

CHARGING INFRASTRUCTURE

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Week-11

Lecture-54

Lec 54: DC Charging (CCS2)-V

Hello everyone, welcome to the lecture number 54 of this NPTEL lecture series on charging infrastructure and in this lecture we will continue our discussion on the DC charging system using the CC2 charger plug. So in the last class we have studied about the 7 OSI layer model and we understood that once the charger plug gets connected with the vehicle inlet connector the PLC modems of the EV and EVAC will get logically connected and that happened because of the slack procedure after that they will be ready on which the communication can be done and that communication it is happening using the 7 OSI layer which is open system interconnection layers and because of the seven OSI layer, these communication becomes reliable, have the proper error control is been taken care and the communication is been well structured. So that's why once the PLC modems get logically connected, they will be ready to exchange the information or the data.

and that data is structured or you can say that they will be ready to exchange the messages and that messages will be sent to from one PLC modem to another PLC modem following this protocol defined in those seven OSI layers and that is something called as the high level communication in the CCS to DC charging systems. so we have studied about seven osl layer which starts with application i mean obviously we are seeing from the sender perspective or the source perspective so we have application layer at the top we have presentation layer we have session layer we have transport layer network layer data link layer and the physical layer if we see in the entire I mean the all these you know the basic general information and some of the user case definition will be defined in ISO 15118-1 standard again these layers are basically consisting of several protocols so one will be there which will encompassing in all the layers

Then we have the 15118-2, which actually talks about the protocol descriptions, the different layers, which requirements, what are the requirements, what are the PD condition, what are the results, what is needed. And this is actually deriving some of the concepts from the different protocols.

and those are like for application layer I mean these are all included in this ISO 15118-2 standard and so in the application layer it's the messages I mean how the messages are being transmitted that will be determined how the message are structured those things will be defined generally it is vehicle to grid application layer messages then SDP which is nothing but SECC discovery protocol discovery protocol now this is important because in the EVSE and in the EV we have you know at the front end we have the PLC modems PLC modems in the EV as well as in the EVSE however after the PLC modems you know in the EVSE once the PLC modems get the messages over the CP line via power line communication over the cpn pe line via power line communication this modem will be communicating with the secc now this secc may be placed inside the evsc sometimes it may also be placed in the data center of the charging station service provider i mean in the centralized office it will be placed sometimes it will be inside the evsc sometimes it will be outside the evsc so that's why this sccc we should also get a you know valid address a logical as well as physical address and which will be communicating with the plc modem which will be placed at the front end on the evse while doing the communication between ev and evse so that's why a dedicated protocol which is called as the SCCC discovery protocol will be used and that will be placed in the application layer then the second one is presentation layer where the how the data will be represented will be mentioned and the data will be following the XML format or EXI format which is you know sensible markup language

or this is efficient xml interchange so you know they will be structured that messages or the data will be structured following the extensible markup language or using the efficient xml interchange format then the session layer now this session layer will be following a protocol which is vehicle to grid session layer protocol which will be again included in iso 15118-2 standard this transport layer things will be possible via the three different protocols one is tcp which is transmission control protocol control protocol then UDP which is the user datagram protocol again we are not going into individual protocols because that is again the very common protocols which are being used when the two systems are in the network the courses related to network it will be

taught in much detail then to ensure the secure data transmission between the two entities they will be following the TLS which is nothing but transport layer security protocol again that is another kind of protocols which have been there and then we have a network layer where the ipv6 you know this protocol will be used to determine the ip addresses and whenever there is error message there will be icmp v6 based a protocol which has been followed i mean those messages will be structured using icmp v6 where this is nothing but internet control message protocol

and then when we have the data link and physical layer whose information is been written in the ISO 15118-3 standard and also basically it is on using the PLC and this is the slack operation which is been performed so here you know it is been following home plug Green PHY standard, I mean those PLCs and the slack procedures in the PLC will be following the home plug Green PHY base standard. So application layer will provide all the protocols. It will support the network application in the system, which is any application which uses the internet to do the communication. so it has certain protocols in case of ccs2 it is v2g layer message protocols and sdp protocol again these message protocols are you know the different messages which are being shared between the ev and evsc whenever charging has been taking place

so here that thing is there then once the data is been entered using the application layer protocol in the system the presentation layer will convert the data into the machine understandable format which can be understand by the machine and then the session layer will comes in which makes the session or create the session between the two systems which are being communicating with each other where again authorization and authentication will be taken place authentication will be taken place and then the session And then the session management will be taken place, which we had discussed in the last class. Then once the session is being created between the two systems, then comes your transport layer where the data which has been received from the session layer because session layer also controls the flow of data. So that's when it reaches to the transport layer where the segmentation of the data will be taken place. Segmentation and also the flow control will be taken place and the

your error control will also be taken place that means it ensures the reliable communication between the two system and then again following certain protocols like TCP UDP TLS then after that there will be network layer in the network layer the segments will be appended with

the IP address of these sender and the receiver or source and the destination that's when it from the segment it will form the IP packets and here we are actually doing the logical addressing that means assigning the IP addresses logical addressing and also routing and path determination will also be taken place so both the things I mean how the data is being routed from one network to another network with the least resistance will also be defined and then after the IP packet which will be there in the network it will go to the where the IP packets will be appended with the MAC addresses of the source and the destination that's when it forms the frames and in the data link layer it will actually be doing the physical addressing that means defining the MAC addresses or adding with the IP packet and also it controls how the data is being placed in the actual physical media or you can say the channel through which the data has to flow so controls the placement of data in the media media means the channel over which the actually the signal has been flowing and then the physical layer will actually convert those the frames which is in the form of bits bits to signals and it will define the property of the signals in the following certain protocols which will be packaged in the physical layer so this is how the communication will be taken place

Similarly, we have also seen how the high level communication in CC2 charging system can be implemented using the seven OSI layers. Now, in this case, we have already discussed in the previous class where we have seen that in the physical layer, the initial condition or precondition before the physical layer is nothing but the plugs get connected. I mean, the charger plug gets connected with the EV as a result of which the control pilot and protective earth are connected and then the PWM with a duty ratio of 3 to 7 percent is initiated over the control pilot line which indicates that the vehicle enters into the B2 state and since the PWM is between 3 to 7 percent it indicates that now the high level communication need to be implemented over the control pilot and protective earth line via PLC based communication. And on both the sides, we have the home plug green phi compatible modems, that means on the EV as well as on the EVAC side.

Both the sides must have the home plug green phi compatible modems. Now, this particular layer consists of protocol which actually performs the functionality. It is nothing but the protocol is responsible to stabilize the physical link on the control pilot and protective earth wires to the opposite side. Opposite side means for EV it is EVAC, for EVAC it is EV. And the result will

be the PLC modules which are there are ready for communication with a stabilized frequency band of 2 to 28 MHz.

Now this layer ensures the start of physical connection to provide the data transfer between the EV and EVSE and it also defines the physical properties of the physical media such as voltage levels, frequencies etc. Now comes the data link layer. In the data link layer it comprises of the protocol which is responsible to actually stabilize the communication link. Now this particular layer protocol will start when there is a successful stabilization of the physical layer protocol. that means once the PLC modems are connected and they ensure that they are physically connected then only the protocols corresponds to the data link layer will be initiated and the protocols in this particular layer will be responsible for configuration of the PLC nodes will also be responsible to perform the slack

procedure and ensures that the correct plc modem of ev and evse are having the logical connection with each other and finally it set up the logical connection of the plc modems following the slack procedure so it this layer ensures an error-free data transfer of data frames from one node to the another node and again it is following the slack procedure now comes the network layer protocols now in the network layer protocol will be initiated only once the data link layer protocols are been stabilized successfully that means modems are now logically connected and they can do the communication with each other and this particular layer protocols are responsible to implement IPv6 internet protocol to define to define IP addresses and that is done primarily by using the Slack procedure which is nothing but stateless address auto configuration So using this stateless address auto configuration, the IP addresses of different nodes, that means the PLC modem of EV and EVSE as well as supply equipment, communication controller and electric vehicle communication controllers so using this particular ip addresses this will be defined and this particular thing also ensures that there is a unique addresses for all the nodes which are being communicating in this particular network so there is a unique ip addresses defined to the supply equipment communication controller the electric vehicle communication controller the plc modem of ev plc modem of evse

and then finally there will be implementation of the icmp version v6 which is nothing but your internet control message protocol to actually send dedicatedly the error messages so when the error messages are being sent they are sent via icmp v6 protocol and when the normal messages

are sent they are sent by the slack procedure which is used to define the ip addresses for different nodes which are been communicating with each other and this layer will actually determines or controls the path of connections through which the data has to travel between the sender and the receiver or the source and the destination further the outcome of this will be all the nodes will obtain the valid IP addresses Now comes the transport layer protocol. In the transport layer protocol, they will only be initiated once all the network layer protocols are been stabilized successfully. That means all the nodes retrieves the IP addresses.

That means their logical addressing is been performed. Now the protocols in this particular layer will be used to actually do the reliable, fast and safer communication and that is among all the nodes which are actually communicating with each other. That means we are talking about EV, EVSE, supply equipment communication controller, the electric vehicle communication controller. So, in CCS2, for reliable communication, they follow the transmission control protocol. For fast communication, they use the user datagram protocol.

And for safer communication, they actually use the transport layer security based protocol. However, sometimes it is optional, but it can be incorporated as well. That means in the ISO 15118, for the transport layer protocols, the TCP, UDP and TLS protocols are being incorporated. for providing the reliable fast and safer communication so the outcome will be stabilizing the reliable fast and safe data connection between the nodes now this layer ensures the fast reliable safer communication between the nodes now node means the PLC modem of EV, EVAC, supply equipment communication controller and electric vehicle communication controller.

Then comes the session layer protocols. Now the session layer protocols will be initiated once there will be successful establishment of the transport layer protocol and the protocol in this particular layer will be responsible to implement vehicle to grid transport protocol which is nothing but also called as the V2GTP protocols. Further the protocol also responsible to stabilize, manage and terminate the connection between the nodes by using the IP addresses and the port numbers. and then it is also responsible to implement the session layer header which contains basic information like protocol version like protocol could be of different version so the protocol version for both the source and the destination should be same so that will be

added up in the session layer header which is nothing but the protocol version now the payload type

and the payload size payload means the kind of data which is to be transferred the format of data in which they are being sent so those things should be defined so the outcome will be the stabilization of charging session connection between the node that means between the EV and EVSE which they will be communicating so this layer ensures the stabilizing the session for data exchange between nodes that means your EV and EVSE Then comes the presentation layer protocol and in the presentation layer protocol it is only be implemented once they successfully stabilize the session layer and in this case both the EV and EVSE use the data encoding format which is nothing but EXI which is we know as we have discussed it is nothing but efficient extensible markup interchange. So, they are I mean both the EVA and EVAC use this EXI format to do the encoding. So, the protocol corresponds to this protocol layer will have the functionality which includes the coding and decoding from the application to the network layer format and particularly the V2G EXI protocol consists of two different message sets which are V2G application layer protocol handshake messages and V2G application layer messages so one is the handshaking messages another one is the actual messages which is being shared between the EV and EVSE and the protocol is also responsible to implement the message header which contains the session ID

the notification to initiate or when to stop, the signature, the message body. Along with that, it will also have the message body which represent the message information. so the outcome will be you know you have the validity and compatibility of exchange messages is ensured between the ev and evac so this layer actually transforms the data which enables the correct data exchange between the ev and evac so it act as a translator of the system so on both the sides this kind of this encoding and decoding will be taken place such that the messages from the application layer will be converted into the that particular format which can be understandable by the ev on one side and evac on the other side and then finally comes the application layer protocol in application layer protocol it will be the pre-condition or the initial condition will be the there will be successful establishment of all the presentation layer protocols and in this particular layer it primarily manages the messages which is taking place between the ev and evac it takes care of all the messages which are being exchanged between ev and evac it is also

responsible for stabilizing the charging procedure that means identification pre-charging charge security check extra all the kind of messages it is responsible for that and the application protocol messages

are used to actually select the charging standard between the EV and EVSE so it could be possible that both the EV and EVSE will be having different charging standard so the application protocol messages must be there to ensure that both the EV and EVSE must be having the same charging standard So in this case the EV sends the supported application protocol request which contains all the standard which EV can support with that particular EV can support and then EVSE will select one of the standards by sending the supported application protocol response with the selected scheme ID. So all the protocols are associated with the scheme ID and which is been sent from the EV to the EVSE saying that this many protocols protocols the EV can support and then EVIC will select one of the protocol out of that because it could be possible that EVIC will be implementing the protocol messages of some different standard that means for example we have DIN spec 701 21 and also we have ISO 15118 both have nearly the same kind of messages but there are some messages which are different from each other so that's why the EV must send the information to EVSE that whether it can able to support that particular standard or not and then EVSE must select for which standard it is been

configured and accordingly it should select that particular standard and send the response message to the EV and then it ensures that all the messages which are shared between EV and EVSE are compatible to each other and thus can able to ensure the proper operation of the EV and EVSE so the outcome of this will be representing the messages and the required communication protocol so after this the messages will be represented and the communication protocols will be implemented and this layer ensures the initialization and configuration of the charge process so this is how the protocols are arranged in seven layers and each layer performs the specific functionality that means the protocols are responsible to do that particular specific functionality and that is how it is been implemented in the CCS2 now we know that in our EVSE what we have is we have our supply equipment communication controller which is SCCC which is actually communicating with the PLC modem which is present at the front end and then after that we have the CP and PE line over which the high frequency signals are

superimposed and which is then be connected to the EV on the other side via the you know charger plug and on the other side we again have CP and PE which is again connected to the PLC modem And after that what we have is we have on the EV side we have EV communication controller. So in this case what we have is that sometimes now this supply equipment communication controller may be placed inside the EVSE or it may be also placed in a data center of the charging station service provider.

So we need to define the IP address for the supply equipment communication controller. So to get the IP address of SECC the EV uses the SECC discovery protocol. which is nothing but is a UDP based protocol which is nothing but user datagram protocol and which ensures the fast communication between the two nodes which are communicating with each other. So, in this case what happens is that the request for the SECC discovery protocol is sent from the EV to the SECC and in that message it contains the session ID for which the ev and evac are being configured and then after receiving that request the secc will respond to it and in the response message it it contains the secc ip it contains the session id and it contains the secc tcp port which will be used for communication so this is how the ev will discover the secc and will define the ip address of the secc so in summary if we see

What we have is, we have all the seven layers starting from physical to the application layer and over the period of time, first the control pilot signaling is being done. That is done via certain kind of message which we have studied. There we will be following the IEC 61851-1 and which is actually nothing but 1 kHz PWM. After the control power signalling is done, the network is being set up. That network is being set up using the GreenFi based standard.

And before that, once the 1 kHz PWM is set, the PWM duty ratio is being set between 3 to 7%. Then it will ensure in the physical layer, the HomePlug GreenFi compatible PLC modems are ensured. That will be ensured in the physical layer. and then after that the data link layer will take in place which also be included in home plug green five base and this is basically doing the slack operation and after the slack operation is done since it is a network setup the ip will be defined using the sl double ac procedure and that will actually define the IP addresses between the EV and EVSC modems and then in the same place after this somewhere between this thing the using the UDP the SECC discovery protocol will be done to define the IP addresses to the SECC as well.

Apparently it will be done so here the PLC modems get IP addresses here the SCCC we will get the IP addresses And then after this, it will enter into the transport setup where they will be following the TCP and TLS protocol for reliable and safe data transmission. And then after that, what happens is that after the transport setup is done, they will go into the security protocol setup where they will following the tls protocol at the same time there will be again another parallelly in in the transport layer the v2g transport protocol will also be activated and then after security is been defined uh the session setup will be defined in the session setup we have a vehicle to grid transport protocol then we'll be using the xml or exi format data will be defined and that will be covered in the session layer as well as in the presentation layer as well and finally the data transfer will be taking place and that data transfer is actually be done in the terms of messages which is generally being you know different protocol messages which is been shared between the EV and EVSE controllers via EVSE modem so now let us understand or how the protocol messaging in case of CCS2 charging system are been implemented

which are using the high level communication so if we see what we have is on one side we have the EV controller on other side we have the EVAC controller and to do the communication what we have is we have EVCC which is electric vehicle communication controller and we have SCCC which is supply equipment communication controller this is supply equipment communication on other side we have EV communication controller And after this, we have our PLC modems, which will be converting that messages from the EVCC into the form, which can be superimposed on the CP and PE line to be sent to the PLC modem of other side, which is nothing but the EVAC. And that PLC modem will be then sending a message to the supply equipment communication controller. So, there will be a lot of communication, there will be a lot of messages, which are shared between the EVCC and the SCCC.

And they are actually sent using the simple request and response protocol where our EV is always the master and it will always request. So mostly, the request will be initiated by the EV. And those messages will be there in the form of a request. So the EV is always the master, and the EVSE will be the slave, which will respond to the request sent by the EV. Thus, the EV will always request, and the EVSE will always respond to that request, which is done by the EV.

In the request, if you see, we first have the communication setup sequence. So initiation will be done by setting up the communication between the EV and the EVSE. After that is done, there

will be certain services which the EV and EVSE will provide. So the identification of those services, the authentication of those services, and then the authorization of those services will take place. And then after that, there will be target setting and charge scheduling, which will take place. That means the configuration of the charging parameters, and then the power delivery stage will take place. After that, once charging is initiated, there will be continuous charging, and there will be continuous information shared between the EV and EVSE. The EV will keep on requesting different voltages and currents from the EVSE.

And the EVSE will then respond to those requests from the EV. Finally, at the end of charging, there will be several procedures which have to be followed before the plug can be unmated. So this procedure has to be followed, and if this sequence is not followed, there will be a critical error. In case of a critical error, the EVSE will answer the wrong request with a response code, which is nothing but a failed sequence error. And after the error is received, the session will be closed immediately. That means the communication session will be closed immediately between the EV and EVSE. So this procedure and this sequence of procedures have to be followed when the power transfer is done between the EV and EVSE.

Now, in this if you see, the communication is started whenever the charging state reaches to its b2 state that means the initiation of the logical connection will be started by the plc modems once that logical connection is being done and then after that the charging state enters into the state c before it goes for the cable check procedures and once the cable check procedure is been done everything is okay pre-charging will take place then the power delivery request will be taking place then the current demand request will be taking place and then the actual power transfer will be taking place and then after that what happens is that before the start of the end of charging is initiated the charging state will then enter into the B state and then finally it goes into the session stop request and then finally the communication gets stopped now in between if there is some error the EVAC will then switch off his oscillator which will again send the error messages to the EV and then the required shutdown procedure can be initiated if required so this is how it starts from B to state where the logical connection is being initiated then the service discovery request will be taking place after that the charging state will enter into the state C before the cable check response and then after the initiation of end of charging initiated before that the charging state will enter into the B state and then finally there will be

contactors get open up and then the charger gets unlocked to be removed from the vehicle inlet connector so the initiation is started now here we assume that our plc modems are logically connected and the supported application protocol request and response are being shared between EV and EVSE and that's when both the EV and EVSE knows that what will be the charging standard which will be followed actual version and number of that and then after that there will be creation of the session so here the session setup stage will be taken place so after this you know this condition has been already been taken place after that there will be new session which will be created. Now in this new session what happens is that first the EV will send the session setup request and in that request they will define the session ID to be 0 and the EVSE will then respond to that request and then in the response message what they will do is they will send the new session ID and this session ID which will be sent by the EVSE will be then used will be then used will then be used during the entire communication process.

So once the session IDs are been defined it will be used throughout the communication process until the communication gets ended up. Now in case if the EV sends the invalid session ID so if EV sends invalid session ID the EVSE will then respond send the response with response code fail and this is nothing but using the session setup response message which is you know here just setup session setup response message in the session setup response message they will just send that there will be the response code failed that message they will be sending if in case the ev sends the invalid session id now this particular thing is essential because in case if there is a restart session is taking place and it is especially happening only in case of only in case of ISO 15118 case in case there will be restart of the session so EV will then send the session setup session request with the

with the last session id which was used and the evac will then respond with the same session id so in case if there is a restart of the session so the EV will then send the session setup request with the last session id which was used so if during the restart of the session if the EV sends invalid session id then the EVSE will then send the response with the response code field in case if there is a correct session id or which is same as the last session id so EVSE will send the same session id with the response code as okay old session so using this the session are set up between the EV and EVSE after the sessions got set up between EV and EVSE there will be service discovery request and response between the EV and EVSE because EV must also

know what kind of services that particular EVSE is providing at the same time what kind of services they can use while doing these charging so the EV will then request to EVSE about the information of available services with them And the EVSE will respond to it and then after that the EV will request a particular service once they know what kind of services which EVSE can provide. For example, one basic service could be vehicle charging, could be the payment which will be done after the charging is been done, could be just the certificate installation.

could be just the authorization any kind of services which can be done particularly in case of ISO 15118 the details about the services what will be the parameters related to those services can be requested from the EV using the service details request and the EVIC will then respond with the service detail response messages and this service detail contains all the information regarding the services all the important parameters related to those services which are been there and that's when the EV will understand what kind of services which the EVIC can provide and accordingly EV will then request that required services payment service selection in pivot service selection in iso that particular message is called as a payment service selection in case of dean spec 70121 it is nothing but the service payment selection so in this kind of thing what happens is that for example in this particular thing the evac can request the type of payment and it could be you know contract based payment or it could be the external base payment anything could be possible and then EV will then add the list of services which should be used while doing that particular payment while facilitating that particular payment and after this there will be authorization So for example, authorization could be one way is using the RFID cards.

So in that authorization, the messages include which is nothing but contract authentication in case of DIN spec 70121. In case of ISO 15118, the message name is authorization request and response message. So, the EVA will then send the request authorization request message to the EVAC and the EVAC will respond to that that whether that particular charging is authorized or not. So, there will be waiting until the session is authorized by the EVAC. So, EVAC takes some time for example, if the user goes and use that RFID card in the EVAC.

So, the EVAC will then evaluate whether that particular card is authenticated or not once they authorize that particular and then the charging will start and during the charging the EV will then ask the EVSE about the authorization and then the EVSE will then take some time to respond that whether that session is authorized or not so that is nothing but the authorization part that is

another kind of services which will be provided by the EVSE. Now, once the authorization is done, once the payment service selection is done, once the service discovery system is done, then comes your the charger parameter discovery because now the charging has to start. So, before starting that charging, the exchange of charging parameters such as maximum voltage, maximum current and power has to be taken place and that for that the EV will

send the charging parameter discovery request charging parameter discovery request this is the name of the message which will be sent from the EV to EVSE and then it will be sent multiple times until the EVSE will send a response message And because EVSE takes some time to evaluate the parameters and then send it back and once they will send it back they will make the EVSE processing field which is one of the kind of a variable they will make it equal to finished. And in case if the EVSE parameters are not been determined what they will do is they will send the EVSE processing is nothing but equal to ongoing. if parameters are not determined are not determined. If the parameters are determined then the EVSC will make the field nothing but equal to finished.

Now after this the charging state will now enter into the state C where it starts with the cable check and this is nothing but it is a continuous monitoring of the insulation resistance as we have discussed and in this case the cable check request is sent by the EVSC. by the EV multiple times during the EVSE operations or during the operation when the power is being transferred from EVSE to EV. And then EVSE will take some time to respond to that. It will take some time to determine the insulation resistance. If it is in the process, they will put the field EVSE processing is equal to ongoing.

If that is completed, they will send the response with the insulation resistance method and they will make the EVSE processing field to be equal to finished. So, we have EVSE processing field or you can say the variable which is it is finished if it is done if completed the processing is completed that means the instruction resistance is determined and it is ongoing if if processing is not finished is not completed that means the cable is check is still going on then after the cable check is done the pre-charge state will start and in this pre-charge state the pre-charge request will be sent by the EV until the EV can measure a voltage on the EVAC side which matches the battery voltage with the tolerance of 20 volt because we have discussed that if there is no matching of the voltage there will be huge inrush current to be flowing between the EV and

EVAC So, they must ensure that the voltages will be within the tolerance range of 21. So, EV will send the request and EVAC will then respond to that request with the current voltage level what they have at its output that means at the DC plus and the DC minus.

so after pre-charging request is concerned it has been responded from the evsc what will be its voltage if the voltages is within the tolerance length then comes the power delivery stage where it will be initiated by the request from the ev which is nothing but the power delivery request which has been sent by the ev after the pre-charging is been done successfully And then after that, the EVAC will respond to that power delivery request. And after receiving the power delivery response, the EV will close its contactor switch and proceed with the charging process. so in this case after pre-charging condition arises there comes the power delivery stage where the power delivery request will be sent by the ev and once that particular thing is done the response will be sent by the evsc and once the power delivery response is achieved the ev will close the contactor switch and proceed with the charging process now during the charging process when we are at this place there will be the current demand which will be continuously requested by the EV during the charging process so depending upon the SOC level of the battery pack the EV will continuously changing its current demand and each request which contains the request for the required charging voltage and charging current at the DC plus and DC minus output and EVIC will process that particular demanded values

and then set the power source to the required values that means the you can say the power conversion unit it will ensure the working of the power conversion unit such that that it will be set at the required values at its output and along with that EVAC will respond you know in this case the EVAC will also respond back with the present level of voltage and current at its short pole in that response that particular information will be there and in case there will be error So, the EVAC can trigger the stop of charging by sending a notification inside the current demand response. Now, once the battery reaches to its required SOC level, the EV will then start the end of charging process. During that time, the EV will stop the charging process which is just by sending the power delivery message.

So, by sending power delivery message response message and once the power delivery response messages is been obtained by the EVAC then the EV will change the state of switch S2 and that's when the charging state will enter into the state B and then the EVAC will respond

to the power delivery response and after this the welding detection will be taken place now this is welding detection is optional step and this welding detection is to ensure that the DC contactors are opened or not in that what happens is that the welding detection request will be sent by the EV and once the welding detection request is been sent by the EV the EVSC will request to that welding detection response which contains the major voltage of DC plus and DC minus line and if the measured voltage is not equal to zero then it indicates that there is some problem that EVSC contactor does not get open up or they get heated up and gets melted and gets welded up So, in that case, the error message will be initiated and the EV will then respond to that by opening its conductor.

And finally, there will be session stop stage where the EV will then initiate the session stop request which will be responded by the EVAC and that is when the communication session will be stopped between the EV and EVAC. And then one can remove the charger plug from the vehicle unit connector. So we have seen that in CC to DC charging system the communication is very complex and a lot of information need to be exchanged between EV and EVAC and that information also must have to be properly secured also must be does not have any error must be error free must be secured must be properly managed or you can say properly arranged and at the same time it is a lot of information need to be exchanged continuously So that's why we require the high level communication and since a lot of information has to be done so that information cannot be sent by PWM based communication. So we require a dedicated communication channel which is done via PLC over the CP and PE line which is done by superimposing the very high frequency band signals between 2 to 28 MHz over the 3 to 7% PWM of 1 kHz frequency.

And then in this system we have seen different charging sequences. Different charging sequences. After that we have seen how the Modems after getting connected, how they get logically connected? In case when we have DC charging station where several modems are present, how one should ensure the correct modem to be logically connected?

After the logical connection, communication can be done over the PLC, and that is achieved using high-level communication following the 7-layer OSI model. So, we have seen how this process takes place. We have understood different aspects of the CCS to DC charging system. Now, from the next class onwards, we will explore other DC charging systems and understand

how they work accordingly. So, thank you very much for your patience in listening to this lecture.

With this lecture, we will conclude our discussion on the CCS2 DC charging system and begin exploring a new DC charging system in the next class. Thank you.