Analysis of EMC Mode Conversion Measurement and Common Mode Impedance Effect

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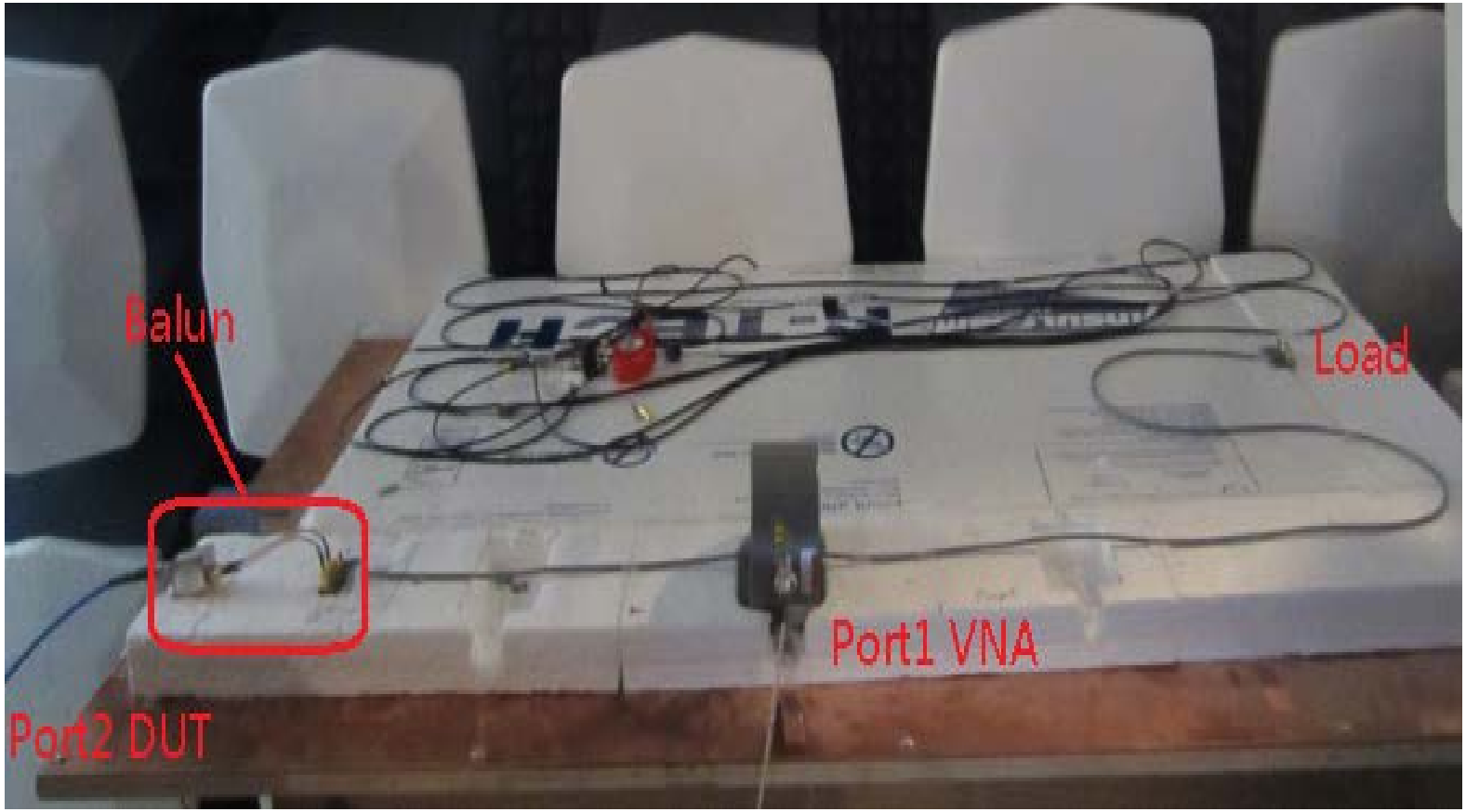
Outline

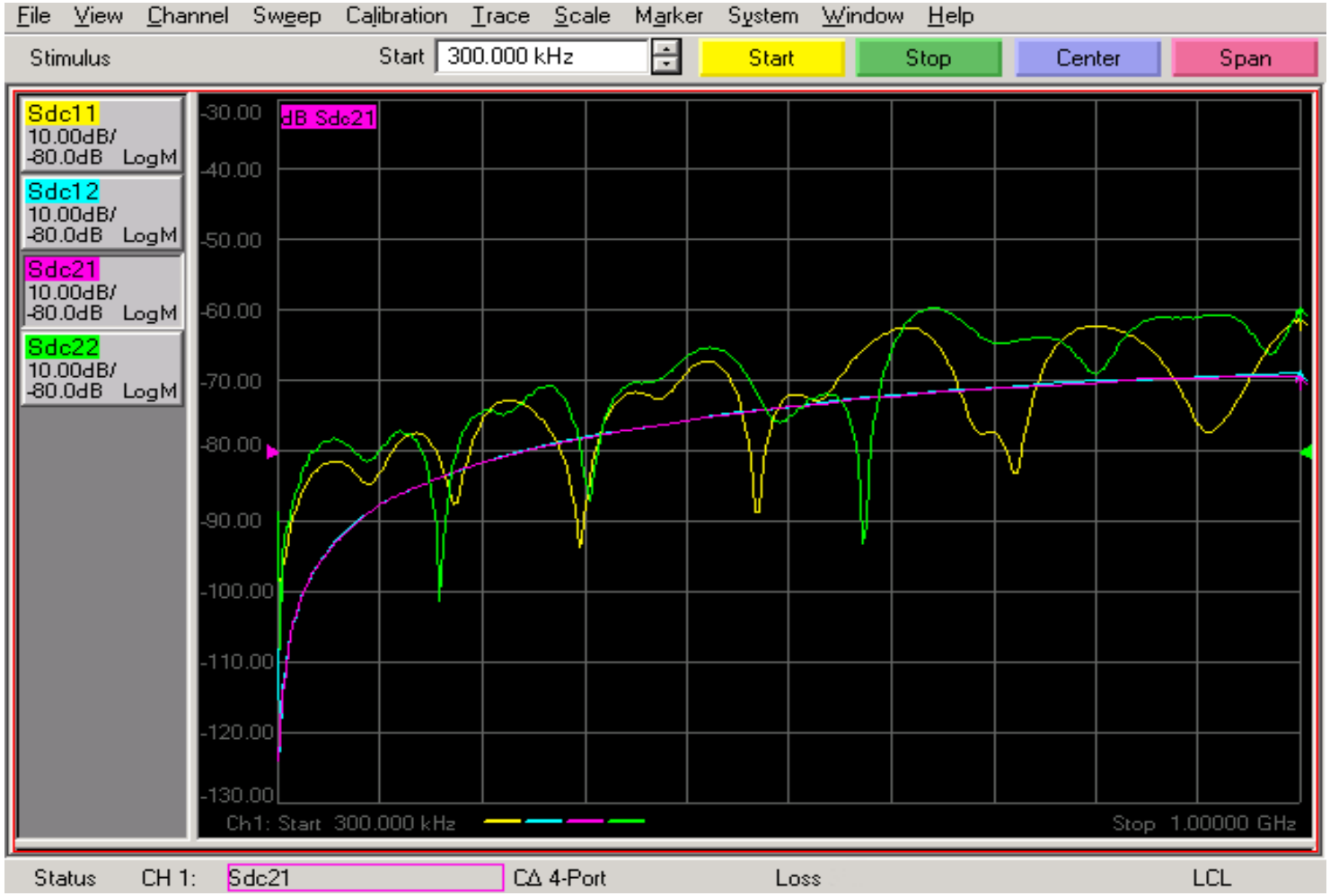
- BCI with 2m UTP cable Mode Conversion measurements
- Time domain differential noise measurement
- Correlation between frequency domain prediction and time domain measurements
- Comparison of 3-port measurement and 2-port with a Balun measurement
- Common mode Impedance effect Study
- Mode conversion baseline discussion

Measurement setup

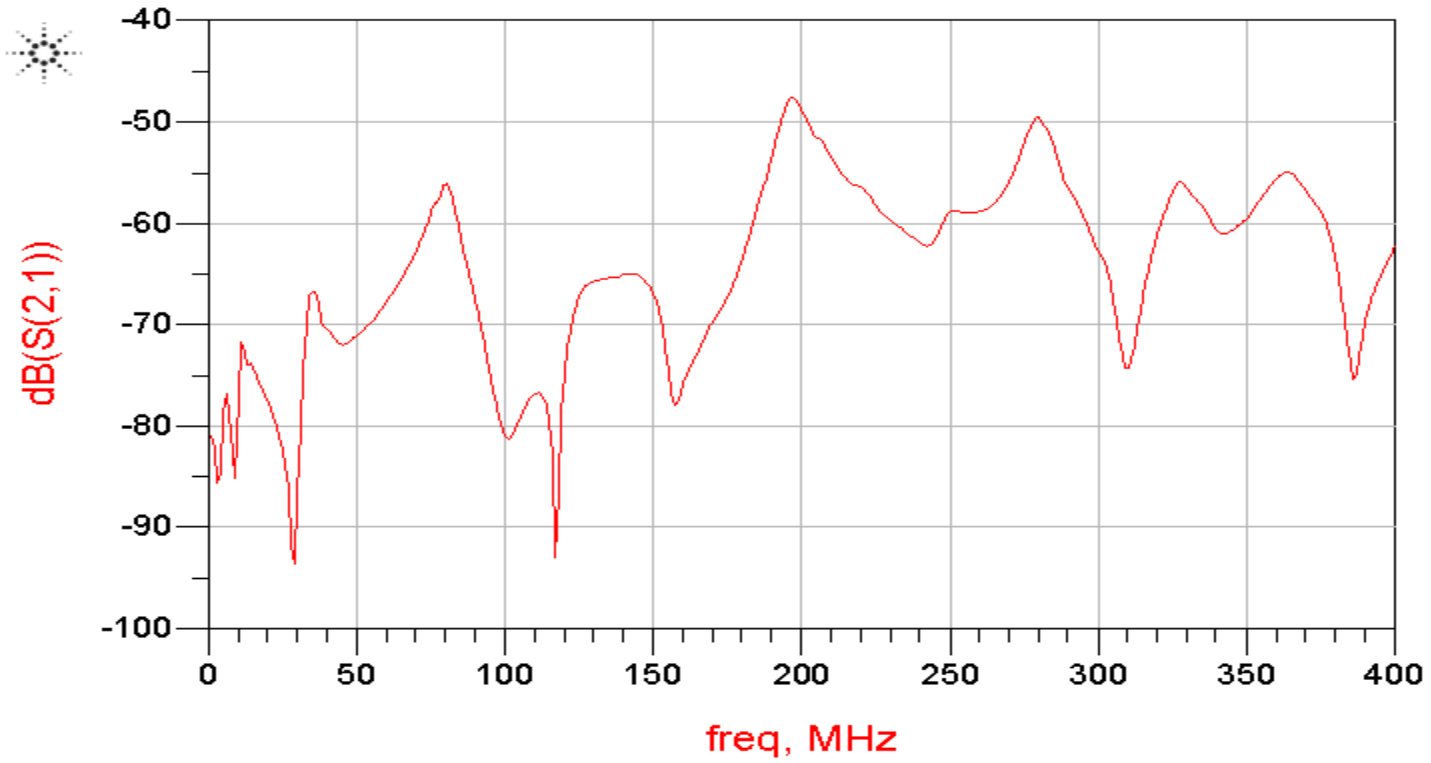
- A Balun used to isolate the interference from the measurement



Calibration Noise Floor with VNA/SMA Cable

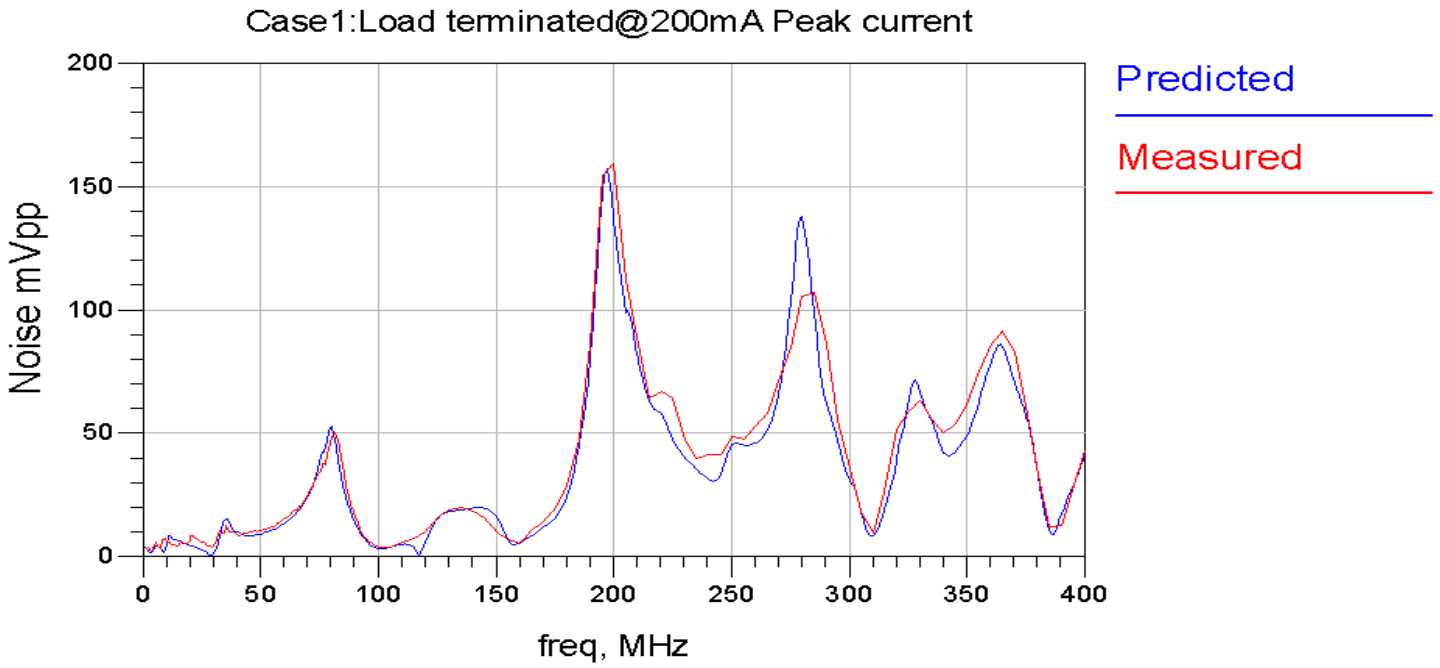


Case 1: Measured 2-Port S-parameter with the common mode of load end terminated to the Metal Plain

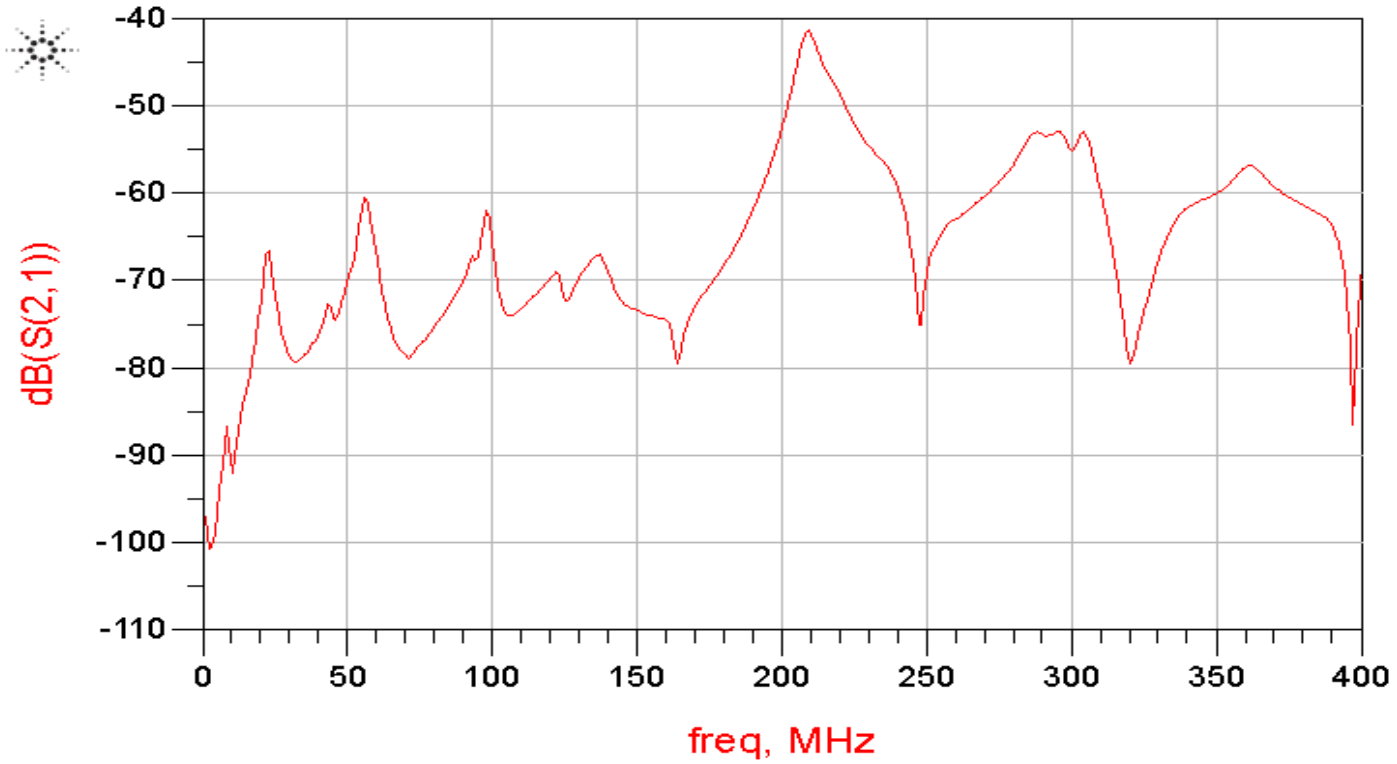


Predicted vs. Measured for Case1

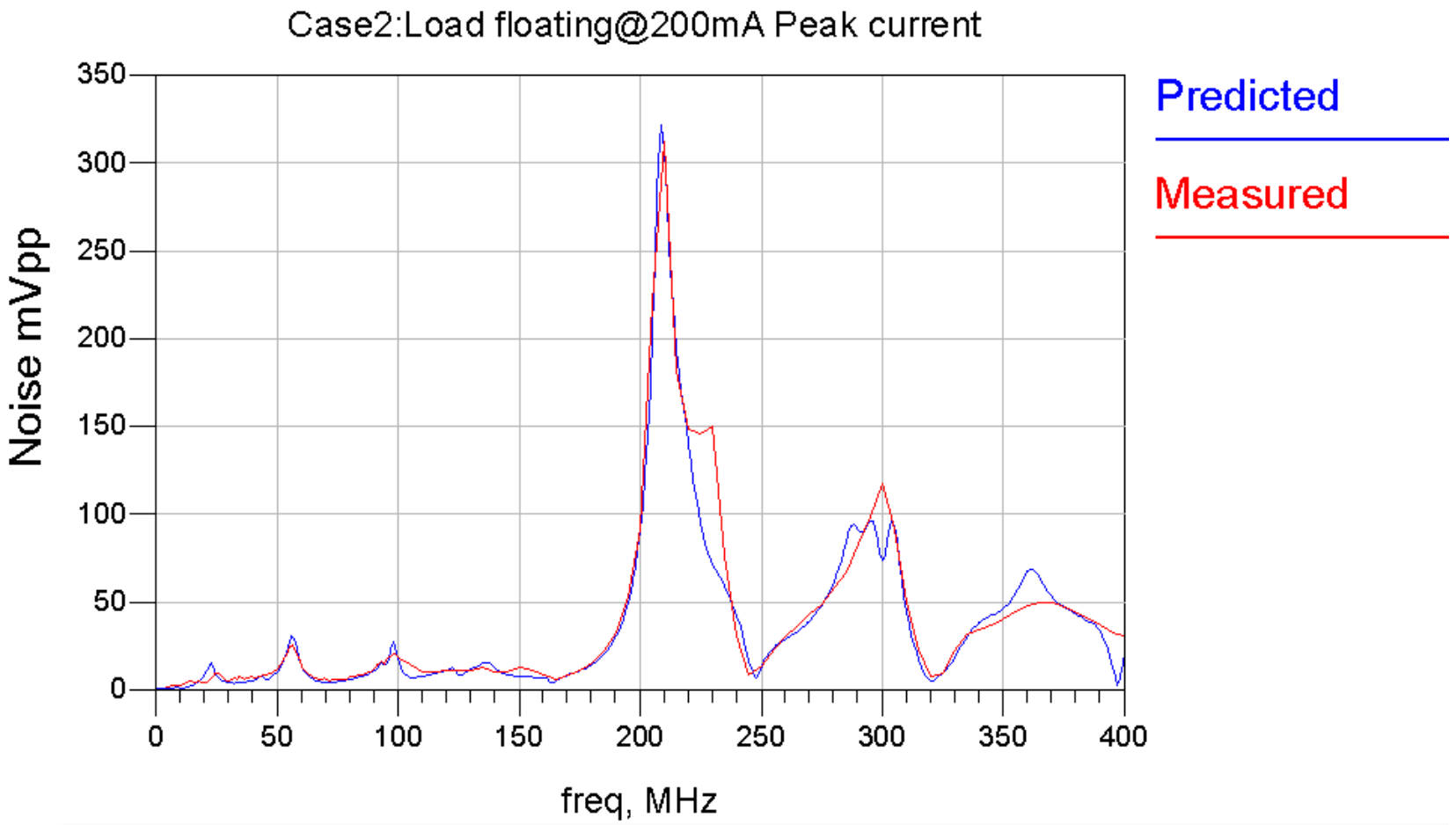
- Predicated -simulation results from S-parameter measurement
- Measured – time domain interference measurement



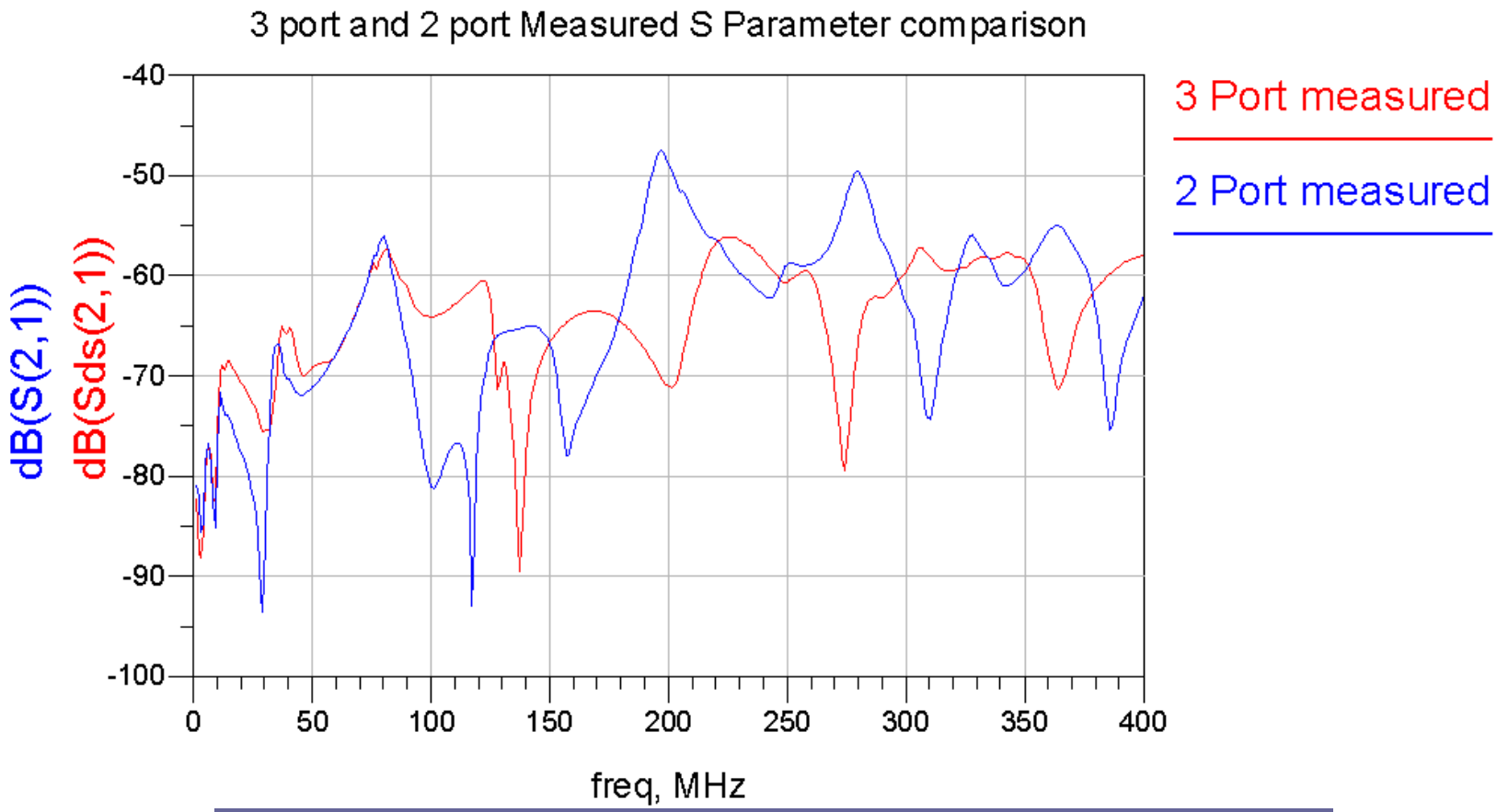
Case 2: Measured 2-Port S-parameter with the floating common mode connection of the load end



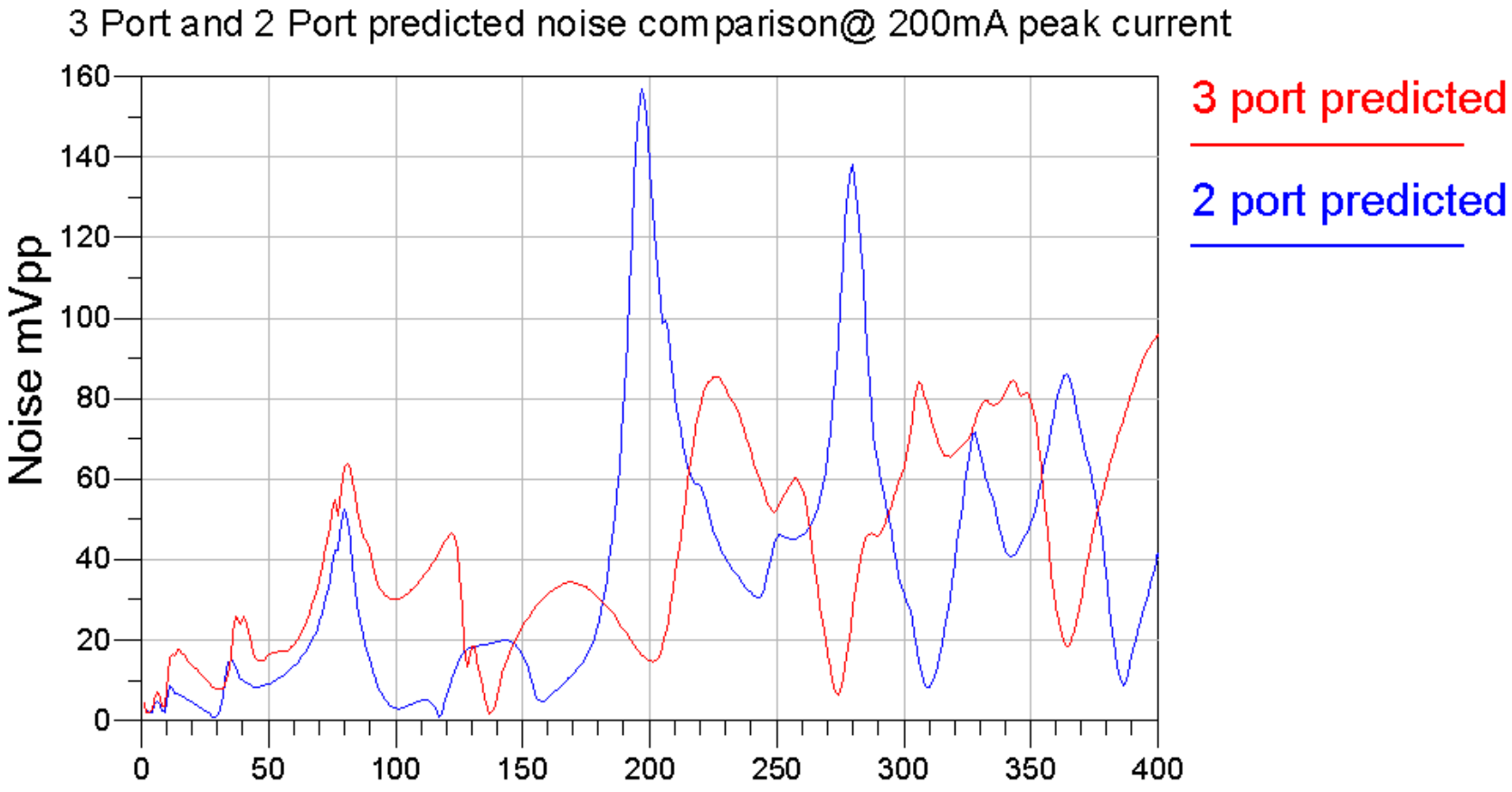
Predicted vs. Measured for case2



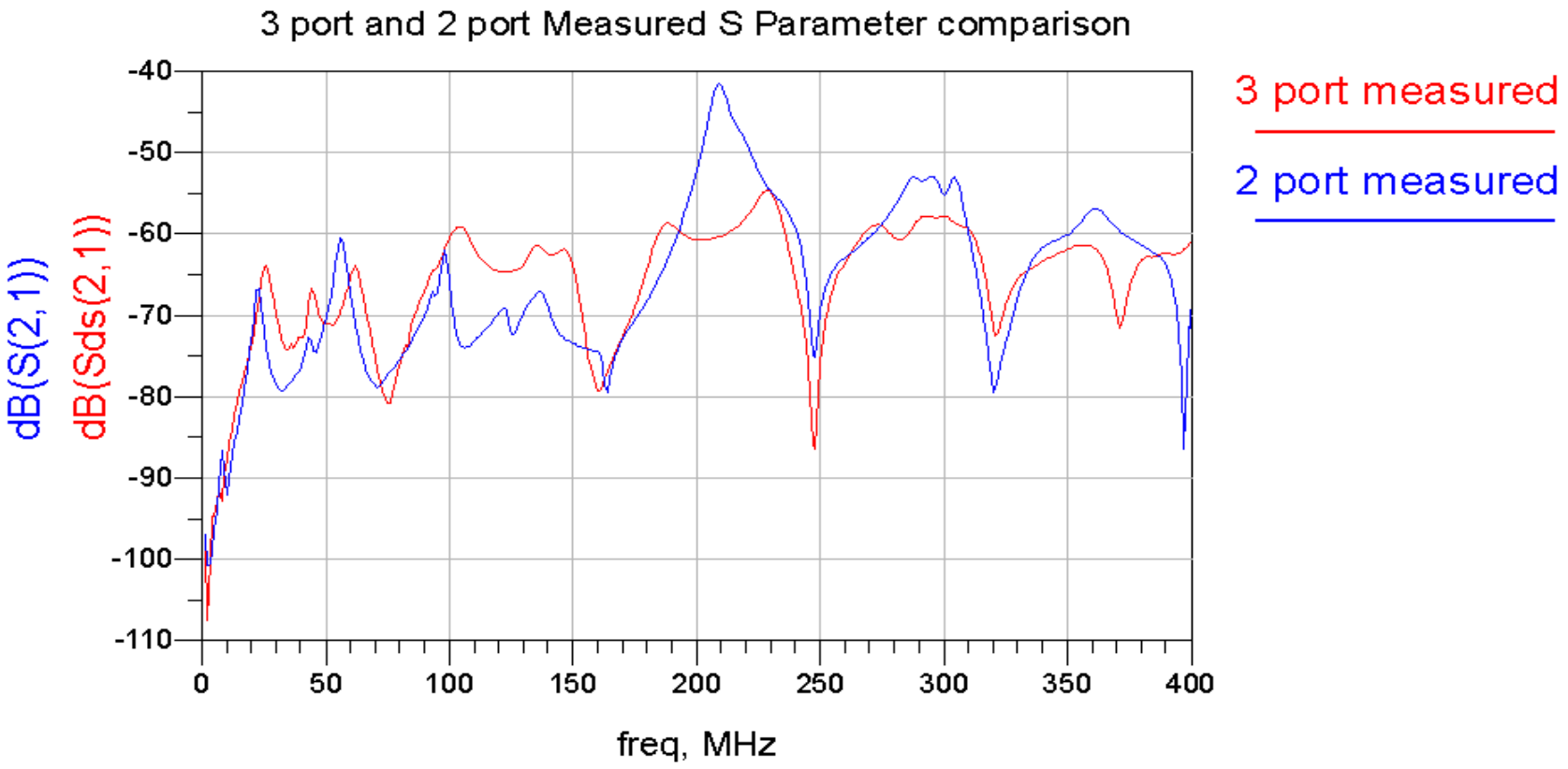
3-Port and 2-port with Balun Mode Conversion Comparison for Case1(the load end common mode termination of 25 Ohms)



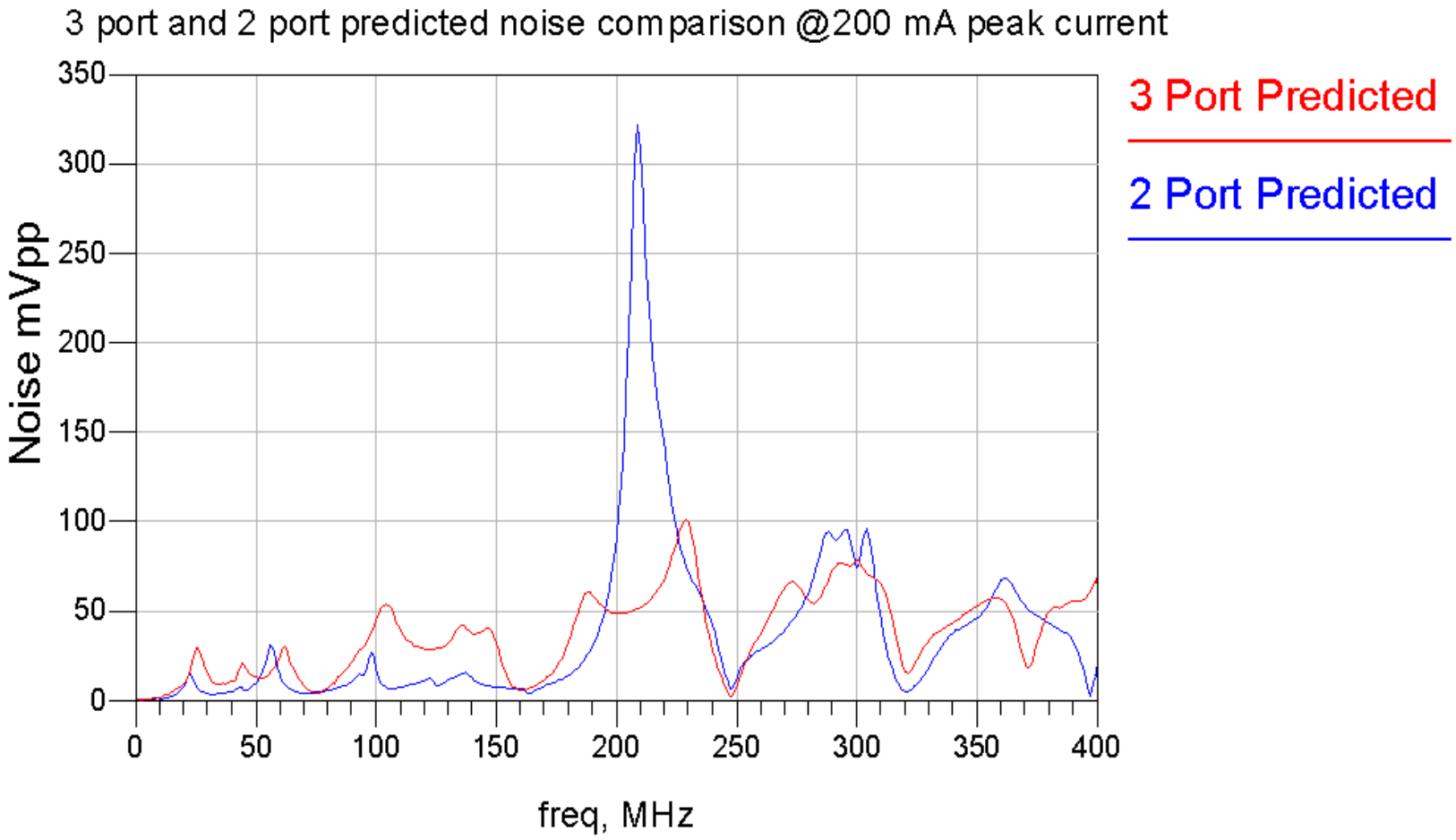
3-port and 2-port with Balun Predicted Noise Comparison for Case1



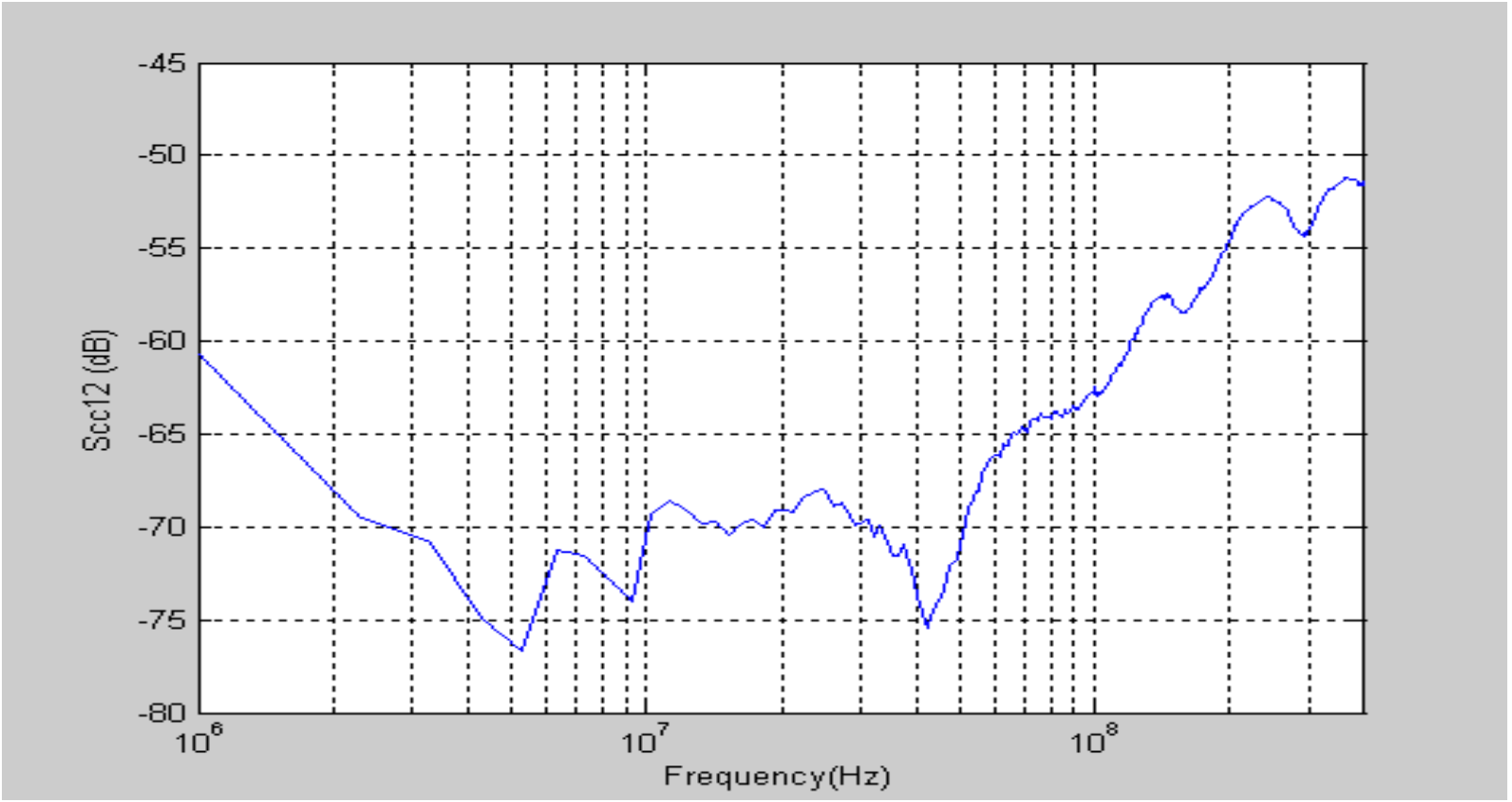
3-port and 2-port with Balun Mode Conversion Comparison for Case2 (The load end common mode floating)



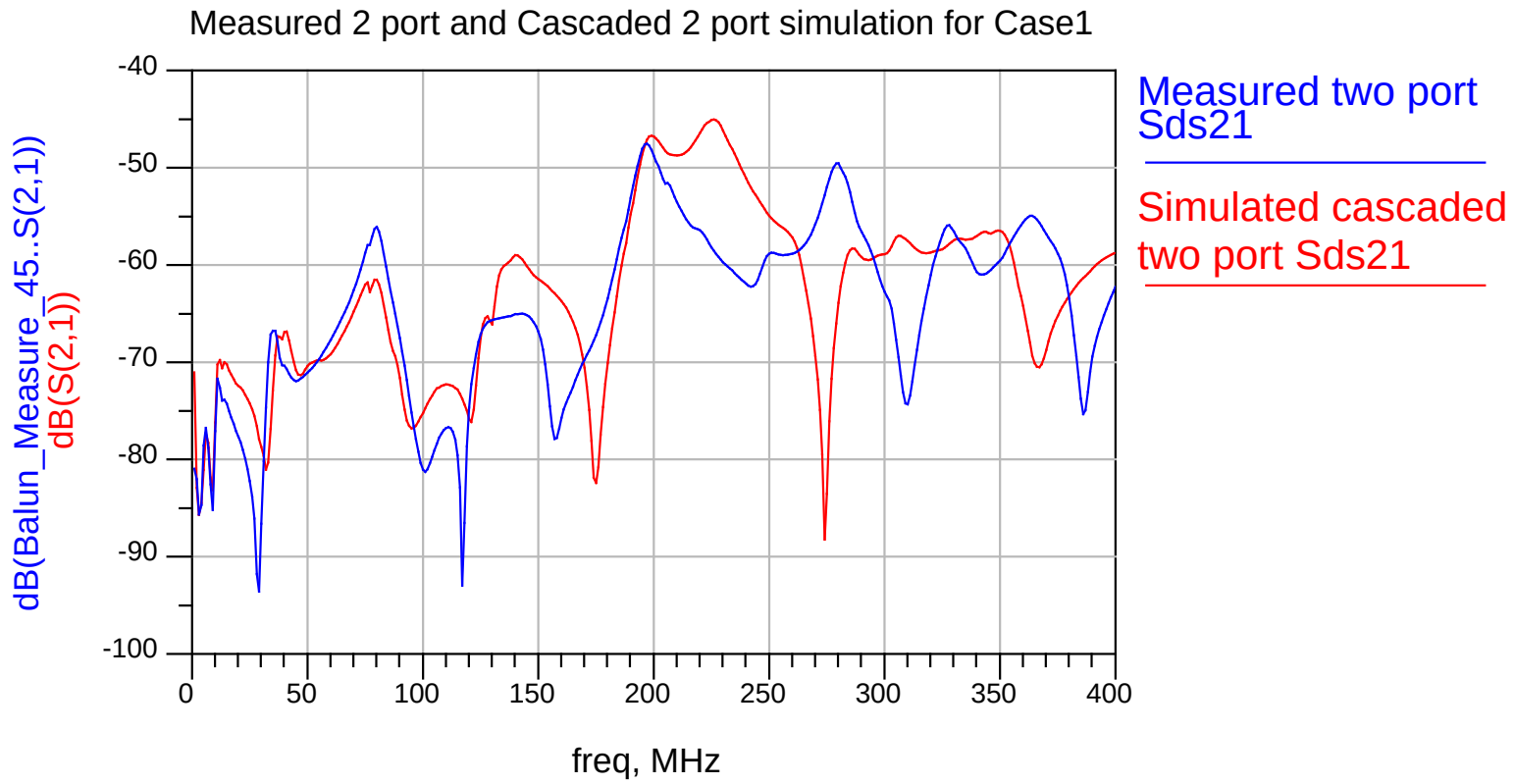
3-port and 2-port with Balun Predicted Noise Comparison for Case2



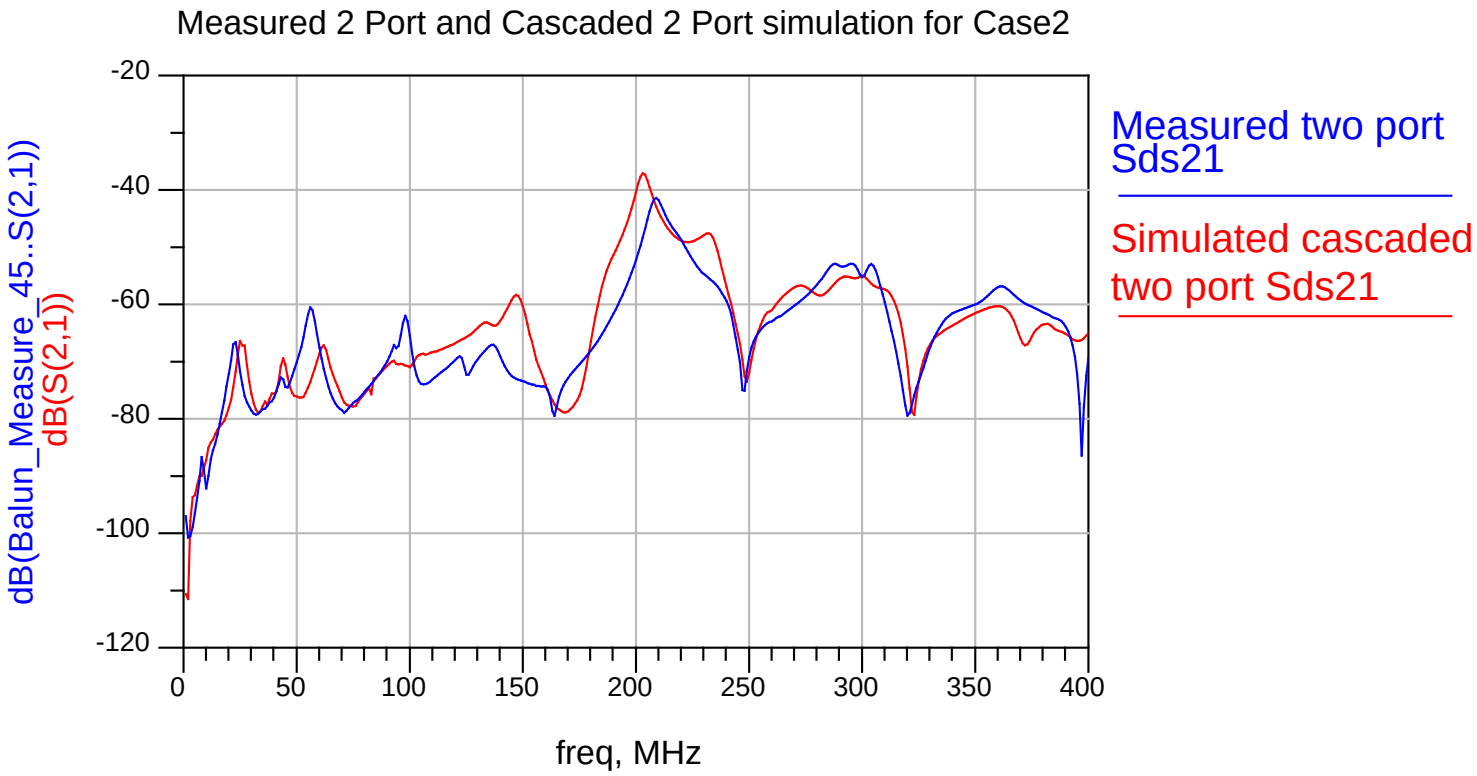
Balun S-parameter (balanced to un-balance Transfer Function)



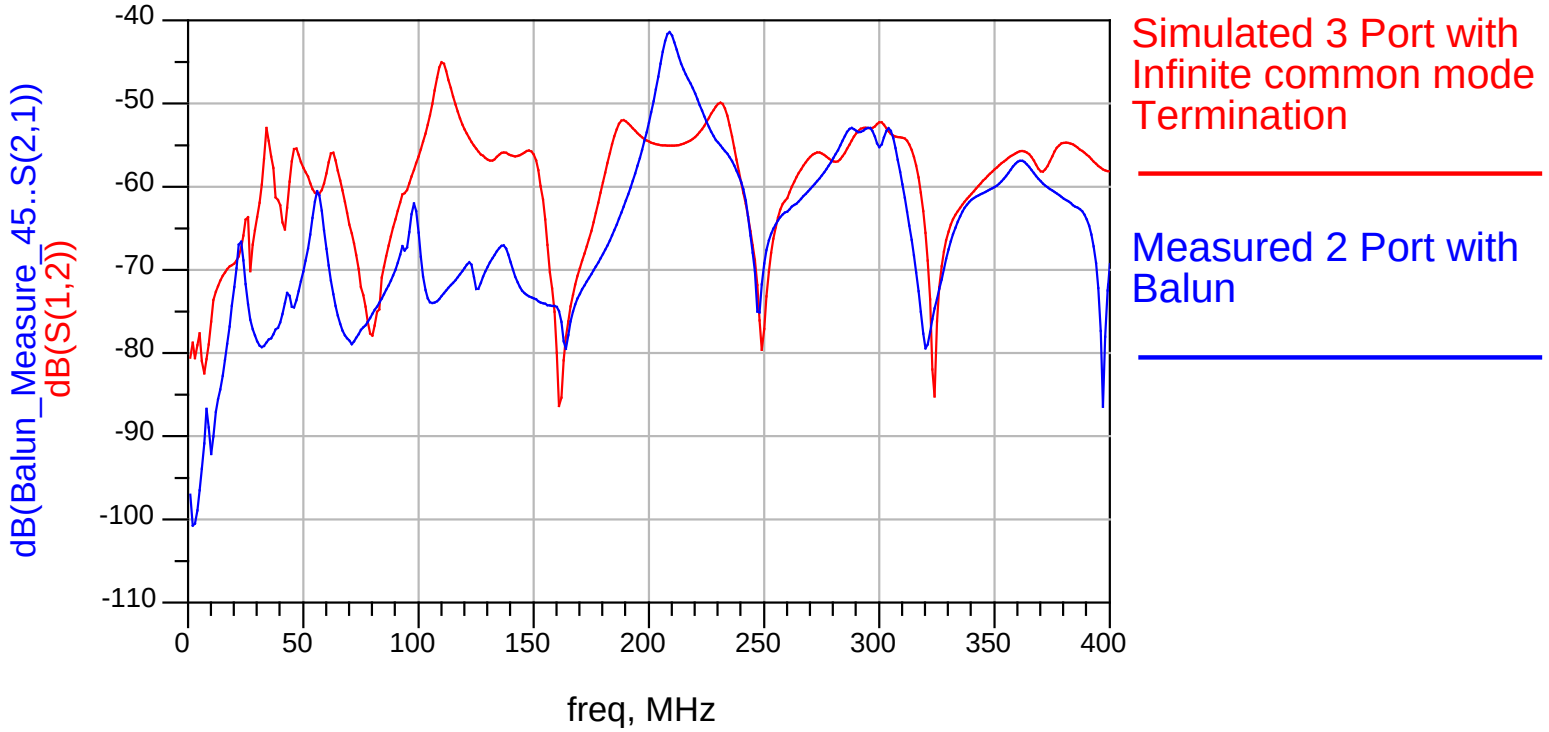
2-Port Measurement vs. 3-Port Balun Cascaded to 3-Port Cable Simulation for Case1



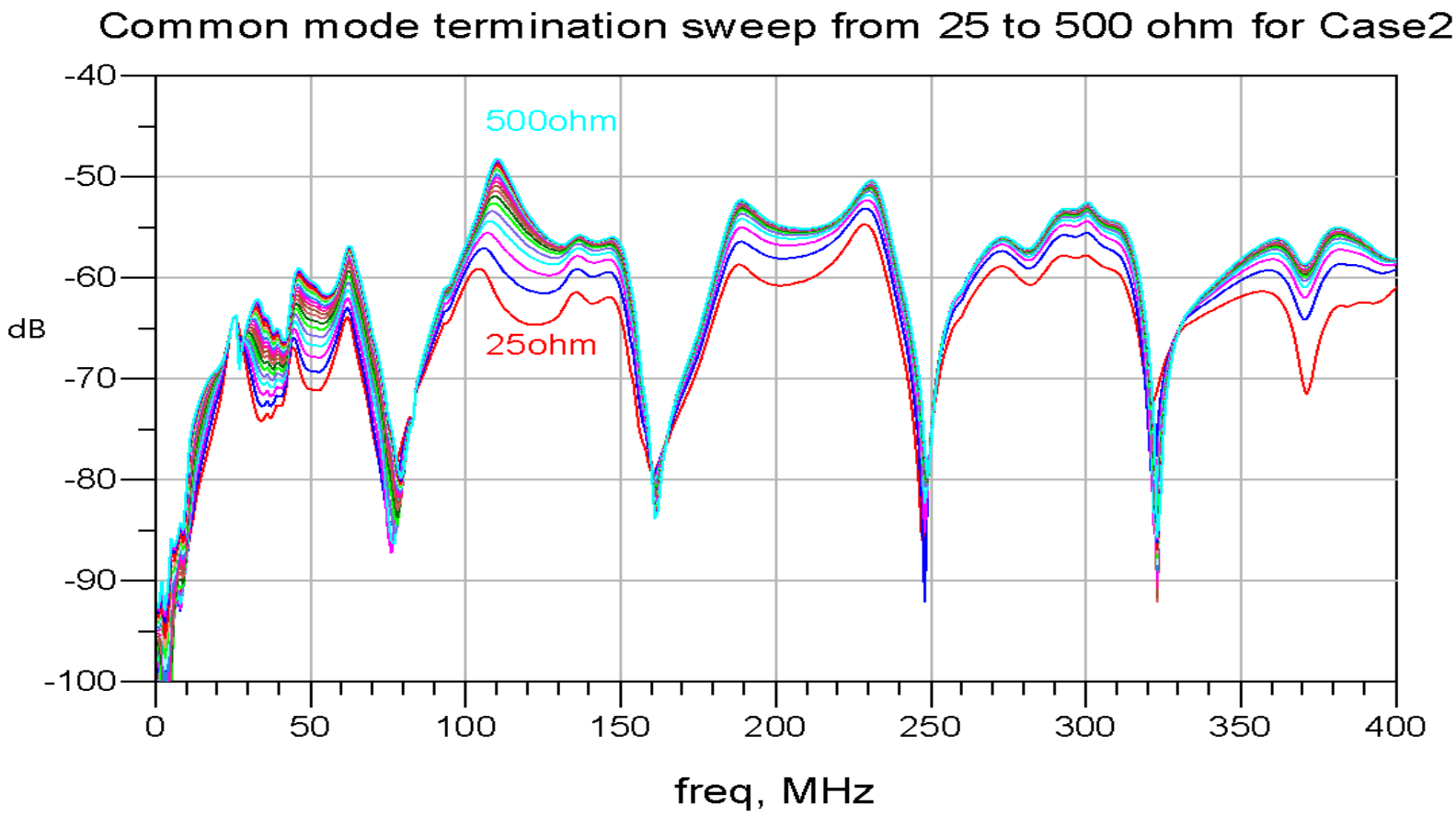
2-Port Measurement vs. 3-Port Balun Cascaded to 3-Port Cable Simulation for Case2



3-port simulation vs. 2-port measurement (3.5dB difference, both ends floated)



Mode Conversion vs. Impedance Variation (6dB difference of peak value, simulations from 3-port BCI S-parameter measurements)



Conclusions

- Predicted differential voltages based on S-parameter measurements correlate well with the time domain measurements.
  - The time domain measurement validates the Frequency domain measurement
- The common mode impedance does affect the mode conversion
  - 6dB difference observed by 2-port measurement
- 3-port and 2-port measurement methods cause 4dB difference for case1 and 10dB difference for case2
  - Case1:
    - 3-port: both ends terminated to 25Ohms
    - 2-port: one end (Balun side) floating, the other end (load side) terminated to 25Ohms
  - Case2:
    - 3-port: one end (measurement side) terminated to 25Ohms, the other end (load side) floating
    - 2-port: one end (Balun side) floating, the other end (load side) terminated to 25Ohms

Discussions

- Peak or RMS
  - BCI standard defines the current unit as a RMS value though different OEMs define their own BCI current limit line
  - Many OEMs if not most, use 200mA RMS as test standard. 802.3bp should define and have a consensus on the current limit line used in the EMC baseline, for example, 200mA RMS

-50dB Mode Conversion Limit Line

- 3-port BCI test S-parameters mode conversion (-55dB) is less than -50dB
  - Terminated on both side with common mode impedance of 25Ohms
- 2-port BCI test S-parameter (one end terminated with 25Ohms and the other end floated)
  - 4dB worse than that of the 3-port measurement
- 2-port BCI test S-parameter (two ends floated)
  - 6dB worse than one end terminated and another end floated
- Considering BCI Current limit defined as RMS Value
  - 3dB more interference power compared with the peak value, at least -53dB should be considered

Signal Budget Consideration

- Insertion Loss Baseline
- Modulation Scheme and Bandwidth
- FEC Coding Gain
- One-pair affirmation based on EMC Mode Conversion Limit line of -60dB (less than 100mVpp observed) and 200mA peak current limit
- Considering 60mVpp PHY (e.g. PAM4) requirement and -45dB worst case for cable
  - -66dB 3-port limit line required

EMC Mode Conversion Baseline

- Not only to meet the achievable baseline of cable
  - -50dB 3-port S-parameter
- But also to meet the signal budget requirement
  - -66dB(?) for the worst case
- Gap between the cable balance and the signal budget requirement
  - Gap: 16dB (200mA RMS current limit)

Discussion on the PHY Transient Performance

- EMC Baseline should be followed by Cable, connector and PHY venders
- Lower the transient BER requirement would reduce the SNR budget requirement (16dB gap), how low we can go? Bottom line?
- Lower the transient BER requirement would have limit on the critical and time-sensitive applications