Memorandum

To the working engineers in the world, a follow up to the recent panel session with *Microwave Journal*. Thank you for attending.

The maturity of RF electronics has led to proliferation into many varied systems resulting in many engineers working on multiple aspects of these systems. As system complexity grows, inevitably there are aspects to which designers will have limited prior exposure. With limited time and increased schedule pressure, the working engineer may benefit from material that bridges the gap between theoretical text-book style descriptions and real world design implementations--phased arrays are an example. The links below are included to support this, as well as assist engineers to conceptualize the impact their efforts have on larger systems' designs.

Phased Array Antenna Patterns
A primary motivator for phased array development is to replace mechanically rotating structures with flat surface programmable antennas. Phased arrays are becoming the antenna of choice in modern radio systems leading to the need for fundamental principles to be explained without the heavy mathematics needed in antenna design. These articles informed by internal training sessions wherein antenna patterns were described relative to FFT methods were well-understood by the audience. From the lectures, the descriptions evolved into a series of foundation principles for phased array antenna patterns.

Phased Array Antenna Patterns—Part 1: Linear Array Beam Characteristics and Array Factor | Analog Devices

Phased Array Antenna Patterns—Part 2: Grating Lobes and Beam Squint | Analog Devices

Phased Array Antenna Patterns—Part 3: Sidelobes and Tapering | Analog Devices

Receivers
Radio architecture decisions commonly start with the receiver definition. The receiver has the difficult task of processing very small signals at or below system noise. In many cases this reception is in the presence of large interference leading to challenging dynamic range specifications. These descriptions provided are aimed at basic receiver considerations.

A Review of Wideband RF Receiver Architecture Options | Analog Devices

Receiver Design Considerations in Digital Beamforming Phased Arrays (.PDF Download) | Microwaves HYPERLINK "https://www.mwrf.com/home/whitepaper/21847443/receiver-design-considerations-in-digital-beamforming-phased-arrays-pdf-download"& HYPERLINK "https://www.mwrf.com/home/whitepaper/21847443/receiver-design-considerations-in-digital-beamforming-phased-arrays-pdf-download" RF (mwrf.com)

As distributed receivers are integrated into digital beamforming phased arrays, there are dynamic range improvements that can be realized. Measured examples of a multi-channel receivers are summarized in these links.

A Measurement Summary of Distributed Direct Sampling S-Band Receivers for Phased Arrays | Analog Devices

Hybrid Beamforming Receiver Dynamic Range Theory to Practice | Analog Devices

Phase Noise
Phase noise is a critical metric in RF design. These descriptions are intended to provide practical insight along with acknowledging many great references on the topic. First some measured examples of evaluating phase noise contributors.

Empirically Based Multichannel Phase Noise Model Validated in a 16-Channel Demonstrator | Analog Devices

Transceiver Phase Noise Teardown Informs Performance Capability with an External LO | Analog Devices

It is accepted that low phase noise design requires low noise power supplies. However, there are limited measured examples that describe implementation details to consider or provide a method to calculate what is required. These examples aim to quantify the impact of power supply noise on phase noise.

Improved DAC Phase Noise Measurements Enable Ultralow Phase Noise DDS Applications | Analog Devices

Power Supply Modulation Ratio Demystified: How Does PSMR Differ from PSRR? | Analog Devices

As phased locked loops become distributed in phased arrays, methods are needed to evaluate the phase noise contribution at the system level. Here the noise transfer functions are described in the first link and applied at a system level in the second link.

Phase Locked Loop Noise Transfer Functions (highfrequencyelectronics.com)

System-Level LO Phase Noise Model for Phased Arrays with Distributed Phase-Locked Loops | Analog Devices

Spurious Mitigation Methods in Phased Arrays
Similar to the distributed receiver improvements described above distributed waveform generators can be configured for significant spurious improvement when transmit signals combine in the air during radio transmission. Two measured examples are:

RF Transceivers Enable Forced Spurious Decorrelation in Digital Beamforming Phased Arrays | Analog Devices

Hybrid Beamforming Transmit Calibration with SFDR Optimization | Analog Devices

Notable RF References
Many great designers and writers have come before us. The links above are a minor contribution into the world. The references cited here are foundational to our profession.

RF Circuit Design References (highfrequencyelectronics.com)

The area of RF/Microwave electronics is continually growing and expanding. The industry has created a wealth of information readily available to learn from and to which we may contribute.

All the best in your career and endeavors.

Sincerely,
Peter L. Delos