SOLUTIONS FOR LOAD-FLOW AND SHORT CIRCUIT PROBLEMS USING E-TAP

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ABSTRACT

This research article presents a solution set for a real-time power system (1). This work can be taken as continuation of solution sets for the power system contingencies, what is discussed in our earlier paper (1). These solutions are obtained by simply changing the transmission size, adding OLTC'S and adding capacitor bank suitably to obtain the results. The tool used for building and obtaining the results is E-TAP.

Keywords: Contingencies in power system, Capacitor bank, E-TAP, OLTC'S, Transmission size

INTRODUCTION

In earlier research article (1), an Algerian power system network of 220/63/33KV was selected and a short circuit failure was simulated in U1 and U2 feeders. U1 and U2 feeders are the feeders of Ghaza Ouet – 220/63/30 KV which is referred as Tlemcen, Beni-Poste feeders. These results are published in the research article (1). This current research article proposes certain solution sets for the contingencies that as triggered due to the short circuit fault. The main contingency what is observed in the earlier work is drop in the voltage. Voltage profile as been badly affected because of the short circuit fault also power factor in the power system has also been collapsed.

On considering the various remedies to stabilize the voltage profile and to increase the power factor, changing the transmission line comes as a better choice. Moreover, by changing the OLTC'S taps voltage can be regulated to the desired levels, in addition capacitor banks have been placed suitably to increase the power factor of the system.

SYSTEM DESCRIPTION

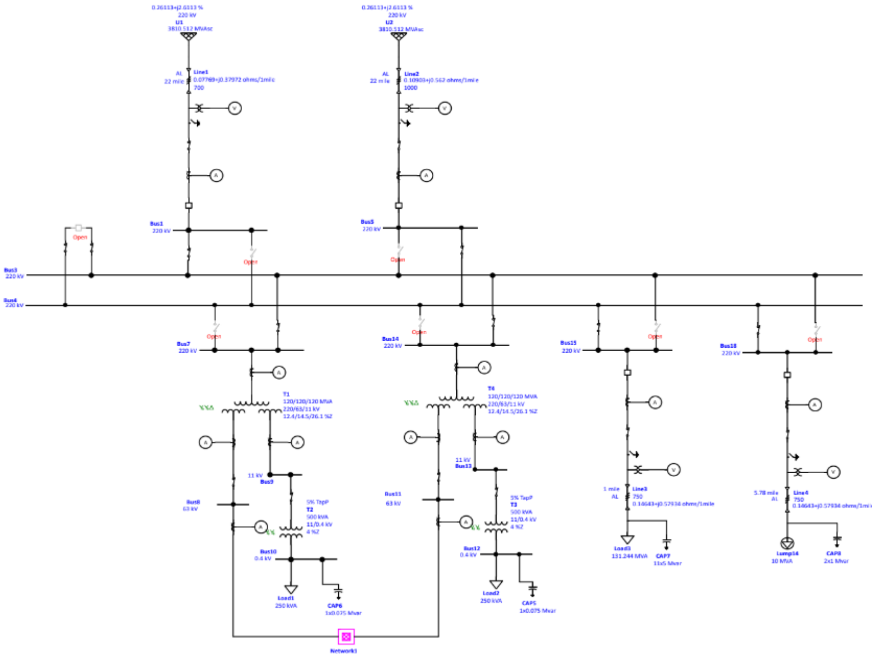

Fig: 1- Main network with faultless condition (Load flow analysis)

In the Fig: 1 the main network without any fault condition is shown. It can be observed that both U1 and U2 feeders are active and the power system is in the normal mode of operation.

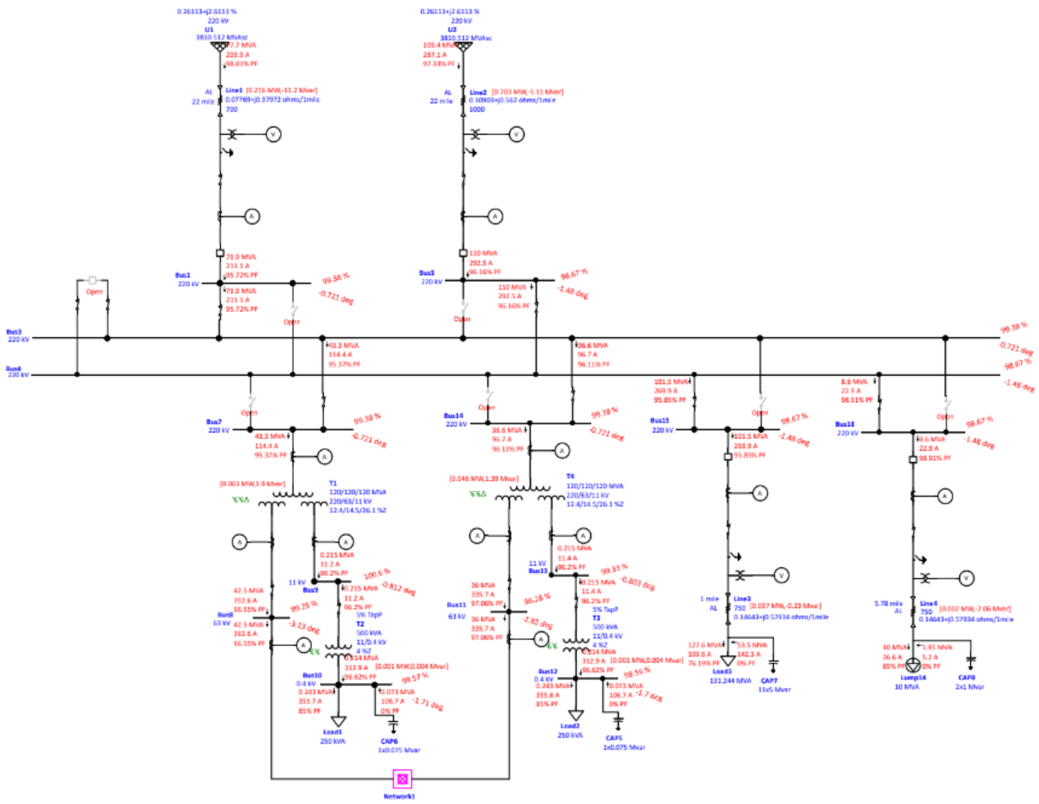

Fig: 2- Main network with faultless condition – Results

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Load flow analysis is done on the above Fig: 2 in the corresponding results are shown as values in the Fig:2 itself. This is the case of load flow analysis when U1 and U2 are active.

CONTINGENCY TEST CASES

As in the earlier research article (1), contingency is created by shorting the feeder U1. Once U1 feeder is shorted the network will be as shown below,

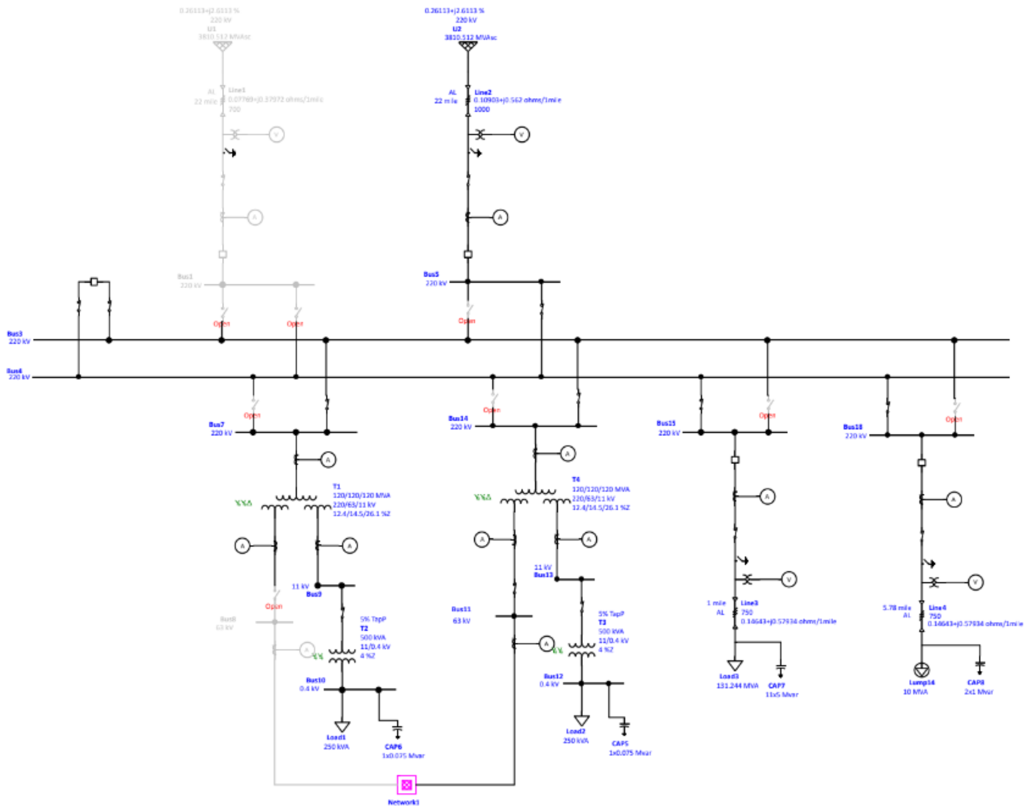

Fig: 3-Contingency case (Shorting the U1 Feeder)

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RESULTS OF CONTINGENCY CASE (SHORTING THE U1-FEEDER)

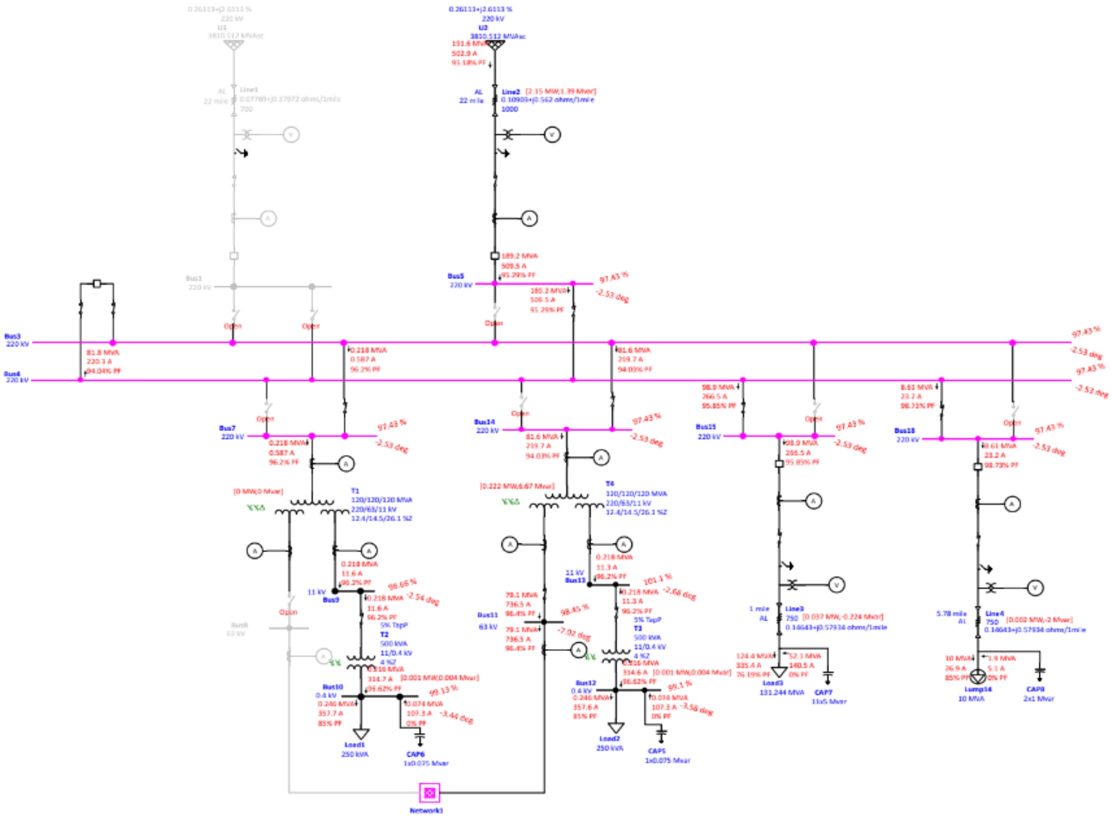

Fig: 4-Contingency Case -Result

From the above figure it is very clear that the main feeder U1 is shorted (2) and load flow analysis is done. From the load flow analysis, we can observe the power flow between the various buses, the power factor at the bus points and the reactive power support in the network. It gives the complete analysis of a thorough load flow study. The pink coloured buses can be taken as candidate buses in this research study.

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RESULTS AND DISCUSSIONS

On conducting the load flow during contingency conditions a thorough data analysis has been observed and it

Is tabulated as follows

Table: 1-Load Flow Report

LOAD FLOW REPORT

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
Bus1	220.000	99.379	-0.7	0.000	0.000	0.000	0.000	Bus2	-76.527	-23.143	211.1	95.7	
								Bus3	76.527	23.143	211.1	95.7	
* Bus2	220.000	100.000	0.0	76.783	11.972	0.000	0.000	Bus1	76.783	11.972	203.9	98.8	
Bus3	220.000	99.379	-0.7	0.000	0.000	0.000	0.000	Bus1	-76.527	-23.143	211.1	95.7	
								Bus7	41.327	13.032	114.4	95.4	
								Bus14	35.200	10.110	96.7	96.1	
Bus4	220.000	98.672	-1.5	0.000	0.000	0.000	0.000	Bus5	-105.762	-30.204	292.5	96.2	
								Bus15	97.260	28.937	269.9	95.8	
								Bus18	8.502	1.267	22.9	98.9	
Bus5	220.000	98.672	-1.5	0.000	0.000	0.000	0.000	Bus6	-105.762	-30.204	292.5	96.2	
								Bus4	105.762	30.204	292.5	96.2	
* Bus6	220.000	100.000	0.0	106.465	25.097	0.000	0.000	Bus5	106.465	25.097	287.1	97.3	
Bus7	220.000	99.379	-0.7	0.000	0.000	0.000	0.000	Bus3	-41.327	-13.032	114.4	95.4	
								Bus8	41.327	13.032	114.4	95.4	-1.250
								&Bus9					
Bus8	63.000	99.252	-3.1	0.000	0.000	0.000	0.000	Bus20	41.057	11.077	392.6	96.5	
								Bus9	-41.057	-11.077	392.6	96.5	
								&Bus7					
Bus9	11.000	100.581	-0.8	0.000	0.000	0.000	0.000	Bus10	0.207	0.059	11.2	96.2	1.250
								Bus7	-0.207	-0.059	11.2	96.2	
								&Bus8					
Bus10	0.400	98.566	-1.7	0.000	0.000	0.206	0.055	Bus9	-0.206	-0.055	312.9	96.6	
Bus11	63.000	98.279	-2.8	0.000	0.000	0.000	0.000	Bus22	34.947	8.665	335.7	97.1	
								Bus13	-34.947	-8.665	335.7	97.1	
								&Bus14					
Bus12	0.400	98.560	-1.7	0.000	0.000	0.206	0.055	Bus13	-0.206	-0.055	312.9	96.6	
Bus13	11.000	99.333	-0.8	0.000	0.000	0.000	0.000	Bus12	0.207	0.059	11.4	96.2	
								Bus14	-0.207	-0.059	11.4	96.2	
								&Bus11					
Bus14	220.000	99.379	-0.7	0.000	0.000	0.000	0.000	Bus3	-35.200	-10.110	96.7	96.1	
								Bus11	35.200	10.110	96.7	96.1	

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
								&Bus13					
Bus15	220.000	98.672	-1.5	0.000	0.000	0.000	0.000	Bus16	97.260	28.937	269.9	95.8	
								Bus4	-97.260	-28.937	269.9	95.8	
Bus16	220.000	98.602	-1.5	0.000	0.000	97.223	29.167	Bus15	-97.223	-29.167	270.2	95.8	
Bus17	220.000	98.638	-1.5	0.000	0.000	8.500	3.322	Bus18	-8.500	-3.322	24.3	93.1	
Bus18	220.000	98.672	-1.5	0.000	0.000	0.000	0.000	Bus17	8.502	1.267	22.9	98.9	
								Bus4	-8.502	-1.267	22.9	98.9	
Bus19	63.000	99.252	-3.1	0.000	0.000	0.000	0.000	Bus20	-41.057	-11.077	392.6	96.5	
								Bus24	27.753	8.333	267.6	95.8	
								Bus28	13.304	2.744	125.4	97.9	
Bus20	63.000	99.252	-3.1	0.000	0.000	0.000	0.000	Bus8	-41.057	-11.077	392.6	96.5	
								Bus19	41.057	11.077	392.6	96.5	
Bus21	63.000	98.279	-2.8	0.000	0.000	0.000	0.000	Bus22	-34.947	-8.665	335.7	97.1	
								Bus25	21.783	5.336	209.1	97.1	
								Bus27	13.164	3.329	126.6	96.9	
Bus22	63.000	98.279	-2.8	0.000	0.000	0.000	0.000	Bus11	-34.947	-8.665	335.7	97.1	
								Bus21	34.947	8.665	335.7	97.1	
Bus24	63.000	99.252	-3.1	0.000	0.000	0.000	0.000	Bus34	27.753	8.333	267.6	95.8	-1.250
								Bus19	-27.753	-8.333	267.6	95.8	
Bus25	63.000	98.279	-2.8	0.000	0.000	0.000	0.000	Bus35	21.783	5.336	209.1	97.1	-1.250
								Bus21	-21.783	-5.336	209.1	97.1	
Bus26	63.000	98.279	-2.8	0.000	0.000	0.000	0.000	Bus33	0.000	0.000	0.0	0.0	
Bus27	63.000	98.279	-2.8	0.000	0.000	0.000	0.000	Bus33	13.164	3.329	126.6	96.9	
								Bus21	-13.164	-3.329	126.6	96.9	
Bus28	63.000	99.252	-3.1	0.000	0.000	0.000	0.000	Bus32	13.304	2.744	125.4	97.9	
								Bus19	-13.304	-2.744	125.4	97.9	
Bus32	63.000	97.720	-4.9	0.000	0.000	13.193	3.402	Bus28	-13.193	-3.402	127.8	96.8	
Bus33	63.000	98.279	-2.8	0.000	0.000	13.164	3.329	Bus26	0.000	0.000	0.0	0.0	
								Bus27	-13.164	-3.329	126.6	96.9	
Bus34	30.000	99.405	-5.1	0.000	0.000	27.715	7.295	Bus24	-27.715	-7.295	554.8	96.7	
Bus35	30.000	98.790	-4.4	0.000	0.000	21.759	4.702	Bus25	-21.759	-4.702	433.7	97.7	

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Table: 2-Bus loading Summary Report

Bus Loading Summary Report

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus1	220.000										79.950	95.7	211.1	
Bus2	220.000										77.711	98.8	203.9	
Bus3	220.000	3150.0									79.950	95.7	211.1	6.7
Bus4	220.000	3150.0									109.990	96.2	292.5	9.3
Bus5	220.000										109.990	96.2	292.5	
Bus6	220.000										109.383	97.3	287.1	
Bus7	220.000										43.333	95.4	114.4	
Bus8	63.000										42.525	96.5	392.6	
Bus9	11.000										0.215	96.2	11.2	
Bus10	0.400				0.206	0.055					0.243	85.0	355.7	
Bus11	63.000										36.005	97.1	335.7	
Bus12	0.400				0.206	0.055					0.243	85.0	355.6	
Bus13	11.000										0.215	96.2	11.4	
Bus14	220.000										36.623	96.1	96.7	
Bus15	220.000										101.474	95.8	269.9	
Bus16	220.000				97.223	29.167					127.599	76.2	339.6	
Bus17	220.000		8.500	5.268		-1.946					10.000	85.0	26.6	
Bus18	220.000										8.595	98.9	22.9	
Bus19	63.000										42.525	96.5	392.6	
Bus20	63.000										42.525	96.5	392.6	
Bus21	63.000										36.005	97.1	335.7	
Bus22	63.000										36.005	97.1	335.7	
Bus24	63.000										28.977	95.8	267.6	
Bus25	63.000										22.427	97.1	209.1	
Bus26	63.000													
Bus27	63.000										13.578	96.9	126.6	
Bus28	63.000										13.584	97.9	125.4	
Bus32	63.000		10.650	6.600	2.543	-3.199					15.521	85.0	145.6	
Bus33	63.000		13.164	8.158		-4.829					15.487	85.0	144.4	
Bus34	30.000		22.224	13.773	5.490	-6.479					32.605	85.0	631.2	
Bus35	30.000		17.492	10.840	4.268	-6.139					25.599	85.0	498.7	

Table: 3-Branch loading summary report

Branch Loading Summary Report

CKT / Branch		Busway / Cable & Reactor			Transformer				
					Capability	Loading (input)		Loading (output)	
ID	Type	Ampacity (Amp)	Loading Amp	%	(MVA)	MVA	%	MVA	%
T2	Transformer				0.500	0.215	43.1	0.214	42.7
T3	Transformer				0.500	0.215	43.1	0.214	42.7
T6	Transformer				40.000	28.977	72.4	28.659	71.6
T7	Transformer				40.000	22.427	56.1	22.262	55.7
T1	3W XFMR p				120.000	43.333	36.1		
	3W XFMR s				120.000	42.525	35.4		
	3W XFMR t				120.000	0.215	0.2		
T4	3W XFMR p				120.000	36.623	30.5		
	3W XFMR s				120.000	36.005	30.0		
	3W XFMR t				120.000	0.215	0.2		

Table: 4-Branch loss summary report

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	-76.527	-23.143	76.783	11.972	256.3	-11170.4	99.4	100.0	0.62
Line2	-105.762	-30.204	106.465	25.097	702.8	-5106.9	98.7	100.0	1.33
Line3	97.260	28.937	-97.223	-29.167	37.4	-229.7	98.7	98.6	0.07
Line4	-8.500	-3.322	8.502	1.267	1.6	-2055.4	98.6	98.7	0.03
Line5	13.304	2.744	-13.193	-3.402	111.2	-657.3	99.3	97.7	1.53
T1	41.327	13.032	-41.057	-11.077	63.2	1896.5	99.4	99.3	0.13
	0.000	0.000	-0.207	-0.059			99.4	100.6	1.20
T2	0.207	0.059	-0.206	-0.055	0.7	3.7	100.6	98.6	2.02
T3	-0.206	-0.055	0.207	0.059	0.7	3.7	98.6	99.3	0.77
T4	35.200	10.110	-34.947	-8.665	46.2	1386.7	99.4	98.3	1.10
	0.000	0.000	-0.207	-0.059			99.4	99.3	0.05
T6	27.753	8.333	-27.715	-7.295	38.0	1038.3	99.3	99.4	0.15
T7	21.783	5.336	-21.759	-4.702	23.2	634.3	98.3	98.8	0.51
					1281.5	-14256.5			

* This Transmission Line includes Series Capacitor.

Table: 5-Alert Summary Report

Alert Summary Report

	% Alert Settings Critical	% Alert Settings Marginal
Loading		
Bus	100.0	95.0
Cable / Busway	100.0	95.0
Reactor	100.0	95.0
Line	100.0	95.0
Transformer	100.0	95.0
Panel	100.0	95.0
Protective Device	100.0	95.0
Generator	100.0	95.0
Inverter/Charger	100.0	95.0
Bus Voltage		
OverVoltage	105.0	102.0
UnderVoltage	95.0	98.0
Generator Excitation		
OverExcited (Q Max.)	100.0	95.0
UnderExcited (Q Min.)	100.0	

It is observed from the alert summary report as shown in Table-5; clear indications about the setting points are indicated. These results are obtained using ETAP tool.

LOAD FLOW OF TEST CASE-N1

In continuation with the earlier results the following tables explains the complete data for branch loss summary, branch loading summary, bus loading summary, load flow analysis and alert summary report for the contingency case N-1 with feeder U1 shorted. It is imperative that the clear variation in the transmission size, adjusting the OLTC'S taps and capacitor bank have suitably streamlined the power system.

CONCLUSION

This research work has thoroughly analysed a power system network. This power system network is a real time system and has been analysed through E-TAP tool. A short circuit contingency in the incoming feeder U1 and its after effects in the power system has been analysed through load flow analysis. Effective solutions are also imposed by changing the transmission size from 700 KCMIL to 1000 KCMIL which has significantly reduced the voltage drop. Moreover, added OL- Taps to all transformers to regulate the voltage at it's LV bus (with a setting of +10%, 1.25 step size, 1-tap). Also, added capacitor bank at the load end to increase the power factor at the incomer side. The voltage has increased to marginal value of 95% to 97.5% which is shown in the pink colour. Similarly, power factor has increased in all incomers nearing to unity. These results and conclusion clearly indicates how a contingency can be managed and how E-TAP tool is useful in getting the results. Future researchers can travel in contingency analysis and solutions.

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