Semester 1

Basics of active and non-linear electronics

RF Power Amplifiers (JM Nebus)

TUTORIAL N°1

– Let us consider the RF modulated signal $x(t) = A \cdot (1 + k \cdot \cos(\Omega t)) \cdot \cos(\omega_0 t)$ which is a voltage across a 50 Ω resistor .

$x(t) = X(t) \cdot \cos(\omega_0 t)$: X(t) is the envelope signal of x(t)

A= 1 V and k is the amplitude modulation index : $0 \le k \le 1$

$\Omega \ll \omega_0$ and $T_{env} = \frac{2\pi}{\Omega} = N \cdot T_c = N \cdot \frac{2\pi}{\omega_0}$, N is an integer of large value

1) Plot the shape of the time domain waveform of x(t) for k= 1 and k= 0.5

2) Plot the spectrum of the signal x(t)

3) Plot the shape of the square of the signal x(t) for k=1

4) Calculate the expression of :

the instantaneous and the average powers of the RF modulated signal x(t)

the instantaneous and the average powers of the signal envelope : X(t)

5) Do the numerical applications for the different powers and the peak to average power ratios (PAPR) for two cases k=1 and k= 0.5

6) We consider a 50 Ω matched power amplifier .

When the amplifier is driven by a pure sine wave $Vin(t) = A \cdot \cos(\omega_0 t)$ it handles a maximum input power of 100 mW (= 20 dBm = -10 dBW) before beginning to reach a non linear regime .

What is the corresponding value of A_max.

7) Now the considered amplifier is driven by the RF modulated signal x(t) with k=1

What is the maximum average power of x(t) acceptable to insure a linear behaviour of the power amplifier .What is the corresponding value of the magnitude A .

8) Let us suppose that the output signal of the amplifier y(t) can be expressed in the following form :

$y(t) = a \cdot x(t) + b \cdot x(t)^2 - c \cdot x(t)^3$ with a , b , c three positive real numbers

Calculate the expression of y(t) and plot the shape of the spectrum of y(t) .

Same question for

$$x(t) = A \cdot \cos(\omega_1 t) + A \cdot \cos(\omega_2 t) = 2A \cdot \cos((\frac{\omega_2 - \omega_1}{2})t) \cdot \cos((\frac{\omega_2 + \omega_1}{2})t) = 2A \cdot \cos(\Omega \cdot t) \cdot \cos(\omega_0 t)$$

9) What is the output signal spectrum shape if a band path filter having its center frequency at F_0 is connected at the output of the power amplifier .

10) For the signal $x(t) = A \cdot \cos(\omega_1 t) + A \cdot \cos(\omega_2 t)$, what is the maximum acceptable value of the average power of each separated tone (at frequency F_1 or F_2) before the amplifier reaches its non linear behaviour