**Analog Electronic Circuits**
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**Lecture - 17**
**Robust Biasing with Source Feedback - Part 1**

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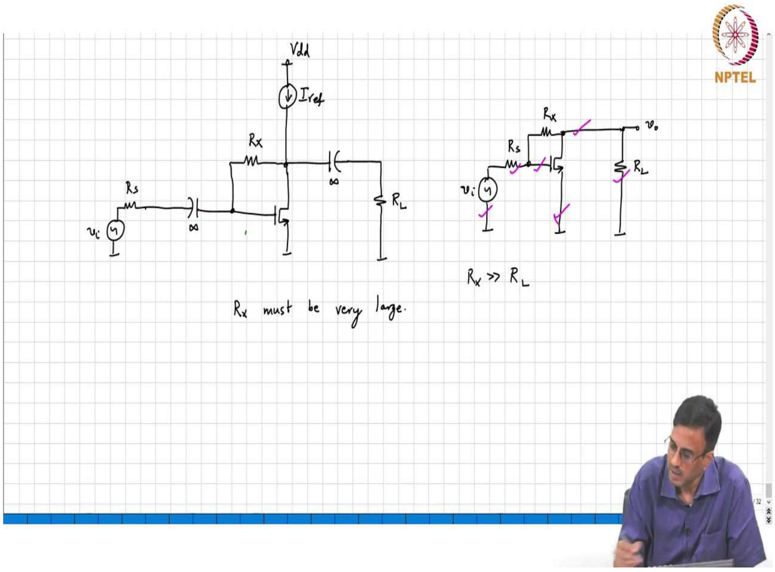


So, to summarize the method of bias stabilization, what did we do? We basically are comparing the drain current. With the reference current and tweaking the gate voltage, alright. But remember that in a MOS transistor.

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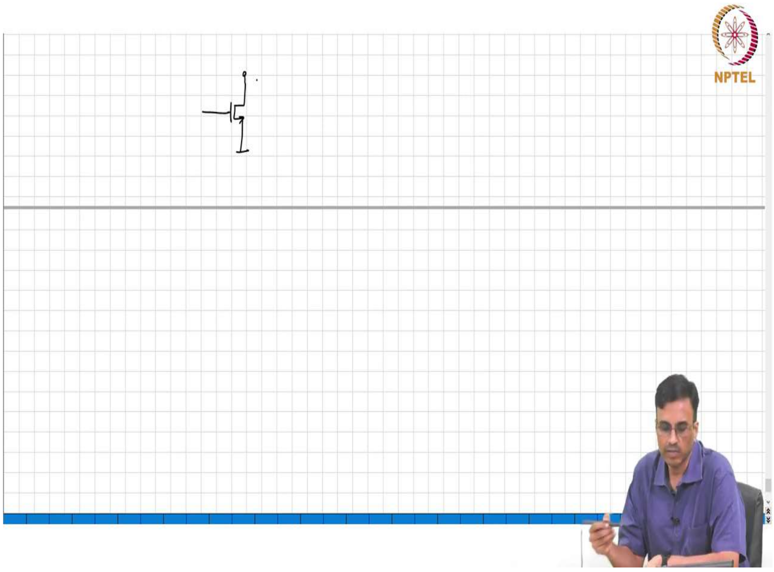

How did we do this? We had the transistor and we stuck and we measured the drain current. But remember that in a MOS transistor the gate current is 0.

So, what comment can you make about the drain current and the source current? So, in other words if the gate current is 0, it must follow that the drain current and the source current are identical. So, in principle there was no compulsion to stick that ammeter in the drain, we could have as well put it in the?

Student: In the source.

In the source. Alright, and remember that the gate source voltage, I mean the current in the transistor is governed by the gate source voltage, not the absolute gate voltage. It depends on the gate source voltage and what we did was earlier we measured the current in the drain and varied the gate source voltage by keeping the source voltage fixed and wiggling the gate. I mean, what are the fundamental ways of wiggle? I mean how can you change the gate source voltage?

I can think of at least three ways of doing it. What are the three ways? One is to fix the $v_s$. Wiggle the gate that is what we have done right the other is?

Student: Fix the gate.

Fix the gate?

Student: Wiggle the source.

Wiggle the source, right. What is the third way to vary?

Student: Both.

Both right to push the gate up pull the source down, correct. Similarly, we can measure the whole idea behind feedback was to measure the current in the transistor and tweak the gate source voltage in the right direction, correct.

So, we can measure in two places namely either stick the ammeter in the drain or the ammeter in the?

Student: Source.

Source, correct? So, the two ways of measuring the quiescent current in the transistor. There are at least two ways of varying the gate source voltage in the right direction to make sure that $I_D$ or the quiescent current in the transistor is equal to $I_{ref}$.

So, how many are the minimum number of techniques you can think of to stabilize the bias in the transistor? We can think of at least 4 ways of doing it right. So, you measure in the drain, you vary $V_{GS}$ by keeping the source fixed and varying the gate potential that's what we have done now.

Now, you have all the other permutations and combinations. We can measure current in the source, vary the source voltage, we can measure current in the drain, vary the source voltage and so on. So, we will take a look at all of them.

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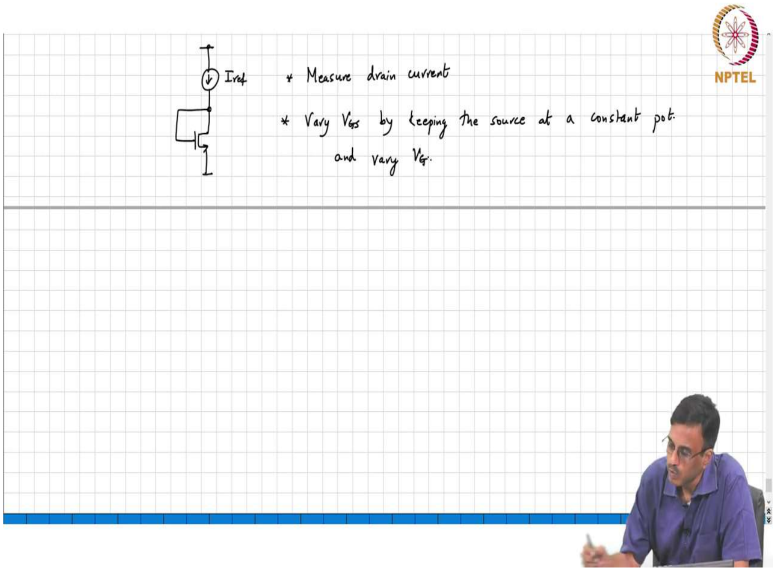


But today we will look at the second example which we now measure. So, this way of doing this is to measure drain current vary $V_{GS}$ by keeping the source at a constant potential and vary $V_{GS}$ alright.

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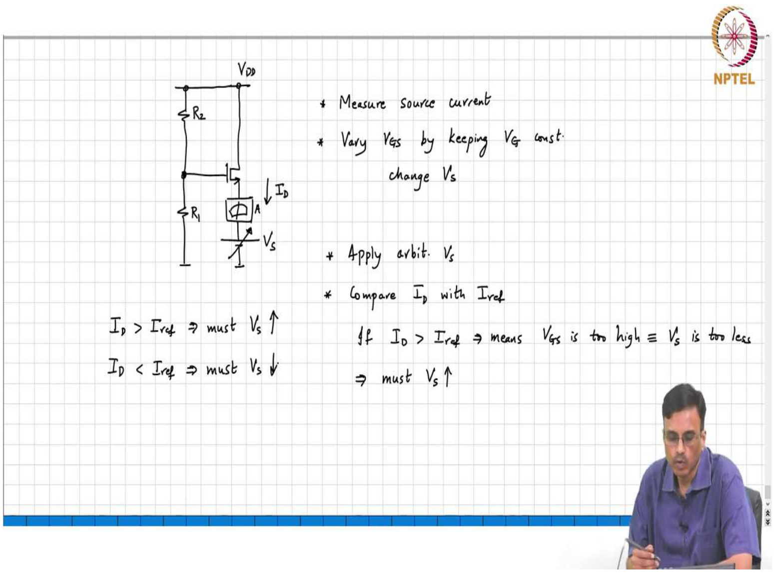


So, now let us take a look at a system where we keep the gate voltage fixed $V_G$ is fixed. So, $V_{dd}$ how do we fix $V_G$. one way of doing it is to simply put some kind of potential divider this is $R_1$ and what will we do? We want to measure source current vary $V_{GS}$ by keeping $V_G$ constant and changing $V_S$. So, the basic idea is therefore, like this.

So, this is the ammeter and this is our variable voltage source. So, what we are measuring is $I_D$ which is the same as $I_S$. So, common sense, what are we going to do? Can somebody tell me a clean step by step way of finding the correct magic $V_S$. So, yeah for a given $V_S$. So, apply arbitrarily. There will be some current $I_D$ that will be the result. Then what compare $I_D$ with?

Student: $I_{ref}$.

So, if $I_D$ is greater than $I_{ref}$ what does it mean? $V_G$ is fixed, you cannot mess with $V_G$. The only thing you have is $V_S$. $I_D$ greater than $I_{ref}$ means what?

Does it mean that the gate source voltage is too much or too little?

Student: Too much.

Means $V_{GS}$ is too high which means $V_S$ is too low. So, what must you do? Must increase $V_{S,}$ alright. So, in other words if $I_d$ greater than $I_{ref}$ must increase $V_{ref}$ on the other hand, if $I_D$ is less than $I_{ref}$ what must we do? What does it mean? If $I_D$ is less than $I_{ref}$ it means that $V_{GS}$ is?

Student: Too small.

Too small, but $V_G$ is fixed.

So, it must mean that $V_S$ is.

Student: Too high.

Too high and therefore, we must reduce $V_S$ is that clear. So, now, the basic idea is known. What are we supposed to do therefore, we must compare $I_D$ and $I_{ref}$. So, what physical principle will be used to compare two currents? KCL again. So, what so where do you what do we where do we this is $I_D$ or $I_S$.

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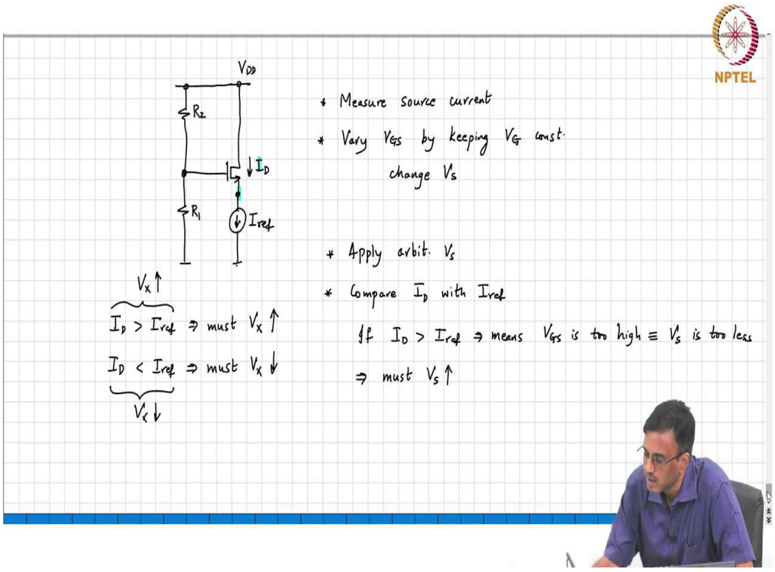


How do we compare it? You connect a current source here alright. Now what so this is $I_D$ this is $I_{ref}$ that is the potential of node x. If $I_D$ is greater than $I_{ref}$.

What comment can you make about the potential of node x? More current more charge is being pumped into the node than is being withdrawn from the node right alright. Then what comment can we make if $I_D$ is greater than $I_{ref}$ $V_X$ will tend to go?

Student: Up.

Up, alright. So, in other words if $V_X$ goes up we must increase $V_S$ which is the same as x, alright. The potential of node x must be increased and if $I_D$ is less than $I_{ref}$ what does it mean? What will happen if $I_D$ is less than $I_{ref}$?

Student: $V_X$.

$V_X$ will fall down, but that is what we needed to do anyway, correct. So, what do you suggest we do?

Student: nothing to be.

There is nothing to be done; the very act of simply sticking that current source in the source of the transistor automatically ensures that the current in the transistor is exactly equal to $I_{ref}$.

And if you are not convinced, just think about this way let us, say momentarily for some reason $I_D$ has suddenly increased. Then what comment can you make about $V_X$? It will also increase and therefore, tend to reduce the gate source voltage and bring the current?

Student: Down.

Down does make sense? Again, you can see that even though it's not evident unless you think about it there is negative feedback here too just like there was in the case with the diode.

Alright, I mean negative feedback does not know you most likely looked at negative feedback as a block diagram? Forward amplifier, feedback block you subtract. In the real-world negative feedback life does not come in block diagrams. It is all there I mean you know everything that we are doing is basically feedback, but you do not see that the forward amplifier feedback block all that is it does not come labelled. It is for you to sit, think carefully and recognize what is going on, alright.

So, basically this will ensure that the current in the transistors is equal to $I_{ref}$. I mean and some of you may be wondering if you know this so self-evidently. Why is all this strange analysis needed ? Is in Kirchoff's law simply telling you that $I_{ref}$ is equal to you know $I_D$ I mean what is all this you know long winded argument? Why did we have to even derive it like this and the answer to that is that such arguments can be very deceptive.

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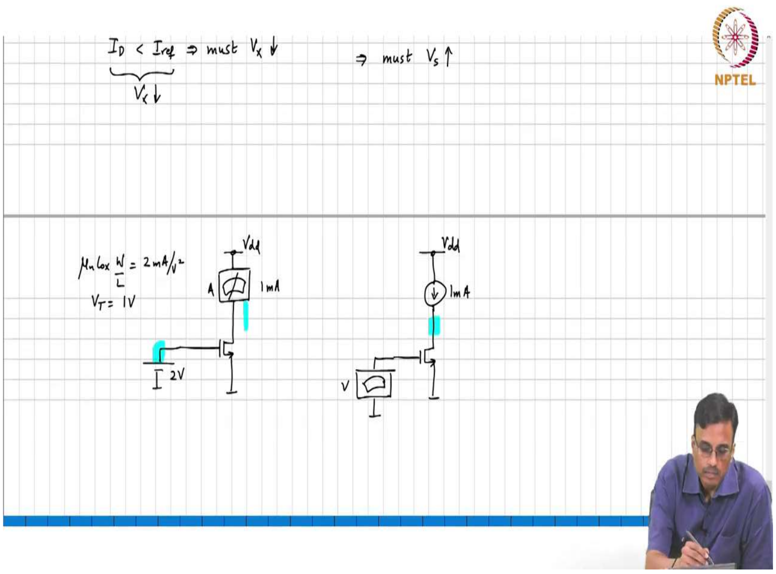

So, here is an example, here is an experiment. The transistor properties are known $\mu_n C_{OX}$ W/L is 2 milliamps per volt square $V_T$ is 1 volt and I am applying 2 volts here. This is $V_{dd}$ which is sufficiently large and I stick an ammeter here. What will the reading on the ammeter be?

Student: 1 million.

1 million, very good, alright. Now, I am going to do another experiment using the same transistor. This is a 1 milli ampere current source and I put a voltmeter there. So, what will the voltmeter read? So, the crucial point that we are missing here when we do that is that we remember that the MOS transistor is a unilateral device. Why do we say a MOS transistor is a unilateral device? What is the cause and what is the effect?

Student: $V_G$ is the cause.

$V_G$ is the cause and $I_D$ is the effect. Just because there is a relationship between $V_{GS}$ and $I_D$ does not mean that you can go and turn the relationship the other way and then expect that you push a current into the drain and a?

Student: Voltage.

Voltage will develop at the gate and what I mean is how do we know that the transistor is a unilateral device?

Student : $Y_{12}$.

$Y_{12}$ which quantifies the effect of an excitation at the output at the drain on the?

Student: Input port.

Input port, we know that $Y_{12}$ is 0. So, that basically means that you know wiggling the drain does not magically cause it?

Student: Gate.

Gate at I mean voltage at the gate. So, if you do this experiment you will burn the transistor because the voltage at the drain will go to infinity and it will break the transistor. Another way of thinking about it is that you study hard and then your CGPA hopefully reflects what you know correctly.

But if I take a you know blank grade card and print you know CGPA of 10.2 on the grade card does not suddenly mean that it will come into your mind from you know outer space you understand. So, this is the I mean though you would be tempted to use Kirchoff's law at the drain and say well you know and put the we know the equation and put the stuff in and then conclude that $V_{GS}$ is 2 volts that certainly not true, alright. So, I will stop here.