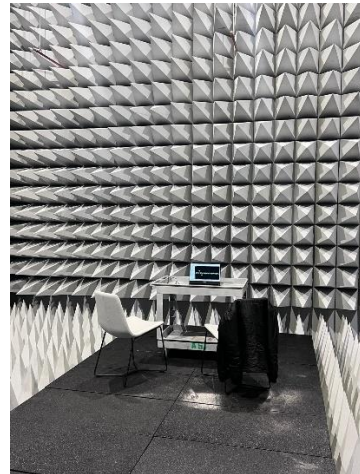


# Initial Anechoic Chamber Frequency Identification of Biometric Sensor Systems for Spaceflight

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The University of Arizona's Applied Research Building hosts a large walk-in Anechoic Chamber. This room is non reflective and echo free, built with carbon filled foam materials on the wall, floor and ceiling to adsorb radio waves. Using the said facility, we took a spectrum analyzer inside to provide us an initial scope of frequencies used by commercially popular biometric sensor units and their respective operative computers we could anticipate using during spaceflight. We were most interested in categorizing the Bluetooth signals and any potential leakage into other frequencies.



We began our testing with scanning a wide frequency band (0Hz 5000 MHz) as well as a more focused Bluetooth band, albeit expanded slightly past the known 2.402 GHz to 2.480 GHz frequencies to 2.35 GHz to 2.5 GHz. After obtaining baseline frequency readings on the outside and inside of the anechoic chamber we then proceeded to test three computing devices always on airplane mode: iPad Air, iPhone 13 Pro, and Lenovo Legion Y-530 laptop. With these computers, specifically the iPhone 13 Pro, we then connected to our sensors to obtain their communication frequencies. The sensors were tested individually with no other RF emitting devices inside the chamber. The sensors include: Oura Ring, Polar H10 heart rate strap monitor, Calibre Metabolic Mask, and the Dexcom Stelo CGM (continuous blood glucose monitor).

Each biometric sensor system required a device to communicate with. In our case, the iPhone 13 was the most capable as it was updated to iOS 17.7.2 which allowed successful pairing with all sensors.

The spectrum analyzer was a Tiny SA Ultra. This unit was selected as an affordable off the shelf product for initial testing and frequency categorization. The unit manufacturer also maintains a robust online wiki to support its user community.

The components in the unit were chosen to obtain a balance between cost and performance, thus the unit does have its known limitations. These include but are not limited to a minimum resolution bandwidth of 2.4 KHz, measurement time increases below 30kHz, sensitivity reduction below 0.1MHz, as well unit MCU radiation harmonics at 48MHz. These details and others can be read about online at the Tiny SA wiki found here: <https://tinysa.org/wiki/pmwiki.php?n=Main.HomePage>.

Once the unit was properly calibrated, we tested the following configurations individually:

- 1) Unit only, outside of anechoic chamber and inside of chamber at 0Hz to 5000MHz and 2.35GHz to 2.5GHz
- 2) Unit with Lenovo Legion Y-530 laptop inside chamber
- 3) Unit with iPad Air inside chamber
- 4) Unit with iPhone 13 Pro inside chamber
- 5) Unit with iPhone 13 Pro and Polar H10 heart rate monitor inside chamber
- 6) Unit with iPhone 13 Pro and Oura Ring monitor inside chamber
- 7) Unit with iPhone 13 Pro and Dexcom Stelo CGM inside chamber
- 8) Unit with iPhone 13 Pro and Calibre Metabolic Mask inside chamber

Below you will find our initial readings. These readings were displayed and captured as a graphical chart using a MAX HOLD trace then exported as a CSV file. From this file the visual wave forms were recreated in Microsoft Excel.

**Conclusions and learnings:** Given the nature of radio frequencies we identified early on that it would be advantageous to identify the specific frequencies used by any flight provider for operational and emergency systems, such as recovery parachutes, to test on and near those frequencies to determine any potential for interference from the listed biometric sensors.

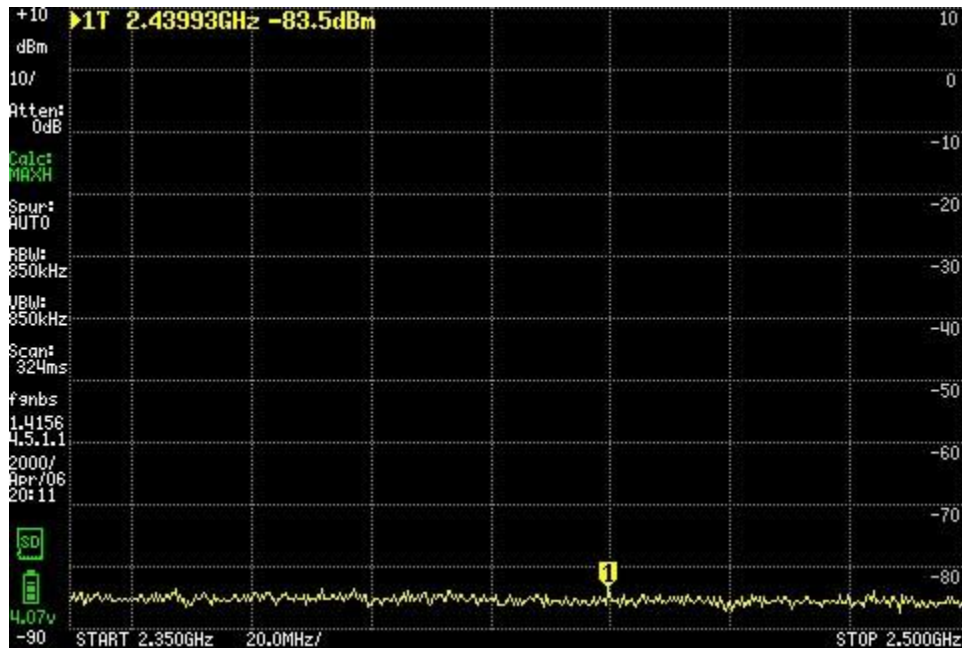
The resolution of our wide band scan was not sufficient for determining any frequency changes for each sensor outside of our tested 2.35GHz to 2.5GHz. Some sensors only send packets of information periodically. If this transmission was made outside of the time necessary for the unit to complete a scan there is a potential it could have been missed during the time allotted for testing.

For example, the Dexcom Stelo only updates and sends Bluetooth signals once every 15 minutes. The refresh rate of the TinySA unit was only able to capture a single transmission during the scanning period. Additionally, because of our time restrictions no wideband transmissions were captured and recorded for the sensors given the nature of the test unit.

There were no observed Bluetooth transmissions ever from the iPad or iPhone. All sensors did successfully display Bluetooth only transmissions from the 2.402GHz to 2.48GHz range.

These readings are only a starting point for conversation and not meant to be used to determine full compatibility with any flight system.

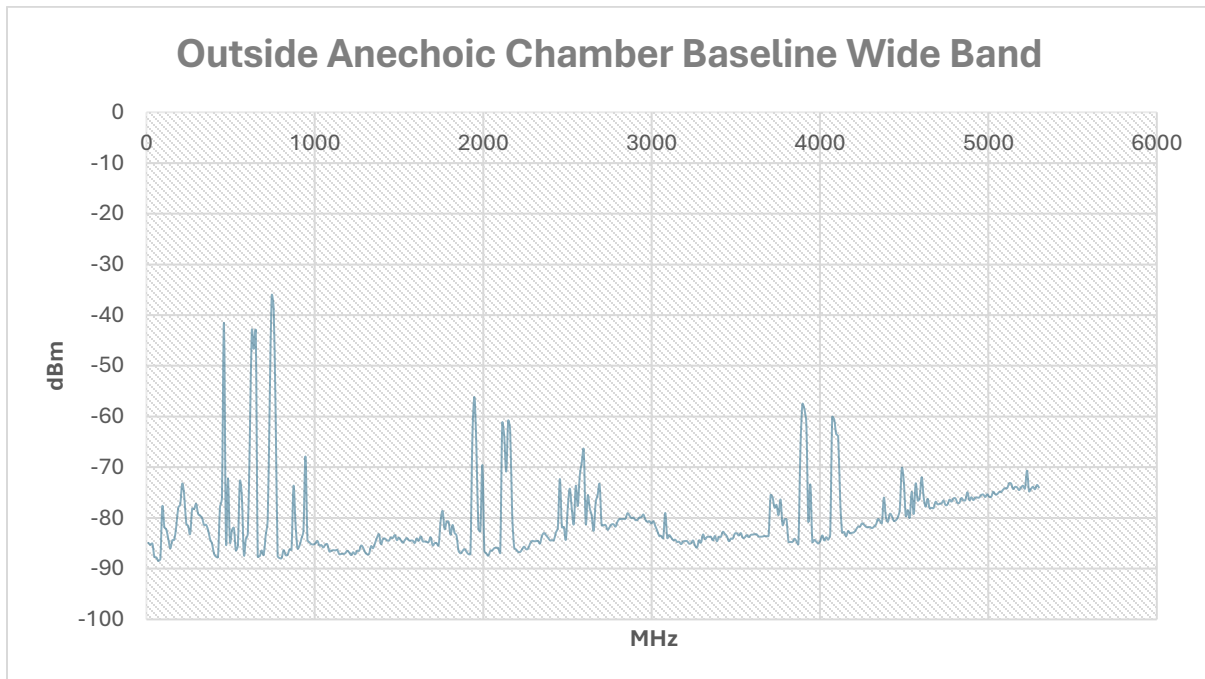
**Example of a visual screen capture on the unit:**



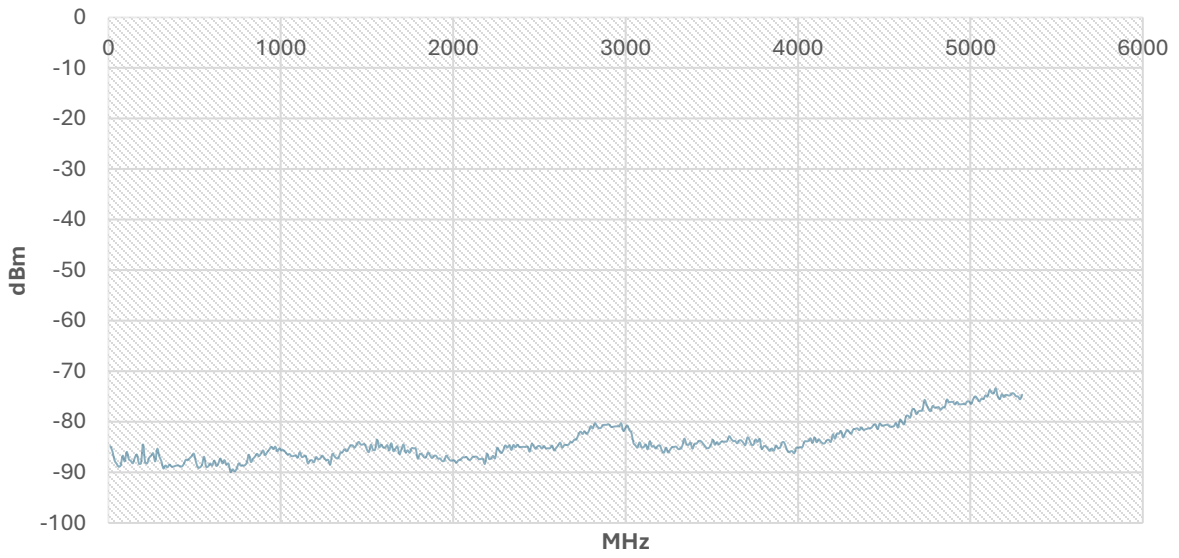
## Tested Frequency Readings

These graphical frequencies were recreated off exported CSV files saved from testing.

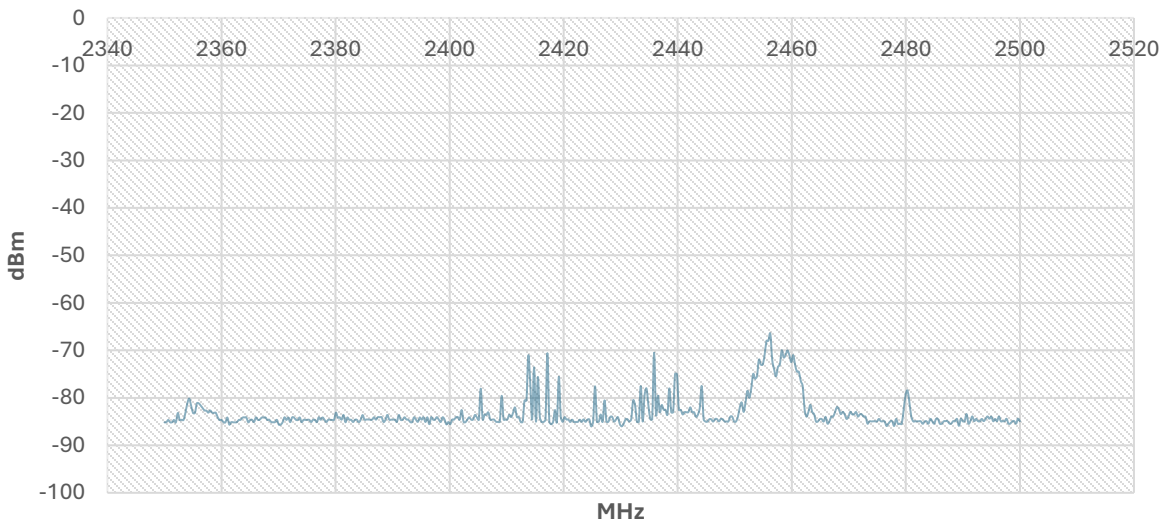
- 1) Outside Anechoic Chamber Baseline Wide Band
- 2) Inside Anechoic Chamber Baseline Wide Band
- 3) Outside Anechoic Chamber Baseline Bluetooth
- 4) Inside Anechoic Chamber Baseline Bluetooth
- 5) iPad Air (airplane mode) Wide Band
- 6) iPhone 13 (airplane mode) Wide Band
- 7) Lenovo Legion Y-530 Laptop Wide Band
- 8) iPad Air (airplane mode) Bluetooth
- 9) iPhone 13 (airplane mode) Bluetooth
- 10) Polar H10 + iPhone 13 Bluetooth
- 11) Oura Ring + iPhone 13 Bluetooth
- 12) Dexcom Stelo CGM + iPhone 13 Bluetooth
- 13) Calibre Metabolic Mask + iPhone 13 Bluetooth



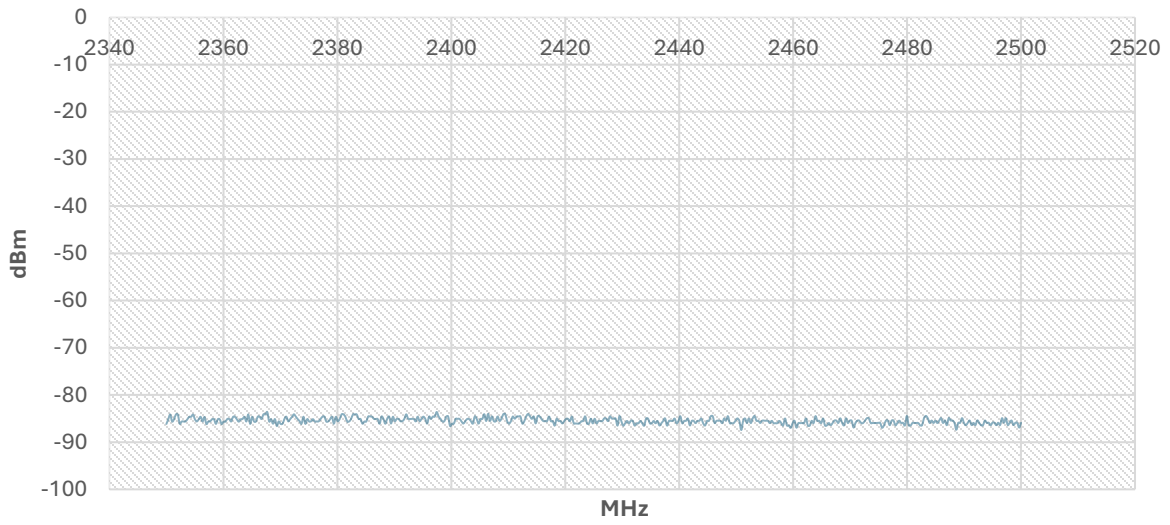
### Inside Anechoic Chamber Baseline Wide Band



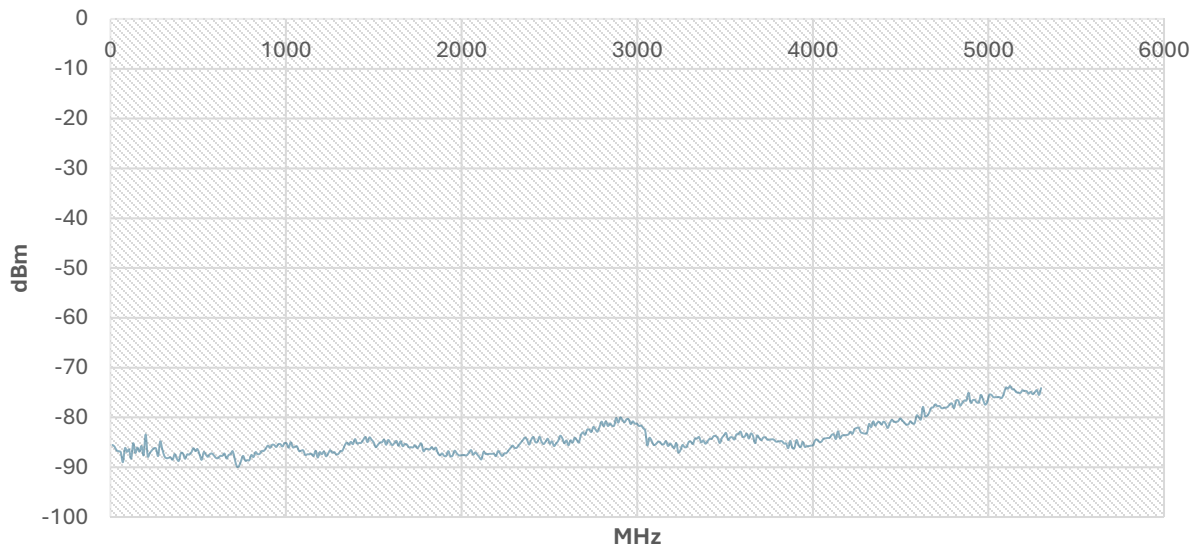
### Outside Anechoic Chamber Baseline Bluetooth



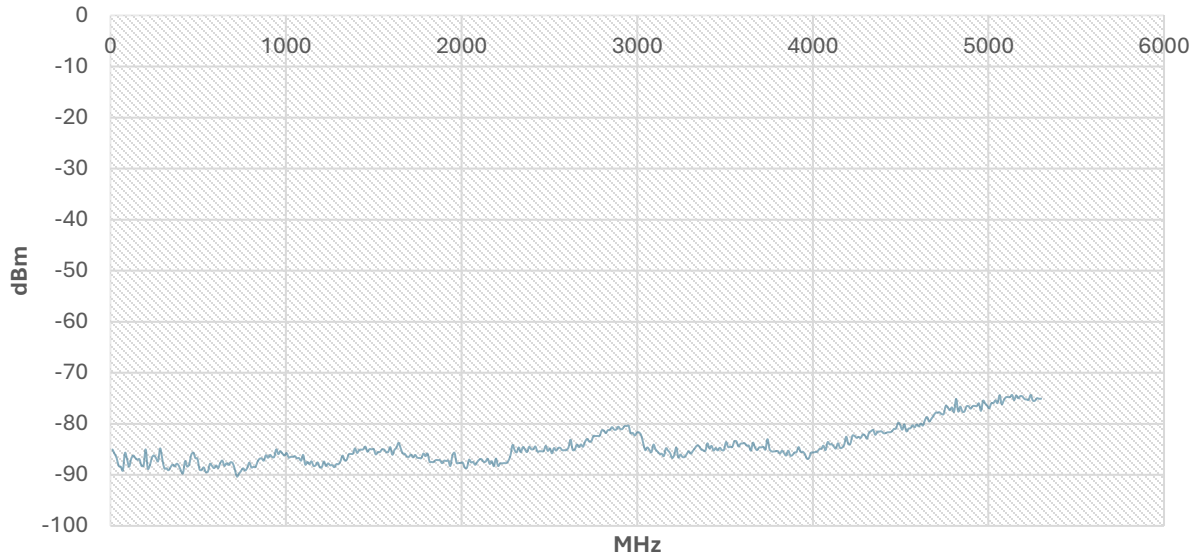
### Inside Anechoic Chamber Baseline Bluetooth



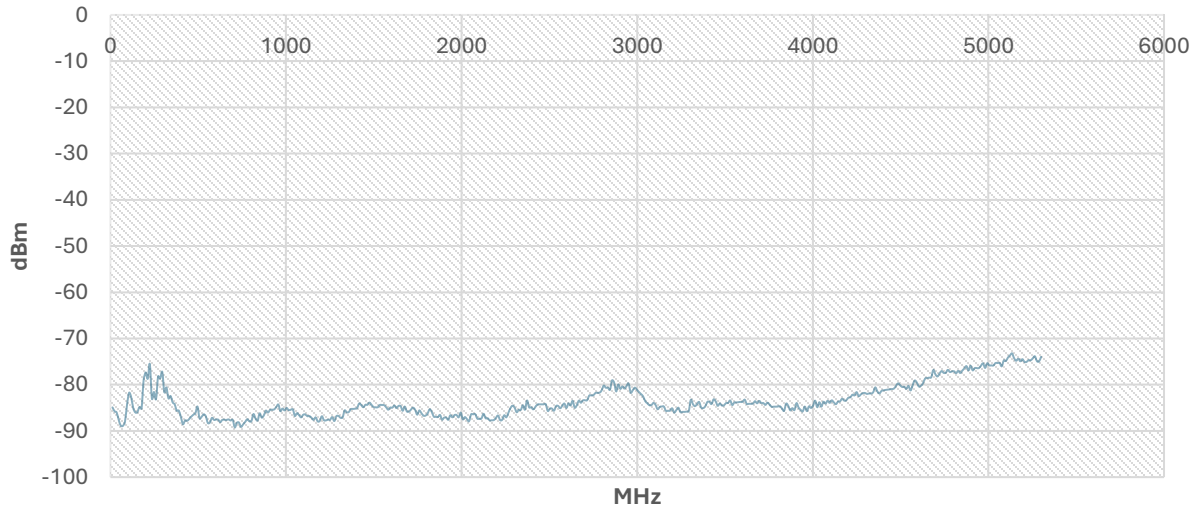
### iPad Air (airplane mode) Wide Band



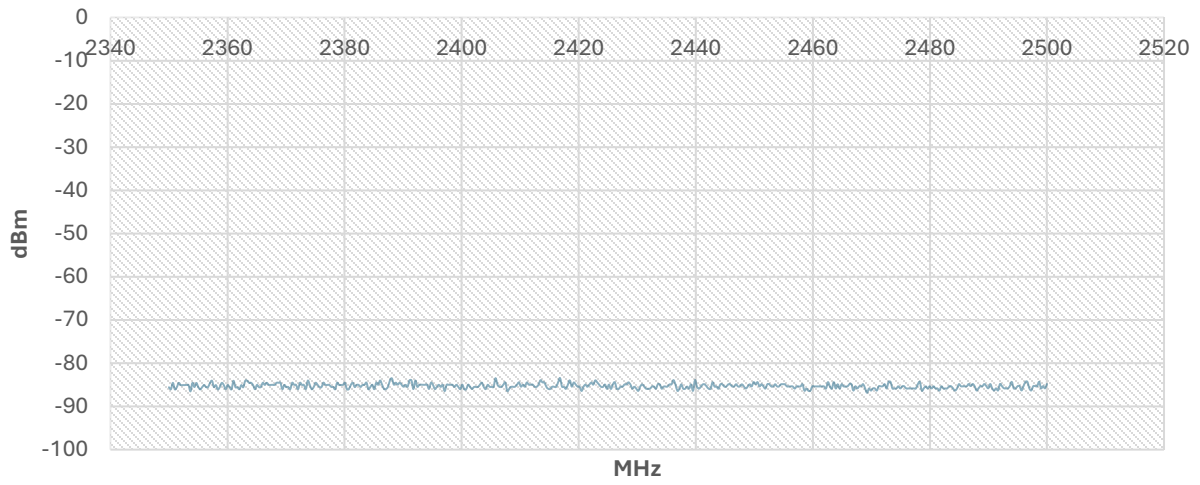
### iPhone 13 (airplane mode) Wide Band



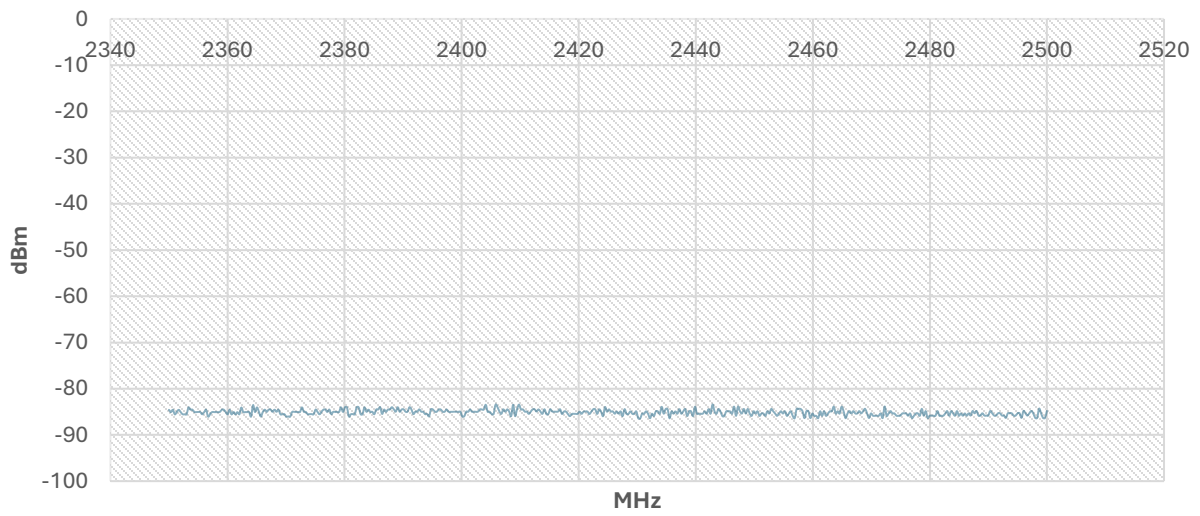
### Lenovo Legion Y-530 Laptop Wide Band



### iPad Air (airplane mode) Bluetooth

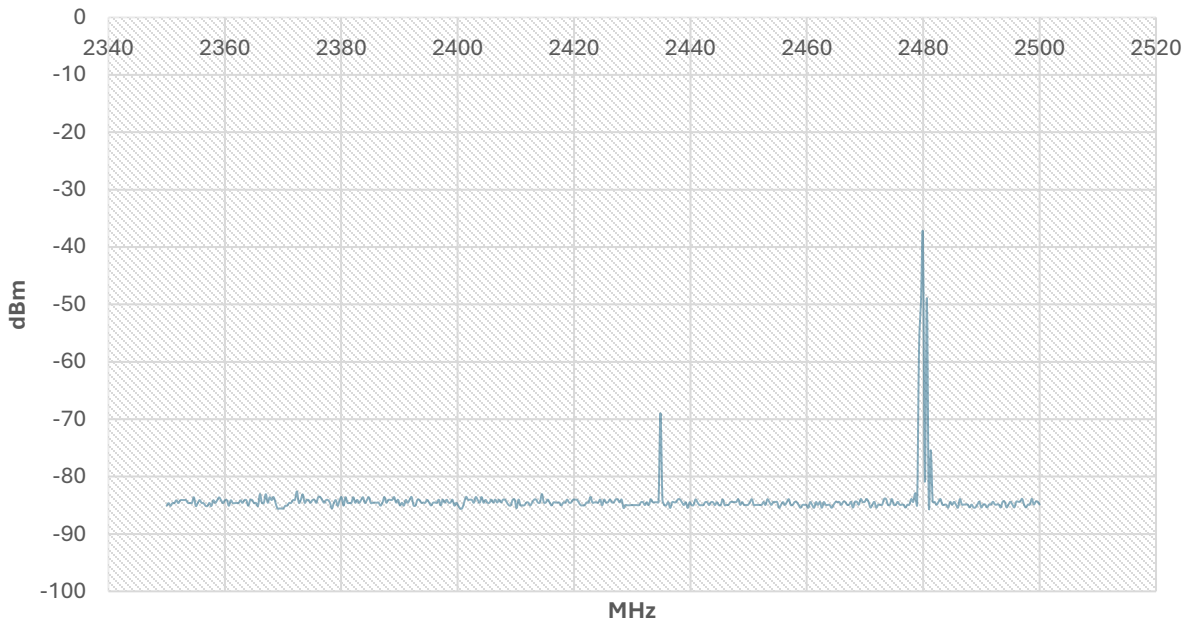


### iPhone 13 (airplane mode) Bluetooth

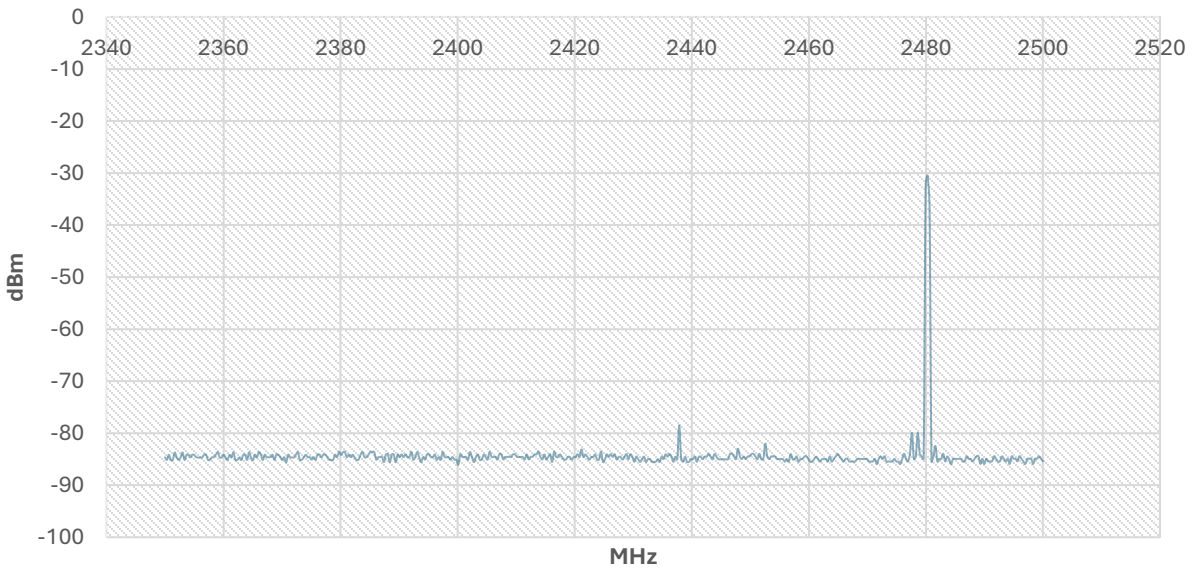




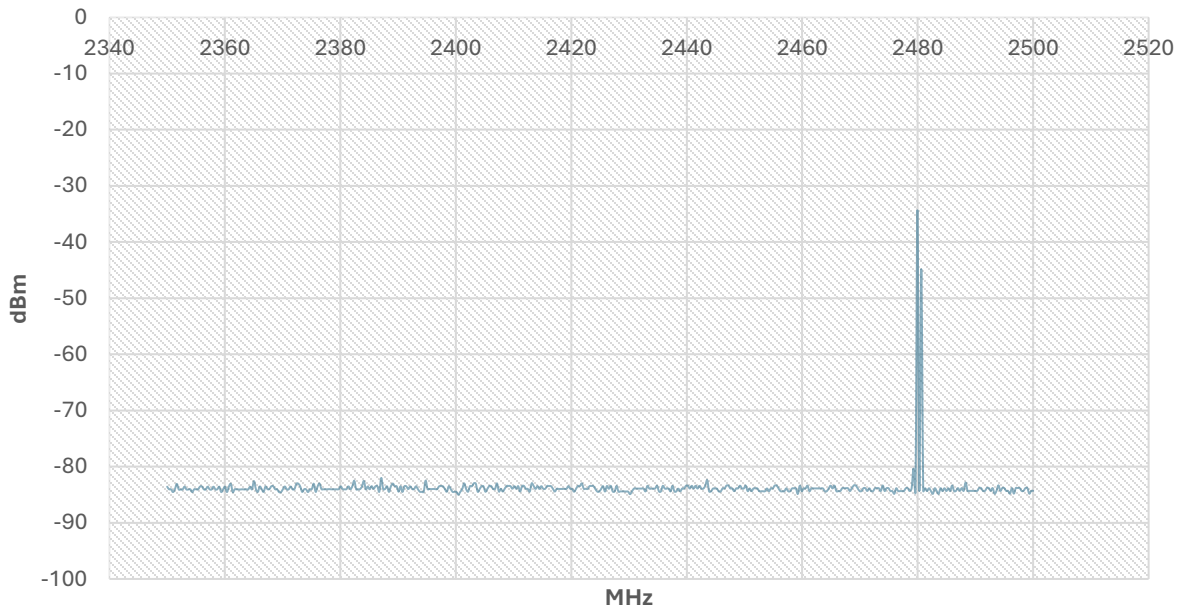
### Polar H10 + iPhone 13 Bluetooth



### Oura Ring + iPhone 13 Bluetooth



### Dexcom Stelo CGM + iPhone 13 Bluetooth



### Calibre Metabolic Mask + iPhone 13 Bluetooth

