Aspects of Digital Beam Forming Errors for Radar and Communication Systems

James P. Conroy*[(1)], Amir I. Zaghloul [(1,2)]
[(1)] Virginia Tech, Falls Church, VA 22043, USA
osujim1@vt.edu, amirz@vt.edu
[(2)]US Army Research Laboratory, Adelphi, MD 20783, USA
amir.i.zaghloul.civ@mail.mil

Due to recent advancements in the development of RF receivers, digital beam forming (DBF) is now being more commonly utilized in radar and communication systems. With its potential for increased flexibility compared to its analog counterpart, DBF is being increasingly relied upon to perform critical functions such as adaptive beam forming for jammer cancellation. The key to realizing the potential of DBF is the accurate sampling and subsequent digitization of the signals incident at the aperture of the antenna system. This paper examines the errors which may occur within the receive chain of a coherent radar or communication system with the goal of obtaining physical insight into their potential impact on radar system performance. Correlated errors not historically considered with centralized analog architectures- a key difference between analog and digital beam forming- are often important for DBF systems as they utilize parallel distributed receivers. The potential impact of antenna polarization and type on a received waveform will be explored using HFSS and MATLAB simulations. A quadrature receiver signal model, which includes amplitude errors and IQ imbalance, is presented and used to demonstrate the impact on Doppler performance and the origin of time side lobes (TSLs). Errors resulting from the non-linear operation of low-noise amplifiers will be considered and the effects of intermodulation investigated by analyzing the degradation of beam forming performance. The generation of spurious signals due to quantization error in an analog-to-digital converter (ADC) will be reviewed and a trade study of frequency, number of bits and sample rate will be completed. It will be shown that given prior knowledge of the existence of certain errors that their impact can be minimized, while some errors such as those generated by non-linear components can create signal distortions that cannot be removed.