Software Defined Radio based Mixed Signal Detection in Spectrally Congested and Spectrally Contested Environment

Kaiyu Huang, Yang Qu, Zhiping Zhang
Vasu Chakarvarthy, Lin Zhang and Zhiqiang Wu

Wright State University
Air Force Research Laboratory
Sun Yat-sen University

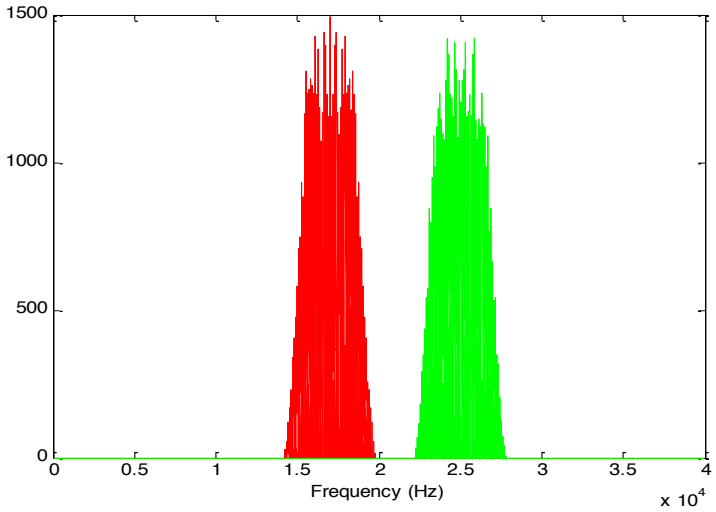
Acknowledgement

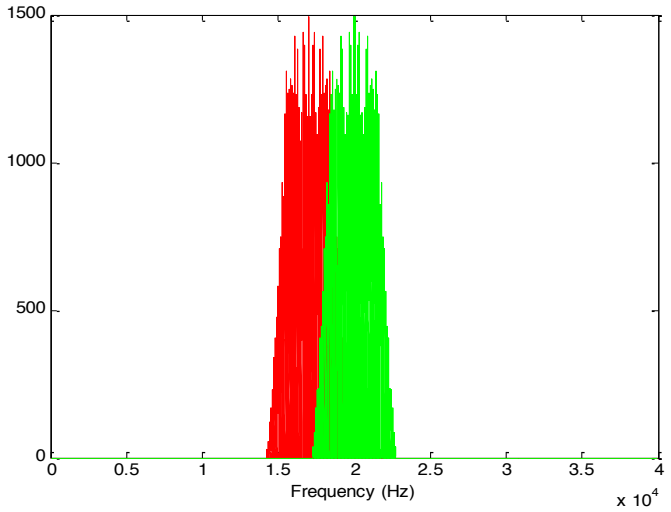
- Ohio Federal Research Network (OFRN) Project “Intelligent Channel Sensing based Secure Cross Layer Cognitive Networking for Resilient Space Communication”
- NASA Glenn
- AFRL
- ONR
- NSF

Outline

- Motivation
- Cyclostationary Analysis/SCF of Mixed Signal
- Software Defined Radio Implementation
- SDR based Mixed RF Signal Generator
- SDR based Mixed RF Signal Detector
- Examples
- Conclusions

Motivation


1500
1000
500
0
0 0.5 1 1.5 2 2.5 3 3.5 4
Frequency (Hz)
x 10^4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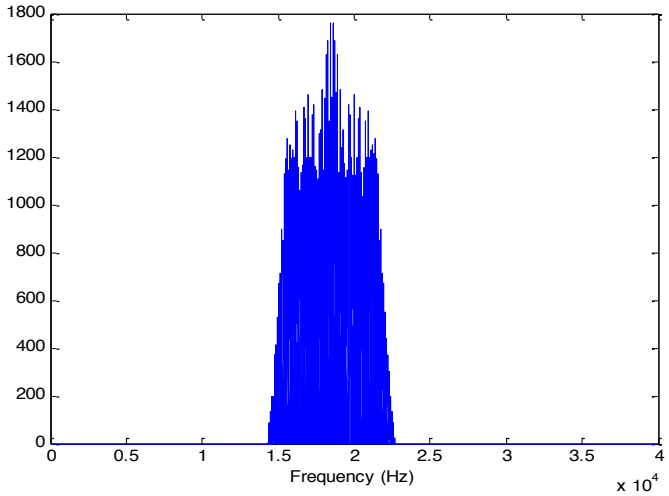
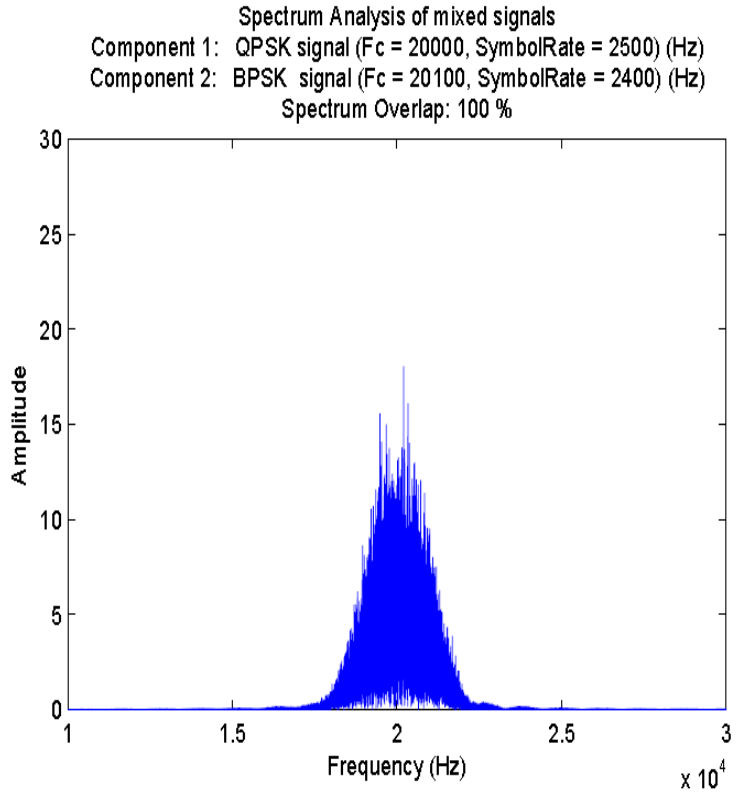
Frequency (Hz)
x 10^4

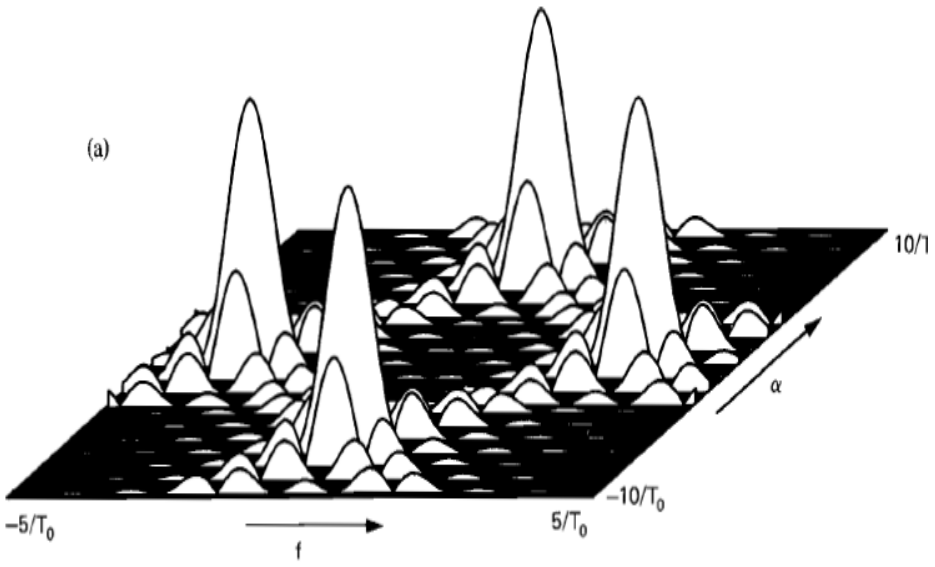

1800
1600
1400
1200
1000
800
600
400
200
0
0 0.5 1 1.5 2 2.5 3 3.5 4
Frequency (Hz)
x 10^4

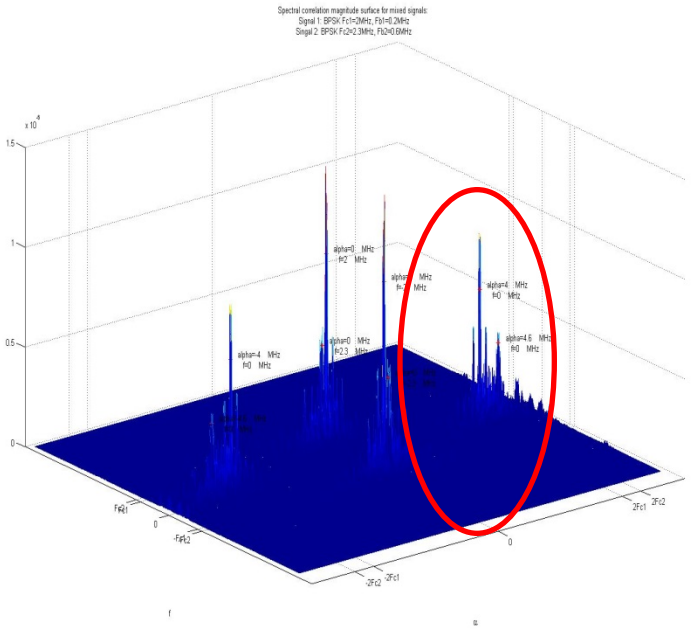
Mixed Signal Detection/Identification

- Mixed signal: multiple signal components with significant spectrum overlap
- Spectrally congested and contested environment
- Cognitive radio and dynamic spectrum access network

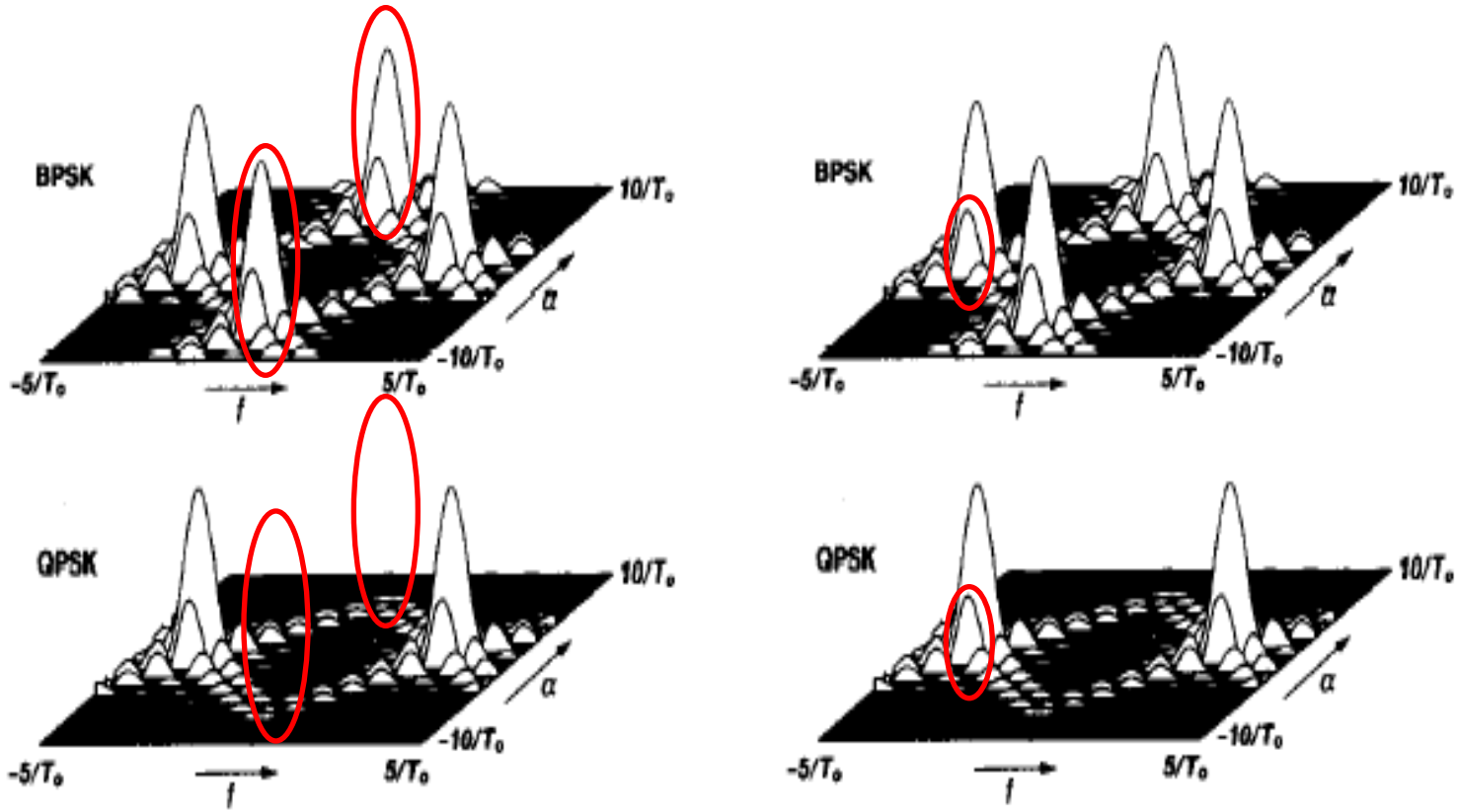


Spectral Correlation Function (SCF)





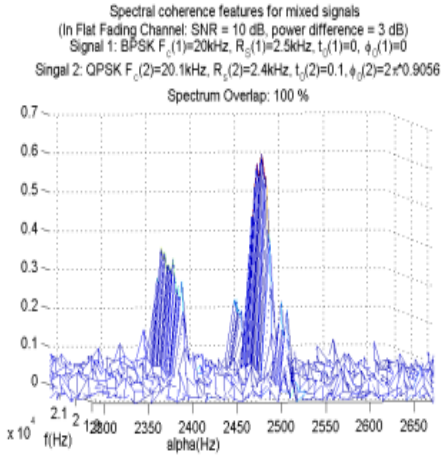
SCF and SOF of Mixed Signals with Higher-order Modulations



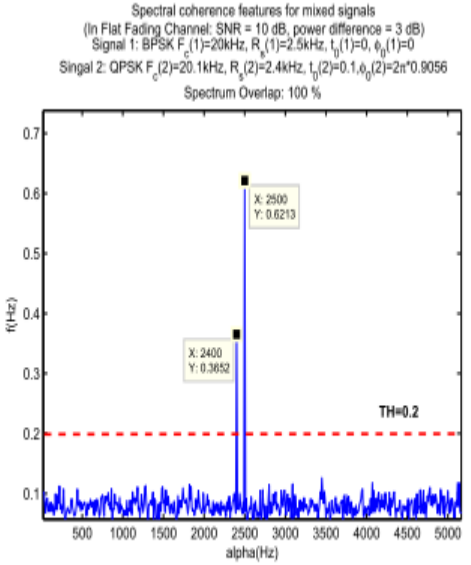
SOF based Mixed Signal Detection and Symbol Rate Estimation

Three-step algorithm to detect signals

1. Estimate the mixed signal's carrier frequency $\hat{f}_c$ and null-to-null bandwidth $\hat{B}$ through spectrum analysis.
2. Calculate the SOF around $\hat{B}/2$ for a cyclic frequency span of $\hat{B}$ with fine resolution.
3. Identify the number of signals and estimate

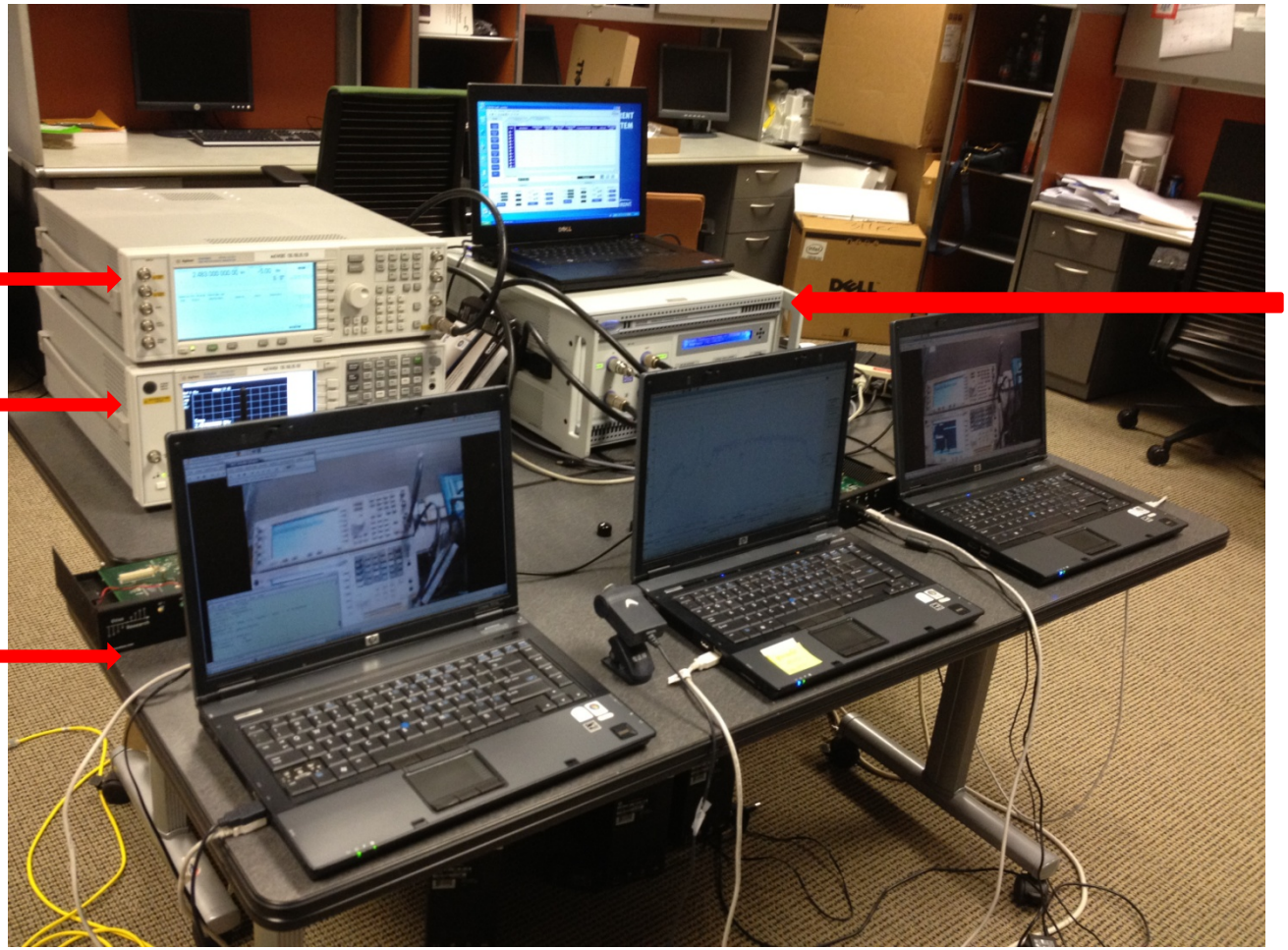


(a) 3-D view



(b) α view

SDR Implementation



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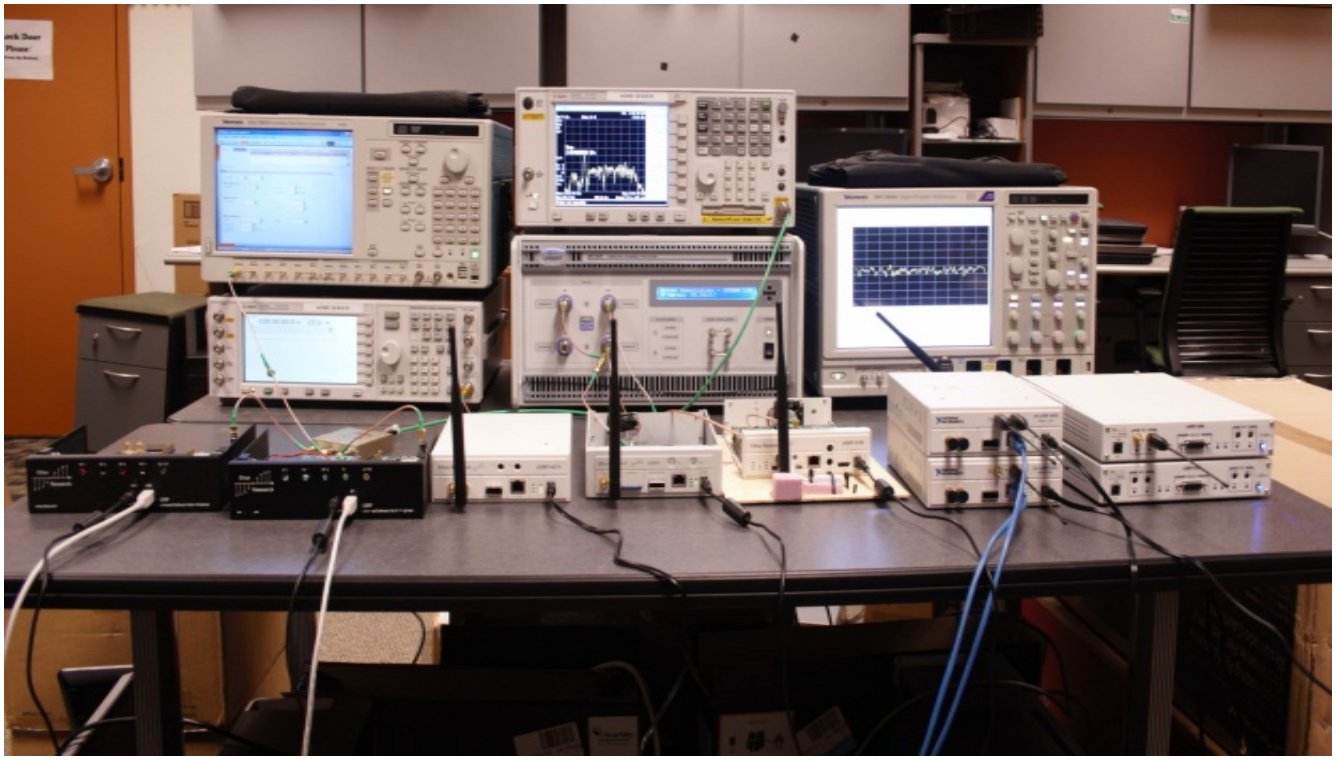

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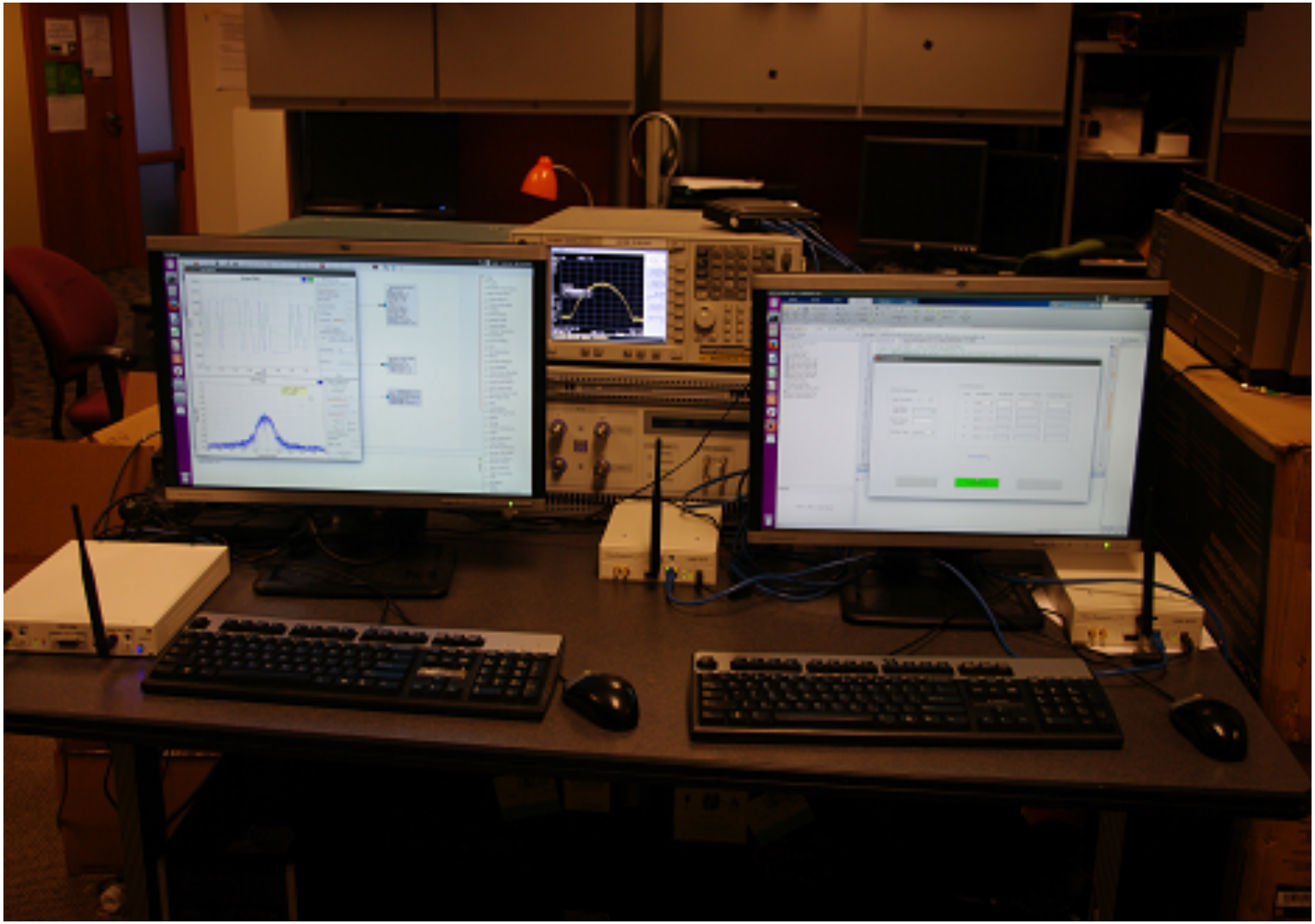
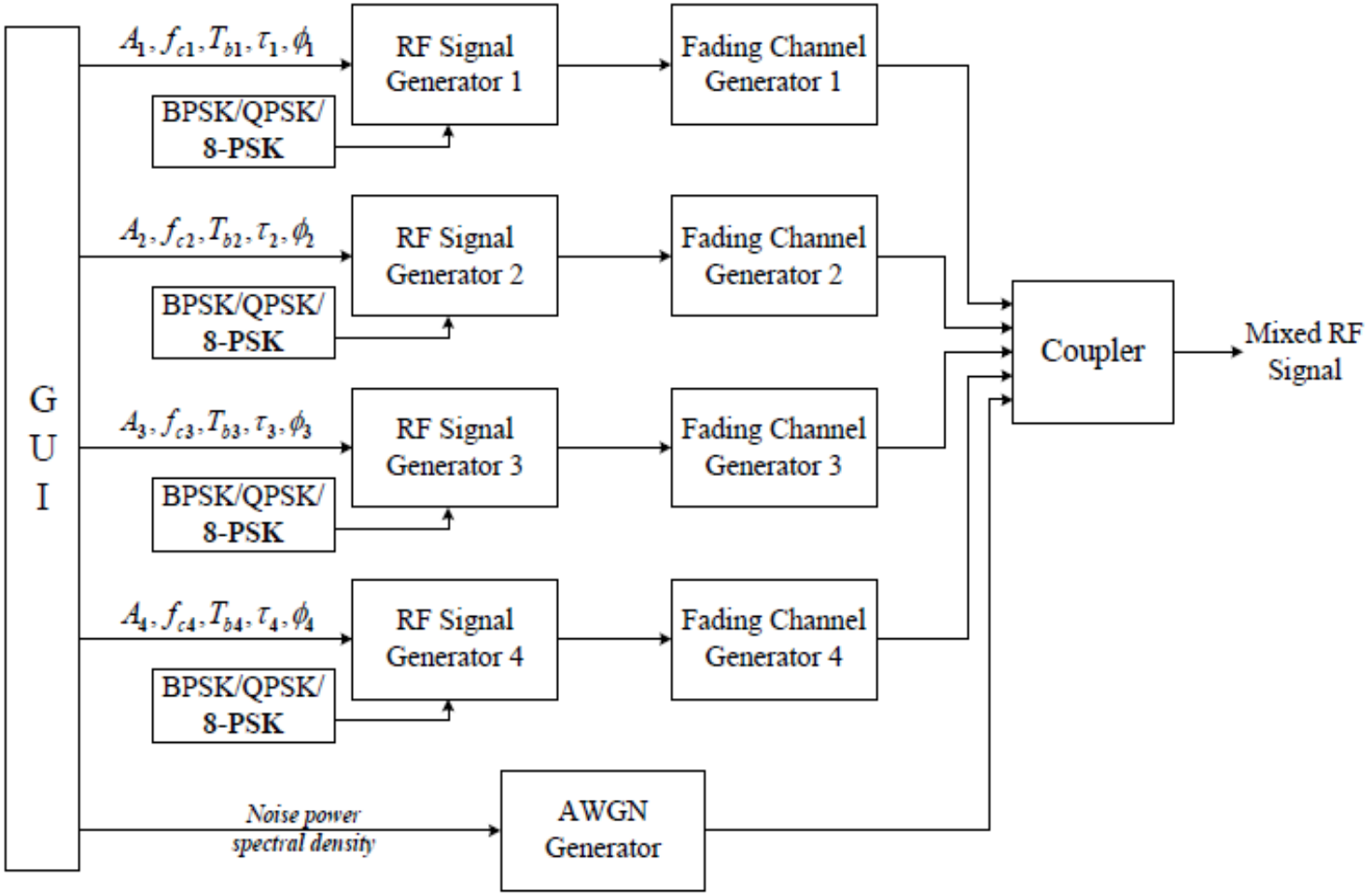
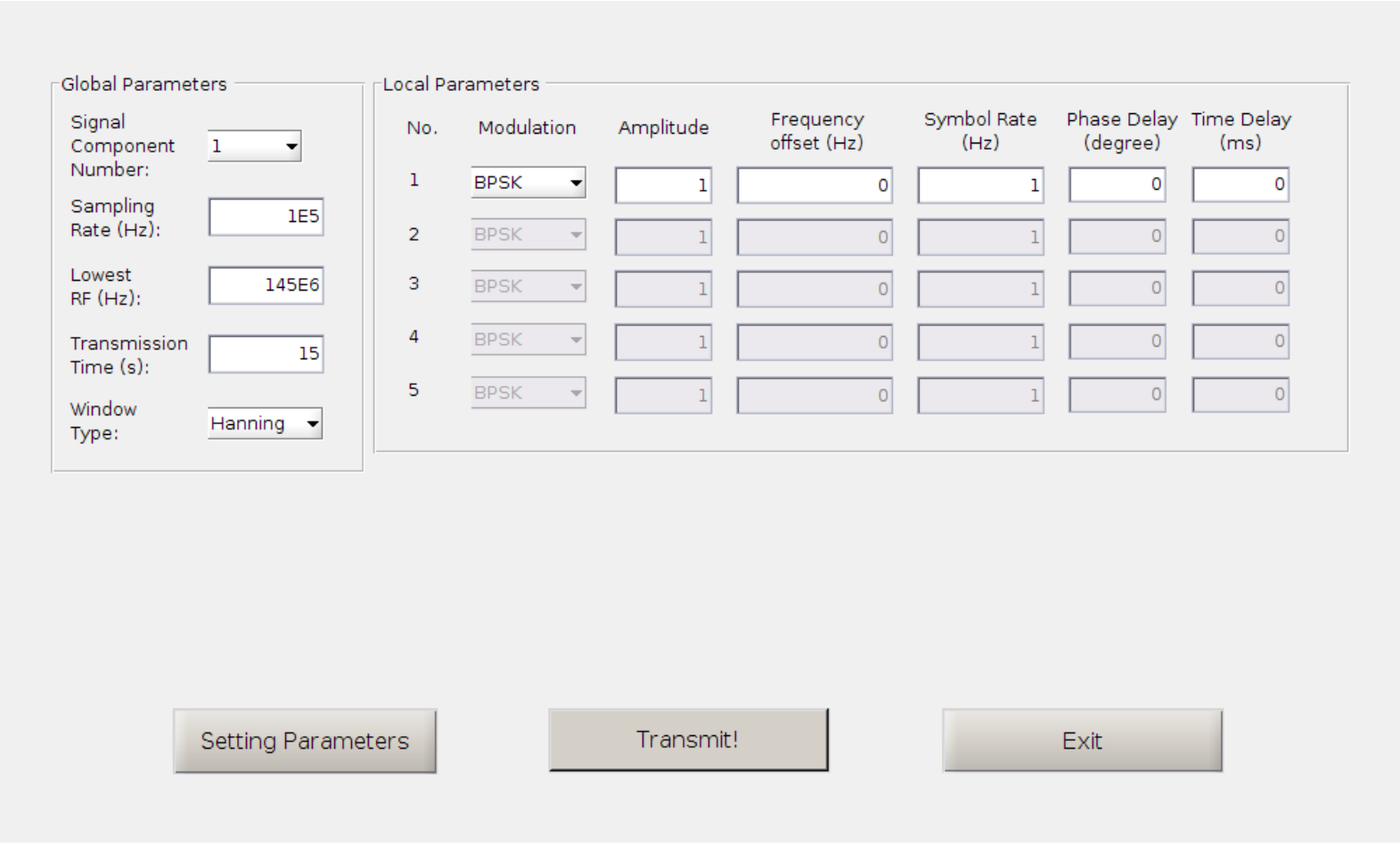


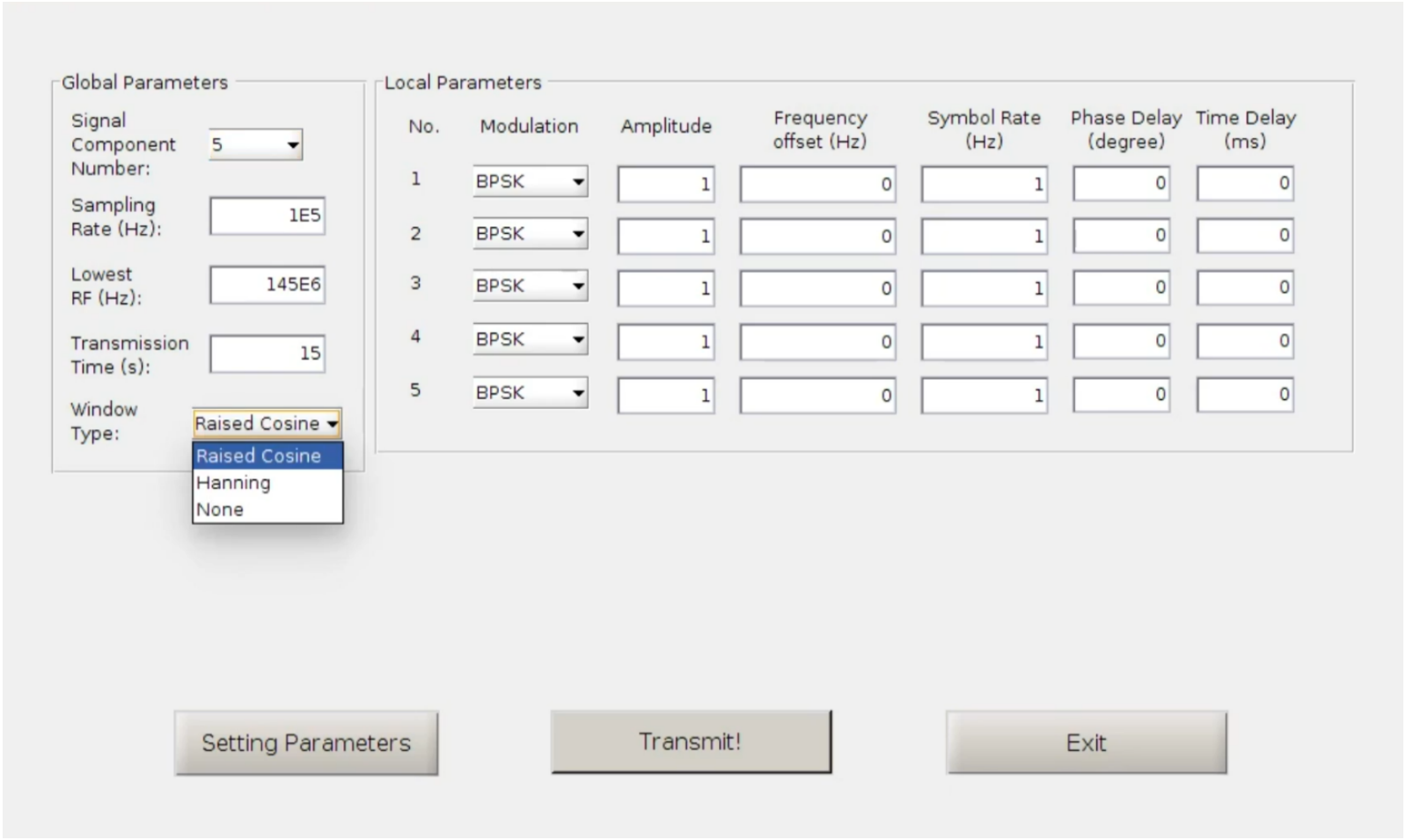
Mixed RF Signal Generator



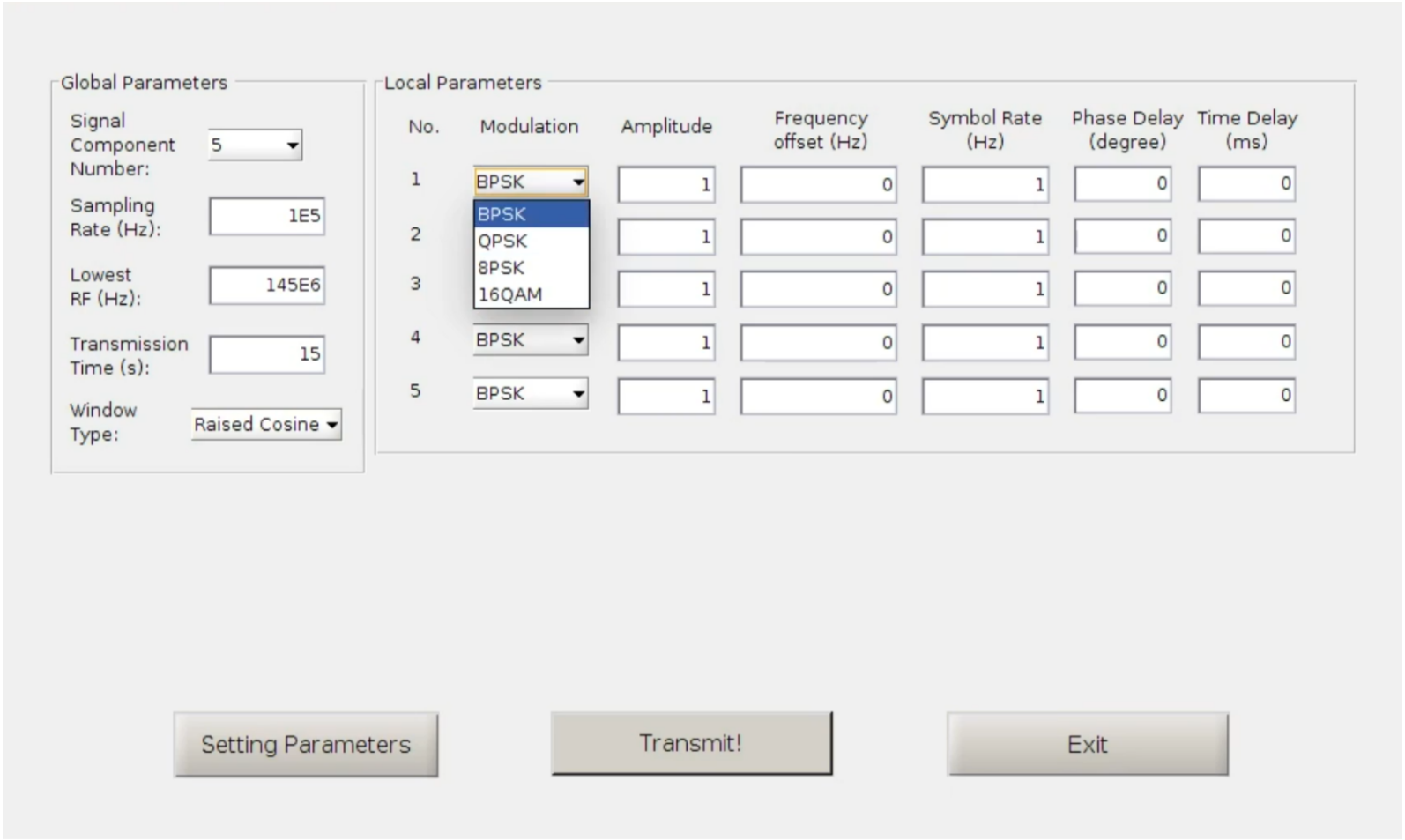
SDR based Mixed Signal Generator



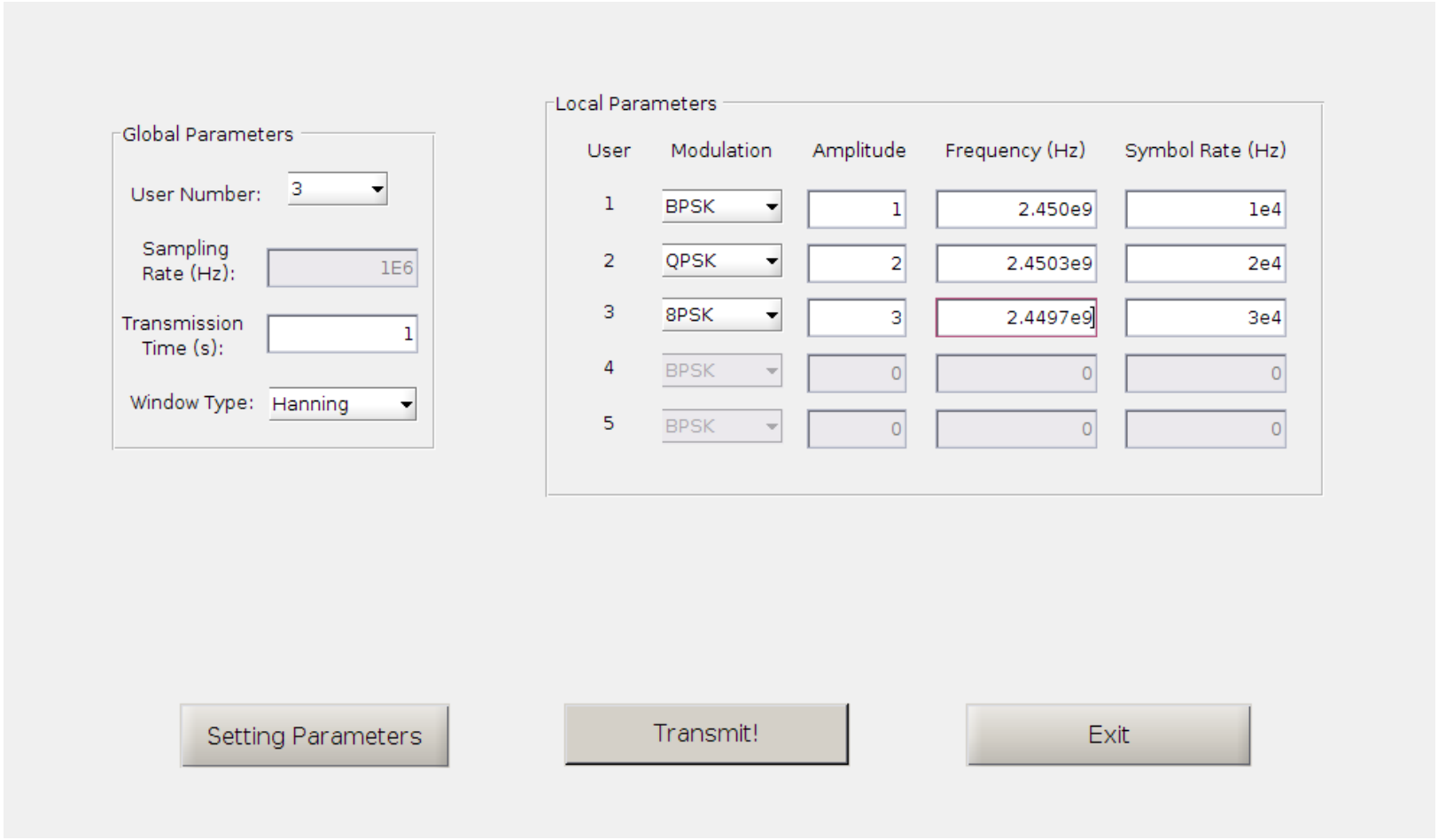
Pulse Shaping Filter



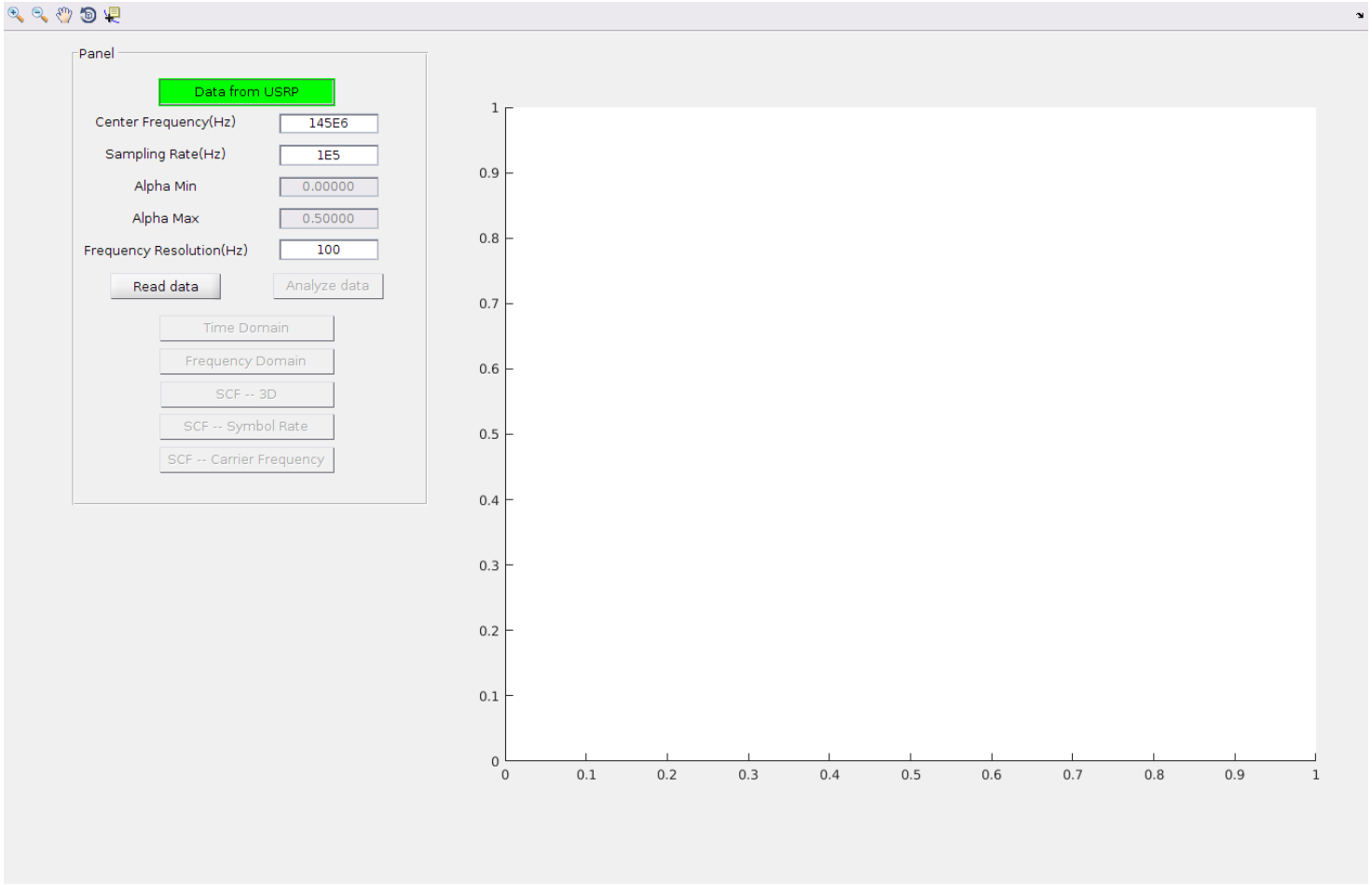
Modulation Type



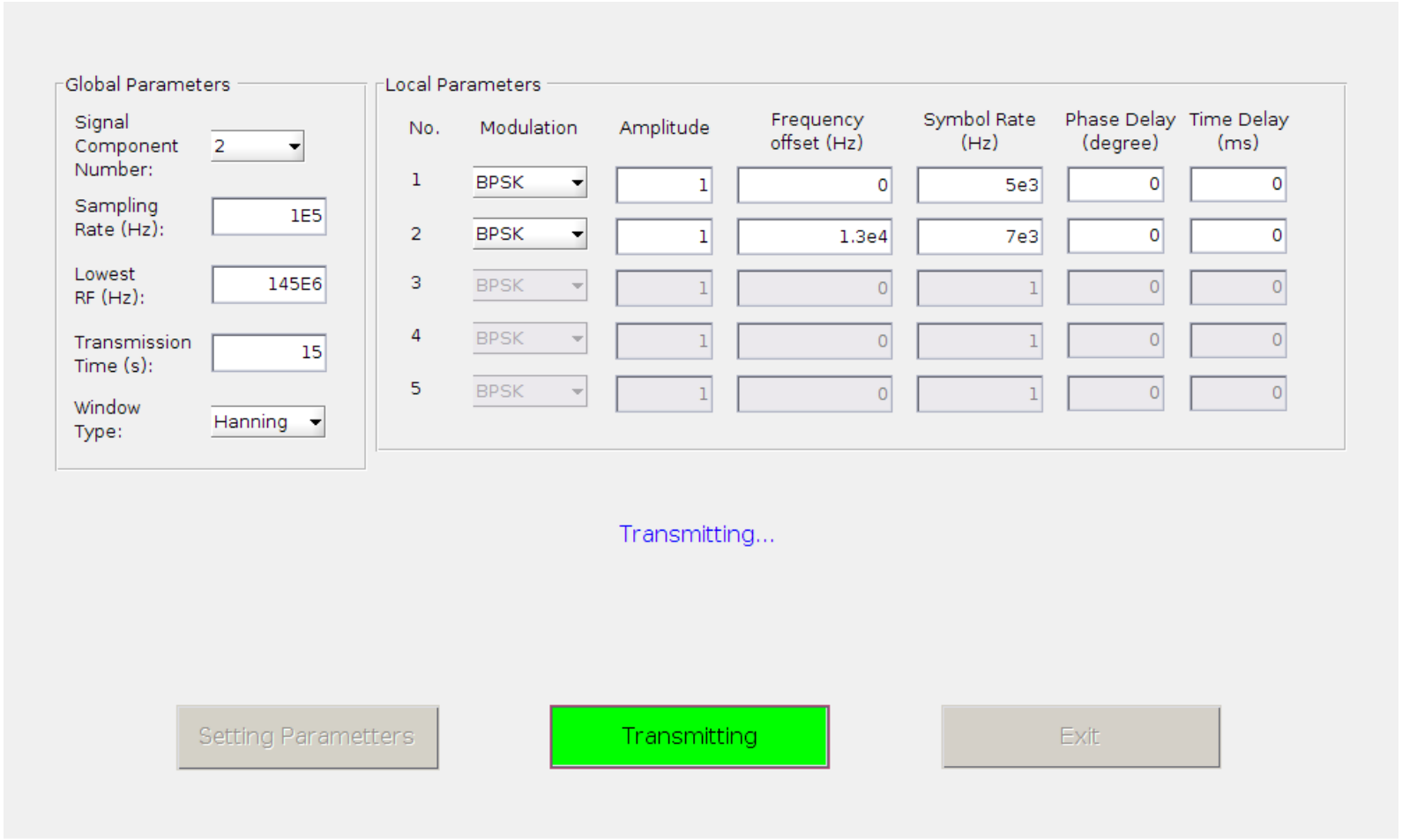
Other Parameters



Mixed Signal Detector



Case 1: Signals without Overlap



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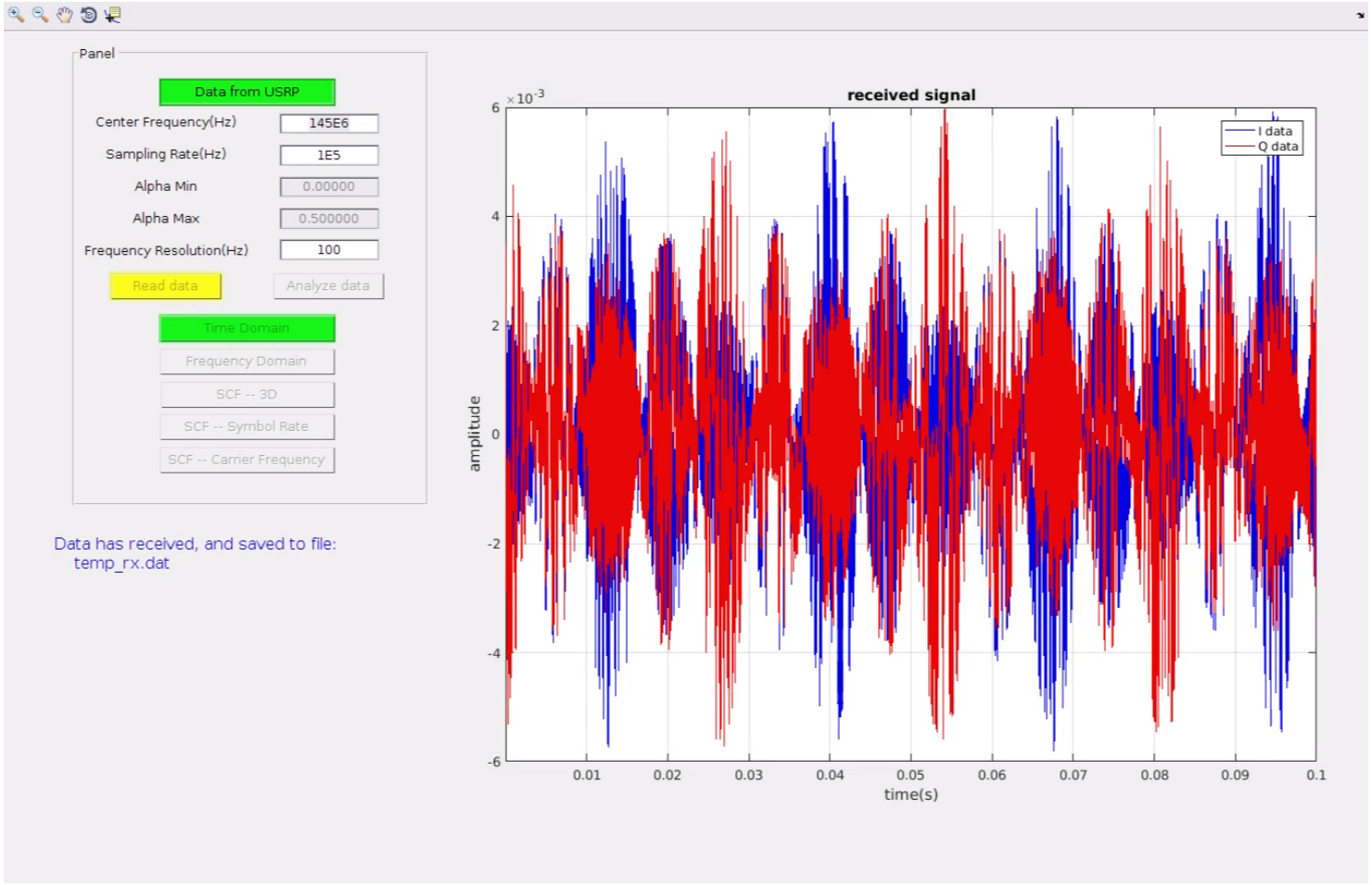

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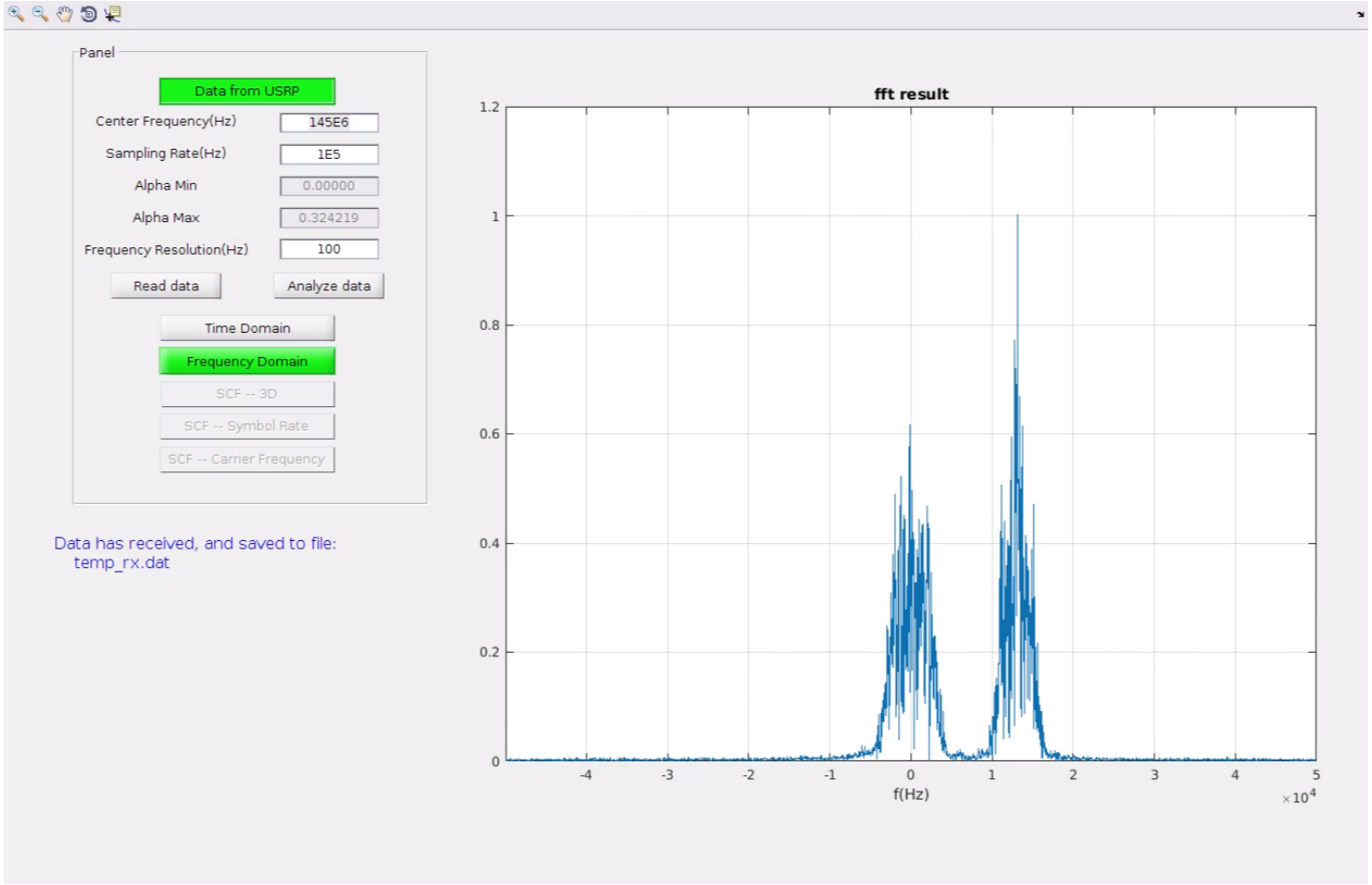

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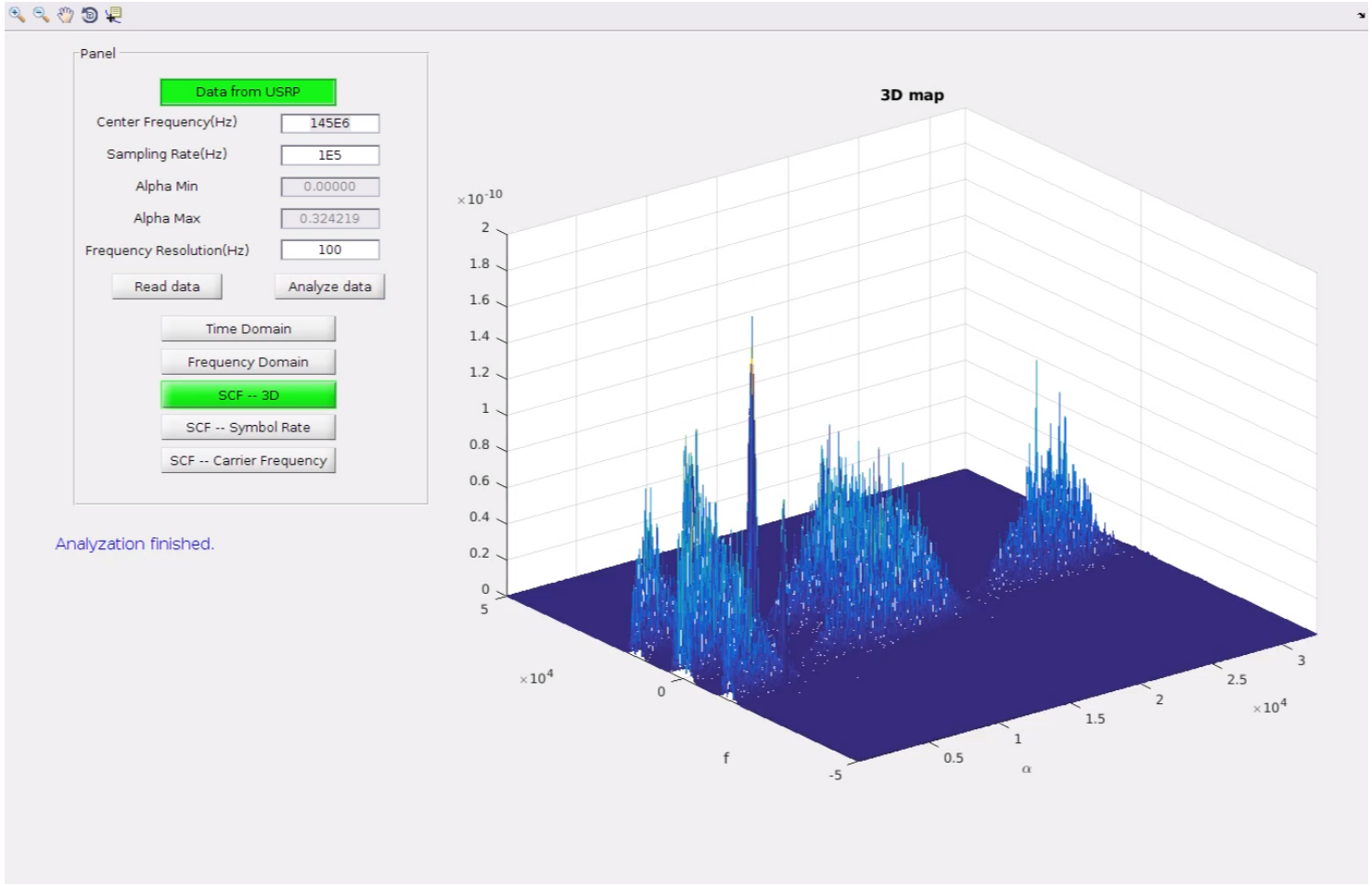

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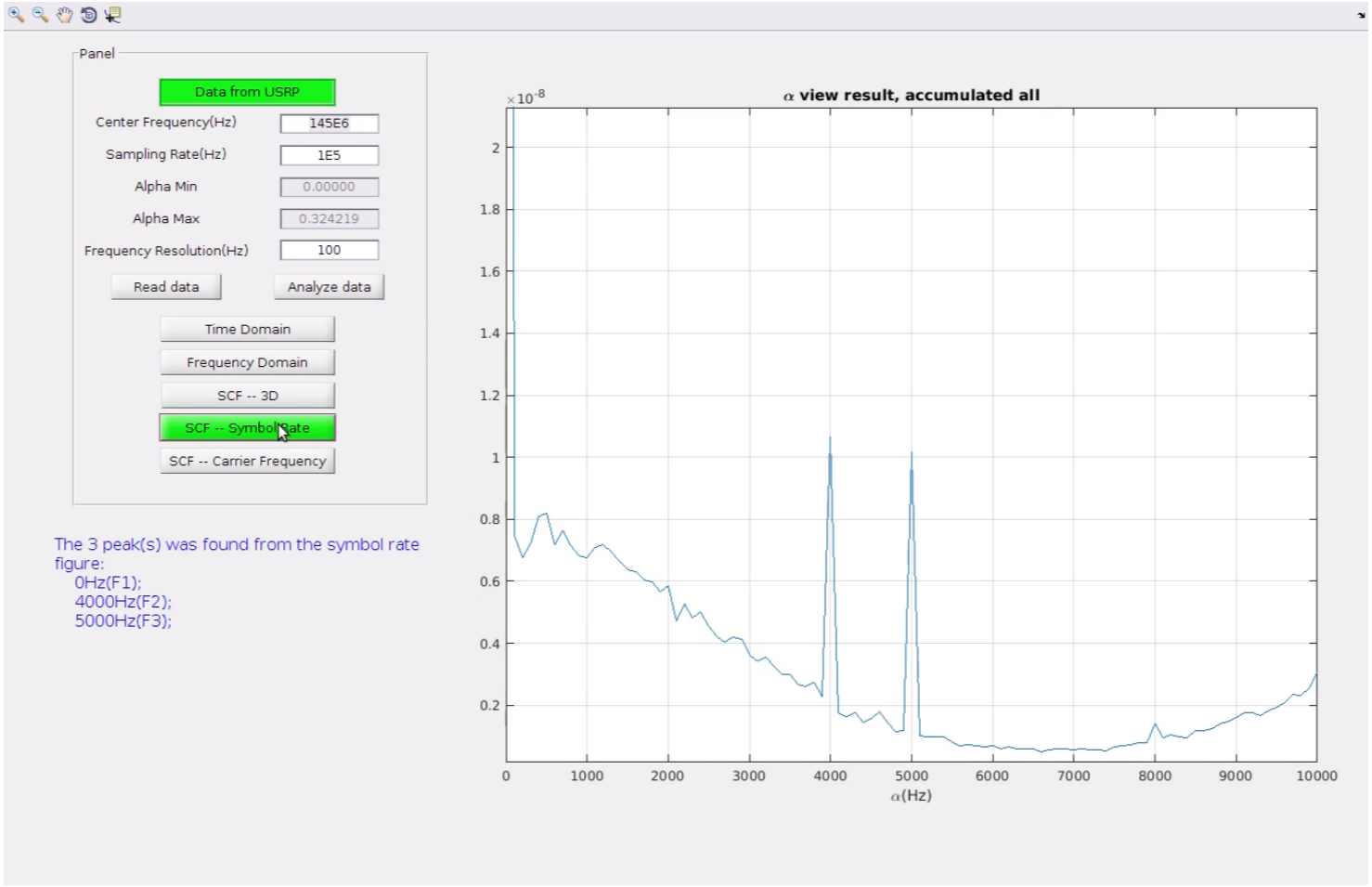
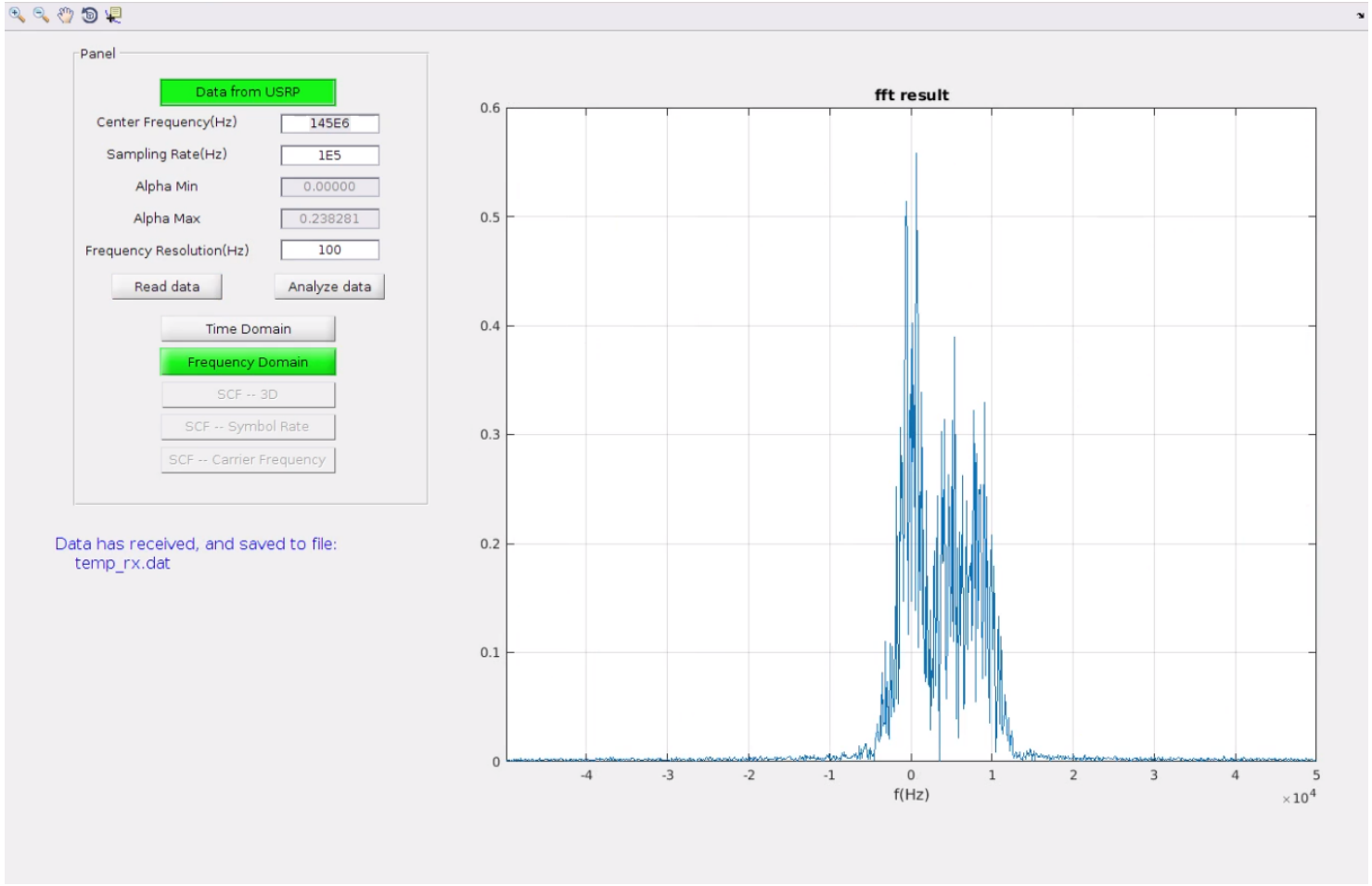


Case 2: Signal with Significant Overlap



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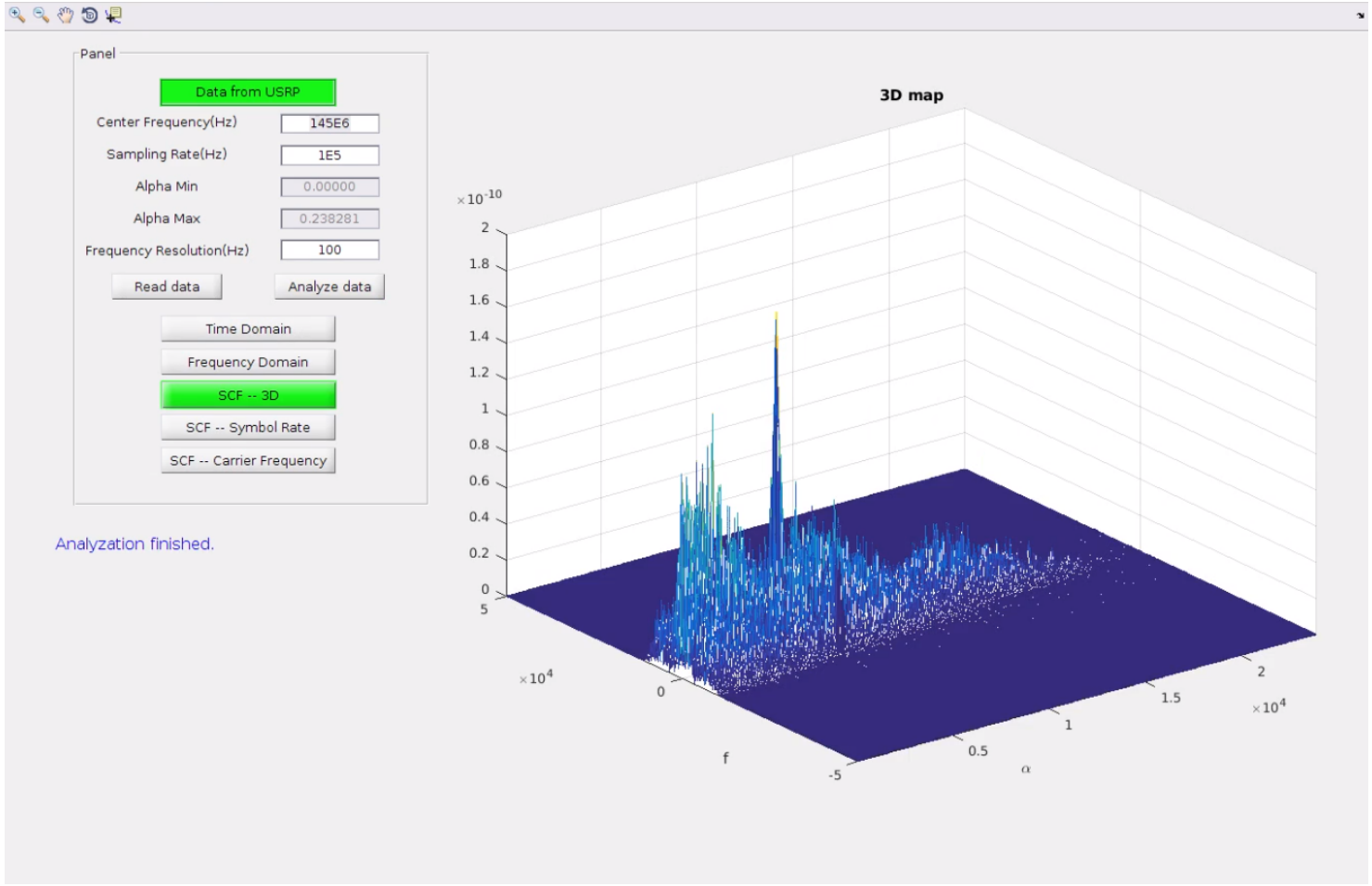

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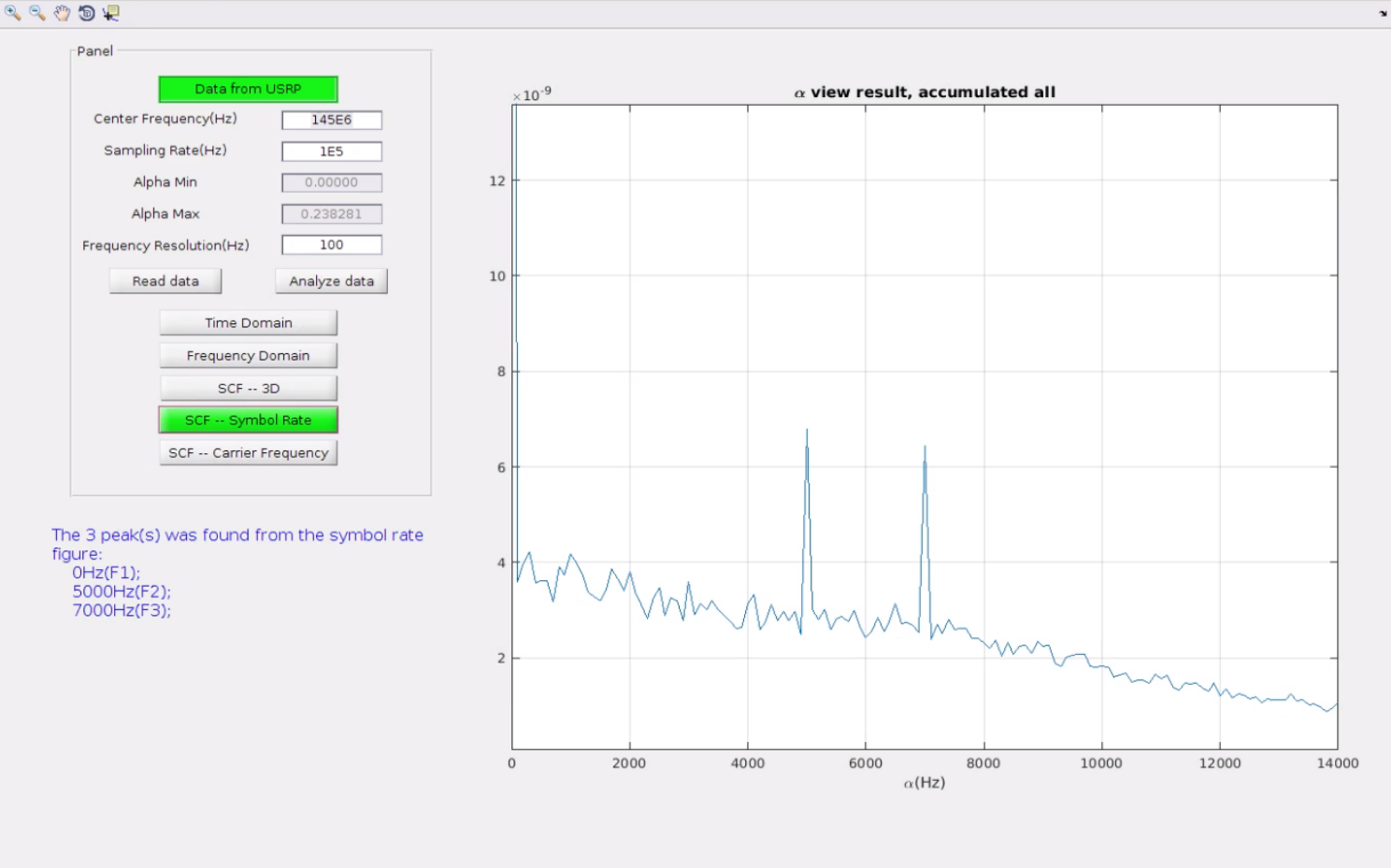
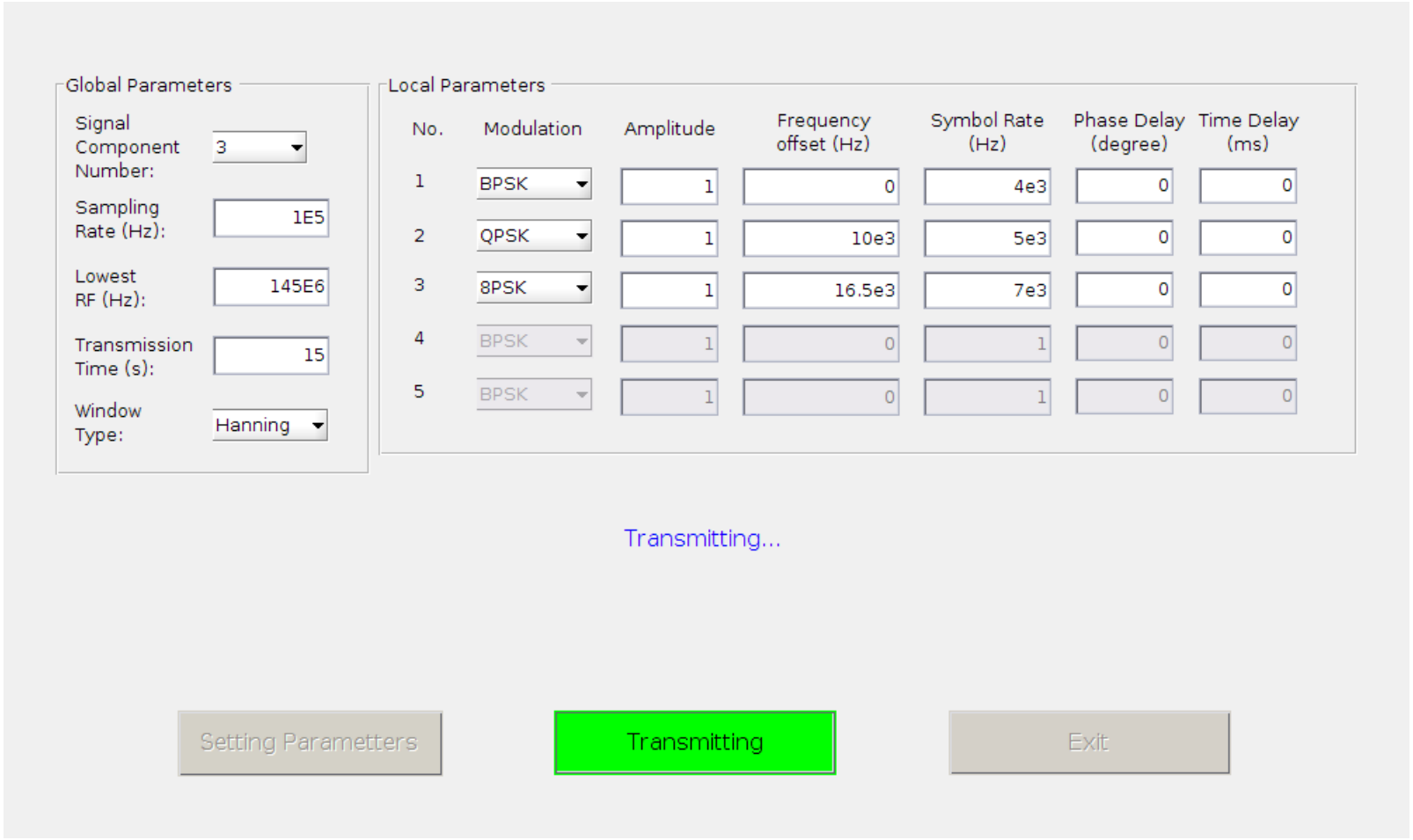


Case 3: 3 Signals Mixed Together



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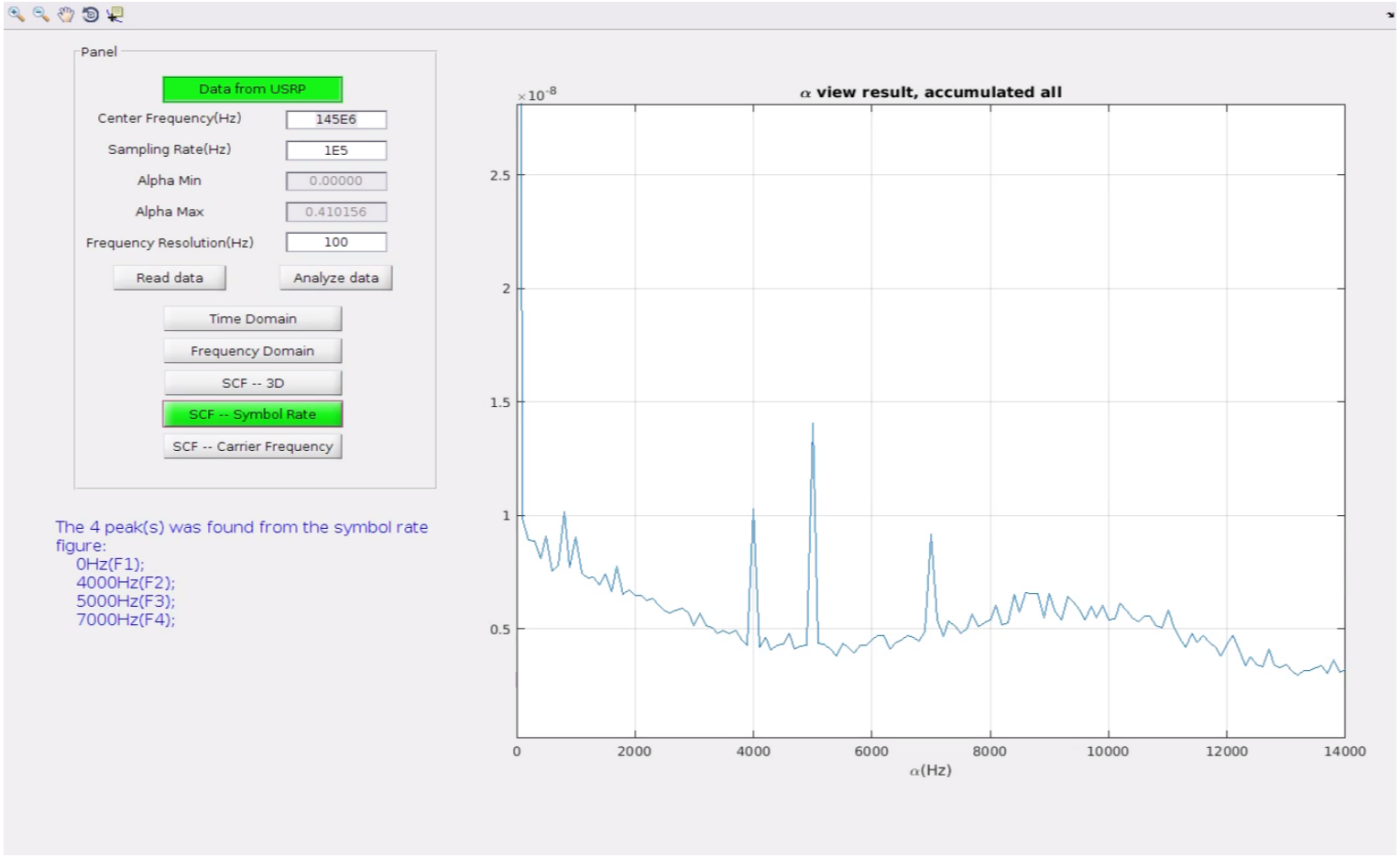

Conclusions

- Cyclostationary Analysis based Mixed Signal Detection
- SDR Implementation and Demonstration
- SDR Mixed RF Signal Generator
- SDR Mixed RF Signal Detector