OFDM Transmission via Magnetic Induction in Highly Conductive Environments

Farouk Jawhari[2]**, Guillaume Ferré**[1]**, Dominique Dallet**[2]

[1]SIGNAL AND IMAGE PROCESSING, IMS-Lab
[2]CSN, IMS-Lab

This study considers the challenge of wireless communication in highly conductive underground environments (in drilling operations, the mud can exhibit extremely high conductivity, often around 100 S/m), where attenuation can reach over 200 dB at a distance of 0.5 m [2]. We draw on the dual capabilities of Magnetic Induction (MI)[1] and Orthogonal Frequency Division Multiplexing (OFDM) paired with a new, optimized propagation path model that estimates extreme losses across distances of up to 7 m. We implement a MATLAB script to adaptively refine the usable channel bandwidth as a function of the measured channel loss and utilize coil designs that allow up to 100 turns to achieve an additional 2 to 3 dB improvement on uninformed coil designs. To combat frequency-selective fading, pilot symbols are inserted and channel equalization is performed, and to approximate realistic underground constraints, the transmitter power is restricted to 1 W.

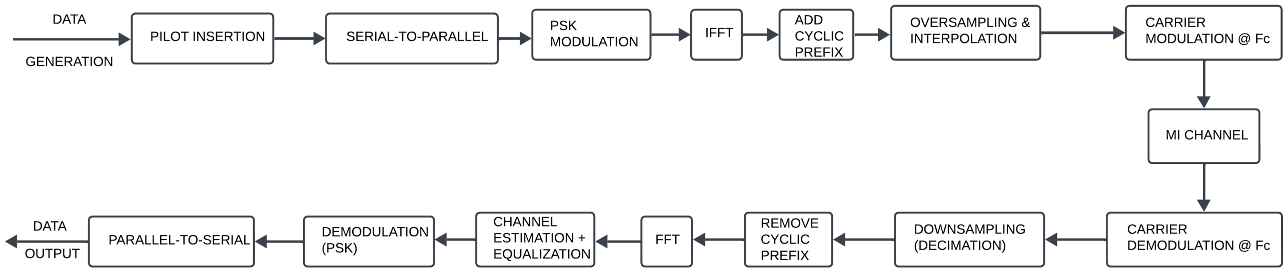

Figure 1: System Block Diagram

The results of the numerical simulation reveal the possibility of QPSK transmission over distances of 3.5 m before the roll-off becomes significant enough to motivate a transition to BPSK greater than 4 m; while resulting in a reduction in the data rate by 50%, the bit error rate remains tractable. The desire to minimize large losses at high conductivity emphasizes the advantage of judicious treatment of bandwidth, and the contribution of sophisticated error correction could be used to increase reliability at increased ranges. Although these optimizations prove the feasibility of short-range MI-OFDM in 100 S/m media, field tests are still required. The work is ongoing, with efforts that include helping to validate the model against hardware tests and optimizing error correction strategies to maximize the effective communication distance for the challenging subterranean environment.

References

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