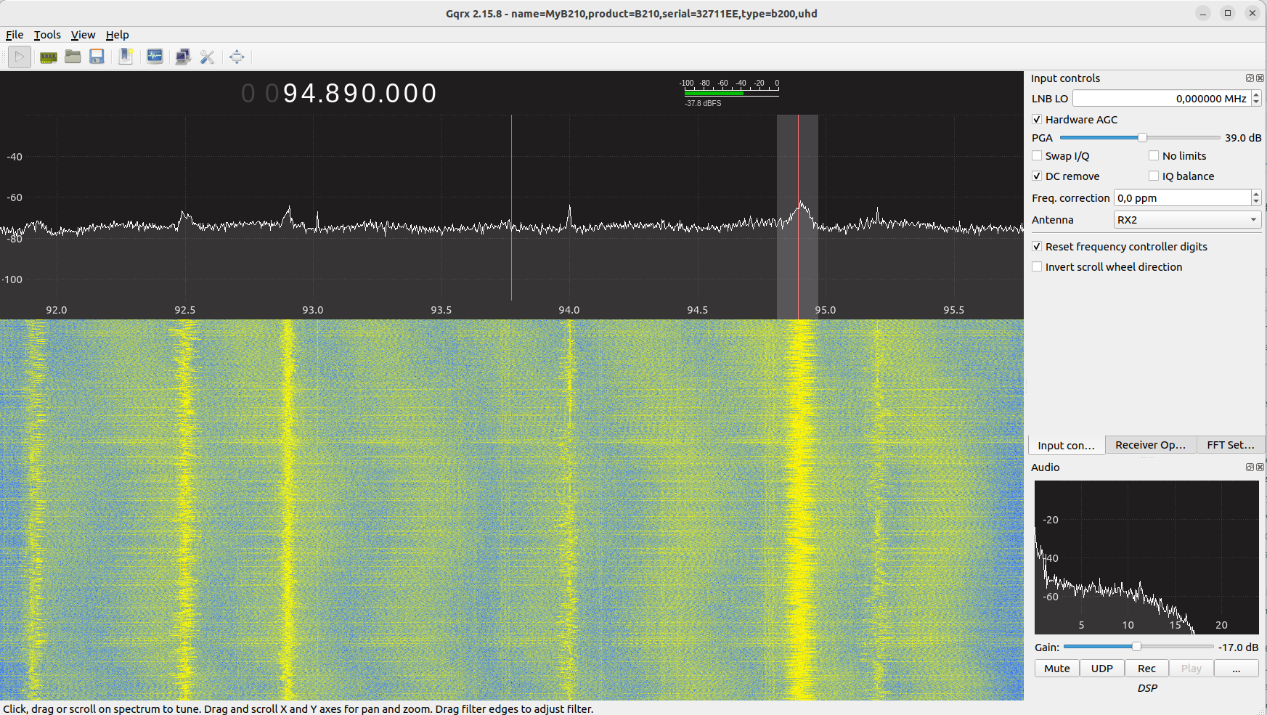
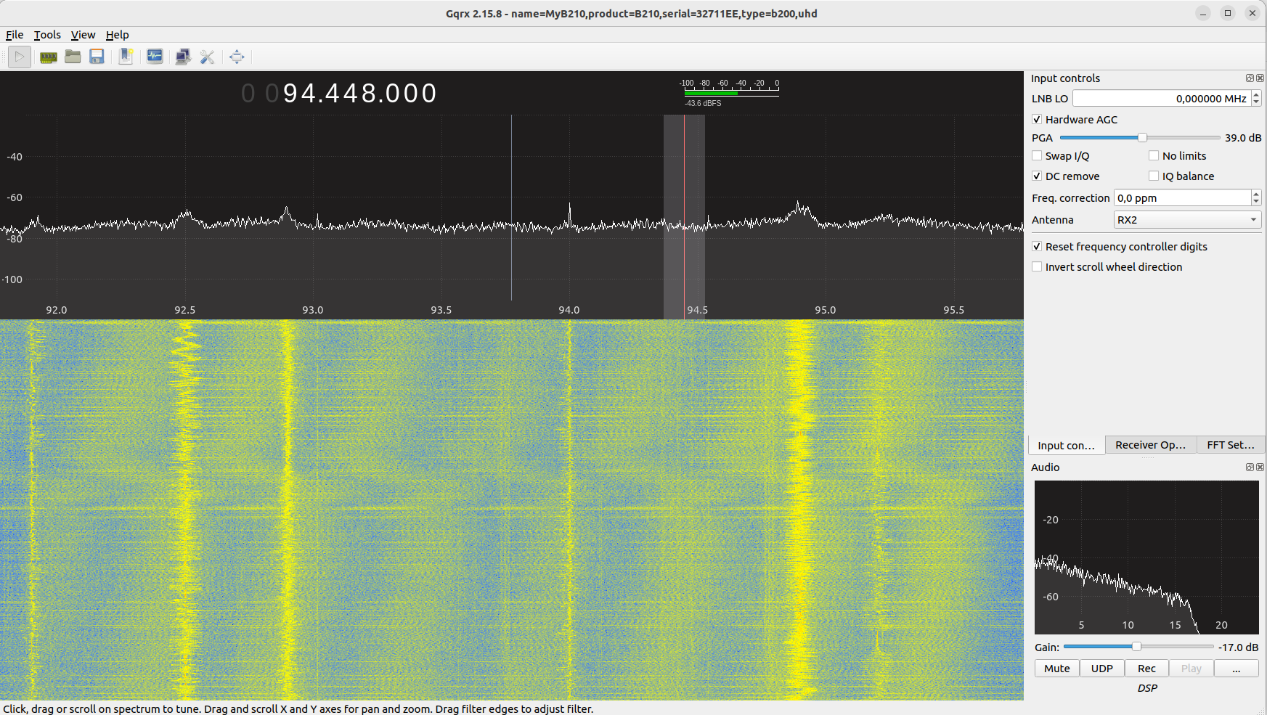
3.4 FM

In this part, after starting gqrx program for listening the radio and loading the config for lab2FmWhole.conf, we could analyze the FM signal spectrum. Changing the central spectrum to 94.89 MHz, we could find a peak here, at this time, there is voice in the channel

In this figure, we could see seven channel peaks. And the max frequency is 94.89MHz.



The second figure is screenshotted when the channel is silent. The max frequency is also 94.89MHz.



3.5 Post measurements questions

(31) By observing the screenshots we got from the experiment, we could see that the result is basically match the preliminary exercise results.

(32) According the second figure in the FM part, the max frequency is 94.89MHz.

(33) The most significant factor is the difference in power levels between the uplink and downlink. The downlink, which is the transmission from the base station to the mobile device, typically operates at a much higher power level than the uplink. This is because base stations are equipped with more powerful transmitters and better antennas. On the other hand, the uplink, which is the transmission from the mobile device to the base station, operates at lower power to conserve the mobile device's battery and to minimize interference with other devices.

Uplink signals are more susceptible to interference and noise since they are transmitted at lower power. This can also make the uplink spectrum appear weaker or more cluttered in a spectrum analysis.

(34) For 3G measurement, by the permission of the teaching assistant, we skip this part as the 3G services are nearly replaced by 4G and 5G now.

(35) Same as (34).

(36) In LTE (Long-Term Evolution) networks, the uplink signal often does not cover the entire bandwidth due to several factors related to the technology's design and the nature of wireless communications. The reasons are as follows,

LTE uses a flexible bandwidth allocation mechanism. The amount of bandwidth allocated to each user in the uplink is dynamically adjusted based on demand and network conditions. In many cases, not all users require or are allocated the full bandwidth. For example, if a user is only sending small amounts of data (like texts or small emails), the network allocates only a portion of the available bandwidth to that user.

LTE uplink uses SC-FDMA technology. Unlike the downlink, which uses OFDMA (Orthogonal Frequency Division Multiple Access), SC-FDMA is less prone to high Peak-to-Average Power Ratio (PAPR) issues. This characteristic allows more efficient power usage but also means that the uplink signal might not spread across the entire available bandwidth, as SC-FDMA inherently concentrates energy in a narrower band compared to OFDMA.

(37) In LTE (Long-Term Evolution) networks, multiple users share the same bandwidth through a combination of advanced multiplexing techniques. The two primary methods are:

Orthogonal Frequency Division Multiple Access (OFDMA) for Downlink:

Frequency Division: In OFDMA, the available bandwidth is divided into many narrowband subcarriers. Each subcarrier can be independently modulated and assigned to different users. This allows multiple users to transmit simultaneously but on different frequencies within the overall bandwidth.

Orthogonality: The key feature of OFDMA is the orthogonality of subcarriers, which means they are mathematically arranged in such a way as to prevent interference between them. This increases the efficiency of spectrum usage.

Dynamic Allocation: The network dynamically allocates subcarriers to users based on their data requirements and channel conditions. Users with higher data demands or better channel conditions might be allocated more subcarriers.

Single Carrier Frequency Division Multiple Access (SC-FDMA) for Uplink:

Single Carrier: Unlike OFDMA, SC-FDMA uses a single carrier for each user. It is similar to OFDMA in dividing the bandwidth into subcarriers, but it employs a different technique for modulating data onto these subcarriers.

Lower Peak-to-Average Power Ratio (PAPR): SC-FDMA is chosen for the uplink primarily because it has a lower PAPR compared to OFDMA. This makes it more power-efficient, which is crucial for battery-operated mobile devices.

Resource Block Allocation: Like in the downlink, the network dynamically allocates resource blocks (group of subcarriers) to different users based on their data needs and channel conditions.

(38) In many cellular network technologies, including LTE, it's common for uplink transmissions (from the mobile device to the base station) to use lower frequencies compared to downlink transmissions (from the base station to the mobile device). There are several practical and technical reasons for this arrangement:

Propagation Characteristics: Lower frequencies generally have better propagation characteristics – they can travel longer distances and penetrate obstacles more effectively. This is advantageous for uplink signals, which are transmitted from mobile devices that have less power and smaller antennas compared to base stations.

Power Efficiency: Mobile devices are limited in their power output to conserve battery life. Lower frequencies are more energy-efficient for transmission, which is crucial for mobile devices that operate on battery power.

Reduced Interference: Lower frequency bands tend to have less interference, which is beneficial for uplink transmissions as they originate from a wide variety of locations and conditions, often in environments with a high potential for interference.

Antenna Size and Design: Lower frequencies require larger antennas for optimal performance. While base stations can accommodate large antennas (necessary for the higher-frequency downlink), mobile devices need smaller antennas that are more suited to the lower frequencies used for uplink.

Spectrum Allocation and Regulations: Radio frequency spectrum is a regulated resource, and the allocation is governed by international and national bodies. Historically, lower frequency bands were among the first to be allocated for mobile communications, and these bands have been traditionally used for uplink due to their favorable propagation characteristics.

Network Planning and Capacity Management: Separating uplink and downlink frequencies helps in network planning and management. Different frequencies can have different cell sizes and coverage areas, which can be strategically used to optimize network capacity and performance.

4. Path loss measurement

4.1 Calibration

For the first part of the section 4, we need to record the gain we had to set in Gnuradio program to achieve this signal level (which is -40 dB): for both receivers at both frequencies (2.46GHz and 5.8GHz).

The results we record are as follows:

|  |  |  |
| --- | --- | --- |
|  | RX1 | RX2 |
| 2.46GHz | 27 dB | 30 dB |
| 5.8GHz | 31 dB | 43 dB |

图形用户界面, 应用程序

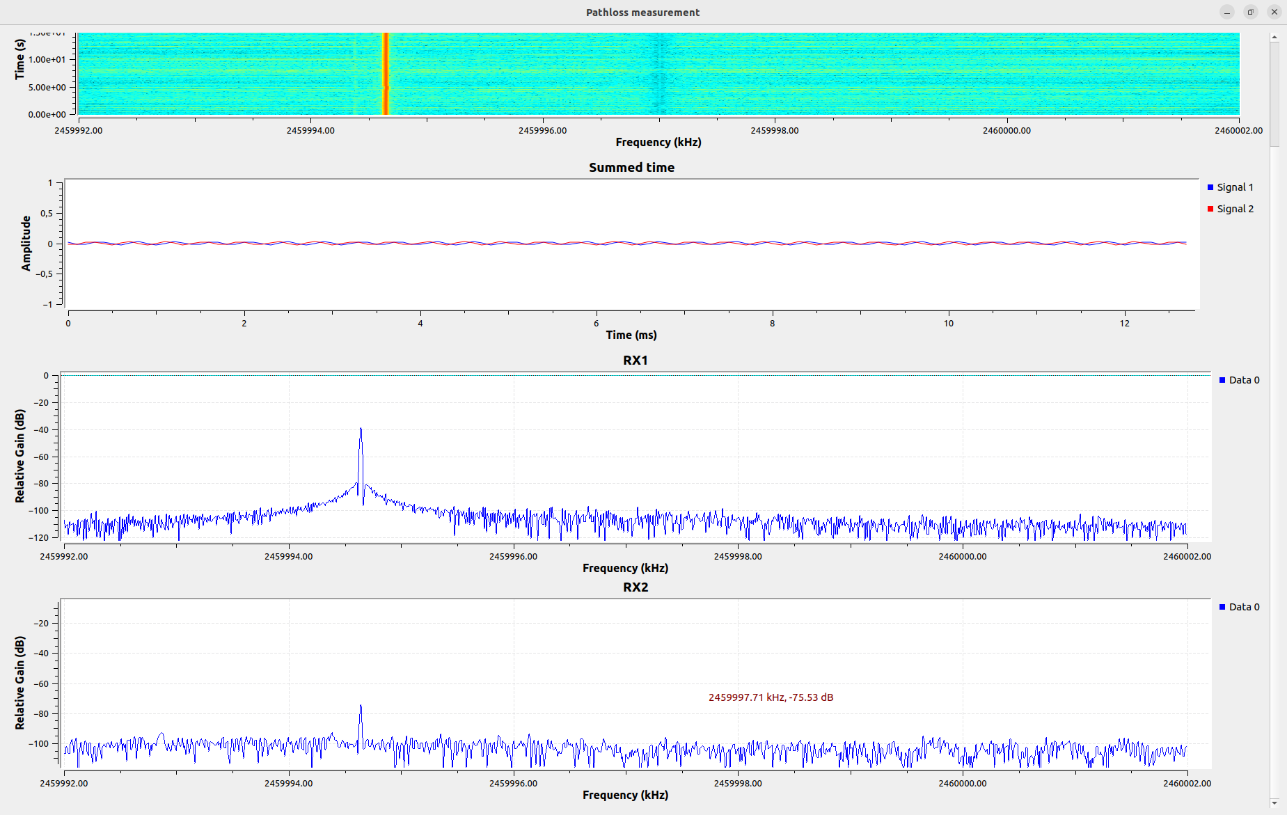
描述已自动生成

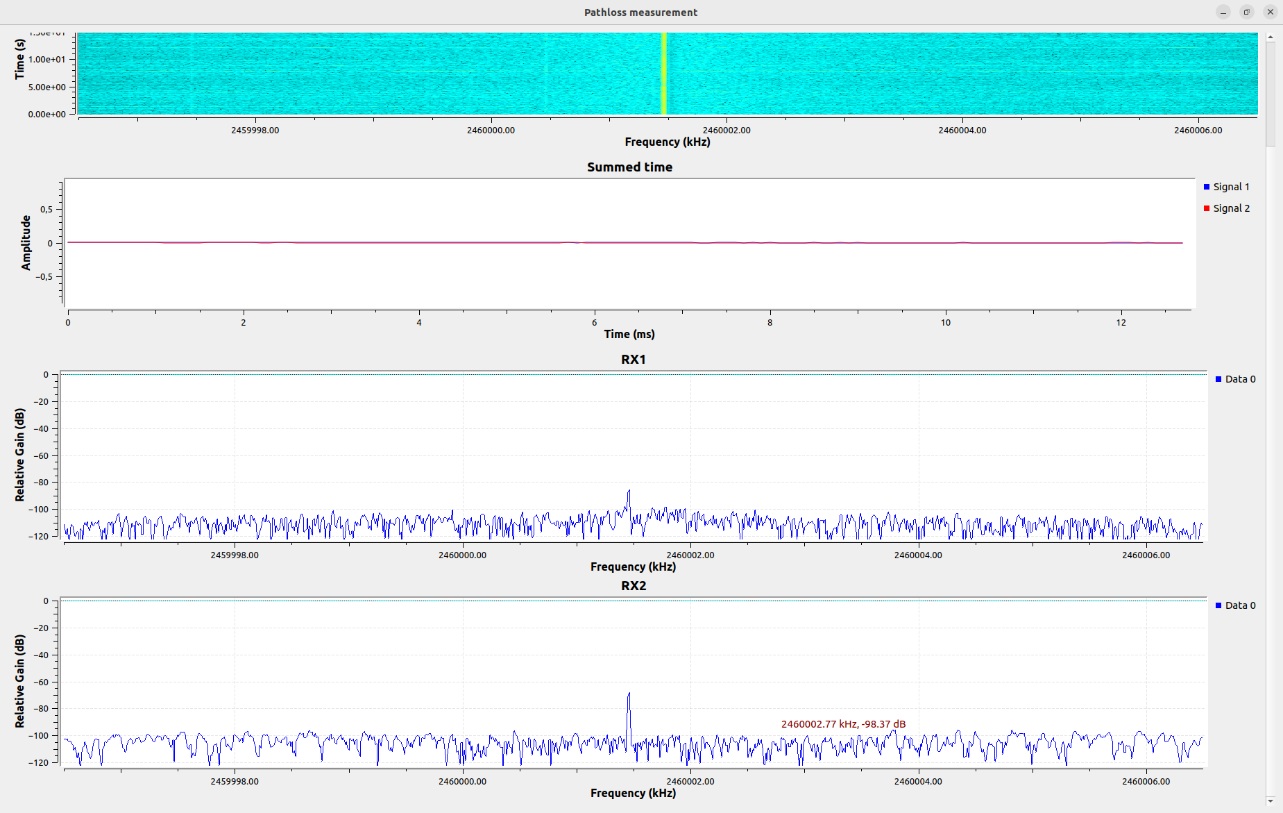
The measurement windows include:

Time-Frequency: Focus on a narrower frequency band, as indicated by the orange vertical line which may represent a specific frequency of interest or a center frequency around which measurements are being taken.

The second window, labeled "Summed time," is not displaying any visible data for 'Signal 1' and 'Signal 2'. It intended to show the amplify of signals over time, but it is currently empty.

The third and fourth windows are labeled "RX1" and "RX2", respectively. These are showing the received signal strength indicator (RSSI) measurements for two different receivers or channels, over a frequency band. These plots are commonly used in radio frequency (RF) analysis to evaluate the power present in a received radio signal, which can be important for determining the quality of the signal reception.





4.2 Hallway measurement

Test the path loss like:

图形用户界面

中度可信度描述已自动生成

The output of 2.46GHz is like:

图形用户界面

描述已自动生成

The output of 5.8GHz is like:

图表

描述已自动生成

As we didn’t save the csv file and the file pathloss.m, We analyze the results get from lab.

According to the figure, we could see both fast fading and slow fading, in small period of time, we could see that the line shaking and change rapidly, and in a long term we could see the trend of the curve changing slowly.

The short distance between the transfer and receiver may cause the reflection of the signal. cause the fast fading. As the moving of the transfer, the obstacles such as the door of the lab and the chair in lab may cause the slow fading.

By observing the two figures, for 2.46GHz, the average signal power of antenna 1 is about -80dB, antenna 2 is about -90dB. For 5.8GHz, the average signal power of both antenna 1 and antenna 2 are about -85dB.

For the location of our antennas, we were at the position RX3 in the picture hence the values of pathloss maybe lower than the other groups, as we sit near the door.