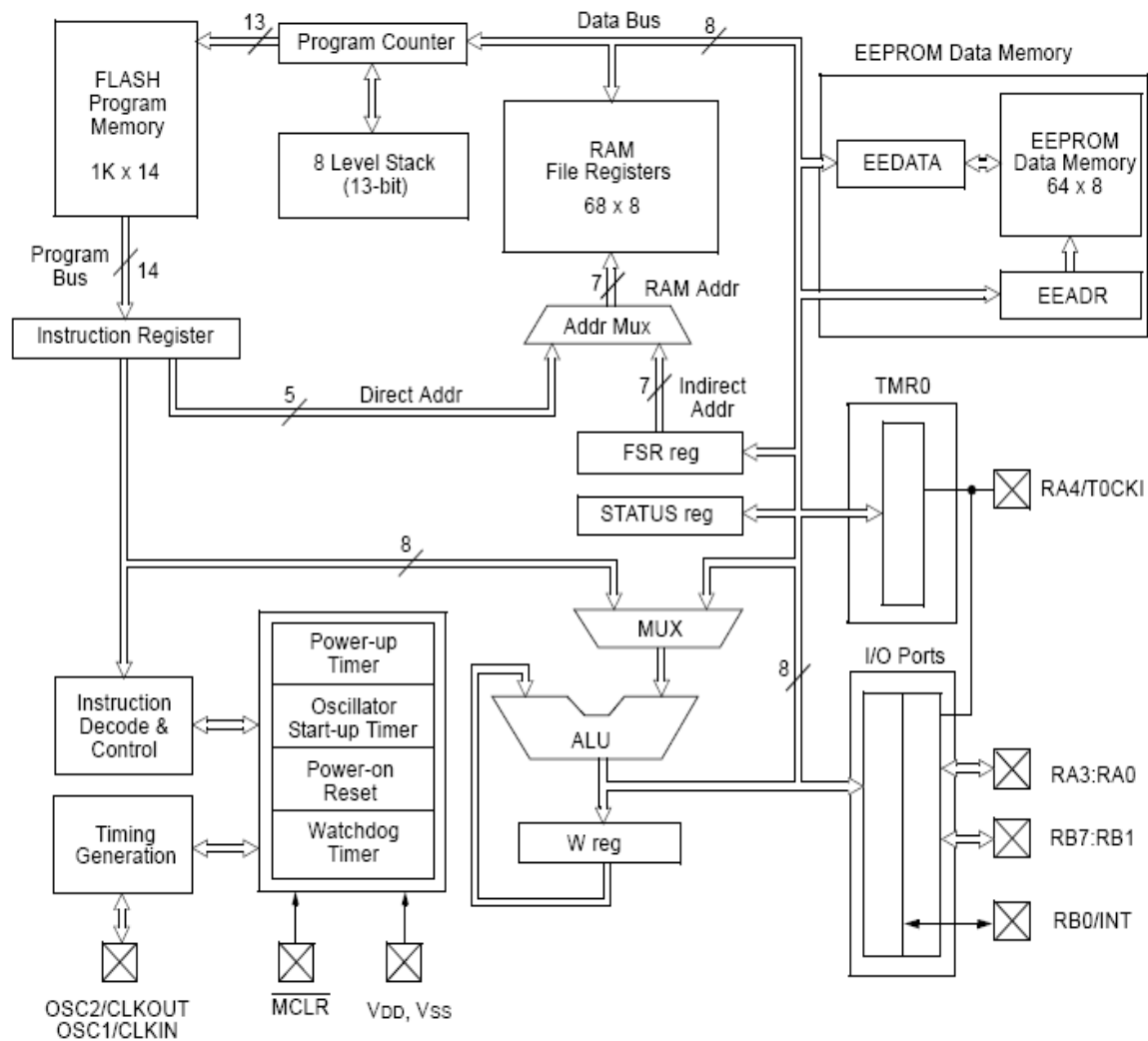


Fig.5.3 Block Diagram of “PIC16F84A”

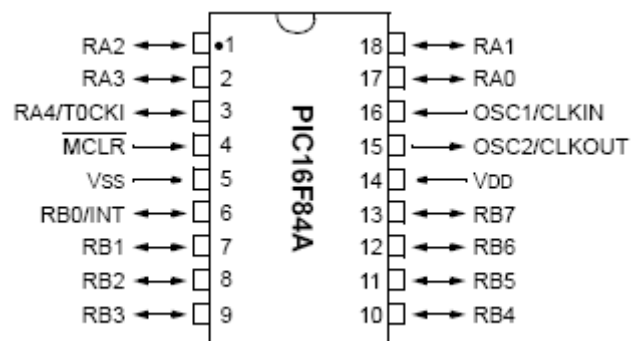


Fig.5.4 Pin Diagram of PIC16F84A

The PIC16F84A belongs to the mid-range family of the PIC microcontroller devices. The program memory contains 1K words, that interprets to 1024 directions, since every 14 bit program memory word is that the same dimension as every device instruction. The information memory (RAM) contains sixty eight bytes, knowledge EEPROM is sixty four bytes.

There are 13 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

There square measure 2 memory blocks within the PIC16F84A. These square measure the program memory and also the knowledge memory. Every block has its own bus, in order that access to every block will occur throughout a similar generator cycle.

The data memory will more be attenuated into the overall purpose RAM and also the Special perform Registers (SFRs). The operations of the SFRs that management the “core” square measure represented here. The SFRs accustomed management the peripheral modules square measure represented within the section discussing every individual peripheral module.

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

The EEPROM knowledge 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 operate Registers. There are four SFRs wont to browse and write this memory. These registers are

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

EEDATA holds the 8-bit data 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 browse 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 similarly as from chip to chip. Please talk to AC specifications for precise limits.

When the device is code protected, the central processing unit could still browse and write the info EEPROM memory. The device coder will not access this memory.

The Timer0 module timer/counter has the subsequent options

- 8-bit timer/counter
- Readable and writable
- Internal or external clock select
- Edge select for external clock
- 8-bit software programmable pre scaler
- Interrupt-on-overflow from FFH to 00H

What sets a microcontroller excluding different processors are special circuits to wear down the wants of real time applications. The PIC16F84A encompasses a host

of such options supposed to maximize system dependableness, minimize value through elimination of external elements, offer power saving operative modes and supply code protection. These options are

- OSC Selection
- 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 might be shut-off solely through configuration bits. It runs off its own RC generator for additional dependableness. There are 2 timers that supply necessary delays on power-up. One is that the generator Start-up Timer (OST), supposed to stay the kick in RESET till the oscillator is stable.

The other is that the Power-up Timer (PWRT), that provides a hard and fast delay of 72 ms (nominal) on power-up solely. This style keeps the device in RESET whereas the facility provide stabilizes. With these 2 timers on-chip, most applications want no external RESET electronic equipment. SLEEP mode offers a awfully low current power-down mode. The user will wake-up from SLEEP through external RESET, Watchdog Timer Time-out or through Associate in Nursing interrupt. many generator choices are

provided to permit the half to suit the applying. The RC generator possibility saves system value whereas the phonograph recording crystal possibility saves power. a collection of configuration bits are wont to choose the varied choices.

5.3.2 OSCILLATOR TYPES

The PIC16F84A is operated in four completely different generator modes. The user will program 2 configuration bits (FOSC1 and FOSC0) to pick out one of these four modes.

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

The PIC16F84A differentiates between varied varieties of RESET

- Power-on Reset (POR)
- MCLR during normal operation
- MCLR during SLEEP
- WDT Reset (during normal operation)
- WDT Wake-up (during SLEEP)

A Power on Reset pulse is generated on-chip once VDD rise is detected (in the vary of one (2V - 17V). To require advantage of the POR, merely tie the MCLR pin directly (or through a resistor) to VDD. This can eliminate external RC elements sometimes required to make Power-on Reset. A minimum rise time for VDD should be met for this to control properly.

When the device starts traditional operation (exits the RESET condition), device operative parameters (voltage, frequency, temperature, etc.) should be met to confirm

operation. If these conditions aren't met, the device should be command in RESET till the operative conditions are met.

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 inside RC generator. The chip is unbroken in RESET as long because the PWRT is active. The PWRT delay permits the VDD to rise to an appropriate level.

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

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

The interrupt management register (INTCON) records individual interrupt requests in flag bits. It additionally contains the individual and international interrupt alter bits. The worldwide interrupt alter bit, GIE (INTCON<7>), permits (if set) all unmasked interrupts or disables (if cleared) all interrupts. Individual interrupts is disabled through their corresponding alter bits in INTCON register. Bit GIE is cleared on RESET. The “return from interrupt” instruction, RETFIE, exits interrupt routine equally as sets the GIE bit, that re-enables interrupts. The RB0/INT pin interrupt, the metallic element port amendment interrupt and also the TMR0 overflow interrupt flags are contained within the INTCON register.

When Associate in Nursing interrupt is skilled, the GIE bit is cleared to disable to any extent further interrupt, the name and address is pushed onto the stack and also the laptop is loaded with 0004h. For external interrupt events, like the RB0/INT pin or PORTB amendment interrupt, the interrupt latency are 3 to four instruction cycles. The

precise latency depends once the interrupt event happens. The latency is that the same for each one and 2 cycle directions. Once within the Interrupt routine, the source(s) of the interrupt is determined by polling the interrupt flag bits. The interrupt flag bit(s) should be cleared in software package before re-enabling interrupts to avoid infinite interrupt requests.

5.4 DRIVER UNIT

5.4.1 OPTOCOUPLERS

There are several things wherever signals and knowledge ought to be transferred from one system to a different among a bit of physical science instrumentation, or from one piece of kit to a different, while not creating an on the spot homicide electrical affiliation. Typically this is often as a result of the supply and destination are (or could also be at times) at terribly completely different voltage levels, sort of a chip that is working from 5V DC however getting used to regulate a triac that is shift 240V AC. In such things the link between the 2 should be Associate in Nursing isolated one, to safeguard the chip from over voltage injury.

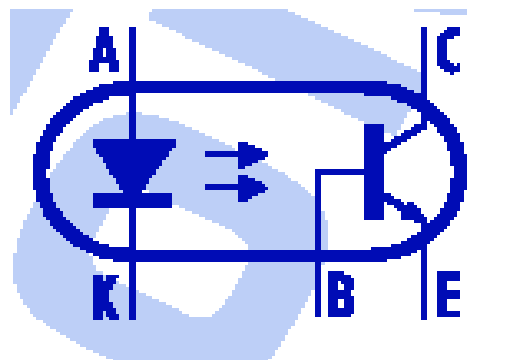


Fig.5.5 Optocouplers

Relays will after all offer this type of isolation, however even tiny relays tend to be fairly large compared with ICs and lots of of today's different miniature circuit elements, as a result of they're electro mechanical, relays are not as reliable and solely capable of comparatively low irradiation operation. wherever tiny size, higher irradiation and larger dependability square measure vital, a far higher different is to use associate

optocoupler. These use a beam of sunshine to transmit the signals or knowledge across associate electrical barrier, and reach glorious isolation.

Optocouplers generally are available in a little 6-pin or 8-pin IC package, however square measure primarily a mix of 2 distinct devices associate optical transmitter, generally a metallic element chemical compound LED (light emitting diode) associated an optical receiver like a photo transistor or light-triggered diac. the 2 square measure separated by a clear barrier that blocks any electrical current flow between the 2, however will enable the passage of sunshine.

The most vital parameter for many Optocouplers is their transfer potency, typically measured in terms of their current transfer magnitude relation or CTR. this is often merely the magnitude relation between a current modification within the output electronic transistor and therefore the current modification within the input LED that created it.

Typical values for CTR vary from 100 percent to five hundredth for devices with associate output photo transistor and up to 2000% roughly for those with a Darlington electronic transistor combine within the output. Note, but that in most devices CTR tends to vary with absolute current level. generally it peaks at a LED current level of regarding 10mA, and falls away at each higher and lower current levels.

Other optocoupler parameters embody the output transistor's most collector-emitter voltage rating VCE (max), that limits the availability voltage within the output circuit; the input LED most current rating IF (max), that is employed to calculate the minimum worth for its series resistor; and therefore the Optocouplers information measure, that determines the best signal frequency which will be transferred through it ó determined chiefly by internal device construction and therefore the performance of the output Photo transistor.

5.4.2 APPLICATIONS

- 1) Power supply regulator
- 2) Digital logic inputs

3) Microprocessor inputs

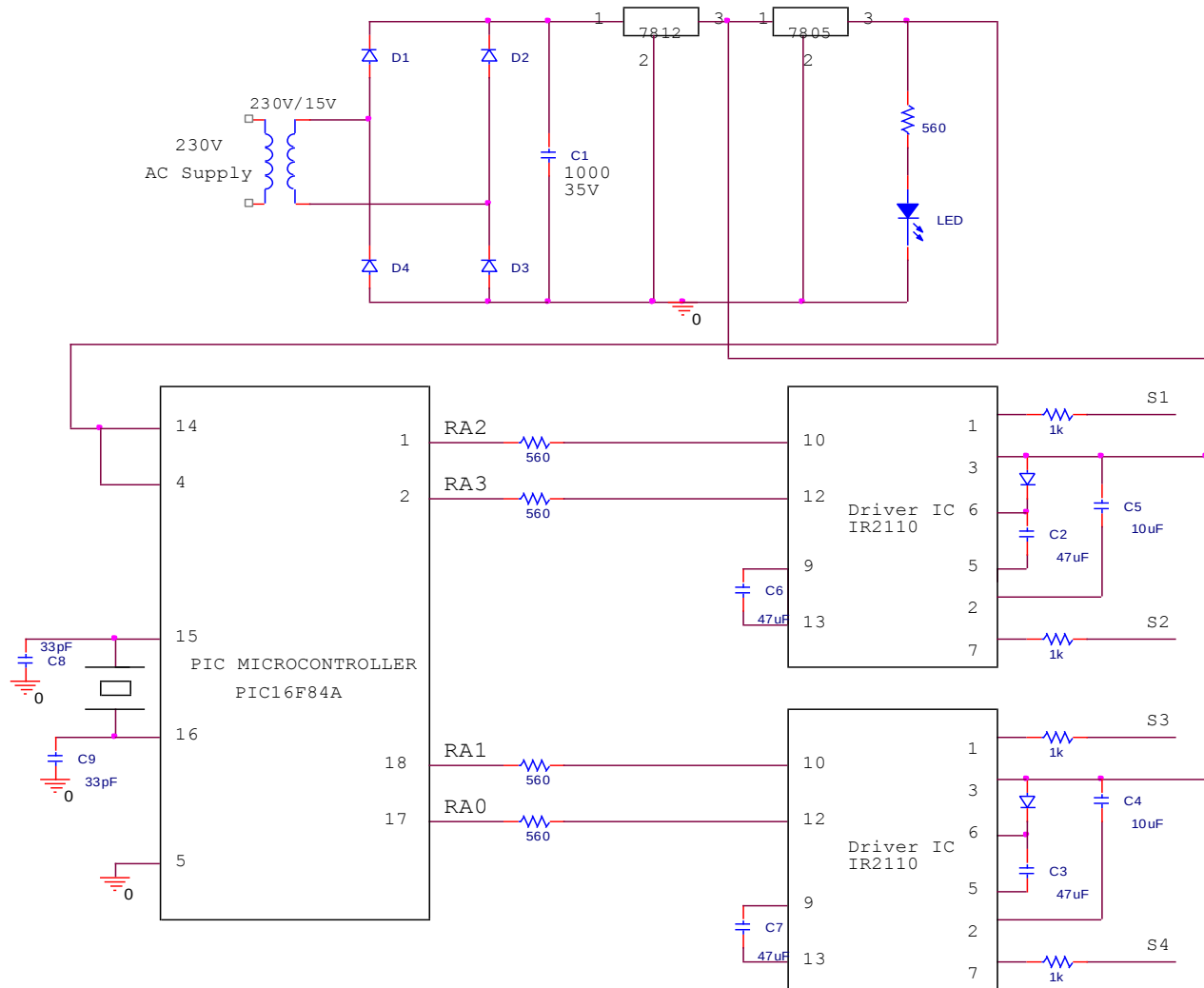


Fig.5.6 Controller circuit

5.5 MOSFET

5.5.1 INTRODUCTION

The following sections describe the elements used and their properties poignant the look of multi level electrical converter. The MOSFET or Metal chemical compound Semiconductor Field result Transistors by the so much commonest field result electronic transistor in each digital and analog circuits. The MOSFET consists of a channel of n-type or p-type semiconductor material ,and is consequently referred to as NMOSFET or a PMOSFET. sadly, several semiconductors with higher electrical

properties than semiconducting material like metallic element chemical compound don't kind sensible gate oxides and so aren't appropriate for MOSFETS.

The gate terminal may be a layer of poly semiconducting material (poly crystalline silicon) or aluminum placed over a channel, however separated from the channel by a skinny layer of insulating silicon Oxide.

A simplified diagram of the N-channel sweetening 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 beneath 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 ensue between the N+ (drain) N (enhanced region) N+(source). Increasing or decreasing in size so dominant conductivity, varied the voltage between the gate and body modulates the conduction of this layer and makes it doable to regulate this flow between drain and supply.

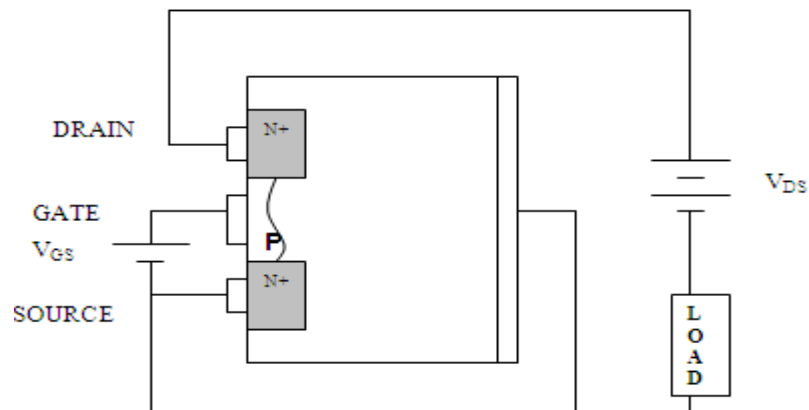


Fig 4.1

Fig. 5.7 Simple model of an N-channel enhancement type MOSFET

In observe, a reasonably massive current within the order of 1-2A will be needed to charge the gate capacitance at activate to confirm that change times square measure tiny, thanks to gate outpouring current, nano amps square measure required to keep up the gate voltage once the device is ON.

A negative voltage is commonly applied at put off to discharge the gate for irradiation turn out. It's obvious that quicker change irradiation will be obtained with elegant gate driver circuits.

5.5.2 FEATURES OF POWER MOSFETS

Power MOSFET has lower change losses however its on-resistance and conductivity losses square measure additional. MOSFET may be a voltage controlled device.

MOSFET has positive temperature co-efficient for resistance. This makes simultaneous operation of MOSFET straightforward. 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 different devices in parallel. In MOSFET secondary break down doesn't occur, as a result of it's positive temperature co-efficient. Power MOSFETS in higher voltage ratings have additional conductivity losses

5.5.3 IRF 840- POWER MOSFET

- 1) Dynamic dv/dt Rating
- 2) Repetitive Avalanche Rated
- 3) Fast switching
- 4) Ease of paralleling
- 5) Simple Drive requirements

5.6 EXPERIMENTAL RESULTS

STATCOM primarily based 3 section 2 bus system Hardware set up is appeared in Fig 5.8.

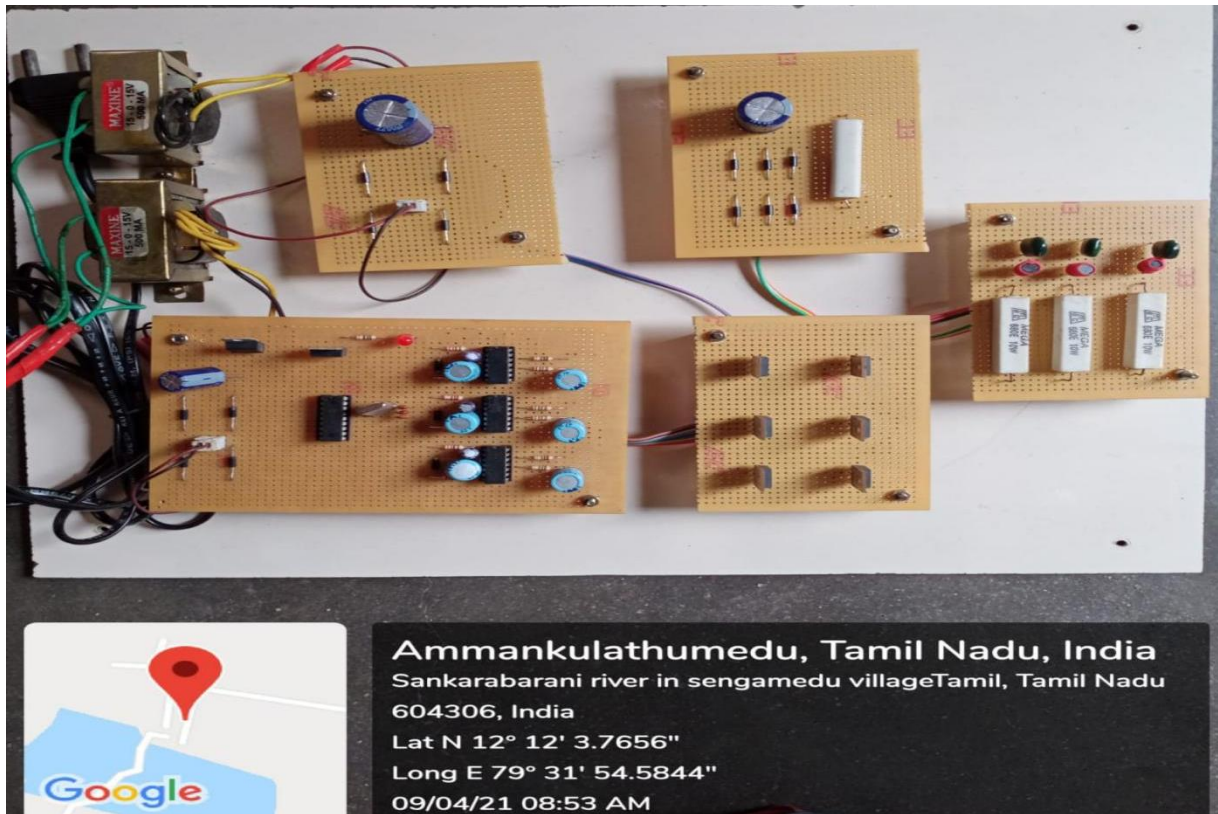


Fig. 5.8.Hardware set up

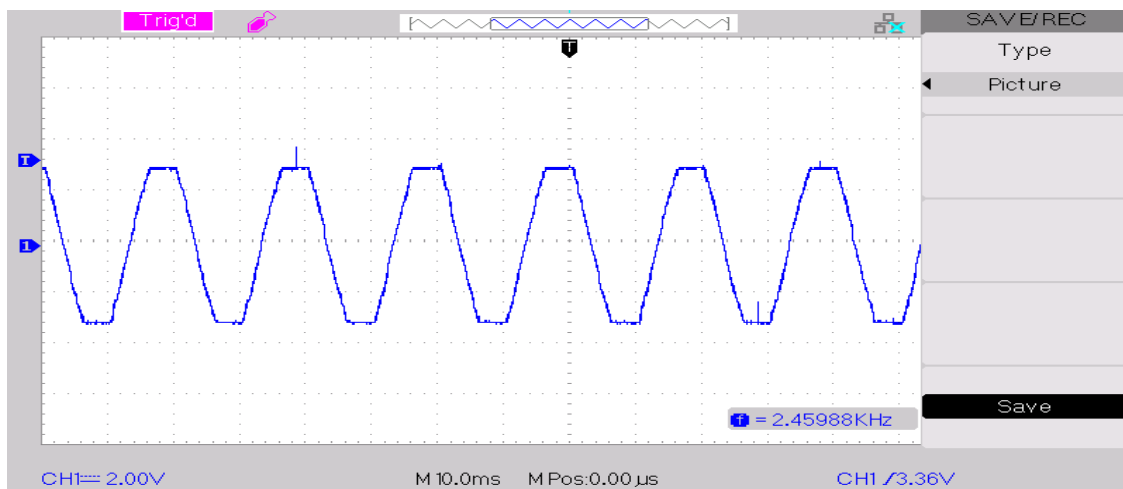


Fig. 5.9.Input voltage

Input voltage as shown in Fig 5.9 voltage across the rectifier as shown in Fig 5.10.Switching pulse of electrical converter money supply,M3, and M2,M6 as shown in

Fig 5.11&5.12. Output voltage across electrical converter with RL load is appeared in Fig 5.13.

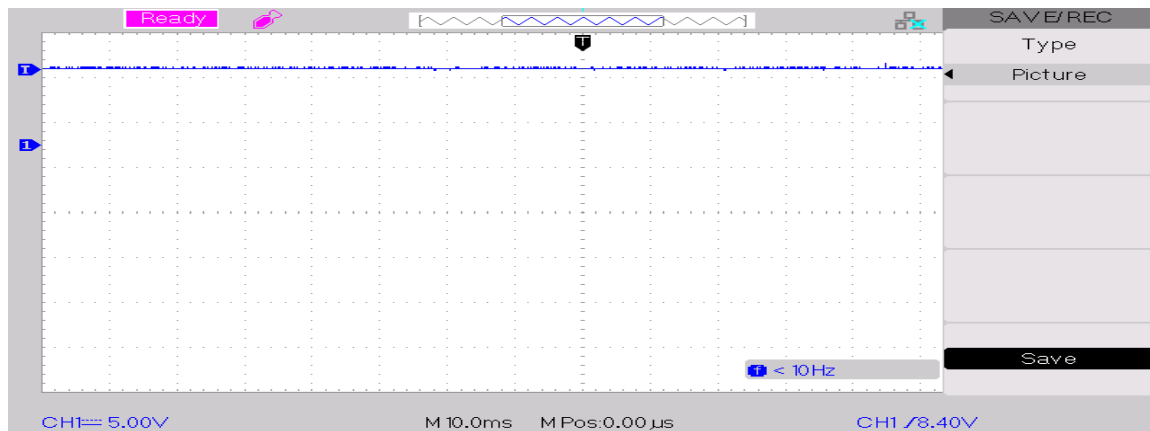


Fig.5.10.Voltage across Rectifier

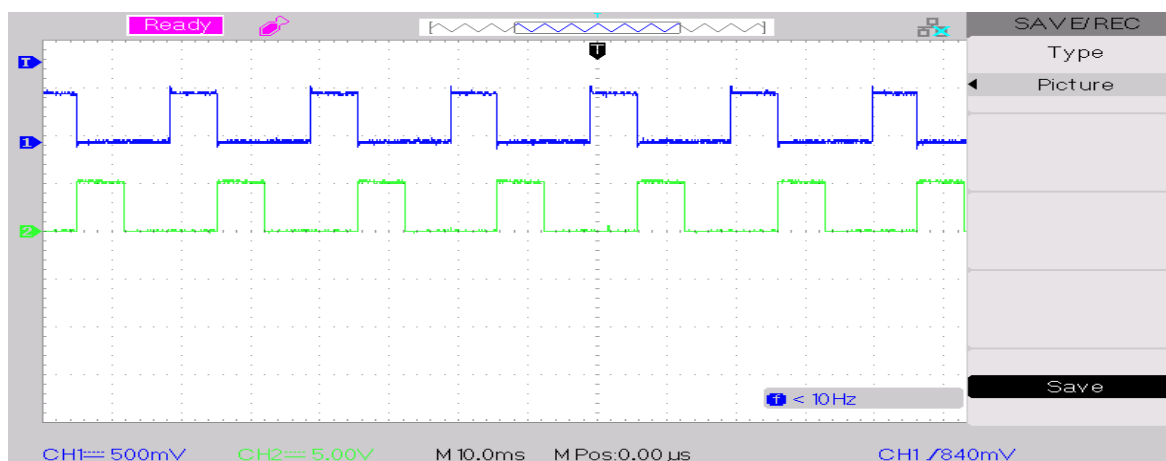


Fig 5.11.Switching pulse for inverter M1, M3

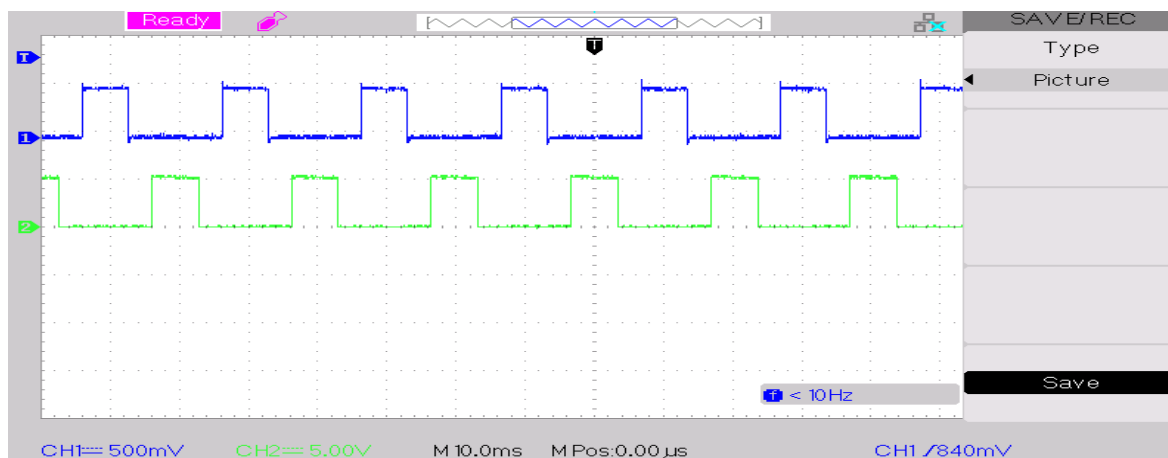


Fig 5.12.Switching pulse for inverter M2, M6

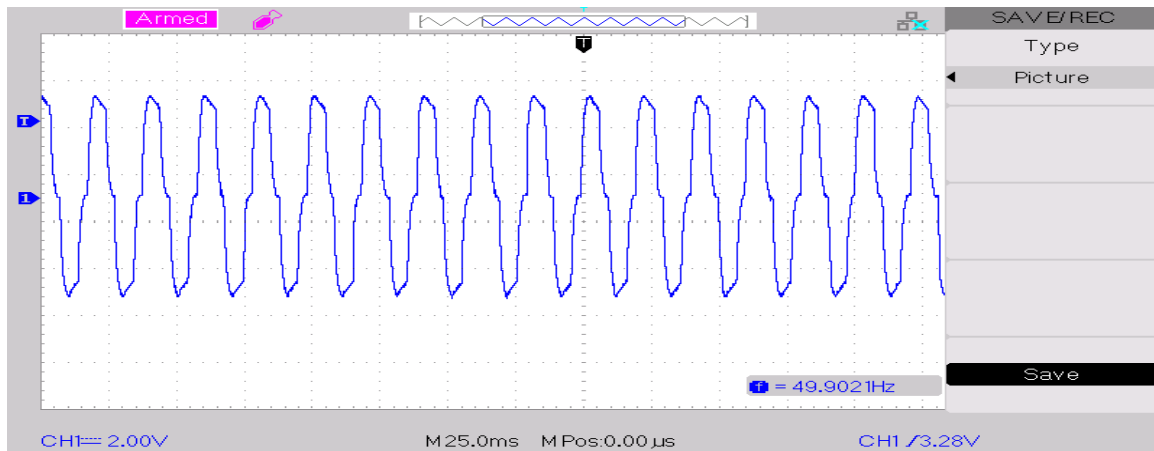


Fig 5.13.Voltage across RL load

CHAPTER 6

CONCLUSION

The closed-loop system optimized FOPI D and PR controlled VSI primarily based STATCOM systems area unit sculptures square and simulated with success. Their results area unit compared that shows that optimized PR controlled system offers superior performance to optimized FOPID controlled system. The planned VSI primarily based STATCOM system has benefits like low Doctor of Theology, Reduced losses and heating. Output Voltage is improved from 3000V to 4200V by adding STATCOM. Real power is improved from 0.046MW to 0.075MW adding STATCOM. Reactive power is improved from 0.024MVAR to 0.040MVAR by adding STATCOM. Voltage Doctor of Theology is reduced from 27.79% to 4.84% by using STATCOM. Current Doctor of Theology is reduced from twenty four.25% to 4.59% by using STATCOM. Voltage Doctor of Theology is reduced from four.13% to 3.81% by using STATCOM. Current Doctor of Theology is reduced from four.02% to 3.58% by using STATCOM. the increase time is reduced from 0.38s to 0.37s by using optimized PR controller. the height time is reduced from 0.39s to 0.38s by using optimized PR controller. The subsiding time is reduced from 0.73s to 0.50s by using optimized PR controller. The steady state error is reduced from 1.89V to 1.42V by using optimized PR controller.

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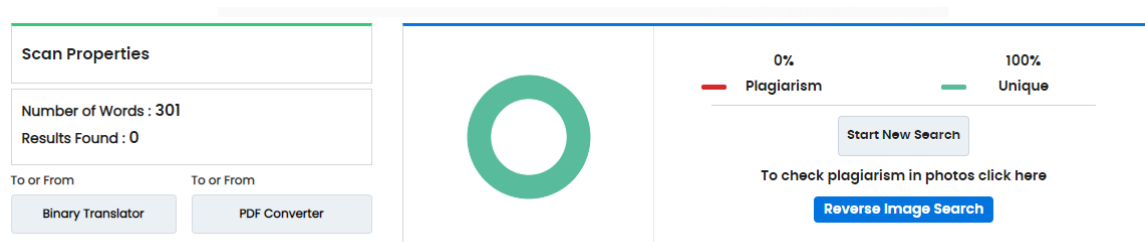
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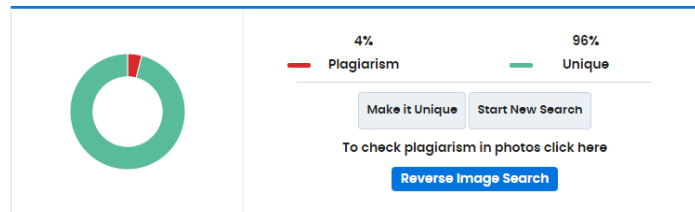
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