TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Electrical and Computer Engineering, Communications Laboratory, Chair for RF and Photonics Engineering

Tabasco - Talbot effect based carrier generation with phase noise suppression

Part of the Priority Programme "Electronic-Photonic Integrated Systems for Ultrafast Signal Processing" (SPP 2111)

Z. al-Husseini, N. Neumann, D. Plettemeier

Motivation

Millimeter wave carrier generation

- Basis for the expansion of existing frequency bands to millimeter wave
- Numerous applications:
  radar, wireless communication systems, hybrid opto-electrical systems

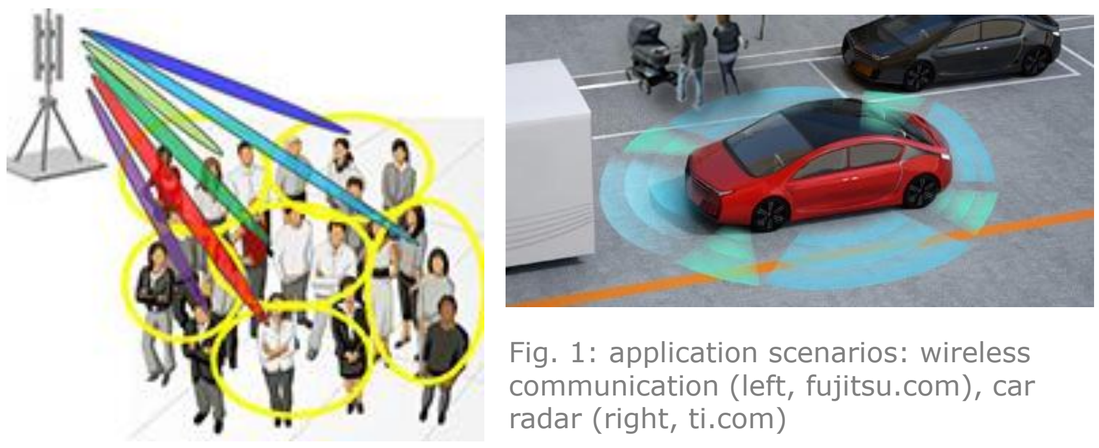

Fig. 1: application scenarios: wireless communication (left, fujitsu.com), car radar (right, ti.com)

Requirements and challenges

- Compact size, cost-effective production, reliability → on-chip realization
- Low phase noise
- Upconversion based millimeter wave carrier generation implies intrinsic phase noise increase $PN_{increase} = 20\log_{10} m$

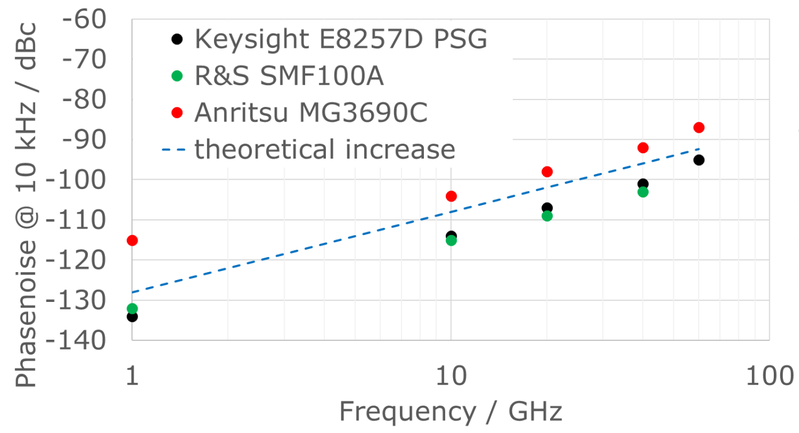

Fig. 2: phase noise depending on frequency, data from state-of-the-art frequency generators

→ new approaches needed for millimeter wave generation with low phase noise

Proposed approach

Temporal Talbot effect based RF upconversion

- Frequency upconversion by constructive superposition of m[th] line in optical comb at the detector
- Upconversion scheme and phase noise suppression have been shown ***but***

- Existing solutions rely on fiber optics → bulky, stability issues

→ electronic-photonic integrated solution needed

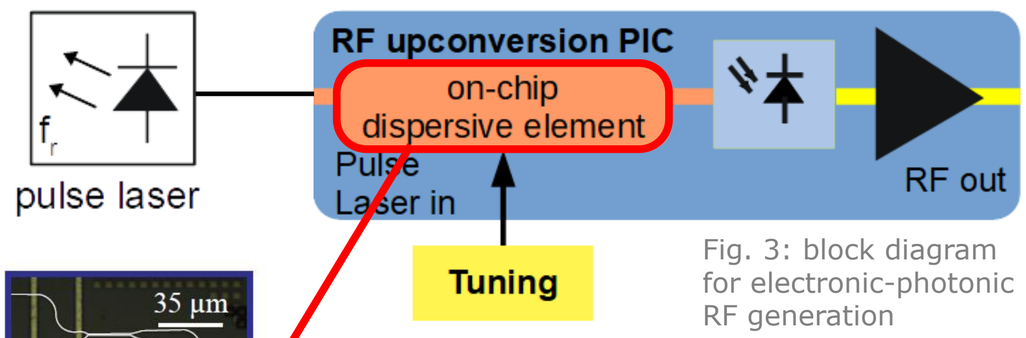

Fig. 3: block diagram for electronic-photonic RF generation

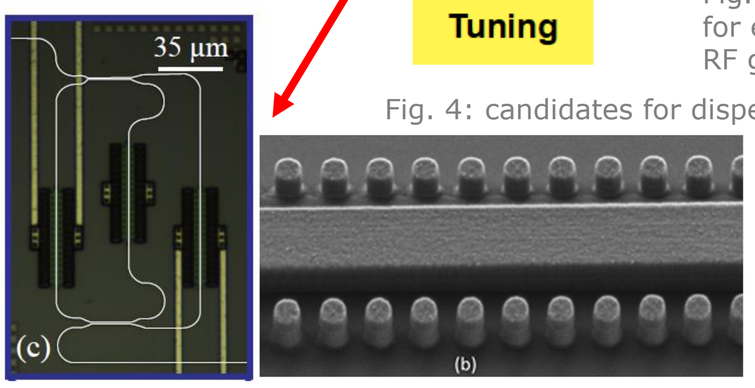

Fig. 4: candidates for dispersive element: grating based (left), cascaded ring resonator (right)

Sahin, E., et al. "Large, scalable dispersion engineering using cladding-modulated Bragg gratings on a silicon chip." Applied Physics Letters 110.16 (2017): 161113.

[Notaros, Jelena, et al. "Programmable dispersion on a photonic integrated circuit for classical and quantum applications." Optics Express 25.18 (2017): 21275-21285.]

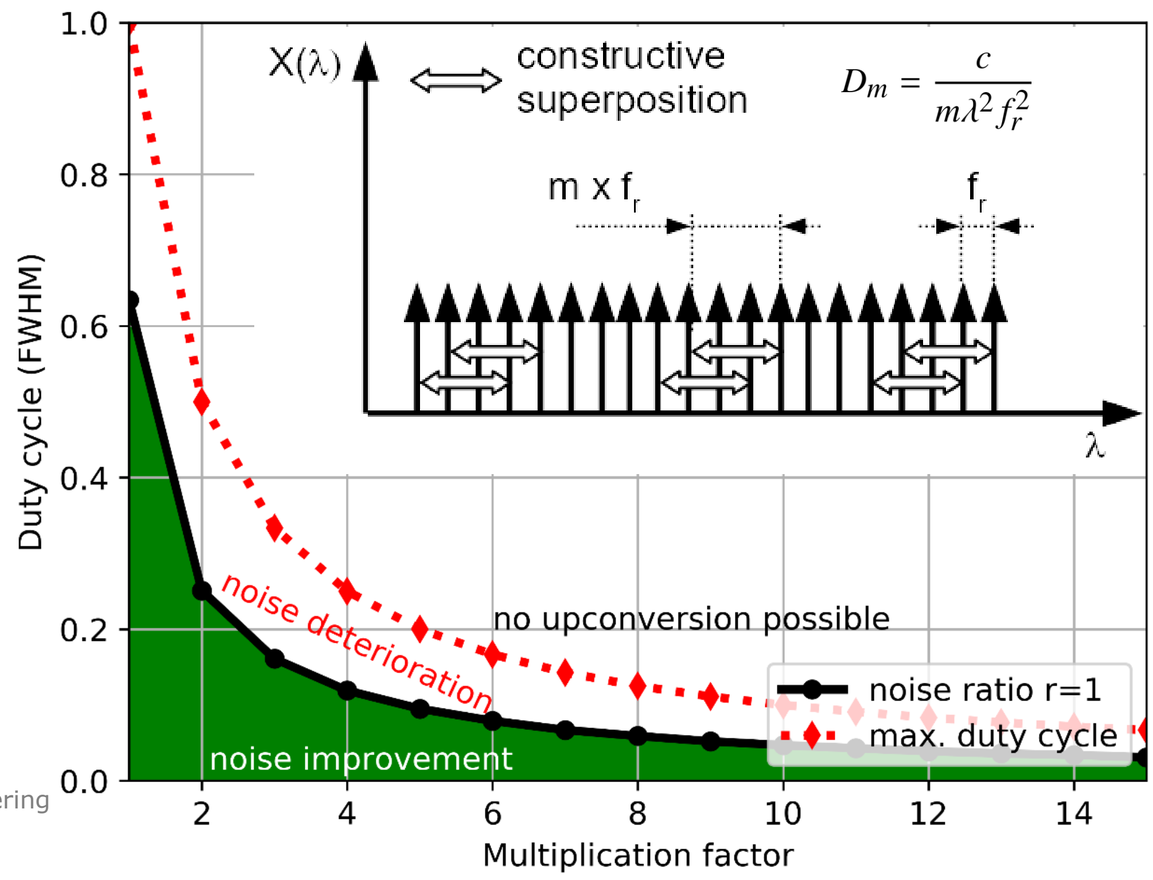

Fig. 5: Talbot effect based RF generation: principle (inset), phase noise dependency on multiplication factor and duty cycle (i.e. temporal pulse width / spectral comb width)

Laser pulse width	50 fs (fixed due to existing laser source)
Laser repetition rate	100 MHz (fixed due to existing laser source)
Output frequency	30 … >100 GHz (limited by opto-electrical conversion)
Upconversion factor	300 … 1000 (with existing laser source)
Required dispersion	12500 … 42000 ps/nm (with laser pulse width, repetition rate and upconversion factor of existing source)

Tab. 1: Preliminary system parameters of Talbot effect based RF upconversion

Advantages and challenges

- ***Power efficient:*** whole spectrum is used (in contrast to filtering approaches
- ***Phase noise suppression:*** averaging effect due to different spectral contributions
- ***Flexible:*** dispersive element selects upconversion factor
- ***Broad spectrum / narrow pulses*** for noise improvement (may be shared)
- ***Tunable dispersive element integrated*** with O/E conversion

Novelty and future extensions

- 1[st] time on-chip realization of Talbot effect based RF generation with co-integration of opto-electrical conversion in EPIC technology will pave the way for practical use of this approach
- Further integration as option for phase 2
  - Electronic functionality (e.g. hybrid upconversion with low phase noise optical 1[st] stage and integrated electronic 2[nd] stage, power amplifiers, …)
  - Integrated pulse laser source for more compact device

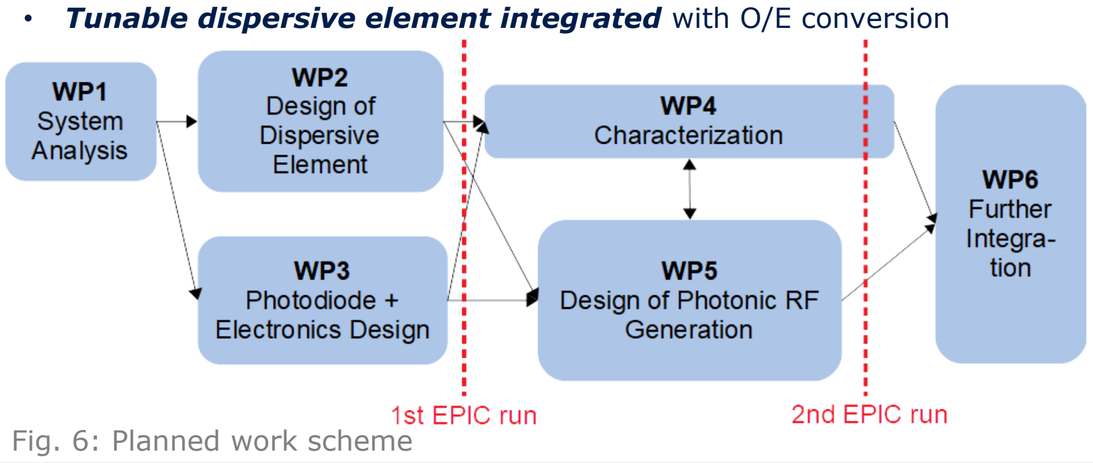

Fig. 6: Planned work scheme

FAKULTÄT ELEKTROTECHNIK UND INFORMATIONSTECHNIK

Gefördert durch DFG Deutsche Forschungsgemeinschaft