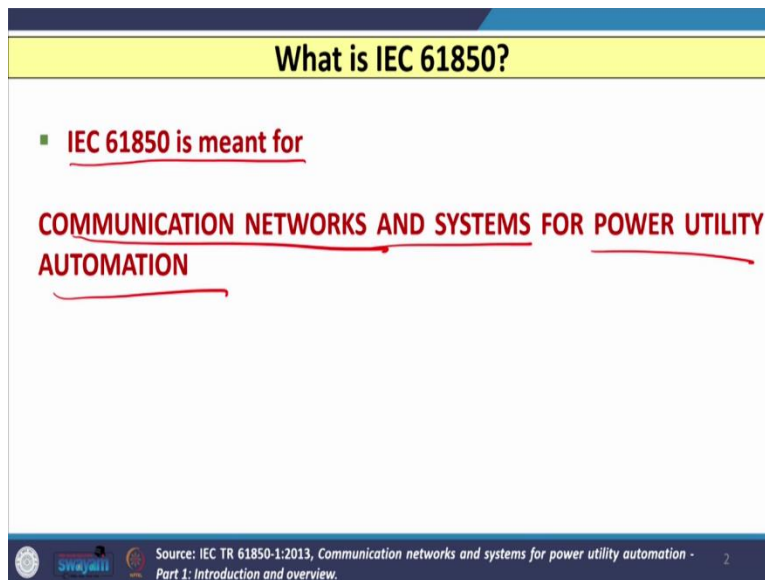**Digital Protection of Power System**
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Lecture 35
Introduction to IEC 61850 dash I

Hello friends, so in this lecture we will discuss about the IEC 61850 that is the communication protocols used to transfer the information and to models any syncrophaser based devices between substations or between substation and control center and so on.
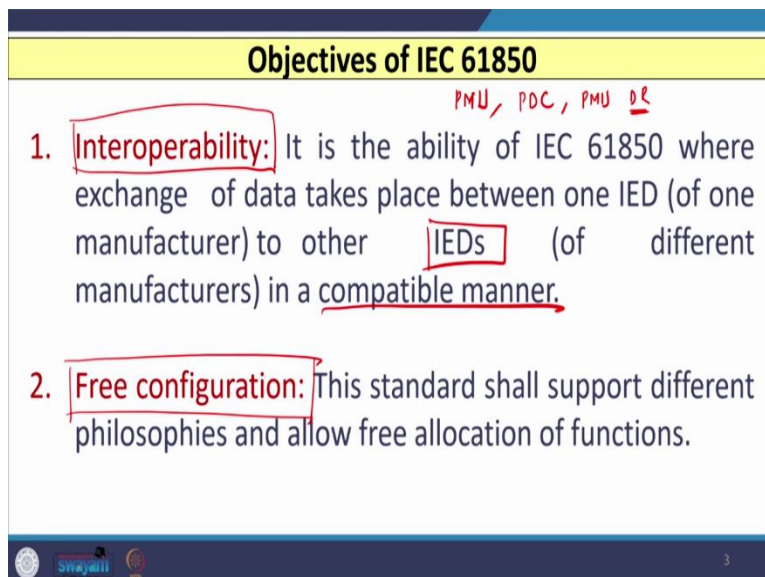
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So, let us see first what is IEC 61850 is meant for, so IEC 61850 is meant for communication networks and systems for power utility automation. Earlier this IEC 61850 it is also known as substation automation protocols, however later on the name has been changed and it has been given communication networks and systems for power utility automation. So, IEC 61850 is a communication protocol used for networks and systems and this is especially for power utility automation.

Now, let us see what is the main objective of IEC 61850? So, the first objective of IEC 61850 is the interoperability. We know that interoperability is the ability of IEC 61850 where exchange of data that is to be taken place between the one IED of one manufacturer to several other IED's of different manufacturers in a compatible manner.

So, interoperability indicates that IED, it can be a PMU, it can be a PDC, anything, so when one IED wants to communicate with one another IED of different manufacturer installed in same substation or maybe in remote substations in a compatible manner then how the exchanges that is possible and this is the main objective of IEC 61850.

Then when we have number of IED's installed at local substations or remote substations and if one IED wish to communicate with other IED's of different manufacturers then how this can be possible in a compatible manner? So, this is the main objective of IEC 61850 and as I told you IED that is nothing but intelligent electronic devices this can be a PMU that is phasor measurement unit or device, it can be PDC, phasor data concentrator or it can be PMU enabled relays. So, we do have PMU enabled digital relays are also there or numerical relays are also there, so this can be also treated as intelligent electronic devices and the interoperability is the main objective of the IEC 61850.

The second objective of IEC 61850 is the free configuration, so utilizing these standards that is IEC 61850 standards, this shall support different philosophies and it will also allow free allocation of function. So, any type of functions that can be defined in particular IED let us say manufactured by one manufacturer and the same can be also defined in some different IED of different manufacturer and communication between these two IED's of different manufacturers that can be possible we can define any functions, so that free type of configuration is also allowed and possible in IEC 61850, so such type of provisions are also there in IEC 61850.

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The third important objective of IEC 61850 is the long term stability, so it must be able to follow whatever is the new upcomings or progress that is to be coming in communication technology as well as evolving system requirement. So, any new communication is coming or any new technology is coming in communication then this IEC 61850 or protocol is capable to incorporate such things that is why the term long term stability play an important role. The fourth objective of IEC 61850 is the storing of the data, so a common method or a common format that is given or suggested in IEC 61850 for storing the entire or the complete data.

So, this four that is interoperability, second is the free configuration, third is the long term stability, and four is the data storing these four are the main objectives of IEC 61850 and because of these four objectives the IEC 61850 is widely applicable and adopted by all the relay manufacturers, all the substations throughout the world.

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The fifth objective which is also there that is known as the testing of the particular IED, so this testing defines the complete testing required for a particular equipment which confirms a particular standard, so that is IEC 61850 standards. So, you have to test the IED and while testing the IED's also you can this confirms that ok, this IED is compatible with this IEC 61850 protocol or maybe some other protocol as we have discussed in case of introduction to PMU's. This is a single standard, so this gives a single protocol for complete substation considering modeling of different data required for substation and this is a single standard.

So, if any relay manufacturer or IED manufacturer or PMU manufacturer, manufactured a device or IED which is compatible with this standard then those different devices of different manufacturers can communicate with each other using this IEC 61850 standard. Now, let us see what are the different parts of this standard that is IEC 61850.

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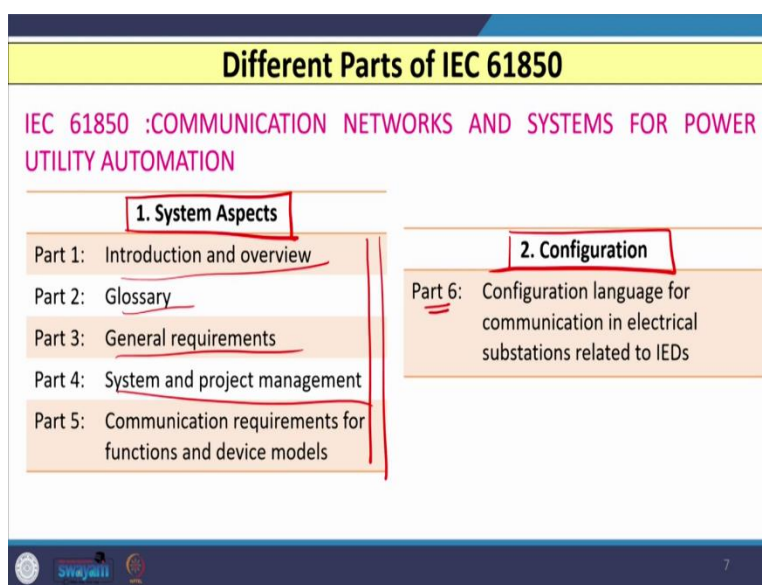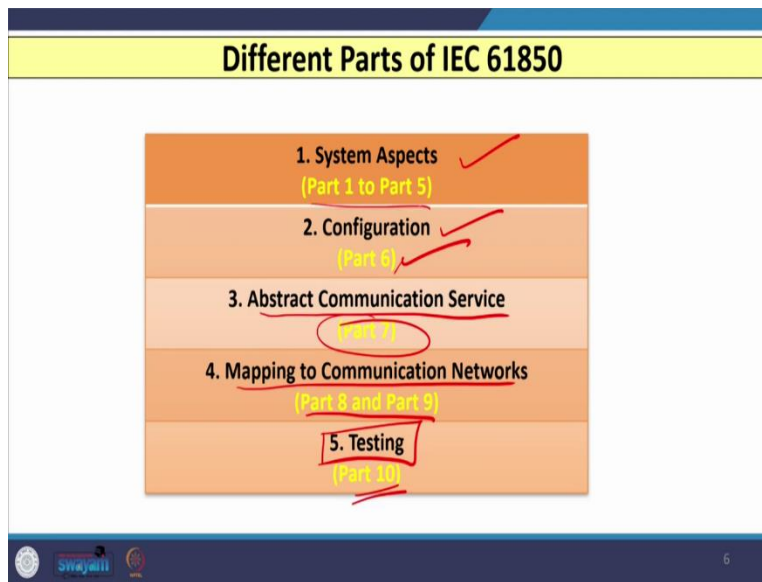
So, IEC 61850 contains majorly 5 parts that is first is the system aspects, so part 1 to part 5 are covered in system aspects, we will discuss in detail what is system aspects, what is to be given in this, but it contains the 5 parts. The second is related to the configuration, what is the configuration of the network or IED and that is given or discussed in part 6.

The third important point is related to the abstract communication service, so how communication is carried out the entire process things that are discussed in third part and that is basically in part number 7. The fourth that is related to the mapping to communication network, so once

communication is carried out what are the different layers available in this network and how the mapping is carried out.

So, whether the mapping is carried out using some interpreter or maybe it will be carried out by some layers, so that will be discussed in this mapping to communication network parts and that contains two parts, part 8 and part 9, and the last part, fifth one that is related to the testing of a particular device or IED and that is mentioned in part 10.

Let us see first that in part 1 that is system aspects, second configuration, third abstract communication service, fourth mapping to communication network, and fifth testing what is to be given, what is inside this, let us see first and then we will discuss in detail what are the suggestions or what are to be discussed in each part.

So, if I consider the first part that is the system aspect point then that contains 5 parts, and this 5 parts are from part 1 to part 5 and in this parts the introduction, glossary terms are defined in second part, the general requirements are given in part 3, system and project management related issues are discussed in part 4, and communication requirements for functions, and different device models are discussed in part 5.

So, your system aspects which contains 5 parts, from part 1 to part 5 basically the overview, the general requirements, the requirements related to system and project, how the management is carried out, and what are the communication requirements for different functions, and models these things are discussed in system aspects part.

The second is nothing but the configuration block, so in configuration block the part 6, it is related to the configuration language, so what type of language is used for communication in electrical substations related to IED's. So, basically the syntax or the core of this that is discussed in configuration part and especially in part 6.

The third block that is the abstract communication service block, in this block several parts that is in part 7, part 7 is divided in several sub parts. So, you can see (as shown in above slide) that in part 7-1 principles and models are discussed, in part 7-2 abstract communication service interface that is ACSI is discussed, in part 7-3 common data classes are discussed, in part 7-4 compatible logical node classes and data classes are defined, how we can define these things that is logical nodes and data classes, how we can define, how one logical node will communicate with other logical nodes, so that is mentioned in 7-4,and in 7-5 part the IEC 61850 that is modeling concept that is mentioned in this.

This are the conventional 7-1 to 7-5 parts available or covered in abstract communication service part, after that they have added several other parts also in the fourth block that is nothing but the mapping to communication networks and in this mapping to communication networks they have added the 7-410 part, so this is related to hydroelectric plants and the communication for monitoring and control that is given in this part.

So, in 7-420 part that is second one; the basic communication structure related to the distributed generators or distributed energy resources in terms of logical nodes this is also discussed. In part 7-500, how we can use the logical nodes to model the functions of a substation automation system that is also discussed in 7-500. In 7-510 use of logical nodes to model functions of a hydro power

plant that is mentioned and in 7-520, how we can use the logical nodes to model the functions of distributed energy resources that are also mentioned.

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Different Parts of IEC 61850

1. System Aspects (Part 1 to Part 5)
2. Configuration (Part 6)
3. Abstract Communication Service (Part 7)
4. Mapping to Communication Networks (Part 8 and Part 9)
5. Testing (Part 10)
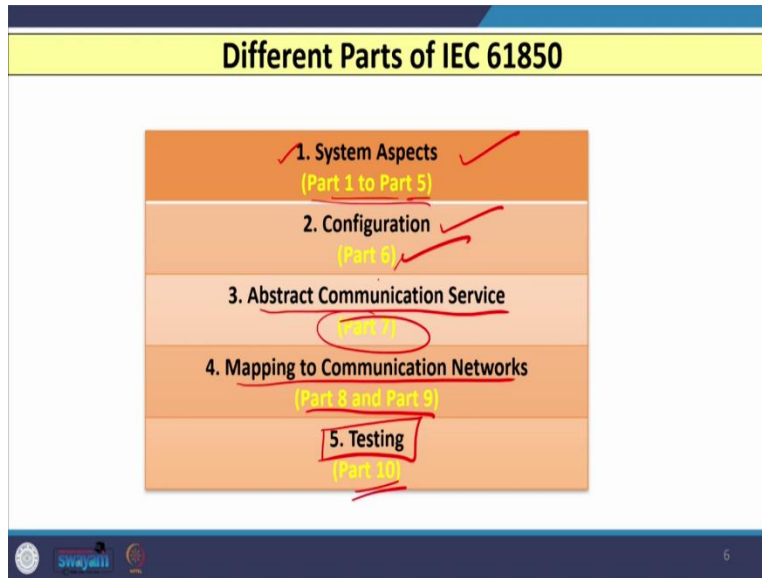
In the same thing if I consider the eighth part, in mapping to communication networks then in part 8-1 mapping to MMS and ISO oblique IEC for 8802-3 that is mentioned, in 80-1 guidelines are given in details regarding the exchange of information from a CDC based data model using IEC 60870-5-101/104. In ninth part that is the 9-2, sampled values, how we can have the sampled values over ISO or IEC 8802-3 that is mentioned.

In 9-3, precision time profile for power utility automation is discussed and after this one they have added that is part 90-1 and this is related to the IEC 61850 for communication between two substations. So, when we wish to communicate between two substations this is mentioned in 90-1. In 90-2, if we wish to communicate between substations and control centers then those things are mentioned in part 90-2.

In 90-3 part, IEC 61850 information related to condition monitoring that is given, and in part 90-4 network engineering guidelines for network engineers are mentioned and in part 90-5 how 61850 is used to transmit synchrophasor information according to IEEE C37.118 that is elaborated in this 90-5 part.

The last part that is the fifth block that is the testing block where the conformance testing that is to be carried out that is mentioned in part 10. So, now what we will do, we will discuss this each block starting from system aspects that is part 1 to part 5, configuration that is given in part 6, abstract communication service that is in general form part 7, and mapping to communication

network in part 8 and part 9, and then testing in part 10, we will discuss this what is the significance of each of this part.

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1. System Aspects of IEC 61850

- **Part-1:** It gives <u>introduction and overview</u> of IEC 61850 standard.

- **Part-2:** It contains <u>glossary of technology and definitions used</u> in context of substation automation system in different parts of the standard.

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1. System Aspects of IEC 61850

- **Part-3:** It gives <u>general requirements of the communication network</u>.

(i) <u>importance is given to quality requirement of</u> communication network.
(ii) communication network must remain immune to the change in environmental conditions.

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So, with this let us see the first one that is the system aspects related to the IEC 61850. So, in this aspect as I told you 5 parts are available you can see here that 5 parts are available and let us see what the importance of each parts. So, in system aspects part 1 gives the introduction and overview of the entire IEC 61850 standard, so the introduction and overview related to these standards that is mentioned in part 1. In part 2 of system aspects it contains glossary of technology and definitions

used in context to the substation automation system in different parts of this IEC 61850 standard this is mentioned in part 2.

In part 3 of system aspects it gives the general requirements of the communication network and especially special attention is given related to the quality requirement of the communication network, and communication network must remain immune to whatever changes that is to be happened in environmental conditions. So, those aspects are also considered and elaborated in part 3 which are related to what are the general requirements of communication network.

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2. Configuration of IEC 61850

- **Part-6: Configuration Language for Electrical Sub-station IEDs**
  - It specifies a file format for describing communication related to IED configurations. This includes
  - Parameters of IED.
  - Communication system configuration.
  - Switchyard structures.

In part 4 of system aspects this is related to the system and project management and this system and project management is discussed with reference to engineering processes and its supporting tools, what is the life cycle of IED's and what is the overall system and quality assurance, how we can carried out this, so those issues are discussed in part 4 and basically it is related to system and project management and in the last part, part 5 of the system aspects this defines the performance requirement of different functions that is being implemented using communication and this includes all known functions.

So, based on this architecture of communication network, what is the architecture of this, and what is the application that can be implemented for a given network are to be decided based on requirement given of different functions which we wish to implement using communication. Now, this is all related to the 5 parts available in system aspects of IEC 61850.

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Now, the second one is the configuration part. So, you can see here in configuration part we have the part 6, so let us discuss what is mentioned in configuration of IEC 61850.

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So, this part 6 that is the configuration of IEC 61850 it is basically the configuration language for electrical substations of IED's and this specifies a file format for describing the communication related to IED configurations, so what type of file format that is suggested or supported by IED's that is mentioned in this part 6, and this includes parameters of IED's, communication system

configuration, and what is the switchyard structures, all those things are covered in part 6 of the configuration of IEC 61850.

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3. Abstract Communication Services of IEC 61850

- **Part-7:**
  Abstract Communication Services

  - It applies to the ACSI (Abstract Communication Service Interface) <u>communication in sub-stations and feeder applications</u>.

  - The ACSI provides <u>interface between a client and a remote server</u>.

3. Abstract Communication Services of IEC 61850

- **Part-7:**
  Abstract Communication Services

  - It provides <u>fast and reliable system-wide distribution</u> between an application in one device and many remote applications in different devices.

The main purpose of this part 6 that is to exchange the IED capability descriptions and substation automation system descriptions between IED engineering tool and the system engineering tool of different manufacturers in a compatible manner, so this is specially related to the interoperability objective of the IEC 61850. In part 6 the defined language that is known as substation configuration description language and basically it is denoted by the term SCL. So, SCL is related to the substation configuration description language and this is the language used by all the IED and supported by IEC 61850 and this language is based on markup language may be version can be new upcomings available in communication network or in this language.

Now, the third block is related to the abstract communication services of IEC 61850 and this has part 7, so basically in part 7 they have discussed the principles and models which we are going to use in this IEC 61850. So, this will provide help to understand the basic modeling concept and description methods for a particular model. In this also abstract communication related informations are also given and this is going to apply to the abstract communication service interface communication in substations as well as feeder applications. So, the ASCI that is abstract communication service interface gives or provide the interface between the client and a remote server.

So, if we have a client let us say at local point we have IED and if we have some IED at remote point then how the communication is carried out, how the interfacing is carried out that is discussed in this abstract communication service interface. This also provides fast and reliable system wide distribution between an application in one device and many applications in different device. So, those types of communications are also covered in abstract communication service block.

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3. Abstract Communication Services of IEC 61850

- **Part-7:**
  Compatible Logical Node Classes

  - It specifies the compatible logical node names and data names for communication between IEDs.

Then some common data classes in which they have specified the data classes related to substation applications; this also applies to descriptions of device models and functions of substation and feeder equipment, so this are also covered in part 7 under common data classes. Under part 7 in compatible and logical node classes this specifies the compatible logical node names and data names for communication between two IED's, so how the logical names are given, what is the importance of logical functions, how the logical nodes are defined, may be how the logical nodes that communicates with other logical nodes of other IED, so all those things are covered in part 7.

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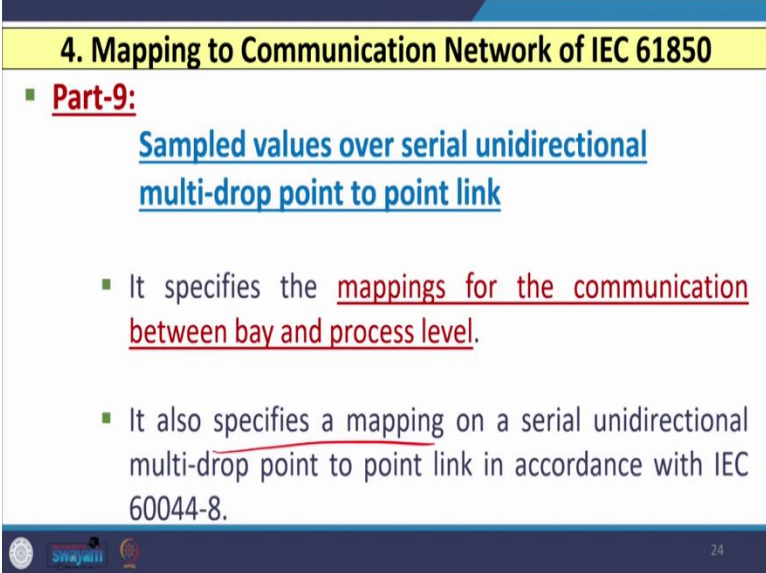
4. Mapping to Communication Network of IEC 61850

- **Part-8: Mapping to MMS and ISO/IEC 8802-3**

  - It specifies a method of exchanging time-critical and non-time-critical data through LAN by mapping ACSI to MMS (Manufacturing Message Specification) and ISO/IEC 8802-3.

Now, let us see the fourth part that is mapping to communication network of IEC 61850. So, in this part 8, it is related to mapping to MMS which is nothing but manufacturing message specification and ISO/IEC 8802-3. So, in this this has specified a method for exchanging some time critical and non dash time critical data.

So, normally time critical data are those which are used for protection functions, may be acquired directly may be raw samples are there or may be used by some status of circuit breakers, and some non-critical data may be some reporting data are there, maybe some measuring data are there, so those are non time critical datas.

So, this exchange of time critical and non time critical datas either through LAN that is local area network by mapping ASCI with MMS and ISO/IEC 8802-3. So, these are specified in part 8 of mapping to MMS and ISO/IEC under mapping to communication networks.

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In part 9 of mapping to communication networks of IEC 61850, sampled values over serial unidirectional multi drop point to point link related information is provided and it specifies the mappings for the communication between bay and process level. So, bay is basically nothing but your bus bar and then the process level, so how the mappings in terms of communication between the bay and the process level is to be carried out that is specified or given in this part 9. In part 9 it is also specified that how the mapping on a serial unidirectional multi drop point to point link in accordance with this IEC 60044-8 is to be carried out this is also mentioned here.

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Further, the sampled values over ISO/IEC 8802-3 in this they have specified the specific communication service mapping that is SCSM, for transmission of sample values according to the abstract specification as per IEC 61850-7-2 standard that is also mentioned in part 9.

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Further in part 9, precision time protocol profile for power utility automation is also mentioned and in this they have defined the timer requirements to achieve the IOS synchronization classes that is also completely elaborated and discussed in part 9 under the mapping to communication network of IEC 61850.

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Moreover, in part 9 that is under the mapping to communication network of IEC 61850 they have mentioned the procedure for communication between substation to substation, so how the communication between two substations that is to be carried out. They have also mentioned how the communication between substation and control center is to be carried out, how the communication in case of condition monitoring is to be carried out, and using IEC 61850 to transmit the synchrophasor information as per IEEE C37.118 standard, how the transmission of the syncrophasor information as per this IEEE C37.118 standard that is to be carried out, all these things, all the issues related to this communication between substation to substation, between substation to control center, in case of condition monitoring or in case of transmission of syncrophasor information or data that is completely elaborated in part 9.

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5. Testing of IEC 61850

- **Part-10: Conformance Testing**

  - It specifies the procedure for conformance testing of products implemented with this communication protocol.

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Approach to Standardization

Approach of IEC 61850:-

- To meet the basic requirement of IEC 61850 i.e. interoperability and free configuration, the IEC 61850 is built over a standard Open System Interconnection (OSI) 7 layer model.

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In part 10, the issues related to the testing of IEC 61850 that is mentioned, so part 10 conformance testing related information is given and in this it is specified that the procedure for conformance testing of product which we wish to implement with this communication protocol that is how it is implemented, so complete information related to this that is to be elaborated in this part 5 that is related to the testing of the IEC 61850.

So, the next information is related to the standardization, because if we wish to use IEC 61850 protocols then IEC 61850 has given some arrangement and, in this regard, to meet the fundamental requirements of this IEC 61850 that is interoperability and free configuration in IEC 61850 this

protocol is built over a OSI 7 layer model and this OSI is nothing but open system interconnection 7 layer model.

These 7 layers they have indicated that what is the importance of each layer, we have physical, layer data layer, application layer and so on we will discuss. So, in this OSI 7-layer model they have mentioned that what is the importance of each layer, and how the communication for each layer is processed in IEC 61850 and in this by default arrangement is based on OSI 7-layer model requirement.

So, in this lecture we started our discussion with the importance or introduction of IEC 61850 that is the protocols and then we have discussed the six important objectives of this IEC 61850 and out of that the interoperability and long-term stability and free configuration this three are the most important objectives of IEC 61850 and then we have seen that different 5 aspects. Initially if we go for these aspects then we have seen that starting from the first block that is system aspects and then if we move from system aspects to configuration aspects then abstract communication service part mapping to communication network and testing part, we have discussed that in each block different parts are there.

And we have discussed that at last that if we wish to avail the facility of this IEC 61850 standard then by default arrangement is given or considered in IEC 61850 based on OSI 7 layer model that is Open System Interconnection seven layer model where 7 number indicates there are seven different types of layer available in this IEC 61850 under OSI 7 layer model, and the functions and importance of this different 7 layers we will discuss in the next class. Thank you.