Power System Dynamics, Control and Monitoring
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Lecture – 48
AGC in deregulated system (Contd.)

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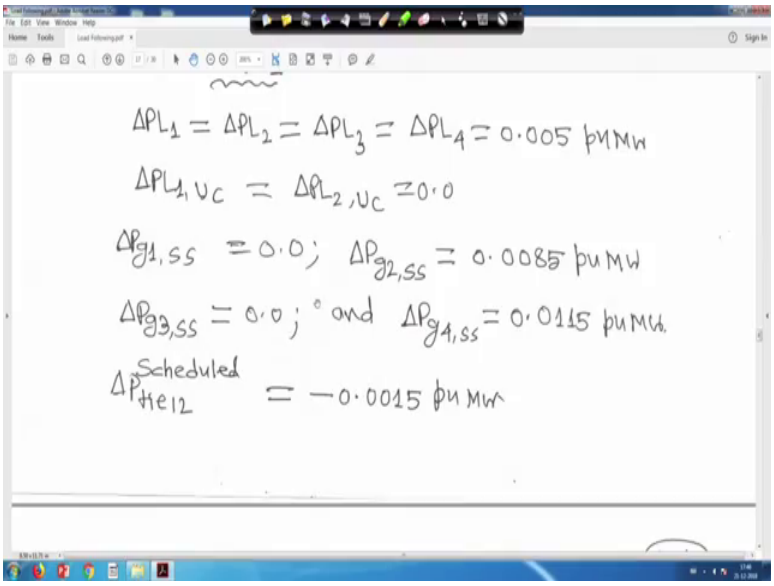

Ok. So, we are back again. So, this is actually whatever see in this, so all steady-state value of generation and delta P tie 1 2 all will remain same, only the only that two units earlier it was not under AGC, now it is under AGC right.

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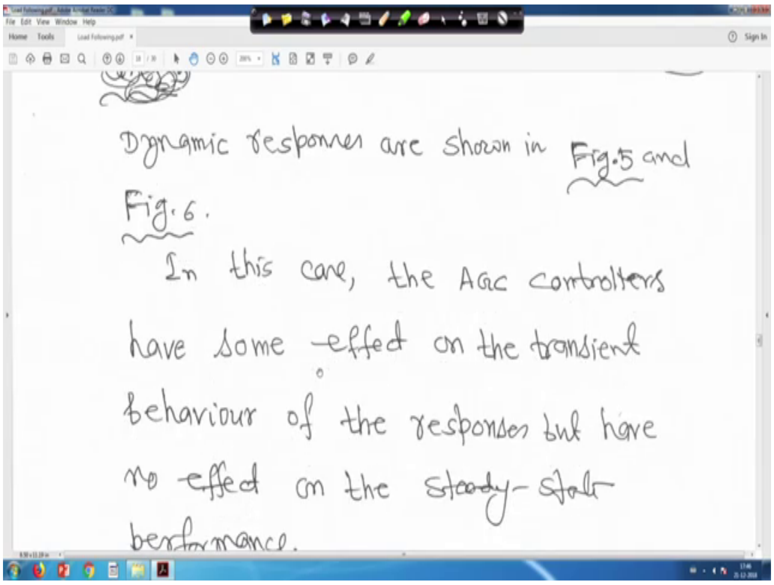

So, dynamic responses are shown in figure 5 and 6 right. So, in this case, the AGC controllers have some effect on the transient behaviour of the responses, but have no effect on the steady-state performance right.

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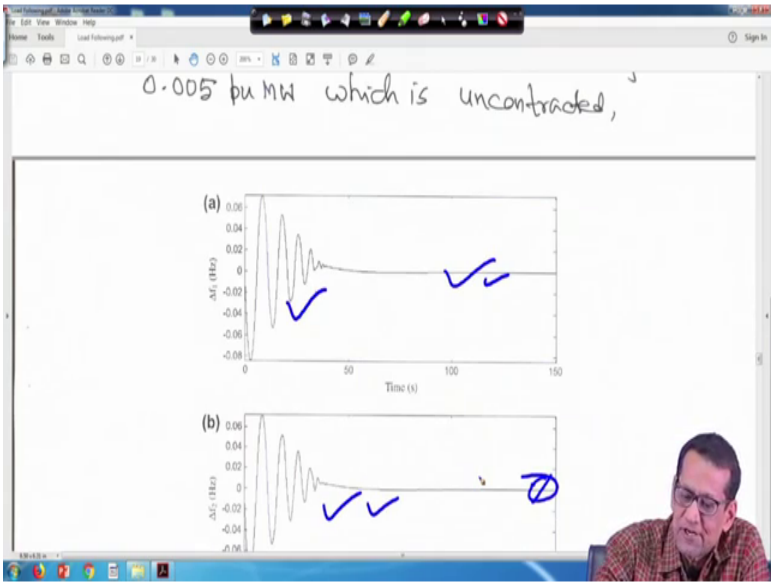

So, be case 3, before going to case 3, let us go to these things. So, this time if you look into that, unit 1 and unit 3 are in your what you call are under AGC. So, peak deviation everything is same, but unit 1 and unit 3 it has your what you call that you are AGC controller right, so that is why that and whatever gains other things are taken for integral controller and load following controller, I will give you later.

A parameters whatever earlier I said, it remains same right. So, but it is frequency and other things all reaching a steady-state, and that APF that your ACE participation factor also has effect on transient responses, but there is no effect on the steady-state. Similarly, for your delta f 2 also right. So, it is also lot of oscillations, but ultimately it is going to steady-state to 0 right.

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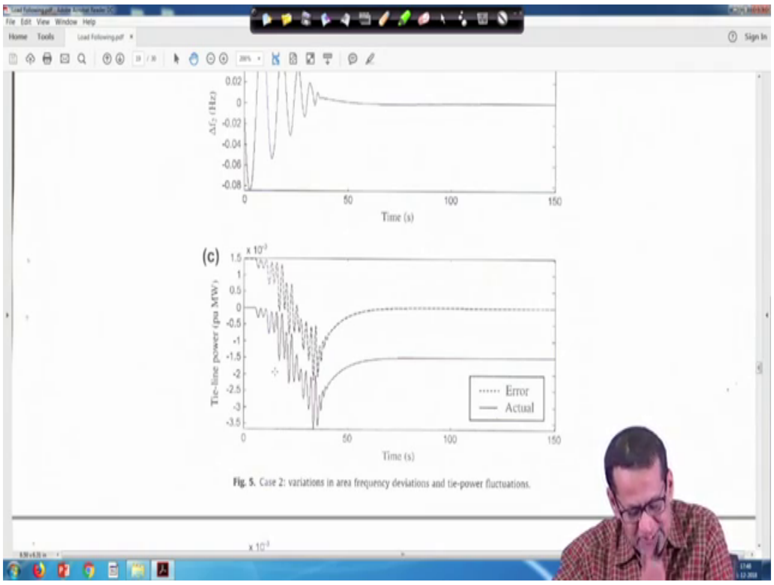

So, similarly that tie power error, you can see the lot of oscillations are there right, when AGC controllers are there. But, actually this gains and this thing some arbitrary value, we took right actually not optimised not optimised, it is some arbitrary value, if you optimise perhaps the response will be better.

So, in this case you are if you look into that actual also same thing is coming minus your 0.0115 per unit megawatt 00, your what you call 00115 per unit megawatt. And at steady-state error is vanishing, this is 0, actually this is actually your 0 line, this is 0 line right, this is actually 0 line. So, it is it is going to 0 right. So, only thing is that because of this controller and this thing AGC controller as well as APF right that only the transient behaviour has changed, but steady-state values remains same right.

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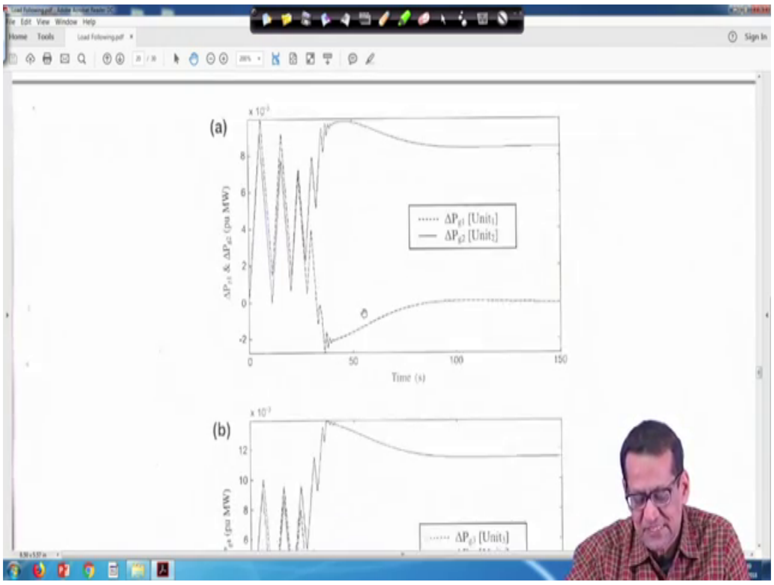

Similarly, that generation also that transient behaviour has changed. But, delta P g 1 as usual it is coming to 0, because it is under AGC, and there was no contract with any other DISCO. So, ultimately delta P g 1 has steady-state, it is generating 0 power right. But, during transient your transient behaviour, but transient operation; transient time duration right, it is some generating some power increase, decrease, increase, decrease, but finally it is settling to a 0 at steady-state right.

And delta P g 2 also as steady-state, whatever value was there earlier 0.0085 per unit megawatt, so it is coming here right. So, only thing is that, that responses that transient compared to the case 1, now the case 2 transient behaviour have changed right.

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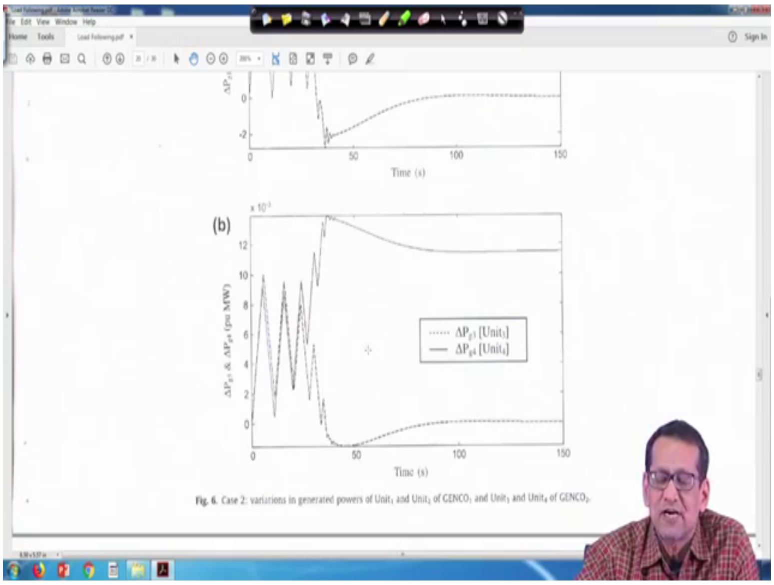

Similarly, delta P g 3 and P g 4; delta P g 3 again it is going to your what you call the 0, because this is 0 line, as steady state is 0 and delta P g 4 is matching a steady-state value right. So only thing is that because of AGC controller that you are transient behaviour actually changes, but steady-state value remains same.

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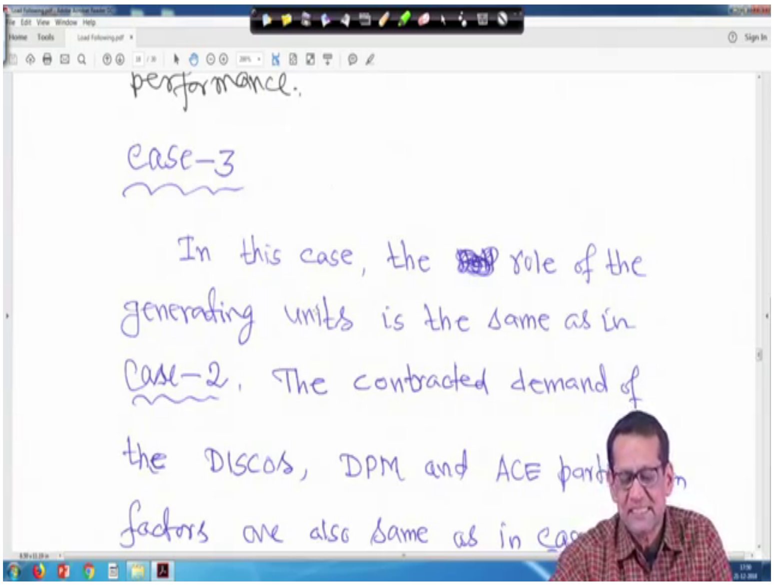

Now, next one is that we will come back to this that case 3 right, so that responses which I showed that is for case 2. Now, case 3 in this case, the role of the generating units is the same as in case 2. The contracted demand of the DISCOS that is distribution companies

DPM and ACE participation factor also same as in case 2. So, everything remain same, ACE participation factor also remain same.

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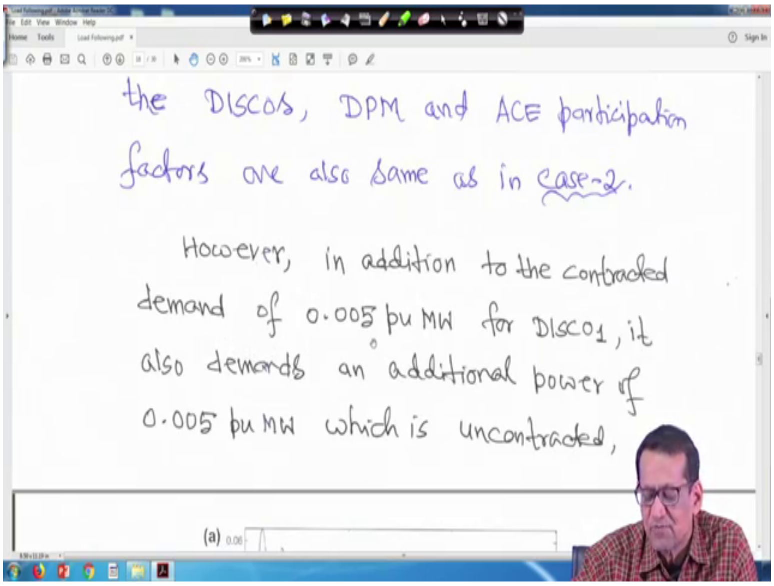

But, however in addition to the contracted demand of 0.005 per unit megawatt for DISCO1, it also demands an additional power of 0.005 per unit megawatt which is uncontracted that mean distribution company one, its contacted power demand was point total demand was 0.005 megawatt. In addition to that, it also want that 0.005 per unit megawatt, which is uncontracted right. So, this I will skip, because I have already explained right.

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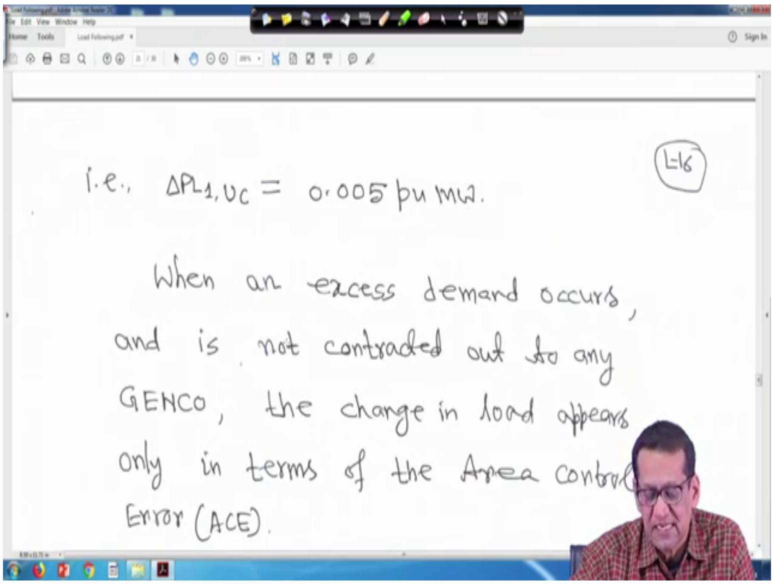

Now; that means, that delta P L 1 uncontracted is 0.005 per unit megawatt. Now, when an excess demand occurs that we have discussed earlier and is not contracted out to any generation companies right, the change in load appears only in terms of the area; only in the terms of the area control error right.

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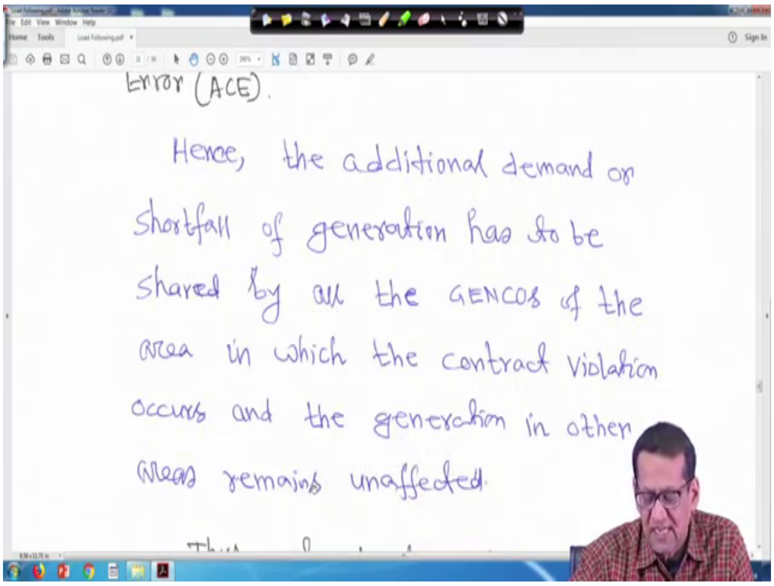

Hence, the additional demand or shortfall of generation has to be you are shared by all the GENCOS of the area in which the contracted violation occurs. And the generation in other areas remains unaffected right.

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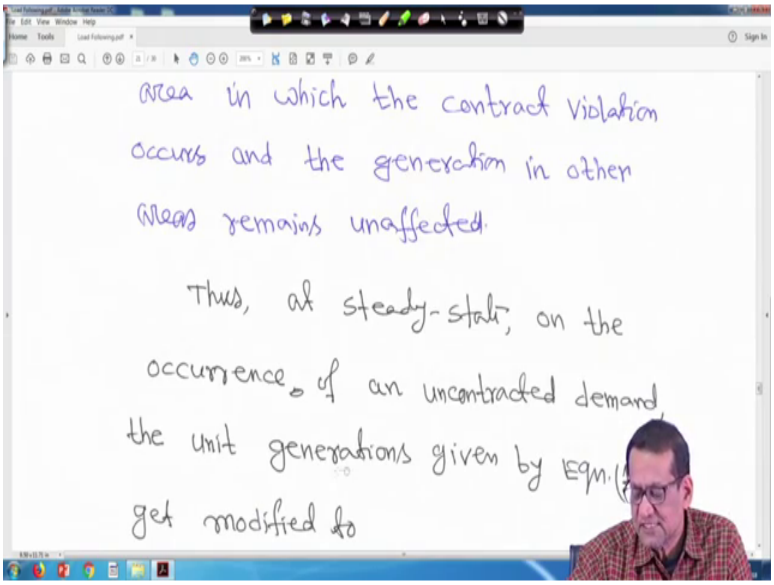

Thus, at steady-state on the occurrence of an uncontracted demand, the unit your generation given by equation 17 get modified to.

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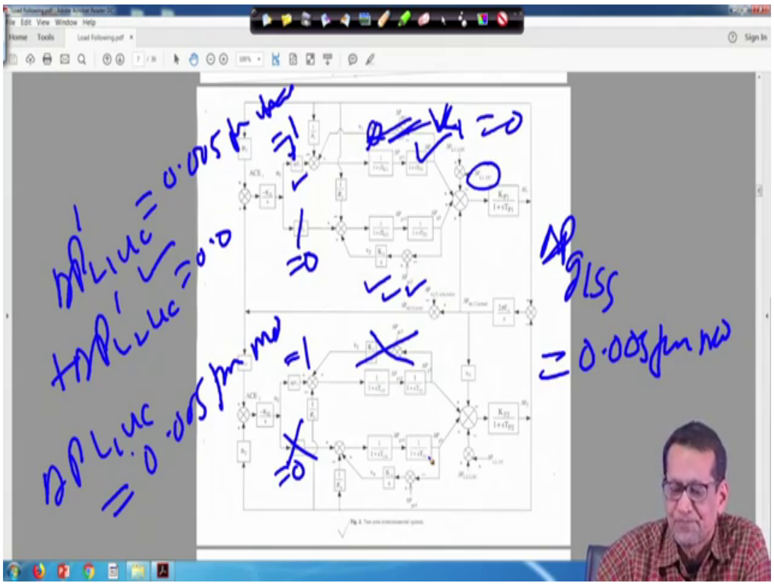

So, first before this telling this one, that modification, I will go to the diagram once again. So, what happen in this case now, you then we will go to the simulation, then everything that sorry, then everything your what you call will be clear to you. So, in this case, that this a your unit 1 that is this unit 1 and it was in an in area-1 that un that uncontracted DISCO 1 that one has a demand some excess power that is 0.005 per unit megawatt right.

So, and second thing is that you are this unit 1, actually not under your AGC, so that mean this part should not be there, so K 1 should be is equal to 0 right. So, keep K 1 is equal to 0, then in this case APF APF 2 for this case is equal to 0 and this value is equal to 1 right. So, earlier we have seen that when there was no uncontracted power demand delta P g1 was actually a steady-state, it was 0.

Now, this load following controller is not there for your unit 1, but your that is K 1 0. But, it is under AGC, because APF 1 is 1 and APF 2, actually it is 0 and it is under load following that is unit 2, but uncontracted power demand has happened here. So, there are two DISCOs in each area that means, I am writing here, so that means delta P L 1 u c dash, it actually it was 005 per unit megawatt right, this demanded by DISCO 1.

But, in area-1 that P L 2 dash u c equal to 0.0 that is that is I am making P delta P L dash right that means, delta P L 1 u c that total uncontracted demand delta. P L 1 u c right is equal to this one plus this one that is actually nothing but 005 per unit megawatt right. I am putting dash, do not confuse here also delta P L 2 u c is there that is nothing but delta P or what you call the delta P L 2 3 dash u c plus delta P L 2 dash delta P L 2 dash your P L to u c delta you are here, it is making delta P L 1 that is delta P L 3 dash u c plus delta P L 4 dash u c right.

So, there should not be confusion, so that means this delta P L 1 u c basically 0.005 megawatt, but this unit that is your unit 2, it is under your load following. So, this generation will at this delta P g 2 will change this load. So, this unit will not generate that extra power 0.005 per unit megawatt, but this unit is not under load following. But, it is under AGC and APF is 1 that means, delta P g 1 will generate that will take care of that and generating additional power and it will give it to the distribution company 1 right.

So, at steady-state at steady-state in this case delta P g 1SS, it must be is equal to 005 per unit megawatt, because APF is 1 and this is 0. Even if you APF; suppose, for example if you make APF is equal to 0.7 in APF is equal to here it is 0.3, but it will not help to generate that 0.005 by this one. So, it will be a it will be a contradiction, because whatever is there generation that contracted power for unit 2, this unit 2 generation will change this load right.

So, in this case APF is equal to 1 and this thing APF 1 1 and your APF 2 is 0. And here no uncontracted power demand. So, in this case this thing will remain same. So, there will be no load following here, APF should be is equal to 1, APF should be this unit will be load following right.

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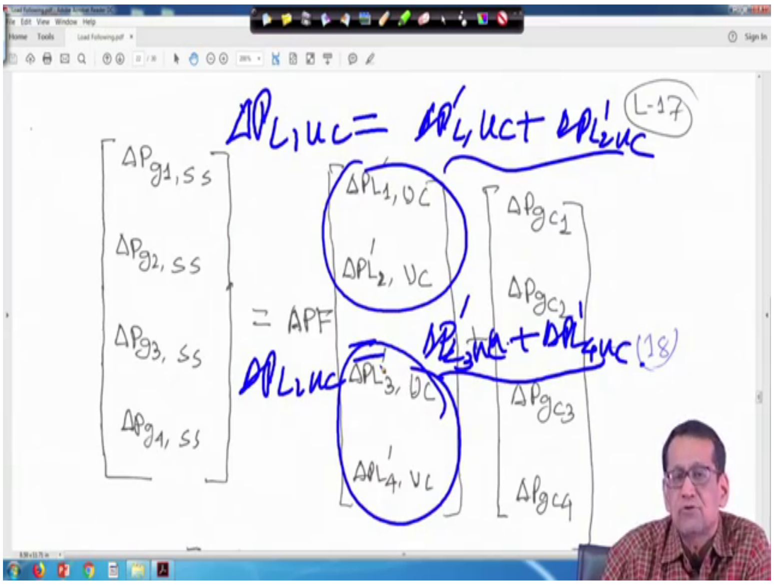

So, I hope this has been understandable to you, so that means, I will go back to that case right. So, just hold on. So, this I skip, I told you already shown for that case 2. So, now that means, thus a steady-state on the occurrence of an uncontracted demand, the unit generation given by equation 17 get modified to. So, we write like this that delta P g 1 steady-state, delta P g 2 steady-state, delta P g 3 steady-state, delta P g 4 steady is equal to APF that is ACE participation factor into the delta P 1 does uc means, that is the uncontracted power demand, if any demanded by DISCO 1 distribution company 1.

Delta P L 2 dash uc means, uncontracted power demand demanded by DISCO 2 right. Then this is delta P L 3 dash uc that is uncontracted power, demand demanded by DISCO 3. And delta P L 4 un your what to called dash un uc that is uncontracted power demand, demanded by your DISCO 4 right, so that means in the block diagram whatever we have seen that in general that your delta P L 1 uc actually is equal to delta P L 1 dash, I told you this one plus delta P L 2 dash uc right.

Similarly, in area-2 somewhere I am trying to accumulate it over writing on it, delta P L 2 u c is equal to delta P L 3 dash u c plus delta your P L 4 dash u c right. So, these two has to be added, because all these things right. This is for delta P L 1 u c for that is for area-1, and this is for area-2 right, if there is any.

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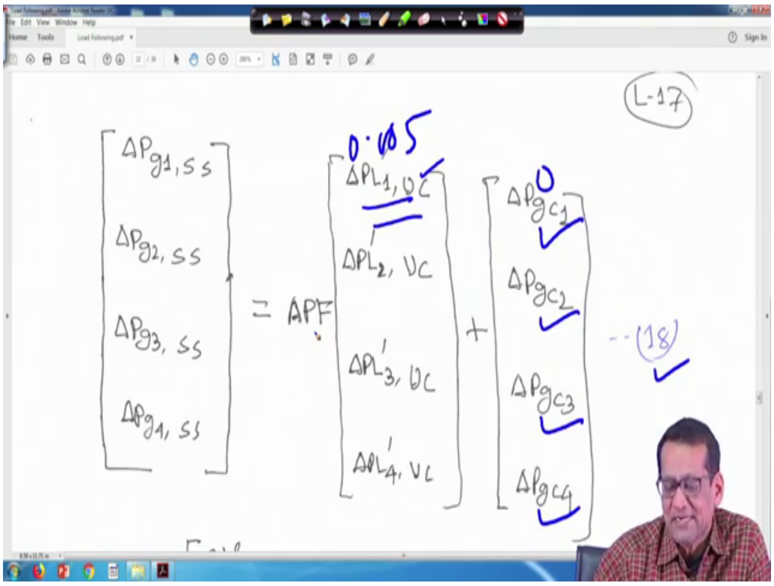

So, and this is actually ACE participation factor plus whatever contracted power demand you have, delta P gc1, delta P gc2, delta P gc3, delta P gc4, this is equation 18 right. So, if it is so that means, that in the area-1, the distribution company 1 actually, that demanded 0.005 extra power. So, this should be 0.005 right.

And delta P gc1 contracted power demand, because it was not under load following. So, it was 0 and this was 005, so steady-state it will be 0.005. And this APF matrix, I will show you it is a diagonal 1 APF 1 is 1 right, it multiplied by that so same thing will come. So, just you have to put, so what is ACE participation factor this APF matrix I call right.

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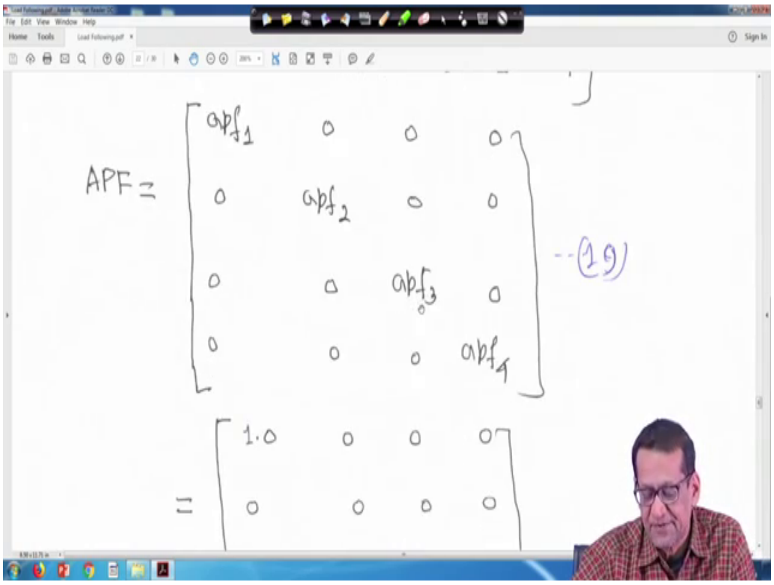

So, this APF matrix actually is this one, this is apf 1, apf 2, apf 3, apf 4. So, in this case, apf 1 is 1; apf 2 is 0; and again apf 3 is 1; and apf 4 is 0. But, in area-2 there was no uncontracted one, but apf 3 is 1 that means, unit 3 as under AGC, but there is no load following, so that load following controller the value K 3 will be is equal to 0 right, so that is why, it is 1 this matrix is this is 1, so this is 0, this is 1, and this is 0, only two element non-zero elements right.

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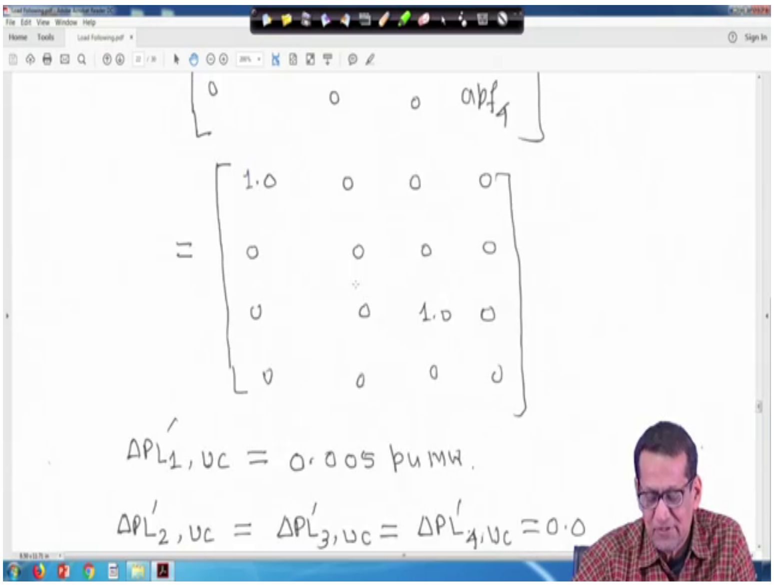

Therefore, delta and it is I told you delta P L 1 dash uc is 0.005 per unit megawatt, that is demanded by the distribution company 1 right, but all other delta P L 2 dash uc is equal to all this thing delta P L 3 dash uc delta P L dash uc is equal to 0. So, if you use this; so therefore if you use this thing, this called as this equation 18.

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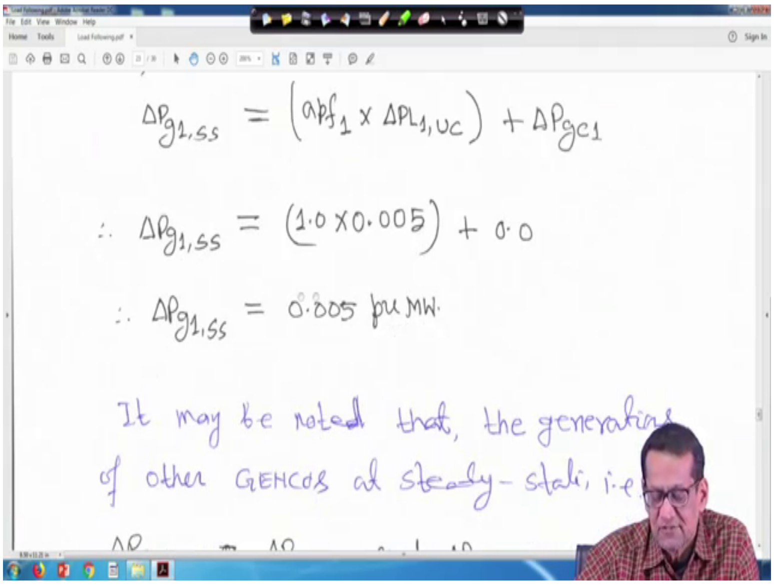

Then your delta P g 1, ss will be apf 1 into delta P L 1 uc plus delta P gc1. So, delta P gc 1 is 0, so it is actually delta P g 1 ssSS is equal to 0.005 per unit megawatt that I told you.

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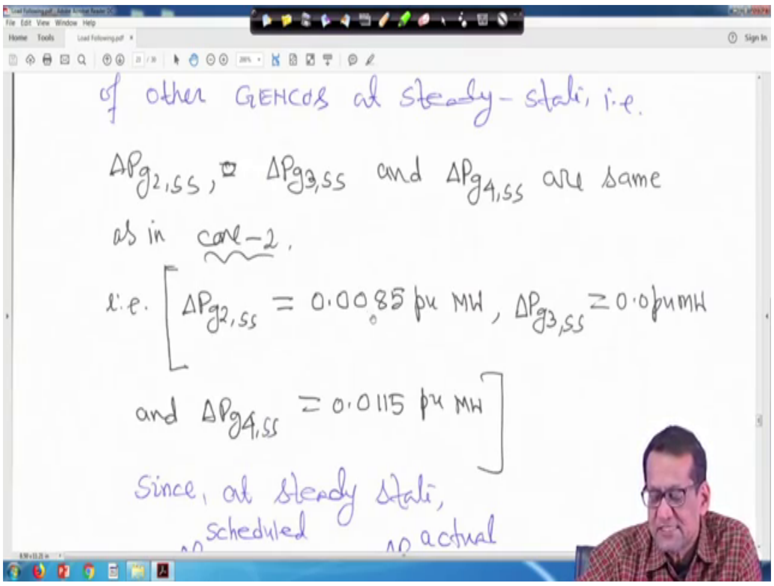

Now, it may be noted that the generations of other GENCOs at steady-state that is delta P g 2 SS delta P g 3SS and delta P g 4 ssSS are same as in case2. Because, if you use this formula, all you will get this is APF. So, this APF you put it here, and multiply and get all these delta P g SS, so you will get the same thing; same as in previous case. So, that means, your delta P g 2, ss is 0.0085 per unit megawatt delta P g 3 steady-state is equal to 0.0 per unit megawatt. And delta P g 4 ssSS is 0.0115 per unit megawatt.

Now, since at steady-state the delta P tie is scheduled actually delta P tie 1 actual, so delta P tie error also will be 0.0. But, has some uncontracted demand is there and grc is there, so dynamic responses will be deteriorating right.

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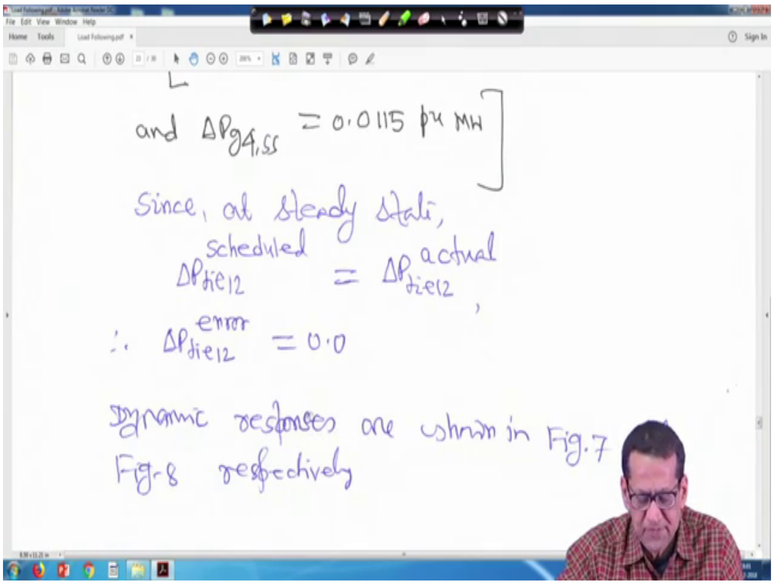

So, dynamic responses are shown in figure 7 and 8. So, when you come to figure 7 that lot of oscillations are there in frequency deviation, but you will see that are steady state it is 0, the deviation is 0. Sim ilarly, for frequency deviation in area-2 right, that is also a steady-state frequency deviation is 0, but some oscillations are there.

And when that extra; another thing is that, previous cases we have seen, the peak deviation was what you call minus 0.08 hertz right. But, now in this case, the peak deviation is much higher right it is much higher. So, here also same thing right, so because this has happened because of uncontracted power demand right.

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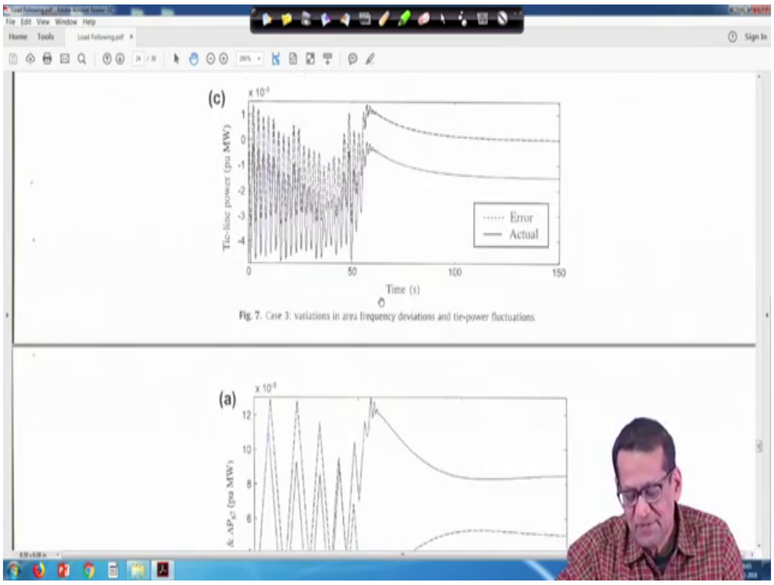

And here also because of uncontracted power demand, if you look into that that huge oscillations in tie power your error as well as actual huge oscillations are there, but at steady-state that your actual power some steady-state value will be there, we have calculated already. But, tie dash 1 is error, but error will be 0, because this is a 0 line, so error will be 0 right, so that means uncontracted power demand also as soon as is coming apart for your contactor 1, that dynamic responses actually getting deteriorating right.

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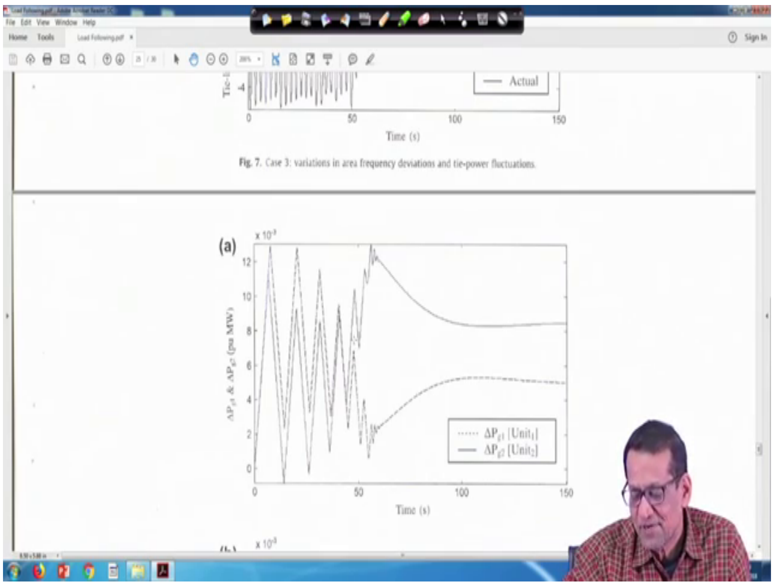

Similarly, if you look into the generation also same field, same case, but in this case you will see that delta P g1 as steady state generating 0.005 per unit megawatt right. So, this is your steady-state, it is matching right. It is actually scale is you can see and multiplied by 10 to the power minus 3. So, and delta P g 2 that unit 2, whatever power it suppose to generate, so it is generating here right.

So, already it is your what you call, it is coming it is up to 150 second, it was drawn right. So, already whatever steady-state value may this thing, it is matching. Similarly, for your what you call for delta P g 3 and delta P g 4. So, delta P g 3 also it is coming to 0 it is 0, and delta P g4 also settling to its that is your po[int]- 0.0115 I think right that steady-state value as steady-state, so that means, uncontracted power demand is taken care of by the unit which were in that area-1 which are under AGC right.

And another thing is you can see examine of your own that suppose some uncontracted power demand is there and there is no integral controller that means, no units are in AGC. And just see that how things are you can put it in simulink also no problem. What is happening? Something will happen right. So, and why what it is whether just check whether frequencies going to the steady-state values or not and delta P tie error also going to steady-state values or not when no AGC controller, but uncontact is as your load following controller will be there, but no AGC controller that is K I 1 is equal to K I 2 is equal to 0 right. And just see uncontracted power demand what is happening.

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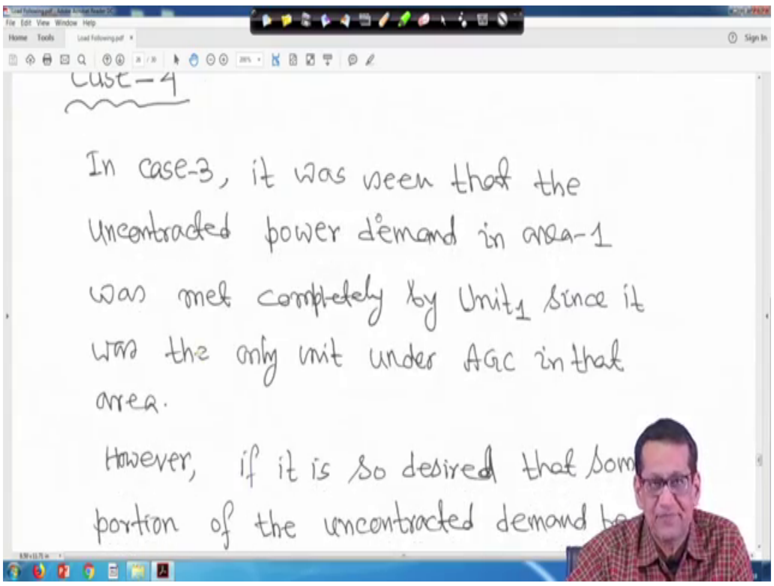

So, next one is case 4 right. So, in this case it was a in the case 3 actually, it was seen that the uncontracted power demand in area-1 was met completely by unit1, since it was the only unit under AGC in that area right. However, if we desire; I mean, if it is so desired that some portion of the uncontracted demand be taken up by other unit that is unit2 in area-1 right.

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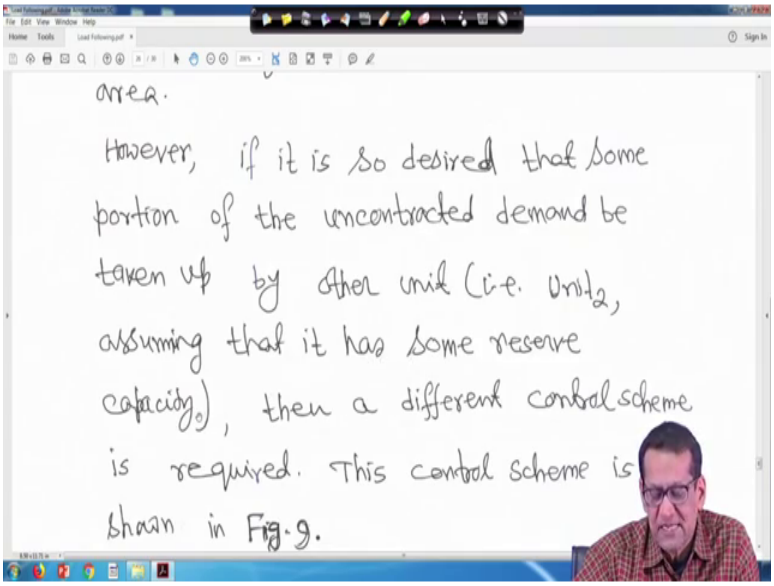

Assuming that it has some reserve capacity that is you are spinning reserve right, then a different control scheme is required. And this called to control scheme actually is shown in figure 9 right I will show you the figure 9.

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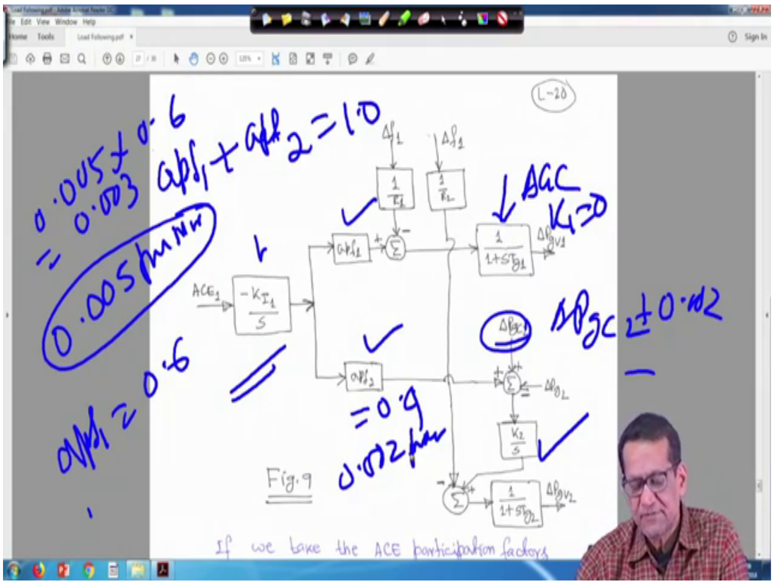

So, actually what happened, first you see this figure. So, first you see this just let me little bit reduce. So, if you see this one, then in this case what will happen that it will not has a whole, it has drawn here, but I will go to that diagram once again. So, in this case if you seen that this is my ACE controller right for your that AGC controller for area-1, integral controller only minus K I 1 upon S right.

Now, apf 1 and apf 2 to you are what you call that is your ACE participation factor. But, question is that this unit 1 is under AGC, but not load following that means, if other things are not shown here, it will be huge then, I wil l go to that once again to the diagram, I will tell you in detail. So, AGC and in this case you are what you call, that load following controller gain was 0. And similarly, in this case you are what you call that load following controller is here right, but this part earlier was not in AGC. But, as soon as what we are doing is this apf 1 that ACE participation factor 1, then apf 2 is equal to 1.0 right.

Now, if we want that this unit we will say, and say 60 percent of that total uncontracted power demand right of my our total uncontracted power demand was 005 per unit megawatt that demanded by DISCO 1. We want the unit which is under ag AGC, it should give 60 percent of that; that means, my apf 1 is equal to 0.68 that means, at steady-state unit 1 should generate that 0.005 into 0.6 right, so 0.005 into 0.6 that is 0.003 per unit megawatt right.

And this apf 2, suppose this is now 0.4, because this is 0.6, it is 0.4 total will one. So, this 0.4 means that this unit 2 apart from you are supplying its contacted demand, it should also this you are what you call, generate this power for DISCO 1 right, so that means a 0.4 into 0.005; 0.002 per unit megawatt that means, this addition to its contacted power demand delta P gc is as its contacted power demand is delta P gc 2. In addition to that it should give this power, that is my say 0.002 in this case right.

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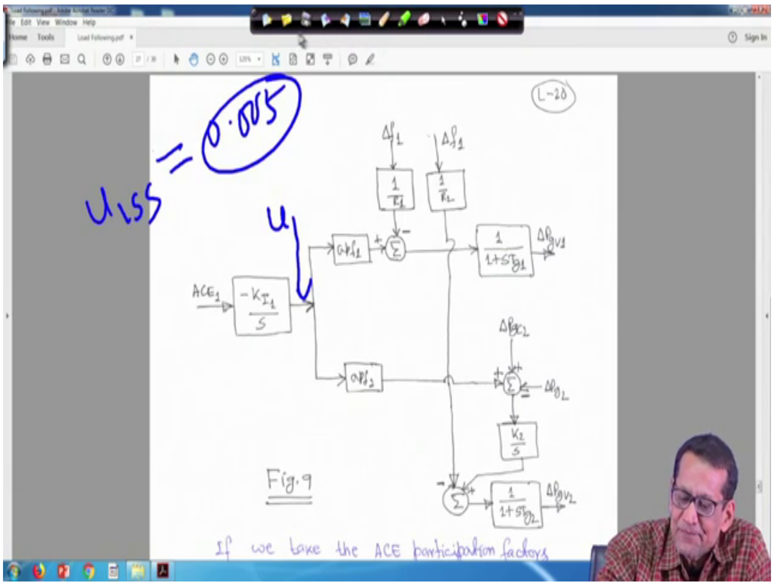

So, how we will conceive that, I told you in the beginning that this is that u 1, that is your what you call that your that output of the controller. So, at steady-state I told you generally what happened at steady-state that u 1 value at steady-state, it actually become your what you call, that total power generated right by the your generator right because AGC controller.

So, u what happened, u 1SS will be is equal to your whatever uncontracted power demand will come right, that will be say in this case 0.005. So, a steady-state if you plot it, you will see that u 1 steady-state actually is showing 0.005, so that is equivalent to your whatever controller output will come at steady-state that is equivalent to that uncontracted power demand.

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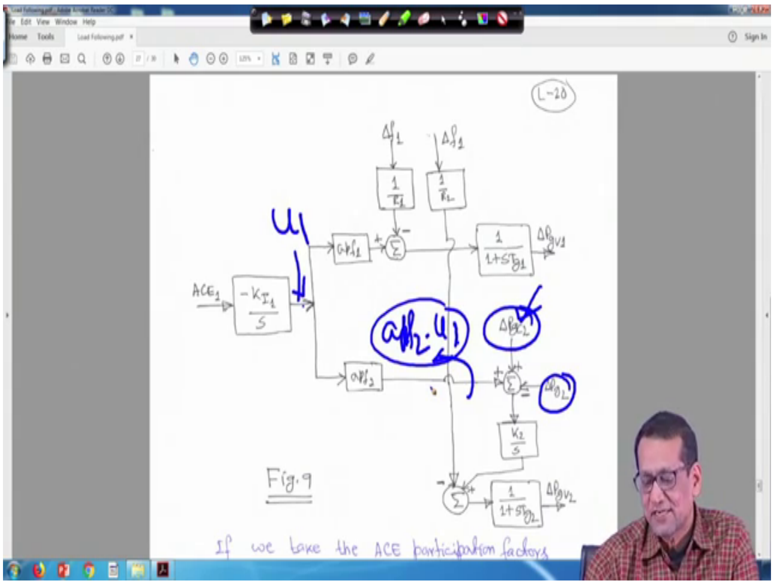

So, that is why that is why what we have done is that, your this is my u 1 in the area-1. So, a feedback is given here that is take output of this one that is here it is going actually here, I am making it here that it is apf 2 into u 1 right. This is going that means, it is basically it is what it is coming delta P gc 2 plus apf 2 into u 1 right, so that means, this generation delta P g 2, actually it will chase this contacted power demand this one plus apf 2 into u 1.

This is actually with the with the during transient this will change, but delta P gc2 contract it will remain constant, because it is contracted power demand. But, during transient it will change, but at steady-state it will generate the additional 0.002 per unit megawatt right that means that means, I will go back to once again to that block diagram just, because here only partially it was done.

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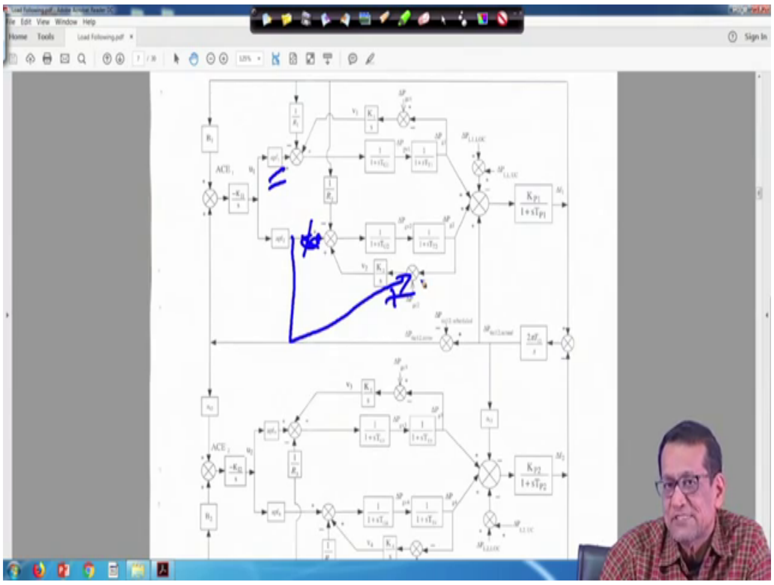

So, if you go to that block diagram here right, so in this case what will happen that this is my apf 2 right, and this is my load following thing, so what will happen that this apf 1 will be there. And instead of giving this one right, you can put this one to here this block that is what has been done there, so it should not be there.

Such that apart from this and suppose this is 60.6, so 60 percent of the your total power whatever uncontract one will be generate by this GENCO unit 1. And apart from generating contacted power by generating unit 2 right, this additional uncontracted demand also will be supplied, if the unit 2 as sufficient reserve right, so that is why, this way it has been made, but load following controller sorry load following controller is already there right. So, this is actually your what to call this additional thing it has come. So, everything is taken together.

Now, now if we take the ACE participation factor that apf 1 suppose if we take 0.8, and apf 2 0.2 that means, that generation unit1 will generate 0.004 per unit megawatt steady-state 0.8 into 0.005, so 0.004. And apart from generating contacted power of unit2, it will generate additional power that extra that is 0.001 that has to be added and that should be the steady-state. Now, with all other conditions remaining the same as in case 3, the uncontracted power demand in area-1 will be shared in proportion to the ACE participation factor of the units in area-1. Then, at steady-state unit1 and unit2 will generate the following power as equation 18 right.

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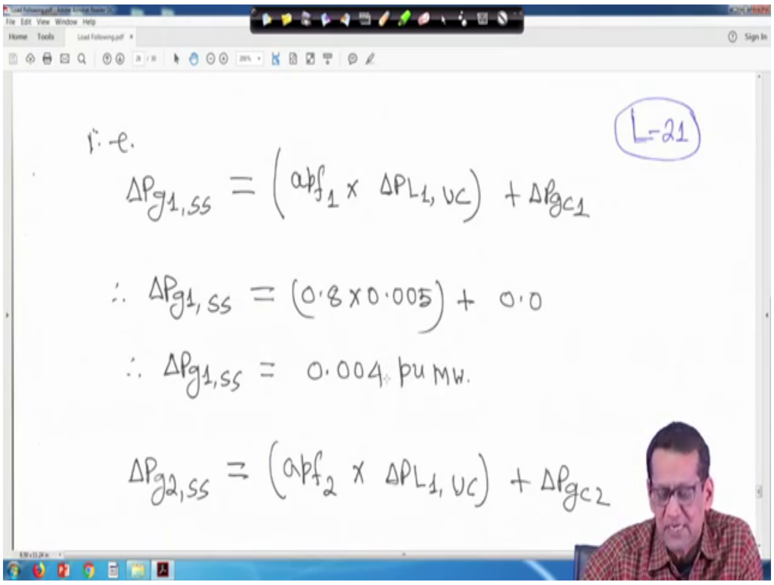

So, delta P g 1 ssSS I told you, it will be apf 1 into delta P L 1 uc, so that is nothing but your 0.8 into 0.005, so 0.004 megawatt, I told you. Delta P g 2, ss will be contacted power delta P gc 2 plus apf 2 into delta P L 1 uc.

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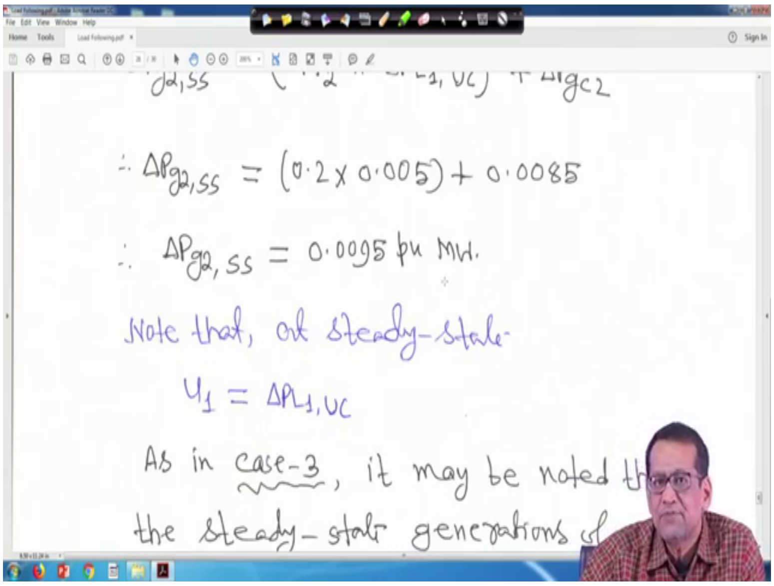

So, 0.2 into 0.005 plus 0.0085, so it is actually 0.0095 per unit megawatt right.

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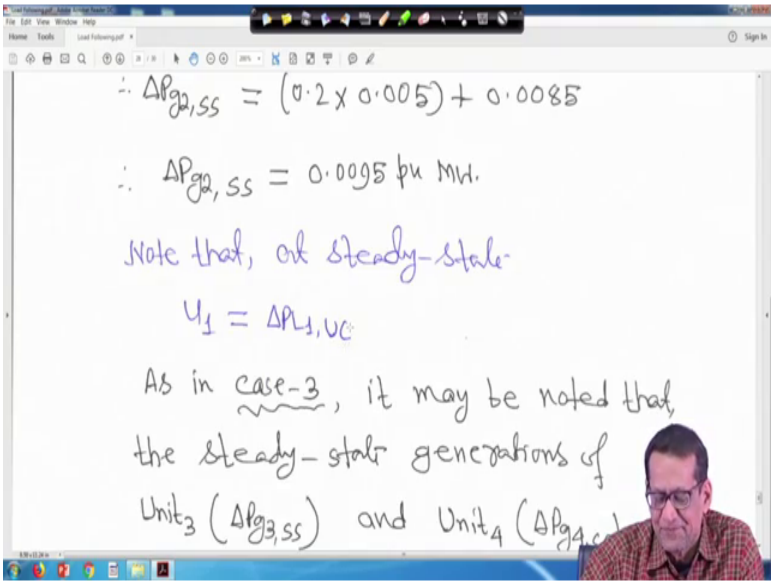

Note that, a steady-state I told you, u 1 will be is equal to uncontracted power, you can verify through its simulation although this plot was not shown, but you can verify. As in case 3, it may be noted that the steady-state generation of unit 3 and unit 4 remains same, because we did not disturb any other thing in the area-2 right.

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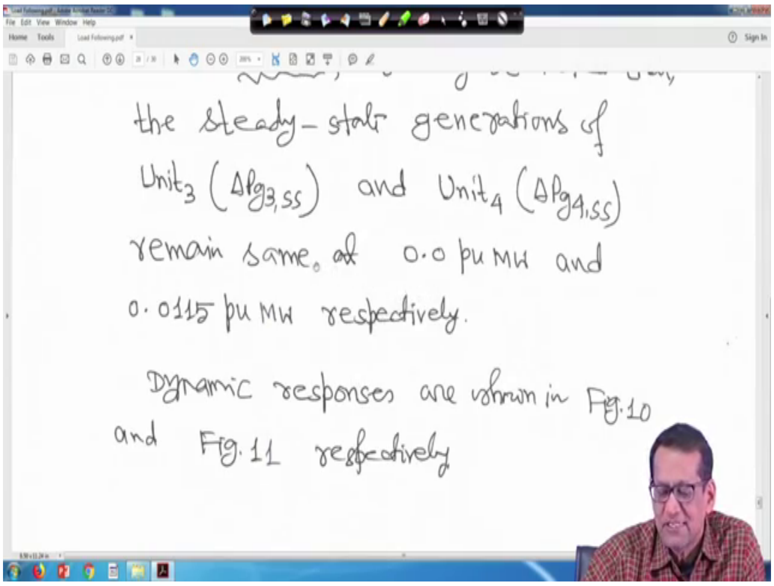

And so it is actually delta P g3 steady-state will be 0.0 per unit megawatt and delta P g 4, ss will be 0.0115 per unit megawatt respectively right. So, dynamic responses are shown in figure 10 and 11. Now, if you look into that, that this is delta f 1 frequency going to your steady-state is going to the deviation is going to 0 values. Delta f 2 going to steady-state, going to 0 value frequency deviation. And tie power same as we lot of oscillations, but all these things it is matching right.

And if you see delta P g1 right delta P g1 that dashed 1, now generating 0.04 per unit megawatt as this thing. And this delta P g 2 apart from its uncontracted power demand, it has taken that 0.001 additional power. So, 0.095 per unit megawatt right, so that is happening here, because this if we look at the scale, this is happening.

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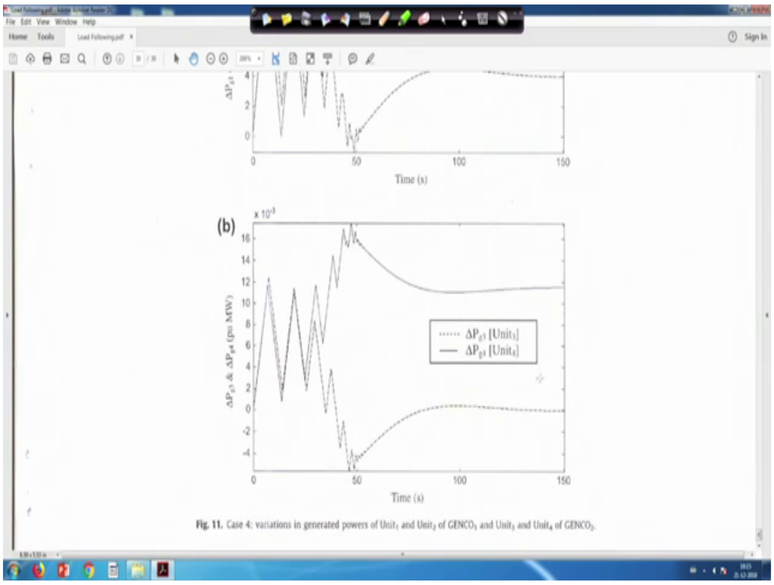

Similarly, for your delta P g 3 and P g 4, so delta same as before; so, delta P g 3 is coming to steady-state at 0.0 and delta P g 4 same as before right. So, same value it is showing. So, so this is your what you call that your variations of is whatever is happening that is during transient, but during steady-state, I mean that the time of steady-state, all these things are becoming you are what you call, the matching to a steady-state value right. So, only thing is that just I would like to tell that simulation thing we cannot do in the exam right. So, only steady-state thing, so how formulas are given, how things are happening, everything you have to study.

Thank you very much. We will be back.