Signal Power Variation for Bio-Radar Applications

Carolina Gouveia[†‡], Beatriz Cruz[*], Pedro Pinho[*†] and Daniel Albuquerque[§]
[*]Instituto Superior de Engenharia de Lisboa, 1959-007 Lisboa, Portugal
[†]Instituto de Telecomunicações, 3810-193 Aveiro, Portugal
[‡] Universidade de Aveiro, 3810-193 Aveiro, Portugal
[§]Centro de Investigação em Serviços Digitais CISeD, ESTGV - Politécnico de Viseu, 3504-510 Viseu, Portugal

***Abstract*—Micro-Doppler radars have been widely used for the remote vital signs acquisition. In those cases, the signals quality is directly related with the received power provided by the reflecting chest-wall. In order to determine which is the optimal radar configuration, it is important to study the signal behavior in the near-field region considering the Radar Cross Section (RCS) of the human chest. In this work, simulations are performed to characterize the received signal power variation, considering the subject distance in relation to the radar.**

***Index Terms*—Doppler radar, vital signs, near-field radar, radar cross section**

I. Introduction

Continuous-wave (CW) radars, from now on referred as *Bio-Radar*, are able to monitor the respiratory and cardiac signal remotely, by transmitting continuously an electromagnetic wave towards the subject's chest-wall, where is therein reflected, producing a phase modulation according with the thoracic motion.

The overall system performance depends on the received echo power, which could be inferred using the radar equation [1]. This equation takes into account the transmitted power and the antennas gain, the propagation path, and the target's Radar Cross Section (RCS). Traditional radar systems are typically analyzed assuming that the target is in the far-field region [1]. This approach reduces the analysis complexity and simplifies the RCS computation, which could be considered constant for each target. However, the bio-radar is implemented in short-range (less than 2 m), and although it is possible to operate in the antennas far-field region, the same cannot be applied on the target side due to the human body dimensions.

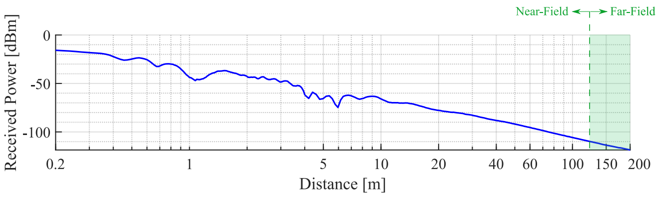
Thus, despite the radar equation being valid for both near- and far-field regions [1], the RCS is difficult to quantify not only because the radar could be operating in a near-field region, but also due to the complex human body shape.

In this work, a bio-radar application scenario was simulated and the received power variation was verified according to the target distance. The simulation demonstrates that the bio-radar is operating in a near-field region most of the times.

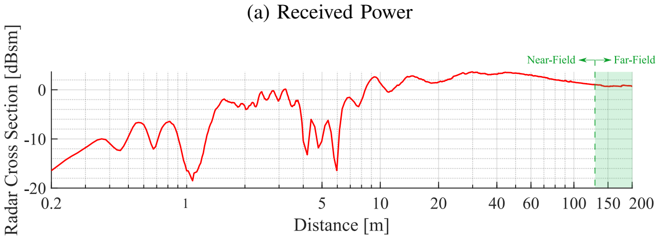
II. Near-Field Simulation

The simulations were performed in the WaveFarer software from REMCOM®, where two directive antennas were located in front of a 3D subject model with 1.76 m height, aligned with his diaphragm. The radar was operating in CW mode at 5.8 GHz.

The received power, as well as the measured RCS were verified while varying the distance between the subject and the antennas, within the range of $0.2 - 200$ m. The results can be observed in Figure 1.



(a) Received Power



(b) RCS

Fig. 1: Received power and RCS variation according to the distance.

The received power decreased almost linearly, excepting on the first 10 meters where a wide power oscillation was obtained. A similar effect was observed in the RCS and both presented a null around 1 m. Considering that the highest target dimension h is the subject's height, one can compute where the far-field region starts, using $R > \frac{2h^2}{\lambda}$ [2]. It starts around 120 m and the simulation supported this fact, since from this distance forward the RCS varies less than 1 dB [2]. Thus, one can conclude that the bio-radar operation is always performed in near-field due to the target's dimension. As far as we know, the literature focusing on the bio-radar development do not raised this issue. Since the received power presents wide variations in a 2 m range, we believe that this aspect requires a deep study in order to determine which is the best operating distance for each subject.

References

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