ROBOTICS

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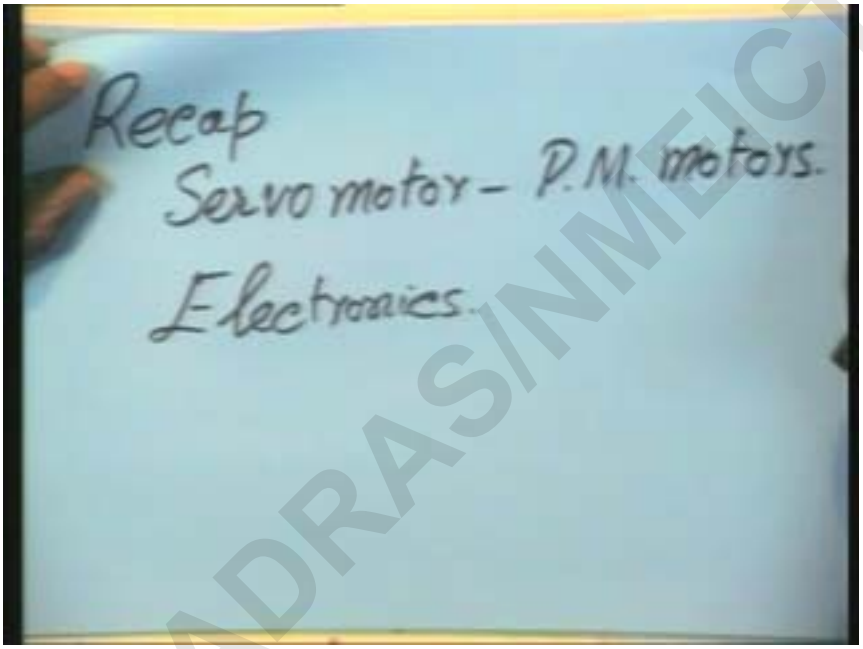
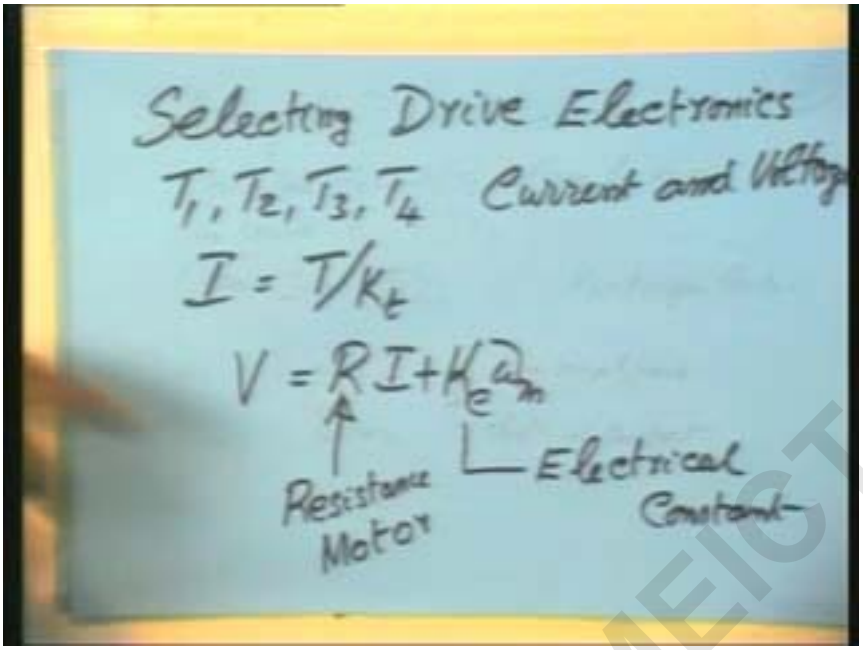
Lecturer no-8

Actuators - Electric, Hydraulic, Pneumatic Time(1:09 min)

welcome to this week I will be this will be my last lecture from tomorrow onwards one of my colleagues will take over professor b seth I will just recapture what we have done in the last class lecture(Refer slide time1:37 min)



we had looked at servo motors particularly the pm permanent magnet motors okay this is what we had seen in last class we had looked at the capabilities then we had also seen how to select them gone up to the point of selecting the motor the next step is the select the electronics now electronics okay the power file how to select we will briefly look at that before we pass on to the stepper motors okay (Ref slide time:121)



now the drive electronics which are used for drive electronics there are other electronics for the feedback and control and all that we are mainly examine on the drive electronics for the servo motors for the servo motor yesterday I have shown you how to calculate the various task for continues a rms value and peak value and all this we have looked at we had seen various segments of the motion incremental motion the acceleration segment the deceleration segment the uniform velocity segment all this individually we had calculated all the task T one T two T three and T four yesterday we have done that based on that we have selected the motors the previous class

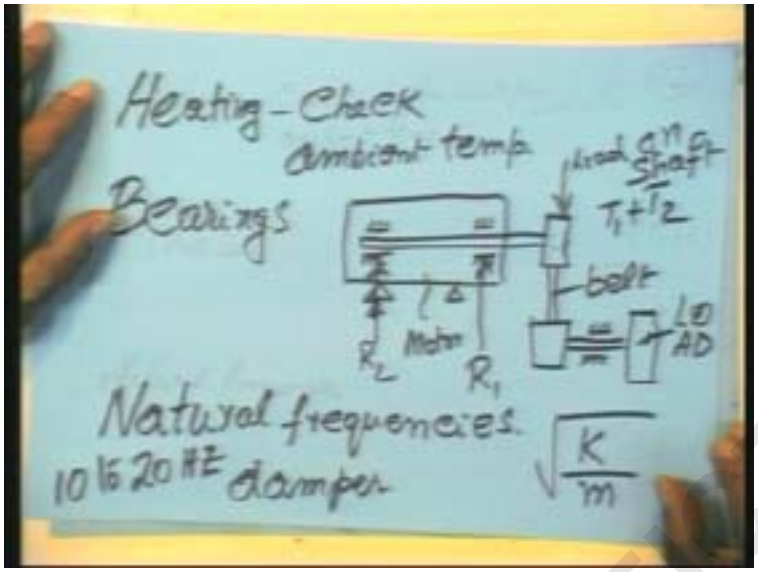
now what we have to do is for each of this periods T one and T four T one comma T two comma T three and T four as the task each of the periods segments T one is for the acceleration about the pitch of the T come T two is for the uniform velocity where most of the time we are overcoming the what we call friction load unless there is another external load T three is the deceleration phase where need certain task then T four is of course the task with zero in our case example we have taken

now for each of this we will have to calculate the current and voltage remember current will depend on the torque and voltage will depend on the current and voltage for each of the segment we have to calculate okay the current I is given by the torque divided by what is known as a torque constant of the motor kt K suffix t the torque constant first lets have each of the statement You know the task we use to state that which is usually a constant for the given motor why should I say constant for given motor use that to calculate what is the current and make sure that electronics will sub stain the current you know you have the peak current you have the continues current electronics must able to many electronics device may be able to give something more than what they are designed for for a very brief period so you have to look out you have the peak current as well as the continues a rms current look at both go to the catalog with give to the drive

and then make sure that it satisfy you requirement this is how electronics been selected okay

now for the voltage it will also supply the depict voltage because speed depends on the volt you are moving the motor over wide range of speed that is actual rate maintaining the uniform velocity go down you requiring differing voltage during various phases okay for that we have to make sure you voltage is also adequate so the voltage is calculated as RI plus Ke okay where Ke is the electrical constant and R is the motor resistance there is going to be voltage drop because of the resistance that we have to check it out depending on the current flowing for each of this segment you calculate this for rms value and also you calculate the voltage you know the torque individual segment you know the aromas torque you know the resistance of the motor which is given in the catalog by the motor manufacturer then you can calculate this turn and then add to it Ke is given by the manufacturer it is the motor speed take the maximum speed of the motor and add it something omega m is the speed of the motor the electric constant ke is given by the manufacturer okay

so you will know the voltage maximum voltage require using this two you can select the drive okay if rapacity electronics is not available you may have to revise your motor design or you may have to look over another comparable we usually motor manufacturer give the electronics also along it may send volt by the same path this is how the drive electronics are selected for a servo meter the reason why i have gone through the servo motor is that one we are frequently encounter as you looking to the area of robotics now after you have done all this there are certain things we have to do not mentioned here if you go to any motor manufacturer or any standard text book on servo drive you will feel that heating is the very important condition that is very important condition heating up of the motor if your selection of the drive is not careful the electronics or motor is not done properly you are not careful you might end up having a motor which tends to heat up when it heats up as you know most of the permanent motor or any motor heating is the process damage excessive heating in a PM motor because of rare at magnets they are not very good conductor of heat so if any heat is there any cycling of heat may lead to magnet losing its magnetic properties so that why heating has to address carefully You will find that almost all motor manufacturers will give you curve by you can determine what is the raise in temperature given in an ampere temperature or they may provide a small formula which you used to look at heat so heating is the very important thing (Refer slide time 8:44)



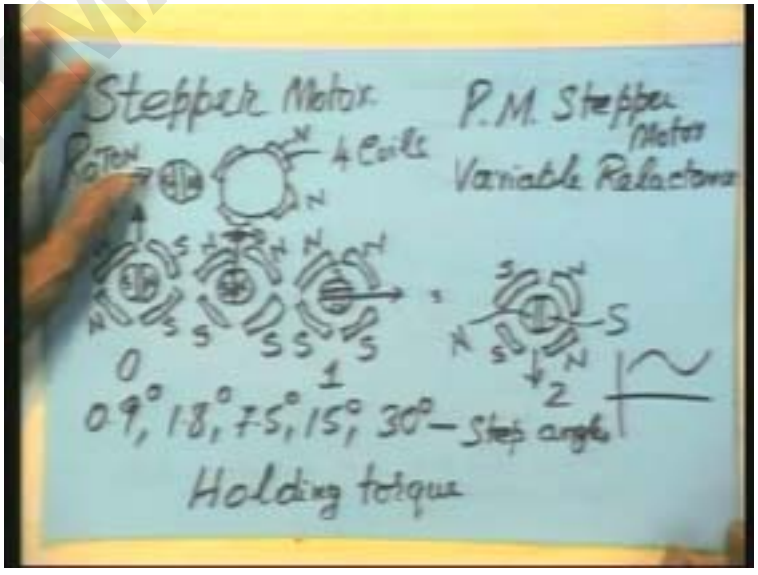
heating check remember ambient temperature is this space if you are a operate very close to furnace and all you have to worry about the ambient temperature you may have to provide some fans or you know motors come with or come without blow air blow air through the motor in order to cool it so your selection will depend on you may have to select the motor with blow air helping it to exercise iam talking about incremental motion that what we have to encounter in the baud the arm move accelerate moves the constant velocity diesel rate then weight keep on moving that what difficulty start the continues motion the motor is rotating continuously to attain some curry state fairly straight forward to estimate this things the drive electronics the motor rating heating all this fairly straight forward then at doing with incremental motion one has to be rectifier

there are some other things which i would like to base on the experience i havei would like to touch up in the motor selection see motors typically are called upon to the drive a load through a motor shaft and there might be either a bell or a gyres connection it to the load let see here here is a bell i am showing the bell drive this is the motor there is a motor start shaft inside through a bell drive it is driving the load the load is here load this is the load as you all aware the bell exacts the tension T one plus T two where T one is the tide side and T two is the slack side tension there will be tension in the drive which will tend to pull this two pulleys together in gyres also there is going radial force gyres base remember that length of loading the motor bearings or gear box you know it depends on whether you are directly using a motor or you have a gear box attached okay

it will end up loading this now you have purchase the motor you have to make sure that this barings will take up this there is something we have to mention many a time you may have to ask the what you call that manufacturer that you have such a particular load on it the tension of the belt can barings take it out we can easily estimate the reaction on the bearings this is R two baring here sorry this is one baring this is second baring they may be R one and there is a load here load on shaft you can estimate this from simple mechanics by equation by looking at the torque moments and the forces equilibrium you

can estimate the reaction and go to and ask him whether this particular baring will visitant that and life of the baring we have to work out the life rate at which we are working based on that getting average speed we have to work out what will be the life of the bearings most manufacturer will give you this data but many a the time the normal catalog contain it we have to go back to the manufacturer about this one more check we have to make sure bearings they can visitant many i have seen many designers you know ignoring this and paying a lot for it the because whole motor is damaged virtually what the baring are damaged another thing you have to look at is the natural frequencies there is the natural frequency the drive system from the motor to the load lot of stiffness is involve tosdoronal stiffness so many things root k by m is natural frequency of any system incase of tostanal system we will have to replace by this i the moment of inertia

so you know the individual system natural frequencies in the transmission line you make sure that the motor this you operate ever from the natural frequencies but if you go through with natural frequencies you have to provide a damp many a time that will happen typically the natural frequencies in this drives okay the natural frequencies of the varies drive element system will be usually the order of say about ten to twenty hertz ten to twenty hertz that is okay cycles per second ten to twenty hertz the natural frequencies one can estimate those natural frequencies of various segments of transmission system and see whether the motor can be kept away the drive the posting frequency can be kept away or if you have to pass through the natural frequency to attain you have to make sure there are rumpus otherwise vibration second resonance will second so this are some of the things which one should examine as he uses this motors okay and the associated so we have now more or less seen the various what you call servo their capabilities and how to select them and verifying whether your design is okay this are the steps we have seen as per servo motors are concern permanent magnet there are many other types of servo motors ac servo motors were not touching upon them because not enough time for this in this course but this background will help you look at those also open a book any text book there is another drive which is frequently to use (Refer slide time 15:42 min)



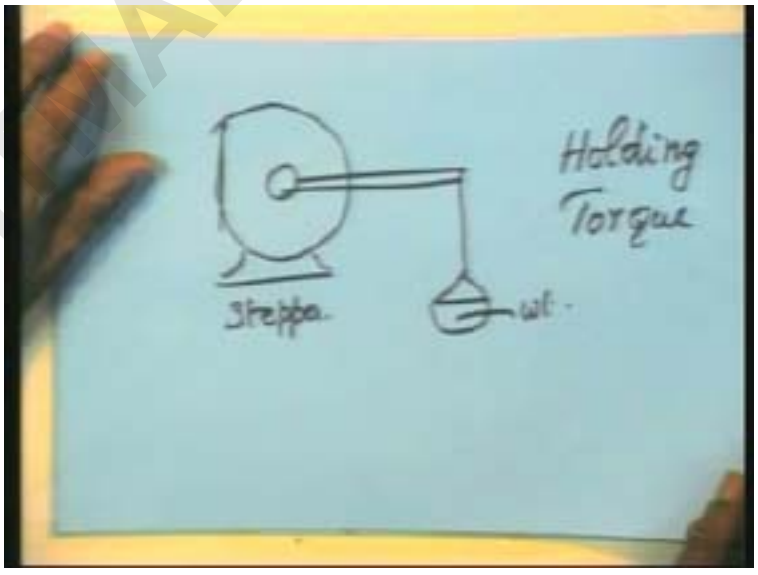
the stepper motor here i have told you long back perhaps sequence of pulses to the motor turns in through one degree let see how the stepper motor functions because you know that what will give us a feel of what is going on essentially what it contain is a rotor and theater like any motor now mind you all this stated now coming out in the linear drive also that means no longer the stepper motor and servo motor just those rotate where the shaft rotate you can also have a translating stage given by this stage that is that design of that more or less is not similar selection of those are in similar lines so we wont touch them

now the in the case of the stepper motor the router there are two types of course motors what is known as variable reactance motors another is the permanent magnet motor okay many of you might be the variable reflection motors we have a soft steel rotor okay soft steel rotor rotor tends to be light where as permanent magnet stepper motor you have permanent magnet as a router i will just touch up on the permanent magnet stepper motor PM Stepper Motor now there are many more things about stepper motors you know which i am not going to discuss because you always look up a book and then variable reluctance i will just touch up on some important aspects variable reluctance is the other one okay now let us look at the permanent magnet stepper motor i have got a router which on one side got a south pole and another side a north is the router then i have got a theater here of four coils these are the coils i will show them outside one two dispose ninety degrees apart these are the four parts this could be either north or south depending how you current how you pushing the current north or south similarly this also could be north or south this also could be north or south remember mind you this is permanent magnet router so this is a router two halves not two halves one side is south and one side is north now let as assemble this and see what will happens now i have got south here and I have got north here okay i have this four magnets surroundings this initially this is north this is north and this is south and this is south and the rotor position is given by the swap thus the reference position iam not showing the entire circle of the theater i am just showing this four okay north south north south then what you do is you switch this so that this becomes south and this becomes north and this is till north this is till south it is a very simple way of understanding stepper motors that its this is south and this is north

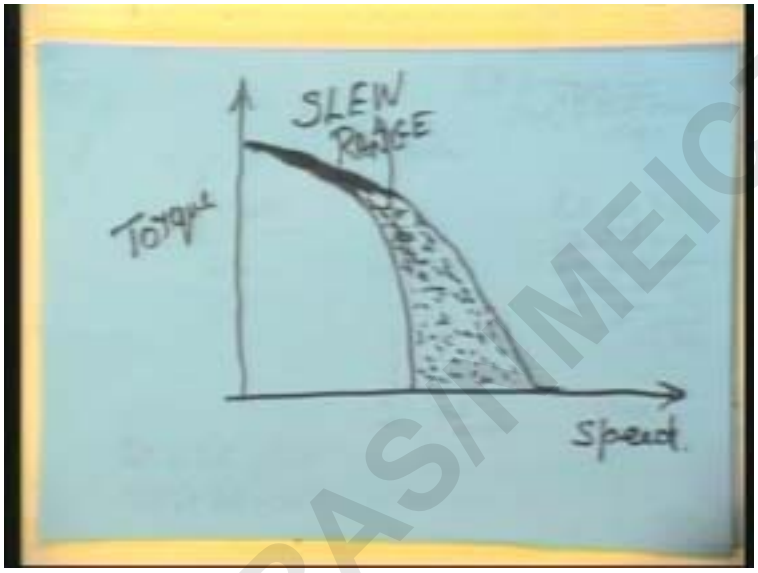
you switch this is originally north south now it has become south north then what will happen is this rotor will start rotating the rotor will starts rotating that arrow it will start rotating okay and it will occupy this position it will occupy this has become north see the rotor has rotated ninety degrees it will occupy this this is north this is south this is north this is south it has turned form here to the momentum has switched from north to south i have switch to south to north this way the rotor will rotate you can I think you can visualize you see the poles this repulses this attacks now it has moved through ninety degrees right half way through see what happens is as the switch now again switch again ones more in order to further move it this is north this is south i now switch it so that now show you in this picture after when i deed okay currently this point it is south here this is north i think letters are not large but you will have to fix here now when i switch it here

north south south north again compare this two have been switched the rotor now occupy this position where this is north this is south where this is south from here it has come out so every time I switch this magnet the electric coil the rotor keeps rotating okay now the torque output of the rotor is going to fluctuate as it moves between this magnet so you will not get a you will get a torque vary allocation and the minimum push or minimum torque is obtained when it is in between two positions see that is starting here and ending here some were in the forty five degrees in between the minimum torque that is the running torque there is a huge push here towards the end also there is enough of force available but in the middle there is a lowest position where see this is the ninety degree one when I have shown in the middle you get the lowest torque that is the one that governs how much torque that motor can deliver that is known as the running torque that is known as the running torque

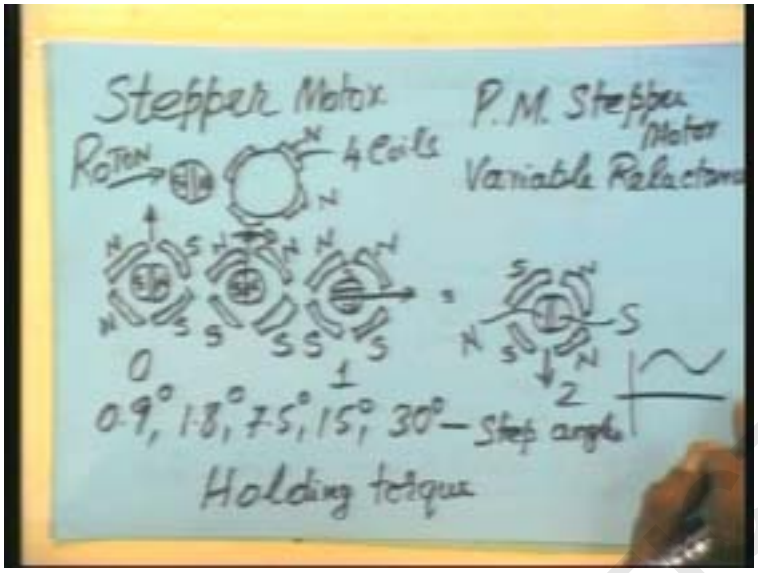
okay in between two positions in between one steps break through the steps thats where the torque obtain is the minimum that is the one that governs how much task that the motor can provide that is known as the running torque okay at the initial point that it starts it has sufficient torque large torque at the end also it has large torque available but in the middle you will find that torque drops slightly okay is that clear between the two magnets some were is it clear now this is step zero it has come to step one and it has come to step two step one from here to here and another step from here which one we will come to that sometimes it can stop in the middle stop in the middle the varies the lowest torque point if the friction is large then it comes to the lowest torque point it may not go beyond okay now typical step size is available standard motor is “zero point nine” “one point eight “degrees then we can code “seven point five” degrees fifteen degrees thirty degrees and so on this are called as the step angles they are called step angles one more think the stepper motor which you should know what is known as the holding torque if you energize the stepper motor the shaft doesn’t rotate but it hold on to the particular load that is one could show it like this stepper (Refer slide time 24:45 min)



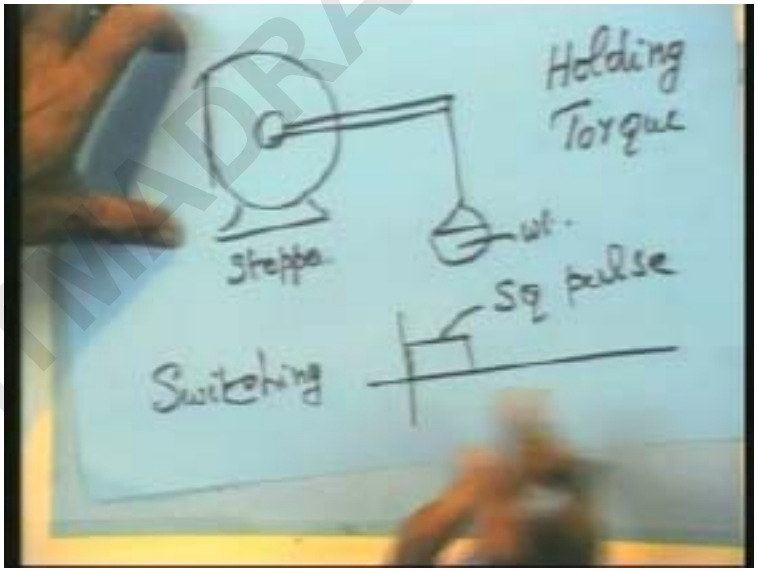
this is the stepper motor stepper motor shaft on that you put a arm hang a weight energize the motor motor will hold the the holding torque is the torque at which the motor can continue to hold any more weight you put the torque increase not able to hold that is known as the holding torque you know this holding torque because if you want to hold the robot arm up and you want to keep it there keeping the motor energize it will keep the arm what is known as the holding torque okay this is also given by the motor manufacturer give to what is the holding torque of them stepper motor now we will come to the performance of the stepper motor stepper motor performance characteristics okay (Refer slide time 25:58 min)



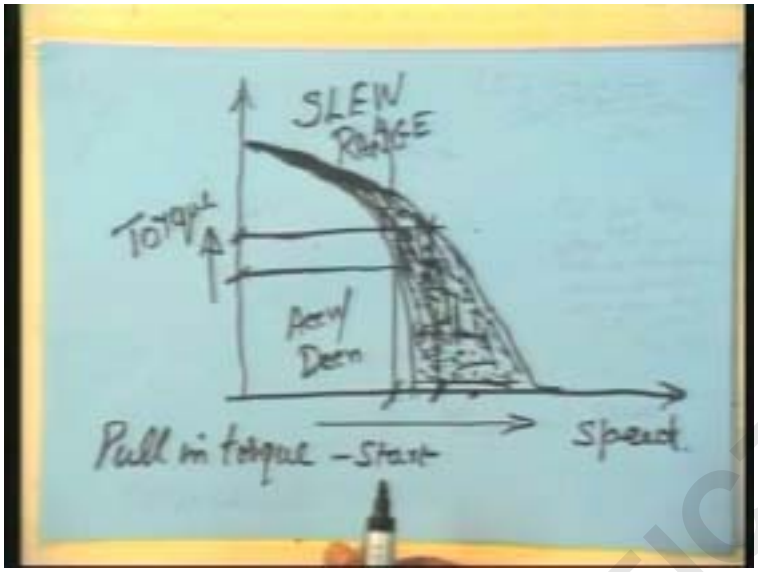
if i plot torque versus the speed i get two curves sorry this will be outside this intermediate this one slightly let we see this intermediate area is called the slew range darken area the dot whole think whole of this including this is called the slew range this is the torque versus the speed notice that the speed is on the x axis and the torque is on the y axis you know is not the way we did it for the servo motor this is known as the slew range okay (Refer slide time 27:25 min)



now let us go back to the stepper motor you are given it a series of pulses in order to make it step you are switching these coils giving it a series of pulses the moment you switch because of the inductance of the coils okay the inductance of the coils plays a significant role in the torque availability a slowest switching rates that is a lowest speed the inductance doesnt have a much of a effect on the torque but as you increase a speed you are switching at a very fast rate current in the coil will not raise (Refer slide time 28:08 min)



you are essentially the switching is a square plus but because of inductance it no longer require it is a raise time there is a halt time okay as this slowest speeds this particular phenomena doesn't have much effect on the torque capability available torque but as the speed increase you are switching it a faster rate the inductance starts playing your role and the torque available decreases okay the torque available decreases as you increases okay alright is that okay (Refer slide time 29:05 min)



now lets see what happen what is the meaning of all this how does it affect us just darken this little more the slew range in the slew range where the switching is higher as you can see as you increase the speed is increase in the slew range where switching is higher the torque is poor consequently we can only overcome the friction torque cannot accelerate and decelerate this one the motor is picked up speed and you have come to this zone cross this line this boundary you crossed this you come to this should not expect motor to be accelerated it and decelerated it very large rates because the torque available is very low and the consequence of the motor will if you try to attempt to either accelerate or decelerate at very high rate when i am saying very fast rate and then the motor will slept and miss some of this types in this zone

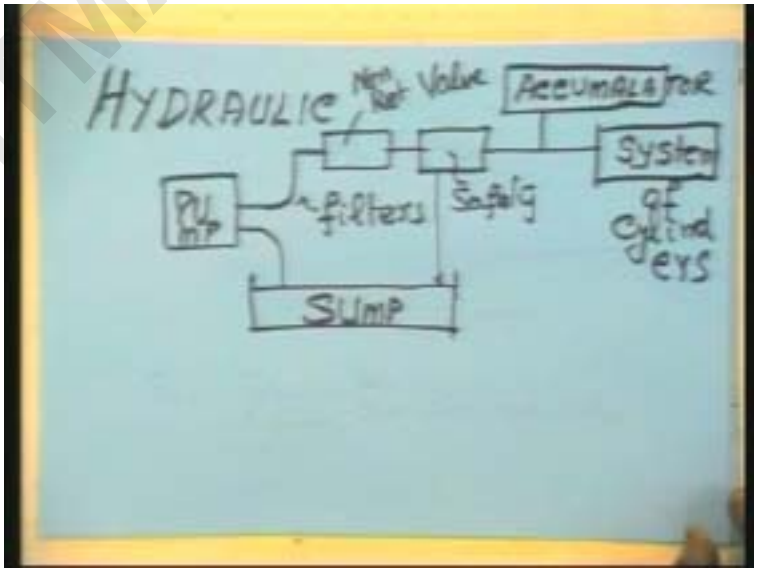
okay you got it you know when the motor is moving at a very high speed you are given at a sequence of pulses now you want to increase the speed suddenly try to increase accelerate motor will miss that when it operating there is no such problem here below the that is mean you try to operate acceleration and deceleration should be done within this

okay when you enter this slew range operation center the slew range dont try to accelerate or decelerate now this is some thing which most navies scroll not look at slew range the torque range and the slew there are not
so there is what is known as the pull in torque for that means suppose you have motor and a load okay you want to supposing you have specific torque here now as long as your speed is i have the torque one point i draw horizontal line i come up this okay this is the maximum speed within which you can safely accelerate and decelerate this is the pull in torque given a torque load this is a maximum speed if you look at a speed start from the speed if you have the speed operating speed is here you want then if the torque is above this you will able to accelerate it comfortable if the torque is below this you will be able to accelerate comfortable load torque the load torque if load torque is below this able to accelerate it comfortable now you have accelerated let us say you have entered this zone don't try to accelerate or decelerate this outer boundary determine what is known as the pull out torque suppose i have the torque here load torque and corresponding to this any

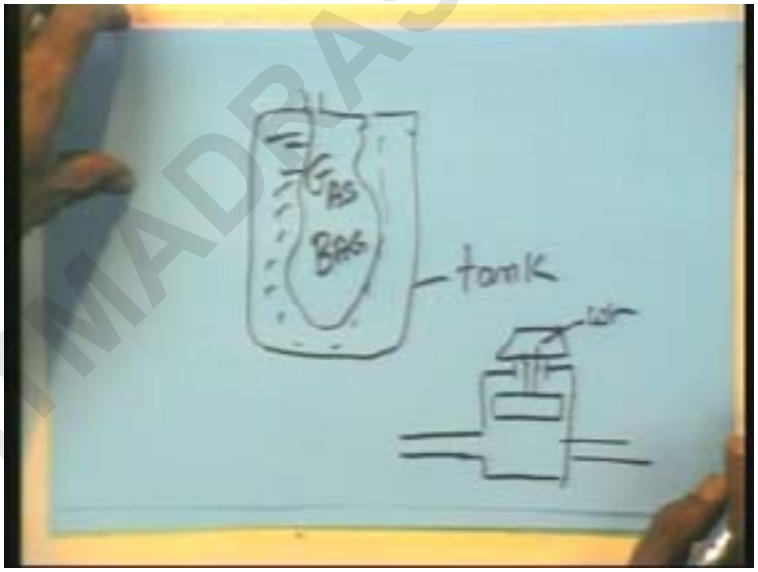
if i try to go beyond this speed the motor will starts loosing the steps until the speed it will be easy try to beyond this boundary coming out mind you the load torque is here iam crossing this boundary and coming out if i try to go beyond this speed i have drawn this any point beyond this speed the motor will loss the steps there are the points you have bare in our mind when you are selecting stepper motor for your choice

okay now regarding calculating the size of the stepper and all procedures are similar to what we have seen in the servo motor procedures are similar only think you have to remember is that you have to carefully operate the stepper if you violate this you will loose steps that's the one okay now that go in to the slew range and out you have to accelerate very slowly or decelerate very slowly another think let us look at it again given a torque low there is a maximum speed beyond which you cannot comfortably accelerate or decelerate okay this is the speed given a torque okay and you can move at a constant beyond it a particular level speed it will start in this zone it will be in synchronies with the switching following the switching it will follow the switching without loosing the step beyond the particular speed it will start loosing these are the things so this is the acceleration and deceleration zone here if you are careful your motor will not miss step if you are not careful but cross this boundary you ask for more speed than the motor will lose steps these are the two points designing servo motors

okay they are many other servo like the micro servo and all that iam sorry designing stepper motors there are many other micro stepper and all that i will leave it to you have all those micro steppers and all they are become very quite popular used for various this by by and large complete my way we have looked at the electrical activators you know in this course we are only going to give to you some flavor of all this activators we are not going to depth of this activators because each of this constitute have separate course by itself servo motor design servo motor control and all this has full course can be taught on that like wise in stepper motor also there are full books which will you give you details but just you know what are the basis
(Refer slide time 36:30 min)



now let us look at the hydraulic and pneumatic systems now we just look at hydraulic and pneumatic activities here also i will just touch upon on something which will allow you to do some reading on you own as you go hate a typical hydraulic system i will talk interchangeable both hydraulic and nomadic because many things are similar here and both it consist of a pump and a tank of oil called a sump is the sump where oil is contain then it take in oil feeds it to the system if you want the system is sitting here there is a system of cylinder which you want to power system of cylinders system of cylinders the pumps take in oil from the cylinder and pumps it out there may be filters on the way in order to filter the oil these are very sensitive to dust particularly the servo hydraulic are very sensitive to dust they are very fine they are fine hole they are fine hole through which oil flow so they are very sensitive to dust so you must have proper filter also you must have remove moisture there should be in the oil air should not be entrapped air should not entrapped in the oil so when you start your system take quit some time to fill it up with a oil and make sure there is no entrapped there entrapped moisture oil will ret air it when there is moisture you have to make sure that then valve and things then there is what is non return valve this is a typical non return valve then there is a pressure release valve a safety valve you know sometimes for some reason if the pressure in the system goes up the valve will release the oil usually back to the sump remember that you can through the oil all over the shaft floor it goes back to the sump then there is what is known as the accumulator you know in all these systems pressure plugtivate this accumulator is a very simple device (Refer slide time 39:16 min)



essentially you have a tank i will put in on top with a gas bag in it you know you can do one thing the one simple accumulator do have oil flowing like this okay through a positioned cylinder keeping a weight on top this should be a simple accumulator oil flowing out whenever the system pressure goes down goes up this weight is pushed up this system pressure goes down stream the weight comes down and maintain the same pressure that what is the you must have heard of accumulator is several instance this is what accumulator is instead of this we now have is gas bag inside and oil is around there

is a bag of gas (some noise) is the pressure increase the gas is squeeze and from the inlet side if pressure decreases the speed of gas bag expand then maintain the same pressure on the line that all weight of you find this all in a simple device which has been the accumulator
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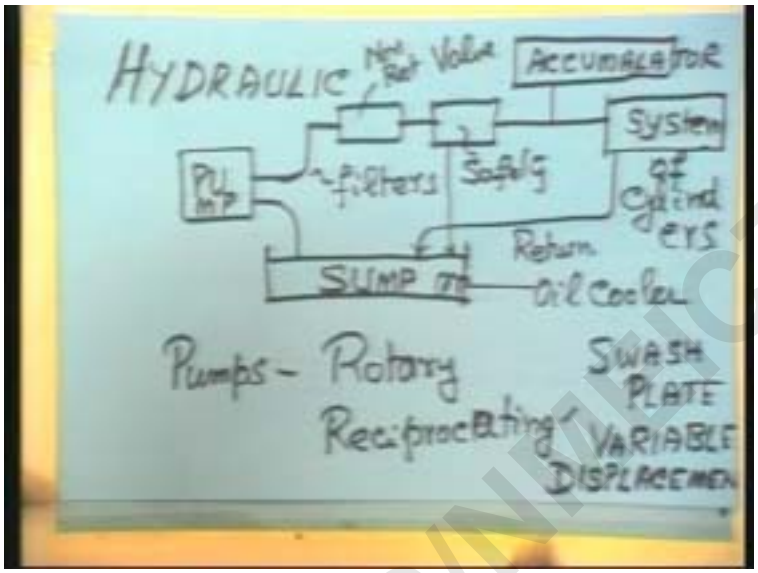
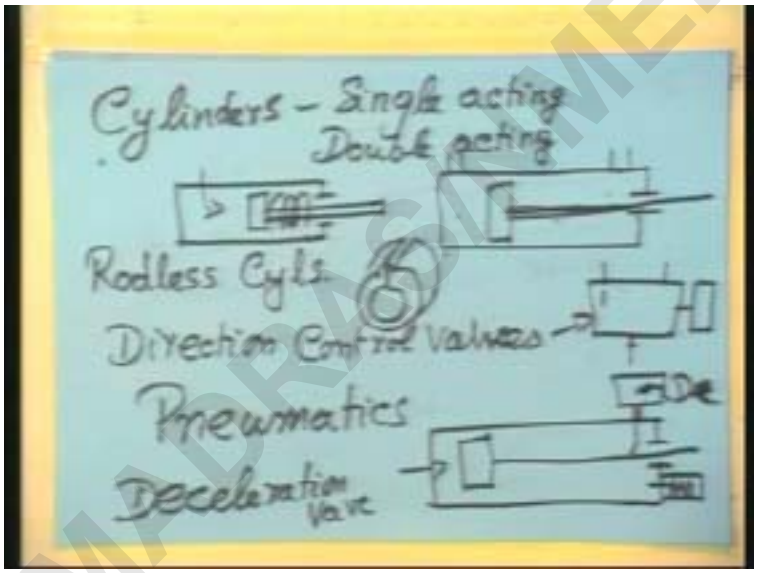


then there is go to the system of cylinder if you want to control from here there is a system return to the sump there are several types of pumps rotary and reciprocating positive drive rotary and reciprocating positive drives there is a very interesting pump called the swash plate based on the swash plate i think you should look out this particular it is a variable displacement pump you can vary the stroke variable displacement i leave it to you the seat in a very interesting mechanism variable displacement

see you can control flow by having a valve on the line or you can vary the pump strokes number of stokes or whatever it is in order to control the flow that must be is the variable displacement okay these are the various pumps which are used in
in the case of pneumatic you will end up with a compressor and compress line and there also you will have a filter and you have delimitifier the dryers you like to be their drive the two ways of drying you pass it to some silica gel something like that are you another way of drying now a days which are very popular is a refrigeration system through which the air is passed it sucks out the moisture it you know condenser is the moisture take it out we have it in one of our lab the very compact you know because the moisture in the air will condense somewhere and create problems the pneumatic systems you don't want to moisture going on to particularly in places like mumbai where there is lot of moisture this become quite important in it dry air dry air system you either pass it through some gel delimitifier i mean silica gel or something like that

okay or you have low temperature system where moisture condense is an extract this is what done in the air conditioner in air conditioner there are delimitifiers which are commercially available this is as for as pneumatic is concern in hydraulic you have to make sure no moisture begin with in the oil because moisture in presence of moisture the oil did earl rating very fast it is one more point which you know as is oil is circulating doing work high pressure low pressure it tends to heat on so here there is always a heat you know oil cooler is inserted in to the sump there is a oil cooler in an oil is working in a closed loop inside a close loop it circulate it tends to heat up you know the pump is putting some energy it tends to heat on there will be friction in the cylinders that will generate some heat oil will tend to heat on that heat has to be extracted there is an oil cooler in the sump many a time it is in the sump sometimes you may have to put it on one of the lines in order to extract the so the oil temperature is maintained otherwise you know the performance system will keep change so these are some of the elements of a pneumatic and hydraulic system typically the pneumatic and hydraulic system drive what are known as the cylinders (Refer slide time 44:51 min)



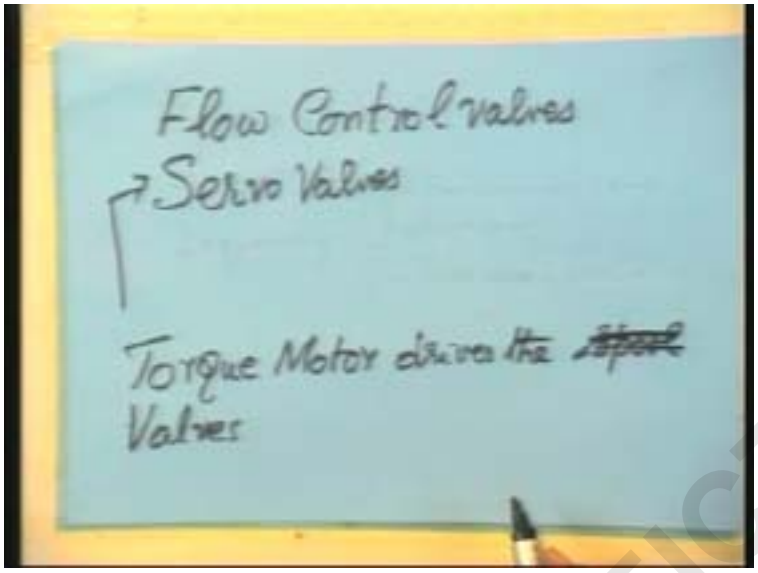
there are two types of cylinders there are cylinder there are two types one is single acting and another is double acting single acting and double acting iam referring to the reciprocating type of cylinders the single acting cylinder is the name looks permutable but actually it is a very simple device when you admit oil or air on this side of pistol the pistol move compressing the spring and the return motion is by this that's way called as single acting one direction the oil are pneumatic hydraulic or pneumatic pressure acts when motion is in one direction if the return motion is through a swash sometimes we called him spring return and all but this known as the single acting system when you are admitting oil to both sides for the motion oil or both side you have what is known as the double acting these are some of terminologies which you should familiar with double acting you have to admit oil on on this side to push it this way you have to admit oil on this way push it on this way this is known as the double acting obviously supposing you are calculating how much is the particular amount of pressure oil pressure you have you know much load is available load torque is an you know this course available so you

will multiply the pressure by the area of the pistol but on this side remember the pistol rod is hiding here the area is cut down this area minus this area this has to be kept in mind double action okay it has to be kept in mind on one side you get lesser course because of the resonance there are rod less cylinders there are what are known as rodless cylinder more expansive they are more expensive essentially the cylinder will be something like this is a cut here take a tube cut it along the length split it okay that is

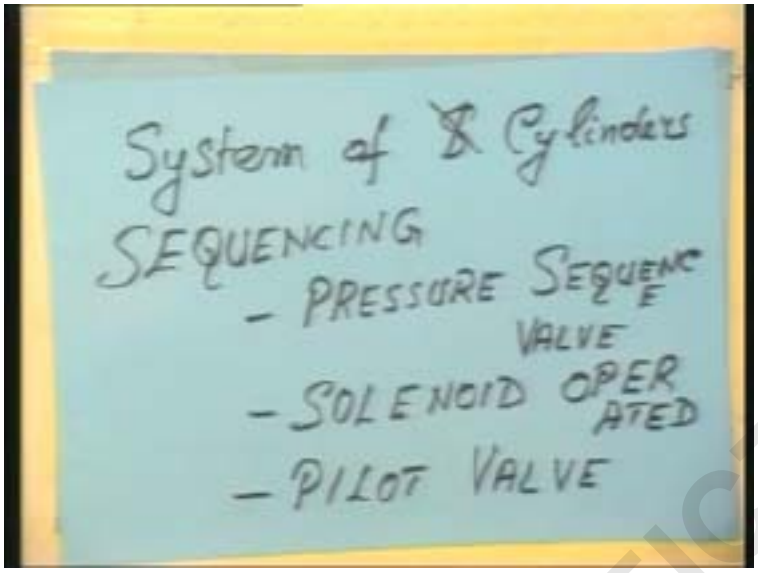
okay now pistol is kept here and some thing project out of the pistol through the split and that is the one thing and there are along this length in order to feel the air in there are flaps which close like this magnetite and seen the air or whatever it is rod less or mostly used in the pneumatic so there is no pistol sticking out the hole thing moves the way and that way something moves like this no pistol sticking rod less cylinder you can look up the web you can see the they will show it in the website many people used it but there is leakage here and all those problem side now when you like to double acting cylinder you like it to move this way and that way obviously you have to admit the oil inside to move in this way and then there are what are known as direction control valves

essentially what they do is you have valve like this there is a solenoid usually solenoid move the pool inside so the oil which comes in goes either to this side or that side remember when you are moving like this oil inside of this pistol suppose if you are moving this way oil on this pistol on this side will be send to the sump are taking care of the direction control i have told back operated by the solenoid last time i had brought few of the valve all look like that pool which moves up and down connecting to this port to this port(some noise) okay now when you when you have pneumatics i have told you last time the pistol tends to go to the other end the piston once you admitted air here the piston tends to go to the other end there is no control everything just routing on as the air is admitted usually they put what is known as deceleration valve here

the deceleration valve this is what it is this the one air on this side you control the rate at which is exiting and consequently decelerate okay decelerate going in banking decelerate sometimes there are external shock absorbers fitted here shock observer externally a spring and a dash bar they are also use a deceleration valve plus this or pneumatics is quite fast like simply goes but high speed also means that suddenly it goes and bang and so you have to add this devices in order to towards the end of the control what you have to this deceleration valves then shock observer all this are used for now admitting air to this through what are known as solenoid valves many if you are electrically activating through digital control admitting switching this valve from i mean valve which admit solid (Refer slide time 51:40 min)



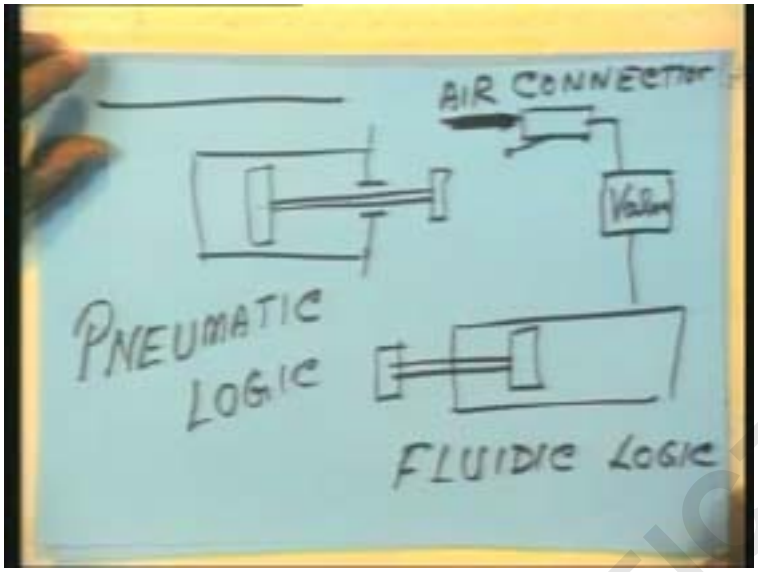
now if you really want to have control on the flow you are what are known as flow control valves now if you there are shapers and there are machines where a tool reciprocate driven by a hydraulic cylinder you can set the flow control valve towards specific speed and then you can have it reciprocating up and down okay there are also known as what are known as servo valves these are essentially flow control valves but you can control the flow by a servo motor which drives the valve small torque motor they are called torque motor in the servo valve a torque motor drives the spool drives the valve let us say because there are so many valves types of valves there are spools there are flappers so many types essentially what it does is depending on the feedback from the cylinder feedback control torque motor positions the flow control valve needle or spool are whatever it is so as to control obviously when you are doing such a control you could have a very quick response so you tend to use several device flappers so many things are there in order to control the flow the cylinder starts moving you want to control accelerate decelerate all these things are done by the servo valves okay (Refer slide time 53:46 min)



now when you have system of cylinder working this is a typical either both in pneumatic or hydraulic cylinder typical one you know you have a machine where you have number of pneumatic cylinders this moves first when that has completed the next one move this is known as a sequencing you have to sequence them in a particular fashion sequencing then there are several valves which are used that is what is known as pressure sequence valve

there are several one is pressure sequence valve see it is typically used like this you have a job grip when the gripping force has require this an adequate force when the gripping force is adequate to lift the job that mean the pressure is cylinder of a particular value that value the gripping force is adequate you know that you have grip it with so many so much pressure is there in the cylinder when that pressure is reach only then will it allow the next cylinder which moves the job forward you have grip it now the next cylinder moves the job forward must act weight will you grip make sure pressure in cylinder is the right amount and then only you let the next fellow that is what the pressure is sequence you sense the pressure and then decide the next pressure sequence value

alternately mostly what you have solenoid operated this a special valve now let say you are gripping an object you have solenoid switching the cylinder it will go and grip the object but you are not sure applying right pressure that is what this fellow comes very easily the pressure sequence valve until it is touches the pressure it won't allow subsequent operation to begin the pressure sequence where as the solenoid operated valve you can sequence them you have set of cylinders one moving in a x direction another in the y direction you want to move x first followed by z and then y then solenoid operation these are some of the valves which are used sometimes what they do is if they having solenoid operating that means the electric power is required to operate the solenoid which in turn will operate the valve which in turn that mean the solenoid is directly driving the valve spool so that what are known as the other valve what is known as the pilot valve (Refer slide time 57:03 min)



for example what you could do is when the cylinder motion is completed cylinder motion here usually the word used this you know always think about the pistol moving but the terminology used by the industry is the cylinder motion it is very peculiar we have to suppose you know this has hit this may trip a limit switch which in turn might see there the air air connection to the limit switch you have a pressure line you have a narrow line going here that it connect to a limit switch also limit switch is this will turn the operate the actual valve which in turn will operate the other cylinder next cylinder so these are the pilot valves you shall using a separate electrical connection to this this you can both are mounted together that means instead of electric solenoid opening the valve we use pneumatic pressure to open the valve

so pneumatic logic is used in these cases what you have is just like you have this bread board you know you can connect the various valve on that using the pneumatic logic you can sequence the valve you want then the signals to the corresponding valve connect the valve pneumatic valve so people use this so called pneumatic logic this here then you can avoid the electric then in the case of hydraulic one there are people come out with the fluidic logic

so you know you have a several technologies available for you as for as activators are concern several technologies we have mostly looked at the basic electrical activators there are many more it is endless the amount of talking one can do about activators

so i will summaries what we have seen in the particular lecture you have looked at element electric activators in the last lecture and this lecture particularly the stepper and servo we look at their performance characteristics how to select them what are the important considerations we also very briefly looked at what are known as pneumatic and hydraulic systems it is a very simple view and it will be useful to you as you go along in the next lecture i think we will be talking about sensors you know we are looking at a various sub systems of the robot we started with the main body then looked at the rest we look at them back that exact we are going then next we will see

sensors then we will starts looking at controls and dynamitic and controls that will be after we have finish this particular set of lectures on basic systems sub systems of robots okay thank you very much