PERFORMANCE EVALUATION OF CASCADED MULTILEVEL CONVERTER BASED STATCOM

.A DISSERTATION

Submitted in partial fulfillment of the
requirements for the award of the degree
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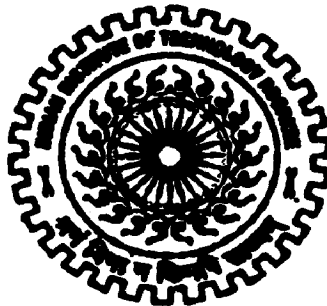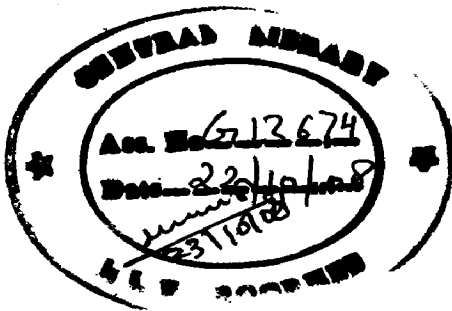in
ELECTRICAL ENGINEERING
(With Specialization in Power System Engineering)

By

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CANDIDATE'S DECLARATION

I hereby declare that the work that is being presented in this dissertation report entitled **"Performance Evaluation of Cascaded Multilevel Converter based STATCOM"** submitted in partial fulfillment of the requirements for the award of the degree of Master of Technology with specialization in "Power System Engineering", to the Department Of Electrical Engineering, Indian Institute Of Technology, Roorkee, is an authentic record of my own work carried out under the esteemed guidance of Dr. Biswarup Das & Dr. Pramod Agarwal, Department of Electrical Engineering.

I have not submitted the matter presented in this dissertation report for the Award of any other degree or diploma.

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Acknowledgement

I write "He" (capital 'h') to pronoun both of my Guides.

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ABSTRACT

In this thesis the voltage control performance of the Cascaded Multilevel Converter (CMC) based STATCOM has been studied. Specifically, a 21 level CMC based STATCOM has been considered and its performance for controlling the bus voltage under fault conditions has been investigated in a practical power distribution system. For determining the switching angles of the CMC based STATCOM, an optimization methodology based on Sequential Quadratic Programming technique, has been used so as to minimize the THD of the STATCOM output voltage. Subsequently, a feedback linearization based on non-linear control law has been designed for the STATCOM voltage regulator. However it was found that under severe fault conditions, the performance of the non-linear voltage controller is quite unsatisfactory. To achieve satisfactory performance of the STATCOM voltage controller, Fuzzy Control systems have been proposed in this thesis. Two different fuzzy control systems namely indirect and direct have been developed in this thesis for this purpose. In the indirect control scheme, the angle difference between the STATCOM bus voltage and the STATCOM output voltage (δ) is used as the control signal, whereas the direct control system, both the modulation index and the angle δ are used as control signals. The performances of these two developed control schemes have been studied with severe symmetrical and unsymmetrical faults. From detailed non-linear simulation studies it has been observed that the performance of the direct fuzzy control system is considerably superior to that of the indirect control scheme.

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Nomenclature

AC	Alternating Current
CMC	Cascaded-Multilevel Converter
DC	Direct Current
DCMC	Diode-Clamped Multilevel Converter
ETO	Emitter Turn Off thyristor
FACTS	Flexible AC Transmission Systems
FCMC	Flying Capacitor Multilevel Converter
FPIC	Fuzzy Proportional Integral Controller
GA	Genetic Algorithm
GA	Genetic Algorithm
GTO	Gate Turn-Off thyristor
IEEE	Institute of Electrical and Electronics Engineers
IGBT	Insulated Gate Bipolar Transistor
IGCT	Insulated Gate Commutated Thyristor
SHEPWM	Selected Harmonic Elimination Pulse Width Modulation
SPWM	Sinusoidal Pulse Width Modulation
SQP	Sequential Quadratic Programming
STATCOM	Synchronous Static Compensator
SVC	Static VAr Compensator
THD	Total Harmonic Distortion
TVA	Tennessee Valley Authority
VSC	Voltage Source Converter

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1.1   The Problem

The electric power network is a very complex and dynamic system consisting of distributed generators, interconnected transmission and large number of reactive loads. As a result requirement of flexible control of electric power is essential to provide a better adaptation to varying operational conditions and improve the usage of existing installations. FACTS have been defined by the IEEE as follows [1]:

"A power electronic based system and other static equipment that provides control of one or more AC transmission system parameters to enhance controllability and increase power transfer capability."

The FACTS concept was originally created in the 1980s to solve operation problems due to the restrictions on the construction of new transmission lines, to improve power system stability margin and to facilitate power exchange between different generation companies and large power users.

FACTS devices can be applied for [2]

• Power flow control,

• Increase of transmission capability,

• Voltage control,

• Reactive power compensation,

• Stability improvement,

• Power quality improvement,

• Power conditioning,

• Flicker mitigation,

• Interconnection of renewable and distributed generation and storages.

Most of the industrial loads such as induction motors operate at moderately low power factor. Around 60% of the utility load consists of motors and hence the overall power factor of the power system is low. The typical load power factors are given in the Table1.1 [3]. So to prevent the transmission line and the generators from breaching their VA ratings, compensators are installed to maintain the required voltage support and the voltage profile.

Table1.1: Typical Power Factor of Some Industrial Plant

Industry	% of Power Factor	Industry	% of Power Factor
Chemical	80-85	Arc welding	35-60
Coal mine	65-80	Machine shop	45-60
Electroplating	65-70	Arc furnace	75-90
Hospital	75-80	Spraying	60-65
Office building	80-90	Weaving	60-75

The dynamic response of these compensators should be fast enough to cope up with the frequent incoming and rejection of reactive loads, as observed in Table1.2. In case of highly loaded line experiencing symmetrical faults, when the reactive current requirement increases which results high transient shaft torque and rotor acceleration on generators the problem become more severe. So this concludes that during faults the compensators are of critical importance with respect to transient stability.

Table1.2: Typical Voltage Fluctuation Standards

Load	Limits of Voltage Fluctuations
Large Motor starts	1-3% depending on frequency
Mine winders, excavators and large motor drives	1-3% at distribution voltage level $\frac{1}{2} - 1\frac{1}{2}$ % at transmission voltage level
Welding Plant	$\frac{1}{4} - 2$% dependent on frequency
Induction Furnace	Up to 1%
Arc Furnace	$< \frac{1}{2}$%

The evolution in the fabrication of semiconductor devices both in low power family like microprocessors which are used for mathematically complex digital control and also in the high power range for power stage of converters such as IGBT, ETO, IGCT, GTO etc. are increasingly finding places in FACTS technology. The high power electronic switches used should have the following characteristics [3]:

1. High forward and reverse voltage blocking ratings
2. High current during conduction states
3. Low off state leakage current

4. Low on-state voltage drop across the switch

5. Low turn-on and turn-off losses

6. Controlled switching characteristics during turn-on and turn-off

7. Capability to handle its rated voltage and current at the same time without the need for derating.

8. High dv/dt and di/dt ratings

9. Ability to operate in high temperatures

10. High input impedance.

The FACTS controllers can be divided into following categories

1. Series controllers

2. Shunt Controllers

3. Combined Series-Shunt Controllers

The Shunt controllers mainly the SVC (Static VAr Compensator) and STATCOM (Synchronous Static Compensator) have gained popularity in terms of reactive power support and dynamic response. Again the STATCOM is more superior to SVC in terms of V-I and V-Q characteristics, transient stability, dynamic response and capability to exchange real power.

1.2   STATCOM Operation

The STATCOM is a static counter part of the rotating synchronous condenser but it generates/absorbs reactive power at a faster rate because no moving parts are involved. The schematic of STATCOM is shown in Fig. 1.1(a). In principle, it performs the same voltage regulation function as the SVC but in a more robust manner because unlike the SVC its operation is not impaired by the presence of low voltages.

(a)   (b)
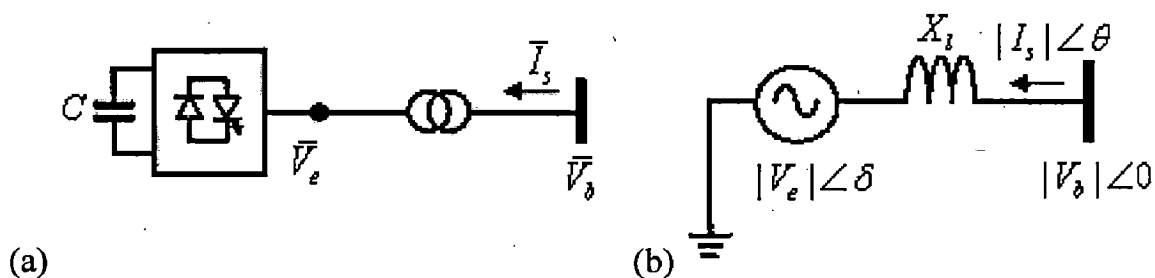
Figure 1.1: (a) VSC connected to ac network and (b) Equivalent Circuit.

The exchange of reactive power between the converter and the ac system can be controlled by varying the amplitude of the three phase output voltage V_e of the converter in Fig. 1.1(b). That is if the amplitude of the output voltage is increased above that of the utility bus voltage V_b then a current flows through the reactance from the converter to the ac system and the converter generates capacitive reactive power for the ac system. If the amplitude of the output voltage is decreased below the utility bus voltage then the current flows from the ac

system to the converter and the converter absorbs inductive-reactive power from the ac system as shown in Fig 1.2(a). If the output voltage equals the ac system voltage, the reactive power exchange becomes zero, in which case the STATCOM is said to be in floating state. Adjusting the phase shift between the converter output voltage and the ac system voltage can similarly control real power exchange between the converter and the ac system from its dc energy storage as shown in Fig 1.2(b). If the converter output voltage is made to lead the ac system voltage. On the other hand it can absorb real power from the ac system for the DC capacitor voltage if its voltage lags behind the ac system voltage.
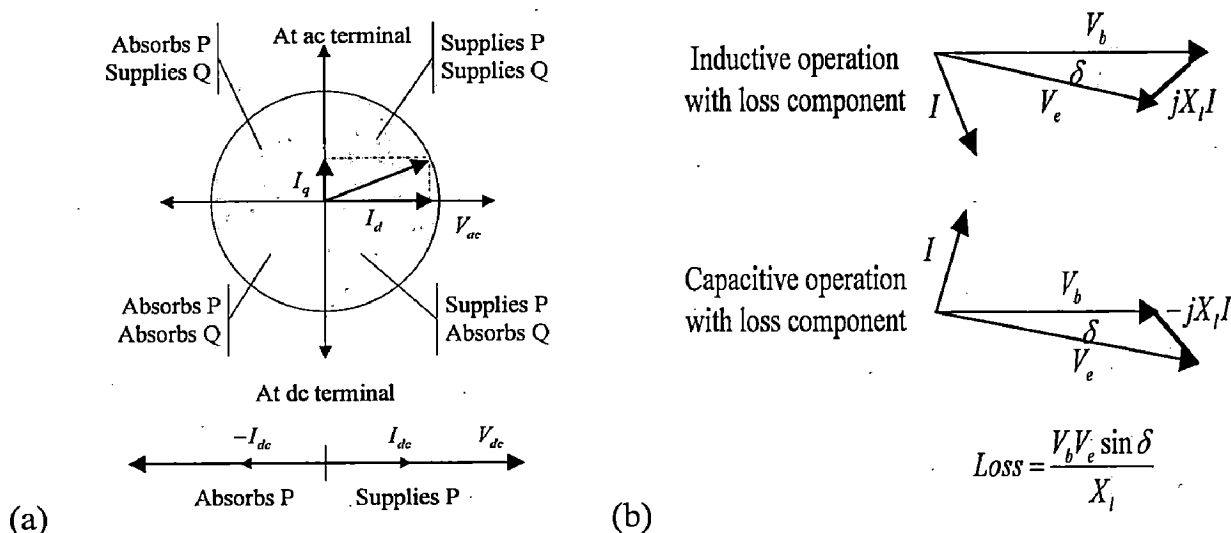
Figure 1.2 (a) Power exchange between the STATCOM and the ac system. (b) Vectorial representation between voltage and current

1.3 Requirement of exchange of real power

In practice, the semiconductor switches of the conductor are not lossless, so the energy stored in the dc capacitor is eventually used to meet the internal losses of the converter, and the dc capacitor voltage diminishes. However when the STATCOM is used for reactive-power generation, the converter itself can keep the capacitor charged to the required voltage level. This task is accomplished by making the output voltages of the converter lag behind the ac system voltages by a small angle (usually in the $0.1°$-$0.2°$ range). In this way, the converter absorbs a small amount of real power from the ac system to meet its internal loss and keep the capacitor voltage at the desired level. The Fig 1.3 shows the average waveforms of the phase voltage $V_{an,}$ the fundamental phase voltage, the system bus voltage V_b and the current I_{ca} flowing through the capacitors. The capacitor current either lags or leads the phase voltage by $90°$ depending on whether the converter acts capacitive or inductively. The average charge on each dc capacitor over every half cycle is equal to zero and because of this symmetric charge flow the voltage on all the dc capacitor remains theoretically balanced. However the power losses in the converter and an unbalanced operation of the three phase system the capacitor

voltage may drift away from their set levels. In principle the charge and hence the voltage across each capacitor is maintained by prolonging or shortening the current flow through it which is achieved by shifting the switching pattern. The first wave form depicts the extra charging of capacitor to raise its falling voltage when the converter is producing the leading VAr. In the positive half cycle of I_{ca}, C1 conduction is increased by $\Delta\theta_1$ where as in the negative half cycle it is reduced by the same amount. Reflecting this behavior are shaded areas in which the positive half cycle is larger than in negative half cycle indicating extra charging of C1.
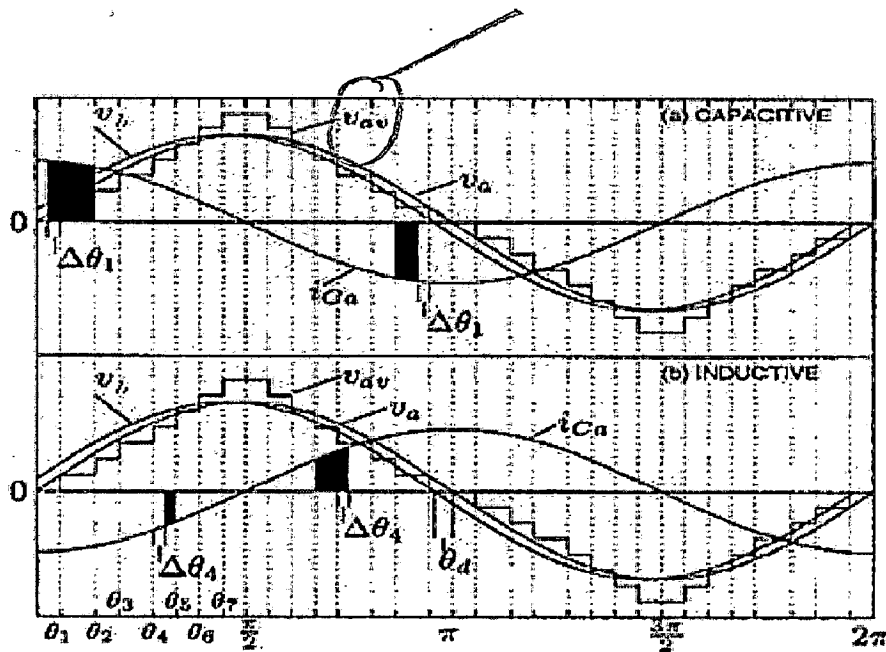
Symbols do not match with text

Figure 1.3 Modulating charge and discharge to of capacitor to control their voltages

1.4 STATCOM operating characteristics – The regulation slope

STATCOM operate with a slope reactance typically between 2% and 5% as shown in Fig 1.5(a) which is much lower than the value of the coupling reactance given as natural characteristics in Fig 1.4 (a). Because the coupling reactance is fixed, the converter source voltage must therefore be changed i.e. raising it to V_e (high) to obtain the desired leading current condition or reducing it to V_e (low) for lagging conditions as shown in Fig 1.5 (a). This can be done by changing the switching pattern and then followed by changing the dc source voltage. At reduced voltage the STATCOM can continue to be operated at rated leading (or lagging) current with a constant transient overload current margin.
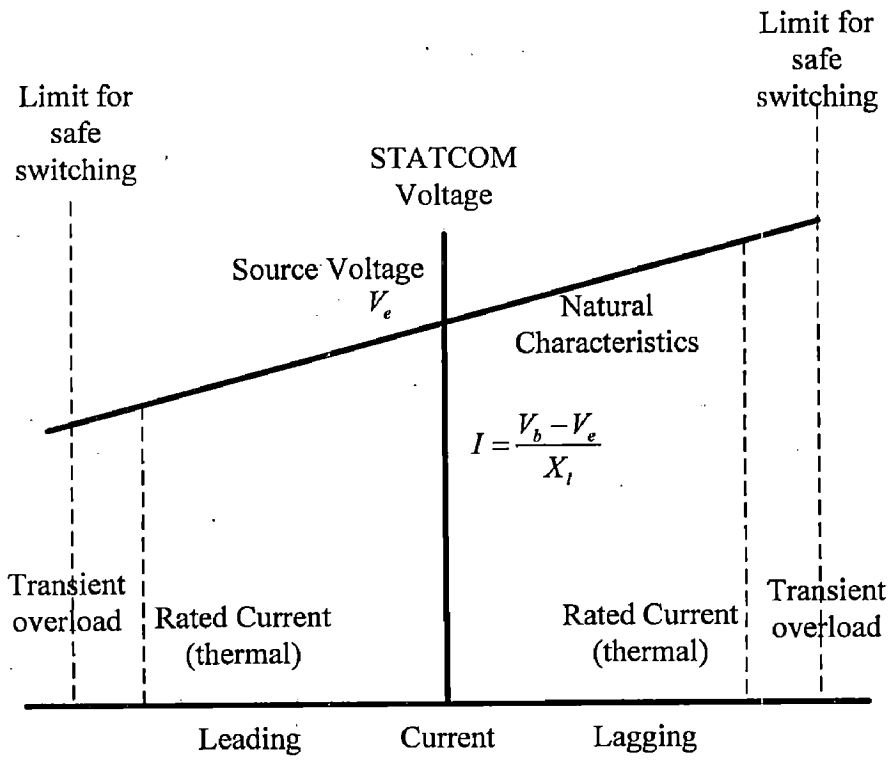
(a)
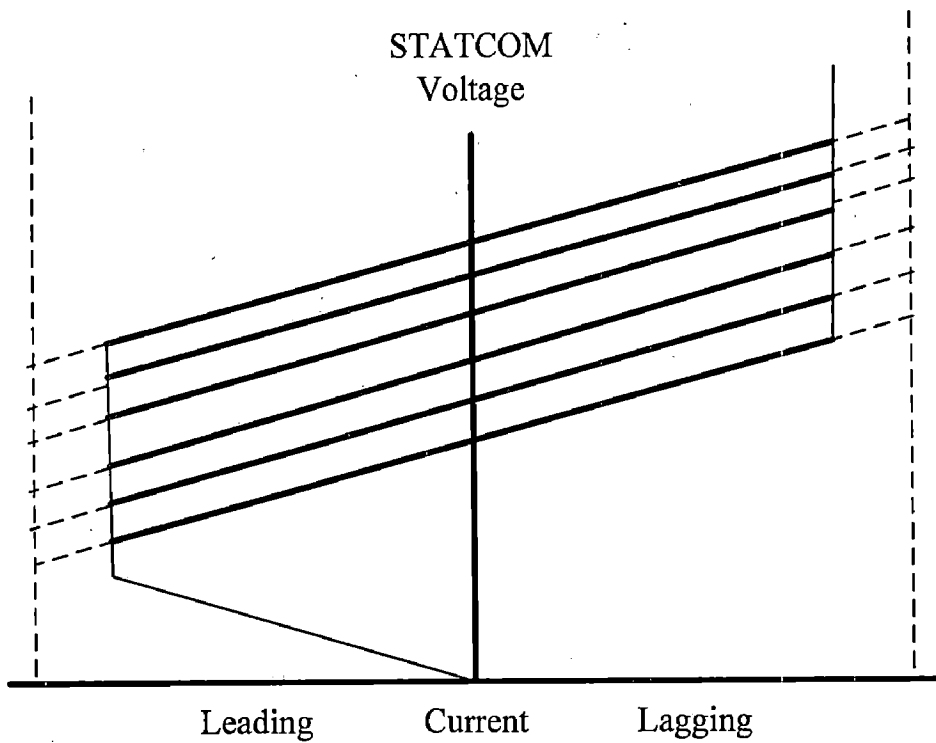
(b)

Figure 1.4 (a) Natural V-I characteristics of a STATCOM. (b) Family of V-I characteristics of a STATCOM.

The STATCOM is not used as a perfect terminal voltage regulator, but rather the terminal voltage is allowed to vary in proportion with the compensating current. There are several reasons for this [4].

1) The linear operating range of a compensator with given maximum capacitive and inductive ratings can be extended if a regulation droop is allowed. Regulation droop means that the terminal is allowed to be smaller than the nominal no load value at full capacitive compensation and conversely, is allowed to be higher than the nominal value at full inductive compensation.

2) Perfect regulation (zero droop) could result in poorly defined operating point and a tendency of oscillation, if the system impedance exhibits a flat region in the operating frequency range of interest.

3) A regulation droop tend to enforce automatic load sharing between static compensator as well as other voltage regulating device normally employed to control transmission voltage.

So the modulation index can be related to I_q(req) as $mV_{dc} = V_{d\_rated} + (\omega l)I_{q\_req}$ which is the equation of the natural characteristics.

1.5   Transient response

The steady state operating condition of a STATCOM is dependent on the system voltage and the STATCOM source voltage and its coupling impedance. Thus with an open circuit system voltage V_{b1} in Fig 1.5(b) slightly lower than the target voltage of the STATCOM steady state characteristics, the STATCOM draws a small capacitive current I_1. In order to generate this current the STATCOM source voltage V_{e1} must be slightly higher than the target voltage. If the system voltage is depressed due to a fault to a value V_{b2}, the point of intersection of the system characteristics and the STATCOM controlled characteristics demands a current I_2. Initially before there has been any change of STATCOM source voltage, the STATCOM current increases substantially from I_1 to $I_2^{'}$ this is increased by control action to the required value I_2 by an increase of source voltage to V_{e2} normally within one half cycle.

STATCOM Voltage

Natural Characteristics

$V_{e(high)}$

V_b

Controlled Characteristics

$V_{e(low)}$

Leading　　　Current　　　Lagging

(a)

STATCOM Voltage

Natural Characteristics

V_{e2}

V_{e1}

Controlled Characteristics

V_{b1}

V_{b2}

System Characteristics

I_2　　I_2'　　I_1

Leading　　　Current　　　Lagging
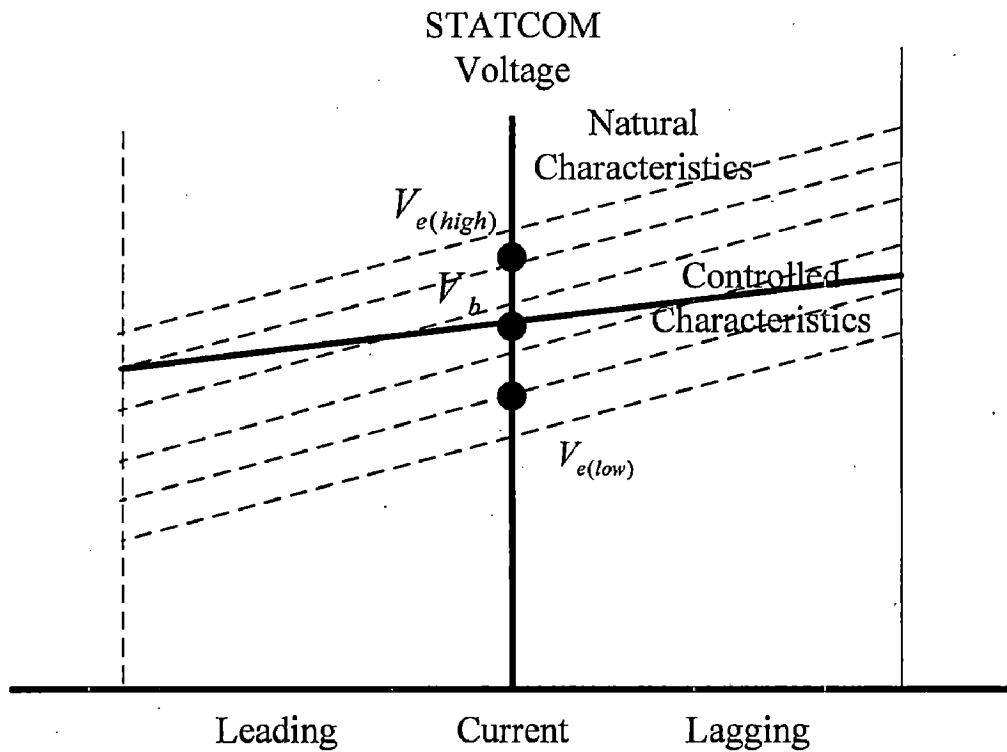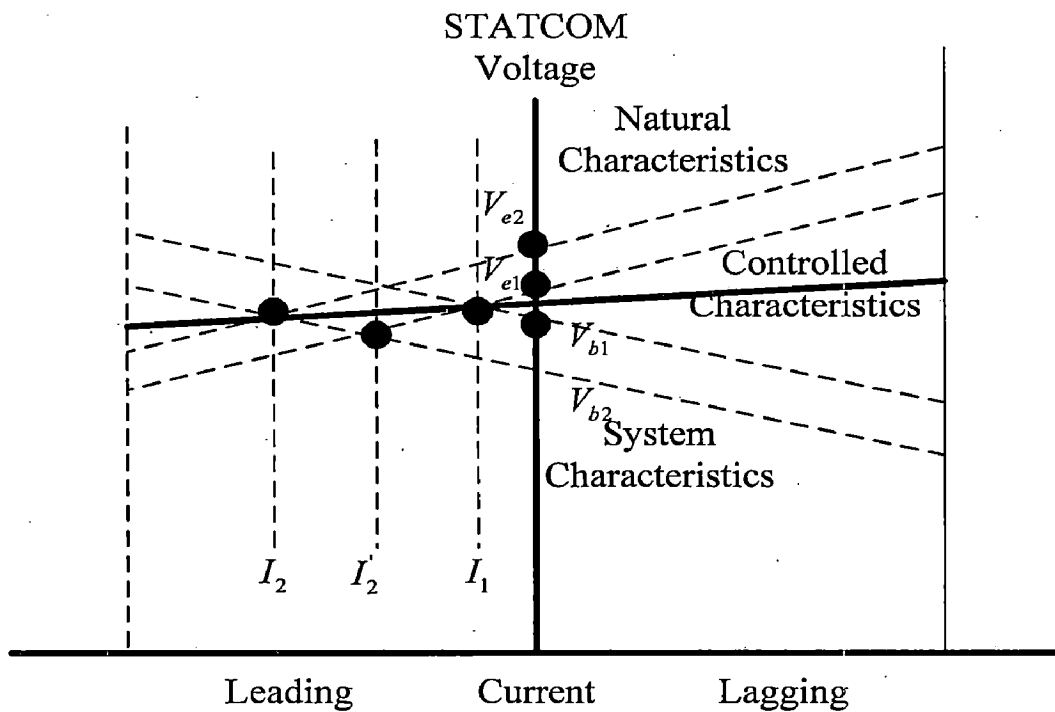
(b)

Figure 1.5 (a) Controlled V-I characteristics of a STATCOM. (b) Response of a STATCOM to a system voltage change

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1.6 Literature Review

In 1995 a ±100MVA STATCOM was commissioned for the Tennessee Valley Authority (TVA) at the Sullivan Substation at North-Eastern Tennessee [5].It is supplied by the 500 kV bulk power network and by four 161 kV lines. The Sullivan 500 kV feed supplies about 55 percent of the winter peak load of 900 MW. The 500 kV bus is tied to the 161 kV bus through a 1200MVA transformer bank. The STATCOM is connected to the 161 kV bus where it is required to regulate the voltage during the daily load cycle so that the tap changer on the transformer bank can be used less often. A standard 84 MVAr switchable bank of capacitors are installed adjacent to the STATCOM and its switchings are normally coordinated with the STATCOM so as to reduce STATCOM loading and to provide an overall controllable VAr range from 100 MVAr inductive to 184 MVAr capacitive. Another example of ±100MVA STATCOM installed at SDG&E's Talega 138kV substation in October 2002[6]. It consists of two groups of Voltage Source Converter 50MVA each. Each 50MVA converter group consists of four sets of 12.5MVA modules plus a 5MVAr harmonic filter, with a nominal phase to phase ac voltage of 3.2 kV and a DC link voltage of 6000V.
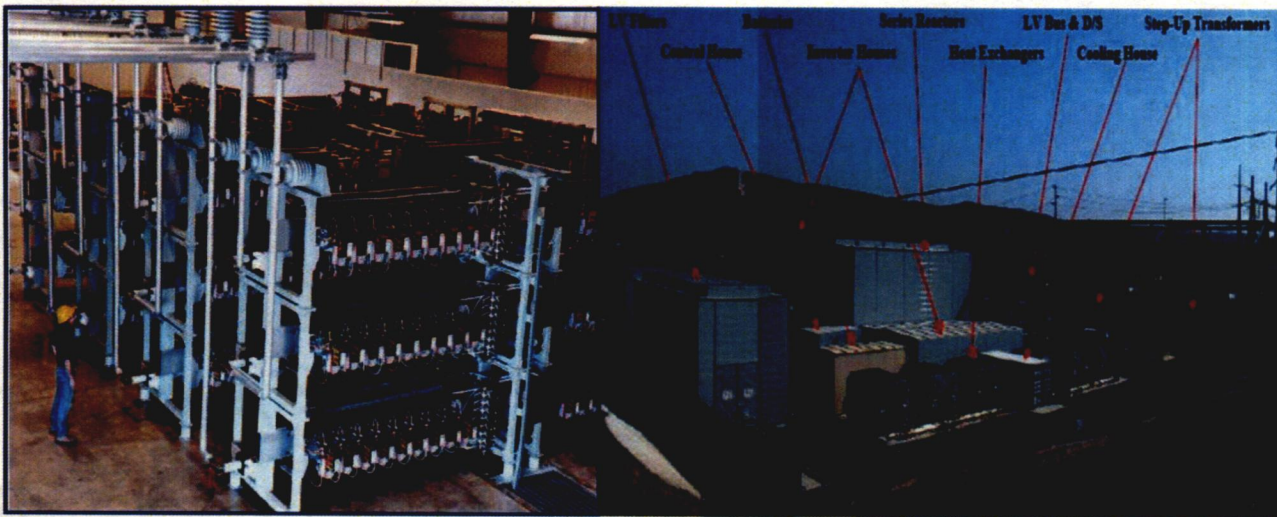
Figure 1.6 (a) TVA STATCOM inverter valve layout. (b) ±100 SDG&E Talega STATCOM

But they suffered from many drawbacks like bulky zigzag transformers for 48 pulse output waveform, complex switching strategy and higher snubber losses, which encouraged the development of multilevel STATCOM.

The topology of Multilevel converter is further divided into 1)Diode clamped converter 2)Flying Capacitor converter 3) Cascaded Multilevel converter. The concept of the Cascade Multilevel Converter is put forward by Peng in 1996 [7] and concludes that Cascaded Multilevel Converter can be used as a STATCOM for reactive power control.

The Phase Shifted Multilevel Pulse Width Modulation and the capacitance requirement for acceptable ripple at full capacitive output is given by Nwanpa [8]. The initial charging of the capacitors by charging resistors is also designed for restricting the initial inrush current.

Shen et. al. [9] has performed the system calculations in per unit and designed PI controller for STATCOM application. The open loop time constant of the STATCOM has been shown to be operating point dependent in this paper.

Bacha et.al [10] has shown the poles of the STATCOM depend on operating point and proposed a nonlinear controller for robust STATCOM controlling.

The vector control for static VAR compensators with decoupled PI controller has been proposed by Mehta and Schauder [11].They are classified as type I and type II control. The inverter is modeled in DQO reference frame and the state space representation is derived. In type I controller both the modulation index and the phase are the control input to the inverter. The second type deals with fixed modulation index and phase difference as the only control variable which has got application in transmission line ASVC's.

The exact linearization via state feedback for nonlinear control has been proposed by Qiang Song [12] and the controller is tested at ±30kVar prototype fabricated at Tsinghua University. The capacitor voltage unbalance is also minimized by THD minimization and fundamental voltage equalization and finally firing pattern swapping is employed. This is achieved by three times switching in a quarter cycles. The initial condition for the optimization problem is still to be decided for the best harmonic performance.

Tamer et.al.[13] have applied genetic Algorithm for solving SHEPWM for Cascaded Multilevel Converter. Binary coding system has been employed to perform selection, crossover and mutation in GA.

Soto et.al.[14] have successfully realized the nonlinear controller and applied pole placement to derive the controller gains. The validity of the controller is justified by 5 level STATCOM connected to infinite bus.

The fuzzy logic has been conceived by Lofti Zadeh, many versions of pi and pid [15] controller has been proposed for complex single input and single output system. Morris et.al [16] have employed two new structure fuzzy control algorithm. The control signal is obtained from a combination of generator speed deviation and STATCOM bus voltage deviation fed to the variable structure fuzzy controller. The controller evaluated in single machine and multi machine power system subject to a wide range of operating condition change.

1.7 Organization of the thesis

Chapter 1 The Operation and state of the art technology available for SATACOM controller design has been explored.

Chapter 2 In this chapter a new initial condition algorithm by phase shift method has been applied and superior harmonic performance as compared to Song[9] has been achieved.

Chapter 3 The requirement of charging circuit for STATCOM has been highlighted and the Mathematical Model is derived.

Chapter 4 The fuzzy indirect control has been designed for STATCOM and the system performance during fault is evaluated. The control parameters are tuned by simplex optimization method.

Chapter 5 The indirect controller of chapter 5 together with an additional fuzzy controller is used for direct controlling of STATCOM. The performance is evaluated in distribution grid.

Chapter 6 Conclusion and future scope of this thesis have been discussed.

2.1   Types of Multilevel Converters

Multilevel Voltage Source Converters (VSCs) are emerging as a new breed of power converter options for high-power applications. The multilevel VSC typically synthesize the staircase voltage wave from several levels of dc capacitor voltages. One of the major limitations of the multilevel converters is the voltage unbalance between different levels. The techniques to balance the voltage between different levels normally involve voltage clamping or capacitor charge control. In the past two decades, several multilevel VSC topologies have been reported and studied, i.e., diode clamped, flying capacitor and Cascaded-Multilevel Converter (CMC) [7] topologies.
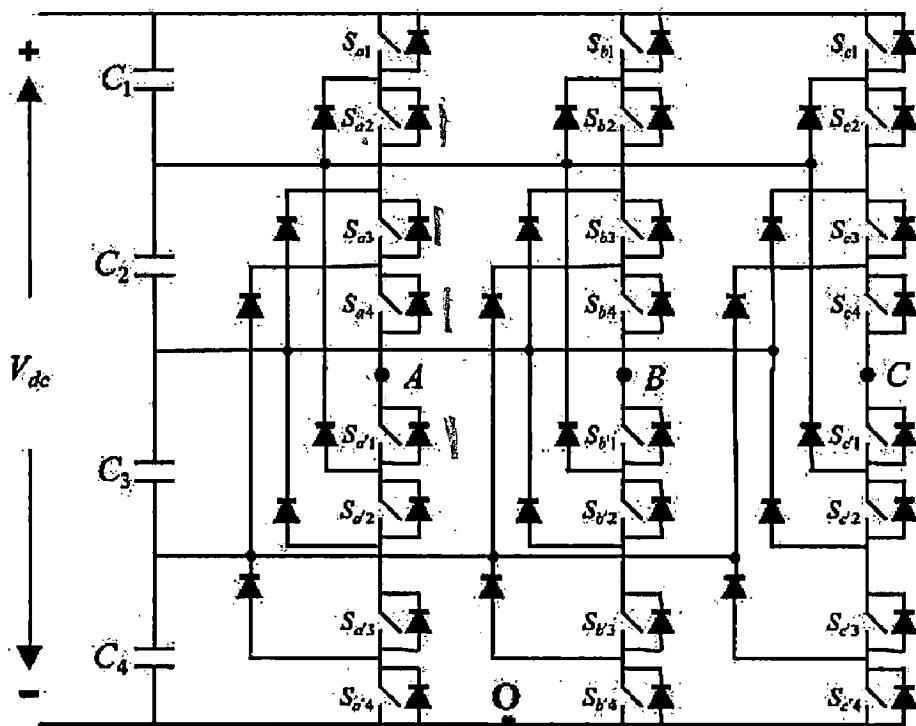
Figure 2.1 Diode Clamped Multilevel Converter

Fig. 2.1 shows a five-level Diode-Clamped Multilevel Converter (DCMC) in which the dc bus consists of four capacitors. For dc-bus voltage V_{dc}, the voltage across each capacitor is V_{dc} /4 and each device voltage stress will be limited to one capacitor voltage level through clamping diodes. With different switching combinations, multilevel voltages can be synthesized. For voltage level V_{dc}, turn on four upper switches; for voltage level ¾V_{dc}, turn on Sa2, Sa3, Sa4, Sa'1; for voltage level 1/2 V_{dc}, turn on Sa3, Sa4, Sa'1, Sa'2; for voltage level 1/4 V_{dc}, turn on Sa4, Sa'1, Sa'2, Sa'3; for voltage level 0 V_{dc}, turn on the lower four switches.

Fig 2.2 shows a five-level Flying Capacitor Multilevel Converter (FCMC) topology. The voltage level defined in the flying-capacitor converter is similar to that of the diode-clamp type converter. The voltage synthesis in a flying-capacitor converter has more flexibility than a diode-clamp converter. For voltage level V_{dc}, turn on all upper switches; for voltage level ¾ V_{dc}, there are three combinations: (a) Sa1, Sa2, Sa3, Sa'4, (b) Sa4, Sa'1, Sa'2, Sa'3 , (c) Sa1, Sa3, Sa4, Sa'2. For voltage level ½ V_{dc}, there are six combinations: (a) Sa1, Sa2, Sa'3, Sa'4, (b) Sa3, Sa4, Sa'1, Sa'2, (c) Sa1, Sa3, Sa'2, Sa'4, (d) Sa1, Sa4, Sa'2, Sa'3, (e) Sa2, Sa4, Sa'1, Sa'3, (f) Sa2, Sa3, Sa'1, Sa'4. For voltage level ¼ V_{dc}, there are three combinations: (a) Sa1, Sa'2, Sa'3, Sa'4, (b) Sa4, Sa'1, Sa'2, Sa'3, (c) Sa3, Sa'1, Sa'2, Sa'4. For voltage level 0, turn on all lower switches.
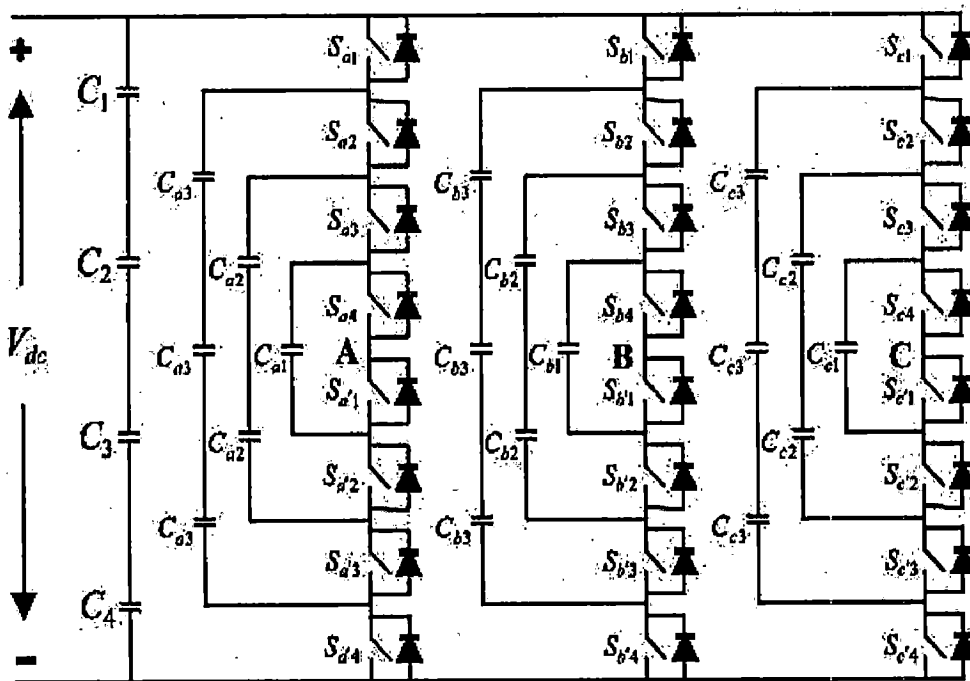
Figure 2.2 Flying Capacitor Multilevel Converter

The third type of multilevel converter, namely the Cascaded Multilevel Converter (CMC) is increasingly used at high power area due to its direct high voltage output with no need of transformer. Fig. 2.3 shows the topology of a CMC. The "level" in a cascaded-inverters based converter is defined by p=2N+1, where p is the output phase voltage level and N is the number of dc sources. For example, a 7-level cascaded-inverters based converter will have three DC sources. Compared to diode-clamped multilevel converters and flying capacitor multilevel converters, CMC is easy to design and assemble because of the uniform circuit structure of the converter units. Modularized circuit layout and packaging is possible in CMC topology, because each level has the same structure, and there are no extra clamping diodes or voltage-balancing capacitors, which are required in the DCMC and the

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FCMC. The number of output voltage levels can then be easily adjusted by changing the number of full-bridge converters.
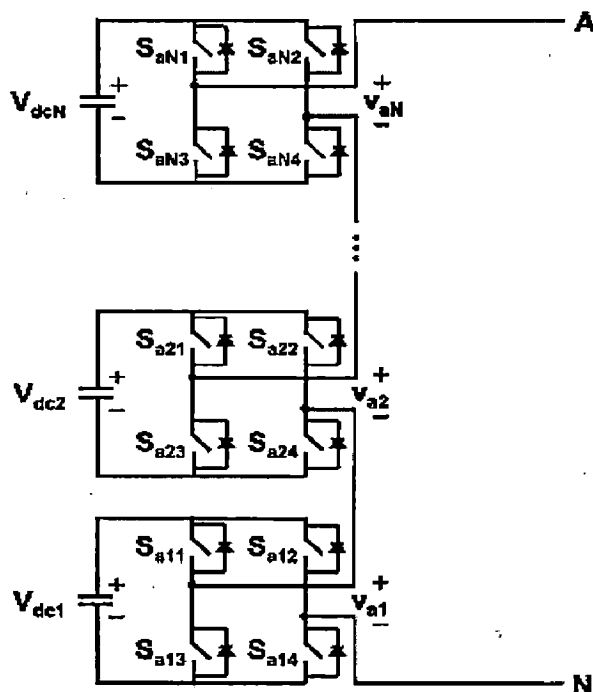
Figure 2.3 Cascaded Multilevel Converter

Table 2.1 [7] compares the main power component requirements per phase leg among these three multilevel VSCs, where p is the number of voltage levels. In Table 2.1, the number of main switches and main diodes needed by each converter to achieve the same number of voltage levels is the same. But DCMC (diode-clamp) needs extra clamping diodes, FCMC (flying-capacitor) needs extra balancing capacitors and CMC needs extra DC bus capacitors. So the number of total devices required for each converter is different. To synthesize the same number of voltage levels, the CMC requires the least number of total main components.

Table 2.1: Comparison of power component requirements per phase leg.

Converter Type	Diode-Clamp	Flying Capacitors	Cascaded Multilevel
Main switching devices	2(p-1)	2(p-1)	2(p-1)
Main diodes	2(p-1)	2(p-1)	2(p-1)
Clamping diodes	(p-1)(p-2)	0	0
DC bus capacitors	(p-1)	(p-1)	2(p-1)
Balancing capacitors	0	(p-1)(p-2)/2	0
Total	$p^2 + 2p - 3$	$(p^2 + 8p - 8)/2$	(9/2)(p-1)

Table 2.2: Advantages and Disadvantages of different multilevel VSCs in a nutshell.

Converter Type	Diode-Clamp	Flying Capacitors	Cascaded Multilevel
Advantages	(1) DC-link capacitors are common to three phases. (2) Switching frequency can be low. (3) Reactive current and negative-phase-sequence current can be controlled.	(1) The clamping capacitor's voltage is automatically balanced. (2) Reactive current and negative-phase-sequence current can be controlled.	(1) No clamping components are necessary. (2) Low switching frequency can be used. (3) Low harmonics, small footprint and modular (4) Both real and reactive power can be exchanged
Disadvantages	(1) Many diodes are used for clamping. (2) Many diodes make physical layout difficult, (3) Problems with DC-link voltage control.	(1) Low switching frequency makes the clamping capacitors large. (2) An excessive number of capacitors is used for clamping. (3) Complicated selection of switch for real power conversion	(1) DC-link capacitors voltages are unbalanced for fundamental switching.

Among these three types of converters, CMC has been studied in this thesis for its suitability to control voltage in a power distribution system. Now, for applying any multilevel VSC, proper switching scheme must be adopted for optimal performance of the converter. In the literature, following methods have been suggested for switching a CMC; 1) Sinusoidal PWM [17] 2) Space vector PWM [18] 3) Non Sinusoidal carrier PWM[19] 4) Mixed PWM[20] 5) Special structure of cell connection [21] and 6) Selected harmonic elimination PWM(SHEPWM)[22]. The SHEPWM methods can theoretically provide the highest quality among all the available techniques but suffers from the following drawbacks 1) high computational requirement 2) large look up table in flash ROM 3) non convergence at some modulation index and multiple solution at some modulation index. When SHEPWM is applied at fundamental switching frequency, the power sharing among the cells are unequal, as a result the capacitor voltage among the cells fluctuates in a particular phase. On the other hand, the

advancement in the power semiconductor device technology allows us to increase the switching frequency of the device to 150 Hz. [12]. In this thesis also, the switching frequency of the device has been assumed to be 150 Hz as shown in Fig 2.4(a). However, to decide the switching angles, an optimization based technique has been used, which is described in the next subsection.

2.2 Optimal Pulse Width Modulation

The improvement in the power semiconductor device to operate at higher frequency, allow us to increase the switching frequency to 150 Hz with marginalized increase in the switching losses. This increase in the degree of freedom can be used to equalize the capacitor voltage by constrained optimization problem. The constrained formulation for equal power sharing is given by equal magnitude of fundamental voltage among the cells given by Eqns. (2.1)-(2.10). In this thesis, a 21 level CMC has been used. The 3 times switching in quarter cycle for ten cells H Bridge allow us to theoretically eliminate 41 order harmonics for solving 30 unknowns in 30 equations. The eliminated harmonics are given by Eqns. (2.11)-(2.30). The original harmonic elimination technique with equal fundamental voltage sharing can be modeled by the following equations, where α_i's are the firing angles in the first quarter of the sine wave.

(a)

(b)
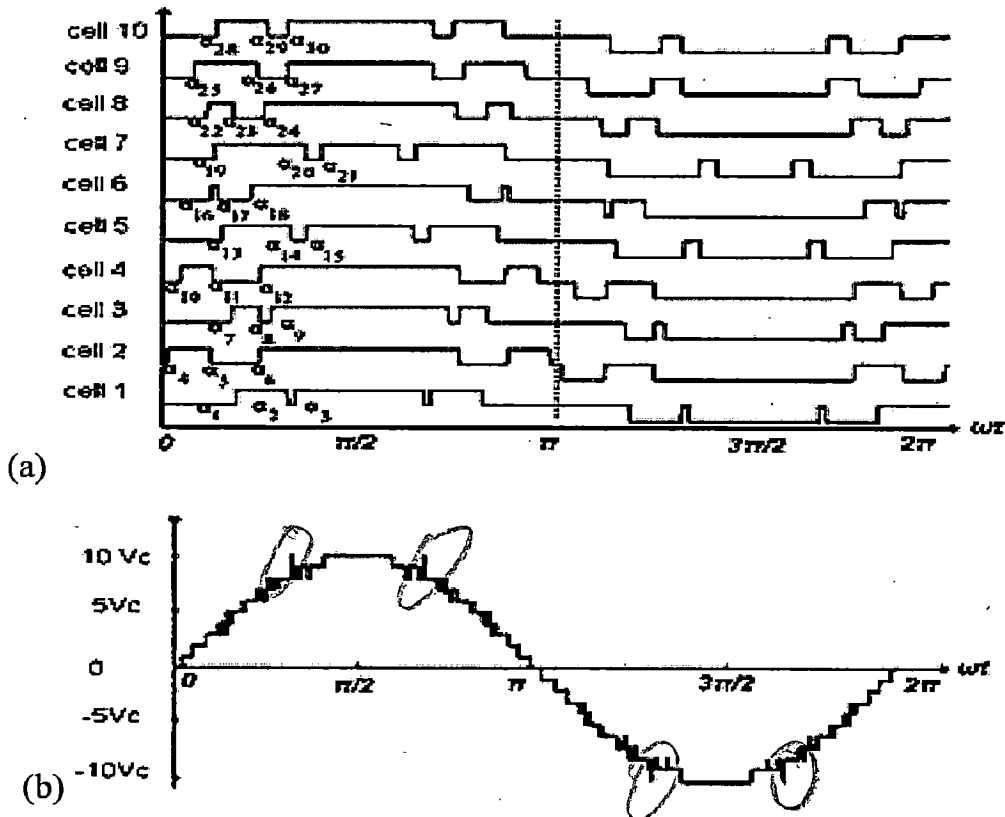
Figure. 2.4 (a)Waveform of the output voltages of the inverter cells. and (b) synthesis of output phase voltage.

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$$\cos\alpha_1 - \cos\alpha_2 + \cos\alpha_3 = m\tfrac{\pi}{4} \tag{2.1}$$

$$\cos\alpha_4 - \cos\alpha_5 + \cos\alpha_6 = m\tfrac{\pi}{4} \tag{2.2}$$

$$\cos\alpha_7 - \cos\alpha_8 + \cos\alpha_9 = m\tfrac{\pi}{4} \tag{2.3}$$

$$\cos\alpha_{10} - \cos\alpha_{11} + \cos\alpha_{12} = m\tfrac{\pi}{4} \tag{2.4}$$

$$\cos\alpha_{13} - \cos\alpha_{14} + \cos\alpha_{15} = m\tfrac{\pi}{4} \tag{2.5}$$

$$\cos\alpha_{16} - \cos\alpha_{17} + \cos\alpha_{18} = m\tfrac{\pi}{4} \tag{2.6}$$

$$\cos\alpha_{19} - \cos\alpha_{20} + \cos\alpha_{21} = m\tfrac{\pi}{4} \tag{2.7}$$

$$\cos\alpha_{22} - \cos\alpha_{23} + \cos\alpha_{24} = m\tfrac{\pi}{4} \tag{2.8}$$

$$\cos\alpha_{25} - \cos\alpha_{26} + \cos\alpha_{27} = m\tfrac{\pi}{4} \tag{2.9}$$

$$\cos\alpha_{28} - \cos\alpha_{29} + \cos\alpha_{30} = m\tfrac{\pi}{4} \tag{2.10}$$

$$
\begin{aligned}
&\cos 3\alpha_1 - \cos 3\alpha_2 + \cos 3\alpha_3 + \cos 3\alpha_4 - \cos 3\alpha_5 + \cos 3\alpha_6 \\
&+ \cos 3\alpha_7 - \cos 3\alpha_8 + \cos 3\alpha_9 + \cos 3\alpha_{10} - \cos 3\alpha_{11} + \cos 3\alpha_{12} \\
&+ \cos 3\alpha_{13} - \cos 3\alpha_{14} + \cos 3\alpha_{15} + \cos 3\alpha_{16} - \cos 3\alpha_{17} + \cos 3\alpha_{18} \\
&+ \cos 3\alpha_{19} - \cos 3\alpha_{20} + \cos 3\alpha_{21} + \cos 3\alpha_{22} - \cos 3\alpha_{23} + \cos 3\alpha_{24} \\
&+ \cos 3\alpha_{25} - \cos 3\alpha_{26} + \cos 3\alpha_{27} + \cos 3\alpha_{28} - \cos 3\alpha_{29} + \cos 3\alpha_{30} = 0
\end{aligned} \tag{2.11}
$$

$$
\begin{aligned}
&\cos 5\alpha_1 - \cos 5\alpha_2 + \cos 5\alpha_3 + \cos 5\alpha_4 - \cos 5\alpha_5 + \cos 5\alpha_6 \\
&+ \cos 5\alpha_7 - \cos 5\alpha_8 + \cos 5\alpha_9 + \cos 5\alpha_{10} - \cos 5\alpha_{11} + \cos 5\alpha_{12} \\
&+ \cos 5\alpha_{13} - \cos 5\alpha_{14} + \cos 5\alpha_{15} + \cos 5\alpha_{16} - \cos 5\alpha_{17} + \cos 5\alpha_{18} \\
&+ \cos 5\alpha_{19} - \cos 5\alpha_{20} + \cos 5\alpha_{21} + \cos 5\alpha_{22} - \cos 5\alpha_{23} + \cos 5\alpha_{24} \\
&+ \cos 5\alpha_{25} - \cos 5\alpha_{26} + \cos 5\alpha_{27} + \cos 5\alpha_{28} - \cos 5\alpha_{29} + \cos 5\alpha_{30} = 0
\end{aligned} \tag{2.12}
$$

$$
\begin{aligned}
&\cos 7\alpha_1 - \cos 7\alpha_2 + \cos 7\alpha_3 + \cos 7\alpha_4 - \cos 7\alpha_5 + \cos 7\alpha_6 \\
&+ \cos 7\alpha_7 - \cos 7\alpha_8 + \cos 7\alpha_9 + \cos 7\alpha_{10} - \cos 7\alpha_{11} + \cos 7\alpha_{12} \\
&+ \cos 7\alpha_{13} - \cos 7\alpha_{14} + \cos 7\alpha_{15} + \cos 7\alpha_{16} - \cos 7\alpha_{17} + \cos 7\alpha_{18} \\
&+ \cos 7\alpha_{19} - \cos 7\alpha_{20} + \cos 7\alpha_{21} + \cos 7\alpha_{22} - \cos 7\alpha_{23} + \cos 7\alpha_{24} \\
&+ \cos 7\alpha_{25} - \cos 7\alpha_{26} + \cos 7\alpha_{27} + \cos 7\alpha_{28} - \cos 7\alpha_{29} + \cos 7\alpha_{30} = 0
\end{aligned} \tag{2.13}
$$

$$
\begin{aligned}
&\cos 9\alpha_1 - \cos 9\alpha_2 + \cos 9\alpha_3 + \cos 9\alpha_4 - \cos 9\alpha_5 + \cos 9\alpha_6 \\
&+ \cos 9\alpha_7 - \cos 9\alpha_8 + \cos 9\alpha_9 + \cos 9\alpha_{10} - \cos 9\alpha_{11} + \cos 9\alpha_{12} \\
&+ \cos 9\alpha_{13} - \cos 9\alpha_{14} + \cos 9\alpha_{15} + \cos 9\alpha_{16} - \cos 9\alpha_{17} + \cos 9\alpha_{18} \\
&+ \cos 9\alpha_{19} - \cos 9\alpha_{20} + \cos 9\alpha_{21} + \cos 9\alpha_{22} - \cos 9\alpha_{23} + \cos 9\alpha_{24} \\
&+ \cos 9\alpha_{25} - \cos 9\alpha_{26} + \cos 9\alpha_{27} + \cos 9\alpha_{28} - \cos 9\alpha_{29} + \cos 9\alpha_{30} = 0
\end{aligned} \tag{2.14}
$$

$$
\begin{aligned}
&\cos 11\alpha_1 - \cos 11\alpha_2 + \cos 11\alpha_3 + \cos 11\alpha_4 - \cos 11\alpha_5 + \cos 11\alpha_6 \\
&+ \cos 11\alpha_7 - \cos 11\alpha_8 + \cos 11\alpha_9 + \cos 11\alpha_{10} - \cos 11\alpha_{11} + \cos 11\alpha_{12} \\
&+ \cos 11\alpha_{13} - \cos 11\alpha_{14} + \cos 11\alpha_{15} + \cos 11\alpha_{16} - \cos 11\alpha_{17} + \cos 11\alpha_{18} \\
&+ \cos 11\alpha_{19} - \cos 11\alpha_{20} + \cos 11\alpha_{21} + \cos 11\alpha_{22} - \cos 11\alpha_{23} + \cos 11\alpha_{24} \\
&+ \cos 11\alpha_{25} - \cos 11\alpha_{26} + \cos 11\alpha_{27} + \cos 11\alpha_{28} - \cos 11\alpha_{29} + \cos 11\alpha_{30} = 0
\end{aligned} \tag{2.15}
$$

$$\cos 13\alpha_1 - \cos 13\alpha_2 + \cos 13\alpha_3 + \cos 13\alpha_4 - \cos 13\alpha_5 + \cos 13\alpha_6$$
$$+\cos 13\alpha_7 - \cos 13\alpha_8 + \cos 13\alpha_9 + \cos 13\alpha_{10} - \cos 13\alpha_{11} + \cos 13\alpha_{12}$$
$$+\cos 13\alpha_{13} - \cos 13\alpha_{14} + \cos 13\alpha_{15} + \cos 13\alpha_{16} - \cos 13\alpha_{17} + \cos 13\alpha_{18}$$
$$+\cos 13\alpha_{19} - \cos 13\alpha_{20} + \cos 13\alpha_{21} + \cos 13\alpha_{22} - \cos 13\alpha_{23} + \cos 13\alpha_{24}$$
$$+\cos 13\alpha_{25} - \cos 13\alpha_{26} + \cos 13\alpha_{27} + \cos 13\alpha_{28} - \cos 13\alpha_{29} + \cos 13\alpha_{30} = 0$$

$$\tag{2.16}$$

$$\cos 15\alpha_1 - \cos 15\alpha_2 + \cos 15\alpha_3 + \cos 15\alpha_4 - \cos 15\alpha_5 + \cos 15\alpha_6$$
$$+\cos 15\alpha_7 - \cos 15\alpha_8 + \cos 15\alpha_9 + \cos 15\alpha_{10} - \cos 15\alpha_{11} + \cos 15\alpha_{12}$$
$$+\cos 15\alpha_{13} - \cos 15\alpha_{14} + \cos 15\alpha_{15} + \cos 15\alpha_{16} - \cos 15\alpha_{17} + \cos 15\alpha_{18}$$
$$+\cos 15\alpha_{19} - \cos 15\alpha_{20} + \cos 15\alpha_{21} + \cos 15\alpha_{22} - \cos 15\alpha_{23} + \cos 15\alpha_{24}$$
$$+\cos 15\alpha_{25} - \cos 15\alpha_{26} + \cos 15\alpha_{27} + \cos 15\alpha_{28} - \cos 15\alpha_{29} + \cos 15\alpha_{30} = 0$$

$$\tag{2.17}$$

$$\cos 17\alpha_1 - \cos 17\alpha_2 + \cos 17\alpha_3 + \cos 17\alpha_4 - \cos 17\alpha_5 + \cos 17\alpha_6$$
$$+\cos 17\alpha_7 - \cos 17\alpha_8 + \cos 17\alpha_9 + \cos 17\alpha_{10} - \cos 17\alpha_{11} + \cos 17\alpha_{12}$$
$$+\cos 17\alpha_{13} - \cos 17\alpha_{14} + \cos 17\alpha_{15} + \cos 17\alpha_{16} - \cos 17\alpha_{17} + \cos 17\alpha_{18}$$
$$+\cos 17\alpha_{19} - \cos 17\alpha_{20} + \cos 17\alpha_{21} + \cos 17\alpha_{22} - \cos 17\alpha_{23} + \cos 17\alpha_{24}$$
$$+\cos 17\alpha_{25} - \cos 17\alpha_{26} + \cos 17\alpha_{27} + \cos 17\alpha_{28} - \cos 17\alpha_{29} + \cos 17\alpha_{30} = 0$$

$$\tag{2.18}$$

$$\cos 19\alpha_1 - \cos 19\alpha_2 + \cos 19\alpha_3 + \cos 19\alpha_4 - \cos 19\alpha_5 + \cos 19\alpha_6$$
$$+\cos 19\alpha_7 - \cos 19\alpha_8 + \cos 19\alpha_9 + \cos 19\alpha_{10} - \cos 19\alpha_{11} + \cos 19\alpha_{12}$$
$$+\cos 19\alpha_{13} - \cos 19\alpha_{14} + \cos 19\alpha_{15} + \cos 19\alpha_{16} - \cos 19\alpha_{17} + \cos 19\alpha_{18}$$
$$+\cos 19\alpha_{19} - \cos 19\alpha_{20} + \cos 19\alpha_{21} + \cos 19\alpha_{22} - \cos 19\alpha_{23} + \cos 19\alpha_{24}$$
$$+\cos 19\alpha_{25} - \cos 19\alpha_{26} + \cos 19\alpha_{27} + \cos 19\alpha_{28} - \cos 19\alpha_{29} + \cos 19\alpha_{30} = 0$$

$$\tag{2.19}$$

$$\cos 21\alpha_1 - \cos 21\alpha_2 + \cos 21\alpha_3 + \cos 21\alpha_4 - \cos 21\alpha_5 + \cos 21\alpha_6$$
$$+\cos 21\alpha_7 - \cos 21\alpha_8 + \cos 21\alpha_9 + \cos 21\alpha_{10} - \cos 21\alpha_{11} + \cos 21\alpha_{12}$$
$$+\cos 21\alpha_{13} - \cos 21\alpha_{14} + \cos 21\alpha_{15} + \cos 21\alpha_{16} - \cos 21\alpha_{17} + \cos 21\alpha_{18}$$
$$+\cos 21\alpha_{19} - \cos 21\alpha_{20} + \cos 21\alpha_{21} + \cos 21\alpha_{22} - \cos 21\alpha_{23} + \cos 21\alpha_{24}$$
$$+\cos 21\alpha_{25} - \cos 21\alpha_{26} + \cos 21\alpha_{27} + \cos 21\alpha_{28} - \cos 21\alpha_{29} + \cos 21\alpha_{30} = 0$$

$$\tag{2.20}$$

$$\cos 23\alpha_1 - \cos 23\alpha_2 + \cos 23\alpha_3 + \cos 23\alpha_4 - \cos 23\alpha_5 + \cos 23\alpha_6$$
$$+\cos 23\alpha_7 - \cos 23\alpha_8 + \cos 23\alpha_9 + \cos 23\alpha_{10} - \cos 23\alpha_{11} + \cos 23\alpha_{12}$$
$$+\cos 23\alpha_{13} - \cos 23\alpha_{14} + \cos 23\alpha_{15} + \cos 23\alpha_{16} - \cos 23\alpha_{17} + \cos 23\alpha_{18}$$
$$+\cos 23\alpha_{19} - \cos 23\alpha_{20} + \cos 23\alpha_{21} + \cos 23\alpha_{22} - \cos 23\alpha_{23} + \cos 23\alpha_{24}$$
$$+\cos 23\alpha_{25} - \cos 23\alpha_{26} + \cos 23\alpha_{27} + \cos 23\alpha_{28} - \cos 23\alpha_{29} + \cos 23\alpha_{30} = 0$$

$$\tag{2.21}$$

$$\cos 25\alpha_1 - \cos 25\alpha_2 + \cos 25\alpha_3 + \cos 25\alpha_4 - \cos 25\alpha_5 + \cos 25\alpha_6$$
$$+\cos 25\alpha_7 - \cos 25\alpha_8 + \cos 25\alpha_9 + \cos 25\alpha_{10} - \cos 25\alpha_{11} + \cos 25\alpha_{12}$$
$$+\cos 25\alpha_{13} - \cos 25\alpha_{14} + \cos 25\alpha_{15} + \cos 25\alpha_{16} - \cos 25\alpha_{17} + \cos 25\alpha_{18}$$
$$+\cos 25\alpha_{19} - \cos 25\alpha_{20} + \cos 25\alpha_{21} + \cos 25\alpha_{22} - \cos 25\alpha_{23} + \cos 25\alpha_{24}$$
$$+\cos 25\alpha_{25} - \cos 25\alpha_{26} + \cos 25\alpha_{27} + \cos 25\alpha_{28} - \cos 25\alpha_{29} + \cos 25\alpha_{30} = 0$$

$$\tag{2.22}$$

$$\cos 27\alpha_1 - \cos 27\alpha_2 + \cos 27\alpha_3 + \cos 27\alpha_4 - \cos 27\alpha_5 + \cos 27\alpha_6$$
$$+\cos 27\alpha_7 - \cos 27\alpha_8 + \cos 27\alpha_9 + \cos 27\alpha_{10} - \cos 27\alpha_{11} + \cos 27\alpha_{12}$$
$$+\cos 27\alpha_{13} - \cos 27\alpha_{14} + \cos 27\alpha_{15} + \cos 27\alpha_{16} - \cos 27\alpha_{17} + \cos 27\alpha_{18} \qquad (2.23)$$
$$+\cos 27\alpha_{19} - \cos 27\alpha_{20} + \cos 27\alpha_{21} + \cos 27\alpha_{22} - \cos 27\alpha_{23} + \cos 27\alpha_{24}$$
$$+\cos 27\alpha_{25} - \cos 27\alpha_{26} + \cos 27\alpha_{27} + \cos 27\alpha_{28} - \cos 27\alpha_{29} + \cos 27\alpha_{30} = 0$$

$$\cos 29\alpha_1 - \cos 29\alpha_2 + \cos 29\alpha_3 + \cos 29\alpha_4 - \cos 29\alpha_5 + \cos 29\alpha_6$$
$$+\cos 29\alpha_7 - \cos 29\alpha_8 + \cos 29\alpha_9 + \cos 29\alpha_{10} - \cos 29\alpha_{11} + \cos 29\alpha_{12}$$
$$+\cos 29\alpha_{13} - \cos 29\alpha_{14} + \cos 29\alpha_{15} + \cos 29\alpha_{16} - \cos 29\alpha_{17} + \cos 29\alpha_{18} \qquad (2.24)$$
$$+\cos 29\alpha_{19} - \cos 29\alpha_{20} + \cos 29\alpha_{21} + \cos 29\alpha_{22} - \cos 29\alpha_{23} + \cos 29\alpha_{24}$$
$$+\cos 29\alpha_{25} - \cos 29\alpha_{26} + \cos 29\alpha_{27} + \cos 29\alpha_{28} - \cos 29\alpha_{29} + \cos 29\alpha_{30} = 0$$

$$\cos 31\alpha_1 - \cos 31\alpha_2 + \cos 31\alpha_3 + \cos 31\alpha_4 - \cos 31\alpha_5 + \cos 31\alpha_6$$
$$+\cos 31\alpha_7 - \cos 31\alpha_8 + \cos 31\alpha_9 + \cos 31\alpha_{10} - \cos 31\alpha_{11} + \cos 31\alpha_{12}$$
$$+\cos 31\alpha_{13} - \cos 31\alpha_{14} + \cos 31\alpha_{15} + \cos 31\alpha_{16} - \cos 31\alpha_{17} + \cos 31\alpha_{18} \qquad (2.25)$$
$$+\cos 31\alpha_{19} - \cos 31\alpha_{20} + \cos 31\alpha_{21} + \cos 31\alpha_{22} - \cos 31\alpha_{23} + \cos 31\alpha_{24}$$
$$+\cos 31\alpha_{25} - \cos 31\alpha_{26} + \cos 31\alpha_{27} + \cos 31\alpha_{28} - \cos 31\alpha_{29} + \cos 31\alpha_{30} = 0$$

$$\cos 33\alpha_1 - \cos 33\alpha_2 + \cos 33\alpha_3 + \cos 33\alpha_4 - \cos 33\alpha_5 + \cos 33\alpha_6$$
$$+\cos 33\alpha_7 - \cos 33\alpha_8 + \cos 33\alpha_9 + \cos 33\alpha_{10} - \cos 33\alpha_{11} + \cos 33\alpha_{12}$$
$$+\cos 33\alpha_{13} - \cos 33\alpha_{14} + \cos 33\alpha_{15} + \cos 33\alpha_{16} - \cos 33\alpha_{17} + \cos 33\alpha_{18} \qquad (2.26)$$
$$+\cos 33\alpha_{19} - \cos 33\alpha_{20} + \cos 33\alpha_{21} + \cos 33\alpha_{22} - \cos 33\alpha_{23} + \cos 33\alpha_{24}$$
$$+\cos 33\alpha_{25} - \cos 33\alpha_{26} + \cos 33\alpha_{27} + \cos 33\alpha_{28} - \cos 33\alpha_{29} + \cos 33\alpha_{30} = 0$$

$$\cos 35\alpha_1 - \cos 35\alpha_2 + \cos 35\alpha_3 + \cos 35\alpha_4 - \cos 35\alpha_5 + \cos 35\alpha_6$$
$$+\cos 35\alpha_7 - \cos 35\alpha_8 + \cos 35\alpha_9 + \cos 35\alpha_{10} - \cos 35\alpha_{11} + \cos 35\alpha_{12}$$
$$+\cos 35\alpha_{13} - \cos 35\alpha_{14} + \cos 35\alpha_{15} + \cos 35\alpha_{16} - \cos 35\alpha_{17} + \cos 35\alpha_{18} \qquad (2.27)$$
$$+\cos 35\alpha_{19} - \cos 35\alpha_{20} + \cos 35\alpha_{21} + \cos 35\alpha_{22} - \cos 35\alpha_{23} + \cos 35\alpha_{24}$$
$$+\cos 35\alpha_{25} - \cos 35\alpha_{26} + \cos 35\alpha_{27} + \cos 35\alpha_{28} - \cos 35\alpha_{29} + \cos 35\alpha_{30} = 0$$

$$\cos 37\alpha_1 - \cos 37\alpha_2 + \cos 37\alpha_3 + \cos 37\alpha_4 - \cos 37\alpha_5 + \cos 37\alpha_6$$
$$+\cos 37\alpha_7 - \cos 37\alpha_8 + \cos 37\alpha_9 + \cos 37\alpha_{10} - \cos 37\alpha_{11} + \cos 37\alpha_{12}$$
$$+\cos 37\alpha_{13} - \cos 37\alpha_{14} + \cos 37\alpha_{15} + \cos 37\alpha_{16} - \cos 37\alpha_{17} + \cos 37\alpha_{18} \qquad (2.28)$$
$$+\cos 37\alpha_{19} - \cos 37\alpha_{20} + \cos 37\alpha_{21} + \cos 37\alpha_{22} - \cos 37\alpha_{23} + \cos 37\alpha_{24}$$
$$+\cos 37\alpha_{25} - \cos 37\alpha_{26} + \cos 37\alpha_{27} + \cos 37\alpha_{28} - \cos 37\alpha_{29} + \cos 37\alpha_{30} = 0$$

$$\cos 39\alpha_1 - \cos 39\alpha_2 + \cos 39\alpha_3 + \cos 39\alpha_4 - \cos 39\alpha_5 + \cos 39\alpha_6$$
$$+\cos 39\alpha_7 - \cos 39\alpha_8 + \cos 39\alpha_9 + \cos 39\alpha_{10} - \cos 39\alpha_{11} + \cos 39\alpha_{12}$$
$$+\cos 39\alpha_{13} - \cos 39\alpha_{14} + \cos 39\alpha_{15} + \cos 39\alpha_{16} - \cos 39\alpha_{17} + \cos 39\alpha_{18} \qquad (2.29)$$
$$+\cos 39\alpha_{19} - \cos 39\alpha_{20} + \cos 39\alpha_{21} + \cos 39\alpha_{22} - \cos 39\alpha_{23} + \cos 39\alpha_{24}$$
$$+\cos 39\alpha_{25} - \cos 39\alpha_{26} + \cos 39\alpha_{27} + \cos 39\alpha_{28} - \cos 39\alpha_{29} + \cos 39\alpha_{30} = 0$$

$$\cos 41\alpha_1 - \cos 41\alpha_2 + \cos 41\alpha_3 + \cos 41\alpha_4 - \cos 41\alpha_5 + \cos 41\alpha_6$$
$$+ \cos 41\alpha_7 - \cos 41\alpha_8 + \cos 41\alpha_9 + \cos 41\alpha_{10} - \cos 41\alpha_{11} + \cos 41\alpha_{12}$$
$$+ \cos 41\alpha_{13} - \cos 41\alpha_{14} + \cos 41\alpha_{15} + \cos 41\alpha_{16} - \cos 41\alpha_{17} + \cos 41\alpha_{18} \quad (2.30)$$
$$+ \cos 41\alpha_{19} - \cos 41\alpha_{20} + \cos 41\alpha_{21} + \cos 41\alpha_{22} - \cos 41\alpha_{23} + \cos 41\alpha_{24}$$
$$+ \cos 41\alpha_{25} - \cos 41_{26} + \cos 41\alpha_{27} + \cos 41\alpha_{28} - \cos 41\alpha_{29} + \cos 41\alpha_{30} = 0$$

$$\alpha_1 < \alpha_2 < \alpha_3 \qquad (2.31)$$

$$\alpha_4 < \alpha_5 < \alpha_6 \qquad (2.32)$$

$$\alpha_7 < \alpha_8 < \alpha_9 \qquad (2.33)$$

$$\alpha_{10} < \alpha_{11} < \alpha_{12} \qquad (2.34)$$

$$\alpha_{13} < \alpha_{14} < \alpha_{15} \qquad (2.35)$$

$$\alpha_{16} < \alpha_{17} < \alpha_{18} \qquad (2.36)$$

$$\alpha_{19} < \alpha_{20} < \alpha_{21} \qquad (2.37)$$

$$\alpha_{22} < \alpha_{23} < \alpha_{24} \qquad (2.38)$$

$$\alpha_{25} < \alpha_{26} < \alpha_{27} \qquad (2.39)$$

$$\alpha_{28} < \alpha_{29} < \alpha_{30} \qquad (2.40)$$

$$0 \leq \alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7, \alpha_8, \alpha_9, \alpha_{10}, \alpha_{11}, \alpha_{12}, \alpha_{13}, \alpha_{14}, \alpha_{15}, \alpha_{16}, \alpha_{17}, \alpha_{18}, \alpha_{19}, \alpha_{20}, \alpha_{21}, \alpha_{22}, \alpha_{23}, \alpha_{24}, \alpha_{25}, \alpha_{26}, \alpha_{27}, \alpha_{28}, \alpha_{29}, \alpha_{30} \leq 90 \qquad (2.41)$$

The inequalities from Eqns. (2.31)–(2.40) are expressed in Ax<B form by the following matrix. The B matrix has been chosen to maintain a margin of 0.5° between each angles of a single cell so that the two angles are resolvable in a discrete time simulation.

$$\begin{pmatrix} 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \\ \alpha_5 \\ \alpha_6 \\ \alpha_7 \\ \alpha_8 \\ \alpha_9 \\ \alpha_{10} \\ \alpha_{11} \\ \alpha_{12} \\ \alpha_{13} \\ \alpha_{14} \\ \alpha_{15} \\ \alpha_{16} \\ \alpha_{17} \\ \alpha_{18} \\ \alpha_{19} \\ \alpha_{20} \\ \alpha_{21} \\ \alpha_{22} \\ \alpha_{23} \\ \alpha_{24} \\ \alpha_{25} \\ \alpha_{26} \\ \alpha_{27} \\ \alpha_{28} \\ \alpha_{29} \\ \alpha_{30} \end{pmatrix} < \begin{pmatrix} -0.5 \\ -0.5 \\ -0.5 \\ -0.5 \\ -0.5 \\ -0.5 \\ -0.5 \\ -0.5 \\ -0.5 \\ -0.5 \\ -0.5 \\ -0.5 \\ -0.5 \\ -0.5 \\ -0.5 \\ -0.5 \\ -0.5 \\ -0.5 \\ -0.5 \\ -0.5 \end{pmatrix}$$

2.3 Optimization by Genetic Algorithm

The first 10 equations correspond to equalization of fundamental voltages of the ten bridges. The linear inequalities and bounds are the validations for the practical correct solutions for the variables to be use as firing angles. The problem is modified to minimization one by replacing the 20 nonlinear equations to a single Total Harmonic Distortion function as

given in Eqns. (2.42). The nonlinear equality constraints are from Eqns. (2.1)-(2.10). The linear inequality constraints are Eqns. (2.31)-(2.41) and bound is given by Eqns. (2.41) Genetic Algorithm is used as a first attempt to obtain the global minimum of the constrained THD function for modulation index 0.550 to 1.000 in steps of 0.001. Two sets of parameters for Genetic Algorithm have been applied with different crossover function in the GA toolbox [23]. The results obtained are quite similar but far from being acceptable as the THDs obtained in these two methods, as shown in Fig. 2.5 and Fig 2.6., are unacceptably high.

Table 2.2: The parameters for Genetic Algorithm

GA parameter set	Details of set 1	Details of set 2
Initial Population range	0,90	0,90
Initial Population size	100	100
Crossover fraction	0.6	0.6
Migration direction	both	both
Generations	30	30
Selection function	roulette	roulette
Crossover function	Uniform	Heuristic 1.3165
Mutation	Adaptive feasible	Adaptive feasible

The fitness function which is to be minimized is the Total Harmonic Distortion given as:

$$THD = \sum_{n=1,3,5,\ldots}^{41} \begin{aligned}[\frac{4}{n\pi}(\cos n\alpha_1 - \cos n\alpha_2 + \cos n\alpha_3 + \cos n\alpha_4 - \cos n\alpha_5 + \cos n\alpha_6 \\ + \cos n\alpha_7 - \cos n\alpha_8 + \cos n\alpha_9 + \cos n\alpha_{10} - \cos n\alpha_{11} + \cos n\alpha_{12} \\ + \cos n\alpha_{13} - \cos n\alpha_{14} + \cos n\alpha_{15} + \cos n\alpha_{16} - \cos n\alpha_{17} + \cos n\alpha_{18} \\ + \cos n\alpha_{19} - \cos n\alpha_{20} + \cos n\alpha_{21} + \cos n\alpha_{22} - \cos n\alpha_{23} + \cos n\alpha_{24} \\ + \cos n\alpha_{25} - \cos n\alpha_{26} + \cos n\alpha_{27} + \cos n\alpha_{28} - \cos n\alpha_{29} + \cos n\alpha_{30})]^2 \end{aligned} \quad (2.42)$$
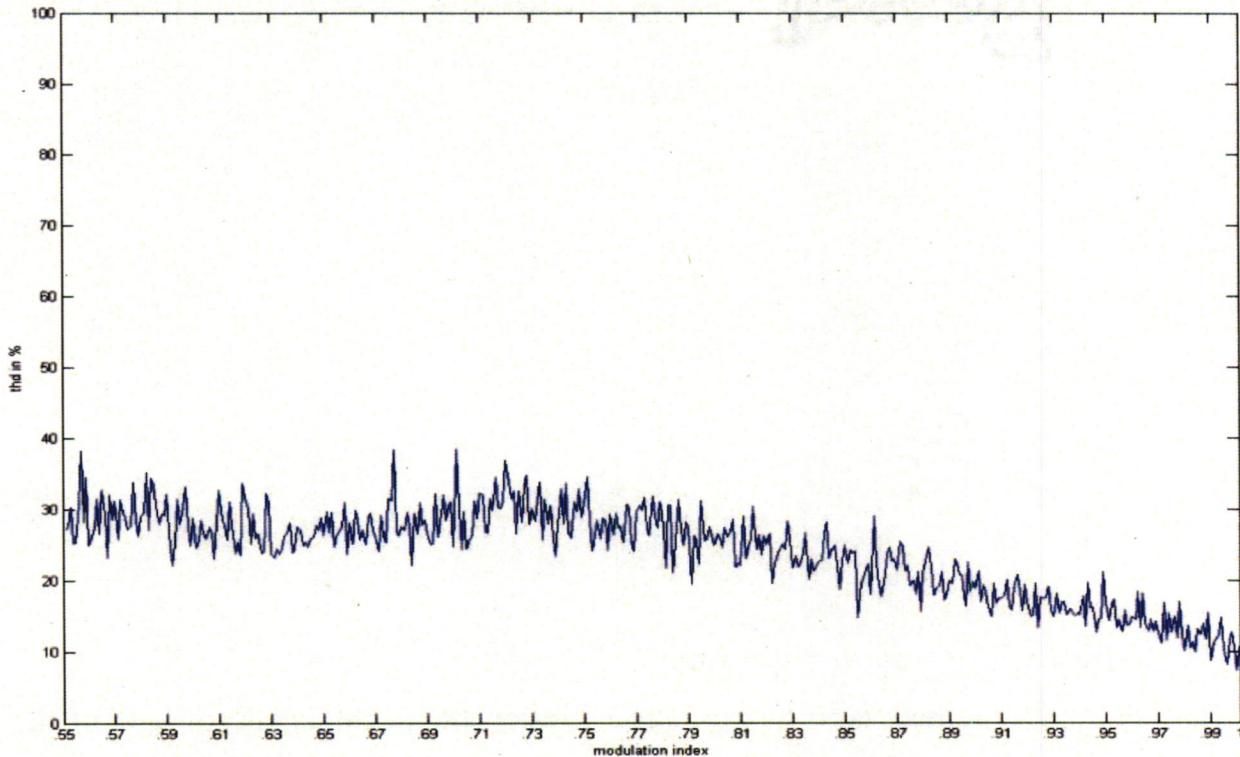
Figure 2.5 Variation of %THD obtained by GA with set 1
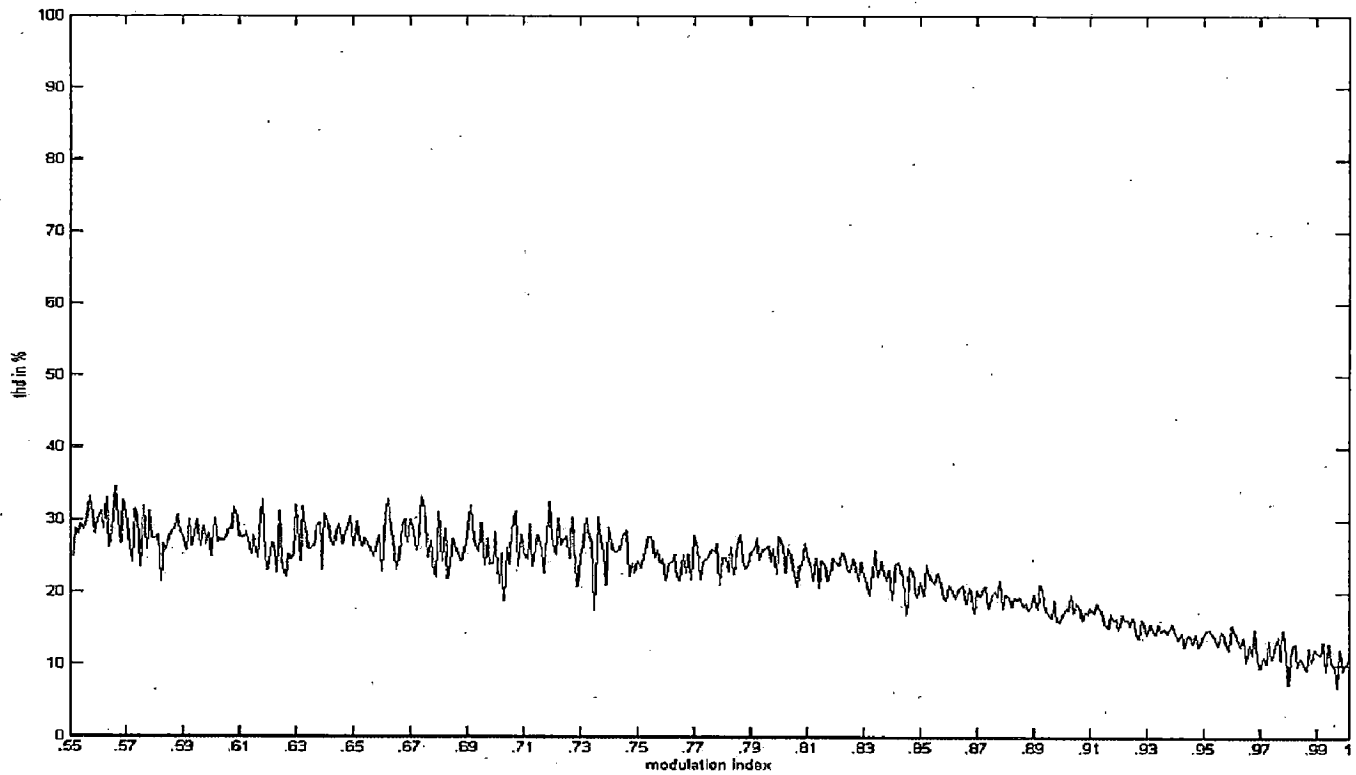
Figure 2.6 Variation of %THD obtained by GA with set 2

The crossover function which generates new individual from the existing population has been applied are Uniform and Heuristic with fraction 1.13165. The Heuristic crossover creates children that lie on the line containing the two parents, a small distance away from the parent with the better fitness value in the direction away from the parent with the worse fitness value, but still the performance has not improved.

To find the switching angles with acceptable level of THD, the sequential quadratic programming (SQP) technique has been used. The initial conditions for SQP are computed by the algorithm described in next subsection.

2.4   A new initial condition algorithm for THD minimization

Elimination of lower order harmonics from only one cell which will be called a general SHEPWM method can be obtained by solving a system of 3 equation for three times switching in quarter cycle. Phase shift is an effective and simple method to decrease harmonic content in multilevel converter. Here phase shift together with 3 levels SHEPWM is used to obtain starting point for multilevel optimization. To preserve the high amplitude of the fundamental, the phase shift angle β among the 10 cells should be small. By 3 levels SHEPWM third and fifth harmonics are eliminated. For calculating phase shift harmonic order 11 is considered for which the value of β is 3.273° [24] as shown in appendix A. The 30 initial condition for each modulation index are obtained as follows, where a, b, c are the firing angles of the first cell in quarter cycle.

$$\cos a - \cos b + \cos c = m\tfrac{\pi}{4} \tag{2.43}$$

$$\cos 3a - \cos 3b + \cos 3c = 0 \tag{2.44}$$

$$\cos 5a + \cos 5b + \cos 5c = 0 \tag{2.45}$$

$$
\begin{aligned}
x0 = [&a,b,c,a-\beta,b-\beta,c-\beta,a+\beta,b+\beta,c+\beta,a-2\beta,b-2\beta,c-2\beta,\\
&a+2\beta,b+2\beta,c+2\beta,a-3\beta,b-3\beta,c-3\beta,a+3\beta,b+3\beta,c+3\beta,\\
&a-4\beta,b-4\beta,c-4\beta,a+4\beta,b+4\beta,c+4\beta,a-5\beta,b-5\beta,c-5\beta]
\end{aligned} \tag{2.46}
$$

The alternative initial condition, which are

$$
\begin{aligned}
x0 = [&a,b,c,a+\beta,b+\beta,c+\beta,a-\beta,b-\beta,c-\beta,a+2\beta,b+2\beta,c+2\beta,\\
&a-2\beta,b-2\beta,c-2\beta,a+3\beta,b+3\beta,c+3\beta,a-3\beta,b-3\beta,c-3\beta,\\
&a+4\beta,b+4\beta,c+4\beta,a-4\beta,b-4\beta,c-4\beta,a+5\beta,b+5\beta,c+5\beta]
\end{aligned} \tag{2.47}
$$

have not been consider because some initial condition results in angles greater than 90 degree. The %THD is plotted with modulation index from 0.550 to 1.000 in steps of 0.001. In Fig. 2.7 the MATLAB plot is the arithmetic function value for given modulation index and the PSCAD plot is the THD for the synthesized inverter voltage waveform. The optimization toolbox has been used to minimize the THD function. The algorithm used is Sequential Quadratic Programming Quasi Newton Line Search. The constrained satisfaction graph is also plotted in Fig 2.8 and the number of iterations for each modulation index optimization is plotted in Fig 2.9. This concludes the validity of the phase shift method by very good convergence and the satisfaction of the constraints which enlightens us to do away with the individual DC voltage controllers. In the next chapter STATCOM operation has been discussed in detail.
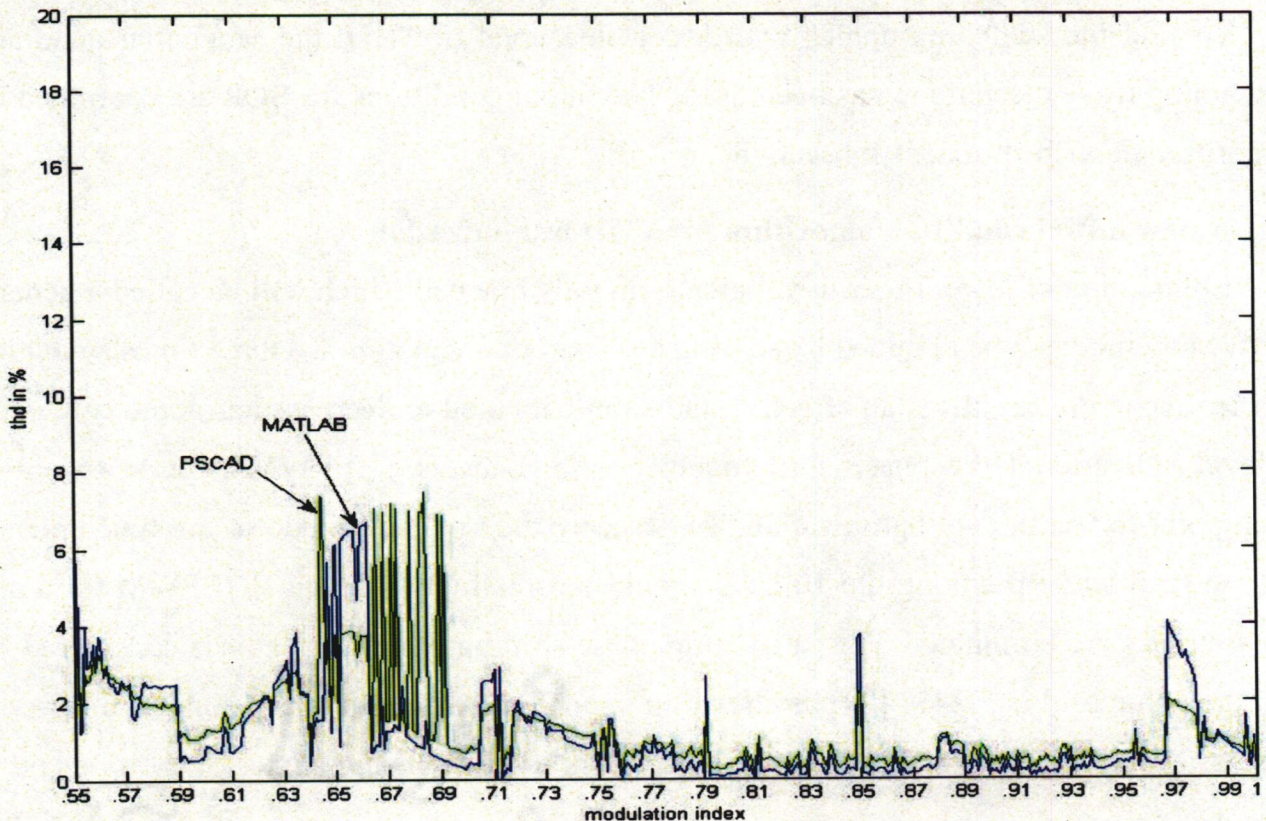
Figure 2.7 variation of % THD obtained by SQP

24
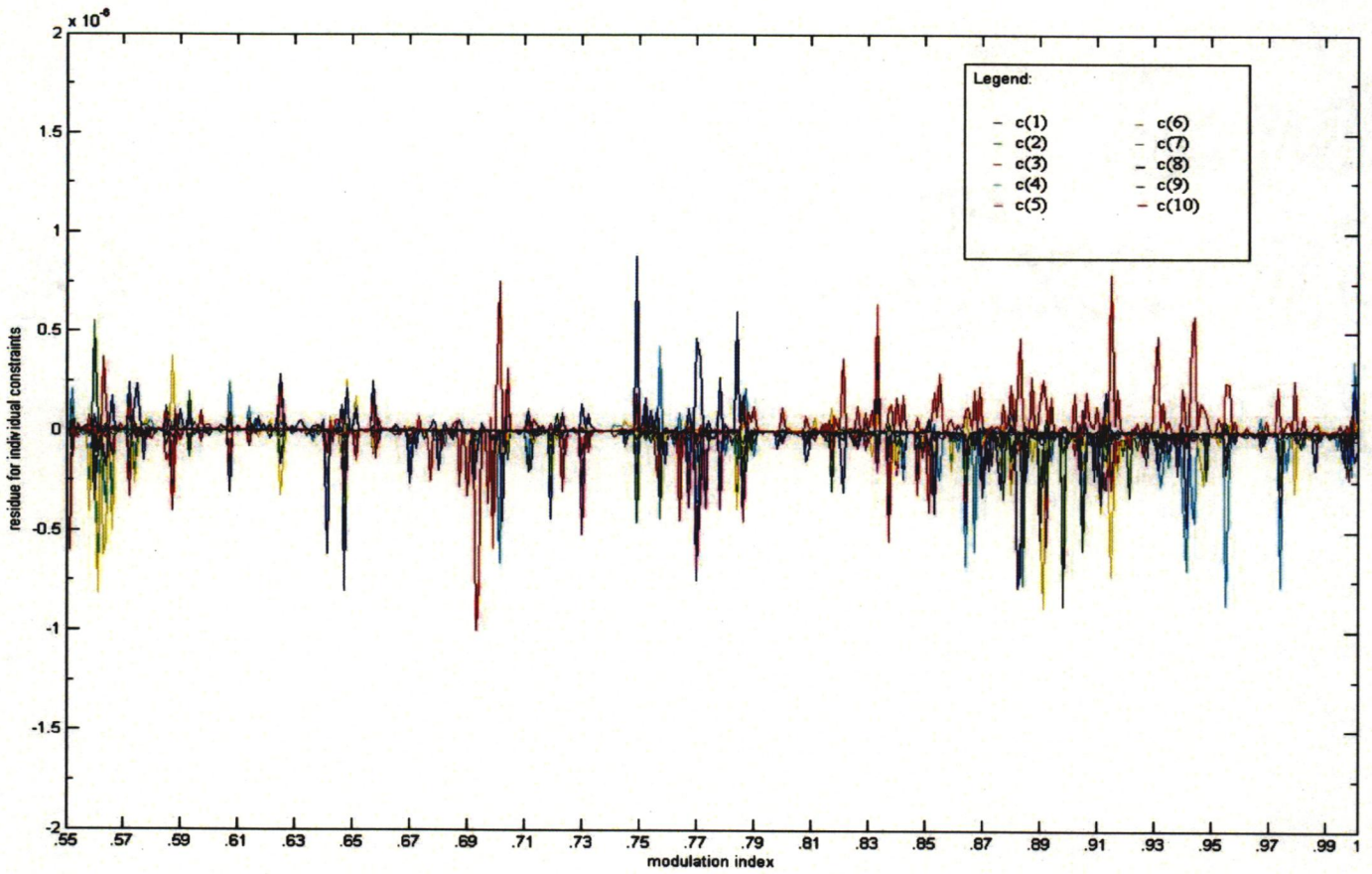
Figure 2.8 constrained satisfaction
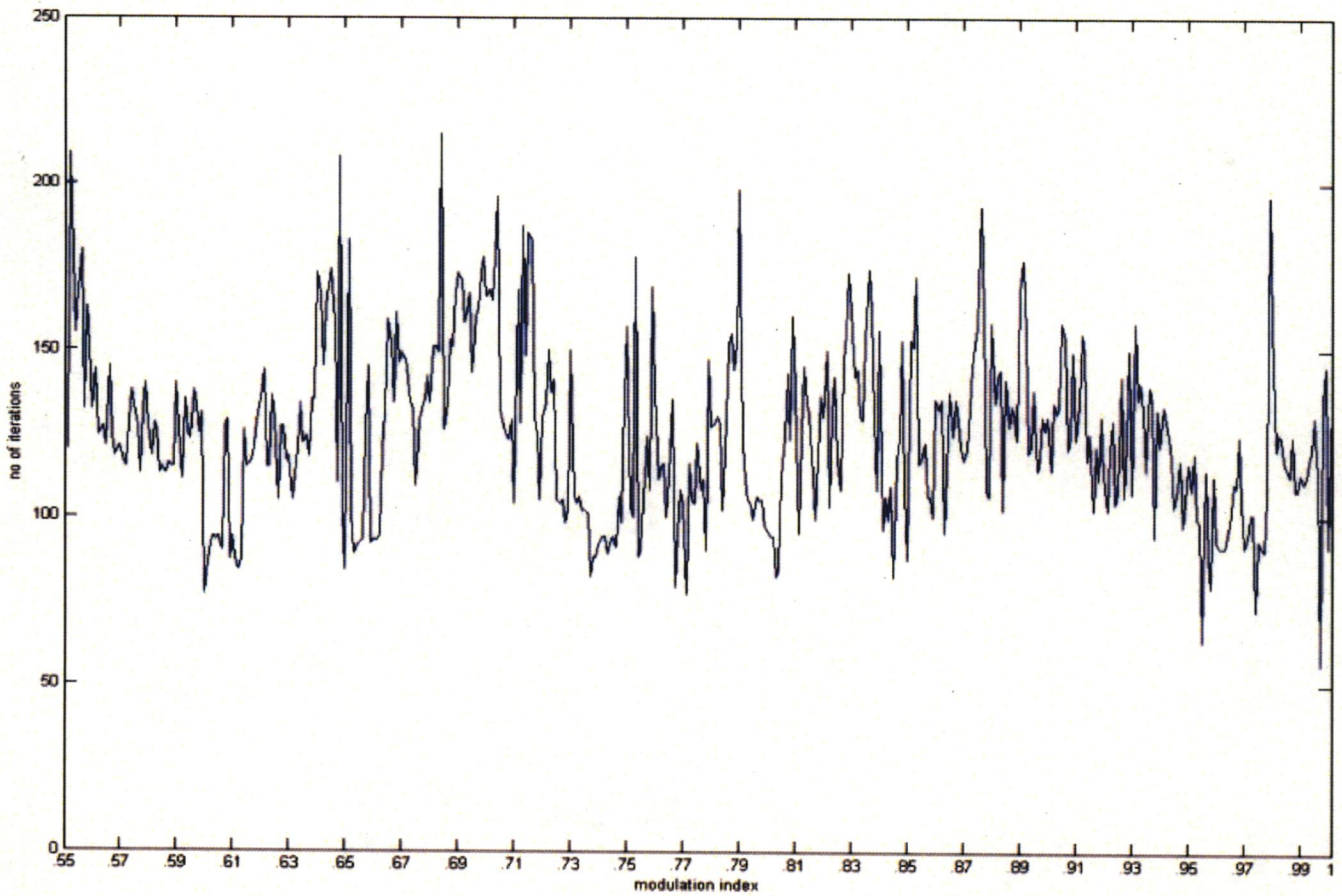
Figure 2.9 No. of iterations of SQP

25

3.1 The Distribution system

The performance of STATCOM has to be evaluated in a practical grid. The 27 bus distribution system as shown in Fig 3.1[25] has been considered in this work and been simulated in PSCAD. The distribution system consists of single generator of 132 kV. The weak bus named 'Southery 11 BB' is identified to have a voltage of 0.92 pu during normal operation. As a result the STATCOM has been placed at this bus with a rating of ±30 MVA.
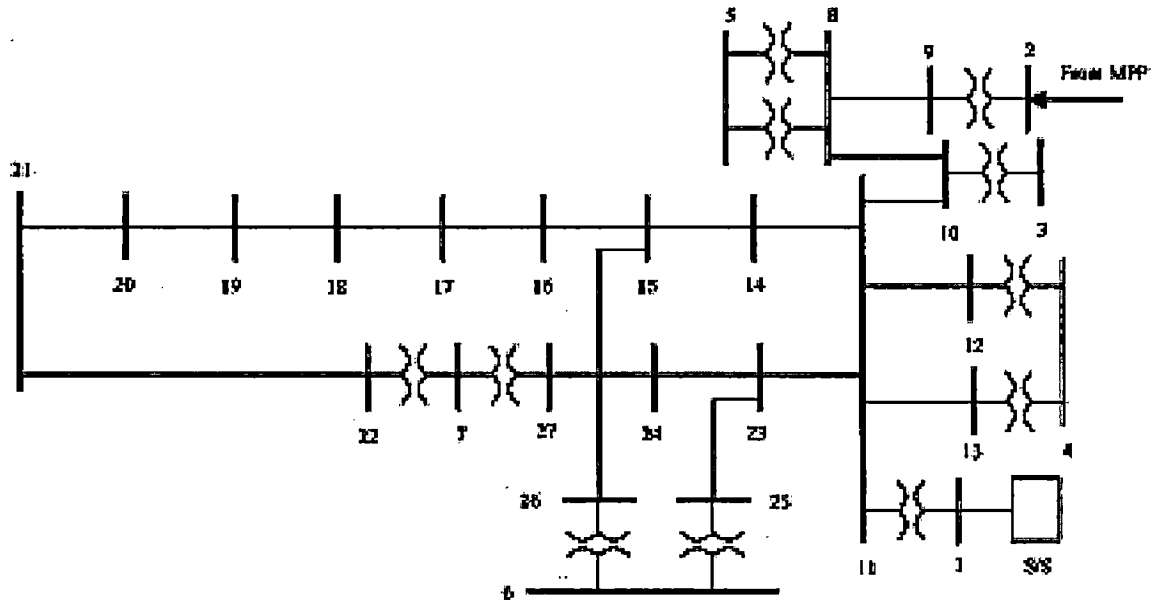
Figure 3.1 Single Line Diagram of Distribution system

3.2 System start up

The task of starting up the STATCOM is to bring the reactive power output to a certain level in a very short time, while maintaining all the switching devices within their ratings. The challenge of starting up the STATCOM lies in the fact that, before startup, the dc capacitor voltages are zero. It is observed, however, that when all the active switches are suppressed (no gating signals are supplied to these switches), the STATCOM system is actually composed of several cascading full-bridge rectifiers with no dc-side load except the dc capacitors. The balanced charging has been achieved without excessive absorption of the current above the transformer ratings.

The system is in rectifying mode from 0 to about 1.5s. At about 1.2s, the resistor is bypassed and the gating signals of the STATCOM active switches are enabled at 1.5s. The modulation index is ramped down from 1 to 0.656 to prevent the voltage dip when the power switches are enabled and the delta is fixed at 4.98 degree. This results in the increase in the capacitor voltage to 1.1547pu. At about 3.1s, the dc capacitor voltage reaches the required

level and the STATCOM is put into regulation mode. From 0 to 3.1s, the STATCOM is absorbing more real power than its total component loss. As a result, the capacitor voltage keeps increasing. After 3.1s the real power absorbed by the STATCOM equals its total component loss. Hence, the dc capacitor voltage maintains the same level as shown in Fig 3.2 (c). The next section deals with mathematical model and designing of nonlinear control system.
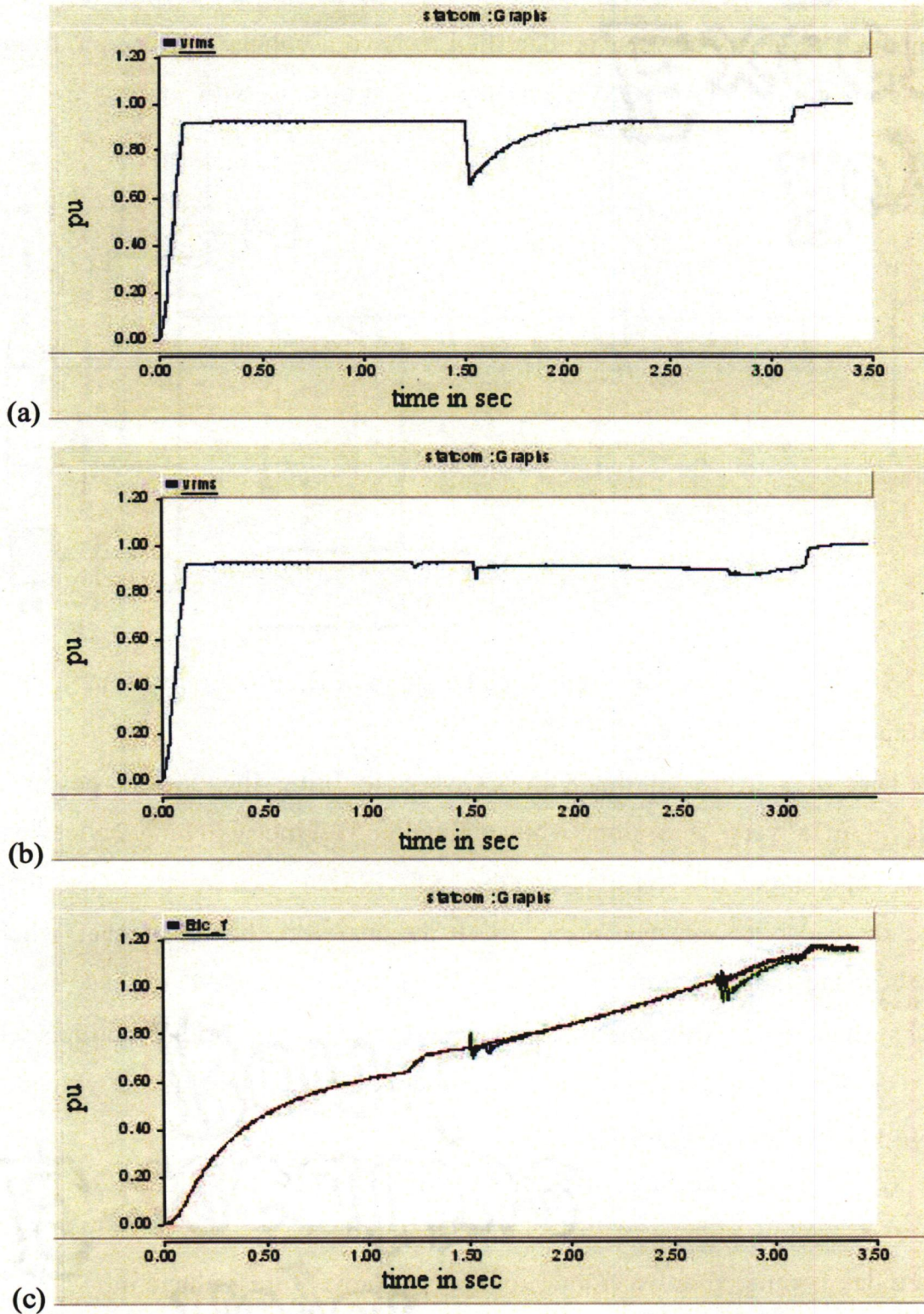
Figure 3.2 (a)Vrms without modulation index ramp (b) (c) Vrms and Vdc(3 phase) with ramped modulation index

3.3   Vector representation of instantaneous three-phase quantities

The main function of the STATCOM is to regulate the transmission line voltage at the point of connection. It achieves this objective by injecting a controlled reactive current to the line. The STATCOM also has the intrinsic ability to exchange real power with the line. As there are no sizeable power sources or sinks associated with the inverter and its DC-side components, the real power must be actively controlled to a value which is zero on average and which departs from zero only to compensate for the losses.

A set of three instantaneous phase variables that sum to zero can be uniquely represented by a vector in orthogonal coordinates by Parks' transformation [6]. This is also called DQ transformation. The DQ transformation expresses synchronous three phase time varying quantity to a time invariant vector in synchronously rotating frame. The three phase voltage source as modeled in PSCAD can be expressed in DQ frame by the given transformation.

$$[c] = \frac{2}{3} \begin{bmatrix} \sin(\omega t) & \sin(\omega t - \frac{2\pi}{3}) & \sin(\omega t + \frac{2\pi}{3}) \\ \cos(\omega t) & \cos(\omega t - \frac{2\pi}{3}) & \cos(\omega t + \frac{2\pi}{3}) \end{bmatrix}$$

(3.1)

So that the voltage source

$$[v_a \quad v_b \quad v_c]^t = \begin{bmatrix} v_m \sin \omega t & v_m \sin(\omega t - \frac{2\pi}{3}) & v_m \sin(\omega t + \frac{2\pi}{3}) \end{bmatrix}^t$$

(3.2)

in DQ frame transforms to

$$\begin{bmatrix} v_d \\ v_q \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \sin(\omega t) & \sin(\omega t - \frac{2\pi}{3}) & \sin(\omega t + \frac{2\pi}{3}) \\ \cos(\omega t) & \cos(\omega t - \frac{2\pi}{3}) & \cos(\omega t + \frac{2\pi}{3}) \end{bmatrix} \begin{bmatrix} v_m \sin(\omega t) \\ v_m \sin(\omega t - \frac{2\pi}{3}) \\ v_m \sin(\omega t + \frac{2\pi}{3}) \end{bmatrix} = \begin{bmatrix} v_m \\ 0 \end{bmatrix}$$

(3.3)

To use the inbuilt abc->dq transformation of PSCAD which is

$$[c] = \frac{2}{3} \begin{bmatrix} \cos(\omega t) & \cos(\omega t - \frac{2\pi}{3}) & \cos(\omega t + \frac{2\pi}{3}) \\ \sin(\omega t) & \sin(\omega t - \frac{2\pi}{3}) & \sin(\omega t + \frac{2\pi}{3}) \end{bmatrix}$$

(3.4)

Necessary correction has been done in the model by interchanging 'd' and 'q' signals [26].

3.4   Equivalent circuit and equations

Fig. 3.3 shows a simplified representation of the STATCOM, including a DC-side capacitor, an inverter, and series inductance in the three lines connecting to the transmission line. This inductance accounts for the leakage of the actual power transformers. The circuit also includes resistance in shunt with the capacitor to represent the switching losses in the inverter, and resistance in series with the AC lines to represent the inverter and transformer conduction losses. The inverter block in the circuit is treated as an ideal, lossless power converter.
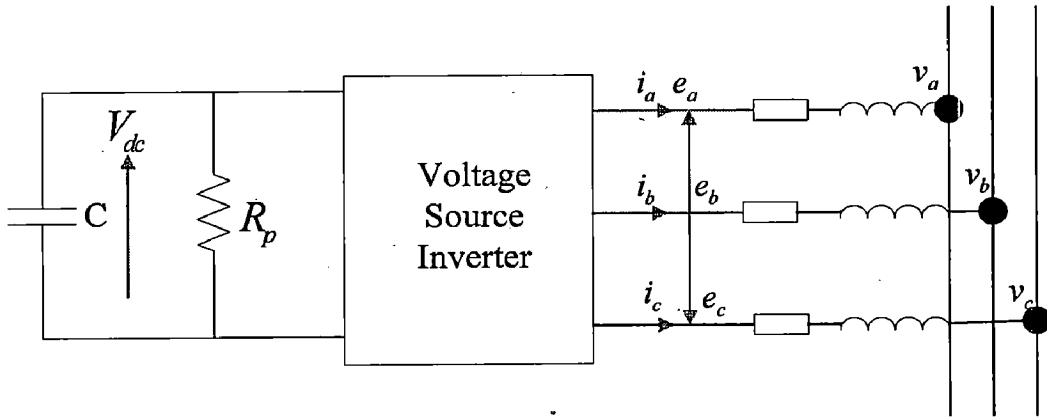
Figure 3.3 Equivalent circuit of STATCOM

In terms of the instantaneous variables shown in Fig. 3.3, the AC-side circuit equations can be written as follows:

$$
p\begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} = \begin{bmatrix} \dfrac{-R_s}{L} & 0 & 0 \\ 0 & \dfrac{-R_s}{L} & 0 \\ 0 & 0 & \dfrac{-R_s}{L} \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} + \begin{bmatrix} (v_a - e_a) \\ (v_b - e_b) \\ (v_c - e_c) \end{bmatrix}
\tag{3.5}
$$

where p = d/dt,

Using the transformation of variables defined in Eqns. (3.1), Eqns. (3.5) can be transformed to the synchronously rotating reference frame as follows:

$$
p\begin{bmatrix} i_d \\ i_q \end{bmatrix} = \begin{bmatrix} \dfrac{-R_s}{L} & \omega \\ -\omega & \dfrac{-R_s}{L} \end{bmatrix} \begin{bmatrix} i_d \\ i_q \end{bmatrix} + \frac{1}{L}\begin{bmatrix} (v_d - e_d) \\ -e_q \end{bmatrix}
\tag{3.6}
$$

where $\omega = d\theta/dt$.

The STATCOM dc-side circuit equation can be written as

$$
q = Cv_{dc}
\tag{3.7}
$$

30

$$\frac{dq}{dt} = C \frac{dv_{dc}}{dt}$$

(3.8)

$$i_{dc} = C \frac{dv_{dc}}{dt}$$

(3.9)

$$P_{dc} = v_{dc} i_{dc} = v_{dc} C \frac{dv_{dc}}{dt}$$

(3.10)

$$P_{ac} = \frac{3}{2} v_d i_d$$

(3.11)

$$\frac{dv_{dc}}{dt} = \frac{3 v_d i_d}{2 C v_{dc}}$$

(3.12)

Where 3/2 is the reference frame transformation constant and e_d, e_q are defined as

$$e_d = m v_{dc} \cos \omega t$$

(3.13)

$$e_q = m v_{dc} \sin \omega t$$

(3.14)

Where m is the modulation index defined as

$$m = \frac{V_{phase\_peak}}{V_{dc}}$$

The state space model in R-I frame for the STATCOM circuit can be written as follows

$$p \begin{bmatrix} i_d \\ i_q \\ v_{dc} \end{bmatrix} = \begin{bmatrix} -\frac{R_s}{L} & \omega & \frac{v_d}{L} \\ -\omega & -\frac{R_s}{L} & 0 \\ \frac{3 v_d}{2 C v_{dc}} & 0 & 0 \end{bmatrix} \begin{bmatrix} i_d \\ i_q \\ v_{dc} \end{bmatrix} - \frac{1}{L} \begin{bmatrix} v_{dc} & 0 \\ 0 & v_{dc} \\ 0 & 0 \end{bmatrix} \begin{bmatrix} m \cos \omega t \\ m \sin \omega t \end{bmatrix}$$

(3.15)

3.5 Exact linearization via feedback

The system described is a multi-input-multi-output with two input and two output. The system is coupled and nonlinear because it contains multiplication of states and the input variables. In order to decouple and linearize the model in Eqns. (3.15), the input–output linearization technique is applied [14][27]. The system is equivalent as two linear subsystems. These subsystems can be decoupled provided that the matrix in Eqns. (3.24) is not singular. In this case, the decoupling matrix is Eqns. (3.24) considering normal operating conditions, is not singular and the system can be transformed into two decoupled linear systems. The state variables in the linear and controllable system are defined as Eqns. (3.25). Eqns. (3.27) can be used to design a control law for the tracking of a desired trajectory. Comparing Eqns. (3.15) with Eqns. (3.16) the state space form

$$\dot{x} = f(x) + g(x)u$$
$$y = h(x) \tag{3.16}$$

where $x = [i_d \quad i_q \quad v_{dc}]'$ then,

$$f(x) = \begin{bmatrix} -\dfrac{R_s}{L}x_1 + \omega x_2 + \dfrac{v_d}{L} \\[2mm] -\omega x_1 - \dfrac{R_s}{L}x_2 \\[2mm] \dfrac{3v_d x_1}{2Cx_3} \end{bmatrix}, \quad g(x) = \begin{bmatrix} -\dfrac{x_3}{L} & 0 \\[2mm] 0 & -\dfrac{x_3}{L} \\[2mm] 0 & 0 \end{bmatrix} = [g_1 \quad g_2] \quad y(x) = \begin{bmatrix} x_3 \\ x_2 \end{bmatrix} = \begin{bmatrix} h_1 \\ h_2 \end{bmatrix}$$

and

The Lie derivatives are as follows:

$$L_{f1}h_1 = [0 \quad 0 \quad 1]f(x) = \frac{v_d x_1}{Cx_3} \tag{3.17}$$

$$L_{g1}L_f h_1 = [\frac{v_d x_1}{Cx_3} \quad 0 \quad -\frac{v_d x_1}{Cx_3^2}]g_1 = -\frac{v_d}{CL} \tag{3.18}$$

$$L_{f1}^2 h_1 = [\frac{v_d x_1}{Cx_3} \quad 0 \quad -\frac{v_d x_1}{Cx_3^2}]f(x)$$

$$= (-\frac{R_s}{L}x_1 + \omega x_2 + \frac{v_d}{L})\frac{v_d}{Cx_3} - (\frac{v_d x_1}{Cx_3^2})(\frac{v_d x_1}{Cx_3}) \tag{3.19}$$

$$L_{g2}h_2 = -\frac{x_3}{L} \tag{3.20}$$

$$L_{g2}L_f h_1 = 0 \tag{3.21}$$

$$L_f h_2 = -\omega x_1 - \frac{R_s}{L}x_2 \tag{3.22}$$

$$L_{g1}h_2 = 0 \tag{3.23}$$

The decoupling matrix $E(x) = \begin{bmatrix} L_{g1}L_f h_1 & L_{g2}L_f h_2 \\ L_{g1}h_2 & L_{g2}h_2 \end{bmatrix} = \begin{bmatrix} -\dfrac{3v_d}{2CL} & 0 \\[2mm] 0 & -\dfrac{x_3}{L} \end{bmatrix}$ \tag{3.24}

The transformed state variables are defined as

$$z_1 = x_3 \quad z_2 = \frac{3v_d x_1}{2Cx_3} \quad z_3 = x_2 \tag{3.25}$$

From this the following state space equation is obtained

$$\dot{z}_1 = z_2 \quad \dot{z}_2 = v_1 \quad \dot{z}_3 = v_2 \tag{3.26}$$

Where v1 and v2 are the new control inputs

The final control laws are given by

$$u_1 = \frac{-L_f^2 h_1 + v_1}{L_{g1} L_f h_1} = \frac{-R_s x_1}{x_3} + \frac{\omega L x_2}{x_3} + \frac{v_d}{x_3} - \frac{L v_d x_1^2}{C x_3^3} - \frac{L C v_1}{v_d} \tag{3.27}$$

$$u_2 = \frac{-L_f h_2 + v_2}{L_{g2} h_2} = \frac{-\omega L x_1}{x_3} - \frac{R_s x_2}{x_3} - \frac{L v_2}{x_3} \tag{3.28}$$
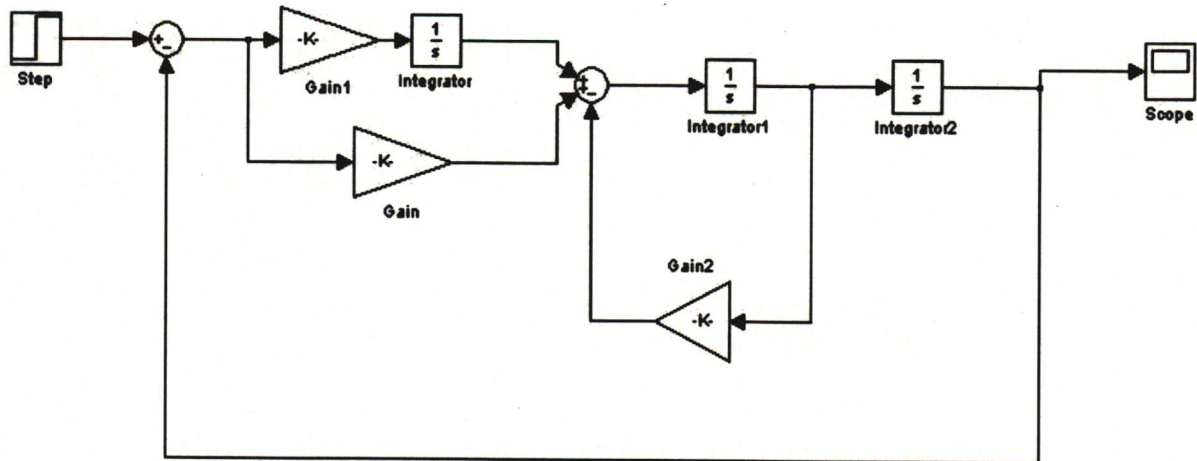
Figure 3.4 Control system for d-axis
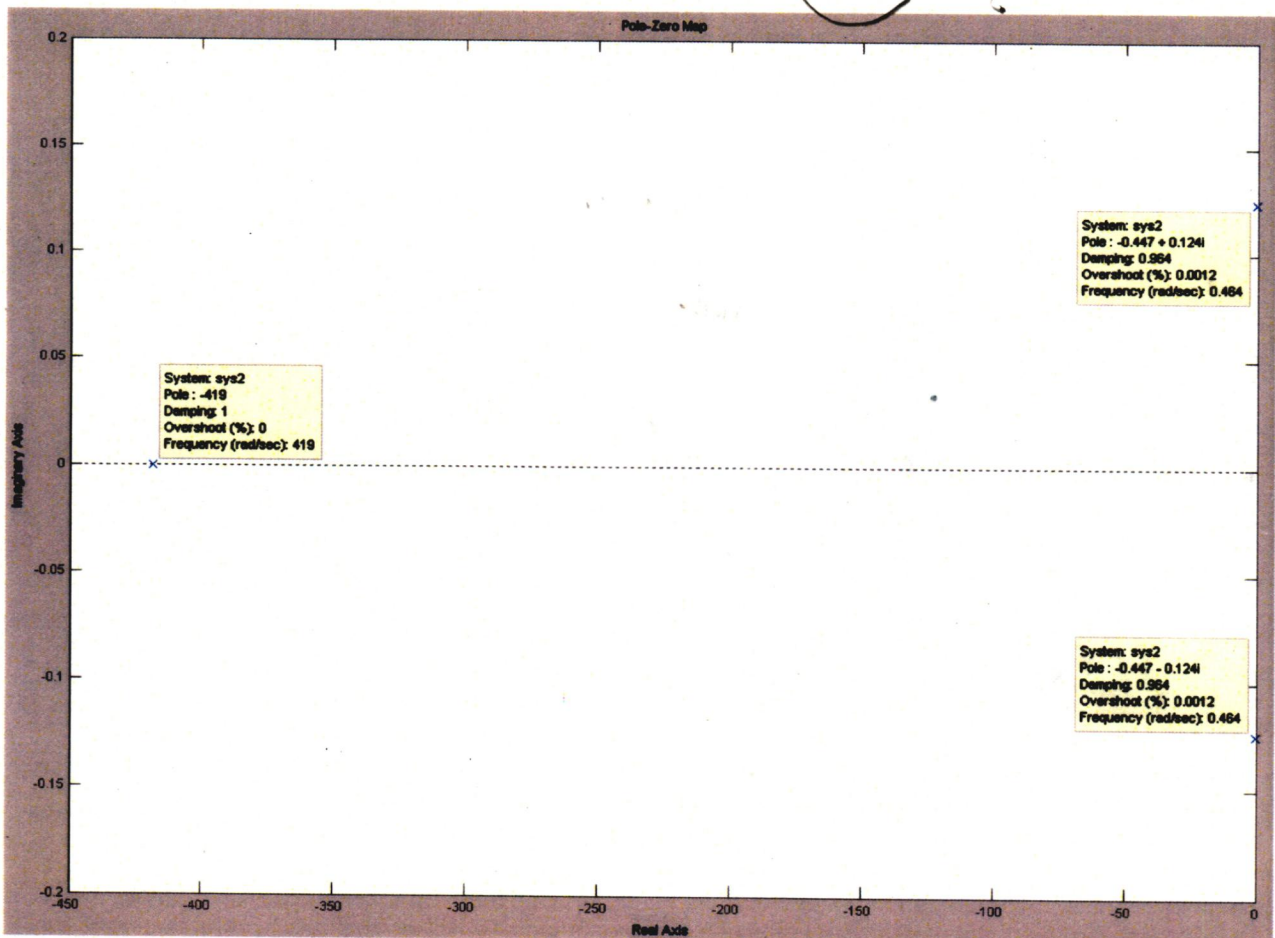
Figure 3.5 Pole placement for d-axis control system
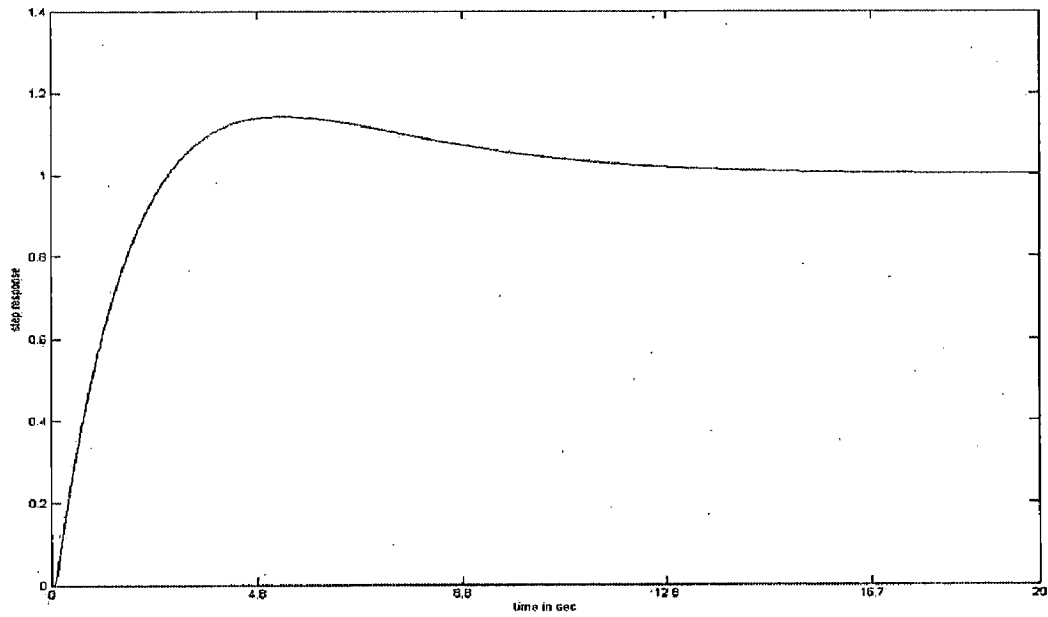
Figure 3.6 Step response for d-axis control system
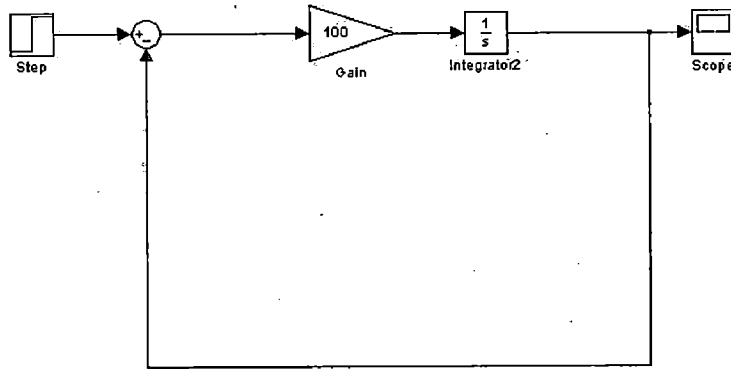
Figure 3.7 Control system for q-axis
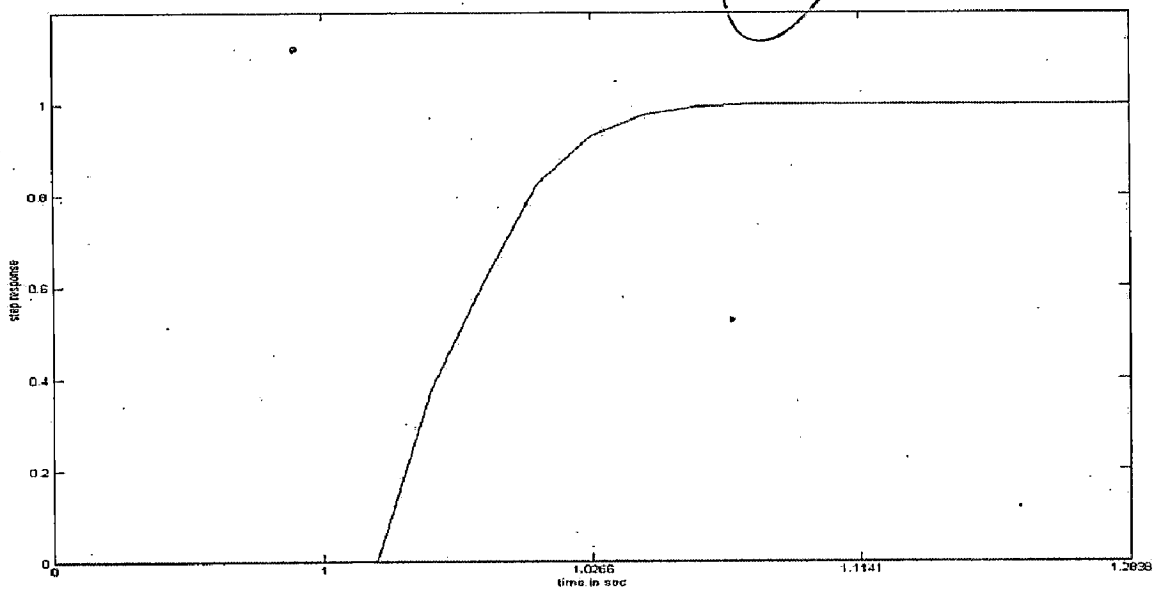
Figure 3.8 Step response for q-axis control system
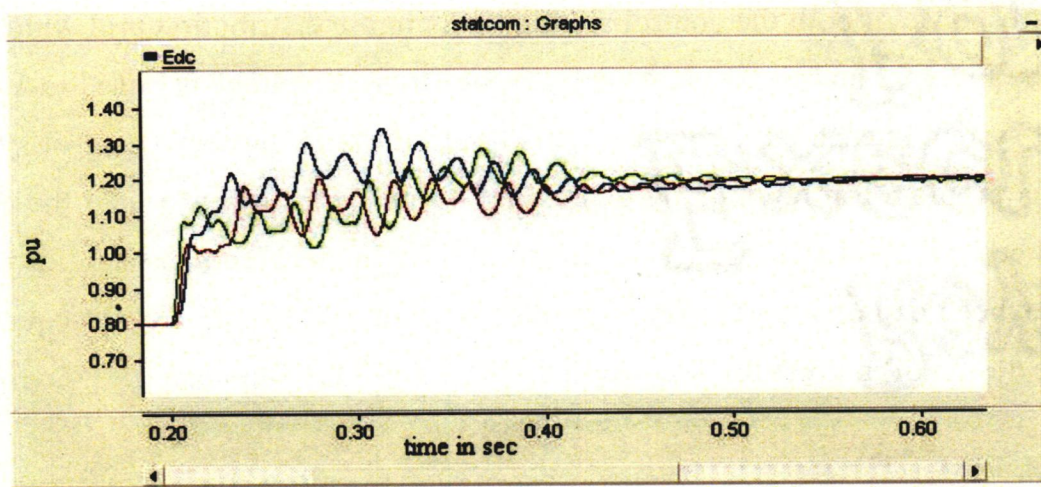
Figure 3.9 V_{dc} response in infinite bus for exact linearization

The poles are placed at -0.477±0.124 and -419 to obtain the damping 0.964 at frequency 0.464 rad/sec and overshoot of 0.12% by adding a PI controller in the error input. The dc response at single machine infinite bus system is shown in Fig 3.9 for the obtained controller gains. It has to be noted that the obtained response highly in accordance to the proposed dynamics. The response is also compared with the approximate linearized equation proposed by Q. Song [12] which are stated below.

$$u_1 = \frac{-R_s x_1}{x_3} + \frac{\omega L x_2}{x_3} + \frac{v_d}{x_3} - \frac{L v_1}{x_3} \tag{3.29}$$

$$u_2 = \frac{-\omega L x_1}{x_3} - \frac{R_s x_2}{x_3} - \frac{L v_2}{x_3} \tag{3.30}$$
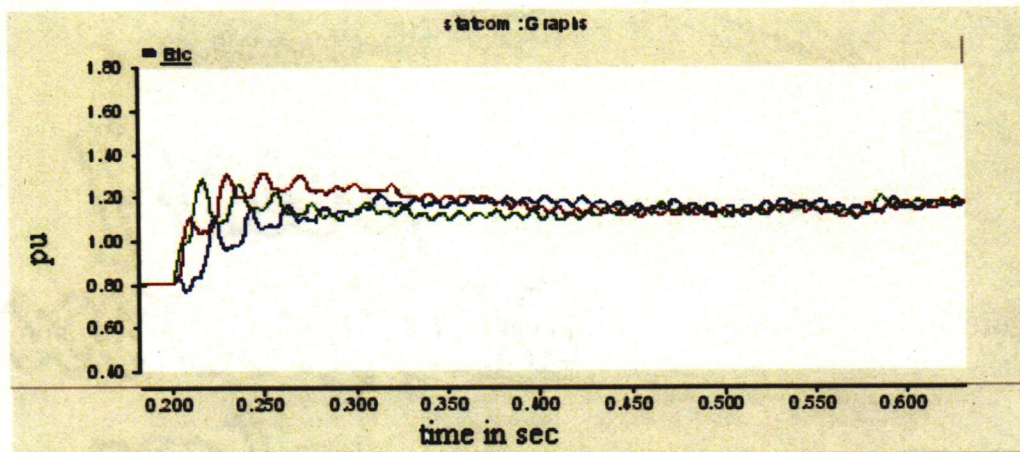
Figure 3.10 V_{dc} response in infinite bus for approx linearization

Now both the controllers of Eqns. (3.27)-(3.28) and Eqns. (3.29)-(3.30) are evaluated in the distribution grid one at a time. The plot for V_d is observed in Fig 3.11 for Eqns. (3.27)-(3.28). The plot for V_d for Eqns. (3.29)-(3.30) is similar. Here V_d is considered to be constant in the State Space model of the STATCOM which is actually the case for infinite bus system. But for the finite distribution system the value of V_d is dependent on the reactive current requirement and hence the plot of V_d is not a constant as compared to the infinite bus system.

Naturally the response of both the control strategy fails in the distribution grid which has been observed in the Fig 3.12 and Fig 3.13. At 3.1 sec the DC link voltage is raised to 1.15 pu, but as the control system is enabled the voltage falls because of the defective control system. The remedy of this problem can be done by expressing V_d as a function of I_q and the decoupling matrix has to be re-evaluated for exact linearization. The model free approach for controlling the system has been explored and fuzzy logic control is one of them. The subsequent chapter deals with the design of indirect fuzzy controller for STATCOM application.
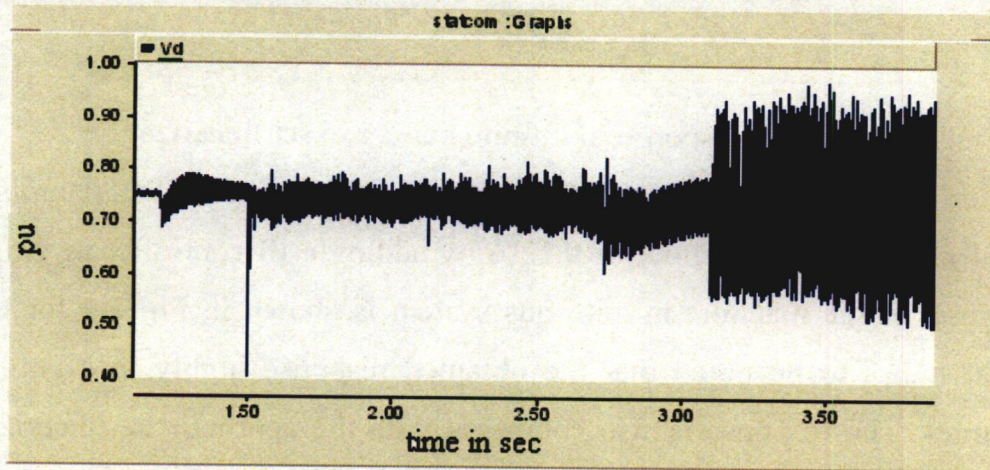
Figure 3.11 V_d plot for the distribution grid
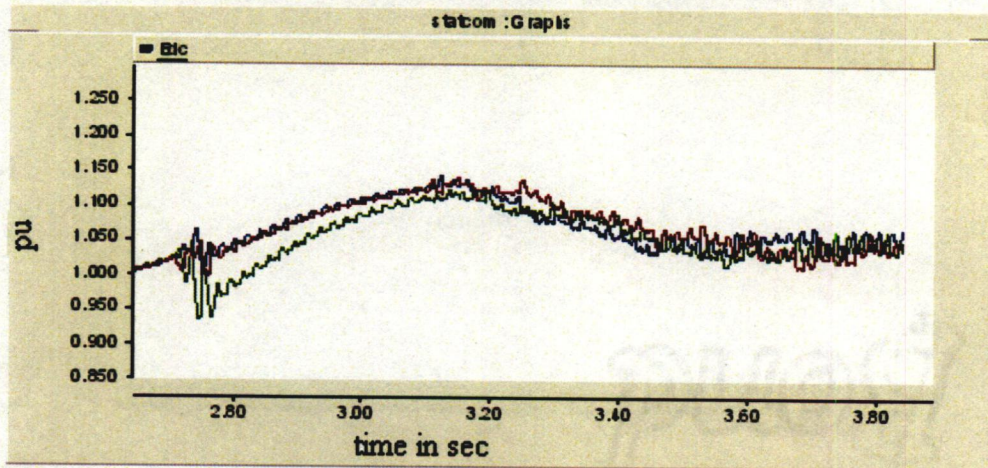
Figure 3.12 V_{dc} in grid for exact linearization on enabling control system
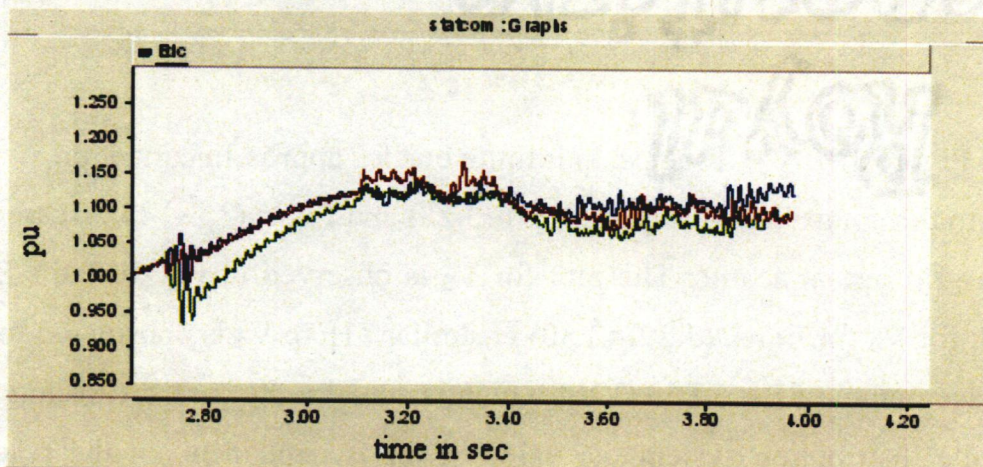
Figure 3.13 V_{dc} in grid for approx linearization on enabling control system

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The indirect fuzzy PI controller has been applied in this chapter. The modulation index is kept constant at 1.000 and the only control variable is delta. The input is the error between reference voltage and bus voltage V_{rms} as shown in Fig. 4.3 and the capacitor voltage level is allowed to vary to inject the required reactive current for bus voltage regulation.

4.1   Fuzzy PI controller

The block diagram of the Fuzzy PI Controller (FPIC) is shown in Fig. 4.1 [15]. In this figure, e(k) is the error at the k-th sample and it can be written as e(k) = ysp – y(k) where, y(k) is the actual system output and ysp the set-point or desired system output at k-th sample respectively. The change in error is defined as

$$\Delta e(k) = e(k) - e(k-1)$$

The quantities e and Δe are converted to normalized quantities eN and ΔeN respectively by using the Scaling Factors (SFs) Ge and GΔe. These normalized quantities eN and ΔeN are crisp in nature and therefore need to be first converted to their corresponding fuzzy variables. After fuzzification, the fuzzified inputs are given to the fuzzy inference mechanism which, depending on the given fuzzy rule base, gives the normalized incremental change in control output (ΔuN). The output ΔuN is converted into actual incremental change in control output (Δu) by using the scaling factor Gu. For implementing the fuzzy inference engine, the "min"operator for connecting multiple antecedents in a rule, the "min" implication operator, and the "max" aggregation operator have been used. Actually, the output ΔuN from the inference mechanism is fuzzy in nature, hence, to determine the crisp output, these fuzzy outputs need to be defuzzified. The centroid defuzzification scheme has been used here for obtaining the output Δu as shown in Fig.4.1. Finally, the actual value of the controller output (u) is computed by

$$u(k) = u(k-1) + \Delta u(k)$$
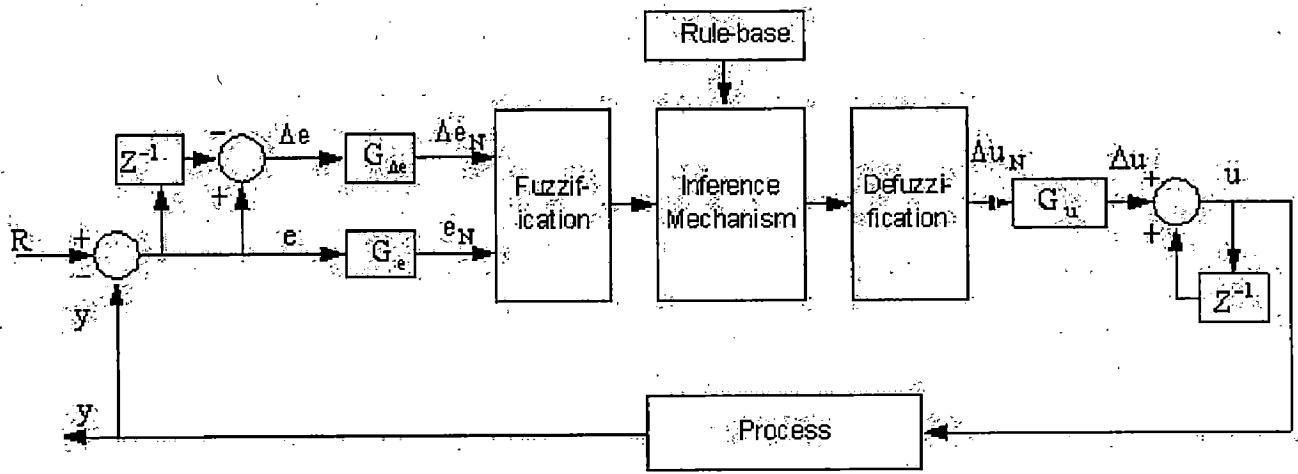
Figure 4.1 Fuzzy PI controller

The relationships between the SFs (Ge , GΔe and Gu) and the input and output variables of the FPIC are as follows:

$$eN = Ge.e$$

$$\Delta eN = G\Delta e.\Delta e$$

$$\Delta u = Gu.\Delta uN$$

Here Ge, GΔe and Gu are the SFs for e, Δe and Δu respectively and eN, ΔeN and ΔuN are normalized quantities.

The SFs are the main parameters used for tuning any Fuzzy Logic Controller (FLC) because variation of the SFs changes the normalized universe of discourse of input & output variables and their corresponding membership functions. Generally, selection of suitable values for Ge, GΔe and Gu are made based on the knowledge about the process to be controlled and sometimes through trial and error to achieve the best possible control performance. This is so because, unlike conventional non-fuzzy controllers, there is no well-defined method for selecting appropriate values of SFs for FLC. However, if required, it is possible to tune these parameters to achieve a given control objective using some optimization techniques. In this work, the appropriate values for Ge, GΔe and Gu have been determined by using Simples Algorithm [26] as shown in Fig 4.4.

Each fuzzy control rule in the controller rule base is of the form

" If e is E and Δe is ΔE, then Δu is ΔU"

where E, ΔE and ΔU are the fuzzy sets corresponding to error, change in error and the incremental change in the control output respectively. In this work, for both the inputs (e and Δe) and the output (Δu), seven fuzzy subsets have been used. These are: PB (positive big), PM (positive medium), PS (positive small), ZE (zero), NS (negative small), NM (negative medium) and NB (negative big). For each of these fuzzy sets, triangular membership function (MF) has been used. These membership functions have been defined on the common

normalized domain [-1, 1] and are shown in Fig. 4.2. From this figure it is observed that the triangles are symmetric with equal base having 50% overlap with neighboring MFs. As each of the two inputs has seven fuzzy sets, there are altogether 49 control rules in the FPIC. The rule base for computing the output Δu is shown in Table 4.1 which is a widely used rule base designed with a two-dimensional phase plane [28]. The control rules in Table 4.1 are built based on the characteristics of the step response. For example, if the output is falling far away from the set point, a large control signal that pulls the output toward the set point is expected, whereas a small control signal is required when the output is near and approaching the set point.
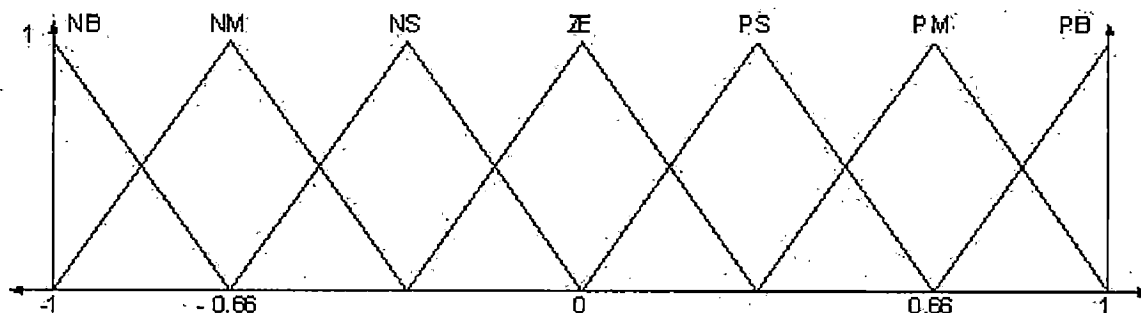
Figure 4.2 Fuzzy Logic Rule Definition

Table 4.1: Fuzzy logic Rule Base

Δe/e	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NM	NS	NS	ZE
NM	NB	NM	NM	NM	NS	ZE	PS
NS	NB	NM	NS	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PS	PM	PB
PM	NS	ZE	PS	PM	PM	PM	PB
PB	ZE	PS	PS	PM	PB	PB	PB

The scaling factors are tuned by simplex algorithm in PSCAD. The objective function considered here is the integral square error defined as $F = \int_0^{t_{sim}} e_p^2(t)\ dt$ for a step response. The optimized step response is shown in the Fig 4.5. The optimized scaling factors are 4222 , 0.814815 and -0.0275035.

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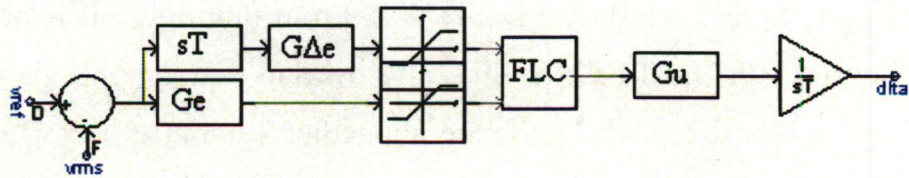
Figure 4.3 Indirect Fuzzy controller
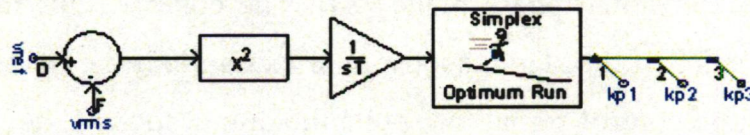
Figure 4.4 Optimization block for step response.
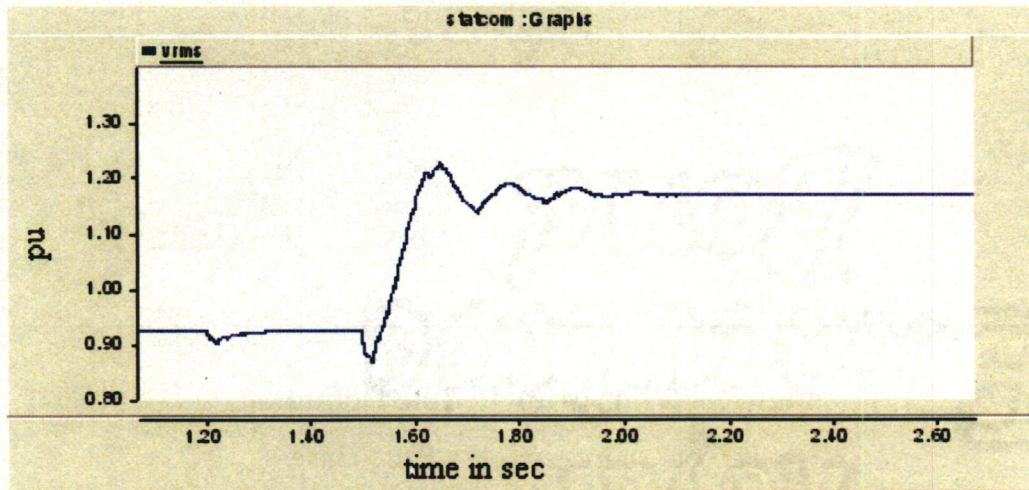
Figure 4.5 Optimized step response for indirect Fuzzy controller

4.2   Performance of indirect fuzzy controller

The controller is then tested for voltage regulation and the response during three phase to ground fault at 'Southery 33 BB' is shown. The control signal delta varies according to the operating point and so the dc voltage of the capacitor changes. The bus voltage further dips to 0.81 pu during three phase to ground fault on the high side of the distribution transformer as shown in Fig 4.6. The ±30MVA STATCOM is to be installed at the load bus to provide the required voltage support during normal operation and during fault. The voltage sags and swells have to be reduced by installing the STATCOM. The inception of fault at 4 sec is accompanied by increasing the capacitor voltage to 0.9 pu and consequently the reactive current supplied by the STATCOM increases to 0.5 pu as shown in Fig 4.8 and Fig 4.10. The swapping [12] has been implemented to balance the individual capacitor voltage. The three phase total dc link voltage has been observed to be equal and hence there is no need for per phase dc voltage controller. It has been observed that the slow dynamics of the capacitor results in the low voltage dips at the occurrence of the fault. The clearing of the fault at 7.5 sec is also accompanied by large voltage swells to about 1.15 pu as shown in Fig 4.7. The controller designed in this chapter can now be successfully applied in capacitor voltage control in direct

fuzzy control for STATCOM. This is possible because the capacitor dynamics time constant is same in both the control.
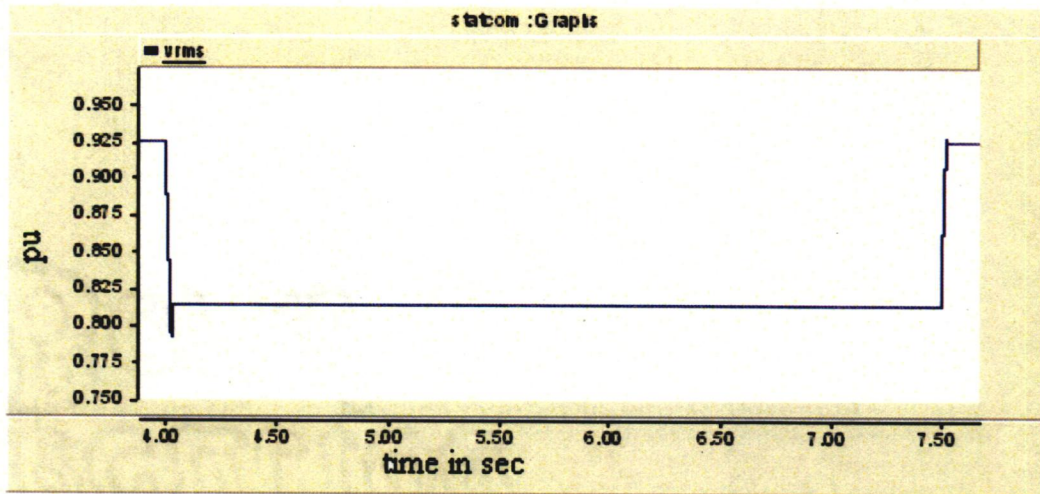
Figure 4.6 V_{rms} without STATCOM for 3Ph-G fault
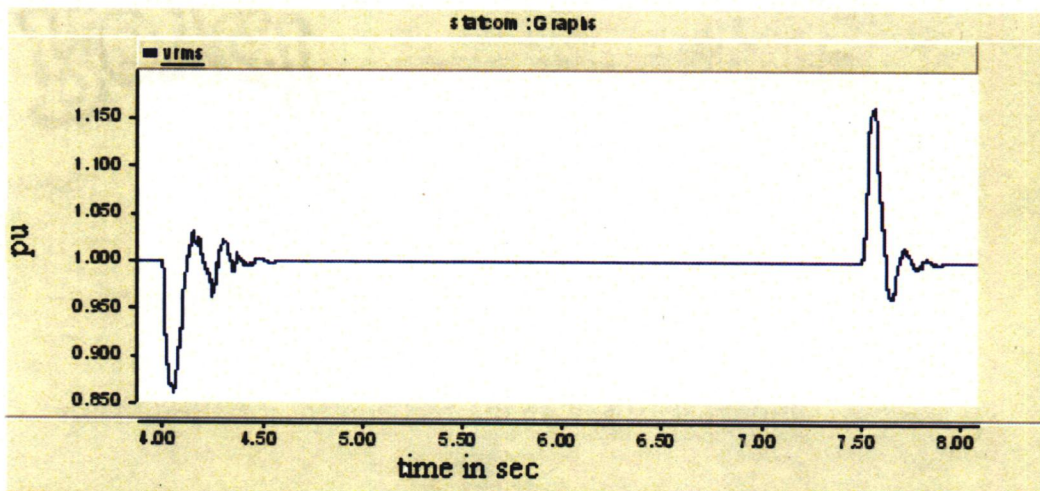
Figure 4.7 V_{rms} with indirect controlled STATCOM for 3Ph-G fault
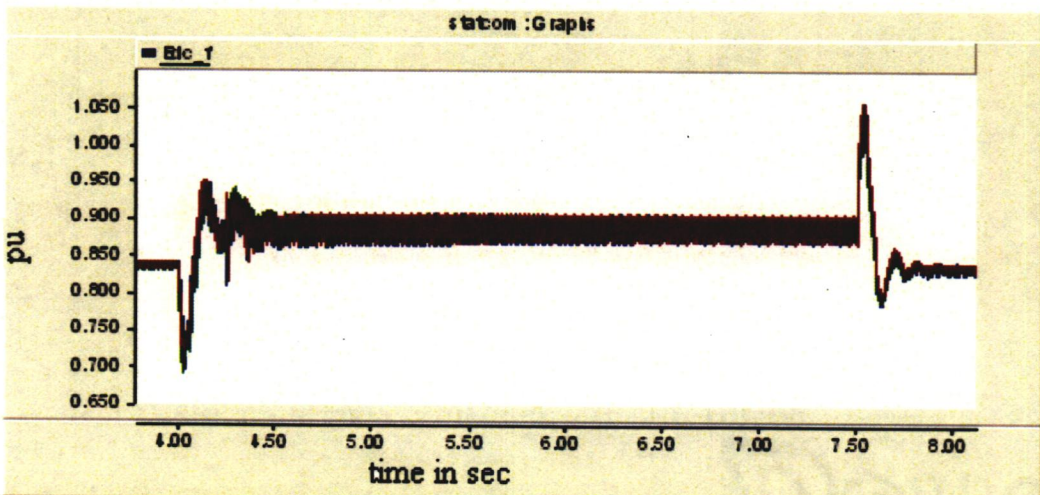
Figure 4.8 3-Ph DC link voltage with indirect control for 3Ph-G fault

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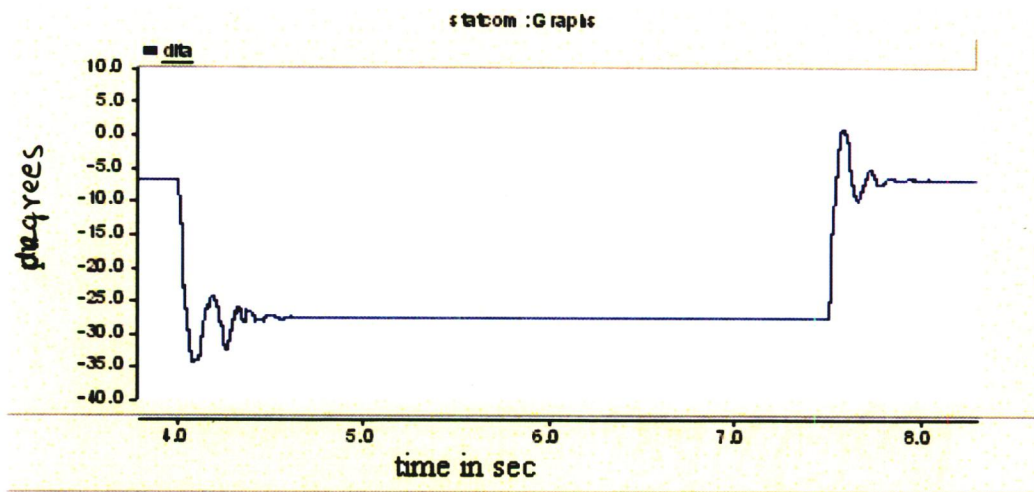
Figure 4.9 Output of indirect controller (delta) for 3Ph-G fault
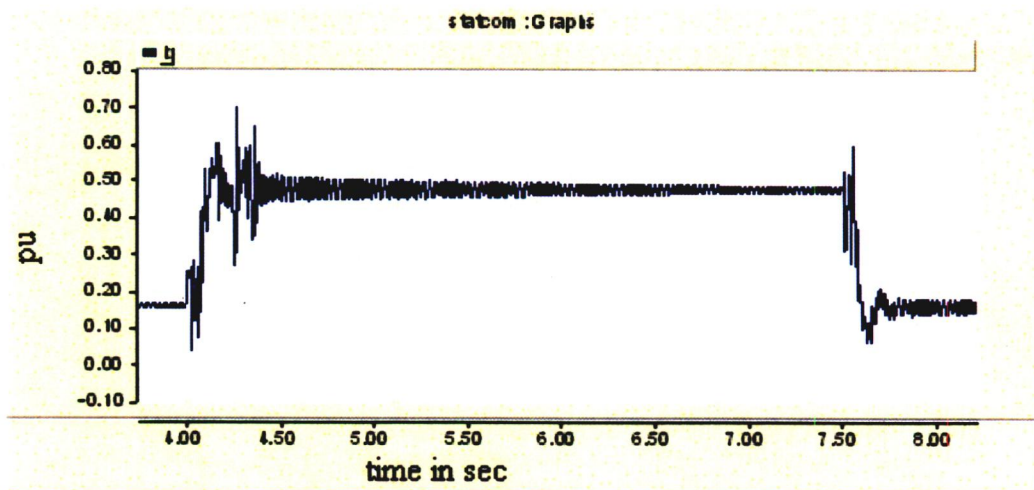
Figure 4.10 I_q with indirect control for 3Ph-G fault
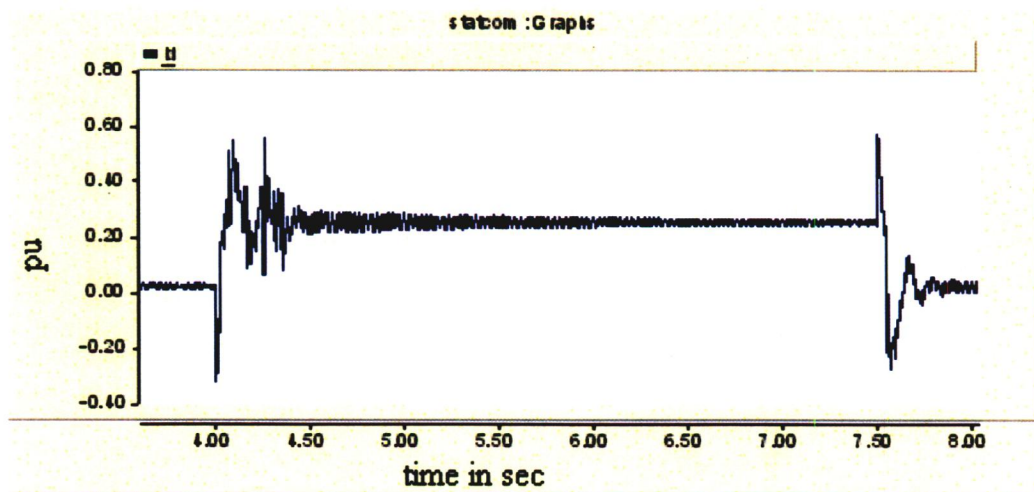
Figure 4.11 I_d with indirect control for 3Ph-G fault

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The responses of the indirect controller for Line to Ground (L-G) fault at same bus for 3.5sec are shown from Fig 4.12 to Fig 4.14. The DC link voltage corresponding to the faulted phase has been observed to be less than that of the healthy phases. The reactive current I_q supplied by the STATCOM oscillates with an offset. The bus voltage V_{rms} is maintained after small disturbance.
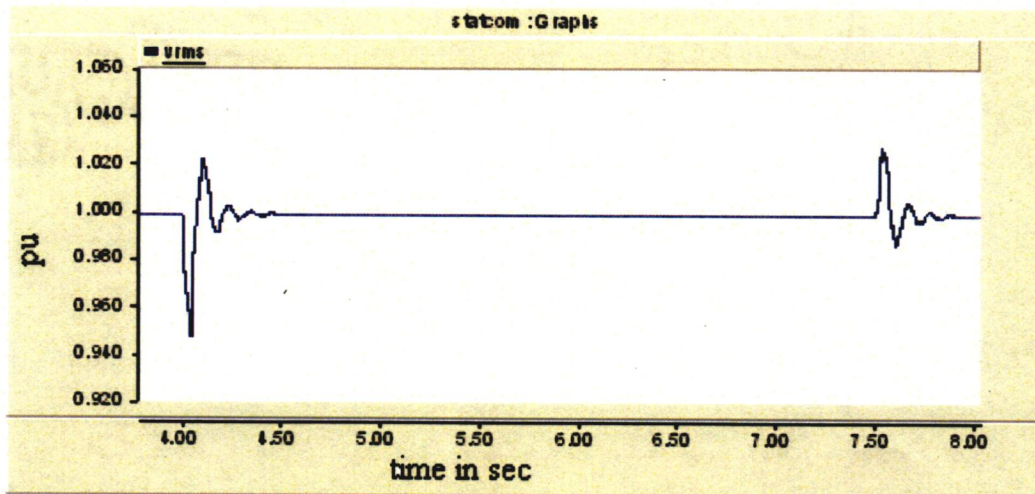
Figure 4.12 V_{rms} with indirect controlled STATCOM for L-G fault
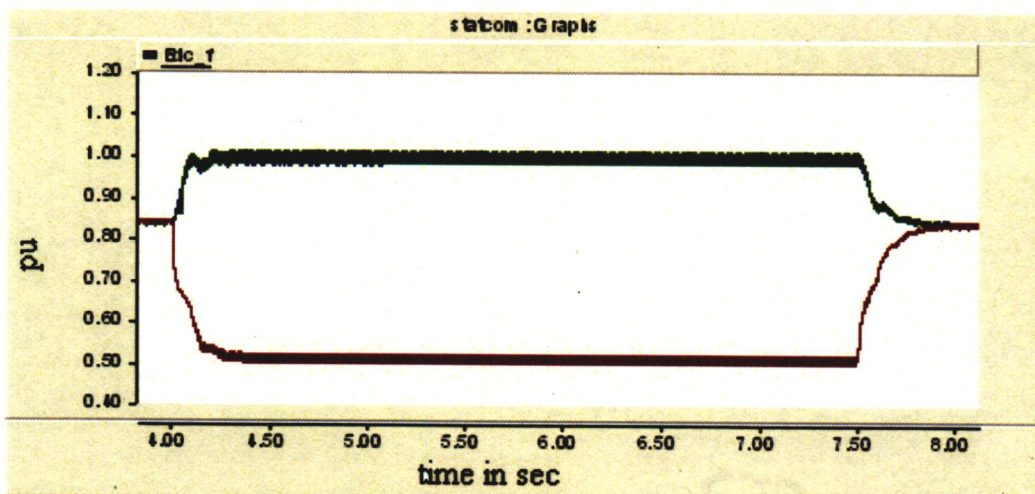
Figure 4.13 3-Ph DC link voltage with indirect control for L-G fault
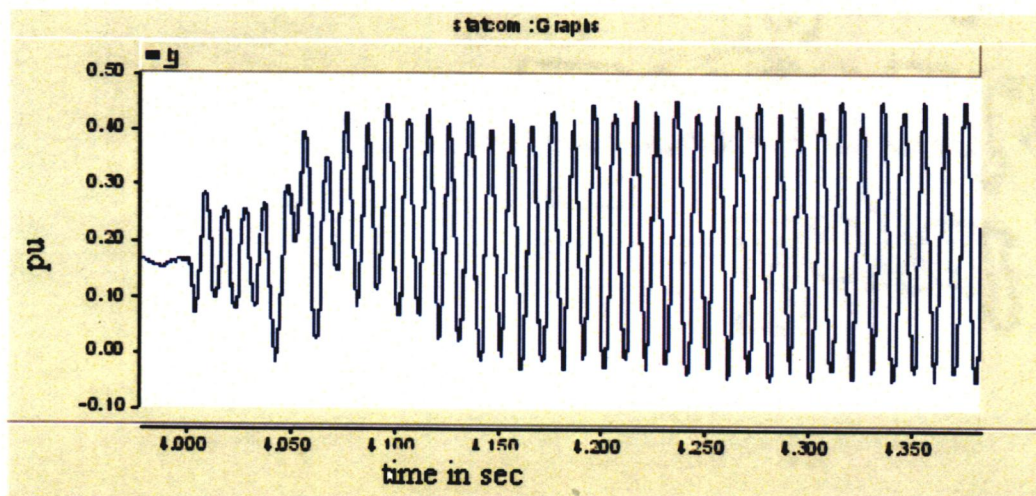
Figure 4.14 I_q with indirect control for L-G fault

Fig 4.15 to Fig 4.17 are the response of the controller for Line to Line (L-L) fault at the same bus for 3.5 sec.
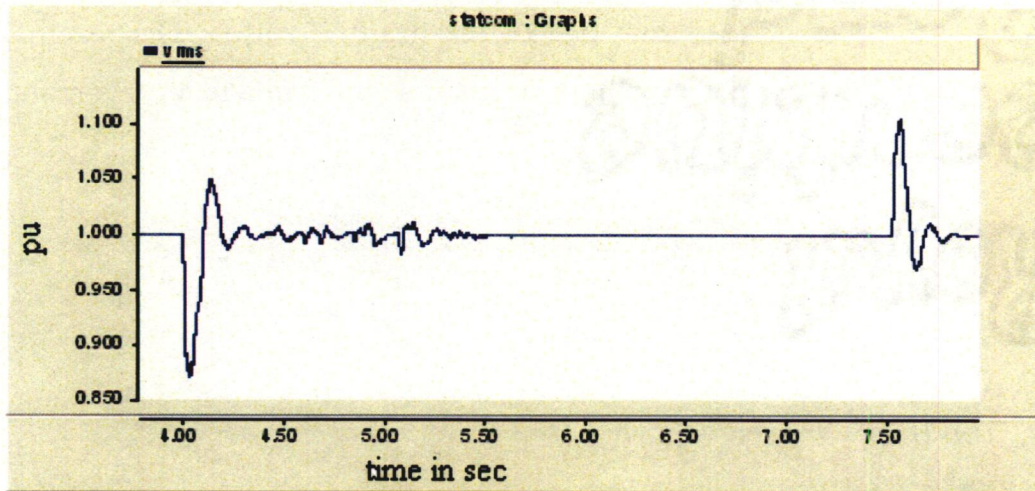
Figure 4.15 V_{rms} with indirect controlled STATCOM for L-L fault
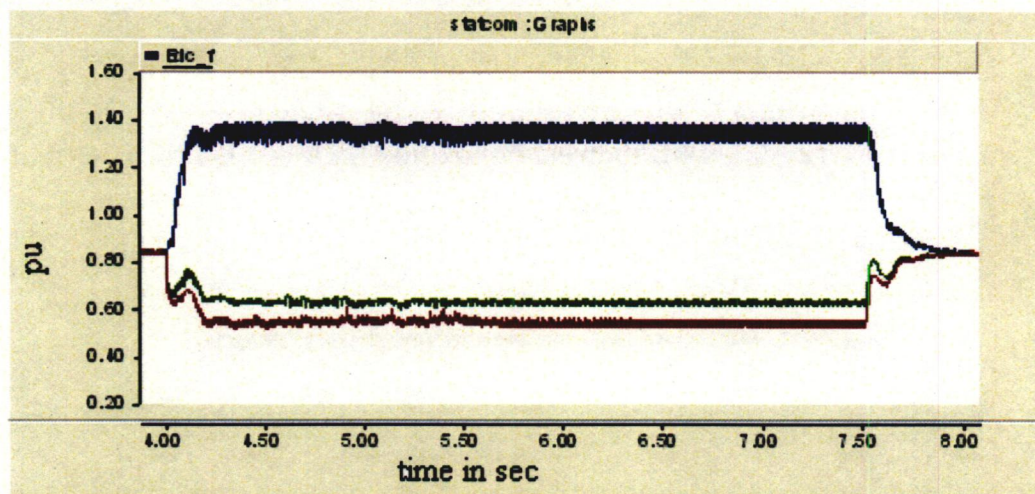
Figure 4.16 3-Ph DC link voltage with indirect control for L-L fault
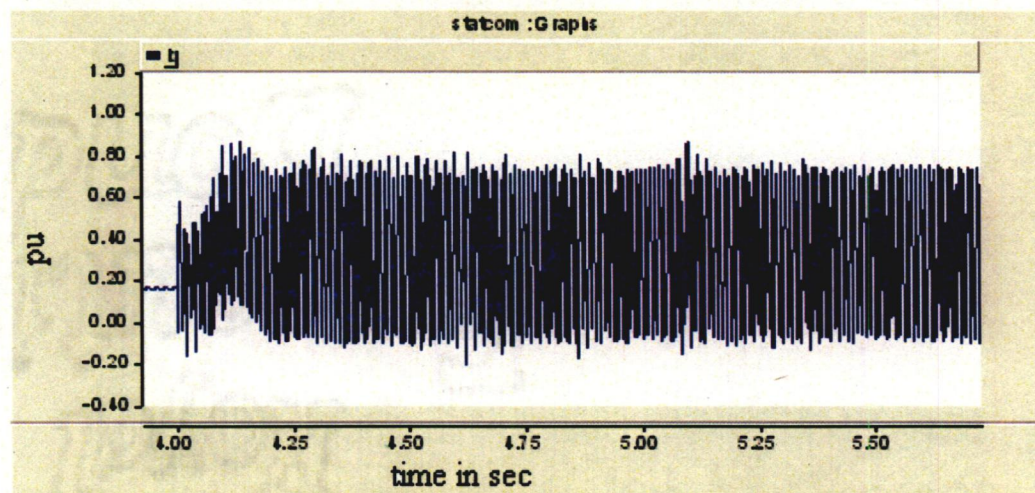
Figure 4.17 I_q with indirect control for L-L fault

Figs 4.18 to Fig 4.20 are the response of the controller for Double Line to Ground (LL-G) fault at the same bus for 3.5 sec.
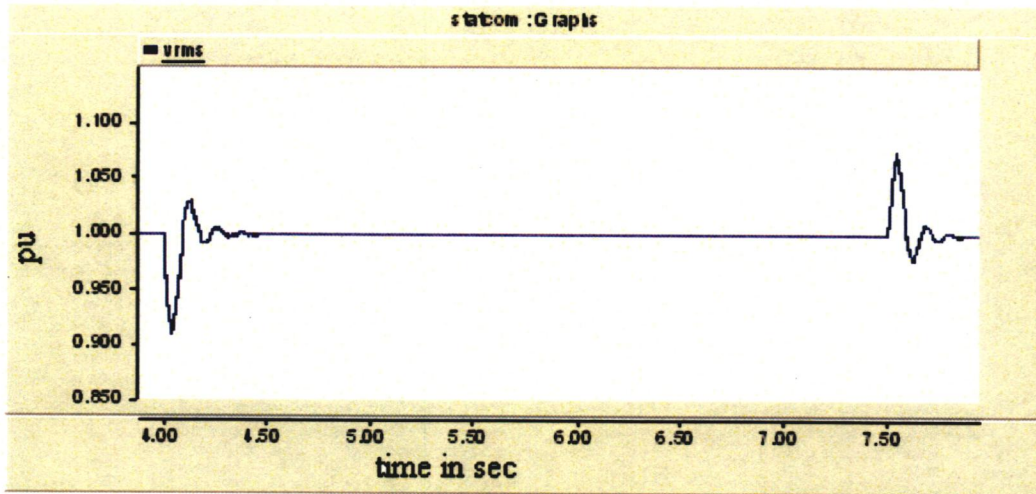
Figure 4.18 V_{rms} with indirect controlled STATCOM for LL-G fault
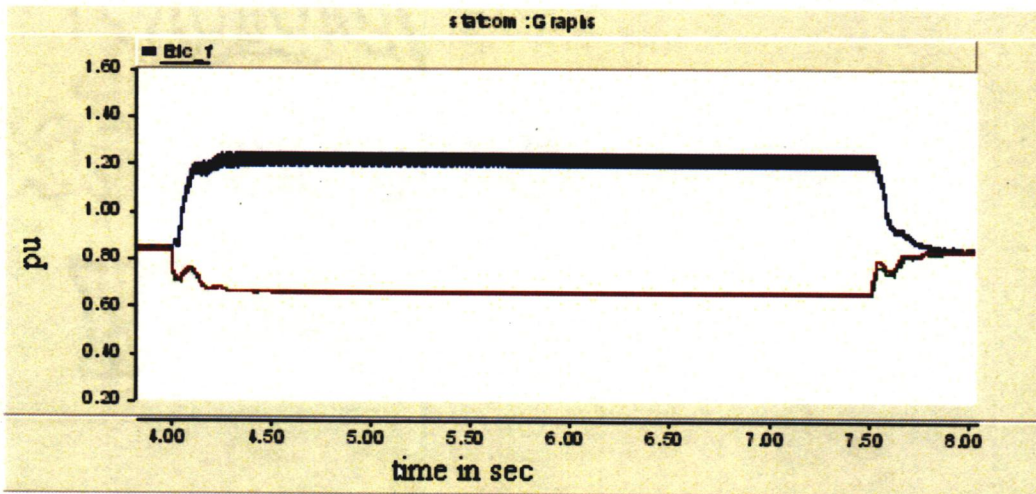
Figure 4.16 3-Ph DC link voltage with indirect control for LL-G fault
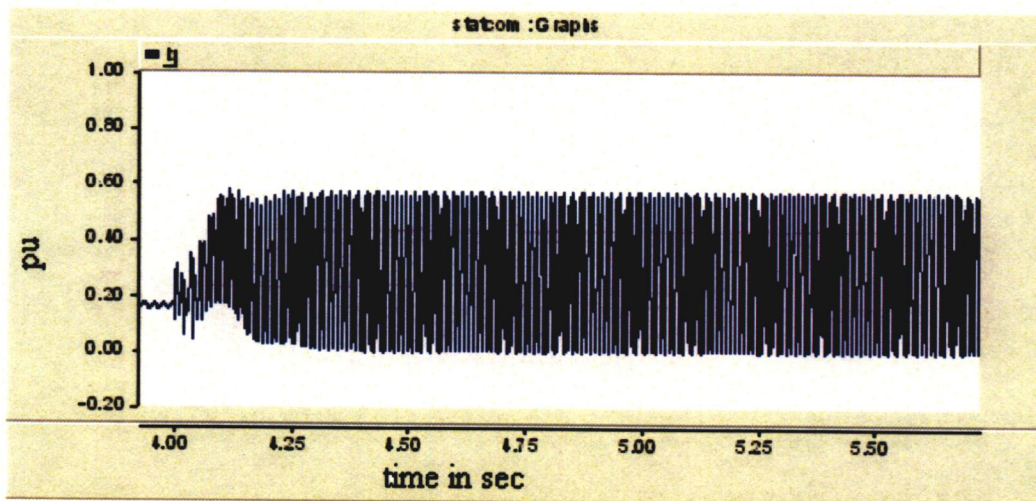
Figure 4.17 I_q with indirect control for LL-G fault

5.1   Direct fuzzy controller design

The direct fuzzy controller design which has both the modulation index and the phase as output has been attempted. The dc capacitor voltage is maintained by controlling the delta of the inverter and the bus voltage support is achieved by controlling the modulation index. The controller for the dc voltage loop has been designed by the previous indirect controller by replacing the input as the error between reference and V_{dc}. This is justifiable because the time constant and the capacitor dynamics remain same. The bus voltage controller has been designed by considering the regulation slope as ωl and the offset as V_d (rated) which is the equation of the natural characteristics of the STATCOM. The controller input is the error between reference and the bus voltage V_{rms} as shown in Fig 5.1. The output of the controller is I_q(required). The modulation index is calculated by the following equation

$$m = \frac{V_{d\_rated} + (\omega l)I_{q\_req}}{V_{dc}}$$
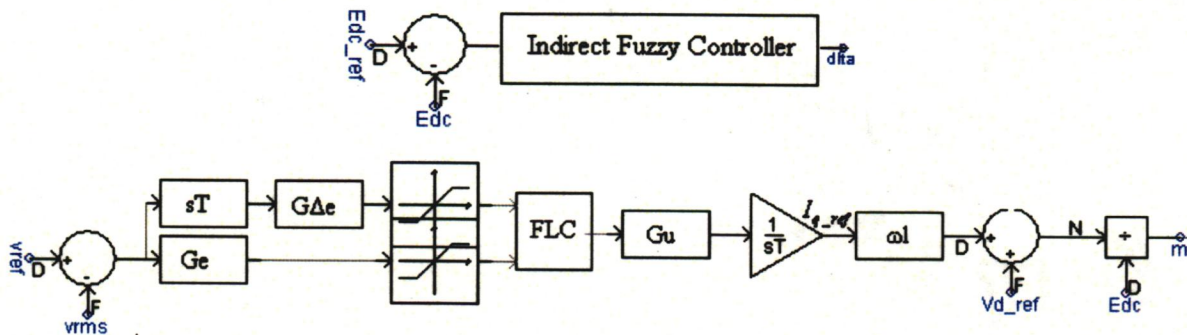
Figure 5.1 Scheme of STATCOM direct controller
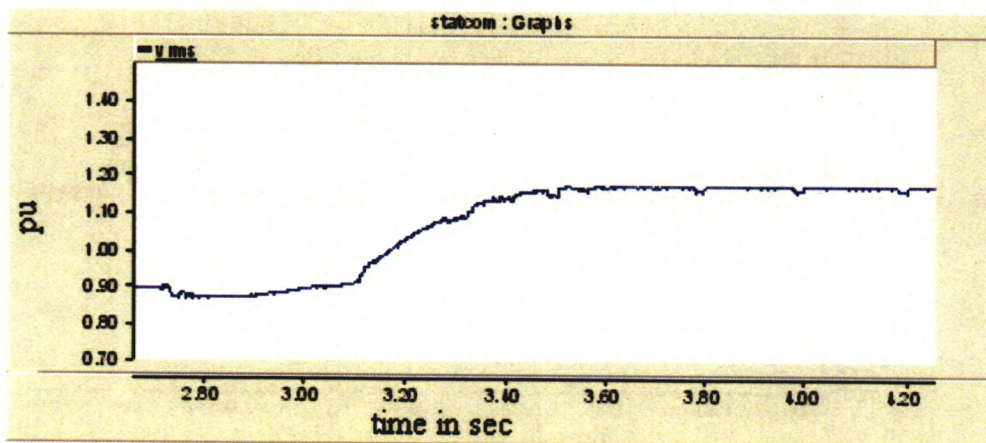
Figure 5.2 Optimized step response for direct Fuzzy controller

5.2   Performance of direct fuzzy controller

The controller gains are tuned for minimum integral square error by the simplex method. The optimized controller with STATCOM is then installed in the distribution grid for

performance evaluation. In the normal operation the STATCOM supplies 0.15 pu of reactive current to maintain the reference voltage level. The STATCOM also draws a small amount of real power in the form of I_d for required V_{dc}. The capacitor voltage ripple has been observed to be less while supplying 0.15pu of reactive current which subsequently increases on increasing the supplied I_q by the STATCOM. The inception of three phase to ground fault for 3.5sec at 'Southery 33 BB' is accompanied by increase in injected I_q by the STATCOM to 0.5pu and the capacitor voltage ripple as shown in Fig 5.7 and Fig 5.4. The capacitor voltage is maintained by the indirect controller independent of the bus voltage but has been noted by a slight dip for few cycles. This results in an increase modulation index to supply the reactive current at reduced capacitor voltage in Fig 5.5. The stabilization of capacitor voltage results in less fluctuation of the output of the modulation index controller. The voltage dips has been reduced to 0.92pu on the inception of the fault and is much better than the indirect controller. The response during the fault clearance is more remarkable as the maximum voltage swells is reduced to 1.05 pu in Fig 5.3.
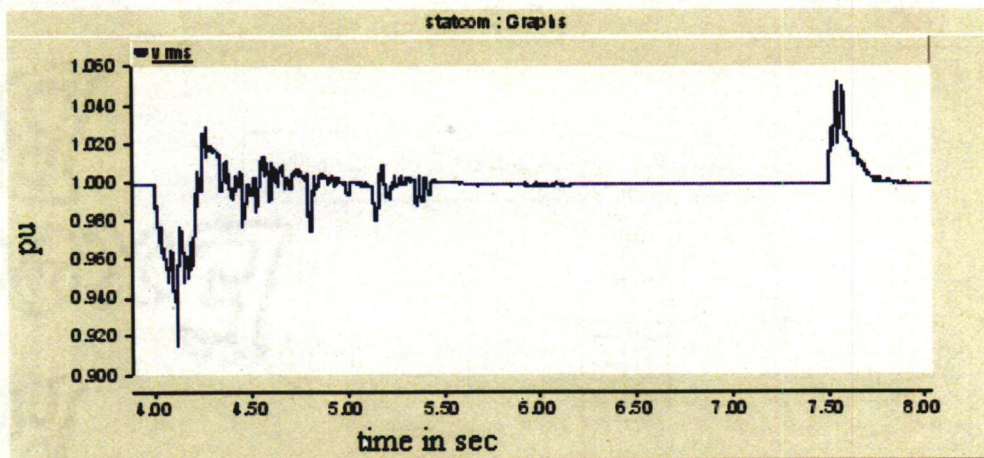
Figure 5.3 V_{rms} during for 3Ph-G fault for direct control
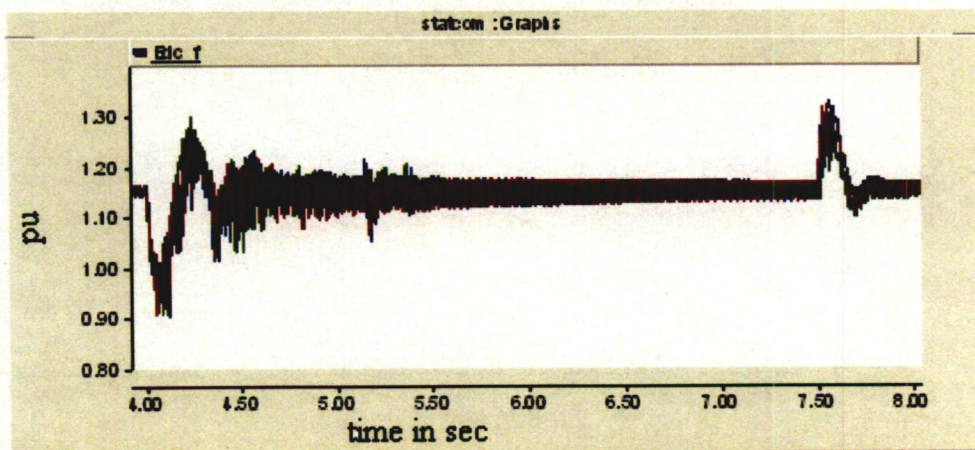
Figure 5.4 3-Ph DC link voltage with direct control for 3Ph-G fault
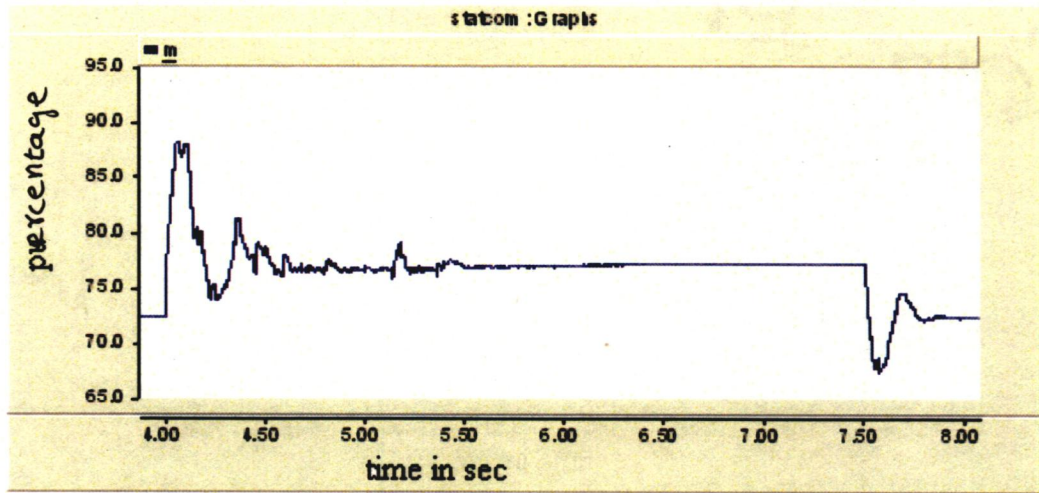
Figure 5.5 Output 1 of direct controller (modulation index) for 3Ph-G fault
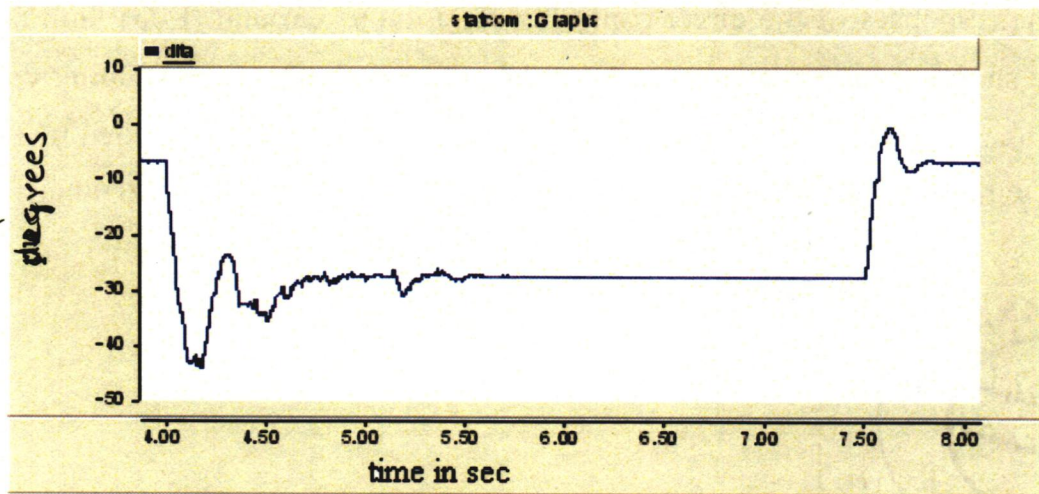
Figure 5.6 Output 2 of direct controller (delta) for 3Ph-G fault
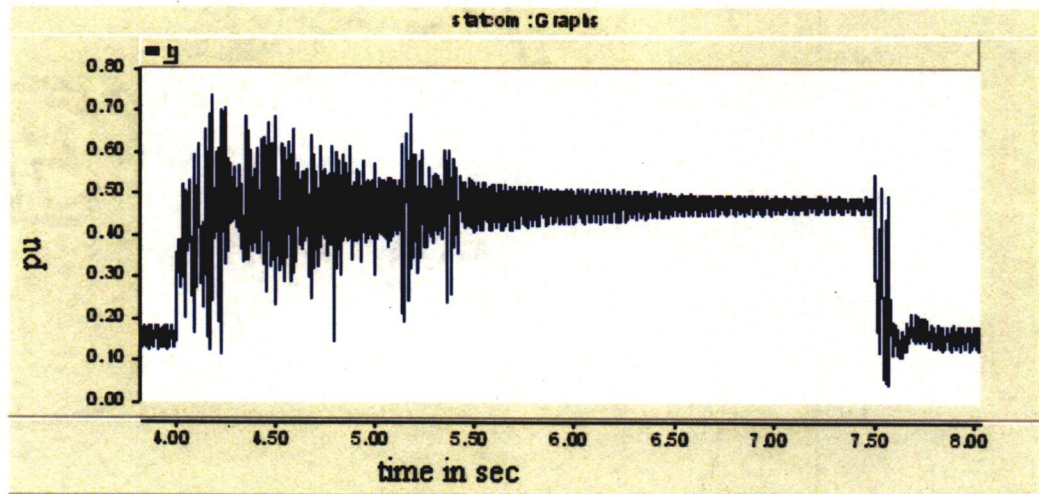
Figure 5.7 I_q with direct control for 3Ph-G fault
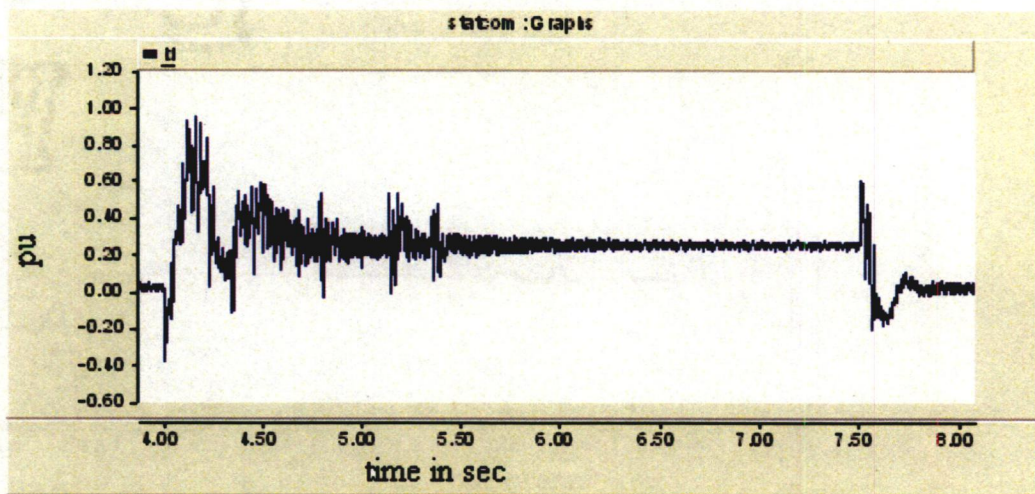
Figure 5.8 I_d with direct control for 3Ph-G fault

The responses of the direct controller for Line to Ground (L-G) fault at same bus for 3.5sec are shown from Fig 5.9 to Fig 5.11. The faulted phase of the DC link voltage has been observed to be less than the healthy phases. The reactive current I_q supplied by the STATCOM oscillates with an offset. The bus voltage Vrms is restored with a dip of 0.99pu.
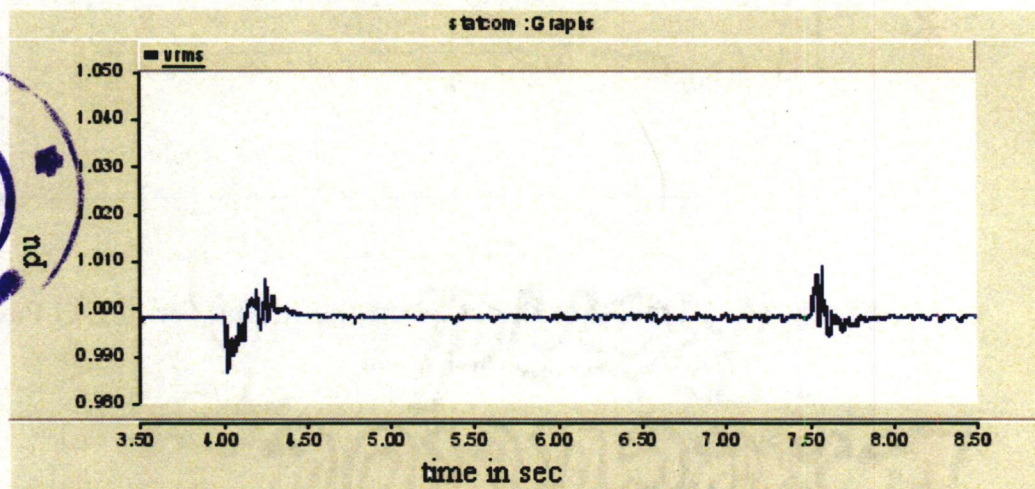
Figure 5.9 V_{rms} with direct controlled STATCOM for L-G fault
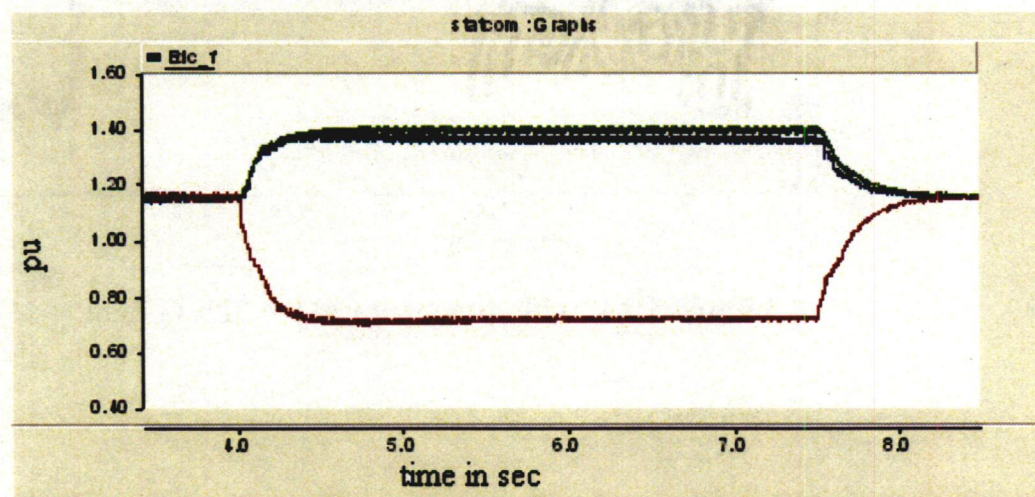
Figure 5.10 3-Ph DC link voltage with direct control for L-G fault

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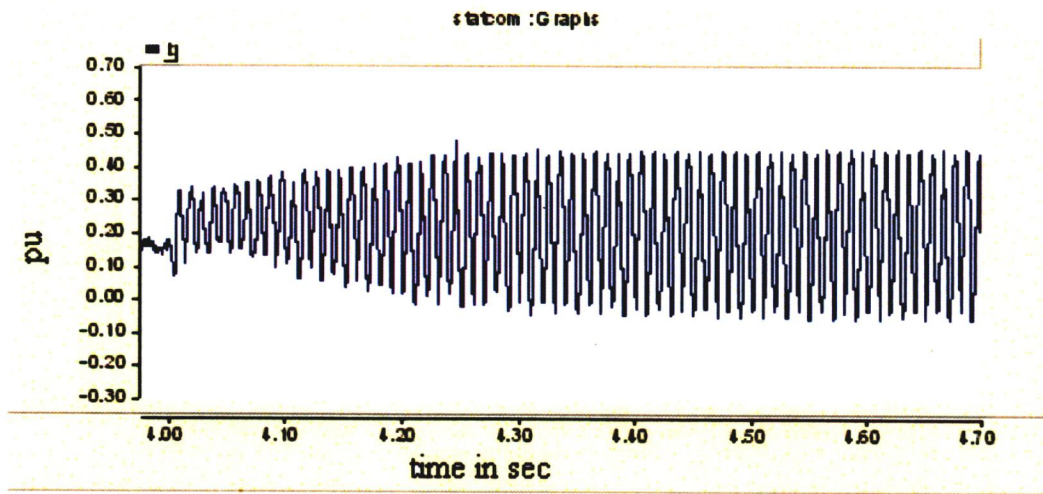
Figure 5.11 I_q with direct control for L-G fault

Fig 5.12 to Fig 5.14 are the response of the controller for Line to Line (L-L) fault at the same bus for 3.5 sec.
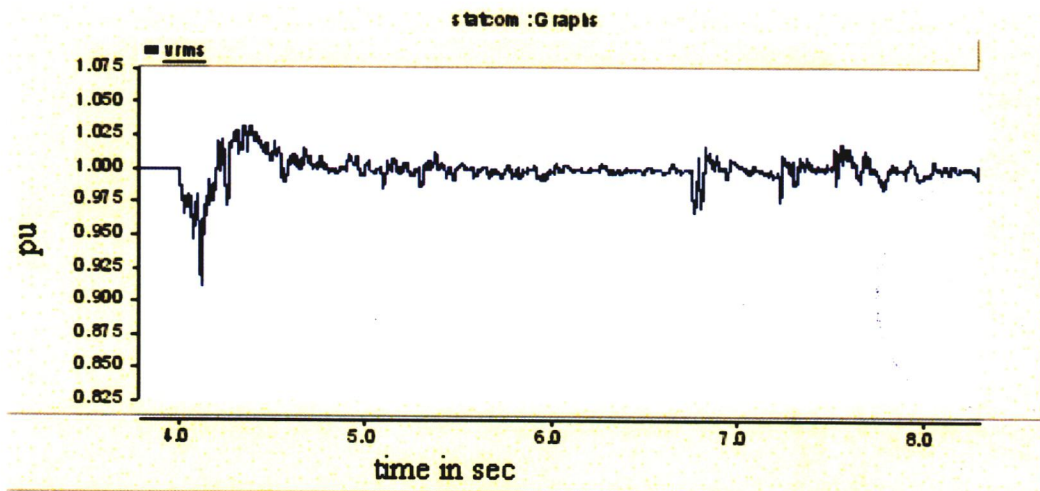
Figure 5.12 V_{rms} with direct controlled STATCOM for L-L fault
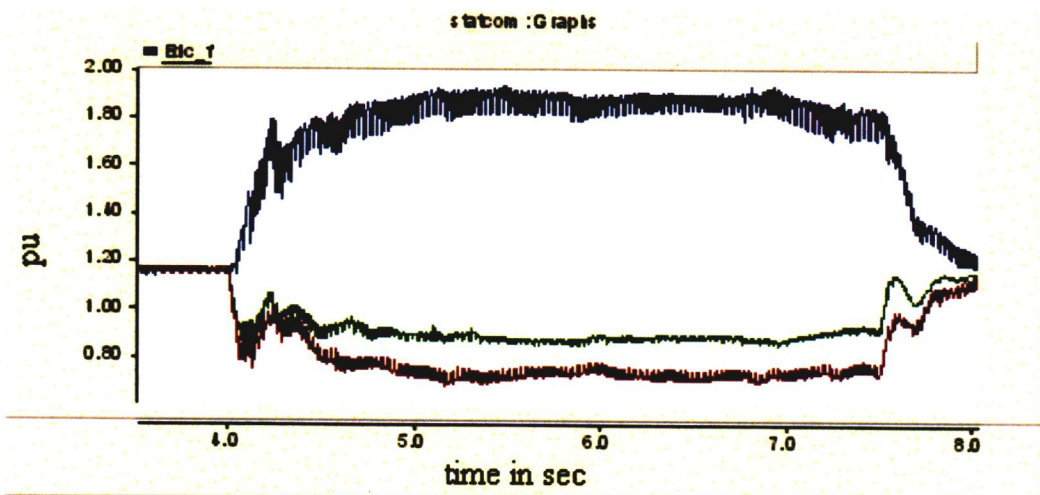
Figure 5.13 3-Ph DC link voltage with direct control for L-L fault
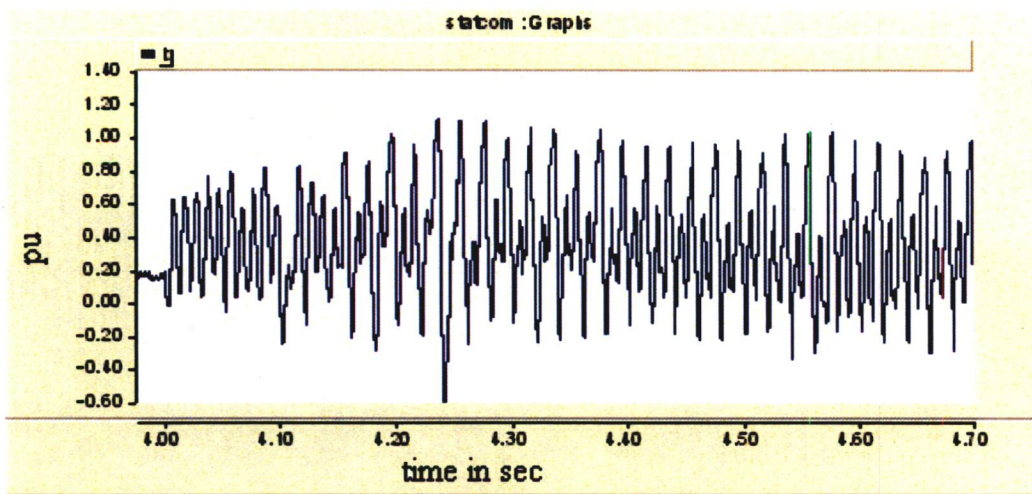
Figure 5.14 I_q with direct control for L-L fault

Fig 5.15 to Fig 5.17 are the response of the controller for Double Line to Ground (LL-G) fault at the same bus for 3.5 sec.
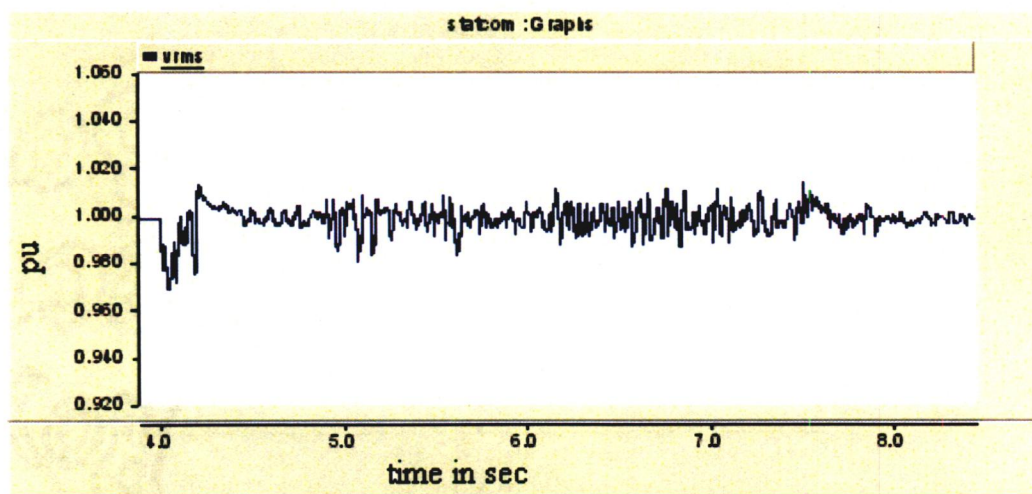
Figure 5.15 V_{rms} with direct controlled STATCOM for LL-G fault
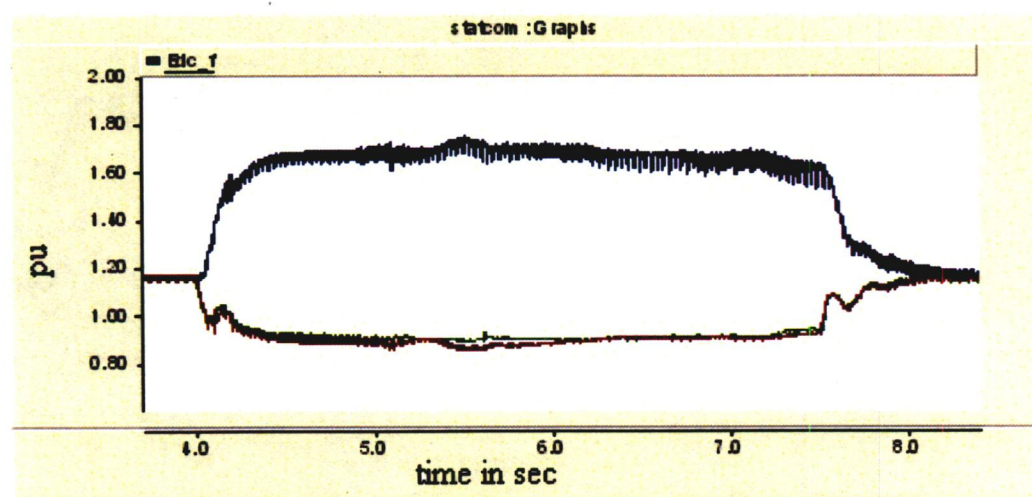
Figure 5.16 3-Ph DC link voltage with direct control for LL-G fault
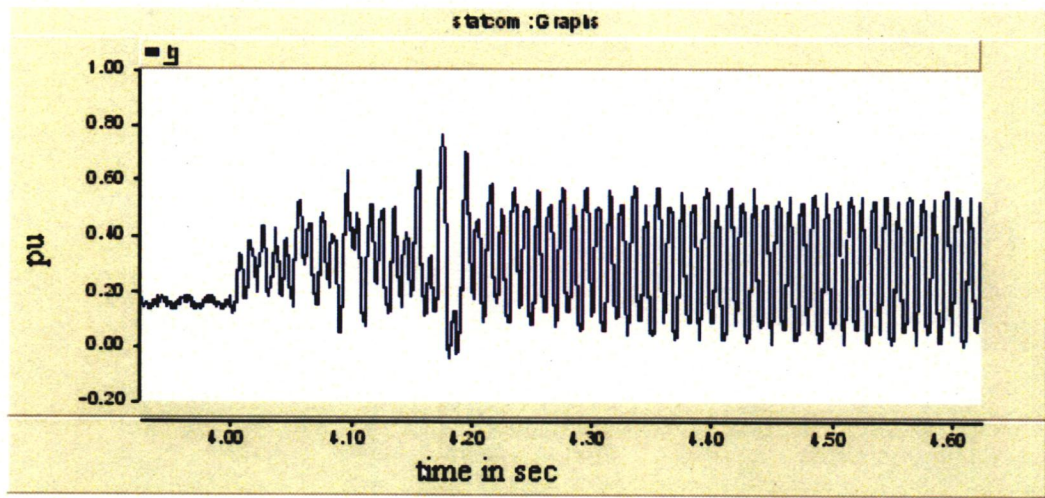
Figure 5.17 I_q with direct control for LL-G fault

The main contribution of this dissertation is the development and tuning of Fuzzy Controller for STATCOM application. The direct control of STATCOM is a two input two output system as a result the designing of multi input multi output is quite difficult. This problem is solved by first designing the indirect Fuzzy controller which is a single input single output system, and then the design of direct Fuzzy controller has been achieved independently. The Optimization of the firing angles which has very low THD and good constrained satisfaction has been shown to be possible. The linear interpolation of modulation index has been done away as the look-up table has been stored with modulation index in steps of 0.001. The response of the controller for symmetrical fault is acceptable. In cases of unsymmetrical faults the problem with the unbalanced DC link capacitor voltages can be corrected by implementing per phase control of the DC voltage. The performance of the STATCOM for incoming and rejection of reactive load would be similar to the three phase to ground fault which has been observed to be satisfactory.

The membership function for the FPIC considered here is uniform, but the unequal voltage sag and swells during inception and clearing of faults provides the possibility to test the controller with non uniform membership function. The hardware and the computational requirements of the FPIC would be much simpler than the Exact nonlinear control system. The Fuzzy logic optimized PLC's from ABB and FANUC can be considered for the controller design. The complicated firing rule can be easily be fabricated by latest Field Programmable Gate Array (FPGA) from Xilinx or Altera. The power stage has to be designed considering the system rating and the switching loss. The latest family of Insulated Gate Commutated Thyristor (IGCT) and Emitter Turn Off (ETO) thyristors are viable options. In whole the thesis explored the possibility to use Fuzzy Logic for Cascaded Multilevel Converter based STATCOM successfully.

[15]   Mudi R. K. and Pal N.R., "A robust self-tuning scheme for PI- and PD-type fuzzy controllers", IEEE Trans. on Fuzzy Systems, vol. 7, no. 1, Feb. 1999, pp. 2-16.

[16]   Stella Morris·, P. K. Dash and K. P. Basu, "A fuzzy variable structure controller for STATCOM", Electric Power Systems Research, vol 65, issue 1 April 2003 pp. 23-24

[17]   B. Mwinyiwiwa, Z. Wolanski, and B. T. Ooi, "Microprocessor-implemented SPWM for multiconverters with phase-shifted triangle carriers," IEEE Trans. Industry Applications, vol. 34, pp. 487–494, May/June 1998.

[18]   S. M. Tenconi, M. Carpita, C. Bacigalupo, and R. Cali, "Multilevel voltage source converters for medium voltage adjustable speed drives," in Proc. IEEE International Symposium on Industrial Electronics, vol. 1, 1995, pp. 91–98.

[19]   P. W. Hammond, "Medium voltage PWM drive and method," U.S. Patent 5 625 545, Apr. 29, 1997.

[20]   S. Ito, K. Imaie, K. Nakata, S. Ueda, and K. Nakamura, "A series of PWM methods of a multiple inverter for adjustable frequency drive," in Proc. 5th European Conf. Power Electronics and Applications, vol. 4, 1993, pp. 190–195.

[21]   E. Cengelci, P. Enjeti, C. Singh, F. Blaabjerg, and J. K. Pederson, "New medium voltage PWM inverter topologies for adjustable speed ac motor drive systems," in Proc. IEEE APEC'98, vol. 2, 1998, pp. 565–571.

[22]   G. Carrara, D. Casini, S. Gardella, and R. Salutari, "Optimal PWM for the control of multilevel voltage source inverter," in Proc. 5th European Conf. Power Electronics and Applications, vol. 4, Brighton, U.K., Sept. 13–16, 1993, pp. 255–259.

[23]   MATLAB/SIMULINK www.mathworks.com

[24]   L. Li, D. Czarkowski, Y. Liu, and P. Pillay, "Multilevel Selective Harmonic Elimination PWM Technique in Series-Connected Voltage Inverters," IEEE Trans Industry Applications, vol. 36, no. 1, Jan./Feb. 2000 , pp. 160–170

[25]   Biswarup Das and Bikash C. Pal,"Voltage Control Performance of AWS Connected for Grid Operation", IEEE Trans. on Energy Conversion, vol. 21, no. 2, June 2006 pp. 353-361

[26]   PSCAD/EMTDC, Manitoba HVDC research centre, Canada.

[27]   Qiang Lu, Y. Sun and Shengwei Mei "Nonlinear Control Systems and Power Systems Dynamics", Kulwer Academic Publisher.

[28]   Han-Xiong Li and H. B. Gatland , "Conventional Fuzzy Control and Its Enhancement", IEEE Trans. on Systems, Man, and Cybernetics- Part B: Cybernetics, vol. 26, no.5, October 1996, pp. 791-796.

APPENDIX-A

A.1 Calculations for Base values

S_{base} =Rating of the STATCOM

$\quad$ =±30MVA

V_{base} =Rated system voltage

$\quad$ =11kV

$$I_{base} = \frac{S_{base}}{\sqrt{3}V_{base}}$$

$$= \frac{30 \times 10^6}{\sqrt{3} \times 11 \times 10^3} = 1.57459 \, kA$$

DC link voltage in pu, $V_{dc}^{'} = \frac{\sqrt{2} \times V_{phase\_peak}}{V_{base}}$

$$= \frac{\sqrt{2} \times \sqrt{2} \times V_{line}}{\sqrt{3} \times V_{base}} = 1.1547$$

$$Z_{base} = \frac{V_{base}}{\sqrt{3}I_{base}} = \frac{V_{base}^2}{S_{base}}$$

$$= \frac{11^2}{30} = 4.03333$$

Coupling Resistance R=0.0605Ω

Per-unit resistance $R^{'} = \dfrac{R}{Z_{base}} = 0.015$

Coupling Inductance L=0.00192576H

Per-unit reactance $X_l^{'} = \dfrac{\omega L}{Z_{base}} = \dfrac{2 \times \pi \times 50 \times 0.00192576}{4.03333} = 0.15$

Base voltage in DQ frame $V_{DQ\_base} = V_{base}$

Base current in DQ frame $I_{DQ\_base} = \dfrac{S_{base}}{V_{DQ\_base}} = \sqrt{3}I_{base} = 2.72727 \, kA$

A.2 Phase shift for multilevel optimization

$\beta = \dfrac{2 \times \pi}{N_{cell} \times h_{selected}} = \dfrac{2 \times \pi}{10 \times 11} = 3.273°$ where $h_{selected}$ = Harmonic to be eliminated by phase

shift[24]

A.3 Capacitor voltage ripple

$$\Delta V_c = 4.33\% V_{dc}$$

$$= \frac{4.33 \times \sqrt{2} \times \sqrt{2} \times V_{line}}{\sqrt{3} \times 100} = 550 \text{ V}$$

A.4 Required total link Capacitance per phase

$$C_p = \frac{I_{peak}}{2\omega\Delta V_c} = \frac{\sqrt{2} \times 1574.59}{4 \times \pi \times 50 \times 550} = 0.006443768F$$

A.5 Minimum modulation index for the system

$$Q = \frac{3}{2}(V_{ph\_peak})\cos\delta \times \frac{(V_{ph\_peak})\sin\delta}{R}$$

$$= \frac{3}{2}\sqrt{2}(V_{ph})\cos\delta \times \frac{\sqrt{2}(V_{ph})\sin\delta}{R}$$

$$= \frac{3}{2}\frac{(V_{ph})^2}{R}\sin 2\delta$$

For Q=-30MVA, R=0.0605Ω and $V_{ph} = \frac{11}{\sqrt{3}}kV$

$$2\delta = -\sin^{-1}\frac{30 \times 2 \times 0.0605 \times \sqrt{3}^2}{3 \times 11^2}$$

$$\delta = -0.8595656°$$

Now, using

$$mV_{dc} = \sqrt{2}V_{ph}(\cos\delta + \tfrac{X}{R}\sin\delta)$$

$$m_{min} = \frac{\sqrt{2} \times 11}{\sqrt{3} \times 12.7}(\cos\delta - 10\sin\delta)$$

$$m_{min} = 0.601$$

APPENDIX-B

Optimized values of angles in degrees for modulation index 0.550 to 1.000 in steps of 0.001

m	α_1	α_2	α_3	α_4	α_5	α_6	α_7	α_8	α_9	α_{10}	α_{11}	α_{12}	α_{13}	α_{14}	α_{15}	α_{16}	α_{17}	α_{18}	α_{19}	α_{20}	α_{21}	α_{22}	α_{23}	α_{24}	α_{25}	α_{26}	α_{27}	α_{28}	α_{29}	α_{30}
0.550	32.1876	65.5222	90.0000	28.3200	50.9826	79.5595	39.8385	68.4908	88.2370	24.8274	46.5710	77.7694	48.8058	76.9004	90.0000	24.4496	25.5749	64.9815	47.6110	75.9841	90.0000	15.4859	25.4180	68.1935	55.5845	82.3442	90.0000	6.2622	31.6671	73.1990
0.551	31.1430	64.9585	89.8565	35.9272	60.9328	83.7524	41.0874	71.2794	90.0000	26.6500	54.3937	83.0384	51.9185	79.3956	90.0000	17.6178	30.4279	70.0058	57.0029	83.5785	90.0000	12.8152	14.8624	64.8994	61.5265	86.4782	89.0013	4.6942	37.8715	76.9678
0.552	31.1108	64.8295	89.8462	35.2193	58.6516	82.1355	40.3367	70.8093	90.0000	26.3591	52.2485	81.3876	50.4770	78.2965	90.0000	17.4218	29.8805	69.7278	55.2731	81.5064	89.3368	12.7281	14.6423	64.8091	59.9168	85.3286	89.2136	4.7303	36.7068	76.1931
0.553	34.8924	67.3002	90.0000	30.2503	53.8933	80.8057	40.2161	70.7744	90.0000	31.2124	45.7738	73.9446	46.2176	75.0725	90.0000	25.8069	29.4504	66.1189	51.5550	77.2570	88.1008	16.1919	30.5948	70.4408	57.0962	83.7478	90.0000	6.9022	36.5418	75.8184
0.554	30.9461	64.8872	89.8934	33.5088	56.3690	81.0744	39.3235	68.4303	88.3289	23.1678	50.1866	81.0227	53.6923	80.9666	90.0000	25.6288	29.0357	65.9325	48.8835	77.0549	89.9120	16.2274	23.1688	66.7777	58.1984	84.6910	89.9623	6.8528	34.7190	74.6800
0.555	29.5553	64.2793	90.0000	33.3311	56.1845	80.9726	38.6938	67.8946	88.1828	22.3943	49.4013	80.6730	48.1698	76.6257	89.9838	24.5301	27.2370	65.4635	53.4355	80.8029	90.0000	16.0243	21.8792	66.2515	58.0939	84.4879	89.1039	6.6838	33.9420	74.1991
0.556	33.7576	66.7518	90.0000	33.0108	51.6313	77.3595	40.0030	69.1608	88.4863	17.9683	46.4231	79.9341	49.1244	77.1206	89.7042	16.7884	36.0356	69.3501	47.2550	75.9921	90.0000	13.0689	15.7178	64.8373	56.0022	82.9648	90.0000	4.6391	31.3745	72.9180
0.557	35.7977	68.0609	90.0000	27.5552	50.2009	78.9889	39.8638	67.6302	87.1065	21.1923	45.8607	78.3754	47.9345	76.5549	90.0000	20.5531	37.3093	72.7528	47.3607	76.1186	90.0000	14.2178	18.0963	65.2517	55.4813	82.5762	90.0000	4.8495	23.5162	69.0229
0.558	38.8273	64.1152	84.5040	26.3458	54.3750	82.8425	31.3309	65.4224	90.0000	17.2829	42.2443	77.0743	43.5437	73.3457	90.0000	33.8321	35.1117	64.8106	52.1386	79.8922	90.0000	12.6868	14.6143	64.5126	56.7790	83.7067	90.0000	4.6912	29.7170	71.9356
0.559	39.5867	65.1035	85.1469	26.9326	52.5749	81.0703	34.8169	67.5459	90.0000	18.1428	43.5195	75.6494	44.4586	76.5714	90.0000	66.9452	50.9905	79.0232	90.0000	13.2629	15.8336	64.6746	55.7917	82.9252	90.0000	4.8140	30.6825	72.3878		
0.560	39.8926	67.2087	86.5630	27.5217	50.1044	78.7916	35.9148	68.2802	90.0000	20.8148	45.7927	78.3259	47.4677	76.3387	90.0000	20.8061	37.4965	72.6370	47.5272	76.3838	90.0000	14.1361	18.0476	65.1083	55.2923	82.5554	90.0000	4.8092	23.4745	68.8641
0.561	40.4619	66.5210	85.5158	28.3198	50.7407	78.8648	37.2244	69.1658	90.0000	18.4324	44.4851	78.1504	45.3481	74.8000	90.0000	24.1362	38.8248	72.1155	49.0683	77.6108	90.0000	13.6191	16.5702	64.7102	54.9715	82.2353	90.0000	4.7894	25.7004	69.8076
0.562	40.0892	66.5261	85.7170	27.5631	50.1658	78.7281	36.2459	68.5867	90.0000	16.6777	44.9333	78.0111	46.0150	75.3404	90.0000	21.8195	37.8787	72.4014	48.3074	77.0712	90.0000	13.9636	17.5427	64.8850	54.8929	82.3158	90.0000	4.7634	23.6743	68.8574
0.563	39.9580	66.5325	85.7624	27.4116	50.1899	78.7727	35.9979	68.4779	90.0000	20.1694	45.1746	77.9685	46.2296	75.5466	90.0000	21.1635	37.6299	72.4466	48.1820	77.0214	90.0000	13.9947	17.7255	64.8881	54.9216	82.3849	90.0000	4.7512	23.3371	68.6659
0.564	40.0818	66.0234	85.1698	27.6549	51.1453	79.3650	36.4468	68.8111	90.0000	18.4719	43.7410	77.4696	44.4834	74.3066	90.0000	23.0669	38.0471	71.9154	49.3647	77.9786	90.0000	13.6276	16.5645	64.5568	54.8203	82.3467	90.0000	4.7647	24.5047	69.1239
0.565	40.1413	66.3434	85.3800	27.5485	50.5248	78.8794	36.2770	68.7514	90.0000	19.5995	45.1076	78.0261	45.8084	75.3265	90.0000	21.8988	38.1029	72.3736	48.6650	77.4841	90.0000	13.9665	15.5979	64.7534	54.8377	82.4064	90.0000	4.7662	23.7703	68.7538
0.566	40.1604	65.9230	84.9366	27.6066	51.2372	79.3690	36.4651	68.8192	90.0000	18.4700	43.9226	77.5068	44.5152	74.4232	90.0000	23.0114	38.2314	71.9633	49.4230	78.1158	90.0000	13.6206	16.5949	64.4685	54.7243	82.3358	90.0000	4.7528	24.4663	69.0116
0.567	36.3359	64.5324	85.9995	27.5436	54.6251	82.0919	38.6012	70.3553	90.0000	17.1669	40.3865	75.4300	42.0267	72.6918	90.0000	23.4291	37.9617	71.5673	51.3328	79.6608	90.0000	12.9953	15.0464	64.1098	57.1264	84.4067	90.0000	5.2020	24.7754	69.1214
0.568	36.6363	64.4958	85.7422	27.8778	54.9342	82.1445	41.1732	72.1446	90.0000	17.1760	40.5748	75.5070	41.1987	72.1622	90.0000	24.2325	39.7986	72.3911	51.3736	79.7390	90.0000	12.8084	14.8495	64.0497	57.1174	84.4950	90.0000	4.5318	25.7891	69.5350
0.569	36.4816	64.4278	85.7280	27.7097	54.7617	82.0357	40.8596	71.9755	90.0000	17.0512	40.3089	75.3202	41.0995	72.1409	90.0000	24.0684	39.6220	72.2960	51.1246	79.6665	90.0000	12.7277	14.6877	63.9736	57.0423	84.4262	90.0000	4.4839	25.5522	69.3814
0.570	36.6441	64.5058	85.6564	27.5489	54.5113	81.8594	42.0377	72.8408	90.0000	17.0179	40.3484	75.3102	38.1187	70.1806	90.0000	23.2703	37.8735	71.4341	51.2141	79.7039	90.0000	12.9318	14.9893	63.9590	56.7454	84.2215	90.0000	4.5323	24.7787	68.9773
0.571	40.1547	65.8285	84.6278	27.5096	51.1388	79.1076	44.9305	74.9595	90.0000	18.6715	44.6599	77.7379	36.3645	69.0962	90.0000	25.5795	38.4374	72.0370	49.2053	78.1770	90.0000	13.6116	16.8835	64.3135	54.4733	82.3790	90.0000	4.8109	24.2588	68.6734
0.572	40.3111	65.6767	84.3420	27.4262	51.3051	79.2330	44.6656	74.8128	90.0000	18.6510	44.4776	77.5676	36.3381	69.1277	90.0000	25.5349	38.5291	72.0677	49.3264	78.3168	90.0000	13.5837	16.8586	64.2367	54.3658	82.3362	90.0000	4.6831	24.1545	68.5905
0.573	39.6328	66.1705	85.1871	27.5498	52.8555	80.3720	46.1799	75.9739	90.0000	20.9595	47.0909	78.6363	36.3275	69.2441	90.0000	20.7292	38.3505	72.6025	50.9651	79.6441	90.0000	14.0089	18.4933	64.6507	53.7050	83.1186	90.0000	4.9117	23.7516	68.3457
0.574	39.8937	66.3084	85.1012	27.7166	53.1681	80.5011	46.2510	76.0732	90.0000	20.7500	47.2614	78.7939	36.5731	69.3732	90.0000	21.4989	38.7983	72.5574	51.2702	79.9312	90.0000	14.2061	18.9749	64.7188	55.3808	83.2637	90.0000	5.0476	24.2024	68.4816
0.575	42.0134	67.9677	85.1961	27.8047	53.7426	80.8816	45.3490	75.4525	90.0000	22.7383	46.5387	77.4561	36.7344	69.5242	90.0000	24.4906	40.3947	72.3517	50.7881	79.5961	90.0000	14.6047	24.2566	66.6947	55.8129	83.6678	90.0000	4.5918	25.1006	68.8766
0.576	42.3101	67.9929	84.9745	27.6364	53.8056	80.9668	44.7661	75.0724	90.0000	22.6697	46.0730	77.0919	36.6901	69.5439	90.0000	24.9484	40.5739	72.2256	50.7098	79.5802	90.0000	14.4730	24.6475	66.8578	55.7588	83.6681	90.0000	4.5754	24.9888	68.7790
0.577	41.1586	67.4949	85.2361	27.6388	53.7263	80.8553	45.6205	75.7453	90.0000	22.5542	46.7908	77.6243	36.4807	69.4587	90.0000	23.2335	39.7221	72.3367	50.7912	79.6900	90.0000	14.3065	23.1809	66.2057	55.7830	83.7334	90.0000	4.7847	24.6845	68.5751
0.578	42.5174	68.3616	85.0874	28.1131	54.0364	80.8388	45.1104	75.4169	90.0000	22.3828	46.5415	77.4595	36.9016	69.7750	90.0000	26.0271	41.1222	72.0202	50.8448	79.7779	90.0000	14.2281	24.1455	66.6002	55.8021	83.7946	90.0000	4.6935	26.8523	69.5441
0.579	42.5887	67.9646	84.6242	27.7134	53.3543	80.5887	44.6218	75.1071	90.0000	22.3821	46.1091	77.0930	36.7433	69.7433	90.0000	25.7047	40.9573	72.0069	50.4838	79.5399	90.0000	14.2909	24.2111	66.5636	55.3030	83.4258	90.0000	4.5746	26.1316	69.1627
0.580	42.6654	67.9615	84.5236	27.4627	53.5334	80.6436	44.2380	74.8755	90.0000	22.4133	45.8204	76.8217	36.6337	69.7000	90.0000	25.8894	40.9361	71.8604	50.5165	79.5165	90.0000	14.2175	24.3918	66.6152	55.2612	83.4190	90.0000	4.5909	25.9979	69.0453
0.581	42.1538	67.6004	84.4891	27.6234	53.4430	80.0491	44.5873	75.1751	90.0000	22.2889	46.0132	76.9662	36.5815	69.7148	90.0000	24.8596	40.5733	72.0281	50.2757	79.4684	90.0000	14.3432	23.8221	66.2785	55.1576	83.3961	90.0000	4.5184	25.5758	68.8114
0.582	42.0585	67.5898	84.4982	27.6471	53.5205	80.4555	44.6381	75.2586	90.0000	22.2632	46.0799	76.9791	36.5291	69.7295	90.0000	24.8081	40.5626	71.9962	50.2738	79.5127	90.0000	14.3281	23.7613	66.2066	55.1937	83.4712	90.0000	4.5372	25.6140	68.7792
0.583	42.8218	68.0481	84.3620	27.4317	53.4422	80.4470	44.0822	74.9029	90.0000	22.2816	45.8199	76.7341	36.4948	69.7557	90.0000	26.6447	41.1569	71.5188	50.2179	79.5148	90.0000	13.9850	24.3216	66.4983	55.0308	83.3598	90.0000	4.5972	26.7888	69.2814
0.584	42.5123	67.6354	84.1434	27.2773	53.2016	80.2776	43.3718	74.4404	90.0000	22.2707	45.1531	76.2029	36.1992	69.6169	90.0000	25.5774	40.4701	71.4934	49.8480	79.2721	90.0000	14.2452	24.1178	66.2887	54.8384	83.2688	90.0000	4.4967	25.8019	68.7736
0.585	42.4292	67.4880	84.0176	27.3139	53.0539	80.0950	43.5472	74.6123	90.0000	22.0555	45.2695	76.3252	36.2534	69.6990	90.0000	25.4516	40.5442	71.5538	49.7438	79.2369	90.0000	14.1234	23.7974	66.1300	54.6391	83.1502	90.0000	4.5272	25.9096	68.7731
0.586	42.6615	67.6236	83.9404	27.0903	53.0228	80.1278	43.2050	74.4151	90.0000	22.0647	45.0993	76.1360	36.1545	69.6847	90.0000	26.1813	40.6826	71.2661	49.7191	79.2635	90.0000	14.0080	23.9380	66.1825	54.5491	83.1372	90.0000	4.5386	26.3404	68.9273
0.587	42.5398	67.5315	83.8924	27.1051	53.0015	80.0581	43.1464	74.4202	90.0000	22.0291	45.0488	76.0816	36.0413	69.6616	90.0000	25.8799	40.5656	71.2778	49.6129	79.2269	90.0000	14.0160	23.9018	66.1063	54.5190	83.1423	90.0000	4.5234	26.1135	68.7728
0.588	42.2713	67.2175	83.7377	27.0293	52.7325	79.9296	42.9341	74.3165	90.0000	21.8200	44.7733	75.9152	35.9173	69.6319	90.0000	25.2866	40.2315	71.2722	49.3590	79.0762	90.0000	14.0954	23.5105	65.8636	54.2983	83.0068	90.0000	4.5093	25.7487	68.5544
0.589	39.8685	64.9202	83.1678	26.6807	51.1502	78.6760	44.0076	75.1287	90.0000	18.4009	44.5031	76.8830	35.5331	69.4404	90.0000	21.6745	38.3995	71.5183	48.4590	78.4305	90.0000	13.3928	16.6519	63.3937	53.2566	82.2048	90.0000	4.4918	23.5786	67.5310
0.590	39.6089	64.4965	82.9037	26.3145	50.4480	78.2414	41.8389	73.6420	90.0000	17.3578	42.2278	75.5578	34.9151	69.1075	90.0000	22.0257	37.5689	70.7726	47.7097	77.9068	90.0000	13.0147	15.5186	63.0883	52.6683	81.7760	90.0000	4.3998	23.5649	67.4841
0.591	39.5342	64.4662	82.8788	26.1556	50.4885	78.2991	41.4908	73.3476	90.0000	17.2464	41.9363	75.3437	34.7538	69.0570	90.0000	22.0210	37.3992	70.6373	47.6623	77.9170	90.0000	12.9027	15.3512	63.0161	52.6856	81.8354	90.0000	4.4117	23.4569	67.3877
0.592	39.8487	64.8607	82.9903	26.5968	51.0251	78.4773	43.3477	74.7966	90.0000	17.9494	43.8923	76.4387	35.3830	69.4916	90.0000	21.9205	38.3812	71.2675	48.1456	78.3294	90.0000	13.2593	16.3234	63.1726	53.0181	82.1485	90.0000	4.4565	23.7724	67.4721
0.593	39.7278	64.7324	82.9060	26.4397	50.8594	78.1518	43.2681	74.1518	90.0000	17.5236	42.9021	75.8224	35.0903	69.3005	90.0000	22.0806	38.0354	70.9305	47.8595	78.1582	90.0000	13.0076	15.8604	63.0196	52.8773	82.0804	90.0000	4.4278	23.7846	67.4311
0.594	39.6490	64.6764	82.8603	26.3282	50.8504	78.3692	42.1834	74.0694	90.0000	17.5039	42.7410	75.6846	34.9526	69.3230	90.0000	21.9869	37.9155	70.8419	47.7925	78.1535	90.0000	13.0563	15.7827	62.9558	52.8336	82.0907	90.0000	4.4170	23.6598	67.3289
0.595	39.5909	64.6323	82.8122	26.2287	50.8396	78.3596	42.1318	74.0802	90.0000	17.5220	42.7284	75.6237	34.8372	69.3005	90.0000	21.8490	37.8404	70.8000	47.7338	78.1551	90.0000	13.0484	15.7957	62.9112	52.7915	82.1023	90.0000	4.4058	23.5113	67.2166
0.596	39.5346	64.5788	82.7542	26.1372	50.8204	78.3397	42.1234	74.1211	90.0000	17.5363	42.7530	75.5901	34.7433	69.2913	90.0000	21.7005	37.7825	70.7731	47.6761	78.1574	90.0000	13.0425	15.8072	62.8657	52.7397	82.1060	90.0000	4.3976	23.3652	67.1054
0.597	39.4104	64.2936	82.5290	25.8163	50.3598	78.0728	41.7551	73.9119	90.0000	17.4242	42.4367	75.3572	34.4442	69.1579	90.0000	21.3548	37.4298	70.6318	47.3445	77.9535	90.0000	12.9379	15.5684	62.7689	52.3205	81.8135	90.0000	4.3442	22.8773	66.8528
0.598	39.3048	64.3446	82.5975	25.8757	50.5343	78.1388	41.9726	74.1097	90.0000	17.5204	42.6717	75.4451	34.4088	69.1678	89.9844	21.2901	37.4372	70.6138	47.3543	78.0068	90.0000	12.9622	15.7037	62.7532	52.4858	81.9933	90.0000	4.3855	22.8899	66.8057
0.599	39.5015	64.3209	82.6330	25.7004	50.6226	78.2378	39.3084	72.3445	90.0000	19.6915	40.3895	73.1067	34.0735	69.0332	90.0000	19.6616	36.5884	70.6283	47.0746	77.4628	89.6286	13.4346	16.9315	62.5625	52.1804	81.9330	90.0000	4.4517	22.4170	66.5528
0.600	39.5015	64.3253	82.2633	25.7494	50.5889	78.1461	39.2934	72.3335	90.0000	19.8092	40.4772	73.0776	34.0314	69.0294	90.0000	19.5465	36.6040	70.6314	47.0877	77.4077	89.6133	13.4334	16.9252	62.9168	52.0649	82.1744	90.0000	4.4279	22.4651	66.5250
0.601	39.5608	64.2714	82.2307	25.6371	50.6229	78.1767	39.2670	72.4114	90.0000	19.8710	40.5601	73.0649	33.9102	69.0294	90.0000	19.3310	36.5164	70.6044	46.9720	77.4475	89.5988	13.4016	16.8812	62.8602	52.2508	81.1816	90.0000	4.4095	22.2988	66.4092
0.602	39.9706	64.2183	82.1308	25.4892	50.6174	78.1916	39.2124	72.4223	90.0000	20.0145	40.5978	72.9923	33.8993	69.0711	90.0000	19.0555	36.4962	70.6400	46.9830	77.4878	89.5851	13.3491	16.7606	62.7840	52.5036	81.1892	90.0000	4.3898	22.2562	66.3441
0.603	39.5610	64.1698	82.0474	25.4259	50.6091	78.1669	39.2948	72.5242	90.0000	20.0224	40.7125	73.0206	33.8559	69.0934	90.0000	18.9229	36.5454	70.6691	46.9389	77.4972	89.5717	13.2969	16.6889	62.7237	52.4548	81.1956	90.0000	4.3807	22.1733	66.2616
0.604	39.5528	64.1263	81.9677	25.3700	50.5733	78.1172	39.3369	72.5994	90.0000	20.0255	40.8118	73.0402	33.8282	69.1250	90.0000	18.8035	36.5691	70.6772	46.8692	77.4675	89.5594	13.2634	16.6175	62.6587	52.3910	81.1900	90.0000	4.3634	22.1129	66.1889
0.605	39.5088	64.0990	81.9258	25.3708	50.5263	78.0339	39.5189	72.7675	90.0000	19.9224	40.9919	73.1333	33.7687	69.1378	90.0000	18.8125	36.6376	70.6697	46.7955	77.4512	89.5512	13.2192	16.5834	62.6084	52.2922	81.1565	90.0000	4.3758	22.0423	66.1096
0.606	35.7109	70.3653	90.0000	25.9797	45.4078	73.7868	40.6736	73.6384	90.0000	21.1354	39.3809	71.5660	34.5528	69.9666	90.0000	17.7858	35.0329	69.9666	46.7955	78.9772	89.7465	13.0025	16.0094	62.4316	48.4918	78.9772	89.7465	4.3253	25.0600	66.4909
0.607	35.7477	70.4359	90.0000	25.8916	45.6550	73.9729	40.6736	76.6384	90.0000	21.2914	39.7191	71.6889	32.1261	68.2756	90.0000	17.7780	32.2851	68.6385	64.3016	79.1193	13.0217	16.1242	62.4118	48.5124	79.0146	89.7229	4.3646	25.1387	66.4723	
0.608	39.3955	64.1329	81.8929	25.2274	50.5463	77.9741	39.2549	72.7335	90.0000	20.0281	40.9810	72.9669	33.5269	69.0803	89.9451	18.3646	36.4189	70.4727	46.6644	77.4881	89.9478	13.1440	16.5294	62.4583	52.3095	83.3065	90.0000	4.4094	22.0441	65.9598
0.609	39.4533	64.0415	81.7273	25.1060	50.4709	77.9215	39.0547	72.6482	90.0000	20.2706	40.9443	72.8072	33.4177	69.0767	89.9572	18.1686	36.3036	70.4849	46.6066	77.4744	89.5314	13.0532	16.3130	62.3617	52.1729	82.2430	90.0000	4.3772	22.0564	65.9183
0.610	39.5376	64.0565	81.6412	25.1786	50.4479	77.8257	39.3181	72.8696	90.0000	19.7961	41.1383	73.0634	33.5469	69.1498	89.9091	18.7483	36.6606	70.4676	46.5401	77.4901	89.5499	13.1188	16.5307	62.3797	52.0473	82.1183	90.0000	4.3629	21.9734	65.8361
0.611	39.4751	64.0856	81.6624	25.1702	50.5201	77.8403	39.3689	72.9504	90.0000	19.4923	41.1836	73.1543	33.5659	69.0911	89.7988	19.1244	36.7187	70.3272	46.4786	77.5728	89.6303	13.1626	16.6851	62.3514	52.1064	82.2807	90.0000	4.3380	22.0337	65.8136
0.612	39.4446	64.1085	81.6573	25.1104	50.5992	77.8827	39.5109	73.0917	90.0000	19.2001	41.2954	73.2854	33.5711	69.0587	89.7208	19.3603	36.8206	70.2616	46.4930	77.6898	89.6878	13.1565	16.7002	62.3070	52.1075	82.3271	90.0000	4.3193	21.9779	65.7429
0.613	35.9714	70.8610	90.0000	25.6107	45.7959	73.3233	40.5594	73.8422	90.0000	21.3126	40.1034	71.6560	32.8731	68.9965	90.0000	17.0336	34.1239	69.3204	43.8175	64.1761	78.7257	12.7670	15.4571	61.9655	48.2201	78.9401	89.6056	4.2721	23.1018	66.1692
0.614	36.7345	71.3866	90.0000	25.4431	45.6332	73.8310	40.5054	73.8526	90.0000	21.0298	40.2266	71.7999	33.7567	69.5634	90.0000	16.9785	35.6272	70.2057	43.7052	64.0210	78.6168	12.6245	15.3186	61.9084	48.0778	78.8781	89.5984	4.2386	22.7880	65.9889
0.615	33.5147	69.4684	90.0000	25.4061	55.7403	73.8805	40.4576	73.8671	90.0000	21.1272	40.2534	71.7338	36.5644	71.3269	90.0000	16.8722	35.3275	70.0058	43.8053	64.0641	78.5397	12.6279	15.2681	61.8414	48.0523	78.8753	89.5696	4.2530	22.8364	65.9590
0.616	33.3675	69.4298	90.0000	25.4263	55.9200	73.9587	40.4972	73.9407	90.0000	21.0754	40.4641	71.8497	36.7838	71.5127	90.0000	16.9525	35.4123	69.9853	44.0172	64.1492	78.4219	12.6377	15.3988	61.8271	47.9798	78.8105	89.5149	4.2697	22.8410	65.9103
0.617	36.7032	71.5093	90.0000	25.3626	45.9414	73.9564	40.6014	74.0579	90.0000	21.0058	40.5856	71.9117	33.2642	69.4173	90.0000	16.9736	35.3182	69.8728	43.3689	64.1274	78.3902	12.6710	15.4186	61.7738	47.9832	78.8346	89.4910	4.2737	22.7923	65.8400
0.618	36.2526	71.2740	90.0000	25.3153	45.9036	73.9024	40.4397	73.9955	90.0000	21.1039	40.3847	71.6900	32.8805	69.2416	90.0000	16.6718	34.7149	69.5489	43.8800	64.0929	78.3756	12.5607	15.1419	61.6672	47.9475	78.8593	89.4968	4.2367	22.8729	65.8280
0.619	36.1269	71.2432	90.0000	25.2632	45.9908	73.8766	40.3975	74.0315	90.0000	21.0724	40.3738	71.6471	32.6071	69.1315	90.0000	16.9321	34.4688	69.3523	43.9012	64.0936	78.3152	12.5520	15.1715	61.6270	47.8537	78.8076	89.4705	4.2297	22.8591	65.7733
0.620	31.8491	68.7466	90.0000	25.4106	45.4298	73.4128	39.7820	73.6480	90.0000	21.3872	39.5566	70.9250	35.2720	70.1951	89.4645	16.3549	33.1440	68.6130	43.4449	64.1195	78.6146	12.4646	14.8922	61.5150	47.5211	79.1798	90.0000	4.2013	23.2667	65.9013
0.621	32.7493	69.3099	90.0000	25.2085	45.6435	73.9140	41.0705	74.5636	90.0000	21.1787	41.0999	72.0107	36.0424	71.2857	90.0000	16.3487	34.4836	69.3625	43.7961	64.0633	78.2699	12.2473	14.7929	61.4391	47.9387	78.8616	89.3705	4.1797	22.9750	65.7281
0.622	31.7707	68.7988	90.0000	25.5053	46.2662	73.9020	40.9946	74.5585	90.0000	21.6214	41.0228	71.7401	35.4552	70.9707	90.0000	16.0868	33.2361	68.6482	43.9265	64.2493	78.3026	12.4183	14.6540	61.3547	47.9909	78.9157	89.3398	4.1778	23.6408	65.9676
0.623	35.1221	70.8146	90.0000	25.4186	46.1816	73.8304	40.5402	74.2972	90.0000	21.3894	40.4694	71.4016	31.1962	68.5250	90.0000	16.1186	32.6679	68.2580	43.6973	64.1298	78.3087	12.4970	14.7734	61.3211	41.0485	79.0466	89.3805	4.2232	23.4746	65.8420
0.624	25.3093	64.4194	88.9769	31.9360	50.2244	73.6663	41.3106	74.8674	90.0000	21.6054	42.2490	75.2078	36.1280	71.4814	90.0000	16.3975	34.0701	68.8933	45.9159	68.8924	81.1124	12.7441	15.4451	61.4053	51.5603	82.4378	90.0000	4.2854	23.6521	65.8653

0.625	31.4967	68.7894	90.0000	25.5204	46.6235	74.0242	41.0398	74.7295	90.0000	21.6801	41.1713	71.6779	35.4193	71.0914	90.0000	15.7007	33.1361	68.5580	43.9443	64.3673	78.2607	12.2734	14.3158	61.1396	48.2010	79.1550	89.2834	4.2130	23.3208	65.8963
0.626	30.9538	68.5356	90.0000	25.7779	46.5540	73.8088	40.8173	74.6248	90.0000	21.7197	41.0310	71.5140	35.0214	70.8964	90.0000	15.7060	32.2459	68.1231	43.9437	64.3689	78.2166	12.3571	14.3896	61.0887	48.0575	79.0566	89.2486	4.1580	24.1439	65.9952
0.627	30.3805	68.2695	90.0000	25.8966	46.5994	73.7424	40.8336	74.6826	90.0000	21.6981	41.0025	71.4591	34.7772	70.7961	90.0000	15.8012	31.9049	67.7184	43.8191	64.3251	78.2185	12.4615	14.5649	61.0617	48.1567	79.1488	89.2203	4.1866	24.2542	65.9932
0.628	30.5780	68.4257	90.0000	25.5632	46.5895	73.7937	40.7599	74.6792	90.0000	21.5747	40.9608	71.4308	34.8113	70.8643	90.0000	15.4571	32.1551	67.9132	43.8276	64.2883	78.1326	12.2618	14.1672	60.9463	48.0777	79.1047	89.1908	4.2119	24.0358	65.8436
0.629	30.2508	68.2959	90.0000	25.9630	46.7554	73.7366	40.6419	74.6461	90.0000	21.6627	40.9306	71.5282	34.6962	70.8425	90.0000	15.3542	31.8607	67.7256	43.8563	64.3809	78.1517	12.2514	14.158	60.8830	48.1729	79.2137	89.1819	4.1837	24.3730	65.9484
0.630	29.9980	68.2078	90.0000	26.4037	46.9344	73.6232	40.5242	74.6134	90.0000	21.7929	40.9464	71.2408	34.5818	70.8213	90.0000	15.5799	31.5459	67.5174	43.9482	64.5369	78.1844	12.4079	14.1598	60.8904	48.2581	79.3068	89.1649	4.2054	24.8049	66.0941
0.631	56.7307	63.0812	81.5550	24.0379	51.8287	78.4441	41.5926	75.3865	90.0000	16.7059	43.0654	74.4329	32.3767	68.1912	88.7078	19.5580	35.3856	68.3734	46.1397	78.6199	90.0000	12.2915	14.9542	61.0110	52.4466	83.4590	90.0000	4.1296	20.9659	64.4070
0.632	29.7008	68.1453	90.0000	26.6627	47.2329	73.6367	40.5559	74.7281	90.0000	21.8084	41.0816	71.2334	34.5077	70.8721	90.0000	15.2816	31.5287	67.4116	43.9859	64.6753	78.1934	12.3045	14.1726	60.7314	48.4491	79.4914	89.1136	4.2394	25.0713	66.1158
0.633	29.6597	68.1719	90.0000	26.4845	47.1582	73.6157	40.5129	74.7457	90.0000	21.6950	41.0470	71.2062	34.4232	70.8691	90.0000	14.8884	31.4536	67.4312	43.9119	64.5761	78.1084	12.1259	13.7192	60.5977	48.3349	79.4290	89.0776	4.1835	24.8955	65.9899
0.634	29.6572	68.2191	90.0000	26.9254	47.2698	73.3476	40.3790	74.7024	90.0000	21.8601	41.0027	71.0632	34.5569	70.6569	89.6789	15.1372	31.6461	67.4218	43.9656	64.9315	78.3527	12.2805	14.0615	60.6029	48.3418	79.8513	89.4579	4.2261	25.3834	66.1639
0.635	36.2159	62.8413	81.4665	23.9062	52.3190	78.7095	41.8419	75.7437	90.0000	16.3759	43.2906	74.5035	32.0179	67.9121	88.4600	19.6542	34.8094	67.7874	46.0151	78.7120	90.0000	12.2129	14.6516	60.7356	52.2514	83.7238	90.0000	4.1037	20.9949	64.2208
0.636	36.0518	62.7526	81.4391	23.8215	52.4443	78.7998	42.1097	75.9748	90.0000	16.5362	43.6649	74.6768	31.9508	67.9090	88.8477	19.2417	34.6780	67.8063	46.1209	78.8356	90.0000	12.1666	14.6964	60.7082	52.6054	83.8122	90.0000	4.0880	20.6185	64.0234
0.637	35.6553	62.8415	81.7083	24.0632	53.3554	79.3941	42.9137	76.5803	90.0000	16.6677	44.7009	75.3388	31.7228	67.6421	88.2732	19.5579	34.1599	67.3271	46.7010	79.3093	90.0000	12.3122	14.8654	60.6706	52.5299	84.1975	90.0000	4.0997	21.1494	64.1829
0.638	36.4597	63.0780	81.3970	24.4694	55.0134	80.5442	43.7601	77.2229	90.0000	17.0279	45.6297	75.8646	32.3750	68.5061	88.6864	19.7097	35.3484	67.9560	47.3192	79.8148	90.0000	12.4874	15.2038	60.6765	53.9378	84.6107	89.6365	4.0889	21.6798	64.3487
0.639	34.8323	64.3999	83.5042	28.7415	56.7446	80.0119	44.2334	76.8782	89.2902	21.9985	47.6498	75.6209	28.2182	57.7107	90.0000	15.1649	31.5180	67.0972	48.7908	80.9707	90.0000	12.3949	14.1762	60.3484	55.0703	85.5677	89.5233	4.2310	25.9645	66.1928
0.640	32.3522	57.8276	79.0268	23.4982	59.6129	84.7546	42.9014	76.7105	90.0000	14.6114	45.0856	76.0518	35.9332	71.3697	89.2887	7.3005	34.7987	70.6145	47.4763	80.0237	90.0000	8.7152	10.5462	60.1179	55.9984	86.7576	90.0000	1.8780	4.2024	59.9667
0.641	32.7760	63.2589	83.5344	25.3513	55.8258	80.7089	44.2319	77.6969	90.0000	20.9800	47.7489	73.9886	35.8071	70.5302	88.5240	13.0472	34.8270	69.5043	48.9764	81.2033	90.0000	5.8619	23.3253	64.7264	54.4911	85.5615	90.0000	2.7661	4.1052	59.8650
0.642	32.7041	63.2183	83.4918	25.2653	55.7937	80.6736	44.1825	75.9074	90.0000	21.0495	47.7370	75.9074	35.7484	70.4753	88.4615	13.2385	34.7867	69.3853	48.9312	81.2143	90.0000	5.5825	23.3186	64.7045	54.4310	85.5576	90.0000	0.1265	24.4016	59.7781
0.643	32.5271	63.0857	83.4234	25.1422	55.6361	80.5776	43.9722	77.6045	90.0000	20.9299	47.5383	75.7537	35.4472	70.2537	88.3831	13.2009	34.4365	69.1336	48.7791	81.1440	90.0000	5.5795	23.1510	64.5804	54.3003	85.4961	90.0000	0.0000	24.3005	59.7262
0.644	32.6122	63.1286	83.3705	25.1318	55.7192	80.5776	44.0217	77.6854	90.0000	20.9162	47.6112	75.7679	35.6817	70.4418	88.3789	13.2009	34.7294	69.2634	48.7581	81.1735	90.0000	5.5766	23.1510	64.5324	54.2963	85.5380	90.0000	0.0000	24.2131	59.6746
0.645	31.2601	67.5569	88.0787	23.0605	52.5052	78.7448	41.3951	75.9017	90.0000	16.3512	42.2512	74.0151	35.3658	62.1867	89.9266	18.5096	33.9486	67.1792	45.7246	78.9581	90.0000	12.0050	19.6506	61.9519	52.4966	84.1326	90.0000	4.1371	14.6338	61.5268
0.646	30.3281	65.9013	86.9890	25.9243	51.5120	76.6826	35.7435	72.2856	90.0000	20.4688	40.7671	70.8602	38.9558	64.8761	81.1230	19.5692	35.3170	66.4936	44.4068	78.0521	90.0000	13.0549	24.5832	63.7320	52.0259	83.8036	90.0000	4.4895	17.9873	62.5122
0.647	31.1812	69.6728	90.0000	33.8283	56.9696	77.1425	35.6822	71.9071	89.6306	22.5396	42.0582	70.9131	46.6972	67.9655	82.8105	5.7820	33.7311	69.8247	45.3666	78.7895	90.0000	13.9363	33.8868	68.4244	54.3621	85.1979	89.0648	0.0297	2.5711	59.5261
0.648	30.5592	64.5666	85.5669	24.7373	50.5959	76.3796	35.2253	72.0641	90.0000	20.3253	40.8559	70.8793	39.3557	65.0761	90.0598	19.0314	34.3258	66.4146	44.4802	78.1965	90.0000	12.9129	23.2050	63.0426	51.0774	81.1464	90.0000	4.3017	17.6152	62.2985
0.649	30.6091	64.8664	85.7681	24.8619	50.6892	76.3537	35.4338	72.2381	90.0000	20.2271	40.8947	70.8946	39.2480	64.9512	80.8686	19.4532	33.4791	66.3658	44.4461	78.2182	90.0000	12.9327	23.3396	63.0555	51.1575	83.2546	90.0000	4.3237	18.0121	62.3829
0.650	31.2881	69.8757	90.0000	33.6808	56.6702	76.8309	37.7024	73.1493	89.4771	13.6556	40.2006	72.3857	37.6371	69.4785	84.0686	16.0622	36.3449	68.8203	44.9164	78.9687	90.0000	11.2484	19.1098	61.2562	50.7650	83.3554	90.0000	3.9591	13.6897	66.6088
0.651	26.6074	65.3394	86.1089	25.4740	51.1159	76.3340	35.7210	72.5078	90.0000	19.6242	40.7587	70.9226	38.8592	64.7155	80.8095	20.2781	33.7806	66.1436	44.3435	78.2368	90.0000	12.9845	24.1277	63.2884	51.4353	83.5634	90.0000	4.2026	18.1066	62.3162
0.652	30.5001	64.9216	85.7384	25.1730	50.9020	76.2491	35.3976	72.3578	90.0000	19.8319	40.6933	70.7556	39.9124	64.7728	80.7826	19.9792	33.3465	66.0650	44.2755	78.2342	90.0000	12.9946	23.7228	63.0514	51.2187	83.4385	90.0000	4.3334	18.0984	62.2598
0.653	30.4123	64.3489	85.2189	24.7696	50.5360	76.0864	34.9912	72.1591	90.0000	20.0192	40.7332	70.6679	39.1526	64.9029	80.7031	19.3819	33.1303	65.9855	44.1826	78.2140	90.0000	12.8878	23.2491	62.8157	50.7883	83.1470	90.0000	4.3195	17.8218	62.1137
0.654	30.3454	64.2112	85.0832	24.7017	50.4492	76.0003	34.8409	72.1160	90.0000	20.0695	40.7117	70.5871	39.1544	64.8951	80.6491	19.2078	32.9988	65.9207	44.1080	78.2069	90.0000	12.8602	23.1723	62.7380	50.6614	83.0934	90.0000	4.3170	17.7332	62.0324
0.655	30.1176	63.5427	84.5505	23.8564	49.8403	75.8303	34.3796	71.8878	90.0000	20.0697	40.6631	70.5056	39.3259	64.9495	80.5435	18.1627	32.4708	65.9254	43.9860	78.1662	90.0000	12.7094	22.2136	62.3089	50.0626	82.6740	90.0000	4.2345	16.9192	61.7134
0.656	29.9828	63.4428	84.4832	24.0632	49.7884	75.6563	33.9934	71.6952	90.0000	20.4359	40.5651	70.2556	39.9262	64.9457	80.5267	17.3113	32.0707	65.9960	43.7126	78.0646	90.0000	12.5735	22.5050	62.4159	49.9743	82.6511	90.0000	4.2172	16.2194	61.4368
0.657	30.7181	59.5409	80.6051	22.3012	49.3228	75.9593	35.5759	72.7021	90.0000	19.3268	40.0754	71.9046	38.7485	69.5830	81.1265	17.6662	35.3099	69.0960	43.7126	78.0646	90.0000	8.0492	9.8808	59.2679	50.0382	82.7459	90.0000	2.7507	4.9826	59.1108
0.658	32.0185	61.4749	81.5782	23.0910	50.6198	76.6221	37.0044	73.6325	90.0000	17.6817	42.2294	72.2723	39.8939	69.9186	84.6688	16.0622	36.3449	68.8203	44.9164	79.9687	90.0000	11.2484	19.1098	61.2562	50.7650	83.3554	90.0000	3.9591	13.6897	66.6088
0.659	32.1648	61.6421	81.6028	23.3379	50.9044	76.7024	37.5239	74.0069	90.0000	17.4672	42.8423	72.7275	40.3410	70.3158	84.7094	16.7260	37.1091	69.0610	45.0947	79.1429	90.0000	11.3191	19.4750	61.3267	50.8539	83.4701	90.0000	3.9156	14.0343	60.6553
0.660	32.2241	61.7459	81.6213	23.3753	51.0048	76.7211	37.5817	74.1538	90.0000	17.5311	43.2245	72.9333	40.6893	70.5273	84.6370	16.8918	37.4657	69.1927	45.2072	79.2699	90.0000	11.3938	19.7313	61.3566	50.8161	83.4859	90.0000	3.8898	14.1863	60.6482
0.661	32.2234	61.7995	81.6203	23.3086	51.0189	76.6316	37.4992	74.0848	90.0000	18.0506	43.4603	72.8895	40.8520	70.5887	84.5433	16.4954	37.3911	69.2179	45.2349	79.3358	90.0000	11.3498	20.0279	61.4301	50.7614	83.4885	90.0000	3.8553	14.1041	60.5762
0.662	39.4746	61.4709	76.9600	22.7568	57.3777	82.2030	31.1836	68.8499	88.5541	16.9567	41.8052	72.0116	36.8883	73.7474	90.0000	16.7797	35.7226	68.0094	45.0342	79.2307	90.0000	11.8025	18.6389	60.7496	54.3811	85.8544	89.4366	4.0140	14.4473	60.6092
0.663	39.5207	61.5357	76.9602	22.9226	57.6346	82.2411	31.2955	68.9972	88.5885	16.7021	41.7945	72.0828	73.9933	37.0828	73.9900	17.1815	36.0338	67.9853	45.5249	79.2858	90.0000	11.6617	18.9106	60.8311	54.3905	85.8709	89.4003	3.9960	14.3440	60.5295
0.664	50.5304	59.2690	80.1451	22.3319	55.6656	80.7624	34.1671	70.0344	87.9624	15.9785	44.3436	74.5570	45.8249	79.9011	90.0000	7.0727	22.6904	68.2403	42.1783	79.7171	90.0000	8.8989	9.7547	58.8999	53.3288	85.3602	89.7036	0.0000	3.2996	58.6780
0.665	30.1820	59.2866	80.2936	22.3487	55.4535	80.5331	33.8841	69.8177	88.7720	14.1411	44.4333	74.4619	42.1111	77.3171	90.0000	6.2741	22.2365	68.0293	45.7497	79.8920	90.0000	9.2448	10.6397	58.7960	53.1496	83.3059	89.7480	0.8664	3.2347	58.6133
0.666	30.5320	58.9916	80.5976	22.4234	55.5270	80.5200	34.5809	70.0181	87.6231	14.8742	44.6705	74.4698	42.4568	77.6014	90.0000	10.8365	33.3305	67.7694	45.8362	80.0007	90.0000	12.2204	12.7204	58.5878	53.0836	83.3096	89.7594	3.8916	12.3194	59.8441
0.667	30.3491	58.8736	79.7569	22.3061	53.8941	80.8270	33.8527	69.9787	87.9508	14.0871	44.0154	74.1519	41.7004	77.1280	90.0000	6.0087	32.4261	68.0722	45.6126	79.8838	90.0000	9.5521	10.8056	58.6681	53.4333	85.4815	89.6056	0.0000	2.9324	58.4965
0.668	31.5232	56.8888	77.3800	22.2373	57.8366	82.2590	36.2061	71.0272	87.5431	6.8943	42.2378	74.2865	39.9929	76.0262	90.0000	13.9649	35.8003	68.5762	44.9174	79.4275	90.0000	8.3456	10.1372	58.6929	53.6038	86.0196	90.0000	0.7016	3.4343	58.4713
0.669	31.4104	56.8733	77.3810	22.6550	57.7179	82.1443	36.0684	70.9068	87.4654	6.8685	42.1795	74.1183	39.8482	73.9769	90.0000	13.8942	35.5952	68.4175	44.7900	79.3819	90.0000	8.2596	10.0298	58.6328	53.4909	86.0136	90.0000	0.5246	3.3572	58.4154
0.670	31.3247	56.8832	77.3890	22.5796	57.5620	81.1952	35.8573	70.7503	87.3872	6.6781	42.0426	73.9993	39.7351	75.9512	90.0000	13.8393	35.8206	68.2405	44.6914	79.3571	90.0000	8.4221	10.0339	58.5533	53.3786	85.9683	90.0000	3.2266	58.3566	
0.671	31.3053	58.3235	78.5967	22.3346	56.2184	80.9063	35.1903	70.1598	87.1823	7.4407	42.2403	74.0630	40.4583	76.4746	90.0000	13.7836	34.6039	67.7346	44.7289	79.4297	90.0000	4.4530	9.7249	58.5952	53.1197	85.6867	89.8816	0.2793	3.3121	58.3086
0.672	31.1465	58.8027	79.0515	22.2768	55.5857	80.3518	34.9561	69.8565	89.9866	7.8083	42.2317	73.8894	40.5200	76.5621	90.0000	13.7502	34.2473	67.4766	44.5241	79.3291	90.0000	7.1119	9.7668	58.6015	52.7410	85.4445	89.8973	0.0000	3.2746	58.2540
0.673	31.0525	58.9412	79.1759	22.3548	55.3442	80.0742	34.8396	69.6959	86.8574	7.6232	42.1465	73.8088	40.4842	76.5845	90.0000	13.8260	34.1343	67.3394	44.3827	79.2741	90.0000	7.4002	9.8575	58.5242	52.5391	85.3619	89.9304	0.8789	3.5149	58.2099
0.674	30.6692	59.1740	79.5333	22.0506	55.3875	80.1814	34.7458	69.5045	86.8908	10.6889	42.1322	73.2433	40.1860	76.4323	90.0000	13.9700	33.4716	66.8528	44.6415	79.5045	90.0000	12.0532	12.5532	58.1634	52.6856	85.2612	89.6687	3.9105	11.5910	59.2500
0.675	30.8751	58.8363	79.0857	22.1573	55.2025	79.9406	34.4575	69.5020	86.8028	7.7414	41.8993	73.5261	40.1859	76.4785	90.0000	13.6708	33.6961	67.0165	44.1699	79.2145	90.0000	7.4345	9.6620	58.3216	52.4208	85.3226	89.8951	0.6203	3.3591	58.0969
0.676	30.6885	58.9144	79.2052	22.2016	54.9802	79.6927	34.4642	69.3803	86.6398	3.7772	41.7893	73.4327	40.1570	76.5056	90.0000	13.7016	36.6932	66.9216	44.0326	79.1630	90.0000	7.2529	9.6024	58.2843	52.2122	85.2551	89.9028	0.0000	3.2723	57.9889
0.677	30.6372	58.8733	79.1502	22.1635	55.0493	79.6821	34.2773	69.3204	86.6443	7.4819	41.8008	73.3996	40.0726	76.4959	90.0000	13.6800	33.4201	66.7865	44.0146	79.1961	90.0000	7.2529	9.6024	58.2843	52.2112	85.2551	89.9028	0.0000	3.2723	57.9889
0.678	30.5286	58.8331	79.1255	22.0871	54.8226	79.5139	34.2660	69.2143	86.5062	7.0522	41.4890	73.1930	39.8583	76.4006	90.0000	13.6130	33.4101	66.7126	43.7999	79.0903	90.0000	7.6854	9.6088	58.1665	52.0270	85.1724	89.9216	0.8251	3.3834	57.9364
0.679	30.0426	58.7933	79.0896	22.0230	54.7445	79.4278	34.2108	69.1225	86.4062	6.8051	41.3517	73.0822	39.7043	76.3453	90.0000	13.5836	33.3454	66.6324	43.7186	79.0789	90.0000	7.9814	9.6579	58.0756	51.9398	85.1487	89.9217	1.1633	3.4723	57.8826
0.680	30.4054	58.7600	79.0339	21.9694	54.7744	79.4272	34.1042	69.1211	86.6198	7.1230	41.3617	73.0018	39.6592	76.3622	90.0000	13.5235	33.2596	66.5354	43.6633	79.0858	90.0000	7.4235	9.4242	58.0651	51.9387	85.1758	89.9046	0.3771	3.2231	57.8248
0.681	30.3635	58.7025	78.9595	21.9221	54.7524	79.3811	34.0902	69.0979	86.3609	6.9107	41.2674	72.9167	39.5493	76.3364	90.0000	13.4934	33.2263	66.4863	43.5759	79.0702	90.0000	7.5925	9.4126	57.9838	51.8842	85.1781	89.9047	0.0000	3.1584	57.7688
0.682	30.2577	58.6252	78.9008	21.8703	54.6950	79.3074	34.0505	69.0396	86.2835	6.3352	41.1078	72.8292	39.4061	76.2830	90.0000	13.4833	33.4636	66.4073	43.4636	79.0373	90.0000	8.3182	9.7017	57.8688	51.7973	85.1512	89.9013	0.0000	3.0133	57.7063
0.683	30.6979	61.7778	81.4051	19.3827	55.9073	81.0947	39.0067	72.5118	86.5680	15.0147	46.6219	75.5872	45.0350	80.1978	90.0000	22.6126	42.0414	69.1476	45.1475	80.2786	90.0000	5.4539	20.8730	61.6194	52.6047	85.9352	90.0000	4.2349	17.5625	57.6205
0.684	29.9817	58.7035	79.0184	21.7336	54.4428	79.0582	33.6246	68.7498	86.1601	6.9084	40.9586	72.5630	39.2406	76.2737	90.0000	13.3875	32.6631	66.0308	43.3024	79.0162	90.0000	7.6618	9.3604	57.8035	51.5899	85.0619	89.8850	1.6383	3.7512	57.6236
0.685	30.0305	58.6246	78.8790	21.6403	54.4800	79.0783	33.7368	68.7968	86.0965	7.0657	40.9369	72.4809	39.1354	76.2516	90.0000	13.2842	32.8033	66.0906	43.2582	79.0312	90.0000	7.0311	8.9750	57.7730	51.5747	85.0895	89.8795	0.0237	3.0544	57.5491
0.686	29.9390	58.5948	78.8538	21.6317	54.4090	78.9768	33.5428	68.7243	86.0359	6.6148	40.7930	72.3913	39.0331	76.2315	90.0000	13.2835	32.6927	65.9761	43.1271	78.9856	90.0000	7.5650	9.1346	57.6693	51.4778	85.0635	89.8844	0.0431	3.0222	57.4937
0.687	29.9175	58.5399	78.7711	21.6057	54.4222	78.9517	33.5904	68.7352	85.9745	6.4538	40.7258	72.3172	38.9333	76.2132	90.0000	13.2688	32.7540	65.9668	43.0605	78.9851	90.0000	7.7378	9.1916	57.5995	51.4463	85.0763	89.8768	0.0052	2.9784	57.4376
0.688	29.8210	58.5116	78.7496	21.5418	54.3408	78.8623	33.5810	68.6447	85.9056	6.1868	40.6118	72.2229	38.8297	76.1926	90.0000	13.2383	32.6235	65.3479	42.9596	78.9608	90.0000	8.0304	9.3048	57.5169	51.3329	85.0447	89.8734	0.0000	2.8898	57.3788
0.689	29.7663	58.4904	78.7130	21.4882	54.3027	78.8050	33.5331	68.5998	85.8451	6.2260	40.5439	72.1248	38.7448	76.1691	90.0000	13.1816	32.5700	65.6996	42.7883	78.9337	90.0000	8.1245	9.2819	57.3934	51.2891	85.0330	89.8664	0.0008	2.8864	57.3512
0.690	29.7024	58.4575	78.6777	21.4427	54.2544	78.7361	33.4870	68.5477	85.7769	6.0474	40.4506	72.0338	38.6494	76.1691	90.0000	13.1816	32.5700	65.6996	42.7883	78.9337	90.0000	8.1245	9.2819	57.3934	51.2163	85.0154	89.8608	0.0000	2.8128	57.2673
0.691	29.6259	58.4650	78.6701	21.4033	54.2251	78.6807	33.3983	68.4714	85.7096	6.3372	40.3967	71.9169	38.5602	76.1581	90.0000	13.2212	32.4207	65.5846	42.7378	78.9446	90.0000	8.2543	9.4522	57.3309	51.1629	85.0006	89.8426	2.1647	4.0025	57.2493
0.692	29.6074	58.4202	78.5946	21.3085	54.2245	78.6695	33.4513	68.5218	85.6823	6.4365	40.3758	71.8437	38.5288	76.1843	90.0000	13.0241	32.4796	65.6190	42.6811	78.9513	90.0000	7.5470	8.9756	57.3323	51.1345	85.0213	89.8404	0.8708	3.0266	57.1654
0.693	29.5309	58.4220	78.5887	21.2927	54.1503	78.5680	33.3056	68.3965	85.6006	6.3890	40.2842	71.7395	38.4223	76.1624	90.0000	13.0422	32.3329	65.4728	42.5812	78.9283	90.0000	7.3721	8.7805	57.2600	51.0348	84.9824	89.8341	0.5460	2.9396	57.1112
0.694	29.4546	58.4313	78.5893	21.1948	54.1501	78.5581	33.2332	68.3514	85.5532	6.8481	40.2832	71.6357	38.3755	76.1788	90.0000	12.9781	32.2376	65.3891	42.5730	78.9685	90.0000	7.1124	8.7338	57.2370	51.0006	84.9792	89.8125	2.0004	3.8460	57.0830
0.695	29.4167	58.3820	78.5195	21.1199	54.0822	78.4572	33.2055	68.3063	85.4812	6.5075	40.1623	71.5477	38.2602	76.1515	90.0000	13.9551	32.2167	65.3330	42.4418	78.9333	90.0000	7.0346	8.5558	57.1630	50.9185	84.9630	89.8152	2.7928	57.0019	
0.696	29.3543	58.3558	78.4821	21.1416	54.0181	78.3768	33.1583	68.2338	85.3945	6.2663	40.0448	71.4487	38.1629	76.1339	90.0000	12.3934	32.1486	65.2489	42.3329	78.8950	90.0000	7.3074	8.6156	57.0795	50.8197	84.9236	89.8076	0.7773	2.9351	56.9468
0.697	29.2822	58.3565	78.4728	20.9909	54.0155	78.3840	33.0707	68.1735	85.3412	6.9209	40.0703	71.3394	38.0978	76.1408	90.0000	12.7671	32.0353	65.1738	42.3453	78.9494	90.0000	6.4154	8.2147	57.0829	50.7942	84.9323	89.7810	1.7951	3.4755	56.9019
0.698	29.2372	58.2839	78.3862	21.0566	53.9156	78.2315	33.0685	68.1231	85.2503	5.7618	39.8284	71.2629	37.9700	76.1061	90.0000	12.9107	32.0434	65.0938	42.1240	78.8436	90.0000	9.2281	8.8966	56.9251	50.6659	84.8791	89.7923	0.3693	2.6385	56.8271
0.699	28.6500	58.4502	78.7747	20.9392	54.2462	78.5019	31.7959	67.9363	85.7346	12.8878	41.1270	70.8871	38.8642	76.5953	90.0000	7.7148	30.4555	65.1611	42.8100	79.3611	90.0000	6.2355	8.8816	57.1174	51.0337	85.2371	89.8187	1.9842	3.7385	56.8067
0.700	29.0131	58.4242	78.5276	20.6758	54.0787	78.4128	32.2807	68.0529	85.1973	7.5267	41.0924	71.1994	38.0534	76.2517	90.0000	12.8254	31.8261	64.8886	42.4449	79.1553	90.0000	11.1072	11.6072	56.7660	50.6902	84.8851	89.6895	4.0235	7.2950	57.0334
0.701	28.3474	58.3665	78.7574	20.8348	54.0049	78.2814	31.1530	67.8199	85.6571	12.8763	41.1620	70.7488	38.6226	76.4764	89.8203	6.7792	30.0238	64.9522	42.6802	79.3631	90.0000	7.5042	8.9376	56.8395	50.7688	86.2574	89.9705	2.5166	4.4153	56.7317
0.702	28.0580	58.2691	78.7665	20.7935	53.9083	78.1375	31.2416	67.7028	85.6543	13.0643	41.0317	70.6353	38.5510	76.4291	89.7740	5.1260	29.7737	64.9749	42.6219	79.3631	90.0000	9.8194	10.5925	56.7044	50.7001	85.2948	90.0000	2.1382	2.6560	56.5956
0.703	28.0384	56.6742	79.0589	22.9186	54.2532	77.5680	31.3182	67.7842	85.6449	12.1925	40.6676	70.5372	38.3296	76.3165	89.7572	4.7802	29.6390	64.8638	42.3857	79.2521	90.0000	18.9274	21.8995	57.3672	50.7821	85.4036	90.0000	2.0194	2.7884	56.5251
0.704	28.8664	60.7013	80.4135	22.3600	56.1694	79.3477	33.1375	69.1267	85.8681	19.3210	45.3001	71.7119	40.2195	77.8932	90.0000	10.4812	31.8435	65.2224	45.2385	81.3158	90.0000	13.5199	21.0535	59.0776	51.3830	85.5337	86.6172	3.7842	11.9695	57.7673
0.705	28.8408	60.7654	80.4371	22.4320	56.1865	79.2885	33.0449	69.1822	85.9366	19.7498	45.6632	71.8562	39.8666	77.6529	90.0000	10.3940	31.7800	65.1533	45.4120	81.4717	90.0000	13.1891	21.3357	59.2330	51.4028	85.5583	89.5812	3.8178	11.5974	57.6216
0.706	28.8015	60.8170	80.4564	22.4700	56.1628	79.2078	32.9911	69.1574	85.8977	19.8919	45.7993	71.8606	39.6660	77.5676	90.0000	10.2354	31.7565	65.1213	45.4411	81.5382	90.0000	12.8774	21.5346	59.3470	51.3665	85.5464	89.5527	3.8351	11.1559	57.4636
0.707	28.7654	60.8454	80.4536	22.4999	56.0929	79.0913	32.8672	69.2186	85.9774	20.0252	46.0718	71.9714	39.3432	77.4034	90.0000	10.0440	31.6819	65.0657	45.5413	81.5658	89.9103	12.6225	21.7027	59.4320	51.3303	85.6245	89.6137	3.8825	10.7188	57.3080
0.708	28.6725	60.8871	80.4899	22.4343	55.9671	78.9648	32.8065	69.2325	85.9783	20.1200	46.2559	72.0296	39.1769	77.3416	90.0000	9.7324	31.6283	65.0440	45.5918	81.6075	89.8711	12.3978	21.7801	59.4496	51.3237	85.6710	89.6204	3.8945	10.1644	57.1340
0.709	28.9245	61.2310	80.6265	22.4445	56.1196	79.0438	33.3238	69.4825	85.8296	20.1389	46.5142	72.1719	39.0884	77.3305	90.0000	12.0741	32.5576	65.0504	44.5672	81.8377	90.0000	10.3579	21.7644	58.8769	51.3348	85.5534	89.4296	3.9791	10.4764	57.1400
0.710	35.1622	71.9675	87.1533	34.1062	61.8822	78.4093	28.2918	64.7962	84.0922	25.9409	51.0521	73.3215	40.4648	78.2660	89.9888	20.3361	32.1152	62.1627	48.8512	84.2387	90.0000	12.1313	37.3171	67.9598	53.1596	87.5954	90.0000	0.0193	25.2655	62.3265

0.711 28.0192 67.8985 87.0263 35.6050 61.5843 77.2185 30.7923 62.9122 81.0979 22.0557 44.9829 70.1891 38.6539 76.5964 89.4675 19.4034 35.5918 64.8926 45.0823 81.5080 90.0000 11.9229 29.4017 63.1799 52.0394 86.7495 90.0000 9.9825 21.0178 60.3763
0.712 37.6347 74.5670 88.0863 33.7390 67.0010 83.2036 29.1575 59.3357 78.7011 20.6389 50.8229 75.2203 41.5166 78.5087 89.4466 16.9997 33.1254 63.8723 48.4581 84.0325 90.0000 12.2777 39.9704 69.6073 53.1131 86.5989 89.3414 4.0825 17.1333 58.8445
0.713 37.1873 66.3145 80.5004 29.2015 62.8485 81.7540 34.9887 70.8117 86.0206 22.8014 48.2392 72.2925 42.2650 79.6272 90.0000 20.4844 40.2698 67.2799 46.7467 82.8056 90.0000 12.2591 34.0194 65.6921 51.5190 85.8812 89.6324 4.0522 22.7019 60.9866
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0.716 34.2654 63.7035 79.6930 33.5773 60.7275 77.3985 28.4853 66.7362 85.5051 19.0478 41.4585 68.4980 38.6735 77.1216 89.7417 21.1432 35.5049 63.6579 42.6817 80.0502 90.0000 11.9698 31.8349 64.3000 50.8562 86.0478 90.0000 3.9693 20.0014 59.7066
0.717 33.8673 62.4919 78.7743 32.2942 60.5955 77.9487 28.4413 66.5902 85.3465 18.7482 41.2080 68.3760 38.1236 77.0823 90.0000 20.9379 34.2440 62.8749 42.5980 79.7100 89.6768 11.9536 31.0321 63.7880 50.7384 86.0014 90.0000 3.9294 19.5150 59.4669
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0.719 33.6142 63.2644 79.5259 33.3201 60.4466 77.1546 28.4482 66.6419 85.3005 18.7837 41.2112 68.2692 38.4300 77.0335 89.7082 20.7335 34.6512 63.1219 42.5705 80.0685 89.9584 11.9363 31.6822 64.0683 50.6889 86.0497 90.0000 4.0158 19.4126 59.3158
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0.727 32.6575 61.3322 77.9478 27.6821 60.4352 79.6971 32.6459 67.0770 83.1969 17.5783 41.7687 68.6835 38.3034 77.6575 90.0000 20.1157 34.1106 62.6167 42.5004 80.4279 90.0000 11.8266 30.3444 62.9212 49.1566 84.3021 89.0675 3.9184 17.8862 58.3324
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0.744 39.4406 67.2914 78.5742 35.1526 59.5135 74.0946 28.3935 63.9146 81.7007 26.0046 39.0938 62.5037 34.4785 75.2663 89.2127 19.8039 26.4757 57.4311 39.4318 79.1324 89.9716 11.9096 33.6490 64.0286 47.7810 84.2631 89.2935 3.9370 37.9073 67.9761
0.745 39.1634 67.0963 78.5240 35.5843 59.4059 73.6912 28.4531 64.0593 81.7580 25.7189 39.0157 62.5379 34.0328 74.8530 89.9857 19.8170 26.2631 57.2406 39.4207 79.1999 90.0000 11.9241 33.6639 63.9597 47.5285 84.2814 89.4353 3.9768 37.9084 67.8815
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0.747 35.3285 65.7083 79.5007 38.3082 60.3007 72.6953 29.1958 65.6822 82.7885 26.6439 41.5524 63.8175 33.6910 74.1463 88.4050 19.7900 27.7780 57.9599 41.6416 80.7569 90.0000 11.8303 33.5968 63.8396 47.1859 84.6678 90.0000 3.9181 36.6604 66.9697
0.748 37.7891 66.1016 80.7058 37.9625 60.7992 73.3254 26.7135 66.3094 84.4905 29.0940 46.0287 65.9237 34.0962 74.8932 88.8560 19.4850 28.0283 58.1657 44.5625 82.7296 89.9115 11.7240 32.7675 63.3067 46.8548 85.5820 89.7757 3.9231 36.0153 66.5042
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0.797	33.8534	69.7115	81.8223	26.3390	55.3587	72.6496	26.1898	62.3592	78.8982	18.4259	37.7755	62.1184	39.3523	77.3741	85.9122	12.7249	42.4019	67.1104	40.1738	82.0100	89.9501	11.1036	26.4995	57.3422	44.9691	85.2767	89.9531	3.3633	12.9022	52.9323
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0.800	33.6866	69.4237	81.5070	27.4940	55.5486	72.1237	25.9388	62.0376	78.5829	18.4369	37.4013	61.7027	39.3682	77.1985	85.5950	11.2749	41.8548	66.8926	39.3889	81.6895	90.0000	12.9619	27.4277	57.2215	44.6890	85.1328	89.8722	3.7025	13.3379	52.8839
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0.806	28.5774	60.2413	75.4510	31.8091	56.0186	69.9923	24.9980	67.1744	83.4174	18.1344	42.3497	65.0550	35.4125	74.0630	84.6863	15.4462	33.3487	59.7662	40.8242	82.8114	89.9170	10.9072	27.5857	57.4921	44.5025	85.4006	90.0000	3.6764	15.6224	53.2628
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0.808	30.1053	60.5636	74.8778	29.7358	55.3974	70.4785	25.4082	68.3064	84.2050	18.0639	43.6436	65.9491	34.4256	73.7278	84.8398	10.7757	36.1455	61.9994	38.6311	81.6167	90.0000	12.7965	28.5515	57.4642	44.8154	85.7115	90.0000	3.5652	12.8446	53.2010
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0.810	40.8784	66.1010	73.4293	25.6894	55.4297	72.3962	32.4735	70.8424	83.0673	13.2825	44.1727	67.6561	32.5926	73.3019	85.3551	18.0709	31.4255	57.3968	40.6180	82.9409	90.0000	10.4137	39.8956	65.1743	45.4686	86.1004	89.8350	3.4853	13.1518	52.2808
0.811	39.6519	66.0768	74.1848	25.5661	54.4174	71.4882	29.4206	71.2342	84.4922	10.6207	44.5793	68.5082	33.6476	72.9208	84.3651	18.0476	29.5975	56.2424	41.7182	83.7153	90.0000	12.0620	39.4836	64.4790	45.6216	86.4203	90.0000	3.5213	12.0639	51.9200
0.812	39.4386	65.4565	73.6907	25.6292	54.4603	71.4944	29.3954	71.3750	85.0744	10.4547	44.0231	68.0743	33.6151	72.2862	83.7291	17.9563	29.5424	56.1899	41.3361	83.4054	89.9003	12.3636	39.0195	64.0321	45.1922	86.1590	90.0000	3.4705	12.2582	51.9188
0.813	40.3434	65.1081	72.7070	25.5559	54.2008	71.2578	33.5200	70.5862	82.1127	10.3300	43.2867	67.5009	39.9427	71.7986	85.4584	17.9489	29.3639	56.0327	38.8901	82.3233	89.7229	12.0689	38.7566	63.8678	44.8311	85.9481	90.0000	3.3431	11.8662	51.7595
0.814	39.6733	64.3631	72.4052	25.4339	54.5638	71.5771	33.3901	70.4963	82.0540	10.4055	42.8068	67.0823	29.7416	71.8818	85.2953	17.8950	29.3639	56.1913	38.9517	82.5129	89.6922	13.2914	38.2906	63.1935	44.5830	85.8049	89.9866	3.4308	13.1371	52.0528
0.815	40.2512	64.1453	71.7616	25.4397	54.4997	71.3721	32.5512	71.5616	82.4503	10.3687	42.5560	66.8558	29.8621	71.4203	84.7503	17.9123	29.7899	56.1911	38.8189	81.9990	89.9909	12.5528	37.9267	63.0764	44.3288	85.2874	89.6037	3.4417	12.3926	51.7858
0.816	40.5596	63.7944	71.1708	25.4609	54.5399	71.4494	33.3643	69.7693	81.2864	10.8023	42.4318	66.6288	29.5400	71.2508	84.7041	17.8754	29.6777	56.0836	38.0452	81.4252	89.8590	12.1027	37.4318	62.7941	44.1368	85.3430	89.7481	3.5238	12.2791	51.6913
0.817	40.8311	63.8815	71.0187	25.4347	53.9691	70.9243	33.3441	69.7294	81.1243	11.2041	42.6439	66.6525	29.2052	70.6712	84.2734	17.9358	29.2247	55.7379	37.5068	81.2797	90.0000	11.7935	37.0239	62.7582	44.0566	85.0402	89.4572	3.5086	11.4220	51.4102
0.818	40.4197	63.7499	71.1295	25.2953	53.1825	70.2689	33.0936	69.3142	80.9139	10.4576	42.1860	66.4197	28.3451	70.4205	84.4068	17.8268	28.1821	55.1157	37.2913	81.1928	90.0000	9.8521	36.5739	62.5941	43.8816	84.9969	89.4906	3.4985	9.7396	50.9568
0.819	40.0297	62.8357	70.4838	25.2881	53.8679	70.8090	32.9067	69.1247	80.7920	10.5037	41.5951	65.9300	29.0974	70.4517	84.0277	17.7607	28.9282	55.5193	36.8973	80.9978	90.0000	11.3627	36.2087	61.8642	43.5516	84.7407	89.4184	3.4946	11.3514	51.2782
0.820	39.9285	62.2464	70.1379	25.1983	53.9720	70.8909	32.7328	68.8671	80.5981	10.4930	41.4123	65.7500	29.3230	70.4258	83.8472	17.7813	29.1036	55.5602	36.5202	80.8152	90.0000	11.8022	35.6296	61.4474	43.4317	84.6586	89.3742	3.4311	11.7510	51.3239
0.821	40.9358	62.8242	69.7516	25.1799	55.1743	71.8855	33.1780	68.8513	80.2922	13.9063	42.9051	66.0083	30.1709	71.2282	84.1885	17.8832	30.4723	56.2892	35.9162	80.4996	90.0000	10.6200	35.5104	61.5787	44.1894	85.2635	89.4072	3.3238	13.9890	51.8995
0.822	40.2930	61.7585	69.1429	25.2108	54.6152	71.3422	32.6620	68.4301	80.1329	10.5716	41.3694	65.6043	30.2202	70.3349	83.2220	17.8036	30.1950	56.0958	35.1564	80.0967	90.0000	11.4416	34.3800	60.5989	43.0143	84.3423	89.2551	3.4775	11.6114	51.1728
0.823	40.7347	62.2288	69.2320	25.1834	54.7538	71.4264	35.4150	68.3781	78.4696	13.1396	42.2640	65.6307	30.0663	70.7143	83.6146	17.7465	30.1407	56.0297	32.7321	78.7655	90.0000	15.5207	34.7868	61.0220	43.6425	84.8424	89.2770	3.4871	13.1806	51.5457
0.824	40.9658	62.5868	69.3614	25.1326	55.3290	71.8984	33.4433	68.7041	79.8677	13.6964	42.8736	65.8918	30.3268	71.1880	83.8879	17.8245	30.8903	56.4048	35.1472	80.1827	90.0000	10.5761	35.0748	61.1473	44.0180	85.2070	89.3352	3.5093	13.8037	51.6720
0.825	40.8386	62.4348	69.2582	24.9829	54.5703	72.0400	33.2980	68.5941	79.7991	14.8438	43.0193	65.5412	30.5481	71.3337	83.8687	17.5925	31.0493	56.5337	34.9011	80.0849	90.0000	15.5450	34.7421	60.8848	44.0953	85.2374	89.2667	3.5761	14.7169	51.9112
0.826	44.5279	60.4130	64.5595	25.0184	53.5755	70.3466	29.3616	69.0373	82.2439	9.1710	43.8514	67.5014	33.9796	66.9541	77.8208	17.6663	29.1522	55.3036	31.5446	77.9114	89.9603	10.5008	32.5328	59.4314	41.3560	86.6329	89.4833	3.4353	9.2264	50.3870
0.827	39.5778	60.6921	68.3913	25.0629	55.1865	71.6641	34.1646	67.3776	78.0679	10.5126	40.5583	64.7826	31.5479	70.8791	82.8260	17.6741	31.5777	56.7251	31.7667	78.4478	90.0000	12.6279	32.8890	59.1069	42.6539	84.2476	89.1809	3.4577	12.7225	51.1861
0.828	40.7918	61.9717	68.7075	25.4641	55.0694	71.3347	36.6732	68.7752	77.8611	10.2793	41.8771	65.7362	28.1735	70.0971	83.7281	17.6518	36.6033	60.1277	33.2094	78.5158	90.0000	12.6827	28.5820	56.4378	42.8507	85.3258	89.9765	3.3262	12.7050	51.1346
0.829	41.5058	62.3508	68.5146	25.4814	55.6433	71.7771	35.2989	68.5454	78.4215	17.5116	44.7581	65.9506	27.7596	70.8248	84.5692	14.7470	35.6102	60.1961	33.3823	79.3912	89.9897	10.1311	28.3084	56.6320	45.0806	86.4542	89.6086	3.2484	14.4488	51.6055
0.830	40.4267	60.0946	67.9426	25.0941	59.2539	73.0781	34.0944	65.9113	76.5901	17.6852	42.0648	63.7986	34.3035	73.9397	84.1381	13.5775	34.3202	59.6204	31.9409	78.0491	89.8064	10.4491	33.0558	59.5621	43.5298	85.8059	90.0000	3.3417	13.6812	51.2950
0.831	40.5621	60.9829	67.7880	25.0046	58.4576	74.3642	33.8801	63.8168	76.5784	17.5900	42.0624	63.7788	33.7021	73.4039	83.8948	13.6189	33.6307	59.1089	31.6467	77.8823	89.9353	10.3749	32.6925	59.2964	43.3361	85.6579	89.9406	3.3854	13.6381	51.2286
0.832	40.9156	61.0192	67.5243	24.9405	56.6730	72.7752	33.4738	66.2736	77.1921	17.4854	42.7302	64.2646	32.6955	71.2948	83.2708	14.2518	32.2879	58.0214	31.0276	78.2328	89.9732	10.0724	32.0305	58.8523	43.6355	85.1158	89.1491	3.3331	14.1408	51.3294
0.833	40.7361	60.9628	67.5492	24.8996	56.5065	72.6005	33.9643	66.4187	77.0029	17.3165	42.6483	64.2092	32.6345	72.1030	83.1416	15.0335	33.4987	58.5093	30.6056	78.0853	90.0000	10.2258	30.9276	58.1337	43.6034	85.0384	89.0491	3.3129	14.7400	51.4646
0.834	22.1478	66.5343	82.7033	24.9108	51.1600	67.9630	32.2974	67.1387	78.4568	3.7687	43.5200	67.5226	41.1829	79.6277	85.2704	17.4515	43.3515	63.1503	44.6140	86.7420	90.0000	10.3723	22.2937	53.3721	40.5346	83.3538	89.3664	1.1770	1.6770	49.0952
0.835	25.2076	60.4113	78.5533	20.6405	51.5365	70.0004	32.8993	69.3289	80.2596	10.0978	39.5299	66.2471	41.0284	79.4039	85.1063	17.4524	44.8665	65.7529	45.3677	87.3204	90.0000	7.1142	20.8419	53.2681	35.8098	80.8467	89.7754	3.2844	6.8592	49.4363
0.836	28.5596	60.1733	73.9992	24.9448	54.5864	70.7705	30.9143	69.4068	81.3507	10.0311	41.1184	58.1111	33.0255	74.9856	85.5708	17.4729	43.1741	64.4047	43.6881	85.9383	89.7529	11.8276	28.7173	56.3013	40.9089	83.3466	89.0429	3.3624	15.9293	50.4525
0.837	24.6487	59.9502	75.5670	28.1810	55.0123	69.5544	31.6872	68.5395	80.0779	17.5203	55.0376	58.4970	36.3274	75.9189	84.5471	12.9852	40.5750	63.7362	42.9254	85.7067	90.0000	16.6015	27.9064	56.0713	38.4511	81.6726	88.9074	3.5072	13.1788	50.7345
0.838	24.3233	59.4461	75.2100	30.9791	55.1430	68.1401	28.9064	67.0188	80.0271	17.4809	34.3867	58.0222	36.0540	75.7118	84.4623	14.2809	40.5150	63.3011	42.9997	85.8025	90.0000	10.4913	28.0766	56.1376	38.2124	81.5621	88.9011	3.5617	14.5111	51.0830
0.839	24.8966	60.4044	75.7735	32.3729	54.7884	66.9855	27.4116	65.8240	79.5855	17.4204	35.6396	58.8344	39.0023	76.6019	84.4803	13.1785	40.3844	63.3487	42.3758	85.3721	89.9488	10.1854	27.5531	55.8549	36.0952	80.3949	88.9820	3.3124	13.1705	50.6307
0.840	25.2837	60.3518	75.5104	26.4410	54.2516	69.6002	32.3554	68.6757	79.7097	12.1497	40.9021	64.0260	39.6348	76.2769	82.7131	17.4377	35.3151	58.5552	35.5040	80.4014	89.2892	10.2013	27.0079	55.4944	42.2383	84.7652	89.3916	3.3510	12.1945	50.2916
0.841	26.1588	60.4192	75.1319	25.1935	53.8863	69.8161	32.4124	68.8355	79.7843	11.0653	40.7218	64.0876	39.6996	76.0175	82.3913	17.3812	35.4718	58.6286	35.5601	80.3929	89.2033	10.3444	26.6122	55.1917	41.9653	84.6011	89.3677	3.3208	11.2863	49.9546
0.842	25.7679	60.3971	75.2495	24.7795	53.5199	69.6398	32.2408	68.6864	79.6906	11.2638	40.6021	63.9079	39.3283	76.0715	82.6178	17.3153	35.6418	58.7148	35.8795	80.5650	89.1415	10.2512	25.8397	54.7402	42.0659	84.7707	89.4229	3.3461	11.3673	49.9546
0.843	26.5136	60.5094	74.9571	24.8543	53.9620	69.9381	32.3046	69.0819	79.9851	11.6739	40.8607	63.9545	39.4960	75.9976	82.3926	17.3312	35.6171	58.6396	35.7520	80.7523	89.3560	10.3548	26.7056	55.1309	42.1799	84.6222	89.1535	3.3383	11.8889	50.0337
0.844	25.7555	61.0279	75.7234	32.3271	54.3453	66.3740	25.8165	65.5952	79.8711	11.8325	40.3726	63.5144	39.0030	76.8055	83.4529	17.3940	36.6920	59.3053	36.8931	80.8881	88.7690	10.4446	26.8724	55.1478	42.1364	85.4877	90.0000	3.3022	12.2068	50.0643
0.845	25.1345	60.2688	75.2691	32.0463	53.8336	66.0353	25.3452	64.9914	79.4747	12.6450	39.8447	62.8900	38.3049	76.2524	83.3051	17.3069	35.9655	58.7812	36.5583	80.6261	88.6656	10.0833	25.8637	54.6239	41.9854	85.4313	90.0000	3.2878	12.6270	50.1245
0.846	25.0499	60.2314	75.5261	32.1347	53.3778	65.5321	24.8030	64.6450	79.3438	11.7562	39.6335	62.8988	38.5264	76.1741	83.0445	17.2424	35.5929	58.7698	36.3335	80.4369	88.5662	9.9940	25.1986	54.2353	41.6109	85.2187	89.9927	3.2333	11.7236	49.8210
0.847	24.6427	61.0515	76.0940	32.4055	50.2226	62.5637	27.2908	63.9424	81.3905	8.4432	42.1578	65.3314	38.0548	77.5778	84.6691	19.3512	38.1568	59.4660	42.9165	86.1437	89.9911	9.6374	12.6598	51.6070	40.0707	83.0190	88.7669	3.2817	7.9325	48.9087
0.848	25.9429	60.9267	75.3617	32.2880	53.4840	65.4371	24.6633	63.7909	78.6947	14.7607	39.5889	61.9861	38.6110	75.8391	82.5731	17.2607	38.2683	60.2530	41.5037	80.1706	84.9618	10.1025	25.4743	54.2464	38.3338	83.2066	90.0000	3.2508	14.5332	50.3333
0.849	25.3848	61.4108	76.0025	32.6706	54.0133	65.6309	25.7637	63.1883	77.4514	16.0916	39.4287	61.4191	39.5880	76.1833	84.2429	16.3862	38.3605	60.5579	41.0472	79.2159	84.2756	9.9372	26.4804	54.7677	37.6260	82.8071	90.0000	3.0809	14.9322	50.6186
0.850	25.0815	59.5138	74.3826	31.7692	53.2173	65.4054	24.9696	64.4759	78.9336	11.6973	39.0905	62.3217	37.7768	75.5689	82.7383	17.1835	35.1476	58.0016	35.8126	80.2460	88.5060	10.0898	25.6090	54.2098	41.4240	85.1981	89.9160	3.2961	11.7319	49.5825
0.851	23.4071	58.9474	74.5444	31.1215	52.2585	64.8873	24.6197	63.2908	77.9513	17.1020	39.4709	61.0177	38.1902	75.5152	82.3839	11.5446	32.9317	58.1345	33.8933	79.2786	88.6058	10.1065	23.7137	53.1690	41.5711	85.2160	89.7914	3.3396	11.5557	49.4733
0.852	23.8711	57.9269	73.3992	31.1530	52.5559	63.0797	25.9283	63.7732	77.7755	17.0750	35.1007	56.5678	36.5608	74.4008	82.2506	10.2948	37.4785	61.3903	34.2899	79.2250	88.2857	9.9313	25.4379	54.0418	40.7857	84.9515	90.0000	3.3501	10.0733	49.0460
0.853	24.3206	59.4500	74.5154	31.0018	55.1267	67.3837	30.2856	66.8352	78.4747	12.1215	39.9931	62.7185	38.4821	75.6330	82.2155	17.0961	35.5317	56.7898	34.2233	79.7118	88.7570	10.1098	29.9370	56.4925	41.7633	85.1425	89.5004	3.3388	12.1683	49.5206
0.854	24.4827	59.4062	74.3600	32.1693	54.7941	66.3738	28.9845	65.8493	78.1636	11.6491	39.7721	62.6179	38.6838	75.3916	81.8931	17.1701	33.8648	56.9308	33.8444	79.2464	88.3647	10.1164	29.4019	56.1081	41.3693	85.0611	89.6357	3.2830	11.8244	49.3715
0.855	24.5428	59.4052	74.2865	32.3321	54.6558	66.1063	28.5706	65.6180	78.1058	11.6457	39.7606	62.5597	38.7910	75.5832	81.8912	17.1406	34.0369	57.0021	38.8223	79.2939	88.4804	10.1162	29.0938	55.8283	41.2173	85.0420	89.6720	3.2846	11.8068	49.3073
0.856	24.5234	59.5089	74.3408	32.5228	54.7425	66.0227	28.5649	65.7506	78.1860	12.4184	40.3900	62.7838	39.5826	75.8476	81.5993	17.1032	34.0853	56.9939	33.6630	79.1607	88.3930	9.9827	29.2058	55.9413	41.1147	84.4692	89.6220	3.2120	12.4015	49.4178
0.857	24.5649	59.5291	74.2943	33.3439	54.6956	65.4416	28.5262	65.2312	77.6757	12.0357	40.2813	62.7452	39.7996	75.7745	81.3420	17.1319	34.2353	57.0306	33.0089	78.5918	88.1492	9.9773	29.2574	55.8997	40.7453	84.9023	89.7523	3.1843	12.1262	49.2834
0.858	24.6907	59.5762	74.2353	33.8767	54.5719	64.9561	28.0242	64.5735	77.2631	11.6862	39.7405	62.3837	39.3974	75.5180	81.3044	17.0902	34.5059	57.1736	32.5510	78.3711	88.1358	9.8817	28.7774	55.5835	40.4949	84.8238	89.7923	3.2102	11.7349	49.1152
0.859	24.3961	58.8253	73.6446	32.0119	53.6211	63.1755	27.8760	64.8227	77.5189	9.9999	39.0023	62.1765	35.5409	75.0746	81.3699	17.0166	35.5933	56.5333	33.4308	78.7639	87.9967	10.0540	28.2836	54.9828	40.3966	84.8692	89.8562	3.2425	11.1165	48.8909
0.860	26.4587	60.0128	73.7402	34.9867	53.4158	63.1176	27.7450	63.7616	77.9146	10.0357	40.9188	63.4882	39.8879	75.5367	81.0129	17.0653	35.3456	57.6460	32.0347	78.6115	88.5574	10.0497	27.0786	54.3687	41.0762	84.8386	89.3372	3.2172	10.6804	48.7234
0.861	25.6665	59.7656	73.8331	34.6821	53.0143	62.9015	24.5807	64.1952	78.1992	9.4402	41.4815	63.9637	41.2960	76.0384	80.4794	17.0262	35.0419	57.3831	31.9570	78.2298	88.1795	9.8049	26.4310	56.1407	40.0882	84.5192	89.6357	3.2872	9.3210	48.3044
0.862	27.4880	60.8163	73.8843	34.5477	52.5537	62.1777	76.4435	13.5959	40.0225	24.5897	39.7590	64.5841	76.8177	79.4974	80.6526	17.1053	36.3618	58.2283	30.0272	77.6831	87.5622	9.8366	28.2253	55.0536	40.0331	84.9127	89.9992	3.0732	13.5321	49.4063
0.863	24.4331	62.7312	76.9666	35.3182	53.8011	63.1000	26.7174	59.9716	73.3415	11.3845	39.7843	62.2294	39.4266	75.1646	80.7116	16.8041	35.5740	57.7331	31.8737	78.0581	87.9653	9.8537	27.2291	54.4274	40.1835	84.7998	89.7449	3.2308	11.1845	48.7484
0.864	25.5864	59.3379	73.2081	34.2211	52.6041	62.6755	24.3402	62.9191	77.1312	10.0043	39.9408	62.5808	39.7091	75.2161	80.5341	16.8683	34.4150	56.8676	31.6599	77.9033	87.8815	10.0467	26.2658	53.7955	39.8467	84.6514	89.7687	3.2608	10.1227	48.3455
0.865	24.2840	59.0165	73.5820	32.5294	54.4365	65.2289	25.5850	65.1493	77.2019	10.7833	39.5097	62.0601	38.6912	75.1310	81.0569	16.9536	33.8221	56.3858	32.9619	78.8695	87.8908	10.2089	29.2497	55.4100	40.5326	85.1233	89.7510	3.2839	11.0844	48.5202
0.866	24.1034	58.7269	73.3536	31.9224	53.8888	65.1184	25.8231	65.0410	77.0853	10.9192	39.3584	61.8713	38.4695	74.9499	80.9742	16.8799	33.2263	55.9614	32.8448	78.6172	87.8581	10.0090	28.9610	55.2272	40.4639	85.1003	89.7277	3.2842	11.0123	48.4416
0.867	24.0153	58.4668	73.1123	31.6690	54.3459	64.8312	23.3780	64.6784	76.7731	9.9710	38.8007	61.6163	38.1144	74.6515	80.8599	16.8210	32.9599	55.7519	32.7430	78.4311	87.6857	10.6134	28.7054	54.8900	40.5351	89.8323	89.2923	10.6604	48.2922	
0.868	24.1034	58.6900	73.2268	32.0172	53.2980	64.4378	27.9590	64.5541	76.7700	9.7634	39.1818	61.8778	39.3901	75.0315	80.3767	16.6178	33.3430	55.7622	32.9009	78.4927	87.5703	16.3016	28.9163	54.6267	39.2074	84.6559	90.0000	3.2885	10.3728	48.2325
0.869	23.9761	58.5403	73.1006	31.6088	53.6772	64.9633	28.5725	64.8867	76.7700	9.9452	38.8262	61.5371	38.1207	74.6965	80.8088	16.7997	33.1295	55.7623	32.9009	78.4927	87.5703	16.3016	28.9163	54.6267	39.2074	84.6559	90.0000	3.2885	10.3728	48.1014
0.870	23.8860	58.4129	72.9781	31.4986	55.5420	64.8531	28.4241	64.8731	76.7929	9.2460	38.7163	61.5403	38.2436	74.6891	80.6789	16.8273	33.0854	55.5690	32.8915	78.4019	87.4414	10.1204	28.6994	54.8299	39.7758	84.9886	89.8799	3.2977	9.4422	47.8245
0.871	23.8155	58.2699	72.8334	31.3977	53.3442	64.6899	29.0458	64.6636	76.2444	9.6910	38.5897	61.3156	37.9116	74.3474	80.5070	16.6645	32.5136	55.2954	32.3507	78.1072	87.3993	10.0462	29.2608	54.9459	39.8679	85.0810	89.8680	3.2678	10.6253	48.0438
0.872	23.9242	58.9018	73.3042	28.6618	54.1266	66.8340	33.1467	67.2839	76.4816	11.3639	39.5806	61.7001	40.2764	75.3855	79.9651	16.7133	33.7443	56.0385	31.9995	77.4256	86.8745	9.8766	29.2916	55.1222	38.7770	84.5647	90.0000	3.2598	11.3985	48.1824
0.873	23.7331	58.6042	73.0720	35.5500	59.0471	67.2707	31.0669	67.6557	77.9211	16.6261	35.8385	57.4435	40.5734	75.7395	80.0720	10.7929	39.9968	62.0032	33.5480	78.5146	87.0567	9.8475	33.2820	57.5634	38.0233	84.6390	90.0000	3.2556	10.7657	47.9587
0.874	23.7103	58.5716	73.0055	35.4399	59.2568	67.4863	31.0500	67.9404	78.1535	16.6419	35.5445	56.9978	38.1081	75.7315	81.5560	9.7791	39.6195	61.8326	35.5898	80.5781	87.8381	11.7705	35.2497	58.3387	40.6483	85.4992	89.6005	3.2665	10.7144	48.0875
0.875	23.6820	58.5608	72.9607	35.0827	59.4594	67.8490	31.6510	16.6162	35.5445	65.5978	38.1081	81.7315	81.5560	16.6021	37.2555	58.2886	36.3307	80.6397	87.4185	11.1164	35.1624	57.0508	39.7421	85.1319	89.9742	3.2669	11.1645	47.8782		
0.876	23.6261	58.9053	73.2448	35.7188	59.1095	68.3068	30.7067	68.9482	79.1973	9.8869	39.5371	61.7734	39.6368	76.2714	81.0699	16.6021	37.2555	58.2886	36.3307	80.6397	87.4185	11.1164	31.1624	57.0508	39.7421	85.1319	89.9742	3.2669	11.1645	47.8782
0.877	23.6113	58.6783	73.0011	33.5367	58.8127	68.0931	30.9417	68.7132	78.8055	11.0907	39.9030	61.6666	40.4271	76.0499	80.2912	16.5490	36.0698	57.4172	35.7051	79.7222	86.8369	9.7780	33.3120	57.3835	38.7272	84.7593	90.0000	3.2434	11.0632	47.7929
0.878	23.6581	58.6304	72.8916	32.2912	58.0762	68.0976	31.6048	68.7379	78.4320	11.2942	39.7424	61.4535	40.1029	75.8940	80.3048	16.4688	35.3232	56.8721	35.3186	79.4969	86.7944	9.6035	32.8776	57.0828	38.6427	84.7515	90.0000	3.2193	11.1409	47.7542
0.879	23.8246	57.3650	71.6474	29.6572	60.6470	71.8472	42.0518	73.2446	76.3222	16.7390	42.8602	62.2410	33.9890	72.2157	80.4066	12.5836	36.3602	58.6885	40.2905	79.2309	83.4287	9.6898	31.5998	56.1955	34.3453	82.2147	90.0000	3.1040	12.5890	48.1032
0.880	23.6751	56.6978	71.0728	30.2902	56.6593	69.6475	37.6616	70.0085	76.0309	16.6777	35.6524	56.9217	34.9125	72.6873	80.2872	9.7931	38.6508	60.8861	40.2868	79.0352	83.1626	11.8448	32.5231	56.2467	33.7429	81.9297	90.0000	3.1840	11.9103	47.8429
0.881	23.7390	55.5754	70.0093	29.6254	58.4847	69.7947	37.5567	69.6085	75.6004	16.7125	35.2510	56.5776	34.2650	72.0360	79.9846	9.7435	38.3915	60.6498	40.0536	78.6340	82.9020	11.9569	31.2856	55.3738	33.1970	81.6710	90.0000	3.1435	12.0488	47.8239
0.882	23.6536	53.9543	68.5824	29.2019	57.8211	69.3670	36.0088	68.1497	75.1685	16.6982	34.1247	55.7567	34.7960	71.5372	79.1511	9.6900	37.7567	60.1582	40.1591	78.0475	82.2087	12.9001	30.0574	54.3041	31.5487	80.8236	90.0000	3.1294	12.9084	48.0146

0.883	29.7787	58.3199	69.4678	11.7841	55.6262	73.7893	33.3504	70.7254	79.1477	23.6619	44.4774	60.5868	43.9698	76.2843	77.8246	16.6912	34.8918	56.2291	39.1952	78.6100	83.3389	9.8696	31.2249	55.7056	33.6191	81.9967	90.0000	3.1329	11.9583	47.6777
0.884	32.4536	57.9918	67.6350	23.4779	58.0572	72.1726	30.7759	68.2302	78.1123	10.0033	33.8658	57.3273	41.4144	60.8362	38.6260	78.5439	83.5884	10.2115	32.2366	56.2214	33.6751	82.0734	90.0000	3.2575	10.4348	47.2056				
0.885	29.2476	55.2655	66.9001	23.5885	58.2227	72.2266	31.6706	67.6914	77.0799	16.5649	35.0032	56.2618	38.4090	74.6686	79.8700	10.4777	38.5708	60.4232	39.1094	79.1597	83.8457	9.4896	30.0589	54.9513	34.5429	82.6099	90.0000	3.1904	10.2579	47.1061
0.886	27.8837	53.3618	63.8753	23.5365	57.7089	71.7431	30.7365	66.6560	76.5507	16.4991	33.8581	55.4268	37.6364	74.0941	79.7456	11.2943	38.5190	60.1567	39.5474	79.0433	83.4061	9.4500	28.1495	53.7670	34.3873	82.2665	90.0000	3.2161	11.0303	47.2372
0.887	27.5941	53.0055	65.6609	23.5540	57.4371	71.4465	30.8342	66.3556	76.1693	16.4967	33.5433	55.1605	37.4451	73.7350	79.4871	10.6142	38.0894	59.9465	39.2385	78.6919	83.2110	9.6208	27.9549	53.5536	33.4716	82.0961	90.0000	3.2125	10.5103	47.0436
0.888	27.1459	52.3251	65.2433	23.5000	56.7385	70.8020	30.4633	65.8556	75.8467	16.4296	32.4681	54.4118	32.6231	73.0898	81.6007	11.3891	37.9178	59.6010	39.0816	80.2200	84.7760	9.5584	27.4249	53.2065	37.2747	84.3583	90.0000	3.1640	11.2178	47.1679
0.889	23.3366	50.8824	65.7361	25.1053	57.3309	70.5809	30.6001	66.1725	76.0272	16.3063	33.2324	54.9074	33.0932	73.2744	81.4760	9.4023	37.6782	59.7941	37.3946	80.1426	85.7020	9.8963	25.2557	51.8654	38.3951	85.2185	90.0000	3.2493	9.5689	46.6925
0.890	23.2879	50.8925	65.7166	25.1028	57.4344	70.6267	30.5632	66.2488	76.0721	16.2827	33.4017	54.7941	33.2458	73.4047	81.4923	9.1642	37.6956	59.7988	37.5402	80.2079	85.6326	9.9036	25.2242	51.7992	38.4305	85.1609	90.0000	3.2424	9.3428	46.5795
0.891	32.0226	58.0448	67.5914	9.5201	53.5779	72.1039	32.8832	68.7535	77.1505	23.1872	44.2074	60.1727	38.2422	75.4434	80.4607	16.2228	33.7726	55.1899	43.7848	85.9832	87.2548	12.6176	30.3406	54.0572	29.3480	79.7126	89.6152	3.1921	12.3425	47.3028
0.892	29.4202	55.6031	66.7679	23.2067	58.2502	72.0795	30.8499	67.9854	77.4728	10.1225	38.2321	59.8907	37.7546	75.3223	80.6005	16.3573	36.0775	56.6829	38.9640	80.1647	84.6149	8.7217	29.8366	54.5785	35.5296	83.7329	90.0000	3.2460	9.1275	46.4081
0.893	29.4593	55.4593	66.3770	23.1967	57.4909	71.3591	31.7277	67.3638	76.3681	9.9909	37.7703	59.5359	37.9689	74.2614	79.3817	16.3067	34.5617	55.5905	38.2435	78.7099	83.5838	9.3133	30.0834	55.0574	34.0901	82.7155	90.0000	3.2029	9.6216	46.4613
0.894	30.1021	56.2448	66.8800	23.0904	57.7632	71.5983	34.3540	68.1578	75.6036	9.4879	37.9583	59.7161	32.7305	77.8951	85.9502	16.2120	35.0670	55.9171	38.2927	74.2832	79.1538	10.6429	32.1658	55.5380	38.1429	85.1155	89.9530	3.2186	10.4512	46.5964
0.895	27.9426	53.9169	65.8911	23.0458	58.3976	72.1359	36.2607	67.5137	73.7960	10.8451	38.3925	59.6975	30.3768	75.8110	85.1048	16.2049	35.5418	56.1960	39.4871	73.9534	77.9996	9.2366	28.0951	53.2686	36.5889	84.2608	90.0000	3.2330	10.3936	46.5190
0.896	27.1749	53.0825	65.4955	23.1696	58.0156	71.6959	34.4991	67.0834	74.3969	16.2051	34.7585	55.5970	30.5122	76.3661	85.5314	11.3188	38.4058	59.5493	39.1307	73.8347	78.0875	9.5065	27.5778	52.8551	37.5869	84.8438	89.9336	3.1902	11.1747	46.6615
0.897	24.8516	51.9215	65.5535	23.8587	58.0244	71.3665	34.1328	67.1962	74.6723	16.2236	34.5894	55.4194	30.5098	76.9571	86.0641	18.2873	59.5069	38.3264	73.8007	78.5221	9.4031	25.2506	49.8585	3.1748	10.7942	46.5009				
0.898	22.9968	51.3419	65.8308	23.5747	58.2711	70.8729	34.0477	67.1514	74.6323	16.0397	34.3895	55.2892	30.3162	76.8616	86.0240	10.8001	38.9052	59.9214	38.4876	73.5764	78.1540	9.3297	25.5815	51.6482	38.5075	85.4312	89.8615	3.2435	10.4702	46.3510
0.899	29.3755	57.1603	67.8557	9.6616	54.2758	72.2935	32.9987	69.6297	77.5566	23.0593	43.4433	59.2010	38.0541	75.9884	80.7488	16.1935	33.7630	54.7538	43.1369	81.1540	82.5229	10.4031	30.5253	54.2735	31.8085	81.7356	90.0000	3.1773	10.4918	46.2993
0.900	30.9464	56.2976	66.1659	22.2876	57.3569	71.0348	31.0288	67.5692	76.6136	16.0030	40.2366	59.4031	32.8309	74.7799	82.5818	10.6288	32.7259	55.5781	40.1998	82.1100	85.3924	9.3246	31.9779	55.3665	37.9043	85.2862	90.0000	3.2419	10.2990	46.1836
0.901	30.2720	55.4095	65.6878	22.8928	56.9079	70.5858	30.8645	66.9393	76.0564	16.0403	39.7048	58.9409	31.9389	74.0684	82.3270	10.5213	32.0806	55.1271	39.7504	81.6199	85.1501	9.1190	30.9325	54.6861	37.8301	85.2856	90.0000	3.1948	10.0240	46.0577
0.902	27.3464	52.6061	64.6926	23.0035	59.7064	72.9995	38.1613	66.6346	71.1223	15.9953	42.6152	61.1144	30.6951	73.6402	82.5188	12.5147	33.6741	55.6398	42.0081	74.4423	76.4916	9.4767	27.7804	52.6403	32.2935	82.3244	89.8186	3.1843	12.3762	46.6278
0.903	21.1038	52.2495	66.5351	27.1253	58.4881	70.0082	38.1396	67.8709	72.5784	16.1221	41.1397	59.9352	32.3543	71.1464	79.1284	12.2633	33.2396	55.3600	40.8008	77.2742	80.0660	9.4738	27.6901	52.5366	30.9896	81.0951	89.6134	3.1713	12.2127	46.4986
0.904	22.7032	52.5671	66.7136	33.1104	57.3663	65.6917	38.1689	66.3941	71.0798	11.4766	38.2429	58.9767	30.2075	67.7685	77.0476	15.8547	33.5029	54.4157	37.9163	75.4615	80.0889	9.4170	28.6507	53.0314	28.6128	80.1262	89.7936	3.2440	11.2271	46.1744
0.905	29.9803	55.0620	65.6637	22.8575	55.5481	69.2050	33.8844	66.5542	73.8292	16.1289	33.2333	54.0848	32.1750	71.7777	79.8011	9.3649	36.1118	57.8605	38.5493	78.9507	83.0868	10.7600	31.5662	54.5211	34.4794	83.2739	89.7950	3.0915	10.6640	45.9752
0.906	28.5177	56.6189	67.4738	11.8378	51.4036	72.5045	32.3510	69.0880	77.8400	22.2916	42.7020	58.2712	38.8038	76.8212	80.0777	16.3054	35.7807	55.7328	41.1704	80.7741	82.7570	9.4958	30.4725	54.0453	34.0050	82.9653	89.7106	3.0163	11.9739	46.2749
0.907	31.0210	56.5464	66.0061	15.9948	55.3846	71.3894	29.2662	68.0922	77.6952	22.7336	41.8607	57.6687	37.8791	76.1516	80.6537	10.5860	34.0934	56.1169	41.5617	81.1302	83.2057	9.4532	30.1434	53.7928	33.5166	82.8221	89.7949	3.0224	10.4831	45.7951
0.908	29.4788	56.4637	66.7297	15.9664	55.7395	71.6588	31.7488	68.8876	77.1161	22.7552	42.5370	58.1419	42.2096	76.1418	77.7622	9.4136	33.5563	55.9476	37.6564	77.5486	82.1221	10.6960	30.8650	53.9214	32.7839	82.2315	89.6640	3.1724	10.5969	45.7637
0.909	31.4822	57.1280	66.1785	10.6396	53.1625	70.6908	31.6862	68.0634	76.3159	22.7334	43.6381	58.9807	29.3906	75.3284	84.4505	15.8534	32.7334	53.6199	43.7378	79.3705	79.8705	9.0202	30.3561	53.9001	37.4464	84.8678	89.4580	3.1708	10.1243	45.5821
0.910	30.5788	55.1405	64.8273	22.6643	56.0114	69.4538	31.1744	66.1507	74.7252	15.8884	39.1523	58.1036	30.5746	73.0665	81.6623	9.0661	31.4140	54.5052	37.3448	81.3816	86.0110	9.9502	31.1605	54.1635	39.1806	86.5001	89.5016	3.1948	9.5100	45.3702
0.911	29.5861	55.1314	65.3182	22.5642	55.5374	69.0278	35.7511	66.7815	72.6521	9.3233	36.1230	57.5569	32.6429	71.1260	78.6421	15.8152	34.0333	54.4041	37.9165	77.7536	82.2070	9.1163	31.9870	54.1817	33.3429	82.6083	89.4985	3.1424	11.7095	45.8778
0.912	22.9007	51.7467	65.5284	12.5435	55.1130	71.8135	37.7371	67.9940	72.5328	26.3719	42.7834	56.3388	33.2071	73.3289	80.4177	15.9931	33.8427	54.1576	42.1107	76.1058	77.6102	9.4167	26.9044	51.5727	30.3205	81.0698	89.5245	3.1325	12.4643	46.0359
0.913	22.6511	51.6519	65.5034	15.8110	55.5808	71.3283	34.5229	61.9775	74.4464	26.3985	40.8564	54.7113	41.0968	76.2983	79.1069	12.7284	35.4701	56.2162	38.4844	75.1651	79.0282	9.3745	26.6628	51.3848	29.9877	80.8485	89.4281	3.1893	12.6027	46.0107
0.914	31.0662	56.8950	65.9548	15.7797	55.4177	71.1477	29.3150	68.4920	77.7285	22.6360	42.4532	57.8109	34.4176	77.0131	83.2439	11.8079	35.2110	56.2171	41.8733	85.5478	87.0848	9.3519	30.5576	53.6822	37.8615	84.7757	88.8877	3.1656	11.7044	45.6862
0.915	29.5935	55.9041	65.8161	15.6782	55.3201	71.0443	31.2825	68.4570	76.6310	22.5655	42.0585	57.4755	33.2795	76.0083	82.8529	12.6274	33.9833	55.1083	41.5554	84.2994	86.0059	9.3339	30.9312	53.8668	37.6201	85.0310	89.2248	3.1738	12.4237	45.8326
0.916	29.3244	55.5101	65.5547	15.7100	54.9270	70.6462	31.2904	67.9679	76.1132	22.5074	41.9972	57.2412	32.3595	75.3981	82.7445	14.4716	34.4716	41.3960	83.5717	85.3404	9.2773	30.4924	53.5442	37.3953	85.0971	89.4025	3.1726	11.3632	45.4641		
0.917	22.7975	51.5786	65.1799	14.4568	54.4614	72.2796	38.3849	68.1191	71.9992	25.7681	42.5260	56.1793	34.7790	73.9965	79.9477	15.4307	35.9226	55.5236	41.4075	75.7453	77.5012	9.3122	26.3481	50.9523	29.9002	80.9506	89.3926	3.0223	13.9635	46.2037
0.918	22.2017	51.5939	65.1844	13.3312	55.8204	71.9570	37.9995	68.1867	72.2682	25.9948	42.4808	55.9674	34.5110	73.8085	79.8733	15.7560	35.4308	55.0134	41.4674	76.1265	77.7931	9.3464	26.4641	50.9879	29.9645	81.0165	89.3806	3.1442	13.2228	45.8939
0.919	22.5687	51.2896	64.9287	13.3251	55.9611	72.2078	38.3494	68.0898	71.8991	25.5568	41.9089	55.6789	34.9095	73.3597	79.3540	15.6259	35.9542	55.3734	40.8307	76.3680	78.4151	9.3371	25.9240	50.6242	29.7869	80.9145	89.3233	3.1454	13.0639	45.7807
0.920	22.8861	51.1195	64.5969	13.9520	56.3163	72.1410	38.3363	67.7198	71.4991	26.4744	41.9137	56.0808	34.5004	73.1541	79.1498	15.3625	35.6188	55.1655	40.6896	76.6898	78.7824	9.2822	25.3927	50.2789	29.7764	80.9796	89.3478	3.0821	13.4999	45.8625
0.921	25.5336	51.3941	64.9343	13.3106	55.5395	71.5756	37.9276	68.1196	72.1075	25.7649	42.1356	55.6446	34.3117	73.2677	79.3231	15.5149	35.3033	54.4377	41.0940	76.8446	78.6202	9.2911	26.1967	50.6723	29.7968	80.9867	89.2997	3.1520	13.0911	45.5631
0.922	25.5175	51.4014	64.8977	13.7306	55.5870	71.4659	37.9148	68.0668	72.0169	25.5703	42.1374	55.5886	34.2584	73.1208	79.1648	15.3414	35.3327	54.8599	41.0258	77.1171	78.8906	9.2165	26.2093	50.6368	29.7825	81.0122	89.2870	3.1531	13.3660	45.6881
0.923	29.0868	55.6095	65.4259	12.7100	54.4159	70.6509	31.5849	68.4855	76.1256	22.3211	42.0299	57.1359	33.7434	76.0238	82.2467	15.7143	34.7789	54.2918	41.2395	84.0281	85.5837	9.4934	31.2513	53.4449	37.5010	85.0465	88.9728	3.1215	12.6989	45.4167
0.924	29.4531	55.5420	65.1180	12.3806	53.8332	70.1779	33.3351	67.9378	74.5826	22.3057	41.7911	56.8991	30.9644	74.3681	82.0865	15.4831	34.0341	53.7931	41.1328	83.2874	84.8703	9.2740	30.8357	53.3147	37.1493	84.9728	89.0677	3.1695	12.1972	45.1976
0.925	27.9802	53.4816	63.9940	22.2504	53.2121	66.4337	37.0291	65.4185	69.8701	11.1552	34.1680	55.0556	32.8923	67.8884	74.7392	15.5077	34.1137	53.7844	29.9769	74.3211	82.5008	9.1709	28.4030	51.7642	34.8026	83.6831	89.1177	3.1617	10.9112	44.7702
0.926	24.4835	51.0754	63.5450	22.8633	54.2502	67.0398	36.4882	65.5866	70.3291	15.3871	34.8330	54.2716	29.9138	68.6400	77.0131	13.0247	34.0308	54.4268	36.1729	76.6297	81.2987	9.1384	25.5193	50.0281	32.4705	82.5074	89.1973	3.0399	12.6910	45.2291
0.927	24.5688	51.0175	63.4048	22.7538	54.3465	67.1220	36.2942	65.4908	70.3109	15.3980	35.0085	54.4363	29.8179	68.8072	77.1758	12.9276	34.0119	54.3853	36.4329	76.9464	81.4093	9.0772	25.5146	49.9794	32.6042	82.6135	89.1856	3.0969	12.6674	45.1432
0.928	21.1606	53.8686	66.8987	28.3946	53.4959	63.6383	36.1370	65.1745	70.0563	15.4966	33.6280	53.2837	30.4697	68.8304	76.8158	10.9671	35.4860	55.8494	32.7120	76.8455	83.3947	9.1007	29.3965	52.2163	36.4098	84.6428	89.0017	3.1140	10.7319	44.5339
0.929	27.2244	51.7336	62.6301	22.0815	53.4142	66.4837	33.0619	64.1220	70.8520	14.1895	33.9384	53.8584	29.4740	71.3005	77.7934	14.6077	33.8670	53.6801	36.9618	77.8250	81.8655	9.2682	27.4381	50.9352	34.1209	83.3671	89.0095	3.1820	13.3780	45.2478
0.930	28.7866	53.0573	62.9339	22.1102	54.6487	67.5085	31.4295	64.6971	72.2694	10.7703	33.9280	53.3626	30.0460	71.3057	79.2499	14.1265	35.0460	37.1489	79.7721	83.8300	9.9780	29.4125	52.1368	36.9969	85.2627	89.1783	3.1126	10.4000	44.3205		
0.931	27.6321	51.9773	62.5331	22.2744	53.9724	66.7963	32.0808	64.0133	71.2119	9.0713	34.4586	55.3719	30.3025	69.9307	77.8197	15.6175	33.3197	52.8615	36.3459	78.1629	82.4795	10.0372	28.4449	51.2601	35.1667	84.0544	89.0081	3.1012	9.8144	44.1075
0.932	27.7810	51.7226	62.3873	22.2575	54.0434	66.8168	31.8965	63.9830	71.2387	9.1015	34.3614	55.2445	30.4587	70.0540	77.8114	15.5808	33.4924	52.9367	36.1488	78.2156	82.6037	10.4046	28.2768	51.0160	35.1667	84.2144	89.9576	3.0780	10.2580	44.1557
0.933	28.1662	52.8588	62.9366	22.0223	54.1104	66.9233	33.2691	64.6334	71.0295	15.4343	34.3837	53.5505	29.8288	70.0720	78.1061	10.6668	34.9085	55.2412	36.2416	78.6094	82.8919	9.1612	28.8500	51.5802	35.8822	84.4909	88.9367	3.1232	10.5244	44.1566
0.934	27.0792	51.7368	62.4541	22.1974	54.1895	66.8724	32.5840	64.3159	71.0727	10.2327	34.0707	54.2761	29.8009	70.1195	78.1199	15.4399	34.7753	53.7687	35.8987	78.7724	83.2110	9.1884	27.6640	50.7963	36.2434	84.7627	88.9497	3.1426	11.9475	44.4875
0.935	27.6181	51.9352	62.3000	22.0928	53.8841	66.5972	32.0652	63.9734	70.9926	9.0345	34.2092	54.9883	30.4637	69.9782	77.5977	15.5086	33.8132	53.0145	35.8185	78.1575	82.6059	10.6654	28.6439	51.0061	35.7263	84.3981	88.8455	3.0597	10.4747	44.0191
0.936	17.3482	51.7201	62.1988	22.0630	53.5492	66.3537	32.3076	63.8058	70.6489	10.2861	34.1886	54.6621	29.8507	69.6656	77.5282	15.4336	33.7478	52.9376	35.9505	78.1299	82.4552	9.1368	27.9984	50.8559	35.4581	84.2724	88.8316	3.1131	11.1760	43.8730
0.937	25.6382	50.4380	61.8821	22.1001	53.8411	66.4583	32.7568	63.8799	70.4155	13.6525	34.2463	53.7862	29.5086	69.6566	77.6852	15.0728	34.4630	53.5007	35.7489	78.5281	82.9220	9.0523	26.2045	49.7896	36.1911	84.7368	88.8198	3.0302	13.2079	44.6945
0.938	26.6310	50.8847	61.7269	22.1190	53.4962	66.0979	31.5704	63.3499	70.5340	10.1734	34.4239	54.7389	29.9473	69.5063	77.2720	14.4655	32.8857	52.2174	35.6773	77.9768	82.3745	9.1440	27.3284	50.3720	35.5207	84.3353	88.7684	3.0839	10.1277	43.7329
0.939	27.2324	51.4552	61.8710	22.0182	53.7123	66.2804	32.1927	63.6556	70.4278	10.5748	35.1366	55.0924	29.7636	69.6003	77.4099	14.4555	33.0375	52.2683	35.7016	78.3142	82.6479	9.1089	28.0684	50.7662	35.9378	84.6479	88.7904	3.0430	10.5131	43.7708
0.940	27.1871	51.3250	61.7280	21.9907	53.5646	66.1123	31.8798	63.4890	70.3979	10.3623	34.9736	54.9704	30.0468	69.6196	77.2375	15.4737	32.8951	52.1071	35.5804	78.1796	82.5409	9.1105	28.1849	50.7787	35.9194	84.6340	88.7423	3.0148	10.3235	43.6583
0.941	27.0357	51.0609	61.5214	21.9920	53.4675	65.9771	31.8974	63.2821	70.1437	10.6402	34.9149	54.8123	29.6886	69.3154	77.0821	15.4180	32.7849	51.9931	35.5314	78.0712	82.4172	9.0804	27.8064	50.4969	35.7893	84.5654	88.7052	3.0403	10.5662	43.6549
0.942	26.7470	50.8149	61.4014	22.0646	53.4003	65.8390	31.7049	63.1528	70.0809	10.6965	34.7939	54.6598	29.7122	69.2335	76.9454	15.4153	32.7217	51.8934	35.4059	77.9625	82.3380	9.1384	27.5469	50.2700	35.7928	84.5639	88.6567	3.0531	10.7084	43.6267
0.943	26.5259	50.5967	61.2706	22.0248	53.3142	65.7301	31.6513	63.0457	70.9614	10.8531	34.7982	54.7516	29.6201	69.1232	76.8401	15.4029	32.6311	51.7780	35.3295	77.8886	82.2646	9.0823	27.3005	50.0753	35.8125	84.5603	88.6129	3.0165	11.4084	43.5938
0.944	26.6931	50.5173	61.1169	21.8479	53.4017	65.8302	30.6978	63.0304	70.4237	15.2981	36.2460	54.3145	29.4969	69.6817	77.3926	15.3351	31.3955	52.0332	35.8358	78.5907	82.6151	9.0269	27.2486	49.9969	36.3913	84.9644	88.6129	3.0365	11.4084	43.6921
0.945	26.6325	50.4261	61.1159	21.8648	53.3522	65.7305	31.3095	63.1015	70.1086	15.2439	35.8334	53.9771	29.3192	69.4548	77.2180	11.7061	31.9822	52.3229	35.7449	78.4447	82.4790	9.0496	26.8634	49.7041	36.2002	84.8593	88.5764	3.0541	11.5896	43.6779
0.946	26.1808	50.3266	61.0536	21.8465	53.2039	65.5580	31.4069	62.9923	69.9031	15.1954	35.5213	53.7118	29.3108	69.2282	76.9585	11.9010	32.1676	52.3400	35.6023	78.1980	82.2738	9.0359	26.7162	49.5608	36.0622	84.7481	88.5020	3.0650	11.7648	43.6633
0.947	25.9347	50.0445	60.8779	21.7829	53.1533	65.4900	31.6244	62.8095	69.5605	14.7843	35.5878	54.8356	29.1191	68.8181	76.6150	13.4382	32.4021	52.0147	35.7300	77.9643	81.9105	8.9713	26.4068	49.3328	35.9204	84.6114	88.4042	3.0041	12.9601	43.9725
0.948	25.9257	50.0027	60.7943	21.7560	52.9911	65.2299	31.4964	62.6460	69.4288	14.5903	35.4940	53.7733	29.1994	68.6881	76.4039	13.6249	32.3300	51.8531	35.7127	77.7460	81.6715	8.8906	26.4769	49.3311	35.9204	84.5711	88.3190	2.9843	12.9570	43.9082
0.949	26.0867	49.9336	60.6010	21.7325	52.7321	65.0414	31.1612	62.4303	69.3624	15.0232	35.1789	53.3533	29.2848	68.6931	76.3296	12.4701	31.9862	51.8946	35.3693	77.7121	81.7942	9.9933	25.5890	49.3168	35.5369	84.5946	88.3346	3.0485	12.2415	43.6126
0.950	26.1154	49.8478	60.1459	21.7203	53.0532	65.2789	29.1036	62.5208	70.4997	15.1034	35.6203	53.8999	31.2380	69.9872	75.5905	11.9756	31.8611	51.8864	35.5960	79.9122	81.4124	9.0031	26.6690	49.2654	35.8959	84.6580	88.3298	3.0235	11.8320	43.4251
0.951	26.2818	49.7794	60.2630	21.6853	52.6865	64.9213	29.4439	62.1541	69.9298	15.1034	35.5347	53.4717	30.3869	69.3151	76.2603	12.0261	31.2716	51.4222	35.3442	77.6789	81.6852	9.0043	26.6553	49.3537	35.9626	84.6393	88.2278	3.0475	11.8921	43.3758
0.952	25.7773	49.4772	60.2009	21.7507	52.6350	64.7997	29.7898	62.0324	69.5850	14.4812	35.6512	53.6974	30.1190	68.8397	75.8954	13.7559	31.5510	51.0363	35.5312	77.4163	81.2708	8.8791	26.4963	49.1072	35.9145	84.5294	88.1008	2.9911	13.0208	43.6683
0.953	25.8327	49.4458	60.0938	21.7090	52.5255	64.6703	29.9824	61.9388	69.3463	14.0582	35.5558	53.7021	29.9552	68.6486	75.7602	14.2754	31.5778	50.8544	35.3537	77.3274	81.2415	8.8840	26.6139	49.1162	35.9821	84.5460	88.0326	2.9907	13.1354	43.6407
0.954	25.1415	49.2954	60.2532	22.3474	53.2196	64.1746	30.1499	62.2672	69.5186	14.5296	35.5920	53.5278	29.7749	69.1935	76.3200	15.5339	31.6705	50.5088	35.9183	77.8763	81.4056	8.8035	26.4182	48.9573	35.5156	84.5362	88.2505	3.0238	14.5271	44.0534
0.955	26.4897	49.2435	59.4769	21.6150	52.0579	64.1995	29.7779	61.1643	68.6294	12.0721	34.7253	53.5542	29.8305	68.0030	75.1012	15.0755	31.0238	50.1019	34.4777	76.7379	81.0962	8.8991	27.2156	49.3539	35.8200	84.4892	87.9811	3.0130	11.9045	43.1194
0.956	24.9405	48.8584	59.8665	21.8163	52.8331	64.7484	28.7822	62.0629	69.9472	14.2081	35.3469	53.6133	31.5536	69.1217	75.6152	14.4000	32.2735	51.0884	35.3224	77.3417	81.1374	8.8374	25.6207	48.3646	36.6151	84.6960	87.9451	3.0218	13.4080	43.5386
0.957	24.9367	48.7671	59.7367	21.8251	52.5595	64.4537	29.0338	61.7490	69.4743	14.2841	35.7151	55.2267	31.1133	69.0619	75.3545	14.4364	32.0637	50.9012	35.4036	77.2777	80.9799	8.8445	25.2561	48.3089	35.8747	84.6058	87.8747	2.8722	13.4767	43.5623
0.958	24.1440	47.9294	59.3403	21.8879	52.5907	64.4054	28.4169	61.3534	69.3714	11.8418	35.2268	53.8026	31.5521	68.8951	74.9108	15.1760	31.8890	50.4792	34.7672	76.8001	80.8346	8.8010	24.7666	47.7624	35.8510	84.5283	87.8668	2.9431	11.7002	42.8655
0.959	24.0597	47.8613	59.2693	21.9739	52.5081	64.2470	28.4773	61.3298	69.2704	12.0935	35.0980	53.5900	31.5099	68.9212	74.9122	15.1819	32.0274	50.5118	34.8150	76.8634	80.8239	8.8575	24.7466	47.6785	35.8150	84.5348	87.8493	2.9431	12.0380	42.9015
0.960	24.4424	47.8571	59.0302	21.8481	52.2331	64.0863	28.5420	61.0029	68.8826	12.1070	35.2733	53.6561	31.0220	68.4770	74.6991	15.0939	31.5624	50.1670	34.7885	76.7155	80.6477	8.3303	25.0994	47.8241	35.8770	84.5146	87.7479	2.9508	11.9842	43.2183
0.961	24.5585	47.7423	58.8221	21.8065	52.2809	64.0163	28.5280	60.7657	68.6192	11.7094	35.3850	55.7821	30.8130	68.2098	74.5062	15.0950	31.3182	49.9417	34.7322	76.5876	80.5085	8.7903	25.2051	47.8323	35.9105	84.5052	86.6738	2.9595	11.5701	42.6267
0.962	24.3787	47.6524	58.7877	21.8180	52.2404	63.9264	28.5042	60.5767	68.5662	11.7189	35.3706	53.7136	30.8185	61.8983	77.4456	15.6698	31.3525	49.9179	34.7248	76.5749	80.4546	8.7719	25.0628	47.6937	35.8939	84.5067	87.6399	2.9621	11.5739	42.3612
0.963	24.3263	47.4885	58.6099	21.8613	52.1166	63.7488	28.5803	60.5767	68.3184	11.9581	35.3605	53.3890	30.5730	62.9000	74.3190	15.0147	31.1498	49.6782	34.6771	76.5027	80.3740	8.8260	25.0734	47.6277	35.8290	84.5006	87.5249	2.9525	11.4742	42.5749
0.964	24.2578	47.3816	58.4979	21.8270	52.0308	63.6374	28.5399	60.4770	68.1973	12.0004	35.3220	53.4896	30.5336	67.9038	74.2194	15.0140	31.1498	49.6782	34.6771	76.5027	80.3197	8.8050	25.0080	47.5336	35.8344	84.5073	87.5855	2.9603	11.8616	42.5146
0.965	24.6501	48.1179	58.8930	21.7104	52.4350	63.9915	28.2955	61.2321	68.9823	11.4133	34.9825	53.3439	31.9274	68.8830	74.3676	15.1253	32.2737	50.4222	34.5673	76.6698	80.5020	8.8360	25.2861	47.6263	35.7364	84.5428	87.6331	2.9429	11.3981	42.2307
0.966	26.8750	45.7605	55.6422	21.2131	52.0367	63.7933	33.8059	57.1761	61.9770	8.9520	36.5513	54.9564	25.7394	64.8800	73.5946	15.2162	30.3782	48.9697	37.5015	63.5188	67.7159	9.9034	25.0178	47.1742	31.4514	74.8915	80.4296	2.9127	9.9879	41.8295
0.967	27.7577	45.4320	55.4085	21.2789	52.6524	64.2643	34.5752	58.3215	62.5322	9.0395	39.1919	56.8431	23.5987	63.7174	73.3869	15.0901	31.3808	49.6325	39.8602	68.4406	68.9406	8.8809	24.3883	46.4798	31.7495	74.7368	80.0739	2.9867	9.4477	41.5248
0.968	27.5970	45.6168	55.0059	21.1434	52.7183	64.3216	34.5288	57.6965	61.9119	9.1398	38.5495	56.2871	24.2754	69.2886	72.6513	15.1048	31.3931	49.5768	39.2391	70.8298	71.6918	9.2729	24.0638	46.6521	31.8460	74.5841	79.8270	2.9822	9.4196	41.5708

0.969	27.5586	45.6864	55.0335	21.2120	52.5331	64.0806	34.4369	58.5922	52.2788	9.1444	39.0564	56.6134	24.9146	64.1139	73.1003	15.0598	30.9962	49.2623	39.7235	67.6737	68.1737	9.2384	24.7469	46.9852	31.4797	74.5689	79.9618	2.9557	9.4398	41.5100
0.970	27.3075	45.7201	55.1491	20.9275	52.8673	64.4393	33.8476	57.5231	62.0777	9.3856	38.2373	55.8973	24.2608	64.5945	73.7891	15.0533	31.7149	49.6973	38.8785	54.3029	65.3565	9.0653	23.9165	46.4914	32.6843	75.4622	80.1427	2.9740	9.4908	41.4533
0.971	26.7081	45.6564	55.3701	21.0905	52.3566	63.8735	31.8910	57.9088	63.5872	8.5872	37.8452	55.7016	25.5490	65.0175	73.5758	15.1408	30.7100	48.9211	38.8932	65.8015	66.7857	8.6032	24.7534	47.0005	33.6205	75.3425	79.4591	2.9304	8.2138	41.0906
0.972	26.0727	45.5281	55.5471	21.2404	52.2394	63.6596	31.5983	58.3397	64.1163	8.4528	37.9632	55.7590	26.5291	65.0266	73.0884	15.2073	30.3944	48.6248	39.1587	67.5882	68.3296	8.2423	25.1938	47.2649	33.6020	75.0498	79.1357	2.8461	7.7592	40.9322
0.973	26.1559	45.3552	55.2983	21.3641	52.2786	63.5939	31.0511	57.8184	63.8904	10.0079	37.9978	55.4280	26.3980	64.4865	72.5911	15.1632	30.1528	48.4176	38.9518	68.8140	69.6403	8.6692	25.1198	47.0751	33.7229	74.7208	78.6979	3.0138	9.7426	41.3096
0.974	26.2583	45.4913	55.3065	21.3283	51.9377	63.2574	30.8493	57.9534	64.0831	9.5897	38.0582	55.5048	26.8780	64.4887	72.3203	15.0527	30.1270	48.3786	38.9422	70.1649	70.9428	8.9926	25.7079	47.2901	33.9467	74.9070	78.7081	2.9686	9.6701	41.2264
0.975	26.0964	45.5221	55.3652	21.4873	51.7068	62.9382	30.4170	57.7567	64.0927	9.6944	37.6828	55.1486	27.2889	64.3370	71.9327	15.1115	29.8354	48.1024	38.5149	71.2077	72.2144	9.9724	26.0174	47.4168	33.9602	75.0172	78.7631	2.9339	9.8051	41.1955
0.976	25.7837	45.5322	55.4855	21.5486	51.3913	62.5845	29.7942	57.6550	64.2755	9.8106	37.1332	54.6614	27.7842	64.3419	71.6489	15.0398	29.5402	47.8702	37.8684	71.7398	73.1146	9.0096	26.1065	47.4009	34.0817	75.2635	78.8906	2.9595	9.9670	41.1674
0.977	23.9224	44.9763	55.9001	21.7486	50.9156	62.0319	28.1784	57.5809	65.0415	11.0696	36.3332	53.7348	29.2934	64.6852	71.1677	14.8588	29.5248	47.8622	37.0395	71.1609	73.0208	8.6372	26.6397	46.5578	34.1196	75.2556	78.8158	2.9776	10.8062	41.3270
0.978	26.2733	51.0534	59.9986	21.4151	43.1544	55.4815	28.3672	56.6198	63.9987	14.6476	36.6357	52.9102	20.3750	62.7064	73.1878	6.8488	27.1293	48.2997	33.9423	76.0074	79.6119	9.0772	20.8175	44.3273	37.2757	84.7471	86.3340	3.0721	7.1686	40.3822
0.979	25.2615	48.7074	58.3695	20.4202	45.9545	58.1987	30.8467	57.3724	63.2859	12.8981	33.3367	50.9800	26.0120	61.8699	70.0209	15.2518	29.9693	47.9006	32.4929	71.6063	76.0549	8.9241	24.0529	46.0381	34.9018	79.5587	82.5304	2.8319	13.2868	41.9817
0.980	27.4549	48.7901	57.2390	20.9633	46.5786	58.4503	29.1571	56.5894	63.4462	12.7687	33.3920	50.9982	26.0632	61.3827	69.4921	14.8788	29.2302	47.4771	33.1290	70.1850	74.2624	8.8568	26.0327	47.1440	34.7968	76.7836	79.7969	2.9206	12.8354	41.7548
0.981	27.6959	47.5949	55.9846	20.8444	47.5693	59.3909	27.8013	56.1252	63.6864	15.1178	34.0227	50.6616	26.0696	62.4399	70.4339	13.1201	28.3661	47.4286	33.4858	72.1864	75.9733	8.8613	25.9886	47.0552	35.0157	79.7068	82.5208	2.8959	13.4211	41.8887
0.982	28.2314	47.9299	55.9264	20.7248	47.5693	59.2917	27.4080	56.0594	63.7785	15.1937	34.3498	50.8152	26.2846	62.5775	70.4151	13.0743	28.4888	47.4609	33.6737	72.2095	75.8424	8.8602	26.2855	47.1726	35.1084	79.7005	82.4155	2.8887	13.4420	41.8291
0.983	27.4472	47.7368	56.1412	20.7552	47.7549	59.3863	27.8933	56.4114	63.8034	14.9812	34.0498	50.6107	27.1482	62.7339	70.1024	13.7215	28.2691	47.0532	34.3130	72.0061	75.7449	8.7827	27.0862	47.6161	35.0528	79.6248	82.3272	2.8189	13.8745	41.9199
0.984	27.6927	48.0905	56.2662	20.7190	47.7952	59.3836	28.6051	56.5829	63.5369	15.1105	33.7025	50.2576	27.0532	62.5304	69.9082	13.4417	27.8554	46.8151	33.1675	71.8564	75.6906	8.8121	28.4304	48.3919	34.9215	79.5323	82.2658	2.8177	13.7217	41.7979
0.985	29.8307	49.2384	55.9992	20.8437	46.7303	58.3657	27.5178	55.5922	63.1389	12.6133	33.1090	50.5516	27.5771	61.2406	68.3855	15.1504	28.5637	46.6337	32.5654	69.2514	73.4348	8.8975	28.9952	48.6764	34.6671	76.2710	79.1361	2.8559	12.9026	41.4434
0.986	33.5425	50.9662	55.2006	20.9226	45.3104	57.0706	26.9140	54.3083	62.2160	12.5627	34.6109	51.5836	27.2527	59.5484	66.9074	14.9040	27.1027	45.7144	29.6868	67.1957	72.9479	8.8086	29.3985	48.8963	35.0447	75.7654	78.3700	2.8941	12.6433	41.2856
0.987	32.3380	50.2227	55.2437	20.9337	45.1258	56.8560	26.6022	54.0555	62.0921	12.7853	32.8302	50.1886	26.9965	59.5062	66.9460	14.8522	26.4820	45.2776	30.4923	67.4073	72.6824	8.7741	30.0899	49.3700	34.3365	75.3832	78.3117	2.9306	12.8842	41.2270
0.988	31.5384	49.6285	55.1503	20.8756	45.0286	56.7446	26.4545	53.9736	62.0408	12.8726	32.1131	49.6010	27.0528	59.4452	66.8122	14.7151	26.4116	45.2194	30.5214	67.3174	72.5328	8.7618	30.0899	49.2407	34.3771	75.6332	78.3057	2.8497	14.0956	41.3205
0.989	30.3104	48.6971	55.0058	20.7915	44.8169	56.5477	26.1821	53.7470	61.9193	12.9420	30.3444	48.3049	27.2471	59.3378	66.5659	14.4406	26.1711	45.1031	30.5830	67.1537	72.2944	8.7286	30.6306	49.5480	34.0878	75.1765	78.2044	2.9478	12.7520	41.1128
0.990	27.9211	48.7850	56.4381	20.6839	47.3731	58.7199	27.5031	56.6076	63.8369	13.5548	32.9766	49.8874	31.6147	62.2329	66.9508	15.1296	29.5134	46.9649	31.3063	68.2847	72.9541	8.7747	29.3534	48.6344	34.6412	76.1244	78.7768	2.8514	13.9228	41.4613
0.991	28.0961	48.7163	56.2233	20.6940	47.2562	58.5624	27.3375	56.3943	63.6734	13.5779	32.8411	49.7251	31.5608	62.1016	66.8212	15.1521	29.3951	46.8155	31.2652	68.1646	72.8127	8.7694	29.4683	48.6507	34.5737	75.9853	78.6324	2.8506	13.9860	41.4164
0.992	28.5511	48.7642	55.9523	20.6854	47.0421	58.3290	27.0074	56.0099	63.4347	13.6383	32.6497	49.5115	31.3852	61.7611	66.5106	15.2024	29.2269	46.6225	31.0953	67.8183	72.5213	8.7187	29.7139	48.7625	34.5344	75.8033	78.4311	2.8863	14.1215	41.3954
0.993	28.8205	48.6855	55.6700	20.6524	46.7464	58.0357	26.8522	55.6432	63.1235	13.9020	31.9906	48.9037	30.9379	61.4507	66.6037	14.8139	28.6613	46.2594	31.0606	67.3683	72.0038	8.6443	31.5099	49.8647	34.2491	78.0913	78.0913	2.8485	13.8959	41.1791
0.994	29.3360	48.9200	55.5139	20.7074	46.2379	57.5235	26.6106	55.2123	62.7965	13.7467	30.8542	48.1021	30.5708	60.9196	66.0637	14.8139	28.6613	46.2594	31.0606	67.3683	72.0038	8.6443	31.5099	49.8647	34.2491	75.3384	78.0913	2.8485	13.8959	41.1791
0.995	29.9526	49.0768	55.2443	20.6987	46.0779	57.3368	26.5808	54.9137	62.4853	13.7653	30.0212	47.4655	29.8664	60.3904	65.8975	14.0484	28.8203	46.5662	30.8616	67.0390	71.7498	8.5993	32.0385	50.1780	34.4150	75.1810	77.7445	2.8766	13.2385	40.8735
0.996	27.3533	47.0263	54.8493	20.3526	47.9568	59.0442	28.0949	55.0941	61.8152	14.2538	32.8684	49.2348	31.2090	61.2286	65.9025	16.0652	29.1984	46.0329	33.8559	65.2651	68.2699	8.6641	30.2970	48.8812	32.3967	70.4325	74.0564	2.7732	15.4132	41.6290
0.997	33.8830	50.5583	53.9737	20.7040	45.9152	57.0884	26.3441	54.0492	61.7066	12.6563	28.0668	46.3905	29.2800	59.8660	65.6175	14.5758	31.1178	47.8300	30.1320	66.6181	71.6375	8.6638	34.4667	51.7636	34.5739	74.9900	77.3712	2.9088	12.6285	40.5236
0.998	30.6981	48.9104	54.4653	20.6980	44.5221	55.8507	26.4985	53.5851	61.1505	12.1337	27.5287	46.1362	27.3718	58.7483	65.5069	14.2320	28.6392	46.1975	30.1979	66.3893	71.3337	8.5412	32.5194	50.3477	34.4919	74.7364	77.1217	2.9597	11.8231	40.1867
0.999	28.7719	46.9730	53.8137	20.4589	47.5160	58.4614	27.1255	54.3453	61.4776	14.4883	29.8499	46.8629	30.6935	60.8122	65.6458	15.3570	31.0492	46.7613	33.0463	65.2982	68.6368	8.7305	32.0520	49.9268	32.9124	70.7343	74.0345	2.7730	15.1090	41.3042
1.000	32.2839	51.1409	55.4313	20.4905	47.2256	58.1443	26.7633	56.0860	63.2261	14.5102	30.9339	47.5415	32.5184	61.6483	65.3508	13.4601	31.0246	47.9474	30.3692	66.9117	71.6535	8.6335	34.8633	51.8842	35.1289	75.3700	77.2843	2.8442	13.4492	40.6057

STATCOM Circuit Layout

PSCAD Model of distribution grid