Analog Circuits
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Lecture – 11
Frequency Response of Amplifier

Let us do a high frequency response or actually frequency response I is only a word we may also like to see the lower frequency response also we would like to buy our use for higher frequencies essentially is the capacitance related that is why I would use I but need not worry higher means really ten hertz is also higher than DC okay another thing we are other they showed you that there is a low frequency.

There is a mid band and there is a high frequency regions in normal amplifiers you have done already an experiment in what is it called opamps you must have observed there that there is a gain even at 0 that is DC is that correct there is a because opamp can amplify even DC ok, so there is nothing called lower cutoff in opamps no is that clear there is no lower cutoff in open you get the point the response of an open if you see carefully.

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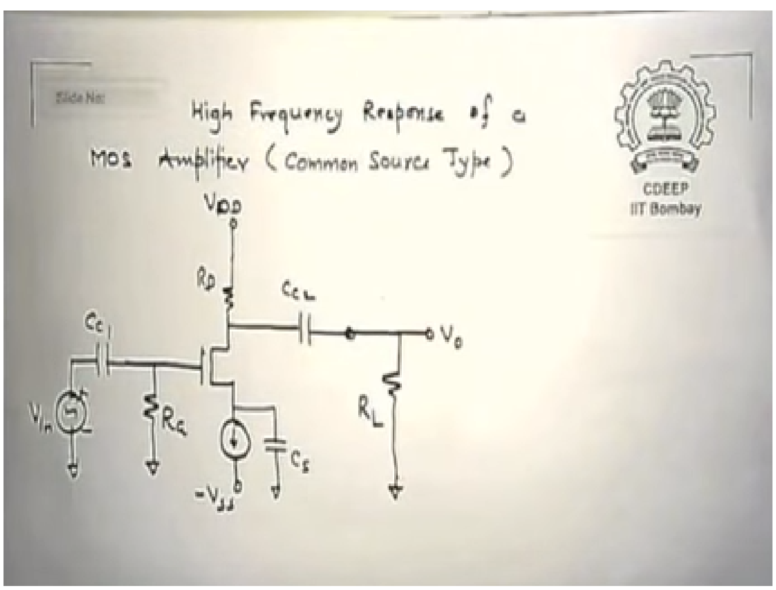

It always looks something like this gain db sorry versus say this is like this that means since said DC amplification is done in opamp this is true whereas in any AC couple amplifier which we shown here. There are capacitances which will always give you AB and high pass low pass property and therefore there will be a lower cutoff as well as there will be and higher cutoff, so a frequency.

Other day I showed you if I will see a response of this gain versus Omega Radian frequencies, so you have something like this frequency we call mid band where gain is constant somewhere like and this we call AV0 this essentially 0 does not mean 0 frequency okay, sometimes it is also called DC gain okay.

So please remember in this amplifier when I say it is ADC gain it does not mean 0 frequency again this is why I am trying to say word again when I in a normal AC couple amplifiers when I say DC gain I mean mid band gain is that correct it does not essentially say that it is at 0 frequency what essentially we are saying remove all capacitances for solutions that we call the mid back is that correct.

This is an issue which must be modified when we go to open in open there is a 0 frequency gain also possible is that clear so please do not confuse many times this DC gain of opamp no camera and DC gain here are not identical terms is that clear here essentially means capacitance removed whatever resistive kind of thing gives me load that I will call DC or AV0 is that clear. This is my definition not in the sense my means this is what most circuit people believe in the case of analog and therefore we will follow that terminology okay.

Then we will say okay the 3 db point somewhere here if you see this I will call Omega L which is the load cutoff and somewhere here I will call Omega H as the cut off and we will declare the bandwidth is Omega H enough covariance do divided by 2 pi, you will get in frequency hertz, so that is the mid band.

The bandwidth is defined where the mid band gain occurs is that correct the definition of bandwidth for is the play is the frequency band in which mid band gain is constant that for we say it is mid band is that that is the definition we will use in all R analysis and this is my way of telling because some way you know you read books.

You find suddenly they change terminologies in math to bipolar they change and from also they keep changing so I just wanted to clarify what I meant when I wrote something that okay, this is a definition and nothing great about you may call this FL and this FH it does not matter as long as you get this frequency man okay.

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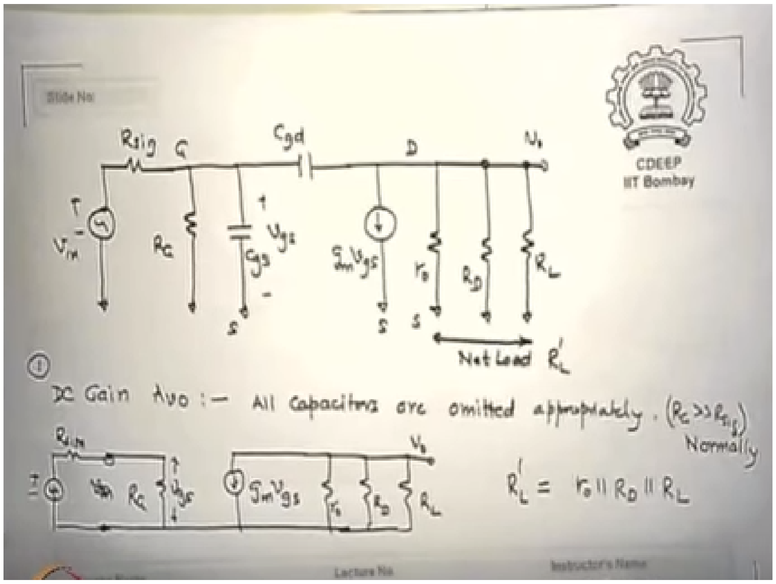

This is only a normal nature systems, which many years we have been using so Vinay Mizuki having drawn that figure I can make equivalent circuit of this I have an input source which is AC signal small signal. This is the source impedance R signal then there is a RG which is the bias resistance which may be due to the RG1 or RG2 parallel combinations then of course.

This may be taken to VSS but this is drawn for AC, so all power DC terminal terminals in into ground so this is grounded then there is a capacitance Cgs which is due to the gate to source capacitance and there is a capacitance which is this how much is Cgs normally typically Cox x W x L is that correct Cox x W x L Cgs it can be 2/3.

If it is in saturation it will be full Cox or if it is in depends normal cases one may use Cox but normally in our analysis I will give a value. How much is Cgs this is the gate to draw in capacitance and what is this related to in real transistor the overlap capacitance between gate to drain is Cgd, so there I said you know when in saturation.

There is no Cgd no it is actually overlap capacitance always exist okay, so whatever is w into overlap into Cox will be the seasonings this value also will specify then there is the current source due to amplifiers gm Vgs downwards because it supposedly it is a 180 phase out then R0 is the output resistance Rd is the resistance the drain and RL is the actual load externally put okay and we call this net load as parallel combination of R0 RD RL, which is on L dash okay.

I am right now trying to really look for cut offs okay and I am more interested to see the higher cut off so for higher cut offs will show you the other problems this is called 0 value method to get FL and FH separately, so I will show you one essentially right now I am looking for dominant poles okay on the upper side because please remember okay I should have clarified this normally his viewpoint is very good.

So I must clarify typically this WL value will be order of tens of hertz typically I am not saying every time depends on the value of time constant R and C valid it may be different but maybe not more than 100 hertz any D okay, it will be less than 100 hertz WH will be in tens and 100s of kilowatts or megahertz okay.

So you can see 10 to power 6 -0.0010 1000 K -minus 100 hertz is almost as 100 kilo hertz is that correct so the number why is this number actually is very small we are interested in the other side I may love to find where is it which I will evaluate then but right now I would only look for higher frequency side where is the cutoff is that clear.

So I am now I am not saying what I said otherwise, but this is the fact which I am right now so okay so what he is saying I am neglected CC 1 CC 2 and these are called coupling capacitance and this is called bypass capacitor and this is for the bias purposes this is for coupling AC and DC, so we remove right now CC1 CC2 close in my circuit and last time I did say you these are the capacitance series which frequencies.

They are at the low frequency, so we will actually find using them where is the load is that correct for the higher cutoff side 1 upon j omega CC is small enough short circuits this is large enough opens we just removed them is that clear this is what essentially we say high frequency response.

We remove both sides CC1 is typically 1 micro farad to 5 micro farad at higher frequencies between kilohertz and above this is a short circuit right now this to ground there is so common emitter common source is rounded through VSS okay.

So if they now say DC gain what is the word I already defined DC gain means they were all capacitances and find the gain, so I remove Cga Cgd and I get this circuit which is R signal Rg gmVgs r0rd r dash rather say RL dash I may also neglect at times RG is much larger than R signal and since they are in series I may as well neglect RS in terms of RG.

Otherwise Vgs is how much RG upon RG +R Vin but let us say value now I can even neglect that but right now I am keeping you to show it so in numbers sometimes you may see the number large you can neglect that and get away.

So that AV dash 0 we will call it gain of this amplifier transfer S call it this 0 without capacitance how much it will be this gm times this okay gm times this x RG upon RG +RS RG upon RG +RS this is because of Vgs is ratio of RG and RS to Vin is that correct this is V0/N x gm sorry - sign x RL dash is that okay.

This is the DC gain is that okay this again is gmRL, so actually if you see RG is rather than this it is nothing but gmRL-gmRL is that correct and RL is parallel combination of this r0 is normally very high so it is parallel combination of Rd and although typically both are 5 kilo ohms or 10 kilo ohms.

This will be gm x 5 kilo ohms or something because I0 in order of the will be order is that clear so you can always get so called DC or mid band gain by just solving a simple circuit without any worry on that okay, this is the mid band gain I want to find how long this mid band gain remains in this case when I say constant gain.

so this frequency gain at those frequencies where none of the capacitances are dominating the my output is essentially called the mid band this value essentially means no effect of Cgs no effect of Cgd no effect of cc1. This is the gain maximum possible which remains constant for burst frequency regions when all these capacitances can be neglected.

Some way either open or short such that the gain comes from to be this is the mid band is that correct, this is the DC word we are used mid band is the DC gain please remember my DC and open DC is not same because I will come to it again now we define yes that is called current gain this is not this is a voltage gain please remember unless stated.

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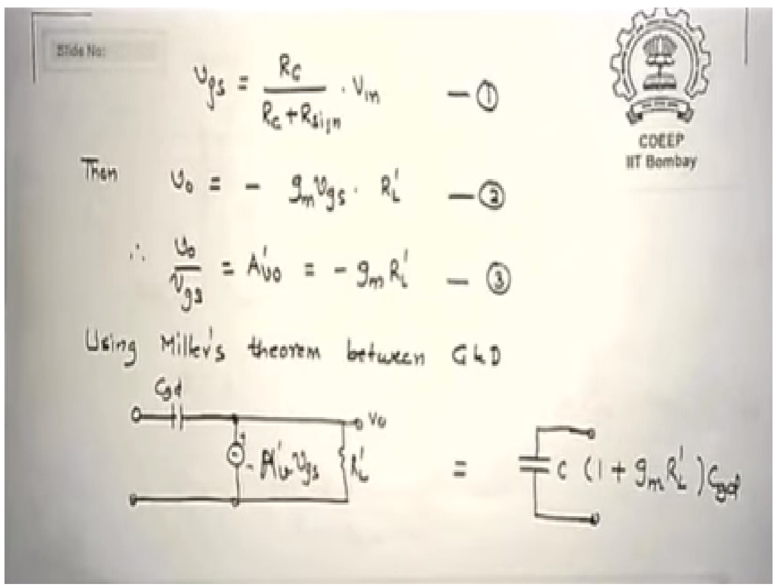

Otherwise we are talking of voltage gain as I told you there are 4 gains possible voltage by current voltage their voltage current by voltage current my current so unless specified we will specify its assumption is we are looking for voltage amplification why we say so where our input sources voltage signal we do not mind calling it transconductance as well because if you leave the RL you have a current please okay.

If you read the mode you are near current there at the output now this ratio of this current to the input signal is also a transconductance gain that is essentially called capital gm why it is capital because GM x Vgs, Vgs you take from the input side the ratio of then L/V is essentially the transconductance key, but if you multiply that with the load then it becomes the voltage key is that correct.

So basically we are only looking right now voltages I am not saying we do not need any time the other gains this problem right now we are looking for voltage gates if we define 2 terms okay one we call is omega 0 we will just come to this numeral you which I am talking about okay let us come this latter okay, so Vgs is RC upon R signal beam I think what I have stated I repeat V0-gm Vgs RL dash.

So v-0/VT SAV-0-gm RL dash then if I substitute Vgs from here I can get AV0 as well okay now this issue is very interesting, now look for I am now interested to see the effect of capacitances but still I am not interested in capacitances like CC1 CC2 and CSC or CS whatever it is I am only looking for now Cgs and CJD.

Why we are interested in these 2 because these are internal capacitances of the device I are no control the others I can change I can put 5 micro farad I can put 30 micro farad is that correct these are beyond me so I must know what are these doing inside, So I will see if you have a CJD like this coming from the output side this is AV Vgs other okay and if you see this is your input side this is your output side.

If I apply miller's theorem what did I say that this will reflect into input how much gain 1+gain times magnitude times the capacitance will be reflected at then and how much will be reflected the output same value are Cgd because a upon 1+a same as 1. So, if Cgj will come at the output and 1+gm and the gain is 1+gm RL dash x Cgd will reflect into input side.

So now I started looking for influence of capacitances the other side will be only Cgd I am only looking for the input side right okay I reflected it then okay your answer is here this is Cgs this is one the gmR LCG-SE GD this is your external on the output side only capacitance is cgd, please remember externally if there is ARC you must also use Cgd pal+CL as the net capacitance what I am saying is in actual circuit you may also get a CL here.

So the net capacitance is this + this so the pole position may change on this side depending on the actual capacity load if it occurs and where this sort of normally will occur whenever I will connect one amplifier output to the next amplifier input the CGS of that all of this will be now paralleled with this Cgd itself is that correct that will be the output side for the first stage is that one clear.

If I can have 2 amplifiers the input of the next stage will be now shown as the output of the first stage so that time you must not forget this capacitances right now it is a single stage I said no other external capacitance I am being a theory I am giving you problems then in real life you must take actual values whatever they come okay.

I want to know what is the input impedance you can see from here RG parallel 1 upon this total of course this is equivalent of that C equivalent J Omega times C equal and parallel RG is the CNC please remember Zn is seen after the source there any seen after the source do not connect RS into that calculation of Zn is that correct sauce is not mine this is device and other things are mine.

So I am trying to see what is the input resistance or impedance I am seeing into the gate of this transistor or gate of this amplifier input of this yeah you are right actually there the assumption is that the DC gains are reflected okay the Millers theorem assumes the DC gain the given problem is if that is an AC gain then the reflection will be AC gain times.

That then whether that will become very difficult to solve is that correct because you will a transgender it is a square term will start appearing so in real spice it does take care of that but in solving this is the easiest waste with all use the DC gains that is how you first calculate the DC gains is that clear your point of is very taken because that gain of an amplifier is not independent of frequency.

So it should also reflect in the input but that is what we are saying it is only DC variance, which the plants okay yes this is Cgd is reflected as gain times the Cgb, so yeah this is an admittance one part this is 1 upon C is therefore, their impedance see if it is a capacitor to use do not calls it that is what that I say use why if it is a resistive or inductive in that turns field Z is that correct so this is a capacitance used Y okay.

So the capacitance reflected is always multiply the capacitance by the gain value is that correct same way it will be further inductance also but that time it will be Z times the gain will appear is that it will always be multiplied by the DC gain okay, so if I calculate seven I will get this, so I will be able to evaluate it in I already said Vgs is there in upon ZN+R signal times.

Now what is the difference i did from the last case instead of leaving capacitors now I am using certain says in calculations is that clear that is all that I am doing, so Vgs is therein upon zn+R signal times being there it was what our G upon so instead of RG, now it is a parallel combination of Rgn this additional CGS+ this value C equivalent value okay.

Have not been bisque now I will do I also calculate V0, V0 is GN0 how much is Z0 can anyone tell how much is that 0 if I see from here parallel combination of this is that ler but there is something more will appear 1 this is 1+RL dash CGDS this is the parallel combination with Z0 we will see please say Z0 is seen here okay.

So the parallel combination of load and that capacity one upon C will be the Z01 upon that of course because the capacitance yes I agree so you are perfectly right the way it is done since during the DC gain calculation we are used our L prime as with all L we are continuing it, but you are perfectly right we should have gone these are error and you only use already double dash to calculate it these are values.

I think you have very good understanding I feel that I have transferred what I wanted the way we are calculating is to get roughly the value of 3 DB point now all that will show when we will start operating will never go close to 3 DB point we know if the game will start to be down there, so will be always before that is that so any over estimation or under estimation.

We will see that which one is lower and we will use that as a marker let us say I were 100 megahertz so I am not going to use 100 mega in my any music I will say ok used at least 50 or D rate as I say 50% so you will never close to 3DB point, so these calculations though are not accurate but these are easier analytically done and I keep saying if you solve numerically all these values you need not worry because you give the circuit you give the notes.

It will always take care of everything automatic because it has it can solve numerically any number of steps it does not ask me anything but for us if we cannot keep using that then it becomes longer and longer to evaluate is that correct there is nothing wrong what you said but the way we calculates to know where are we okay.

So I now get a address which is the gain of this amplifier with capacitances gm RL dash upon all under CGS CG upon this so this is the net term I am going to get so how many poles you see here you so can look at it this is okay please remember what did I do I only calculated V0 in terms of this Vgs are replaced by this okay, Vgs are replaced in terms of V in by this is Z0 times GM RL - this into this totally is mine V0 V0/V in is the actual high frequency gain ok.

How many poles you see how many once you are seeing in this trance function how many s 2 terms which are connect this s + Omega 1 x S+ Omega 2 are you seeing 2 terms one on the bigger bracket one in the smaller bracket, so there are 2 phase seen by you is that clear - pole seen by you one related to this one related to this okay.

So one related to this and one related to this there are 2 poles available to you okay which one came vary the key here okay that was I call DC came because you know that deep huh oh because there is no frequency term I use I thought since I am going to use ABS 0 tomorrow for the gm ro frequency here I wanted to separate DC from there if I right yeah well you have a point if I write this essentially means 0 frequency okay so I wanted to separate that from my DC value, so this is symbol please do not get a book may have another simple.

I used only simplified it because I did not want to confuse yourself with this AV0 with a V dash 0 this every does 0 is only inverted to gm RL whatever by input impedance input list so I wanted to make it a little clearer that this is DC value okay, please remember in this frequency terms are available but we are saying frequency 0 is that clear frequency 0.

You if I now write this 2 times once again like this is AV0 upon this I get s upon RL dash Cgds+1 upon sorry are in - C cube the rest terms are calculated where are in dash is RG parallel our signal so this is how frequency gain is it ok this is the high frequency gain why I keep saying higher frequency means I am not looking for lower cutoff right.

Now BC gain R mid band gain till higher frequencies see AV0 means at 0 frequency the frequency gain that may not be 0 till it may be-D beats if you see our mid band function this may actually go something like this so 0 frequency gain may be negative value okay but when I say AV 0 dash I call it this one DC is that clear as I said this is my normal pleasure if you are you need a book and they are another normal feature which you are reading.

You can use that as well my Norman clay chairs are mine I do not actually eyes do read books I am not saying my own book at least I see these dates otherwise normally do not really look into books except for the numbers because if I do a numerical value I will choose from the book because they are accurate numbers but otherwise I really do not solve problems actually looking at democracy.

So I am just telling you this my Norman Fletcher are mine over the years I have developed so I use them so now if you see these 2 bills which I did we have tuples I define 2 frequencies Omega 0 and Omega 1 as are in CEQ and Omega 1 is all L does Cgd which are coming from the 2 terms which I just wrote then I get S+ Omega 0 +S+ Omega 1 if I divided Omega 0 Omega 1 I can take that out and this will be mine actually it 1 upon S Omega 0+S1.

Why it is still giving you-20db can you tell me why it will be-20db down because s upon Omega 0 equal to something when I make s his J Omega s is J Omega by J Omega 0 magnitude well how much it will be Omega/ Omega 0 square+1 under root of that that is 3d bit down when Omega=Omega 0, but by first wise this is-sign going.

So it is going down by 20 DB per decade oh sorry 45 degree per decade is that clear so ok this s by omega0 SS J Omega J Omega/Omega 0 equal+1 so when I write Omega=Omega 0 I am saying J Omega or sorry 1+g0 is that correct so essentially I am saying-1 is that clear-1, which means operator is now showing its opposite sign signal going through is that correct, so it will always be value will be reducing as Omega will start increasing beyond Omega 0 is that clear.

This is what essentially means okay all to say we are not done it but I suppose in your theory somewhere we say that all the poles are right now in the left half plane of Sigma J Omega axis - all of them are on the-XS are called left up plane I think if I go controlled part at here to do too much but maybe a band I will give a talk on what is this root focus technique or what is this.

So called Sigma J Omega just for your understanding that what is the stability what people are talking about ok now in this since you got 2 poles one for Omega 0 one from Omega this whichever is dominant one can see from here the web this is higher F this is hired by typical values you will find and you will to your surprise you will find say Omega 1 will be smaller than because this value will be larger than this.

So it this value will actually start dominating is that correct this value will be start dominating however I cannot say always because depending on the values of CJD and all C equivalent I calculate whichever dominates will be the dominant pole which is dominant in the case which one will be called dominant if Omega 0 is less than Omega 1 Omega 0 is the dominant if Omega 1 is less than Omega 0 then Omega 1 is determined dominant means the pole.

Where the gain really start dropping past okay which is the first appearing the second will add another 20 DB down, but by then already we are gone now okay so the first pole is of interest where the gain starts falling is that clear, so that is why you must evaluate, which is the dominant pole we are interested in the mid band frequency, where it starts dropping and that dropping world we are interested in this value from here.

It may actually go further second poll is that correct there will be a second poll, so this is not a dominant Pole dominant the first where gain starts falling so we must value it which is the dominant pole okay, so this is how we evaluate the fh, r in the transfer function now something we missed in this I have a look at 30 other day when I was talking about 0 and 1 sorry 0 and poles.

If there is a capacitance between the drain and the gate or any not even in any impedance there are 2 forward paths available which other 2 paths I said one through the transistor and other through the capacitance or that to the output and if there are phases since they are opposite in phase if their magnitude happens at a given frequency to be same then they will cancel and that is what we say it is a 0 okay.

In this there was a Cgd but I did not see any 0 in my transfer function is that clear I only got 2 poles okay how one of them is dominant I figured out but I do not know the world is 0 so assumption here was something as if that 0 is existing much higher value than even the second pole.

Let us say second pole occurred at one megawatt first at 500 megahertz a kilo Hertz then the occurring say 10 megahertz, 10, 100 megahertz or gigahertz, this was as if my assumption therefore I said okay 0 is up not my value but I have not checked whether 0 is really occurring at much higher frequency what is the problem of 0 occurred earlier.

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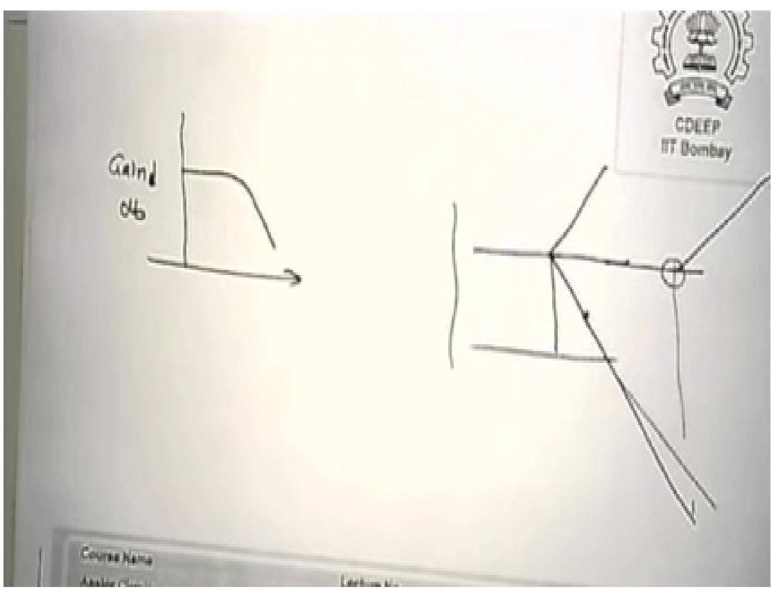

What did I say other doing if you are a pole like this and if 0 occurs then the gain may become constant it will cancel 20 DB+-20 DB it will cancel it out is that correct, but at this 0 occurs somewhere here this is already-80 DB let us say so this is 20 DB + means -60 DBR slope may change, but it is still-60 DB down it is going down is that clear.

So, the 0 occurrence may or may not affect depends on where that occurs okay in this all evaluation I did I assume as if there was no 0 close to poles is that correct I must verify possibly yes it was, so that is that is not the Millers problem that is what I was saying the Manor the well Miller did it actually lost the connection feed forward okay is that correct please remember.

What I said by doing a Miller's theorem we actually lost feed forward connections therefore the 0 was removed by is that clear this was the limitation of Miller's theorem that is what I keep are you are asking is it look there is a problem if I use Miller's theorem all the time so here is the one see I already explained you fully.

So, here is done in which I do not assume any Miller's theorem okay all then are this is EJ after Rgi all right now neglected but you can use RG also Cgd yeah because it no if you better implicit the plot always gives you feedback part feedback are taken care but feed forward I am not taking is that clear that I said you to place the signal gets connected one is feed forward otherwise and feed forward gives you 0.

That is why the 2 at the drain maybe opposite signs unless there is a feed-forward there is no 0 okay feedback I had taken here okay drain to source I did I came back I have one upon gm times I RL times I got that back but there is no feed forward term I left since I left followed the path I did not get my 0 exactly, so to get now 0 is that point clear 0 I told it just now what is the theorem.

I said the feed for white gives this one part from gate to drain direct feed forward the other is through the transistor okay 180 degree out of phase both of them if at a given frequency the 2 values contribution to voltages at the drain cancels because of opposite sign then he says you know exists V0 goes to 0 what is the 0 means V0 goes to 0.

So it can occur without shorting at a given frequency V0 may go to 0 which is the one we said 0 0 of the transfer function is that clear so this remove inputting MLS theorem we used only remember I keep saying feedback, now this feedback turn left feed forward and that is why I did not see my 0 is that clear but I will not you know Sarah.

What did I do I took care of its value into input and output by the and the open the path between gate and drain so the connection that we will get in drain by actually using the Miller's theorem both my feed forward path no connection between gate entry if there is no connection between gate and drain there is no question of cancellations up to such voltage contributions.

So to avoid this situation okay I will now say queue okay do not use theorem every time this is what my general telling to you people use Miller's theorem, so very easily so I brought this example from your days to show that Miller's theorem is not what is a panacea for every solutions at times your feed power may be very weak and therefore the PHA had no time 0 occurs all essentially 0 occurs at infinite yeah.

This situation is fair enough here where the feed forward it, it only takes feedback that is the mean that is what Miller I said and that is why I said you that you always feel much easier to immediate miss your Miller's theorem equivalent and short circuit because then it becomes very easy to solve okay. But in doing so points well not very much, but G0 may not be available so here is a solution okay.

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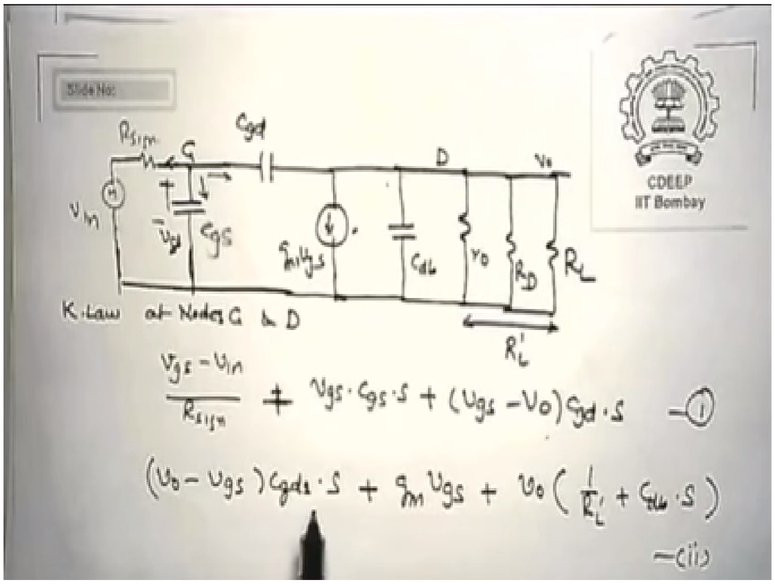

Only thing I right now left to see grg okay they say Cgs Cgd Cdb r 0r dr l okay this is gm Vgs, so now I write 2 equations for the 2 loops okay Vgs-VN-VN/R signal is one current in this path okay.

This part what is the theorem i am applying the net current is 0 at the node G okay net current is 0 at this they mix other current is this okay which is VG Cgo says okay GV is the current GV is the current is that okay GV is the current, so this current the third is this current which is Vgs-V0 x Cgds is that okay.

So the net current that gate is 0 so I wrote one equation like this I went to this node drain now V0-vgs into c GD s into S this is the current coming from this side sorry this side rather this side it is going+GM Vgs+V0 upon this resistance together whatever is current flowing please circuit if this is together are equivalent this is this current V0 1 upon r l dash + current in this.

So C DV bias there is a current here there is a current in this there is a current here and there is a current here is that okay, so at the drain again I summed up all the currents and made it to 0, so 2 node equations I solved and I have 2 equations available to me as one and 2 now do you see here.

I am not leaving any term Cgd feed-forward is also I have taken feedback also I have taken is that clear is that clear so this method does not leave either feed-forward or feedback it takes care of both the terms and since it takes care of both the terms it will create all the poles and you will also create a corresponding 0 is that clear.

So I please do not say that Miller theorem was wrong with them Miller theorem is most times is very good it gives almost accurate results but that means assumption was that 0 values are such that they are too far okay.

But if they are not because we do not know what is GM we do not know what to see g8 CJD valid if 0 occurs we must know where is it ok.

It may or may not be affecting our actually mid fall okay, but if it happens we must know where that is the trick you should know, so if I I may not solve all of it our taken I I just the rest of the thing has been taken from book actually not this book but I do not know, which book I write some terms, which is Cgds.

There are 3 capacitances here Cgd Cgs and CDB the combination of these will always occur please remember what is combination CGS x Cdb Cdb x this into 3 possible combinations this terms occur in our solving so I define that as theta and if I use now solve this equation I get in denominator please remember what do I solve from here I again solve V0 by then and get abs function.

I did not, I have solved it when I am not showing you okay, I am just trying to finally reach here then I see D is equal to s upon Omega P 1+1 s upon Omega T, where Omega P 1 and omega P to R that is corresponding same poles which we discussed earlier and if you see this product of this what will occur SS square upon this+s+1.

This is second-order denominators SS square terms appearing product of the 2 means 2 poles, I am confirming it these 2 will always give you a SS square + basically +C if the transfer function is as this kind it will always be equal to S + Omega, 1 + some constant s + Omega 2, you can always be like this ok.

So, this essentially means I can get from the denominator to pole values is that okay I can get to poles from the denominator of this I am not solving I am just telling you what we did however as I said and still not got my 0 so okay I went back from the equation to I bought the value of VG s in terms of V0 okay.

In terms of from the equation to please note down this because this is important VG s is-v-0 see it is promised equation is same CDS x 1 upon all and - CD - upon gmc gds gm-egm and I substitute that in equation 1 what is interesting for me will be 0 by pianist then I am looking for so if I such get v-0 from videos from this substitute.

In this then I can get my trance function gain V0s by Vin= Cgds-gm other - divided by all this just note down this Cgds-gm x RL - that is the numerator divided by R signal x RL dash ETA square + all the big bracket into s+1 do you see that function is s square + A square basically + C it is a square.

I would have left it to solve for you because I do not know how to solve but just to give an idea I said you can always solve this method what is this method is saying solve nodal equation or you can use cache F mesh equation on several measures you can solve a mission, so there is no question that first you solved by not only you can use Sigma V or Sigma I either of them values currents here.

So there are the current sources I see everywhere so also it is better if I use at node equations spice use Sigma y 0 that is G are you the matrix g is the matrix visa matrix okay since it is also is equal to GV I thought I should always show you their method okay they say where to point as I say s square s + 1.

So it has it because I did not solve for you full of it but I will just tell you one of the points which I am assuming dominant okay and I hope you know this is the dominant I can solve both of them and get but my intuition tells from the values I know this is the dominant foot okay if Omega P 1 is less than Omega P 2.

Then we will say Omega P1 is a dominant put and this is the value now do you see in our expression which I wrote just now okay RS x1+GM our elder CJD+RS into CGS+RL - si UD+C -CDB is the dominant one upon that is the dominant pole okay that is to say at Omega=Omega P 1 the value becomes denominator becomes 0 and therefore the magnitude tends to infinite.

Now if you see my expression our signal into CGS RL dash x Cgd + gdb okay in the minor scales what did we miss 0 if you see this expression in the numerator c JD is-GM so at any one frequency s but their frequency Omega then this term will go to 0 which is called Omega Z which is gm upon Cgd with a + sign please remember 0 should occur.

This should be-there it was + everywhere therefore it was on the left half-plane 0 is occurring either on the imaginary axis or on the right half-plane positive value okay so A0 is existing at gm/Cgd, Cgd is typically very, very low okay gm is of the order of 3 and 4 will become value mage in any a magnitude nickel Tina happy the coins I J Omega/IC.

I got some Lewis its car magnet this is 1 + 1, 3d is that correct that is 3d be Java this car lock function, Nicola log of numerator Nicola so this will be 20 log of this, so it will start browsing because this will be stronger as the frequency increases this term will become larger and larger so 20 DB KO purchase anthology is that correct but at the frequency.

Where they are equal it will be a 0 will occur is that correct this is what the so you know + and - dictated -20dbs one which has a 1 upon something will always be because 20 log will come if it is the numerator+20 will come is that correct so this essentially means that there is a 0 exist CG giving very small GM is a little e hi typically.

This will be less than a puff okay less than a puff at least step of so how much it will be 10 to power 9 typical value may be 10 to power 9 Hertz 1 upon 2 pi, so something related to hundreds of megahertz please take it what I said GM is the order of 10 to power-3 CG it is of the order of-

12 this is order of+9 if I divided by frequency 1 upon 2 pi x 10 to power 9 this is roughly 1 x 10 to power or 1.5 x 10 to power 8.

That is something like 18 1 80 megahertz is that correct 1 80 megahertz the right somewhere less than one megahertz the frequency stones so this 0 is that clear now why, why we were justified even in Miller's theorem because this value was far away from my poles before it went to 60 DB down the 0 is not operating is that correct it is 2 hours higher that means till it went to-60 DB 0 is not operating.

So I am carried but let us say my C0 value is high enough all to say I put additional capacitors across CJD from drain to source what can occur 0 will be brought left as much as I want is that clear which means it may start actually closer to the pole itself and therefore I may actually make it 0 both equal goal value same as 0 value.

In that case what will happen the gain with a black band will gain Mr. Ferleger start B plot is that clear to you I told you other day if at a given pole I put a 0 then the value becomes constant in the next there this starts falling by40 DB but this will always go 20 DB, so then-20 it will start going till that time the gain will become so what will it will improve the bandwidth so this is called pole 0 compensation.

So capacitance additionally can report from brain to gate to adjust your value but this is not very easy it will actually do something some other day I will explain yes however that is that that is actually a certain situation it is like a pole now it has a value which is adding to a pole value it will act like a pole then you pull it down by J Omega terms it will come in into the denominator if that + occurs only the GM there is a-sign between them offers that is the positive value 0 occurs then only it is a 0 that clear is that issue clear to you so in this problem.

What did we try to show you that Miller's theorem was valid even in this case but in real life you should not use that always Miller theorem is valid is that right so what is that solution I suggested to you, you just put a network use Kirchhoff's law solve a network and get 0 then posed as they come magnitude was some maybe domino and some may not be dominant so it is up to you.

When I plot the bode plot I will see which one is dominating there okay till that as if I let them rest is I am not useful is that okay, so these issues are very crucial for you and this I think is must be understood by you all that by sometimes Miller's theorem is valid so what is their import what is the value I am saying if the Cgd value is very small then the feedback is dominant but feed forward is not is that correct.

If the Cgd value or the admittance connecting drain to create or output to input is very, very small then the feed forward value will be very, very high 0 es will come very, very high and therefore only feedback will start dominating is that otherwise that is the feed forward can also start dominating is that correct if see dude is very high it is this value which will dominate not this one okay so is that point.

Now clear I can solve any problem any number of poles any number of 0s I get back below capacitance only with showing it in a way with jitter capacitance from there with now there is a possibility which I said other day that you may get something like this what does that mean that the 2 poles are identical.

So you can actually there are cases in real life when you actually get cubes now what does this essentially means for you can think like this whole block is no TVs are there -20 -Cos a game Casa false A 60-60 degree yeah-40 DB against false The Sharper cutoff ruling is that cleared this whole.

I saw 20 DB here a 40 D we are near 60 DB us is that correct so one method of actually creating a sharper cut off for the filters is to get a transfer function where you may get square or cube tones is that correct your filter the theory, but in it what is the filter I am saying in filter ideally I want this kind of response are they responsive everything paths and beyond this no pass okay.

This is say no pass filter how because I am a SR I can convert this close to this by adjusting values says that I may get a transfer function in which 3 poles are identical okay and if that occurs if very sharp cut offs can be achieved so you see sharp cutoff of course by doing what we call Shiva show filters will look into this Max and a flat filter but ever actually we tailor this to get poles closer okay.

So that shot falls so this is clear to you so points and 0 is decided up to, which signal they will pass and biloba signal may have not pass or vice versa is that clear. Thank you for the day.