PN2060C Phase Noise Analyzer

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Summary

The PN2060C Phase Noise Analyzer measures the amplitude, phase noise of high-performance RF sources.

Features

Independent input and reference frequencies from 1 to 200MHz
No phase-locking or measurement calibration required
Dual reference oscillator inputs allow cross-correlation measurements
Measurement results are saved to file automatically
Scripts are provided for post-data manipulation, raw data (full 4 channels baseband, 32Mbytes/S) can be exported for further analysis
USB3.0 interface with high-speed data exchange
Allan deviation: two channel cross-correlation supported

Measurements

Phase noise at offsets from 0.01Hz to 1MHz and levels typically below -185dBc/Hz (10MHz floor)
One high quality USB3.0 cable is enough to complete data collection and power supply

System Noise Floor Specification:

Offset	10MHz carrier (90minutes)
1Hz	-130
10Hz	-150
100Hz	-165
1KHz	-175
10KHz	-180
>100KHz	-180

Electrical Specifications: Input Signal Level: 10dBm (max), Input Impedance: 50

Mechanical Specifications

Size: 11 x 10 x 4 (cm), Power: USB3.0 power supply with about 1.3A. Operating Temperature: 0-30deg

Unit Weight: 0.5kg.

Front Panel: SMA RF connector (DUT1, DUT2, REF1, REF2)

Real Panel: Type-C (USB3.0 to Type-C cable needed)

Software: 1) WIN7/WIN10/WIN11 64bit supported (test setup, real-time update of phase noise, and collect raw data), scripts for post-process.

Driver: USB3.0 interface

1. Software and driver installation

1) PN2060, complete test setup and real time data process.
2) Matlab script: post-data process, data smooth, spur removal, marker, etc., and raw data analysis.

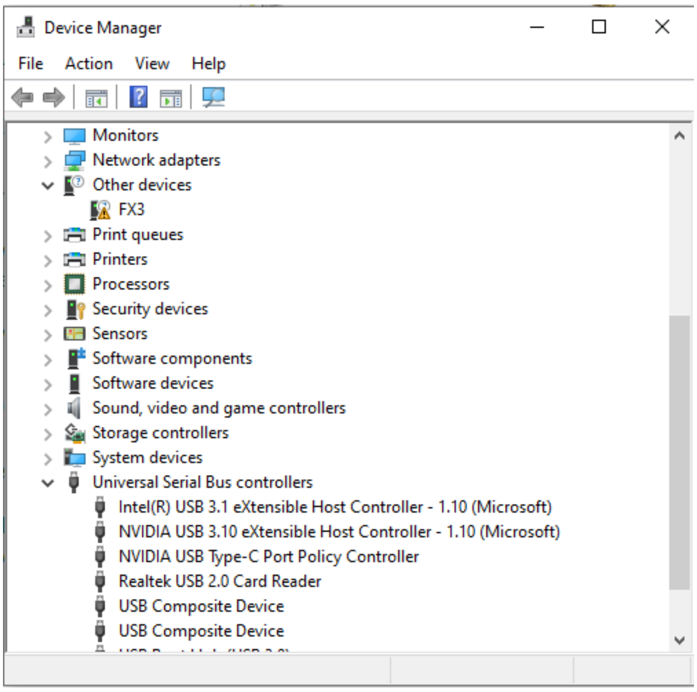
1.1 system support

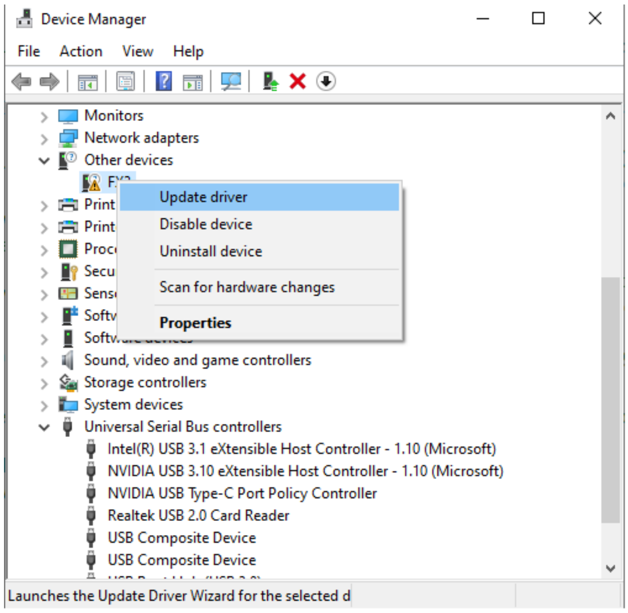
win7/win10/win11 64bit systems are supported. USB3.0 port is necessary in PC/laptop (not work with type-C)

The preferred PC configuration: 1)CPU >= i5 11gen; 2) RAM >=8G; 3) Solid-state-driver; 4) B760M mainboard. Old PC (over 5 years) is not recommended.

1.2 Driver installation

1) Connect pn2060 to laptop, and please go to Device Manager, find “FX3”. Then step by step in the following.




Device Manager
File Action View Help
Monitors
Network adapters
Other devices
Update driver
Disable device
Uninstall device
Scan for hardware changes
Properties
Sound, video and game controllers
Storage controllers
System devices
Universal Serial Bus controllers
Intel(R) USB 3.1 eXtensible Host Controller - 1.10 (Microsoft)
NVIDIA USB 3.10 eXtensible Host Controller - 1.10 (Microsoft)
NVIDIA USB Type-C Port Policy Controller
Realtek USB 2.0 Card Reader
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USB Composite Device
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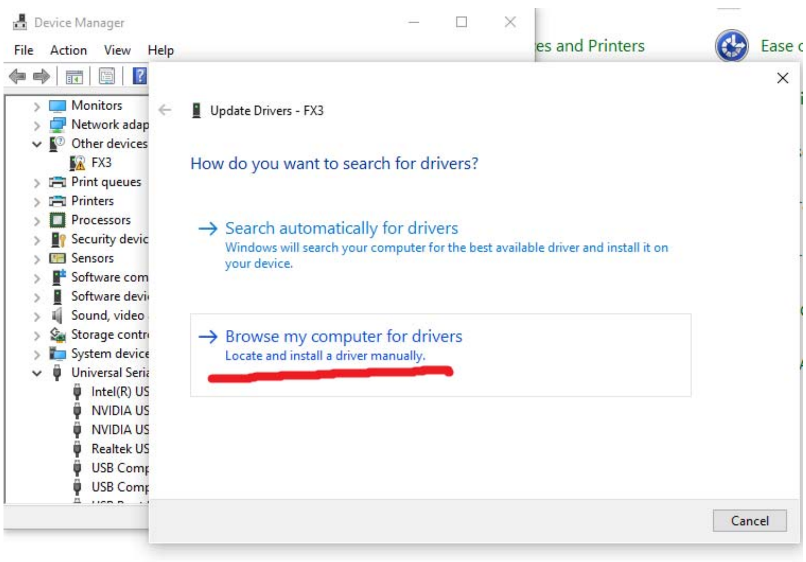
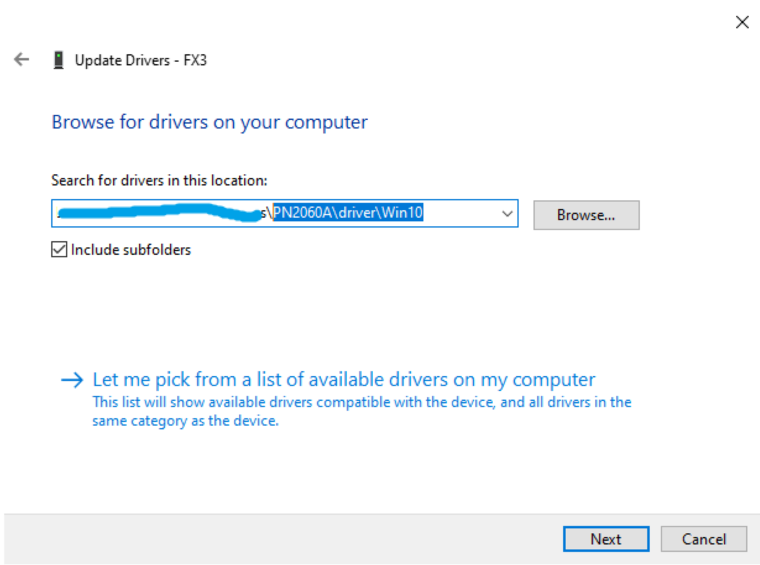
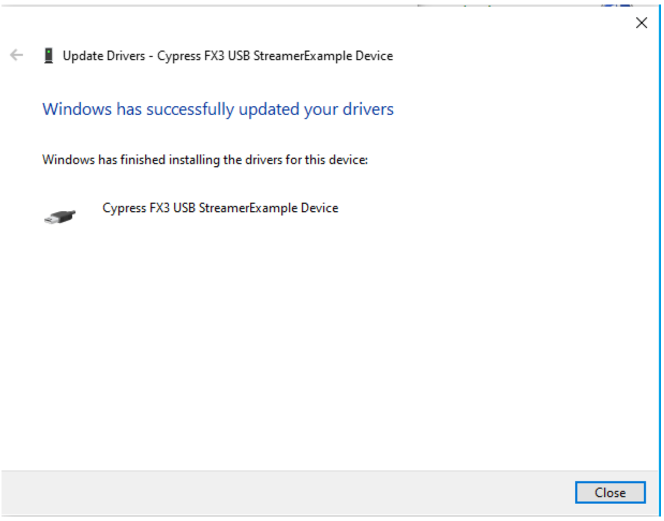
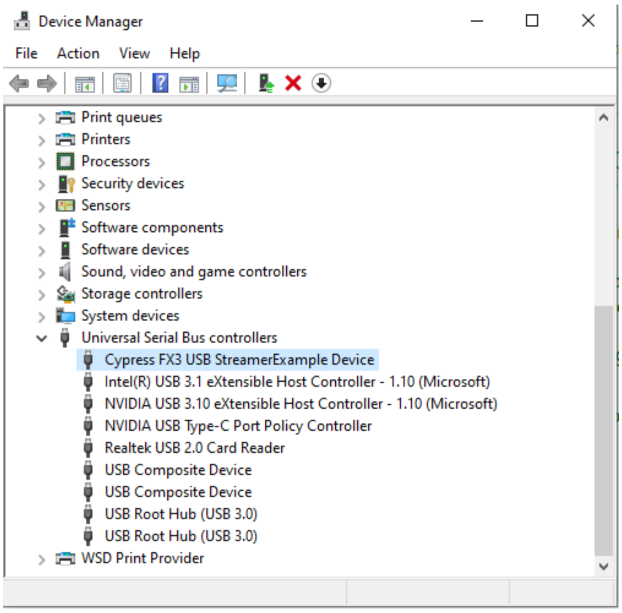

Device Manager
File Action View Help
Update Drivers - FX3
How do you want to search for drivers?
Search automatically for drivers
Windows will search your computer for the best available driver and install it on your device.
Browse my computer for drivers
Locate and install a driver manually.
Cancel


Update Drivers - FX3
Browse for drivers on your computer
Search for drivers in this location:
PN2060A\driver\Win10
Browse...
Include subfolders
Let me pick from a list of available drivers on my computer
This list will show available drivers compatible with the device, and all drivers in the same category as the device.
Next
Cancel



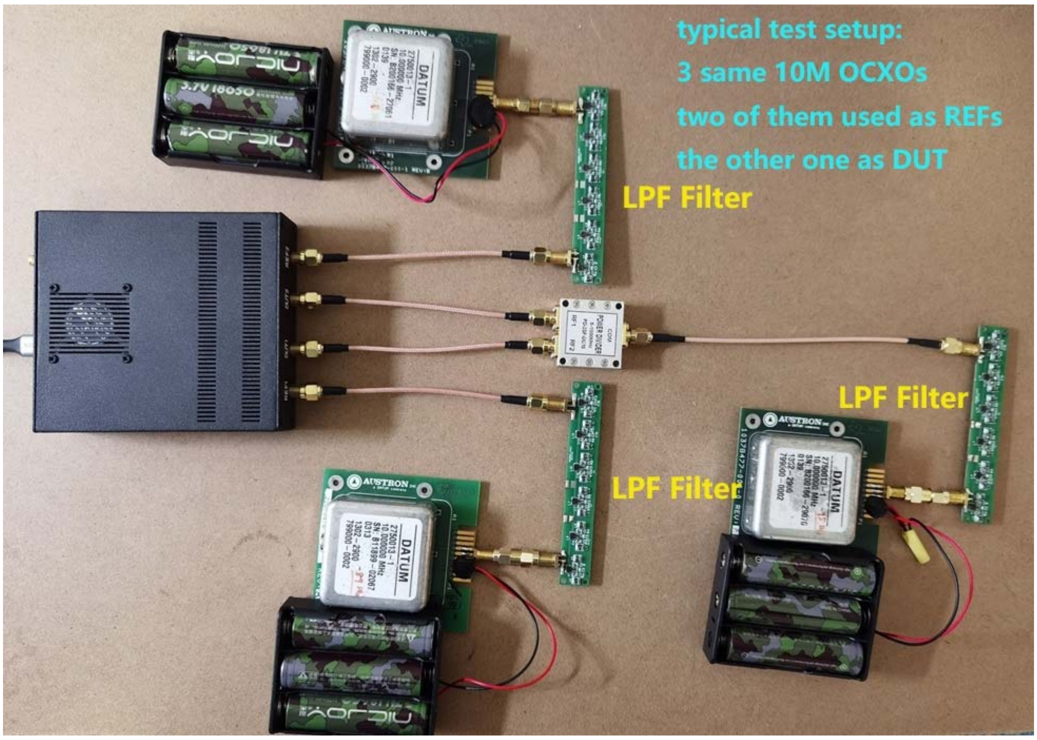


2) When the driver installation is completed, un-plug USB3.0 cable, and recycle laptop **(very important)**
3) Connect pn2060 with laptop, and try to run pn2060.exe in the SW package.
4) Install matlab (2022), and run the script “pndata_spur_remove.m”.

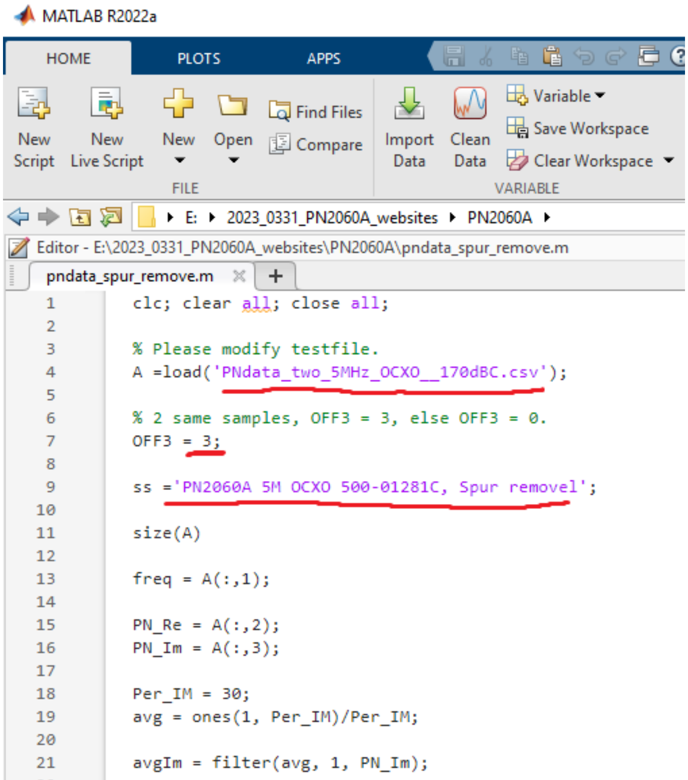
2. Test setup

2.1 Dual references are preferred

Lots of tests are performed, and the dual references setup is the best among them, please refer to the following setup before performing tests.



1) DUT should be powered with battery (or high-quality linear power supply).
2) Connect the DUT to a power splitter, and then connect them to variable attenuators or directly to DUT1 & DUT2 of the pn2060.
3) References should be connected to REF1 & REF2 respectively. The frequencies of two REFs should be nominally same (usually two 10MHz or two 100MHz).
4) The frequencies of the DUT should be less 10 times of the frequencies of the REFs. It is preferred to use high quality and high frequency references.
5) Input REF FREQ in pn2060 (Hz), and input DUT FREQ (Hz), and press “Apply” button.
6) Press “Start” button, and watch the trace (It needs about 30 minutes for the internal clock to stabilize, please wait about 30min before performing serious tests).
7) Please press “Stop” button when you are satisfied with the results, and close pn2060. Go to the directory of pn2060, and you will find a file named “pndata.csv”. The screen plots are saved in this file.
8) Modify the script, and run. Then you will obtain the final results. The script is simple, and can be easily converted to python or other formats.



3. Others Setup

1) Fast, slow: if your PC is very old, please try to use slow option, i.e., select “slow”, and press “Apply”, then re-run pn2060.exe.
2) 2048, 4096, etc. higher the FFT size, more times are needed, but with a higher frequency resolution.
3) AN noise (amplitude noise): Choose “AN” on the UI, and press “Set”. Then, close the pn2060 application and run again. Otherwise, errors may be prompted.
4) CLK IN, CLK OUT: continue developing, not supported.
5) Raw Data: check the box and press “Apply”, then “start”. Data streams (about 32Mbytes/s) will be written to your disk (solid-state-disk is necessary).
6) AllanDEV: Check the “AllanDEV” box on the UI, and press the “apply” button, then press “start”.
7) TAP(1-4): ENBW will be changed accordingly. The raw-data will be filtered with ENBW before calculation.
8) “Four Channel”: data streams of the four channels will be uploaded to PC simultaneously.
9) “Spur Removal”: instrument generated spurs will be removed (experiment only)
10) “Server”: Data stream (TCP) can be sent to other applications.
11) “Marker”: phase noise @ 1Hz, 10Hz, 100Hz, 1KHz, 10KHz, 100KHz will be displayed.

Notes:

1) Please check the USB3.0 interface carefully, it doesn’t work with a type-C interface on a laptop, doesn’t work with adapters, and doesn’t work with USB2.0 interface.

2) Please try to do a 180deg rotation of the type-C interface if encounter problems, after plug-in, wait 3-5 seconds before running the application (always check the driver in the “device manager”).

Attentions:

1)The current is about 1.1-1.5A totally, which can vary with the frequency of the system's clock. The USB3.0 of some PCs cannot provide such a high current while some of them work normally. Some USB3.0 cards can be helpful. The following types of USB3.0 cards have been fully tested and verified.

Update for some mainboards: the economical one (MSI H610 Series) cannot work properly, MSI B760M is verified and running without problems.

2) The default clock is the internal one, with a fixed frequency of 133MHz, which can help you to verify the performance quickly. When you are familiar with this device, you can try to use an external high-quality clock. Some modifications (minor) are necessary when changing the system's clock. Simulation results show that the following frequencies are "good" ones for a DUT of 10MHz: 13x.2MHz, 13x.4MHz, 13x.6MHz, 13x.8MHz, where "x" can be any value. These frequencies of the ADC clock generate little spurs when the frequency of the DUT or SYS_CLK is drifted. Then, it is easier to be removed by the algorithm.

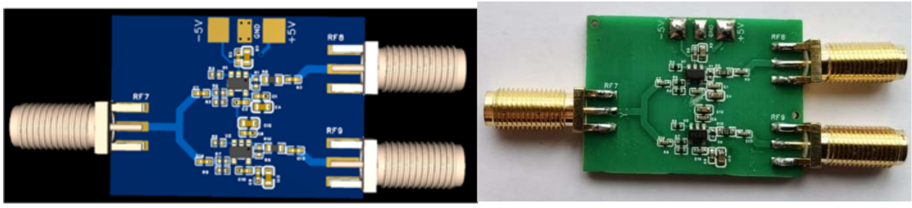
3) A fan is installed internally. It can be removed to avoid noise and potential magnetic coupling between the fan and the rf transformers (many of them onboards). As the fan is running with a speed about 6000rpm (or about 100Hz), some spurs (100Hz, 200Hz, 300Hz, 400Hz, 500Hz, and etc.) maybe visible.

4) The device should be connected to the USB3.0 interface in the back-panel of a PC, not the one in the front panel. The USB3.0 in the front panel usually has a long line connected to the motherboard with exposed connectors, where additional noises may be introduced and the noise floor may be degenerated also.

5)If the sampling frequency of the ADC is lower, the system's noise floor may tend to be raised also, especially when the frequency of the DUT is high (e.g., 100MHz). It may be the ADC's characteristics.

6)For the PN2060C V1.1, more filtering elements are added in the front-end of the ADCs. So, additional losses are induced.

7)The second-Nyquist zone and beyond: When diving into deep water area, all the phenomena reported in [1]-[3] can be encountered with different value of attenuators and with different bandwidth of filters. And aliasing may bring errors in noise floor measurements. An active power splitter is designed to perform some experiments. Test results shown that artifacts are more easily occurred with this active power-splitter.



8) Be careful of the phase difference between DUT1 & DUT2. According to [4], artifacts will be introduced with these differences. These kinds of artifacts are theoretically existed in the digital phase noise analyzer. FSWP utilizes another architecture which is trying to minimize them [5, p18].

9) Make a reliable connection between the type-C connector and the device. Always check the validity of the driver in "device manager". Try to make a 180-degree rotation if necessary.

References:

[1] Y. Gruson, A. Rus, U. L. Rohde, A. Roth, and E. Rubiola, "Artifacts and errors in cross-spectrum phase noise measurements," Metrologia, vol. 57, no. 5, pp. Art. no. 055 010 p. 1–12, Oct. 2020, open access.

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[3] Nelson CW, Hati A, Howe DA. "A collapse of the cross-spectral function in phase noise metrology". Rev Sci Instrum. 2014 Feb;85(2):024705.

[4] Nelson, C.W., Hati, A. and Howe, D.A. (2013), Phase inversion and collapse of cross-spectral function. Electron. Lett., 49: 1640-1641. https://doi.org/10.1049/el.2013.3022

[5] https://scdn.rohde-schwarz.com/ur/pws/dl_downloads/dl_application/application_notes/1ef94___/ 1EF94_1e_Pulsed_Phase_Noise_Meas.pdf

[6] MicroChip. UHF and Microwave Measurements with the 53100A Phase Noise Analyzer(AN3899).

[7] Andrew Holme. http://www.aholme.co.uk/PhaseNoise/Main.htm

[8] Drew Wollin. https://vk4zxi.blogspot.com/2023/07/an-economical-way-to-measure-phase.html

[9] IW3AUT. http://www.iw3aut.altervista.org/wordpress/?page_id=1570

[10] Grove, J. et al., "Direct-digital phase-noise measurement," Proc. of 2004 IEEE International Frequency Control Symposium, Montreal, Canada, pp. 287-291, August 2004.

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[12] https://rubiola.org

[13] https://vk4zxi.blogspot.com/2024/02/pn2060a-ghz-phase-noise-measurement.html

[14] https://scdn.rohde-schwarz.com/ur/pws/dl_downloads/dl_application/application_notes/1gp66/1GP66_4E.pdf

Acknowledgement:

I would like to thank for Andrew Holme. In the very beginning of the development of the PNA, I have learned a lot from Andrew's wonderful work [7] and also asked for some helps. In the process of my design, I have gradually developed my own codes from PN2060A to PN2060C. But still use part of Andrew's source codes in current release. Andrew has granted permission for me to use his source codes. I would thanks to Jim Henderson, Pual Hsieh, and Drew Wollin for their valuable feedbacks and discussions, where Jim Henderson implemented a mixer-based down-converter to extend the frequency range. Drew Wollin has written an introduction and review for beginners [8]. Pual Hsieh has some valuable discussions with me for potential improvement. I am also would like to thanks IW3AUT for the file converter tool which makes it compatible with other applications [9].