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Simulation of IEEE 9 Bus System in PSCAD Software

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Abstract: ***Fault analysis study is the important parameter of economic, reliable and secure power system planning and operation. Power system studies are important during the planning and conceptual design stages of the project. This paper presents the fault analysis on IEEE-9 bus system. The line to ground fault is created on bus 5th and analyzed the variation in Voltage, Real power, Reactive power on different buses. The fault at 5th bus of IEEE-9 bus system is analyzed on PSCAD software.***
Keywords: PSCAD, fault analysis, power system stability, IEEE-9 bus system

I. INTRODUCTION

Electric fault analysis has been recognized as an important for secure power system planning and operation. When large faults occur in interconnected power system, the power systems equipments security has to be examined. Security of power systems equipments depends on the observation of their protective ratings of parameters voltage, power etc.

With the help of PSCAD software we analyze the performance of voltage, real & reactive power before the fault, during the fault, and post fault also we can analyze how a fault at any single bus affects the performance on different buses. Post fault means after the fault. Post fault observation determines the permanent isolation on faulty bus. By the permanent isolation in the system, the system voltage is decreases then the stability of the system is also decreases and becomes the system unstable.

II. POWER SYSTEM STABILITY

Power system stability is defined as the capability of a system to maintain an operating equilibrium point after being subjected to a disturbance for given initial operating conditions. Power system stability is categorized based on the following considerations:[3]

1) The nature of the resulting instability mode indicated by the observed instability on certain system variables.
2) The size of the disturbance which consequently influences the tool used to assess the system stability.

In this paper the power system stability is determine by system voltage. [1]

$$P = P(\max) \times SIN(\Delta) = E \times V \times SIN(\Delta cr - \Delta 0) / X$$

During LG Fault ($0.30 \le t \le 0.35$ sec), the system voltage is decreases according to the above relation if the voltage is decreases then the P (max), Δcr is also decreases. Critical Clearing time (CCT) is directly proportional of Δcr, so CCT also decreases.

Critical Clearing time (CCT) for a given fault which define as the maximum allowable value of the clearing time for which the system remains to be stable. The power system shall remain stable if the fault is cleared within this time. However, if the fault is cleared after the CCT, the power system is most likely to become unstable.

III. TYPES OF FAULT

A. *Open circuit fault*

The open circuit fault mainly occurs because of the failure of one or two conductors.

The open circuit fault is divided into

1) Open Conductor Fault
2) Two conductors Open Fault
3) Three conductors Open Fault

B. *Short Circuit Fault*

In this type of fault, the conductors of the different phases come into contact with each other with a power line, power transformer or any other circuit element due to which the large current flow in one or two phases of the system. The short-circuit fault is divided into the symmetrical and unsymmetrical fault.

C. Symmetrical Fault

The conductors of the different phases come into contact with each other with a power line, power transformer or any other circuit element due to which the large current flow in one or two phases of the system. The symmetrical fault is sub-categorized into line-to-line-to-line fault and three-phase line-to-ground-fault.

1) *Line – Line – Line Fault:* The L – L – L fault occurs rarely, but it is the most severe type of fault which involves the largest current.
2) *Line – Line – Line to Ground Fault:* The L – L – L – G fault occurs between the three phases and the ground of the system. The probability of occurrence of such type of fault is nearly 2 to 3 percent.

D. Unsymmetrical Fault

The fault gives rise to unsymmetrical current, i.e., current differing in magnitude and phases in the three phases of the power system are known as the unsymmetrical fault. It is also defined as the fault which involves the one or two phases such as L- G, L – L, L – L – G fault**.**

1) *Single Line-to-Line Ground:* The single line of ground fault occurs when one conductor falls to the ground or contact the neutral conductor. The 70 – 80 percent of the fault in the power system is the single line-to-ground fault.
2) *Line – to – Line Fault:* A line-to-line fault occurs when two conductors are short circuited. The percentage of such type of faults is approximately 15 – 20%.
3) *Double Line – to – line Ground Fault:* In double line-to-ground fault, the two lines come in contact with each other along with the ground. The probability of such types of faults is nearly 10 %.

IV. METHODOLOGY

This paper using PSCAD software to simulate and analyzed fault conditions occur in transmission system. PSCAD provides functions for analyzing power system transients. PSCAD enables users to build a circuit diagram, running simulations, analyzing results, managing data in fully integrated graphical environment, control and meter so that users can change systems parameters during the simulation run and can obtain results.

V. RESULT ANALYSIS

A. Case-1: Bus No. 1 as Swing Bus (V_1 =1.0 PU)

TABLE.1 Results of voltage and Power for case-1

Bus no	Voltage (PU)	Voltage (KV)	P (Generation) (MW)	Q (Generation) (MVAR)
1	1	16.5	72	22.4
2	1.017	18.30	162	14
3	1.009	13.92	85.5	-9.02
4	1	230	0	0
5	0.97	223.1	0	0
6	0.99	227.7	0	0
7	1.013	233	0	0
8	1.001	230.23	0	0
9	1.015	233.45	0	0

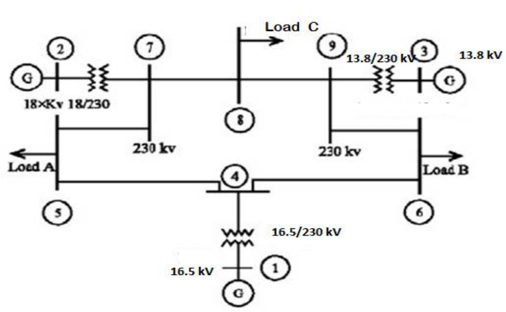

Fig. 1 Single Line Diagram of IEEE 9 Bus system

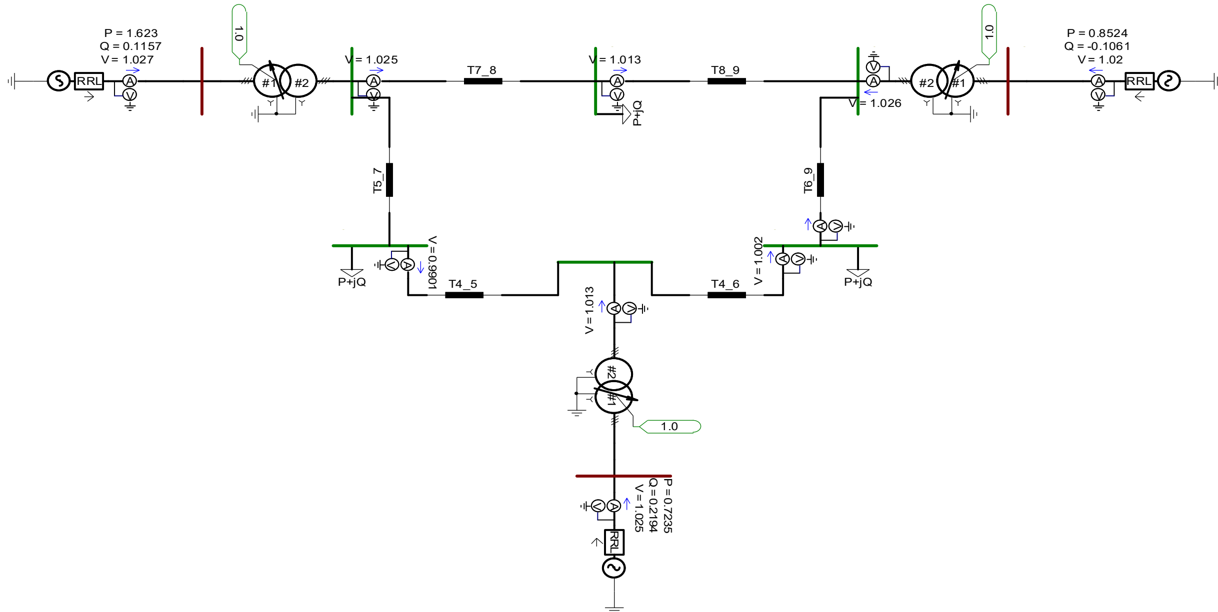

Fig.2 Simulation results for Case-1

B. Case-2: Bus-I as Swing bus (V_1=1.0 PU) and 10% increment in load (both P & Q)

TABLE.2 Results of voltage and Power for case-2

Bus no	Voltage (PU)	Voltage (KV)	P (Generation) (MW)	Q (Generation) (MVAR)
1	1	16.5	93.2	48
2	0.988	17.8	169	16.5
3	0.98	13.53	90.13	-7.5
4	0.987	227	0	0
5	0.953	219.2	0	0
6	0.965	222	0	0
7	0.982	225.9	0	0
8	0.968	222.64	0	0
9	0.985	226.5	0	0

C. Case-3: Post Fault at Bus 5

TABLE.3 Results of voltage and Power for case-3

Bus no	Voltage (PU)	Voltage (KV)	P (Generation) (MW)	Q (Generation) (MVAR)
1	1	18	14.28	45.65
2	1.143	230	118.6	-12.35
3	1.107	230	60.85	-13.61
4	1.026	230	0	0
5	0.0004127	13.8	0	0
6	1.042	230	0	0
7	1.15	230	0	0
8	1.126	230	0	0
9	1.113	16.5	0	0

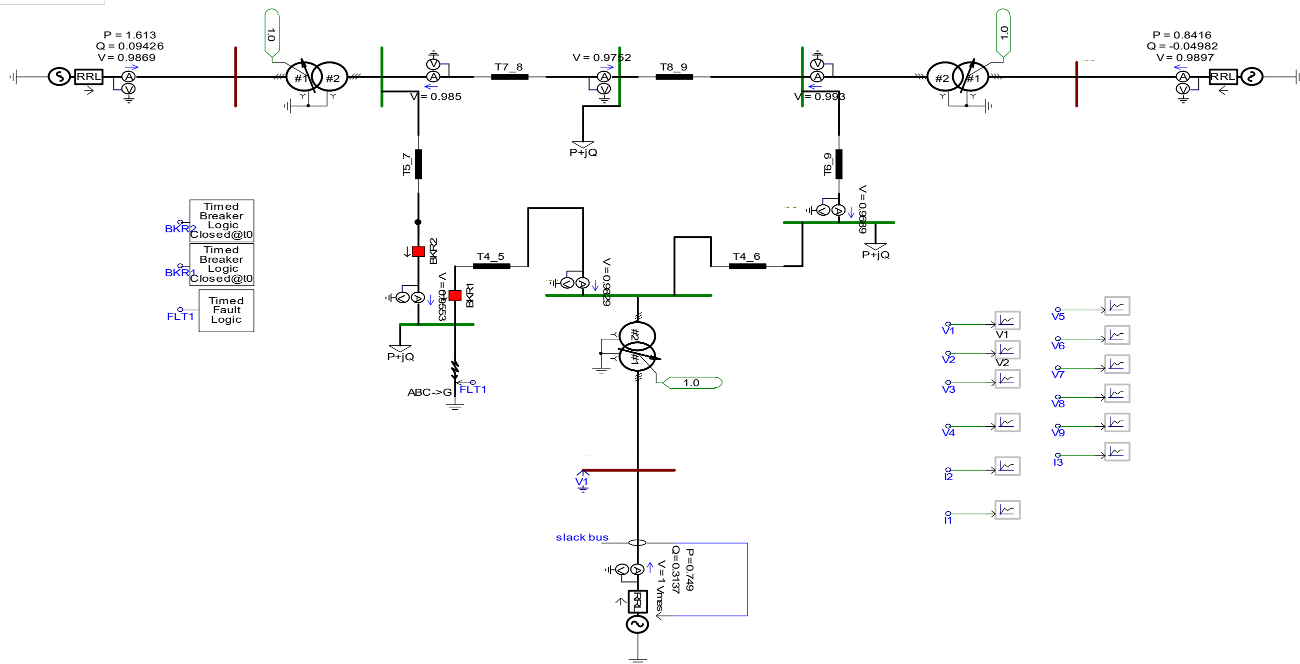

Fig.3 Simulation results for Case-3

The single line diagram of the IEEE-9 bus system on PSCAD is shown in figure. For this system transformer, line and load parameters data are given in appendix. The base values of generators and transformers are 230KV and 100MVA. The system contains 9 buses with 3 generators connected to the network through 3 step up transformers and 3 loads.

The purpose of fault analysis is –

1) By calculating the bus voltage, real power and reactive power for comparing it to the equipment ratings and protective device trip levels.
2) Identify the best and worst operating condition.

The circuit breaker is operated near the faulted bus then the generator across its remove from the system. It may result in imbalance between the total generation and total load power, the system is affect. The system becomes unstable because fault affected the system voltage. The voltage level at faulty bus becomes reduce ever since the fault operates at the bus, the total generation power is less than the total load power.

The operating time of line to ground fault is 0.30 second to 0.35 second, duration of fault is 0.05 sec. Then the circuit breaker operates at 0.30 sec and the number of operation for the circuit breaker is one

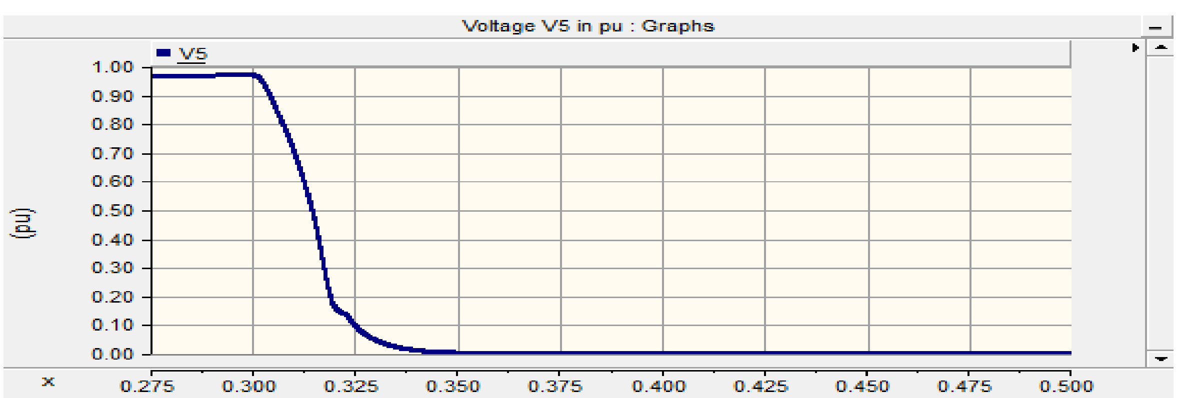

Fig.4 voltage waveform at bus 5

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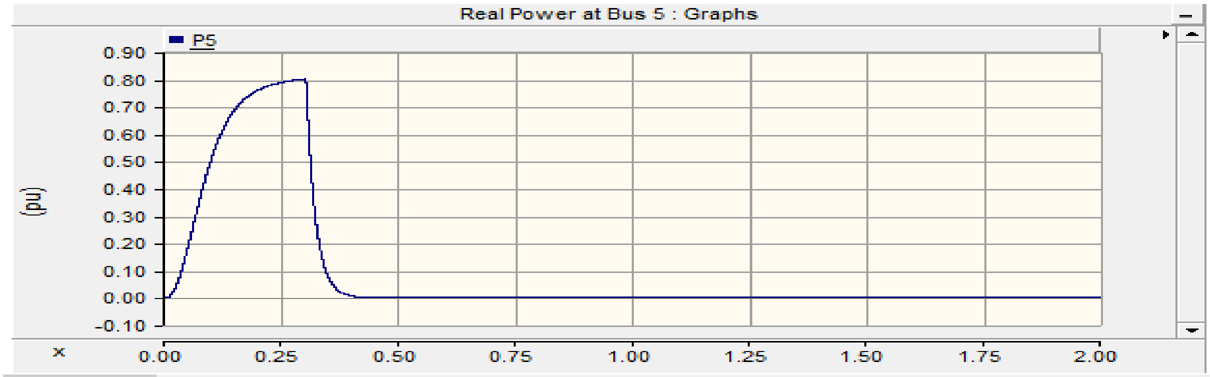

Fig. 5 real power waveform at bus 5

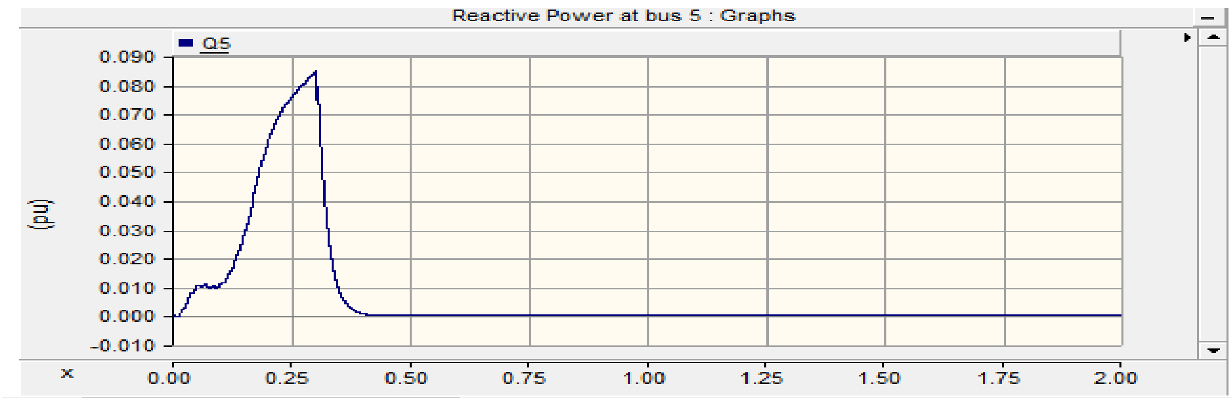

Fig. 6 reactive power waveform at bus 5

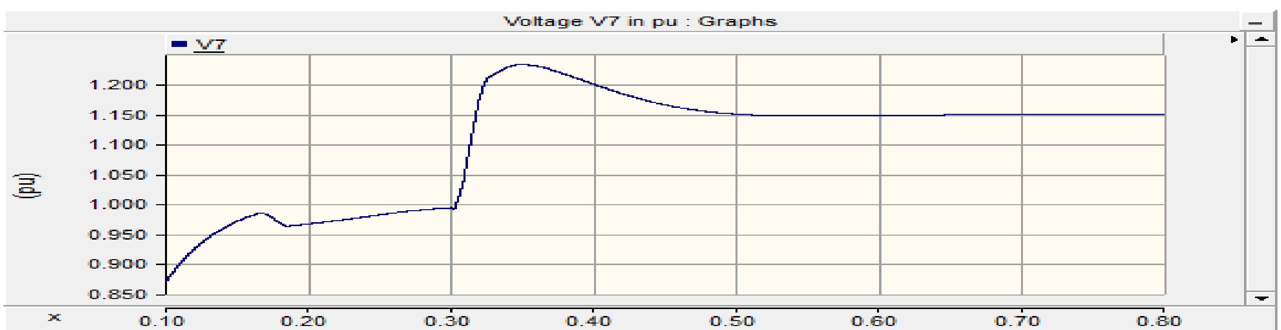

Fig. 7 voltage waveform at bus 7

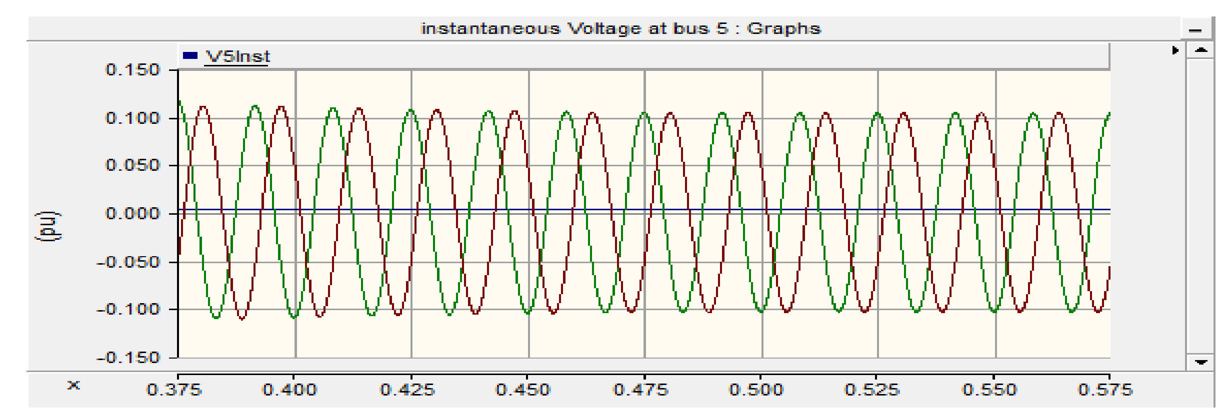

Fig. 8 instantaneous voltage waveform at bus 5

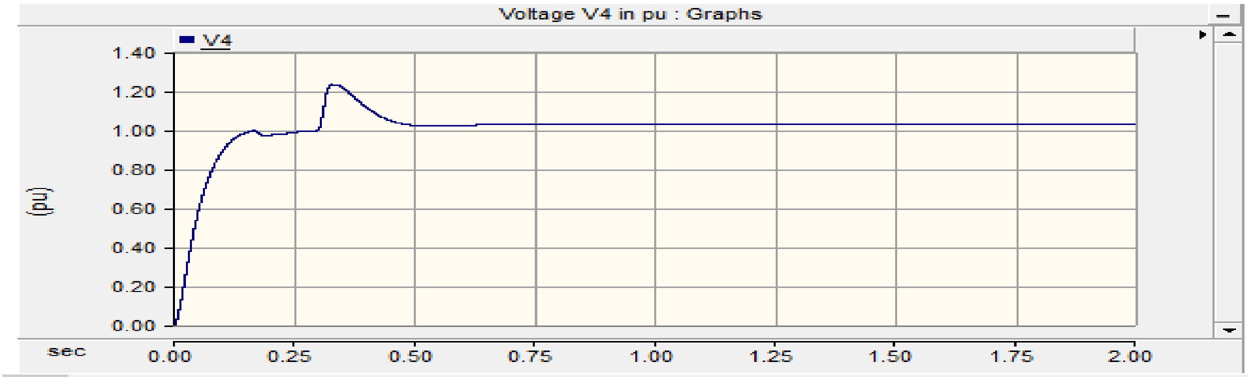

Fig. 9 voltage waveform at bus 4

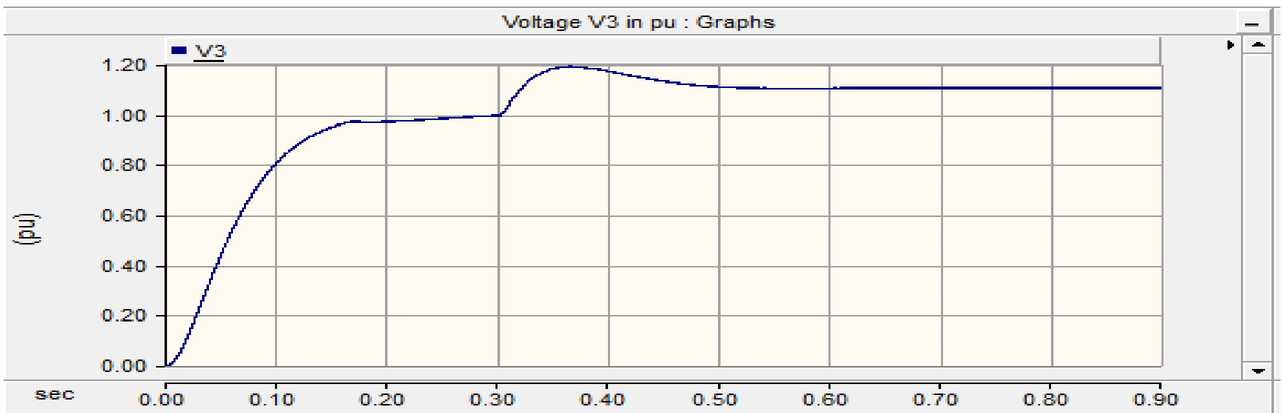

Fig. 10 voltage waveform at bus 3

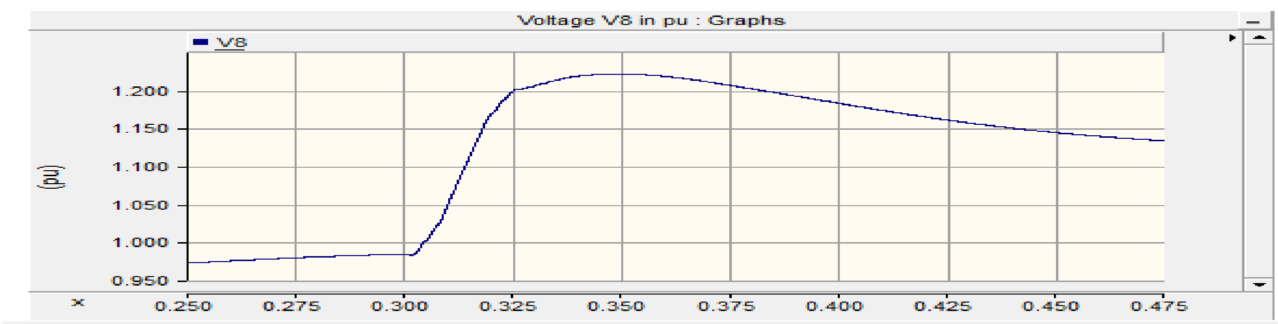

Fig. 11 voltage waveform at bus 8

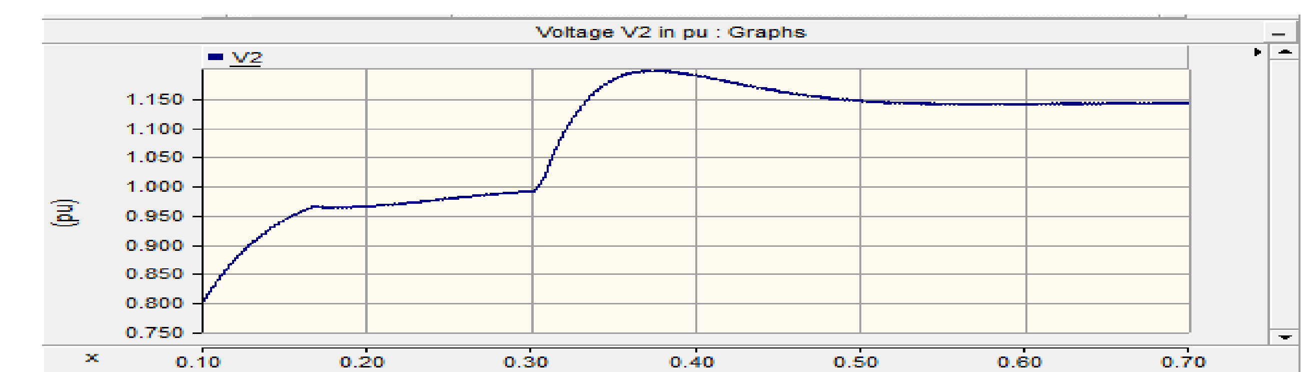

Fig. 12 voltage waveform at bus 2

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VI. CONCLUSION

Fault analysis on transmission line has performed on PSCAD software. The waveforms of real power, reactive power and voltage at different buses have analyzed by applying the line to ground fault at bus 5 using a device named timed fault control logic. So, this analysis greatly helpful in the future for the analysis of the fault on the transmission lines also for the selection of the protective equipments of proper rating.

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APPENDIX

TABLE.4 Line data of IEEE 9 bus system

From Bus	To Bus	R (PU)	X (PU)	SUSCEPTANCE (PU)
1	4	0	0.0576	0
4	5	0.0170	0.0920	0.158
5	6	0.039	0.17	0.358
3	6	0	0.0586	0
6	7	0.0119	0.1008	0.2090
7	8	0.0085	0.0720	0.1490
8	2	0	0.0625	0
8	9	0.032	0.161	0.306
9	4	0.01	0.085	0.176

TABLE.5 Load data of IEEE 9 bus system

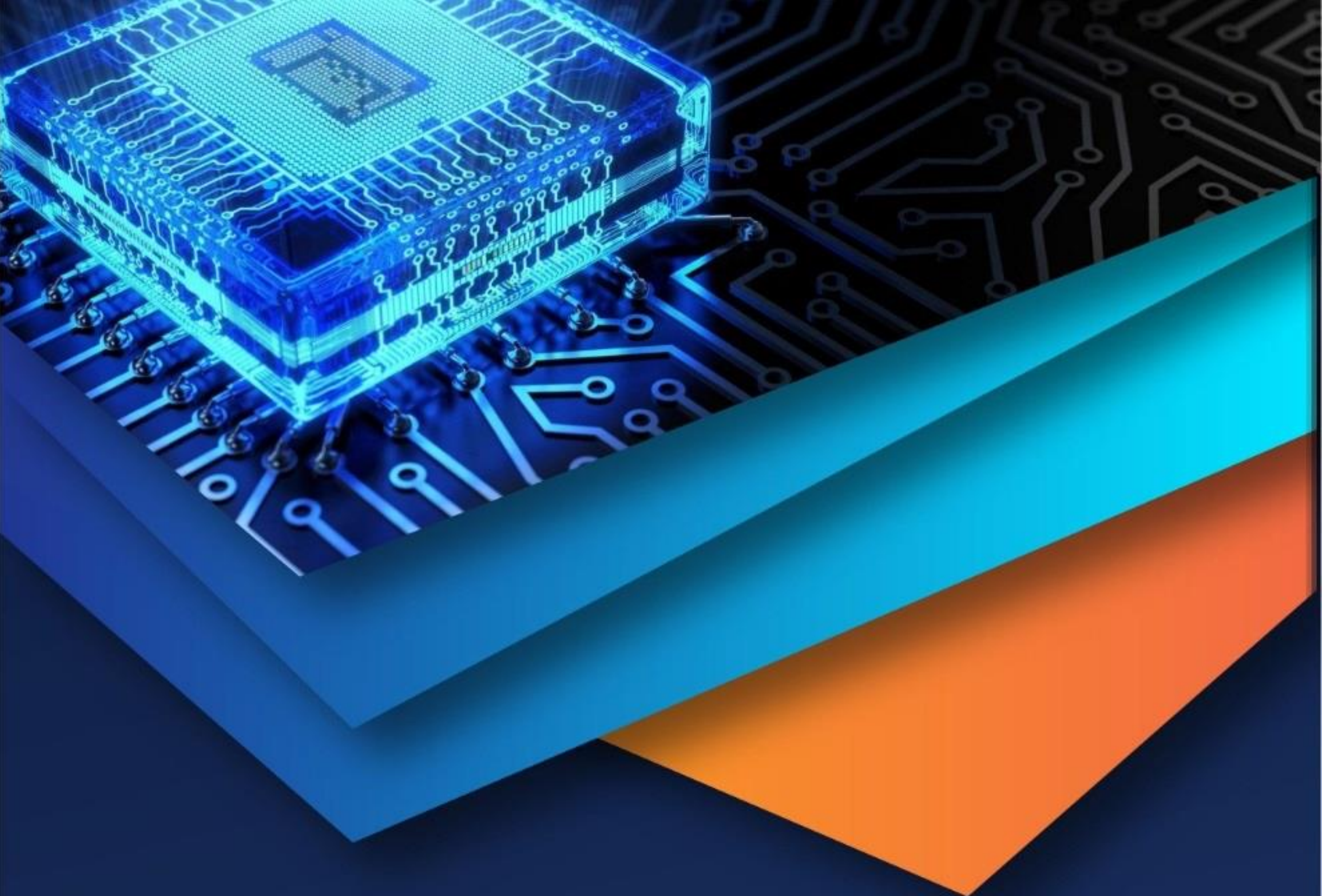
Bus no.	P (MW)	Q (MVAR)
1	0	0
2	0	0
3	0	0
4	0	0
5	137.5	55
6	99	33
7	0	0
8	110	38.5
9	0	0

TABLE.6 Transformer data of IEEE9 bus system

Line	MVA rating	kV rating (PRI/SEC)	R (PU)	X (PU)
1-4	100	16.5/230	0	0.0576
2-7	100	18/230	0	0.0625
3-9	100	13.8/230	0	0.0586

TABLE.7 Load Data for IEEE 9 bus system (After 10% increment)

Bus no.	P (MW)	Q (MVAR)
1	0	0
2	0	0
3	0	0
4	0	0
5	125	50
6	90	30
7	0	0
8	100	35
9	0	0



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