Immunity Measurements and Considerations for 10BASE-T1S

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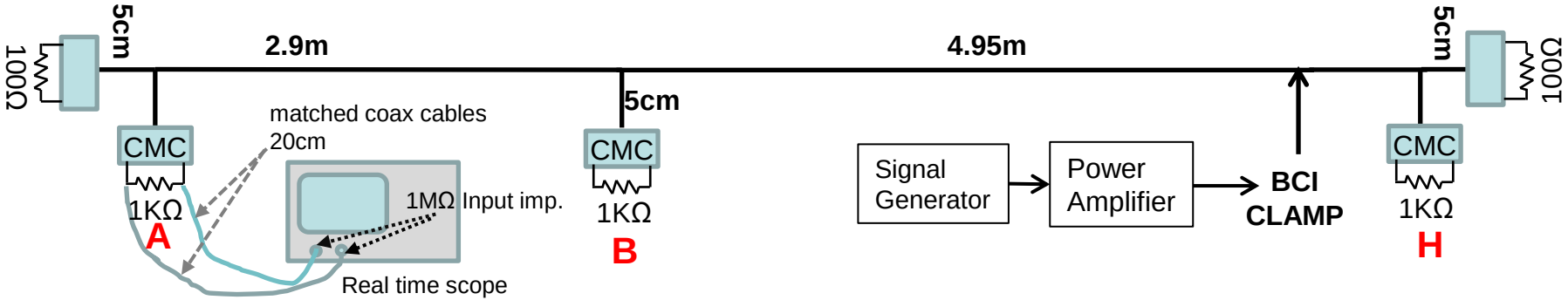
Problem Statement and Objective

- What is effect of CW interference on 10BASE-T1S multidrop channels?
- Utilize Bulk Current Injection (BCI) test method to quantify and measure the common mode (CM) & differential mode (DM) voltages induced on a multidrop cable configuration.
- Besides compliance to ISO11452-4, BCI can be a useful tool to predict in-car noise immunity.
- Given BCI measurements, evaluate if Broadcom proposed preamble can synchronize in noise levels obtained in BCI test and detect DME payload.

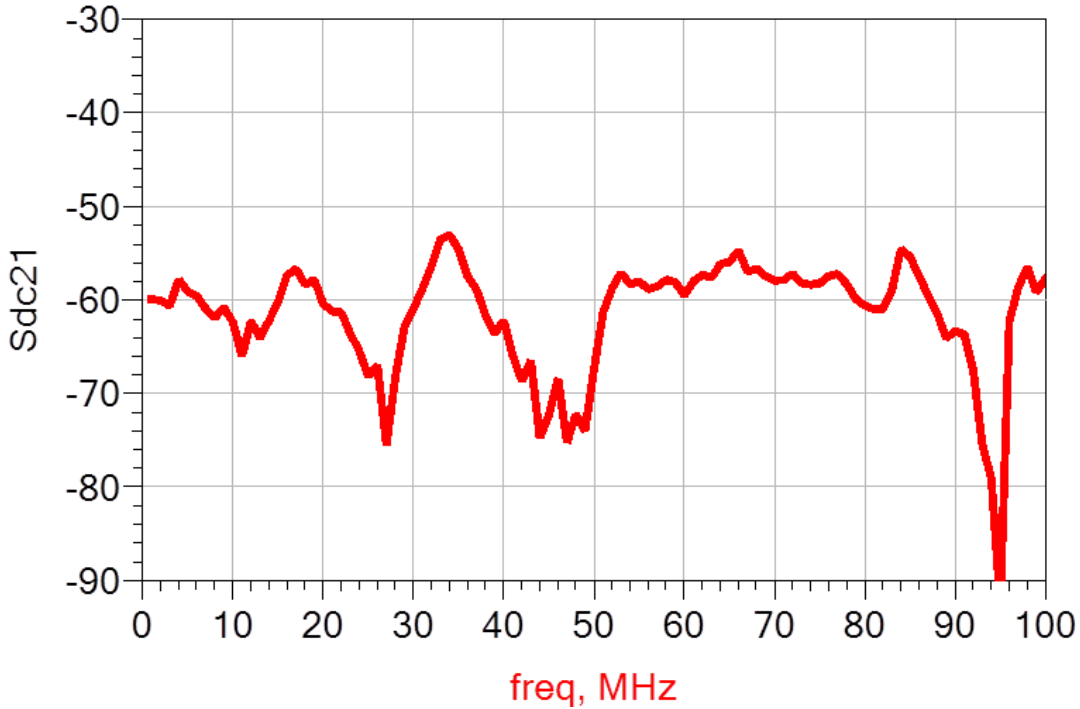
“min” Passive Linear Topology BCI Setup



- “min” Passive linear topology from [1] except 100Ω passive termination at cable ends[2].
- 100BASE-T1 Cables 5cm above ground plane.
- 100BASE-T1 CMC and **1KΩ** differential termination at nodes. Node ground connected to gnd plane
- BCI clamp located 75cm from end of 4.95m side of harness.
- Injection is calibrated for 200mA over 50Ω Load
- Sweep CW from 1MHz to 50 MHz in 250kHz steps.
- Measure common-mode CM and DM noise at points A and B after CMC using oscilloscope.

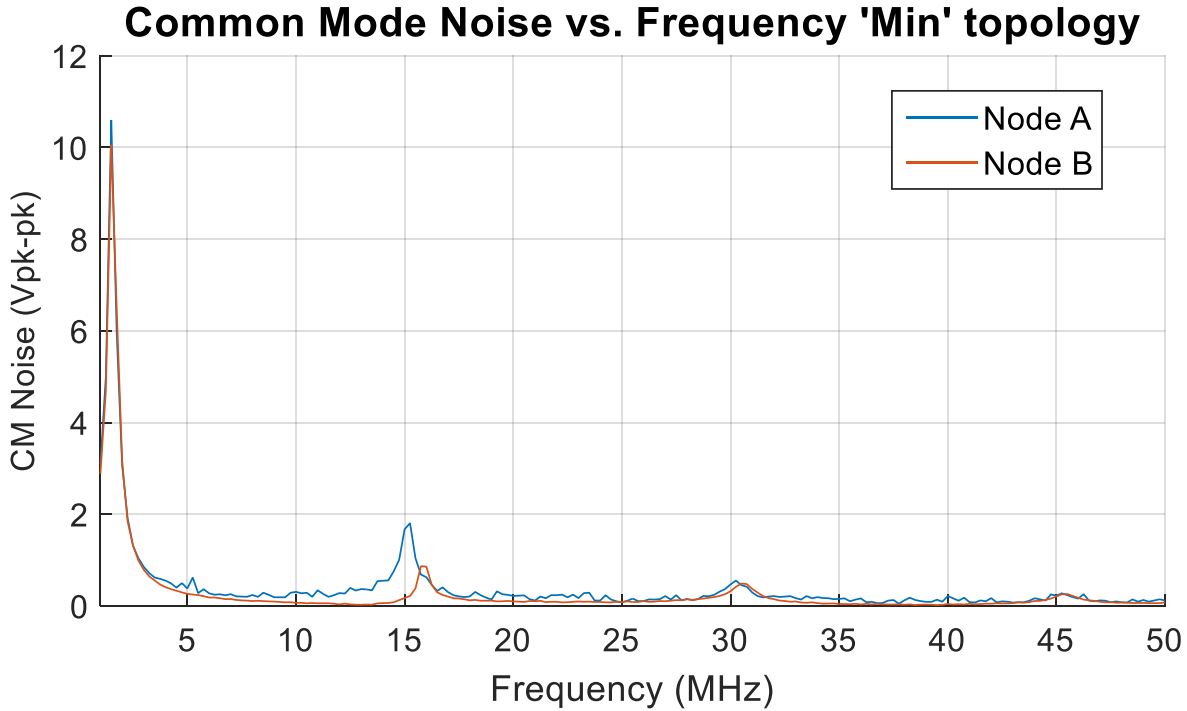
[1] “10SPE automotive PHY multidrop topology proposals”, Buntz, http://www.ieee802.org/3/cg/public/adhoc/buntz_10SPE_05b_0329.pdf
[2] 802.3cg Draft 1.1 147.5.1.2 & Figure 147–10

Measured Sdc21 from Node “H” To Node A



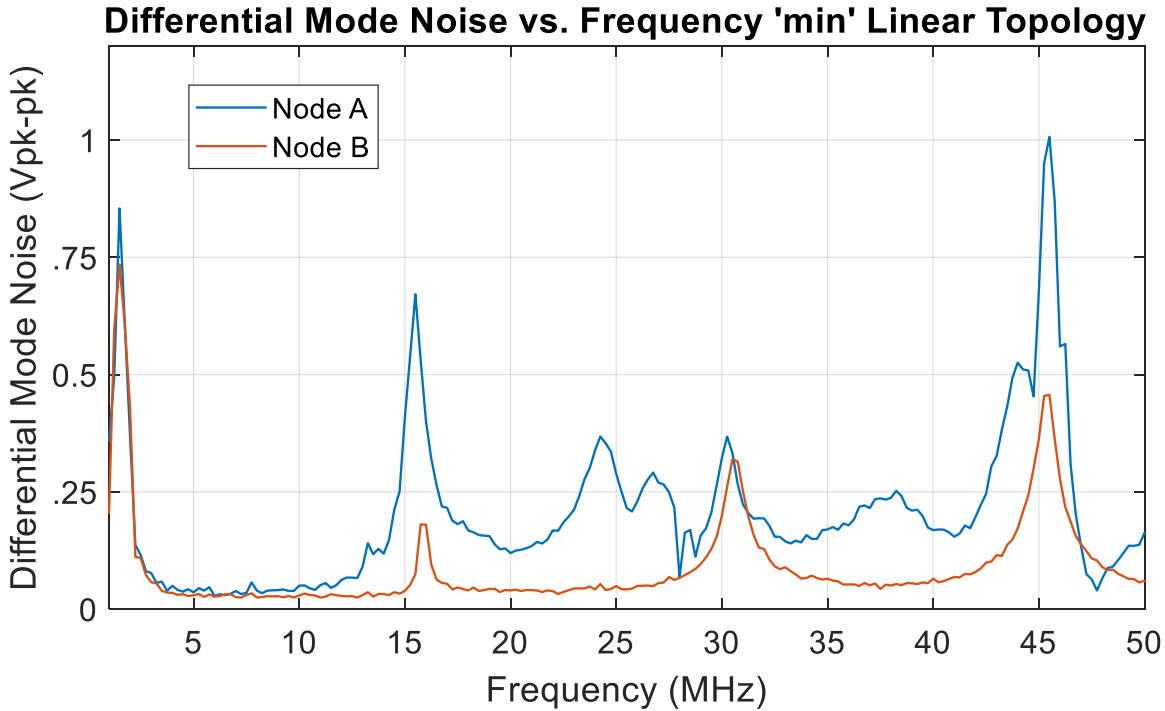
Mode conversion of cable harness is well below Mode Conversion limit defined in 147.6.3 D1.1

Common Mode Voltage Measurement



- Significant common mode on cable especially at resonances and low frequencies

Differential Mode Voltage



- Significant differential mode noise present on PHY side of CMC as well.
- Note in comparison with slide 5 how CM is generally attenuated by CMC but DM is not

Observations

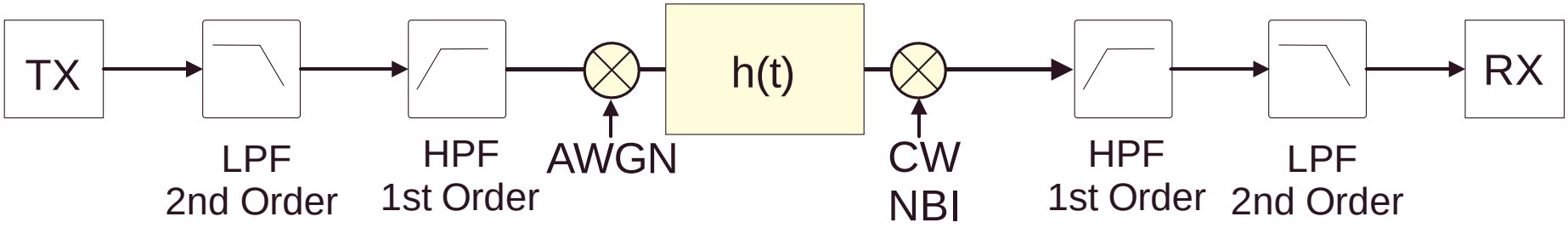
- The results show substantial common-mode and differential-mode noise at nodes A and B of the ‘min’ topology with BCI test level of 200mA.
- Other OEM BCI test levels could be higher (up to 355mA)
- Some cable topologies could have worse resonances.
- Cable harness had good Sdc21. Other cables may have more conversion.
- Frequencies below approx. 3.75MHz and above 20MHz can be filtered out.
- High-pass filtering at RX causes droop and low-pass filtering causes ISI.
- The passband (3.75MHz-20MHz) can have large CM and DM noise present.
- The 10BASE-T1S preamble needs to synchronize under operating conditions.

[1] “Improvements http://www.ieee802.org/3/bp/public/nov14/cordaro_3bp_01_1114.pdf

Preamble and DME Payload Simulation

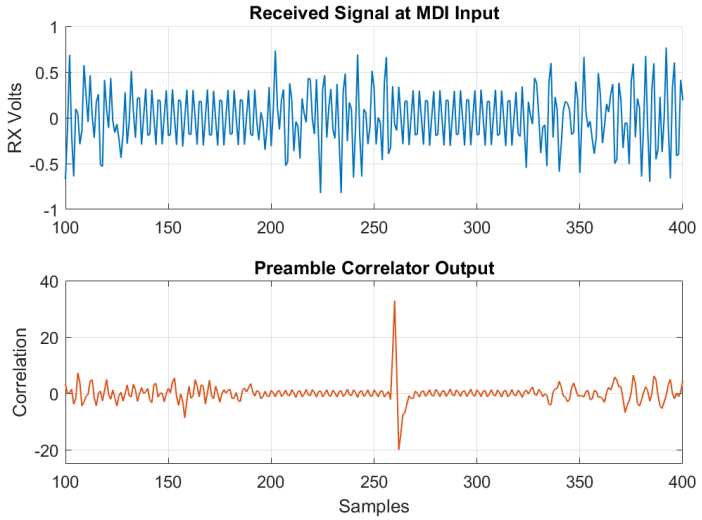
- BCI test shows more than 675mV pk-pk CW is possible in-band when resonances occur on cable harness.
- Even if the high peak at ~1MHz is outside of the passband (under ~3.75 MHz), due to its high level it can still affect the receiver.

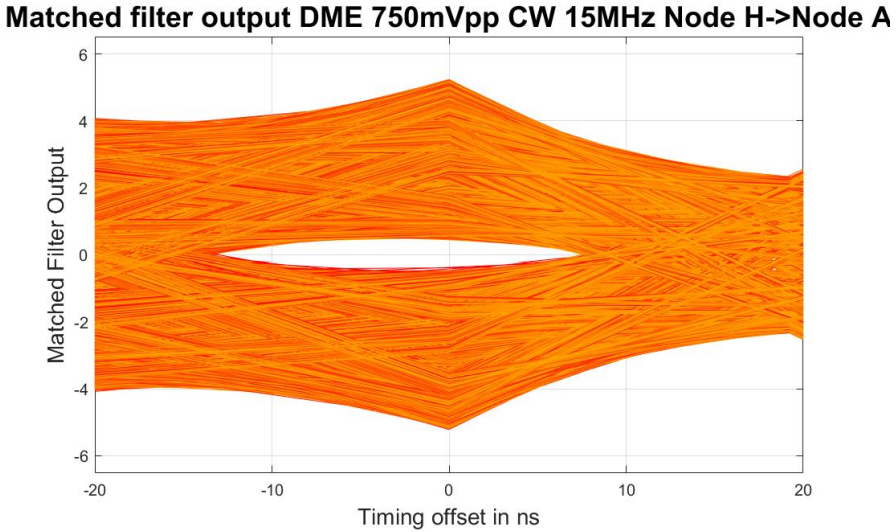
Simulation Setup for Eye Diagram



- TX: 512 byte 12.5Mbps scrambled data frames
  - DME T3/T2 of 40ns/80ns per table 147-2
- TX Voltage: 1Vpk-pk at transmitter into 10Ω
- TX Filtering:
  - 2nd order Butterworth TX LPF: fc of 20MHz
  - 1st order TX HPF, fc of 100kHz
- White noise -30dBc
- H(t) “Min” channel. Node A->Node “Head”
- CW of 750mV pk-pk 1-30MHz on cable
  - CW phase swept from $-\pi$ to π in $\frac{\pi}{20}$steps
- RX Filtering:
  - 1st Order Butterworth HPF fc of 3.75MHz
  - 2nd order Butterworth RX LPF fc 27MHz
- 2x OSR Budišin MF for proposed preamble
- 2x OSR Matched Filter for DME for payload

Received Signal MF Outputs for Preamble and DME





- Preamble matched filter output easy to detect and sync even in presence of high CW interference
- DME matched filter Eye Open

Conclusions

- Significant common mode and differential mode noise was measured on a 10BASE-T1S multidrop cable with a BCI test level of 200mA.
- Proposed preamble is able to synchronize under high differential noise conditions.
- The effect of high CM noise on PHY performance should be evaluated.
- For further work, we plan to investigate other cable topologies.