# Measuring Digital Radar Receiver Spectral Purity

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## Summary

It is essential when developing new radar systems to understand the performance of each of the system components. While there are many different types of radar, we are specifically interested in bi-static or passive radar systems using a receiving array with tens or hundreds of receiver channels and one or more powerful unwanted in-band signals. Such signals may be, for example, from a nearby transmitter in a continuous-wave bi-static radar or a close-by emitter of opportunity in a passive radar. In these cases, achieving and confirming high performance in each receiver channel is paramount.

Well-known receiver performance metrics include spurious-free dynamic range and noise figure; however, an equally important metric is receiver spectral purity. Spectral purity distortion is immediately recognisable as spectral-spread in both Doppler and range surrounding a strong target return. Poor receiver spectral purity can compromise target detection in the presence of sizeable direct-path transmitter signals or strong clutter returns. In such a circumstance, spectral spreading at a low level from the transmitter or clutter signal in range-Doppler space will obscure weak target returns at nearby Doppler frequencies or adjacent range cells. Improving receiver spectral purity will correspondingly improve radar system target detectability and overall performance.

Modern phased array radars have digital waveform generation per transmitter channel and digital reception per receiver channel. At the current state-of-the-art, the spectral purity performance of waveform generators is typically worse than for receivers. This imbalance means that a direct measurement approach using a single waveform generator connected to a single receiver fails. The spectral purity of the receiver is better than that of the waveform generator, and a one-to-one measurement is ineffective because the waveform generator spectral purity dominates with the receiver spectral purity being unmeasurable. Our challenge is to measure receiver spectral purity. Since contemporary receiver designs digitise the received signal, it is also impossible to use traditional test and measurement equipment, which assume access to analogue parts of the overall signal processing chain. Hence we also need an algorithmic solution.

One conventional approach uses multiple waveform generators operating in parallel where the output is formed by coherently summing the signal from each waveform generator. Provided one uses enough waveform generators; a single receiver spectral purity becomes measurable. Unfortunately, this fails without a sufficient number of waveform generators, and these may not be affordable or even available.

This paper presents a new method that simultaneously uses a single waveform generator splitter combination and multiple receivers to measure each receiver's spectral purity. We exploit the plane-wave spatial structure of the waveform generator and splitter combination signal while noting the residual unstructured spatial signal corresponding to the individual receiver spectral purity distortion. We then use spatial processing methods to isolate the uncorrelated spectral purity distortion corresponding to each receiver.