Synopsis

Title of the Thesis : Precoding and Channel Estimation Schemes for MIMO VLC Systems

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Increase in the usage of smartphones and growing demand for data have resulted in congestion in the RF spectrum. To ease the overcrowding of RF spectrum, there is a need for wireless communication systems that can complement RF based communication systems. Visible light communication (VLC) is proving to be an attractive alternate for wireless communications in indoor and vehicular environments. In VLC, light emitting diodes (LEDs) and photo detectors (PDs) serve as transmitters and receivers, respectively. Using multiple-input multiple-output (MIMO) techniques is one way to increase the spectral efficiency. Spatial multiplexing (SMP), spatial modulation (SM), generalized spatial modulation (GSM), dual-LED complex modulation (DCM), and quad-LED complex modulation (QCM) are some of the MIMO modulation schemes that are suited for MIMO VLC. The degrading effect on the performance of the modulation schemes due to the presence of high degree of spatial correlation is one of the major issues in MIMO VLC systems. We consider the use of precoding at the transmitter as a promising approach to alleviate this issue. Most precoding schemes require channel state information at the transmitter (CSIT). CSIT is usually obtained by estimating the channel at the receiver and sending this estimate to the transmitter through feedback. Therefore, the performance of these precoding schemes depends on the accuracy of channel estimation. In this thesis, our main focus is on designing precoding schemes and channel estimation schemes for MIMO VLC systems. Our contributions can be classified into three parts as follows.

In the first part, we propose two efficient precoding schemes for point-to-point MIMO VLC systems which employ DCM and QCM schemes. The first proposed precoder is for DCM, and it is termed as "optimized diagonally precoded DCM" (ODP-DCM). In ODP-DCM, symbols emitted by the LEDs are weighted such that the normalized

minimum distance of the received signal set is maximized. The second precoder is for both DCM and QCM, and it is termed as "pseudo-random phase precoded DCM/QCM" (PRPP-DCM/QCM). In PRPP-DCM/QCM, pseudo-random phase matrices which do not need any channel knowledge at the transmitter for their construction are used as the precoding matrices. Numerical results show that the proposed precoding schemes achieve good performance and alleviate the effect of spatial correlation in MIMO VLC channels.

In the second part, we are concerned with precoding in point-to-point and multiuser MIMO VLC systems under maximum and average power constraints. Average power constraint is considered to ensure that the LEDs maintain a desired intensity of light for the purpose of illumination. Maximum power constraint arises due to the maximum current rating of the LEDs. We propose a weighted precoding scheme for point-to-point MIMO VLC which uses suitable scaling and DC-biasing to satisfy the aforementioned power constraints. We also consider the extension of this scheme to multiuser MIMO VLC using block diagonalization. Results show that SMP and DCM schemes achieve significant improvement in performance by using this precoding technique in both point-to-point and multiuser MIMO VLC systems.

In the third part, we are concerned with channel estimation in VLC systems under maximum and average power constraints. In particular, we consider extensions to combinational codes for optimal pilot transmission assuming that the receiver employs a zero-forcing decoder. We construct optimal codes which need much fewer pilot channel uses for channel estimation compared to that needed by combinational codes. We propose a recursive algorithm to construct such codes that are short in length and meet the optimality constraints. The bit error performance achieved using the estimates of the channel obtained using the proposed codes are shown to be quite close to that with perfect channel knowledge.