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Multi Contingency Analysis In Power System Using Fast Decoupled Load Flow

***Abstract**. A multi-contingency analysis is essential to modern power systems that improve system security. It helps to identify and analyse the various possible contingencies that may arise during the operation of a power system. The anticipation of multi-contingency (N-2) cases is a very important task since most of these forced multiple outages can cause serious troubles within a short time, like severe violations of operation constraints, cascading failures, and system blackouts. Identifying these multiple outages will help with planning ahead to reduce the impact of these risks. This paper introduces an algorithm for analyzing the power system under multi-contingency analysis occurrence using the Fast Decoupled load flow method. The proposed algorithm was applied to the IEEE-30 Bus test system under different scenarios of multiple outages including the most severe case represented by the separation of bus-bars. The results show the effectiveness of the proposed algorithm regarding analysing and monitoring bus voltage, line flow, and total system losses. All programs were written in a MATLAB environment.*

Streszczenie. Analiza wieloawaryjna jest niezbędna w nowoczesnych systemach elektroenergetycznych, które poprawiają bezpieczeństwo systemu. *Pomaga zidentyfikować i przeanalizować różne możliwe zdarzenia awaryjne, które mogą wystąpić podczas pracy systemu elektroenergetycznego. Przewidywanie przypadków wieloawaryjnych (N-2) jest bardzo ważnym zadaniem, ponieważ większość takich wymuszonych wielokrotnych przestojów może w krótkim czasie spowodować poważne problemy, takie jak poważne naruszenia ograniczeń operacyjnych, kaskadowe awarie i przerwy w dostawie prądu systemu. Identyfikacja tych licznych przestojów pomoże w planowaniu z wyprzedzeniem i zmniejszeniu wpływu tych zagrożeń. W artykule przedstawiono algorytm analizy systemu elektroenergetycznego przy wystąpieniu analizy wielowarstwowej z wykorzystaniem metody szybkiego oddzielonego przepływu obciążenia. Zaproponowany algorytm został zastosowany w systemie testowym magistrali IEEE-30 w różnych scenariuszach wielokrotnych awarii, w tym w najcięższym przypadku reprezentowanym przez oddzielenie szyn zbiorczych. Wyniki pokazują skuteczność zaproponowanego algorytmu w zakresie analizy i monitorowania napięcia magistrali, przepływu linii i całkowitych strat w systemie. Wszystkie programy zostały napisane w środowisku MATLAB.* (***Analiza wieloawaryjna w systemie elektroenergetycznym z wykorzystaniem szybkiego odłączonego przepływu obciążenia***)

Keywords: Multi-contingency, Fast Decouple Algorithm, Bus- bar separation.
Słowa kluczowe: Wieloawaryjność, szybki algorytm odłączania, separacja szyn zbiorczych.

1.Introduction

Contingency analysis is a widely used technique to assess power system reliability. It involves analyzing the behaviour of power systems under various contingencies to identify potential week points and take corrective measures. Contingency Analysis is one of the "static security analysis" applications in a power utility control center. It deals with any external or internal sudden event that occurs during the study state operation of a power system that cause forced outage of one or more equipment of an electric network [1]. This forced outages may be lead to exceeding the operation limit, isolating some areas from the network, cascading outages, partial or total shutdown depending on a given network operation state [2]. Contingencies cause two type of violations those are: Low voltage violations which indicates that the voltage at the bus may be lower than expected, and Line MVA Limits Violations when a line's MVA rating exceeds a certain rating [1]. There are three levels of contingency analysis those are:

1. Single(N-1)contingency: it is occur when abnormal event case failure of one power system equipment like (transmission line , generation unite…..etc.)
2. Multiple or Secondary contingency : which contains
   - (N-1-1) contingency : in this level abnormal event case failure of two power equipment sequentially rather than simultaneously
   - (N-2) Contingency :in this level abnormal event case failure of tow power equipment at the same time
3. (N-X) Contingency where (X) number of equipment in power system to be failure.

This work consider the (N-2) contingency level.

Many methods and practices have been developed to perform contingency analysis, in reference [1, 3], DC load flow analysis with a linear sensitivity factor is used for finding critical contingencies. In references [4–10], AC load flow with voltage and real power performance index are used to rank contingencies according to their severity. A new algorithm with linear techniques is used in reference [11] for computing the hybrid performance index. References [12–20] proposed an Artificial intelligence techniques for contingency analysis. in [21] According to the North American Electrical Reliability Corporation (NERC), the power system should be secure for any single contingency case, ,so power system operators are looking for secure operation in multiple outage cases. In reference [22] an algorithm for double line outages is introduced.

All previous studies discuss the effects of single and multiple contingencies for lines and generation units, ,but they didn't discuss the most important and severe forced outage that takes place when a three-phase short circuit occurs at the bus-bar terminal , leading to the separation of the bus-bar and all lines connected to it. In this case, sudden and large changes in both the configuration and the state of the system may lead to a partial or total shutdown. This paper produces an algorithm to analyze the power system under different scenarios of multiple outages, taking into account multiple contingency events with a bus-bar outage and using fast decoupled load flow method.

2. Fast decoupled load flow (FDLF) problemM

The Fast Decoupled load flow method is based on Newton's load flow method, but it ignores the J2 and J3 Jacobean element because of the poor coupling between ″P-V″ and ″Q-δ″ quantities in a power transmission system .This approximation makes a fast algorithm the best one of AC methods when we need to create a program to analyze an electric network under the stress of different cases of multiple outages because it uses little memory and always comes to convergent results. From Newton's load flow method we have

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} J1 & J2 \\ J3 & J4 \end{bmatrix} \begin{bmatrix} \Delta\delta \\ \Delta|v| \end{bmatrix} \quad (1)$$

According to Fast decouple (FDLF) approximation .the element J2 and J3 of the Jacobian matrix is set to zero. Thus eq. (1) become

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} J1 & 0 \\ 0 & J4 \end{bmatrix} \begin{bmatrix} \Delta\delta \\ \Delta|v| \end{bmatrix} \tag{2}$$

$$\Delta P = J1 \Delta\delta = \left[\frac{\partial P}{\partial \delta}\right] \Delta\delta \tag{3}$$

By evaluate $J1, J4$ after many approximations, the equation of Fast algorithm become

$$\frac{\Delta P}{|vi|} = -B' \Delta\delta \tag{4}$$

$$\frac{\Delta Q}{|vi|} = -B'' \Delta |v| \tag{5}$$

Consequently, this technique is very useful in contingency analysis where rapid simulation of multiple disruptions is required. The flow chart of the Fast Decoupled algorithm is shown in fig. bellow

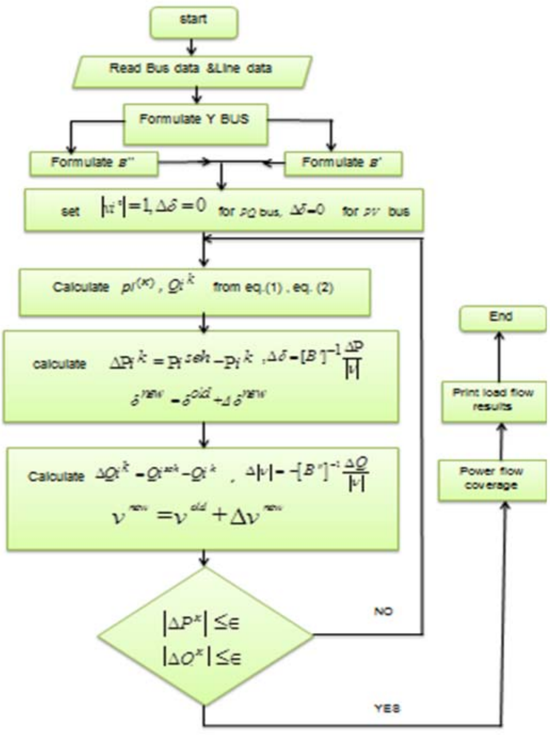


Fig. 1 FDLF flow chart

3. The structure of the multi-contingency program by fast decouple load flow

A program was written for multi contingency analysis using MATLAB m- files, taking into account six types of contingencies those are:

- Double T.L failure.
- T.L and generating unite failure.
- Double generating unite failure
- Bus bar and T.L failure .
- Bus bar and generation unite failure
- Double Bus bar failure.

The structure of the program is shown below:
Step 1: Read bus & line input data
Step 2: Formed Y BUS of input data
Step 3: Find pre-contingency Fast decouple load flow and record the results
Step 4: Choose multi contingency case
Step 5: Input No .of multi equipment failure
Step 6: Read new input data
Step 7: Formed new YBUS
Step 8: Find post – contingency load flow
Step 9: Save results
Step 10: End
Figure (2) show the flow chart of the multi contingency analysis program.

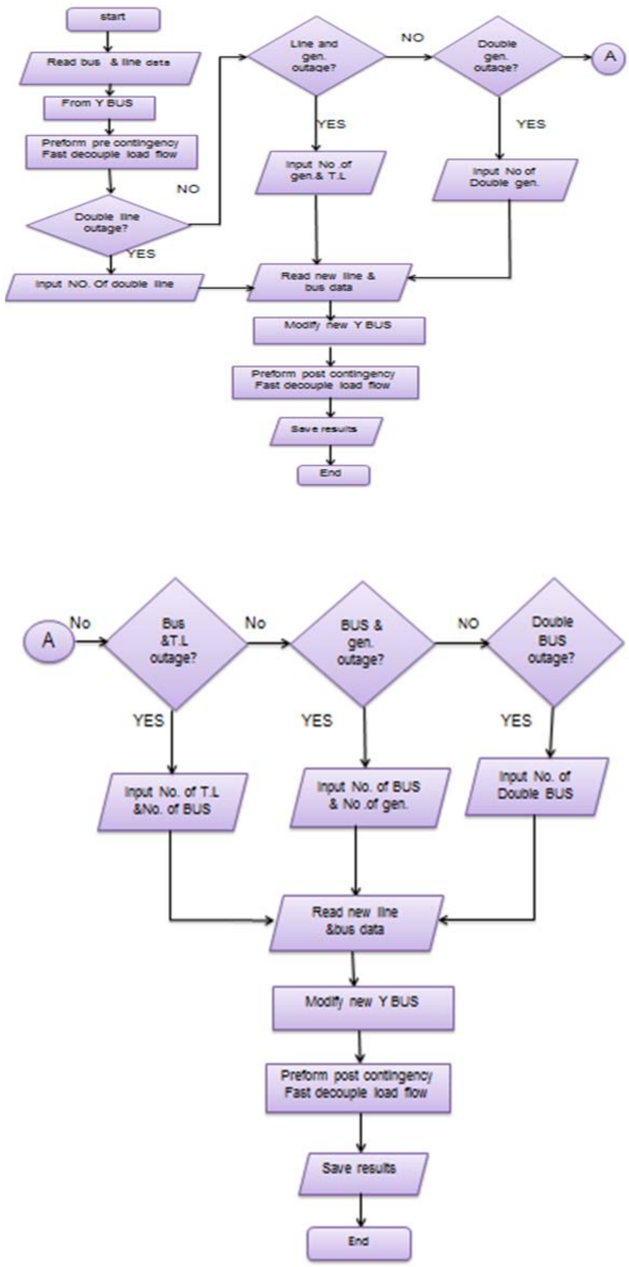


Fig. 2 Multi contingency analysis program flow chart

4.Case study

The proposed algorithm is used to analyze the IEEE-30 bus, Figure (3) shows the one-line diagram of the system. The bus and line data of the IEEE -30 bus system are given in Ref.[23-24].

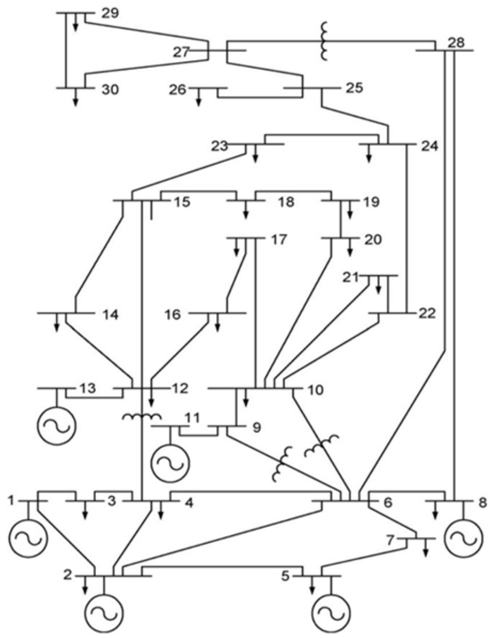


Fig. 3 Single line diagram of IEEE 30- Bus system

The system under consideration was exposed to different cases of failure and was analyzed concerning the effect of each multi-outage on bus voltage, line flow, and total system MW losses. In this paper three cases were studied.

4.1 TOW transmission line failure

The proposed algorithm was applied on the IEE-30 bus system under the outages of branches (1-2) and (6–8). Tables (1) and (2) show the results of bus voltage, line flow, and overall line MW loss in the pre- and post-contingency cases. while Figure 4 (a, b) shows result representation before and after this multiple loss.

Table 1. Voltage magnitude and phase angle before and after the contingency

Bus Number	Pre-contingency voltage Mag (P.U)	Post-contingency voltage Mag. (P.U)	Pre-contingency voltage angle Deg.	post-contingency voltage angle. Deg.
1	1.0500	1.0500	0	0
2	1.0400	1.0400	-3.6929	-25.9299
3	1.0273	1.0121	-5.7546	-19.2088
4	1.0215	1.0118	-6.9128	-23.2743
5	1.0100	1.0100	-10.4137	-30.5959
6	1.0174	1.0163	-7.9862	-25.8844
7	1.0066	1.0059	-9.5091	-28.3377
8	1.0100	1.0100	-8.1236	-27.6262
9	0.9760	0.9746	-10.3522	-28.0334
10	0.9550	0.9526	-12.4003	-29.9730
11	1.0500	1.0500	-8.9565	-26.6357
12	0.9971	0.9948	-12.0735	-29.0587
13	1.0500	1.0500	-11.1541	-28.1372
14	0.9768	0.9746	-13.0651	-30.1298
15	0.9679	0.9654	-13.0455	-30.1881
16	0.9716	0.9691	-12.5076	-29.7358
17	0.9543	0.9517	-12.6710	-30.1398
18	0.9502	0.9476	-13.6316	-30.9274
19	0.9431	0.9405	-13.7583	-31.1461
20	0.9452	0.9427	-13.4836	-30.9183
21	0.9413	0.9388	-12.9415	-30.5130
22	0.9418	0.9393	-12.9274	-30.4975
23	0.9470	0.9445	-13.3709	-30.6871
24	0.9283	0.9258	-13.4063	-30.9615
25	0.9228	0.9201	-13.2323	-31.0641
26	0.9032	0.9005	-13.7437	-31.5786
27	0.9289	0.9263	-12.8104	-30.8121
28	1.0149	1.0141	-8.4750	-26.7110
29	0.9068	0.9041	-14.3094	-32.3201
30	0.901	0.9	-15.3930	-33.4104

Table 2. Active power flow before and after the contingency

Line NO.	Start bus	End bus	Pre-contingency MW flow	Post--contingency MW flow	Post-Contingency MVA	MVA limit	% Over MVA limit
1	1	2	116.720	0	0	130	outage
2	1	3	58.758	190.487	190.545	130	46%
3	2	4	34.579	-20.153	29.934	65	NO
4	3	4	54.942	173.191	181.180	130	39.3%
5	2	5	63.032	44.719	44.954	130	NO
6	2	6	44.988	3.733	11.379	130	NO
7	4	6	46.232	102.292	109.157	65	67.9%
8	5	7	-10.910	-28.374	31.835	90	NO
9	6	7	34.090	52.356	52.507	65	NO
10	6	8	10.180	0	0	70	outage
11	6	9	18.282	16.563	21.764	130	NO
12	6	10	12.582	11.613	11.613	32	NO
13	9	11	-12.000	-12.000	37.186	65	NO
14	9	10	30.282	28.564	34.852	65	NO
15	4	12	34.67	38.400	38.565	65	NO
16	12	13	-12.000	-12.000	40.912	65	NO
17	12	14	8.462	8.845	9.573	32	NO
18	12	15	19.042	20.673	23.967	32	NO
19	12	16	7.976	9.684	12.758	32	NO
20	14	15	2.094	2.466	3.050	16	NO
21	16	17	4.339	6.029	8.633	16	NO
22	15	18	6.582	7.469	8.573	16	NO
23	18	19	3.308	4.184	5.229	32	NO
24	19	20	-6.210	-5.336	5.345	32	NO
25	10	20	8.500	7.609	7.697	32	NO
26	10	17	4.728	3.040	3.047	32	NO
27	10	21	16.048	15.982	18.948	32	NO
28	10	22	7.787	7.743	9.057	32	NO
29	21	22	-1.590	-1.656	2.117	32	NO
30	15	23	6.048	7.132	9.628	16	NO
31	22	24	6.12	6.018	6.837	16	NO
32	23	24	2.756	3.832	6.038	16	NO
33	24	25	0.073	1.038	1.445	16	NO
34	25	26	3.553	3.554	4.279	16	NO
35	25	27	-3.487	-2.522	2.878	16	NO
36	28	27	16.852	15.883	8.462	16	NO
37	27	29	6.219	6.220	6.455	16	NO
38	27	30	7.129	7.130	7.337	65	NO
39	29	30	3.713	3.713	3.765	16	NO
40	8	28	2.141	-8.000	8.162	32	NO
41	6	28	14.755	24.019	25.850	32	NO
Total MW losses			10.078MW	25.086 MW			

The previous tables and bare graph in Fig 4(a,b) show that both the magnitude and phase angle of the voltage on each bus remains within the allowable range (the voltage on each bus remains within the approved range of (1.1 V to 0.9 V, +45 to -45 degrees). While the flow of the line was increased in the branches (1-3), (3-4), (4-6), and (6-7) because the interruption of the branches (1-2) pushes the generated power to flow through the system only from these branches. This increased line flow can lead to system overload and possibly even cascading outages. On the other hand, after this multi-disturbance, it can be seen that the total line losses increased by 150% MW.

4.2 Busbar and T.L failure

The suggested algorithm was implemented on the IEEE-30 bus system when bus bar No. 4 and branch (2-6) were separated. One should note that when bus bar No. 4 is separated, all lines connecting to it will be opened .Tables (3) and (4) indicate the results at each bus voltage, line flow, and active loss of all lines prior to and after the numerous interruptions. As Figures 5(a ,b) represents this outcome.

The preceding Tables and bare shapes in Figure 6 (a, b) demonstrate that the following contingency produced voltage violations between 0.23% and 7.45% at buses 3, 9, 10, 11, 15,……27,29 and 30, while line flow was increased at branches (1-2), (2-5) ,(5-7), (6-7), and branch (28–27). The total system MW losses have increased by 334.9% MW. Due to these great total line losses ,voltage violations, and overloads, the system might fail or shut down entirely if a remedial action scheme or a special protection scheme [25] is not working to mitigate the specific contingency.

Table 3. Voltage magnitude and phase angle before and after contingency

Bus Number	Pre-contingency voltage Mag (P.U)	Post-contingency voltage Mag. (P.U)	Pre-contingency voltage angle Deg.	post-contingency voltage angle. Deg.
1	1.0500	1.0600	0	0
2	1.0400	1.0430	-3.6929	-6.1791
3	1.0273	1.0609	-5.7546	-0.2517
4	1.0215	0	-6.9128	outage
5	1.0100	0.9900	-10.4137	-30.5876
6	1.0174	0.9459	-7.9862	-45.2601
7	1.0066	0.9436	-9.5091	-39.6736
8	1.0100	0.9600	-8.1236	-45.8440
9	0.9760	0.8691	-10.3522	-51.0723
10	0.9550	0.8698	-12.4003	-55.1718
11	1.0500	0.8686	-8.9565	-49.1777
12	0.9971	0.9328	-12.0735	-62.2416
13	1.0500	1.0210	-11.1541	-61.2309
14	0.9768	0.9064	-13.0651	-62.5462
15	0.9679	0.8975	-13.0455	-61.5692
16	0.9716	0.8977	-12.5076	-59.7195
17	0.9543	0.8719	-12.6710	-56.8549
18	0.9502	0.8727	-13.6316	-60.3401
19	0.9431	0.8619	-13.7583	-59.3083
20	0.9452	0.8629	-13.4836	-58.3478
21	0.9413	0.8560	-12.9415	-55.9954
22	0.9418	0.8570	-12.9274	-56.0341
23	0.9470	0.8710	-13.3709	-60.0483
24	0.9283	0.8467	-13.4063	-57.4024
25	0.9228	0.8505	-13.2323	-55.1056
26	0.9032	0.8292	-13.7437	-55.7102
27	0.9289	0.8634	-12.8104	-53.3251
28	1.0149	0.9462	-8.4750	-46.1133
29	0.9068	0.8394	-14.3094	-55.0664
30	0.901	0.8255	-15.3930	-56.3337

Table 4. Active power flow before and after contingency

Line NO.	Start bus	End bus	Pre-contingency MW flow	Post--contingency MW flow	Post-Contingency MVA	MVA limit	% Over MVA limit
1	1	2	6	198.967	200.776	130	54%
2	1	3	58.758	2.403	4.144	130	NO
3	2	4	34.579	0	0	65	Outage
4	3	4	54.942	0	0	130	Outage
5	2	5	63.032	220.404	221.281	130	70.21%
6	2	6	44.988	0	0	130	Outage
7	4	6	46.232	0	0	65	Outage
8	5	7	-10.910	126.925	126.936	90	41%
9	6	7	34.090	-93.496	100.746	65	35.5%
10	6	8	10.180	12.017	37.440	70	NO
11	6	9	18.282	37.128	37.522	130	NO
12	6	10	12.582	23.826	24.242	32	NO
13	9	11	-12.000	-11.999	12.006	65	NO
14	9	10	30.282	49.126	49.141	65	NO
15	4	12	34.67	0	0	65	Outage
16	12	13	-12.000	-12.000	59.895	65	NO
17	12	14	8.462	5.182	8.809	32	NO
18	12	15	19.042	4.195	23.483	32	NO
19	12	16	7.976	-8.577	22.644	32	NO
20	14	15	2.094	-1.095	5.399	16	NO
21	16	17	4.339	-12.635	21.977	16	NO
22	15	18	6.582	-2.118	11.543	16	NO
23	18	19	3.308	-5.495	11.484	32	NO
24	19	20	-6.210	-15.103	16.427	32	NO
25	10	20	8.500	17.846	18.423	32	NO
26	10	17	4.728	22.389	24.665	32	NO
27	10	21	16.048	17.916	19.544	32	NO
28	10	22	7.787	8.996	9.521	32	NO
29	21	22	-1.590	0.245	3.776	32	NO
30	15	23	6.048	-3.513	14.100	16	NO
31	22	24	6.12	9.146	9.183	16	NO
32	23	24	2.756	-6.959	13.490	16	NO
33	24	25	0.073	-6.953	7.640	16	NO
34	25	26	3.553	3.562	4.293	16	NO
35	25	27	-3.487	-10.670	10.682	16	NO
36	28	27	16.852	24.251	25.127	16	57.04%
37	27	29	6.219	6.242	6.490	16	NO
38	27	30	7.129	7.159	7.380	65	NO
39	29	30	3.713	3.720	3.774	16	NO
40	8	28	2.141	3.848	5.145	32	NO
41	6	28	14.755	20.519	23.748	32	NO
Total MW losses			10.078MW	43.569MW			

4.3 Busbar and Gen. unite failure

The IEEE-30 bus system was examined in this case when bus bar No. 18 and the generator unit at bus bar No. 13 were simultaneously disconnected from the system due to any sudden damage. Tables (5) and (6) reflect the outcome at each bus voltage, line flow, and system loss, while Figures 6 (a,b) show representations of these results prior to and after these multiple-state outages.

Table 5. Voltage magnitude and phase angle before and after contingency

Bus Number	Pre-contingency voltage Mag (P.U)	Post-contingency voltage Mag. (P.U)	Pre-contingency voltage angle Deg.	post-contingency voltage angle. Deg.
1	1.0500	1.0600	0	0
2	1.0400	1.0430	-3.6929	-6.1791
3	1.0273	1.0609	-5.7546	-0.2517
4	1.0215	0	-6.9128	outage
5	1.0100	0.9900	-10.4137	-30.5876
6	1.0174	0.9459	-7.9862	-45.2601
7	1.0066	0.9436	-9.5091	-39.6736
8	1.0100	0.9600	-8.1236	-45.8440
9	0.9760	0.8691	-10.3522	-51.0723
10	0.9550	0.8698	-12.4003	-55.1718
11	1.0500	0.8686	-8.9565	-49.1777
12	0.9971	0.9328	-12.0735	-62.2416
13	1.0500	1.0210	-11.1541	-61.2309
14	0.9768	0.9064	-13.0651	-62.5462
15	0.9679	0.8975	-13.0455	-61.5692
16	0.9716	0.8977	-12.5076	-59.7195
17	0.9543	0.8719	-12.6710	-56.8549
18	0.9502	0.8727	-13.6316	-60.3401
19	0.9431	0.8619	-13.7583	-59.3083
20	0.9452	0.8629	-13.4836	-58.3478
21	0.9413	0.8560	-12.9415	-55.9954
22	0.9418	0.8570	-12.9274	-56.0341
23	0.9470	0.8710	-13.3709	-60.0483
24	0.9283	0.8467	-13.4063	-57.4024
25	0.9228	0.8505	-13.2323	-55.1056
26	0.9032	0.8292	-13.7437	-55.7102
27	0.9289	0.8634	-12.8104	-53.3251
28	1.0149	0.9462	-8.4750	-46.1133
29	0.9068	0.8394	-14.3094	-55.0664
30	0.901	0.8255	-15.3930	-56.3337

Table 6. Active power flow before and after contingency

Line NO.	Start bus	End bus	Pre-contingency MW flow	Post--contingency MW flow	Post-Contingency MVA	MVA limit	% Over MVA limit
1	1	2	116.720	123.308	125.152	130	NO
2	1	3	58.758	61.437	61.56	130	NO
3	2	4	34.579	36.539	36.845	65	NO
4	3	4	54.942	57.473	57.478	130	NO
5	2	5	63.032	64.565	64.594	130	NO
6	2	6	44.988	47.797	47.810	130	NO
7	4	6	46.232	49.140	51.615	65	NO
8	5	7	-10.910	-9.462	13.096	90	NO
9	6	7	34.090	32.626	32.638	65	NO
10	6	8	10.180	10.527	10.558	70	NO
11	6	9	18.282	21.833	23.944	130	NO
12	6	10	12.582	14.524	15.004	32	NO
13	9	11	-12.000	-12.000	42.710	65	NO
14	9	10	30.282	33.833	45.088	65	NO
15	4	12	34.67	36.123	41.781	65	NO
16	12	13	-12.000	0	0	65	NO
17	12	14	8.462	6.526	6.890	32	NO
18	12	15	19.042	12.815	13.833	32	NO
19	12	16	7.976	5.587	5.764	32	NO
20	14	15	2.094	0.239	0.576	16	NO
21	16	17	4.339	2.050	2.101	16	NO
22	15	18	6.582	0	0	16	Outage
23	18	19	3.308	0	0	32	outage
24	19	20	-6.210	-9.501	10.091	32	NO
25	10	20	8.500	11.921	12.771	32	NO
26	10	17	4.728	6.987	9.446	32	NO
27	10	21	16.048	15.935	19.564	32	NO
28	10	22	7.787	7.716	9.453	32	NO
29	21	22	-1.590	-1.721	1.731	32	NO
30	15	23	6.048	4.724	5.534	16	NO
31	22	24	6.12	5.926	7.841	16	NO
32	23	24	2.756	1.487	1.916	16	NO
33	24	25	0.073	-1.386	1.481	16	NO
34	25	26	3.553	3.568	4.302	16	NO
35	25	27	-3.487	-4.951	5.746	16	NO
36	28	27	16.852	18.353	20.133	16	25.8%
37	27	29	6.219	6.226	6.464	16	NO
38	27	30	7.129	7.137	7.347	65	NO
39	29	30	3.713	3.714	3.767	16	NO
40	8	28	2.141	2.515	3.398	32	NO
41	6	28	14.755	15.885	17.316	32	NO
Total MW losses			10.078MW		10.547MW		

Based on the tables and Figure 6(a, b) , it can be noted that the unexpected removal of the generating unit connected to bus No. 13 in conjunction with a sudden separation of bus No. 18 caused a reduction in voltage at buses 19, 26, 29, and 30. The value of this drop ranged between 0.1% and 3% and also caused an increase in power flow at the branch (26-27). In addition, system loss increased by 4.65%.

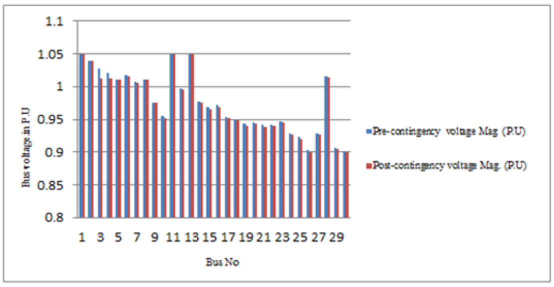


Fig. 4a: Bus voltage before and after the outage

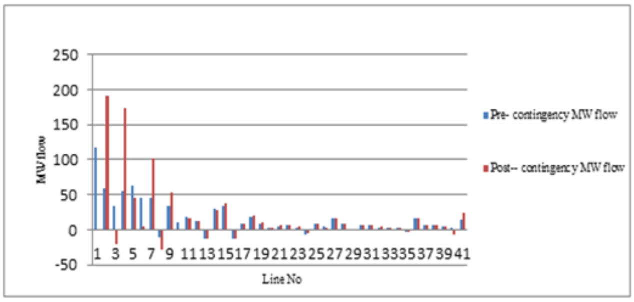


Fig.4b: Line flow before and after the outage

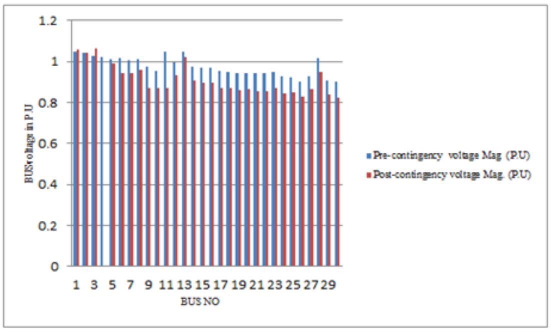


Fig. 5a: Bus voltage before and after the outage

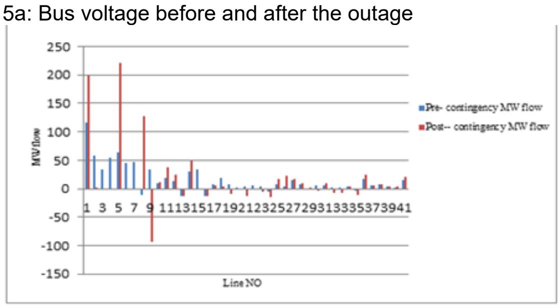


Fig 5b: Line flow before and after the outage

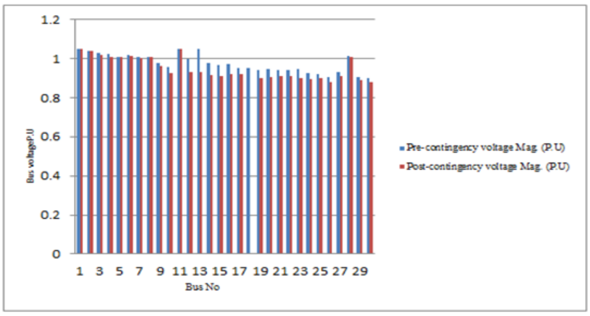
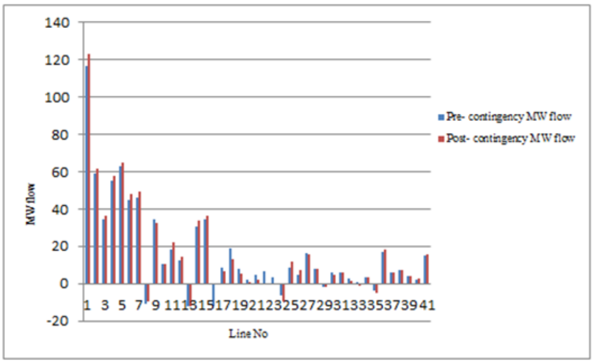


Fig. 6a: Bus voltage before and after the outage



Fi. 6b: Line flow before and after outage

5. Conclusion

Any power system may be exposed to any abnormal condition that causes losses of two elements at the same time. This paper deals with the discussion of the effect of multi contingency on a power system taking into account the most severe case which is the separation of bus bars using fast- decoupled load flow method. From the obtained results, it was very clear that some multiple outages, do not cause a violation of the operating limits, while others forced failures, such as the separation of bus bars, cause the voltage magnitudes on some buses to go out of the permissible range or increase the flow of capacity on certain lines. In addition to the increment of total system losses, there are some of multiple outages that led to the collapse of the system. The impact of these multiple outages on network performance depends on the type of equipment that exited and its location in the network. Therefore, having a program capable of analyzing the network when exposed to any of the double exit cases is a very important matter

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