

# HY-330

fall semester 2021

## Introduction to telecommunication systems theory

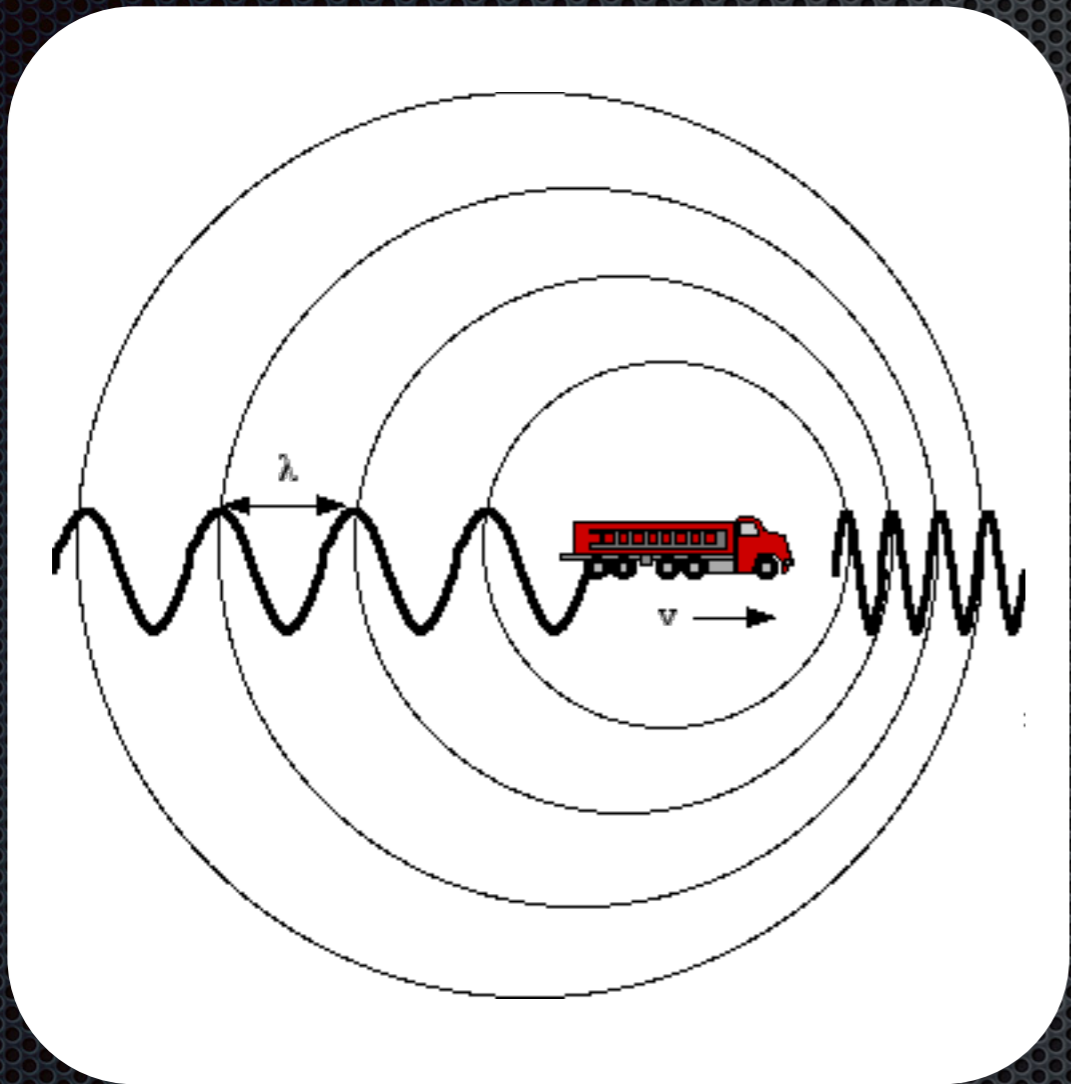
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# Degradation causes

- ✦ Doppler effect/shift
  - ✦ CFO estimation
- ✦ Inter Symbol Interference
  - ✦ Cyclic Prefix, Guard Interval
- ✦ I - Q imbalance

# Doppler effect/shift



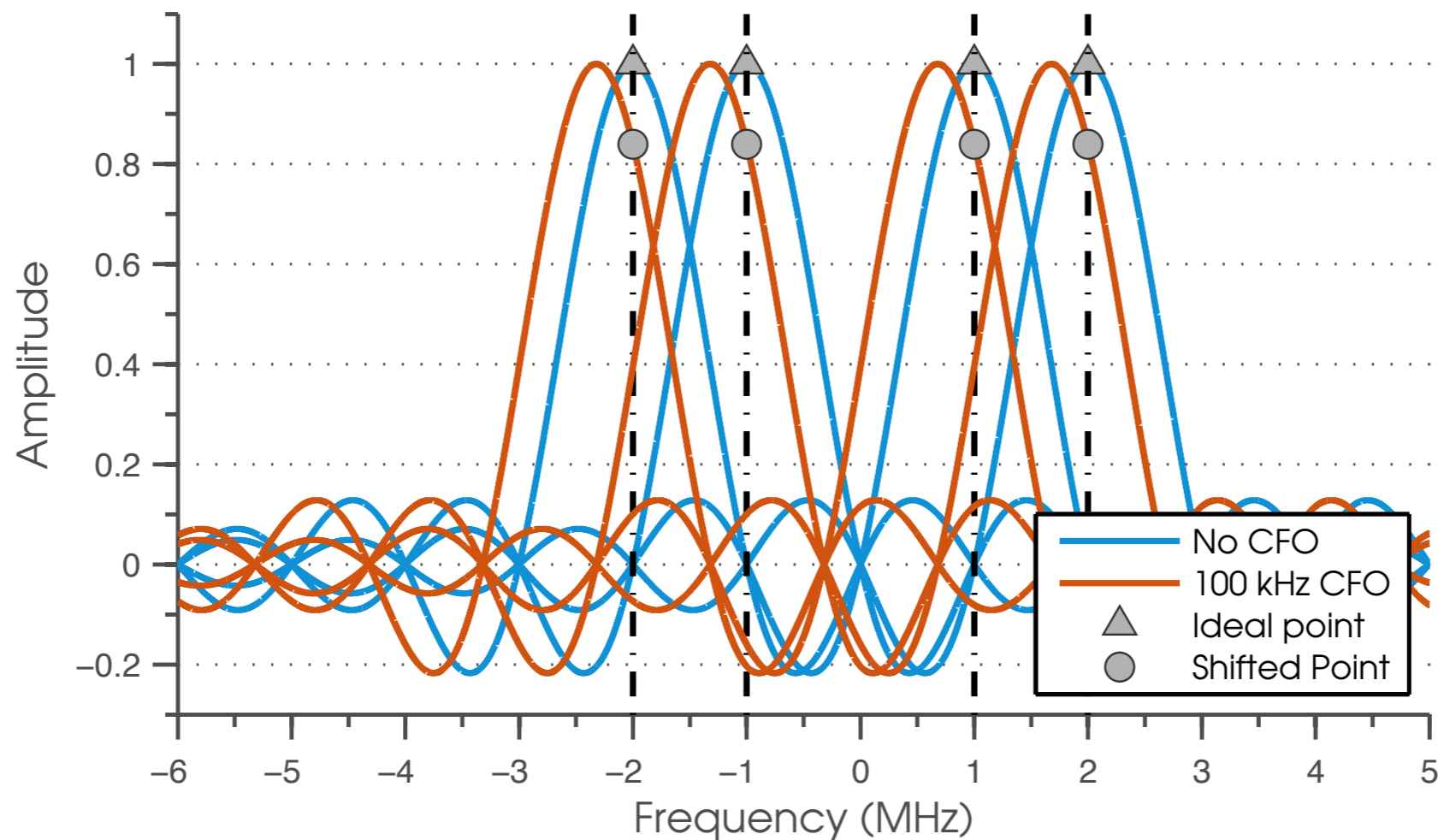
$$f = \left( \frac{c + v_{Rx}}{c + v_{Tx}} \right) f_0$$

$$f = \left( 1 + \frac{\Delta v}{c} \right) f_0$$

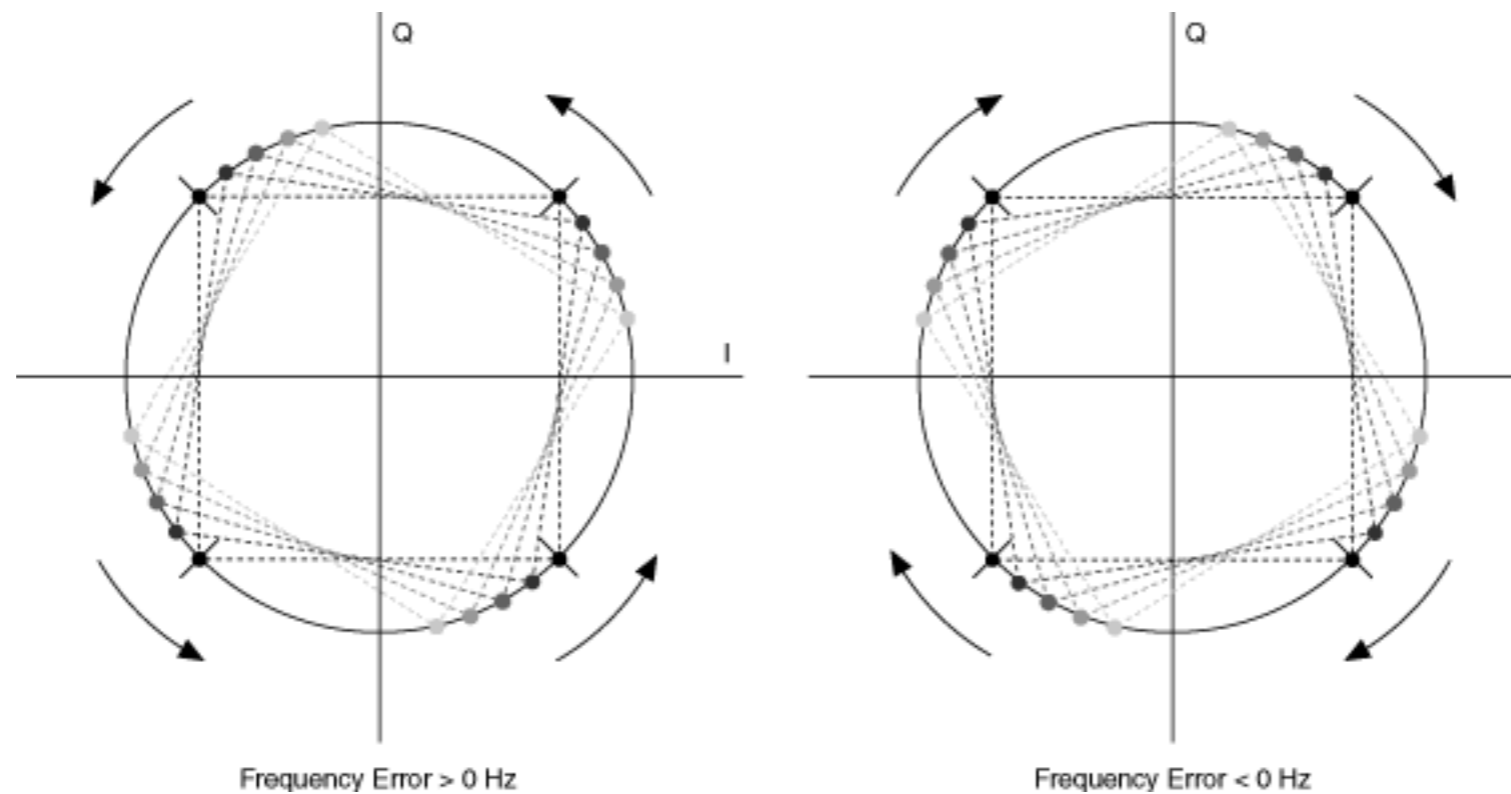
$$\Delta f = \frac{\Delta v}{c} f_0$$

$$\Delta f = f - f_0 \quad \Delta v = v_{Rx} - v_{Tx}$$

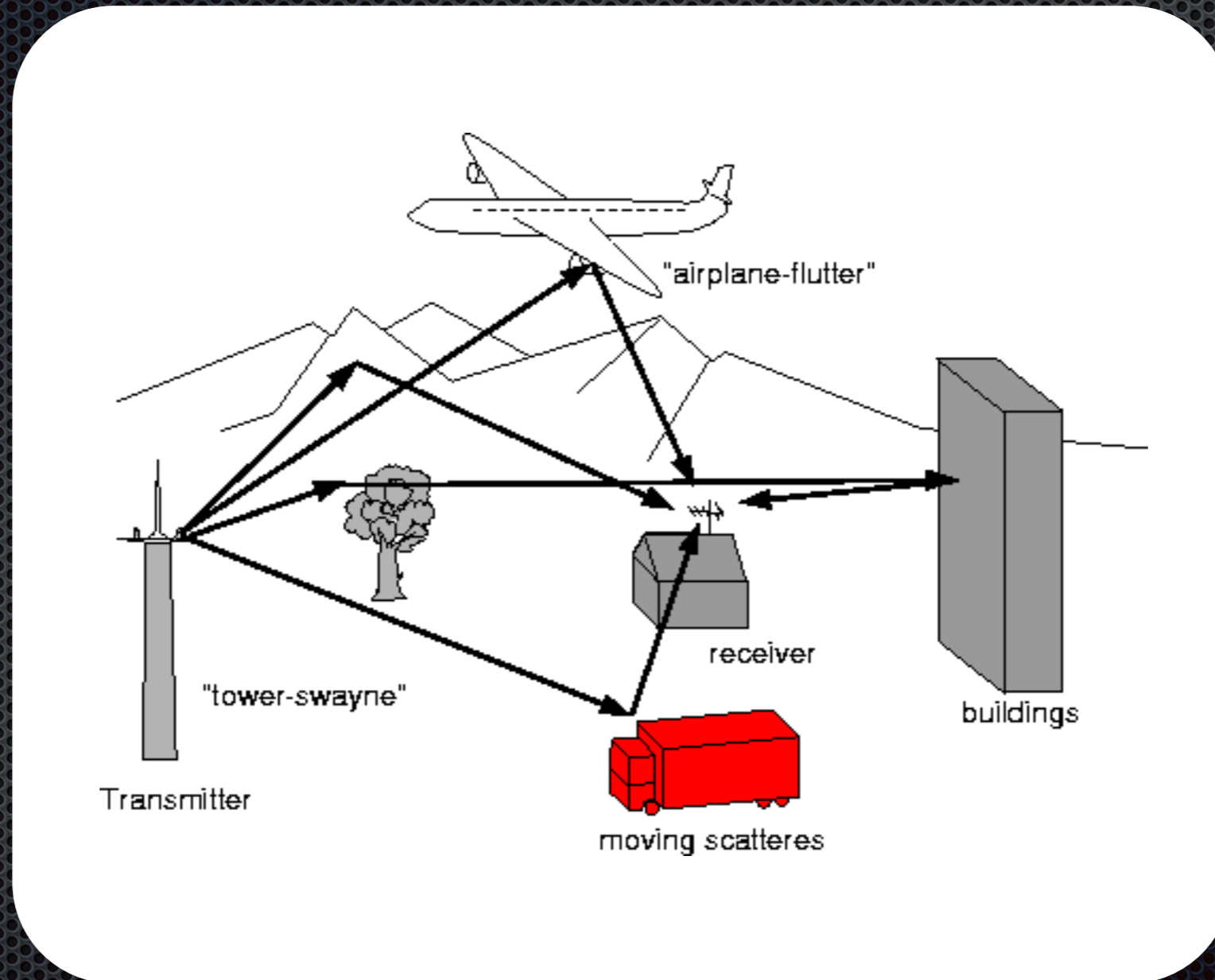
# CFO in frequency domain



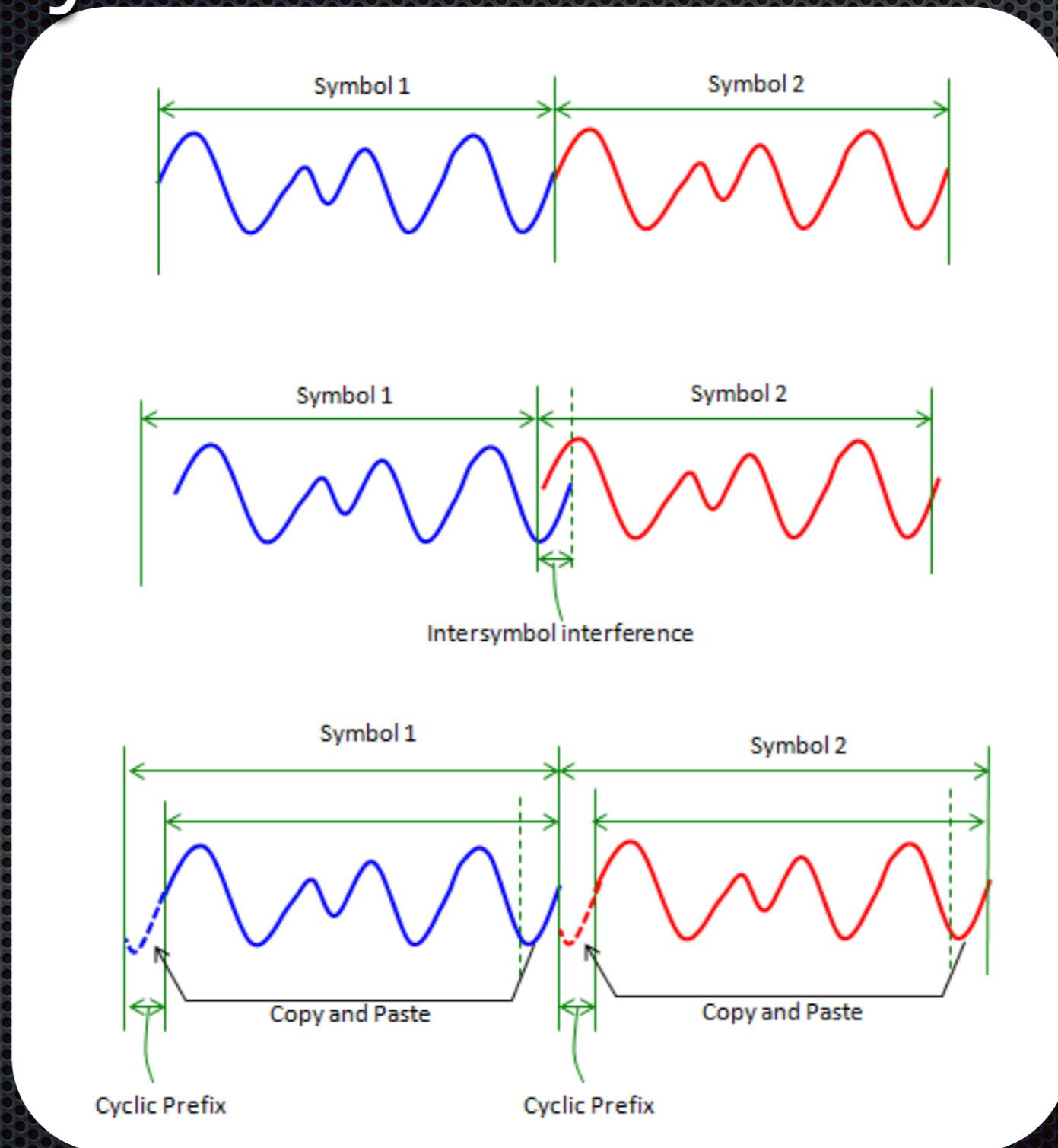
# CFO in constellation



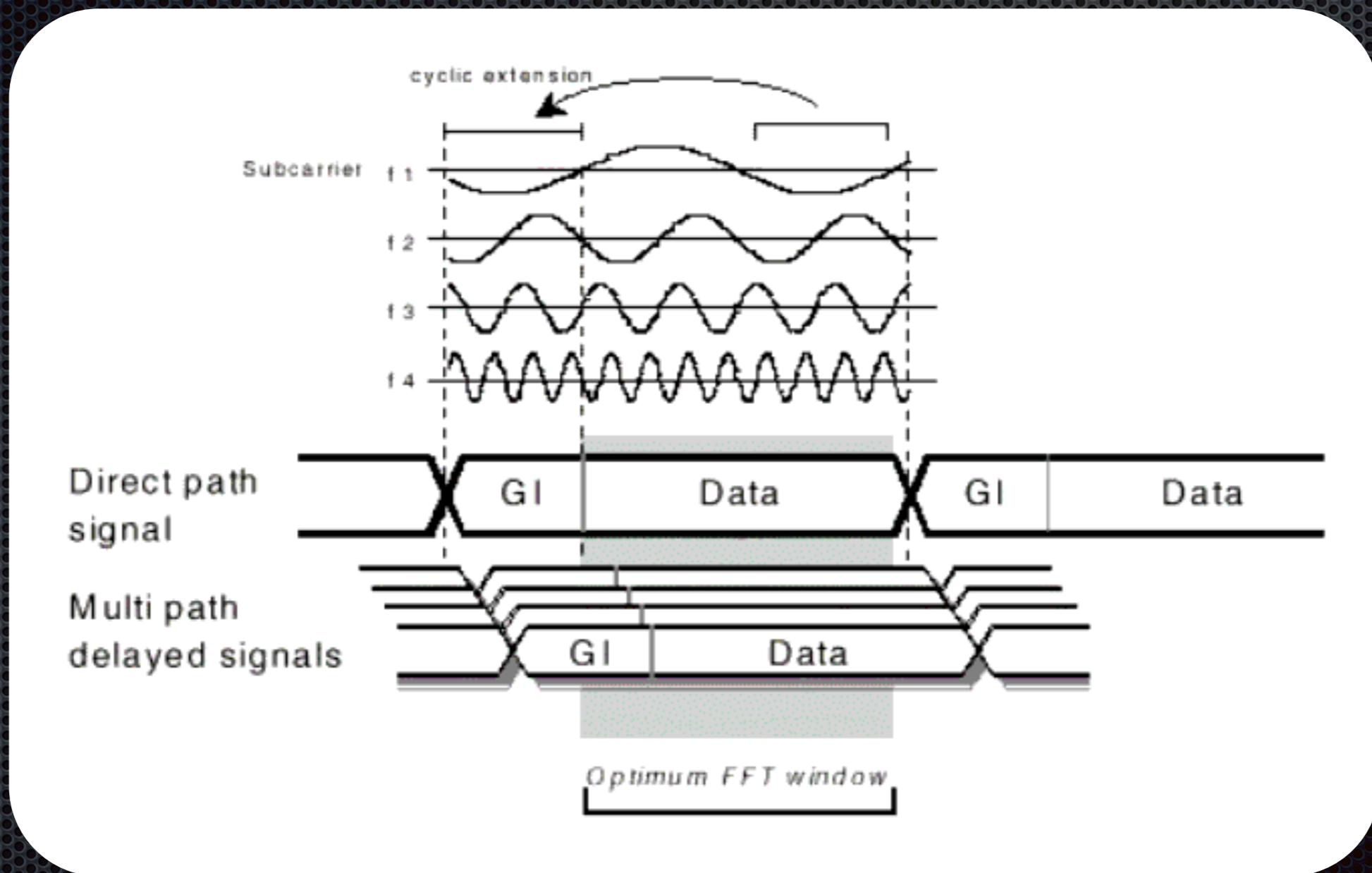
# Multipath



# Inter Symbol Interference

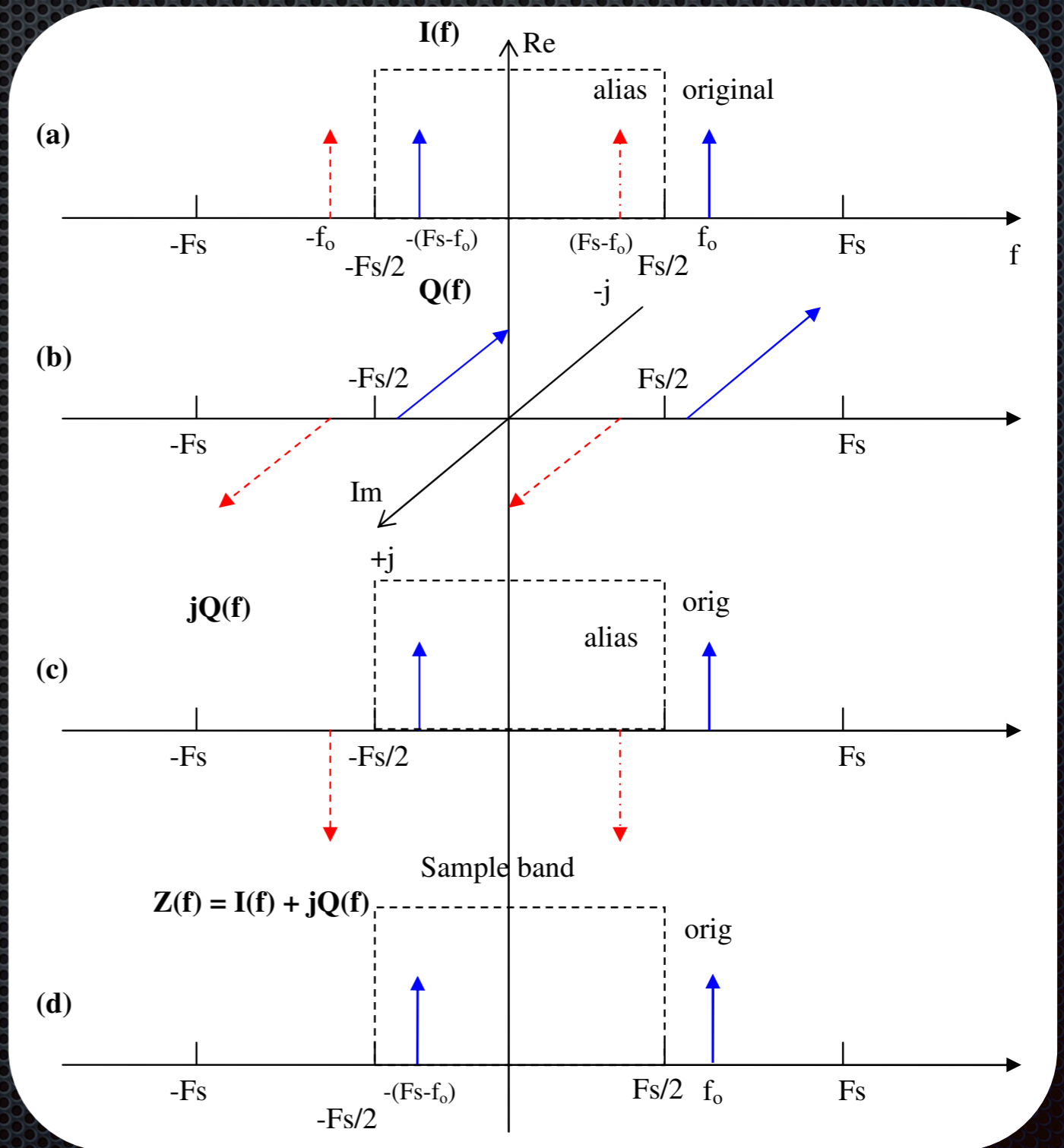
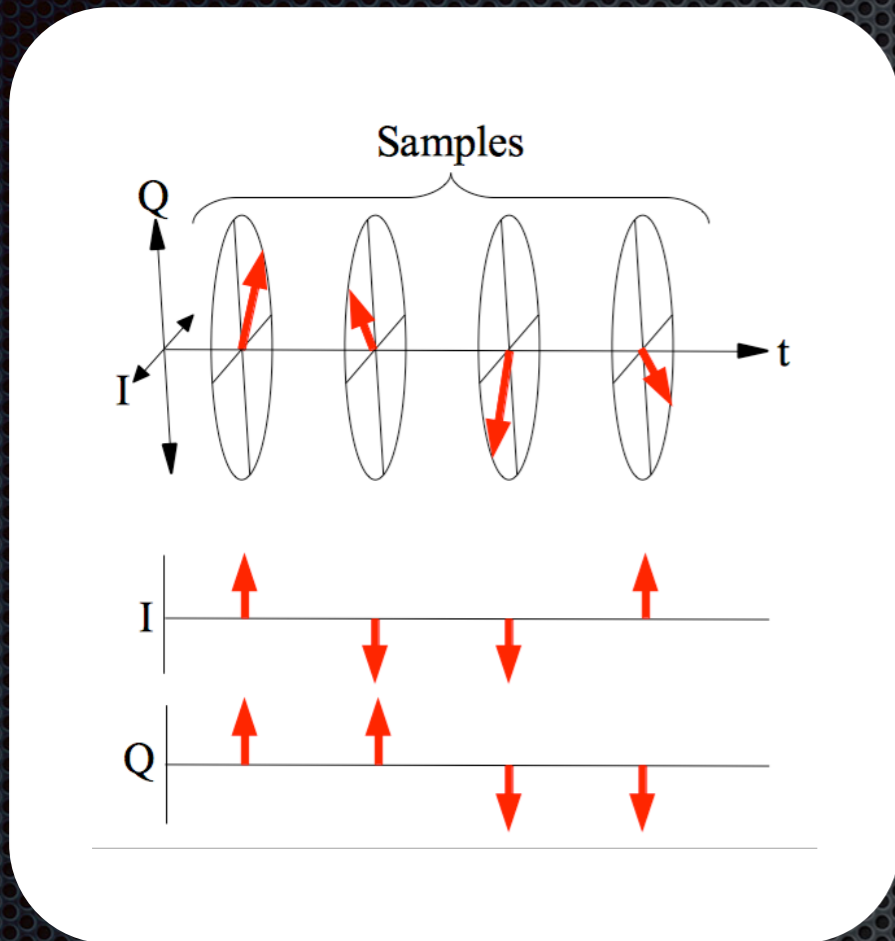


# Cyclic Prefix

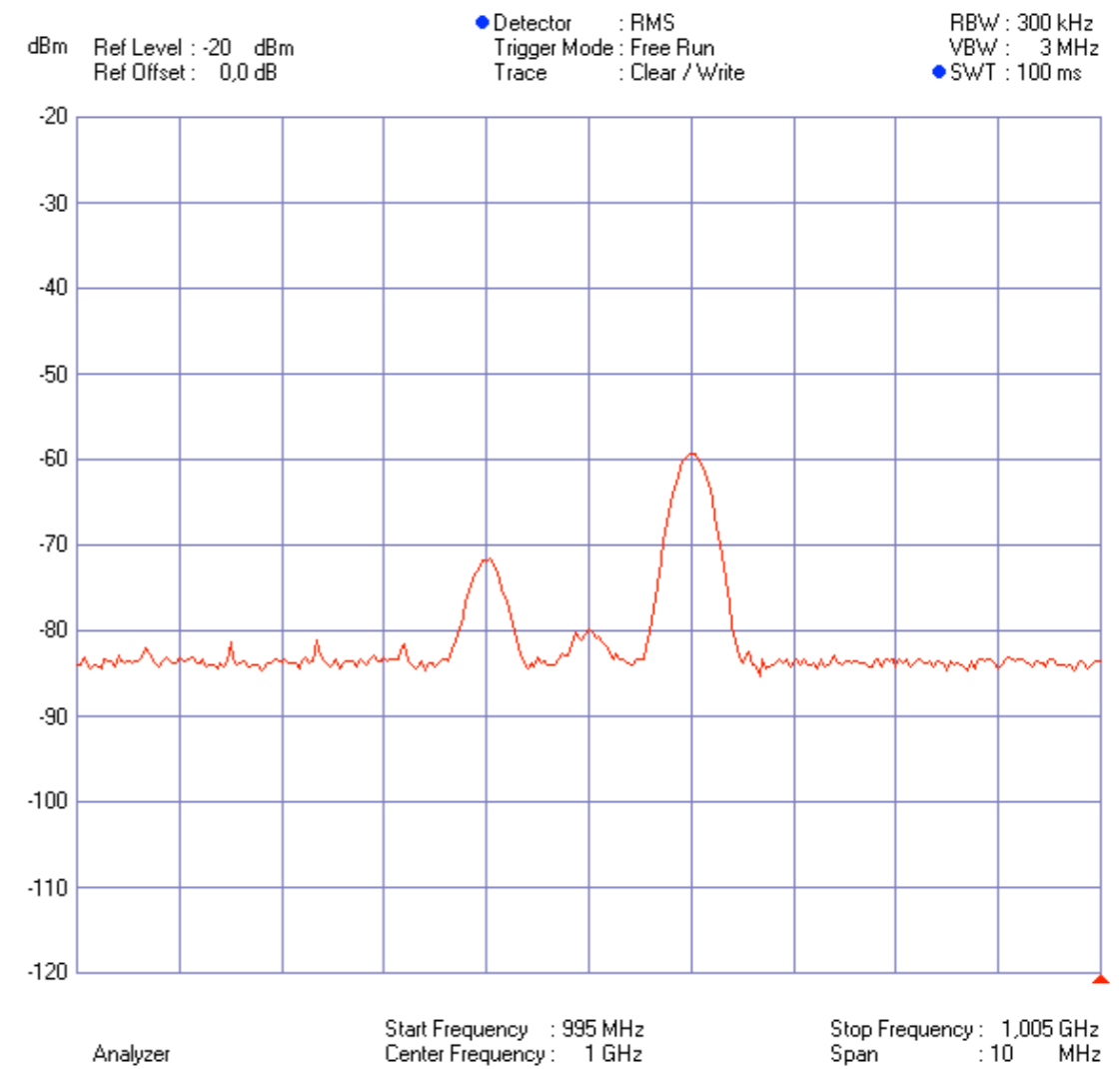
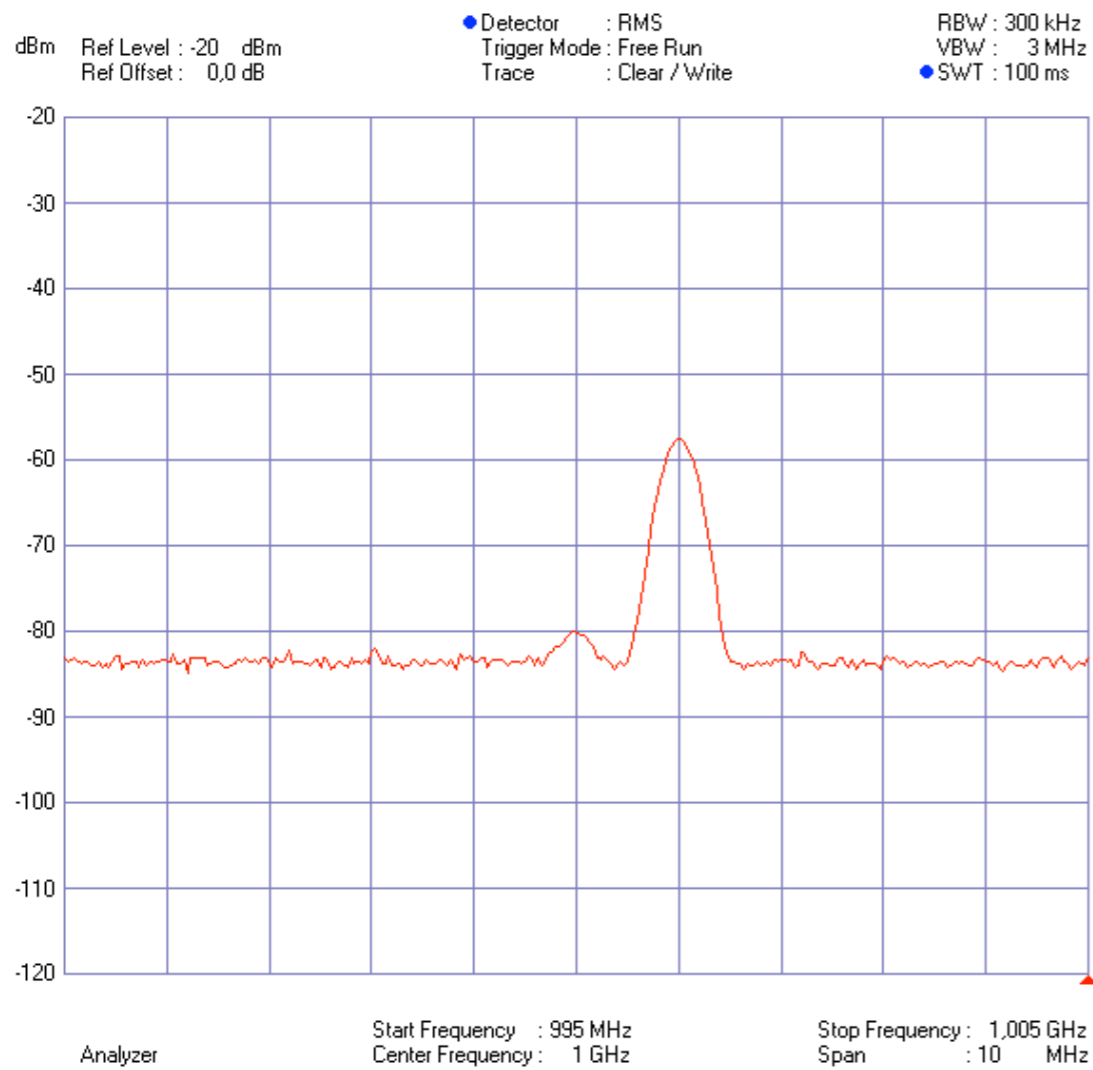




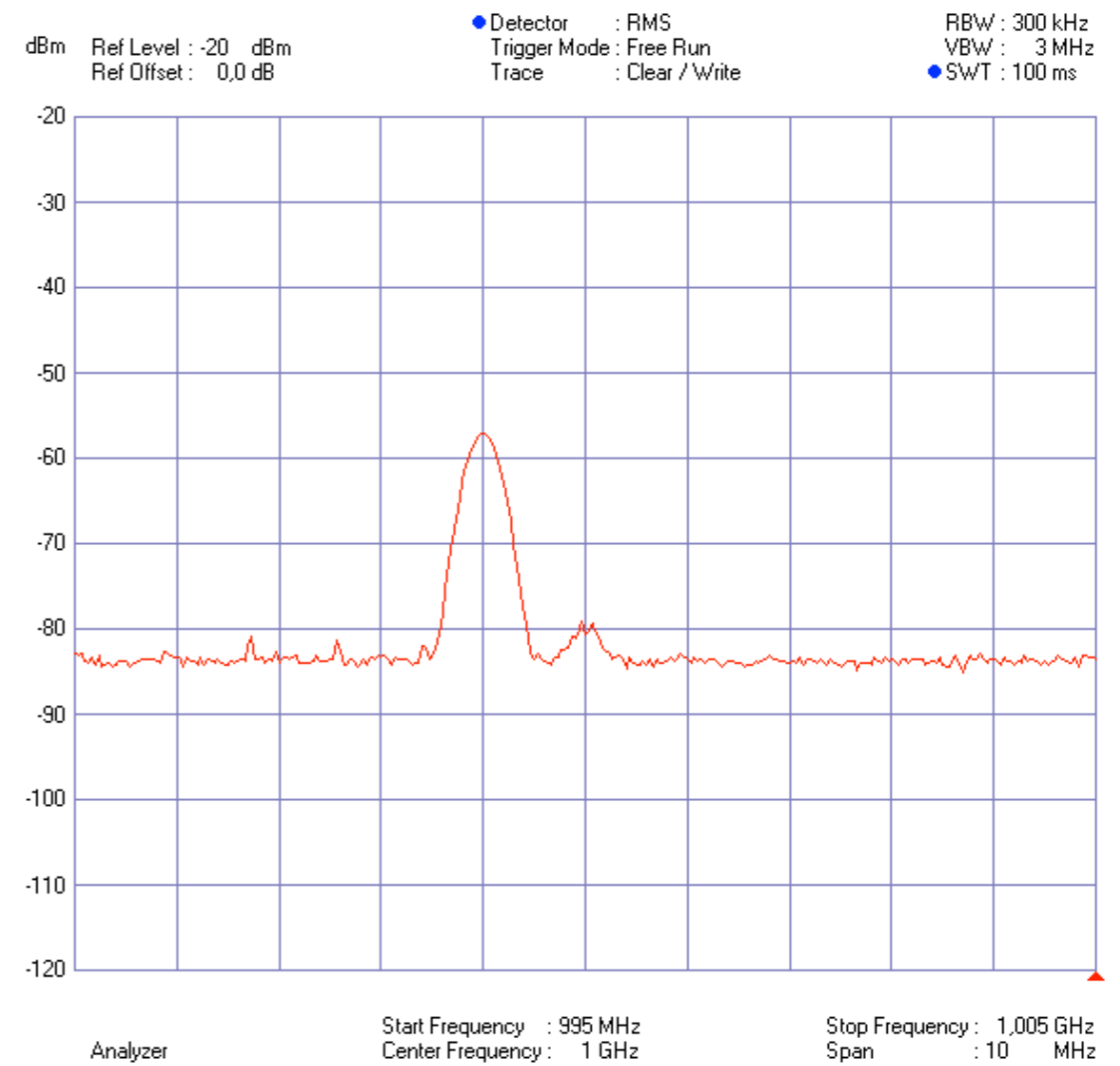
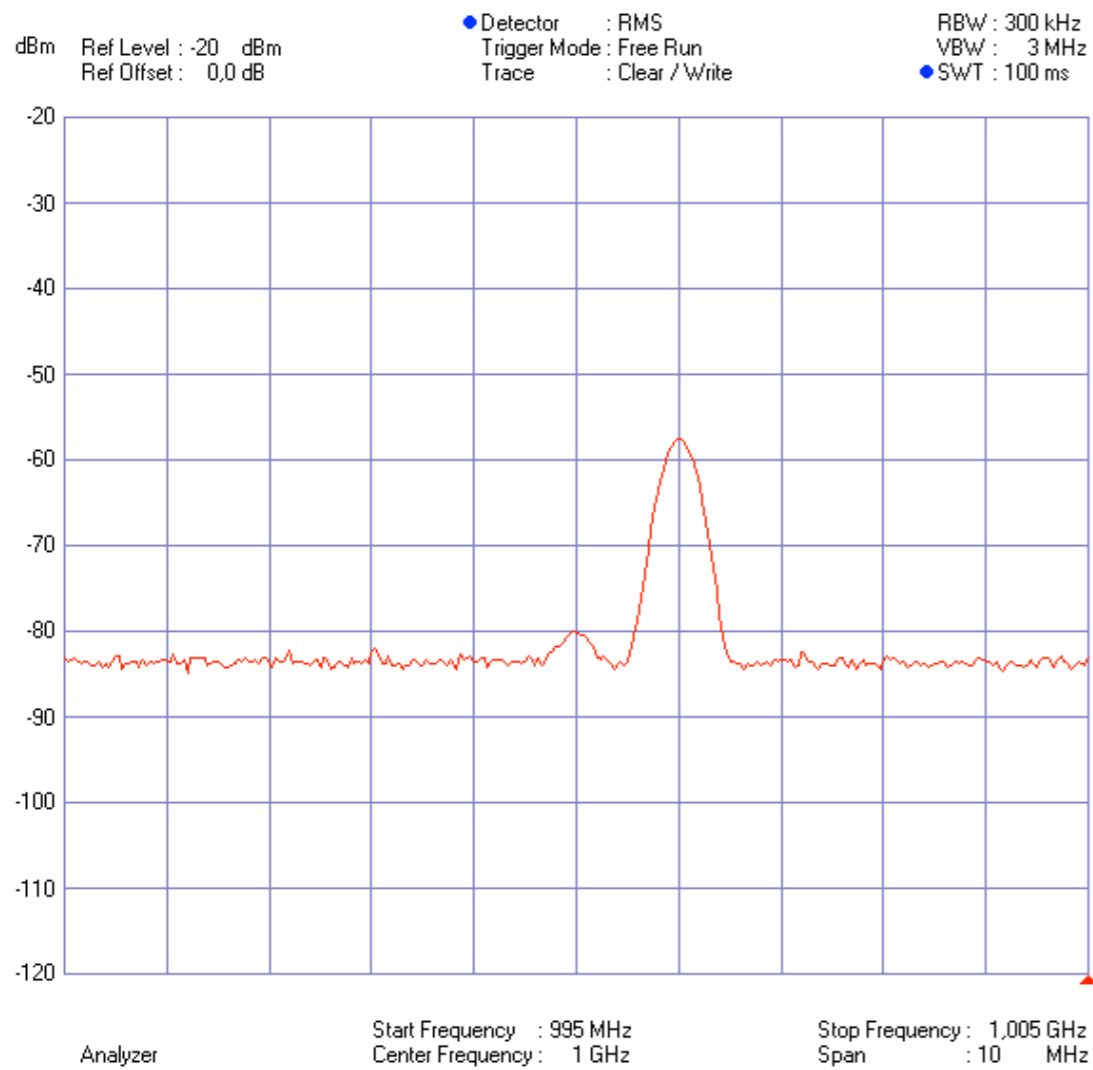
# I-Q imbalance



# IQ imbalance



# IQ swap



# Problems in the Tx-Rx chain

