The phase noise measurement personality on the Agilent Technologies N8201A Option 226 performance downconverter synthetic instrument module provides advanced and comprehensive RF and microwave measurement capability. You can add the phase noise measurement personality to transform the N8201A into a one-button phase noise tester. Whether you’re in R&D or manufacturing, the N8201A Option 226 phase noise personality provides a comprehensive measurement solution to characterize the phase noise behavior of your systems and components easily, quickly, and accurately.
Phase Noise Measurements Made Easier, Faster, and More Accurate

High-purity, high-stability signals have become more important to the modern communications, aerospace, and defense industries. Phase noise is one of the most crucial measures to evaluate the short-term stability of a signal. Therefore, an accurate, fast, and easy-to-use phase noise measurement tool is critical in the R&D and manufacturing environments.

In addition to its superior combination of speed, accuracy, flexibility, and dynamic range, the N8201A offers a Phase Noise Measurement Personality - providing an ideal tool for design verification and troubleshooting, as well as production-line testing. By adding this measurement personality, you integrate a phase noise tester and a high-performance spectrum analyzer into one box.

- Expand design possibilities with powerful measurement capability and flexibility.
- Expedite troubleshooting and design verification with an intuitive user interface and numerous features.
- Streamline manufacturing with speed, reliability, and ease of use.
- Maximize yields with accurate measurements and operator independent results.

This technical overview includes
- measurement details
- demonstrations
- N8201A key specifications
- ordering information
- related literature

All demonstrations utilize the N8201A and the E4438C ESG vector signal generator. Keystrokes surrounded by [ ] indicate hard keys located on the soft front panel GUI, and key names surrounded by { } indicate menu keys located on the right edge of the display.
# Demonstration preparation

Begin by connecting the 50 Ω RF output of the ESG vector signal generator to the 50 Ω RF input of the N8201A with a 50 Ω RF cable. Turn on the power in both instruments.

Start the Agilent N8201A Option H02 Spectrum Analyzer GUI.

(Start > All Programs > Agilent SI Tools > N8201A Option H02 Spectrum Analyzer GUI.)

This exercise demonstrates how to set up the ESG to provide an RF test signal. If you do not have an ESG available, you can turn on the N8201A's internal RF reference signal (50 MHz) to run the following demonstration. Since the N8201A’s center frequency defaults to 50 MHz, you do not need to change the center frequency of the N8201A as shown in next section.

## Phase noise log plot

Log plot measures single-sideband phase noise (in dBc/Hz) versus offset frequencies expressed in logarithmic scale. This allows you to view the phase noise behavior of the signal under test across decades of offset frequencies.

- View entire phase noise behavior across a wide range of offset frequencies (10 Hz to 100 MHz).
- Simultaneously display up to seven decades of offset frequency in logarithmic scale.
- Measure phase noise with a user-specified number of averages.
- Perform trace smoothing with user-adjustable smoothing segment length.
- Utilize a suite of comprehensive N8201A marker functions.
- Search carrier frequency automatically.
- Apply multilevel video filtering.
- Make single and continuous measurements.

This exercise demonstrates the one-button phase noise log plot measurement.

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### Instructions Keystrokes

**On the ESG:**

<table>
<thead>
<tr>
<th>Product type</th>
<th>Model number</th>
<th>Required options</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESG vector signal generator</td>
<td>E4438C</td>
<td></td>
</tr>
<tr>
<td>Performance downconverter</td>
<td>N8201A</td>
<td>Option 226 – phase noise measurement personality</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instructions</th>
<th>Keystrokes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enter phase noise measurement mode.</td>
<td>[Preset] [Mode] (Phase Noise)</td>
</tr>
<tr>
<td>Set center frequency to 1 GHz.</td>
<td>[FREQUENCY] {1 GHz} and Enter from the keyboard</td>
</tr>
<tr>
<td>Activate log plot measurement.</td>
<td>[MEASURE] (Log Plot)</td>
</tr>
<tr>
<td>Observe the phase noise curve in a default setting.</td>
<td>(Meas Setup)</td>
</tr>
</tbody>
</table>

**If no source is available:**

<table>
<thead>
<tr>
<th>Instructions</th>
<th>Keystrokes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turn on the N8201A's internal 50 MHz RF reference signal.</td>
<td>[Preset] [Mode] (Phase Noise) [Input/Output]</td>
</tr>
<tr>
<td>(Input/Output) [Input Port] {Amptd Ref}</td>
<td></td>
</tr>
</tbody>
</table>

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This exercise demonstrates how to set up the ESG to provide an RF test signal.

If you do not have an ESG available, you can turn on the N8201A’s internal RF reference signal (50 MHz) to run the following demonstration. Since the N8201A’s center frequency defaults to 50 MHz, you do not need to change the center frequency of the N8201A as shown in next section.

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This exercise demonstrates the one-button phase noise log plot measurement.
Averaging and video filtering are part of the measurement. Therefore, every time you change the number of averages and/or level of video filtering, you need to restart the measurement to obtain the results. Smoothing, on the other hand, is a post-processing operation on the stored data. You can observe the smoothed results while you are changing the length of the smoothing segment. Implementations of video filtering and smoothing are fast, whereas averaging takes longer.

### Span and amplitude

#### Instructions Keystrokes

**Specify the span of offset frequencies:**

- Set start offset frequency to 100 Hz. 
  - [SPAN] (Start Offset) (100 Hz) and Enter from the keyboard
- Set stop offset frequency to 100 MHz. 
  - (Stop Offset) (100 MHz) and Enter from the keyboard

**Specify amplitude scale:**

- Set reference value to –85 dBC/Hz. 
  - [AMPLITUDE] (Ref Value) (–85 dBC/Hz) and Enter from the keyboard
- Set scale per division to 7 dB. 
  - (Scale/Div) (7 dB) and Enter from the keyboard
- Restart the measurement. 
  - [Restart]

### Averaging, video filtering and smoothing

#### Instructions Keystrokes

**Activate averaging and set average number to 5.**

- [Meas Setup] (Avg Number) until “On” is underlined, then (5) and Enter from the keyboard
- Restart the measurement (Figure 2). 
  - [Restart]
- Disable averaging. 
  - Press (Avg Number) until “Off” is underlined
- Activate video filtering and set filtering level to “Maximum”. 
  - [Filtering] (Maximum)
- Restart the measurement. 
  - [Restart]
- View smoothed data trace with raw or averaged trace turned off. 
  - [Trace/View], press (Trace) until “1” is underlined, (Blank)
- Adjust length of smoothing segment. 
  - [Meas Setup] (Smoothing), then press [⇓] or [⇑], or rotate the knob
- Observe the displayed traces with different smoothing segments (Figure 4).

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These exercises demonstrate the N8201A's flexibility that enables you to optimize your phase noise measurements.
Figure 3. Phase noise plot with video filtering

Figure 4. Smoothed phase noise plot
Spot frequency phase noise

If you are interested in phase noise versus time at a single offset frequency, use the spot frequency phase noise measurement.

- Monitor phase noise fluctuation versus time at a user-specified single offset frequency (between 100 Hz and 100 MHz).
- Use the N8201A’s phase noise optimization feature to minimize the downconverter’s internal phase noise.
- Check carrier frequency drifting with carrier signal tracking.
- Search carrier frequency automatically.
- View results in graphic and numeric list formats.

**In this exercise, you will measure the spot frequency at 20 kHz and explore the signal tracking and the carrier frequency drifting features.**

### Instructions

<table>
<thead>
<tr>
<th>Instructions</th>
<th>Keystrokes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activate the spot frequency measurement.</td>
<td>[MEASURE] {Spot Frequency}</td>
</tr>
<tr>
<td>Specify the spot frequency to 20 kHz.</td>
<td>[Meas Setup] {Spot Offset} {20 kHz} and Enter on the keyboard</td>
</tr>
<tr>
<td>Adjust amplitude scale to optimize the display. Observe the real-time phase noise display at 20 kHz offset frequency (Figure 5).</td>
<td>[Amplitude] {Phase Noise} {Ref Value} (-110 dBc/Hz) and Enter on the keyboard (Scale/Div) {0.5 dB} and Enter from the keyboard, then rotate the knob for fine adjustment with either {Ref Value} or {Scale/Div} pressed</td>
</tr>
<tr>
<td>View spot frequency phase noise with a table of numerical readouts.</td>
<td>[Trace/View] {Numerical}</td>
</tr>
<tr>
<td>Return to graphical view.</td>
<td>(Graphical)</td>
</tr>
<tr>
<td>Turn on signal tracking to check carrier frequency drift. Check the carrier frequency drifting at a fixed time interval, for example at each 10 percent of one sweeping cycle.</td>
<td>[Frequency], toggle (Signal Track) to “On” (Tracking) {Mode} (Interval) {Interval} (10) and Enter on the keyboard</td>
</tr>
<tr>
<td>Adjust amplitude scale of frequency drifting (or Delta Frequency). Observe the spot frequency phase noise with carrier drifting plot (Figure 6).</td>
<td>[Amplitude] {Delta Freq} {Scale/Div}, then rotate the knob to an optimized display</td>
</tr>
<tr>
<td>Check the frequency stability of the carrier signal when the carrier drifting goes beyond the specified tolerance. This example uses a ±1 dBc/Hz tolerance level.</td>
<td>[Frequency], toggle (Signal Track) to “On”, (Tracking) {Mode} (Tolerance) {Tolerance ±} (1 dBc/Hz) and Enter on the keyboard</td>
</tr>
<tr>
<td>Set amplitude scale of frequency drifting (or delta frequency) to 1 kHz/Div.</td>
<td>[Amplitude] {Delta Freq} {Scale/Div} {1 kHz} and Enter on the keyboard</td>
</tr>
<tr>
<td>Check frequency drifting at the “Delta Freq” panel while manually adjusting the ESG RF output frequency by ±2 kHz increments.</td>
<td>Set ESG: [Frequency], then rotate the knob clock- or counterclock-wise around the previously specified center frequency</td>
</tr>
</tbody>
</table>
Figure 5. Spot frequency phase noise

Figure 6. Phase noise with carrier drifting
Displayed average noise level (DANL) measurements

The DANL floor of a spectrum analyzer sets limitations for measuring the smallest input signal, usually at the far-out offset frequencies. When the amplitude of a signal under test is getting closer to the DANL floor, a significant measurement error can occur, which makes the measurement no longer valid. To help you ensure the measurement is valid, the N8201A with the phase noise measurement personality measures the DANL floor and displays it along with the phase noise plot. It also automatically optimizes the N8201A input attenuation level for the far-out offset frequency to lower the DANL floor for a better measurement sensitivity.

- Measure and reference the DANL of the N8201A to the carrier amplitude.
- Display the DANL floor together with the log plot phase noise.
- Store and record traces easily.

The following exercise demonstrates the DANL measurements, display, and optimization.

### Instructions Keystrokes

<table>
<thead>
<tr>
<th>Instructions</th>
<th>Keystrokes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-enter phase noise measurement mode in the N8201A.</td>
<td>[Preset] [Mode] {Phase Noise}</td>
</tr>
<tr>
<td>Set center frequency to 1 GHz.</td>
<td>[FREQUENCY] {1 GHz} and Enter on the keyboard</td>
</tr>
<tr>
<td>Activate log plot measurement.</td>
<td>[MEASURE] {Log Plot}</td>
</tr>
<tr>
<td>Adjust the X-scale.</td>
<td>[SPAN] {Start Offset} {1 kHz} and Enter on the keyboard {Stop Offset} {100 MHz} and Enter on the keyboard</td>
</tr>
<tr>
<td>Adjust the Y-scale.</td>
<td>[AMPLITUDE] {Ref Value} {–85 dBc/Hz} and Enter on the keyboard</td>
</tr>
<tr>
<td>View the smoothed phase noise plot without raw data.</td>
<td>[Trace/View], toggle (Trace) to underline “1”, (Blank)</td>
</tr>
<tr>
<td>Transfer the smoothed phase noise curve from “Trace 2” to “Trace 3”.</td>
<td>Toggle (Trace) to underline “2”, (More 1 of 2) (Operations) {2 → 1}.</td>
</tr>
<tr>
<td>Activate the DANL measurement. Note the stepped DANL floor that results from the DANL optimization (Figure 7, lower trace).</td>
<td>[Meas Setup] {Meas Type} {DANL Floor} [Restart]</td>
</tr>
</tbody>
</table>

Figure 7. DANL floor displayed with a smoothed phase noise plot.

![Image of a graph showing the relationship between frequency offset and phase noise, with labels for Carrier Power, Carrier Freq, Signal Track, Off, and DANL Attenuation. The graph shows a smoothed phase noise plot with a stepped DANL floor, indicating the optimization process.]
There are two ways to measure the DANL floor. One way is to remove the signal from the N8201A and terminate the RF input of the N8201A with a 50 Ω termination. The other way is to suppress the input signal to a negligible level at the input mixer by increasing the input attenuation to 70 dB. While the measurement personality defaults to the latter, you can also choose to physically remove the signal from the N8201A RF input and terminate it as follows.

### Phase noise cancellation

The N8201A also features phase noise cancellation. Using a source with low phase noise, you can eliminate the influence of the N8201A’s internal phase noise on measurement results for close-in offset frequencies.

- Improve measurement accuracy and sensitivity.
- Make the best trade-off between cancellation effectiveness and computation time with user-selectable thresholds.

<table>
<thead>
<tr>
<th>Instructions</th>
<th>Keystrokes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set DANL measurement method as “Removal”.</td>
<td>[Input/Output], toggle (DANL Method) to underline “Removal”</td>
</tr>
<tr>
<td>Activate the DANL measurement.</td>
<td>[Restart], then you will see an instruction panel, follow the instructions to remove the signal from the N8201A input and to connect a 50 Ω termination at the RF input. Press [ESC] to continue.</td>
</tr>
</tbody>
</table>
Integrated noise

Different applications require different measures for evaluating phase noise behaviors. In the digital world, root-mean-square (rms) phase deviation/jitter (in degrees or radians) and rms phase jitter (in seconds) are used more frequently to evaluate the stability of a high-frequency clock. On the other hand, the residual FM is more important to amplifier designers and manufacturers. With the N8201A, these measures can be calculated by positioning a pair of markers to specify the interval of integration.

- Characterize phase noise related behaviors from different angles for various applications.
- Adjust integration bandwidth by positioning a pair of markers on the log plot.
- Calculate rms phase deviation/jitter in degrees or radians.
- Calculate rms phase jitter in seconds.
- Calculate the residual FM in Hz.
- View numeric marker readings for calculated results.

With the phase noise plot obtained in the previous demonstration, use the markers to make the integrated noise measurements.

<table>
<thead>
<tr>
<th>Instructions</th>
<th>Keystrokes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear the DANL floor from the results obtained in the previous demonstration.</td>
<td>[Trace/View], toggle (Trace) to underline “2”, (Blank)</td>
</tr>
<tr>
<td>Set the starting point of the integration interval to 10 kHz. Notice a marker labeled “1” shows up on the phase noise plot at 10 kHz offset frequency.</td>
<td>[Marker] (More), toggle (Marker Trace) until “1” is underlined, (More) (Normal) (10 kHz) and Enter on the keyboard</td>
</tr>
<tr>
<td>Activate the rms phase deviation (in degrees) measurement. Notice a marker labeled “1R” superimposed on the marker labeled “1”.</td>
<td>(RMS Noise) {RMS Noise Degree}</td>
</tr>
<tr>
<td>Set the ending point of the integration interval to 1 MHz. The rms phase deviation/jitter in degrees between 10 kHz and 1 MHz is shown in the top right corner of the display (Figure 8).</td>
<td>(1 MHz) and Enter on the keyboard</td>
</tr>
<tr>
<td>Change the rms phase deviation/jitter into radians. Notice the readout in the top right corner changes to radians.</td>
<td>(RMS Noise Radian)</td>
</tr>
<tr>
<td>Change the rms phase jitter into seconds. Notice the readout in the top right corner changes to seconds.</td>
<td>(RMS Noise Jitter)</td>
</tr>
<tr>
<td>For residual FM, set the integration interval starting from 30 kHz. Notice a marker labeled “1” shows up on the phase noise plot at 30 kHz offset frequency.</td>
<td>[Marker] (Normal) (30 kHz) and Enter on the keyboard</td>
</tr>
<tr>
<td>Activate the residual FM measurement, and set the integration interval ending at 1 MHz. The top right corner of the display shows the integration interval and the residual FM in Hz (Figure 9).</td>
<td>(Residual FM) {1 MHz} and Enter on the keyboard</td>
</tr>
</tbody>
</table>
Figure 8.
RMS phase deviation in degrees

Figure 9.
Residual FM
Phase noise measurement personality

**Measurement modes**
- Spectrum monitor
- Log plot
- Spot frequency

**Offset frequency range**
- Minimum offset frequency: 10 Hz
- Maximum offset frequency: 100 MHz
- Spot frequency measurement: 100 MHz
- Log plot measurement: Up to 10 GHz

**Maximum number of decades**: 7

**Maximum input signal level**: +20 dBm

**Minimum input signal level**
- For optimum dynamic range: –50 dBm

**Measurement accuracy (nominal)**
- Amplitude accuracy: ±0.29 dB (RSS of error sources, each of which is warranted, not including repeatability)
- Amplitude repeatability: ±0.34 dB rms (example standard deviation at 10 kHz offset, 4% smoothing, medium video filtering. Can be reduced with more smoothing, filtering and averaging)

**Video filtering**
- Four levels:
  - None (VBW/RBW = 1.0)
  - Little (VBW/RBW = 0.3)
  - Medium (VBW/RBW = 0.1)
  - Maximum (VBW/RBW = 0.03)

**Smoothing**
- Fine-adjustable between 0% and 16%

**rms noise calculation**
- Rms phase deviation, rms phase jitter, and residual FM are calculated over a user-specified integration interval

**System phase noise**
- See Figures 10 and 11.

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**Figure 10. Nominal phase noise of different LO optimizations**

**Figure 11. Nominal phase noise at different carrier frequencies (CFs)**

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1. See the N8201A performance downconverter synthetic instrument module data sheet for more specification details (literature number 5989-5720EN).
## References

### Web resources

For additional information on synthetic instruments, visit:

**www.agilent.com/find/synthetic**

For additional information on instrument security issues, visit:

**www.agilent.com/find/security**

For information about renting, leasing, or financing Agilent’s latest technology, visit:

**www.agilent.com/find/buy/alternatives**

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**www.agilent.com/find/accessories**

For additional information about Agilent PSA Series spectrum analyzers, visit:

**www.agilent.com/find/psa**

### Related literature

#### Synthetic instruments

- **N8201A Performance Downconverter Synthetic Instrument Module, 3 Hz to 26.5 GHz, Data Sheet**
  Literature number 5989-5720EN

- **N8201A Option 219 Performance Downconverter Synthetic Instrument Module 3 Hz to 26.5 GHz, Technical Overview and Self-Guided Tour for the Noise Figure Measurement Personality**
  Literature number 5989-6747EN

- **N8201A Option 226 Performance Downconverter Synthetic Instrument Module 3 Hz to 26.5 GHz, Technical Overview and Self-Guided Tour for the Phase Noise Measurement Personality**
  Literature number 5989-6748EN

- **N8201A Option V7L Performance Downconverter Synthetic Instrument Module 3 Hz to 26.5 GHz, Technical Overview and Self-Guided Tour for the Fast Rise Time Video Output**
  Literature number 5989-6749EN

- **N8211A Performance Analog Upconverter Synthetic Instrument Module, 250 kHz to 20/40 GHz, Data Sheet**
  Literature number 5989-2592EN

- **N8212A Performance Vector Upconverter Synthetic Instrument Module, 250 kHz to 20 GHz, Data Sheet**
  Literature number 5989-2593EN

- **N8221A IF Digitizer Synthetic Instrument Module, 30 MS/s, Data Sheet**
  Literature number 5989-2594EN

- **N8241A Arbitrary Waveform Generator Synthetic Instrument Module, 15-Bit, 1.25 GS/s or 625 MS/s, Technical Overview**
  Literature number 5989-2595EN

- **N8242A Arbitrary Waveform Generator Synthetic Instrument Module, 10-Bit, 1.25 GS/s or 625 MS/s, Technical Overview**
  Literature number 5989-5010EN

- **N8201A-H02 Compact Performance Spectrum Analyzer for ATE Applications**,
  Literature number 5989-5721EN

#### Spectrum analyzer literature

- **PSA Series High-Performance Spectrum Analyzer, Brochure**
  Literature number 5980-1283E

- **Agilent PSA Series Spectrum Analyzers, Data Sheet**
  Literature number 5980-1284E
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Malaysia 1 800 888 848
Singapore 1 800 375 8100
Taiwan 0800 047 866
Thailand 1 800 226 008

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Switzerland (German) 0800 80 53 53 (Opt 1)
United Kingdom 44 (0) 118 9276201

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www.agilent.com/find/contactus

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