Investigating Frequency Use

W-T1: Leon Schnetzer
Wireless Networks – Prof.in Dr.in Karin Anna Hummel

Content

- Motivation
- The upper midband
- Interference in radio astronomy
- Scanning frequency bands
- Conclusion
- References

Frequency usage in Austria

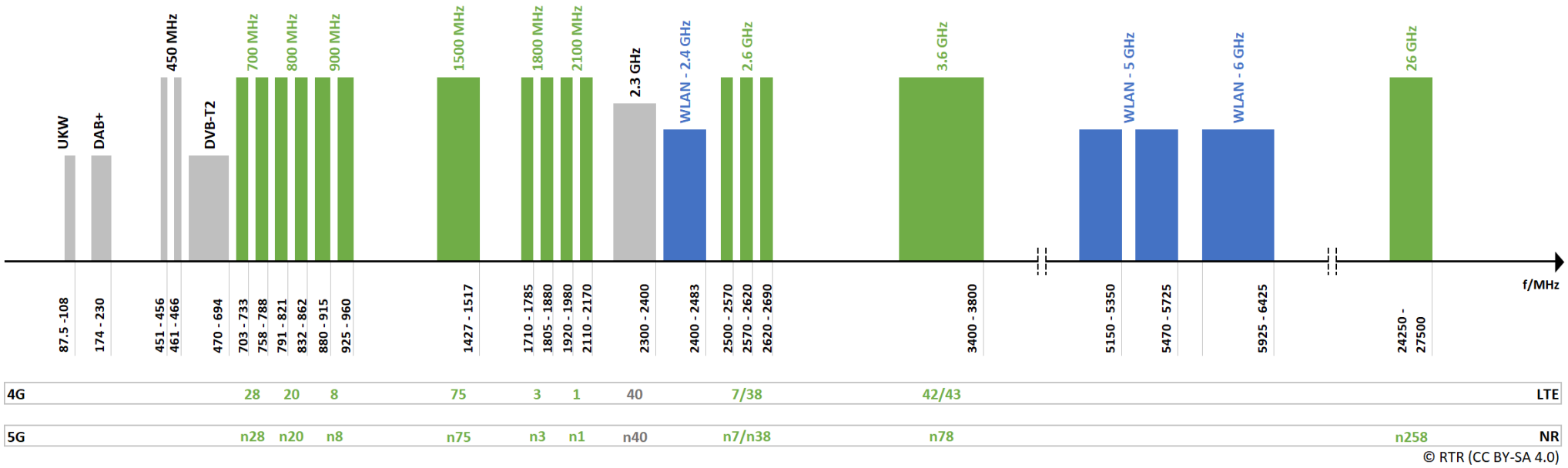

Fig (1).: FRQ-Spectrum

Frequency usage in Austria

LTE & 5G frequencies

- 700, 800, 900 MHz
- 1.5, 1.8 GHz
- 2.1, 2.6 GHz
- 3.6 GHz
- 26 GHz (5G)

WIFI bands

- 2.4 GHz
- 5 GHz
- 6 GHz

Frequency usage in Austria

Other usecases of the sub 6GHz bands

- UKW/VHF (Radio Broadcast)
- DAB+ (Radio Broadcast)
- DVB-T2 (TV)
- Wireless cameras

Frequency usage in Austria

1500 MHz

- Used for NR (5G)
- Supplimentary Downlink
  - Only for transmissions from Base station
- TMA (Magenta)
- H3A (Drei)
- A1 TA (A1)

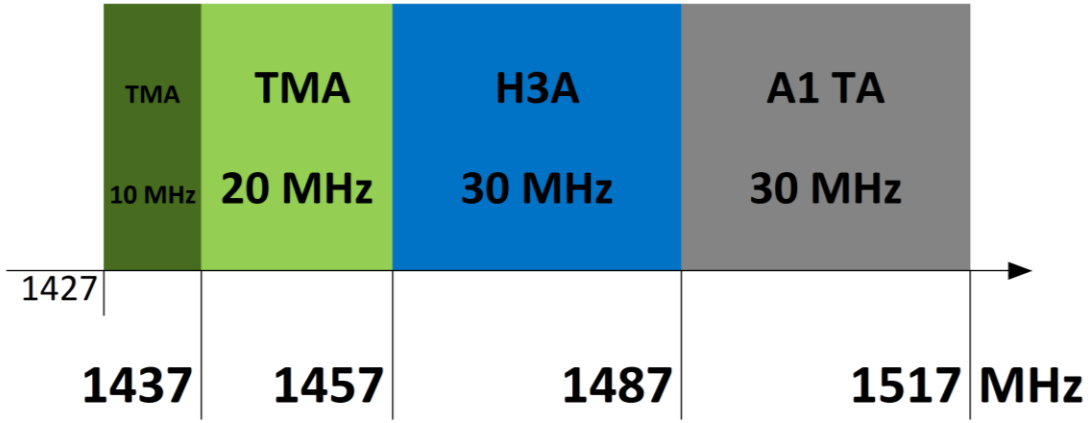

Fig (2).: 1500 MHz

Frequency usage in Austria

Cons of sub 6 GHz

- Slower data transmisson rates
- Not much free space

mmWaves

- Frequency range > 24 GHz
- Very high data transmission rates
- Limited coverage (especially indoor)

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The upper midband

- Frequency range: 7 GHz – 24 GHz
- Better datatransmission than sub 6 GHz
- Better indoor coverage than mmWaves
- Not as heavily used as sub 6 GHz

The upper midband

Data transfer rate

- 18 and 24 GHz bands get rates up to 1.92 Gbit/s
- For the lowest 10% the lower bands are significantly faster than 18 and 24 GHz
- Note: Best curve picks highest available frequency

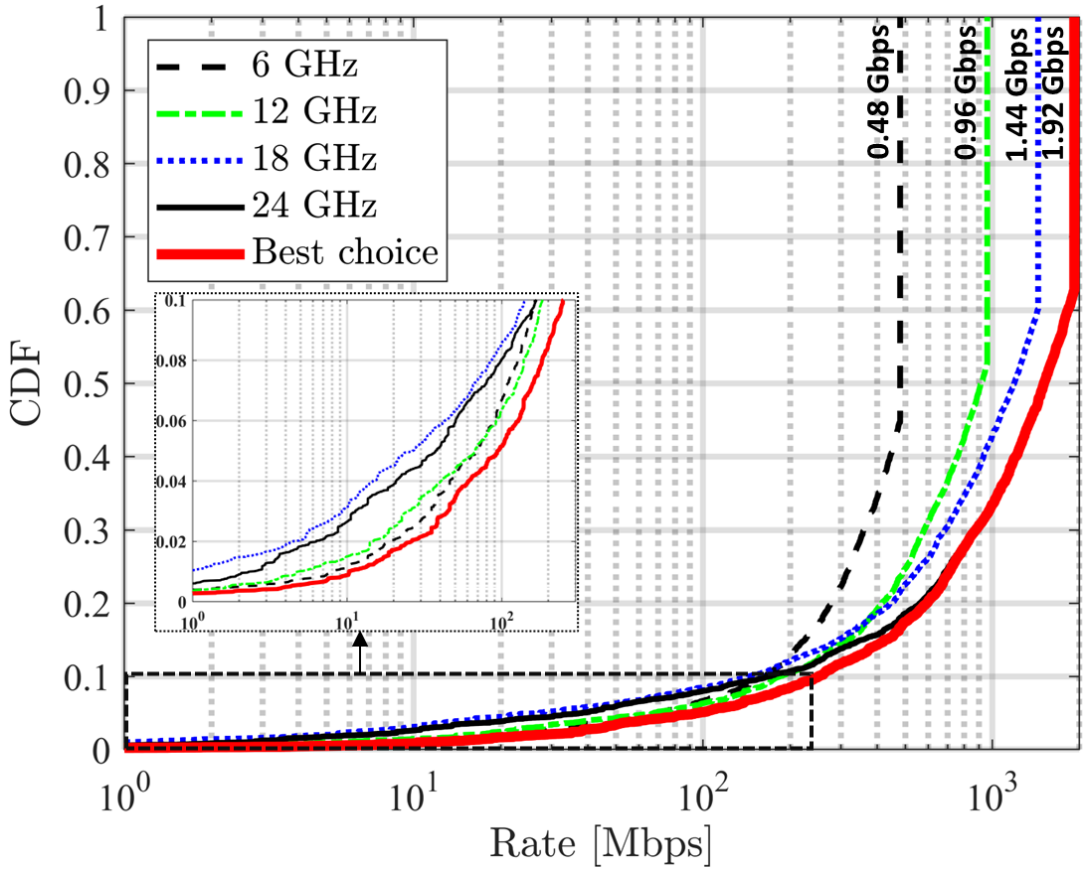

Fig (3).: Unobstructed transfer rates

The upper midband

Penetration Loss

- Huge loss in signal strength for concrete and IRR glass
- Loss gets worse with higher frequencies
- Solution -> Jumping between multiple frequencies

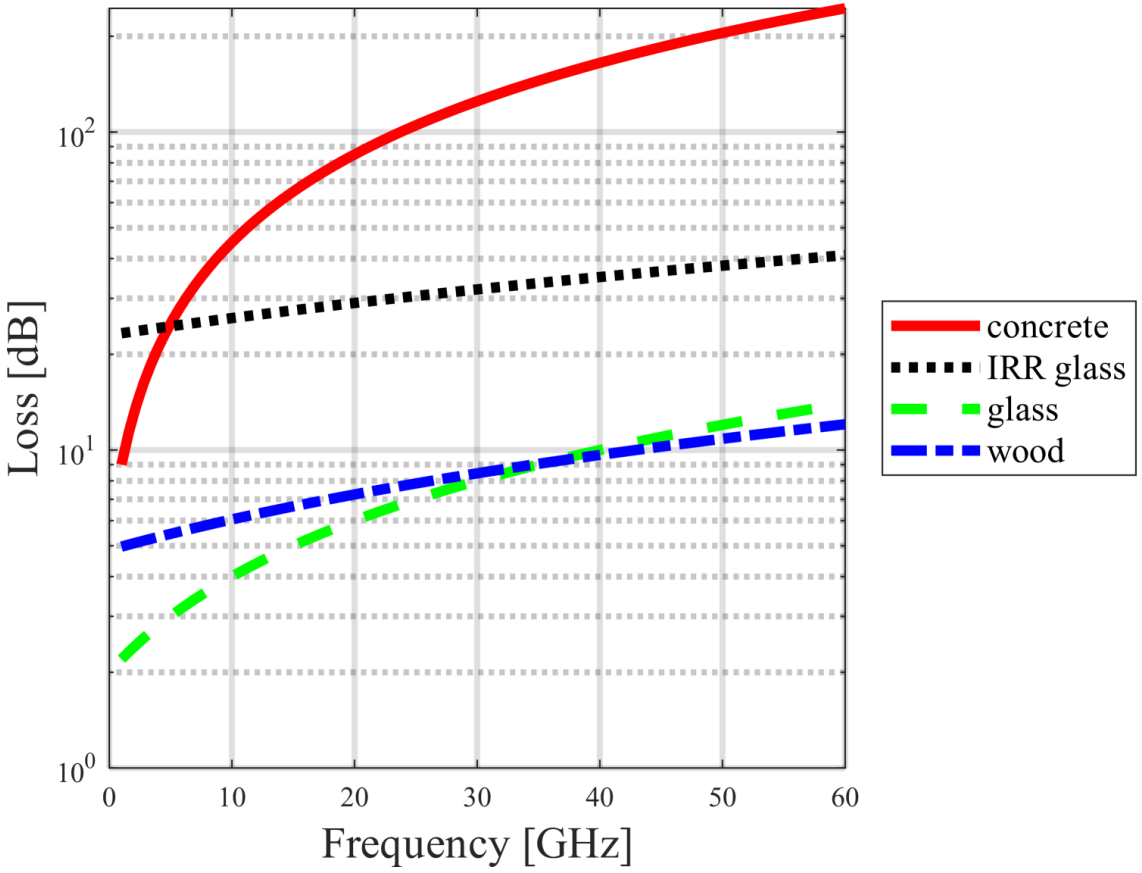

Fig (4).: Penetration Loss

The upper midband

Problems and Challenges

- Frequency space is already partly occupied by other actors
  - Military usage, commercial satellite usage
- 5G for mobile from satellites is planned
- Wireless networks could interfere with radio astronomy

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Interference with radio astronomy

- Electromagnetic impulses studied fall into the upper midband
- Small impulses measured in jansky: $1Jy = 10^{-26}\ Wm^{-2}\ Hz^{-1}$
- Data of non repeatable events could get lost

Interference with radio astronomy

Problematic Frequencies

- 1612 MHz
  - Used by IRIDIUM
  - Leaked signals are 10^{11} stronger than astronomical signals
- 10 – 15 GHz
  - Houses signatures of molecules essential for understanding lifeprocesses

Radio Quiet Zones

- Places where the usage of electrical equipment is restricted
- Have to be set up by countries
- Used by most astronomical stations

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Scanning frequency bands

Spectrum analyzer

- Possibly wider spectrum range
- More expensive

Software defined radio

- Limited frequency spectrum
- Problems when identifying weak signals
- Can be used with PCs easily
- Inexpensive

Scanning frequency bands

Hackrf One

- SDR by Michael Ossman
- Frequency range: 100 MHz to 6 GHz
- Sweeping speed: 8 GHz

Fig (5).: Hackrf One

Scanning Frequency bands

Setting up the Hackrf

- Install the Hackrf software
- Update the firmware (help article)
- Run '$ hackrf_info' to verify installation
- Use '$ hackrf_sweep' to sweep frequency ranges

DragonOs

- Specific Ubuntu based OS for SDR usage
- Has analyzing software preinstalled
- Can be booted from usb.

Scanning frequency bands

QSpectrumAnalyzer:

- Can directly be used with hackrf_sweep
- Select hackrf_sweep as backend and samplerate is set automatically
- Can use sweeps commandline arguments

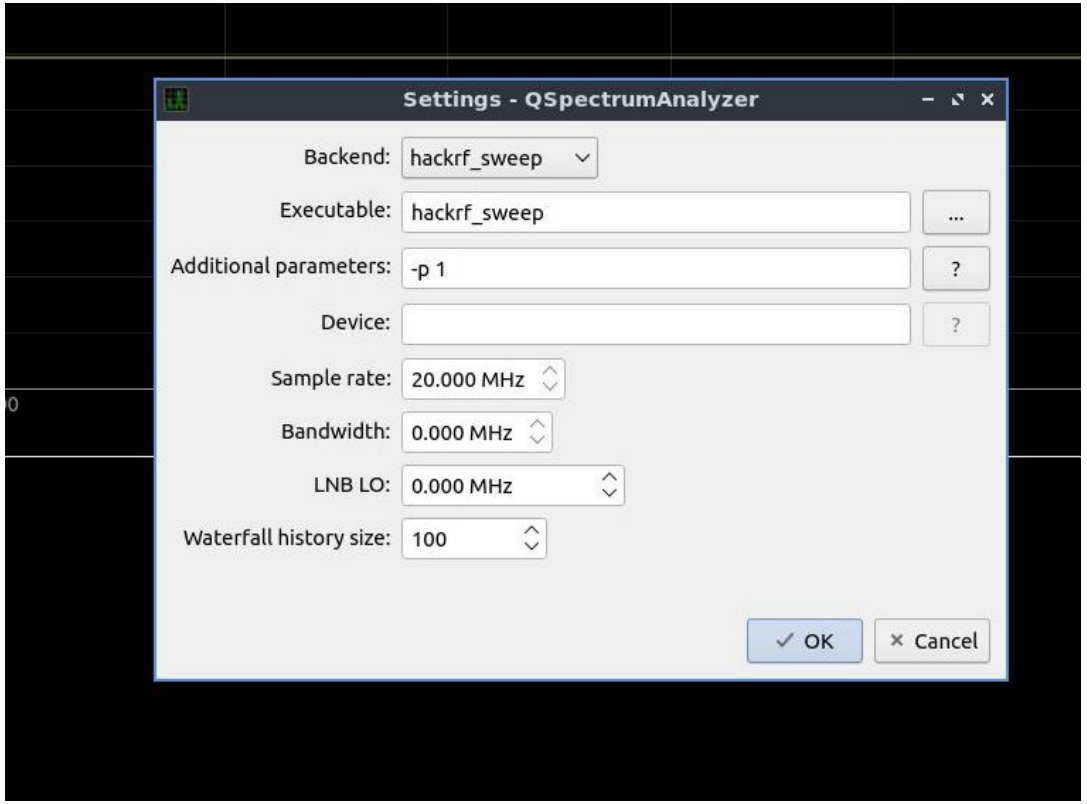

Fig (6).: QSpectrumAnalyzer Setup

Scanning frequency bands

My Findings

- Location: HS16
- Time: 15:10
- Antenna: WIFI
- Sweeping range: 100 MHz – 6 GHz

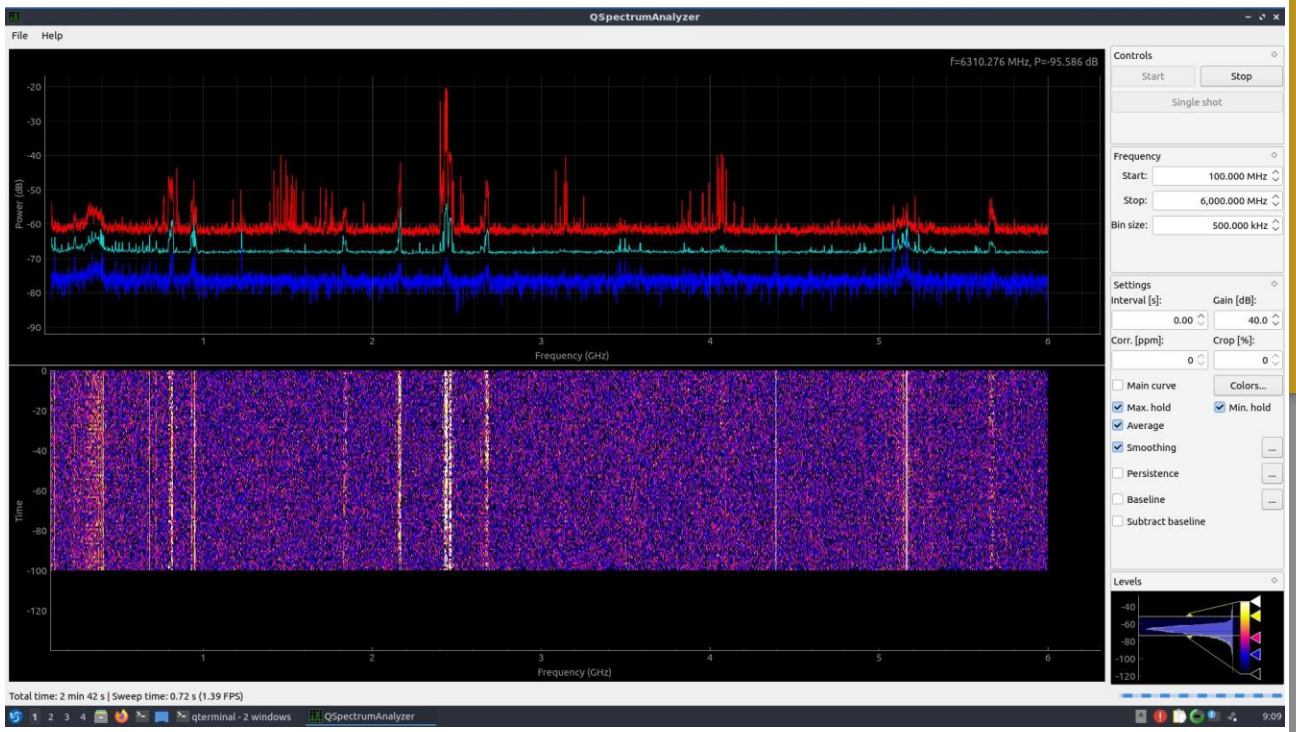

Fig (7).: Full Frequency Sweep Wifi

Scanning frequency bands

My Findings

- Location: HS16
- Time: 15:56
- Antenna: Cellular
- Sweeping range: 100 MHz – 6 GHz

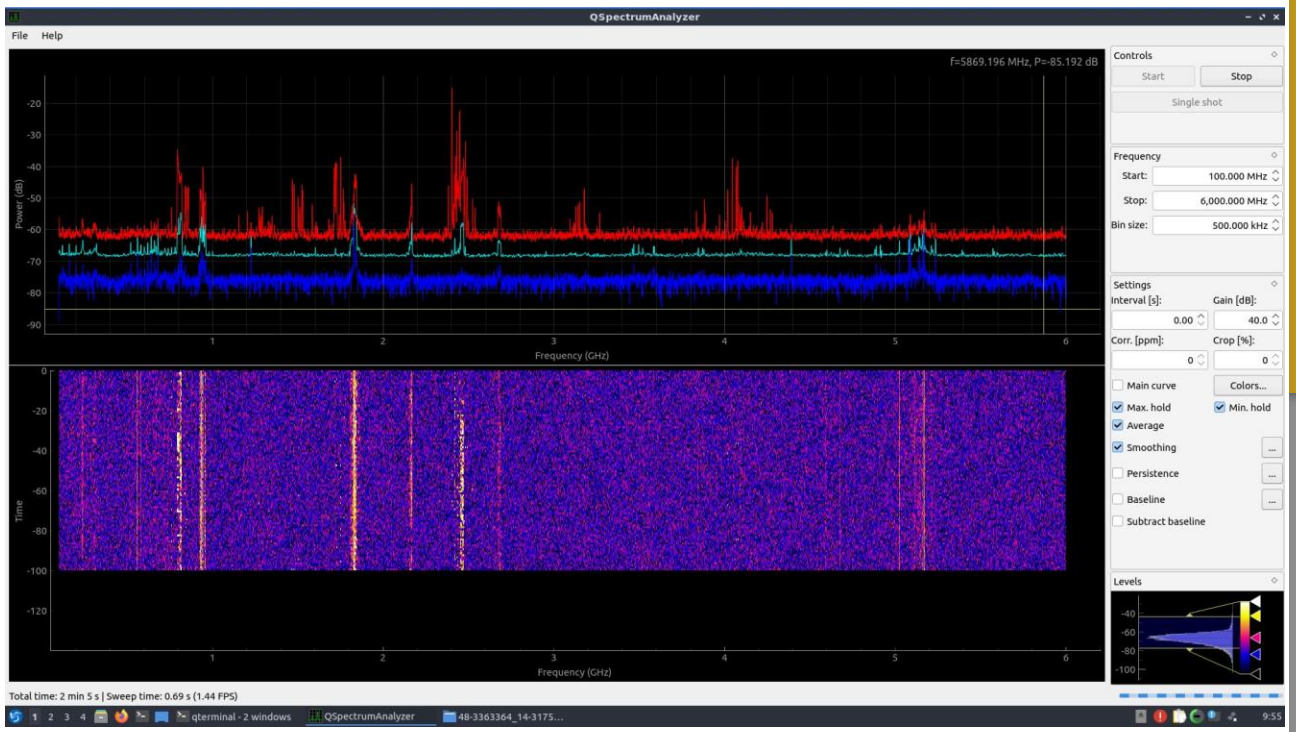

Fig (8).: Full Frequency Sweep Cellular

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Conclusion

- The sub 6 GHz bands are pretty full
- The upper midband has some desirebal features and could aid the demand of more coverage and higher speeds
- There are still challgenges that need to be looked into
- Use SDRs like the Hackrf to do frequency scanning yourself

References

Frequency use in Austria:

- https://www.rtr.at/TKP/was_wir_tun/telekommunikation/spectrum/bands/FRQ_spectrum.en.html
- https://www.rtr.at/TKP/was_wir_tun/telekommunikation/spectrum/bands/1500MHz/Spectrum1500MHz.en.html

The upper midband:

- Kang et al., "Cellular Wireless Networks in the Upper Mid-Band," in IEEE Open Journal of the Communications Society, doi: 10.1109/OJCOMS.2024.3373368.

Interference with radio astronomy:

- Kang et al., "Cellular Wireless Networks in the Upper Mid-Band," in IEEE Open Journal of the Communications Society, doi: 10.1109/OJCOMS.2024.3373368.
- Umar, R., Abidin, Z. Z., and Ibrahim, Z. A., “The importance of Radio Quiet Zone (RQZ) for radio astronomy”, in 2012 National Physics Conference: (PERFIK 2012), 2013, vol. 1528, no. 1, pp. 32–37. doi:10.1063/1.4803564.

Scanning frequency bands

- A. Fanan, N. Riley, M. Mehdawi, M. Ammar and M. Zolfaghari, "Comparison of spectrum occupancy measurements using software defined radio RTL-SDR with a conventional spectrum analyzer approach," 2015 23rd Telecommunications Forum Telfor (TELFOR), Belgrade, Serbia, 2015, pp. 200-203, doi: 10.1109/TELFOR.2015.7377447
- https://hackrf.readthedocs.io/en/latest/index.html

References

Images:

- Fig (1).: https://www.rtr.at/TKP/was_wir_tun/telekommunikation/spectrum/2023-07-12_FRQ_Spectrum.png
- Fig (2).: https://www.rtr.at/TKP/was_wir_tun/telekommunikation/spectrum/1500MHz.png
- Fig (3).: Kang et al., "Cellular Wireless Networks in the Upper Mid-Band," in IEEE Open Journal of the Communications Society, doi: 10.1109/OJCOMS.2024.3373368.
- Fig (4).: Kang et al., "Cellular Wireless Networks in the Upper Mid-Band," in IEEE Open Journal of the Communications Society, doi: 10.1109/OJCOMS.2024.3373368.
- Fig (5).: https://greatscottgadgets.com/images/h1-preliminary1-445.jpeg
- Fig (6).: Selfmade Screenshot
- Fig (7).: Selfmade Screenshot
- Fig (8).: Selfmade Screenshot

- Note: All pictures of the scans I made will be made available on this GitHub repository in the following days.