08-280r0

Active Copper Cables for SAS-2.x, Part 3:

Performance Update, Power Supply Signal Integrity Study

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QUELLAN
MORE SIGNAL | LESS NOISE

Issues We Needed to Address (from 08-103r0)

- Performance:
  - Can the 20 meter reach target be achieved with active cables? Yes
  - Can SAS protocol features be supported with active cables? Yes
- Power Delivery:
  - Will using some of the ground pins for power and sense affect signal integrity (crosstalk)? No
- Backward Compatibility
  - Will passive cables work on active ports? Active cables on passive ports?
  - Is keying needed? New Keying proposal from Molex addresses this

Performance (PlugFest and Internal testing results):

The Good News:

- 15m (26 AWG), 20m (26 AWG), 25m (24 AWG) active cables, prototyped by Quellan and Molex, tested at the Plugfest and privately.
- 15m (26 AWG) active cable interoperated with multiple silicon vendors at 6G, error free. 3G worked error free on all lengths.
- OOB worked in all cases, never an issue!
- Doomsday scenarios of DFE schemes collapsing because of active cable limiting output did not materialize.
- Did I say OOB works!

Things to Improve:

- Anything longer or thinner that 15m 26 AWG (or 20m 24 AWG) is challenging with this prototype implementation. Cable termination area and solder pad layout on the prototype paddle card identified as the culprit.

Next Steps:

- Improved paddle card layout and cable termination to get up to 25m cable to work
- SSC testing
- STP flow control (buffer size investigations)

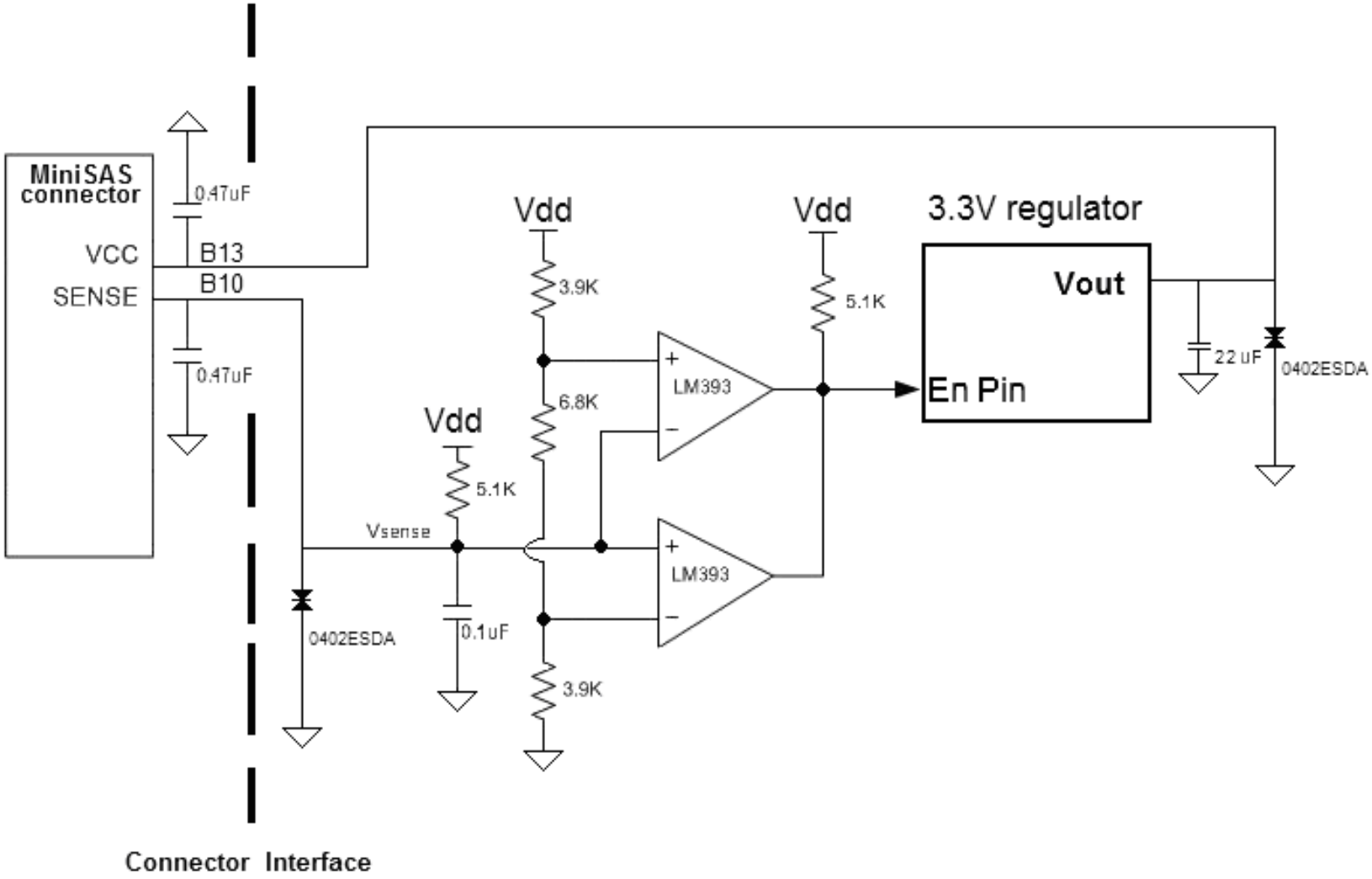
Power Delivery:

- A concern is sometimes voiced that using ground pins for power may undermine crosstalk performance, in particular when a passive legacy cable is used on an active port.
- Experience from other standards suggest that bypassing the ground pins with chip capacitors combined with capacitive coupling of the power planes and the ground planes on the system side relieves this concern.
- Sense pin is beneficial for active cable recognition and power supply logic, enabling safe operation of powered ports with legacy passive cables. It is a proven method used in InfiniBand, 10GBASE-CX4, etc.

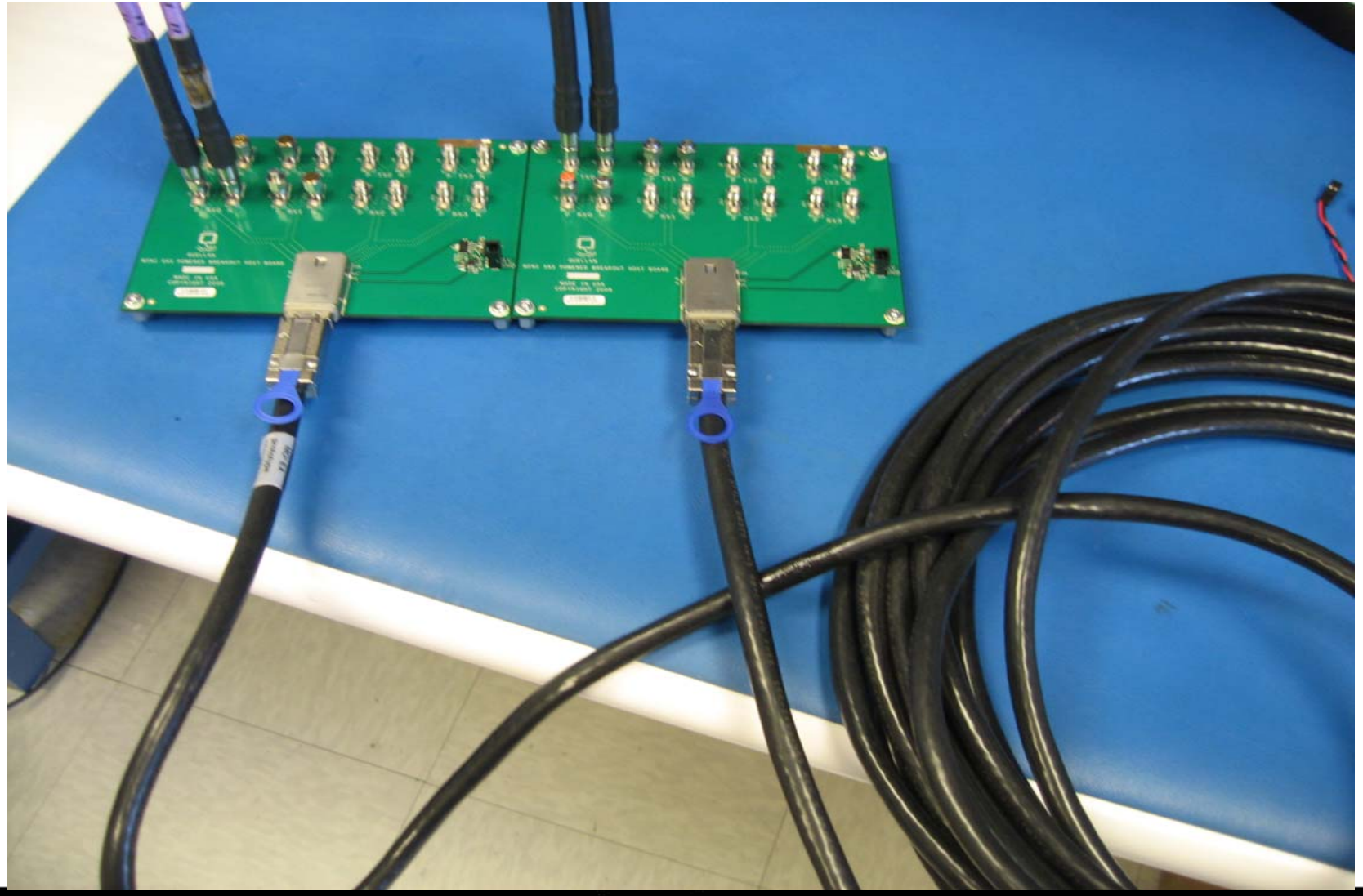
Power Delivery *(continued):*

- To confirm, the following test has been done:
  - An SMA test board was fabricated to emulate an active system per active SAS-2.x spec (08-052), complete with voltage sense logic circuitry (see next slide).
  - A 10m mini-SAS passive cable assembly was connected to two of these boards.
  - NEXT, FEXT as well as TX/TX and RX/RX isolation was measured with an Agilent VNA. Worst case NEXT was also compared to results with a passive Molex SMA board.
  - The results are shown to be well within the passive cable crosstalk spec, and no detrimental effect of using B13 for Vcc and B10 for Sense was seen.

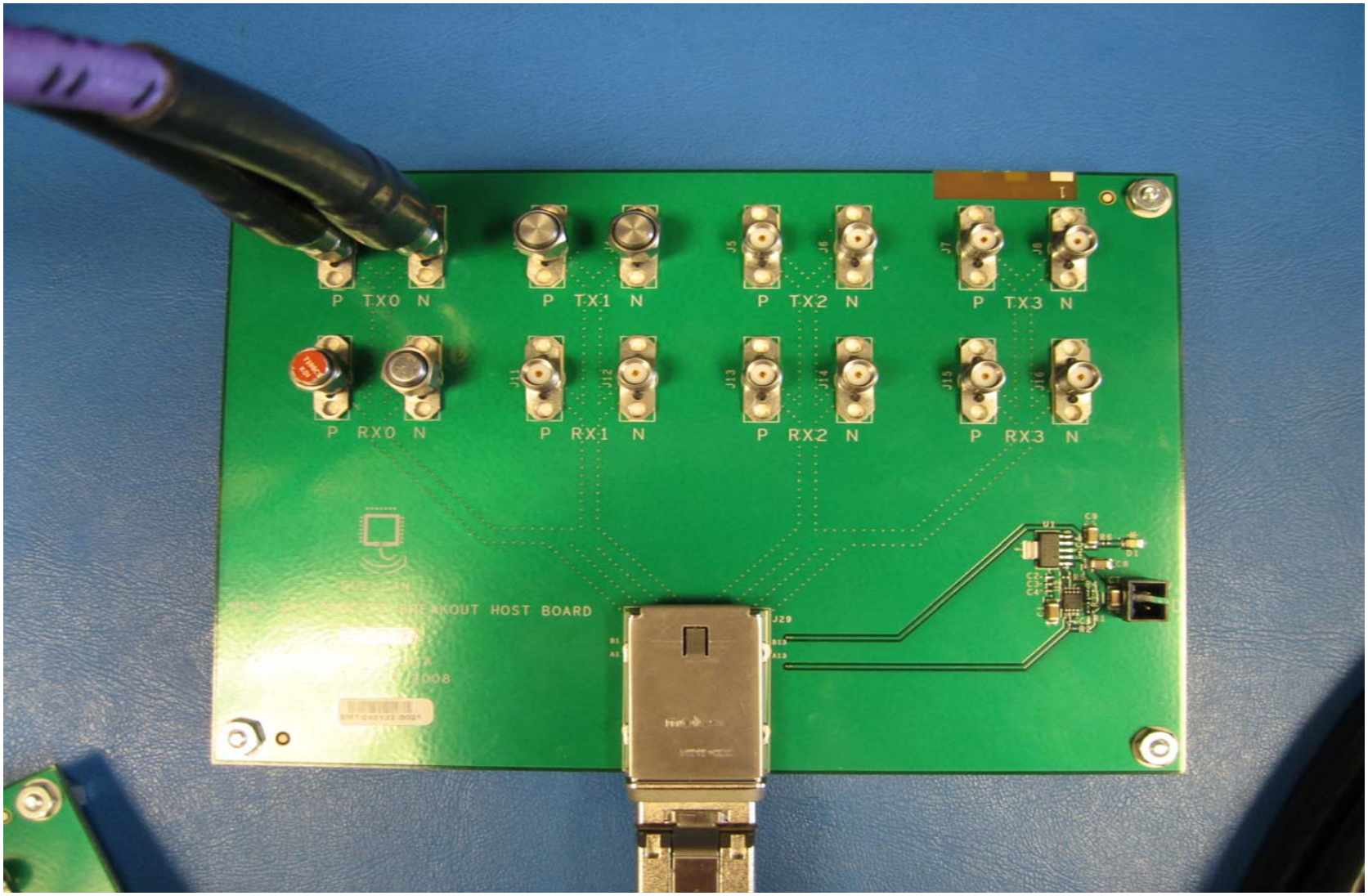
System Test Board Circuitry



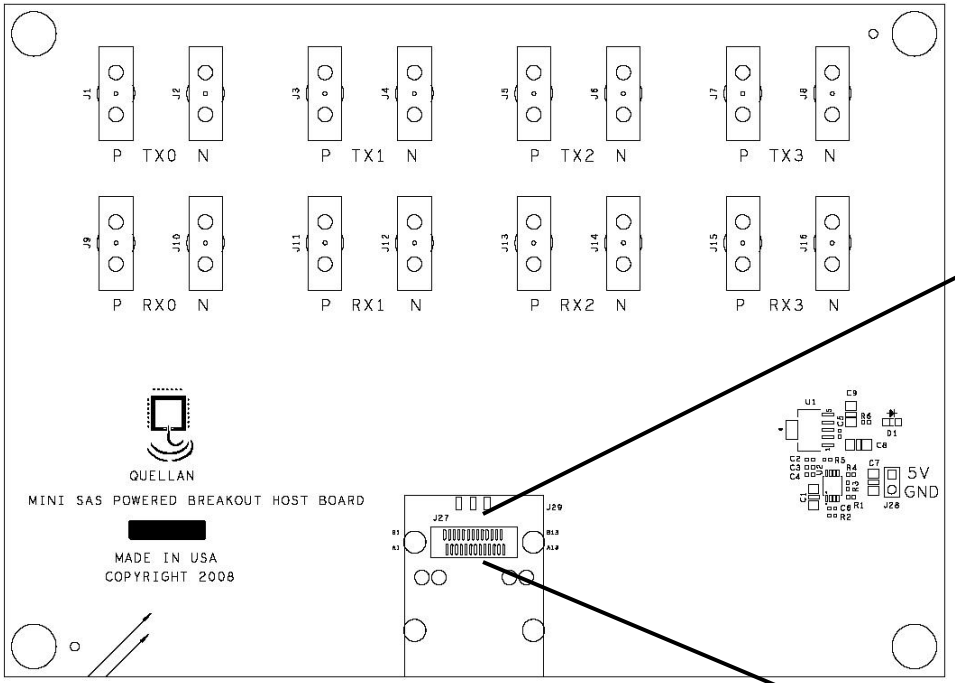
Test Setup : 10m 24AWG Passive Cable with Active Board



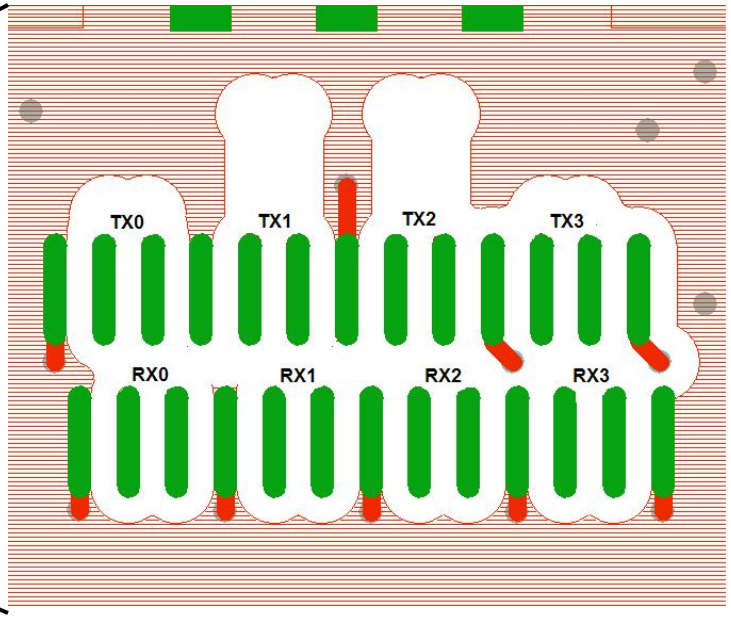
VNA Test Setup



Test Setup (continued)



Solder Pad Area on Board



MiniSAS 4X Requirements (SAS2r14a)

Table 52 — S-parameters of cable assemblies and backplanes

Characteristic [a] [b] [c]	Reference	L (dB)	N (dB)	H (dB)	S (dB / decade)	f_{min} (MHz)	f_{max} (GHz)
S_{CC22}	Figure 124 (see 5.3.6.5.2)	-6.0	-5.0	0	13.3	100	6.0
S_{DD22}	Figure 124	-10	-7.9	0	13.3	100	6.0
S_{CD22}	Figure 125 (see 5.3.6.5.2)	-26	-12.7	-10	13.3	100	6.0
S_{CD21}	Figure 125	-24	-24	-24	0	100	6.0
Maximum near-end crosstalk (NEXT) for each receive signal pair [d]		-26	-26	-26	0	100	6.0

[a] All measurements are made through mated connector pairs.

[b] The range for this frequency domain measurement is 10 MHz to 6 000 MHz.

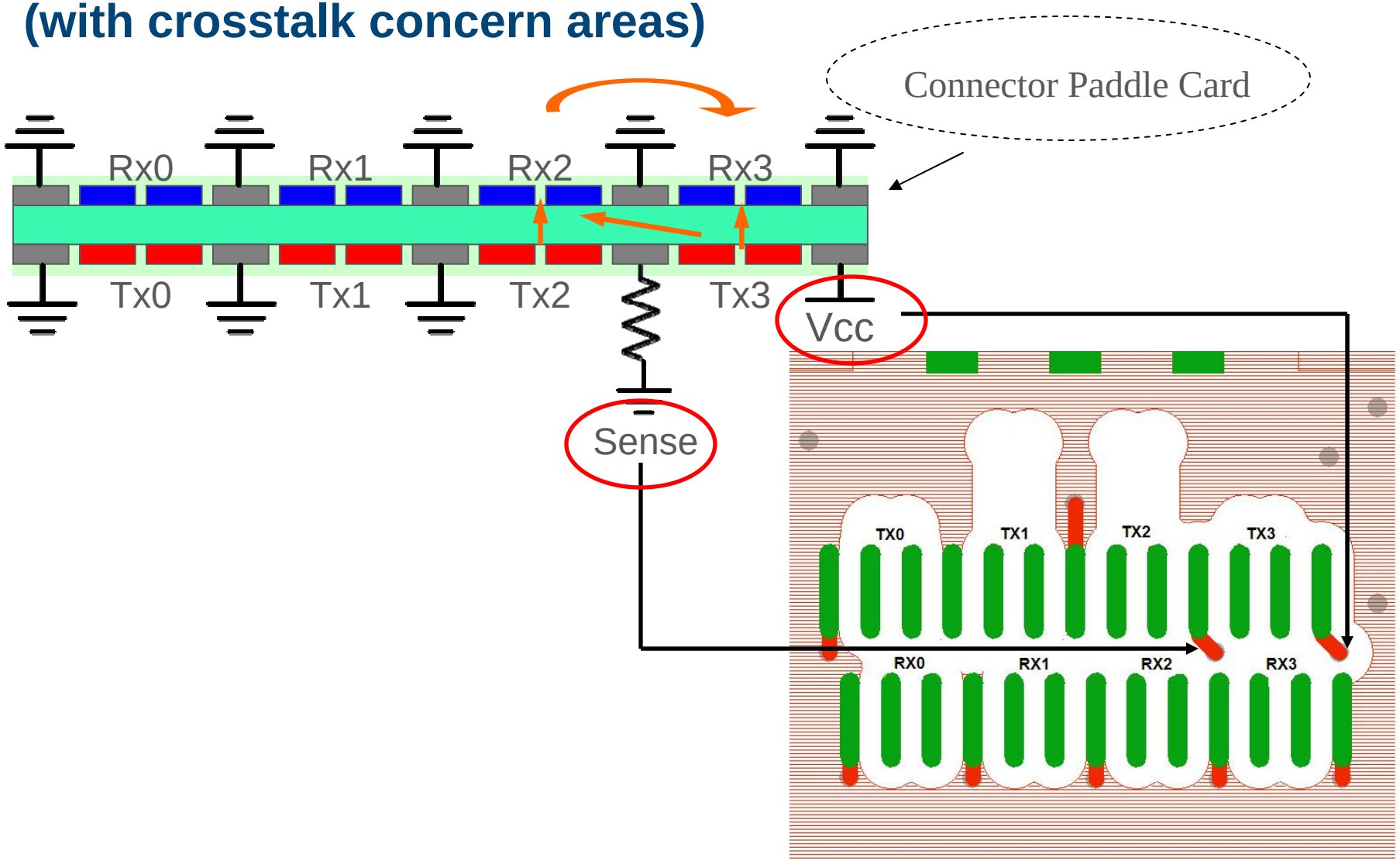
[c] Specifications apply to any combination of cables and backplanes that are used to form a TxRx connection.

[d] Determine all valid aggressor/victim near-end crosstalk transfer modes. Over the complete frequency range of this measurement, determine the sum of the crosstalk transfer ratios, measured in the frequency domain, of all crosstalk transfer modes. To remove unwanted bias due to test fixture noise, crosstalk sources with magnitudes less than -50 dB (e.g., -60 dB) at all frequencies may be ignored. The following equation details the summation process of the valid near-end crosstalk sources:

$$TotalNEXT(f) = 10 \times \log \sum_{1}^{n} 10^{(NEXT(f)/10)}$$

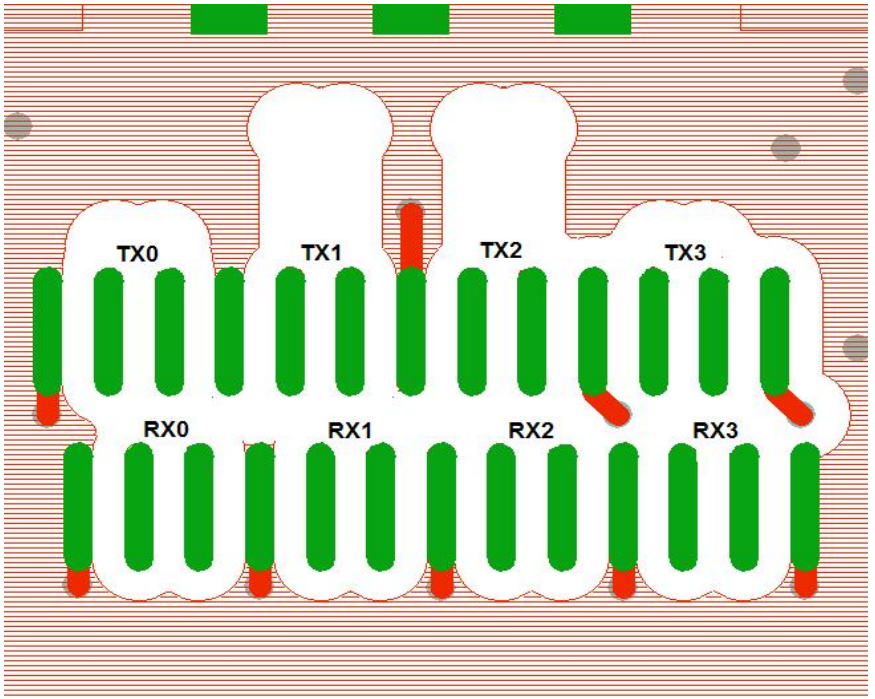
All NEXT values expressed in dB format in a passive transfer network shall have negative dB magnitude.

Pinout Structure of Active MiniSAS Connector (with crosstalk concern areas)

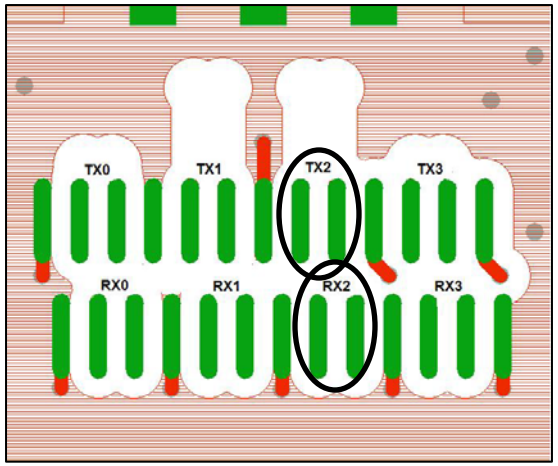


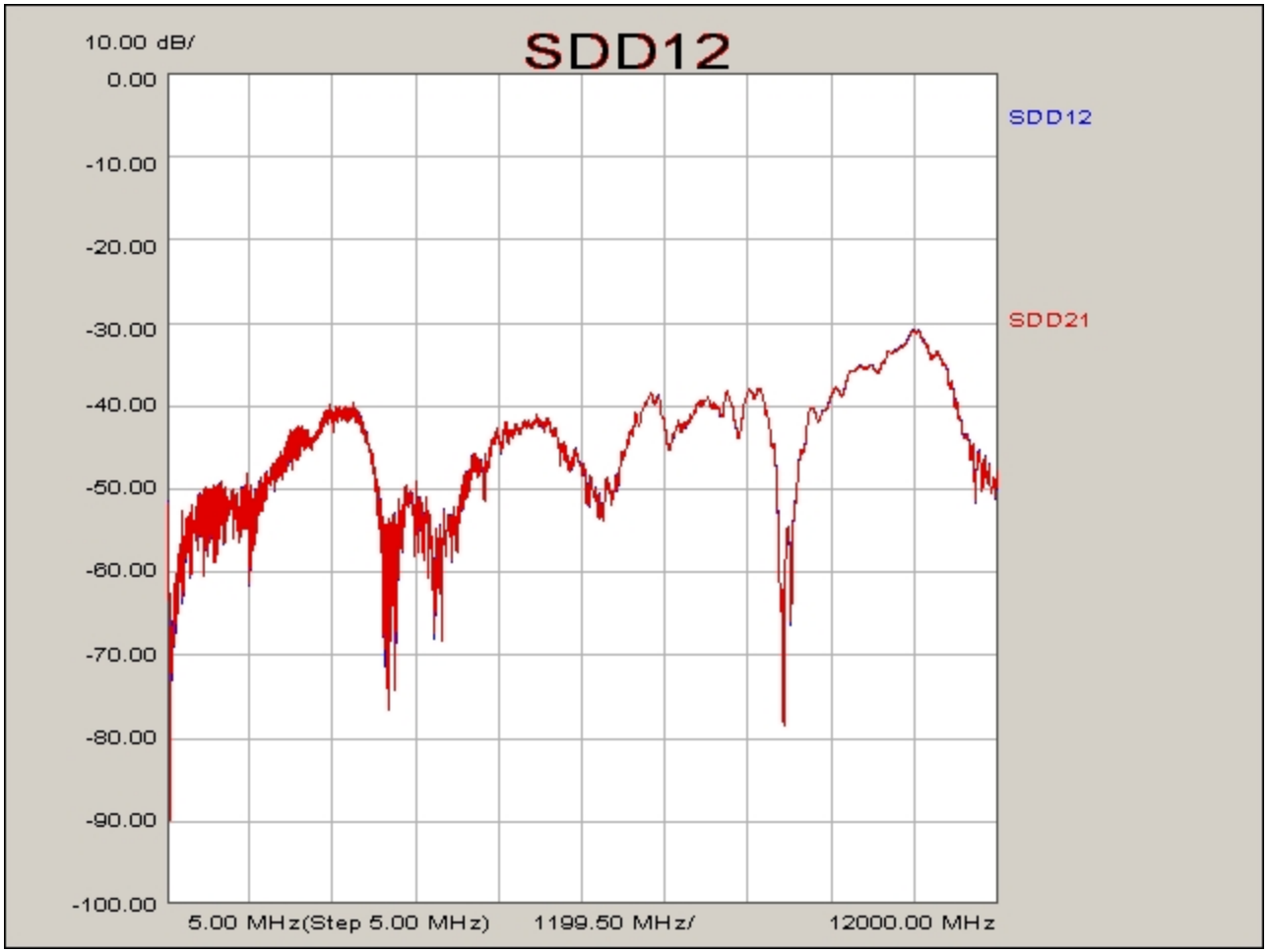
Test Measurements Noise Immunity (Received XTALK)

- Two active breakout boards, 10m passive cable.
- VNA setup: 50MHz – 12GHz; Terminate unused SMA's to 50 Ohm
- Measurements:
  - Near-End Sdd21:
    - TX1 to RX2
    - TX2 to RX1
    - TX2 to RX2
    - TX2 to RX3
    - TX3 to RX2
    - TX3 to RX3
  - Far-End Sdd21:
    - TX0 to RX1
    - TX3 to RX2
  - TX/TX or RX/RX Isolation Sdd21:
    - TX2 to TX3

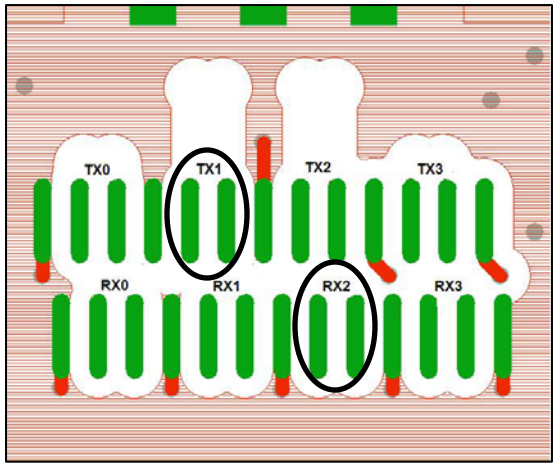


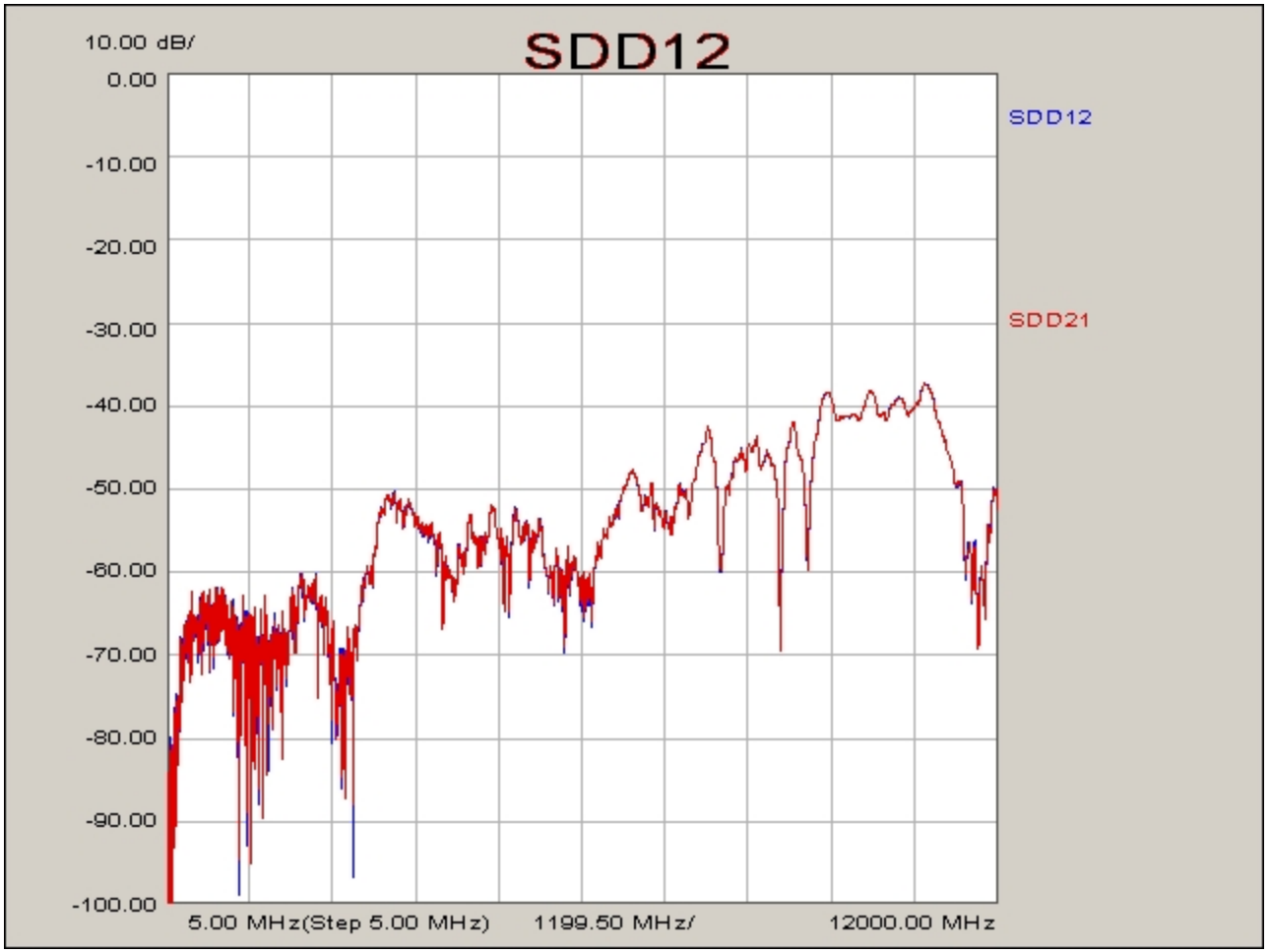
NEXT Measurement TX2 -> RX2



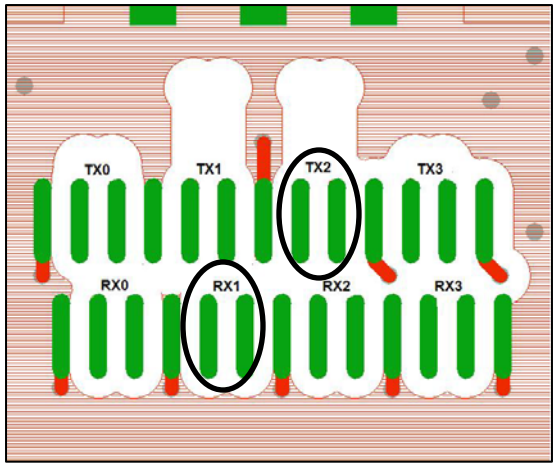


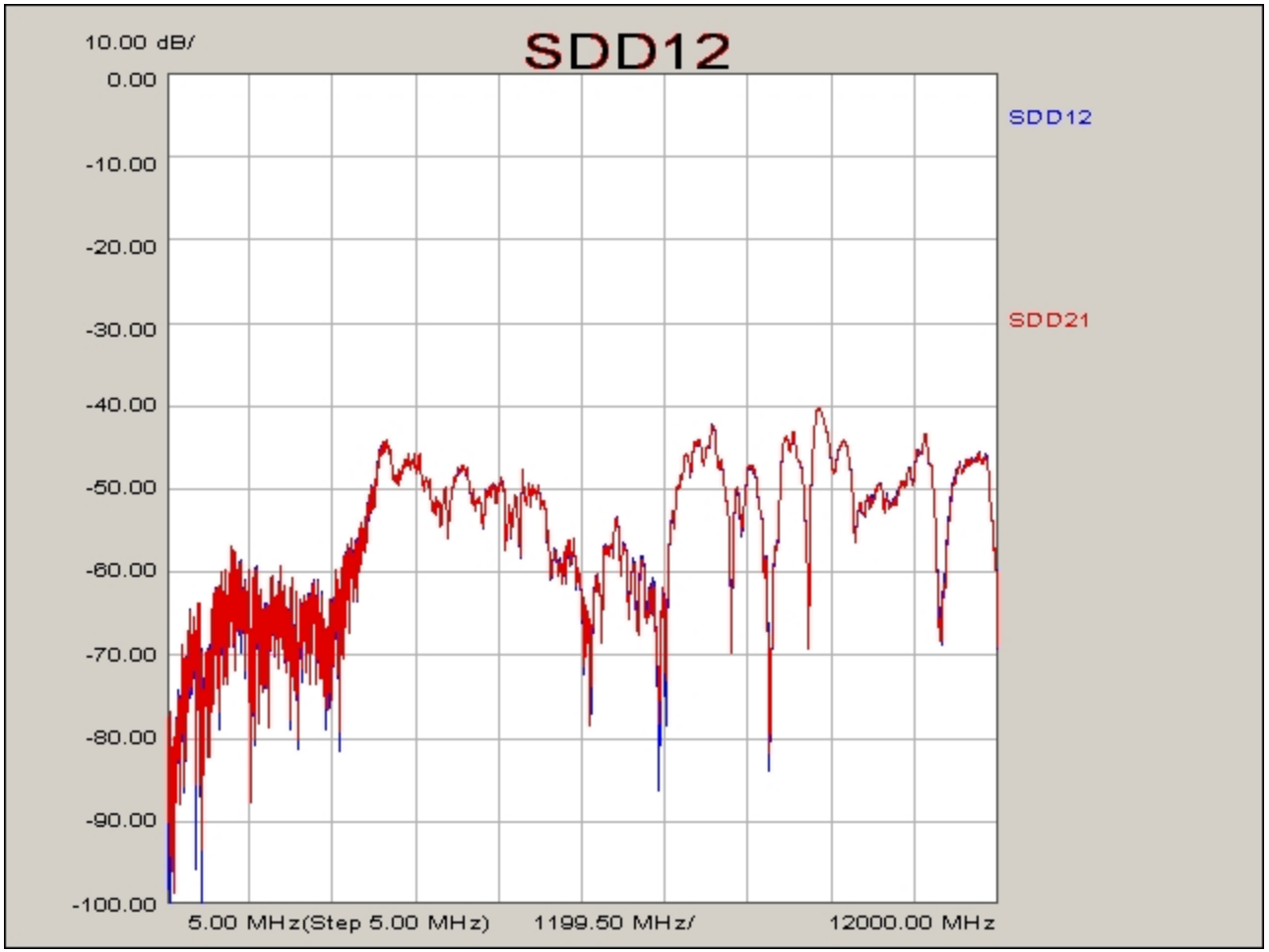
NEXT Measurement TX1 -> RX2



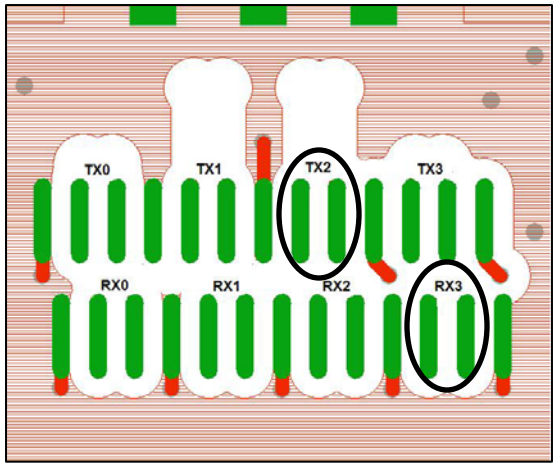


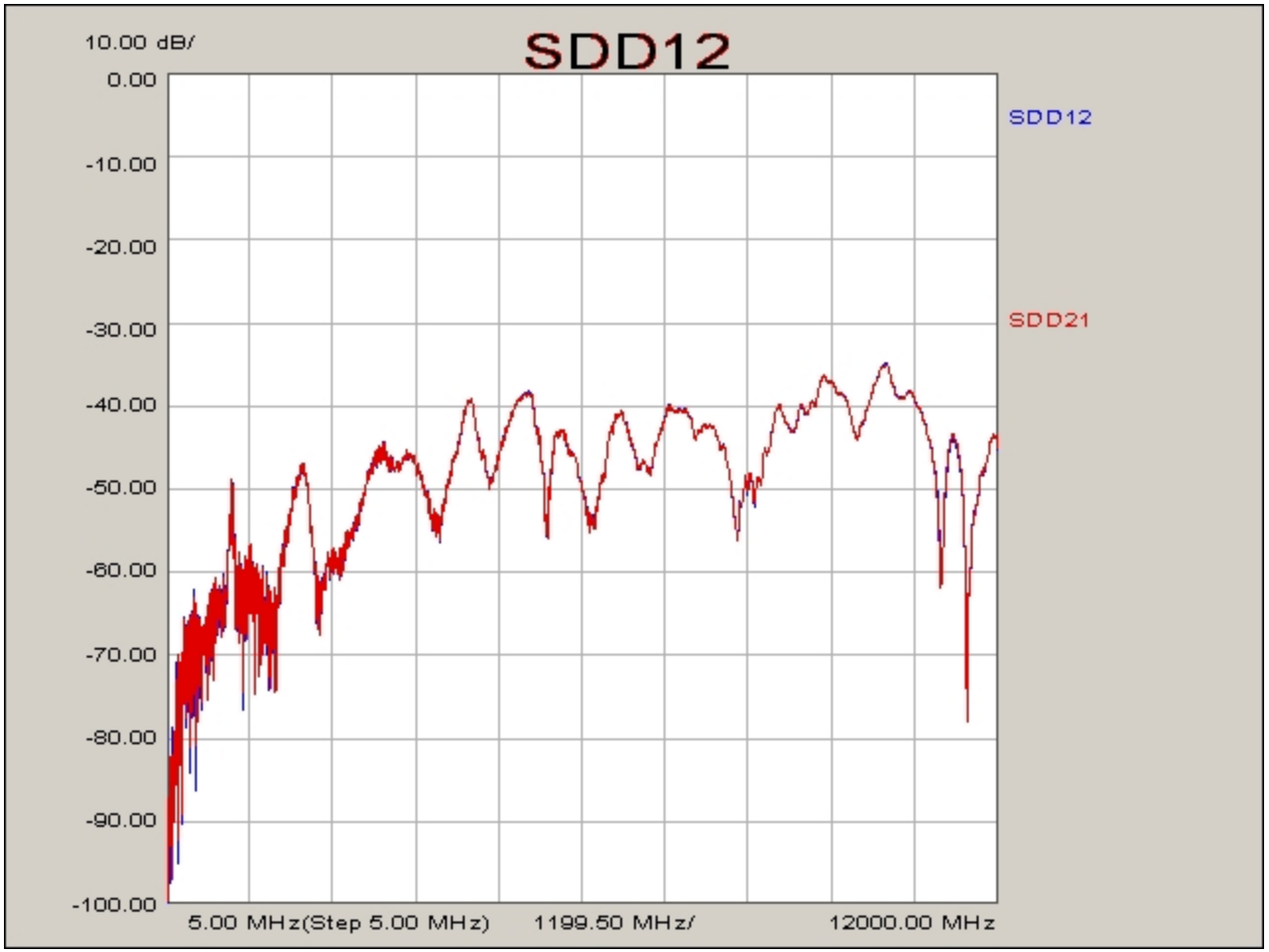
NEXT Measurement TX2 -> RX1



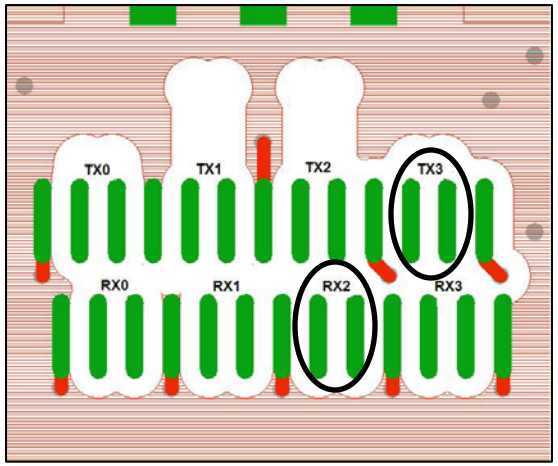


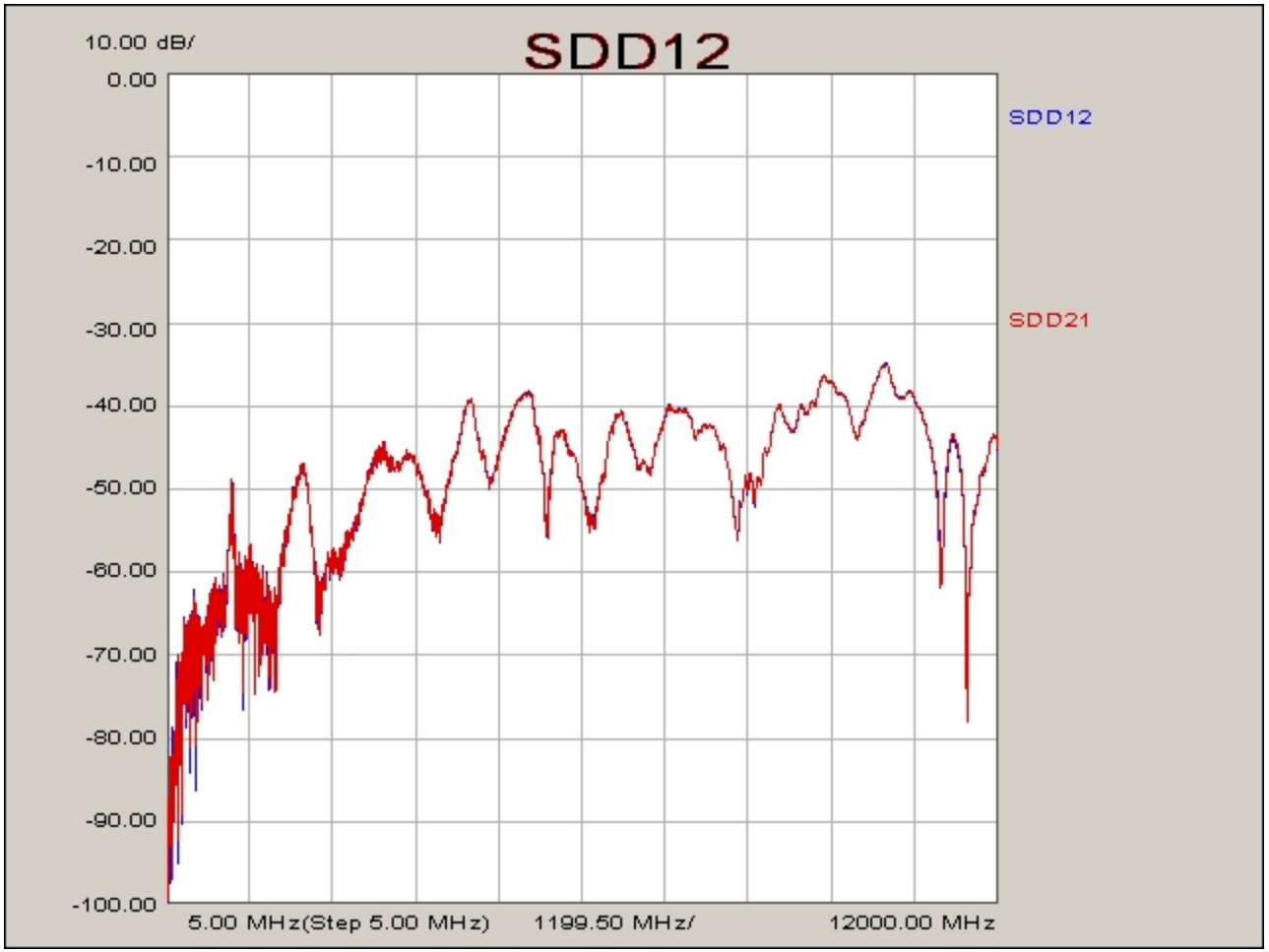
NEXT Measurement TX2 -> RX3



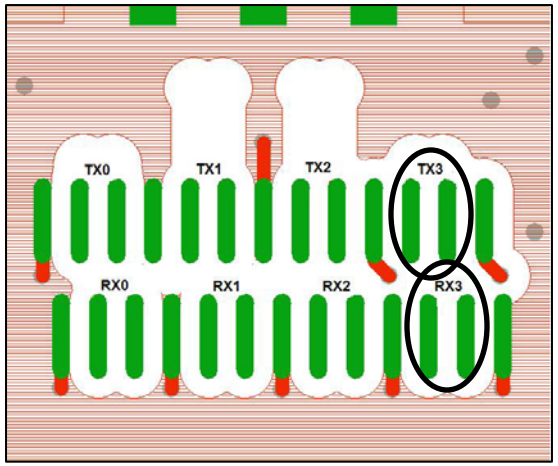


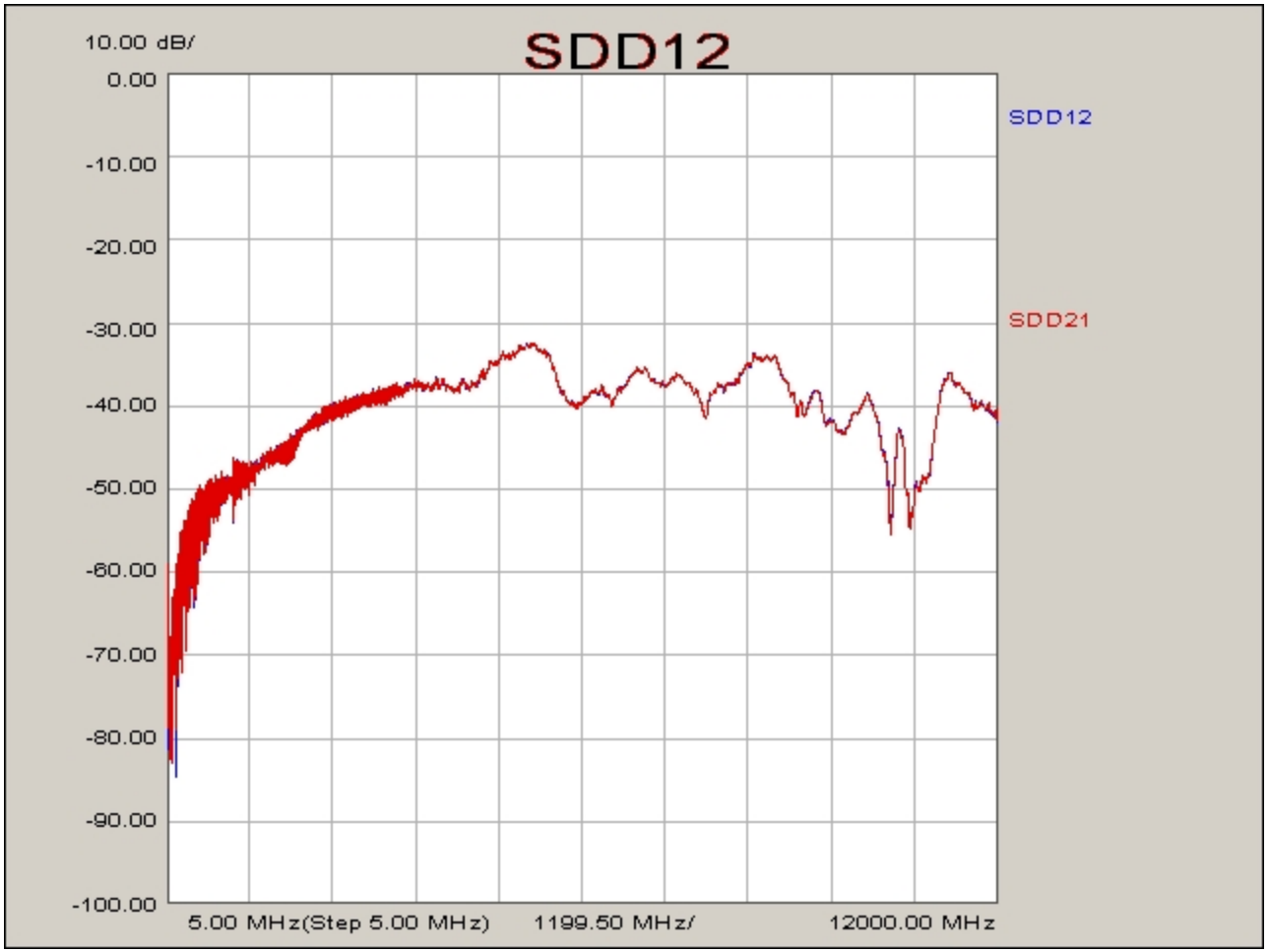
NEXT Measurement TX3 -> RX2





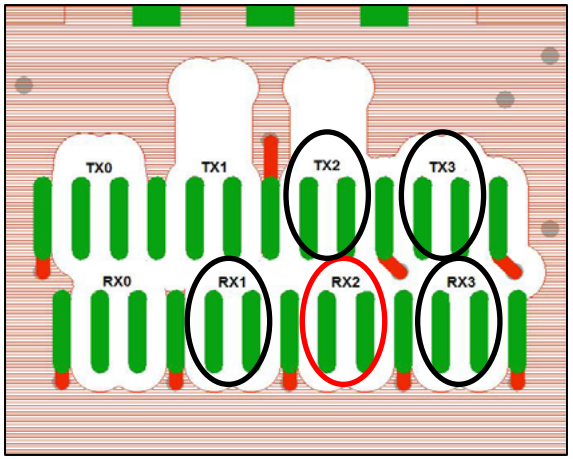
NEXT Measurement TX3 -> RX3

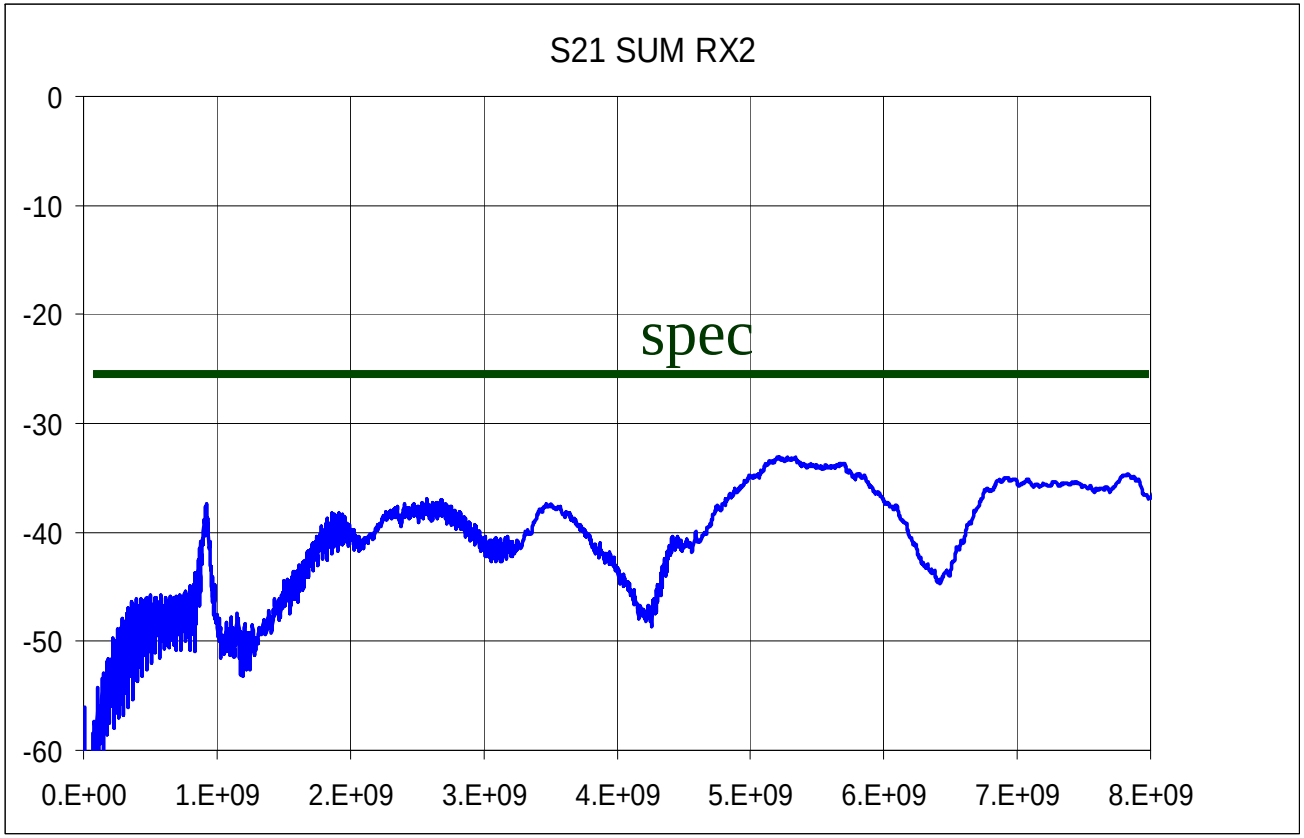




NEXT Measurement Sum around RX2

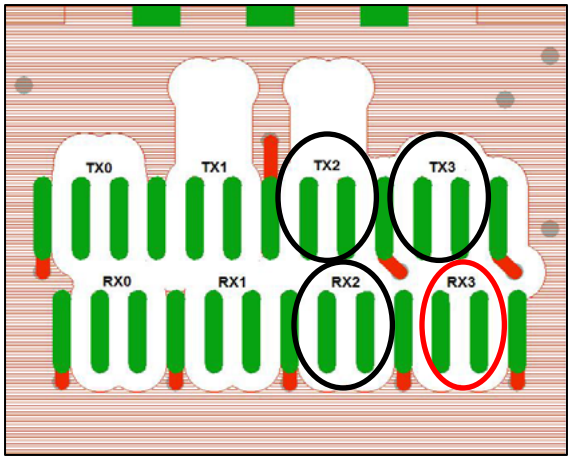
$$NEXT_{Total} = 10 * LOG_{10} \sum_{1}^{4} 10^{NEXT(f)/10}$$

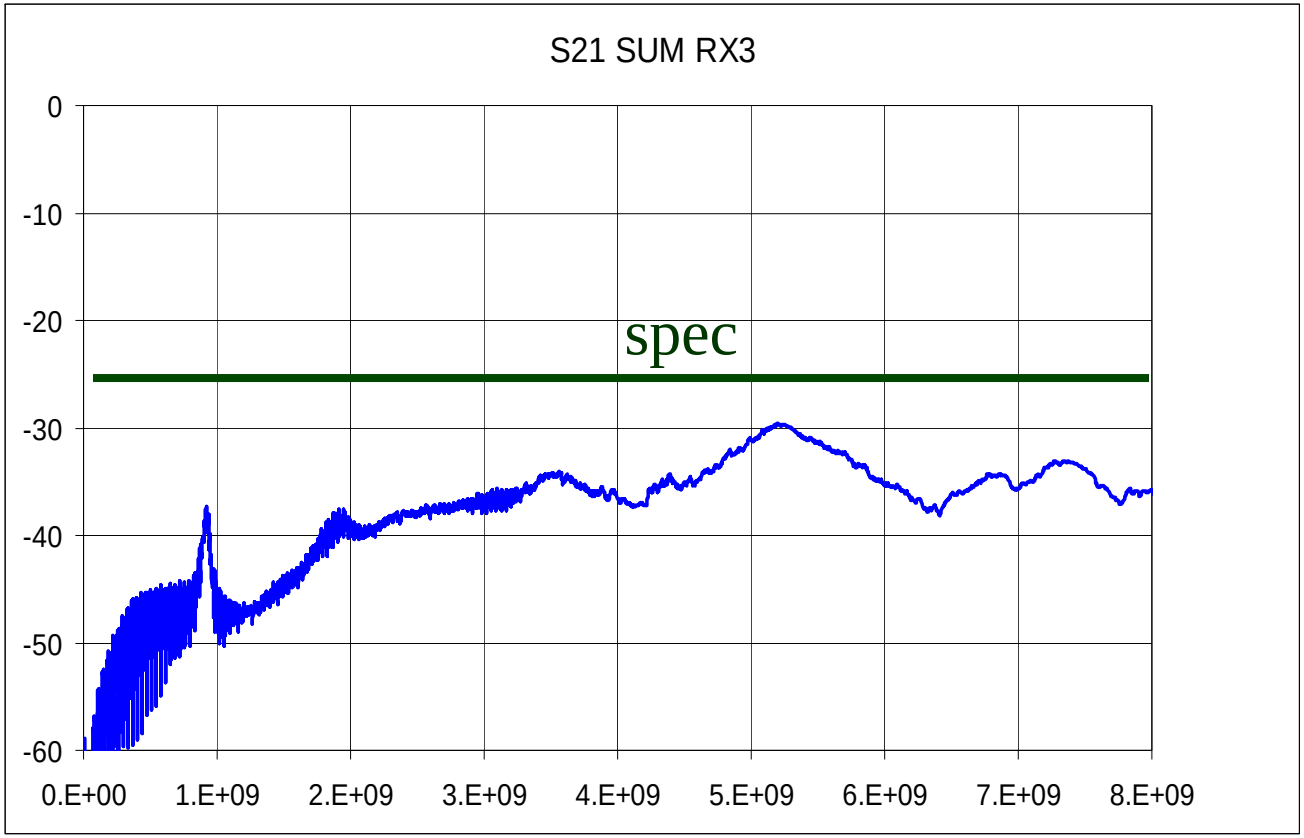




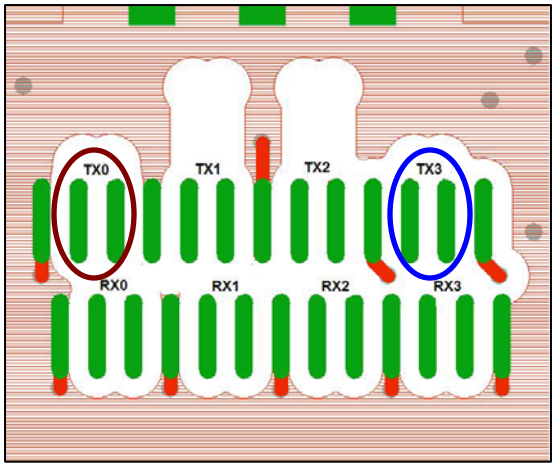
NEXT Measurement Sum around RX2

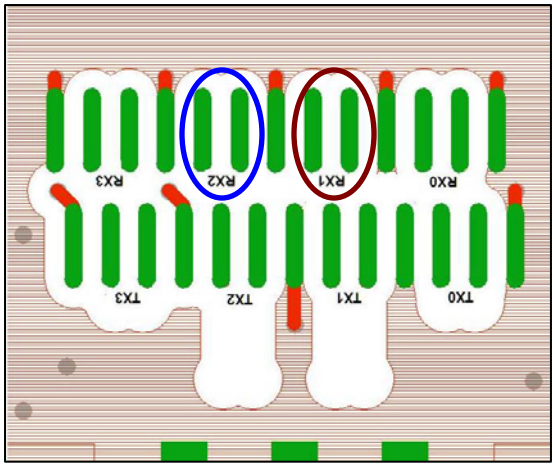
$$NEXT_{Total} = 10 * LOG_{10} \sum_{1}^{4} 10^{NEXT(f)/10}$$

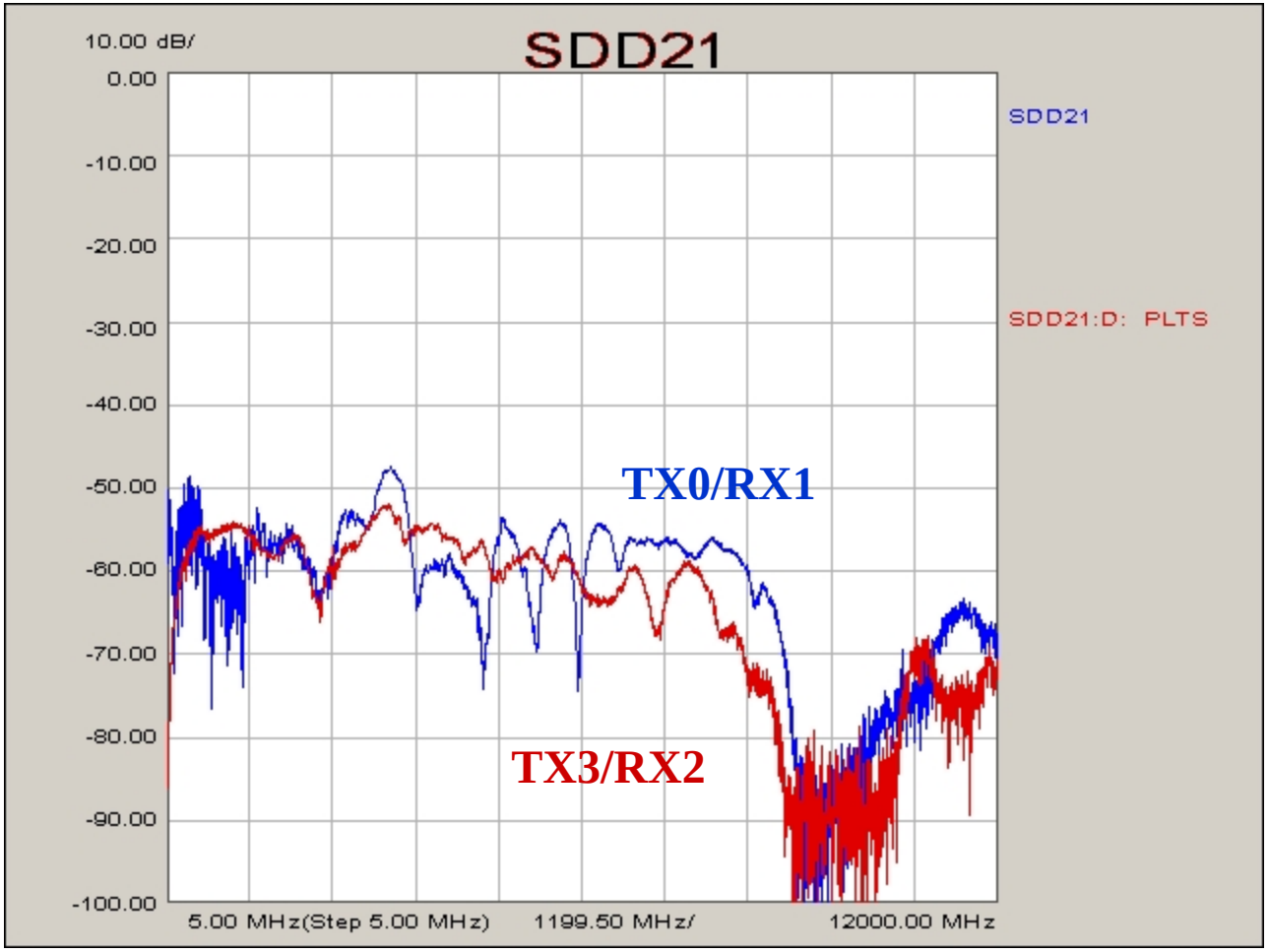




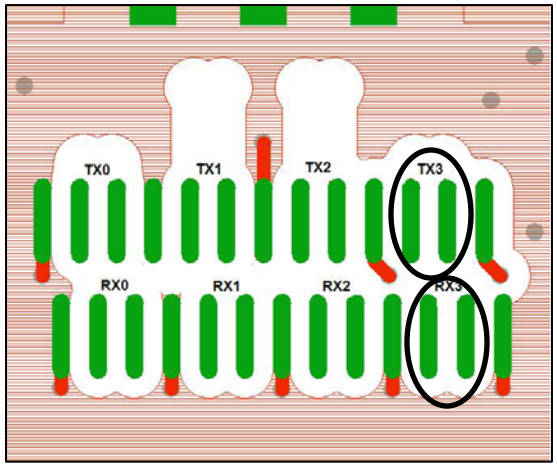
FEXT Comparison TX0 -> RX1 and TX3 -> RX2

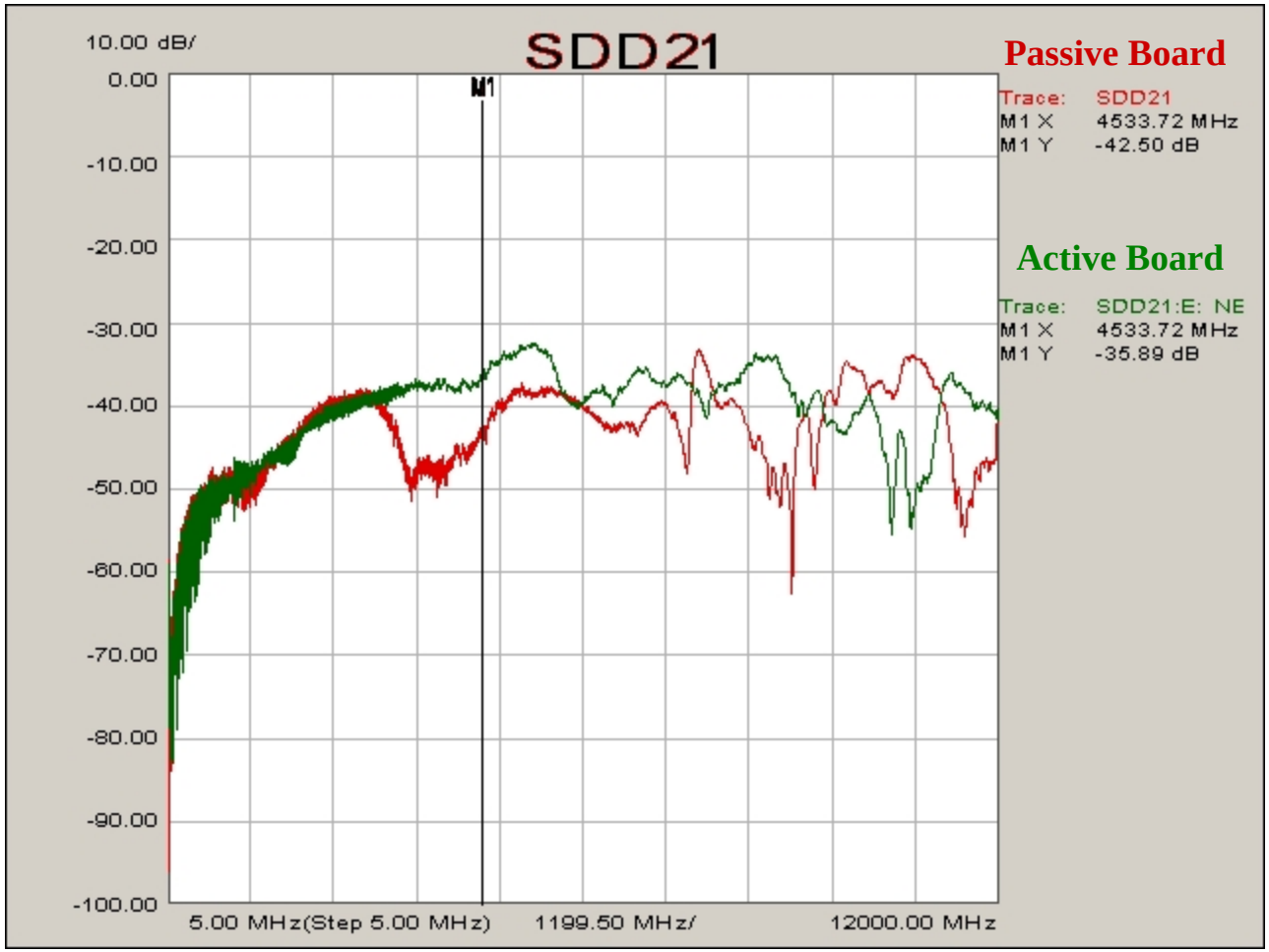




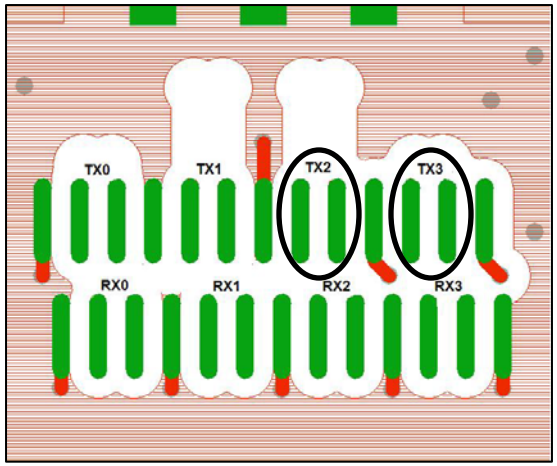


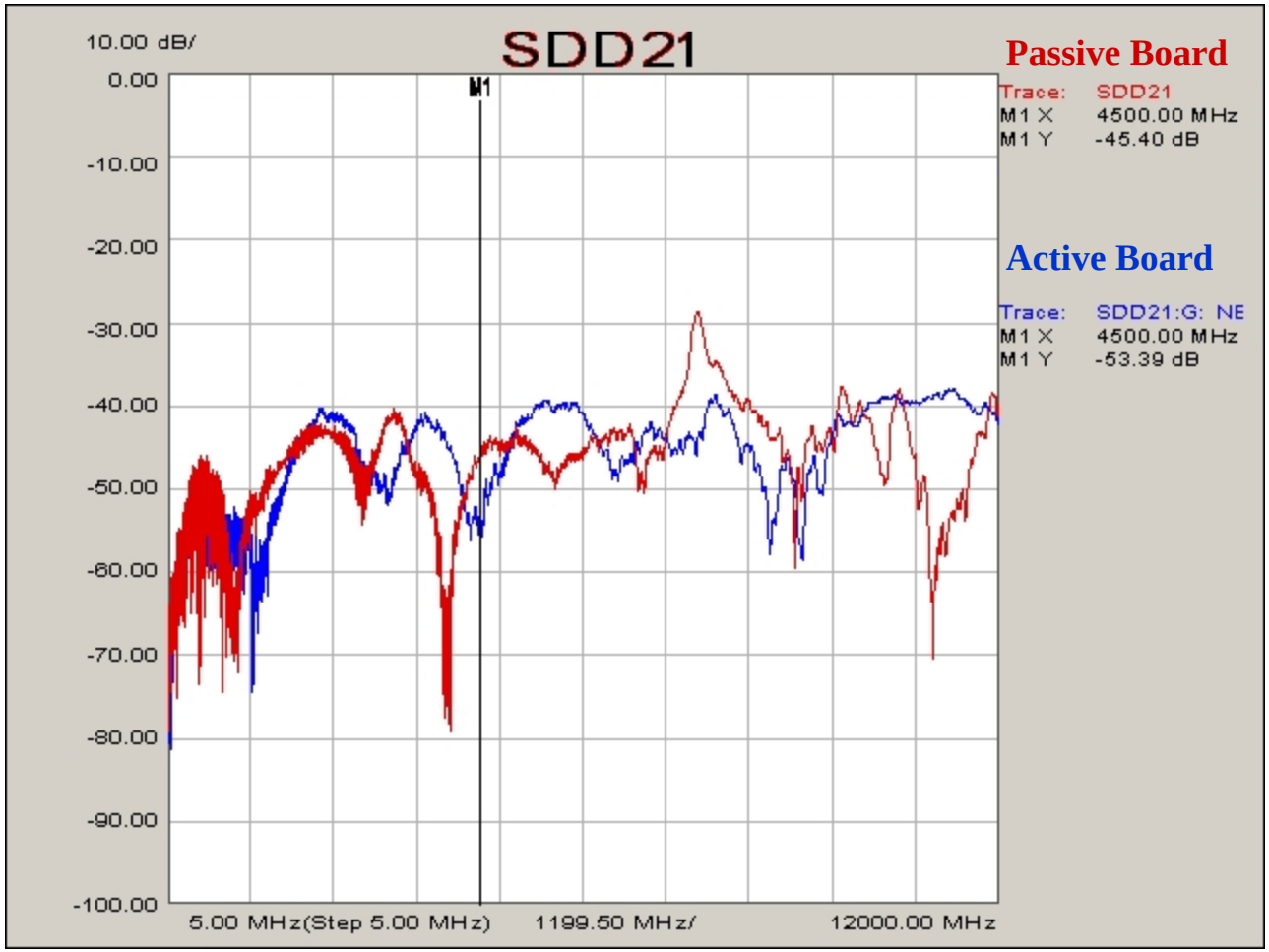
NEXT Measurement TX3 -> RX3 (Comparison: Quellan Active Board vs Molex Passive Board)





Isolation Measurement TX2 -> TX3 (Comparison: Quellan Active Board vs Molex Passive Board)





Conclusion

- No Effect of Power Supply and Sense System Board Circuitry on Passive Cable Crosstalk performance, if done with careful coupling of the B10 and B13 pins to ground.
- Crosstalk is well within the SAS-2 specification, with no change observed compared with passive designs outside minor PCB design variations.
- Recommend adopting the proposed power delivery and sense scheme as the safest and “path of least resistance” solution.
- Reference design for power supply and voltage sense logic can be included as an informative annex (see update to 08-052).