Analog-to-Digital Conversion Schemes in Beyond-Fifth and Sixth Generation Wireless Communication Systems

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A Thesis for the Degree of Ph.D. in Engineering

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Thesis Abstract

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Thesis Title

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Thesis Summary

With a marked rise in a plethora of wireless devices and emerging use cases in the future, larger data traffic needs to be supported. The development of the existing fifth generation (5G) network is designed to satisfy these demands. Furthermore, increasing factory automation and the transition from Industry 4.0 to the upcoming Industry X.0 paradigm will accelerate the demands of wider coverage and higher connection density in 5G designs. In recent years, massive MIMO has been implemented in two ways, namely centralized and distributed antenna deployment. For reducing cost and power consumption, massive MIMO communications adopt hybrid transceivers, which combine analog phase shifters and power amplifiers with digital signal processing units. However, hybrid-mode implementations are confronted with inter-user interference (IUI) due to a larger beamwidth. On the other hand, using a low-resolution analog-to-digital converter (ADC) in the BS can also achieve better energy efficiency (EE), but it will cause severe quantization distortion in a received signal. With the trends of ADCs, current research indicates that low-resolution ADCs are very promising for massive MIMO and cell-free networks. Therefore, the focus of this thesis tends to address the above challenges to better improve the spectral efficiency (SE) and the EE of the system, and we assert that the ongoing research on massive MIMO and cell-free distributed antennas are the key to future wireless communications. To this end, a low-complexity and low-power full-digital receiver with a practical quantized signal detection scheme is designed. Further, an adaptive-resolution (AR) ADC scheme is proposed to the cell-free distributed antenna system to mitigate the serious quantization distortion.

Chapter 1 is the introduction. It mainly describes the evolution of wireless communication systems, the major demands of beyond-5G and the sixth generation (6G), the key issues of current 5G networks, and related research motivations.

Chapter 2 is the design of a low-power and low-cost massive MIMO system. It includes a quantization range control scheme in a massive MIMO system with low-resolution ADCs and the selection of detection schemes to derive effective ADC quantization range limit coefficients and reduce computational complexity for the system, respectively.

Chapter 3 is the design of ADCs in the access points (APs) of a cell-free distributed antenna system (DAS). AR-ADC scheme is proposed for each AP, and it can refer to factors such as propagation loss, quantization distortion, and IUI, and then reasonably switch a flexible low-resolution ADC component to improve system throughput and reduce energy consumption.

Chapter 4 summarizes the results of this thesis and presents conclusions with future works.