Wideband Compact Cryogenic Receiver QRFH
- SN: 01 -
FAT

Test Report

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1. INTRODUCTION

1.1 Purpose

Tests have been conducted on the Wideband Compact Cryogenic Receiver QRFH SN01 in Callisto laboratory and outside for the noise temperature according to the procedures described in test plan AD 3.

The tests included RF testing and cryogenic testing.

1.2 Applicable & Reference Documents

This section lists other documents which are referred to in the main body of this document. In cases when the document cited is listed without an issue number, revision number or date, then the reader should refer to the latest available issue.

1.2.1 Applicable Documents

AD 1 Callisto Proposal , Ref. PRP/685/3606 issue 1.0 dated 11th April 2016

AD 2 User Manual, QRFH Compact Wideband Cryogenic Receiver, DOC/1704/3991

AD 3 Test Plan Procedure QRFH Compact Receiver, TST/1704/3990, Issue 1.0

AD 4 Interface Control Document, ICD/1704/3992, issue 1.0

2. TEST RESULTS SUMMARY

Result "R" column = Passed (P), Marginal (M), Failed (F)

Parameter	Specifications	Results	Verification Method	R	Comments
Frequency Band	2 – 14 GHz		AT		
Port X		2-14GHz		P	
Port Y		2-14GHz		P	
Noise Temperature	<40K		AT		at cryogenic temperature
Port X		97% of the meas <40K		P	TLNA=71K
Port Y		94% of the meas <40K		P	TLNA=71K
Gain	>55dB		AT		
Port X		55.2dBmin		P	Gain extracted from NT meas
Port Y		55.4dBmin		P	
Gain Flatness	10dBpp		AT		
Port X		7.8dBpp		P	Worst case, gain extracted from NT meas
Port Y		8.7dBpp		P	
Output Return Loss	10dBmin		AT		
Port X		11.8dBmin		P	14dB typical
Port Y		11.8dBmin		P	14dB typical

Pout 1dB	+20dBm		CT; D		
Port X		+20dBm		P	
Port Y		+20dBm		P	
Gain via test input			AT		No specification defined for this parameter
Port X		18.7dB<G<43.5dB			
Port Y		19.7dB<G<43.8 dB			
Cooldown Time to reach NT<40K	<5 hours		AT		
Port X		4Hrs		P	
Port Y		4Hrs		P	
Noise calibration	None		AT	P	The NT measurement performed with the noise diode is comparable with the NT measurement done with the sky method
Phase calibration	None		AT	P	The minimum picket level at 14GHz available at the output of the receiver is around -70.5dBm.
Cold Head Base Temperature	80K	75K	AT	P	
Cooldown Time to base temperature	not specified	1h16	AT		
Warm-up Time (base temp-->280K)	not specified	15Hrs	AT		
RF Input	Free space radiation	Ok	D	P	
RF output connector	SMA	Ok	I	P	
Port X		Ok		P	
Port Y		Ok		P	

10MHz Phase Calibration Input	SMA	Ok	I	P	
Dimensions (mm)	l=612 * Phi=311		I	P	Excluding supports and connectors
Weight (kg)	<27kg	26.8Kg	AT	P	Excluding supports and cables
Operating Orientation	Any		D	P	
Operating Temperature	-10°C to +40°C		D	P	
Storage Temperature	-40°C to +60°C		D	P	
Relative Humidity	to 90% non condensing		D	P	
Ventilation Requirement	Forced air cooling	Ok	I	P	
Max Power Consumption	400W	345W	AT	P	
Input Voltage	90—264VAC / 47—63Hz	Ok	D	P	
Distance between receiver and PSU Drawer	<20m	Ok	AT	P	Split M&C – 5m between receiver and DAQ-PSU enclosure – 20mbetween DAQ-PSU enclosure and PC enclosure
LMS parameters display		Ok	AT	P	
LMS functions		Ok	AT	P	
LMS log files		Ok	AT	P	
Remote communication		Ok	AT	P	
Cryocooler MTTF	200,000 hours		D	P	

Table 2-1: Test Results Summary

3. DETAILED TESTS RESULTS

3.1 Thermal Tests

Result "R" column = Passed (P), Marginal (M), Failed (F)

Ref	Parameter / Requirement	Spec	Result	R	Comments
	Date: 02/07/15				
	Cooldown time	---			
	to RF specification	5 hours	see Table 2-1		5 hours expected to reach RF specification (NT<40K)
	on cold head	295K to <100K	0h21	-	
	""	295K to Base temperature	1h16	-	
	on LNA	295K to <100K	0h27	-	
	""	295K to Base temperature	7hrs	-	
	on feed base plate	295K to <150K	4h46	-	
	""	295K to Base temperature	15hrs	-	
	Base Temperatures	**Tset = 75K**			
	Cold head	~75K±0.5K	75K	P	
	LNA	<85K	76K	P	
	Feed [base]	<130K	123K	P	
	Feed [top]	<150K	135K	P	
	Cooler Input Power		60W		
	Compressor Temperature	<70°C	20°C	P	

Ref	Parameter / Requirement	Spec	Result	R	Comments
	Ambient(Room) Temperature		15°C		Receiver in Callisto Garage, winter time.
	Warmup time (no heaters)	100K to 295K No spec.	15hrs		

Table 3-1: Test Result Sheet n°1 - Thermal Tests

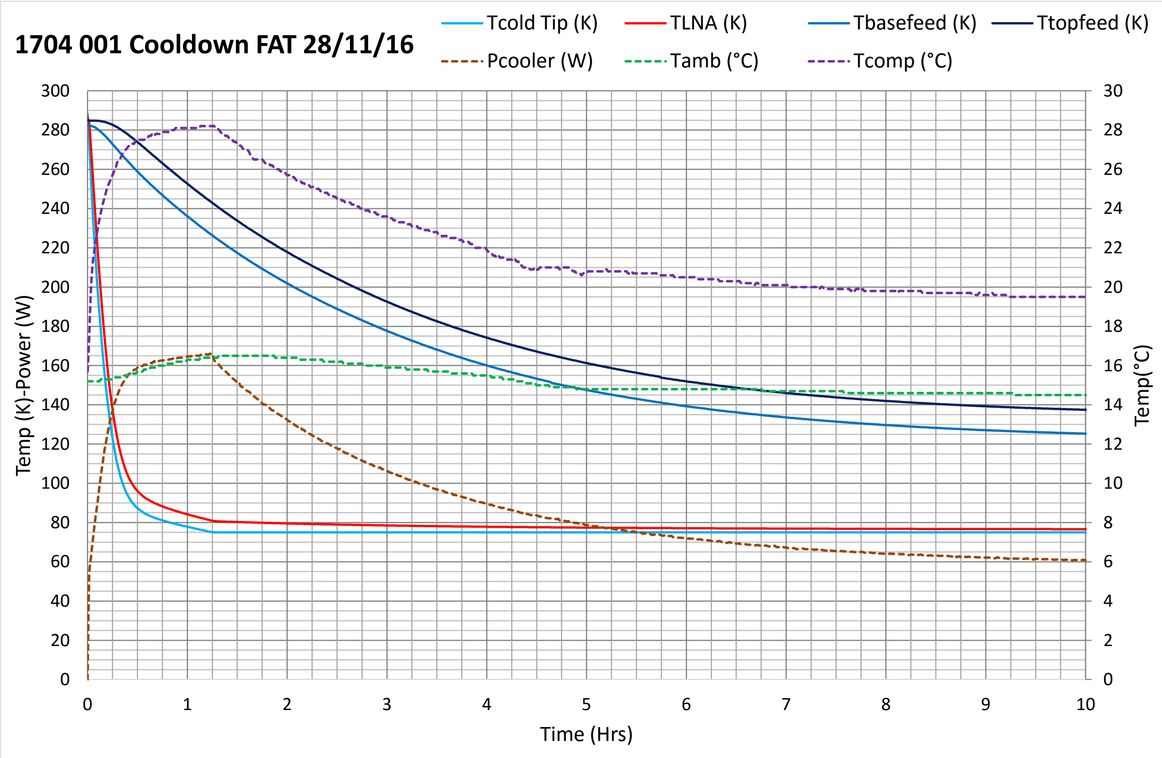


Figure 3-1 : Cooldown

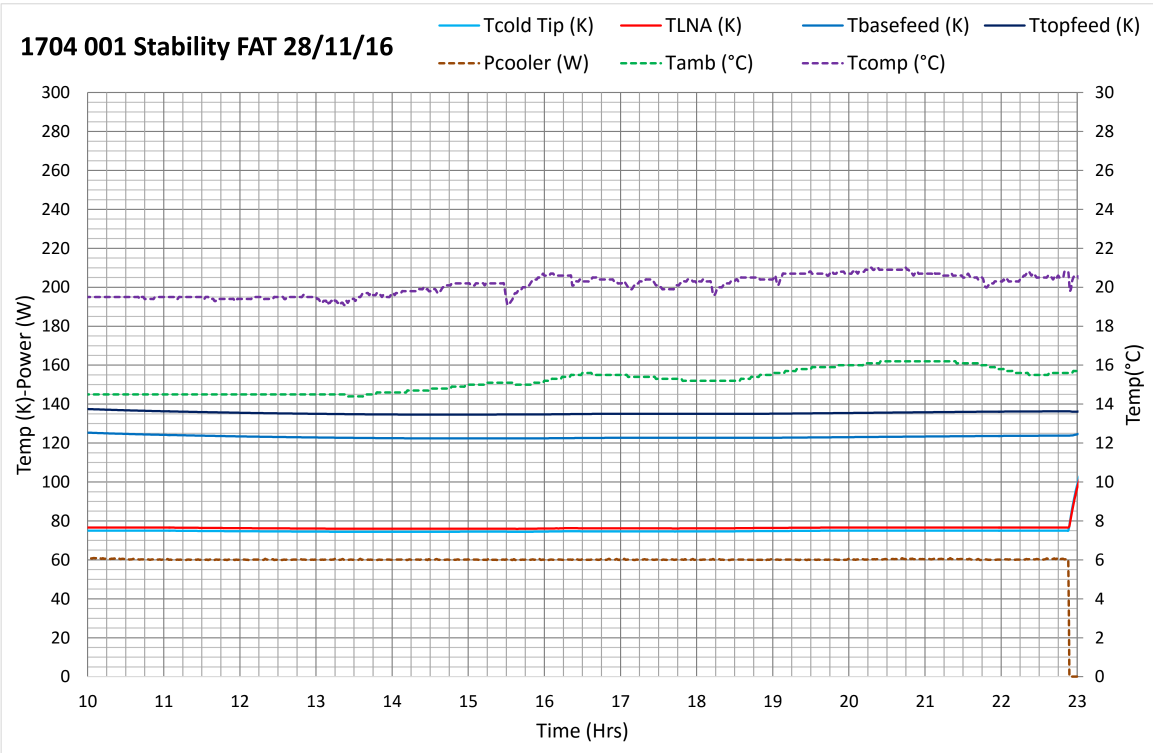


Figure 3-2: Stabilization – Base Temperature

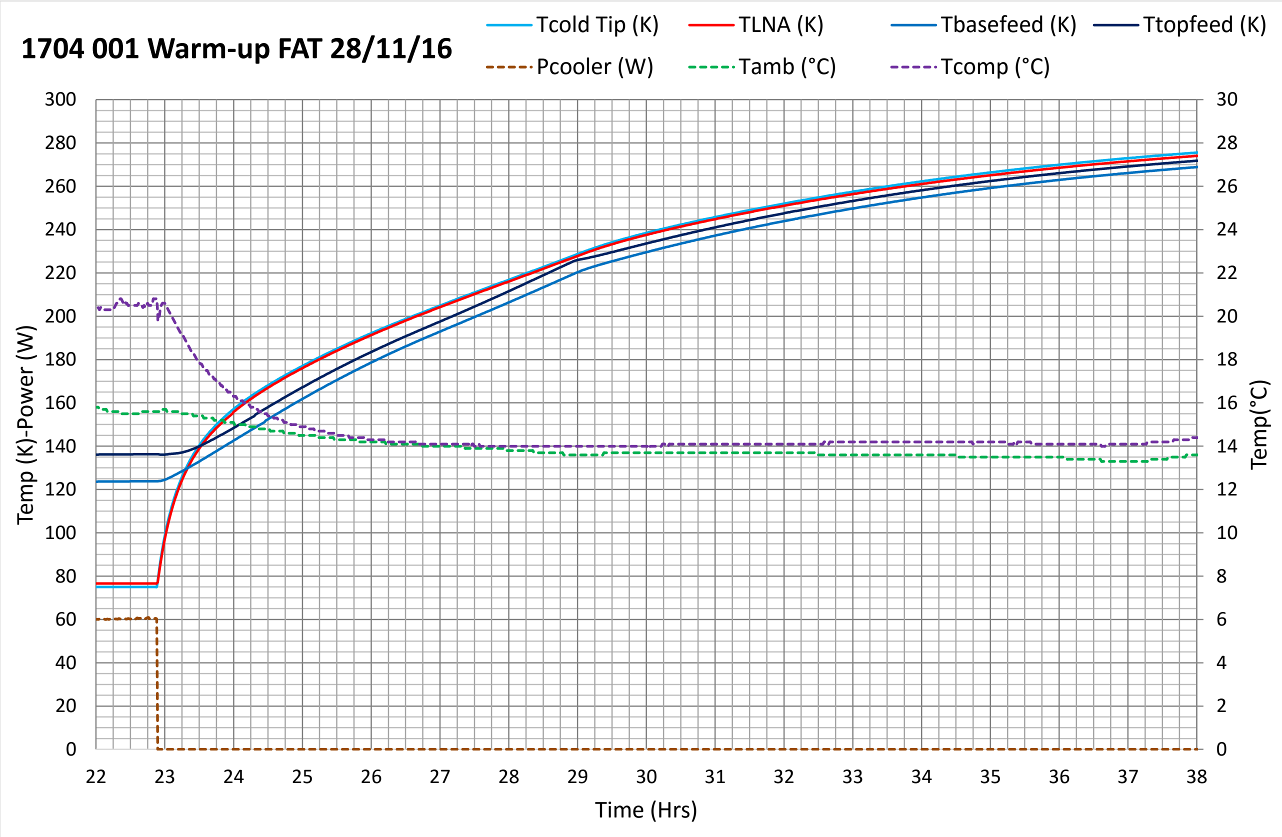


Figure 3-3 : Warmup

3.2 RF Tests

Result "R" column = Passed (P), Marginal (M), Failed (F)

<table>
<tr><th>Ref</th><th>Parameter / Requirement</th><th>Spec</th><th colspan="3">Result</th><th>R</th><th>Comments</th></tr>
<tr><td></td><td>Cryogenic Temperature</td><td>---</td><td colspan="3"></td><td></td><td>TcryoLNA = 76K</td></tr>
<tr><td></td><td>Frequency Band</td><td>2 – 14 GHz</td><td colspan="3">2-14GHz</td><td></td><td></td></tr>
<tr><td rowspan="6"></td><td rowspan="6">Noise Temperature</td><td rowspan="6">Max<40K</td><td></td><td>Port X</td><td>Port Y</td><td rowspan="6">P</td><td rowspan="6">Due to winter condition, the physical temperatures of the system were lower than set (75K) and so the NT measured is lower than predicted (TLNA=71K; Tbase feed=111K and Ttopfeed=124K).
On the other hand the NT measurement is degraded by the RFI observed at low frequency. (See NT graph Figure 3-16: NT Measurement raw data for TLNA=71KFigure 3-16)

Port X: 97% of the NT measurement is in specification from 3GHz up to 14GHz.
Port Y: 94% of the NT measurement is in specification from 3GHz up to 14GHz.</td></tr>
<tr><td>Min Meas</td><td>22.5K</td><td>23.7</td></tr>
<tr><td>Max Meas</td><td>42.1K</td><td>50.3K</td></tr>
<tr><td>Mean Meas</td><td>30.2K</td><td>30.5K</td></tr>
<tr><td>Min Trend</td><td>27K</td><td>26.5K</td></tr>
<tr><td>Max trend</td><td>40K</td><td>43K</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">Gain</td><td rowspan="2">>55dB</td><td>Port X</td><td colspan="2">Port Y</td><td rowspan="2">P</td><td rowspan="2">Gain extracted from NT meas</td></tr>
<tr><td>55.2dBmin</td><td colspan="2">55.4dBmin</td></tr>
<tr><td></td><td>Gain Flatness</td><td>10dBpp</td><td>7.8dBpp</td><td colspan="2">8.7dBpp</td><td>P</td><td>Worst case gain extracted from NT meas</td></tr>
<tr><td></td><td>Output Return Loss</td><td>>10dB</td><td>11.8dB min</td><td colspan="2">11.8dB min</td><td>P</td><td>14dB typical</td></tr>
<tr><td></td><td>Pout 1dB</td><td>+20dBm</td><td colspan="3">+20dBm</td><td>P</td><td>By design</td></tr>
<tr><td></td><td>Gain via test input (Port X)</td><td>-</td><td colspan="3">18.7dB<Gain<43.5dB</td><td></td><td></td></tr>
</table>

Ref	Parameter / Requirement	Spec	Result	R	Comments
	Gain via test input (Port Y)	-	19.7dB<Gain<43.8 dB		
	Gain via test input stability (Port X)	-	@2GHz / 60min: 0.04dBpp @8GHz / 60min: 0.03dBpp @14GHz / 60min: 0.07dBpp @2GHz / 60sec: 0.02dBpp @8GHz / 60sec: 0.01dBpp @14GHz / 60sec: 0.03dBpp		Most of the gain variation is probably due to the measurement set-up. A specific calibration of the VNA as to be performed at 14GHz to improve the test set-up stability.
	Gain via test input stability (Port Y)	-	@2GHz / 60min: 0.03dBpp @8GHz / 60min: 0.05dBpp @14GHz / 60min: 0.05dBpp @2GHz / 60sec: 0.02dBpp @8GHz / 60sec: 0.03dBpp @14GHz / 60sec: 0.14dBpp		Most of the gain variation is probably due to the measurement set-up. A specific calibration of the VNA as to be performed at 14GHz to improve the test set-up stability.

Table 3-2: Test Result Sheet n°2 – RF Tests

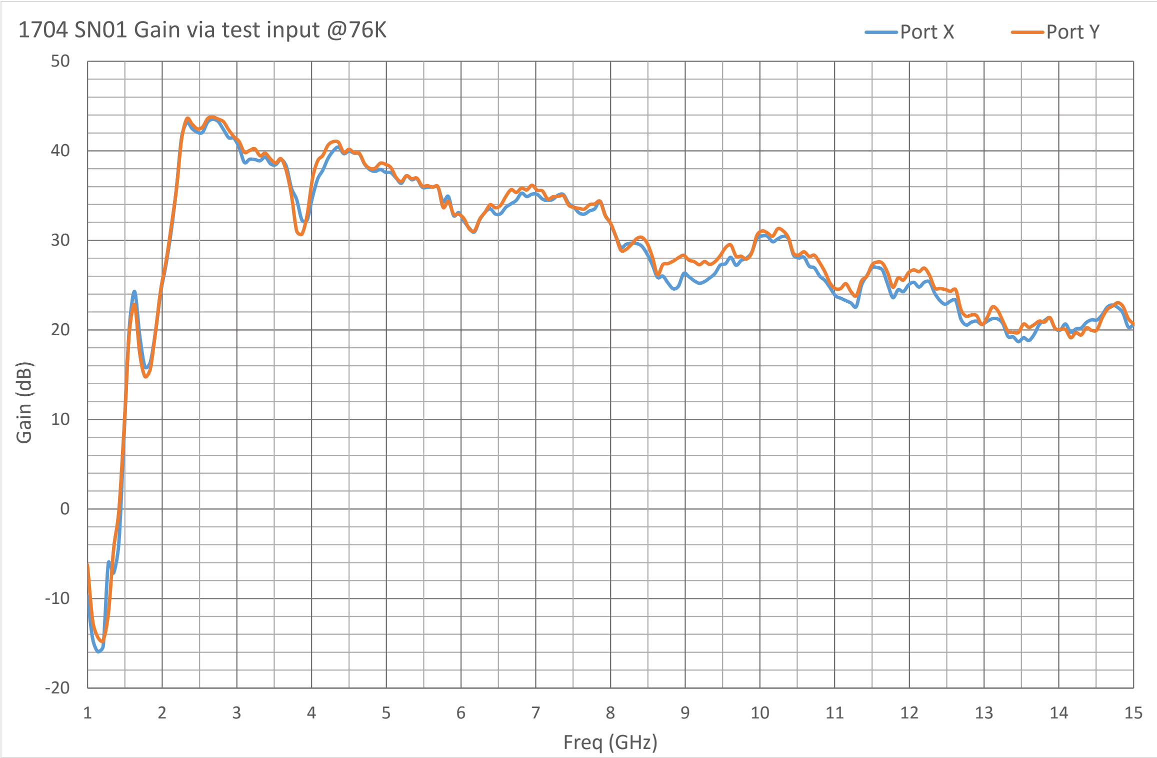


Figure 3-4: Gain via test input for TLNA=76K

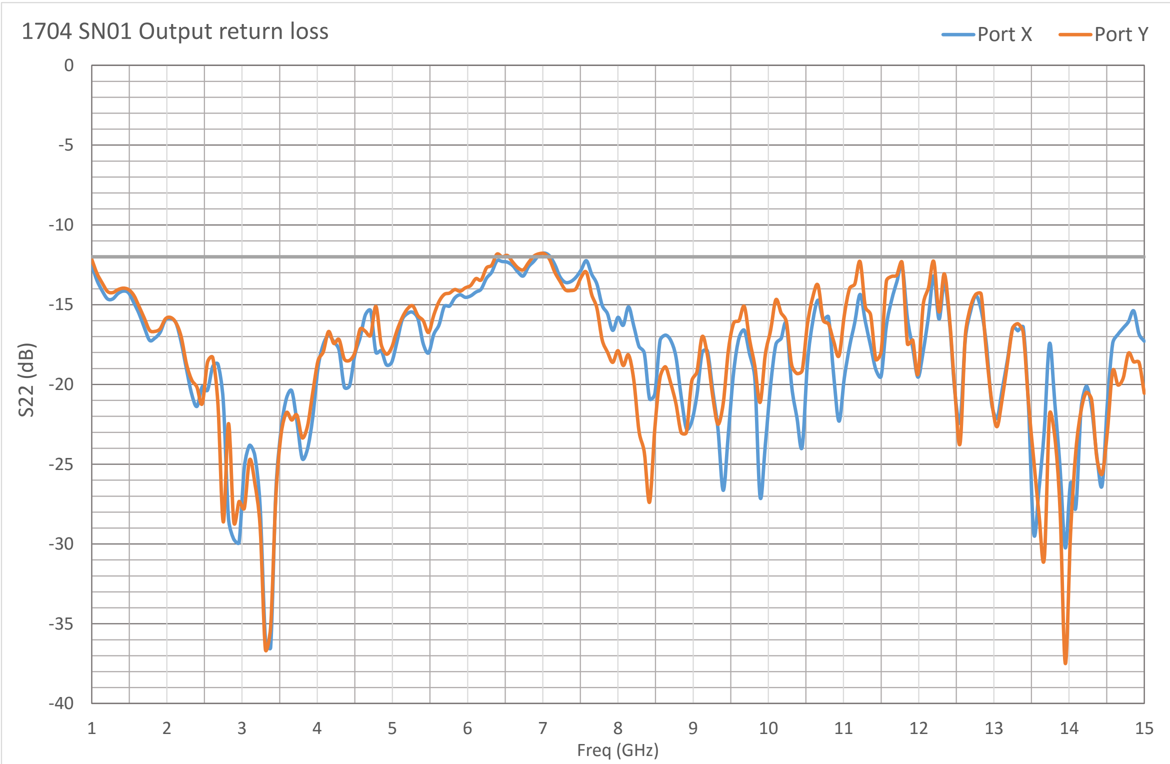


Figure 3-5: Output Return Loss

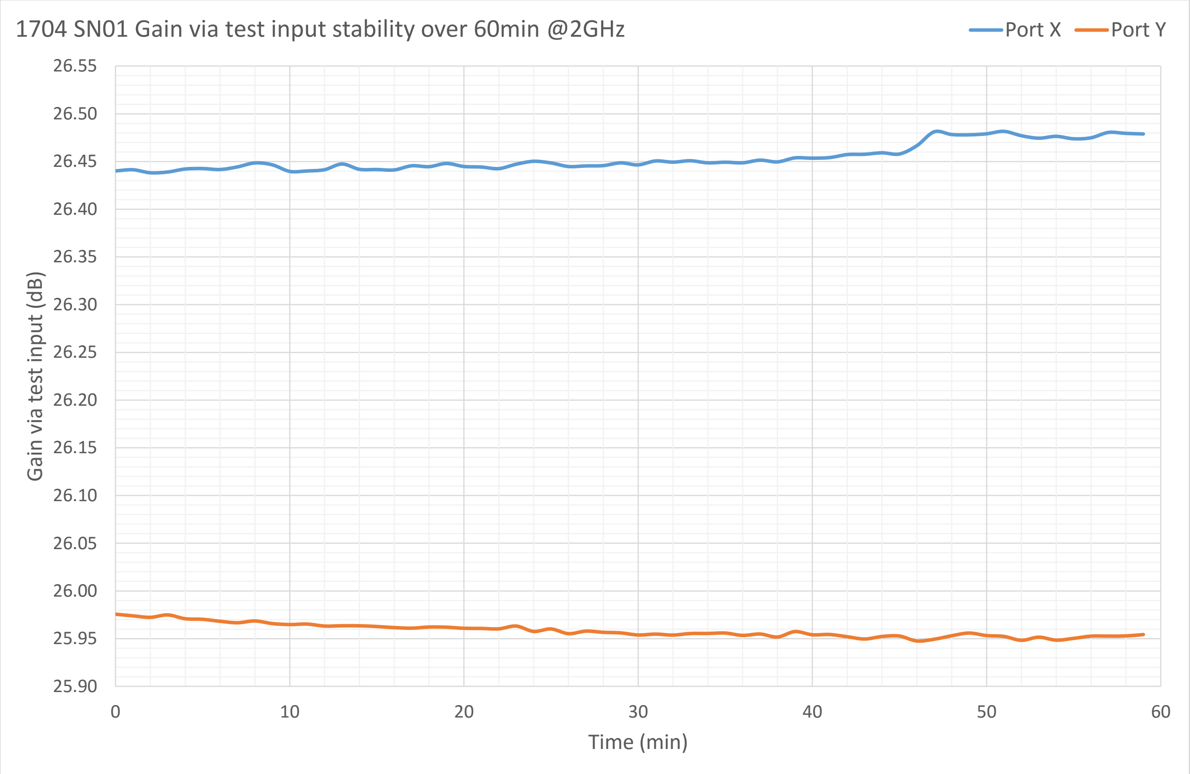


Figure 3-6: Gain via test input stability over 60min (1 sample per min) @2GHz

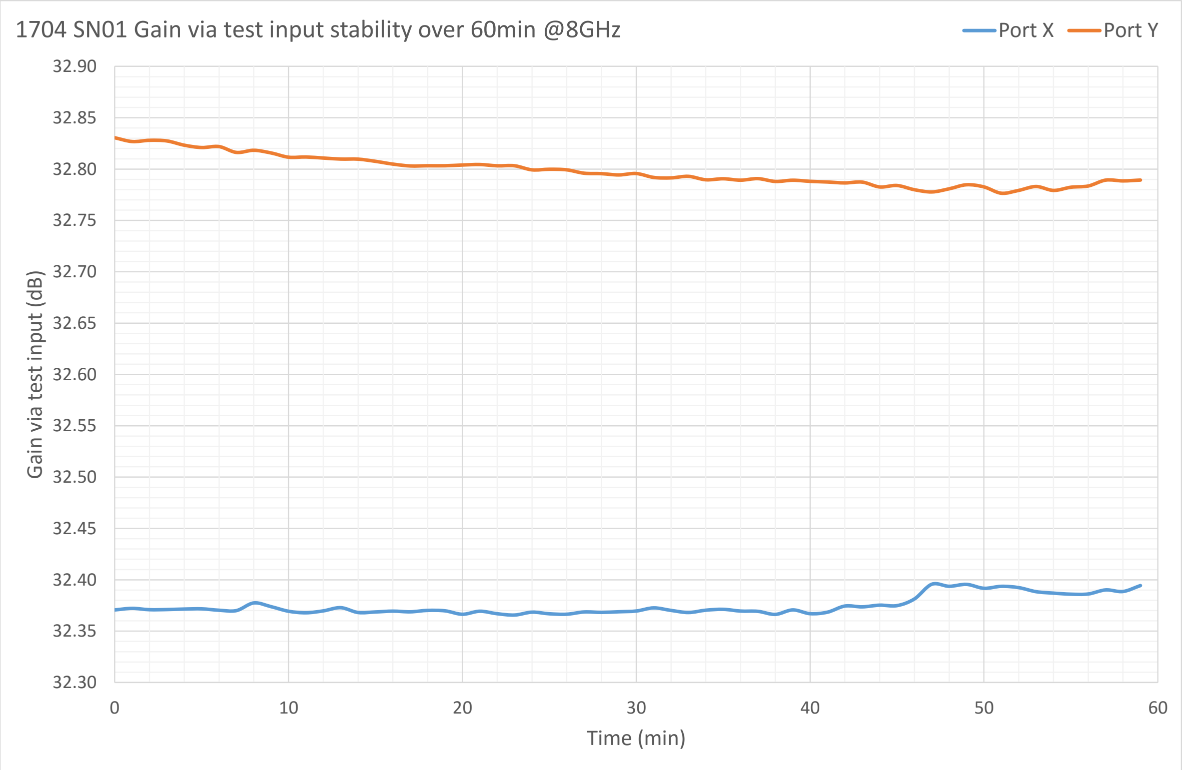


Figure 3-7: Gain via test input stability over 60min (1 sample per min) @8GHz

Figure 3-8: Gain via test input stability over 60min (1 sample per min) @14GHz

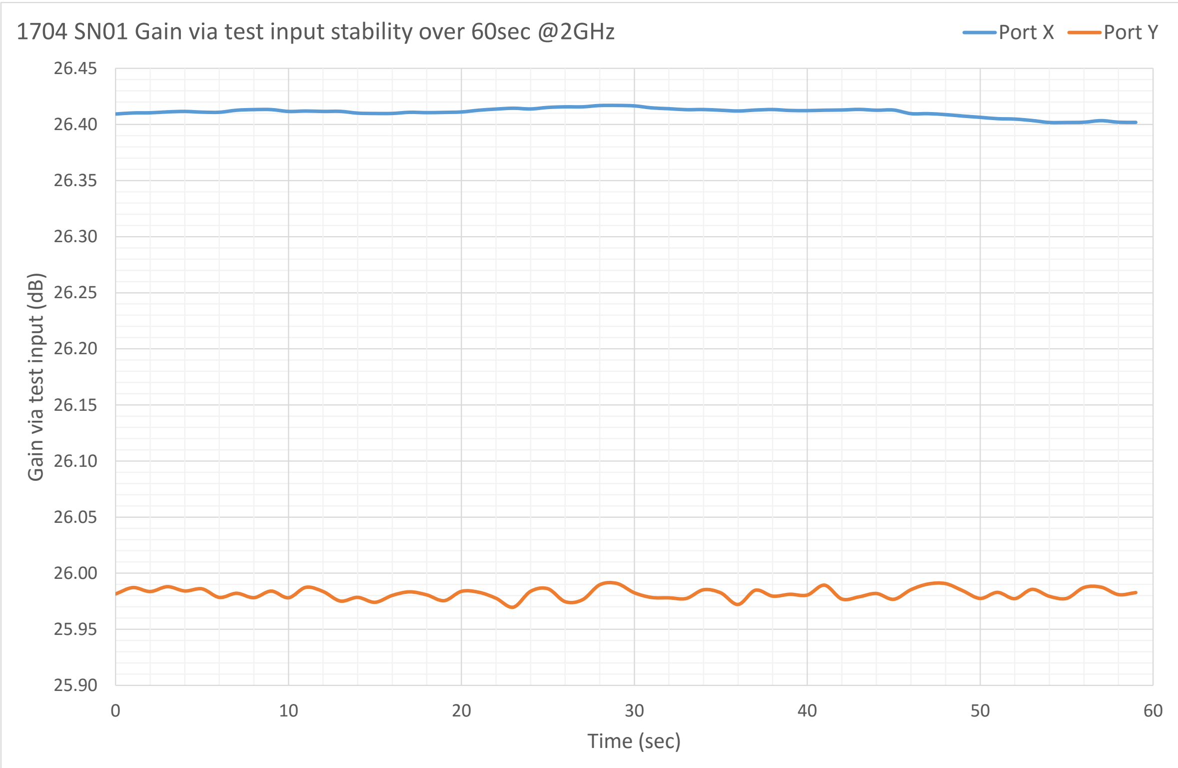


Figure 3-9: Gain via test input stability over 60sec (1 sample per sec) @2GHz

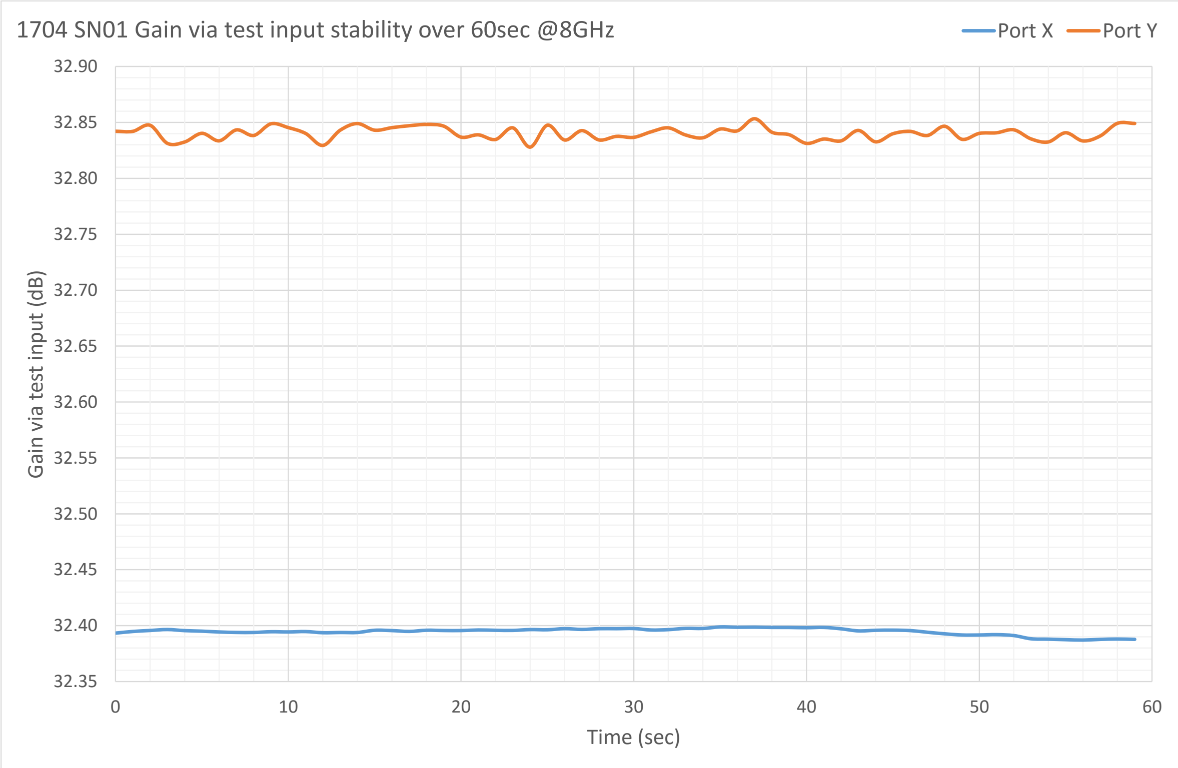


Figure 3-10: Gain via test input stability over 60sec (1 sample per sec) @8GHz

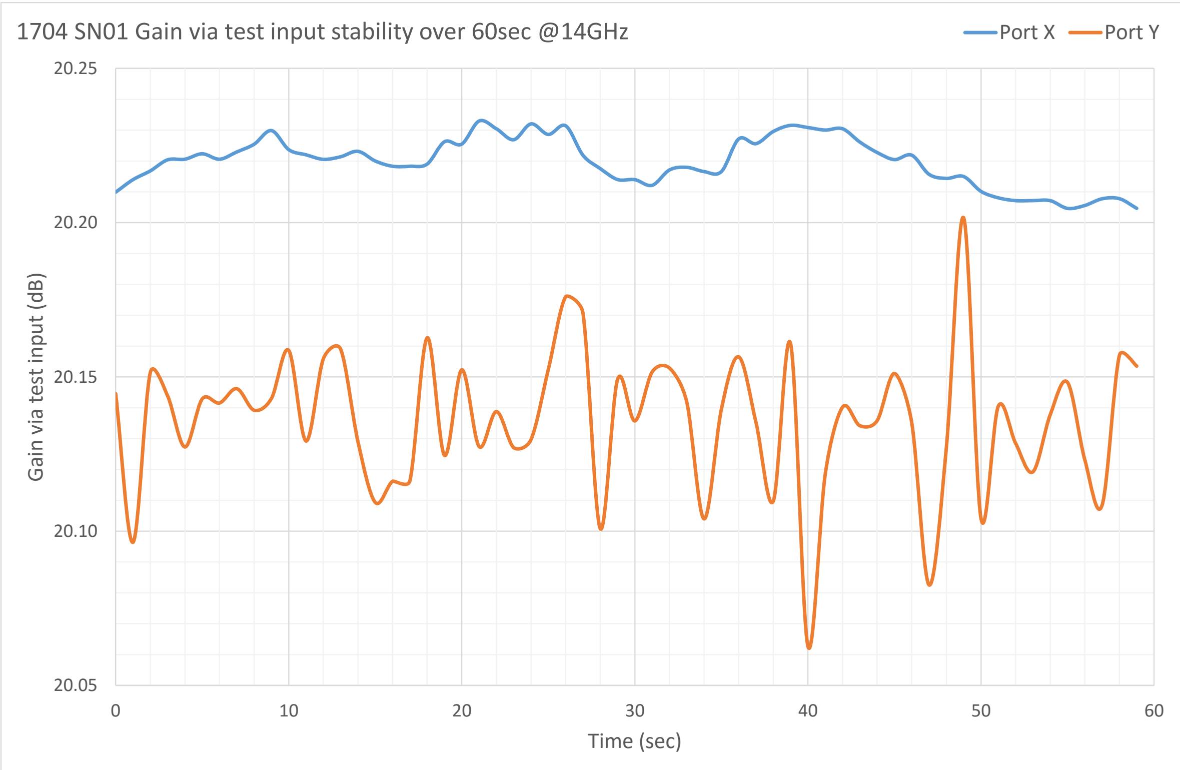


Figure 3-11: Gain via test input stability over 60sec (1 sample per sec) @14GHz

The gain of the receiver has been extracted from the noise temperature measurement using the following formula:

$$G = \frac{P_{hot}}{(T_e - T_{hot}) \times B \times k}$$

With:

- G = Gain of the receiver
- Phot = Power measure at the output of the receiver when the hot load is in front of the receiver
- Te = Noise temperature of the receiver
- Thot = Noise temperature of the hot load
- B = Bandwidth (Resolution Band Width set on the spectrum analyser)
- K = Boltzmann constant

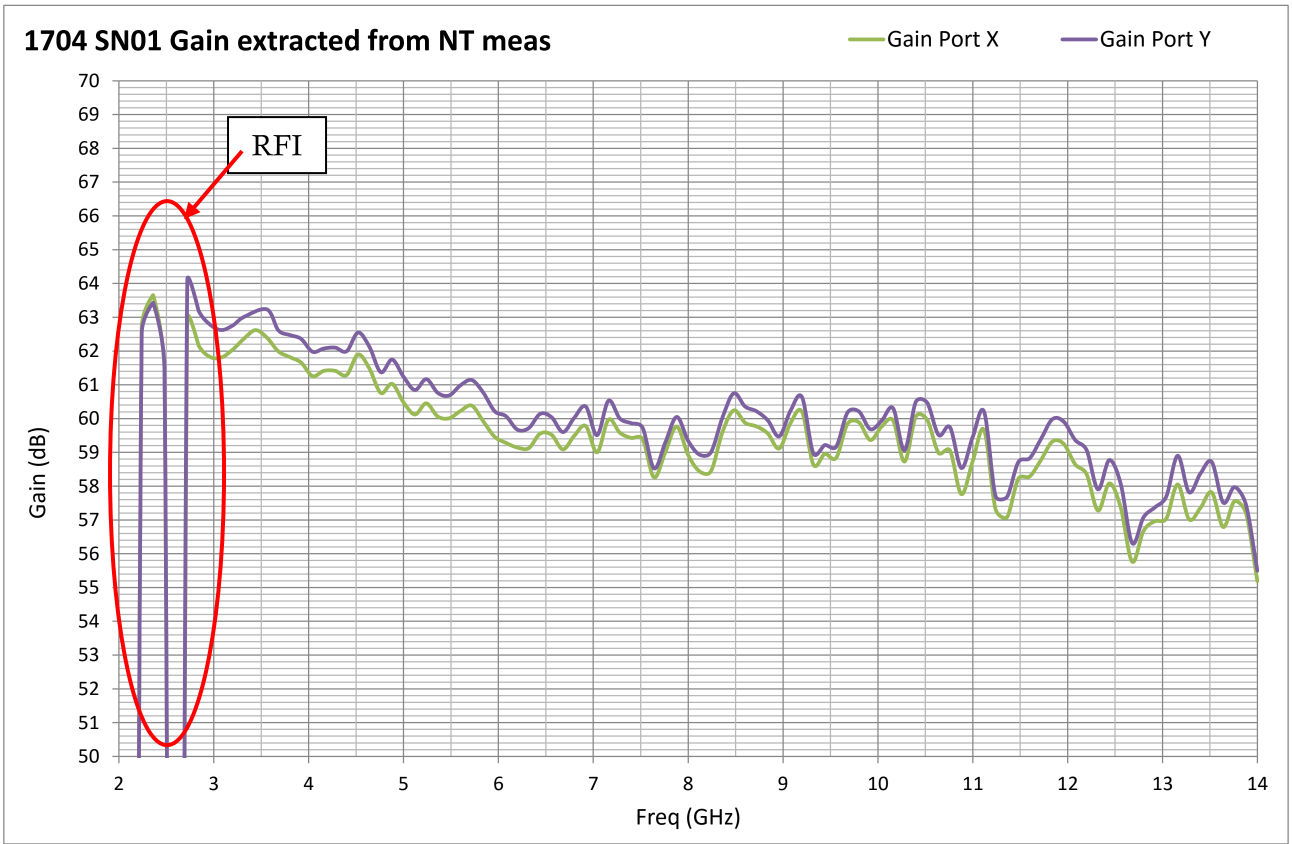


Figure 3-12: Gain extracted from NT measurement.

The gain extracted from the NT measurement is noisy but it gives a good trend for the overall gain of the receiver.

3.2.1 Noise temperature measurement

Due to the increase of mobile phone antenna installation around the Callisto premises it become more and more difficult to make clean and valuable noise temperature measurement on the QRFH receiver. Indeed the increase of RFI measured in the Callisto laboratory is problematic for this type of measurement:

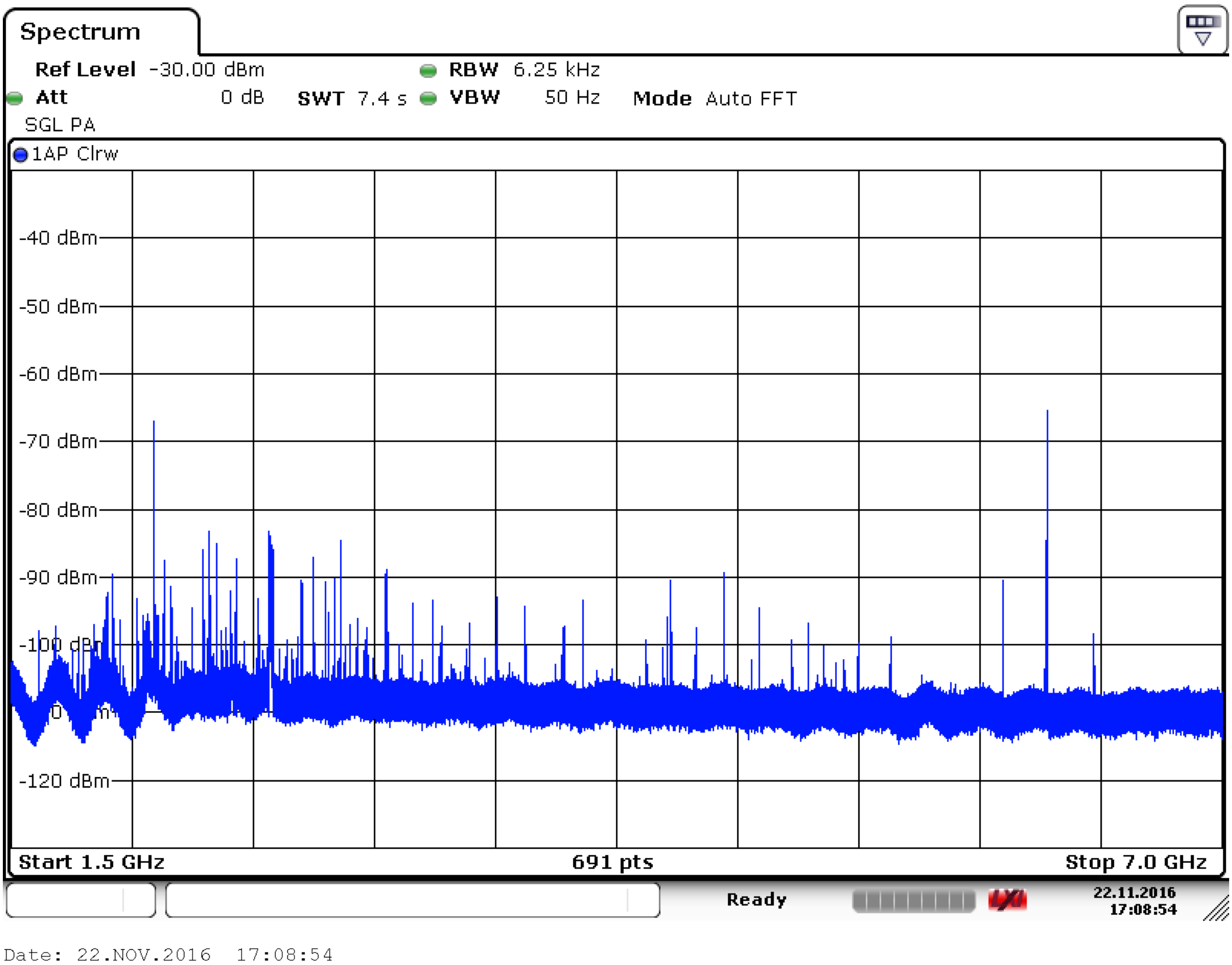


Figure 3-13: RFI survey in the Callisto laboratory, output of an amplifier, at low frequency the RFI are mixed by the amplifier.

The RFI have a direct impact on the NT measurement (noise peak) but the RFI are also mixed by the amplifiers of the receiver and so the overall noise floor increases.

It is difficult for us to find a convenient place without RFI to make the NT measurement but we have tried to move to a place with less RFI (countryside):

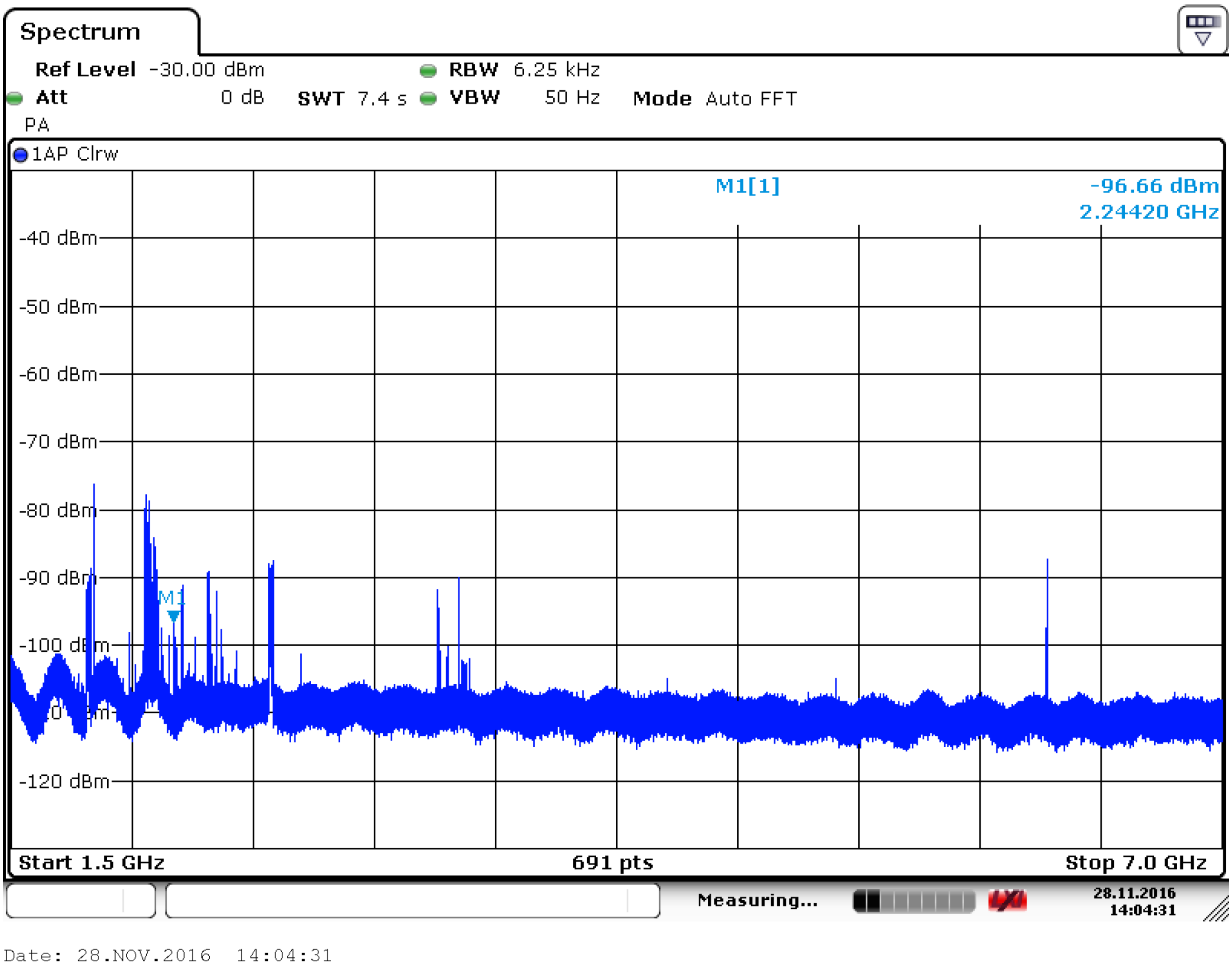


Figure 3-14: RFI survey of the NT measurement place.

Figure 3-15: NT measurement test set-up.

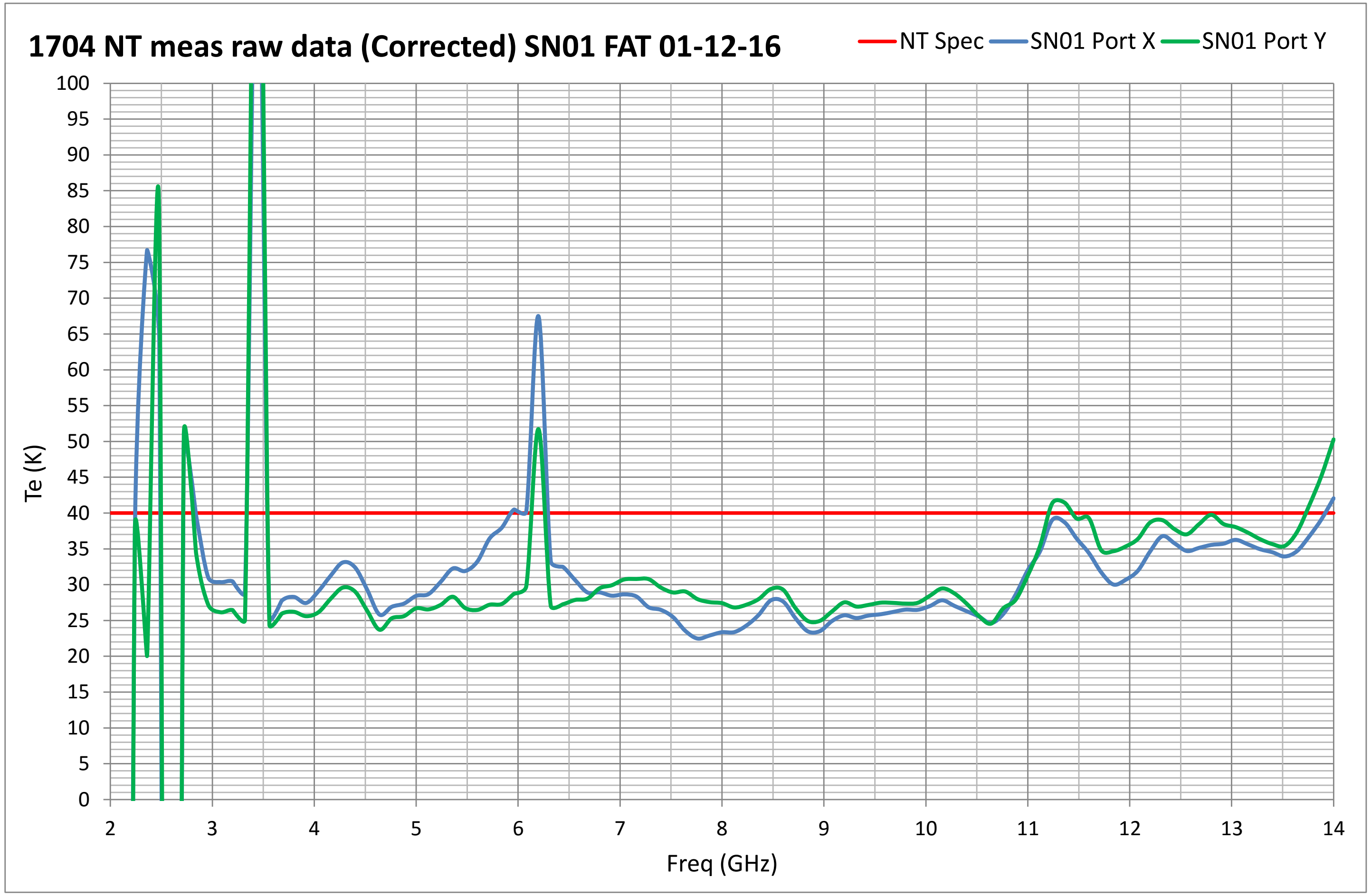


Figure 3-16: NT Measurement raw data for TLNA=71K

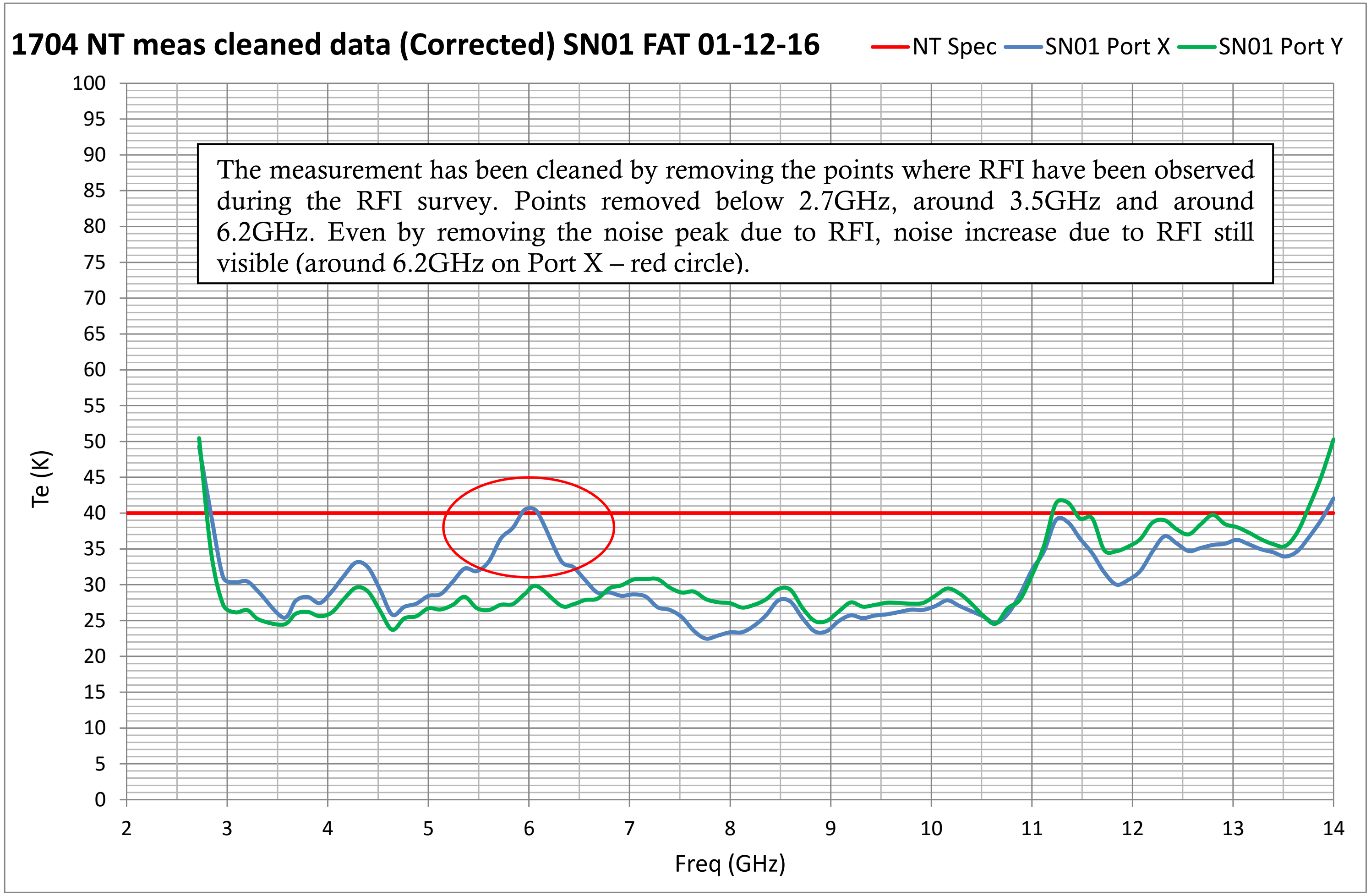


Figure 3-17: NT Measurement cleaned data for TLNA=71K

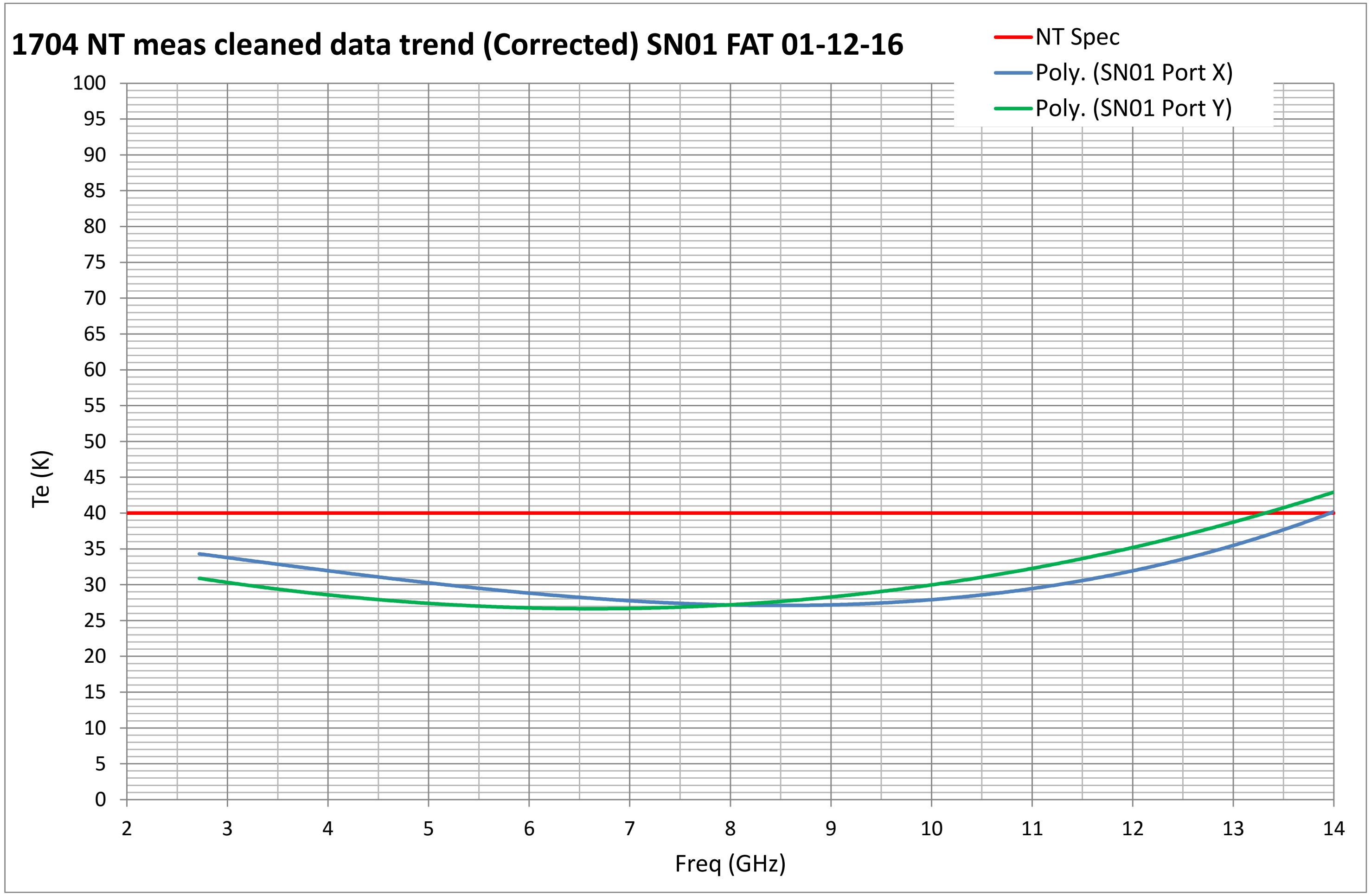


Figure 3-18: NT Measurement cleaned data trend for TLNA=71K

3.2.2 Noise Calibration

The purpose of this circuit is to inject two levels of noise in the QRFH receiver in order to do a noise measurement using the Y-factor method. The noise is generated by a noise diode and the level of noise is set using a variable attenuator. This noise signal is injected inside the QRFH feed by a probe antenna.

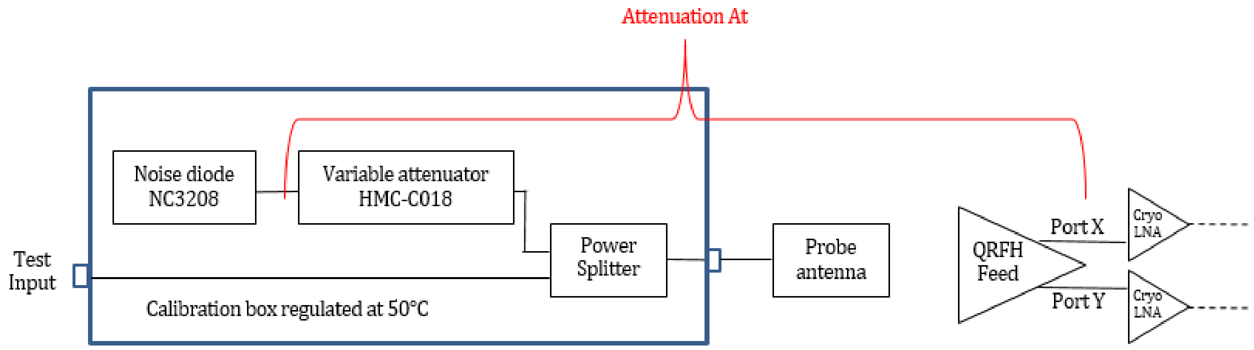


Figure 3-19: Noise calibration circuit

The two levels of noise have been defined by UTAS Tn1=10K and Tn2=0.5K. The theoretical attenuation (At) required to achieve Tn1 and Tn2 has been calculated according to the ENR of the noise diode at 50°C from the calibration data given by the noise diode manufacturer. The following tables give the variable attenuator settings to generate Tn1 and Tn2:

1704 QRFH SN01 Attenuator Settings for Noise Calibration Port X (ND AE849)											
Freq (GHz)	ND ENR (dB) @50°C	Td ND @50°C (K)	At1 calculated for Tn1=10K (dB)	Att1 set on HMC-C018 (dB)	At1 measured (dB)	Effective Tn1 (K)	At2 calculated for Tn2=0.5K (dB)	Att2 set on HMC-C018 (dB)	At2 measured (dB)	Effective Tn2 (K)
2	31.99	458851.93	46.62	10.0	46.60	10.04	59.63	23	59.5	0.51
3	31.70	429231.43	46.33	21.0	46.40	9.83	59.34	31.5	56.8	0.90
4	31.61	420433.84	46.24	14.0	46.00	10.56	59.25	27.5	59.4	0.48
5	31.51	410870.20	46.14	18.0	45.90	10.56	59.15	31	59.3	0.48
6	31.45	405236.82	46.08	14.5	45.90	10.42	59.09	27.5	59	0.51
7	31.28	389691.84	45.91	15.5	46.10	9.57	58.92	27.5	58.5	0.55
8	31.11	374743.59	45.74	13.0	45.70	10.09	58.75	25.5	58.5	0.53
9	31.21	383465.73	45.84	8.0	46.10	9.41	58.85	20.5	58.9	0.49
10	31.23	385234.39	45.86	7.5	45.90	9.90	58.87	20	59	0.48
11	31.26	387902.70	45.89	6.0	45.80	10.20	58.90	19	58.8	0.51
12	31.38	398762.17	46.01	4.0	45.80	10.49	59.02	17.5	59	0.50
13	31.56	415624.49	46.19	1.5	46.30	9.74	59.20	14.5	59.2	0.50
14	31.55	414669.25	46.18	0.0	47.00	8.27	59.19	12.5	59.3	0.49

1704 QRFH SN01 Attenuator Settings for Noise Calibration Port Y (ND AE849)										
Freq (GHz)	ND ENR (dB) @50°C	Td ND @50°C (K)	At1 calculated for Tn1=10K (dB)	Att1 set on HMC-C018 (dB)	At1 measured (dB)	Effective Tn1 (K)	At2 calculated for Tn2=0.5K (dB)	Att2 set on HMC-C018 (dB)	At2 measured (dB)	Effective Tn2 (K)
2	31.99	458851.93	46.62	10.0	46.60	10.04	59.63	23	59.5	0.51
3	31.70	429231.43	46.33	21.0	46.40	9.83	59.34	31.5	56.8	0.90
4	31.61	420433.84	46.24	14.0	46.00	10.56	59.25	27.5	59.4	0.48
5	31.51	410870.20	46.14	18.0	45.90	10.56	59.15	31	59.3	0.48
6	31.45	405236.82	46.08	14.5	45.90	10.42	59.09	27.5	59	0.51
7	31.28	389691.84	45.91	15.5	46.10	9.57	58.92	27.5	58.5	0.55
8	31.11	374743.59	45.74	13.0	45.70	10.09	58.75	25.5	58.5	0.53
9	31.21	383465.73	45.84	8.0	46.10	9.41	58.85	20.5	58.9	0.49
10	31.23	385234.39	45.86	7.5	45.90	9.90	58.87	20	59	0.48
11	31.26	387902.70	45.89	6.0	45.80	10.20	58.90	19	58.8	0.51
12	31.38	398762.17	46.01	4.0	45.80	10.49	59.02	17.5	59	0.50
13	31.56	415624.49	46.19	1.5	46.30	9.74	59.20	14.5	59.2	0.50
14	31.55	414669.25	46.18	0.0	47.00	8.27	59.19	12.5	59.3	0.49

Find below a description of each column of the table above:

- ND ENR @50°C (dB): ENR of the noise diode @50°C from the calibration data given by the noise diode manufacturer.

- Td ND @50°C (K): Noise generated by the noise diode in Kelvin. Derivate from the noise diode ENR @50°C.

- At1 calculated for Tn1=10K (dB): Attenuation At1 calculated in order to inject Tn1=10K in the QRFH receiver.

- Att1 set on HMC-C018 (dB): Attenuation set on the variable attenuator to achieve the closest value of AT1 calculated in order to inject Tn1. The variable attenuator has a minimum resolution of 0.5dB.

- At1 measured (dB): Due to the resolution of the variable attenuator it is not possible to achieve the exact calculated value of At1. At1 measured is the closest value achievable.

- Effective Tn1 (K): According to the At1 measured the effective Tn1 has been re-calculated.

The last 4 columns are identical to the previous ones but for the Tn2=0.5K.

The operating of the noise calibration has been tested. The Y-factor of the receiver has been measured when the noise diode is off and when the noise calibration circuit injects Tn=10K. The measurement has been performed at 4GHz and 9GHz on both port. The receiver noise temperature has been calculated using the Noise Adding Radiometer formula:

$$NT(K) = \frac{Tn}{(Y-1)}$$

	Output Power ND Off (dBm)	Output Power ND On (Tn=10K) (dBm)	Y-factor (dB)	Y-factor (ratio)	NT (K) ND method
Port X @4GHz	-49.5	-48.53	0.97	1.25025903	40.0
Port Y @4GHz	-49.1	-48.08	1.02	1.264736347	37.8
Port X @9GHz	-53.89	-53.02	0.87	1.22179966	45.1
Port Y @9GHz	-53.96	-53.11	0.85	1.216186001	46.3

The receiver noise temperatures in the table above are not corrected (Tsky…) and are in the order of magnitude of the measurements performed with the hot/cold method using the sky as a cold load.

The noise calibration circuit is operational.

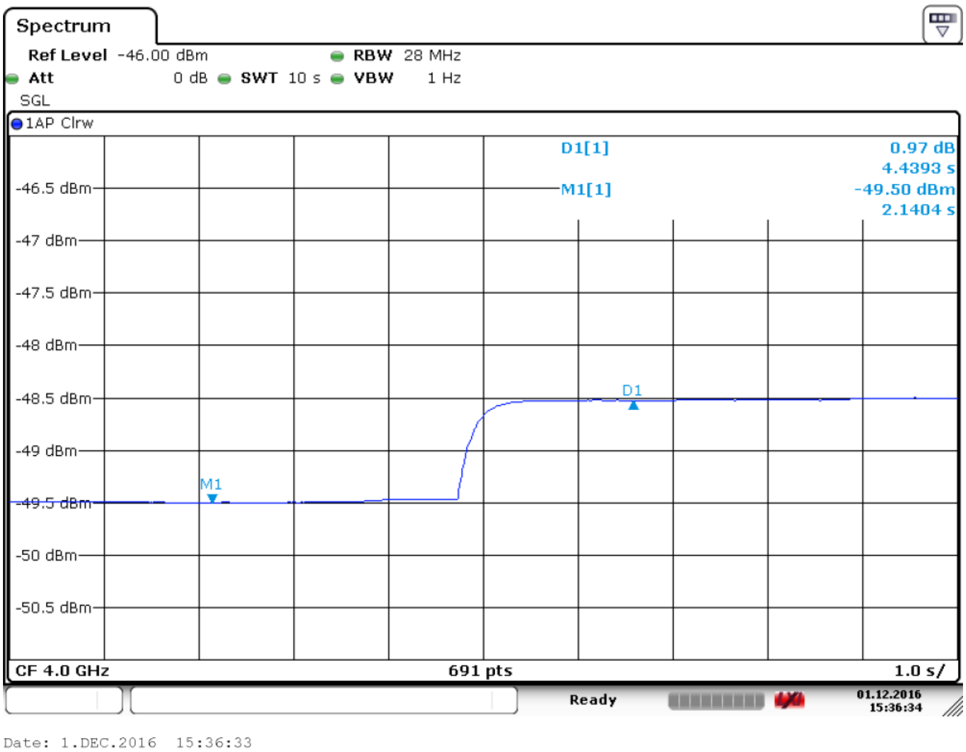


Figure 3-20: Y-factor measured with the noise diode On (Tn=10K) and off @4GHz port X

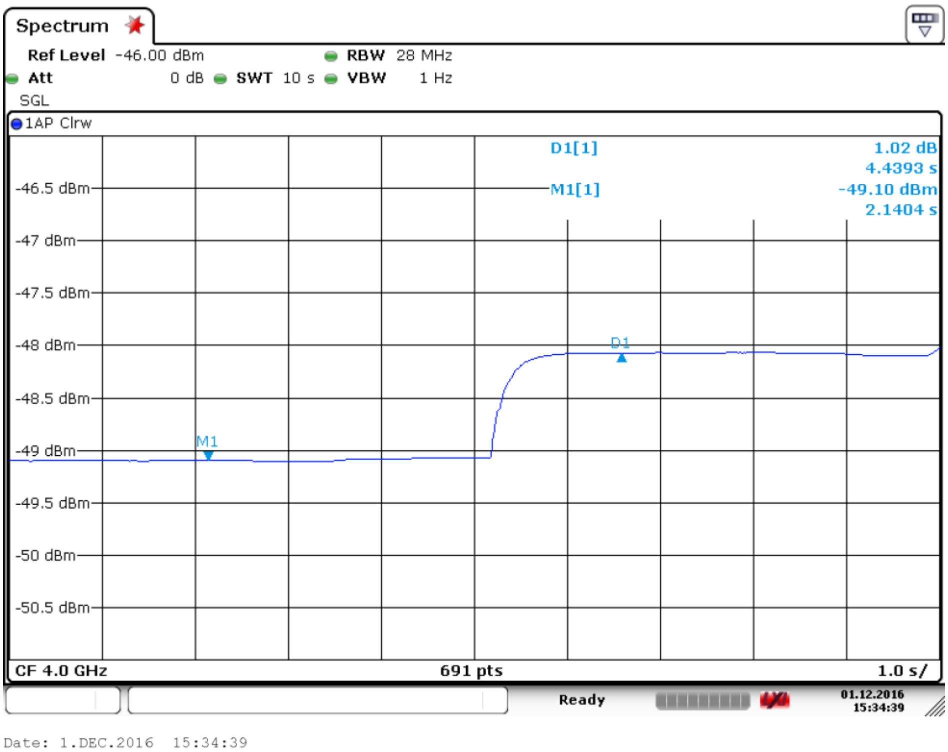


Figure 3-21: Y-factor measured with the noise diode On (Tn=10K) and off @4GHz port Y

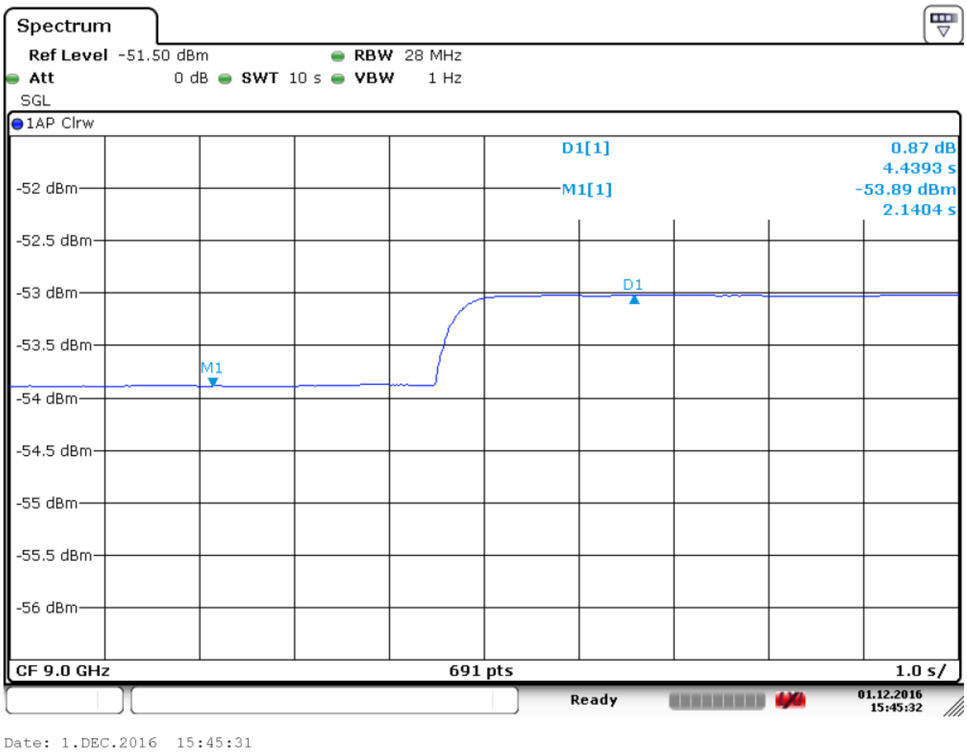


Figure 3-22: Y-factor measured with the noise diode On (Tn=10K) and off @9GHz port X

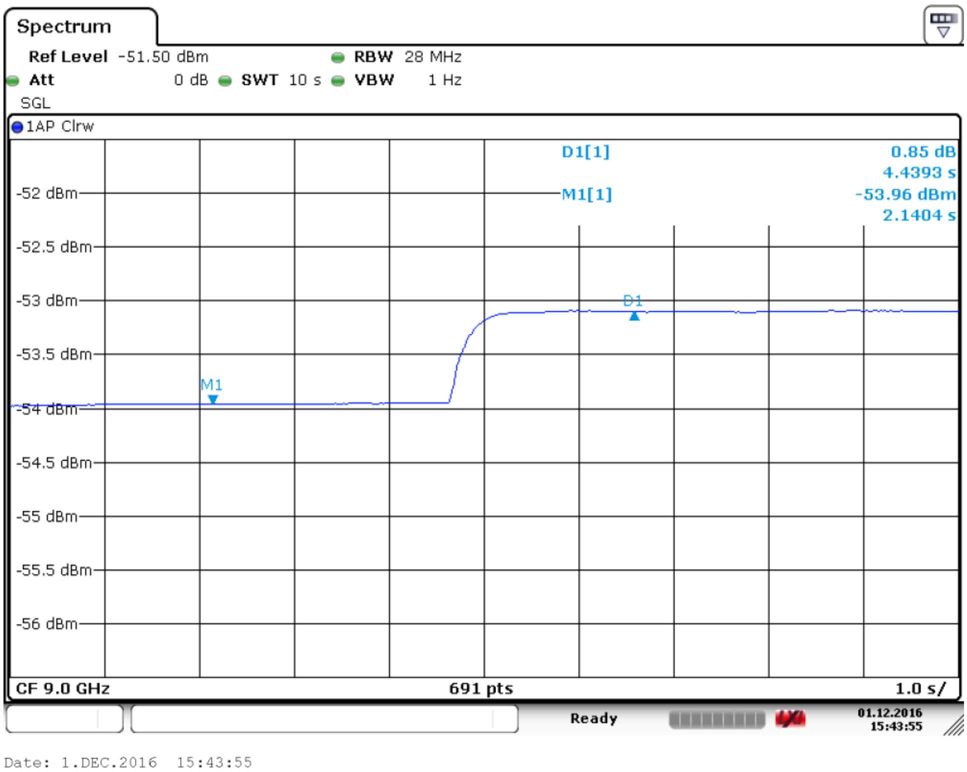


Figure 3-23: Y-factor measured with the noise diode On (Tn=10K) and off @9GHz port Y

3.2.3 Phase Calibration

The purpose of the phase calibration circuit is to generate a comb spectrum signal up to 14GHz with spectral lines at 10MHz spacing, which are derived from an input reference frequency signal available in the station. The phase calibration circuit configuration is shown below:

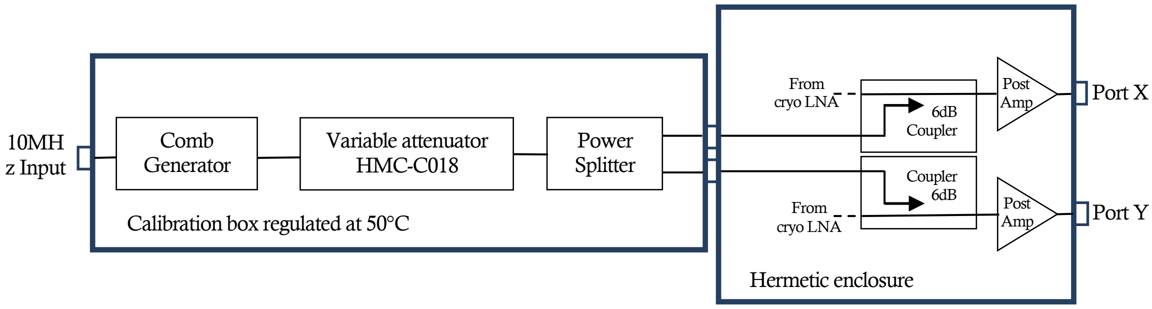
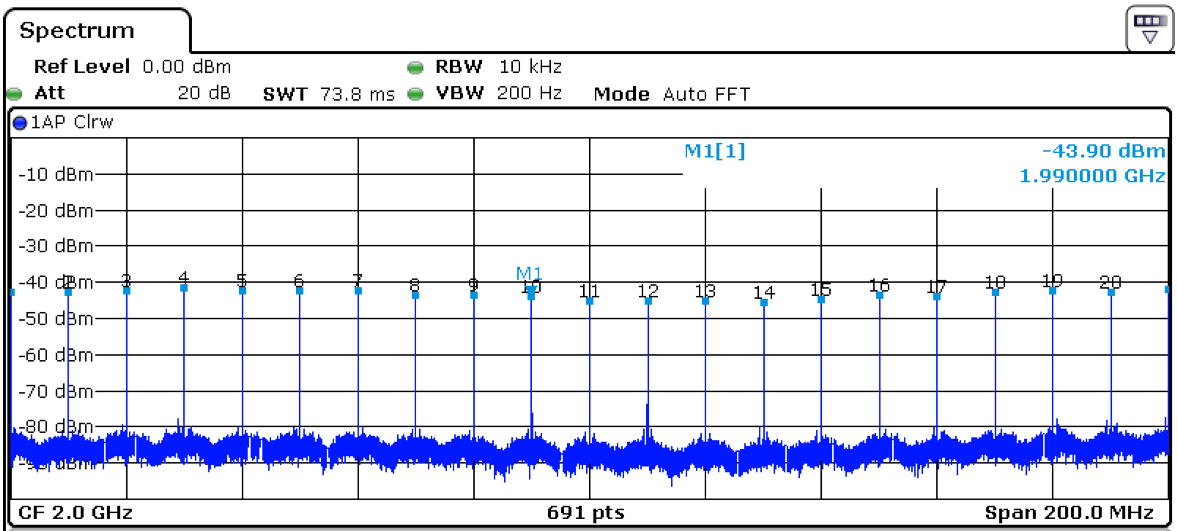


Figure 3-24: Noise calibration circuit

The comb generator has been tested alone with +10dBm input power and 15V/70mA power supply:



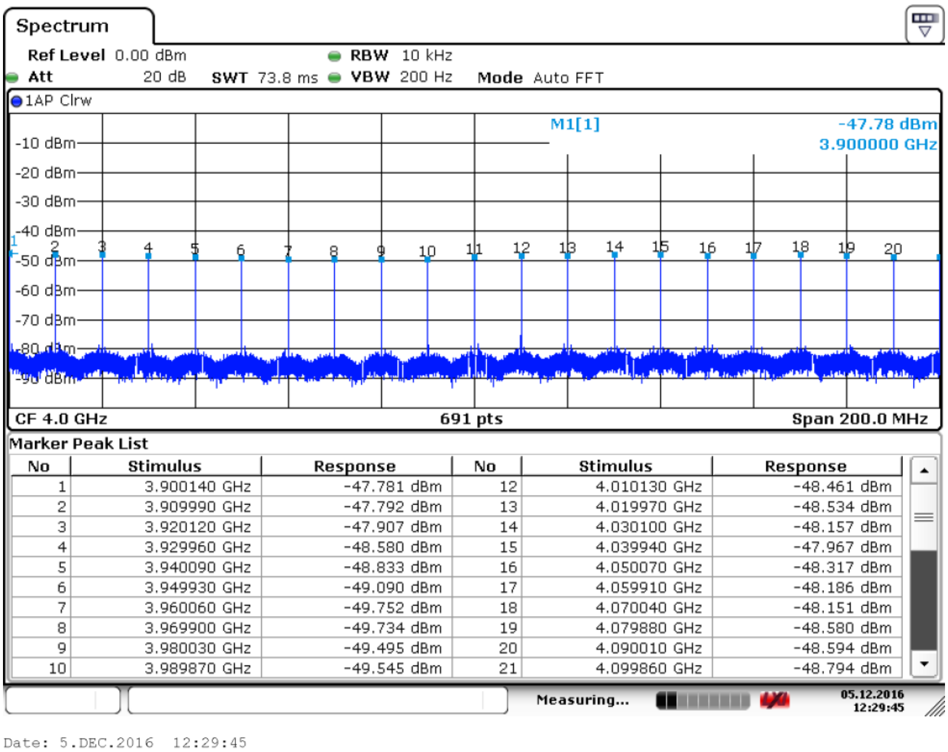
Marker Peak List

No	Stimulus	Response	No	Stimulus	Response
1	1.900140 GHz	-42.662 dBm	12	2.010130 GHz	-45.293 dBm
2	1.909990 GHz	-42.847 dBm	13	2.019970 GHz	-44.965 dBm
3	1.920120 GHz	-42.276 dBm	14	2.030100 GHz	-45.422 dBm
4	1.929960 GHz	-41.707 dBm	15	2.039940 GHz	-44.757 dBm
5	1.940090 GHz	-42.484 dBm	16	2.050070 GHz	-43.679 dBm
6	1.949930 GHz	-42.467 dBm	17	2.059910 GHz	-43.831 dBm
7	1.960060 GHz	-42.266 dBm	18	2.070040 GHz	-42.869 dBm
8	1.969900 GHz	-43.372 dBm	19	2.079880 GHz	-42.177 dBm
9	1.980030 GHz	-43.675 dBm	20	2.090010 GHz	-42.556 dBm
10	1.989870 GHz	-43.896 dBm	21	2.099860 GHz	-41.965 dBm

Measuring... 05.12.2016 12:28:41

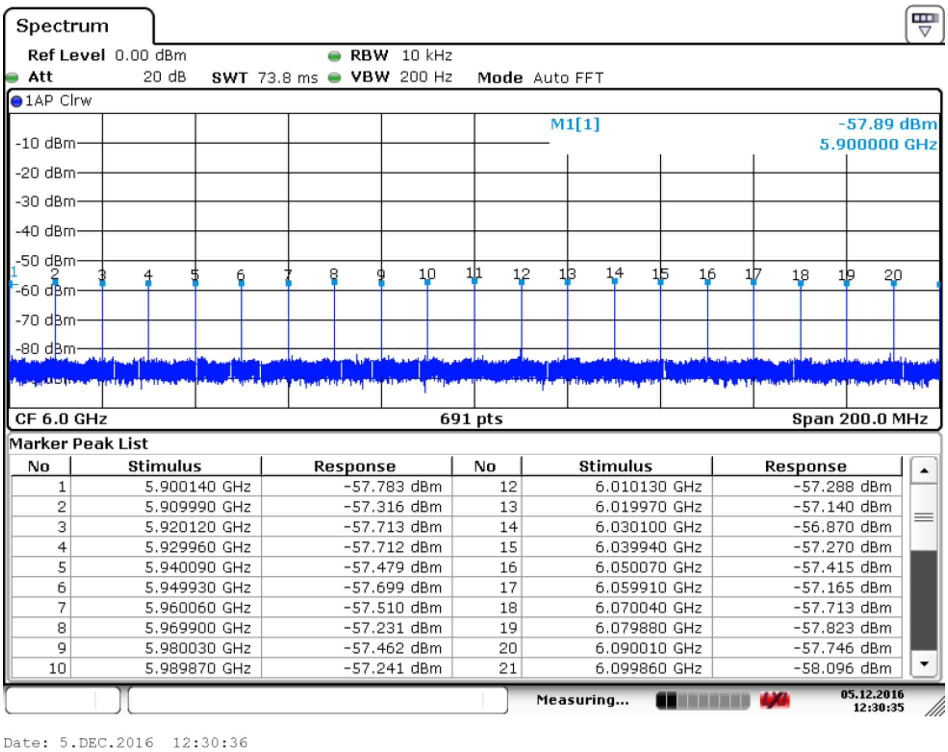
Date: 5.DEC.2016 12:28:40

Figure 3-25: Comb generator output with +10dBm 10MHz input @2GHz



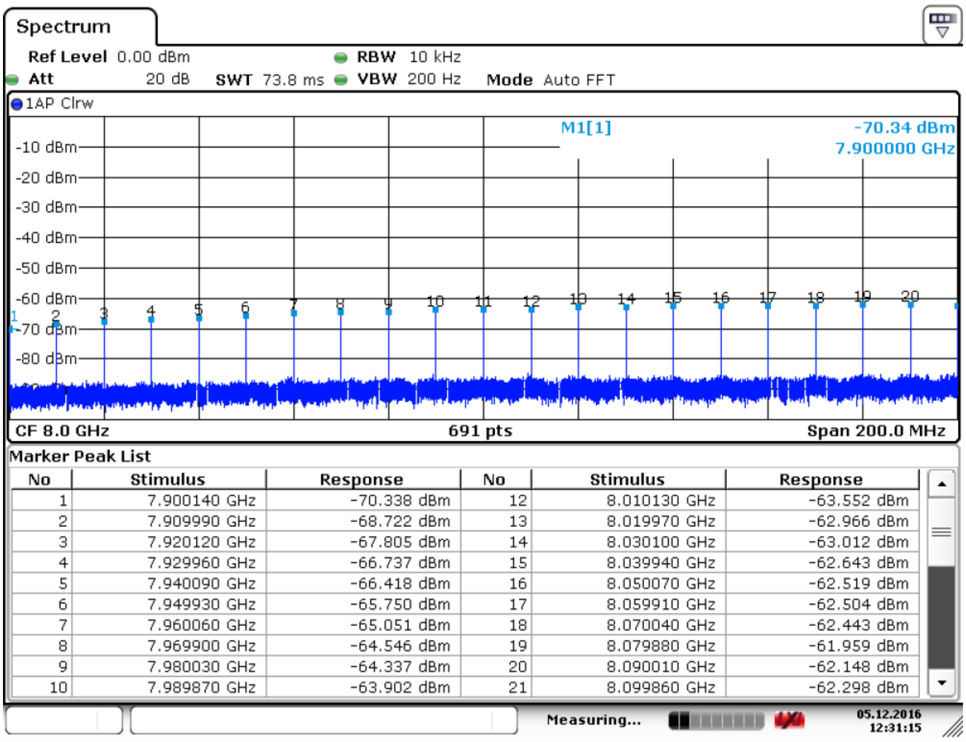
No	Stimulus	Response	No	Stimulus	Response
1	3.900140 GHz	-47.781 dBm	12	4.010130 GHz	-48.461 dBm
2	3.909990 GHz	-47.792 dBm	13	4.019970 GHz	-48.534 dBm
3	3.920120 GHz	-47.907 dBm	14	4.030100 GHz	-48.157 dBm
4	3.929960 GHz	-48.580 dBm	15	4.039940 GHz	-47.967 dBm
5	3.940090 GHz	-48.833 dBm	16	4.050070 GHz	-48.317 dBm
6	3.949930 GHz	-49.090 dBm	17	4.059910 GHz	-48.186 dBm
7	3.960060 GHz	-49.752 dBm	18	4.070040 GHz	-48.151 dBm
8	3.969900 GHz	-49.734 dBm	19	4.079880 GHz	-48.580 dBm
9	3.980030 GHz	-49.495 dBm	20	4.090010 GHz	-48.594 dBm
10	3.989870 GHz	-49.545 dBm	21	4.099860 GHz	-48.794 dBm

Figure 3-26: Comb generator output with +10dBm 10MHz input @4GHz



No	Stimulus	Response	No	Stimulus	Response
1	5.900140 GHz	-57.783 dBm	12	6.010130 GHz	-57.288 dBm
2	5.909990 GHz	-57.316 dBm	13	6.019970 GHz	-57.140 dBm
3	5.920120 GHz	-57.713 dBm	14	6.030100 GHz	-56.870 dBm
4	5.929960 GHz	-57.712 dBm	15	6.039940 GHz	-57.270 dBm
5	5.940090 GHz	-57.479 dBm	16	6.050070 GHz	-57.415 dBm
6	5.949930 GHz	-57.699 dBm	17	6.059910 GHz	-57.165 dBm
7	5.960060 GHz	-57.510 dBm	18	6.070040 GHz	-57.713 dBm
8	5.969900 GHz	-57.231 dBm	19	6.079880 GHz	-57.823 dBm
9	5.980030 GHz	-57.462 dBm	20	6.090010 GHz	-57.746 dBm
10	5.989870 GHz	-57.241 dBm	21	6.099860 GHz	-58.096 dBm

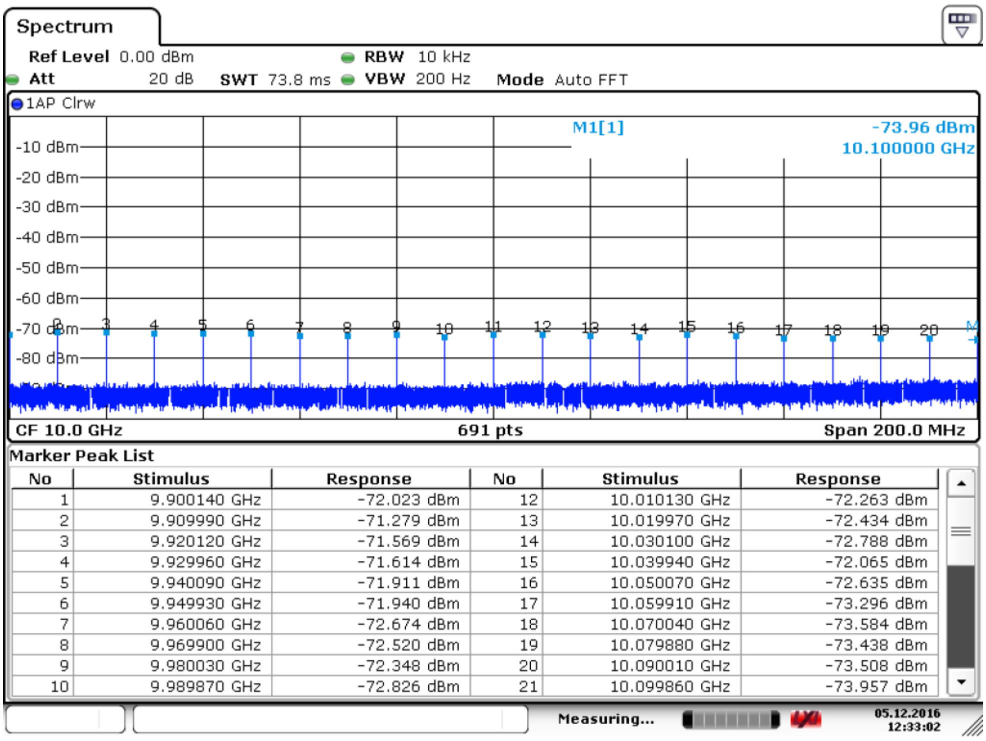
Figure 3-27: Comb generator output with +10dBm 10MHz input @6GHz



No	Stimulus	Response	No	Stimulus	Response
1	7.900140 GHz	-70.338 dBm	12	8.010130 GHz	-63.552 dBm
2	7.909990 GHz	-68.722 dBm	13	8.019970 GHz	-62.966 dBm
3	7.920120 GHz	-67.805 dBm	14	8.030100 GHz	-63.012 dBm
4	7.929960 GHz	-66.737 dBm	15	8.039940 GHz	-62.643 dBm
5	7.940090 GHz	-66.418 dBm	16	8.050070 GHz	-62.519 dBm
6	7.949930 GHz	-65.750 dBm	17	8.059910 GHz	-62.504 dBm
7	7.960060 GHz	-65.051 dBm	18	8.070040 GHz	-62.443 dBm
8	7.969900 GHz	-64.546 dBm	19	8.079880 GHz	-61.959 dBm
9	7.980030 GHz	-64.337 dBm	20	8.090010 GHz	-62.148 dBm
10	7.989870 GHz	-63.902 dBm	21	8.099860 GHz	-62.298 dBm

Date: 5.DEC.2016 12:31:15

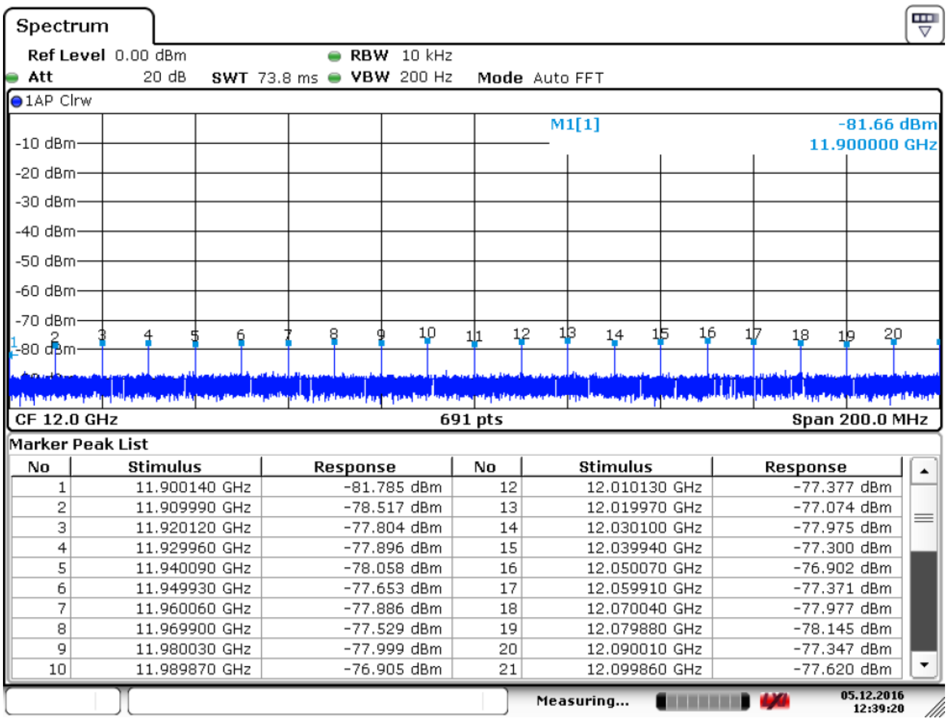
Figure 3-28: Comb generator output with +10dBm 10MHz input @8GHz



No	Stimulus	Response	No	Stimulus	Response
1	9.900140 GHz	-72.023 dBm	12	10.010130 GHz	-72.263 dBm
2	9.909990 GHz	-71.279 dBm	13	10.019970 GHz	-72.434 dBm
3	9.920120 GHz	-71.569 dBm	14	10.030100 GHz	-72.788 dBm
4	9.929960 GHz	-71.614 dBm	15	10.039940 GHz	-72.065 dBm
5	9.940090 GHz	-71.911 dBm	16	10.050070 GHz	-72.635 dBm
6	9.949930 GHz	-71.940 dBm	17	10.059910 GHz	-73.296 dBm
7	9.960060 GHz	-72.674 dBm	18	10.070040 GHz	-73.584 dBm
8	9.969900 GHz	-72.520 dBm	19	10.079880 GHz	-73.438 dBm
9	9.980030 GHz	-72.348 dBm	20	10.090010 GHz	-73.508 dBm
10	9.989870 GHz	-72.826 dBm	21	10.099860 GHz	-73.957 dBm

Date: 5.DEC.2016 12:33:02

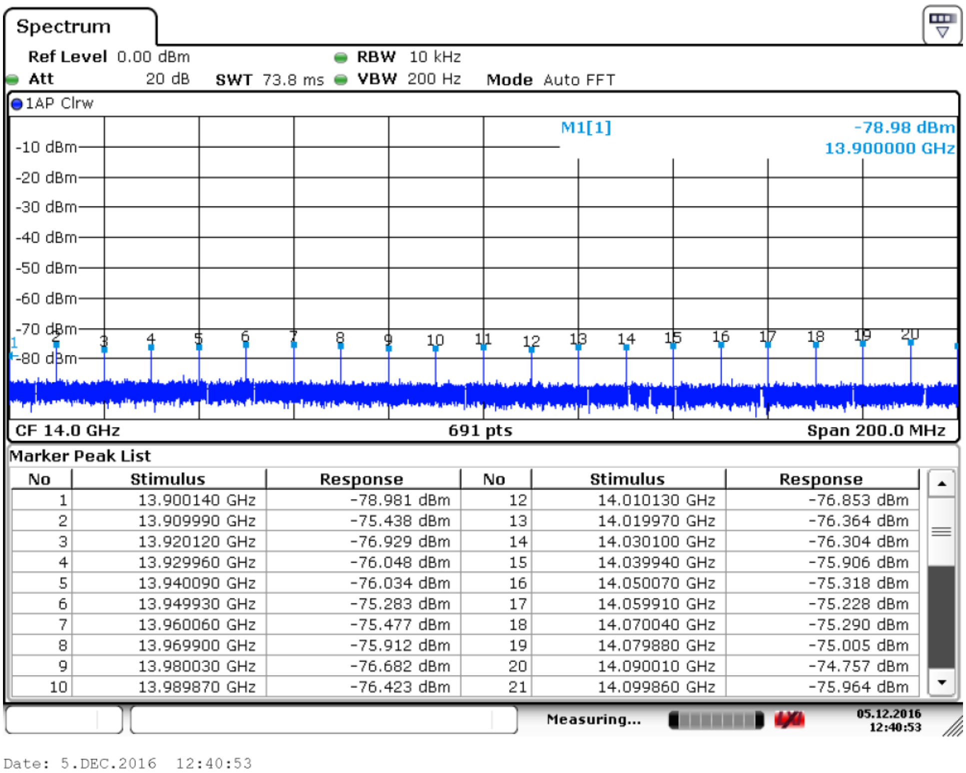
Figure 3-29: Comb generator output with +10dBm 10MHz input @10GHz



No	Stimulus	Response	No	Stimulus	Response
1	11.900140 GHz	-81.785 dBm	12	12.010130 GHz	-77.377 dBm
2	11.909990 GHz	-78.517 dBm	13	12.019970 GHz	-77.074 dBm
3	11.920120 GHz	-77.804 dBm	14	12.030100 GHz	-77.975 dBm
4	11.929960 GHz	-77.896 dBm	15	12.039940 GHz	-77.300 dBm
5	11.940090 GHz	-78.058 dBm	16	12.050070 GHz	-76.902 dBm
6	11.949930 GHz	-77.653 dBm	17	12.059910 GHz	-77.371 dBm
7	11.960060 GHz	-77.886 dBm	18	12.070040 GHz	-77.977 dBm
8	11.969900 GHz	-77.529 dBm	19	12.079880 GHz	-78.145 dBm
9	11.980030 GHz	-77.999 dBm	20	12.090010 GHz	-77.347 dBm
10	11.989870 GHz	-76.905 dBm	21	12.099860 GHz	-77.620 dBm

Date: 5.DEC.2016 12:39:20

Figure 3-30: Comb generator output with +10dBm 10MHz input @12GHz

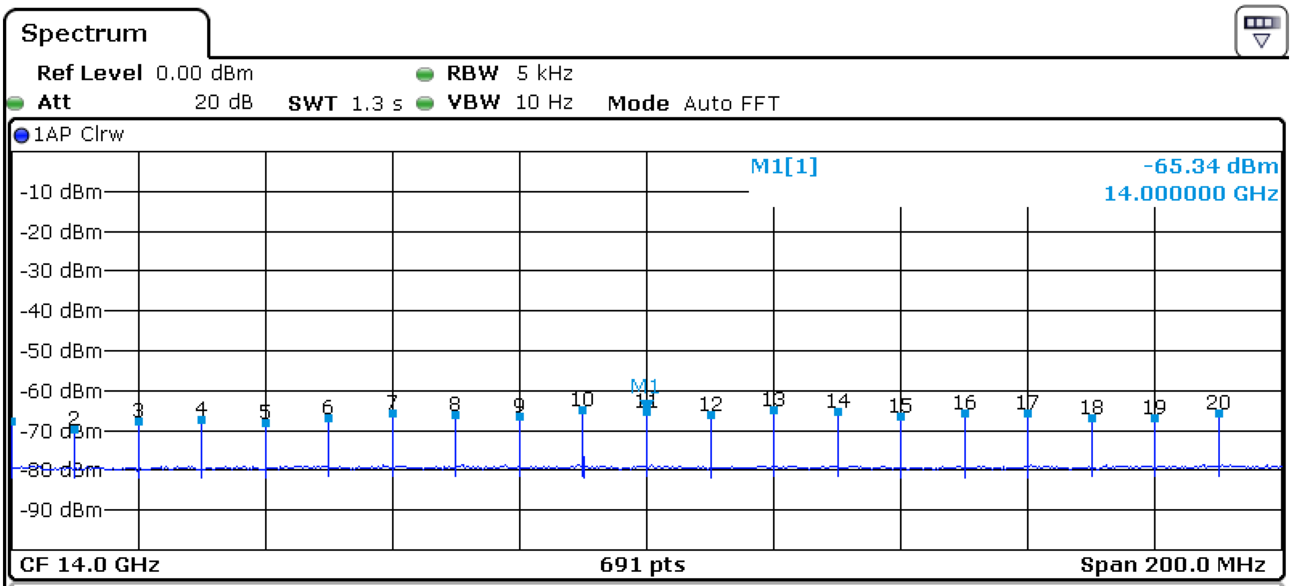


No	Stimulus	Response	No	Stimulus	Response
1	13.900140 GHz	-78.981 dBm	12	14.010130 GHz	-76.853 dBm
2	13.909990 GHz	-75.438 dBm	13	14.019970 GHz	-76.364 dBm
3	13.920120 GHz	-76.929 dBm	14	14.030100 GHz	-76.304 dBm
4	13.929960 GHz	-76.048 dBm	15	14.039940 GHz	-75.906 dBm
5	13.940090 GHz	-76.034 dBm	16	14.050070 GHz	-75.318 dBm
6	13.949930 GHz	-75.283 dBm	17	14.059910 GHz	-75.228 dBm
7	13.960060 GHz	-75.477 dBm	18	14.070040 GHz	-75.290 dBm
8	13.969900 GHz	-75.912 dBm	19	14.079880 GHz	-75.005 dBm
9	13.980030 GHz	-76.682 dBm	20	14.090010 GHz	-74.757 dBm
10	13.989870 GHz	-76.423 dBm	21	14.099860 GHz	-75.964 dBm

Figure 3-31: Comb generator output with +10dBm 10MHz input @14GHz

The minimum output level of the picket is higher than -80dBm up to 14GHz with +10dBm input power.

In order to validate the phase calibration signal injection, the output of the receiver has been measured with the comb generator on (+10dBm input power) and with the variable attenuator set to the minimum attenuation. The measurement has been done at 14GHz where the amplitude of the picket are the lowest:



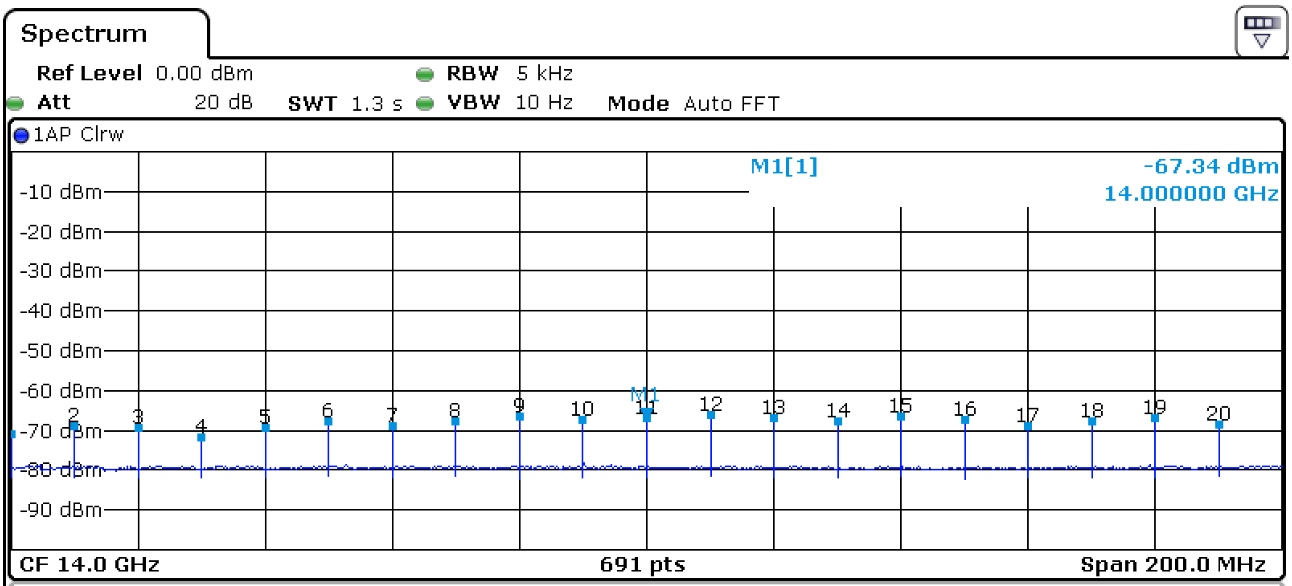
Marker Peak List

No	Stimulus	Response	No	Stimulus	Response
1	13.900140 GHz	-67.821 dBm	11	14.000000 GHz	-65.335 dBm
2	13.909990 GHz	-69.613 dBm	12	14.010130 GHz	-66.038 dBm
3	13.920120 GHz	-67.617 dBm	13	14.019970 GHz	-65.090 dBm
4	13.929960 GHz	-67.157 dBm	14	14.030100 GHz	-65.163 dBm
5	13.940090 GHz	-68.328 dBm	15	14.039940 GHz	-66.461 dBm
6	13.949930 GHz	-67.069 dBm	16	14.050070 GHz	-65.921 dBm
7	13.960060 GHz	-65.625 dBm	17	14.059910 GHz	-65.632 dBm
8	13.969900 GHz	-66.156 dBm	18	14.070040 GHz	-67.045 dBm
9	13.980030 GHz	-66.480 dBm	19	14.079880 GHz	-66.794 dBm
10	13.989870 GHz	-64.978 dBm	20	14.090010 GHz	-65.667 dBm

Measuring... 29.11.2016 19:03:40

Date: 29.NOV.2016 19:03:39

Figure 3-32: Port X output @14GHz when comb generator on with +10dBm input power



Marker Peak List

No	Stimulus	Response	No	Stimulus	Response
1	13.900140 GHz	-71.005 dBm	11	14.000000 GHz	-67.087 dBm
2	13.909990 GHz	-69.051 dBm	12	14.010130 GHz	-66.174 dBm
3	13.920120 GHz	-69.388 dBm	13	14.019970 GHz	-66.766 dBm
4	13.929960 GHz	-71.588 dBm	14	14.030100 GHz	-67.759 dBm
5	13.940090 GHz	-69.313 dBm	15	14.039940 GHz	-66.682 dBm
6	13.949930 GHz	-67.942 dBm	16	14.050070 GHz	-67.368 dBm
7	13.960060 GHz	-69.013 dBm	17	14.059910 GHz	-68.966 dBm
8	13.969900 GHz	-67.772 dBm	18	14.070040 GHz	-67.654 dBm
9	13.980030 GHz	-66.706 dBm	19	14.079880 GHz	-67.063 dBm
10	13.989870 GHz	-67.289 dBm	20	14.090010 GHz	-68.542 dBm

Measuring... 29.11.2016 19:07:13

Date: 29.NOV.2016 19:07:12

Figure 3-33: Port Y output @14GHz when comb generator on with +10dBm input power

The maximum picket level at 14GHz available at the output of the receiver is around -71.5dBm.

The phase calibration circuit is operational.

LIST OF ABBREVIATIONS

Acronym	Meaning
A	Ampere
AD	Applicable Document
AIL	Action Item List
DC	Direct Current
DR	Design Review
FAT	Factory Acceptance Tests
h	Hour
ICD	Interface Control Document
IR	Infra-Red
IRF	Infra-Red Filter
K	Kelvin
LAN	Local Area Network
LNA	Low Noise Amplifier
mA	MilliAmpere
mbar	Millibar
min	Minute
MTBF	Mean Time Between Failure
mV	MilliVolt
NT	Noise Temperature
OSAT	On-Site Acceptance Tests
PC	Personal Computer
pre-FAT	preliminary Factory Acceptance Tests
s	Second
sec.	Second
SoW	Statement of Work
TBC	To Be Confirmed
TBD	To Be Defined
V	Volt
W	Watt
WO	Work Order
WP	Work Package
Ω	Ohm