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Design and Analysis of a Gaussian UWB Pulse Generator with sensing techniques

N. Revathy* and C. Gomathy**

ABSTRACT

This paper presents a Gaussian UWB transmit only pulse generator which has resistive and capacitive sensing . The pulse generator is designed for IEEE 802.15 Wireless Body Area Network (WBAN) technology which uses short pulse width to achieve low power consumption without multipath fading and interference and it provides inter-operability with other narrowband technologies. The pulse generator has a VCO in which the sensing techniques are analysed.Three configurations of pulse generators for UWB transmit-only system is presented for low power applications. The Gaussian pulses satisfy UWB power and frequency constraints. The first configuration is tunable pulse generator, which consumes power of 5.45 µW and is applicable to local personal communication system. In the next configuration, resistive sensing controls the voltage in a VCO, it consumes power of 0.145 µW at frequency of 46 MHZ. The capacitive sensing has reduced number of buffer stages generates power of 0.133 µW at 250 MHz frequency. The simulation results show the performances of the pulse generators which meets the FCC requirements.

Index Terms: Ultra Wideband (UWB); Wireless Body Area Network (WBAN); Ultra Wide Band (UWB) transmitter; Voltage Control Oscillator (VCO); UWB Transmit-only system; Tunable pulse generator; resistive sensing; capacitive sensing

1. INTRODUCTION

Ultra Wideband (UWB) is a radio technology having bandwidth exceeding lesser of 500MHZ or 20% arithmetic centre frequency according to Federal Commissions Committee (FCC). Ultra Wideband is a future wireless low power communication technology, with its applications in a private and commercial sector. [1] UWB technology has vast potential for low-power, low-cost radio as it transmits information through short base band pulses without employing a carrier. In order for UWB applications to coexist with common wireless communication systems without any interference, the FCC has defined PSD masks for different applications. A substantial change occurred in February 2002, when the FCC issued that UWB could be used for data communications as well as for imaging and location applications[1].

FCC has defined UWB in three bands: 0~960 MHz, 3.1~10.6 MHz and 22~29 MHz The work focuses on the first band as it has a longer transmit distance, lower power consumption and lower complexity of implementation, suitable for implementation in low data rate applications such as WBAN [3][5], wireless sensor networks, RF-ID, portable instrumentation etc.

WBAN represents the relationship between connectivity and miniaturization of devices. It consists of a number of devices which is placed or implanted in a person body that is used for a number of applications including medical, consumer electronics, personal entertainment and others. The FCC has approved the allocation of 40 MHz of spectrum bandwidth for medical BAN low-power, wide-area radio links at the 2360-2400 MHz unlicensed band and may be used in all areas including residential. In the UWB system, the considerable complexity on receiver side enables the development of ultra low power and low complex UWB transmitters for uplink communication, thereby making it a perfect candidate for WBAN. The low

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power radio technology such as Bluetooth and Zigbee cannot meet this stringent constraint and new pioneering solutions must be found. To adapt to this requirement and to have power consumption less than 100μW, the UWB technology is used. The two designs of pulse generators of a UWB transmitter is discussed in the following section. The details about the performance metrics of UWB pulse generator obtained for WBAN applications.

In this paper we present the design and measured results of an integrated FCC-compliant UWB transmitter circuit that exhibits high efficiency. The measured power consumption of 0.145 ìW compares very favorably to all other UWB-IR Transmitter designs. This transmitter circuit can be controlled to operate in 3 different bands of UWB FCC regulations. To the best of our knowledge, at such low power, the design presented here is the lowest power transmitter reported for this range of pulse-rates.

2. UWB TRANSMITTER ARCHITECTURE

The block diagram of UWB transmitter is shown in Figure 1 which consists of a pulse generator, pulse shaping circuit and an antenna. The proposed pulse generator generates pulses optimally with the desired centre frequency and bandwidth. It can adjust the pulse width, adding flexibility for use with different UWB applications. [6-8]The pulses determine the power spectrum of the transmitted signals. To ensure enough current is fed into the pulse shaping circuit, a buffer is designed in the pulse generator.

3. THE PULSE GENERATOR

The Pulse Generator (PG) is the essential component in the UWB transmit only system. It is the most critical block in terms of power and frequency specifications. [9] This paper proposes three configurations of UWB pulse generators. The three different pulse generators are designed and analyzed based on power and frequency parameters obtained corresponding to control voltage input.

Design 1: Tunable Pulse Generator

The schematic of our pulse generator is shown in Fig. 2. It is composed of 2 components: a voltage control ring oscillator (VCRO) and an output buffer [2] [14]. The heart of the proposed PGs is the ring oscillators.

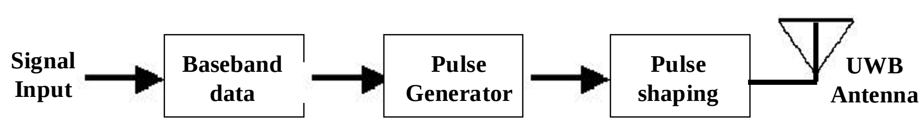

Figure 1: UWB Transmitter Architecture

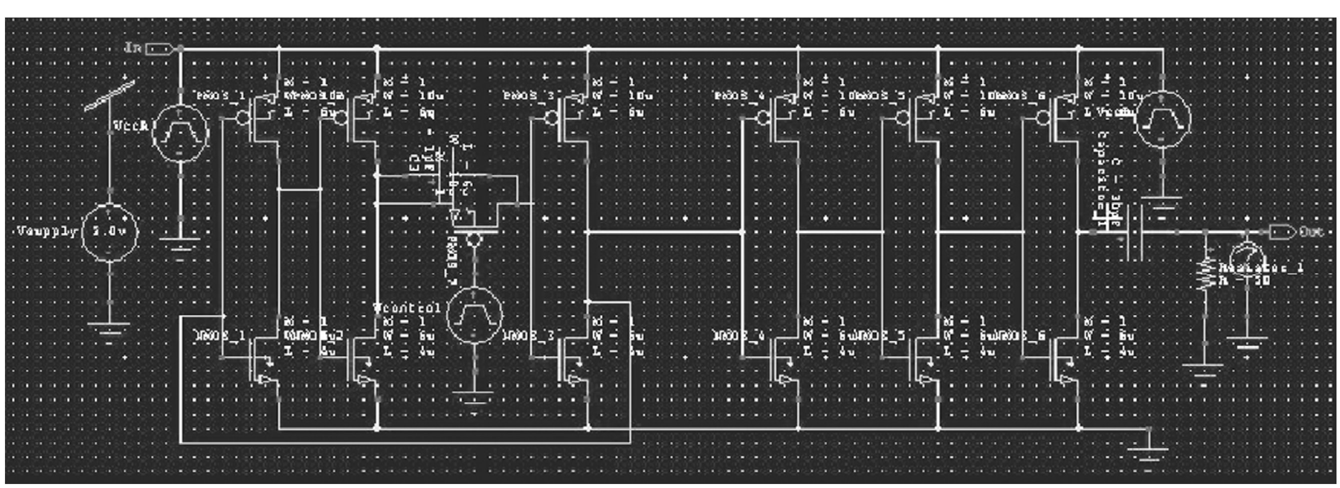

Figure 2: Schematic of Tunable Pulse Generator

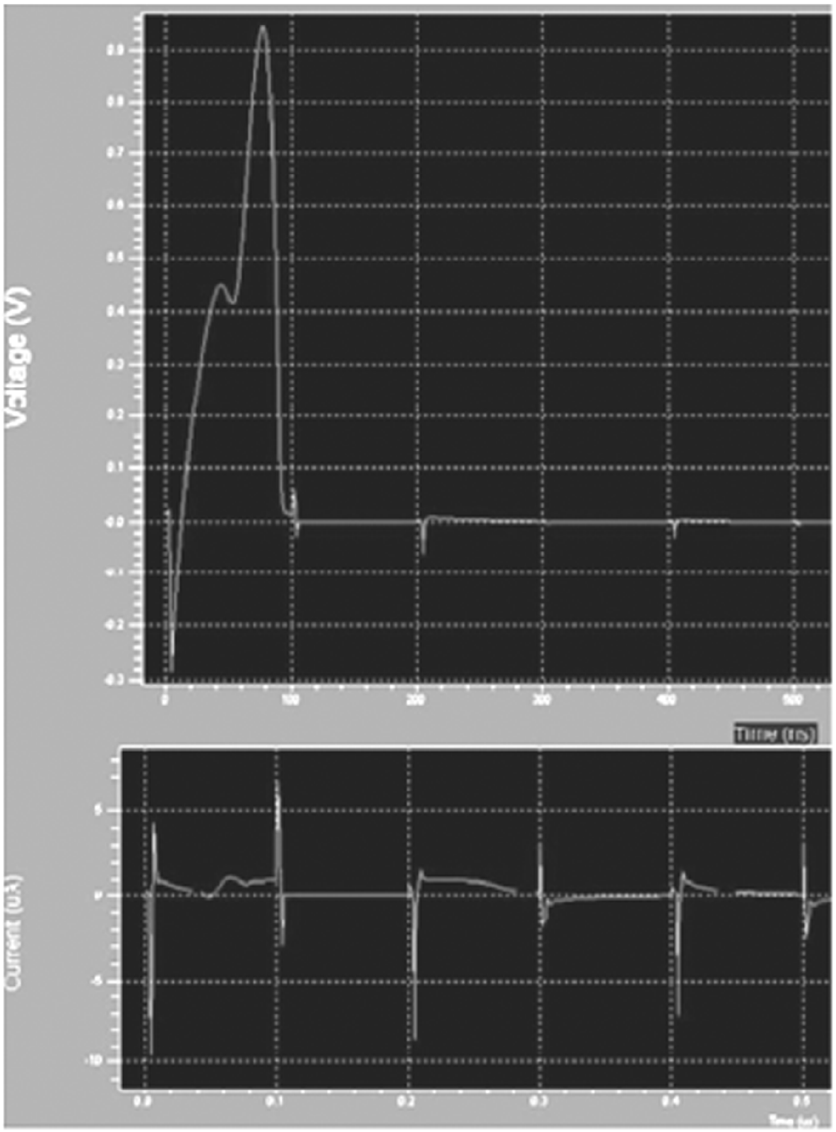

Figure 3: Output pulses generated by tunable pulse generator

The VCRO with auxiliary delay paths are often employed for obtaining higher oscillation. The PG is implemented with a 3-stage inverter based ring oscillator and output buffer with 3 inverters.

The figure 3 shows the output pulses generated by tunable pulse generator using Schematic Editor of the Tanner tools. The output generated is a Gaussian pulse of frequency 0-960 MHz which is mostly used in UWB communication because of its ease in generation, smooth transition in time domain and better frequency response.

With pulse shaping circuit, the control voltage controls the pulse amplitude by generating voltage 0.9v and current of 6µA. The total power consumption of 5.4µW is favorable to all UWB transmitter designs.

Design 2: Pulse Generator With Sensing Input

This section describes the proposed pulse generator with sensing input approach for sensing the changes in the pulse generator design corresponding to the changes in the control voltage in the system level. [9] In this design, the change in output voltage is obtained by resistive sensing or capacitive sensing instead of tuning the supply voltage. The only disadvantage is the presence of a higher level of jitter at lower frequencies. Supply induced jitter reduction techniques are discussed in the next section.

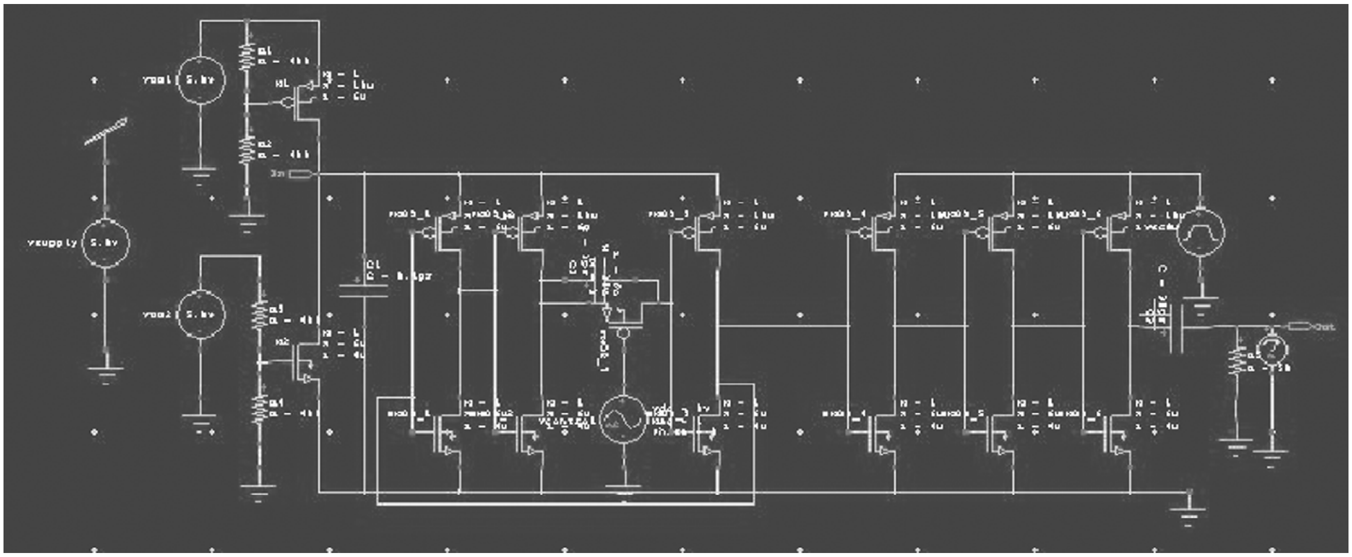

Figure 4: Modified Pulse Generator with sensing input

The power consumption is reduced by decreasing the control voltage to the buffer or by using lesser stages in the buffer, thus pulse generator is designed with reduced buffer stages. [10] Two types of sensing input is applied to pulse generator: resistive sensing and capacitive sensing.

3.1. Resistive Sensing

A ring oscillator [13] can be implemented odd number of single ended inverters. It can be utilized to translate the resistive changes to frequency variations. A pulse generator in Fig. 4. is implemented with resistive sensing input to control the voltage and frequency variations. [10] In order to convey the resistive changes to oscillator control voltage the simple interface circuit including M1, M2 and interface resistors are designed. Since M1 and M2 are designed to operate in saturation the input output transfer characteristic is supposed to be linear.

The output generated by pulse generator is shown in Fig. 5. simulated using Schematic Editor of using tanner tools. The voltage obtained in this pulse generator is 22 mv at 45 MHz frequency range with control input voltage of 1.5 v. The total power consumption in this pulse generator with resistive sensing input is 0.15 μW.

3.2. Capacitive sensing

The capacitive sensing [7] input is applied to pulse generator to cancel out the voltage variable parasitic capacitances Cp associated with the inverter transistors. The ring oscillators used in telecommunication industry suffer from phase noise. Phase noise [12] in the frequency domain translates to jitter in the time domain. The main contributor to the phase noise close to the centre frequency is the flicker noise of the inverters tail current supply that up-converts into the close vicinity of the oscillation frequency. Insertion of a large capacitance between the supplying tail current and the current as illustrated in Fig.4.can be used to reduce this noise.

For Cp = 1pF the added parasitic is the order of parasitic capacitances of transistors. Therefore, the supply voltage controls the oscillation frequency. However for Cp = 7, 15 pF the added capacitance dominates the node capacitance values.

The pulse generator for Cp = 0.1pF is designed in Fig.6.with control input voltage of 1.5 v. This design is simulated with Schematic Editor in Tanner tools, it generates an output voltage of 0.5 mv at 250 MHz

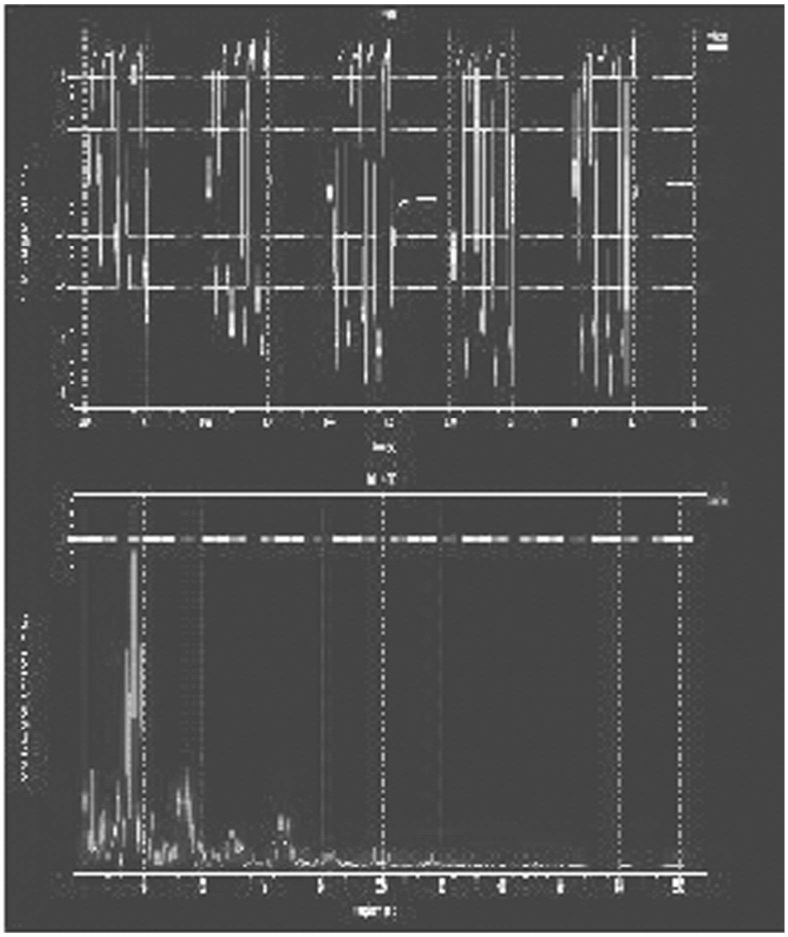

Figure 5: Output pulses generated through Resistive sensing

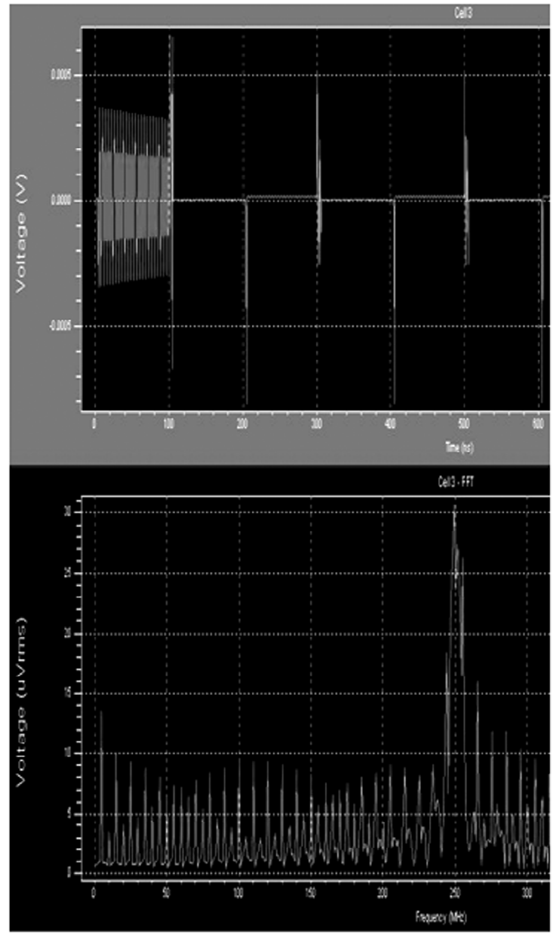

Figure 6:

frequency. The output obtained in this design have power consumption of 0.132 µW and has improved the frequency compared to tunable pulse generator design and resistive sensing design which was discussed in the previous section.

4. SIMULATION RESULTS

4.1. Comparison of Pulse Generators Design

The pulse generators discussed above satisfy FCC regulations of frequency 0 to 960 MHz and 3.1 to 10.6

GHz spectrum range; however the effective isotropic radiated power is kept below -41dBm/MHz. A low-power tunable transmitter for ultra-wide band (UWB) radio was designed and fabricated. The design is based on a ring oscillator VCO, to produce short pulses. Both the pulse duration and frequency is controllable by two voltage biases. The transmitter can be used in both pulse-amplitude modulation (PAM) and pulse-position modulation (PPM).

The comparison of pulse generators according to various parameters are shown in Table I. The simulation results of pulse generator is shown in Fig.7.for frequency versus control voltage transfer characteristics for the pulse generators designs. The frequency variations implies that capacitive sensing provides optimum values. The power versus control voltage is shown in Fig.8.which was obtained by integrated simulation in Tanner software. This reveals the consumption of power is much lesser in third design compared to other designs and is much preferable for short range applications.

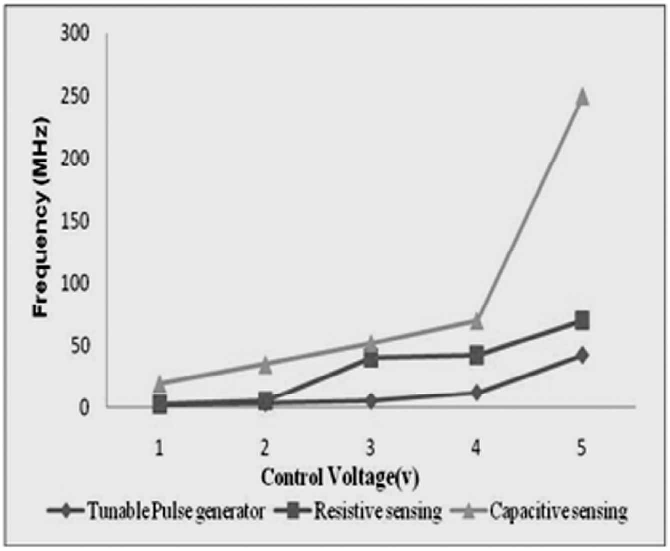

Figure 7: Simulation of pulse generator frequency versus control voltage transfer characteristics

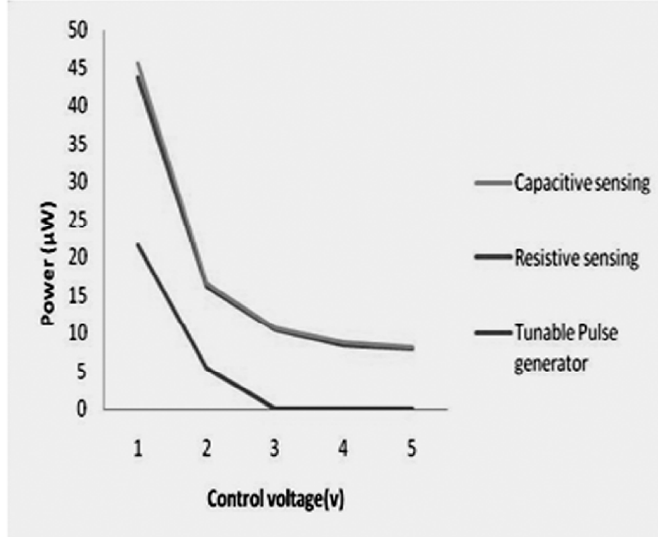

Figure 8:

Table 1
Comparison of UWB Pulse Generators

Parameters	*Tunable Pulse Generator*	*Resistive Sensing Pulse Generator*	*Capacitive Sensing Pulse Generator*
Amplitude of pulse	0.9 v	22 mv	0.5 mv
Frequency(MHz)	42 MHz	45 MHz	250 MHZ
Power consumption(µW)	5.4 µW	0.145 µW	0.132 µW

Table 2
Summary of UWB Pulse Generator

1.	Control Voltage(Vcontrol)	1.5 v
2.	Frequency(MHz)	250 MHz
3.	Power consumption(µW)	0.132 µW
4.	Amplitude of pulse	0.5 mv

4.2. Summary of Pulse Generators

The table II provides the summary of the properties obtained in the third design of pulse generator. The analysis obtained by the simulation results using Tanner tools depicts clearly that pulse generator with capacitive sensing input will provide better performance.

5. CONCLUSION

This paper shows that the low complexity UWB Transmit-only system designed with low power UWB pulse generator having capacitive sensing input can be applied to WBAN applications. Minimizing the jitter and phase noise is important concern, it is reduced in Fig.4.by cancelling out the effects of parasitic capacitance.

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REFERENCES

[1] FCC, Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, Washington DC, April 2002, vol. 02-48

[2] Wei Tang, A. Gandreou, Eugenio Culurciello, "A low-power silicon-on-sapphire tunable ultra-wideband transmitter," ISBN: 978-1-4244-1683-7, IEEE International Symposium on Circuits and Systems, 2008. ISCAS 2008.

[3] M.R.Yuce, Kasun M. Thotahewa, "Development of low power UWB body sensors," ISBN:978-4673-1157-1/12/ $31.00,IEEE 2012

[4] L. Moreno-Hagelsieb, B. Foultier, G. Laurent, R. Pampin, J. Remacle, JP.Raskin, D. Flandre, "Electrical detection of DNA hybridization: Three extraction techniques based on interdigitated Al/Al2O3 capacitors", Biosensors & Bioelectronics, 22 (9-10): 2199- 2207 APR 15 2007.

[5] Bin Li, Ming Jian Zhao, "20-pJ/Pulse 250 Mbps Low-Complexity CMOS UWB Transmitter for 3–5 GHz Applications "IEEE Microwave and wireless component letters, Vol. 23, No. 3, March 2013

[6] Ho Chee Keong and Mehmet Rasit Yuce "Transmit Only UWB Body Area Network for Medical Applications," IEEE International Symposium on Microwave, pp. 2200–2203, December 2009.

[7] M. Miao and C. Nguyen, "On the development of an integrate CMOS based UWB tunable-pulse transmit module," IEEE Transactions on Microwave Theory and Technologies, vol. 54, no. 10, pp. 3681– 3687, October 2006.

[8] T. Opperman, M. Hamalainen, and J. Iinatti, UWB Theory and Applications, John Wiley & Sons, September 2004.

[9] A. Fort, C. Desset, J. Ryckaert, P. De Doncker, L. Van Biesen, and S. Donnay, "Ultra wide-band body area channel model," International Conference Communications, May 2005.

[10] M. Ghavami, L. Michael, and R. Kohno, Ultra Wideband Signals and Systems in Communication Engineering, 2nd Edition, John Wiley & Sons, 2007.

[11] D. O'Donnell and R. W. Brodersen, "A flexible, low power, DC-1 GHz impulse-UWB transceiver front-end," in IEEE International Conference on Ultra-Wideband, pp. 275–279, September 2006.

[12] J. Foerster, E. Green, S. Somayazulu, and D. Leeper, "Ultra-wideband technology for short- or medium-range wireless communications," Intel Technology Journal, vol. 5, no. 2, pp. 1–11, May 2001.

[13] Patrick P. Mercier, Denis C. Daly, and Anantha P. Chandrakasan, "An Energy-Efficient All-Digital UWB Transmitter Employing Dual Capacitively-Coupled Pulse-Shaping Drivers" IEEE Journal of Solid- State Circuits, Vol. 44, No. 6, June 2009.

[14] F. Nekoogar, F. Dowla, and A. Spiridon, "Self organization of wireless sensor networks using Ultra- Wideband Radios," IEEE Radio and Wireless Conference, pp. 45–454, September 2004.

[15] T. Zasowski, G. Meyer, F. Althaus, and A. Wittneben, "UWB signal propagation at the human head," IEEE Transactions on Microwave Theory and Techniques, vol. 54, no. 4, pp. 1836–1845, June 2006.