A REAL-TIME HEALTH MONITORING SYSTEM FOR REMOTE PATIENTS USING WEARABLE SENSOR

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ABSTRACT This paper introduces a wearable Tele-ECG and heart rate (HR) monitoring system which has a novel architecture including a stretchable singlet redesigned with textile electrodes (TEs), textile threads, snap fasteners, Velcro, sponges, and an ECG circuit. In addition, a Bluetooth low energy (BLE), a smartphone, a server, and a web page have been added to the system for remote monitoring. The TE can be attached to and removed from the singlet by a Velcro, which allows the user to dry-clean the TE easily for long-term use. A new holter-based ECG system has been designed to evaluate the TE-based ECG system and the average correlation between the recorded ECG signals is obtained as 99.23%. A filtered digital signal, with a high signal-to-noise ratio of 45.62 dB, is transmitted to the smartphone via BLE. The ECG signal is plotted, the HR is calculated with 1.83% mean absolute percentage error, and displayed. The data are sent to the server, allowing the patient's physician to analyze the signals in real time through the web page or the smartphone. If HR reaches beyond the normal range or user presses the "HELP" button on the smartphone screen, the physician is informed automatically by an short message service (SMS) with a location pin on the map. The battery lasts approximately 14 days and when it needs replacement, the system automatically alerts the users by an SMS and a flashing LED. This fast and uninterrupted telemonitoring system has the potential to improve the patient's life quality by providing a psychological reassurance

INTRODUCTION:

During the recent decade, rapid advancements in healthcare services and low cost wireless communication have greatly assisted in coping with the problem of fewer medical facilities. The integration of mobile communications with wearable sensors has facilitated the shift of healthcare services from clinic-centric to patient-centric and is termed as "Telemedicine" in the literature [1]. In the larger perspective, telemedicine can be of two types: (1) live communication type, where the presence of the doctor and patient is necessary with additional requirements of high bandwidth and good data speed, and (2) store and forward type, which requires acquisition of medical parameters such as vital signs, images, videos, and transmission of patients data to concerned specialist in hospital [2, 3]. According to existing medical surveys, telemedicine has been adopted to take care of the patients with cardiac diseases, diabetes, hypotension, hypertension, hyperthermia, and hypothermia [4–8]. The most promising application is in real-time monitoring of chronic illnesses such as cardiopulmonary disease, asthma, and heart failure in patients located far from the medical care facilities through wireless monitoring systems [9]. Heart diseases have become one of the leading causes of human fatalities around the world; for instance, approximately 2.8 million people die each year as a result of being overweight or obese as obesity can lead to adverse metabolic effects on blood pressure and cholesterol which ultimately increases the risks of coronary heart disease, ischemic stroke, diabetes mellitus, and a number of common cancers [10]. According to WHO, it has been estimated that heart disease rate might increase to 23.3% worldwide by the year 2030 [11]. The treatment of such chronic diseases requires continuous and long term monitoring to control threat. PATIENT care demands on hospitals are on the rise in parallel with the growth of the world population and the accompanying rise in chronic diseases. According to the mortality statistics recorded in 2015, 17.7 million people have lost their lives due to cardiovascular diseases in the world. This number corresponds to 31% of the total number of deaths [1]. Instrumentation and measurement (I and M) are a keystone to diagnose each disease [2]. ECG measuring is quite important to examine and monitor a patient with heart problems. In a conventional ECG measuring system, Ag/AgCl electrodes are attached to the body, with conducive gel at the electrode–skin interface, for signal acquisition to derive certain ECG leads. The conductive gel may be toxic and cause skin irritation [3], [4] and the Ag/AgCl electrodes may cause allergic reactions of the skin [5]. Despite their high conductance initially, after prolonged use, Ag/AgCl, lose their adherence resulting in signal loss and requiring replacement. Therefore, the use of Ag/AgCl electrodes for extended periods of patient monitoring is not appropriate. As alternatives, dry metal electrodes have been used [6], [7] and some studies have explored textile electrode (TE) that has a minimal effect on patient's normal lifestyle [8]–[12]. The TE also has high contact conductivity that is essential for a reliable ECG acquisition [13], [14]. TE can be used to pick up ECG, EEG, and electromyogram (EMG) signals and they have been proven to be as reliable as Ag/AgCl electrodes [15]. In normal conditions, the conductance of TEbased ECG monitor is regarded as equivalent to Ag/AgCl. Humid conditions are advantageous rather than detrimental to TE-based monitor due to the electrolytic properties of sweat. The electrolyte includes molecules and ions. Therefore, it increases electrical conductivity [16], [17]. Contactless ECG sensors provide the convenience of monitoring in nonhospital environments [18]. Diverse ECG measurement systems have been reported including systems that can be fixed to chair [19], bed [8] or can be adapted to clothes [20]–[22]. Nemati et al. [3] demonstrated a wireless ECG monitoring system which consisted of a belt stretched inside a T-shirt and equipped with three capacitive electrodes, where the ECG measuring is transmitted to a PC, requiring the user to own a PC. However, once this proposed system is preferred, the patients can use their existing cell phone for monitoring the vital signs. Mahmud et al. [6] collected ECG signals using two electric potential integrated circuit sensors fitted in a phone case and were able to transmit the signal with an Rfduino through Bluetooth low energy (BLE) and displayed the ECG signal on a cell phone. They also use smartphone memory to save ECG data, which is not appropriate for multiple usages due to limited data storage. In this paper, both local memory and server are implemented to allow multiple patient follow-ups without limitation to data storage. Chamadiya et al. [8] performed ECG measurements with electrodes fitted on stretchers, wheelchairs, and patient beds. They installed the conventional Ag/AgCl and TE on the same measurement setup to compare the results of both electrode types and concluded that there was no discrepancy between the measurements of the two types. In their work, the patient had to be stable in the supine position dictated by the measurement system or had to maintain contact with electrodes reclining back in a chair, which restricts the movement of the patient. On the other hand, in this paper, the person does not need to recline against or maintain contact with anything and, hence, favorable since the ECG is acquired under normal motion and living conditions. Pani et al. [23] concluded that ECG devices as wearable devices, using either dry or wet TE, without any discomfort to the patients. TE is used in this paper as well. For remote monitoring, a smartphone, an Internet of Things (IoT) server, and a web interface are implemented in the system. To monitor ECG, Yoo et al. [24] developed a 24-h data acquisition system comprising TE in a smart dress. However, they reported ECG signal without heart rate (HR) or location. Lamonaca et al. [25] equipped a smartphone with new sensors and used existing sensors on the smartphone to measure the body posture, falling, HR, blood oxygen saturation, eye pathologies, and respiratory system. Their system does not have a wearable part, and the HR was calculated using captured face image providing an added benefit for the user in case of instant HR measurement [25]. However, in case HR must be measured continuously, the system proposed in this paper would be preferred since the system measures ECG and HR continuously in real time. Pandian et al. [26] measured noninvasive physiological parameters and saved ECG data using electrodes placed on a vest. They also indicated photoplethysmogram, body temperature, blood pressure, galvanic skin response, and HR [26]. They used wireless and GPS module with their circuits for data transmitting without smartphone or BLE. As a result, their system consumes more power, and they reported that their system runs for a limited time of 4.5 h, which is not optimal. However, the proposed system in this paper can run approximately 335 h (14 days) continuously. Using a smartphone instead of a device without GPS was found more useful [27]. Arteaga-Falconi et al. [28] utilized the benefits of smartphone and developed a mobile biometric authentication by using measured ECG signal. This could be merged with the wearable ECG monitoring systems. To solve energy consumption, Luo et al. [29] proposed an ECG compression process, using which allowed lowering of data transmission and power consumption. They send the data to a computer with a wireless module. The user is required to use a computer for the initial setup. However, once the proposed system is chosen, the users do not need to have a computer. They can easily use an existing smartphone with the developed custom application. Dionisi et al. [30] proposed a flexible solar panel for their wearable monitoring system, which is a convenience to the user as it mitigates power consumption and frequent battery replacement problems. However, in the evening or midnight, the system stops since it needs daylight to operate. In this paper, the demonstrated system runs uninterrupted for a long time independent of daylight. In the future, a hybrid system could be developed, consisting of both solar panel and a battery. In this paper, a wearable Tele-ECG monitoring system with a novel architecture consisted of TE, Velcro, textile thread, snap fasteners, sponge, and ECG front end has been designed to monitor ECG of the users while allowing the users to have a comfortable daily life and maintain better hygiene. In the previous studies, TE was generally sewn on a T-shirt or belt [9], [13]. In this case, cleaning of TE is not easy since the TE needs to be dry-cleaned. In addition, the TEs have to be sewn to different sized clothes for different weighted people. On the other hand, in this paper, the novel architecture is designed to achieve good quality ECG signal with TEs that can be easily attached, transferred, or removed from any different sized clothes by the Velcro. The TE can be easily dry-cleaned and its position adjusted on a human body. Also, there is no electrical cable on the system as the ECG signal is carried by the textile thread. The attached snap fasteners receive the ECG signals from the textile thread and transfer it to the electronic ECG circuit. The developed ECG I and M system measures the ECG signal, detect the HR, monitor them on both a cell phone and a web page, and record the signals both in the cell phone memory (if necessary) and custom server. The ECG front-end circuit has been designed and integrated with a CC2650MODA which is a 32-bit ARM Cortex-M3-M0 microcontroller (MCU) in industrial scientific and medical band incorporating a BLE to transmit the data using a radio link. The electronic card prototype has been enclosed in a case produced with a 3-D printer. The circuit card and three TEs have been fitted inside the stretchable singlet. Analog signals picked up by TE are amplified and filtered by the front-end circuit, then digitized and further filtered by a digital filter (DF) in the MCU and ultimately sent to a smartphone using the BLE. In addition to viewing the ECG signal and HR on the physicians' smartphone screen, the data are retransmitted to the server. Moreover, the physician can be alerted automatically during an emergency HR level or by pressing a specialized "HELP" button for immediate attention, which could provide faster healthcare access to the patients. The medical specialists can view the ECG, HR, medical history, and location information of patients. To evaluate ECG, a holter-based new ECG system has also been designed and the data have been recorded from both TE- and holter-based systems. Their average correlation of ECG signals is 99.23% and maximum signal-to-noise ratio (SNR) value of TE-based system is 45.62 dB. To evaluate HR, the both designed system and a fingertip pulse oximeter have measured the HR values in the same condition and their minimum mean absolute error (MAE) and mean absolute percentage error (MAPE) are 1.1% and 1.83%, respectively. Merging new technologies provides several novelties to this paper as easily washable TE and BLE usage are more novel than Ag/AgCL electrodes and Bluetooth/cable usage. Battery life of nearly 14 days of the proposed study is another novelty. The automated emergency alert with calculated HR value, manual help request, and battery replacement alert contribute novelties of the system that are aimed to enhance user experience. Additional novelties are that the physician can control the system; can add or remove new patients, follow vital signs in real time with location information, and add patients' medical history to the server and observe them continuously on the smartphone or web interfaces. The developed system is appraised to be quite beneficial for cardiac patients and their physicians

LITERATURE REVIEW:

In "S. Shirmohammadi, K. Barbe, D. Grimaldi, S. Rapuano, and S. Grassini, "Instrumentation and measurement in medical, biomedical, and healthcare systems," IEEE Instrum. Meas. Mag., vol. 19, no. 5, pp. 6–12, Oct. 2016"

Proper measurement is crucial in the medical, biomedical, and healthcare fields because it forms the basis of medical diagnosis, prognosis, and evaluation. In fact, it is known that "measuring is the cornerstone of medical research and clinical practice" [1]. Medical professionals such as doctors or clinical laboratory scientists must have confidence in the results reported by their instruments or their measurement methods to make the correct decision for their patient. While in many industries incorrect measurements would simply lead to customer dissatisfaction or loss of money, in the medical field incorrect measurements could be fatal and lead to loss of life. Hence, we can say that proper instrumentation and measurement is vital in the medical field. In this article, we take a look at the latest biomedical topics from the perspective of Instrumentation and Measurement (I&M), and we summarize the latest medical I&M topics published in IEEE Transactions on Instrumentation and Measurement (TIM), to familiarize medical practitioners and researchers in how to achieve a proper medical I&M paper. We also briefly introduce the IEEE Instrumentation and Measurement Society's (IMS) main medical conference, the IEEE Symposium on Medical Measurements and Applications (IEEE MeMeA), which promotes the I&M aspects of the medical field in general, and we present guidelines on the I&M aspects that are useful for authors with primarily biomedical backgrounds who would like to publish in IEEE TIM. I&M as a field is primarily interested in measuring, detecting, monitoring, and recording of a phenomenon referred to as the measurand, and associated calibration, uncertainty, tools, and applications. The fundamentals of I&M apply to any kind of instrument or measurement, including medical ones. As such, it is not surprising to see that IEEE TIM, the flagship journal of the IMS, receives a significant number of submissions in the medical field. Many of the submissions are in medical imaging, which we consider part of Vision Based Measurement, a subject area already discussed in another overview article [2]. The remaining submissions, especially in recent years, are mostly in the subject areas of physiological monitors and sensors, and health parameters monitoring, which are the subjects of this article. It is not surprising to see more submissions in these specific subject areas because of the ever-increasing advancements in today's mobile devices with touchscreens, context monitoring, voice and gesture recognition, etc., which has created a boom in their usage in medical applications. It should be noted that this article is meant as an overview only and we cannot cover in detail the complete range of I&M aspects in the medical field: measurement accuracy, uncertainty, instrument reliability, calibration against the gold standard, and complying with various regional, national, or international medical regulations. With this in mind, let us start by looking at physiological monitors and sensors from an I&M perspective. Physiological Instruments The technological revolution in recent years has opened opportunities for bringing medical facilities to everyone's home doorstep. This is realized not only by numerous apps available for smartphones, such as [3] and [4], but also by specialized devices, which are provided in portable format. For such devices, two major open questions arise for the I&M community: • How can we safeguard that the clinical quality of measurements is achieved using the low cost measurement equipment in a home environment? and ‣ How are abuse and misusage avoided when medical devices are brought into a home environment and then operated by a lay user? The most important key to solving these questions is to enhance the signal quality. Since specialized equipment forces the price extremely high, inexpensive low cost equipment can be equipped with advanced signal processing tools, which are not expensive. In addition, specialized sensors can be replaced by lower cost sensors or measurement devices, which a layperson can operate that have a dedicated mathematical model or data analysis technique that can compute the physiological parameter of interest from the acquired measurements.

IN "E. NEMATI, M. J. DEEN, AND T. MONDAL, "A WIRELESS WEARABLE ECG SENSOR FOR LONG-TERM APPLICATIONS," IEEE COMMUN.MAG., VOL. 50, NO.1, PP. 36–43, JAN. 2012"

Ubiquitous vital signs sensing using wireless medical sensors are promising alternatives to conventional, in-hospital healthcare systems. In this work, a wearable ECG sensor is proposed. This sensor system combined an appropriate wireless protocol for data communication with capacitive ECG signal sensing and processing. The ANT protocol was used as a low-data-rate wireless module to reduce the power consumption and size of the sensor. Furthermore, capacitive ECG sensing is a simple technique that avoids direct contact with the skin and provides maximum convenience to the user. In our work, small capacitive electrodes were integrated into a cotton T-shirt together with a signal processing and transmitting board on a two-layer standard printed circuit board design technology. The entire system has small size, is thin, and has low power consumption compared to recent ECG monitoring systems. In addition, appropriate signal conditioning and processing were implemented to remove motion artifacts. The acquired ECG signals are comparable to ones obtained using conventional glued-on electrodes, and are easily read and interpreted by a cardiologist Electrocardiography (ECG) is one of the most widely used vital sign sensing and health monitoring methods and provides useful diagnostic information about the cardiovascular system. It can be used as powerful indicator of some specific physiological and pathological conditions of humans. With the increase in coronary diseases during the past few decades, continuous monitoring of the ECG signal of high-risk patients can play an important role in immediately detecting pathological signatures and arrhythmias. Using this concept, any deviation of the health status of an individual from their norm can be detected and sent to a health center for early and further analysis and preventative actions. Studies have proven that this type of ECG monitoring, if it does not interfere with daily activities, can improve the diagnosis and therapy of some of the most prevalent cardiac diseases [1–3]. Currently, ECG can be performed using many methods. The conventional clinical ECG system employs 12 or 15 Ag-AgCl electrodes (wet ECG), which are affixed to specific parts of the chest, arms, or hands and legs. This often requires cleaning the attachment site and, if necessary, shaving the hair off some parts of the body. In this way, the electrodes, which consist of gel in the middle of a pad, can be used to provide a conducting medium for charge transfer between the electrodes and the body. To keep the electrodes in place, extra adhesive tape is also applied. Although this type of ECG provides good signal quality, it is inconvenient and may cause skin irritation, allergic reactions, and inflammation due to toxicological issues of the gels in long-term treatments [1–4]. In addition, the quality of the signal will be reduced as the gel dehydrates during prolonged use, and replacement of the gel is typically infeasible. Furthermore, since it is difficult to keep the adhesives entirely separate from each other over the long term, cross-coupling between neighboringelectrode sites can occur through leakage current [5]. Therefore, the wet ECG electrode system may be unsuitable for long-term ECG monitoring. One of the main goals of this project is to provide maximum convenience to the user or patient during ECG measurements, especially for prolonged use. Therefore, special consideration is taken regarding two interfaces: the patient-sensor and sensor-cardiologist interfaces. A convenient interface between the body and the sensor can be realized using a non-contact ECG sensing

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method. An efficient wireless protocol plus well designed software is also needed to assure convenience in the sensor-cardiologist interface. Alternatives for wet ECG that potentially provide comfortable patient-sensor interface are dry-electrode or capacitively-coupled ECG (CC-ECG) methods. In the dry-electrode ECG, a metal plate is placed on the skin instead of wet electrodes, so the problems of using gel are eliminated. However, it still has direct contact with the body, so it may cause skin irritation and allergies after prolonged use. On the other hand, in the capacitive method used in this work, there is no direct contact with the body. Instead, a thin layer of insulator is placed between the body and the metal electrode. In one method, the electrodes can be unnoticeably applied to a cloth that can be worn by the patient to provide ubiquitous (U) healthcare ECG sensing. Following this idea, a wireless, portable ECG sensor was designed in which the following key considerations were targeted: convenience, portability, and small size. Convenience and portability were achieved by using the capacitive ECG sensing approach, utilizing a small wireless module, and also by employing inexpensive standard off-the-shelf (OTS) integrated circuits (ICs) in small packages. In addition, we used a standard two-layer printed circuit board (PCB) design for the signal processing board, which resulted in a thin, small-area sensor. To obtain long battery lifetime, all components of the sensor were chosen from low-power ones, and some battery-saving techniques such as idle mode signal sampling were employed. In particular, for data communication, which is always one of the most power-hungry parts in similar sensors, an extremely low-power wireless communication protocol was used. These special considerations resulted in a low-power, small form factor, accurate and easy-to-use wireless ECG sensing system

IN "A. M. KHAIRUDDIN, K. N. F. K. AZIR, AND P. E. KAN, "DESIGN AND DEVELOPMENT OF INTELLIGENT ELECTRODES FOR FUTURE DIGITAL HEALTH MONITORING: A REVIEW," IN PROC. IOP CONF. SER., MATER. SCI. ENG., VOL. 318, NO. 1, MAR. 2018, P. 12073" Electrodes are sensors used in electrocardiography (ECG) monitoring system to diagnose heart diseases. Over the years, diverse types of electrodes have been designed and developed to improve ECG monitoring system. However, more recently, with the technological advances and capabilities from the Internet of Things (IoT), cloud computing and data analytics in personalized healthcare, researchers are attempting to design and develop more effective as well as flexible ECG devices by using intelligent electrodes. This paper reviews previous works on electrodes used in electrocardiography (ECG) monitoring devices to identify the key ftures for designing and developing intelligent electrodes in digital health monitoring devices. Traditionally, patients with cardiovascular diseases are required to monitor their heart conditions on a continuously basis. The diagnosis and measurement of the patients' vital signs need to be performed in controlled environment such as at the medical centers or hospitals. This clinic-centric approach requires patients to regularly visit the medical centers and hospitals. This traditional approach however can be very costly, tiring and time consuming for the patients. More recently, the Internet of Things (IoT) and supporting technologies such as cloud computing and big data analytics are helping to shift the clinic-centric approach towards the person-centric model or personalized healthcare [1]–[3]. The adoption of IoT, cloud computing and big data analytics in the healthcare industry is not only changing its landscape but also enables a new way of organizing the delivering of health care and health related services in the industry. For instance, with IoT, it is now possible to provide high quality personalized health to all individuals anytime, anywhere and when needed. More specifically, the IoT supported personalized healthcare allows health care and health related services to be delivered to an individual based on his or her unique biological, behavioral, cultural, and social characteristics [4]–[6]. As one of the major innovations in digital technology, the IoT is also increasingly changing the way in which the medical centers and hospitals in the health care sector operate. Since its introduction and adoption in the health care sector, this digital technology has been able to provide various medical and health care applications to the medical centers and hospitals. Among the essential medical applications provided by IoT include; remote health monitoring and delivery, chronic diseases and post-surgery care, fitness programs, elderly care, compliance with treatment as well as medication at home In addition, the IoT as interconnected technology enables medical devices such as ECG, sensors, diagnostic and imaging devices to be connected to each other as well as between doctors and their patients. These networks of IoT-based devices have helped to not only improve the detection, prevention and treatment of diseases but also reduce medical costs, increase the quality of life and enhance the experience of the patients that use these medical devices [8]–[10]. The major innovations in digital technologies have also made it possible to design and improve the capabilities of existing medical devices such as ECG devices and their essential components. More specifically, the improvement in the contemporary ECG devices has mainly resulted from the adoption of the advances and capabilities found in the IoT and supporting technologies such as cloud computing and big data analytics. However, the literature reveals not only little research but also limited information on the development of intelligent electrodes used in contemporary ECG devices. This paper reviews previous works on ECG devices to identify the key features that useful for designing and developing intelligent electrodes for digital health monitoring.

IN "M. S. MAHMUD, H. WANG, A. M. ESFAR-E-ALAM, AND H. FANG, "A WIRELESS HEALTH MONITORING SYSTEM USING MOBILE PHONE ACCESSORIES," IEEE INTERNET THINGS J., VOL. 4, NO. 6, PP. 2009–2018, DEC. 2017" This paper presents the design and prototype of a wireless health monitoring system using mobile phone accessories. We focus on measuring real time Electrocardiogram (ECG) and Heart rate monitoring using a smartphone case. With the increasing number of cardiac patients worldwide, this design can be used for early detection of heart diseases. Unlike most of the existing methods that use an optical sensor to monitor heart rate, our approach is to measure real time ECG with dry electrodes placed on smartphone case. The collected ECG signal can be stored and analyzed in real time through a smartphone application for prognosis and diagnosis. The proposed hardware system consists of a single chip microcontroller (RFduino) embedded with Bluetooth low energy (BLE), hence miniaturizing the size and prolonging battery life. The system called "Smart Case" has been tested in a lab environment. We also designed a 3D printed smartphone case to validate the feasibly of the system. The results demonstrated that the proposed system could be comparable to medical grade devices. H EALTHcare monitoring through smart phones has been increasing rapidly in recent years, due to its ubiquity, accessible and easy to use. However, quality and affordability of the health care systems are major problems around the globe. A large number of people with low income facing issues with the high cost of healthcare system; Moreover, many individuals are not able to get the quality of health care they need. The cost of healthcare monitoring in the United States alone is 393.5 billion in the year of 2005 [1]. According to [2], total medical cost is 4 million each year for non-cardiac cases. With the help of a smartphone based healthcare monitoring system, we can reduce these costs. This system can allow users to have instant medical checkup, lab reports and store these data for later use. The stored information can be used [3]- [4]. Smart phone applications like prescription reminder, calorie measurement, appointment with medical doctors, hospital locators can ease the accessibility. Nowadays, smartphones are not only for communication purpose as they used to be, and they could support a wide range of applications. A large number of smartphone based medical devices are becoming more popular for fitness [5]- [8]. Health monitoring devices are being miniaturized in size and are more user friendly, which allow complex computation and sensing vital information such as heart rate, ECG, Oximetry and respiration. Statistics show that remote monitoring devices have played a vital role to reduce the re-hospitalization rate

BLOCK DIAGRAM:

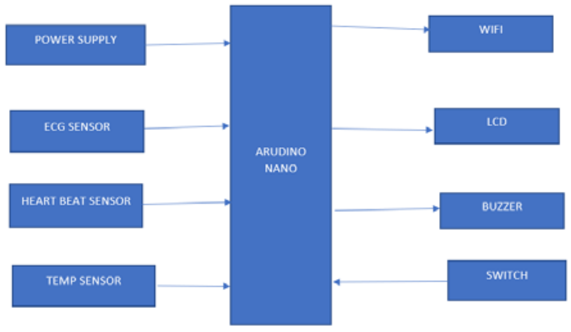
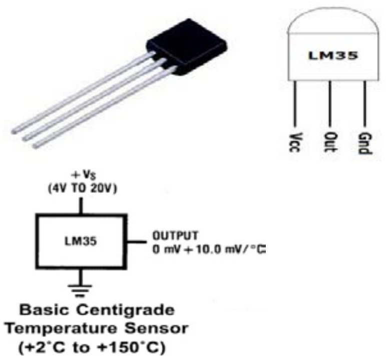


Fig: Block Diagram Of wireless tele-ecg monitoring system using iot

Health monitoring is the major problem in today's world. Due to lack of proper health monitoring, patient suffer from serious health issues. There are lots of IoT devices now days to monitor the health of patient over internet. Health experts are also taking advantage of these smart devices to keep an eye on their patients. With tons of new healthcare technology start-ups, IoT is rapidly revolutionizing the healthcare industry. Here in this project, we will make an **IoT based Health Monitoring System** which records the patient heart beat rate and body temperature and also send an email/SMS alert whenever those readings goes beyond critical values. Pulse rate and body temperature readings are recorded over ThingSpeak and Google sheets so that patient health can be monitored from anywhere in the world over internet. A panic will also be attached so that patient can press it on emergency to send email/sms to their relatives.

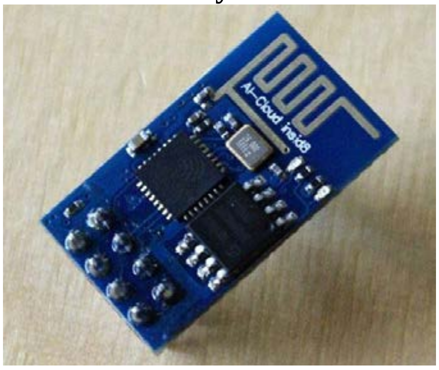
LM35 Temperature Sensor

LM35 is aanalog linear temperature sensor. Its output is proportional to the temperature (in degree Celsius). The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every ^{o}C rise or fall in temperature. It can be operated from a 5V as well as 3.3 V supply and the stand by current is less than 60uA.



ESP8266-01

Most people call ESP8266 as a WIFI module, but it is actually a microcontroller. ESP8266 is the name of the microcontroller developed by Espressif Systems which is a company based out of shanghai. This microcontroller has the ability to perform WIFI related activities hence **it is widely used as a WIFI module**.



There are two of ways to work with your ESP8266 module. This tutorial will help you to get started with ESP8266. One way is by using the AT commands. The other way is by using the Arduino IDE. Here we will use AT commands to send data from Arduino to ESP.

ECG MODULE:

AD8232 ECG SENSOR WITH ECG CABLE AND ELECTRODES

The AD8232 Single Lead Heart Rate Monitor is used to measure the electrical activity of the heart. This electrical activity can be charted as an ECG or Electrocardiogram and output as an analog reading.

ECGs can be extremely noisy, the AD8232 Single Lead Heart Rate Monitor acts as an op amp to help obtain a clear signal from the PR and QT Intervals easily. The AD8232 is an integrated signal conditioning block for ECG and other biopotential measurement applications. It is designed to extract, amplify, and filter small biopotential signals in the presence of noisy conditions, such as those created by motion or remote electrode placement.

The AD8232 Heart Rate Monitor breaks out nine connections from the IC that you can solder pins, wires, or other connectors to. SDN, LO+, LO-, OUTPUT, 3.3V, GND provide essential pins for operating this monitor with an Arduino or other development board. Also provided on this board are RA (Right Arm), LA (Left Arm), and RL (Right Leg) pins to attach

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and use your own custom sensors. Additionally, there is an LED indicator light that will pulsate to the rhythm of a heart beat.

Features :

- Operating Voltage - 3.3V
- Analog Output
- Leads-Off Detection
- 3.5mm Jack for Biomedical Pad Connection

Package Includes :

- 1 x ECG Sensor
- 1 x Professional ECG Cable
- 3 x Disposable Surface Electrode

CONCLUSION In this paper, a wearable wireless Tele-ECG monitoring system is demonstrated. The system has a novel architecture which includes a singlet redesigned by attaching TE, textile thread, snap fasteners, Velcro, soft sponge, ECG front end, and MCU. The instruments on the singlet acquire the ECG signal and transmit it to a cell phone. The ECG signal along with the measured HR is depicted on the cell phone and then transmitted to a server, which allows the physician to observe the signals through the webpage and the smartphone. In addition, a holter-based ECG measuring system has been designed to compare TE-based system. Both systems have been evaluated with 30 volunteers in standing, walking, and going upstairs conditions. The highest SNR value of TE- and holter-based systems is 45.62 and 45.89 dB, respectively. The average correlation of ECG measurements of two systems in each condition is 99.23%. In addition, the HR is measured with both systems for each group and with fingertip pulse oximeter for all patients. The smallest MAE and MAPE are obtained as 1.1% and 1.83% between the TE-based system and the pulse oximeter. The wearable system merges the latest technologies such as TE, BLE, smartphone, server, and webpage to utilize and combine all the advantages into one telemonitor. The significant advantage and novelty of the proposed telemedicine technology is the combination of the best available technologies and the addition of few other features. No single reported device has all the features and benefits of the proposed device: comfort in daily life, easy to clean, high-quality ECG by TE, fast data transmission, long battery life with approximately 14 days, remote multiple-patient following by physicians, manual and automatic emergency requests, medical history, and geographical location tracking. The proposed system can potentially reduce congestion of hospitals and the cost of the medical examination since the patients can be monitored remotely for heart problems. As the future work, additional sensors can be added to the proposed system to measure the temperature, SpO2, and movement of users and the TE can be employed to detect EEG or EMG

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