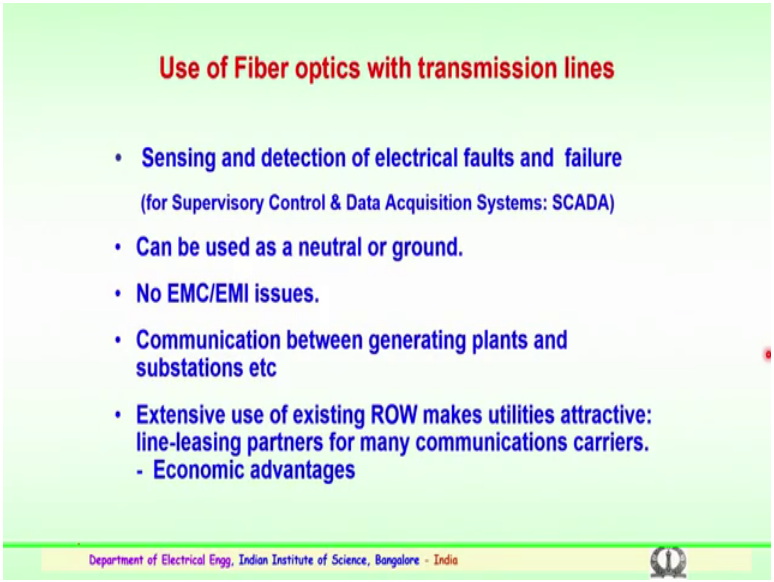
Advances in UHV Transmission and Distribution
Prof. B Subba Reddy
Department of High Voltage Engg (Electrical Engineering)
Indian Institute of Science , Bangalore

Lecture – 29
Introduction to the use of Fiber optic cables, OPGW

So good morning, we where discussing about the importance of a grounding. The electric and magnetic fields in the a vicinity of the substation. How to mitigate the fields particularly the electric and magnetic fields. So, several options for a the mitigation techniques were discussed. Now in this class we will try to see the importance of the communication channel, how the fiber optic is important for the transmission lines and also, how it could be used for the data communication.

(Refer Slide Time: 00:51)



So, the use of fiber optics with increase in voltage levels have also been added the with the ground wire which is connected to the topmost portion of the tower. So, the main importance of going in for fiber optic cable is helpful apart from the ground wire which performs the minimum creating a path for the lighting aspect. So, this ground wire which is overhead ground wire will also act for the or for the communication purpose.

So, very important aspect going in for fiber optical communication. So, the main use of fiber optics with transmission lines used to see that how proper sensing and detection of a electrical faults and in case of failures. And this data is being given to the SCADA

system, that is SCADA supervisory control and data acquisition systems, which will be helpful in take in the proper decisions for eliminating the isolating the line where the failure has occurred. And fiber optics also can be used as a neutral or a grounded connection. Using the fiber optics cable also reduces the electromagnetic compatibility and electromagnetic interference issues going in for a regular cable, where this signals could cause an issue.

So, with the help of a fiber optic a cabling the reduction of electromagnetic compatibility and interferences issue are reduced. And the fiber optics help in communicating that is a data communication from the generating plants or to the substations or to the control centers etcetera. This will be helpful in proper diagnosing and taking the remedial solutions. And we know that we have discuss about the a right of way which is a very important in case of the tower configuration. And as the high voltage levels of UHV and EHV.

So, we use lot of space for that that is extensive use of the right of way. Could also be used by the utilities particularly for communication where a line leasing could be carried out. So, this is a again on economic advantages for a going in for fiber optic communication systems.

(Refer Slide Time: 04:19)

So, the optical ground wire or OPGW as it is a shown here, is basically a cable here you can see the cable here. It is similar to the ground conductor and the size of the cables

here very depending upon the different voltage levels. You can see in a several standard conductors are there similar to a normal high voltage conductor. And this is used for the overhead ground connection that is the earthing connections on the top of the towers ah.

So, basically you can see that in one of the slot on the conductor arrangement, you have a fiber optical link or a fiber optical cable which is being a seen here. This will help in the communication of the data and the information to be sent from the generation to the substation level or to the SCADA centers where this information will be highly helpful. So, we will look into the importance of the optical fiber ground wire, and what is composition of that how it is being useful for the communication and data transfer particularly for the electrical utility service.

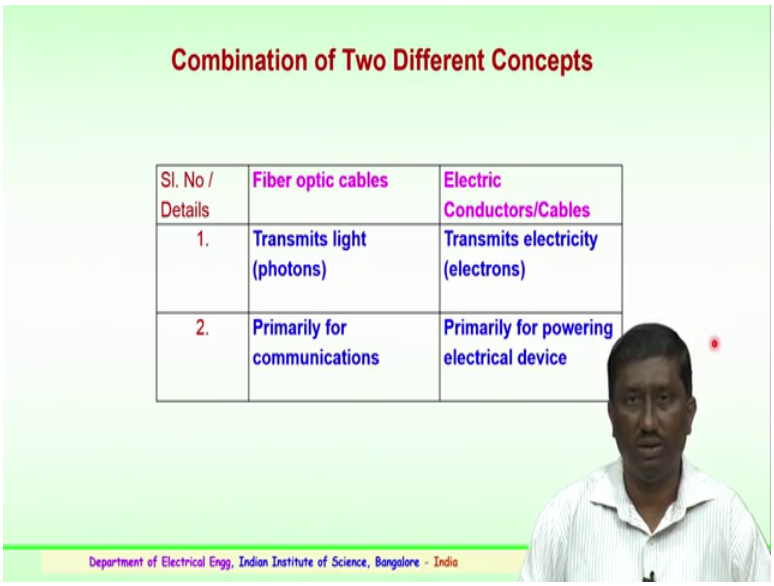
So, optical fiber ground wire is a composite conductor or a wire, which basically serves as a conventional overhead ground wire this is conventional overhead ground wire, with the added benefit of providing high capacity and reliable fiber optic communication. So, that is the importance of going in for optical ground wire you can see the fiber optic link which is embedded into the conductor, that is a overhead ground conductor, which will help in the communication in of the data.

(Refer Slide Time: 06:43)

So, various types of optical ground wires are shown here. You can see depending upon the voltage level the transmission voltage level, the size of the optical ground wire dimension changes the diameter its increased as the voltage level increases. So, you can

see here the optical fiber conductors are embedded in the conductors. You can see for various voltage level the size is different, and the optical link which is inside the conductor connected to topmost tower that is the earthing conductor will be helpful for the data communication.

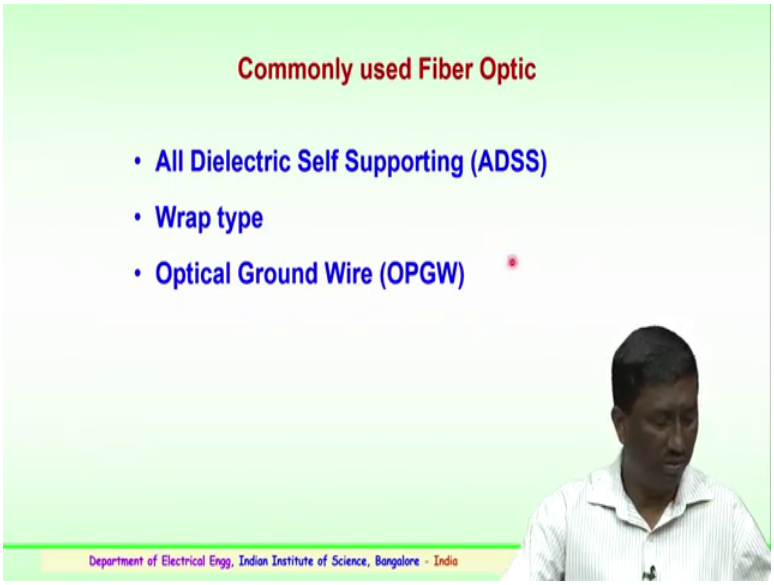
(Refer Slide Time: 07:29)



So, when you look into the different concepts we have two concepts here presently one is the conductor another is the optical fiber optic cable which is being embedded into the conductor which is being connected in the overhead transmission, for grounding aspect mainly. So, fiber optic cables, we know that mainly the concept is because the it emits fiber optic emits light because of the photons present, and because of the photonic affect here in the electric cables or a conductor the transmission of electricity happens because of the electrons. And we know that fiber optic cables are primarily used for the communication of the data. And in case of electrical conductor or cables these conductors or cables are primarily used for powering the electrical devices or transmission transmitting the power or distribution the power.

So, these are the major two different concept which are being embedded together for The optical ground wire.

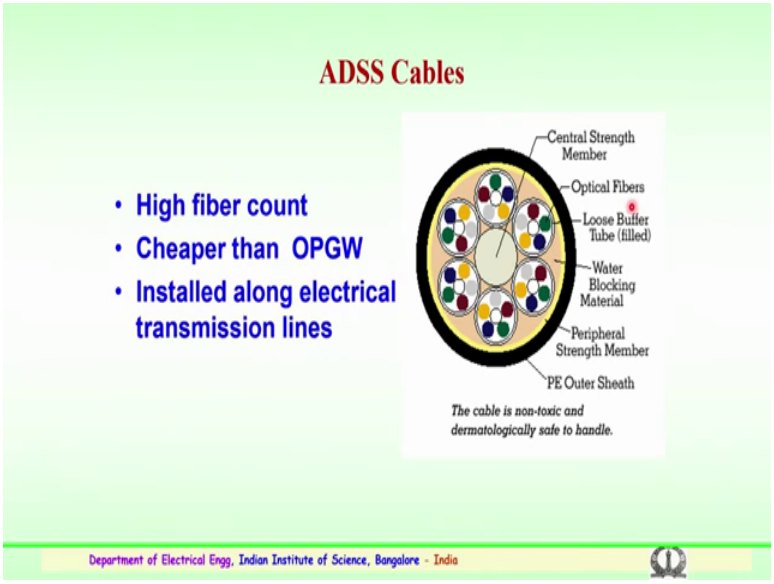
(Refer Slide Time: 08:49)



So, you see the commonly used presently in the transmission or distribution or which its being employed or adopted the technology may be of various types. So, some of the commonly adopted fiber optic technology are the number one being the all dielectric self supporting type of technology that is ADSS, which is one type of commonly used fiber optic link the second being the wrap tap type, and the third is the optical ground wire. So, these are the three types of fiber optic technology which is being presently used for in the transmission or by the distribution utilities.

So, we will look into the important of the optical ground wire and how it is helpful For us.

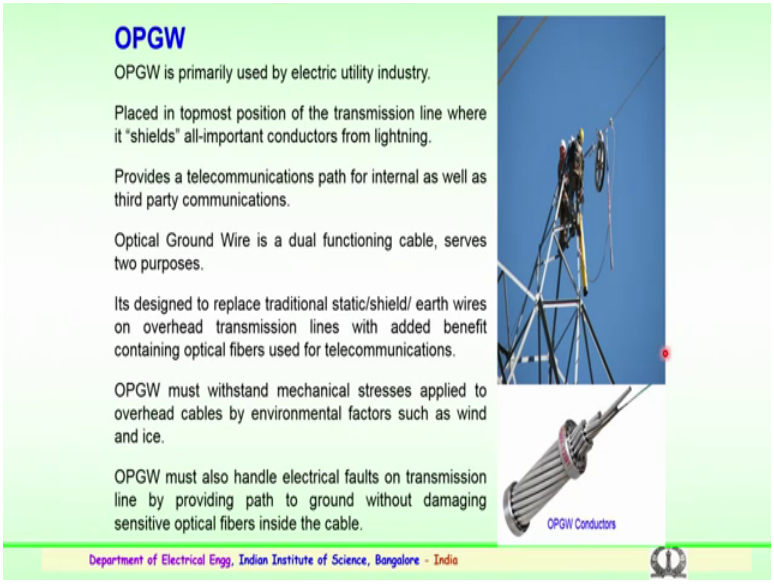
(Refer Slide Time: 09:49)



So, before that the all dielectric self supporting generally consist of high fiber count. And it is more economical then the optical ground wire, and it is installed along the electrical transmission lines. So, we can see here the structure of the all dielectric cable which is used for the communication is shown here. It consists basically of a central core which is strength mechanical a strength member the followed by that you can see the optical fibers which are of desirable numbers, then you have a buffer tube which is filled adjacent to the fiber communicating cables.

Then there is a layer which protects the water entering the fiber optic link which is shown in orange color here. Then you have a yellow peripheral strength member to protect the other layers which have been mentioned here. Then you have a total outer sheath that is a polyether in insulating sheath which is a helpful do see the insulation affect of the entire a cable. So, this cable particularly the optical fiber cable which is used the all dielectric self supporting type of cable which is used is non toxic, and also safe to handle that is important. So, it is not, it is very easy to handle for by the utility engineers.

(Refer Slide Time: 11:44)



To be look into the optical ground wire how important is this.

So, you can see the topmost portion of the tower is the optical ground wire which performs the dual functions. Here is this particular optical ground wire which may consist of a similar construction is primarily used by the electrical utility industries. And as mentioned its placed in the topmost position of the transmission line or a tower where it shields all important conductors particularly from lightings. So, in lightning strikes this conductor will be helpful to see the surge from the lightning or the over voltage is develop should be safely transmitted to the ground through the ground earthing electrodes.

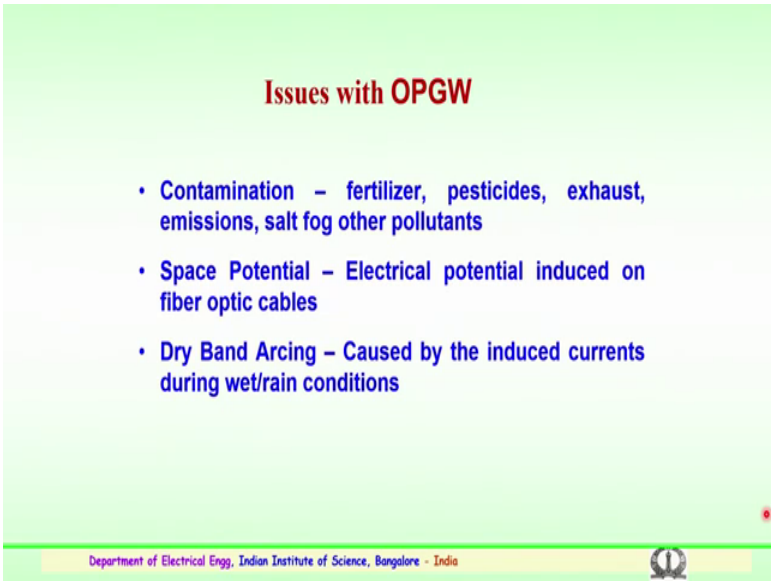
So, apart from that it provides a telecommunication path as mention the earlier the optical fiber link whatever fiber cable which is embedded here, this will try to provide the telecommunication path for internal as well as third party communications through this network arrangement. The optical ground wire as mentioned earlier performs a dual function one is the acts as a functioning cable or a conductor, for the diverting of the surges or over voltages during the lightning strike and also for the communication aspect.

So, it is designed basically to replace the traditional static or a shielded earth wires which we use normally earlier which were employed for the overhead transmission. This has an additional benefit which contains the fiber optic cable for telecommunications as well. So, the optical ground wire must withstand mechanical stresses because this is embedded

in the conductor. So, mechanical stresses it has to be able to withstand, which are generally apply to the overhead conductors or cables, and also it has to withstand to the environmental factors such as wind the ice loading and any other contamination affects.

Apart from this mechanical and environmental stresses, the optical ground wire must also be able to handle electrical faults which could which is the network see on the transmission line and this faults should be the able that the optical ground wire will provide a path to the earthing or a grounding system without damaging this fibers, that is the optical fibers which are inserted in the cable. So, very important in the faults should be diverted to the outer periphery of the grounded electrode without damaging the inside fiber optic cable.

(Refer Slide Time: 15:17)

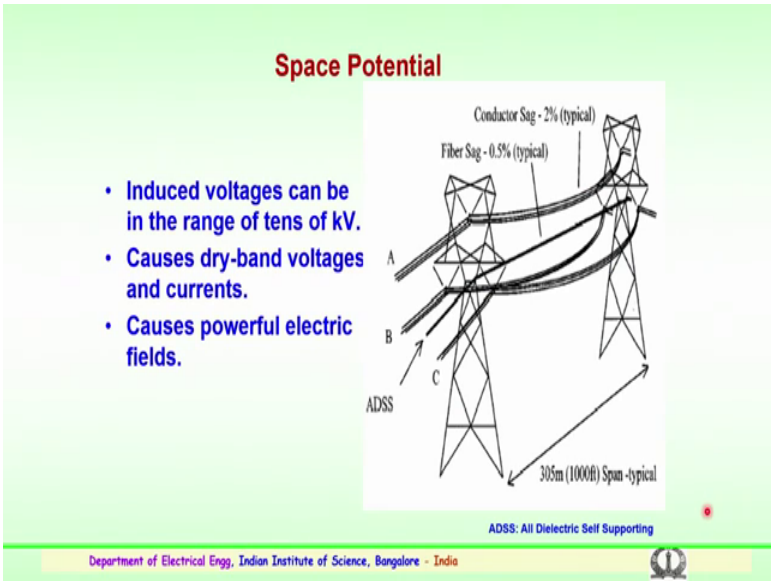


Issues are related with the optical ground wire, as mentioned earlier apart from the environmental mechanical environmental conditions, the mechanical stresses the electrical stresses inside it has to be able to withstand. So, further contamination or pollution which occur because of a the activity in the field the fertilizer spray or the pesticides spray. And also due to the exhaustive emissions this could be because of the burning kills near the transmission lines where the emissions could interact with cable, and in some cases if the transmission a lines could also be affected with the salt fog pollutants.

So, the contamination is an issue where this could be a problem to the optical ground wires, then space potential So, there could be a electrical potential which could be induced on the fiber optic cables. Because of the interaction with the space conductors which are sometimes nearby to the optical ground wire. Where the raise in potential could again cause the space potential on the conductor and this could be an issue with the using of optical ground wire.

Formation of dry band arching. So, we have a discussed about the dry band arching or the partial arcs or the scintillations, which are normally caused by the induced currents particularly during the conditions like fog drizzle wet or rain conditions, here on the conductor surface the contaminants spread over of period of time because of a several activities. And because of the wet conditions the uneven distribution of the pollutants on the surface could lead to the current which flows because of the induced affect and the appearance of wet and are dry conditions or bands on the surface can create a dry band arching or a partial arcs or scintillations are this again could cause current (Refer Time: 18:12) flow on the optical ground wire.

(Refer Slide Time: 18:18)



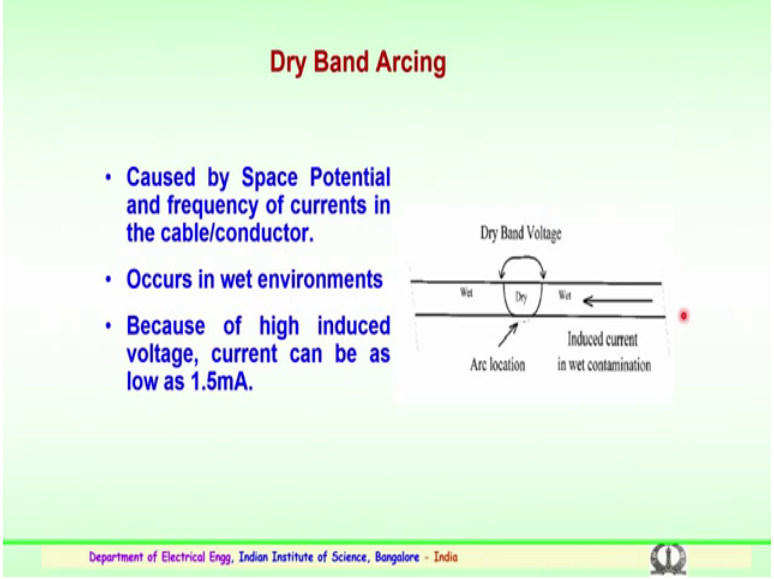
So, this is a example of how between the two towers the conductors which are connected, one example is all dielectric self supporting cable that is the optical cable, which is being connected for communication purpose. You can see here in case a typically the conductor sags between two to five percent. So, during that period there is a

chance of because of the wind and other conditions. So, likely induced potential on the surface of the optical all dielectric optical cable.

So, this would create a potential on the surface in the range of sometimes tens of kilovolts. So, this induce voltage is can go up to tens of kilovolts. And further depending upon the contamination on the surface and due to rain or fog or drizzle there could be formation of wet and dry bands. And this causes the dry band a voltage is further flow of currents on the surface. And sometimes this could cause a powerful a electric fields also depending upon the induced voltage levels and the voltage level of the transmission system.

So, the space potential affect has to be properly a considered and it has to be mitigated.

(Refer Slide Time: 20:00)

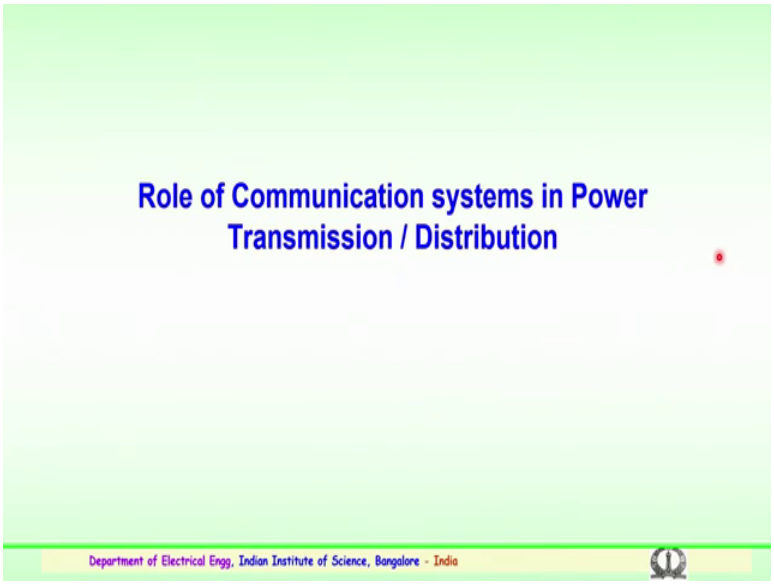


There the dry band arching is again caused by the space potential has mentioned. And here the frequency of the currents in the cable or conductor and depends upon the type of potential the magnitude of the potential, and how much is a induced current during the wet or the moist conditions. So, because of the dry and wet band which are formed on the surface and because of the induced currents there could be a small arching which are known as a dry band arching.

So, this dry band arching could be a continuous or it depends on the potential and the induced currents. So, these type of dry band arching is generally observed in wet

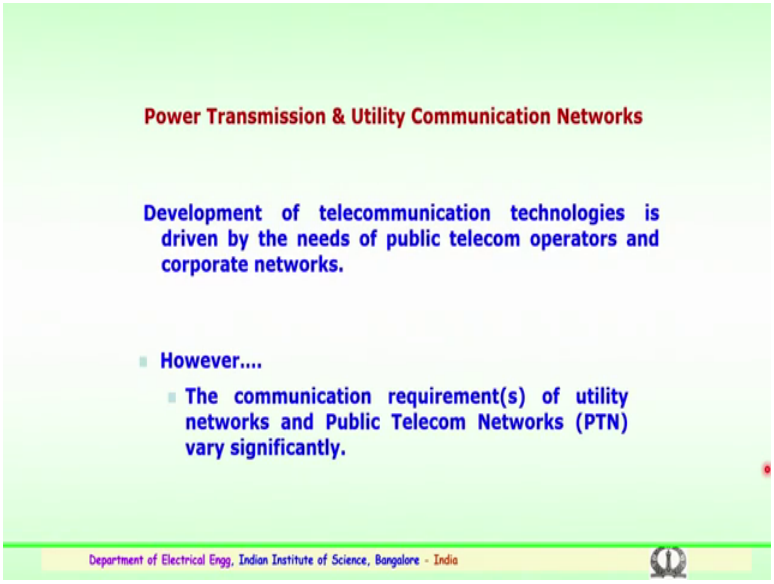
environments and because sometimes these voltage or a currents which are induced could be very high, and the currents sometimes could be as low as one point five mill amperes also. So, these are the concerns pertaining to the optical ground wire which is being used as a dual service which is for the communication as well as for the earthing aspects.

(Refer Slide Time: 21:28)



There was about the importance of going in for optical ground wire advantages of that. So now, we see the role of communications systems particularly in the power transmission or a distribution substations and networks. This communication systems apply a very important role in the transmission and distribution networks.

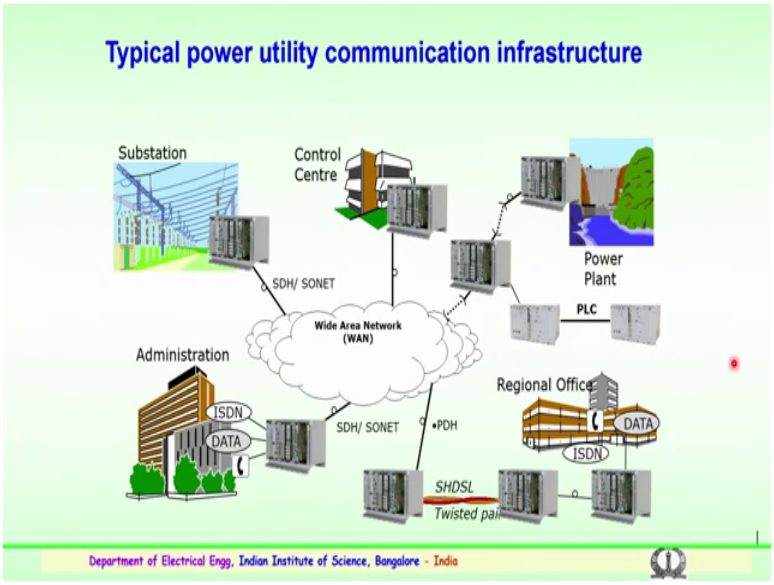
(Refer Slide Time: 21:56)



So, power transmission and utility communication networks both have been the development of a telecommunication technologies, which have been driven a by the need of public telecom operators as well as the corporate networks.

So however, the communication requirements of utility network and public telephone or a telecom networks depends vary significantly from the a utility perspective.

(Refer Slide Time: 22:34)



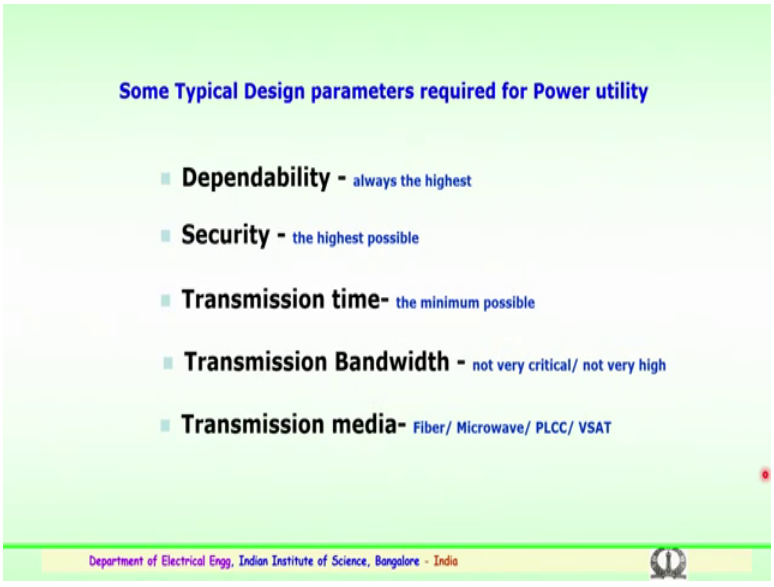
When we closely monitor typical power utility communication infrastructure. So, this is given like this shown in this figure here. You can see a substation could be of medium

size high voltage or extra high voltage substation, and this could be the control centre you have a generating plants again generating plants could be of thermal nuclear or any other generating sources.

So, from here the communication is generally done by various technologies, which are being a adopted it could be a wide area network using LAN connectivity or a wireless connectivity. And further this communication is helpful in collecting the data and supplying it to the administration or the control arrangement. So, this could be of several layers, where the data is been communicated and suitable arrangements are made to see that the monitoring of data and the usage of data, and the remedial measures in case of the failures of the equipment could be done.

So, various type of communicating cables could be of optical fiber link or it could be of wireless communication, which is very helpful in the present day power utility communication networks.

(Refer Slide Time: 24:10)

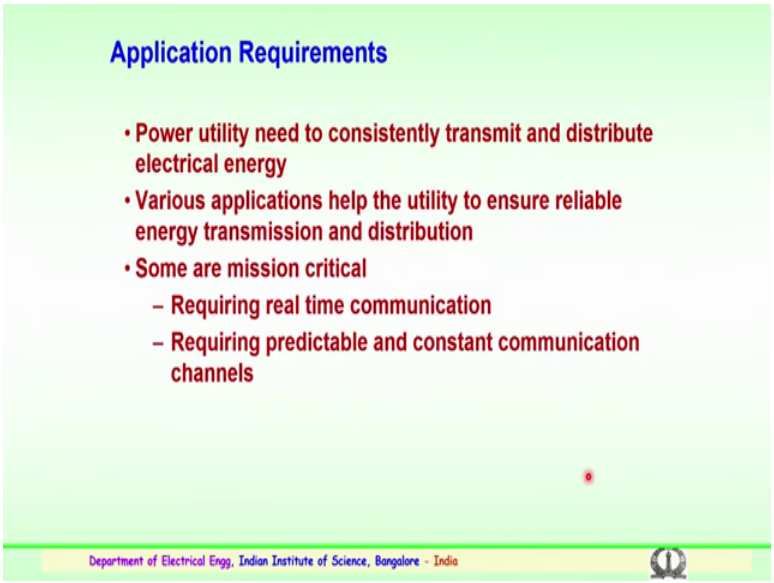


So, some typical design parameters which could be required for the power utility engineers, he is the important being the dependability. This has always the highest requirement. So, the dependability followed by the security have the highest possible dependability.

Then you have the transmission time, the time communication should be the minimum as possible or the data collection should be the minimum time, where the data could be communicated or data could be analyzed or data could be monitored. So, within a minimum possible time, and the transmission bandwidth which is required for the parameters for the transmission of power for a power utility, may not be very critical, could not be very high also. So, the bandwidth again depends upon the system number of parameters to be measure number of connectivity number of the voltage level and the devices which are connected depends on the information of all these things.

So, finally, is the transmission media. So, whether what type of transmission media is to be employed for the power utility. It could be a fiber optical communication it could be a microwave which is operating at a very high frequency, or could be power line carrier communication or it could be sat satellite based communication. So, power utilities have all these transmission media have been being used over the period of time. So, very important for the power utilities to properly choose the technology depending upon their required information.

(Refer Slide Time: 26:09)



So, the main application requirements of the power utility. First of all it should be need to consistently transmit and distribute the electrical energy in the highest possible advantages as possible way. The second being the various applications could be which will be helpful for the utility particularly to ensure the reliable energy transmission and

distribution very important aspect. And some of the applications are very, very critical there is a mission critical very high importance this could be the required real time communication a important communication data transfer, then requiring predictable and constant communication channels for the power transfer by the power utility personnel. So, very important applications which are required by the utility engineers.