Ain Shams University

Faculty of Engineering

Electronics & Communications Engineering Department

A Massive MIMO Digital Beamforming mmWave Transceiver for 5G

Graduation Project

Academic Year 2024 - 2025

Introduction:

Base stations consisting of large numbers of antennas that simultaneously communicate with multiple spatially separated user terminals over the same frequency resource and exploit multipath propagation are one option to achieve high spectral efficiency. This technology is often referred to as massive MIMO (multiple-input, multiple-output).

Beamforming is the ability to adapt the radiation pattern of the antenna array to a particular scenario. In the cellular communications space, many people think of beamforming as steering a lobe of power in a particular direction toward a user.

Analog beamforming adjusts the phase of signals using analog components, making it more power-efficient but less flexible, as the entire array shares a single RF chain as in Fig. (a). Digital beamforming processes signals digitally, allowing for more precise and adaptive control of beams, with each antenna having its own RF chain as in Fig. (b), but at the cost of higher power and complexity.

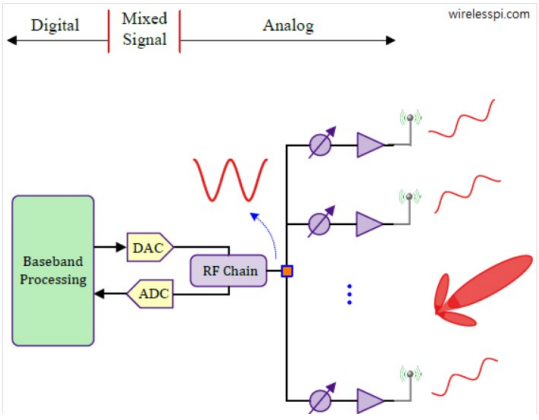

Fig. (a)

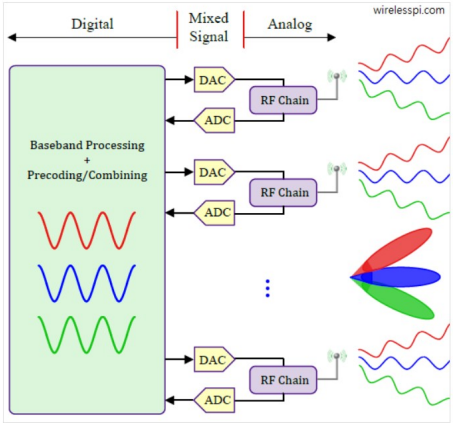

Fig. (b)

System Description:

In Fig. (c) The proposed system is an RF to Bits Chain that transfer signal from Bits to beams for both transmitter and receiver systems. The chain include three main domains, an RF front end domain that transfer the signal from and to the digital end sustaining its quality and operational specifications for a Macro wide area operation, the Analog Mixed Domain transfer the signal from the RF Front End to the Digital End, while digital domain processes the data for beamforming operation including needed phase shifting, filter and processing as up and down conversion that hence allow the full bits to RF operation. Finally comes the Serdes interface to allow high speed digital data to be transmitted and received within a standardized approach following the JESDB interface that will allow the system to be efficient, reliable and agile in its operation. This system expresses the real operation of a modern transceiver system that is necessary for modern MIMO and Massive MIMO in the mmWave ranges.

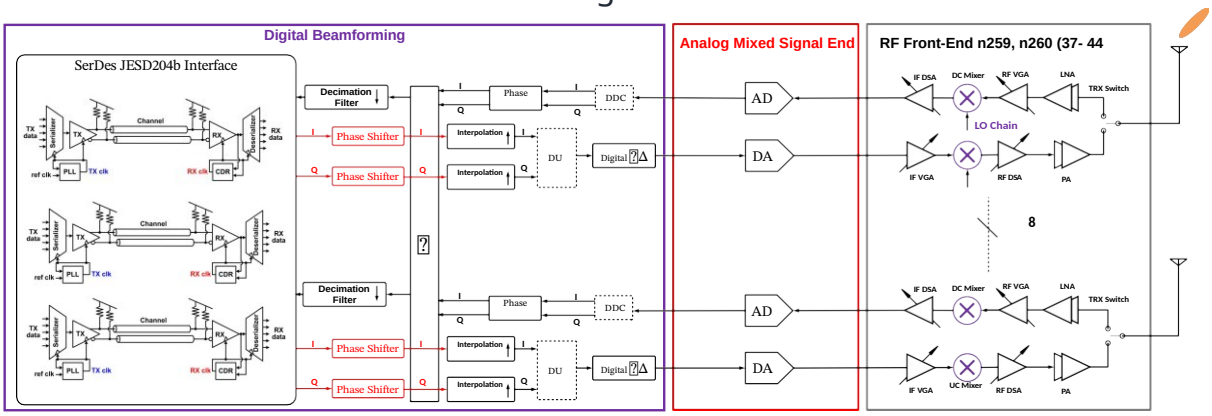

Fig. (c)

Objective:

There are several frequency bands dedicated to the 5G standard: the sub-6-GHz range mainly less than 6 GHz and the mmWave range between 24 GHz and 55 GHz.

The objective of this project is to design a low-power digital beamforming architecture dedicated to 5G at 39 GHz.

The Project includes:

- System Modelling and Digital Design of the transmitter blocks (Arranged respectively after Serdes):
    - Phase Shifter
    - Interpolation filter
    - Digital up converter
    - Digital sigma delta

- System Modelling and Digital Design of the receiver blocks (Arranged respectively after ADC):
    - Digital Down converter

- Phase shifter
- Digital sigma Delta
- Decimation filter

Number of students: 7

Deliverables & Timeline:

- Three Months: System Modelling using MATLAB/Simulink.
- Two Months: RTL Design.
- Two Months: ASIC flow (Logic Synthesis , Place & Route).

Supervisors:

- Dr. Michael Ibrahim: michael.ibrahim@eng.asu.edu.eg
- Dr. Theodora Mamdouh: theodora.mamdouh@eng.asu.edu.eg

References:

- Analog Devices article-Massive MIMO and beamforming
- Wirlesspi article-Difference between Analog and Digital BPF