

CHARGING INFRASTRUCTURE

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Week-01

Lecture2

Lec 02: Building Blocks of an ACEV Charger

Hello everyone welcomes to this lecture number two of the NPTEL lecture series on charging infrastructure in today's lecture. In present lecture we will study different building blocks of an EV charger So before starting that, let us recap some of the understanding we have developed in the previous lecture. So we have seen different kinds of EVs which are present around us. That means we have understood something related to EV ecosystem where we have primarily focused on the powertrain systems where we have actually the two kinds of powertrain system.

We have a low voltage system. We have a low voltage battery packs or batteries which goes between 48 to 72 volt for which the charging system supporting 40 to 120 volt are present. And then second kind of powertrains having a high voltage batteries. A high voltage batteries are the primary energy source, energy storage source in your battery powered electric breaker. Where the voltage levels will be somewhere between 350 volt to 500 volt.

in that particular 350 volt to 500 volt voltage range now if you look very carefully so since there are two kinds of i mean the from the perspective of the batteries there are two kinds of batteries which are there so we have when we go along in this particular course you will see that there are two kinds of chargers which are focused on these two applications primarily from from the perspective of a dc chargers we will see that Then the next thing we have understood different charging modes of an EV battery and we have stabilized that the important or the most commonly used charging modes are basically CC followed by CV which is constant current and constant voltage with you



know different sometimes people also use multi-step constant current charging as well. So, we have seen that we generally while charging they use CC followed by CV profile charging profiles particularly for the lithium ion batteries which are primarily used which are commonly used in EVs at present. and then we have seen the necessity of an EV charger like why the dedicated charging system or an charger is needed primary to basically meet the different charging profile of battery determined by the BMS of the battery pack and

At the same time, providing sufficient protection, again, from a safety perspective also. It also provides, you know, the data for meeting purposes. So, for different aspects, dedicated systems are needed. And, a dedicated EV charger system is needed for charging your battery-powered electric vehicle. So, let us see what the building blocks of an EV charger are.

So, let us start with what the different building blocks of an EV charger are. Now, if you look from the top level, these are again discussed from the top level. We will go into detail in depth as we go along in this course. So, the first and foremost thing is obviously a power conversion unit, primarily because you have an AC voltage source and the batteries are DC voltage sources. So, you need a certain kind of power conversion to take place. From which, convert that AC into a DC with required protection and different grid-connected requirements, so all those things will be there. It needs a dedicated power conversion unit, which could be either inside the vehicle itself or outside the vehicle, depending on whether the chargers are defined as off-board chargers or on-board chargers.

We will see as we go along what these terminal energies are, which are present. So, we have a power conversion unit, and in that power conversion unit, we have an AC-DC converter followed by an isolated DC-DC converter. Most of the chargers have this kind of configuration, and these configurations will facilitate the required operation of an EV charger as well as following the required charging profile, which is determined by the BMS of a battery pack. And then it has different filters, because the kind of current which has to go into the battery pack has to be ripple-free.

All those things will be determined by the filters. At the same time there are filters which are there to confirm the EMI, EMC requirements. So you have so there are some filters as well along with this power conversion unit as well. Then to make sure the power is converted safely at the same time, I mean at the same time it needs to also understand the status of vehicle as well as the charger at every instance of time. So there is a dedicated, the charger need to have a dedicated communication port or you can say communication channel.

where you know the informations are exchanged between the charger and the EV which is get plugged from the charger now the I mean as we go along you will see that there are different ports which are present onto the charger plugs like proximity and proximity pilot control pilot in case of can you have can high and can low can low dedicated can low ports or you can say that pins for for communicating or for having a dedicated communication channel as well And these two things will be the integral part of this and these two things will be placed or you can say that you will have a dedicated electric breaker supply equipment which is I mean for the AC charger it will be an AC electric breaker supply equipment. If it is DC charger it will be a DC electric breaker supply equipment. Now what is an electric breaker supply equipment?

So electric breaker supply equipment is nothing but Equipment which is kept in between the grid and the vehicle and it performs all the functionality I mean for ACEVSE it performs you know safety related things it will do it will do metering for metering purposes. exchanging information all those perspective this particular EVSE will be there and you can say indirectly that these two things sometimes will be kept inside that EVSE or you can say that it is a system which is placed between the grid and the EV. and then you have something called a dedicated connector which is connected between the EVSEs and your vehicle so you have a dedicated connectors as well as a cable so if you have a EVSE then you have a charging plug coming out of the EVSE connected through a cable Again, these form factors of the charging plug as well as this charging plug will be going into the vehicle inlet connector which is present in an electric vehicle.

So, these two form factors of this plug and the inlet connector has to match with each other. At the same time, the cable also need to have a required connection. know

dimensions like the length of the cable which generally comes in the range of 5 meter 7.5 meter or 10 meter again so these are also a important aspect because if let's say if someone is building a ev charger then this connectors has to be a such connector which is been accepted by different vehicle manufacturer so that connectors the form factors of the connector the size shape all those six must match with the vehicle inlet connector so that thing also have to be taken care very uh precisely it has to be taken care at the same time the the kind of cables need to be used the length of cables all those things are also very necessary when you are when you are designing or when you are building an EV charger so this will be the building blocks of an EV charger now let us see specifically what is an what are there in that in an AC EV charger let's say if you are going to a charging station you have an AC charger you have a DC charger

and let's say you plugged your vehicle with the ac charger so what are things are present inside the ac charger let us see that expert so if we look carefully since it is an acv charger we require an ac evac which is an ac electric vehicle supply equipment now if you look very carefully This ACEVSE system, why it is called an ACEVSE system? Because why it is called an AC charger which has ACEVSE? It's because you are directly putting that AC directly into your vehicle and all the power conversion will be taking place inside the vehicle. let us see what are things are there in an ACEVSE again you will see that all those building blocks what we have discussed in the previous slide those building blocks will be either kept will be kept somewhere in that ac charger system or in any charger system so let us see first how what are the things which are present in an ac charger so if you look very carefully. When you are doing an ACEVSE charging what you have is you have a something called ACEVSE which is AC Electric Vehicle Supply Equipment now in ACEVSE you have input coming from the grid this could be either single phase or three phase depending upon the amount of the power level of this AC charger and this single phase and three phase generally if you look I mean generally the power level for this AC chargers which are present is somewhere between you know 2 kilowatt to 22 kilowatt generally so generally You will be using either a single phase or a three phase connection directly from the grid. And if you look very carefully in the ACEVSE , since it is an ACEVSE , the output of this will also be in AC. So here you have the AC.

And if you look very carefully inside the ACEVSE , the things what you have is, you have the first important things, nothing but a safety interlocks or safety devices, which are nothing but, if I write what are the things which are there, you have contactors, you have relays, to basically take action in case there is some fault or in case the controller in the charger demands to cut off or to connect the input to the output. And you have again as I mentioned controller, so you have one controller also present. Sometimes this is also called as the supply equipment communication controller or sometimes also called as a charger controller as well. So, you have a dedicated controller which will be placed in an EVSE

And you have sensors installed in that EVSE. Now, those sensors are primarily, if I write down the sensors which are present, mostly voltage sensor and current sensor. So, it senses the input it senses the voltages of phases as well as it also measures the amount of current which is being taken out of that ac vac and now if you see so this output of this particular thing is an ac which actually goes directly into the vehicle So directly in case of AC charger you are plugging directly AC into your vehicle and on the vehicle what you have is you have after the AC input what you have is since your batteries are DC so you need to convert that AC into DC so what you have is you have and rectifier.

Now this particular rectifier converts AC into a DC and this DC will be fed to a isolated DC-DC converter which actually gives output in the form of controlled control DC. Now why you need to have the control DC? If you have to follow certain charging profile then you need to operate your DC-DC converter in such a manner that that particular charging profile is obtained.

At the same time, you have isolation such that there is isolation between the battery to which it is connected and the AC input. Then after that, what you have is Let me uniformly define the arrows, so this will be in this manner. Here, you have a DC, and then you have the output, which is the kind of DC output you want at its output. This particular isolated DC-DC converter can be operated to give you that. Then, this output DC, which is in a controlled manner, you can pass it through protective devices. Again, for the protection, protective devices in the form of contactors or relays can be put. And then after that, this protective device goes into the EV battery.

So, you have the desired DC voltage, which will be coming over here and going into the EV battery, and which will be used to charge the EV battery. Again, you can ensure CC or CV charging by appropriate operation of this isolated DC-DC converter. And once this EV battery is there, it will be monitored by the BMS, which is nothing but a battery management system that continuously monitors voltage, current, and temperature of battery cells. I mean, they could either monitor individual battery cells in a battery pack or some number of battery cells in a battery pack. So, they will continuously monitor the voltage and current which is getting injected into this one, and how much amount of current. Sometimes, currents are optional; they also measure just the voltage and temperature. It all depends upon the kind of BMS one is using. Now, this BMS

Depending upon the amount of current going into the battery or the voltage imposed upon the battery bank, it decides to what level or whether the particular output of the DC converter is following the particular charging profile or not. Then, it will communicate with the controller, which is another controller, which is nothing but a controller that actually controls duty ratios or phase shifts of these power electronic switches used in this rectifier and isolated DC-DC converter, such that it defines the references or defines what kind of voltage it needs to have at the output of the isolated DC-DC converter. Accordingly, this DC-DC converter and rectifier will operate in such a manner that the required DC voltage will be obtained at its output. So, this BMS will determine what will be the output coming at the output of the power conversion unit. And this battery management system will also communicate with the controller present inside the ACEVSE via a dedicated communication channel or a dedicated communication pin present in a connector that gets plugged into the EV.

So, you have a dedicated communication channel. Channel or port, you can say, and it will be communicating with the ACEVSE. I mean to define whether the EV is ready to accept that charge or not, and also whether the charger is ready to charge the vehicle or not. All that information will be exchanged. Different statuses will also be exchanged between the BMS and the ACEVSE, and this ACEVSE will also be communicating with the CMS, which is nothing but a central management system from the charging station service provider. Now, this is this is to actually do a lot of metering purposes to

understand the status of the charging station or the ACEVSE , which is installed in the charging station. So, they will also do communication between the BMS and the controller of EVSE. So, in total, if you see

the building block of an ACEVSE , the ACEVSE comprises a dedicated controller, different sensors for metering, for providing information related to metering, as well as for protection and safety interlocks to take required action whenever there is any fault or whenever the vehicle demands that they do not want the charge—the battery is fully charged, and they do not require any charging. Now, if you look very carefully at the entire system, between the vehicle and the ACEVSE , it is the vehicle—meaning you can say that the BMS of the vehicle is the master. It tells what kind of voltage it needs at the output of the isolated DC-DC converter.

Or it tells—it continuously monitors the battery status and tells whether the battery is safe, whether the charge is safe or not. All that information is the BMS, which will be communicating it with the controller of this power conversion unit. And at the same time, it will also be communicating with the ACEVSE . And it is the BMS that tells the ACEVSE whether the battery is ready to accept the charge or not. And if you look very carefully, this particular AC charger—the entire power conversion is taking place inside the vehicle itself. That means the power conversion unit, which is placed onto the vehicle, and thus this particular

this particular charger or when the AC charger gets plugged in you use this power conversion unit which is placed onto the vehicle and this power conversion unit is sometimes also called as the onboard charger where the power conversion is taking place onto the vehicle and you are directly plugging AC into your vehicle so that is why in case of AC charger you have an ACEVSE which is just doing so ACEVSE is actually performing if you see first is nothing but it will it is performing metering operation I mean it provides information for metering purposes it does monitoring whether the Whether keep on monitoring whether the EV is ready or not or when to turn off when to engage when not to engage or when to keep the AC at its output all those things will be so AC will keep on monitoring that will keep on taking information from the BMS and accordingly decide whether to keep the output on or not. And the third important thing it

takes care of safety that means in case of some problem happening in the vehicle the BMS will respond to controller of the ACEVSE and ACEVSE will then control the safety interlocks to basically open up the to basically disengage between the grid and the output and then the output does not have any AC at its output. So,

The ACEVSE does not do any power conversion, but it keeps on monitoring the status of the amount of power which is going into your vehicle and thus helps in performing metering, monitoring and safety functionalities. While on the other hand, you have an onboard charger, sometimes abbreviated OBC as well, onboard charger, where actually your power conversion is taking place and which converts an AC voltage into a DC voltage which is being used to charge the EV batteries and this onboard charges is controlled by its own controller which is again gets input from the BMS to understand what kind of voltages and currents are needed at the output. So, this is the entire building block of an ACEV charger where you can see that we have just an ACEVSE whenever we have an ACEV charger, we have an ACEVSE the input is a grid output is also an AC which get directly plugged into your vehicle and inside your vehicle it is the onboard charger where the actual power conversion that means conversion from AC to DC is taken place. So, with this, I end this lecture.

Thank you for patiently listening to this.

