A STOCHASTIC MODEL FOR OPTOELECTRONIC RADAR FREQUENCY GENERATORS

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Radars are commonly divided into two categories: *pulsed radars*, which can determine the distance of a target with the delay-time of a microwave pulse's echo; and *continuous wave radars*, which are rather suitable for the evaluation of velocities, as they measure Doppler shifts induced by moving targets. However, very accurate measure of these Doppler shifts is possible only when the emitted microwave is very pure, that is, almost free of phase noise. Electronic circuitry generally fails in providing such ultra-pure microwaves.

An interesting alternative to reduce phase noise is the generation of ultra-pure radio-frequencies with opto-electronic oscillators (OEOs). Beyond the scope of continuous-wave radars, OEOs can generate ultra-pure microwaves for many other applications, ranging from satellite telecommunication systems to ultra-low jitter clocks. In their simplest architecture, they are built with a Mach-Zehnder modulator fed by a continuous-wave semiconductor laser, and subjected to an opto-electronic feedback loop consisting in a thermally stabilized fiber delay-line. To close the feedback loop, the optical output of the fiber is converted into an electrical signal by a photodiode, and applied to the Mack-Zehnder electrode after amplification and filtering.
We propose the following model to investigate the behavior of OEOs

$$\dot{\mathcal{A}} = -\mu\mathcal{A} - 2\mu\gamma[1+\xi_m(t)]e^{-i\Omega_0 T}\cdot \mathrm{Jc}_1[2|\mathcal{A}_T|]\mathcal{A}_T + \xi_a(t)$$

where μ is the half-bandwidth of the filter, Ω_0 is its central frequency, γ is the gain of the feedback loop, T is the delay time and Jc_1 stands for the Bessel-cardinal function. The variable $\mathcal{A}(t)$ is the complex amplitude of the microwave envelope, while $\xi_a(t)$ and $\xi_m(t)$ are gaussian white-noise contributions, responsible for the phase noise. Our aim is to demonstrate that this model correctly explains the various deterministic and stochastic aspects of the OEOs' dynamics. Analytical predictions are confirmed by numerical simulations and experimental measurements.