

What 6G requires from microwave photonics?



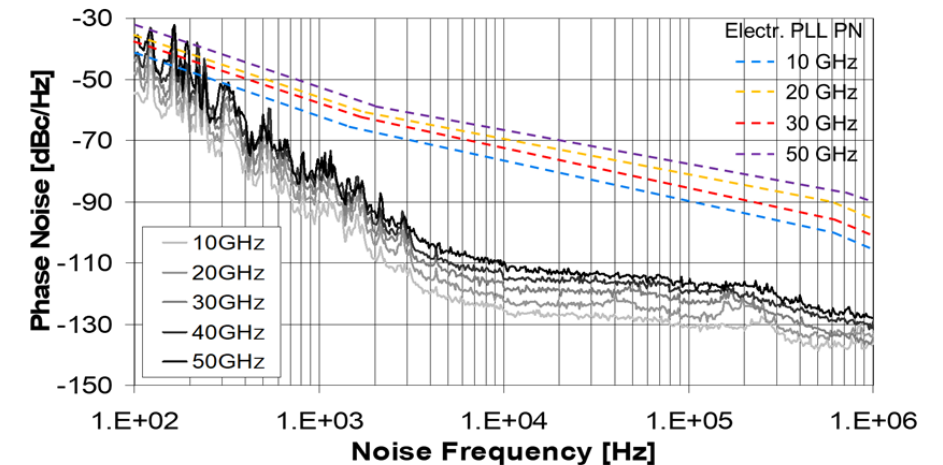
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Microwave photonics applications in radio systems



- Radio over Fiber
 - Decreasing power consumption, size and weight of the antenna unit
- Optical Beamforming
 - Low phase noise, squint free beamforming up to high frequencies, including mmW and THz
- Optical generation and distribution of frequency references
 - Low phase noise, accurate tunable frequency references over a wide frequency range

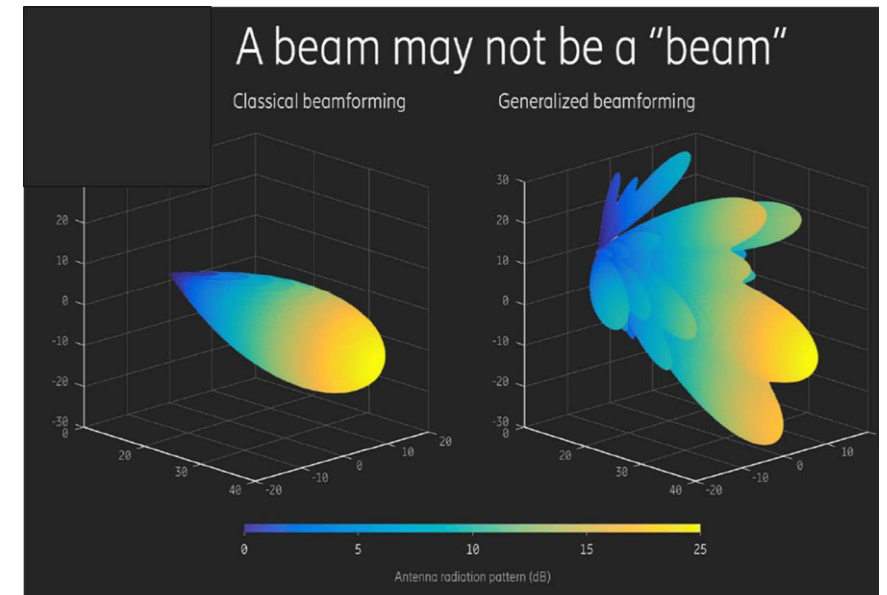
Optical: -130 dBc/Hz with 1MHz offset at 30 GHz
Electrical: -100 dBc/Hz with 1MHz offset at 30 GHz



Issues



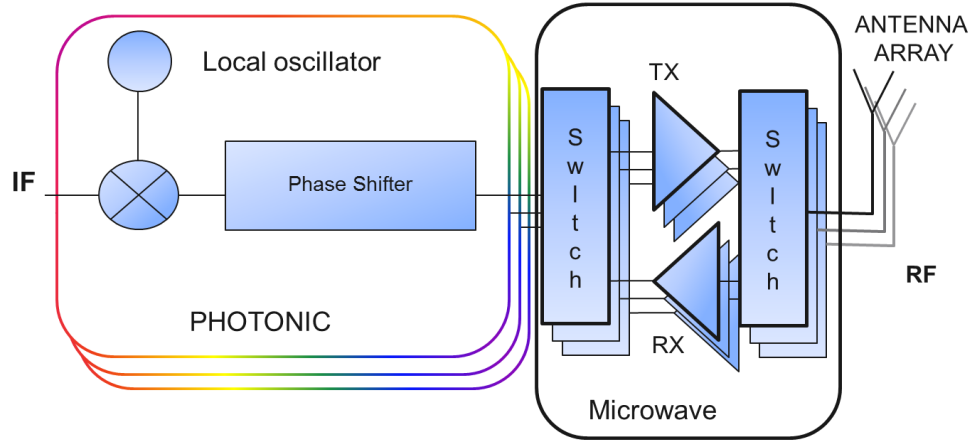
- Radio over Fiber
 - Poor dynamic range, not suitable for macro cells
 - No standard technique for signal multiplexing, switching, protection and QoS monitoring.
- Optical Beamforming
 - Only phase-shift is performed, it lacks the flexibility of digital beamforming (e.g. for multi-user)
 - Needs integrated and cost-effective optical systems-on-chips.
- Optical generation and distribution of frequency references
 - High insertion loss of the passive optical distribution circuit
 - Needs integrated and cost-effective optical systems-on-chips.



An example of optical beamforming

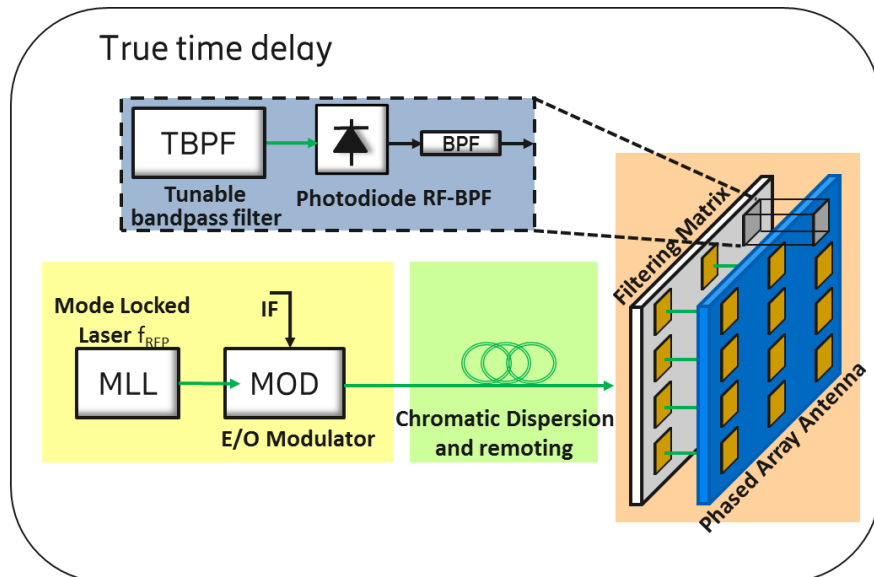


Phase shift



- Opto-BF building blocks:
 - tunable phase-shifter/TTD elements
 - Optical tunable band-pass filters
 - Photo-detectors
 - Splitters/combiners

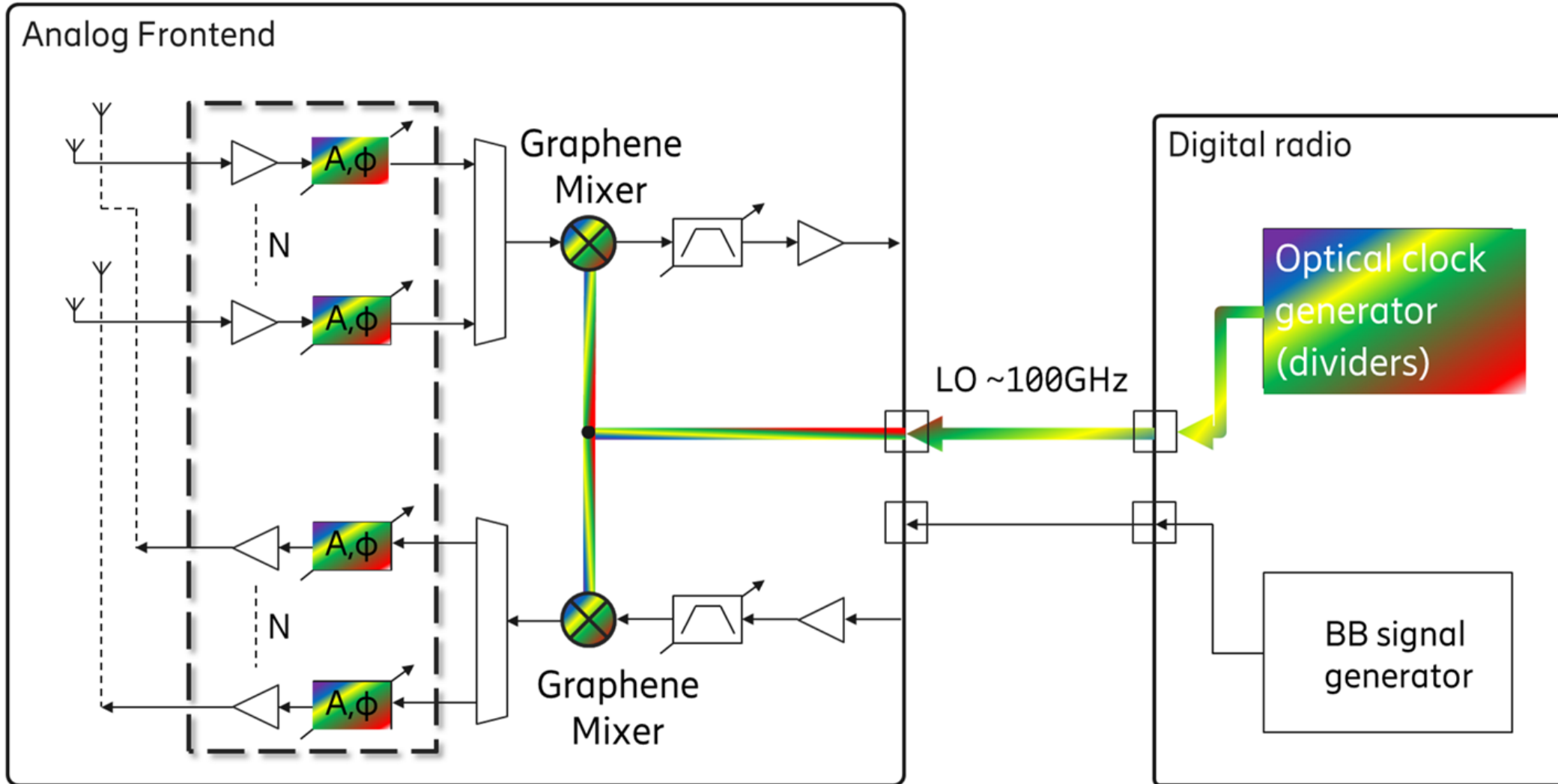
True time delay



- IN principle, photonic integration enables size and weight compatible with arrayed antennas at low power consumption but ...
- ... cost and yield?

G.Serafino et al., a Beam-Forming Network for 5G Systems Based on Precise Optical Clock and Phase Shifting, 20th International Conference on Optical Network Design and Modeling (ONDM 2016), May 9-12, 2016, Cartagena, Spain

An example of frequency reference distribution



Challenges



- The application area of RoF in mobile network still need to be identified, and the performance adjsuted accordingly (small-cell? FWA?)
- Integrated photonics has a high potential but also unsolved issues (insertion loss, cost effective III-V Silicon Integration, lack of a strong ecosystem,...)
- How can optical beamforming be cost-effectively integrated with digital beamforming to provide more flexibility?

