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81 GHz PMCW automotive radar front-end integration

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Research context and motivation

- With the rapid development of mmWave technology, radar and communication are aiming at joint design. Moreover, the performance of single radar, with the increasing complexity of electromagnetic environments, is limited. Therefore, the use of multiple radars can enhance the sensing capability and networking them through communication techniques is crucial to merge detection data and to mitigate interference. Particularly, there is a strong demand for integration of radar and communication in some scenarios where space, power and spectrum are extremely limited, such as vehicle-to-vehicle network.

- The most interesting and promising modulated waveform for automotive radar, which has been the focus of research in recent years, is the Phase-Modulated Continuous Wave (PMCW). It uses sequences of symbols that, in automotive applications, are binary mapped onto 0- and 180-degree phase shifts of a continuous mmWave carrier. Both for radar performance and implementation simplicity PMCW has extremely attractive properties.

Addressed research questions/problems

- The main research focus is prototyping a PMCW automotive radar system with full capability to implement a joint communication and sensing paradigm.

- A starting prototype of a binary-PMCW radar system has been assembled by the radar research team using evaluation modules of the different components. The promising performance of the binary-PMCW radar further push the research toward the integration of the radar front-end in a single printed circuit board.

Novel contributions

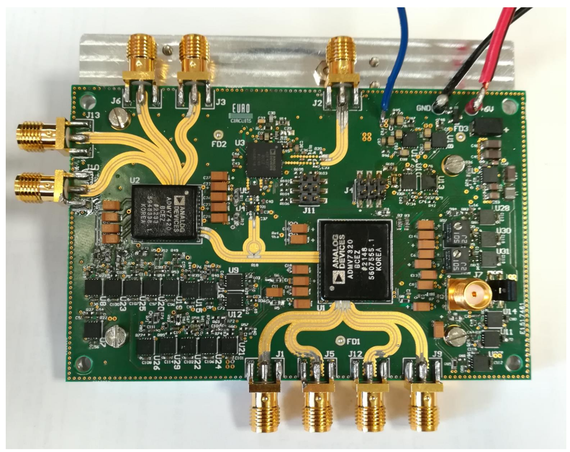
- Binary-PMCW radar is gaining popularity in the automotive radar industry since it has many advantages over the more common Frequency Modulated Continuous Wave (FMCW) radar. In particular, there is no range-Doppler coupling, it has better resilience to interference, larger maximum velocity, and improved High Contrast Resolution. A great advantage of PMCW radar is its intrinsic ability to exploit joint communication and radar sensing, which is also useful for further mitigating mutual interference and facilitating ghost targets removal.

- Despite the growing interest in PMCW technology there are still only limited examples of radar systems using this waveform for automotive applications.

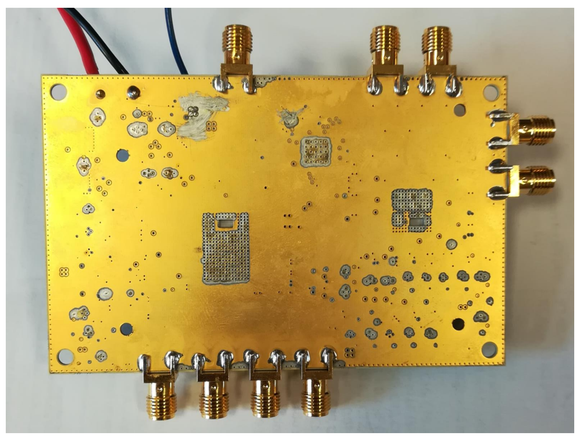
- The innovation of the integrated RF front-end with respect to common FMCW radar also comes from the up and down converter ICs since they are natively equipped with 81 GHz waveguide launcher. This allows the adoption of full metal waveguide-based antennas with extremely lower losses and increased efficiency.

Adopted methodologies

- An innovative printed circuit board has been designed and prototyped to host the 81 GHz up and down converters, as well as the phase-locked loop frequency synthesizer. The components has been placed on the top side of the board while the bottom side has been used to connect to a carefully designed aluminum block. The latter has three main functions: dissipate the heat, guide the mmWave signal to antennas and support the same antennas.



Top side of the board



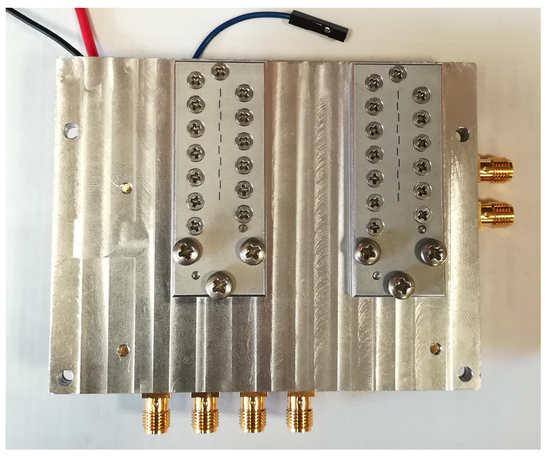
Bottom side (GND plane and waveguides)

- The design has been focused on minimizing as much as possible the size of the board while maintaining the full functionality of the components and maximizing their noise immunity.

- Rogers4350B low dissipation factor dielectric material has been used to achieve reduced signal loss at high frequencies.

- Two slotted waveguide antennas, completely designed and manufactured in our laboratory, have been connected to the transmitter and the receiver respectively.

- The system is currently under laboratory test.



Aluminum block and slotted waveguide antennas

Future work

- Test the performance of the system and compare with the non-integrated version in controlled and real environment.

- Design and prototype a board with multiple transmit and receive channels to exploit benefits of MIMO systems.

- Further integration into a single integrated circuit.

Publications

- Published works: 1 journal, 0 conferences
- Submitted works: 0 journal, 0 conferences

- Caffa, M.; Biletta, F.; Maggiora, R. Binary-Phase vs. Frequency Modulated Radar Measured Performances for Automotive Applications. Sensors 2023, 23, 5271. https://doi.org/10.3390/s23115271

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