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# 802.3CG EMISSION LIMITS AND PSD MASK

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# 802.CG

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# 802.3cg Short-Reach PHY

## Problem Definition

- Emission Limits for entire frequency range of interest not 100% clear
- Analytical method to check proposed transmission waveforms against emission limits is needed
  - To double-check measurements
  - To evaluate tweaks to the transmit waveform faster
- Needed for the draft/standard
  - Definition of transmit PSD (and transmit amplitude) in conjunction with
  - Mode conversion limit curve which
  - Satisfies emission limits with a non-zero margin

# 802.3cg Short-Reach PHY

## Emission Limits

- Definitions by OEM

- Deviate only in details from each other

- For example BMW Group Standard GS95002-02 (2013)

- Stripline test

- Stripline Transfer Function

- Only flat between 30MHz and 200MHz (for CM-Termination 25Ω, plateau is -8dB)

- 20dB/dec outside plateau

GS95002-02 2013-07 (Table 8, page 17) - Stripline Limits

| Band | Broadcasting |             | Limit Class AV (rms) in dBμV |      |    |    |         |     |  |
|------|--------------|-------------|------------------------------|------|----|----|---------|-----|--|
|      | Wavelength   | MHz         | MHz                          | 3    | 4  | 5  | RBW/kHz |     |  |
| 1    | LW           | 0,15 bis/to | 0,28                         | 44   | 34 | 24 | 10      |     |  |
| 2    | MW           | 0,52 bis/to | 1,73                         | 37   | 29 | 21 | 10      |     |  |
| 3    | KW           | 75m         | 3,85 bis/to                  | 4    | 33 | 27 | 21      | 10  |  |
| 4    | KW           | 49m         | 5,8 bis/to                   | 6,3  | 33 | 27 | 21      | 10  |  |
| 5    | KW           | 41m         | 7,1 bis/to                   | 7,6  | 33 | 27 | 21      | 10  |  |
| 6    | KW           | 31m         | 9,3 bis/to                   | 10   | 33 | 27 | 21      | 10  |  |
| 7    | KW           | 25m         | 11,5 bis/to                  | 12,1 | 33 | 27 | 21      | 10  |  |
| 8    | KW           | 22m         | 13,5 bis/to                  | 13,9 | 33 | 27 | 21      | 10  |  |
| 9    | KW           | 19m         | 15 bis/to                    | 15,8 | 33 | 27 | 21      | 10  |  |
| 10   | KW           | 16m         | 17,4 bis/to                  | 17,9 | 33 | 27 | 21      | 10  |  |
| 11   | KW           | 15m         | 18,9 bis/to                  | 19,1 | 33 | 27 | 21      | 10  |  |
| 12   | KW           | 13m         | 21,4 bis/to                  | 21,9 | 33 | 27 | 21      | 10  |  |
| 13   | KW           | 11m         | 25,6 bis/to                  | 26,1 | 33 | 27 | 21      | 10  |  |
| 14   | UKW          |             | 76 bis/to                    | 108  | 18 | 12 | 6       | 120 |  |

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## Emission Limits

- Definitions by OEM

GS95002-02 2013-07 (Table 6, page 15) - Capacitive Voltage Measurement

- Deviate only in details from each other

- For example BMW Group Standard GS95002-02 (2013)

- Capacitive Coupler test

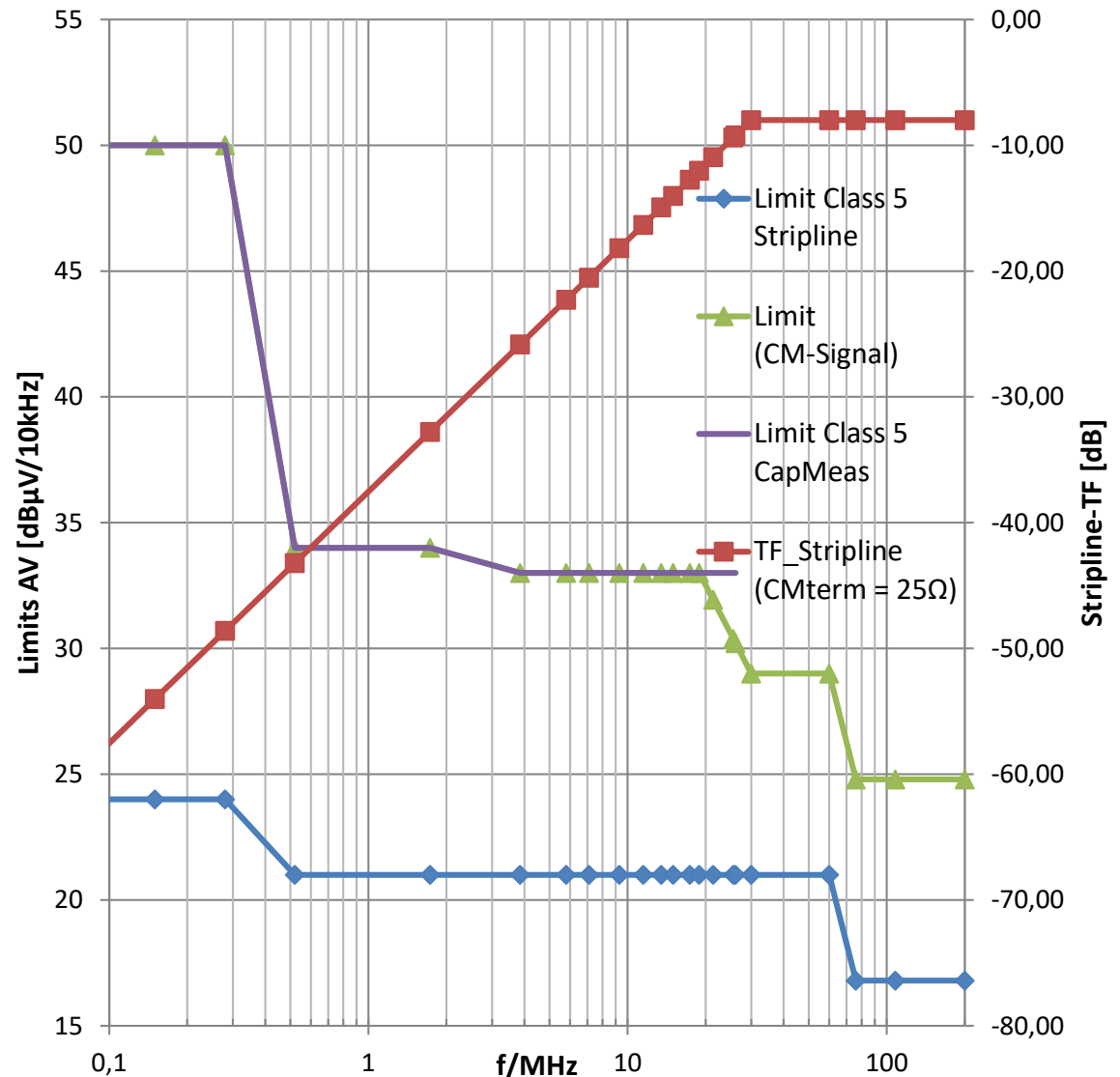
- GS defines to mathematically remove all attenuation in measurement setup from measured values  
→ Transfer Function is 0dB

| Band | Broadcasting |     | MHz  |             | Limit Class AV (rms) in dBμV |    |    |         |
|------|--------------|-----|------|-------------|------------------------------|----|----|---------|
|      | Wavelength   |     |      |             | 3                            | 4  | 5  | RBW/kHz |
| 1    | LW           |     | 0,15 | bis/to 0,28 | 70                           | 60 | 50 | 10      |
| 2    | MW           |     | 0,52 | bis/to 1,73 | 50                           | 42 | 34 | 10      |
| 3    | KW           | 75m | 3,85 | bis/to 4    | 45                           | 39 | 33 | 10      |
| 4    | KW           | 49m | 5,8  | bis/to 6,3  | 45                           | 39 | 33 | 10      |
| 5    | KW           | 41m | 7,1  | bis/to 7,6  | 45                           | 39 | 33 | 10      |
| 6    | KW           | 31m | 9,3  | bis/to 10   | 45                           | 39 | 33 | 10      |
| 7    | KW           | 25m | 11,5 | bis/to 12,1 | 45                           | 39 | 33 | 10      |
| 8    | KW           | 22m | 13,5 | bis/to 13,9 | 45                           | 39 | 33 | 10      |
| 9    | KW           | 19m | 15   | bis/to 15,8 | 45                           | 39 | 33 | 10      |
| 10   | KW           | 16m | 17,4 | bis/to 17,9 | 45                           | 39 | 33 | 10      |
| 11   | KW           | 15m | 18,9 | bis/to 19,1 | 45                           | 39 | 33 | 10      |
| 12   | KW           | 13m | 21,4 | bis/to 21,9 | 45                           | 39 | 33 | 10      |
| 13   | KW           | 11m | 25,6 | bis/to 26,1 | 45                           | 39 | 33 | 10      |

# 802.3cg Short-Reach PHY

## Emission Limits

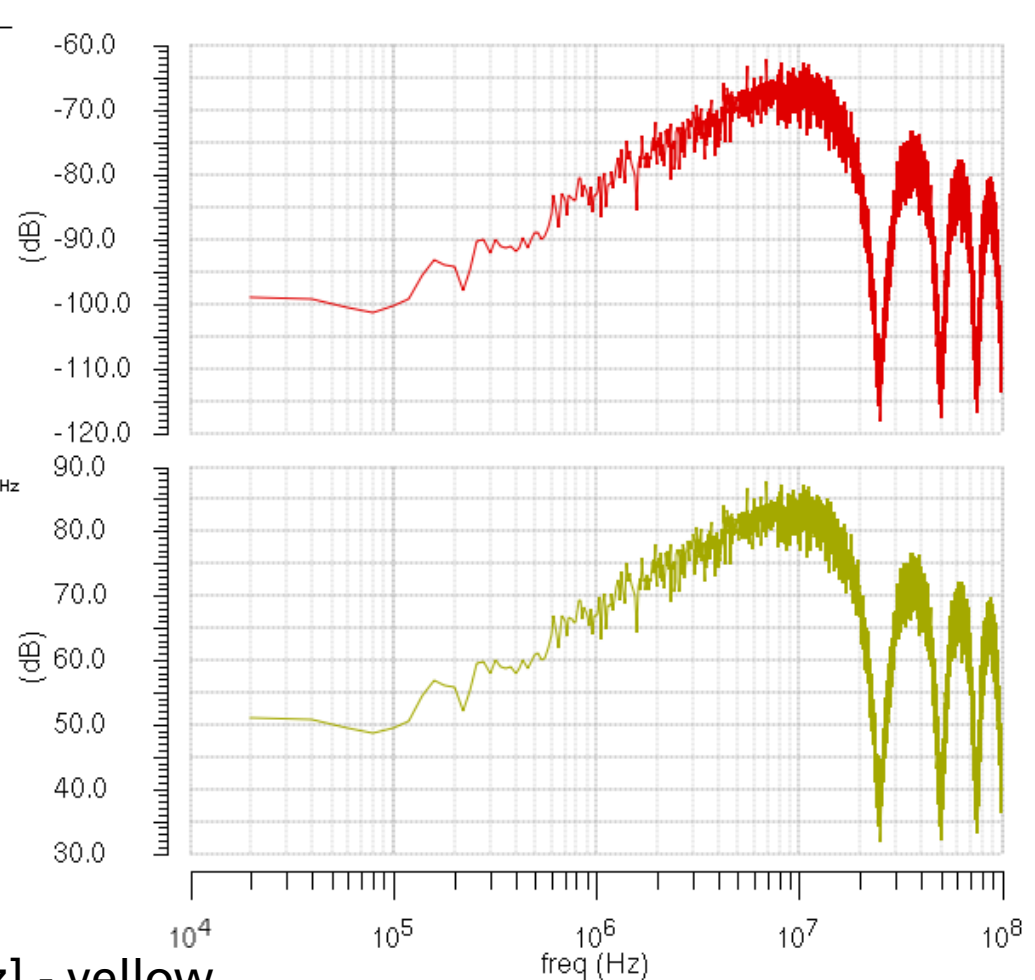
- Both tests apply
  - Capacitive Coupler limits directly as limits on CM
  - Stripline limits converted to CM via transfer function
- Resulting limit is minimum of both curves (green line)
  - Below 20MHz -> capacitive coupler
  - Above 20MHz -> stripline
- Stripline Band 14
  - RBW: 120kHz → 10kHz
  - Limit 10.79dB higher



# 802.3cg Short-Reach PHY

## Transient TX Waveform to Emission Spectrum

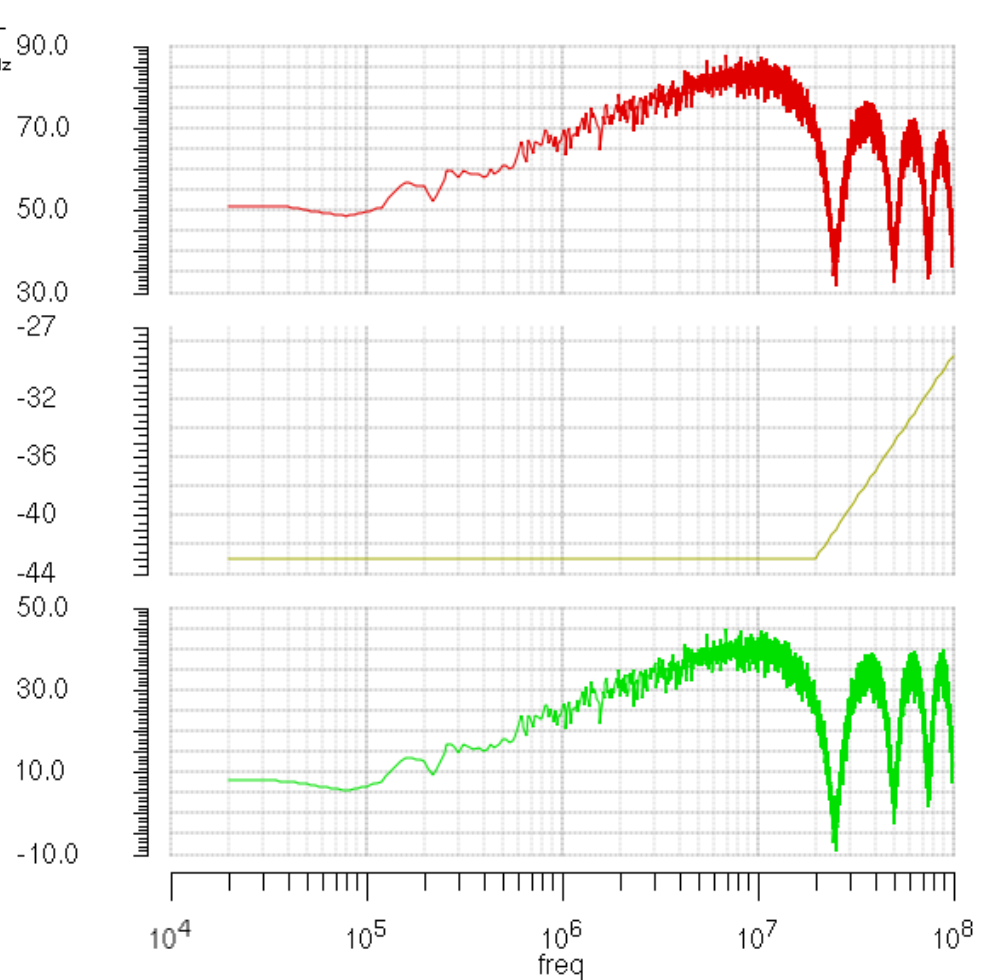
- PSD [dBm/Hz] - red
  - Transient signal: PRBS11, 4b5b, scrambler, DME
  - $200\mu\text{s} - 2500 \cdot T_{\text{sym}}$
  - $2^{14}$  point DFT
  - 20kHz step
- dBm  $\rightarrow$  dB $\mu$ V: +110dB
  - dB $\mu$ V = dBm +  $10\log(Z) + 90$
  - $Z = 100\Omega$
- ./Hz  $\rightarrow$  ./10kHz: +40dB
  - +  $10 \cdot \log_{10}(10\text{k})$
  - TX- Spetrum [dB $\mu$ V/10kHz] - yellow



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## Transient TX Waveform to Emission Spectrum

- TX-Spectrum - red Name  
■ TXdiff\_dBuV/10kHz
- Differential signal
- + Mode Conversion ■ MC\_dB
- Frequency dependent
- TX-Spectrum - green ■ TXcm\_dBuV/10kHz
- Common mode signal





# 802.3cg Short-Reach PHY

## TX PSD & Emission Spectrum – 1Vpp - MC: 43dB 20MHz

### ■ Transmit PSD

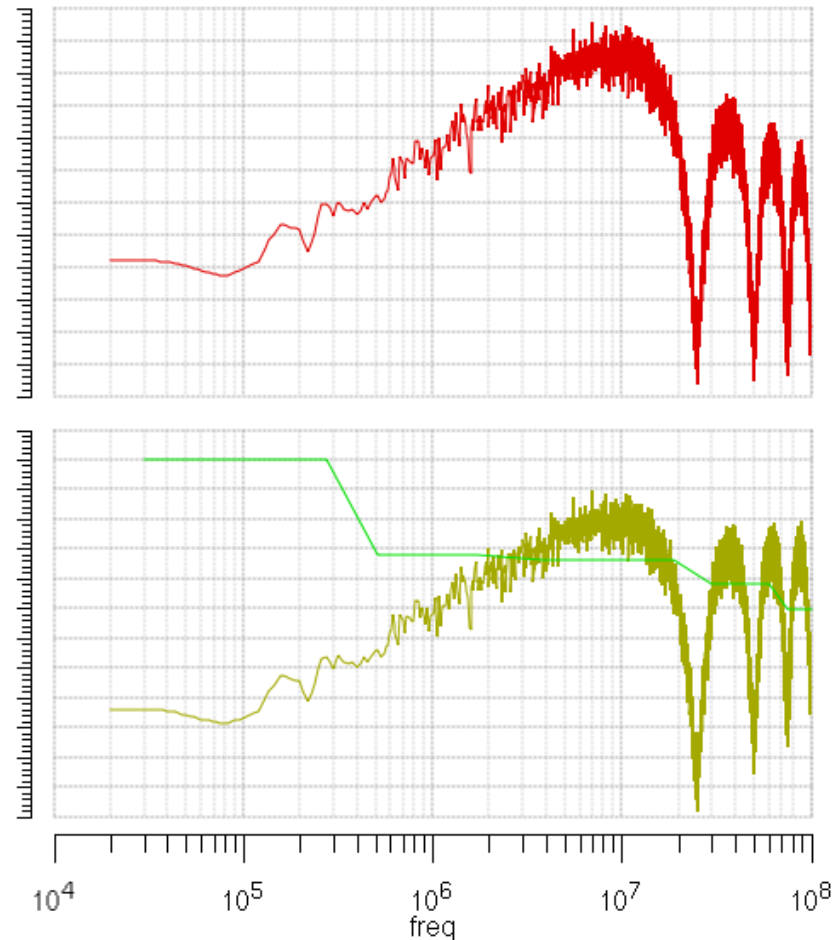
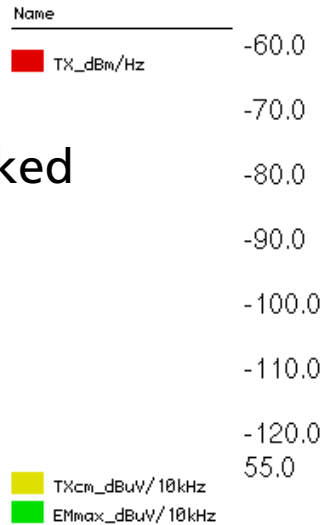
- Freq-domain integration checked vs. Time-domain integration ✓

- Level consistent with other presentations

### ■ Emissions

- Strong violations

- → Parameter combination of draft 1.1 is not feasible



# 802.3cg Short-Reach PHY

## TX PSD & Emission Spectrum – 0.4Vpp - MC: 46dB 12MHz

### ■ Transmit PSD

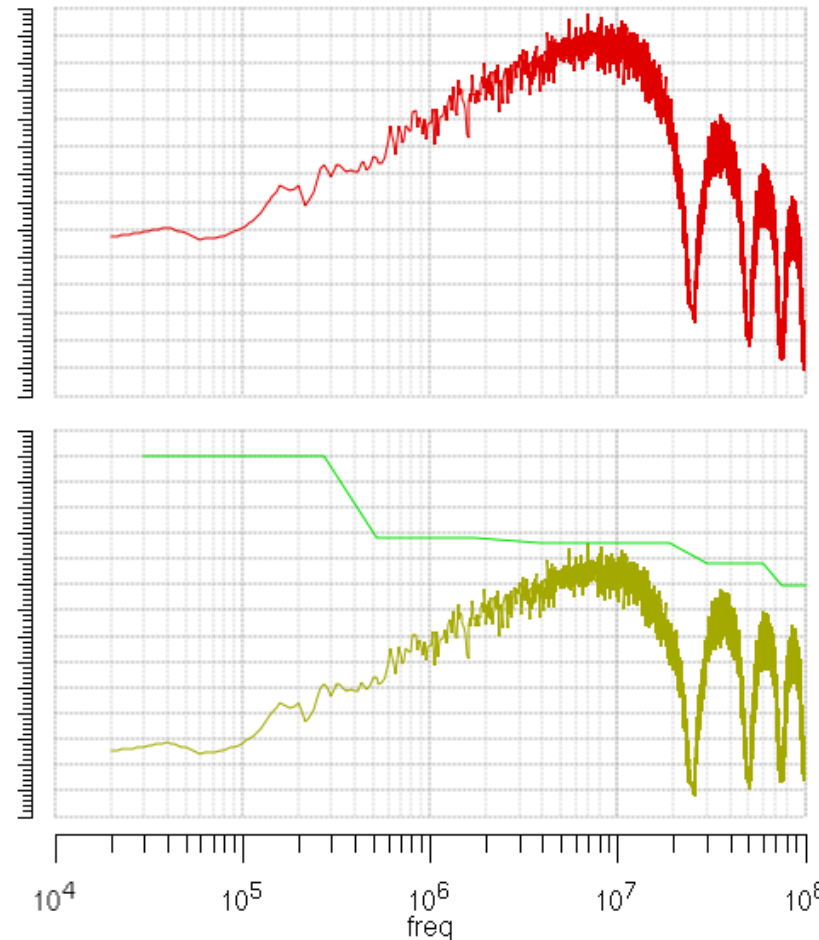
- About -8dB because of smaller amplitude

- TX uses 1st order low pass  
 $f_{-3dB} = 15\text{MHz}$

### ■ Emissions

- Zero margin (tiny violation, other patterns need to be checked)

- Parameter combination much more feasible



# 802.3cg Short-Reach PHY

## Emission Limits and PSD mask

### Conclusions

- 10SPE waveform has signal components in frequency range, where both capacitive coupler and stripline test apply for emissions
  - Transfer function stripline is well understood
  - Transfer function capacitive coupler is based on BMW GS text
- Parameter combination  
Emission limits & Mode Conversion & TX PSD mask/amplitude  
needs an overhaul