TITLE OF THE THESIS : EFFICIENT TIMING AND FREQUENCY SYNCHRONIZATION FOR MULTI-BAND OFDM BASED ULTRA-WIDEBAND SYSTEMS

AUTHOR : DEBARATI SEN

ABSTRACT :

The ubiquitous trend to "go wireless" is a symbol of our need for independence and flexibility. To allow for such an "all-wireless" world, large amounts of information with widely varying content have to be exchanged with high speed, utilising low power and low cost. Ultra-wideband (UWB) is a leading contender for enabling this capability. Multi-band orthogonal frequency division multiplexing (MB-OFDM) based transmission of UWB signal is an attractive solution for high speed (480 Mbps and beyond), low power, low cost, short range communication systems. MB-OFDM is a combination of multicarrier data communication using OFDM and the frequency hopped transmission of the OFDM symbols over multiple frequency bands. Reliable timing offset and carrier frequency offset (CFO) estimation are vulnerable issues for this system to achieve an acceptable bit-error performance. Dispersive wireless channel, oscillator frequency drift and Doppler frequency shift are the main reasons for timing offset and CFO in OFDM-UWB systems. The frequency dependent dispersive effects of UWB channel on a received waveform and frequent arrival of stronger multipath component on delayed clusters make synchronization a more challenging task in a UWB receiver. This necessitates innovative approach for good signal reception and detection in receiver. After a thorough review of the literature and motivated by the deficiencies of the existing synchronization schemes, in this thesis, we address the issue of design and analysis of fast timing and frequency synchronizers of low complexity for MB-OFDM UWB receivers which result in good performance even in low SNR region (≤ 8 dB).

In the first part of the thesis work (Chapter 3 and Chapter 4), we investigate the issue of CFO estimation in MB-OFDM systems and propose an iterative CFO estimation scheme over a single-band which yields a good bit error rate (BER) performance. Then we explore an improved CFO estimator by incorporating the multi-band transmit diversity. This estimator lowers the estimation error variance by about three times compared to the single-band based scheme. Both the estimators improve error variance than other existing algorithms in low SNR zone (≤ 8 dB). Performances of both the estimators are evaluated in terms of computational complexity and Cramer-Rao lower bound (CRLB). In the next portion (Chapter 5 and Chapter 6) we propose two timing synchronizers: first one is cross-correlation function (CCF) based and applicable for transmission over single-band; the second scheme is energy based, fast, compatible to frequency dependent dispersive effect of multi-band transmission. Performance evaluation of the timing synchronizers includes probability of correct detection of timing instant and sign al-to-interference ratio (SIR). Extensive simulation studies of these parameters along with the BER performance for coded and uncoded systems and mean squared error (MSE) are also provided. Chapter 6 also deals with the derivation of a simplified expression of BER for a coded UWB system including both of our proposed multi-band synchronizers under log-normal faded UWB channel. A comparison between the analytical expression and the simulation result exhibits a good match.

KEY WORDS – Ultra-Wideband, MB-OFDM, Synchronization, Carrier Frequency Offset, Timing Estimation, BER Analysis, SNR, MSE, Synchronization Probability