802.3CG EMISSION LIMITS AND PSD MASK

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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 maximum transmit PSD (and transmit amplitude) in conjunction with
  - Mode conversion limit curve which
  - Satisfies emission limits with a non-zero margin

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Emission Limits – Transformed into CM 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

Broadcasting						Limit Class AV (rms) in dBµV			
Band		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 – Transformed into CM limits

- Definitions by OEM
  - 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

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

Band	Broadcasting	Wavelength	MHz		MHz	Limit Class AV (rms) in dBµV 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

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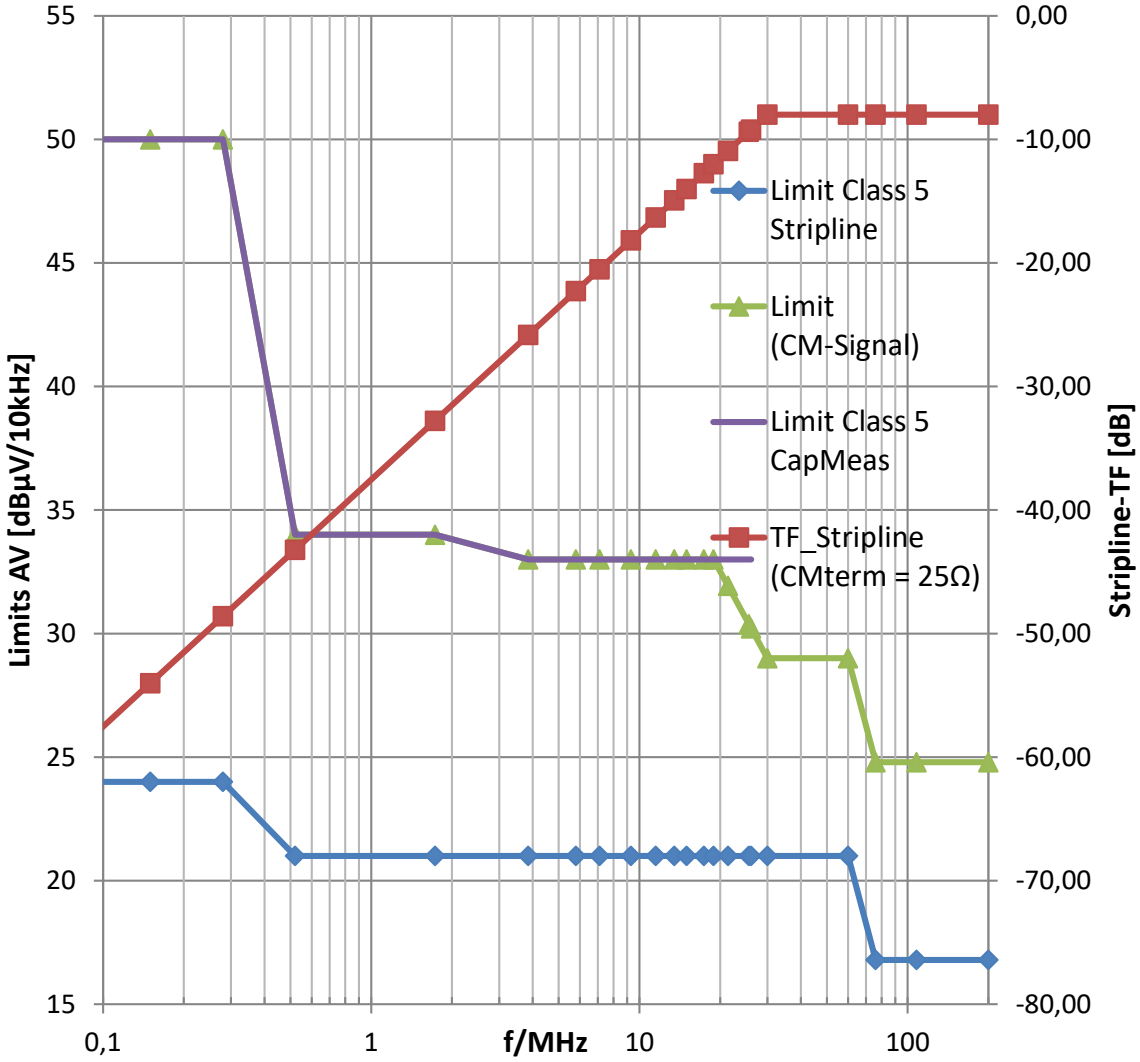
Emission Limits – Transformed into CM limits

- 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 -> capacitve coupler
  - Above 20MHz -> stripline
- Transform Stripline Band 14
  - RBW: 120kHz → 10kHz
  - → Limit 10.79dB higher



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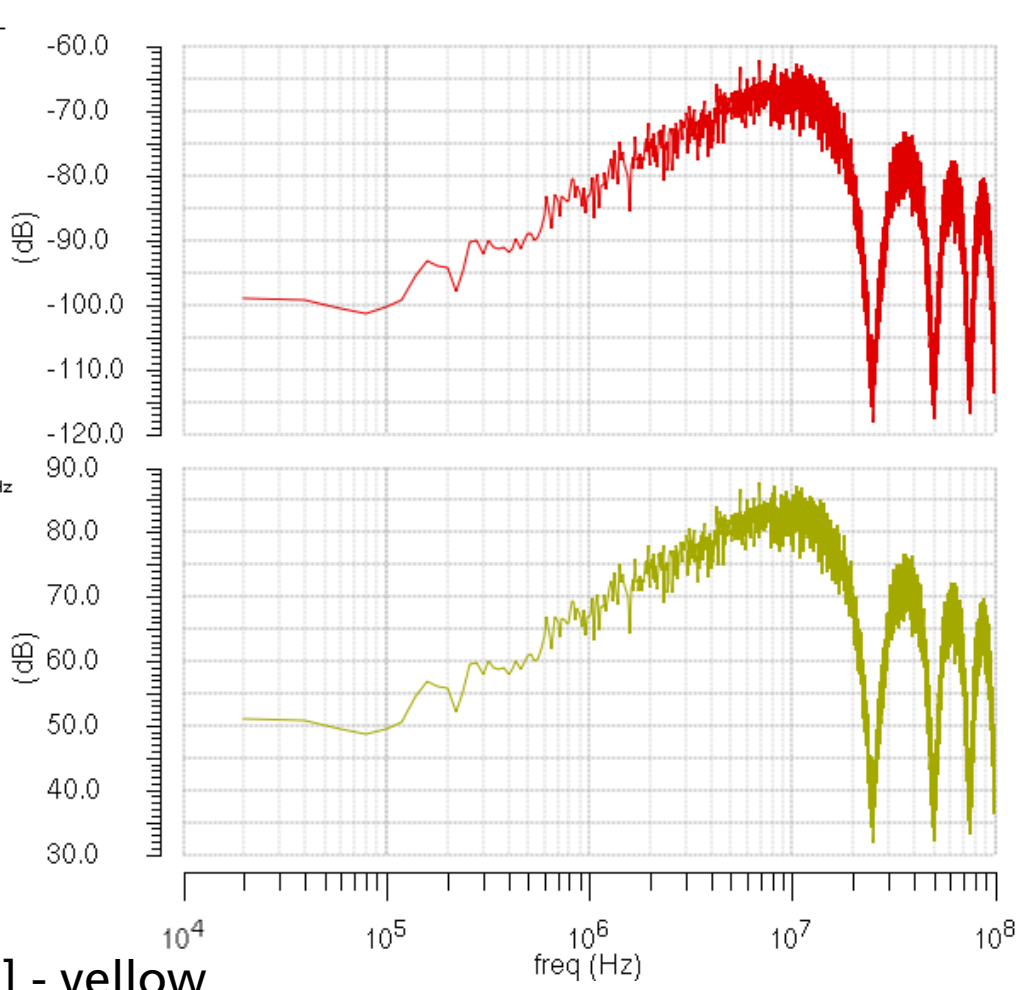
Transient TX Waveform to Emission Spectrum

- PSD [dBm/Hz] - red
  - Transient signal: PRBS11, 4b5b, scrambler, DME
  - 200µs – 2500*T_{sym}
  - 2^14 point DFT
  - 20kHz step
- dBm → dBµV: +110dB
  - dBµV = dBm + 10log(Z) + 90
  - Z = 100Ω
- ../Hz → ../10kHz: +40dB
  - + 10*$\log_{10}$(10k)
  - TX- Spetrum [dBµV/10kHz] - yellow



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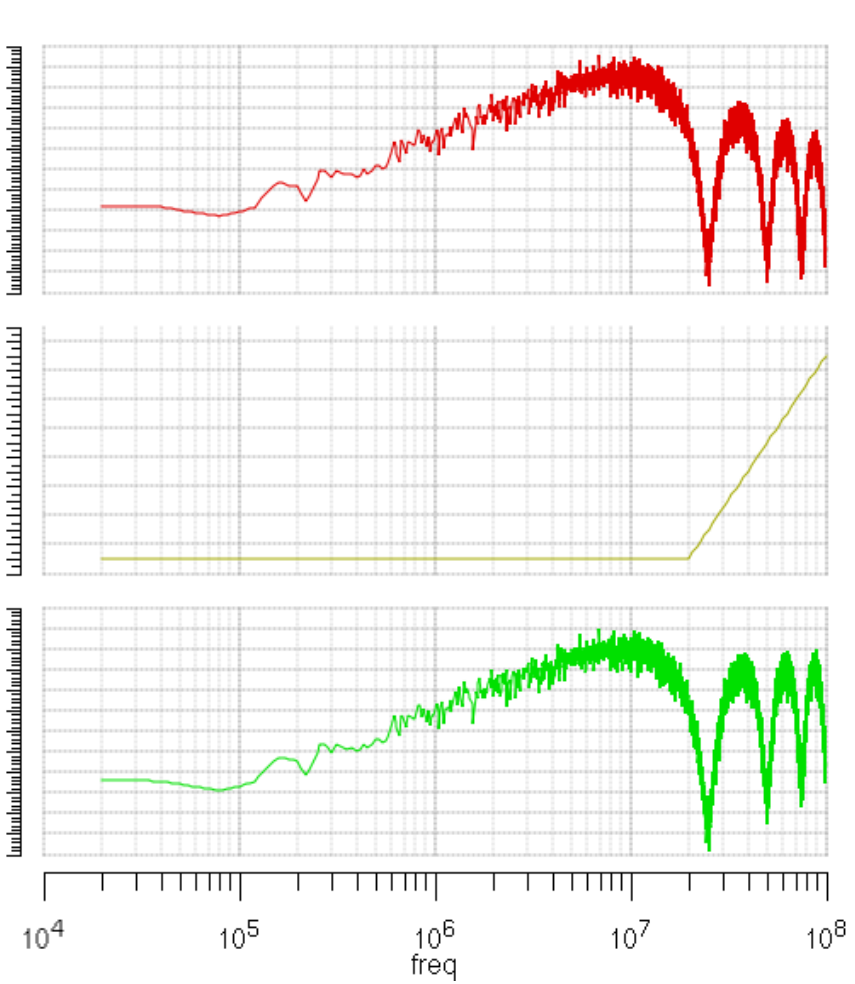
Transient TX Waveform to Emission Spectrum

- TX-Spectrum - red
  - Differential signal
- + Mode Conversion
  - Frequency dependent
- TX-Spectrum - green
  - Common mode signal



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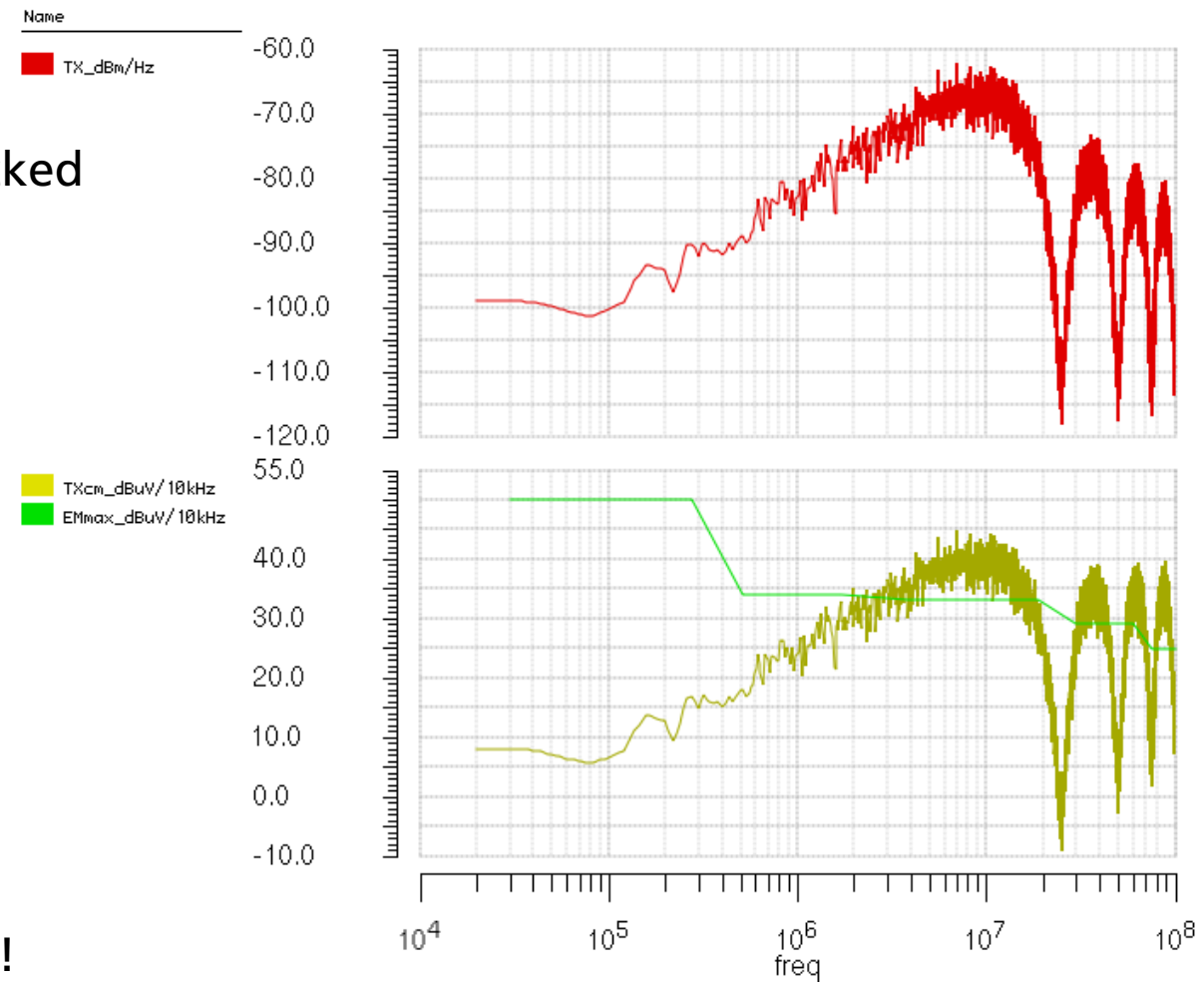
TX PSD & Emission Spectrum – 1Vpp - MC: 43dB 20MHz

- Transmit PSD
  - Freq-domain integration checked vs. Time-domain integration √
  - Level consistent with other presentations
- Emissions
  - Strong violations
- → Parameter combination of draft 1.1 violates these limits!



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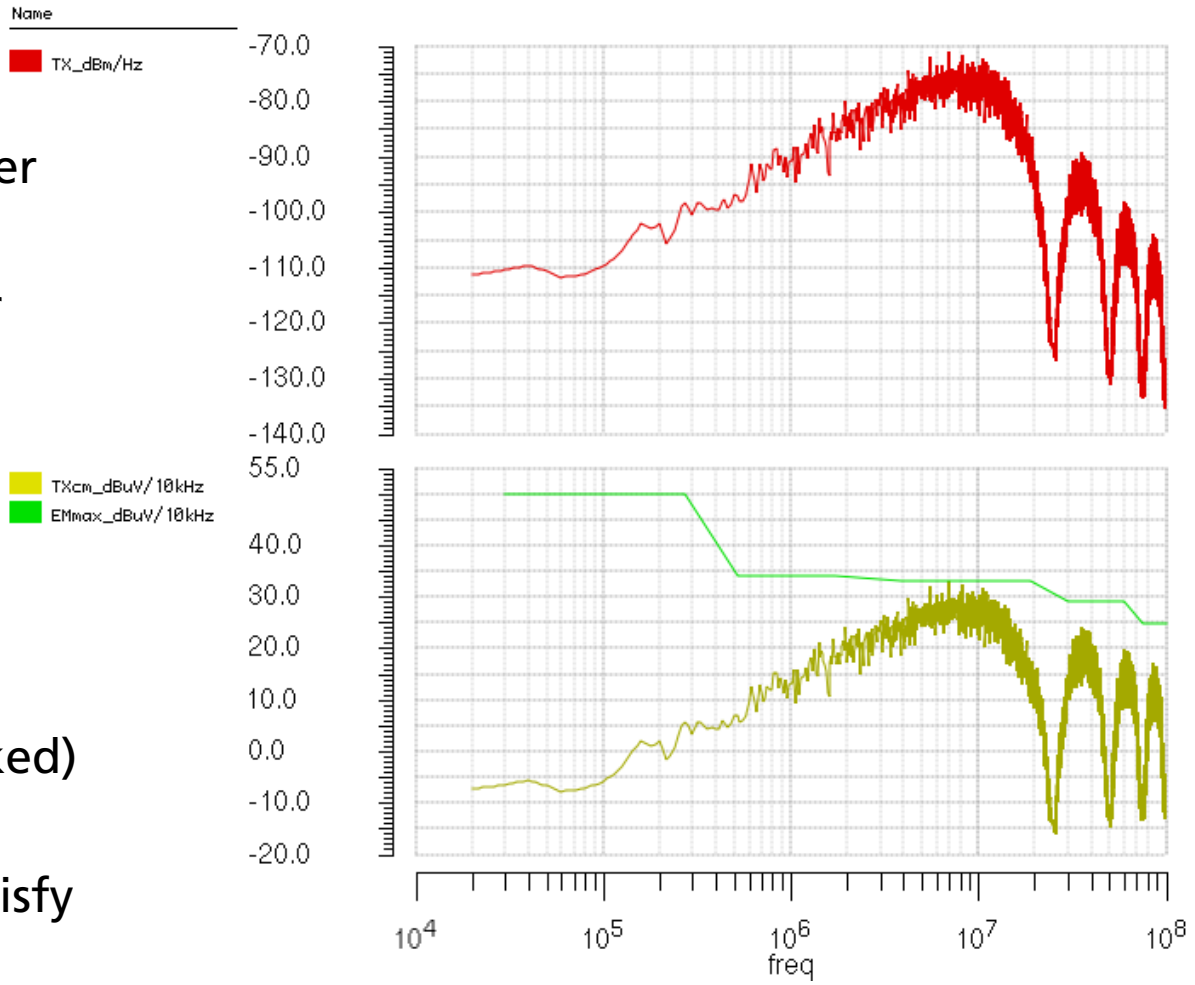
TX PSD & Emission Spectrum – 0.4Vpp - MC: 46dB 12MHz

- Transmit PSD
  - About -8dB because of smaller amplitude
  - TX uses 1st order low pass f_{-3dB} = 15MHz
- Emissions
  - Zero margin (tiny violation, other patterns need to be checked)
- Above parameter combination can satisfy limits



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Emission Limits & TX PSD - Problem Statements revisited

- „Emission Limits for entire frequency range of interest not 100% clear“
  - Stripline test
    - „only“ informative, but widely used
    - Stripline TF leads to CM limits shooting up at low frequencies
  - Capacitive Coupler
    - Easy to transform limits to CM, but test not widely used
    - Test known to cause problems in measurement, because of interaction with DUT (citation OEM) – not a problem in calculation
  - Radiated Emissions Test (Antenna measurement)
    - Accepted sign-off test, but time-consuming
    - Transfer function / transformation of limits to common mode difficult

→ Problem partly solved … stripline + radiated emission test apply

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Emission Limits & TX PSD - Problem Statements revisited

- „ Analytical method to check proposed transmission waveforms against emission limits is needed“
  - „To double-check measurements“
  - „To evaluate tweaks to the transmit waveform faster
- → Problem still remains … no known „universal“ TF for antenna test

- „Needed for the draft/standard“
  - „Max. TX PSD in conjunction with mode conversion limit curve which satisfies emission limits with a non-zero margin“
- → Problem still remains …
  - → Analytical method not achieved
  - → Canovatech-presented radiated emission test does not allow for any statement, because „ECU on – TX off“ already violates limits

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Emission Limits and PSD mask - Conclusion

Need More Information

- → Radiated Emission Test with cable according to specification (focus: mode conversion at limit)
- → Do 100Base-T1 implementations pass limit class 5, when they operate on combination of every spec limit?!
- → Is there an approximation of the transfer function for radiated emissions test?