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Ultra wideband pulse generator circuits using Multiband OFDM

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***Abstract*— Ultra wideband technology is the cutting edge technology for wireless communication with a wide range of application. In this, to generate an Ultra wideband pulses based on wavelet packets, different circuits are proposed. In this, wavelet packets are quasi-orthogonal and have an identical time duration and therefore it is useful for the ultra wideband pulse shape modulation systems. The different circuits are based on the equations defining the wavelet packet and their performance is noted by simulation .Also using analog to digital converter(ADC) sampling frequency is increased and their performance is generated by MATLAB. Newly the MB OFDM produce a tremendous result in the UWB and produces a high data rate and the output are shown in Matlab.**

***Index Terms*— UWB, ADC, OFDM, MATLAB**

I. INTRODUCTION

In the last twenty years, mathematical and other research has its interest in theoretical and applied mathematics in relation to wavelet analysis. In early stages the main aim was to get multiresolution signal decomposition. Later, ultra wideband made tremendous changes and gained some interest due to its high data transmission rate. The transmission rate of ultra wideband involves very short duration and low duty-cycle pulses at very low power to carry the messages. Ultra wideband signals have a -10dB bandwidth and its exceeds 500 MHz and is of the order of one to several gigahertz.

Any ultra wideband system should not cause a interference to other wireless services which uses the same frequency band. Pulse shape modulation is a very good technique used for ultra wideband communications and this technique introduces more degrees of freedom to the system, hence the robustness increases. In general, a pulse shape modulation system is based on a set of pulses that are orthogonal and have almost identical time duration. To target this goal, different base pulses have been investigated such as hermite polynomials, prolate spheroidal wave functions or wavelet packets [10].

In addition, low cost circuitry is an important criterion underlying the principles of ultra wideband technology. Taking this into consideration, wavelet packets become even more appealing. Indeed, due to the definition of these pulses, this paper shows that different circuit architecture can be implemented to generate the wavelet packets. This paper is splitted as follows, the method to generate the wavelet packet, different circuits are generated and the comparison about these circuit is given and newly the implementations of adc using these circuits have been discussed and finally the conclusions are given.

II. THEORY OF WAVELET PACKETS

First, let L^2 (a, b) denote the collection of measurable functions f, defined on the interval (a,b),that satisfy

$$\int_a^b |f(x)|^2 dx < \infty \quad - (1)$$

Let's $\emptyset \epsilon L2(R)$ characterize a scaling function and $\Psi \epsilon$ L2 (R) its corresponding wavelet as defined. Then, the two-scale relation of $\emptyset$ is described by a unique l^2 sequence $\{p_k\}$

$$\emptyset(\mathbf{x}) = \sum_{k=-\infty}^{\infty} p_k \, \emptyset(2x - k) - (2)$$

Called the two-scale sequence of $\emptyset$.Then the two-scale relation of the corresponding wavelet is given by Ψ.

$$\Psi(x) = \sum_{k=-\infty}^{\infty} q_k \, \emptyset(2x - k) - (3)$$

CIRCUITRY

CONVOLUTION BASED CIRCUIT

These circuits are based on different interpretation of defining the wavelet packets. This leads to different implementations, all having some advantages and disadvantages that will be discussed in the next section. The four circuits are designed with Simulink Ready made functions are generally used in the design process, however the initial states of the different blocks are individually adjusted depending on the system requirements.

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In the rest of the paper, discrete signals are considered and N_1 denotes the desired number of samples of the wavelets, while T_1 denotes the sampling time.

If we denote * the discrete convolution, can be rewritten as

$$\mu 2l(n) = p(n) * \mu l(2n) \quad -(4)$$

$$\mu 2l + 1(n) = q(n) * \mu l(2n) \quad -(5)$$

Let Mod (.,.) denote the modulus after division. ρ is defined by

$$P(n)=\begin{cases} p_n & \text{if } Mod(n-1, N_s)=0 \\ o & \text{otherwise} \end{cases}$$

A possibility to improve this problem is to use the convolution by Fast Fourier Transform (FFT). If we denote Mk(f),P(f) and Q(f) the Fourier Transform of is equivalent to

$$M_{2l}(f)= P(f).Ml(2f)$$

$$M_{2l+1}(f)=Q(f).Ml(2f)$$

Then, by applying the Inverse Fast Fourier transform (IFFT) to the result of the product, we obtain the desired signal. Note that Ns must be a power-of-two in order to use this method. The circuit based on this method is represented in Fig.2

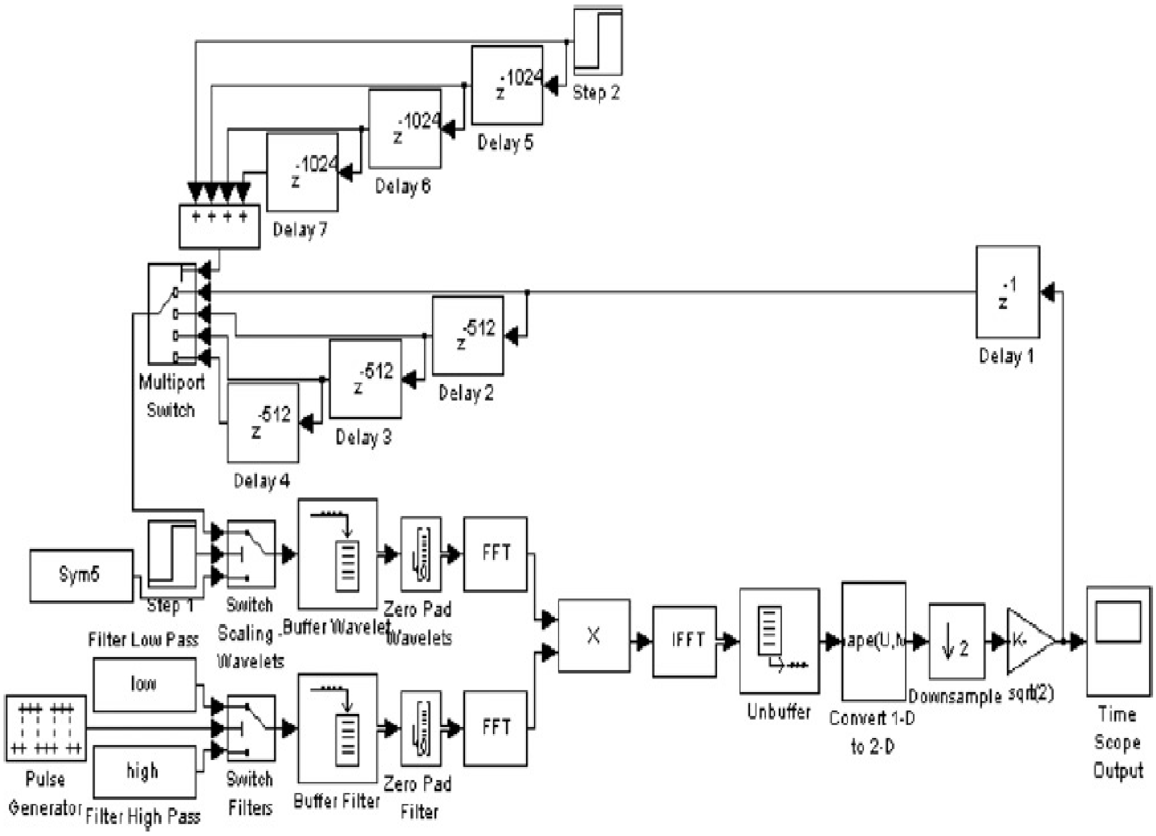

Fig2: Convolution by FFT-based circuit

Sum Based Circuit

Another approach is to generate the wavelets according to (6). In this case, time consumption and memory requirements are kept to an acceptable level as only sum operations are performed. Furthermore, the filter banks are not necessary. However, compared with the convolution-based methods, circuits are less compact as the number of coefficients describing the reconstruction filters of the wavelet packets {Pk} and {qk}.

Modified Sum-Based Circuit

In fig 4, a circuit using a similar approach is represented, the difference with the previous circuit is that the number of gain blocks needed can be reduced. Indeed, according to (9), (p_k) and (q_k) are quadratic mirror filters. Thus, the coefficients describing (q_k) are directly derived from (p_k).

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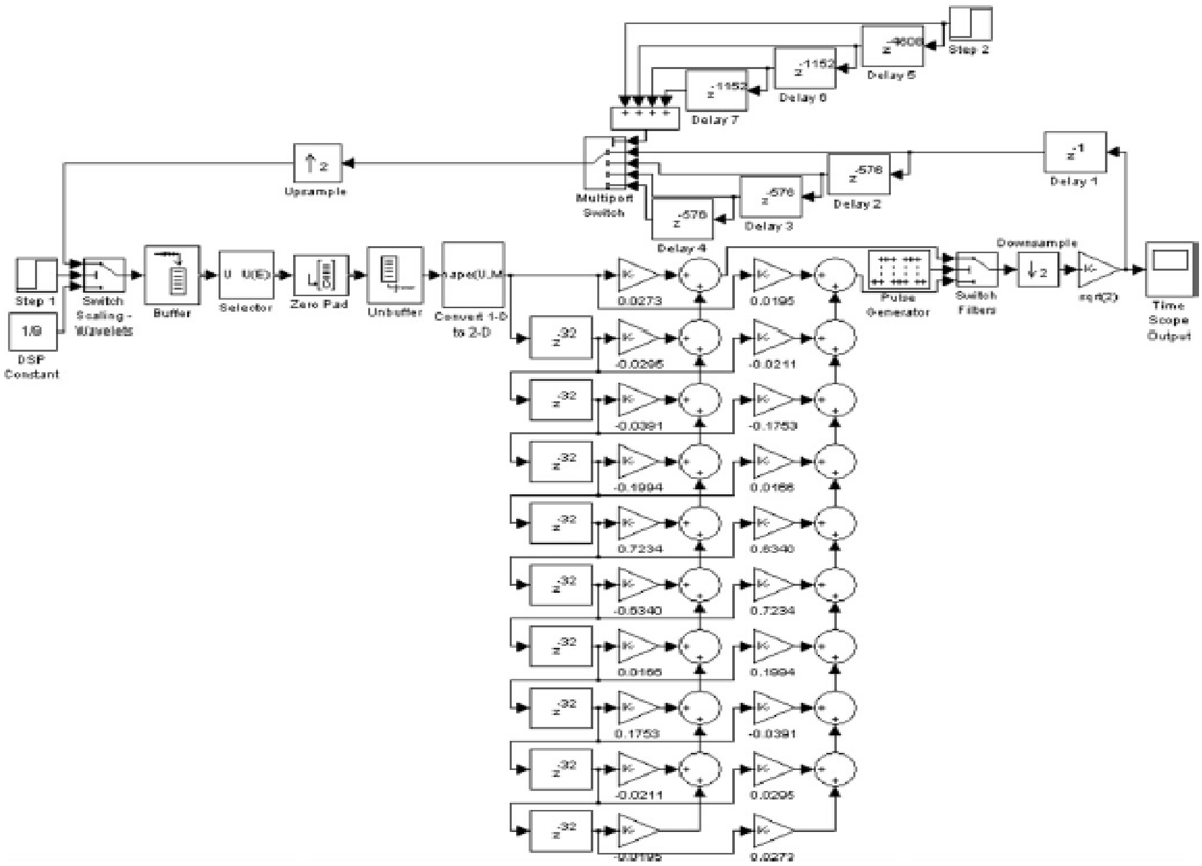

Fig3: Sum based circuit

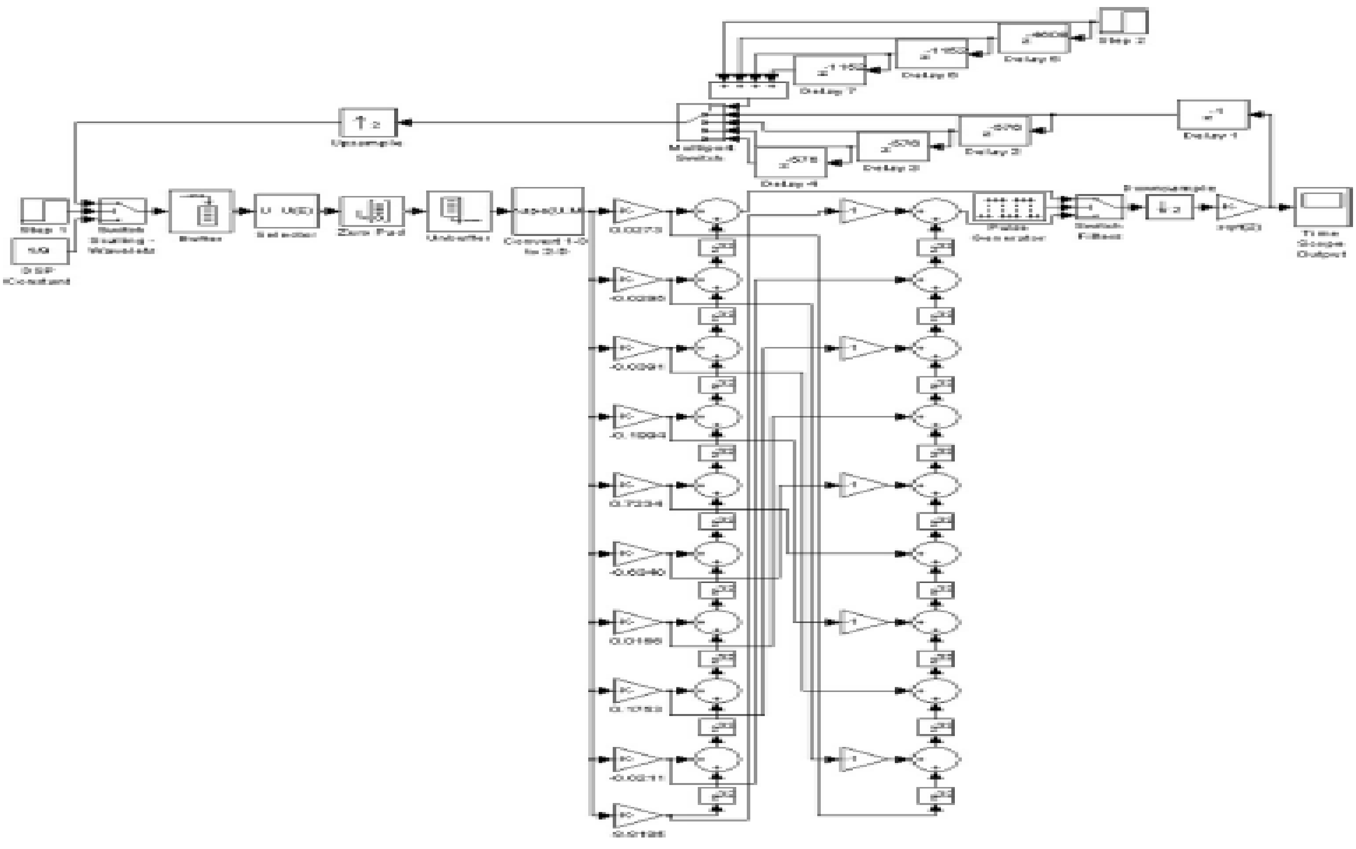

Fig4: modified sum-based circuit

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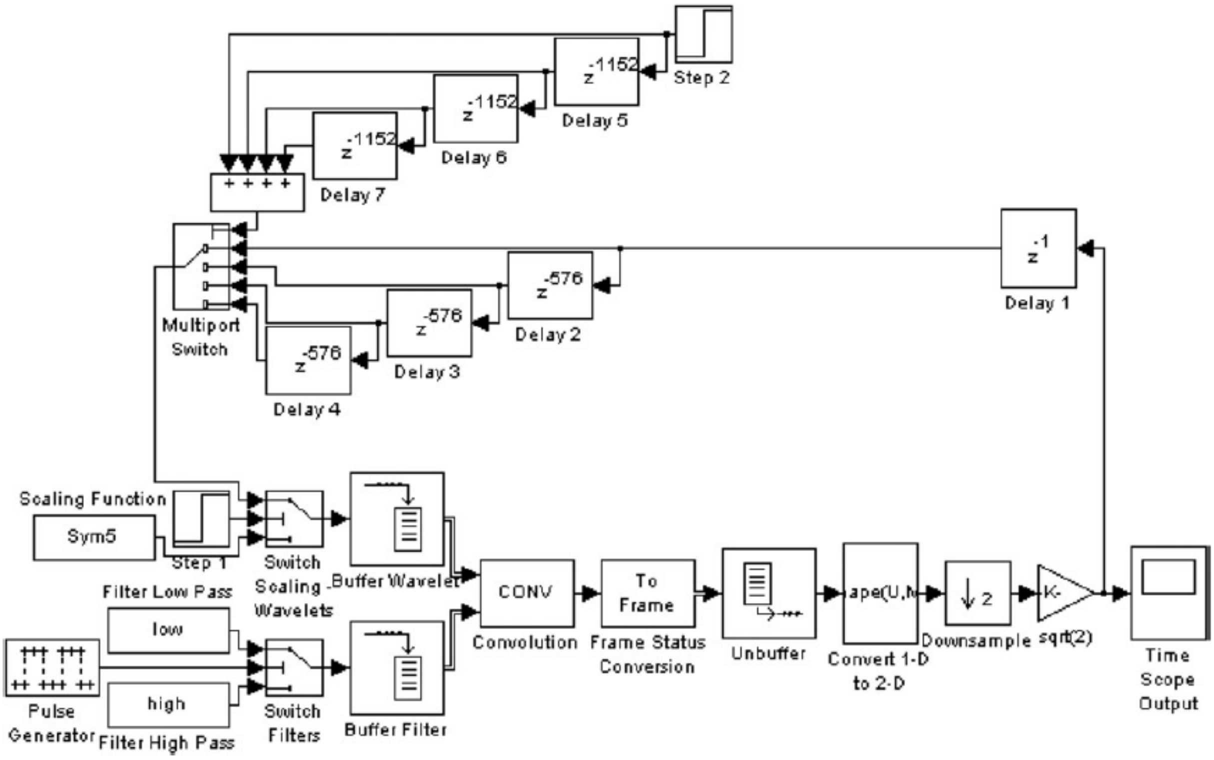

Fig1: convolution based circuit

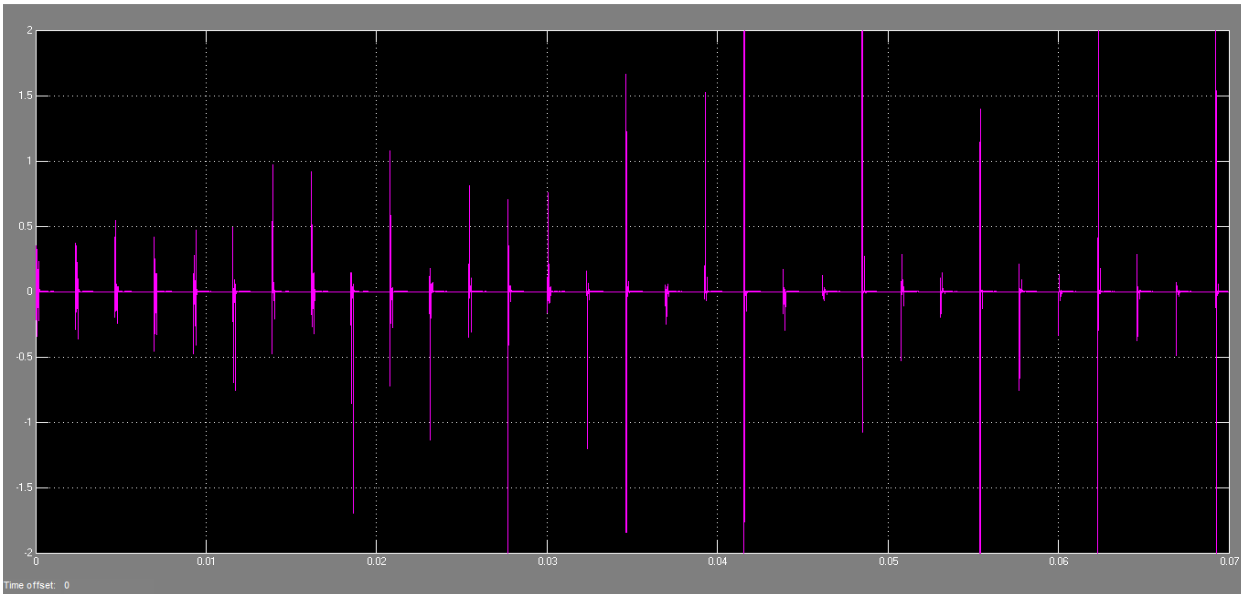

Fig6: Output for convolution based circuit

COMPARISON

To compare this these methods is to look at their output performance. To achieve this, the output of each circuit is compared against a reference set of wavelet. This benchmark is based on the desired wavelets generated with MATLAB wavelet toolbox {12} using the same parameters.

As can been seen in Fig.5, which displays the output of the sum-based circuits, it may be concluded that the generated wavelets are similar to the desired ones. Note that the first six pulses correspond to the successive iteration of the scaling function. In fig 6 it shows the output of the convolution based circuit, it can be seen again that the generated wavelets are in accordance to the desired ones and fig 7 shows the output of convolution by FFT-based

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circuit. One can notice that a small discrepancy occurs in the amplitude and time duration of the generated wavelets compared with the outputs of the other circuits. This is attributed to FFT constraint which requires the signal to be a power-of-two-length. However, their pulse shapes remain in correct proportion.

Indeed, as stated earlier, the main advantage of the convolution-based circuits is their compact structure that allows them to be implemented in small devices. On other hand, practical implementation of real-time convolution is not perfect as it generally performed by sliding windows. IN spite of being less compact than convolution-based structures, sum based circuits outweigh this problem by using mainly sum and gain blocks.Indeed,opposed to convolution techniques, real-time implementation of these components does not hold any negative implication.

CHARACTERISTICS

Even though these circuits are based on different approaches, they have some common characteristics. However, sum-based circuits include a scaling function generation by iteration. This implies some difference in the setup of some of the delay blocks compared with the convolution based circuits where the scaling function is stored in a bank, details will be given when this case occurs, in the following, N_{coeff} denotes the number of coefficients describing the reconstruction filters $\{p_{k}\}$ and $\{q_k\}$. note that the sampling time T_s in the convolution-based circuits is twice the sampling time used in the sum-based circuits.

At the initialization, the switch denoted switch scaling-wavelets is set such that the scaling function goes through the switch. When the scaling function is generated by iteration, note that the scaling function bank is replaced by a DSP constant C defined by

$$C = \frac{1}{Ncoeff - 1}$$

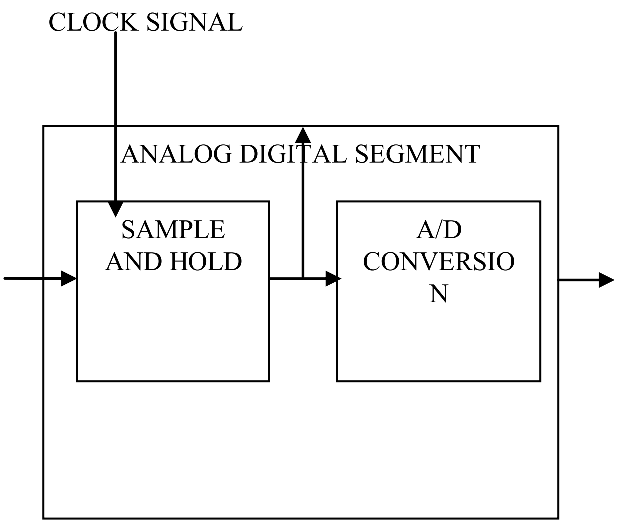
After the buffers and zero pad blocks are $2N_s$ in length in order to store the up sampled versions of the wavelets. Concerning the pulse generator that commands the switch denoted switch filters, its parameters are defined as follows:

The period is set to 8 N_s samples (4 N_s in the convolution based circuits due to the slowest sampling time).the pulse width is set to $4N_s$,or $4N_s+4N^{iter}$,N_s depending on the scaling function being stored in a bank, or generated by iteration respectively ($2N_s$ in the convolution-based circuits). In the above , N_{iter} denotes the number of iteration required to obtain a good version of the scaling function.

Concerning the delay, related to the gain describing the reconstruction filters coefficients in the sum-based circuits, their value is set to

$$\frac{Ns}{Ncoeff - 1}$$

ANALOG TO DIGITAL CONVERTOR



Figs 5 BLOCK DIAGRAM OF ADC

In this analog to digital convertor , the sampling and quantization is done where the high sampling frequency is executed and finally the data rate has been increased. In the above different circuits the implementation of adc can be used and the data transmission rate also increases, the output is shown below for the ADC

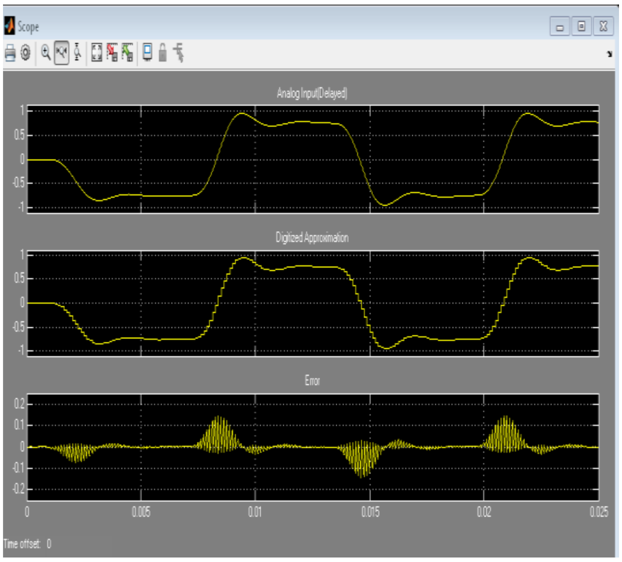


Fig6: output of the ADC

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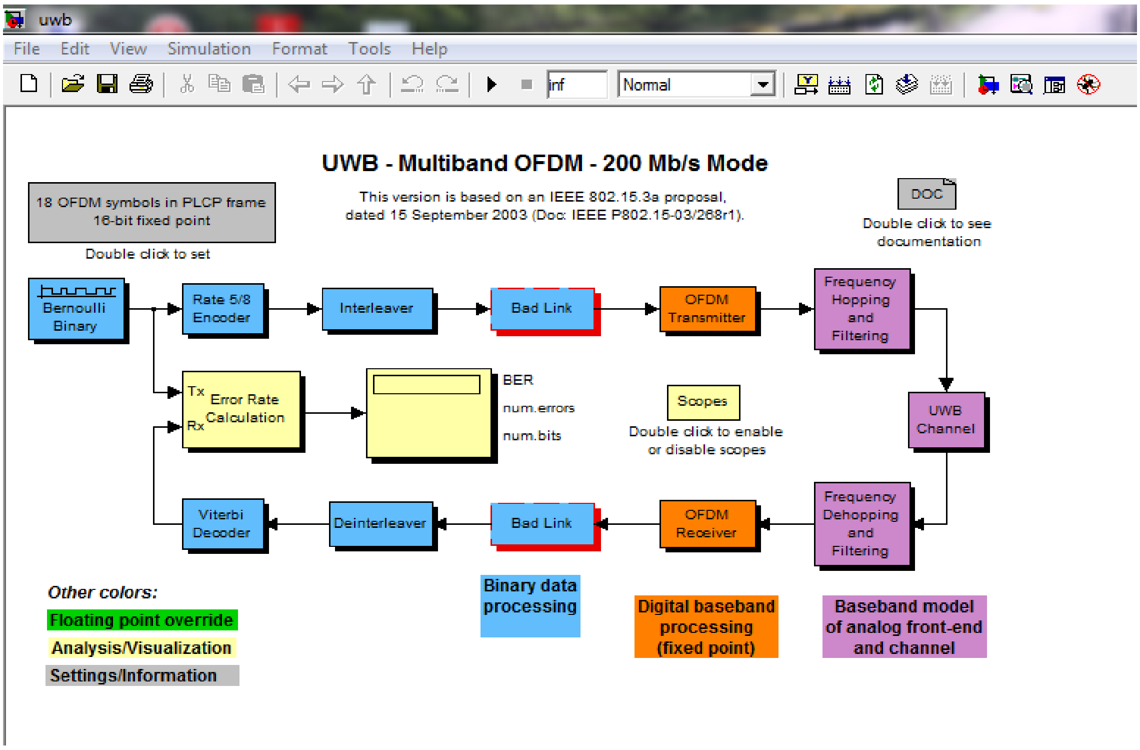

*** Generating UWB channel impulse responses ***

*** Channel model 1 ***
Model Parameters
Lam = 0.0233, lambda = 2.5000, Gam = 7.1000, gamma = 4.3000
std_ln_1 = 3.3941, std_ln_2 = 3.3941, NLOS flag = 0, std_shdw = 3.0000
Model Characteristics
Mean delays: excess (tau_m) = 5.0 ns, RMS (tau_rms) = 5
paths: NP_10dB = 12.5, NP_85% = 20.8
Channel energy: mean = -0.4 dB, std deviation = 2.9 dB

*** Channel model 2 ***
Model Parameters
Lam = 0.4000, lambda = 0.5000, Gam = 5.5000, gamma = 6.7000
std_ln_1 = 3.3941, std_ln_2 = 3.3941, NLOS flag = 1, std_shdw = 3.0000
Model Characteristics
Mean delays: excess (tau_m) = 9.9 ns, RMS (tau_rms) = 8
paths: NP_10dB = 15.3, NP_85% = 33.9
Channel energy: mean = -0.5 dB, std deviation = 3.1 dB

*** Channel model 3 ***
Model Parameters
Lam = 0.0667, lambda = 2.1000, Gam = 14.0000, gamma = 7.9000
std_ln_1 = 3.3941, std_ln_2 = 3.3941, NLOS flag = 1, std_shdw = 3.0000
Model Characteristics
Mean delays: excess (tau_m) = 15.9 ns, RMS (tau_rms) = 15
paths: NP_10dB = 24.9, NP_85% = 64.7
Channel energy: mean = 0.0 dB, std deviation = 3.1 dB

*** Channel model 4 ***
Model Parameters
Lam = 0.0667, lambda = 2.1000, Gam = 24.0000, gamma = 12.0000
std_ln_1 = 3.3941, std_ln_2 = 3.3941, NLOS flag = 1, std_shdw = 3.0000
Model Characteristics
Mean delays: excess (tau_m) = 30.1 ns, RMS (tau_rms) = 25
paths: NP_10dB = 41.2, NP_85% = 123.3
Channel energy: mean = 0.3 dB, std deviation = 2.7 dB

Output for UWB-multiband OFDM

OVERVIEW OF MULTIBAND OFDM

In the above circuit a MB-OFDM system for wireless UWB communication was described. The performance results show that this system is able to support a data rate of 200 Mbps at distance of over 10m. Thus the output of orthogonal frequency division multiplexing is high and the parameters values are discussed above.

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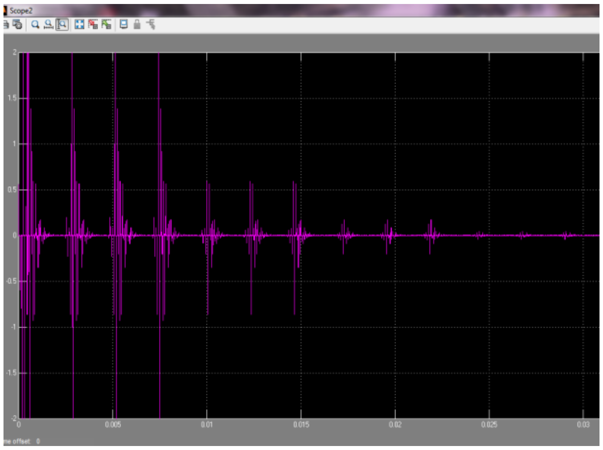

Fig8: Output for sum based circuit

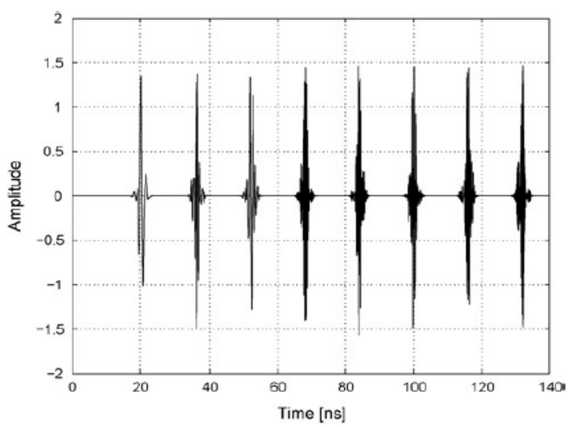

Fig9: output of the convolution by FFT based circuit

CONCLUSION

In this paper, different circuits have been seen, these circuits allowing the generation of wavelet packets pulse shape for ultra wideband communication. Each and every circuit has its advantages and its disadvantages. Moreover, a sum-based circuit is the good for the wavelet packets generation. We also used ADC (analog to digital convertor) to have these circuits fully operational. Therefore, there are many different circuits to generate these UWB pulses and some of them are discussed here. And newly the UWB-multiband OFDM is used to achieve high data transmission.

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