Fault Analysis and Protection of Electric Vehicle Charging Station using Fast Charging Method

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Abstract —

In this paper the proposed model of an electrical vehicle charging station is suitable for the fast DC charging multiple electric vehicles. The station consists of a single grid-connected inverter with a DC bus where the electric vehicles are connected. The control of the individual electric vehicle charging processes is decentralized, while a separate central control deals with the power transfer from the AC grid to the DC bus. The electric power exchange does not rely on communication links between the station and vehicles, and a smooth transition to vehicle-to grid mode is also possible. Design guidelines and modelling are explained in an educational way to support implementation in Matlab/Simulink. Simulations are performed in Matlab/Simulink to illustrate the behaviour of charging station. The result shows the feasibility of the model proposed and the capability of the control system for fast charging method.

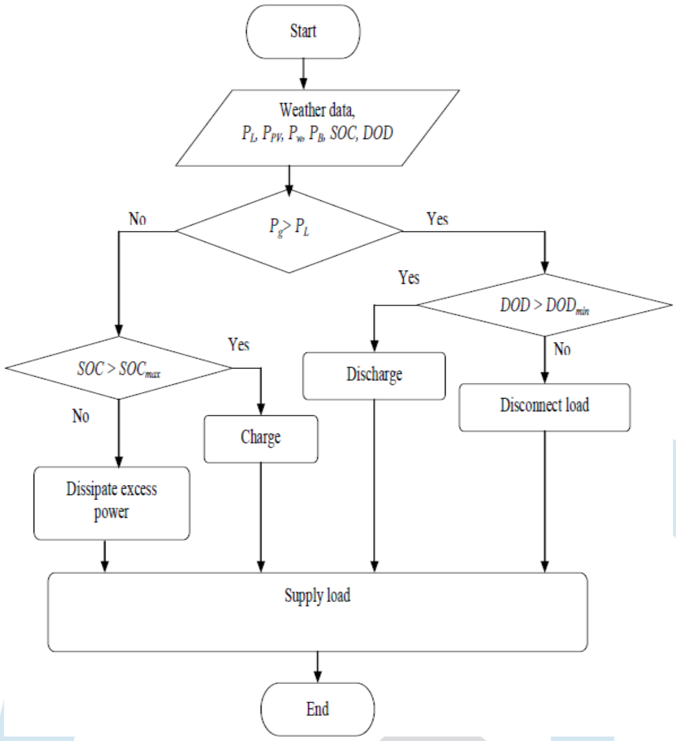
Keywords—Charging station, Electric vehicle, Fastcharging method, Protection of the System.

I. INTRODUCTION

Nowadays, the use of electric vehicles (EVs) has expanded due to various environmental and economic benefits. However, given that EVs are considered as loads that are not fixed in one place and can be connected to different parts of the power system at different times, challenges are undeniable. With the growing pollution problems, greenhouse effects and increasing prices of the petroleum products, the transport sector has covered its way to the use of Electric Vehicles (EVs). Large scale use of EVs requires an increase in number and complexities of Electric Vehicle Charging Stations within distribution network. An understanding of charging station configuration and its fault behaviors is important in order to develop a comprehensive protection system.Charging time reduction is one of the key goals in making electric vehicles user-friendly. In this context, fast DC charging offers an interesting opportunity. It allows for reducing charging times to ranges of 10 to 20 minutes .The SAE J1772 standard defines three levels of fast DC charging as DC Level 1 200/450 V, up to 36 kW (80 A); DC Level 2 - 200/450 V, up to 90 kW (200 A) and DC Level 3 200/600 V DC (proposed) up to 240 kW (400 A) [1]. All levels use off-board electric vehicle supply equipment (EVSE). In this paper, modelling and simulation of an electric vehicle charging station for fast DC charging are proposed and formulated in an educational way in order to allow its implementation and further research on the topic. In the following sections, important aspects of an EV charging station model are developed. In Section II, the Proposed methodology of the circuit is considered. Control methods for DC charging of EVs and the charging station and fault analysis are considered in Section III. In section IV, Protection technique are explained. In Section V, MATLAB SIMULINK model and result are discussed. Finally, conclusions are presented in section VI. Due to recent developments in electric mobility, public charging infrastructure will be essential for modern transportation systems. As the numbers of electric vehicles (EVs) increase, public charging infrastructure needs to adopt efficient charging practices. A keychallenge is the assignment of EVs to charging stations in an energy efficient manner. It can be seen that the inverter is interfaced to the network through an LCL filter and a transformer; while a single DC bus feeds all individuals battery chargers[2].A variety of aspects needs to be taken into account when designing the circuit of the charging station. These aspects, from a technical point of view, include the following: Area made available for parking of vehicles; this influences the number of cars that can be placed and charged. Estimation of the demand for fast charging slots in the location[3].Network parameters, i.e. nominal voltage and allowable power levels at the point of common coupling(PCC).Maximum charging power rate for individual vehicles.

II.PROPOSED METHODOLOGY

The flow chart of proposed system as shown in Figure 1.On the one hand, the inverter deals with the power exchange between the AC grid and the DC bus. Simultaneous EV charging and a smooth transition to vehicle-to-grid (V2G) mode is also possible. This control does not rely on communication links between the inverter and individual EVs. On the other hand, the control of the individual EV depends on battery state of charge SOC and depth of discharging DOD.The stability of the DC bus depends directly on the DC capacitance size. Basically, it has to support the DC current ripple. As many EV chargers can be connected to the DC bus, ripple current can be very high needing for a huge capacitance. A good method to define the capacitance of a DC bus, including the resistance and the inductance of the cable is reported in [4]. Additionally, a practical method is reported in [5][6]. In this work, both methods are taken into account, and the DC capacitance is determined by the capacitor energy rate of change during transients and the rated active power. In the flowchart we take grid power, line power, depth of discharge and state of charge.



IV. FAULT ANALYSIS

Dissimilar to conventional AC distribution frameworks,
Fig 1. Flowchart of Charging and Discharging
Firstly we start the system then we collect the data like power of line, power of PV, power of grid. After the collection of data we check the conditions. If the grid power is greater than line power if it is yes then we use depth of discharging (DOD). If DOD power is greater than DOD minimum then system start discharging if it is no then disconnects the load. If grid power is greater than line power if the condition is No then we use state of charging (SOC). If SOC power is greater than SOC Maximum if it is yes system start Charging. In this way we provide electricity to the vehicle , then system get stop. In this project Boost convertor is used in that voltage constant and current increase, hence the battery charge fast and appliances is not damaged.
The key principle that drives the boost converter is the tendency of an inductor to resist changes in current by either increasing or decreasing the energy stored in the inductor magnetic field.In the boost converter, the output voltage is always higher than the input voltage.
Fig1. Shows flowchart of charging and discharging and Fig2. Shows the Block diagram of Fast Charging method.

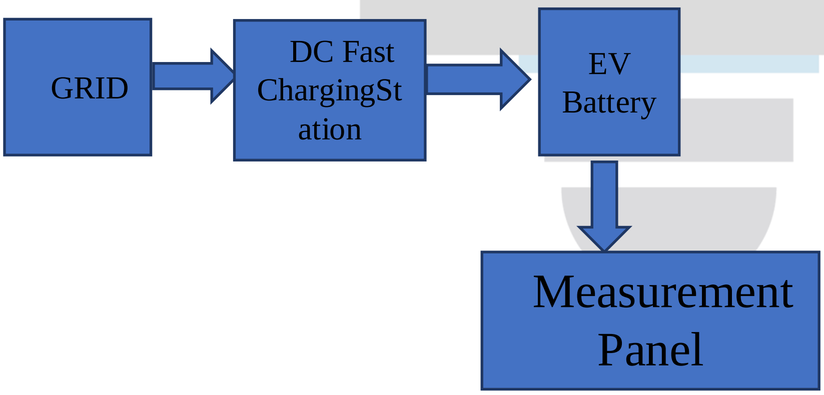


Fig2. Block diagram of Fast Charging Method

III. FAULT ANALYSIS

Dissimilar to conventional AC distribution frameworks, DC distributionsystems don't have long stretches of functional experience and guidelines. Converters would quiet themselves down when if there should arise an occurrence of a shortcoming secluding the DC transport. There would be different sorts of shortcomings happening both on AC side as well

as DC side[7]. The flaws that for the most part happen on DC side of such power frameworks cause quick release of DC transport capacitance which might prompt under voltage conditions and harms the actual capacitors because of drop down in voltage [8]. The present circumstance emerges when appropriate worth of DC transport capacitance isn't picked. Generally, under voltage conditions are followed by over current conditions on AC side as the control system of inverter tries to draw more power in order to compensate for the under voltage on DC bus. Delayed unattended shortcomings on DC side may in some cases bring about voltage inversions which prompts the release of batteries associated with DC transport and can likewise make critical flows move through converter freewheeling diodes causing harm.
Prior to going on onto issues investigation, the advantages and disadvantages of having a DC transport framework is talked about in short[9]. The DC frameworks will lessen the quantity of transformation stages expected for coordinating a lower voltage result of a discontinuous age asset to the electric matrix working at a lot higher voltage. More DC supply is presented than AC framework because of high normal voltage and furthermore works with in decrease of link sizes. No misfortunes like Skin impact and receptive influence misfortune exist and along these lines further develop influence move. Resembling of numerous assets is attainable and no issue of recurrence guideline emerges as in AC frameworks.Proficient interconnection of appropriated energy assets and capacity frameworks are conceivable. The DC voltage reaction enjoys a benefit of least ward on AC network conditions and arrangements. On the opposite side, plan of high velocity DC circuit breakers with required appraisals is a test ahead as the times recognized to respond to say the least are a lot more limited for DC frameworks than AC partners[10].Voltage Source Converters (VSC) may experience internal switch faults that can cause line to line short-circuit fault. This is a terminal fault for a device that can't be cleared and in most cases it requires replacement of the device. Hence, DC protection should be made to detect over current conditions for line-line and line-ground faults.
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IV.PROTECTION TECHNIQUE

Generally AC circuit breakers and wires are being utilized for security against deficiencies on DC frameworks as well. The primary explanation being more limited reaction time, are additionally modest contrasted with DC partners? The AC security gadgets are more natural and an incredible exploration has been placed into them [11]. Assurance against DC frameworks is trying because of lower impedance in DC frameworks and quick improvement of shortcoming current. Contrasted with AC frameworks, shortcomings in VSC based DC frameworks create multiple times quicker, requesting a quicker reaction from assurance gadgets. A unified power flow controller (UPFC) is an electrical device for providing fast-acting reactive power compensation on high-voltageelectricity transmission networks. It uses a pair of three-phase controllable bridges to produce current that is injected into a transmission line using a series transformer. The controller can control active and reactive power flows in a transmission line.Unified Power Flow Controller (UPFC), as a representative of the third generation of FACTS devices, is by far the most comprehensive FACTS device,[2] in power system steady-state itcan implement power flow regulation, reasonablycontrolling line active power and reactive power, improvingthe transmission capacity of power system, and in power system transient state it can realize fast-acting reactive power compensation, dynamically supporting the voltage at the access point and improving system voltage stability, moreover, it can improve the damping of the system and power angle stability[12].

The UPFC uses solid state devices, which provide functional flexibility, generally not attainable by conventional thyristor controlled systems. The UPFC is a combination of a static synchronous compensator (STATCOM) and a static synchronous series compensator (SSSC) coupled via a common DCvoltage link[13].

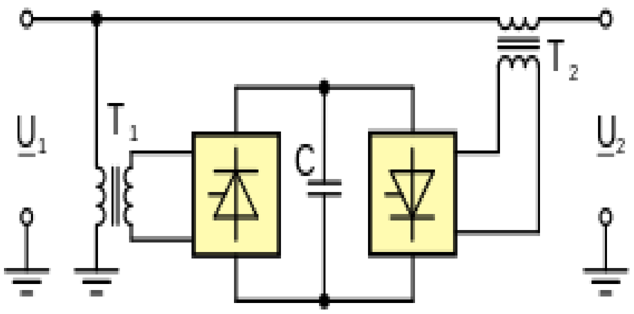

Fig 3. Series between distribution system and Load

The main advantage of the UPFC is to control the active and reactive power flows in the transmission line. If there are any disturbances or faults in the source side, the UPFC will not work. The UPFC operates only under balanced sine wave source. The controllable parameters of the UPFC are reactance in the line, phase angle and voltage. The UPFC concept was described in 1995 by L. Gyugyi of Westinghouse.The UPFC allows a secondary but important function such as stability control to suppress power system oscillations improving the transient stability of power system[14].
A DVR is a solid state power electronics switching device consisting of either GTO or IGBT, a capacitor bank as an energy storage device and injection transformers. It is linked in series between a distribution system and a load. The basic idea of the DVR is to inject a controlled voltage generated by a forced commuted converter in a series to the bus voltage by means of an injecting transformer[15][16]. A DC to AC inverter regulates this voltage by sinusoidal PWM technique. All through normal

operating condition, the DVR injects only a small voltage to compensate for the voltage drop of the injection transformer and device losses. However, when voltage sag occurs in the distribution system, the DVR control and synthesizes the voltage required to preserve output voltage to the load by injecting a controlled voltage with a certain magnitude and phase angle into the distribution system to the critical load[17].

Note that the DVR capable of generating or absorbing reactive power but the active power injection of the device must be provided by an external energy source or energy storage system. The response time of DVR is very short and is limited by the power electronics devices and the voltage sag detection time. The predictable response time is about 25 milliseconds, and which is much less than some of the traditional methods of voltage correction such as tap-changing transformers[18][19].

V. MATLAB SIMULINK MODEL AND RESULT

The proposed system is implemented using MATLAB 2017A on personal computer. The proposed system used fast charging of battery which is simulated using MATLAB Simulink. The MATLAB Simulink model of fast charging method is shown in Fig 4.

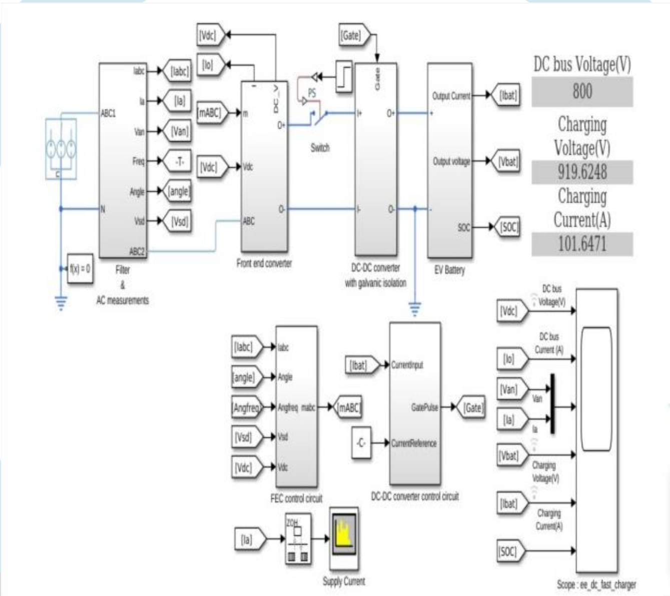

Fig4. MATLAB Simulink Model of Fast Charging Method

Fig 5. Shows the supply current given to the system. If fault is physically occur in grid then filter is used to remove the fault . And Phase locked loop (PLL) is used . PLL is electron circuit with voltage driven oscillator that constantly adjust to match the frequency of an input signal. PLL's are used to generate, stabilize, modulate, demodulate, filter or recover a signal from noisy communication channel where data is interrupted. Fig 6. Shows the Waveform of Battery Charging Method. In that case we increase the value of current then battery will charge fast.

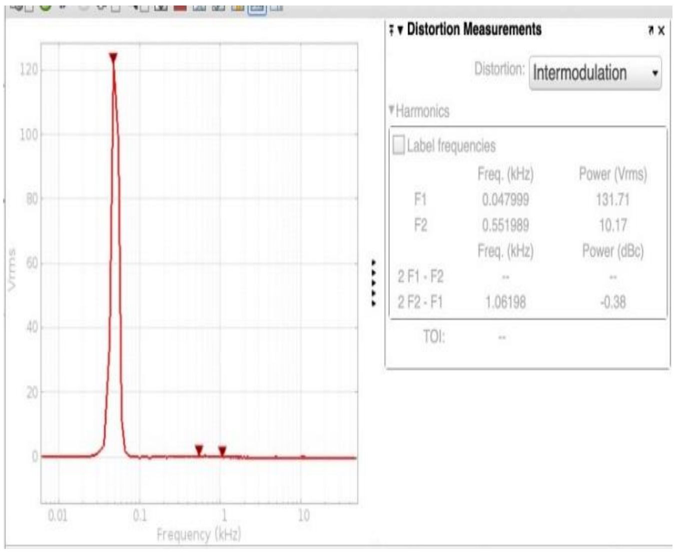

Fig 5. Supply current given to the System

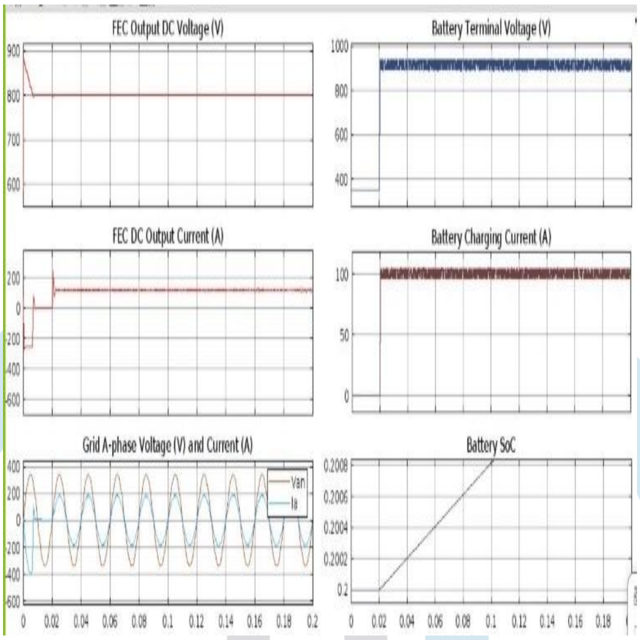

Fig6. Waveform of Battery Charging Method

VI.CONCLUSIONS

In this project , a novel method was proposed for fast charging of Electric Vehicles batteries. From the proposed model conclude that using current control method Electric Vehicle battery can be fast charge from its desire time by 20-30% The novel dissertation work has conclude that Faults occurs in charging duration of battery such as harmonic can be easily removed by filtering circuit used in a System.

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