International Journal of Engineering Inventions
e-ISSN: 2278-7461, **p**-ISBN: 2319-6491
Volume 2, Issue 4 (February 2013) PP: 10-18

Ofdm Detection on Umts Utra-Fdd up-Link and Implementation of the Modulator/ Demodulator by Ifft/ Fft Algorithms

Ngom Agnès[1], Ouya Samuel[2], Farssi Sidi Mohamed[3], Ouess Mohamed El – Amine[4], Ndiaye Abdourahmane[5]
[1, 2,4,5]Laboratoire d'Informatique, Réseau et Télécommunication (LIRT), Dakar Cheikh Anta DIOP University, SENEGAL
[3] Laboratoire d'Imagerie Médicale et BioInformatique (LIMBI), Dakar Cheikh Anta DIOP University, SENEGAL

Abstract:- In [1], we had applied OFDM modulation on UMTS UTRA-FDD up-link for multiplexing the physical data channels of a same mobile. We had given the expression of the OFDM signal emitted by a mobile having to send simultaneously K data symbols by channel for a total of N channels. In this paper, because the OFDM symbols was formed by chip time in [1], we process then the demodulation by chip time of the OFDM signal in [1] after its crossing of a perfect (without noise) frequency selective mobile radio channel. For that purpose, we give at first in the second section: the received OFDM signal expression, the integral expression to be calculated to demodulate the sent information about an any channel q, and the operation to do for obtaining the useful information about this channel q knowing its frequency response. It is however necessary to note that the OFDM modulation principle adopted in [1] and the OFDM demodulation principle adopted in this paper at the second section, leads to conceive a system with N individual modulators and N individual demodulators. Afterward, with the aim of proposing for the UMTS UTRA-FDD up-link a less complex OFDM modulation/OFDM demodulation system, we have in this paper at the third section, implemented the OFDM modulator and demodulator with the IFFT and FFT algorithms. Finally we simulated the received OFDM signals for the OFDM symbols specified in the fourth section and the received symbols on every channel after sampling of the two first received OFDM signals corresponding to the two first emitted OFDM symbols.

Key Words:- FFT, IFFT, OFDM, UMTS, UTRA-FDD

I. INTRODUCTION

In this paper, we make demodulation by chip time of the OFDM signal formed in [1] for multiplexing the data channels of a same mobile on the UMTS UTRA-FDD up-link. For that purpose, we call back in the first section the characteristics of the mobile radio channel in which the OFDM signal has to propagate. In the second section, we present the OFDM demodulation in the case where the propagation takes place in a noiselessly channel selective in frequency. It is in the third section that we implement the OFDM demodulator/OFDM modulator for the UMTS UTRA-FDD up-link with the FFT/IFFT algorithms; to decrease the complexity of an OFDM modulation/OFDM demodulation system which would impose the conception of N individual modulators and N individual demodulators. In the fourth section, we present simulations of the received OFDM signals from the first chip time to the eighth chip time and corresponding to the OFDM symbols that we had simulated in [1]. Also in this last section, we have simulated at precise moments of the first chip time and the second chip time, the symbols received on each of the four considered data channels.

II. THE MOBILE RADIO CHANNEL

The mobile radio channel is defined, on the one hand, by all the emitting and receiving organs, and on the other hand, by the space of propagation (called propagation channel) separating these two organs. In this space, the radio signal propagates by undergoing several electromagnetic phenomena due to the obstacles such as diffusion, diffraction, reflection, and refraction. So, the emitted signal reaches the receiver by following several paths with different delay times so that the received signal is the sum of the overlaid signals from these various paths. We say that the propagation channel is a multi-paths channel or a dispersive in time channel because at a given moment, every signal of a path is characterized by its amplitude, its phase and its delay time. This temporal characteristic of the channel leads fading in the frequency domain and the channel is considered as selective in frequency.

It is necessary to note that the radio signal undergoes alterations linked not only to its interactions with the propagation channel obstacles but also to the variability of the channel which can be temporal or spatial. The temporal variability is due to the propagation channel objects movements and the spatial variability is due to the transmitter and or/receiver movements. The consequence of this variability is a variation of the frequency of the received signal called DOPPLER shift with regard to that of the emitted signal. In the case of the temporal variability, we are in the presence of a local variation of the channel: the transmitter and the receiver being fixed, alone the paths of the emitted signal which are going to meet the objects in movement will be affected by a DOPPLER shift. In the case of the spatial variability, we are in the presence of a global variation of the channel: the propagation channel is different for every movement of the transmitter and or/receiver and all the paths of the emitted signal are affected by a DOPPLER shift.

Let us suppose that it is the receiver which is in movement. If α is the angle between the direction of the received signal and that of the movement, then the DOPPLER shift is given by the relation:

$\frac{v}{c} f_0 \cos(\alpha)$ **[2]** (1)

where v is the speed of the receiver, c the speed of the light, and f_0 the frequency of the emitted signal. In this paper, we consider a propagation channel without DOPPLER effects: thus the transmitter and the receiver are fixed and there is no movement of the objects of the channel. This type of channel, only characterized by the multi-paths phenomena, is said selective in frequency and the received signal r(t) is related to the emitted signal s(t) by the relationship:

$r(t) = h(t) * s(t)$ (2)

$h(t) = \sum_{k=1}^{N_t} a_k e^{j\theta_k} \delta(t - \tau_k)$ **[2]** (3)

is the impulse response of the channel and $N_t, a_k, \theta_k, \tau_k$ are respectively the number of paths followed by the signal s(t), the amplitude, the phase, the delay time of the kth path. The corresponding transfer function is given by:

$H(f) = \sum_{k=1}^{N_t} a_k e^{j\theta_k} e^{-j2\pi f \tau_k}$ **[2].** (4)

III. OFDM DETECTION ON UMTS UTRA-FDD UP-LINK IN THE CASE OF A PERFECT FREQUENCY SELECTIVITY CHANNEL

II.1) OFDM signal transmission

In this paper, we choose to work with a frequency selective channel which does not introduce noise and DOPPLER shift. The frequency selectivity of the channel is determined by the different path delays of the signals. Let us consider an emitted impulse of duration T_s corresponding to a symbol; the received impulse is the sum of all the impulses arriving with different delay times. The emitted impulse undergoes then a temporal spreading Δ_τ. This spreading can generate interference between symbols and cause errors during the demodulation. But we can neglect the interference between symbols if the following condition is satisfied:

$\Delta_\tau \ll T_s$ **[2].** (5)

To fight against interference between symbols, sophisticated methods are used as equalizers, spreading spectrum and OFDM modulation. OFDM allows to make transmissions for broadbands, to fight against the frequency selectivity of the channel and thus finally to facilitate the symbols demodulation. That's why we have chosen it and applied it on the UMTS UTRA-FDD up-link.

In **[1]**, we had seen that the OFDM signal emitted on the UMTS UTRA-FDD up-link by a mobile having to send simultaneously K data symbols by channel for a total of N different channels was written:

$S_{ofdm}(t) = \sum_{m=0}^{K-1} \sum_{i=0}^{p-1} \sum_{n=0}^{L-1} \sum_{r=0}^{N-1} s_{r,in}^{m} \ e^{-j2\pi f_r (mT_s + (il+n)T_c)} e^{j2\pi f_r t}$ (6)

P represents the number of bits contained in a symbol

L represents the length of the spreading code used for coding the bits

$S_{r,in}^{m}$ is the elementary information sent on the channel r at the moment t-mTs-(iL+n)T_c

$S_{r,in}^{m} \in \{-1, 1\}$ **[1]**

f_r is the carrier frequency used on the channel r

T_s is the symbol time

T_c is the chip time.

Let us pose:

$\theta_{r,in}^{m} = 2\pi f_r (mT_s + (iL + n)T_c)$ (7)

and

$C_{r,in}^{m} = S_{r,in}^{m} e^{-j\theta_{r,in}^{m}}$. (8)

So the OFDM signal sent at the nth chip time of the ith bits of the mth symbols is written:

$S_{ofdm}(t - mT_s - (iL + n)T_c) = \sum_{r=0}^{N-1} C_{r,in}^{m} \ e^{j2\pi f_r t}$. (9)

By noting:

$S_{ofdm,in}^{m}(t) = S_{ofdm}(t - mT_s - (iL + n)T_c)$ (10)

then the equation (9) becomes:
$S_{ofdm,in}^{m}(t) = \sum_{r=0}^{N-1} C_{r,in}^{m}\, e^{j2\pi f_r t}$. (11)
As the demodulation will be done by chip time T_c (the OFDM symbols in **[1]** was formed by chip time), we determine the OFDM signal received by chip time which is $R_{ofdm}(t - mT_s - (iL+n)T_c)$.
But we know that if at a given moment t, the emitted signal is S(t), then after having cross over a channel which impulse response is h(t), the received signal R(t) will be written:
R(t)= S(t)*h(t) . (12)
Let us pose:
$h_{in}^{m}(t) = h(t - mT_s - (iL+n)T_c)$ (13)
the channel impulse response at the nth chip time of the ith bits of the mth symbols and
$R_{ofdm,in}^{m}(t) = R_{ofdm}(t - mT_s - (iL+n)T_c)$. (14)
Thus by analogy with equation (12) we have:
$R_{ofdm,in}^{m}(t) = S_{ofdm,in}^{m}(t) * h_{in}^{m}(t)$ (15)
$R_{ofdm,in}^{m}(t) = \int_{(m-1)T_c}^{mT_c} h_{in}^{m}(\tau).\, S_{ofdm,in}^{m}(t-\tau)d\tau$. (16)
By replacing $S_{ofdm,in}^{m}(t-\tau)$ with its expression we obtain:
$R_{ofdm,in}^{m}(t) = \int_{(m-1)T_c}^{mT_c} h_{in}^{m}(\tau).\,(\sum_{r=0}^{N-1} C_{r,in}^{m} e^{j2\pi f_r(t-\tau)})d\tau$ (17)
$R_{ofdm,in}^{m}(t) = \sum_{r=0}^{N-1}[\int_{(m-1)T_c}^{mT_c} h_{in}^{m}(\tau).\, c_{r,in}^{m} e^{j2\pi f_r(t-\tau)}d\tau]$ (18)
$R_{ofdm,in}^{m}(t) = \sum_{r=0}^{N-1}[C_{r,in}^{m} e^{j2\pi f_r t}.\int_{(m-1)T_c}^{mT_c} h_{in}^{m}(\tau)e^{-j2\pi f_r \tau}d\tau]$. (19)
If we note the Fourier transform by TF, we see that:
$\int_{(m-1)T_c}^{mT_c} h_{in}^{m}(\tau)e^{-j2\pi f_r\tau}d\tau = TF[h_{in}^{m}(\tau)] = H_{in}^{m}(f_r) = H_{in}^{m}(r)$ (20)
because in **[1],**
$f_r = f_c + \frac{r}{T_c}$. (21)
Finally,
$R_{ofdm,in}^{m}(t) = \sum_{r=0}^{N-1} C_{r,in}^{m}.\, e^{j2\pi f_r t}.\, H_{in}^{m}(r)$. (22)
$H_{in}^{m}(r)$ is the frequency response of the channel r at the moment t-mT_s-(iL+n)T_c. It is considered constant in the OFDM symbol duration T_c.

II.2) OFDM demodulation: detection of the sent symbols

By analogy with the OFDM symbols demodulation principle in [3], [4], and [5] then the symbol sent on the carrier q is obtained by calculating the integral:
$Y_{q,in}^{m} = \frac{1}{T_c}\int_{(m-1)T_c}^{mT_c} R_{ofdm,in}^{m}(t).\, e^{-j2\pi f_q(t-mT_S-(iL+n)T_c)}dt$ (23)
$Y_{q,in}^{m} = \frac{1}{T_c}\int_{(m-1)T_c}^{mT_c}[\sum_{r=0}^{N-1} C_{r,in}^{m}.\, e^{j2\pi f_r t}.\, H_{in}^{m}(r)].\, e^{-j2\pi f_q(t-mT_S-(iL+n)T_c)}dt$ (24)
$Y_{q,in}^{m} = \frac{1}{T_c}\int_{(m-1)T_c}^{mT_c}[\sum_{r=0}^{N-1} C_{r,in}^{m}.\, H_{in}^{m}(r).\, e^{j2\pi f_r t}].\, e^{-j2\pi f_q(t-mT_S-(iL+n)T_c)}dt$. (25)
$Y_{q,in}^{m} = \frac{1}{T_c}\int_{(m-1)T_c}^{mT_c}[\sum_{r=0}^{N-1} S_{r,in}^{m}.\, e^{-j2\pi f_r(mT_S+(iL+n)T_c)}.\, H_{in}^{m}(r).\, e^{j2\pi f_r t}].\, e^{-j2\pi f_q(t-mT_S-(iL+n)T_c)}dt$ (26)
$Y_{q,in}^{m} = \frac{1}{T_c}\int_{(m-1)T_c}^{mT_c}\{\sum_{r=0}^{N-1}[S_{r,in}^{m}.\, H_{in}^{m}(r).\, e^{j2\pi f_r t}.\, e^{-j2\pi f_q t}.\, e^{-j2\pi f_r(mT_S+(iL+n)T_c)}.\, e^{j2\pi f_q(mT_S+(iL+n)T_c)}]\}dt$. (27)
Knowing that:
$f_r = f_c + \frac{r}{T_c}$ and $f_q = f_c + \frac{q}{T_c}$ (28)
then equation (27) becomes:
$Y_{q,in}^{m} = \frac{1}{T_c}\int_{(m-1)T_c}^{mT_c}\{\sum_{r=0}^{N-1}[S_{r,in}^{m}.\, H_{in}^{m}(r).\, e^{j2\pi(r-q)\frac{t}{T_c}}.\, e^{-j2\pi(mT_S+(iL+n)T_c)(\frac{r-q}{T_c})}]\}dt$ (29)
$Y_{q,in}^{m} = \frac{1}{T_c}\{\sum_{r=0}^{N-1}\{\int_{(m-1)T_c}^{mT_c}[S_{r,in}^{m}.\, H_{in}^{m}(r).\, e^{-j2\pi(mT_S+(iL+n)T_c)\left(\frac{r-q}{T_c}\right)}.\, e^{j2\pi(r-q)\frac{t}{T_c}}]dt\}\}$ (30)
$Y_{q,in}^{m} = \frac{1}{T_c}\{\sum_{r=0}^{N-1}[S_{r,in}^{m}.\, H_{in}^{m}(r).\, e^{-j2\pi(mT_S+(iL+n)T_c)(\frac{r-q}{T_c})}.\int_{(m-1)T_c}^{mT_c} e^{j2\pi(r-q)\frac{t}{T_c}}.\, dt\ ]\}$. (31)
But:
$\int_{(m-1)T_c}^{mT_c} e^{j2\pi(r-q)\frac{t}{T_c}}.\, dt = \begin{cases} \mathrm{T_c\ si\ r = q} \\ \mathrm{0\ si\ r \neq q} \end{cases}$ (32)
Finally
$Y_{q,in}^{m} = S_{q,in}^{m}.\, H_{in}^{m}(q)$. (33)
Thus
$S_{q,in}^{m} = \frac{Y_{q,in}^{m}}{H_{q,in}^{m}}$. (34)

Here, we see that to find at reception the symbol emitted on the channel q at the nth chip time of the ith bits of the mth symbols, it is simply enough to divide $Y_{q,in}^{m}$ by the corresponding channel frequency response. Fig.1 shows the modulator/demodulator system with N individual modulators/demodulators.

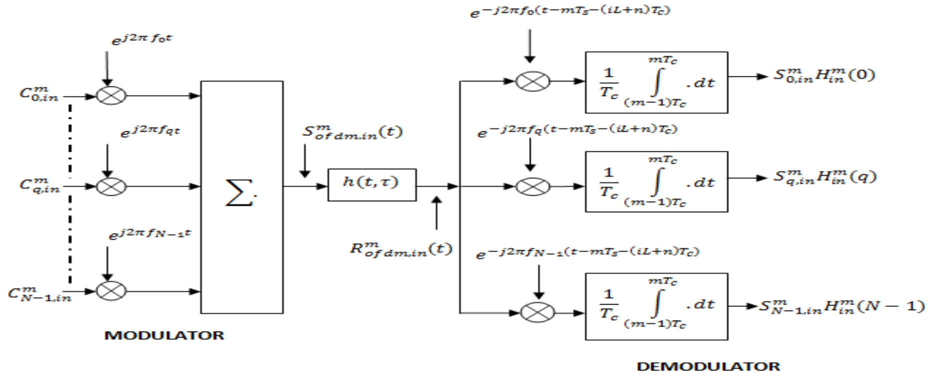

Fig.1 : MODULATOR/DEMODULATOR SYSTEM ON UMTS UTRA-FDD UP-LINK WITH N INDIVIDUAL MODULATORS/DEMODULATORS

IV. IMPLEMENTATION OF OFDM DEMODULATOR/OFDM MODULATOR ON UMTS UTRA-FDD UP-LINK BY THE FFT/IFFT ALGORITHMS

III.1) THE OFDM demodulator

According to **[1]**, the signal $S_{ofdm\,,in}^{m}(t)$ occupies the bandwidth [f_c ,f_c+B] with :

$B = N.\frac{1}{T_c}$. (35)

Also $R_{ofdm\,,in}^{m}(t)$ occupies the bandwidth [f_c , f_c+B].

We want to demodulate the signal $R_{ofdm\,,in}^{m}(t)$. For that purpose, we have first to transpose it into bandbase signal by making a translation of $f_c + \frac{B}{2}$ and after to discretize it. The received bandbase OFDM signal spectrum will occupy the bandwidth $\left[\frac{-B}{2}, \frac{B}{2}\right]$ and the maximal frequency will be:

$f_{max} = \frac{B}{2} = \frac{N}{2T_c}$. (36)

To discretize the received bandbase OFDM signal, we have to find a sampling frequency f_e which performs the SHANNON theorem. According to SHANNON, the sampling frequency f_e have to satisfy the condition:

$f_e \geq 2f_{max} = B = \frac{N}{T_c}$. (37)

Then we choose as sampling frequency

$f_e = \frac{N}{T_c}$. (38)

Thus the sampling period is:

$t_e = \frac{T_c}{N}$. (39)

Then we are going to sample the received baseband OFDM signal at the moments:

$t_{n'} = n' t_e = n'\frac{T_c}{N}$ (40)

n’ is an integer.

The received OFDM signal after the frequency transposition of $f_c + \frac{B}{2} = f_c + \frac{N}{2T_c}$ is written:

$$X_{in}^{m}(t) = R_{ofdm\,,in}^{m}(t).\, e^{-j2\pi\left(f_c+\frac{N}{2T_c}\right)(t-mT_s-(iL+n)T_c)} \quad (41)$$

$$X_{in}^{m}(t) = \left[\sum_{r=0}^{N-1} C_{r,in}^{m}.\, e^{j2\pi f_r t}.\, H_{in}^{m}(r)\right].\, e^{-j2\pi\left(f_c+\frac{N}{2T_c}\right)(t-mT_s-(iL+n)T_c)} \quad (42)$$

$$X_{in}^{m}(t) = \sum_{r=0}^{N-1}\left[C_{r,in}^{m}.\, H_{in}^{m}(r).\, e^{j2\pi\left(f_c+\frac{N}{2T_c}\right)(mT_s+(iL+n)T_c)}.\, e^{j2\pi f_r t}.\, e^{-j2\pi\left(f_c+\frac{N}{2T_c}\right)t}\right] \quad (43)$$

$$X_{in}^{m}(t) = \sum_{r=0}^{N-1}\left[C_{r,in}^{m}.\, H_{in}^{m}(r).\, e^{j2\pi\left(f_c+\frac{N}{2T_c}\right)(mT_s+(iL+n)T_c)}.\, e^{j2\pi\left(f_c+\frac{r}{T_c}\right)t}.\, e^{-j2\pi\left(f_c+\frac{N}{2T_c}\right)t}\right] \quad (44)$$

$$X_{in}^{m}(t) = \sum_{r=0}^{N-1}\left[C_{r,in}^{m}.\, H_{in}^{m}(r).\, e^{j2\pi\left(f_c+\frac{N}{2T_c}\right)(mT_s+(iL+n)T_c)}.\, e^{j2\pi\left(\frac{2r-N}{2T_c}\right)t}\right] . \quad (45)$$

By sampling it at the moments $t_{n'}$ we have:

$$X_{in}^{m}(t_{n'}) = X_{in}^{m}(n'\frac{T_c}{N}) \quad (46)$$

$$X_{in}^{m}(t_{n'}) = \sum_{r=0}^{N-1}\left[C_{r,in}^{m}.\, H_{in}^{m}(r).\, e^{j2\pi\left(f_c+\frac{N}{2T_c}\right)(mT_s+(iL+n)T_c)}.\, e^{j2\pi\left(\frac{2r-N}{2T_c}\right).n'\frac{T_c}{N}}\right] \quad (47)$$

$$X_{in}^{m}(t_{n'}) = \sum_{r=0}^{N-1}[C_{r,in}^{m} \,.\, H_{in}^{m}(r).\, e^{j2\pi\left(f_c+\frac{N}{2T_c}\right)(mT_s+(iL+n)T_c)} .\, e^{j\frac{2\pi n'r}{N}} .\, e^{-jn'\pi}] \qquad (48)$$

$$X_{in}^{m}(t_{n'}) = \sum_{r=0}^{N-1}[(-1)^{n'} .\, C_{r,in}^{m} \,.\, H_{in}^{m}(r).\, e^{j2\pi\left(f_c+\frac{N}{2T_c}\right)(mT_s+(iL+n)T_c)} .\, e^{j\frac{2\pi n'r}{N}}]. \qquad (49)$$

By replacing $C_{r,in}^{m}$ with its expression in the equation (8) we obtain:

$$X_{in}^{m}(t_{n'}) = \sum_{r=0}^{N-1}[(-1)^{n'} .\, S_{r,in}^{m}\, e^{-j\theta_{r,in}^{m}} .\, H_{in}^{m}(r).\, e^{j2\pi\left(f_c+\frac{N}{2T_c}\right)(mT_s+(iL+n)T_c)} .\, e^{j\frac{2\pi n'r}{N}}] \qquad (50)$$

By replacing $\theta_{r,in}^{m}$ with its expression in the equation (7) we have:

$$X_{in}^{m}(t_{n'}) = \sum_{r=0}^{N-1}[(-1)^{n'} .\, S_{r,in}^{m}\, e^{-j2\pi f_r(mT_s+(iL+n)T_c)} .\, H_{in}^{m}(r).\, e^{j2\pi\left(f_c+\frac{N}{2T_c}\right)(mT_s+(iL+n)T_c)} .\, e^{j\frac{2\pi n'r}{N}}] \qquad (51)$$

$$X_{in}^{m}(t_{n'}) = \sum_{r=0}^{N-1}[(-1)^{n'} .\, S_{r,in}^{m} .\, H_{in}^{m}(r).\, e^{-j2\pi\left(f_c+\frac{r}{T_c}\right)(mT_s+(iL+n)T_c)} .\, e^{j2\pi\left(f_c+\frac{N}{2T_c}\right)(mT_s+(iL+n)T_c)} .\, e^{j\frac{2\pi n'r}{N}}] \qquad (52)$$

$$X_{in}^{m}(t_{n'}) = \sum_{r=0}^{N-1}[(-1)^{n'} .\, S_{r,in}^{m} .\, H_{in}^{m}(r).\, e^{-j2\pi\left(\frac{r}{T_c}\right)(mT_s+(iL+n)T_c)} .\, e^{j2\pi\left(\frac{N}{2T_c}\right)(mT_s+(iL+n)T_c)} .\, e^{j\frac{2\pi n'r}{N}}] \qquad (53)$$

$$X_{in}^{m}(t_{n'}) = \sum_{r=0}^{N-1}[(-1)^{n'} .\, S_{r,in}^{m} .\, H_{in}^{m}(r).\, e^{-j2\pi\left(\frac{2r-N}{2T_c}\right)(mT_s+(iL+n)T_c)} .\, e^{j\frac{2\pi n'r}{N}}] \qquad (54)$$

$$X_{in}^{m}(t_{n'}) = \sum_{r=0}^{N-1}[(-1)^{n'} .\, S_{r,in}^{m} .\, H_{in}^{m}(r).\, e^{-j\pi\left(\frac{2r-N}{T_c}\right)(mT_s+(iL+n)T_c)} .\, e^{j\frac{2\pi n'r}{N}}] . \qquad (55)$$

Let us pose:

$$B_{r,in}^{m} = S_{r,in}^{m} .\, H_{in}^{m}(r).\, e^{-j\pi\left(\frac{2r-N}{T_c}\right)(mT_s+(iL+n)T_c)} \qquad (56)$$

$B_{r,in}^{m}$ is a complex number, and for a given chip time where m, i, n, N, T_c, T_s are known, it depends only on the frequency variable r.

Then,

$$X_{in}^{m}(t_{n'}) = \sum_{r=0}^{N-1}(-1)^{n'} .\, B_{r,in}^{m} .\, e^{j\frac{2\pi n'r}{N}} . \qquad (57)$$

The equation (57) can be written again:

$$X_{in}^{m}(n') = \sum_{r=0}^{N-1}(-1)^{n'} .\, B_{r,in}^{m} .\, e^{j\frac{2\pi n'r}{N}} . \qquad (58)$$

The discreet form of the received bandbase OFDM signal is finally:

$$X_{in}^{m}(n') = (-1)^{n'} .\, [\sum_{r=0}^{N-1} B_{r,in}^{m} .\, e^{j\frac{2\pi n'r}{N}}] . \qquad (59)$$

We specify that **n'** is a temporal variable and **r** a frequency variable.

Let us pose:

$$Z_{in}^{m}(n') = \frac{X_{in}^{m}(n')}{(-1)^{n'}} . \qquad (60)$$

Then:

$$Z_{in}^{m}(n') = \sum_{r=0}^{N-1} B_{r,in}^{m} .\, e^{j\frac{2\pi n'r}{N}} . \qquad (61)$$

We see that:

$$Z_{in}^{m}(n') = IFFT[B_{r,in}^{m}] . \qquad (62)$$

Thus

$$B_{r,in}^{m} = FFT(Z_{in}^{m}(n')) . \qquad (63)$$

The principle scheme of the demodulator by chip time is then:

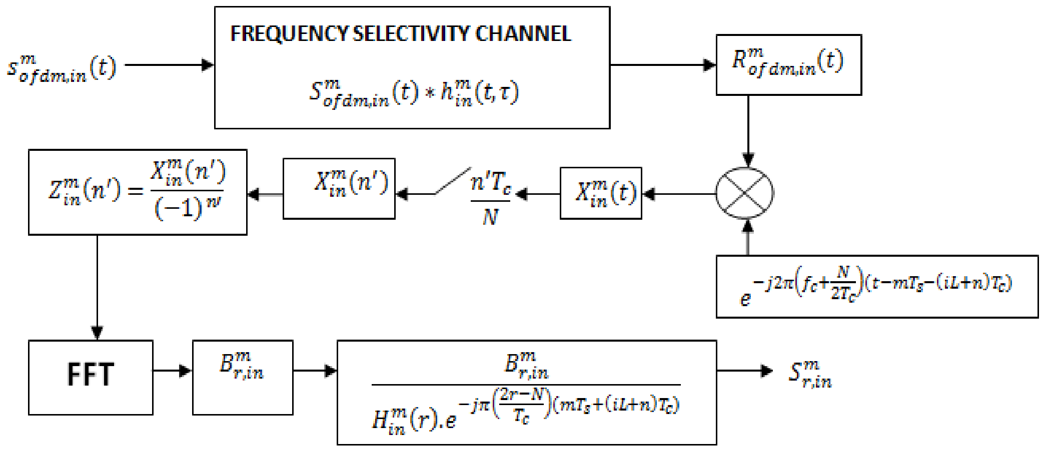

Fig.2: OFDM DEMODULATOR ON UMTS UTRA-FDD UP-LINK

III.2) THE OFDM modulator

The discretization of the signal $S^m_{ofdm,in}(t)$ gives:

$S^m_{ofdm,in}(t_{n'}) = \sum_{r=0}^{N-1} C^m_{r,in} . e^{j2\pi f_r t_{n'}}$. (64)

Then by replacing f_r and $t_{n'}$ with their expressions we have:

$S^m_{ofdn,in}(t_{n'}) = \sum_{r=0}^{N-1} C^m_{r,in} . e^{j2\pi(f_c+\frac{r}{T_c})\frac{nT_c}{N}}$ (65)

$S^m_{ofdn,in}(t_{n'}) = \sum_{r=0}^{N-1} C^m_{r,in} . e^{j2\pi(f_c\frac{nT_c}{N}+\frac{rnT_c}{T_cN})}$ (66)

$S^m_{ofdn,in}(t_{n'}) = \sum_{r=0}^{N-1} C^m_{r,in} . e^{j2\pi\left(\frac{n'+rn'}{N}\right)} = \sum_{r=0}^{N-1} C^m_{r,in} . e^{\frac{j2\pi rn'}{N}} . e^{\frac{j2\pi n'}{N}}$. (67)

Thus:

$S^m_{ofdm,in}(n') = e^{\frac{j2\pi n'}{N}} . [\sum_{r=0}^{N-1} C^m_{r,in} . e^{\frac{j2\pi r n'}{N}}]$. (68)

Finally

$S^m_{ofdm,in}(n') = e^{\frac{j2\pi n'}{N}} . IFFT(c^m_{r,in})$ (69)

The principle scheme of the modulator by chip time is:

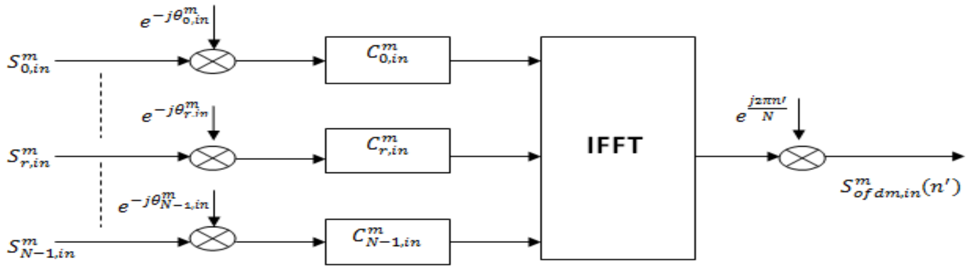

Fig.3: OFDM MODULATOR ON UMTS UTRA-FDD UP-LINK

V. SIMULATIONS

We limited ourselves to the sending of one data symbol by channel: A0=00 for the channel r=0, A1=01 for the channel r=1, A2=10 for the channel r=2 and A3=11 for the channel r=3. The used OVSF codes are respectively: C0=[1 1 1 1] for the channel r=0, C1=[1 1 -1 -1] for the channel r=1, C2=[1 -1 1 -1] for the channel r=2 and finally C3=[1 -1 -1 1] for the channel r=3. The corresponding OFDM symbols sent from the first chip time to the eighth chip time are respectively:

S_1=[1, 1, -1, -1], S_2=[1, 1, 1, 1], S_3=[1, -1, -1, 1], S_4=[1, -1, 1, -1], S_5=[1, -1, 1, -1], S_6=[1, -1, -1, 1], S_7=[1, 1, 1, 1], S_8=[1, 1, -1, -1] (see **[1]**).

In a first time, we have simulated the OFDM signal received at each chip time which is $R^m_{ofdm,in}(t)$.

At the moment $t - mT_s - (iL+n)T_c$ and by analogy with equation (3), the impulse response of each channel **r** is written:

$h^m_{in}(t) = \sum_{k=1}^{N_t} a^m_{k,in} . e^{j\theta^m_{k,in}} . \delta(t - mT_s - (iL+n)T_c - \tau^m_{k,in})$ (70)

where N_t, $a^m_{k,in}$, $\theta^m_{k,in}$, and $\tau^m_{k,in}$ are respectively the number of paths followed by a signal emitted on the channel r, the amplitude, the phase and the delay path of the signal having followed the path k. We have chosen $N_t = 10$ for the simulations and $a^m_{k,in}, \theta^m_{k,in}, \tau^m_{k,in}$ are random variables.

The transfer function corresponding to (70) is:

$H^m_{in}(f_r) = \sum_{k=1}^{N_t} a^m_{k,in} . e^{j\theta^m_{k,in}} . e^{-j2\pi f_r(mT_s+(il+n)T_c+\tau^m_{k,in})}$. (71)

It is constant in the duration of an OFDM symbol and because $f_r = f_c + \frac{r}{T_c}$, then we can also write it:

$H^m_{in}(r) = \sum_{k=1}^{N_t} a^m_{k,in} . e^{j\theta^m_{k,in}} . e^{-j2\pi\left(f_c+\frac{r}{T_c}\right)(mT_s+(il+n)T_c+\tau^m_{k,in})}$. (72)

For each chip time (fig.4 to fig.11), we represented the real part and the imaginary part of the received OFDM signal. We don't observe the same curves for the same sent OFDM symbols; and this is due to the fact that the signal received on a channel r is written according to the equations (22), (8) and (7):

$R^m_{ofdm,in}(t,r) = C^m_{r,in} . e^{j2\pi f_r t} . H^m_{in}(r) = S^m_{r,in} . e^{-j2\pi f_r(mT_s+(iL+n)T_c)} . e^{j2\pi f_r t} . H^m_{in}(r)$. (73)

From the equation (73), we see that each elementary information $S^m_{r,in}$ of an OFDM symbol (see **[1]**) sent on the channel r, is received on this channel multiplied by a term $\boldsymbol{e^{-j2\pi f_r(mT_s+(iL+n)T_c)} . e^{j2\pi f_r t} . H^m_{in}(r)}$ which varies according to the indices r, m, i, and n. The indices r, m, i, and n represent respectively the considered channel, the mth data symbol A^m_r **[1],** the ith bit $A^m_r(i)$ **[1],** and the nth chip. It is also necessary to note that the same

OFDM symbols don't correspond to the same values of channel parameters ($a^m_{k,in}, \theta^m_{k,in}$ and $\tau^m_{k,in}$). Thus, it is normal that we don't have the same curves for the same OFDM symbols.
In a second time, with others values of channel parameters, we sampled the received signal from the first OFDM symbol (fig.12) at **t=0,0005s**, after the received signal from the second OFDM symbol (fig.15) at t à **t=2Tc** and we represented the real and imaginary values of the symbols received on each channel r (fig.13 and fig.14 for fig.12; fig.16 and fig.17 for fig.15).

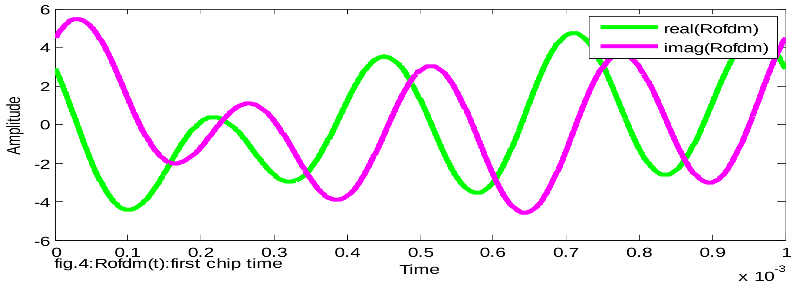

fig.4:Rofdm(t):first chip time

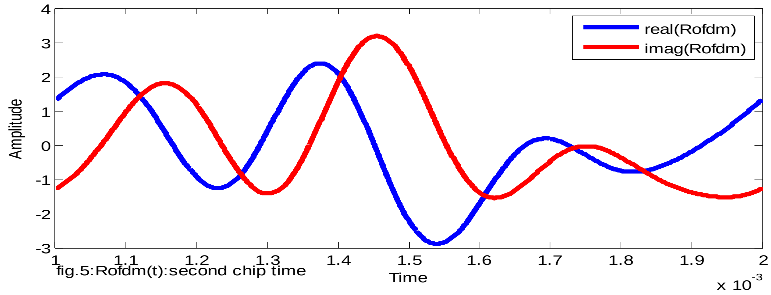

fig.5:Rofdm(t):second chip time

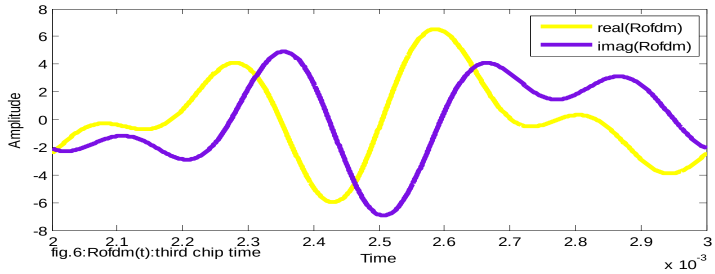

fig.6:Rofdm(t):third chip time

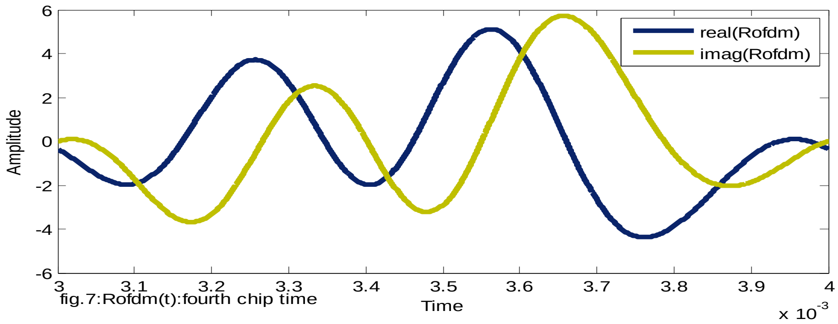

fig.7:Rofdm(t):fourth chip time

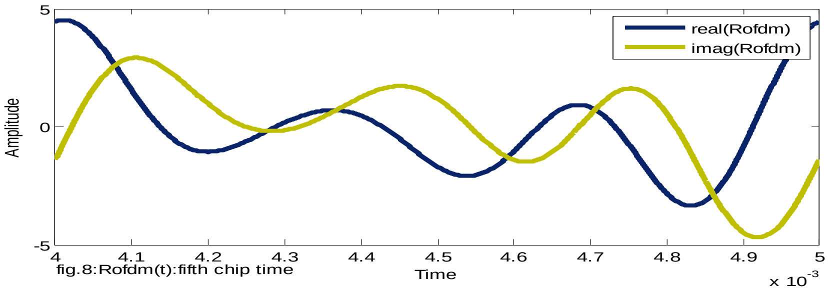

fig.8:Rofdm(t):fifth chip time

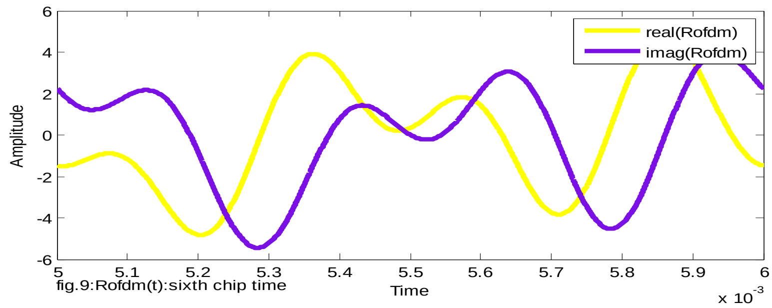

fig.9:Rofdm(t):sixth chip time

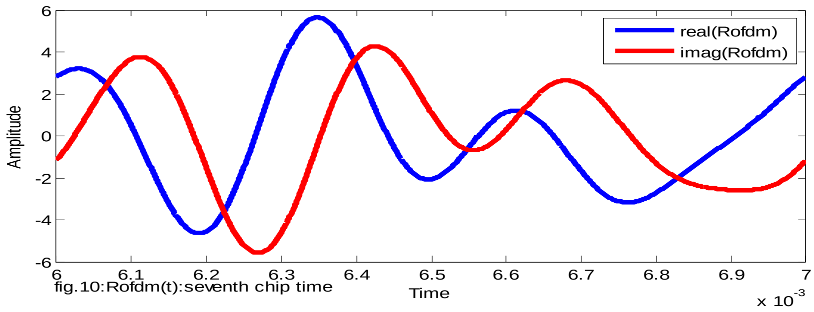

fig.10:Rofdm(t):seventh chip time

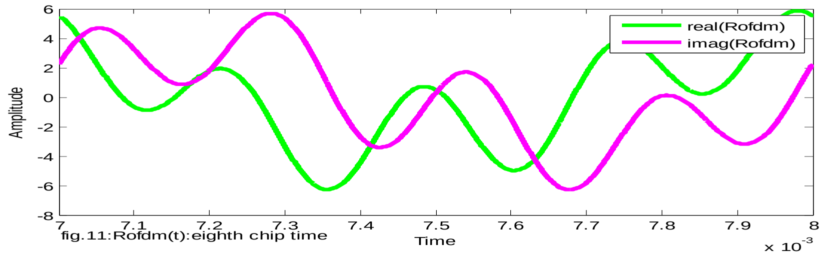

fig.11:Rofdm(t):eighth chip time

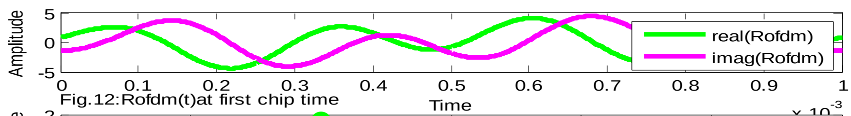

Fig.12:Rofdm(t)at first chip time

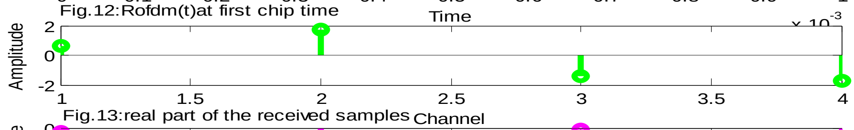

Fig.13:real part of the received samples

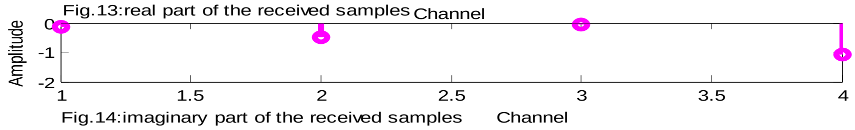

Fig.14:imaginary part of the received samples

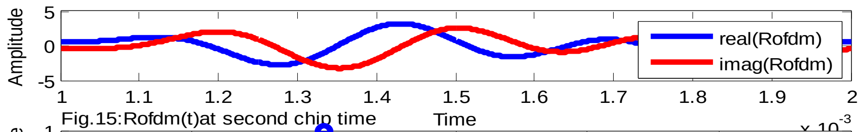

Fig.15:Rofdm(t)at second chip time

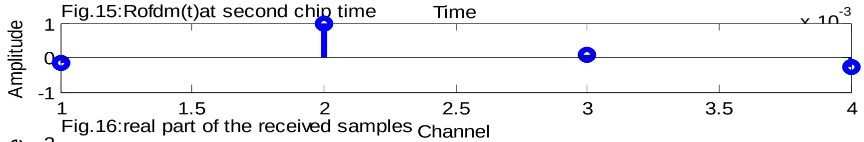

Fig.16:real part of the received samples

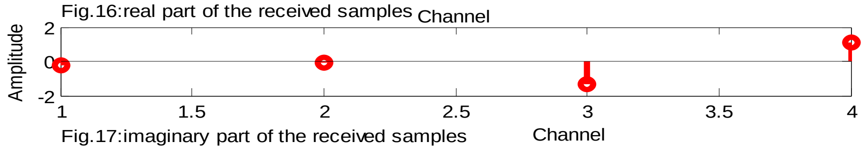

Fig.17:imaginary part of the received samples

VI. CONCLUSION

This work has permit us to conceive for the UMTS UTRA-FDD up-link, a less complex OFDM modulator/demodulator system by chip time, in the case where a mobile have to send simultaneously **K** data symbols by channel for a total of **N** channels. This system involves the **IFFT algorithm** for the implementation of the OFDM modulator in place of **N** individual modulators and the **FFT algorithm** for the implementation of the OFDM demodulator instead of **N** individual demodulators. However, this work is to be continued for taking into account a guard interval **tg** for the OFDM symbols to be sent and the case where an White Gaussian noise is added to the channel. The insertion of a guard interval **tg** to the OFDM symbols will permit to fight against interferences between OFDM symbols and so to improve the quality of the transmission. The addition of noise in the channel will allow us to consider the most practical case**.** After all, it will be needed in the case of a noisy frequency selective channel, to see with which optimal channel estimation technique, we shall find at the reception with a low bit error rate, the OFDM symbols which were emitted.

REFERENCES

1) Ngom Agnès, Ouess Mohamed El-Amine, Bouallègue Ridda, Ouya Samuel, Farssi Sidi Mohamed; "Application of OFDM modulation on up-link in UMTS UTRA-FDD for multiplexing physical data channels of a same mobile"; International Journal of Engineering Inventions, Volume1, Issue7 (Octobre 2012), pp:36-43.
2) Henrik Schulze, Christian Lüders ; "Theory and application of OFDM and CDMA"; Copyright 2005 John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex P019 8SQ, England, pp:51-65.
3) Erik Dahlman, Stefan Parkvall, Johan Sköld; "4G: LTE/LTE- Advanced for Mobile Broadband", Academic Press, 21 mars 2011, pp: 27-43.
4) Srinivas Yerramalli, Milica Stojanovic and Urbashi Mitra; "Data detection techniques for OFDM signal over DOPPLER –distorded channels"; In Proc.of the 5th International Workshop on Underwater Networks (WuWNET) (short paper), Woodshole, Massachusetts, Octobre 2010.
5) Song Lijun, Tang Youxi, Li Shaoqian, Li Yingtao; " Ber performance of differential demodulation OFDM system in multipath fading channels"; GLOBECOM 2003, 0-7803-7974-8/03/&17.00 volume1 IEEE 2003.