Vehicle to Vehicle Charging with New Perspective for Power Transfer

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Abstract

Electric vehicles are regarded as one of the most trending technology in the automobile Industry. Recent studies conducted in 2020 show that electric vehicles have already been established in many developed countries such as USA, Japan, Denmark, France, Belgium, United Kingdom, Austria, China, Finland, Portugal, Netherlands, Sweden, Iceland and Norway. Over one million Electric Vehicles have been sold around the world and in India between April to December 2019 about one thousand five hundred and fifty four EV's were sold. This shows that EV are the future of transportation with respect to roadways. Though EV have advantages such as reduction in running cost, low maintenance, Low pollution, Low GHG production, Improved Safety and easy access to fuel as it is in terms of electrical energy. EV's also come in different varieties such as BEV, PHEV and HEV. This report will mainly focus on BEV vehicles as they are usually bought by users. Even though EV's have many advantages, There is a slight issue that exists for EV user and that is the charging options when 'NO' charging stations are to be found when the EV's battery is drained or is said to have consumed all its charge .Whenever an electric vehicle has to be charged it requires a charging unit to be present. In cases where there is no charging stations available a suitable system is proposed to charge the vehicle in need of power from an EV that has sufficient power and is capable of discharging or transferring power to the EV that is in need of power. The protocol that has been suggested in this system combines the V2G and G2V protocols. This concept uses the fast charging method that is being employed in almost every electric vehicle in order to achieve two main criteria which are transfer of power and fast charging of EV in a very short span.

Keywords: V2V Charging, Electric vehicle, Contingency Charging, V2G and G2V Protocols

1. Introduction

An electric vehicle, briefly EV, uses one or a lot of electric motors or traction motors for propulsion. The amendment in electricity as fuel instead of fossil fuels has already begun. In the past few years, there have emerged several energy unit makers like Tesla, Kia Soul, Navistar, and Kandi to many others. And since of them, there have conjointly been several technological developments particularly in the areas of batteries and motors of an EV. The few major elements of electric vehicle are,Transmission,Motor,Controller,BMS(Battery Management System) and Battery pack.The Engine of a standard IC Engine automobile is replaced by an electrical Motor and thus the fuel tank is replaced by the Battery Pack. Of all the elements solely the Battery Pack and Motor alone contributes to about quite 50% of the entire car's weight and thus the value of it. Another necessary element of an EV is that the charger. a mean E-Car takes a minimum of five hours to charge to a higher potential. It gets plugged into the AC mains and converts the AC to DC to charge the batteries. Charging is also a method throughout that the batteries and charger ought to exist and you cannot push current within the battery if the battery is not ready to accept it. There are many sorts of chargers; the foremost common types are discussed below.

Level 1 Charger: These are the foremost basic chargers that take an extended time to charge the batteries since they operate in 120V AC, then convert this to DC and use it to charge the batteries. This present rating of the charger conjointly are going to be low somewhere close to 8-10 A, thus sending less current and taking an extended time to charge your batteries overnight. On the positive facet, this technique improves the life cycle of the battery since our charging current may be a smaller quantity. Level 2 Charger: These are comparatively quicker than a Level one charger. Level 2 chargers operate higher voltages like 240V or higher than and even have a high current rating close to 40A to 50A. This makes the automobile to get charged quickly. Level 3 chargers: These game-changers are referred to as a result of the superchargers or quick chargers. They will charge your car to 60% of its total capacity within a half-hour . The drawback is that since it's pushing loads of current within your battery like 100A for a Tesla the time period of the battery usage is reduced. Also, most superchargers do not charge the batteries until 100% since longer time period isneeded to charge the battery from 80% to 100%.

An electrical vehiclemight even be powered through a collector system by electricity from off-vehicle sources, or might even be self-contained with a battery, solar panels or an electrical generator to convert fuel to electricity. Out of these types, the Battery electrical vehicles are commercially used. Battery electric vehicles use electricity, which is stored during a battery pack to power an electric motor and switch to run the wheels. Once depleted, the batteries are recharged using grid electricity by plugging it into the charging unit or charging stationis more or less just like charging a mobile. In some cases where there are none of the above mentioned sources of charging aautomobile is out there, this proposed system of vehicle to vehicle charging is going to be an answer at the contingency situation.

2. Existing system

The existing system consists of the two separate protocols known as the Grid to vehicle protocol and Vehicle to grid protocol. In the Grid to vehicle protocol system it is made up of a grid which is also considered as the charging station and a vehicle which refers to an EV that needs to be charged. Similarly in the Vehicle to Grid protocol system a grid and EV is present but here the grid is the one that requires charge. Therefore the two concepts can be understood with clarity using the following diagrammatic explanation. In G2V and In V2G

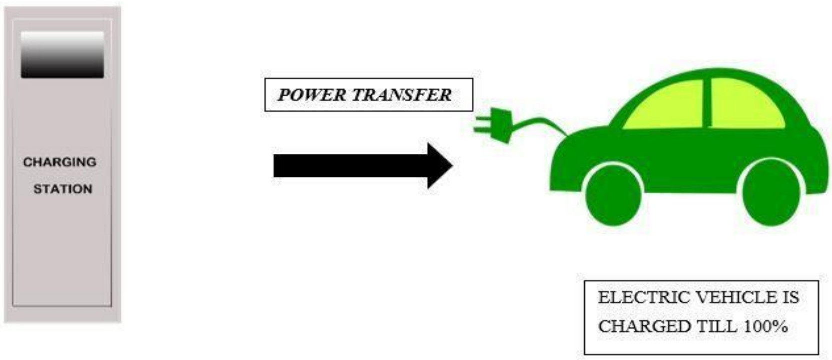

Figure 1: Illustration of G2V Protocol

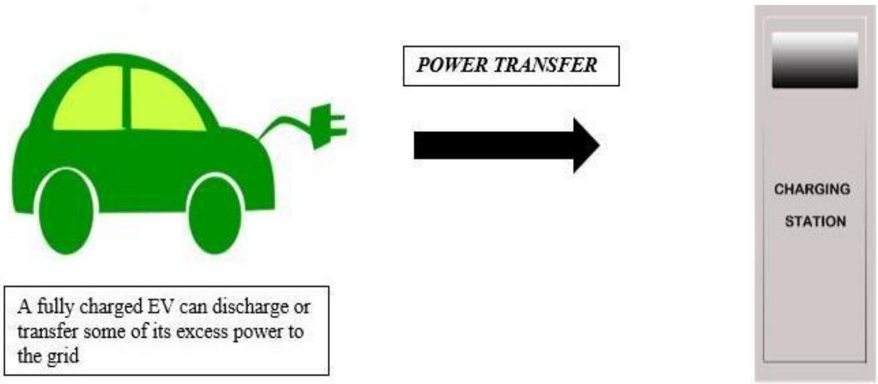

Figure 2: Illustration of V2G Protocol

2.1 Methods of Implementing V2V charging

There are also some methods that implemented direct V2V charging using various aspects.A system was proposed with energy transfer between two EV on-board chargers using an IoT platform supported with MQTT protocol is implemented through a communication network. The proposed V2V operation can reduce the strain on the grid while exploiting the unused energy of the EV batteries [1]. The indirect method of power transfer from a vehicle to vehicle is the use of an aggregator where the Vehicles parked in the parking lot are used for energy transfer through a connected bus in the parking lot itself. Then an efficient charging-discharging EV pair matching scheme is implemented to improve the energy exchange efficiency and eliminate the congestions in the parking places. These are generally known as connected ad-hoc networks [2]. When an EV has its batteries depleted and it's impossible to visit a charging station besides, the normal indirect V2V method performs four power conversions (dc-dc, dc-ac, ac-dc, dc-dc), which decreases the facility transfer efficiency between EVs. To beat this issue, an immediate V2V method, the on-board dcV2V, with only two conversions (dc-dc, dc-dc) can be used based on the feasibility of the operating modes. This direct method used the on-board chargers [3]. There is also a scheme to synchronize the charging between the two EV by the usage of a dual converter (cascaded bidirectional converters) in the EV which enables fast DC charging or discharging which implements the average current control method. Cascaded Bidirectional converters can even facilitate the charge transfer when the electric vehicles battery voltage levels are different, that's why cascaded converters has been employed. This scheme is implemented when an EV is stranded without battery charge and no access to EV charge station [4]. So far we have seen the direct and indirect methods of charging a vehicle form another vehicle using the on-board chargers. There are methods that are implemented using off-board chargers and wireless charging technologies.The wireless charging can be done if the transmitter coil and receiver coil are the same size and closely wound, the system can achieve high mutual inductance. If the size of transmitter coil and the receiver coil are different, the coil will require an optimal design. This is based on the fundamental theory of multi-turn coil design with angular offset. This structure of wireless V2V charging technology that can work together with plug-in EVs charging or operate independently. One issue with the wireless V2V charging technology is the angular offset due to the change in the location of the vehicle [5].

2.2 Disadvantages of existing system

Even though the existing systems seems too good to be true there is a major drawback when it comes to charging a fully drained battery when no charging station can be found nearby. When an EV has discharged all its power available in the battery the EV cannot be operated or in other words comes to a stand-still position. Thus major issue of the existing system is that it does not provide a technique to charge a vehicle in a contingency situation (there is no charging station available).

3. Proposed system

The proposed system is capable of overcoming the disadvantages present in the existing by mainly combining the two separate protocols into one compact system. As mentioned, It consists of the V2G and G2V protocol in which required as there will be a donor EV and a receiver EV. While the V2G (Vehicleto-Grid) protocol works, The donor EV is connected to a Charger (DC-DC converter) where the donor EV is the Vehicle and charger (receives power) is considered as the grid and when G2V (Grid-to-Vehicle) protocol is activated the other end of the charger (transmits power) acts as Grid and the receiver EV is the Vehicle. Time to charge (minimum charge to drive the vehicle to the nearest charging station) vehicle is within a matter of few minutes. User can drive the EV without any anxiety and not be worried about running out of charge.The proposed system mainly consists of components such as two Electric vehicles (donor and receiver vehicle), Fast charging Gun, Buck converter, Microcontroller and CAN bus module. The component are diagrammatically represented in Figure 3.

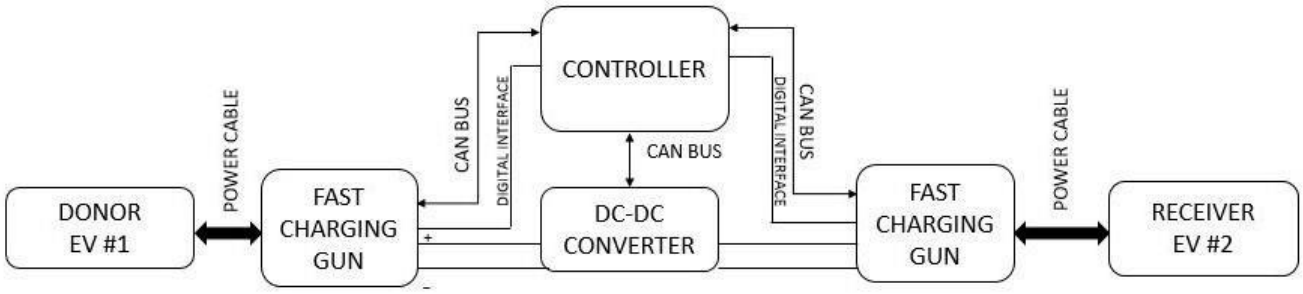

Figure 3: Proposed System

3.1 Battery

It is a storage device that is charged by Direct Current and similarly it is capable of discharging DC charge. The battery is placed in both the Donor and Receiver Electric Vehicle. The most commonly used voltage rating in electric vehicles is 72V with different Ah rating.

3.2 Fast Charging Gun (FCG)

The FCG consists of two types of cables which are Power transfer cable and CAN bus cable. The Power transfer cable is used to pass electric charge from one EV to another EV. The CAN bus cable is used for communication between the two EV's and the controller

3.3 DC-DC Converter

The type of DC-DC converter used here is a buck converter. The buck converter is used to step down the voltage from a fully charged donor battery and then give it to a totally drained receiver battery. As the receiver EV battery is completely drained we cannot connect the two batteries directly as it may affect the receiver Battery. Therefore the Voltage is stepped down and then given to the battery.

3.4 Controller

The controller plays an important role in the whole process as it acts as a transmitter and receiver terminal for information and signal to be sent and shared. The controller used here is "arduinouno R3" which is connected to CAN bus module to share data between the two EV's.

3.5 CAN bus

CAN bus module is used to carry data from the donor vehicle to the receiver through the buck converter by following the CHAdeMO protocol. It enables the user to know the start of charging, End of charging, remaining time for charging and so on. The CAN bus keeps exchanging data from the start till the end to ensure that the charging is safe and is taking place in desired method.

3.6 Digital Interfaces

These are input and output ports that enable connection between the two electric vehicles either through software or hardware.

4. Hardware and Software

The working of the proposed system can be classified into the hardware and software system which are explained in a well-defined manner in the following flowcharts. Both the hardware and software are essential where the hardware transfers the power and the software which helps us to the status of various signals or elements involved in power transfer. Also the compatibility check is done before the initiation of each signal to ensure that the process is fault free.

4.1 Hardware Flowchart

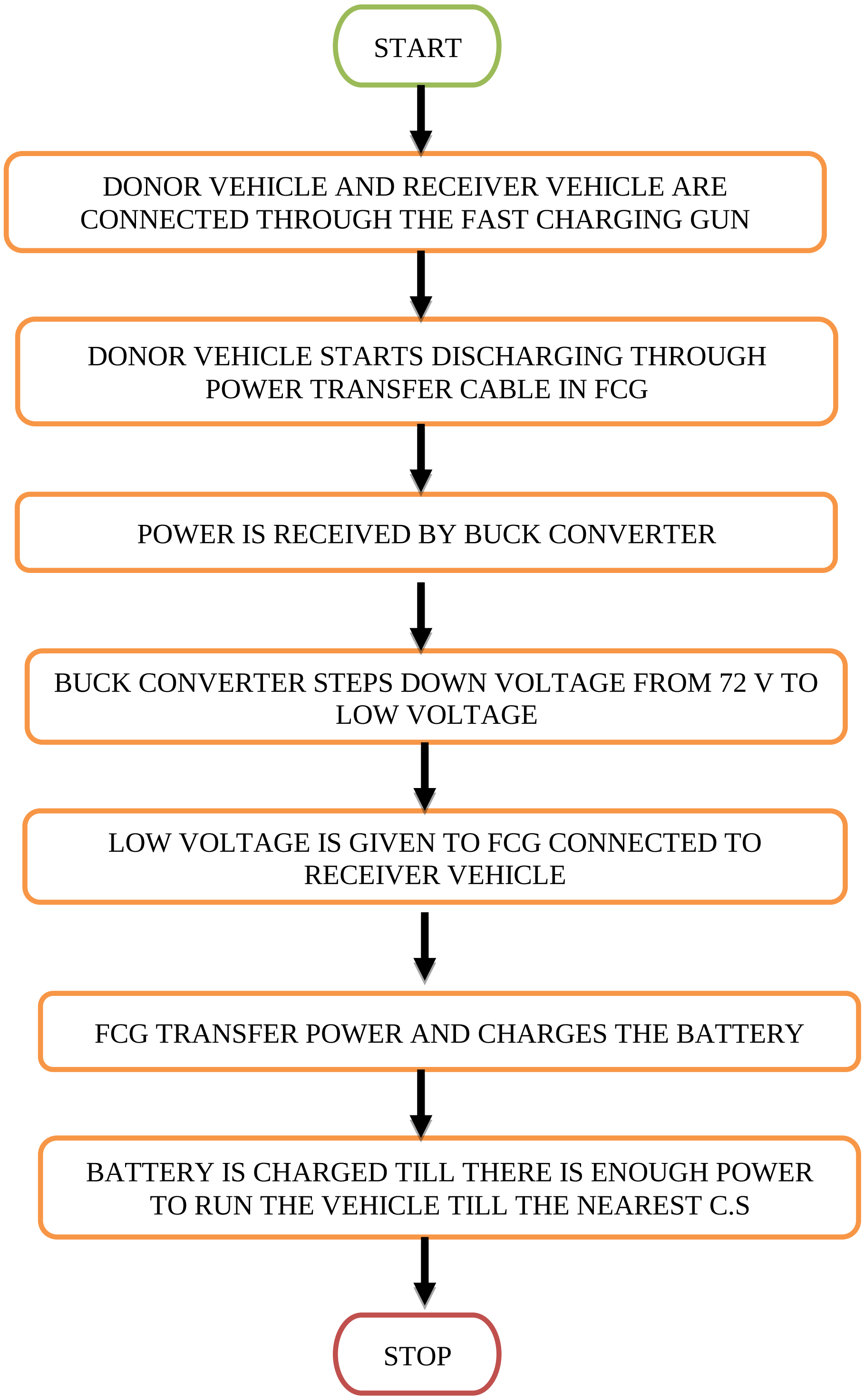

Figure 4 : Hardware Flowchart

4.2 Software Flowchart

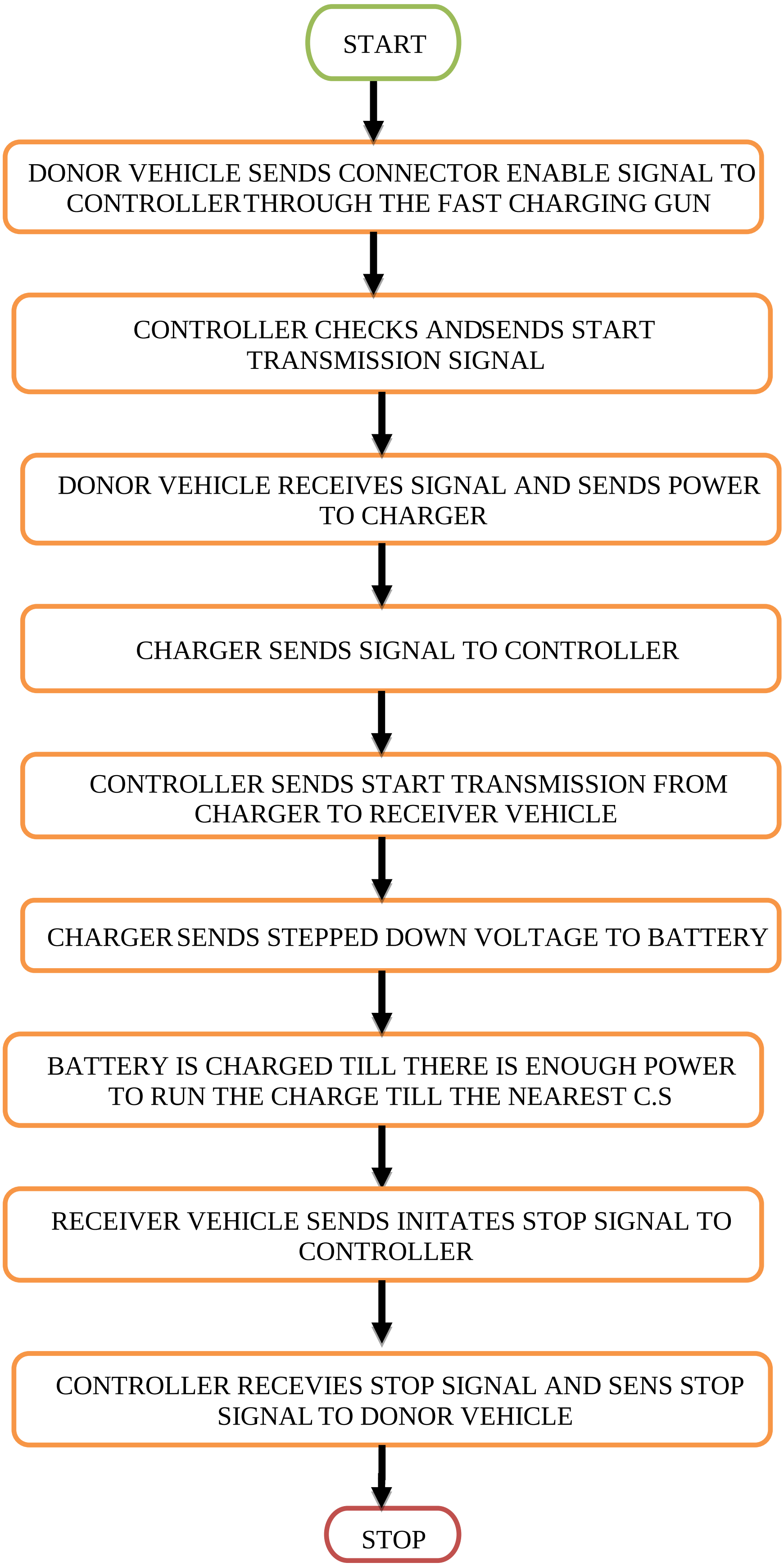

Figure 5: Software Flowchart

4.3 CHAdeMO Protocol

CHAdeMO is that the brand known for quick charging technique for battery electric vehicles delivering from 6KW upto 400KW of high-voltage DC via a special electrical connective that is additionally referred to as fast charging gun. Recent projects are working on the improvement side to make the charger to deliver 900KW. The maximum average power delivered to the vehicle is 62.5KW. It is projected as a worldwide business customary by an association of the same name.

CHAdeMO was formed by The Tokyo Electric power Company, Nissan, Mitsubishi and Fuji Heavy Industries (the manufacturer of Subaru vehicles). Toyota later joined as its fifth executive member. CHAdeMO is an abbreviation of "CHArge de MOve" or it can even be termed as "charge for moving". The name could also be a paranomasia for "O cha demo ikagadesuka" in Japanese, translating to English as "How about some tea time?", relating the time it might take to charge the vehicle.CHAdeMO a protocol for DC quick charge, for high-voltage (up to 500 VDC) and high-current (125 A). The connective is such as by the JEVS (Japan Electric Vehicle Standard) G105-1993 from the Japan Automobile Analysis Institute. The connective includes 2 giant pins for DC power, and different pins to carry CAN-BUS connections.Because CHAdeMO ports do not support AC charging, cars should have 2 charging ports – one for AC Level 2 charging, the opposite for CHAdeMO.Accessible charging methods are:

4.3.1 Office/ home charging

EV is typically charged with a small onboard charger at home or office, called "normal charging

4.3.2Destination charging

Fast or semi-fast charging (20kW) is the ideal consideration for destination charging in reference to middle distance or for short distance. As an example, Drivers can be benefited from quick chargers which are made available in big stores, a drug store, a shopping mall, or a restaurant parking space.

4.3.4 Pathway charging

Fast charging units are necessary for long distance inter-city drive. Drivers will be able to charge with the quick chargers installed along the major roads and the highway road service areas.

5. Connector Interface (Special Electrical Connector or FCG)

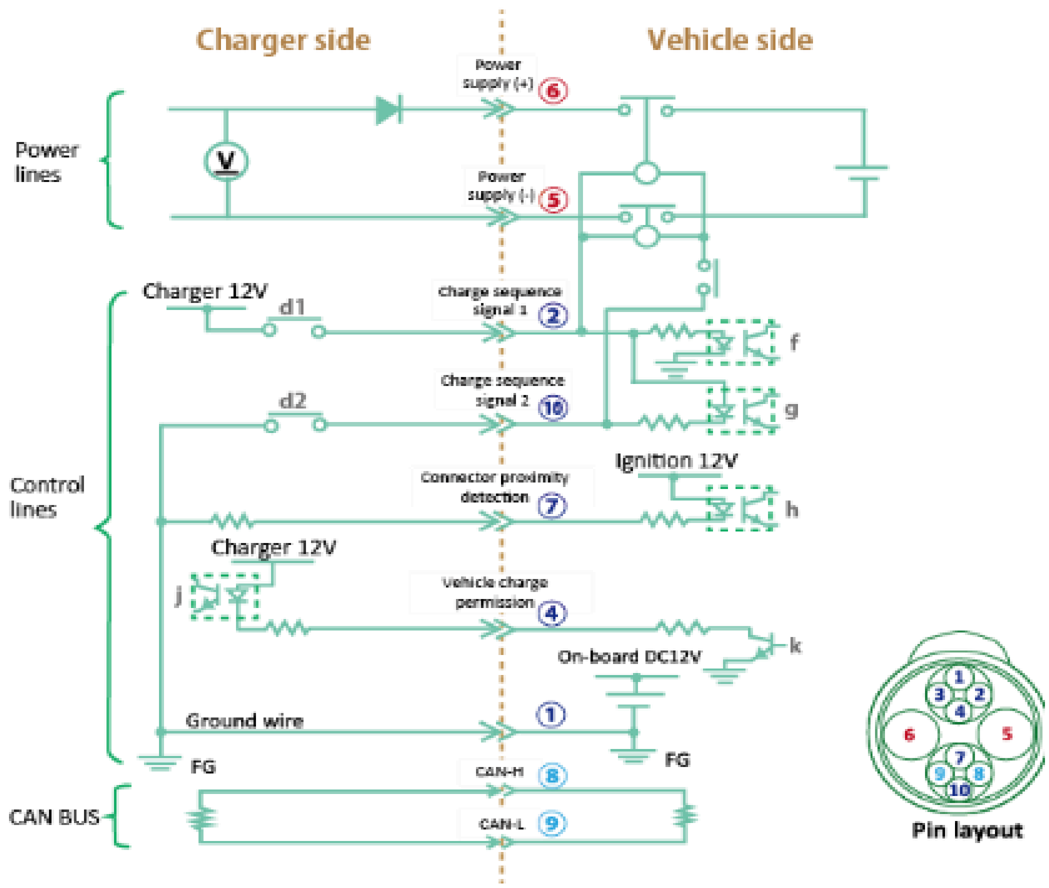

Figure 6: Connector Interface Circuit

The start of signal (d1 on) is given to the vehicle from the charger. Charger pulls Pin 2 up to 12v and the vehicle recognize start-of-charging. Receives battery parameters, charger does a compatibility check which is sent over a CAN link. And then vehicle transmit battery parameters: Vmax to stop charging, target voltage, total battery capacity etc,. The charger transmits charger parameters: Vo(max), Io(max), error flag, etc., Sent over CAN Bus to the vehicle (Receive charger parameters), do compatibility check that is to calculate the max charging time. The vehicle Sends Start Permission Signal(k ON) and the car grounds pin4 then the charger is able to Recognize start Permission Signal(j ON). Connector lock and perform insulation test, send charging ready signal(d2 ON) Charger grounds pin 10 and the vehicle recognize charging ready signal(g ON), EV main contactor is ON. The charger receives current requirement, adjust to within 2% output and the CAN bus sends current requirement every 100ms. The vehicle BMS monitors battery SOC, Temp, and input current, calculates current requirements. Charging reaches end SOC set in charger or the vehicle is stopped from charging by user. Zero current is sent by the vehicle as the current requirement to the charger over CAN bus thus the charger displays an output of zero current. Recognize charging stop(j OFF) , Car disconnects pin 4 from ground and the vehicle confirms zero current, EV contactor off, send charge stop signal(k OFF). The charger terminates the charging process(d1,d2 OFF) and the charger disconnects Pins 2 & 10, hence it unlocks connector User Removes CHAdeMO connector from Vehicle. There are many protocols that has established the method of V2X or V2V charging and one of them was the CHAdeMO which published its V2V protocol in 2014. The only protocol for charging that remains standardized even today which defines the V2X and has EV and their chargers that are capable all the time is CHAdeMO charging protocol. This makes them a standard protocol, most of the manufactures use them to be incorporated in the DC Charging units. Due to the high power transfer(for 400 KW ultra-fast charging) efficiency this standard is a better competent with the CCS ultra-fast chargers at same level of power transfer.

6. Conclusion

The proposed system uses a wired power transfer technology with an external charger (converter unit) which overcomes the disadvantages of the existing systems proposed earlier. The power transfer efficiency is improved and with this technology the possibility of high power transfer within a short span of time is possible without any interruption or damage. Wired technology is advantageous over the wireless systems because it eliminates the DSRC and angular offset problems. Thus removes the usage of large inductor coils on the transmission and reception vehicles. To think if there are any negatives in this system then it could only be the carry of the external charger unit with the cable. But considering the advantage of solving all other major issues in charging the stranded vehicle this could be the most optimal solution for charging a vehicle from another vehicle.

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