Demultiplexing of Signals on the Downlink OFDM in UTRAN-FDD

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ABSTRACT

In this paper, we have analysed the received signal without multipath at Additive White Gaussian Noise (AWGN) with a Signal to Noise Ratio (SNR) per sample, 10 dB, 8 dB, 6 dB and 4 dB respectively. We present the received signal with a multipath channel with noisy, the signal to noise ratio of 6 dB is studied and a multipath channel noiseless. And doing these studies, we considered the impulse response.

KEYWORDS

OFDM, UTRAN, FDD, SNR, SISO, AWGN, demultiplexing, multipath, impulse response, transmitted signal and the received signal

1. INTRODUCTION

One problem which arises in analog communication or digital communications networks in telecommunications, especially in third generation cellular networks, is the signal reception without a total degradation of the transmitted signal. The radio layer standard raises many problems which limit the performances originally advanced. On the downlink, these problems are mainly related to the propagation channel which, because of its multipaths.

As the paper [1] solved the problem of low speed transmission and sends its own signal.

In this paper, we studied the received signal with and without noise with signal to noise ratio is low and used in a multipath channel and without multipath. In this paper too, we work in a Single Input, Single Output (SISO) linear and time varying.

2. OFDM SIGNAL TRANSMISSION A NOISY CHANNEL WITHOUT MULTIPATH

Passing to the transmission channel, the signal is delayed, weakness, distortion and interference. First at the receiver input, we neglect the distortion and we considered that the interference is to add to the transmitted signal a random signal the level of which is distributed according to a

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Gaussian. This signal is called Additive White Gaussian Noise (AWGN). In a mobile radio system, the Gaussian noise is not only the noise of the receiver (thermal noise) but also to all interferences, including co-channel interference due to the reuse of the same frequency on several cells [2] and [3].

The expression of the received signal becomes:

$r(t) = S(t) + B(t)$ (1)

with $S(t) = \sum_{k=1}^{K} s_k(t)$ et $B(t) = \sum_{k=1}^{\infty} B_k.\varphi_k(t)$ [1]

then the received signal is in this way :

$r(t) = \sum_{k=1}^{K} s_k(t) + \sum_{k=1}^{\infty} B_k.\varphi_k(t)$ (2)

with $s_k(t) = \sqrt{\xi_k} \sum_{m=1}^{M} b_k(m) \sum_{n=0}^{N-1} a_k(n) \sum_{i=0}^{N-1} (\alpha_i + j\beta_i) e^{j2\pi\left(f_0+\frac{i}{T_s}\right)\left(t-\left(m+\frac{n}{L}\right)T\right)}$ (3)

so $r(t) = \sum_{k=1}^{K} \sqrt{\xi_k} \sum_{m=1}^{M} b_k(m) \sum_{n=0}^{N-1} a_k(n) \sum_{i=0}^{N-1} (\alpha_i + j\beta_i) e^{j2\pi\left(f_0+\frac{i}{T_s}\right)\left(t-\left(m+\frac{n}{L}\right)T\right)} + \sum_{k=1}^{\infty} B_k.\varphi_k(t)$ (4)

3. OFDM SIGNAL TRANSMISSION IN A MULTIPATH CHANNEL

A receiver receives a composite signal including various echoes of the same transmitted signal. Each signal follows a particular path and it comes with a lag compared to the other. Then there is the multipath propagation. Is a propagation channel characterized by its impulse response, that is to say the development of the received signal if a pulse is emitted. The impulse response is highly dependent on the particular environment in which we place ourselves but we can identify common features with the type of environment. A multipath channel is equivalent to a filter. The channel impulse response is the impulse response of the filter. The transfer function of the filter is the Fourier transform of the impulse response [2].

3.1. OFDM SIGNAL TRANSMISSION IN A PERFECT CHANNEL

We consider that the transmission is performed without adding noise. Then the received signal is the convolution of the transmitted signal and the channel impulse response.

And the received signal takes the following form:

$r(t) = S(t) * h(t)$ (5) [4]

$$\Rightarrow r(t) = \sum_{k=1}^{K} s_k(t) * h(t)$$

With $s_k(t) = \sqrt{\xi_k} \sum_{m=1}^{M} b_k(m) \sum_{n=0}^{N-1} a_k(n) \sum_{i=0}^{N-1} (\alpha_i + j\beta_i) e^{j2\pi\left(f_0+\frac{i}{T_s}\right)\left(t-\left(m+\frac{n}{L}\right)T\right)}$ [1]

The transfer function of a multipath channel can to write in general:

$h(t) = \sum_{i=0}^{N_p} c_k(t)\delta(t - \tau_k(t))$

Where τ designates the delay evolves over time t and where δ is the Dirac function. $\tau_k(t)$ parameters represent the delays of the various paths; $c_k(t)$ the complex coefficients give the phase and amplitude of each journey.

A currently used model consists in supporting the variation over time of various parameters is slow compared to the transmission rate. It is therefore considered that these parameters are constant during a transmission of a block of information but may vary from one transmission to another. Specifically, we assume that τ_k are fixed and do not depend only on the environment (dense urban, rural, mountainous and others) and the coefficients$c_k(t)$ are random: the phase is uniformly distributed and the amplitude follows a Rayleigh law [7]. The models specify the average value of the amplitude. We can write the expression of the impulse response in this way:

$$h(t) = \sum_{k=1}^{K} \gamma_k e^{j\theta_k} \delta(t - \tau_k) \quad \text{[5] and [6]}$$

$h(t)$: Impulse response of multipath channel

γ_k : k[th] path amplitude
$e^{j\theta_k}$: Phase k[th] path
τ_k : k[th] path delay
$\delta(t - \tau_k)$: the Dirac function
so the received signal becomes:

$$r(t) = \sum_{k=1}^{K} \left[\left(\sqrt{\xi_k} \sum_{m=1}^{M} b_k(m) \sum_{n=0}^{N-1} a_k(n) \sum_{i=0}^{N-1} (\alpha_i + j\beta_i) e^{j2\pi\left(f_0 + \frac{i}{T_s}\right)\left(t - \left(m + \frac{n}{L}\right)T\right)} \right) * \gamma_k e^{j\theta_k} \delta(t - \tau_k) \right]$$

$$r(t) = \sum_{k=1}^{K} r_k(t) \quad (6)$$

With $r_k(t) = \left(\sqrt{\xi_k} \sum_{m=1}^{M} b_k(m) \sum_{n=0}^{N-1} a_k(n) \sum_{i=0}^{N-1} (\alpha_i + j\beta_i) e^{j2\pi\left(f_0 + \frac{i}{T_s}\right)\left(t - \left(m + \frac{n}{L}\right)T\right)} \right) * \gamma_k e^{j\theta_k} \delta(t - \tau_k) \quad (7)$

3.2. OFDM SIGNAL TRANSMISSION IN A NOISY CHANNEL

The received signal with Additive White Gaussian Noise is the way

$$r(t) = S(t) * h(t) + B(t) \quad (8)$$

$$r_k(t) = \left(\sqrt{\xi_k} \sum_{m=1}^{M} b_k(m) \sum_{n=0}^{N-1} a_k(n) \sum_{i=0}^{I-1} (\alpha_i + j\beta_i) e^{j2\pi\left(f_0 + \frac{i}{T_s}\right)\left(t - \left(m + \frac{n}{L}\right)T\right)} \right) * \gamma_k e^{j\theta_k} \delta(t - \tau_k) + B(t) \quad (9)$$

with $B(t) = \sum_{k=1}^{\infty} B_k . \varphi_k(t)$ avec $B_k = \langle \varphi_k , B \rangle$

Then $r_k(t) = \left(\sqrt{\xi_k} \sum_{m=1}^{M} b_k(m) \sum_{n=0}^{N-1} a_k(n) \sum_{i=0}^{I-1} (\alpha_i + j\beta_i) e^{j2\pi\left(f_0 + \frac{i}{T_s}\right)\left(t - \left(m + \frac{n}{L}\right)T\right)} \right) * \gamma_k e^{j\theta_k} \delta(t - \tau_k) + \sum_{k=1}^{\infty} B_k . \varphi_k(t) \quad (10)$

4. SIMULATIONS AND RESULTS

To simulate the OFDM signal in the downlink of UMTS, we will give values to the unknown to have the simulation results such as $\xi_k = 2$; $\alpha_i = 2$; $\beta_i = 1$; $T = 2\pi$; $f_0 = 2$; $T_s = 2.5$; $L = 30$; $a_1(n) = [1,-1,-1,1,-1,1,-1,-1]$; $b_1(m) = [1,1,-1,1,-1,1,1,-1,1,-1]^t$ and the transmitted signal has the following expression:

$$s_1(t) = \sqrt{\xi_1} \sum_{m=1}^{10} b_1(m) \sum_{n=0}^{10} a_1(n) \sum_{i=0}^{10} (\alpha_i + j\beta_i) e^{j2\pi\left(f_0+\frac{i}{T_s}\right)\left(t-\left(m+\frac{n}{L}\right)T\right)}.$$

The results obtained from Matlab, are shown respectively in figure 1, figure 2, figure 3, figure 4, figure 5, figure 6 and figure 7.

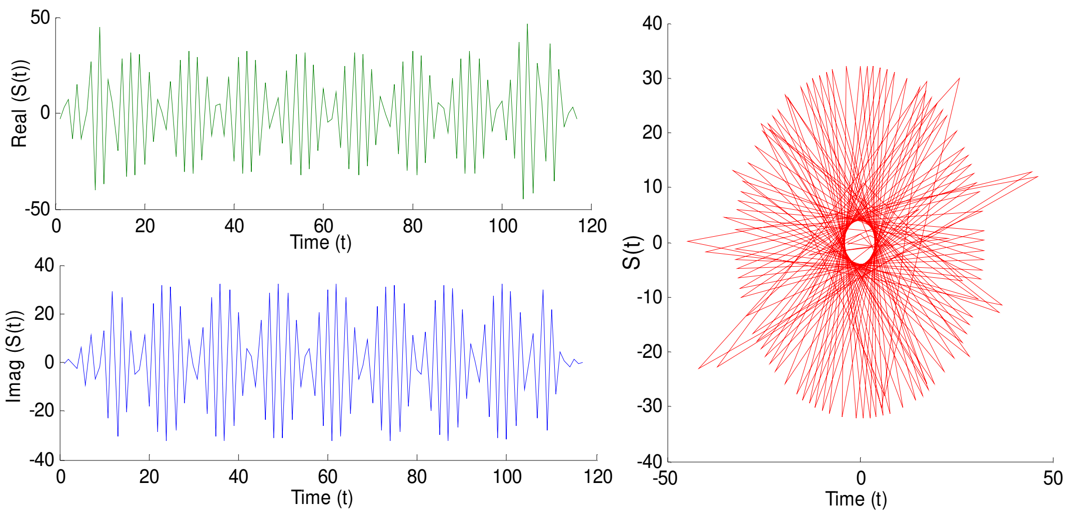

Figure 1: the signal to be transmitted

The curves in color green and blue respectively show the real part and imaginary part of the signal S(t) which is presented in red color. The signal S(t) has almost a form of circle because of the concentration of sinusoidal signals. This signal S(t) rotates in the center of the pair (0,0). The real and imaginary signal is sinusoidal torque begins at the point (0,0) and get to the point of torque (110.0) but have a change in amplitude and different phase. We consider the imaginary part as a signal to be transmitted.

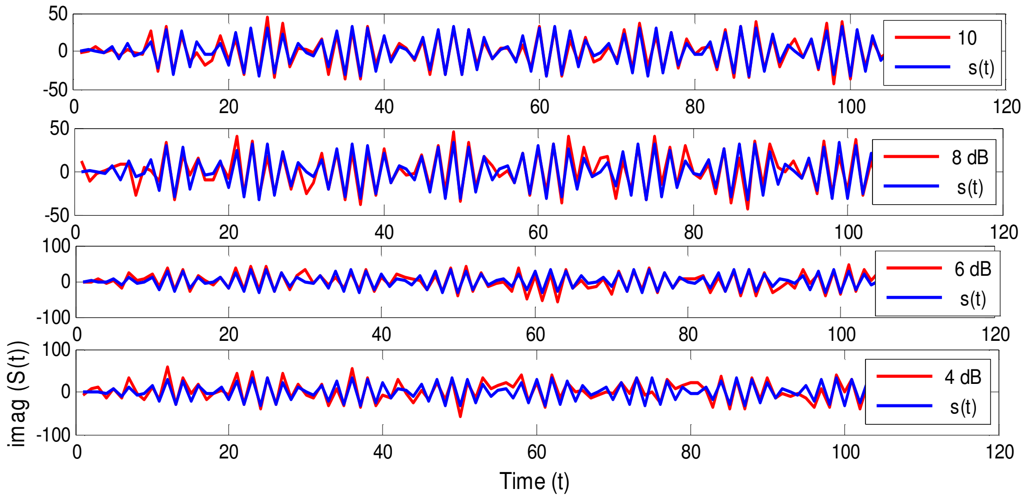

Figure 2: Comparison of noisy signals at the reception

We have just presented the noisy signal with a SNR of 10 dB, respectively, 8 dB, 6 dB and 4 dB. The red color signal is added to a Gaussian white noise. This noisy signal undergoes a small deformation which, in consequence of the decrease in the value of SNR, degrades the original signal. We assume that s(t) equals imag(S(t)). The value of the signal to noise ratio considered is 6 dB and used in figures under-mentioned.

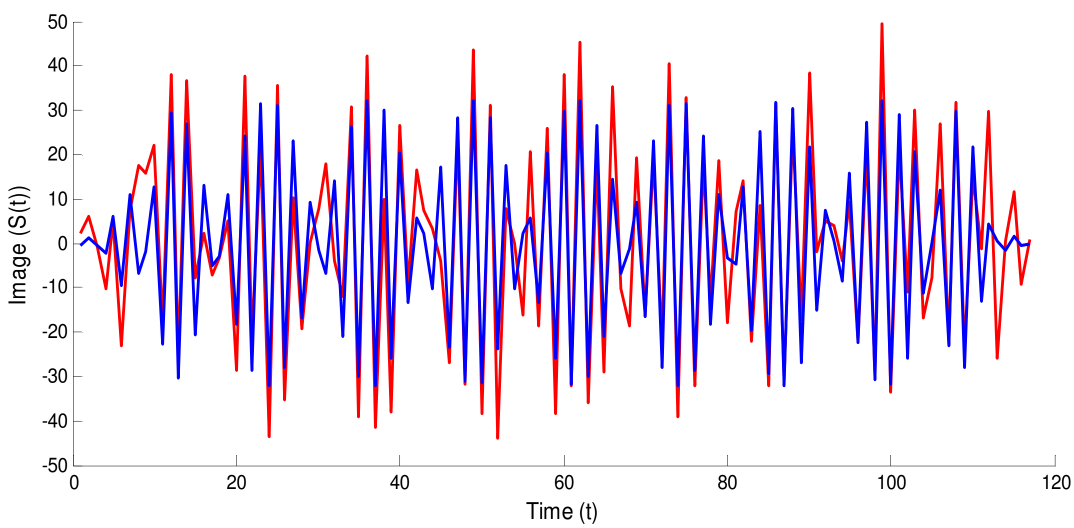

Figure 3: Noisy received signal without multipath

The transmitted signal s(t) has the color blue and the noisy signal for red color with an SNR of 6dB. The noisy signal which starts at the point of torque (0.2) changes its appearance before the initial signal arrives. But these two signals arrive at the same time t = 110. The signal s(t) has an amplitude which varies between [-30, 30] and the noisy signal varies in the interval [-45, 45]. This deformation of the signal necessity a band-pass filter for noise to diminish.

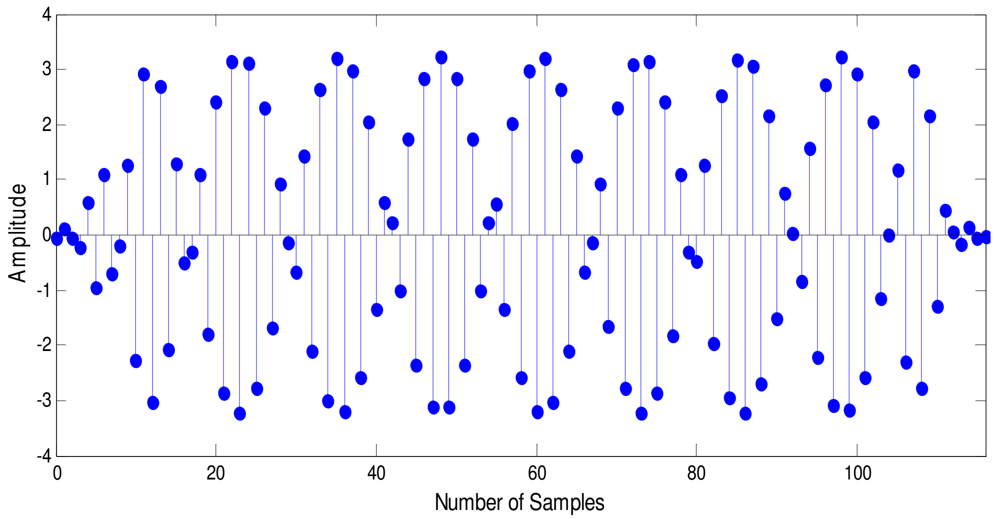

Figure 4: Impulse Response

We have presented the channel impulse response, which has the value 10 as a denominator coefficient for a signal s(t) transmitted. The impulse response is the only measure which provides all the features of the place at one point. The amplitude of the response varies between -3,5 and 3,5.

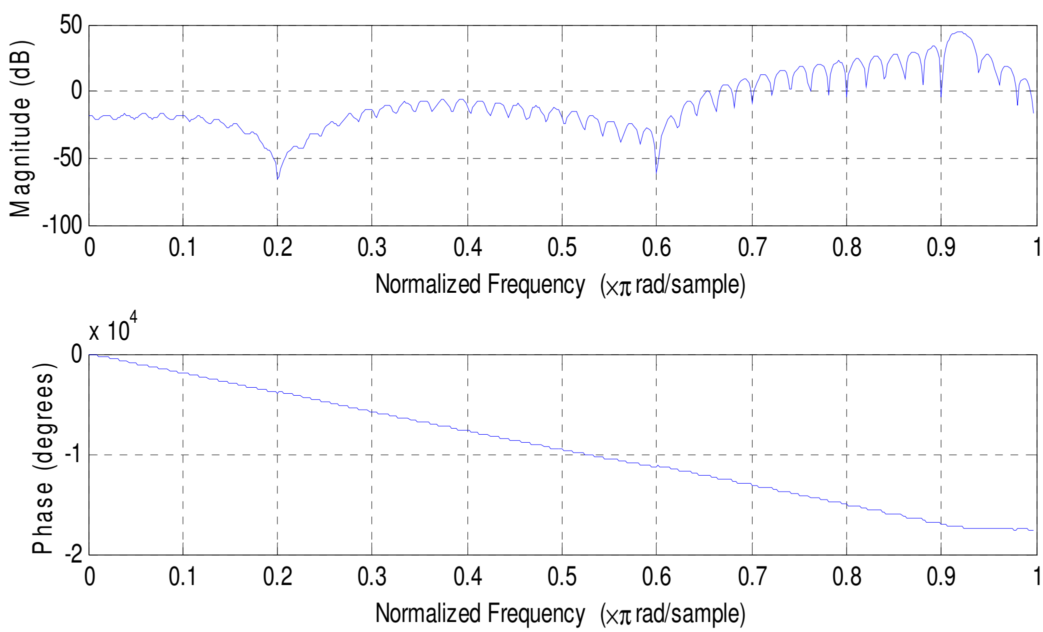

Figure 5: Frequency Response

In the Figure 5, the magnitude varies between -48 to 50. Normalized frequency varies between 0 and 1, it is changing the shape of the curve gradually.

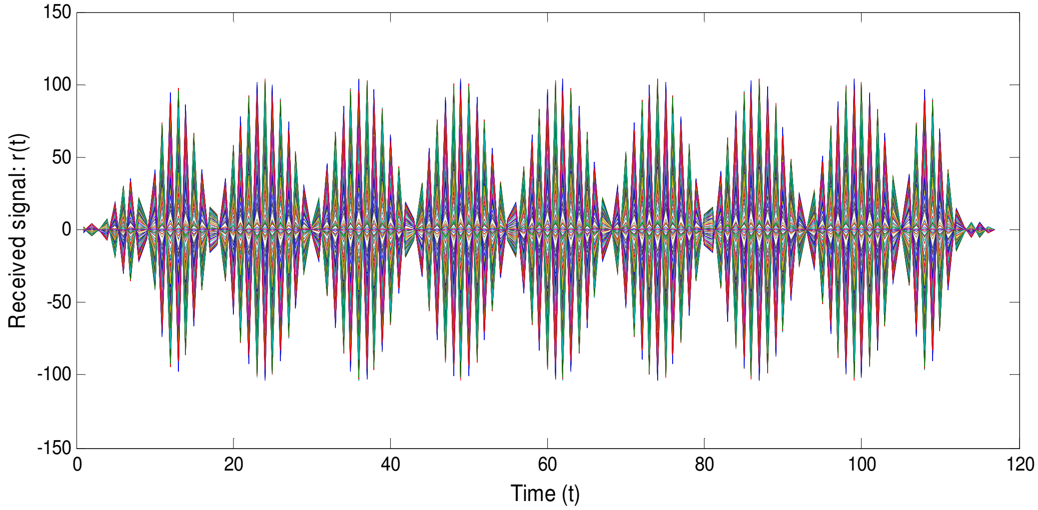

Figure 6: Received signal with multipath

The received signal varies with the various paths between -100 and 100. This variation is higher than the one of the transmitted signal and the one of the noisy signal without multipath reception. There is a small distortion of the signal that the signal will be reconstructed during the quantification

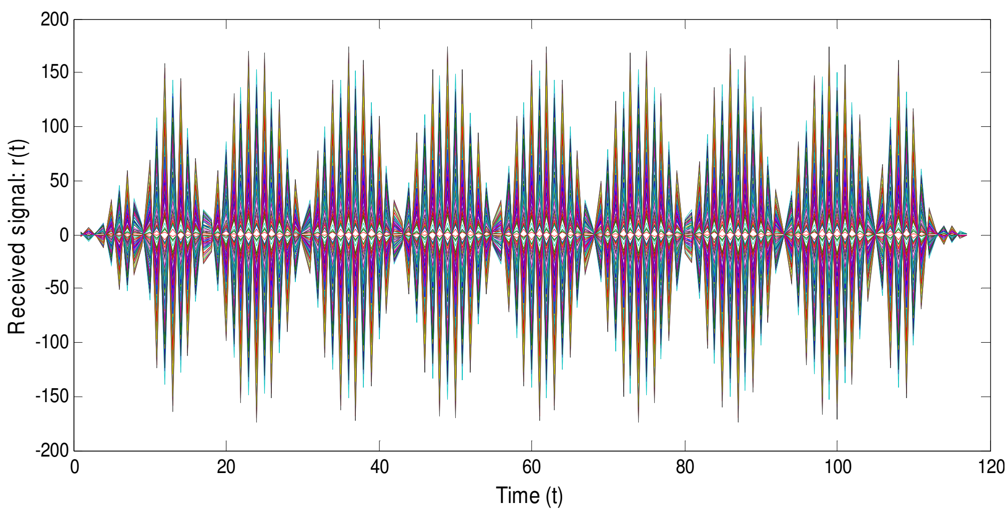

Figure 7: Noisy received signal with multipath

The received signal with a Gaussian noise has amplitudes which vary between -155 and 155. The received signal has been degraded compared to the multipath signal without noise fig 5. But there is no deviation of the signal when at time t = 0 or t = 110.

5. CONCLUSION

In order to continue the previous work [1] for multiplexing OFDM signals at a rate of 22,5 Mbit/s, we were able to transmit these signals in a RAKE receiver. The results obtained in the context of a transmission on the downlink from the UTRAN-FDD show that the signal has undergone a slight bend at the finish of the receiver regardless of the signal to noise ratio used (10, 8, 6 and 4 dB). This deformation will be restored during the quantification. So we succeeded to transmit a signal s(t) with or without multipath.

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