PC Based Wireless Vital Sign Monitor Using Zigbee Communication

A.R. Fikar, A. Rahman, A. Rizal, S. Hadiyoso, and Jondri

Biomedical Signal Processing & Instrumentation Research Group,
Telkom School of Engineering
Telkom University, Bandung, Indonesia
{arl,sgo,jdn}@ittelkom.ac.id

Abstract— **Electrocardiogram (ECG), SpO2 and body temperature are vital sign for human body. In some condition, these signals are monitored using vital sign monitor to determine patient's health condition. Vital sign monitor usually placed beside patient's bed and doctor need to come to monitor patient's condition.**

In this research, we design low cost wireless PC based vital sign monitor. The design device consist of acquisition modules to capture ECG signal, SpO2 and body temperature and additional device to monitor flow rate of fluid from infusion pump. All the signal are displayed into a tiny graphic LCD while the all signal's data transmitted into PC via zigbee communication. In PC display, we show ECG and SpO2 signal, body temperature, heart rate and flow rate.

From device testing, the device worked well for maximum transmission distance of 50 meters. By this condition, we can monitored patient's vital sign from another room. So doctor or nurse does not need to come to patient's room to monitor patient's vital sign.

Keywords— **vitalsign monitor, ECG, SpO2, heartrate, zigbee.**

I. INTRODUCTION

Electrocardiogram (ECG) is a signal formed as a result of the electrical activity of the heart. ECG is taken by placing electrodes on the patient's body. ECG signal has a specific form that can be used as a reference to determine the health condition of the heart by a cardiologist [1]. ECG signals were recorded using an electrocardiograph device. Photoplethysmogram (PPG) is a signal of the pumping activity of the heart was observed by an optical sensor. ECG and PPG is usually monitored continuously in patients during treatment in an intensive care unit[2]. This device is called the bedside monitor. Doctors monitor patients' health conditions through this device.

In this research is designed a device similar to a bedside monitor with additional transmission device. ECG and PPG signal, the patient's temperature, and additional device to monitor flow rate of fluid from infusion pump acquired then transmitted to be monitored by a doctor even if he was not in the patient's room. It is hoped that doctors do not need too much to get into the room. In previous works, we used wireless LAN as data transmission protocol, but we met some problem in security and power consumption[3]. To solved this matter, we use zigbee protocol as low-power and short-range data transmission[4].

II. SYSTEM DESIGN

A. Hardware Design

The hardware for this device includes the following blocks:

- Power Supply
- ECG
- PPG
- Temperature Detector
- Infusion Detector
- Minimum System of Microcontroller
- Wireless Communication

Power supply block is a device that provides power source to all blocks of the transmitter. Power supply block consists of a CT transformer, bridge diode, and the regulator. In this research, used transformer CT 1A, bridge diode circuit compose of 4 pieces diodes. For the needs of the system requires power source 5 V and - 5 volts, therefore using a LM7805 regulator for +5 volt and a LM7905 regulator for -5 volt. Power source between the microcontroller and the analog block are separately.

ECG block is a system that is used for ECG signal conditioning to obtain a signal that can be processed in the microcontroller. It consists of electrodes, amplifier circuit, low pass filter circuit (20 and 40 Hz), and the clamper circuit.

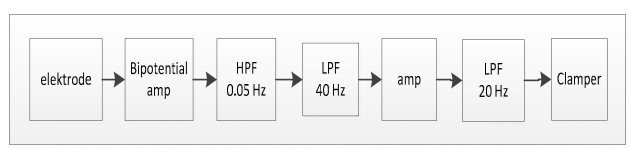

Fig. 1: ECG block

Circuit blocks of PPG are used for PPG signal conditioning to obtain a signal that can be processed in the microcontroller. PPG block consists of sensor (LED and LDR), amplifier circuit, low pass filter circuit 20 Hz, and adder. Temperature block consists of LM35 temperature sensor which directly connected to the ADC pin on the microcontroller.

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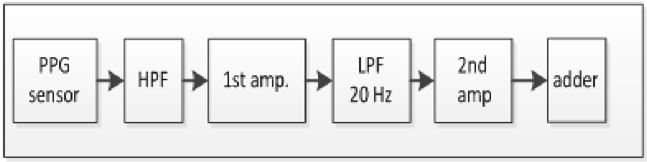

Fig. 2: PPG block

The working principle of drip counters sensor is when the drip blocking the LED light and photodiode, the output voltage will change. To get ADC value at the time of the drip by manual calibration so that it can determine the ADC value that represents that there is a droplet. The design and installation of the sensor infusion set can be seen in Figure 3.

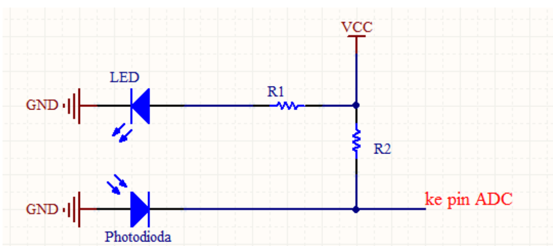

Fig. 3: Infusion drop sensor

To Multiplex 4 signal needed digital multiplexer system to unify all the signals are then sent. In this research, the working principle of digital multiplexer is implemented in microcontroller ATmega16. A.0 pin on the microcontroller ATmega16 as ADC input signal is used for PPG, A.1 Pin used for ADC input ECG signal, A.2 pin used for LM35 temperature sensor and pin A.3 used for sensors infusion.

In this research, we used an embedded wireless RF module as interface data transfer through the medium of air. RF wireless embedded modules used XBee Pro Device from the Digi-International product [5]. Data communication XBee Pro with the devices is using RS232 serial data communication. Data that sent by microcontroller received through DIN pin (Data IN) of XBee Pro module.

B. *Software Design*

Cardiac signal, body temperature and the drip counter software application is part of the vital signal monitoring system. This application will connect to hardware devices through the ZigBee communication. This application will receive the data and separate the transmitted data then displays the data into a graph. Flowchart of program applications can be seen in Figure 4.

The monitoring application designed to display the ECG signal, PPG signals, body temperature, and the condition of the patient intravenous fluids that can only be used on windows based operating systems only.

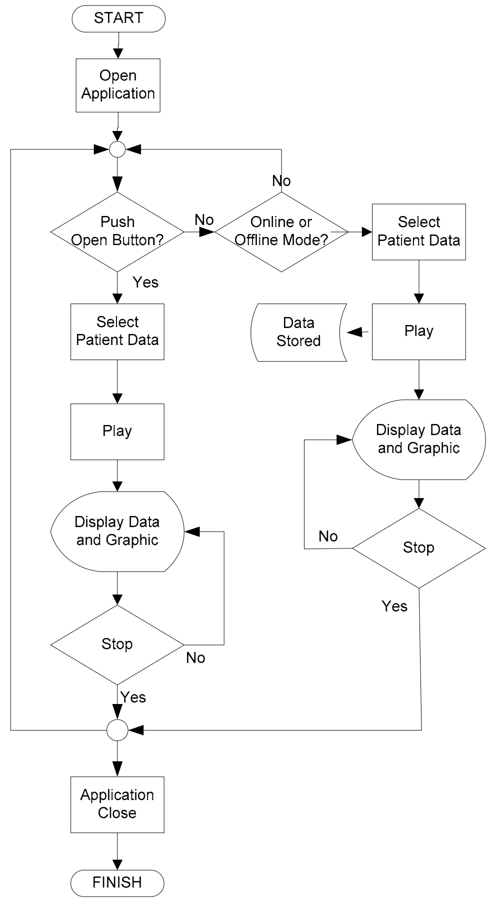

Fig. 4: Flowchart Program

III. Result

A. *Analog Block*

Measurement result of the hardware design is done by looking at the output of each signal processing block. For measurement used the RIGOL oscilloscope to see the output analog signals.

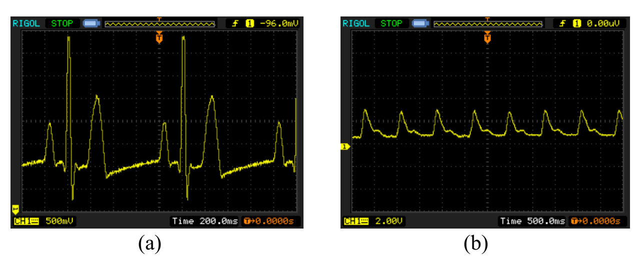

Fig. 5: (a) PPG Signal (b) ECG Signal

From the figure above shows the ECG and PPG signals were directly taken from the patient's body. Both of the signals are clean from noise and basic form of both clearly visible. It can be concluded that the analog signal acquisition device can work well.

Temperature sensor testing is done by measuring the output voltage temperature sensor using a voltmeter then compares its value with a digital thermometer. The output voltage of sensor that shown are not directly show the temperature value so that needs to be converted according the following equation:

$$Temp = Output\_Voltage / 10mV \qquad (1)$$

B. Digital Block

Testing in this section consists of digital multiplexing serial communication block. Testing was conducted to determine whether the format of the data sent is appropriate. To determine whether the multiplexing system is suitable can be seen from the serial data that sent. The test is performed using hyperterminal application. Figure 6 is the result of reading the data transmitted by the hardware.

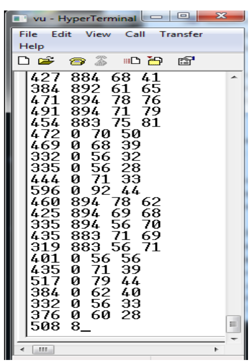

Fig. 6: Data Received On Hyperterminal

Description: column 1 for the ECG, column 2 for PPG, column 3 for body temperature, and column 4 for drop infusion.

Then this data will be reprocessed to separate the data that has been sent from the hardware to be able to separate the data of ECG, PPG, temperature sensor, and drop infusion and grouped according to the data, respectively.

C. Application Testing

Figure 7 is application program being executed.

Fig. 7: Application Display While Program Is Running

From the figure above shows that the ECG signal data, PPG, temperature, and the drip can be displayed on the application program, through graphs and number. Further accuracy tests be done to determine the accuracy of the application that has been designed. Accuracy to be measured was the accuracy of the temperature value, drip in a minute, and heart rate values are compared with existing tools or manual count. Testing result shows accuracy for temperature measurement reaches 98,27% and 99,88% for heart count. Accuracy for drip counter reach 98,09% form manual counting. While maximum transmission distance of 20 meters at line of sight and 10 meters at non line of sight.

IV. CONCLUSION

From the results of the testing and analysis that has been done on the design of ECG, PPG, body temperature and infuse condition monitoring system based ZigBee communication, some conclusions can be drawn as follows:

1. Analog front end can work well, able to remove noise so form the ECG and PPG signals clearly visible.
2. Application that has been designed can monitor the ECG, PPG, body temperature and infusion conditions simultaneously using the Zigbee communication media with a maximum distance of 20 meters.
3. In testing the accuracy between the LM35 sensor and digital thermometer is 98.16%.
4. The accuracy of drip infusion count obtained from the application that has been designed reach 98.09%.
5. The accuracy of heart rate count obtained from the application that has been designed is equal to 99,88%

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Author: Achmad Rizal
Institute: Telkom University
Street: Jl Telekomunikasi no 1
City: Bandung
Country: Indonesia
Email: arl@ittelkom.ac.id