

Exploring the Optimal Control of Power system's Operational Reliability

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Abstract. With the rapid development of power industry in China, academic research on power system is also gradually deepening. How to ensure the reliable operation of power system and minimize operating costs has become a hot topic in academic research. Therefore in this paper, we explore the optimal control of power system's operational reliability in detail. Hopefully, our study could bring some inspiration to relevant researchers.

Introduction

At the current level of science and technology, we cannot eliminate risks during the operation of power system, which means a lot of uncertainty always accompanies the power system. What we can do is to minimize the uncertainty of power system and reduce operating costs of the power system in this process. Only in doing this will the better development of power industry in China gain more powerful support.

Overview of the Optimal Control of Power System's Operational Reliability

To complete this paper with high quality, first of all we need to gain a deep understanding of the concept of optimal control of power system's operational reliability. Tab. 1 defines this concept in detail. From this table, we can easily find that evaluating costs and benefits of the system's operational reliability quantitatively was the basis of this study.

Tab. 1 Definition of the Optimal Control of the Power System's Operational Reliability

Costs of operational reliability	Expected operating costs of the system under various disturbances
To enhance operational reliability	To reduce outage cost;
The optimal control of operational reliability	To look for the system's optimal operating points and coordinate costs and benefits

In an actual survey conducted by the author, it was found that the operational reliability, which had been widespread in academic circles in recent years, was somewhat similar to online control. But combined with the goal of the optimal control of power system's operational reliability, we can see their differences more intuitively. Tab. 2 shows a comparison between the optimal control of operational reliability and online control. From this comparison, we can gain a deeper understanding of the subject of this paper [1].

Tab. 2 A Comparison between the Optimal Control of Operational Reliability and Online Control

Control Strategy	Basis	Purpose	Control Variable	Objective Function	Algorithm
Optimal Control	Evaluation of costs of operational reliability	To coordinate costs and benefits of operational reliability;	Active output and reactive output of generator, etc. Load shedding amount of load nodes, etc.	To minimize expected social cost;	Intelligent optimization algorithm;
Online Control	Evaluation of operational reliability;	To evaluate operational reliability;		To minimize control cost	Intelligent optimization algorithm;

The Model and Algorithm of the Optimal Control of Power System's Operational Reliability

A. The evaluation of costs of operational reliability

To ensure the better proceeding of follow-up studies, the evaluation of costs of operational reliability must arouse our attention. Here, the indexes of costs of operational reliability can be expressed with the following formulas:

$$E_{TOC}(t) = \sum_{m \in N_G} \sum_{K \in S} P_k(t) F_{Gm}(P_{Gmk}(t))$$

$$E_{TIC}(t) = \sum_{m \in ND} \sum_{K \in S} P_k(t) F_{Gi}(VC_{ik}(t))$$

$$E_{TSC}(t) = E_{TOC}(t) + E_{TIC}(t)$$

Where $E_{TOC}(t)$, $E_{TIC}(t)$ and $E_{TSC}(t)$ refer to the expected operating cost, expected outage cost and expected social cost of operational reliability at the time t in the future. From here, we can determine the formula of outage cost, i.e., $F_{Ci}(C_{ik}(t)) = C_{ik}(t) I_{EARi}$. Further on, given the non-aftereffect property of Markov process, we identified the cycle of computing control strategy as 1h. Thus, we can obtain an algorithm to evaluate costs of operational reliability. The algorithm was obtained according to the flow chart shown in Fig. 1 [2].

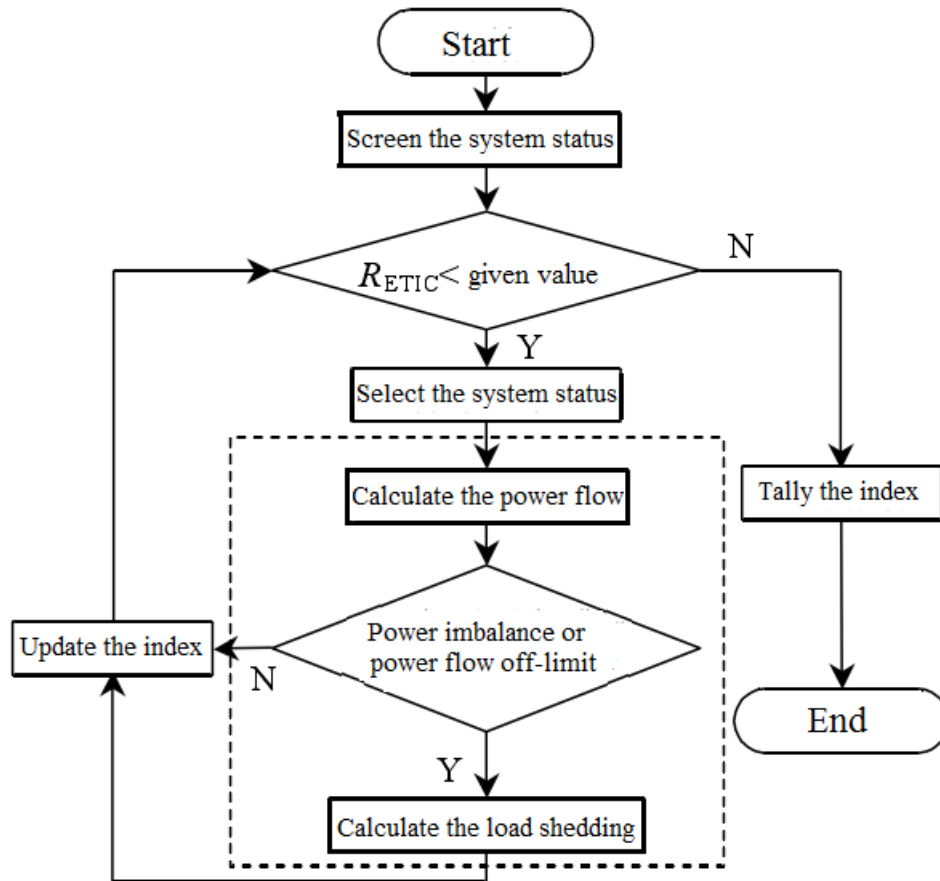


Fig. 1 The Flow Chart of the Algorithm to Evaluate costs of operational reliability

B. The model of the optimal control of operational reliability

In this paper, when determining the model of the optimal control of operational reliability, since this model mainly provided an initial operating point for the system, we must clarify control measures that we can take during this process, i.e., to adjust the active output and reactive output of generator. These required us to expand on the basis of the evaluation of reliability costs. From this, we can obtain a mathematical model for the optimal control of operational reliability, i.e.,

$$s.t. U_{i0} \sum_{j=1}^{nb} U_{j0} (Gi_j \cos \delta_{ij0} + Bi_j \sin \delta_{ij0}), \text{ etc.}$$

After determining the mathematical model for the optimal control of operational reliability, we needed to study how to implement the algorithm. Considering that the proposed model of the optimal control of operational reliability in this paper involved the evaluation of costs of operational reliability and the model itself was a highly nonlinear stochastic programming issue, we strove to convert it into a deterministic algorithm to complete the present study successfully. For the sake of feasibility, we selected particle swarm optimization to undertake this conversion. The position of particle in the algorithm was just a controlled variable of the optimization calculation. The fitness of particle was equal to the value of objective function. By means of power flow calculation, we can eliminate equality constraint produced by the process of conversion. Tab. 2 shows a flow chart of the algorithm of the optimal control of operational reliability. From this chart, we can better understand the study in this section.

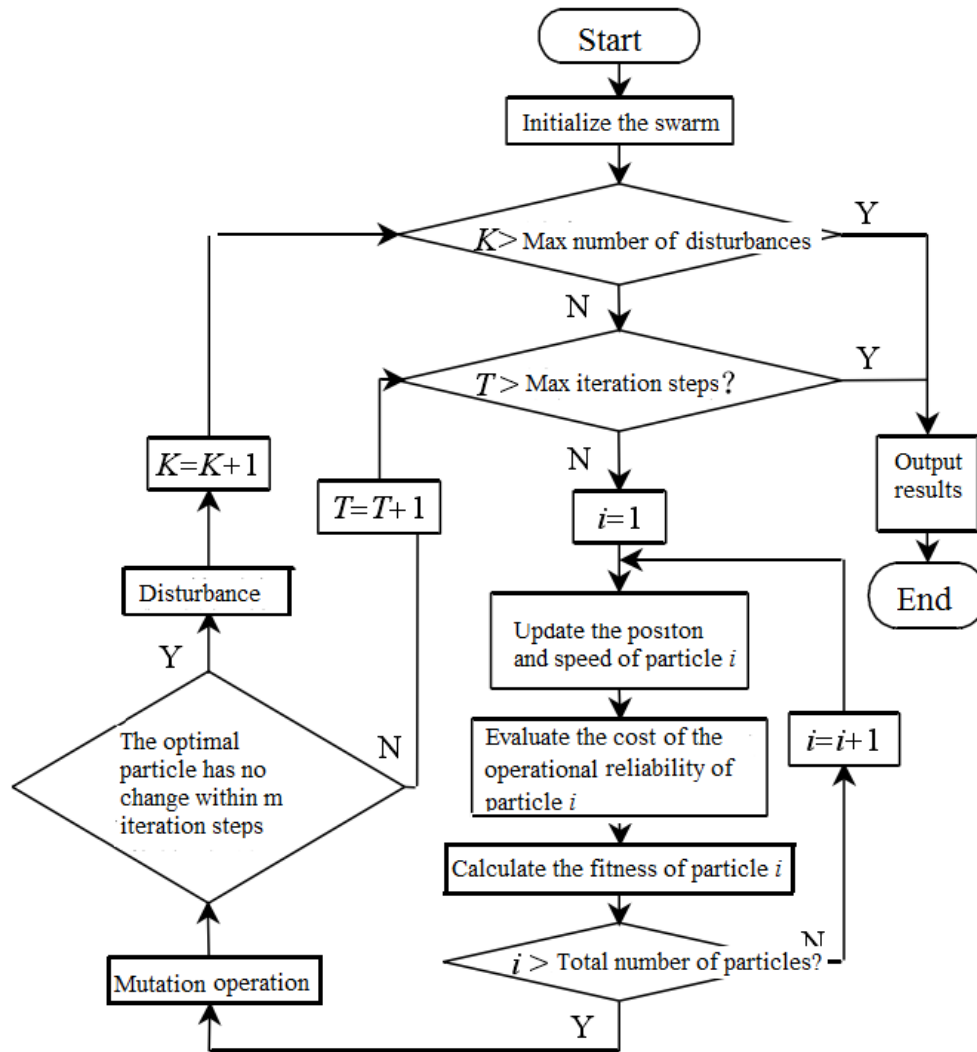


Fig. 2 The Flow Chart of the Algorithm of the Optimal Control of Operational Reliability

Analysis of a Calculating Example

To better complete the study in this paper, the author selected IEEE RTS-79 reliability test system as the research object. Tab. 3 shows parameters related to the system visually. Thereby, the author

determined the minimum deterministic generating cost, i.e.

$$D_{TOC}(t) = \sum_{m \in NG} F_{GM}(P_{Gmk}(t))$$

Considering the difference between optimal power flow and security constrained optimal power flow criteria, the author identified the indexes of costs of the system's operational reliability after different control strategies, as shown in Tab. 4.

From this, the author found that the optimal control of operational reliability studied in this paper can minimize expected social cost, which made it possible to coordinate operational reliability and costs, which were hard to achieve before.

Tab. 3 Parameters of the Calculating Example

System Load	Total Capacity	Installed	Number of Generators	of	Bus
3850MW	3405MW	32	Size of Particle	24	Mutation Probability
Predicted Time	Index Accuracy	200	Swarms	0.3	
60min	RETIC>90%	Convergence	Convergence		
Start Condition of Disturbance	Criterion 1	Criterion 2	Total Iteration		
m=10	10 disturbances	Steps: 100			

Tab. 4 Indexes of the Costs of the System's Operational Reliability

Control Strategy	ETOC	ETSC	ETI C	DTOC
Optimal Control of Operational Reliability	32110.5	32128.97	18.4	34074.8
Optimal Power Flow	33724.6	33737.74	13.0	34927.9
Optimal Power Flow	32808.4	334553.8	645.	33172.3

Conclusion

In the present study on the optimal control of power system's operational reliability, the author elaborates on the concept of optimal control of power system's operational reliability, the model, algorithm and analysis of a calculating example of the optimal control of power system's operational reliability. Combined with this series of work, we can gain an in-depth understanding of the optimal control of power system's operational reliability. Hopefully, this cognition could bring some inspiration to relevant researchers.

References

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