Control Engineering
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Lecture - 15
Models of Industrial Control Devices and Systems (Contd...)

Last time if you recall we were discussing an error detector called synchro error detector.

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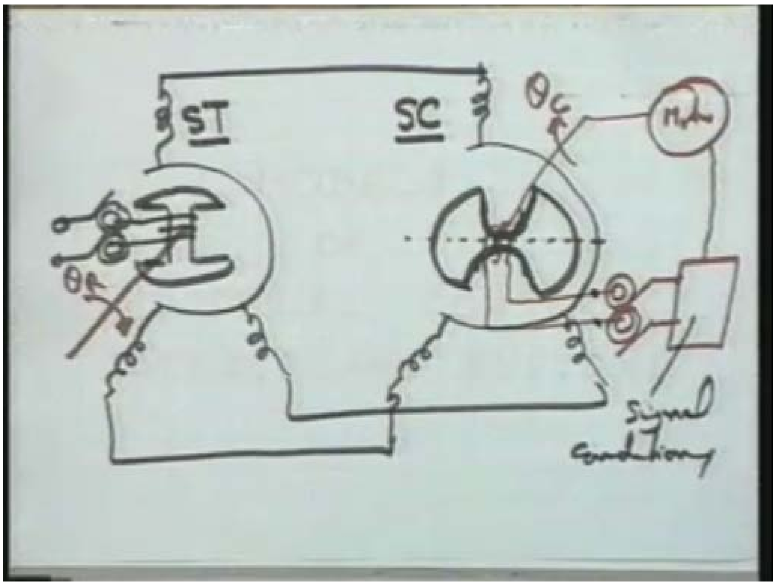

I gave you this block this schematic diagram. In this particular diagram two devices are connected: One device is referred to as the Synchro Transmitter and the other device is the Synchro Controlled Transformer. I told you that the two devices are identical in nature but for the difference in their rotor construction there is a demand of on this particular rotor to be more to be cylindrical so that the impedance seen by this signal condition in the wire should not be a function of the rotor position. Now the requirement of this is that you see a signal which is proportional to the difference of the two shaft positions should be available to us. You keep in mind; we have already seen that how a particular potentiometer pair works.

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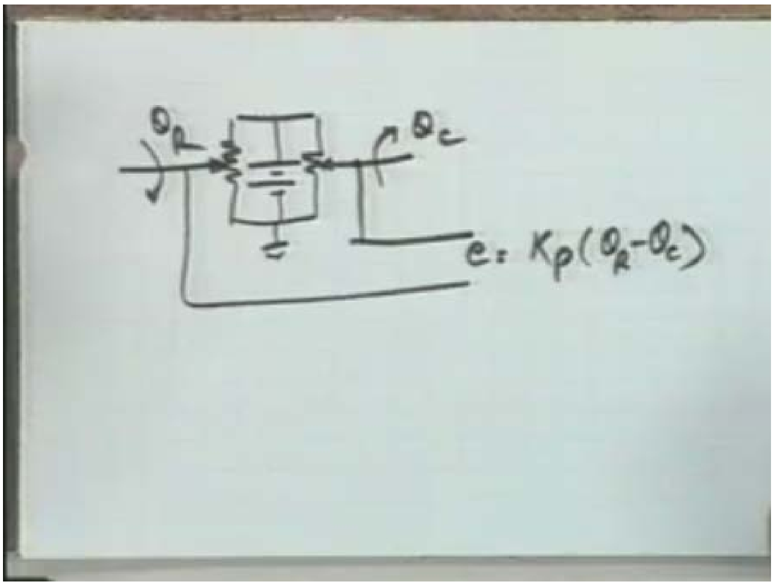

Let us say this is a potentiometer pair, this is your signal theta R the reference, this is signal theta C the control signal (Refer Slide Time: 2:17); if I take up this, this signal e we have seen is equal to K P a constant a potentiometric constant into theta R minus theta C that is it is proportional to the difference of the two shaft positions. So exactly identical arrangement identical equation will come with the synchro pair the only thing is that the synchro pair is an AC device and is acting on the high frequency signals. So in this particular case you will find that theta R is the reference position and theta C is the controlled position (Refer Slide Time: 2:49) and you want to use this device as an error detector so that the signal available here is an error signal is a signal proportional to the difference between theta R and theta C.

This is what we are going to see as to how it works, how we get a signal which is proportional to the error between theta R and theta C. For that I will like you to refer to the synchro transmitter construction synchro transmitter working. In the case of a synchro transmitter let me say that this is the flux pattern and I take the transmitter in what is called the null position. So this is theta is equal to 0 theta is being measured with respect to this position, this is synchro transmitter, this is the flux pattern.

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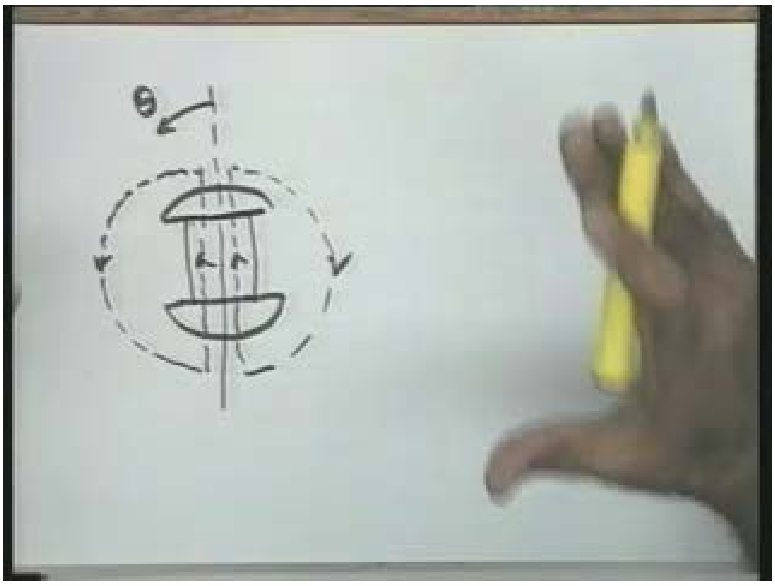

Now, since the EMF induced due to this flux pattern is being fed to this synchro control transformer we can say that the flux pattern in the synchro control transformer will be identical. So this is the flux pattern as far as synchro control transformer is concerned. Now let me assume that the synchro control transformer has got this position at certain time. I want you to help me; what will be the voltage induced in the rotor of the control transformer? This is the voltage e which I am taking (Refer Slide Time: 4:40). I repeat my question. The synchro transmitter is in the null position and this is the flux pattern indicated, the identical flux pattern in the synchro control transformer is shown over here and this is the position of the rotor of the synchro control transformer, I measure the angle alpha with respect to this position. So in this particular case please see that as far as this synchro transmitter is concerned maximum flux is linked with this winding and this being 90 degrees angle so no flux is linked with this winding and the angle the voltage at this particular point will be zero.

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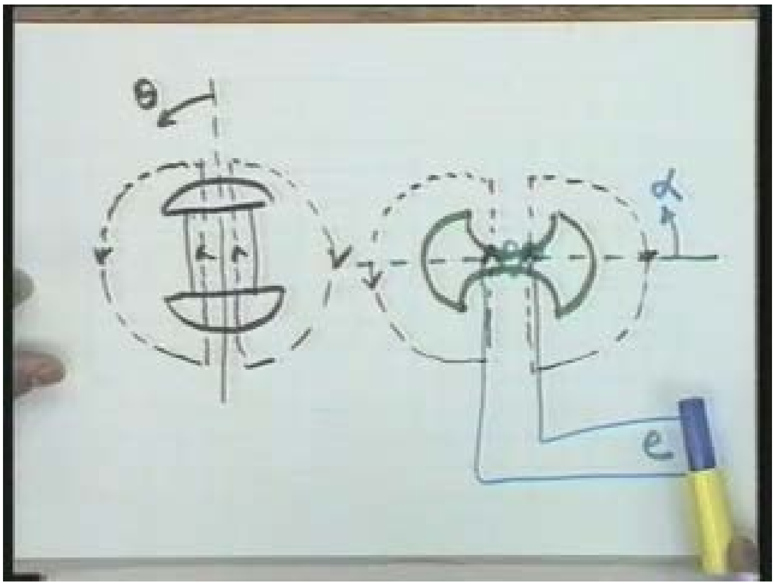

So, in this particular situation when I take a rotor in this position the voltage induced in the rotor winding of the control transformer is zero. But now you take a situation that this particular synchro transformer rotates by an angle theta and this control transmitter rotor rotates by an angle alpha so the net angle between the axis of the transmitter and the control transformer is 90 minus theta plus alpha and therefore voltage induced e m let me call it will be equal to k dash E R cosine of 90 minus theta plus alpha into sin omega c t. This is what we have been discussing last we have discussed last time if you recall that this becomes the factor which corresponds to the angle between the two which corresponds to the positions of the two.

When you take theta and alpha is equal to 0 with respect to the positions shown over here you find that the voltage induced is 0 and when theta is taken with respect to the null position and alpha is taken with respect to the positions shown in that particular case voltage induced is given by this expression (Refer Slide Time: 6:42). So, when theta and alpha have got 90 degrees angle between the two between the two rotors that is theta and alpha correspond to 90 degrees angle then the synchro pair is referred to be working in the electrical zero position. I make a statement over here; electrical zero position.

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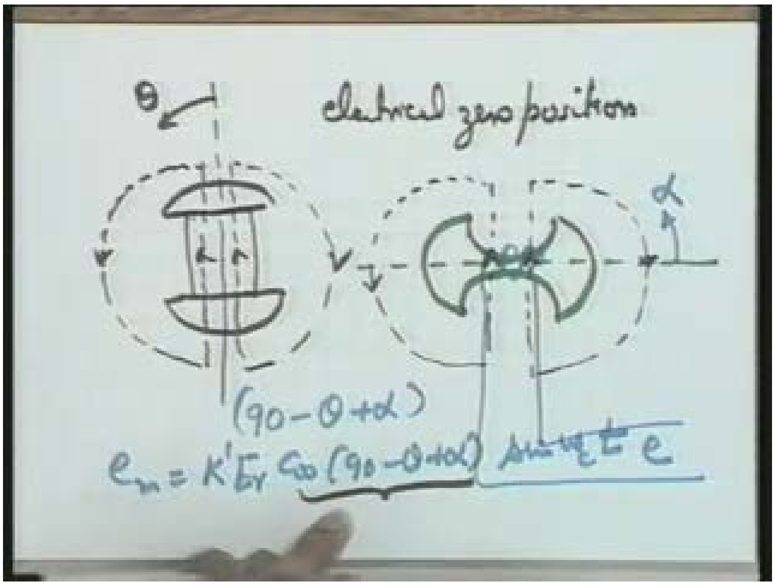

In an electrical zero position the voltage induced in the rotor winding will be 0. So it means in any position where this is theta with respect to the reference and this is alpha with respect to the reference I have the voltage e m, I repeat this expression, K dash E r cos 90 minus theta plus alpha sin omega c t. This can be written as K dash E r sin theta minus alpha sin omega c t.

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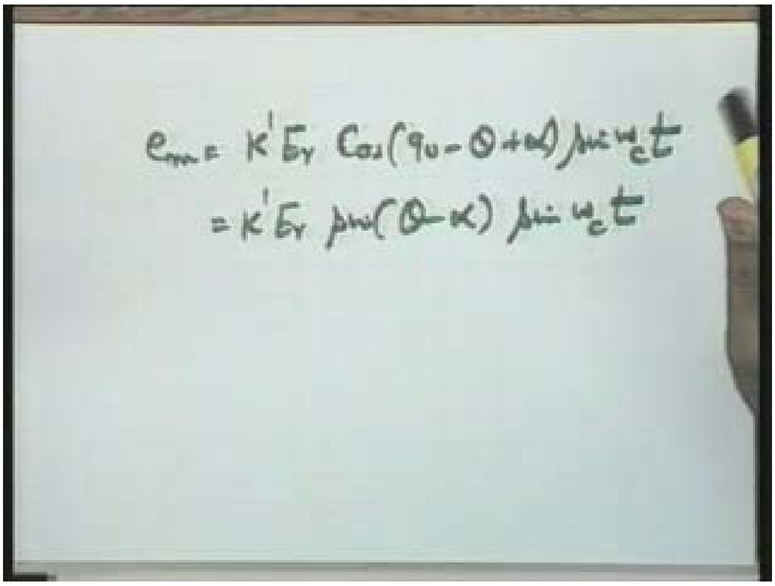

Now recall the statement that the synchro pair is going to be used as an error detector in a control system. So it means, as soon as the error theta minus alpha is equal to phi becomes greater that 0 the function of the controller will be to reduce this error to 0 as soon as possible. So it means once this synchro pair is taken as a part of a feedback control system, I need your attention and comment on this point, once this synchro pair is part of a feedback control system the claim is this that phi will be very small because as soon as phi of the order of 5 7 degrees appear the control system will act in such a way as to reduce this phi to be equal to 0. That is, the command is theta and controlled variable is alpha, if the control system is working effectively the controlled variable has to be equal to command signal and therefore phi will be nearly equal to 0. Under this assumption I can write in my model sin theta minus alpha is nearly equal phi itself because for small values of theta sin theta is equal to theta in appropriate units. So, if that is the case the expression becomes: e m is equal to K dash E r phi t sin omega c t. This point may please be noted. The assumption involved may be noted.

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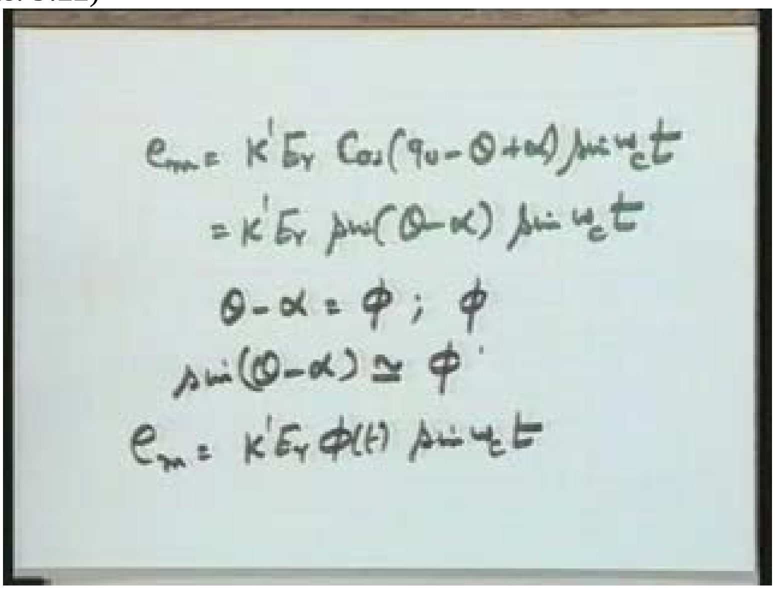

You see, a highly nonlinear expression, the sinusoidal expression has been converted into a linear expression over here under the assumption that theta minus alpha will be equal to phi a very small value which will be true only if the synchro pair is acting as an error detector in a feedback mechanism. As an independent device no, theta minus alpha can take any value but if you are using this in a feedback system naturally phi will be very small and this approximation is valid.

Now look at the input output configuration of this device. I can say that, as far as this device is concerned input is phi t like in the case of potentiometer pair. You see, the input is phi t which is the error between the two shaft positions the reference shaft and the feedback shaft, the reference shaft and the controlled shaft. So this is the input. And what is the output? The output is the signal e m which is available at the rotor terminals of the control transformer. So, as far as input output model of the system is concerned I want the input output model to appear like this:

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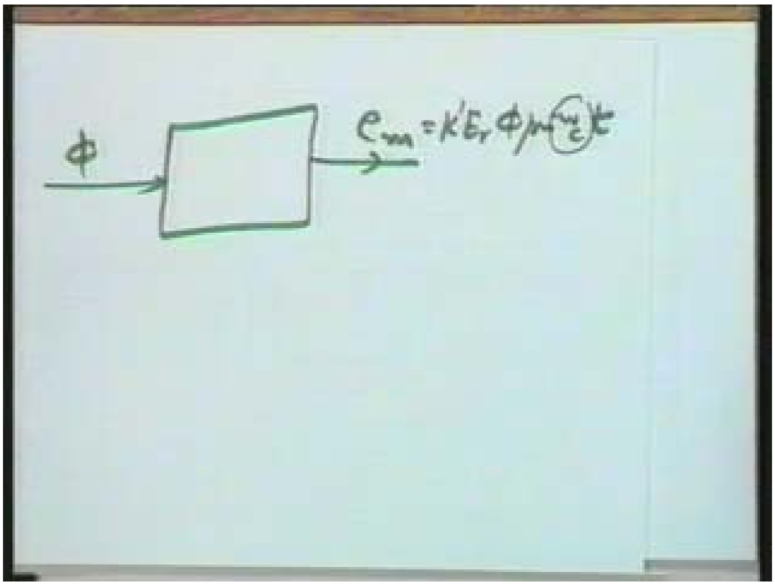

This is input phi and the output is e m. Now here I need your attention please. If I want to derive a transfer function model for this system where input is phi and output is e m and you will recall your e m is equal to K dash E r phi sin omega c t the mathematical is going to be complex. However, at this juncture, I will use the information that omega c is simply a carrier which is the operational frequency of the device we are going to use; 50 cycles, 400 cycles per second, 1000 cycles per second or the typical frequencies you used. So since it is the operational frequency of the device it really does not carry any information about the error of the system.

For example, if I take this total quantity as e c let me call it that e c(t) sin omega c t is e m. What is the nature of this signal? The nature of this signal, let me take a typical signal is going to be like this: (Refer Slide Time: 11:54) this is the output of the synchro error detector. Now look at this output, actually the error phi is given by e c(t) which is nothing but the envelop of this particular signal. So it means, as far as the carrier is concerned the carrier does not carry any information about the control action; the carrier is coming just because the device is operating at a frequency omega c. So it means, as far as the mathematical model is concerned, as far as the transfer function model is concerned I may be worried only about the carrier e c about the envelop e c and I should not concern myself with the total output e m which is a modulated signal coming from the synchro error detector and hence I can say, as far as mathematical model, from the point of view of control analysis and design is concerned the mathematical model will look like this: phi is the input and e c is the output where e c is the envelop of the modulated signal.

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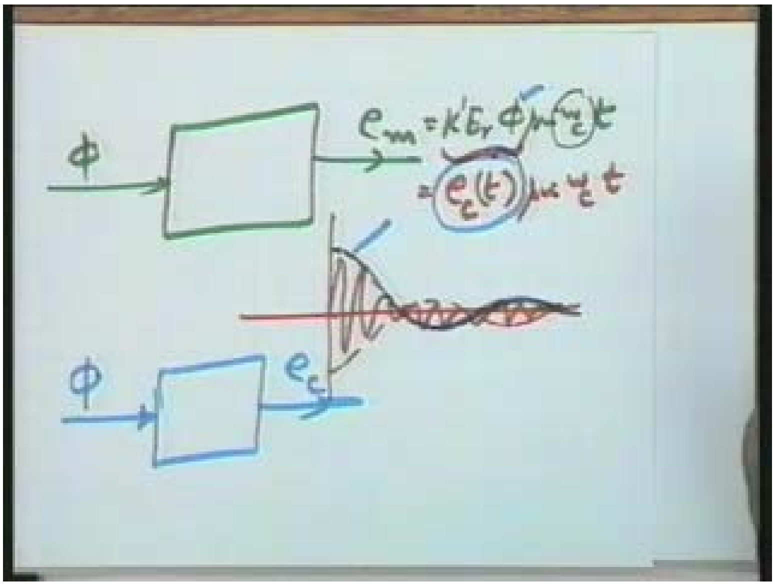

And now if you see this you can easily write the output E c(s) divided by input phi(s) is nothing but a constant K s which is called the sensitivity of the synchro error detector. It is identical to constant K P which you have utilized in the case of a potentiometric error detector. So this constant K s is important to me as far as the flow of information is concerned and this constant K s does not depend upon the carrier frequency. So this, there was a little confusion in last time also as to why I am interested only in the envelop and not in the total information as far as mathematical modeling is concerned. I hope this situation now should be little more clear compared to the last lecture that my interest is in the information flow and I am not interested in the working of the device though I know that higher frequency will be required if I want to make my device immune to low frequency noise signals and the selection of the carrier frequency is dependent upon this information as to what type of noise signals are going to enter the loop as far as the control system is concerned.

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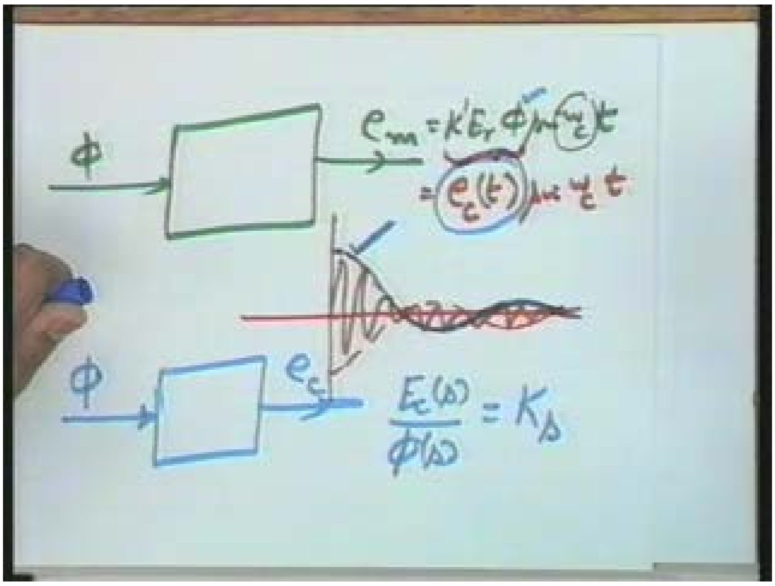

This is another consideration. At this juncture, we are interested in the feedback loop model and therefore my interest will be between phi and e c. So now I have a mathematical model, a simple mathematical model the assumptions involved should be known to you, a simple mathematical for the synchro error detector. The name synchro error detector will be given to the device consisting of a transmitter and a control transformer pair and symbolic representation of the synchro error detector could be of this type; there is no need of showing all the windings rotors etcetera all the time. Let me say that this is the rotor of the transmitter (Refer Slide Time: 15:04) the three stator connections here and this is the output of the control transformer and you can say that here I have theta R and here I show theta C.

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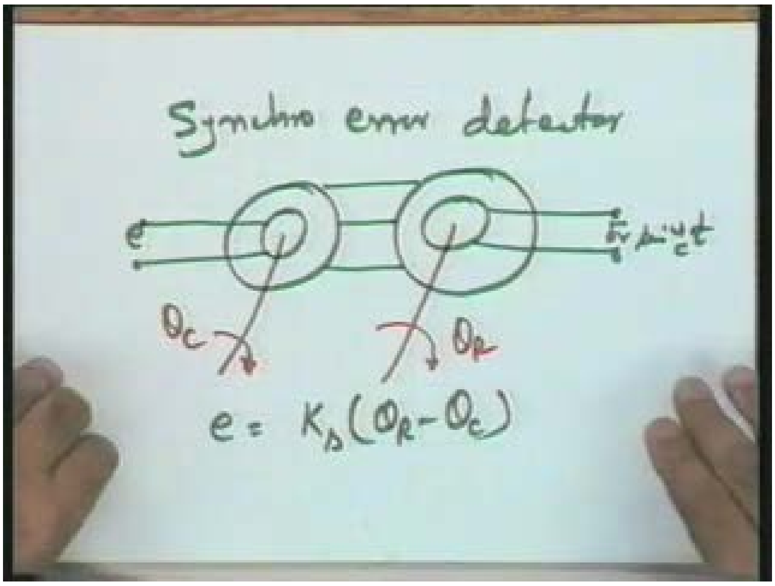

This becomes the symbolic representation, a symbol showing a synchro pair I will be mostly using this when I take up feedback systems and the mathematical model this is your E r sin omega c t you can take, this is your e at this particular point e is equal to K s theta R minus theta c becomes the mathematical model for my system where the carrier part has been removed only the envelop part has been taken.

Now, since I have taken this as a rotating device let me take a linear device. Also, since the action is identical I will quickly give you the mathematical model for this situation. Now, instead of a rotary motion I have a linear motion that motion I call it y and this particular device has got a cylindrical form and here (Refer Slide Time: 16:32) I wind the primary and the secondary windings; let me take this as the primary winding, to the primary winding I give AC supply here of frequency omega C that becomes the carrier. A secondary split into two parts, let me call this as S 1 and this as S 2 the two secondaries and I connect them in anti-phase and this is the output e.

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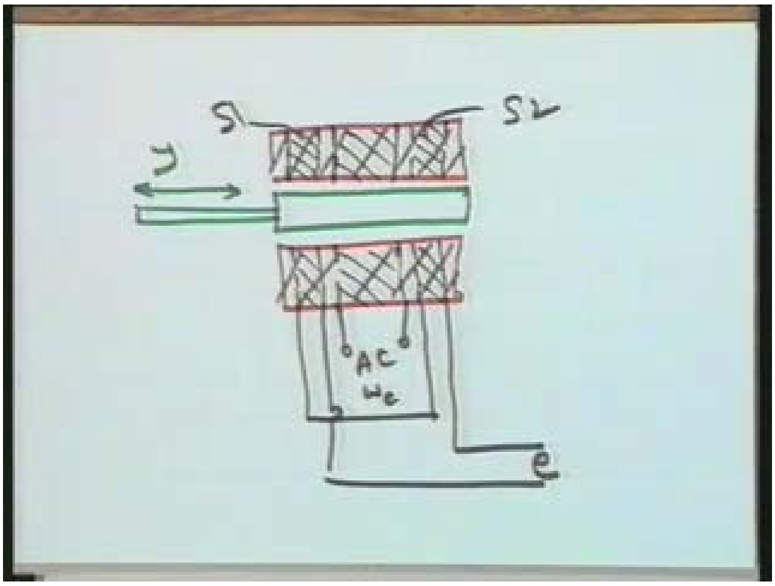

Now let us see how this device works. Some you might have already come across this device. This is your LVDT Linear Variable Differential Transformer LVDT device. in this particular case just see, its working is simple, similar type of transformer action will be there; let us see the core is in the central position exact central position, the flux is flux lines are linked to the two secondaries and since they are in phase opposition the net voltage e available here is 0 when they are exactly when the core is exactly in the centre position.

Now, take the core to the right more flux lines are linked to S 2 compare to that in S 1 and therefore a voltage e of certain polarity will appear over here. Take the reverse action, the core in the opposite direction more flux lines are linked to S 1 then to S 2, a voltage e will appear but of reverse polarity with respect to the earlier position. So it means the polarity of the voltage over here is going to give you the direction whether the y movement is this way or that way and the magnitude of e over here is going to give you the magnitude of the displacement. This LVDT device is a device which gives you a signal proportional to the linear motion synchro device which we have considered earlier gives you a signal which is proportional to the angular motion.

So what is e?
In this particular case please see; e will be given by, omega C is the carrier frequency some constant K E r let us is the voltage applied to the primary winding into y(t) sin omega c t this is going to be the signal; e m let me call it means it is a modulated signal which will appear at this point. e m is equal to K E r y(t) sin omega c t the carrier part is definitely appearing over here.

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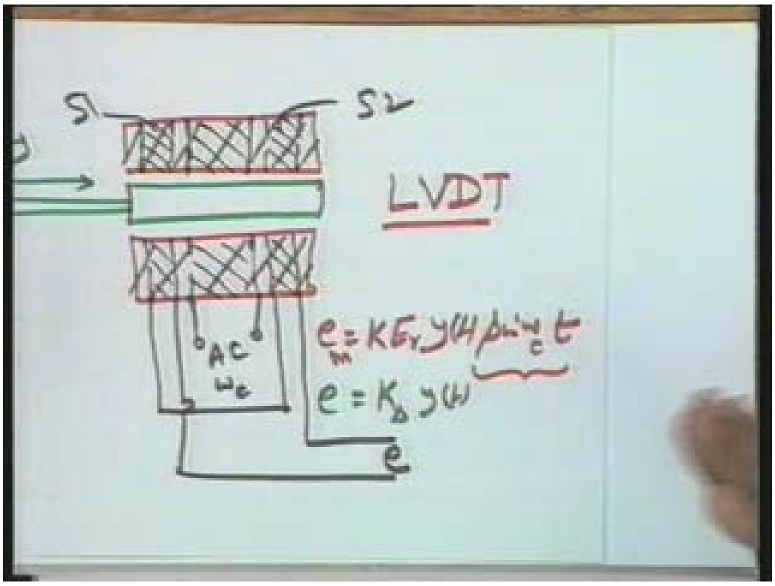

Same argument: please see, as far as the information is concerned it is carried in the envelop of this particular signal and therefore I will be interested in the signal e is equal to K s into y(t) where K s is the sensitivity of this device. So the mathematical model for me as far as LVDT is concerned is again only a constant sensitivity which you should understand is the ratio between the envelop of the output signal and the displacement y of the core. So this part should be made should be very clear and I am sure when I take the complete block diagram the flow of the modulated signal and the flow of the signal the envelop part after demodulation is carried out will become very clear.

A quick glance at the tachogenerator also should be helpful at this stage. The tachogenerator what is the input please; the input is P theta dot. Let me say here I have a reference winding and E r sin omega c t I take as the input to this reference winding. The output here is again going to be a modulated signal; the output is a modulated signal, e m which as you know depends upon the frequency omega c the carrier and the theta dot that is the input to the particular mechanical input to the rotor. So e m if I write the complete expression is going to be: K E r omega the sin omega c t. This is your modulated signal as far as the output of the AC tachogenerator is concerned.

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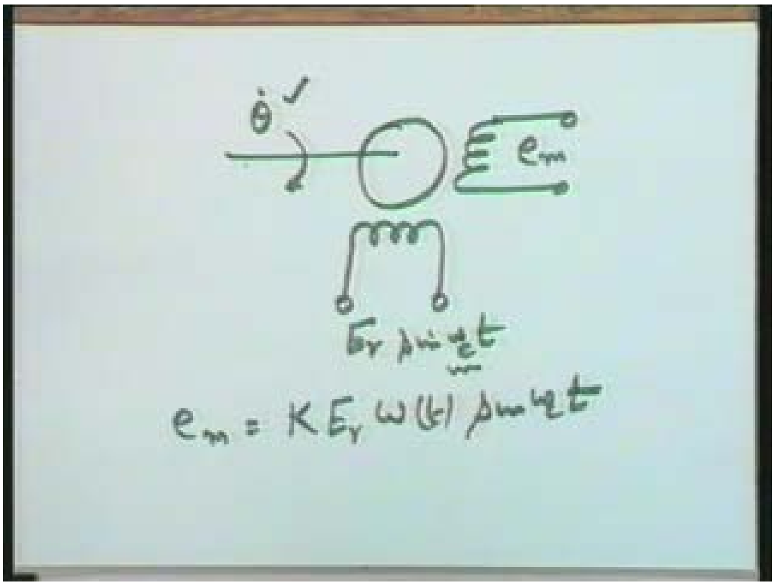

This problem was not there in the earlier case the DC tachogenerator because the output was proportional to speed and the output was a low frequency signal, it was a DC signal. But in this case also mathematical modeling gives you the same picture because I will be interested in the error signal e is equal to K t into omega(t) where this depends only on the envelop of that signal. So demodulation is assumed to be carried out so that you have extracted the envelop and the input output relationship is given by the envelop of the signal of the modulated signal.

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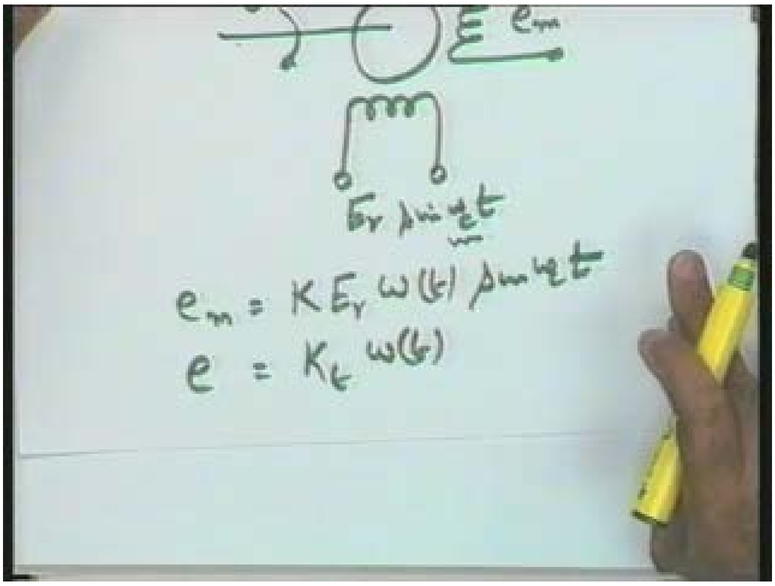

I think with this we have given you all the tools necessary to take up a complete block diagram using all these types of components. But before I do this if you do not mind I like to review the motor case again; just giving you the final result.

The motor has a reference winding, a two-phase motor, I had shown a capacitor here phase shifting capacitor E r sin omega c t is the reference voltage (Refer Slide Time: 22:28) this is the voltage here, now I need not put a modulator I have explained it to you, the input to this system is going to be e m input to the control phase is going to be e m a modulated signal may come directly or using a modulator.

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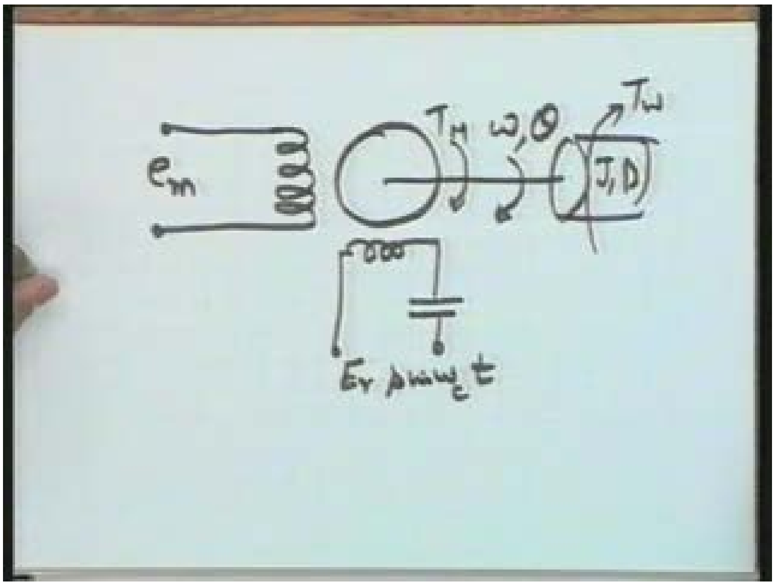

For example, please tell me do you really need a modulator if a synchro error detector is feeding this particular control phase voltage. the synchro error detector, understand my question, the output of the synchro error detector which is the output of the rotor of the synchro control transformer if I directly connect to the control phase voltage control phase winding over here in that particular case no modulator is required in between because the control phase voltage requires a modulated signal and synchro error detector is directly giving you a modulated signal.

So in this case I can say that the output of the synchro error detector is directly being given to the control phase of the motor. But when you come and take up the transfer function of the motor you could take the transfer function between the envelop of this signal and the speed of the motor or position of the motor because the information in the system is carried into the envelop is carried by the envelop and not by the carrier. So, though the signal coming over here is directly e m my mathematical model will concern itself with the envelop and the speed and this relation we have already derived. Let me take omega as the speed, theta as the position and here a take the load as J and B and I had taken T M as the disturbance T W as the disturbance, T M is the torque over here.

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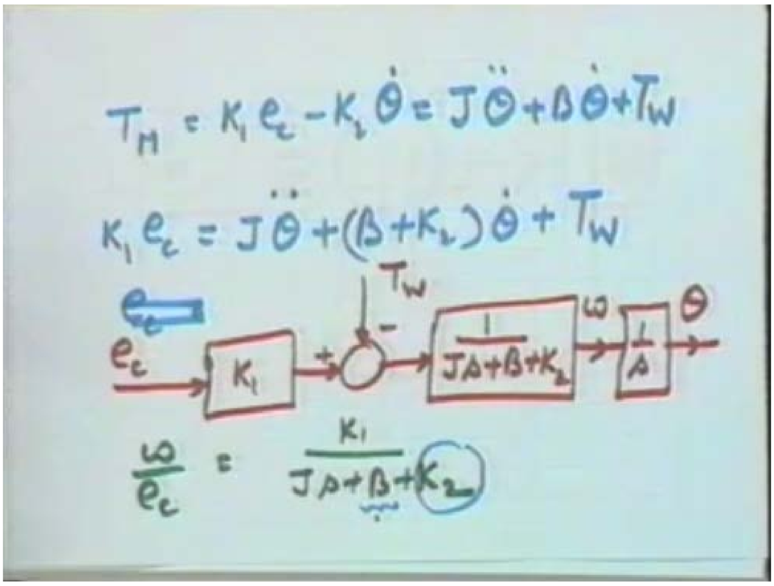

Now please see, I think I can use exactly the same slide which I used last time. This was the mathematical model we had derived using the torque speed characteristics. T M, recall the equation please; TM is equal to K 1 e c minus K 2 theta dot e c is the envelop of the input to the control phase voltage minus K 2 theta dot is equal to J theta double dot plus B theta dot plus T W.

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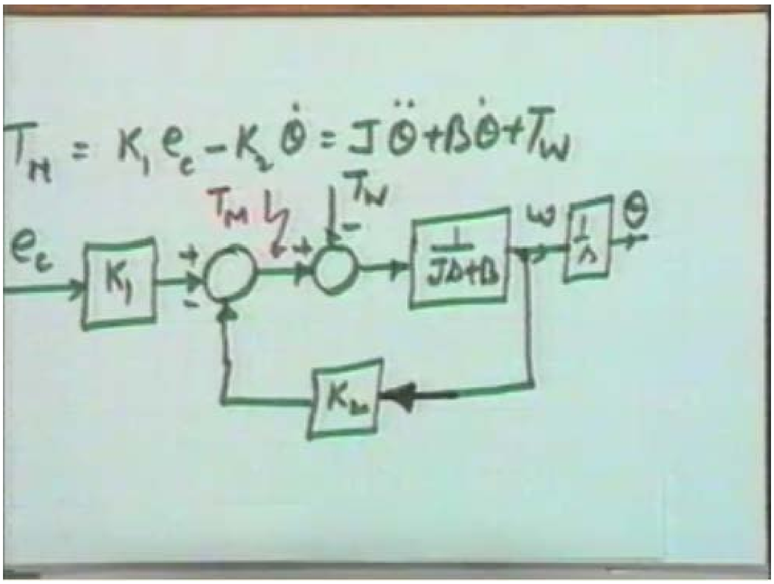

Please see, e c is the input K 1 e c coming over here, I put a block over here and from this I will give you a signal K 2 theta dot, what is the advantage of this representation? The advantage of this representation is this that now the torque produced by the motor is available as a variable. See this little change I am making in the block diagram I have given you earlier (Refer Slide Time: 25:30). Though the two block diagrams are identical as far as the input output information is concerned but this block diagram gives you the torque produced by the motor as a variable in the system. so T M you can see, is given by K 1 into e c minus K 2 into theta dot so it means this should come from the omega from speed and this particular block diagram I will complete.

Help me please, what should I do next? If you are getting me please help me what should I do next, how do I complete this block diagram? T M is available, T M is the torque produced by the motor. [Conversation between Student and Professor – Not audible ((00:26:09 min))] I can now take up the disturbance torque here. this is plus, this is minus, this is T W so that now this is the net torque available to drive the load and the load is given by 1 over Js plus B so this gives me omega. Please see now, from here I pick up omega (Refer Slide Time: 26:34) and it is the feedback loop inherent feedback loop in the system. You have not connected any device to B to give the feedback, this is an inherent feedback loop in the system identical to the situation we had in an armature controlled DC motor. so this omega if you are interested in theta you can put 1 over s over here and a transformer function between theta and e c or a transformer function between theta and T W is available.

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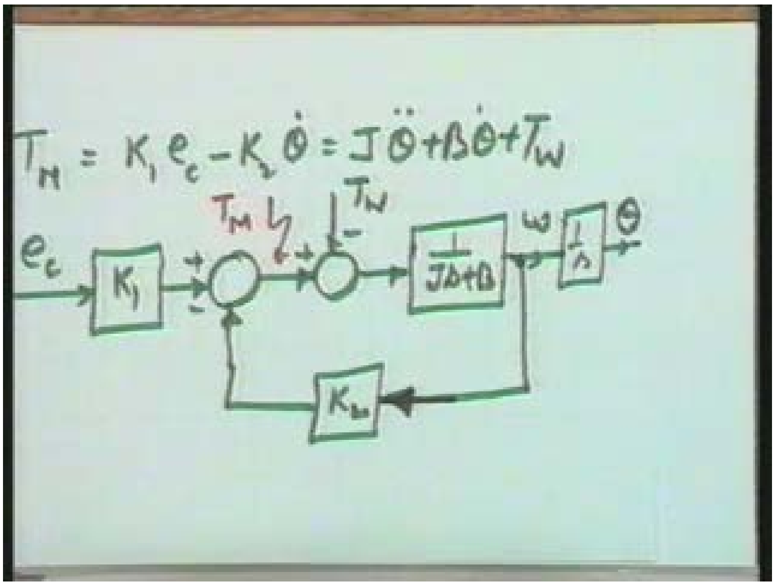

I make a statement that this particular block diagram is more complete in the sense it gives you information about the torque produced by the motor and it brings out the inherent feedback nature of the system and we will be mostly using this particular block diagram whenever an AC motor is taken as a component in a feedback system.

I think we are ready with the tools, the tools have been completed and I can take a practical situation now. The practical system I take and you will help me to draw the block diagram of the system. The system is a heavy telephoto camera is there and I want to use a motor an AC motor to control the position of the telephoto camera. This is the requirement this is the control problem. I repeat the control problem: The load is a telephoto camera a heavy load which you want to control with the help of the devices we have considered today and in the last lecture that is an AC motor, a synchro error detector and other devices if required.

So what I do is I first consider well sorry the diagram has not come nicely but does not matter, this explains the situation; this is the camera and naturally I will require large torques to rotate it and for that I am going to use a gear train because large torques will be required for its rotation and a motor cannot produce that much of torque so a suitable gear will be required. this is the gear train (Refer Slide Time: 28:55) and this particular gear the primary gear has teeth N 1, the secondary gear has teeth N 2 and as you see this will result into torque magnification and speed reduction. So this particular gear, naturally, the motor is going to produce the torque and drive this particular gear and if I am going to use an AC motor the schematic will look like this:

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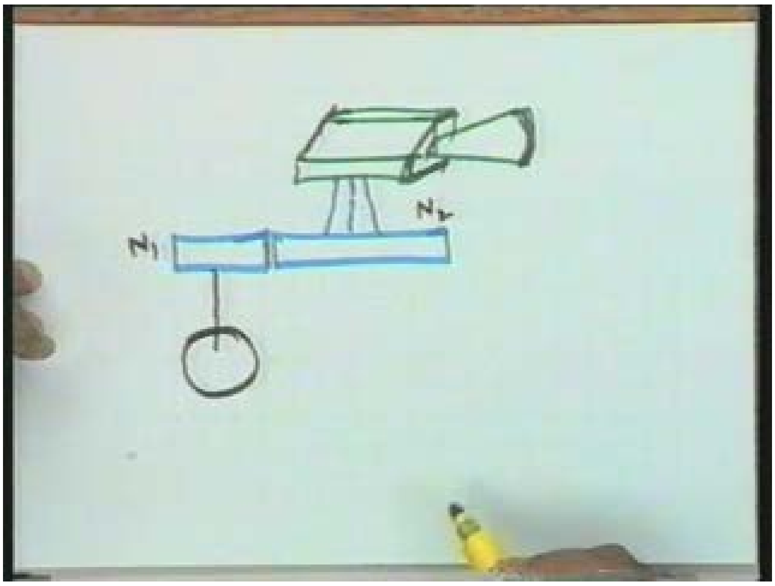

AC motor is driving this and the torque produced is T M and the position is theta M. Here let me say the position is theta L and let me say that there is a disturbance on the system and this disturbance could be taken as T W. T W is the disturbance. Now this particular motor will have two windings: One will be a reference winding so let me have a reference winding and a phase shifting capacitor over here. The control phase winding is going to is going to have the voltage e m which is the modulated signal. This particular modulated signal should be proportional to the error between the commanded position and the actual position. The actual position of the camera is given by theta L. Now you require a commanded position.

How do we give the command?
Let me say that to this particular signal I give the command this way: theta R this is your E r sin omega c t coming over here, a synchro pair here. Yes, you see that this is my spotting scope, this is the spotting scope and the spotting scope is the command signal as well because if you have spotted a particular scene which you want to capture a particular situation which you want to capture in your camera you will like that your camera should follow the command over here. So this spotting scope is….. the movement of this spotting scope is the command signal and this is the controlled signal. You want that theta R minus theta L should be reflected as far as this voltage input is concerned.

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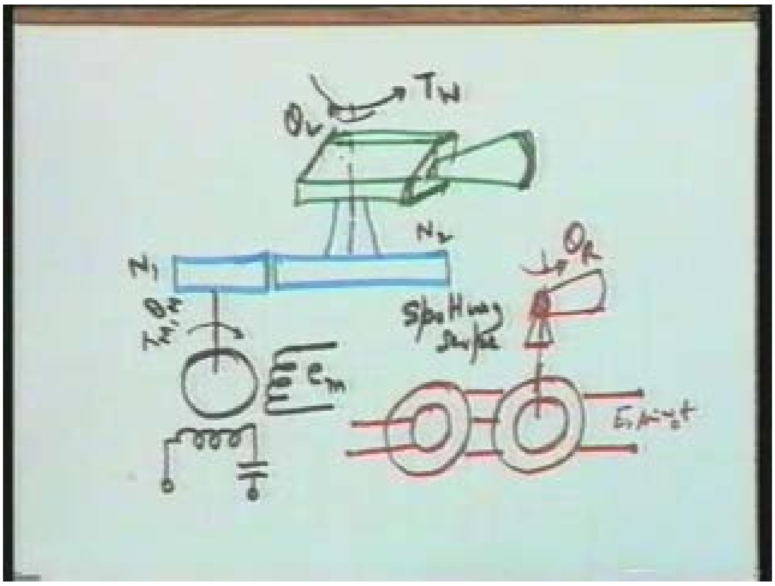

Tell me please, how do I connect the synchro pair? Just see, this is your reference signal of the synchro transmitter this is my synchro transmitter device and this is synchro control transformer (Refer Slide Time: 32:12). So, though it has not nicely come under this particular diagram but I think it will become clear if I connect this so this particular gear is mechanically connected to this rotor so that the input to this particular synchro pair is theta R minus theta L, I hope this is clear. As far as this synchro pair is concerned the transmitter is rotating the transmitter movement is given by theta R and the control transformer rotor movement is given by theta L a suitable mechanical link. So it means this particular signal is a modulated signal omega c being the modulation frequency and the envelop is proportional to the error between theta R and theta L.

Now this is an intelligence signal. This particular signal may not have the required power to drive the AC motor. So what do you require? You simply require a suitable amplifier an AC amplifier between this input and this output. So let me say that between these two devices between these two signals I connect an amplifier of amplification K A so naturally this becomes the total block diagram, the total schematic diagram. Though it has not come nicely but i think the functioning of the system is more or less clear.

So see the nature of the signals in this particular case. Nowhere demodulation or modulation is required because the signals are of the nature that the devices are compatible. In this particular case theta R minus theta C is a DC device DC signal, theta R minus theta L is a DC signal and the output of the synchro device is a modulated signal. So, as such your synchro device, if you see the basic definition of a modulating device, your synchro device is acting as a modulator because it is accepting a DC signal which is theta R minus theta L and is giving out a modulated signal whose frequency is given by omega C. Now this modulated signal is being amplified by an AC amplifier and the output is a modulated signal again here, the frequency in the reference here also should be same as that omega C for the two devices to be compatible. So this modulated signal is being fed to the control phase and this control motor is producing a torque and hence a position theta M which is again a DC signal.

Can I say that in this particular case your AC motor is acting as a demodulator. So it means actually the two devices are compatible; one is acting as a modulator, the other as a demodulator. So the input here is a DC signal, the output of the total device is a DC signal the total system is functioning on the DC information signal and hence in between modulation or demodulation devices are not required. Now, in this particular case if I want a mathematical model of this particular system the carrier frequency part I will simply remove.

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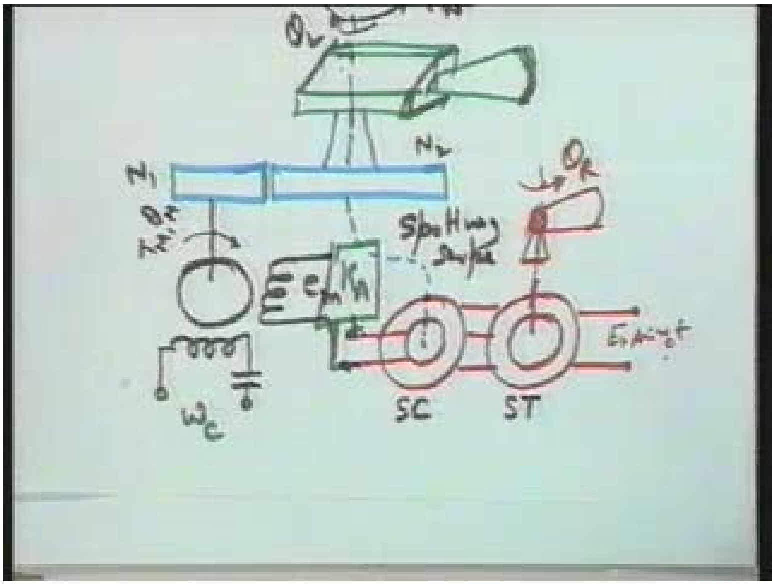

If I remove the carrier frequency part and I want to write the mathematical model the system you will help me, I will first get the block diagram and reduce that block diagram into a suitable transfer function model. So I get started with the command signal, yes, this is theta R, it is being compared with the actual signal actual controlled signal which you know is theta L. so please speak out what should I put over here so that here is the input signal that is here is the error signal produced by the synchro error detector. At this particular point………… [Conversation between Student and Professor – Not audible ((00:36:16 min))] K s the sensitivity of the synchro error detector so here I have the output of the synchro error detector the envelop of it only. Now this is going to the motor no amplifier so this is K A so here is an amplified signal which is being fed to control phase of the servo motor. Now I will like to take up the transfer function model or the block diagram model of the servo motor.

Recall the block diagram I have K 1 over here a constant of the servo motor. This K 1 this gives me a K 1 into AC signal this I can take as e c variable the envelop of the input to the control phase. So this is plus and here it is minus, yes here I have the torque produced by the motor, I have the error signal here, the disturbance signal here help me what should I write here the disturbance signal at this particular point I need your help please, is it T W think about it I proceed further. So this is the net signal which is coming nT W.

[Conversation between Student and Professor – Not audible ((00:37:43 min))]
Please see, it is nT W because the disturbance reflected on the motor is nT W where n is the gear ratio. T W is not directly acting on the motor now it is through the gear set and therefore the disturbance is nT W. So this is the net torque available to drive the load and the load

parameters of the camera are J L and B L let me say; when they are reflected onto the motor let us say they become J and B therefore I am writing 1 over J s plus B. The parameters of the camera the telephoto camera are different; they are J L and B L. The values J and B are the values equivalent values when J L and B L have been reflected onto the motor shaft and the inertia and friction of the motor shaft also has been added to those values. So I get this as the effective model on the motor shaft. This gives me omega, here I put a block 1 over s over here, this gives me theta, from omega I pick up this particulars feedback signal which is inherent in the motor, the constant is K 2, this completes the block diagram model of the motor.

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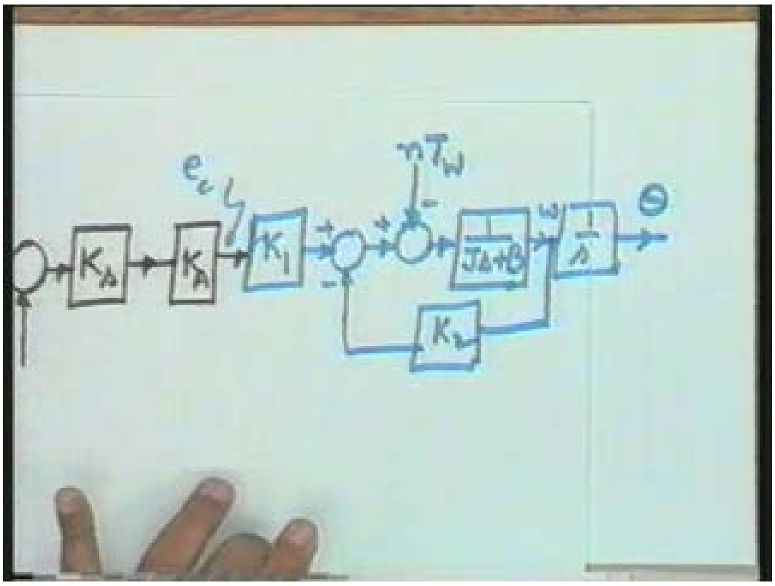

The only point of caution is this that the nT W is the reflected torque on the motor and J and B are the equivalent quantities on the motor shaft. Now this theta M this theta M has to be converted into theta L so let me put a gear ratio n over here this becomes theta L. Well, the management of the slide is to be done properly so that it is visible to you. Yes, I hope this is okay now. This is theta M the motor shaft position, I am putting a gear ratio n over here this is theta L the load shaft position and to the synchro error detector it is the load shaft position which is being fed back and therefore I connect this and take it to the error detector and complete the block diagram. The block diagram now should be seen in this way wherein the output is theta L the position of the telephoto camera and the input is theta R which is the position of the spotting scope.

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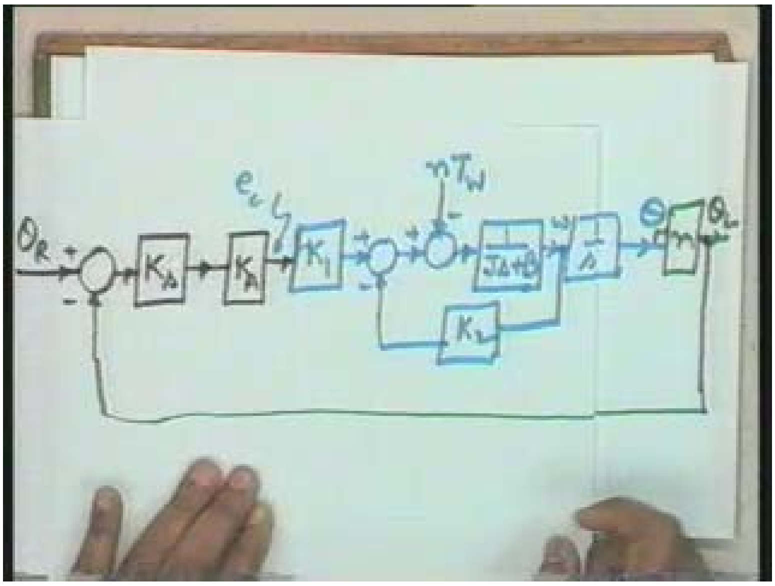

So what you require is when you move this spotting scope the telephoto camera should automatically move without any transients. you have to suppress the transients so that it should not oscillate and you should suppress this accuracy, at the steady state the accuracy should be as you want that is theta R should be equal to theta L the steady state error should be reduced to zero this is what you want and this is what is the control design problem.

And when we come to design you will see that this pure amplifier which is nothing but only a proportional control will be replaced by a more sophisticated controller which may have some proportional action, integral action, derivative action or some other action. This point may please be noted. At this juncture, the interest is only to give you the hardware familiarity. The control problem is still ahead of us. We have to define the control problem and solve the control design problem. The control design problem will be of this nature, please get the feel of it that I want theta L to follow theta R under suitable performance specifications.

The performance specifications will be of the nature that under steady state condition theta R should be equal to theta theta L should be equal to theta R exactly with no error and theta L should approach theta L theta R with minimum of transients and to achieve this objective I will replace this block (Refer Slide Time: 41:57) by a more complicated block and that particular block will be referred to as a controller and the objective will be to design that controller and three basic actions of the controller have already been hinted at; the three basic actions are: The proportional action, the integral action and the derivative action. Well, these are only the guidelines; the controller actions which are more complex than these actions are also allowed. This will be your controller problem as we will see.

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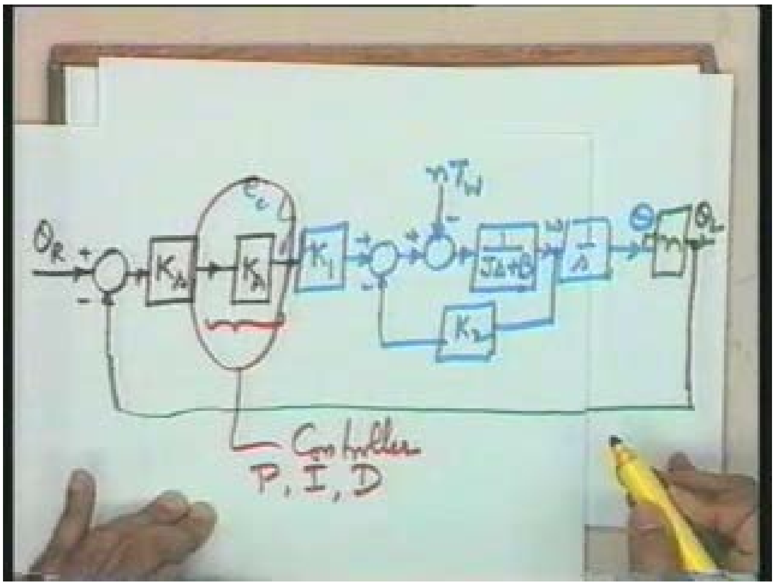

Yes, one more situation; you help me in this particular situation. One more feedback situation and again I expect, well I think let me create suitable space and therefore I take a gear train this way. I have a gear set, on this side I have a load (Refer Slide Time: 43:00) and let us say that the parameters of the load are J L and B L and the torque on the disturbance torque is T W and the position is theta L as far as the load is concerned.

Now I have two restrictions please. You have to give me a suitable system configuration and then we shall convert that configuration into a block diagram. I want to drive this load, the restriction I have is this that I want to use a DC motor and not an AC motor as an actuator. You know that DC motor is a linear device, the torque speed characteristics of the DC motor are linear as oppose to AC motor and the torque handling capability of a DC motor is more than that of an AC motor for an equivalent size. So I want to go for a DC motor as an actuator. So it means, as far as this primary gear is concerned (Refer Slide Time: 44:01) this primary gear is connected to a DC motor. So this is the armature voltage e a which is the controlling signal, this is one constrain.

Another constrain is this that, instead of a potentiometric error detector I want to use a synchro error detector, the reason, potentiometric error detector has got the resolution problem; it has got a better resolution the synchro error detector and it has a better linearity property it has better ruggedness compared to the potentiometric error detector. Since the contact problem is there in potentiometric error detector synchro error detector is normally preferred over the potentiometric one. So with that in mind I want to settle for a potentiometric the synchro error detector for this system. So, for that, you please see, the load will be connected to the rotor of the synchro controlled synchro transmitter, this is your reference voltage (Refer Slide Time: 45:08), this is the rotor of the synchro transmitter and here is a synchro control transformer. Sorry I take this as the output at this particular point and the shaft of this will now be connected to this……, reference will come to…. I mean, could you get the type or error, I am making an error I will correct this error but let me see whether you have got the error or not; what is the type of error? Yes.
[Conversation between Student and Professor – Not audible ((00:45:48 min))]

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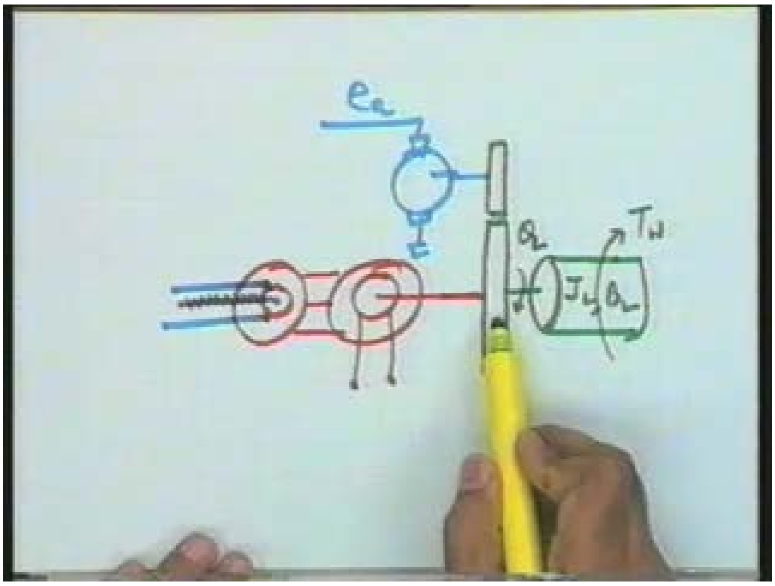

Please see, what I have done is this particular gear which is the controlled position should be connected to the control transformer and not to the transmitter. This is the error I have made and therefore let me redraw this diagram.

Motor connection is alright, motor is alright, this is your load J L B L and here I take theta L this is the disturbance. Now this is the shaft over here (Refer Slide Time: 46:32) the reference in this particular case let me take a synchro control transformer pair like this, this load should be connected here and here is your reference supply and here is your reference input theta R. The synchro transmitter will have the reference input the command signal and the synchro control transformer will have the controlled shaft connected to it. So this is the controlled shaft I have connected to it. Now where is the output? The output in this particular case is available here. Let me say that this is the output from the synchro control transformer.

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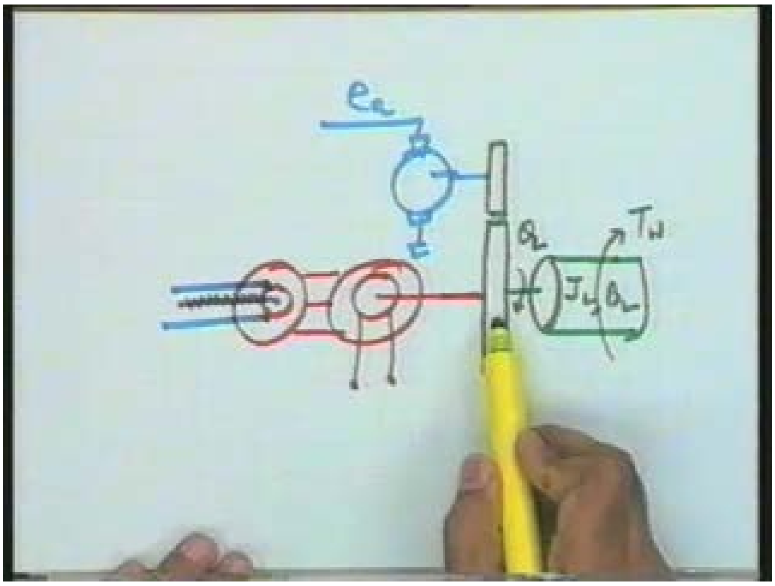

Now I need your help please. What should I do if I want to interface this particular signal to the DC motor after appropriate amplification? I need suggestions from you. After appropriate amplification this particular signal has to be connected to armature of the DC motor. I had two constrains. I wanted to use DC motor as an actuator and I wanted to use synchro pair as an error detector, suggestions please?
[Conversation between Student and Professor – Not audible ((00:48:03 min))]
The answer has turned out to be too simple. So let me make it a little more complicated. My question I want to make a complicated question, more complex. What I wanted to do is this particular signal i know I want that is to go to a controller and the controller is a PD controller proportional derivative. It is a PD controller that is I want to generate a signal which is proportional to this signal and a component is proportional to the derivative of the signal; a PD controller is to come in between so what do you suggest in this case.

Can I use Op-Amp directly here?
Suggestion is Op-Amp. PD circuit I want to use; and where is the PD circuit? Let me make an appropriate PD circuit: R 1 C I am making minus plus this is a PD circuit R 2 over here, this you can verify very easily that it gives you a signal which is proportional to the error and proportional to the derivative of the error where e error is the input over here, it is a PD circuit.

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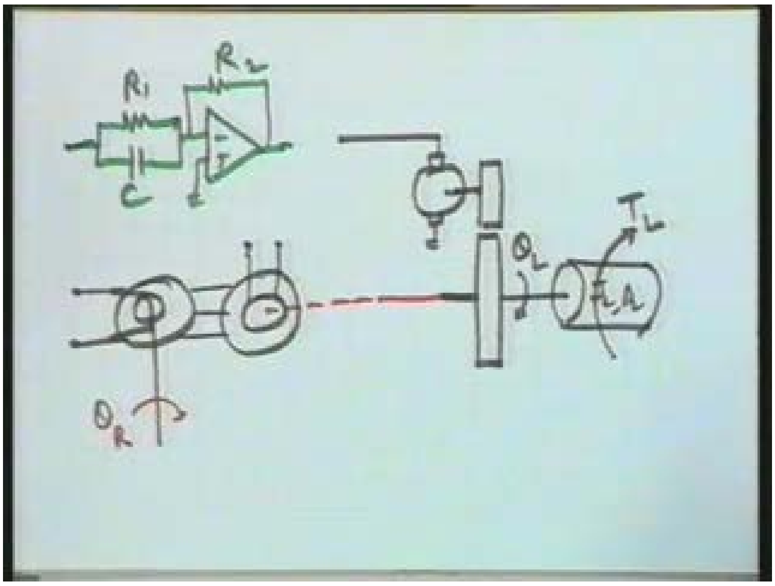

Now, my question to you is can I connect this as an input here?
[Conversation between Student and Professor – Not audible ((00:49:27 min))]
We want an envelop detector, why? We want to……….
This point may please be noted that the PD action the proportional derivative action which you want to take this is on the information which is there as far as this particular system is concerned the information about the error. You will not like to take the derivative of the carrier and feed it to the motor, this point may please be noted; you will not like to take the derivative of the carrier you will like to take the derivative of the envelop only because envelop is the information signal which gives you the information about the error between theta R and theta L.

So you definitely require, in this particular case, if a PD circuit, if suppose you rather did not use a PD circuit over here an AC amplifier could have been taken and after the AC amplifier a rectification could have given you a DC signal, please see, if derivative action was not required and AC amplifier over here followed by a rectifier was a suitable system configuration. But if derivative action is required the derivative has to be taken on the information signal so it is necessary that you first extract that envelop and for that you will require a demodulator here so that the envelop is extracted this particular envelop now is the input to this particular PD circuit so that the output at this particular point is proportional to the signal e and the derivative of the signal.

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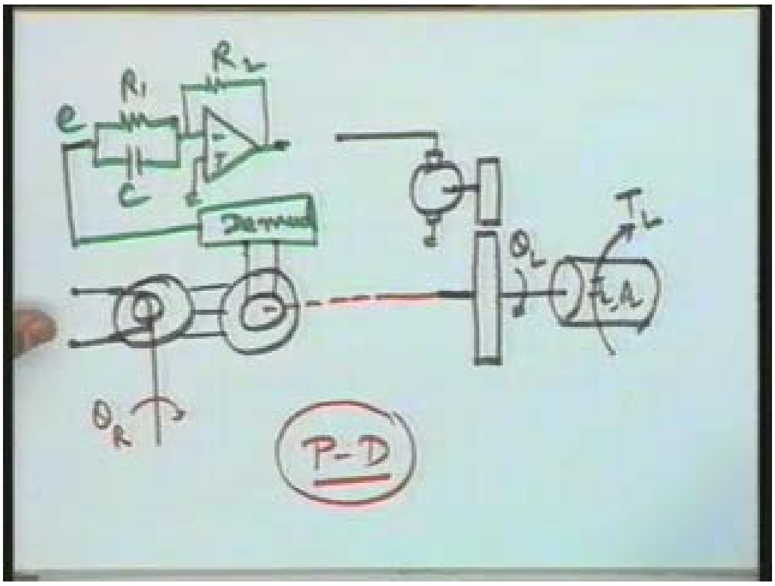

I will leave this an exercise to you that here if I have an amplifier K A, this is an e a this is an amplifier with the amplification K A this gives the complete block diagram of the system. However, one point I am leaving pending to you that as far as this particular portion is concerned when you take up the transfer function of this a negative sign will be introduced so please take care of this. Take a suitable inverting amplifier over here to take care of that negative sign.

You will see you write the transfer function of this a negative sign will be introduced, use any inverting amplifier at particular point of transfer function one so in that particular case the negative sign will be annulled and you will be able to get a positive transfer function over here.

Last point: how about the transfer function of the d modulator please?
You said that you are using the demodulator between this signal and e and if you write a block diagram for this particular system you will require a demodulator transfer function. Help me, what should be the transfer function of the demodulator? Could we take it as a unity? If you assume ideal conditions that input to this actually is a modulated signal but you have been taking only the envelop the output is the envelop so envelop you have extracted so the transfer function between the envelop of the modulated signal here and the output of the demodulator is equal to 1. So if you assume the demodulator as an ideal operation in that particular case the transfer function of the demodulator could be taken as unity.

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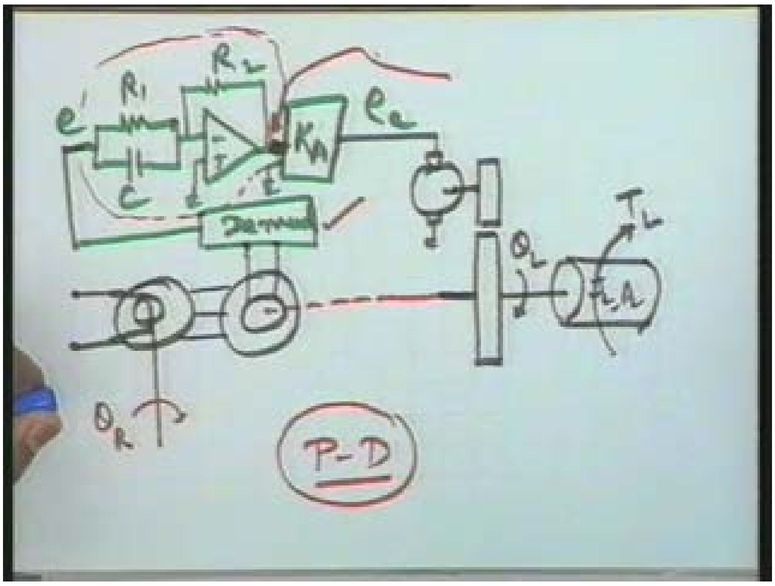

So just one minute; theta r is your command signal, theta l is coming from here K s this is the output from the synchro error detector, demodulator gives you 1 so there is no need of this, (Refer Slide Time: 53:24) this I am writing as K s into 1 plus T ds as the transfer function of a PD controller which you can get in terms of resistance and capacitance values given to you and assuming that a suitable inverting amplifier you have already introduced, here I have an amplifier K A this gives you this signal e a, use a motor here this gives you the signal theta M theta M gear ratio n this gives you the signal n and this is fed back so this is the complete block diagram.

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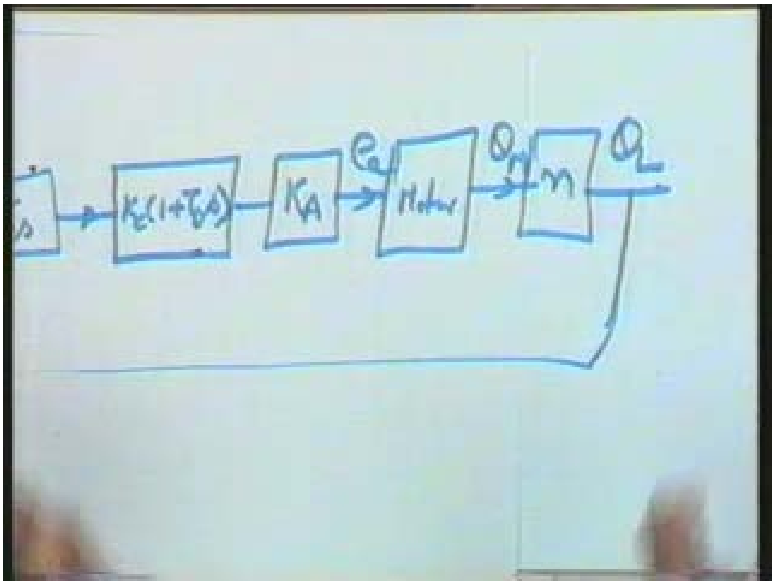

The motor I am using as a block. The complete block diagram of the motor is already known to you, thank you.