HEBT – Active splitter

TEST REPORT

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Solkan, 21-10-2016

Contents

1. Introduction

This document addresses functional and performance measurements/tests performed on the Active splitter, which is part of WP D4b. The Active splitter was developed according to requirements given in CDR for this WP i.e. "it026_CDR_BPM_Data_Acquisition_HEBT_WP_D4_FAIR_1.04.pdf" (Chapter 3.5). The tests were done according to the list of relevant tests specified in Chapter 4 of the CDR. However some additional tests were done as well.

Table 1: *Active splitter specifications*

Item	Description
Splitter	1 -> 2 (4x), unused outputs should be terminated with 50 Ohm
Inputs	4 N-type connectors on the back panel
Outputs	8 SMA connectors on the front panel
Bandwidth (-3 dB)	at least from 40 kHz to 55 MHz
Gain	0 dB
Maximal input voltage	2 Vp
Input impedance	50 Ohm
Output impedance	50 Ohm
S11, S22	-20 dB
Power supply	230 VAC
Power status monitor	LEMO connector (5 V TTL, high when power supply is OK), LED (on when power supply is OK)
Housing	Height: 1U, Width: 19", Depth: 286 mm

2. Input and output return loss

CDR test 4.7
Target value: -20 dB

Measurement equipment:

- VNA (Vector Network Analyzer): Agilent E5071C
- VNA Electronic calibration module: Agilent N4691-60006
- DUT: Active splitter

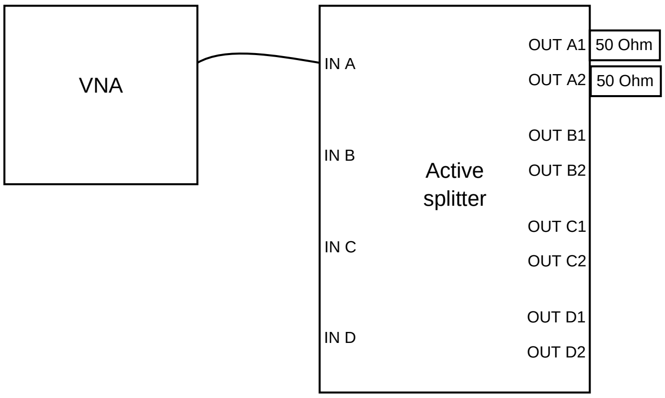

Figure 1: *Measurement setup for S11 measurement*

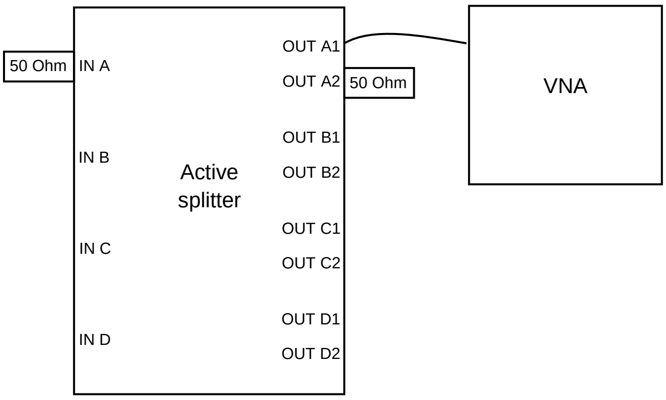

Figure 2: *Measurement setup for S22 measurement*

Input and output return losses were measured on all channels. Unconnected RF connectors were terminated with 50 Ohm. Results are presented in Figure 3 and Figure 4.

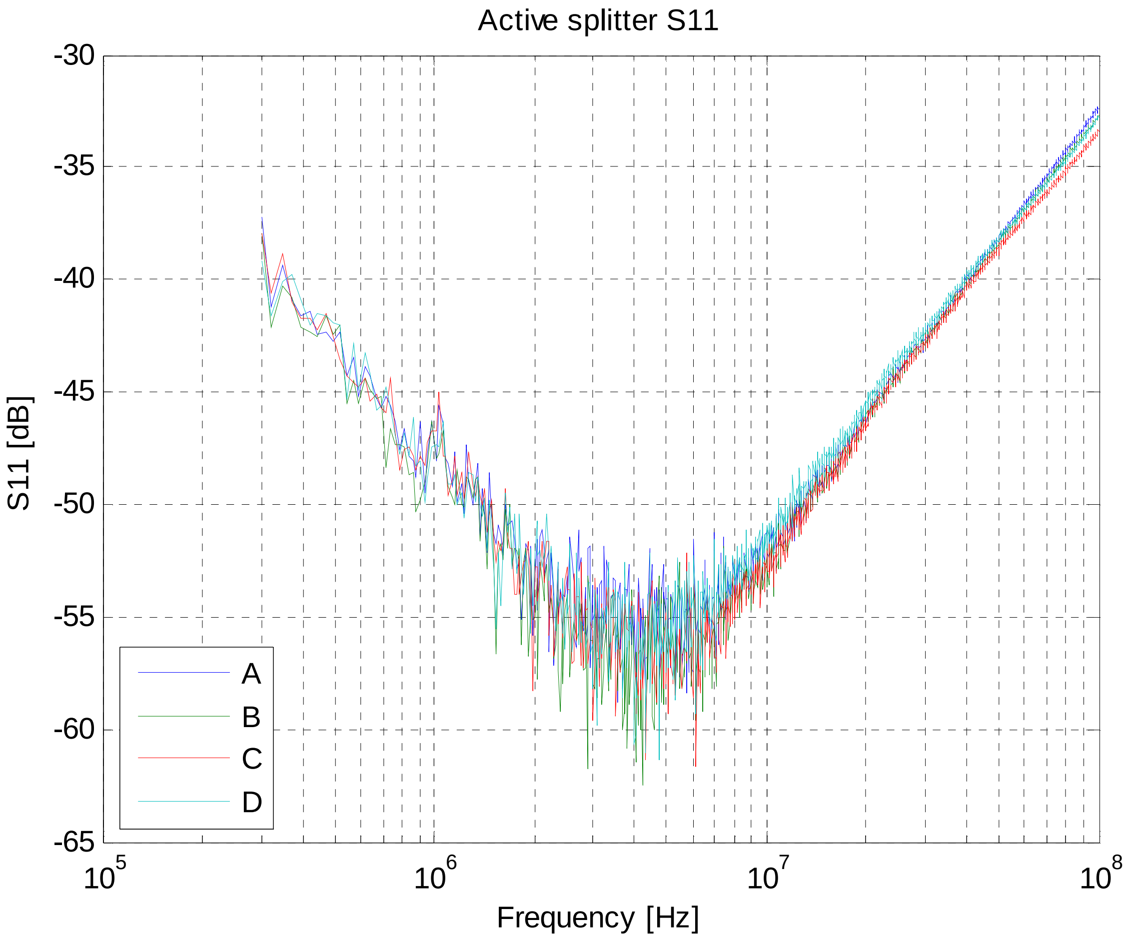

Figure 3: *Input return loss S11 on all channels*

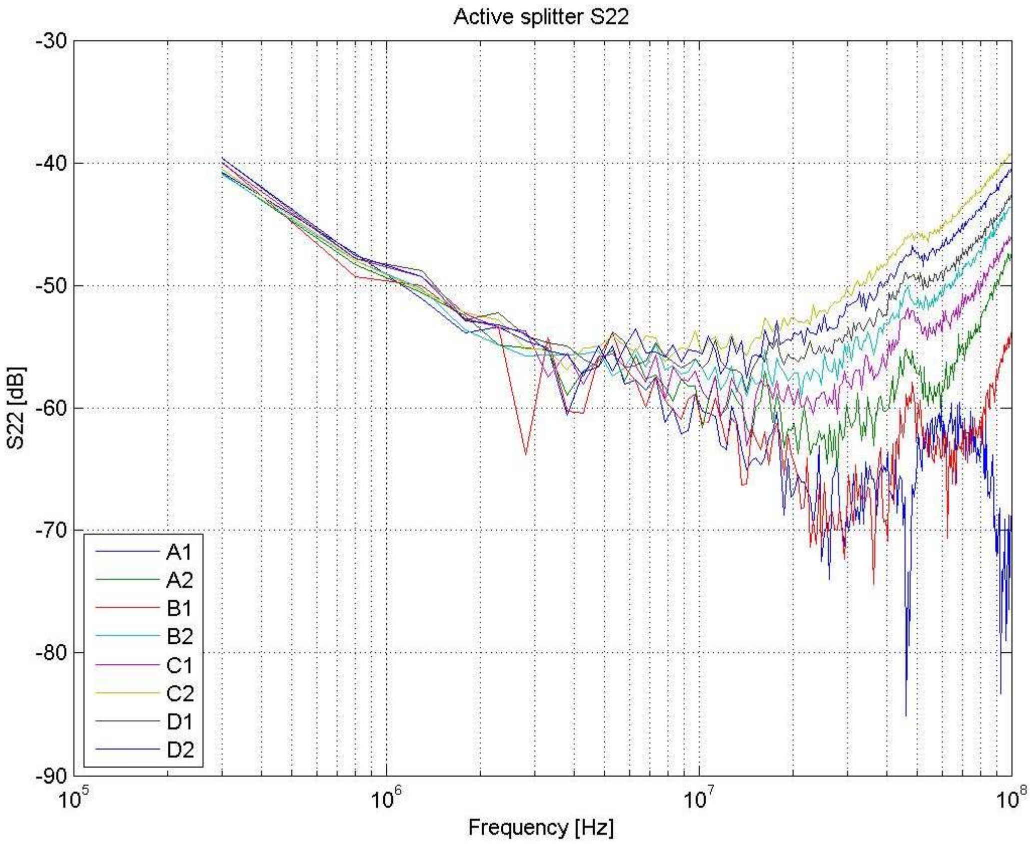

Figure 4: *Output return loss S22 on all channels*

3. Gain and bandwidth

CDR test 4.6, 4.8
Target value for bandwidth (-3 dB): at least from 40 kHz to 55 MHz
Target value for gain: ~0 dB

Measurement equipment:

- VNA (Vector Network Analyzer): Agilent E5071C
- VNA Electronic calibration module: Agilent N4691-60006
- Signal generator: Agilent 33250A
- Signal analyzer: Rohde & Schwarz FSQ
- DUT: Active splitter

As Vector Network Analyser (VNA) is limited to 300 kHz at low frequencies the frequency response measurements were done with two measuring setups. At low frequencies an RF signal generator and a Signal Analyser were used (see Figure 5). Frequency response of the setup without DUT was measured first and this result was later used to correct measurements obtained with DUT. In this way deviations of the measurement setup are excluded. At high frequencies measurements were done with the VNA (see Figure 6).

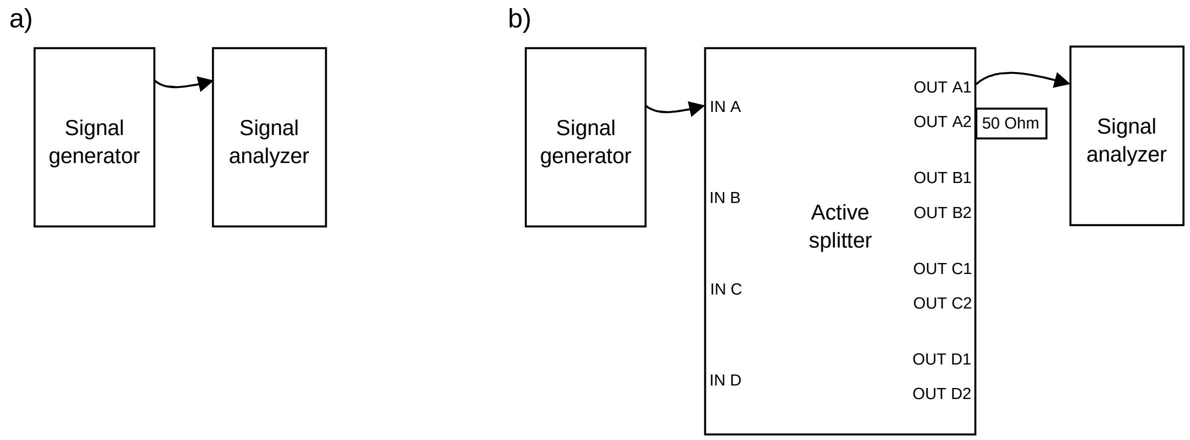

Figure 5: *Measurement setup for low frequencies: a) Setup measurement, b) DUT measurement*

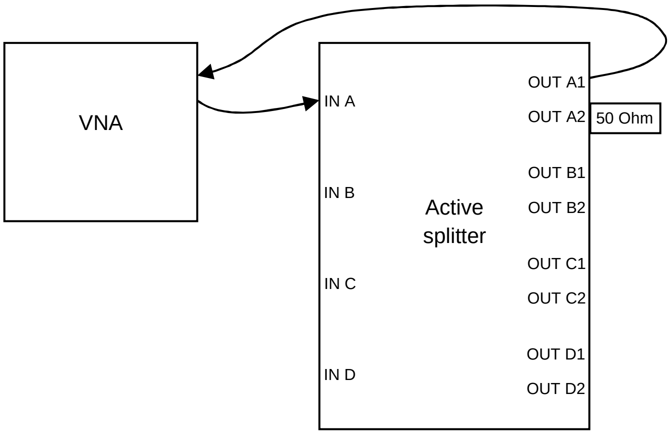

Figure 6: *Measurement setup for high frequencies*

Following are the measured frequency responses. These figures are suitable for gain flatness and 3 dB point representation. Figure 7 represents measurement at low frequencies. Figure 8 and Figure 9 represent measurements at high frequencies that were done with the VNA. We can observe that the lower cutoff frequency (-3 dB) is below 40 kHz and the upper cutoff frequency (-3 dB) is above 55 MHz.

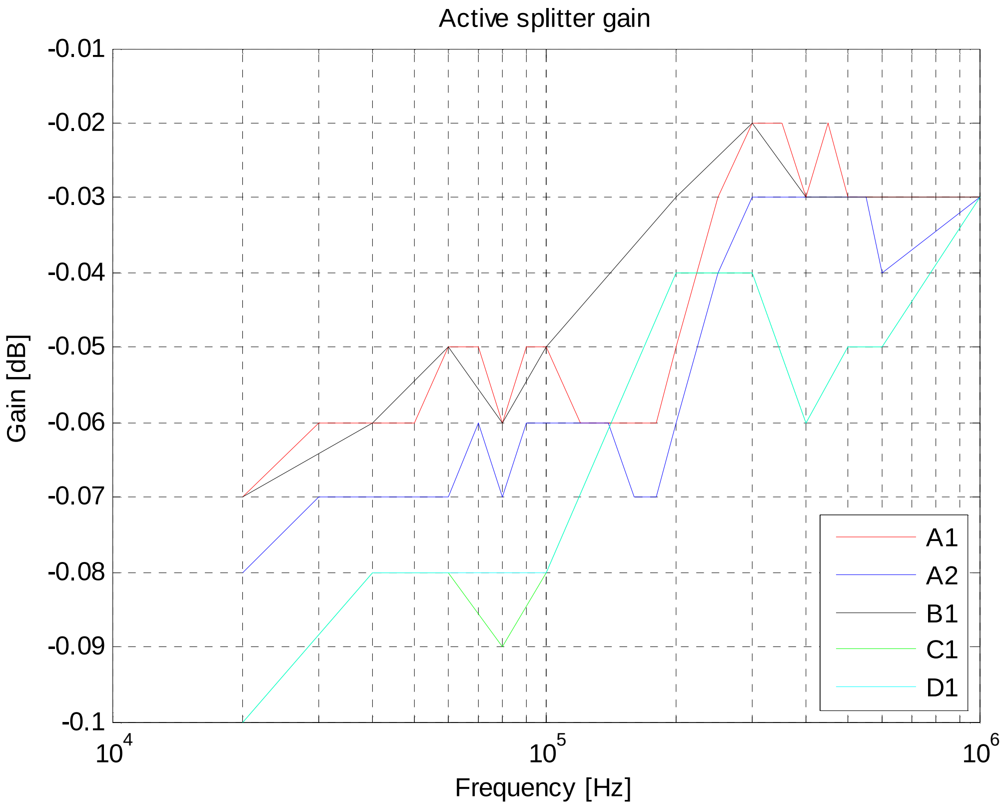

Figure 7: *Frequency response at lower frequencies*

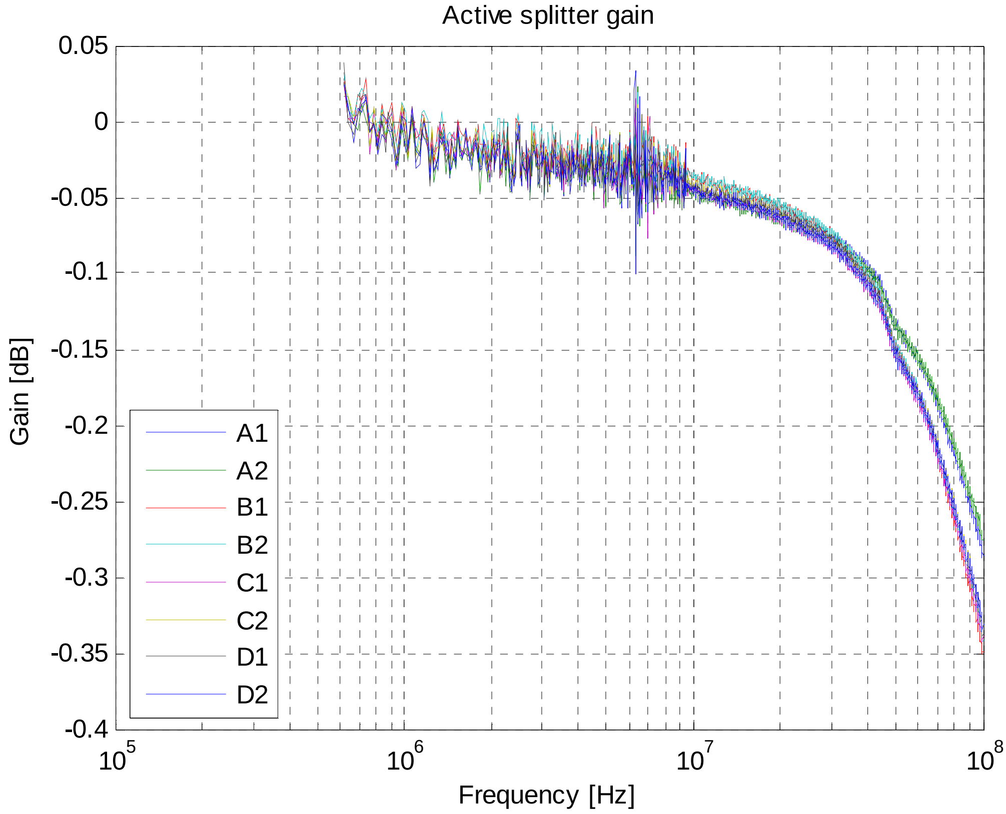

Figure 8: *Frequency response at higher frequencies*

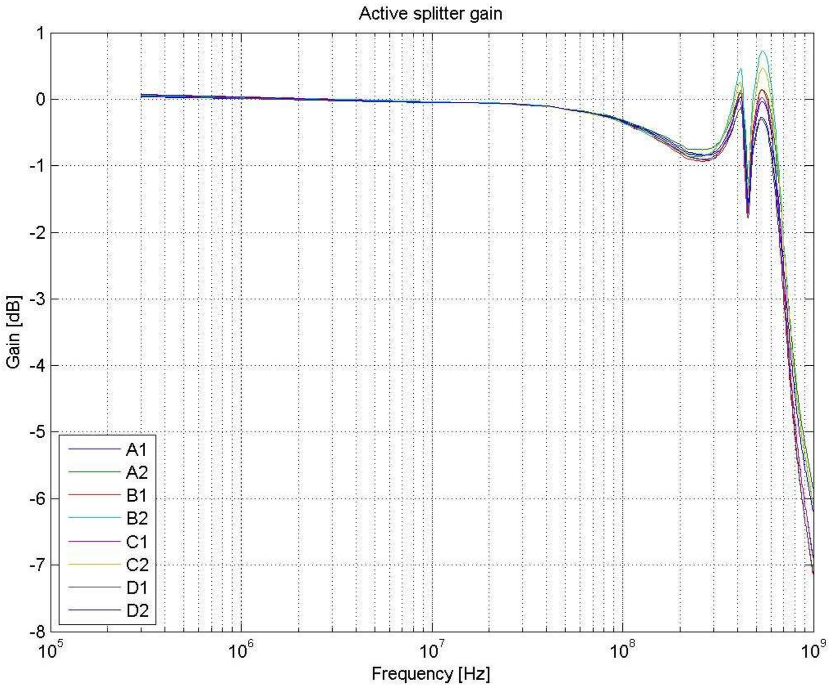

Figure 9: *3dB point identification*

4. Gain differences between channels

CDR test 4.8
Target value for maximum deviation of the gain between channels: 0.1 dB

Measurement equipment and measurement setup: Same like in Chapter 3 for measurements at high frequencies.

The frequency response measurements are compared among all channels and differences are presented in Figure 10.

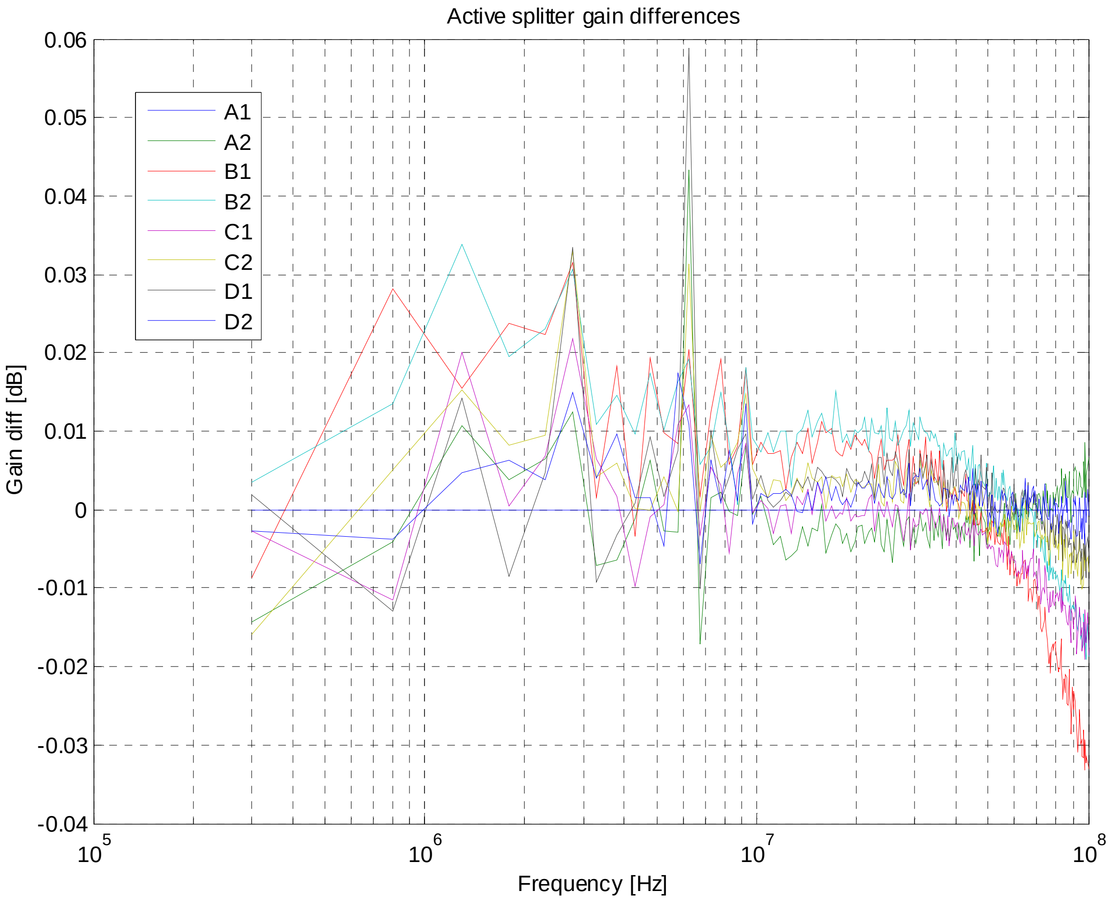

Figure 10: *Gain differences between channel A1 and all other channels*

5. Noise characterization

Measurement equipment:

- Oscilloscope: LeCroy SDA 13000
- Low Pass Filter (LPF): Mini Circuits SLP-100+ (100 MHz)
- DUT: Active splitter

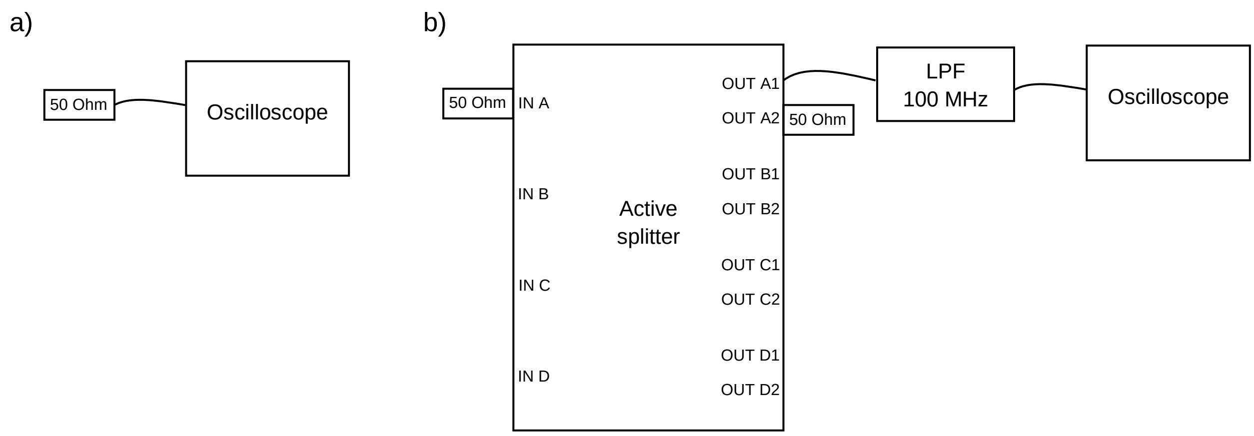

Figure 11: *Measurement setup for noise characterization: a) Setup, b) DUT*

Added noise has been measured through oscilloscope in a 100 MHz bandwidth. Results are reported in the table below as output referred RMS voltage.

Table 2: *Noise characterization*

Channel	Measured noise Active splitter + osciloscope [uVrms]	Measured noise osciloscope [uVrms]	Active splitter added noise [uVrms]
A1	406.8	389	119
B1	406.5	389	118
C1	406.5	389	118
D1	407.2	389	120

6. Maximal output level

Active splitter maximal output level without compression was measured.

Measurement equipment:

- Signal generator: Agilent 33250A
- Oscilloscope: LeCroy SDA 13000
- DUT: Active splitter

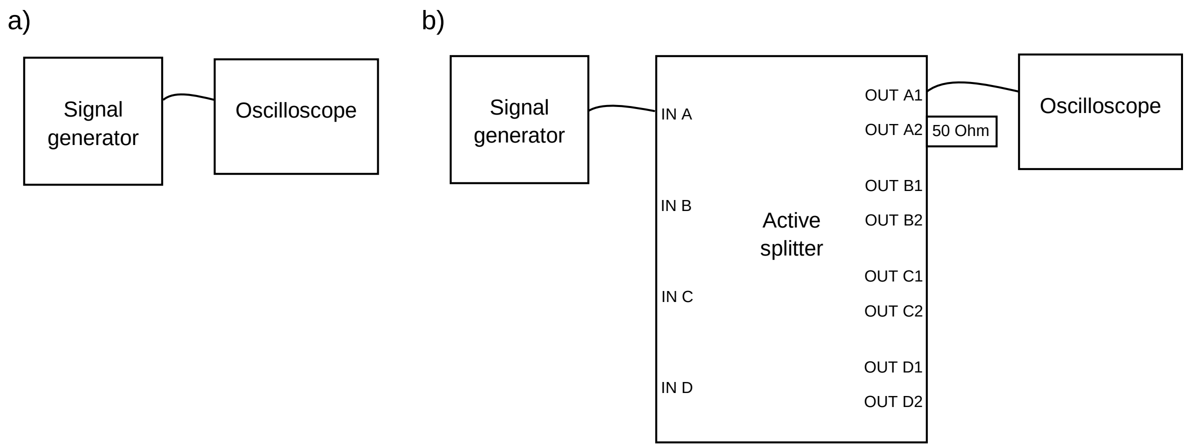

Figure 12: *Measurement setup for output level: a) Setup, b) DUT*

From the results presented in Table 3, Figure 13, Figure 14 and Figure 15 we can say that the Active splitter maximal output level without compression is ±2 Vpeak.

Table 3: *Output signal level*

Input signal amplitude [Vpp]	Setup measurement [Vp]	Active splitter measurement [Vp]	Gain difference [dB] (setup vs. active splitter)
3.8	1.91	1.897	0.06
3.9	1.96	1.947	0.06
4	2.01	1.993	0.07
4.1	2.07	2.025	0.19
4.2	2.11	2.048	0.26

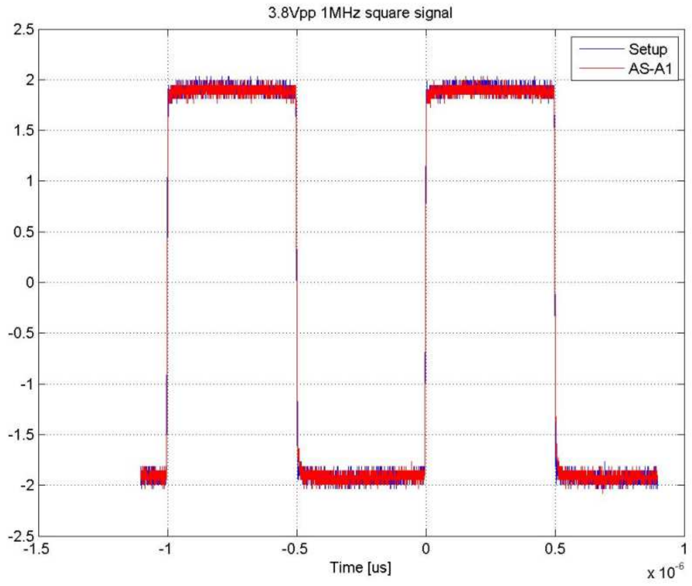

Figure 13: *Setup and AS output signal at 3.8 Vpp signal*

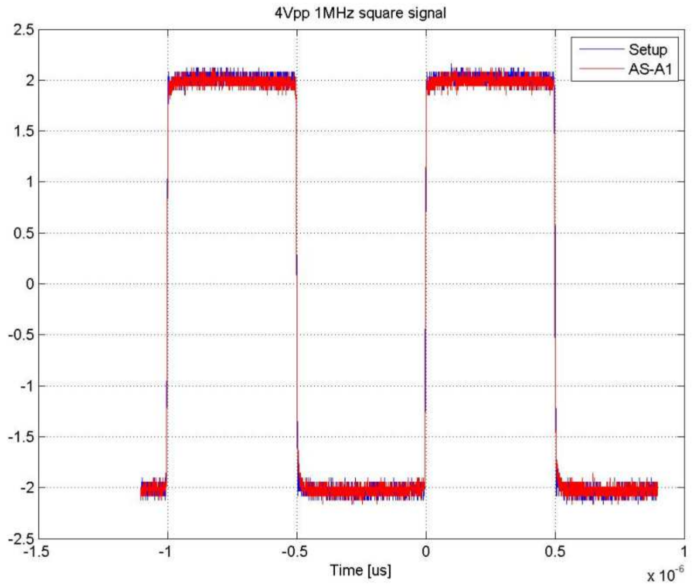

Figure 14: *Setup and AS output signal at 4 Vpp signal*

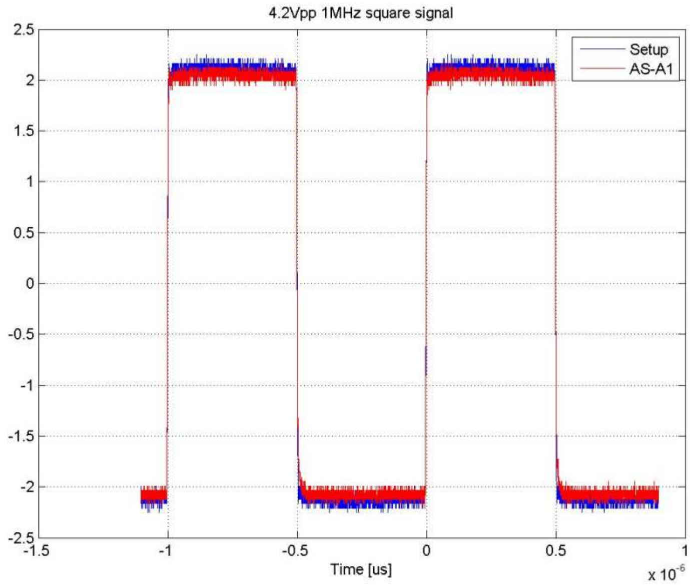

Figure 15: *Setup and AS output signal at 4.2 Vpp signal*

7. S-parameter measurements with terminated and opened monitoring output

It is foreseen that the monitoring output is always terminated with 50 Ohm during normal operation. However additional S-parameter measurements were done also without 50 Ohm termination of the monitoring output i.e. with opened monitoring output. The measurements were done with a VNA.

Measurement equipment:

- VNA (Vector Network Analyzer): Agilent E5071C
- VNA Electronic calibration module: Agilent N4691-60006
- DUT: Active splitter

See Figure 1 for S11 measurement setup. The monitoring output wasn't terminated with 50 Ohm in the additional measurement.

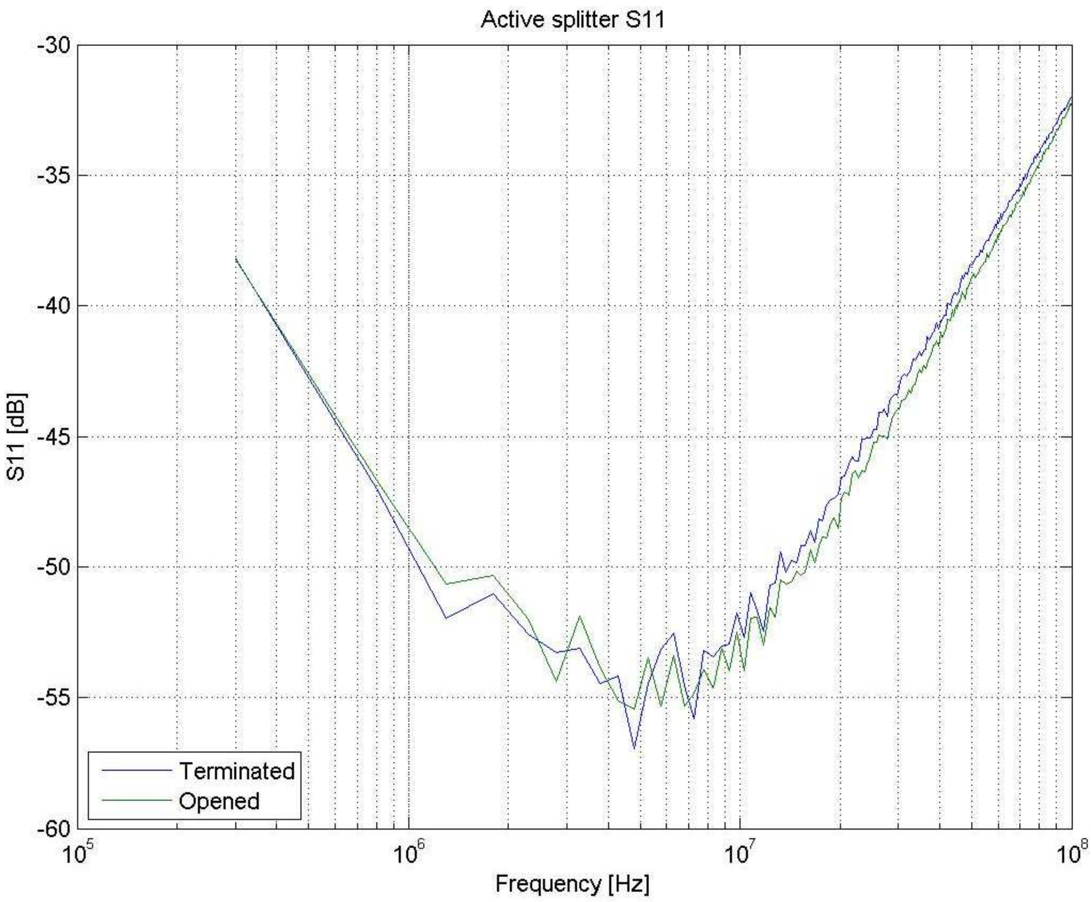

Figure 16: *Input return loss S11 on channel A with terminated and opened output port A2*

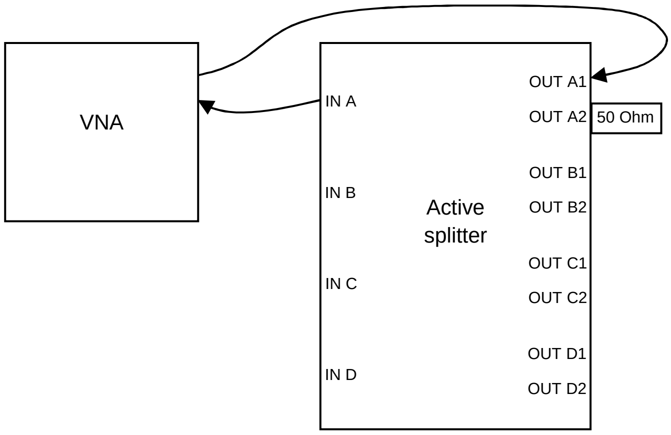

Figure 17: *Measurement setup for S12 measurement*

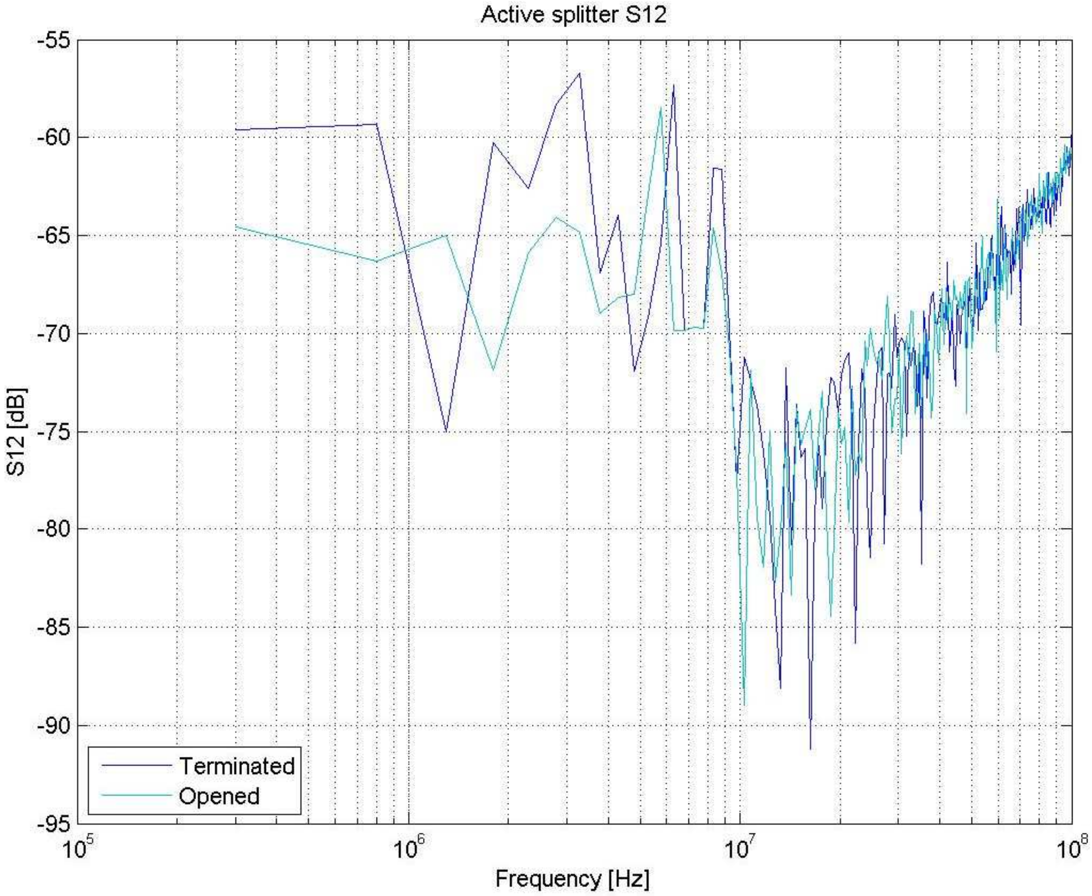

Figure 18: *Isolation S12 on channel A with terminated and opened output port A2*

See Figure 6 for S21 measurement setup. The monitoring output wasn't terminated with 50 Ohm in the additional measurement.

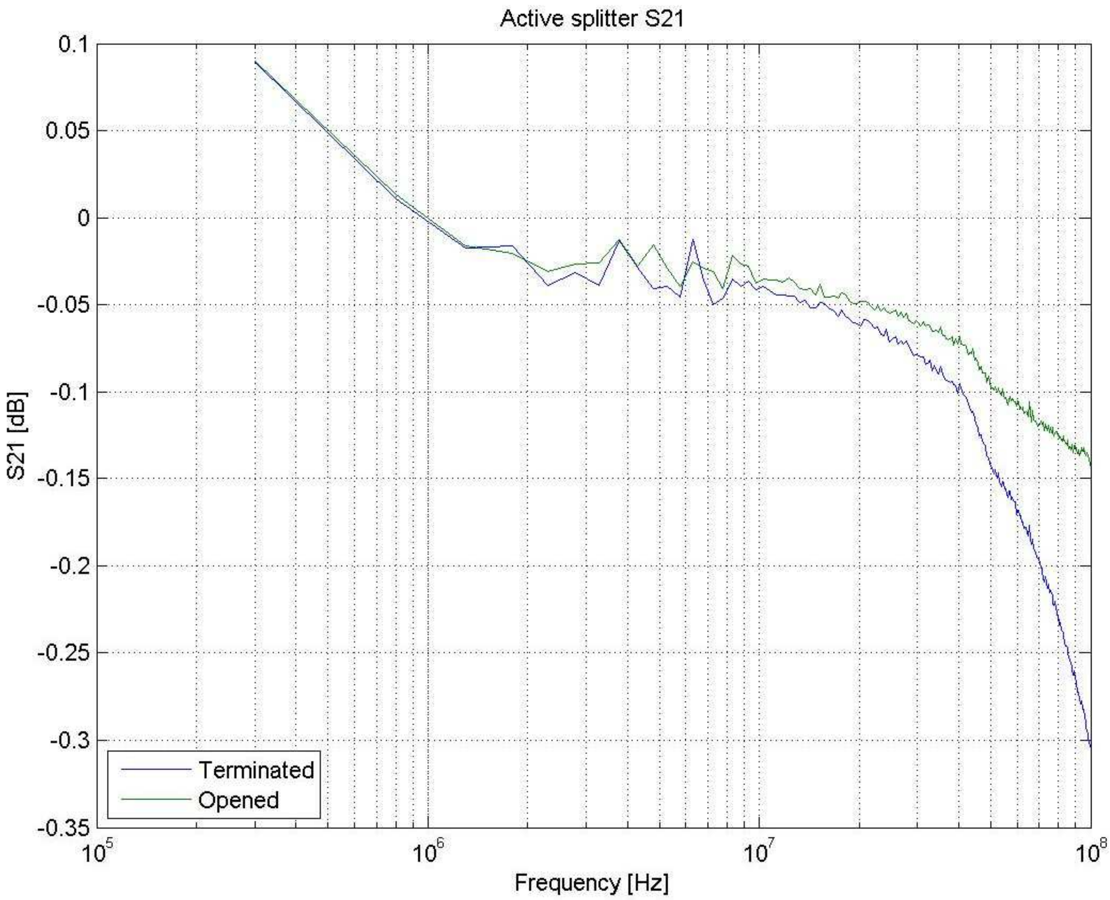

Figure 19: *Frequency response S21 on channel A with terminated and opened output port A2*

See Figure 2 for S22 measurement setup. The monitoring output wasn't terminated with 50 Ohm in the additional measurement.

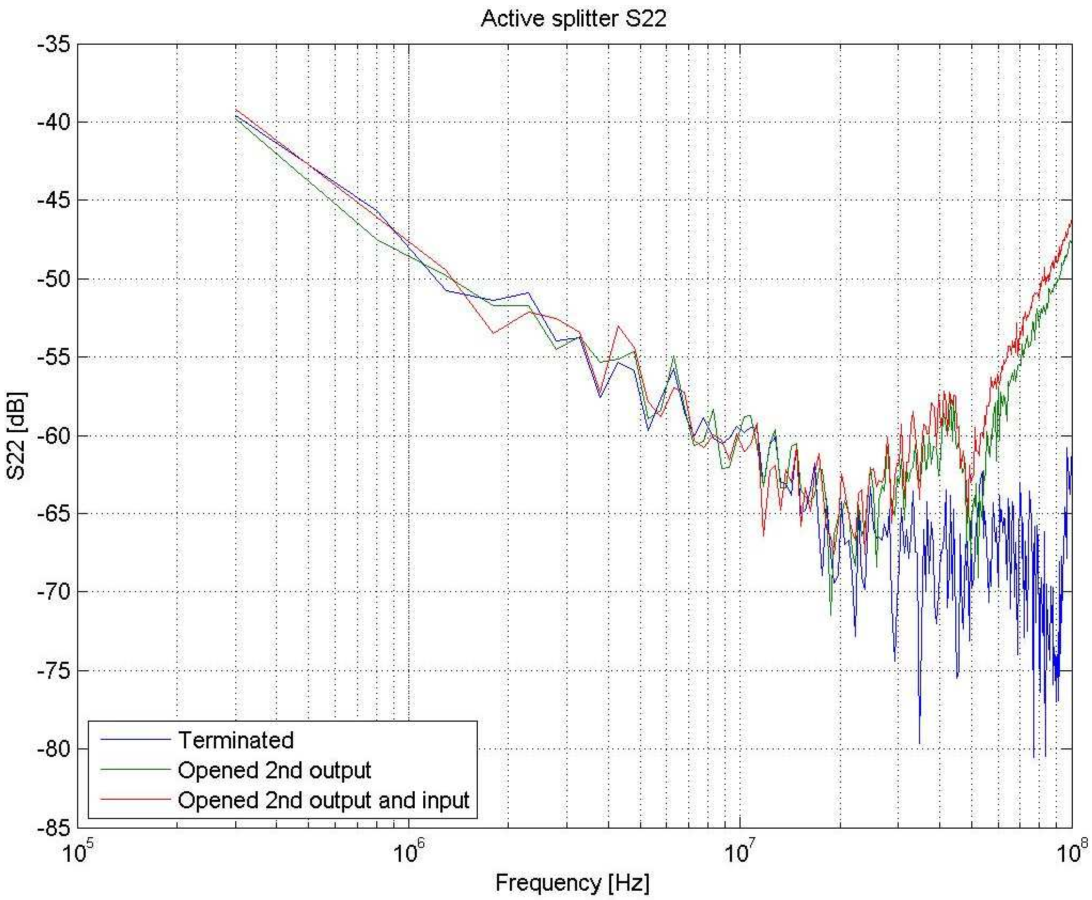

Figure 20: *Output return loss S22 on output port A1 with terminated and opened output port A2 and with opened input*

8. Common mode behavior in time domain for all four channels

Measurement equipment:

- Signal generator: Agilent 33250A
- Oscilloscope: LeCroy SDA 13000
- DUT: Active splitter

Measurement setup can be seen in Figure 12 b).

Gain difference between channels in time domain or common mode behavior in time domain for all four channels was checked with the following measurements. 100 ns pulses with 2 MHz repetition rate were used. Three sets of measurements with 0.09 Vpp, 1 Vpp and 2.2 Vpp pulse amplitudes were done. The same signal was applied to all channels. The monitoring outputs were terminated with 50 Ohm. The output signal was measured for all four channels and compared as it is represented in figures below. Gain differences between channels are summarized in the below tables as well.

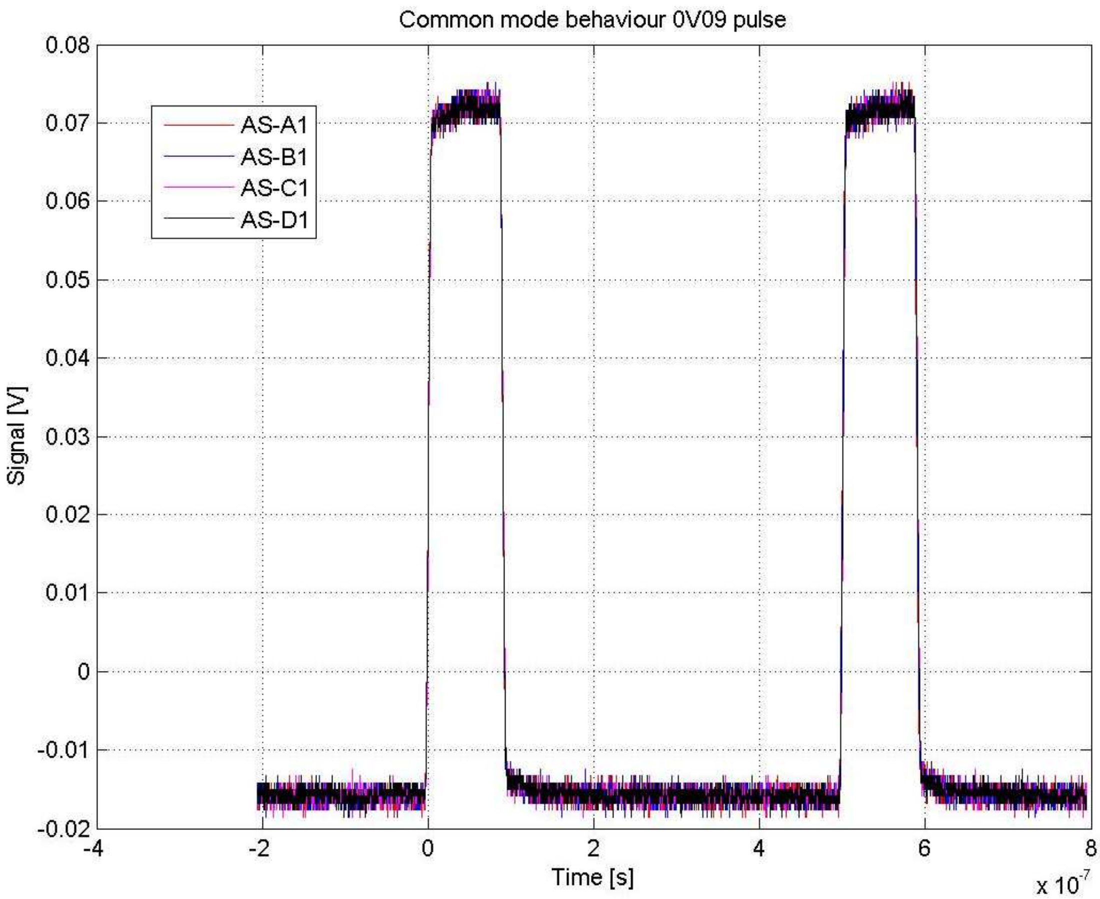

Figure 21: *Output signals on four channels for 0.09 V input signal*

Table 4: *Output signal amplitudes for 0.09V input signal and corresponding gain differences vs. channel A*

Channel	Amplitude [Vpp]	Gain difference [dB]
A	0.0880	0
B	0.0880	0.0015
C	0.0879	-0.0007
D	0.0877	-0.0231

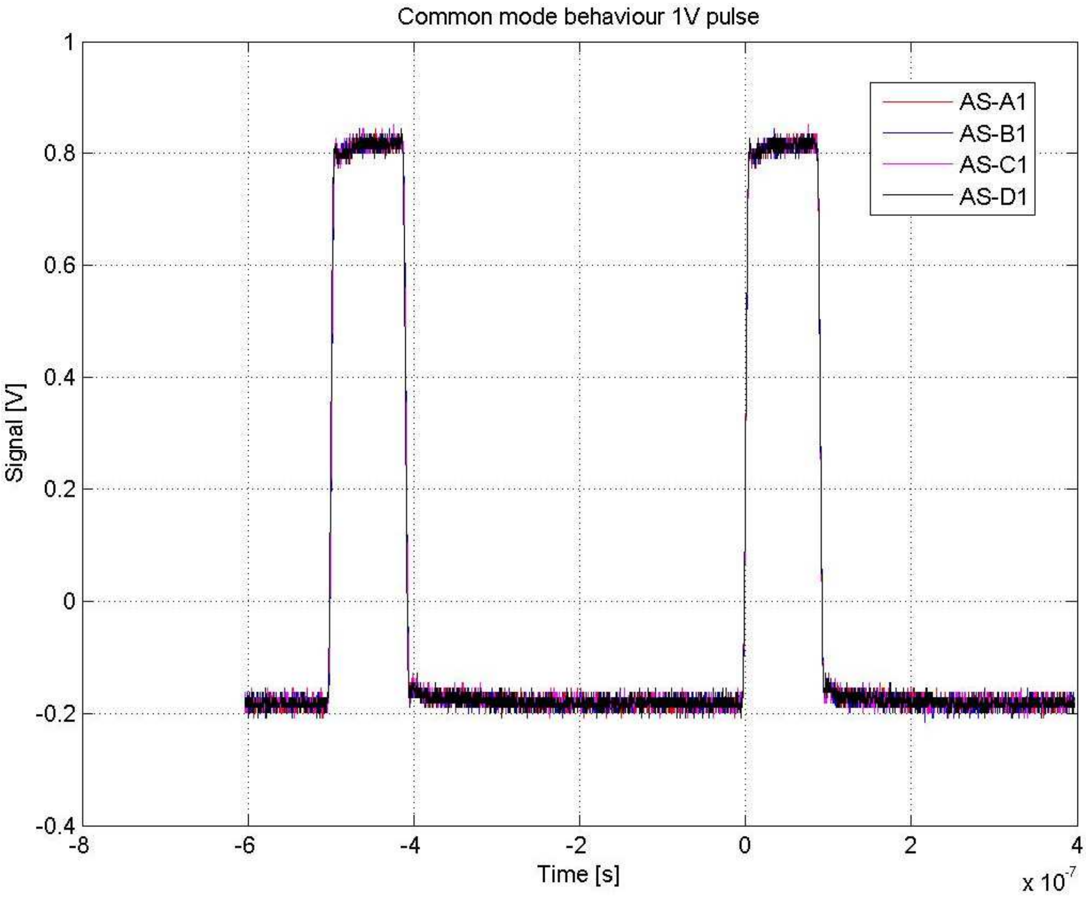

Figure 22: *Output signals on four channels for 1 V input signal*

Table 5: *Output signal amplitudes for 1 V input signal and corresponding gain differences vs. channel A*

Channel	Amplitude [Vpp]	Gain difference [dB]
A	0.9993	0
B	0.9995	0.0012
C	0.9993	0.0000
D	1.0000	0.0060

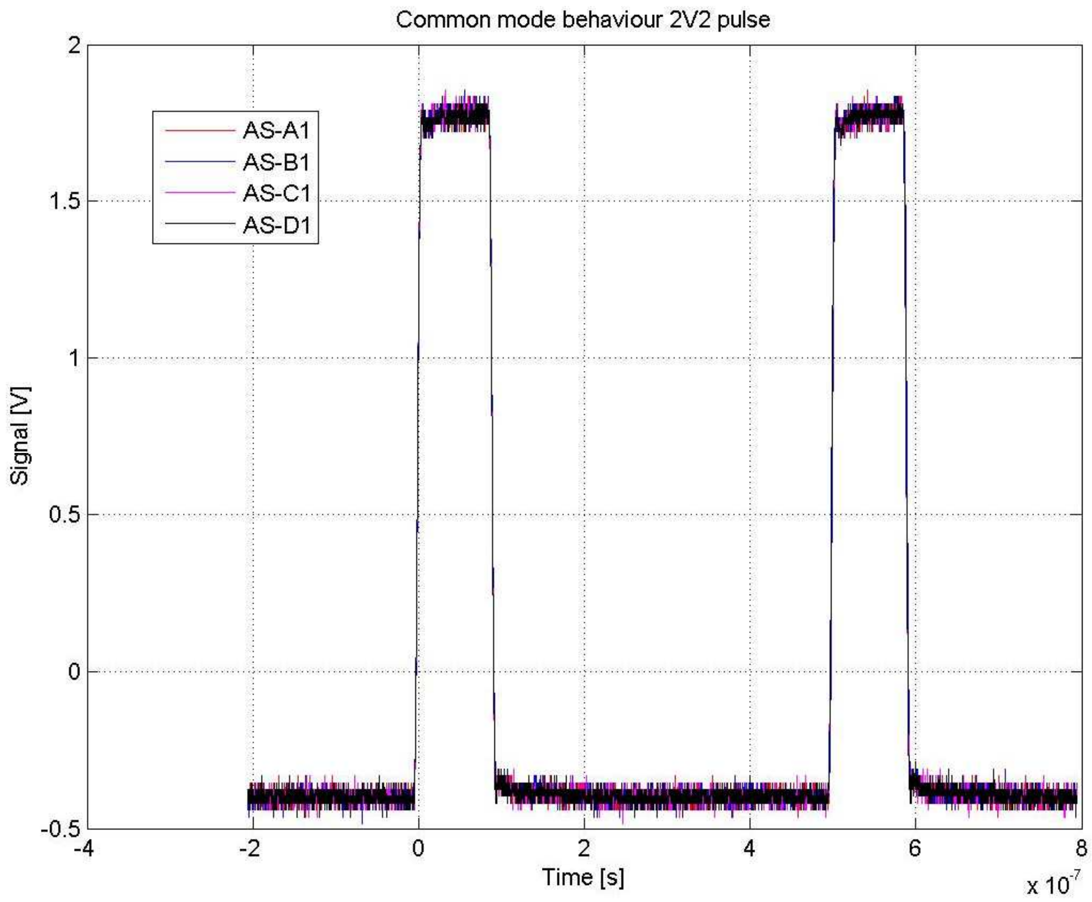

Figure 23: *Output signals on four channels for 2.2 V input signal*

Table 6: *Output signal amplitudes for 2.2 V input signal and corresponding gain differences vs. channel A*

Channel	Amplitude [Vpp]	Gain difference [dB]
A	2.1737	0
B	2.1792	0.0216
C	2.1737	0.0000
D	2.1733	-0.0019

9. Conclusions

One can see that the measurement results reported in the above chapters are within target values specified in the CDR.