

# Multipath Fading Demonstration Platform using Software Defined Radio

Naoki Sean Pross    Sara Cinzia Halter

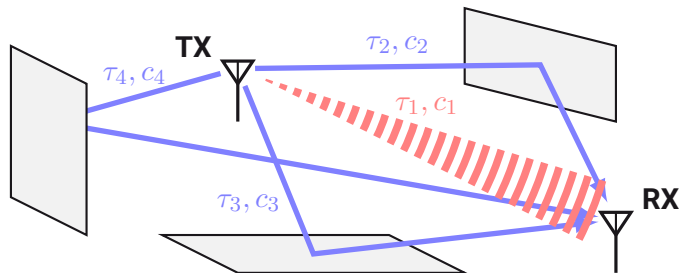
OST FHO Campus Rapperswil

23. December 2021

# Table of Contents

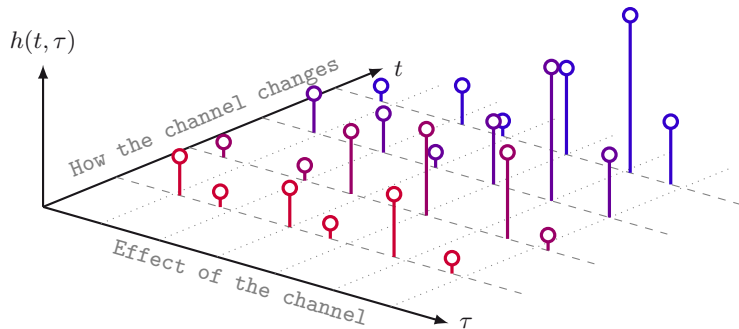
- 1 Multipath Fading
  - Discrete-time model
  - Statistical model
- 2 Implementation
  - Transmitter and Receiver Chains
  - Channel model
- 3 Conclusion
- 4 Demonstration

# Multipath fading



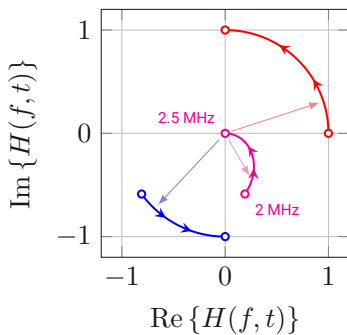
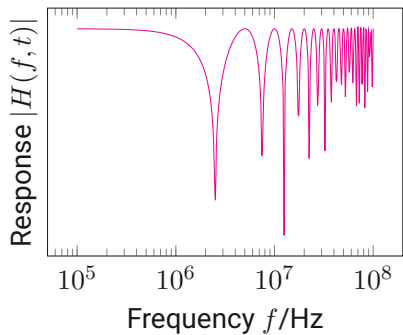
$$r(t) = \sum_k c_k s(t - \tau_k).$$

# Impulse response of a multipath fading channel

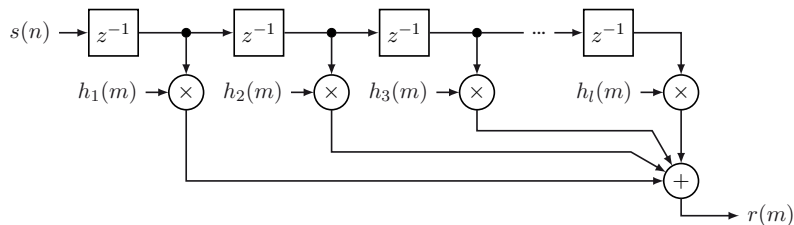


$$h(\tau, t) = \sum_k c_k(t) \delta(\tau - \tau_k(t))$$

# Spectrum of a multipath fading channel



# Discrete-time and FIR



$$h_l(m) = \sum_k c_k(mT) \operatorname{sinc} \left( l - \frac{\tau_k(mT)}{T} \right)$$

# Statistical model

Assuming WSSUS

$$\theta_k \sim \mathcal{U}(0, 2\pi)$$

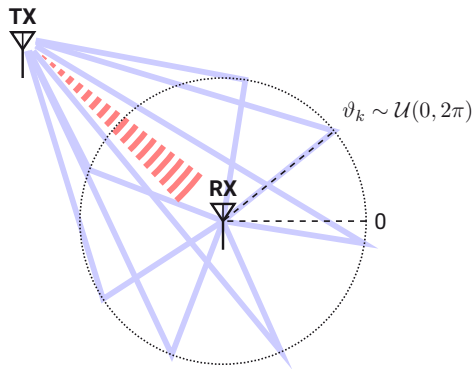
The NLOS Fading

$$f = \lim_{N \rightarrow \infty} \frac{1}{\sqrt{N}} \sum_{k=1}^N e^{j\theta_k}$$

$$f \sim \text{Rayleigh}$$

if there is a LOS

$$f \sim \text{Rice}(K)$$



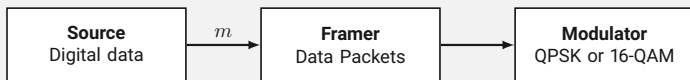
# Table of Contents

- 1 Multipath Fading
  - Discrete-time model
  - Statistical model
- 2 Implementation**
  - Transmitter and Receiver Chains
  - Channel model
- 3 Conclusion
- 4 Demonstration

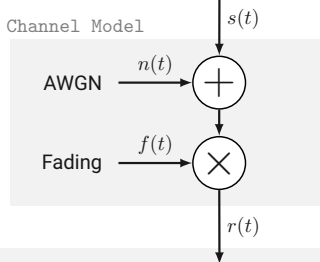


# Block Diagram

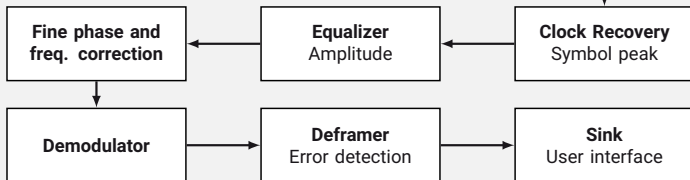
Transmitter



Channel Model



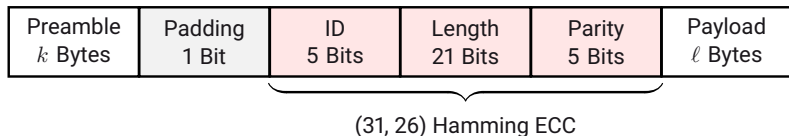
Receiver



# Transmitter

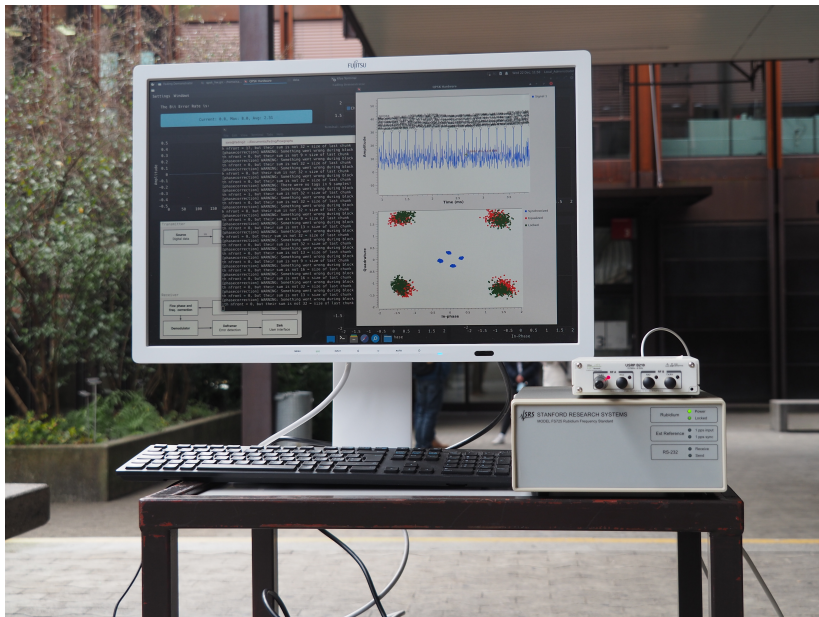


# Framed data packets

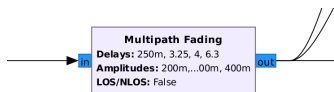


- Very short payload
- $k$ -Byte preamble is a Barker code 0x1f35 for Sync
- Should be replaced with CAZAC

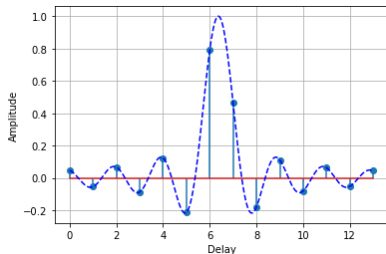
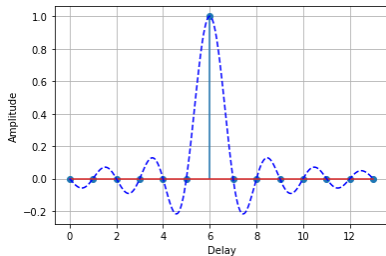
# Receiver



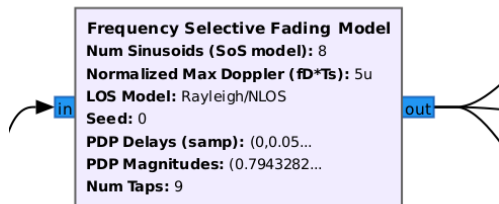
# Discrete-time model



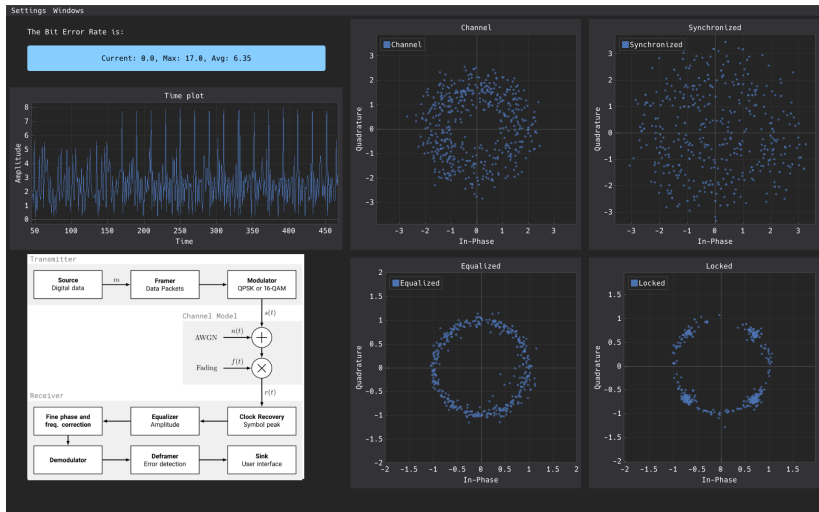
- FIR filter
- Allows for non integer delays



# Statistical model



# Graphical user interface



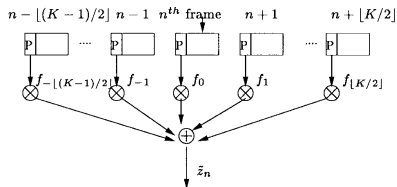
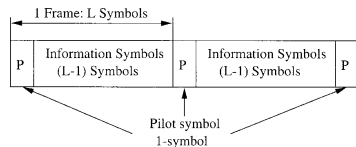
Built with DearPyGUI, talks to GR via UDP/IP.

# Table of Contents

- 1 Multipath Fading
  - Discrete-time model
  - Statistical model
- 2 Implementation
  - Transmitter and Receiver Chains
  - Channel model
- 3 Conclusion
- 4 Demonstration



# Further steps



- Improve BER measurements and simulations
- Improvements in the GUI front-end
- Portable transmitter on a Raspberry Pi
- Channel parameters estimation with PSAM

# Table of Contents

- 1 Multipath Fading
  - Discrete-time model
  - Statistical model
- 2 Implementation
  - Transmitter and Receiver Chains
  - Channel model
- 3 Conclusion
- 4 **Demonstration**

- Simulation
  - Discrete-time model
  - Statistical model
- Hardware