# Implementing JRC Transceiver on RFSOC

## Technology Description

n the millimeter-wave and sub-6 GHz bands, next-generation wireless communication systems are expected to support high-mobility Vehicle-to-Everything (V2X) communication services. These systems require precise user tracking to form well-directed beams and achieve the desired throughput. One promising solution is Joint Radar-Communication (JRC) systems, which offer accurate localization without the need for separate radar transceivers and dedicated spectrum. JRC systems achieve this by embedding radar waveforms within the communication spectrum.

This project aims to develop High-Level Synthesis (HLS) Intellectual Properties (IPs) for JRC transceivers on FPGA. We will conduct functional and complexity analysis across different wireless channel environments, target patterns, and word lengths. Our novel contributions include hardware IPs for LDPC (Low-Density Parity-Check) encoders and decoders, scramblers and descramblers, QPSK (Quadrature Phase Shift Keying) modulators and demodulators, as well as IEEE 802.11ad/ay-based OFDM PHY layers for both single and multi-antenna systems, and beamformers.

The project's objective is to demonstrate the Bit Error Rate (BER) between the input and output codewords, showcasing the effectiveness of the JRC system in various conditions.

## Theme

This project is based on a combination of **wireless communication technology**, **joint radar-communication (JRC)** systems, and **FPGA-based hardware development**. It leverages advanced **signal processing** techniques for modulating and demodulating signals (such as QPSK) and utilizes **OFDM (Orthogonal Frequency Division Multiplexing)** for high-throughput communication in the millimeter-wave and sub-6 GHz bands. The project also involves the development of **HLS IPs** on FPGAs for key components like LDPC encoders and decoders, scramblers, and beamformers. Overall, it focuses on enhancing V2X communication through precise user tracking and efficient spectrum usage.

## Applications

- **Vehicle-to-Everything (V2X) Communication:** Enhances real-time communication and tracking for autonomous driving and smart transportation.
- **Autonomous Vehicle Navigation:** Enables precise localization and obstacle detection for self-driving cars.
- **Military and Defense Applications:** Provides secure communication and radar functionalities for vehicles and drones.
- **5G Networks:** Improves user tracking and beamforming for high-speed, high-frequency communication systems.

# Use Cases

- **5G Wireless Infrastructure:** RFSoCs are used in 5G base stations to enable direct RF signal processing, improving performance and reducing hardware complexity. They help in handling wideband signals, massive MIMO, and beamforming, which are essential for 5G communication.
- **Radar Systems:** RFCos are employed in military and commercial radar systems for real-time signal processing, where the integration of high-speed ADC/DACs and FPGA logic enables faster and more efficient detection and tracking of objects.
- **Software-Defined Radio (SDR):** RFSoCs support SDR applications by providing a flexible, programmable platform to handle different communication protocols and frequencies, making them ideal for adaptive communication systems in defense and aerospace industries.

# Target Users

- **Telecommunication Companies:** For deploying 5G infrastructure and enhancing wireless communication networks.
- **Defense and Aerospace Industries:** For developing advanced radar systems, electronic warfare solutions, and secure communication systems.
- **Research Institutions and Universities:** For conducting research and development in fields like software-defined radio (SDR), satellite communications, and wireless signal processing.
- **Manufacturers of Communication Equipment:** To integrate RFSoC in devices like base stations, signal analyzers, and test equipment for high-performance communication systems.

# List of Features:

- **Integrated RF Analog-to-Digital (ADC) and Digital-to-Analog (DAC) Converters:** Enables direct RF signal sampling and transmission, eliminating the need for external RF components.
- **Programmable FPGA Logic:** Provides flexibility for custom digital signal processing (DSP) and control logic, allowing users to implement tailored algorithms.
- **Multi-core ARM Processor:** Allows for general-purpose processing tasks such as control, communication, and data management, integrated into the same chip.
- **Wideband RF Capability:** Supports wide bandwidths necessary for applications like 5G, satellite communication, and radar.
- **High-Speed Data Processing:** Enables real-time data acquisition and processing for high-performance applications like radar and communication systems.