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Wearable ECG Recording and Monitoring System based on MSP430 Microcontroller

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***Abstract*– Today a large attention is given to the development of innovative wearable or ambulatory systems that able to monitor physio-pathological parameters of individuals in their daily activities. The goal to progressively move the health costs from cure to prevention leads to focus on the wellness and preventive cardio fitness. This report describes Wearable ECG recording system aiming to providing continuous monitoring of ECG signal which is amplified by the instrumentation amplifier (INA 321 from Texas Instruments).The acquired ECG signals are converted into the suitable format by the ultra low power microcontroller (MSP 430FG439) for storage in SD card.**

***Index Terms*– WECG, WD, AECG, SD and ECG**

I. INTRODUCTION

IN recent years there has been great interest in wearable telemedicine area. Wearable telemedicine which can provide non invasive and continuous monitoring of various physiological parameters is expected to be the most important and feasible method under the new generation medical care system [2]. Intelligent wearable electronics and telemedicine are very promising development areas which will extend monitoring, increase patient's comfort and improve the living standard of patients. There is an increasing demand for long term continuous monitoring of a patient's ECG and activity which offers the opportunity to evaluate the performance of a cardiovascular system. The ECG signal is a parameter that is easily accessible in theory by placing electrodes on the patient's body.

A low power, portable and easily implemented recorder is necessary for patients. Such recorder with off the shelf components is realized with mixed signal processor (MSP).This ECG is recorded for 24hr using a SD card.

There are many Wearable ECG recording systems developed by many research groups.

"Holter ECG recorder" is invented by American physician Holter in 1961 such a non-invasive, practical, precise and repeatable methods is manipulated comprehensively in the clinic of heart diagnosis. Patients can bring Holter to record the 24h ECG at home whenever sleeping, walking, and eating. Thus, the Holter recorders require portability, low power, sufficient capacity for storing the ECG data, and capability of communication [3].

A routine long-term monitoring of ECG is recommended for the people at the potential risk for earlier diagnosis and cure of the developing cardiac disorder. However, such monitoring has not been given due importance in the practice. It is mostly avoided because of the time and resource constraints, unless the patient has already been reported for a serious heart disorder that requires immediate attention. An AECG (Ambulatory Electrocardiogram) by WD (wearable device) is a practical solution to prevent this situation. Very small-size, light-weight, WD for cardiac monitoring are now available which can continuously record AECG for many days. The purpose of the AECG by WD is long-term monitoring of the heart while the patient is allowed to perform his/her routine activities.

For Ultra wearability, high output and low power some ECG monitoring system that takes the advantage of QUASAR's ECG sensors[4] and wireless sensor nodes is developed. That system is having four major blocks: ECG sensors, data sampling, wireless transmission and Host interface.ECG signals are first digitized by the ADC and transmitted wirelessly to a base station that interface with a host computer via USB, fast Ethernet etc.

Use of Advanced telecommunicating technologies for remote diagnosis is growing rapidly and there are products and projects within mobile ECG recording using internet solution, Bluetooth technology, Cellular phones, WAP based implementation and Wireless local area network (LAN) [5]-[11].

Another system, wearable mobihealth care system aiming at providing long-term continuous monitoring of vital parameters using portable patient unit (PPU) and a wearable shirt (WS) to monitor ECG and other parameters [2]. They have integrated fabric sensors and electrodes in to WS. Using this approach long term continuous monitoring can be possible without making patient uncomfortable and restrict their mobility. The PPU will analyze physiological signals in real time and takes the decision whether the person is in danger or not. When the person is in danger the PPU will alert

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the person and in case of an emergency automatic call will be transferred to the medical service center.

Our system will detect the ECG signal and is stored in SD card which can be analyzed by the expert.

II. SYSTEM ARCHITECTURE

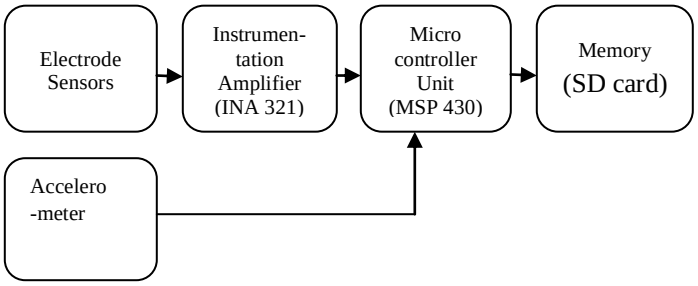

Fig.1: ECG recording System

A. ECG Electrodes

The ECG signal is measured with the button type ECG electrodes and it is given to Instrumentation amplifier for the amplification. This Disposable ECG electrodes uses an AG/AgCl sensor element and solid conductive & adhesive Hydro-gel for adhesion. The AG/AgCl sensor element has the best sensitivities and the solid conductive & adhesive hydro-gel has very low impedance and is non-irritating, non-sensitizing and non-cytotoxic to the skin.

Fig. 2: ECG Electrode

B. Analog System

The electrical signal derived from the electrode is typically 1mv peak-peak. An amplification is required to render this signal usable for the heart rate detection. Realization of clean amplification of ECG signal is not easy task because noise is also amplified with the ECG signal. In certain situation the noise can completely override the ECG and render the amplified signal useless.

A better approach is to use a differential amplifier. A differential amplifier used here is INA 321 instrumentation amplifier that has perfectly matched and balanced integrated gain resistor. The device is operated on minimum 2.7v single power supply. The INA provides a fixed amplification of 5x for the ECG signal .With its CMRR specification of 94db extended up to 3 kHz the INA rejects the common-mode noise signals including the line frequency and its harmonics.

The ECG signal at the output of INA 321 is further amplified by OA0 of MSP430FG439.

C. Accelerometer

Accelerometer has been proposed as being suitable for monitoring human movements and has particular applicability to the monitoring of free-living subjects. It has been used to monitor a range of different movements including gait, sit-to-stand transfers, postural sway, and falls. As for our system, the main purpose is to monitor abnormal events, such as falls or long periods without movement. Falls are very serious risk for the elderly, particularly for those living in the community.

D. Microcontroller Unit (MSP 430)

The Texas instruments MSP 430 family of Ultra low power microcontrollers consist of several devices featuring different sets of peripherals targeted for various applications. It is having five power saving modes which makes it suitable for the battery operated instrumentation. The special features of this microcontroller that we are going to use are ADC, OP-AMPs, DAC, USART.

E. Sampling

The amplified ECG signal is given to the MSP430FG439 which is having internal on chip analog to digital converter ADC12. Precise sampling period is achieved by the ADC12 conversion with Timer_A pulses. Timer_A is clocked by the ACLK which is generated from 32,768 KHz crystal oscillator. The most important signal to be captured is the EKG signal and its fastest time is 20 ms. By keeping the sampling period of about 2ms we can capture 10 samples at QRS complex. The QRS complex gives is the indication of the heart rate.

F. Filtering

The sampled ECG signal contains some amount of line frequency noise. This noise can be removed by low pass filtering the signal. The filtered signal can be output on the display unit by the DAC of MSP 430 or can be transmitted to the PC using UART of the MSP 430 or can be stored on the SD card. Here we are storing the ECG signal in the SD cards.

G. Storage- Memory card

An SD card is very suitable to implement, since its communication bases on an advanced nine pin interface and its design is operated in a low voltage. SD card can be controlled with SPI mode which is a serial communication. The communication can be done with only three lines Serial out (SO), Serial in (SI) and Clock as shown in Fig. 3.

Fig. 3: Memory Card

The SPI communication can be implemented with embedded peripheral in MSP30.We have used the microsSD memory card from Scandisk©. Thus storing the ECG signal is simpler with SD card. For storing 1 ECG beat for 0.8 second 10KB is required. So on 2GB Card 3.7 hrs data can be stored. For large data storage we can use higher capacity card.

III. RESULTS

Ideally the ECG Signal available at DAC0 output should look like as shown in the Fig. 4:

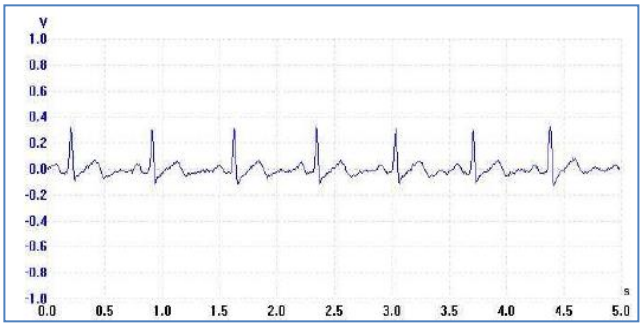

Fig. 4: Expected ECG Signal [12]

But due to some internal and surrounding artifacts, mainly the 50-Hz power line interference, the system output does not exactly match the ideal ECG output. The output coming at DAC0 output on DSO is as shown in the Fig. 5:

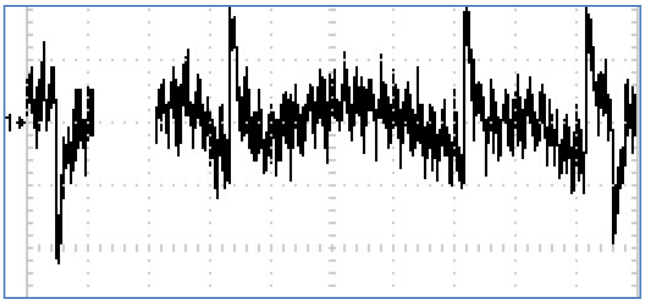

Fig. 5: Actual ECG signal

IV. CONCLUSION

Wearable devices are extensively used for continuous heath monitoring of the people suffering from the cardiac disorder like atrial fibrillation, ventricular tachycardia etc who also choose to lead an active lifestyle. In this report brief introduction of AECG (Ambulatory ECG) recording system is present. We have got the ECG signal successfully recorded on SD card using this system, now the Accelerometer part is to be added for Ambulatory ECG. After successful recording of the AECG signal on SD cards, we may insert the CC2500 transceiver module to incorporate the wireless protocol in the W-ECG recorder.

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