CHARGING INFRASTRUCTURE

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Week-01

Lecture-4

Lec 04: Review of EV Charger Types and Nomenclatures

Hello everyone, welcome to this NPTEL lecture series on charging infrastructure and in this lecture, which is lecture number 4, we will discuss some of the EV charger types which are there and its nomenclature, some of the standards which they have been following, in which standards they have been included, all those things we will study in this particular lecture, this one. So, in the last class, we have discussed about what is a building block in a dc charger you know what is, I mean we have dcvsc we have EV in the DCEVSE we have the entire power conversion which is taking place and that is why since we the entire power conversion is taking place inside the dcvsc a lot of information from the vehicle because our batteries are kept on the vehicle and it has the bms which actually keeps on monitoring its status so that has to be continuously communicated to the EVSE or electrical supply equipment and then supply equipment has to you know respond to that particular request from the EV particularly from the BMS and then accordingly they have to adopt to that request which has been done by the BMS.

So they require a dedicated communication channel and the communication since a lot of continuous stream of data has to be shared between the evsc and ev they follow the high level communication which is done via plc in some cases you know for example in CCS2 they follow CCS2 charging system they follow plc in some of the charging system they follow can communication CAN communication which is control laser network communication and PLC means power line communication. And if you look very carefully the output DC which we are getting in there that is basically controlled DC or you can say that the voltage and current is as per the voltage and current demanded by the vehicle controller. And on the other side, the

EVSE controller, which is also sometimes called as a supply equipment communication controller, communicates with the central management system or you can say charging station, which is provided by the charging station provider to basically help the charging station service provider to basically do the metering, monitoring of the DCVSEs and different, you know, other logging purposes, understanding the user behavior and then try to incorporate several offers you know provided to the user so in total we have you know in case of dc charging we have DCEVSE which comprises of power conversion unit which has the rectifier and dc-dc converters and safety interlocks like relays contactors then you also do a lot of insulation monitoring you do a lot of you know temperature monitoring of the dcvac systems and those things will be communicated via supply equipment communication controller

which does communication with the vehicle via dedicated communication channel that is mostly done using PLC and CAN communication and on the other side they do communication with the cms system so this is how the dc charging system takes place now let us try to understand what is there in public charging station now this we are talking about from the broader perspective let's say this is a public charging station And in this we have several EVSEs which are being installed. For example, EVSE 1, EVSE 2 and so on EVSE N. And this EVSE could be either having single charging gun. or double charging gun it could be single charging gun or it could be double charging gun depending upon what kind of EVSEs you are installing it could be AC EVSEs or it could be DC EVSEs so EVSE could be AC or DC EVSE for example if you are having just the AC charger you put the AC EVSE if you wanted to have the DC charger you will put DC EVSE at the same time you will have either single charging gun or you can say the plug which goes and plugged into the vehicle inlet connector.

So that is one charging gun or it could have two charging gun or it could have multiple charging gun depending upon what kind of EVSE which is been there. Mostly if you see it is single charging gun or dual charging gun charging station systems are there. There is some thing where you will also see three charging sockets where one can three charging socket in EVSE which can be connected via vehicle via a wire which is coming from the vehicle. in some cases but mostly EVSEs have single charging or dual charging now in this one there are certain you know you have this AC grid which is coming in mostly you know this charging station will have its own you can say you know transformer which is been there dedicated for this entire charging station

then it will have its own switch gear systems , you know for safe operation of this EVSE like circuit breakers or relays which has been kept in and then this line which will be going will be going to different EVSEs depending upon you know if there is you know generally 33 kV or 11 kV line will be coming in mostly three-phase supply will be coming in and then again it depends on local power system architecture and local transmission and distribution companies and then depending upon what is the EVSC input requirements the conversion of voltage levels are taking place, mostly it is 400 volt three-phase AC , so each public charging station will have its own switchgear systems installed within itself further the public charging station must also have sometimes they have within them they have the central management system or sometimes if the charging station service provider is having multiple charging stations so they could have a single master central management system placed in the central facility or there could be one possibility central management system for each charging station so they will have they will be connected with each EVACs via a communication line And all the EVSEs will be communicating with the central management system to log the required data and to ensure the proper operation of this charging station. And in this particular thing, the EVSEs could be from different manufacturers. Similarly, the central management system could be there from different manufacturers.

So, there also the communication between them, there also they should follow a certain kind of standard where they have to ensure the proper operation of charging station. further there should be a proper distance between the EVSE such that the vehicle entry and exit can be possible with that and in India the EVSE requirements are defined in AIS 138 part-1 for conductive AC charging system part-2 for conductive DC charging system and this AIS 138 is from ARAI India Further, local government bodies and distribution companies will mandate the guidelines related to public charging stations and one need to follow those guidelines while installing the public charging stations. In India, already the guidelines have been released by the government. So, if someone wants to put in the charging station, they have to follow those guidelines while ensuring the proper operation of charging station.

So, after understanding DCEVSE, ACEVSE, and charging stations, let us try to understand, one by one, the different classifications and nomenclature that exist in this EV charging ecosystem. So, the first classification will be based on the mode of charging. So, the mode of charging could be three or four modes: Mode 1, Mode 2, and Mode 3. These modes are for

AC charging, and this is for DC charging. Now, if you look carefully, Mode 1 is the simplest method, where you just plug in a wire from a 5-ampere or 15-ampere home socket, which is already present in your home.

So, it is primarily for home charging, where you have an onboard charger that performs the required power conversion from AC to DC. Inside the electric vehicle, you have the onboard charger. This is primarily for AC charging and home charging, which generally has a limited power rating. They are basically used for overnight charging or slow charging of the vehicle. Then comes Mode 2 charging. In Mode 2 charging, you again have a 5-ampere or 15-ampere wall socket. Along with that, you have a control unit with integrated protection systems, such as RCD (Residual Current Device) protection, incorporated into it.

So, it is again for home charging because it uses a 5-ampere or 15-ampere wall socket. So, it is for home charging. But in this case, a portable charger is incorporated with RCD protection arrangements, and thus it will have some kind of control as well as protection. Then you have Mode 3 charging. If you look carefully, Mode 3 charging is for AC charging systems. It has a dedicated EVSE, particularly for AC charging. This dedicated EVSE has a specific connector and is installed either in a charging station or at home, as these EVSEs are not large.

So again, this is for AC chargers. Similarly if you see the mode 4 charging in the mode 4 charging it is primarily for the DC charging with a dedicated DC EVSE which is being installed mostly it is for the charging station because generally the DC charging systems are I mean the DCEVSE is a bigger in size because your power conversion unit is actually a high power conversion unit so these are generally for high power this one and since a lot of dedicated communication is there you require a dedicated EVSE so that dedicated EVSE systems are being there. So, this is primarily for DC chargers. So, these are the ways by which the different modes of EV charging will be taking place and the different charging systems are defined as mode 1, mode 2, mode 3, mode 4.

This mode 3 and mode 4 are primary for charging station where you have a dedicated EVSEs which are being used. which are been there and do communication with the central management system which are been installed by charging station service provider. So, this is how the modes of charging are been classified. Now let us see depending upon the different power levels of EV

charger how the charging levels are been classified. Now this is based on the power levels and it varies from country to country because different countries have different voltage levels of transmission and distribution system so that is why this power level varies from country to country so, in India let us see how the charging levels are been defined now they are been defined you know as level 1 level 2 level 3 for AC and DC system now let us see the level 1 AC charging level now it has the voltage level 230 volt and the power level which goes maximum up to 3.5 kilowatt which is nothing but you will get it when you multiply 230 volt multiplied by 15 you will get the value somewhere around 3450 watt which is within the you know maximum 3.5 kilowatt range Now for the DC charging for level 1 you will have voltage level which is greater than 48 volt and goes up to 72 volt and which will have the power level maximum going maximum up to 15 kilowatt Generally this is there for the system which can support a maximum up to 200 ampere so this will give you 72 volt time multiplied by 200 which is somewhere around 14400 Similarly, when you see the level 2 charging level for AC system, it will have the voltage level going from 380 volts to 400 volts and the power level goes maximum up to 22 kilowatts. So, when you have the system with maximum up to 22 kilowatts, you can classify that charging level as the level 2 AC charging system.

similarly let us see the level 3 now the level 3 ac charging system it is employed you know with the voltage level going from 200 to 1000 and the power level greater than 22 kilowatt and when we see the level 3 dc charging system it has the voltage level going from 200 to 1000 volt and the power level goes maximum up to 400 kilowatt mostly in the same range you know greater than 22 kilowatt to up to going up to 400 kilowatt so this is what you will see you know you have the level one for ac and dc which has the different voltage levels and the power levels which are been defined You have level 2 for AC, which has the power level, you know, power level and voltage level which have been defined. And similarly, you have the level 3 for AC and DC, which has the voltage and the power level which have been defined. And it is primary from Indian perspective because different countries will have different voltage levels of transmission and distribution.

So, this charging level, you know, this power level of this charging will vary from country to country. Now, since we have understood the modes of charging, we understood the levels of charging. Now, let us see what are the different charging plugs which are been there, charging

plug and vehicle inlet connectors which are been there and what are the standards are defining those particular systems. And first, we will see for the AC and then we will move to DC. In AC, you know, the first and foremost thing, you know, it come up with the AC type 1, which was originated from U.S., a primary because they have the you know single phase or dual phase AC distribution system. So, they come up with a system which can support this single-phase AC charging and when a lot of manufacturer come up with their elective worker. So, they understood the requirement for the interpretability and that is why the SAE sit together and they come up with this AC type 1 you know charging a charger socket. Now in this you have two AC pins if you see two AC power pins L1 and then neutral if in case they are using single phase if they are using two phase split phase so it is L1 and L2. And for signals or you can say for the communication they have the control pilot and proximity pilot and they have the power earth or you can say power or you can more precisely you can say protective earth pin.

To take care of, you know, in case there is some safety-related issue that comes up. So, this particular Type 1 charger uses the SAE J1772 signaling protocol for communication, which is the PWM-based protocol, a PWM-based communication protocol. It is sometimes also called the low-level communication. And primarily because, you know, this is the AC charging system. So, you are actually doing power conversion inside the vehicle. So, you do not need to send the battery status to the EVSE regularly. So, that is why this signaling protocol is good enough to manage those essential communications between the EV and EVSE.

It is a family originated in the US, and other parts of the world, like Japan, are using them. It is popularly known as, you know, the SAE J1772 connector, Type 1 connector, or Yazaki connector because it was first manufactured by a company named Yazaki. Both, you know, the charger plug—meaning the plug which is coming out of the charging gun—and the vehicle inlet connector are counterparts to each other when they get mated up. So, I mean, the pins are actually connected in a proper manner, and the form factors are, you know, uniform. Now, if you look very carefully, since CP and PP—which are Control Pilot and Proxy Pilot—do the communication, the size of the pins is smaller compared to the power pins where the actual power is flowing from the charger. That is why you can see the dimensions also change. Now, if you see The AC Type 1 supports single-phase AC charging. But when we go for high power levels, three-phase AC charging is required, and hence the International Electrotechnical

Commission sat together and came up with a new charger connector, which is also called the AC Type 2 connector. Now, if you look very carefully, the AC Type 2 connector—the AC Type 2 charger plug—has the L1, L2, L3, and neutral connections, so it supports both three-phase and single-phase AC charging. Mostly, it is for high-power three-phase and low-power single-phase.

And it is also called the Mennekes connector because it was the Mennekes company that made this connector, you know, the first time they made the connector. And all these connector specifications, like form factor, size of the power pin, and size of the communication pins, are defined in the IEC 62196 standard. And although they support a three-phase AC system, they use the signaling protocol same as that of Type 1, which is SAE J1772, based on the PWM-based communication to inform some of the status of the EV and EVSE. And it has been adopted in Europe, the UK, and India primarily for high-voltage propulsion systems, which use high-voltage batteries like 400-volt battery packs or 800-volt battery packs.

So, they use this AC type 2 charger plug and vehicle inlet connector. And the rest of the world except China, Japan and US. Because US and Japan use type 1 and we will see what China uses. So, there if you look very carefully, this is your neutral, this is your L3, this is your L2, this is your L1, this is your protective earth pin and if you look this is your CP and and this is your PP pin.

So, if you look the dimensions of other pins like L1, L2, L3 and neutral is bigger as compared to CP and PP because over CP and PP line it's the communication which is taking place while the L1, L2, L3 or neutral the power is actually flowing between them. So, this is what AC type 2 is there and it supports the three phases as compared to the AC type 1 which only supports the single phase. then comes china in china they uses gbt which is coming formulated by gao bio standardization commission from china they uses the separate charger plug which is consists of two signal pin which is cp and cc you know control palette and charging confirmation pin so they use the CP and CC and they use the L1, L2, L3 and neutral here also it is CC and it also supports both the single phase and three phase AC and the connector specification is given in like the form factor the size of the pins are given in GBT20234.2 standard. So, this is things which is been used in China And in India, with more and more vehicles coming up with electric

powertrain, so the Department of Heavy Industry Government of India decided to have the standard for AC charging.

That's when they come together and they come up with the AC-001 charging system where they use AC. the IEC60309 industrial plug connector which has the female plug on the EVSE and it has the male plug which comes from the EV via cable. So, the cable which gets plugged into it and the EVSE which is been there AC 001 EVSE if you see they have you know three type of this connector which is been there this is female plug on the EV on the EVSE female plug you know female part of IEC 60309. plug will be there three will be there and these are all independent plugs and they all support single phase loop the pin are line neutral and protective earth so in this one it supports three independent output so each output can support up to 3.3 kilowatt so, overall it supports maximum so overall evac support maximum up to 10 kilowatts and in this case, there is no communication which will be there between EV and EVSE.

So, there is no communication between EV and EVSE and this charger plug which is coming connected to there is no communication between them however there is a communication between EVSE and central management system and that is done via OCPP protocol which is open charge point protocol they have different versions however this charging system supports version greater than OCPP 1.5 again the input is same three phase 415 volt and output is you know three single phase which is going into the vehicle so this is the simplest charging system it was there to support the interpretability of the charging evs now these are mostly used in early models of car having the low voltage system early models of three wheeler evs the golf carts and those systems very early models however The scenario changes, you know, as we go along and a lot of, you know, AC type to come in. Then the IES standard came in. So, different kind of standard have come in.

So, but this was still there, still in existence in India. So, that's why this was the AC charging system which was there in India. Primary for, you know, early model cars and three wheelers having the low voltage battery. So, they have their onboard chargers on the vehicle which can convert, you know, the required DC power to the system. Then let us take the DC charger plugs and vehicle inlet connectors because in the DC charger plug we have a dedicated communication which is done via either PLC power line communication or control leader network communication system.

Now the first one is DC CHAdeMO. which is adopted in Japan and it was the initiative by Japanese manufacturer and you can see it is one of the early DC charging systems which was came into existence different companies like Fuji Heavy Industries Limited, Toyota, Nissan Tokyo electric power company Mitsubishi they came together and they come up with the standard for DC charging system which is called commonly called as a CHAdeMO and within the CHAdeMO standard all the communication related things and the connectors related things are being defined And this CHAdeMO was adopted in different countries in the local standardization bodies adopted things from CHAdeMO to actually also support the CHAdeMO DC charging system. It uses dedicatedly uses CAN communication and it is used primarily for DC charging.

So, it does not support AC charging. It only supports a DC charging. So, it has a DC plus, DC minus line. It has the charge start and stop thing. It has a CAN high, CAN low pins.

It has charge enable disable pin and this is the no connection pin you have. so it supports up to 500 volt to 125 ampere it was the first generation you know standard the second generation have also come up with 1000 volt and 400 ampere so again these standards are keep on modifying getting modified the current levels have been modifying the voltage levels have been modifying but it supports only DC it supports only DC charging that was the problematic thing because one has to install ZMO vehicle inlet connector to facilitate the DC charging and also either type 1 or type 2 vehicle inlet connector to support the AC charging so that was the biggest bottleneck and that's why people thought of why can't we have the combined charging system where we just use one vehicle inlet connector and with one vehicle inlet connector we can support both AC as well as DC charging that's why the CCS1 and CCS2 came into existence now the combined charging system one in the combined charging system it supports both AC type 1 charging system and the DC charging how it does let us see that if you look very carefully the vehicle inlet connector it has L1 L2 control pilot proximity pilot protective earth so if you look this one this top part of vehicle inlet connector top part of vehicle inlet connector can accommodate type 1 charger plug so just by using the top portion one can support the ac charging while one if one has to do the dc charging using CCS1 vehicle inlet connector then they will be plugging the CCS1 charger plug dc charger plug which consists of DC plus dc minus and then in the top portion these two l1 and l2 pins were not there only the

proximity pilot control pilot and protective earth is there so then this will go and gets plugged it onto this this one so the entire part will be used where the l1 and l2 pins will be there will not be any electrical connection and the entire thing will be used to do the to facilitate the dc charging So, what happens is that just by using single vehicle inlet connector one can support both AC which is AC type 1 you know it can support both AC type 1 charger plug as well as the DC CCS 1 charger plug. And that is why the inventory for the EV manufacturers or for the OEMs get reduced because they have to just install just one connector which can support both AC and DC charging. So that is the reason why this got a lot of traction and that's why it got incorporated by IEC 262196 and primarily because since in US and in Japan type 1 AC charging plug was there that's why CCS1 have come into existence. It uses PLC communication which is power line communication power line communication for DC charging

And the PWM signal signaling, which is the same following the same, you know, SAE J1772. Here in the power line communication, when they are doing the power line communication for DC charging, the communication standard will be given in ISO 15118 or DIN spec 70121 or in ISO 15118, where the high-level communication protocols are defined. And in IEC 61851, aspects related to different charging stages, charging states, and sequences are included. Thus, these standards define protocols for high-level communication. Because a lot of information needs to be exchanged during communication. And, you know, when they are doing AC charging, it is SAE J1772.

So, just by using one vehicle inlet connector, both AC and DC charging can be done. It is used in the US and Japan, the two countries where it has been used extensively because they have the AC Type 1 charging system available. So, it is in the US and Japan where they have been used. Then comes the DC-CCS2. Since the US and Japan use the Type 1 AC charger plug.

So, while the rest of the world uses AC Type 2 because it can support a 3-phase AC system. So, that's why there comes the necessity to have a vehicle inlet connector that can support both AC Type 2 and DC charging, or it can support both AC and DC charging, and that's why the Combined Charging System 2 has come into the picture. If you look very carefully, it has the same thing. If you look at the top portion of that, it has the same L1, L2, L3, and neutral pins, control pilot, and proximity pilot on the vehicle inlet connector. So, using this, one can plug the AC Type 2 connector and do the AC charging. You know, it can accommodate the AC Type 2

charge connector and can facilitate the AC charging. While whenever someone wants to do DC charging, they will be using the DC CCS2 charger plug, which looks like it has only control pilot, proximity pilot, protective earth, and DC plus and DC minus lines. So, whenever they plug into this charger plug, the entire thing will be used where there is no connection for L1, L2, L3, and neutral, and that's when this system will actually support DC charging.

suppose the DC ceases to charging. So, a facilitated DC charging. if you look carefully you know the actual charger plug looks like I mean the plug which is coming from the EVAC will look will have only this thing where this is control pilot proximity pilot and this is the protective earth this is DC plus and this is DC minus which actually got you know which got which will be covered over here so it has you know this one will be the this one will be the PP this one will be the CP and this is you know L1 L2 L3 neutral which is they have pin on the vehicle side but on the connector side there is no pin so this will be there which will just go into this but will not make any electrical connections it has also a protective earth and then you have a DC minus connector goes into this and you have DC plus connector which goes into it and that is when you will see that you know it supports you know this part can able to accommodate ac type 2 connector and the entire part can able to accommodate the you know this bottom dc plus dc my connection and CP and PP and protective earth will able to support the DC CCS2 charging system so with just one connector with just one vehicle inlet connector

So, you are what you can say the inventory for the EV manufacturers got reduced. So, with just one vehicle inlet connector, one can support both AC and DC charging. And that is the reason why this charging system got quite famous among different manufacturers. And in India, mostly this CCS2 charging system is being used for high voltage, high voltage, you know, propulsion system which has the high voltage battery. And it can support maximum up to 1000 volt.

And the current level will vary. Maximum it can support to 500 amperes. And you will find up to 400 kilowatt CCS2 charging system is been there. However commercially power level going up to 50 to 60 kilowatts is available with two charging guns. With each charging gun supports up to 30 kilowatts.

Here the communication is done via PLC for DC charging and that is done via high level communication which is been incorporated in ISO 15118 and the IEC 161851 which defines

different charging stages and we have DIN SPEC 70121 which is there in Germany. In India, ISO 15118 is being incorporated by Bureau of Indian Standards to facilitate DC charging system via CCS2 charging systems. Further, the IEC 61851 includes different charging states, sequences and stages of charging which the system has to follow. And in India, it has been included in AIS-138, which is Automotive Standard, Indian Standard 138 Part 2, which supports the DC charging system. However, in BI since the CHAdeMO and DCCCS2 is been there it is been incorporated in BI standard also as IES17017-2-3 this plug socket information is been there which has both CCS2 and CHAdeMO which is been there.

So, this AIS 138 include the detailed instructions about the charging system. However, the IAS BI standard takes the overall or you can say from the broader perspective the charging system what goes in or broader requirements or broader framework you can say. So, all those things will be determined in these different standards. In India mostly in India the DC CCS2 charging system is used to support the charging the high voltage battery system for a high voltage power turn or high-performance power you can say Then, as in China it was AC-GBT connector, so you will also have the DC counterpart.

It originates from China. It has, you know, it supports only DC plus and DC minus. Along with that, you know, you have S plus and S minus for communication, CAN high and CAN low basically. can low part be there then you have auxiliary supply is there so this is a plus and this a minus is for auxiliary supply this is actually to power the controllers and auxiliary systems involved in charging process and this is incorporated in this specification is being incorporated in 20234.3 standard You know in that standard this connector specification has been given.

It can support up to 1500 volt and maximum current goes up to 800 amperes. Again, this current rating will be getting updated with newer and newer version of these standards. Now, in India, just like we have AC-001, the Department of Heavy Industries also come up with BEVC-DC-001, which is Bharat Electric Vehicle DC Charging System, which is called as a DC-001. Now in this the EVSE will have the input 3 phase AC which is 3 phase 415 volt and its support maximum up to 10 kilowatts for 48-volt system and 15 kilowatts for 72-volt system. Mostly it supports up to 200 amperes for 48-volt system.

I mean here also it supports maximum up to 200 ampere which corresponds to nearly 15 kilowatts for 72-volt battery system and 10 kilowatts for 48-volt battery system. So, it is primarily being used for low voltage battery system because in India it's the initial three-wheeler and e-car models which were using low voltage powertrain having 48 to 72-volt batteries and this they use to charge the batteries. Thus, they require dedicated charging system to support fast charging of early three-wheeler and first-generation e-car models as generally three-wheelers were commercial vehicles where user do not want to wait for longer period for charging. Hence, Ministry of Heavy Industries in Government of India in 2017 came up with BEVCDC001 standard to support the fast charging of vehicles having low voltage powertrain with the 48- and 72-volt battery packs. Since it is the DC charging system, continuous exchange of information is required which is done by high level communication following 7 open system interconnection layers.

In this, the communication related information is derived from IEC 61851-24 while the application derived from GB/T27930 standard with some modifications related to operating conditions like temperature humidity etc and it also uses GB/T standard which is GB/T20234.3 connector with the standard 5 meter cable and which has the same thing and it supports the CAN communication similar to that of the GB/T dc however GB/T dc supports up to 1500 volts but this specifically in india is used to support the low voltage battery power trains where you have 48 volt batteries 72 volt batteries Manufacturers are also looking for upgrading to 96 volt powertrain. Now in India for two-wheeler electric vehicles different manufacturers uses different vehicle connectors and charging systems mostly using portable chargers.

With which interpretability of two-wheeler electric vehicle charging system is not possible. Now the interpretability is needed to facilitate public charging station especially for two wheeler electric vehicles which can also accommodate three-wheeler electric vehicles as three-wheeler and two-wheeler electric vehicle uses batteries within the same voltage level mostly from 48 to 72 volt that is why bureau of Indian standard come up with a new charging system with new connector which is incorporated in 170 IS17017-2-6 standard also called as a type 6 connector DC type 6 connector which supports the DC charging of the EV battery so it looks something like this if you look the shape of this it has DC plus DC minus it has auxiliary 1 and auxiliary 2 pins it has communication 1 and communication 2 basically it is done via you know

the communication is done via CAN communication which is given integrities are been given in IS17017-25 standard here if you see the COM1 it is CAN high.

And this is you know com 2 is can load channel will be there and it supports up to 12-kilowatt power level going up to 120-volt dc so it is like 120-volt dc and 100 amperes current it can support. So, for light electric vehicle having low voltage powertrain, we require a dedicated charging system. So, that is why they came up with new charger standard which was defined in IES 17017-2-6 while the communication was incorporated in this one. So, one was DC-001 and another one was this type 6 DC connectors which have been incorporated by the BIS standard. then they also realizes okay apart from that we also need the combined charging system just like we have combined charging system for high voltage powertrain why can't we have combined charging system for for light electric vehicles that means the having the low voltage powertrain or you can say having the low voltage ev batteries so that's why they come up with a new standard which is a new charger plug which was incorporated in IS17017-2-7 standard and it supports both AC and DC charging for LEV's light electric vehicle the communication is done using CAN communication which was incorporated in IS 17017-31 and it is also sometimes called as a type 7 connector because it is been incorporated in section 7 of part 2 of IS 17017 standard it supports up to 12 kilowatt for DC charging of 120 volt and for AC it supports 240 volt maximum up to 32 ampere it supports if you look very carefully this is only supporting single phase charging primarily for two wheelers. If you look very carefully it has the form factor similar to that of type 2 but it has the pins which are different which is neutral life dc plus dc minus a control palette proximity palette can high and can low spins which are being there so that is why using this they can able to do both ac as well as dc you know charging combined charging system is being there which is being incorporated in IES17017 -part 2 of IS17017. So, we see summary of reason why you know chargers, connectors which are being used. In US, you are using the Type 1 for AC, CCS1 for DC.

They also use CHAdeMO. The US also has Tesla chargers in their ecosystem, which supports both AC and DC charging of EVs. However, it is their proprietary connector, and only Tesla EVs can be charged using Tesla chargers. That is why we did not include discussions related to Tesla charger plugs and vehicle inlet connectors. In Japan, they use Type 1 for AC and

CHAdeMO for DC. In the European market and most of the world, they use Type 2 and CCS2. In China, they use GB/T AC and GB/T DC.

While in India, we have a lot of connector systems. We have the AC001. We have both IS 17017-2-7. We have AC Type 2 to support AC charging. We have, you can say, GB/T or DC001.

We have the IS 17017-2-7, IS 17017-6 connectors, and CCS2. and CHAdeMO. So, if you look carefully, this is primarily for high-voltage powertrains or those accommodating high-voltage batteries. This is for powertrains accommodating low-voltage batteries. With these connectors and standards, they can support dedicated charging stations for high-voltage batteries, like those in four-wheelers and commercial SUVs, and low-voltage batteries in two-wheelers or three-wheelers. Looking again at the summary: CCS originated in the US and was adopted worldwide. The charging connector is in SAE J1772 and IEC 62196-2. Communication supports PLC, and the charging types are AC and DC. CHAdeMO originated in Japan and was adopted worldwide.

The charging connector was a CHAdeMO connector. They use CAN communication. They support DC charging. The GB/T originated from China, and they use the connector defined in the GB/T20234 standard. Communication uses CAN, especially for DC, and they support both AC and DC. In India, or in Bharat, we use the connector GB/T20234, IEC6039, which is DC001 and AC001.

We use connectors with specifications given in IS170172 for AC. For DC, we also use the CCS2 charging system, which is incorporated in IS2. 17017-2 Section 2, and then they use either CAN or PLC. If they use CCS2, they also use PLC, and it supports AC and DC charging. In India, if you look carefully, we have DC001 and AC001 standards, which were initiated by the Ministry of Heavy Industries. They still coexist. Along with that, we have the AIS 138 standard, which has Part 1 for AC charging systems and Part 2 for DC charging systems, including specifications for both. They have also adopted the CCS2 charging system and incorporated it.

In Part 1, they incorporated the Type 2 charging system. Part 2 also accommodates CHAdeMO. Then comes the BIS standard, which introduced the 17017-2 standard, where

Section 2 applies. Section 2 primarily discusses the AC Type 2 charging system. Section 3 covers the DC charging system, which includes CHAdeMO and CCS2. It is Section 3. Further, for light electric vehicles, they introduced Section 6 and Section 7. Section 6 covers DC low-voltage light electric vehicles. Section 7 covers both AC and DC for light electric vehicles.

They have section 24 which includes CAN communication primarily for supporting CHAdeMO. They have section 25 for CAN communication and they have also come up with section 31 for CAN communication. This is for type 6 or you can say for light electric vehicle and this is for type 7 to accommodate both type AC and DC. And then they also accommodated ISO 15118 for supporting the CCS2 communication via PLC in CCS2. So, this is the scenario in Indian perspective which has been there.

You know still a lot of things are there which is still in the you know what you can say transition state. Mostly in India for high voltage battery it is CCS2. For in DC and AC type 2 for you know for AC and the charging stations are in in India are primarily having EVACs which can support these two-charging systems and why this has been there because mostly we require dedicated charging system for our cars for four wheelers for three wheelers they were using DC001. Now it will also coexist with you know type 6 and type 7 which will actually support the powertrain with the low voltage battery and here it is powertrain with the high voltage battery so in one public charging station there could be EVSEs which support charging of EVs with low voltage batteries and there could be EVSEs which supports charging of EVs with high voltage batteries primary for four wheelers So in this lecture we have seen an overview of different kinds of charging systems and standards which exist in different parts of the world and we have also discussed particularly what exists in India.

Further in this lecture we have also discussed different kinds of classification as per charging modes and charging levels. However, I would like to emphasize that this EV charging ecosystem is evolving with new technological advancements and amendments in various standards across different countries. So, one need to keep themselves updated. With this, thank you very much for patience listening to this lecture. We will see you in the next lecture.

Thank you.