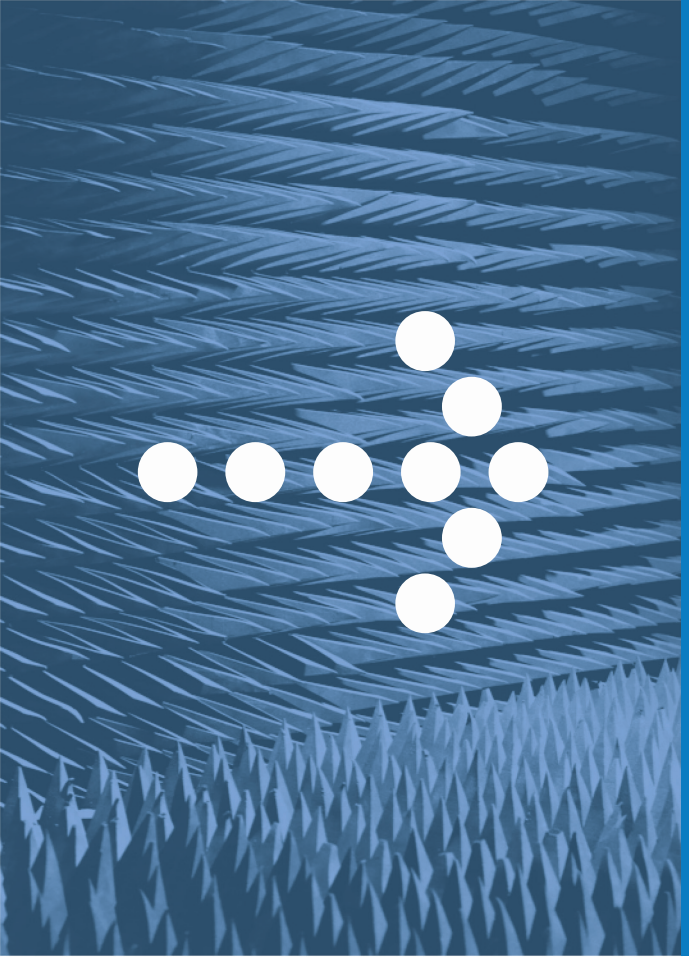

Emission from Wireless Power Transfer of Electrical Vehicles

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FOI

Background

- New application within the wireless power transfer (WPT) technique
- Stationary inductive charging of vehicles, WPT-EV
  - Frequency band 79–90 kHz
  - Compared to wireless charging of other devices, such as mobile phones, significantly higher power
- Risk that the WPT-EV may cause electromagnetic interference in radio communication systems
  - Communication systems nearby in frequency
  - But also possible that harmonics and other emissions may occur at higher frequencies and impact systems
- Aim: to get information of the emission from a WPT-EV station to understand the potential risk these kinds of equipment may constitute to communication systems

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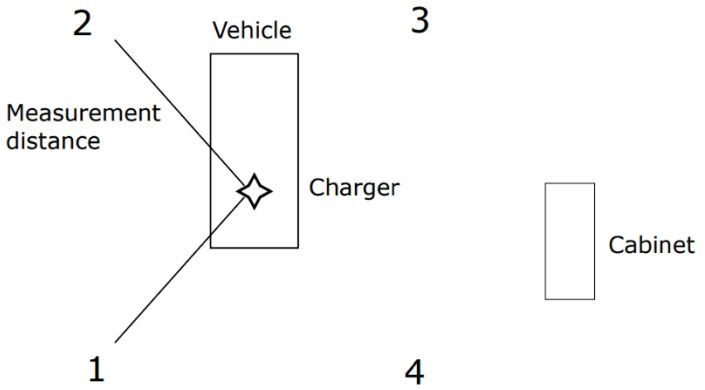
Measurements

- 5–7 July 2022
- Measured outdoors on a installed WPT-EV system and a vehicle charging
- WPT-EV station
  - 43 kW
  - Charging frequency 83 kHz
  - Guiding frequency 85 kHz

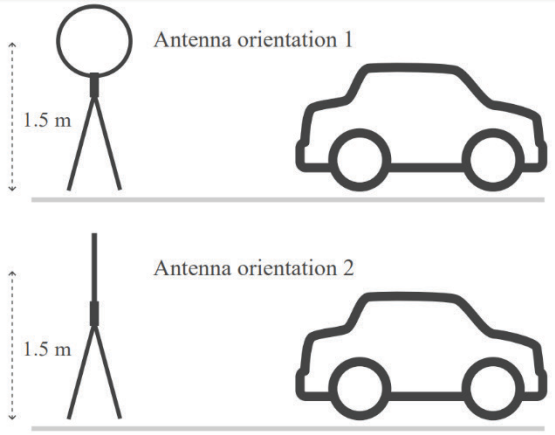
Measurements

- Frequency band 9 kHz to 1 GHz
  - 3 and 10 m
  - different positions
- Measurement cases
  - **Background** – WPT-EV system without power
  - WPT-EV system on, but no charging
  - Vehicle (not charging)
  - **Vehicle charging**



Measurement setup

- Measuring receiver in time domain mode (FFT) – R&S ESRP
- Measure Peak Max hold and spectrogram
- Antennas
  - Active loop antenna from R&S of type HFH2-Z2E, powered by a IN600 Bias Unit from R&S
    - Antenna orientations 1 & 2
  - Biconical antenna (30-200 MHz)
    - Horizontal and vertical polarisation
  - Log-periodic antenna (200 MHz-1 GHz)
    - Vertical polarisation
- Measured results are compensated for antenna factors, attenuation/gains etc.



Frequency range	Bandwidth
9-150 kHz	300 Hz
150 kHz – 30 MHz	10 kHz
30 MHz – 1 GHz	100 kHz

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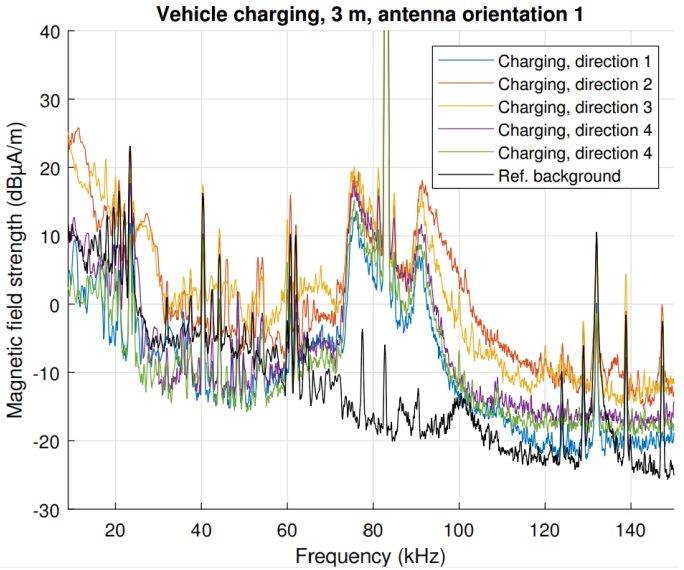
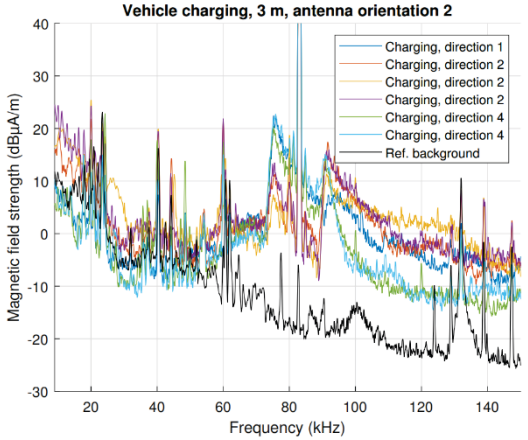
Results: 9-150 kHz

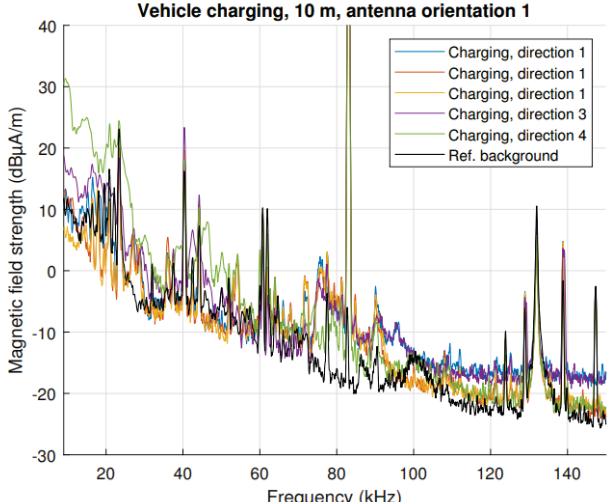
- Background measured at site with WPT-EV system without power
- The charging frequency, identified as 83.025 kHz, is clearly visible
- Some differences in levels between the measured results at different positions and antenna orientations

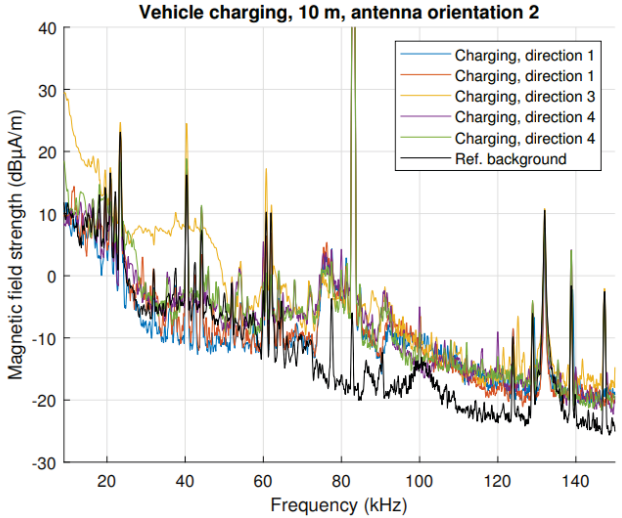




Results: 9-150 kHz

- Similar but lower values at 10 m
- Differs between measurement positions and antenna orientations





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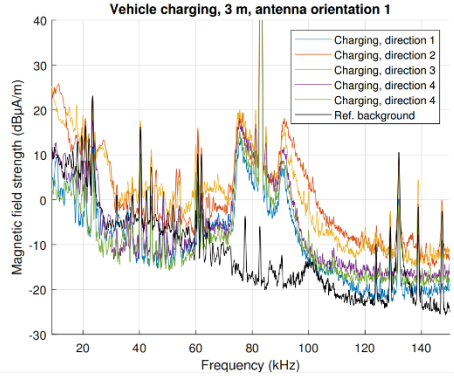
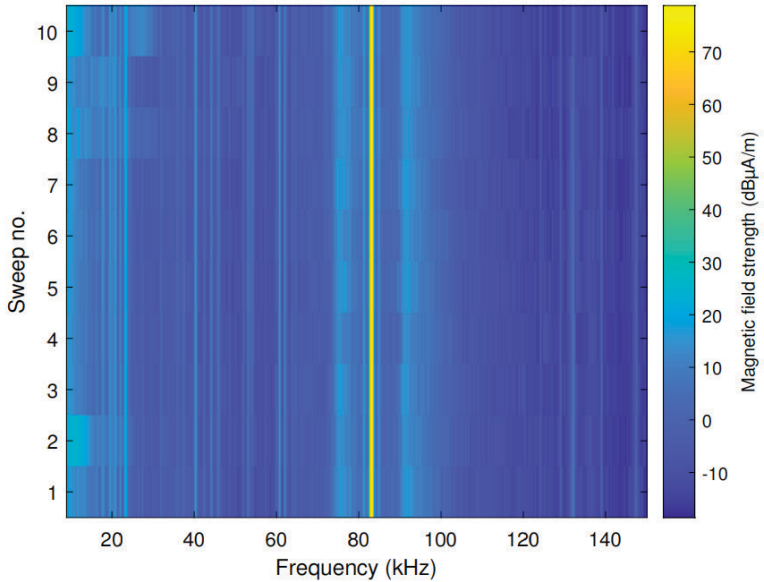
Results: 9-150 kHz

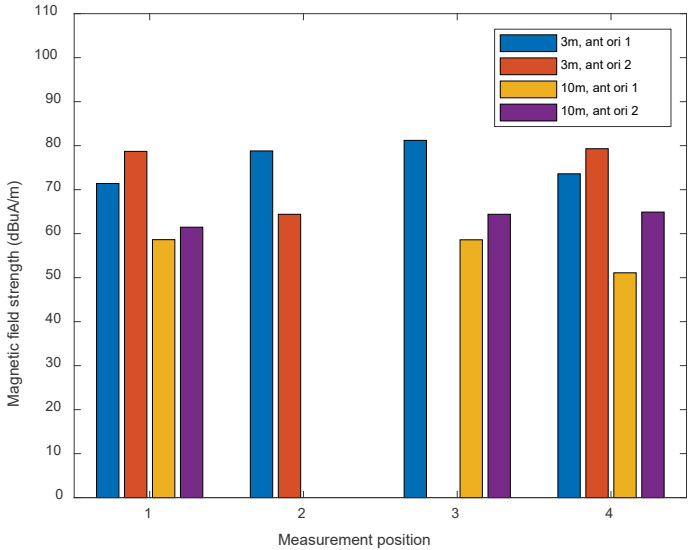
- Spectrogram, (10 sweeps and a measurement time for each sub-band of 100 ms)
  - vehicle charging at 3 meter with antenna orientation 1 and direction 1
- Charging frequency is transmitted continuously during the charging and consists of a sine signal





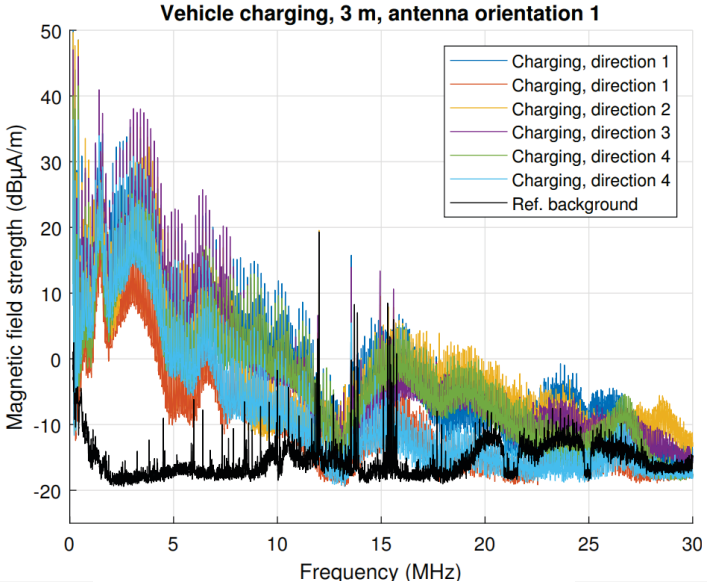
Results: level variations in different directions

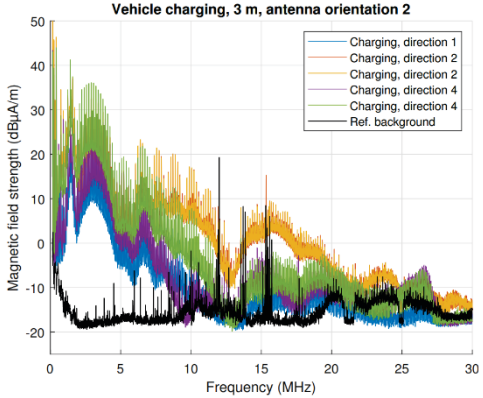
- Not clear which measurement direction that attains the highest levels
- Many reasons for why level variations at different locations are difficult to analyse
  - Outdoor measurements
    - buildings and structures occur within distances of the same order as the measurement distance => multipath propagation and subsequent interference cancellation/contribution
  - Measurement object itself is anisotropic - two large coils possibly coaxially misaligned, vehicle contains auxiliary electronics, cables, a motor, and is inherently radially asymmetric
  - Measurements partly in the near field
    - $\lambda/2\pi$, the near field extends to about 10 m for 5 MHz
    - Lower frequencies: made in near field => coupling between the measured object and the measurement equipment



Results: 150 kHz-30 MHz

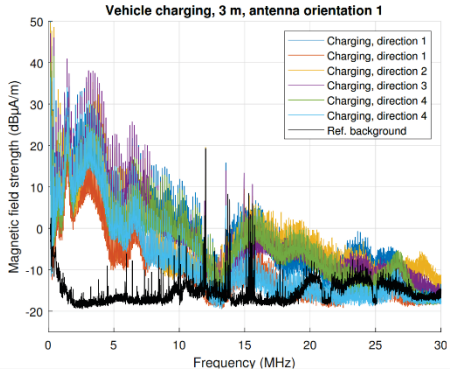
- 3 m distance
- Emissions are clearly visible above the background
- Narrowband signals
- Difference between measurements/positions, but no clear trend

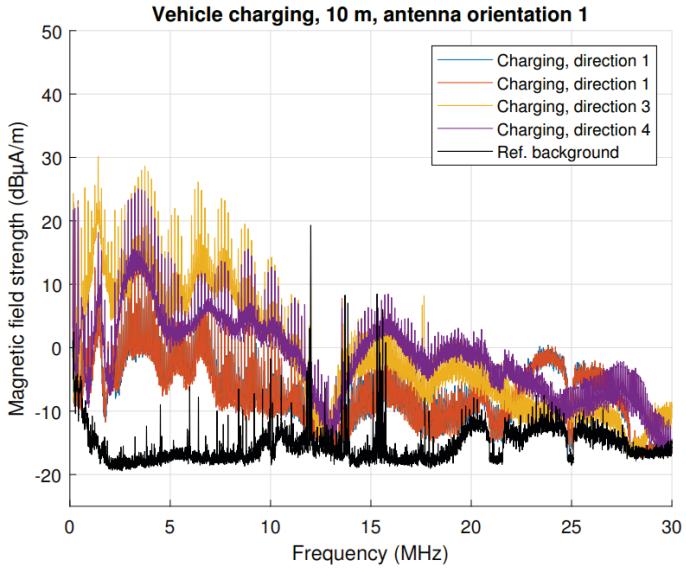


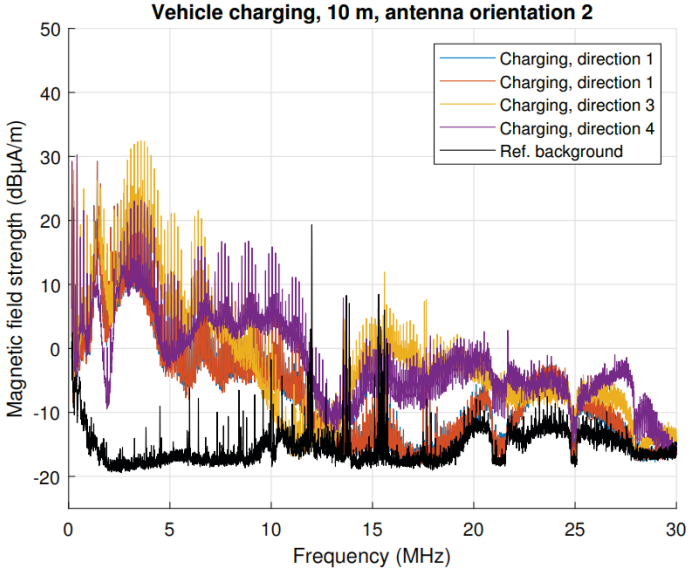


Results: 150 kHz-30 MHz

- For frequencies above 12 MHz: levels and behaviours very similar to the 3 m results







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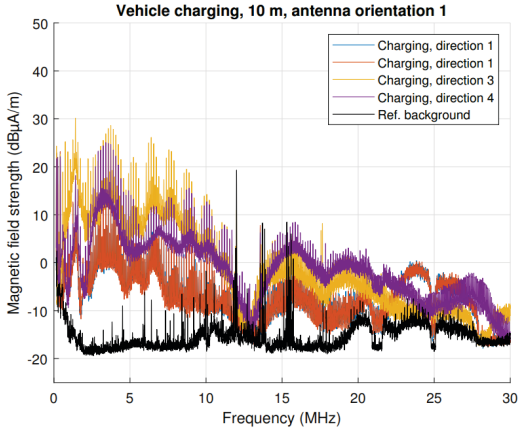
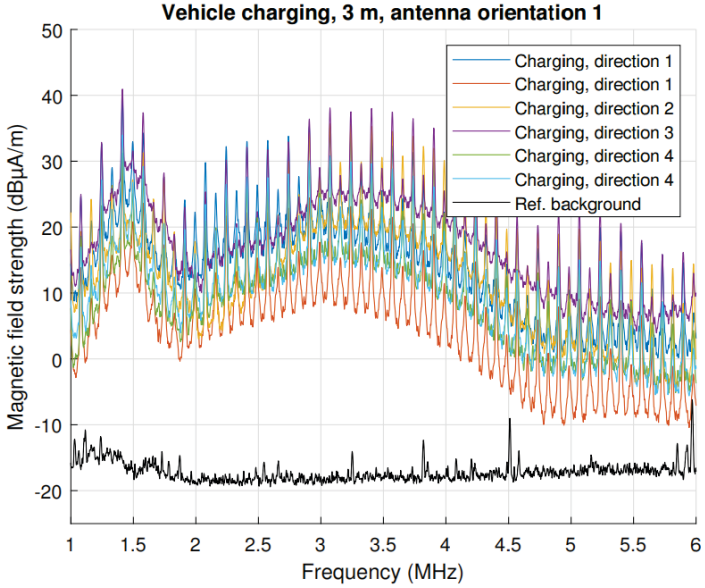
Results: 150 kHz-30 MHz

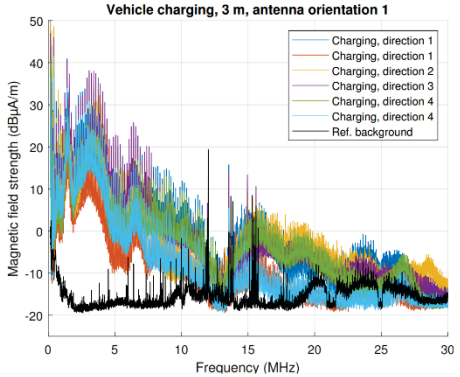
- Narrowband signals
- Enlarged view of 1–6 MHz:
- Frequency distance:
  - between high peaks is 166 kHz
  - between a high peak and its smaller neighbour peak 83 kHz (charging frequency)

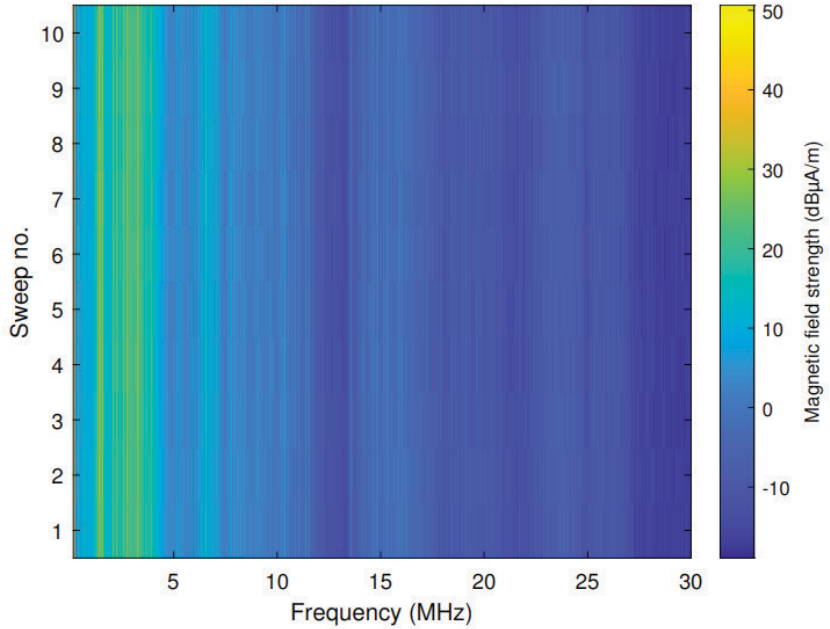




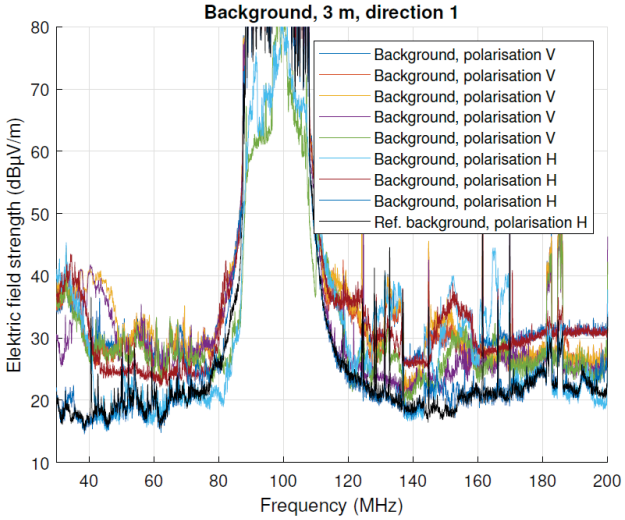
Results: 150 kHz-30 MHz

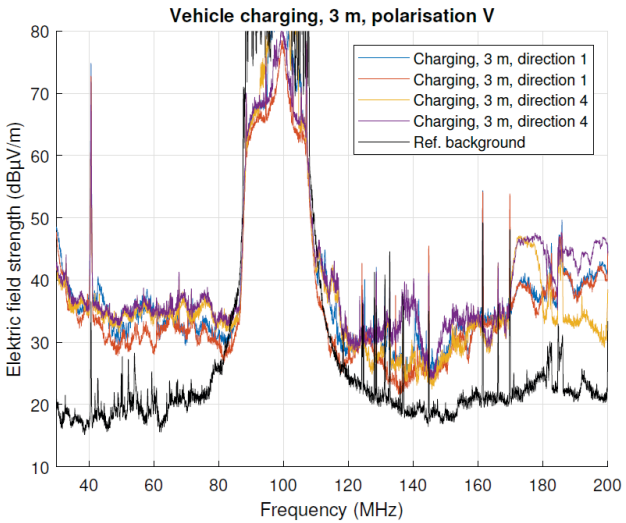
- Clear that the levels are constantly transmitted over 10 sweeps

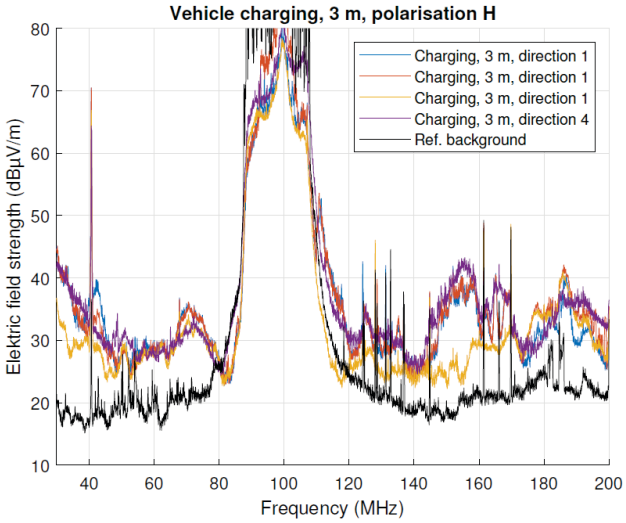




Results: 30-200 MHz







- Filter for fm radio
- Noisy environment

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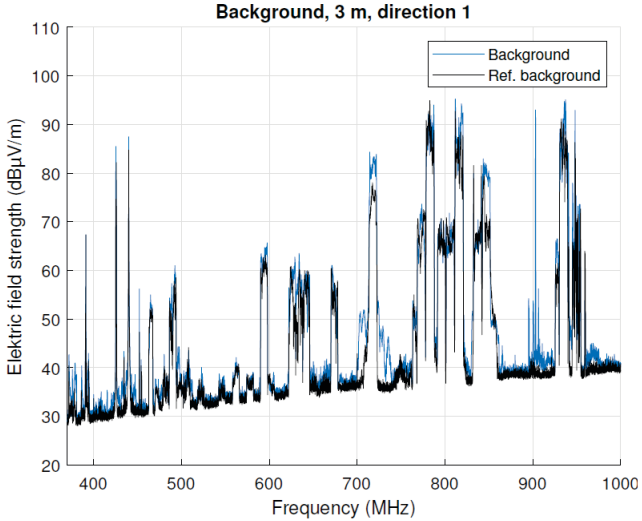
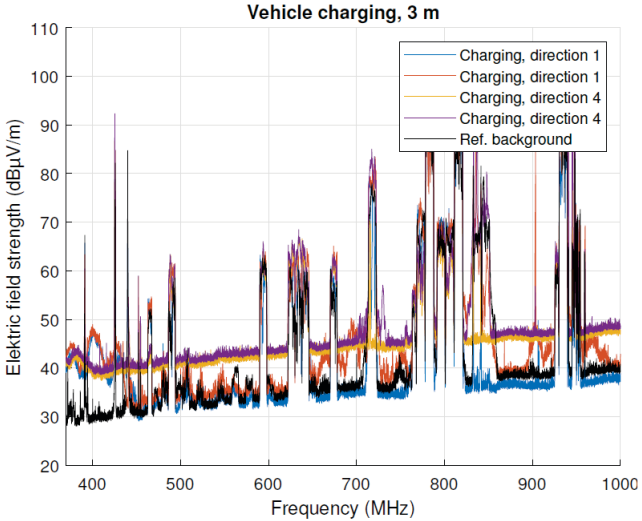
Results: 200 MHz-1 GHz





- Many transmitters in the band

Conclusions

- Investigation of the emitted electromagnetic field from an outdoor situated WPT-EV system between 9 kHz -1 GHz
- Charging frequency of 83.025 kHz
  - between 64 and 81 dBµA/m at 3 meter
  - between 58 and 65 dBµA/m at 10 meter
- HF band
  - emissions clearly visible above background, for 1-12 MHz, constant in magnitude
  - evident comb spectra originated from the charging frequency
- 30 MHz-1 GHz
  - Noisy environment -> hard to distinguish emissions from vehicle charging

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