

# Evaluation of an affordable open source phase noise analyzer

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Phase noise, stemming from random phase fluctuations in a signal, is typically attributed to diverse factors such as electronic components, thermal noise, and environmental conditions. The accurate measurement and comprehensive characterization of phase noise play a pivotal role in assessing the stability of ultra-low phase noise oscillators. While very expensive industrial phase noise analyzers excel in precisely measuring the phase noise of such oscillators, the availability of an easily deployable open-source phase noise analyzer remains a gap. This paper aims to assess the performance of the open-source Direct Digital Phase Noise Measurement Bench<sup>1</sup> developed by A. Holme. A comparison between A. Holme's Direct Digital Phase Noise Measurement Bench and Microship's 53100A Phase Noise Test Set is given. The performance of the A. Holme open-source analyzer aligns closely with that of the 53100A, except in the measurement of ultra-low phase noise oscillators, where it reaches a limit of -135 dBc/Hz at a 1 Hz Fourier frequency.

To compare the two analyzers, a series of Power Spectral Density (PSD) measurements were conducted concurrently on both the A. Holme analyzer and the 53100A, ensuring identical measurement conditions. Following this, a series of noise floor was undertaken on both analyzers to highlight their differences. For the experiments, various sources were selected to serve either as the Device Under Test (DUT) or as the reference. It is imperative that all chosen sources have frequencies falling within the operational frequency range of both analyzers. The A. Holme analyzer utilizes the DC1525A ADC board, enabling a working capacity of up to 125 Msps. Consequently, the A. Holme analyzer can effectively measure the phase noise of oscillators up to 62.5 MHz (Shannon limit is  $125/2 = 62.5$  MHz). On the other hand, the 53100A can measure oscillators up to 200 MHz. However, both analyzers are unable to measure phase noise below 1 MHz. Therefore, the selected sources must have frequencies within the [1 MHz, 62.5 MHz] range.

For the purposes of this paper, measurements were conducted with different level noise sources such as two HSO14 Rakon 5 MHz quartz oscillators, two USO 10 MHz quartz oscillators Lab made, and two synthesizers from Rohde & Schwarz: SML01 and SMA100.

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<sup>1</sup> A.Holme, "Direct digital phase noise measurement", <http://www.aholme.co.uk/PhaseNoise/Main.htm> , 2023.