Semester S1 –Basics of active and non linear electronics

RF Power amplifiers (JM Nebus)

TUTORIAL N° 3

I.1.1.1 Operating classes of a Fiel Effet Transistor

Let us consider the schematic of Figure 1. The drain bias voltage V_{DD} is equal to 25V

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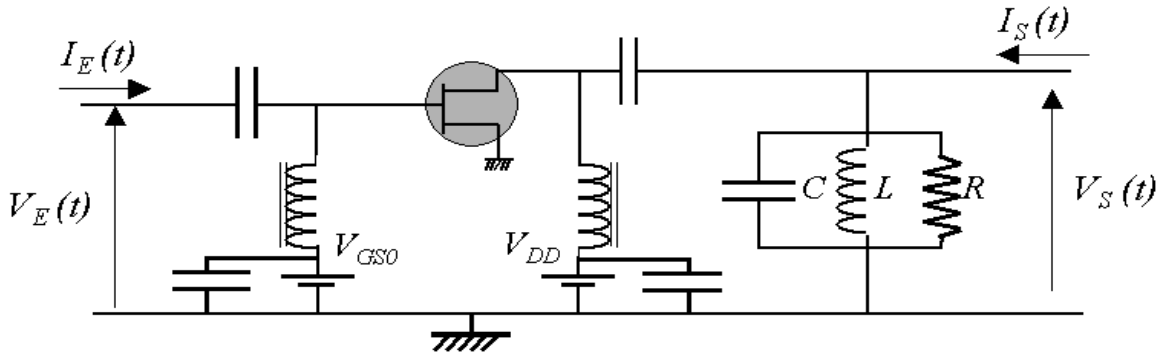

Figure 1

The static I/V characteristics of the transistor are plotted in figure 2 . The pinch off voltage Vp= - 4V and the maximum drain current Idss = 1A .

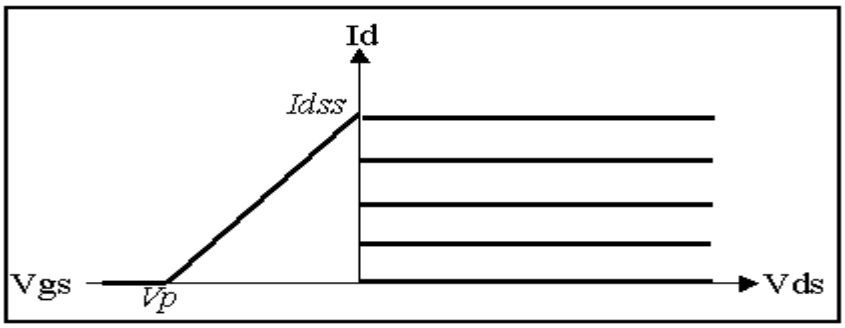

Figure 2

The input gate source voltage Vgs(t) will be set to have a maximum value of 0V at t=0 in order to get the maximum acceptable swing of the gate source voltage and consequently the maximum swing of the output drain current Id(t)

$$Vgs(t) = Vgs_0 + V_E(t) = Vgs_0 + Vgs_1 \cdot \cos(wt)$$
$$Vgs(0) = 0$$

1) We will study three different conditions corresponding to three different operating classes

Case N° 1 Class AB ($\varphi = 120° = 2\pi/3$)

Case N° 2- Class B ($\varphi = 90° = \pi/2$)

Case N° 3 Class C ($\varphi = 60° = \pi/3$)

Answer to the following questions for the three cases :

1) Calculate the value of the corresponding bias voltage Vgs_0 and the magnitude of the RF voltage Vgs_1
2) Plot the time domain waveform of Vgs(t) below figure 2 and Id(t) on the right side of figure 2
3) Calculate the values of the drain current components Id_0 at DC and Id_1 at the fundamental frequency using the following equations

$$Id_0 = \frac{I_p \cdot (\sin(\varphi) - \varphi\cos(\varphi))}{\pi(1-\cos(\varphi))}$$

$$Id_1 = \frac{I_p \cdot (\varphi - \sin(\varphi)\cdot\cos(\varphi))}{\pi(1-\cos(\varphi))}$$

4) We want to have the maximum drain voltage swing in order to have the maximum output RF power. What is the corresponding value of Vds_1

5) What is the value of the load resistance R that is required to get the maximum output RF power .

6) Calculate the values of the RF ouput power Pout, the DC consumption P_{DC} and the drain efficiency $\eta_d = P_{out} / P_{DC}$

7) Plot the load lines on the I/V characteristic graph

8) The fundamental operating frequency is F_0 = 2 Ghz , and the value of the capacitance C of the parallel resonating circuit is 0.5 pF . Calculate the value of the inductance L

9) We consider now that the input resistance and capacitance of the transistor are respectively Rg=5Ω and Cgs= 6 pF .

Calculate the power added efficiency PAE and the power gain