Ambulatory Monitoring System

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Abstract— This paper discuss the design of Portable wireless Ambulatory monitoring system also called as Ambulatory monitor using MSP430 microcontroller and wireless Zig-Bee transmission protocol. The Ambulatory monitor consist of a Physiological parameter sensors combined with the MCU measuring the ECG, Blood Pressure, Temperature and pulse rate and the same data is continuously wirelessly transmitted to nursing station and is displayed and save on computer, without interference with the spontaneous activities of patient.

Index Terms – Ambulatory monitor, zig-bee, ECG, Blood Pressure, Heart rate, Temperature, MSP430, cc2530, cc2519.

I. INTRODUCTION

The traditional medical examination involves a number of chemical, physical and electro-physiological measurements. These measurements are of very short duration and comprise no more than a physiological snapshot of the patient’s condition. However, when one wants to perform functional tests on patient, which are expected to have some relationship to his behavior in normal life, the measurements have to be made over a long period. Ambulatory monitoring concerns itself with the extension of such measurements into the time domain on unrestricted ambulatory (mobile) patients during everyday stress and activity as well as during periods of sleep. Therefore, the precise objective of ambulatory monitoring is to record one or more physiological variables continuously or repeatedly, without interference with the spontaneous activities of the subject by the restraints of conventional laboratory instrumentation and without influencing the variable being measured. Ambulatory monitoring is not only an invaluable aid to the physician in the differential diagnosis of many unexplained symptoms like dizziness, syncope and palpitation but it also provides accurate data for the evaluation of drug therapy, stress testing, artificial pacemakers, status of myocardial infarction and several other problems in research programmed. The technique is so well established now that it is predicted that within the next decade, ambulatory monitoring departments will become a common feature in the hospital service, accepted as a matter of course just like the X-ray or pathology department. [5]

Ambulatory monitoring of ECG is called Holter monitor. This test is performed in order to find the cause of chest pain, shortness of breath, palpitations, collapse or dizzy spells. There are two types of monitors, the Holter Monitor and an Event Monitor. A 24 hour ambulatory E.C.G. monitor or Holter Monitor is used to record cardiac symptoms, which occur occasionally. "Ambulatory" just refers to the fact that you can walk around and perform all your normal activities during the day. The monitor is like a mini E.C.G. machine. The standard E.C.G. machine only takes a snapshot of your heart rhythm whereas the Holter can record your heartbeat for 24 hours or longer if necessary. If the technician puts on an event monitor you generally wear this for one week. The technician will explain how to put on new electrodes if you need to Like the E.C.G.; electrodes (stickers) are applied to the skin. These electrodes are attached to the monitor by cables. You can go home and continue with your normal daily activities. You should record the time you get symptoms if any and how you feel and what you are doing at the time. You will also need to write down what time you eat, drink, slept, wake up, exercise and take your tablets at. The technician will tell you the time you are to return back to the cardiology department with the monitor. When you return, the technician will remove the monitor. The information on the monitor will be analyzed by a technician and the results reported by a cardiac doctor. The report will then be sent to your doctor. When you are wearing a Holter or an event monitor you cannot take a bath or a shower. If the monitor gets wet it will be destroyed. The monitors are very expensive to replace. If you feel any symptoms such as palpitations, light headedness or shortness of breath while wearing the monitor the doctor will be able to find out if your heart is the cause. The result of the test will be sent to the doctor requesting the test and/or filed in your hospital chart. The technician cannot give you any results from this test. The results will be sent to the doctor who requested the test.

Ambulatory blood pressure (ABP) monitoring involves measuring blood pressure (BP) at regular intervals (usually every 20–30 minutes) over a 24 hour period while patients undergo normal daily activities, including sleep. The portable monitor is worn on a belt connected to a standard cuff on the upper arm and uses an oscillometric technique to detect systolic, diastolic and mean BP as well as heart rate. When complete, the device is connected to a computer that prepares a report of the 24 hour, day time, night time, and sleep and awake (if recorded) average systolic and diastolic BP and heart rate. The accuracy of ABP monitoring has been validated in a range of patients including young,
elderly, pregnant and obese subjects (provided the correct size cuff is used). Ambulatory BP monitoring is safe and is not usually associated with complications. Occasionally edema or petechiae of the upper arm or bruising under the inflating cuff may occur. Modern ABP devices are quiet, lightweight and easy to wear, but inflation of the cuff may cause some transient discomfort, particularly in people with hypertension or when multiple readings are triggered due to errors in measurement. Ambulatory BP measurements during the night may disturb sleep; potentially requiring retesting if there are poor nocturnal BP measurements. [8]

Ambulatory BP monitoring provides a more reliable measure of a patient’s BP than isolated clinic measures and is not subject to the ‘white-coat effect’, which can overestimate BP, particularly in susceptible patients. While clinic measurement of BP is useful for screening, and in the management of suspected and true hypertension. Ambulatory BP and home BP measurements add considerably to the accurate diagnosis of hypertension and the provision of optimal care. Recent recommendations from expert groups such as the United Kingdom’s National Institute for Health and Clinical Excellence strongly advocate wider use of ABP monitoring in the diagnosis and management of hypertension. [8]

II. WIRELESS TRANSMISSION METHOD

Many of the wireless monitoring system currently being produced use Bluetooth networking systems, which is the first task group of the IEEE 802.15. There are three advantages to using Bluetooth over other low-power PLAN systems:
1. High frequency-to-noise ratio (up to -104dB receiver sensitivities, and transmission strengths of 23dBm or more)
2. Capable of high data rates, theoretically up to 2.1 Mbit/s (Bluetooth 2.0)
3. Bluetooth technology is present in many cellular phones, PDAs, and notebook computers, making any Bluetooth-enabled device very technologically compatible

Bluetooth is also a very mature technology, with a multitude of chipsets available from many vendors and well-explored transmission and encryption software. However, it shares the downsides of all PLAN systems, which include short-range effectiveness and weakness towards interference, as it shares the 2.4GHz band with the higher-power 802.11 WLAN traffic. Bluetooth also possess a number of additional disadvantages specific towards our needs. First, Bluetooth transceiver chips are somewhat high-power for this application; up to 190mA during transmission, and even with a low duty cycle, current draw is still higher than would be preferred. Second, the protocol stack for Bluetooth transmission is much larger than that of other PLAN systems, and therefore demands a microcontroller with greater memory.

Besides Bluetooth, there are other wireless variants within the 802.15 specification that are very applicable to small-area, low-bandwidth uses such as patient monitoring. The IEEE 802.15.4 task group focuses on low-bit-rate WPAN, with peak speeds of 100-250 kbps. ZigBee provides an upper-level specification for the 802.15.4 standard, which is targeted towards Wireless Personal-Area Network. Typical transmission distance is only a few meters for these LANs. Applications needing long battery life, secure networking, and a low data rate. The advantages to using a ZigBee-based wireless transmitter include:
1. Very long battery life, with average current draws in the 30mA range for Tx. This current draw is low enough to last almost 100hrs on a single AA battery.
2. Secure data transfer, with 128-bit encryption
3. Simple, integrated architecture using the ZigBee specification
4. ZigBee-compliant hardware is very inexpensive. An entire transceiver solution at quantities of 1000 can cost less than US$5.

Although ZigBee lacks the throughput of even Bluetooth, which is a low-data specification, it certainly has a high enough data rate for an uncomplicated sensor reading; in fact, target applications for ZigBee include wireless sensors and monitors, such as water or gas metering, or medical monitoring, in this case. Also, ZigBee is well suited to Reduced Function Device (RFD) networking, in a simple star-style network opposed to the mesh or cluster-tree network topologies. This is ideal for a group of sensor-transmitter communicating with a single receiver, as in our application.

Figure 11: ZigBee network topologies
III. FINAL AMBULATORY MONITOR DESIGNE

A. Circuit implementation

Figure 1 depicts the system block diagram. ECG sensor consists of mainly parts are. The first is instrumentation amplifier with high CMRR (Common Mode Rejection Ratio) to remove the noise induced from body and amplify the difference between right and left body parts. The left and right thumbs are input as signal detection of ECG. The analog amplified ECG voltage is fed to processor to pass through digital FIR filters. High pass and low pass filters are implemented to get ECG signal of proper range. The processor converts these signals to analog output in serial format and pulse output. The serial data is 1 byte every 5 mili-second. Each byte can be from 0-255 indicating an analog value of the signal. The pulse output is also fed to onboard LED to indicate the heart beat and same is output through optocoupler. Board uses two optocoupler to isolate the board from external voltages since any little noise from external source can be amplified as noise. So to get clean ECG signal the board is operated from 3V battery isolated from external supplies.

For Heart Beat, output is calculated from the analog output by monitoring the analog waveform and when it detects a peak(R wave) in last 100 samples average value then the on board LED is made on and same pulse output is made through optocoupler. This pulse output signal can directly be fed to microcontroller pins.

For Blood pressure, the automated oscillometric method of non-invasive blood pressure measurement has used. The cuff of monitor is placed on wrist. An occluding cuff deflates from a level above the systolic pressure, the artery walls begin to vibrate or oscillate as the blood flows turbulently through the partially occluded artery and these vibrations will be sensed in the transducer system monitoring cuff pressure. As the pressure in the cuff further decrease, the oscillations increase to maximum amplitude and then decrease until the cuff fully deflates and blood flow returns to normal. Oscillometric pulses generated in the cuff during inflation or deflation. Blood pressure values are determined by oscillometric pulse index. These values are further passes to microcontroller for wireless transmission.

Temperature is sensed by a thermistor having a resistance of 100ohm (at 20°C) placed in emitter of transistor. Changes in resistance of the thermistor with changes in temperature are measured in a bridge circuit and indicated on a led. The measuring range is 30-42°C.

The real time samples are also send via transreceiver chip CC2530-CC2519 to PC. A separate PC GUI displays these samples a graphic trace.

B. Wireless Module Interface

To make the application wireless, the MSP430 needs to interface to some of the existing transceivers. As discussed previously, an on-board option has been provided to interface with the wireless world via the pin headers supporting the CC11xx, CC2500, CC2420, CC2430 EMK boards and the eZ430-RF2500T target. These devices are low-cost, single chip transceivers equipped with serial interfaces that can be used to directly communicate with the MSP430. The transceiver modules CC11xx, CC2500, CC2420, CC2430 EMK and eZ430-RF2500T target boards are connected to the USART/SPI pins of the MSP430FG437.

The eZ430-RF2500T target is also connected to the USART/UART pins of the MSP430FG437. The UART Tx and Rx lines are routed directly to the eZ430-RF 6-pin header and via jumpers to the USB circuitry.

C. LabVIEW Ambulatory Monitor GUI

A customized LabVIEW GUI application has been developed to display the signal samples on the PC. There is no need to install LabVIEW to run the Ambulatory GUI application. The users only need the LabVIEW Run-Time Engine or the stand-alone executable to run the Ambulatory GUI on a PC.

LabVIEW stand-alone applications include executable files that are distributed to users. However, these executables produced by the application builder (in LabVIEW) are not truly standalone in that they also require that the LabVIEW run-time engine to be installed on the target computer on which users run the application. Therefore, the user requires the LabVIEW run-time engine to run the stand-alone executable. The LabVIEW run-time engine helps load and run LabVIEW VI. This GUI application is different from the

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scope.exe GUI application that is provided along with the application report SLAA274. It’s a lot simpler to get the GUI running and it eliminates the protracted and error prone process of running the application from the command prompt. See the Demo – Ambulatory Monitor document for the step-by-step explanation of running the Ambulatory monitor GUI application. The document is present in the Revised Ambulatory monitor Application zip folder.

IV. CONCLUSION
Most of the current-model of ambulatory monitoring system available to monitor individual parameter like, Electrocardiogram (Holter monitor), Blood pressure (ABPM) and Heart Beat (heart beat analyzer). To save critical patients life, we have to monitor & diagnose more than one parameter at a time. So, we can analyze it very accurately. The ZigBee (CC2530) specification is much more suited to wireless patient monitoring, it has the advantages of significantly increased battery life, a simpler yet still secure transmission scheme, and lower system cost than others. A prototype Ambulatory monitoring system using ZigBee prototype has been designed. The system allows healthcare personnel to monitor a patient’s ECG, BP, temperature and heart rate vital signs from a remote location without requiring the physician to be physically present to take the measurements. The mobile nature of the system allows ambulatory patients the freedom to move around the hospital when practical while remaining constantly monitored.

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