

Development of Wireless Bio-telemetry System Using FM Stereo Method For Exercising Rehabilitation Patients

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Abstract - Development of a telemetry system using FM stereo method for exercising rehabilitation patients was performed in this study. The transmitting unit detects and sends two kinds of patient's vital signals, respiration and heart sound signal, simultaneously. The stationary receiving unit receives and analyzes the signals and alerts a nurse to the dangers of the patient if necessary. The system could be simplified and minimized in size by using commercialized electronic components. This system can be useful to monitor the exercising rehabilitation patients' vital signals and control patients' condition and the level of their exercise.

Keywords –biotelemetry, FM stereo

I. INTRODUCTION

A bio-telemetry system has been needed to monitor exercising patients' vital signals such as heart rate and respirations in rehabilitation medicine. General measuring method that can be applied for a patient in stationary state cannot be used for exercising patients due to noise generated by the exercising patient's movement. In addition, the new system should not use wires connecting a signal collection unit and monitoring unit.

Respiratory inductive plethysmography (RIP) method was used to detect patient's respiration signal and a microphone sensor was used to detect patient's heart sound.

The previously developed system utilized a frequency division method and needed two trans-mission modules. The equipment was too big for the patients to carry and it restricted patients' exercising activity and convenience of carriage [1]. This study focused on reducing the size of the transmitting unit that can be easier to be attached to an exercising patient. The standard FM stereo modulation method and a commercialized single IC chip were incorporated to reduce the size of the transmitter and increase signal-to-noise ratio. In the receiving unit a standard FM receiving module could be used to restore the original signal with very low cost. After detecting, the original signal is processed by digital filters, and the extracted patients' parameters are displayed on CRT monitor.

II. METHOD

A. Transmitting Unit

The heart sound signal detected by a microphone sensor is frequency-modulated by a voltage-controlled oscillator and

fed to the left audio channel input of the standard frequency modulation IC (BH1416F, Rohm). The respiration signal detected by the inductance belt is mixed with a 450 kHz sine wave from the local oscillator to get a 12 kHz bandwidth respiration signal and fed to the right audio channel input of the IC. The block diagram of transmitting unit is shown in Fig.1.

The sensor for the heart sound detection was designed by using a condenser microphone and can to be attached on the body surface. The sensor for the respiration signal was designed based on the respiratory inductive plethysmography(RIP) method [1]. The single chip IC (BH1416F) for generation of standard FM stereo signal has a built-in voltage-controlled oscillator (VCO), a phase-locked-loop (PLL) circuit, a pre-emphasis circuit, and a low-pass filter (LPF) circuit. A 3V power from the battery pack was supplied to the transmitting unit and boosted to a 5V by using a voltage converter IC (MAX777, Maxim).

B. Receiving Unit

In the receiving unit, the double frequency-modulated vital signals are received and demodulated through a commercialized FM stereo receiving module and the resulting two signals are fed to PLL circuits again to recover the original signal. The recovered respiration and heart sound signals are fed to analog-to-digital converter through a 2-to-1 analog multiplexer and a low-pass filter. The converted vital signals are processed and analyzed in the digital signal processing module to get the parameters for the patients. The block diagram of receiving unit is shown in Fig. 2.

The extracted parameters are sent to a PC via serial communication to be displayed, monitored, and saved.

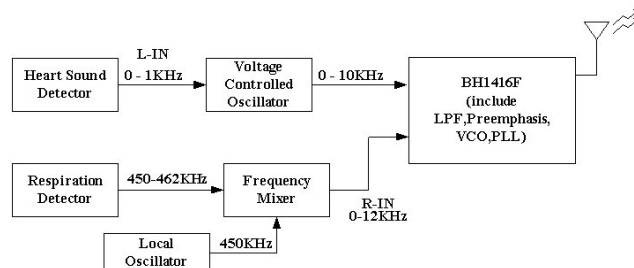


Fig. 1. Block diagram of the transmitting unit.

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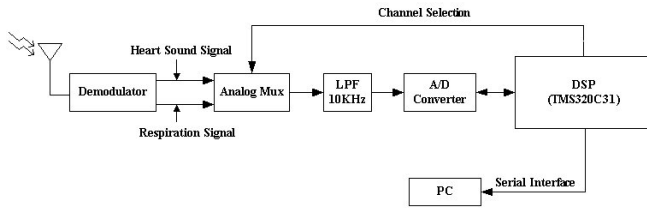


Fig. 2. Block diagram of the receiving unit.

III. RESULTS

The output signal of the heart sound detector is shown in Fig. 3. The data consisting of 7,000 samples were acquired from a male subject and digitized in 15 kHz sampling rate through a 12-bit analog-to-digital converter board.

The frequency-modulated heart sound signal from the voltage-controlled oscillator is shown in Fig. 4 and the respiration waveforms obtained from the frequency mixer are shown in Fig. 5 for inspiration and expiration.

Fig. 6 shows a recovered heart sound signal and a first-demodulated respiration waveform in the receiving unit.

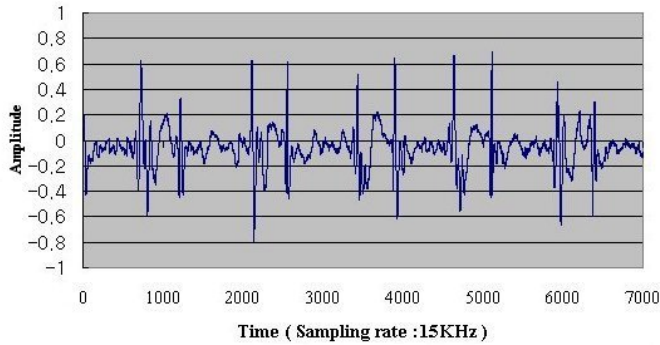


Fig. 3. Output signal of the heart sound detector.

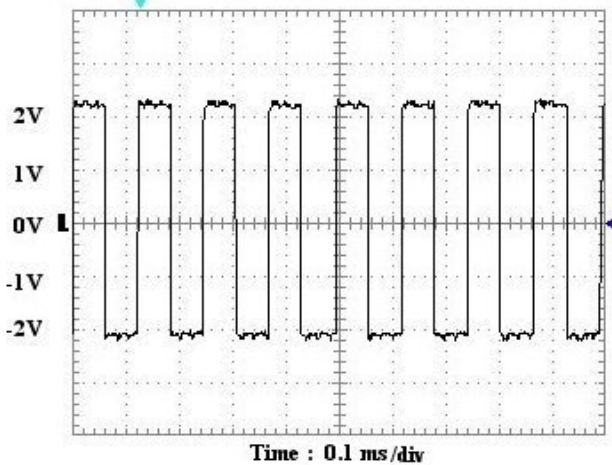


Fig. 4. Frequency-modulated heart sound signal.

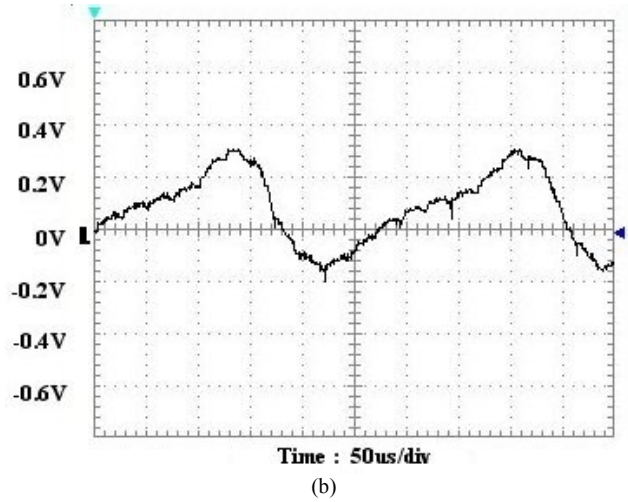
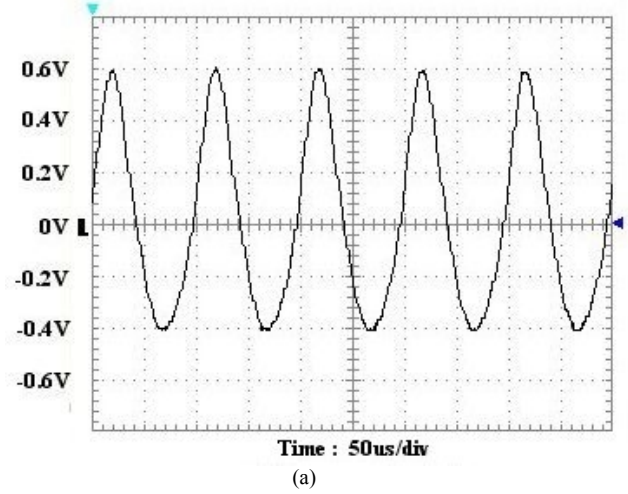


Fig. 5. Frequency-modulated respiration signals. (a) For inspiration (b) For expiration.

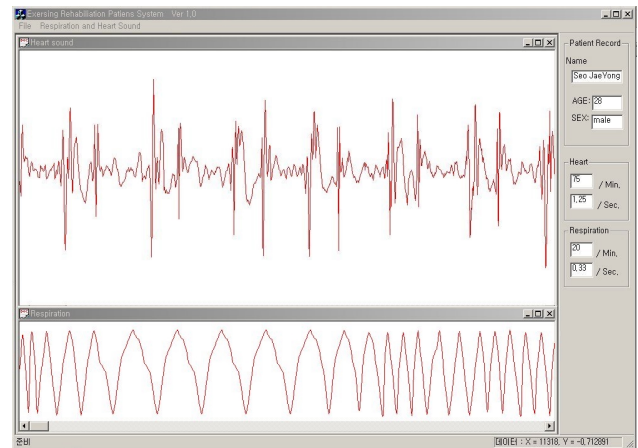


Fig. 6. Recovered signals.

IV. CONCLUSION

The developed system in this study can help that exercising patients' vital signals can be monitored remotely in real time. Physical therapists can monitor patients' present quantity of exercise and decide the time and degree of physical therapy and check patients' vital safety.

In addition, the size of the transmitting unit reduced by incorporating stereo FM method and dedicated IC chips, and this decreased patients' restriction in exercising activity.

Effective noise elimination algorithms and sophisticated monitoring algorithms are required to detect the dangerous status of the exercising patients and warn the therapists of the dangers of patients.

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