The Beams and Applications Seminar Series

Phase noise and frequency stability in oscillators

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Host: A. Nassiri / T. Berenc, ASD

An oscillator is a loop in which a resonator sets the oscillation frequency and an amplifier compensates for resonator power loss. The amplifier also sets the amplitude through gain saturation. When phase noise is introduced, the oscillator converts it to frequency noise, hence the oscillator phase fluctuation diverges in the long run. This phenomenon is referred to as the “Leeson effect”.

We first explain the phase-to-frequency conversion mechanism as a property of feedback, followed by the relationships between the noise of the internal components (sustaining amplifier, resonator, etc.) and the oscillator phase noise.

Next, we discuss the analysis of the phase noise spectra found in the datasheet of commercial oscillators. The analysis provides information on the most relevant design parameters, like the quality factor Q and the driving power of the resonator, and the flicker noise of the sustaining amplifier.

Finally, we show the derivation of the phase noise formulae from elementary properties of the resonator. The amplitude stabilization mechanism stretches the resonator time constant. The approach is general, and applies to quartz, RLC, microwave cavity, delay-line, laser, etc.

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