Design and Analysis of a High Data Rate Ultra-Wideband Transmitter for Narrowband Interference Avoidance

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Abstract- With the increase in wireless consumer electronics and services, interference between the wireless systems has become an important issue that must be addressed by finding proper hardware and software solutions. A typical computer station may have many wireless peripheral devices running at the same time, such as keyboard, mouse, printer, scanner, internet phone etc., which may interfere with devices such as Bluetooth, 802.11 wireless local area networks (WLANs), WiMAX, GPS, GSM, etc. Interference of these devices with each other and with other devices must be avoided or at least mitigated. Effective methods to mitigate interference among various systems have become a subject of much research effort. In the United States, the Federal Communication Commission (FCC) manages and regulates the wireless frequency spectrum. Traditionally, the FCC allocates bands of frequencies for various services, including cellular phones, GPS, AM and FM radio, and over-the-air television broadcasts [1]. These bands are typically non-overlapping, as each band assigned to a specific service. Some of these bands have been auctioned off, such as the PCS (Personal Communication Service) cellular bands, with licenses costing billions of dollars [2]. The FCC has also allocated various frequency bands that are license-exempted. These "unlicensed" bands, such as those around 2.4GHz and 5GHz, can be used to design and operate wireless systems without the need to obtain expensive licenses. Many wireless applications have flourished in these unlicensed bands, such as cordless telephones, Bluetooth [3] headsets, 802.11b/g WLANs [4], and WiMAX (Worldwide Interoperability for Microwave Access) [4]. Compared to the traditional method of having a single application per frequency band, multiple applications operating in the same frequency band is a more efficient use of the spectrum. However, many applications in the same frequency band lead to interference. This is analogous to a large room full of people talking; it can be difficult to ignore the noise and concentrate on a single conversation. To filter out interference from other systems, various techniques may be used. One of the important methods to operate a large number of computer peripherals with wireless connectivity is Ultra-Wideband (UWB) pulse systems. A variety of techniques for mitigating interference with other narrow band (NB) wireless systems have been suggested. Most of which however are either too complicated to implement or suffer inadequate performance. Recently however, a new type of pulse shapes have been developed analyzed and tested at IIUM Laboratories, have shown excellent compliance with the FCC regulations regarding Spectral Mask and Power Level requirements, which are especially important for Ultra-Wideband (UWB) systems [5]. The FCC has allocated 7.5GHz bandwidth for UWB use, from 3.1GHz to 10.6GHz [6]. Within this frequency band, there already exist many applications, such as the 5.8GHz unlicensed bands where 802.11a WLAN, cordless telephones, various radars, operate, and the WiMAX which operates at 3.7GHz. Since UWB systems also operate in these frequencies, they are a potential source of interference. The proposed research aims at producing a transceiver on a chip which employs the pulse shapes that have already been proven to comply with the rules of the FCC, which will provide an ultimate solution that circumvents all envisaged problems.

Keywords- *UWB, PLAN, Connectivity, Gb Pulse, MIMO*

I. INTRODUCTION

Ultra wideband (UWB) is a wireless communication technology based on short pulses in time, and ultra wideband in frequency in contrast with conventional narrowband wireless communication systems. The history of UWB has begun in 1895 when Marconi did his first experiment of transmitting pulses throughout his spark gap radio transmitter, while the first wireless link that connected two post offices in London was tested in 1901 [7]. However, the narrowband wireless communication systems have dominated over the wide band systems, where the narrowband systems are more spectrally efficient. In the beginning of 1960s, the interest on using the UWB in military purposes has back, while the term "Ultra Wide-Band" is considered in 1989 by the U.S. Department of Defence (DoD). After the U.S. Federal Communication Commission (FCC) has recognized the significance of the UWB technology, the authorization of using the UWB in commercial uses has been given in 2002. The FCC main regulations for the UWB include restricting the maximum pulse power to -41.3 dBm/MHz at the license-free frequency range between 3.1-10.6 GHz and with a pulse bandwidth larger than 500 MHz (FCC E.T Docket 98-153 2002).

These UWB FCC regulations are for a short range wireless communication up to ten meters, which the work of this thesis is related to, while there are other spectral masks for other UWB applications like the UWB FCC spectral mask for vehicular radar systems. The FCC indoor and the outdoor spectral masks that limit the level of the Effective Isotropic Radiated Power (EIRP) for UWB systems are shown in Figure 1.

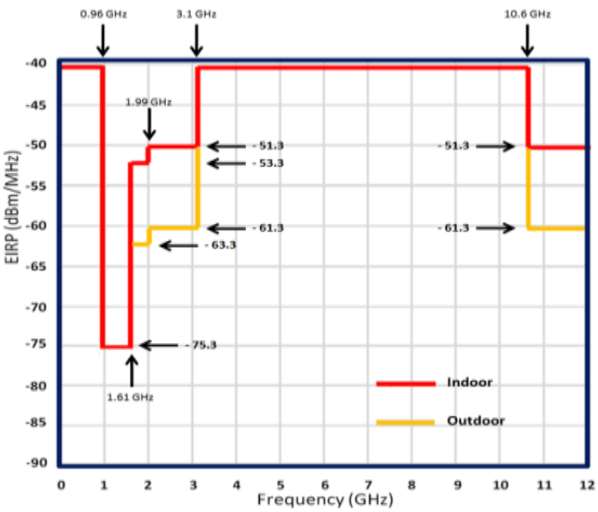

Fig.1: UWB FCC spectral mask for indoor and outdoor systems [7].

II. TRANSMISSION TYPES

There are two types of UWB systems based on the transmission type and the way of using the UWB bandwidth. The first type is the impulse radio ultra wideband (IR-UWB) technique, which represents the main type of the UWB technology and depends on using the UWB bandwidth as a one part [7]. IR-UWB represents the main transmission type of UWB because it is similar to the technique that is used by Marconi in 1895, while the second type is actually derived from the main type. The second type is called Multi-Band Orthogonal Frequency Division Multiplexing (MB-OFDM) and depends on dividing the UWB bandwidth into multiple bands of minimum 500 MHz [7]. The Direct Sequence UWB (DS-UWB) technique is considered as a type of IR-UWB, where Code Division Multiple Access (CDMA) can be used for multi-access. However, this research is focused on the main principle of the UWB which is the IR-UWB.

III. MODULATION TYPES

Different modulation techniques have been used in the UWB systems, where some of them are similar to the modulation techniques that are used with narrowband systems while other modulation techniques are different. One of the modulation techniques that are commonly used is Pulse Position Modulation (PPM), which is called Time Modulation (TM) as well. In PPM, the UWB transmitter sends the pulses at specific instances of time, where if the pulse is received before the reference or at the reference then the pulse represents 0, while if after the reference then the pulse represents 1. The On-Off Keying (OOK) is a simple modulation technique for UWB, where it depends on the presence and absence of the pulse to represent 1 and 0 respectively. Bi-Phase Modulation (BPM) is another modulation for UWB and it is called BPSK (Binary Phase Shift Keying) as well [7], where usually there are two pulses with phase difference of 180^o to represent the 1 and 0.

IV. TRANSMITTER MODEL

Figure 2 below shows the proposed transmitter block diagram, which consists of pulse generator, modulator, and antenna.

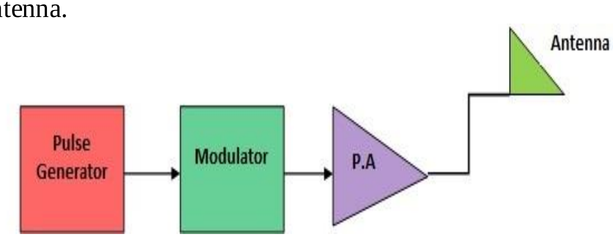

Fig.2: Block diagram for the proposed transmitter.

Half-wave rectified sine wave pulse generator proposed by [5], [8-10], as a new simple technique by using a sine wave rather than using one of the conventional Gaussian family of pulses, which lead to a complex transceiver. This approach is chosen to generate the required half rectified sine wave is different from the regular use of half wave rectifier circuits, like diode and AND Gate because of their limitations [11]. Instead, two 1 GHz sources are used with mixer 1. One is a sine wave (s1) and the other is a train of square pulses (s2) with pulse width 0.5ns. Mixer 2 is used to shift the spectrum of the generated half-wave rectified sine wave. The frequency of s4 is 8 GHz, it represents the shifting frequency. Shifting the spectrum pushes the fundamental harmonics to the upper part of the FCC mask for the UWB. A Parallel coupled micro-strip filter has been selected for his wide bandwidth and simple implementation. From the different types of band-pass filter responses like Bessel, Butterworth and Chebyshev, it is found that the Chebyshev response is more suitable, because it has a good attenuation rate beyond the band-pass range, which is important to shape the spectrum. Figure 3 shows the output pulse from the Chebyshev filter in time and frequency domains [8-10].

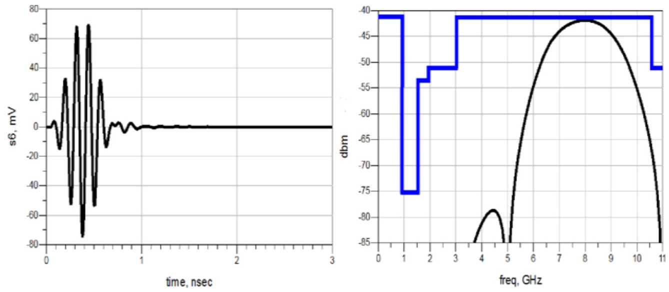

Fig.3: The filter output in time and frequency domains. The generated pulse has spectrum with power concentrated between 5 GHz to 11 GHz [8-10].

The modulator and antenna will be discussed in the preliminary results in Section X.

V. RECEIVER MODEL

The receiver architecture is broadly categorized into two types namely, non-coherent and coherent architecture [12] as follows:

A. Non-coherent receiver architecture

Figure 4 illustrates the typical non-coherent receiver architecture for pulse based UWB. Use of BPSK modulation is most common in this kind of architecture. The received pulses are amplified by the LNA (Low Noise Amplifier). They are self-mixed at the mixer and passed through the low pass filter. The VGA (Variable Gain Amplifier) then amplifies the pulses which are then compared by the comparator to detect the base band data. This architecture is very simple because the complex synchronization circuits are not necessary as in coherent receiver. Furthermore, the influence of multi-path and non-linearity of antenna is also less in this architecture. However, since the received signal amplitude is very low, the amplitude of mixer output after self-mixing the pulses is extremely low. A number of gain stages are required in order to bring the signal to a detectable level. This in turn increases the power consumption of the circuit, so this research deals with this receiver.

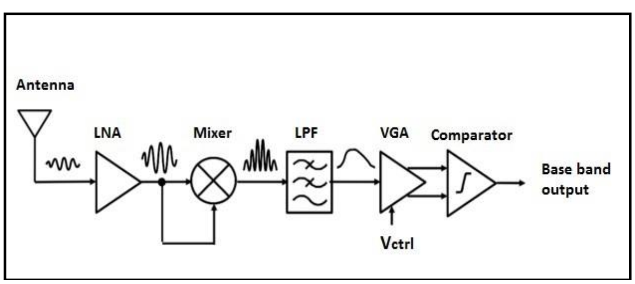

Fig.4: Non-coherent receiver architecture [12].

B. Coherent receiver architecture

As illustrated in Figure 5, the coherent receiver typically consists of a template pulse generator and timing controller for controlling the generation of template pulses. Unlike non-coherent architecture, the received pulses are first amplified, then mixed with template pulses and then passed through integrator and comparator to get the original data.

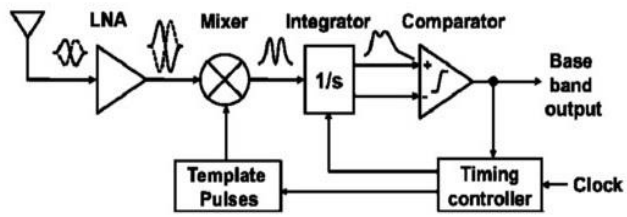

Fig.5: Coherent receiver architecture [12].

VI. PROBLEM IDENTIFICATION

The UWB interference on narrowband systems is a major problem that limits the use of UWB technology in a wide variety of applications. The UWB pulsed signal does not only degrade the performance of the narrowband systems, but it may cause a total signal block.

1. It has been shown in [13] that The UWB source gives interference very similar to Gaussian noise for both Bluetooth and GSM.
2. From [14] showed that the range for the minimum data rate of the IEEE 802.11a WLAN get reduced by five times of the initial distance in case of hemispherical distribution of UWB transmitters around the WLAN receiver. Since, the IEEE 802.11a WLAN operate inside the UWB spectrum, so the co-existence of both technologies will be a big challenge.
3. In [15] revealed that UWB source added many bits for both WiMAX and UTMS receivers and vice versa.
4. It has been shown in [16] that the critical case of attenuation in the signals and sometimes the signals blocked in the hospital where all technologies worked together like UWB, PCS, WiMAX, WLAN IEEE 802.11a/b/n.
5. In other hand C-band satellite TV reception suffers total loss of sound and picture when the TV antenna is within the effective range of the UWB device of a few meters [17]. Figure 14 below shows the interferences among these wireless technologies.

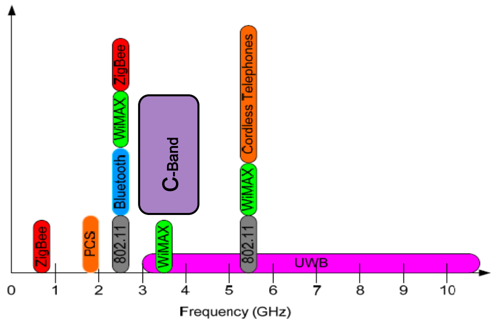

Fig.6: The interferences among wireless technologies [17].

As seen in Figure 6, there are 3 NB systems interfere with UWB from 3.1 to 10.6 GHz as follows:

- WiMAX based IEEE 802.16d for internet access at 3.4 GHz.
- C-Band T.V. satellite around 4 GHz.
- Mobile WiMAX based IEEE 802.16e for mobile phone; WiFi based IEEE 802.11 a/n for internet access, and Cordless Telephone at 5.5 GHz.

VII. OBJECTIVES OF THE STUDY

1. To design, analysis, and implementation of a micro-strip monopole antenna connected to the half rectified monocycle sine wave pulse generator that operates between 5-11 GHz and 5.5-11 GHz [5], and [8-10] to transmit IR-UWB pulses which operate within FCC high data rate limit from 6 to 10.6 GHz by means a transmitter design.

2. Open Issue Design, analysis, and implementation of a non-coherent receiver with the same micro-strip monopole antenna as designed for the transmitter.

3. Combine the transmitter in item 1 and the receiver in item2 together on a chip to achieve a transceiver that operates from 6-10.6 GHz.

4. Benchmark the simulation and practical results with the pervious works in a data rate, energy consumption, distance, and technology.

VIII. METHODOLOGY

The methodology adopted in this paper in order to achieve the set of objectives above is as stated below and shown in Figure 7.

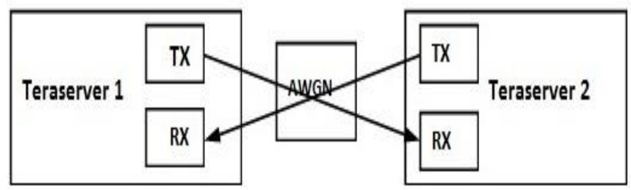

Fig.7: Methodology block diagram.

a. Investigate on the transceiver techniques that have been used in the recent methods of UWB interference mitigation.
b. Proposed a novel transceiver that consists of a transmitter and receiver is as stated below.
   The proposed transmitter model explained in Section IV, which consists of a half rectified sine wave pulse generator that proposed in [5], and [8-10] which operates from 5-11 GHz and propose an OOK modulator with a micro-strip monopole antenna, that match with the proposed pulse generator in [5], and [8-10].
   The proposed receiver includes a wideband Low Noise Amplifier (LNA), a multiplier as squarer, an analog integrator, a hold buffer (S/H) and a comparator which acts like a simple Analogue to Digital Convertor (ADC) as shown in Figure 8 below.

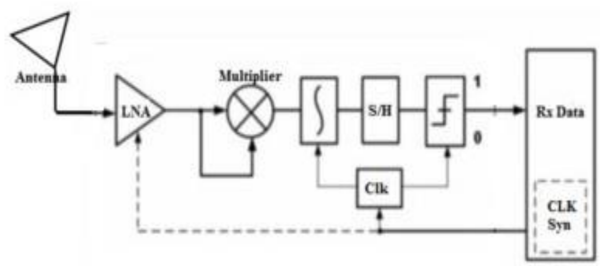

Fig.8: Block diagram for the proposed receiver.

Propose IR-UWB Transceiver based on the investigations from above, the following architecture is proposed for IR-UWB transceiver design, which combines the transmitter and receiver by analogue switch shown in Figure 9 below:

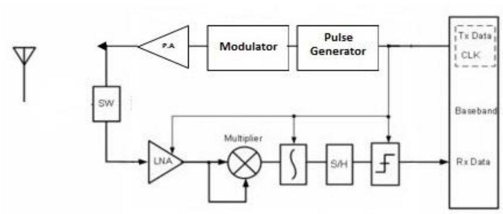

Fig.9: IR-UWB transceiver.

AWGN (Additive White Gaussian Noise) channel assumed between transmitter and receiver, by means between two transceivers. The Noise is fixed for a fixed bandwidth.

IX. SCOPE

The scope of the paper is assigned to the IR-UWB transmitter rather than the MB-UWB and uses portions the monocycle sine wave pulses generator proposed in [5], and [8-10], with a micro-strip monopole antenna and the future work will be IR-UWB Non-Coherent Transceiver rather than coherent.

X. RESULTS

Pulse Generator (Review Previous Work Simulation) [5], [8-10] as shown in Figure 10, the block diagram of the proposed UWB pulse generator [5], and [8-10], consists of two mixers and one band-pass filter. Microwave mixers can be used like double balanced mixer or stages as follows:

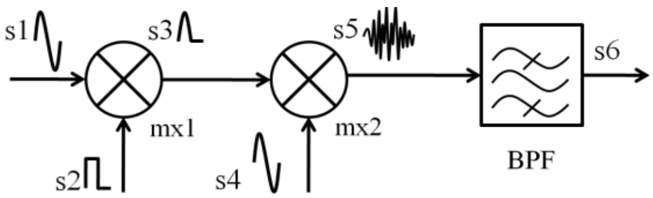

Fig.10: The proposed IR-UWB pulse generator block diagram [5], [8-10].

A. *Generate Half-Wave Rectified Sine Wave*

The approach that has been chosen to generate the required half-wave rectified sine wave does not use a regular half wave rectifier circuits like diode or AND gate, because their limitations [11, 2009]. Instead, two sources are used with mixer 1. Both sources are working on 1GHz with 1V. The pulse width of the square pulse train s2 is 0.5ns as in Figure 11 and Figure 12 shows the signal S3, which outputs from Mixer 1 in time and frequency domain.

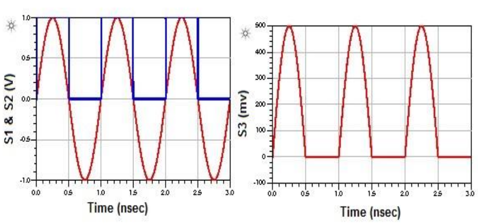

Fig.11: A 1GHz half-wave rectified sine wave on the right plot.

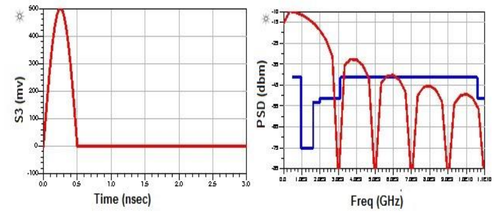

Fig.12: The signal S3, outputs from Mixer 1 in time and frequency domain.

B. *Pulse Spectrum Shifting*

Mixer 2 is used to shift the spectrum of the generated half-wave rectified sine wave. The frequency of s4 represents the shifting frequency and it is 8GHz. Shifting the spectrum has been used to shift the fundamental harmonics to the upper part of the UWB FCC mask. Figure 13 shows the signal S5, which outputs from mixer 2 in time and frequency domain.

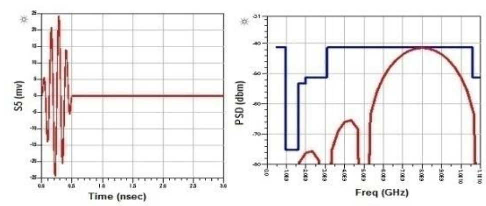

Fig.13: The signal S5, which outputs from mixer 2 in time and frequency domain.

C. *Filter the Generated Half-Wave Rectified Sine Wave*

Parallel coupled micro-strip filter has been selected for his wide bandwidth and simple implementation. Different types of band-pass filter response, like Bessel, Butterworth and Chebyshev are available. Chebyshev response is selected because it has good attenuation rate beyond the band-pass range, which is important to shape the spectrum to adjust the UWB pulse spectrum. Figure 14 shows the signal S6, which outputs from filter in time and frequency domain.

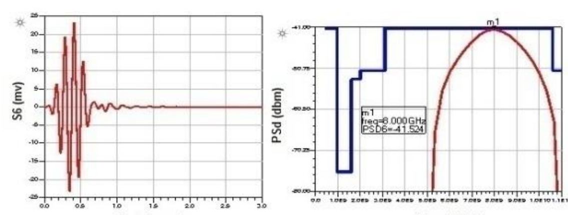

Fig.14: The signal S6, which outputs from filter in time and frequency domain.

Complementary Work

(a) Modulator Design

Proposed transmitter uses a simple OOK (On-OFF Keying) modulator. OOK is a modulation scheme that does not require pulse negation [7]. In OOK, the data is represented by presence or absence of a pulse (e.g., symbol"1" is represented by transmitting a pulse, and symbol"0" by transmitting nothing.) [7]. Figure 15 below shows the schematic diagram of OOK modulator. OOK modulator consists of Bit Sequence Generator with one symbol by means 8 bits "11110110" that equivalent to decimal No. 9, so this modulator transmits No.9 as a 7- Segment display. The last bit"0" is for the dot in 7-Segment display. These bits sequences multiply by a pulse generator by using AND Gate.

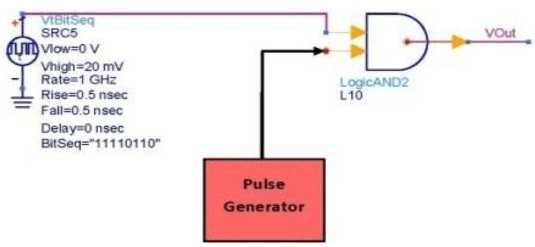

Fig.15: OOK modulator.

(b) Antenna Design and Result

Antenna design in ultra-wideband (UWB) systems is a major challenge. For, in contrast to conventional systems, wherein waveform distortion by the antenna is negligible, there is potentially significant waveform distortion by UWB antennas. A further challenge to UWB system design is posed by mandated limits on power spectrum density, such as the FCC emission mask, so this transceiver uses the same simple monopole antenna for both transmitter and receiver that operate from 6-10.6 GHz, because the monopole antenna is a good candidate for IR-UWB that operate from 6-10.6 GHz [18, 2011]. UWB antennas act as band-pass filters [19, 2008], therefore the proposed antenna consists of a high-pass and low-pass filters with the resistance radiation (Rrad). The (Rrad) is an important parameter to reproduce the radiated waveform, furthermore, the transfer function [19, 2008]. The optimizations of the component values are made in Agilent ADS 2013.06. Figure 16 below shows the schematic diagram for the proposed RLC monopole antenna with the antenna gain result at 0.7 (-1.54 dB) to pass frequencies from 6-10.6 GHz.

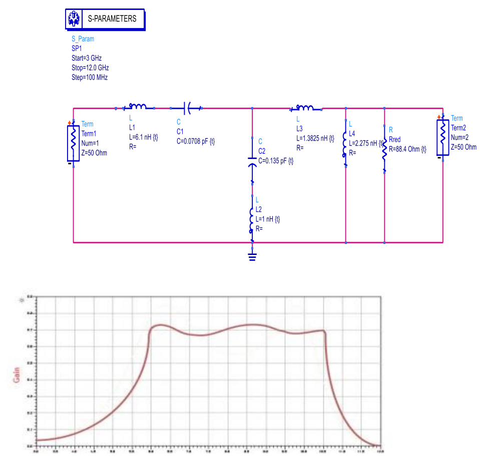

Fig.16: Schematic diagram for the proposed monopole antenna with the antenna gain result at 0.7 (-1.54 dB) to pass frequencies from 6-10.6 GHz.

On Chip Antenna Design

By simulating in a momentum software package under Agilent ADS 2013.06, the on chip monopole antenna designed in the air layer and it operates at 8.3 GHz, then $\lambda = c/f$, where c is the speed of the light which = 3*10^8 m/sec^2, then the length of the antenna = 36 mm and the size(s) $= \frac{\lambda}{4} = 9\,mm$. The width (W) of the antenna is adjusted by the Agilent ADS 2013.06 tuner which equal to 2.4 mm. Figure 17 shows on chip monopole antenna prototype made of copper with L=36 mm, W=2.4mm, and S=9 mm and it placed on the air layer over the GaAs layer. The GaAs layer is assigned to transceiver design. Figure 18 shows the antenna gain for both RLC and a prototype monopole antenna at 0.7 (-1.54 dB).

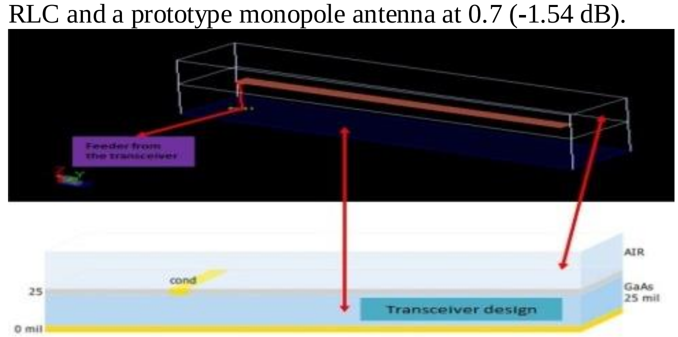

Fig.17: On chip monopole antenna prototype with L=36 mm, W=2.4mm, and S=9mm on the top of GaAs layer.

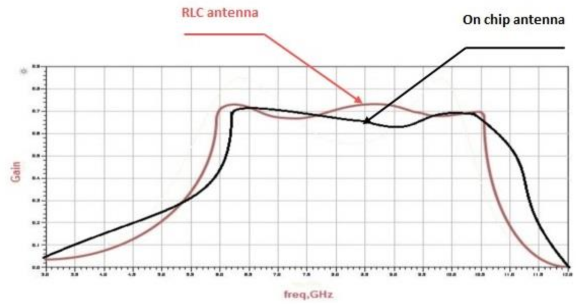

Fig.18: Antenna gain for both RLC and a prototype monopole antenna at 0.7 (-1.54 dB).

Transmitter Design and Results

Figure 19 below shows the block diagram for the proposed transmitter.

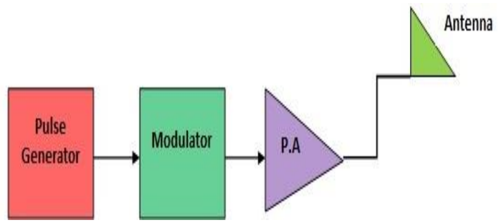

Fig.19: Proposed transmitter block diagram.

The complete transmitter design and schematic in Agilent ADS 2013.06, which comply with FCC mask indoor and outdoor, shown in Figure 20 and Figure 21 shows the output pulse from the transmitter in time and frequency domain.

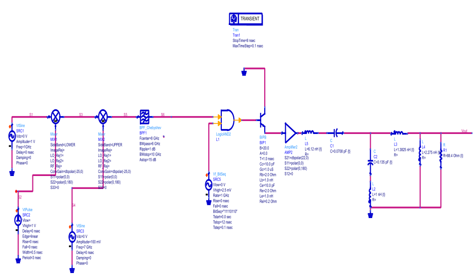

Fig.20: Transmitter schematic and design in Agilent ADS 2013.06.

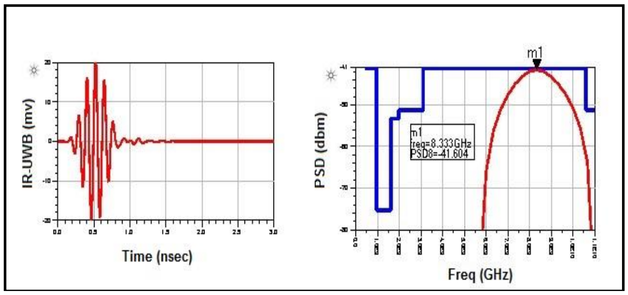

Fig.21: Output pulse from transmitter in time and frequency domain with 20mV p.p

As mentioned in modulator design this transmitter transmits one symbol by means 8 bits "11110110" that equivalent to decimal No. 9, so this transmitter transmits No.9 as a 7- Segment display. The last bit"0" is for the dot in 7-Segment display, this work is only to check the proposed IR-UWB transmitter. As shown in Figure 22, the base-band signal (bits) carried by the repeated IR-UWB at 8 nsec to transmit pass-band signal.

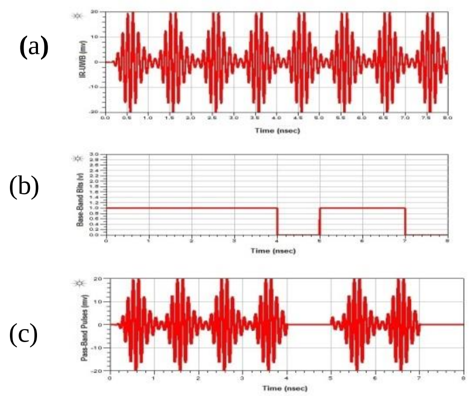

Figure 22: IR-UWB pulses are shown in (a), base-band signal (bits) is shown in (b), and pass-band signal is shown in (c).

XI DISCUSSION & CONCLUSIONS

As seen from Figure 20: Transmitter schematic and design in Agilent ADS 2013.06. This transmitter used 2 Mixers for pulse shaping, its known that the Mixer increases the voltage, so the gain conversion adjusted from dbpolar (0,0) to dbpolar (-25,0). For the Mixer 1, the side band LOWER selected to be *If-Rf*= 2 GHz (where the square pulse width=0.5 nsec, *f*=1/0.5=2 GHz) - 1 GHz= 1 GHz. And for the Mixer 2, the side band UPPER selected to be *If+Rf* =1GHz+7GHz = 8 GHz. The band-pass filter type BPF_Chebyshev selected and adjusted its parameters as *fc*=8 GHz, BWpass=6 GHz with Ripple =1 db, BWstop= 10 GHz with Astop= 15 db. Biploar transistor used as a common collector (buffer means input=output and it do not use for protection the input maybe burned by the output and vice versa) between the pulse generator and the antenna, because the antenna affected on the pulse that generated from the pulse generator, which make a distortion in the PSD, also the transmitter used the Power

Amplifier (PA) for two reasons, firstly the antenna works as a power attenuator and secondly to transmit the pass-band signal to 10 m. The parameters for the Power Amplifier adjusted to S11=S12= dbpolar (0,0), S22= dbpolar (0,180), S21= dbpolar (22,0), the later is an important parameter for the power increasing.

This paper concluded that the pulse generator which proposed in [5, 2012], [8, 2011], [9, 2012], and [10, 2012] interferes with 5 GHz and 5.5 GHz. The important problem is in the around frequency 5 GHz as mentioned in the Problem Identification, Section VI, so it has been published a paper concerned with the overlapping frequency around 5 GHz among wireless technologies in [20, 2010]. The author in [20, 2010] solved the problem by notching PSD around 5 GHz as shown in the Figure 23 below, therefore, the RLC/on chip monopole antenna solved two problems, first modified the frequency range for the pulse generator from 5, 5.5- 11 GHz to the FCC high data rate frequency limit from 6-10.6 GHz. Second, by added the antenna to the pulse generator, the later became a transmitter that required gain within 1 m distance comes out to be -1.54 dB.

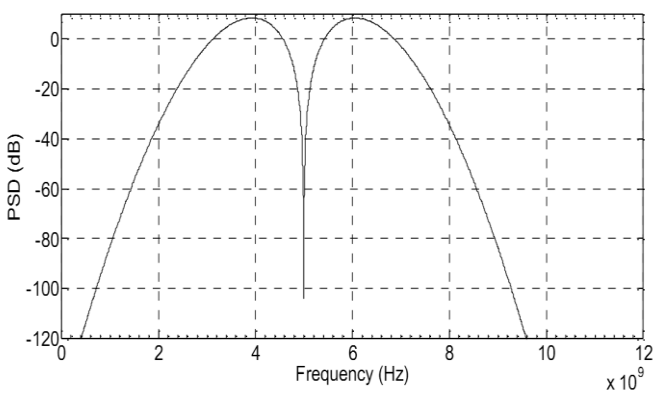

Fig.23: The generated pulse spectrum in [20, 2010] with creating a notch around 5 GHz for NB interference mitigation.

XII REFERENCES

[1]. FCC Online Table of Frequency Allocation, 47, C.F.R.&2.106, Revised on April 16, 2013, Federal Communications Commission, Office of Engineering & Technology, Policy & Rules Division, 2013.

[2]. Wireless Telecommunications and Wire line Competition Bureaus Seek Comment on NTUA Wireless, LLC'S Petition for Forbearance Form Eligible Telecommunications Carrier service area Requirement, Federal Communications Commission 445 12th St., S.W. Washington, D.C. 20554, Released: November 1, 2013.

[3]. Inigo Puy, "Bluetooth", Hochschule Furtwangen University, pp. 1-20, 2008.

[4]. IEEE Standard for Information Technology- Telecommunications and Information Exchange between Systems-Local and Metropolitan Area Networks-Specific Requirements, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, IEEE Computer Society, Sponsored by the LAN/MAN Standards Committee, 2007.

[5]. Ahmed R. Mohammed (Supervised by Prof. Dr. Eng. Khalid A.S. Al-Khateeb), "Novel Ultra-Wideband Pulse Generation Technique and Narrowband Interference Mitigation, A Thesis Submitted in Fulfillment of the Requirement for the Degree of Doctor of Philosophy, Kulliyyah of Engineering, IIUM, Malaysia, 2012.

[6]. Federal Communications Commission, "Revision of part 15 of the commission's rules regarding ultra-wideband transmission systems: First report and order," Apr. 2002. ET-Docket 98-153.

[7]. H. Nikookar, et al., "Introduction to Ultra Wideband for Wireless Communications", England, Springer, 2009.

[8]. K. Al-Khateeb and A. Mohammed, "A 1-Gbps IR-UWB Pulse Generator for 802.11a and WiMAX Interference Avoidance", 2011 IEEE 3rd International Conference on Communication Software and Networks (ICCSN), pp. 446-449, 2011.

[9]. Ahmed R. Mohammed, et al., "Novel Low Cost IR-UWB Pulse Generator Based on Monocycle Sine Pulse Shaping", International Journal of Electronics, Taylor & Francis Publications, 00:00, 0000-0000. (ISI with Impact Factor 0.440). ISSN (Online): 0020-7217, ISSN (Print): 1362-3060, 2012.

[10]. Ahmed R. Mohammed, et al., "A Novel IR-UWB Pulse Generator Design Using BPM and FM Technique", Istanbul University - Journal of Electrical and Electronics Engineering, IU-JEEE Vol. 12, No. 2, pp.1505-1509, 2012.

[11]. M. Kumngern, "A Wide-Band Half-Wave Rectifier," Integrated Circuits, ISIC '09. Proceedings of the 2009 12th International Symposium On, vol., no., pp.A98-501, 14-16, 2009.

[12]. A. Schenk and Robert F. Fischer, "Multiple-Symbol-Detection-Based Non-coherent Receivers for Impulse-Radio Ultra-Wideband", Int. Zurich Seminar on Communications (IZS), pp. 70-73, 2010.

[13]. http://www.ofcom.org.uk/static/archive/ra/topics/research/rtcg/.

[14]. Santosh Reddy Mallipeddy and Rakhesh Singh Kshetrimayum, "Impact of UWB Interference on IEEE802.11a WLAN System", Communications (NCC), 2010 National Conference on Communication, pp. 1-5, 2010.

[15]. V. Somayazulu, et al., "Detect and avoid (DAA) mechanisms for UWB interference mitigation", in Proc. IEEE Intl. Conf. Ultra-Wideband (ICUWB), Waltham, MA, USA, pp. 513- 518, 2006.

[16]. http://www .kaloramainformation.com/Wireless-Opportunities-Healthcare-6501845/

[17]. Y.Wang, and J. Coon, "Active Interference Cancellation for Systems with Antenna Selection" IEEE International Conference on Communications (ICC 2008), pp.3785-3789, 19-23, 2008.

[18]. Lu Guofeng, et al., "Antenna and Pulse Designs for Meeting UWB Spectrum Density Requirements", IEEE Conference on Ultra Wideband Systems and Technologies, pp. 162-166, 2011.

[19]. B.S.Yarman, "Design of Ultra-Wide Band Antenna Matching Networks", Springer, 2008.

[20]. V. Mir-Moghtadaei et al., "A New UWB Pulse Generator for Narrowband Interference Avoidance' 15th IEEE Mediterranean Electrotechnical Conference, pp. 759-763, 2010.

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