Pulse Dispersion in Phased and Timed Arrays

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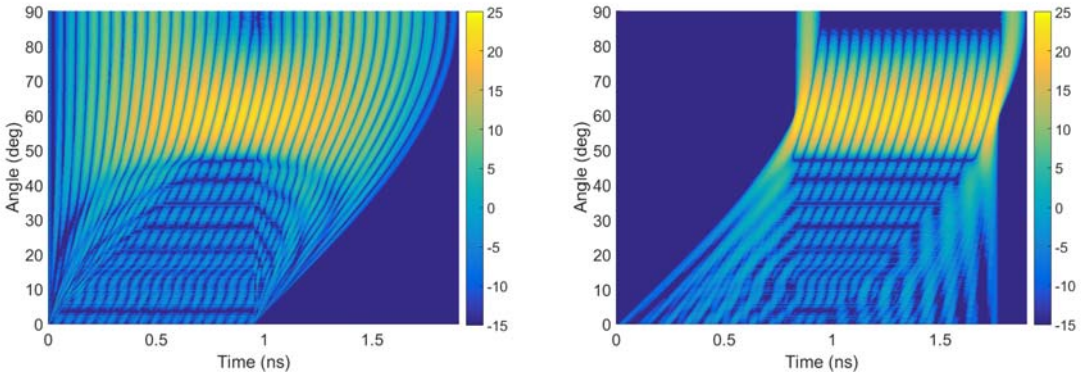
Modern communication systems need to transmit and receive very wideband signals. High demands on the antenna performance in modern communication systems call for array beamforming. Classic arrays use phase shifters to collimate the beam, however the term "phased", implies narrow bandwidth. Wideband signals have a very short time duration that impacts the total signal received by an antenna array.

When a pulse is incident on an antenna array, the elements of the array receive the wideband signal at different instances in time. Phase shifters align the phase of the signals at each element such that they add up in phase, however due to the shift in signal envelope the total plus, i.e. the sum of the pulses received by the phased array, exhibit some dispersion. The solution to this problem is to use time-delay-units, as opposed to phase shifters, which shift the signal envelope, providing wide instantaneous signal bandwidth. These types of arrays are referred to as timed arrays.

To demonstrate this concept, we model a 20 element linear array with a 25 dB Taylor taper. A 0.95 ns rectangular pulse centered at 10 GHz is incident on the array with a 60 degree incidence angle. The received pulse shape for a phased array and a timed array system are shown in Fig. 1. Note that the phased array shows significant pulse dispersion, while a timed array shows a perfect received pulse with no dispersion. It is important to note that with a phased array the pulse entering the sidelobes experiences increased dispersion the further it is from the main beam.



(a) (b)

Fig. 1. The pulse shape in dB for the 20 element array with a 60º scanned beam: (a) phased array, (b) timed array.

Phased array antennas will inevitably exhibit pulse dispersion when receiving or transmitting wideband signals because shifting the signals is not adequate to align the pulses. This presentation will outline the limitations of phased array antennas arising from their limited instantaneous bandwidth and provide a comparative study of pulse dispersion in phased arrays as a function of beam scanning. We delineate the system level requirements for wideband communications in antenna arrays and demonstrate that phased arrays are limited by pulse dispersion in wideband systems.