Analog Circuits
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Week- 03
Module -03
Feedback

Hello, welcome to another module of this course analog circuits. So, in the previous few lectures we studied about the frequency response and the various poles zero configurations of a transfer function of a system of an analog circuit, now in this module we will be covering an very important aspect of analog circuit design which is known as feedback.

So feedback is a very commonly employed technique for all analog circuits it is also used for digital circuits but more commonly used for analog circuits feedback is a means to rectify something or to kind of sense what is at the output of a system and then and then use some of that output back at the input, so as to correct something or to enhance the performance of the system.

Now usually feedback can be applied in various ways just by putting a resistance in some part portion of an analog circuit can introduce a feedback, so it is sometimes difficult to understand also whether there is indeed a feedback present in order to systematically study feedback we will just first look at the system level model of feedback and from there go on to the circuit level.

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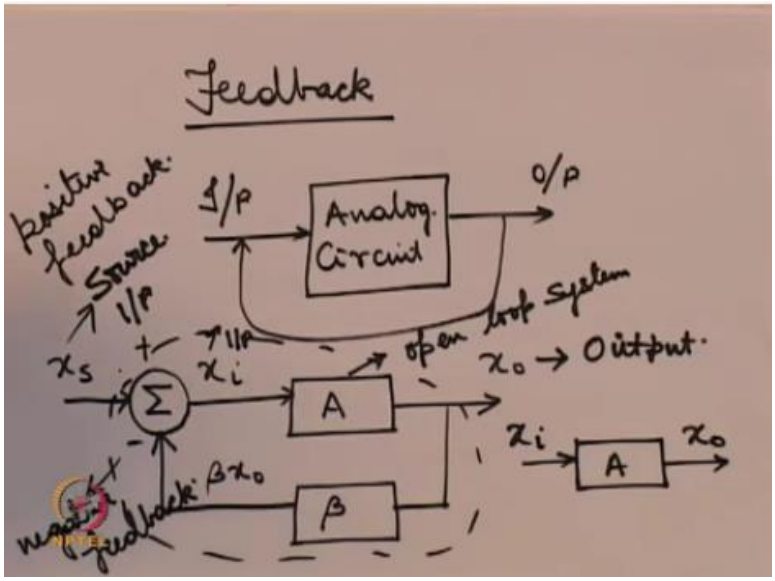

So when I say feedback suppose you have a system, you have an input, you have an output now what feed in feedback we do is we take some of the output and feed it back to the input now it is not that there is some sensing circuit always present for sensing what is the output is just that the circuit is cleverly designed so that this output is automatically fed to the feedback and depending on how we close this loop that is whether it is positive or negative feedback

We can control certain parameters of a circuit so the block diagram you know we can suppose you have your system which produces a gain A and suppose x0 is your output and say the input to this system is xi then feedback the feedback circuit is usually represented by this block beta like this.

So here the output some portion of that is multiplied by the feedback factor beta X0 and feedback to the source input xs so xs represents the source input this x0 represents the output this is your open loop system, open loop system means a system where this loop this feedback loop is not present and this xi is the actual input to the system, now of course here we are making certain assumptions, what are some of the assumptions?

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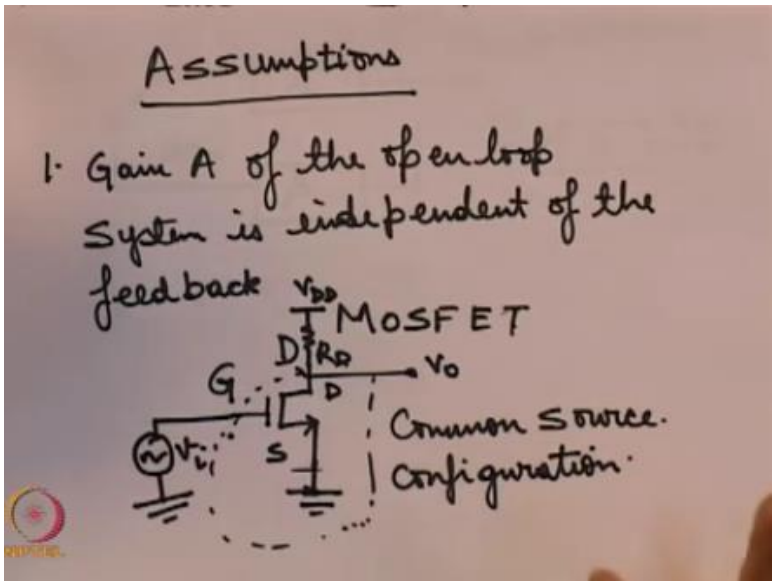

First is the gain A of the open loop system is independent of the feedback so what it means is that if we go back to our block diagram for a moment then this A which represents the open loop system so the closed loop system is this whole system with feedback open loop system is this system only without any feedback, so alternative way of representing the open loop system is simply like this.

Now the assumption is that this gain A is independent of this feedback factor or this gain A will not change when a feedback is put this is of course a very difficult condition to achieve usually this is not valid but then in some cases we can indeed approximate the gain to be independent for example suppose you have a MOSFET transistor we shall be studying about MOSFET's later on but for now it has 3 terminals and one of the circuits ok, so here this is what is known as a common source configuration.

Now here the path of the signal is from the gate to the drain in the forward part of course the MOSFET is least affected the output of what I mean is the output of this MOSFET very negligibly affects the input and even if we feed this V or somehow back to the input using some circuitry the gain of this MOSFET will be least affected this kind of configuration this assumption rather this gain A of the open loop system is independent of the feedback is in is valid we will assume it to be valid not strictly but for our practical purposes we shall assume that this assumption is valid .

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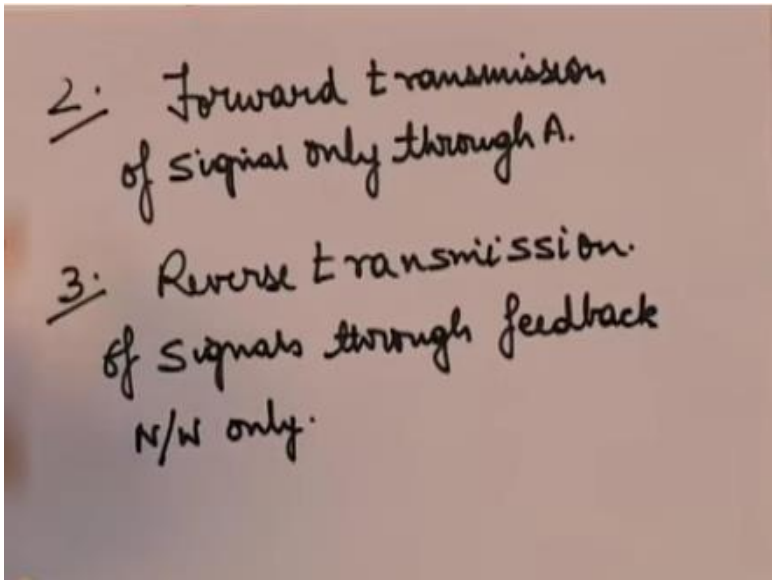

The next assumption, forward transmission of signal only through A that is only if a signal for this closed loop system this may closed loop system I am in this entire system if a signal is to pass from the input to the output then in the forward path that is from input to output it will pass only through A not through this beta block, so that means that so the beta on the other hand will not play any role in transmitting any signal from the input to the output.

And the third assumption is reverse transmission of signals through feedback network only which is the reverse thing that if any signal has to go from the output to the input and it can only go through this beta block and not through this A block so with these 3 assumptions let us see what the output will be in terms of the input when feedback is present.

So once again if we go back to our block diagram of feedback, so it is like this we have our A beta like this and the part of the output x0 is fed back to the input, now note here I have written a minus sign here this kind of feedback refers to a negative feedback. So we have 2 types of feedback 1 is negative feedback and the other is positive feedback.

When we have negative feedback, what happens is a part of the output xi is fed back negatively to the source that is some part of the output is subtracted from this input from the source xs before feeding it to this A block in the case of positive feedback the part that is taken from the

output is added to the source input and then fed to the block A let us see what happens when we have negative feedback.

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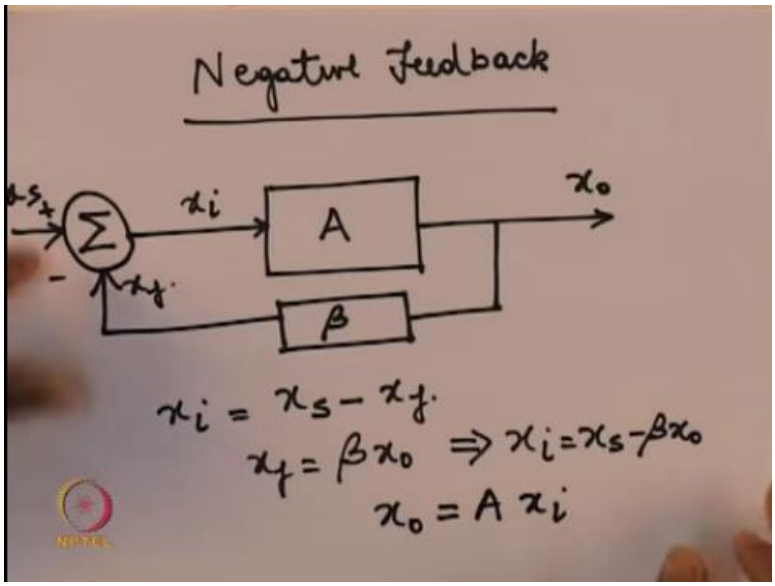

Just redraw this plug diagram once ok this is xi this is xf so the input that is going into this block A xi is = xs - xf here of course xi and xf are all signals ok I have not said whether they are voltages or currents later on when we actually see some circuits is xi can take like the value of a voltage or a current xi for now will be (()) (13:28) will be the difference between xs and xf and this xf is given as beta times x0 so then we have our xi is = xs - beta x0 now this x0 itself is = A times xi.

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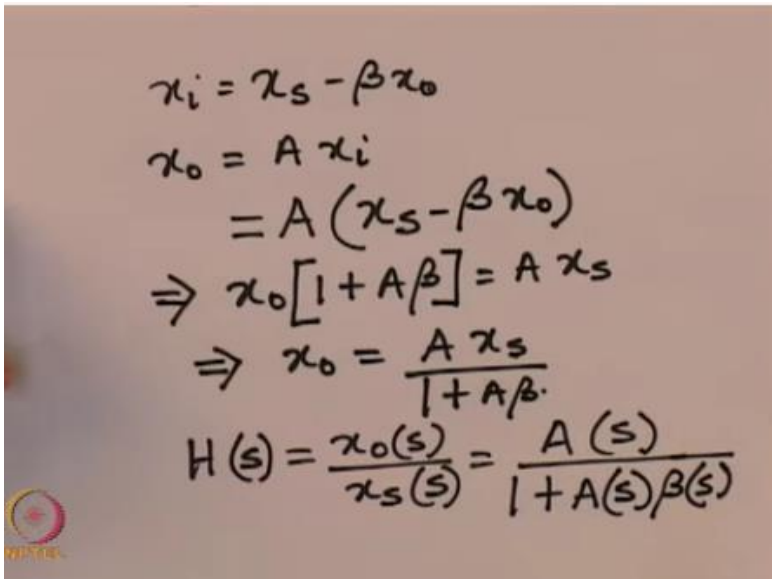

So then from here we can write xi which is = xs - beta x0 and then x0 which is = A of xi so now if I substitute this xi value here so this comes out to A multiplied by x of S - beta x of 0 from where we get x of 0 1+A beta is = A of xs and from this we can write x of 0 is = A xS 1+A beta hence the gain or H if we want to find out the transfer function which is the ratio of x0s upon xs of S that will be given by A of S upon 1+A of S beta of S so this is the complete derivation if we if on the other hand we had positive feedback then let us see what would be the case.

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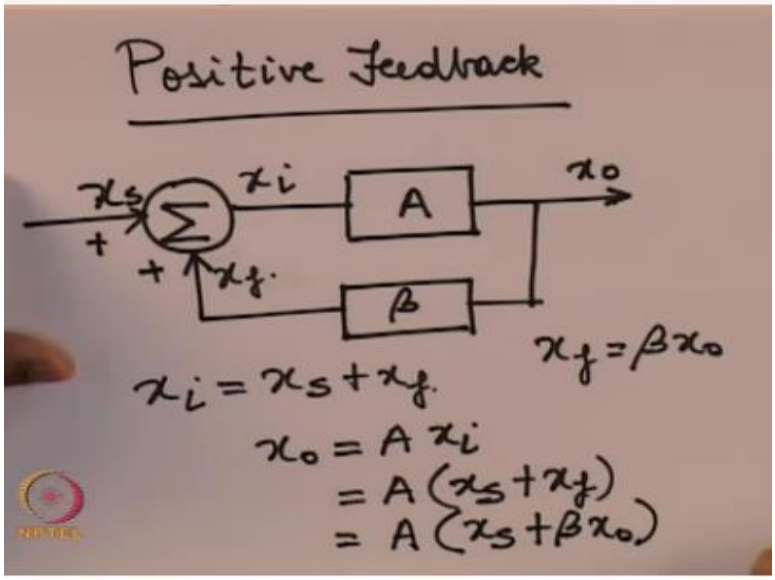

So in the case of positive feedback as I had mentioned a part of x0 is added to the source input Xs ok and proceeding similarly as we had done for the negative feedback case we find that here this xi is = x of S + x of f x of f remains the same and then x of 0 as in the previous case it is = A of xi which is = A of x of S + x of f which in turn is = A of x of S + beta x0 from where we can write the value of x0 in terms of xs as follows.

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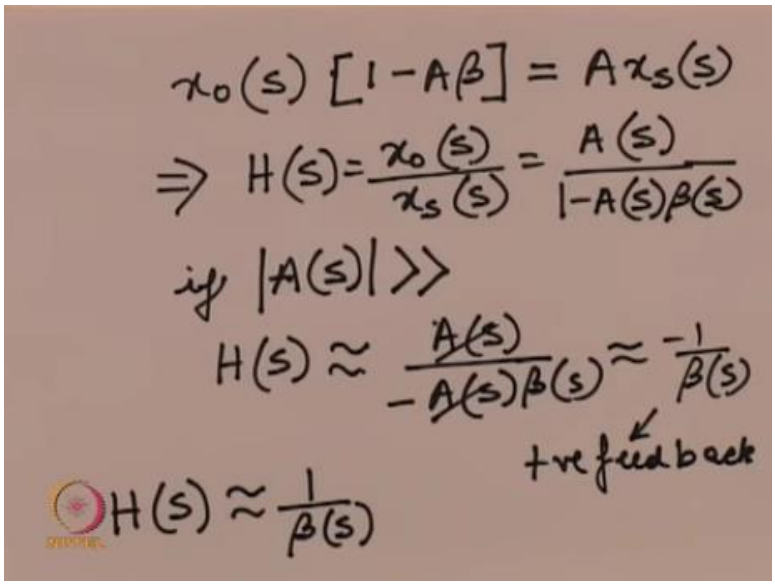

So we have x0 of S 1 - A beta this is = A of xs of S from where we can write the transfer function = x0 of S upon xs of S given by A of S - A of S beta of S so again we get the complete formulation for H of S, but here instead where as in the previous case for that is the negative feedback case our formula looked like this with a plus sign in the denominator.

In this case we have a negative sign in the denominator note one thing that the gain which was previously just A of S is now modulated by this beta S one simple thing that we can see here that if A of S or rather I should say the magnitude of A of S is very large then H of S can be approximated, as first of all A of S, now this if A of S is much larger than this whole product A of S beta S can be considered negligible to one and this becomes equal to beta S, so then now A of S cancels and this is approximately to 1 upon beta is similarly so this is for positive feedback

For negative feedback H of S will be approximately equal to, now what is the significance of this result see by using a feedback loop what we have done is we have complete and of course provided the gain of the open loop gain A of S is quite large by introducing this feedback gain what we have done is we have completely removed the impact of the gain block and our closed loop that is with feedback the gain is only dependent on the feedback factor so then this is an advantage because why is this an advantage because we can program our own gain.

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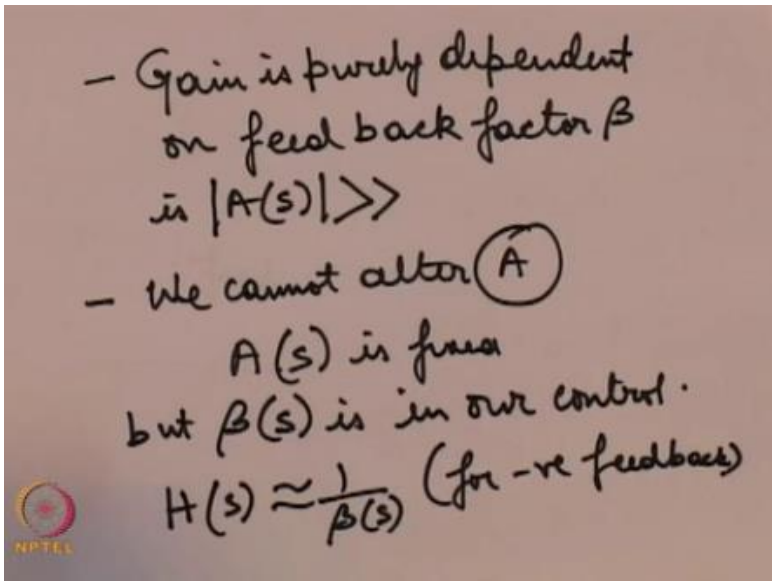

Now, so what we see gain is purely dependent on feedback factor beta, if magnitude of A of S is very large we cannot alter A is not it, because we have been given a open loop system we have to modulate the gain of the system but we cannot we cannot go inside that open loop system and change its contents so A is fixed so A of S is fixed but beta of S is in our control so if beta of S is in our control A of S is fixed and gain H of S is approximately = 1 upon beta S for negative feedback.

Then the advantage that we get is that, we can now completely design the gain of this closed loop system by modifying the beta feedback factor, hence the overall gain of the system becomes in our control.

In the next class we will continue with this with our discussion on feedback and we shall see some other properties that feedbacks helps us achieve, so we saw one property already that when we introduce a feedback the an provided the open loop gain is sufficiently large the gain of the overall system that is the closed loop system becomes dependent only on the feedback element or the feedback circuit and the open loop system does not play any role similarly we shall see certain effects on the input impedance, output impedance, then the bandwidth of the system. So that is what we will cover in the next module, thank you.