M2 Integration Circuits Systems

EA2 - Année Scolaire 2016-2017(S1)

Exam

Durée 1h30 - Authorized documents and calculator

Exercices

Tous les exercices sont indépendants.

Direction de la Formation Initiale
Département Communications et Électronique
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Exercice 1 - RF Receiver for 3G W-CDMA : Noise Figure requirement

As shown in figure 1, a 3G W-CDMA system which applies frequency division duplex (FDD), employs simultaneous transmission and reception. Thus, a duplex filter is required to provide isolation between the transmitter and the receiver. The performance of this duplex filter has implication for the overall noise figure of the receiver.

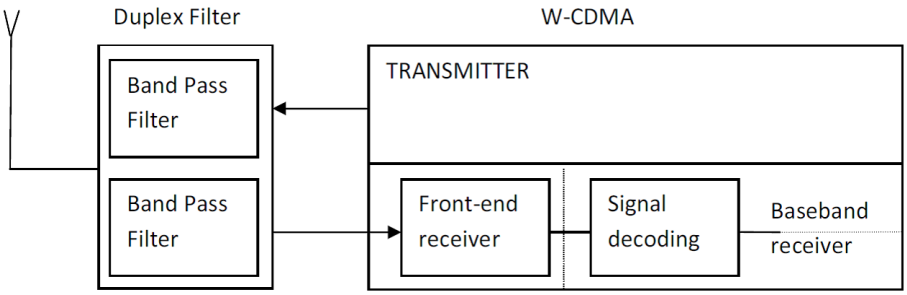

FIGURE 1 – Duplex arrangement of a mobile receiver unit for 3G W-CDMA.

The W-CDMA system characteristics for the receiver are the following :
- Downlink frequency band (Rx) : 2110 to 2170 MHz
- Nominal channel spacing : 5 MHz
- Channel bandwidth : 3,84 MHz equal to Chip rate : 3,84 Mbps Receiver test scenario applying FDD :
- User bit rate : 12.2 kbps
- BER $< 10^{-3}$ which corresponds to (Eb/N0)min =(SNRmin) after decoding = 7 dB

The noise figure (NF) of the receiver is calculated from the standard's reference sensitivity test. The desired channel power is PS = -117 dBm. The noise at the antenna is only thermal noise ($k = 1.38.10^{-23}$ J/K, T=290K). The performance of the duplex filter results in a 4 dB loss in the receive path.

Question 1.1 Calculate the actual SNR at the receiver input. An indication : the power spectral density (PSD) of the thermal noise at the antenna is -174 dBm/Hz at room temperature.

Question 1.2 Assuming a uniform power for the useful signal inside the channel bandwidth, calculate the signal power spectral density (PSD) at the receiver input.

In the baseband receiver, there is a dispreading process (signal decoding) which concentrates the original signal energy spread overall the channel bandwidth into bandwidth that corresponds to the user bit rate but it does not modify the noise spectral power density (noise is not concentrated in a smaller bandwidth).

Question 1.3 Calculate the PSD of the useful signal after dispreading. (Assume that the receiver gain is 1 (0 dB) for this calculation).

Question 1.4 Calculate the resulting improvement in SNR due to signal decoding or dispreading Gp.

Question 1.5 Calculate the maximal allowable NF of the front-end receiver

Exercice 2 - Frequency Synthesis

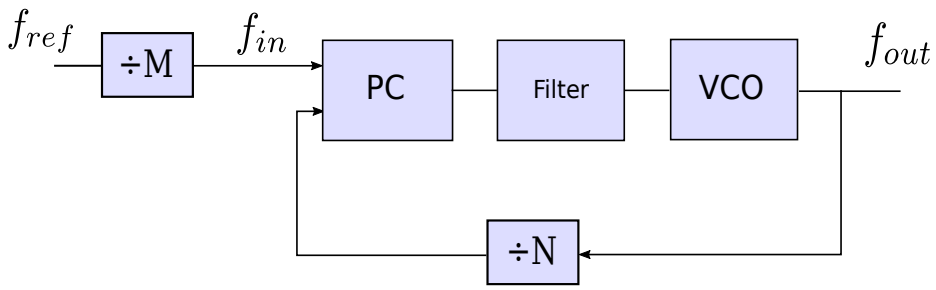

FIGURE 2 – Phase Locked Loop (PLL)

A phase locked loop is used for the local oscillator of a Bluetooth receiver (figure 2) with an integer frequency divider N in the feedback loop and an integer divider M on the reference frequency f_{ref}. The frequency conversion is direct (FI = 0) and the central frequencies of the 79 channels of the system are generated by the PLL :

$$f_k = (2402 + k)\ MHz, \qquad k = 0, ..., 78$$

The reference frequency is obtained from a quartz oscillator with $f_{ref} = 10\ MHz$.

Question 2.1 Determine the value of the division factor M. Deduce the value of the division factor N in function of the channel k.

Question 2.2 What is the impact of the division factor N on the phase noise L_r of the quartz reference source in the PLL bandwidth ?

Exercice 3 - Transmitter and Receiver Switch

This switch consists of AsGa MESFET transistors with grid length of 0.8 μm. At the frequency of 1.9 GHz, the isolations are 29-35dB and the insertion losses are 0.9-1.5 dB.

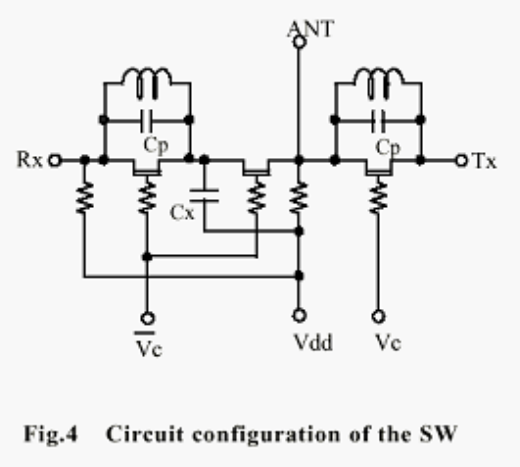

Fig.4 Circuit configuration of the SW

Question 3.1 Explain the operation of this duplexer.

Question 3.2 What is its function in an RF transmitter and receiver ?

Question 3.3 Why use AsGa ?

Question 3.4 Why use the L, Cp elements ?

Question 3.5 In your opinion,what is the size (grid development) of the MesFet ?

Question 3.6 Why do we get different values of isolation and losses ?