IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p-ISSN: 2278-8735
PP 60-66
www.iosrjournals.org

Wake-Up Receiver Design for Low Power Consumption Based On HBC

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Abstract: *HBC is widely used which has multiple advantage due to electric field is modulated and induced to a human body ,as it possible to transfer data wirelessly using the human body as a transmission medium. First, reducing the traffic load from the radio channels becoming more congested as no of connected wireless devices increases. Then, HBC can potentially provide higher security than RF communication since the electric field stays closer to a human body and then, the attenuation in the HBC frequency band is lower than radio technologies for wireless body area networks. To improve the energy efficiciency in HBC by utilizing a wake-up receiver. The use of WURs can significantly reduce the energy consumption and increase the lifetime of the sensing applications. HBC combined with a Superregenerative WUR solution which operates at sufficiently low power enables to achieve high sensitivity consuming µW, in order to obtain high sensitivity by keeping energy consumption low.*

Keywords: *Human Body Communications, Pulse Width Modulation, Wireless Body Area Networks.*

I. Introduction

Wireless body area networks (WBAN) have been solving the challenges to provide high energy efficiency. Although there are multiple aspects that affecting energy consumption of WBAN including the sensors, the processing units and communications.WBAN enables the sensing applications to make the wireless communication more energy efficient, robust and reliable.HBC enables interesting new application possibilities such as the business cards can be exchanged by a handshake, secure doors can be opened without keys and photo taken with a mobile phone can be printed just by touching a printer. It also addresses the problem of energy consumption for transferring data wirelessly since HBC[2] operates at lower frequency bands which feature lower attenuation than the traditional wireless sensor and actuator network (WSAN) radio technologies, such as,e.g., ultra-wideband (UWB) and ZigBee.

WBAN consist of a number of sensors that are either placed on a person body or are small enough to be implanted. The main characteristic of WBAN[3,4] is that the sensors are heavily power constrained and power budget for communication is limited. Numerous communication protocols were developed such as reducing the power consumption, while still keeping the network functionality and flexibility. These sensors also need to transmit data at wide range of data rates (Body temperature, Heart rate, Glucose level, ECG, EEG, etc.).

II. Comparison Of The Low Power Technologies Using WBAN

Among all the wireless communication technologies available today on the market, there are three that are used often in WBANs. One of them is ZigBee, which has been on the market for a quite long period of time. The two others are the Bluetooth Low Energy (BluetoothSmart), which is the low-power modification of the Bluetooth technology, and the impulse radio ultrawideband (IR-UWB) which is targeting on the medical use cases among others. As can be observed, HBC transceivers[10] are operating in much lower frequencies than other wireless technologies. Lower operation frequency may enable to design transceivers that consume less power than transceivers in higher frequencies. In HBC, a transmitter couples with a body through capacitive coupling that creates a quasi-static electric field around the human body. Since the electric field stays close to the body, it gives two significant benefits. First, interference impact with other wireless devices is minor. Second, it enhances security compared to traditional wireless technologies for WBAN. the HBC is mostly limited to the surface of the user's body and thus can hardly have a path length exceeding few meters. For the other technologies, the communication distances of dozens to hundreds of meters under the line-of-sight condition can be reached. This can be used for integrating the WBAN with the other wireless networks operating in the environment.

III. Human Body Communications

HBC transceivers are operating in lower frequencies than other wireless technologies. Lower operation frequency may enable to design transceivers which consumes less power than transceivers in higher frequencies. In HBC, a transmitter couples with a body through capacitive coupling[11,12] that creates a quasi-static electric field around the human body. Since the electric field stays close to the body, it gives two significant benefits of the communication and the processing applications.

- Interference impact with other wireless devices.
- It enhances security compared to the traditional wireless technologies for the WBAN by making the radio signal which is more difficult.

HBC is mostly limited to surface of the user's body and thus can hardly having a path length exceed

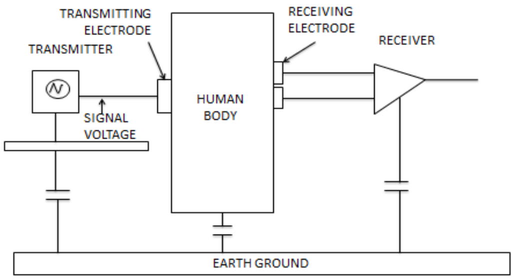

Figure.1 Block Diagram of the Human Body Communication in which electrode connected between the human body and receiver.

Few meters. For the other technologies, the communication distances of dozens to hundreds of meters under the line-of-sight condition can be reached. This can be used for integrating the WBAN with the other wireless networks operating in the environment as well as the industrial and medical applications.

3.1.Challenges Of Human Body Communication

One of the challenges at the moment of HBC technology is coupling the HBC[9] transceiver and the user's body acting as communication media. In the Sot A solutions, this is typically done by the means of electrodes and a special gel. Even though the connection may be good enough at the very beginning, as the time goes sweating and movement gradually makes the connection looser and performance of communication can degrade. However, better attachment solutions are expected to emerge for electrodes when the HBC technology will be more mature. The major challenges of HBC compared to the traditional radio technology are threefold are

- It alleviates the traffic load from the radio channels, which are becoming more and more congested, as the number of connected wireless devices increases rapidly.
- HBC can potentially provide higher security than traditional RF communication since the electric field stays in the vicinity of a human body, which makes eavesdropping more challenging.
- The attenuation in the HBC frequency band is lower than in bands used by the other radio technologies for wireless body area networks.

3.2 Dielectric Properties Of A Human Body

The human body is not uniform, i.e., it consists of different types of tissues that have unique dielectric properties[13,14]. There is a commonly used online database which provide the dielectric properties of body tissues at different frequencies.

When a signal is induced to the human body, e.g., via electrode, an electric field is originated around the human body. The relative permittivity of a tissue is inversely proportional to the electric field strength.The electric field strength at a distance R from a charge Q can be derived from Maxwell's equations and it is given as,

$$\vec{E} = \frac{Q}{4\pi\varepsilon R^2} = \frac{Q}{4\pi R^2 \varepsilon_0 \varepsilon_r} \quad (1)$$

where
ε is permittivity

ε_r is the relative permittivity of the material (tissue in this context)
$\varepsilon_0$is electric constant (8.854×10−12F/m).
However, the relative permittivity does not have an impact on the electric flux density, which describes how an electric field flows in this context through the human body as

$$\vec{D} = \varepsilon\vec{E} = \varepsilon_0\varepsilon_r\vec{E} = \frac{Q}{4\pi R^2} \qquad (2)$$

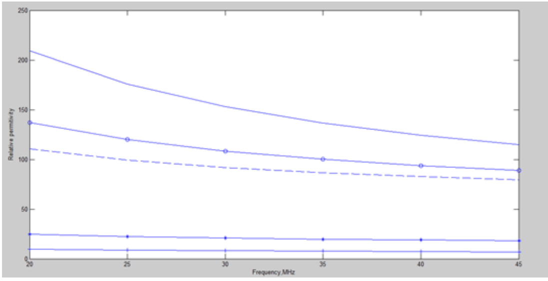

Figure.2 Relative permittivity in different tissues where calculated the dielectric properties from 20MHz-45MHz.

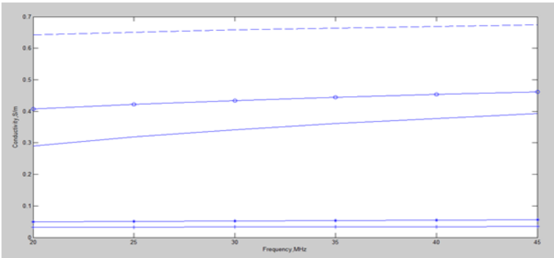

Figure.3 Electrical conductivity in different tissueswhere calculated the dielectric properties from 20MHz-45MHz.

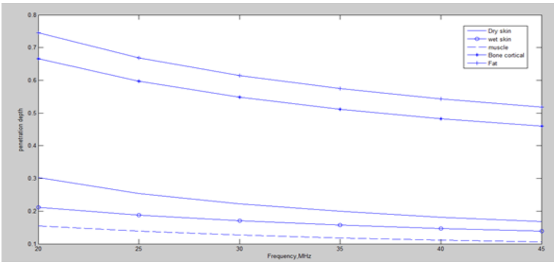

Figure.4 Penetration depth is unique for each tissuewhere calculated the dielectric properties from 20MHz-45MHz.

As can be seen, the relative permittivity does not have an impact on the electric flux density which describes how an electric field flows in this context through the human body such as the cortical bone, muscle, dry skin, wet skin and fat when the dielectric properties is calculated in the different tissues from 20MHz-45MHz which consumes power supply upto 40µW.

3.3 Pathloss With Some Of Diferrentelectrode Location

Theelectric field penetrates the skin; thus, the tissue beneath the skin is expected to have an impact on the electric field strength. Therefore, we measured the impact of electrode locations on the path loss. The electrode locations are chosen based on the tissue type beneath the dry skin. Tissues of interest are the same as used in the muscle, fat, and cortical bone.

The path loss are measured at the different distances with the three different frequencies. The radio signal sustains substantial losses when coupled with the body, but the propagation over the body channel has very moderate losses and scales up slowly with the increase of the distance travelled.

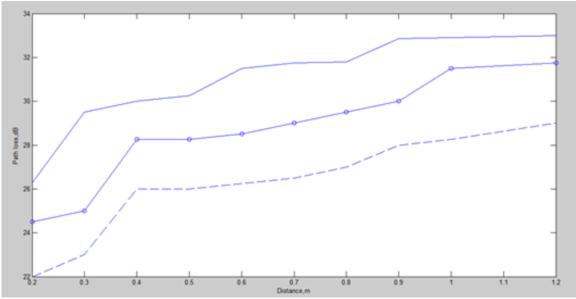

Figure.5 The effect of the distance on the path loss for HBC channel is calculated the distance travelled towards the human body.

The free space path loss can be written as the logarthimic value for the dielectric properties is calculated as,

$$FSPL = 10 \times \log_{10}\left(\frac{4\pi d}{\lambda}\right)^2 \quad (3)$$

where

d is the distance travelled between the different sensor node attached to the body.

λ is the wavelength between the effect on the path loss for the human body communication.

IV. Wakeup Receiver Architecture Design

The WUR is designed to be used in energy constrained WBAN[1] nodes that utilize HBC channels. The major function of the receiver is to monitor the radio channel [15]and to issue an interrupt for the wake-up signal of the node once the signal with the proper address is received. The further data exchange relies on the main radio transceiver of the node. Additionally, the designed WUR[5,6] can be used by the the SRO to oscillate the operating for receiver's data rate, selectivity, and gain. It essentially defines the sampling rate of a super regenerative receiver. Superregenerative receiver operating at lower bands of having high inductance and capacitance for the LC resonator which has the wakeup receiver signal detected by the wakeup receiver sensor to detect the signal which is amplified to the comparator and matching network results in detecting the signal used by the sensor in the human body utilizing the wakeup transceiver.

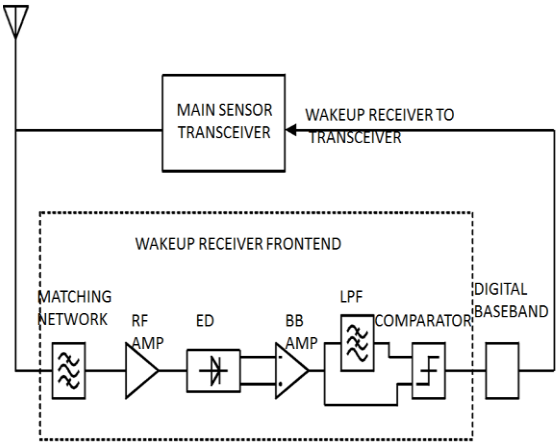

Figure.6 Design of Wakeup Receiver Architecture in which describes the wake-up signal can be detected by the sensor inside the human body.

The receiver continuously listens for a pre-defined wake-up signal and on its reception activates the other electric circuitry (e.g., sensing, processing, and communication). The use of WURs can significantly reduce the energy consumption and increase the lifetime of the sensing applications. The principleoperation of the Superregenerative receiver[7,8] have theperformance of the Superregenerative WUR.

4.1 Simulation Results Of Superregenerative WUR

The Superregenerative receiver representing the frequency generative signal of pulse width modulation of super regenerative signal.

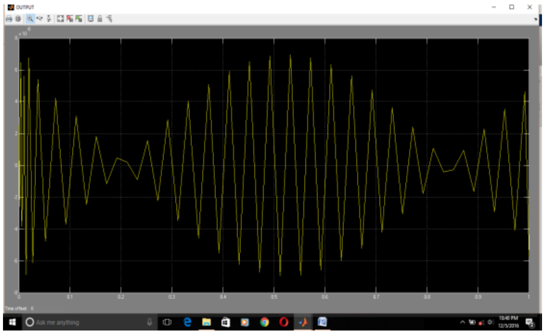

Figure.7 Simulated Results of Superregenerative Receiver can be designed in the Simulink software which produce theparticular range of frequency generative signal

4.2 Results For Power Consumption Of SENSOR

The simulation results provides all the above requirements for the energy consumption with better accuracy.

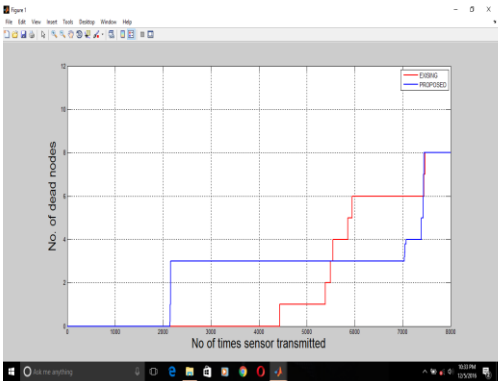

Figure.8 Simulated Result of Power Consumption for WBAN is compared between the two communication which provides the energy efficient to improve the utilization of energy consumption.

4.3 Results For Pathloss Of Wakeup Receiver

The pathloss increases when the distance between the transmitter and receiver increases. Pathloss is defined as the disance travelled between two sensors mode of any different path connected to the sink which provides the high sensitiity for low power transmission.

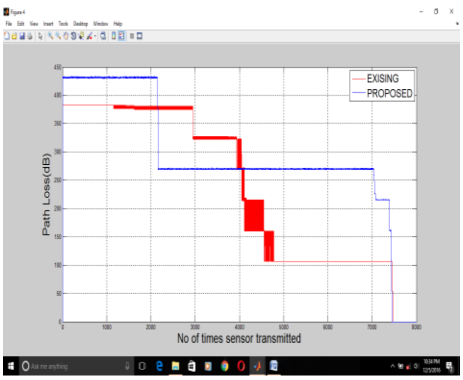

Figure.9 Simulated Result of Pathloss for Wakeup Receiver is compared between the where any of two communication connected utilize the low transmit power at two sensors.

4.4 Results Of Energy Consumption For WUR

The Superregenerative receiver provides the better reception of information at sink when the sensor transmits.The result shows that the proposed method has very good sensitivity and accuracy.

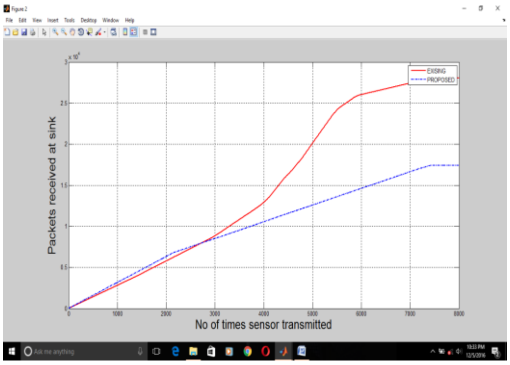

Figure.10 Simulated Result for Power Consumption of WUR is compared between the two communication which provides the better accuracy and energy efficieny.

V. Conclusion

Human body communications is an attractive alternative to the traditional WBAN radio technologies and can be used in the field of medical and fitness applications. The major advantages of HBC compared to the traditional radio technology such as, the data traffic is alleviated from the air radio channels thus reducing the load on them, the electric field stays close to the body surface and so the communication becomes more secure and the lower attenuation enables to use lower transmit power. The result shows that the performance of the superregenerative receiver providing the good sensitivity obtaining the low power consumption can effectively save the energy of each sensors, balance energy consumption and prolong the lifetime of sensing application in Wireless Body Area Networks. HBC improves the energy consumption, sensitivity, and the data rate of a WUR than other WBAN technologies. TheSuperregenerative receiver generating the low bit rate at high sensitivity improving the energy efficiency of the wake-up receiver.

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