Optoelectronic Oscillator incorporating a Microwave Photonic Filter

Liana Paolino
Dr. Xiaoke Yi
School of Electrical and Information Engineering
FACULTY OF ENGINEERING & INFORMATION TECHNOLOGIES

An optoelectronic oscillator (OEO) is a hybrid oscillator that uses photonic and electrical components to generate low noise and high frequency oscillations.

1. Motivation

Increasing market demand for high frequency oscillators to:

- Extend the capacity and speed of next-generation radar and communication systems.
- Overcome performance deficiencies of prevailing electrical oscillators at high frequencies.

2. Project Aims

To develop a novel OEO that employs an optical filter to generate oscillations with:

- Low noise
- High spectral purity
- Fine tunability
- High frequency and wideband operation

3. Design Principle

The OEO design utilises a microwave photonic filter (MPF) as a frequency selective element in the oscillator feedback loop.

- Multiple discrete modes are sustained at frequencies where the total phase change along the circulating path *L* is a multiple of 2π.
- The single passband MPF isolates one discrete mode to realise single-tone oscillation at the filter centre frequency.
- An amplifier provides gain compensation.
- Continuous tunability of the OEO is achieved by adjusting the filter centre frequency to capture different modes.

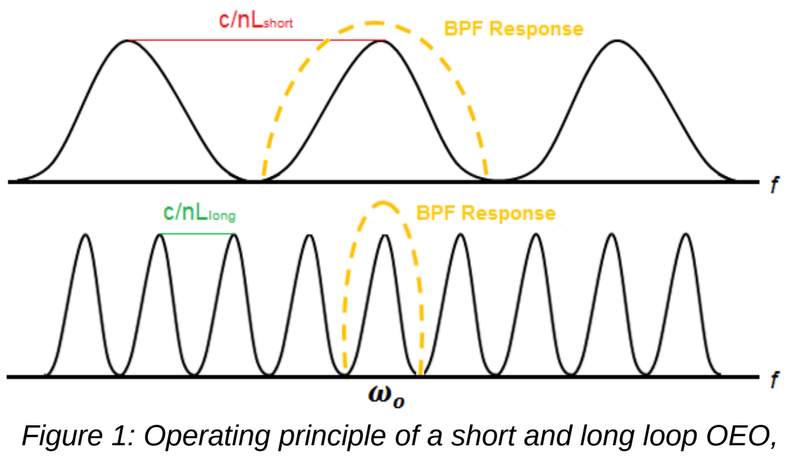

Figure 1: Operating principle of a short and long loop OEO, showing the BPF requirement for single-mode oscillation.

4. Oscillator Schematic

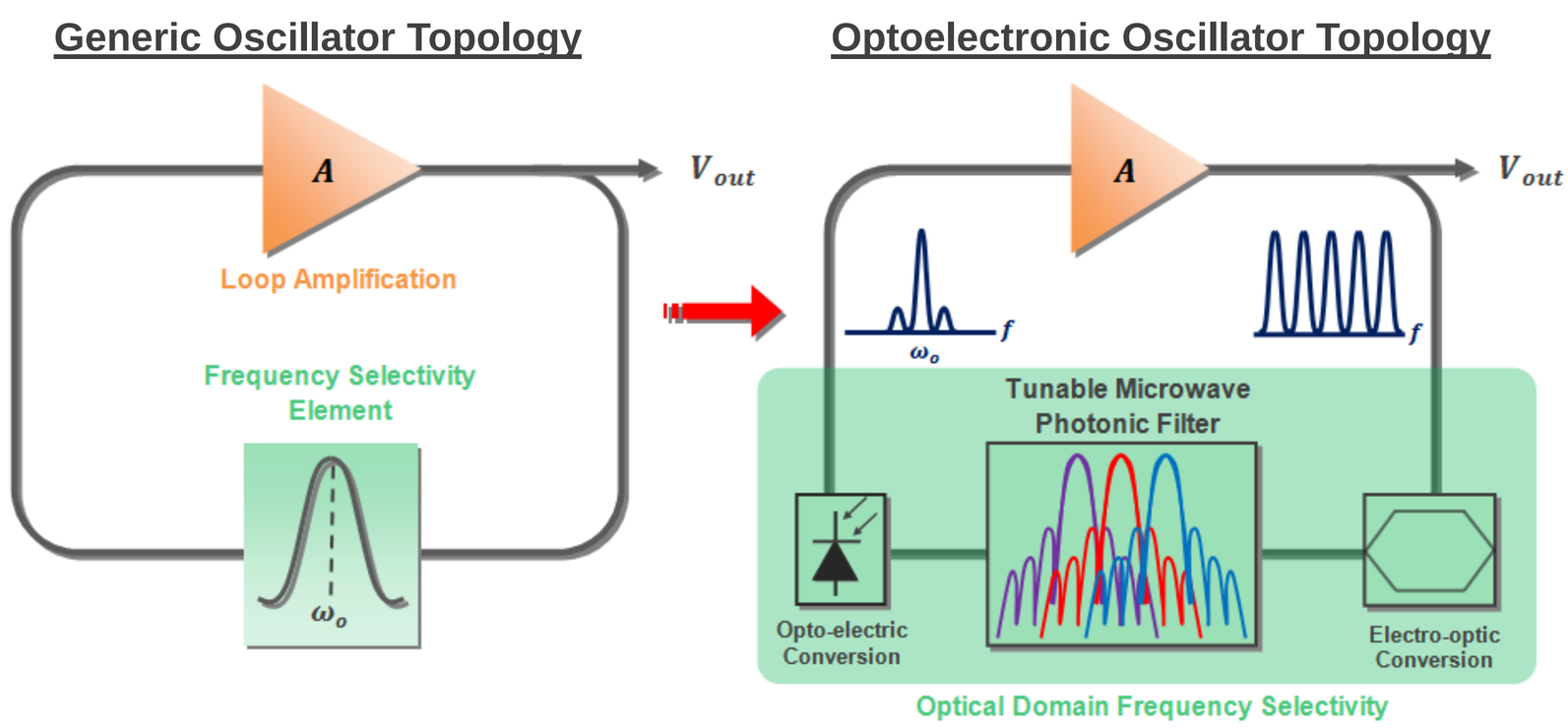

Figure 2: Schematic diagram of a generic oscillator and the optoelectronic oscillator design.

5. Experimental Results

- The initial filter design [1] with a 3-dB bandwidth of 94 MHz provided oscillations in the range of 0-3 GHz.
- An alternative wideband filter [2] enabled high-frequency oscillations within the range of 0 to14 GHz for a filter 3-dB bandwidth of 0.18 GHz.

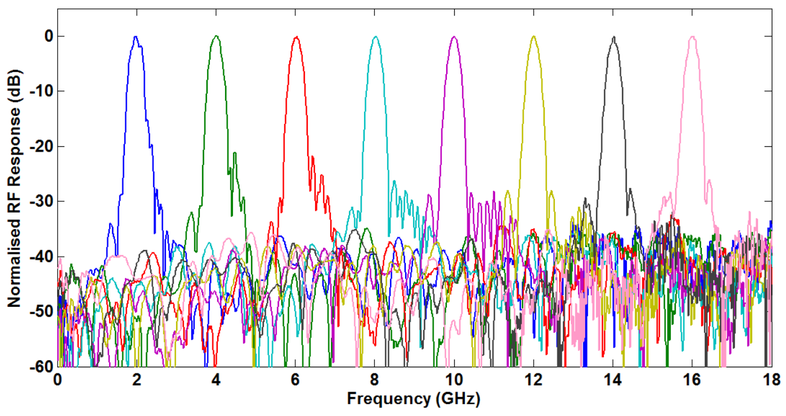

Figure 3: Tuned RF responses of the microwave photonic filter [2].

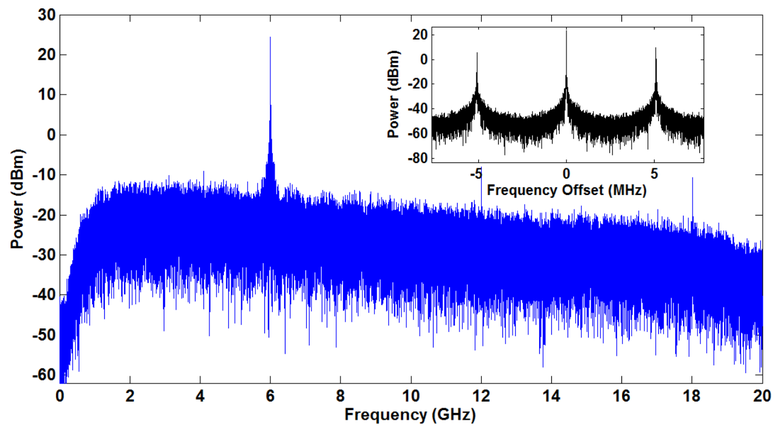

Figure 4: Measured spectrum of a 6 GHz oscillation, with a zoom-in view of the fundamental mode inset.

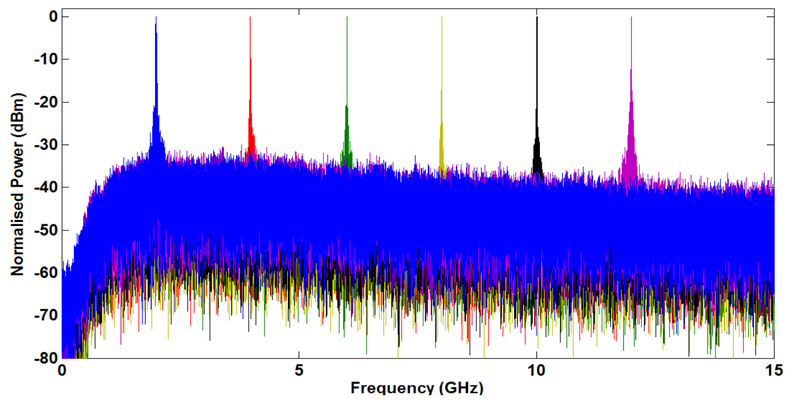

Figure 5: Normalised OEO spectra tuned over a frequency range of 0 to 14

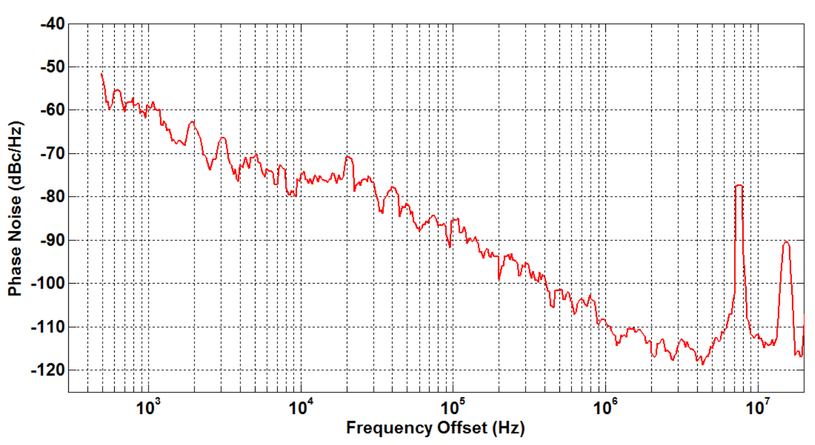

Figure 6: Phase noise response of the OEO signal.

- The OEO phase noise plot exhibits a noise floor of -118 dBc/Hz at a 4 MHz offset.

6. Conclusion

Integration of a single passband MPF in the OEO feedback loop as a frequency selective element produced continuously tunable oscillations up to 14 GHz.

7. Applications

- Wireline and Wireless Communications
- Medical Imaging and Diagnostics
- Defence Systems
- Radar Technology
- High-Precision Clock Signals
- Testing Instruments
- High-Speed Microprocessors
- Radio Astronomy

8. References and Related Papers

[1] T. X. H. Huang, X. Yi, and R. A. Minasian, "Single passband microwave photonic filter using continuous-time impulse response," *Opt. Express,* vol. 19, pp. 6231-6242, 2011.

[2] L. Li, X. Yi, T. X. H. Huang, and R. A. Minasian, "Shifted dispersion-induced radio-frequency fading in microwave photonic filters using a dual-input Mach Zehnder electro-optic modulator," Opt. Lett., vol. 38, pp. 1164-1166, 2013.