Fixed-Point Arithmetic for Implementing Massive MIMO Systems

Mi Tian, Mihai Sima, and Michael McGuire

Department of Electrical and Computer Engineering, University of Victoria
P.O. Box 1700 Stn CSC, Victoria, B.C. V8W 2Y2, Canada
tianmi66@uvic.ca, msima@ece.uvic.ca, mmcguire@uvic.ca

Abstract—Massive MIMO base stations are expensive to build due to the requirement for a large number of RF transceivers and high-resolution analog-to-digital converters. A way to reduce the implementation cost is to build the base stations with inexpensive hardware, resulting in the received signals to be coarsely quantized. First, the required signal power needed to achieve different receiver Bit-Error Rate (BER) levels is determined, as well as the extra signal power needed due to the quantization for given BER levels. To implement the data detection and decoding process in real time, fixed-point arithmetic with reduced precision is used. This article also reports the minimum wordlength needed to maintain the BER at acceptable levels. Specifically, the eigenvalue decomposition, which is the most computationally demanding portion of the receiver algorithm, can be calculated with wordlengths of 7 and 10 bits for eigenvectors and eigenvalues, respectively.

Keyword—Massive MIMO, fixed-point arithmetic.

Mi Tian was born in the People’s Republic of China in 1988 and received her B.S. degree in optical communications engineering from Jilin University, Changchun, Jilin, China, in 2010, her M.S. degree in analogue and digital integrated circuit design from Imperial College London, U.K., in 2011, and her Ph.D. degree from the University of Victoria, British Columbia, Canada, in 2021. She is currently a postdoctoral fellow in the Department of Electrical and Computer Engineering at the same institution. Her research interests include wireless communication systems, hardware implementation on FPGAs of massive MIMO communication systems.

Mihai Sima (S’00-M’04) was born in Romania in 1964 and received his B.Eng. degree in electronics engineering from Polytechnic Institute of Bucharest, Romania in 1989, and his Ph.D. degree in computer engineering from Delft University of Technology, The Netherlands, in 2004. Since 2003, he has been a faculty member in the Department of Electrical and Computer Engineering at the University of Victoria, British Columbia, Canada. His research interests include computer architecture and engineering, reconfigurable computing, embedded systems, circuit design, and hardware security.

Michael McGuire (S’95-M’97) was born in Canada in 1970 and received his B.Eng. in computer engineering from the University of Victoria, British Columbia, Canada, in 1995, his M.A.Sc. in electrical engineering from the same institution in 1997, and his Ph.D. from the University of Toronto in 2003. Since 2003, he has been a faculty member in the Department of Electrical and Computer Engineering at the University of Victoria. Dr. McGuire's research area is in the application of signal processing to communications, developing new techniques for Faster-than-Nyquist signaling, iterative channel estimation/data detection, and wireless radio localization suitable for advanced wireless systems.