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Systematic FAULT Analysis OF Five Bus Power System by applying Single Line to Ground Fault

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Abstract **A huge amount of power is being transmitted over long distances via transmission lines. But transmission lines are located in the open atmosphere and they are severely affected by different types of abnormal faults. The work specifies the complete and through fault analysis on 5 Bus Power System using Power World Simulator. A fault is initiated in the lines through different stages in order to check the system behavior under these conditions.**

***Keywords* —Fault Analysis, Power Flow, Power System (PS), Power World Simulator (PWS)**

I. INTRODUCTION

The operating condition of a **PS** is set to have sinusoidal steady state condition carrying normal load currents and bus voltages within the prescribed limits. During this process or operation if a fault or disturbance occurs it resembles into the change of real parameters of current and voltage creating a deviation of angles between current and voltage. A short circuit fault occurs when the insulation of the system fails to result in low impedance path either between Phase(s) to Ground or Phase to Phase between Phases and Earth or both. Although there are several types of faults which result in **PS** failures and these involve faults which change with time periods, high impedance fault which is one phase to earth short circuit causing excessive voltage rise making flashover and short circuit on healthy elsewhere in the system and this is known as a country fault. Moreover, internal faults on transformers, reactors, and machines as well as faults between a number of windings with the same phase causing severe damage. The paper gives a step ahead work in analyzing the behavior of the Five Bus Power System during fault under case step by step in order to check the real condition of the system when subjected to faults. The fault being setup is single line to ground fault.

II. SHORT CIRCUIT ANALYSIS

Short circuit Analysis is carried out in electrical power utility systems, industrial power systems and power station auxiliary systems. The Reasons for which short-circuit calculations are performed include:

1) Power System Health, Equipment and personnel safety considerations
2) Design, operation, and protection of power systems
3) For the design of power equipment

III. NATURE OF FAULTS

Characteristics of faults hugely impact the insulation which results in deterioration of parameters making **PS** to cause the failure of system, set values and components. The first is an insulation failure which is caused by short circuit which results into the development of thermal stresses due to sudden overvoltage condition or heavy current flows, as **F**ig.1 represents the types of fault on the Transmission System.

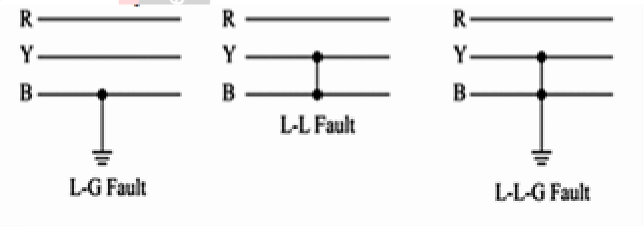

Fig. 1 Type of Fault on The Transmission System

Highly responsible factors are failures of joints on cables or overhead lines or failures of all the three phases of a circuit breaker or disconnect or to open or close, lightning strikes, accumulation of snow or ice, heavy rain, strong winds or gales, salt pollution depositing on insulators on over headlines and in substations, floods and fire adjacent to electrical equipment.

Faults are usually categorized by the negative and zero phase sequence voltages and currents, they generate at the fault location elsewhere in the **PS** particularly at the substations where electrical machines are connected.

To characterize the short-circuit indeed from one short-circuit source, or an entire system, the concept of fault analysis is useful which involves the basic terms given below:

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1) Short circuit fault level

$$MVA = \sqrt{3}\ \ V_{Phsae-Phsae\,(kv)}\ \ x\ \ I_{rms\,(kv)}$$

where

$I_{rms\,(KV)}$ is the **rms** short circuit current infeed at the point of fault

$V_{Phsae-Phsae(kv)}$ is the **prefault** phase to phase voltage at the point of fault

MVA_{Infeed} at a busbar

2) The equivalent system impedance $Z_{s(Pu)}$ seen at the busbar in per unit on MVA_{Base} and phase to phase $V_{kv}^{Prefault}$ is given by

$$Z_{s(Pu)} = \frac{MVA_{Base}}{MVA_{Infeed}} \times \frac{V^2_{Prefault\,(kv)}}{V^2_{Base\,(kv)}}$$

Where the definition of base quantities is presented in which prefault and base voltages are equal, we have

$$Z_{S(Pu)} = \frac{MVA_{Base}}{MVA_{Infeed}}$$

High system strength is characterized by a high short circuit fault level in-feed and thus low system impedance and vice-versa. Z_s is also equal to the Thevenin's impedance.

3)

$$Fault\ MVA = \frac{Base\ MVA}{PU\ X_{equivalent}}\ \ MVA\ (lagging)$$

4)

$$Per\ Unit\ Fault\ (or\ Short-circuit)\ Current\ \ \ I_{sc\,Pu} = \frac{Base\ MVA}{PU\ X_{equivalent}}$$

Fault Current

$$I_{sc} = \frac{Fault\ MVA\ \ x\ \ 10^3}{PU\ X_{equivalent}}\ amperes$$

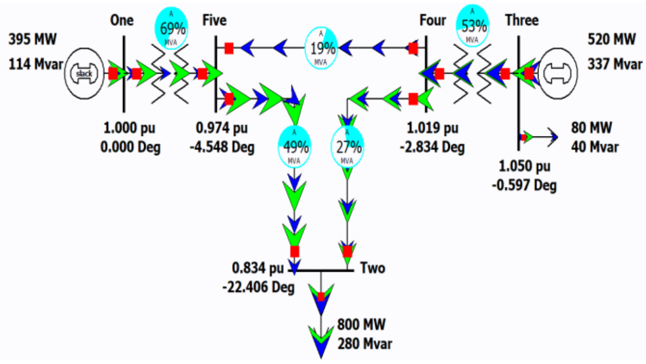

Fig. 2 Represents 5 Bus Power System for Fault analysis

As the three case strategies are being calculated in the **PWS** regarding the fault analysis shown in Fig.2. During investigation when the fault is being setup system parameters are chosen step by step based on various values so that different behaviors are observed which specify the system condition when a fault has occurred. These values very actively specify that what happens to the normal operation of any **PS** during critical conditions of the fault(s) which severely suppresses its components and their set parameters.

Symmetrical components are derived to analyze unsymmetrical faults, as Fig.3 shows. The unsymmetrical network can be expressed in terms of three linear symmetrical components. The three symmetrical components are positive sequence component, negative sequence component and zero sequence component.

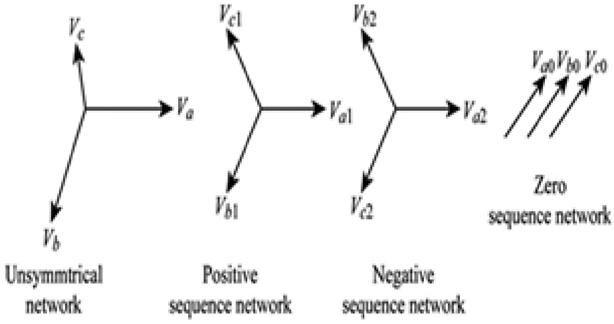

Fig. 3 **Symmetrical Components**

IV. SINGLE LINE TO GROUND FAULT

Single Line to ground fault is the mostly occurring Fault (60 to 75% of occurrence) and is being set in the line **[From Bus-5 (345.0 KV) to Bus-2 (345 KV)]** to which target point is kept **70%** of line distance where actually the fault occurs in the system. During the fault interfacing with normal system operation, Fault Impedance is usually set with the values of **R** and **X** as **0.0100** and **0.02000** respectively. For current the Magnitude is usually kept **10.426pu** and current scaling is kept as **1.0000**. The Scale magnitude is **10.426pu** and if Angle is **24.64pu**. Sub transient phase current of phases. Details are provided in Tables 1, 2, 3, 4, 5, 6, 7 and 8. Also Figures 4 and 5 show the graphical analysis of phase voltages and phase currents during L-G fault.

Table 1 Sub-Transient Phase current of Phases A, B, & C

Phase A	**Phase B**	**Phase C**
10.426pu or 24.64^0	0.000pu or 180.00^0	0.000pu or 180.00^0

Table 2 **Line Bus Records During the Fault**

S No	**Phase Volt A**	**Phase Volt B**	**Phase Volt C**	**Phase Ang A**	**Phase Ang B**	**Phase Ang C**
1	0.72921	0.73384	1.10786	-33.05	-114.61	106.01
2	0.33588	1.1164	2.01799	109.22	144.32	100.17
3	0.75604	0.7887	1.1477	-30.97	-115.02	105.91

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		9	6			
4	0.67185	0.95237	2.3257	80.07	152.85	109.08
5	0.09388	0.83411	0.70031	0	180	180
6	0.00781	0.86884	0.44102	0	180	180

Table 3 Line Parameters during the Fault which led changes in the other parameters of the % Bus power system

S No	From Name	To Name	Xfmr	Phase Cur A From	Phase Cur B From	Phase Cur C From	Phase Cur A To	Phase Cur B To	Phase Cur C To
1	One	Five	YES	4.60807	4.12851	4.34928	4.60807	4.12851	4.34928
2	Four	Two	NO	3.20999	3.60657	3.3439	3.88212	2.20808	5.04973
3	Five	Two	NO	0	0	0	0	0	0
4	Fault Pt	Two	NO	7.37517	5.09312	6.93236	7.20932	4.65703	7.31662
5	Three	Four	YES	5.88185	5.37261	5.17815	5.88185	5.37261	5.17815
6	Five	Four	NO	3.03147	1.66529	2.86188	2.7626	1.86651	2.09579
7	Five	FaultPt	NO	7.63924	5.4339	6.46499	7.77055	5.09305	6.93229

Table 4 Information and behavior of loads during fault which are connected in the power system

Number of Buses	Name of Bus	Phase Cur A	Phase Cur B	Phase Cur C
2	Two	9.17668	6.81969	12.27232
3	Three	0.61335	0.63992	0.93115

Table 5 The sequential data for phases which show that corresponding network model is also simplified in sequence domain

From Number	To Number	Seq. R 0	Seq. X 0	Seq. C 0
1	5	0	0.02	0
4	2	0.02	0.25	1.72
5	2	0.01	0.13	0.88
6	2	0	0.04	0
3	4	0	0.01	0
5	4	0.01	0.06	0.44
5	6	0.01	0.09	0

Table 6 Sequential Domain for the two generators

Generators on number of Buses	MVA Base	Step R	Step X	Step Tap
1	100	0	0	1
3	100	0	0	1

Table 7 Positive sequence and negative sequence impedance Y-Bus Matrices during single phase to ground fault

S No	Bus 1	Bus 2	Bus 3	Bus 4	Bus 5	Bus 6
1	3.73-j50.72				-3.73+j 49.72	
2		18.35-j 78.64		-0.89+j 9.92	0.00+ j).00	-5.95+j 65.69
3			8.18-100.80	-7.46+j99.44		
4		-0.89+9.92	-7.46+j99.44		-3,57+j39.68	
5	-3.73 + j 49.72	0.00+ j 0.00		-3.57+39.68	9.85-J117.11	-2.55+j 28.23
6		-5.95+j 65.69			-2.55+j 28.232	8.50 – j93.48

Table 8 Negative sequence Y-Bus matrices during the single line to ground fault which results in the creation of new valued parameters

S No	Bus 1	Bus 2	Bus 3	Bus 4	Bus 5
1	0.00-j1.000				0.00+J0.00
2		1.07-j10.60		-0.36+j397	-0.71+j7.94
3			0.00+j1.00	0.00+0.00	
4		-0.36+j3.97	0.00+j0.00	1.79-j18.76	-1.43+j15.87
5	0.00+j0.00	-0.71+j7.94		-1.43+j15.87	2.14-j2.15

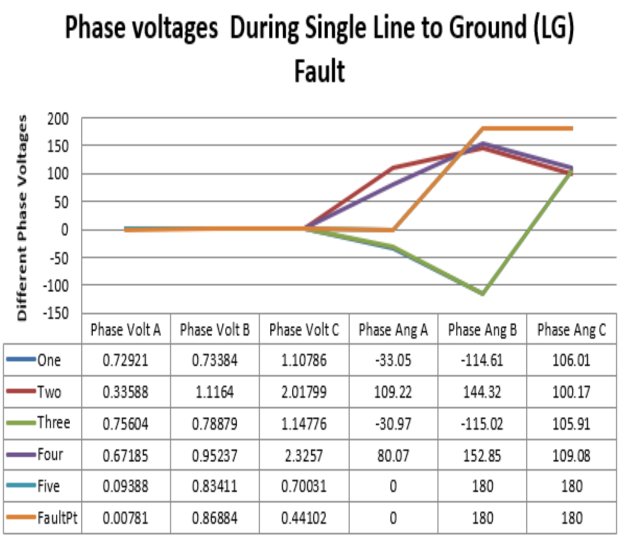

Figure 4 Graphical Analysis of the Single Line to Ground L-G Fault directly depicts how change happen in the different phase voltages

Line Parameters during the Fault which led changes in the other parameters of the % Bus power system

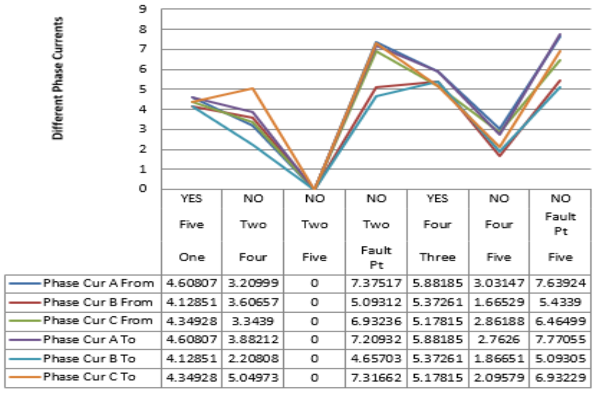

Figure 5 Graphical Analysis giving disturbance in Phase Current parameters

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V. CONCLUSION

The Fault analysis clearly revealed that when providing some critical values so that fault comes into play for the system under investigation gives the actual behavior of the power system whose lines are under stresses due to the occurrence of Faults. Determination of Fault Limit values gives an insight into how we can maintain and retain any power system to a normal operation whose lines/ components are exposed under changing environmental conditions and furthermore, this paper also directs that how we can make any new potential power system by considering these values for design.

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