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Department of Electrical, Electronic and Computer Engineering

ESC 320

Special Assignment 2

Multidimensional Modulation: 3GPP2 Uplink Transmitter and Receiver Simulation

16 September 2013

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FORM A

UNIVERSITY OF PRETORIA

FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND IT

DEPARTMENT OF ELECTRICAL, ELECTRONIC AND COMPUTER ENGINEERING

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1. Introduction

The trend for modern computers is towards more mobile and portable systems. This puts a large demand on the available cellular data communication systems. The density of modern urban cellular data users is so high that conventional frequency division or time division would simply not manage to accommodate all these users. Techniques like CDMA developed to provide a clever combination of the previously mentioned methods, to enable multiple users access to the network in a dynamic way that allows for maximum frequency band utilisation at all times and the highest possible data rates. The aim of this assignment is to explore, by means of simulation, the technique of CDMA to implement a 3G cellular data link.

2. Method and Implementation

Matlab and simulink was used to build a simulation of the system by combining subsystem blocks graphically to realise the whole. A 4 channel system was represented with test data originating from 4 random sequence generators. These where first combined to two channels by using orthogonal Walsh coding, and then into one channel by means of quadrature modulation.

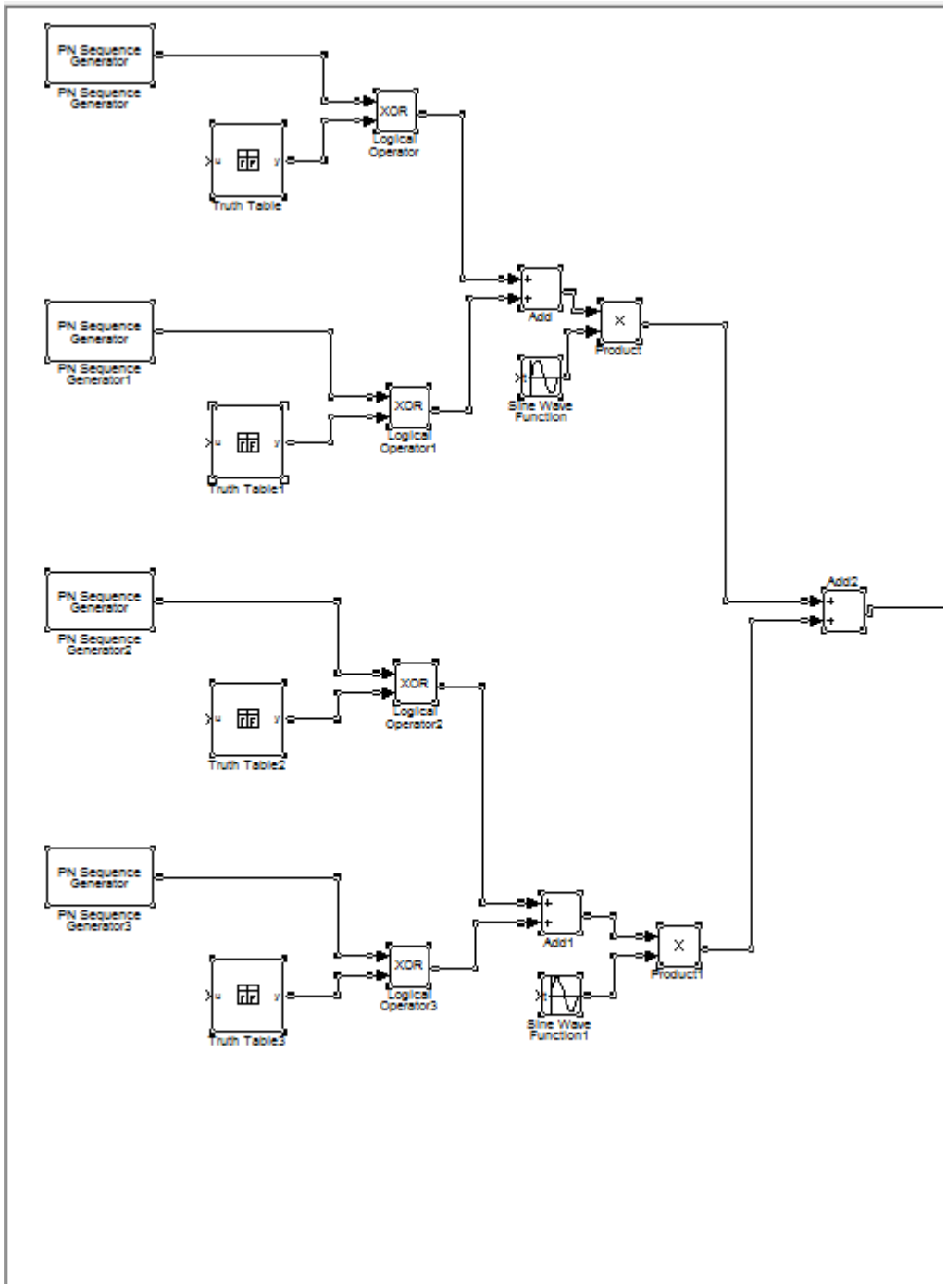


Figure 1 Transmitter block diagram

A demodulation was the designed and simulated to reverse the modulation and restore the original 4 channels of data streams.

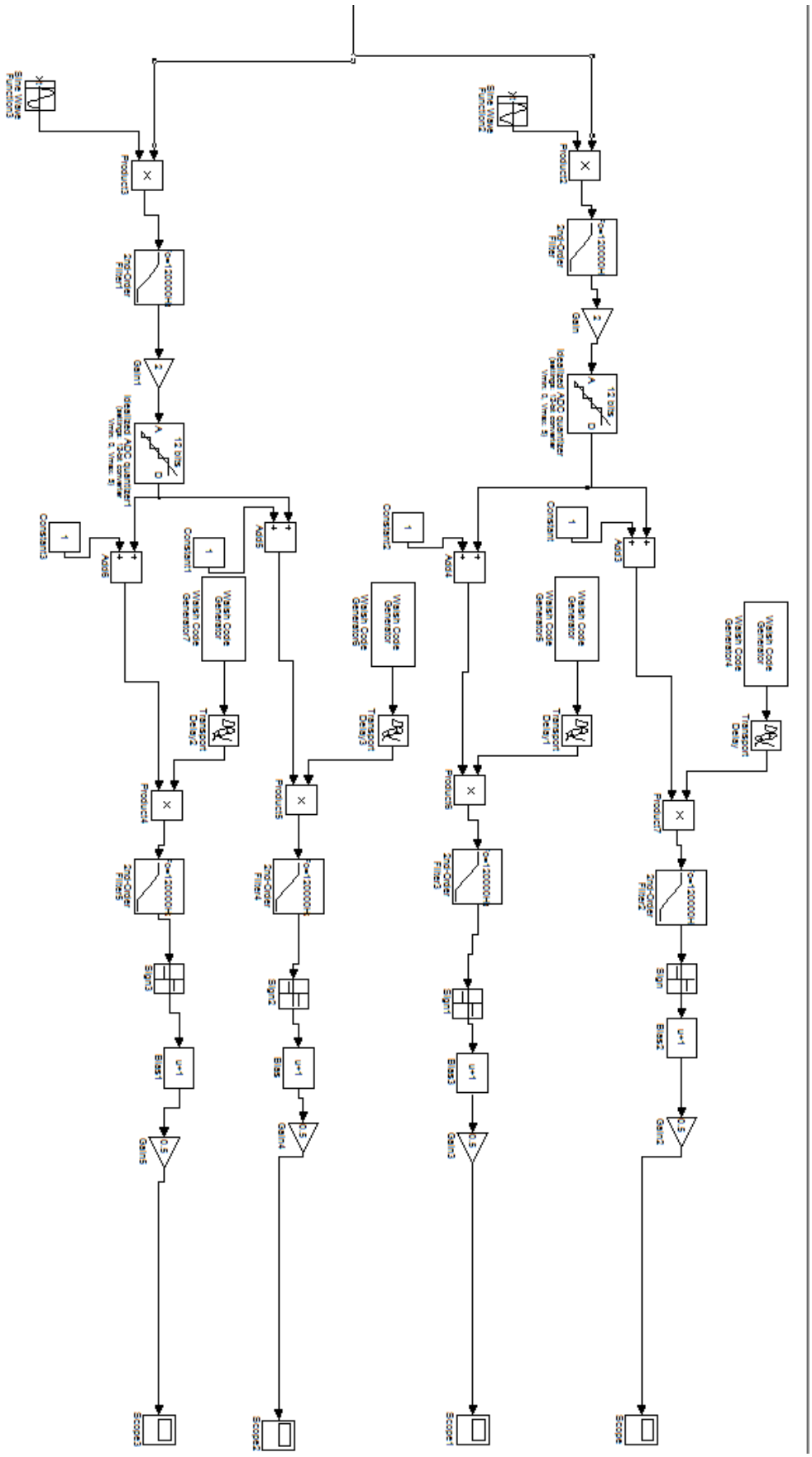


Figure 2 Receiver block diagram

3. Results

3.1 Time domain results

The random input data is shown below with a data rate of 2.4 kilo-symbols.

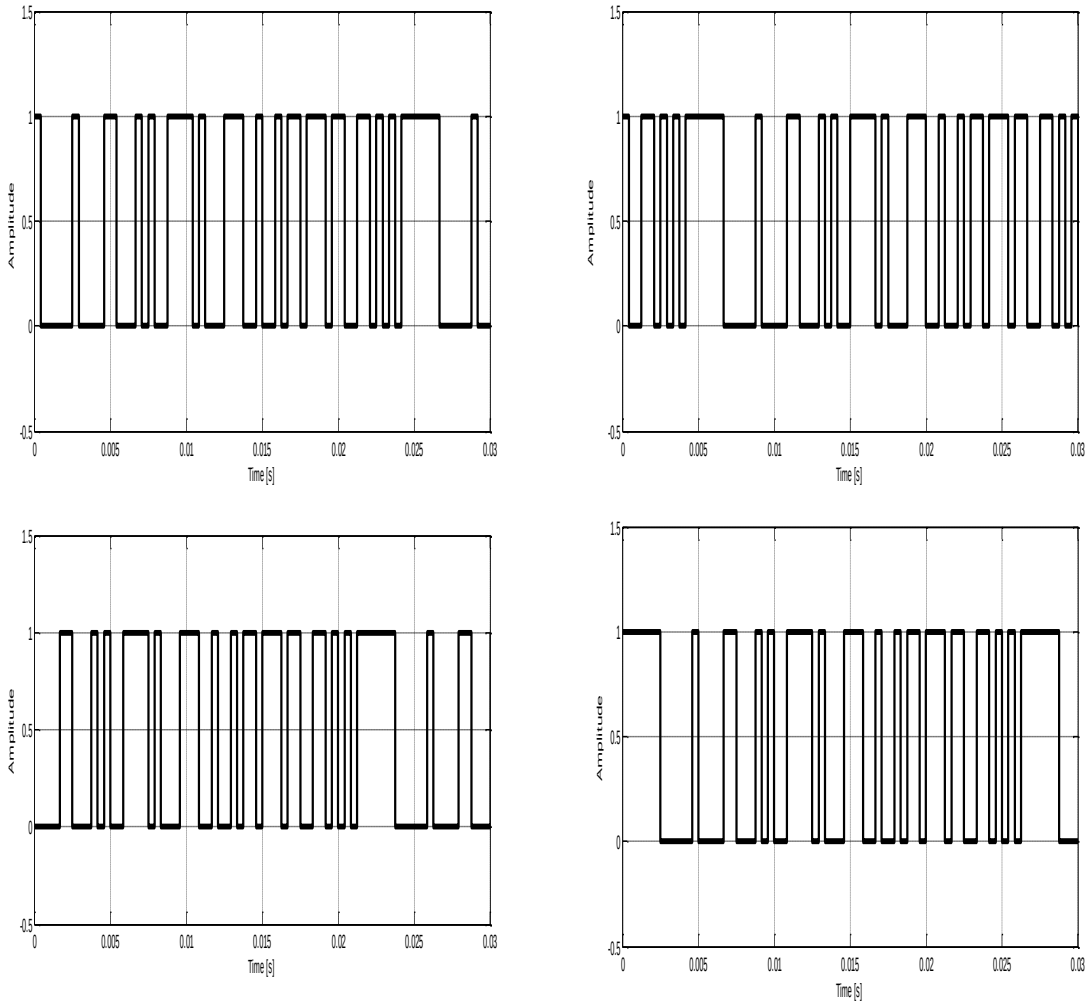
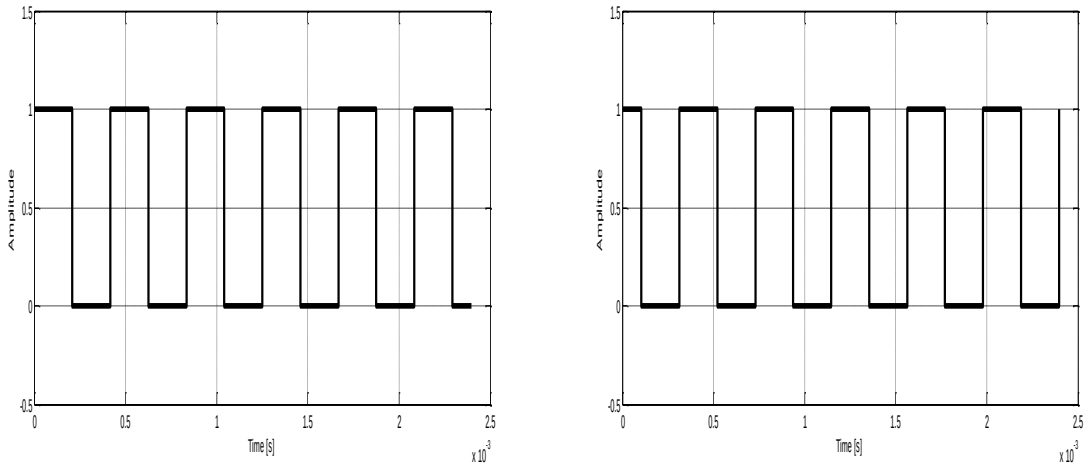


Figure 3, Input data (1-4 left to right, top to bottom)

Welsh codes with $\{d_i(t)\}$, i=1,2,3,4 respectively and length of L=8



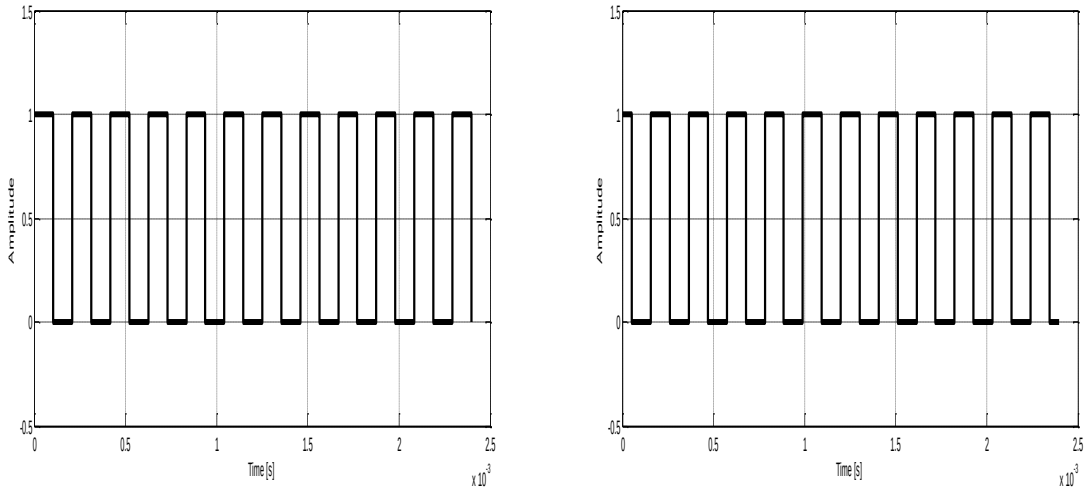


Figure 4 Walsh Codes (1-4 left to right, top to bottom)

After modulo-2 addition of the welsh codes and data signals the following spread spectrum signals exist.

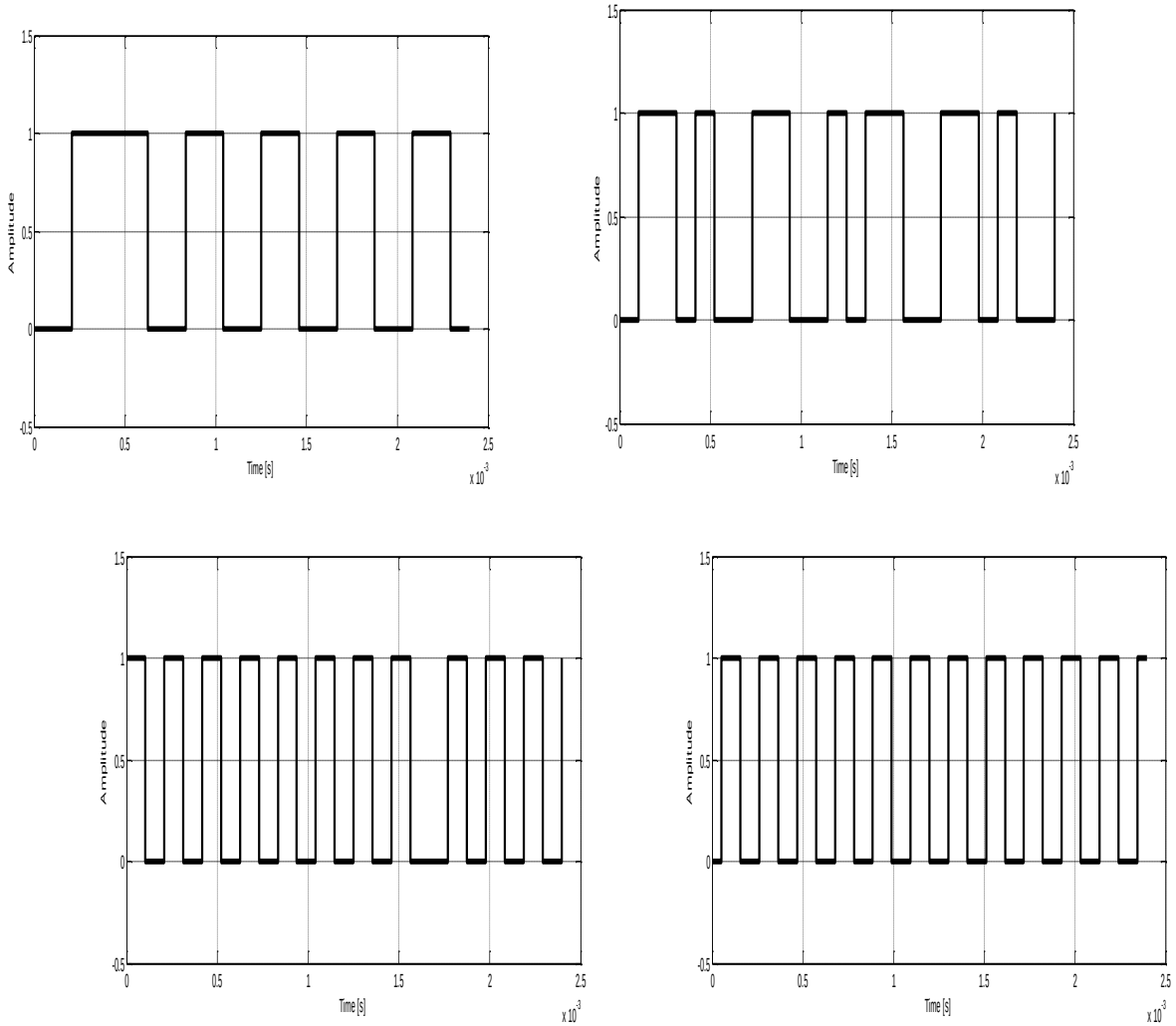


Figure 5 Spread spectrum signals (1-4 left to right, top to bottom)

The following signals exist at the various steps of modulation.

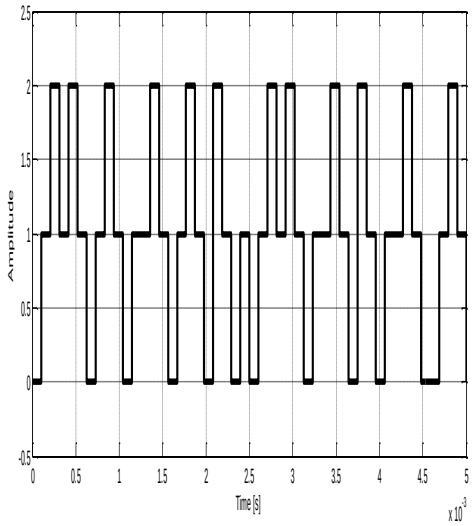
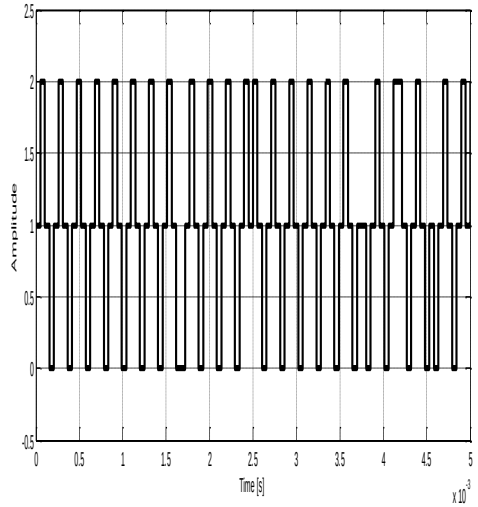


Figure 6 I channel data sequence



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Figure 7 Q channel data sequence

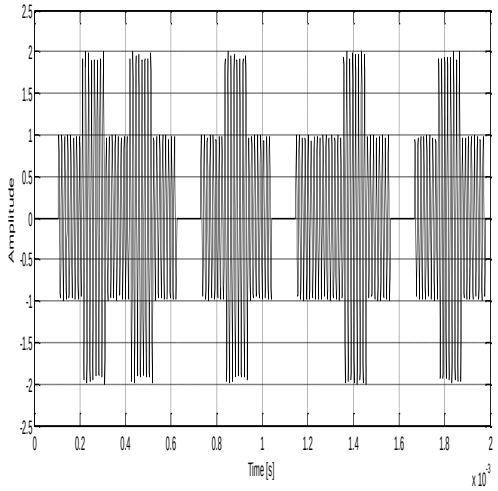


Figure 8 Modulated I channel

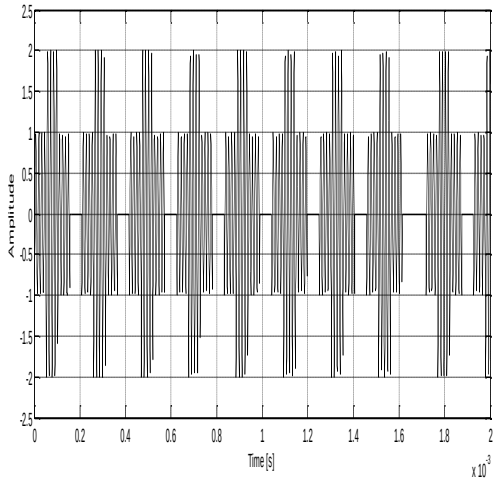


Figure 9 Modulated Q channel

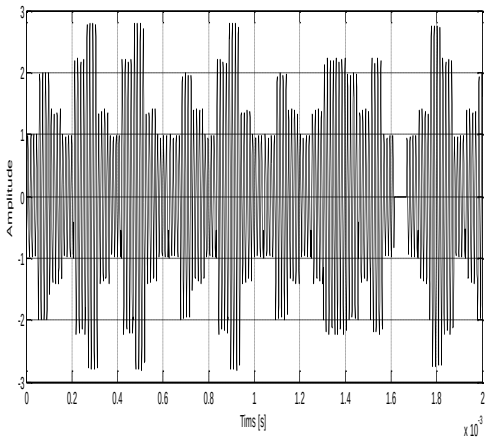


Figure 10 Transmitted signal

The following figures show the demodulated I and Q channels after quantisation and filtering to remove high frequency components.

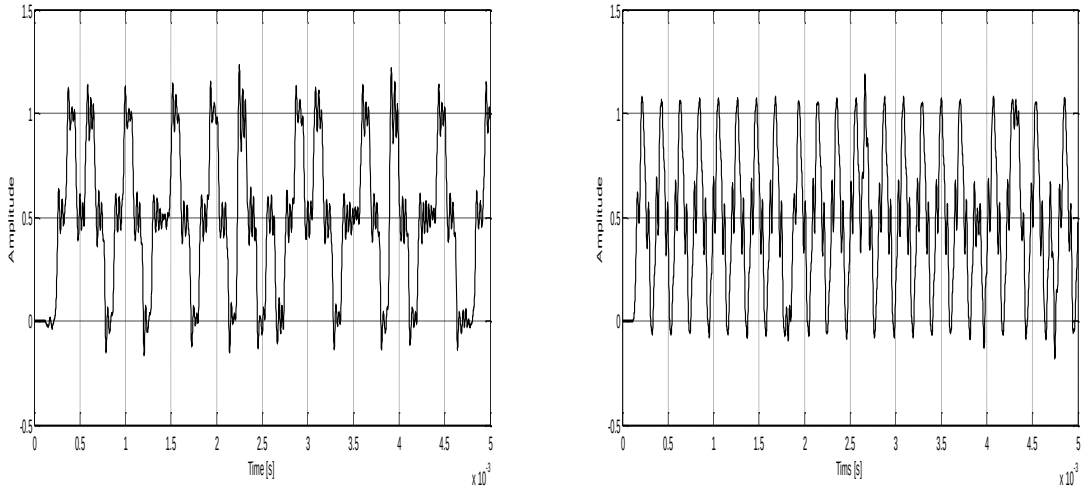


Figure 11 I cannel and Q channel (left to right)

After de-spreading and some signal conditioning to remove unwanted high frequency effects the following data was recovered.

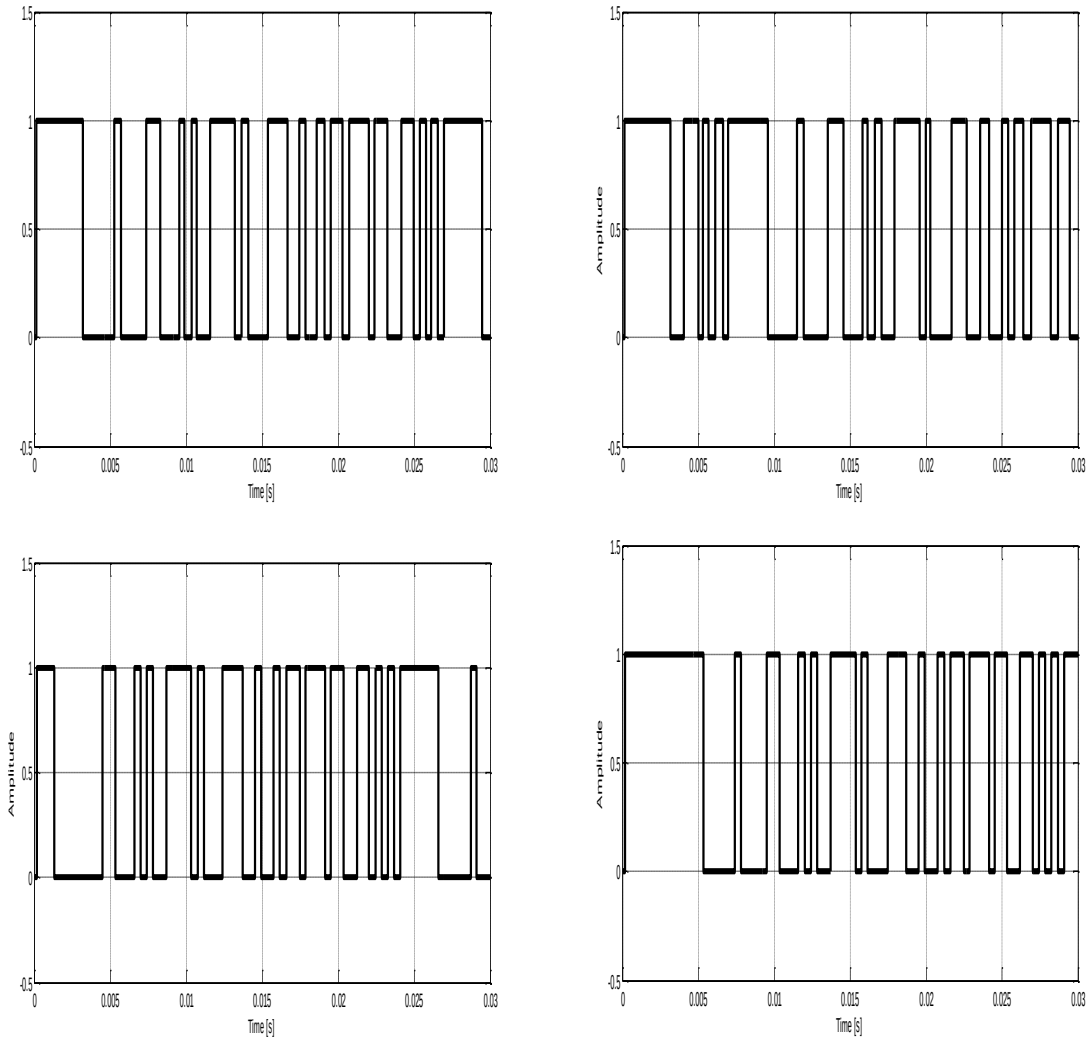


Figure 12 recovered data (1-4 left to right, top to bottom)

3.2 Frequency domain results

Al channels showed a PCD similar to channel one shown bellow

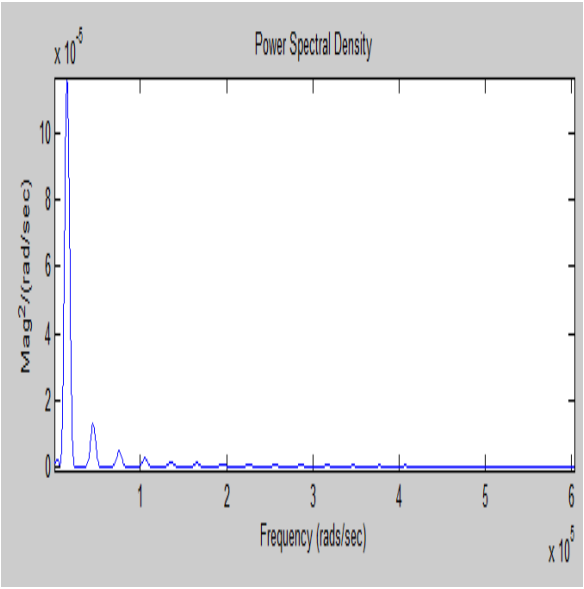


Figure 13 PCS of random data

The transmitted signal had a PCD as shown here.

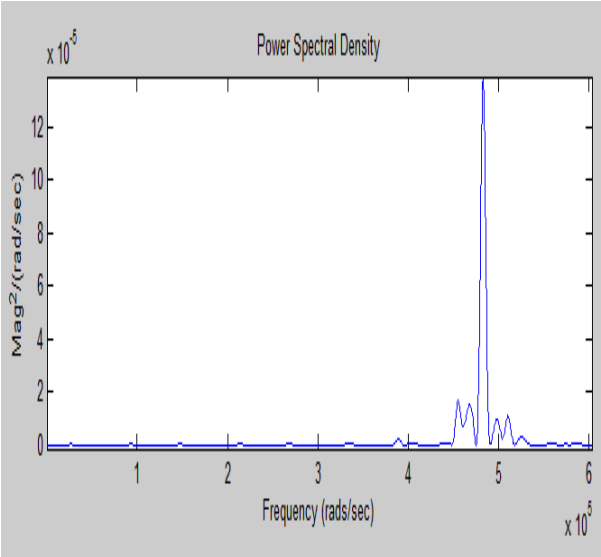


Figure 14 PCD transmitted signal

4. Discussion

Comparing the PCD of the input and transmitted signals shows the significant ability to transmit all four channels in a bandwidth only slightly larger than a single random sequence. A bandwidth conservation of almost four times is shown.

In the time domain it can be seen that data is hardly visible in the transmitted signal. Yet the data can be accurately recovered from it.

5. Conclusion

3GPP2 successfully manages to put 4 channels into the bandwidth of one while at the same time ensures a level of scrambling that meets the need for security and privacy. Although undesired high frequency components are present initially after demodulation filtering and conditioning can eliminate these effects.

6. References

Lathi B.P & Ding Z. 2010. *Modern Digital and Analogue Communication Systems*, 4th ed. Oxford: Oxford University Press.