Abstract: This paper considers the use of massive multiple input, multiple output (MIMO) combined with single-carrier with frequency-domain equalization (SC-FDE) modulations, associated to millimeter wave (mm-Wave) communications. A comparison of the proposed massive MIMO using pre-processing (precoding) and post-processing is performed in this paper. In this paper, we consider three different types of pre and post-processing algorithms: Zero Forcing (ZF), Maximum Ratio Combining (MRC), and Equal Gain Combiner (EGC). The advantage of both MRC and EGC relies on avoiding the computation of pseudo-inverse of matrices. Their performance of MRC and EGC can be very close to the matched filter bound just after a few iterations of a new proposed interference cancellation, even when the number of receive antennas is not very high.

Massive MIMO schemes involving several tens or even hundreds of antenna elements are expected to be central technologies for 5G systems. To avoid implementation complexity, massive MIMO schemes should have low complexity, namely by using simple techniques to separate data streams that avoid matrix inversions inherent to conventional MIMO receivers. 5G (Fifth Generation) systems are supposed to have much higher capacity and spectral efficiency requirements than current systems, and many techniques are independently emerging for these systems. mm-Wave communications are expected to be a crucial part of 5G systems due to their increased channel coherence bandwidth, as compared to centimeter Wave, and there are already some standards like 802.11ad. These systems use carrier frequencies above 30 GHz where we have large unoccupied bandwidth (there are proposals for several bands in the vicinity of 40GHz, 60Ghz, 70GHz, or even above). However, mm-Wave transmission has important problems like high free-space path losses, very small diffraction effects, huge losses due to obstacles and implementation difficulties, namely with the power amplification. On the other hand, the small wavelength means that we can have small antennas and small-sized antenna aggregates with a large number of elements, facilitating the deployment of massive MIMO (m-MIMO) schemes. Moreover, the high reflection effects can be used to improve coverage. By taking advantage of these characteristics we can design mm-Wave communications with capacities several orders magnitude above current wireless systems. In fact, mm-Wave systems can take full advantage of techniques like small cells networks (pico or femto) and m-MIMO schemes. By combining small cells with m-MIMO systems we can have large gains to cope with propagation losses and/or accommodate a large number of co-channel users, with high frequency reuse.

As with other wireless systems, mm-Wave communications should have high power and improved spectral efficiencies, which are conflicting requirements. In general, high spectral efficiency means using large constellations and strictly band-limited signals, which have high power requirements and the inherent high peak-to-average power ratio (PAPR) leads to low amplification efficiency.

Block transmission techniques, with appropriate cyclic prefixes and employing FDE techniques (Frequency-Domain Equalization), have been shown to be suitable for high data rate transmission over severely time-dispersive channels. OFDM (Orthogonal Frequency Division Multiplexing) is the most popular modulation based on this technique. Single Carrier (SC) modulation using FDE is an alternative approach based on this principle. As with OFDM, the data blocks are preceded by a cyclic prefix, long enough to cope with the overall channel length. Due to the lower envelope fluctuations of the transmitted signals (and, implicitly lower PAPR), SC-FDE schemes are especially interesting when a low-complexity and efficient power amplification is required.

A promising Iterative Block – Decision Feedback Equalization technique (IB-DFE) for SC-FDE was proposed and extended to other diversity and spatial multiplexing scenarios. These IB-DFE receivers can be regarded as iterative DFE receivers where the feedforward and the feedback operations are implemented in the frequency domain offering much better performance than non-iterative methods. IB-DFE receiver can also be regarded as turbo equalization schemes that are implemented in the frequency-domain.

In the downlink direction, since the base station has improved computing capabilities, as compared to mobile terminals, a better m-MIMO approach relies on using precoding. A disadvantage of the precoding using the ZF algorithm relies on the need to compute the pseudo-inverse channel matrix, for each frequency component. In this paper, we avoid this by implementing the m-MIMO using both precoding and post-processing based on MRC and EGC. Since these algorithms originate a certain level of interference, we include an interference cancellation process, whose design is based on the IB-DFE receiver, which makes these algorithms performing very close to matched filter bound.

In this paper we propose an m-MIMO architecture using an efficient precoding using broadband mm-Wave communications that can employ highly efficient, low-cost saturated amplifiers.

Keywords—Massive MIMO, precoding, SC-FDE, 5G, Interference Cancellation, mm-Wave.