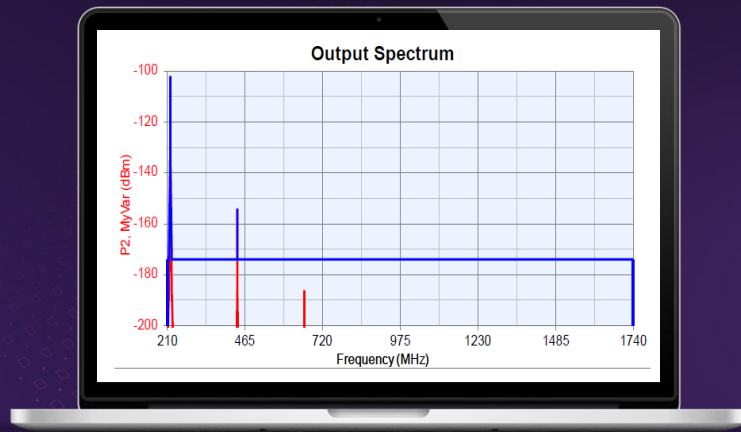




TECHNICAL
OVERVIEW

How Can Phase Noise Be Below the Noise Floor?

PATHWAVE

Spectrasys is **not** a Harmonic Balance simulator. As a spectral domain simulator, it keeps track of these four things totally separately and independently:

1. Signals
2. Harmonics
3. Intermod
4. Noise

Noise is further broken down into 1.) thermal noise, and 2.) phase noise. Once these four are calculated, they are plotted on the same spectrum graph. Since signals can exist below $-174 \text{ dBm}/\sqrt{\text{Hz}}$, when they get plotted on the same set of axes, some of them appear lower than thermal noise.

Spectrasys never artificially alters the power level of a signal just to make it look good on a graph. So, the following is possible (Figure 1).

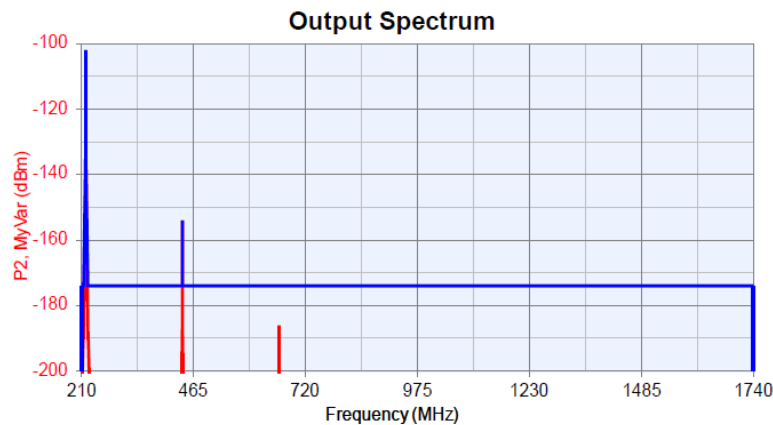


Figure 1.

Notice in Figure 1 that the 3rd harmonic at 660 MHz is below the noise floor (blue). The signal is really there, but of course you wouldn't be able to see it on a spectrum analyzer. But in Spectrasys, because the harmonics are calculated separate from everything else, they appear as seen here.

 **KEYSIGHT**
TECHNOLOGIES

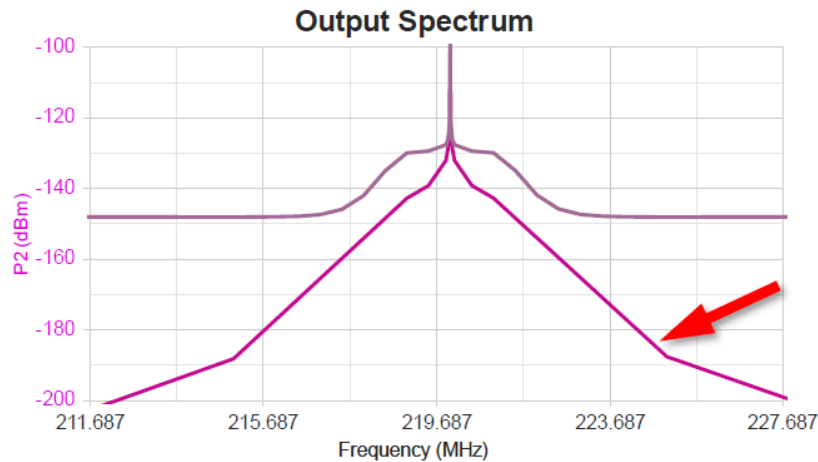


Figure 2.

The same happens with phase noise. In Figure 2, the phase noise (red arrow trace) close-in to the carrier is above thermal noise, but farther away falls below the thermal noise floor of -174dBm. The way to read this graph is to always look at the highest trace because that will be the total spectral power at a given frequency.

If you don't want to see this separate phase noise trace – that is, if you only want to see the “node total” trace – just set up your analysis options on the Composite Spectrum tab as shown in Figure 3.

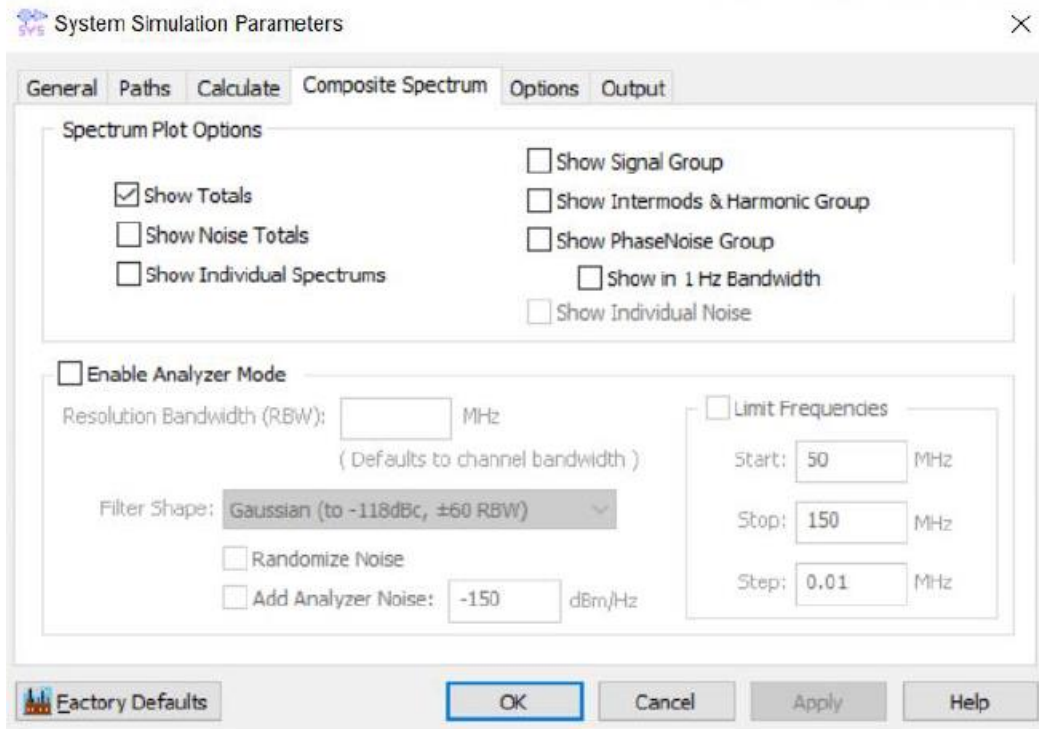


Figure 3.

Unchecking the Show boxes as shown in Figure 3, results in the spectrum shown in Figure 4. Phase noise still contributes to the total, but is not visible as a separate trace.

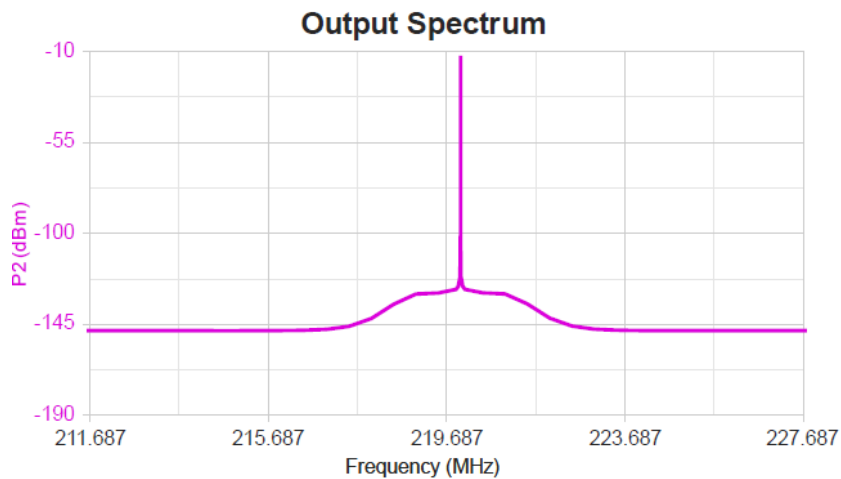


Figure 4.

Finally, the noise floor power level in dBm is directly affected by Measurement Bandwidth you choose in the analysis. If you choose 1 Hz, then that's the bandwidth used to integrate noise power at each point along the trace. If you choose 1 MHz, the noise floor will be 60 dB higher. So the user has total control over the bandwidth, and thus the displayed noise level.

Learn More:

- [PathWave System Design \(SystemVue\)](#)
- [Spectrasys RF System Simulation](#)

Learn more at: www.keysight.com

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