CHARGING INFRASTRUCTURE

Prof. Apurv Kumar Yadav

Department of Electrical Engineering

Indian Institute of Technology Roorkee

Week-01

Lecture3

Lec 03: Building Blocks of a DCEV Charger

Hello everyone, so we are at lecture number 3 of this NPTEL lecture series on charging infrastructure. In this lecture, we will see the building blocks of a DCEVSE charger. But before that, let us recap some of the things we studied in the previous lecture or what we have studied so far. So, if we recall what we have studied, we have covered different aspects of an EV charging system, like the necessity of the EV charging system—why we need a dedicated charger system when you want to charge an EV. In that process, we have seen the building blocks of an EV charger, and we have seen the ACEV charger, where we examined an ACEV charger.

which actually comprises an ACEVSE. And in that ACEVSE, we have a dedicated controller. We have sensor systems that can sense the voltages and currents going through or entering the vehicle, primarily for monitoring, or this information can also be used for metering purposes. Then there are certain safety interlocks present, like contactors and relays, which are used for the safe operation of that AC charger. For instance, if there is a problem with the vehicle or the ACEVSE, these safety locks are used.

to de-energize the grid from the vehicle. At the same time, through these safety interlocks, the controllers can decide when to engage and when to disengage the grid from the EV. Then from that, at the output of AC, we have an ACEVSE. At the output of ACEVSE, we have the AC that is going into the vehicle. Inside the vehicle, there is a rectifier that converts the AC, which gets plugged in, into DC voltages—into a DC quantity.

And then this DC will be passing through an isolated DC-DC converter to actually provide the AC. controlled or you can say the regulated dc output where depending upon the charging profile the BMS can instruct the isolated dc converter to apply the required voltage at its output And then this output will be going through the protective device and it will be going into the EV batteries which is directly going into the EV batteries. And this isolated DC-DC converter will also provide the isolation between the EV battery and the AC which gets plugged into the vehicle. And the BMS will be continuously monitoring the voltage, current, the temperature of the battery cell.

Sometimes they just monitor voltage and temperature. It depends upon the BMS manufacturer or the battery manufacturer what they actually want to monitor. Generally, this monitoring is done to continuously understand the status of the EV battery pack at the same time whether the battery pack is in the safe operation or not or while the charging is taking place. So, all those things will be continuously monitored by BMS depending upon the status of a battery pack. It is a BMS which determines the kind of the charging, at what stage of the charging profile

our charger is and accordingly it will instruct the power conversion unit which is comprises of rectifier and dc-dc converter that they need to apply or they need to keep this amount of voltages or current at its output and along with that the BMS will be also communicating with the controller of an ACEVSE which inherently is also communicating with the central management system provided by the charging stations service provider for basically to do different functionalities like metering and then the monitoring of the ac charger which are placed in the charging station and If you look very carefully, the ACEVSE which are present, which is basically electric vehicle supply equipment, when we use an AC charger, we need to have the ACEVSE. And when you have an ACEVSE, the purpose or the functionality of ACEVSE is just three, which is to monitor the status of the charging, to comply to that and provide the information for metering purposes. At the same time,

Provide the safety functionality in case a fault happens on the vehicle or on the EVSE itself, so they will also take care of the safety features as well. Now, in case of AC, You will see that the entire power conversion, which is converting the AC voltages from the grid into the DC voltages because our batteries are DC sources. So, all that power conversion takes place inside the vehicle, which means the power converters or power conversion unit is kept on the vehicle, and that is what is also called the onboard charger. So, whenever you are plugging in AC into your vehicle via ACEVSC, the power conversion takes place inside the vehicle using the onboard charger, and this is the way by which this AC charger works. You will also see one more thing: While charging a battery pack, it is the BMS that is the master, which will define the required voltages or voltage output of the power conversion unit, and it is also the one that will respond to ACEVSE when to energize, turn on, or keep the

output on or when to keep the output off. So, the BMS is the master, while the controller in the ACEVSE is the slave. It will just follow what the BMS tells it to do. Now, let us see. So, this is what we talked about the ACEVSE charger, where the bifurcations are very clearly mentioned, and we have the ACEVSE and an onboard charger on the vehicle.

Now, let us see what all things are there in the case of a DC EV charger. Now, if you look at a DCEV charger, since it is a DC EV charger, we require a DCEVSE, a dedicated DC EVSE, which is nothing but a DC electric vehicle supply equipment. Now, what is this? Let us see. Now, if you look very carefully again, the charger is nothing but the system that converts the grid AC into DC in a safe manner, and continuous monitoring takes place. So, the same components are there, but the main component will remain the same. However, their location varies. So, let us see what is there in DC EVSE. In DC EVSE, what we have is again an input from the AC, so from the grid. And generally, these DC chargers or DC EV chargers are meant for high power, basically high-power chargers.

So, they generally take input from the three-phase grid. And generally, their power range is from, I mean, it goes from 15 kilowatts, to upwards of 200 kilowatts. I mean, you can also see some of the chargers going up to 400 kilowatts as well, available in this ecosystem. So, it takes input from the three-phase grid because these are meant for high-power charging, or particularly, you can say fast charging. It is being used, so you take either a three-phase connection or three-phase—you have to take the three-phase connection from the grid. And then, so here we have an AC which gets into the DC

EVSE. So, this is our output here, whatever gets plugged into the vehicle. Since it is a DC charger, you are plugging in directly DC onto your electric vehicle or onto your vehicle. So, that means you need to convert that AC into DC inside the EV itself. So, that means this particular AC is going into the rectifier, which actually converts

AC into DC. And again, I will draw the DC just to keep things uniform. Let me draw this single line here. So, this rectifier will again convert AC into DC. Now, this DC will be going again into this isolated DC-DC converter. Isolated DC-DC converter, you have now again

If you see why we need this isolation, it is just to have the isolation between the grid and the battery, which will be there in the vehicle. So, that isolation is there. And at the same time, you need to control, you need to apply the required DC at its output. So, that is why this isolated DC-DC converter is being used in this system. And then after that, you have again the safety interlocks.

The same relays, contactors, and high-voltage contactors will be there. Contactors and relays—I mean, these are the components that will help connect the output of the DC-DC converter to the vehicle. So, once it gets connected, it will be energized. I mean, the input will be given to the vehicle. Now, this particular DC output you are getting here is again controlled—or you can say regulated—DC. The amount of voltage to be maintained at the output will be determined by the BMS in the vehicle.

Now, the DC output will be directly plugged into the vehicle, where you have protective devices like contactors and relays. After these protective devices, it will go directly into the EV battery. Directly charging the EV battery. So, there is no power conversion taking place inside or on the vehicle. So, these onboard chargers will be bypassed in the case of a DCEV charger.

And again, the BMS will be there, communicating and continuously monitoring the voltage, current, and temperature of the battery cells. To ensure the charging is done safely and the battery pack operates safely. That is why the BMS continuously monitors the voltage, current, and temperature of the battery cells. And this BMS will communicate with the controller—the charger controller present on the DCEVSE. Now, this particular controller is sometimes also called the supply equipment communication controller.

You can name this as SECC, supply equipment communication controller. And so there is a dedicated communication channel between the BMS and the controller. So this is a dedicated communication channel. Or you can say port channel. We have a dedicated communication channel which will be exchanging a lot of information between the vehicle and the charger controller.

Much information will be exchanged between the BMS and the controller. And why this particular lot of information needs to be exchanged between the BMS and the charger controller is because the entire power conversion is taking place inside the DCEVSE. So, DCEVSE is quite a complicated system where the entire power conversion is taking place. Further, a lot of data is continuously exchanged between EV and EVSE. So, generally, this dedicated communication channel is there, and they do something called high-level communication, which requires a dedicated communication channel like CAN communication channel or PLC-based communication channel. High-level communication that we will study as we proceed. So, the thing which I am trying to convey is that a lot of information is exchanged between this controller and BMS, and why? Because the entire power conversion is taking place outside the DCEVSE. If you look very carefully in case of ACEV charger.

The information between the BMS and the controller of the AC EVSE, there is not much information needed to be shared because the entire power conversion is taking place inside the vehicle. And that will have the dedicated communication channel between the BMS and the controller of the onboard charger. So, there is a lot of information exchange between BMS and the controller of the onboard charger, but here in case of DCEVSE or in case of a DC charger where we have a DCEVSE. There is a lot of continuous information that needs to be exchanged between the battery, between the BMS and the DCEVSE. And this controller will then be used to actually define the different phase shifts or different duty ratios of the powertrain switches which are being used in this rectifier and the DC-DC converter. So, basically, this controller will determine how these power converters, rectifiers, and this isolated DC converter need to be operated such that the required value of DC voltage can be obtained at its output, which gets plugged into your EV, into your electric vehicle.

And again, this controller will then be communicating with Again, the central management system provided by the charging station service provider. This is again for metering purposes or understanding how long this EVSE has been operating to determine how much time this EVSE is engaged with the vehicle plugged into this DC EVSE. So, what does this DC EVSE do? Some of the important functionalities it performs are

Again, the power conversion. This is the biggest difference between an AC EVSE and a DC EVSE. The entire power conversion needs to take place inside the EVSE itself, requiring dedicated or continuous data from the BMS to understand how and when to operate, how to function, to detect faults, when to engage, and when to disengage. That is why the power conversion takes place inside the DC EVSE. Again, the second thing is monitoring—continuous monitoring and metering.

For metering purposes, information will be exchanged with the central management system, along with safety precautions in case a fault occurs in the vehicle or the charger. Thus, there is continuous sharing of information between the BMS and the charger controller, or in other words, between the vehicle and the EVSE, respectively. Now, if you look carefully at this particular system, here again, your BMS is the master while the charger controller is the slave. The reason I mention this is that the BMS knows which charging profile needs to be applied or used while charging the specific battery pack in a vehicle. It continuously monitors the voltages, currents, and temperatures applied to the battery pack and instructs the charger controller about the charging stage and required voltage output.

then this charger controller will react to that particular information from the bms and accordingly it will tell or it will tell to the rectifier and the isolated dc converter that you need to operate in such a manner that the required dc output voltage need to be put in such that the required current and the voltages will be drawn by the battery pack so if you look very carefully the basic difference between the ac charger and the dc charger is in the ac charger the power conversion is taking place onto the vehicle and that is why you have an onboard charger while in case of a dc charger the power conversion or the power converter units are kept outside the vehicle and is primarily because you have the very high power power converters where the size of power converter is enormous which cannot be put onto the vehicle because it will unnecessarily increase the unladen weight of the vehicle unladen weight means when there is no one onto the vehicle just the weight of the vehicle so this weight of the vehicle is something which has to be reduced as much as possible to increase its range and that's why whenever one is going for the high power charging you one need to go to a DC charging DC charger which is nothing but a DCEVSE and there it can facilitate the high power charging or the high power charging are used to charge the vehicle in very small amount of time maybe 15 minutes or 30 minutes period of time however the ac charges are generally being kept for overnight charging of a vehicle or in the scenarios where the user has enormous time with itself or will have the good amount of time like going from in between five to four to six hours if they have

so they can use the wall mounted acv charger or wall mounted ACEVSE because they are smaller inside so they can be easily mounted however in case of when someone wants to charge the vehicle fastly or you can say in just 15 to 30 minutes then they go for a dc charger which is nothing but a DCEVSE and which has the entire power conversion is taking place inside the EVSE itself and there is no power conversion on 2D vehicle or you can say that the onboard charger is bypassed in case of DC charging. And so that is why sometimes it is called since the power conversion is taking place outside the vehicle, it is also sometimes called as the off-board charger. as the power conversion is taking place outside the vehicle it is not happening inside the vehicle and since the power conversion is taking place outside the vehicle one need to share a lot of information of the battery pack i mean continuous the sharing of information of the status of a battery pack need to be communicated to the supply equipment communication controller to so that to understand at what stage of the charging profile the battery pack is and accordingly they can tell to this rectifier and the DC-DC converter that apply the required DC voltage and current.

So, thus the BMS is the one who is the master which will tell the charger I mean to tell the charger that this kind of voltage or current you apply at your output. So, in summary if we see we have studied AC charger which has AC EVSE and requires onboard charger for the power conversion and then we have seen the DC charger which has a DC EVSE where the entire power conversion is taking place outside the vehicle. thus it is if you look uh carefully it is difficult uh for i mean to manufacture or to design a dc charger a DCEVSE as compared to is difficult to design or manufacture as compared to this EVSE and one important thing is also there since this EVSEs are connected to the vehicle one need to make sure that this EVSEs must be comply to a certain standard such that this the EVSEs which are been installed can be connected to any vehicle or any car which is coming to the charging station and which gets connected to the EVSEs.

So, thus a dedicated standard or protocol needs to be followed by these EVSEs. to ensure that the interoperability between different manufacturers is also possible. So, thank you for patiently listening to this lecture number 3 for this NPTEL course. We will cover the remaining portions in the subsequent lectures. Thank you.