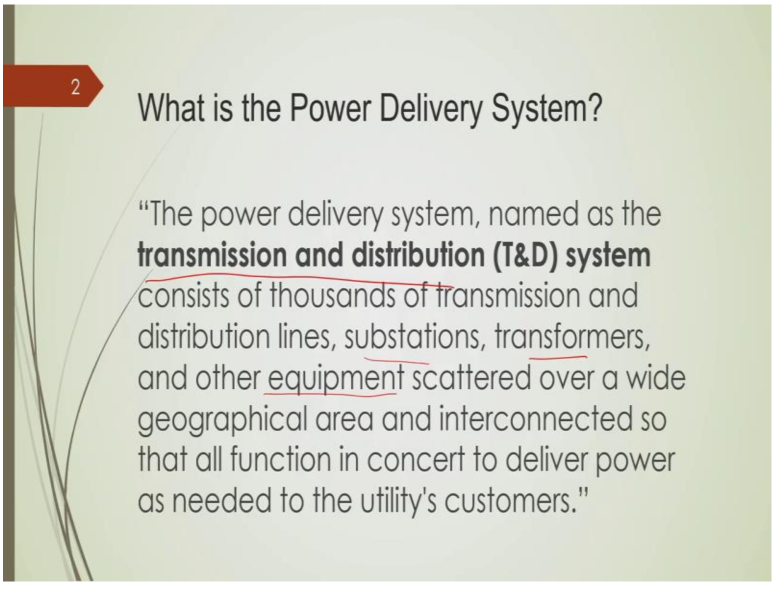
Operation and Planning of Power Distribution Systems
Dr. Sanjib Ganguly
Department of Electrical and Electronics Engineering
Indian Institute of Technology, Guwahati

Lecture - 02
Power Delivery System: A brief Overview

So, in this lecture, I will basically introduce Power Delivery System. So, what is the definition formal definition of power delivery system? So, you can see this I have quoted from a book which I kept in my reference. So, although this is not very standardized definition, but it gives the idea what is power delivery system.

(Refer Slide Time: 01:01)

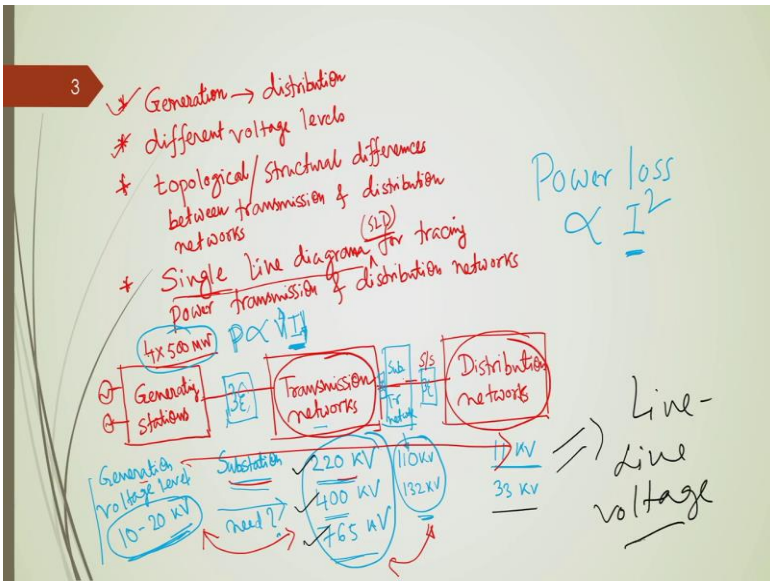


Here, power delivery system is basically also named as transmission and distribution system transmission and distribution system. It consist of thousands of transmission line and distribution lines. It also consists of several other things like substations, transformers, and several other equipment scattered over a wide geographical area.

And as far as the transmission line is concerned, they are interconnected. Why they are interconnected system? Already, I mentioned in my last lecture. And the distribution networks are something different than the transmission network, but all together they act as a unit to bring power from the generating station to the door of the customers.

So, in order to understand this in detail, let me chalk out some idea about this power transmission and distribution system.

(Refer Slide Time: 02:06)



So, here let me talk about some four important features; number one is how power is transmitted from generating station or from generation to distribution. Then, I will talk about, as I mentioned in my last lecture that, from generation to distribution there exist multiple voltage levels.

So, I will talk about different voltage levels which exist from generating station to towards the distribution. Then, I will talk about topological or structural differences between transmission and distribution systems or transmission and distribution networks. And also, I will talk about some brief idea about single line diagram which we use to trace the power transmission and distribution networks; some idea about single line diagrams.

So, this I will elaborate in my one of my modules of this course. But, here I will give you brief idea about single line diagram; single line diagram for tracing power transmission and distribution networks.

So, these four aspects I will chalk out and give you a feel about understanding these power transmission and distribution. Now, let me draw a block diagram; block representation to illustrate how power is transmitted and distributed from the generator side to the customer. So, first we will have generating station. Suppose this box is representing generating station.

Now, one generating stations may have multiple number of generators; they are connected in parallel so that they can share load and this I am talking about this particular generating station. I am talking about is the conventional type of generating station like thermal power generating station.

Typically, in India if you visit a conventional thermal generating station you will see there exist 4 to 5 units. So, we basically represent them as 4 multiplied by 500 megawatt generating station. It means that we have five 500 megawatt generation unit or we have 4 number of 500 megawatt generators. Alternatively, we can call it as we have 4 units of generating station each having capacity of 500 megawatt.

So, altogether this particular generating station is providing you 2000 megawatt of power. Now, after this generation, of course, this 2000 megawatt is not directly sent to the customers because as a customer our requirement is not in that level. So, it undergoes several transformations. It undergoes several transformations before it reaches to the customer side; before it reaches to the customer side.

So, what exactly these transformation took place? After this generating station, we have transmission networks; we have transmission networks. What is the purpose of transmission networks? They are used to evacuate the power which is generated in the generating station.

And they are responsible to bring this power to the area where customers live or where we have power demand. So, this transmission networks are essentially the carrier of power and they are directly connected to the generating stations and then, brought power to the nearby area where people live.

Now, next building block is off course, our distribution system or distribution networks. Now, what is the purpose of these distribution networks? These distribution networks are basically responsible to distribute power to the customers. We have different types of customers and they have different requirements. So, these distribution networks take power from the transmissions networks and distribute among the customers, this is simple philosophy.

Now, we have hundreds of generating stations in the airport we have several 1000 circuit kilometer of transmission line and we have very very large number of distribution networks. They involve the overall power transmission and distribution.

Now, the question is do we bring power from this generating station to the distribution networks at the same voltage level? The answer is certainly no. So, that is why I said that there exist different voltage levels. Those things I will be discussing. Now generally this generation voltage level is typically around 10 to 20 kV kilovolt; kV stands for kilovolt.

So; that means, these generators generate that amount of power 500 megawatt power each of these generator generate at a voltage level of 10 to 20 kilovolt. Now, this 10 to 20 kilovolt is not transmitted by the transmission network. So, we upgrade this voltage level. We upgrade by this voltage level to the voltage level of the transmission networks. So, this upgradation took place in substation. So, what is that substations? In substation, we have different number of transformers and their purpose is to upgrade this voltage level from generation voltage level to the transmission level voltage.

Now, what are the transmission level voltages we have in India? We have different transmission level voltage starting from 220 kilovolt, then 400 kilovolt and 765 kilovolt. So, these are the different transmission voltage levels. So, in the substation we have transformer this sign is representing a transformer there are multiple number of transformer as such which are basically responsible to convert this voltage level to generation voltage level to transmission voltage level, ok.

Now, the question is why we need this transformation why we need this transformation? Why do not we generate whatever voltage that voltage we should not transmit? So, there are some issues. Particularly you know this power if I represent it as capital P it is proportional to voltage multiplied by current. Power is proportional to voltage multiplied by current.

Now, if we transmit huge amount of power at lower voltage level of course, the current flow through this transmission network could be higher. Whereas, if we go for higher and higher voltage level this current which will flow through this transmission network will be less.

The intention of transforming this generation voltage level to the transmission voltage level is to reduce the amount of current that should flow through the transmission line. Now, the question is why we need this reduction of this current? Now there are two important aspects; one is the construction of transmission lines. They are made of transmission line conductors.

And this conductor size the conductor cross section depends upon how much current you intend to flow through this particular transmission line. So, if you construct a transmission line which should carry higher amount of current, you need to go for higher cross sectional size of the conductor which will increase the cost and it creates even constructional complexities.

So, this is one aspect that if we can reduce the amount of current we need a conductor having lower cross sectional size therefore, if constructional means power and all these things would be less expensive. This is one issue. Another issue is that while transmitting power from generating station to the customers via this transmission and distribution networks there exists a power loss which is very important factor and this power loss is proportional to the square of the current. It is basically I square R loss that we know.

Now, if we can reduce the current; obviously, this power loss will be reduced. So, these are the two important things that one should remember for which we go for the change of this generation voltage level to a higher value transmission voltage level. Or alternatively, I can call that is the reason why a transmission voltage level is higher than the generation voltage level.

Now, the question is after transmitting this power with this higher amount of voltage level we need to again downgrade the voltage level. So, sometimes this transmission networks is directly connected to the distribution networks or there exist again an intermediate block which we called as sub transmission line; sub transmission line or sub transmission network whose voltage level is little less than this transmission network voltage level; it is around 110 kV or 132 kV and so on.

Now, this sub transmission network are basically of multiple numbers who brought this power to the nearby of the distribution networks. Now again so in that case in order to have this sub transmission networks whose voltage level is less than the transmission networks voltage level.

So, we need some voltage transformation; we need transformer in between or we need some substations to be installed beyond this transmission network or at the junction of the transmission networks and sub-transmission networks where we will be having multiple numbers of transformers to convert the voltage level from the transmission line voltage level to the sub-transmission line voltage level.

And then, this sub-transmission network is connected to the distribution network whose voltage level is normally around 11 kV or 33 kV in India, mostly it is 11 kV distribution voltage level is used in India.

So, in order to again change this sub-transmission line voltage level to the distribution network voltage level, we need to install another types of switching substation which will be responsible for transforming this sub-transmission voltage level to the distribution voltage level.

So, this is how power flow from generating station to distribution network. So, there exists multiple numbers of components which include substation which include transmission network, which include distribution network, which include several different types of substation. For example, this if you visit any thermal power plant in India you will see inside the thermal power plant complex there exist a substation. This substation is basically for upgrading this voltage level from generation voltage level to the transmission line voltage level.

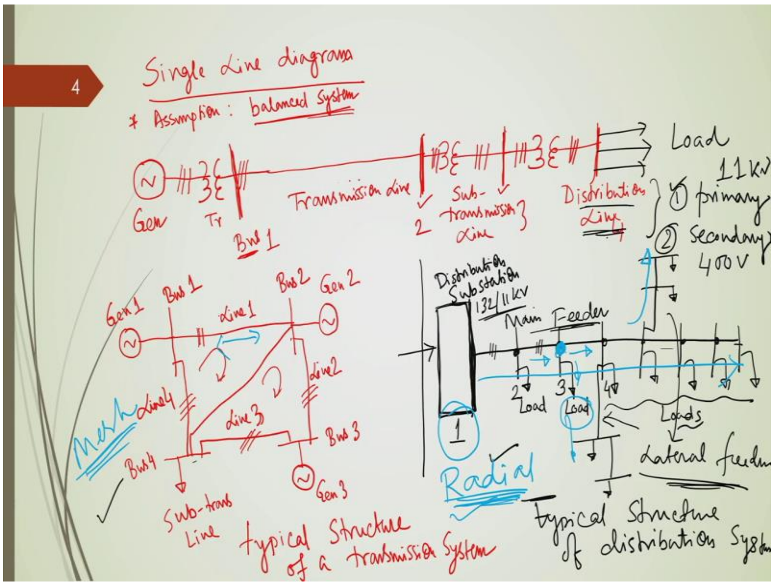
But apart from that, there exist other types of substation as I said in between these distribution networks to sub-transmission networks. This is to transform this sub transmission voltage level to the distribution network voltage level. Also in between transmission network to sub-transmission network, this is to transform the transmission line voltage level to the sub-transmission line voltage level.

So, you can see, there are various voltage transformations took place in the process of power flow from generating station to the distribution networks, first upgradation of voltage level from generating voltage level to the transmission line voltage level, then down gradation of this voltage level from transmission and sub-transmission voltage level to the distribution network voltage level. So, this should be understood as a power distribution engineers or researchers.

So, these first two aspects already I discussed. Now next two things that I should discuss before I show my slides to you, one is topological or structural difference between the transmission and distribution networks; another is single line diagram.

That means basically there exist some differences between the transmission network structure and distribution network structure that is the thing that one should understand. And also, there is a practice to represent this transmission and distribution networks with a single phase equivalent circuital form. We call it a single line diagram. Sometimes, we abbreviate it as SLD. So, these two things I will discuss before I show you my slides to you.

(Refer Slide Time: 19:50)



So, first let us discuss single line diagram, what is single line diagram? So, as you know I hope that most of you have some fair idea about this three-phase electrical system. You know that as long as we consider the system is balanced we can represent a three phase system in a single phase equivalent form.

So, here the assumption is that; we have a balanced system. Now what do you mean by balanced system? Balanced system means we have a three-phase voltage source which is having equal magnitude of this voltage and they are equal phase angle apart to each other.

Similarly, we have identical three loads which carry equal amount of current and also these currents are exactly equal angle space to each other. So, both the voltage and current magnitudes in the individual phases are equal and they exactly are 120 degree apart to each other.

Now, as long as this works we can represent, we can simplify this 3-phase system in a single phase equivalent form and we usually represent this single line diagram like this. Suppose, this is my generator, then, we have off course, this transformer this is suppose the representation of the transformer.

And although, they are of 3-phase, generator is of 3-phase generator; transformer is of 3-phase transformer. You know line or cable which is connecting this generator to transformer they are also of 3-phase, but we can represent them in equivalent single phase form and we keep a symbol like 3 parallel lines to symbolize that. Although we are representing them in a by a single line, but they are actually of 3 phase.

So, then we have this transmission line and then this transmission line is also 3-phase. Then, we also have again transformer for sub transmission line which is also 3-phase and then again, we have some transformers and distribution line which are also 3 phase. This is the way of typical presentation or typical single line diagram of a typical power system. This type of things you might have seen in your undergraduate level power system course.

So, this is the representation of transmission line. This is the representation of sub-transmission line and this is the representation of distribution line and this nodal point or junction between this voltage level of this transmission line. They are represented by these thick parallel lines.

They are basically called as bus. So off course, this bus is the nodal point of this generating station and the transmission lines; this bus is the nodal point of the transmission line to sub-transmission line; this bus is again the nodal point of the sub-transmission line and the distribution lines.

So, these are called bus and many times we also provide some nomenclature of those buses like bus 1, bus 2, bus 3, bus 4. So, these things probably you might have seen in your undergraduate power system course. So, this is the single line diagram and we follow this in this is standardized single line diagram. We follow worldwide to represent transmission and distribution networks.

Now, as I said what is the topological difference of a typical transmission line and a typical distribution line? So, in order to understand that let me draw a typical single line diagram of a transmission network and a typical single line diagram of distribution network.

So, suppose this is typical representation of a transmission line. So, here if you look at this representation, single line diagram representation, this is suppose generator 1; this is suppose generator 2; this is suppose generator 3 which are located and which are spread in a vast geographical area. But, they are connected through this transmission line. So, this is one transmission line; this is another transmission line; this is another transmission line; and this is another transmission line.

We can represent this nodal point at the nomenclature of these buses. Suppose this is bus 1; this is bus 2; this is bus 3; and this is bus 4. So, we have here you know a 4 bus system and we also have a 3 generators connected in 3 buses and in one bus we do not have any generator. But, this is connected to the sub transmission network to feed the load.

Now, we have 4 transmission lines; this is suppose line 1 which is connecting bus 1 to bus 2; this is suppose line 2 which is connecting bus 2 to bus 3; let us name this one is line 3 which is basically connecting bus 3 to bus 4 and this is line 4.

So, they are all transmission lines. We represent them by a single line diagram, but they are of 3-phase like this. So, you know if you want to represent this 3-phase nomenclature then you can provide these 3 parallel lines which will signify that they are of 3 phase. But, normally we do not keep this dotted line. We can simply write which means as a power system engineers we understand that they are of 3-phase, but we are representing them in a single phase equivalent form.

This is the typical structure of a transmission line, structure of topology of a transmission system. We have 4 number of buses. We have 4 number of lines. This is the typical system, but normally practical transmission network is of having multiple number of generators, hundreds of generators and hundreds of lines.

And topology also changes. There may exist another line which is connecting bus 2 and bus 4 and so on. So, there might be different type of structure, but this is the general single line diagram to represent a transmission system.

Now, what we can note down from this figure? That you can see that normally transmission network is a type of mesh network. So, it creates loop and it creates meshes whereas, there is a difference of this network topology of the distribution networks. So, let us see how this distribution networks will look like. As I said, distribution network will basically stacked you know beyond this sub-transmission network and they are connected to the load; they are connected to the load.

And there are two types of distribution networks; one is called primary distribution network another is called secondary distribution network. This primary distribution network is normally of 11 kV and the secondary distribution network in India is normally of 400 volt three phase. By the way, one thing I should tell that for those who do not have idea that whatever these voltage levels I have shown in my last slide that 10 to 20 kV, this 220 kV, 400 kV, 765, 11 kV, 33 kV, all are basically line to line voltage.

So, many times this is not specified, but as a power system engineers you should know that they are line to line voltage. They are 3-phase voltage and this is the voltage between two lines.

Now, let us see that how a distribution network looks likes. So, as you can see that distribution network is far away from the generator. So, distribution network is far away from the generators and that is why normally you know conventional type of distribution system there is no generating source. Conventional type, I am talking about now things are changing with time. Those things I will discuss in my different modules, but a conventional distribution networks they do not have any generating source connected.

So, they are started with one feeding point and that feeding point is the basically distribution substation; this distribution substation is connected with the sub-transmission system and a distribution network starts with this distribution substation and inside this distribution substation we have different distribution transformers which transforms the sub-transmission voltage level to the distribution voltage level.

Let us consider that 132 by 11 kV transformers. There might be multiple number of transformers which are basically used to transform this voltage level and to distribute. Now, then how this distribution networks looks like then we have a long distribution lines and these distribution lines are connected with different nodal points connecting different nodal points each nodal points is having certain load connected to it, each nodal points is having certain load connected to it.

So, this is shown. So, each of are having certain loads. So, these are all loads; these loads you can consider as the residential complex or a small residential locality or maybe a commercial complex or maybe an industrial complex and so on.

So, basically distribution networks having a long period these are all 3 phase. So, you can understand these lines are of 3 phase, but they are directly connected to the load. Now, this long distribution lines which are basically connected to the distribution substation towards the load. They are basically also named as distribution feeder.

This is a trunk feeder and there might be some lateral feeders, as well; like this particular node is connected to another load. For example here, then this one is connected to another load; this particular nodal point is connected to another load. So, these are basically called lateral feeders. This is main feeder; this is main feeder or trunk feeder and these are called lateral feeders.

So, in a typical distribution network, we have multiple number of main feeders and each main feeder is connected to a multiple number of lateral feeders. Now sometimes, in order to analyze this distribution network, we also rename this nodal point as 1, 2, 3, 4 and so on.

So, we generally keep the substation as number 1 bus and then next nodal point is bus 2 or node 2; next nodal point is bus 3 bus 4 and so on. So, this one has to understand. Now, if you look at this distribution network, this is a typical structure of distribution systems. Now if you look at this difference between this structure and this typical structure of transmission system, then one can understand that normally this transmission system is of mesh system having loops. And, what is the purpose of this mesh system? This has some advantage; what is that advantage? The advantage is that because of this mesh structure they are more reliable; reliability is higher.

Whereas, this distribution network, they are basically of radial in structure they are basically of radial in structure. What do you mean by radial? Radiality or radial structure means power flow is always unidirectional, ok power flow is always unidirectional starting from this substation towards this load. So, power flow is always unidirectional.

Whereas, in transmission line power flow is bidirectional; power can flow from bus 2 to bus 1 or vice-versa. So, the distribution networks intentionally kept as radial so that power flow is unidirectional and because of that this system is very simpler to operate.

So, if power flow is the unidirectional you can understand that suppose at any nodal point what is the power that is flow from this point to that point, this point to that point that is node 2 to node 3 you can easily determine by applying Kirchhoff's current law at this particular node.

So, the power flow between this node 2 to node 3 would be simply equal to simply equal to this which is power flow summation of this power flow from node 2, 3 to 4 and the power which is drawn by this particular load. So, if you apply KCL over here, you can eventually find out what is the current or power that is flowing through this any particular line, but things is not as that simpler to for this type of mesh system, ok.

So, you can understand by looking at the difference of these topological or structural difference of these two systems ok and because of this simplicity the protection system design is and protection logics are much simpler for this radial system. And that is why in India or in other countries also distribution networks are purposefully kept as radial even though they are not radial, but they are operated at radial I will show you in later course of time they are operated as radial so that this will work with simple operational logic, ok.

(Refer Slide Time: 37:32)

So, with this let us see some other factors for power delivery system, first of all you can see what are the goals of power delivery system this goal is to cover utility service territory reaching all the customers who is to be connected.

So, as a power distribution engineer your goal would be to design a network such that all the customers under your geographical territory would get power from your network, ok. So, this is one thing. Second thing is that they should have sufficient capability to meet the peak demand. Now what is peak demand? Again, it is a technical term I will discuss in my next lecture.

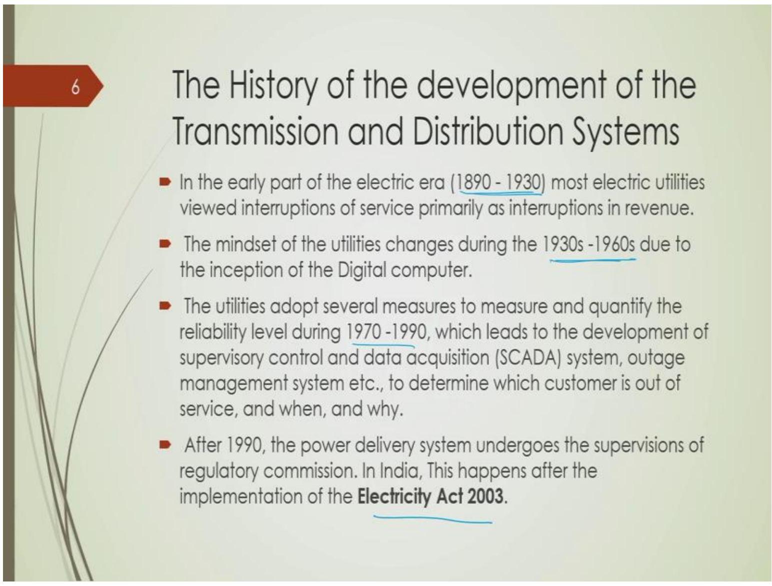
But one should understand that you know the load is certain parameter which is changing with time sometimes load demand is very high sometimes it will very less. So, whenever it is very high your design networks should have the capability to meet that particular demand.

Then next thing is that provides satisfactory continuity of service as in my introductory lecture I mentioned as being a customer we do not listen anything but we want that we should have uninterruptable power in order to achieve this you should have a very reliable network, ok. So, in order to have a satisfactory continuity you should have a very reliable network. So, these things we have to ensure.

So, this is also one of the goals for power delivery system also we should provide stable voltage quality, what is voltage quality all these things I will discuss in later course of time, but as a customer for example, most of us customer are of single phase customers. So, our rated voltage level is 230 volt single phase. So, whatever may happen to the network, but I wish to have this 230 volt available at my home ok. So, this one everybody should understand ok and that is basically called voltage quality I will discuss and also to maintain the power quality to the customer.

So, there are many power quality issues particularly with the inception of various types of sophisticated electronic devices by the customers, but they are very sensitive of this voltage. So, we should maintain this quality. Now, this I already discussed the historical development of transmission and distribution system.

(Refer Slide Time: 40:12)

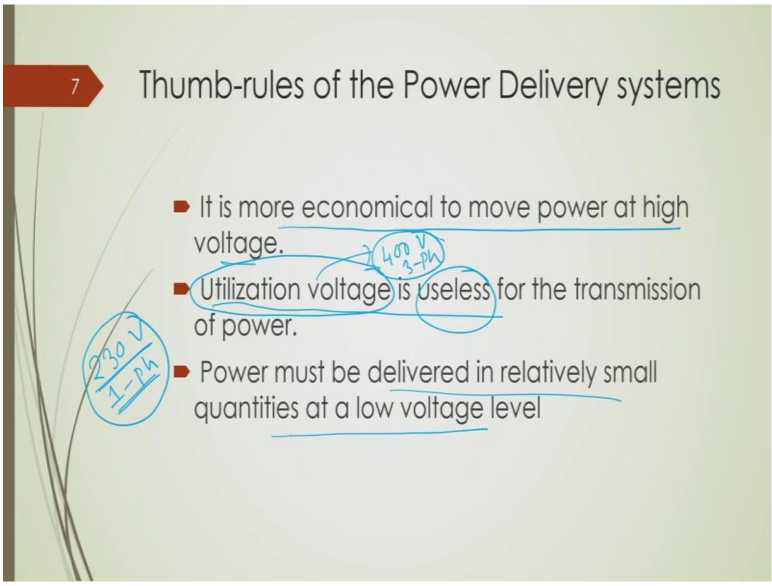


It was started in as I mentioned in the last lecture last two decades of 19th century and slowly slowly it started to flourish in different parts of the world in between 1900; 1910 to 1950-60 then there was a time that people were not much expectation not much expectation.

So, if there was any power interruption they think that ok this is natural ok, but things was change after the inception of digital computer. So, they are very sensitive of this interruption. So, we do not wish to have any interruption in order to save those electronic devices. So, mindset of the consumers change during that point of time ok.

Now, by keeping all this in mind we have this system restructuring in our country as well as in other countries. In India it was happened after the implementation of electricity act 2003 and they are after that lot many changes took place and power business becomes more competitive and there are more participation of various players, ok.

(Refer Slide Time: 41:30)

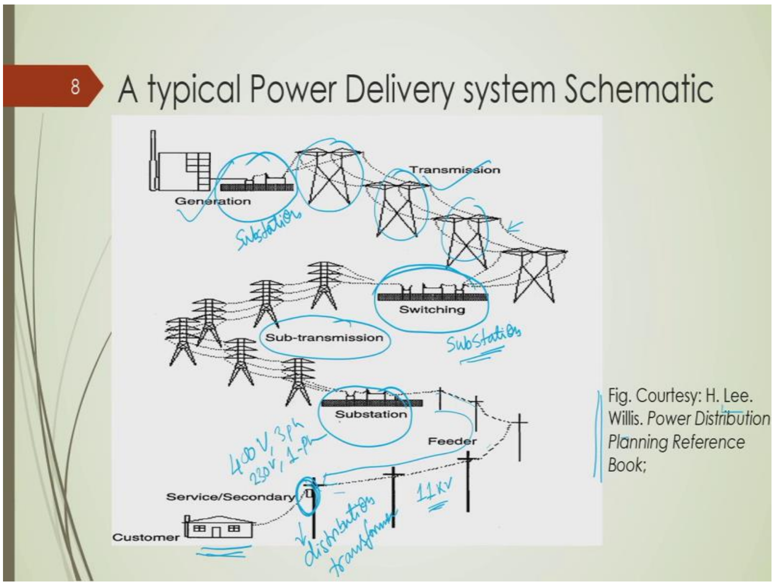


So, there are some thumb rule for power delivery system already I mentioned that what are the thumb rule it is more economical to move power at the high voltage ok. So, this already I mentioned why we go for that. Second is utilization voltage is useless. What do you mean by utilization voltage?

This utilization voltage is the voltage at which a device consume power, ok for us it is all of the residential customers we have these devices rated as 230 volt single phase ok for a residential customer or voltage level in our country is 230 volt is a single phase that is the utilization voltage ok and some of the industries they have equipment which are rated of 400 volt 3 phase.

So, for them this utilization voltage is 400 volt. So, normally you know this 400 volt 3 phase and 230 volt single phase they are of utilization voltage in our country and you can go back and see that these voltages are useless in the sense that we cannot transmit and distribute or we can generate and distribute the customers with this utilization voltage, ok. So, power must be delivered to the relatively small quantities at the lower voltage level this is known to us.

(Refer Slide Time: 42:57)

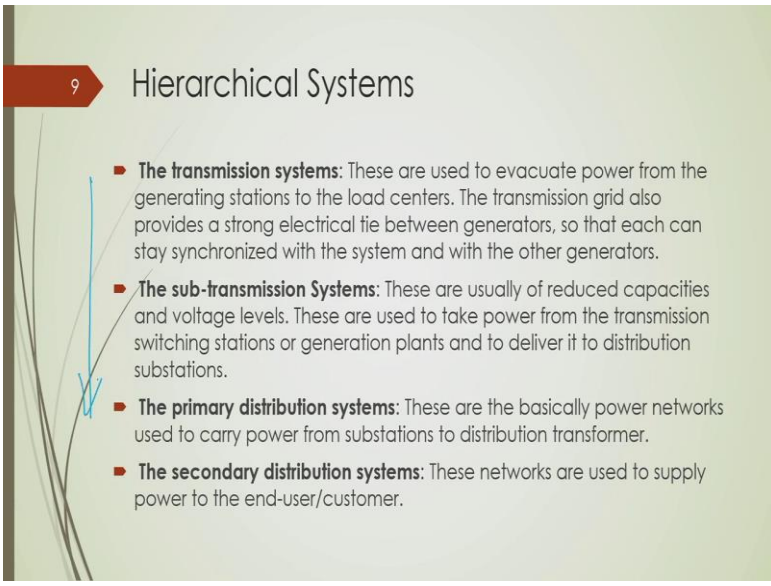


So, this is a typical power delivery system acknowledge this figure from this Lee Willis book you can see that this is the generators then we have this transmission network, these are basically typical representation of transmission line towers and they are having you know transmission lines connected to it transmission conductors connected to it.

Then we have switching station or substation, this is substation where you downgrade this voltage level. So, this is the substation at which voltage is upgraded this is the substation at which voltage is upgraded, this is the substation at which voltage is downgraded to the sub transmission line voltage level and then further this is the substation where voltage is further downgraded to the distribution level voltage, ok.

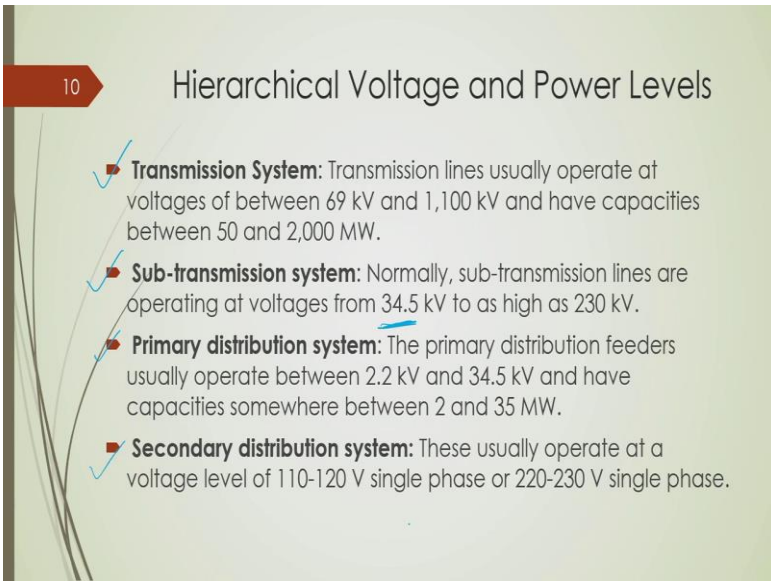
So, this is the brief overview of a power delivery system then this is the distribution feeder which brings power to the customers and this is the basically primary distribution feeder in our country it is of 11 kV. So, again we need to downgrade this voltage level by using distribution transformer this is the distribution transformer to the utilization voltage level, this utilization voltage level as you know it is of 400 volt 3 phase or 230 volt single phase, ok.

(Refer Slide Time: 44:33)



So, next we go for this hierarchical system. So, you know this transmission system it is used to evacuate power then we have it is the first hierarchical system which is near to the generating station then we have sub transmission system which is basically the junctional point of this transmission system with the primary distribution system and then we have primary distribution system and we have secondary distribution system. So, this is the hierarchical system already I discussed and I chalked out to illustrate you.

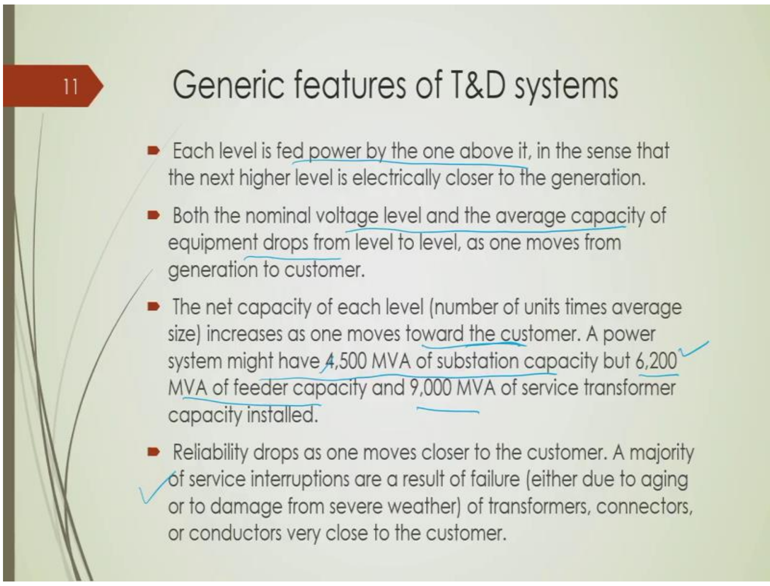
(Refer Slide Time: 45:09)



And these are the typical voltage levels of this transmission sub transmission primary distribution and secondary distribution as I mentioned. I mentioned these voltage levels of our country, but in other countries they have different with different voltage levels. For example, this we use 33 kV they use 34.5 kV; we use 11 kV, they use 13.8 kV; but there exist hierarchical voltage level and power levels; those things you have to understand.

So, of course, one thing you have to remember here is that these are transmission system its capacity is much higher it can carry several megawatts of power sub transmission system this is the multiple numbers, but its capacity is bit lower then primary distribution system each capacity is much lower only they can provide you 2 to 5 or maximum 10 megawatt of power and then secondary distribution system capacity is further low.

(Refer Slide Time: 46:10)

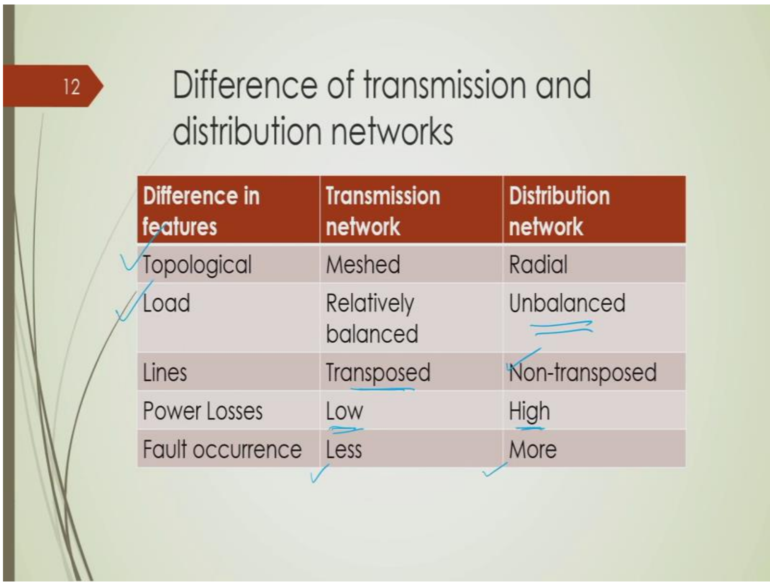


So, these are the generic features that one should know that each level of power is fed power by the one above of it. For example, sub transmission level gets power from the transmission network distribution networks gets power from the sub transmission network ok. Now both the nominal voltage level and the average capacity of the equipment drop from level to level as one moves from generating substance to the customer.

So, net capacity of each level increases as one moves towards the customer for example, a power system might have 4500 MVA of substation capacity, but 6200 MVA of feeder capacity it means that one feeder is not having 6200 MVA capacity, but there exists a huge number of feeders.

And if you aggregate all this capacity, it would be much higher than the transmission capacity. Similarly, it should have 9000 MVA service transformer; it does not mean that 1's transformer or transformer 2's rating is 9000 MVA, but if you aggregate the whole capacity it will be something like that. Then also reliability drops this thing I will discuss in due course of time. It means that distribution networks they suffered from more number of outages and therefore, they are less reliable than the transmission networks why so, I will discuss.

(Refer Slide Time: 47:43)



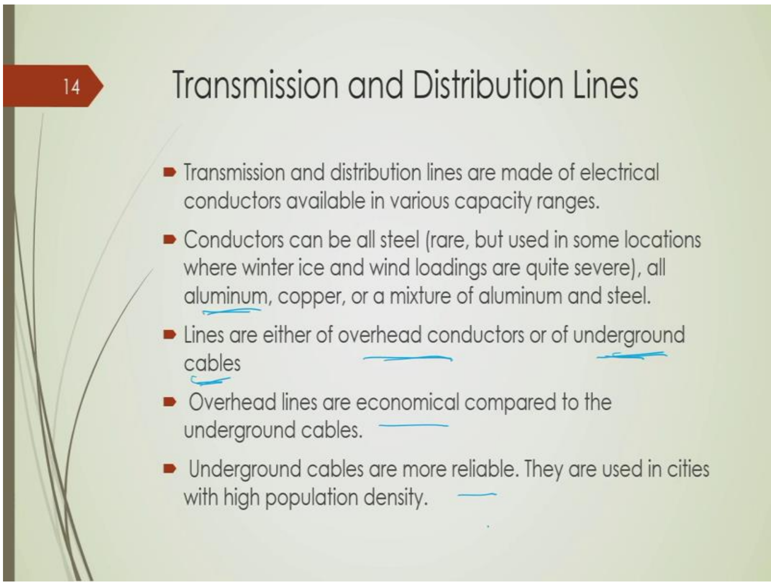
This is the difference of transmission and distribution networks already I discussed the topological difference, but balanced and unbalanced wise you know transmission network is relatively balanced and distribution network is relatively unbalanced.

But primary distribution networks are of unbalanced; the lines are of transposed in transmission networks so that it can reduce the amount of voltage imbalance, but in distribution networks we do not have transposed line. Power loss is usually low in transmission network because as you know it is having higher voltage capacity lower current. So, in distribution network, it is high. Fault occurrence whichever I mentioned in my last slide is less in transmission network and high in distribution network.

(Refer Slide Time: 48:34)

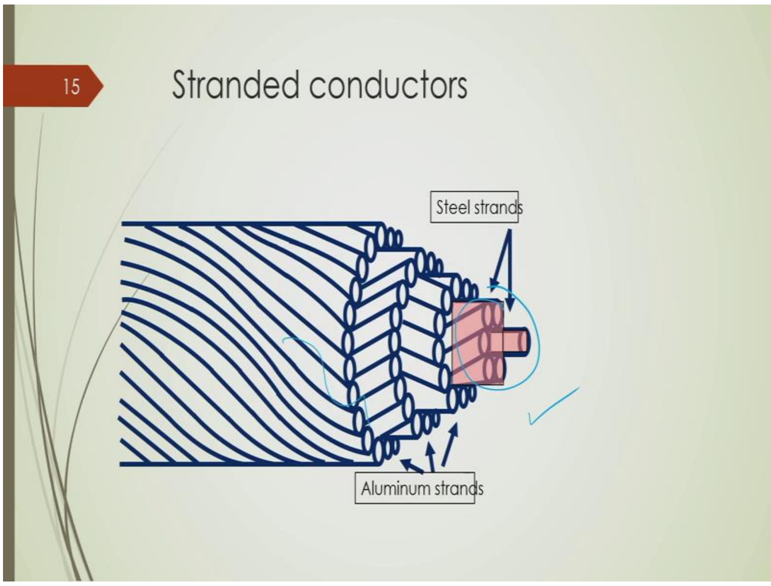
So, these are the utility transmission and distribution equipment, already I mentioned about all of them like transmission distribution lines, switching station, substation, service transformer, then also we have some other equipment like reactive power compensator; those things I will discuss in due course of time and some other compensator we also have we will discuss.

(Refer Slide Time: 48:59)



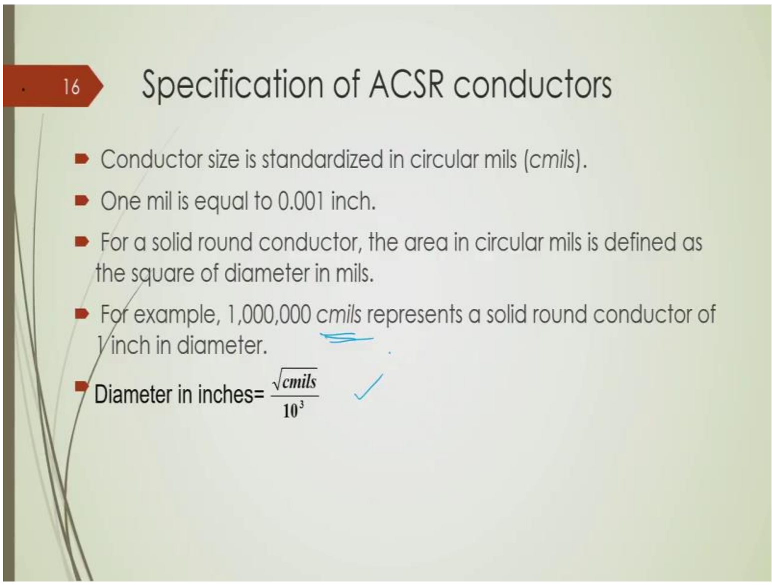
So, next we have some generic features of transmission and distribution lines; they are made of electrical conductor and you know mostly we use aluminium made conductor and these lines can be either overhead conductors or underground cables, but except some new metropolitan cities they use the underground cables for distribution purpose only, but transmission lines are of all are of overhead lines or having overhead conductors, so, as the distribution line also because underground cables are basically costly equipment. So, overhead line is of economical; underground cables are more reliable, but they are costly. So, they are used in highly population density areas.

(Refer Slide Time: 49:50)



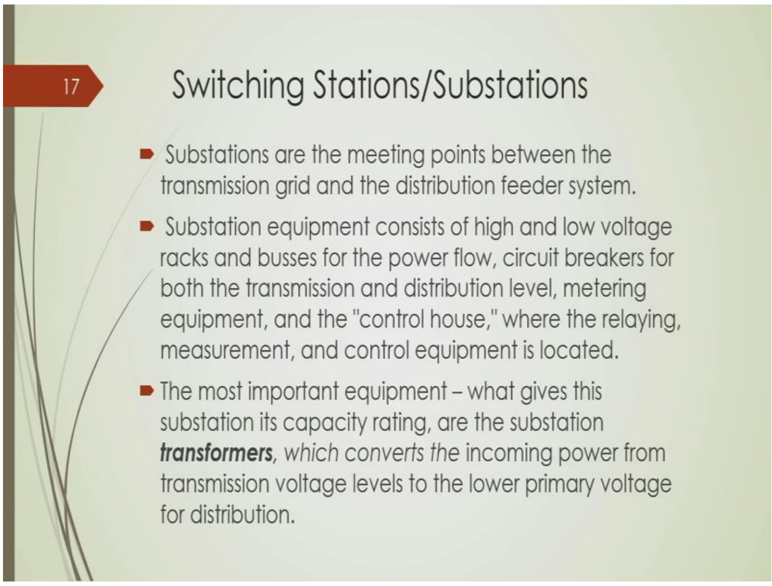
This is the stranded of a conductor; this is how it looks; we have the stranded conductors; this is the steel strands which we use for tensile strength of the conductor and this is how different strands aluminum strands are used to flow this power.

(Refer Slide Time: 50:07)



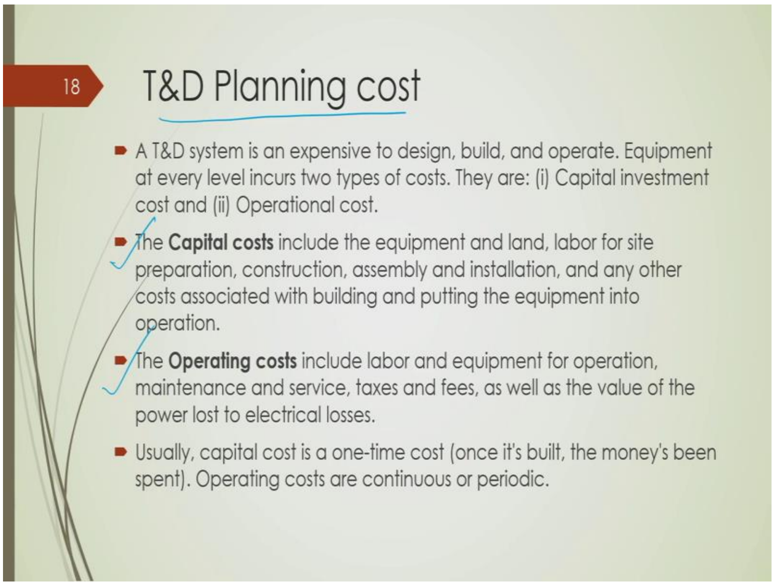
There are some specification by which we differentiate one type of conductor to the other conductors. Normally cmils is one of the definitions. So, this is how we can convert cmils to diameter in inch.

(Refer Slide Time: 50:23)



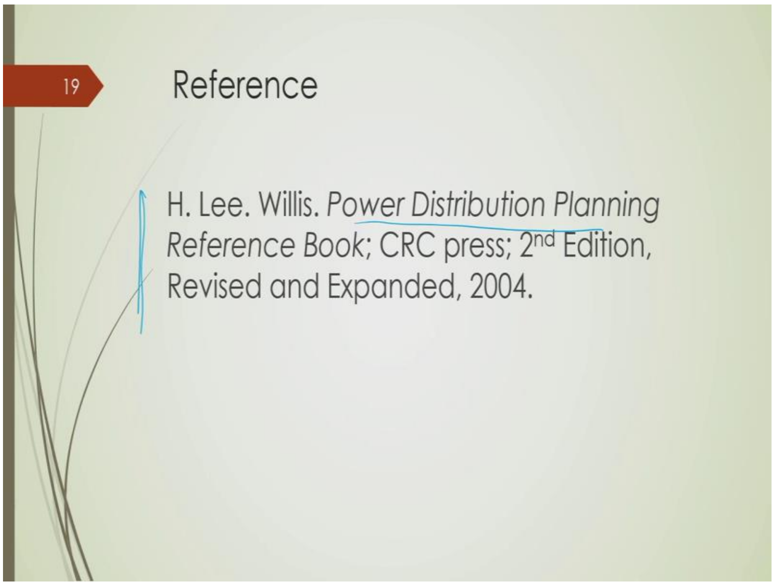
So, this already I discussed this switching substation is another important switching station and substation is another important thing for transmission and distribution of power. In fact, in our IIT Guwahati campus we also have a distribution substation. So, if you visit there you will see there are many equipment; many equipment which include circuit breaker which include different protection system control and there is a control room to monitor all these things.

(Refer Slide Time: 50:57)



These are some of the things which will be required for planning of our transmission and distribution system. So, there are two types of planning cost; one is called capital cost another is operating cost. Capital cost involves this installation and installation cost of the new equipment or for new reinforcement of the equipment; operating cost is for operational cost wise like it includes the cost of this maintenance it also includes the cost of the power loss those things I will discuss.

(Refer Slide Time: 51:31)



And this is the book which I have followed for preparing the slides. So, I sincerely acknowledge this book H. Lee. Willis Power Distribution Planning to get various ideas of this lecture.

Thank you.