High Sensitivity Doppler Radar System for detecting Respiration and Heart Rate Using Improved Isolation Technique

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Abstract

This study presents a 14 GHz CW Doppler radar to measure respiration and heart rate. An improved antenna isolation technique is used to detect the heart rate of humans for long range detection. Arctangent demodulation without dc offset compensation can be applied because of the heterodyne receiver structure. HRV(heart rate variability) analysis of the radar system and the ECG(electrocardiogram) signal, which is measured directly, are compared. Based on the measurement results, the proposed radar detects the respiration and the heart rate with a small error rate.

1. Introduction

Conventionally, the system for measuring the heart rate uses the electrodes which are attached to the arm and chest. In comparison with contact measurement system, non-invasive detection system using the continuous wave signal has the advantage of detecting human behind the wall and other applications. Bio radar system uses the signal reflected by biomaterials. By passing the signal into the filter, it is possible to distinguish the heart rate and respiration very accurately. In published several papers, It was demonstrated through a number of experiments [1]. But, published papers have limitations that can be only measured at short range. In this paper, by using the improved isolation technique, it is possible to measure heart rate and respiration at a distance of more than 50 meters.

2. System Design

The radar system for measuring heart rate and respiration are composed of transmitting and receiving antenna, transmitter for transmitting the RF signal to the target, receiver to make IQ(in-phase & quadrature-phase) signal, and baseband that separate heartbeat signal and breathing signal through the demodulated IQ signal. The radar system introduced in this paper is the super-heterodyne architecture, the operating frequencies are 14GHz and 11.7GHz. 14GHz with Doppler signal reflected from the target is mixed with 2.3GHz LO(local oscillator) signal, and is converted to 11.7GHz, and once again transmits 11.7GHz of RF signal to the target. 11.7GHz reflected from the target is mixed with the 12.61GHz signal generated by transceiver, ultimately converted to 920MHz of IF(intermediate frequency) signal. The IF signal passing through the down converter is converted to 480MHz. The final IF signal is demodulated as IQ signal that have in-phase and quadrature-phase. Using the arctangent demodulation, an accurate heart rate is extracted from IQ signal [2]. By the system structure using the frequency of 14GHz and 11.7GHz described above, the proposed architecture is a useful for the better performance in terms of improving the isolation and the sensitivity.

3. Conclusion

In this paper, we proposed the improved antenna isolation technique for monitoring of vital signal such as respiration and heart rate with different two frequency bands, which has advantage of the low power of the leakage signal and enhancing the Doppler signal.

4. References

1. M. Baboli, A. Singh N. Hafner, V. Lubecke, “Parametric Study of Antenna for Long Range Doppler Radar Heat Rate Detection”, in International Conference of the IEEE EMBS, USA, 2012.

2. Byung-Kwon Park, Olga Boric-Lubecke, and Victor M. Lubecke, “Arctangent Demodulation with DC Offset Compensation in Quadrature Doppler Radar Receiver System”, IEEE Transactions on Microwave Theory and Techniques, vol.55, no.5, 2007

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