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Millimeter-Wave Sourceless Receiver Array

Ruizhi Liu*, Ke Wu
Poly-Grames Research Center, Polytechnique Montréal, Montréal, QC, Canada, H3T 1J4

1. Extended Abstract

In the currently much-anticipated 5G wireless communication systems, there are two critical requirements, namely high spectral efficiency and high energy efficiency. With these two specifications in mind, transmission data rate at 10 Gbps and beyond should be expected. Judging from hardware architectures and implementations, millimeter-wave technologies may represent a promising candidate for high-speed wireless networks owing to its available spectral resources. Naturally, the size of circuits and systems at millimeter-wave frequency is relatively small, which may be easy to integrate.

However, conventional millimeter-wave receivers have their own issues in practical applications. In the deployment of current wireless systems, the scale of a receiver antenna array is quite substantial and may contain many independent channels. AC (LO – local oscillator) and DC sources should be provided to each channel to ensure its signal and energy supply. Therefore, a complex and costly feeding and biasing network needs to be designed and implemented in the receiver array. As operating frequency goes up, transmission loss would increase. Consequently, the feeding and biasing network over the millimeter wave band can lead to a serious power budget and efficiency issue.

To this end, some attempts have been made to improve the energy efficiency issue of millimeter-wave receivers. Fukuda et al. came up with a scheme of local-oscillator-less mobile stations [1]. In their work, the internal AC (LO) source is replaced by a CW extraction loop (a sort of carrier recovering technique), which can detect the CW source received by antennas. In this way, the AC feeding network can be replaced by the embedded CW extraction loop, which presents an excellent way of simplification. However, the biasing network for power supply still needs to be arranged in the circuit topology.

To enhance the energy efficiency further, a millimeter-wave sourceless receiver embedded with DoA estimation is proposed by our research group [2]. Compared with the conventional receivers, our sourceless receiver architecture is totally passive. AC source and DC power supply with their wired networks are eliminated, which reduces the transmission loss introduced by such networks. The sourceless receiver we designed is also designed together with the function of DoA estimation [3], which could detect the incident angle of RF signals. However, the detecting distance is not far enough and the DoA estimation is limited to only one dimension for the early demonstrations.

In this paper, a millimeter-wave sourceless receiver architecture is designed to fulfill the requirements of high energy efficiency in connection with 5G wireless network design. To mitigate the performance degradation issue caused by the feeding and biasing networks, the proposed receiver is designed as a total passive architecture. The core part of the proposed receiver is related to millimeter-wave antenna array and six-port network with coherent demodulation. By improving the DoA estimation technique based on six-port networks, the proposed receiver can estimate the three-dimensional spatial location of RF signal received, which can be applied to the development of a smart array system which will be widely used in future wireless networks.

2. References

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