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Power Quality Improvement of Nine Bus System during Line Interruption Using IVDFC

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Abstract

IVDFC is one of the recent FACTS controller which can improve the voltage stability. IVDFC can be used to improve receiving end voltage of multi bus system. This paper shows the conception and simulation of nine bus system with line interruption .The objective of this work is to improve the real and reactive powers by employing IVDFC. Nine bus systems with line interruption and without IVDFC are simulated. The nine bus system with line interruption and addition of IVDFC is also simulated and the results are presented. The comparative study is presented to demonstrate the improvement in the power quality by adding IVDFC. The results indicate that real and reactive powers are improved by adding IVDFC.

Keywords: IVDFC,Power Quality,Voltage Sag

INTRODUCTION

Efficient power factor improvement technique and energy conservation of power system is given by aslam [1]. Optimal size and location of shunt capacitors for reduction of losses on shunt capacitors for reduction of losses on distribution feeders is given by lee [2]. Application of fuzzy logic and particle swarm optimization for reactive power compensation of radial distribution systems is given by grace [3]. Minimisation of power loss in distribution networks by different techniques is given by Wagner [5]. Combined system for harmonic suppression and reactive power compensation is given by zhu [6]. A STATCOM topology with reduced DC link voltage rating for load compensation with non-stiff source is given by Mishra [7]. A transformer less DSTATCOM based on a multivoltage cascade converter requiring no DC sources is given by sano [8]. Adaptive theory based improved linear sinusoidal tracer control algorithm for DSTATCOM is given by arya [9]. A novel DC voltage control method for STATCOM based on hybrid multilevel H-bridge converter is given by du [10]. Directly connected static VAR compensation in distributed system applications is given by berkebile [11]. Fault ride through a DFIG wind turbine using a dynamic voltage restorer during a symmetrical and asymmetrical grid faults is given by Fuchs [12]. Three phases HFL-DVR with independently controlled phases is given by sabahi [13]. Low voltage ride –through capability for wind generators based on DVR’s is given by Castro [14]. Line – interactive single phase dynamic voltage restorer with novel sag detection algorithm is given by Han [15]. A fast and effective control scheme for dynamic voltage restorer is given by ajaei [16]. Implementation and control of a dynamic voltage restorer using space vector pulse width modulation for voltage sag mitigation is given by omar [17]. A novel minimal energy consumption strategy for the interline dynamic voltage restorer is given by banaei [18].Evalution of a multilevel cascaded type dynamic voltage restorer employing discontinues space vector modulation is given by Williams [19]. A novel technique to compensate voltage sags in multiline distribution system the interline dynamic voltage restorer is given by choi [20]. The interline power flow controller concept: a new approach to power flow management in transmission systems is given by sen [21]. Interline dynamic voltage restorer: An economical way to improve interline power quality is given by choi [22]. Investigation on inter line dynamic voltage restorer in multi feeder distribution system for voltage sag mitigation is given by massoud [23]. Investigation on interline dynamic voltage restorer with virtual impedance injection is given by Ahmed [24]. Investigation on inter feeder power flow regulator: load sharing mode is given by Ahmed [25]. The above literature does not deal with comparison of results with and without line interruption in nine bus system. The improvement in power quality using IVDFC during interruption is not reported in the above papers. This work deals with modelling and simulation of nine bus system with and without IVDFC.

SYSTEM DESCRIPTION

Conventional system of nine bus system is shown in Figure 2.1. The nine bus system using three generators buses and six load buses. During their operation the fault occur in one line affects the whole system and recovery of a system takes place due to IVDFC

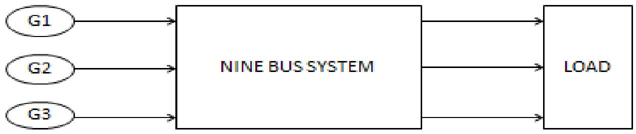


Figure 2.1. Conventional System

Proposed method of nine bus system with IVDFC is shown in Figure 2.2. The system describes that, the two generators are in unison operation and by improving the transient stability IVDFC is used. If fault occurs in one generating part, it affects the whole system and sudden insertion of another generating unit gives unequal power distribution system. In order to overcome this problem, IVDFC is used and voltage is directly improved without using any external units

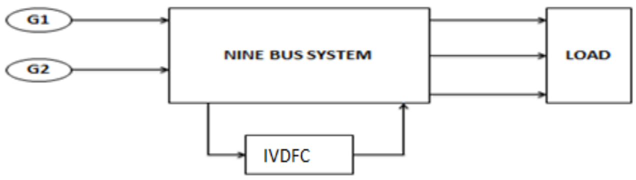


Figure 2.2 .Modified System with IVDFC

Single line diagram of nine bus system with IVDFC is shown in Figure 2.3

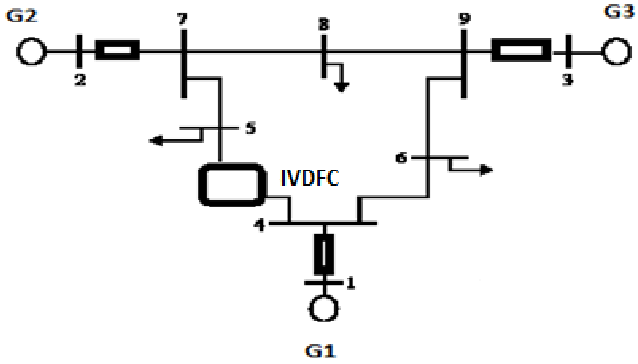
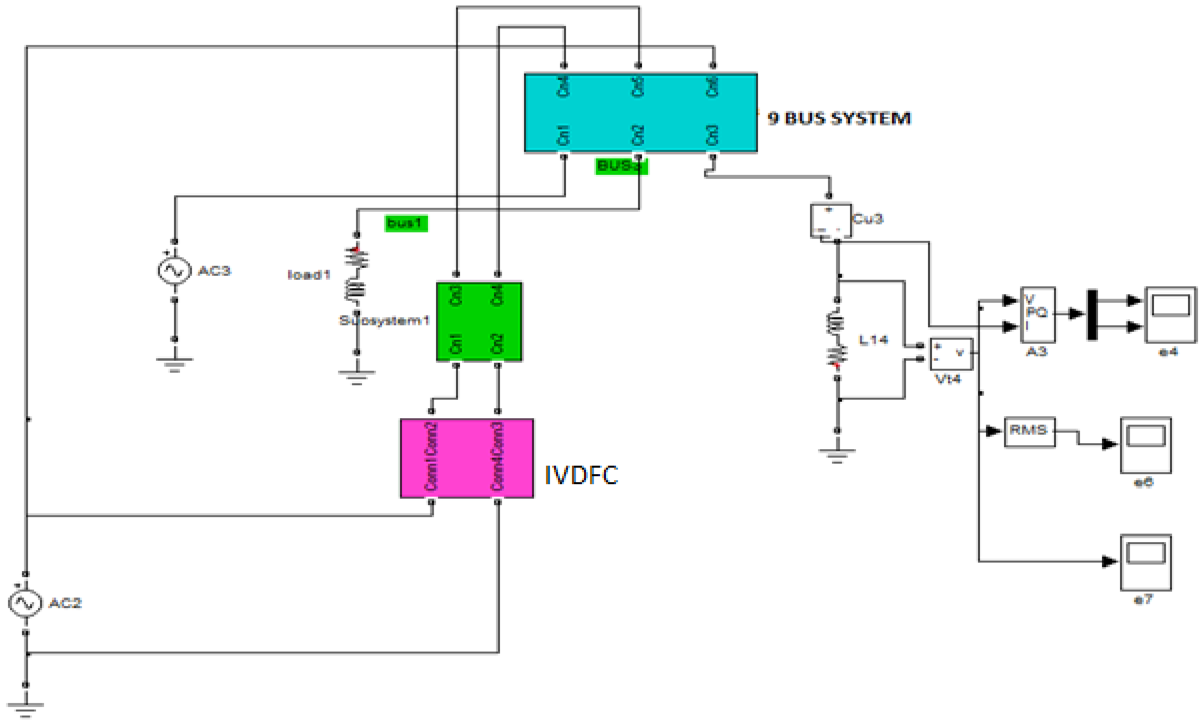


Figure.2.3. Single Line Diagram of Nine bus system with IVDFC

SIMULATION RESULTS:

Nine bus system in normal condition is shown in Figure 3.1.The receiving end voltage is shown in Figure 3.2 and the peak value of voltage is 6600volts. Circuit of IVDFC is shown in Figure 3.3.The circuit consists of a rectifier and inverter .The DC link voltage is shown in Figure 3.4. The value of DC link voltage is 4300volts.The real & reactive powers are shown in Figure 3.5.



Figue 3.1. Nine bus system in normal condition

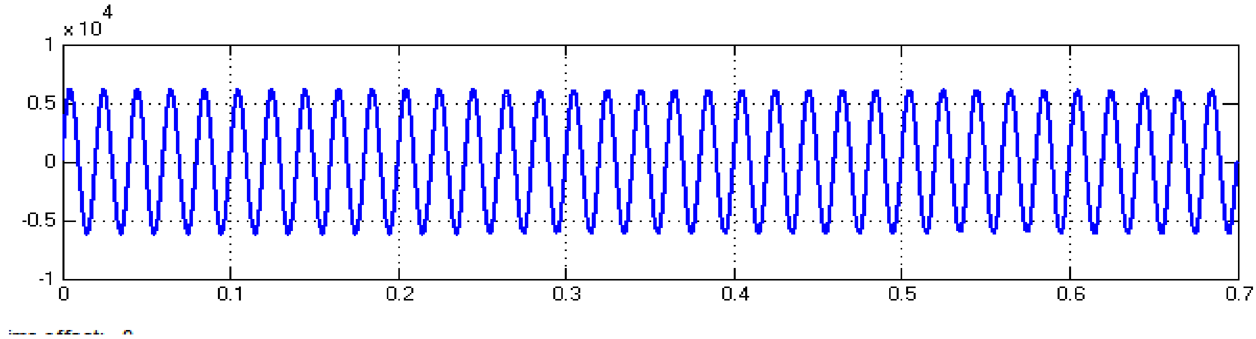


Figure 3.2.Voltage at bus five

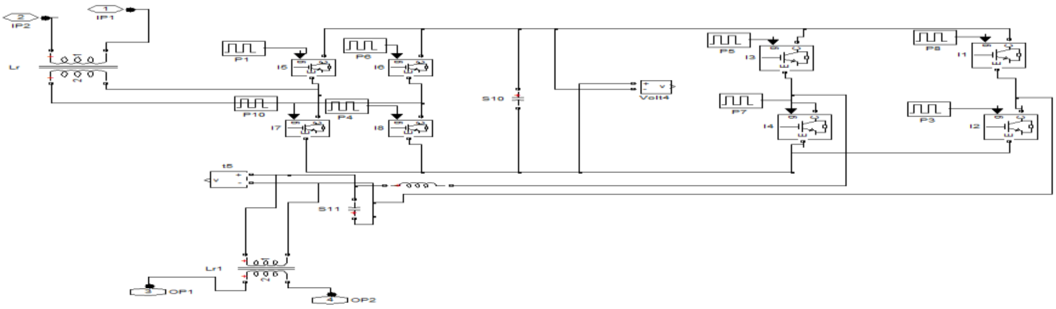


Figure 3.3. Circuit of IVDFC

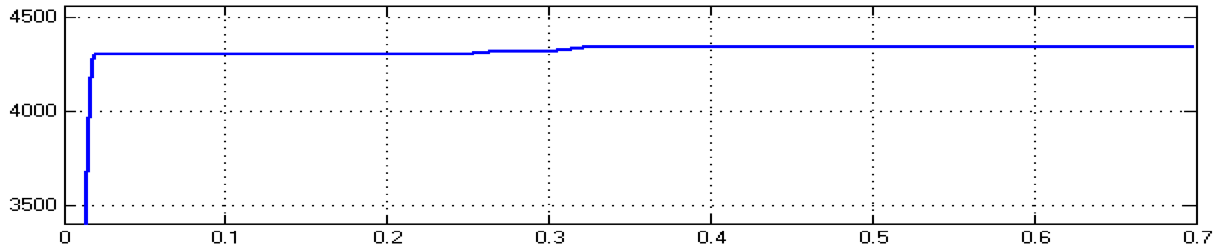


Figure 3.4. RMS output voltage

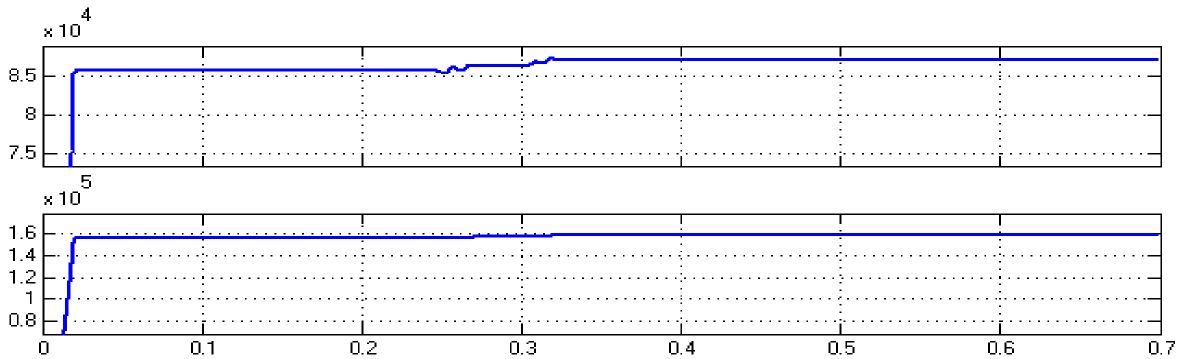


Figure 3.5. Real & Reactive powers

Simulink model with line 2 open and IVDFC in off condition is shown in Figure 3.6. Receiving end and its voltage is voltage is shown in Figure 3.7. The peak value is 5200volts.The RMS receiving end voltage is shown in Figure 3.8. It settles at 4000volts.Real & Reactive powers are shown in Figure 3.9. and value of real power is $6*10^4$ W and reactive power is $1.5*10^5$VAR .

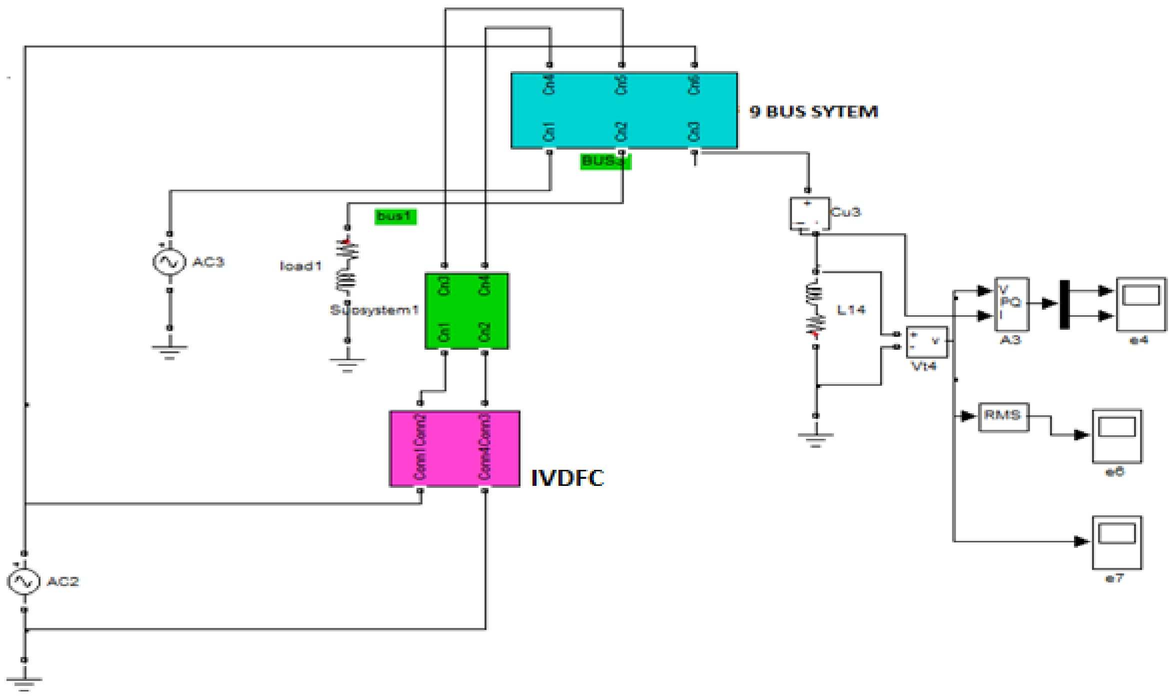


Figure 3.6. Line 2 open and IVDFC in Off condition

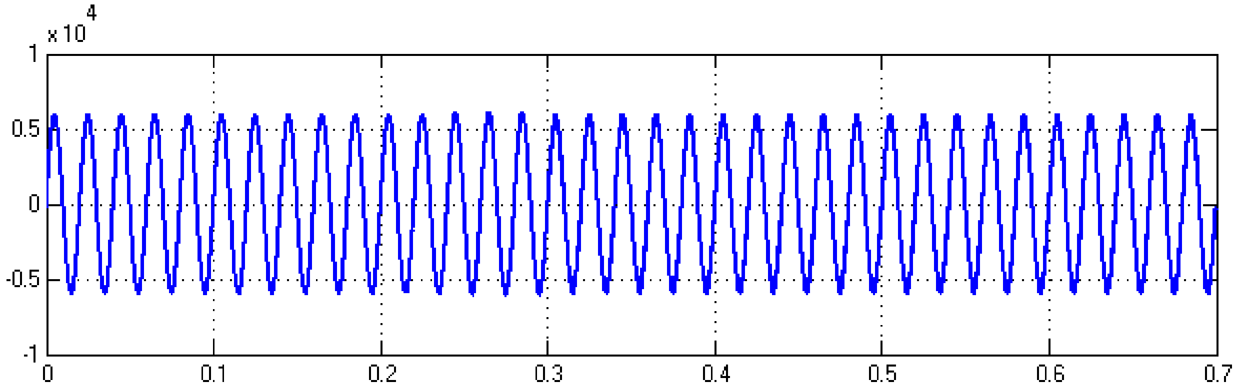


Figure 3.7. Voltage at bus five

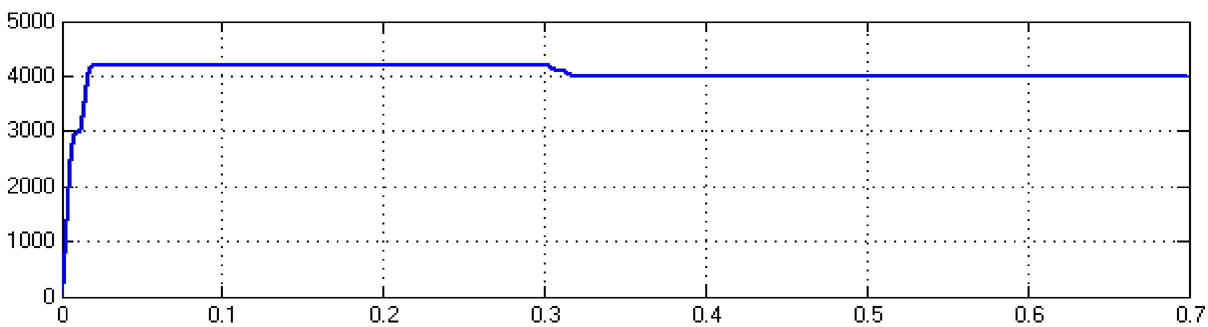


Figure 3.8. RMS output voltage

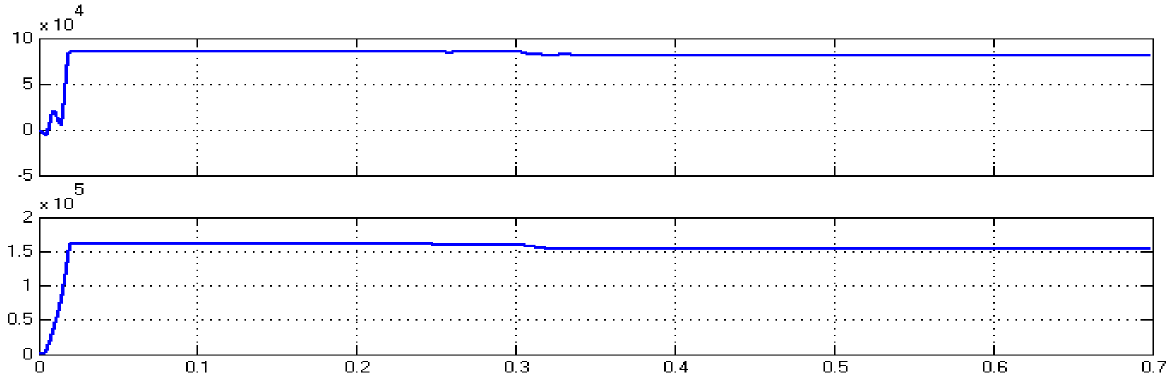


Figure 3.9. Real & Reactive powers

Simulink model with line 2 open and IVDFC in on condition system is shown in Figure 3.10.The receiving end voltage is shown in Figure 3.11 and the peak value of voltage is 5200volts.Circuit of nine bus system is shown in Figure 3.12.

Line between buses 3 and 8 is interrupted. The RMS output voltage is shown in Figure 3.13.The RMS value is 4340volts.The real and reactive powers are is shown in Figure 3.14. The real power is 0.081MW and reactive power is 0.156MVAR.

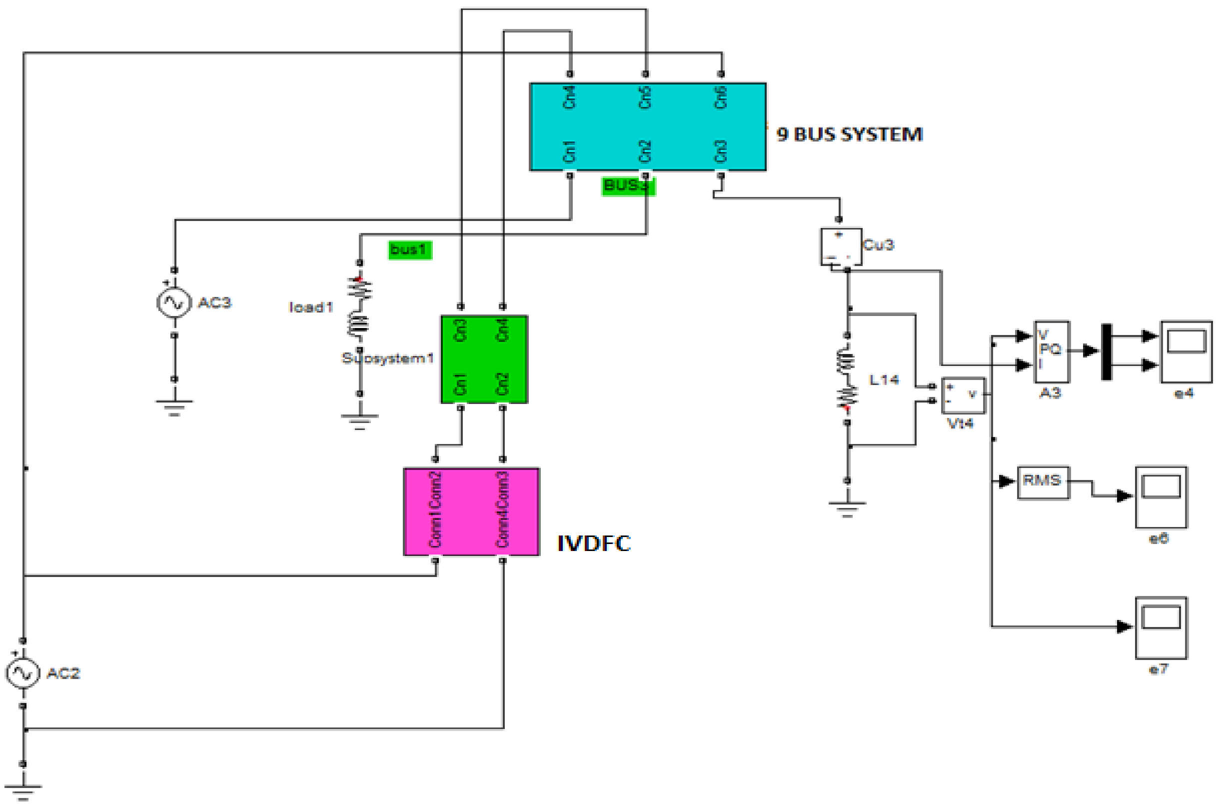


Figure 3.10. Line 2 open and IVDFC in on condition

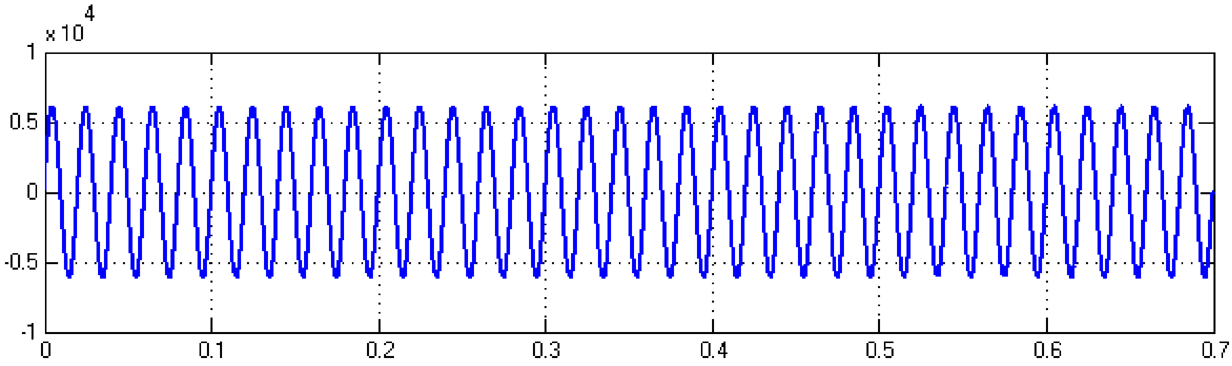


Figure 3.11. Voltage at bus five

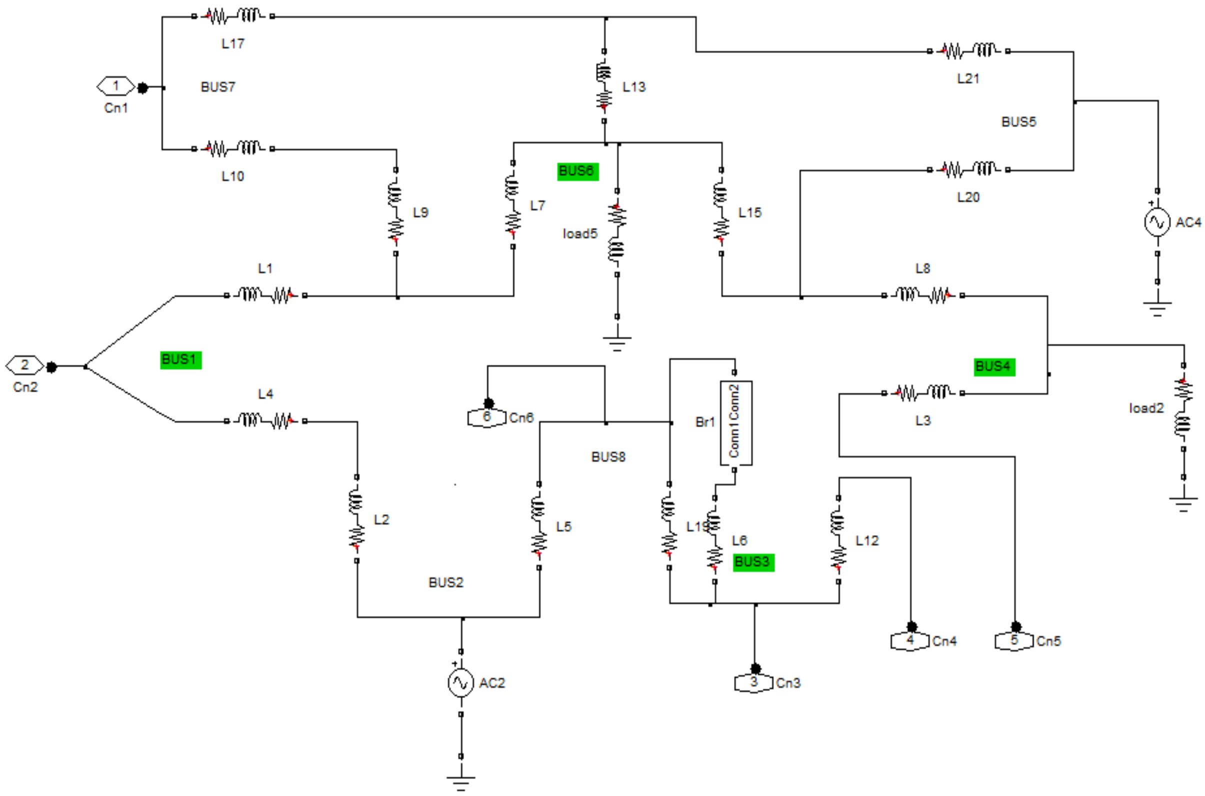


Figure 3.12. Circuit model for nine bus system

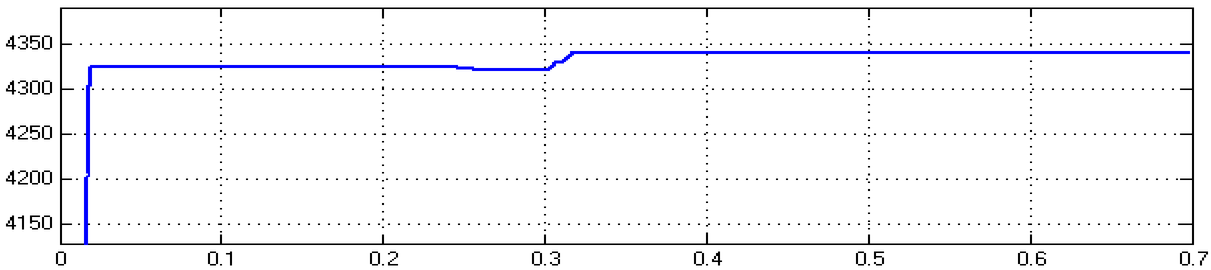


Figure 3.13. RMS output voltage

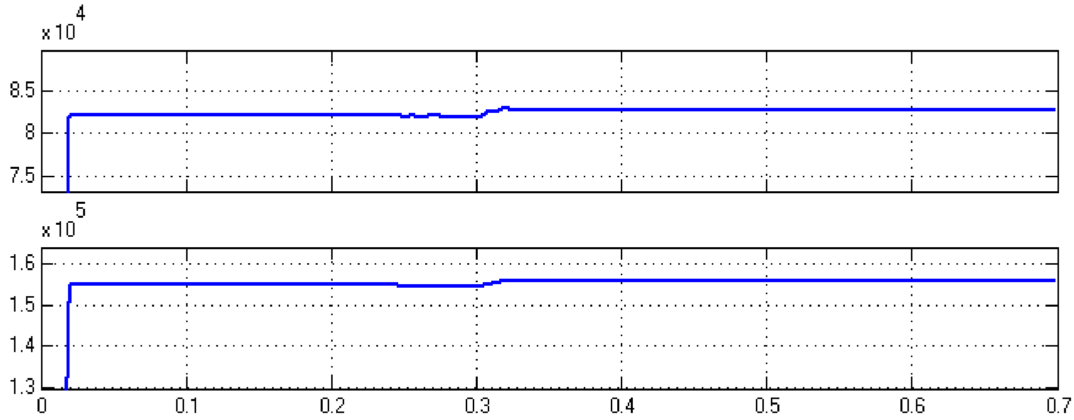


Figure 3.14. Real & reactive powers

The comparison of real & reactive powers is shown in Table-1, If can be scan that the voltage, real power and reactive power are almost equal to the values under normal condition

Table-1 Comparision of Real & Reactive Powers

9-bus IDVR	Vo	Real power(MW)	Reactive power (MVA)
Normal condition	4.41kv	0.083	0.159
Line 2 open & IVDFC off	4.05kv	0.079	0.150
IDVR & Line 2 open	4.4kv	0.081	0.156

OUTAGE OF GENERATOR

Nine bus system with one genearor system with open and without IVDFC system is shown in Figure 4.1. The voltage at bus 5 is shown in Figure 4.2 and its peak value is 3250volts. Real and reactive power system are shown in Figure 4.3 Real and reactive power are 0.442MW and 0.412MVA.

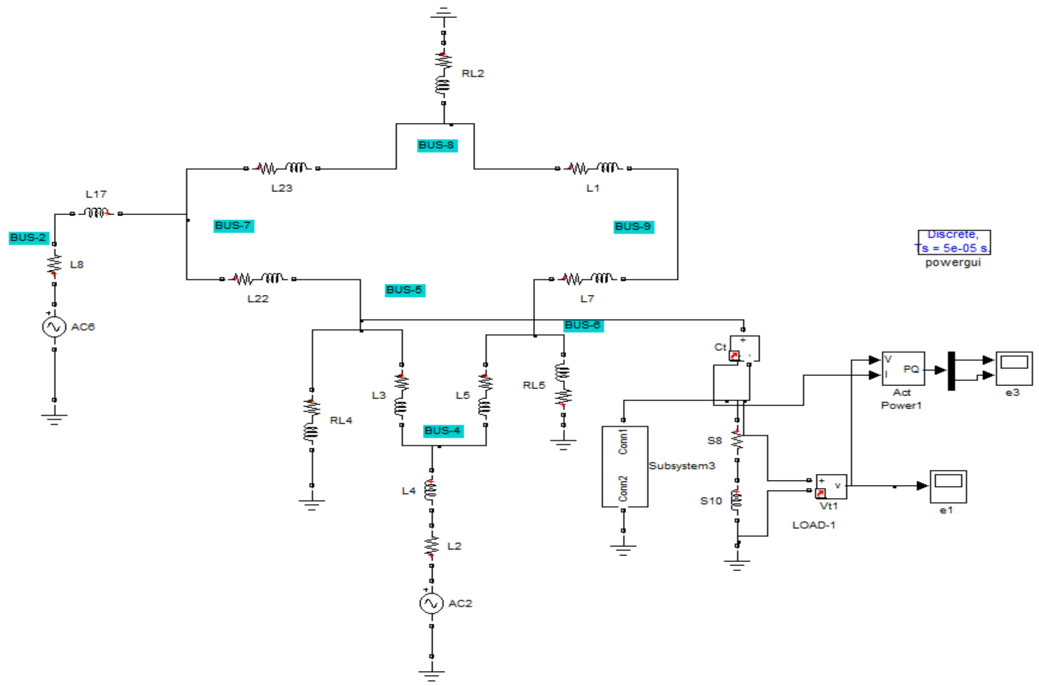


Figure 4.1. Nine bus system with one generator open and without IVDFC

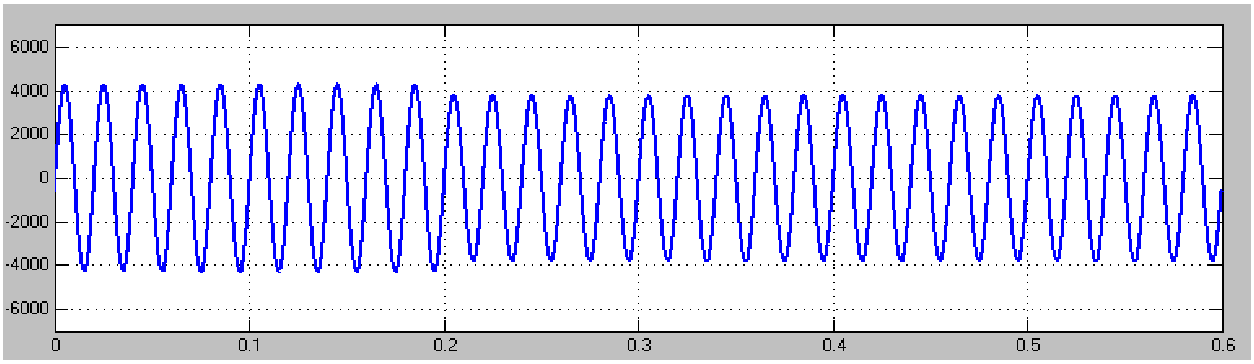


Figure 4.2. Voltage at Bus 5

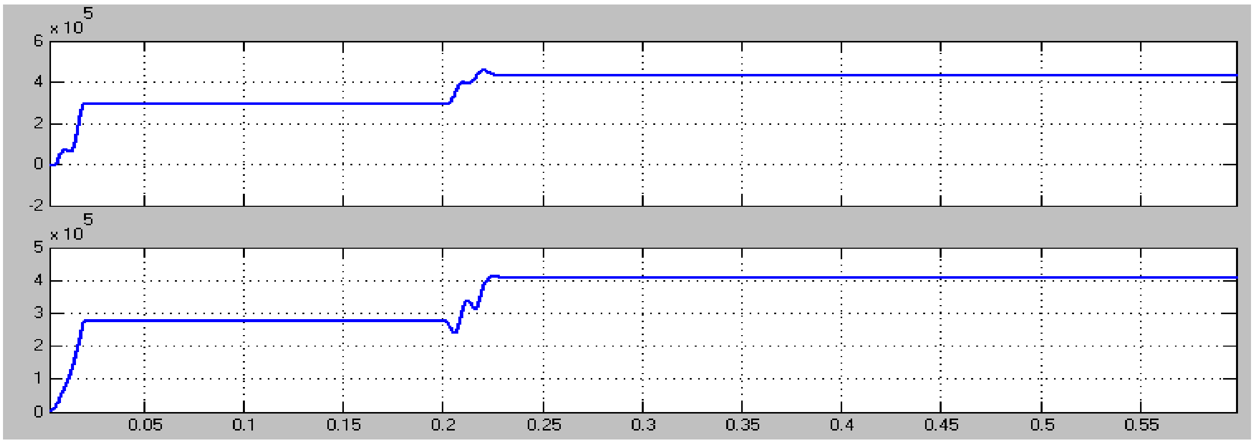


Figure 4.3. Real & Reactive powers

Nine bus system in healthy condition system is shown in Figure 4.4. The voltage at bus 5 is shown in Figure 4.5 and its peak value is 4920Volts. Real and reactive powers are shown in Figure 4.6. Real and reactive power is 1.124MW and 1.152MVAR.

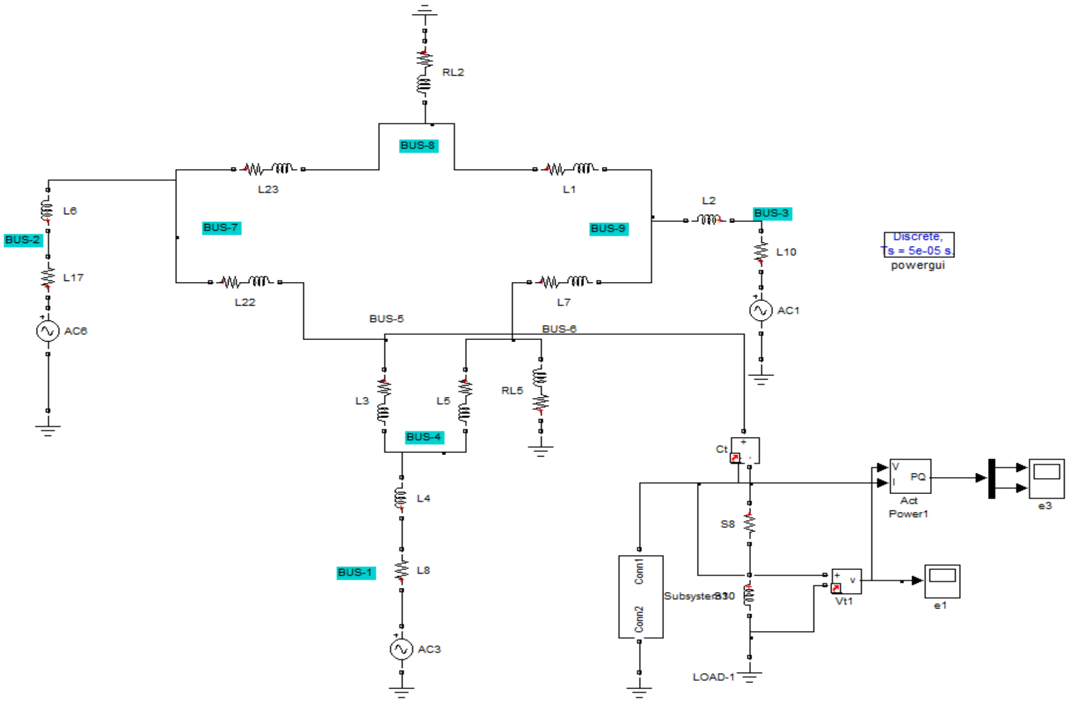


Figure 4.4. Nine bus system in healthy condition

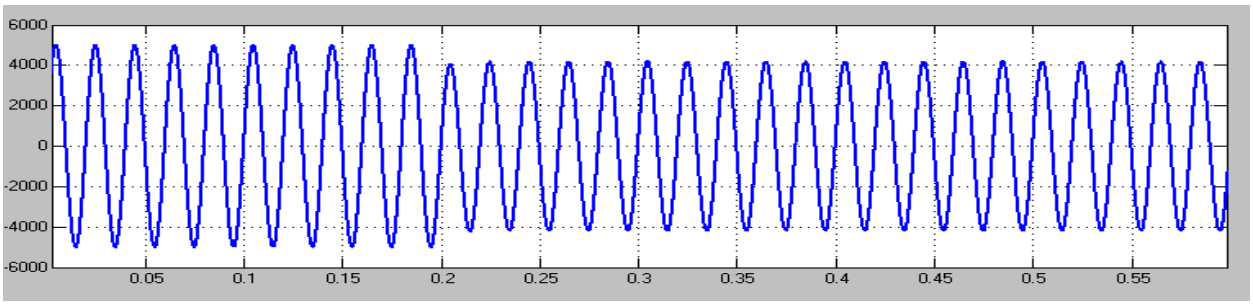


Figure 4.5. Voltage at Bus 5

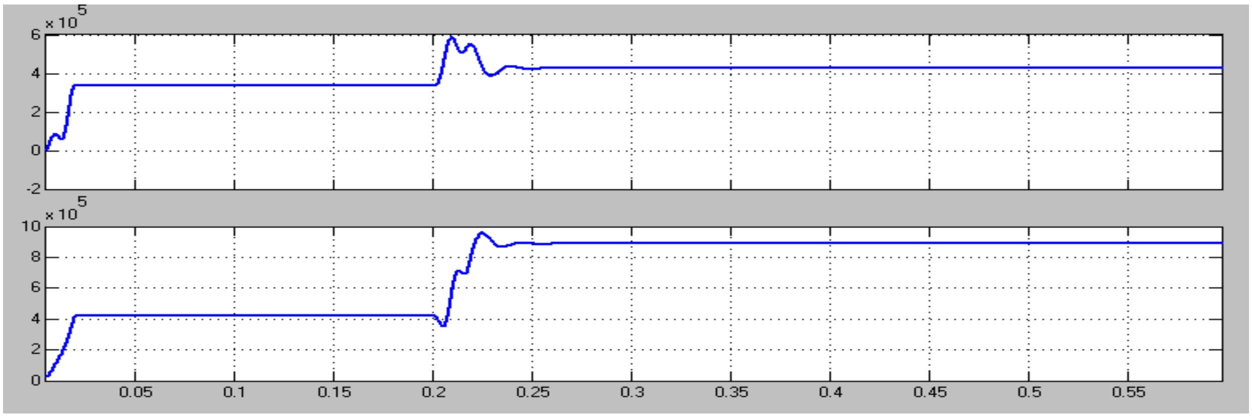


Figure 4.6. Real & Reactive powers

Nine bus system with one generator open and with IVDFC system are shown in Figure 4.7. The output voltage at bus 5 is shown in Figure 4.8 and its value is 4300volts. The real and reactive powers system are shown in Figure 4.9. Real and reactive power value are 0.986MW and 0.931MVAR

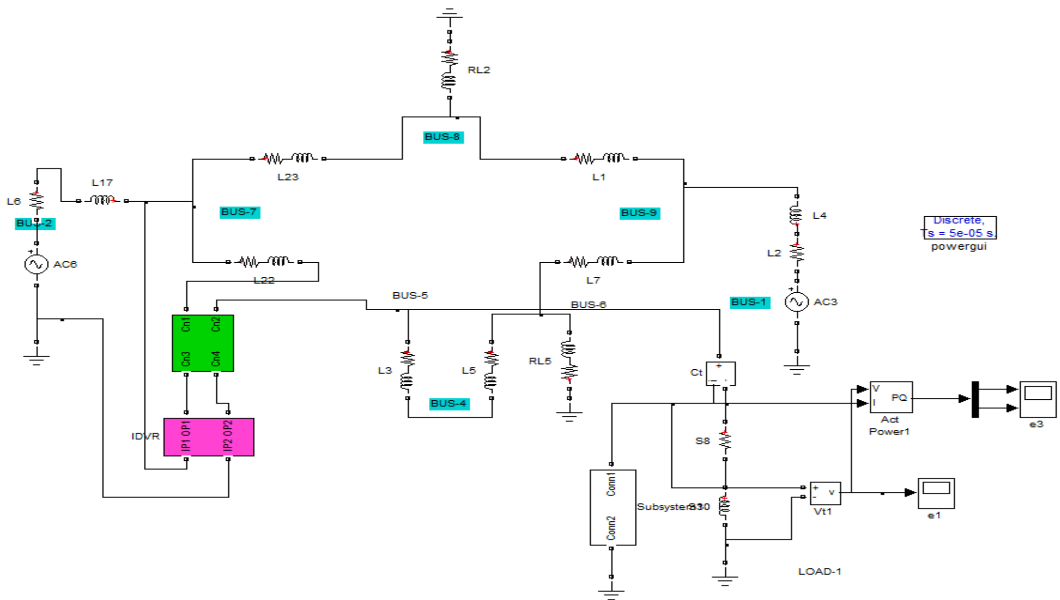


Figure 4.7. Nine bus system with one generator source open and with IVDFC

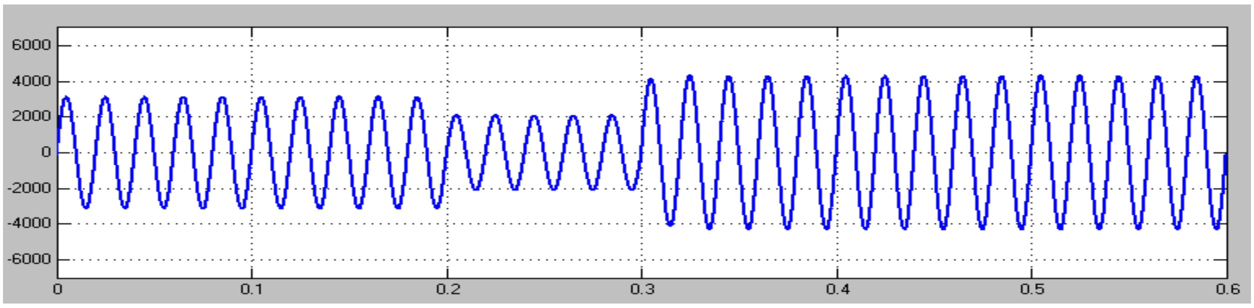


Figure 4.8. Voltage at Bus 5

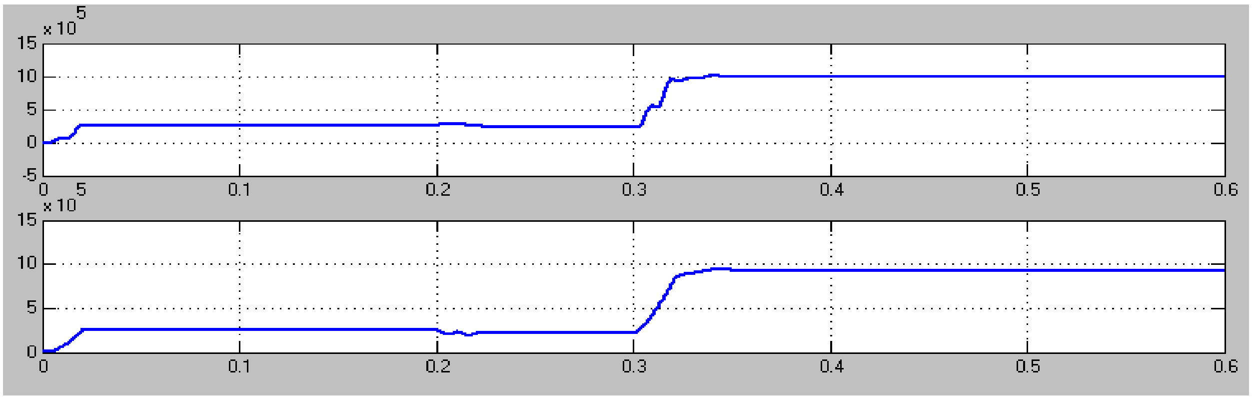


Figure 4.9. Real & Reactive Powers

Table 2. Comparison of Output Voltage, Real Power & Reactive Power

9-bus system	Output voltage (V)	Real power(MW)	Reactive power(MVAR)
One Generator Source Open And Without IVDFC	3250	0.442	0.412
Healthy Condition	4116	0.471	0.815
One Generator Source Open And With IVDFC	4300	0.986	0.931

CONCLUSION:

The results of nine bus system with and without IVDFC are presented. The real power increases from 0.079MW to 0.081MW by adding IVDFC. The reactive power increases from 0.15 to 0.156 MVAR. That the IVDFC is capable of maintaining normal real and reactive powers during contingency condition. The disadvantages of proposed system are the requirement of two converters. Nine bus system with generator outage is also studied. The IVDFC maintains normal voltage during outage of one generator

The Scope of present work is power quality improvement in nine bus system using IVDFC .The contingency studies in fourteen bus system will be done in future. The studies will be extended for multiple line interruptions.

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Appendix-I

Simulation parameters:

Bus data

BUS NO	VOLTAGE	LOAD IMPEDANCE	
		RESISTANCE	INDUCTANCE
Bus 1	6350	-----	-----
Bus 2	-----	35Ω	48mH
Bus 3	6350	-----	-----
Bus 4	-----	12Ω	23mH
Bus 5	6350	-----	-----
Bus 6	-----	20Ω	63mH
Bus 7	6350	-----	-----
Bus 8	-----	56Ω	86mH

Line data

BUS	LINE IMPEDANCE	
	RESISTANCE	INDUCTANCE
Bus 1-2	3Ω	50mH
Bus 2-4	3Ω	18mH
Bus 4-6	11Ω	24mH
Bus 8-7	19Ω	26mH
Bus 7-5	21Ω	37mH
Bus 3-5	16Ω	72mH
Bus 3-6	46Ω	58mH

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Dr B.Baskaran has obtained his BE in Electrical and Electronics Engineering and ME in Power System. His specialization in Ph.D. is Power Electronics (matrix converter).He has a vast teaching experience of 27 years. He has guided 8 research scholars. He has 13 international publications in his credit. Presently, he is working as professor in Electrical department in Annamalai University, Chidambaram, India