Signal Generation and Detection for Microwave Photonic Radar Systems

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Abstract

Linear frequency modulated (LFM) signals are widely employed in modern radar systems due to their significant time-bandwidth product and inherent pulse compression capability. Conventional radar entails the use of electronic methods for signal generation and processing. However, these methods face significant challenges due to their limited bandwidth, restricted functionality, high jitter, slow processing speed, and inadequate resolution. To address these problems, photonics-based radar technologies have been proposed to overcome the bottleneck of electronics for microwave generation and processing. Photonic technologies offer unique characteristics, which include wide bandwidth signal generation, processing, low jitters, low-loss transmission, immunity to electromagnetic interference (EMI), and compatibility with radio-over-fiber technology. The primary objective of this approach is to leverage the benefits of photonic technologies for the purpose of generating, processing, controlling, and distributing microwave waveforms enabling intricate functionalities that cannot be directly executed in the RF domain.

The primary focus of the research in this thesis is based on the LFM signal generation, processing, and detection utilising a dual-drive Mach Zehnder modulator (DDMZM), which offers a significant level of flexibility and ease of use due to the presence of only a single DC bias. The thesis investigates various aspects of microwave photonic radar, such as MWP link design for signal generation showing dual and cross chirp generation in two different frequency bands, ultra-wideband and frequency-agile waveform generation, photonic signal processing, range processing, velocity estimation and performance evaluation of FMCW radars in lab environment. The experimental validation of the radar system's shows the potential of its capabilities in real-world scenarios. Additionally, the thesis discusses the limitations of microwave photonic radar and proposes future research directions to overcome these challenges and explore new opportunities for its advancement.