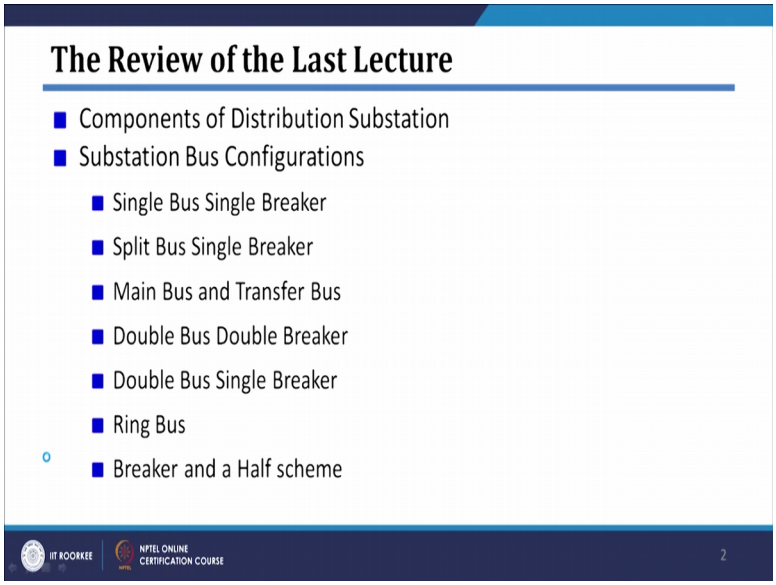
Electrical Distribution System Analysis
Dr. Ganesh Kumbhar
Department of Electrical Engineering
Indian Institute of Technology, Roorkee

Lecture - 03
Components of Distribution System and Feeder Configurations

Dear students, welcome to this lecture number 3 of the course Electrical Distribution System Analysis. Title of this lecture is Distribution System Feeder Configurations. Before going to the distribution system feeder configurations we will see what we have seen in the last lecture. Last lecture we have seen a components of distribution system substations.

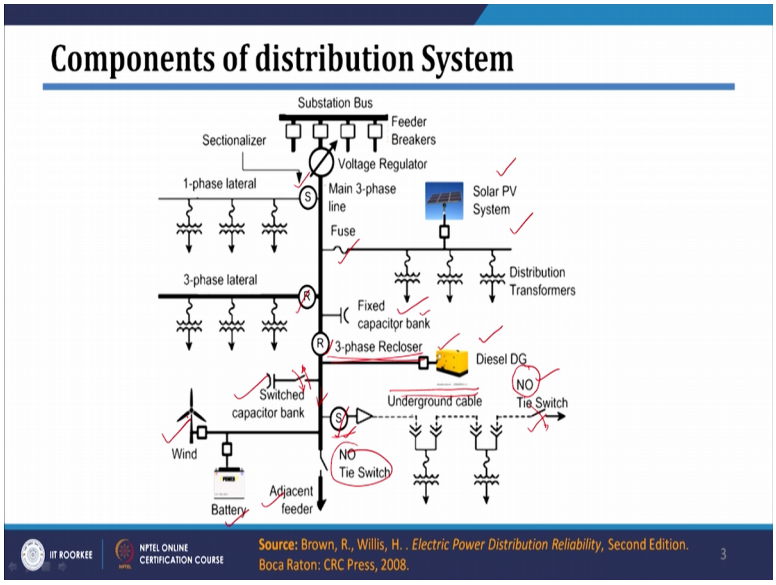
(Refer Slide Time: 00:49)



So, various components of substations starting with isolator switch then current transformer, potential transformer, circuit breaker and then we have seen various bus configurations.In the bus configurations or bus layout we have seen various configurations, there are seven such configurations. Single bus single breaker configuration, split bus single breaker configuration, main bus and transfer bus configuration, double bus double breaker configuration, double bus single breaker. Then there is a ring bus and then there is breaker and half scheme. Out of these different bus configurations we have seen that single bus single breaker configuration which is this which is very cost effective.

However, we have seen that reliability of this configuration is very low. The configuration which is based on double bus and double breaker scheme we have seen that it is most reliable configuration. However, cost involved of this configuration is very high. Then we have seen two more configurations which are give which gives better reliability those are ring bus configuration and your breaker and half scheme. So, we have we are seen this configuration in the last lecture. And as I told you in today's lecture we will see a various feeder configurations. Before going to the feeder configuration we will see: what are the components of distribution feeder.

(Refer Slide Time: 02:41)



So, if you see this particular figure I have shown various components of distribution feeder.

So, distribution feeder will start from your substation bus. So, there will be various number of feeders we will start from this substation and there is possibility that there will be 8 to 10 feeders which will be starting from a typical substation. The first point will be actually feeder breaker which is basically required for protection of this feeder whenever, there is fault on a feeder. Then there will be a voltage regulator, voltage regulator may be your optional component if there is on load tap changer present on a substation transformer we do not need voltage regulator there.

The function of voltage regulator is to maintain the voltage of distribution system in of the limits which are given in the standards. So, there will be say plus minus 10 percent of

voltage limit which will be given in this standard then, voltage regulator will be set such that the voltage were the distribution system will be maintained at plus minus 10 percent.

Then there will be actually various laterals. So, this is your mainline which is called as 3-phase mainline which is basically 3-phase and then there will be various laterals which will be connected to this mainlines. So, this is 1-lateral which is 3-phase then there is a another lateral which is 3-phase and then there will be this single phase lateral. So, there they possibility that laterals which are going out of this main 3-phase line will be single phase or 2-phase which is called as v phase also sometimes and then there is 3- phase laterals.

Then there is fuse, as I told you it is for the protection purpose of the feeder. Sometimes we use these reclosers or this sectionalizer to disconnect a line during the faults. This sectionalizer switch we will work wind coordination with your recloser, the function of recloser is similar to our circuit breakers. So, recloser will work only when there is fault. But different between recloser and circuit breaker is that recloser will work whenever there is temporary fault or permanent fault. So, it will first check fault is temporary or permanent, if the fault is temporary the recloser will first open the circuit and then whenever after sometime it will again close the circuit to check the fault is temporary or permanent in nature. If the fault is permanent in nature it will completely open the circuit.

Then you will find there are different types of capacitor, like I shown it here which is one is fixed capacitor bank and then there is switched capacitor bank. So, capacitor banks are basically provide to provide the reactive power support in the distribution system. So, fixed capacitor will be permanently connected to the distribution system. However, this switched capacitor will be connected or disconnected depending among loading condition. So, whenever there is highly loaded condition during in this distribution system then it will be switched on whenever, lightly loaded condition is there in distribution system it will be switched off.

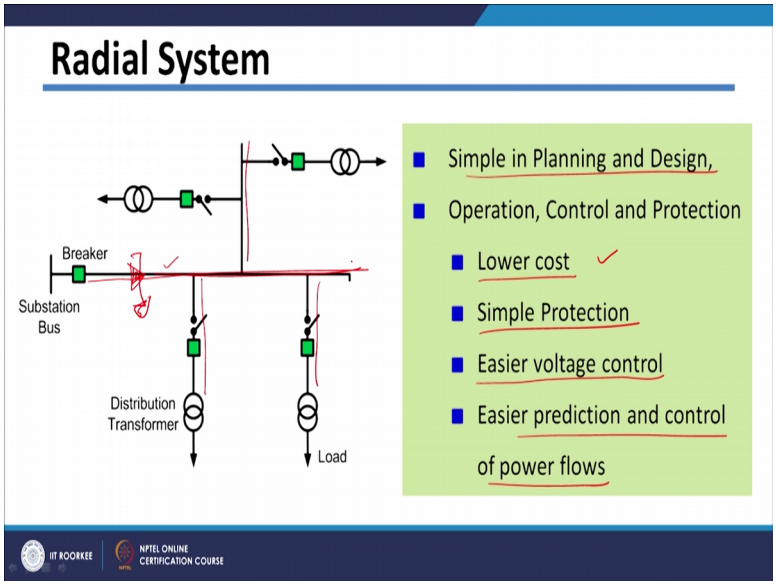
Then however, this fixed kind of capacitor will remain connected to the distribution system whatever loading condition. Then some laterals may be having your underground cables, some or laterals will be having overhead lines like I have shown it here. Then

there will be some number of tie switches adjacent feeder, there is one more tie switch here.

So, these are these tie switches will be in normally in open condition. So, this is normal open condition; however, when whenever required we can close it and we can connect it to other feeder. So, these are the components of your distribution system. However, there are many new components are getting introduced to this distribution system. These are some of the components like solar PV system where the solar energy will be connected to the distribution system. Then there is diesel generator set which will be connected distribution system. Then there is battery and then there is wind energy which will be connected to the system.

So, because of connection of these new components the distribution system will no longer remain passive in nature, it will become active because it will having some kind of sources. So, whenever these sources present into the system your protection of the system will become critical. So, we need different kind of protection scheme or protection settings of existing protective relays will need to be changed.

(Refer Slide Time: 08:20)



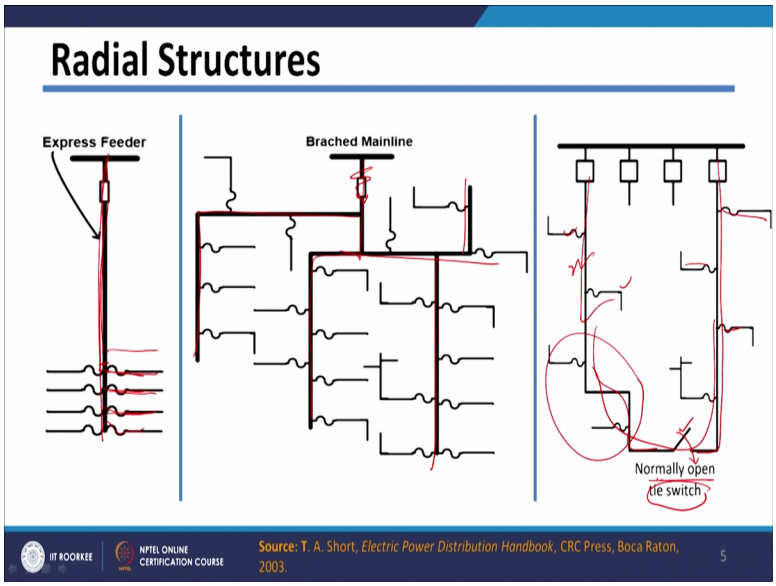
Now, we will see various feeder configurations. So, first commonly used feeder configuration is radial system. So, in this figure I have shown it so, there will be actually feeder mainline which is going and then laterals will be connected to this main feeder.

So, if you see here these in this case no lateral is forming any loop or no mainline is forming any loop. So, it is that is why it is called as a radial kind of system.

So, as I as I written it here it is simple in planning and design. So, while designing and planning it is simple. During the operation control and protection also if you see the cost of the system is very less. Because we need only one power is actually flowing in only one direction and you need to design your protection circuit, as well as your main feeder accordingly and which will actually save your cost of your system. So, cost of the system will be low. Protection will be simple because your current or short circuit current will be flowing only in one direction. So, your protection will be simple.

Then it is easier to control the voltages into the system because voltage drops will be only in only one direction, if there are no active component present into the distribution system the voltage control of the system will be easier. Then it is also easy to predict and control the power flow over radial system. So, it is easy to control the control as well as calculate the power flows over this system. Our problem is this system is that whenever, there is fault at upstream network all the consumers which are connected to this mainline will be out of power. So, if you see the reliability of this system will be very less.

(Refer Slide Time: 10:24)



There are some more configurations of this radial structure. So, as I shown it here there will this one single mainline and then there will be laterals which are connected to this

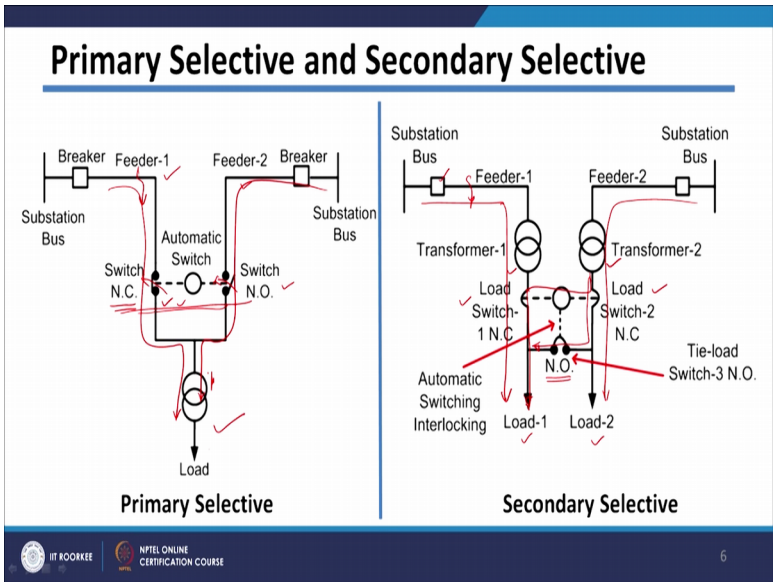
mainline. This is a general configuration then another configuration which is express which is called as express feeder.

So, in case of express feeder up to some length of the feeder there will not be a load connected and then after some time there will be load connector. So, up to this it is called as express feeder because it is a loads are not connected to some extent on this particular feeder. Then another configuration another configuration of radial figure is shown it here, you can see that it is having very branched kind of mainline. So, mainline is actually branched to various structure which are shown here ok. So, this is again one more structure.

Now, to improve the reliability as I told you reliability of this structure is very low because whenever, there is fault on upstream network all the consumers which are connected downstream to that point will be out of power. To improve the reliability sometimes these kinds of radial network will be provided with tie switch. So, this tie switches will be in normally in open condition and then these loads will get power from this direction through this feeder. And this other loads will get power from this side of the figure and this switch will be open condition.

But whenever there is fault at some point of the feeder we can actually close this switch and we can still feed power to some of the consumer through this particular path. So, we can see that reliability is getting improved because of providing this one normally open tie switch, then another configuration which is called as primary selective and secondary selective. So, first we will see primary selective configurations.

(Refer Slide Time: 12:23)



So, in this case to improve the reliability the loads will be provided power from two feeders. So, you can see here the for this particular load power is provided by feeder number 1 as well as feeder number 2, but in this case one of the feeder the switch will be normally open and another feeder the switch will be normally close. So, in normal condition power will be flowing from this direction. However, whenever there is some fault on this particular feeder number 1 we can open this switch. So, it will become normally open and we can close this switch and then in that case power will be flowing from this direction.

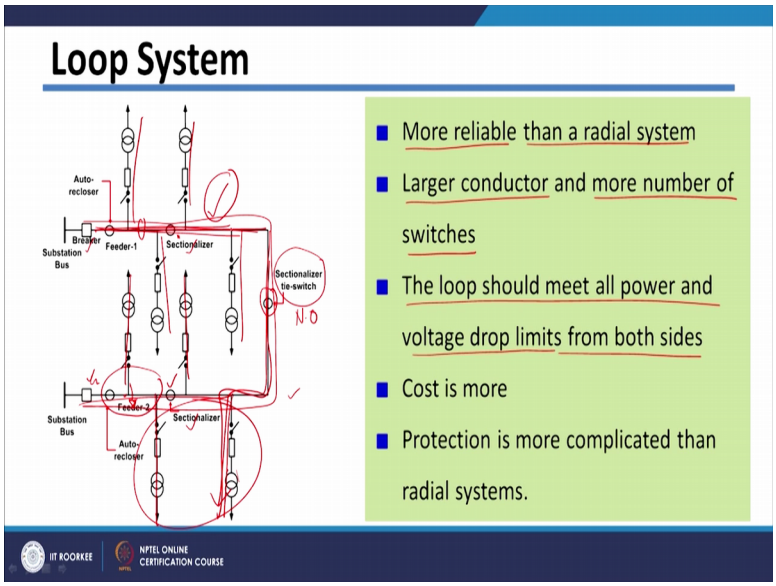
So, we do not need to keep the customer out of the power and that is why the reliability of the system is increasing. Now, this switch is there automotive switches so, whenever there is fault on one network we can actually automatically connect to another network. Now, in this case if you see these switches are connected at the primary side of the distribution system. So, this is your primary side of the distribution system and then these switches are connected at the primary side that is why there it is called as primary selective scheme.

Now, if you see the second figure your structure is similar. However, your switches are provided at the secondary of the transformer. So, this is your secondary of the transformer and this switches which is load switch 1 and load switch 2 they are provided at the secondary side of these transformers. And as I told you there are say two loads

load 1 load 1 and load 2. So, whenever generally this load 1 will be feeder from feeder number 1 and load 2 will be fed from feeder number 2. However, whenever there is fault on say feeder 1 this breaker will open. So, that is why there will not be power flowing from this direction, but by closing this particular switch we can still give the power to this particular consumers through this path.

So, in that case sorry in it will actually through this particular path. So, this switch will be normally open; however, during fault on one of the feeder this switch can be close to provide the power to the consumer, who will be out of power. So, these called as secondary selective scheme.

(Refer Slide Time: 15:31)



Next scheme is actually called as loop system or sometimes it is also called as ring main kind of system. This loop system is actually shown in this particular figure. So, if you observe this figure it is forming some kind of ring kind of structure. So, it is actually forming this ring kind of structure here and this ring is provided with different switches. So, here there are circuit breakers, here there are sectionalizers and then there is one sectionalizer switch tie switch is here, which is actually normally open condition.

So, because of that the consumers which are connected so, connected to the feeder number 1 are basically, these consumers will get power from feeder number 1. And these remaining consumers will get power from feeder number 2 because this switch is normally open. But whenever there is fault on any section of the feeder say, fault has

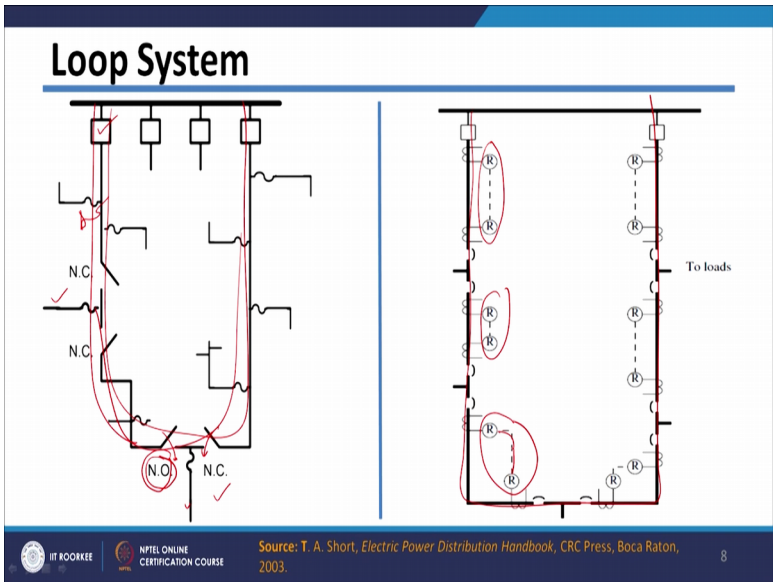
occurred at this point then this sectionalizer and this breaker will open and which will isolate only this many consumers. We can still feed the power to this these consumers by closing this normally open switch and the power will be fed through feeder 1 taking this particular path here.

So, as you can observe the reliability of the system is increasing that is system is becoming more reliable than your radial system. Because we have seen that in case of radial system whenever, there is fault in the upstream network all the consumer which are connected at the downstream part of the network they get out of the power. However, the disadvantage of this scheme is we need larger conductor because whenever, as I told you whenever there is fault suppose fault on this particular breaker then all the consumers still this point will be fed from this side.

So, this size of this conductor or size of this feeder should be as has so, that there will not be it can carry full amount of power through this particular feeder. Also we have seen that in this particular scheme we need more number of switches. So, because of large conductor size and more number of switches this scheme is becoming little bit costlier than your radial system. Then as I told you this loop which we were forming should meet all the power and voltage drop limit requirements of both the sides. Means, it should actually both the feeders should be design such that they will provide power to all the consumers as well as the voltage drop whenever, only feeder 1 is working and this feeder is out just I will erase.

So, whenever there is power is provided from this path to all the consumers so, voltage drop from this point to this point will should be within the limit. So, conductor size should be chosen such that the voltage drop from this point till this point will be within the limit so, voltage drop should be in the limit. Then we are seen the cost is more because we are having higher number of switches and there is larger conductor. Also we can see that there is protection which is little bit complex than your radial system.

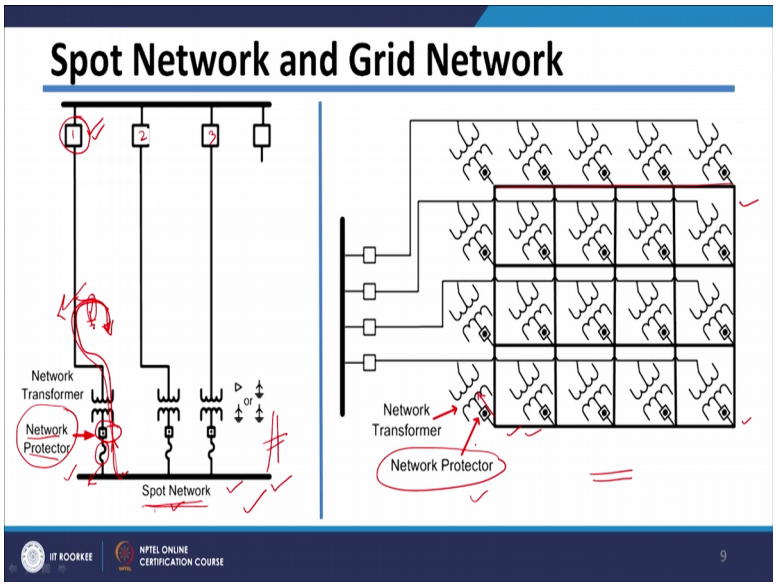
(Refer Slide Time: 19:19)



So, here I have shown one more scheme it is similar to this ok. So, in this case also you are having this loop here and this is your normally open switch. So, all these lower switch are connected to this feeder and this switch is normally close. So, till this load a power will be fed from feeder number 1 and till this load the power will be fed from feeder number 2. But whenever, there is some fault on some side of the feeder say fault is here in that case this breaker will get open and you can still feed the power by closing this particular switch from this side. So, this critical consumer will get power from this side.

So, we can see that reliability is increasing. Rarely this scheme or this kind of network is operated at connected loop, means not in radial fashion loop will be continuously connected, but in that case we need better protection system with fiber optic cable. So, we can see that here there better protection system better realigning is shown with fiber optic connection because, we need fast response for connection and disconnection of feeder section for this particular scheme.

(Refer Slide Time: 20:44)



Next configuration is spot network or grid network. So, if we can observe this figure in this particular scheme this scheme is generally used for secondary distribution system. So, here this system this part we know that it is secondary distribution system here and this is called as spot network or spot bus. To improve the reliability the number of feeders which are connected to this particular spot network are may be 4 or 5. In this case we have shown these 3-feeders which are actually feeding power to this particular spot bus.

So, because of more number of feeders which are giving power to this spot network this scheme becomes more reliable. However, cost of this scheme will be little bit higher than your radial scheme and then there is we need these network protectors for protecting the network. Because, if you see there is if there is some kind of upstream fault means suppose if there is fault on this line this breaker will get open.

And since, these bus is connected what will happen is this is grounded because fault is happened at this point and then power will be flowing short circuit current will be flowing through this direction. Means, there is actually reverse power flow because of this is ground point here and then this is high voltage point. So, power will be flowing like this or it is basically short circuit power.

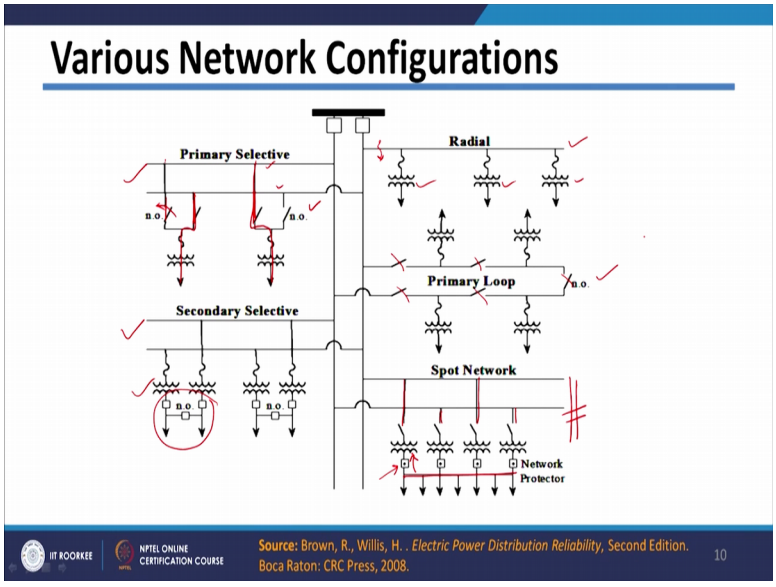
To avoid this backward short circuit current flow or you can say reverse flow these network protectors are given. So, function of the network protector to protect the

network whenever, there is a reverse power flow ok. They will basically not operate whenever this fault on secondary network. So, second whenever this fault on secondary side of the network you can see that this fuse will get operated or if that fuse operate this circuit breaker should be operated similar to this one more scheme which is called as grid network.

So, in this particular figure I have shown the grid network. So, if you see this grid network it is similar to your spot network, we can see that this grid which is actually low voltage grid which is formed here will be actually fed from many number of transformers and many number of feeders at various different locations. So, because of that reliability of this scheme increases; however, the cost of the system will be very very high.

So, this spot network and grid network scheme will be only used whenever there is important consumer or you can say there is important areas if you are feeding then you need the network. Important areas like say there are some kind of business park or special economic zones then in that case you need to found this kind of grid network, which are basically very very reliable kind of networks. In this case also to avoid the reverse power flow to the transformer we are providing with network protectors. This is actually summary of various network configurations.

(Refer Slide Time: 24:38)

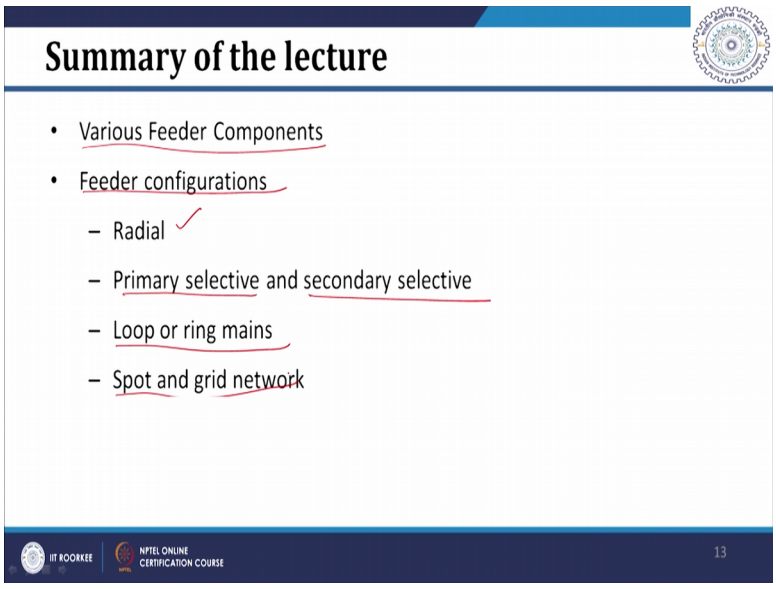


So, if we can see we have seen that there is radial configuration which is shown on this particular lateral. So, in this case whenever as I told you whenever this fault on upstream network all the consumers which are connected to this particular feeder will be out of power. So, reliability is very low and to increase the reliability we know that we can use your primary selective network or secondary selective network; where primary selective we are in two options. There are two buses sorry two feeders and you can connect this load to any of the feeder ok. So, this switch is normally open switch and this is normally closed. So, here it is normally close and this is normally open.

So, in normal condition power will be coming from this, this power will be coming from this node. So, whenever required you can switch on load to another feeder. The secondary selective also works similar way, only the switches are connected at the secondary side of the transformer. Then we have seen the primary loop system, in which we can see that the more number of switches are provided. So, depending upon location of fault we can close and open some kind of switches here so, that all the consumers will be remain in circuit. And then to improve the reliability further as we have seen we can use this spot network.

So, spot network or this grid network will be fed from many feeders and they will be provided with this network protector to avoid the reverse power flow.

(Refer Slide Time: 26:33)



So, in this particular lecture we have seen various components of your feeder. Then we have seen feeder configurations, those configurations are basically radial configuration, primary selective and secondary selective configuration, loop and ring mains configuration and then spot and grid network.

Thank you.