Phase noise & digital noise: what is it and why it is important for groundbreaking RF-applications.

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Abstract

For more than a decade, digital electronics has a massive impact on about every research field offering flexibility, robustness and reconfigurability.

1 Introduction

Numerous developments of complex scientific instrumentation now employ routinely partial or fully digital systems, inherited from telecommunications and Software Defined Radio (SDR).

Within the framework of Time & Frequency metrology, it has become challenging in the development of modern sensitive instrumentation where quantization noise and signal noise paths take a significant place for qualifying ultrastable clocks, oscillators, frequency transfer and timing systems.

From Amateur Radio to VLBI (Very-long-baseline interferometry), DSN (Deep Space Networks), LIGO(Laser Interferometer Gravitational-Wave Observatory)[1], Evolved LISA(Laser Interferometer Space Antenna)[2], ACES (Atomic Clock Ensemble in Space), . . . , it is worth to note that some knowledge on instrumentation limitations and their proper characterization is of importance.

Unfortunately there is a lack on handy design tools and techniques for complex designs leading to high computational efforts in programming and prototyping that are ultimately greatly error prone.

Although a few of valuable libraries and software do exist (GNURadio[3], Spiral[4], liquidsdr[5]. . .), they are currently not adapted to oscillator metrology modeling (parametric noise simulations, variances, normalized spectra . . .).

Along the journey, I propose to present different techniques and pitfalls in the measurement and qualification of the digital signal processing chain kernel (Signal→ADC→DDC) commonly used in every SDR environment[6, 7].

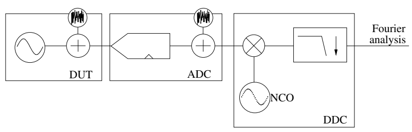

Figure 1: Elementary digital processing chain for oscillator metrology

I will also show how it is currently difficult to perform such characterizations within the GNU Radio context.

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