Diyala Journal of Engineering Sciences Vol. 13, No. 01, March 2020, pages 58 -65 ISSN 1999-8716
DOI: 10.24237/djes.2020.13106 eISSN 2616-6909

A Reliable and Economic Power System Dispatch

Jabbar Qasim Fahad
Al-Ma'mon University College, Department of Electrical Power Techniques.
Jabbarfahad54@gmail.com

Abstract

A line bus security index is added to the generation cost forming a new objective function a suitable for optimal power system dispatch. The value of this security index is directly proportional to the sum of the squares of voltages of both bus voltage and line flows. Normal as well as contingency states of a power system are successfully dispatched. Result obtaining during a normal state of both the 6-bus and modified 30-bus cost. Both systems are also dispatched when the outage contingencies are assumed. Successful dispatch results are obtained without any load shedding. Power system reliability is seen to be greatly improved through the present reliable optimum dispatch.

Keywords: Power system reliability; generation cost; power; bus voltage.

Paper History *:(Received :26-11-2016 ;Accepted :12-5-2019)*

Introduction

Conventional economic dispatch is usually carried out in two stages; the P-and Q-dispatches. The p-dispatch [4, 5] minimizes a generation cost function:

F(p)=$C_s(P_s)+\sum_2^{NG} C_i(P_i)$ (1)

Controls variables consider in the P-dispatch are active power of generators, except for slack generator. Since P_s is a state variable, only the power generations P_2, P_3…….P_{NG} are updated during each iteration of the minimization algorithms, while P_s calculated after load flow solution and Cs(Ps) is consequently evaluated.

The Q-dispatch [1,2,6,7] minimizes the total active transmission losses. Control variable of this dispatch comprise; the generator bus voltages, transformer taps, and reactive power of VAR-sources. The P-variable are fixed during the Q-dispatch. When Q-variable is allowed to change, transmission losses are dispatched and power injection from slack generator overcomes the active and reactive power imbalance of the system. The following points can, however, be abstracted:

1. Cost of slack generator C_s (P_s) depends on all control variables of both P-and Q- dispatches. It is noted that the cost function (1) comprises in addition to the P-variables and Q- variables, which are inherently included in Ps and C_s (P_s) (5,6).This applies that the fixed values of the Q- variables affected the result P-dispatch obtainable in each iteration.
2. Conversely, since the generator powers are fixed during the Q-dispatch the result of this dispatch are thought to be effected by those fixed P-variables.
3. The Q-dispatch results in the minimum active transmission losses. If these losses are added to the total and constant active power of system loads, it gives the sum of generators active power. Minimization of these losses, thus, means minimization of the total generation. It is thought (9) however, that the Q-dispatch is basically run in order to allow a dispatch of the Q-variables. Its results reduce the total power generation to a minimum. Remembering that the P-dispatch minimizes the total generation cost, the Q-dispatch is far away from the cost minimization because it minimizes only the total generation.
4. Decoupling between P-and Q-dispatches [10, 11,12,14] is theoretically impossible. Existence of slack generator is the reason for this inevitable coupling due to the following:

(i) $P_s$andC_s (P_s) depend on both the P- and Q-variable.

(ii) The variable transmission losses in Q-dispatch are relied to the existence of slack generator which can inject any power imbalance during fixation of power generations and load power.

5. Since the Q-dispatch minimizes the total power generations by minimizing transmissions losses and does not minimize the generation cost, the P-dispatch can be economically preferred on the Q-dispatch (6, 9) provided the Q-variables are allowed to change during this P-dispatch.
6. Unifying the two P- and Q-dispatches in a single one enables the dispatcher to a voided reversible switching usually made between P-and Q-dispatches (9, 13).

In this paper a new objective function is tested for economic dispatch. The function is the sum of the generation cost and line- bus security index. The index is the sum of penalized violations of both line flow and bus voltages. The DFP(Davidon-Flitcherpowell) method, previously tested by the author (8,9),is used to economically- allocate power generations, reactive powers of generators, and VAR-sources as well as transformer taps during normal state . Contingency studies are also carried out and a dispatch of the system is made when some expected line outage occur. All buses and line directly connected to the faulted line are excluded from the line –bus security index. The flows of these line and voltages of those buses are allowed to iteratively change within normal prescribed limits. The flows of other lines and voltages of other buses are included in the security index. Violations from precontingency values of these line flows and those bus voltages are penalized and added to generation cost to form the objective function during contingency. The results obtained from this economy security dispatch are compared other methods in that load shedding can avoided and reliability of the system is improvedthat load shedding can avoided, and reliability of the system is improved.

Diyala Journal of Engineering Sciences Vol. 13, No. 01, March 2020, pages 1 -8 ISSN 1999-8716
DOI: 10.24237/djes.2020.13101 eISSN 2616-6909

Mathematical formulation

In conventional P-dispatch the objective function to be minimized is the sum of generators costs (4) .Here the objective function is composed of two components. The first component is quadratic cost function of all generators (1).The second component is the line bus security index:

s=(L_j,V_j)=$\sum_{j=1}^{NL} ML_j(L_j - L_{jo})^2$+$\sum_{j=2}^{N} MV_j\ (V_j - V_{jO})^2$ (2)

Bus 1 is the slack; its voltage is fixed during the dispatch and is not included in this security index. Throughout subsequent iterations of an economic dispatch, the active power flows must be limited like all state and control variable of the system. Here the line bus security index has a line flow penalty term $ML_j(L_j - L_{jo})^2$.At the end of the dispatch the line flow Lj will generally violate its central valueL_{jo}, But with the lowest minimum violation. To possess suitable vulnerability for the line, its resulting line flow should be lower enough than its upper limit. This can be achieved when the base flow $L_{jo}$is suitably-defined by the dispatcher. A value L_{jo}as large as 80 percent of upper limit in both directions is adopted for a system in normal operating state .During contingency, however, L_{jo} is taken equal to the precontingency value in both directions for all lines far from contingency.

Base value of bus voltage

Bus voltage is assumed to be dispatch with on 0.95-1.05. The base value V_{jO}must be selected in this range. But since the bus voltage, like any state variable, will be updated through the iterative steps of the dispatch algorithm, it is adventurous to adopt a unified value for V_{jO} for small buses. A flat voltage profile of 1p.u is used here.

The objective function F(X) can, thus, be formed:

F(X) = $(a_s + b_s p_s + c_s p_s)^2$+$\sum_{j=2}^{NG}\ (a_i + b_i p_i + c_i p_i)^2$+$\sum_{j=1}^{NL}\ ML_j(L_j - L_{jo})^2$+$\sum_{j=2}^{N}\ ML_j(V_j - V_{jO})^2$ (3)

[X] =[$P_2 \ldots P_{NG} t_1 \ldots . t_{NT}$Q2…..$Q_{TNG}$] (4)

The set of control variables, X, contains the active powers of the generators, except the slack, transformer taps and reactive power of both generators and VAR-sources, while generator active power explicitly appear in the objective function, slack power, line flows as well as bus voltage, however, state variable through which all control variables can be dispacted.The load flow solution determines the power of slack generator, the line flows, and all the bus voltages except the slack bus. All the buses are treated as P-Q buses. Economy-security dispatch problem for contingency-free systems become:

For minimize F(X) subject to;

P_{i1}<$P_i < P_{i2}$i=1-TNG
Q_{i1}<Q_i>Q_{i2} i=1-TNG
P_i -P_{Di}-$\sum_j^i Pij$ =0
$Q_i - Q_{Di}$-$\sum_j^i Qij$ =0 i=1-N
0.95<V_i> 1.05 i=1-N
$-P_{iju}$<P_{ij}>P_{ij}All lines (5)

The gradient of the objective function can be evaluated;

$$\left[\frac{\partial F(x)}{\partial x}\right] = \left[\ \frac{\partial F(X)}{\partial p}\frac{\partial F(X)}{\partial t}\frac{\partial F(X)}{\partial Q}\right]^T \quad (6)$$

$$\left[\frac{\partial F(x)}{\partial t}\right] = \left[\ \frac{\partial F(X)}{\partial P1}\frac{\partial F(X)}{\partial P2}\ldots\ldots\frac{\partial F(X)}{\partial Pi}\ldots\ldots\frac{\partial F(X)}{\partial PNG}\right]^T$$

$$\left[\frac{\partial F(x)}{\partial p}\right] = \frac{\partial F(X)}{\partial t1}\frac{\partial F(X)}{\partial t2}\ldots\ldots\frac{\partial F(X)}{\partial ti}\ldots\ldots\frac{\partial F(X)}{\partial PNG}]^T$$

$$\left[\frac{\partial F(x)}{\partial Q}\right] = \left[\ \frac{\partial F(X)}{\partial Q1}\frac{\partial F(X)}{\partial Q2}\ldots..\frac{\partial F(X)}{\partial Qi}\ldots\ldots\frac{\partial F(X)}{\partial QTNG}\right]^T \quad (7)$$

$$\left[\frac{\partial F(x)}{\partial Pi}\right] = (b_i + 2c_i p_i) + (b_s + 2c_s p_s)\frac{\partial ps}{\partial pi} + \sum_{j=1}^{NL} 2ML_j\,(L_j - L_{j0})\frac{\partial L_j}{\partial P_j} + \sum_{j=2}^{NL} 2MV_j\,(V_j - V_{j0})\frac{\partial V_j}{\partial p_i} \quad (8)$$

$$\frac{\partial F(x)}{\partial ti} = (b_s + 2c_s p_s)\frac{\partial ps}{\partial ti} + \sum_{j=1}^{NL} 2ML_j\,(L_j - L_{j0})\frac{\partial L_J}{\partial t_J} + \sum_{j=1}^{NL} 2ML_j\,(L_j - L_{j0})\frac{\partial L_J}{\partial t_J} + \sum_{j=2}^{NL}\ 2MV_j\,(V_j - V_{j0})\frac{\partial V_J}{\partial t_i} \quad (9)$$

$$\sum_{j=2}^{NL} 2MV_j\left(V_j - V_{j0}\right)\frac{\partial V_j}{\partial Q_j}\left[\frac{\partial F(x)}{\partial Qi}\right] = (b_s + 2c_s p_s)\frac{\partial ps}{\partial Qi} + \sum_{j=1}^{NL}\ 2ML_j\,(L_j - L_{j0})\frac{\partial L_J}{\partial Q_J} \quad (10)$$

It is found, however, that a better formulation can be obtained when augmented gradients for both line flow $\frac{\partial Lj}{\partial x}$, and the bus voltage $\frac{\partial Vj}{\partial x}$ are used:

$$\frac{\partial Lj}{\partial x} = \sum_{j=1}^{Nl} ML_j(L_j – L_{jo})\frac{\partial Lj}{\partial x} \quad (11)$$

$$\frac{\partial Vj}{\partial x} = \sum_{j=2}^{N}\ ML_j(V_j – V_{jo})\frac{\partial Vj}{\partial x} \quad (12)$$

After line tripe a new dispatch is necessary to reallocate the power of generators and VAR- sources as well as transformer taps, which bring the system to the newoptimal dispatch. Line outage greatly affects the bus voltages and the lines flows of buses and the lines directly connected to the fault line .Other bus voltages and line flows far from contingency dispatch, bus voltage near contingency are allowed to be within their secure limits (5). As for lines near contingency, their power flows are constrained by their upper limits in both directions. This implies that these bus voltages and those line flows, near line trip, are excluded from the line-bus security index (2), and in the objective.

Function (3). The objective function during contingency becomes:

F(X)=$(a_s + b_s p_s + c_s p_s)^2$+$\sum_{j=2}^{NG}(a_i + b_i p_i + c_i p_i)^2$+$\sum_{j=1}^{NL} MLj(Lj - Ljo)^2$+$\sum_{j=2}^{N}\ MLj(Vj - Vjo)^2$ (13)

The economy–security dispatch problem during contingency has to be:

Minimize Fc(x),subject to the same constraints (5) .The base values for line flows and bus voltage during contingency dispatch (20,21) are assume to be equal to the their precontingency schedules.

Diyala Journal of Engineering Sciences Vol. 13, No. 01, March 2020, pages 1 -8 ISSN 1999-8716
DOI: 10.24237/djes.2020.13101 eISSN 2616-6909

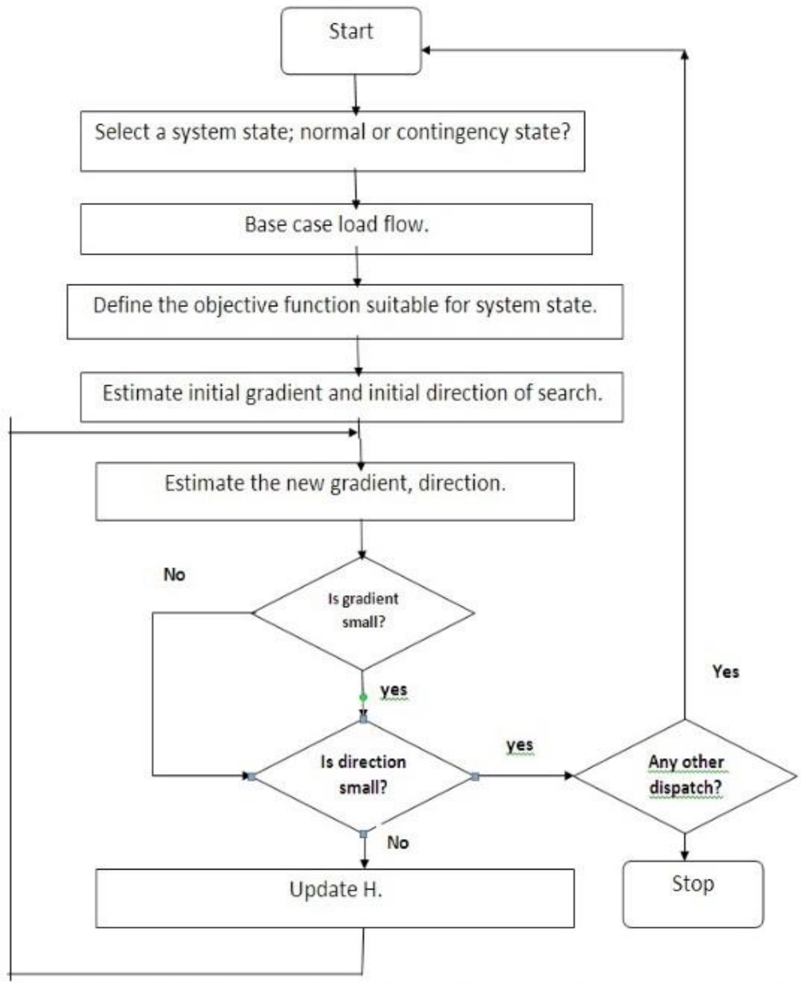

Fig (2) optimal dispatches for a system during normal or contingency state

Minimization Algorithm

The DFP-method of unconstrained optimization was previously tested by the author [8] and proved to be efficiently applicable for optimal dispatch. The DFP-procedure for cost-minimization, utilizes Powell's quadratic interpolation [14] as linear search method .Executive steps of such minimization algorithm is summarized here;

Step.1 Through a familiar starting point of the set of control variable evaluates the gradient of the objective function as defined (6-19).

Step.2 The direction of linear search is estimated;

$$d= -H\frac{\partial F(X)}{\partial x} \quad (14)$$

The positive definite matrix H is a given a unitary starting value, and is updated for each iteration in the dispatch [8, 15]

Step 3 In this direction d,powell's quadratic interpolations tried find the optimum correction of control variables which bring the objective function to new minimum.

Step.4 updated both; the gradient $\frac{\partial F(X)}{\partial x}$,and H ,and return to the step1. Minimization procedure comes to an end when both of direction and gradients reach a prescribed tolerance. Fig (1) illustrates steps (1-4) of minimization procedure.

Power Flow Limit of a Line

Active power transmission through the line connecting bus i to bus j can be express by the polar form;

$$P_{ij}=V_i^2G_{ij} - V_iV_j(G_{ij}cos\theta_{ij} + B_{ij}sin\theta_{ij})(15)$$

For all transmission line, the inductive impedances results in a susceptance component having negative sign. The power flow becomes;

$$P_{ij}=V_iV_jB_{ij}sin\theta_{ij}+G_{ij}(V_i^2 - V_iV_jcos\theta_{ij} \quad (16)$$

Diyala Journal of Engineering Sciences Vol. 13, No. 01, March 2020, pages 1 -8 ISSN 1999-8716
DOI: 10.24237/djes.2020.13101 eISSN 2616-6909

Assuming a flat voltage profile $V_{i=}V_j = 1\ p.u$

$P_{ij} = B_{ij} sin\theta_{ij} + G_{ij}(1 - cos\theta_{ij})$(17)

The maximum allowable power flow through a line is defined by considering both thermal and stability limits. The thermal is determined by an upper value of active line losses while stability limit is represented by an upper limit of transmission angle.

A maximum line angle of 0.2 radians can be adopted for a contingency-free system. During contingency, however, some line is inevitably subjected to higher power flow, due to an outage of one or more adjacent lines. It is necessary for a dispatcher to adopt a relatively higher value of line angle in order to increase reliability of a system during contingencies. In this paper, a maximum line angle of 0.4 rad is assumed to overcome both thermal and stability limits of a line in both normal and contingency states.Table.1 show the line impedance, admittance and estimated MW-flow limits of lines in the 6-bus system.

Table.2 shows the corresponding values for the modified IEEE 30-bus system. These MW-flow limits are estimated via (16) with 0.4 rad. Upper limit of transmission angle.

Numerical Results

Both of the ward and hale 6-bus [7] and modified IEEE 30-bus system, are dispatched. Generator power limits, cost coefficients, transformer taps and load data of both systems are given in Appendix.

The 6-bus system

The six-bus system, Fig(2) is dispatched for both normal as well as contingency states. For contingency-free system, the dispatch algorithm had completed 4-iterations to reach the lowest minimum generation cost of 5775.28$/Hr. Table.3 which indicates the pronounced improvement than the 588.609$/Hr. obtained by reference [9] for this system. Contingency dispatches made, included two cases for line outage, namely the outage of the line 2-5 and line 2-3 Lines and buses that are directly connected to the faulted line are excluded from the line -bus security index (2). During a dispatch, the power flow in these lines and voltages of those buses, are allowed to change within their accepted limits other lines and buses of the system are included in the line-bus security index and the objective function in which violation of bus voltage V_j , during iterative steps, is penalized to be around its precontingency value but in both directions.Table.4 show results of the bus voltage and MW-flows of buses and lines adjacent to contingency

Table.1 MW-flow limits of lines in the 6-bus system.

Line i-j	R_{ij}	X_{ij}	G_{ij}	$-B_{ij}$	MW-flow Limit
1-6	0.123	0.518	0.433	1.824	74.45
1-4	0.080	0.370	0.558	2.582	104.96
4-6	0.097	0.407	0.554	2.325	94.91
6-5	0.000	0.300	0.000	3.333	129.78
5-2	0.282	0.640	0.576	1.038	45.00
2-3	0.723	1.050	0.445	0.646	28.67
4-3	0.000	0.133	0.000	7.519	292.78

Table.2 MW-flow limits of some lines in the 30-bus system.

Line i-j	R_{ij}	X_{ij}	G_{ij}	$-B_{ij}$	MW-flow Limit
1-3	0.0452	0.1852	1.244	5.097	208.3
2-4	0.05750	0.1737	1.708	5.197	215.8
2-5	0.0472	0.1983	1.136	4.773	194.8
2-6	0.0581	0.1763	1.686	5.117	212.6
1-2	0.0192	0.0575	5.228	15.650	650.7
5-7	0.0460	0.1160	2.953	7.448	313.4
12-15	0.0662	0.1304	3.097	6.099	261.9
14-15	0.2210	0.1997	2.491	2.251	107.3
18-15	0.107	0.2185	1.807	3.691	158.0
22-24	0.1150	0.1790	2.541	3.995	174.1
23-24	0.1320	0.2700	1.462	2.989	127.9
25-26	0.2544	0.3800	1.217	1.817	80.4
25-27	0.1093	0.2087	1.967	3.765	162.1

Values of R_{ij} , X_{ij} , G_{ij} , $and\ B_{ij}$ are in p.u for a 100 MVA

Diyala Journal of Engineering Sciences Vol. 13, No. 01, March 2020, pages 1 -8 ISSN 1999-8716
DOI: 10.24237/djes.2020.13101 eISSN 2616-6909

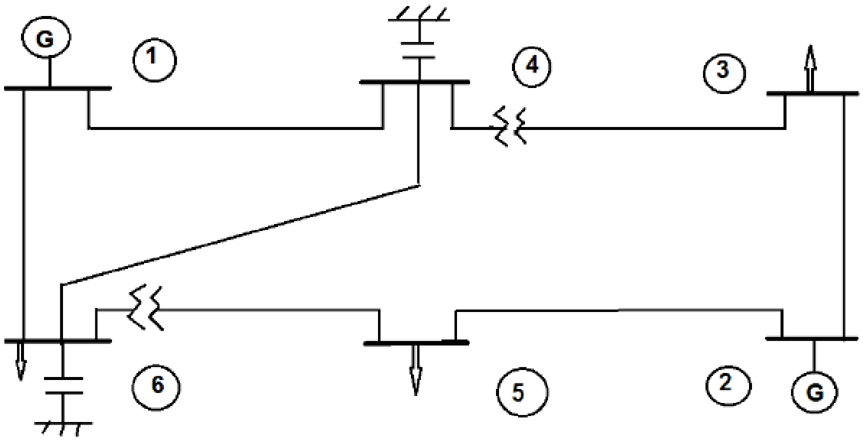

Fig (2) the 6-bus system

Table .3 optimal dispatch of the 6-bus system

Case	Total coast $/Hr	Off nominal taps% Bus 4	6	Generator MW P_1	P_2	Generator MVAR Q_1	Q_2	Q_3	Q_4
Normal case	575.23	2.5	5.5	89.5	547	31.6	29.3	4.2	2.6
Outage of line 2-3	584.80	4.4	4.2	90.6	540	28.8	30.2	5.0	2.1
Outage of line 2-5	598.46	1.2	7.5	93.0	480	22.5	23.1	3.4	3.7

Table .4 Dispatched bus voltages and line flows close to contingency in 6-bus

Outages of the line i-j	Buses connected to the line i-j	Bus voltage Before contingency	Bus voltage After contingency	Other line connected to bus i-j	MW-flow in line Before contingency	MW-flow in line After contingency
2-5	2	1.01	1.05	2-3	15.30	43.0
	5	0.96	1.01	5-6	-7.52	30.2
2-3	2	1.01	1.05	2-5	39.70	54.0
	3	0.97	0.95	3-4	41.8	55.4

The 30-bus system

In appendix-A table.5 show the results obtained for a dispatch of the 30-bus system in both contingency and contingency-free states. The four line outages, previously selected [13], comprise lines 1-2, 2-5, 15-23, and 24-25.

Contingency-free dispatch is ended after 3-iteration with a final minimum generation cost of 801.28/Hr. This is an improved figure for the generation cost if compared with 804.853$/Hr. [6] and 805.3$/ Hr. [13].

The same objective function is minimized to reallocate powers of generators and VAR-sources as well as transformer taps after a line trip. Table.6 shows the resulting voltage voltage of buses and MW-flows of the lines directly connected to any of the buses of a line trip.Table.6 in appendix shows the resulting voltages of buses and MW-flows of lines directly connected to any of the buses of a line trip. All the dispatched MW-flows are within their limits estimated in Table.2. The dispatched voltages of buses close to the contingency, In appendix-A Table.6, are not greatly their precontingency schedules.

Diyala Journal of Engineering Sciences Vol. 13, No. 01, March 2020, pages 1 -8 ISSN 1999-8716
DOI: 10.24237/djes.2020.13101 eISSN 2616-6909

Result and Discussion

In this paper a new objective function is suggested and test trough the present reliable and economic power system dispatch. This function comprises, in addition to the total generation cost, a line –bus security index which economically- limits the violations in bus voltages and line flows. During a contingency dispatch, the objective function contains penalized violations of only bus voltages and line flows that are not directly connected to the contingency, however allowed to vary within normal acceptable limits and are executed from the line –bus security index. Application made for 6-bus and 30-bus test systems show validity of the present reliable and economy-security dispatch contingency without any load curtailment.

Appendix -A

Table.5 optimal dispatch of the 30-bus system during normal and contingency states

case	Total Cost S / Hr	Off- normal Taps%				Generated MW						Generated	
		11	12	15	36	P1	p2	p5	p8	p11	p13	Q1	Q2
Normal case	801.28	6.3	6.1	4.3	5.8	162.5	77.1	16.5	9.9	9.8	12.0	16.2	24.7
Outage of line 1-2	840.72	5.2	6.7	3.8	6.3	152.0	90.1	18.1	10.0	11.0	13.0	16.8	26.1
Outage of line 2-5	925.98	6.5	5.7	3.2	5.3	160,0	69.	52.0	8.1	9.1	8.90	14.2	25.6
Outage of line 15-23	809.33	4.9	5.6	6.5	4.8	162.2	77.0	18.0	10.0	9.5	13.3	15.7	22.4
Outage of line 24-25	821.26	5.1	5.9	5.7	4.2	154.0	82.0	19.7	11	12	12.8	16.8	27.3

MVAR												
Q5	Q8	Q10	Q11	Q12	Q13	Q15	Q17	Q20	Q21	Q23	Q24	Q29
22.8	19.2	1.20	23.5	0.8	31.4	0.90	1.10	0.75	0.50	1.6	3.6	1.80
20.2	20.1	0.95	24,2	1.05	25.6	1.10	0.60	1.10	075	1.35	3.8	1.95
18.8	18.5	1.05	19,8	0.90	27.2	1.20	0.55	0.90	0.65	0.85	3.15	1.35
19.2	15.7	1.35	21.6	1.10	28.2	0.75	1.25	0.45	1.05	1.20	2.05	2.10
23.4	21,2	0.85	22.8	0.65	34.1	0.40	0.85	1.20	0.40	1.15	3.55	1.90

 ISSN 1999-8716
DOI: 10.24237/djes.2020.13101 eISSN 2616-6909

Table.6 Dispatched bus voltages and line flows close to the contingency in the 30-bus

Outage of the line i-j	Buses connected to the i-j	Bus voltage		Other line connected to bus i or j	MW-flow in line	
		Before contingency	After contingency		Before contingency	After contingency
1-2	1	1.03	1.050	1-3	94.4	152
	2	1.04	1,035	2-4	10	-16.3
				2-5	97.4	95.1
				2-6	15.0	-14.8
2-5	2	1.040	1.030	1-2	70.0	65.0
	5	1.025	1.045	2-4	10.0	32.0
				2-6	15.0	98.0
				5-7	15.0	52.0
15-23	15	0.950	0.970	14-15	2.3	1.9
	23	0.960	0.980	12-15	5.2	4.1
				18-15	3.2	2.6
				24-23	1.1	3.2
24-45	24	0.980	1.010	24-23	1.1	0.9
	45	0.960	0.950	22-24	6.5	10.1
				25-26	3.5	3.5
				27-25	6.4	3.9

List of search abbreviations

P, Q	Active and reactive power respectively
F (p)	Total generation cost
P_i	Active power of generation at bus i
$C_i(P_i)$	Cost of generation at the bus i
P_s	Active power at slack generator
C_s (P_s)	Cost of slack generator
NG	Total number of generators in the system
a_i,b_i ,c_i	Cost coefficients of generator at bus i
a_s ,b_s, c_s	Cost coefficients of slack generator
S(L_j,L_j)	Line-bus security index
L_j	Active power flow in line j \
L_{jo}	Base value of L_j
V_j	Voltage of bus j
V_{jO}	Base value of Vj
ML_j ,MV_j	Line flow and bus voltage penalties respectively
N	Total number of buses in the system

F(X)	Objective function during normal state
F_O(X)	Objective function during contingency
X	Set of control Variable
P_{i1}.P_{i2}	Lower and upper limits of generator active power at bus i
Q_{i1},Q_{i2}	Lower and upper limits of generator reactive power at bus i
P_{Di}	Active power of a load connected to the bus i
Q_{Di}	Reactive power of a load connected to the bus i
P_{ij}	Active power flow from bus I to the bus j
P_{iju}	Upper limits of Pij
Q_{ij}	Reactive power flow from bus i to bus j
NR	Number of VAR sources
NT	Number of tap-changer transformers in the system
TNG	Total number of generators and VAR-sources
n_o	Number of lines directly connected to a contingency
D	direction of linear search
H	Positive definite matrix related to the DFP-method
R_{ij}	Resistance of line i-j

Diyala Journal of Engineering Sciences Vol. 13, No. 01, March 2020, pages 1 -8 **ISSN 1999-8716**
DOI: 10.24237/djes.2020.13101 **eISSN 2616-6909**

Reference:

Paper in a journal

[1]. Quirino Morante, Nadia Ranaldo, Alfredo Vaccaro, *Member*, *IEEE*, and Eugenio Zimeo –"Pervasive Grid for Large-Scale Power Systems Contingency Analysis"; IEEETransactions on industrial informatics, vol. 2, no. 3, august 2006

[2]. Arfita Yuana Dewi, Sasongko Pramono Hadi, Soedjatmiko – "Contingency Analysis of Power System Electrical Operation"; Proceedings of the International Conference on Electrical Engineering and Informatics Institut Teknologi Bandung, Indonesia June 17-19, 2007

[3]. Prabha Kundur (Canada, Convener), John Paserba (USA, Secretary), Venkat Ajjarapu (USA) – "Definition and Classification of Power System Stability"; IEEE Transactions on power systems, vol. 19, no. 2, May 2004

[4]. Bosc p.p. van den'' optimal static dispatch with linear quadratic, and nonlinear function of the fuel costs''IEEE Trans.on power systems apparatus and system,Vol.PAS -104,no 12,December 1985 ,pp.3408.

[5]. Xu gueyu, galiane, and lows. ''Decoupled economic dispatch using the participation factor load flow''IEEE,Trans.on power apparatus and systems ,Vol.PAS-104 NO.6,June 1985,pp.1377-1384.

[6]. Sun D,T. and shoults R.R''A preventive strategy method for voltage and reactive power dispatch''IEEE Trans.on power apparatus and system,Vol,PAS-104,No.7, July 1985,pp.1670-1676.

[7]. Elangovan s.''New approach for real power loss minimization''IEE Proceedings, Vol.130 pt.c, No.6, November 1983, pp.295-299

[8]. Deyab M.S.''Optimum rescheduling of active and reactive powers using the dfp-method ''The bulletin of the faculty of Engineering Alexandria univ.1985, pp.13-26.

[9]. Lee K.Y,parkY.M. And Ortiz J.L.''A united approach to optimal reactive power dispatch'',IEEE Trans.on power apparatus and system ,vol.PAS.-104,No.5 May 1985 ,pp.1147-1153.

[10]. Burchett R.C,Happ H.H, and wirgan K.A.''Large scale optimal power flow'',IEEE Trans, on power apparatus and systems,Vol.PAS -101,No10 October 1982 pp.3722-3732.

[11]. Burchett R.S, Happ .H.H , Virath D. R. and wirgau k.A.''Developments in optimal power flow'' IEEE Trans.on power apparatus and systems,Vol.PAS-101,No.2 Febreuary,1982,pp.406-414.

[12]. Reymond R.S. and sun D.T. ''optimal power flow based on P-Q decomposition'' IEEE Trans.on power apparatus and systems, Vol.PAS-101, No.2 February, 1982, pp.397-405.

[13]. Jabbar.K. Fahad ''Secure power system Dispatch using the DFP-method, AL-Ma'moon college journal Baghdad Iraq Volume 20, 2012

[14]. Power M,J.D. ''An efficient method for finding the minimum of a function of several variables without calculating the derivatives ''computer journal,7,1964 pp.155-162.

[15]. Wals G.R.''method of optimization'' Wiley-interscience publications-1975