Impact of used frequency spectrum on the automotive harness

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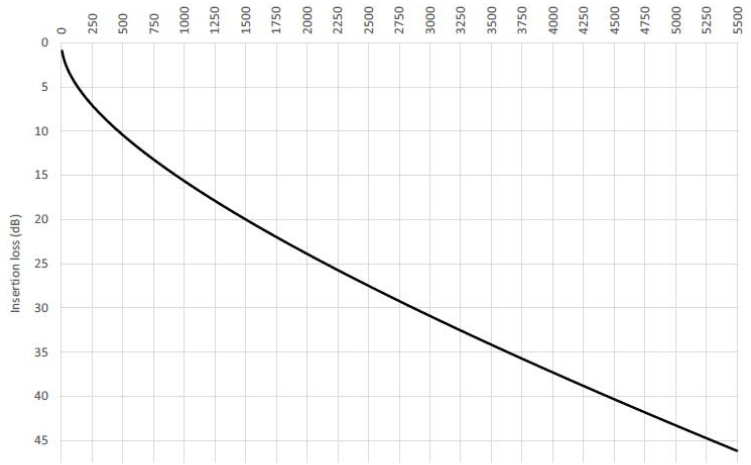
Agenda

- Background
- Physical impact of higher frequency
- Impact on connectors
- Impact on cables
- Impact on ECU
- Conclusion

Background

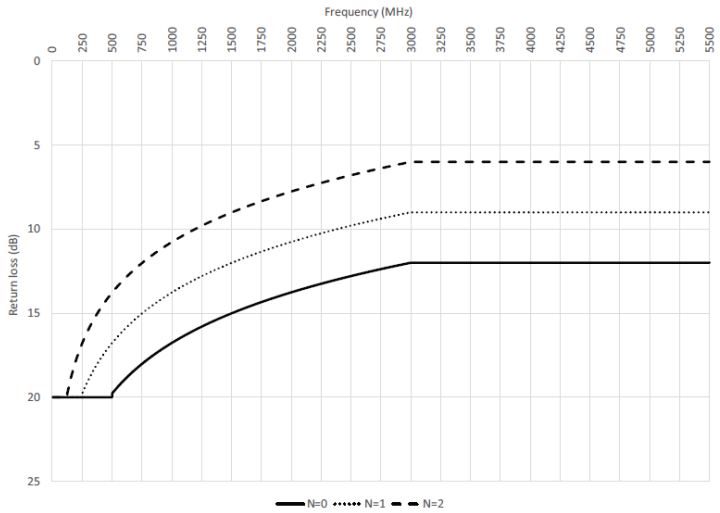
- The current proposal for the Bandwidth for 10GBit/s is defined up to 5.5GHz
  - Possible modulation decisions could use the full bandwidth
  - There where also proposals which need only up to 3GHz
- We discussed the Impact of the used bandwidth with internal Harness and ECU experts



$$\text{Insertion loss}(f) \le 0.0030\,f + 0.40\sqrt{f}$$

where

f is the frequency in MHz; $5 \le f \le 5500$



$$\text{Return Loss} \begin{cases} 20 \text{ dB} & 5 \le f < 500/2^N \text{ MHz} \\ 12 - 3N - 10\log(f/3000) \text{ dB} & 500/2^N \le f \le 3000 \text{ MHz} \\ 12 - 3N \text{ dB} & 3000 \le f \le 5500 \text{ MHz} \end{cases}$$

where

f is the frequency in MHz; $5 \le f \le 5500$

Physical impact of higher frequency

Impedance mismatches shorter than λ/10 have no major impact on the RF parameters of an electrical channel.

In this span several effects in the harness are acceptable (minor impact):

- Untwisted areas
- Distance between wires
- Different conductor diameter
- Different dielectricum
- Shield discontinuities

→ Things that happen in every connector and on the way from the wire to the PCB

Examples for λ/10:

400MHz → 67 mm (1000BASE-T1)

3 GHz → 9 mm

5.5 Ghz → 4,9 mm (actual proposed limit line)

→ Mechanical components should be smaller and more precise

Impact on connectors

For 5.5 GHz all components have to be smaller and more precise than for 3GHz
if all electrical discontinuities together should be smaller than λ/10

- Connectors might have a higher relative cost
- Process and machinery to connect a cable to the connector is more complex for higher frequencies.
- Connectors are filigree and less mechanically robust
  - Worker in the production and in the repair service can easy damage small precise connectors (damaging the contact spring influences the resistance and the sensitivity for vibrations)
  - If a connector is damaged the complete cable segment has to be replaced

Possible consequences:

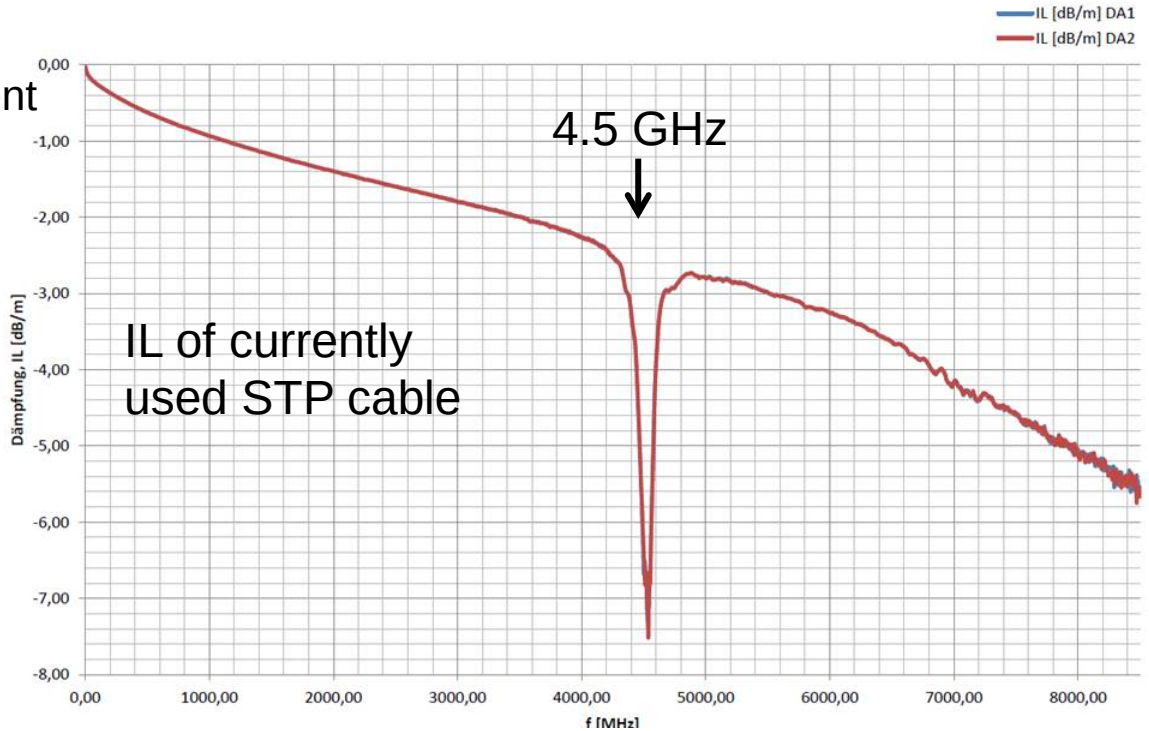
- Welding /soldering (by laser) instead of a crimp to connect the wire
- Special plastic to fulfill electrical and mechanical requirements
- Special technique for shield conducting

Impact on cables

For 5.5 GHz SPP cable might be necessary instead of STP

- SPP cable has a higher relative cost than STP
- There is no practical experience with SPP cable in vehicles
- Mechanical robustness of SPP (e.g. banding test) might be worse compared to STP
  - Depending on the direction of bending
- EMI might be worse for magnetic coupling (no twist that compares the induction)

If STP cable is used it should be different from currently used automotive STP cable



Impact on ECU

- The PCB material used in ECUs has a high insertion loss at high Frequencies
- Often it is not possible to have a short PCB connection between the PHY and the connector (e.g. > 20cm in some ECUs)
- PCB layout might be more complex

Conclusion

If there is the possibility to use a lower Bandwidth cable e.g. 3GHz and still fulfil all functional and EMC requirements we should not use 5.5 GHz

Thanks!