Design of a 60 GHz Band Patch Antenna Array for Vital Signs Monitoring Based on Doppler Radar Principles

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Abstract—This project describes an ultra-wide patch antenna array in the 60 GHz band (60-64 GHz) with improved gain and beamwidth to remotely detect human respiratory and heartbeat frequencies using the Doppler radar principle. By using CST Microwave Studio software, ultra-wide element microstrip antenna arrays of 6 × 1, 3 × 2 and 6 × 2 SMD elements have been simulated, and they are optimised to operate properly at 60-64 GHz.

Introduction

As healthcare technology continues to evolve, in recent years there has been an increased interest in developing non-contact methods to monitor vital signs such as heart rate and respiratory rate [1]. This project uses the 60 GHz band, aiming to take advantage of its higher resolution and greater bandwidth compared to lower frequencies. The proposed system is based on the Doppler radar principle, which provides high resolution and accurate velocity measurements that are particularly beneficial for monitoring subtle physiological signals such as breathing and heartbeat [2].

Methodology

1. Antenna Choice

In this project, three ultra-wide element microstrip antenna arrays with 6 × 1, 3 × 2 and 6 × 2 patch elements are chosen to design. At 60-64 GHz, the reflection coefficient of the system should be lower than -10 dB to ensure that most of the input signal is absorbed or transmitted by the antenna.

2. Doppler radar principle

Using the Doppler radar principle to enable highly accurate long-range measurements of subtle physiological signals such as respiration and heartbeat.

3. Simulation Models

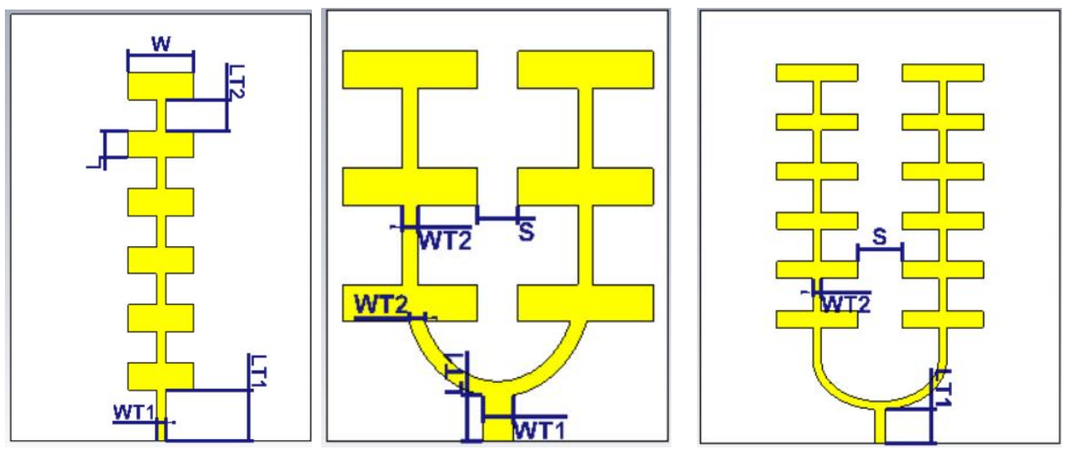

Figure 1. Antenna arrays with (a) 6 × 1, (b) 3 × 2 and (c) 6 × 2 patch elements

Results and Discussion

1. Results for Antenna arrays with 6 ×1

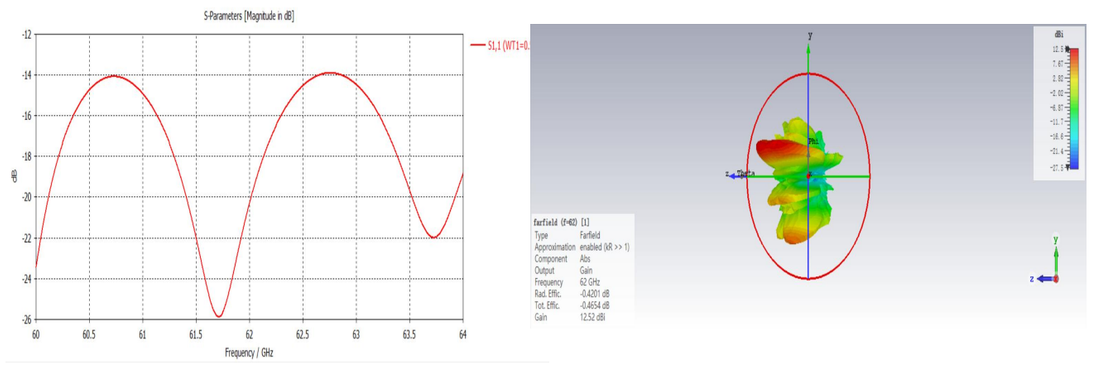

Figure 2. S11 and far-field plots of a 6*1 antenna array

2. Results for Antenna arrays with 3 ×2

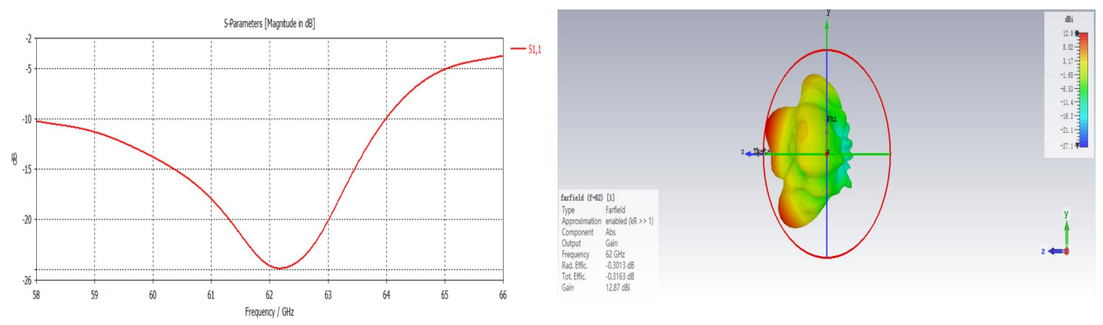

Figure 3. S11 and far-field plots of a 3*2 antenna array

3. Results for Antenna arravs with 6 ×2

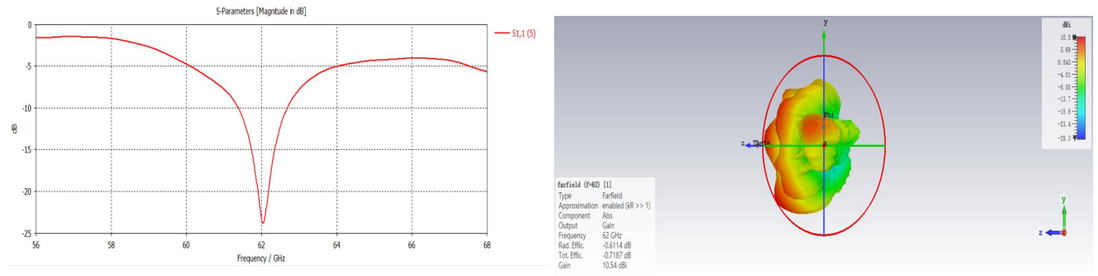

Figure 4. S11 and far-field plots of a 6*2 antenna array

Conclusion and Future Work

In conclusion, this research comprehensively investigates the application of ultra-wide patch antenna arrays operating in the 60 GHz band for remote vital signs monitoring. The gain of the antenna is getting smaller as the patch or element increases. In the future, try again to optimize the 6×2 antenna array to get the desired results, the 6 × 1 antenna arrays can be studied in depth, and the input signal will be modulated using the FMCW principle.

Selected References

[1] T. Adiono et al., "Respinos: A Portable Device for Remote Vital Signs Monitoring of COVID-19 Patients," in IEEE Transactions on Biomedical Circuits and Systems, vol. 16, no. 5, pp. 947-961, Oct. 2022, doi: 10.1109/TBCAS.2022.3204632.

[2] G. Duggal, S. Sundar Ram and K. V. Mishra, "Micro-Doppler and Micro-Range Detection via Doppler-resilient 802.11ad-Based Vehicle-to-Pedestrian Radar," 2019 IEEE Radar Conference (RadarConf), Boston, MA, USA, 2019, pp. 1-6, doi: 10.1109/RADAR.2019.8835525.

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