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POWER SYSTEM STABILITY STUDY OF DIFFERENTBUS SYSTEM WITH POWER SYSTEM STABILIZER

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Abstract:
In this paper an IEEE 9 bus and 15 buses system is simulated in MATLAB SIMULINK SOFTWARE. This paper deals with the improvement of transient stability of a 9 buses and 15 bus test system fewer than three phase fault using Power System Stabilizer. The results are obtained with and without Power System Stabilizer. Analysis of result shows that PSS has reduced the fault clearing time up to some extent as compared to the fault clearing time without PSS.

Keyword: IEEE 9 bus system, 15 Bus system, Power system stabilizer (PSS), Transient stability, Three Phase Fault.

I. INTRODUCTION

Power supply systems are wide and are spread over a large distance. Over such a large distances lot many problems are encountered. As the demand for power is increasing day by day the burden on the transmission lines is also increasing. When the burden on the transmission line increases the transient stability of the system is affected because of the disturbances. So the system is subjected to loss the stability and this is dangerous as the fault at one location transfers to the other part of the system also. The power oscillations is a very challenging problem in power systems. Hence study of power system is important during the designing and planning of a plant. Study of system stability is essential for economic, reliable and secure power systemplanning and operation. Power system stability of an electrical power system is can be maintained by using FACTS devices or by introducing power system stabilizers, Some of the parameters involve which are affected are the rotor speed, bus voltage, power flow and other system variables.

The inadequate damping of system oscillations leads to the stability problem. To improve the overall power system dynamic performance for the control of electromechanical oscillations Power system stabilizers (PSS) can be used as an additional block for the generator excitation control or the Automatic Voltage Regulator (AVR).

II. TEST SYSTEM

A. IEEE 9–Bus Power System

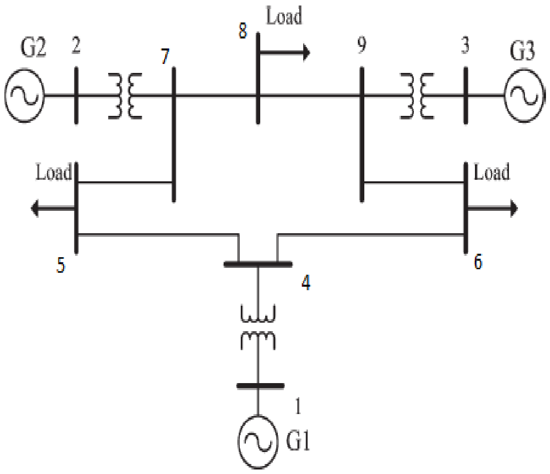


Fig. 1

Above figure shows single line diagram of an IEEE 9 bus power system. The system used in this paper is of 100 MVA voltage level. The data for the 9 bus system is taken from the reference [1]. The system consists of three generators one is source generatorand the other two are load generator, three transmission lines, three transformers and three loads. The line of interest for study is the line extending between bus 8 to bus 9. Synchronous machine are associated with the generator 2 and generator 3. Also the power system stabilizer is connected to the synchronous machine of generator 2 and 3.Where Bus 1 is the source bus, Bus 2 and 3 are the generator or the voltage bus and bus 4,5,6,7,8 and 9 are the load buses.

B. Data Sheet of 9 Bus System

TABLE I: Network Admittance including load Equivalents

	BUS No	Impedance		Admittance	
		R	X	G	D
Generator					
No 1	1-4	0	0.1184	0	-8.4459
No 2	2-7	0	0.1823	0	-5.4855
No 3	3-9	0	0.2399	0	-4.168

					4
Transmission Line					
	4-5	0.0100	0.0850	1.3652	-11.6041
	4-6	0.0170	0.0920	1.9422	-10.5107
	5-7	0.0320	0.1610	1.1876	-5.9751
	6-9	0.0390	0.1700	1.2820	-5.5882
	7-8	0.0085	0.0720	1.6171	-13.6980
	8-9	0.0119	0.1008	1.1551	-9.7843
Shunt Admitance					
Load A	5-0			1.2610	-0.2634
Load B	6-0			0.8777	-0.0346
Load C	8-0			0.9690	-0.1601
	4-0				0.1670
	7-0				0.2275
	9-0				0.2835

Table II : Generator Data

Generator	1	2	3
Rated MVA	247.5	192.0	128.0
KV	16.5	18.0	13.8
Power Factor	1.0	0.85	0.85
Type	Hydro	Steam	Steam
Speed	180 r/min	3600r/min	3600 r/min
Xd	0.1460	0.8958	1.3125
Xd’	0.0608	0.1198	0.1813
Xq	0.0969	0.8645	1.2578
Xq’	0.0969	0.1969	0.25
Xl (leakage)	0.336	0.0521	0.0742
Td0’	8.96	6.00	5.89
Tq0’	0	0.535	0.600
Stored Energy at rated speed	2364 MW.s	640 MW.s	301 MW.s

The generator internal voltage and their initial angles are given in pu by

$$E_1\angle\delta_{10} = 1.0566\angle 2.2717$$

$$E_2\angle\delta_{20} = 1.0502\angle 19.7315$$

$$E_3\angle\delta_{30} = 1.0170\angle 13.1752$$

TABLE III :Reduced Y Matrix

Type of Network	Node	1	2	3
Prefault	1	0.846-j2.988	0.287+j1.513	0.210+j1.226
	2	0.287+j1.513	0.420-j2.724	0.213+j1.088
	3	0.210+j1.226	0.213+j1.088	0.277-j2.368
Faulted	1	0.657-j3.816	0.000+j0.000	0.070+j0.631
	2	0.000+j0.	0.000-	0.000+j0.

		000	j5.486	000
	3	0.070+j0.631	0.000+j0.000	0.174-j2.796
Fault Cleared	1	1.181-j2.229	0.138+j0.726	0.191+j1.079
	2	0.138+j0.726	0.389-j1.953	0.199+j1.229
	3	0.191+j1.079	0.1999+j1.229	0.273-j2.342

The system base is chosen to be 100 MVA and all the impedance value are taken corresponding to this base. Table 1 shows the equivalent shunt admittance for the load and the corresponding Y matrix is given in [1]. Table 2 gives the generator data were generator 1 is hydro and generator 2 and 3 are steam generator. The reduced Y matrix is shown in table 3 for prefault network, faulted network and the network with the fault cleared. The transmission line are having π connections. The system is first tested without any fault after obtaining the stable result and the results fault is created between bus no 5 and 7 and then the system is run. The parameters which are observed are rotor speed, active power and the reactive power and line voltage.

C. 15 Bus Power System Model

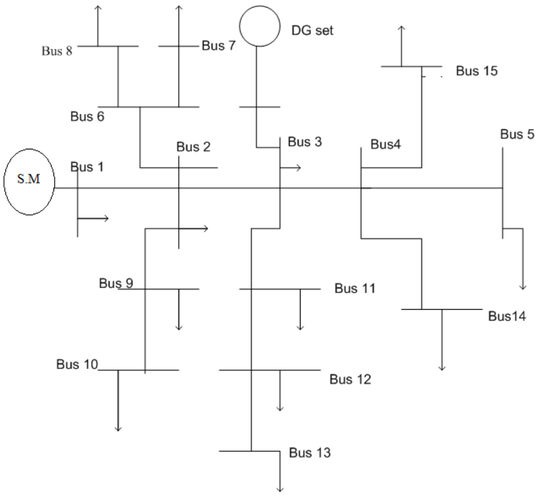
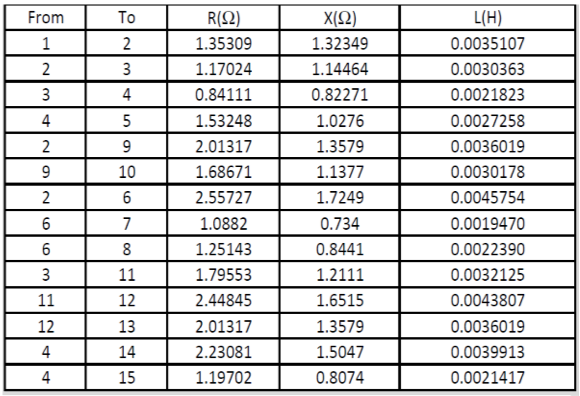


Fig. 2

TABLE IV :15 Bus Line Data



From	To	R(Ω)	X(Ω)	L(H)
1	2	1.35309	1.32349	0.0035107
2	3	1.17024	1.14464	0.0030363
3	4	0.84111	0.82271	0.0021823
4	5	1.53248	1.0276	0.0027258
2	9	2.01317	1.3579	0.0036019
9	10	1.68671	1.1377	0.0030178
2	6	2.55727	1.7249	0.0045754
6	7	1.0882	0.734	0.0019470
6	8	1.25143	0.8441	0.0022390
3	11	1.79553	1.2111	0.0032125
11	12	2.44845	1.6515	0.0043807
12	13	2.01317	1.3579	0.0036019
4	14	2.23081	1.5047	0.0039913
4	15	1.19702	0.8074	0.0021417

III. POWER SYSTEM STABILIZER

The power system stabilizer (PSS) is a device that measures improvements in system stability when added to a generator's automatic voltage regulator (AVR) and increases the power system stability. Power system stabilizer finds the fluctuations of generator output power and in result controls the excitation. Although the output power of the generator is decided by the turbine mechanical torque the generator output power can be maintained by changing the excitation value. PSS detects the change in generator output power and controls the excitation value and reduces the swing in the power system. The main function of PSS isto damp generator rotor oscillations which occurs due to electromechanical dynamics and are known as electromechanical oscillations [2]. The PSS is a feedback controller, part of the control system for a synchronous generator, which acts through the excitation system, adding a signal to modulate the field voltage.

There are two types of stabilizers model one is generic model using the acceleration power (Pa= difference between mechanical power Pm and output electrical power Peo) and other is a Multi-band stabilizer model using the speed deviation (dw). In this paper Generic power system stabilizer block is connected to the synchronous machine. It consists of a low-pass filter, a general gain, a washout high-pass filter, a phase-compensation system, and an output limiter. The input to the PSS is the synchronous machine speed deviation with respect to nominal (dw in pu) or the acceleration power (Pa=Pm-Pe in pu). The output is the stabilization in voltage waveform, in pu which is connected as one of the input of the excitation system.

Block diagram of a power system stabilizer is shown in fig 2. It consists of a sensor block, overall gain, washout, lead lag filter 1 and 2 and a limiter. The washout block is used to decrease the overall response of the damping during severe events also it severs as a high pass filter which permits the signal associated with oscillations in speed of the rotor to pass as it is i.e remains unchanged but blocks the steady state change to modify the terminal voltages. The phase lead blocks are used to compensate for the lag between the PSS output and control action and the electric torque. PSS gain is an important factor as the damping provided by PSS is directly proportional to the gain. Up to a certain value of gain the damping begins to decrease.

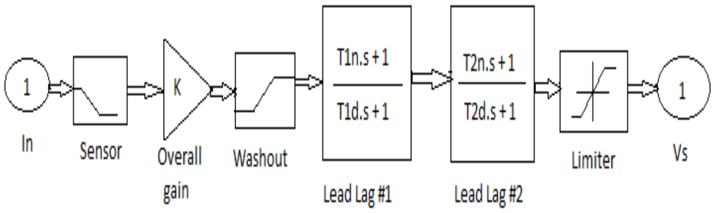


Fig. 3

IV. SIMULATION RESULTS

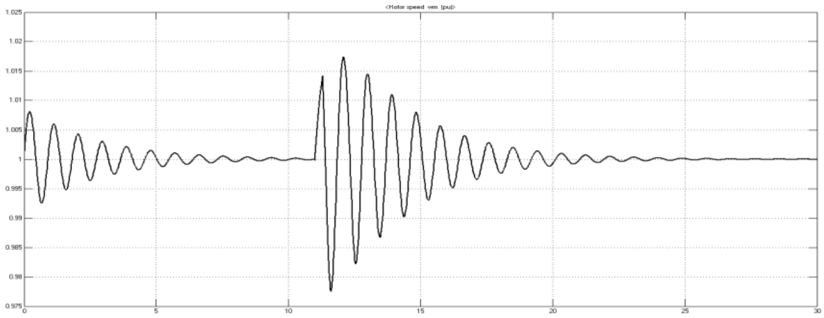


Fig.4Rotor speed without PSS

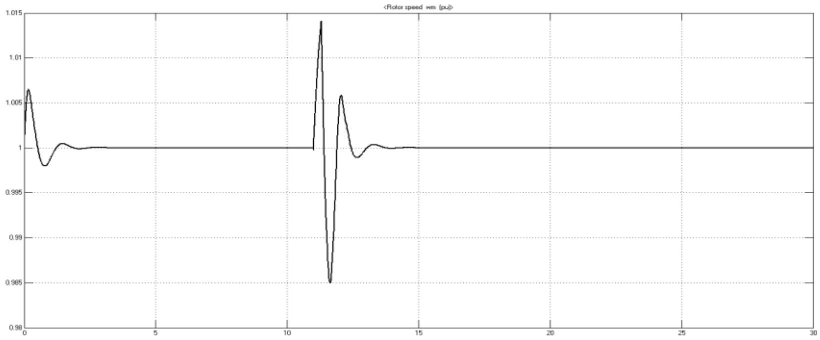


Fig.5Rotor speed with PSS for 9 Bus System

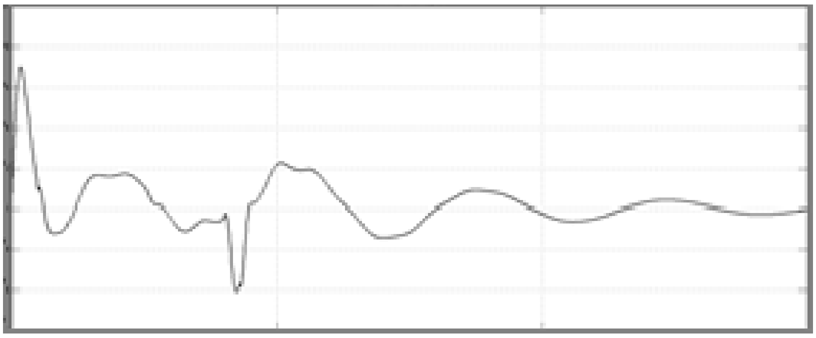


Fig.6Rotor speed with PSS for 15 Bus System

From fig 4 the result shows that the rotor speed is very unstable during the three phase fault and fig 5 shows that pss has improve the rotor speed to the value of 1 pu for 9 bus and fig 6 shows the result for 15 bus both the results are observed under three phase fault.

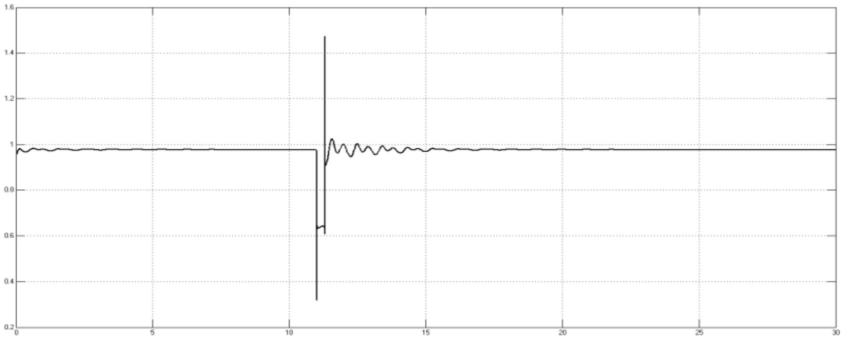


Fig.7 Line Voltage without PSS

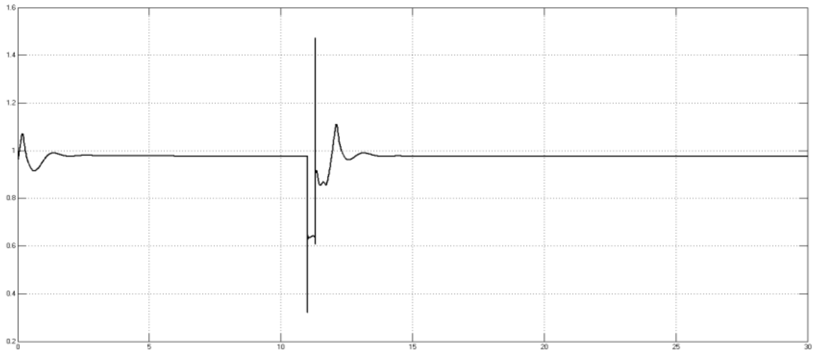


Fig.8 Line Voltage with PSSfor 9 Bus System

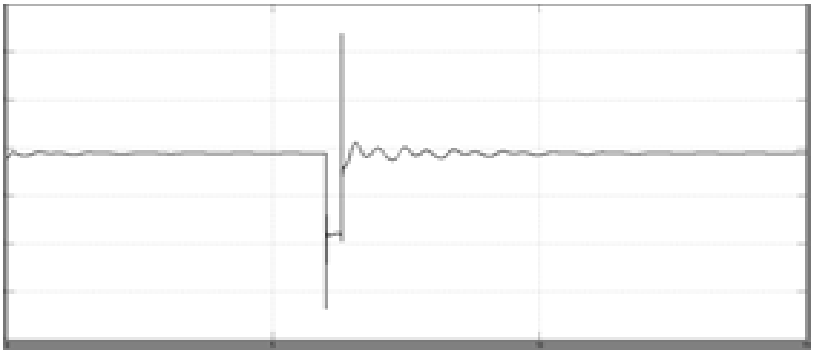


Fig.9 Line Voltage with PSS for 15 Bus System

Fig 7 shows the line voltage without PSS and Fig 8 shows the line voltage of 9 bus system with PSS and Fig 9 shows the result for 15 bus system with PSS.

V. CONCLUSIONS

After observing the simulation results and the waveforms it can be concluded that the power system stabilizer plays a major role in settling the system after a fault has occur. Time required for system to become stable has reduced. Thus the PSS damps the rotor oscillations up to some extent. Without PSS there are lot of fluctuations in the rotor speed, line voltage and all other parameters. With PSS the system has become stable. Further scope in this paper could be to connect a FACTS device so that the system becomes stable in a short duration of time and also other parameters like active power and reactive power can be studied.

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