Contingency Ranking and Analysis Using Mipower

Shahnawaaz Shaikh, Vijayalaxmi Lingaraddi

Engineering in Electrical and Electronics, VTU
Belgaum, India

***Abstract*— Maintaining power system security is one of the challenging tasks for the power system engineers. The security assessment is an essential task as it gives the knowledge about the system state in the event of a contingency. Contingency analysis technique is being widely used to predict the effect of outages like failures of equipment, transmission line etc., and to take necessary actions to keep the power system secure and reliable. The off line analysis to predict the effect of individual contingency is a tedious task as a power system contains large number of components. Practically, only selected contingencies will lead to severe conditions in power system. The process of identifying these severe contingencies is referred as contingency selection and this can be done by calculating performance indices for each contingencies. The main motivation of the work is to carry out the contingency selection by calculating the two kinds of performance indices; voltage performance index (PIV) and over load performance index (PIF) for single transmission line outage. With the help of Fast Decoupled Load Flow (FDLF), the PIV and PIF will be calculated in Mi-Power and further results will be verified in MATLAB. This provides an effective mean to rank the contingencies for various loading and generation levels in a power system. The effectiveness of the method has been tested on, IEEE-14 bus system.**

***Keywords*— contingency analysis, Mipower, MATLAB, contingency ranking, PIV, PIF.**

I. INTRODUCTION

A reliable, continuous supply of electrical energy is essential part of today's complex societies. In recent years the power systems are pushed to operate closer to their limits due to the combination of increased energy consumption and various kinds of obstructions to extension of existing transmission system. A power system is said to be secured when it is free from danger or risk. Security is ability of the system to withstand any one of the pre-selected list of contingencies without any consequences.

Conventional methods for contingency analysis involve load flow analysis which is an iterative method. Various methods like AC load flow and several performance index (PI) based methods are used for power system contingency analysis. In conventional methods a power flow solution is required at each iteration, which is again an iterative method itself. Therefore these methods are not suitable for online applications due to the large computation time. All these approaches involve a huge number of AC load flow calculations to determine the bus voltages and line flows for each contingency. It is a challenging task for today's high speed computers and efficient algorithms. Another difficulty is that contingency analysis always uses approximate fast converging load flow algorithms such as Fast Decoupled load flow analysis which has poor convergence characteristics when dealing with heavily loaded power systems. There are other simple techniques such as most popular DC load flow analysis. The results are acceptable when compared with standard AC load flow method; however it can only provide the Real Power (MW) flow under each contingency. Therefore voltage violations and line over loads due to excessive Reactive Power (Var) flows cannot be detected using this method. Distribution factors and sensitivity analysis, another method based on linear model can also be used for this purpose but this method cannot provide accurate solution for a large power system due to its nonlinearity.

II. CONTINGENCY ANALYSIS

Contingencies are defined as potentially harmful disturbances that occur during the steady state operation of a power system. Load flow constitutes the most important study in a power system for planning, operation and expansion. The purpose of load flow study is to compute operating conditions of the power system under steady state. These operating conditions are normally voltage magnitudes and phase angles at different buses, line flows (MW and Mvar), real and reactive power supplied by the generators and power loss.

In a modern Energy Management power system security monitoring and analysis form an integral part but the real time implementation is a challenging task for the power system engineer. A power system which is operating under normal mode may face contingencies such as sudden loss of line or generator, sudden increase or decrease of power demand. These contingencies cause transmission line overloading or bus voltage violations. In electrical power systems voltage stability is receiving special attention these days. During the past two and half decades it has become a major threat to the operation of many systems.

A. Methods of Contingency Analysis

The different methods used for analyzing the contingencies are based on full AC load flow analysis or reduced load flow or sensitivity factors. But these methods need large computational time and are not suitable for on line applications in large power systems. It is difficult to implement on line contingency analysis using conventional methods because of the conflict between the faster solution and the accuracy of the solution. Some important methods are and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

- AC load flow method
- Performance index method

B. Load flow methods

Mathematical techniques used for load flow study are

- Gauss seidal method
- Newton Raphson method
- Decoupled method
- Fast decoupled load flow method

III. Modelling of Contingency Analysis

Since contingency analysis involves the simulation of each contingency on the base case model of the power system, three major difficulties are involved in this analysis. First is the difficulty to develop the appropriate power system model. Second is the choice of which contingency case to consider and third is the difficulty in computing the power flow and bus voltages which leads to enormous time consumption in the Energy Management System. It is therefore apt to separate the on-line contingency analysis into three different stages namely contingency definition, selection and evaluation. Contingency definition comprises of the set of possible contingencies that might occur in a power system, it involves the process of creating the contingency list. Contingency selection is a process of identifying the most severe contingencies from the contingency list that leads to limit violations in the power flow and bus voltage magnitude, thus this process eliminates the least severe contingencies and shortens the contingency list. It uses some sort of index calculations which indicates the severity of contingencies. On the basis of the results of these index calculations the contingency cases are ranked. Contingency evaluation is then done which involves the necessary security actions or necessary control to function in order to mitigate the effect of contingency [4].

A. Voltage performance and overload performance index

Voltage performance index is calculated by,

$$Pip = \sum_{i=1}^{l} \left(\frac{pi}{pi(\max)}\right)^{2n}$$

Where,
Pi = Active Power flow in line i,
Pimax= Maximum active power flow in line i,
n is the specified exponent,
L is the total number of transmission lines in the system.
Pimax can be calculated using, Pimax=Vi*Vj/X

Where,

Vi = Voltage at bus i obtained from FDLF solution.

V = Voltage at bus j obtained from FDLF solution.
X=Reactance of the line connecting bus 'i' and bus 'j'.
Reactive performance index can be calculated by

$$PI_V = \sum_{i=1}^{Npq} \left[\frac{2(Vi - Vinom)}{Vimax - Vimin}\right]^2$$

Where,
Vi= Voltage of bus i.
Vimax and Vimin are maximum and minimum voltage limits.
Vinom is average of Vimax andVimin.
Npq is total number of load buses in the system.

B. Section Headings

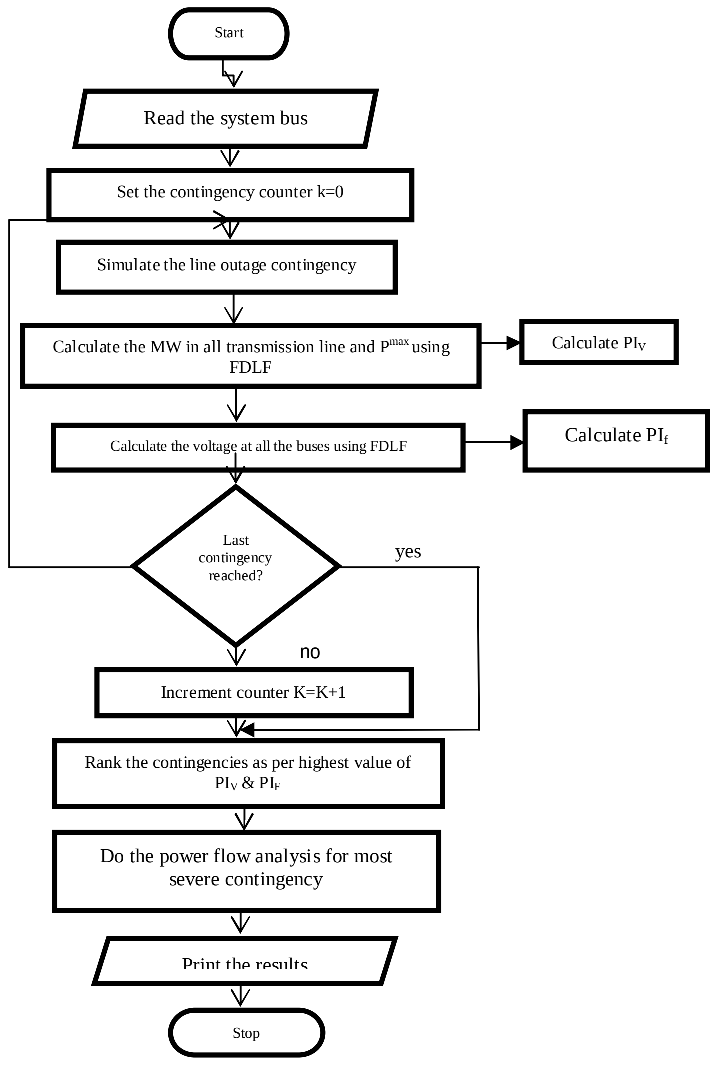

Fig 1: Flowchart for contingency ranking

IV. CASE STUDY

IEEE-14 bus system is been modeled in Mipower software which consists of 1 slack bus, 9 load buses and 4 generator buses. Here we check stability of a 14-bus system for transmission line outages. Two indices are taken for ranking of contingencies they are PIV and PIF, based on the above mentioned indices the overall contingency rank is obtained. The active power flow in each transmission lines that has been obtained using FDLF.At the later stage the results are compared with the MATLAB results. The figure 2 shows the IEEE-14 bus system which is modeled in Mipower.

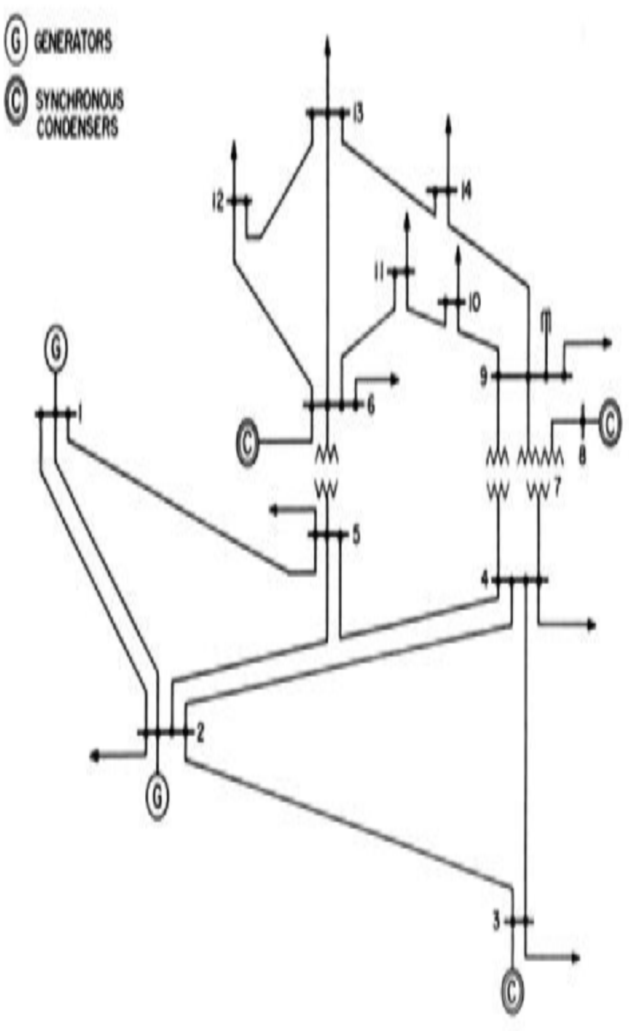

Fig 2: IEEE-14 bus system

V. RESULTS

A. *MIPOWER RESULTS*

I. MIPOWER LINE FLOW RESULTS

LOADING / LINES	60% FORWARD		70% FORWARD		80% FORWARD		90% FORWARD		100% FORWARD		120% FORWARD	
	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
BUS 5- BUS 6	25.776	16.334	30.402	15.469	35.059	14.688	39.744	13.889	44.458	13.072	53.995	10.173
BUS 4- BUS 9	10.079	-1.802	11.621	-1.481	13.156	-1.060	14.685	-0.629	16.208	-0.191	19.229	-0..014
BUS 4- BUS 7	17.171	-10.767	19.874	-10.95	22.575	-10.851	25.272	-10.751	27.965	-10.653	33.346	-12.817
BUS 1- BUS 2	77.980	-0.050	97.315	-5.396	116.92	-10.579	136.84	-15.598	157.07	-20.449	198.33	-11.296
BUS 1- BUS 5	41.875	2.915	50.247	3.084	58.672	3.066	67.170	3.260	75.738	3.673	93.418	9.474
BUS 2- BUS 5	26.024	-1.357	29.935	-0.667	33.801	-0.358	37.700	0.057	41.633	0.581	49.892	1.108
BUS 2- BUS 3	43.389	5.245	50.615	6.635	58.066	5.626	65.592	4.718	73.198	3.914	87.957	9.445
BUS 2- BUS 4	34.496	-4.680	39.943	-3.989	45.333	-3.886	50.765	-3.668	56.239	-3.329	67.641	-2.048
BUS 3- BUS 4	-13.964	-5.756	-16.458	-5.315	-18.768	-2.829	-21.05	-0.254	-23.318	2.414	-28.493	1.071
BUS 4- BUS 5	-36.169	11.115	-42.509	11.678	-48.735	13.253	-54.93	14.888	-61.106	16.584	-73.835	16.077
BUS 6- BUS 11	4.009	-0.244	4.846	0.711	5.693	1.674	6.550	2.663	7.419	3.679	9.196	5.811
BUS 6- BUS 12	4.563	1.159	5.380	1.489	6.199	1.823	7.023	2.164	7.851	2.512	9.527	3.234
BUS 6- BUS 13	10.483	3.002	12.344	4.047	14.215	5.105	16.097	6.186	17.993	7.291	21.833	9.593
BUS 7- BUS 8	0	-10.678	0	-12.67	0	-14.323	0	-16.020	0	-17.770	0	-25.035
BUS 7- BUS 9	17.132	-0.864	19.824	0.748	22.514	2.275	25.199	3.822	27.878	5.390	33.219	9.670
BUS 9- BUS 10	3.517	4.868	3.940	4.689	4.355	4.511	4.763	4.317	5.165	4.105	5.944	3.618
BUS 9- BUS 14	5.994	3.609	6.859	3.592	7.719	3.581	8.574	3.564	9.424	3.541	11.106	3.477
BUS 10- BUS 11	-1.892	1.361	-2.369	0.601	-2.855	-0.158	-3.347	-0.935	-3.847	-1.728	-4.870	-3.380
BUS 12- BUS 13	0.881	0.149	1.076	0.299	1.274	0.450	1.474	0.603	1.678	0.760	1.085	0.0113
BUS 13- BUS 14	3.014	-0.465	3.657	0.092	4.311	0.652	4.973	1.226	5.646	1.816	3.052	0.0932

Fig 3: Line flow results obtained from Mipower

II. *LOSSES*

LOADING / LINES	60% FORWARD		70% FORWARD		80% FORWARD		90% FORWARD		100% FORWARD		120% FORWARD	
	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
BUS 5- BUS 6	0.0002	1.9175	0.0002	2.4100	0.0003	3.0060	0.0004	3.7053	0.0005	4.5121	0.0006	6.5344
BUS 4 - BUS 9	0.0001	0.5162	0.0001	0.6806	0.0001	0.8682	0.0001	1.0823	0.0001	1.3234	0.0002	1.9269
BUS 4 - BUS 7	0.0387	0.7749	0.0489	0.9782	0.0599	1.1977	0.0724	1.4475	0.0864	1.7281	0.1274	2.5477
BUS 1 - BUS 2	1.0503	-2.6425	1.6345	-0.859	2.3681	1.3809	3.2573	4.0957	4.3082	7.3042	6.7967	14.9597
BUS 1 - BUS 5	0.8571	-1.2498	1.2289	0.2983	1.6700	2.1299	2.1853	4.2678	2.7765	6.7200	4.2650	12.9315
BUS 2 - BUS 5	0.3533	-2.5843	0.4680	-2.223	0.5970	-1.8218	0.7431	-1.3671	0.9070	-0.8576	1.3292	0.5203
BUS 2 - BUS 3	0.8330	-0.4584	1.1348	0.8312	1.4761	2.2693	1.8710	3.9328	2.3208	5.8279	3.4545	10.7339
BUS 2 - BUS 4	0.6353	-3.3730	0.8499	-2.703	1.0944	-1.9490	1.3718	-1.0937	1.6833	-0.1347	2.4846	2.4357
BUS 3 - BUS 4	0.1372	-3.2698	0.1862	-3.115	0.2321	-2.9889	0.2927	-2.8249	0.3687	-2.6212	0.5645	-1.9791
BUS 4 - BUS 5	0.1818	-0.7868	0.2479	-0.569	0.3266	-0.3150	0.4166	-0.0244	0.5180	0.3026	0.7619	1.1135
BUS 6 - BUS 11	0.0134	0.0280	0.0199	0.0417	0.0292	0.0612	0.0415	0.0869	0.0569	0.1518	0.0995	0.2084
BUS 6 - BUS 12	0.0238	0.0495	0.0335	0.0696	0.0448	0.0933	0.0580	0.1207	0.0729	0.4289	0.1101	0.2292
BUS 6 - BUS 13	0.0686	0.1351	0.0975	0.1920	0.1318	0.2596	0.1718	0.3384	0.2178	0.4946	0.3331	0.6559
BUS 7 - BUS 8	0	0.1746	0	0.2477	0	0.3178	0	0.3997	0	0.7887	0	1.0053
BUS 7 - BUS 9	0	0.2815	0	0.3788	0	0.4954	0	0.6319	0	0.0330	0	1.1991
BUS 9 - BUS 10	0.0100	0.0264	0.0104	0.0278	0.0110	0.0293	0.0117	0.0311	0.0124	0.2461	0.0143	0.0380
BUS 9 - BUS 14	0.0540	0.1149	0.0667	0.1420	0.0813	0.1729	0.0976	0.2075	0.1157	0.0310	0.1597	0.3397
BUS 10 - BUS 11	0.0039	0.0091	0.0043	0.0101	0.0060	0.0140	0.0089	0.0208	0.0132	0.0310	0.0270	0.0632
BUS 12 - BUS 13	0.0016	0.0014	0.0024	0.0022	0.0036	0.0033	0.0050	0.0045	0.0067	0.0061	0.0113	0.0102
BUS 13 - BUS 14	0.0141	0.0288	0.0205	0.0417	0.0292	0.0594	0.0405	0.0824	0.0544	0.1110	0.0932	0.1897

Fig 4: Losses results obtained from Mipower

II) Loading

LOADING / LINES	60% LOADING	70% LOADING	80% LOADING	90% LOADING	100% LOADING	120% LOADING
BUS 5 - BUS 6	19.7&	22.1&	24.7&	27.4^	30.3^	36.4^
BUS 4 - BUS 9	6.4&	7.4&	8.3&	9.3&	10.3&	12.4&
BUS 4 - BUS 7	12.8&	14.4&	16.0&	17.6&	19.2&	23.3&
BUS 1 - BUS 2	73.6$	91.9#	110.8@	129.9!	149.4!	187.4!
BUS 1 - BUS 5	39.6^	47.5^	55.4$	63.4$	71.5$	88.6#
BUS 2 - BUS 5	24.9&	28.7^	32.3^	36.1^	39.8^	48.2^
BUS 2 - BUS 3	41.8^	48.8^	55.8$	62.9$	70.1$	85.5#
BUS 2 - BUS 4	33.3^	38.4^	43.5^	48.7^	53.9$	65.4$
BUS 3 - BUS 4	14.9&	17.1&	18.5&	21.0&	23.8&	29.2^
BUS 4 - BUS 5	37.1^	43.3^	49.6^	56.0$	62.5$	75.7#
BUS 6 - BUS 11	3.8&	4.6&	5.5&	6.6&	7.7&	10.2&
BUS 6 - BUS 12	4.4&	5.2&	6.0&	6.9&	7.7&	9.5&
BUS 6 - BUS 13	10.2&	12.1&	14.1&	16.1&	18.1&	22.4&
BUS 7 - BUS 8	10.0&	11.9&	13.4&	15.1&	16.8&	23.9&
BUS 7 - BUS 9	16.0&	18.6&	21.2&	24.0&	26.8^	33.0^
BUS 9 - BUS 10	5.6&	5.7&	5.9&	6.1&	6.3&	6.7&
BUS 9 - BUS 14	6.5&	7.2&	8.0&	8.8&	9.5&	11.2&
BUS 10 - BUS 11	2.2&	2.3&	2.7&	3.3&	4.0&	5.7&
BUS 12 - BUS 13	0.8*	1.1&	1.3&	1.5&	1.7&	2.3&
BUS 13 - BUS 14	2.9&	3.5&	4.1&	4.9&	5.6&	7.4&

Fig 5: Loading results obtained from Mipower

B. *Matlab Results*

I. LINE FLOWS

LOADING / LINES	60% FORWARD		70% FORWARD		80% FORWARD		90% FORWARD		100% FORWARD		120% FORWARD	
	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
BUS 5- BUS 6	25.762	16.251	30.403	15.134	35.046	14.354	39.715	13.556	44.411	12.740	53.743	11.661
BUS 4 - BUS 9	9.941	-1.343	11.475	-1.109	13.014	-0.730	14.547	-0.343	16.073	0.051	19.146	0.792
BUS 4 - BUS 7	17.284	-9.246	19.976	-9.429	22.678	-9.281	25.375	-9.136	28.069	-8.994	33.554	-9.231
BUS 1 - BUS 2	77.979	-0.050	97.304	-5.393	116.913	-10.575	136.825	-15.594	157.054	-20.444	198.374	-12.184
BUS 1 - BUS 5	41.828	3.212	50.203	3.325	58.623	3.307	67.113	3.500	75.675	3.911	93.199	9.084
BUS 2 - BUS 5	26.011	-0.986	29.923	-0.366	33.786	-0.056	37.681	0.359	41.610	0.883	49.582	0.976
BUS 2 - BUS 3	43.426	5.114	50.640	6.631	58.094	5.622	65.623	4.714	73.232	3.910	88.646	2.636
BUS 2 - BUS 4	34.472	-4.138	39.917	-3.484	45.305	-3.380	50.734	-3.160	56.205	-2.822	67.303	-2.642
BUS 3 - BUS 4	-13.928	-5.079	-16.436	-4.812	-18.744	-2.324	-21.029	0.253	-23.291	2.922	-27.810	7.796
BUS 4 - BUS 5	-36.128	10.363	-42462	10.795	-48.694	12.366	-54.901	13.999	-61.079	15.693	-73.603	17.926
BUS 6 - BUS 11	3.991	0.117	4.832	1.118	5.671	2.037	6.520	2.980	7.379	3.950	9.048	5.593
BUS 6 - BUS 12	4.571	1.206	5.388	1.541	6.206	1.870	7.028	2.205	7.854	2.547	9.502	3.210
BUS 6 - BUS 13	10.479	3.188	12.342	4.257	14.208	5.292	16.087	6.350	17.978	7.431	21.753	9.482
BUS 7 - BUS 8	0.000	-10.926	0.000	-12.74	0.000	-14.289	0.000	-15.889	0.000	-17.540	0.000	-22.349
BUS 7 - BUS 9	17.284	0.956	19.976	2.385	22.678	3.862	25.375	5.357	28.069	6.870	33.554	10.714
BUS 9 - BUS 10	3.534	4.503	3.951	4.280	4.375	4.148	4.793	4.000	5.204	3.836	6.088	3.827
BUS 9 - BUS 14	5.991	3.374	6.850	3.328	7.717	3.347	8.579	3.360	9.437	3.368	11.212	3.612
BUS 10 - BUS 11	-1.875	0.999	-2.358	0.195	-2.835	-0.519	-3.318	-1.249	-3.807	-1.996	-4.727	-3.174
BUS 12 - BUS 13	0.888	0.195	1.085	0.352	1.281	0.497	1.479	0.645	1.681	0.796	2.072	1.061
BUS 13 - BUS 14	3.016	-0.234	3.666	0.352	4.313	0.883	4.968	1.429	5.633	1.989	6.922	2.920

Fig 6: Line flow results obtained from MATLAB

II. *LOSSES*

LOADING / LINES	60% FORWARD		70% FORWARD		80% FORWARD		90% FORWARD		100% FORWARD		120% FORWARD	
	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
BUS 5- BUS 6	0.000	1.913	-0.000	2.392	0.000	2.988	0.000	3.686	-0.000	4.491	-0.000	6.537
BUS 4 - BUS 9	0.000	0.495	0.0000	0.659	-0.000	0.486	0.000	1.060	0.000	1.301	-0.000	1.903
BUS 4 - BUS 7	0.000	0.724	0.000	0.926	0.000	1.146	0.000	1.395	0.000	1.675	0.000	2.404
BUS 1 - BUS 2	1.050	-2.643	1.634	-0.860	2.368	1.379	3.257	4.093	4.307	7.301	6.802	14.974
BUS 1 - BUS 5	0.857	-1.248	1.228	0.297	1.669	2.126	2.183	4.261	2.773	3.709	4.241	12.828
BUS 2 - BUS 5	0.353	-2.582	0.468	-2.222	0.597	-1.820	0.743	-1.366	0.907	-856	1.311	0.460
BUS 2 - BUS 3	0.833	-0.457	1.136	0.836	1.477	2.275	1.873	3.940	2.323	5.837	3.456	10.689
BUS 2 - BUS 4	0.633	-3.374	0.848	-2.704	1.092	-1.950	1.370	-1.096	1.681	-0.137	2.457	2.342
BUS 3 - BUS 4	0.133	-3.277	0.184	-3.119	0.231	-2.989	0.293	-2.821	0.371	-2.613	0.579	-1.995
BUS 4 - BUS 5	0.180	-0.792	0.245	-0.576	0.324	-0.323	0.413	-0.033	0.515	0.294	0.763	1.115
BUS 6 - BUS 11	0.013	0.028	0.020	0.043	0.030	0.063	0.043	0.089	0.058	0.122	0.096	0.200
BUS 6 - BUS 12	0.024	0.050	0.034	0.070	0.045	0.094	0.058	0.121	0.073	0.152	0.110	0.229
BUS 6 - BUS 13	0.069	0.137	0.098	0.194	0.133	0.262	0.173	0.340	0.219	0.431	0.332	0.653
BUS 7 - BUS 8	0.000	0.183	0.000	0.250	-0.000	0.316	0.000	0.393	0.000	0.482	0.000	0.802
BUS 7 - BUS 9	0.000	0.287	0.000	0.390	0.000	0.512	0.000	0.654	0.000	0.816	-0.000	1.244
BUS 9 - BUS 10	0.009	0.024	0.009	0.025	0.010	0.027	0.011	0.029	0.012	0.032	0.015	0.041
BUS 9 - BUS 14	0.052	0.111	0.065	0.138	0.080	0.169	0.096	0.205	0.115	0.244	0.164	0.349
BUS 10 - BUS 11	0.003	0.008	0.004	0.010	0.006	0.014	0.009	0.022	0.014	0.032	0.025	0.058
BUS 12 - BUS 13	0.002	0.001	0.003	0.002	0.004	0.003	0.005	0.005	0.007	0.006	0.011	0.010
BUS 13 - BUS 14	0.014	0.028	0.021	0.042	0.030	0.061	0.041	0.084	0.055	0.113	0.090	0.183

Fig 7: Losses results obtained from MATLAB

III. LOADING

LOADING / LINES	60% LOADING	70% LOADING	80% LOADING	90% LOADING	100% LOADING	120% LOADING
BUS 5- BUS 6	19.7&	22.1&	24.7&	27.4^	30.3^	36.4^
BUS 4 - BUS 9	6.4&	7.4&	8.3&	9.3&	10.3&	12.4&
BUS 4 - BUS 7	12.8&	14.4&	16.0&	17.6&	19.2&	23.3&
BUS 1 - BUS 2	73.6$	91.9#	110.8@	129.9!	149.4!	187.4!
BUS 1 - BUS 5	39.6^	47.5^	55.4$	63.4$	71.5$	88.6#
BUS 2 - BUS 5	24.9&	28.7^	32.3^	36.1^	39.8^	48.2^
BUS 2 - BUS 3	41.8^	48.8^	55.8$	62.9$	70.1$	85.5#
BUS 2 - BUS 4	33.3^	38.4^	43.5^	48.7^	53.9$	65.4$
BUS 3 - BUS 4	14.9&	17.1&	18.5&	21.0&	23.8&	29.2^
BUS 4 - BUS 5	37.1^	43.3^	49.6^	56.0$	62.5$	75.7#
BUS 6 - BUS 11	3.8&	4.6&	5.5&	6.6&	7.7&	10.2&
BUS 6 - BUS 12	4.4&	5.2&	6.0&	6.9&	7.7&	9.5&
BUS 6 - BUS 13	10.2&	12.1&	14.1&	16.1&	18.1&	22.4&
BUS 7 - BUS 8	10.0&	11.9&	13.4&	15.1&	16.8&	23.9&
BUS 7 - BUS 9	16.0&	18.6&	21.2&	24.0&	26.8^	33.0^
BUS 9 - BUS 10	5.6&	5.7&	5.9&	6.1&	6.3&	6.7&
BUS 9 - BUS 14	6.5&	7.2&	8.0&	8.8&	9.5&	11.2&
BUS 10 - BUS 11	2.2&	2.3&	2.7&	3.3&	4.0&	5.7&
BUS 12 - BUS 13	0.8*	1.1&	1.3&	1.5&	1.7&	2.3&
BUS 13 - BUS 14	2.9&	3.5&	4.1&	4.9&	5.6&	7.4&

Fig 8: Loading results obtained from MATLAB

Legend:
! Number of lines loaded beyond 125%
@ number of lines loaded between 100% and 125%
# number of lines loaded between 75% and 100%
$ number of lines loaded between 50% and 75%
^ number of lines loaded between 25% and 50%
& number of lines loaded between 1% and 25%
* number of lines loaded between 0% and 1%

C. RANKING OF CONTINGENCIES

I. LINE OUTAGE

SL NO	LOADING / BUS	60%		70%		80%		90%		100%		120%	
		PIV	PIF	PIV	PIF	PIV	PIF	PIV	PIF	PIV	PIF	PIV	PIF
1	1-2	12	1	8	1	13	1	17	1	1	1	1	1
2	1-5	14	2	9	2	8	2	9	2	10	10	3	2
3	2-5	11	11	7	11	7	11	7	11	9	2	16	11
4	2-3	10	3	10	3	11	3	8	3	11	3	2	3
5	2-4	15	4	12	4	9	4	10	4	8	5	17	4
6	3-4	4	6	5	7	6	6	6	6	12	4	9	6
7	4-5	9	5	13	5	10	5	11	5	15	7	15	5
8	6-11	8	8	11	8	14	8	13	8	13	8	11	8
9	6-12	13	9	14	9	12	9	12	9	17	6	10	10
10	6-13	16	7	17	6	17	7	16	7	16	9	12	7
11	7-8	17	10	16	10	16	10	15	10	14	12	14	9
12	7-9	6	12	15	12	15	12	14	12	7	17	13	12
13	9-10	7	16	6	16	5	16	5	17	3	13	8	17
14	9-14	5	13	4	13	4	13	3	13	4	16	7	13
15	10-11	3	17	2	17	2	17	2	16	2	15	5	16
16	12-13	1	14	1	14	1	15	1	15	5	11	4	15
17	13-14	2	15	3	15	3	14	4	14	6	14	6	14

Fig 9: Line outage results obtained from Mipower

II. TRANSFORMER AND LINE OUTAGE

SL NO	LOADING / BUS	60%		70%		80%		90%		100%		120%	
		PIV	PIF	PIV	PIF	PIV	PIF	PIV	PIF	PIV	PIF	PIV	PIF
1	1-2	12	1	8	1	13	1	17	1	1	1	1	1
2	1-5	14	2	9	2	8	2	9	2	10	10	3	2
3	2-5	11	11	7	11	7	11	7	11	9	2	16	11
4	2-3	10	3	10	3	11	3	8	3	11	3	2	3
5	2-4	15	4	12	4	9	4	10	4	8	5	17	4
6	3-4	4	6	5	7	6	6	6	6	12	4	9	6
7	4-5	9	5	13	5	10	5	11	5	15	7	15	5
8	6-11	8	8	11	8	14	8	13	8	13	8	11	8
9	6-12	13	9	14	9	12	9	12	9	17	6	10	10
10	6-13	16	7	17	6	17	7	16	7	16	9	12	7
11	7-8	17	10	16	10	16	10	15	10	14	12	14	9
12	7-9	6	12	15	12	15	12	14	12	7	17	13	12
13	9-10	7	16	6	16	5	16	5	17	3	13	8	17
14	9-14	5	13	4	13	4	13	3	13	4	16	7	13
15	10-11	3	17	2	17	2	17	2	16	2	15	5	16
16	12-13	1	14	1	14	1	15	1	15	5	11	4	15
17	13-14	2	15	3	15	3	14	4	14	6	14	6	14

Fig 10: Transformer and line outage results obtained from Mipower

VI. CONCLUSION

The study has been carried out for the contingency selection and ranking which are important for contingency analysis by evaluating two Performance indices namely:(PIV)Voltage Performance indices and (PIF)Overload Performance indices. These indices are calculated for IEEE 14-bus using the Fast Decoupled Load Flow(FDLF) method. By using Mi-power and MATLAB results have been verified.

REFERENCES

[1] Allen Wood and Woolenberg,"Power Generation Operation and Control",Wiley India 2nd Edition, 2009.

[2] Sttot B, Alsac O and Monticelli A.J,"Security Analysis and Optimization",Proc. IEEE,vol.75,No.12.pp.1623-1644,Dec 1987.

[3] Lee C.Y and Chen N,"Distribution factor and reactive power flow in transmission line and transformer outages",IEEE Transactions on Power system,Vol.7,No.1.pp.194-200,February 1992.

[4] Sttot B and Alsac O,"fast decoupled load flow",IEEE Transcations on Power Apparatus and systems Vol. PAS-91,No.5,pp-859-862.May 1974..

[5] Singh S.N and Srivastava S.C, "Improved voltage and reactive distribution factor for outage studies", IEEE Transactions on Power systems, Vol. 12, No.3, pp.1085-1093,August 1997.

[6] Peterson N.M, Tinney W.F and Bree D.W, "Iterative linear AC power flow solution for fast approximate outage studies", IEEE Transactions on Power Apparatus and Systems, Vol. PAS-91, No. 5, pp. 2048-2058, October 1972.