Antonio Malacarne

CNIT - National Inter-University Consortium for Telecommunications, PNTLab - Photonic Networks and Technologies Nat'l Lab, 56124 Pisa, Italy

Optical Frequency Combs for Integrated Microwave Photonics

Our society must evolve into a fully connected world through two main technological revolutions: connectivity beyond 5G and industry 4.0, of which "Internet of Things" is an enabling technology. Such a technological transition requires an increasing number of smart sensors and a wider communication bandwidth. In this scenario, microwave photonics (MWP), i.e., the use of photonics in radiofrequency (RF) applications, has been recently demonstrated to overcome the intrinsic limitations of RF electronics such as narrow bandwidth, reduced and slow reconfigurability, sensitivity to electro-magnetic interference and high transmission loss [1]. MWP systems have the potential to revolutionize the connectivity and sensing paradigms providing wideband and frequency flexible operations [1],[2] and distribution [3]–[6] (through low loss and low distortion optical links with extremely high coherence), as demonstrated by few research groups [2],[3],[4],[6]. Reconfigurable and software-defined radiofrequency (RF) transceivers operating in the whole 0.3–300 GHz RF domain find application in many fields such as 5G/6G communications, radar/imaging systems and electronic warfare. In this framework, MWP based on photonic integrated circuits (PICs) is mandatory to reduce size and consumption as requested by compact platforms (e.g., drones and robots) or harsh environments (i.e., satellites).

In this work, several recent advances of integrated MWP (IMWP) for generating high-frequency RF waves with benefits in terms of simultaneous multi-band coherence and low phase noise (PN) are described, with one of the enabling key elements being an integrated optical frequency comb generator (OFCG). The first example of a tunable software-defined RF transmitter integrated on a photonic chip is presented, with tunability range of 0.5-50 GHz and fast tuning (< 200 µs). Its potential up to W-band generation and beyond with low PN is also detailed. Finally, the performance of a first prototype of IMWP-based radar transceiver is presented.

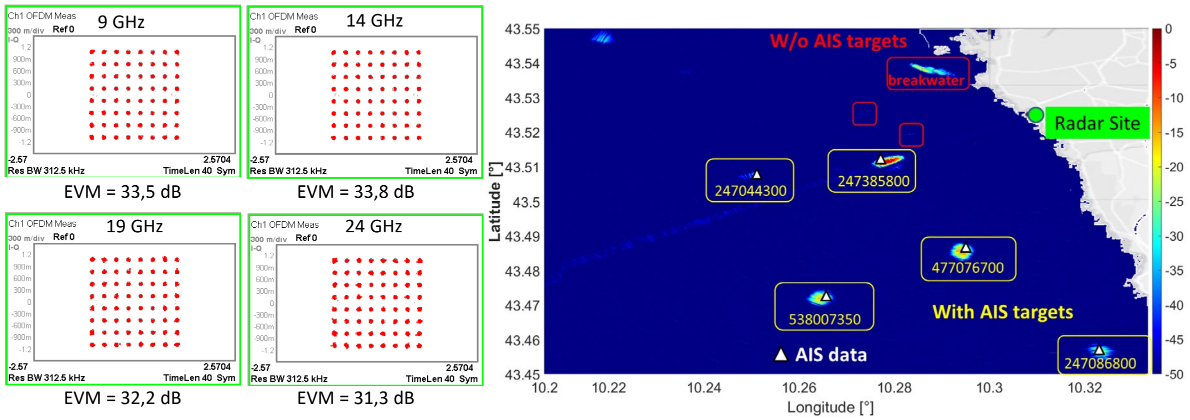

Figure 1: 64QAM constellations of 54Mb/s OFDM signal generated at 9, 14, 19 and 24 GHz (left); radar system validation in X band with rotating antenna (right).

References

[1] Capmany, J., Novak, D. Microwave photonics combines two worlds. *Nature Photon* 1, 319–330, 2007.

[2] P. Ghelfi, et al., "A fully photonics-based coherent radar system," *Nature*, Vol. 507, 2014

[3] S. Rommel et al., "Towards a Scaleable 5G Fronthaul: Analog Radio-over-Fiber and Space Division Multiplexing", IEEE *JLT* Vol. 38, n. 19, 2020

[4] D.F. Paredes-Paliz, "Radio over Fiber: An Alternative Broadband Network Technology for …", *Electronics*, Vol. 9, n. 11, 2020

[5] T. Umezawa, "Radio Over FSO Communication Using High Optical Alignment Robustness 2D-PDA and its Optical Path Switching Performance", *IEEE JLT* Vol. 39, n. 16, 2021

[6] A. Malacarne, et al., "Coherent Dual-Band Radar-Over-Fiber Network With VCSEL-Based Signal Distribution", *IEEE JLT* Vol. 38, n. 22, 2020