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Research Paper**EFFECT OF FAULT RIDE THROUGH CAPABILITY ON
ELECTRIC VEHICLE CHARGING STATION UNDER CRITICAL
VOLTAGE CONDITIONS**¹T.Obulesu,²K.BalaBrahmam,³S.Meena,⁴Tushar Sharma¹⁻⁴Department of EEE, JNTUA College Engineering Pulivendula, Kadapa, India.

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Abstract: A high-quality power supply is required for the proper functioning of the electric vehicle (EV) charging system. However, the voltage quality is one of the significant issues in the distribution grid. This article aims to examine the impacts of voltage disturbance on EV batteries and charging systems, and provides a fault ride-through capability (FRTC) to enhance the voltage quality. The charging system is constructed by the three-phase controlled rectifier and the dc–dc converter. The EV battery pack is modeled with lithium-ion batteries. The FRTC system is designed to improve the voltage quality, and it is achieved through the dynamic voltage restorer. It protects the EV batteries and charging system from the critical voltage sag levels. The performance of the proposed EV charging station (EVCS) has been investigated in 30%, 60%, and 90% voltage sag through the MATLAB/Simulink platform. Also, the real-time validation has been carried out by the software-in-the-loop test with the help of the dSPACE (DS1202) real-time system. The EVCS with an FRTC system provides better performance than the conventional EVCS.

Keywords: Electric vehicle charging station, Li-ion battery charging system, Sag, Load voltages.

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1. INTRODUCTION:

ELECTRIC vehicles (EVs) have become an inevitable load of future power systems. Large-scale integration of EV charging stations (EVCSs) in the distribution grid affects the quality of power in terms of power demand, voltage unbalances, stability, harmonic pollution, and other negative impacts. At the same time, a high-quality power supply is required for the proper operation of the EV charging system. However, in practice, the grid supply is subjected to various power quality issues. The voltage quality is the major issue in the distribution grid due to sudden load changes, electric motor starting, a fault occurring in the distribution grid, accidents in the powerline, and energizing the transformers. The poor voltage quality directly affects the EV charging profile and battery life cycle. In recent days, major research focuses on the impact of EV charging on the distribution

grid. The impacts of plug-in EVs on the distribution power grid have been investigated in. The power converter configurations, battery charging control methods, various impacts, such as harmonics, voltage quality, unbalances, and feeder issues of the EV loads on the low-voltage distribution grid are reviewed. The economic, environmental, power network impacts, and various charging standards of EVs are discussed. The impacts of plug-in hybrid EVs on voltage quality, distribution transformer overload, and aging are assessed.

An advanced low-voltage ride-through capability is implemented for a permanent magnet synchronous generator based offshore wind energy system. The FRTC of a wind energy system is enhanced by an on-load tap changer. The hybrid superconducting FCL is employed, for enhancing the low-voltage ride-through capability in doubly fed induction generator wind

farms. An FRTC for the grid connected hybrid wind/solar system is discussed. The obtained results are compared with the distribution static compensator and crowbar approach. Among these techniques, the DVR-FRTC system provides better performance for voltage quality enhancement. Therefore, the DVR-FRTC system is suggested for EVCS.

2. Literature Review:

The paper discusses transportation of electrification is one of the main research areas for the past decade. Electric vehicles (EVs) are taking over the market share of conventional internal combustion engine vehicles. The increasing popularity of EVs results in higher number of charging stations, which have significant effects on the electricity grid. Different charging strategies, as well as grid integration methods, are being developed to minimize the adverse effects of EV charging and to strengthen the benefits of EV grid integration. The paper introduces the current EV status, and provides a comprehensive review on important international EV charging and grid interconnection standards. Different infrastructure configurations in terms of control and communication architectures for EV charging are studied and evaluated. Finally, the challenges and suggestions for the future development of the EV charging and grid integration infrastructure are evaluated and summarized [1-3]. EV System proposes Trend-setting countries have promoted or even employed an increased number of electric vehicles (EVs) and other distributed energy resources (DERs) in their power systems. This development has triggered new and increasing challenges in the distribution system planning and operation, whereby the distribution systems must adapt to the increased share of DERs. However, EVs may also offer new opportunities and can be used to support the grid by providing several local and global power- and energy-based services. This paper presents a review and

classification of the services potentially available from EVs for distribution systems, referred to as EV distribution system services (EV-DSS). A detailed description of recent services and approaches is given, and an assessment of the maturity of EV-DSS is provided. It is aligned with the current requirements to move toward the realistic implementations of EV-DSS [4-5]. EV Systems proposes the impending environmental issues and growing concerns for global energy crises are driving the need for new opportunities and technologies that can meet significantly higher demand for cleaner and sustainable energy systems. This necessitates the development of transportation and power generation systems. The electrification of the transportation system is a promising approach to green the transportation systems and to reduce the issues of climate change. Remedial measures for harmful impacts are presented and benefits obtained therefrom are highlighted. Bidirectional charging offers the fundamental feature of vehicle to grid technology. In this study, the current challenging issues due to the massive deployment of EVs, as well as upcoming research trends are also presented. It is envisioned that the researchers interested in such area can find this paper valuable and an informative one-stop source. The proposed work develops a probabilistic power flow in order to investigate the impact of the stochastic nature of PEVs, PVs, and conventional load. In this work, the residential premises are modeled for supply through a detailed secondary distribution system, which is integrated as a part of the EDS [6-8]. This Paper proposes the impact of voltage sags on electric-vehicle chargers and presents a method to determine the minimum symmetrical voltage sag during and after which chargers can both be kept stable. The proposed method is based on the constraints of pulse-width modulation (PWM), electric circuits, and small-signal stability. This article enhances the existing research through the inclusion of PEV spatial-temporal (SAT)-charging activities into

the assessment models of DT overload and aging, voltage imbalance, and voltage deviation. The proposed framework provides a more realistic life expectancy for DTs compared with a simplified model in the literature [9-10].

3. Methodology:

In the proposed system, DVR-based FRTC system is designed for EVCS. The controlled rectifier converts the ac grid supply to a pre-defined dc supply. The dc-dc converter generates the appropriate battery charging voltage and current from the fixed dc supply. The DVR is connected to the grid through the injection transformer.

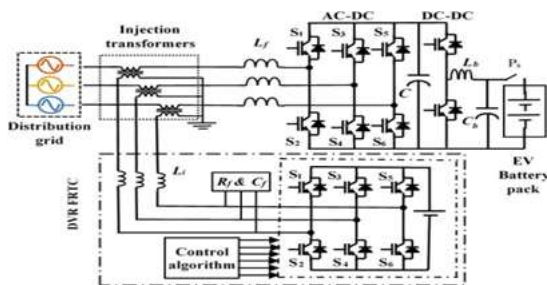


Fig.1. Circuit diagram of the proposed EVCS

3.1: Design of Electric Vehicle Charger:

The EV charger is designed by the controlled rectifier and the chopper. The rectifier input is joined to the utility grid over the inductive filter. The rectifier output voltage should be higher enough to provide good dynamic control and lower enough to evade needless switching losses. The dc voltage is estimated by the following equation:

$$V_{dc} = \frac{2\sqrt{2}V_{L-L}}{\sqrt{3}m} \quad (1)$$

Where m is the modulation index and V_{L-L} is the line voltage. The V_{L-L} is considered 415 V, and m is set as 0.9 to avoid the over modulation effect. Thus, V_{dc} is calculated as 752 V and is chosen as 750 V. The filter capacitor (C) removes the ripples present in the rectifier output voltage. The required value of the filter capacitor is calculated by the following expression

$$C = \frac{P_{dc}}{V_{dc} \times 4\pi \times f \times \Delta V_{dc}} \quad (2)$$

Where f is the grid frequency (50 Hz), V_{dc} is the ripple voltage, and P_{dc} is the rated dc power (14 kW). V_{dc} is considered 1.5% of the rectifier output voltage. Thus, C is calculated as 2862 μF and selected as 3300 μF . The chopper connects the battery with the output terminals of the rectifier. It regulates the rectifier output voltage and generates the appropriate voltage and current or charging the battery. The inductor (L_b) and capacitor (C_b) of the chopper are determined by the following expressions. Where D is the duty ratio, V_b is the battery voltage, V_b is the ripple voltage in the output. I_L is the ripple current, and f_s is the switching frequency.

$$L_b = \frac{D(V_{dc} - V_b)}{f_s \times \Delta I_L} \quad (3)$$

$$C_b = \frac{\Delta I_L}{8 \times f_s \times \Delta V_b} \quad (4)$$

4. Results and Conclusion:

4.1 Performance characteristics without FRTC:

4.1.1 At 30% sag level:

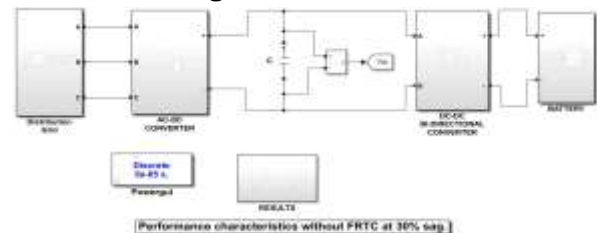


Fig 2. Performance characteristics without FRTC At 30% sag level

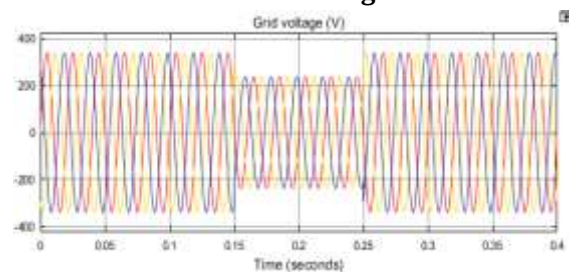


Fig 3. Grid voltage without FRTC At 30% sag level

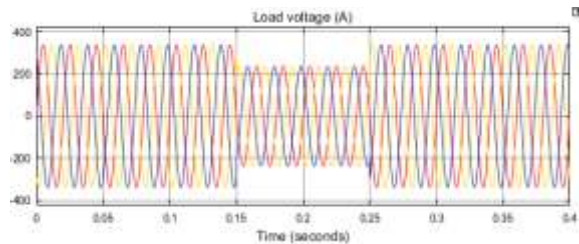


Fig 4. Load voltage without FRTC At 30% sag level

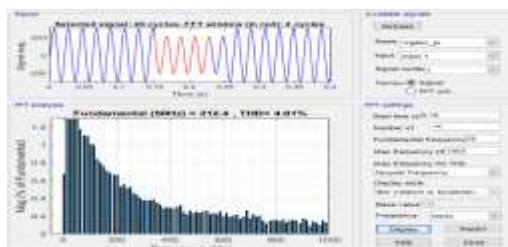


Fig 5. Harmonics without FRTC At 30% sag level

4.1.2 At 90% sag level:

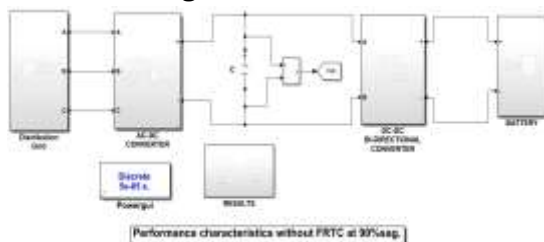


Fig 6. Performance characteristics without FRTC At 90% sag level

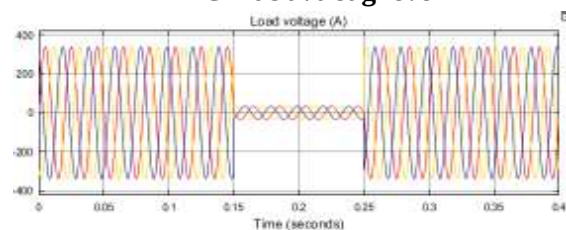


Fig 7. Grid voltage without FRTC At 90% sag level

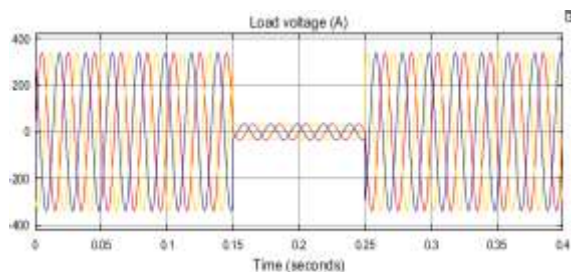


Fig 8. Load voltage without FRTC At 90% sag level

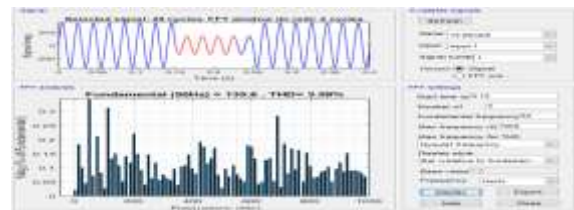


Fig 9. Harmonics without FRTC At 90% sag level

4.2 Performance characteristics with FRTC:

4.2.1 At 90% sag level:

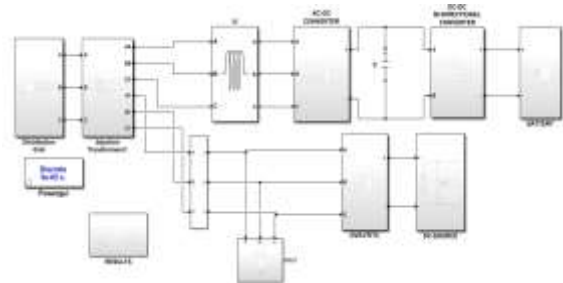


Fig 10. Performance characteristics with FRTC At 90% sag level

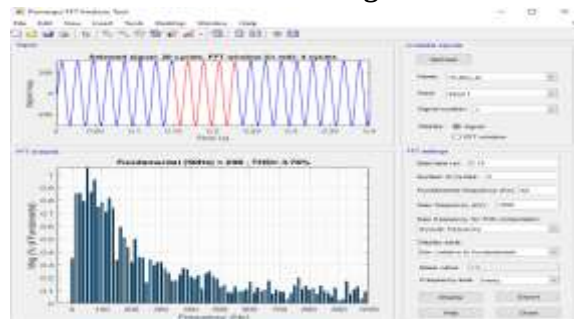


Fig 11. Harmonics with FRTC At 90% sag level

5. Conclusions:

In this project, the impacts of various voltage sag levels on the EV charging system and batteries had been investigated and presented the DVR-FRTC system to improve the load voltage quality. The system was modeled in the MATLAB/Simulink platform to carry out the simulation study. The real-time validation was done through the SIL test in the dSPACE (DS1202) real-time system. The presented system performance had been evaluated for 30%, 60%, and 90% voltage sag levels with and without the DVR-FRTC system. The charging system without DVR-FRTC was operating in the stable mode during 30% voltage sag and

operating in the unstable mode during 60% and 90% voltage sags. However, the charging system with DVR-FRTC was operating in the stable mode for all voltage sag levels because the DVR-FRTC system injects the voltage during the sag period and maintains the load voltage at standard value. Thus, the system was continuously operated in the stable mode. It protects the EV batteries from voltage disturbances and improves the system's reliability. The future work of this study can be considered to analyze the health impacts of the battery and converter components with and without the DVR-FRTC system.

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