Secure IR Communication Design For Pre-Cardiac Arrest Detection In Wireless Body Area Network

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Abstract-This paper has got its vision and practical implementation from the basic idea with regard to Wireless Body Area Sensor Networks (WBASNs). The remote Body Area Sensor nodes are non-invasive which contributes to this project by making it more efficient in prototype design. The added features of low operating power and wireless intra IR communication have modified, the design and patient monitoring to a simplified version. Due to its low operating power and highly infrequent usage of the rechargeable battery power, the idea of zero maintenance is deployed. This system was developed for the earlier detection of cardiac arrest in human body. Though, numerous models were in existence, they are not practically suitable or considered as unique design for this highly secured and more miscommunicated wireless node communication. In this paper we have proposed a novel generation of a unique key for each of the patient to communicate with its own nearby node (mobile) and then to emergency unit. The basic demerit that existed in all the primitive models of direct communication with high power node has been eliminated in this proposed idea. When Wireless Body Area Sensor within two patients comes in more close proximity, there is a chance of cross communication or miscommunication i.e. picking up of sign signal of one patient by another patient (mobile) receiver. This leads to a chaotic situation and may even lead to the death of the patient if the other patient's mobile sensor node is activated. For this reason, a unique ID is build which communicates with the mobile IR unit, where an android app is created to communicate through SMS with the patient caretaker, hospital and nearby ambulance network.

Keywords-- *On body sensor, IR Transmitter, IR Receiver , WBAN.*

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I. INTRODUCTION

Even though a person seems to be with normal health, cardiac arrests are unpredictable and require immediate attention and medication. It might be difficult and impossible to arrange for a rescue system at the time of emergency. Hence, in this paper we have proposed a system to detect the pre-cardiac attack of a patient. The earlier signs of a cardiac arrest include [1] increased heart beat rate, excessive sweating and increased blood pressure. By deploying piezoelectric vibration sensor, piezoelectric pressure sensor and sweat sensor, these abnormalities in a patient body are sensed and an alert signal through SMS is sent to the patient caretaker, ambulance and hospital. This effectively helps in timely arrangement for treatment and immediate rescue of the patient. The sensed parameters are transmitted using intra IR communication making it simple, error-free and cost effective when compared with Radio frequency (RF) Communication system where a detailed compression study is given in the Table.1.which shows that the IR communication is more suitable for short distance communication [2] when compared with RF, with a small miniature structure and the very low interference level in the communication frequency. This system is made more effective and error free by generating a unique key for communication between the patient to the nearby node . The main advantage of this unique key is that the presence of another patient at the same location will seldom disturb the sign signals and the vital sign signals of only the particular patient is picked by his own mobile unit, thereby avoiding cross communication /miscommunication with the nearby proximity user

Table:1: COMPARISON OF RADIO FREQUENCY WITH INFRARED [3]

PARAMETER	RF COMMUNICATION	IR COMMUNICATION
Security	**Low**	**High**
Rf Interference	**Yes**	**No**
Mobility	**Yes**	**No**
Path Loss	**Yes**	**Yes**
Communication Frequency	**2.4Ghz**	**38khz**
Range Of Connectivity	**100 Feet**	**30 Feet**
Fcc Regulations	**Yes**	**No**
Cost	**High**	**Less**
Area Of Coverage	**High**	**Low**
Suitable For Intra Body Communication	**No**	**Yes**
Noise Sources	**Other User Signal**	**Light Source**

The main idea behind this telemetry design of health monitoring is to address the key issues in wireless body area network.

- Designing a reliable sensor.
- Reliable transmission of vital signs.
- Providing privacy and security for patients.
- Maintain error free patient identification in complex environment.

Mobility is the main consideration in this task with the key benefit of off beam communication by applying a unique code for each patient. This is achieved with the benefit of small sensors, low-weight, low-power and, of course a wireless mode.

II. RELATED WORKS

Attiya Baqai et.al, analyzed and had implemented [3] a temperature measuring device, where the room temperature and various body temperatures are measured with a simple LM 35 temperature sensor, and is transmitted over an IR transmitter which is a sony transmitter and receiver communication model. The results obtained were accurate upto 0.4 F compared with a normal citizen thermometer. In this, the IR transmitter and the communication used are sony based product which has very high security and the amount of interference is also too high. Which is being not considered.

Another research effort proposed by author Tuba Yilmaz et.al, has discussed [4] about the vital signals monitoring from various parts of the body like electrocardiograph, pulse, blood pressure and blood glucose. These sensors are placed on the body and the vital signs are monitored. In this, he has discussed about the sensor in and on the body. The sensor placed are communicated through wireless communication protocols. He has also discussed about the basic security in communicating these signals where no separate work is discussed for communication over a longer distance .

III. METHODOLOGY

In this modern era due to pollution and improper food habits, cardiovascular malfunctioning (heart attack) has become unpredictable at any point of time. Taking this emergency condition into consideration, which is life risking and which may also lead to death when unattended, a new simple and low cost device has been constructed with its maximum level of security and is being proposed here and shown in Fig. A unique ID is also provided using a simple inbuilt Relay node circuit which is the distinct idea in this design. All the primitive models discussed failed to give a permanent, low power and simple design. It is shown, when two patients having the same pre-cardiac sensor and transmitter, come in close proximity, with any one of the patient get the pre-cardiac effect the sensors associated with it generates the response to that situation by sending an continuous high signal in the designated

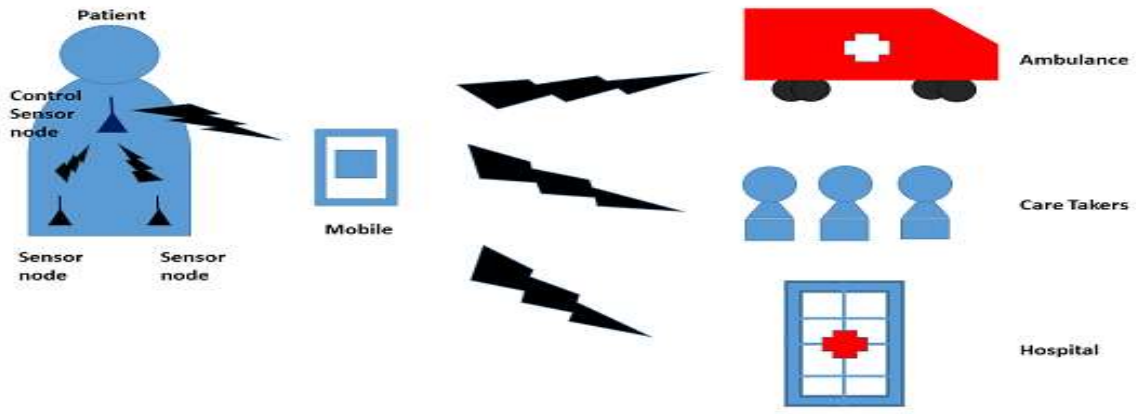

Figure -1.Simplified Note-To-Node IR communication in Wireleless Body Area Sensor Networks

frequency to the IR receiver to activate the alarm which inform the emergency unit ,but during this same instant the patient who doesn't suffer from any cardiac disease, his IR receiver [5] will also pick up the IR transmitted signal from the nearby system and makes the situation of the nearby close proximity patient in a chaos condition, where a signal to the doctor or the caretaker is send via SMS which makes the situation more worse . In this proposed model a small low power consuming relay node is attached before the main IR Transmitter. Here, 2 ideas are merged, first we have avoided a false alarm in sensing the pre-cardiac state by two other or more sensors to monitor the physiological values like blood pressure sensor and sweat sensor. This design is implemented to minimize the wrong alarm of the piezoelectric vibration sensor. When a patient is doing some other intense work that increases heart beat and activate the output, but the sweat or pressure sensors won't get activated as this is not the perfect state and raises a false alarm. Thus any false alarm is detected at this stage and is being disabled. This idea is most diversion of normal WBAN [6] but a security innovation and simple structure. when a pre-cardiac arrest state occurs the heart vibration sensor detects the change and produces a logical high to the one end of the AND Gate ,now in order to verify it and to avoid false detection of the situation it is must to detect a change in physiological change on other body parts, if detected by any one of the sensor kept across the body, the locally present IR transmitter will communicate with the control sensor node, IR receiver from where it activates the unique code assigned for that patient which is the secure mechanism, this signal is detected by the patient mobile from which an emergency message [7] is sent to the caretaker, Ambulance and to the Hospital. In this the second idea of a chaos situation between the close proximity patients are

completely eliminated by generating a unique code stored in it.

IV. HARDWARE IMPLEMENTATION. V.

All the vital signs of the pre-cardiac disease are studied [10] and three different sensor hardware models are placed in various parts of the body, these three sensors work independently and communicate each other through wireless but in line of sight. Below the three different sensors with their monitoring physiological and the transmitter part is explained continued with its block diagram and hardware model.

4.1 PIEZOELECTRIC VIBRATION SENSOR

A piezoelectric vibration sensor is a device that uses the piezoelectric effect, to measure the changes in pressure by converting them to an electrical signal/ charge which is shown in fig.2. Piezoelectric sensors have proven to be versatile tools for the measurement of various processes. Based on piezoelectric principle [8] various physical quantities can be measured, amidst which the most common is pressure. For pressure sensors, a thin membrane and a massive base is used, ensuring that an applied pressure specifically loads the elements in one direction which the quartz crystal could transform this applied mechanical energy into an electrical output. This electrical output voltage induced from pressure is proportional to that applied pressure. These piezoelectric devices are selected for heart beat vibration because it can detect single pressure events. This vibration sensor is placed near to the heart, when the heart functioning of the patient is normal, the vibrations generate an output voltage which is very low that can't be detected. When a pre-cardiac state arises the heart muscle puts a lot of stress and pumps the blood to the choking area to vital organs, now the heart rate increases which indirectly increases the vibration rate of the crystal. At this point an electrical signal is generated at the output that is picked up by the driver circuit. This circuit flows a high voltage and this ensures a logical high to one end of the AND Gate .

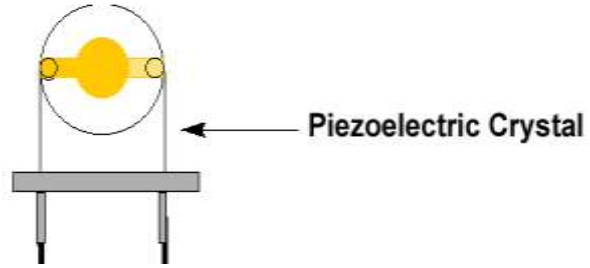

Figure - piezoelectric vibration sensor

4.2 BLOOD PRESSURE SENSOR

The Blood Pressure sensor is used to measure arterial blood pressure in human(noninvasively). It measures the pressure [9] caused by the interaction between the pressure point and the vein blood flow through the brachial artery. During each heart beat the arterial blood pressure varies between two utmost values: the systolic and the diastolic pressure. The piezoelectric pressure sensor shown if Fig.3. is used to determine the blood pressure via the so-called pressure detection method or change in volume of liquids. This is non-invasive technique, placed in the wrist of a human body and tightly plastered, When pressure or force is applied to piezoelectric crystal by the major arterial vessel it gets elastically deformed, this deformation results in a development of electric charge or voltage (which retains for a few second) across the crystal surface which is proportional to the force applied (Figure), where these sensors are used to measure rapidly changing pressures resulting from pressure pulsations. The resulting electric signal flowing in the external circuit can be measured as an indication of the pressure which was applied to the crystal the blood vessel during a pre-cardiac arrest state. The driver circuit attached at the output of the sensor picks the pulse voltage that switch on the IR transmitter of that sensor point this is used as an indication of change in pressure, also a cross verification to avoid the generation of false alarm in the circuit .

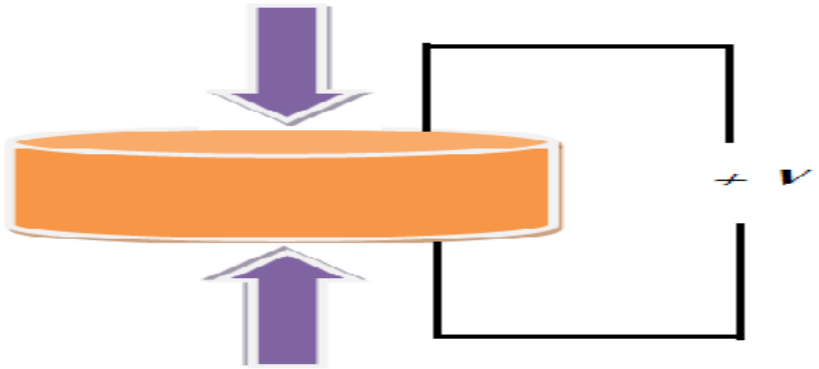

Figure.3. piezoelectric pressure sensor

4.3 SWEAT SENSOR

The sweat sensor is a simple voltage divider circuit which produces the required change in output voltage when a maximum input voltage is applied. When change in the resistance value occurs between the skin surface /skin medium which is shown in figure.4 with its equivalent circuit in figure:5. The human skin has less conductivity during normal room temperature as there is absence of sweat in the body in normal room temperature. Under this condition the resistive place R1 and R2 has more resistive path (less conductivity on the skin surface) thus a zero output voltage is detected. But During early stages of cardiac arrest of patients the sweat rate increases which is an outcome in stress level and the skin surface becomes wet, which gradually reduces the resistance value across the electrodes R1 and R2. When the sweat level increases and lowers the resistive path

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conduction between the two electrodes occur and the applied voltage is diverted to the driver circuit in turn activates the input IR transmitter locally .

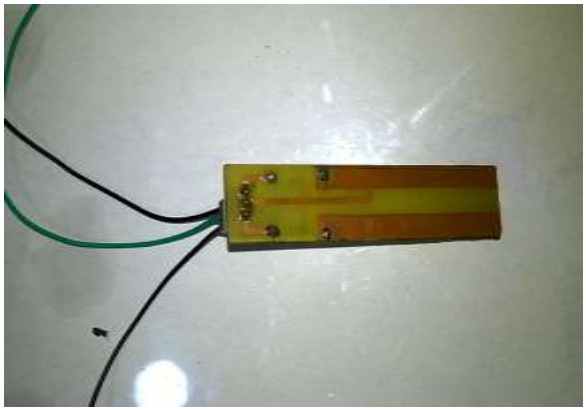

Figure - 4 sweat sensor.

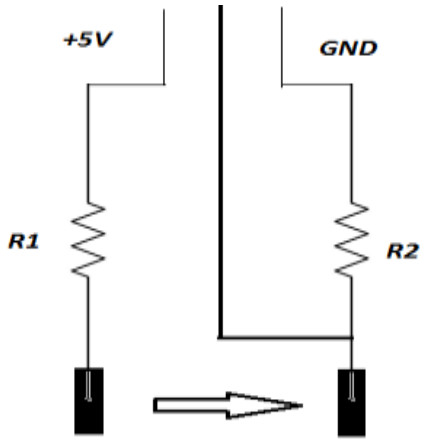

Figure -5 Equivalent circuit .

In the proposed model shown in figure .6 we provide a early detection of cardiac arrest symptoms and inform it to the nearby emergency systems. Any normal human who had not suffered /attacked by the heart attack can use this system for early detection and can reduce the risk or intense damage caused by it.

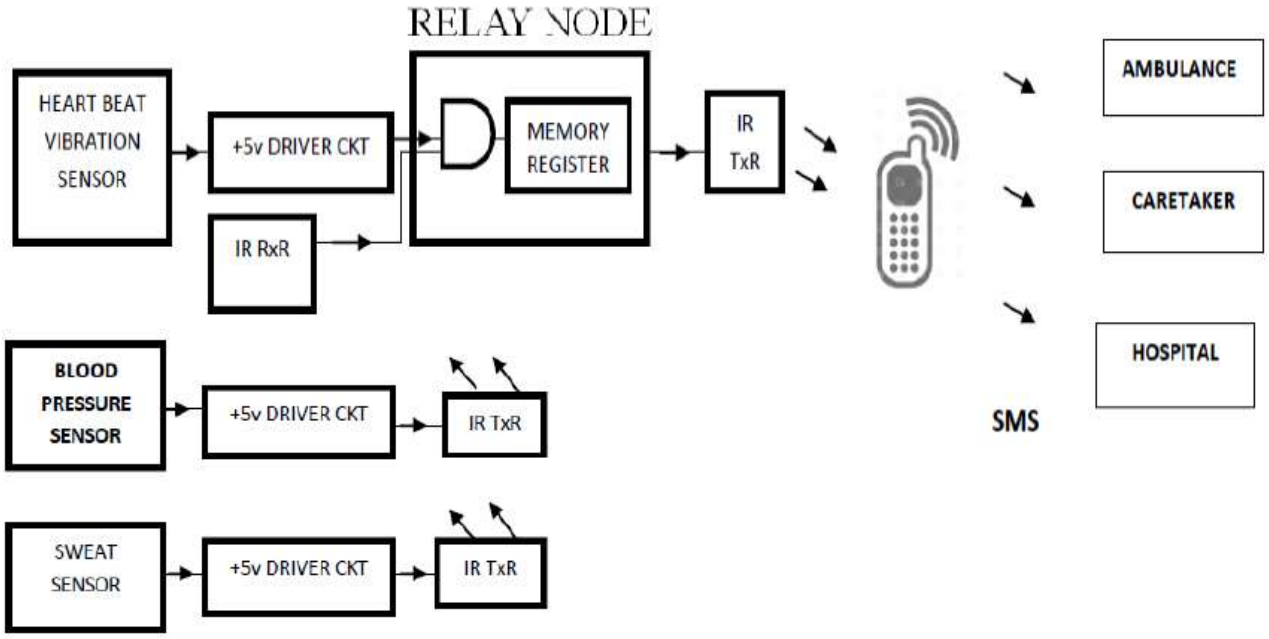

Figure – 6 Block diagram of secure IR module.

During earlier cardiac arrest the major symptoms are [10], increase in heart rate from its normal beats of 72-76 beats/min to 120beats/min. The blood pressure also increases from a normal 120/80 mm Hg to more than 140/90 mm Hg. During this duration the body reacts to get back to normal and thus makes the patient more tensed which increases the sweat level twice the normal value. These parametric changes are taken as our basic sensor input values for early cardiac detection in the proposal.

In this model entirely three distinct body parameters are measured using a wide range of sensor networks which operates independently. Piezo electric vibration sensor is used to monitor the heart vibrations. During normal heart rate the output voltage from the piezoelectric sensor is below the driver circuit threshold so it will not trigger the output . When a critical cardiac arrest occurs or during a pre-cardiac arrest, the heart tries to pump more blood in the blocked blood vessels which indirectly increases the heart beat rate. When the piezoelectric vibration sensor picks up even small change in vibration values there is raise in output voltage level beyond the driver circuit pickup value or threshold. This driver voltage is given as one of the input to the AND gate of the relay node. At this situation the blood pressure also increases very much drastically with an increase in sweat rate where both the pressure sensor and sweat sensor values gets beyond the threshold and activates the IR transmitter.

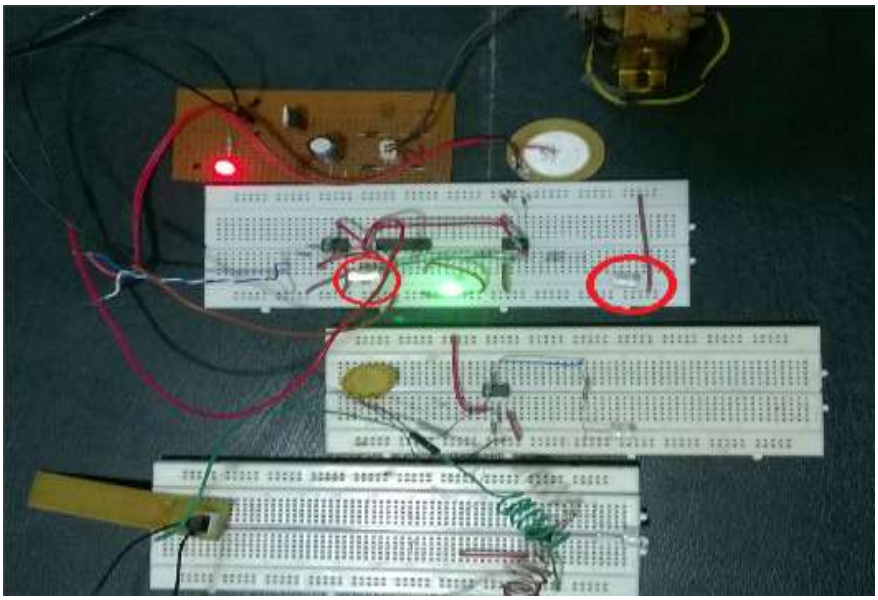

Figure – 7 Hardware Implementation of Sensor And IR Transmitter.

We have designed the relay node as, if any one lower node gets activated the IR receiver at the input of the AND gate which initiate the unique data code that unique individual data stored in the memory unit during initialization is repeatedly sent. When this unique memory bit stored in the unit is received by the mobile unit supported by Android , a preloaded mobile app [7] will send emergency Short Message Service(SMS) to inform the urgency and request for immediate support to the caretaker, hospital and emergency ambulance service.

VI. EXPERIMENTAL RESULT

The IR security sensor system is tested on board in the lab with pressure,vibration and sweat sensor. The test gives positive responses for very close line of sight when tested in lab with the same scenario in real time. But negative results are recorded for longer distance with lot of noise (the surrounding heat source generate noise). It is due to the sensitivity of the IR transmitter and receiver towards heat. The IR transmitter and receiver works as good over the normal range of 3 feet within human body range.

VII. CONCLUSION AND FUTURE SCOPE

The current idea of authentic transmission technology for pre-monitoring of vital signs is a promising one to the traditional flat IR transmission and receiver, designing a non-invasive body worn sensor and wireless transmission with a unique code is very challenging, which needs a broad understanding of the nature of the disease and its effect on physiological parameters. A lot of sensors and wireless transmission are avaliable in various practical designs and in literature survey, it needs an improvement in the authentic communication and a non-invasive monitoring,detection of these parameters, the main constraint for an authentic wireless design are:

- Low power consumption.
- Security.
- Reliable data transmission.
- Faulty communication.
- Conformal design.
- Compatibility.

With all these constraints in mind, building an authentic communication wireless link to an on-body sensor network which provides the maximum mobility to the patient, with no error of mis/wrong communication from other patient sensor network makes our design a superior, distinct and unique model in wireless authentic body area network design.

It is proposed to do the entire communication without IR interference from TV remote and A/C remote control system in this present work these interferences are not considered, also the power consumption of these driver circuit are equal to +5V and sensor are to be made more sensitive .

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