論文 / 著書情報
Article / Book Information

題目(和文)	コンパクトMIMOシステム用最適低雑音受信機の設計
Title(English)	Optimal Low Noise Receiver Design for Compact MIMO System
著者(和文)	ｼﾞﾖﾝｼﾞｴﾎ
Author(English)	Jaeho Jeong
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種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

専攻： Department of	電気電子工学　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　（　工学　）
学生氏名： Student's Name	Jaeho Jeong	指導教員（主）： Academic Advisor(main)	鈴木 博
		指導教員（副）： Academic Advisor(sub)	阪口 啓

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Multiple-input multiple-output (MIMO) systems deploy multiple antennas at both the transmitter and receiver to improve the spectral efficiency and link reliability of wireless communications. With the development of communication theory, the study of MIMO technique has become more feasible, though several problems need to be solved as ever at the receive end mostly. The insufficient antenna spacing due to the small aspect of the receive end causes the mutual coupling (MC) strongly, which deteriorates performance of the MIMO system.

To alleviate the problem, this thesis focus on the low noise MIMO receiver with mutually coupled antennas. We first address a noise matching problem for MIMO receiver with mutual coupling in the presence of correlated fading and noise. To minimize the noise figure, matching network scheme is employed.
As the optimal matching network minimizing the noise figure is hard to realize in practice, we develop symmetrical matching method with simple design procedure, high performance and easy implementation.
For the effect of practical matching circuit, the matching circuit in lossy condition is investigated using Q-factor of circuit parameters with planar network structure in a specific condition.

We furthermore propose a novel low noise model of single front-end MIMO (SF-MIMO) receiver system with parasitic antenna element (PAE) which includes arbitrary signal and noise coupling. Single front-end architecture with PAE in compact array system is investigated for enhancing spectral efficiency and miniaturizing the receiver. The proposed model articulates physical noise sources and relates their spatial correlation with array receive antennas, parasitic element, front-end and matching circuit. After that, the optimal PAE value is derived to maximize channel capacity. Finally, we demonstrate that SF-MIMO system with PAE impacts on performance through analytical and numerical results.

The main contributions of this thesis can be summarized as follows:

- Matching networks for low noise receiver in compact MIMO system with correlated fading and noise are examined. Conventional matching network based on multiport circuit is difficult to implement in practice due to the complexity of multi-layer realization. Assuming symmetrical channel characteristic, symmetrical array antenna and identical front-end, a so-called symmetrical matching of optimal low noise receiver is proposed for simple design procedure, high performance and easy implementation.
- For practical usage of the matching circuit, we theoretically derive the corresponding realization circuit parameters with reduced RF complexity. Furthermore, lossy condition within the matching circuit is studied in a specific realistic simulation condition. The numerical results for the effect of the lossy matching circuit confirm the theoretical and simulation predictions through discrepancies as Q-factor of inductor elements.
- As a new alternative low noise receiver design for compact MIMO system, we proposed new architecture receive design with single front-end (SF) system with parasitic antenna element (PAE). Another characteristic is required by antenna switching for signal multiplexing and SF-MIMO system. PAE affected by mutual coupling between array antenna can compensate for the switching penalty due to analog beamforming.

Chaper 2 presents an overview of the background related to the topic of this thesis. It starts from the introduction of wireless propagation channel. Then signal correlation models without mutual coupling and with mutual coupling are offered. Important MIMO channel model and MIMO capacity concept are discussed. As well as a rigorous form of the ergodic capacity, the asymptotic forms on 2×2 MIMO system are derived and calculated.

Chapter 3 studies a low noise matching model for compact MIMO system. System model using channel model, array antenna, front-end and matching network are employed. Matching network which plays an important role for maximization channel capacity is addressed. Different methods with multiport matching, symmetrical matching and identical self matching are reviewed and compared via simulation.

Chapter 4 describes multiport circuit realization of a two-element compact receiver.
Two network topologies for multiport circuit realization are discussed.
Although multiport matching circuit with coupled signal is difficult to realize, alternative optimal matching which is called as symmetrical matching is designed and lossy condition within the desired matching circuit is examined. In the end, the simulation results for verifying the effect of the proposed matching circuit are also included.

Chapter 5 investigates a new architecture receive system with SF and PAE for compact two array antennas. Two different schemes with SF-SIMO PAE and SF-MIMO PAE are developed for maximization channel capacity. Then the numerical results for verifying the effect of the proposed systems are conducted at certain conditions.