

# Modelling Tunable Integrated Optoelectronic Oscillators

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**Main Topic:** Photonics for free space, 5G and microwave applications

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**ABSTRACT:** Optoelectronic oscillators (OEO) have been widely investigated demonstrating ultra-low phase noise and high frequency microwave (MW) signal generation compared to electronic counterparts. OEOs make use of high Q-factor optical energy storage elements such as low-loss optical fiber or optical resonators (Fabry–Pérot resonator, whispering gallery-mode resonator, or micro-ring resonators (MRR) to generate RF/MW signals with high spectral purity. Recently, wideband tunable and compact integrated OEOs have been the focus of research targeting reduction in the size and improved stability. Frequency tunability is a desired characteristic of oscillators for several applications such as instrumentation, adaptive radars, communication transceivers and phase locked loops. Since OEOs are feedback systems, their modelling is complex as it requires concurrent simulation of electronic and photonic components in the loop. Both steady state analytical (Yao-Maleki) and dynamic (Levy) numerical models have been proposed to describe operation of standard OEOs employing optical fiber and electrical filters [1]. These models must be tailored for each scheme under investigation to include behavioural dynamics and characteristics of photonic components (e.g., optical filters) to clearly understand the impact on performance of scheme while ensuring that all the mathematical assumptions remain valid. Alternatively, computer aided numerical simulations using commercial software like VPI Photonics™ can be employed [2]. These tools have several advantages such as repository of electronic & photonics device models, frequency and time domain simulations and analysis, and co-simulation. The drawback is the trade-off between computational complexity and accuracy of phase noise results (Fig.1(d)). In this work, we have extended the model in [2] to investigate the behaviour of widely tunable hybrid integrated OEO employing Si<sub>3</sub>N<sub>4</sub> MRR as notch filter by including practical device parameters & constraints and considerations of integration platforms. The scheme and salient results are summarized in Fig.1.

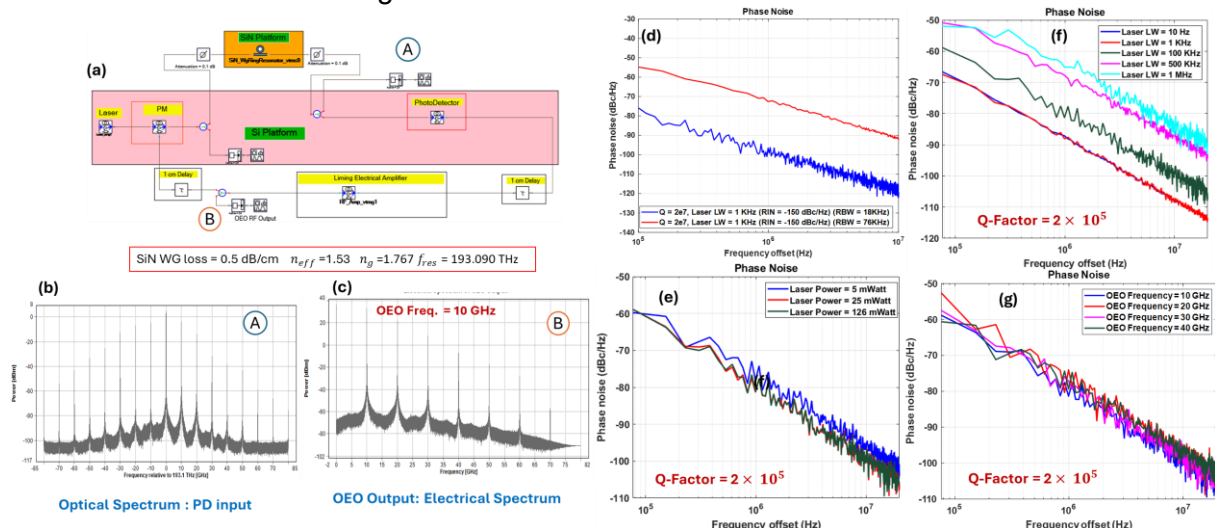


Figure 1. (a) Snapshot of OEO simulation model. (b & c) Optical and electrical spectra. (d) Impact of resolution bandwidth (RBW) on results accuracy. (e, f, g) Impact of laser power, linewidth (LW) and frequency tunability on phase noise performance of OEO, (RBW = 76 kHz).

## References

[1] Levy et al. (2009), 'Modeling optoelectronic oscillators', JOSAB, vol.26, pp. 148–159.

[2] Belkin, M.E., et al. (2011), Tunable RF-band optoelectronic oscillator and optoelectronic computer-aided design model for its simulation. Microw. Opt. Technol. Lett., 53: 2474-2477.