A multifunctional 60-GHz system for automotive applications with communication and positioning abilities based on time reversal

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***Abstract*— This paper reports a multi-functional 60-GHz system which performs promising performances for short-range automotive applications such as short range RADAR with communication abilities. Experimental results validate the ability of the topology to transmit high speed data in the millimetre-wave (MMW) frequency band using Pulse Position Modulation (PPM). Using the same front-end, a positioning functionality is simultaneously assumed successfully in a Time Difference Of Arrival (TDOA) configuration. Furthermore, the Time Reversal (TR) technique is introduced and its impact on the location accuracy is presented and validated by experimental results.**

I. INTRODUCTION

Vehicle safety has already substantially improved in the last decades with the use of new safety technologies. Vehicles with active and passive safety systems allow for more robust passenger compartments, with implemented crumple zones. Restraint systems and airbags ensure that these accidents will eliminate or lessen injuries sustained by the driver and passengers. Radar sensors for driver-assist systems help improve safety and comfort functions in Brake-Assist and Pre-Crash applications providing object detection and localization [1]. SRR are currently operated at 24 GHz. In the future, LRR and SRR will operate mainly in the 76-81 GHz frequency band, at wavelengths in the air in the order of 4 mm. SRR have the ability to measure range, velocity and angle for the targets in the observation area [2]. Considering the 4 GHz allocated bandwidth, this paper presents the impact the Time Reversal technique on the performance of a TDOA positioning system operating in the millimetre-wave near-60 GHz frequency band. In a first part, the 60-GHz transmitter topology is detailed including electrical characteristics. A second section deals with the system performances relative to the PPM radio-communications performed at 60 GHz. Finally, the last part details the positioning strategy including the presentation of the overall set-up, the theory of the used passive TR algorithm and concludes on its impact on location error.

II. SYSTEM TOPOLOGY

A. Transmitter topology

The topology of the overall transceiver, composed by a 60-GHz emitter and a 60-GHz receiver, is depicted in Figure 1: digital data modulate the position of sub-nanosecond pulses provided by an integrated pulse generator. Using a switch, the resulting pulses stream modulates the amplitude of a 60-GHz carrier signal issued from a 30 GHz VCO associated to a frequency doubler. The RF modulated signal is then amplified with the use of a Medium Power Amplifier (MPA) which delivers a peak power equal to 15 dBm. The ED02AH line (ft = 65GHz, using enhanced and depleted HEMTs) from OMMIC foundry has been chosen for the pulse generation. The D01PH line (ft = 120 GHz, using depleted HEMT) from

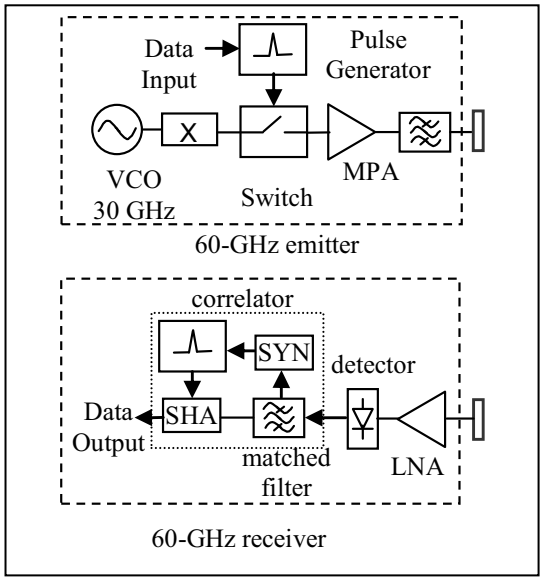

Figure 1 – Transmitter topology