Chalmers University of Technology

EME102: Active Microwave Circuits

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Home Assignment

# Transistor Modelling - Part II

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# 1 Abstract

To determine how to remove the extrinsic parasitics modified the de-embedding method (adding negative valued components to remove the extrinsic components) proposed in Rorsman[1], and suggested in class by Vincent, was utilised. The s-parameters were measured on the transistor, which includes all the parasitics such that having a resistor or inductor with a negative value in series would cancel the respective component, having a negative valued capacitor in parallel would also cancel the respective capacitor. The values of the components was determined in the first task. The setup used is illustrated in the following diagram:

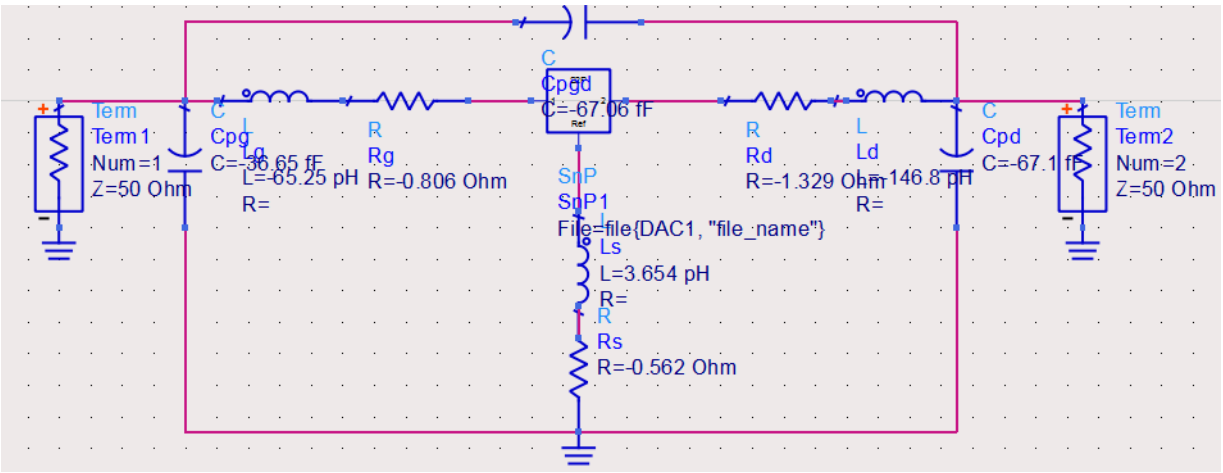


Figure 1: Experimental setup

The intrinsic capacitances like $C_{gd}$,$C_{gs}$,$C_{ds}$; resistances like $R_i$,$R_j$ ($R_{gd}$),$R_{ds}$,$g_m$ and $\tau$ values were determined from Rorsman's paper, particularly equations (11) - (18) after the de-embedding process.

# 2 Plots

Once the values were obtained, the capacitances and resistances were plotted against $V_{ds}$ and $V_{gs}$. All the graphs are at f = 3GHz. The following plots shows the variation of the intrinsic capacitances with respect to the gate-source voltage, $V_{gs}$ varying from 0V to -8V.

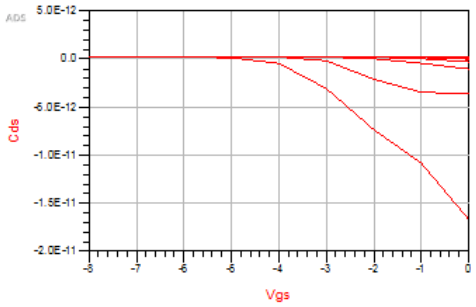


Figure 2: $C_{ds}$ vs $V_{gs}$

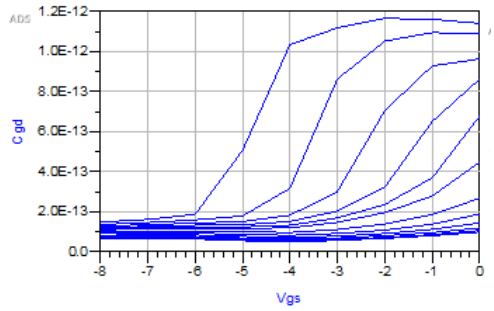


Figure 3: $C_{gd}$ vs $V_{gs}$

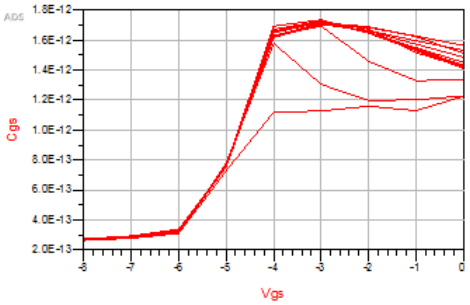


Figure 4: $C_{gs}$ vs $V_{gs}$

The following plots shows the variation of the intrinsic resistances with respect to the drain-source voltage, $V_{ds}$ varying from 0V to 20V.

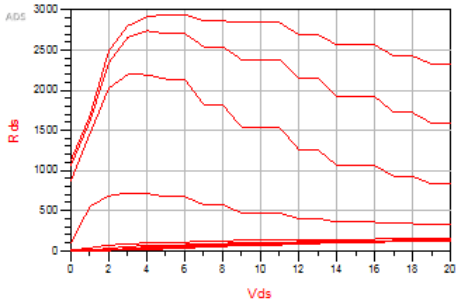


Figure 5: $R_{ds}$ vs $V_{ds}$

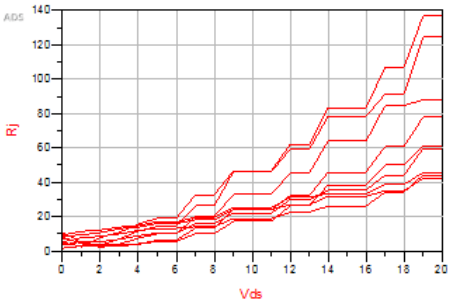


Figure 6: $R_j$ vs $V_{ds}$

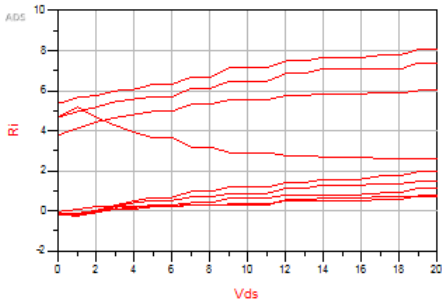


Figure 7: $R_i$ vs $V_{ds}$

The following figure shows the variation of $g_m$ and $\tau$ for a $V_{gs}$ sweep:

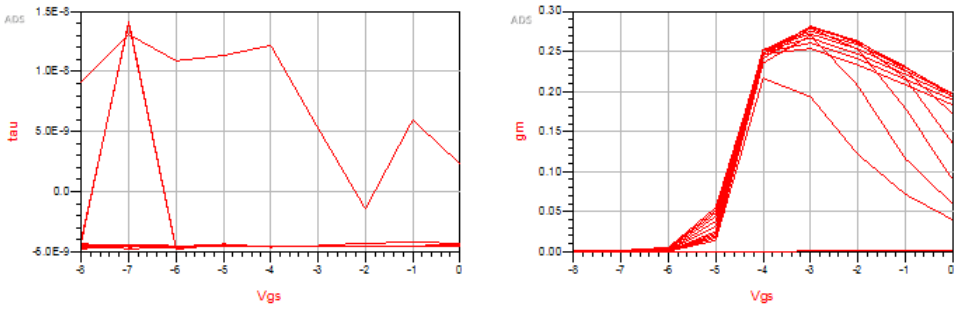


Figure 8: $\tau$, $g_m$ vs $V_{gs}$

From the figure, it is evident that the maximum value of $g_m$ is $\approx 0.281$ which is needed for the next task.

# 3 Intrinsic Parameter Values

The intrinsic parameter values for $V_{ds}$ = 0 V and $V_{gs}$ = -8 V neglecting Re($Y_{12}$) are as follows:

| freq | Cds | Cgd | Cgs | Rds | Ri | gm | tau | Rj |
|---|---|---|---|---|---|---|---|---|
| 3.000 GHz | 1.781E-13 | 1.478E-13 | 2.639E-13 | 1036.090 | 5.351 | 5.732E-6 | 9.088E-9 | |

Figure 9: Table of Intrinsic Parameters, Re($Y_{12}$) negl.

The intrinsic parameter values for $V_{ds}$ = 0 V and $V_{gs}$ = -8 V including Re($Y_{12}$) are as follows:

| freq | Cds | Cgd | Cgs | Rds | Ri | Rj | gm | tau |
|---|---|---|---|---|---|---|---|---|
| 3.000 GHz | 1.781E-13 | 1.478E-13 | 2.639E-13 | 1119.819 | 5.351 | 9.305 | 5.732E-6 | 9.088E-9 |

Figure 10: Table of Intrinsic Parameters, Re($Y_{12}$) incl.

# 4 References

[1] Rorsman, et al. "Accurate Small Signal Modelling of HFET's for Millimeter Wave Applications." IEEE Transactions on microwave theory and techniques 44.3 (1996): 432-437.