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# Human Body Communication Using IoT with GSM Enabled Healthcare Monitoring System

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**Abstract - Increasing market demand for high performance and portable computing devices requires energy efficient devices. When we considered the network of devices, as in the case of the Internet of Things (IoT), this is important to consider low power design at the sensor level as well as in the Human body communication (HBC) has proven to be an efficient mode of communication for the near-field body sensor network module. In this paper, we propose an architecture for an ambulatory health monitoring system using a body coupled communication channel and we added a new feature that is Global System Module (GSM). In GSM module will collect the emergency data when the human body has an abnormal condition. The proposed architecture can be used to do health monitoring using IoT and GSM. When we use human body communication power reduction was observed. The human body acts as a communication module for these sensors to receive the emergency data in the data acquisition module connected to the internet. By providing an efficient communication channel between the sensors, power dissipation of the human body communication system can be greatly reduced.**

**The physician can have the surveillance of patient's health condition for 24 hours using this system. Using PIC microcontroller low-cost Human Body Communication system can be made.**

**Index words - Internet of Things (IoT), Human Body Communication (HBC), Healthcare Monitoring System, Global System Module (GSM), Body Coupled Communication.**

## I. INTRODUCTION

With the increasing features added to a design, there is a continuous need for energy efficient systems [1]. Human body communication (HBC) has proven to be a low power wireless data communication technology [2]. The Internet of Things (IoT) is a way of connecting many sensors through a network which serves as a backbone of smart cities [3]. It turns normal sensors and actuators into smart devices. With such enormous scope for smart networks and devices, the applications can range from smart healthcare monitoring systems to efficient surveillance systems. Wearable designed using Human Body Communication (HBC) can help in energy efficient personal area networks. The medium of the network can be anything depending upon the application. In the healthcare domain, multiple sensors can be integrated to form a personal network and the data obtained can be processed based on the criticality. In order to connect sensors in the network, a wireless module such as Bluetooth or WiFi is required along with RF components. In terms of energy efficiency, these components consume a major portion of power. In this paper, we propose a health monitoring system using HBC, which results in a low power implementation of the sensor network. The human body is used as an efficient communication channel between the sensors, whereas the wireless module such as Bluetooth or Zigbee is limited to one link server, which acts as the access point. An illustration of the application of HBC for IoT is shown in Figure 1. The sensor is placed on the outer layer of the skin, i.e. the epidermis. The main advantage of human body communication is that the electrode does not have to be present exactly over the sensor in order to measure the output. Thus sensor implants that act as transmitters can be placed in the form of a band-aid, chord, band etc., and the output can be measured from the receiver to obtain information from anywhere in the body or outside the body.

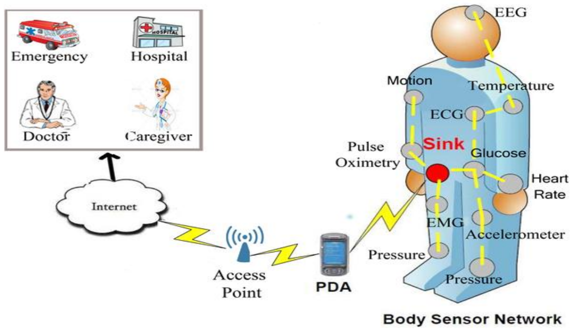


Fig. 1. IoT through Human Body Communication.

## II. LITERATURE SURVEY

**[1] Yusuf Perwe** et al. mentioned the technology uses the minute field of force emitted on the surface of the figure. The thought of RedTacton is the purpose of network transceivers exchange info alternative server receives information exploitation photonic field of force sensors combined with optic crystal lightweight. The communication is possible through any a part of the Human Body. Within the RedTacton thought, we tend to square measure transmittal the info stream relates to (Analog or Digital) as associate input to the electronic equipment.

**[2] Jian Feng Zhaoet** al. analyzed the device nodes together with each the on-body and in-body nodes (implantable devices), usually perform the observance perform (pulse measuring instrument measures SpO2; pressure device measures blood pressure). The physiological information from these nodes over a amount of your time square measure delivered in private and dependably to a relay node or somebody mounted on the body, like a sensible-watch or smart wristband, that square measure rising devices within the medicine business because of their convenience to regulate and perpetually wear behavior. The info square measure then forwarded to the hub and also the central management purpose, from wherever the info square measure accessible to hospital, skilled workers, and emergency center or for private usage.

**[3] Xi Prunus mume Chen** et al. analyzed an additional reliable and fewer vulnerable to interference than the wireless transmission techniques like Bluetooth, Wi-Fi etc. HBC is a promising physical layer answer for the body space network (BAN). The human central nature of HBC offers associate innovative methodology to transfer the health care information, whose transmission needs low interference and reliable electric circuit. A quick survey on the event of HBC, which has the signal propagation mechanisms, channel characteristics and communication performance square measure summarized and self-addressed. Moreover, the experimental problems, like electrodes and grounding methods also are mentioned.

## III. NOVEL CONTRIBUTIONS

In this paper, we present an efficient design of a health monitoring system through HBC for IoT applications using GSM. An ambulatory monitoring system is proposed with an array of sensors as shown in Fig. 3. The proposed monitoring system is energy efficient since it employs a low power communication channel for inter and intra sensor communication, which decreases the power budget of individual sensors. A Simulink® prototype of frequency selective baseband transmission is implemented, which is a service based on touch and play and does not need additional RF components. Multiple Inputs and Multiple output system designs were used for employing the monitoring system in IoT.

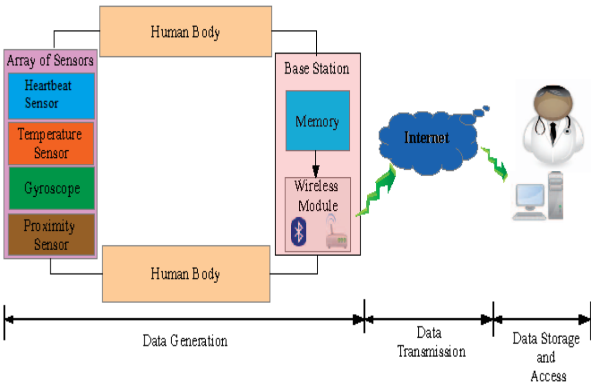


Fig.2. Block level diagram indicating the flow of data in healthcare monitoring through IoT with GSM.

## III. HUMAN BODY COMMUNICATION IN IOT: A BROAD PERSPECTIVE

The human body has conductive tissue under the epidermis layer. At high frequencies, it has some electrical conductivity. Body coupling helps in transmitting electrical signals via the human body but it is dangerous for excessive currents. Limitations on the amount of current that can be passed through the body have been set by many countries. As the electrodes are placed near the skin, the signal frequency increases as the current limit being increased. By providing an efficient communication channel between the sensors and the data acquisition module, power dissipation can be greatly reduced. Figure 2 shows the basic architecture for human body communication in IoT. The human body acts as a communication channel from these sensors to the receiver which is a data acquisition module connected to the Internet.

In Figure 3, a transceiver model for human body communication is presented. It can be observed that the human body can be modeled as capacitors in series with spreading resistance, leading to high pass filters.

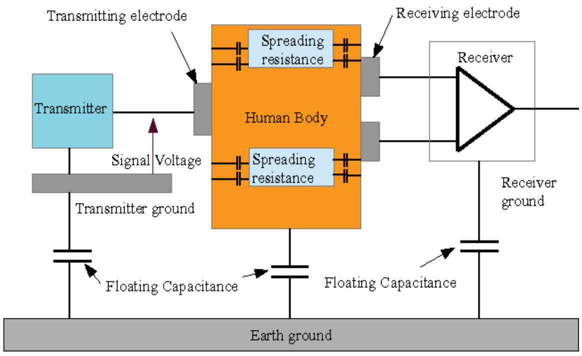


Fig.3. Transceiver model For Human Body Communication.

## IV. RELATED PRIOR RESEARCH

An early personal area network is mentioned in [6]. HBC is achieved by victimization the galvanic coupling, electrical coupling, electrical phenomenon coupling, body coupled communication, etc. Galvanic coupling is achieved by applying signals differentially within the transmitter and receiving signals differentially within the receiver. It had been investigated and analyzed by Oberle in [7] and Hachisuka et al. in [8]. Body coupled communication is achieved by making a possible distinction in one space of the body and analyzing the ensuing potential from alternative areas of the body [9]. The variations within the dedicated tissue layers and geometrical body variations ar analyzed in [10]. The electrical coupling technique is mentioned in [11]. A wider vary of applications is obtained by victimization electro-optic sensors in HBC.

## V.PROPOSED HEALTHCARE MONITORING SYSTEM

The proposed health monitoring system. When the vital signs are to be monitored, the body area network is initiated with a 'Start' signal thereby activating the sensor nodes. The array of sensors starts sensing and their values are transmitted to the base station through body coupled communication (BCC) or through frequency selective baseband transmission (FSBT). The input resistance helps in setting a corner frequency of one high-pass filter and passband level. As the input resistance increases, the level of passband increases and the corner frequency decreases which helps in improving the gain of the BCC channel. Here a MIMO system is considered in the base station as it has become an integral element of wireless communication standards. The Modulator modulates the input signal and gives output as a column vector. This output is fed into the Encoder block which encodes the input message using an orthogonal space-time block code at varying rates depending upon the number of transmission antennas used. The encoded output is transmitted through the MIMO channel. The 6 fading channel is implemented using either Rayleigh or Rician fading channel.

A. Array of Sensors: A detector array may be a cluster of sensors, typically deployed during a bound pure mathematics pattern, used for collection and process magnetic attraction or acoustic signals. The advantage of employing a sensing element array over employing a single sensing element lies within the indisputable fact that associate array adds new dimensions to the observation, serving to estimate a lot of parameters and improve the estimation performance. For example, an array of radio antenna elements used for beam forming can increase antenna gain in the direction of the signal while decreasing the gain in other directions, i.e., increasing the signal-to-noise ratio (**SNR**) by amplifying the signal coherently. A **body area network** (**BAN**), also referred to as a wireless body area network (WBAN) or a body sensor network (BSN), is a wireless network of wearable computing devices. BAN devices is also embedded within the body, implants is also surface-mounted on the body in an exceedingly mounted position wearable technology or is also attended devices that humans will carry in several positions, in garments pockets, by hand or in numerous baggage.

1) Temperature Sensor: A temperature sensor can be designed with the help of ring oscillators [1]. Basic ring oscillator architecture consists of an odd number of inverters. In order to achieve oscillation, the ring should provide a $2\pi$ phase shift and have unity voltage gain at the oscillating frequency. The oscillation frequency is given by the following:

$$f_{osc} = N_{stage}(T_{pd,LH} + T_{pd,HL}) \quad (1)$$

Where N-stage is the number of stages in the ring oscillator and Tpd, LH, and Tpd, HL is the Low-to-High and High-Low propagation delays. These depend on the threshold voltage Vth which is very sensitive to temperature fluctuations. Thus as temperature increases the oscillating frequency decreases.

2) Proximity Sensor: The proximity sensor can also be called a simple distance sensor as it helps in tracking the distance between the object and the sensor. The proximity sensor helps in sensing the distance which is normal to the sensor surface. In the given sensing distance, the sensor detects an object for a given radial offset *R*. The maximum distance that this sensor can detect is defined "nominal range some sensors have changes of the nominal vary or means that to report a graduated detection distance. Some apprehend these processes as "thermo sensation". Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between the sensor and the sensed object.

3) Gyroscope: A gyro detector helps in associatealyzing the orientation of an object. It is utilized in a BAN to research the orientation of the patient or the detector itself. A gyro consists of a little vibratory mass. Once the gyro is turned, the mass experiences a little force that displaces the first mass from its path. The gyroscope uses capacitance to sense this displacement and output a proportional number of counts. A block level diagram of the gyroscope sensor is shown in Fig. 4. The vibrating mass is modeled under MEMS Gyro dynamics. The sensors are subject to static bias and outward noise. Thus these values are added along with the output of the dynamics block. The scale factor helps in converting the output to a proportional number of counts.

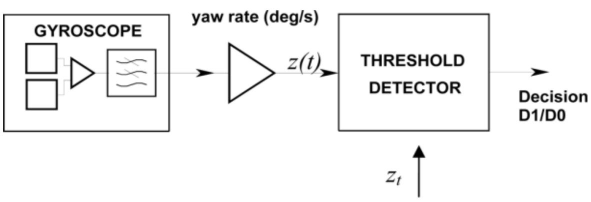


Fig.4. Block Diagram of simple MEMS-based Gyroscope

B. Communication Channel

In the initial days of HBC, it was mainly considered as a way of transferring data through the human body. Though textiles do not need additional amplifying circuitry, they have some drawbacks such as causing inconvenience for the user with all the wires and sensors. Low power radios and BCC have almost the same efficiency and give more flexibility to the user. In a BAN the data rate varies from 10 Kbps to 10 Mbps.

1) Frequency Selective Baseband Transmission: The requirements of BAN can be met only when no RF/IF components are used in the specified frequency band. Walsh code helps in implementing Frequency Selective Baseband transmission (FSBT). A Walsh (Hand mark) code consists of a *Mn* matrix where *n* is an even integer. It has all 1s and 0s such that all rows differ from each other by exactly 1/2*n* positions. In Figure 8 the transmitter and receiver of FSBT are demonstrated. The 64 Walsh code matrixes are divided into 4 subgroups by using the corresponding index. In the transmitter, the input is given to the serial to parallel block which divides the input into 4 subgroups. These 4 signals are given as input for the FSBT Modulator, where the input is spread using a 64 Walsh code in the frequency spreader. Since the human body has high attenuation, the input to the receiver is considered with additive noise and intrinsic channel with the attenuated symbol. The demodulation is done by adopting the maximum likelihood detection method.

2) Body Coupled Communication: Body Coupled communication can be done by either capacitive coupling or galvanic coupling [16]. In the galvanic coupling technique, the transmitter sends a signal through the human body and irrespective of the environment; the receiver receives it [17].

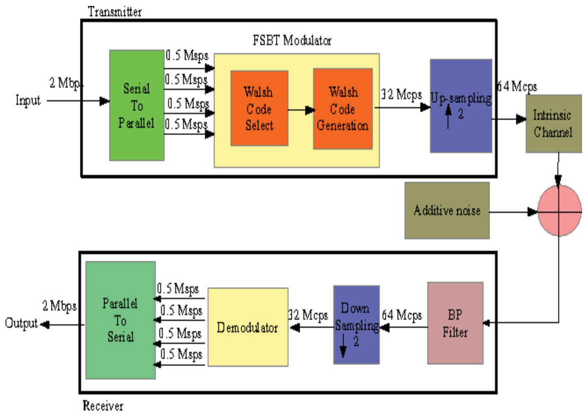


Fig. 5. HBC Block Diagram with FSBT Modulator

Both transmitter and receiver electrodes are directly placed in contact with the skin. Due to its robustness, it is ideal for wearable and implantable devices. But it has a drawback of working efficiently only in smaller distances and limits the transmission rate as it is directly in contact with skin and passing high signals at the transmission end can be harmful for the user. In capacitive coupling, though the transmitter electrode is placed on the human skin, the other electrode is left floating in such a way that the floating electrodes are coupled to ground through the air and creates as return path whereas the attached electrode creates a forward path [18]. Ideally, the simplified BCC model can be implemented as a pair of High pass filters in case of capacitive coupling and in galvanic coupling method as a channel which would only exhibit one high pass filter.

## VI. IMPLEMENTATION AND VALIDATION OF AMBULATORY HEALTH MONITORING SYSTEM

This section presents the implementation of the proposed system using Simulink®. Simulink was used as design validation platform due to its available primitives and libraries [1]. Fig.5 shows the implementation of HBC Block Diagram with FSBT Modulator. Fig. 6 shows the Gyroscope Block Diagram in Simulink®. The input resistance helps in setting a corner frequency of one high-pass filter and pass band level. As the input resistance increases, the level of pass band increases and the corner frequency decreases which helps in improving the gain of the BCC channel. A Rayleigh distribution is used for non-line of sight path and a Rician distribution is used for a line-of-sight path. The encoded signal is given as input to the combiner along with white noise. The output of the combiner is again fed into the demodulator which demodulates the signal at the output.

When FSBT is being used for a communication channel, only the transmitter is used for transmitting the input, at the receiver end the demodulation for FSBT is performed. When sensor values are transmitted along the sensor network, white noise is added to it as it becomes easier to transmit instead of discrete values. Fig. 7 shows the Body modeled as a spreading resistance. The transmitter and receiver are capacitive coupled to the body. The output of the band pass filter used at the receiver module to remove the noise components and to pass the main energy of the signal can be seen [12]. Fig.8 shows a mesh of Walsh code for *n*=64, i.e. *M*64×64 of all 1s.The performance of HBC in FSBT implementation is evaluated based on Average Signal to Noise Ratio and Bit error rate. When body coupled communication was implemented using resistance and capacitance, the channel gain was estimated based on the transmitter frequency. The frequency was varied from 10 MHz to 100 MHz. It can be observed that as the input resistance was increased, the gain increased but the slope gradually decreased, thus indicating variation in corner frequency. It can be observed that power consumption was 3.14 mW which implies a 31 % power reduction compared to the related research work in [19].

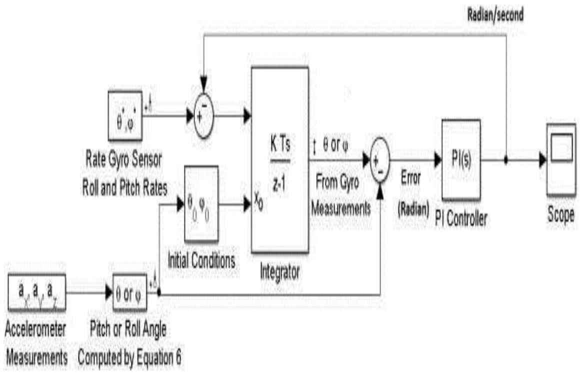


Fig. 6. Gyroscope Block Diagram in Simulink®.

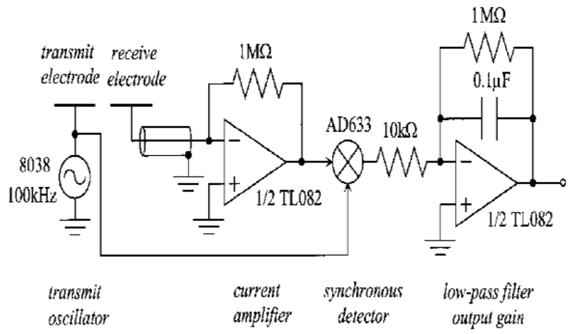


Fig.7. Body modeled as a spreading resistance. The transmitter and receiver are capacitive coupled to the body.

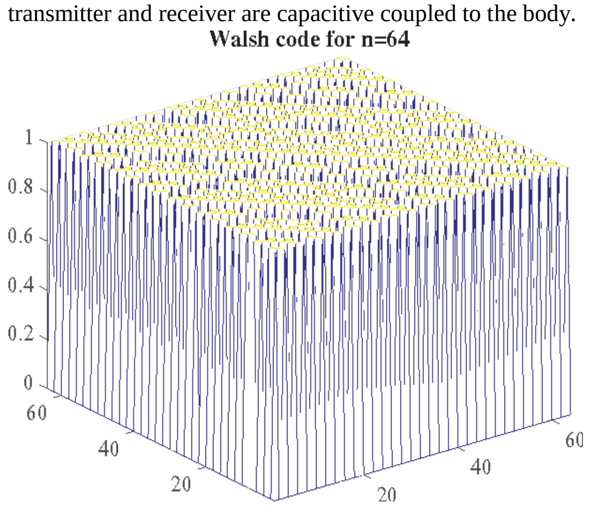


Fig.8. A mesh of Walsh code for *n*=64, i.e. *M*64×64 of all 1s.

## III. CONCLUSION

Finite element stress and model analysis was carried out for the moving blades of a low pressure steam turbine using customized software, dedicated for analysis of steam turbine blades. Steady state stress analysis of the blade is carried out by applying the centrifugal and aerodynamic loading.

Stress categorization at the critical location of the blade root is carried out to find out the membrane, and membrane with bending stress at those locations. Furthermore, the turbine blade failures are to be analyzed and the root causes of the failures are acquired.

This study has discussed an application of the Taguchi method for investigating the effects of heat rate on the steam temperature, steam pressure and quantity of flow rate values in the steam turbine. From the analysis of the results in the steam turbine process parameters using S/N ratio approach, analysis of variance (ANOVA) and Taguchi's optimization method, the following can be concluded that the steam flow rate is the most significant parameter followed by temperature and pressure.

## VII. CONCLUSIONS AND FUTURE RESEARCH

In this paper, we propose a healthcare monitoring system using FSBT and BCC in Simulink® using IoT applications with GSM module. This Human Body Communication helps in reducing the system complexity and power consumption as additional RF components are not being used. A Multiple Input Multiple Output System was used in this design in order to use the system for IoT applications as MIMO has become essential in wireless communication. It was observed that in independent applications such as touch-based intuitive service, FSBT plays an important role in HBC and for inter-sensor communication, BCC is very important as it reduces the power budget of the sensors at a price of higher attenuation. Future research involves developing smaller prototypes of the human body communication channel such that it can be used for integrating real-time sensors to Simulink® and also exploring more communication methods to reduce power consumption in body area networks.

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