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A Unique Health Care Monitoring System Using Sensors and Zig Bee Technology

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ABSTRACT- The paper presents a remote measuring and monitoring system for electrocardiogram (ECG), lung functioning (spirometer), heart rate and temperature signals. The proposed system comprises the design and implementation with subsystems, viz. (A) The hardware module for acquisition, (B) The protocol for standard IEEE 802.15.4 ZigBee system, (C) The radio frequency (RF) trans-receiver circuits and finally (D) A displaying module (PC or mobile devices). Information is sent via IP (GPRS or Wi-Fi) to a database server containing clinical data, which can be accessed on the smart phone and can also be shared with the physician anytime to seek medical advice when needed. The goal of this project is to present the design of a compact sized and user friendly smartphone accessory that can be accounted in clinical care.

Keywords – ECG, Heart Rate, Spirometer, Temperature, ZigBee

I. INTRODUCTION

Rapid economic and industrial development leads to increased intensity in daily life, which brings people negative sentiments, such as nervousness, anxiety, and disturbance. These emotions along with changes of quickly lifestyle result that chronic cardiovascular diseases become the major adult illnesses [1]. Therefore, degenerative diseases have increased rapidly and at the same time it has resulted in the increase in medical treatment cost.

Today's world, people don't use their smartphones for talking as much as they used to, but they are increasingly using them to detect and monitor their health [2]. Indeed today's tele-monitoring devices are smaller and more user-friendly, and can monitor cardiovascular diseases, respiratory disorders, temperature, etc. Recent studies have shown that using tele-monitoring devices, together with patient communications, have a significant impact on efficiency of care and quality of life, while decreasing re-hospitalization rates. Many medical centers nowadays install tele-monitoring devices in patients' home to keep track of their medical condition. Although this is a major breakthrough, it still limits the patient from leaving home without being tele-monitored to keep track of his medical condition. Smartphone technology breaks that limit as the smartphone when equipped with specific accessories and application can be more than just a phone but be also "Smart" to be a "tele-monitoring device" [3].

Mainstream investigation has leaned toward the development of biomedical devices. Almost all observation positions of human health (e.g., ECG, EEG, Blood, and Pressure) can be monitored by the related bio-microsystem device as shown in Figure 1 [4]. A wide range of biomedical devices and systems being integrated on a chip have been developed rapidly. Moreover, telemedicine information system with interactive and intelligent features has become increasingly important to provide the high quality healthcare monitoring.

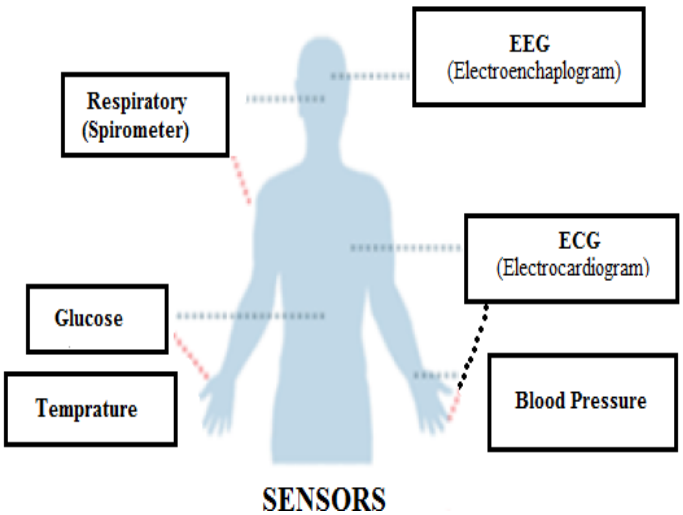

Fig. 1 Different aspects of human body for monitoring

According to the body sensor network, home telecare monitoring allows patients to examine themselves using bio-signal acquisition nodes. The reader can collect the bio-signal on a bio-information node and submit personal data to the healthcare center through the local sensor network. The intelligent healthcare systems [5] can also be applied to monitor the cardiovascular and respiratory disease through wireless communication; in addition, it provides not only reliable medical information to patients for long-term monitoring, but also alarms in the occurrence of critical conditions via the BSN (body sensor network) platform.

II. SYSTEM ARCHITECTURE IN PERSONAL HEALTH MONITORING

An interactive intelligent healthcare and monitoring system (IIHMS) is proposed to enhance the portability and increase the popularization of the home telecare system HTS as shown in Fig 2.

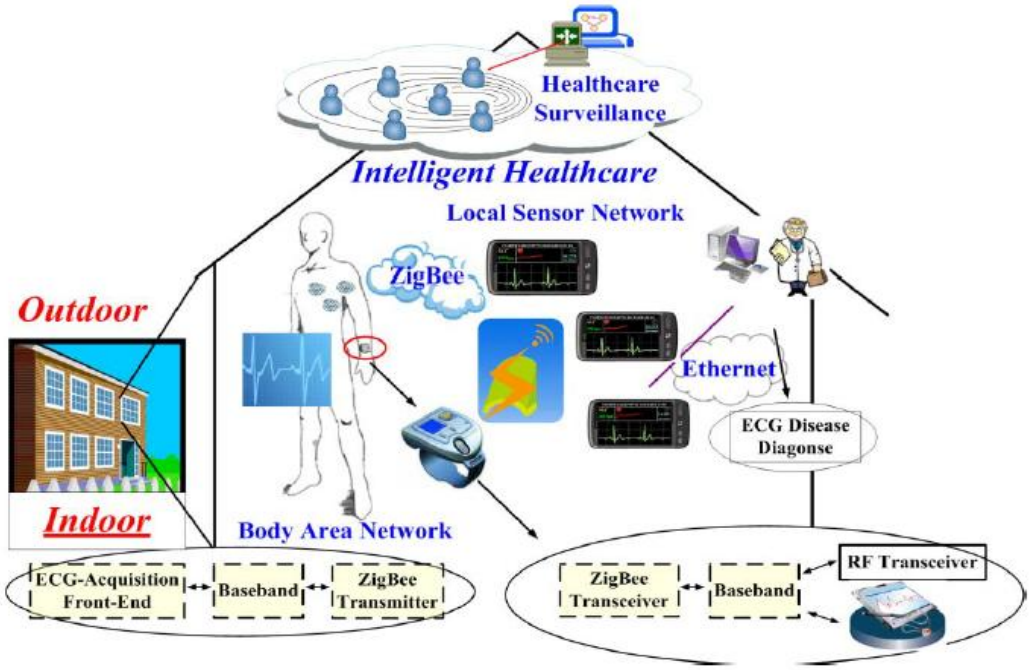

Fig. 2 Intelligent healthcare system

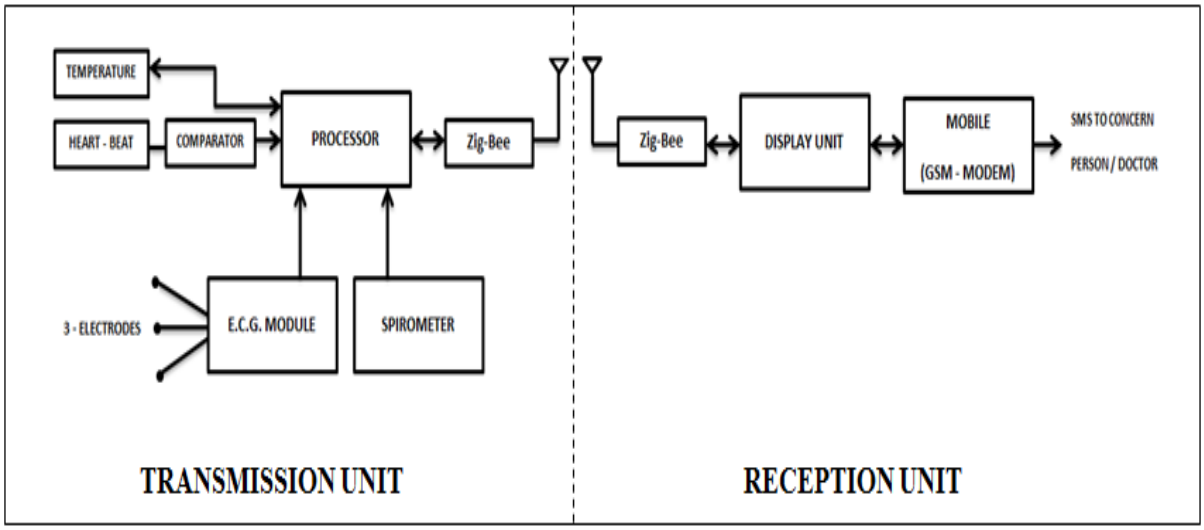

Fig.3 Block Diagram of proposed system

To save cost and improve the quality of medical treatment; a portable device capable of examining ECG signal, heart rate and temperature anywhere and anytime and by itself is be developed. Fig. 2 illustrates the scenarios of IIHMS heterogeneous networks, including a body sensor network and a local sensor network [6]. The IEEE 802.15.4 ZigBee simple protocol specification is suitable to the body sensor network in a near-body application that provides the communication between the acquisition auxiliaries and the wearable device. The local sensor network is the intermediate medium between the wearable device and the portable facility (e.g., mobile phone) for a simple data analysis. In addition, the patient can send personal identification and examination data to the healthcare center or hospital over the internet or through wireless communication systems. The local sensor network not only monitors personal health, but also conveys the advice of the doctor.

Once these data reaches the receiver, they can be displayed on the graphical user interface on a PC or a portable device (e.g., Advanced RISC (reduced instruction set computing) Machine (ARM) based displayer). In particular, the ECG coordinator located in the receiver, which is also controlled by the Zigbee firmware, is responsible for the transmission of the ECG signal to avoid collision.

III. METHODOLOGY

A. Electrocardiogram (ECG) Signals

Electrocardiogram (ECG) is used to measure the rate and regularity of heartbeats, as well as the size and position of the chambers, the presence of any damage to the heart, and the effect of drugs and devices used to regulate the heart. Electrical waves cause the heart muscle to pump. These waves pass through the body and can be measured at electrodes (electrical contacts) attached to the skin. Electrodes on different sides of the heart measure the activity of different parts of the heart muscle. An ECG displays the voltage between pairs of these electrodes, called Leads, and the muscle activity that they measure, from different directions. [7]

The ECG signal can be divided into several parts, ECG waveform components, as illustrated in Fig.5, are:

- The first upward pulse of the ECG, the P wave, is formed when the atria (the two upper chambers of the heart) contract to pump blood into the ventricles.
- The next upward spike segment, the QRS Complex, is formed when the ventricles (the two lower chambers of the heart) are contracting to pump out blood.
- The next section, the ST segment, measures the end of the contraction of the ventricles to the beginning of the rest period before the ventricles begin to contract the next beat.
- The next slight rising section, the T wave, measures the resting period of the ventricles.

The time required to finish a complete cardiac cycle is proportional to the heart rate per minute. The faster the heart rate, the faster the repolarization is, and therefore the shorter the Q-T interval. With slow heart rates, the Q-T interval is longer [8].

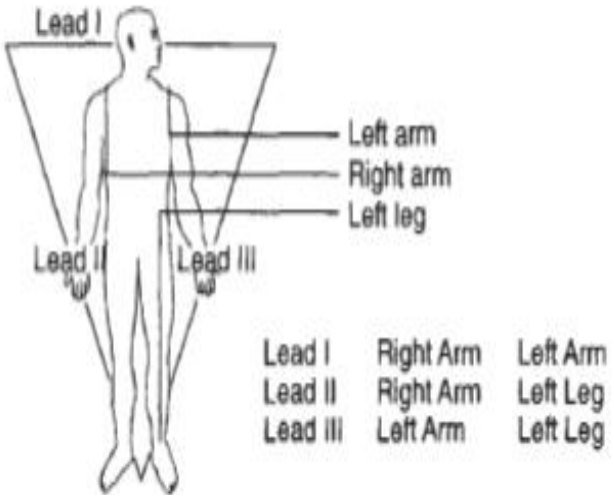

Fig. 4 Lead placement

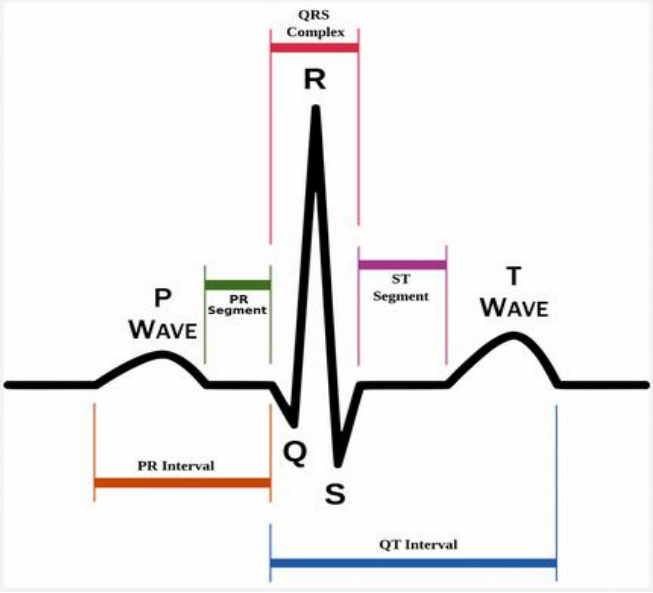

Fig. 5 Schematic diagram of a normal sinus rhythm of a human heart as seen on ECG

B. Heart Rate Estimation

IC LM 358 is used for Heart Beat Sensor .Its dual low power operational amplifier Licit consists of a super bright red LED and light detector. LED needs to be super bright as the light must pass through finger and detected at other end. When heart pumps a pulse of blood through blood vessels, finger becomes slightly more opaque so less light reached at the detector. With each heart pulse detector signal varies this variation is converted to electrical pulse [9].

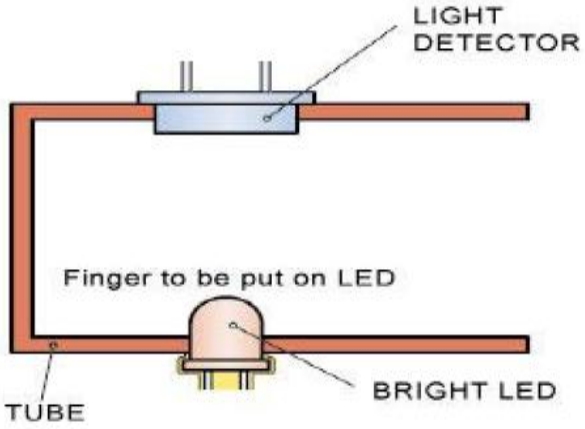

Fig. 6 Heart Beat Sensor

C. Temperature Sensor

The temperature sensor used to measure temperature, is an electronic device which provides a voltage analogue of the temperature of the surface on which it is mounted. The LM35 series are precision integrated-circuit Temperature Sensors whose output voltage is linearly proportional to the Celsius temperature. The sensor circuitry is sealed and not subject to oxidation. The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified [10].

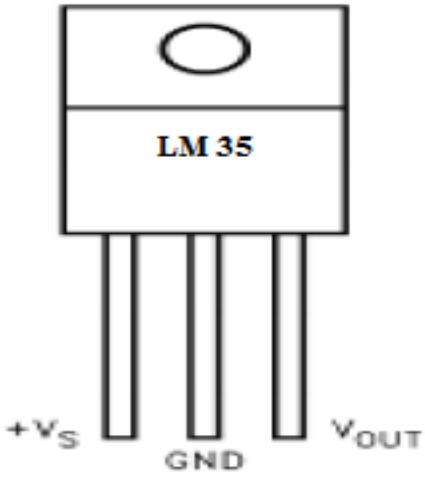

Fig. 7 Temperature Sensor

D. Spirometer

Spirometry is the name of the test, whilst a ***spirometer*** is the device that is used to make the measurements.

Spirometry is a common office test used to diagnose asthma, chronic obstructive pulmonary disease (COPD) and certain other conditions that affect breathing. Spirometry may also be used periodically to check how well your lungs are working once you are being treated for a chronic lung condition.

Spirometry measures how much air you can inhale and exhale. It also measures how fast you can exhale. Spirometry values below average indicate your lungs aren't working as well as they should.

There are various spirometer devices made by different companies, but they all measure the same thing. They all have a mouthpiece that you use to blow into the device. A doctor or nurse may ask the patient to blow into a spirometer (spirometry) if he has chest or lung symptoms [11].

IV. READY TO USE HARDWARE MODULE

A. GSM/GPRS Modem

Designed for the global market, SIM300 is a Tri band GSM/GPRS engine that works on frequencies EGSM 900 MHz, DCS 1800 MHz and PCS1900 MHz With a tiny configuration of 40mm x 33mm x 2.85 mm, SIM300 can fit almost all the space requirement in your application, such as Smart phone, PDA phone and other mobile device. The physical interface to the mobile application is made through a 60 pins board-to-board connector, which provides all hardware interfaces between the module and customers' boards except the RF antenna interface.

The SIM300 is designed with power saving technique, the current consumption to as low as 2.5mA in SLEEP mode. The SIM300 is integrated with the TCP/IP protocol, Extended TCP/IP AT commands are developed for customers to use the TCP/IP protocol easily, which is very useful for those data transfer applications.

It is suitable for SMS, Voice as well as DATA transfer application in M2M interface. Using this modem, you can make audio calls, SMS, Read SMS; attend the incoming calls and internet through simple AT commands.

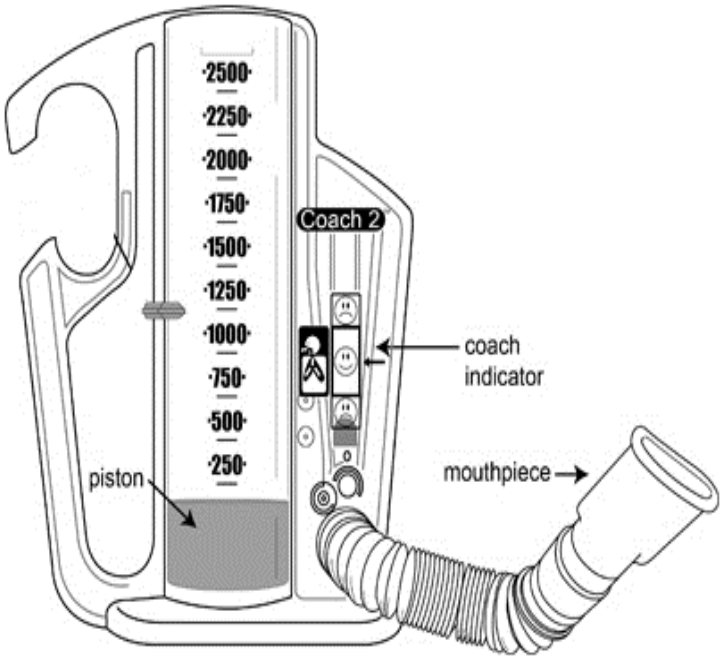

Fig. 8 Incentive Spirometer

Fig. 9 SIM 300 Modem

V. SOFTWARE DESIGN

This includes the coding of Philips LPC2148 processor and coding for downloading the data for Graphical User Interface (GUI) on the server side.

For HTTP: AT+ commands

For LPC2148 Processor: Embedded C using Keil software

For GUI: VB.Net

A. Flow Chart for the designed code

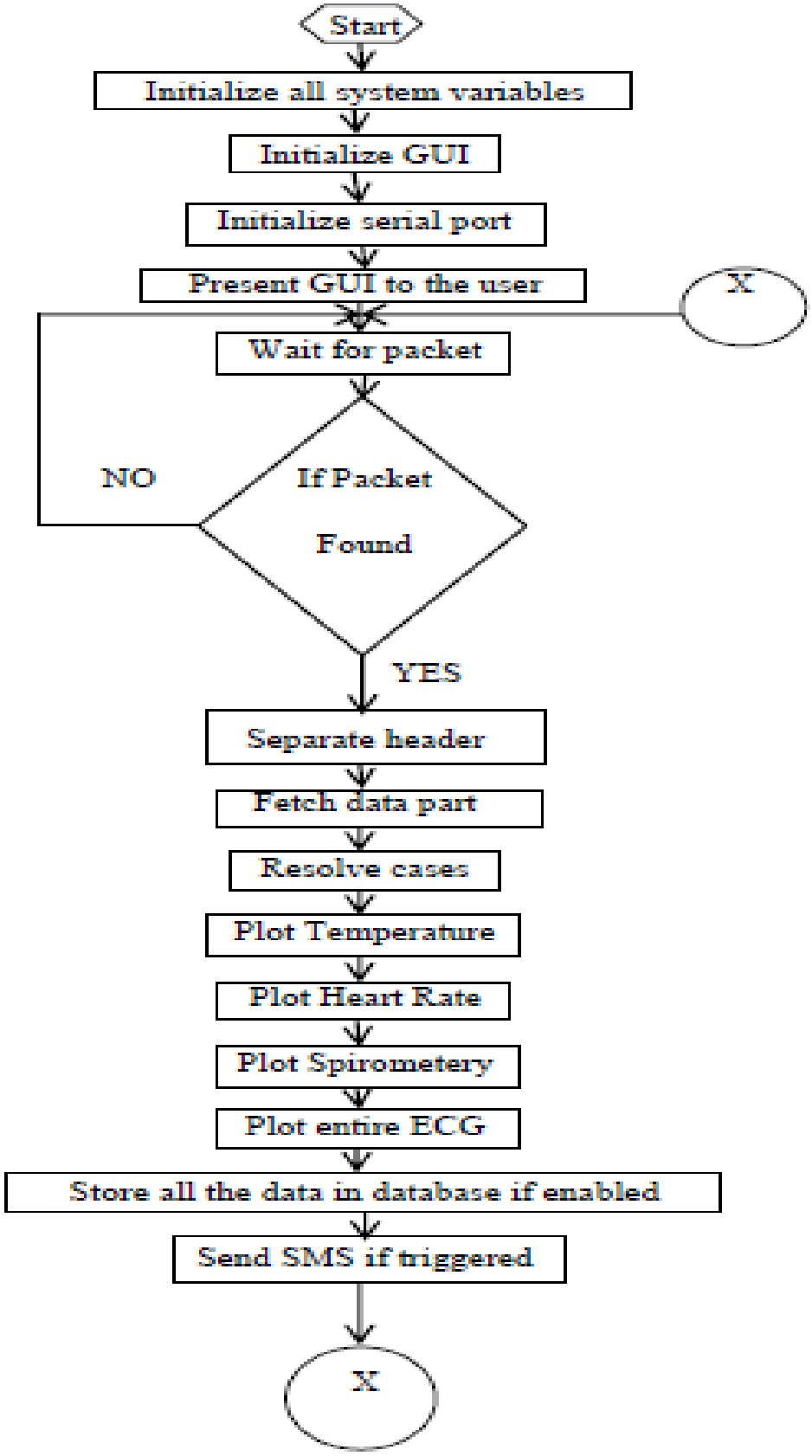

Fig. 10 Flow Chart for the Code

VI. RESULT

The result of this project includes results of compilation, sensors and GUI. The compilation of C code is done using Micro Vision Keil software and indicated the generation of Hex file. The sensor results are generated at different conditions like normal, after running, after wake up etc.

A. Code for the processor

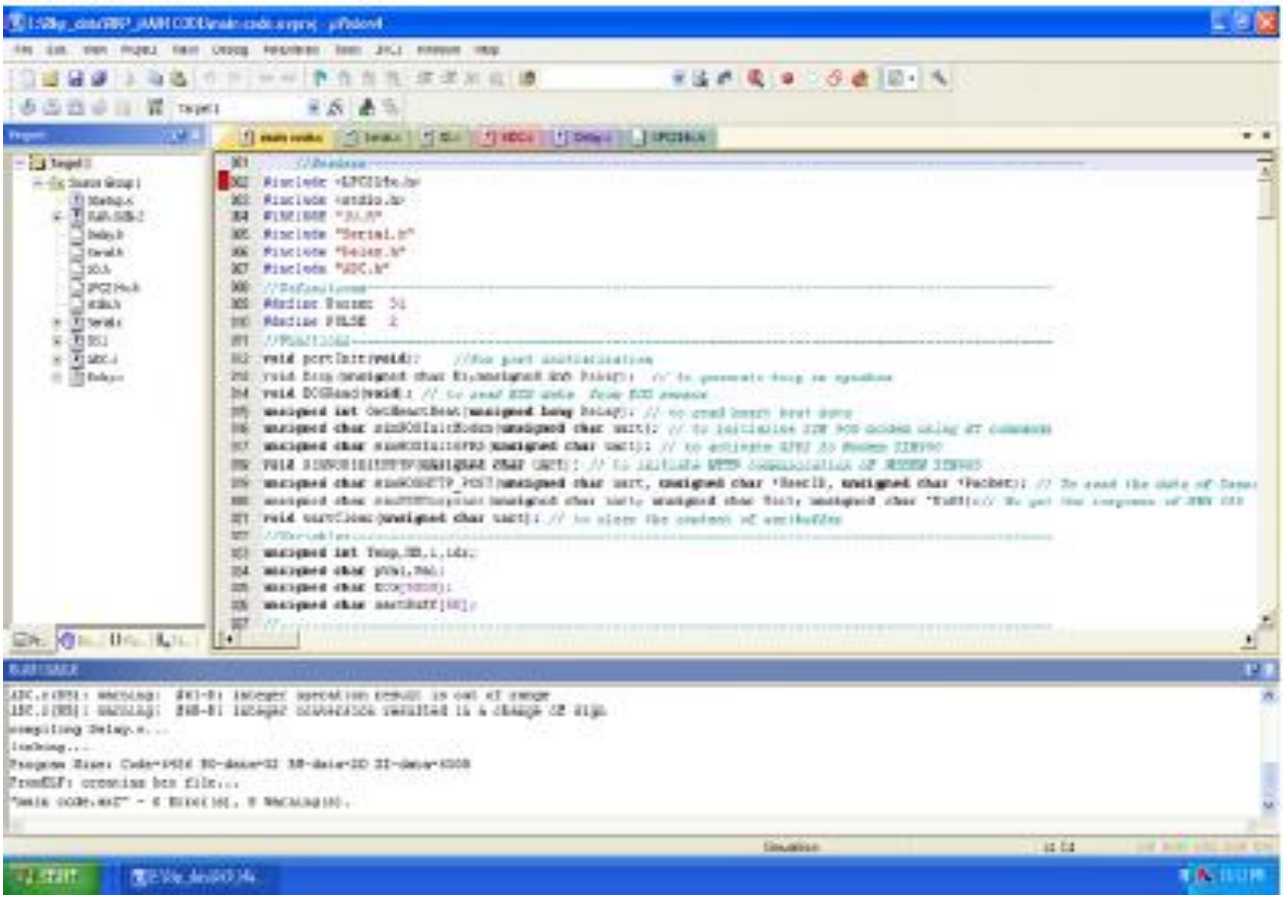

Fig 11: Code for processor

B. Results for ECG, Temperature, Heart Rate and Spiro

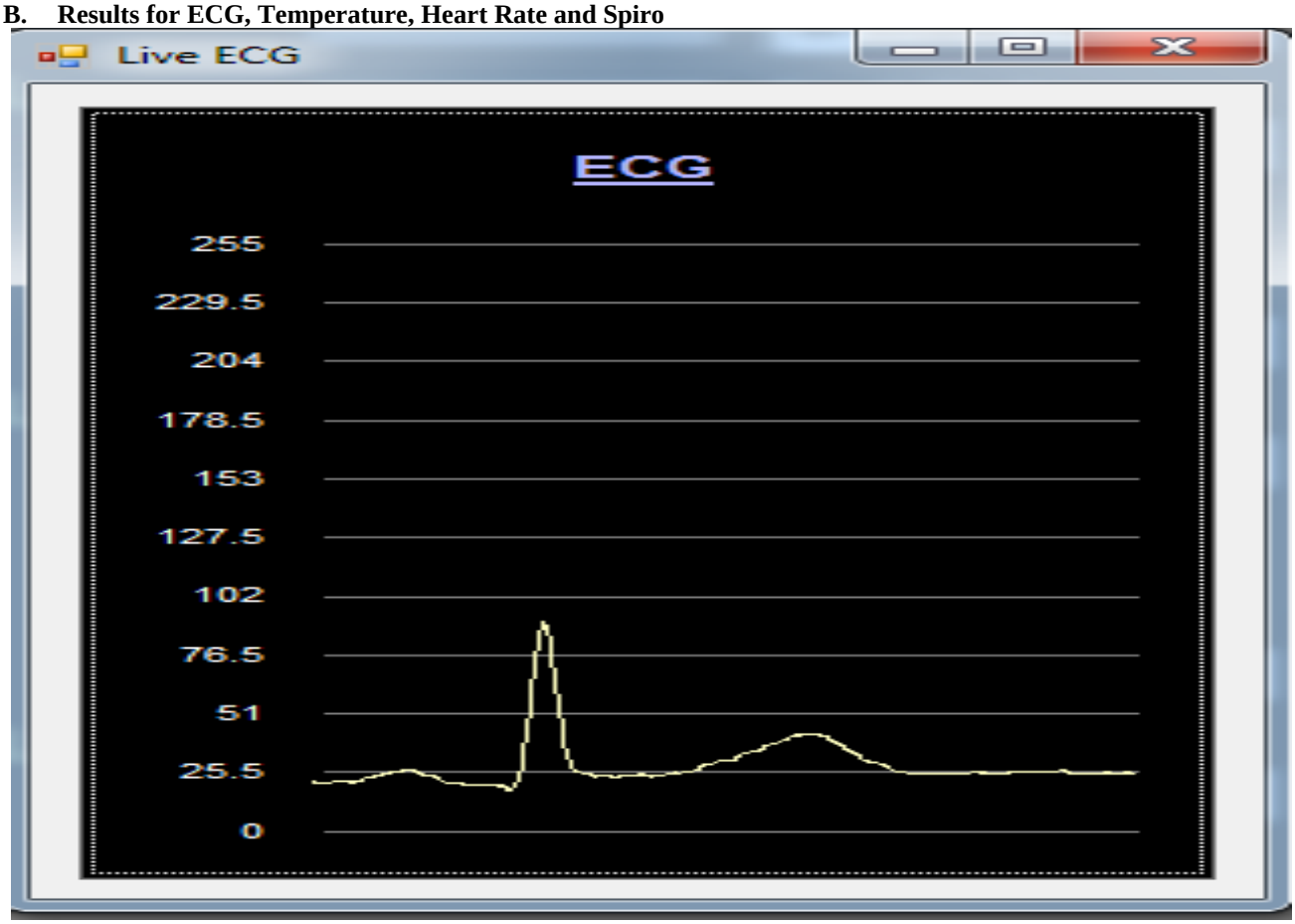

Fig 12: Plot for ECG

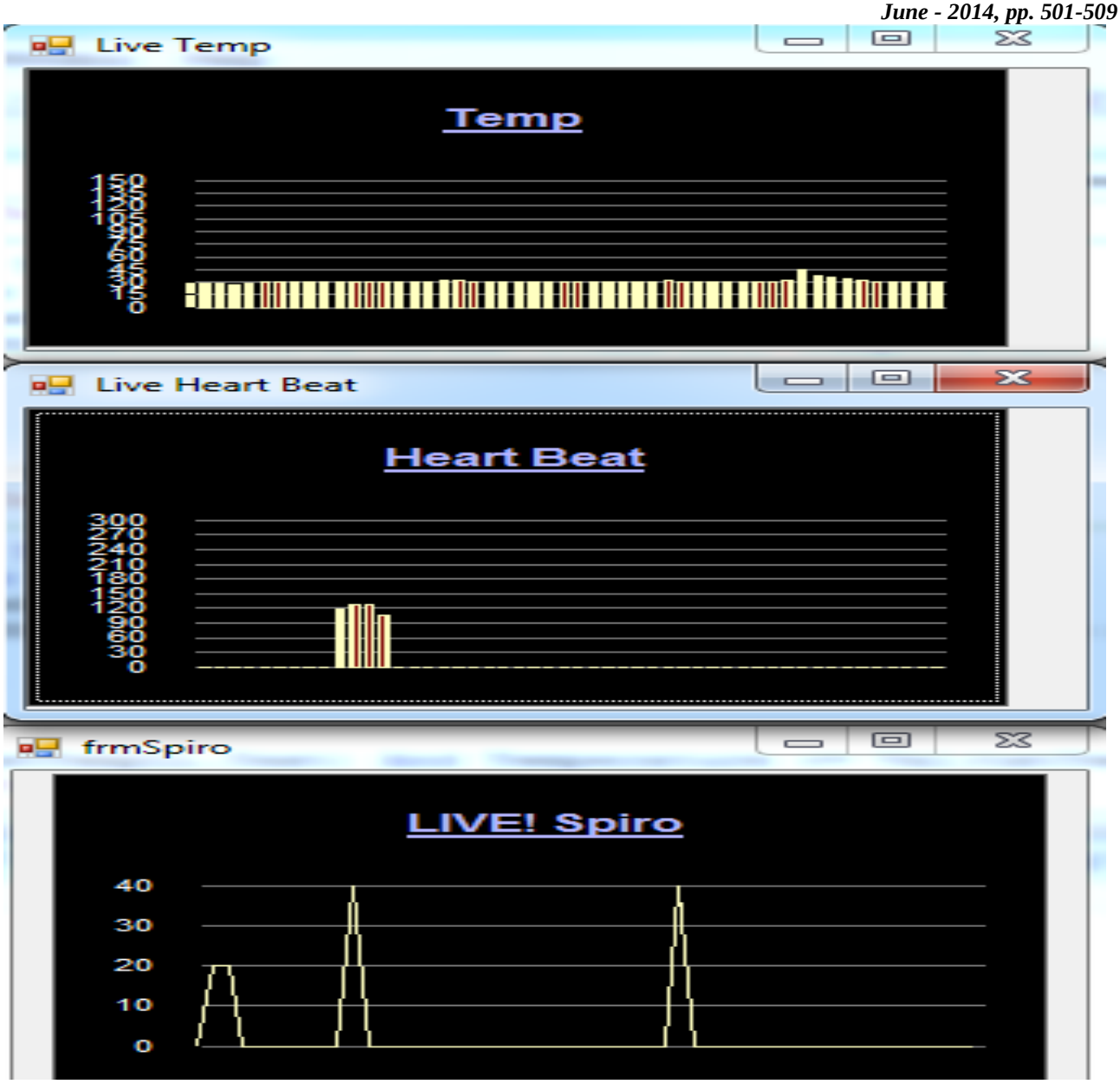

Fig 13: Plot for Temperature, Heart Beat and Spiro

VII. FUTURE MODIFICATION:

There is always chance to improve any system as research & development is an endless process
The following measurements can be done in future

- Blood pressure
- Pulse oximetry
- Galvanic-Skin Resistance
- Anemia
- WEBCAM technology can visualize patient situations

In future, one can design a system which works in two ways, which means when the expert receives the data in the form of waveform, after observing these waveforms the expert will suggest or prescribe the drug for that situation or condition of patient.

VIII. CONCLUSION

An interactive intelligent healthcare and monitoring system (IIHMS) including body sensor network (BSN) and local sensor network has been presented. The wireless bio-signal acquisition System–on–Chip (WBSA-SoC) for BSN application is applied to acquire the real human body temperature, heart rate and ECG signal via IEEE 802.15.4 ZigBee network communication. The high integration WBSA-SoC including an ECG acquisition node, heartbeat and temperature sensor, a spirometer, a processor with ZigBee protocol, a mix-mode interface, and a RF trans-receiver have been designed. In addition, an ARM-based receiver platform with an RF receiver, an analog to digital mixed mode board and an ARM-based displayer to display temperature, heart rate and demonstrate the ECG waveform. According to the real measurement results, health care can be acquired by the proposed WBSA-SoC.

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