Follow-up to 10BASE-T1S Immunity Measurements

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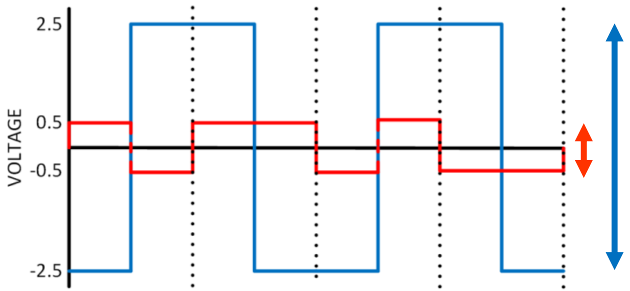
Objectives and Motivation

- This presentation responds to presentation [1] from Ivanov et al. and is a follow-up to Broadcom presentation [2] on noise.
- 10BASE-T uses Manchester Encoding to transmit 5Vpk-pk (nominal).
- 10BASE-T1S uses Differential Manchester Encoding (DME) to transmit 1Vpk-pk^
  - Less transmit swing than 10BASE-T and much higher noise environment.



DME vs. 802.3 Manchester Encoding (x-axis not to scale)

- Revisit noise topic again using Bulk Current Injection (BCI) clamp method[3].

^ TX Voltage currently TBD in 147.5.3.1

BCI Test Motivation

- Examine the feasibility of implementation of 10BASE-T1S for multidrop automotive configurations.
- Investigate possible immunity-related problems.
- Worst-case EMI-coupling clamp locations are different from testing strictly to ISO 11452-4.
  - Strong resonances will be seen at other clamp locations.
- Long harnesses exhibit in-band resonances at lower frequencies than a 2m cable.
- If a problem does not show at standard clamp locations, it does not mean they do not exist.

→Must design systems with margin to handle realistic worst-case conditions.

Difficulties with Measurement

- Conversion
  - Peaks at 15 & 30MHz w/o termination in [2] were real but noise radiated out from amp connector.
  - 100BASE-T1 CMC doesn't have good common to common rejection at low frequency (-20dB).
  - scope converted large common mode voltage to differential noise at 1MHz.

→Eliminate sources of conversion.

  - Use well-shielded differential probe with large CMRR @ 1MHz (Tektronix P6247)
  - Solder short connection directly to PHY-side of CMC.
  - Use coax with low leakage at test frequencies.
  - Add ferrites. Sniff with spectrum analyzer for clean environment with test running.

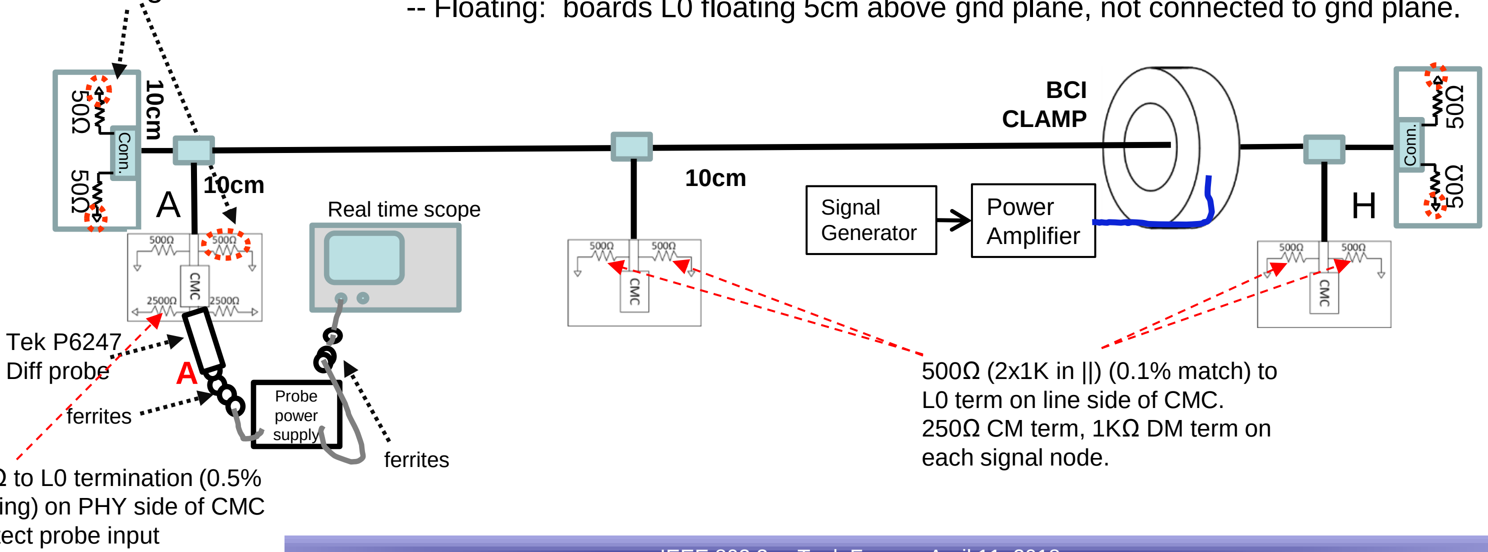
- Termination – different schemes possible. Each has tradeoffs.

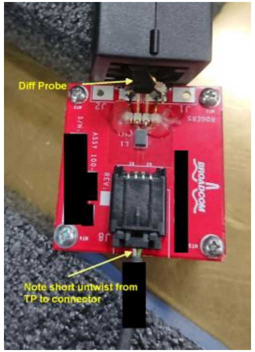
  →Utilize termination scheme similar to [1] (except CM term of 250Ω and DM term 1KΩ -- no moat on board)

- All test setup details available on request.

Test Setup

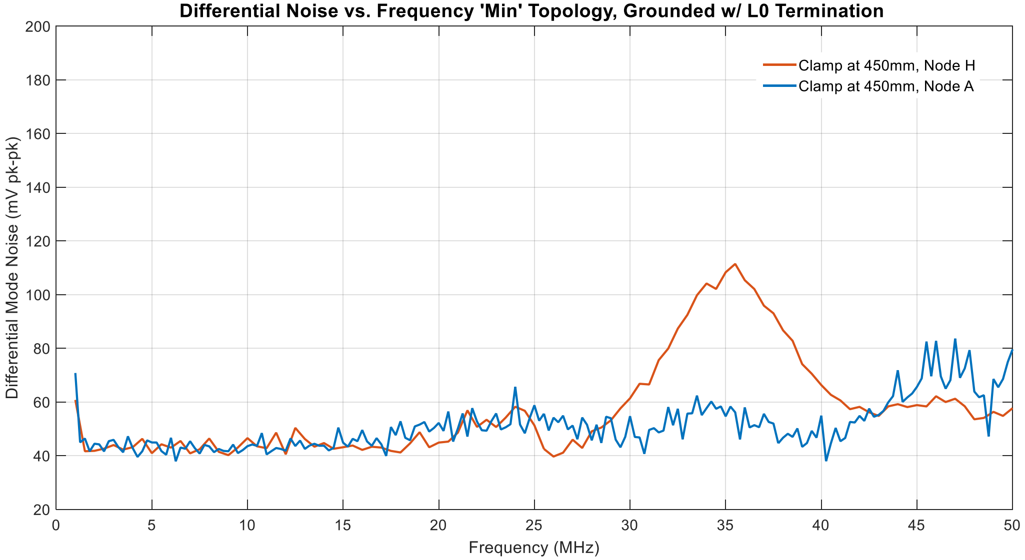
- 100BASE-T1 CMCs at each signal node. CM termination 250Ω to gnd (L0) before CMC.
- 100BASE-T1 cables (26 AWG) in passive linear topology “min” from [4] 5cm above gnd plane. (10cm stubs)
- 100BASE-T1-quality connectors.
- Solder short 2pin connector directly on CMC for noise measurement. Attach differential probe.
- Sniff cable from power amplifier to BCI clamp for any emissions, check connectors. Add ferrites.
- Injection calibrated for 200mA RMS flat level vs. frequency.
- Grounding test conditions: -- Grounded: all board L0 connected to gnd plane
  -- Floating: boards L0 floating 5cm above gnd plane, not connected to gnd plane.





Measurement using differential probe

DM noise, Board Ground Connected to Ground Plane

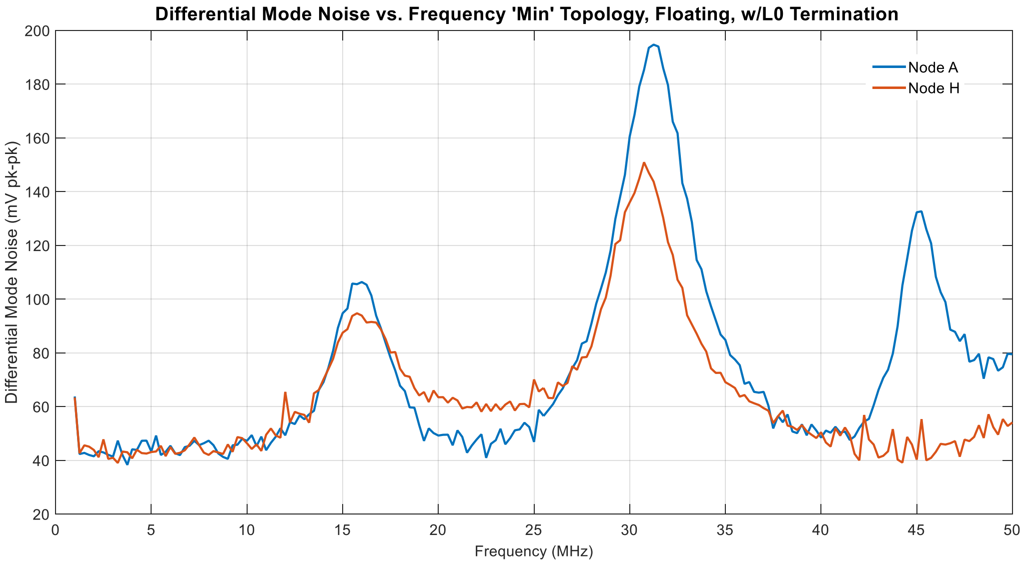


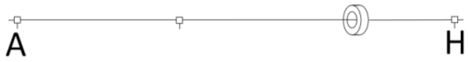
Test Configuration

- DM noise greatly reduced, especially @ 1MHz – due to high CMRR of differential probe
- Note different noise levels at different nodes of the multi-drop configuration.

Note: L0 = Board Ground.

DM Noise, Board Ground Floating Above Ground Plane



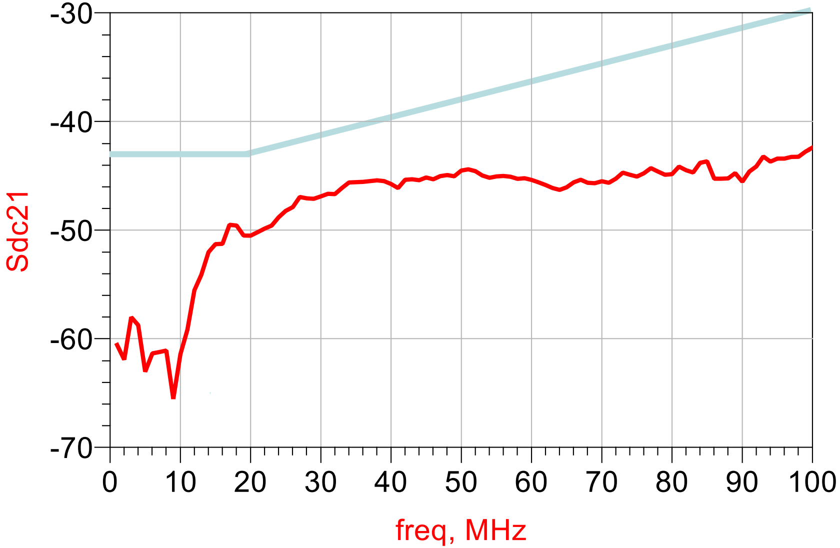


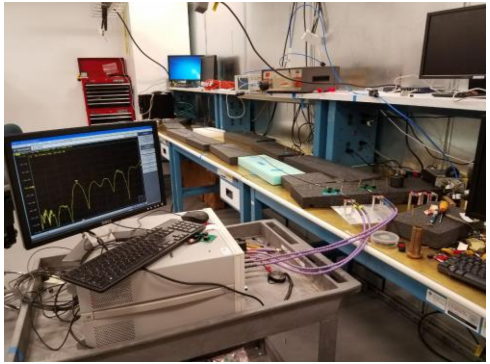
Test Configuration

- Different clamp location (approx. 1500mm) from node H, all nodes floating.

Note: L0 = Board Ground.

Mode Conversion





Mode Conversion Harness Measurement
Using VNA

- Mode conversion plotted for the tested cable harness and 147.6.3 limit.
  - All CMCs removed, harness 5cm above ground plane, common-mode impedance set to 250Ω on both sides.
  - Clause 147 does not specify setup for common mode impedance for mode conversion.
- Noise measurements need to be scaled, considering the mode conversion of the cable harness.

Scaled DM Noise on Cable Harness

	16.67 MHz	33 MHz	50 MHz
Node Board L0 connected to ground plane measured DM Noise, mV	50	100	80
Node Board L0 Floating 5cm above ground plane, measured DM Noise, mV	105	194	132
Mode Conversion Limit	-43.0dB	-38.6dB	-35.0dB
Measured Mode Conversion	-51dB	-46dB	-44dB
DM Scaling Factor	8dB	7dB	9dB
Node Board Grounded Scaled DM Noise, mV	**126**	**224**	**225**
Node Board Floating Scaled DM Noise, mV	**263**	**434**	**372**

- Above numbers are for 200mA BCI test level, additional scaling should be done for customers requiring 355mA test level (15-30 MHz band).
- Based on this data, $500mV_{pk\text{-}pk}$ ($178mV_{RMS}$) CW NBI seems like a reasonable design goal.

Summary

- Noise measurements presented with improved measurement setup and common-mode termination.
- CM-DM conversion of 100BASE-T1-based cable harness measured better than 147.6.3 limit.
- Mode conversion data for components is essential in investigating the noise level.
- Differential Narrow-Band Interference is a concern for 10BASE-T1S.
- A robust preamble is essential to improve system performance.
- Use 500mV$_{pk\text{-}pk}$ (178mV$_{RMS}$) CW NBI added as basis for comparing preambles & BEACONs.

References

[1] “Evaluation of Immunity Aspects in Multidrop Channels” Ivanov et al.
http://www.ieee802.org/3/cg/public/adhoc/Ivanov_8023cg_Evaluation_of_Immunity_Aspects_in_Multidrop_Channels.pdf

[2] “Immunity Measurements and Considerations for 10BASE-T1S“, Cordaro, et al.
http://www.ieee802.org/3/cg/public/adhoc/cordaro_8023cg_Immunity_Measurements_and_Considerations_for_10BASE-T1S.pdf

[3] “A Review of Automotive EMC Environment & Tests” Buntz & Tazebay, pp 26-28
http://www.ieee802.org/3/bw/public/buntz_tazebay_3bw_01_0914.pdf

[4] “10SPE automotive PHY multidrop topology proposals”, Buntz,
http://www.ieee802.org/3/cg/public/adhoc/buntz_10SPE_05b_0329.pdf

Thank You!