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Charging connectors for Electric Vehicles at charging stations

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Abstract: As we know that today a lot of research is being going on to make the EV efficient in terms of performance & mainly consumption of electricity. In most of the countries in the world, the use of EV is very common & so as the problem of frequent charging & discharging of it. For this setting up charging units (CS) at fixed interval of distance is being taken into consideration by many scientists. But again to connect those charging stations to grid will create unwanted switching in the grid which will disturb its efficiency significantly.

Keywords: Electric Vehicle (EV), Charging Stations (CS), Charging connectors, CHAdeMO, SAE.

1. Introduction:

An electric vehicle charging station, also called EV charging station is that infrastructure which supplies electric energy for the recharging of electric vehicles, such as plug-in electric vehicles, including electric cars, or neighborhood electric vehicles or plug-in hybrids.

As market for plug-in hybrid electric vehicles and battery electric vehicle is expanding, the need for easily accessible charging stations, some of which may support faster charging at higher voltages and currents is increasing. Many charging stations are on-street facilities just like road side petrol pumps provided by major government or private electric utilities. They provide one or a range of heavy duty or special connectors suggested by electric charging connector standards.

2. Types of Charging Stations (CS):

They fall under four basic types:

1. Residential charging stations: An EV can be plugged in to recharge overnight in case of residential charging systems. This system generally has no user authentication, no metering, and requires extra wiring for a dedicated charging circuit. Some portable chargers can also be used by mounting on wall as charging station.

2. Charging while parked: It might be a commercial venture for between the utility or private companies & EV owners at some cost or maybe free. This charging may be slow or high speed which will encourage EV owners to recharge their EV while they take advantage of nearby facilities like some food stalls or entertainment. Various locations can be chosen for such a venture which may include parking stations, parking at malls, small centers, and train stations etc.

3. Fast charging at public charging stations >40kW, delivering over 60miles (100km) of range in 10–30 minutes. These chargers can be provided at rest stops to allow owner for longer distance trips or regularly by commuters in metropolitan areas or for charging while parked for shorter or longer periods. Common examples are CHAdeMO, SAE Combined Charging System, and Tesla Superchargers.

4. Battery swaps or charges in under 15 minutes. A specified target for CARB credits for a zero-emission vehicle is adding 200 miles to its range in under 15 minutes of fast EV charging. Previously, this was not possible for charging EVs, but it is achievable with EV battery swaps and Hydrogen Fuel Cell vehicles. In this method the drain out batteries are being replaced by a charged one at battery swapping centers.

Both battery capacity and faster charging requirement of market are increasing, so methods used for charging have needed to change and improve. New options may also be considered like mobile charging stations and charging via inductive charging mats. The different solutions provided for charging connector technology by Japanese company named JEVS G105-1993 with trade name CHAdeMO and U.S. based SAE International's J1772 for charging stations have conflicts in using commercially which is backed by some of the automotive companies have led to delay in the deciding the standards for EV charging plugs.

EV charging is mostly done with the help of either CHAdeMO or SAE (J1772) or TESLA supercharger connector protocols. In this paper we will discuss about CHAdeMO and SAE protocol as they are widely used in the industry.

3. CHAdeMO:

CHAdeMO is the trade name of a quick charging method for battery electric vehicles delivering up to 62.5 kW of direct current (500 V, 125 A) via a special electrical connector designed and manufactured by Japanese company. It is proposed as a global industry standard by an association of the same name and included in IEC 62196 as **type 4**. In addition to CHAdeMO there is another standard known as Combined Charging System, has support from more major auto manufacturers.

CHAdeMO was formed by The Tokyo Electric Power Company, Nissan, Mitsubishi and Fuji Heavy Industries, Toyota. Three of these companies have developed electric vehicles that use TEPCO's DC connector for quick charging.

3.1 DC Fast Charging:

Most electric vehicles (EVs) have an on-board charger that uses a rectifier circuit to transform alternating current from the electrical grid to DC suitable for recharging the EV's battery pack. Cost and thermal issues limit how much power the rectifier can handle, so beyond around 240 V AC and 75 A it is better for an external charging station to deliver direct current (DC) to the vehicle's battery pack. Given these limits, most conventional charging solutions are based on either 240V/30A service in the USA and Japan; 240 V, 70 A service in Canada or the 230 V, 15 A or 3Φ, 400 V, 32 A service in Europe and Australia, whereas SAE J1772-2009 has an option for 240 V, 80 A and VDE-AR-E 2623-2-2 has 3Φ, 400 V, 63 A. Only electric vehicles made by Tesla have a matching rectifier for such charging stations.

For faster charging, dedicated chargers can be built in permanent locations and provided with high-amperage connections to the grid. In this style of connection, the charger's DC output has no effective limit, theoretical or practical. Such high voltage and high-current charging is called a DC Fast Charge (DCFC) or DC Quick Charging (DCQC).

TEPCO has developed patented technology and a specification for high-voltage (up to 500 V DC) high-current (125 A) automotive fast charging via a JARI (Japan Automobile Research Institute) DC fast charge connector which is the basis for the CHAdeMO protocol. The standard for this connector is specified by the JEVS (Japan Electric Vehicle Standard) G105-1993 from the JARI.

In addition to carrying power the connector also makes a data connection using the CAN bus protocol. It is useful for a safety interlock to avoid energizing the connector before it's safe, transmitting battery parameters to the charging station including when to stop charging (because batteries should not get charged above 80% of full capacity), required voltage level at output, battery capacity, and while charging how the station should vary its output current.

4. SAE J1772:

SAE J1772 (IEC Type 1) is a North American standard for electrical connectors for electric vehicles maintained by the SAE International and has the formal title "SAE Surface Vehicle Recommended Practice J1772, SAE Electric Vehicle Conductive Charge Coupler". It covers the general physical, electrical, communication protocol, and performance requirements for the electric vehicle conductive charge system and coupler. The intent is to define a common electric vehicle conductive charging system architecture including operational requirements and the functional and dimensional requirements for the vehicle inlet and mating connector.

The **SAE J1772-2009 connector specification** has been added to the **international IEC 62196-2 standard** with voting on the final specification to close in May 2011. The SAE J1772 connector is considered a **"Type 1"** implementation providing a single phase coupler.

4.1 Properties:

4.1.1 Connector:

The J1772-2009 connector is designed for single phase electrical systems with 120V or 240V such as those used in North America and Japan. The round 43 millimetres (1.7in) diameter connector has five pins, with three different pin sizes (starting with the largest), for each of:

- AC line 1 and line 2
- Ground pin
- Proximity detection, and control pilot

Proximity detection:

Prevents movement of the car while connected to the charger.

Control pilot:

Communication line used to coordinate charging level between the car and the charger as well as other information.

A 1 kHz square wave at ±12 volts generated by the electric vehicle supply equipment on the control pilot to detect the presence of the vehicle, communicate the maximum allowable charging current, and control charging.

The connector is designed to withstand 10,000 mating cycle and exposure to the elements. With 1 mating cycle per day, the connector's lifespan should exceed 27 years.

4.1.2 Charging:

The J1772 standard defines two charging levels:

	Voltage	Phase	Peak current	Power
AC Level 1	120 V	Single phase	16 A	1.92 kW
AC Level 2	240 V	Split phase	32 A (2001) 80 A (2009)	7.68 kW 19.20 kW

The SAE J1772 committee has also proposed a DC connector based on the SAE J1772-2009 AC connector shape with additional DC and ground pins to support charging at 200–450 V DC and 80 A (36 kW) for **DC Level 1** and up to 200 A (90 kW) for **DC Level 2** after evaluating the J1772-2009 connector against other designs including the CHAdeMO DC fast charge protocol by the JARI/TEPCO. The SAE **DC Level 3** charging levels have not been determined, but the standard as it exists as of 2009 has the potential to charge at 200–600 V DC at a maximum of 400 A (240 kW).

4.1.3 Safety:

The J1772 standard includes several levels of shock protection, ensuring the safety of charging even in wet conditions. Physically, the connection pins are isolated on the interior of the connector when mated, ensuring no physical access to those pins. When not mated, J1772 connectors have no power voltages at the pins, and charging power does not flow until commanded by the vehicle.

The power pins are of the first-make, last-break variety. If the plug is in the charging port of the vehicle and charging, and it is removed, the control pilot and proximity detection pin will break first causing the power relay in the charging station to open, cutting all current flow to the J1772 plug. This prevents any arcing on the power pins, prolonging their lifespan. The proximity detection pin is also connected to a switch that is triggered upon pressing the physical disconnect button when removing the connector from the vehicle. This causes the resistance to change on the proximity pin which commands the vehicle's on-board charger to stop drawing current immediately before the connector is pulled out.

5. Conclusion:

Thus we can conclude that among the two types of connectors discussed here, both have their own standards, safety majors to be followed, due to which many automobile companies are using one of the type of connectors. In both the type of connection there is scope of improvement as both are having problem of reduction of harmonics due to switching which will affect the grid efficiency.

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