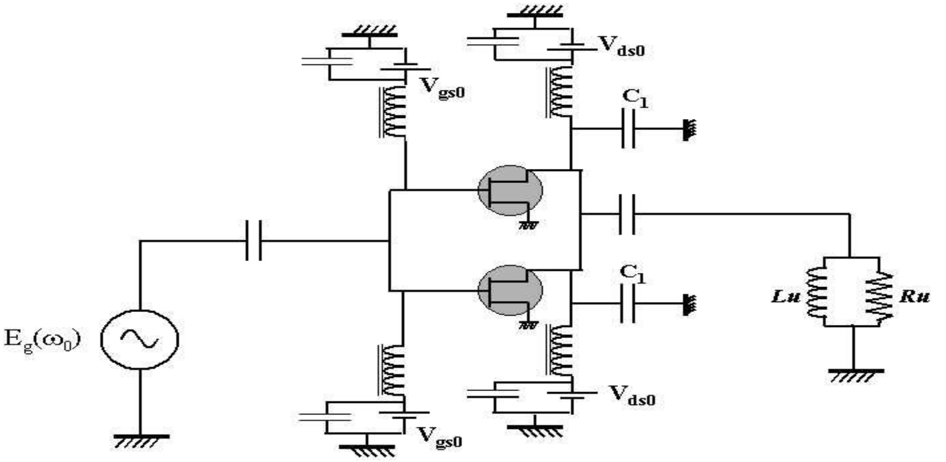
Semester S1 –Basics of active and non linear electronics

RF Power amplifiers (JM Nebus)

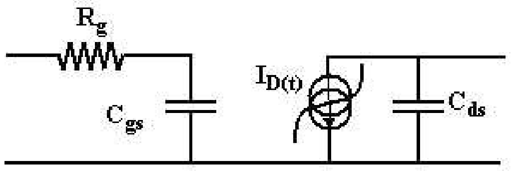
TUTORIAL N° 3

Let us consider the following schematic of an amplifier . The operating frequency is 2 Ghz .



V_{gs0} = -2 V , Vds0 = 10 V , C_1 = 4 pF

The non linear simplified model for each transistor is the following:



Cgs = 1 pF ; Rg = 5 Ω ; Cds = 0.5 pF

$$I_D(t) = f_1(t).f_2(t)$$

$$\text{avec} \quad f_1(t) = I_{dss}\cdot\left(1-\frac{V_{gs}(t)}{Vp}\right)^2$$

$$f_2(t) = (1+K.V_{ds}(t))$$

With I_{dss} = 100 mA Vp = -3V K = 0.05

This model equation corresponds to the saturated region of the transistor

$Vds_{\text{-min}}$= 2V and $Vds_{\text{-max}}$ = 18V and -3V < Vgs < 0V

For Vgs < -3V f_1 (t) = 0 so I_D =0

1) Plot the Id(Vds) characteristic for three values of Vgs (Vgs = 0V , Vgs= -1V , Vgs=-2V)
2) Plot the Id(Vgs) characteristic for three values of Vds (Vds = 2V , Vds= 10V , Vds=18V)
3) Determine the values of the small signal transconductance gm and the output conductance gd of the transistor at the operating bias point (Vgs0=-2V , Vds0= +10V)
4) What is the cutt off frequency of the input (Rg Cgs) circuit of the transistor
5) Now for large signal operation, we want to operate in class B and we want to obtain the maximum output RF power in the load Ru.

For this quadratic Ids / Vgs characteristic, the terms of the Fourier serie of f_1 (t) is given by the following relationships:

$$F_0 = \frac{I_p}{\pi} \frac{\varphi - \frac{3}{4}\sin(2\varphi) + \frac{1}{2}\varphi.\cos(2\varphi)}{(1-\cos(\varphi))^2}$$

$$F_1 = \frac{2I_p}{\pi} \frac{\frac{3}{4}\sin(\varphi) + \frac{1}{12}\sin(3\varphi) - \varphi.\cos(\varphi)}{(1-\cos(\varphi))^2}$$

$$F_2 = \frac{2I_p}{\pi} \frac{\frac{\varphi}{4} - \frac{1}{6}\sin(2\varphi) + \frac{1}{48}\sin(4\varphi)}{(1-\cos(\varphi))^2}$$

Vgs(t)=Vgs0+Vgs1.cos(wt) ; Vds(t)=Vds0-Vds1.cos(wt)

f_1 (t)= F_0+F_1.cos(wt)+ F_2.cos(2wt)+…….

I_D (t)= $I_{D0}+I_{D1}$.cos(wt)+ I_{D2}.cos(2wt)+…….

Determine the values of F0 , F1 , F2 and then the values of I_{D0} and I_{D1}

6) What are the required values for Ru and Lu and what is the corresonding value of the load impedance (Zu= Ru // Lu)

7) What are the values of the ouput power and the DC power of this two cell power amplifier

8) What are the values of the power gain and the power added efficiency