Abstract

The demands for high data rate services and applications in wireless communication have been growing exponentially for decades. To meet these demands of users, multi-input multiple-output (MIMO) wireless systems have been introduced. Space modulation technique (SMT) is a lately developed transmission scheme for the MIMO systems. All transmission schemes introduced in this thesis are based on the SMT principle. Further, the main idea of SMT is to exploit the space as an additional modulation dimension to convey the data. The principle state-of-the-arts of SMT are space shift keying (SSK) and spatial modulation (SM). Furthermore, since SMT requires a single radio frequency (RF) chain to transmit information, it thus reduces the system design complexity and improve the energy efficiency (EE).

The study begins with the spatial constellation design and performance analysis of the SSK modulation with limited-feedback. In SSK, antenna index (AI) is denoted by the spatial constellation symbol. The bit-to-spatial mapping of spatial constellation symbols is adapted according to the partial channel state information (CSI) of the fading channels. More specifically, transmitter (Tx) does not receive perfect information of channel gain, but it is aware about the channel gain ordering. Based on the received partial CSI, Tx adapts the spatial constellation mapping and allocates transmit power weights to each transmit antenna (TA). Furthermore, the power adapted spatial constellation symbols are encoded by using gray coding scheme, which results in unit Hamming distance between adjacent spatial constellation symbols. In addition, maximum–likelihood (ML)-detector exploits to detect an active TA index of the multiple-input single-output (MISO) system. Accurate expressions for the average bit error rate (ABER) for 2×1 and 4×1 MISO systems over Rayleigh fading channel are

derived. Further, an approximate expression for the ABER of a generalized MISO system is also obtained. It is shown analytically that the ABER performance of the proposed SSK scheme can be improved by applying a non-uniform power allocation (PA) to make transmit links more distinguishable at the receiver (Rx). Moreover, we demonstrate analytically that the proposed scheme attains a diversity order which is twice of the conventional SSK scheme.

We than venture into the area of physical layer security (PLS) analysis for SSK-MISO system. The bit-to-spatial mapping of the spatial constellation symbols is adapted according to the partial CSI of the legitimate channel at Tx. Further, Tx also adapts transmit PA weights to each TA according to the partial CSI. Since an eavesdropper (Eve) is not (usually) aware of the legitimate CSI, it cannot successfully decode the AI; thus, transmission over the legitimate channel is secured from the wiretapping of Eve. An important virtue of the proposed scheme is that the Tx does not require full CSI of the legitimate and eavesdropper channels to secure the confidential information. The proposed work focuses on the secrecy rate (SR), secrecy outage probability (SOP), and ABER of the considered MISO system over Rayleigh fading channels. Approximate expressions of Bob's data rate for 2-ary and 4-ary SSK modulations are derived in the closed-form. Furthermore, an upper-bound of Bob's data rate for N_a-ary SSK modulation is also derived. In order to obtain the SR of the proposed scheme, we also evaluate Eve's data rate. Analytical results of SR, SOP, and ABER demonstrate the robustness of the proposed scheme.

Further, we extend our work on PLS to SM-MIMO system, where mapping of the spatial constellation and signal constellation are adapted. In SM-MIMO system, partial CSI of the legitimate channel is exploited by Tx to dynamically adapt the spatial and signal constellations mapping patterns. Thus, Eve cannot successfully decode the confidential information over the wiretap channel, since it does not aware of the spatial and signal constellation mapping rules. Further, an important virtue of the proposed transmission scheme that the Tx does not need to know the full CSI of Eve and legitimate channels. To demonstrate the security guaranteed by the proposed scheme, ABER, SR, and SOP are evaluated.

Apart from this, we present a spectral efficiency (SE) enhancing scheme for a single RF chain MIMO system. We present a quadrature spatial modulation-assisted full-duplex (QSM-FD) communication scheme for the MIMO systems, where transmit and receive antennas are co-located at each node. These antennas can be utilized as either transmit or receive antennas for a symbol duration, which implies that the proposed QSM-FD scheme is implemented with half-duplex (HD) antennas. An adaptive analog self-interference (SI) cancellation model is presented to reduce the SI to a desirable level. An ML-detector is employed that is subject to the residual SI. An upper bound of the ABER for the proposed scheme is also derived. Furthermore, we provide the analytical framework of the ergodic capacity (EC), system throughput, and ergodic spectral efficiency for the proposed QSM-FD scheme.

Finally, the idea of smart propagation environment is introduced, where modulated information carrying signal intentionally modified on the propagation medium to improve the system performance. We present a reconfigurable intelligent surface (RIS)-assisted SSK modulation and reflection phase modulation (RPM) scheme, where RIS embeds its own information in the reflection phase shift of the reflected RF signal. More specifically, the RIS simultaneously performs two tasks: i) reflecting the impinging RF signal with a discrete phase shift and ii) embedding the information bits in the phase shift. We perform joint detection for the RPM and SSK symbols using an ML-detector, and a unified analytical framework is presented for theoretical analysis of the ABER and EC of the proposed scheme. All numerical results are thoroughly verified through the Monte Carlo simulation. Numerical results reveal that the proposed scheme outperforms the conventional SSK scheme.