State-of-the-Art Measurement Techniques for PM and AM Noise

TUTORIAL – QUESTIONS AND ANSWERS

Note from the editor

The questions were asked at various points during the presentation. They were transcribed and are presented here at the end of each tutorial.

JEFF INGOLD (ALLIEDSIGNAL TECHNICAL): Does each spectrum analyzer have its own amplifier?

CRAIG NELSON (SPECTRADYNAMICS): Yes. We use a different amplifier for all of the spectrum analyzers.

JEFF INGOLD (ALLIEDSIGNAL TECHNICAL): And what kind of noise figure?

CRAIG NELSON (SPECTRADYNAMICS): I'm not sure on the actual noise figures of the separate amplifiers. But that all, in a sense, washes out, when we do the noise floor of the amplifier. Well, it's important in the design, obviously.

JEFF INGOLD (ALLIEDSIGNAL TECHNICAL): The overlap in the data, is that the cross–correlation between spectrum analyzers?

CRAIG NELSON (SPECTRADYNAMICS): Yes. Actually, we generally use several frequency spans in the measurements. For this measurement, we probably use a 25 Hz span that covers about to here on the FFT; then we probably use the 400 Hz span, a 1 kilohertz (kHz) span, and a 100 kHz span. And at this point, you can see the selective level meter takes over; and then finally, here the spectrum analyzer takes over.

Now when we sweep the space–modulated signal across, we measure it on all different instruments on the different analyzers. And we measure the same point. And then we can use that to cross the calibration over to different instruments. Then you can see they match up extremely well with this method.

RALPH PARTRIDGE (LOS ALAMOS): You seemed quite confident that you knew that those larger errors were due to the non–linearity in the analyzer. How do you come about that?

CRAIG NELSON (SPECTRA DYNAMICS): Well the error terms are error terms that we calculate, they're not absolute error terms. We measure value; we don't absolutely know what the true value is. So, it's an error analysis that we do through all the system. We figure there is a certain error budget to each term, and we sum those up.

Conclusions

- To increase Fourier range a modulation technique (PM or FM) can be used.
- Using an added noise source greatly simplifies PM and AM measurements as well as decreases measurement times.
- For ultra-low noise floors cross-correlation techniques must me used.

FRED WALLS (NIST): The column there on the right is the confidence for the measurements, not the errors. Because if they were errors and we knew about them, we just back them out and measure it. But that's the sum of the errors from the modulator, the demodulator, the amplifier gains, POLs – wouldn't affect that.

I know it's been a really long session, but do you have any more questions? The one thing that a phase noise standard does not handle is the AM to PM conversions. That's one of the errors that one would have to measure independently.

JEFF INGOLD (ALLIEDSIGNAL TECHNICAL): Could you back up to, I think it was 36? I can see A to B and A to C; but I don't quite see B to C on the three–corner hat. Could you expand a little bit?

CRAIG NELSON (SPECTRADYNAMICS): Well the B to C doesn't really happen.

FRED WALLS (NIST): And it's not needed?

CRAIG NELSON (SPECTRADYNAMICS): It's not needed, because the noise – I'm not saying you get all three of those measurements. With this technique, you only get the noise of the signal source. If you want the noise of all three oscillators, you still have to end up doing measurements. But frequently, you have to measure three oscillators just to get the absolute noise of a single oscillator. Does that answer your question?

JEFF INGOLD (ALLIED SIGNAL TECHNICAL): Yes.

FRED WALLS (NIST): All right, basically the noise in this measurement system and the noise in this reference are uncorrelated with the noise in this measurement in this measurement system. And so when you do the PST of the cross, those noise terms average to zero as one over the square root of the measurements, and they simply drop out. And the fact that the measurements are made simultaneously, then fluctuations in the various ones also cancel better in the noise floors, quite a bit better than what you can get if you did the actual three–corner hat sequentially.

The other difference is when you do the three–corner hat sequentially, you end up subtracting large numbers to get a little one; and so, a small error gets magnified by how much better the oscillator is. In this case, a small error in the calibration here is a small error in the final result, and not magnified by the difference.

MALCOLM CALHOUN (JPL): Do you have any preference between high–level mixers and low–level mixers in your phase noise measurement systems?

FRED WALLS (NIST): It depends on the power of the source. If I have quite a bit of power, then a high–level mixer gives me a little lower noise floor. If I have a small signal, then a low–level mixer will give me a better noise floor.