System Architecture for a Dynamic-Spectrum Radio

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Dynamic-Spectrum Radio System "Top Down Approach"

- Requires accurate transmitter and receiver databases
- Limited by accuracy of propagation models
- Sharing in frequency & location

- Improves spectrum usage for unlicensed but allocated spectrum

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Dynamic-Spectrum Radio System "Bottom Up Approach"

- Discover the actual usage
- Sharing in frequency, location, & time

- Lessens need for accurate databases and propagation models

- Maximizes spectrum reuse

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Paramount Goals for the Dynamic-Spectrum Radio System

- Designed to limit Interference
  - Work in with the existing spectrum users not against

- Transparent to existing spectrum users

- Realizable device
  - Cost (today)

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Design Objectives of the Dynamic-Spectrum Radio System

- Link lengths greater than 10 km possible
  - Longer range than unlicensed services
    - Moderate Transmit Power
    - High Gain Directional Antenna

- Frequency from 500 MHz to 6 GHz
  - Low-Cost Receiver and Transmitter
  - Good Propagation Characteristics

- Temporary frequency use
  - No fixed location-frequency license

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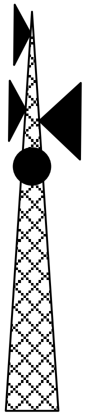
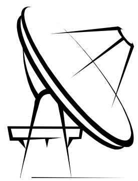
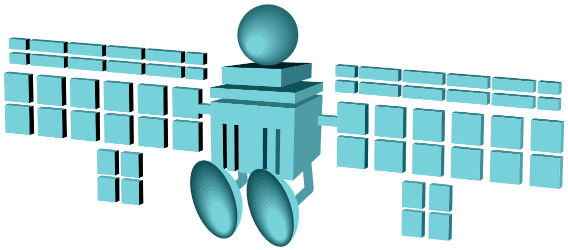
Radio Spectrum Environment



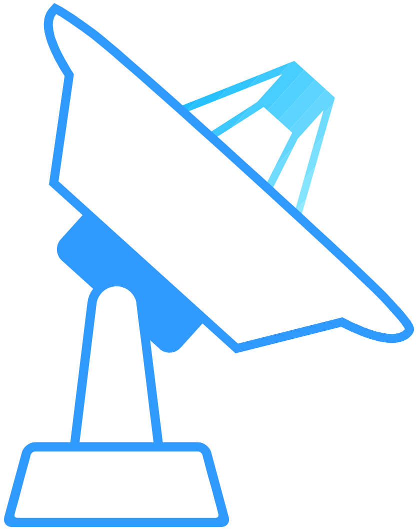
Terrestrial Microwave



Ku-Band Satellite

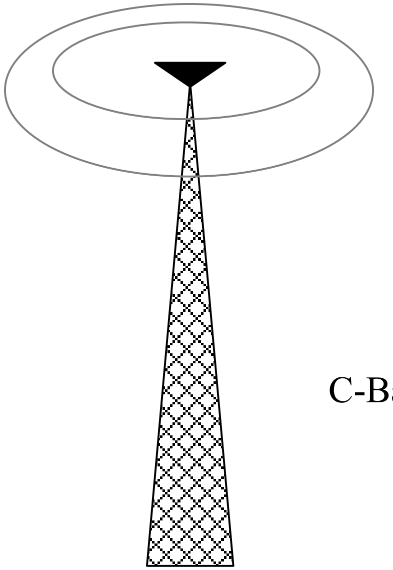


Satellite

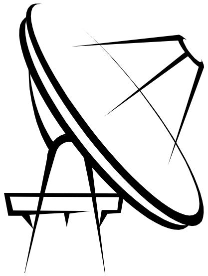


Passive Radio Astronomy

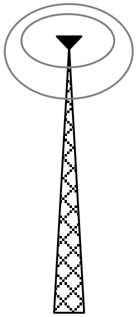
Mobile Services



UHF Broadcaster



C-Band Satellite



Radio Navigation

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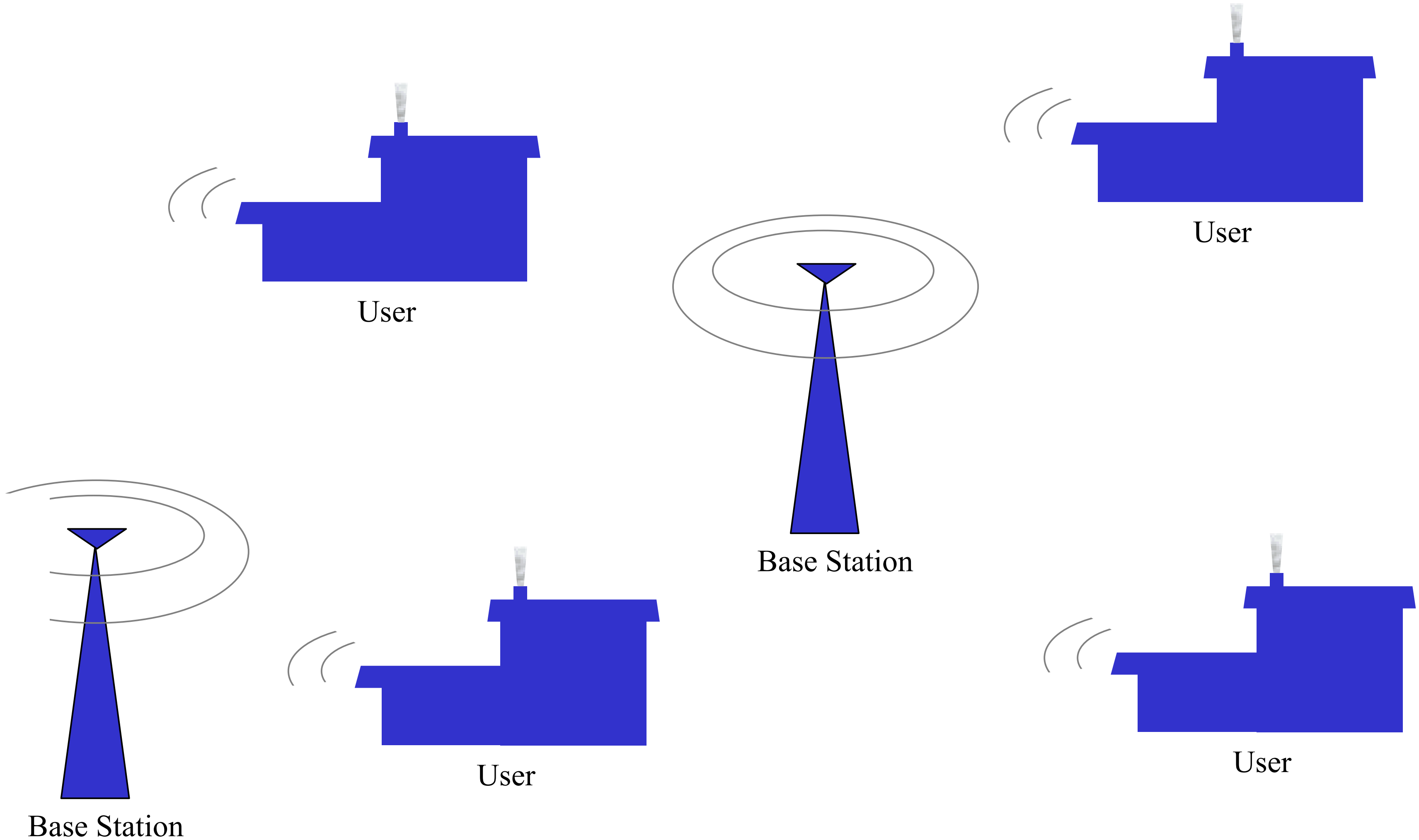
Fielded Dynamic-Spectrum Radio System



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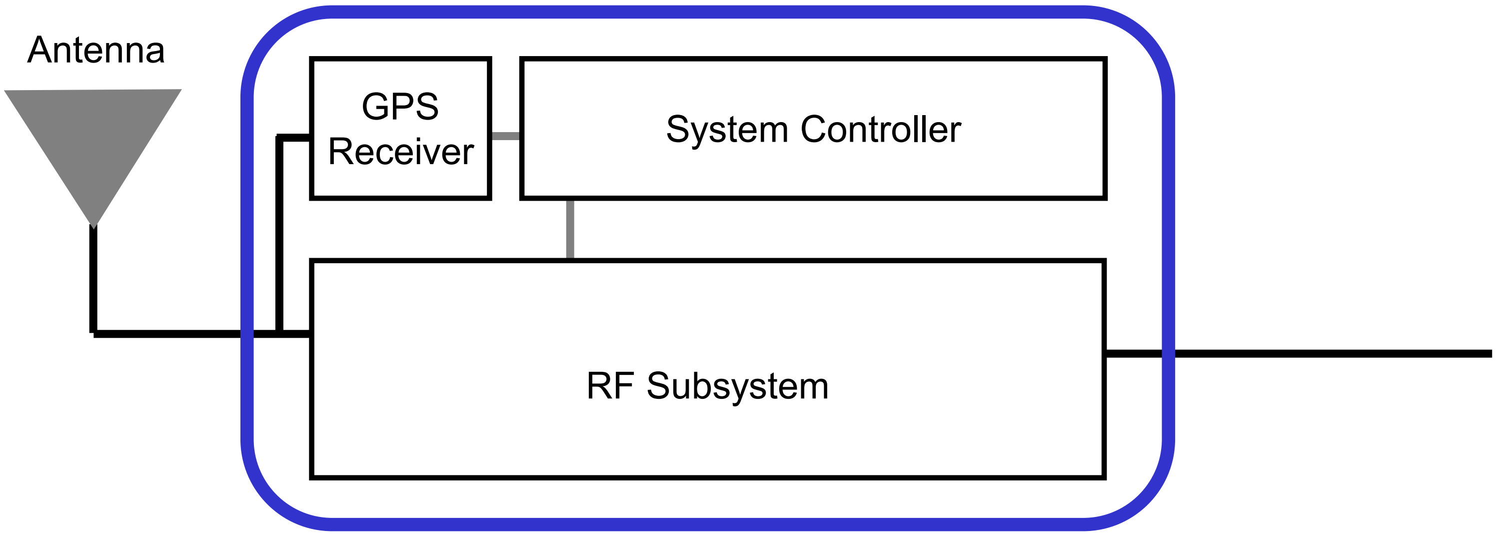
Transceiver Block Diagram



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Base Station Control System

- Obtains:
  - The location of all the users stations
  - The spectrum heard by the users stations

- Has knowledge of:
  - Near by sensitive spectrum users (passive and low power users)
  - Local geographic terrain (propagation characteristics)

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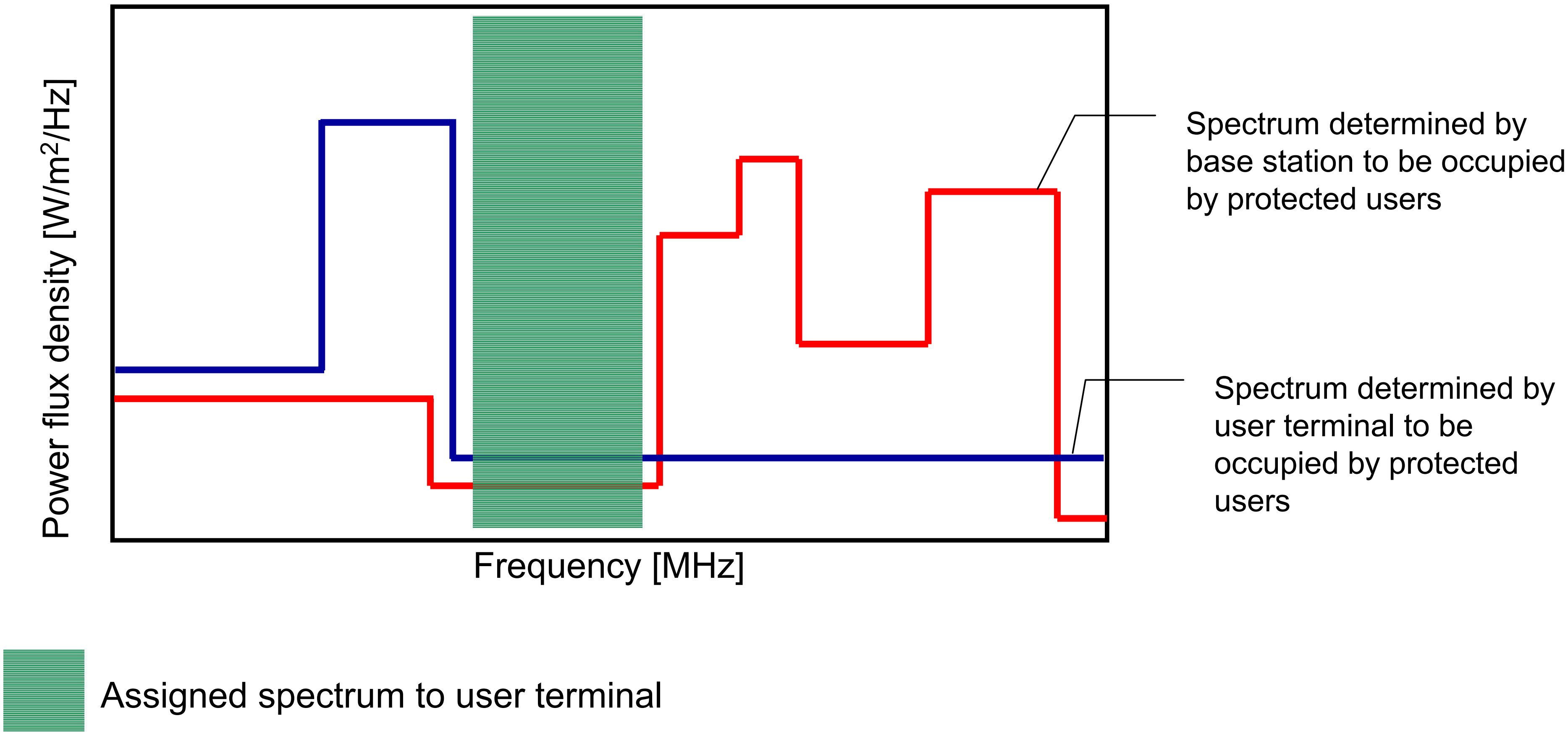
Spectrum Assignment Map for User Terminal



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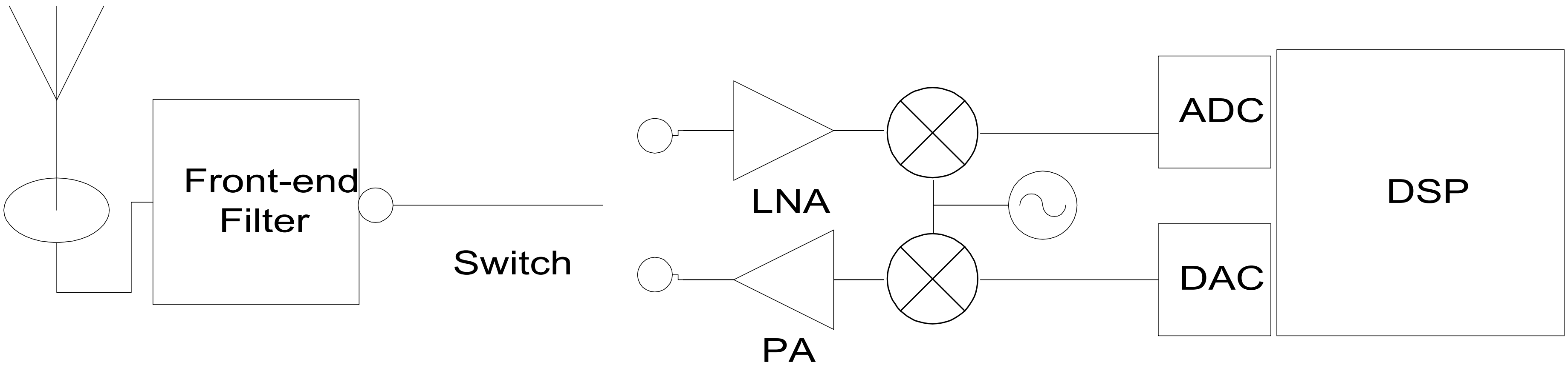
RF Front-end



Analog: octave and multi-octave operation

Not Software Defined!

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Implementation Realties

- Intermodulation
  - LNA (Low Noise Amplifier)
    - Limit Available Spectrum Seen
  - PA (Power Amplifier)
    - Can cause Interference
- TDD preferred over FDD
  - Filter reuse
  - Listen interval

TDD = Time Division Duplexing
FDD = Frequency Division Duplexing

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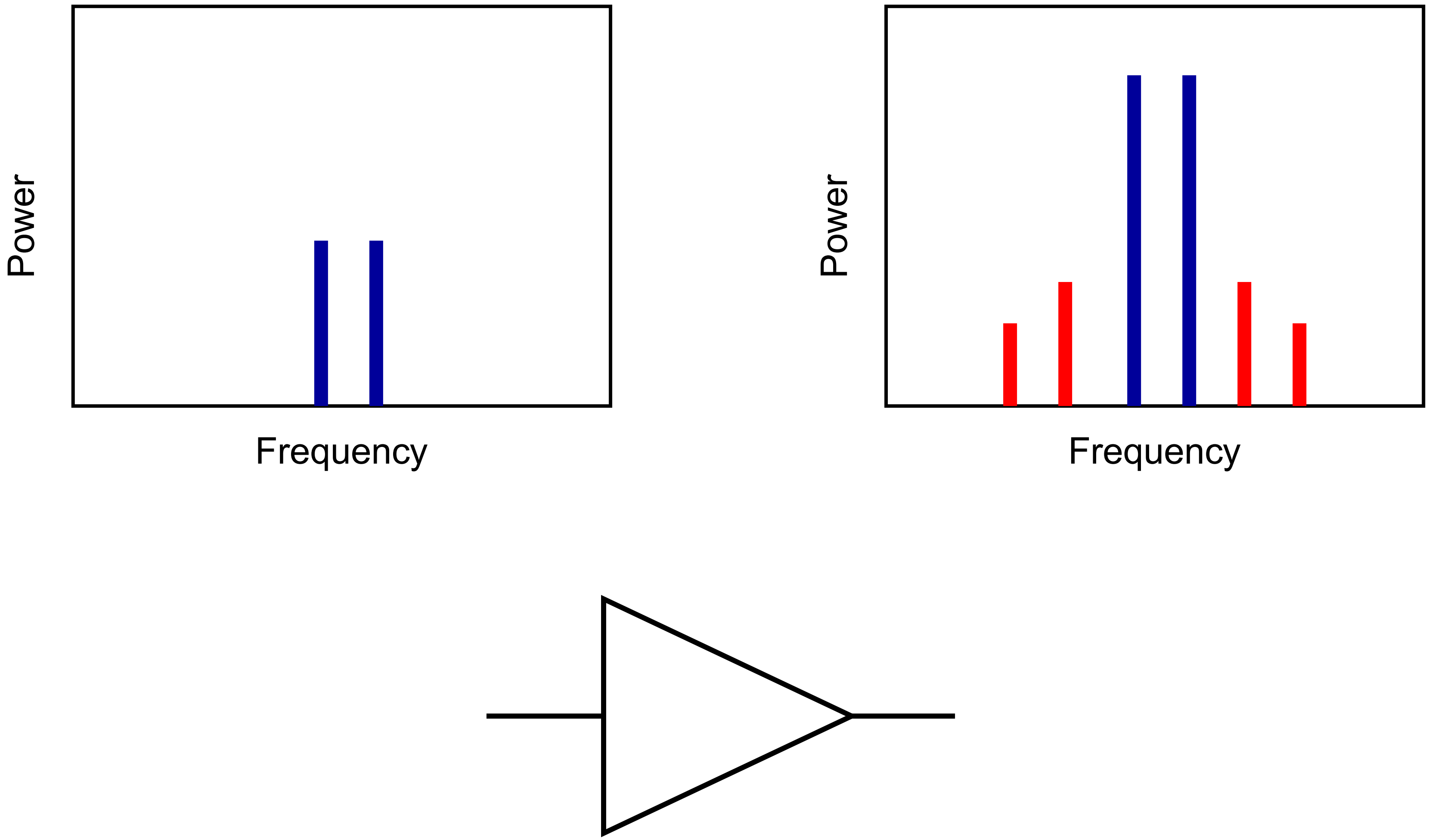
Intermodulation



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Intermodulation Reduction Techniques

- LNA
  - High IP3
  - Attenuation (find optimum amount so that the thermal noise floor reaches the height of the intermodulation products)
- PA
  - Linearization
    - Predistortion
    - Feedforward
    - Feedback

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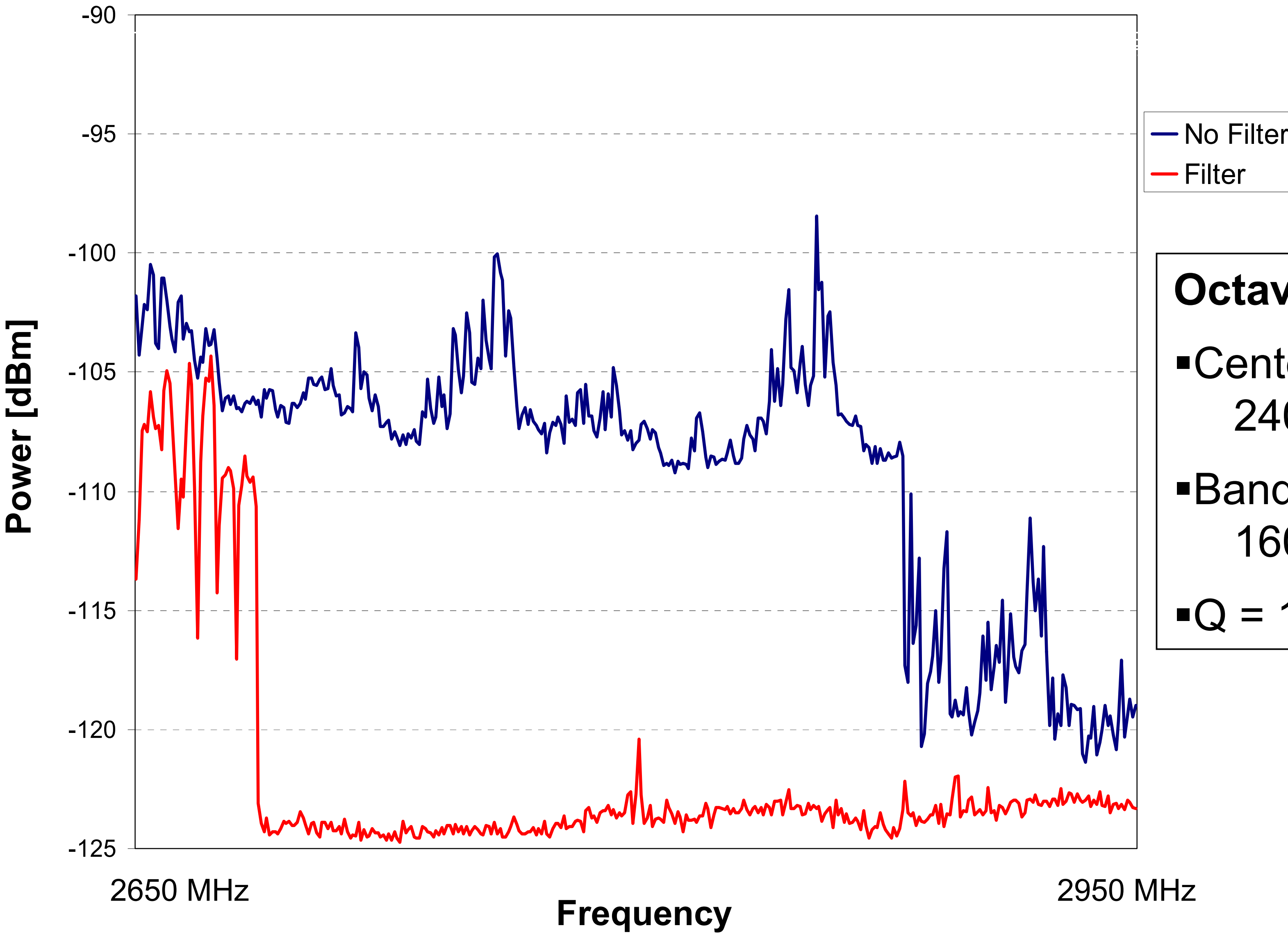
Intermodulation



Octave Filter:

- Center Freq. 2400 MHz
- Bandwidth 1600 MHz
- Q = 1.5

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Unknown Variables

- What band to select?
- Will it be reliable over time?
- Will it work over the long term?

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Spectrum Study Variables

- Frequency
- Time
- Polarization (Linear, Circular)
- Space (Latitude, Longitude, Altitude)
- Azimuth
- Location type (Urban, Suburban, Rural)

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Atlanta Measurement Site

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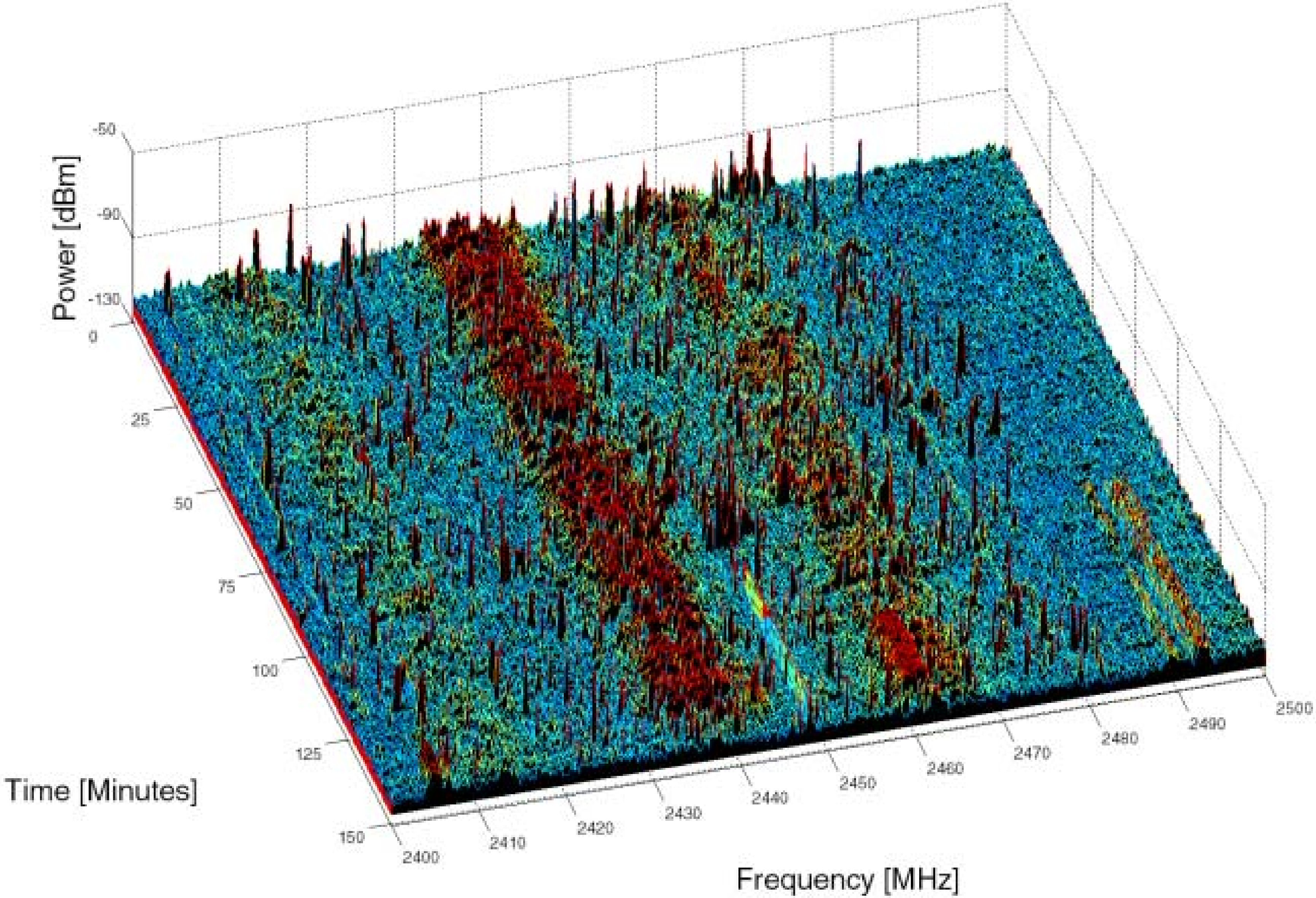
Time Usage Profile



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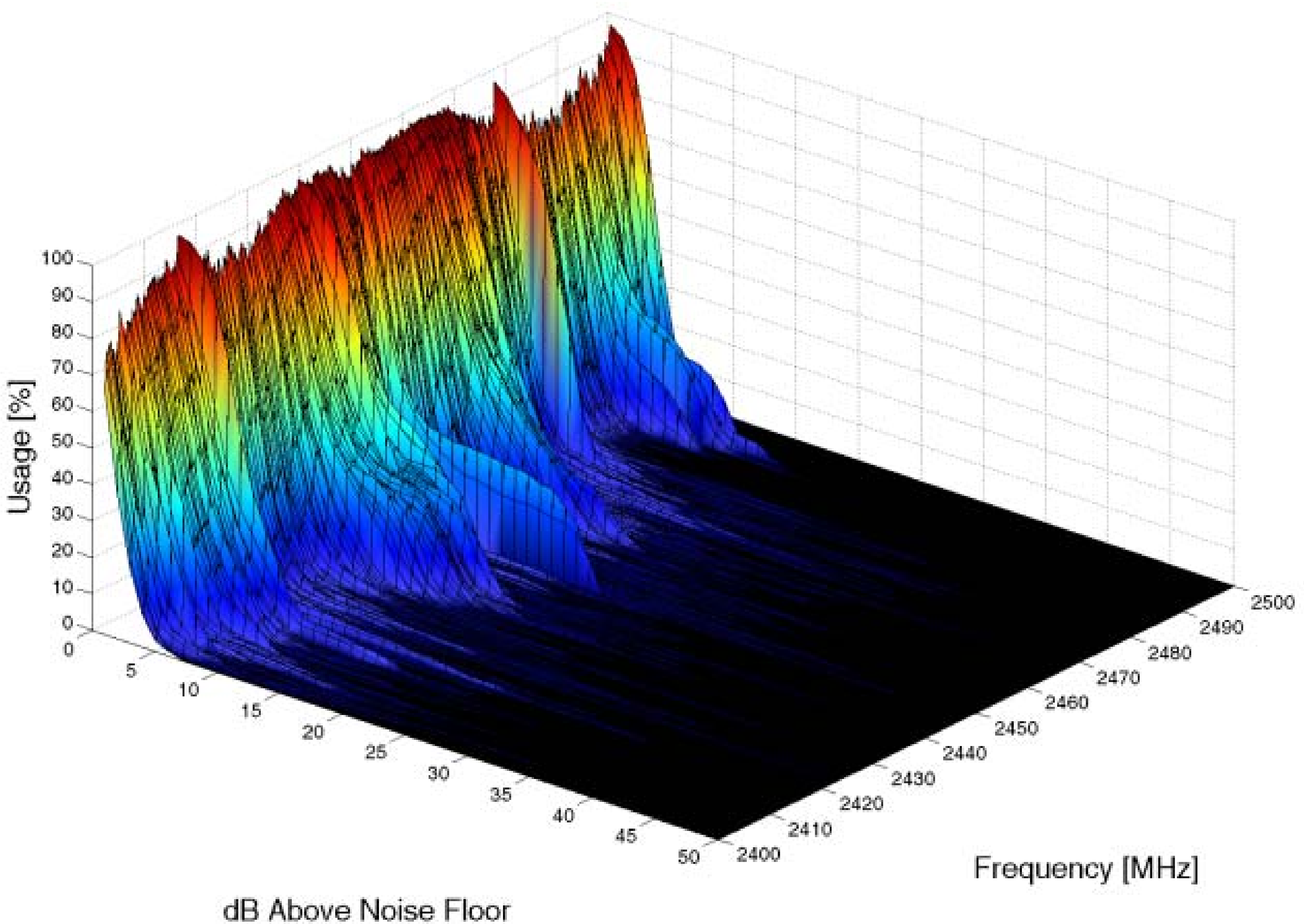
Time Usage Profile: Duty Cycle



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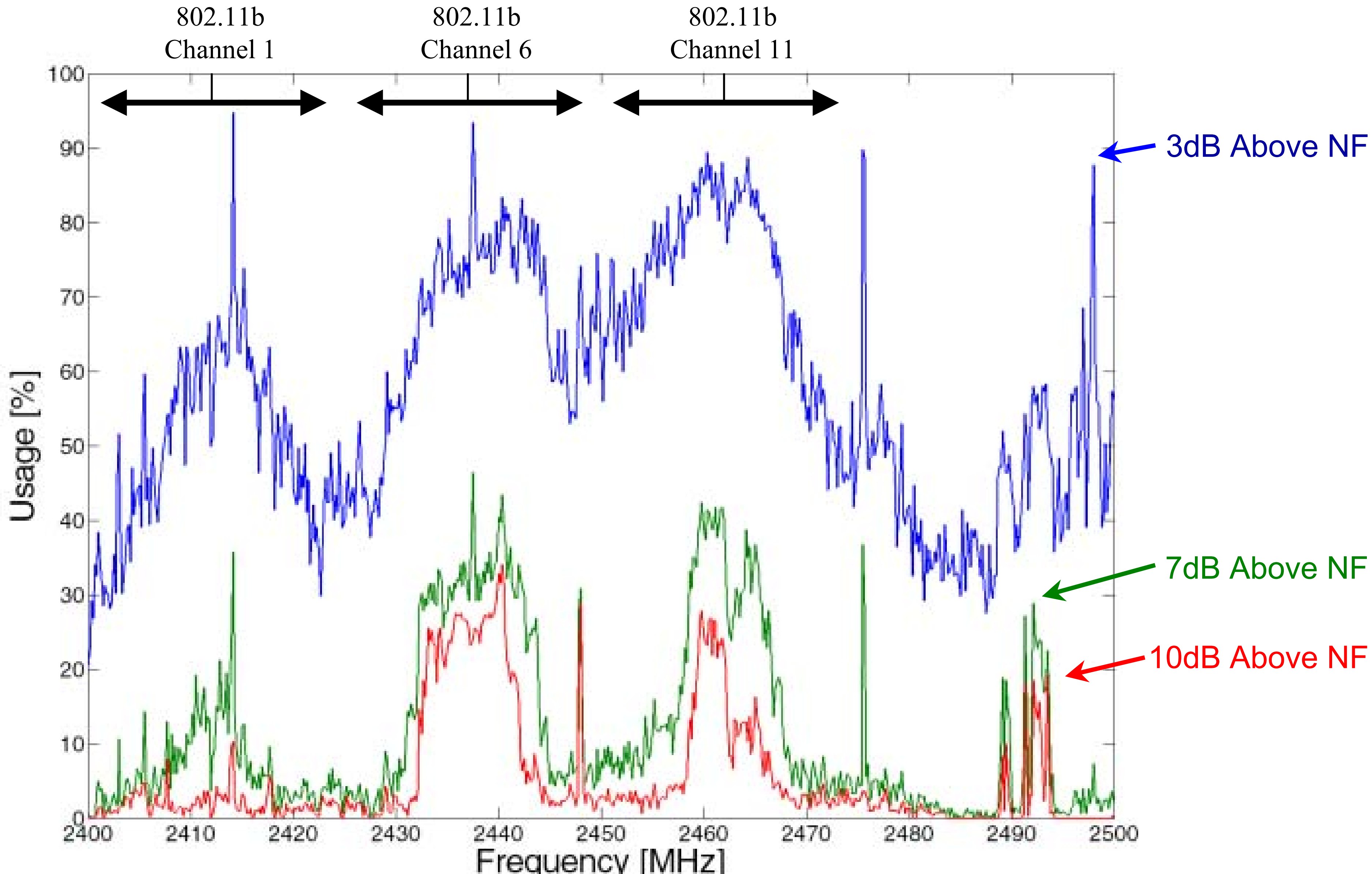
Time Usage Profile:Duty Cycle



NF = Thermal Noise Floor

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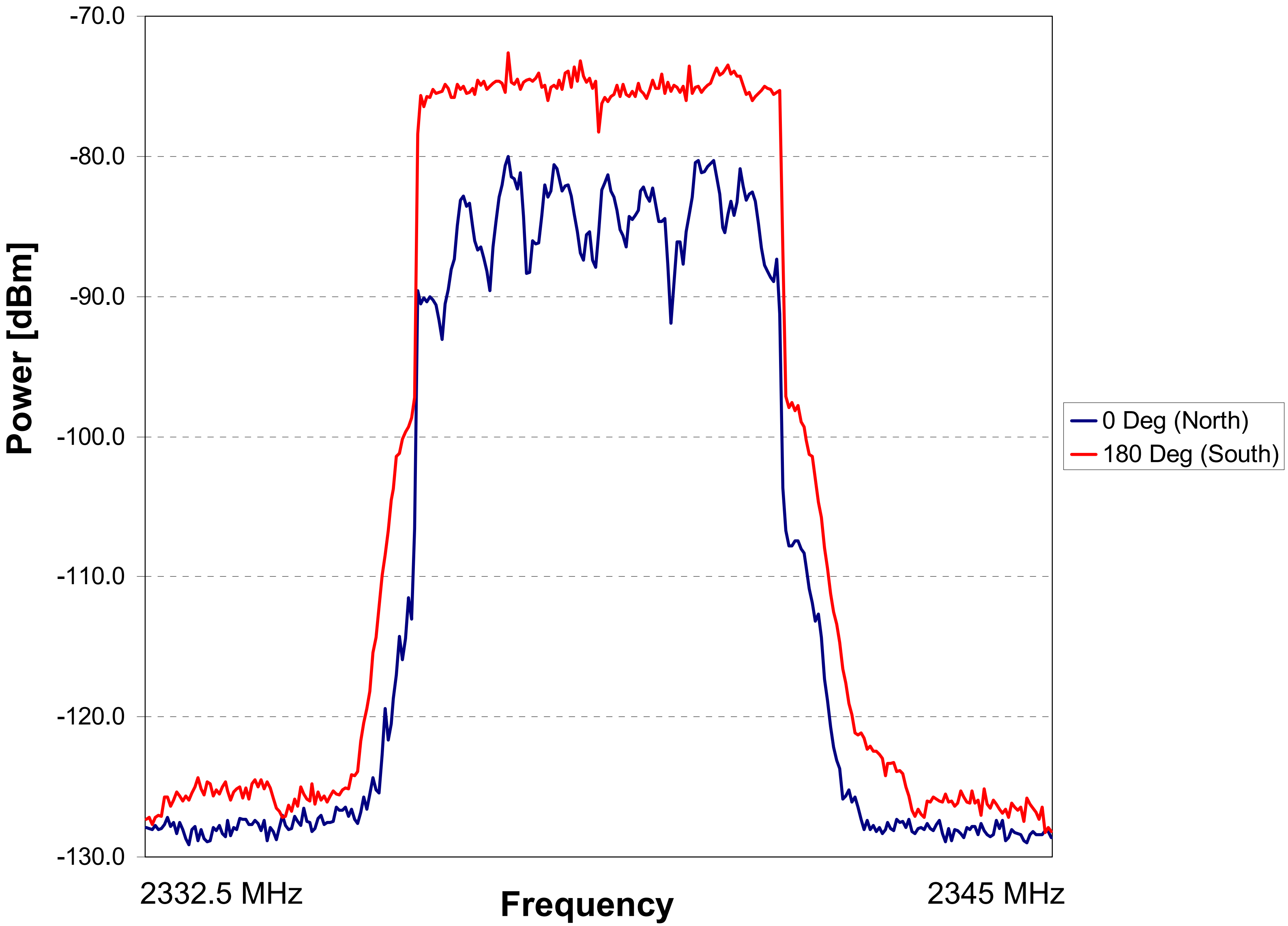
Azimuthal Profile



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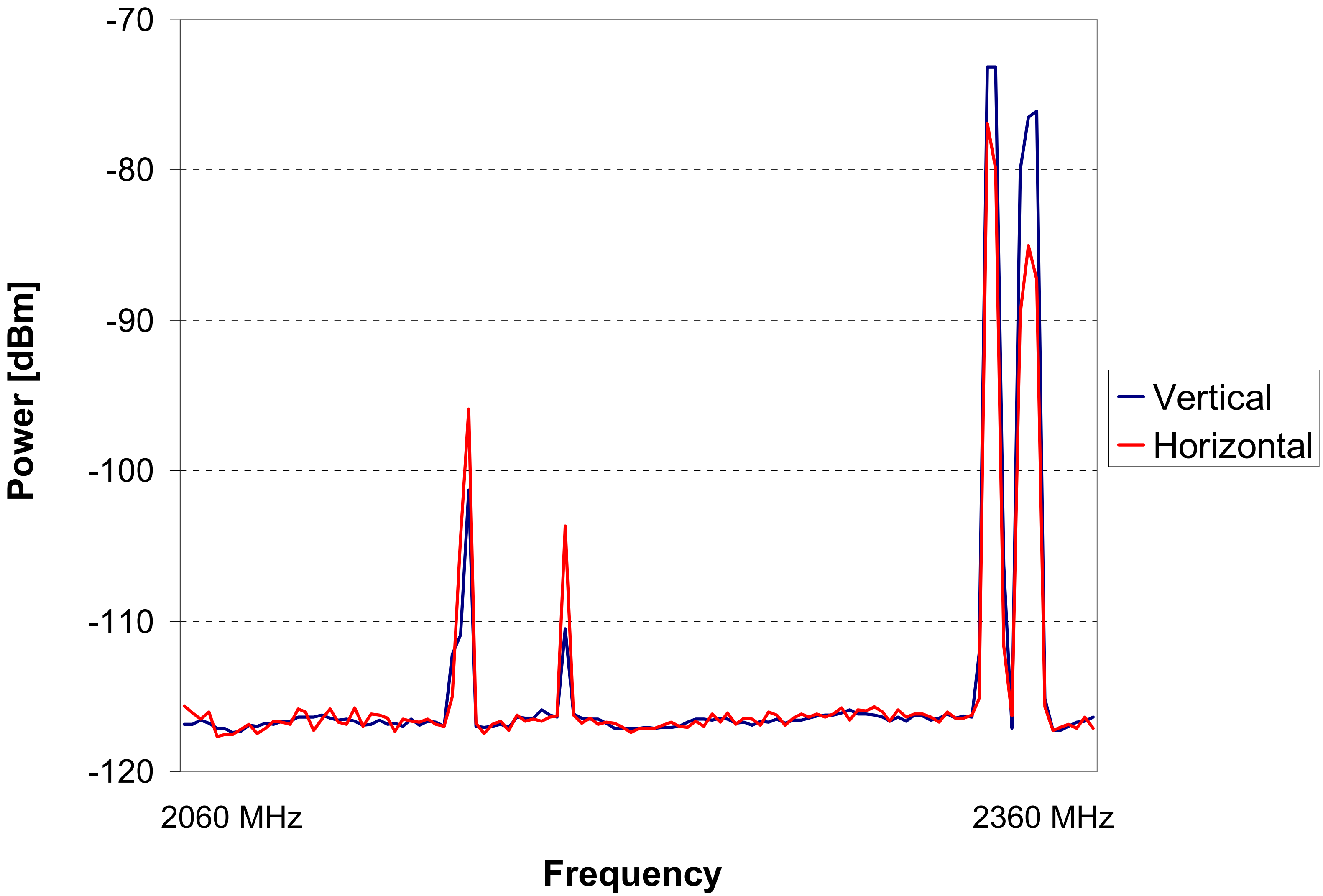
Spectrum Policy
Technological Solutions for Policy Problems

Polarization Usage



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Data Mine Spectrum Measurements

- Find inactivity
  - Frequency
  - Time
- Quantify the amount of reusable spectrum
- Examine periodic usage

- Given a dynamic-spectrum implementation
  - Determine its reliability
  - Predict its long term feasibility

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Dynamic-Spectrum Radio System with Data Mining

- Improves its knowledge of the local spectrum environment over time and with increasing number of users

- Assigns spectrum with respect to the data rate and QoS requirements of the users

QoS = Quality of Service

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Questions

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