

Low Noise Signal Generation and Verification Techniques

Michael M. Driscoll

Northrop Grumman Electronic Systems, Baltimore, Maryland, USA.

Corresponding e-mail: mdriscoll@ieee.org

The need for improved signal detection capability in Communications and Radar System Performance has resulted in requirements for extremely low noise in the signal generation portion of the hardware. Depending on the complexity of the signal generator, the signal path circuitry often includes a cascade of a very large number of non-oscillator as well as oscillator-included components such as amplifiers, mixers, switches, filters, PLL ICs, etc. In addition to the spectral performance of the oscillator(s), the cumulative effect of the residual noise characteristics of the non-oscillator components on output signal noise level and jitter can be significant. Tradeoffs must often be made with regard to maintaining adequate inter-component signal level, linear device operation (to minimize multiplicative noise), and DC power consumption. The use of noise modelling and noise analysis spreadsheets has become a mandatory part of the design process.

Noteworthy strides have been made in order to enhance signal generator spectral purity by employing new technologies and circuit design techniques. These include the following:

1. Acoustic resonator design and processing optimization and screening for low self-noise
2. High Q microwave resonators
3. Noise enhancement, detection, and reduction using carrier nulling and feed-back or feed-forward techniques
4. Noise de-correlation via use of multiple devices
5. Optical techniques

One result of these improvements, however, is that the output signal at-rest phase noise performance is now degraded by significantly lower levels of vibration and acoustic stress. For this reason, improving the vibration immunity of sensitive components represents a current challenging and important task facing the Frequency Control community. In addition to conventional, mechanical vibration isolation

techniques, the successful use of accelerometer-sensed feedback for cancellation of vibration-induced FM in HF crystal oscillators has recently been reported. Here too, the effects of “non-oscillator” component vibration (including mechanical resonances) can be a source of unanticipated signal spectral degradation.

Accurate verification of phase noise performance (especially in the presence of vibration and acoustic stress) of low noise signal generator hardware represents an important, related issue. Measurement results obtained using phase noise measurement equipment can be misleading and lead to erroneous conclusions.

This lecture will cover the aforementioned topics with the goal of acquainting the attendees with both a historical and current perspective regarding the design, performance, and testing of low noise signal generation hardware.



Mike Driscoll joined the Westinghouse Defense Center (now part of Northrop Grumman Electronic Systems) in Baltimore in 1965 after graduating from the University of Massachusetts in Amherst. Since 1968, he has worked primarily on the design and development of low-noise signal generation hardware for use in high-performance radar systems. He was a Senior Consulting Engineer at Northrop Grumman until retiring in February, 2008. He is currently a Contract Engineer, Consulting at Northrop Grumman. His responsibilities include the design and development of high stability oscillators, as well as characterization and reduction of phase noise in RF signal processing components and circuits. He has been a member of the IEEE Frequency Control Symposium Technical Program Committee since 1987. He is an Associate Editor of the *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control* (UFFC) and was the Conference Chair for the 2005, 2006, and 2012 IEEE International Frequency Control Symposia (IFCS). In 1997, he was the recipient of the IEEE UFFC Society Cady award, cited for *Contributions to Low Noise Signal Generator Design*. In 2006, he was a recipient of the Northrop Grumman Lifetime Achievement Award. He is the designated UFFC Society Distinguished Lecturer for 2012–2013. He has published and presented more than 60 papers in IEEE journals and at IEEE conferences. He has presented several IEEE tutorials and Northrop Grumman Instructional Courses and holds numerous U.S. patents dealing with the subject of low-noise signal generation.