A Novel GDI Design of Delta Sigma Encoder for Low Power Wireless Bio Sensors

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***Abstract*—This brief presents a systematic method to reduce power consumption of a wireless sensor node for sensing biomedical signals. The design combines the Delta-Sigma modulator, the Ultra Wideband impulse radio, and the proposed GDI (gate diffusion input) XNOR-Delay based encoder/decoder, which replaces the decimation filter. GDI (Gate Diffusion Input) - a new technique of low power digital circuit design is described. This technique allows reducing power consumption, delay and area of digital circuits, while maintaining low complexity of logic design. The encoder/decoder for both the first and second order Delta-Sigma modulators are presented. The clock synchronization problem is solved by using an asynchronous Ultra Wideband impulse radio. Effects of window length, the order of Delta-Sigma modulation, and the oversampling ratio are studied by simulation using neural and electrocardiography signals. MICROWIND and Xilinx 12.1 has been used to evaluate existing and proposed system performance**

***Index Terms*—Delta Sigma modulation**

I. INTRODUCTION

With ageing of the population, existing medical resources cannot satisfy future healthcare demands of seniors and patients. Resources are limited and it is impossible for most patients to afford long-term hospital stays due to economic restrictions, work, and other reasons, even though their health status must be monitored in a real-time or short periodic time mode. As a result, wireless monitoring medical systems will become part of mobile healthcare centers with real-time monitoring in the future.

In this context, WBAN supporting healthcare applications can offer valuable contributions to improve patient healthcare, including diagnosis and/or therapeutics monitoring. In a short time, WBAN technology has taken its first steps in the medical rehabilitation and monitoring of patients. However, underlying technology is still in an early development stage and typically based on very specific wireless communications technologies. Patients may be comfortably monitored at home while carrying out their daily activities, and medical staff have to monitor many patients simultaneously. The balance between these generally conflicting features means that research in this arena is not finished. In this area, data reliability, power consumption, and small size are very important characteristics to consider when choosing appropriate WBAN sensor nodes. Many studies have been focused on WBANs for medical purposes. However, few works have been concerned with a global solution for tens or hundreds of patients, each of whom is fitted with multiple sensor nodes, and confined to a relatively small environment like an infirmary or a living or dining room of a hospital. Until now, some of the research and studies carried out for hospital environments have obtained results for different nodes in several experimental subjects.

Given the present situation, the aim of this work is to identify and select existing technologies and protocols that satisfy the main requisites of WBANs for the application of healthcare with regard to patient mobility, secured and reliable data, power consumption, and the requirements needed for large amounts of sensor nodes to coexist in a relative small space. To understand the special needs in a medical network, both the protocol stack and understanding of each protocol layer are essential. This paper presents an overview of the state of the art in WBAN. It is mainly focused on architectures and communication protocols for healthcare networks based on WBANs. We analyze the most recent implementation solutions for this type of network, as well as the protocols used at each protocol layer. Each implementation has its own characteristics, advantages, and disadvantages, which are comprehensively described and analyzed in several comparative tables. Moreover, we also provide a comparative study of emerging and existing radio technologies and protocols for nonproprietary WBANs on unlicensed radio frequency bands.

II. Related work

Wouter A. Serdijn et al presented design of a 13.56 MHz/402 MHz autonomous wireless sensor node with asynchronous ECG monitoring for near field communication.

JianfengWu et al proposed a dynamic compression scheme to deal with the challenge of ultralow power and real-time wireless ECG application.

Eddie Law et al presented a new quadrature phase-shift keying (QPSK) modulator for Bluetooth applications with an optimal transaction bandwidth control.

Chen Li et al presented a low-complexity IR-UWB chipset which achieves synchronization and demodulation at the receiver relying only on a ring oscillator clock.

Yasuhiro Nakas et al developed a novel ultra wideband impulse radio architecture for 24 GHz-band short-range radar.

OleksiyKlymenko et al describes a monolithic integrated transceiver chipset intended for impulse radio (IR) Ultra-wide band (UWB) applications including indoor communication and indoor localization.

Noel Baidya et al presents spreading technique as a winsome solution to enhance the range of detection of these biosensors still meeting the regulation of Federal Communication Commission (FCC).

Álvaro Álvarez et al present ranging performance results obtained with realistic low-power, low-complexity Low Data Rate (LDR) evaluation platforms, with two Impulse Radio Ultra Wideband (IR-UWB) transceiver prototypes, and one Zigbee platform.

M. Asbec et al presents a new architecture for an RF phase modulator that significantly improves the phase resolution.

Abhijit V. Bap et al describes an analog-to-digital converter which combines multiple delta-sigma modulators in parallel so that time over sampling may be reduced or even eliminated.

III. EXISTING WORK

In open literatures, there are many researches in design of CMOS encoders and clock gating technique to achieve a low power consumption .

The XNOR-Delay circuits are applied in a wireless sensing system with a DSM as the ADC and a UWB-IR asthe wireless transmitter. The system contains a wireless sensor node and a base station, as shown in Fig. The proposed Delta-Sigma encoder converts the Delta-Sigma bit-stream into an encoded bit-stream to reduce the transmission power of the UWB IR transmitter. The transmitted signal is received and digitized at the UWB IR receiver at the base station. Then the proposed Delta-Sigma decoder converts the received bitstream back to the Delta-Sigma bit-stream. Finally, a Delta- Sigma demodulator recovers the sensed analog signal.

The proposed encoder and decoder is based on XNOR Delay circuits. Encoders and decoders are shown in Fig. Encoder EC1 is recommended for 1st order DSM while EC2 for 2nd order DSM. The feedforward structure is used in the encoder while the feedback structure circuit is used in the decoder. The feedforward XOR-Delay circuit has also been widely used in VCO based Delta-Sigma Modulators and Frequency Delta-Sigma Modulators , while the feedback XNOR-Delay circuit can be considered as a Linear Feedback Shift Register (LFSR), which has been intensively studied for generating pseudo-random numbers. In these circuits, the delay unit z-1 is realized as a D Flip-Flop with the same clock as the Delta-Sigma modulator In the encoder and decoder for the first-order Delta Sigma modulator (Fig.), we have

$$p(n) = \overline{x(n) \oplus x(n-1)},$$
$$y(n) = \overline{p(n) \oplus y(n-1)}.$$

Here, x(n) is the value of the nth bit of the input bit-stream and x(n 1) denotes the value of the previous bit in the bit-stream xfng. Similarly, pfng is the encoder output bitstream (as well as the decoder input bit-stream), and yfng is the decoder output bit-stream. Every bit has a digital value of “1” or “0”, _ denotes XOR operation and _ denotes XNOR operation. Using Eq. (1) and (2) one can obtain

$$y(n) = x(n) \cdot \overline{x(n-1) \oplus y(n-1)}$$
$$+ \overline{x(n)} \cdot x(n-1) \oplus y(n-1).$$

The output of the decoder y(n) is x(n) or x(n) depends on the initial states of the D Flip-Flops in both the encoder and the decoder. The same results apply to the encoder and decoder for the second order Delta Sigma modulator (Fig). If the initial states in the encoder and the decoder are thesame, the encoded bit-stream can be recovered by the decoder without loss.

Encoder with DC analog input The main goal of applying the proposed XNOR-Delay encoder is to reduce the number of bits “1”s in the transmitted bit-stream. Considering in the OOK modulation, the UWB IR transmitter power consumption is directly proportional to the percentage of bit “1”s in the bit-stream. This percentage can also be considered as the average duty-cycling of the bitstream.

Therefore, by reducing the duty-cycling of the Delta- Sigma bitstream, the proposed encoder can save power in the UWB-IR transmitter. The aforementioned processing property aligns with various biomedical signals. For example, neural signals and electrocardiogram (ECG) signals are sparse signals in the time domain. This means that in most of the time, these signals stay around analog “0”. Hence, the system power can be reduced by combining the character of the targeted biomedical signals and the property of the proposed Delta-Sigma encoder circuits.

IV. PROPOSED SYSTEM

The proposed encoder and decoder is based on XNOR Delay circuits. Encoders and decoders are shown in Fig. The feed forward structure is used in the encoder while the feedback structure circuit is used in the decoder. In these circuits, the delay unit z-1 is realized as a D Flip-Flop implemented with GDI

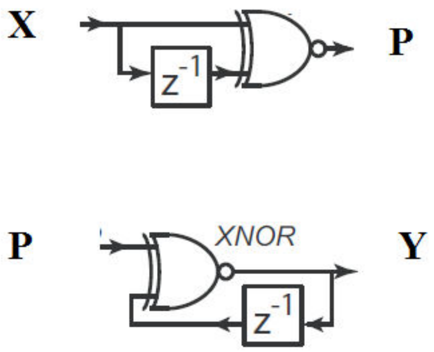

Fig. 1. Encoder and Decoder

In the encoder and decoder we have

$$p(n) = \overline{x(n) \oplus x(n-1)},$$
$$y(n) = \overline{p(n) \oplus y(n-1)}.$$

Here, x(n) is the value of the nth bit of the input bit-stream and x(n - 1) denotes the value of the previous bit in the bit-stream x{n}. Similarly, p{n} is the encoder output bitstream , and y{n} is the decoder output bit-stream. Every bit has a digital value of "1" or "0", ^ denotes XOR operation and ^' denotes XNOR operation.

The main aim of applying the proposed XNOR-Delay encoder is to reduce the number of bits "1"s in the transmitted bit-stream. Considering in the OOK modulation, the transmitter power consumption is directly proportional to the percentage of bit "1"s in the bit-stream. This percentage can also be measured as the average duty-cycling of the bitstream. the proposed encoder can save power in the transmitter.

V. GDI LOGIC

In our proposed encoder consist of DFF and XNOR gate , In order to reduce transistor count and delay complexity DFF and xnor gate designed using gdi logic .

Various logic circuits were investigated and presented in the literature [12][13][14][15], targeting to achieve an optimal design in terms of delay, power and area. Some efficient techniques were developed and adopted by designers for a variety of technologies [1]. Gate-Diffusion-Input (GDI) design technique that was recently established and presented in [15], proposes an efficient alternate method for logic design in standard CMOS and SOI technologies

The basic GDI cell is shown in Fig. 1. Though it look like a conventional CMOS inverter the source/drain diffusion input of both PMOS and NMOS transistor is different. In conventional inverter circuit, source and drain diffusion input of PMOS and NMOS transistors are always connected at VDD and GND potential, respectively. On the other hand, the diffusion terminal turns as an external input in the GDI cell. It supports in the realization of various Boolean functions such as AND, OR, MUX, INVERTER, F1 and F2, as listed in Table 1.

Table 1: Different logic implementation using GDI

N	P	G	Out	F
0	B	A	A'B	F1
B	1	A	A'+B	F2
1	B	A	A+B	OR
B	0	A	AB	AND
C	B	A	A'B+AC	MUX
0	1	A	A'	NOT

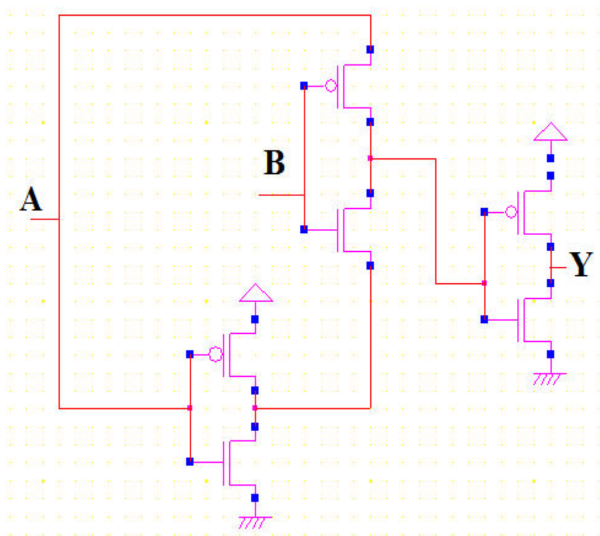

Fig 2. XNOR using GDI

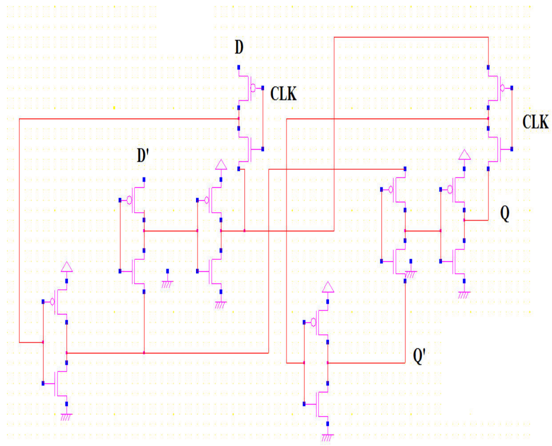

Fig. 3. DFF using GDI

Fig shows GDI implementation of xnor gate and DFF ,for xnor gate requires only 6 transistors and DFF requires 18 transistors

VI. IMPLEMENTATION

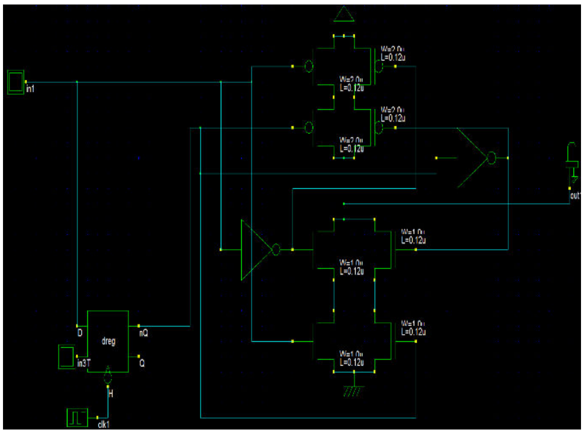

Fig. 4. Existing layout

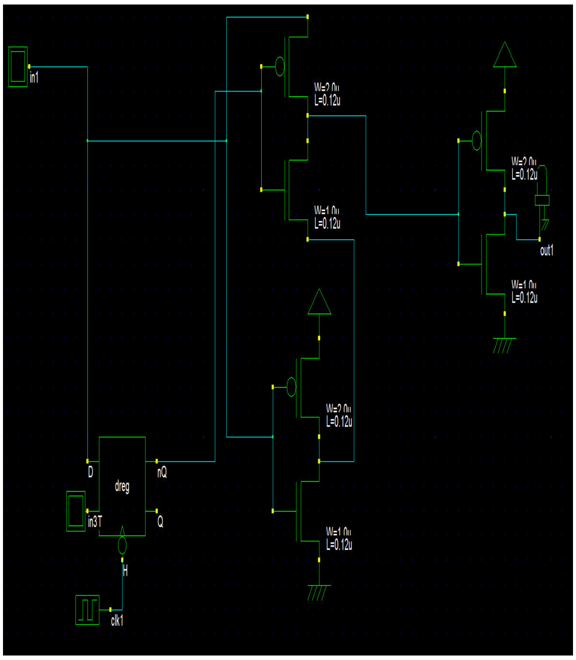

Fig. 5. Proposed layout

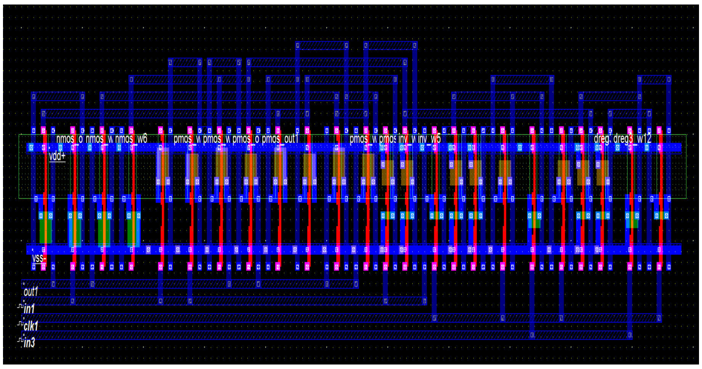

Fig. 6. existing floorplan

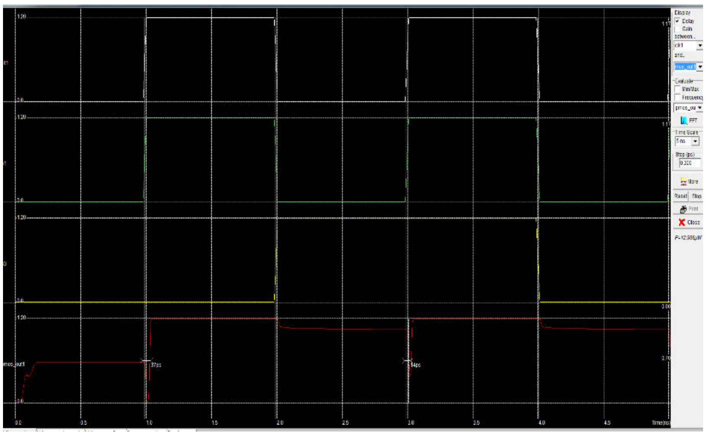

Fig. 7. simulated waveform

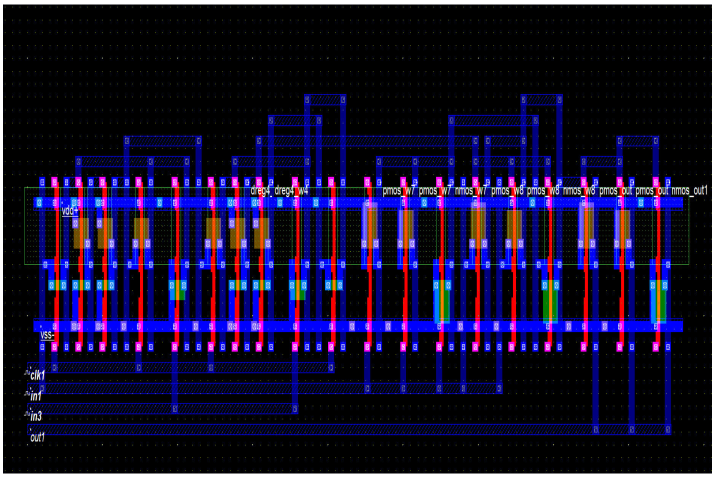

Fig. 8. proposed floorplan

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VII. CONCLUSION

In this project , we presented a new design of an GDI XNOR-Delay based Delta-Sigma encoder for wireless biomedical sensors. We studied the behavior of the encoder and simulated the power consumption of the wireless sensor using a model of the FSK-OOK Ultra Wideband impulse radio. Effects of synchronization, the order of the Delta-Sigma modulator, and the window length are also simulated using two biomedical signals. The simulation results show that if the input signal is sparse, the GDI-XNOR-Delay encoder can replace the decimation filter and greatly reduce the system power consumption. The proposed XNOR-Delay based encoder has good potential to be used in low-power, high-resolution wireless sensors for sensing sparse signals

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