

## **Abstract**

A Single Frequency Network (SFN) refers to a network configuration in which multiple transmitters simultaneously broadcast the same content using the same time and frequency channel. In an SFN, the transmitters are geographically distributed, often with overlapping coverage areas [1]. CP-OFDM or Cyclic Prefix-Orthogonal Frequency Division Multiplexing is the cutting-edge method used to implement SFN in the physical layer. It offers numerous benefits that render it highly suitable for SFN broadcasting. CP-OFDM effectively handles multi-path propagation by incorporating a cyclic prefix, which mitigates signal self-interference and distortion. This capability significantly decreases errors in the received signal, making it particularly crucial in SFN broadcasting scenarios where multiple transmitters' signals may interfere with one another.

5G-NR (5G New Radio) refers to the air interface standard utilized in 5G wireless networks. It plays a vital role in enhancing performance and capabilities compared to previous cellular network generations. Release 15 of 5G-NR, as defined by the 3GPP (Third Generation Partnership Project) [2], primarily focuses on uni-cast transmission and provides a wide range of services through its physical layer. However, the numerologies employed in Release 15, which include a short cyclic prefix, are not suitable for establishing a SFN broadcast network with large inter-site distances. In response to the need for broadcasting and multi-casting capabilities, particularly through LTE-based 5G broadcast, Release 17 was introduced [3]. Nonetheless, the numerologies used in LTE-based 5G broadcast differ from those in 5G-NR, and only a 15 kHz common numerology is available.

Consequently, it is currently not feasible to utilize the numerologies employed in 5G-NR for SFN broadcasting with significant inter-site distances using a traditional receiver structure.

This thesis presents an innovative approach to enable SFN broadcasting over long distances using the 5G-NR. Instead of introducing new numerology options, the thesis focuses on employing advanced receiver techniques.

The first receiver implementation involves the use of optimal channel shortening techniques to equalize the OFDM symbols affected by strong inter-symbol interference (ISI) and inter-carrier interference (ICI). By utilizing this method, SFN broadcasting can be achieved over large inter-site distances, comparable to high-power, high-tower transmission networks, while adhering to the standard 5G numerologies. Through the investigation, it was discovered that a linear channel shortening filter, specifically the 2D-MMSE (Minimum Mean Square Error), can provide near maximum mutual information, assuming a static channel that is known by the receiver.

The second receiver implementation introduces a novel approach to achieving high performance in SFN Terrestrial Broadcasting using 5G-NR. This method utilizes a Recurrent Neural Network (RNN)-based receiver, eliminating the assumption of a static and well-known channel, which was made in the first receiver design. Additionally, a technique of superimposing the pilot signal with the data signal is employed, allocating 100% of the resources to data transmission, thereby enhancing spectral efficiency. The receiver receives a sequence of demodulated OFDM symbols and performs joint channel equalization, channel estimation, and log-likelihood ratio (LLR) computation. The LLR output is then utilized by the channel Low-Density Parity-Check (LDPC) decoder to recover the transmitted data. Simulation results demonstrate that the proposed system can achieve performance similar to classical systems specifically designed for rooftop reception and various mobility scenarios.

Furthermore, the proposed system exhibits high flexibility as it is trained under fixed signal-to-noise ratio (SNR) and speed conditions, yet it demonstrates excellent performance in unseen conditions according to the simulations. Although the RNN-based receiver was initially designed for SFN terrestrial broadcasting systems with mobility, the techniques employed in the design can be applied to any OFDM-based system experiencing strong ISI and ICI. This proposed approach has the potential to simplify the design and deployment of 5G-NR SFN broadcasting, reducing the requirement for additional hardware or software modifications.

While the research yields promising results, there are still several areas that warrant further investigation for future studies. One important aspect to consider is the complexity of the proposed systems and other factors that can impact SFN

networks, such as synchronization. Additionally, it is worth noting that the research conducted was limited to link-level simulations, and further validation at the system level is necessary to comprehensively evaluate the performance of the proposed methods.