ABSTRACT

Wireless relay networks provide extended cell coverage and reduced power consumption. In One Way Relay Network (OWRN), the data transmission is unidirectional in which source node sends information to relay node and then, the relay node sends it to destination nodes. Unlike OWRN, in bidirectional relay network, two source nodes exchange their information through a relay node and thereby doubling the data rate. Network coding is a potential and powerful tool in designing communication networks. It combines and extracts information through simple Galois field additions and multiplications. Using the concept of network coding at the relay node, bidirectional relay network achieves data transfer in three time slots compared to the traditional requirement of four time slots. Later, it is proved that Physical Layer Network Coding (PLNC) at relay requires only two slots to exchange information. As practical wireless communications experience the scattered and delayed propagation paths, Orthogonal Frequency Division Multiplexing (OFDM) is used to overcome the effect of frequency selective fading. The concept PLNC is combined with OFDM to enhance the throughput of a bidirectional relay network over frequency selective fading channel. However, the presence of Radio Frequency (RF) impairments namely, In-phase and Quadrature (I/Q) imbalance and phase noise severely affect the performance of OFDM based bidirectional relay network. I/Q
imbalance are the amplitude and phase mismatches between the in phase and quadrature branches of a wireless transceiver. The phase noise is a time varying drift in the local oscillator phase from the reference phase. The I/Q imbalance and phase noise in transceivers of OFDM based PLNC network manifest as Inter Carrier Interference (ICI) there by lowering the capacity and Bit Error Rate (BER) of bidirectional wireless relay network.

The contributions of this thesis are modeling and analyzing the performance of the OFDM based bidirectional wireless relay network in the presence of frequency dependent and frequency independent I/Q imbalances and phase noise. In PLNC based bidirectional relay network, exchange of signals between the source nodes is achieved in two time slots. In first time slot, OFDM signals are transmitted from both the source nodes to a relay node and the Decode and Forward (DF) relay detects the symbols from the source nodes using the concept of PLNC. In second time slot, based on the detected symbols, an OFDM signal is transmitted to both the source nodes. Analytical expressions are derived for the Signal to interference and Noise Ratio (SINR) at the relay node in the first time slot and at the source nodes in second time slot in the presence of I/Q imbalances. Further, tight upper and lower bound expressions for outage probability and bit error rate at both the time slots are derived analytically. Based on the derived analytical expressions, numerical simulations are carried out to analyze the effect of I/Q imbalances and phase
noise on outage probability and BER for an OFDM based bidirectional relay network.

Based on the numerical analysis, it is observed that both the RF impairments are highly sensitive in bidirectional relay network. As both the I/Q imbalances and phase noise cannot be mitigated in practice, it becomes necessary to find a suitable transceiver structure to suppress the effect of I/Q imbalance and phase noise on BER and outage performance. It is well known that the use of multiple antennas at transmitter and/or receiver greatly improves the link reliability and data rate. However, the use of multiple antennas is not straightforward in PLNC and OFDM based bidirectional relay network since the concept of PLNC cannot be simply applied at the relay node with multiple antennas. In this thesis, a novel architecture with multiple antennas at source nodes is proposed. In the proposed network, source nodes employ multiple antennas and relay node has single antenna. The concepts of Transmit Antenna Selection (TAS) and Maximal Ratio Combining (MRC) are applied at the source nodes in first and second time slots respectively to exploit spatial diversity to improve the outage and BER performance in the presence of I/Q imbalance and phase noise.

The contribution of this thesis is to model and analyze the performance of the proposed bidirectional relay network in the presence of frequency dependent and frequency independent I/Q imbalances and phase noise. Analytical expressions are derived for SINR, outage and BER at both
the time slots. It is proved that the proposed transceiver performs better than the conventional network in the presence of I/Q imbalances and phase noise. The outage and BER performance analysis made in this thesis in the presence of I/Q imbalance and phase noise for the conventional bidirectional relay network and the proposed multiple antenna based transceiver model of bidirectional relay network would be helpful for the practicing engineers.