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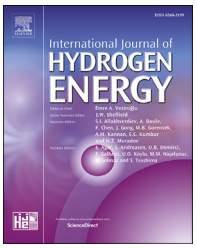

Research on influence and resolution of the relay protections with electric vehicle charging station integrating into distribution network

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ABSTRACT

Electric vehicles have been widely used because of its significant environmental effect, study the influence of the relay protection when electric vehicle charging station integrated into network is important. Three section current protections are configured in distribution network. In this paper, the equivalent model of the charging station is access to distribution network, different fault locations are set up, and the setting value of the corresponding protection are compared with the fault current, finally the impact of the three section current protection is analyzed. A model is built in PSCAD to verify the correctness of the analysis.

Introduction

Electric vehicle (EV) has many advantages, such as high torque, zero pollution, low noise, etc. EV is developed in order to relieve the double pressure of energy resource and environment preservation. Moreover, the capabilities of peak shaving and voltage regulation and the reliability of power supply network could be enhanced by EV charging station. When EV charging station is switched into power distribution grid, it is important that the influences on system protection and the configuration issues are researched, for promoting EV and keeping system security and stable [1,2].

At present, there are many researches on EV. Ref. [2–4] focused on the load characteristics of EV charging station.

Power characteristics for charging station were studied in Ref. [5], and this paper pointed out that there were two kinds of charging modes, slow charging mode and rapid charging mode. The former has the disadvantages of small charge current and long time to charge. However the latter was beneficial to the promotion of EV in the view of its merits, such as larger charge current and shorter time to charge. But the rapid charging mode tended to cause a short duration load fluctuation and a massive impact on the power distribution grid. And on account of harmonics injection, the power quality would be reduced.

The influences of EV charging station on the power distribution grid have been studied now. In Refs. [6–9], this problem was analyzed from two aspects separately, which were power loss and voltage deviation. And the quantitative evaluation of

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the same issue, by means of quadratic programming model and dynamic programming model, was proposed in Ref. [10]. Ref. [12–15] presented the harmonic influences on the power distribution grid from the aspects of simulation model and control strategy of charging station.

However, there are less studies about the influences of EV charging station on the relay protection of power distribution network. And the mechanism of the influences of EV charging station on the relay protection of power distribution network was merely mentioned in Ref. [11]. When EV charging stations are integrated into power distribution network, three-section current protection is applied [6]. Firstly an equivalent model of charging station is presented, then the influences of EV charging station on three-section current protection are studied under the setting principle of three-section current protection. Furthermore, when the EV charging station and normal load are integrated into power distribution grid respectively, the differences of current and voltage are analyzed. Considering of the differences between electrical elements for these two systems aforementioned, a method based on the low-voltage opened over-current protection, is presented to improve the sensitivity of back-up protection device.

Finally a model is built in PSCAD to verify the correctness of the analysis.

Load model of charging station

Before researching the protection of power distribution network, the changes of electric parameters of the whole charging station system need to be analyzed. Because the load changes greatly, the load fluctuation models are studied in the cases of both the slow charging mode and rapid charging mode, respectively. As illustrated in Ref. [4], a holistic approach to the system model is taken to simplify charging station model, in consideration that high-frequency charger is almost in constant power condition during charging process.

At present, the block diagram of EV charger which is mainly researched and used, is shown in Fig. 1. Three-phase ac power source can be converted into direct current by three-phase-bridge uncontrolled rectifier. And the filtered direct current is used as input signal of high-frequency dc/dc power converter. Meanwhile the power battery is charged by the filtered output signal of dc/dc power converter.

The load fluctuation of EV charging station is comparatively large. The output power of each charger varies depending on the types of power batteries, state of charge (SOC), charging mode, and so on. The equivalent structure of charging station is applied to simplify analysis. Because high-frequency switches are adopted in charger and load character is close to pure resistor element, the power factor of charger is very high, even nears to unit 1, Thus the high-frequency input power converter can be instead by resistor in the region of low frequency. The correspondence relation between charging power and equivalent resistance is expressed in (1).

$$R_C = \frac{U_B}{I_1} = \frac{U_B^2}{P_1} = \frac{\eta U_B^2}{P_0} = \frac{\eta U_B^2}{U_0 I_0} \quad (1)$$

where, η is charger efficiency, and I_1 and I_0 are the input and output current, respectively.

The equivalent resistance can be calculated by the corresponding values of high-frequency power converter, and changes with the load of charging station.

The influences on three-section current protection of distribution power network

Petersen-coil grounded way and neutral non-grounded way are widely used in distribution power system, which usually adopts three-section current protection. Considering that short-circuit current will sharply increase, an current increment protection method is proposed in this paper.

Under the condition that only one side of line current can be achieved, a nice three-section current protection method is designed for the purpose of perfect coordination of relay protection. On the premise that both reliability and selectivity are guaranteed, the purposes of the first section current protection is to ensure quickness. The goal of the second section current protection is to ensure sensitivity. And the remaining section current protection is acted as a backup protection. The combination of these three sections is typically used for satisfying four demands (selectivity, sensitivity, rapidity and reliability). Engineering practices show that the merit of this protection technology is that the relay operation has satisfactory reliability and high possibility of setting. The influences of EV charging station integrated into distribution grid on three-section current protection are analyzed as follows.

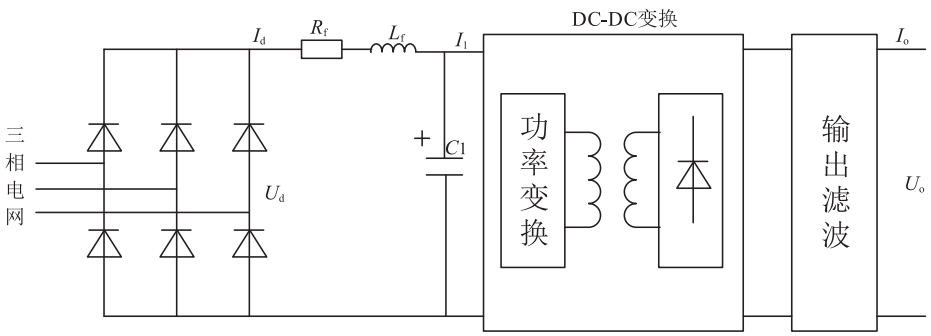

Fig. 1 – Block diagram of high frequency charger.

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