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Abstract:

Since the initial works of van der Ziel, Low Frequency noise (LF noise) has been used to characterize many semiconductors devices. LF noise spectroscopy is a non destructive characterization technique. LF noise analysis is based on the measurement of current or voltage fluctuations around an average value (biasing point). Experimentally, the current or voltage spectral density in a device is measured by a spectrum analyzer. Then, spectral analysis consists in its decomposition into elementary noise components: 1/f noise (1/f shape, related to the fluctuation of the conductivity), Generation-Recombination (G-R) noise (lorentzian shape, associated to trapping-detrapping process) or Random Telegraph Signal (also a lorentzian shape, but in the time domain discrete fluctuations can be observed related to single trap). These two kinds of LF noise components are often called "excess noise" compared to the background noise which is independent of the frequency (white noise): thermal noise/Johnson noise or shot noise.

LF noise measurement requires very good experimental skills in low noise instrumentation : grounding and shielding techniques, low noise amplification, this is critical in minimizing the effects of experimental and environmental noise sources on the device under test (DUT) LF noise measurement is relatively delicate to implement and before performing noise measurement, a calibration procedure is required.

The aim of this tutorial is to present the LF noise measurement technique:

- as a tool to investigate defects in advanced electronic materials and devices.

Due to its sensibility to defects, traps or generation-recombination centers, LF noise is proposed as a good tool to predict the reliability of devices, and to probe the growth processes that produce better quality films with less defects. As it is a non destructive technique, LF noise spectroscopy can be used as a characterization tool for many different devices allowing to an analysis from bulk materials (and associated contact technology) to complex advanced transistors.

- as an important parameter for the design of integrated circuits.

Additionally to the well known High Frequency noise parameters such as Noise Factor, due to up-conversion phenomena, LF noise can impact the behaviour of circuits. In particular, to provide an accurate model of phase noise for non-linear circuits (VCO, mixer, Low Noise Amplifier, ...), it is necessary to provide a compact model of the LF noise excess noise sources (1/f noise component and in a lesser extend GR noise component).