Power System Engineering
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Lecture – 56
Load frequency control (Contd.)

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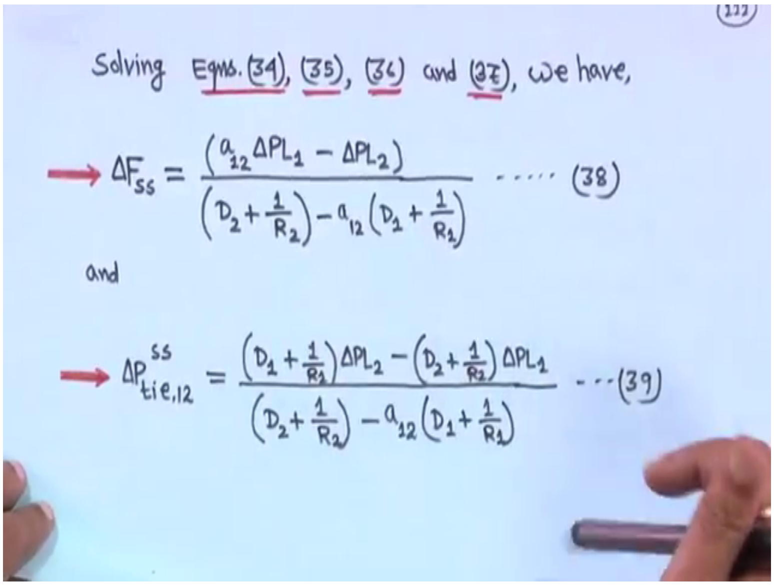

So, ok, so, we have seen that that is the expression for two area inter kinetic system this is frequency a steady state and this is the tie power flowing for 1 2 to the steady state values and we have seen one space circles when disturbance was in area-1 right and area-2 it was 0 and area capacity same for both the areas. So, we took a 1 2 is minus 1 and we choose R 1 is equal to R 2 is equal to R, right.

And, subsequently by considering delta PL 1 is equal to 0.01 delta PL 2 0, a 1 2 is equal to minus 1 and D 1 and D 2 are neglected and R 1 is equal to R 2 is equal to R taken 2.40 hertz per unit megawatt and we showed, we have seen that what will be the frequency error the steady state error of frequency and what will be the tie line power for that. So, that has been done, right.

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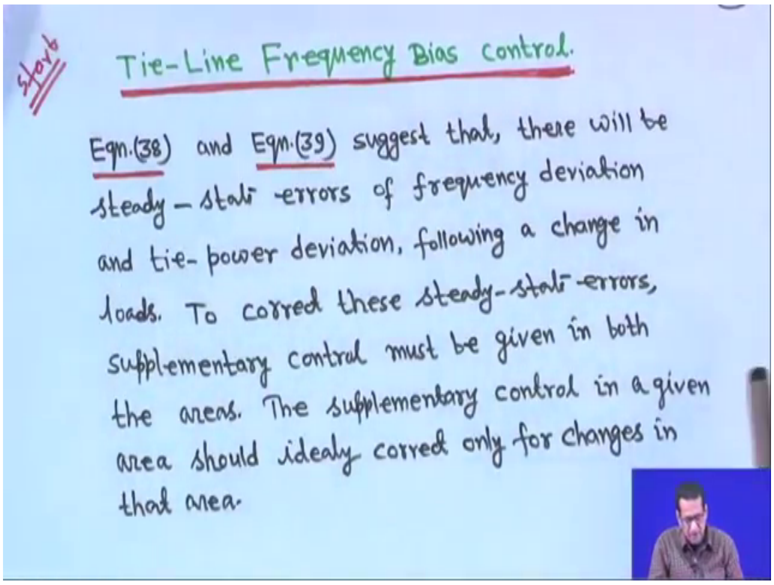

Now, another next is the tie line frequency bias control, right. So, that means, these two equations 38 and 39, it suggest that if your system will uncontrolled then there will be an error in your steady state error of frequency deviation as well as you tie power deviation following a load disturbance, right.

So, in that case in that case we have to we have to bring back this we to system frequency to a nominal value; that means, delta F SS deviation has to be 0 and tie power also steady state flow something is there. So, here also you have to bring back to it is schedule part such that delta P tie 1 2 SS will be 0, because of this reason we will go for tie line frequency bias control.

So, that means, equation-38 and 39 just the previous two equations suggest that there will be steady state error of frequency and deviation and tie power deviation; which I told you right following a change in the load. Now to correct these steady state errors supplementary control must be given in both the areas supplementary, means say integral control action the supplementary control in a given area should ideally correct only for changes in that area; that means, suppose you have a two area system.

And, in area-1 suppose load disturbance is area-1, right. So, it should accumulate it is load in it is a or what you call area-1 whatever power generation had you should accommodate it is old load the right. Of course, I told you that if it is not then it has to borrow power purchase power from the other areas, right. So, supplementary control in a given area should ideally correct only for changes in that area right that is the that is the concept.

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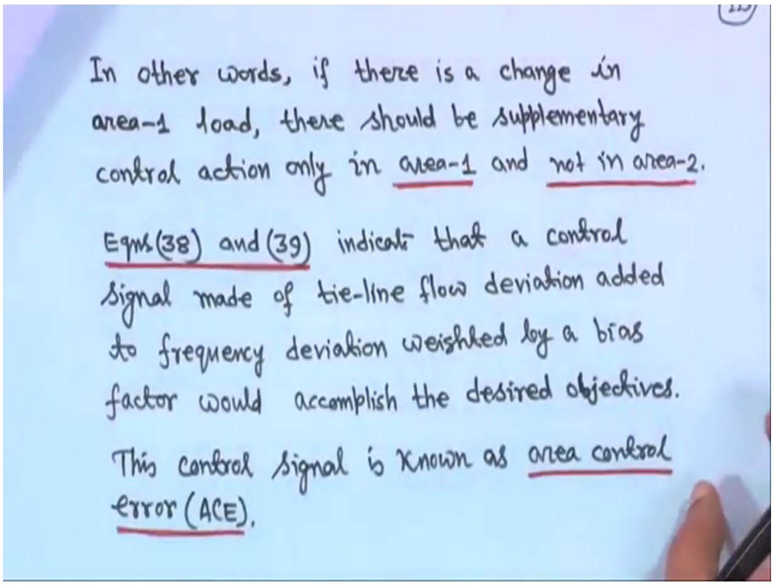

So, if it so, in other words if there is a change in area-1 load there should be supplementary control action only in area-1 not in area two; that means, whatever it is that area-1 supplementary control action actually you what you call will be only in area-1 if there is a load disturbance area-1, but not in area-2 that is the philosophy.

Now, equation-38 and 39 that that those equation for delta F SS and delta P tie 1 2 SS, right indicate that a control single mode of tie line power flow deviation added to frequency deviation weighted to a bias factor would accomplish the desired objective and this signal we call known as area control error.

Because each power system in each area you have your what you call the steady state error in frequency and (Refer Time: 03:42) tie power, right deviation and frequency deviation. So, if there is no controller there will be a steady state error right. So, for this control signal actually you call as area control error or ACE in short form, right.

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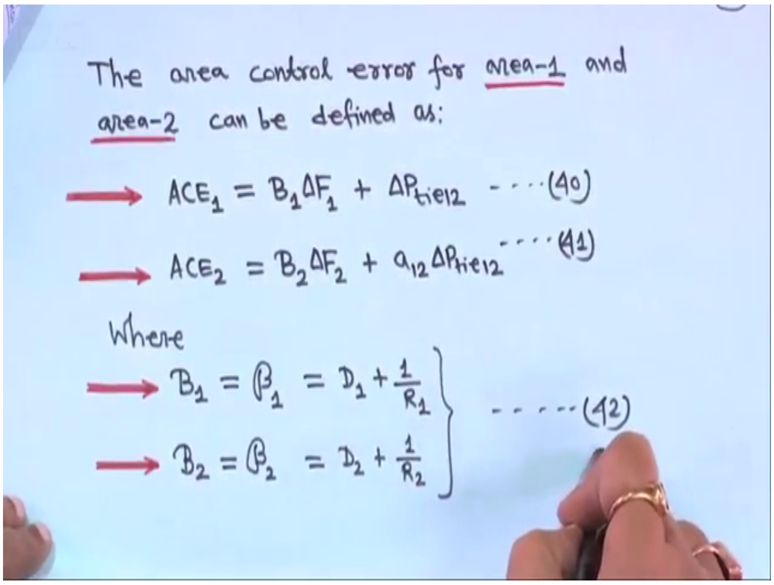

Now, what is ACE? The control area error for area-1 actually here area-2 can be defined as ACE 1 will be B 1 delta F 1 plus your delta P tie 1 2 you have seen know steady state error in general for frequency that is your delta F SS. Say for isolated system right it is basically minus your delta P l upon your you D d D plus 1 upon R, right that we have seen and D plus 1 upon R we are calling say B 1 or beta 1 frequency response characteristic, right.

So, that means, this frequency with frequency this bias factor this B 1 and B 2 are in general B parameter it is called frequency bias constant, right. It is a bias factor. So, ACE 1 is equal to B 1 delta F 1 plus delta P tie 1 2 this is equation 40 and ACE 2 is equal to B 2 delta F 2 plus a 1 2 delta P tie 1 2.

Because, it is B 2 delta F 2 plus delta P tie 2 1 and delta P tie 2 1 is equal to a 1 2 into delta P tie 1 2 which we have seen before, right. Now, where B 1 is equal to beta 1 we call beta 1 beta 2 we call frequency response characteristic, that is B 1 is equal to beta 1 is equal to D 1 plus 1 upon R 1 for area-1 and B 2 is equal to beta 2 is equal to D 2 plus 1 upon R 2, this is for area-2. So, this is equation-42, right. So, this is actually B 1 and B 2 value. Now, let us see.

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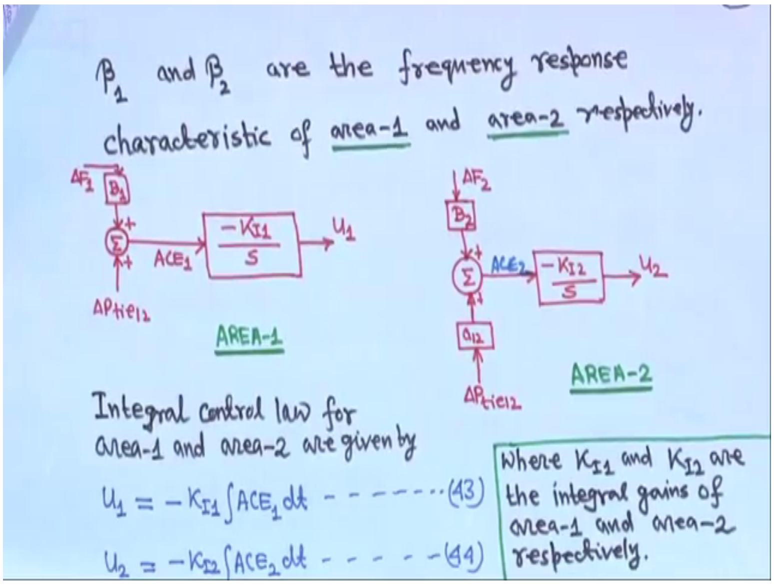

Now, B 1 beta 1 and beta 2 are the frequency response characteristic of area-1 area-2 respectively this we have seen in general that steady state error I told you it is minus delta P l upon your D plus 1 upon R. So, beta is equal to D plus 1 upon R is called area response where your what you call frequency response characteristic right. So, that is why and this is for area-1 and area-2 that is why beta 1 and beta 2 you have taken, right.

So, now this control signal ACE 1 will be basically then delta F 1 will come into B 1 and this is delta P tie 1 2 and output is ACE 1; this ACE 1 will go as an input to the integral controller for two area for two area system just hold on for two area system, right that we have seen the your what you call the block diagram and in this case your just a just let me see the this block diagram this block diagram.

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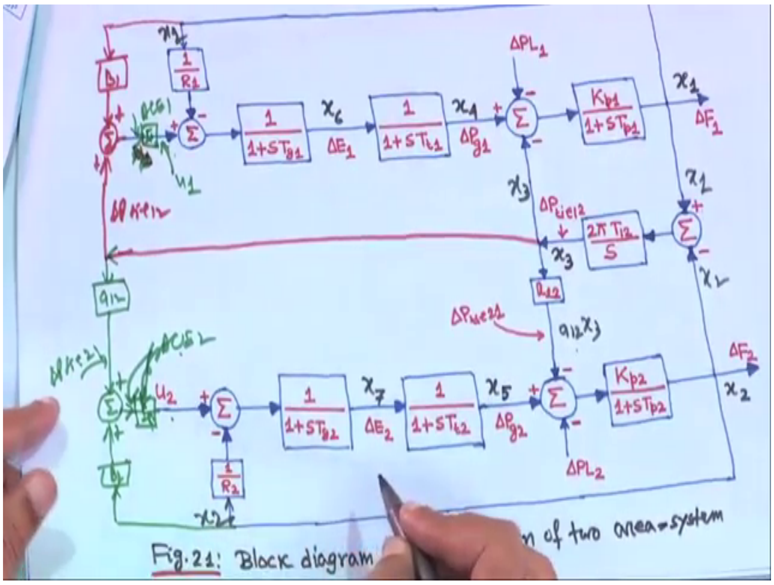

This is u 1 and this is u 2, right and this u 1 actually this u 1 and this u 2; that means, from here I mean if you draw this here from here that this is the delta F delta F 1 this is delta F 1 from here this delta F 1 then make a B 1 and summing you summing it up and this side you take the delta P tie 1 2 1 and this is actually your what you call that your delta P tie 1 2 and this is I am making it for you, right.

For example just see that here for area-1, right, hope it will be accommodated area-1, I am making it for you right this is your for area-1 this is your B 1 right and here you put that summation symbol this is plus, right and this is your u 1 and this side from here it will come that your tie power because this is your tie power. So, and here it is your the this thing what you call plus and this is your delta P tie 1 2. So, this is actually delta P tie 1 2, right and that means, this one actually this ACE 1 this output is this for look this output is ACE 1. So, this is your ACE 1, right.

Similarly, that delta P tie 1 2 making by green ink this is your a 1 2, right because this is delta P tie 2 1. So, it is a 1 2 into delta P tie 1 2 actually, right. So, here you that your this is actually delta P tie 2 1 delta P tie 2 1 is equal to a 1 2 into delta P tie 1 2 and frequency will come from. Here this is your this is your B 2 this is your B 2 and here it is your B 2 into delta F 2 and this is your. So, plus and this part these part actually your ACE 2 output is ACE 2 right and integral control integral control action is there. So, here we are putting your what you call this is integral action is your here integral action I am just making in short because of this is integral control action and this where we are putting say this is u 1 right.

And, similarly here also integral action is there here also integral action is there that is basically minus K upon is integral action is there and this output is u 2, right. So, this portion actually this is u 1 here I have cut it for you, right this is u 1 out this is integral control actually this part this part actually minus K I 1 upon S here it is minus K I K I 1 upon S and this is actually minus K I 2 upon S. So, this is actually minus K I 2 upon S, here it is shown, right.

So, this is integral control, this is integral control there is a controller block this is actually controller block, right because of space I because of this space and this space limitation I could not put here minus K I upon S minus K I 1 upon S and this input to this controller is ACE input to this controller is this your what you call here it is ACE 2, right.

So, this is actually your ACE 2. So, that is why the your what you call this input to this your ACE 2 and input to this controller is ACE 1. So, that is why here we have made it that this thing your this one that ACE 1 going to the integral controller to u 1 and this is ACE 2 going to and this is your delta P tie 1 2 in what I have shown in that block diagram, right. So, that means, integral control is this.

Now, this is integral control law for area and area-2 is given by. So, u 1 is equal to minus K I 1 this is an integrator. So, it will basically minus K I 1 integral of ACE 1 dt this is equation say 43 and u 2 will be minus K I 2 integral of ACE 2 dt this is equation-44 whereas, K I 1 and K I 2 are the integral gain settings for area-1 and area-2 respectively. Now, question is that so that what value of K I 1 K I 2 will choose and those things, but this K I 1, K I 2 all can be optimised right, but those are beyond the scope because in the class we cannot do that because we need simulation.

So, no need actually just for the your u 1, but u 1 is equal to minus K I 1 integral of ACE 1 dt and u 2 will be minus K I 2 integral of ACE 2 dt and K I 1 K I 2 your what you call the integral gain setting and for the system we have chosen. So, actually if we take integral square error technique or so. This K I 1 or K I 2 if I because it is equal area system if we assume these are equal area system this is equal area system that mean both the areas you have the same rated capacity equal area with a 1 2 is equal to minus 1 if it is so right.

Then your if you then gain setting of. So, K I 1 is equal to K I 2 is equal to K I if it is equal area; that means, both equal area means both the areas have identical generating units both the areas have identical generating units, right and your what you and same capacity this area and this area this is thousand megawatt this is also thousand megawatt say and both having the same identical units identical rating.

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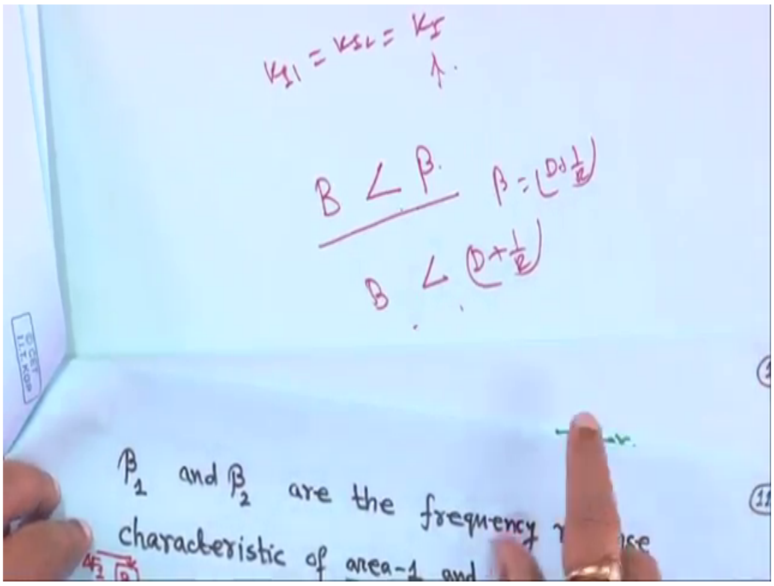

Then only we can make K I 1 is equal to K I 2 is equal to K I same integral gain setting right same integral gain setting. But, if, but if this is a for example, say if this is the non (Refer Time: 11:46) type turbine and here it is (Refer Time: 11:48) turbine, then K I 1 and K I 2 will be difficult even if the rating of both the areas are same because units are different and even for that means, if whatever whenever you are considering K I 1 is equal to K I 2 is equal to k i; that means, this 1 actually your what you call equal your equal area system and identical units identical units in the both the both the areas right.

So, that means, your this for this two areas system actually if you take K I 1 is equal to K I 2 is equal to K I for this system with a standard parameters, right; parameters I will give you later standard parameters right if you see that you will find K I 1 is equal to K I 2 is equal to K I if they are equal area, right it will give you more or less good result for value of K I is equal to 0.7 say roughly 0.7, right.

So, this is actually how one can take that integral control action right, but here also 1 can try with proportional integral or PID, but for thermal units actually PID control is not recommended, right. So, proportional integral is possible and second thing is I told you this area control error, right. Actually it is not feed to the controller continuously it has a sampling your what you call you have to your sample that every sampling instant.

For example for example, t is equal to 2 second, right and this is not shown here not shown here and accordingly you have to evaluate u because any system is a any system you take ideality that it is a basically continuous system only controller part will be in your what you call in this (Refer Time: 13:24) I mean, this system this whole system this thermal system whatever it is it is in continuous system right, but controller you will find in this (Refer Time: 13:33), but the analysis simulation those things are slightly different, but beyond the scope of this course, right.

So, all this things that area-1 and area-2 I showed.

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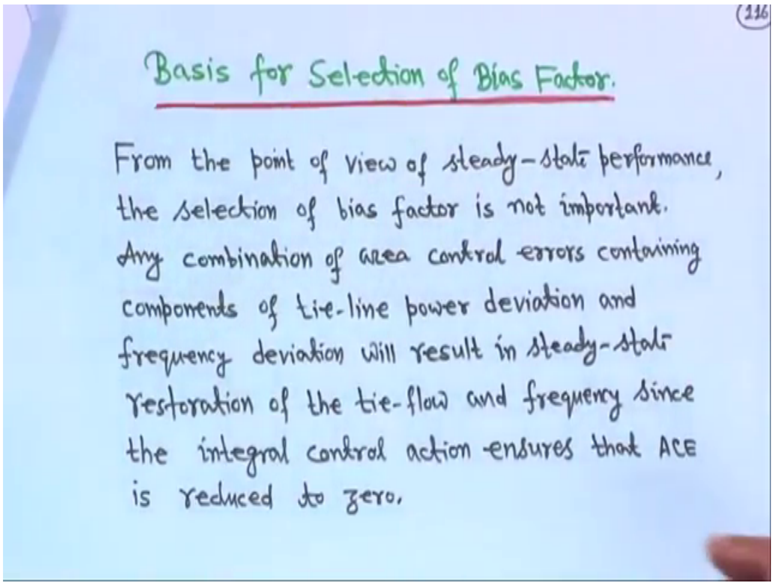

Now, next is the basis of for selection of bias factor that means, B 1 this B 1 and B 2 there should be some criteria for selecting, right. One thing I can before proceeding further I can tell you that B 1 B 2 or you are in general B value with cannot be your cannot be less than beta; that means, this B value B value that frequency bias it cannot be less than beta, it cannot be, right.

This question I am putting it to you and if you can suggest the technical reason why it is then I will appreciate that, I will show you B greater than beta B is equal to beta, but B less than beta is never possible I mean it is it is not recommended it is not at all recommended; that means, at beta is equal to your D in general D plus 1 upon R, right. So, B value it cannot be less than D plus 1 upon R it cannot be less than that, right.

So, this is a question to you and if you can answer this I will appreciate that it is not recommended. So, now, next is that basis for selection of bias factor. So, from the point of view of steady state performance the selection of bias factor is not important, right stay after a steady state or concern is steady state performance is concerned. So, bias factor is not that important, right.

But, for any combination area control errors containing components of tie line power deviation and frequency deviation will result in steady state, your restoration to the tie line flow and frequency since the integral control action ensures that ACE is reduced to 0, right this will happen ACE will be reduced to 0, that is true right for any control any integral control action is there, but you have to select some reason should be there that what will be the frequency bias (Refer Time: 15:31). Generally, if B is equal to beta is recommended value, right.

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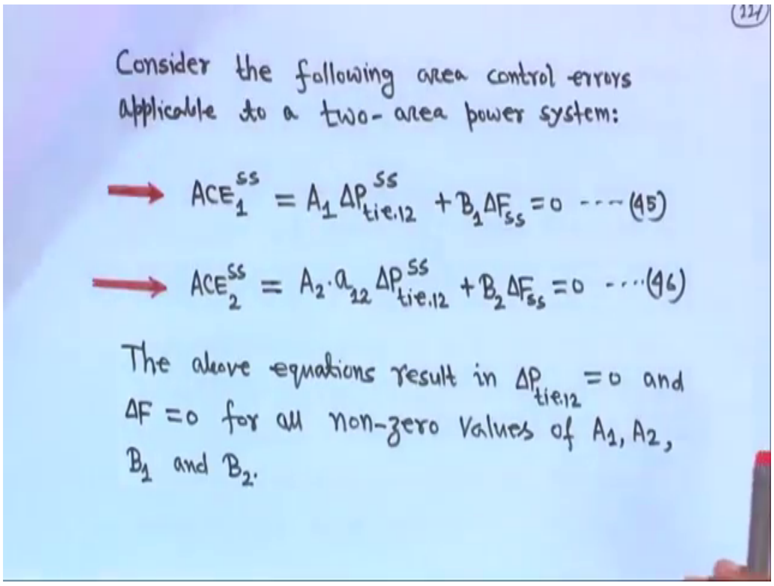

Now, question is consider the following area control errors applicable for a two-area power system. Suppose, ACE we know ACE is equal to we know that we have seen that is your B 1 ACE 1 is equal to B 1 delta F delta F 1 plus delta P tie 1 2. Now, what you can do is suppose ACE 1 steady stable multiplied by some constant A 1 capital A 1 into delta P tie 1 2 SS plus B 1 into delta F SS is equal to 0, this is equation-45 because your whenever you put integral or supplementary control action ACE 1 steady state will become 0. So, that is 0.

But, this is A 1 into delta P tie 1 2 SS plus B 1 A 1 A 2 is some a a 1 is some constant. Similarly, ACE ACE 2 steady state is equal to capital a 2 into small a 1 2 that is the area capacity ratio into delta P tie 1 2 SS plus B 2 delta F SS is equal to 0 this is actually equation-46, right this A 1, A 2 some took constant you have taken arbitrary, right. The above equation result in delta P tie 1 2 0 and delta f is equal to 0 for non 0 values of A 1, A 2, B 1, B 2.

I mean if you if you choose some value of A 1, A 2 and B 1, B 2 right and if you feed that area your as area I mean what I want to mean that area control error ACE 1 you can take A 1 delta P tie 1 2 plus B 1 delta F. Similarly, ACE 2 you can take A 2 a 1 2 delta P tie 1 2 plus B 2 delta f and if you choose some realistic value of A 1 a 2 and B 1, B 2 then what will happen that you will find the steady state value of ACE 1 and ACE 2 both will be 0, I mean in the integral control you ensure that, right.

If you put; that means, however, the composition of ACE signal is more important from dynamic performance consideration right. That means, you can put here A 1, A 2 some values, but you can see during dynamic it during it is transient imbalance know that your where ACE ACE 1, ACE 2 same at the same time delta P tie 1 2 and delta F 1 delta F 2 you have to check there transient behaviour, one thing can happen it may take long time to settle right and may be peak deviation will be much higher.

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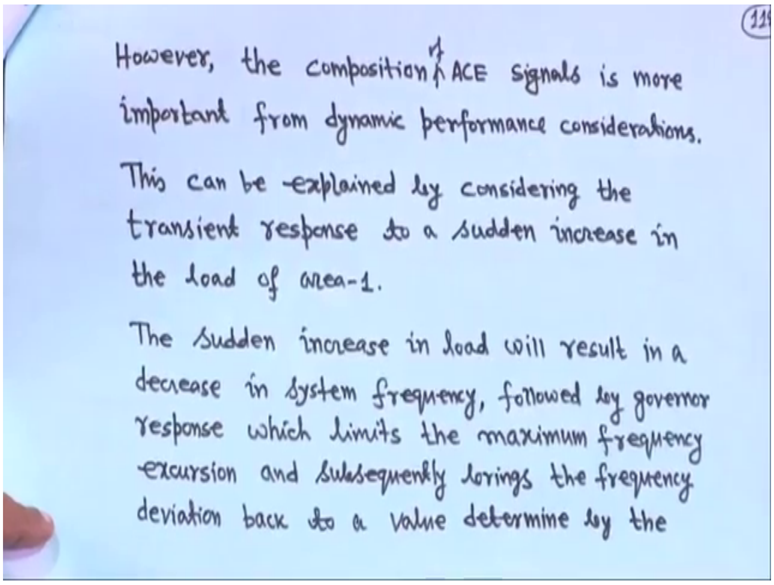

So, that is why that composition of ACE signal is more important from dynamic performance consideration I mean during transient imbalance, right a steady state both are becoming 0. So, this can be explained by considering the terms in response to a sudden increase in the loads say in area-1 right.

So, the sudden increase with load will result in a decrease in system frequency this you know load increases frequency decreases followed by the governor response right which limits the maximum frequency excursion and your subsequently brings the frequency deviation back to a value determine your what you call by the your regulation characteristic of both system.

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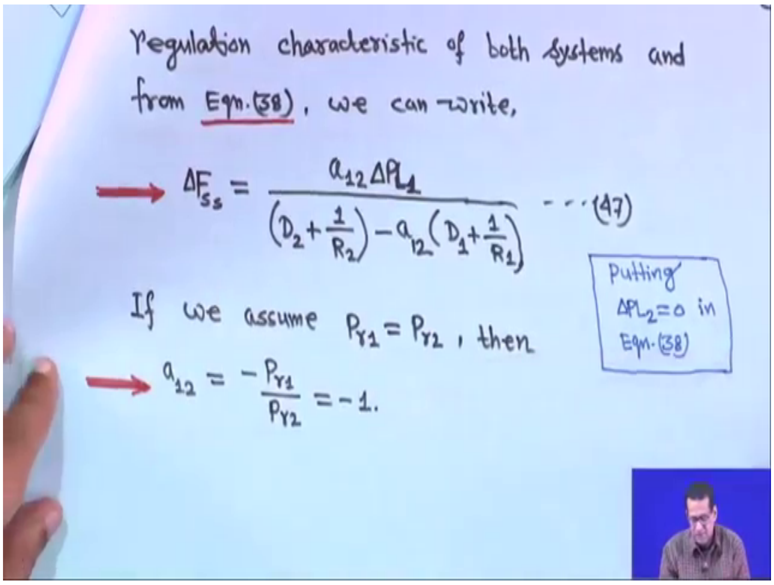

That is that is the regulation characteristic means that is R 1, R 2 the regulation parameter in the area-1 in area-2. So, we can write the steady state value if delta PL 2 is equal to 0, if delta PL 2 is equal to 0 then here in area-1 only load has increased and delta PL 2, 0 then delta f SS is equal to right delta F SS is equal to a 1 2 delta PL 1 upon D 2 plus 1 upon R 2 minus a 1 2 D 1 plus 1 upon R 1 putting delta PL 2 0 in equation thirty 8. So, you get this 1 right.

So, we if we assume the equal area your equal area capacity that is P r 1 or P r 2 something we have seen in just in the previous slide right that a 1 2 is equal to minus P r 1 upon P r 2 is equal to minus 1. So, if it is so, if it so, then your you put it here you put it here this is actually beta 2 and this is actually beta 1, right, beta 2 is equal to D 2 plus 1 upon R 2 and beta 1 is equal to D 1 plus 1 upon R 1.

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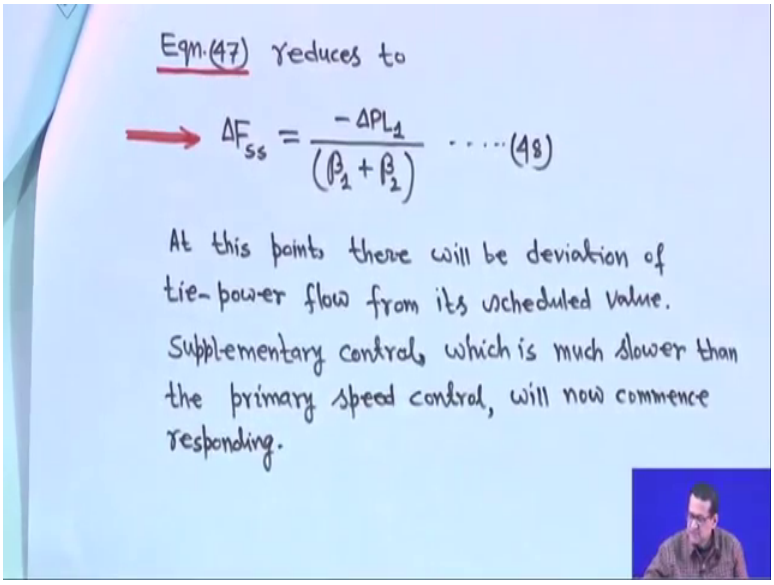

Now, if you put it here then you will this will become actually equation-47 actually reduce to reduces to delta P F SS is equal to minus delta PL 1 upon beta 1 plus beta 2. So, this is equation-48, right.

So, at this point there will be deviation of tie power flow from it is scheduled value because it is frequency is showing the steady state error. So, that is the tie power also will have this steady state value, right. So, supplementary control which is much slower than the primary; primary speed control means the regulation parameter, right and supplementary control which is it comes with a your what you call actually it action starts.

So, in primary speed control parameter action is over right, will now commence responding. So, if that means, it will it will it is a it is a slow process, it is a slow process right.

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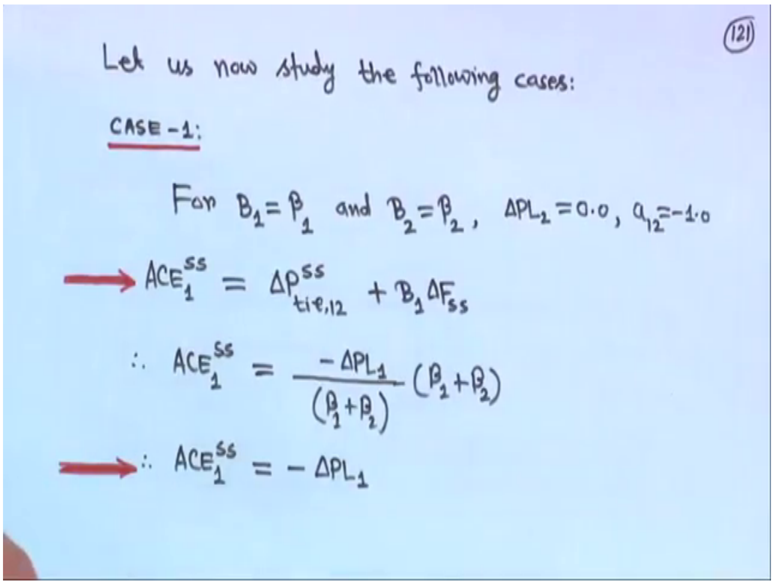

If it is; so, if it; So, then we will we will what you do we will consider few cases later on study the your following one is case-1 say. Case-1 case for B 1 is equal to beta 1 and B 2 is equal to beta 2 say delta PL 2 is equal to 0, a 1 2 is equal to minus 1 and ACE 1 SS is equal to delta P tie 1 2 SS plus B 1 plus delta F SS, right.

Now, using this condition that you will get this one; How you get this one? Just I am showing you how we will get this one just hold on just hold on.

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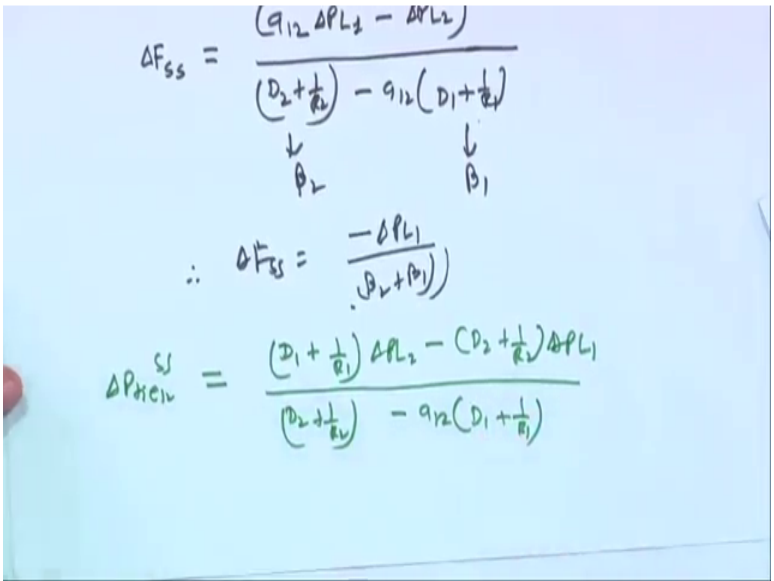

So, what you will get actually we know this expression delta F SS delta F SS is equal to a 1 2 then delta PL 1 minus this one, right divided by your D 2 plus 1 upon R 2 right, minus a 1 2 D 1 plus 1 upon R 1, right.

Now, we know this is actually beta 2 this is actually beta 1 and we have taken here B 1 is equal to beta 1 B 2 is equal to beta 2 and delta PL 2 0 and a 1 2 minus 1. So, if you substitute here this is actually your beta 2 and this is actually your beta 1. So, B is equal to B 2 is equal to beta 2 and B 2 is equal to B 1 is equal to beta 1.

Now, that means, delta F SS then will become delta PL 2 is equal to 0. So, a 1 2 is minus 1. So, it will become delta PL 1 by beta 2 plus beta 1 because a 1 2 is minus 1. So, it will be plus. So, it is delta F SS, just now we have seen this minus delta P L upon beta 2 plus beta 1.

Similarly, for tie power case also tie line power case if you if you just see this one that delta P tie 1 2 SS delta P tie 1 2 steady state right is equal to actually we got this expression D 1 plus 1 upon R 1 delta PL 2 minus D 2 plus 1 upon R 2 your delta PL 1 right, divided by this same numerator denominator right same thing same thing. So, this 1 your D 2 plus 1 upon R 2 minus a 1 2 D 1 plus 1 upon R 1 right putting delta PL 2 0 and this is your what you call beta 2 and this is beta 1 and a 1 2 minus 1.

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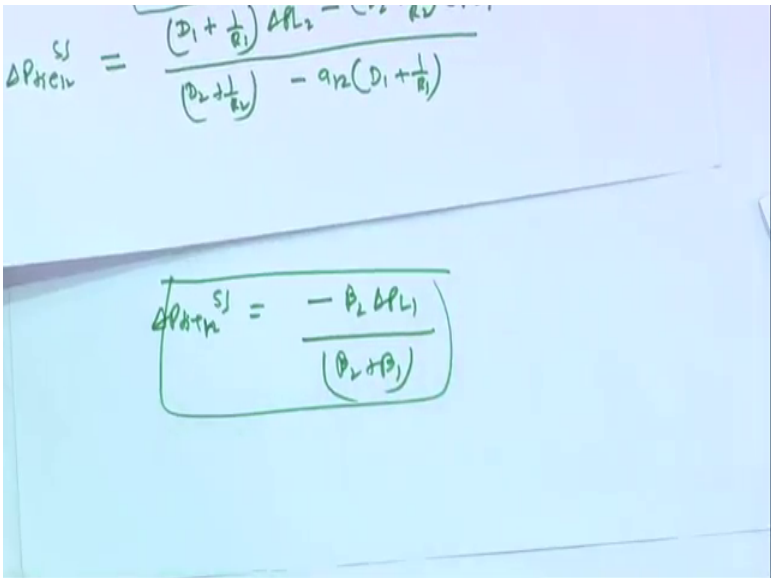

So, this will become actually delta P tie 1 2 SS will be this is this is 0 this delta PL 2 is 0 and this is beta 2. So, it will become minus beta 2 delta PL 1 divided by beta 2 plus beta 1. So, this is this is for this is for frequency and this is for your tie power up putting those things.

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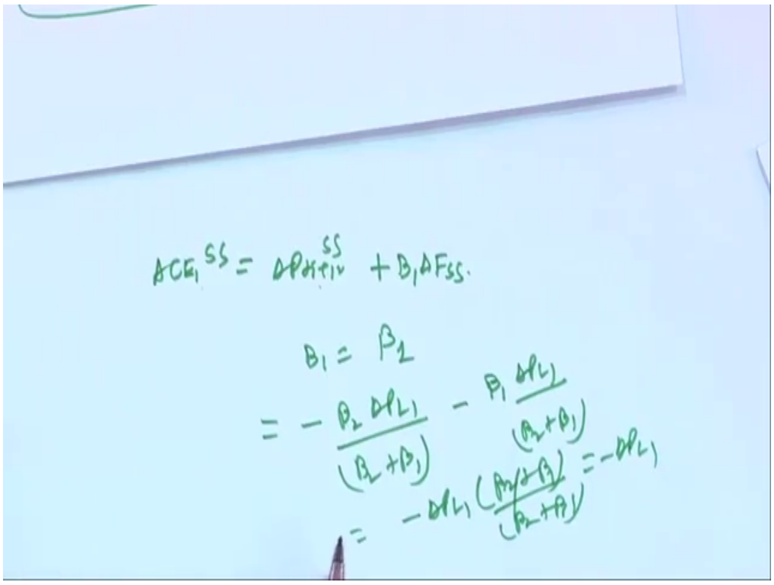

Now, now you the now this 1 your what you call ACE ACE 1 a ACE 1 steady state value right is equal to delta P tie 1 2 steady state plus B 1 your delta F SS this is the steady state value. Now, B 1 is equal to actually B 1 is equal to beta 1, right. So, is equal to delta P tie 1 2 SS is equal to your this one this minus beta 2 delta PL 1 upon beta 2 plus beta 1. So, here you put this one minus beta 2 delta PL 1 divided by beta 2 plus beta 1, right and similarly plus your this is actually B 1 is equal to beta 1 B 1 is equal to beta 1.

So, here in this equation your what you call that your frequency this in this equation you this delta F SS you substitute here, you substitute here. If you substitute you will find this is beta 1 and delta F SS minus is there that is why I am putting minus here that is why minus here then delta PL 1 divided by beta 2 plus beta 1, because B 1 is equal to beta 1 so, that means, if you take minus delta PL 1 common right. So, it will be beta 2 plus beta 1 by beta 2 plus beta 1 it will be cancelled. It will become minus delta PL 1, right.

That is why here we are writing that ACE 1 SS after putting this is minus delta PL 1 right minus delta PL 1. So, this; that means, a steady state value you will find that value of the steady state value of ACE S ACE 1 SS will become minus delta PL 1; that means, it will show some steady state error that is equal to the load disturbance in area-1, ACE 1 steady state value right in the case of uncontrolled mode.

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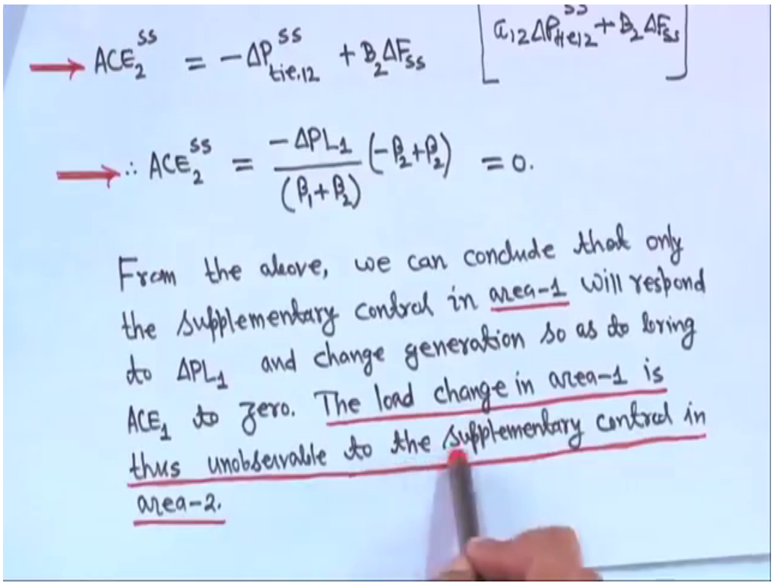

Now, similarly if you make it ACE 2 SS a it is a 1 2 into delta P tie 1 2 S S, but a 1 2 is minus 1. So, it is minus delta P tie 1 2 SS plus B 2 into delta F SS and B 2 is equal to actually beta 2 B 2 is equal to beta 2, right. So, that is why I have put here B 2 is equal to beta 2 if you substitute same expression; that means, your this one this is for delta F SS this is for delta F SS and this is for delta P tie 1 2 SS you can do it simple thing, right this two this two if you put it here.

And, simplify you will get that ACE 2 SS will become 0, right. So, in the I mean if the load disturb; that means, what if the load disturbance has happen in area-1 right then it is showing that it is minus delta PL 1 and if it is if it is in your what you call in area area-2 there is no load disturbance, so, ACE 2 SS actually becoming 0, right.

So, that means, from the above we can conclude that only the supplementary control action in area will area-1 will respond to delta PL 1 and change generation so as to bring ACE 1 to zero, the load change in area-1 is thus unobservable to the supplementary control in area-2. That that in area-1 that the you now from the from the uncontrolled would have operation area-1 it is showing that it is equal to the load disturbance; that means, supplementary control action in area-1 it should respond and it should it should been this ACE 1 to zero, right.

And, wherein ACE 2 SS you have seen zero; that means, ah; that means, the load change in area-1 will be completely unobservable by the your what you call supplementary control in area-2 because in the your what you call that disturbance in area-2 that is delta PL 2 is 0, right. So, so it will be totally unobservable because ACE 2 SS is 0. So, that is actually your what you call that what I will say that steady state from the steady state point of view.

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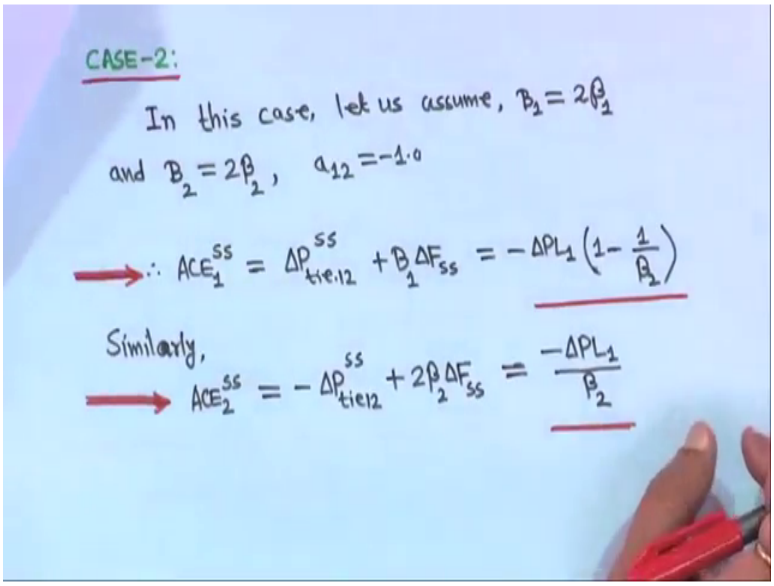

Now, suppose if B greater than beta suppose B greater than beta. So, if B is case 2 in this case, case-2 in this case let us assume B 1 is equal to 2 beta 1 that is your B greater than beta and similarly beta 2 is B 2 is equal to 2 beta 2 and a 1 2 minus 1. Follow the same procedure follow the same procedure in that in that expression of this two thing whatever conditions are given B 2 is equal to 2 beta 2 a 1 2 minus 1 and B 1 is equal to 2 beta 1, you put in this expression. You put in the equation-38 and 39, right, I am I am directly I am showing it I have not because then I can say little bit of time, right. So, you directly you substitute very simple thing just substitute and work out.

If you do so, you will find ACE 1 SS will be your delta P tie 1 2 SS plus B 1 into delta F SS; that is actually if you put those thing it will be minus delta PL 1 into 1 minus 1 upon beta 2 will be there. And, similarly ACE 2 SS if you see it will become minus delta P tie 1 2 SS plus 2 beta 2 delta F SS is equal to this will become minus delta PL 1 beta 2 that mean if B greater than beta this is not becoming 0, it is not becoming 0 and ACE 1 SS will is not becoming just minus delta PL 1 it is 1 minus 1 upon beta 2, it is coming, right.

So, that means, that means that supplementary control action also in area-2 has to be responded because although there is no load disturbance in area-1 I sorry area-2 right. So, that that is because it is coming some steady state value.

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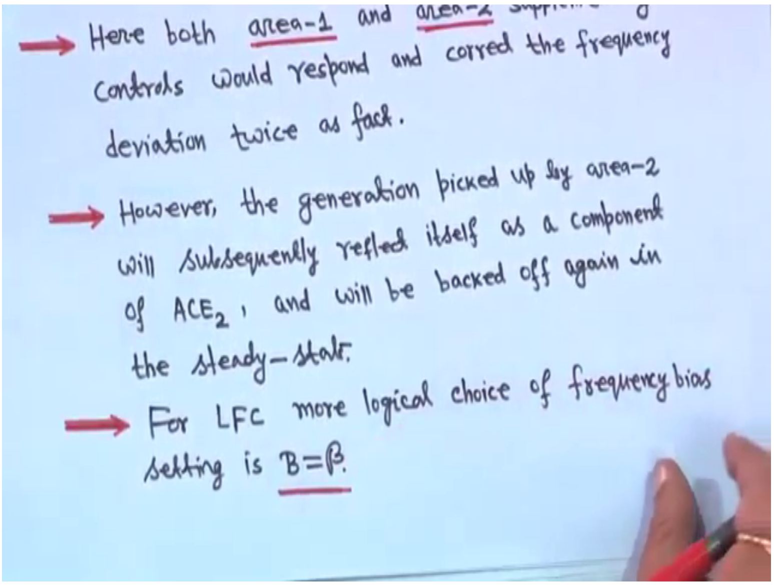

So, that means here both area-1 and area-2 supplementary control would respond would and correct your what you call the frequency deviation twice as passed because we have taken B 1 is equal to 2 beta 1 B 2 is equal to 2 beta 2 , right.

However, the generation picked up by area-2; that means, ACE 2 a SS is given minus delta PL 1 upon beta 2, right picked up a we will subsequently reflect itself as a component of ACE 2, right and will be backed off again in the steady state. So, therefore, the LFC more for LFC load frequency control the more logical choice of frequency bias setting is B is equal to beta, right. So, that is the most logical choice, but B cannot be less than beta, right. So, this is actually given you a question that why B cannot be cannot be less than beta.

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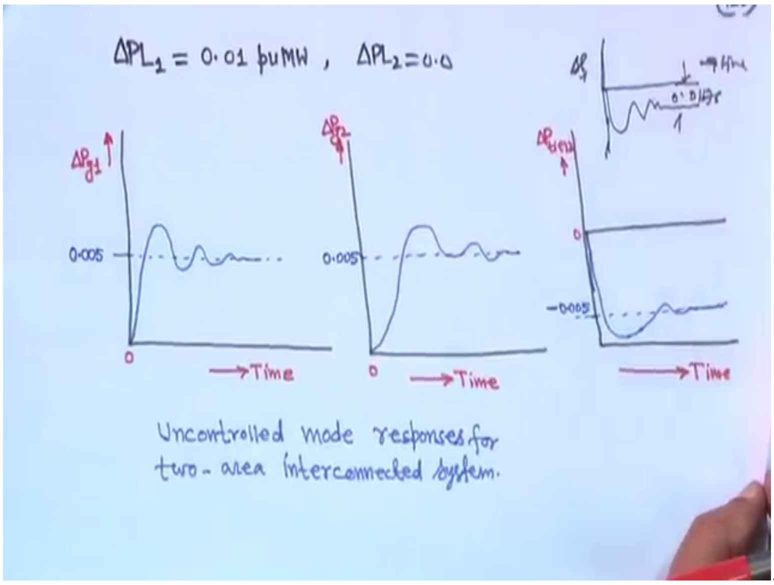

So, if you see the just a response for these area-1 area-2 and this thing for delta PL 1 is equal to 0.01 per unit megawatt, right and per unit megawatt delta PL 2 0 if you plot for example, delta P g 1 this is actually your what you call this case uncontrolled mode uncontrolled mode you will find delta P g 1 making 0.005, but not your what you call not 0.01; because, it is uncontrolled mode.

So, both the generation is your what you call generated S generate responding and generating power 0.005, here also 0.005 because this uncontrolled mode responses of two-area interconnected system and time line power if you plot it is showing minus 0.005 and this is the time this is the response for your what you call your P g 1, this uncontrolled mode that mean u 1 0, u 2 0.

If you make like this from MATLAB supposing if you put all this things you can easily see those what you call this responses and if you put frequency not shown here frequency also will show you the steady state error right frequency here steady state error I made it here. This is time some minus 0.0 0.000 0.01176 will become the steady state minus only, right. So, that means, your what you call that this the uncontrolled mode response these are uncontrolled mode response.

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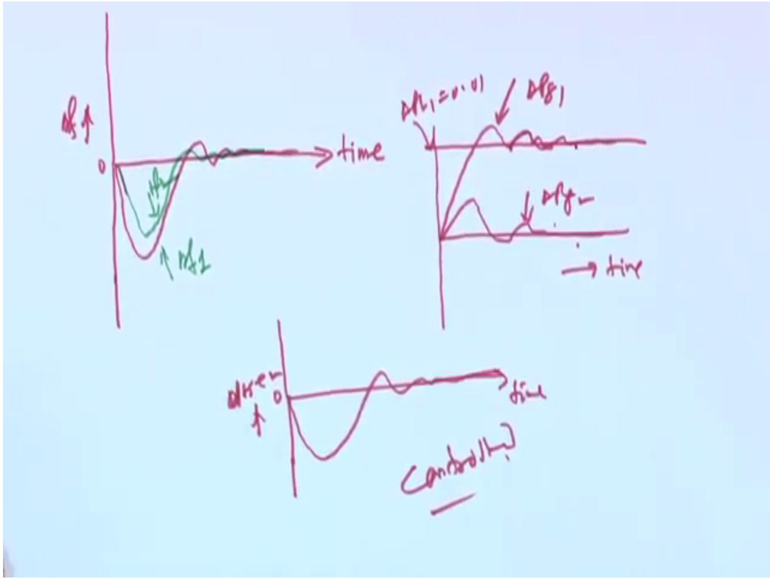

Now, if you if you control if you put the controller here just if you put the controller here then frequency your what you call frequency will be like this is your time this is this is your this is time and this is delta F and this is 0, right and if you this is controlled mode, right. So, frequency will be may be like this it will go like this it will go like this finally, it will settle to 0 this is frequency in area-1 say area-2 also let me make use of another ink area-2 also it will be go like this and go like this finally, go to 0, right.

So, this is actually say this may be delta F 1 disturbance is area-1 and this is also delta F 2 right this is frequency. If you see the generation in that case of area-1 generation say area-1 generation, so, disturbance has occur in area-1. So, this point is say delta PL 1 say is equal to 0.01 see if it is generation will be like these like these will be like these and finally, settle to 0 this is your area-1 area 1 delta P g 1.

And, area-2 case it may be go like this may be go like this and finally, it will come to 0, that this will be your delta P g 2 because this just I am drawing it from my intuition, but simulation will be something, right simulation also ultimately it will settle to 0 delta P g 1 and delta P g 2 settle to 0, right and tie power also tie power also this is your time this is actually your time this is actually your time, right and this is your what you call delta P tie 1 2. If you plot it will be like this like this.

Finally, it will settle to 0, this is control all this things are in controlled mode; that means, that integral control action is there, right.

With this your what you call this conventional part all this things over after this we will see few numerical examples and then little bit on deregulated system and then we will come to unit commitment, right unit commitment actually something will try to make it because as you know that unit commitment is almost impossible to solve in the classroom, right, but little bit easier way we will make it and I am I mean details not possible in this course.

But, some ideas some thought we will get, but after this we will see the derivative version in a g c that is very simple thing only little bit I will show you the regulation just that you can work out in the class classroom only, right before that we will show some example and after that we will move to unit commitment, right.

Thank you very much.