IEEE 802.3dg
Task Force

Terminal Block Measurements

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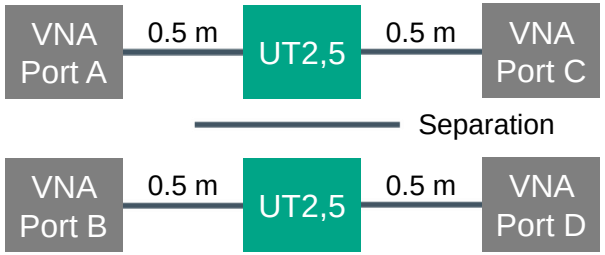
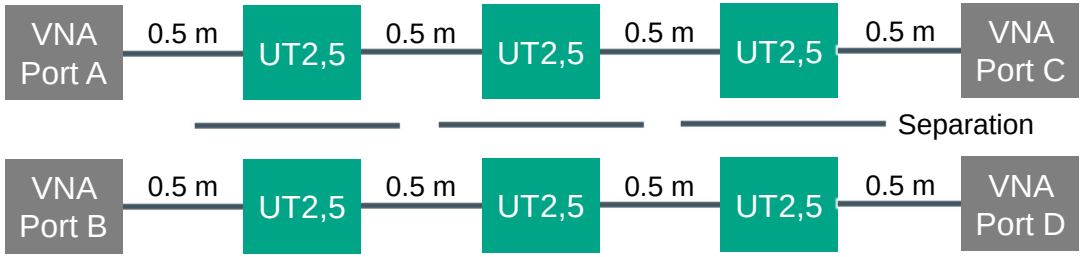
Measurements

- Different neighbored link segments with Phoenix Contact UT2,5 terminal blocks have been measured at room temperature related to crosstalk and return loss.
- The UT2,5 terminal blocks are connected using flexible (fine stranded) AWG18 fieldbus cable with a length of 0.5 m between the VNA and the terminal blocks and also 0.5 m between adjacent terminal blocks.
- Two identical link segments running in parallel have been created to measure the crosstalk.
- For the measurements the AEM MMVNA-100 has been used. This VNA provides 4 differential ports (A, B, C, D) for the measurement of the following link segments:

1 terminal block:



3 terminal blocks:



Measurements

5 terminal blocks:

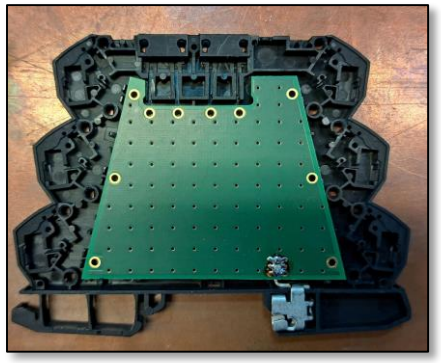
- As resonance effects have been seen in the measurements having very short intermediate cable segments, also an approximately 100 m long link segment has been measured (with the long cable between the second and third terminal block):

5 terminal blocks, 100 m segment:

- Different separation/shielding measures have been applied between the terminal blocks:
  - No separation.
  - 6 mm separation with grounded shielding PCB in between.
  - 12 mm separation with grounded shielding PCB in between.
  - 12 mm separation with grounded shielding PCB in between and also on the left and right side (as in practice there are more than two terminal blocks in a row).

Measurements

- To shield two neighbored terminal blocks from each other, the following shielding elements have been used:



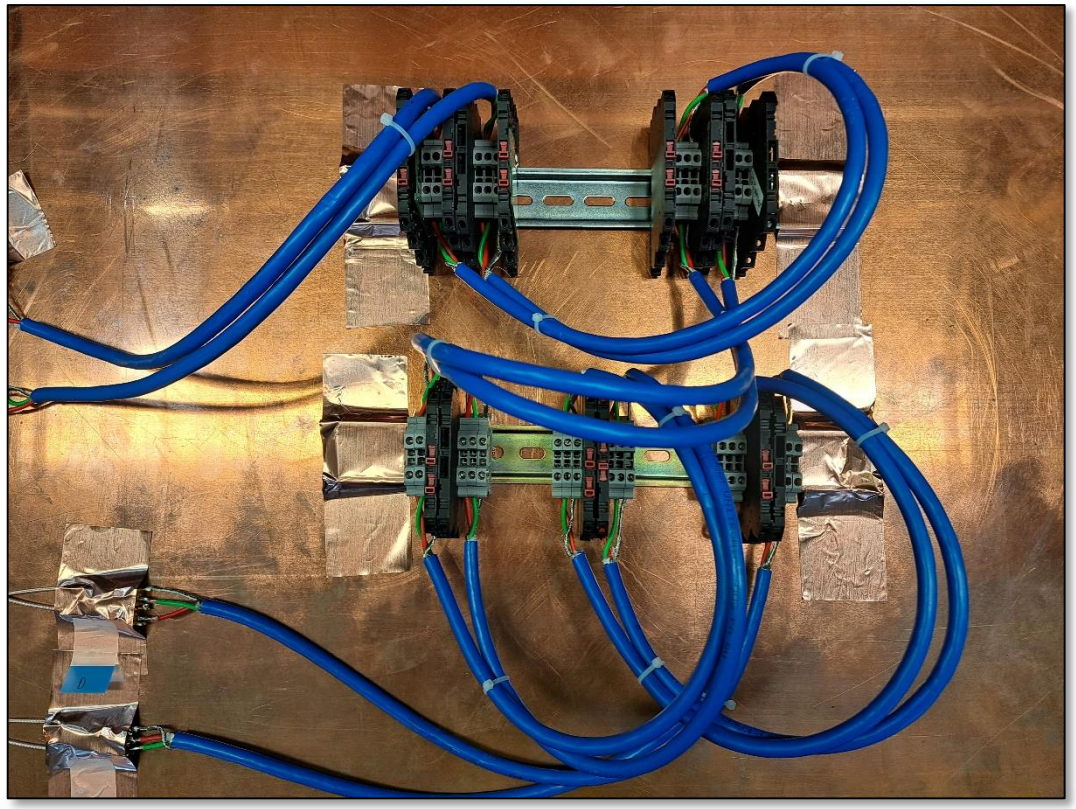
A 6 mm wide housing has a double sided PCB inside, which is connected to the DIN rail.

For a 12 mm wide separation, a spare housing is connected with the shown shielding element to provide a wider separation distance.

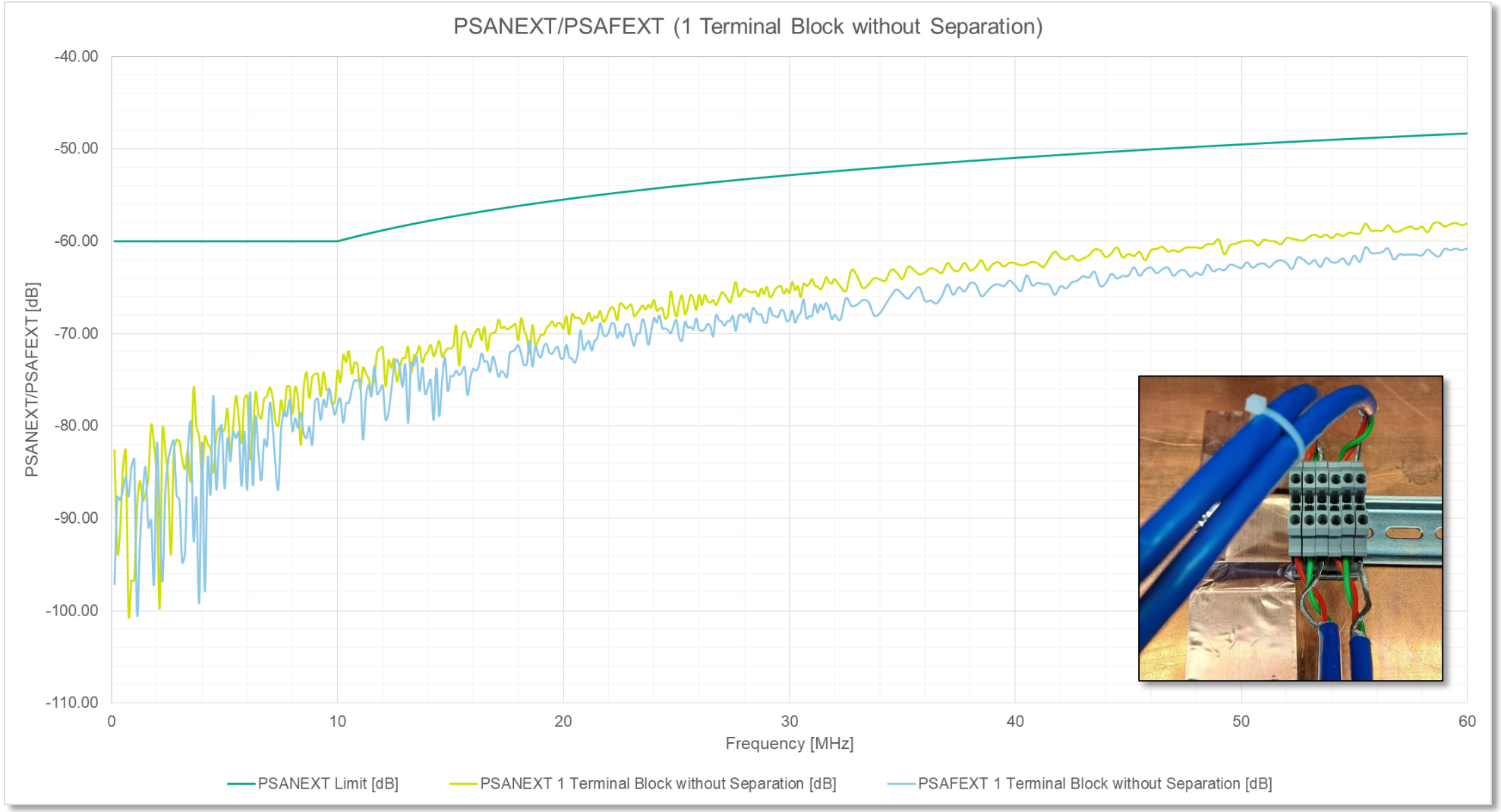
- The complete test setup has been mounted on a large copper plate as ground reference (which was connected using a 1 MΩ resistor to earth).
- The VNA was also placed on this copper plate and the SMA connectors (calibration reference plane of the VNA) were also referenced to this copper plate (using conductive copper tape).
- Compared to a rack mounting of the terminal blocks the seen resonance effects with short cables are larger in this setup (this might be because the way of the field lines to the ground plane is shorter causing less losses in the crosstalk).
- The large copper plate provides a more stable measurement setup compared to the rack mounting and is also nearer at a worst-case scenario related to the seen resonances.
- Also the wiring between the terminal blocks was not done as good as it could have been done in a lab environment, but more like it will be seen in the field, where there are imperfections in the twist of the wires and the layout of the cables.

Measurements

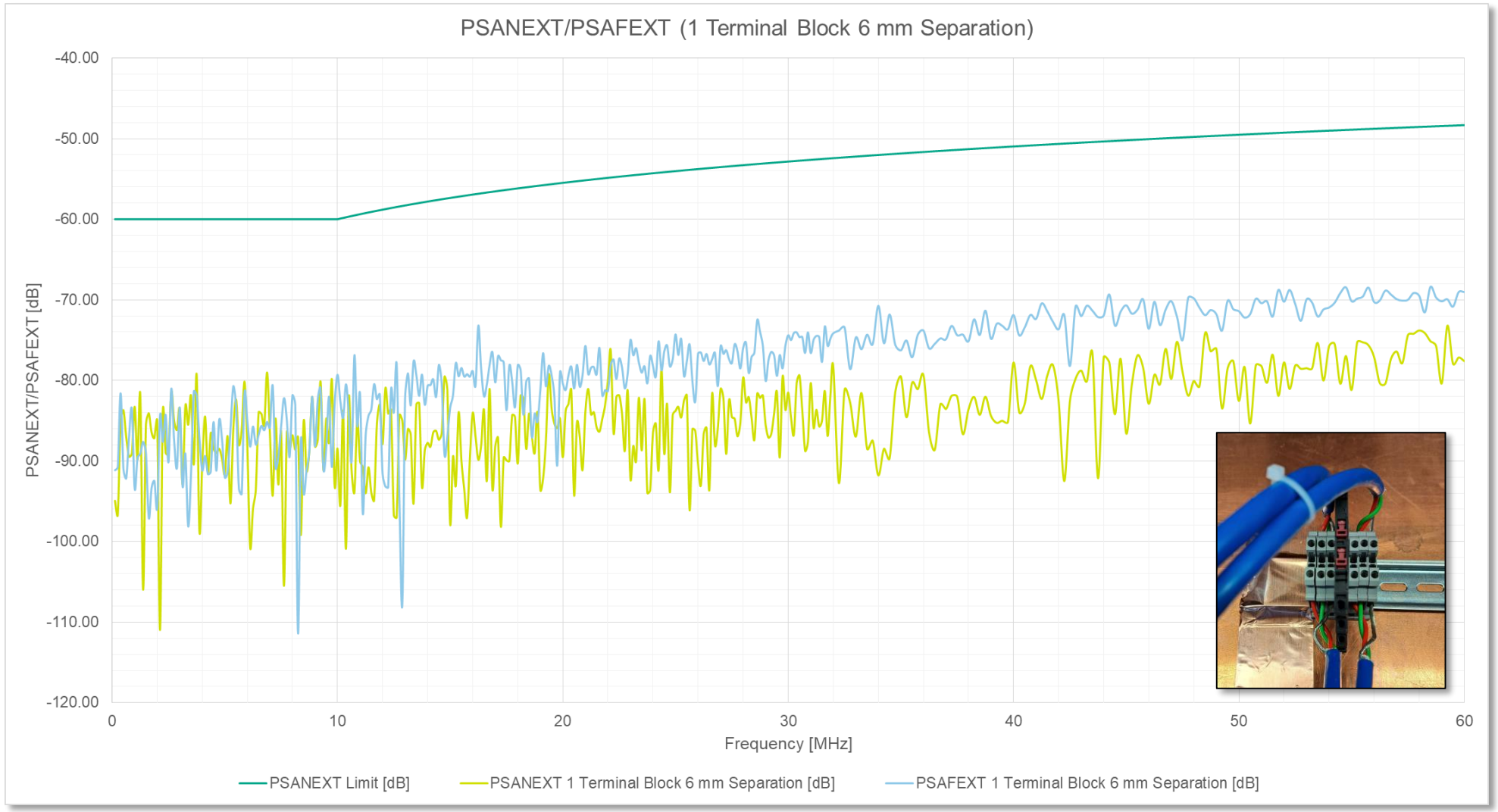
- The following picture shows an example of the measurement setup with the DIN rails, keeping the terminal blocks, taped to the copper plate and 12 mm separation elements between the terminal blocks.
- The first two terminal block groups also have shielding elements on the left and right side (we only built a total of 10 shielding elements, so not on all terminal blocks shielding elements could be placed on the left and right side).



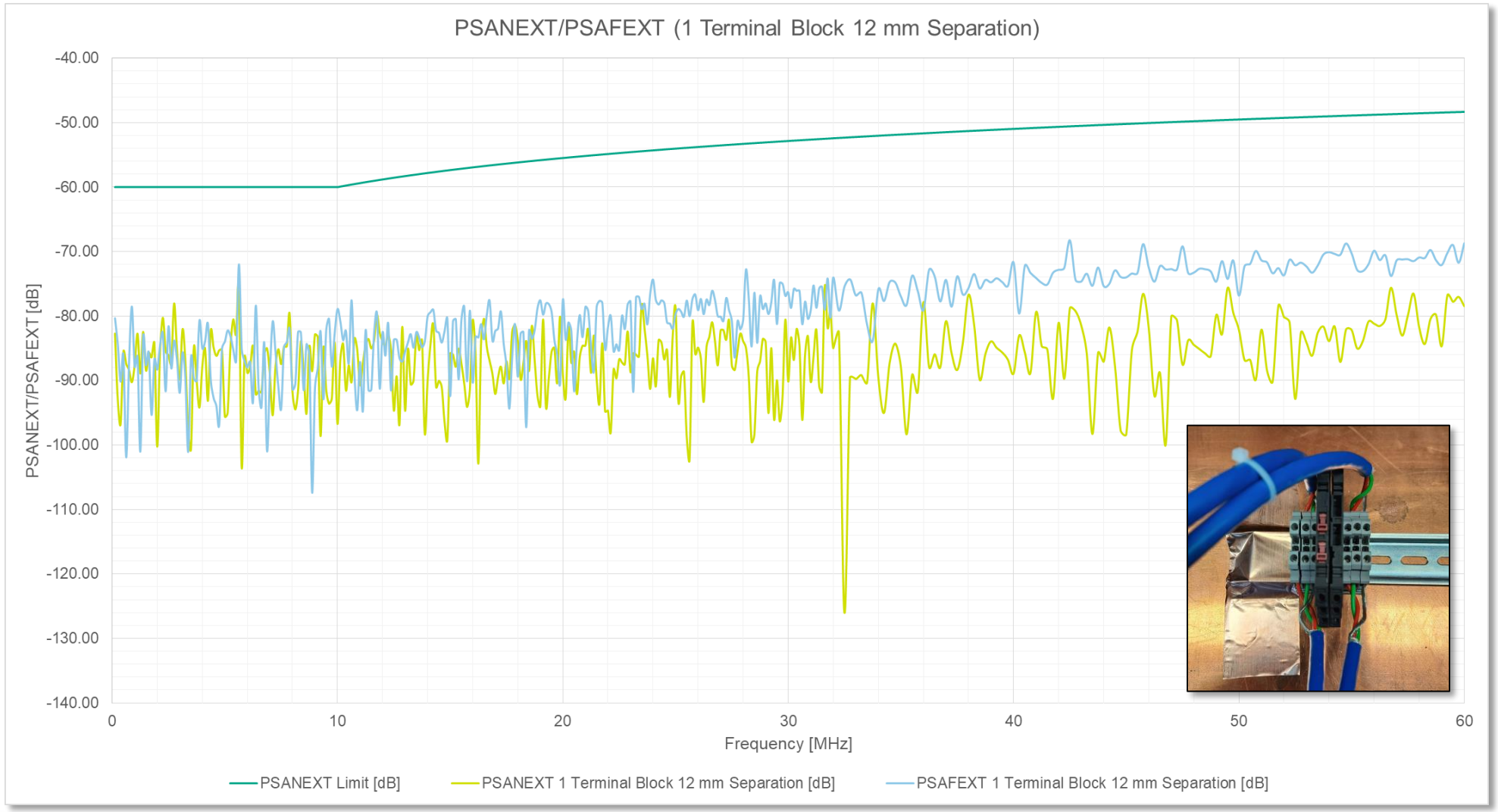
PSANEXT/PSAFEXT 1 Terminal Block without Separation



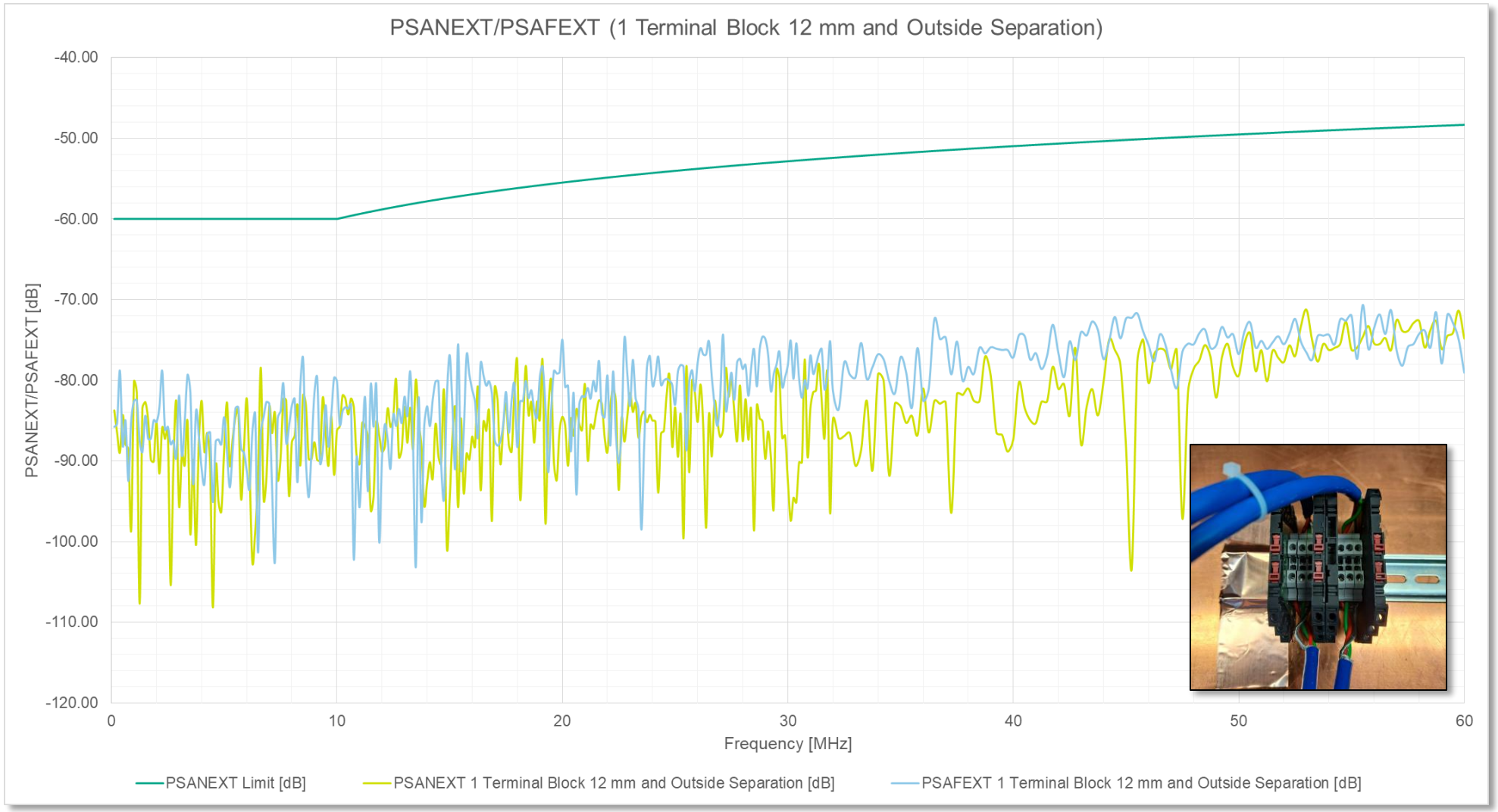
PSANEXT/PSAFEXT 1 Terminal Block 6 mm Separation



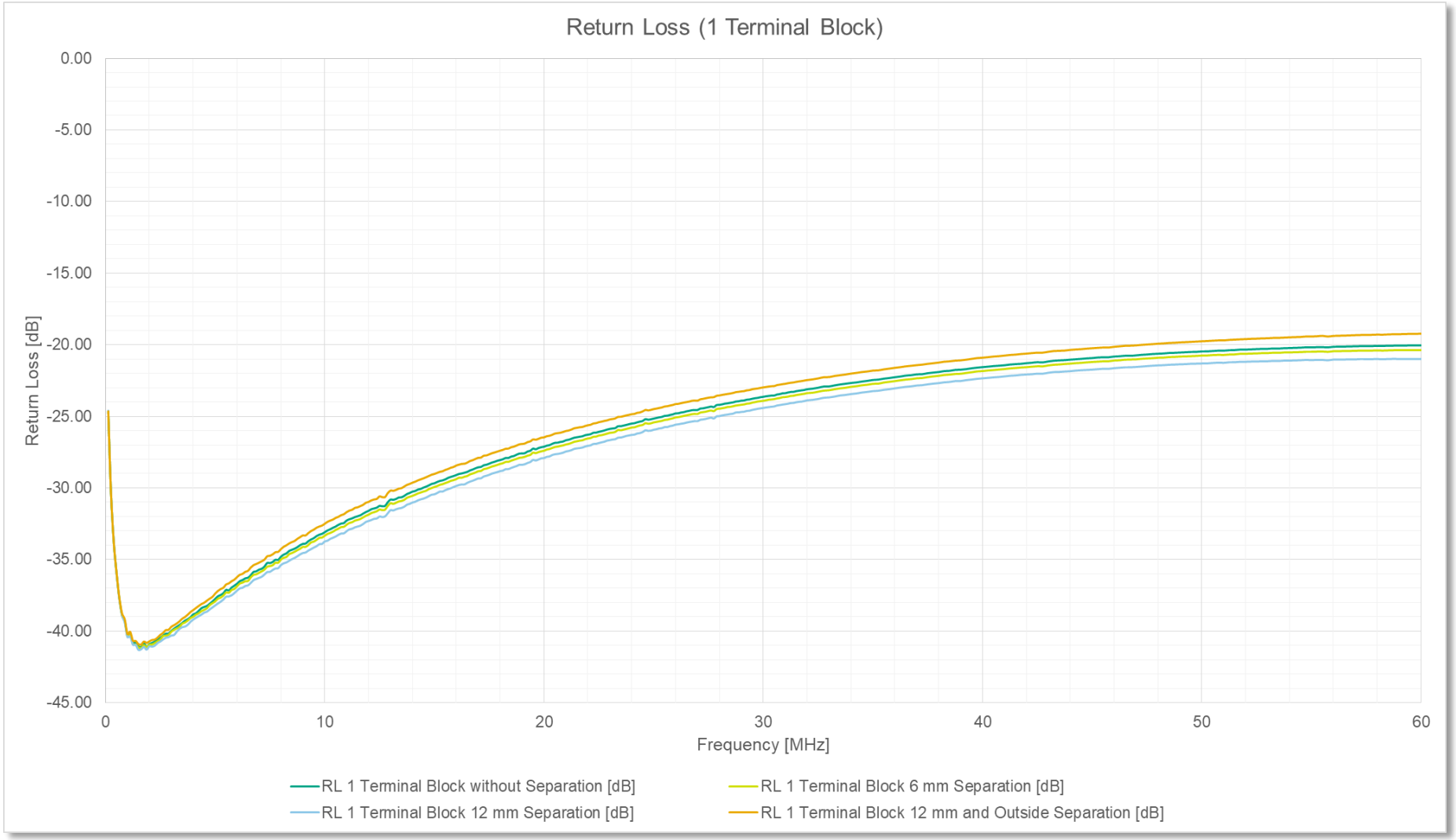
PSANEXT/PSAFEXT 1 Terminal Block 12 mm Separation



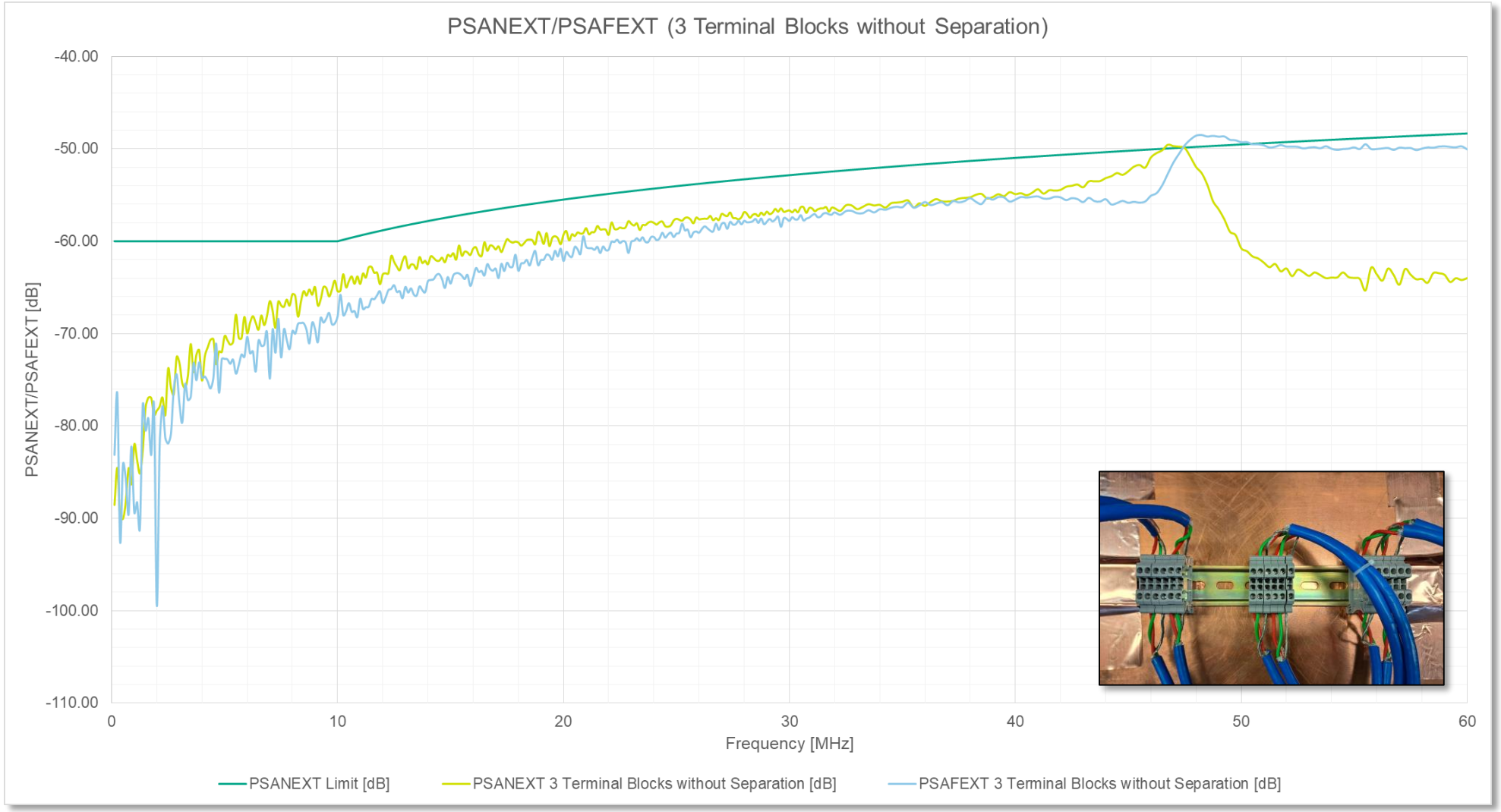
PSANEXT/PSAFEXT 1 Terminal Block 12 mm + Outside



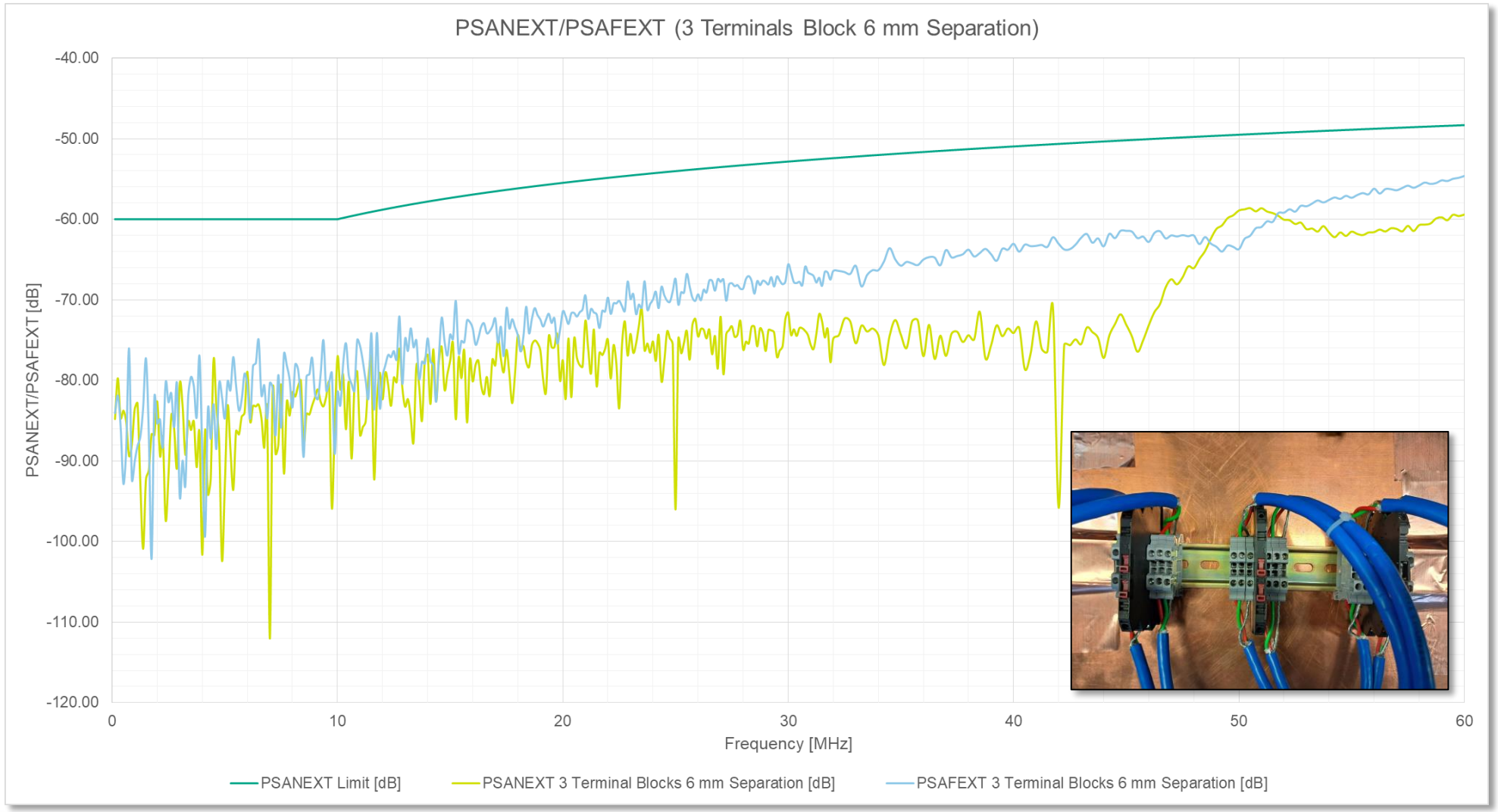
Return Loss 1 Terminal Block



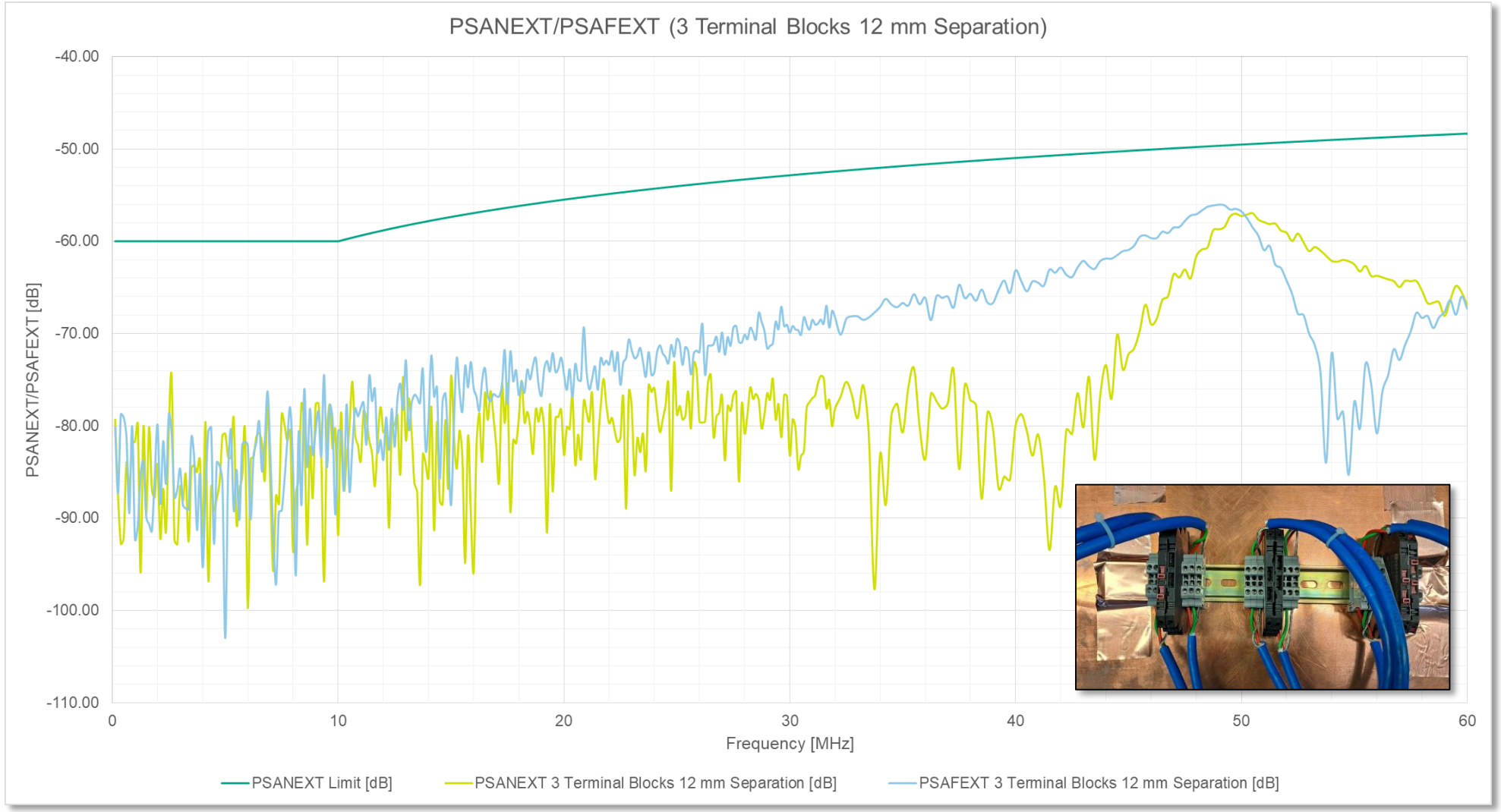
PSANEXT/PSAFEXT 3 Terminal Blocks without Separation



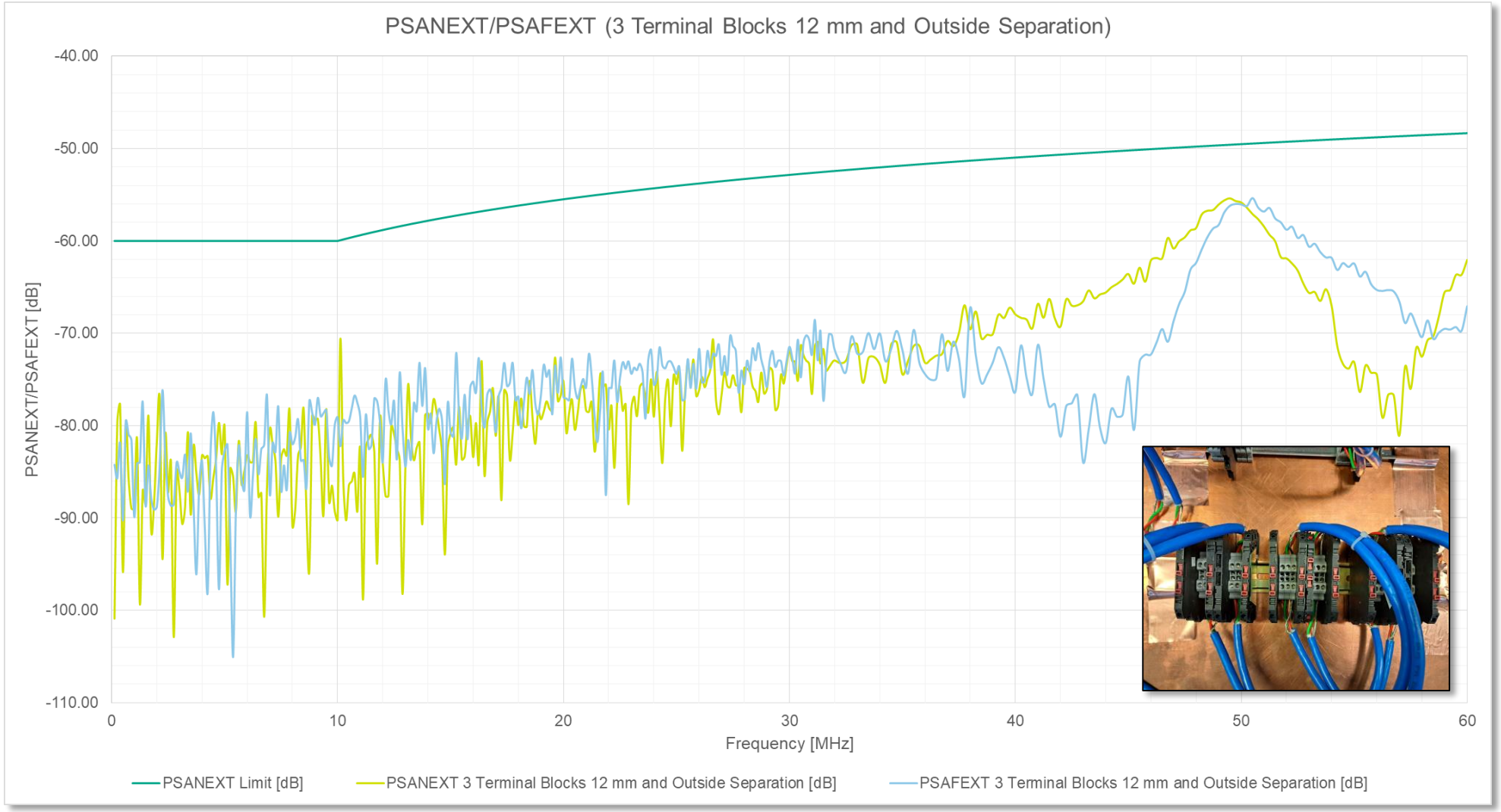
PSANEXT/PSAFEXT 3 Terminal Blocks 6 mm Separation



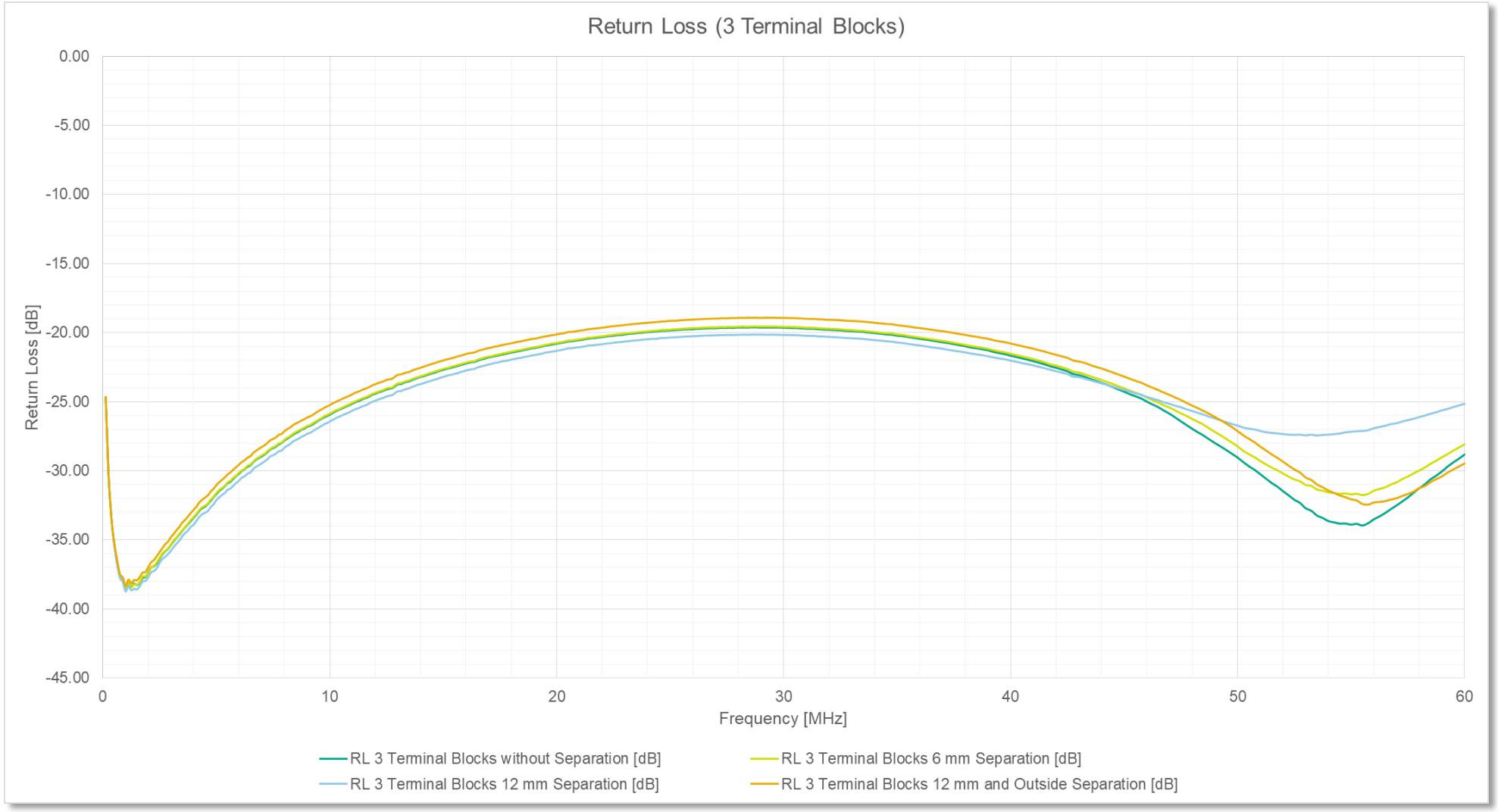
PSANEXT/PSAFEXT 3 Terminal Blocks 12 mm Separation



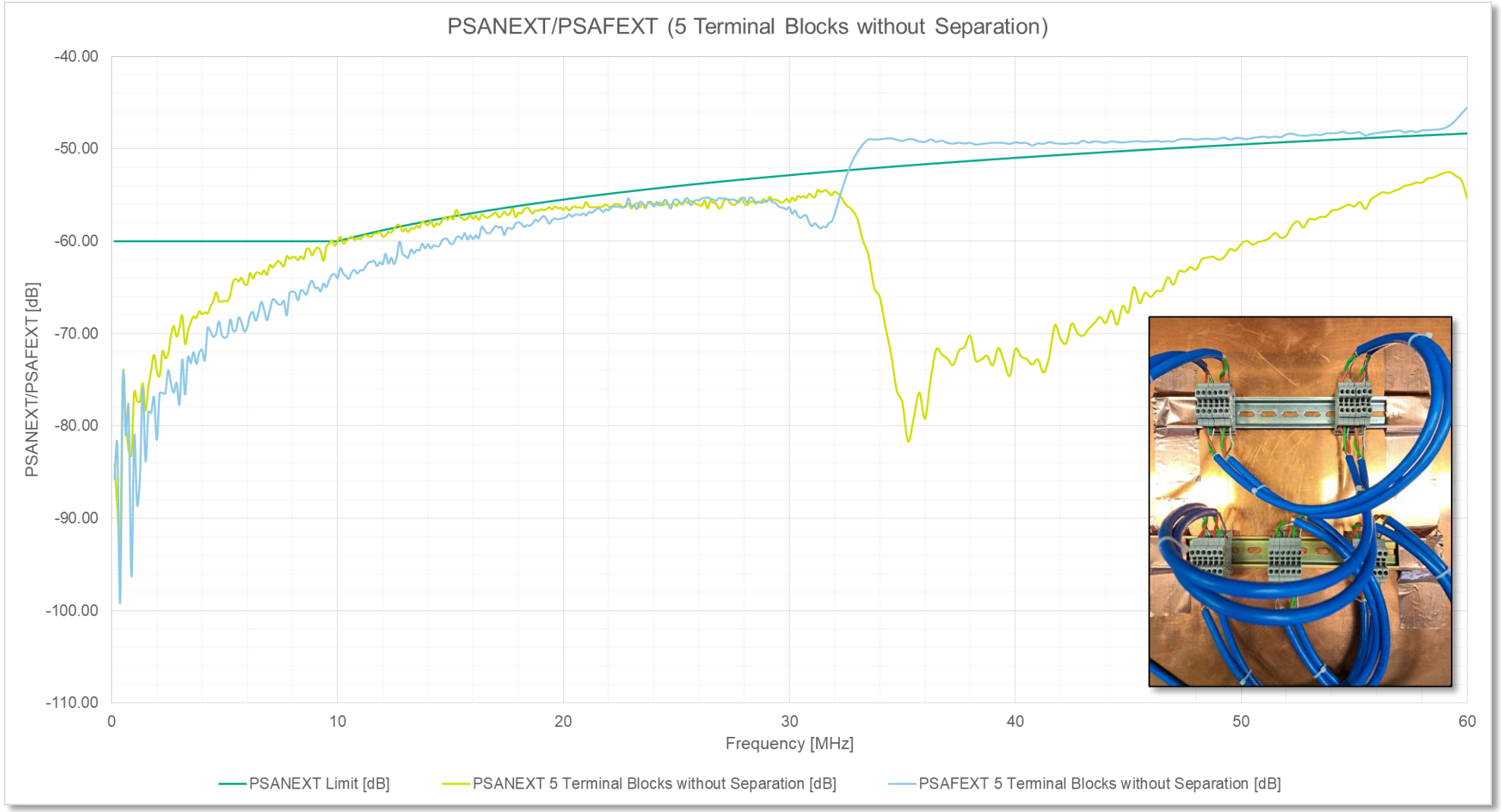
PSANEXT/PSAFEXT 3 Terminal Blocks 12 mm + Outside



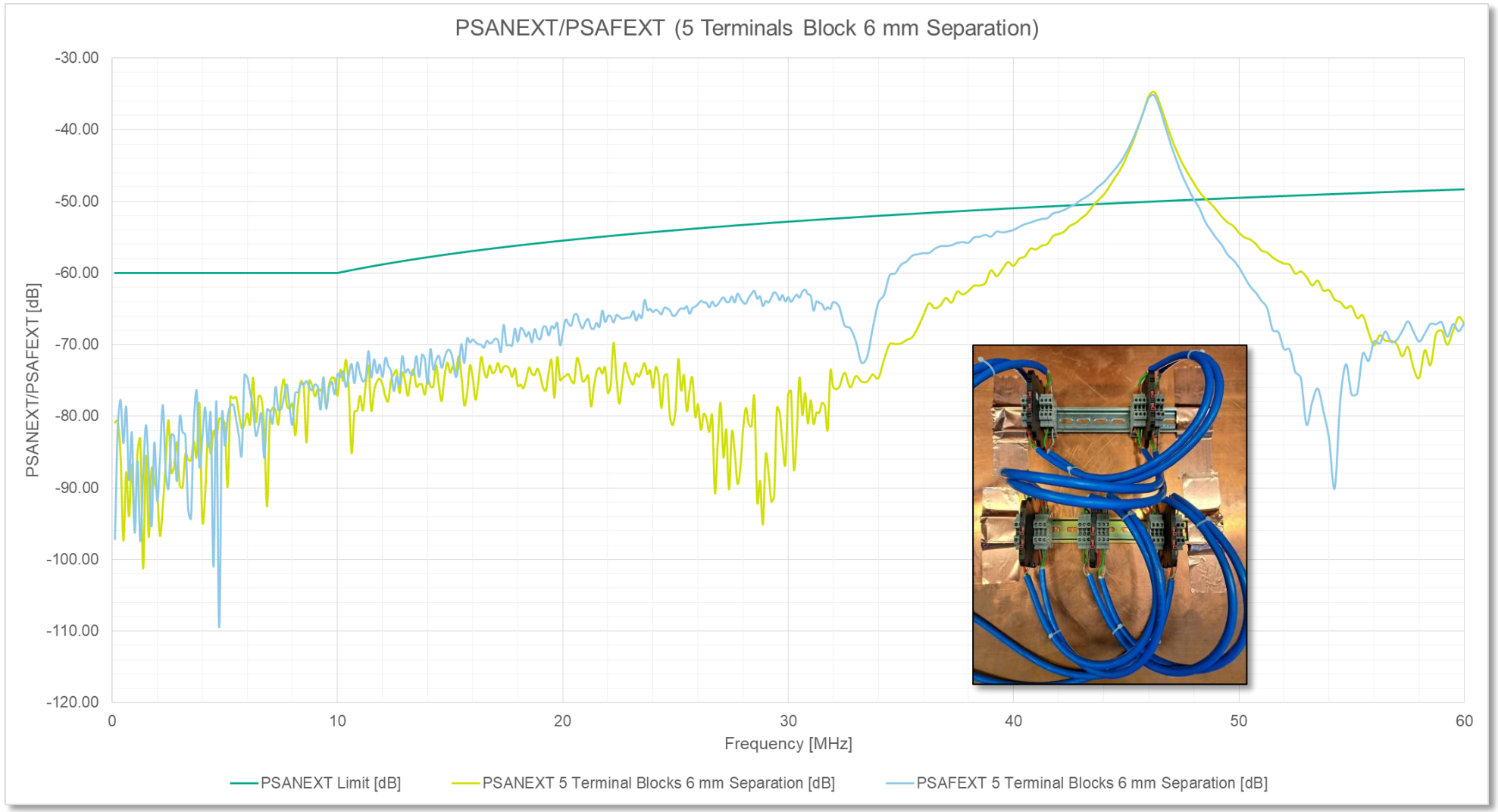
Return Loss 3 Terminal Blocks



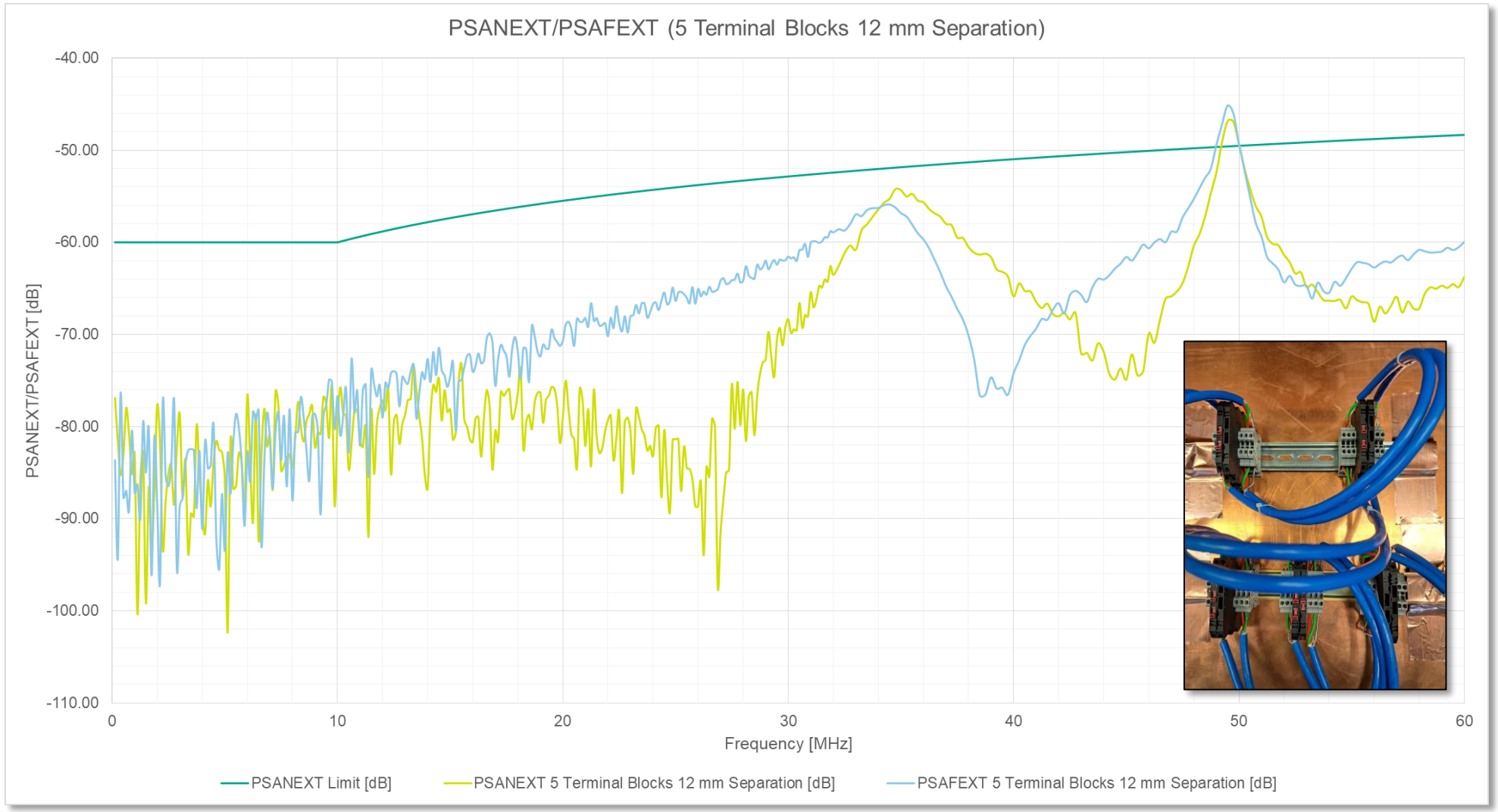
PSANEXT/PSAFEXT 5 Terminal Blocks without Separation



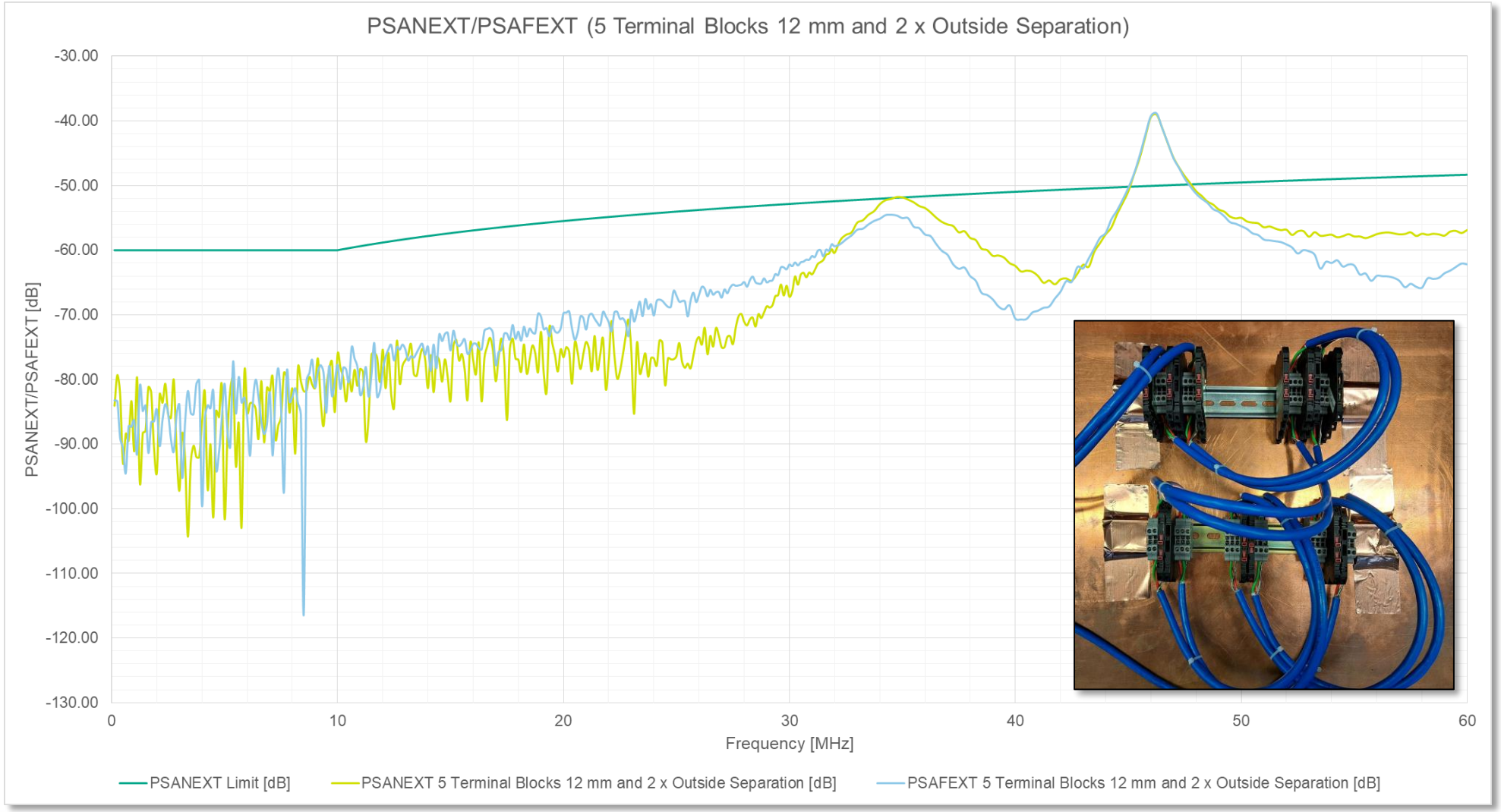
PSANEXT/PSAFEXT 5 Terminal Blocks 6 mm Separation



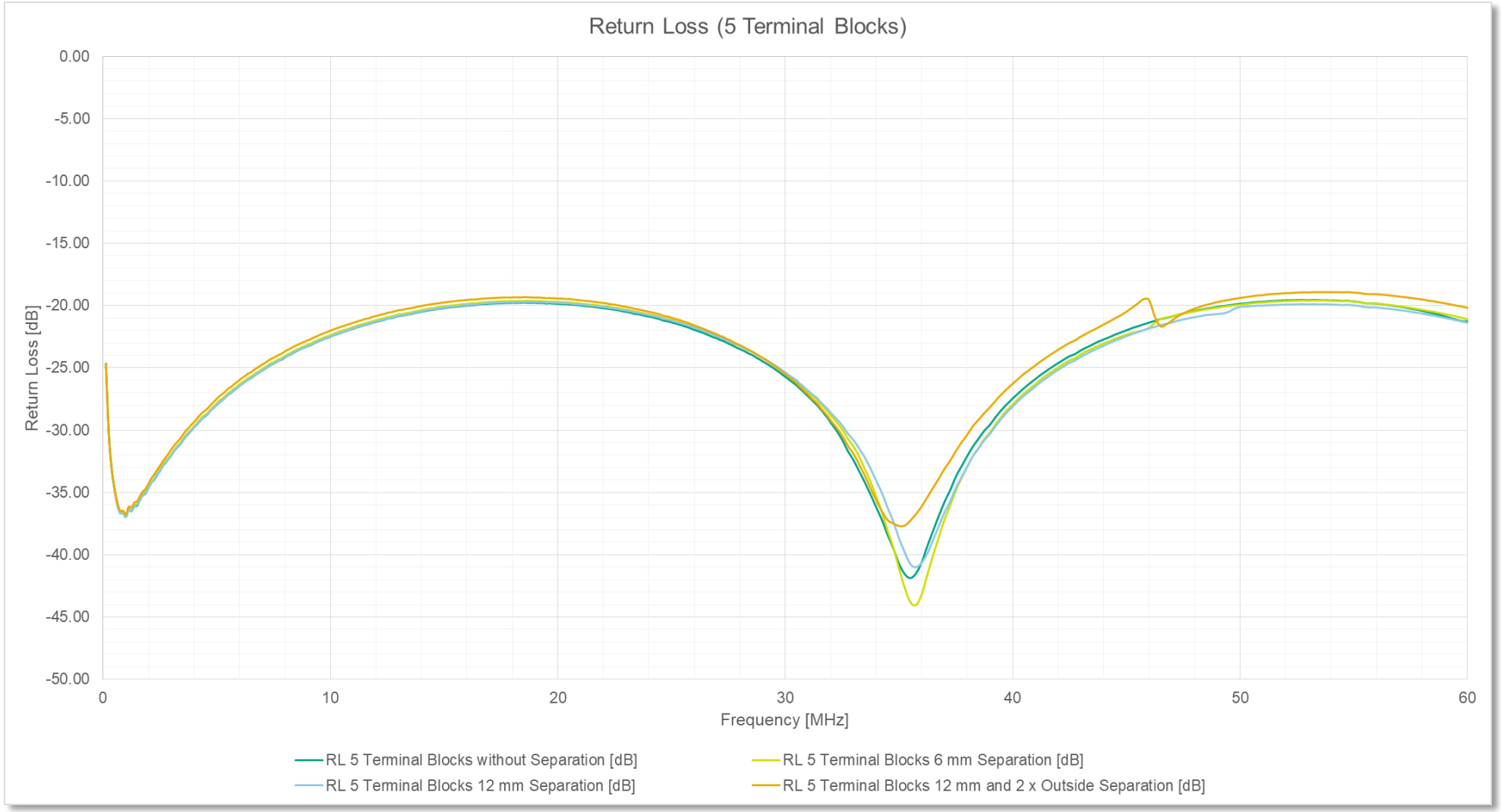
PSANEXT/PSAFEXT 5 Terminal Blocks 12 mm Separation



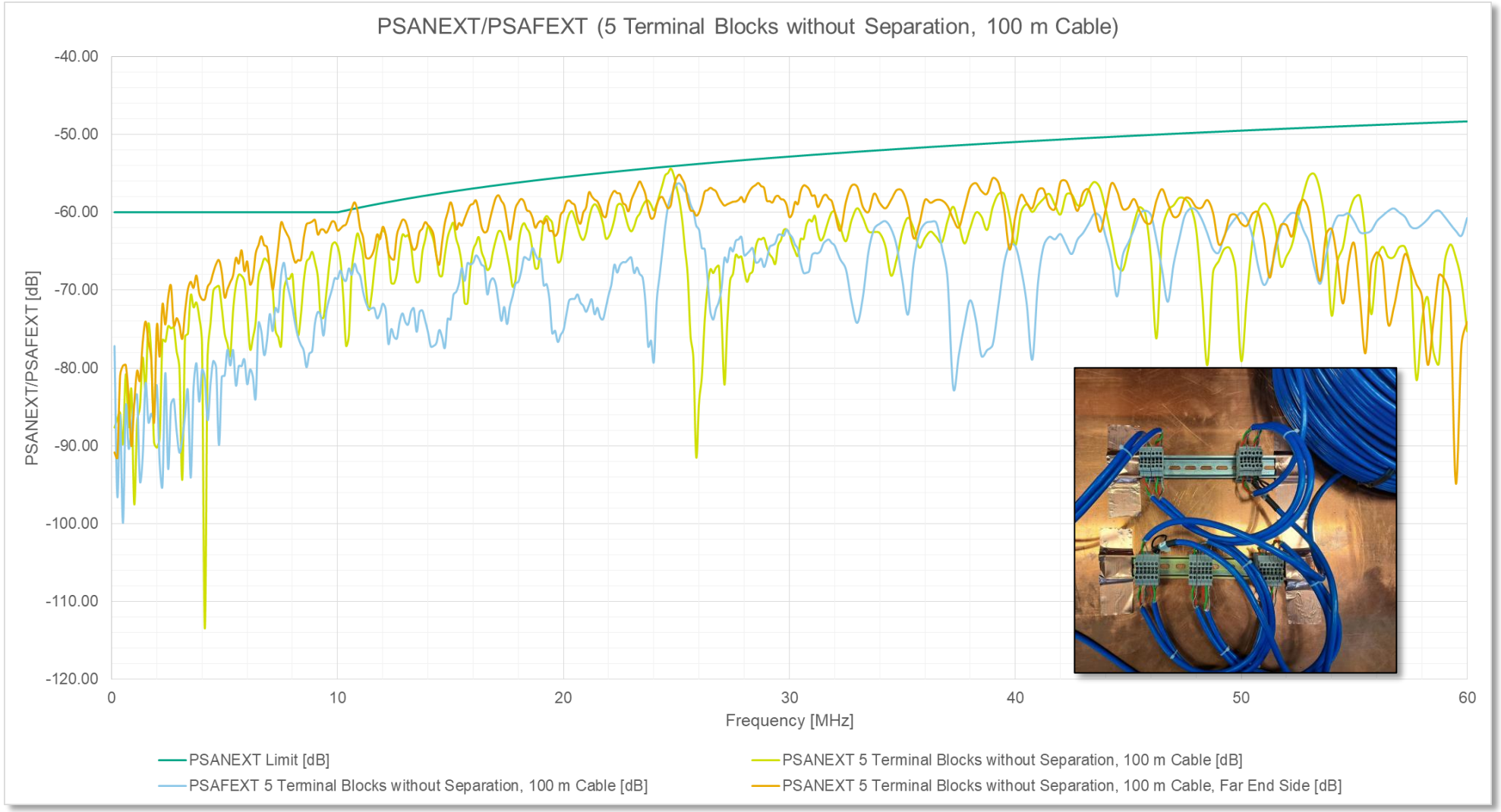
PSANEXT/PSAFEXT 5 Terminal Blocks 12 mm + 2 x Outside



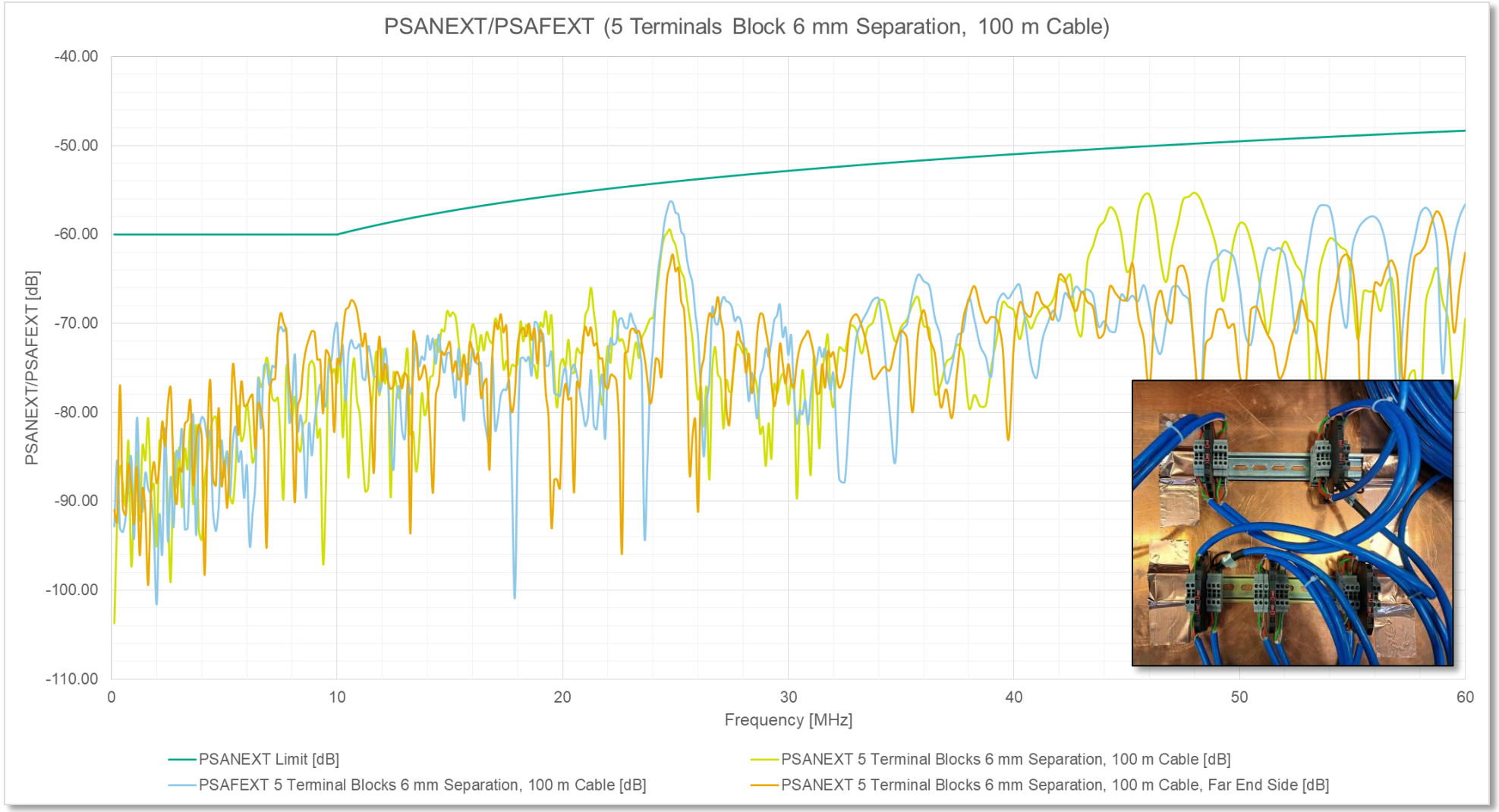
Return Loss 5 Terminal Blocks



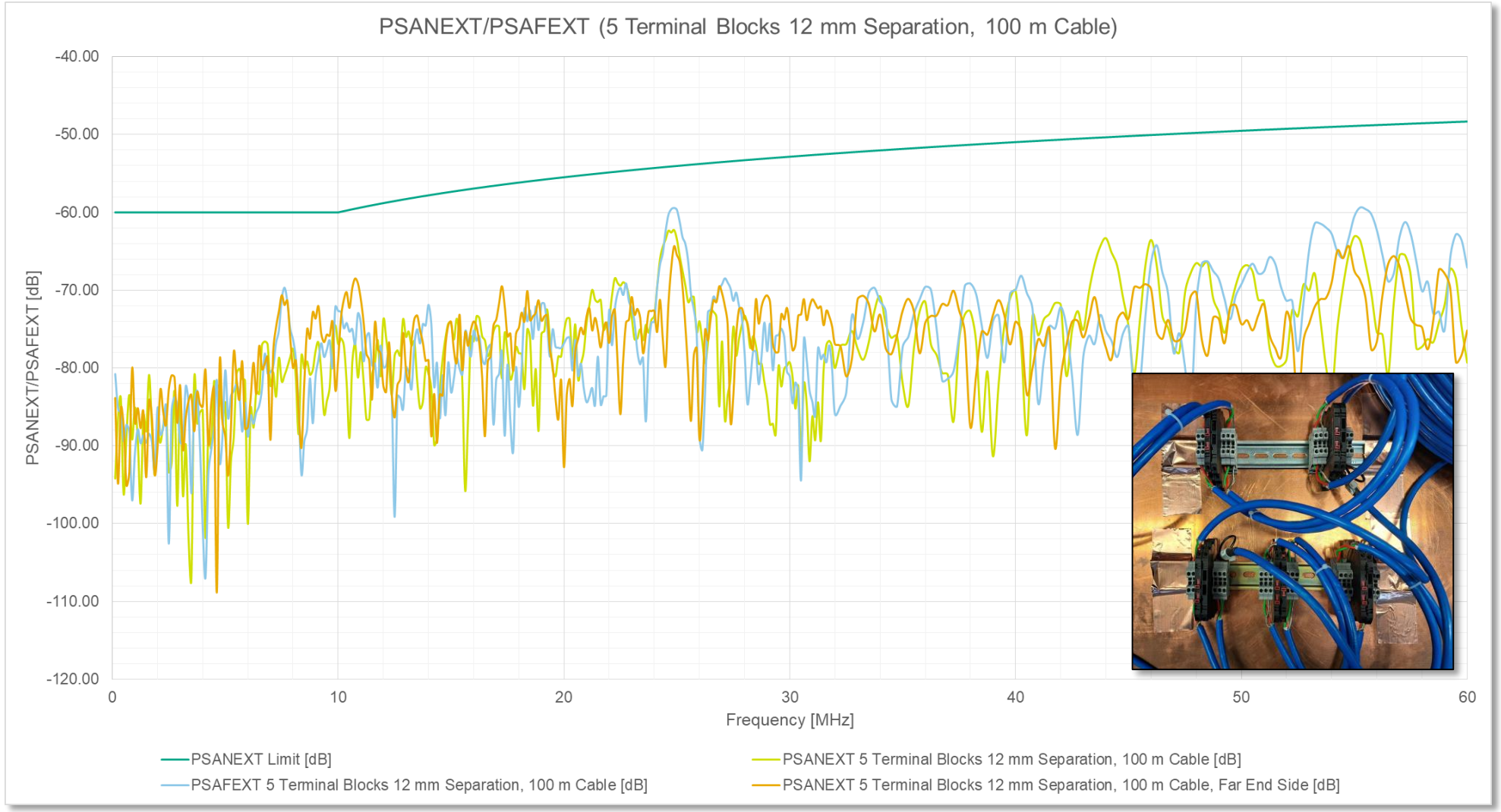
PSANEXT/PSAFEXT 5 Terminals no Separation, 100 m Cable



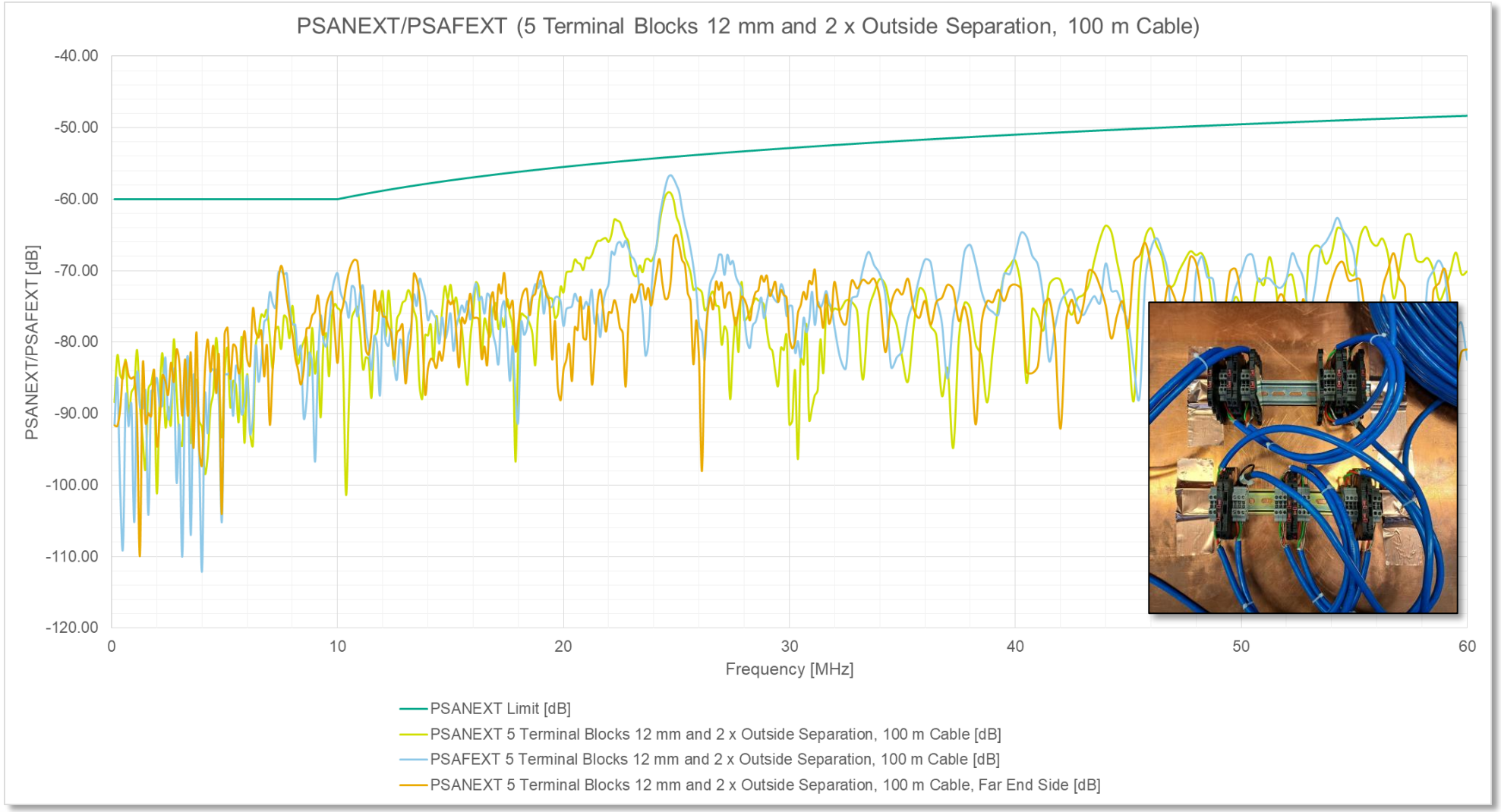
PSANEXT/PSAFEXT 5 Terminals 6 mm Spacer, 100 m Cable



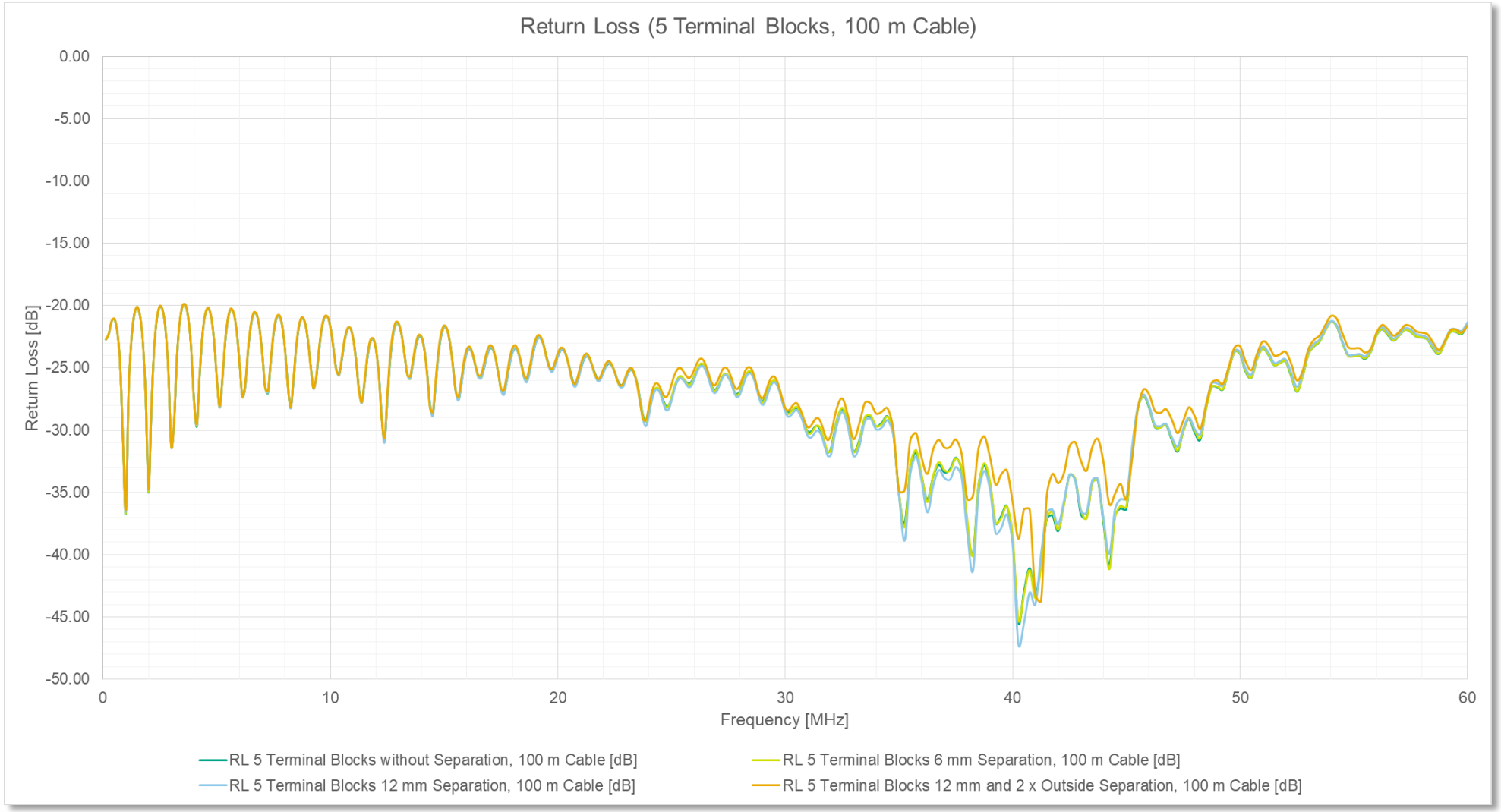
PSANEXT/PSAFEXT 5 Terminals 12 mm Spacer, 100 m Cable



PSANEXT/PSAFEXT 5 Terminals 12 mm + 2 x Outside, 100 m



Return Loss 5 Terminal Blocks, 100 m Cable



Results

- The crosstalk measurements are only done with one disturber, so another 3 - 4 dB must be added if multiple disturbers are present.
- For up to three UT2,5 intermediate terminal blocks the built link segments support the suggested PSANEXT limit of:

$$PSANEXT\ [dB] = 60 - 15 \times log_{10}\left(\frac{f}{10}\right)$$

- The PSAFEXT measurements show a similar level as the PSANEXT measurements, so as a first approach for the PSAFEXT (or PSAACR-F equivalent) the same limit as for the PSANEXT could be reasonable.

- For five intermediate terminal blocks, if mounted on a copper plate, resonance effects occur, which violate the suggested limit line for short segments, nevertheless in such a case the receive signal is pretty strong, as there is no significant insertion loss.
- Compared to the receive signal, the crosstalk is still low, but further analysis, how this can influence the PHY receiver are necessary.
- For an approximately 100 m link segment, splitting the intermediate terminal blocks into two groups, the described resonance effects are not visible anymore in the crosstalk measurements.
- The resonance frequencies are closely related to the link segment length. For just one terminal block (and a 1 m total segment length), the resonance frequency is in the range of 100 MHz and thus out of the 60 MHz bandwidth specified for 100BASE-T1L.
- Having three intermediate terminal blocks, the segment length (λ / 2) is 2 m and the resonance frequency is approx. 50 MHz.
- For five intermediate terminal blocks, the segment length (λ / 2) is 3 m and the resonance frequency is approx. 33 MHz.
- For longer segments the insertion loss gets higher, which attenuates the resonance (and shifts it down to lower frequencies), so that it is no more visible in the crosstalk measurements.

Thank you!