

Implementation of a BPSK Transceiver for use with KUAR

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Outline

- Motivation
- KUAR Overview
- Thesis Objectives
- Proposed Transceiver Design
 - Simulink, Xilinx, Modelsim
- Results
- Conclusion
- Future Work

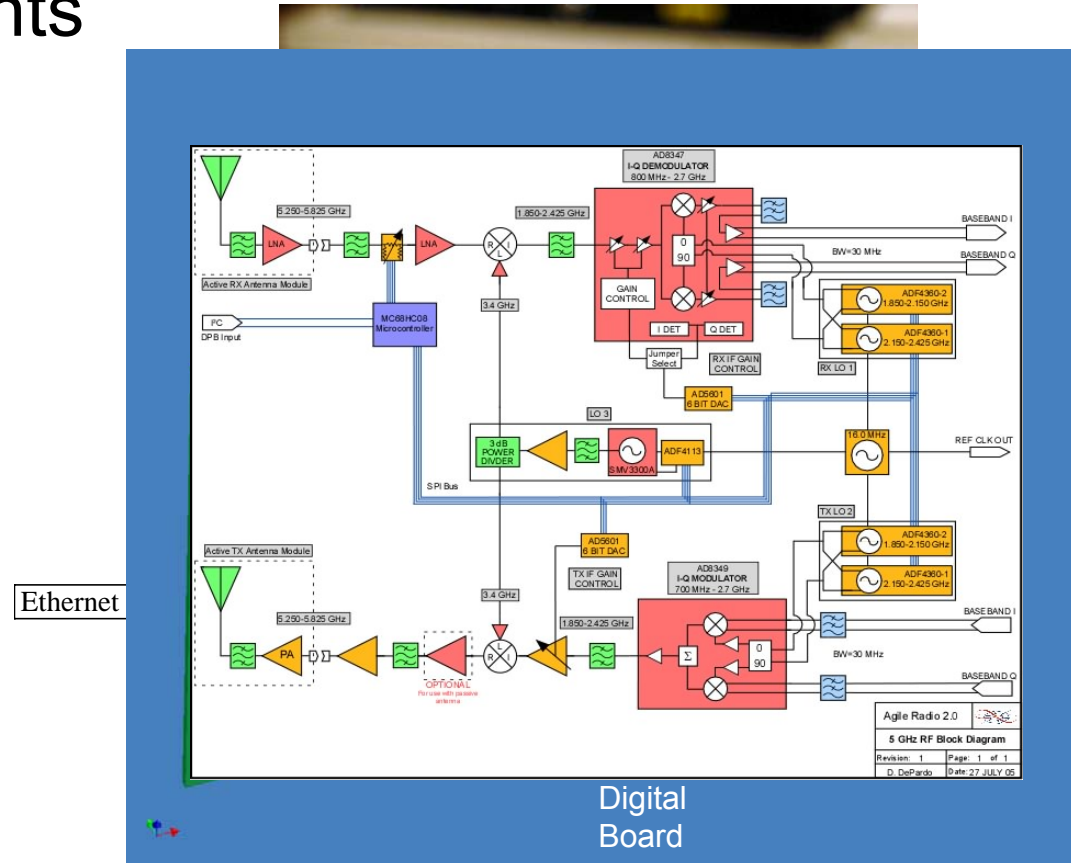
Motivation

- Development of the KUAR
 - Experimental radio
 - Radiates between 5-6 GHz
 - Bank of modulation schemes
 - Media access protocols
 - Adaptation mechanisms
 - Policy development
 - JTRS Test bed

[1]

KUAR Overview

- Several Components
 - Battery
 - Digital board
 - FPGA, DAC, ADC
 - CPH
 - RF Front End
 - Antennas



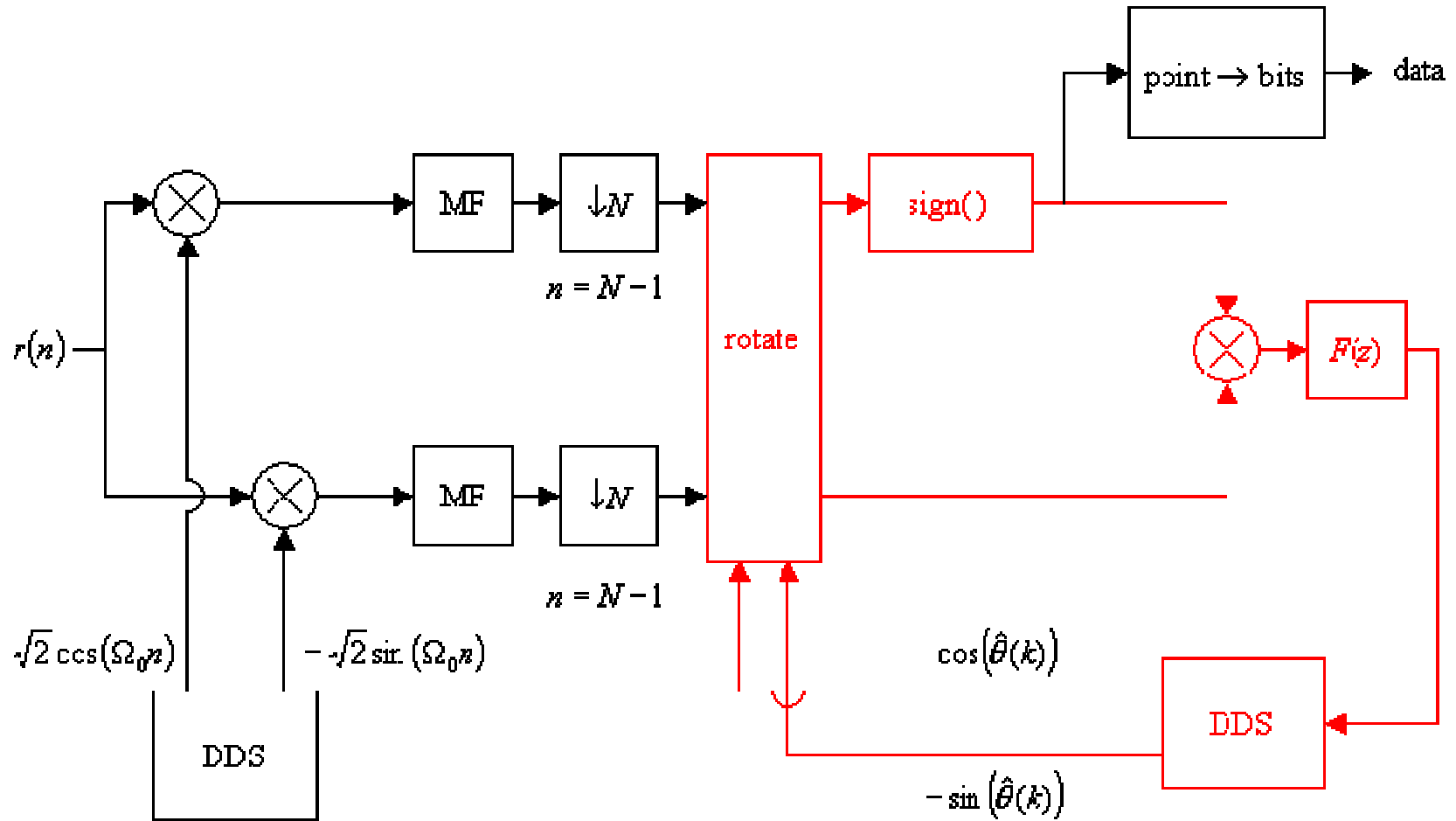
[1]

Images of the KUAR

Thesis Objectives

- Design and construct 1 Mbaud BPSK Transceiver
 - 5 MHz Carrier, 80 Msps
 - Synchronize the carrier
 - Synchronize the symbol
 - Use minimal resources

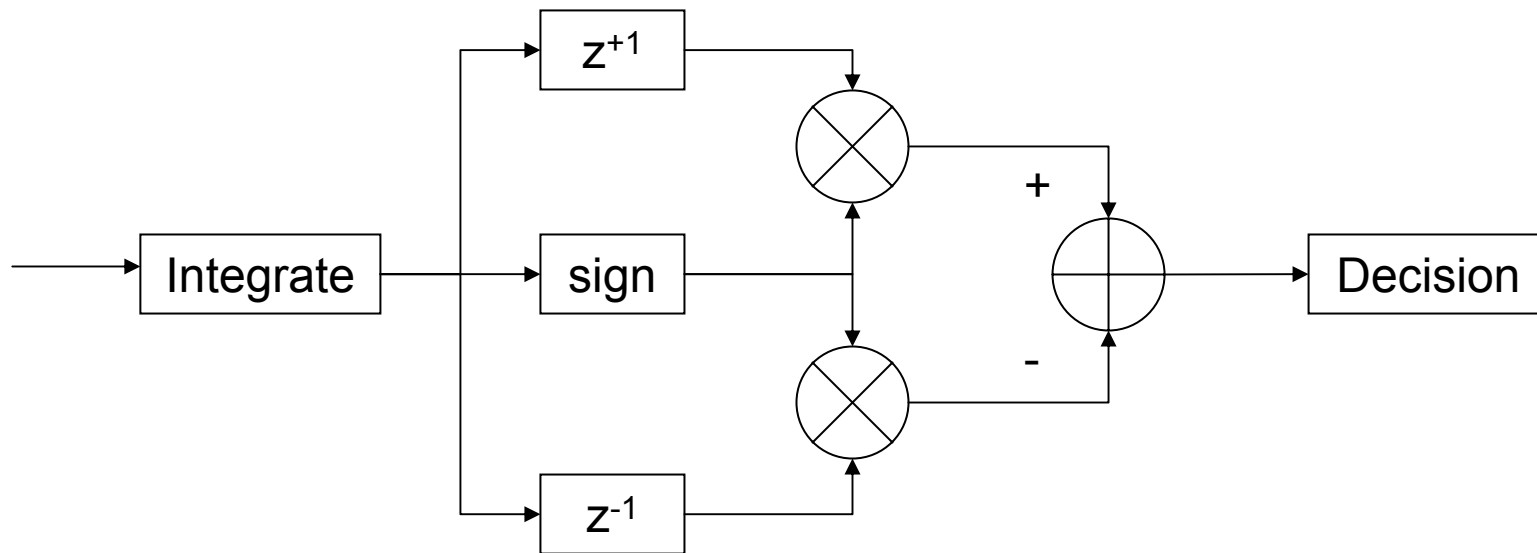
Method of Carrier Synchronization



Rice's digital Costas loop

[2]

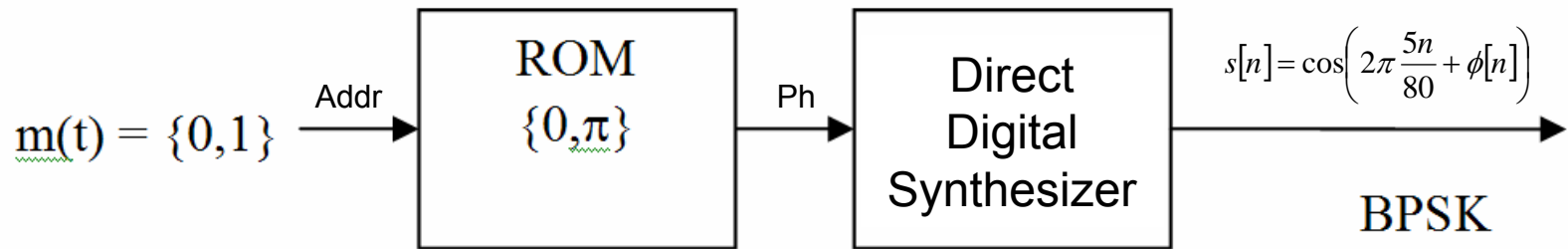
Method of Symbol Synchronization



Georghiades Early-Late Algorithm

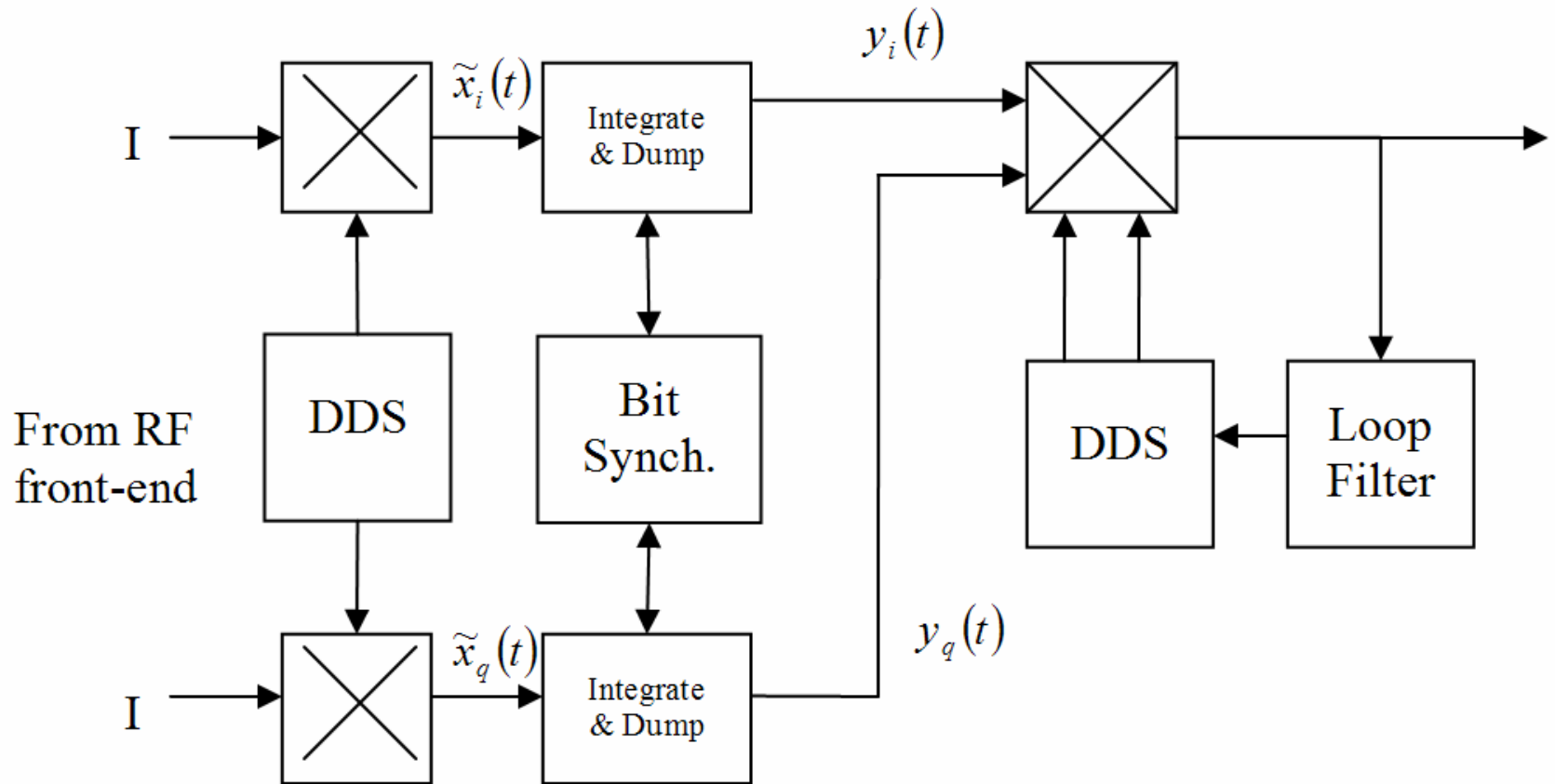
[3]

Proposed Transceiver



Block diagram of transmitter

Proposed Transceiver

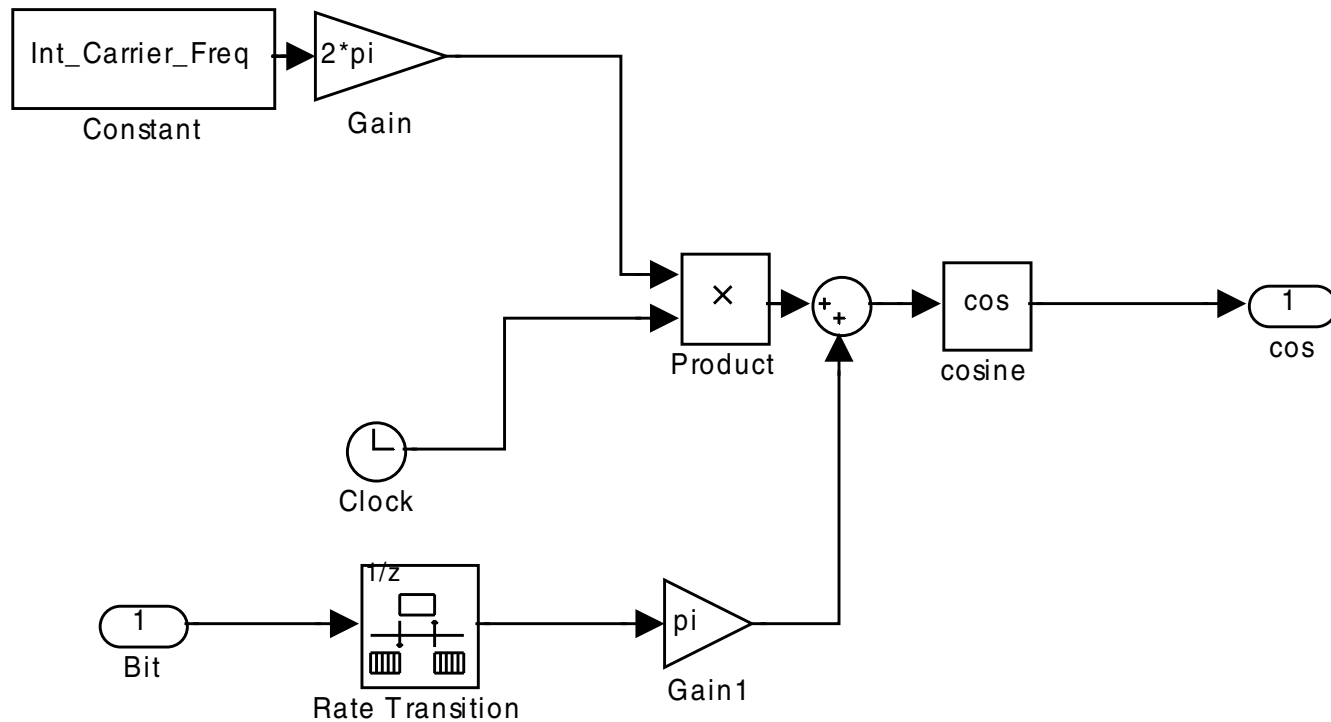


Block diagram of receiver

Simulink Simulation

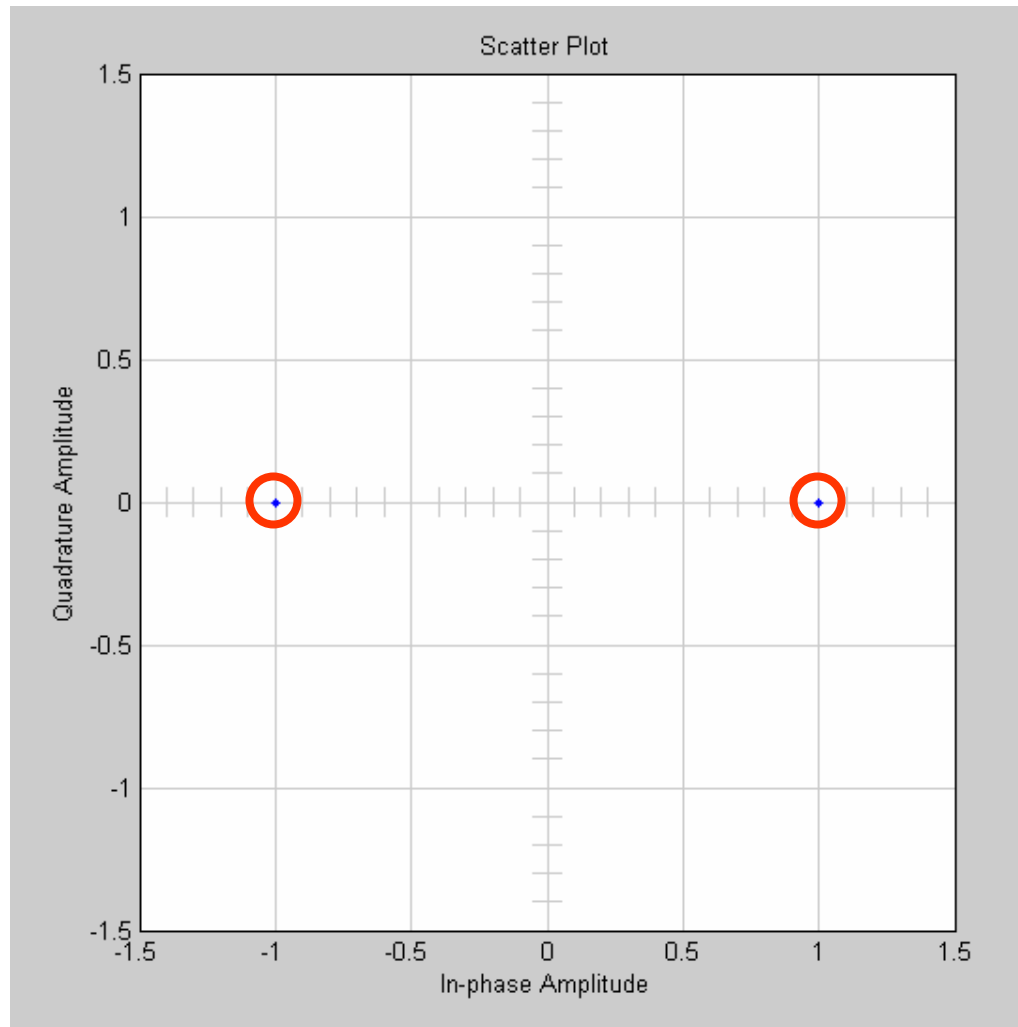
- Proposed Transceiver Design (Simulink)
 - Transmitter
 - Expected outputs
 - Receiver modules
 - Carrier synchronization
 - Symbol synchronization
 - SNR vs. BER

Simulink Simulation



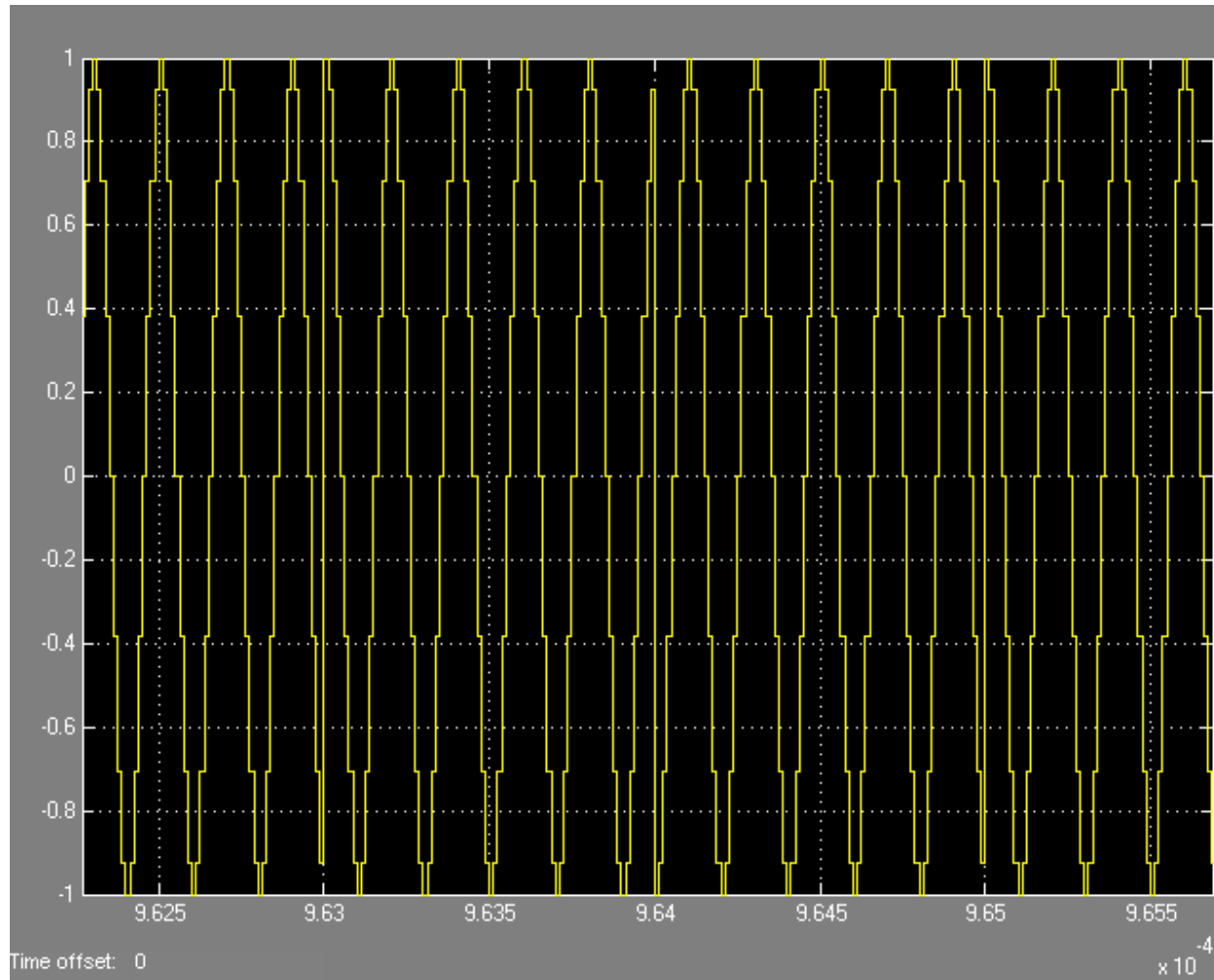
Simulink model of transmitter

Simulink Simulation



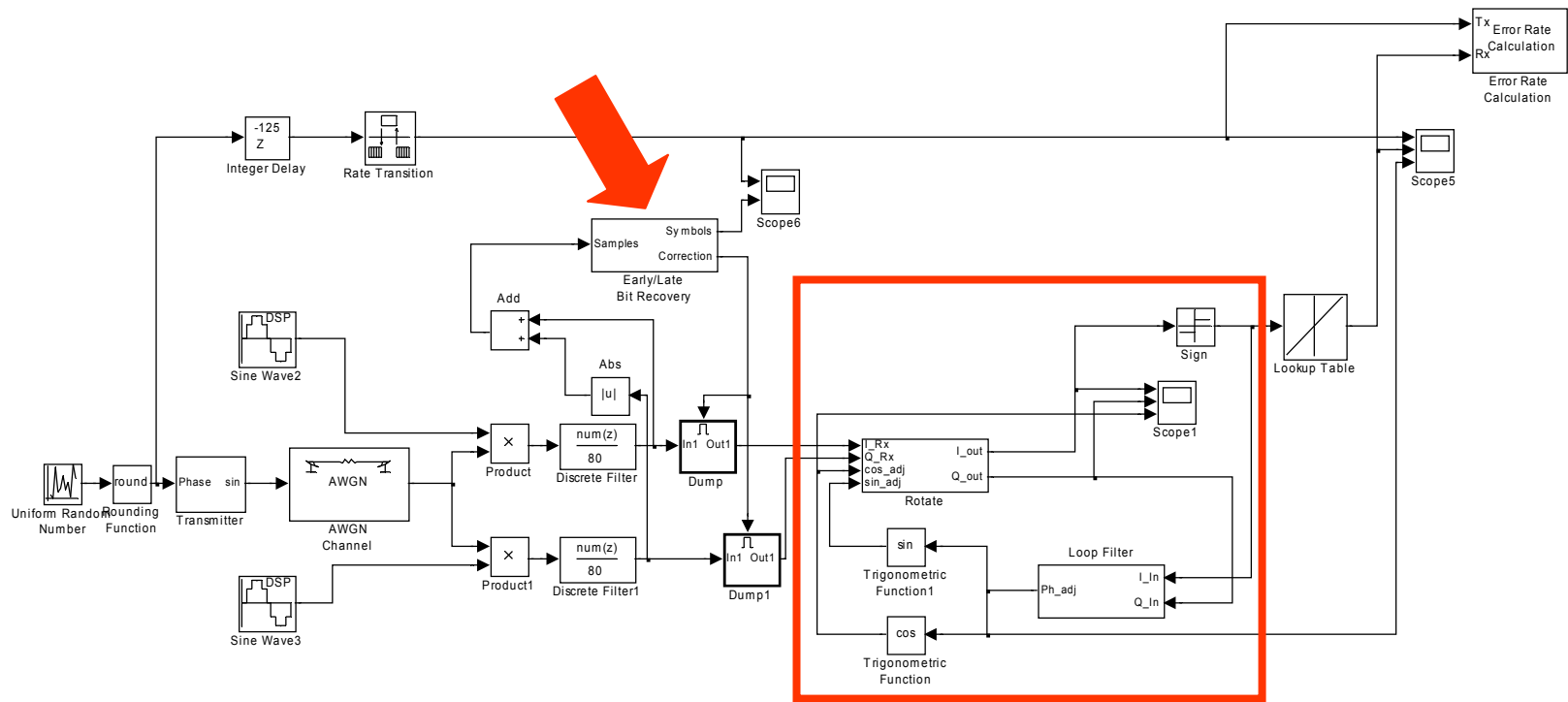
Ideal constellation of the transmitter

Simulink Simulation



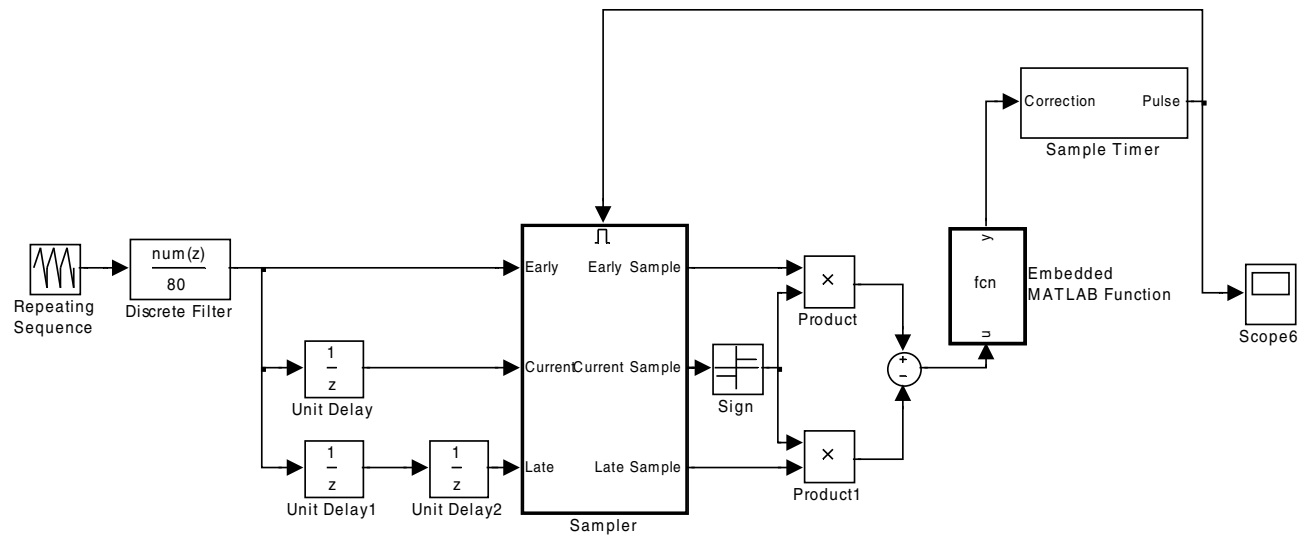
Ideal waveform of the transmitter

Simulink Simulation



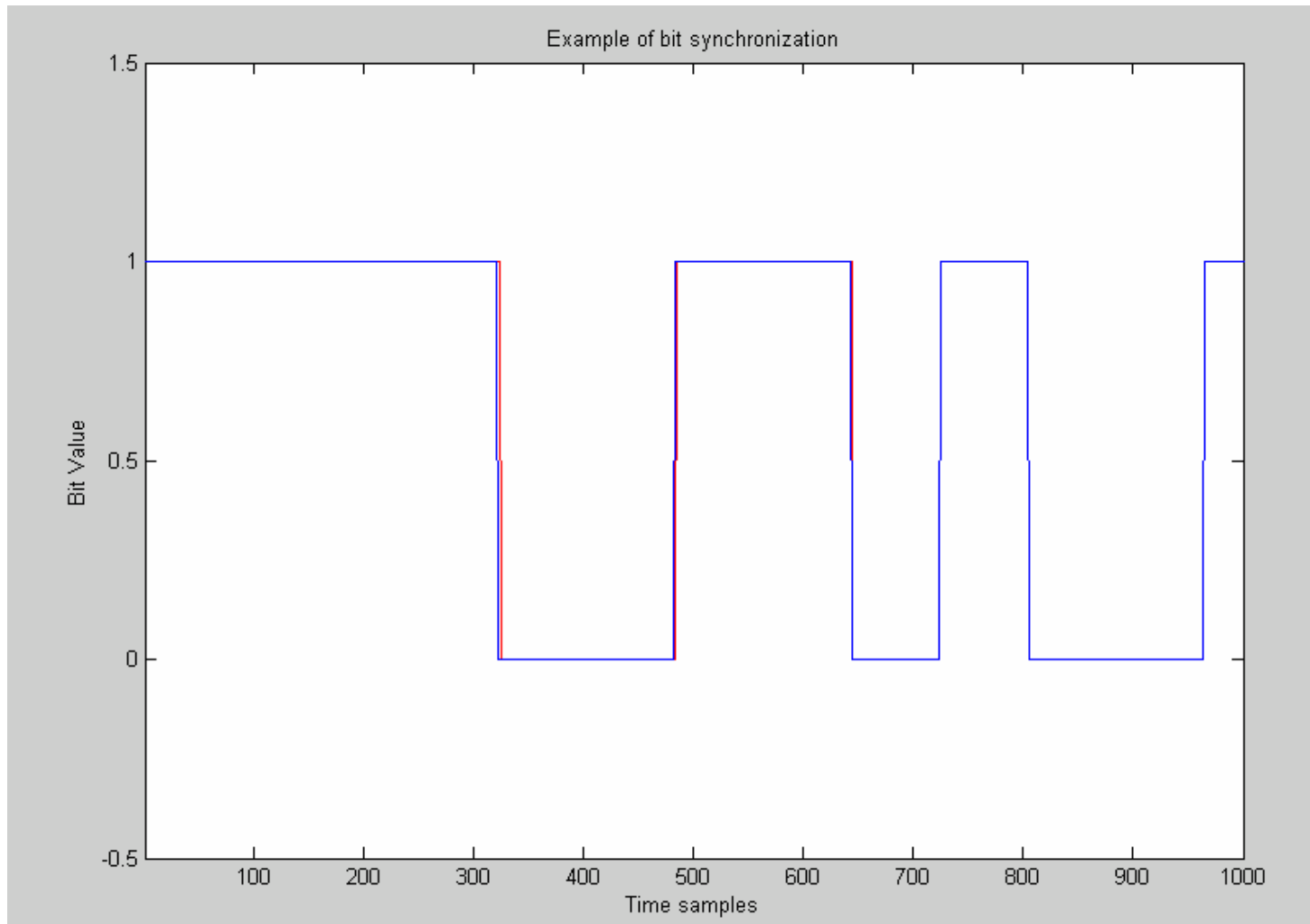
Top level of the simulation of the receiver

Simulink Simulation



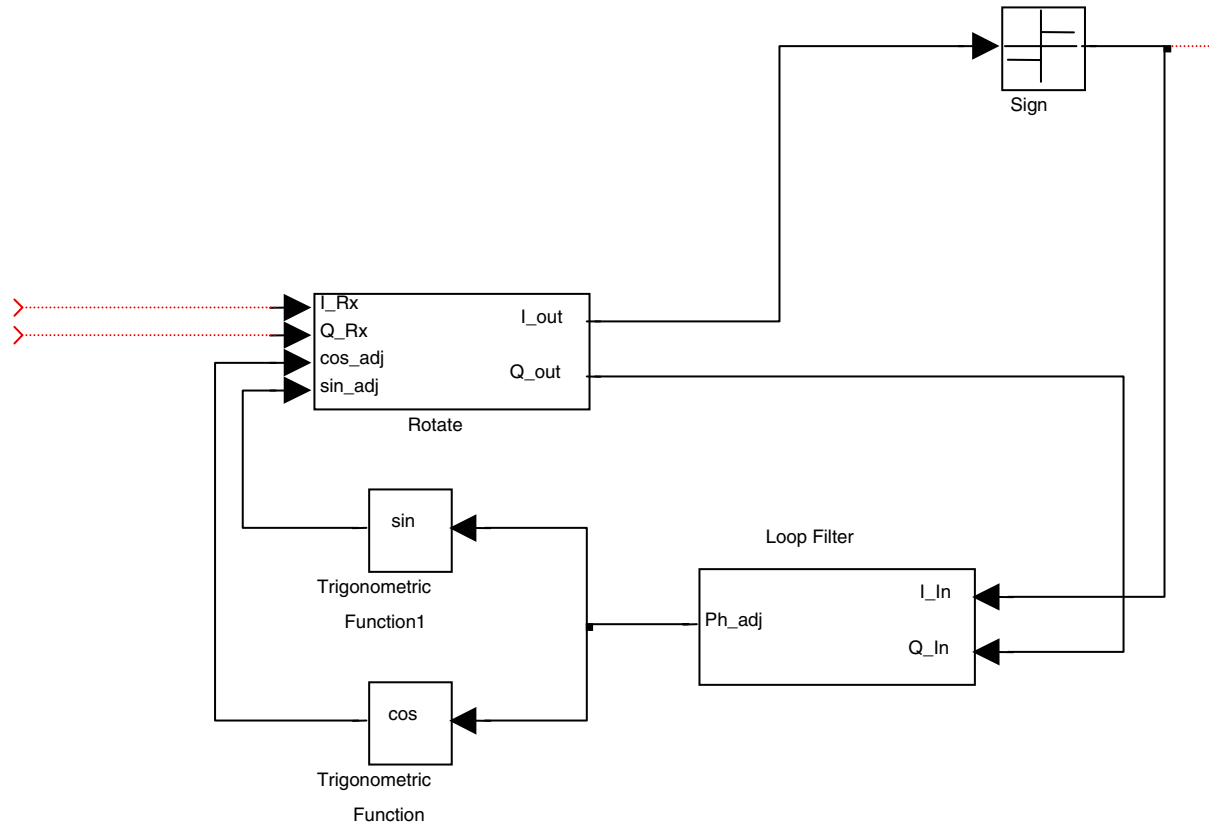
Early-late algorithm simulation

Simulink Simulation



Example of the early-late algorithm synchronizing to a signal

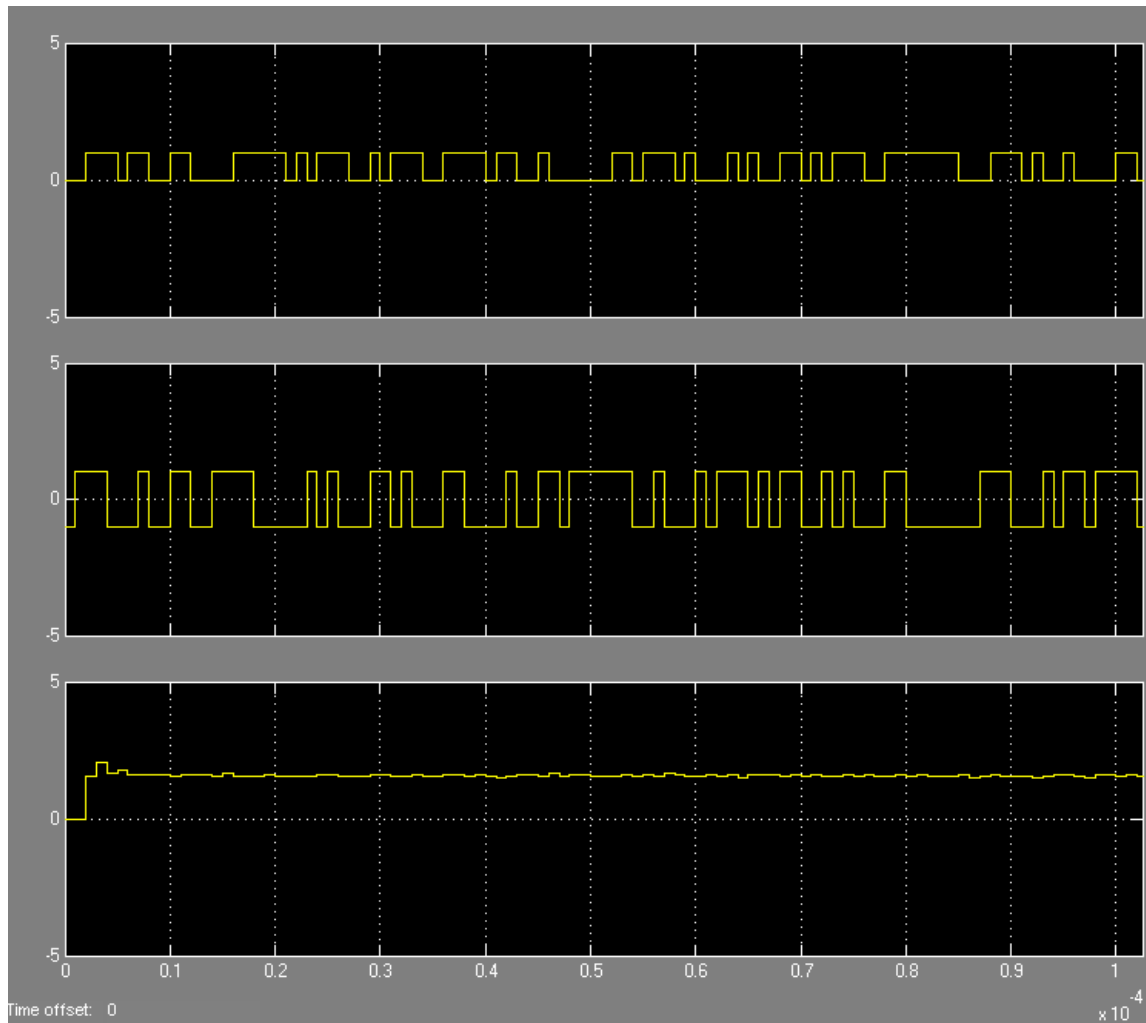
Simulink Simulation



The loop filter section

Simulink Simulation

Transmitted



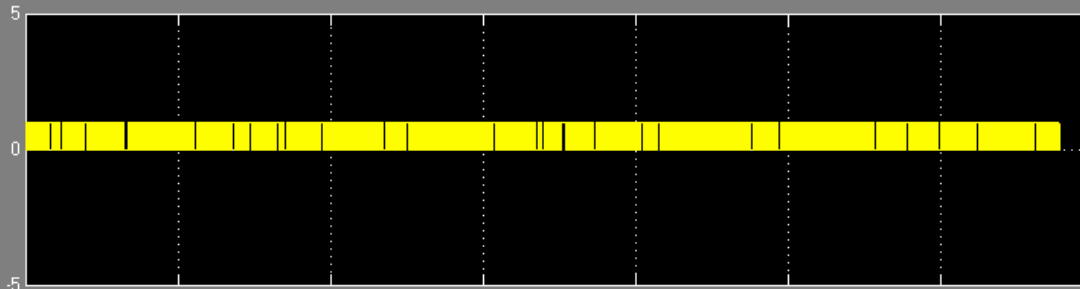
Estimated

Correction

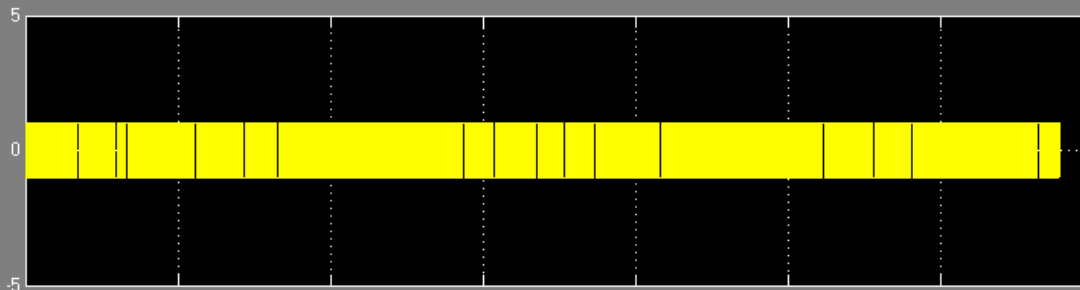
The loop filter synchronizing under constant phase error

Simulink Simulation

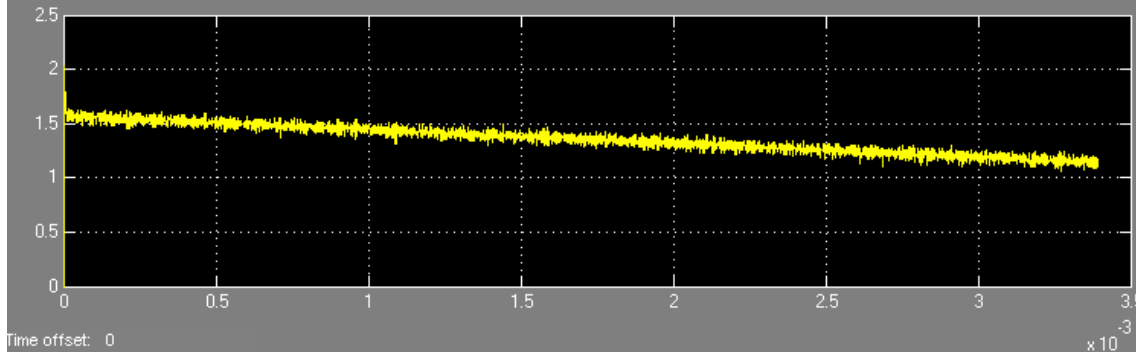
Transmitted



Estimated

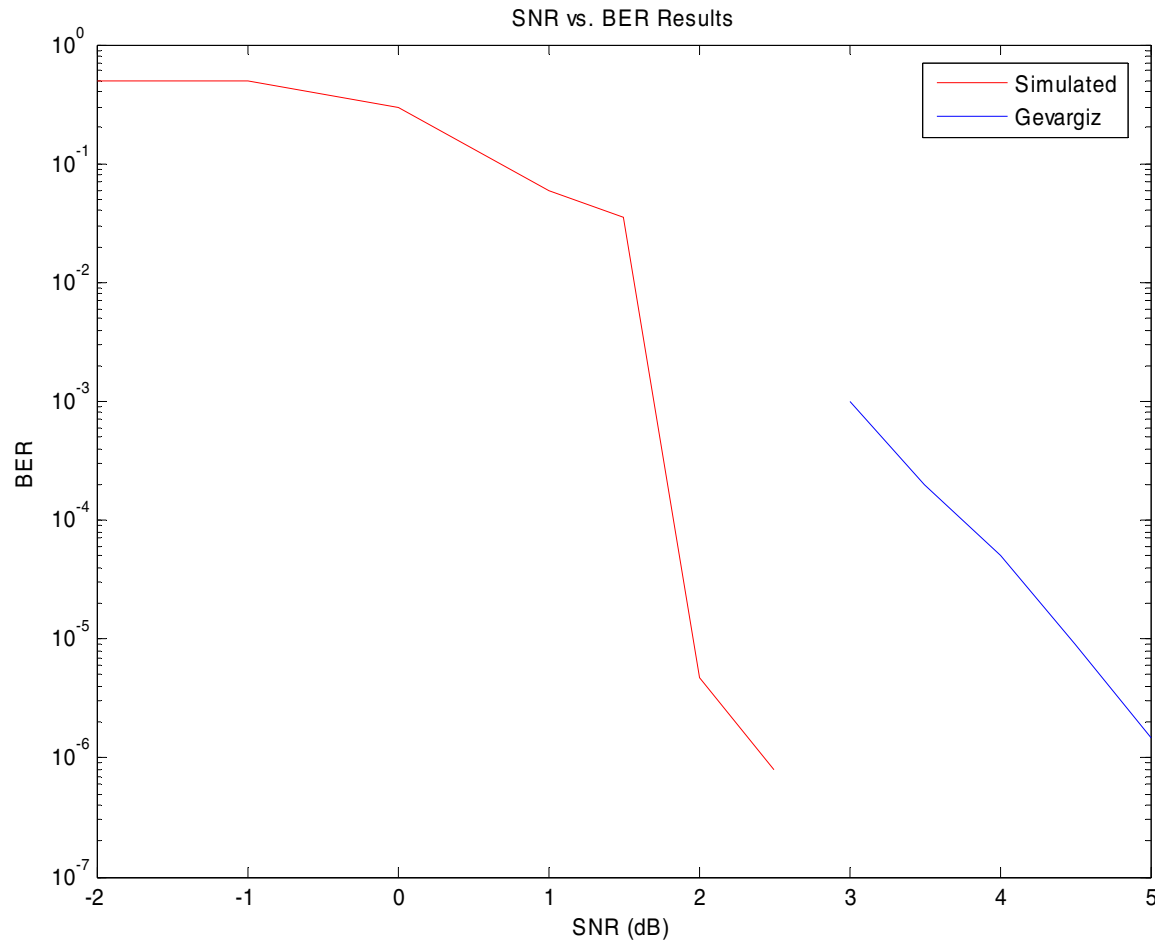


Correction



The loop filter synchronizing under constant frequency error

Simulink Simulation

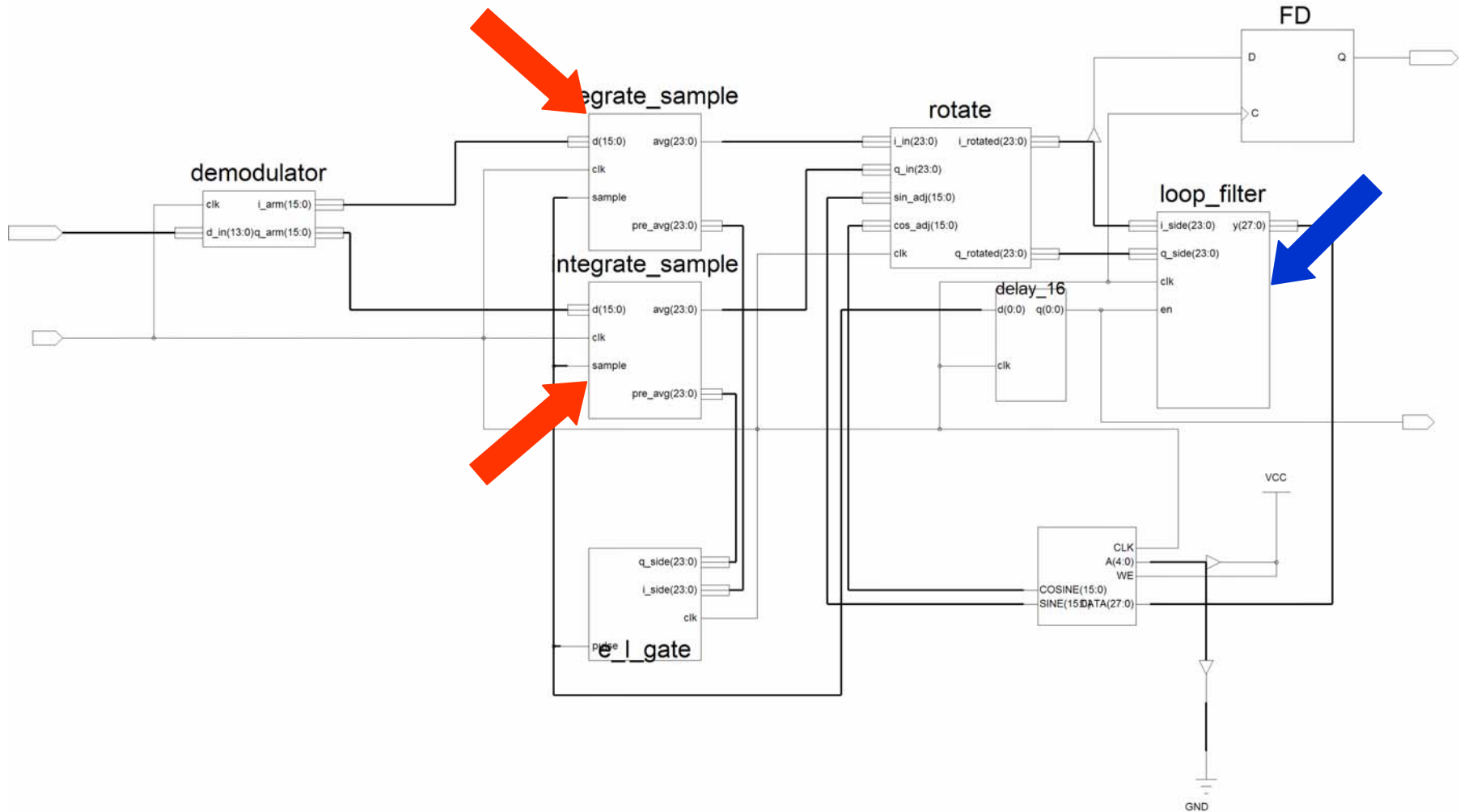


Simulation of the proposed receiver compared to Gevorgiz's receiver

Xilinx Implementation

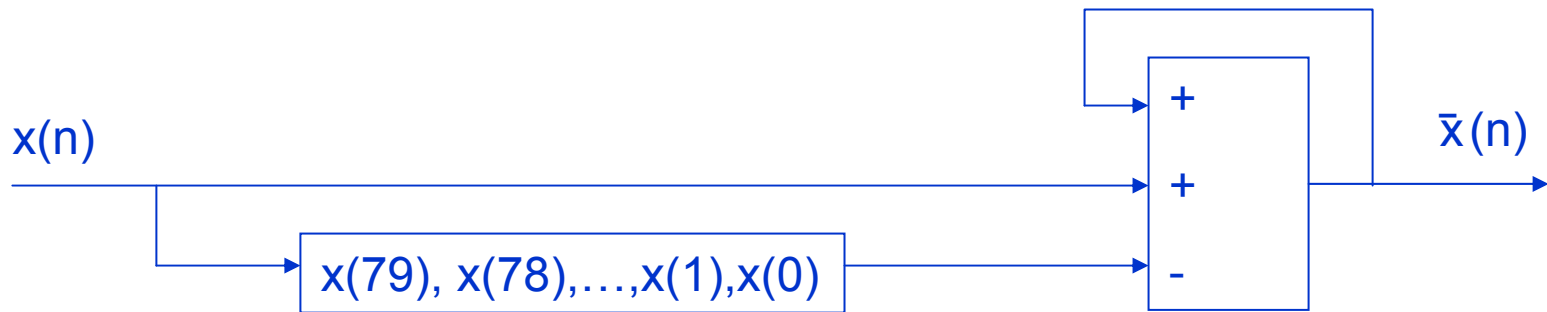
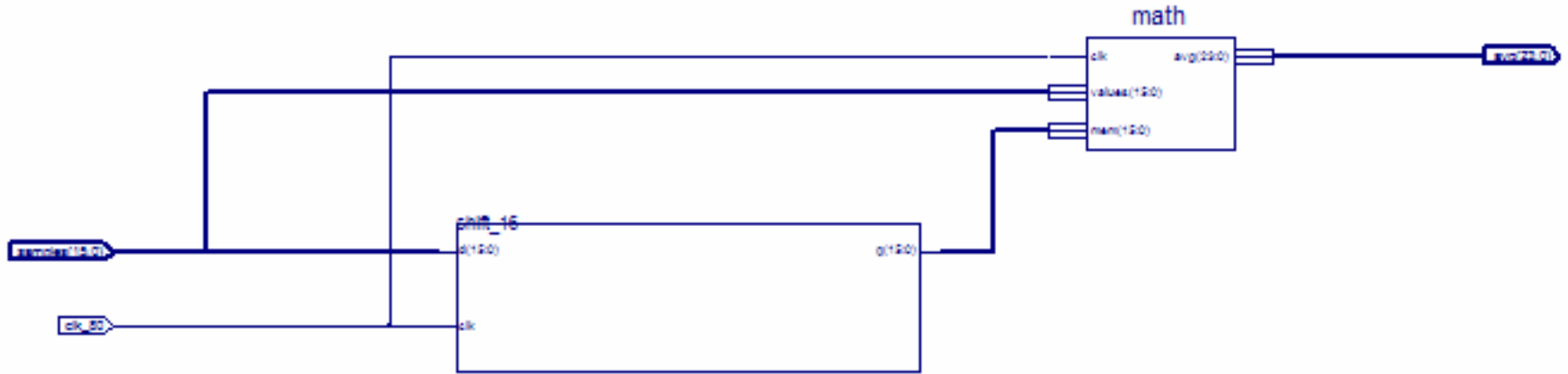
- System overview
- Boxcar filter implementation
- Loop filter implementation
- Synthesis sizing

Xilinx Implementation



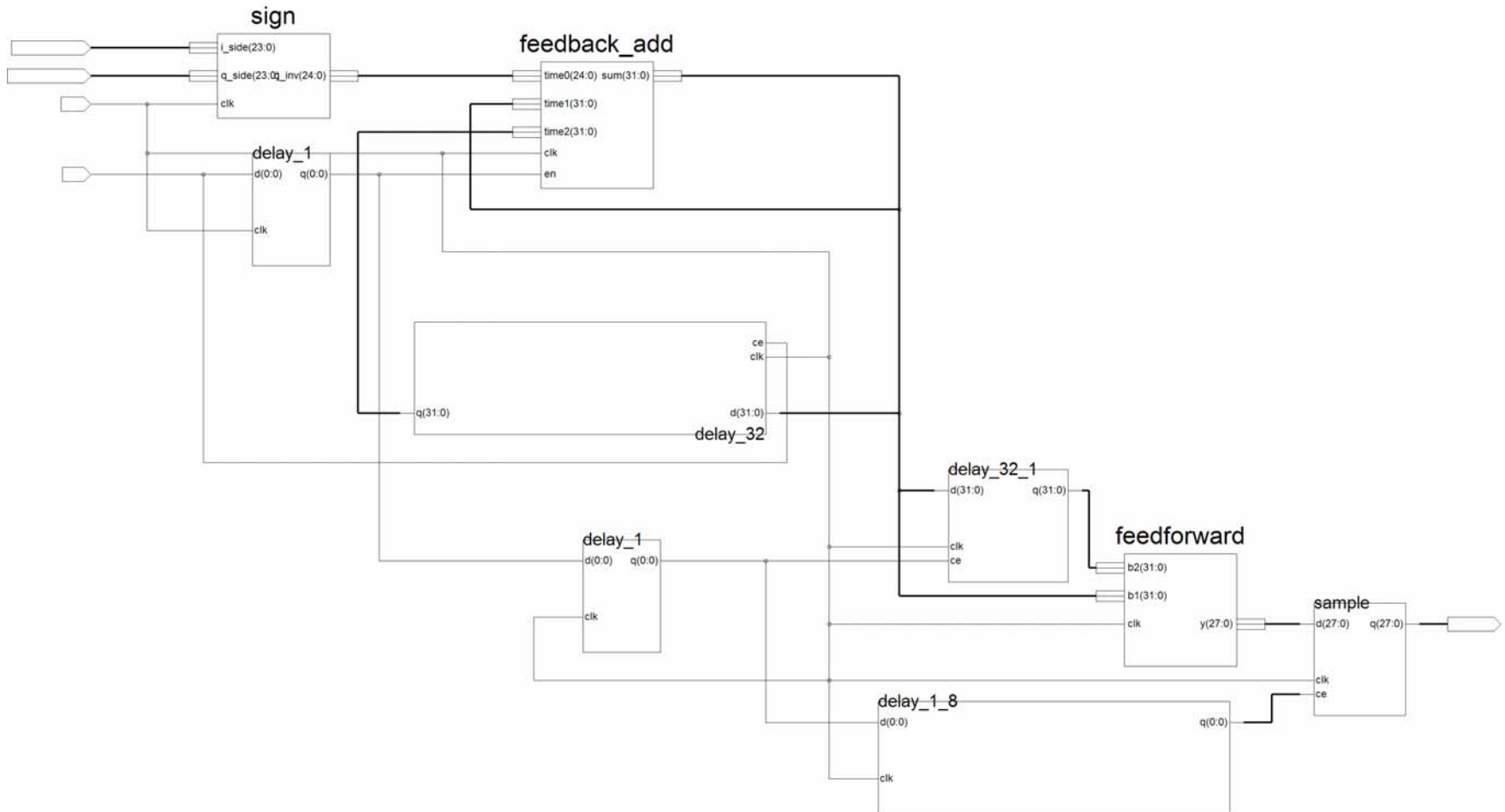
Top level of the Xilinx schematic of the receiver

Xilinx Implementation



Xilinx schematic of the boxcar filter

Xilinx Implementation



Xilinx schematic of the loop filter

Xilinx Synthesis

Table of resource usage

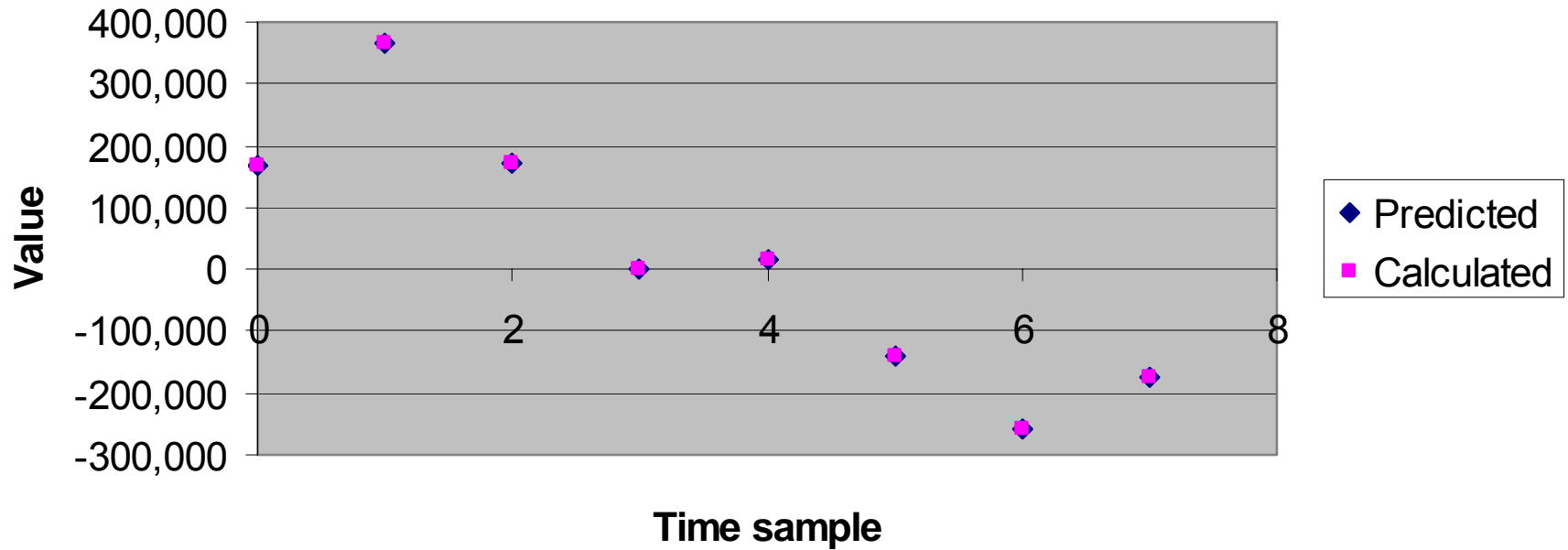
	Receiver	Transmitter	Total
Slices	1481/9280	158/9280	1639/9280
Multipliers	10/88	0/88	10/88
BRAMs	5/88	4/88	9/88
Maximum Freq.	151.469 MHz	250.062 MHz	151.469 MHz

Modelsim Results

- Transmitter output
- Loop filter response
- Early-late gate loop response

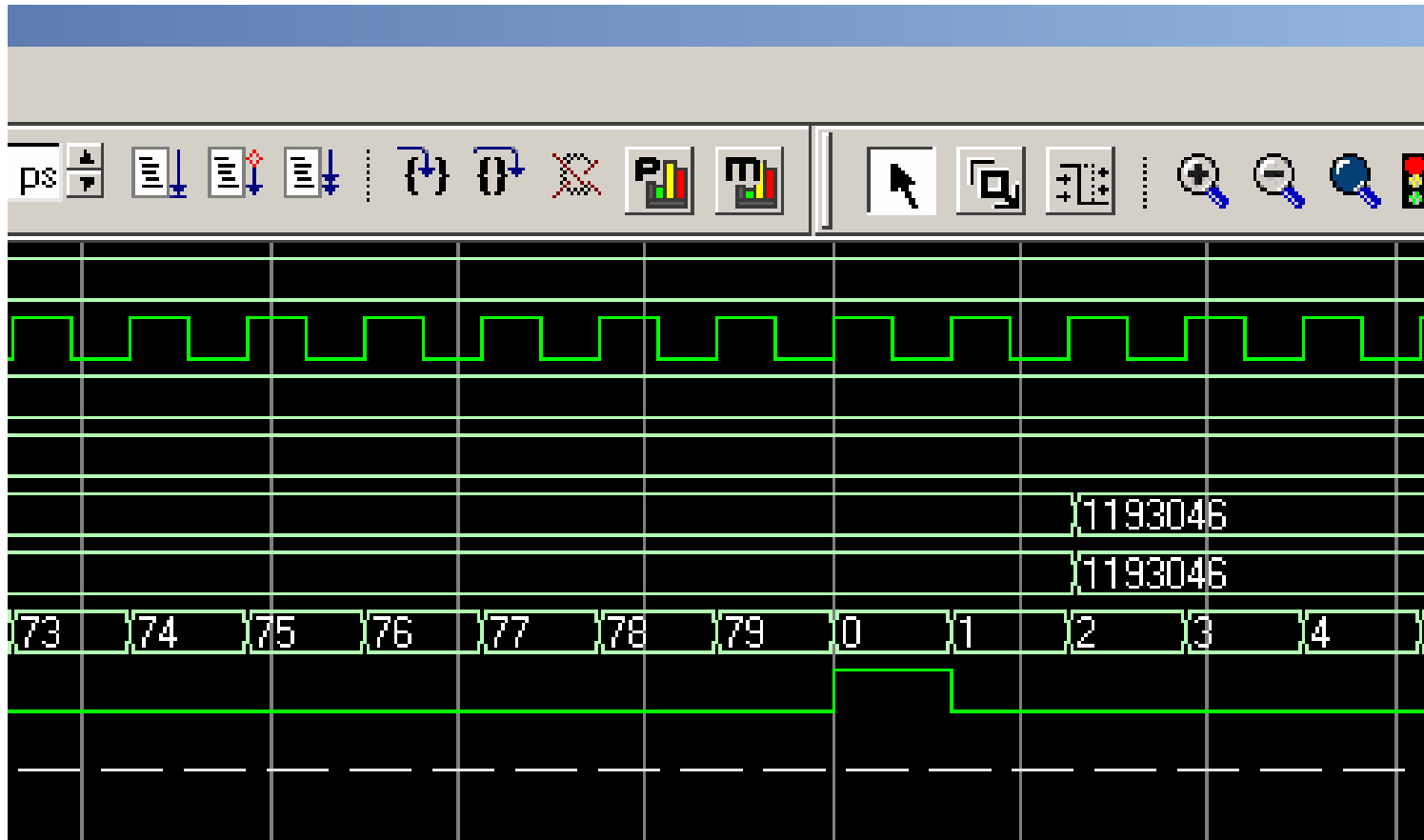
Modelsim Results

Loop Filter Results



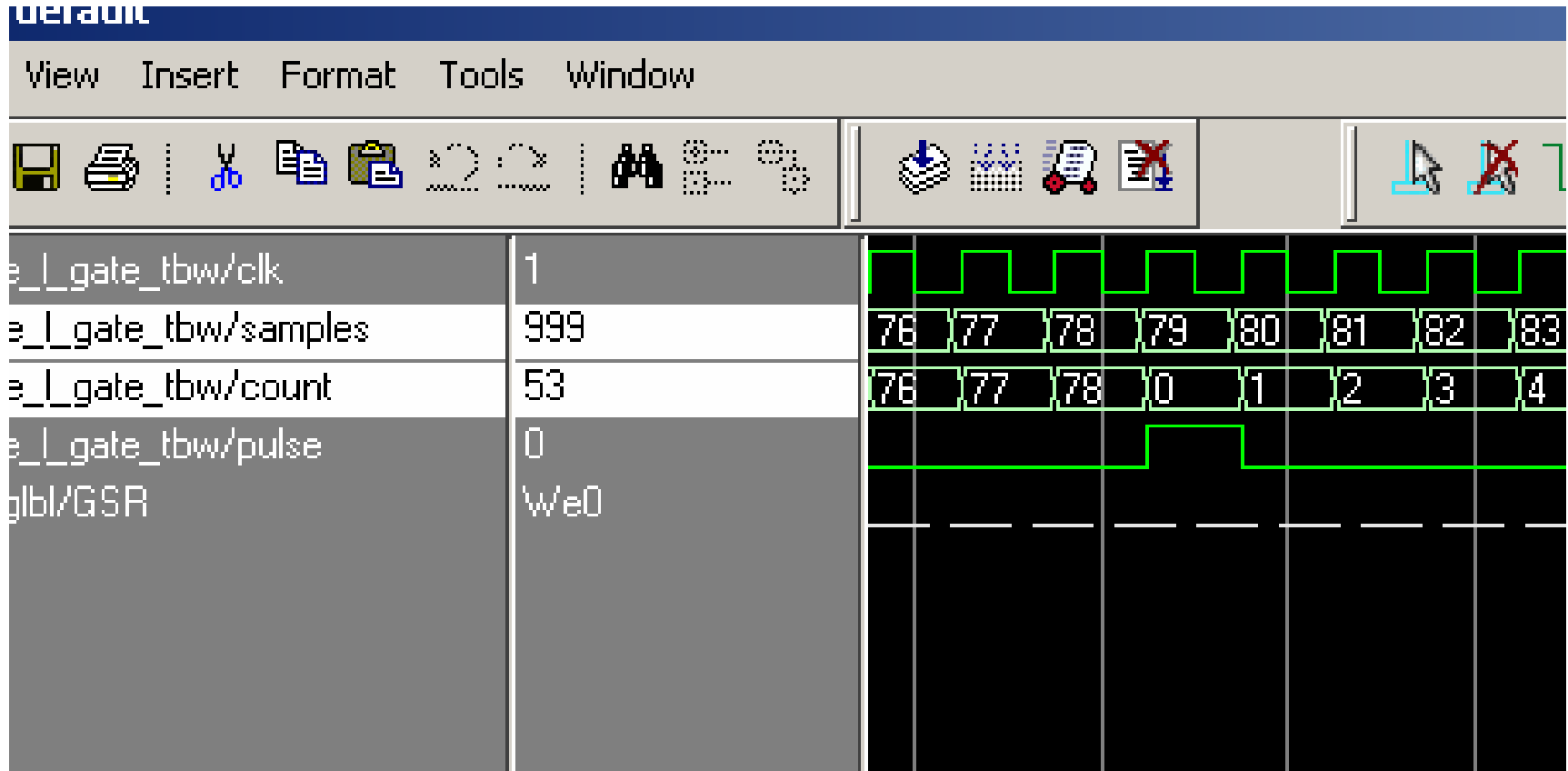
Output of the loop filter compared to expected results

Modelsim Results



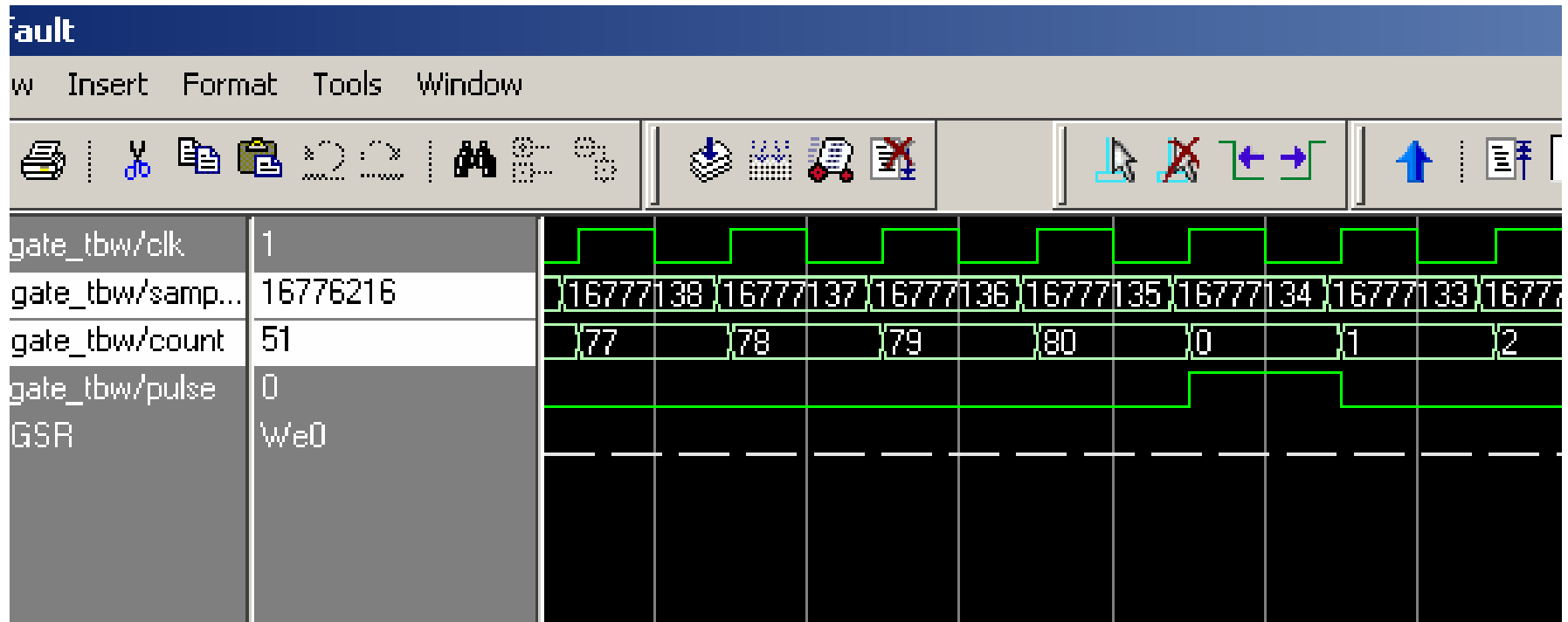
Simulated output of the symbol synchronizer with flat input

Modelsim Results



Simulated output of the symbol synchronizer with increasing input

Modelsim Results



Simulated output of the symbol synchronizer with decreasing input

Concluding Remarks

- Communicated 1 Mbaud of information with carrier of 5 MHz
- Synchronized with the transmitted carrier
- Synchronized the symbol
- Minimized resources
- Provided a tool for researching SDR and communications

Future Work

- This was stepping stone
 - M-PSK, SSB-AM
 - Channel sounding, equalization, fading, multi-path, pulse shaping
- Library of modulation schemes

References

- [1] G. J. Minden, “KU Agile Radio Overview,” University of Kansas, Lawrence, Kansas, 2005.
- [2] M. Rice, “Introduction to Digital Communication Theory,” 2004, <http://www.ee.byu.edu/class/ee485public/e485.fall.04/>. (Will be a book soon)
- [3] C. Georghiadis, “Synchronization,” *The Communications Handbook*, 2nd ed., Ed. J. Gibson, Boca Raton: CRC Press, 2002.

Questions?
