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On Coherency Requirements in Steered Beam Adaptive Antenna Systems

An adaptive antenna is a means of reducing interference and increasing capacity in both 2nd and 3rd generation mobile systems. Different concepts such as fixed beams and steered beams are frequently being discussed. Fixed beams are attractive due to their relatively low complexity while steered beams are attractive due to better performance. However, the cost of a steered beam system is an increased complexity since a steered beam system requires coherency throughout the receiver and transmitter chains. To achieve the desired coherency the system must be properly calibrated during production, and typically also during normal operation.

This contribution presents the effects from calibration errors on the directivity pattern for two different implementations of a steered beam system. One system being equipped with a beam forming network, a butler matrix, in the antenna while the other system contains no rf beamforming apparatus. The calibration errors are applied to the beam space for the system with rf beamforming network and in the element space for the system without this network.

We have studied the effects from relative amplitude (α), phase (β) and time (γ) errors in the two implementations by means of Monte Carlo simulations.

The error distribution is assumed to be a zero mean normal distribution. The parameters in the simulations have then been the standard deviation σ for the three types of errors. The correlation between the different types of errors and between signal branches are assumed to be zero.

In case of time errors the directivity will be time dependent so performance is averaged over time and over chip sequences.

The results show that the sensitivity to calibration errors is reduced, and in some directions even eliminated, when using a butler matrix compared to a system with no butler matrix. The performance improvement of course depends on the error parameters. As an example, in a linear array with four elements the first sidelobe level is reduced approximately 2 dB for σ_α=0.1, σ_β=20° and σ_γ=0.1Tc, where Tc denotes the chip duration.