Immunity Analysis & Test Results via Bulk Current Injection Method for 1-pair UTP Channels

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Overview

- Objective & Setup Information
- Bulk Current Injection (BCI) Test Setup
- CM/DM BCI Transfer Functions
- Mode Transfer Impedance
- CM/DM Noise Calculation
- Conclusions

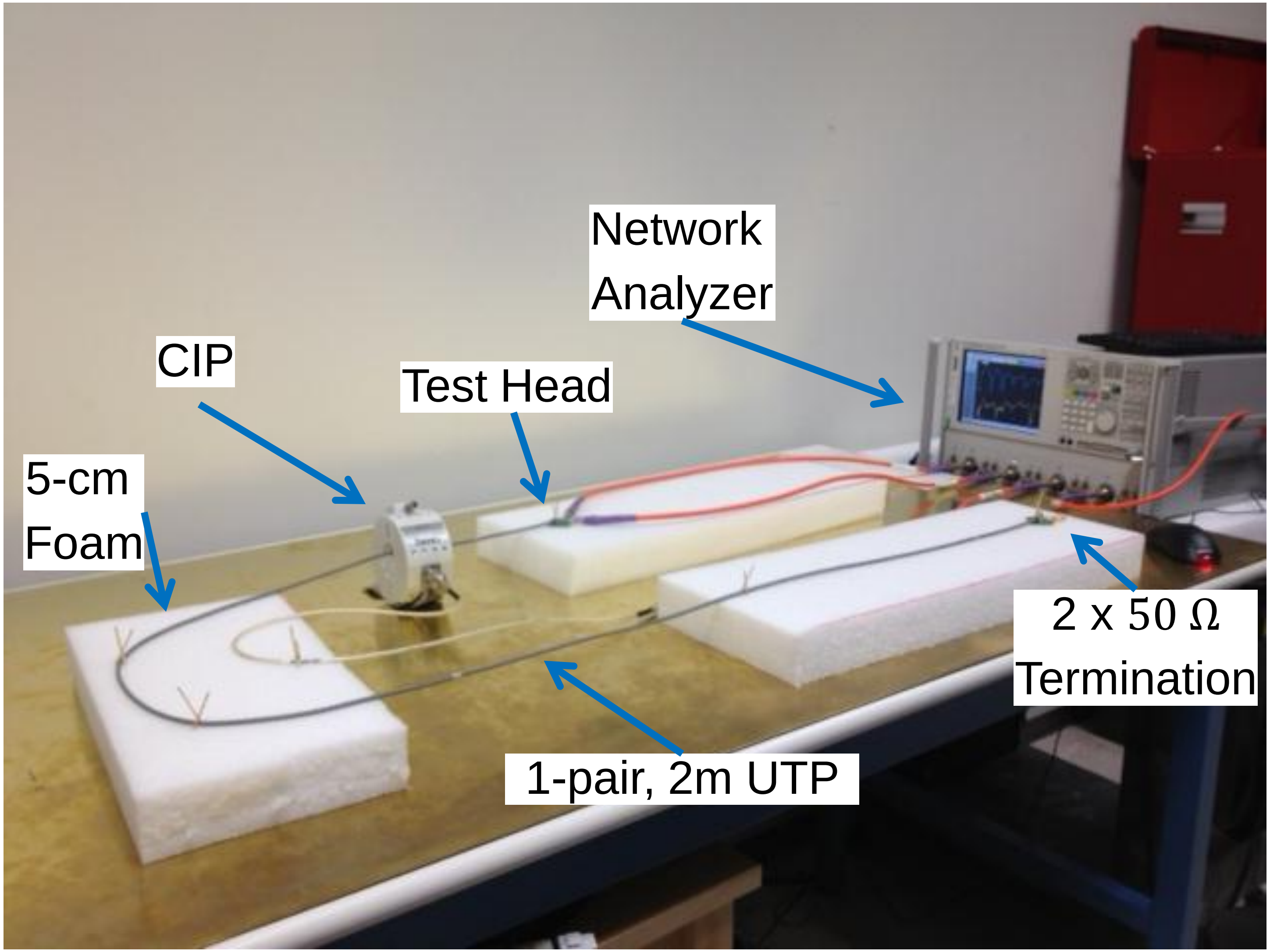
Objective & Setup Information

1. Utilize Bulk Current Injection (BCI) test method to quantify and measure the common mode (CM) & differential mode (DM) transfer function
2. Compute the CM & DM noise for a given BCI Immunity Test Profile

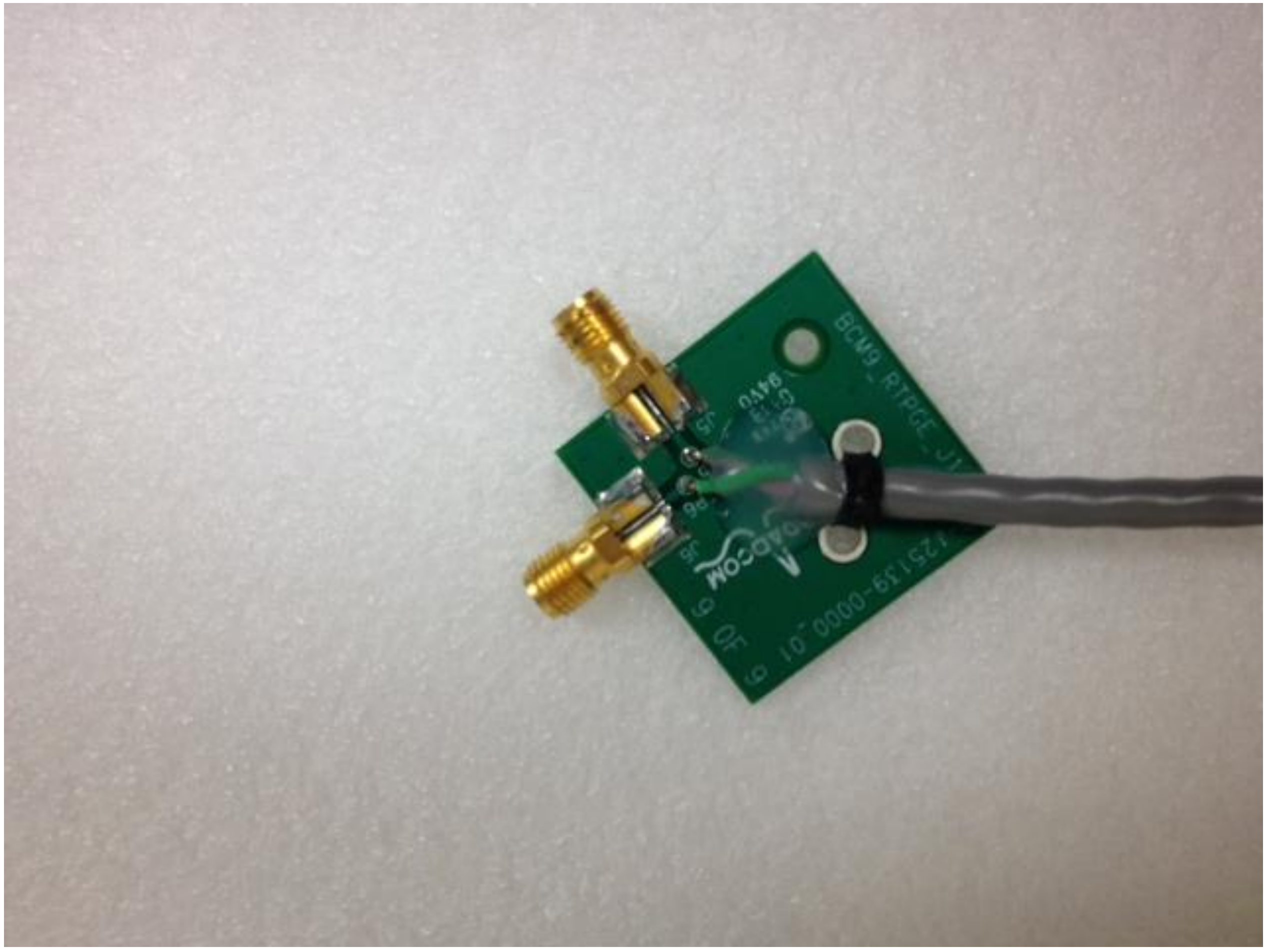
Setup Information:

- 2m 1-pair UTP AWG22 prototype cable is used
- Current Injection Probe (CIP) is used to couple and measure the common mode and differential mode signals
- Well-balanced(!) UTP-to-SMA test heads were utilized to connect the cable under test with measurement equipment
- 3-port Network Analyzer measurements were conducted

Bulk Current Injection Test Setup

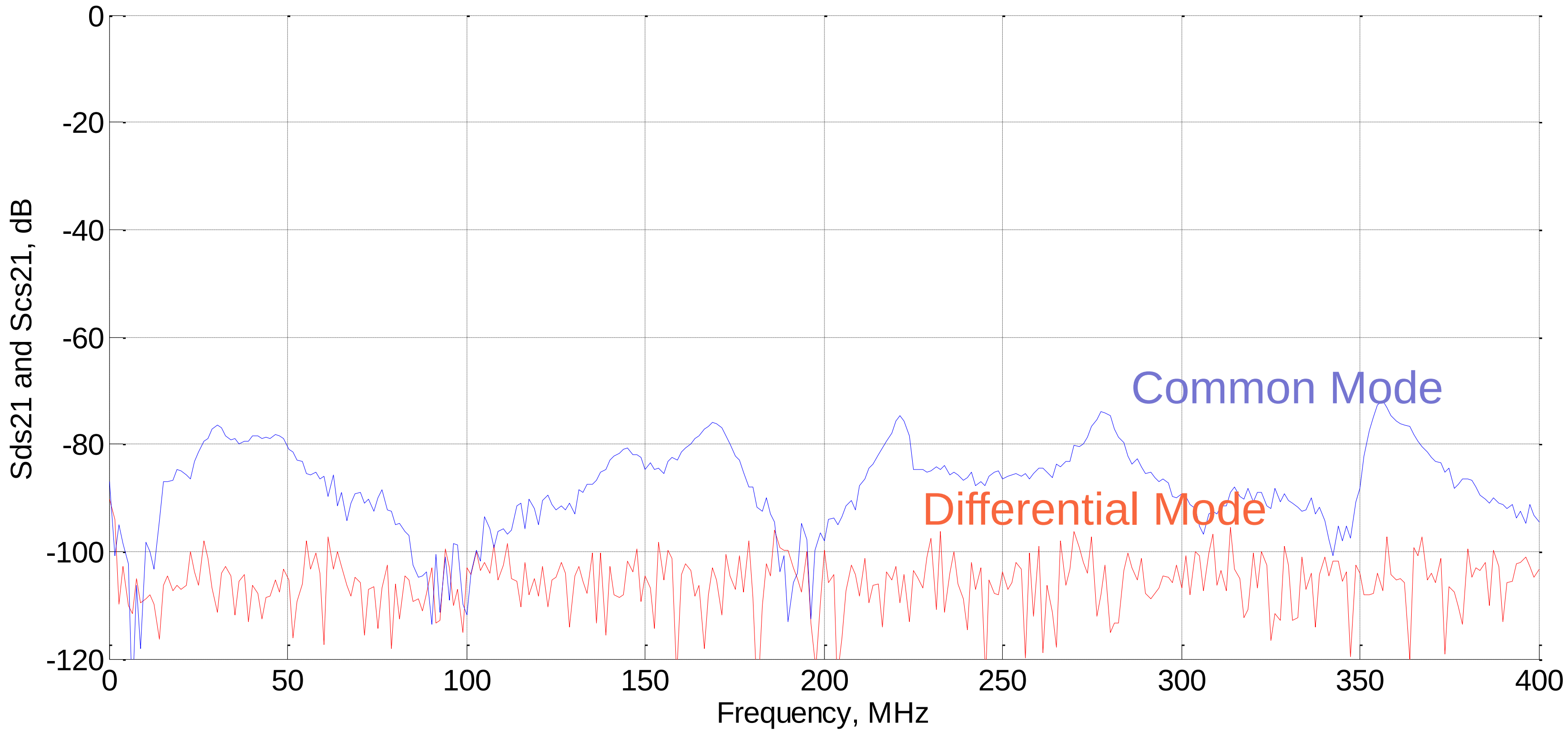


Test Head



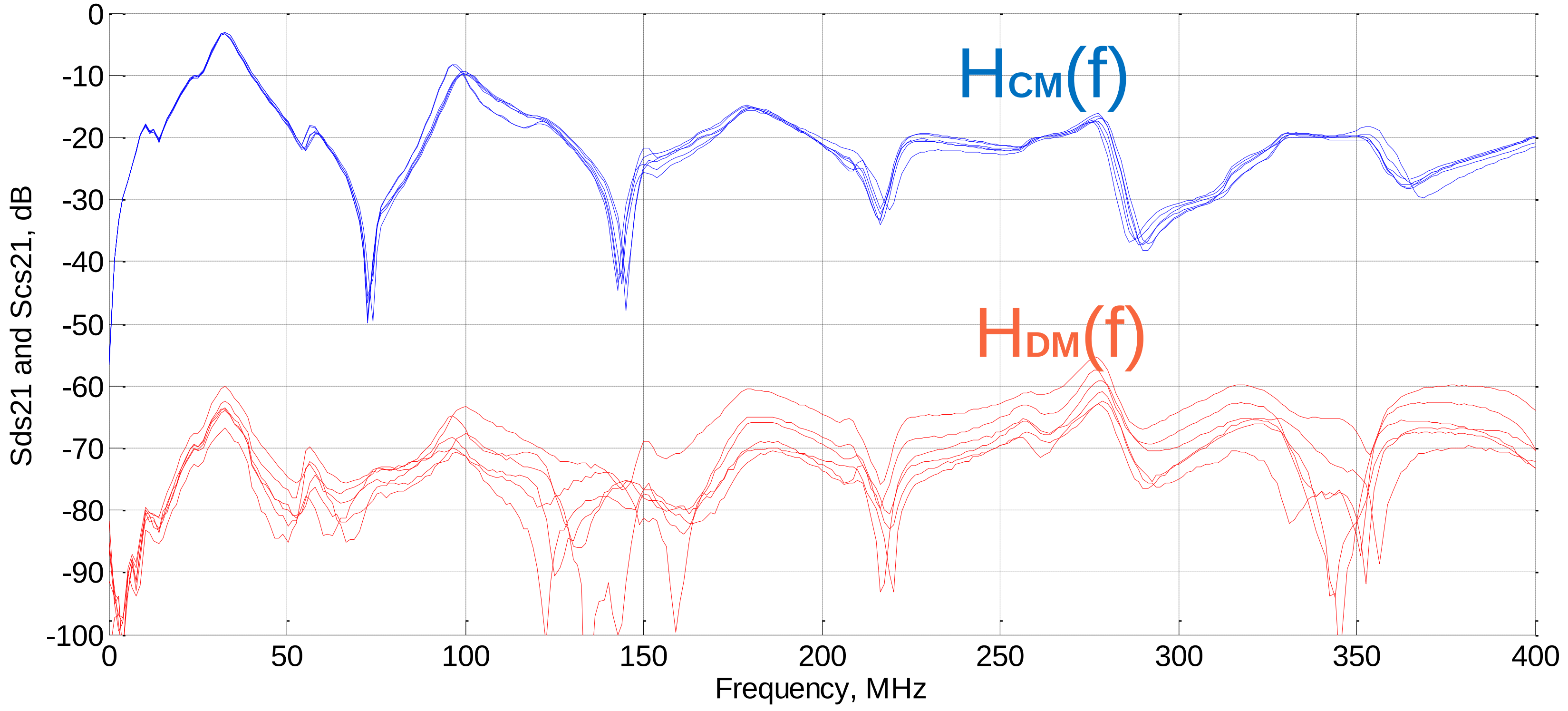
<u>Note:</u> Test Head is critical for imbalance and has to be properly designed, manufactured and measured.

Background Noise



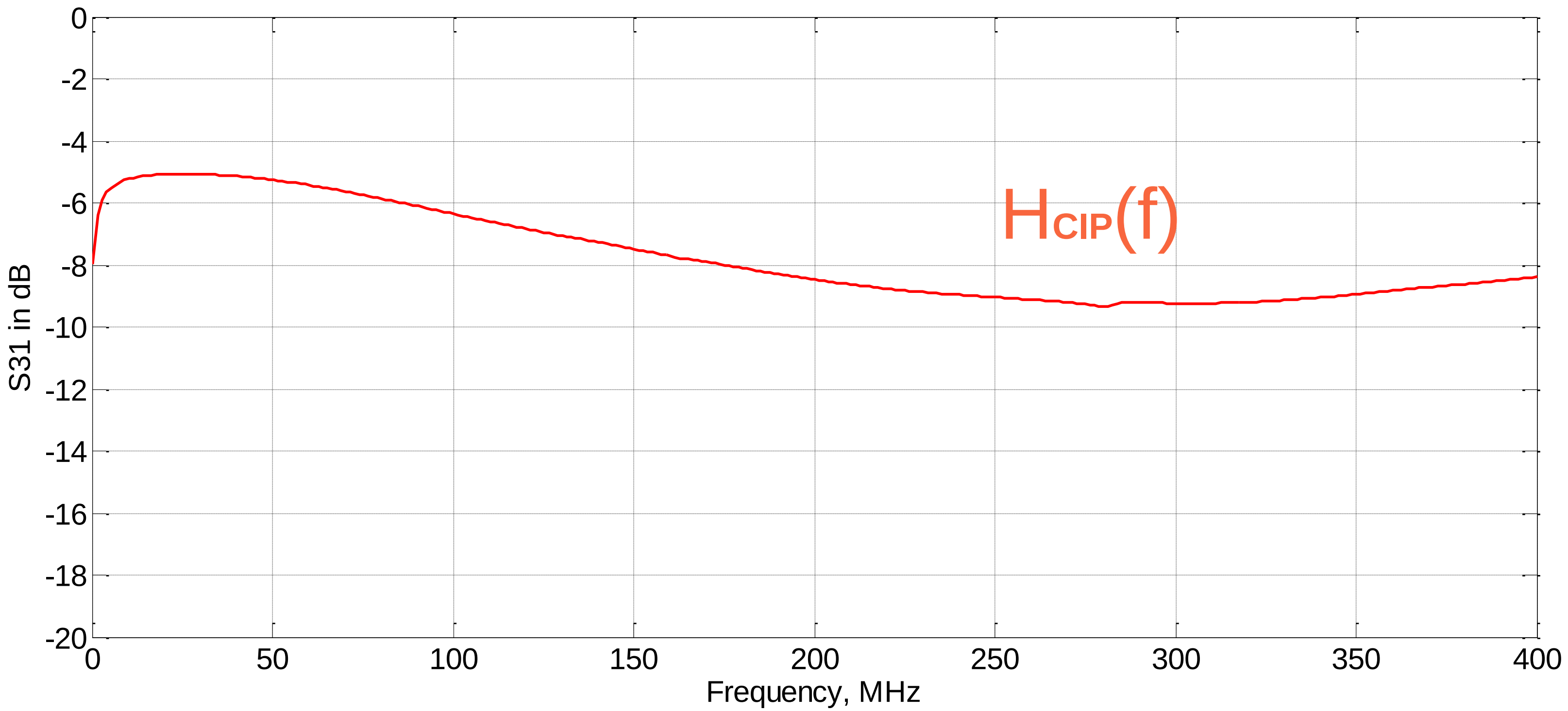
Note: Background Noise is well below measurement values for both CM and DM Transfer function measurements.

CM & DM BCI Transfer Functions



<u>Notes</u>: 3 x 1-pair UTP channels were measured (6 different test heads). The variations in DM noise seen is due to test head soldering process variation.

Current Injection Probe Calibration



Notes: * Current Injection Probe (CIP) transfer function has a few dB variation in coupling factor across the frequency band.

* The 2-port S31 measurement with calibration tool is used to calibrate noise measurements.

Mode Transfer Impedance

- Let a common mode transfer impedance be defined as

$$Z_{CM}[\Omega] = \frac{50\ \Omega}{\sqrt{2}} * \left| \frac{H_{CM}(f)}{H_{CIP}(f)} \right| \quad (1)$$

- Let a differential mode transfer impedance be defined as

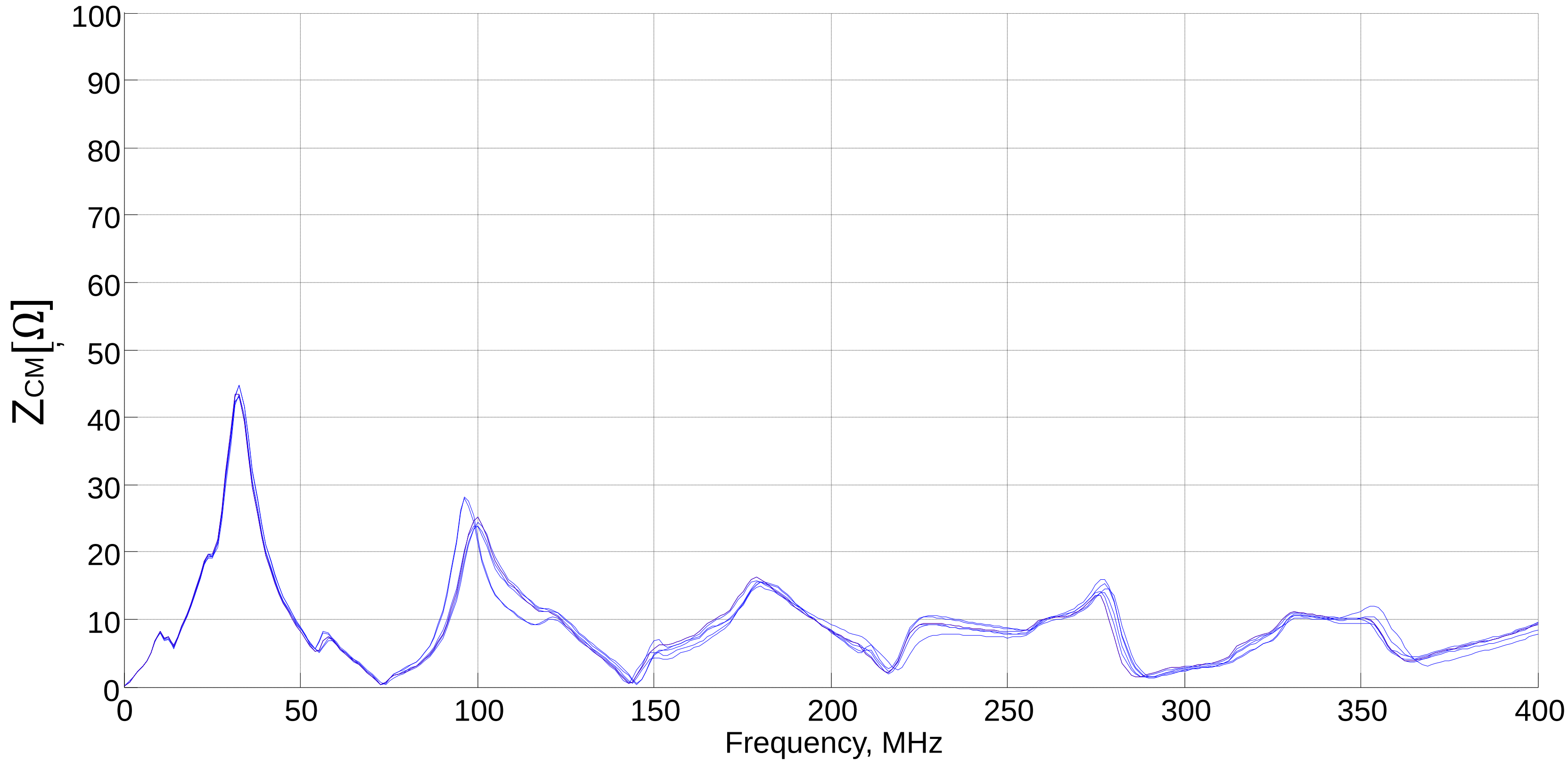
$$Z_{DM}[\Omega] = 50\ \Omega * \sqrt{2} * \left| \frac{H_{DM}(f)}{H_{CIP}(f)} \right| \quad (2)$$

- Then for a given peak BCI current, the input referred common mode and differential mode noise can be calculated as the following:

$$V_{CM}[mV] = I_{BCI}[mA] * Z_{CM}[\Omega] \quad (3)$$

$$V_{DM}[mV] = I_{BCI}[mA] * Z_{DM}[\Omega] \quad (4)$$

$Z_{CM}[\Omega]$ (as measured)

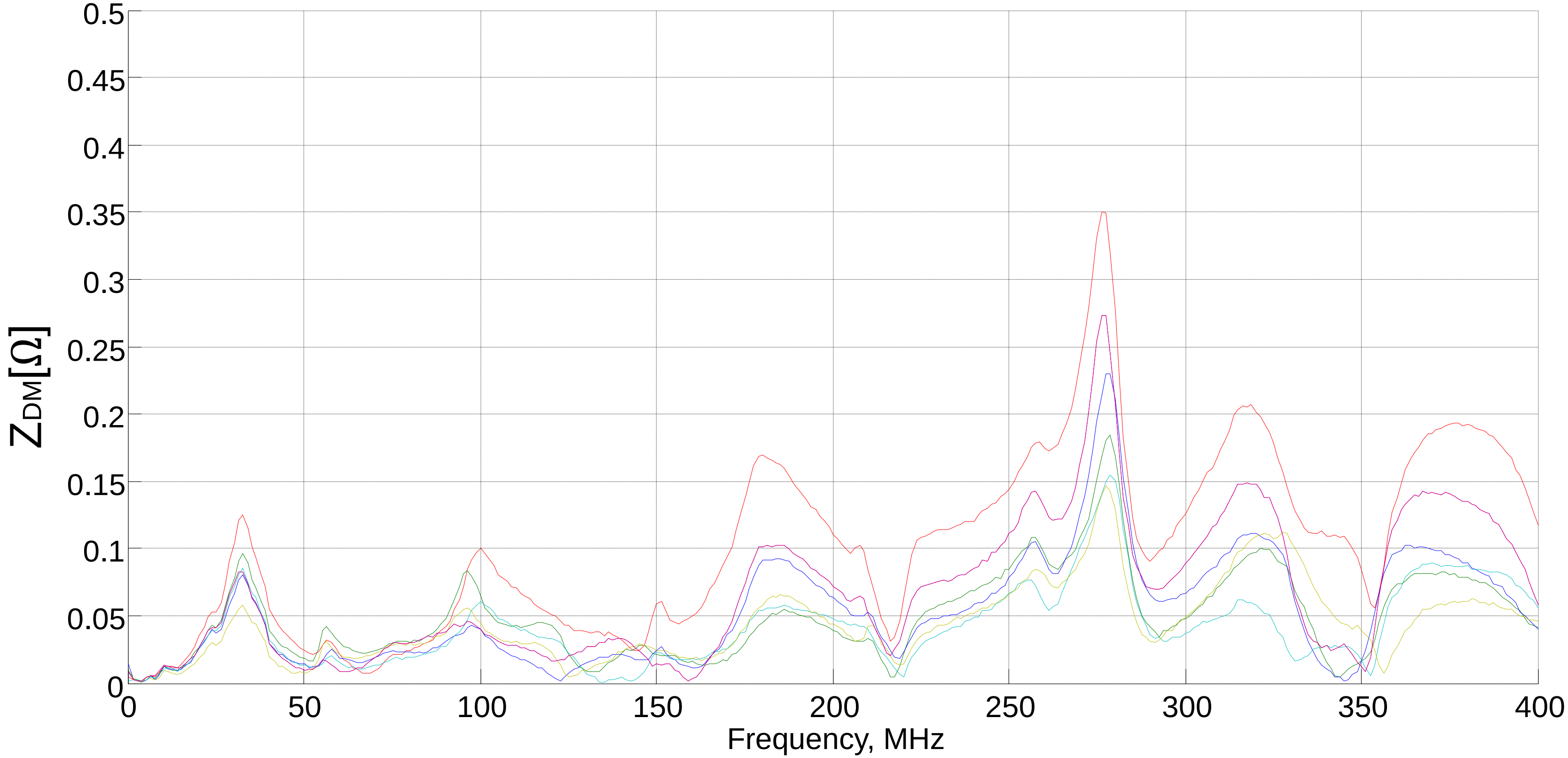


Notes: * Common Mode Transfer Impedance, Z_{CM}([Ω], is shown for 3 cable samples of the same type, 6 ends.

* The results shown are for all 6 ends of the cables.

* All cables show same impedance values.

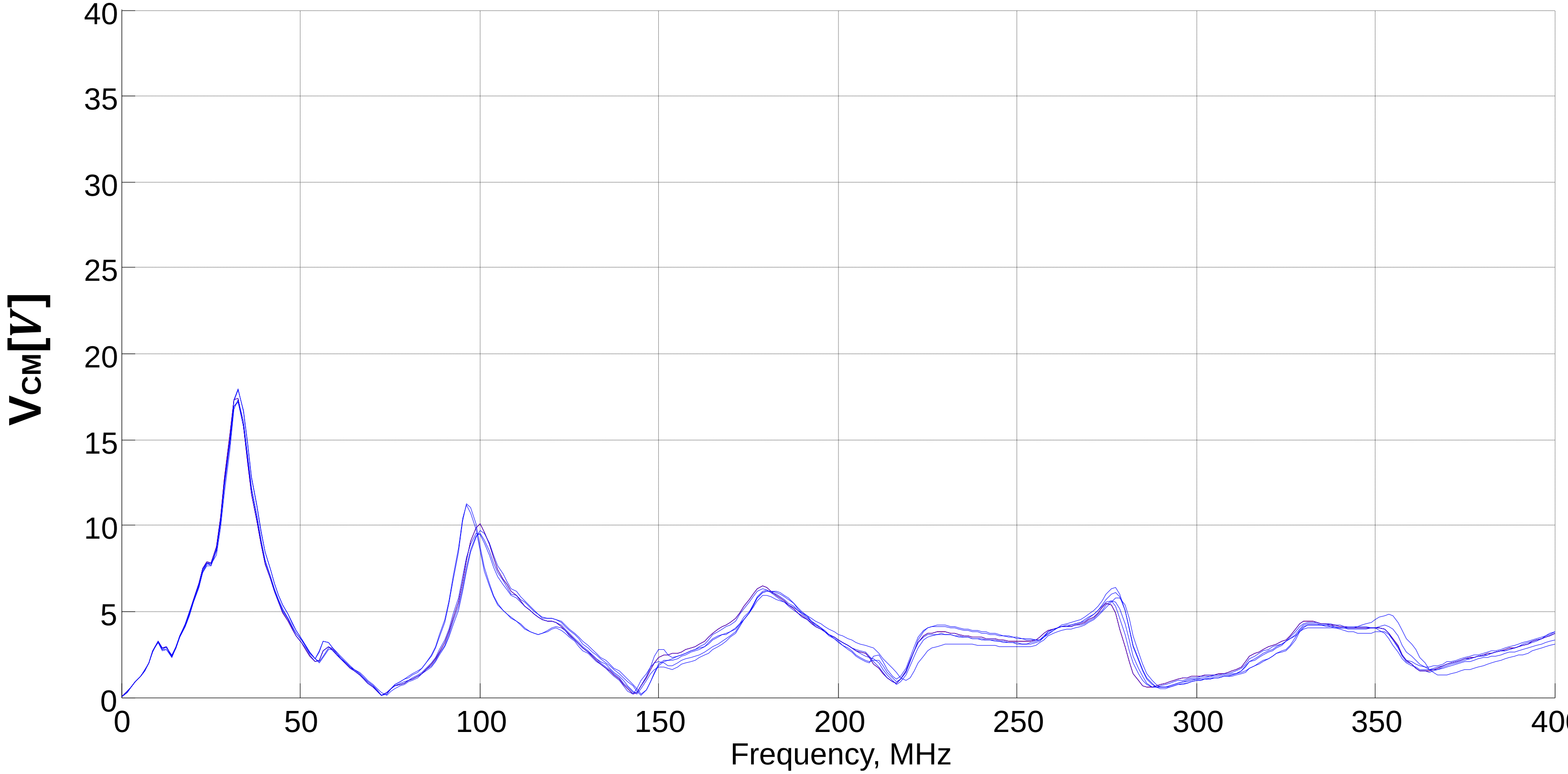
$Z_{DM}[\Omega]$ (as measured)



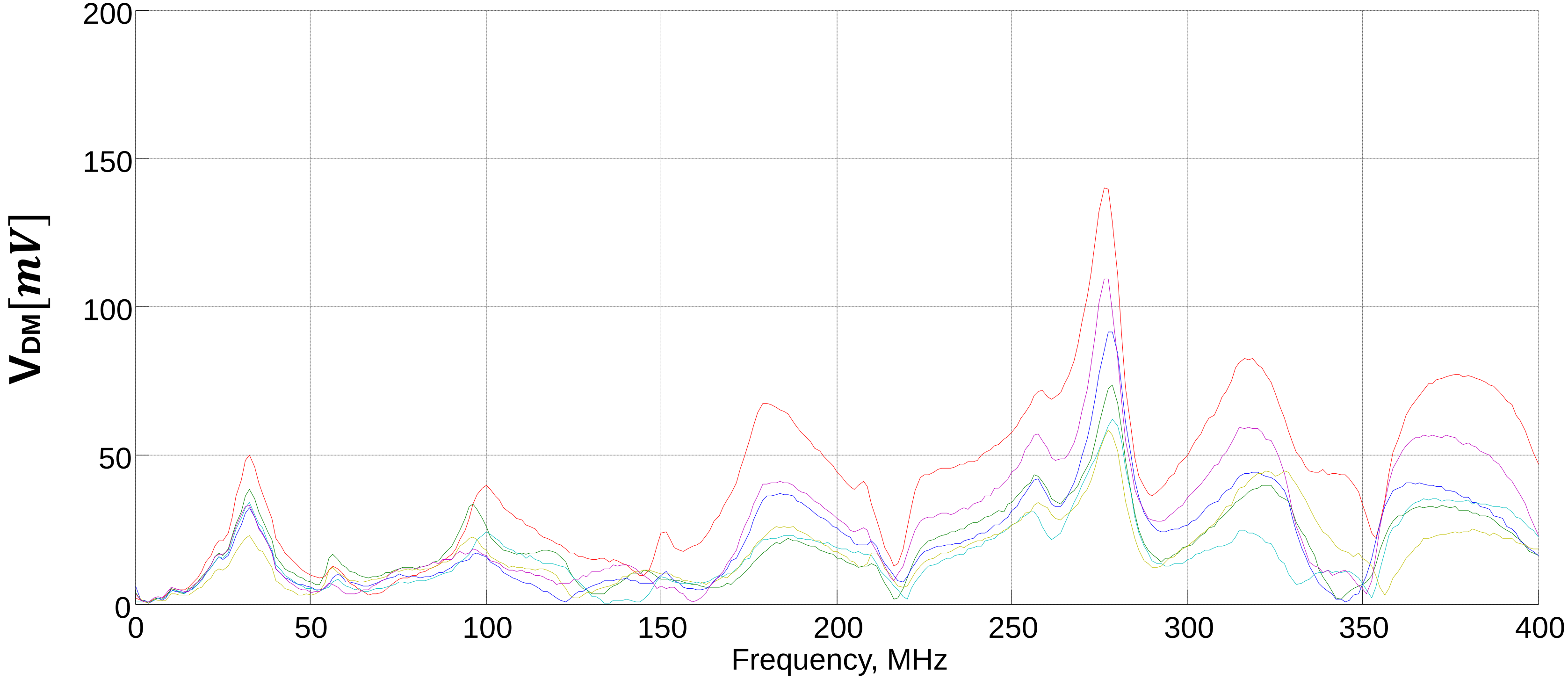
Notes: * Differential Mode Transfer Impedance, $Z_{DM}[\Omega]$, is shown for 3 cable samples of the same type, 6 ends.

* The results shown are for all 6 ends of the cables.

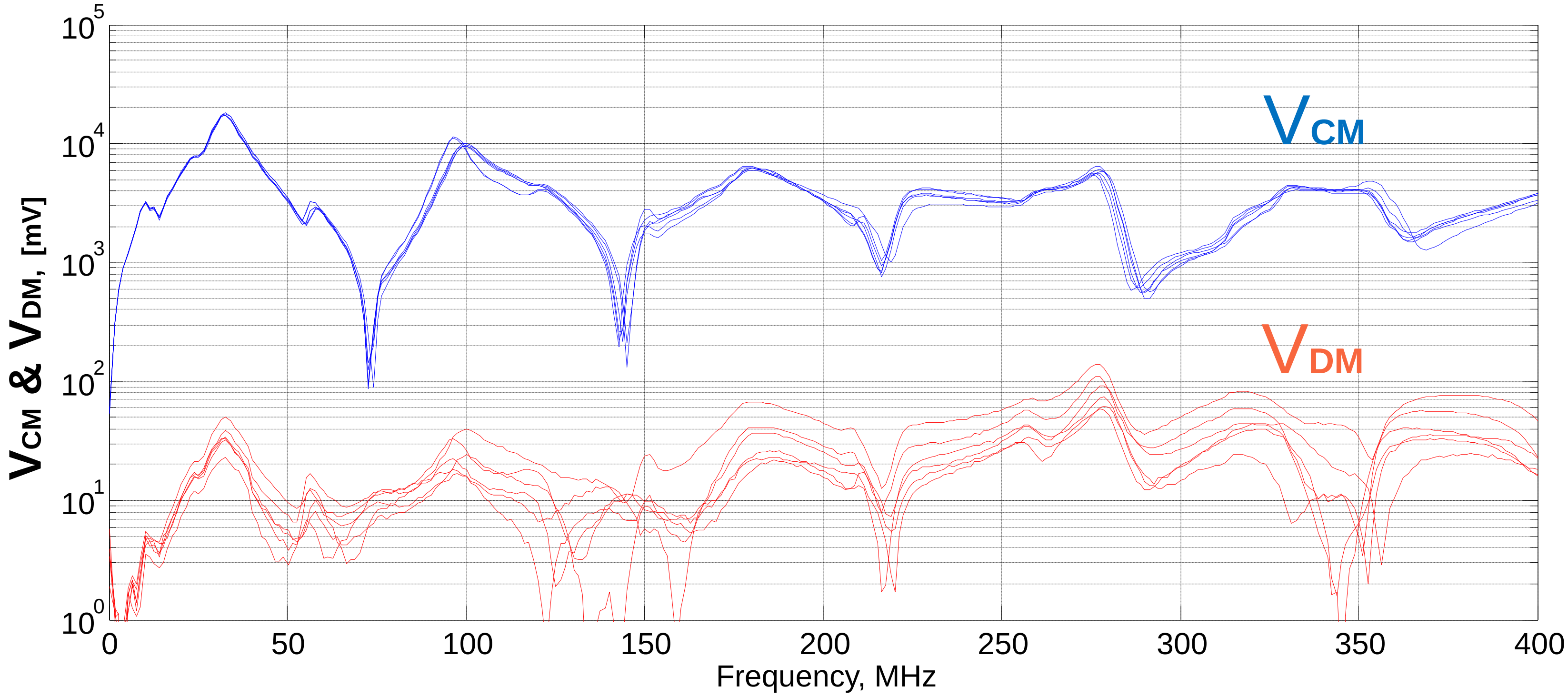
V_{CM} for a constant level BCI (200mA)



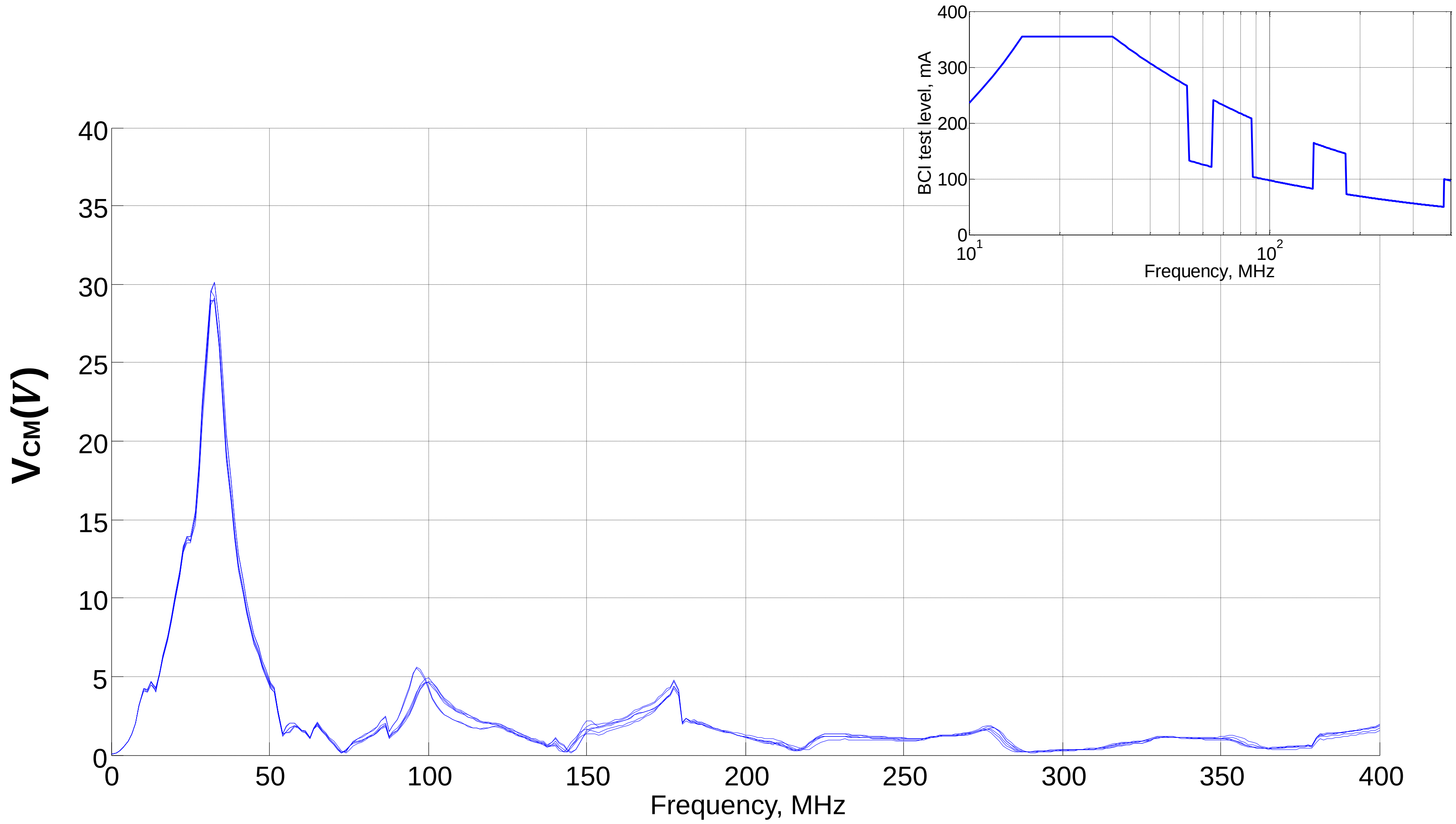
V_{DM} for a constant level BCI (200mA)



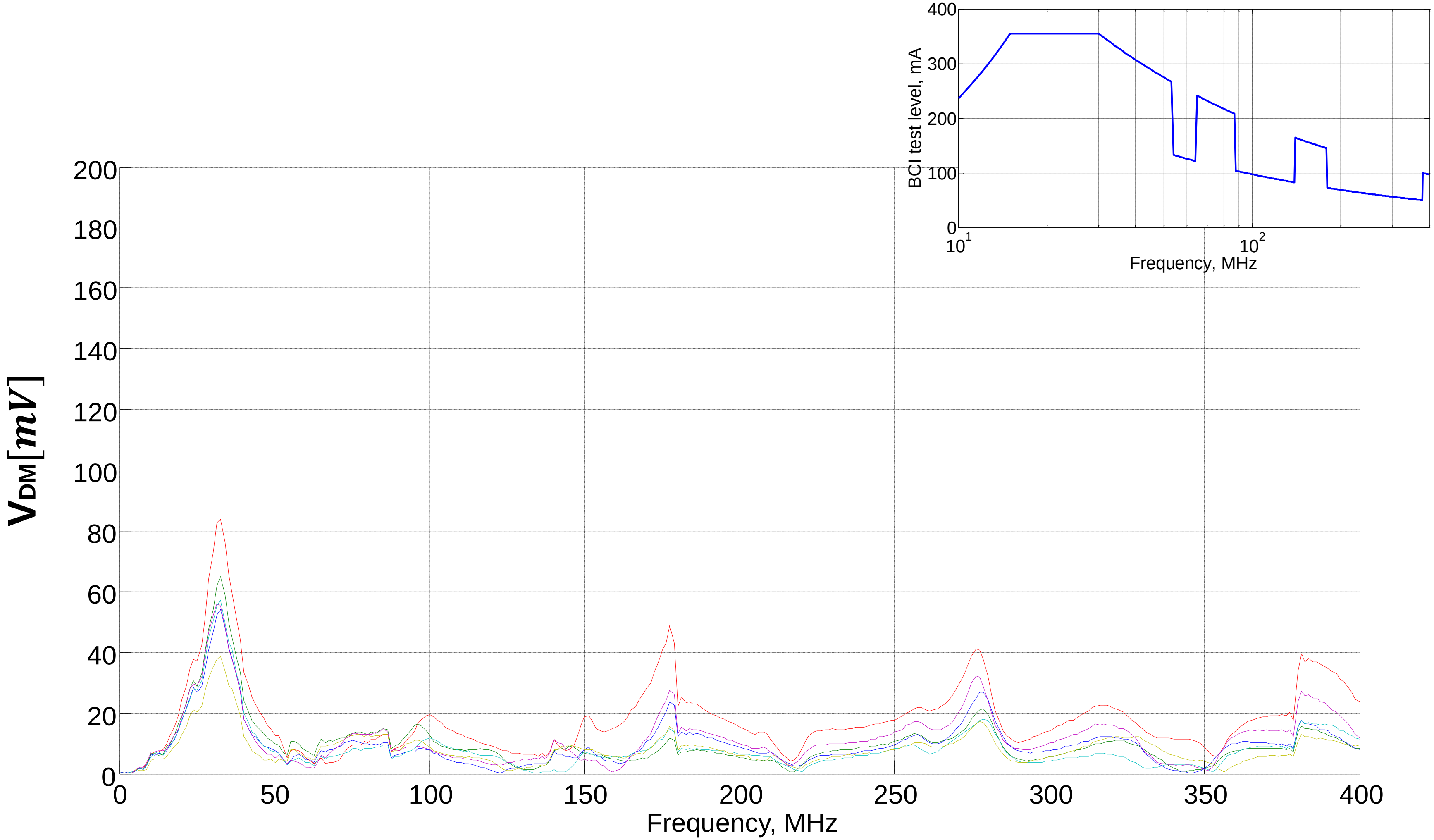
V_{CM} & V_{DM} for a constant level BCI (200mA)



V_{CM} for a BCI Profile (max 350mA)



V_{DM} for a BCI Profile (max 350mA)



Conclusions

- In this contribution, we demonstrate

1. BCI is an effective technique for analyzing and quantifying the ingress model for EMC immunity

2. It is feasible to characterize the mode-conversion channel transfer functions via BCI

3. Given BCI levels & #2, it is also feasible to calculate the CM and DM noise levels at the input of receiver

4. There exist 1-pair UTP channels which can yield DM noise as low as 55mV-pp