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High frequency communication through power coils update

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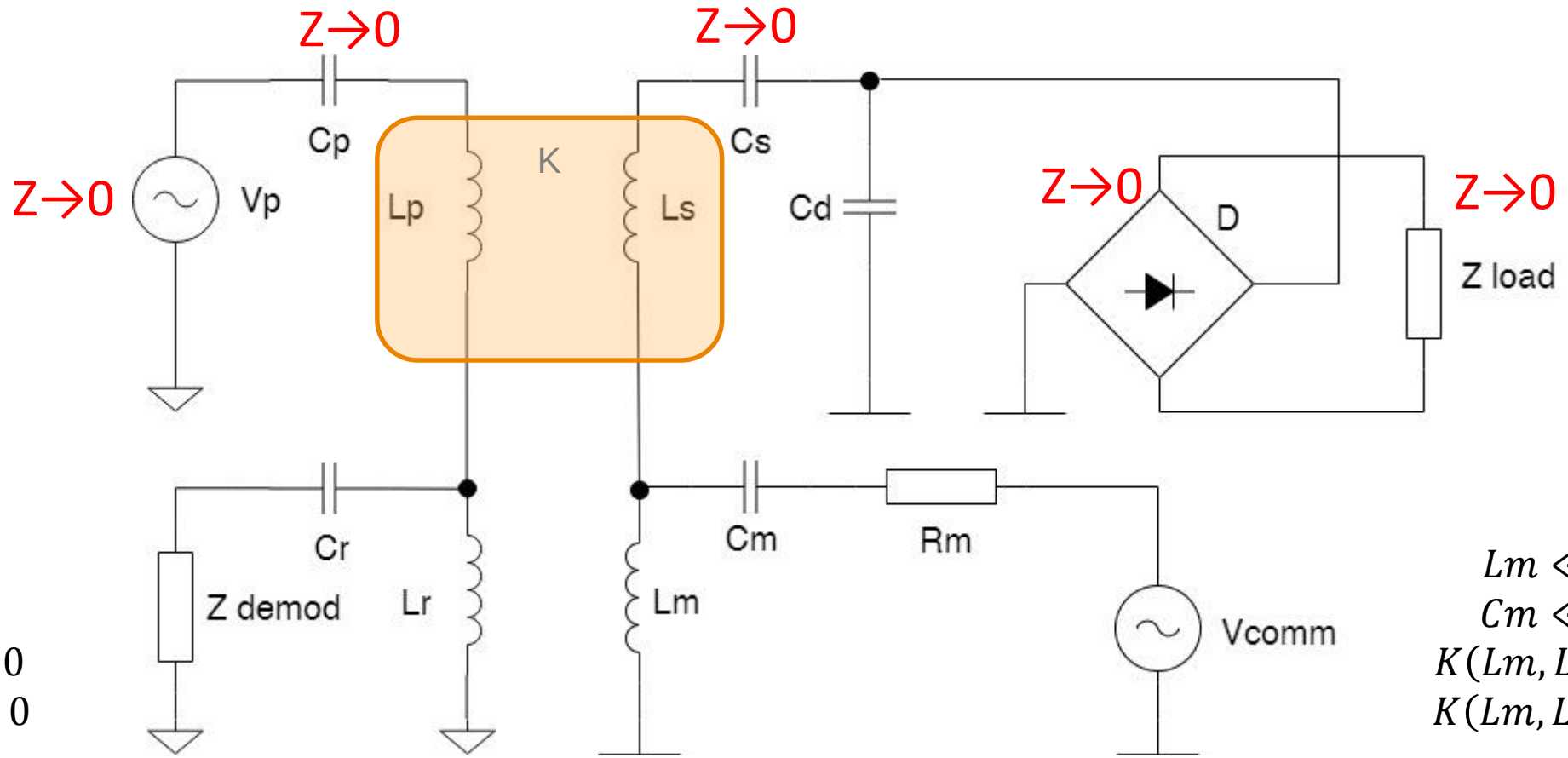
Content

- Recap from 1904
- First high frequency harmonic approximation
- Power coils self resonance concern
- Frequency selection and regulatory affairs
- Conclusions

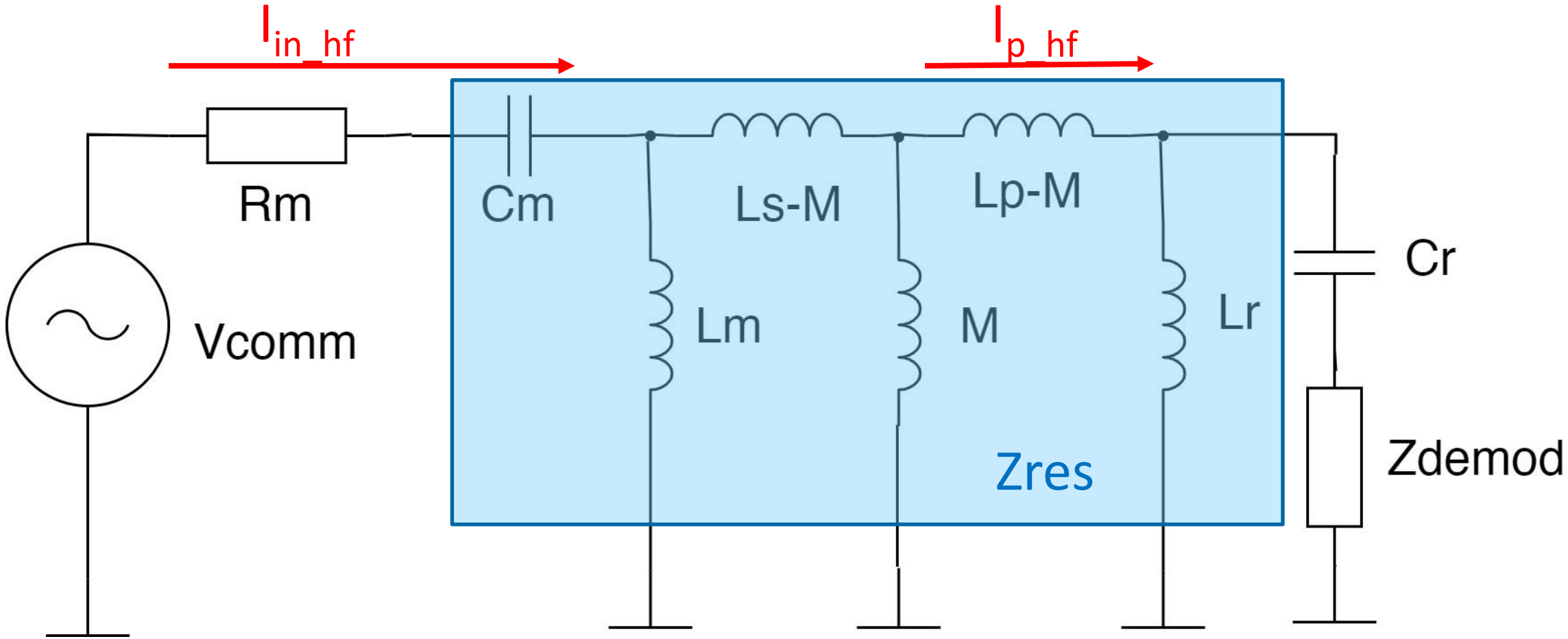
High frequency communication (@1904)



$Lr \ll Lp$
$Cr \ll Cp$
$K(Lr, Lp) = 0$
$K(Lr, Lm) = 0$

$Lm \ll Ls$
$Cm \ll Cs$
$K(Lm, Ls) = 0$
$K(Lm, Lp) = 0$

First HF harmonic approximation



Zres<<Rm

$I_{in\_hf} \approx V_{comm}/R_m$

$$M = K\sqrt{Ls * Lp}$$

First HF harmonic approximation- Relation $I_{p\_hf}(I_{in\_hf})$

Limitations:

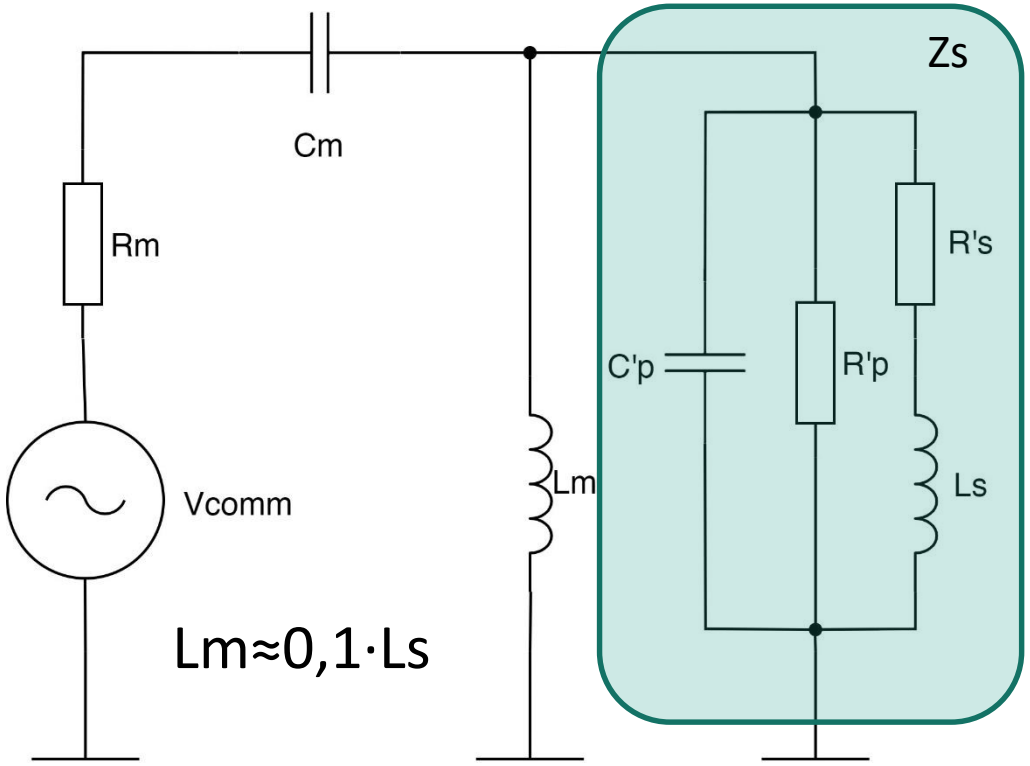
1) Minimal current at demodulator ← 15 $mA_{pk\text{-}pk}$ for Qi, 3 $mA_{pk\text{-}pk}$ for HF only demodulation
2) Maximal available modulation power
3) Maximal H-field strength – current in secondary coil ← Regulatory approval

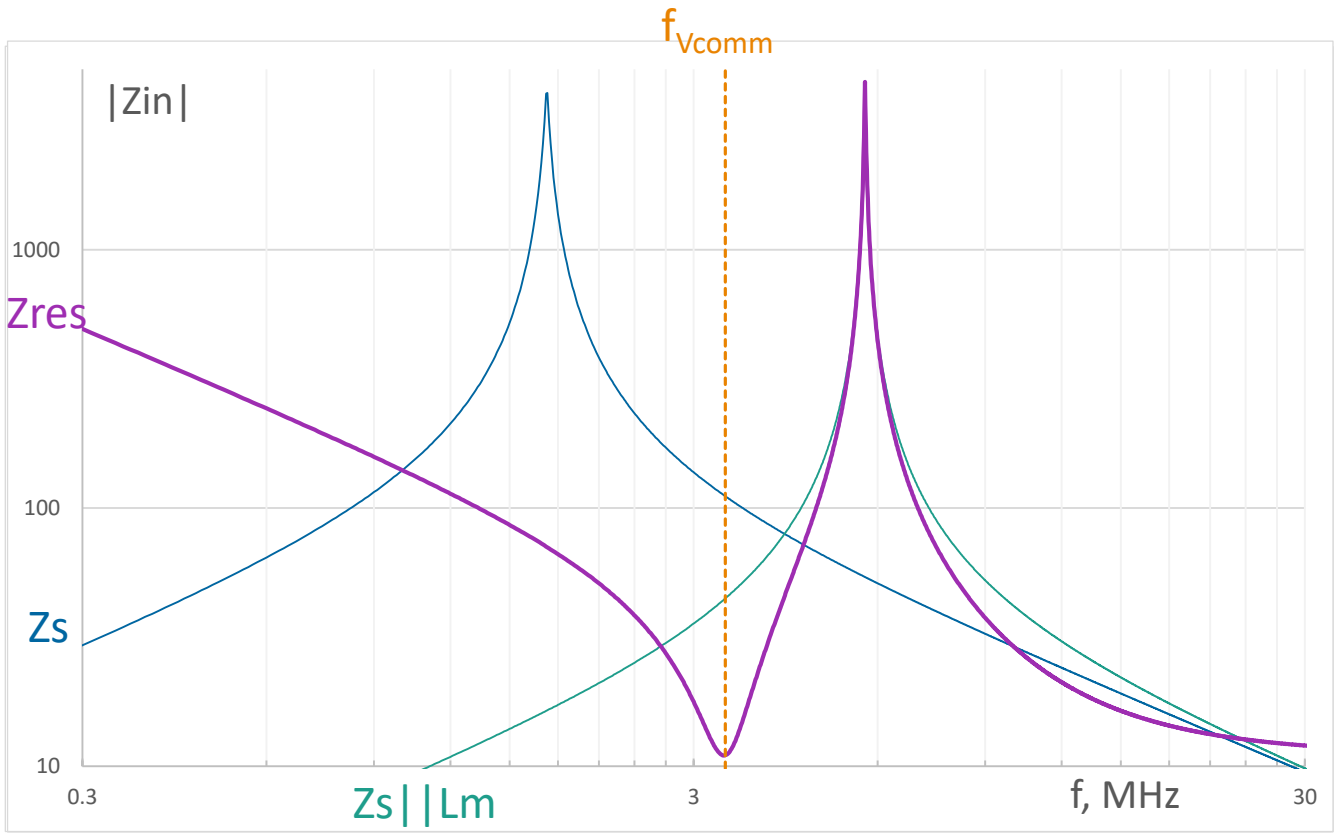
$$I_{p\_hf} = I_{in\_hf} * \frac{K * Lm * \sqrt{LpLs}}{\left(Ls - K * \sqrt{LpLs} + M||Lp + Lm\right) * (Lr + Lp)}$$

$K \downarrow \Rightarrow I_{p\_hf} \downarrow$	$Lp \downarrow \Rightarrow I_{p\_hf} \downarrow$	$Ls \uparrow \Rightarrow I_{p\_hf} \downarrow$

Boundaries are defined only by the power interface

Power coil self-resonance (1)

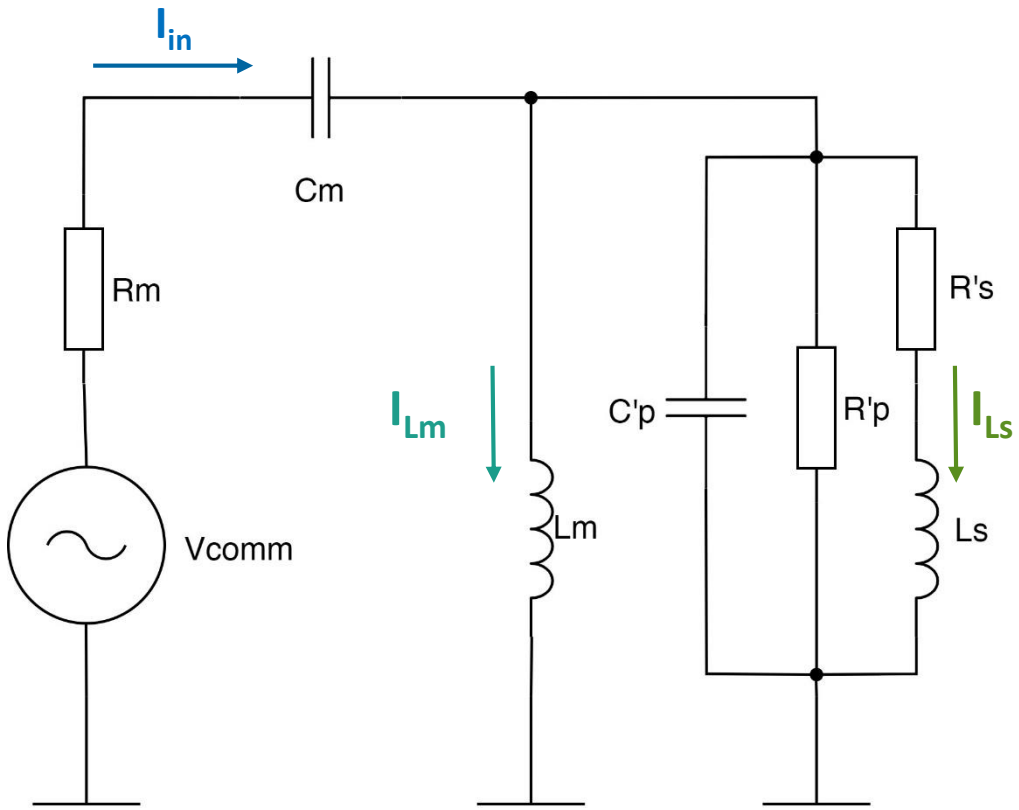


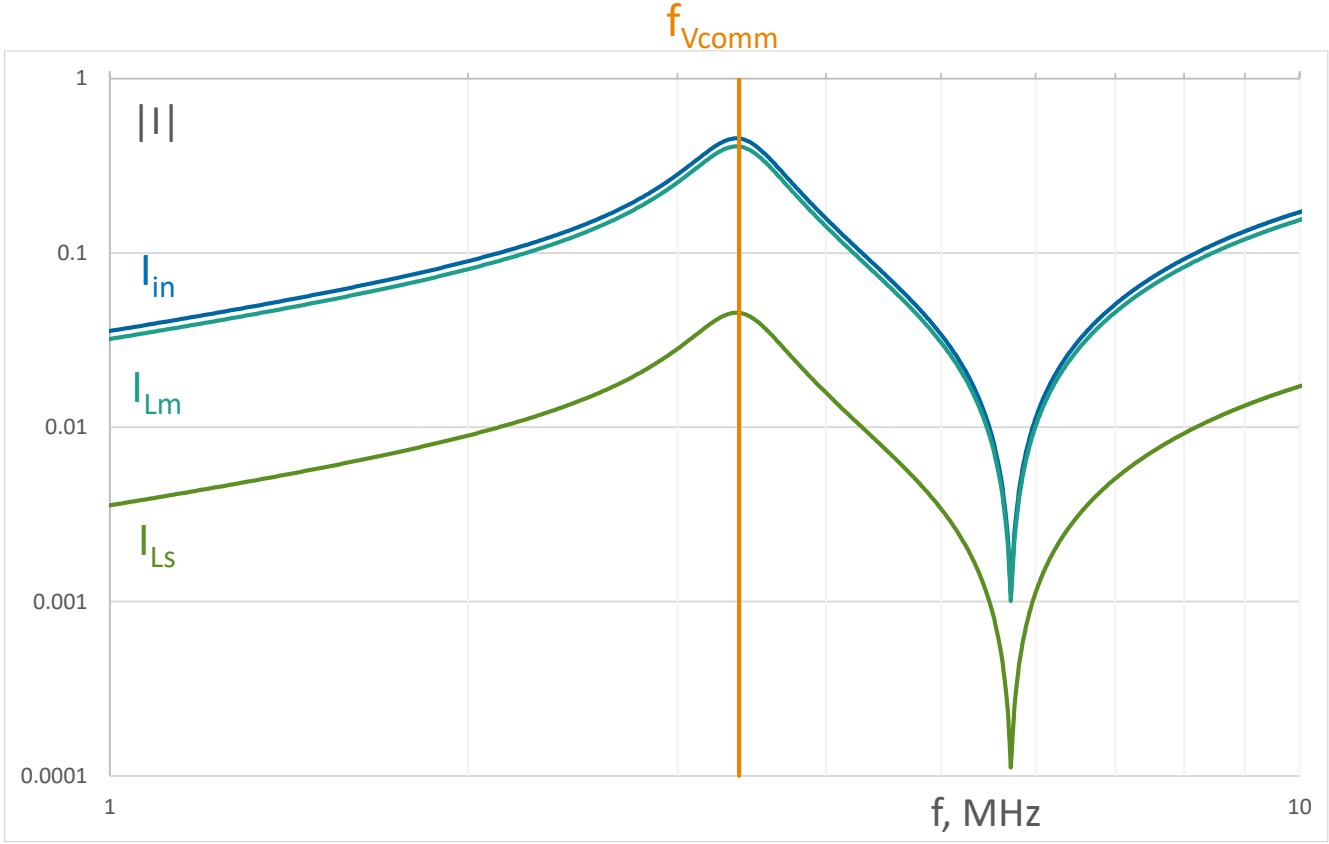


On the resonance frequency f_{Vcomm} the parasitic parallel resonance is **moved in higher frequency region**

Component selection order: Secondary coil → modulation coil → resonant capacitor

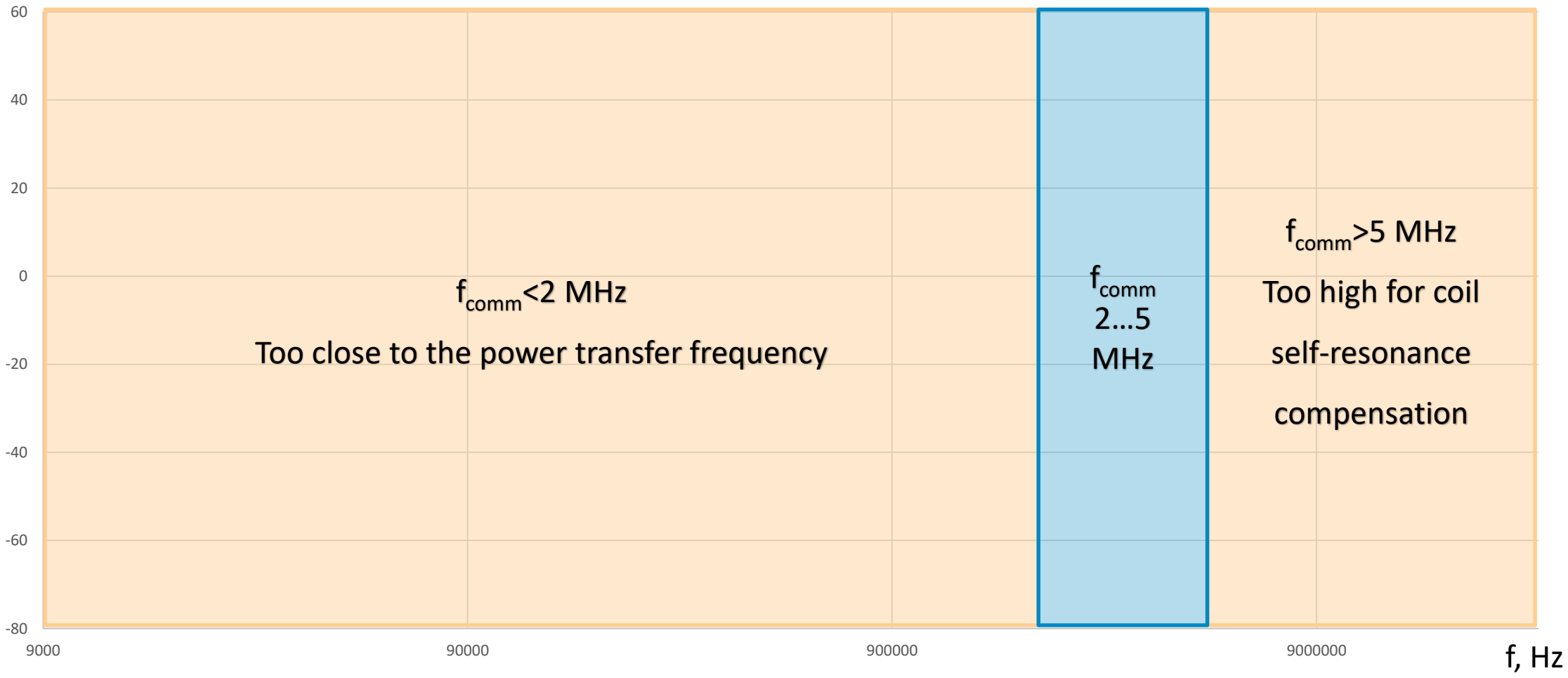
Power coil self-resonance (2)





At the high-frequency resonant frequency, the resonant current divided between Ls and Lm impedance-wise.

Frequency selection



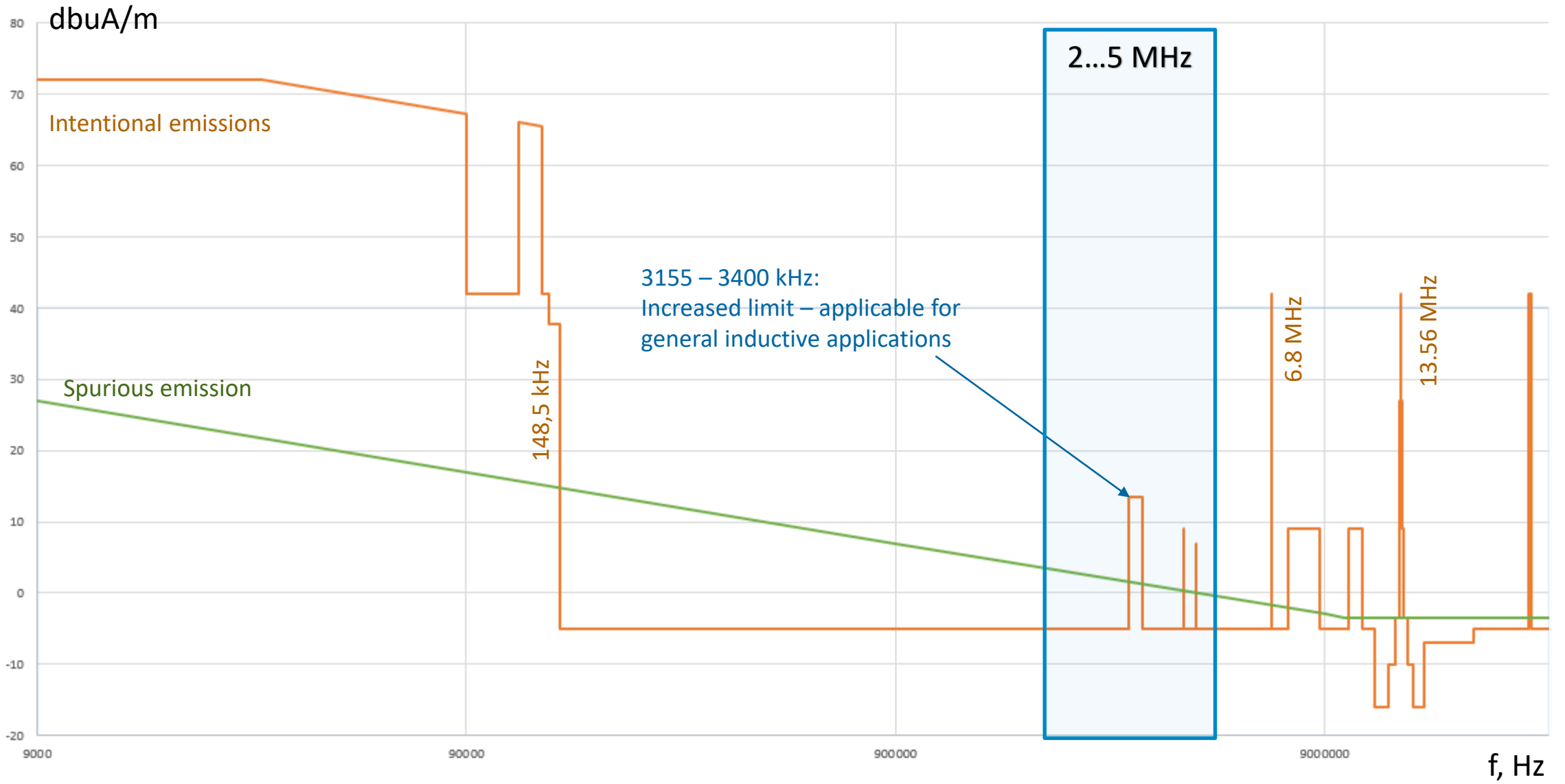
Can we find a frequency in the region from 2 to 5 MHz with relaxed limits and approval for inductive applications

Regulatory

- RWG considers the WPT systems as a radio equipment - ETSI EN 303 417
- The data transfer on high frequency is a H-field emission and has to be assessed with relevant H-field measurement
- Limits from ETSI EN 300 330[1] can be applied for communication channel.
- Spurious limits according to REC 74-01[2]
- Most countries require only product EMC compatibility
- FCC Part 18 is not applicable (RF energy used for communication).
- FCC Part 15 does not limit system to operate on the frequencies other then primary transfer frequency

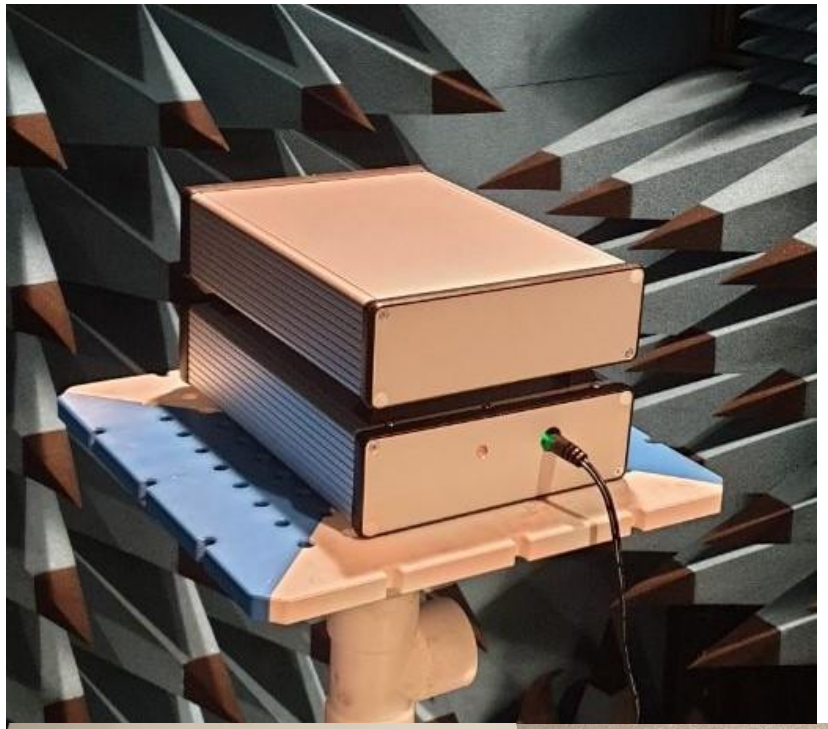
1. Radio equipment in the frequency range 9 kHz to 25 MHz and inductive loop systems in the frequency range 9 kHz to 30 MHz
2. ERC recommendation for unwanted emissions in the spurious domain

ETSI EN 300 330 and REC 74-01 limits (@10m H-field)

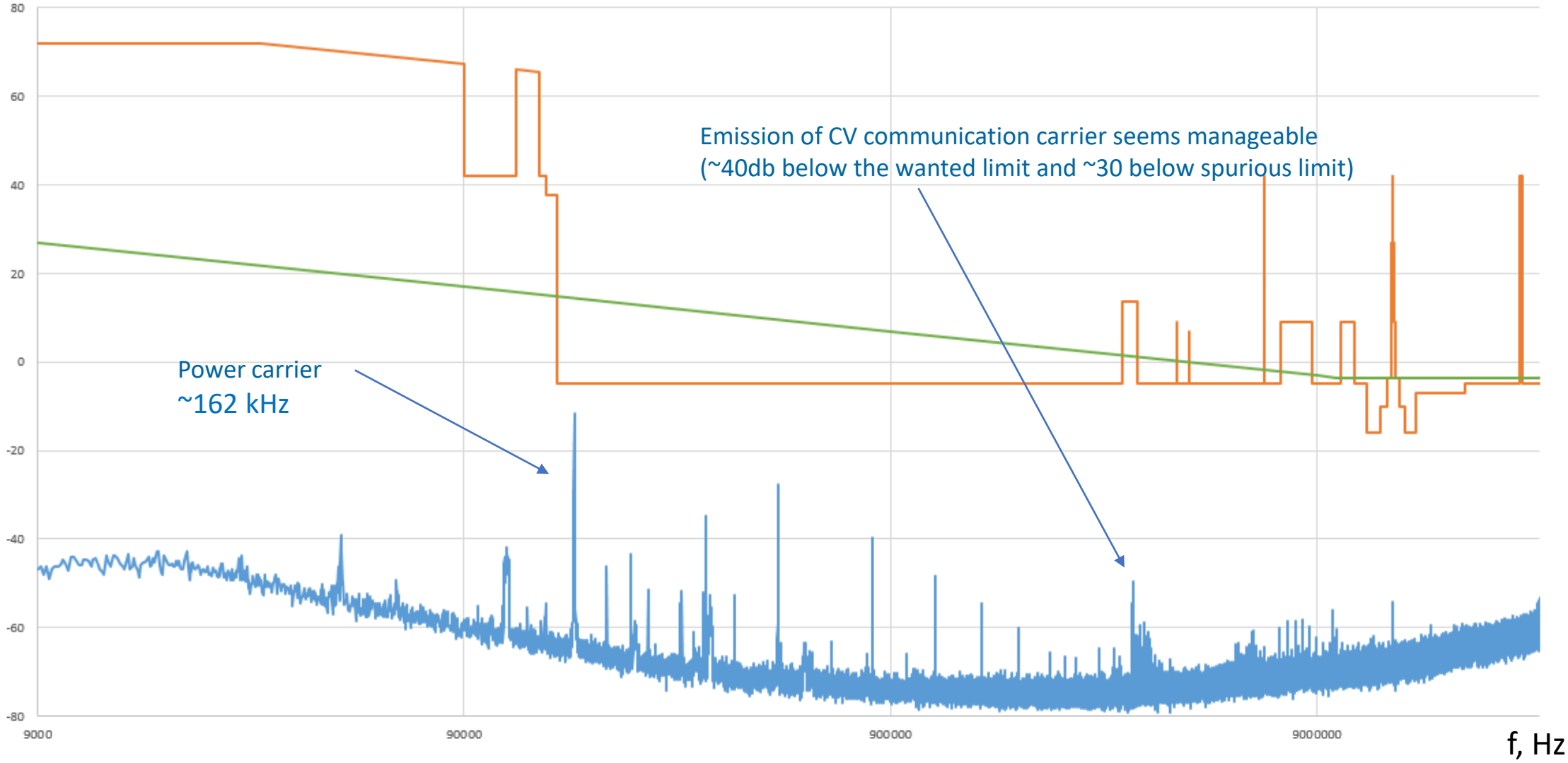


Radiated H-field measurement

- Only pre-compliance testing
- Measurement distance: 3m
- 60 cm loop antenna: R&S HFH2-Z2E
- Analyzer resolution BW **5 Hz**
- PTx and PRx encapsulated in Al housings
- 5mm coil-coil distance
- 15W power transfer
- HF carrier frequency 3320 kHz
- PRx generates high frequency continuously
- HF current in the secondary coil ~40mA rms.



Radiated H-field vs 10m EN 300 330 limit – not calibrated (indicative) measurements



Conclusions

- **Impact of coil self resonance is manageable**
  - Modulation inductor detunes power coil self-resonance to higher frequencies
- **Frequency range from 3155 to 3400 kHz**
  - Can be used general inductive applications (including close-in data links)
  - EN 300 330 limits could be applied for communication channel
- **Clarity on power interface required**
  - To identify technology boundaries
  - Align with future SWG activities on power interface

To be continued.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Reference: Shortlisted regulatory documents

- **ERC/CEPT:** THE USE OF THE FREQUENCY BAND 3155 - 3400 KHZ FOR GENERAL INDUCTIVE APPLICATIONS
- **ECC/CEPT:** THE EUROPEAN TABLE OF FREQUENCY ALLOCATIONS AND APPLICATIONS IN THE FREQUENCY RANGE 8.3 kHz to 3000 GHz
- **FCC:** RF EXPOSURE CONSIDERATIONS FOR LOW POWER CONSUMER WIRELESS POWER TRANSFER APPLICATIONS
- **FCC:** FCC ONLINE TABLE OF FREQUENCY ALLOCATIONS
- **ETSI EN 303 417**: Wireless power transmission systems, using technologies other than radio frequency beam
- **ETSI EN 300 330:** Short Range Devices (SRD)
- **ERC Recommendation 70-03:** Relating to the use of Short Range Devices (SRD)
- **ERC Recommendation 74-04:** Unwanted emissions in the spurious domain
- **ITU-R:** Technical and operating parameters and spectrum use for short-range radiocommunication devices