Handin 2: Extraction of intrinsic parameters.

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February 14, 2017

1 Task 2

In this section I describe the method I used to extract the values of intrinsic components. This method was proposed by Dambrine. The simulation was set up according to Figure 1.

Simulating the scematic shown in Figure 1 yielded S-parameters for the two-port. The extrinsic parameters (calculated in the previous task) could be removed by a series of calculations.

- Convert $\mathbf{S}$ to $\mathbf{Y}_0$.
- Remove extrinsic capacitances (1).
- Convert $\mathbf{Y}_1$ to $\mathbf{Z}_0$.
- Remove extrinsic resistances and inductances (2).
- Convert $\mathbf{Z}_1$ to $\mathbf{Y}$.

$$\mathbf{Y}_1 = \mathbf{Y}_0 - \begin{bmatrix} j\omega(C_{\text{pg}} - C_{\text{pgd}}) & -j\omega C_{\text{pgd}} \\ -j\omega C_{\text{pgd}} & j\omega(C_{\text{pg}} - C_{\text{pgd}}) \end{bmatrix} \tag{1}$$

$$\mathbf{Z}_1 = \mathbf{Z}_0 - \begin{bmatrix} R_g + R_s + j\omega(L_g + L_s) & R_s + j\omega L_s \\ R_s + j\omega L_s & R_g + R_s + j\omega(L_g + L_s) \end{bmatrix} \tag{2}$$

When the extrinsic parameters have been eliminated the intrinsic parameters can be acquired from (3), which yields seven equations (three real and four imaginary).

$$y_{11} = R_i C_{gs}^2 \omega^2 + j\omega(C_{gs} + C_{gd}), \tag{3a}$$
$$y_{12} = -j\omega C_{gd}, \tag{3b}$$
$$y_{21} = g_m - j\omega\big(C_{gd} + g_m(R_i C_{gs} + \tau)\big), \tag{3c}$$
$$y_{22} = g_d + j\omega(C_{ds} + C_{gd}), \tag{3d}$$

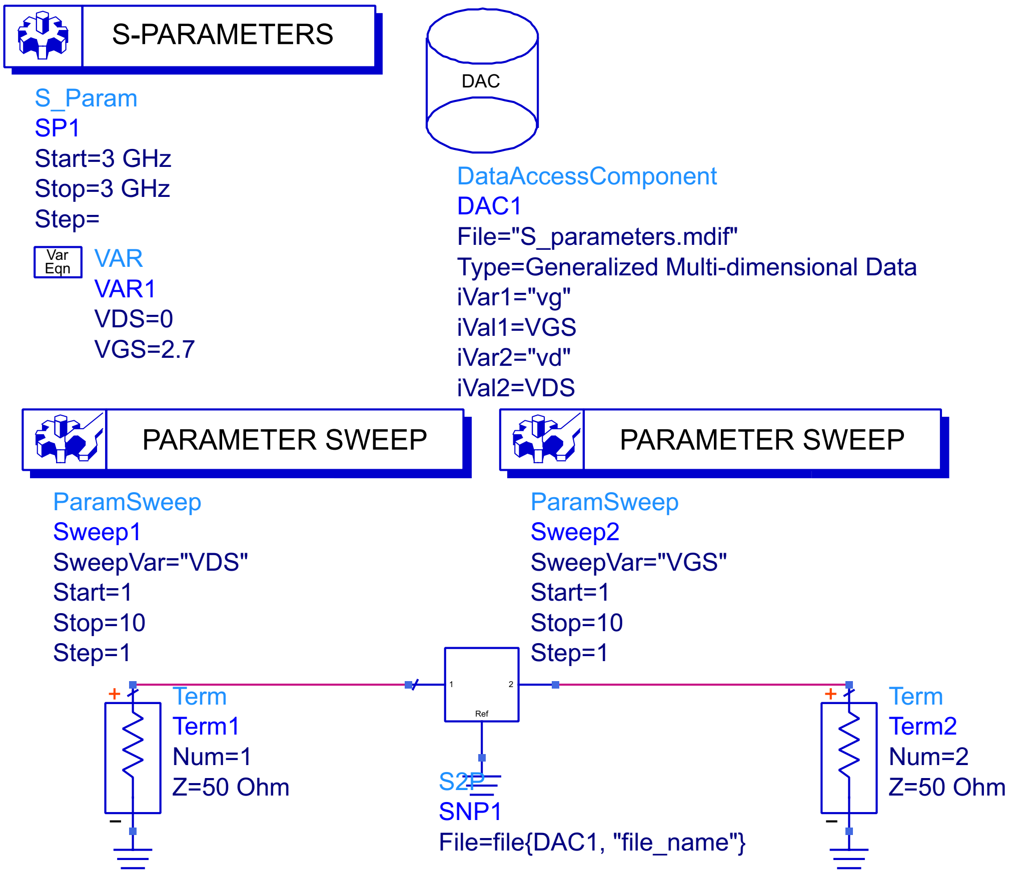

Figure 1: The scematic that was used to produce the results presented in this report.

Variable	Value
R_j	$2.28\,\mathrm{k\Omega}$
C_{gd}	$-23.3\,\mathrm{fF}$
R_i	$5.38\,\Omega$
C_{gs}	$-57.3\,\mathrm{fF}$
R_{ds}	$-7.58\,\mathrm{k\Omega}$
C_{ds}	$-208\,\mathrm{fF}$
g_m	$2.30\,\mathrm{mS}$
τ	$88.3\,\mathrm{ps}$

Table 1: The final values of the intrinsic parameters.

The intrinsic parameters can be seen in (4)

$$
\begin{aligned}
R_j &= -\Re\left(\frac{1}{y_{12}}\right), &\text{(4a)}\\
C_{gd} &= \frac{1}{\omega\Im\left(\frac{1}{y_{12}}\right)}, &\text{(4b)}\\
R_i &= \Re\left(\frac{1}{y_{11}+y_{12}}\right), &\text{(4c)}\\
C_{gs} &= -\frac{1}{\omega\Im\left(\frac{1}{y_{11}+y_{12}}\right)}, &\text{(4d)}\\
R_{ds} &= \frac{1}{\Re(y_{12}+y_{22})}, &\text{(4e)}\\
C_{ds} &= \frac{\Im(y_{12}+yielded_{22})}{\omega}, &\text{(4f)}\\
g_m &= \left|\frac{(y_{12}-y_{21})(y_{11}+y_{12})}{\Im(y_{11}+y_{12})}\right|, &\text{(4g)}\\
\tau &= \frac{\frac{\pi}{2}-\angle(y_{12}-y_{21})+\angle(y_{11}+y_{12})}{\omega} &\text{(4h)}
\end{aligned}
$$

Using the extrinsic parameters calculated during the previous handin yields the values in Table 1

The calculations were done in ADS and the procedure can be seen in Figure 2.

Eqn Rc=0.35 Eqn k=1.38e-23 Eqn nT=200 <- This is just a guess but the result barely changes

Eqn y1=stoy(S) Eqn q=1.6e-19 Eqn Ig=1e-1

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Eqn y2=y1-{{2i*pi*freq*(Cpg+Cpgd), -2i*pi*Cpgd},{-2i*freq*Cpgd, 2i*pi*freq*(Cpd+Cpgd)}}

Eqn z2=ytoz(y2)

Eqn z3=z2-{{Rg+Rs+2i*pi*freq*(Lg+Ls), Rs+2i*pi*Ls},{Rs+2i*freq*Ls, Rg+Rs+2i*freq*(Lg+Ls)}}

Eqn y3=ztoy(z3)

freq	y3(1,1)	y3(1,2)	y3(2,1)	y3(2,2)
VDS=1.000, VGS=1.000 3.000 GHz	0.001 / -86.574	5.937E-5 / 172.2...	5.071E-4 / 97.750	0.004 / -91.066

Eqn Ld=-2.649267790E-8

Eqn Lg=-2.249832141E-8

Eqn Ls=-1.947627751E-8

Eqn Rd=1.153768700E1

Eqn Rg=-7.619322441E-1

Eqn Rs=9.189406369E0

Eqn Cpd=1.377837503E-12

Eqn Cpg=1.665135520E-12

Eqn Cpgd=1.240228378E-12

Eqn omega=2*pi*freq

Eqn Rgd=-imag(1/y3(1,2))

Eqn Cgd=1/(omega*imag(1/y3(1,2)))

Eqn Ri=real(1/(y3(1,1)+y3(1,2)))

Eqn Cgs=-1/(omega*imag(1/(y3(1,1)+y3(1,2))))

Eqn Rds=1/real(y3(1,2)+y3(2,2))

Eqn Cds=imag(y3(1,2)+y3(2,2))/omega

Eqn gm=abs((y3(1,2)-y3(2,1))*(y3(1,1)+y3(2,2))/imag(y3(1,1)+y3(1,2)))

Eqn tau=(pi/2-phase(y3(1,2)-y3(2,1))*pi/180+phase(y3(1,1)-y3(1,2))*pi/180)/omega

freq	Rgd	Ri	Rds	gm
VDS=1.000 , VGS=1.000 3.000 GHz	2.279 k	5.378	-7.577 k	2.300 m

freq	Cgd	Cgs	Cds	tau
VDS=1.000 , VGS=1.000 3.000 GHz	-23.28 f	-57.26 f	-208.1 f	88.28 p

Figure 2: The cell that was used to produce the results presented in this report.