HRPPD backplane crosstalk measurements with a Network Analyzer

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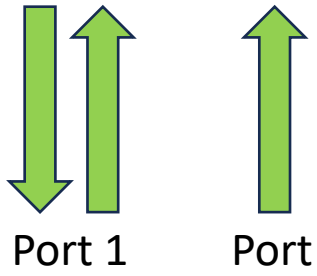
A layman view of a network analyzer

Rohde & Schwarz ZNLE18



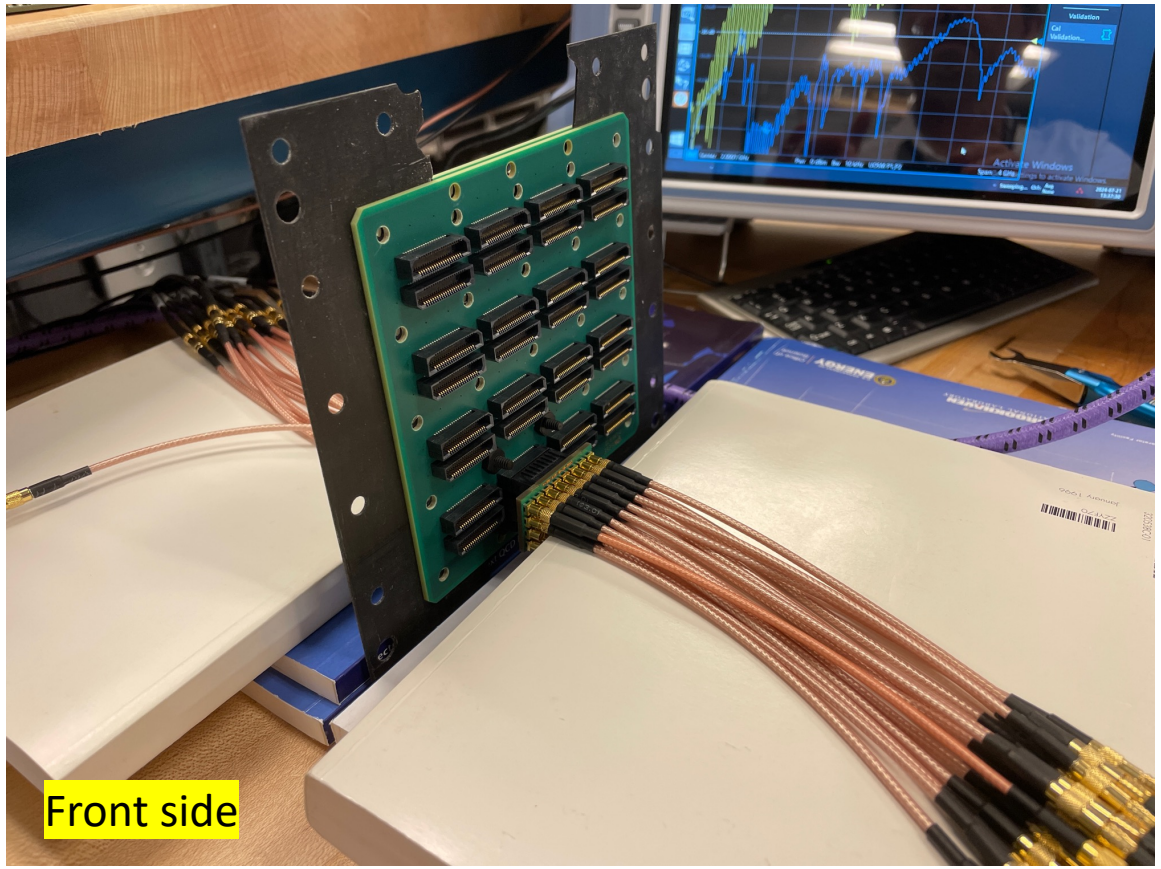
- Port 1: feeds sine signals in a given frequency range into our circuitry, and measures a reflected signal amplitude (aka S11)
- Port 2: measures either a DC-coupled signal amplitude or a crosstalk resulting from this signal propagation through our circuitry (aka S12)

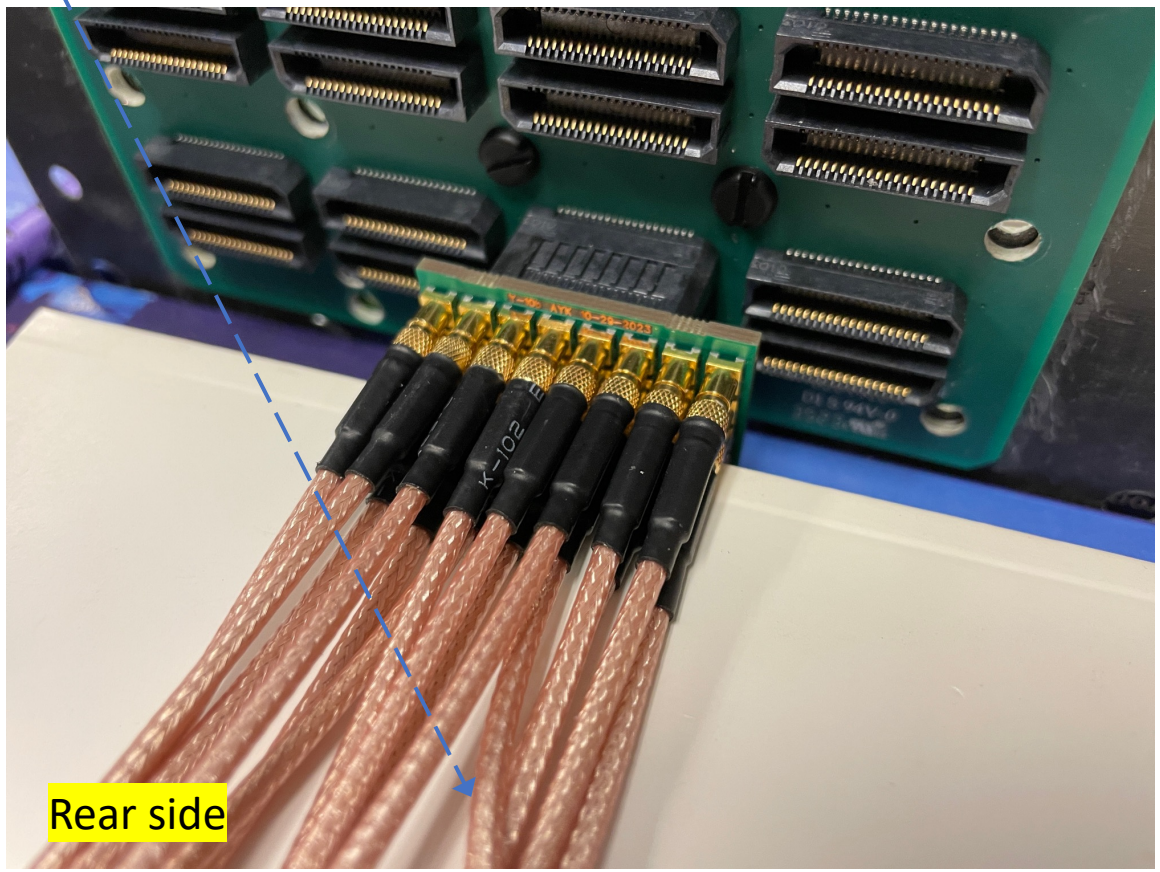
Setup #1: Y05f-Y05f sandwich

Main motivation: verify that crosstalk largely occurs between ground-isolated Samtec connector pin groups

Setup #1 pictures

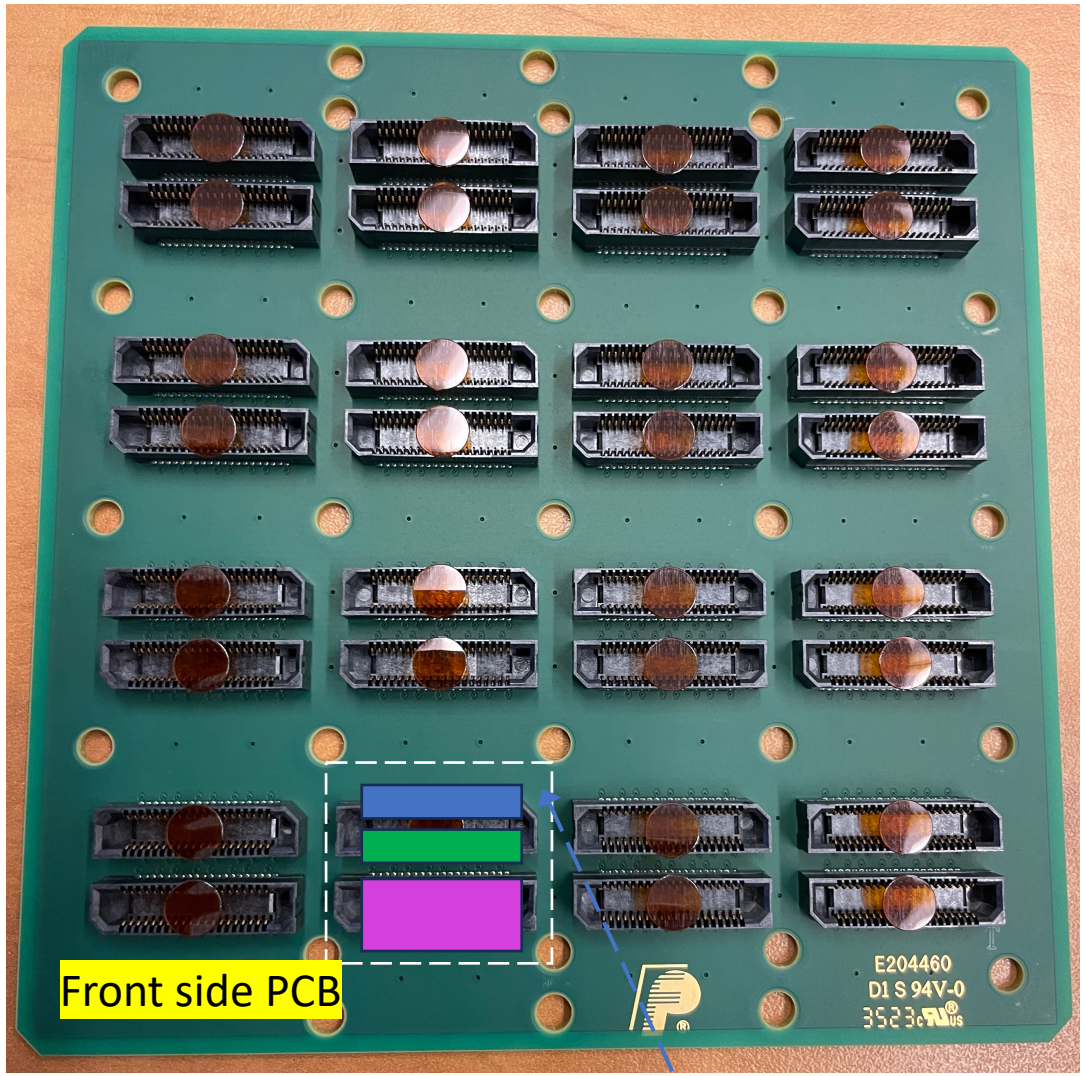
Cable to Port 1 spot (B2 in the scan)

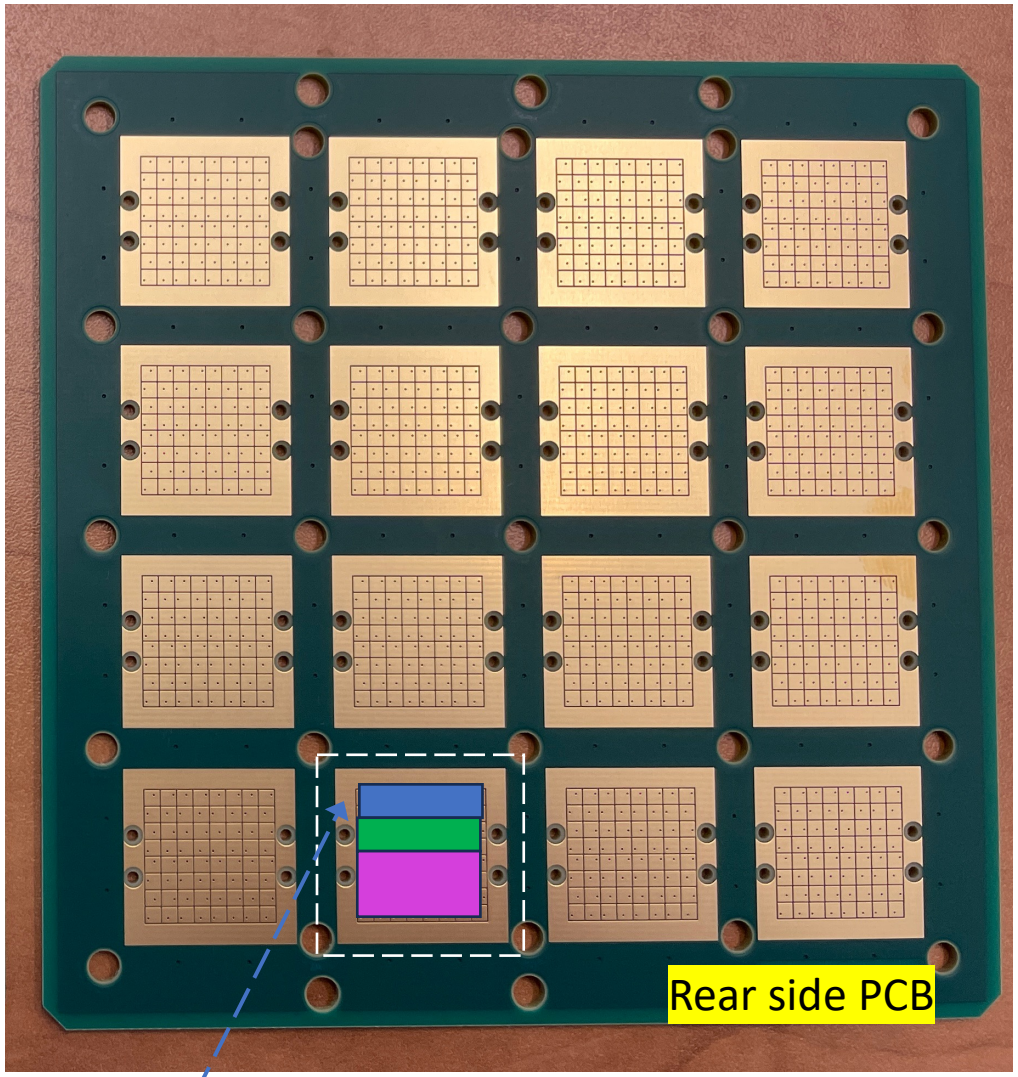




- A Y10b-Y05f-interposer-Y05f-Y10b sandwich
  - Where Y05f is a backplane and Y10b a small Samtec -> MMCX adapter
- 2x8 MMCX->MCX cable pigtails on both sides
  - Permanently connected to V1742 DRS4 digitizer inputs (50 Ohm termination) except for a pair of Port 1 / Port 2 cables
- Rear sandwich side channel B2 -> ZNLE Port 1 (in all the subsequent plots)
- Front sandwich side -> to Port 2 (scan through all 16 MMCX connectors -> 16 plots total)

HRPPD passive interface backplane PCB (Y05f)





16ch used (terminated into 50 Ohm)

16ch floating (got no MMCX cables)

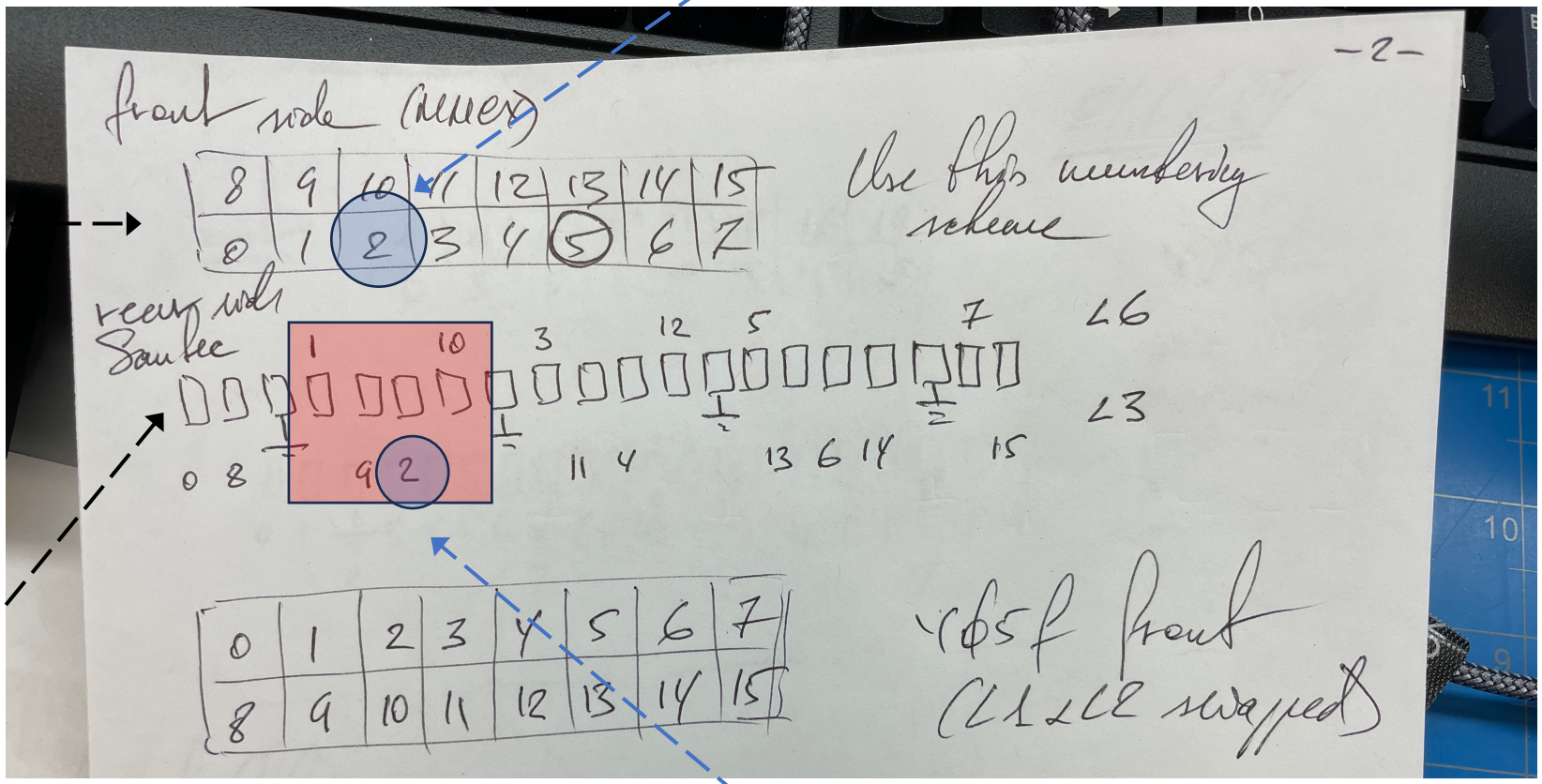
32ch shortened to ground

Setup #1 channel map

Port 1 was connected to this spot in a 2x8 matrix of installed MMCX cables (location as seen from the front side)

Channel 00..15 numbering convention on MMCX adapter

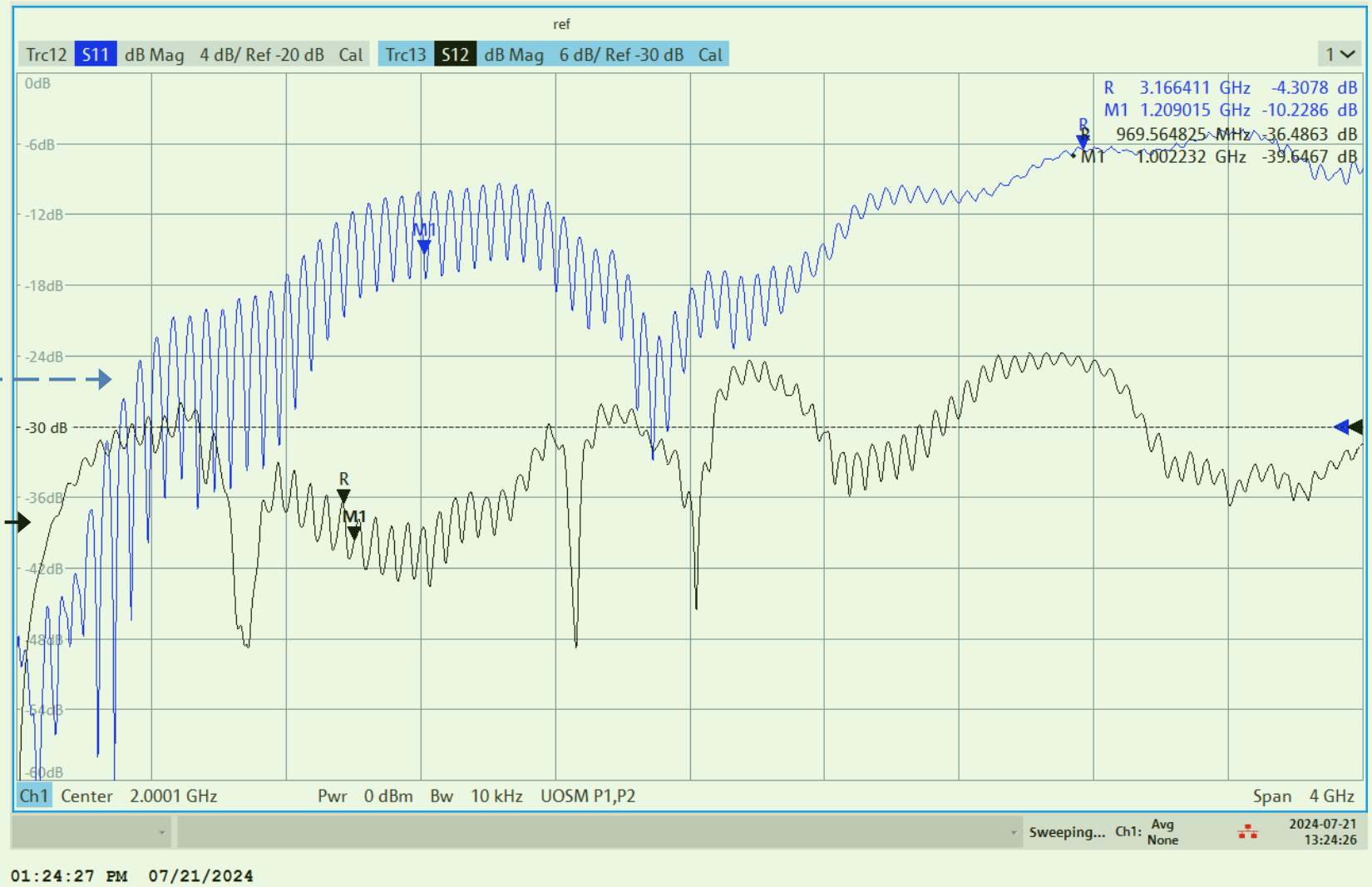
Expect channels 1,9,10 (channel 2 neighbors) to look “bad”



This same channel 2 location on a 2x20-pin ERF8 connector (only one side is of interest)

Effectively use one 20-pin side of a single Samtec ERF8 connector

Screenshot B0 (channel 0)



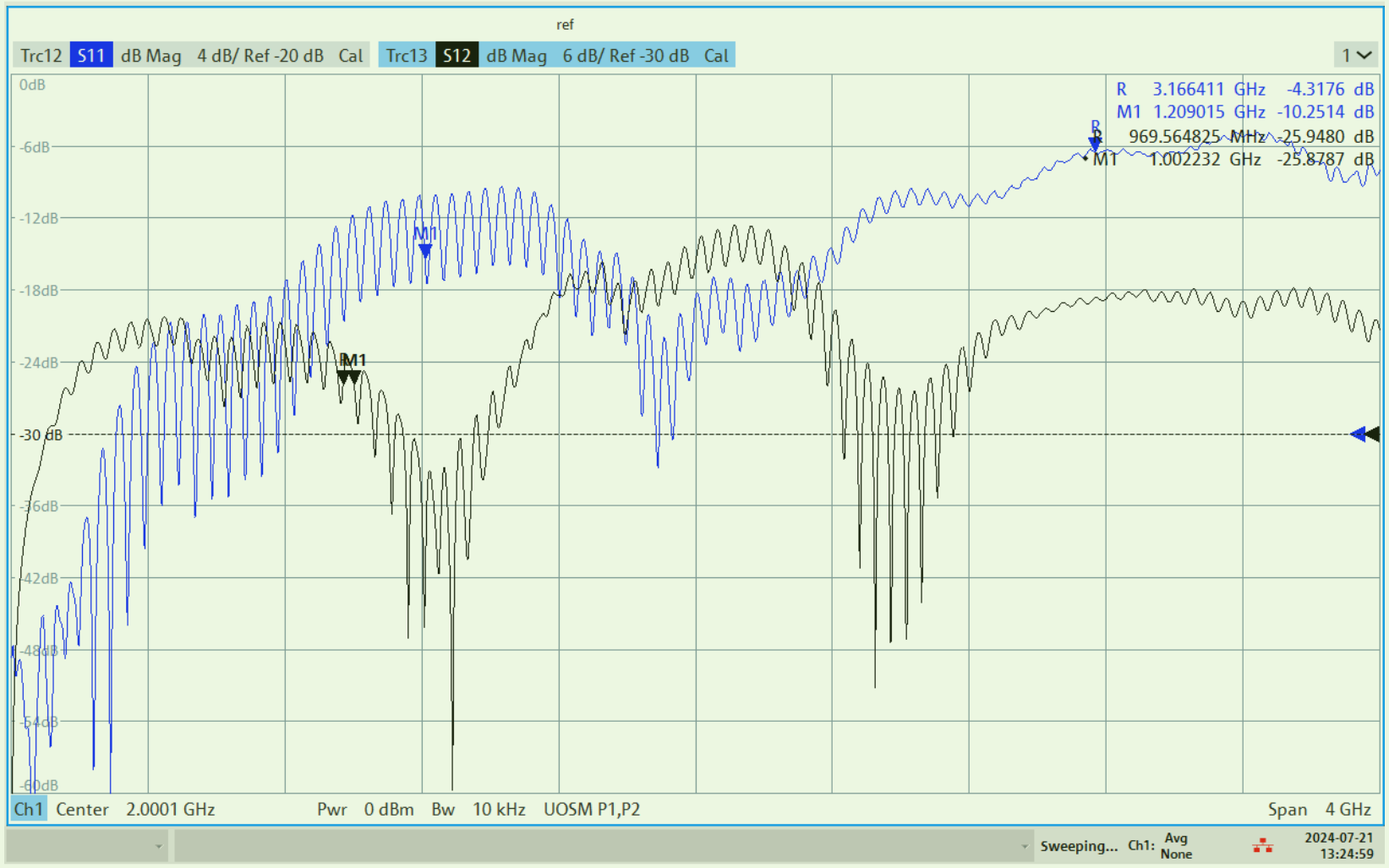
Reflected signal

Crosstalk

Vertical axis: -60 dB .. 0 dB

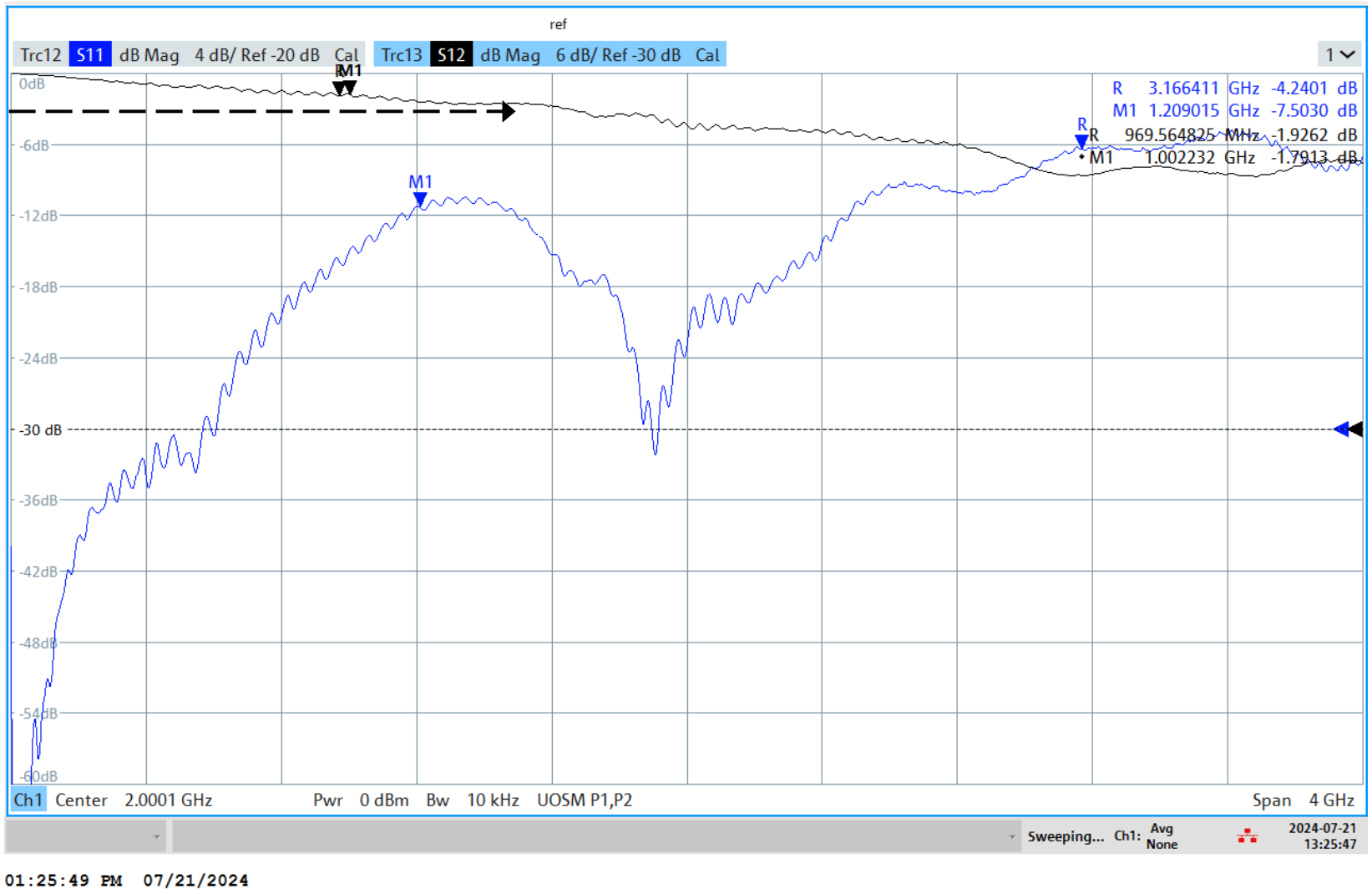
Horizontal axis: 100 kHz .. 4 GHz

Screenshot B1 (channel 1)



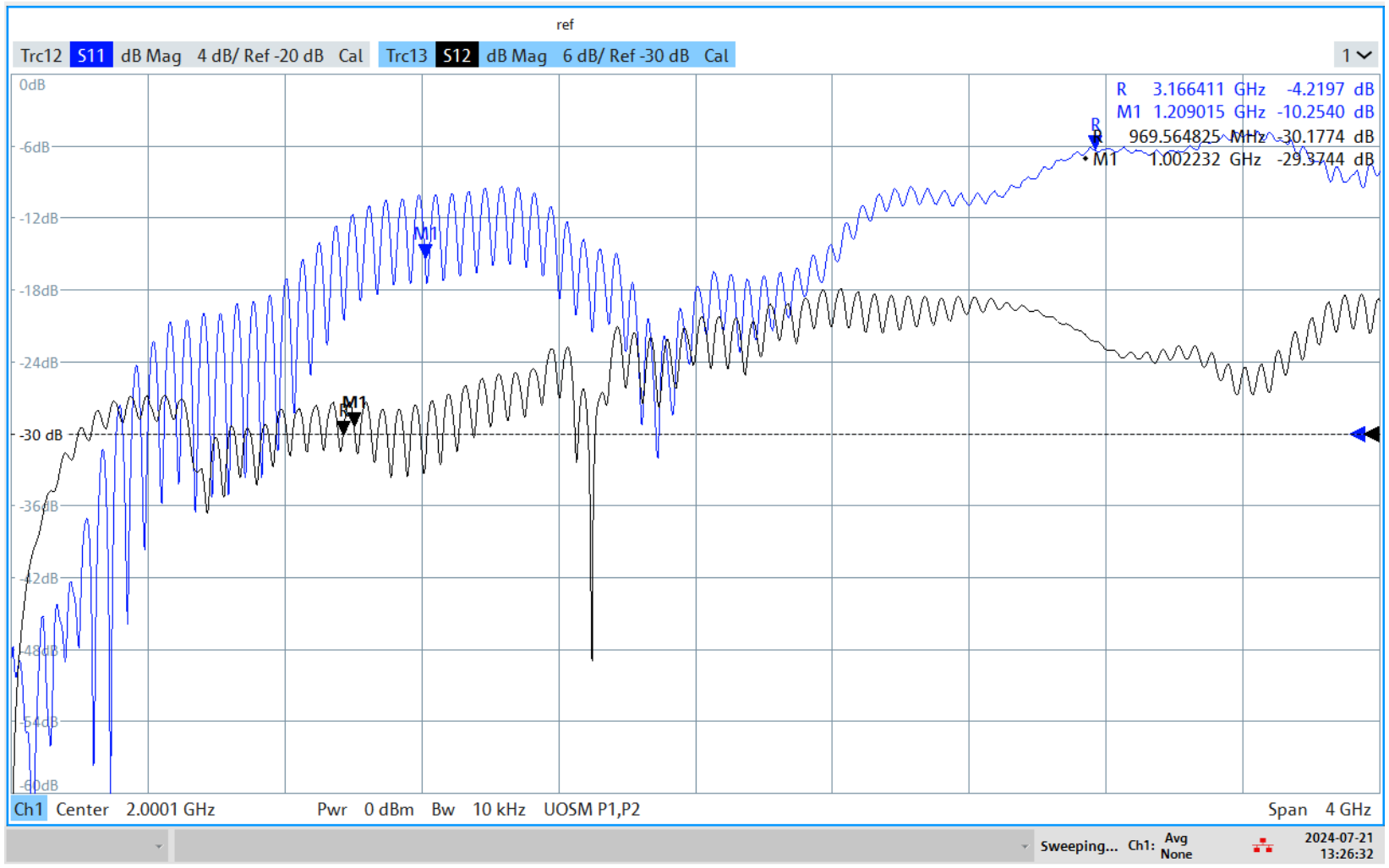
Screenshot B2 (channel 2)

~3 dB attenuation in our frequency range of interest

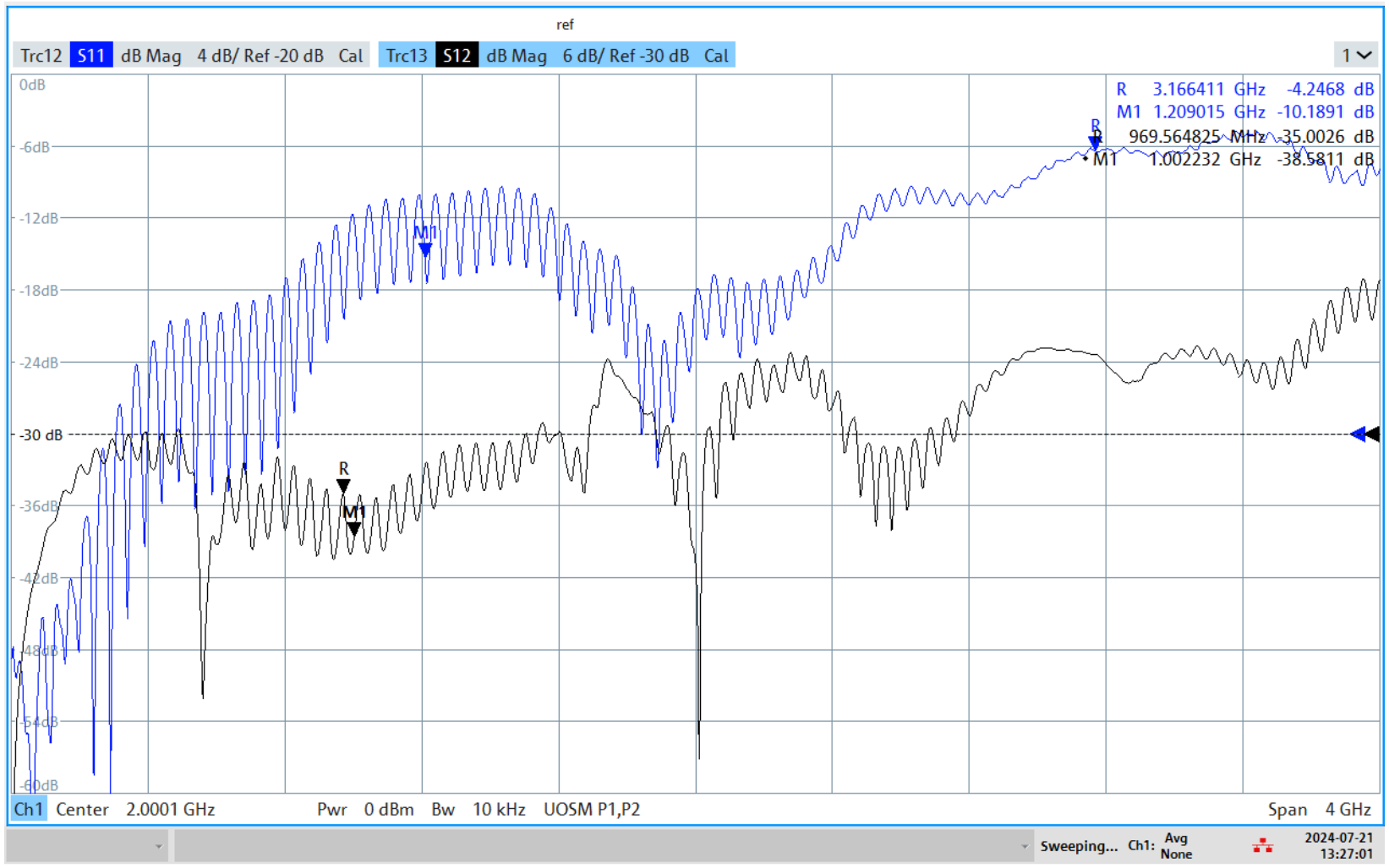


“Rear -> front” through signal (DC coupling)

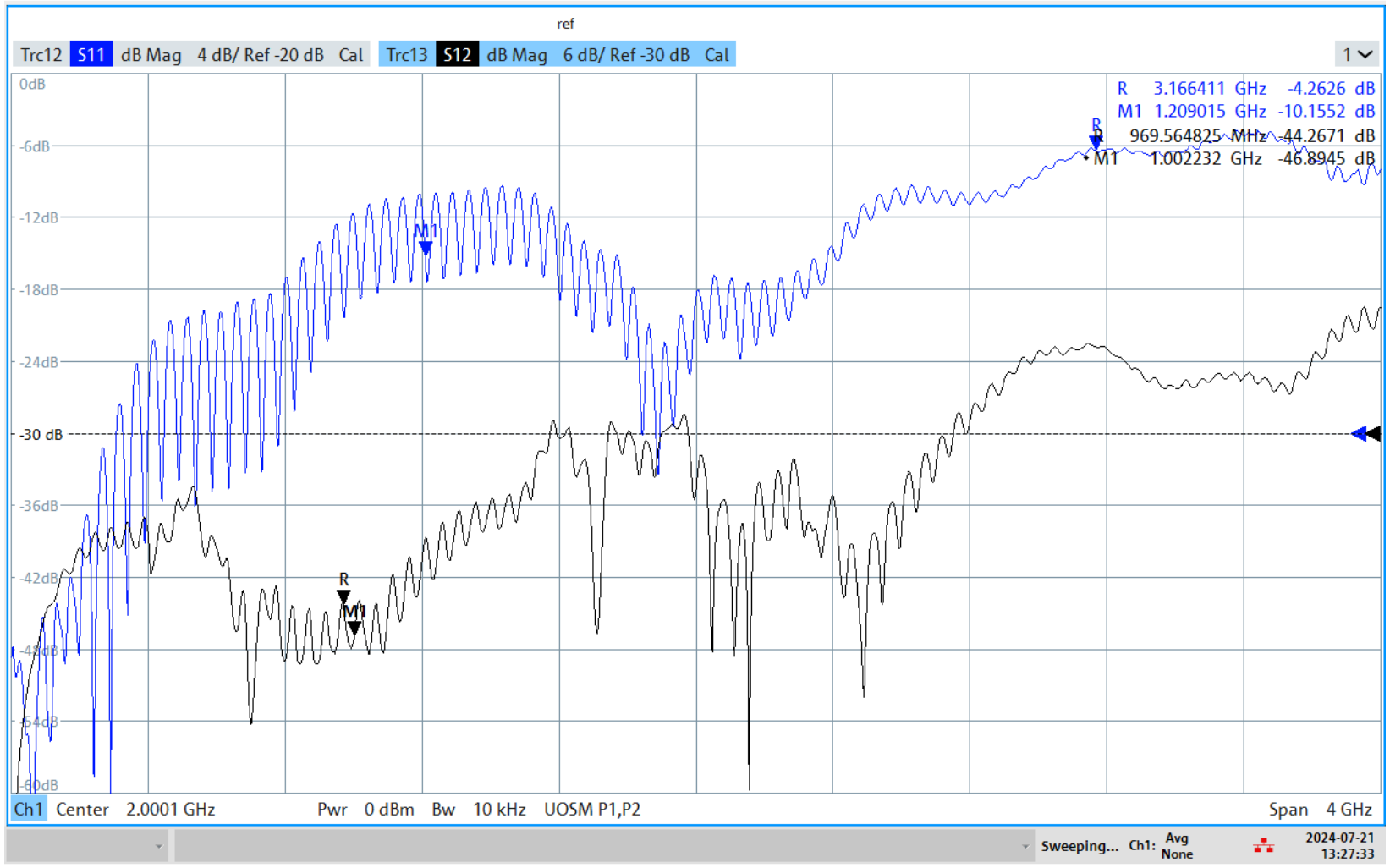
Screenshot B3 (channel 3)



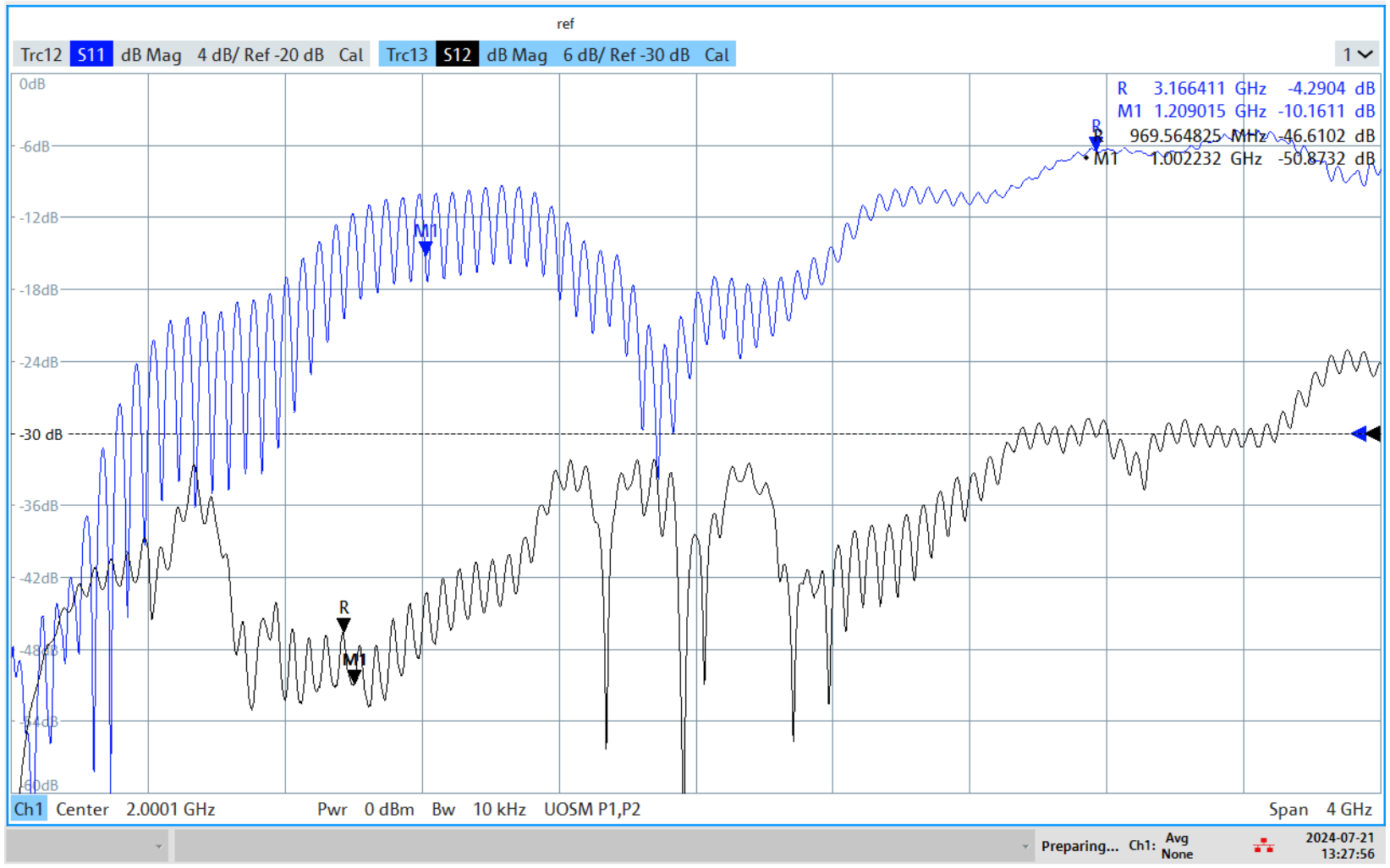
Screenshot B4 (channel 4)



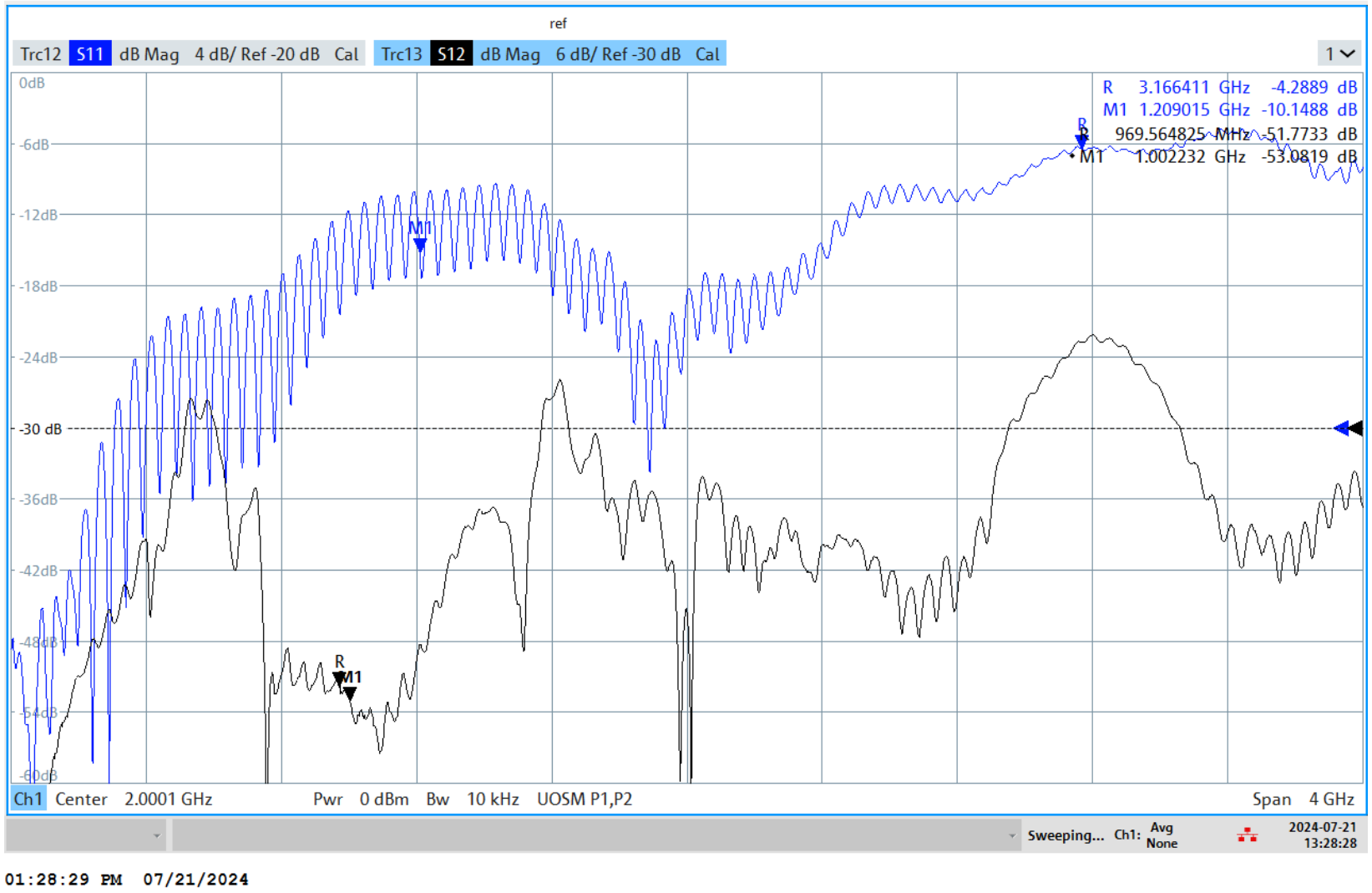
Screenshot B5 (channel 5)



Screenshot B6 (channel 6)

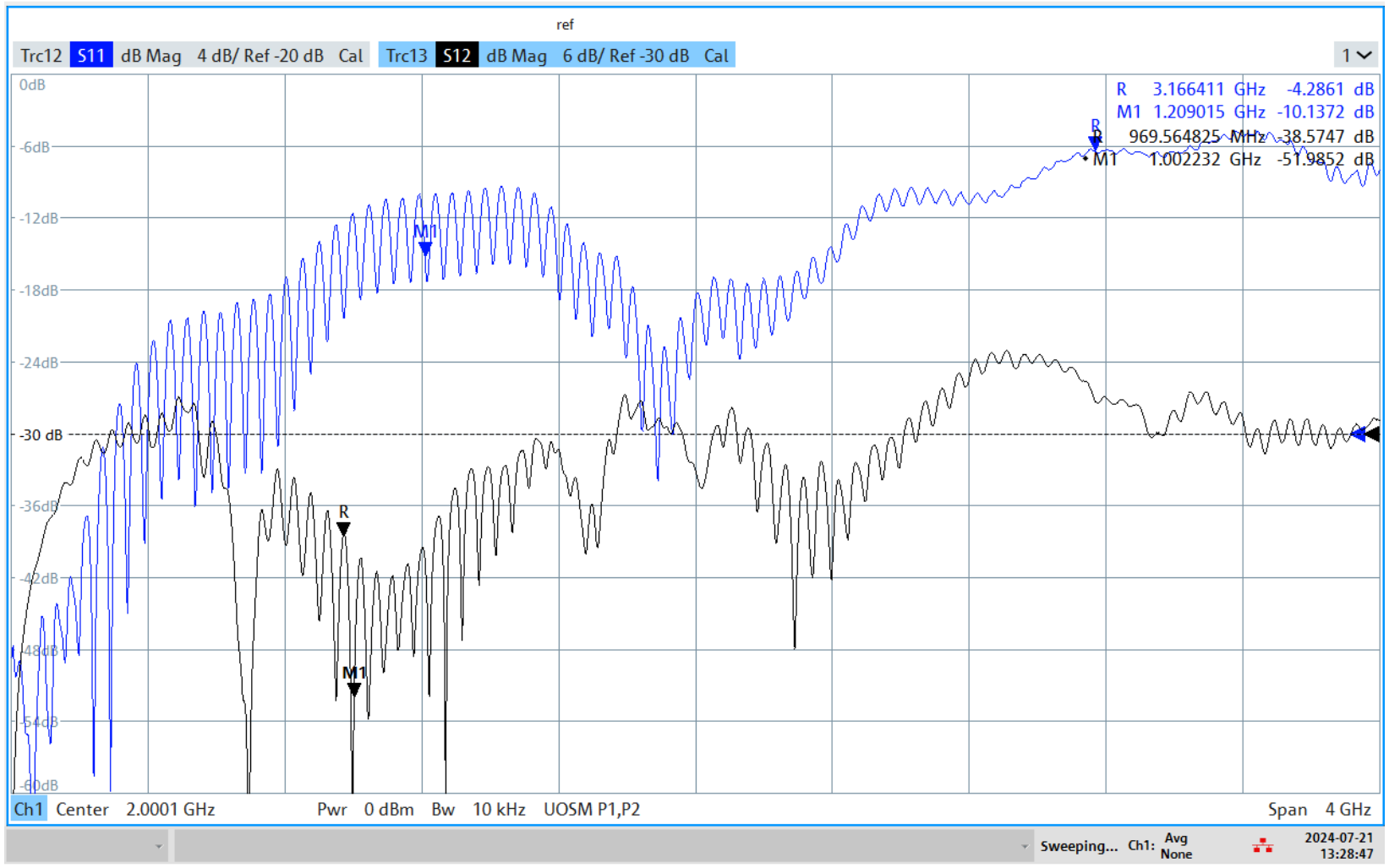


Screenshot B7 (channel 7)

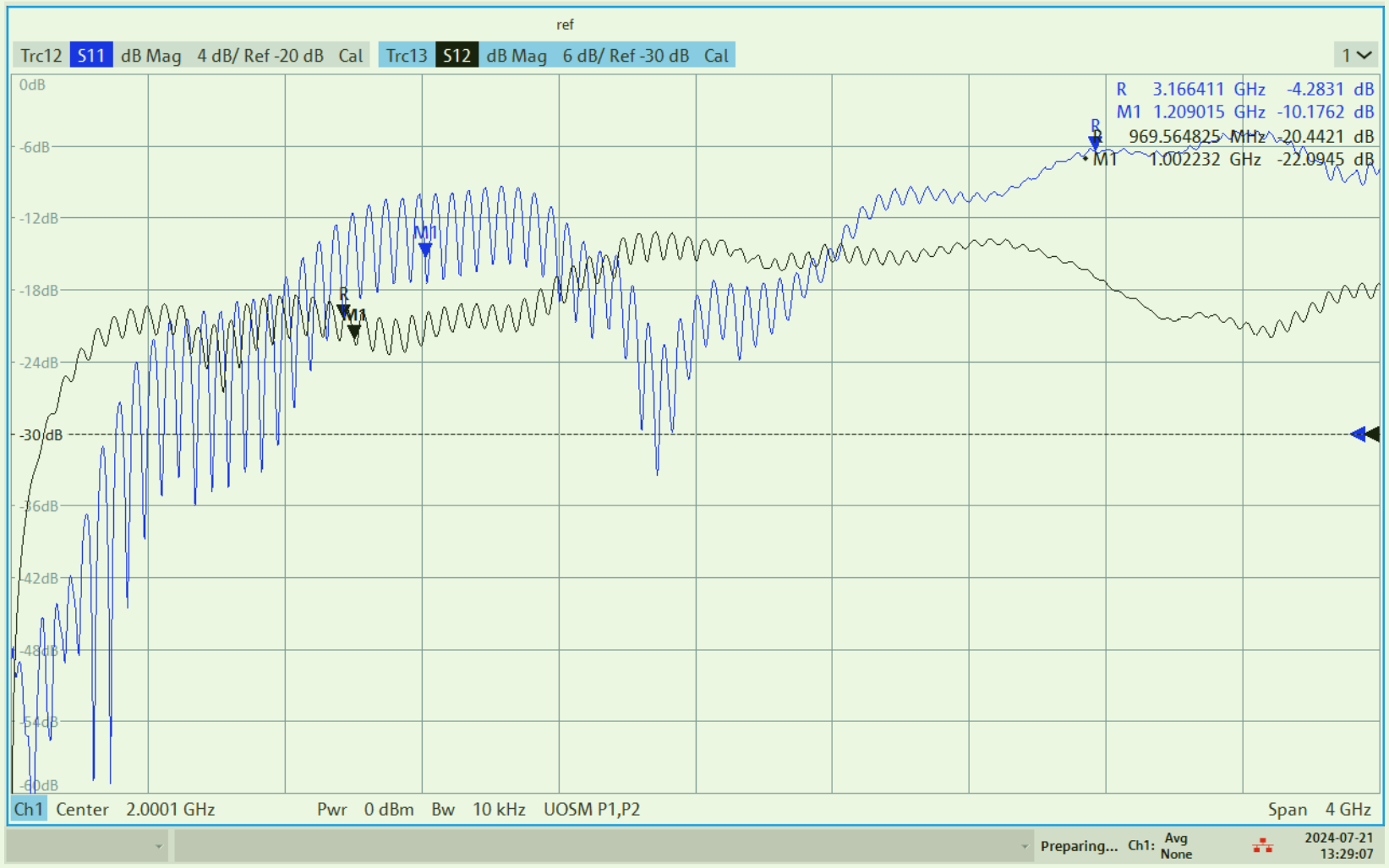


Well, looks different: was no cable at this spot on the rear side (I got only 31 total)

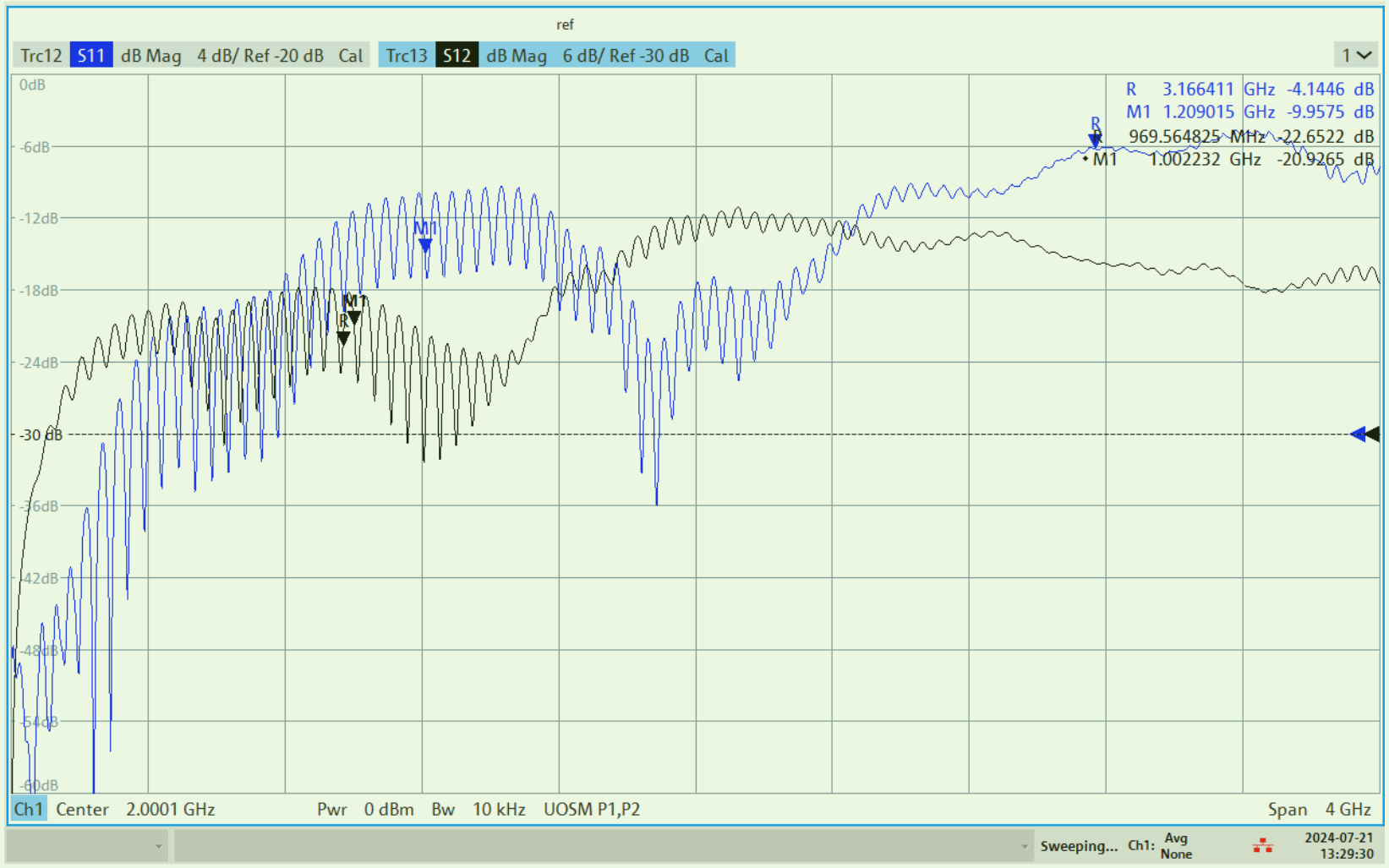
Screenshot T0 (channel 8)



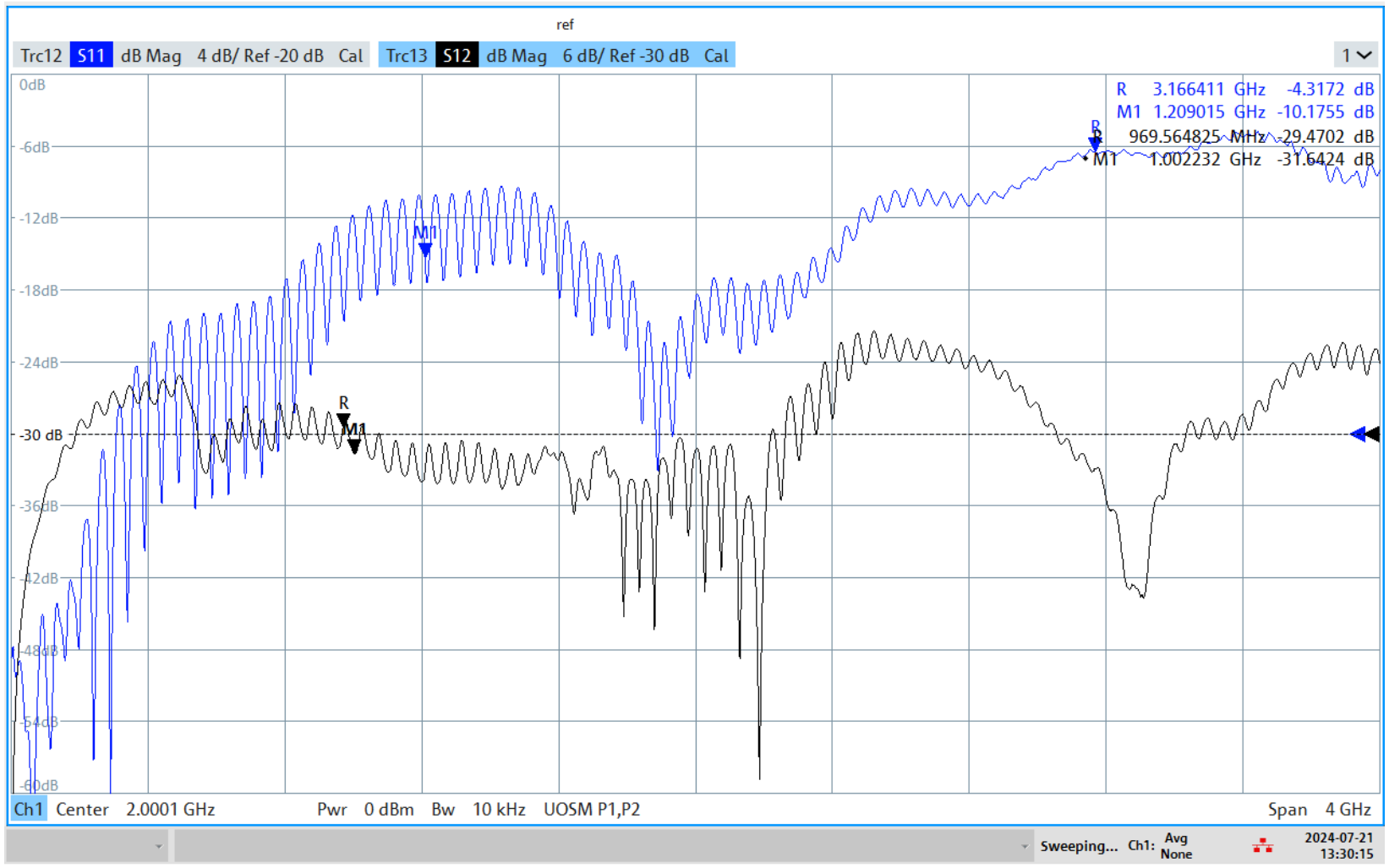
Screenshot T1 (channel 9)



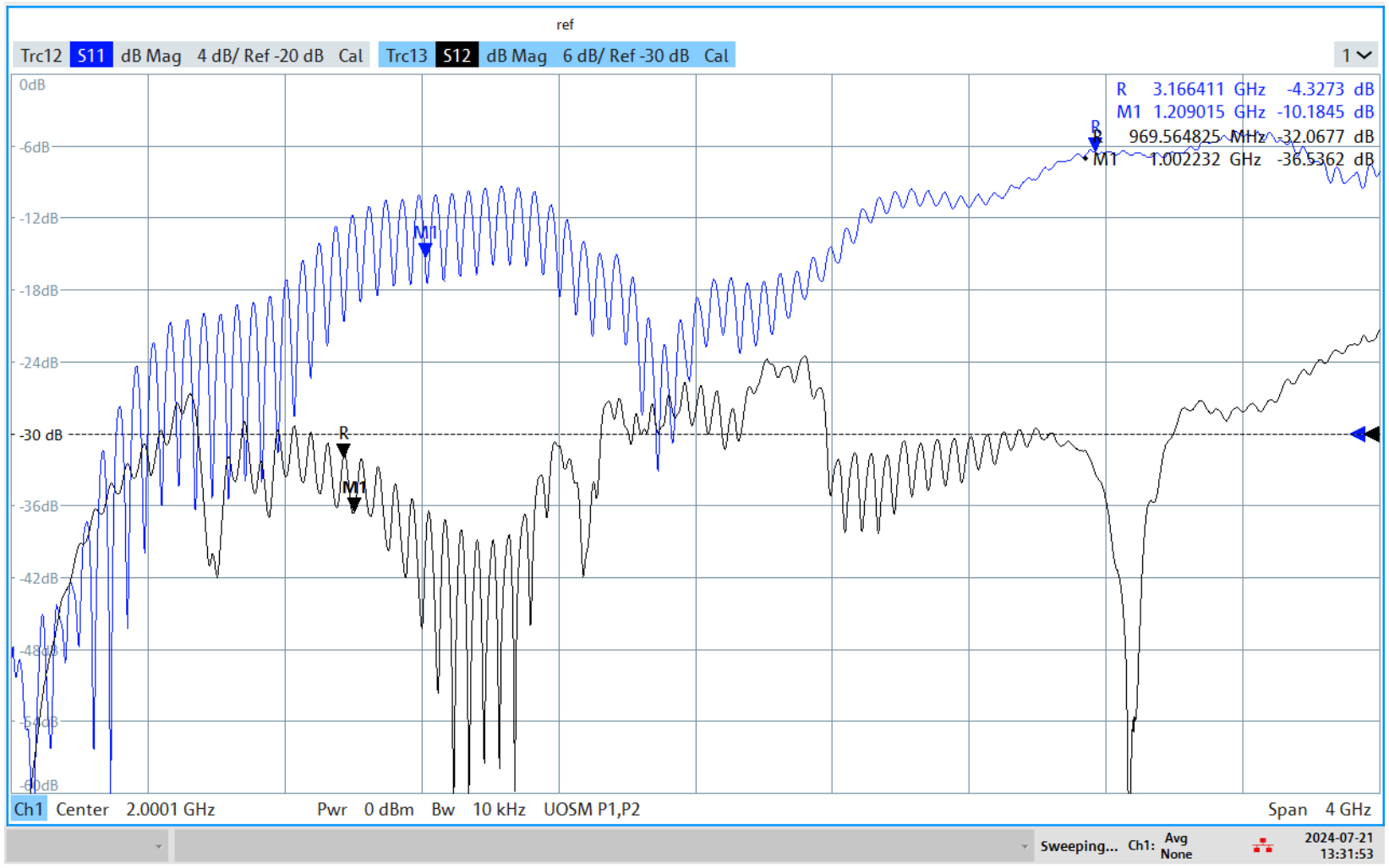
Screenshot T2 (channel 10)



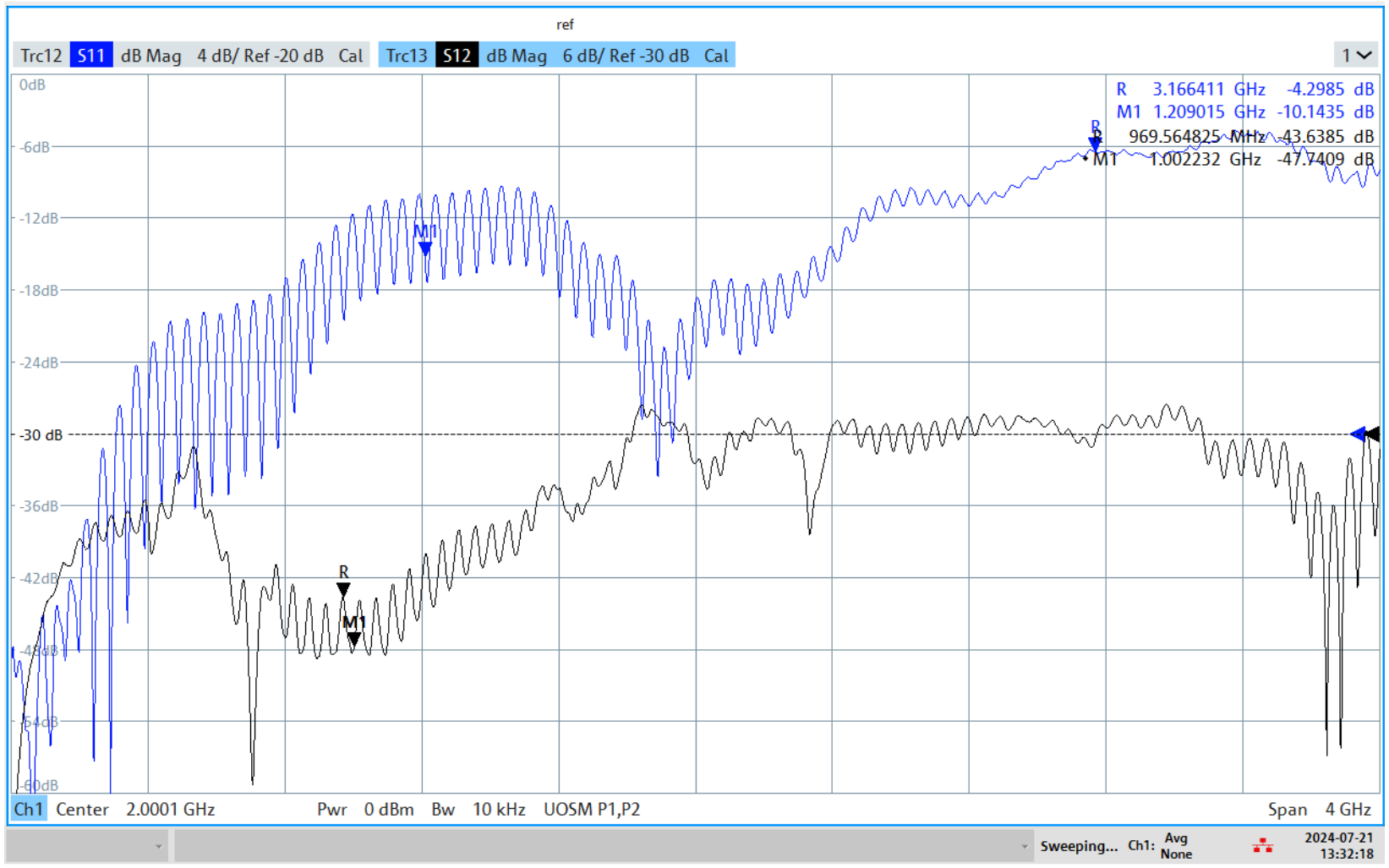
Screenshot T3 (channel 11)



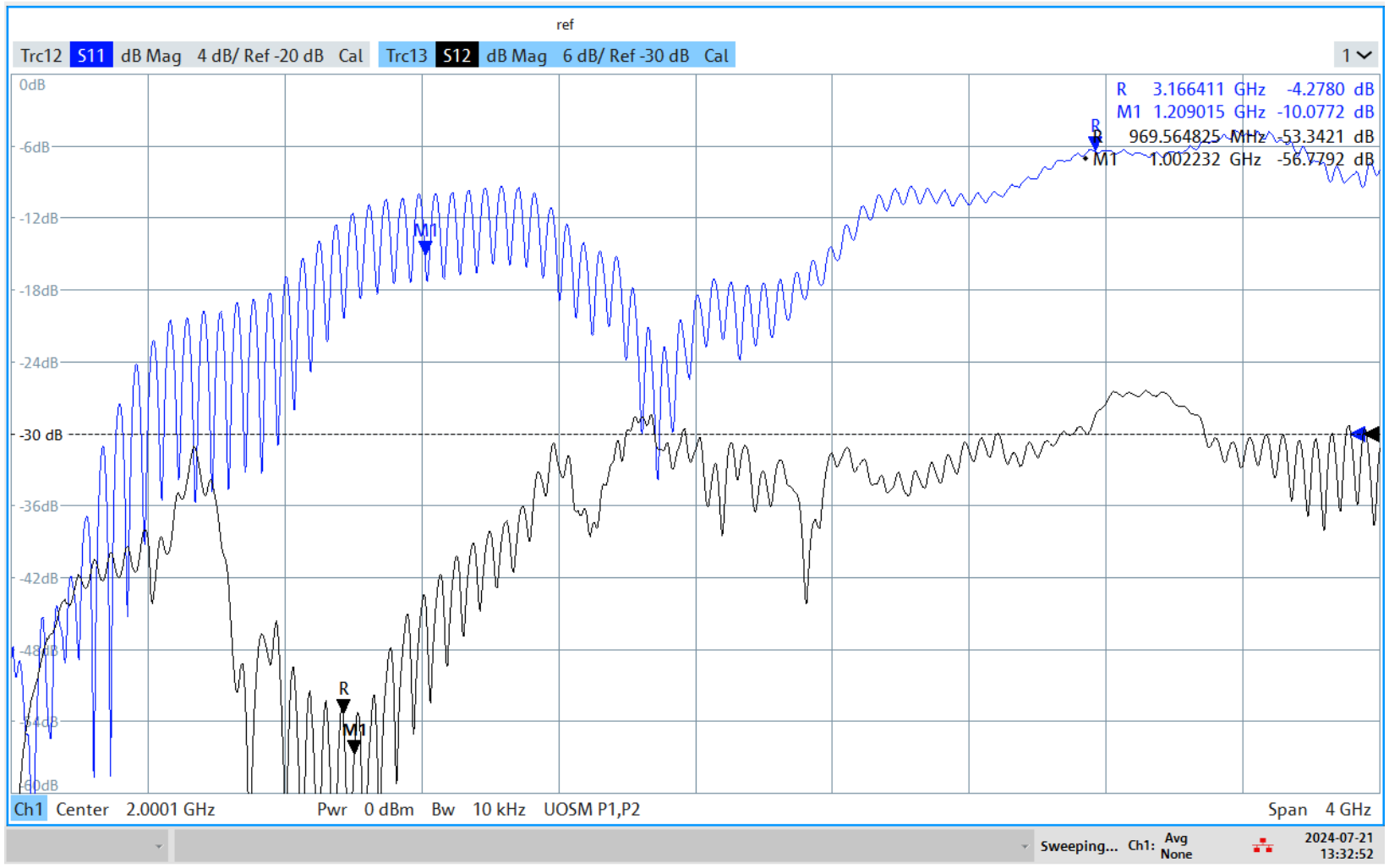
Screenshot T4 (channel 12)



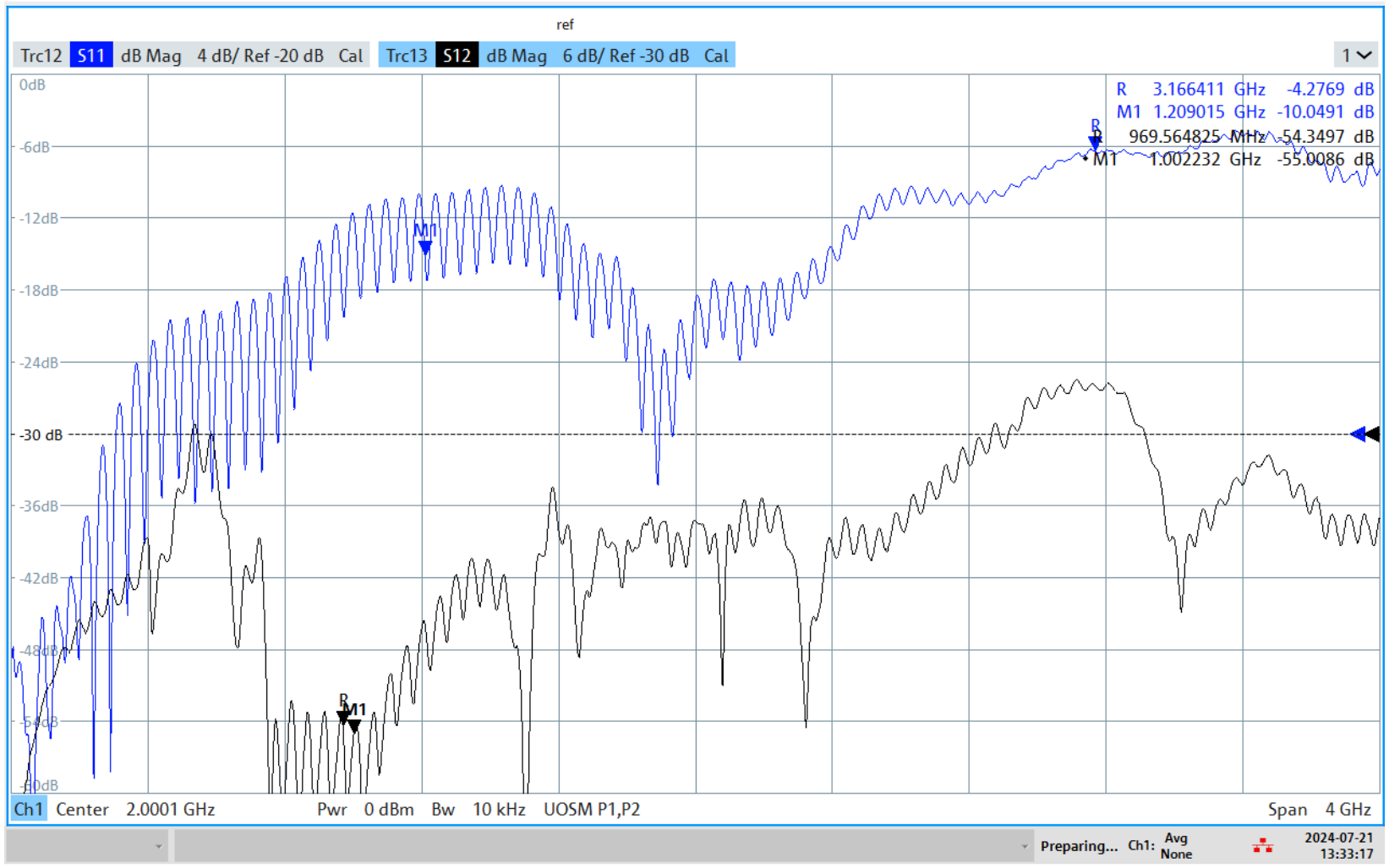
Screenshot T5 (channel 13)



Screenshot T6 (channel 14)

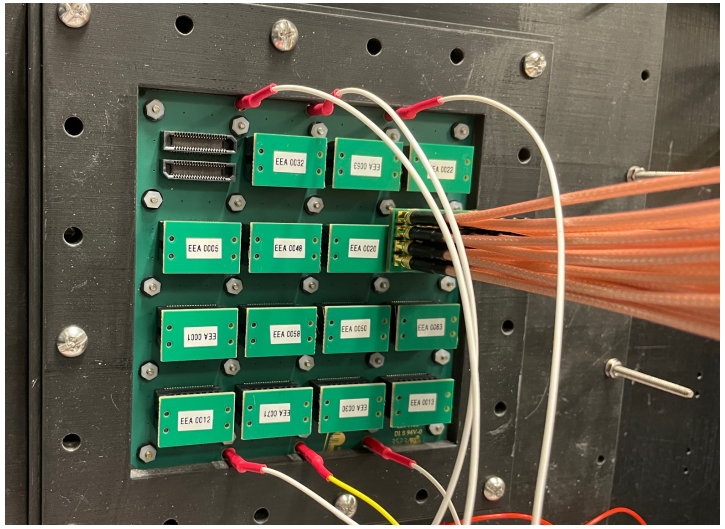


Screenshot T7 (channel 15)



Observations / conclusions

A real-life HRPPD + Y05f + Y10b setup



- Channels 1,9,10 are indeed the worst ones

- Numerical estimate for channels 9,10 in a <3GHz range:
  - Crosstalk signal on a level of ~18 dB (slides 16,17)
  - Direct signal attenuation ~3 dB (slide 9)
  - Can probably take ~15 dB as a crosstalk estimate

  - But this was a **sandwich** made of two sets of Y10b+Y05f boards …
  - … while a real-life HRPPD setup includes only a **single** set (so “twice as low” effect expected)

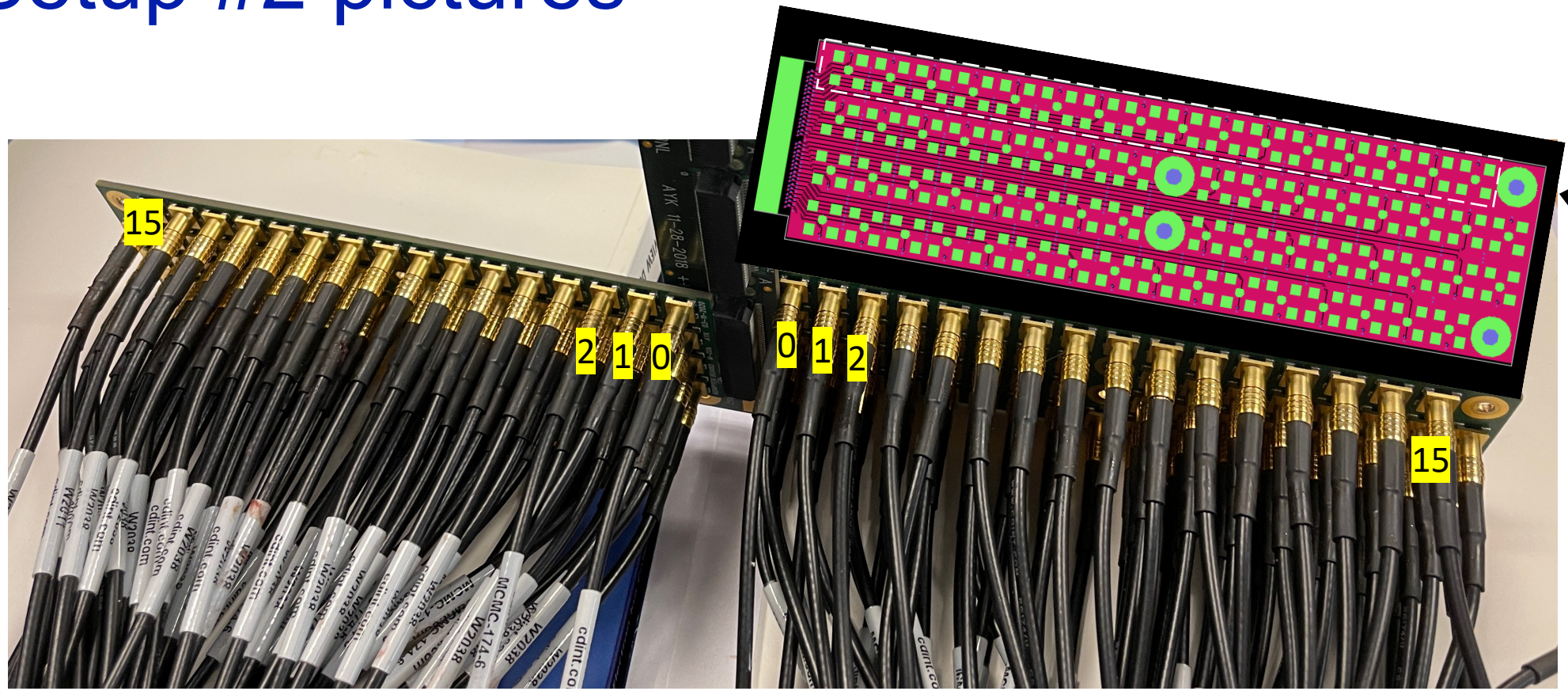
  - An educated expert guess is that this difference costs 6 dB extra rather than √2 …
  - … which brings a real-life configuration best guess estimate to ~21 dB …

  - … which is kind of a crosstalk on a ~10% level seen in real HRPPD signals

Setup #2: M00k-M00k mirror configuration

Main motivation: see a degree of signal degradation in an MCX adapter as a function of trace length

Setup #2 pictures



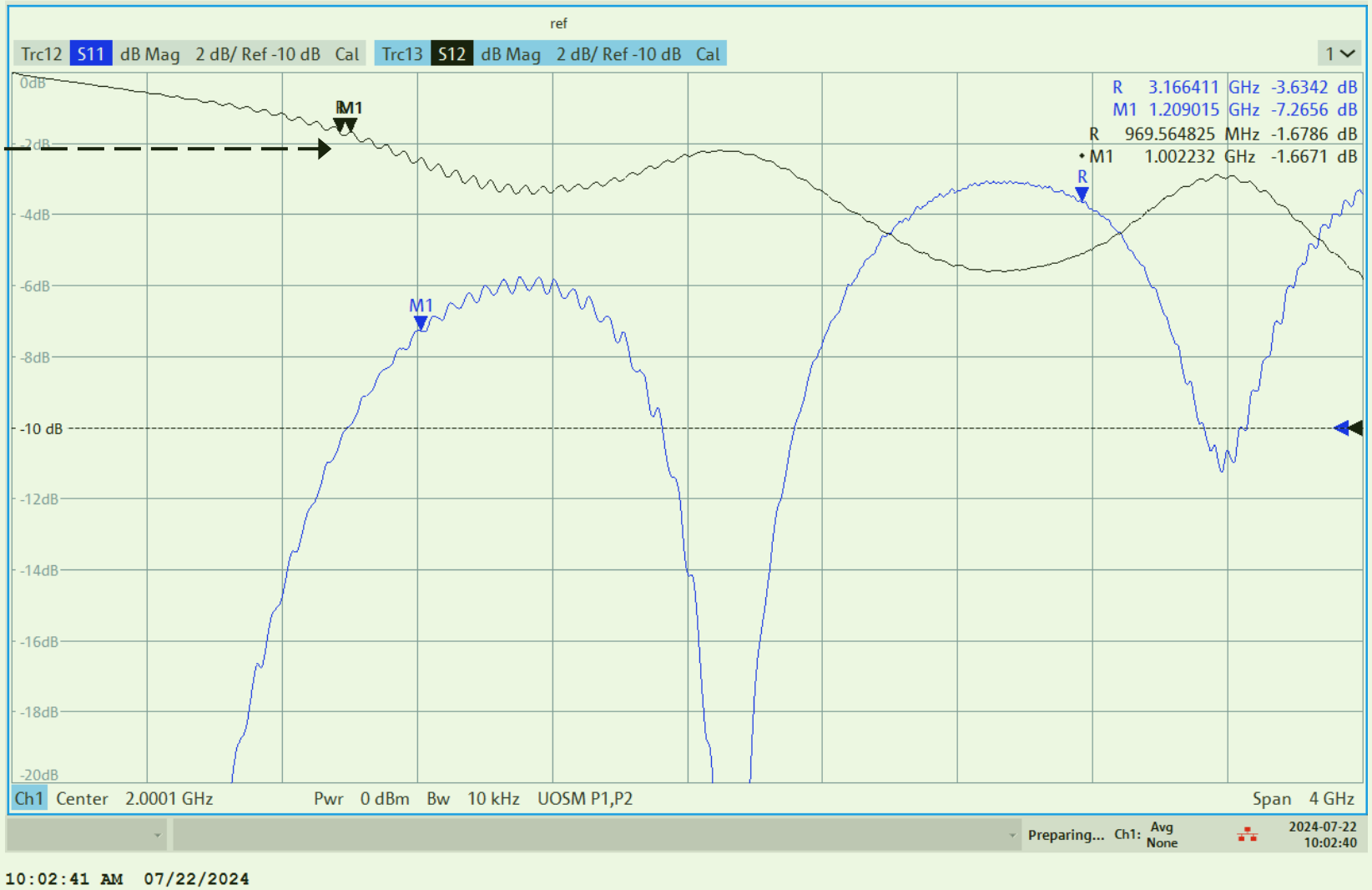
Channels 00..15:
odd on the front side,
even – on the rear one;
adjacent traces in L3 & L6

- A M00k-Z03e-M00k mirror setup
  - Where M00k is an MCX edge adapter and Z03e is a back-to-back Samtec MEC8-DV adapter
- 64 MCX->MCX cables on both sides
  - Permanently connected to V1742 DRS4 digitizer inputs (50 Ohm termination) except for a pair of Port 1 / Port 2 cables

- The next 16 slides are 0(L)->0(R), 1->1, …, 15->15 cases (DC coupling in all cases)

Channels 00

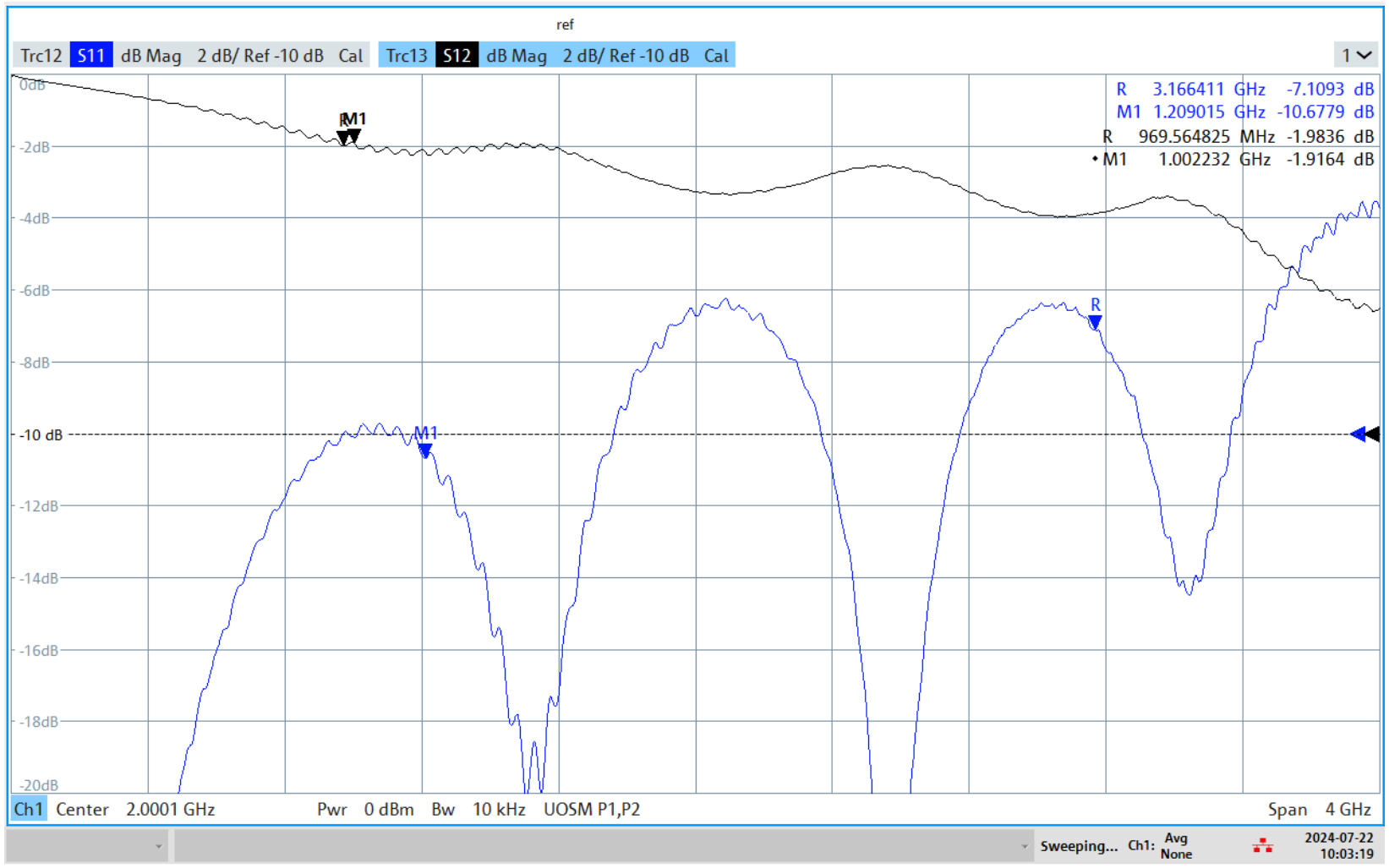
We are interested in attenuation of this signal



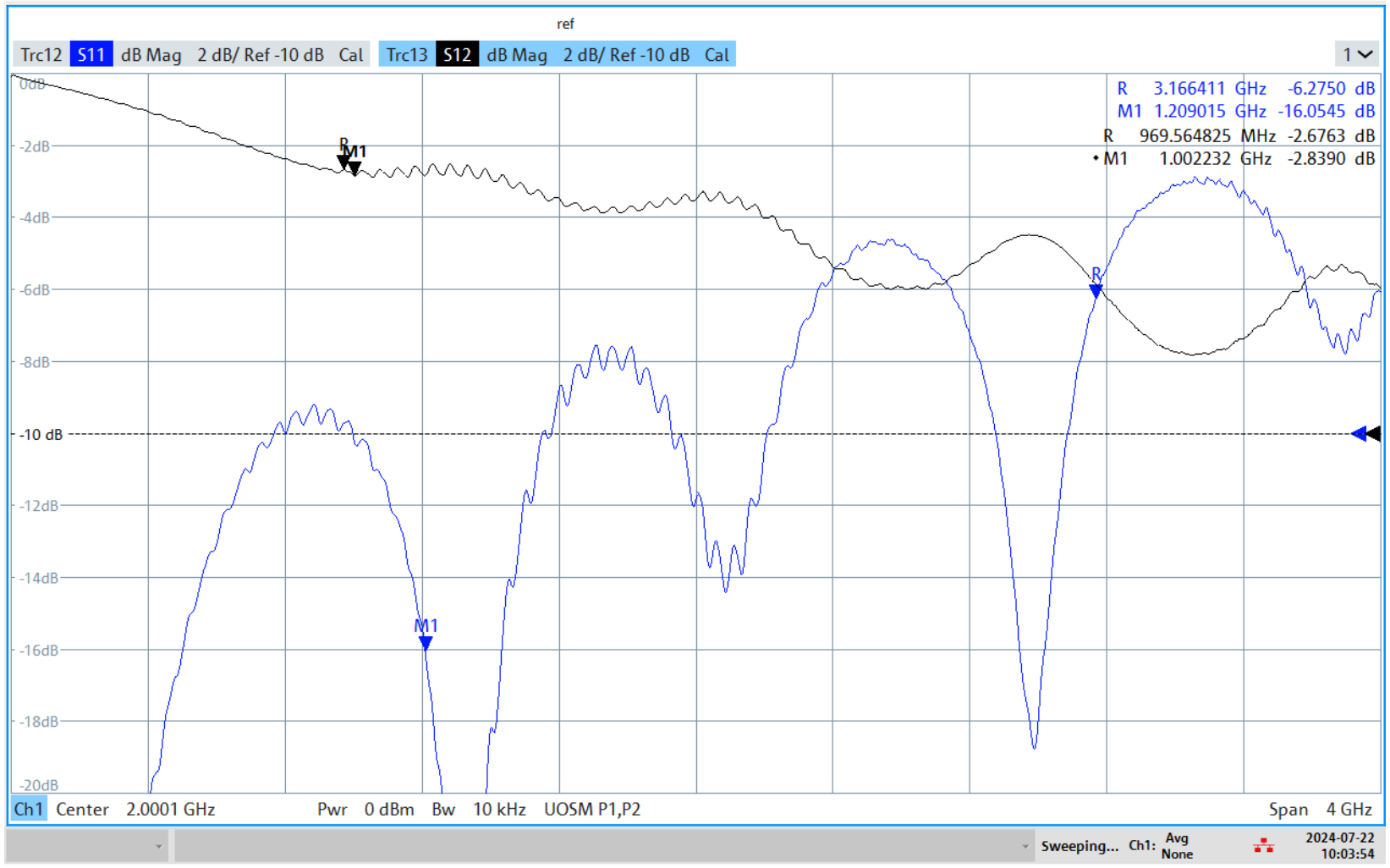
Vertical axis: -20 dB .. 0 dB

Horizontal axis: 100 kHz .. 4 GHz

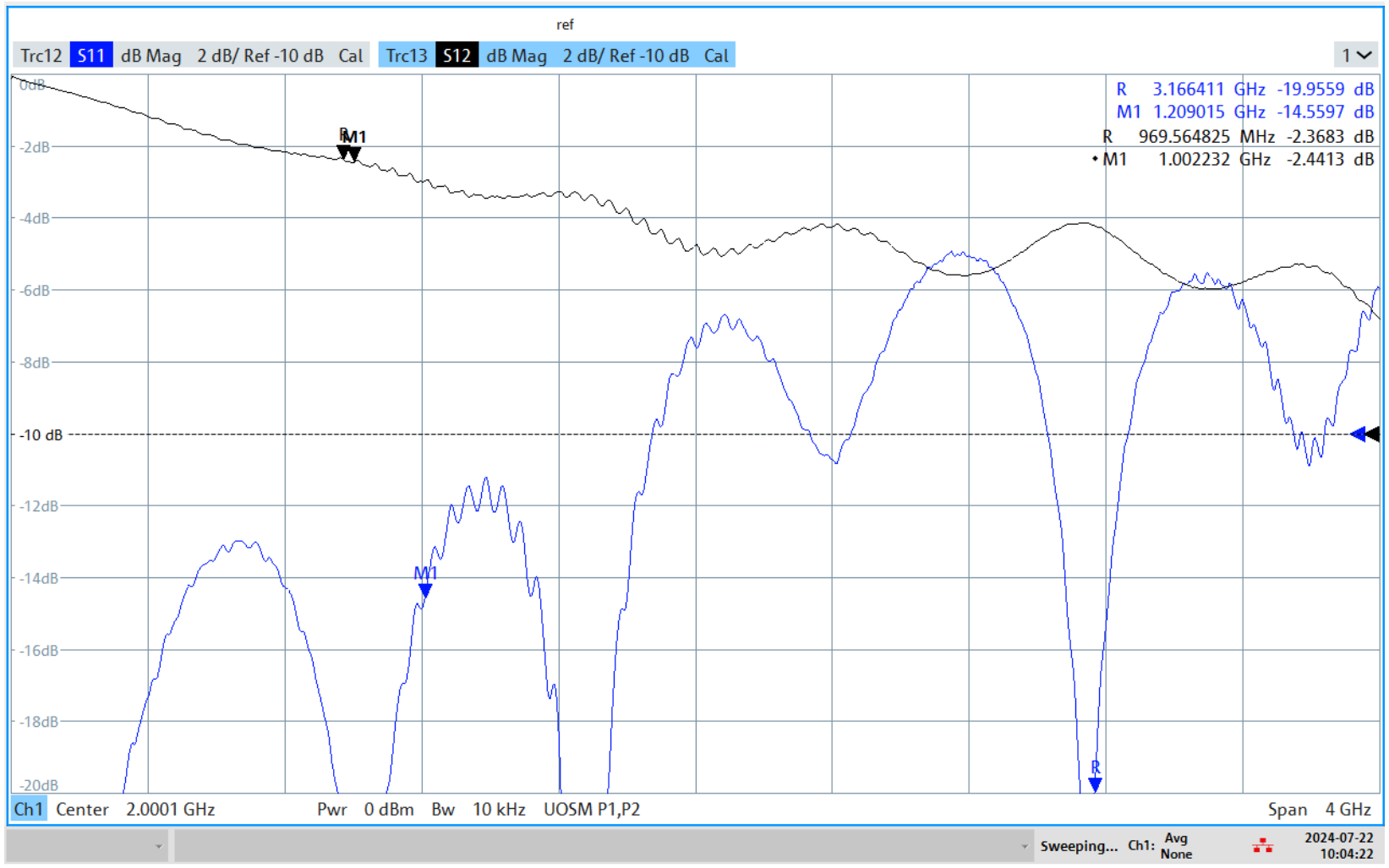
Channels 01


ref
Trc12 S11 dB Mag 2 dB/ Ref -10 dB Cal
Trc13 S12 dB Mag 2 dB/ Ref -10 dB Cal
R 3.166411 GHz -7.1093 dB
M1 1.209015 GHz -10.6779 dB
R 969.564825 MHz -1.9836 dB
M1 1.002232 GHz -1.9164 dB
0dB
-2dB
-4dB
-6dB
-8dB
-10 dB
-12dB
-14dB
-16dB
-18dB
-20dB
Ch1 Center 2.0001 GHz
Pwr 0 dBm Bw 10 kHz UOSM P1,P2
Span 4 GHz
Sweeping... Ch1: Avg None
2024-07-22 10:03:19
10:03:20 AM 07/22/2024

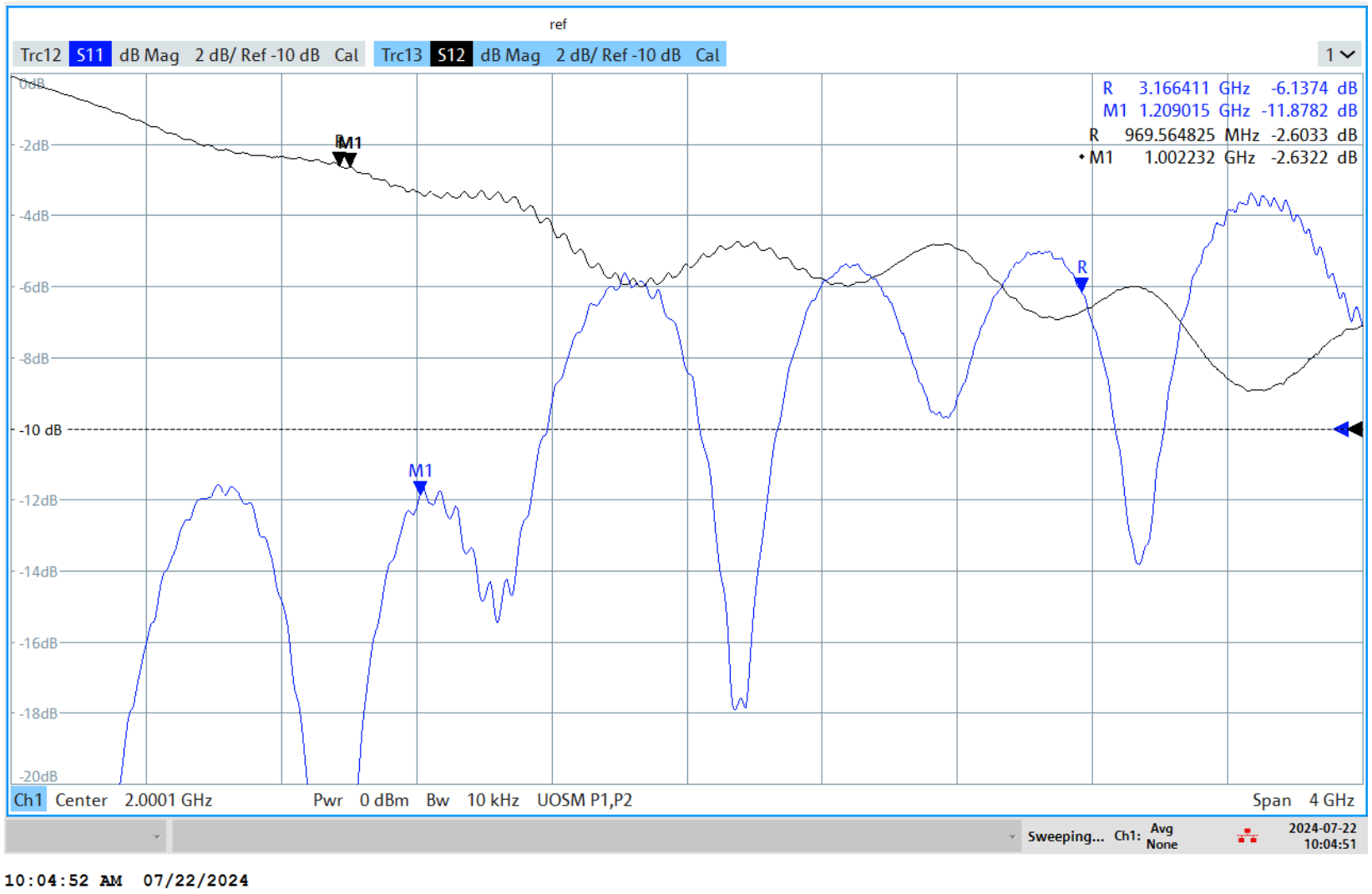
Channels 02


ref
Trc12 S11 dB Mag 2 dB/ Ref -10 dB Cal
Trc13 S12 dB Mag 2 dB/ Ref -10 dB Cal
1
R 3.166411 GHz -6.2750 dB
M1 1.209015 GHz -16.0545 dB
R 969.564825 MHz -2.6763 dB
•M1 1.002232 GHz -2.8390 dB
0dB
-2dB
-4dB
-6dB
-8dB
-10 dB
-12dB
-14dB
-16dB
-18dB
-20dB
Ch1 Center 2.0001 GHz
Pwr 0 dBm Bw 10 kHz UOSM P1,P2
Span 4 GHz
Sweeping... Ch1: Avg None
2024-07-22 10:03:54
10:03:55 AM 07/22/2024

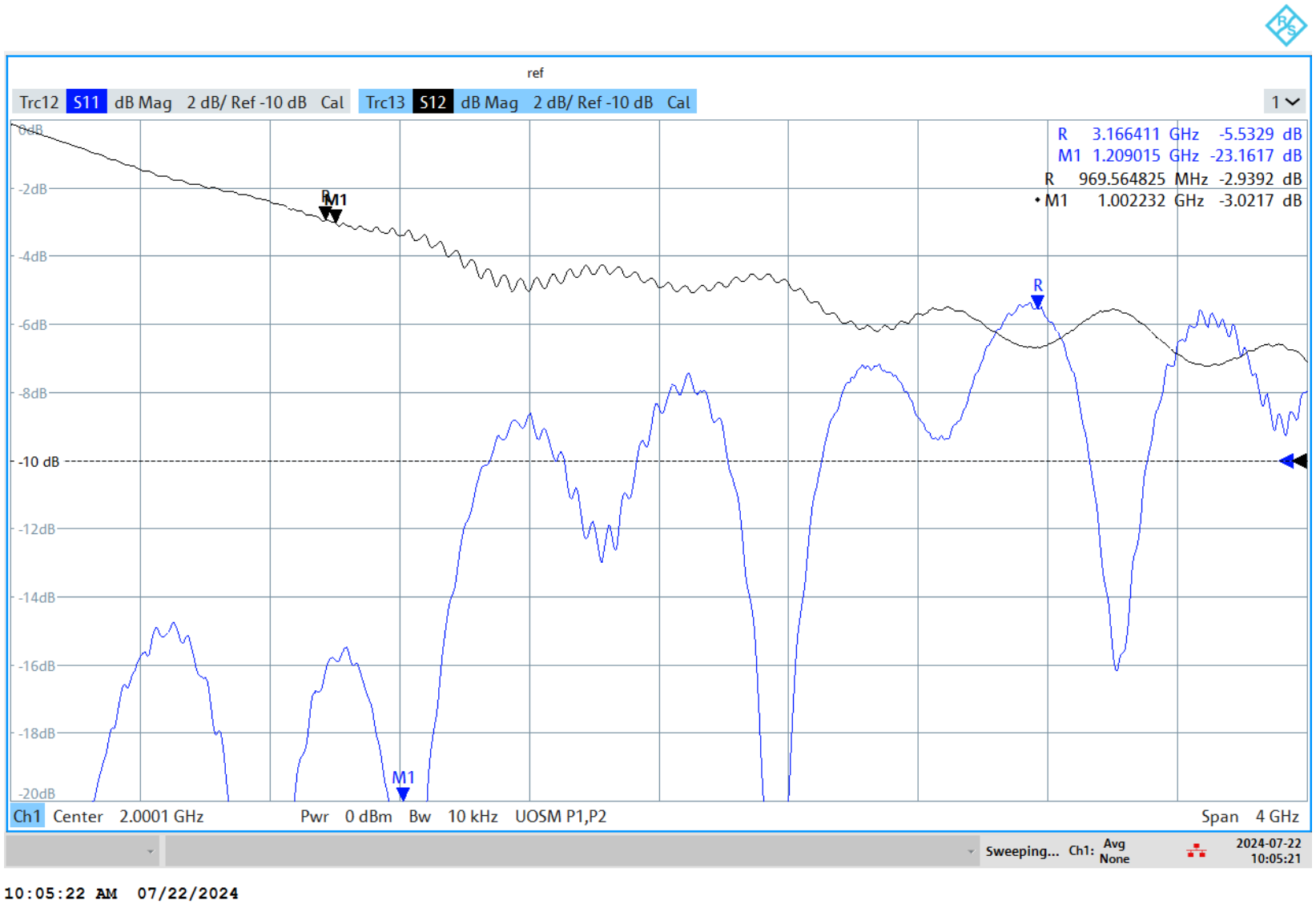
Channels 03


ref
Trc12 S11 dB Mag 2 dB/ Ref -10 dB Cal
Trc13 S12 dB Mag 2 dB/ Ref -10 dB Cal
R 3.166411 GHz -19.9559 dB
M1 1.209015 GHz -14.5597 dB
R 969.564825 MHz -2.3683 dB
M1 1.002232 GHz -2.4413 dB
-10 dB
Ch1 Center 2.0001 GHz
Pwr 0 dBm Bw 10 kHz UOSM P1,P2
Span 4 GHz
Sweeping... Ch1: Avg None
2024-07-22 10:04:22
10:04:23 AM 07/22/2024

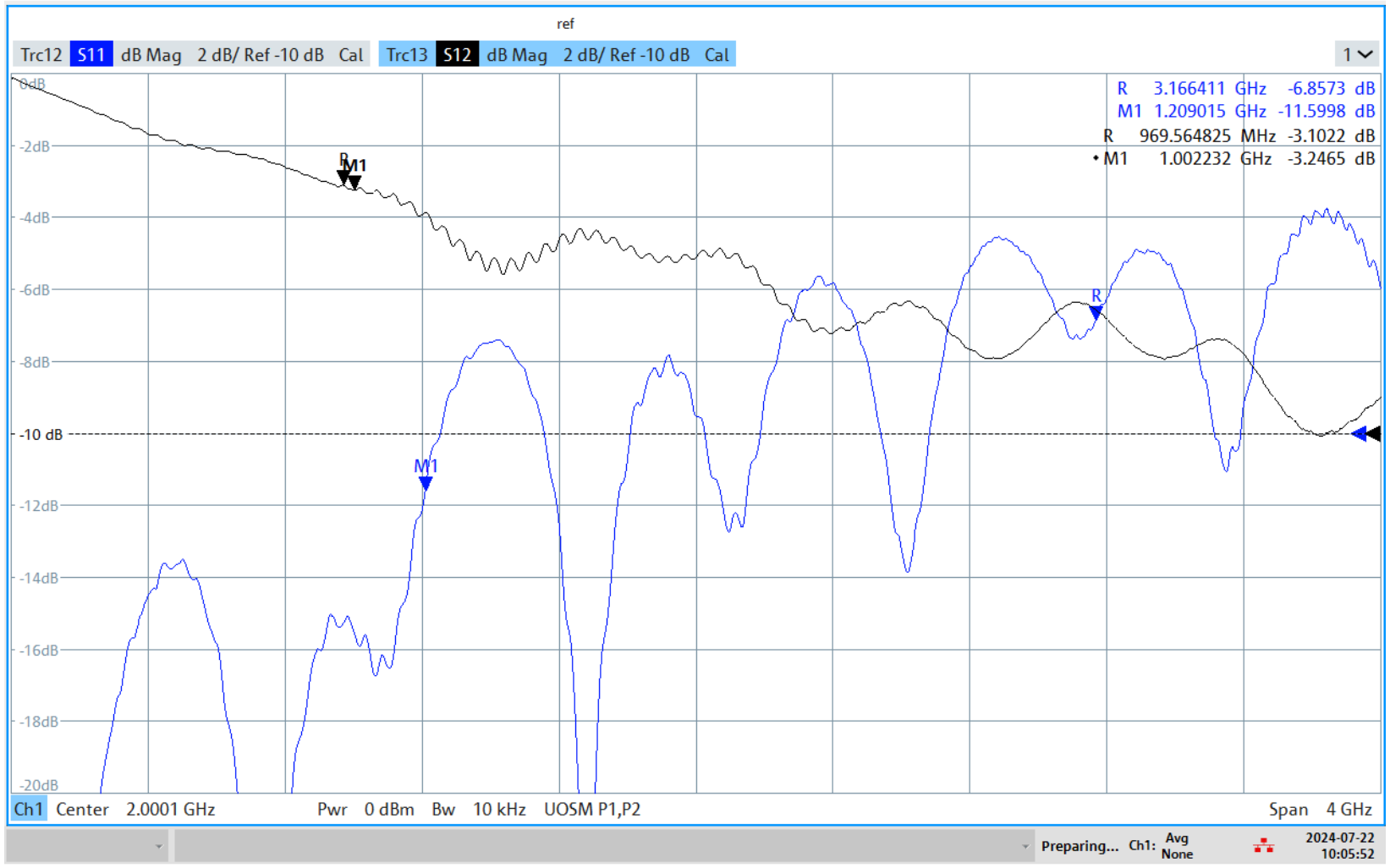
Channels 04


ref
Trc12 S11 dB Mag 2 dB/ Ref -10 dB Cal
Trc13 S12 dB Mag 2 dB/ Ref -10 dB Cal
1
R 3.166411 GHz -6.1374 dB
M1 1.209015 GHz -11.8782 dB
R 969.564825 MHz -2.6033 dB
• M1 1.002232 GHz -2.6322 dB
0dB
-2dB
-4dB
-6dB
-8dB
-10 dB
-12dB
-14dB
-16dB
-18dB
-20dB
M1
R
M1
Ch1 Center 2.0001 GHz
Pwr 0 dBm Bw 10 kHz UOSM P1,P2
Span 4 GHz
Sweeping... Ch1: Avg None
2024-07-22 10:04:51
10:04:52 AM 07/22/2024

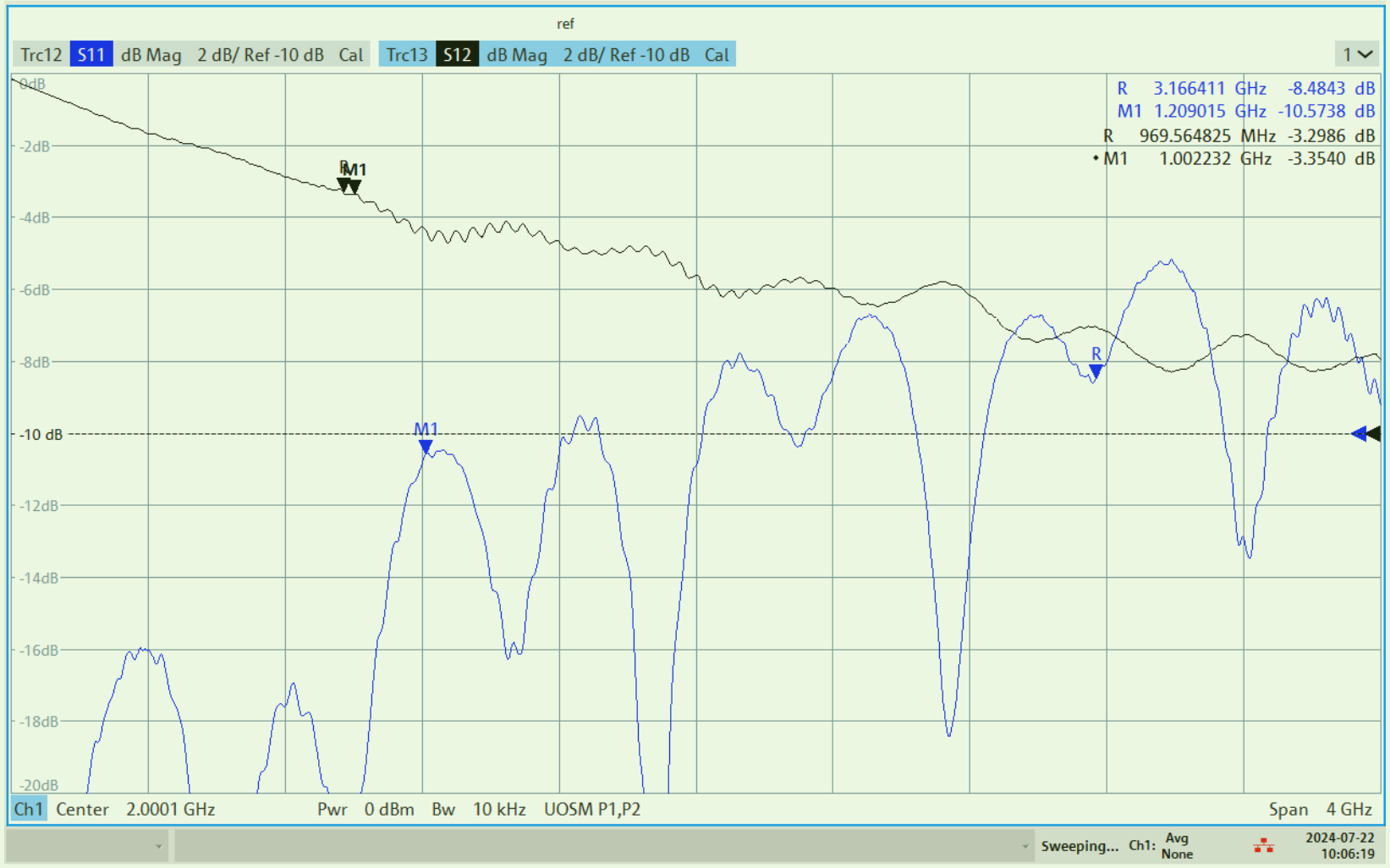
Channels 05


ref
Trc12 S11 dB Mag 2 dB/ Ref -10 dB Cal
Trc13 S12 dB Mag 2 dB/ Ref -10 dB Cal
1
R 3.166411 GHz -5.5329 dB
M1 1.209015 GHz -23.1617 dB
R 969.564825 MHz -2.9392 dB
• M1 1.002232 GHz -3.0217 dB
0dB
-2dB
-4dB
-6dB
-8dB
-10 dB
-12dB
-14dB
-16dB
-18dB
-20dB
R
M1
M1
Ch1 Center 2.0001 GHz
Pwr 0 dBm Bw 10 kHz UOSM P1,P2
Span 4 GHz
Sweeping... Ch1: Avg None
2024-07-22 10:05:21
10:05:22 AM 07/22/2024

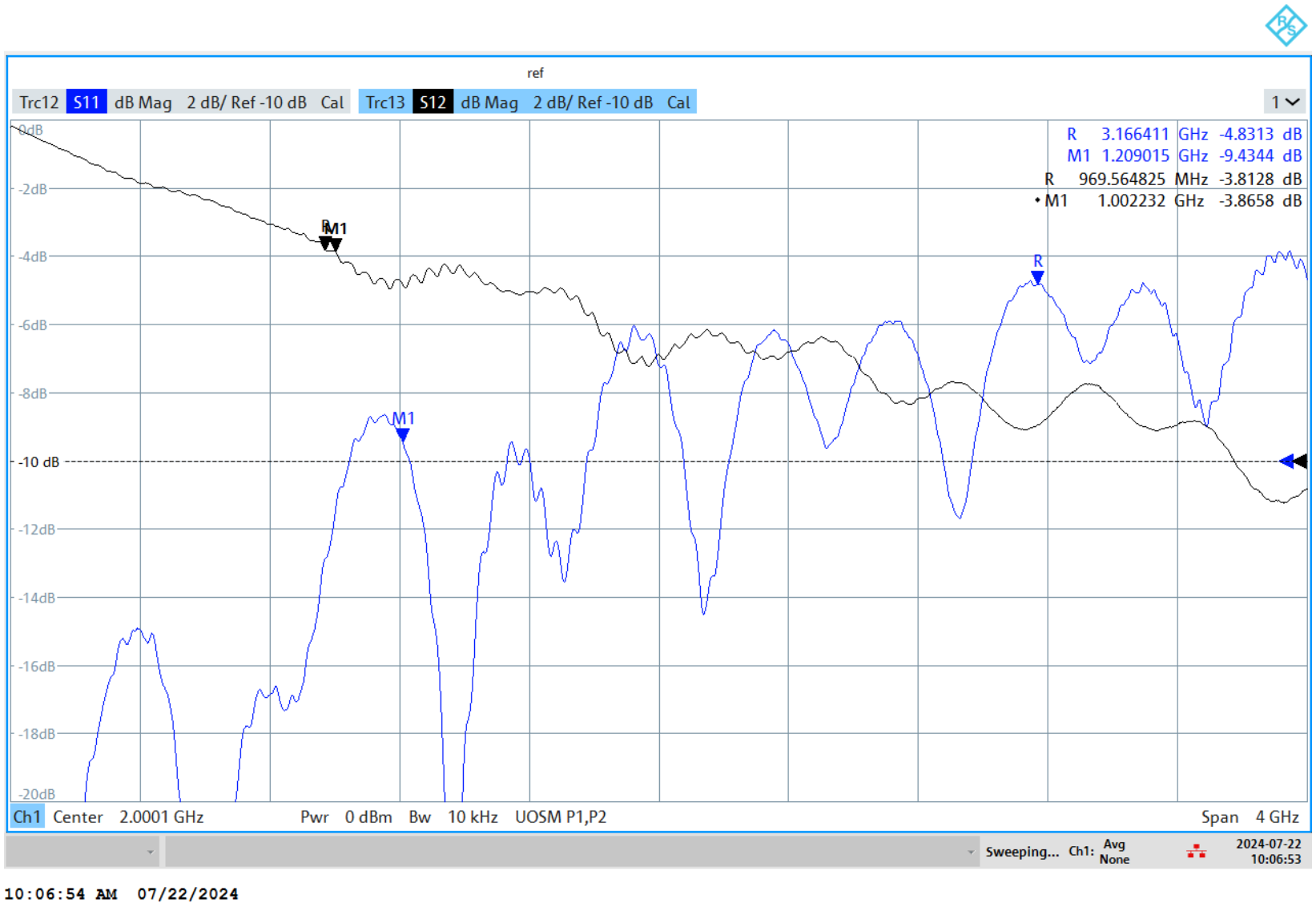
Channels 06


ref
Trc12 S11 dB Mag 2 dB/ Ref -10 dB Cal
Trc13 S12 dB Mag 2 dB/ Ref -10 dB Cal
1
R 3.166411 GHz -6.8573 dB
M1 1.209015 GHz -11.5998 dB
R 969.564825 MHz -3.1022 dB
• M1 1.002232 GHz -3.2465 dB
0dB
-2dB
-4dB
-6dB
-8dB
-10 dB
-12dB
-14dB
-16dB
-18dB
-20dB
R
M1
M1
R
Ch1 Center 2.0001 GHz
Pwr 0 dBm Bw 10 kHz UOSM P1,P2
Span 4 GHz
Preparing... Ch1: Avg None
2024-07-22 10:05:52
10:05:53 AM 07/22/2024

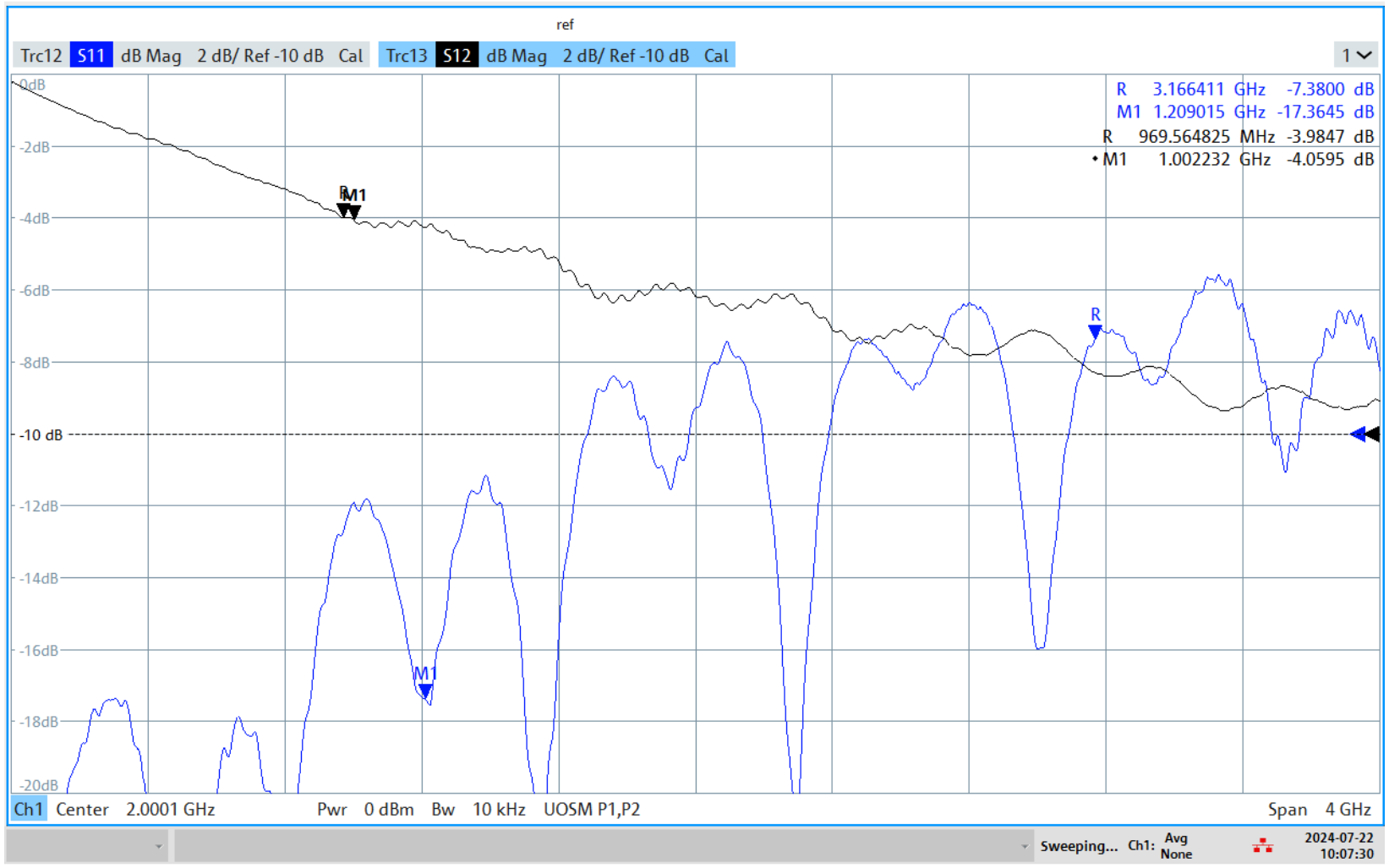
Channels 07


ref
Trc12 S11 dB Mag 2 dB/ Ref -10 dB Cal
Trc13 S12 dB Mag 2 dB/ Ref -10 dB Cal
1
R 3.166411 GHz -8.4843 dB
M1 1.209015 GHz -10.5738 dB
R 969.564825 MHz -3.2986 dB
• M1 1.002232 GHz -3.3540 dB
0dB
-2dB
-4dB
-6dB
-8dB
-10 dB
-12dB
-14dB
-16dB
-18dB
-20dB
R
M1
M1
R
Ch1 Center 2.0001 GHz
Pwr 0 dBm Bw 10 kHz UOSM P1,P2
Span 4 GHz
Sweeping... Ch1: Avg None
2024-07-22 10:06:19
10:06:20 AM 07/22/2024

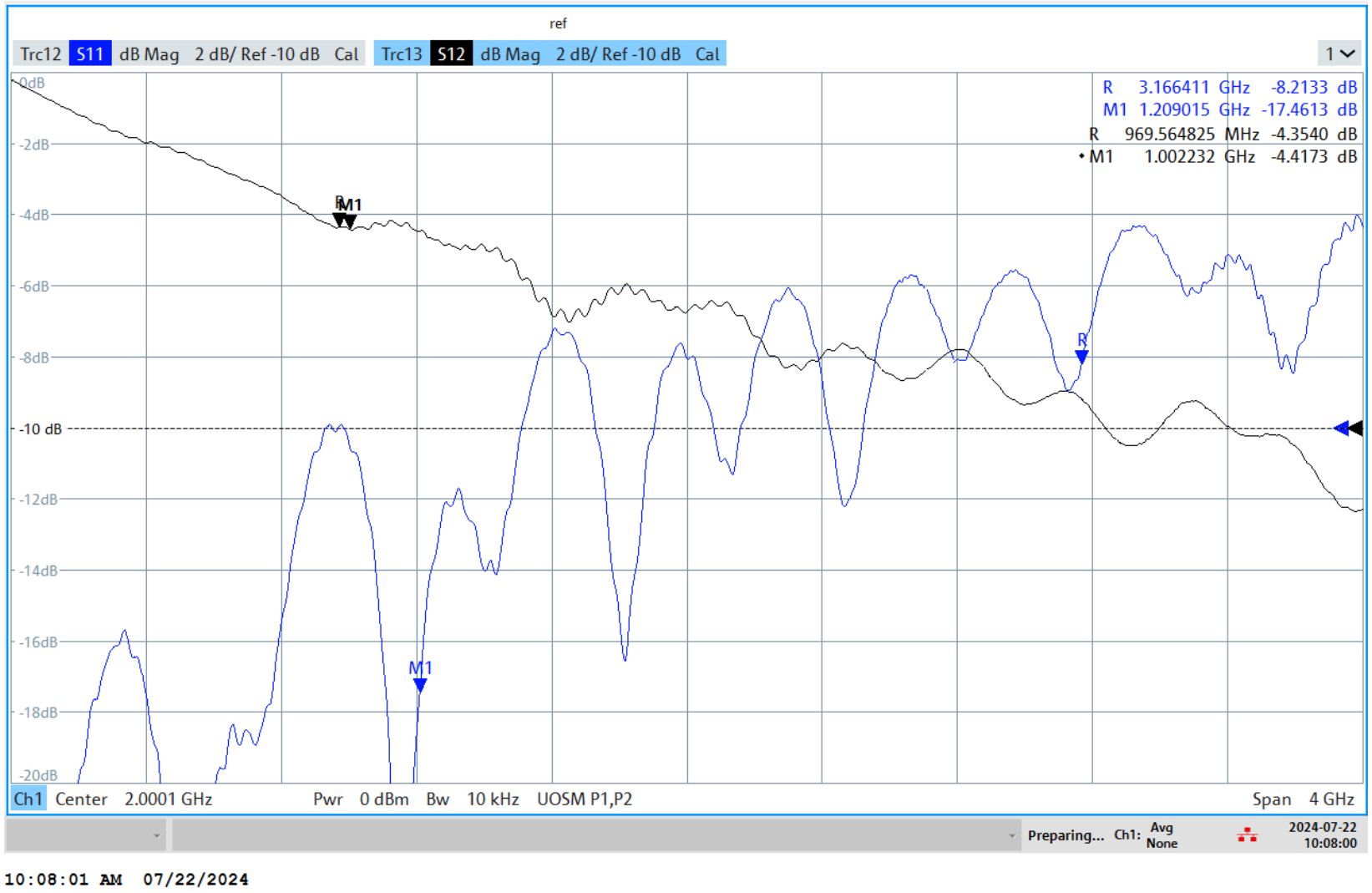
Channels 08


ref
Trc12 S11 dB Mag 2 dB/ Ref -10 dB Cal
Trc13 S12 dB Mag 2 dB/ Ref -10 dB Cal
1
R 3.166411 GHz -4.8313 dB
M1 1.209015 GHz -9.4344 dB
R 969.564825 MHz -3.8128 dB
• M1 1.002232 GHz -3.8658 dB
0dB
-2dB
-4dB
-6dB
-8dB
-10 dB
-12dB
-14dB
-16dB
-18dB
-20dB
M1
R
M1
Ch1 Center 2.0001 GHz
Pwr 0 dBm Bw 10 kHz UOSM P1,P2
Span 4 GHz
Sweeping... Ch1: Avg None
2024-07-22 10:06:53
10:06:54 AM 07/22/2024

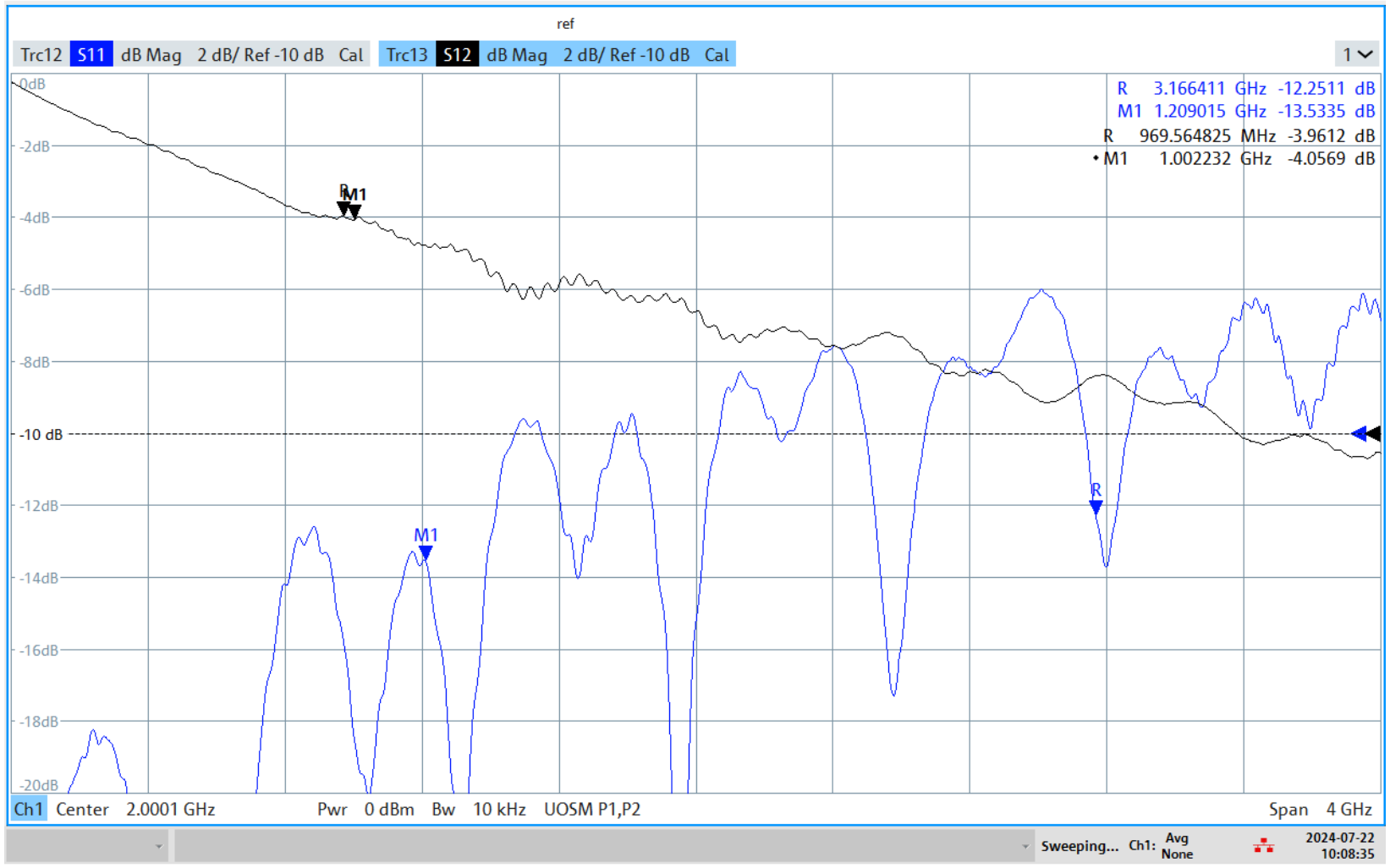
Channels 09


ref
Trc12 S11 dB Mag 2 dB/ Ref -10 dB Cal
Trc13 S12 dB Mag 2 dB/ Ref -10 dB Cal
1
R 3.166411 GHz -7.3800 dB
M1 1.209015 GHz -17.3645 dB
R 969.564825 MHz -3.9847 dB
•M1 1.002232 GHz -4.0595 dB
0dB
-2dB
-4dB
-6dB
-8dB
-10 dB
-12dB
-14dB
-16dB
-18dB
-20dB
M1
R
M1
Ch1 Center 2.0001 GHz
Pwr 0 dBm Bw 10 kHz UOSM P1,P2
Span 4 GHz
Sweeping... Ch1: Avg None
2024-07-22 10:07:30
10:07:31 AM 07/22/2024

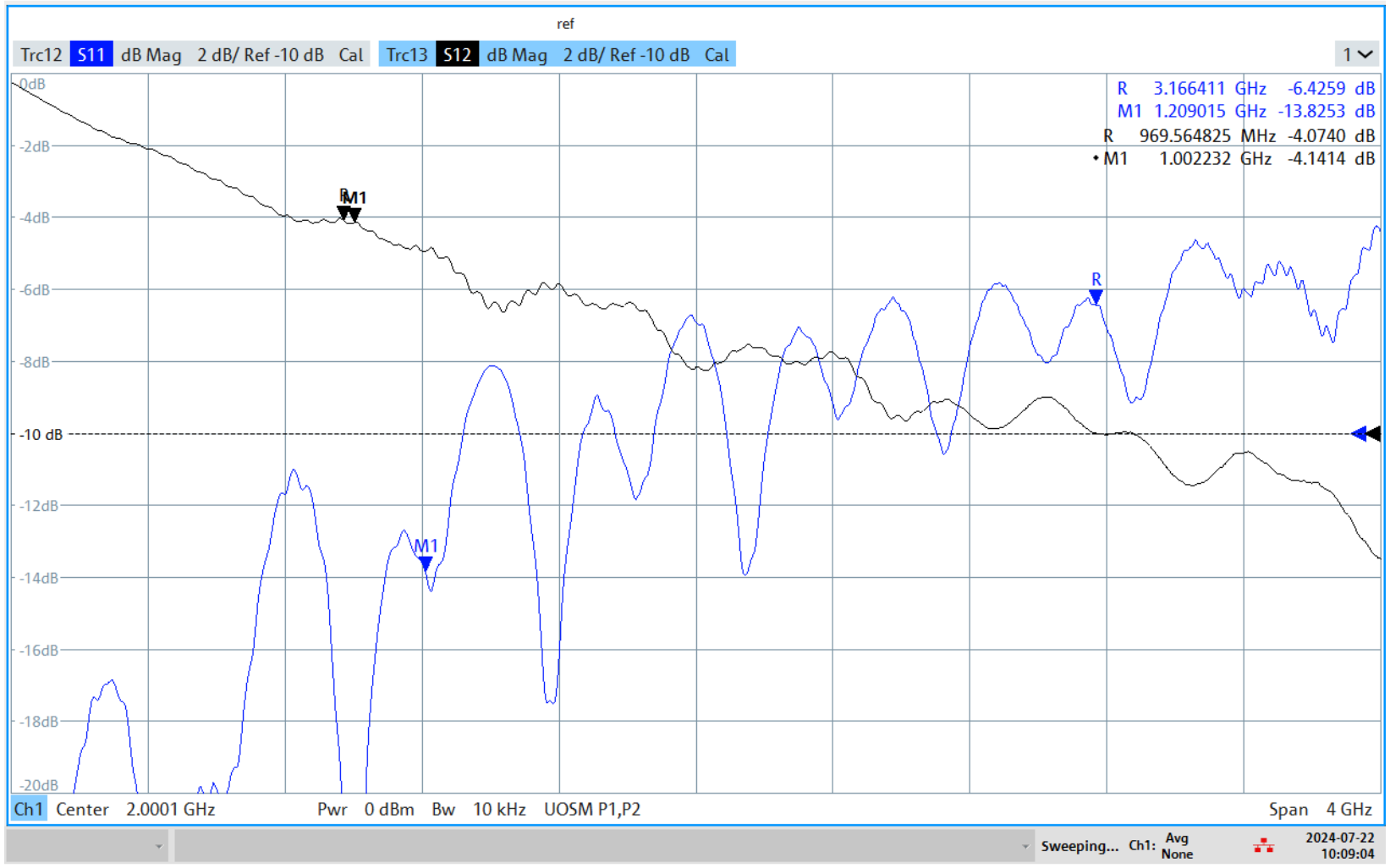
Channels 10


ref
Trc12 S11 dB Mag 2 dB/ Ref -10 dB Cal
Trc13 S12 dB Mag 2 dB/ Ref -10 dB Cal
1
R 3.166411 GHz -8.2133 dB
M1 1.209015 GHz -17.4613 dB
R 969.564825 MHz -4.3540 dB
•M1 1.002232 GHz -4.4173 dB
0dB
-2dB
-4dB
-6dB
-8dB
-10 dB
-12dB
-14dB
-16dB
-18dB
-20dB
M1
R
M1
Ch1 Center 2.0001 GHz
Pwr 0 dBm Bw 10 kHz UOSM P1,P2
Span 4 GHz
Preparing... Ch1: Avg None
2024-07-22 10:08:00
10:08:01 AM 07/22/2024

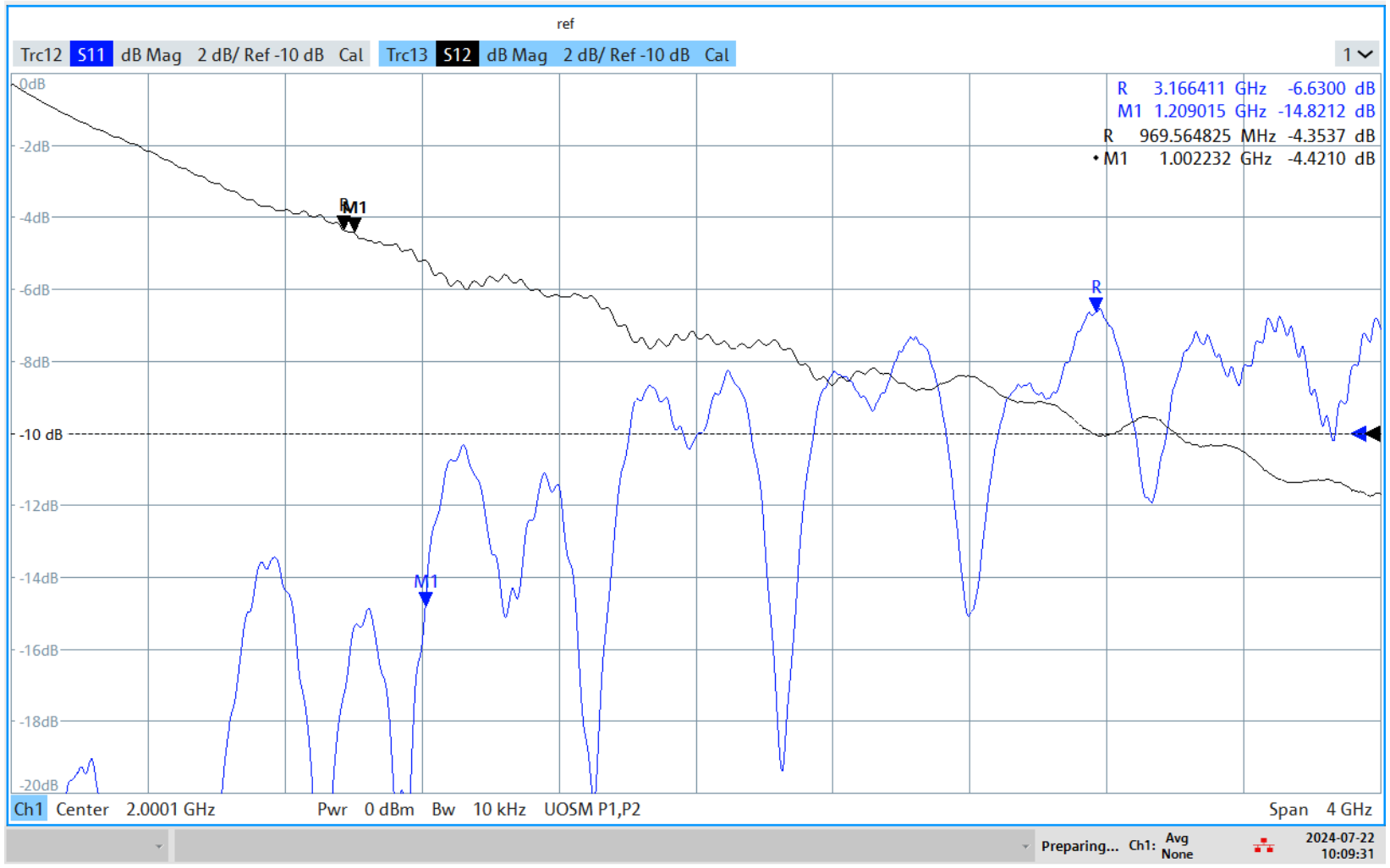
Channels 11


ref
Trc12 S11 dB Mag 2 dB/ Ref -10 dB Cal
Trc13 S12 dB Mag 2 dB/ Ref -10 dB Cal
1
R 3.166411 GHz -12.2511 dB
M1 1.209015 GHz -13.5335 dB
R 969.564825 MHz -3.9612 dB
•M1 1.002232 GHz -4.0569 dB
0dB
-2dB
-4dB
-6dB
-8dB
-10 dB
-12dB
-14dB
-16dB
-18dB
-20dB
R
M1
M1
R
Ch1 Center 2.0001 GHz
Pwr 0 dBm Bw 10 kHz UOSM P1,P2
Span 4 GHz
Sweeping... Ch1: Avg None
2024-07-22 10:08:35
10:08:36 AM 07/22/2024

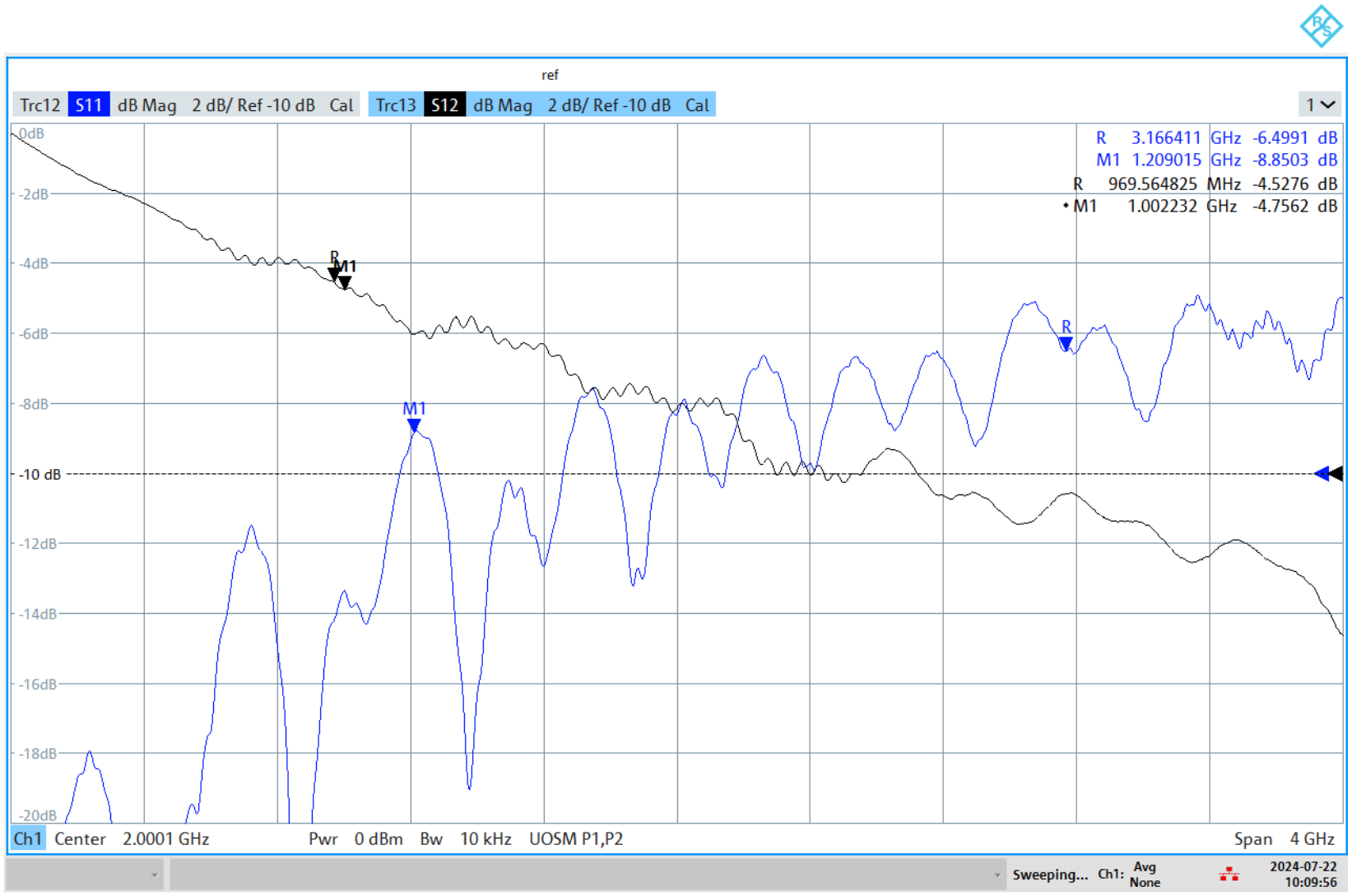
Channels 12


ref
Trc12 S11 dB Mag 2 dB/ Ref -10 dB Cal
Trc13 S12 dB Mag 2 dB/ Ref -10 dB Cal
1
R 3.166411 GHz -6.4259 dB
M1 1.209015 GHz -13.8253 dB
R 969.564825 MHz -4.0740 dB
•M1 1.002232 GHz -4.1414 dB
0dB
-2dB
-4dB
-6dB
-8dB
-10 dB
-12dB
-14dB
-16dB
-18dB
-20dB
M1
M1
R
Ch1 Center 2.0001 GHz
Pwr 0 dBm Bw 10 kHz UOSM P1,P2
Span 4 GHz
Sweeping... Ch1: Avg None
2024-07-22 10:09:04
10:09:05 AM 07/22/2024

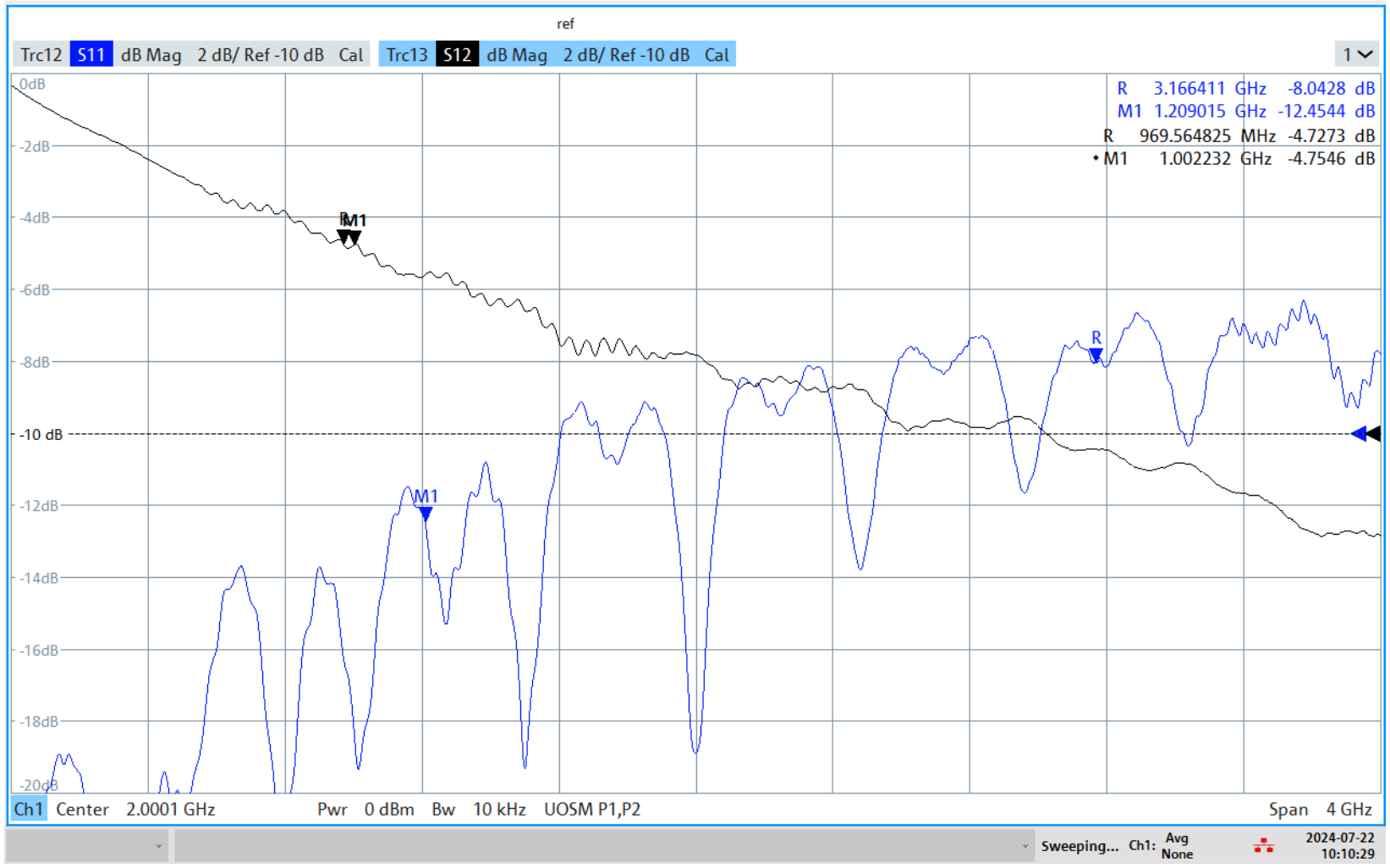
Channels 13


ref
Trc12 S11 dB Mag 2 dB/ Ref -10 dB Cal
Trc13 S12 dB Mag 2 dB/ Ref -10 dB Cal
1
R 3.166411 GHz -6.6300 dB
M1 1.209015 GHz -14.8212 dB
R 969.564825 MHz -4.3537 dB
• M1 1.002232 GHz -4.4210 dB
0dB
-2dB
-4dB
-6dB
-8dB
-10 dB
-12dB
-14dB
-16dB
-18dB
-20dB
M1
R
M1
Ch1 Center 2.0001 GHz
Pwr 0 dBm Bw 10 kHz UOSM P1,P2
Span 4 GHz
Preparing... Ch1: Avg None
2024-07-22 10:09:31
10:09:32 AM 07/22/2024

Channels 14


ref
Trc12 S11 dB Mag 2 dB/ Ref -10 dB Cal
Trc13 S12 dB Mag 2 dB/ Ref -10 dB Cal
1
R 3.166411 GHz -6.4991 dB
M1 1.209015 GHz -8.8503 dB
R 969.564825 MHz -4.5276 dB
•M1 1.002232 GHz -4.7562 dB
0dB
-2dB
-4dB
-6dB
-8dB
-10 dB
-12dB
-14dB
-16dB
-18dB
-20dB
Ch1 Center 2.0001 GHz
Pwr 0 dBm Bw 10 kHz UOSM P1,P2
Span 4 GHz
Sweeping... Ch1: Avg None
2024-07-22 10:09:56
10:09:57 AM 07/22/2024

Channels 15


ref
Trc12 S11 dB Mag 2 dB/ Ref -10 dB Cal
Trc13 S12 dB Mag 2 dB/ Ref -10 dB Cal
1
R 3.166411 GHz -8.0428 dB
M1 1.209015 GHz -12.4544 dB
R 969.564825 MHz -4.7273 dB
•M1 1.002232 GHz -4.7546 dB
0dB
-2dB
-4dB
-6dB
-8dB
-10 dB
-12dB
-14dB
-16dB
-18dB
-20dB
M1
M1
R
Ch1 Center 2.0001 GHz
Pwr 0 dBm Bw 10 kHz UOSM P1,P2
Span 4 GHz
Sweeping... Ch1: Avg None
2024-07-22 10:10:29
10:10:30 AM 07/22/2024

Observations / conclusions

- Re-designed M02b adapters will be ~two times shorter

- Numerical estimate for channels 9,10 in a <3GHz range:
  - Expect at most ~5 dB attenuation (see slide 33)

  - But this was measured for a **pair** of M00k adapters back-to-back …
  - … while a real-life HRPPD setup will include only **one** M02b set …

  - … which means a real-life attenuation using M02b interface will be up to 2-3 dB …
  - … or up to ~25% of signal amplitude, and needs to be calibrated out