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A 2.5 GHz Wireless ECG System for Remotely Monitoring Heart Pulses

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Abstract—A wireless electrocardiograph technology (WECG) which works on 2.5 GHz frequency band has been designed, implemented and evaluated in the actual environments both indoor and outdoor. WECG system has the benefit for improving the quality of the health care services especially for monitoring and evaluating people heart pulses record during the treatments. These are also practically useful to apply on a number medical cases, for instance, the heart disease treatment, early medical treatment at the disaster areas (e.g. earthquake, tsunami, the traffic accident on the road), other remote medical monitoring in health care centers, or intensive care units at the hospital. The WECG technology allows the medical authorities such as doctor and nurses capable to monitor the patients flexibly and immediately from a remote location. The read range testing of wireless ECG system to perform on monitoring the heart pulses was carried out. At indoor environments it can read up to the distance of more than 50 m. When operating at LOS outdoor environment the master unit and local ECG sensor unit can communicate for the distance longer than 250 m.

Keywords – *Wireless ECG, sensor device, and wave propagation environment*

I. INTRODUCTION

Currently the wireless sensor network technology has been specifically applied for many purposes such as for measuring the heart rate signal, for monitoring the rehabilitation process of patients remotely, telemedicine monitoring, analysis of body movements for the physiotherapy treatment, and many others [1-4]. There are various types of wireless electrocardiograph (WECG) has been developed [1, 3-4]. For example, [3] proposed an internet-based wireless technology to monitor the patient's medical condition in order to record medical data continuously. Meanwhile, [4] previously implemented a prototype of telemedicine system that utilizes the flexible technical benefits of a PDA-based telecommunications system.

The preliminary research activity for the development of a reliable wireless sensor prototype for monitoring and recording the environmental parameters have been studied in [4]. The initial system was powerful to utilizes when transferring several important parameters such as temperature, light intensity, smoke levels, and others through of the existing sensor node and remote station connections. Inspiring from the research the typical WECG is currently under investigated by our research group. This technology is very important utilized

especially in the condition in a hospital where the availability of the number of nurses or doctors on duty compared to the number of patients to be served is less. Very hard to imagine an increase in quality of service from hospital to patient if such conditions continue exist. Utilization of wireless sensing technology within the hospital network will impact on the increasing of the efficiency and optimization of resources, manpower and time.

This paper presents one typical model of health monitoring systems that have been studied for several years at the Department of Electrical Engineering UNHAS. One interesting prototype is wireless ECG used to monitor heart rate signals of patients. Using WECG technique will allow a group of nurses or doctors simply monitor the condition of the patient through a remote room that is connected to a wireless sensor network system. The future development of the proposed wireless ECG technology will be continued to a number of technical issues including variations in series of studies related to the utility of more sensitive and precise electrodes sensor to detect the human heart pulses. Other interesting experiment could include the examination of various heart pulses characteristics from very large group of patients and the construction issues such as compactness, easiness, flexibility, simplicity and safety of installation WECG on patient body must be considered. An advanced study regarding the performance of wireless ECG systems in a variety of wireless propagation environment (indoor and outdoor) and the read range capability of ECG system. These will be further discussed later.

II. WIRELESS ECG CONFIGURATION

A typical WECG system used to monitor heart rate signals of patients is illustrated in Fig.1. The designed WECG can serve about n number of ECG sensor nodes to monitor patients in one room and one of the ECG sensor nodes will act as a remote sensor station and communicate directly to the master unit. In practice, the ECG network can have up to k^{th} arrays of sensor unit. The whole WECG nodes are configured in tree topology to allow the extension of the read range distance between nodes could be achieved.

In Fig.2, the more detailed visualisation of the implemented WECG is presented. The sensor node consists of ECG unit (configured from electrodes sensors, series of filters, signal conditioning circuits), microcontrollers, Xbee module and

antenna system. It will continuously transmit the sensed patient's heart pulses through free space propagation channel. At the sink node, the captured RF-signals will be sequentially processed and finally plotted at PC monitor using Borland Delphi program. The testing of WECG is shown in Fig.3

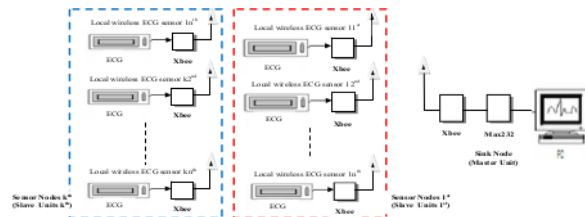


Fig.1: A typical wireless electrocardiograph system operated at 2.5 GHz

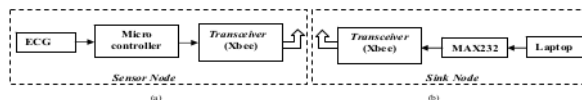


Fig.2: The implemented Wireless ECG System: (a) sensor node (slave unit); (b) sink node (master unit)

III. Wireless ECG System Performance

The development of WECG system, as implicitly explained previously, consisted of two main parts, i.e. the hardware and the software aspects. To guarantee that the hardware design was constructed in a proper way therefore the research was started by studying the related physiological characteristics of the heart signals, measuring the ECG signals conventionally, and to analyze of how the ECG works. By studying the existing ECG, researchers can find out in detail the parts to build and this becomes a reference for designing the intended ECG to meet the required specifications.

The WECG hardware specifications are explained below. The sensor node consists of several essential parts including DC regulator power supply unit (Voltage interval 3.3-5 Volts output), ECG sensor, 8-bit microcontroller ATmega 8535L, a transceiver chip Xbee-Pro 2.4 GHz (Tx-power 1mW and Receiver sensitivity -92 dBm) and an antenna system (integrated with chip or built up). The expected RF-data rate in WECG is approximately 250 kbps. Meanwhile, sink node (master unit) is built from a transceiver chip Xbee-Pro 2.4 GHz, MAX232 interface, DC power supply, and a PC/Laptop.

Another most important testing on WECG circuit was done on the signal conditioning part in order to examine the accuracy on generating the actual heart pulse from human body. Several part of the ECG signal conditioning circuit (SCC) were measured including buffer circuits, instrumentation amplifiers, driven right leg, non inverting amplifier, analog filters, and clamping circuits. Technical understanding of these parts is very useful on distinguishing the actual heart electrical signals

of human body to further process and suppressing the noise level. The following technical specifications represent the actual electrical properties obtained from the circuit testing including the SCC input signal ± 5 mV; CMRR > 100 dB; and signal Bandwidth of 0.5 - 100 Hz.

The read range testing of wireless ECG system to perform on monitoring the heart pulses was carried out. At indoor environments it can read up to the distance of more than 50 m. When operating at LOS outdoor environment the master unit and local ECG sensor unit can communicate for the distance longer than 250 m.

IV. CONCLUSIONS

A typical prototype of wireless electrocardiograph system (WECG) has been presented. The WECG model was tested in various wireless environment both indoor and outdoor in order to evaluate its feasibility to apply in a particular health monitoring facilities. Some technical issues including the accuracy and safety reasons must be studied further in the real medical centres under the doctor evaluation and supervision.

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Fig.3: Wireless ECG development: (a) WECG Testbed configuration at indoor environment, (b) a typical heart pulse detected at Laptop or PC created using the designed Delphi program, (c) Heart pulses on oscilloscope for testing ECG circuit.

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