Reconfigurable Radar Transmitter Based on Photonic Microwave Signal Generation

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***Abstract*— In this paper we propose a photonic technique for a reconfigurable microwave signal generation based on the beating in a photodiode of two laser modes from a regenerative Fiber Mode-Locked Laser (FMLL). The excellent performance of this kind of pulsed laser guarantees high stability to the generated microwave signal even at ultra high frequencies (up to W band). Therefore, by using the proposed architecture, the performance of a reconfigurable full digital coherent radar system can be enhanced in terms of Moving Target Indicator (MTI) improvement factor. Moreover, thanks to the achievable high repetition rates and the coherence properties of the FMLL, this laser scheme has also been proposed for digitizing the received signal by electro-optical sampling. Thus the advantage of using just one device for signal generation in both the transmitter and receiver chain, makes the proposed solution a cost effective architecture for microwave signal generation. Differently from the microwave synthesizers, whose performance strongly deteriorate with increasing frequencies, the photonic radio frequency generation always shows an excellent spectral purity. The results show excellent spectral purity above 5 KHz for the proposed technique compared to a state of the art Agilent synthesizer even though the timing jitter increases for integration time greater than 10 msec. In order to achieve the same stability performance at both high and low frequencies a Phase Locked Loop between the laser and a synthesizer could be used.**

I. INTRODUCTION

In the last few years the intriguing concept of very high performance reconfigurable radar transmitter is becoming feasible, mainly thanks to the wide and growing development of digital solutions for radar system applications. In this scenario a digital approach could have a lot of advantages with respect to the classical radar architecture in terms of transceiver module size and cost, instantaneous pulse bandwidth, software based capability, Multi Functional Radar systems (MFRs) and so on. In addition, the demand of a new generation of surveillance radar, satellite communications, remote sensing and Ground Penetrating Radar (GPR), as well as biomedical imaging, automotive and security systems, has driven the technology development in this direction [1]-[2]. For this new kind of radar the adaptivity of the microwave radio frequency generation according to the changing scenarios is one of the most important requirement, together with high operating frequencies, spectral purity and flexible baseband signal generation. Therefore, both high frequency oscillators with very low phase noise for up/down conversion, and direct RF analogue to digital converters are required.

In a conventional radar system the spectral purity of the microwave signal also depends on the frequency stability of a STAble Local Oscillators (STALO). In order to satisfy the microwave regime and to improve the RF signal stability, the combination of different type of oscillators (acoustic, electrical and so on) is necessary. Some of the weaknesses of this implementation is the usage of low frequency resonant modes, the necessity of a great number of multiplication stages, and the strongly frequency dependent performance of microwave signal in terms of amplitude and phase jitter [3]. This instability can induce a large phase noise on the target and clutter echo and can modify the signal spectrum, masking the presence of a small moving target echo. Moreover it can produce ambiguity on the target radial distance and Doppler frequency estimation, constraining the time delay clutter canceller in MTI processing [4].

In this paper we propose a photonic technique for realizing a reconfigurable microwave signal generation based on the beating of two laser modes from a stable regenerative Fiber Mode-Locked Laser (FMLL). Thanks to its excellent stability, high repetition rates and its potential for integration, this architecture have also been proposed as electro-optical sampler for the received signal [5]. The performance of a reconfigurable full digital coherent radar system will be enhanced in terms of MTI improvement factor. The proposed architecture, based on the use of just one device for both transmitter and receiver chain, also represents a cost effective solution for microwave signal generation. Moreover the nature of this approach guarantees the same performance up to ultra high frequencies. The results show excellent spectral purity above 5 KHz for the proposed technique compared to a state of the art Agilent synthesizer even though the timing jitter increases for integration time greater than 10 msec. In order to achieve the same stability performance at both high and low