QPSK Modulator Implementation on FPGA

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Abstract

This portfolio summarizes the development of a QPSK (Quadrature Phase Shift Keying) communication system implemented on an FPGA. The design uses a Zedboard Zynq-7000, Xilinx Vivado, and the ADAU1761 audio codec to integrate digital hardware design with embedded software. A modular architecture was created, including a custom QPSK modulator and AXI-based interfaces. The system was validated through simulation and laboratory experiments, achieving real-time modulation and symbol transmission.

Introduction

QPSK is a digital modulation technique widely used in modern communication systems. Figure 1 shows its constellation diagram. This project aimed to implement a QPSK modulator on an FPGA platform, integrating both hardware and software components. The objective was to design, simulate, and test a functional system capable of transmitting data entered via a computer keyboard and reproducing modulated signals through an audio codec.

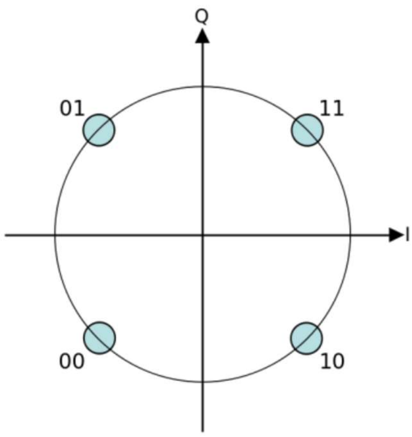

Figure 1. Constellation diagram of QPSK modullation.

System Design

The system was developed using Xilinx Vivado to implement custom IP blocks and AXI-based communication. The architecture consisted of the Processing System, AXI Interconnect, QPSK Modulator, and the Hamster (ADAU1761) codec (see Figure 2).

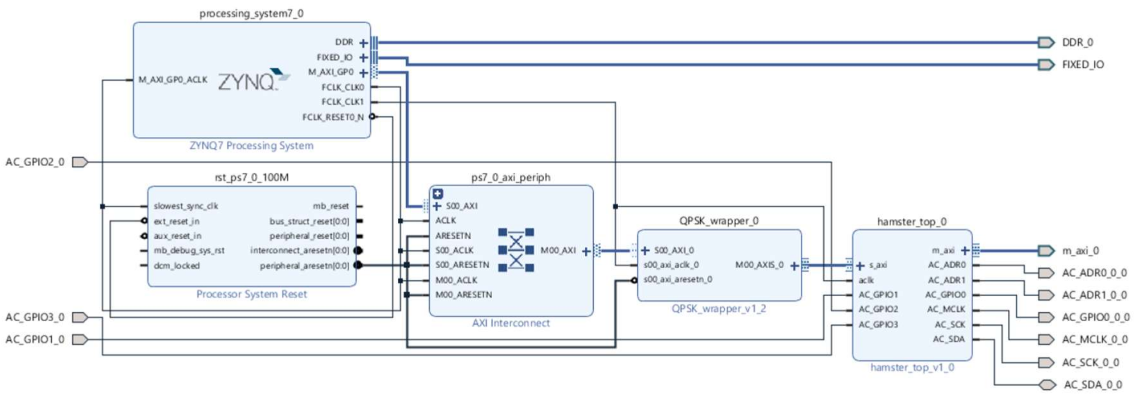

Figure 2. Block diagram of the project.

The QPSK modulator converts input bits into modulated symbols, supported by DDS Compilers to generate sinusoidal carriers with phase shifts of 0, p/2, p, and 3p/2 (see Figure 3).

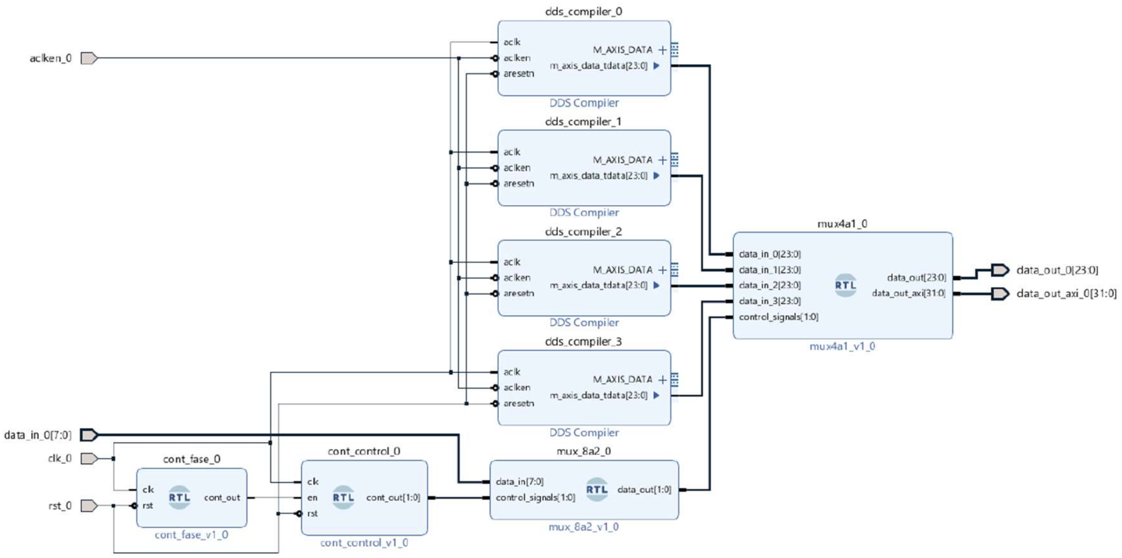

Figure 3. Block diagram of the QPSK modulator.

The Hamster codec converted digital signals into analog audio output, allowing real-time verification of the modulation process.

Implementation & Results

Before implementation, the system was simulated in Vivado, producing highly satisfactory results that aligned with the expected outcomes.

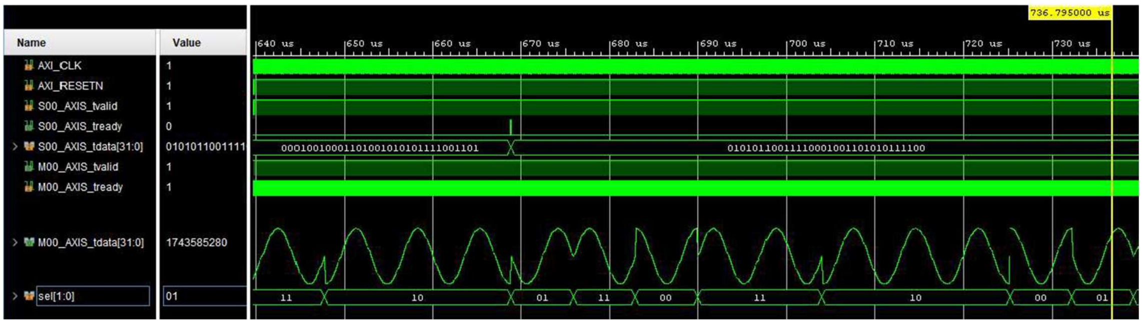

Figure 4. QPSK simulation.

The system was implemented on a Zedboard, with UART communication enabling data input from a PC keyboard. Simulation verified the correct modulation of input bits into QPSK symbols. Laboratory testing confirmed functional signal output, with oscilloscope measurements matching expected phase shifts (see Figure 5).

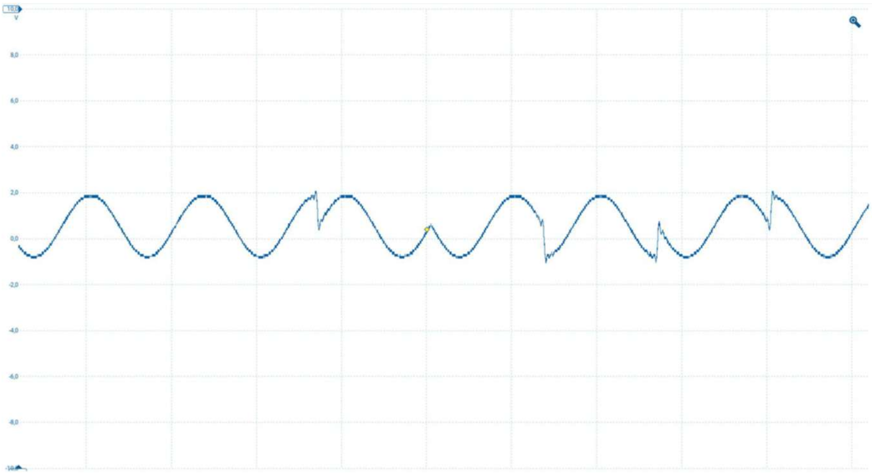

Figure 5. The result obtained when entering the character U.

Conclusion

This project successfully achieved the design and implementation of a QPSK modulation system on FPGA. The system demonstrated correct symbol mapping and real-time audio verification. Future work could focus on optimizing DDS settings to enhance signal quality. The experience strengthened skills in FPGA-based digital design, embedded systems, and communication protocols such as AXI and UART.