What is Amplifier Residual Phase Noise

Amplifier Residual Phase Noise, which can also be known as Additive Phase Noise, is the *additional* Phase Noise or the Phase Noise contribution that an active component, like an amp, adds to an output signal as that signal passes through the device. Phase Noise is a parameter or critical metric for characterizing and defining the performance that differentiates the fundamental noise of the amplifier from the noise of the source at the amp's input.

What's the difference between Residual Phase Noise and Absolute Phase Noise?

Understanding, identifying, and recognizing the difference between Residual Phase Noise and absolute Phase Noise is critical for understanding an amplifier's contribution to the system's overall noise performance.

- **Residual Phase Noise:** The Residual Phase Noise is the Phase Noise that is **added** to the path by the amplifier. When measuring this parameter, the test set uses the same clean signal source for both the device under test (DUT) and a low Phase Noise input reference. The Phase Nose Test Set like the Agilent 5511 or the Rhode FSWP then analyzes but inputs, subtracts out the Phase Noise from the amplifier, and leaves only the Phase Noise contributed by the amplifier or the DUT.
- **Absolute Phase Noise:** The total or complete Phase Noise of the input signal to the amplifier. For a signal generated by a synthesizer or an oscillator, that signal is measured to determine its absolute Phase Noise. When that signal passes through an amplifier for example, the amplifier's Phase Noise contribution combines with the Synthesizer's or oscillator's absolute Phase Noise to produce a new, higher absolute Phase Noise measurement at the amplifier's output.

Why is Residual Phase Noise so important?

In high-performance systems like ground based radar, targeting systems and missile defense applications, every single component in the chain's noise contribution matters to the overall fidelity of the system.

- **Predicting system performance:** By understanding, measuring and then knowing the Residual Phase Noise contribution of the amplifiers in the chain, design engineers can accurately model and predict the total noise of a complex system.

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- **Component Level: Performance:** Actually measuring the Residual Phase Noise contribution is the only way to confidently evaluate and compare the fundamental noise performance of both the Source and the amps in the chain. This is especially important for receive side buffer amplifiers, where the Phase Noise performance is at times slightly degraded when the amp operates past the P1dB point and well into saturation for peak output power performance.

- **Identifying Noise Sources:** Using a specific Residual Phase Noise measurement setup, an engineer can attempt to cancel out the noise contribution from dc sources like a power supply for example, allowing the design engineer to pinpoint the specific component or the even broader, the chain, that is degrading the system's overall performance.

What contributes to an Amp's Residual Phase Noise?

- ✓ **Flicker Noise (1/f noise):** This noise is more significant at close-in offsets, the result of low frequency fluctuations in the amp's transistors.
- ✓ **White Noise:** This noise is a byproduct of the amplifier's Thermal Noise or Johnson Noise. Thermal Noise is simply the white noise that is caused by an amp's transistor as electron's move, as in the case of a Silicon transistor, from the Base to the Emitter.
- ✓ **AM-to-PM conversion:** An amplifier's linearity can degrade at output power levels beyond the amp's linear region or perhaps into saturation. Beyond P1dB, amplitude noise or AM Noise from the dc supply can register as Phase Noise or PM which can increase an amplifier's Residual Phase Noise contribution. Based on the amp's we manufacture here at Spectrum Control, an amp's best Residual Phase Noise performance comes when it is at, or just shy of its P1dB point.