Effective Fault Management in a Deregulated Power Sector Using IPSA Program

[1]Oyetola J.B And [2]Okpeki U.K
[1]Dept. of Electrical/Electronics Engineering,
School of Engineering,
Lagos State Polytechnic Lagos, Nigeria

[2]Dept. of Electrical/Electronics/Computer Engineering
Delta State University, Oleh Campus

Abstract

In this paper, the analysis of faults under deregulated system is emphasised vis-à-vis as it affects the power system parameters (voltage and current). The Interactive Power System Analysis (IPSA) program is employed. Deregulated system under fault is extensively discussed. The symmetrical and unsymmetrical faults are analysed on a six-bus network. The results from the simulation analysis show that fault currents are higher and voltage drops on lines are reduced. The resultant effect is that the entire system is better equipped, efficient and reliable for real-time enhanced fault localisation and isolation in the event of fault occurrence within a short time.

Keywords*: Deregulation, Faults, Protective devices, Power system*

"1. Introduction"

Essentially, before any power system can be successfully deregulated, three organs of control have to be established; electricity regulatory authority, a power transmission company and Independent System Operator (ISO). The electricity regulatory authority is saddled with the responsibility of development and enforcement of power grid operating codes and standards as it relates to generation, transmission, distribution and marketing of electricity. The power transmission company function is to ensure that the power generated at the generating stations is transmitted through its transmission network to various points of power distribution to consumers. This power transmission company is usually owned by the state though operated on its behalf by private entities. This is to ensure that the transmission grid is evenly developed and power is transmitted to all states irrespective of their industrial status. The Independent System Operator (ISO) is also needed to coordinate the operational activities of various players in the system towards the attainment of system reliability, availability and efficiency.

This ISO must have the facilities that enable it to see and control (in real-time) the various switching operations and power flows at major points and nodes of the entire grid network. An enabling economic and social environment that guarantees the security of investors' fund should also be put in place. It is highly impossible to design a fault proof power system, as it is neither practical nor economical. Modern power systems, constructed with high insulation level are economically practical, have sufficient flexibility so that one or more components may be out of service with a minimum interruption of service. Faults occur principally due to failure of insulation, yet faults can also result from electrical, mechanical and thermal failures or from any combination of these. Faults are classified into two categories namely; symmetrical and unsymmetrical faults. Symmetrical faults are three-phase and three-phase to ground fault. Unsymmetrical faults are phase-to-phase, phase-to-phase-to-earth and phase-to-earth. These faults cause damage to lives, properties and equipment and as such it has to be cleared as fast as possible. A comparator methodology is employed between two generators in six-bus bar system. Three-phase fault and line-to-ground was simulated using Interactive Power System Analysis (IPSA).

IJERT

"2. Literature Review"

2.1 Necessity for Fault Calculations

Fault calculations are done primarily for the following: -

(a) To determine the maximum fault current at the point of installation of a circuit breaker and to choose a standard rating for the circuit breaker (rupturing capacity)
(b) To select the type of circuit breaker depending upon the nature and type of fault.
(c) To determine the type of protection scheme to be employed.
(d) To select the appropriate relay settings of the protection scheme

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 1 Issue 9, November- 2012

(e) To coordinate the relay settings in the overall protection scheme of the system

2.2 Fault Calculation

The fault calculations are done to meet the requirements (a) to (e) above not only for the present system requirement but also meet

(i) the future expansion scheme of the system such as addition of new generating units
(ii) construction of new transmission lines to evacuate power
(iii) construction of new lines to meet the load growth and/or
(iv) construction of interconnection tie lines.

The calculations pertaining to asymmetrical faults are done using symmetrical components and also taking into consideration the subtransient and transient reactances of rotating machines such as generators and synchronous motors.

Nevertheless, it would not be out of place to mention that in a large interconnected power system, such fault calculations are today being done using a digital computer and a couple of years back with the aid of a 'Network Analyser'.

The long hand method is tedious, time consuming and may lead to human errors etc.

Basically there are two approaches to fault calculations. These are

(a) actual reactance or impedance method.
(b) percentage reactance or impedance method or per unit (p.u) reactance or impedance method.

Accordingly, there are certain basic formulae which one has to be aware of in fault calculations. Besides, machine and transformer impedance or reactances are always noted in percentage values on the name plate, hence the latter method described in (b) above is in vogue. Fault levels are computed at all the substations for the present system conditions as also for the future conditions. [6]

2.3 Protection and Relaying

The huge capital investment involved a power system for the generation, transmission and distribution of electrical power is so great that proper precautions must be taken to ensure that

(i) the equipment operates as nearly as is it possible at its peak efficiency
(ii) the equipment is protected from faults and damage to equipment is prevented or minimised.
(iii) accident to life and property is avoided.
(iv) the system is provided with uninterrupted service of quality, reliable and dependable.
(v) system instability is prevented[3]

"3. Methodology"

The method adopted in this research work is the conventional model of synchronous generator for both the centralised (on slack bus) and gen 2 (on P & Q bus). They are both modelled as a Thevenin's equivalent circuit (voltage source and series impedance) [4]. A test bed system shown in fig1 is used for calculating fault current with and without the generator 2. The test bed system is a six-bus system with eight distribution lines and sixteen circuit breakers. Per unit bases for this problem are 25MVA and 12kV. A 5-MW generator with equal positive and negative sequence reactances each of value 0.9p.u and a zero sequence reactance of 0.3p.u are installed at bus 6. These formed part of the synchronous, transient and sub-transient primary data. IPSA (Interactive Power Systems Analysis) version1.6.2 and a fault reactance of 0.11p.u on a common base of 25MVA, maximum fault iteration set at 5, various faults such as balanced 3-phase fault and line-to-ground are simulated, and the result recorded form part of the secondary data. The results are presented in table 1 – 4. [2]

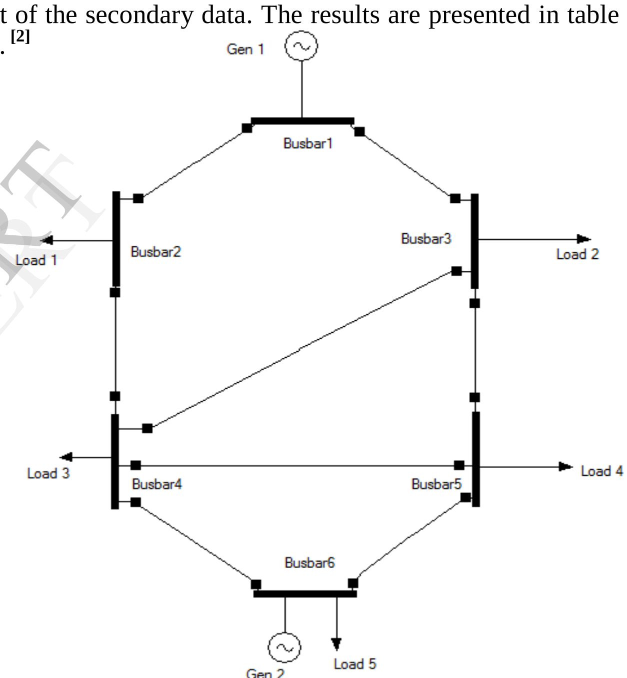


Fig1: Test bed

IJERT

"Table 1: Line properties (on a common base of 25MVA and 12kV)"

From	To	R (p.u)	X (p.u)	R_0 (p.u)	X_0 (p.u)
Busbar 1	Busbar 2	0.0323	0.0761	0.0244	0.07135
Busbar 1	Busbar 3	0.03525	0.0830	0.0267	0.0778
Busbar 2	Busbar 4	0.0206	0.0484	0.0156	0.0454
Busbar 3	Busbar 4	0.0646	0.01522	0.0489	0.1427
Busbar 3	Busbar 5	0.0441	0.1038	0.0333	0.0973
Busbar 4	Busbar 5	0.0558	0.1314	0.0422	0.1232
Busbar 4	Busbar 6	0.0162	0.0380	0.0122	0.0357
Busbar 5	Busbar 6	0.0411	0.0968	0.0311	0.0908

The line properties on a common base of 25MVA and 12kV are shown in the table above.

"Table 2: Balanced 3-phase fault"

Faulted bus	**I_f (kA) without generator 2**	**I_f (kA) with generator 2**	**I_f (kA) difference**
Busbar 1	7.245	7.387	0.142
Busbar 2	6.726	6.890	0.164
Busbar 3	6.704	6.880	0.176
Busbar 4	6.658	6.848	0.190
Busbar 5	6.369	6.551	0.182
Busbar 6	6.412	6.626	0.214

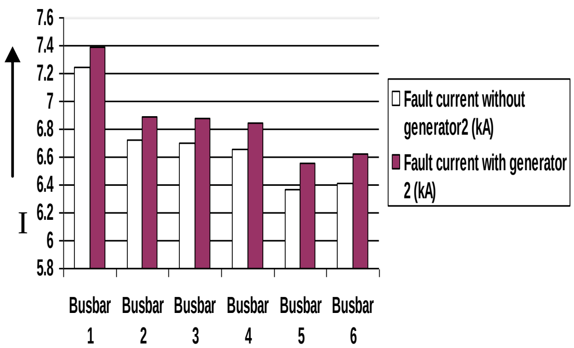


Fig 2: Balanced 3-phase fault

"Table 3: Line-to-ground fault (on red phase)"

Faulted bus	**I_f (kA) without generator 2**	**I_f (kA) with generator 2**	**I_f (kA) difference**
Busbar 1	8.137	8.256	0.119
Busbar 2	7.465	7.604	0.139
Busbar 3	7.432	7.579	0.147
Busbar 4	7.326	7.491	0.165
Busbar 5	7.055	7.215	0.160
Busbar 6	7.061	7.257	0.196

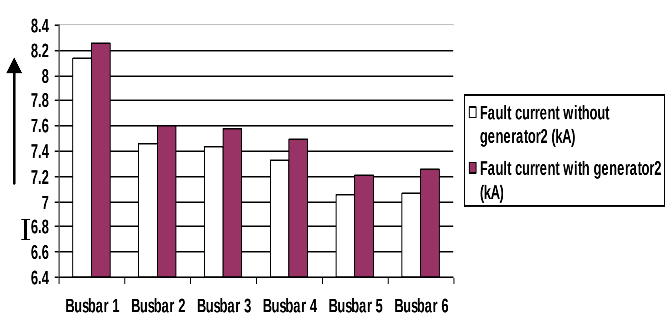


Fig 3: Line-to-ground fault (on red phase)

"Table 4: Voltage drop results"

Busbar	**Voltage drop Magnitude (V) without generator 2**	**Voltage drop Magnitude (V) with generator2**	**Difference in drop**
Bus 1-2	33	21	12
Bus 2-4	14	7	7
Bus 1-3	29	20	9
Bus 3-5	16	7	9
Bus 5-6	4	4	0
Bus 4-6	2	5	-3
Bus 4-5	2	1	1
Bus 3-4	18	8	10

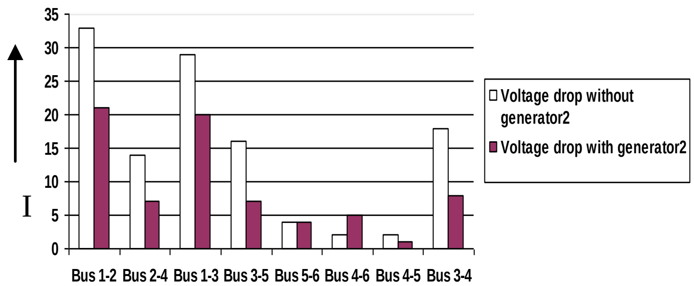
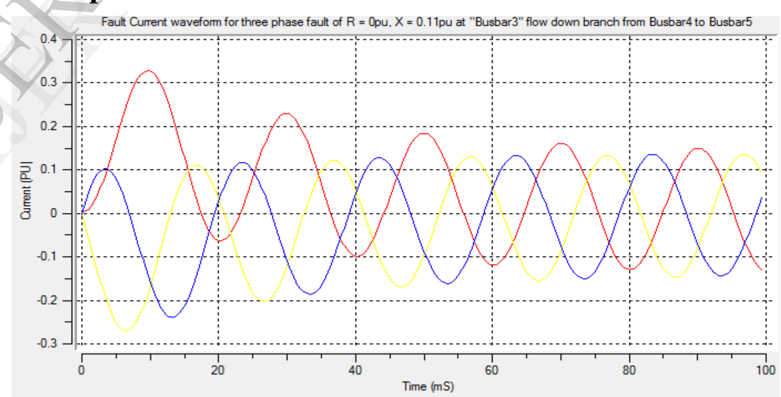


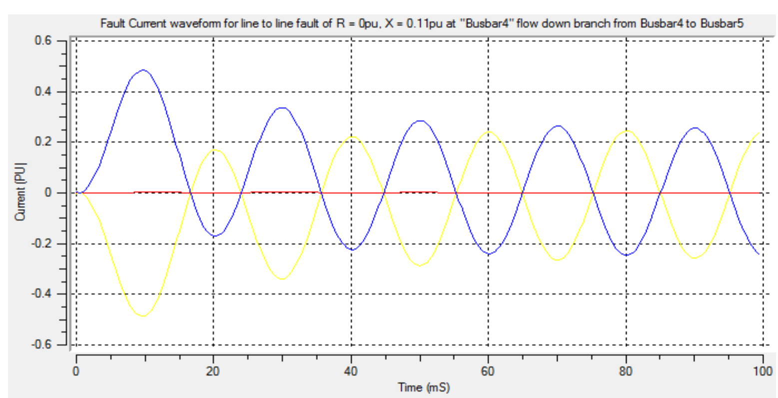
Fig 4: Voltage drop chart

IJERT

"Graph 1"



"Graph 2"



"4. Analysis of Results and Simulation"

Results presented in table 1-4 above were analysed and simulated. In the simulation, the following standard assumptions were made:

- The waveform plots for both types of fault, the fault current is assumed to flow from bus 4 to 5, and the distance along the branch for the fault is assumed to be 44%
- In the voltage drop simulation, a high load of 4MW with power factor 0.95 lagging is assumed at bus 4
- All other line parameters remain the same.

"5. Discussion of Results"

The introduction of generator 2 increases the fault current (I_f) for both balanced 3-phase fault and line-to-ground fault. The highest change in fault current is noticed where the generator 2 is connected. The fault current increases because of reduction of the Thevenin's impedance seen at the bus where the generator 2 is added. The voltage drop is significantly decreased with the presence of generator 2.

The waveform graph for the balanced 3-phase fault, the fault currents all have the same magnitude but are 120^0 apart. The red, yellow and blue phase current patterns are not symmetrical about the time axis. The maximum fault current at the red phase decreases with time, in the yellow and blue phases, it increases with time. However, the peak-to-peak current remains the same. In line-to-ground fault, the waveform is sloping downwards and the maximum current in the red phase decreases with time. A fault current in power systems determine the ratings of circuit interrupting devices and settings of power system protection relays. In essence if the fault current is higher than the previous interrupting capability of the circuit breaker, the fault current might persist and causes damage to personnel and equipment. [1]

In view of the above the following points were hereby suggested to the would-be investors for effective management of the deregulated power system.

(a) fault management is relatively high, this is achieved by putting in place effective and adequate personnel
(b) adequate security over destruction of equipment shall be provided to reduce artificial faults caused by vandals
(c) system reliability and continuity may be hindered, indiscriminate generation into the grid system may also cause power outages
(d) good protective devices will be employed in order to improve the system.
(e) the response time for fault clearance should be fast, so as to improve the system
(f) There should be a network of gas pipelines across the country to facilitate the erection of gas-fired generating turbines at some designated heavy load centers.

"6. Conclusion"

Some of the results achieved in this paper shows that in a deregulated system, with the installation of more generators the fault current increases and this required high and more expensive protective devices to be put in place for reliability and continuity of the system. This research work also provides tremendous insight of the benefits of a deregulated system to consumers. Consumers will pay only for what they consumed; this will reduce the issue of estimated bills. Consumer will have better option, since the monopoly is no more and industry is now competitive, more jobs will be created in power industry. If the capacities that are already installed are improved upon and management efficiency, there would be a huge revenue gain for investors.

IJERT

"7. References"

[1] 'Fault study, analysis and short-circuit calculations' by Mr. L.A. Noronha of PHCN, August 2007
[2] Interactive Power System Analysis (IPSA) program. www.ipsa-power.com/software 2008 version
[3] 'Introduction and philosophy of protection and relaying' by Mr. A. Mohan and Mr. L.A. Noronha of PHCN, August 2007
[4] Nagrath, I.J and D.P. Kothari; Modern Power System Analysis, 2nd edition, Tata Mc Graw-Hill, New Delhi, 1989
[5] Stevenson, W.D; Elements of Power System Analysis, 3rd edition, Mc Graw-Hill Kogakusha Ltd. Tokyo, 1975.