Power System Dynamics
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Lecture - 21
Small Signal Stability of a Single Machine Infinite Bus System-Power System Stabilizers (PSS)

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Friends, today we will continue our study on small signal stability of a single machine infinite bus system. In the previous lecture, we have studied the effect of automatic voltage regulator on the damping and synchronizing torque coefficients. We have seen that in case the operating condition is such that such that the constant K_5 is negative and if we increase the AVR gain then we find actually that the damping torque coefficient becomes negative while the synchronizing torque coefficient is positive that means we have a very conflicting type of effect on the damping and synchronizing torque coefficients, when the AVR is considered. Okay that is now we have also computed through else simple example that if we increase the AVR gain right then the damping torque coefficient becomes more and more negative.

Now to illustrate this thing further for a typical problem, we have computed the K_1cases constants over a wide range of operating condition and we will just examine how these constants vary as the system loading varies.

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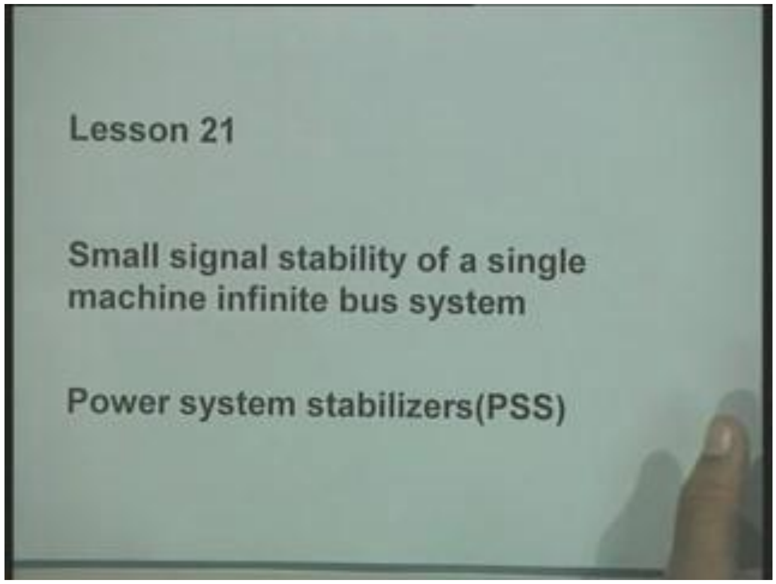

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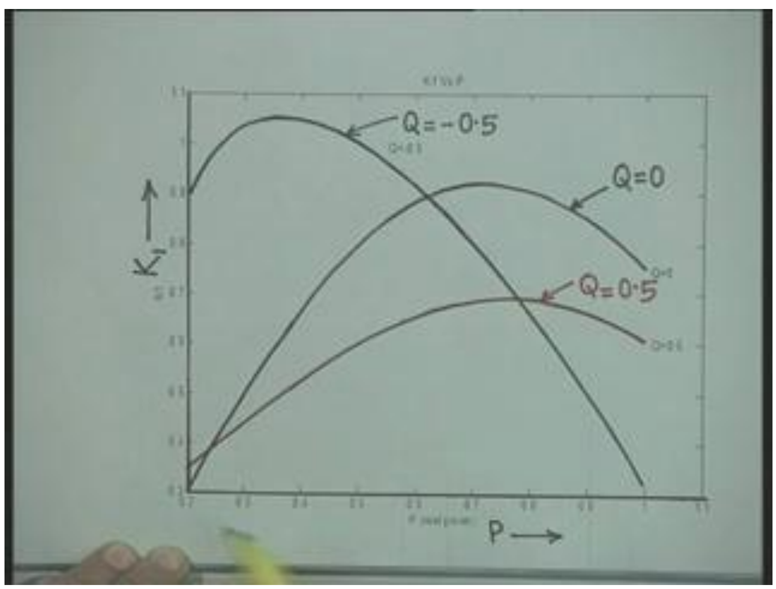

In this figure in this figure we have plotted the variation of constant K_1 as a function of real power output P for 3 different values of reactive power output that is this graph shows this graph shows the variation of K_1 variation of K_1 for Q equal to 0 that is the reactive power output of the generator is 0 and we are varying the real power only okay.

We can see here actually that constant K_1 increases up to some value of real power output and then starts decreasing okay then for reactive power Q equal to 0.5. Okay, now here when I say Q is positive means the we are supplying lagging lagging power factor load, okay therefore for Q equal to .5 right the constant K_1 is varying in this fashion again its variation is similar to what we got for Q equal to 0 it increases it increases and it becomes maximum and then starts decreasing you can see here actually that the value of K_1 is less than is less for Q equal to .5 as compared to what we got for Q equal to 0. Okay another graph which is shown here is that Q is equal to minus .5 that is it supplies leading power factor load okay.

Now we can see here that again K_1 first increases and then starts decreasing, okay therefore the trend is similar and 1 thing we observe that in this complete range where P is varied from .2 to 1 per unit right the K_1 remains constant I am y K_1remains positive not constant K_1 remains positive and it is its magnitude is affected by the reactive power which it supplies.

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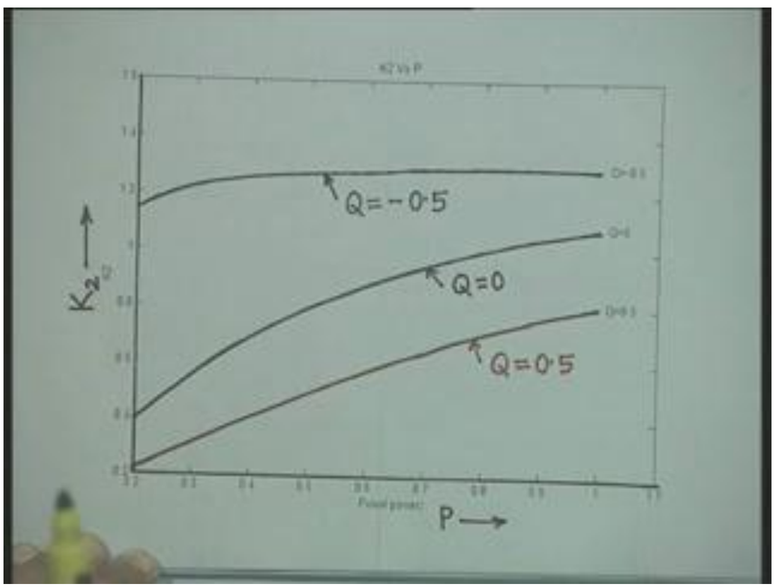

This graph shows the plot of constant K_2 as function of P that is the real power output of the generator for 3 different values of Q right. Now we find here actually that in all the 3 cases where Q equal to 0, Q equal to 0.5 or Q equal to minus 0.5 right. The K_2 is increasing over the range which we have considered from 0.2 to 1 that is this computations have been done or the graphs are plotted for varying real power output from very low value that is .2 per unit to 1 per unit right and further we can see here again that as the reactive power output becomes negative the value of K_2 is more that is K_2 is more for leading power factors load and it decreases when the power factor is lagging right.

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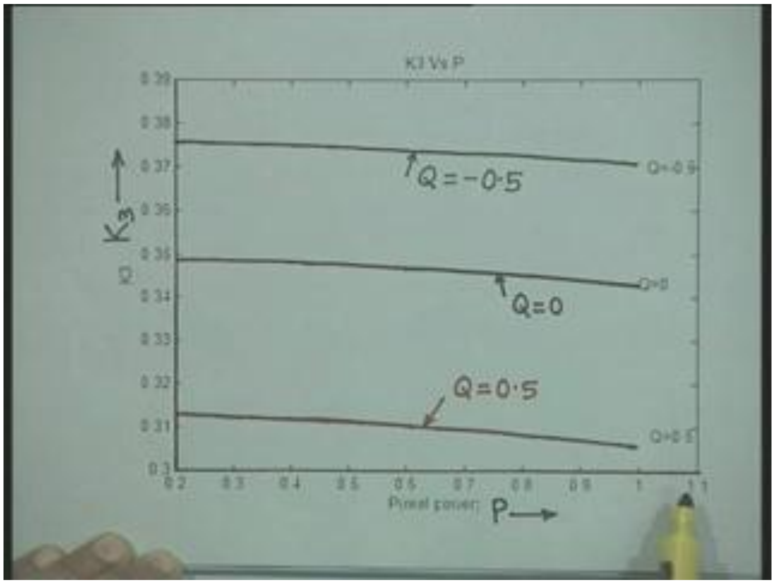

This constant K_3 if you see that it is also affected by the reactive power output Q equal to 0 this is the graph Q equal to minus .5 this is the graph and Q equal to 0.5 this is the graph but for a given value of Q the variation in K_3 as the value the value of P varies is very insignificant, okay this practically it is a flat curve.

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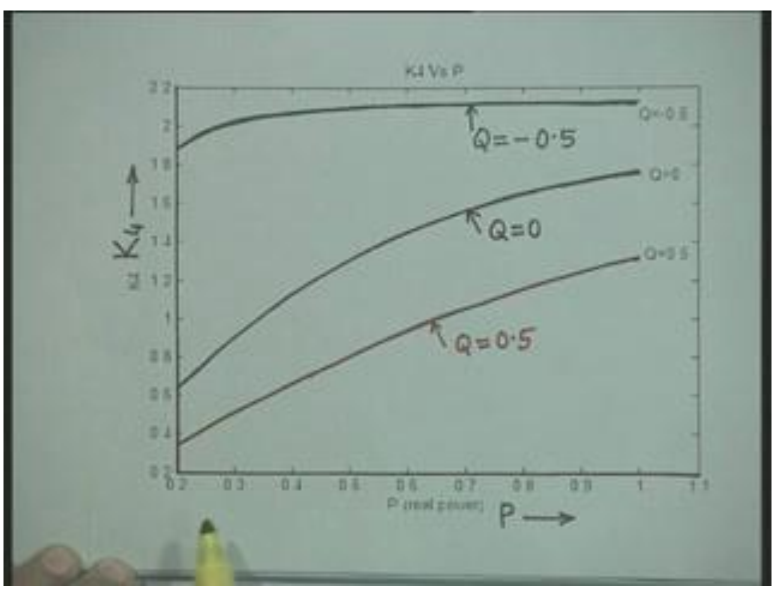

Now this graph shows the variation of constant K_4 as function of real power output P for 3 different values of Q again that is Q equal to 0, Q equal to .5 and Q equal to minus .5 again you can see here actually that the constant K_4 varies as the real power output varies and is also a heavily depended upon the value of reactive power output. But still we can see actually that this constants K_1 to K_4 right over the completely over operating range which we have considered that is ah real power output varying from very low value like point 2 per unit to 1 per unit and the reactive power varying from .5 to minus .5 right the ah constant $K_1$to K_4 remain positive all through.

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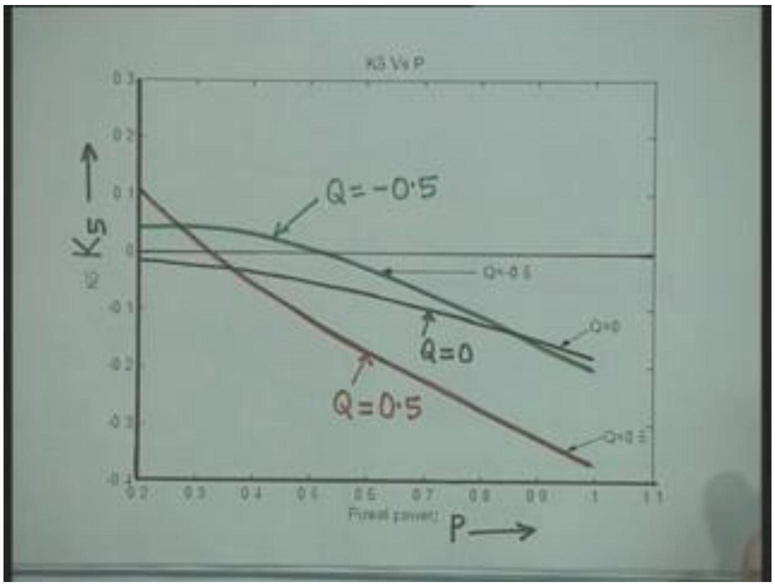

Now here is the plot for constant K_5 again as function of real power P for 3 different values of Q now this line represents the reference axis that is K_5 is 0 right. Now you can see here actually that if I consider Q equal to 0 right in this particular case the the value of K_5 is negative all through from .2 to 1 per unit value of P that is the real power P is varying from .2 to 1 or Q equal to 0, it is all through then when it is plotted for Q equal to .5 right it is seen that for P varying from .2 to some value around .35 or so right the K_5 is positive and then it becomes negative.

Similarly for Q equal to minus .5 K_5 remains positive for about for P equal to .5 nearly and then it becomes again negative therefore this K_5 is the most important parameter right which affects the small signal stability of the system and sometimes we {u} ((00:10:31 min)) we call this K_5 as the culprit. Now we can very clearly see actually in this plot that K_5 is positive for light loading condition right while it becomes negative for heavy loading conditions but even actually in this particular case we find actually that the for a moderate loading also it is negative and once this K_5 is negative right it produces produces negative damping torque coefficient when the AVR gain is increased, okay.

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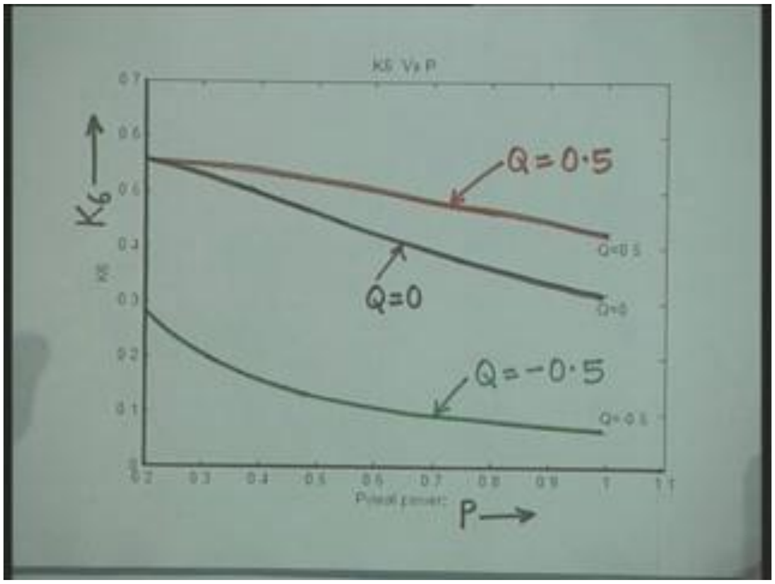

The last plot is for the constant K_6 which shows actually the variation of constant K_6 as function of P for 3 different values of Q, Q equal to 0 Q equal to minus .5 and Q equal to .5 again we can see here actually that yes the constant K_6 is positive all through right and it decreases as the real power output P increases for any value of Q that you can see that Q equal to .5 or Q equal to 0 or Q equal to minus .5 it decreases but we can clearly see actually that the value of K_6 remains positive okay.

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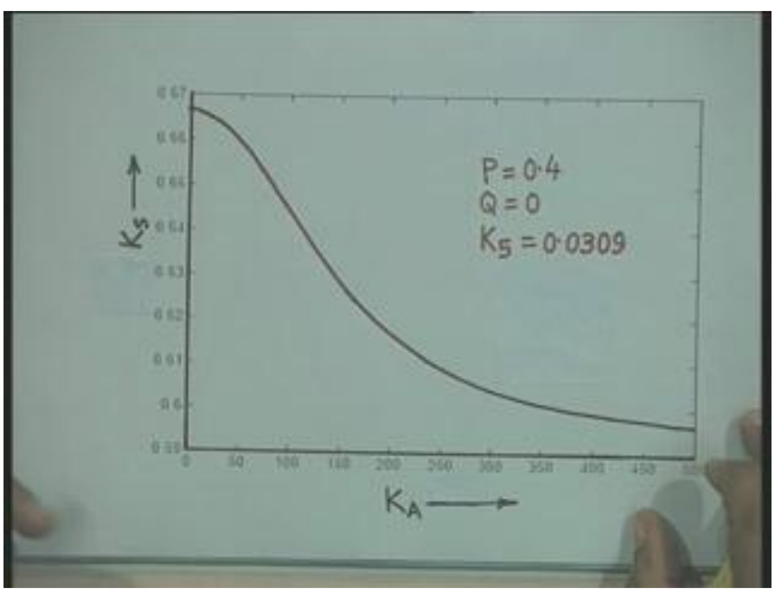

Now to understand more clearly the effect of K_5 on damping and synchronizing torque coefficients, the computations were carried out for synchronizing torque coefficient as a function of K_A that is the AVR gain. Now we have considered 2 loading conditions, 1 loading condition is corresponding to ah loading condition 1 loading condition is such that K_5 comes out to be positive therefore this that is K_5 equal to 0.0309 where the real power output is .4 per unit and reactive power output is 0 that means it is a light loading condition K_5 positive.

Now when we increase this AVR gain then synchronizing torque coefficient this is the synchronizing torque coefficient it decreases right although it is positive all through it decreases, its magnitude decreases.

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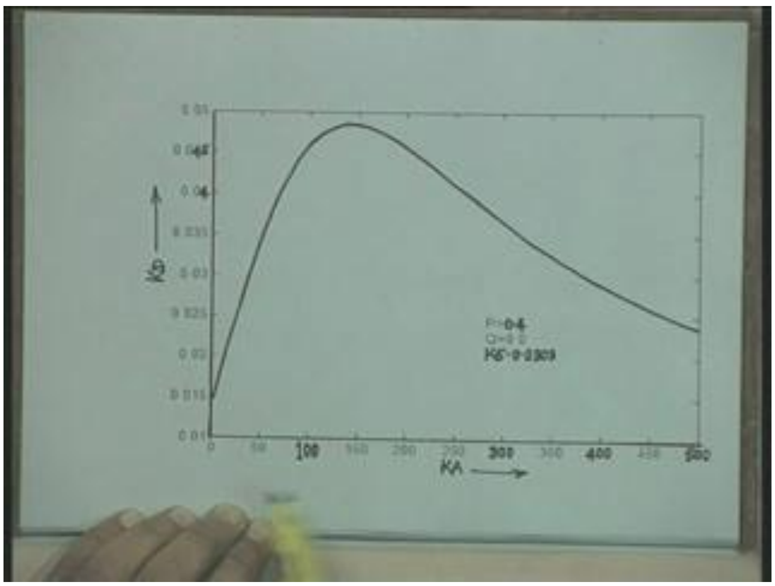

For the for the same operating condition the damping torque coefficient is plotted here and it is seen actually that the damping torque coefficient increases with increase in K_A and it becomes maximum for come value of K_A then it starts further decreasing. Now over this wide range of K_A that is um in this graph the K_A is varied from 0 to 500 right.

Now over this complete range we can clearly see that that the K_S is positive but it decreases however the K_D that is the damping torque coefficient it increases and then starts decreasing but still it is positive all through over the complete operating range that is the K varying from 0 to 500. Then we have consider another loading condition a heavy loading condition the loading condition is that a real power output P is .9 per unit and the reactive power output is .3 per unit for this operating condition and other system parameters okay, the K_5 is computed it comes out to be minus 0.1475.

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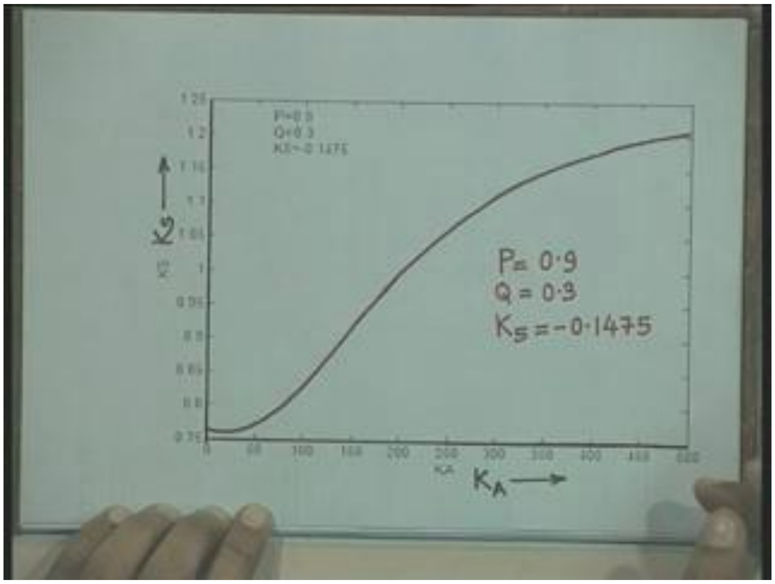

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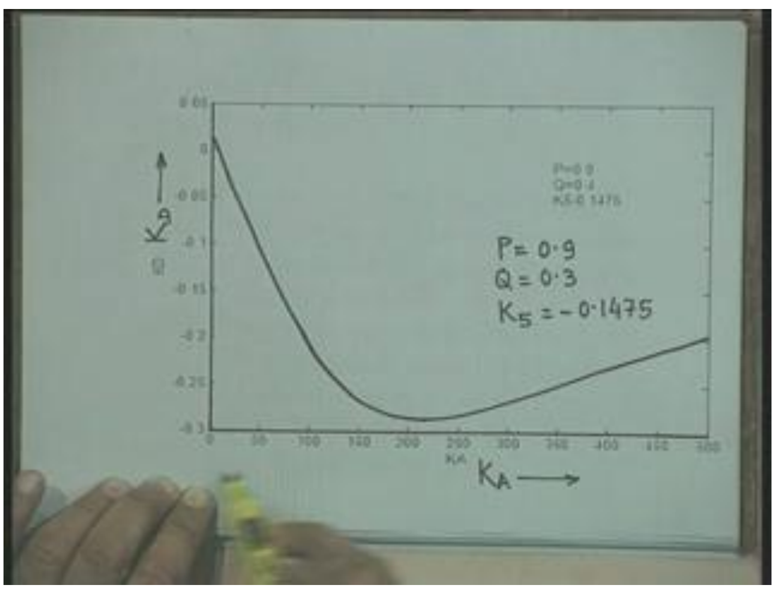

Now considering this K_5 equal to minus 0.1475 okay and all other constants which where computed for this operating condition right the the value of K_S synchronizing torque coefficient and damping torque coefficient are computed. The synchronizing torque coefficient you can see here it increases with the increase in AVR gain K_A right it you know the over a small range over a small range practically it is constant but afterwards it increases and it is positive all through okay. Now you is this graph shows the variation of damping torque coefficient K_D okay, you can easily see that when K_A is 0 the value of K_D is slightly positive.

We have seen actually in the previous discussion right if we do not include the AVR okay and assume assume constant field voltage right and at that time the effect of demagnetization or armature reaction is to give some positive damping torque. Therefore K equal to 0 a small positive damping torque and as the value of K is increase the damping torque becomes 0 right and then it remains negative it becomes it attains some maximum negative value and then it decreases okay and we can see here actually that although it first it is it is positive initially K equal to 0 then it it decreases in a fast rate, it becomes negative right and all the range 0 to 500 the K_D is negative all through right.

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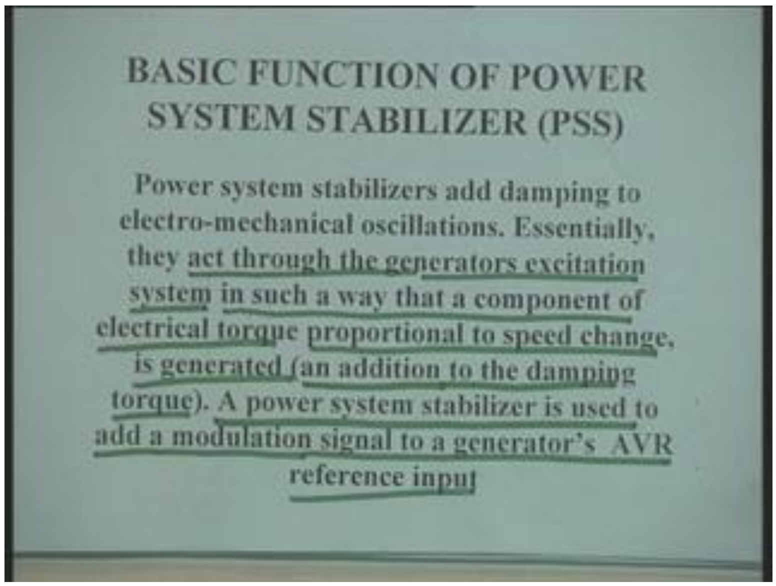

It means we have find here that that the when you include the AVR AVR then the damping torque becomes negative. Okay now in any practical system automatic voltage regulatory is required to regulate the terminal voltage. Okay because we cannot say that we will go for a manual control and keep this field voltage constant if you do that you will find actually that they negative damping torque is not produced but AVR is required and further to regulate the terminal voltage within the certain certain tolerance right. You have to have certain steady state gain larger the value of AVR gain right less will be the steady state error.

Okay and therefore AVR is required to regulate the terminal voltage it has to have large gain because larger the gain of the AVR right its response is going to be fast and the excitation system whose response is fast is capable of improving the transient stability limit of the system. However, when the when we consider a small signal stability or a dynamic stability of the system right we find that it will add negative damping torque coefficient or negative damping torque.

Now when the system has negative damping torque whenever the oscillations are created in the system these oscillations will grow. Okay and when the oscillations grow you will find actually that on any power transmission line you will find actually that due to the rotor oscillations right the the there will be oscillations in the power flow on transmission lines right and the protective relays are provided to to detect these oscillations and protective relays will disconnect the system or trip the transmission line whenever such oscillations are produced, before the system losses synchronism right. But the problem basically is that can be allow the situation to happen answer is obviously that yes, we have to find a solution to overcome this problem of negative damping produced due to the AVR action and the answer is the incorporation of power system stabilizer right.

Now first let us see what is the function of the power system stabilizer? Here I have written basic function of power system stabilizer you have to very clearly understand the basic function then we we will try to see how we achieve this objective. Power system stabilizers add damping to electromechanical oscillations this is a fundament thing that we are we are talking of electro-mechanical oscillations that is the oscillations of the synchronous machine rotors right.

It is a electro-mechanical oscillations essentially essentially the power system stabilizer act through the generators excitation system in such a way that a component of electrical torque proportional to speed change is generated that is we can see here, the PSS act through the generators excitation system that is when I discuss the different type of excitation system at the AVR input I have repeatedly told that there is 1 signal coming from the power system stabilizer okay and we that signal was denoted as V_S a stabilizing signal right.

Therefore we can say here that this act through the generator excitation system and it acts in such a way that a comp1nt of electrical torque proportional to speed change is generated. We know that a torque which is produced in phase with the speed deviation right is the damping torque. The damping torque is K_D into delta omega R right therefore if we can produce a torque which is in phase with speed deviation then it will be it then it acts as a or it acts to damp the oscillations.

Now we can further say that this this torque which is produced is the additional this is an additional an addition to the damping torque because system has its own damping also there is always some damping which is there inherent in the system therefore the PSS will provide a damping torque which will be additional to the existing system damping. A power system stabilizer is used to used to add a modulation signal to the generator’s AVR reference input that is they they stabilizing signal which we which we obtained through the power system stabilizer right that signal will be added at the at the summing point of the AVR or we can say actually that it is added to the AVR reference input okay.

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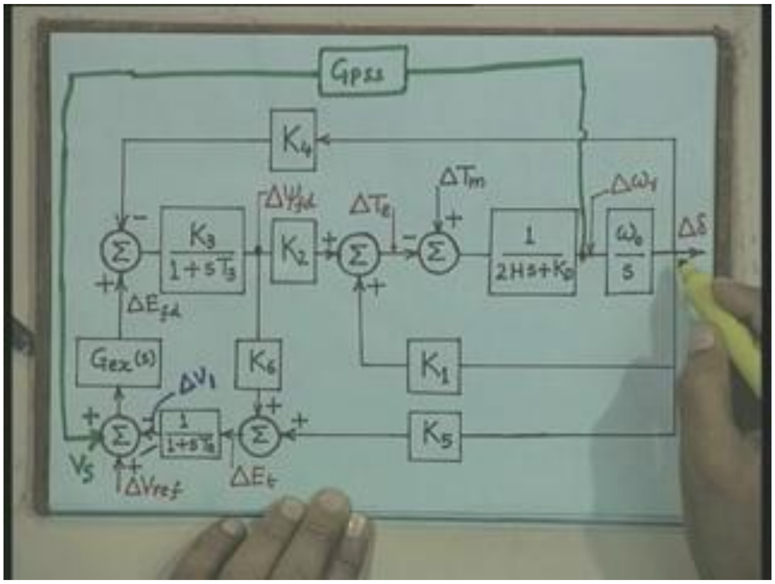

Now let us again come back to our K_1 K_6 model that is the Heffron-Phillips model now in this model let us see how to incorporate the PSS. Now this is a summing point, this is a summing point where the reference voltage is compared with the terminal voltage in the AVR we have this this is the small signal or you can say the small perturbation model therefore all the quantities are shown as deviations from the nominal values right delta V reference is the deviation from the reference of voltage okay then this signal delta V_1 is is corresponding to delta E_t because this transfer function was incorporated to take a account for voltage transducer. Okay therefore at the summing point we want to add a signal this signal we will, we are representing as V_S and this will be added we are putting a plus sign here right.

Now this signal is derived from the speed deviation that is in this transformal transfer function model this is the point where I can sense the speed deviation delta omega r. Okay therefore here I put a transfer function we will denote this as G_{pss} that is the transfer function of the power system stabilizer. Its input is derived from the speed deviation, okay the output of this transfer function that is the will be the stabilizing signal and this stabilizing signal is added to the summing point of the AVR. Okay that is you can see here actually in this block diagram what I have done is I have taken taken input from this point which represents delta omega r. Okay it enters the transfer function of the PSS and output of the transfer function of PSS is the stabilizing signal, this stabilizing signal is put here at the summing point okay.

Now, now we have to see actually that in practice in practice how do we physically realize the speed deviation signal because you can you can sense the speed by putting a speed transducer on the shaft of the synchronous generator that is generally today the standard practice is to have a toothed wheel mounted on the shaft to the synchronous generator and we put a magnetic pickup right. Therefore, the number of pulses which are generated by the magnetic pickup are proportional to the speed of the shaft right and ah we can very very precisely measure the actual speed of the synchronous generator and this speed is compared with the reference speed and the difference is the delta omega the speed deviation. Okay and now what we have to see is see is that what should be the structure of this G_{pss} what should be the transfer function of the power system stabilizer.

Now to understand this what we do is we look at we look at this transfer function model carefully. Now if you see here actually that when this signal V_S is injected here. Okay the let us see that we want to obtain obtain air gap torque or variation air gap torque by varying this V_S. Okay suppose actually I am just putting signal stabilizing signal V_S and I want to know how much is the air gap torque produced due to this signal only that is I want to know how much is the air gap torque produced by this stabilizing signal only.

Now you can easily say that this signal ah or the air gap torque produced can be easily obtained through this loop can you see this this is the loop actually because here we are not going to consider the deviation in angle right that we are looking only that if I am putting this signal how much is the stabilizing produced therefore you have to see very careful here the the let us just look actually how much is the delta psi f_d produced due to V_S. Okay then the the torque produced due to the PSS will be equal to delta psi f_d into K $_2$ that is this is the torque which is going to be produced. Okay and therefore we can say that if we can write the expression for delta psi f_d as a function of V_S right then we can make out actually that if I vary this V_S how much is the stabilizing torque produced, okay.

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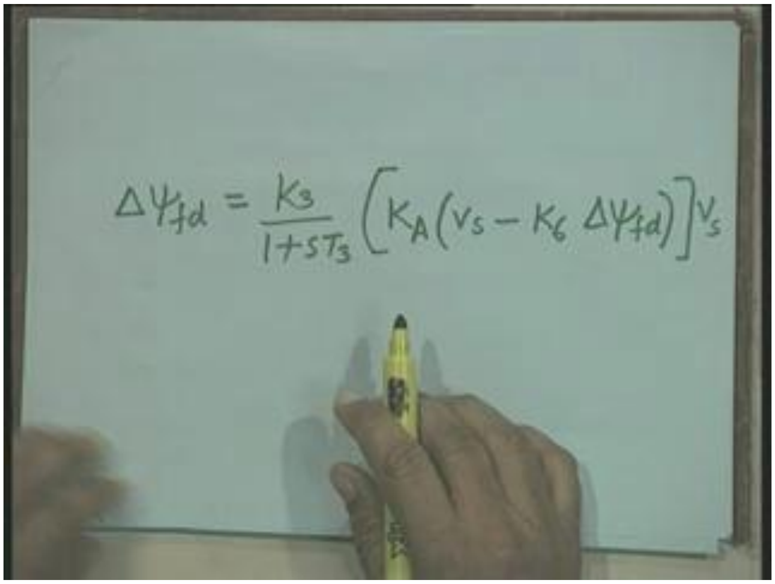

Now you can see that if this V_S is coming here right now to find out this delta psi f_d due to this stabilizing signal only we have to consider only this portion of the transfer function, okay. Now delta psi f_d can be written, Now if I just see it here we can write down looking at this expression delta psi f_d equal to equal to this transfer function that is you put K_3 over 1 plus S times T_3.

Okay, now input to this is coming through this G_{exs} and we will be assuming G_x as as K right therefore this is coming through K_A. Okay and now input to this is V_S minus delta V_1 V_S minus delta V_1 there are assuming delta V reference to be 0, okay therefore we can put K_A you can take this K into into V_S minus further to simplify this understanding, we will assume this T_r equal to 0 this time constant of the voltage sensor or voltage transducer is very small and you can make this T_r to be 0. So that we can say that here it is V_S minus minus K_6 times K_6 times delta psi f_d. Okay that is we get once simple expression this multiplied by V_S then this delta psi f_d, I can write now here delta psi f_d produced due to stabilizing signal only can be written as K_3 divided by 1 plus S times T_3 multiplied by K_A into V_S minus K_6 delta psi f_d, okay.

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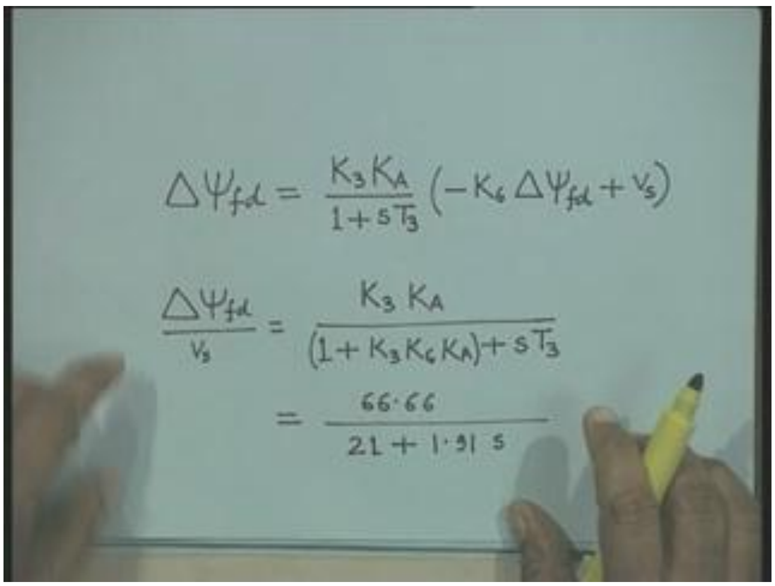

Now this expression this expression which I have written here is simplified and put in this form delta psi f_d equal to K_3 K_A, 1 plus S times T $_3$ in bracket minus K_6 delta psi f_d plus V_S. Okay this is a very important step once you very carefully derive and see that the delta psi f_d produced due to the stabilizing signal V_S can be written in this form. Now here and if you simplify this and and write the expression for delta psi f_d divided by V_S that the transfer function relating the change in flux linkages due to stabilizing signal only the delta psi f_d upon V_S, K_3 K_A divided by 1 plus K_3 K_6 K_A plus s times T_3. This is the simple transfer function you will get relating the change in flux linkage to a stabilizing signal V_S. Okay now to have clear understanding okay about this effect of stabilizing signal on the on the air gap torque produced due to stabilizing signal.

We take this example for a typical example which we consider earlier these where the constants K_1, K_2, K_3, K_4, T_3, K_5 while taken as negative K_6 is taken as 0.3, this T_R is neglected although when the previous case we have taken T_R equal to 0.02 but for the purpose of simplification we are ignoring or we are neglecting this T_R making T_R equal to 0 the effect of neglecting T_R is the or or I can say that the error error caused due to this assumption is practically insignificant .We will assume this G_{ex} the transfer function of the exciter as K_A and its value we will take as 200 a typical value equal to 200. Okay now with this parameters assumed if we make the compute this ratio delta psi f_d divided by V_S it comes out to be equal to 66.66 divided by 21plus 1.91s, okay.

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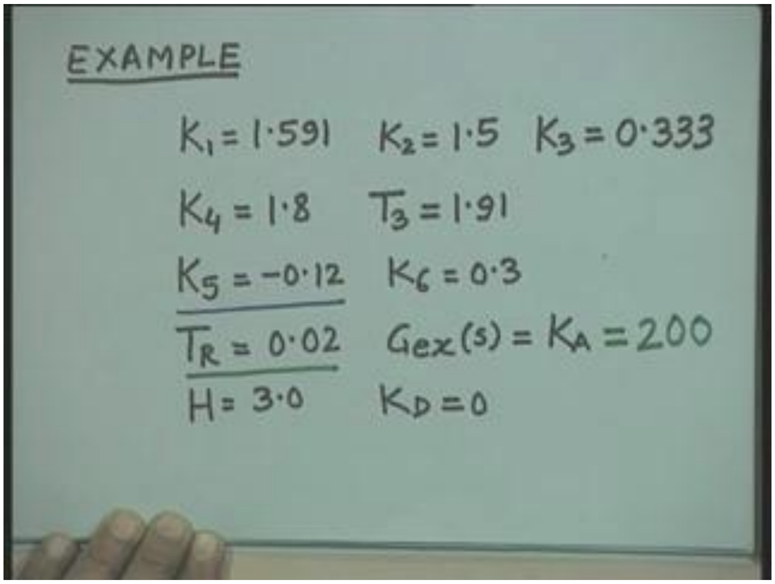

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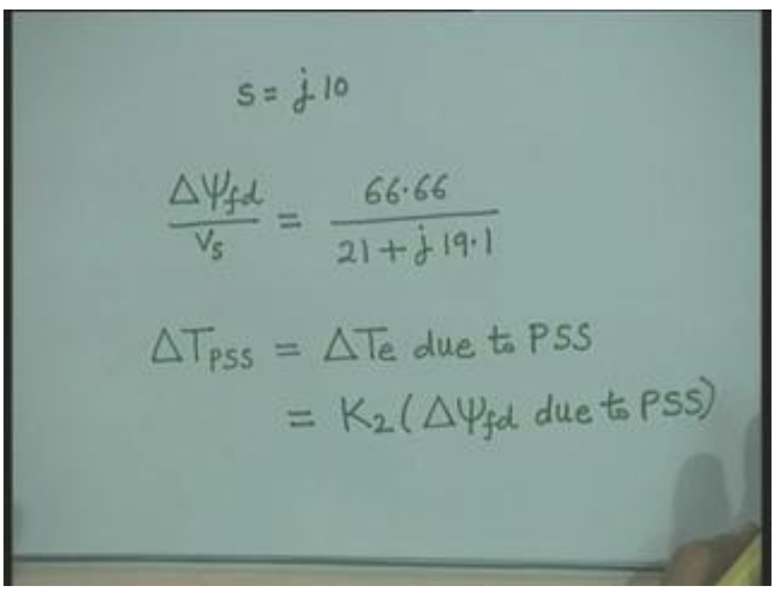

Now you assume that the rotor oscillation frequency is 10 radians per second 10 electrical radians per second, so that put as equal to j10 then this transfer function becomes 66.6 divided by 21 plus j times 19.1 it was 1.91 omega is 10 it becomes 19.1. Now we can write down the delta TPSS that is the air gap torque produced due to the PSS action only is written as can be written as delta T_e due to PSS that is delta T PSS is delta T or air gap torque due to PSS which is going to be equal to K_2 times delta psi f_d due to due to PSS okay. Now we have just now computed actually this delta psi f_d okay as the the transfer function delta psi f_d by V_S okay.

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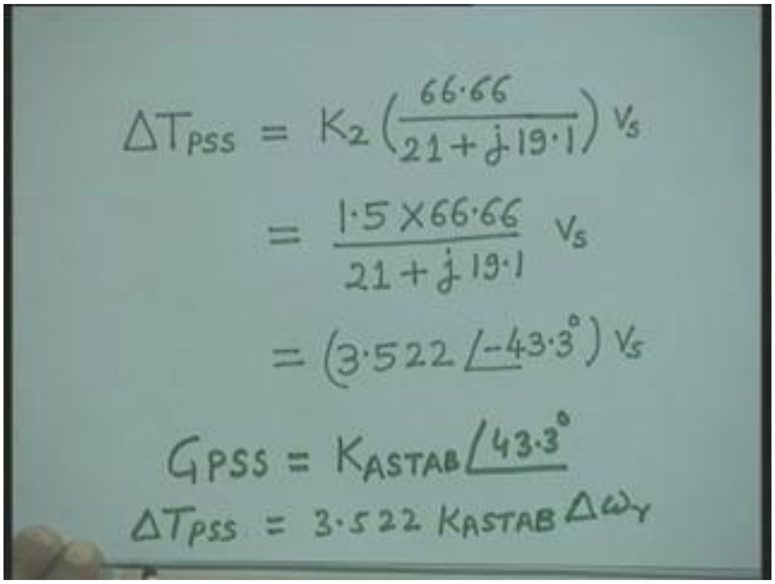

Therefore, now you substitute the expression for or the value for TK_2 right we get the delta T due to PSS as as 1.5 into 66.6 divided by 21 plus j times 19.1 into V_S into V_S. Now for this for this complex you can say the function right we can find out its magnitude and phase angle. We can find out the magnitude and phase angle that is what you have to do is you take the magnitude of the numerator divided by magnitude of denominator and this ratio will give the magnitude then find out the phase angle of the numerator in this case phase angle of the numerator is 0 because it is a real number, find out the phase angle of the denominator. For example, in this case phase angle of this denominator term is going to be say theta is the phase angle its transient inverse 19.1 divided by 21. Okay and therefore the net phase angle of this function will come out to be negative right therefore delta T_{PSS} is obtained as 3.522 the phase angle is minus 43.3 degrees into V_S okay.

Now suppose I want I want that this the torque produced due to PSS is a pure damping torque pure damping torque. Okay in that sense that I must produce this V_S that the stabilizing signal stabilizing signal it should be such that it will it will compensate for this phase length. Okay and therefore if I if I now assume the transfer function I am just putting very high very, you can say a simple case that is if I assume G_{PSS} equal to I am just putting G_{PSS} equal to some constant I call it K_A, a K stabilizer K_{ASTA} stabilizer.

Okay and its phase angle I make it 43.3 degrees, okay then then delta P delta T_{PSS} can be written as 3.522 K_A stabilizer I think we can put this STA as STAB stabilizer, sometimes we use the word K stabilizer only that A can be deleted here into delta omega r because V_S is equal to what is V_S, V_S is equal to GPSS into delta omega r therefore, if I now the assume actually that there G_{PSS} is equal to a constant and having its phase angle equal to 43.3 right then the the air gap torque produced due to PSS is 3.522 into K stabilizing delta omega okay.

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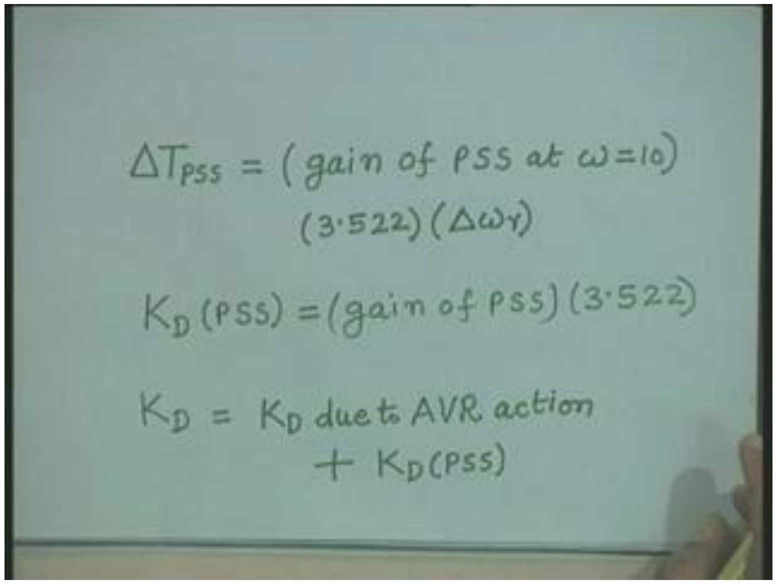

Now if you if you we can write this same thing which I have written just now as delta T_{PSS} is equal to gain of PSS at omega equal to 10 into 3.522 into delta omega r this is what we have written now we will write write down this damping torque coefficient due to PSS, K_D due to PSS will be equal to gain of PSS into 3.522 because this torque is purely a damping torque right and we have compensated for the phase length which is produced by choosing the appropriate transfer function of PSS.

So that we can say that damping torque produced due to PSS is equal to the gain of PSS what so gain you put into 3.522 and the net damping torque which is going to be produced will be equal to K_D due to AVR action plus K_D due to PSS. The net damping torque which is going to be produced will be equal to K_D due to AVR action plus K_D due to PSS plus there will be some inherent damping torque which may be present in the system because we have seen actually that when I did not consider AVR, we did not PSS still there was some damping torque produced positive damping torque due to demagnetization effect.

Okay now suppose I want actually that I want to simply nullify the effect of AVR action right then the the K_D PSS should be equal to the K_D due to AVR action that is negative, for example in the problem which we have taken problem which we had taken earlier we found that K_D equal was found to be minus 12.27 when we have considered only the the effect of effect of field flux changes that is the demagnetization effect or armature reaction effect right. We found actually that the damping torque contributed I am sorry not it was due to the AVR action with K_A equal 200 the damping torque contributed is minus 12.27 right.

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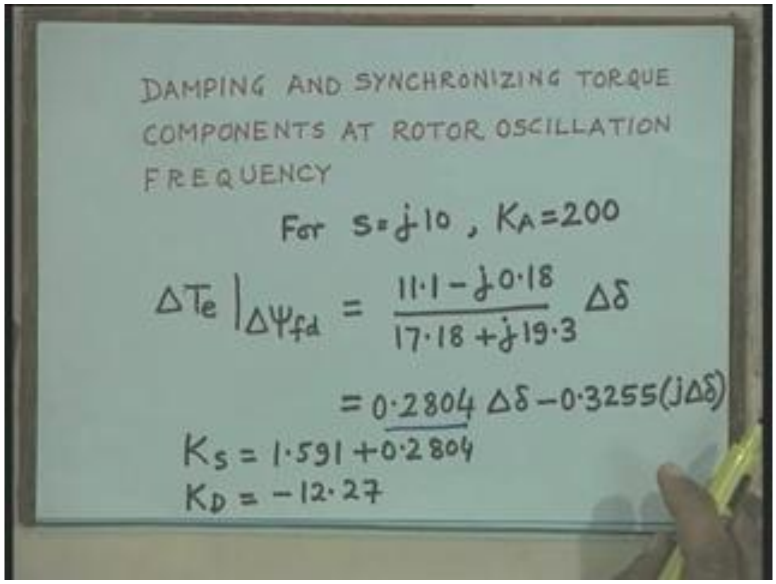

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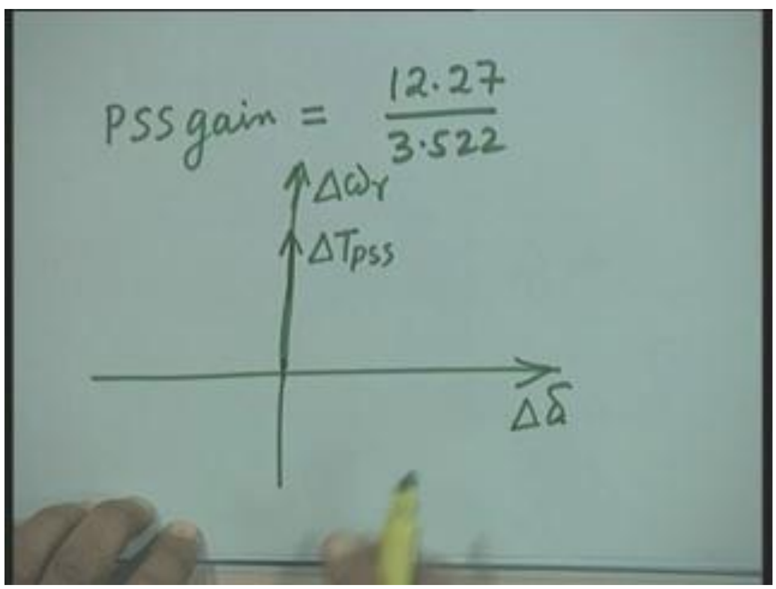

Therefore now if I take the the PSS gain if I take PSS gain equal to 12.27 divided by 3.522 right then this PSS is going to produce positive synchronizing torque coefficient which will just nullify the negative damping torque produced due to the AVR action right but now if I take gain if I take gain which is more than this that is if you set the PSS. So its gain is more than this ratio that is 12.27 divided by 3.522 right then it is going to add to additional damping, it will provide additional damping torque right and therefore we come to 1 very important conclusion that the that the PSS PSS which we have to provide should be in a position to to compensate for this phase length and if you have certain gain.

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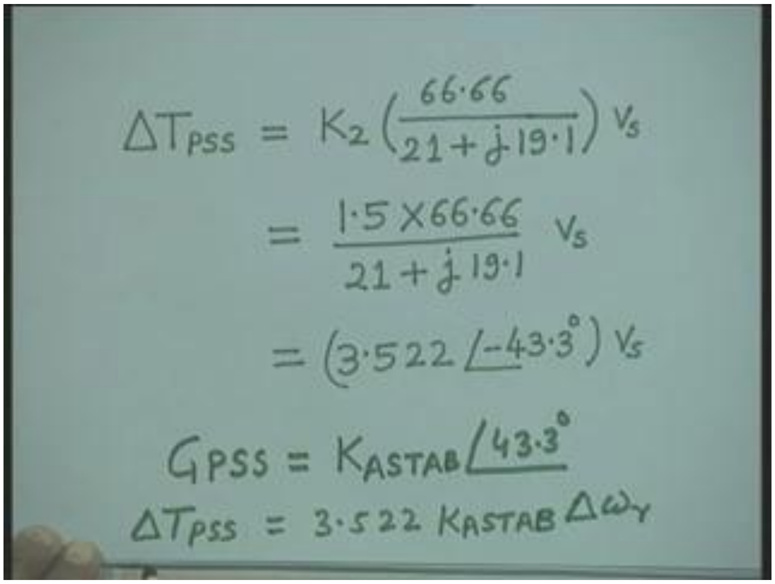

So that it can provide additional damping okay because the the damping due to demagnetization effect was very small although it was positive when we assume this manual control right there was some positive damping but that was very small and therefore actually we want certain damping which will quickly damp out the oscillation whenever there are produced right and therefore there is a necessity to design the PSS properly.

Now another 1 point which you have to understand is that suppose I provide PSS which will not fully compensate for this time ah for this phase length because here the phase angle is 43.3 lagging and if I make PSS to have phase length less than 43.3 that is the PSS compensates for an angle which is less than this that is I can take instead of 43.3 degrees, let us take 30 degrees right.

Now this situation is known as the under compensation that is we are we are not fully compensating the phase length which is there between the stabilizing signal and the air gap torque. Okay now if you have this situation what will happen if you look at the let us look at the let us look at a plain here. I denote this as a delta delta and delta omega r is along y axis okay if suppose you fully compensate for the phase length by choosing the PSS parameters right then the delta T_{PSS} delta T due to PSS will be along this axis right and this is a pure damping torque, okay.

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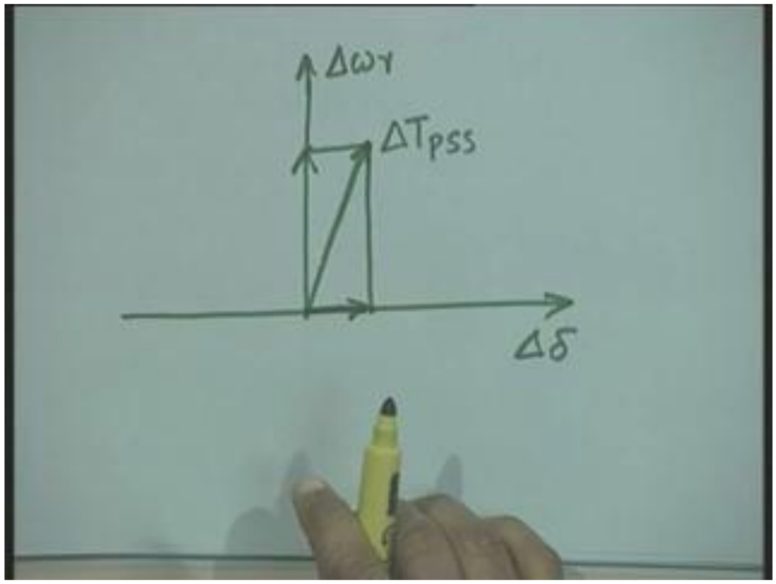

Now suppose you instead of fully compensating if you do ah under compensation under compensation right in that case this is your delta delta this is your delta omega r, delta T_{PSS} will lie somewhere here delta T_{PSS} will be in this position. Okay you understand this point because we have we have we have partially compensated for the system phase length. Now this is the situation then this torque can be this delta T_{PSS} can be resolved into 2 components 1 along delta omega r another along delta delta right.

Now what we see is that this component this is the component of delta PSS along delta delta what is this component know as synchronizing torque and this is this component is the damping torque therefore, the moment you have a situation where you have under compensated right, we get some additional synchronizing torque right and it is desirable because we know that the whenever you design a system when you design a system we should have synchronizing as well as the damping torque coefficient to be positive and here we add this line.

Now you take a third case where if you over compensate for this, suppose you over compensate that is instead of having the phase angle of the G_{PSS} exactly equal to the phase length of the system. Then the delta T_{PSS} is produced can be shown in this plain it will come in this second quadrant that you can put delta T_{PSS} and now you can see here actually that we resolved this into 2 components.

We get a component in phase with delta omega r which is the damping torque and we get another component which is in phase with delta delta synchronous torque coefficient but now we get a negative synchronizing torque coefficient right and therefore in practice in practice it is it is necessary to design the PSS is in such a fashion. So that we do not over compensate okay under compensation if it is there there is no harm the literature shows that 1 can go for under compensation as much as 10 degrees to 30degrees under compensation of the order of 10 degrees to 30 degrees.

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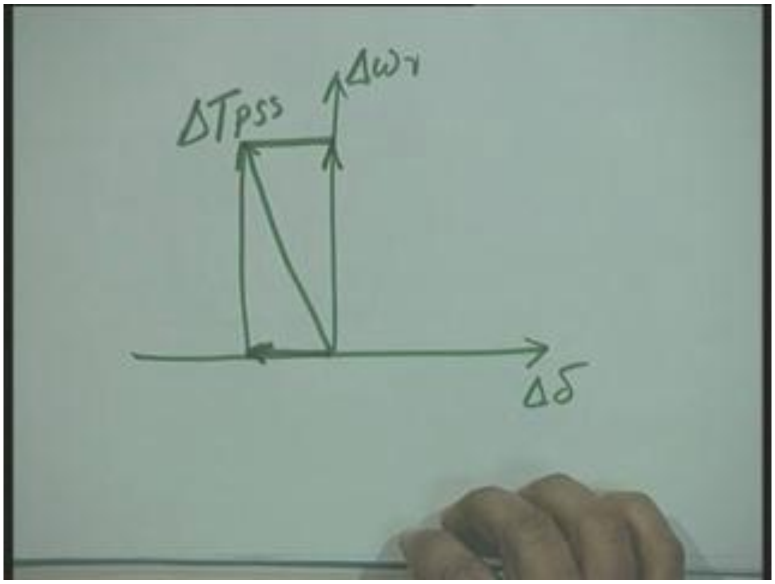

Now what we have considered till now is a simple situation where the excitation system was represented by a constant gain K_A only right. Now this representation is applicable to static excitation system right where the time constant of the exciter is very very low.

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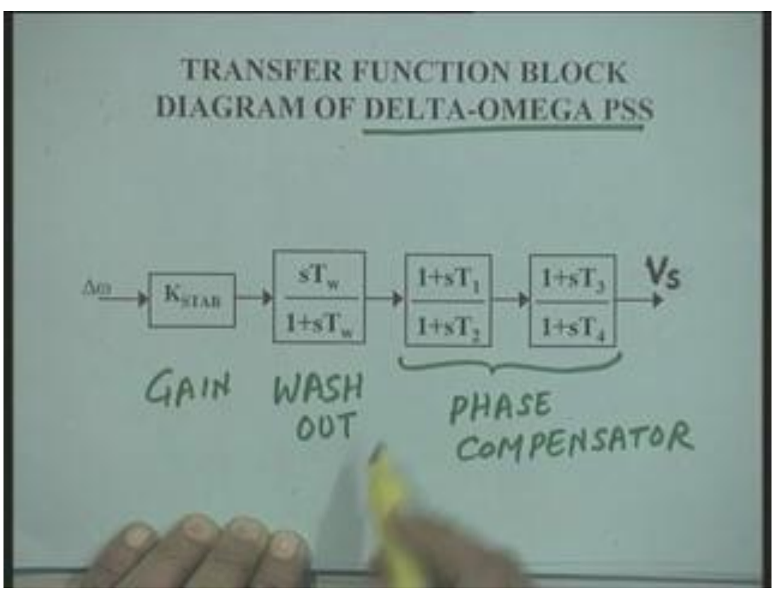

However, when we consider other excitation systems right then we have to account for the actual transfer function of the excitation system and further we can see 2 important points that the the the phase length which is produced depends upon the operating condition because it is function of the system constants and the constants are function of operating condition. Okay and it also depends upon the type of excitation system which we have considered right.

Therefore from that point of view that point of view the transfer function which we have to assume for the for the G_{PSS} are I am sorry transfer function of the power system stabilizer, okay will not be a very simple 1 a general form of the transfer function block diagram of a of delta omega PSS is shown here. Without emphasizing I have told you that the input signal to the PSS is the speed deviation.

Okay and since we want to produce a torque in phase with the speed deviation therefore this is most ah suitable input signal to PSS and this signal is delta omega therefore in the literature this type of power system stabilize or the power system stabilizer with speed deviational input signal is known as delta omega PSS, this is delta omega right therefore it is we use this terminology.

Now here the general transfer function of PSS is shown here that is input to this is delta omega output is the stabilizing signal therefore here first block is showing the stabilizer gain, stabilizer gain. The second block shows ah what is called washout? this is a washout block and these 2 transfer functions represent the phase compensator, phase compensator we have seen the function of these gain how much gain is to be provided because the the gain will determine the amount amount of damping which is going to be produced.

We have also seen the role of this phase compensator because this phase compensator is to provide the required phase compensation that is phase length of the system is to be compensated by putting phase lead therefore compensator is to be provide the desired phase lead for a given frequency. Okay now the function of this washout we will just understand why we require the washout block?

Now we want actually this stabilizing signal to be present only when the rotor is oscillating or there are oscillations in the system. Suppose there is a steady state deviation in the speed from the rated speed to some other value, the steady state deviation right during the steady state deviation we do not want any stabilizing signal to be produced because our basic function is to provide damping to the rotor oscillations. Okay and therefore we provide here a transfer function transfer function whose gain is going to be 0, when their frequency of oscillation is 0.

Therefore, in example in case see sT_w or 1 plus s time T_w that if I put s equal to 0 then this transfer function provide the 0 gain and when there is a steady state change in delta omega no stabilizing signal is produced. Now suppose you provide stabilizing signal or allow the stabilizing signal to be there, stabilizing signal to be there under steady state deviation then it is going to unnecessarily affect our terminal voltage because this signal is entering at the summing point of the AVR. We do not want actually the stabilizing signal to affect the terminal voltage also okay the this transfer function should be a high pass filter. Okay now I will just sum up what we have discussed today. We have studied the effect of variation of loading condition at different constants and we have also studied the how the phase is to be incorporated to obtain the rewire required positive damping. Thank you!