

Analysis of Harmonic Injection and its Impact on Grid due to Electric Vehicle’s Charging Station

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Abstract— The future of automotive market is the electric vehicles only and to fulfill the need the charging station infrastructure is the must. But the electrical vehicles charging station is made up of nonlinear devices thus it injects harmonics into the grid. This paper shows the impact of electric vehicles charging station on grid such as injection of harmonics through MATLAB modeling of charging station connected to grid. Also there are other impacts such as power system stability issues, voltage imbalance.

Keywords: Harmonic Injection, Electric Vehicle

there is AC to DC conversion circuit such as rectifier or converters of various types. After DC there is charging circuit which may be on board (in the car itself) or off board chargers. Also there may be DC to DC fast charger port which charges car in less time. This configuration may differ for different charging stations.

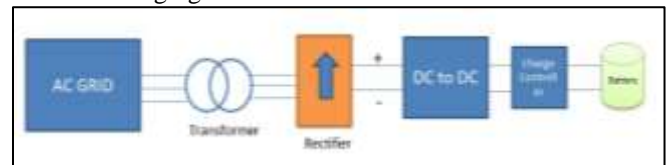


Fig. 1: Block Diagram of EV’s Charging Station

Following tables shows types of EV’s Charging station and time required to charge Electrical Vehicle to drive for 100 km

Power supply	Power	Voltage	Max. current	Charging time
Single phase	3.3 kW	230 V AC	16 A	5–6 hours
Single phase	7.4 kW	230 V AC	32 A	2-2½ hours
Three phase	11 kW	400 V AC	16 A	1½-2 hours
Three phase	22 kW	400 V AC	32 A	44–55 minutes
Three phase	43 kW	400 V AC	63 A	22–28 minutes
Direct current (DCFC)	50 kW	400–500 V DC	100–125 A	19–24 minutes
Direct current (DCFC)	120 kW	300–500 V DC	300–350 A	8–10 minutes

Table 1: Types of Ev’s Chargers

I. INTRODUCTION

With the disturbance of natural contamination and the deficiency of assets, a few nations have started to create electric vehicles and therefore, relating infrastructures, for example, charging stations [1]. Electric vehicle chargers normally embrace single-stage or three-stage circuits. Chargers are partitioned into three levels as indicated by the American Society of Automotive Engineers (SAE) J1772 charging interface standard of the SAE[3]. The primary level is the moderate charging charger that receives a solitary stage uncontrolled circuit. The other two levels are the customary (board) charging or quick (off-board) charging chargers that utilization a three-stage rectifier; the three-stage ordinary charging is at present the most well-known approach to charge electric vehicles[4].

Three-stage uncontrolled, thyristor-controlled, and pulse-width adjustment controlled correction chargers are utilized in charging stations as of now. Shading forms of at least one of the figures in this paper are accessible Chargers with uncontrolled or thyristor-controlled amendment are generally utilized in before built charging stations that produce the most genuine Harmonics[2]. Network voltage produces a throbbing dc voltage at the dc side of the charger after amendment of a three-stage rectifier. The voltage and current at the AC side of the charging station yields a consonant twisting on account of the coupling collaboration between the rectifier. The consonant qualities of an electric vehicle charger and its association with the framework are vital in surveying the symphonious contamination created by chargers. Along these lines, the symphonious diagnostic technique for electric vehicle chargers must be contemplated. Moreover, understanding the consonant emanation of charging stations for multi electric vehicle chargers and its effect on dispersion networks is significant.

II. METHODOLOGY

A. EV’s Charging Station

The basic structure of Charging station is as follows. It has AC power grid supply via transformer. After transformer

B. Matlab Modelling of Charging Station

According to above data and block diagram the MATLAB model of charging station connected to grid is developed. It includes the AC grid as source 3 Phase 50Hz at 11kV and three phase transformer of step down 11kV to 440v 100kVA capacity. For AC to DC conversion rectifier is used. Rectifier is of thyristor controlled 3 phase to DC configuration and 12 pulse generator is used for pulse generation having reference signal of source Vabc_B1. There are two circuits of slow charging and one is of Fast charging type in this charging station. Third charging circuit includes DC to DC conversion and charge controller for Fast charging purpose. The MATLAB model of charging station is as follows

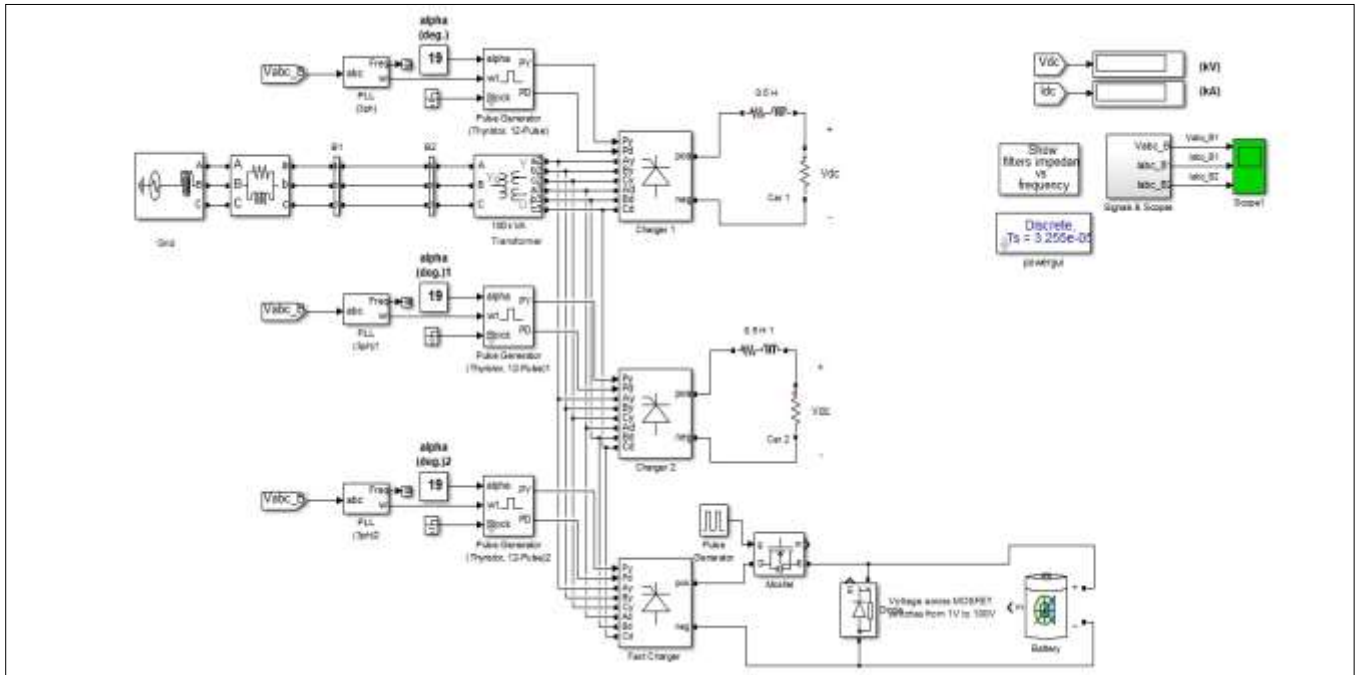


Fig. 2: MATLAB Model of Electrical Vehicles Charging Station

The scopes and displays are used to view the waveforms of voltages and currents at source that is grid. The FFT analysis is used to calculate the harmonics injections into grid.

III. RESULTS AND DISCUSSION

The above model is developed in MATLAB to analyze the harmonic injection into grid. The analysis is made while connecting all three chargers to grid one by one. The inbuilt FFT analysis is used for calculations.

A. While connecting All Chargers to Grid

If we connect the all charging circuits of 2*22kW and 1*50kW capacity to grid it takes almost 2.5-3 Hrs for slow charger and approx. 30to 45 mins for fast charger to charge the battery and thus it injects 7.39 %of THD.

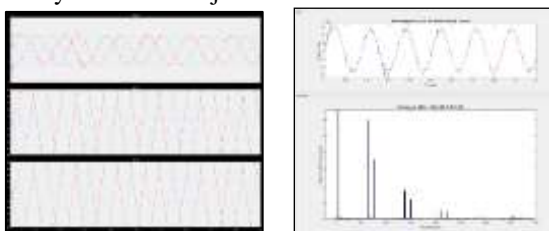


Fig. 3: Waveforms and THD analysis of all chargers connected to grid

B. While connecting two Chargers to grid

If we connect the two charging circuits of 2*22kW capacity to grid it takes almost 2.5-3 Hrs for slow charger to charge the battery and thus it injects 14.69 % of THD.

C. While connecting one Charger to grid

If we connect only one charging circuits of 1*22kW capacity to grid it takes almost 2.5-3 Hrs for slow charger to charge the battery and thus it injects 17.80 % of THD

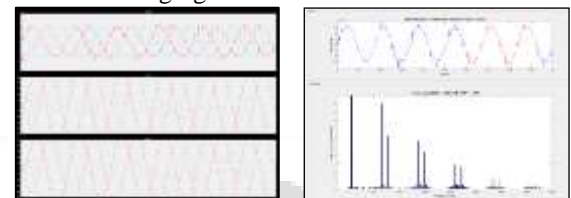


Fig. 4: Waveforms and THD analysis of two chargers connected to grid

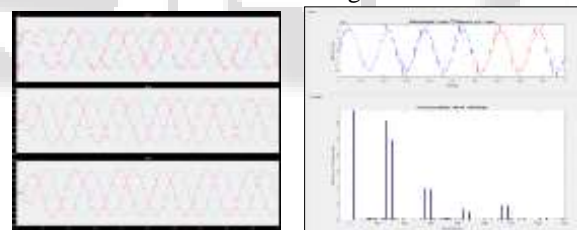


Fig. 4: Waveforms and THD analysis of one charger connected to grid

D. Impact on Grid

In spite of the fact that the zap of the transportation area has numerous great effects like less CO2 discharge, decreased contamination just as less a dangerous atmospheric deviation, the inconvenient effects of the EV chargers on the force circulation organization can't be dismissed. Notwithstanding, the ideal effects of chargers on the force dissemination organization can likewise be accomplished by executing the V2G idea[3]. The working boundaries influenced by arrangement of charging station are represented in Fig.1Tables must occupy a single column, if possible, and must be printed in place. The name is above the table.

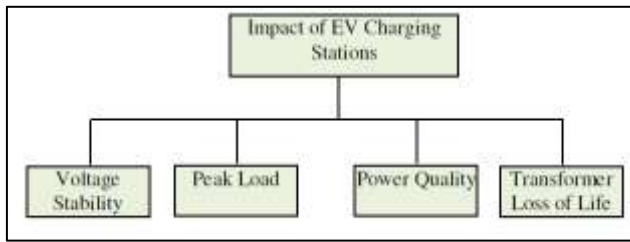


Fig. 5: Impact of EV Charging Station

1) *Voltage Stability*

The danger to voltage solidness is one of the most pivotal unfavorable effects of EV charging station. Hypothetically, voltage steadiness is characterized as the ability of intensity framework to support consistent voltages at all the transports after withdrawal of unsettling influences. Unexpected expansion in load is one of the key elements answerable for voltage precariousness[2]. Due to charging of EVs there is abrupt expansion in load which results in voltage shakiness. introduced a reenactment model of EV infiltration in the force framework circulation. The various situations of EV infiltration were created dependent on constant information of appearance and takeoff of the vehicles. They researched the voltage security at every single hub of the dissemination organization and reasoned that the created situations don't cause voltage insecurity. They broke down the impact of EV load on the voltage dependability of a rearranged 2 transport dispersion organization[4]. They additionally introduced an interesting approach of speaking to EV load. The researched the effect of EV charging load on nodal voltage deviation. The creators did the examination on IEEE 30 test network and inferred that the nodal voltage deviation is legitimately relative to the infiltration pace of the EVs[5].

2) *Peak Load Demand*

The expanded burden interest for EV charging brings about ascent in the pinnacle load interest of the matrix which is joined by decline available for later edge. It is inspected the impact of PHEV load on the Metropolitan circulation organization of Australia [6]. They presumed that with ungraceful accusing and of 100% PEV infiltration 43% pinnacle load moving is required. The impact of uncontrolled EV charging on every day load profile is moreover indicated the improvement in load profile by joining composed charging. Also it is inferred that jumbled charging will build the pinnacle load interest and suggested tax based charging[8]. The every day load variety diverse infiltration of EV. The variety in top burden request of the organization because of quality of EV quick charging stations in the roadways[3].

3) *Power Quality*

Hypothetically, power quality is the capacity of intensity conveyance organization to gracefully a stable and aggravation free Effect of EV Charging Stations. Voltage Security Pinnacle Load Power Quality Transformer Death toll yield which is inside voltage and recurrence resiliences[2]. The non direct trait of the EV charging load is a danger to control quality. Harmonics are a portion of the regular force quality issues. Sounds are sub-parts of current or voltage waveforms whose recurrence is essential various of the reference recurrence[3]. Consonant is estimated by complete consonant contortion (THD) which is the degree of distinction between genuine acquired and reference

recurrence[4]. It is investigated the impact of EV charger load on symphonious voltages of conveyance framework dependent on a few factual investigation[6]. They arranged the chargers dependent on THD delivered. They likewise presumed that even with 45% of EV entrance there is irrelevant voltage twisting during summer. Also it is investigated the impact of non direct EV charging load on power nature of the dissemination framework [5]. They likewise revealed how the presentation and life pattern of the dispersion network supplies like transformer, circuit breakers, and wires are influenced by symphonious contortion delivered by EV loads. It is announced that EV battery charging burden can cause symphonious bending of even half [7]. They likewise planned EV battery charger with natural power quality control include. The recreated Harmonics brought about by PHEV chargers by probabilistic Monte Carlo approach thinking about all the vulnerabilities. They inferred that private Level 1 chargers have serious effect on power quality [8]. The introduction of symphonious investigation of EV charging load on IEEE 34 hub test organization. They inferred that EV with higher SOC will cause less power quality issues. They recommended that the EV charging stations ought to be put far away from the transformers and the charging stations in mechanical region ought to force a cutoff concerning of EV charged every day to diminish power quality issues. It is also introduced how the chargers influence the smooth activity of the power dispersion organization and proposed methods of relieving these issues [6]. They presumed that a planned charging of EV will fathom a large portion of the force quality issues. They dissected the impact of exceptionally non direct EV load on private circulation organization. They presumed that an EV infiltration level of over 25% will influence the force quality.. Researchers performed symphonious examination in presence of EV charging burden and found a huge expansion in third Harmonic current in presence of EV charging loads[3].

4) *Transformer Life*

Huge scope arrangement of EVs creates extra pressure on the circulation transformers which assumes a noticeable job in diminishing the existence pattern of the transformer. Expansion in load causes increment in problem area temperature of the transformer as detailed in [7]. The charging of EVs cause increment in load which thusly causes increment in problem area temperature. In [8] the creators examined the effect of facilitated charging; levy put together accusing and clumsy charging of respect to transformer death toll and presumed that clumsy charging is negative to the exhibition of transformer. The analysts did comparative kind of examination and inferred that awkward charging quickens the maturing of transformers.

IV. CONCLUSION

The harmonic injection of Electric vehicles charging station into grid is analyzed in this paper with the help of MATLAB model. The charging station is having three charging circuits and when we charge through all chargers the THD injection is 7.39% and for two chargers and one charger the THD Injection is 14.69% and 17.80% respectively. Thus due to harmonic injection the power quality of grid network is

affected and also there is impact on life of the transformer. In future there are chances of expansion in load because of foundation of charging stations is in reality a major danger to the security of grid network. This field has seen a number of exploration works in the previous 10 years. All the research works reason that inappropriate arranging of EV charging stations will hamper the smooth activity of the power network. In this manner, the working boundaries of the power grid must be considered while arranging the charging stations.

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