

CHARGING INFRASTRUCTURE

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Week-12

Lecture-58

Lec 58: Charging Stations-I

Hello everyone, welcome to lecture number 58 of this NPTEL lecture series on charging infrastructure. Today, we will discuss some things related to charging stations. So far, we have discussed in detail the power conversion unit of EV AC, or you can say the power conversion unit of EV charging systems. Then, we have studied AC Type 2 charging systems. We have also studied CCS2 DC charging systems. Then, we have also studied DC001-based DC charging systems in detail and understood different communications being used and how key information is shared between the EV and EVSEs. Now, let us revisit different levels of charging, as in public charging stations, one can have more than one EVSE. And EVACs can have multiple charging guns or dispenser units.

Similarly, the EVACs installed at home can also sometimes be termed as charging stations. So, in some standards, the EVACs are also termed as charging stations. Now, in India, if we see, the charging levels are defined as Level 1 AC charging, with a voltage of nothing but 230 volts. Now, this will give a maximum power of less than 3.5 kilowatts, which you will obtain from a 15-ampere cable—nothing but 230 multiplied by 15, which is somewhere around 3.45 kilowatts and within this limit. Then, we have the Level 1 DC charging system for the voltage level of greater than 48 volts. And that will go up to a maximum of 15 kilowatts. For example, when we have 72 volts in BBC DC001 with a maximum current of 200 amperes, it will go somewhere around 14,400 watts, which is well within the 15-kilowatt range. Then, we have Level 2 AC charging, which has a voltage level of 380 to 400 volts and can go up to a power level of

22 kW. Then, we have Level 3 AC charging systems, which have a voltage of 200 to 1000 volts and a power level greater than 22 kW. We also have Level 3 DC charging systems, which have a voltage of 200 to 1000 volts and can go up to a maximum of 400 kW. Again, this number can also go up as the standards are getting revised, and there is a requirement for faster and faster charging. Now, in the charging station, one can have a public charging station. Then, one can have home charging, where in home charging, one can just have an EVSE with a single gun or, you can say, a single connector gun coming out of the EVSE, generally provided by car manufacturers. Fuel manufacturers also provide this kind of home charging or portable charging systems with these electrical components. Then, you have captive charging stations. Now, this captive charging station is mainly used for those places where it is completely used by a particular institution. Then, it could be called a captive charging station, as it is not for public use and is 100 percent used by the institution in which it is installed. And then, you have public charging stations, which are generally placed in those locations that are actually used by the general public, and anyone can use them. One can bring in any manufacturer, and any kind of EVSE can be put in that charging station. So, it is generally used in malls, restaurants, and movie halls.

Parkings, public parkings like hospital parking or stadium parking, could be any public parking places or apartment parking—any kind of parking one can have. So, different types of charging stations have been there. Generally, the local government provides guidelines for setting up public charging stations because they are meant for general public use. However, there are also certain guidelines provided for home charging as well as captive charging stations. But anyway, it is governed by the local government—how much they emphasize safety, the distance between EVSEs, the electrical infrastructure, and other related aspects.

Generally, it is defined by the local government. So, they define the guidelines, and one must follow them to set up a public charging station. However, focusing on public charging stations—generally, a public charging station has its own distribution transformer, or you can say it has its own transformer, switchgear, and safety features—different switchgears like current transformer panels, isolation transformers, cabling, all that information must be there for individual charging stations. Whenever you want to install EVSEs in a public charging station, you can take connections using these components available there.

The guidelines require a dedicated transformer, switchgear, protection systems, safety features, cabling—all must be defined. Let's understand the public charging station scenario: in a public charging station, what you have is—if I talk about public charging station— You can have many EVSEs—either a single EVSE, different EVSEs selectively, a DC charging station with only DC EVSEs, or a mixed charging station with both AC and DC EVSEs, facilitating both fast and slow charging—or, in other words, both DC and AC charging. So, all those features can be available. What I mean is, in a charging station, you have several EVSEs. Let's say you have EVSE 1, EVSE 2, and further EVSEs as well.

You know N number of EVACs one can install. Then in this EVSE, one can have either a single connector gun EVSE or one can have two connector gun EVSE, dual gun EVSE or single gun EVSE. In dual gun EVSE, you will have in the single EVSE panel or you can say in the single EVSE cabinet, you have two separate power conversion units and having the controller associated with them will be there, which can provide the charging for two different vehicles from the same EVSE. so one can either have single connector gun EVSE or one can either have two connector gun EVSEs and then you have a dedicated cabling will be there and you will have dedicated safety devices protection systems associated with that you could have you know you will have your transformer also before the before it is taking input from the grid One can also think about integrating the renewable energy with this setup where instead of the grid, one can have the renewable systems and then connect it through the required power conversion units to supply the EVSE and then EVSE will have its own power conversion systems associated with it.

so in the charging stations you could have multiple EVACs which are there so in charging station assume you have let's say three EVACs which are present EVAC 1, EVAC 2, EVAC 3 now individual EVACs will have its own supply equipment communication controller so they will have SCCC this will also have SCCC and this supply equipment communication controller could be present in EVSE or could be present in central place where the data needs to be communicated from EV to SCCC or supply equipment communication controller and so you will have let's see if we assume that it has three EVSEs so we will have you know one more EVSE let me draw one more EVSE for our easiness and and the third one also has a ccc for charging station you will have charging station service provider you could have dispensing system could be from

some other company similarly here we could have evs from different companies from different industries And then these EVACs are actually getting accumulated in the charging station which is actually monitored by the charging station service provider. So ideally one can also think about having some other kind of shops also there in the charging stations as well.

So, that charging station service provider is the one who is having actually controlled over the entire charging station. And in the charging station, you have different EVACs. It could be DC, it could be AC and the vehicle will come in and it gets plugged into the required EVAC desired of the driver as per the desire of the user who is using that EV. So this charging station service provider obviously controlling this EVSE at the back end and they need to store data to understand how this EVSE works or how they are communicated. So let's say some user comes in before charging.

they will ask for the authorization from the EVSE so those information like which user has come in what is the authorization authentication all those things will be controlled by the system provided by the charging station service provider that is called as a central management system so you need a central management system which is actually in control of the charging station service provider and this central management system will be communicating with the several as you can see supply equipment communication control of different EVSE and this central management system you can say central management system does certain tasks like for example it helps in doing the authentication provides the authorization helps in doing the metering monitoring of the different EVSEs changing the parameters of different EVSEs sometimes one has to define the different limits current limit or one has to define different parameters of the EVSE those things has to be defined then Data logging has to be there. Like let's say one user comes in, they swap their card or you can say RFID card into the charging station or let's say they logged in into the app of the charging station service provider.

So those data has to be stored. So it also does data storing, data logging. Basically, you can say different EVSEs are kind of getting controlled or monitored by the system called as a central management system. Now, this central management system is the one which has to be communicating with the different EVSEs. Now, here there is a problem means this EVSE could be from any manufacturer.

It could be possible that let's say EVSE 1 is from some company, let's say Delta Electronics. EVSE 2 is from some other company, let's say ABB. EVA C3 is from some other company for example again the third one is again from Delta Electronics and this charging management system is under the control of charging station service provider which is the owner you can say which is kind of owner of that particular charging station. So, now this different EVSE has to be communicating with the CMS of any different manufacturer or the CMS could be of any manufacturer, the EVSE could be of some different manufacturer. So, you require interpretability among the EVSEs and the central management system.

So, one require a specific standard of protocol with which whenever the EVSE is communicating with the CMS, they must follow a certain set of rules, certain set of protocols such that the messages which are being exchanged, the kind of messages, the format in which they are exchanged will be defined. So, that is why to ensure that interpretability is done, the standardization is maintained, there is a protocol called as the OCPP open protocol. charge point protocol is been followed and it is a open source protocol which anyone can go to the website and you can download a different version of that OCPP protocol and then can implement the communication between the EVSE and the center management system so what you finally see is we have our EVSE on one end it is connected to EV following certain procedures which has been defined in IEC standards or ISO standards simplest thing let's say if we have CCS2 one simplest thing is ISO 15118 protocol they will be communicating between EVS and EV over the CP line via power line communication And on the other side, the EVAC will be communicating to and fro with the central management system.

Now, this protocol which is being followed between EVAC and CMS is nothing but done by the OCPP open charge point protocol. so if one has to develop an EVSE so in the EVSE we have understood what could be the power conversion unit one can have the supply equipment communication controller which does communication on one hand with EV following a certain ISO protocol or SAE protocol on one hand and can able to communicate between EVSE and EV on one hand on the other hand the supply equipment communication controller has to communicate with the central management system primarily for data storage for authentication authorization billings meeting those purposes monitoring of EVSE so they will be communicating with the central management system and that communication need to be done or has to be done

via OCPP protocol which is open charge point protocol which defines how the communication between the EVAC and the central management system has to be done what will be the data types what will be the messages what will be the format of messages what are the different messages which has to be exchanged between the EVAC and the CNSC And they will also define how they can be implemented.

Now, as I mentioned in a charging station, one can have several EVSEs. One can have several EVSEs. And they will be communicating with the CMS. And all are communicating using OCPP. So, the central management system has to schedule, you know, which EVSE has to send the information and

Those things will be defined in OCPP protocol and how this thing is taken place, how the channel is been formed. So, we can see that we have different OCPP protocols are there which is communicating with CMS. So, there CMS has to define what will be the different messages and protocols or message format and data type which has to be and what kind of message which has to be shared between IVSE and central management system. So, using this OCPP will help to provide the standardization, to provide the interpretability and to provide the faster implementation between the EVSEs and central management system. So, we will now see how this OCPP works and what are the frameworks behind this open charge point protocol.

Now, let us see what is OCPP protocol. Now, OCPP as I mentioned it is open charge point protocol. Now, this protocol was conceptualized by the ELED organization, which is Dutch Grid Operator from Netherlands. Basically, it is a Dutch Grid Operator. So this was initiated by the E-LED organization which realizes that if we have EVSE from different manufacturer and if we have the CMS from different manufacturer, how they will communicate with each other.

Then it was first originated in 2009. The OTPT got originated. We can just write those things. then in 2010 it was the first time when the public version of OCPP protocol is published and these are called as then to be used by open public and they call that as OCPP 1.2 that's a 1.2 version then in 2012 they come up with the OCPP 1.5 adding different features or new features in the OCPP 1.2 and it got named as OCPP 1.5 then after 2012 in 2013 the Open Charge Alliance Open Charge Alliance or you can say OCA is formed

And these were formed when different EV infrastructure experts from the US and Ireland came together with the ELAG organization, and they formed the alliance called the Open Charge Alliance. Now, many infrastructure and EV experts related to the EV ecosystem have joined the Open Charge Alliance, which collectively comes together and formulates the OCPP protocol so that it can be standardized for communication between the central management system and the EVSE. Then, in 2015, OCPP 1.6 was published, introducing new features. After 2015, in 2016, the OCPP 1.6 compliant test tool was launched, which provides guidance on how agencies can use this tool to ensure compliance for manufacturers claiming to support the OCPP protocol. This is also called the OCPP Open Charge Compliance Test Tool. Then, in 2018, a new protocol, OCPP 2.0, was published as an improved version of OCPP 1.6. After 2018, in 2019, the certification program was launched. The OCPP 1.6 certification program was launched, allowing manufacturers or agencies to use this tool and define compliance. In 2016, the certification program enabled entities to approach the OCA and obtain certification for OCPP 1.6. Then, in 2020, OCPP 2.0.1 was published, and in 2022, the OCPP

2.0.1 compliance test tool was made openly accessible. In 2023, the OCPP 2.0.1 certification program was launched. So, every year, there are improvements, and currently, OCPP 2.0.1 is the latest version of the Open Charge Point Protocol. Now, let us briefly summarize how the Open Charge Point Protocol has progressed over the years. Now, let us explore what the Open Charge Point Protocol is. The Open Charge Point Protocol provides a standard protocol

or a standardized protocol for communication between the EVSE and the Central Management System, also known as CMS. This enables the exchange of messages and data between the EVSE and the Central Management System. It defines the types of messages, data formats, use cases, test cases, message arrangements, and other specifications. Again, in the data, it specifies what kind of messages, data types, use cases, test cases, message structures, and other details are defined.

The open charge point protocol standard has some key components which has to be understood what are those key components because once you understand those key components you will be in a position to understand how the OCPP can be implemented and how the framework is being defined. So in that it comprises of OCPP profile, it comprises of data types, what data types it has, what messages it has, What are the configuration keys it has?

What are the use cases and what are the test cases? And with each version of this OCPP protocol, the number of messages, configuration keys, test keys, use cases, all those things will keep on increasing because the new complexities, the new functionalities is being added with the OCPP.

and then once the new new functionalities are being added with OCPP the OCPP can able to also facilitate those different functionality and since one is following the OCPP to develop the communication between CMS and EVSE so then it could be standardized you know if one has to introduce that new functionality they have to just follow those messages and they can just easily upgrade their system to next version of OCPP they have to just change those messages and those data so now let us see what are these components is about so the ocpp profile is actually defines how the two entities communicate which include what are the messages which are being exchanged what are the message formats what is the specific functionality of each entity or you can say of each entity whether it is the EVSE and CMS that means what functionalities are been defined for the EVSE what functionalities are been defined for the CMS so the OCPP profile tells that what are the messages which are been exchanged what are the message formats specific functionality of individual units let's say the authorization has to be done then what the EVSE has to do and what the central management system has to do that functionality will be defined in that OCPP profile then comes the message so the message is nothing but a data unit which is transmitted between the EVSE and the CMS obviously during different stages of charging so it's the data unit which are shared between the EVSE and the CMS what all different messages which are shared between them and again those messages has certain format and purposes so the message are the basically data unit what all data units will be shared between the EVSE and the CMS when the charging is been taken place so that is the nothing but the message nothing but the data which is there

then comes the data type so the ocpp profile uses particular data types to specify the format and organization of the data or you can say the structure of the data how these datas are being structured now this data type could be boolean format could be of string format could be of date and time format now if the messages are used to share date and time Then date time based data type is followed. Then it will also have enumeration kind of representation. So these data types include the different kind of representation of the data in the OCPP messages. So it

defines what will be the type of the data which is been there in the OCPP message and how the data should be represented in what form it should be represented.

So each version of OCPP has different Numbers of data types, I mean new data types will be included, some data types will be removed, all those things will be there. Then comes the configuration key. Now the configuration key is nothing but the setting which actually defines what will be the response of the EVSE during the charging station. so basically it is like one can say that when you use any microcontroller you have to configure those different functionality in that microcontroller like for example when you're doing a communication what will be the border with which you are communicating what will be the number of bits of the data which is being shared between all content similar to that we also have configurations key which is a kind of data which are used to configure

How the data will be exchanged between the two entities that means between the CMS and the EVSE. Here you know it defines different settings, different restrictions or constraints that manages how the charging session is being taken place. That means it keeps on logging that information. Basically it defines the configuration of how the messages should be shared between the CMS and the EVSE. Now this includes charging rate.

That means how the charging rates are defined, it includes maximum power limits, it includes authorization requirements and all these requirements will be defined and every profile contains a collection of predefined configuration keys which actually configures the way by which the message should be exchanged between CMS and the EVSE. So the configuration keys define what should be the charging rate, configure those charging rates, configure those maximum power limits, configure those authorization requirements. So for that purpose these configuration keys are there. Then one has the use cases. Now the use case refers to a particular scenario that the protocol is intended to handle

For example, let's say when you are doing a transaction, so use case include the start transaction and stop transaction. So these are the two quality standardized steps one has to perform while doing the transactions. So for the steps which are well defined and same for all the conditions while performing a particular functionality, we can define the use cases corresponding to that. so basically it is a kind of function let's say when you write a big program

you are using different functions which has to do a specific task or specific requirement so you can import those functions similar to that these are the use cases which are predefined use cases like let's say the transaction has to be done obviously in the transaction one has to start the transaction one has to stop the transactions so whenever we are implementing this OCP you have to just call that start transaction use case stop transaction use case and when you write down the entire communication program so you will just import those use cases and thus arrange them in a proper sequence such that the required procedures can be done then comes your

Test cases, again they are the predefined cases which are used by the developer to ensure that the OCPP protocol is implemented correct or not. Basically, it has the predefined functions which easily developer can import and verify their implementation or how the implementation looks like. So, these are the different components of the OCPP which is there in the OCPP. Now, if you look very carefully, different versions of OCPP, for example, if you talk about OCPP 1.5, it has around 24 into 2 messages. So, there are 48 messages which are there.

There are 42 data types corresponding to how those messages are being structured will be there. And then you have, I mean, out of those 42, those 48 messages will be defined. then you have 15 configuration keys I mean 15 keys you will be using to configure the communication between the CMS and EVAP also to configure some of the features of the EVAP then the next if you talk about OCPP 1.6 in OCPP 1.6 they uses 60 use cases So here they don't define the use cases. One has to write down those use cases by themselves.

But in OCPP 1.6, they will also define the use cases, predefined functions, you can say. Then you will have 28 x 2 messages. Then you have 49 data types. Then you have 43 configuration keys. So you see, as the version increases, the functionalities and the way of representing data vary.

Then in OCPP 2.0, if you talk about it, it has 116 use cases, so further functionalities are being added. One can just import those use cases and sequence them appropriately to perform that particular functionality. Then they have 65 across two messages. They use 129 data types, which are incorporated in OCPP 2.0. They have 85 configuration keys, so you see configuration keys have been added. In OCPP 2.0, they also have a new feature: 260 test

cases, which are also defined. So one can easily import those 260 test cases and verify whether the implementation is correct or not. This is how OCPP progresses over time, implementing different procedures to obtain the required functionality. Now, in the next class, we will see how these OCPP function blocks work and what different functions can be included. We can also see how they can be implemented, and we will carry forward our discussion. Thank you, and we will see you in the next one.