INDIAN INSTITUTE OF TECHNOLOGY
KHARAGPUR

NPTEL
ONLINE CERTIFICATION COURSE

On Industrial Automation and
Control

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Topic Lecture – 20
Special Control Structures (Contd.)

You so this is cascade control very, very common and give significant performance in improvements over very affordable costs in most cases and therefore a widely used now we look at some other control structures namely selective override and split range control so first start with selective control.

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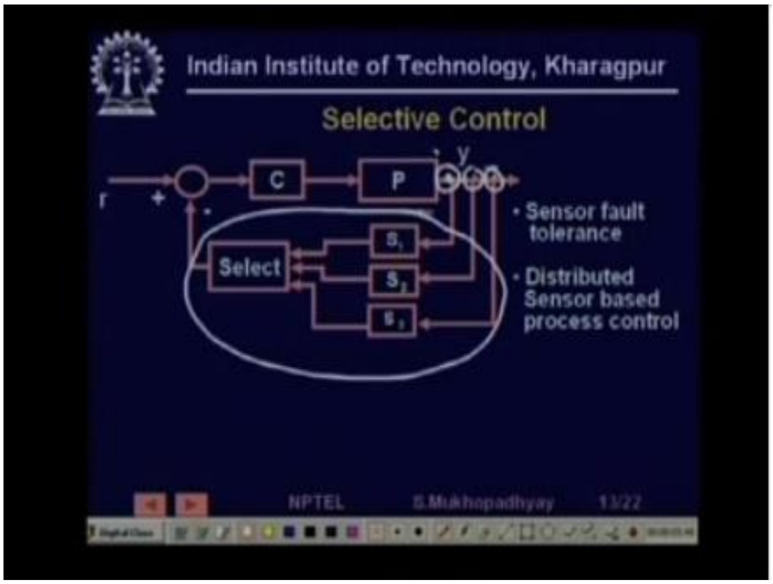

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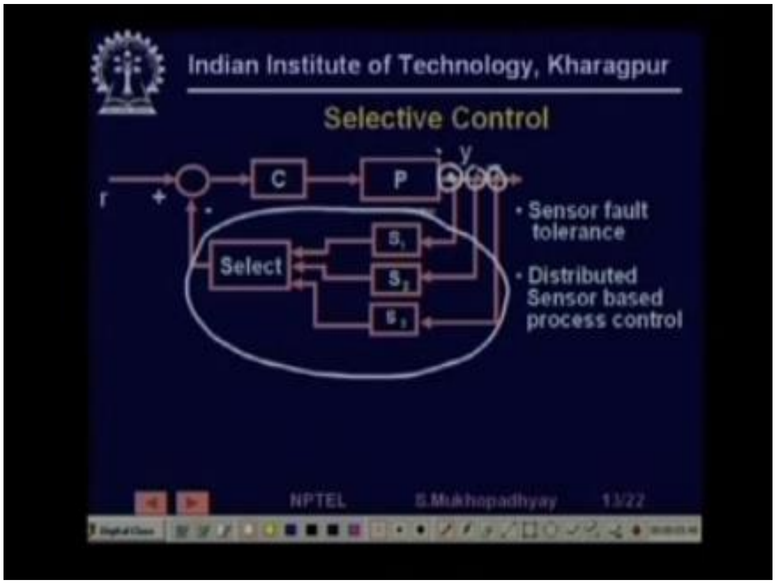

So as we as we said that what we are doing here is that we are just what are we doing the be the loop is standard the only change comes here so what we have shown here is that the same sensor the actually we have shown that as if the same sensor values are being the same process values are being fed but that you that is not so this means that the same process variable for example room temperature are being sensed by. Three different sensors which are at three different locations so therefore although they are being tapped from here.

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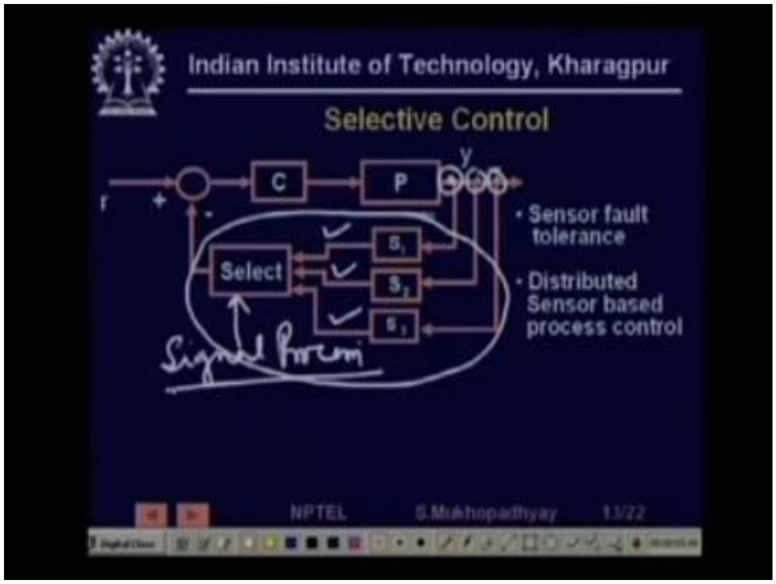

So these signals are not identical but they are there will be similar and then here we have some I mean selection or basically signal processing scheme so we can so what signal this what signal pricing scheme will apply depends on what we want to achieve so for example if you want to achieve an overall temperature of this room so then we should add some sort of an average then we should take.

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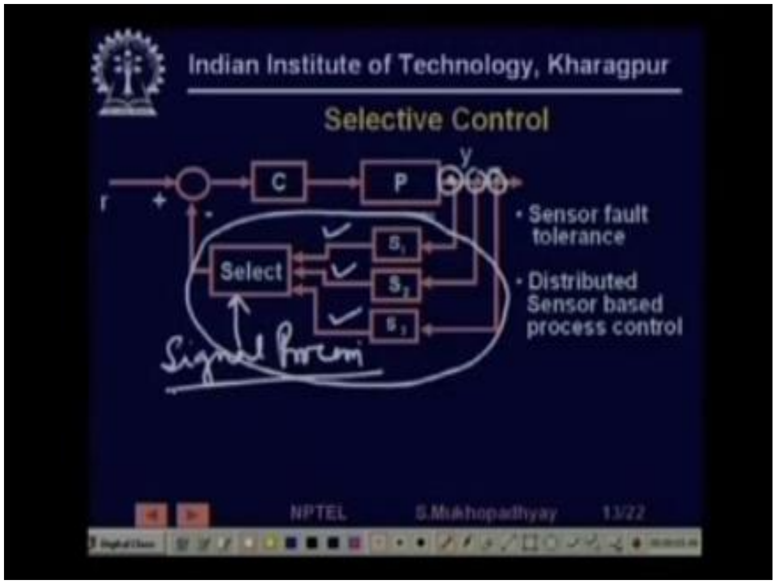

That take an average value this process should not select but rather take average if you want to know if you want to ensure that in no corner of the room the temperature will be more than 25^0C then we should take the highest temperature of these three and try to control that so temperature at every point of the room will be more than this attempt or the will be less than the set temperature so in case of room cooling that that is the case so in case we can you can choose the maximum value right there are even other applications for example sometimes you know there are very catastrophic effects can occur in occur in feedback control loops if one of the sensors feel.

So you can imagine that if there was a single sensor feedback and if the sensor failed some wire torn or something got burnt out some electronic circuit problem immediately suppose that this signal goes to 0.

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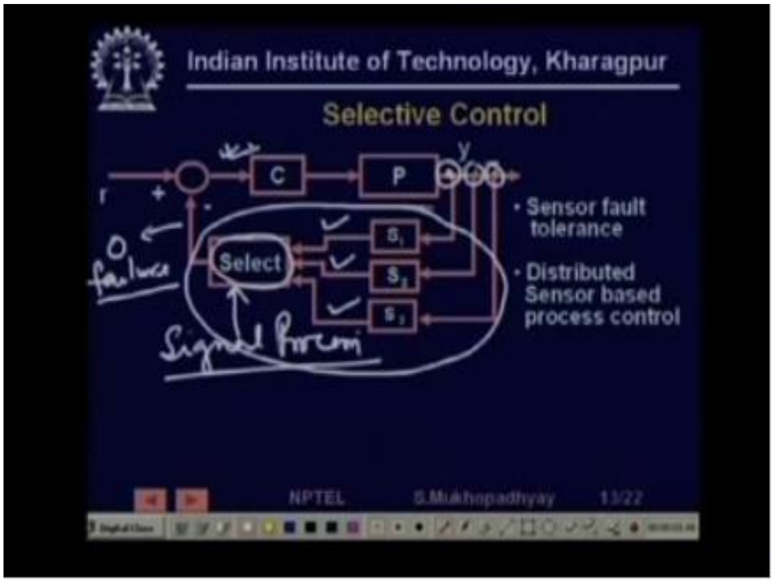

Due to failure then what will happen this will the controller will have no way of knowing it and it will simply see an error and therefore it will try to drive the process unnecessarily but that driving will not will not improve this value because it is due to a failure it is not sensing any more so in such cases industrial accidents may result equipment we met gate did get damaged so what people often do is that.

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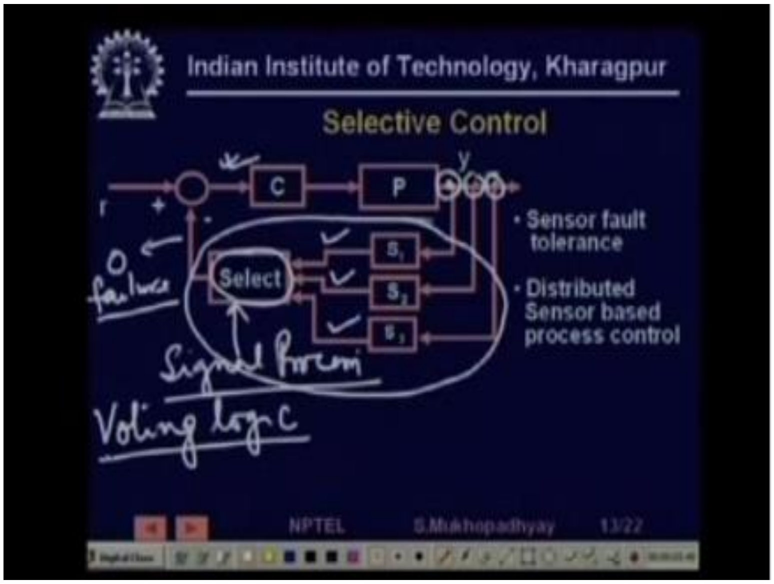

They takes S1 S2 they will put three sensors suppose to send the same variable and then they will put a voting logic that is if all three of the sensors are working are normal they have not failed then their readings are going to be very close if any one of the sensor readings goes significantly away.

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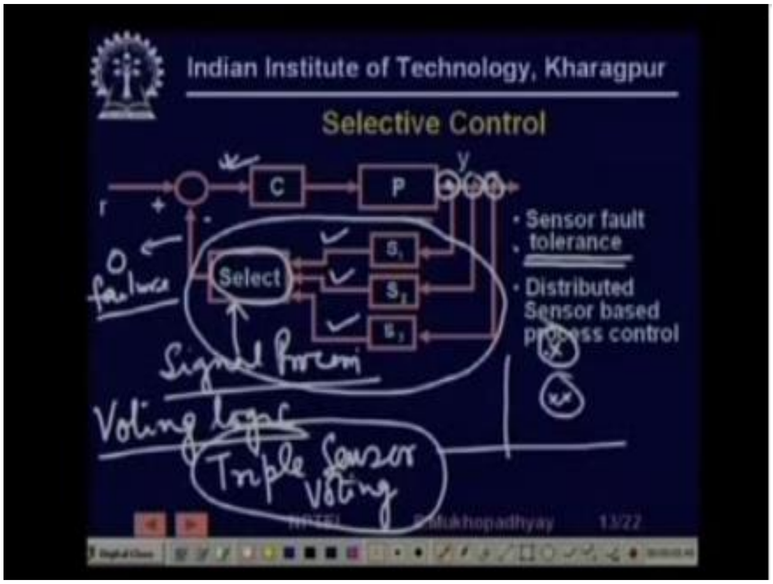

So two of the sensor readings are here while the third one is here means that the third one could be faulty so in which case the third once value will not be used in control so it will be cut out and only the average of these two will be used this is called triple sensor voting triple sensor 14 and often applied in various you know critical control loops so by doing this you can achieve certain degree of sensor fault tolerance so in such situations you can use sensor selective control there are there are even other situations.

Where basically where you can do median filtering that is you can select outliers when if suddenly one sensor gets a big piece of noise then if we choose always the middle value then you can reject noise better so you can it can also use it for doing various kinds of filtering so.

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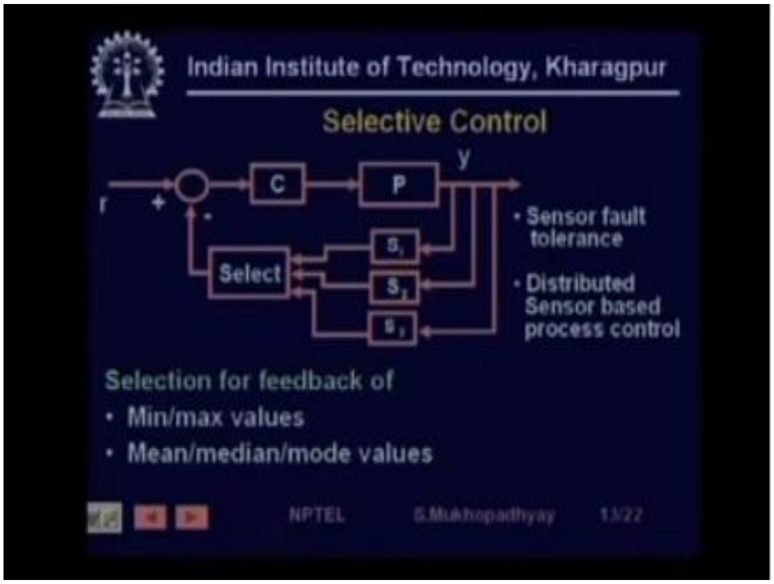

Selection of feedback for either mean minimal maximum values or mean values or median or mode wells so depending on various applications you could choose this is selective not very common sense approach but can sometimes give you significant protection from things like failures coming to override control.

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In override control what we have we have as ink I mean the same system could be operated based on to based on two different you know modes or philosophies so there so basically it is nothing like an if-then-else logic that if as long as this is happening operate the system in this way but if that happens operated that way so essentially this control loop is a sort of a supervisory structure which switches between in this case it will it will switch between two sensors to drive the same actuator and which sensor it will be used depending on which mode it wants to operate the system in.

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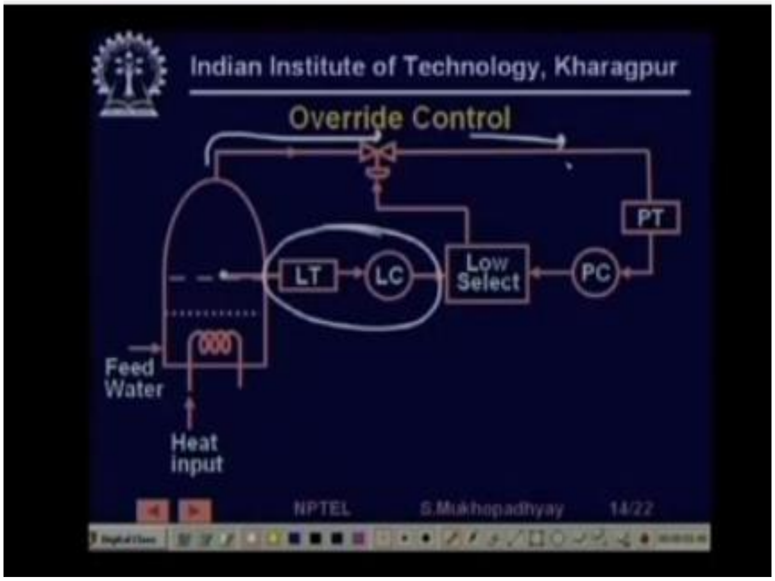

So typical example as a common-sense example here you have some something like a boiler where you we are getting feed water and you are having heat input so you are producing let us say steam so what happens is that you are here we are producing steam you have water and so there is a water level and steam is going out and being used for some purpose maybe for maybe it is a is the steam plant for them for another for the whole factory where 7 verse team is required for several other purposes for heating up certain things so what you want is that you want neither the you do not want the this level to fall to.

Lower levels so if it falls to very low levels then immediately the it is a level loop which should get preference on the other hand if this if the if this if the pressure the pressure of the steam should not go beyond a certain limit because then that may cause leaks that may cause accidents so if the pressure goes up to a over a certain limit.

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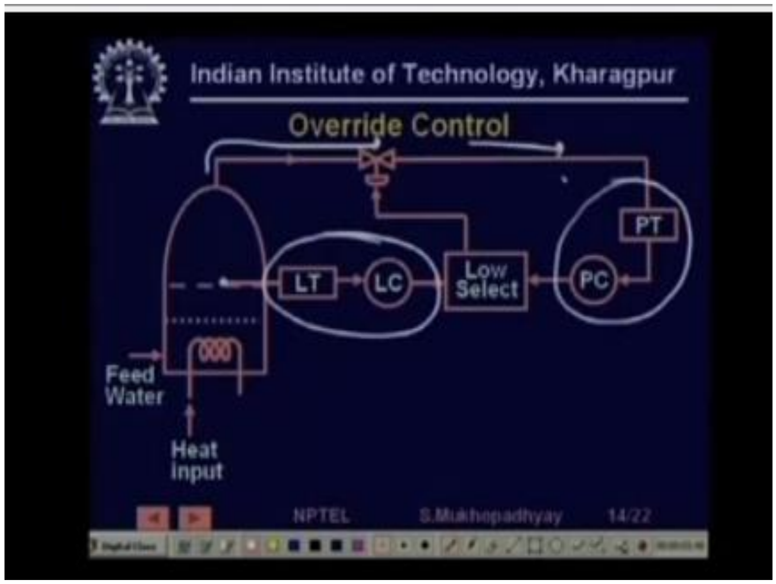

Then the pressure control mechanism should take precedence so you are having two different control loops and which one will take precedence in a in a given situation that depends on the state of to two variables so that happens that is happening because it is like it is like a protective scheme essentially because the controls will be actually so it you know coordinates because how much of steam.

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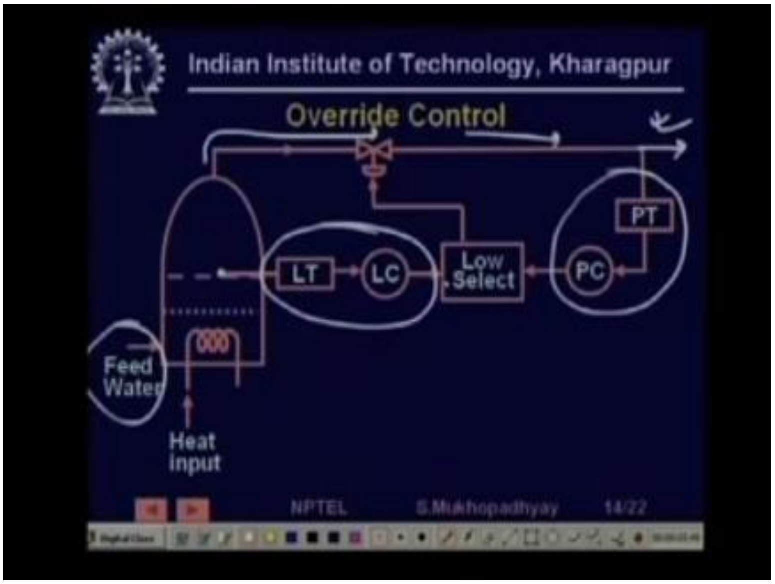

Will be finally drawn here that is also not in the within the purview of this of this controller similarly how much of feed water is going to be fed in that is not also within the purview of this controller so what happens is that if this level is falls too low then what will happen is that the judicious strategy will be to close this valve so that steam is not going out so that will that will raise that will whatever turn it cause is that the level will rise so we are we will not draw steam from here and similarly if the pressure goes too high.

Then also we should close the valve because otherwise it will so the pressure will be controlled so in a depending on these two modes so closing the valve means a lower input opening the valve means higher input so which one needs to close the valves that one will be used so this is so one in one situation one control strategy will override over the other so that is why it is called an override one so very simple and essentially these are.

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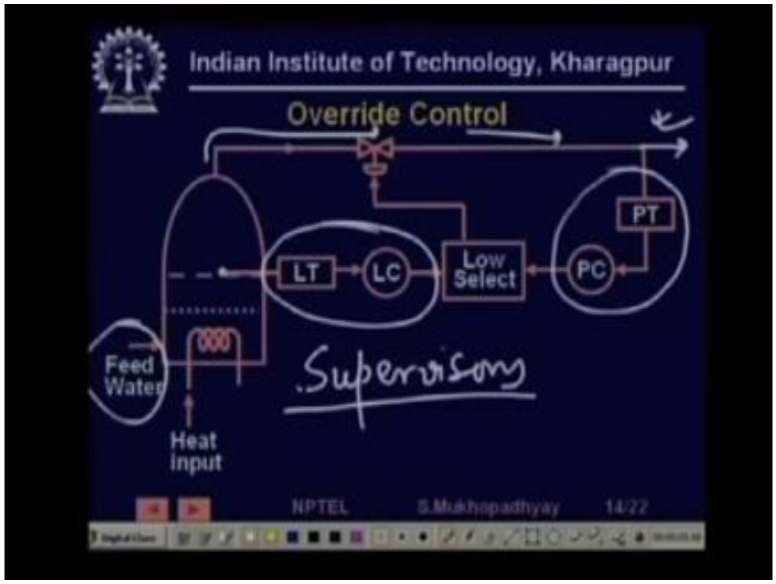

This is a supervisor in control I should say because you are because this is more like you know supervising the supervising the process and changing the changing the configuration of the process so coming back to the next one the last one that is.

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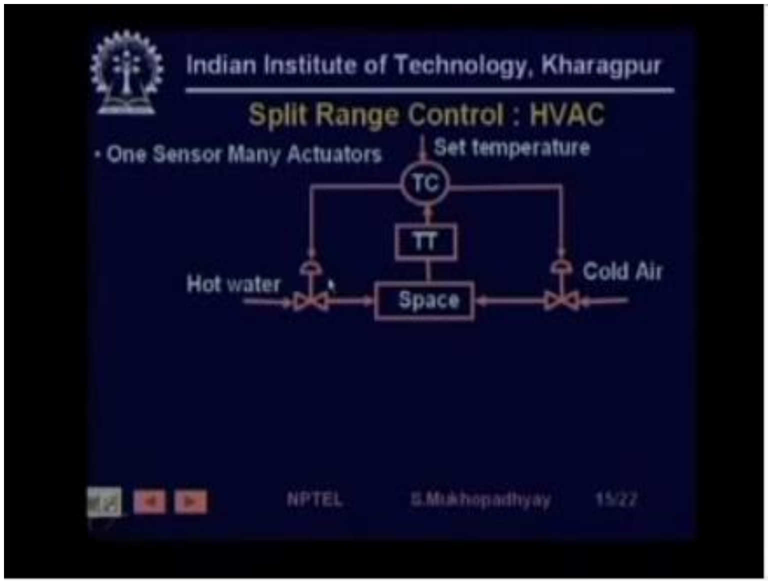

Split range control the first example is of heating ventilation air conditioning so we have the standard this is the space that we want to control there is a temperature transmitter and there is a temperature controller and we also have a set temperature which we generally set using a dial or sometimes using remotes nowadays and the temperature is affected either by hot water you know if you in countries abroad for heating rooms they have they have heat exchangers installed in rooms various corners of the room and through which they say they send hot water or you can have cold air as in as in air conditioning.

And depending on whether you want to heat the room or cool the room that is depending on the set temperature.

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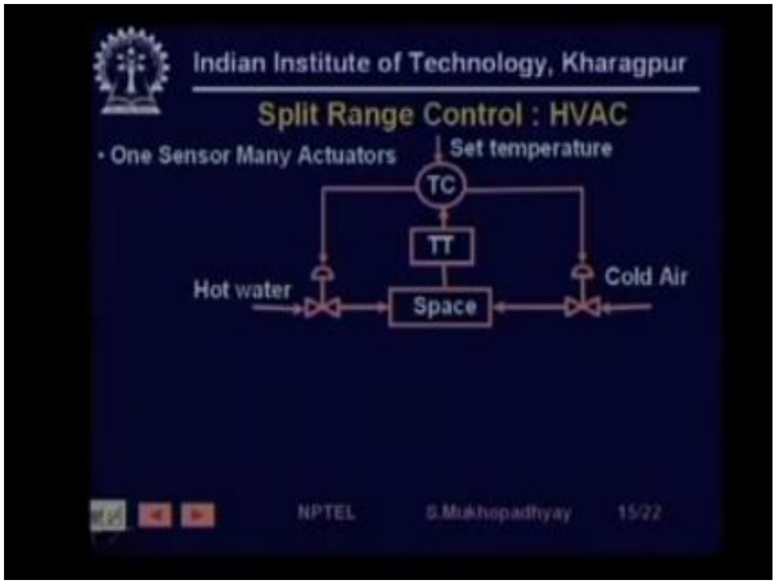

Which is whether it is greater than ambient or less than ambient you have to either activate this.

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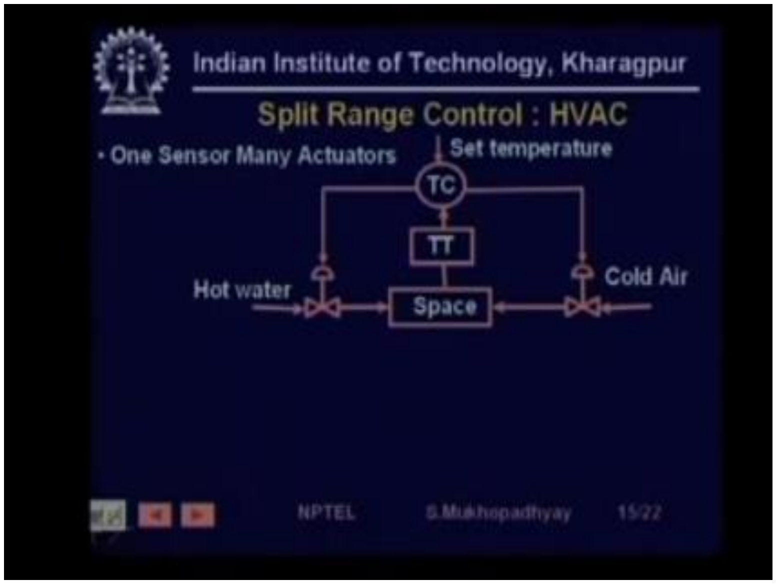

Actuator or activate this actuator so this is so on some range of error so some range of the set temperature so when the set temperature is greater than the ambient temperature in that range you use this actuator that is a hot water actuator.

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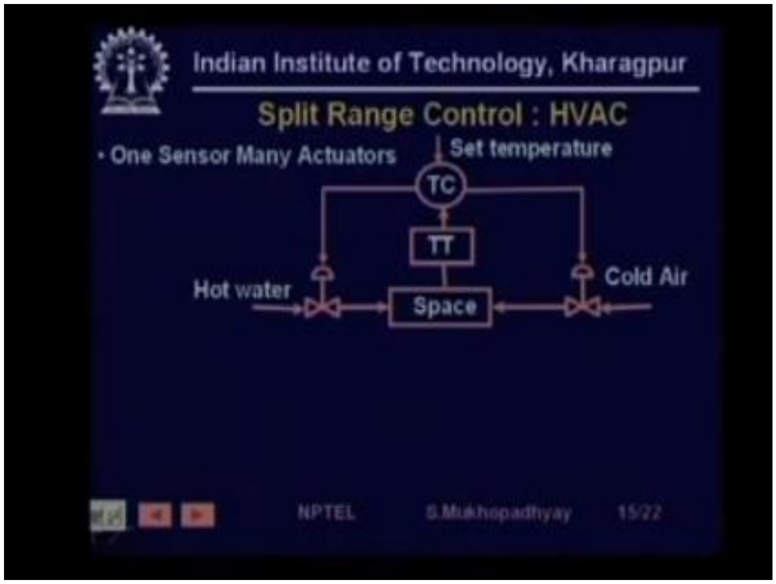

And when the set temperature is below the ambient temperature in that range you use the cold lair actually so this is why it is called a split range control because the range is split into two different control modes so you see that.

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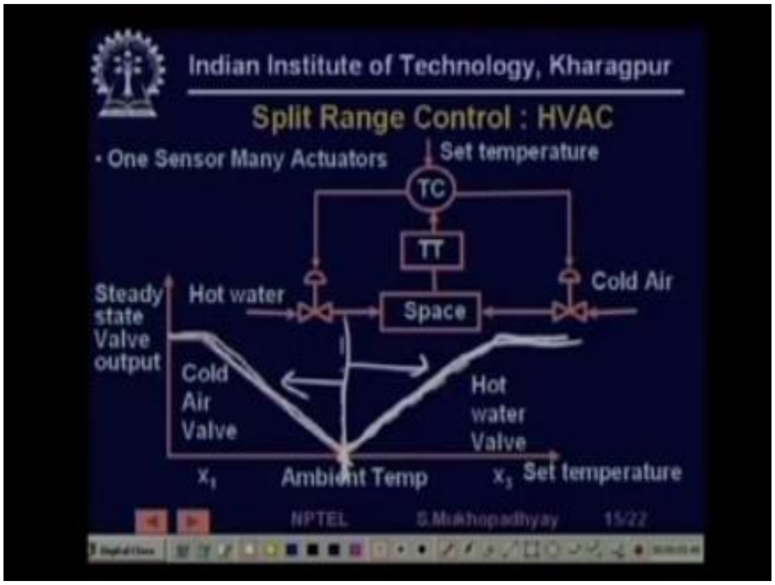

Typically speaking this is the ambient temperature point this is the ambient temperature point and if the set temperature is above it then as the error increases the hot water valves gradually gets opened so the key so the control input that is the overall control input to the to the process we change this temperature in this temperature range it will gradually rise and then finally will become stable similarly when the set temperature is below ambient temperature then the coldwater valve characteristic will be followed and that will right so the overall control input characteristic is like this over the two ranges.

And in this range in this range you operate the cold water valve and in this range you up at the hot water so this is the standard HVAC control of spaces here is another example which is.

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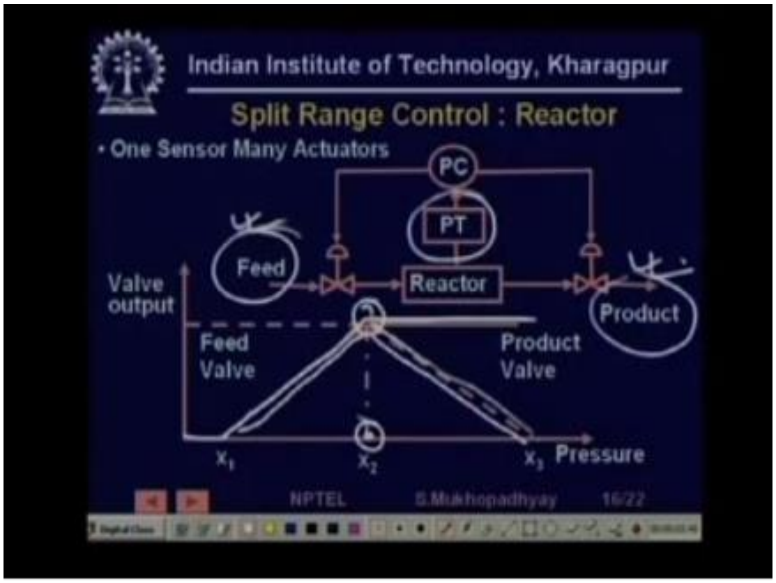

For a reactor which is very similar so here what you do is the reactor you want to control the pressure in the reactor so the pressure in the reactor could be either caused by controlling the feed rate or by controlling the product outflow rate right so in the initial part of pressure you control the you gradually open the you gradually open the product valve so you see this is the product valve characteristic after some time the product valve is fully open so it cannot be so the pressure is increasing so you gradually open the product valve.

Now if at this after this point the pressure cannot be affected by the product valve because the product valve is fully closed so in that situation you start closing the feed valve so the feed valve is operated here so actually your true operating characteristic is this time you open product valve and this time you close feed valve so this is split range control where you have won only one sensor but many actuators so we this is we have come to the end of the lecture and just want to have some concluding remarks firstly on this kind of this.

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Multi sensor multi actuator control which is processes often need supervisory control logic so you see that you apart from your basic control logic which is there in the either in the hot water valve on the club coldwater valve that will be an automatic controller but even View we above that units of logic based on again process variables which will ensure which one will be working with sensor will be active which actuator will be active which controller will be active so this is called supervisory control logic.

And they of a four process operations you often need that so this is sometimes achieved by these control loops.

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So you can switch among operational modes and these supervisory control logic schedules sensors actuators connects sometimes use this actuator sometimes use that actuator so based on operating points and set points and only one thing is that when you are you must ensure that when you are switching from one more to another too much you know bumps we have considered bump less transfers in the context of PID control.

So we should not have too much too many bumps when you are transferring the from one mode to another because that sometimes is not good for actuators or plants so that brings us to the end of the process control module from the next lesson we will enter a different module of sequence control so what did we learn in this module.

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You know industrial sub concluding remarks that industrial processes have sometimes a very complex dynamics they have phase lag they have non linearity gains will change but so that creates complexity well at the same time the process dynamics is slow so sometimes it is good in the sense that you know fast processes are difficult to control but at the same time sometimes you know disturbances also travel slow and there they should be detected early otherwise the large errors may perceive may persist for unacceptably long times.

So one has to take care of sensor and actuator nonlinearities the one of the major actuators called flow valves have significant non linearities several sensors like you know temperature sensors flow sensors also have nonlinearities so they should be taken into account.

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And typically in I think around ninety percent of the cases. PID controllers are used sometimes with various special configurations for anti wind up for bomb placed transfer etc. As we have seen for special structure for feeding back derivatives but generally the controllers are PID they are very extremely common.

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And PID controllers have to be tuned you know control tuning can have significant impact on controllers and there are various for example modern-day controllers come with very quite sophisticated features of tuning software so tuning is very much required.

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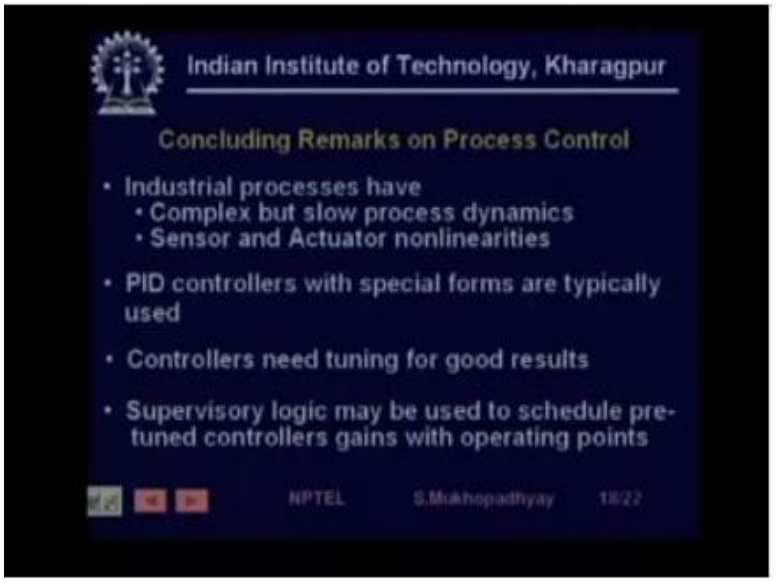

And you also need some time some supervisory logic to you know improve performance prevent failures can carry out diagnostics so all these are also necessary.

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Similarly supervisor logic we also be used to treat interaction between multiple control loops and finally often for taking care for getting the best results often various kinds of special control structures have to be used but the good thing is that with years of experience for most of the common industrial processes very well known solutions exist so one will not worry too much.

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So that is that brings us to the end of the process control module from the next lesson we shall take up sequence control.

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And coming to a lesson review.

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We have we have seen problems of single sensor control cascade control and multi sensor multi actuator control in the form of selective override and split range.

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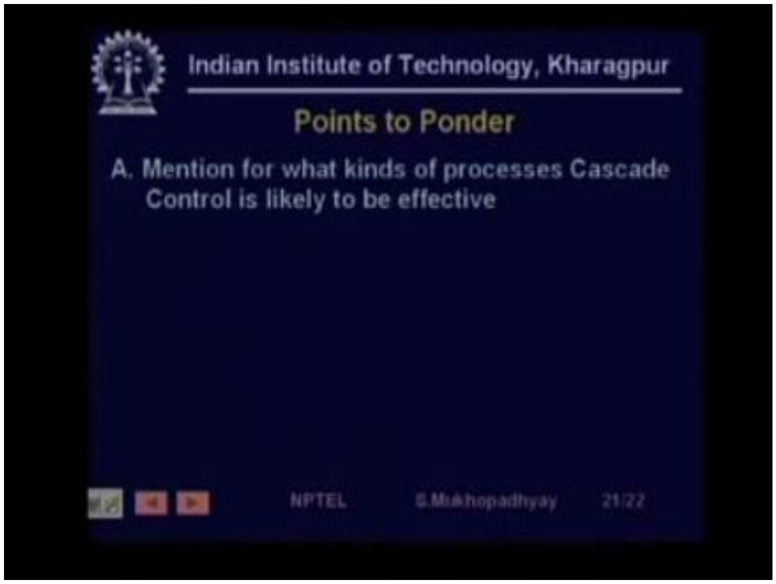

Points to ponder give so you have you mentioned what for what kind of processes cascade control is likely to be effective so take some examples and an examine how the how the two subsystems should be such that process control using is effective.

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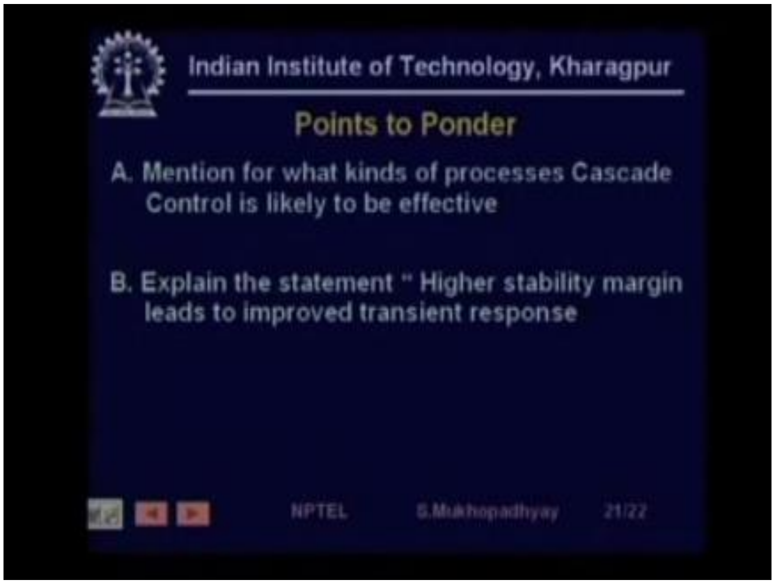

Why higher stability margin leads to improve transient response that is why that try to explain Italy it is related to the basically related to the range of controller gains that you can have and draw the.

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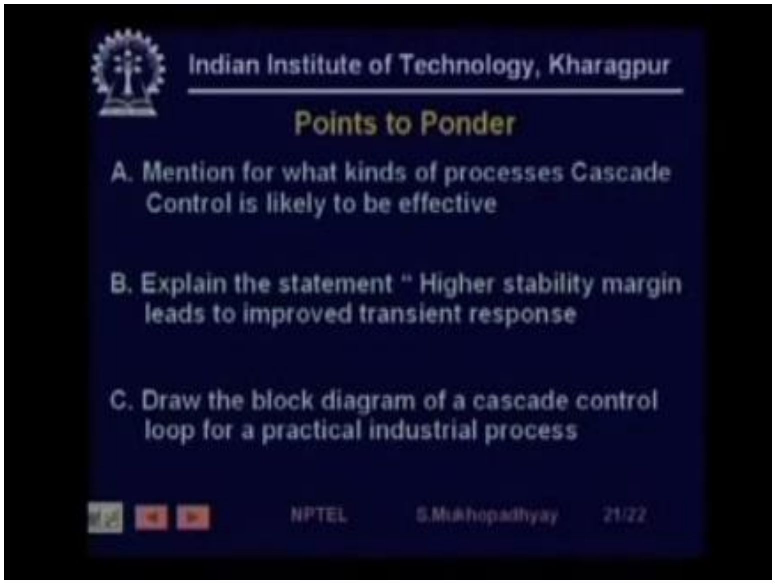

Block diagram of a cascade control loop for a practical industrial process is very important and one should be able to draw it.

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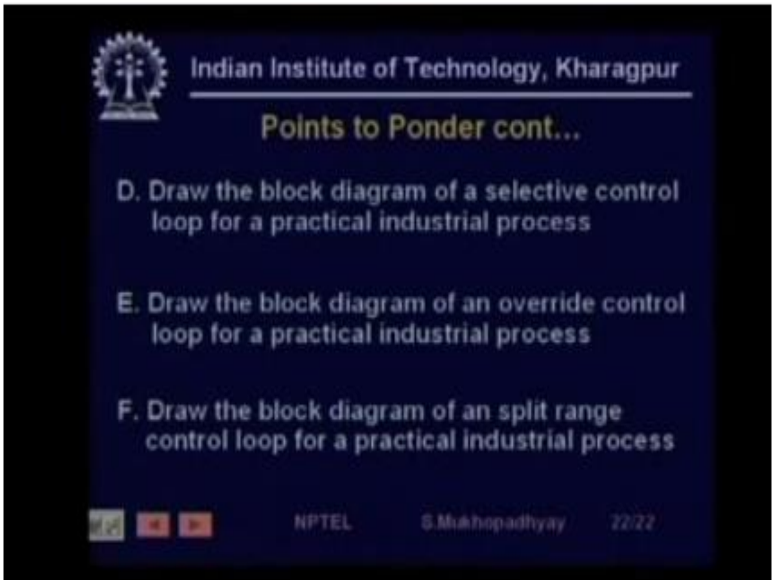

Similarly block diagrams of selective control loops and override and split range control loops are useful exercises to be done.

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So thank you very much.