Noise Penalty Due to Mutual Coupling for Receive Arrays

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For single-antenna systems, the factors that influence the signal to noise ratio and other related performance metrics such as channel capacity are well understood. In order to optimize the performance of multi-antenna systems, these concepts must be must be extended to the array case. The goal of this work is to develop metrics which allow us to quantify the impact of mutual coupling on array receivers and techniques to reduce the system performance penalty caused by mutual coupling.

For a single antenna and front end amplifier, the SNR at the receiver output is maximized by designing the matching condition between the antenna terminals and amplifier input to minimize the noise figure of the amplifier. This optimal noise matching condition can be specified in terms of measured noise parameters of the amplifier and the electrical characteristics of the antenna. It is not obvious how to extend the single-channel procedure to a mutually coupled array antenna with multiple front end amplifiers. It has recently been demonstrated that the system noise in the multi-antenna case is minimized with a multiport matching network between the array and the front end amplifiers that effectively decouples the array ports [Warnick and Jensen, IEEE Trans. Ant. Propag., vol. 55, pp. 1726-1731, 2007]. This result implies that mutual coupling causes a noise performance penalty unless compensation techniques are implemented, and the ideal, optimal decoupling network provides a benchmark against which the performance of simpler and more practical matching networks which do not fully decouple the array ports can be compared. In this work, we develop an efficiency parameter that measures the impact of mutual coupling in terms of its effect on the antenna sensitivity (G/T) of a beamforming array, and we show how this parameter is related to conventional metrics used for transmitting arrays. Numerical results are given to illustrate the magnitude of the mutual coupling penalty for practical array examples.