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The Research of the Smart Automatic Voltage Control(Smart AVC)

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Abstract

This paper begins with a brief introduction to the basic knowledge of Smart, as well as the drawbacks of traditional AVC. Then from four aspects, it expounds Smart AVC's main function comprehensively. By some problems of the conventional AVC's practical application connecting with the actual situation and the new functions of the Smart AVC, this paper points out that the conclusion of Smart AVC is inevitable. It also points out that the future development direction of the Smart AVC.

Keywords: Smart AVC; ”self-healing” ; multi-objective; online control , prevention and evaluation; new energy.

1. Foreword

Smart AVC is an important part of the smart grid’s construction. The technology features of the Smart AVC is information, digitization, automation, and interactive. In Smart AVC’s system’s design and application, it can use structural systematic, fine analysis, intelligent control and interactive harmonization to reflect specifically. At present, the Smart AVC’s building still belongs to the concept level, and its specific implementation is confronted with great difficulties. Simple Smart AVC is not a simple and direct

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organization and integration. It requires co-endeavour between power generation, power supply, users and academia and the engineering profession for smart AVC. In the near future, I believe that Smart AVC will be achieved in our country and it will bring incalculable benefits for our lives and the power grid. Smart AVC system can control the grid real-time operation status, detect and eliminate hidden faults. In the participation of less labor, it can avoid blackouts caused by voltage and has the grid self-healing capabilities. In addition, the Smart AVC can optimize grid operation, support the access to solar, wind and other good distributed power, and reduce the power costs and increase supply reliability [1,2].

2. Traditional AVC and Smart AVC

Domestic reactive power and voltage control (Traditional AVC) began in the 1980s, its control mode has undergone VQC (voltage and reactive power control system of substation), centralized automatic voltage control based on the whole network optimization, the tertiary voltage control of the entire network based on "soft" the partition, the distributed control based on the whole network optimization.

Traditional AVC can solve voltage qualification rate and power factor qualified rate, reduce the net loss rate and effectively reduce the sub-connected switches of power transformer, capacitors, the number of action times of the electric reactor equipment .And traditional AVC play an important role in these facets. But it exists the fault that adjustment process is not enough narrow, and it is not able to achieve the goal of the true sense of reactive power site and stratified balance finely. What’s more, it also cannot control voltage fluctuations completely reasonably and cannot be self-healing to recover voltage in the grid failure [3,4]. Finally, it claims that the control mode of traditional AVC play an important role in its special field. But due to the imperfections of its function, there are a series of much-needed improvements in the operation, which determines the development of the Smart AVC is required.

3. Propose and study of the main function of the Smart AVC

The building of Smart AVC need to address not only the traditional AVC’s existed problems, but also to respond to the new problems that may arise in the smart grid actively. Smart AVC’s objectives are as follows: The research and development of Smart AVC should be carried out on the basis of the traditional AVC, and it could be compatible with traditional AVC, reduce waste, optimize resources. Smart AVC is not subject to any channel or grid failure factors. The results from distributed computing adapt to any changes in the operation mode functionality. Smart AVC creates self-healing rely on the closed-loop control system formulated by in-place calculating compensation. It can avoid the purpose of the power outage due to voltage problems, and can effectively resist the attack to help the grid to improve disaster prevention capacity; and is able to handle huge amounts of data, reactive scheduling and active coordination of scheduling [1,5].

The following is from the four aspects study Smart AVC amply:

3.1 Smart AVC and grid "self-healing"

Smart AVC’s self-healing function is the ability that the system can restore the voltage level in the case of little or no human intervention when grid causes voltage collapse accident. Essentially the grid quickly achieves the capacity of local reactive balance. To achieve smart grid’sself-healing, the core is real-time decision-making online, realizing trouble-free and stable operation, small fault autonomy run. Preventing the occurrence of cascading failures of large area is grid’s self-prevention and self-recover when the big failure event occur.

To achieve the Smart AVC's self-healing function and draw on the power grid running state, the running state of the smart grid could be partitioned first and the nature of the work that it can be divided into a very fragile area, fault disturbance area and repair and maintenance area when the running state is abnormal. After performing workspace, three non-normal zone can be controlled respectively, and ultimately ensure the grid to optimize the control grid of run in the normal zone. So the grid realizes the optimization run, and optimize the allocation of grid resources. In this way, the power grid operation can be divided into the following five areas: optimized operation zone, routine operation zone, abnormal and vulnerable zone, contingency and fault zone and repair maintenance zone.

3.2 optimization modeling based on Smart AVC multi-objective

The multi-objective reactive power optimization modeling of Smart AVC system is transformed by single objective function optimized by traditional power system reactive power flow. The model is:

$$f(x) = \begin{cases} \min(P_{Loss}) \\ \max(\delta_{\min}) \\ \min(\Delta V) \end{cases}$$

Where, $\min(P_{Loss})$ indicates the minimum system active power loss, $\min(\Delta U)$ presents the best System load node voltage level (the minimum voltage fluctuations), $\max(\delta_{\min})$ shows the maximum System voltage stability margin.

Reactive power flow optimization's equality constraints mainly contain flow equations' equation equality constraints, the constraints of control variables (transformer taps' regulation, reactive power compensation capacity's determination, the generator terminal voltage's regulation), which must meet the system power flow equations.

Reactive power flow optimization's variable constraints mainly contain the state variables constraints and control variable constraints, in which the control variable is divided into a variable transformer voltage ratio, reactive power compensation capacity and the generator terminal voltage; and state variables is divided into each load node voltage and injection reactive of power generator and the maximum transmission capacity restriction.

3.3 Smart distribution grid and distribution network AVC

The smart distribution network is an important part of the smart grid, which is related to our smart grid which can be successfully achieved or not. Compared with the traditional distribution network, the smart distribution network has the following characteristics:

1) It has higher supply reliability. It has the ability to withstand natural disasters and external damages, and intelligent processing of real-time prediction of grid security risks and minimize the impact of the distribution network fault on the users.

2) It has higher quality power. It uses advanced technology for power electronics and power quality monitoring and compensation techniques to achieve optimization of reactive power and voltage control. It can ensure voltage uninterrupted power quality sensitive equipment, high quality, and continuity of supply.

3) It is more interactive. It supports in the distribution network access to a large number of distributed power generation unit, energy storage, renewable energy, and the seamless connection to distribution network. And it supports micro-network operation, and increases the flexibility of the distribution network run and load reliability of supply.

The key technologies of smart distribution network AVC is: Intelligent distribution network is a highly open network system, each part of the system can be a two-way communication achieved through the establishment of an advanced communication system. Smart distribution grid AVC carries its own software tools, which are highly integrated interface, trends, reports, and other services within the database, making the system more simple and effective. Smart distribution grid AVC can finely display real-time conditions and matters in the man-machine interface, and can choose to display the conditions and events, event playback, update speed information according to user requirements.

3.4 Smart AVC acceptance of renewable energy

In recent years, with the gradual increase of the energy crisis and the growing awareness of environmental protection, wind power and photovoltaic power generation are increasingly important, and they have become the most promising renewable energy power generation. As the most potential for development of renewable energy generation technologies, wind power has a rapid development in China, and a lot of them are access to the distribution network. Due to random and intermittent of wind energy, wind turbine output power changes with wind speed randomly, and wind farms and network will interfere with the normal operation of the existing distribution system. Therefore, the wind farm active power control incorporated into the distribution network, the reactive voltage regulator and optimized operation with the grid have a widespread concern. Reactive power and voltage control of the traditional grid, by changing the OLTC transformer voltage ratio and switching capacitor banks regulator, reduces network losses and improve voltage quality, when voltage quality requirements are met. Thereby, it enhances the power distribution economy and security of the network operation. The large-capacity wind farms and network operation will interfere with the normal operation of the existing distribution network voltage regulation equipment, and even lead to the distribution network voltage control function failure seriously and affect the optimal operation of the power grid.

Smart AVC system start to use analysis, research and analysis of the equivalent model of wind turbine access system and flow calculation method through the access of renewable energy, especially wind power equivalent model. And it finally studies double-fed motor wind farm network control reactive power voltage optimization, and obtains wind power grid optimization model and method.

4. Conclusion

This paper prospects and studies future Smart AVC grid "self-healing", smart AVC multi-objective optimization modeling, smart distribution grid and distribution network AVC, new energy equivalent access and other features of the model based on the analysis of the drawbacks of traditional AVC. And it describes the new features of Smart AVC different from the tradition AVC in details, and provide new ideas and directions for the future development and improvement of Smart AVC.

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