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Maximization of ATC under Fault Condition Using Differential Evolution

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Abstract: ***The optimal power flow based on available transfer capability proposed for contingent power systems. Generally, in power systems cost is the main objective. But in some areas cost is less importance such as under an emergency state of partial blackout. At that time transmission security is main objective. So, for transmission security, ATC is very useful. Maximizing ATC implies to reduce the probability of wide area block out as a consequence. This paper performs power systems of contingency analysis. After an occurrence specific component failure, implement proposed ATC based optimal power flow for contingent power systems using differential evolution (DE). For ATC salvation use IEEE14-bus test system.***

Keywords: Available Transfer Capability, contingency analysis, performance index, fuel cost, power losses

1. Introduction

Now a day's power systems are large, complex and power transfer quantities. Therefore, the power systems should be considered safe for man, equipment and environment. There were several severe blackout occurred somewhere in the world including Thailand. The case of well known power outage in Italy was dated on September 28, 2003 and this was caused by a power failure in France and Switzerland. The 2003 Italy black out resulted in power outage for about 15% of the whole country. In Thailand, the serious black out was taken place over three decades ago (March 18, 1978).This blackout was caused by the failure of the generator at south Bangkok power plant. The whole area blackout can probably be happened in future cannot be done efficient power system planning.

As mentioned it is necessary to consider the optimal operating point after some equipment failure occurs in the power system. The planning must be done before on actual outage is really happened. Under abnormal condition contingency analysis of power systems [1] is a powerful tool. To increase reliability and safety of the power system, contingency analysis with ATC based optimal power flow has been proposed in this paper in order to maximize the security of transmission system.

2. Contingency Analysis with ATC Based Optimal Power Flow

The contingency occurs for any of collapsing one by one or multiple devices. In this paper, only considered first order contingency. After an occurrence of some specific component failure it is necessary to find an optimal operation. Since the contingency analysis is based on simulation of power system operation under equipment failure, it is time consuming process to complete this study. This process can be shown in figure 1.

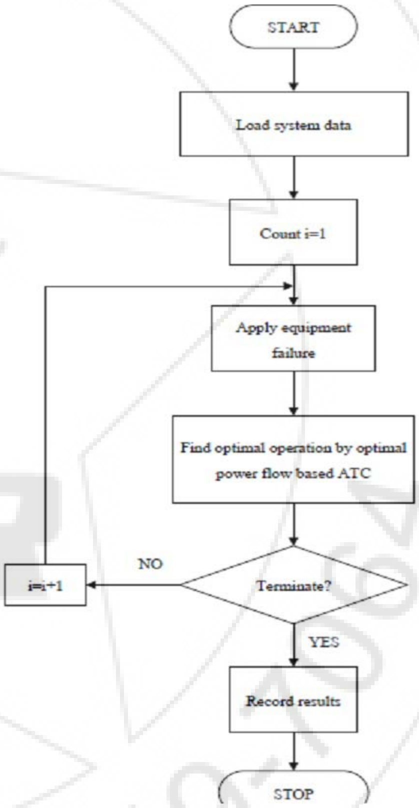

Figure 1: Flow diagram for Contingency Analysis

There are thousands of possible outages for contingency analysis to be studied. This can cause lengthy time to complete task. One of the easiest ways to evolutes transmission security performance. Some sensitivity factors are used e.g. generation shift factor line outage distribution factor active power performance index can be employed.

In this paper optimal power flow problem under some equipment failure as been studied. Under equipment failure objective function different from that of the normal OPF problem. ATC is chosen as the objective.

According to the report of NERC [2], transfer capability refers to the ability of transmission system to reliably

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transfer power from one area to another over all transmission paths between those areas under system conditions. The mathematical definition of ATC given in the report of NERC is, the Total Transfer Capability (TTC) less the Transmission Reliability Margins (TRM), less the sum of Existing Transmission Commitments and the Capacity Benefit Margin (CBM): that is

$$ATC=TTC-TRM-ETC \quad (1)$$

The evaluation of ATC can be formulated as an optimization problem the objective function to be maximized is expressed as (2) and be optimization problem subjected to some constraints.

$$\text{Maximize ATC} \quad (2)$$

3. Differential Evolution

According to the description by Storm and Price [3], the classical differential evolution algorithm can be outlined in the following steps.

A. Initialization

Create answer to the decision variables. (X_i) There are NP sets. The decision variables, D. The calculation of the objective functions of each answer.

B. Mutation

Create tangent vectors of NP sets. (Target vector, $X_{i,G}$ variables, D) 3 random vector that is unique to the tangent vectors. ($X_{r1,G}$, $X_{r2,G}$, $X_{r3,G}$) Mutation (Mutation. $V_{i,G+1}$) by using the equation.(3)

$$Vi,G+1=Xr1,G+F(Xr2,G–Xr3,G) \quad (3)$$

F is weighing factor between 0 to 2

C. Crossover:

The crossover Answer varied according to Equation (4).

Uji,G+1=(U1i,G+1,U2i,G+1,U3i,G+1………,UDi,G+1)

$$\begin{cases} Uji,\ G+1 = (Vji,\ G+1 \text{ if } (randb\ (j) < CR \text{ or } j = rnbr\ (i) \\ (Xji,\ G+1 \text{ if}(randb\ (j) > CR or\ j\ rnbr\ (i) \end{cases} \quad (4)$$

Where

Uji, G+1 = Trail vector

Xji, G+1 = Mutant vector

Vji, G = Target vector

Randb (j) = is a randomly chosen index to ensure that at least one of the variables should be changed between 0-1.

CR = Crossover Constant There is a real number between 0-1.

Rnbr (i) = is the index of the random integer value between 0 – D-1.

D. Selection

The objective function values obtained from trial Vector ($U_{i,G+1}$) and target vector ($V_{i,G+1}$) . Vector that gives a better answer than to be stored. Repeat steps 2 through 4.

4. Simulation Results and Discussion

In this paper, the standard IEEE 14-bus test system [4] was used for test as shown in Figure 2.

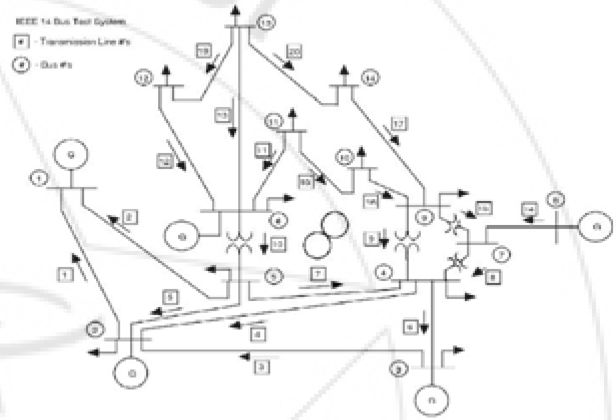

Figure 2: IEEE 14-bus test system

In this paper, optimal operation of contingent power systems based on ATC objective consideration was investigated. The simulation was conducted by performing the first-order contingency by the outage of equipment. The transmission line outage can be considered as 23 separate cases, while generator outages and transformer outages are 4 and 3 cases respectively.

Due to the limit of spaces, only four cases of the transmission outages were discussed (see Fig. 2). When applying for line 1-2 case outage measure the performance of fault implemented contingent power system in Table I. Measure the performance of proposed differential evolution algorithm implemented contingent power system in Table II .From two tables Table II is the best optimal solution.

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Table 1: Performance measure fault implemented contingent Power systems

Branch no	*Bus no*	*To Bus no*	*ATC(MW)*
1	1	2	1027.0000
2	1	5	1207.6000
3	2	3	1026.8000
4	2	4	1027.2000
5	2	5	1027.4000
6	3	4	1027.4000
7	4	5	1027.2000
8	4	7	1027.4000
9	4	9	1027.4000
10	5	6	1027.0000
11	6	11	1027.0000
12	6	12	1027.2000
13	6	13	1027.0000
14	7	8	1026.8000
15	7	9	1027.4000
16	9	10	1027.4000
17	9	14	1026.8000
18	10	11	1027.2000
19	12	13	1027.2000
20	13	14	1027.0000
Results for 1st order contingency			
ATC : 1027.170 PI : 4.769 COST : 1045.000 LOSS : 5.659			

Table 2: Performance measure contingent power system with DE

Branch no	*Bus no*	*To Bus no*	*ATC(MW)*
1	1	2	1129.4000
2	1	5	1128.8000
3	2	3	1129.4000
4	2	4	1129.4000
5	2	5	1129.2000
6	3	4	1129.4000
7	4	5	1129.4000
8	4	7	1129.4000
9	4	9	1129.2000
10	5	6	1129.0000
11	6	11	1129.2000
12	6	12	1129.0000
13	6	13	1129.2000
14	7	8	1128.8000
15	7	9	1129.4000
16	9	10	1129.6000
17	9	14	1128.8000
18	10	11	1129.2000
19	12	13	1129.6000
20	13	14	1129.2000

Results for 1st order contingency
ATC : 1129.230 PI : 4.615 COST : 1050.200 LOSS : 5.012

5. Conclusion

This paper proposed the ATC based optimal power flow for contingent power system using differential evaluation. In a single component outage occurs system must be operated at a safe and also secured operating point. This paper employed the IEEE 14-bus test system to compare fault implemented contingent power system with proposed differential evolution algorithm implemented contingent power systems using measured values. The result showed that the ATC based optimal power flow can guarantee a safe and secure operating condition under a specific component outage.

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