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Ok, so let us change and let us deviate somewhat from the frequency characteristics of a common source amplifier and let us focus on the block diagram of our negative feedback loop because ultimately we know that whatever amplifier high gain amplifier we are making will be putting it in a negative feedback loop right. So, it makes sense to understand why are we doing all these things if the context becomes clear ok. So, let us clear the context of why we are using, why we are interested in this frequency response of the of our amplifier right ok. So, what was let us go back to the block diagram of a negative feedback loop. So, let us say this is the transfer forward gain A and we have some structure like this, this is the structure that we were interested in right and we I mean then we saw that we had modified this structure and we came up with differential amplifier and so on, but still I mean this is the good old structure that can give us a lot of insight right. So, when we when we were developing this structure we assume that this guy is a amplifier without any capacitive effects right there were no capacitance which means there was no frequency dependent effect.

It did not matter whether you are applying an input at 1 Hertz or 1 gigahertz or 1 terahertz the output we assumed would be unattenuated right, but now we know that even though that is a wishful thinking we will not be able to achieve which means that we have to take into account what is the effect of the frequency which means we have to take into account the effects of poles ok. So, now this guy has some pole. So, let us call this the gain or the transfer function and DC of this block is A naught and let us say we have pole 1 by s by P 1 1 plus s by P 2 poles similar to the common source amplifier transfer function that we that we just did ok. So, what will be the impact? So, we can go around and do our analysis right.

So, even before doing this analysis what I would like to do is to give you an intuitive feel of why this becomes critical ok. So, let us do that. So, let us assume that this feedback is not on right. So, let us say this is 0 this is broken and this is how it is and let us further assume that the input is a sinusoid of some frequency omega ok. So, what is and let us assume the input sinusoid.

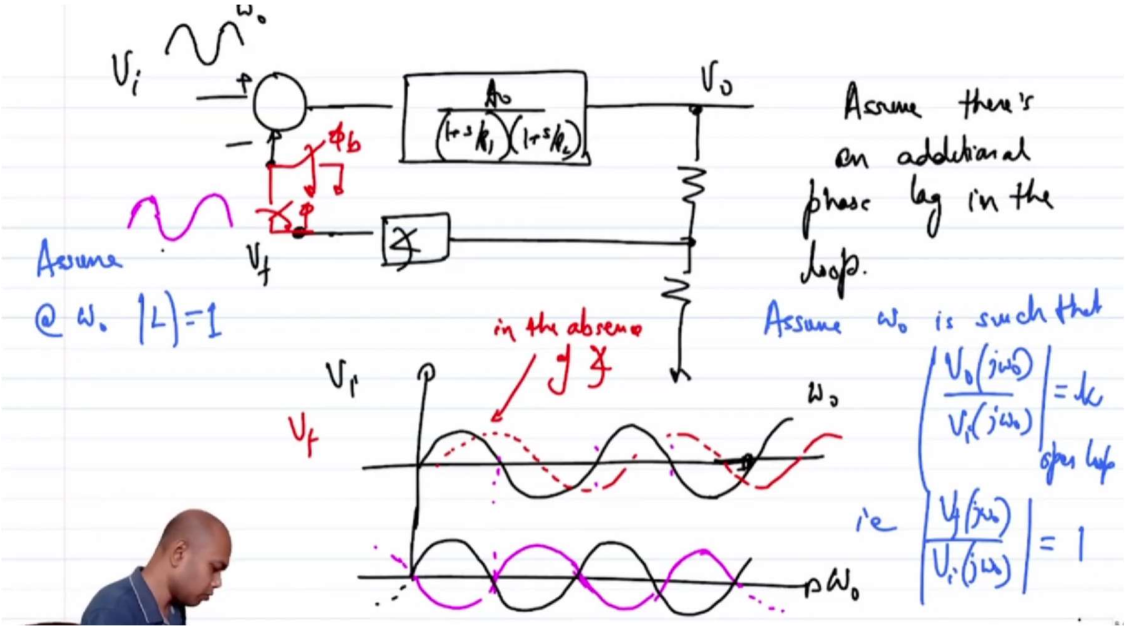
So, V i is equal to V P sin omega naught t and let us assume omega naught is much much less than V 1 V 2 right. So, what will be V naught? If this is ideal voltage control voltage source V naught will be V naught will be A naught times V i right. So, V naught will be some A naught times V i ok. So, if I have to sketch it in the same if I have to sketch it in the same plot right. So, let us say this is A naught.

So, your V i or V i will be something sorry other V naught will be. So, I am messing up my explanation. So, let me try once again. So, so this is V input and this is V naught ok. So, what is what will be the feedback, what will be the feedback voltage 1 over k times V naught.

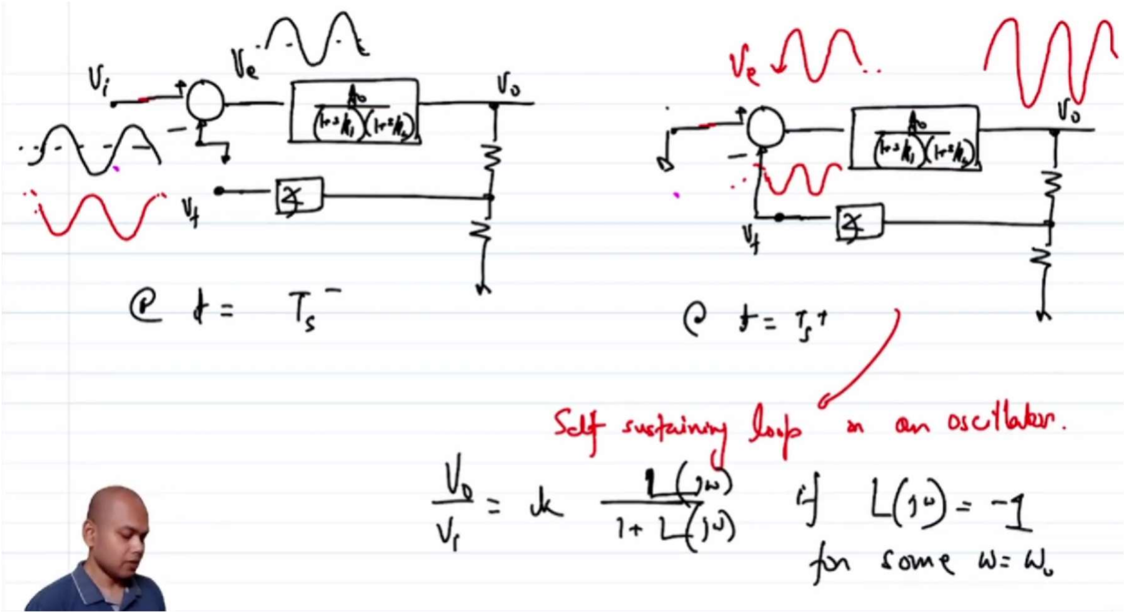
So, it may be a slightly attenuated version of the of V naught right. So, this is V f all good right. So, let us say we change the frequency we change the frequency when you change the frequency what is going to happen two things are going to happen. One if we one the amplitude of the output is going to reduce because the poles are going to kick in ok. And two they are also going to shift in phase right they will not be aligned right the peaks will not align with that a peak of the output or the feedback voltage will not align with the peak of the input right.

So, that is going to happen. So, so at non zero omega naught. So, at any arbitrary omega naught right maybe your input is something like this. So, let me directly sketch the feedback voltage your feedback voltage might be something like this right it can be right. So, your so in other words your input can be if I have to draw it on the same scale.

So, our input feedback voltage can be delayed with respect to the output ok. Fine. So, how much can it get delayed by it can at max get delayed by 180 degree right, but at the frequency at which it can get delayed by 180 degree it is far away from you have we have crossed both the poles like I have left them long back behind which means the amplitude will also be quite small right. So, essentially if what will end up happening is if yeah. So, if let us say your at frequency is far higher than omega naught much much greater than P 1 P 2 right if input is something like this your output will probably be 180 degree delayed.



So, this will be something like this, but heavily attenuated right ok. But let us assume there is another pole in the system right there is some additional delay in the system let us assume there is additional phase lag what can be a source of additional phase lag there can be additional pole there can be an additional pole. So, let us assume that there is an additional pole or even if we do not assume there is an additional pole let us assume that there is an additional delay in the loop. So, let us say there is additional delay some TD right. So, this delay can be because of an additional pole or something else right.



So, let us assume an additional delay V i this is V f for now this is 0 ok. And the additional delay is such that it is such that assume there is an additional let me simply write it phase lag right additional phase additional phase lag in the loop ok. Source can be an additional pole or something else ok. So, what will this do? So, let us assume that this is the case what will this do this will do one of these things right. So, for let us say we had a certain frequency omega, omega naught.

So, in the absence of delay at some pole frequency let us say V f was let us make a further one as assumption and assume omega naught is such that V naught j omega naught by V i j omega naught or other yeah is equal to k ok. So, this is under open loop condition right this is under open loop ok. Which means V naught j omega naught by V i sorry V f j omega naught by j V i dot omega naught is equal to 1 right. So, in other words let us assume we are operating at a frequency where loop k magnitude of the loop k is equal to 1 right. So, which means that at omega naught right mod of l equal to 1 this is assumption right this is assume.

So, in the absence of in the absence of this additional phase we would have had some phase lag right, but the key thing is that V f would have been the amplitude of the V f would have been exactly as the amplitude of the input right. Because we have a by definition we are operating at the frequency where the loop gain is 1. So, maybe your loop our loop gain V f would have been something like this right. So, this is let us assume this is in the absence of extra phase right. But now let us assume we have added an extra phase ok.

So, if we have added an extra phase and let us assume that this extra phase is such that it can push it can delay the it can delay V f by that much amount. So, that we get a total half cycle delay between input and output right. So, maybe I will sketch it out. So, that will make more sense. So, let us say in the presence of this extra phase delay we get this becomes the V f.

This is V i. Correct. So, let us assume this becomes V f ok. So, what is going to happen? So, which means that here I have some sinusoid of some frequency omega some omega naught at V f I get I know the same sinusoid, but it is inverted polarity right. We have 180 degree phase shift gain of 1. So, essentially we get the same sinusoid with the inverted polarity ok fine ok.

So, now what does this mean? As long as the loop is open this does not mean anything, but let us do a thought experiment. A thought experiment is as follows. So, let us assume further that we had a switch right we had a switch this switch are complementary switches at some time that let us assume this is phi and this is phi b right. So, complementary switches. So, when phi is on phi b is off when phi b is on phi is off.

So, right. So, when the loop was broken which means phi b was on and phi was off right this is what we are getting correct. So, now let us say at some time t equal to t naught at any arbitrary time you choose I do the opposite. So, I open phi b and I close phi ok. And also let us do one more thought experiment let us say that this is also phi b ok. So, which means that at some time t naught I am opening I am stopping the input right I am stopping the input and I am pushing the I am connecting the feedback path in the loop right.

So, assume that let us let me redraw it this probably is getting a bit messier to understand. So, let us say I am doing this. So, at some time t right. So, this was grounded this was open let us say this is at so, this is at t equal to some t s minus ok. And let us say at t equal to t s plus that is just after t s what we do we round the input and connect the feedback path here.

What is going to happen? So, let me remind you the fact that at t equal to t s minus the input and the feedback voltages were identical in amplitude, but 180 degree out of phase right. So, if we do this thought experiment what is going to happen? So, the feedback voltage will now appear at the input of the summer right. So, the feedback voltage here is this right ok. So, in the figure on the left in the figure on the left what was the error voltage? The error voltage was exactly equal to V i right. So, this error voltage V e was exactly equal to V i because the feedback was turned off.

In the figure on the left on the right what is going to be the V e? V e will be inverted of the feedback voltage right. So, V e will be inversion of the feedback voltage correct. Same amplitude inverted feedback voltage which means that from the perspective of the amplifier is the input has not changed right. From the perspective of the amplifier then even though you have taken the input out even though the V i is 0, but the amplifier is still getting an input V e is still that value that sinusoid that would have appeared right even if the feedback were absent right. Which means what? If the input of the amplifier if the amplifier does not see any change at its input the output will be exactly the same what it was earlier correct.

So, what would have been the output in this case? Output is basically the inverted version of the input right because amplitude is sorry out in this case k times amplitude and inverted version of the inverted in phase right. So, this when seeps through to V f gets reduced by an amplitude by a factor of k and becomes again equal to the amplitude of the proverbial input which means that this becomes a self-sustaining loop right. So, this will be a self-sustaining loop or an oscillator ok. So, your feedback loop can become an oscillator right. If you get into this condition of loop k n magnitude of the loop k n is equal to 1 and your phase is 180 degree right.

So, in other word what I am trying to say is this is something we for those of you who have taken control theory courses will know. So, what is H what is our V naught over V i? V naught over V i is some I mean ideally the gain of k by L by 1 plus L right. So, if or in this case L is a function of frequency. If L of j omega is equal to minus 1 for some omega equal to omega naught right then what we see we see that V naught over V i goes to infinity right. So, this means that V naught over V i tends to infinity which means we have infinite loop gain and infinite loop gain means what infinite loop gain means you do not need any finite output to get a finite input to get an output.

The moment you turn on the turn on the system the output will be self-sustaining right and I just gave you an example of what might happen right. So, in this case as you can see at the frequency at which your omega at the frequency in which you have you satisfy this criteria of loop gain equal to 1 and the overall delay in the loop overall phase in the loop is equal to 180 degree then this loop can latch on to that particular frequency and you will keep on getting sinusoids of that particular frequency. Now, we might say that if this were to be avoided I simply would not apply any input at the frequency in principle it seems like true but it is not actually practically feasible because ultimately you have noise sources everywhere right. So, there will be even if you have not applied as explicit frequency there will be frequency components in the circuit throughout that I mean because of noise which is like broadband in nature. So, you will have frequencies of all you will have inputs of frequencies of inputs of all frequencies available in the network all the time however small that might be, but it is only sufficient for the loop to latch on to a to any excitation at that frequency right.

The moment the loop finds that any excitation at the frequency which is this bound to it will start oscillating right. So, what we have to do we have to steer clear of this condition of L of G omega to be equal to minus 1 right. So, as you can now see why this why is our why is the frequency response critical in a feedback loop right. So, goal will be our goal will be goal will be to stay sufficiently away from L of G omega equal to minus 1 point right and this is what we will do in the in the in the remaining lectures in this course right ok. Thank you.