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Research Article

LOAD FLOW AND SHORT CIRCUIT ANALYSIS USING ETAP

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ABSTRACT

This research article presents a power system study on a real time power network. The classical test system selected here is Ghazaouet 220/63/30 KV network. ETAP is used as a tool for modelling and simulating load flow as well as short circuit analysis on the above-said test system [1].

Keywords: ETAP, Load flow analysis, Short Circuit Analysis.

INTRODUCTION

Power systems in general are subjected to various studies particularly in understanding their load flow patterns and contingencies that will arise during a short circuit fault [2]. This knowledge is primarily important for power system engineers, to prepare themselves for the emergency [3]. Understanding the contingency situation is important for power system engineers, in order to find different solution sets, like regulating the OLTC'S, changing the cable length to mitigate voltage drop, increasing the transformer capacitors and adding a capacitor bank etc.[4]. Even though many tools are available to build and to simulate a system, still more analysis is required under different test systems is needed to understand the effect of faults in detail[5].

METHODOLOGY FOLLOWED THIS WORK

In this research study, the test system selected is the Ghazaouet 220/63/30KV power system network. This is the test system taken as a classical system for this research case and ETAP tool is used to build the system and to create load flow under normal conditions and a short circuit is made as a contingency and results are obtained. ETAP is the primary tool to achieve the desired results.

SYSTEM DESCRIPTION

The test system is shown in the figure below:

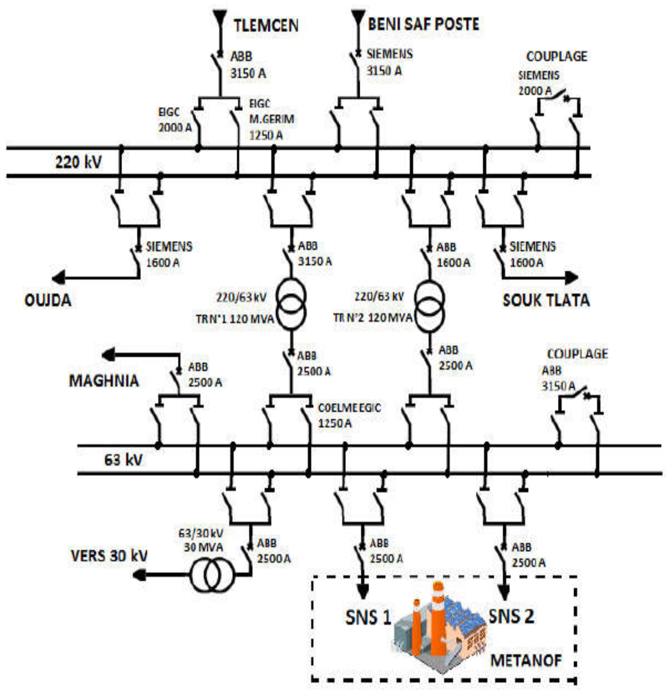

Fig.1 Single Line Diagram of Base System

The following system represented in Fig.1 [6] is a real time classical test system of an Algerian power network with three different voltage rated bus systems of 220/63/30KV. Moreover, it has clearly defined two input feeders shown in the power network as TLEMCEN and BENI SAF POSTE these are the two primarily feeder inputs of the power system shown in Fig:1.

Moreover, it has three power transformers with the rating as follows 220/63KV, transformer1 with power capacity of 120MVA, transformer:2 with a rating of 220/63KV, and a power capacity of 12MVA and the third power transformer with the power rating of 30MVA and 63/30KV as voltage ratings.

For this research article henceforth, the TLEMCEN feeder is named as U1 and BENI feeder is named as U2.

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METHODOLOGY AND TEST CASES

ETAP is used as analysis tool and the above system described in Fig: 1 is modeled in ETAP as follows

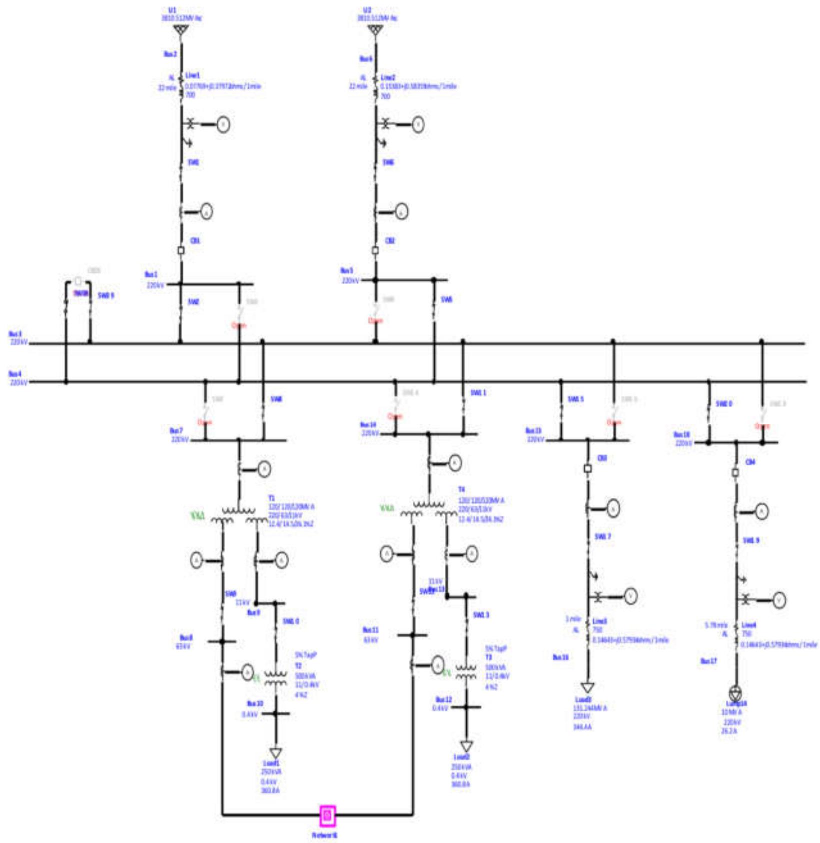

Fig. 2 Single Line Diagram of Load Flow Analysis

The above ETAP model clearly explains the U1 and U2 feeders which forms the power system network. Metering devices are connected suitably as shown in the Fig. 2.

LOAD FLOW ANALYSIS REPORT

Load flow analysis was conducted for the Fig.2 using ETAP under normal conditions and the results are as follows:

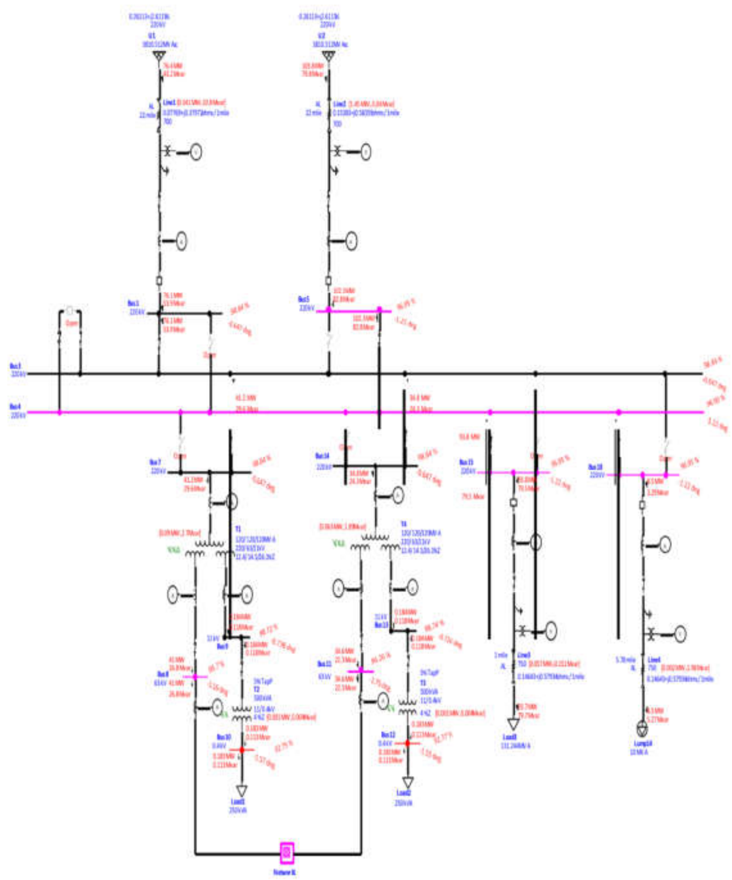

Fig. 3 Load Flow Analysis in ETAP

Load flow results for the power system network under normal conditions are obtained.

INTERPRETATIONS

From the load flow conducted under normal conditions it is imperative that

There are two test cases are formed one is the normal case with terminology N and the other is the abnormal condition with feeder U1 disconnected from the power system network with the terminology N-1.

N is the normal condition and N-1 is the abnormal condition. In the N-1 case the U1 feeder described in Fig. 3 is disconnected and a power system emergency condition is tabulated as below.

Critical Report of N and N-1 Cases

Table 1. Critical report for CASE - N

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus10	Bus	Under Voltage	0.400	kV	0.371	92.7	3-Phase
Bus12	Bus	Under Voltage	0.400	kV	0.371	92.8	3-Phase
Bus32	Bus	Under Voltage	63.000	kV	55.095	87.5	3-Phase
Bus35	Bus	Under Voltage	30.000	kV	28.308	94.4	3-Phase

Table2. Critical report for CASE - N-1

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus10	Bus	Under Voltage	0.400	kV	0.355	88.9	3-Phase
Bus11	Bus	Under Voltage	63.000	kV	55.412	88.0	3-Phase
Bus12	Bus	Under Voltage	0.400	kV	0.355	88.7	3-Phase
Bus13	Bus	Under Voltage	11.000	kV	10.380	94.4	3-Phase
Bus14	Bus	Under Voltage	220.000	kV	208.123	94.6	3-Phase
Bus15	Bus	Under Voltage	220.000	kV	208.123	94.6	3-Phase
Bus16	Bus	Under Voltage	220.000	kV	207.838	94.5	3-Phase
Bus17	Bus	Under Voltage	220.000	kV	208.013	94.6	3-Phase
Bus18	Bus	Under Voltage	220.000	kV	208.123	94.6	3-Phase
Bus19	Bus	Under Voltage	63.000	kV	55.412	88.0	3-Phase
Bus21	Bus	Under Voltage	63.000	kV	55.412	88.0	3-Phase
Bus22	Bus	Under Voltage	63.000	kV	55.412	88.0	3-Phase
Bus25	Bus	Under Voltage	63.000	kV	55.412	88.0	3-Phase
Bus26	Bus	Under Voltage	63.000	kV	55.412	88.0	3-Phase
Bus27	Bus	Under Voltage	63.000	kV	55.412	88.0	3-Phase

Table 3. Critical report for Candidate Buses

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
Bus28	Bus	Under Voltage	63.000	kV	55.412	88.0	3-Phase
Bus3	Bus	Under Voltage	220.000	kV	208.123	94.6	3-Phase
Bus32	Bus	Under Voltage	63.000	kV	49.812	79.1	3-Phase
Bus33	Bus	Under Voltage	63.000	kV	55.412	88.0	3-Phase
Bus34	Bus	Under Voltage	30.000	kV	24.928	83.1	3-Phase
Bus35	Bus	Under Voltage	30.000	kV	24.928	83.1	3-Phase
Bus4	Bus	Under Voltage	220.000	kV	208.123	94.6	3-Phase
Bus5	Bus	Under Voltage	220.000	kV	208.123	94.6	3-Phase
Bus7	Bus	Under Voltage	220.000	kV	208.123	94.6	3-Phase
Bus9	Bus	Under Voltage	11.000	kV	10.405	94.6	3-Phase
T7	Transformer	Overload	40.000	MVA	54.790	137.0	3-Phase

Under- voltage condition is observed, that Bus no: 32has been affected much which is clear from the above two tables.

Branch losses is summarized for N and N-1 cases and it is shown below

Table 4. Critical report of branch loss summary report for CASE - N

Branch Losses Summary Report

Branch ID	From-To Bus Flow MW	From-To Bus Flow Mvar	To-From Bus Flow MW	To-From Bus Flow Mvar	Losses kW	Losses kvar	% Bus Voltage From	% Bus Voltage To	Vd % Drop in Vmag
Line1	-76.076	-53.935	76.417	43.184	340.7	-10750.7	98.8	100.0	1.16
Line2	-102.302	-82.816	103.752	79.778	1450.4	-3037.6	97.0	100.0	3.05
Line3	93.800	79.531	-93.743	-79.682	57.0	-151.0	97.0	96.8	0.13
Line4	-8.500	-5.268	8.502	3.285	2.0	-1982.8	96.9	97.0	0.05
Line5	13.604	8.470	-12.687	-7.862	917.0	607.2	95.7	87.5	8.25
T1	41.248	29.629	-40.974	-26.808	90.1	2704.2	98.8	95.7	3.14
	0.000	0.000	-0.184	-0.118			98.8	98.7	0.12
T2	0.184	0.118	-0.183	-0.113	0.8	4.2	98.7	92.7	5.97
T3	-0.183	-0.113	0.184	0.118	0.8	4.2	92.8	98.7	5.97
T4	34.828	24.305	-34.582	-22.300	62.9	1888.0	98.8	96.3	2.58
	0.000	0.000	-0.184	-0.118			98.8	98.7	0.10
T6	27.371	18.338	-27.319	-16.931	51.5	1407.2	95.7	95.8	0.05
T7	21.418	14.141	-21.385	-13.253	32.5	888.1	96.3	94.4	1.90
					3005.9	-8418.9			

Table 5. Critical report of branch loss summary report for CASE – N-1

Branch Losses Summary Report

Branch ID	From-To Bus Flow MW	From-To Bus Flow Mvar	To-From Bus Flow MW	To-From Bus Flow Mvar	Losses kW	Losses kvar	% Bus Voltage From	% Bus Voltage To	Vd % Drop in Vmag
Line2	-171.806	-140.926	176.216	147.692	4409.3	6766.4	94.6	100.0	5.40
Line3	89.304	75.718	-89.249	-75.862	54.3	-143.7	94.6	94.5	0.13
Line4	-8.500	-5.268	8.502	3.381	2.1	-1887.0	94.6	94.6	0.05
Line5	13.375	8.515	-12.315	-7.632	1060.0	883.5	88.0	79.1	8.89
T1	0.169	0.108	0.000	0.000	0.0	0.1	94.6	94.6	0.00
	0.000	0.000	-0.169	-0.108			94.6	94.6	0.01
T2	0.169	0.108	-0.168	-0.104	0.8	3.9	94.6	88.9	5.72
T3	-0.167	-0.104	0.168	0.107	0.8	3.9	88.7	94.4	5.71
T4	73.832	61.719	-73.309	-50.967	354.8	10643.9	94.6	88.0	6.65
	0.000	0.000	-0.168	-0.107			94.6	94.4	0.24
T7	46.770	34.294	-46.572	-28.862	198.9	5431.2	88.0	83.1	4.86
					6081.0	21702.0			

From the above table it is very clear that the lines from 1-7 are heavily disturbed during contingency in the power system due to the failure of the feeder U1.Similarly for the transformers T1-T 7 huge drop in power is observed [7].

Table 6. Short Circuit Analysis Report

Short-Circuit Summary Report

3-Phase Fault Currents

Bus ID	Bus kV	Device ID	Device Type	Device Capacity (kA) Making Peak	Device Capacity (kA) Ib sym	Device Capacity (kA) Ib asym	Device Capacity (kA) Idc	Short-Circuit Current (kA) I"k	Short-Circuit Current (kA) ip	Short-Circuit Current (kA) Ib sym	Short-Circuit Current (kA) Ib asym	Short-Circuit Current (kA) Idc	Short-Circuit Current (kA) Ik
Bus3	220.000	Bus3	SwtchGear					5.901	13.252				5.124
Bus4	220.000	Bus4	SwtchGear					5.901	13.252				5.124
Bus5	220.000	Bus5	Bus					5.901	13.252				5.124
Bus6	220.000	Bus6	Bus					10.728	26.495				10.000
Bus7	220.000	Bus7	Bus					5.901	13.252				5.124
Bus9	11.000	Bus9	Bus					35.053	89.114				33.566
Bus10	0.400	Bus10	Bus					19.076	42.299				19.060
Bus11	63.000	Bus11	Bus					9.148	22.888				6.447
Bus12	0.400	Bus12	Bus					19.081	42.309				19.060
Bus13	11.000	Bus13	Bus					35.531	90.398				33.566
Bus14	220.000	Bus14	Bus					5.901	13.252				5.124
Bus15	220.000	Bus15	Bus					5.901	13.252				5.124
Bus16	220.000	Bus16	Bus					5.755	12.886				5.013
Bus17	220.000	Bus17	Bus					5.190	11.504				4.544
Bus18	220.000	Bus18	Bus					5.901	13.252				5.124
Bus19	63.000	Bus19	Bus					9.148	22.888				6.447
Bus21	63.000	Bus21	Bus					9.148	22.888				6.447
Bus22	63.000	Bus22	Bus					9.148	22.888				6.447
Bus25	63.000	Bus25	Bus					9.148	22.888				6.447
Bus26	63.000	Bus26	Bus					9.148	22.888				6.447
Bus27	63.000	Bus27	Bus					9.148	22.888				6.447
Bus28	63.000	Bus28	Bus					9.148	22.888				6.447
Bus32	63.000	Bus32	Bus					1.807	3.160				1.537
Bus33	63.000	Bus33	Bus					9.148	22.888				6.447
Bus34	30.000	Bus34	Bus					14.208	35.904				7.478
Bus35	30.000	Bus35	Bus					14.208	35.904				7.478

SHORT CIRCUIT SUMMARY REPORT

The following table clearly explains the shift over in bus voltages and the corresponding short-circuit current in KA, due to the short circuit in the feeder U1. In Bus 9, it can be observed the symmetrical component of the **short-circuit currents** are 36.944KA, 95.756KA and 35.539 KA. Similarly in Bus 13 also a severe emergency condition is felt by the rise of short circuit current to the similar levels of Bus-9. Typical Interpretations can be observed from the above fault analysis [8-13], once on understanding the severity due to the fault current effective remedial measures by having neural controller damping of fault currents can be planned.

Understanding the severity of the fault current is of at most importance to understand the nature of the problem data occurred due to the short-circuit fault in a particular feeder, systematic understanding is a mandatory requirement to plan for the effective solutions[14].

CONCLUSION

This research article has extensively elaborated sudden short circuit in a feeder and the shift over in load flow patterns and the shift over in short circuit currents due to the fault. This is a contingency analysis research over a real time power system. Further, this research can be extended by exploring suitable solutions to damp the short circuit current due to the fault and to balance the load flow by effective strategies in monitoring and control of power [15-18]. This research will definitely provide a lead for researches working in power system contingencies and short circuit problems.

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