Electrical parameters in distribution network with electric vehicle charger

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Abstract: - The aim of this paper is describe behavior of electric vehicle charging at different operating conditions. In paper are analyzed values, which were measured in power system with connected domestic charger and fast charger. The paper describes the charging of electric vehicle in terms of electrical parameters and effects to the power system. During the measurement were analyzed currents, voltages, distortion of measured values and power factor. Measured values can be used for deep analyzes and for better design of distribution network with electric vehicle chargers.

Key-Words: -Fast charger, electric vehicle charging, measuring, current, voltage, power factor

1 Introduction
Electric vehicles are often discussed topic nowadays and problems about design, operation and related systems have not solved. Is necessary attention focus influence to interested systems like power system, which supply battery charging. Discussions on electric vehicle charging dissert about ab-solute work common. Not so frequently is solved problem about influence to power system, voltage and power quality. Charging of electric vehicle has influence to operation of neighbouring appliance connected to power system. Impact to the power system by appliance is defined in standards. Measurements in real applications give answer whether values are in normative limits and where are weaknesses of electric vehicle charging.

2 Analyzed electric vehicle and chargers
Analysis were realised by measuring charging with nor-mal and fast charger. During the charging was connected Peugeot iON. Normal charging carried out with charger for domestic using with normal socket 16 A. Fast charging carried out with fast charger TERRA 51. Fast charger is connected to transformer 22/0.4 kV, 630 kVA. Short-circuit power at the point of charger connection is 2.6 MVA. Between fast charger and transformer is cable NAVY-J 4x25 350 m.

Electric vehicle battery parameters:
- Lithium manganese-oxide battery
- Battery capacity 16 kWh
- 88 individual cells, capacity of one cell is 0.187 kWh
- Maximum cell voltage 4.1 V
- Minimum cell voltage 2.75 V
- Normal charge using domestic supply 220 V AC / 100 % in 6 h
- Fast charge using charging station 330 V DC / 80 % in 30 minutes

Values were evaluated only in AC circuits during the measurements.

3 Measured values in fast charger
Measurements were carried out on fast charger in Bratislava. This charger was built within project VIBRATe. Measurements were carried out at 11. March 2013. During the measurements was switched off heating in charging station. Heating in charging station maintain optimal temperature for best lifespan of electronic systems. Consumption of heating is not included in the results of measurements.

Electrical values were measured by network analyzerElcom ENA 500.11. Network analyzer measured three-phase voltage, three-phase current and current in neutral line. Electric vehicle batteries were nearly completely discharged.
Fast charger can be operated in two modes, like fast charger and like normal charger. Charging mode depends on the charging of battery. If the battery has less than 80% of the energy then fast charging starts. Otherwise start slow charging. Measured values show different between slow charging by domestic charger (described in previous paragraph) and slow charging by charging station.

Charging by domestic charger unlike charging by fast charger has constant current. This different is consequence of battery charging current. Fast charger charge until 80% of battery capacity. Then fast charger turns off. If user wants, he can start second stage of charging. During this normal charging is feasible charge the remaining 20% of the battery.

Network analyzer measured the current flow in neutral line too. Maximum value is at the time of maximum power.

The results of measurements show, that the fast charger has compensation of reactive power. This compensation is designed for compensating of maximum power. Decrease of output power causes decrease of power factor. Fast charger is appliance with output power 50 kW. This is relatively big appliance. Problem with reactive power and power factor is considerable in this case and this problem has to be solved.

4 Measured values during domestic charging
Normal charging was realized in Faculty of electrical engineering laboratory in Bratislava. Temperature in room was approximately 20 degree Celsius. Temperature in room affects temperature of battery and charging process.

Electrical values were measured by network analyzer DEWE 2000. Measuring was realized by
single-phase connection and charger was connected to normal single-phase socket 16 A. Electric vehicle batteries were nearly completely discharged. Results of measuring represent full charging cycle.

Fig.14 Voltage and current during charging with domestic charger

Full charging took less than 6 hours because had vestigial capacity. Charging was short-term suspended, which is probably caused by control charging systems. The reason could be the temperature of the battery.

Fig.15 Detail of starting domestic charger

Variation of voltage depends on power network parameters at the point of charger connection. In this case voltage changes from 222.5 V to 216.5 V by starting of charger.

Fig.16 Power factor during charging with domestic charger

If charger is operated at full power then power factor is more than 0.99. If charger is operated less than full power then power factor is smaller. Minimum power factor is at the end of charging cycle, value is 0.955.

Power consumption of domestic charger is 10 VA at standby mode. At this mode is active power 2 W, THDI is 28 % and power factor is 0.212. Power consumption of domestic charger is 10 VA at standby mode. At this mode is active power 2 W, THDI is 28 % and power factor is 0.212.

Fig.17 Total harmonic distortion of current during charging with domestic charger

During full power charging is distortion of current 8.58 %. Because domestic charger works on a principle of switching power supply so decrease of power will cause worsening of current distortion. Next picture shows detail to changing of power factor and THDI at the end of charging and also at standby mode.
Fig. 18: Detail of total harmonic distortion of current, power factor and current at the end of charging cycle and at the standby mode.

Power consumption of domestic charger is 10 VA at standby mode. At this mode is active power 2 W, THDI is 28% and power factor is 0.212. Result of measuring shows that influence of domestic charger operation to power system is not noticeable. Negative effects are at the end of charging cycle and standby mode but at those modes is very small consumption.

4 Conclusion

Chargers for electric vehicles are appliances which are going to be installed more often. Quantity of charger is going to grow so influence to power system is going to be more considerable. If chargers for electric vehicles will influence to power system negatively then will grow problems with operating. Result of measuring shows that influence of domestic charger operation to power system is not noticeable. Negative effects are at the end of charging cycle and standby mode but at those modes is very small consumption.

Fast charger is large appliance so small problem can have significant impact. Measurement shows problems with reactive power and power factor. These problems enlarge losses and add to the cost. At standby mode problems occur about distortion of current. In this mode are small currents so problems are not significant.

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