Power System Operations and Control
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Module - 5
Lecture - 1
Load Dispatch Centre Functions

Welcome to module number five, and this is the first lecture, and here the module five basically gives information and discussion about the load dispatch centre functions. In the load dispatch centers, various control schemes are there, if I will go for that load dispatch centre. First, let us see what is the various hierarchies in that control of the power system. To see this, I will show this diagram here, already this I have explained in the very introductive lecture that is module number one.

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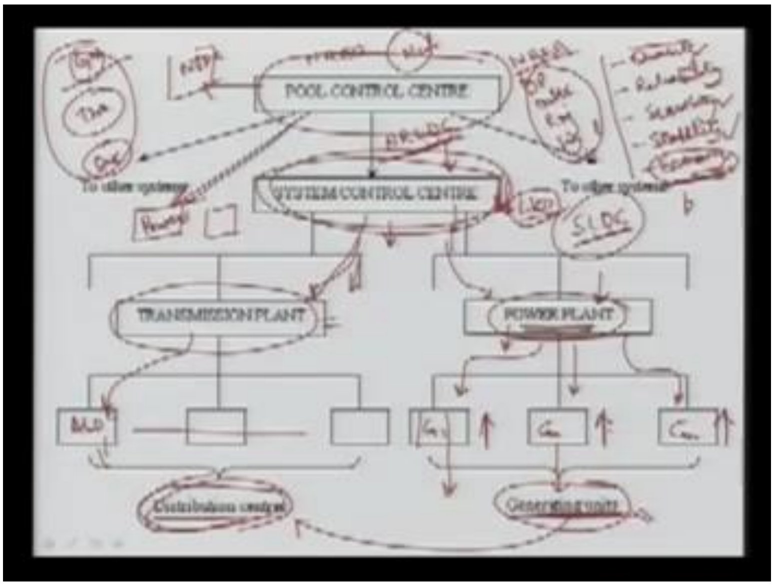

Again, I am going to just going in the brief so that you can understand the other part of this module. In this whole, here if will you start from the very basic, means if you are going for the individual unit here, I have written that is starting from the generating units and one end.

Your distribution units send this another unit, and then we are having the transmission line because here we are having the generating units. They are connected with the distribution systems or even the customers through the various wires, various centers. They are taking place and they are controlling the power, and then the power is coming from the Gemini units to the various customers through various dispatch operations and there various centers are there. To operate the power system, as I said our basic criteria is that we should have that is good quality of power. So, it is called quality, we should have the reliability, we should have secure power system and security is another term.

Here, we should have the stable power system that is called a stability and last, but not the least that we must operate the power system, and the economy that in the cheap way economy. So, we have to go for all these five criteria's and we must operate our power system to provide the sufficient quality of power to the customer. We have to provide the power in the reliable manner, we should have power systems secure enough again to provide the power to our customer. The power system must be stable, and we must operate our arithmetic unit other units so that we can achieve the minimum cost of operation.

Although this idea, now it is changing when it was complete interconnected power system, in the next module I will explain. Now, we are changing transforming from one phase to another phase, where whole this generation, your G generation business. Then, we have this transmission business, and then we have the distribution business all these basically in one utility. So, it is having a bundled power system where the operation of all these small functions is coordinated, but now in the emerging power system, it is slightly different. Here, the generating company there is A, so many generating companies; they are owned and updated by different companies.

Transmission of course, it may be one utility, but again the owner of transmission lines maybe different distribution wire company. There will be a several retail companies, they are buying power from the generating and supplying to the customers. So, there are several utilities here are now involving and they are independently updating, so it is very difficult. Now, we require one system, we require one personal, we require one body, it maybe government body that should monitor all these so that we can free and ff to the customers for taking power from generic.

So, here instead of economy now the earlier we were talking about the minimum cost operation, now it has been changed to minimum price operation that we always that who are going to select what rate? Sometimes even though selling rate may be less than your cost of operation, sometimes of course it will be very high. So, it is now not the cost, now it is a price based operation, and will see in the next module that is an emerged new technologies and operations new area. So, here I am talking about this interconnected power system owned operated by all these three business in one hand, then how it is going to operate?

Even though in this emerging scenario, it may be the different utilities are operating, but the control centers will be just like individual, means it will be interconnected and they must follow this hierarchy, then only the power system will operate. Now, you are starting with the generating units, each generating unit will have own its operating center where it is decided that how much it will be operating? What will be the output? What will be the voltage rating? Which releases are running? Which are in the stand by and so on so forth?

So, each generating unit will have here just why I have written this G, let us go one G 2 and several we are having the generator n number. So, we are having one control units for each generator even though at one power plant, there maybe 2 or 3 units. Here, let us suppose we are having different unit, so they will have a different individual, and then we had a compiled one for these two. Then, they are getting information somewhere from outsource outside basically. So, that is why here I said, so we are having the power plant completely, means at one unit, we are having several unit, then we are having the various power plants control room.

They are controlling the power, how much output will be there and basically that is decided by somewhere else. Basically, these power plant units, for example we have the various power plants in our country. Even this time talking are the up, we have soon, that is A, we are having this, we are having this, we are having this, we are having this. So, these are the thermal power station, so each thermal power station will have one control unit although you can see in opra, we have several unit. So, all the units are having a individually control centers, then it is a coordinated and that basically gets information from your system control centre, and this system control centers is nothing but it is a level or stack level.

So, here we are having the system control centre are the each state level, for example we are having Lucknow. So, this Lucknow centre gives signal gives commands or even though ask these power plants to go for particular level of generation, they are asking that how much earthy power that is they are going to supply. So, it is getting commands from the state level these power individual power plant units control room, they are giving commands. So, the various individual units here, and then finally whole system is operating, so basically the commands are flowing from this side to this side, however this generation is going from this side to this side, here you can say.

So, the power plants they get commands from stack level and that is here we are having Lucknow that is a state dispatch centre, it is called SLDC, state load dispatch centre. Basically, we are having several states are connected that is we are having this NREB, that is called northern regional electricity board. It means we are having several states like we are having UP, we are having Delhi, we are having Rajasthan, we are having Haryana, we are having Jammu and Kashmir, we are having Punjab, we are having Uttaranchal, these are interconnected. They form one, we are called regional electricity board.

So, these are interconnected, so the system frequency basically schema changing based on that system operation looking at the demand this NREB. Here, in our country that is for northern region, similarly we have other region we have the five that is the northern region, western region, we have southern region, we have eastern region and we have northeast region with boards. So, various states are coming in that one, and then finally we are having a national ST that is a interconnected because some of the regional ST boards are interconnected with other one not all, but some of them.

So, we are another hierarchy here, that is called national grid, so, this is state load dispatch centre, get command from this NRIB and this is called your NRLDC northern regional load dispatch centre. Similarly, we have the westerns, we have others, so they are getting the commands from here that you have to generate this much power, and this from that it is power is generated. Similarly, this state load is dispatch centre is also monitoring the load distribution in that state in that region. So, they also operate some of the transmission line, although even though some of the transmission lines, they are in the hand of your power grid, which are your central units.

So, here they are giving command directly to this, these NR, this is the standard you can say diagram, but we have slightly different in the structure in India, here this pool load dispatch. Basically, this NRLDC giving also command not only this system control centers that is a SLDC. It is also giving command to the various other generating power plants here, like your NDPC plants and other NSPC plants. Then, they are managing accordingly because here in this they are getting the shear. So, this NDPC plants are also getting command signal R, basically this instruction that how much they have to produce to maintain the system stability and the reliability.

So, the power grid the transmission plants, here is some of the transmission plants are managed by the state itself. Some of the systems are managed by your power grid and this they are getting the command, and they are getting information about the transmission power control. It means each 422 kVI stations even though 132, they are having one control centre, the purpose of this control to the switch in and switch out to see the various. Those are available in that to operate in the free and in the very reliable manner. So, the transmission plants are also having one, it is basically called substation, means they are having various axillaries.

They are having various lines are coming in and going out, and based on that they are just receiving some command and they are operating. Another here that is we are having the various area load dispatch center that is ALDC here. In UP, we are having the 3, 4 area load dispatch centre because when the system demands more and your generation is less. Then, we have to ask the area load dispatch centre to reduce the loads by one of them or some of the transmission lines. So, they are operating getting this command through this and finally they are just asking the distribution different centre.

Again, they are there, they are just you have to schedule your power accordingly. So, we are having other smaller and smaller distribution centre. These are like 33 kV substation or you can say eleventh and we are just giving power supply to the system. So, this is basically the control hierarchy of your power system, now I standard, what happens? Normally, here your state load dispatch if you are having enough generation, so you have to go for the several function functions include that you have to go for the optimal power flow, you have to set your generating unit in a such a way that you can decrease cost. You have can meet the power in the minimum cost in reliable better quality and without interruption.

So, these are the basic features of the control units based on that they do several other works also. For example, in the generic unit there is a various type of just like a scalar system means we go for the various remove thermal units. They are collecting the information and that information basically goes to the NR system control centre, and there they normally run the load flow optimal power flow, they go for other majors and they are going for control unit. You can see here what is the basic function at one here, the system control centre level or at this level, I will tell you here and then we can see this function.

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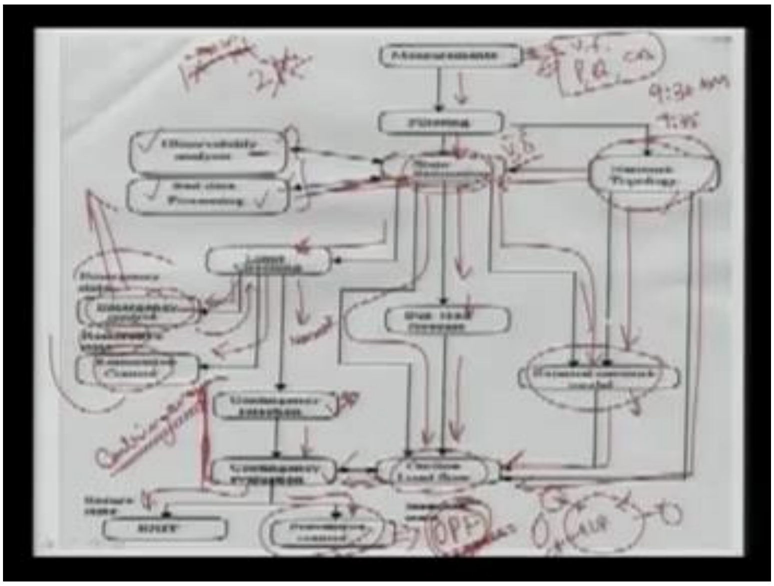

In this one, this is your basic function that is the major, which are coming from the various remove thermal units. The measurements of various things like it is voltage frequency power flows all P and Q and others like you circuit breaker status. They are coming from the various fields from the network from the generic, means several of the system it is measure every time. Then, we go for the filtering their there is some sort of you can see optimization algorithm some sort of programs are there software are there. Here, we are talking about your SLDC, means your state load dispatch centre, we require this one.

In it, I am not talking here in India we are having, but this is a extended practice in the load dispatch centre. We will have all these software to check and to operate the system in the reliable manner.

In the RTU’s sometimes, it is some parties are not always sending the data some parties are collecting the information if there is some fault, but some of the information the continuously are send to the main load dispatch centre. So, some actions can be taken some of the data are stored whenever there is a emergency done that signal normally goes to the control centre. So, there is various types of data that is collected at that various removed thermal units in the distribution side. Also, at the generic we are having these summation, so some information are coming to the load dispatch centre that is here in during the STD state, every few minutes it is coming to that there.

Some of the data's are of course, you can by looking that you can filter it out, means by some logical way for example, you can say it is saying your voltage of any bus operating system, it is saying it is a 2 per unit in STD state. It is not possible because if your system is operating the voltage is must per unit nearby that. If it is two your operators will not operate, it will be trip; it will be bound even if it is not. So, it is not possible, then we can if that I see here, we can filter it out without going for any justification. Similarly, suppose the power flow here in this line is coming some power flow, 10 megawatt, both side 100 megawatt and it is saying this circle is open condition.

So, either this information is wrong or this information is wrong that can be verified and then we can some of the data's can be even though filter out. So, this is the filtering process that basically the filtering, then you can have the network information and that network information basically forms your network topology. It means what is the interconnection right now, what is the configuration of your lines? That is called your network topology, that network topology is basically required, now in the state estimation along with the actual filter data that is coming.

So, we run a state estimation here state estimation, basically we try to determine voltage and angle at all the buses. No doubt you can say why we are measuring here voltage and again we are estimating voltage, what is the difference between these two? Basically, the data which we are getting from these sides various units that is transported over the communication media. So, we are just sending the data there will be some errors in the BTS, there will be some noise. So, those are which you are getting there will be some errors and that error basically we try to minimize based on the various measurements.

So, from here for one thing we are going for several measurements and thereby we are minimizing the error and then we are getting the best estimate out of all these information. So, we get the bus voltage and delta at each in the power system network, now you have again whether you can perform the state estimation or not, there is a various things. We normally go for this to have the very good state estimator we normally go for the conservative analysis, and also we go for the bad data processing means we have to see the bad data which are the bad data, this become this card, those data. Our estimate will be very close if you are including those erroneous highly erroneous data, then your estimate will be again away from that actual value.

So, bad data process and also we have to done after reduction of deletion of these data whether it is possible to go for a state estimation or not. So, we go for the conservative analysis, so these are another software here that the performing these tasks. So, those information's are basically coming here and there and finally we do is state estimation. Once we have done the state estimation, this will give your information have about your external network here. Also, based on the topology and this information, we can form the external network, what is the external network?

Let us suppose I am talking about the UP, here UP power system we are having several interconnections to other numbering state, like we have one Kanpur line that is going to Rajasthan, we are having to here Delhi side. We are also having several lines in other states in write in Uttaranchal etcetera, so for other system it is not possible to model. So, it is we can take the some because if you are going for all the systems interconnected your system will be very wide and analysis will require the huge time. So, for some external equivalent model for this various techniques are available and one software is required for this module.

Then, we can add the external network model that will be used and that will be given here, some loads flow techniques along with the topology, which we are getting here. Now, come to this side the state estimation, once we have estimated your voltage and angle, now you can calculate again axial real and power force in the lines. We can calculate, we can see the voltages, we can see the reactive power generation of the generators we can see the taping system, means all the operating concerns. Now, we can calculate, and we can see by the looking at the voltage and angle.

Then, once you are having, then you can a start processing limit checking means once you have calculated the power flow, for example line flow you can check whether this power flow is less than your rating or not. If it is not less than that, then your system maybe emergency state or it may be in your rest state, then you have to take some emergency control action to bring that system here. It means simply just you have to take the action, after this you have to take this action and then you should not go for other processing here and you have to take because you are in emergency condition, no need to go for air conditions and other evaluation.

Similarly, if you are in this state, then we have to go for this control, now, the question what is your recuperative and emergency control, which also I explained in our previous lecture, if you remember this formula.

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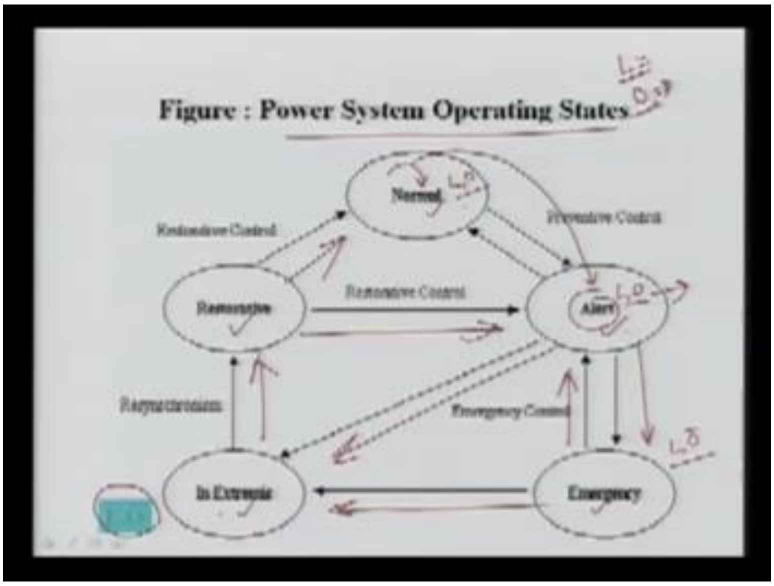

Here, the figure for the power system operating state as I state in the 1967 of the first three state model that is your normal state emergency state and your respective state. After that, it was relied that is not sufficient, and then people went for the five state model. Here, the normal state alerts state emergency state and preservative state and the extirpative state. Here, because these states are defined based on the equality constraints, and your inequality constraints sometimes also called load constraints, here load constraints are nothing but your power balanced equation.

Your operating constraints are nothing but here the limits. Then, your operating limit, your system constraints that is inequality constraints like inequality and your generation limit inequality and reactive power limit inequality and your power flow and several inequality and voltage etcetera. Here, the load constraints are power balanced equation, so, here in your extreme condition, it is both equality and non operating concerns are not satisfied. In the alert, basically normal state your L and O must satisfy, it means your all the operating limits are satisfied, you are satisfying the load constraints, you are here. If there is some condition here, in the normal state, there may be possibility you are here in self in the normalize state or you have landed in the alert state.

Alert state here normal states your L, but in elated here your LNO is also satisfying, but if there is a further consistency, then you are either in emergency state or you are going in the extremis condition. It means your constraints here are you going to be these operating constraints are not satisfied. So, you are in emergency, and you have to go for the emergency control, you have to bring back system your LRT state. You can go in this one, you can go for the load setting here, means you can go load setting and then finally, going for the preservative and you can go for here or in this normal state.

So, these are the various states of the power system which I was explained, so those are used here you can see we have to take the various control x 1 to control that and then we can go for other majors. There is a possibility your system is secured enough means your system is neither in emergency control or emergency state or in preservative state means it is in your normal state. If it is in normal state, present system present operating which we have measured, then you can go for the contingency analysis part, it is called contingency analysis.

I am in this module, I am going to explain this contingency analysis, which is the part of your energy management system, that is, your part is a function at your load dispatch centre. So, I will explain here in detail in this module, to again, now we can finish this here after the estimation. Now, we have to go for the load focus why the question load focus, for example if you have measure the data at 9:30 AM, you did all this calculation, it will require some time filtering state estimation. Now, you have just this, let us go to the 35 here. Now, your load will be changed, so based on that, we can go for the current data plus what is our condition then we can go for the load focus because we are just processing whole this, it meet it 20 to 30 minutes.

So, in that duration, the load will be change, so we can go for the load focus and from the state estimation we can go other information like the circuit status etcetera and then that will be used as the input to your online load flow. So, in this conditional analysis, I will explain here there are various function 1 is called your contingency selection, contingency evaluation. Basically, we do go for the contingency selection, once we rank them, I will come to that point. Then, we go for the evaluation one by one and for that we use the online load flow, and then this method must be very fast because you are doing online.

So, what we do here? We go for the contingency selection because in the power that is a numerous conditions maybe thousands, it is not possible to run the load flow for all the condition ties, because they may not be of interest they may not be critical. So, we have to go for those conditions, those are critical, so we can run any approximate load flow techniques and then we can rank on the critical. We can go online and we can check whether really they are violating the limits or not, then we can go for some actions here. If again your system is after that contingency analysis, it is secure.

Then, again you repeat this process, but if it is not in secure, then you have to take the preventive action because the contingency, which has we are assuming here that has not taken place your system is non normal condition. Then, it is one contingency that is a critical may happen, then our system may go in the LRTR emergency state. So, you have to make the preventive control and then you have to go for there, now here if you are doing some control, now the question arises, why not we can go for that? Since you are changing some settings, setting off may be the transition line setting may be the output are generator taping etcetera at the same time, why not we can achieve some optimal power flow, we can achieve some objective.

So, we can operate our power system in the efficient manner itself, so here normally once you are changing, then it is required, otherwise it is a query state, no need to change the setting because your system is operating very clearly. Since we are changing, then we are going to change in a such a fashion that we can achieve our desired objective maybe it is your economic despairs maybe your optimum react power despairs maybe minimum control action despairs minimum emission despairs or some other optimum power despairs, which already I have discussed in the previous module.

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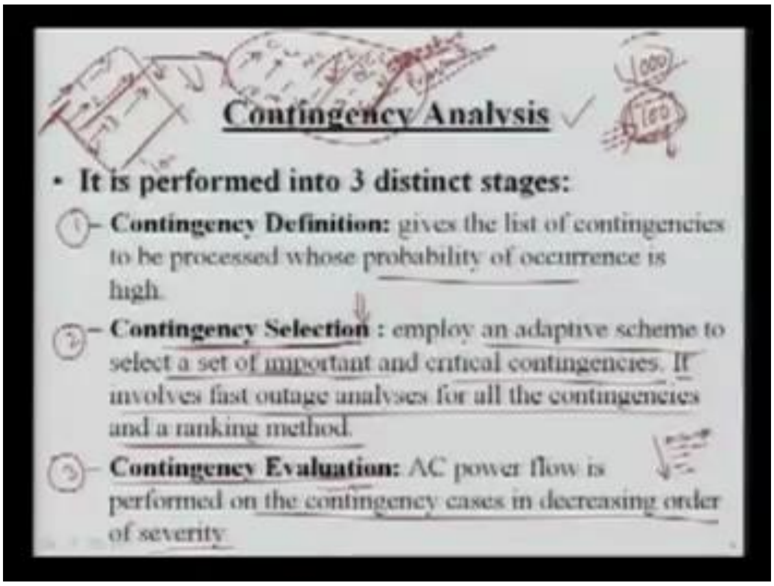

So, let us again go back to this one, sorry the various contingency selection algorithm here I will discuss the contingency analysis point. So, now let us see what is the contingency analysis? Basically, the contingency analysis is confirmed into three distinct stages, those are first one is your contingency definition, second one is your contingency selection and your third is your contingency evaluation. In the contingency definition, it gives the list of contingencies to be processed whose probability of occurrence is high. Now, you can assume a power system like in NRB system, we are having more than 400 puzzles.

I am talking about 132 enable you are going below that, so it may be in 1000 percent we are having more than thousand lines. So, the total number of contingency in this power system maybe thousands, so it is not possible to analyze as I said, so what we do? We go for those contingencies, those probabilities is high and also those are very critical, so what we can do? We can short list out of this, let us go, we are having 1,000 contingency here, in this 1,000, we can just sort out this 100 contingencies. Those probabilities are high and they may be credible contingency, those contingency maybe critical one because outage of some tramline may not humbled operation. It is A, that will not go your system somewhere else the operators know it very well.

So, in this contingency definition, we go for the only the limited contingency in the power system, for which we have to analyze the power system for the security NOC power process, so this is called your contingency definition. Now, in the contingency selection, now you have out of this various thousands, you are having 100 contingencies. Now, you have to go for now contingency selection process, in this contingency selection what we do? These 100 contingencies, we cannot run the load flow for these hundred contingency in the real time because that will require a huge time, so what we normally do? We go for ranking of these conditions; we have to list out the various contingencies name.

Now, we are just ranking these contingencies based on some techniques. It maybe even the using of load flow some approximate load flows technique may be sensitivity factors upload, maybe your distribution factors upload, maybe your some adoptive scheme, some different scheme without load flow. That we can rank them here based on the severity, means the severe contingency will be at the top followed by the next severe followed by next severe and so on so forth. So, the contingency selection employs an adoptive scheme to select a set of important and the critical contingencies.

It involves fast outage analysis for all the contingencies and the ranking method, means we have with it required for ranking method, means we have to rank according to severity, and also we have to go for all these hundred contingency very fast . So, here we required the ranking with the fast, now if you are going for fast. So, the actual AC DC load flow will be not useful, you have to go for some approximate or you can go for some other technique like AI application. That is why people apply here artificial intelligence base technique to very quickly identify the critical, and we can rank this.

Now, once we have rank based on the severity order, means first one is the highest severe, then followed by next severe, then we go for the contingency evaluation and that is your third part, in this third part, what we do? Once we have rank here, the contingency one I can say now write here 1, 2, 3 and we are gone up to 100, we have ranked contingency according the severe. It means this contingency is most severe after then this is severe and then this is severe and so on, we are going down.

In this contingency evaluation process, the AC power flow is performed on the contingency cases in decreasing order of severity as I said here the decreasing order of you. So, we run the load flow here, and then we check whether there is any violation of the system, if it is not, then we can if it is violated. Then, we can go for this one, we can go for this one, and we can go up to that part when there is no violation occurs. Then, we can say that after that those contingency are not going to violate, we are not critical contingencies only these are the critical contingency. If they are going to happen, they are going to occurs in the feature that our system will be not in the normal state, it will be going somewhere else.

So, if these are then 1, we are rank, then we have to take some control action. There is a possibility your rank contingency is your there is a no violation, everything is secure. Your system is still secure outage of these contingency, then you are very happy and then you can go for the next iteration of whole the process. If some of the contingencies are critical, then you have to set your operation in such a fashion that is still I am that is called the preventive equal to this. There is a two type of control that is called your corrective control, you know it very well, corrective and another is preventive.

The difference in the preventive and the corrective is in the preventive desk, you are operating your system in the preventive way that you should not land up in the emergency condition. In another corrective condition, you are in the emergency state, you have to control so that you can have corrective. For example, suppose you are just moving and just you are taking very pic, assume that we will not follow, we are putting your step very continuously and with very monitoring way, so it is called preventive way of moving. Now, suppose you are moving and there is some something happening, and just you are limping here and there.

Suddenly, you are just controlling yourself, then it is called corrective, means at that time we are very alert. So, the preventive control actions are very expensive than your corrective control action. So, we have to see which control action sometimes people say why only preventive it is better to go for the corrective and the preventive both. Normally, in the power system corrective required are very fast, suppose one line is going to trip, what we are going to do? Suppose, you want to reduce the generation, you want to set the load that may require sometime.

So, it is better to go for the preventive, then along with the some conditions corrective actions that can be taken so that you can achieve this. Now, in this ranking, what happens? It is set, suppose one we found that one is critical contingency, then you have to go for the load flow of 2. It is found, it is critical, see third it is found it is non critical contingency; there is no problem in the system operation if this contingency will occur. Now, we should not stop here, in the contingency evaluation, we have to move ahead, we have to again go ahead and what we do? We have to even go for 4, we have to see whether it is a non critical or critical contingency.

If it is non critical, then you can a stop there is a possibility due to your ranking process because you are using some approximate technique, you are not very accurate. So, there may be some exchange of here, so it maybe your critical as well then you can go for it again. So, NC not critical suppose you are getting 6, also not critical, then you can stop and then so you can say only few critical contingencies, now out of 100, we are not more than 10 contingency we are considering. So, this contingency evaluation gives this, the critical contingency identification accurately because this ranking is not accurate, here sometimes we may not get by state.

So, you cannot control other variable, only it is a simple ranking, sometimes we can get some information about the voltage an angle rough estimate at that kind also matches here, but here this exact evaluation is required. So, in this contingency definition, we do not require any software, it is basically the set of the critical contingency that is based and your past information, past experience and others.

You can say basically operators experience that can be collected, and based on that we can go for some contingency definition, we can just put some contingency in that case and based on that, we can go for the contingencies license. Now, this contingencies selection, now we have to use some method some methods to rank them according to their severity that is the rough severity order.

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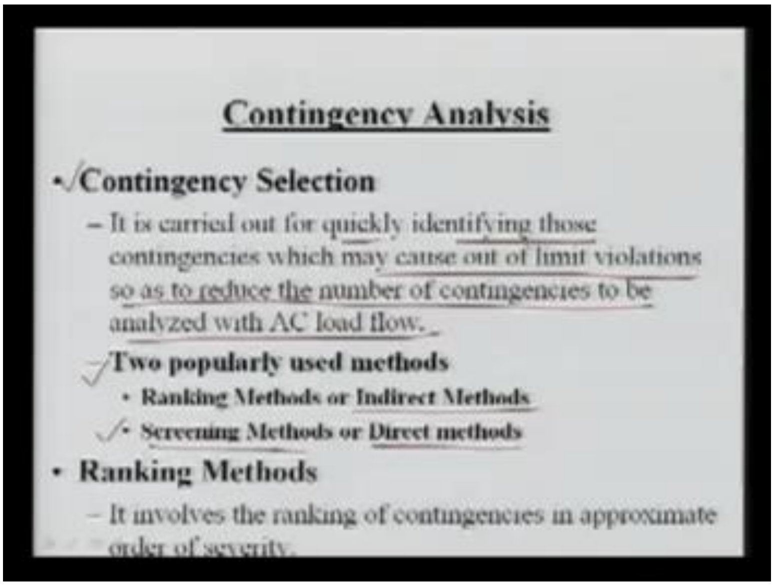

Now, again that I am go to discuss here first contingency selection process, it is carried out for quickly identifying those contingencies, which may cause out of limit violation so as to reduce the number of contingencies to be analyzed with the AC load flow. It means in the contingency selection, we try to reduce the number of contingencies that should be analyzed with the online load flow, AC load flow techniques that is a contingency evaluation process. So, it should be quick and it should be giving some order of severity ranking, now the question again suppose you are having very fast method, so then these two process, suppose you are having very fast contingency evaluation process AC power flow techniques.

There is no need to go for the ranking here 100 conditions, you can run very fast, and then this process can be even though deleted in the modern because our load flow techniques are very fast, we are having very fast computer that will solve the purpose. So, this contingency selection is required when you are the contingency system is very large and also that is your number of here, the contingency sets are very large here 100 is more. In that case, the contingency selection is very important, but this contingency was selection was useful even though for the smaller system, when we had our load flow techniques, your computers were not fast, it was taking lot of time for one load flow, then it was very useful.

Nowadays, if you are it is only to for the larger system because we are having very fast AC power flow load flow techniques, those are used and we are having very fast computers as well. So, we are just going to discuss contingency selection process first, so in this contingency selection, as I said, we have to quickly identify those contingencies, which are causing out of limit violations. So, we can reduce the contingency evaluation process popularly two types of methods are used, one is ranking methods, sometimes they are also called indirect methods and the another is your screening method, they are called direct method. It is ranking methods; basically it involves the ranking of contingency in the approximate order of severity.

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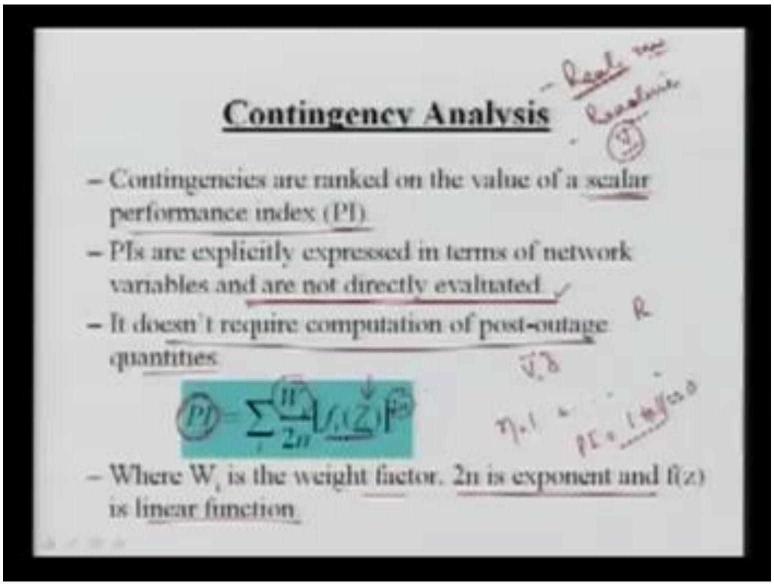

Contingencies are ranked on the value of a scalar performance index that is PI value, so the scalar performance index value PI is are explicitly expressed in terms of network variables and not directly evaluated. Here, we are not evaluating the network variables, it is it is just in terms of network variables, explicitly it is expressed. It means without calculating the variables like voltage and angle, it is some rankings are done, then it is called this one. It does not require the computation of post outage quantities, as I said post outage quantities means voltage and angles at all the busses. It forms some PI here, once at is this contingency selection are contingency analysis is the two parts.

One is your real power contingency analysis, and another is your reactive power contingency analysis. In the real power we always monitor the quantities the power flow in the line. In the reactive power, we monitor the voltage of the busses, so these two are running parallel; means are we can combine the real and the reactive together. It means first real then reactive, first real and then reactive for all the contingencies. So, these real power contingency analyses, where we talk even the megawatt ranking methods and here we are talking the voltage.

So, we will see the both separately real and the equip power contingency analysis so we can form some PI that is the power flow index. That is a scalar value, means is some constant value here and this is a scalar that is why it is retain this performance index. If you are talking about the real, then it is called real power flow performance index and if you are talking about the reactive power contingency analysis, then it is your reactive power performance index PI. Here, this function this is summation of this f I, just we have retain this is the same function f that is our variable Z. Basically, Z is a non-linear function is a linear function, no it is a non-linear function, here it maybe non-linear or linear.

We are having some waving factor here VI and omega I is a weight factor and 2 n is the exponent its power n can vary n is equal to 1 2 2 other value. So, you can say it is a squar we are adding, why it is so? For example, if you are adding some PI here, there is some violation here some error. So, then there is a possibility 1 is added with the negative one it is 0, but in the real sense it is 1 plus 1 here minus you can add it should be more, then we can say the more violation. So, here always we go for the squaring term 2, 4, 6 and so on so forth and we will see what will be the actual value we will see later on.

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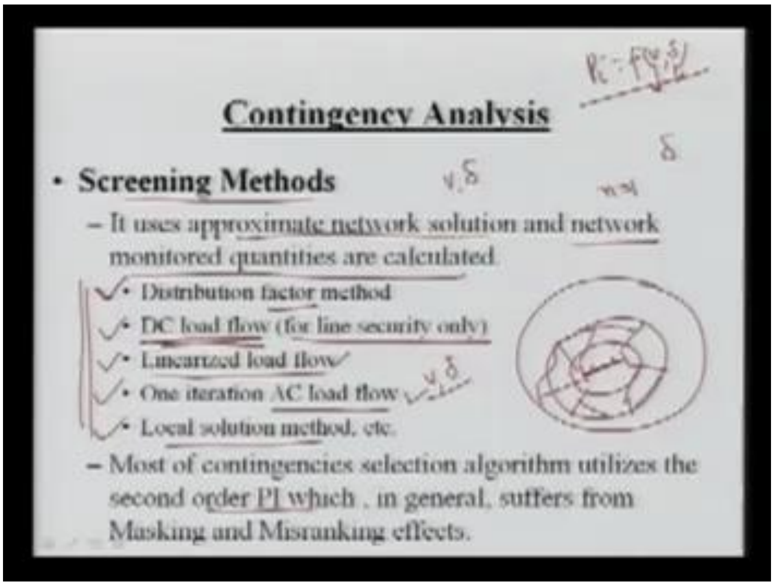

Now, let us see the screening method in the screening methods, it uses approximate network solution as I said ranking method it is not using approximate method, it is somehow some network parameter etcetera that is used. No need to go for the solution, but here we get the solution first again it is approximate solution and solution we are getting the voltage and angles. That is network monitor quantity sometimes called because the voltage and angles are network monitor quantities. So, the various methods are in that we go for your distribution factors methods DC load flow methods it is used for only lines security analysis not for reactive, linearized load flow techniques, one iteration AC load flow techniques, local solution method etcetera.

Several methods local solution methods like here localize solution one dash solution two dash solution they are used. For example, suppose in a power system, here this is your power system this is a line just of your interest it is connected, here it is connected. Here, several lines are they are connected here and this is connected MN, it is connected very intensively connected here. Now, our line intersects is this where we want to see the outage of this line this contingency, what will be impact on the voltage? What will be the impact on the power flow? In the other lines, if this line is out, what we go? We go for the tire localizes solution.

So, sometimes people say that we can go for this tire; we can go for the just other neighboring busses. Then, we can see that only these localize solution may gets some information about that and that can be used, so this is called your local solution method. In this DC load flow, which I will discuss in this module itself we will see what the DC is, it is not direct current load flow; it is not for a DC load flow solution. It is load flow of your AC power system, but it is called DC because only we get this here the delta value we will see the theta. Linearized load flow means we can have the power flow equation this P you know this PI is a function of your voltage, and angle we can linearize the assumption and then we can saw because this is non-linear.

So, we have to go for several iteration if you are linearizing, then you can very quickly you can get the V and delta CL. So, this is your linear solution one iteration you know then you can use any methods or methods or fast equable methods. One iteration solution means you are getting whatever the voltage and delta you can use that for the ranking. In actual complete AC load flow, it maybe 4, 5 iterations for the method for others. So, it will require more time, so here even the one iteration sometimes very accurate. Another is a distribution factors means we can have the outer and we can keep storage some distribution factors.

Based on that outers, we can use those factors and even the small deviation in the power flow that is a loading of the system as well. So, these are the various methods those are used for the contingency selection and that comes in that your screening methods. Most of contingency selection algorithm utilizes the second order PI second order as I said the n is equal to 2, which in general suffers from masking and mis ranking effects. now let us see what is this?

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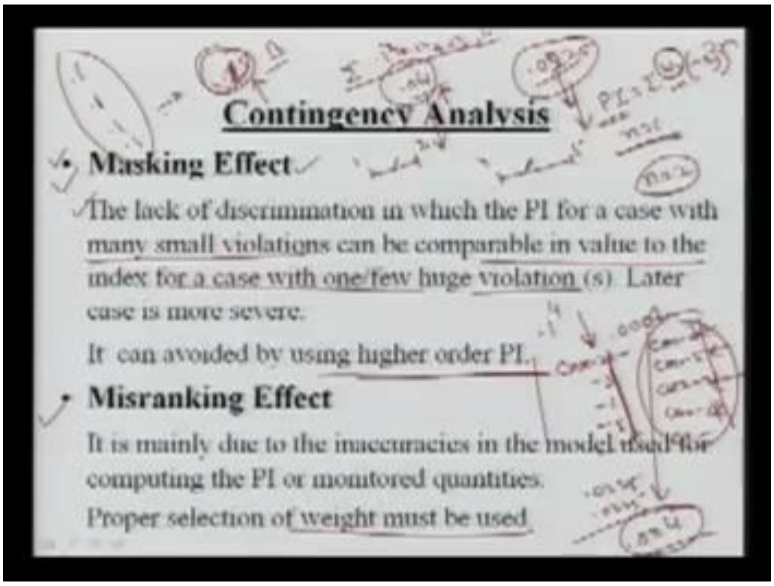

First. see the masking effect as I said if you using this PI here this summation of as I said omega I upon 2 n some function I was using z and power to n I was using this remember 2 n. Basically, here just I will right here this is your 2 n, so, this equal to one means we are just squaring it. So, most of the method they are using the 2, but they are suffering from the masking effect, what is the masking effect? Masking effect it is defined as the lack of discrimination in which the PI for a case with the many small violation can be comparable in value to the index for a case with one or few huge violations, later case is more severe.

For example, let us suppose in your power system one line here is violating 5.1, another line is violating 5.1, but another here, let us suppose is violating by your 0.2. Here, we can also say another line is 0.1 and another 0.1, now, which is more severe? It means we are having four lines, they are violating by this 0.1 per unit the power flow is more and in another case only one line is violating 5.2. So, as per here the masking effect normally this is the more severe than this its small its violation. So, it is said that the lack of discrimination, now you can see if you are using the PI we are using this value the difference.

So, I can say it is a summation, now take this value as unity what we are doing 0.1 square plus 0.1 a square plus 0.1 A square plus 0.1 A square, how much you are getting?

You are getting here 0.4 values here if you are one huge violation you are getting 0.4 although those values are very comparable. Here it is showing sometimes even though I can show you this value let us suppose 1.5. So, if I squaring this you are getting 0.225 now this so that if you are using that power 2, you are getting this value larger than this value and it shows that as per PI definition the PI more means there is a more violation. So, it is more severe than this severity, but it is not this is more severe than this case B is more severe than this case A. So, this is basically the way, so what we do for that?

We can go for order PI means we can go for n equal to 4, 5, 6 means again now I can show you if you are going for higher order let us suppose I am taking again for this example. If you are going for higher order, how much you are getting? Let us suppose you are going n equal to 2 means 4 time, so if you are going to hear is square by 0.1 power 4 means we are getting 0.001 and then it is a 4 added, then it will be 4. Now, if you are going to square here 0.0225, you are going to get somewhere “0.004 here. Now, you can say this value is larger than this value and this is severe case.

So, it is easily avoiding the masking effect, so you have to go for the larger order means n if it is in increase, then the making effect will be minimize or it is eliminated also. So, we can go for the higher order, so this is called your masking effect I hope your means the lake of discrimination in which the PI for a case with the many small. Small is small violation here kind be comparable as I said the values are very comparable here, value to the index for one or few huge violations. So, all over the huge violations are more severe than these small violations. Another one is your mis ranking it is basically due to the inaccuracy in the method used for your computing the PI or monitor quantity.

The proper selection of weight must be use here the omega I can use for the misranking, what is happening? If you are using some approximate method, there is possibility there some of the contingency that it is it is mis rank means there is a possibility the outage of line I can say bus 1 to 2. Another is outer line of 5 to 5 it is saying that this outage is severe than this outage, but practically it is not, so it is called mis rank, means ranking what I can see your ranking method in if you are doing going for the load flow actual load flow your ranking is.

Let us suppose your contingency case, case 2 is most severe, then we are having three we are having one we are having five we are having 4. So, these are the let us suppose order of severity using the load flow, but if you are using the method here there is a approximate method your contingency saying is a case three is very severe. Then, it is saying case five is severe, then it is set case 2 is severe, then it is saying case 3 is case 1 is 4 is severe and so on so forth, so what does it mean? It is saying let us go case 1, so this is the mis ranking, actual ranking should be this one. Once we are running the load flow, this is giving the critical contingency ranking, this is a correct one.

Using approximate method, what we obtain? We obtain this one, so there is a mis ranking, you can say all these mis ranking, it was second is the highest here, it is third number, so it is called mis ranking. So, the mis ranking basically can be avoided by using the optimal way, this omega why we use? It gives another information and that information is basically here this omega one.

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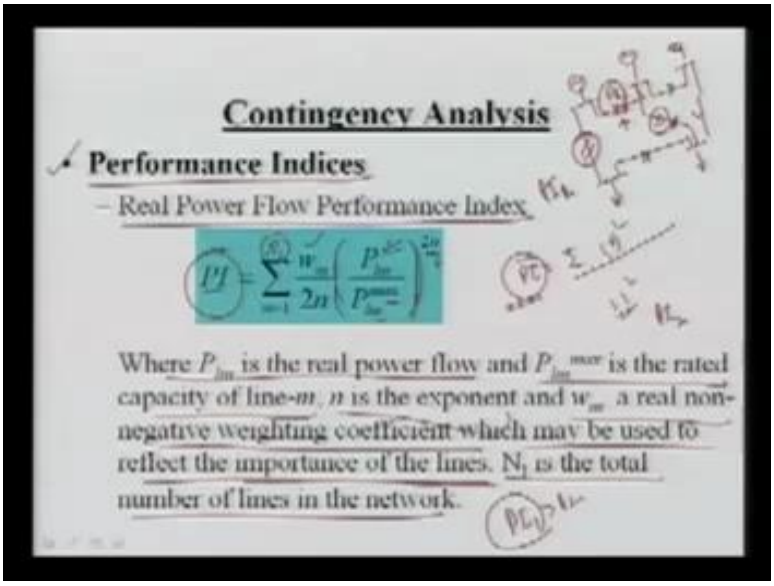

So, you can say this omega m or real non negative weighting coefficient, which may be used to reflect the importance of the lines. Here, in the contingency analysis, just I have set the performance index based method; I am using the real power flow performance index that is the security real power security of the system, here the PI which is define, I will come to that point omega m again is summation of all the lines with some this omega m divided by 2 n.

Here, the exponent that is multiplied by here this P LM, means the power which is flowing P l, this power flow in ms line divided by the maximum rating of that line, the power which can be the P l or that miss line. This is divided by this summation rating, and then we are using the 2 n that is a exponent. Now, this omega one, what I am just willing to say? Let us suppose there is a possibility that one system here, we are having a system, let us just try here, we are having another system here. This is another line, we are having here load and then we are having here load. So, you are having generator here, you are having generator here, and we are having load here.

We are having another line here, now there is a possibility, the outage of this line is very critical for the operator planning, means it is not severe, but the management of this criticality it is very difficult for you. So, then there is a possibility, we can put more weight corresponding to this line, means there is even though a small violation, but we want that this is very critical transmission line that may create lot of problem in the system. So, we can have this omega m for this maybe very large value, so even though there is a small value critically loaded that will reflect here. So, that is why it is said this omega m here is a real non negative weighting coefficient, which may be used to reflect the importance of the line.

So, we can have normally it is unity for all the line, there is no importance if you are putting some important, you can put more value of that line particular line, and then you can add and this PI may give you value. Here, this N l is your number of line as I have written the total number of line in the system. P l max is rated capacity of line m, and n is the exponent here, just we are using all its 2 n a 1, N is equal to 1, 2, 3, 4 so that you can square and P lm is the real power, which is flowing in actual one, this contingency has taken place, so what we do here? In this PI, let us suppose I am just going to out this contingency means this line is trip.

Now, we have to calculate what will be the approximate power flow in these lines, and then we have to form the PI that we have to some that how much power, which is flowing in this line and what is the rating of this line? It means actual power after outage of this plus the rating divided by rating of this line and then similarly, for this similarly, for this, for this and then we are adding together. So, this PI is some scalar value, and that give the relative in parts, let us see whether system is your critical or not.

For example, if your system is not violating this maximum limit or this line, these particular lines, what will happen? The ratio of this power it is a P l divided by P l max will be less than unity. If it is a less than unity, and if you are is squaring it less than unity here, it will be again less or lesser value, but if this value is a seating, then it will be more than unity. If you are squaring and putting higher term, it will be more than 1 and 1. So, if you are going in the direction is violation, this PI value will be more, so this PI gives you are having the higher value of PI, means your system is very critical, if you are getting less PI means your system is very least critical.

So, this PI gives the information about the criticality of your system, and based on that we can rank these contingency. So, this performance in this is very suitable and this gives the relative contingency of the various, suppose this outage, then we can form the PI we can say the PI of outage of contingency one. If this is outage, we can go for another PI and then we can go for the two lines. Similarly, we can go and based on that which PI will be higher that will be say this, let us suppose P 1 is more than PI 2, then we can say this contingency is critical than 2. So, we can rank them in the order of severity, and then we can run our axial load flow to check whether really it is true or not.

Here, we are using some sort of approximate calculation of the line flows, we can some distribution factor method. We can use the DC power flow, and then we can go for the performance index calculation. So, in this section, I can recap in this section we just study the various function of energy management system. We saw the various control like emergency control preventive control corrective control restrictive control, and then we also saw the how this whole hierarchy of the controls are just coordinated. We also saw this various monitoring security monitoring and control functions, in that we saw that there is a contingency analysis part, and we had this three different categories of the contingency analysis in the different parts.

One is a contingency definition, contingency selection and the contingency evaluation. So, in this contingency analysis, we saw the various problems those are occurring like masking effect and your mis ranking. So, we have to take care very carefully that we have to avoid the masking as well as your mis ranking, at the same time, this power flow performance index gives very good information. Of course, we the two way to go for the contingency selection, it may be your ranking method maybe the screening method.

In this performance index is one of the criteria that gives the critical contingency ranking and use it. So, we said that we can give this omega m as well for the relative importance of this. So, these I discuss here for the real power flow performance index this for the real power security analysis. Similarly, next lecture we will see for your rate power security analysis, and also we will see some methods for calculation.

Thank you.