Wideband Compact Cryogenic receiver QRFH SN02 FAT

REPORT

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1. INTRODUCTION

1.1 Purpose & Summary

Tests have been conducted on the Wideband Compact Cryogenic Receiver QRFH SN02 in Callisto laboratory and outside for the noise temperature according to the procedures described in test plan 1.2.1.

The tests included RF testing and cryogenic testing.

The tests have been performed from 08.Mar.2017 to 12.Mar.2017. Thermal and RF tests have been performed both indoor and outdoor. The FAT results are successful, within the specification.

The receiver operation and performance are validated.

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

AD1 Callisto Proposal , Ref. PRP/685/3606 issue 1.0 dated 11th April 2016

AD2 User Manual, QRFH Compact Wideband Cryogenic Receiver, DOC/1704/3991

AD3 Test Plan Procedure QRFH Compact Receiver, TST/1704/3990, Issue 1.0

AD4 Interface Control Document, ICD/1704/3992, issue 1.0

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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		92% of the meas <40K		P	TLNA=77K
Port Y		96% of the meas <40K		P	TLNA=77K
Gain	>55dB		AT		
Port X		58dBmin		P	Gain extracted from NT meas
Port Y		56dBmin		P	
Gain Flatness	10dBpp		AT		
Port X		~5dBpp		P	Worst case, gain extracted from NT meas. Approximated value due to RFI perturbation.
Port Y		~7dBpp		P	
Output Return Loss	10dBmin		AT		
Port X		13.6dBmin		P	14dB typical
Port Y		12.3dBmin		P	14dB typical
Pout 1dB	+20dBm		CT; D		

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Port X		+20dBm		P	
Port Y		+20dBm		P	
Gain via test input			AT		No specification defined for this parameter
Port X		20.4dB<G<44.1dB			
Port Y		19.3dB<G<43.9 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 (see Table 3-3)
Phase calibration	None		AT	P	The minimum picket level at 14GHz available at the output of the receiver is around -52dBm (see Figure 3-26 and Figure 3-29).
Cold Head Base Temperature	80K	75K	AT	P	
Cooldown Time to base temperature	not specified	1h36	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	

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10MHz Phase Calibration Input	SMA	Ok	I	P	
Dimensions (mm)	l=612mm * Phi=311mm		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 – 20m between 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

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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: 09/02/17				
	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	0h25	-	
	""	295K to Base temperature	1h36	-	
	on LNA	295K to <100K	0h39	-	
	""	295K to Base temperature	8hrs	-	
	on feed base plate	295K to <150K	5h50	-	
	""	295K to Base temperature	15hrs	-	
	Base Temperatures	**Tset = 75K**			
	Cold head	~75K±0.5K	75K	P	@10hours in cooldown
	LNA	<85K	77K	P	@10hours in cooldown
	Feed [base]	<130K	134K	M	@10hours in cooldown
	Feed [top]	<150K	144K	P	@10hours in cooldown
	Cooler Input Power		70W		
	Compressor Temperature	<70°C	24°C	P	

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Ref	Parameter / Requirement	Spec	Result	R	Comments
	Ambient(Room) Temperature		18°C		
	Warmup time (no heaters)	100K to 295K No spec.	25Hrs		

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

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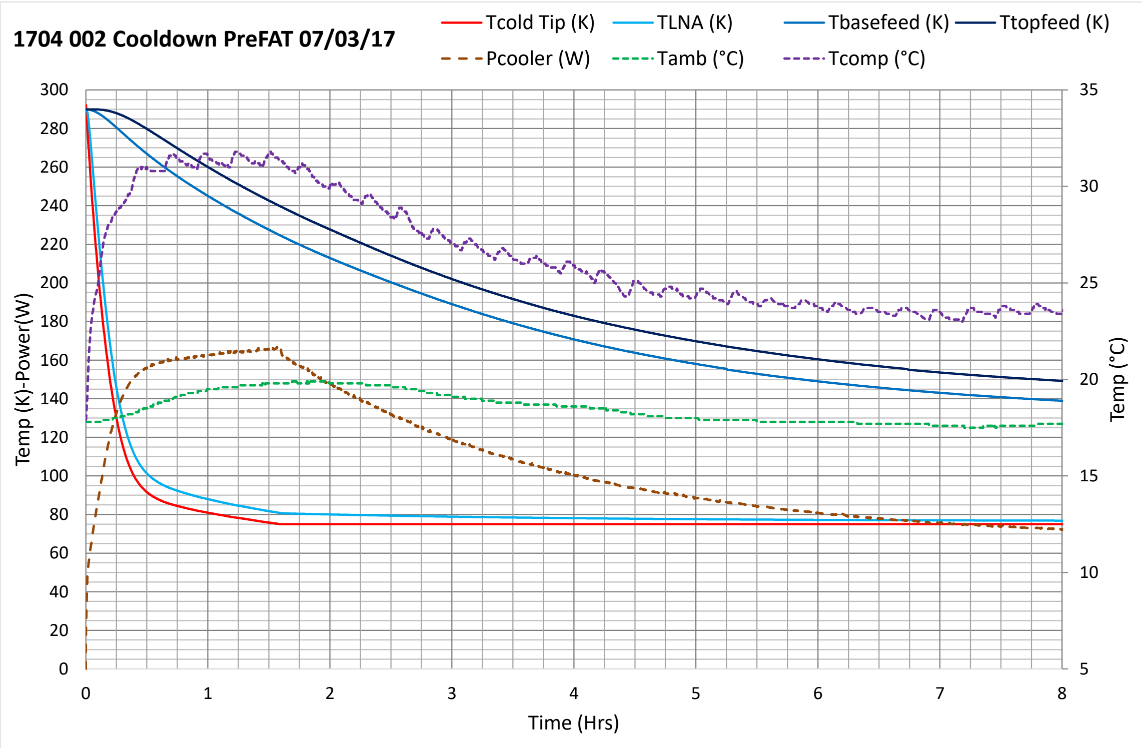

Figure 3-1 : Cooldown

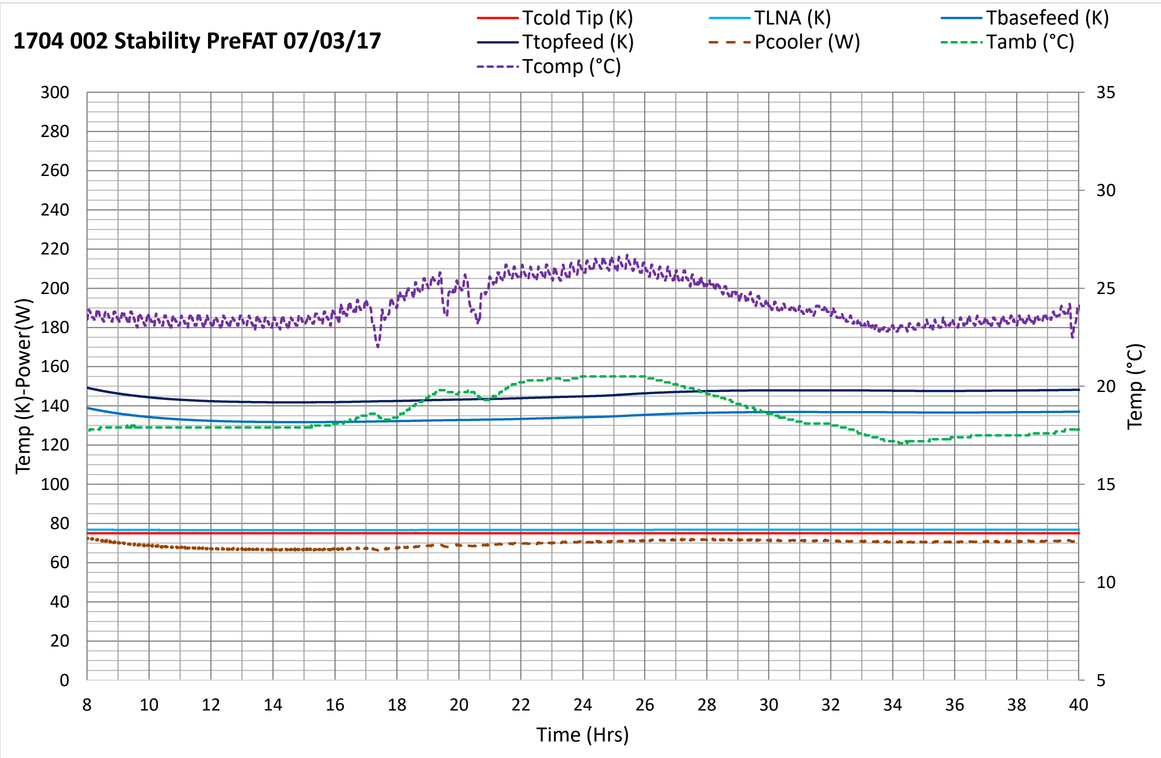

Figure 3-2: Stabilization – Base Temperature

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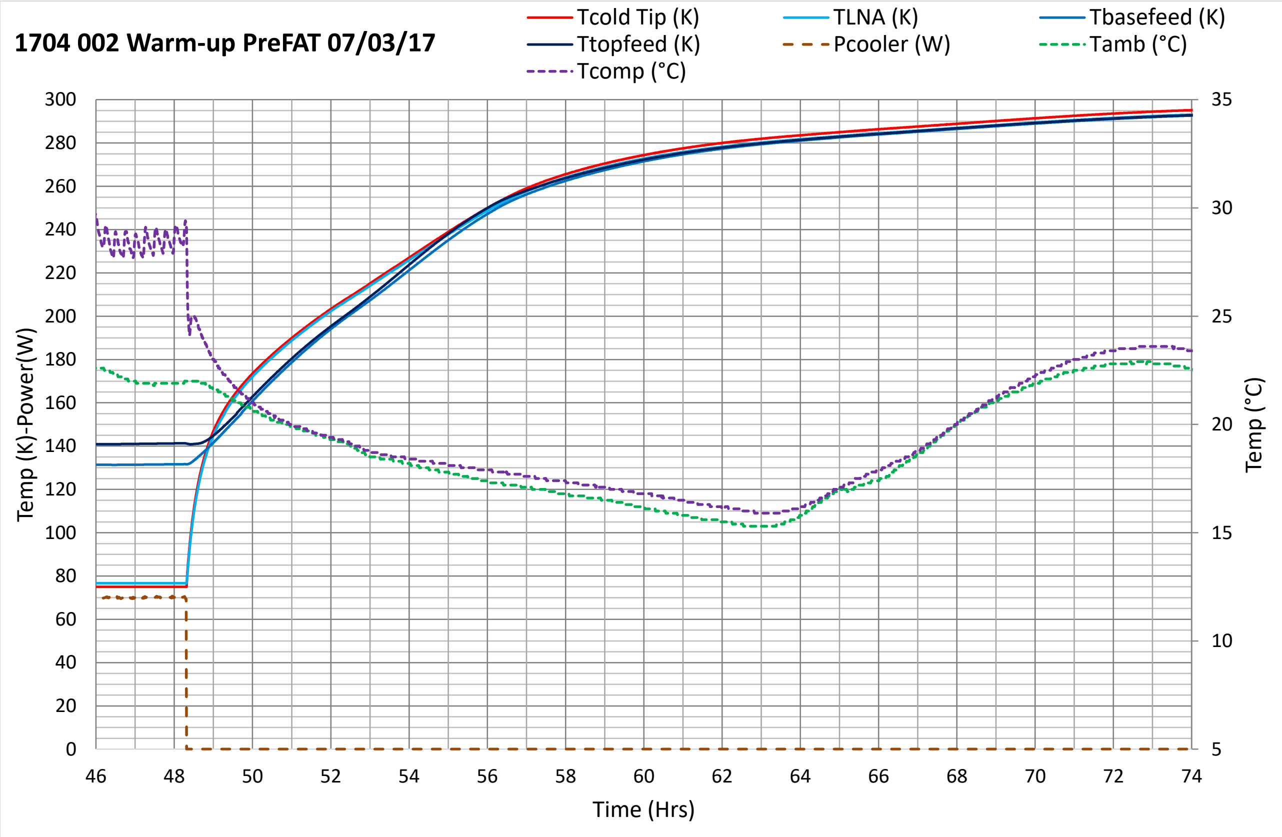

Figure 3-3: Warm-up

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3.2 RF Tests

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

Ref	Parameter / Requirement	Spec	Result			R	Comments
	Cryogenic Temperature	---					**TcryoLNA = 72K**
	Frequency Band	2 – 14 GHz	2-14GHz				
	Noise Temperature	Max<40K		Port X	Port Y	P	The measurement has been done with the following physical temperatures of the (Tcoldtip=75K; TLNA=76.4K; Tbase feed=125.3K and Ttopfeed=136.1K). NT measurement is degraded by the RFI observed at low frequency. (See NT graph Figure 3-16) Port X: 92% of the NT measurement is in specification from 3GHz up to 14GHz. Port Y: 96% of the NT measurement is in specification from 3GHz up to 14GHz.
			Min Meas	26.3K	22.5K		
			Max Meas	53.9K	48.1K		
			Mean Meas	34.2K	29.6K		
			Min Trend	30K	25K		
			Max trend	45K	42K		
	Gain	>55dB	Port X	Port Y		P	Gain extracted from NT meas
			58dBmin	56dBmin			
	Gain Flatness	10dBpp	~5dBpp	~7dBpp		P	Worst case gain extracted from NT meas
	Output Return Loss	>10dB	13.6dB min	12.3dB min		P	14dB typical
	Pout 1dB	+20dBm	+20dBm			P	By design
	Gain via test input (Port X)	-	20.4dB<Gain<44.1dB				
	Gain via test input (Port Y)	-	19.3dB<Gain<43.9 dB				

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Ref	Parameter / Requirement	Spec	Result	R	Comments
	Gain via test input stability (Port X)	-	@2GHz / 60min: 0.05dBpp @8GHz / 60min: 0.05dBpp @14GHz / 60min: 0.03dBpp @2GHz / 60sec: 0.03dBpp @8GHz / 60sec: 0.03dBpp @14GHz / 60sec: 0.02dBpp		Two measurement session have been performed, one with the VNA calibrated between 1GHz and 9GHz and the second session with the VNA calibrated from 13.5GHz up to 14.5GHz.
	Gain via test input stability (Port Y)	-	@2GHz / 60min: 0.04dBpp @8GHz / 60min: 0.08dBpp @14GHz / 60min: 0.02dBpp @2GHz / 60sec: 0.04dBpp @8GHz / 60sec: 0.03dBpp @14GHz / 60sec: 0.02dBpp		Two measurement session have been performed, one with the VNA calibrated between 1GHz and 9GHz and the second session with the VNA calibrated from 13.5GHz up to 14.5GHz.

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

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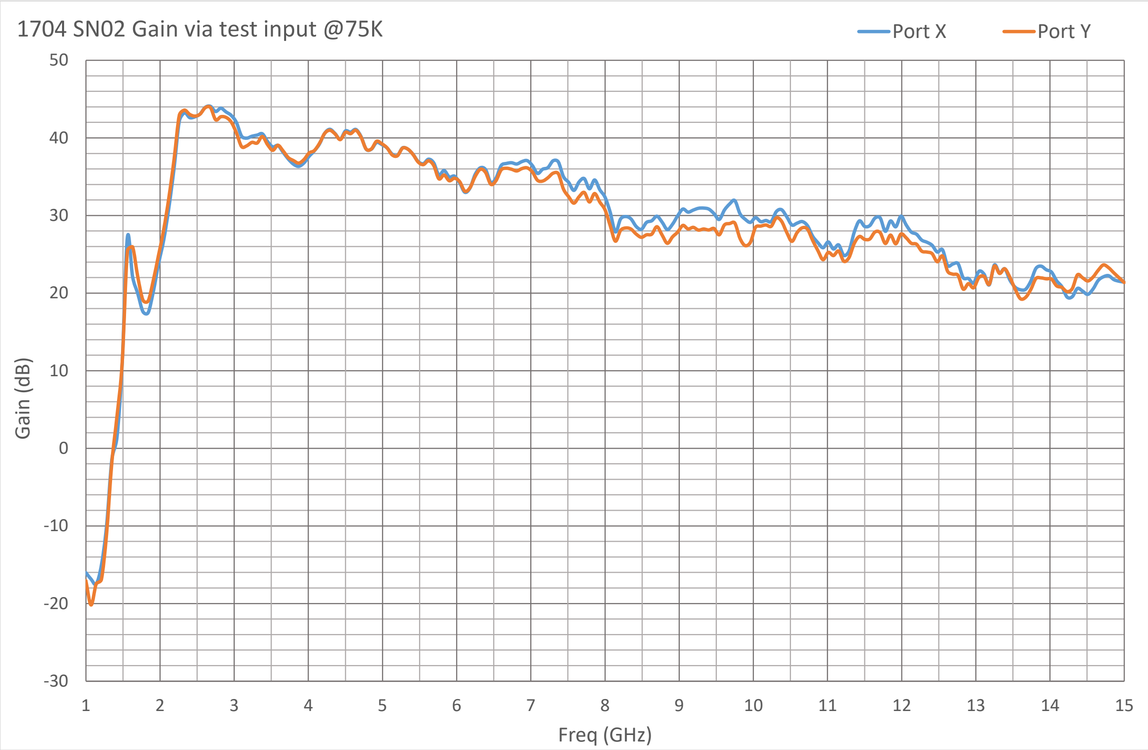

Figure 3-4: Gain via test input for TLNA=76.6K

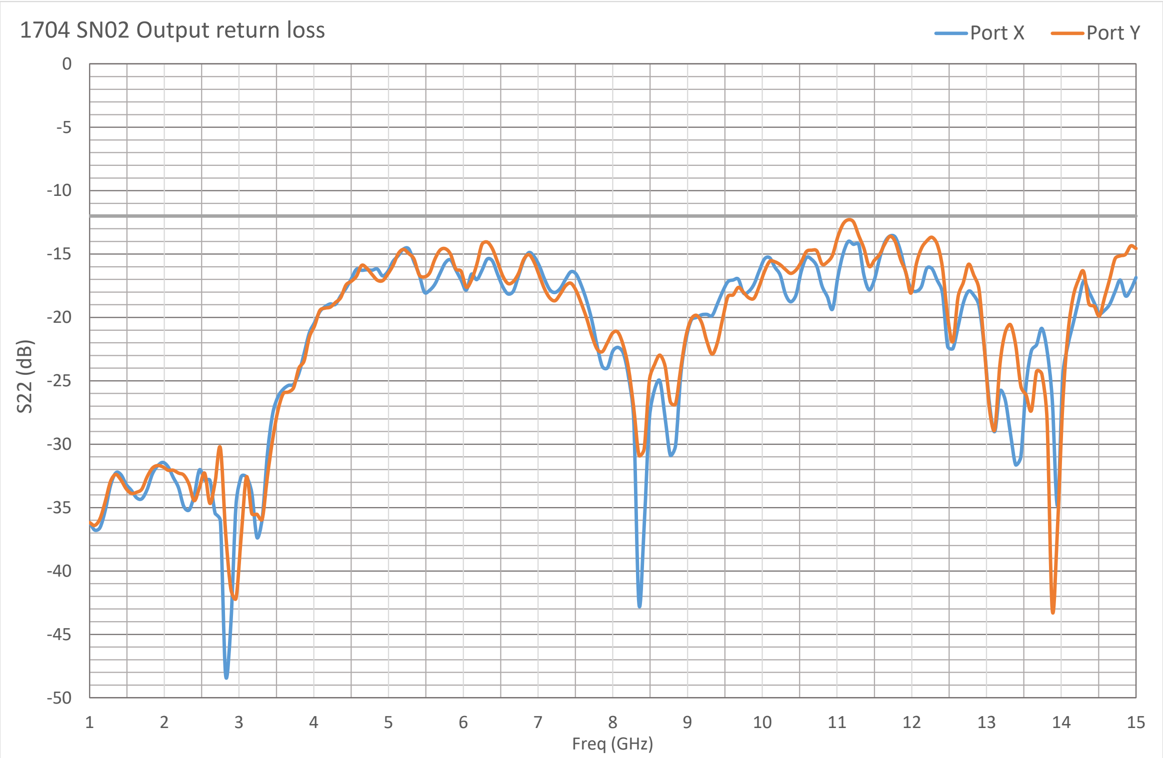

Figure 3-5: Output Return Loss

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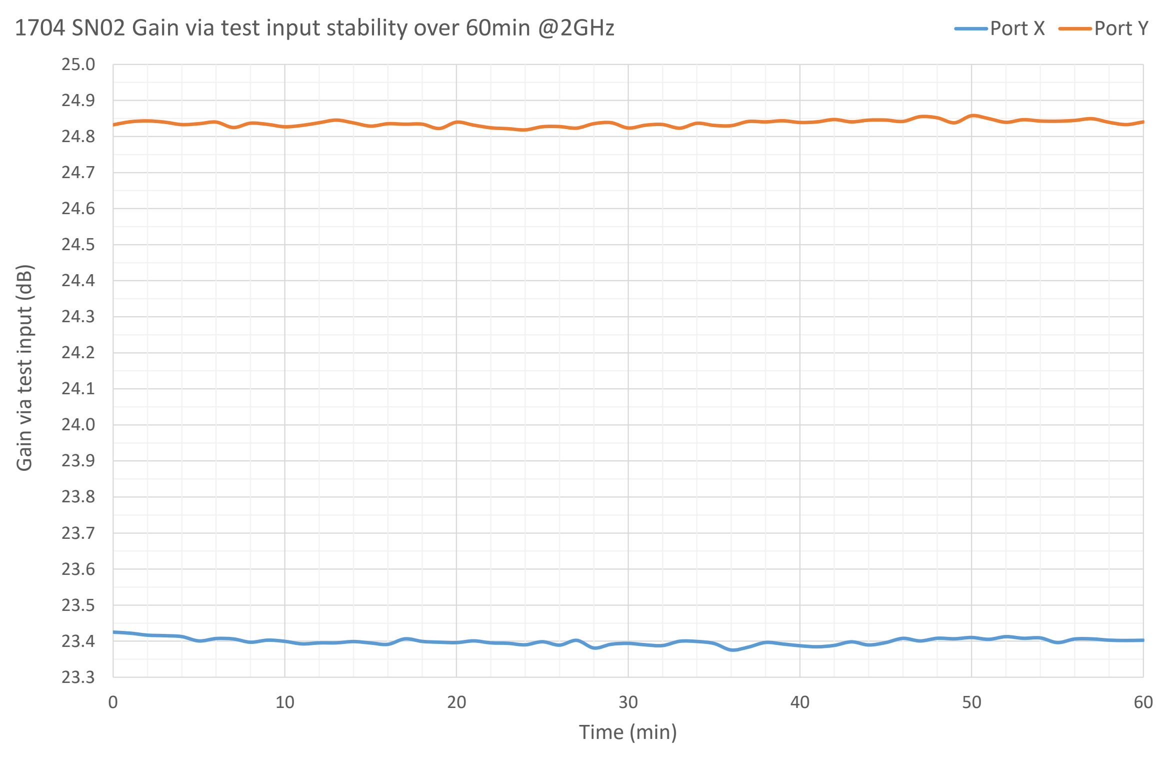

Figure 3-6: Gain via test input stability over 60min (1 sample per min) @2GHz

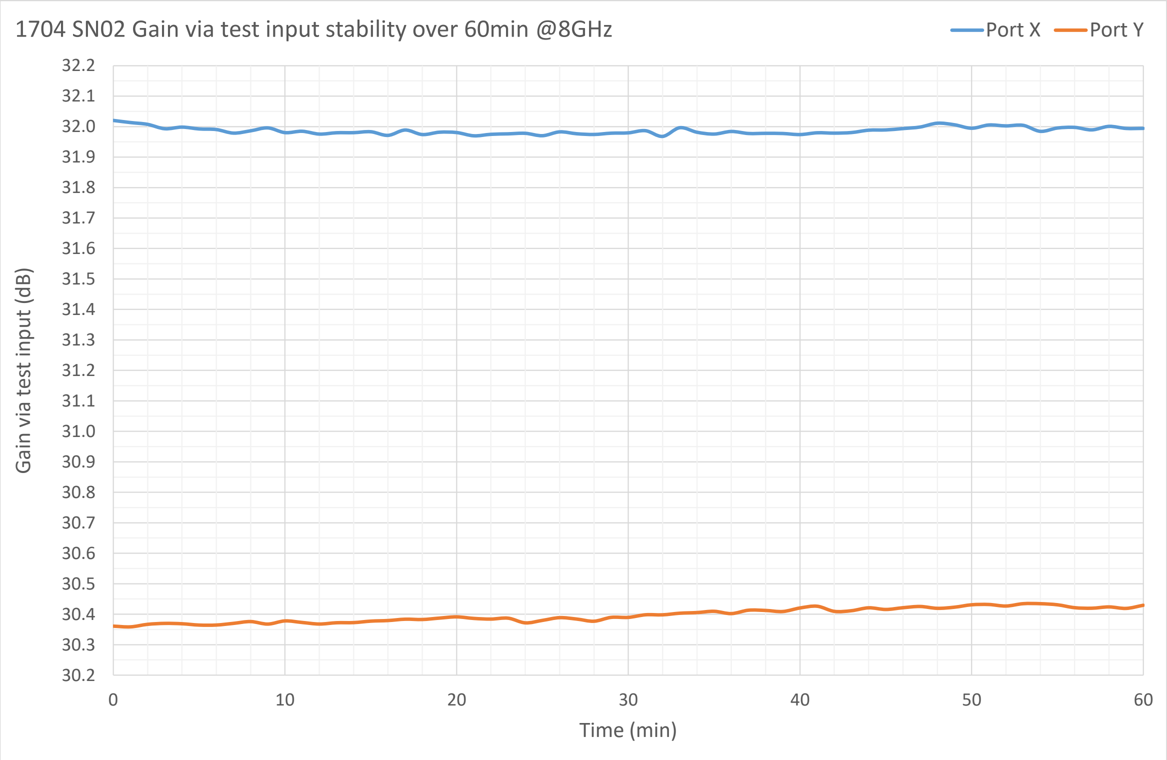

Figure 3-7: Gain via test input stability over 60min (1 sample per min) @8GHz

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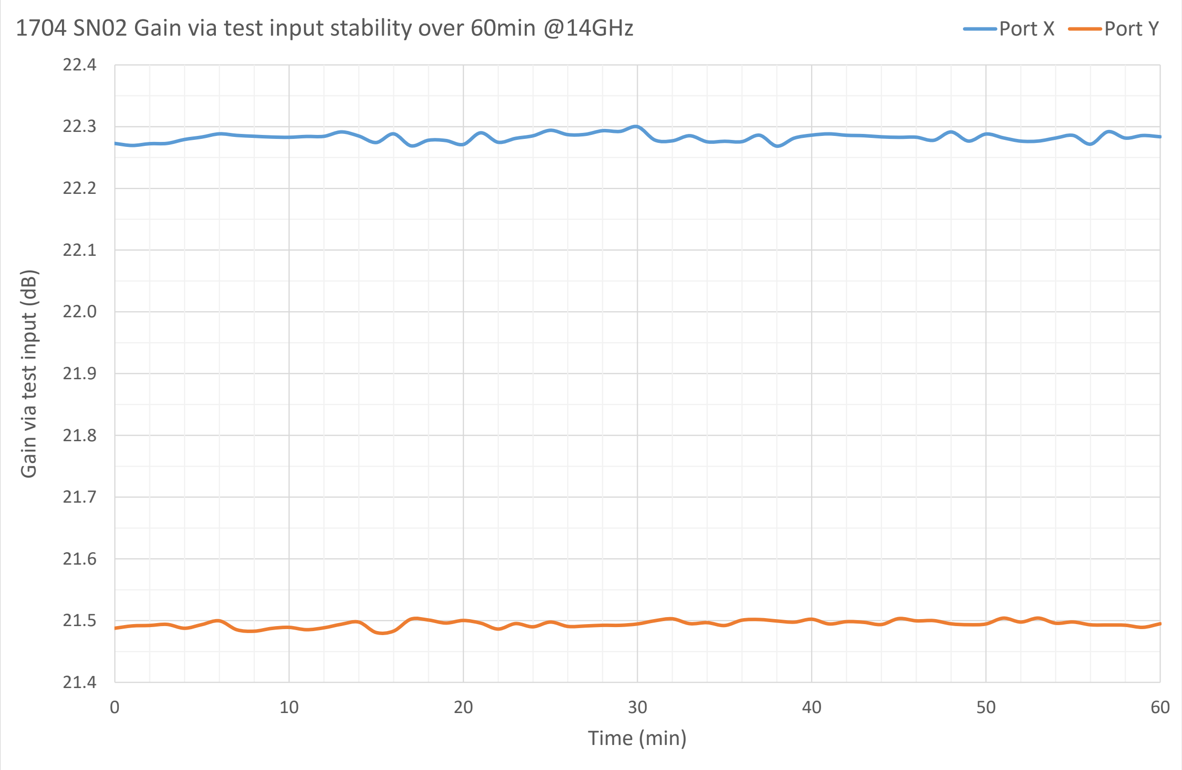

Figure 3-8: Gain via test input stability over 60min (1 sample per min) @14GHz

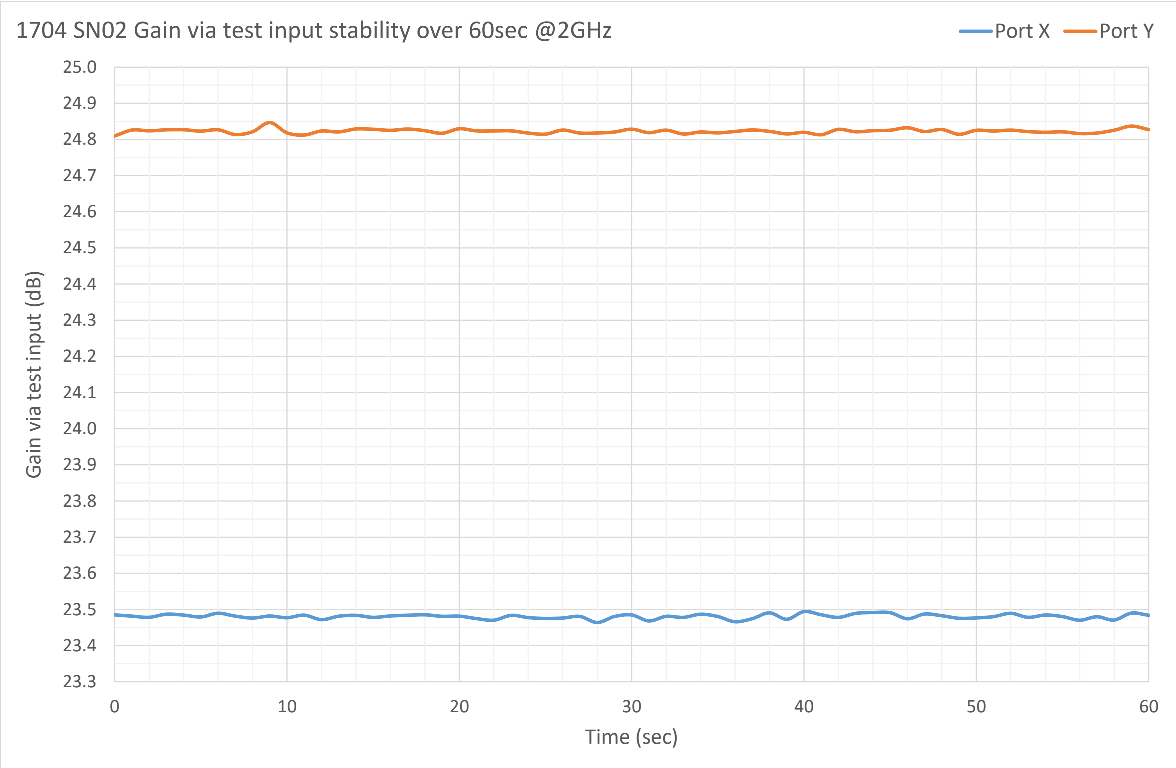

Figure 3-9: Gain via test input stability over 60sec (1 sample per sec) @2GHz

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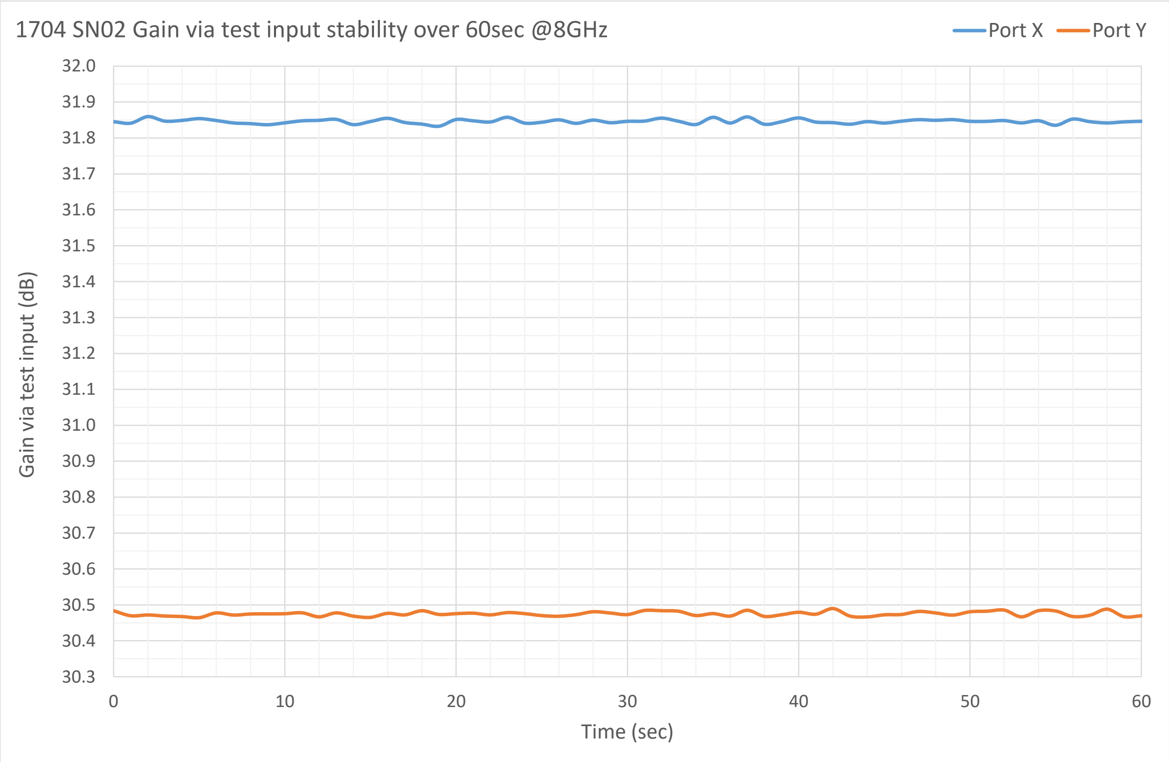

Figure 3-10: Gain via test input stability over 60sec (1 sample per sec) @8GHz

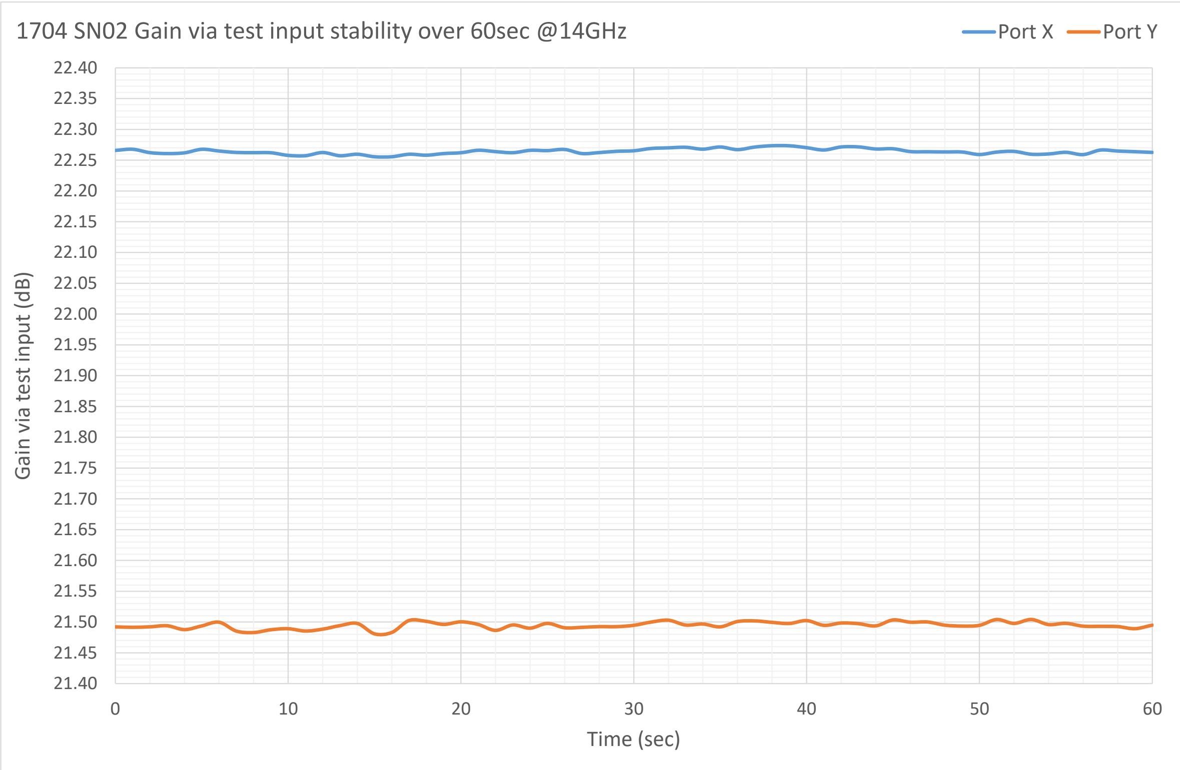

Figure 3-11: Gain via test input stability over 60sec (1 sample per sec) @14GHz

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

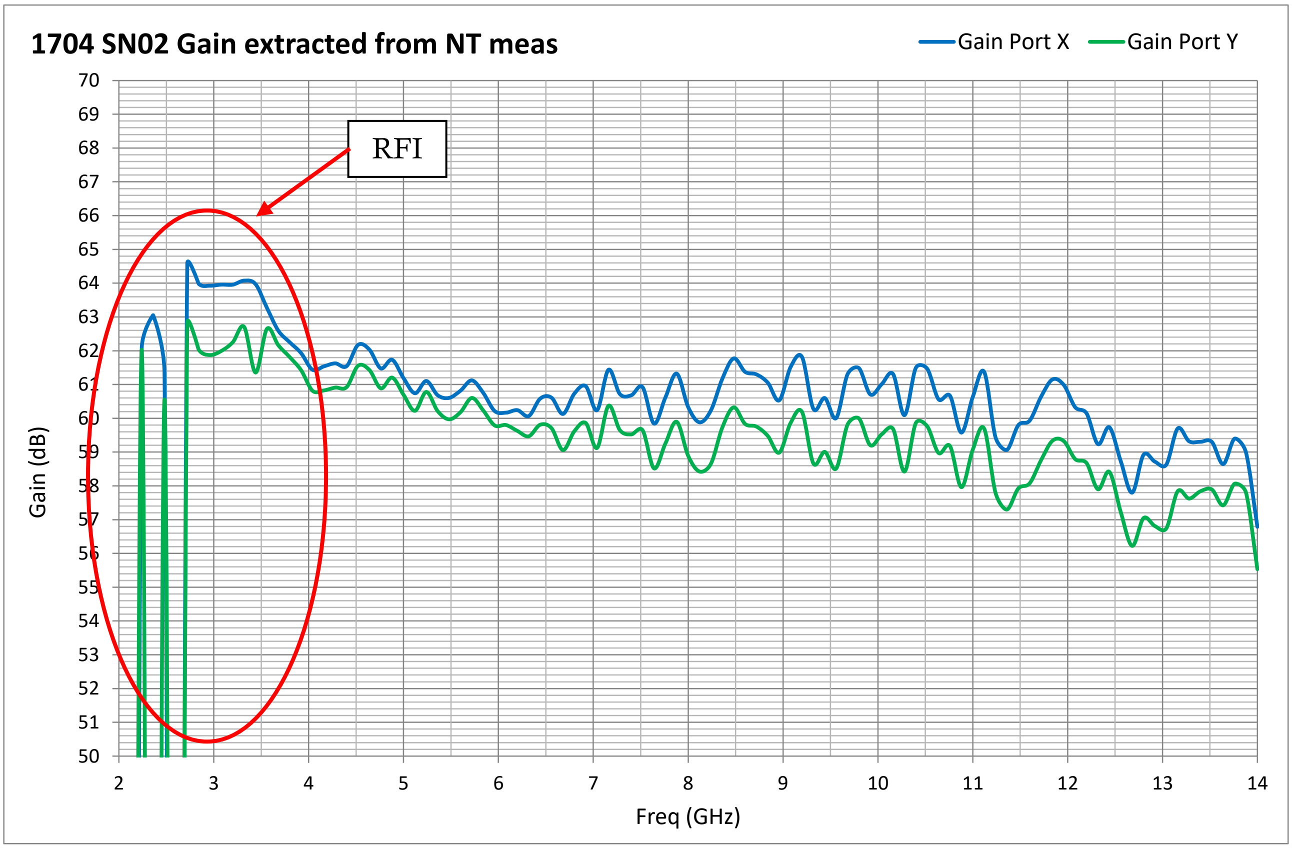

Figure 3-12: Gain extracted from NT measurement.

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

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3.2.1 Noise temperature measurement

Due to the increase of mobile phone antenna installations nearby Callisto's premises it is becoming more and more difficult to make clean and valuable noise temperature measurements on the QRFH receiver. Indeed, the increase of RFI measured in the Callisto laboratory is problematic for this type of measurement:

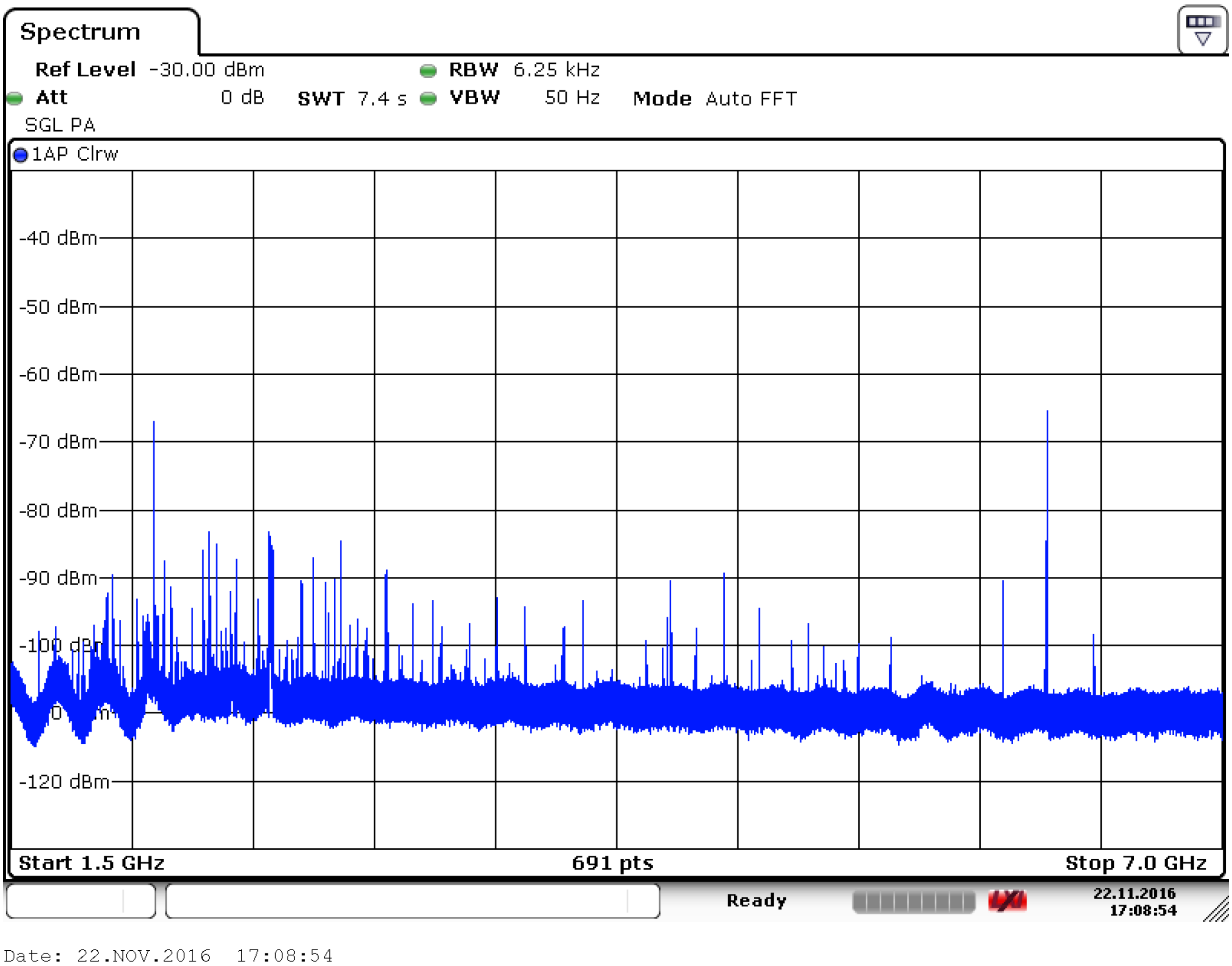

Figure 3-13: RFI survey in the Callisto laboratory, output of an amplifier, at low frequency the RFI are mixed by the amplifier.

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 in the countryside:

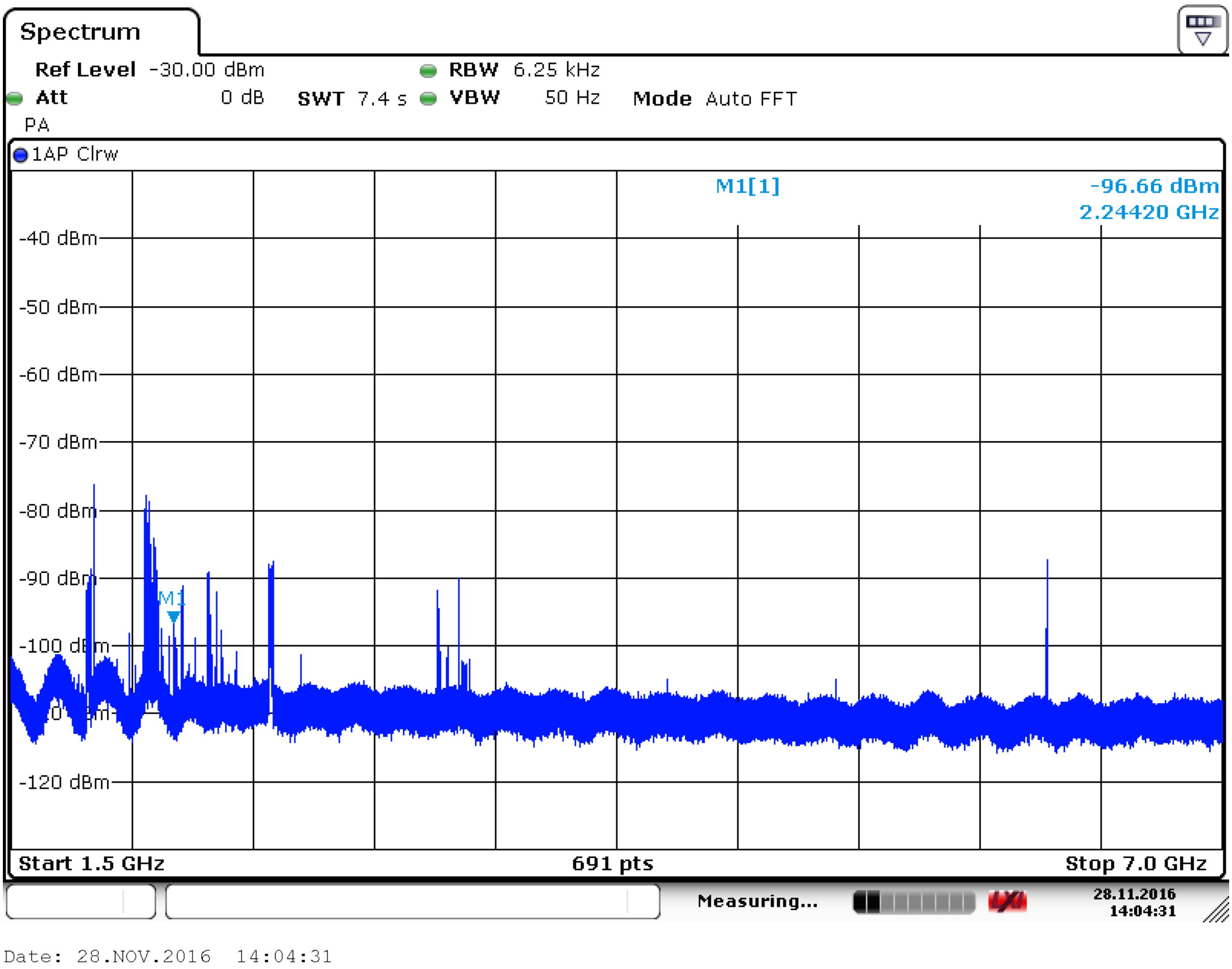

Figure 3-14: RFI survey of the NT measurement location.

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

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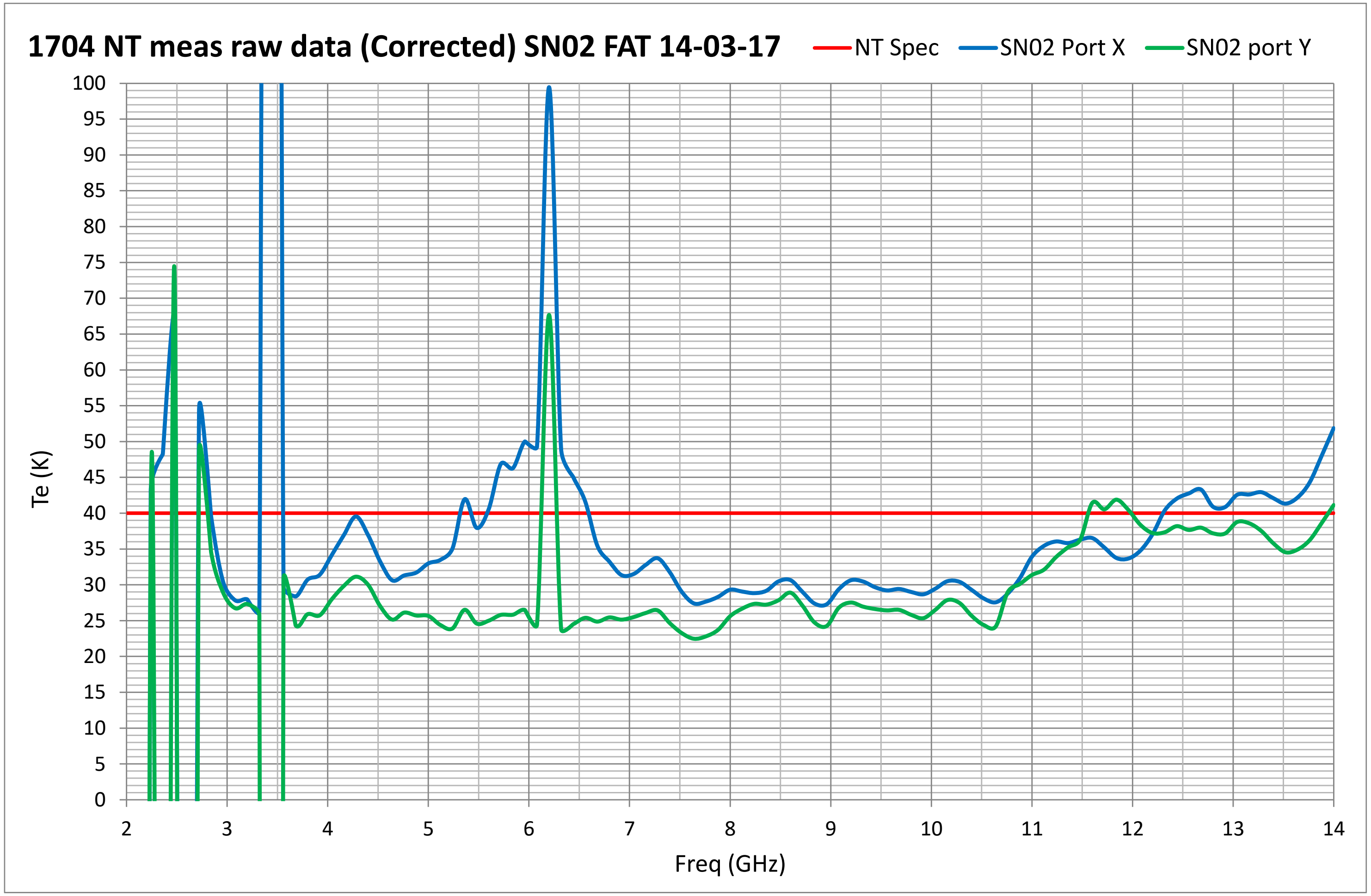

Figure 3-16: NT Measurement raw data for TLNA=77K

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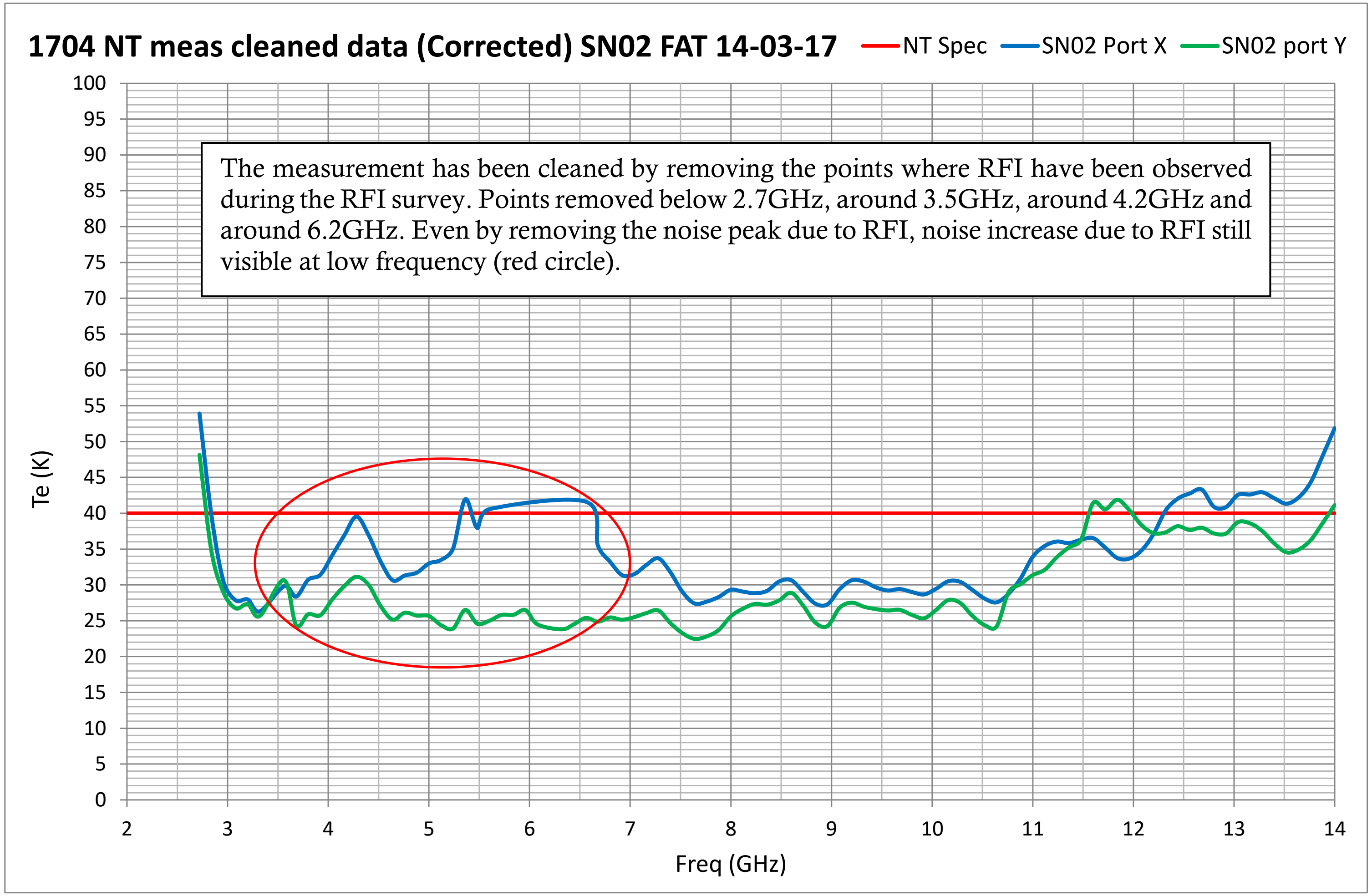

Figure 3-17: NT Measurement cleaned data for TLNA=77K

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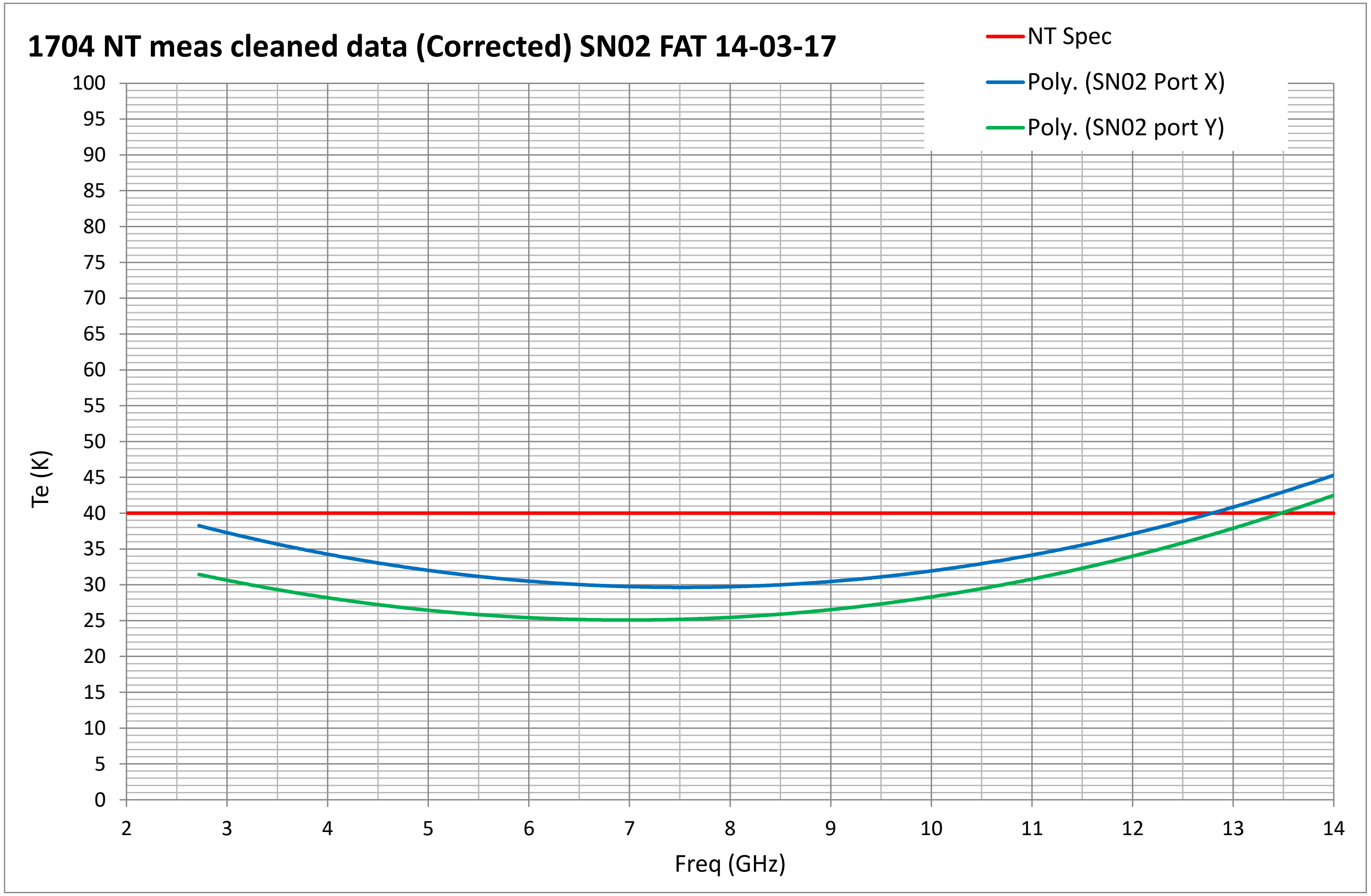

Figure 3-18: NT Measurement cleaned data trend for TLNA=77K

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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.

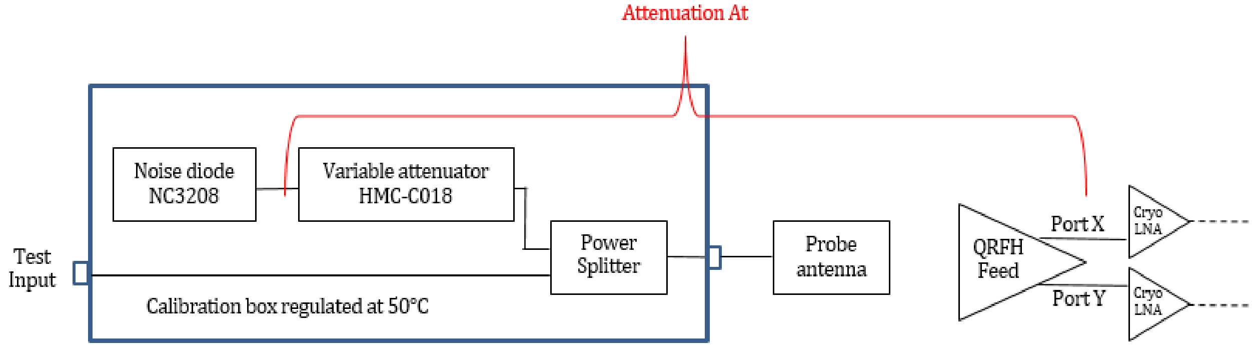

Figure 3-19: Noise calibration circuit

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 theoretical variable attenuator settings to generate Tn1 and Tn2:

1704 QRFH SN02 Attenuator Settings for Noise Calibration Port X (ND AE848)

Freq (GHz)	ND ENR (dB) @50°C	Td ND @50°C (K)	At1 calculated for Tn1=10K (dB)	Theoretical Att1 to set on the attenuator (dB)	At2 calculated for Tn2=0.5K (dB)	Theoretical Att2 to set on the attenuator (dB)
2	32.14	474966.79	46.77	10.0	59.78	23
3	31.95	454647.81	46.58	21.0	59.59	31.5
4	31.80	439222.76	46.43	14.0	59.44	27.5
5	31.64	423346.14	46.27	18.0	59.28	31
6	31.43	403376.26	46.06	14.5	59.07	27.5
7	31.15	378208.37	45.78	15.5	58.79	27.5
8	30.86	353796.98	45.49	13.0	58.50	25.5
9	30.80	348946.69	45.43	8.0	58.44	20.5
10	30.86	353796.98	45.49	7.5	58.50	20
11	30.84	352172.77	45.47	6.0	58.48	19
12	31.02	367063.54	45.65	4.0	58.66	17.5
13	31.36	396931.36	45.99	1.5	59.00	14.5
14	31.52	411816.68	46.15	0.0	59.16	12.5

1704 QRFH SN02 Attenuator Settings for Noise Calibration Port Y (ND AE848)

Freq (GHz)	ND ENR (dB) @50°C	Td ND @50°C (K)	At1 calculated for Tn1=10K (dB)	Theoretical Att1 to set on the attenuator (dB)	At2 calculated for Tn2=0.5K (dB)	Theoretical Att2 to set on the attenuator (dB)
2	32.14	474966.79	46.77	10.0	59.78	23
3	31.95	454647.81	46.58	21.0	59.59	31.5
4	31.80	439222.76	46.43	14.0	59.44	27.5
5	31.64	423346.14	46.27	18.0	59.28	31
6	31.43	403376.26	46.06	14.5	59.07	27.5
7	31.15	378208.37	45.78	15.5	58.79	27.5
8	30.86	353796.98	45.49	13.0	58.50	25.5
9	30.80	348946.69	45.43	8.0	58.44	20.5
10	30.86	353796.98	45.49	7.5	58.50	20
11	30.84	352172.77	45.47	6.0	58.48	19
12	31.02	367063.54	45.65	4.0	58.66	17.5
13	31.36	396931.36	45.99	1.5	59.00	14.5
14	31.52	411816.68	46.15	0.0	59.16	12.5

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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.
- Theoretical Att1 to set on the attenuator (dB): Attenuation to 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.

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

It is recommended to do the calibration of the noise circuit in a place clean of RFI. The idea is to perform a NT measurement with the sky and use this measurement as a reference then do a noise temperature measurement with the noise diode to find the variable attenuator setting in order to match the reference NT meas.

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 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 @9GHz	-52.64	-51.39	1.25	1.333521432	30.0
Port Y @9GHz	-54.5	-53.02	1.48	1.406047524	24.6

Table 3-3: Noise diode NT measurement results

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 (see Figure 3-17).

The noise calibration circuit is operational.

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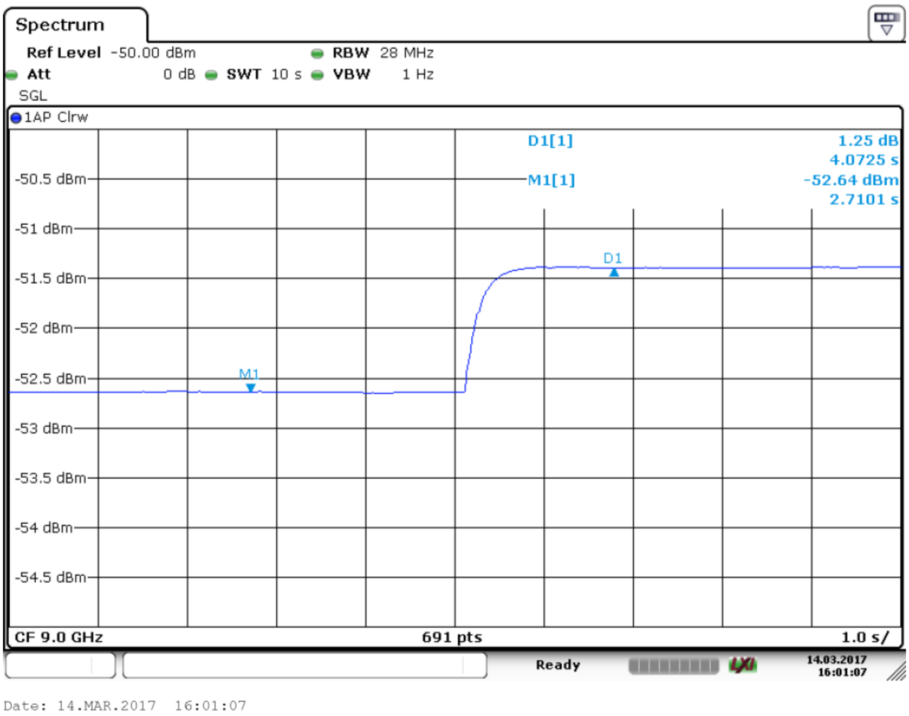

Figure 3-20: Y-factor measured with the noise diode On (Tn=10K) and off @9GHz port X

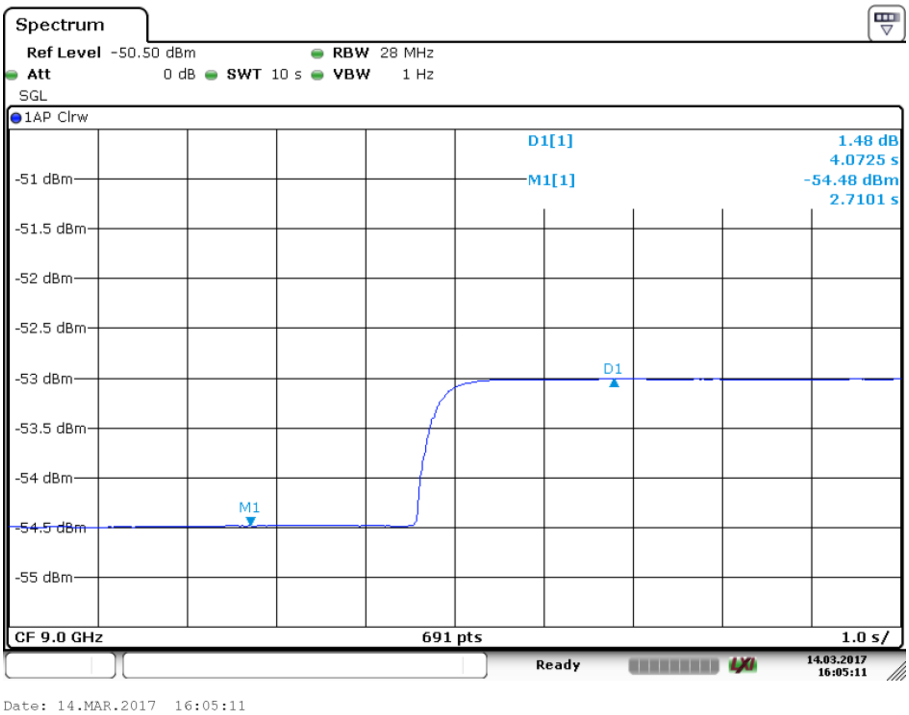

Figure 3-21: Y-factor measured with the noise diode On (Tn=10K) and off @9GHz port Y

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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:

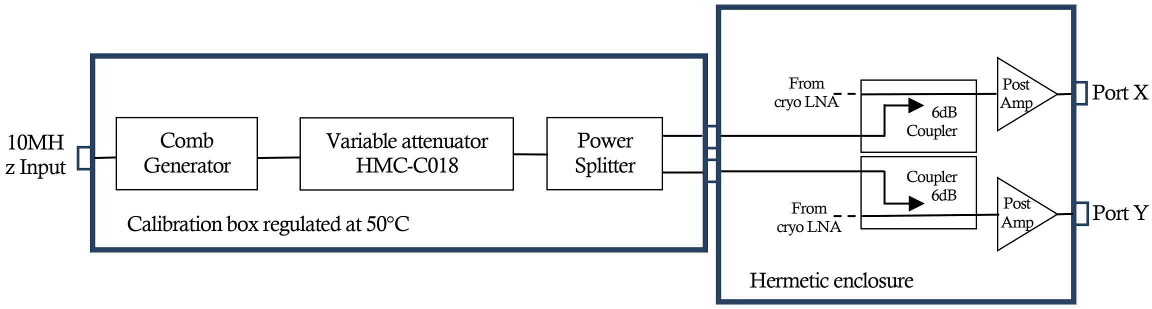
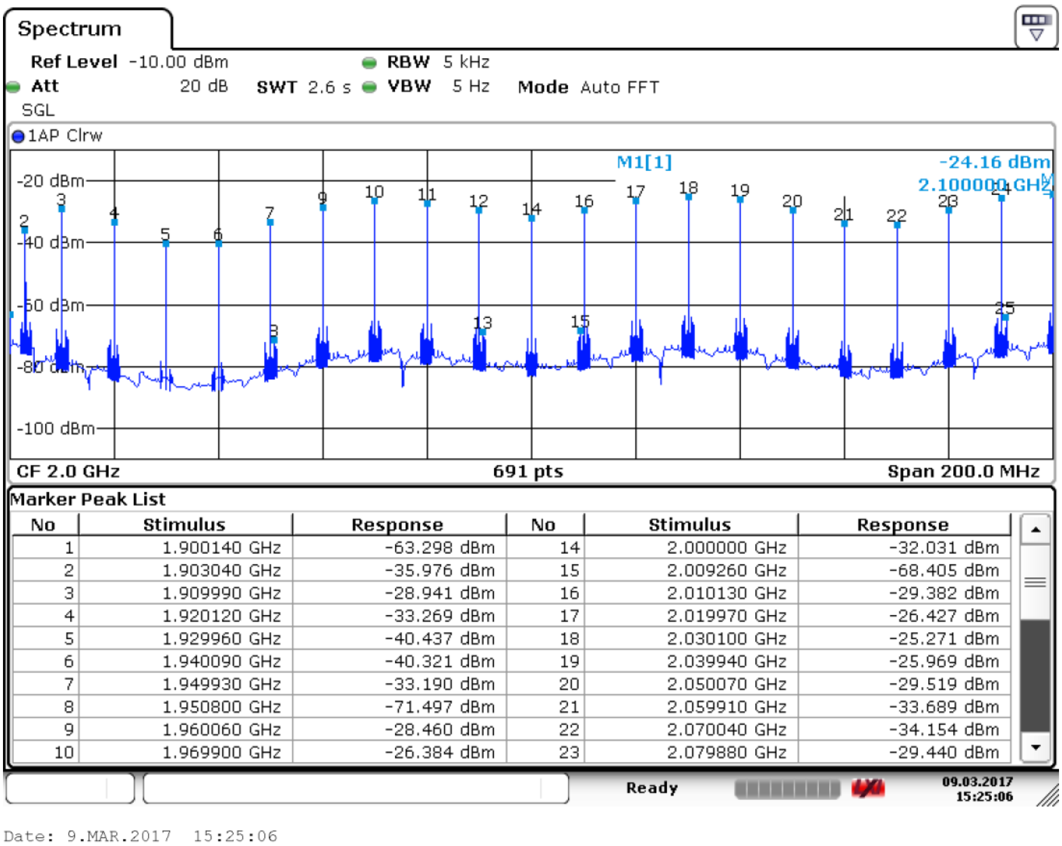


Figure 3-22: Noise calibration circuit

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 performed at 2GHz and 14GHz with various settings of the variable attenuator:



No	Stimulus	Response	No	Stimulus	Response
1	1.900140 GHz	-63.298 dBm	14	2.000000 GHz	-32.031 dBm
2	1.903040 GHz	-35.976 dBm	15	2.009260 GHz	-68.405 dBm
3	1.909990 GHz	-28.941 dBm	16	2.010130 GHz	-29.382 dBm
4	1.920120 GHz	-33.269 dBm	17	2.019970 GHz	-26.427 dBm
5	1.929960 GHz	-40.437 dBm	18	2.030100 GHz	-25.271 dBm
6	1.940090 GHz	-40.321 dBm	19	2.039940 GHz	-25.969 dBm
7	1.949930 GHz	-33.190 dBm	20	2.050070 GHz	-29.519 dBm
8	1.950800 GHz	-71.497 dBm	21	2.059910 GHz	-33.689 dBm
9	1.960060 GHz	-28.460 dBm	22	2.070040 GHz	-34.154 dBm
10	1.969900 GHz	-26.384 dBm	23	2.079880 GHz	-29.440 dBm

Figure 3-23: Port X output @2GHz when comb generator on and attenuator set to 0dB

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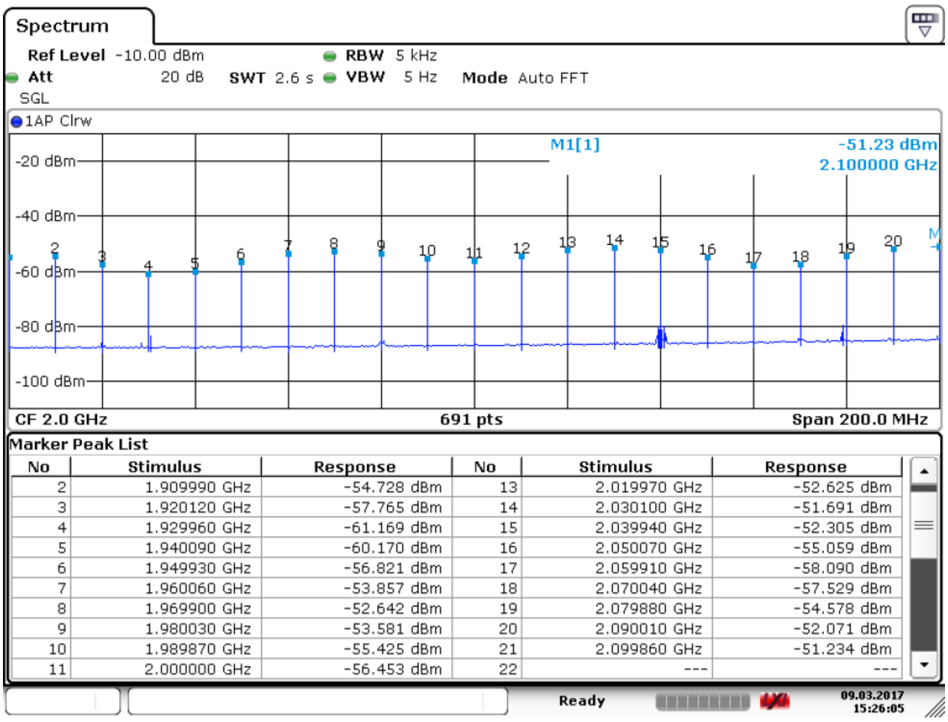

No	Stimulus	Response	No	Stimulus	Response
2	1.909990 GHz	-54.728 dBm	13	2.019970 GHz	-52.625 dBm
3	1.920120 GHz	-57.765 dBm	14	2.030100 GHz	-51.691 dBm
4	1.929960 GHz	-61.169 dBm	15	2.039940 GHz	-52.305 dBm
5	1.940090 GHz	-60.170 dBm	16	2.050070 GHz	-55.059 dBm
6	1.949930 GHz	-56.821 dBm	17	2.059910 GHz	-58.090 dBm
7	1.960060 GHz	-53.857 dBm	18	2.070040 GHz	-57.529 dBm
8	1.969900 GHz	-52.642 dBm	19	2.079880 GHz	-54.578 dBm
9	1.980030 GHz	-53.581 dBm	20	2.090010 GHz	-52.071 dBm
10	1.989870 GHz	-55.425 dBm	21	2.099860 GHz	-51.234 dBm
11	2.000000 GHz	-56.453 dBm	22	---	---

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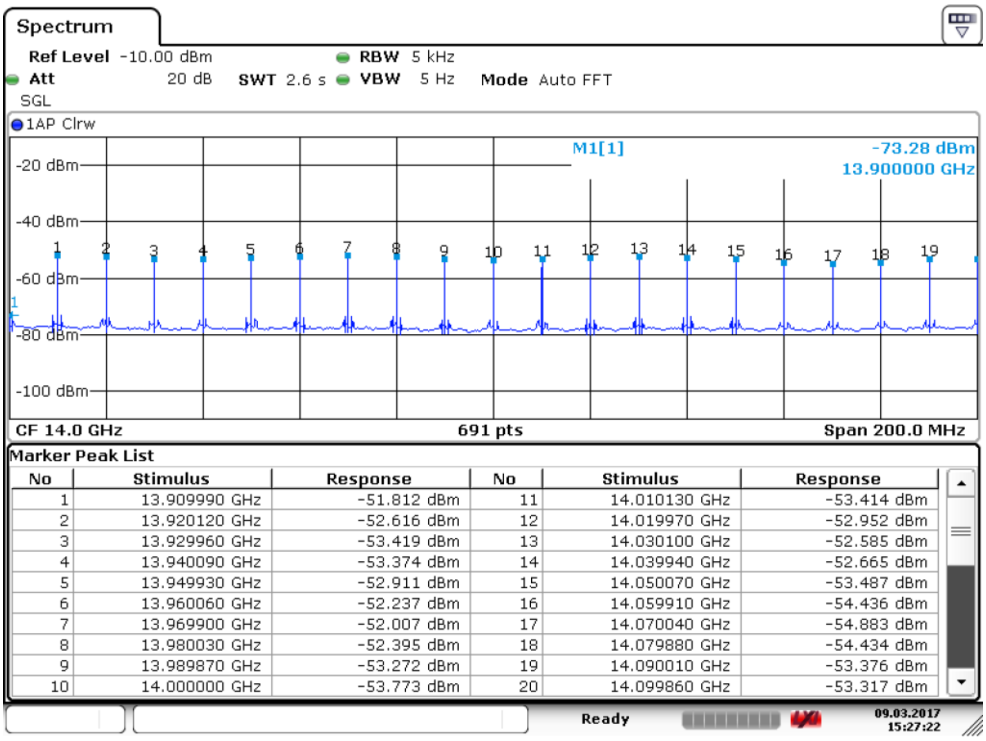
Figure 3-24: Port X output @2GHz when comb generator on and attenuator set to 31.5dB.



No	Stimulus	Response	No	Stimulus	Response
1	13.909990 GHz	-51.812 dBm	11	14.010130 GHz	-53.414 dBm
2	13.920120 GHz	-52.616 dBm	12	14.019970 GHz	-52.952 dBm
3	13.929960 GHz	-53.419 dBm	13	14.030100 GHz	-52.585 dBm
4	13.940090 GHz	-53.374 dBm	14	14.039940 GHz	-52.665 dBm
5	13.949930 GHz	-52.911 dBm	15	14.050070 GHz	-53.487 dBm
6	13.960060 GHz	-52.237 dBm	16	14.059910 GHz	-54.436 dBm
7	13.969900 GHz	-52.007 dBm	17	14.070040 GHz	-54.883 dBm
8	13.980030 GHz	-52.395 dBm	18	14.079880 GHz	-54.434 dBm
9	13.989870 GHz	-53.272 dBm	19	14.090010 GHz	-53.376 dBm
10	14.000000 GHz	-53.773 dBm	20	14.099860 GHz	-53.317 dBm

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Figure 3-25: Port X output @14GHz when comb generator on and attenuator set to 0dB.

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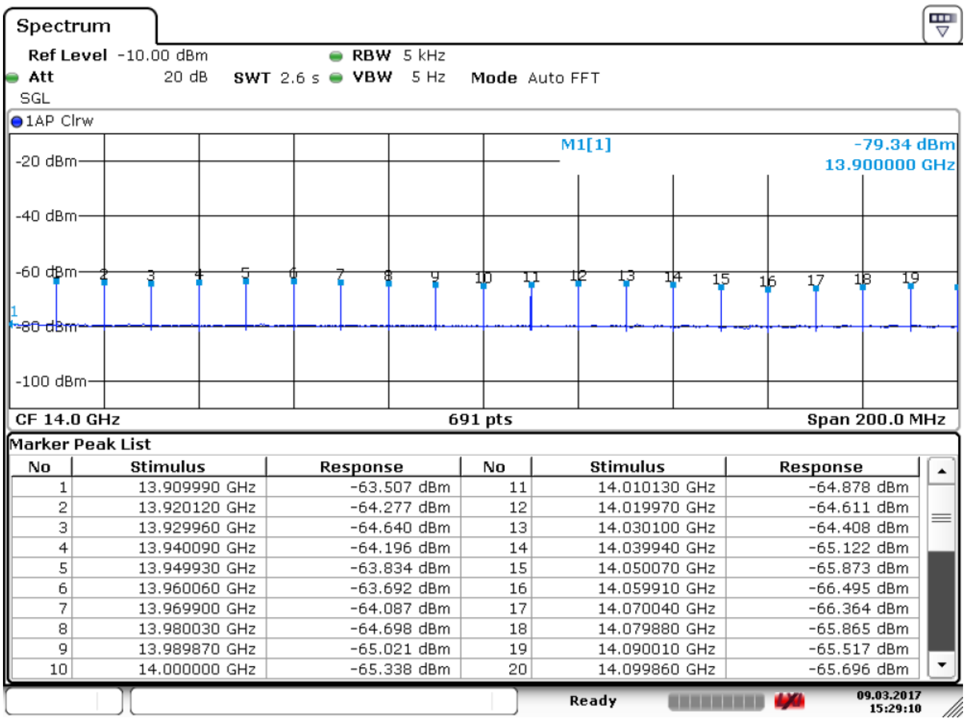

No	Stimulus	Response	No	Stimulus	Response
1	13.909990 GHz	-63.507 dBm	11	14.010130 GHz	-64.878 dBm
2	13.920120 GHz	-64.277 dBm	12	14.019970 GHz	-64.611 dBm
3	13.929960 GHz	-64.640 dBm	13	14.030100 GHz	-64.408 dBm
4	13.940090 GHz	-64.196 dBm	14	14.039940 GHz	-65.122 dBm
5	13.949930 GHz	-63.834 dBm	15	14.050070 GHz	-65.873 dBm
6	13.960060 GHz	-63.692 dBm	16	14.059910 GHz	-66.495 dBm
7	13.969900 GHz	-64.087 dBm	17	14.070040 GHz	-66.364 dBm
8	13.980030 GHz	-64.698 dBm	18	14.079880 GHz	-65.865 dBm
9	13.989870 GHz	-65.021 dBm	19	14.090010 GHz	-65.517 dBm
10	14.000000 GHz	-65.338 dBm	20	14.099860 GHz	-65.696 dBm

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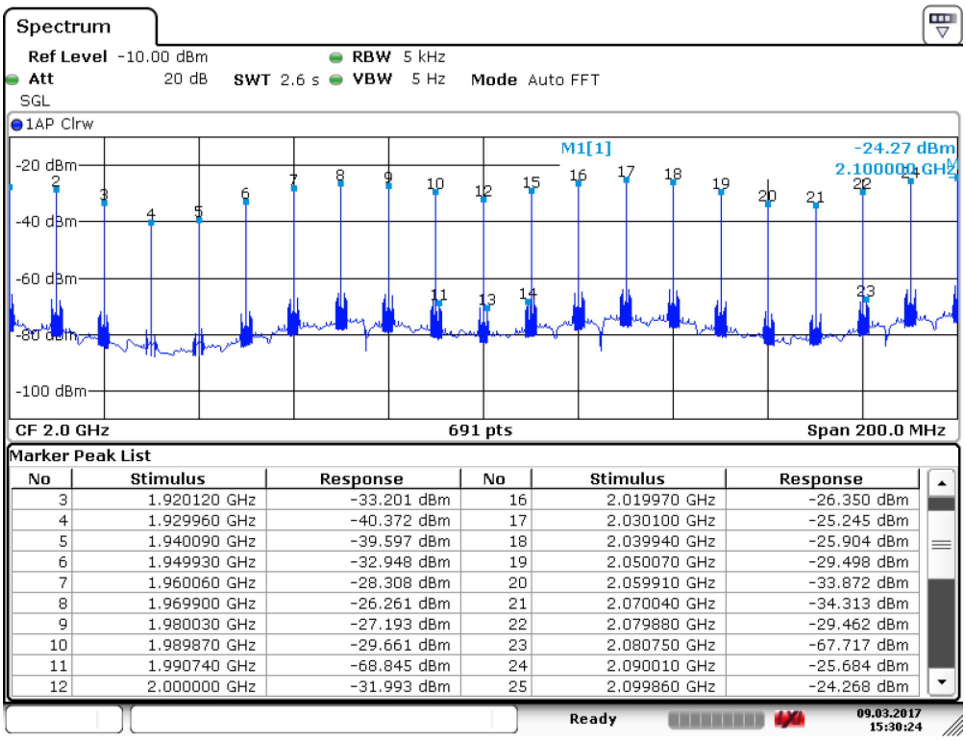
Figure 3-26: Port X output @14GHz when comb generator on and attenuator set to 8dB.



No	Stimulus	Response	No	Stimulus	Response
3	1.920120 GHz	-33.201 dBm	16	2.019970 GHz	-26.350 dBm
4	1.929960 GHz	-40.372 dBm	17	2.030100 GHz	-25.245 dBm
5	1.940090 GHz	-39.597 dBm	18	2.039940 GHz	-25.904 dBm
6	1.949930 GHz	-32.948 dBm	19	2.050070 GHz	-29.498 dBm
7	1.960060 GHz	-28.308 dBm	20	2.059910 GHz	-33.872 dBm
8	1.969900 GHz	-26.261 dBm	21	2.070040 GHz	-34.313 dBm
9	1.980030 GHz	-27.193 dBm	22	2.079880 GHz	-29.462 dBm
10	1.989870 GHz	-29.661 dBm	23	2.080750 GHz	-67.717 dBm
11	1.990740 GHz	-68.845 dBm	24	2.090010 GHz	-25.684 dBm
12	2.000000 GHz	-31.993 dBm	25	2.099860 GHz	-24.268 dBm

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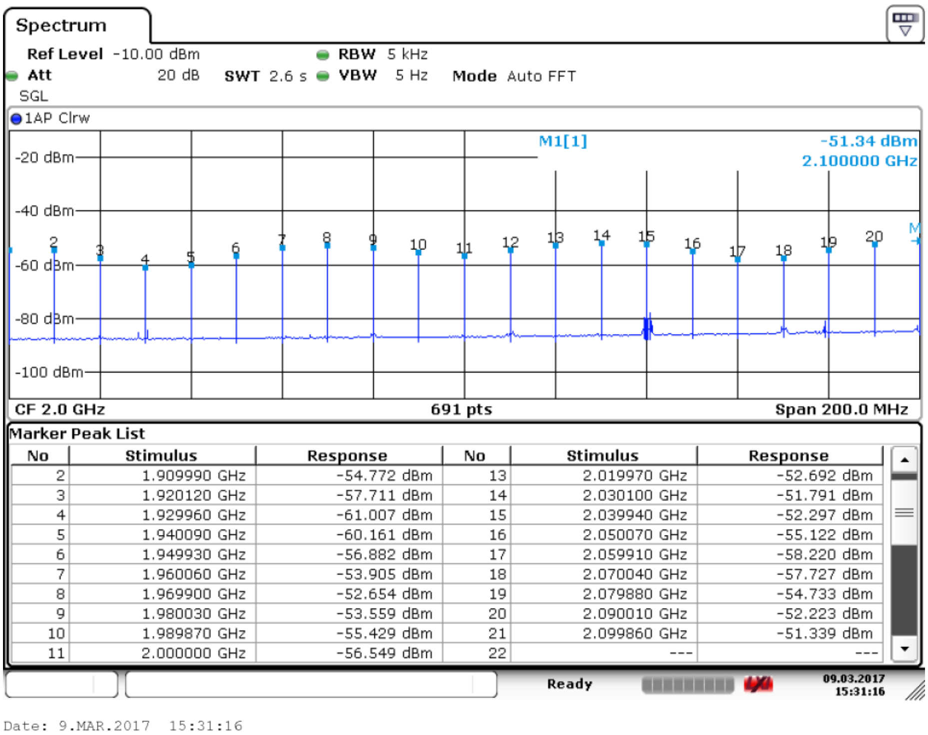
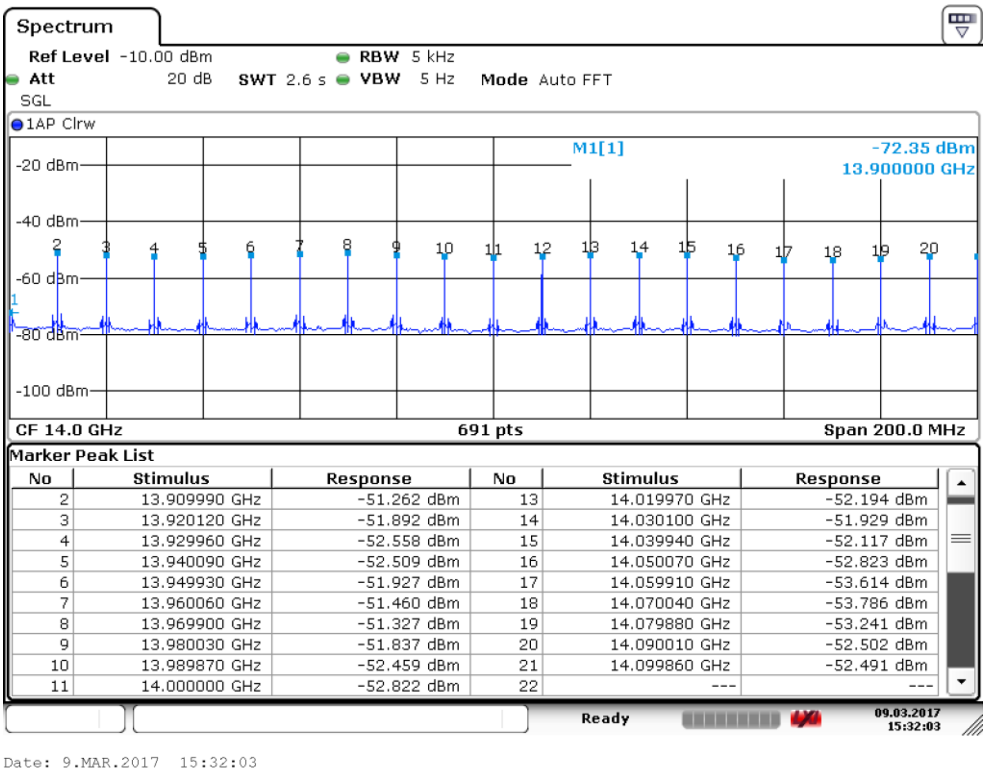
Figure 3-27: Port Y output @2GHz when comb generator on and attenuator set to 0dB



No	Stimulus	Response	No	Stimulus	Response
2	1.909990 GHz	-54.772 dBm	13	2.019970 GHz	-52.692 dBm
3	1.920120 GHz	-57.711 dBm	14	2.030100 GHz	-51.791 dBm
4	1.929960 GHz	-61.007 dBm	15	2.039940 GHz	-52.297 dBm
5	1.940090 GHz	-60.161 dBm	16	2.050070 GHz	-55.122 dBm
6	1.949930 GHz	-56.882 dBm	17	2.059910 GHz	-58.220 dBm
7	1.960060 GHz	-53.905 dBm	18	2.070040 GHz	-57.727 dBm
8	1.969900 GHz	-52.654 dBm	19	2.079880 GHz	-54.733 dBm
9	1.980030 GHz	-53.559 dBm	20	2.090010 GHz	-52.223 dBm
10	1.989870 GHz	-55.429 dBm	21	2.099860 GHz	-51.339 dBm
11	2.000000 GHz	-56.549 dBm	22	---	---

Figure 3-28: Port Y output @2GHz when comb generator on and attenuator set to 31.5dB.



No	Stimulus	Response	No	Stimulus	Response
2	13.909990 GHz	-51.262 dBm	13	14.019970 GHz	-52.194 dBm
3	13.920120 GHz	-51.892 dBm	14	14.030100 GHz	-51.929 dBm
4	13.929960 GHz	-52.558 dBm	15	14.039940 GHz	-52.117 dBm
5	13.940090 GHz	-52.509 dBm	16	14.050070 GHz	-52.823 dBm
6	13.949930 GHz	-51.927 dBm	17	14.059910 GHz	-53.614 dBm
7	13.960060 GHz	-51.460 dBm	18	14.070040 GHz	-53.786 dBm
8	13.969900 GHz	-51.327 dBm	19	14.079880 GHz	-53.241 dBm
9	13.980030 GHz	-51.837 dBm	20	14.090010 GHz	-52.502 dBm
10	13.989870 GHz	-52.459 dBm	21	14.099860 GHz	-52.491 dBm
11	14.000000 GHz	-52.822 dBm	22	---	---

Figure 3-29: Port Y output @14GHz when comb generator on and attenuator set to 0dB.

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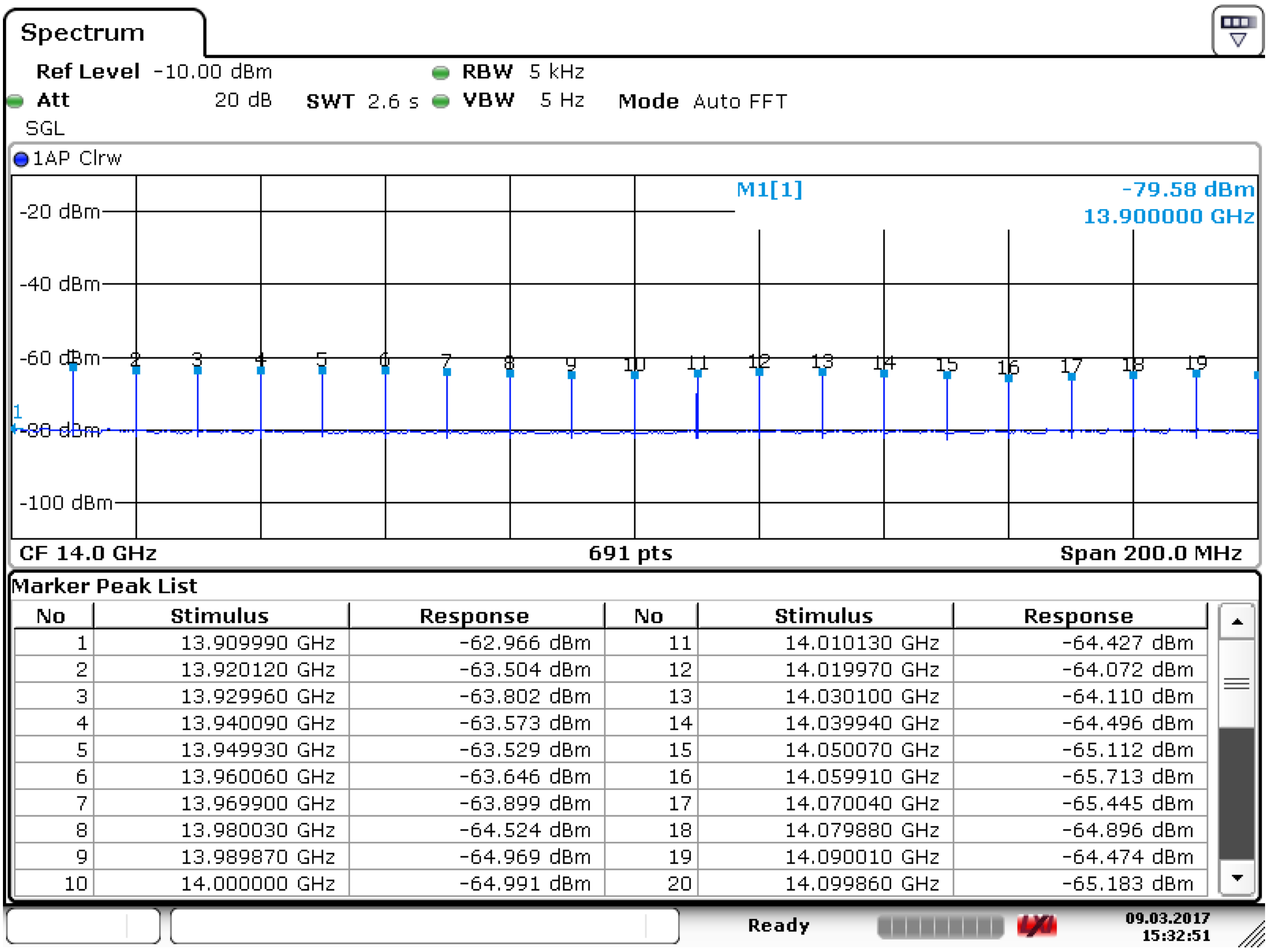

No	Stimulus	Response	No	Stimulus	Response
1	13.909990 GHz	-62.966 dBm	11	14.010130 GHz	-64.427 dBm
2	13.920120 GHz	-63.504 dBm	12	14.019970 GHz	-64.072 dBm
3	13.929960 GHz	-63.802 dBm	13	14.030100 GHz	-64.110 dBm
4	13.940090 GHz	-63.573 dBm	14	14.039940 GHz	-64.496 dBm
5	13.949930 GHz	-63.529 dBm	15	14.050070 GHz	-65.112 dBm
6	13.960060 GHz	-63.646 dBm	16	14.059910 GHz	-65.713 dBm
7	13.969900 GHz	-63.899 dBm	17	14.070040 GHz	-65.445 dBm
8	13.980030 GHz	-64.524 dBm	18	14.079880 GHz	-64.896 dBm
9	13.989870 GHz	-64.969 dBm	19	14.090010 GHz	-64.474 dBm
10	14.000000 GHz	-64.991 dBm	20	14.099860 GHz	-65.183 dBm

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Figure 3-30: Port Y output @14GHz when comb generator on and attenuator set to 8dB.

The maximum picket level at 14GHz available at the output of the receiver is around -53.8dBm for the X port and -52.8dBm for the Y port.

The phase calibration circuit is operational.

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LIST OF ABBREVIATIONS

Acronym	Meaning
σ	Standard Deviation
AD	Applicable Document
AIL	Action Item List
AM	Amplitude Modulation
AZ	Azimuth
BER	Bit Error Rate
Bps	Bits per second
CCSDS	Consultative Committee for Space Data System
CDR	Critical Design Review
DC	Direct Current
ESA	European Space Agency
ESOC	European Space Operations Centre
ICD	Interface Control Document
IF	Intermediate Frequency
k	Boltzman's Constant
K	Kelvin
Kbps	Kilo bps
Kcps	Kilo cps
LAN	Local Area Network
LNA	Low Noise Amplifier
MTBF	Mean Time Between Failure
NASA	National Aeronautics and Space Administration
NF	Noise Figure
PC	Personal Computer
QoS	Quality of Service
RF	Radio Frequency
SoW	Statement of Work
TBC	To Be Confirmed
TBD	To Be Defined
WO	Work Order
WP	Work Package

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