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Band 7 Cartridge#1 Test Report

FEND-40.02.07.00-0010-B-REP

Version: B

Status: draft

2006-01-26

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Change Record

Version	Date	Affected Section(s)	Change Request #	Reason/Initiation/Remarks
A	2006-01-26	all		New document
B	2006-06-01	2, 6, 10, 11 & 12		Modified phase stab. Test results; added spurious, stabilization time and leak rate paragraphs. Also new integrated noise temperature data have been added after triplers had to be replaced

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1 Introduction

1.1 Purpose

This document contains the performance data acquired during the performance verification of the band 7 cartridge #1 detailed in the Technical Specifications [AD1].

1.2 Applicable documents

The following documents are part of this document to the extent specified herein. If not explicitly stated otherwise, the latest issue of the document is valid.

Reference	Document Title	ALMA Doc. Number
[AD1]	Band-7 Cartridge – Technical Specifications	ALMA-40.02.07.00-002-A-SPE
[AD2]	Band-7 Cartridge – Experimental Procedures for Acceptance Tests	A set of documents, including the present one
[AD3]	Data formats for cartridge operating parameters	FEND-40.02.00.00-016-A-STD
[AD4]	Front End Integration Center Database Design Description	FEND-40.09.03.00-007-A-DSN
[AD5]	Band-7 Cartridge Acceptance Test Plan	FEND-40.02.07.00-008-A-PLA

1.3 Reference documents

The following documents contain additional information.

Reference	Document Title	ALMA Doc. Number
[RD1]	Band 7 Cartridge – Statement of Work	FEND-40.02.07.00-001-B-SOW
[RD2]	PAI & PAS Procedures for the ALMA Band 7 Cartridge	FEND-40.02.07.00-005-A-PRO

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2 Noise Performance and output power

2.1 Compliance Matrix

The table below lists the performance compliance for each requirement. Additionally, the electronic database confirming the compliance to the requirements of [AD1] and [AD4] will be completed and supplied along with the cartridge.

Serial No	Item	Specification No	Compliance
3	Performance Requirements		
3.1	Cartridge noise performance	FEND-40.02.07.00-00180-00/T	C
3.3	Cartridge IF output		
3.3.1	IF output power	FEND-40.02.07.00-00200-00/T	
3.3.1.1	<i>Total in-band power</i>		C
3.3.1.2	<i>Total power</i>		C
3.3.2	IF power variations	FEND-40.02.07.00-00210-00/T	
3.3.2.1	<i>2 GHz sub-band</i>		NC (a)
3.3.2.2	<i>Full IF band</i>		C

(a) Non compliant in just one of the 20 test configurations: Pol 0, 303GHz LO, LSB.

2.2 Test Results

Please note: the cartridge#1 performances have been measured using the WCA#1. Some slight variation in output power and noise performances might be seen if another WCA is used to check the performances of the cartridge. For example, we saw an excess noise at some LO frequencies and had to lower the LO output power, hence the junction current to a lower current in order to minimize this effect. In other words: with another WCA, it may be necessary not only to use *different* PA bias settings to achieve the *same* junction current, but it may also be necessary to adjust LO power to a lower junction bias to counter the LO's excess noise. On the other hand, recently delivered B7 laboratory LO seem to have improved in that respect.

The standard test plan was not fully followed for cartridge #1, as concerns rejection measurements across the IF bandpass. This is partly due to the fact that the test plan was discussed after all measurements were done. Polarisation channel 0 was 100% tested at 22 LO frequencies, as per test plan. Polarisation channel 1 was 100% tested at component

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level (sideband separating mixer), with partial testing at cartridge level at five LO frequencies only. Therefore, the corrected noise temperature can only be demonstrated at cartridge level at 22 frequencies for Pol0, and only five frequencies for pol 1.

Nevertheless, the level of agreement between mixer and cartridge measurements is generally good and is shown on specific graphs.

Figure 1 and Figure 2 show the cartridge #1 noise temperature integrated in the IF band versus LO frequency. Figure 5 and Figure 6 show the cartridge#1 noise temperature in the IF band versus LO frequency for three LO frequencies only.

2.2.1 Noise Temperature integrated

LO f_LO (Ghz)	Mixer 1			Mixer 2			LSB			USB		
	V_bias (mV)	I_p (uA)	I_mag (mA)	V_bias (mV)	I_p (uA)	I_mag (mA)	P_hot (uW)	P_cold (uW)	T_rec, LSB (K)	P_hot (uW)	P_cold (uW)	T_rec, USB (K)
283	2.3	30	17	2.3	30	13	0.465	0.185	67.0	0.626	0.243	61.3
287	2.3	30	19	2.3	30	13	0.506	0.193	57.4	0.684	0.256	53.4
291	2.3	30	19	2.3	30	13	0.467	0.175	53.7	0.634	0.235	51.4
295	2.3	30	19	2.3	30	13	0.43	0.164	57.4	0.558	0.21	54.6
299	2.3	30	19	2.3	30	13	0.457	0.175	58.3	0.642	0.245	57.5
303	2.3	30	19	2.3	30	13	0.44	0.17	60.3	0.561	0.213	56.4
307	2.3	30	19	2.3	30	13	0.383	0.146	57.3	0.567	0.211	52.2
311	2.3	28	19	2.3	31	13	0.427	0.17	67.2	0.536	0.213	66.8
315	2.3	30	19	2.3	30	13	0.383	0.155	71.2	0.512	0.206	69.8
319	2.3	29	19	2.3	29	13	0.436	0.19	91.4	0.586	0.257	93.3
323	2.3	30	19	2.3	33	13	0.359	0.143	67.3	0.469	0.183	62.5
327	2.3	31	19	2.3	29.5	13	0.339	0.144	84.0	0.486	0.208	86.1
331	2.3	30	19	2.3	30	13	0.367	0.149	72.0	0.438	0.181	76.5
335	2.3	29.1	19	2.3	30.6	13	0.283	0.112	65.8	0.388	0.153	64.9
339	2.3	30	19	2.3	30	13	0.311	0.125	69.5	0.365	0.15	75.1
343	2.3	28.9	19	2.3	27.4	13	0.275	0.113	75.1	0.369	0.15	72.3
347	2.3	29.6	19	2.3	30.1	13	0.274	0.11	69.2	0.337	0.136	70.5
351	2.3	29.7	19	2.3	30.1	13	0.242	0.0976	70.3	0.34	0.135	66.6
355	2.3	29.8	19	2.3	31	13	0.239	0.0978	74.0	0.271	0.112	76.6
359	2.3	31.1	19	2.3	28	13	0.236	0.106	100.8	0.298	0.136	106.0
363	2.3	30.7	19	2.3	31.2	13	0.206	0.0899	91.8	0.257	0.114	96.8
365	2.3	31	19	2.3	29.5	13	0.192	0.092	123.6	0.255	0.123	126.1

Table 1: Cartridge#1 Pol0 Noise Temperature integrated over the 4-8GHz b/w



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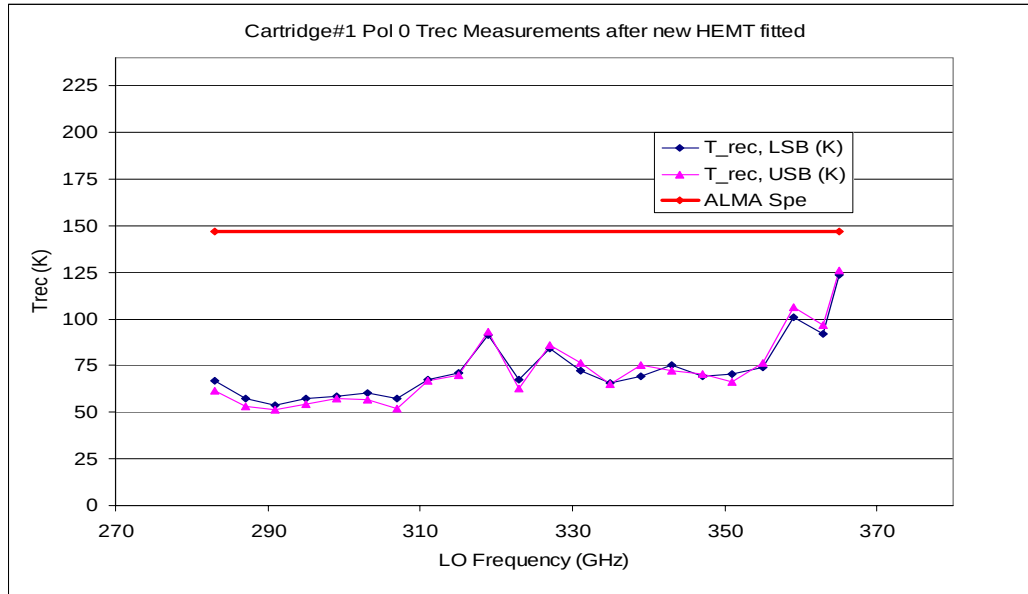


Figure 1: Cartridge#1, Pol 0 Trec integrated over 4-8GHz IF

LO	Mixer 1			Mixer 2			LSB			USB		
f _{LO} (GHz)	V _{bias} (mV)	I _p (uA)	I _{mag} (mA)	V _{bias} (mV)	I _p (uA)	I _{mag} (mA)	P _{hot} (uW)	P _{cold} (uW)	T _{rec} , LSB (K)	P _{hot} (uW)	P _{cold} (uW)	T _{rec} , USB (K)
283	2.27	28	5	2.27	26.5	9	62.1	22.7	48.6	12.2	4.7	59.6
287	2.25	24	5	2.27	24.5	9	60.1	21.5	44.4	10.9	4.08	53.4
291	2.29	28	5	2.29	22	9	55.5	20.1	46.8	10.9	4.09	53.9
295	2.3	28	5	2.3	24.7	9	56.3	20.6	48.8	9.86	3.83	61.5
299	2.29	28	5	2.29	23.2	9	49.2	18.5	54.4	9.9	3.85	61.7
303	2.28	26	5	2.29	20.1	9	52.9	19.7	52.4	11.1	4.21	56.2
307	2.28	20.7	9	2.29	23.1	20	1.62	0.6	51.2	2.61	0.996	57.5
311	2.29	26	5	2.29	27.5	9	48.9	18.8	59.2	10.5	4.08	61.5
315	2.29	27	5	2.29	25.1	9	50.4	19.9	65.2	10.2	4.18	74.4
319	2.31	20.1	9	2.31	21.7	20	1.42	0.53	52.8	2.35	0.888	55.4
323	2.31	20.1	9	2.31	22.5	20	1.53	0.579	55.7	2.79	1.04	52.6
327	2.29	21	5	2.29	22	9	1.44	0.584	71.7	2.65	1.03	61.6
331	2.3	24	5	2.3	24.7	9	45.9	18.2	66.2	9.23	3.82	76.9
335	2.3	20.9	9	2.3	22.2	20	1.43	0.551	59.7	2.54	0.965	56.6
339	2.31	24	5	2.31	23.6	9	38.7	14.9	59.5	7.3	2.93	69.2
343	2.34	26	5	2.33	28.9	9	43.2	16.4	56.4	8.75	3.44	64.2
347	2.34	21.5	9	2.33	22.1	20	1.29	0.519	69.7	2.36	0.923	63.0
351	2.38	26	5	2.33	26.5	9	36.1	14.1	62.7	7.48	2.99	68.2
355	2.36	30	5	2.33	29.3	9	36.7	13.9	55.9	6.41	2.62	73.7
359	2.31	20.1	9	2.31	22.9	20	1.24	0.516	78.4	2.17	0.899	77.2
363	2.34	21.4	9	2.34	21.6	20	1.01	0.435	87.9	2.01	0.815	71.7
365	2.29	21.2	9	2.34	22	20	0.942	0.417	96.2	1.88	0.787	80.0

Table 2: Cartridge#1 Pol1 Noise Temperature integrated over the 4-8GHz b/w

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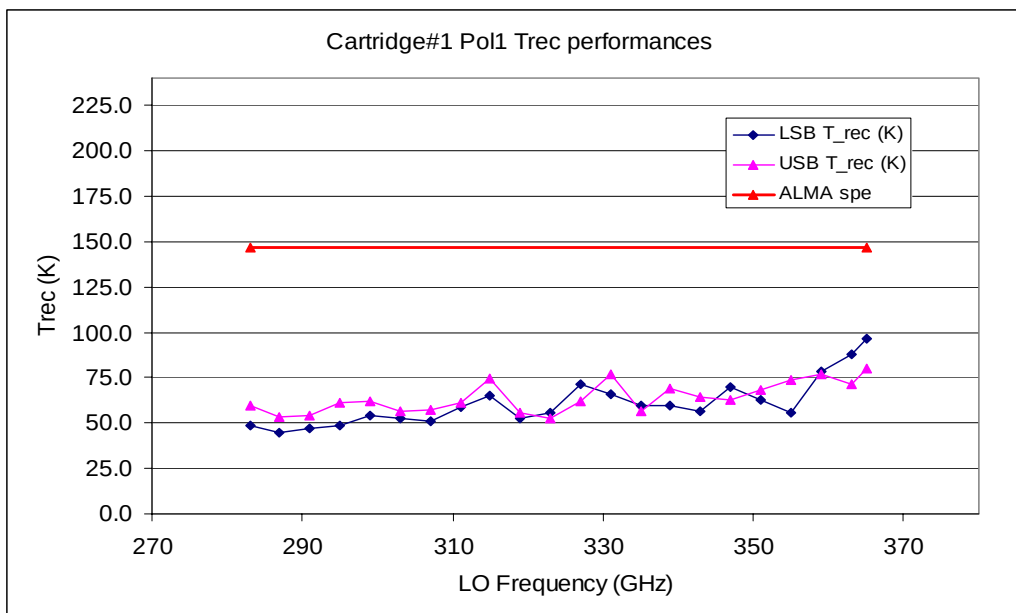


Figure 2: Cartridge#1, Pol 1 Trec integrated over 4-8GHz IF

Prior to delivery of the cartridge#1 and after the Preliminary Acceptance In-house, triplers had to be replaced after their performances degraded. New Integrated Noise Temperature data have been collected and are shown in the Figure 3 and Figure 4 below.



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Table 3: Cart#1 Pol0 Integrated Noise Temperature Table Data with new tripler S00120

LO		Mixer 1			Mixer 2			LSB			USB		
f_LO (Ghz)	PA Vd	V_bias (mV)	I_p (uA)	I_mag (mA)	V_bias (mV)	I_p (uA)	I_mag (mA)	P_hot (uW)	P_cold (uW)	T_rec, LSB (K)	P_hot (uW)	P_cold (uW)	T_rec, USB (K)
283.00	0.98	2.3	25.4	25	2.3	25.8	18	451	167	51.2	622	228	49.2
287.00	1.17	2.3	24.6	25	2.3	25.4	18	478	180	54.7	625	231	50.8
291.00	2.20	2.3	16.5	25	2.3	16.9	18	313	121	60.4	428	165	59.8
295.00	0.81	2.3	27.1	25	2.3	26.7	18	423	157	51.7	519	191	49.9
299.00	1.11	2.3	24.6	25	2.3	25.0	18	426	153	45.2	587	209	43.5
303.00	0.76	2.3	24.8	25	2.3	24.8	18	442	158	44.3	565	199	41.5
307.00	0.79	2.3	24.8	25	2.3	25.8	18	373	135	46.7	521	185	43.0
311.00	1.02	2.3	25.8	25	2.3	24.4	18	407	147	46.3	540	195	46.2
315.00	0.72	2.3	24.6	25	2.3	24.8	18	375	138	49.9	466	168	45.9
319.00	0.99	2.3	24.0	25	2.3	24.6	18	358	136	56.5	504	190	54.9
323.00	0.90	2.3	25.6	25	2.3	23.5	18	371	136	49.2	448	162	46.5
327.00	0.92	2.3	23.8	25	2.3	25.4	18	307	112	48.2	423	153	46.5
331.00	0.79	2.3	25.6	25	2.3	24.2	18	349	126	46.2	415	151	47.7
335.00	0.88	2.3	25.2	25	2.3	24.2	18	289	110	57.0	393	149	56.1
339.00	0.86	2.3	24.0	25	2.3	25.2	18	293	109	52.1	342	127	51.8
343.00	0.73	2.3	24.4	25	2.3	23.1	18	283	103	47.7	363	133	49.1
347.00	0.88	2.3	23.8	25	2.3	24.6	18	264	99	53.8	330	123	52.5
351.00	0.75	2.3	23.8	25	2.3	24.2	18	237	89	54.1	320	119	52.1
355.00	1.05	2.3	24.4	25	2.3	25.8	18	231	87	54.7	271	103	56.7
359.00	0.90	2.3	24.4	25	2.3	25.4	18	233	90	60.2	287	112	62.5
363.00	0.74	2.3	24.2	25	2.3	25.2	18	211	86.4	74.2	262	106	71.1
365.00	0.99	2.3	23.5	25	2.3	25.2	18	188	80	84.5	248	104	80.4

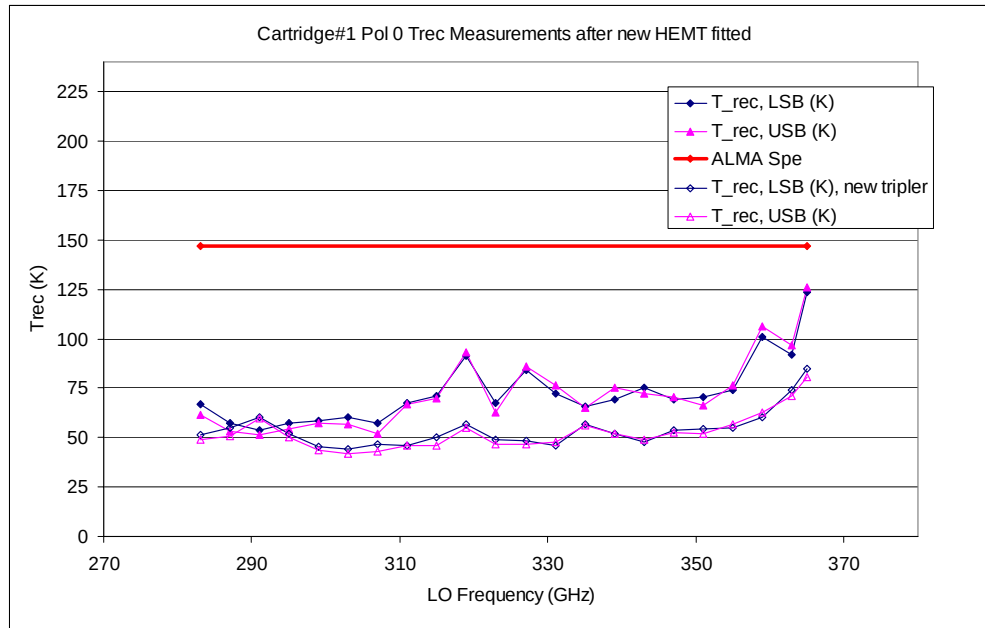


Figure 3: Comparison between integrated Noise Temperature measurements after new tripler (S00120) has been fitted on Cart#1 Pol0. Also the pumping level of the junction has been reduced across the band to about 25uA instead of 30uA.



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LO		Mixer 1			Mixer 2			LSB			USB		
f_LO (GHz)	Vd	V_bias (mV)	I_p (uA)	I_mag (mA)	V_bias (mV)	I_p (uA)	I_mag (mA)	P_hot (uW)	P_cold (uW)	T_rec, LSB (K)	P_hot (uW)	P_cold (uW)	T_rec, USB (K)
283	1.06	2.3	26.0	25	2.3	26.4	16	663	230	38.8	942	342	47.3
287	1.19	2.3	27.3	25	2.3	25.3	16	606	211	39.5	803	291	46.9
291	0.78	2.3	23.8	25	2.3	28.2	16	532	182	36.4	734	259	41.9
295	1.26	2.3	24.2	25	2.3	26.9	16	583	207	43.0	709	271	57.9
299	0.95	2.3	22.2	25	2.3	27.3	16	469	167	43.5	665	242	47.7
303	0.80	2.3	23.8	25	2.3	31.1	16	490	174	43.0	780	274	41.0
307	0.90	2.3	26.4	25	2.3	24.2	16	449	163	47.2	696	250	45.2
311	0.70	2.3	27.8	25	2.3	26.4	16	439	157	44.4	704	249	42.3
315	0.76	2.3	24.7	25	2.3	26.7	16	487	173	43.1	717	260	47.0
319	0.90	2.3	26.4	25	2.3	25.3	16	413	151	48.6	635	234	50.2
323	0.85	2.3	26.2	25	2.3	25.1	16	466	167	44.8	689	251	47.9
327	0.71	2.3	25.6	25	2.3	25.1	16	435	153	41.3	611	221	46.5
331	0.78	2.3	26.2	25	2.3	24.9	16	425	156	49.4	611	229	53.7
335	0.93	2.3	27.1	25	2.3	26.4	16	442	163	50.4	657	254	60.4
339	0.90	2.3	25.6	25	2.3	26.7	16	397	140	41.8	539	198	49.6
343	0.70	2.3	25.3	25	2.3	21.8	16	413	145	40.9	616	220	44.1
347	0.71	2.3	27.6	25	2.3	24.2	16	425	149	40.7	627	225	45.0
351	0.89	2.3	26.7	25	2.3	26.2	16	387	149	59.5	585	228	62.2
355	1.10	2.3	25.1	25	2.3	26.7	16	415	168	71.3	555	250	101.7
359	1.11	2.3	27.8	25	2.3	24.4	16	375	168	99.9	531	245	109.7
363	0.97	2.3	24.4	25	2.3	26.4	16	355	158	97.8	480	234	130.4
365	0.92	2.3	26.9	25	2.3	26.0	16	350	159	104.5	473	225	120.8

Table 4: Cart#1 Pol1 Integrated Noise Temperature Table Data with new tripler S00169

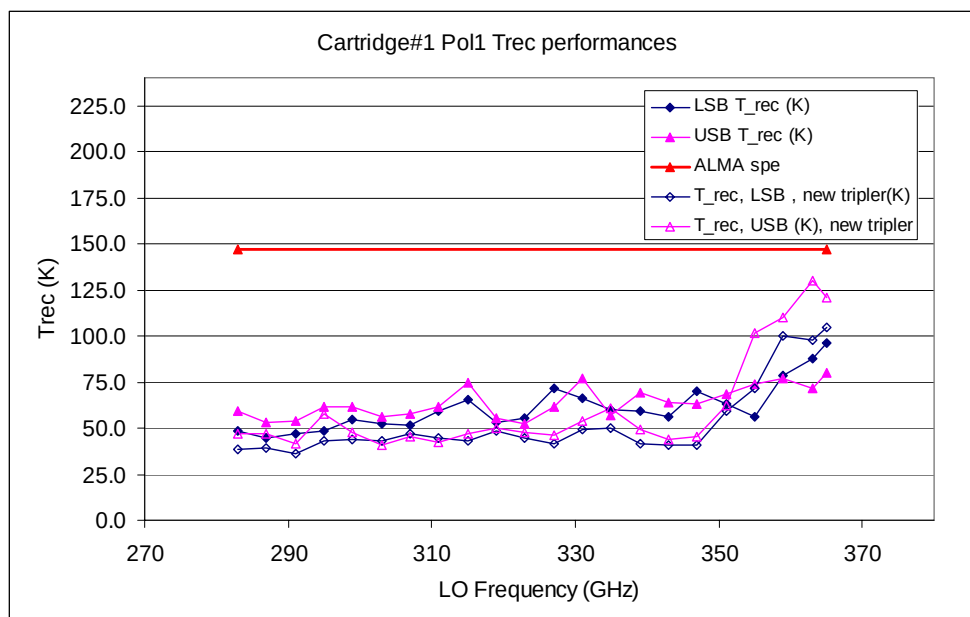


Figure 4: Comparison between integrated Noise Temperature measurements after new tripler (S00169) has been fitted on Cart#1 Pol1. Also the pumping level of the junction has been reduced across the band to about 25uA instead of 30uA

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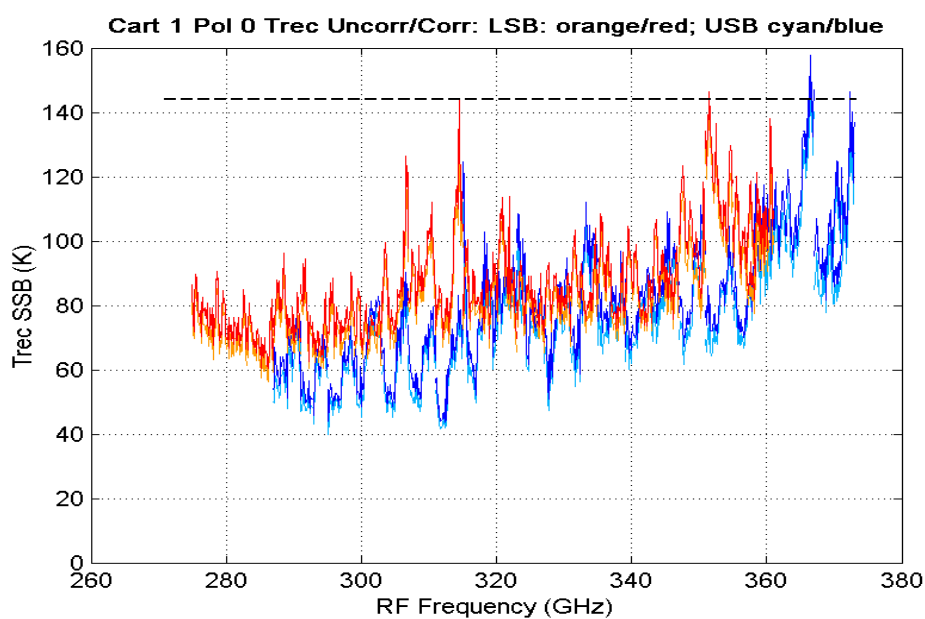


Figure 5: Cart#1 Pol0 Uncorrected/Corrected Trec in IF Band

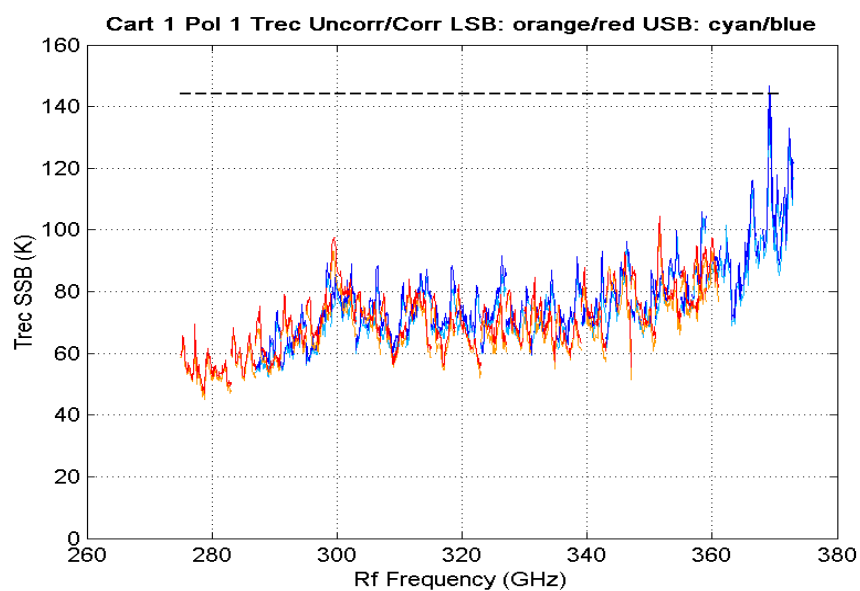


Figure 6: Cart#1 Pol1 Uncorrected/Corrected Trec in IF Band. Measured at 2SB mixer component level

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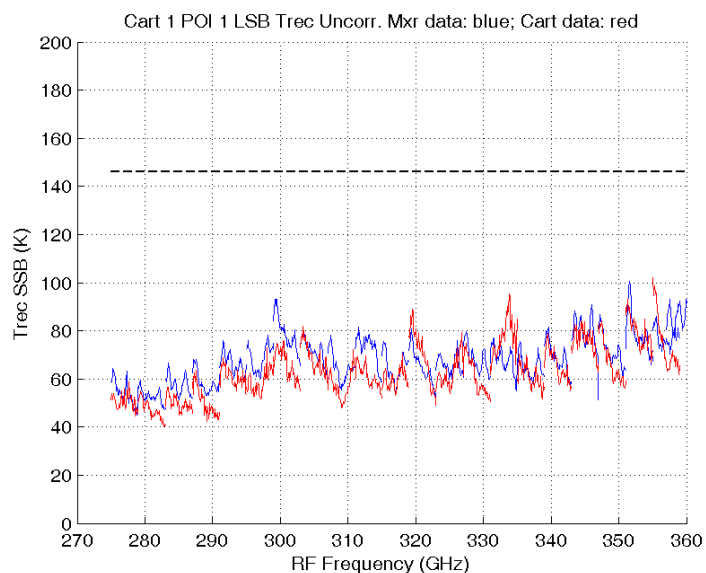


Figure 7. Pol 1 LSB. Comparison of (uncorrected) Trec measured at component (2SB mixer) level and at cartridge verification.

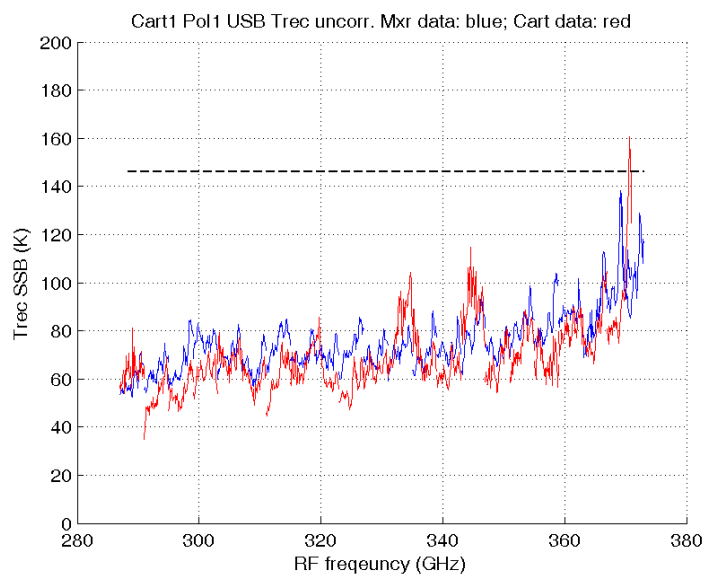


Figure 8. Pol 1 USB. Comparison of (uncorrected) Trec measured at component (2SB mixer) level and at cartridge verification.

2.2.2 Cartridge IF Output Power:

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The cartridge #1 IF output power has been measured with WCA#1 and associated warm IF amplifiers and cables. If the cartridge is measured with another WCA, one can expect some variation in output power due to the use of different amplifiers / attenuators / cables.

Table 5, Table 6 and Table 7 below, show the total in-band power, total power and IF power variation test results.

2.2.2.1 Cartridge Total in-band Power

The in band IF signal level has to be between –27 dBm and –40dBm at the interface, which is the output of the warm IF circuitry (amplifiers, attenuators and cables).

f_LO (Ghz)	Pol0 LSB Output Level	Pol0 USB Output Level	Pol 1LSB Lvel (dBm)	Pol1 USB Lvel (dBm)
283	-33,33	-32,03	-31,92	-30,67
287	-32,96	-31,65	-32,08	-31,1
291	-33,31	-31,98	-32,55	-31,36
295	-33,67	-32,53	-32,13	-31,7
299	-33,40	-31,92	-33,03	-31,8
303	-33,57	-32,51	-33,6	-31,9
307	-34,17	-32,46	-33,54	-31,72
311	-33,70	-32,71	-33,07	-31,25
315	-34,17	-32,91	-3,08	-31,7
319	-33,61	-32,32	-33,63	-31,97
323	-34,45	-33,29	-33,37	-31,93
327	-34,70	-33,13	-33,44	-32,1
331	-34,35	-33,59	-33,54	-32,13
335	-35,48	-34,11	-33,68	-32,25
339	-35,07	-34,38	-33,44	-32,37
343	-35,61	-34,33	-33,07	-31,66
347	-35,62	-34,72	-33,82	-32,77
351	-36,16	-34,69	-34,18	-32,74
355	-36,22	-35,67	-33,85	-33,07
359	-36,27	-35,26	-34,35	-33,13
363	-36,86	-35,90	-34,41	-33,59
365	-37,17	-35,93	-35,04	-34,12
min	-36,86	-35,90	-35,90	-35,90
max	-32,96	-35,90	-35,90	-35,90
average	-34,72	-35,90	-35,90	-35,90

Table 5: Cartridge#1 and WCA#1 Total in-band Power

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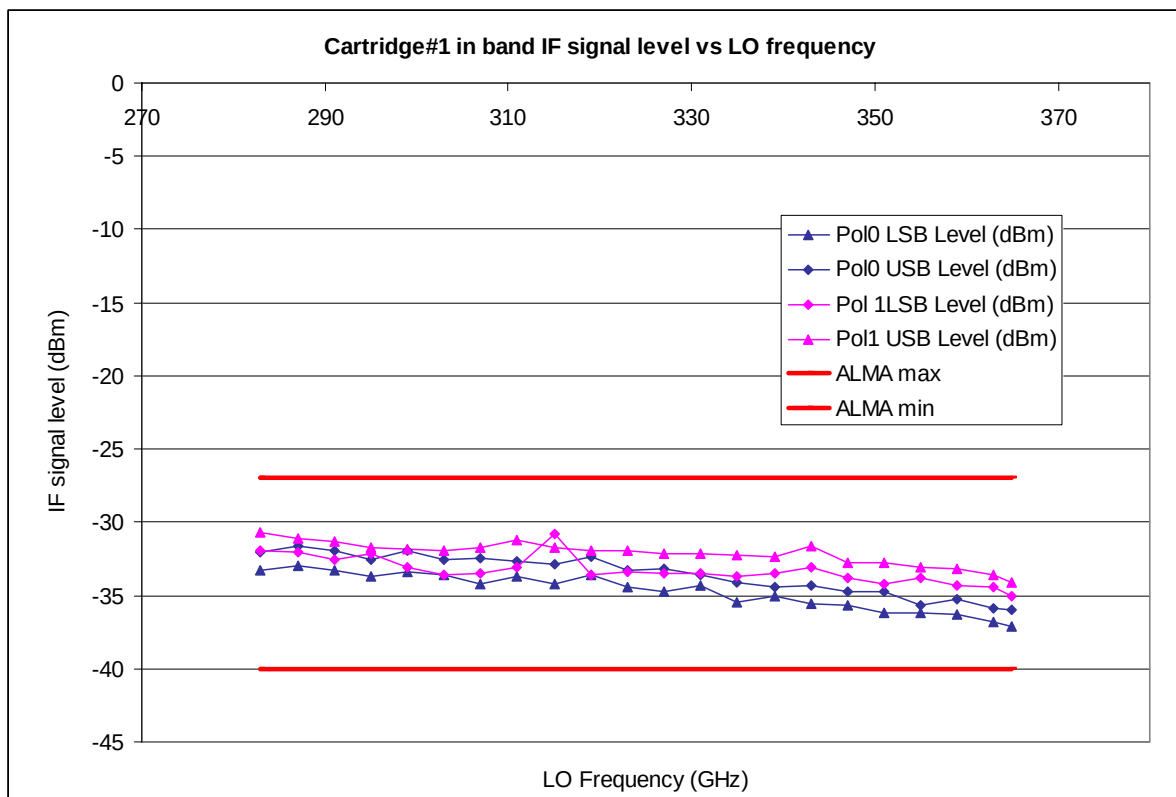


Figure 9: Cartridge#1 in band IF signal level versus LO Frequency

2.2.2.2 Cartridge Total Power

The total IF signal level has to be less than -15 dBm over the 0.01 -18 GHz b/w.

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f_LO (Ghz)	Pol 0 LSB Total Power (dBm)	Pol 0 USB Total Power (dBm)	Pol 1 LSB Total Power (dBm)	Pol 1 USB Total Power (dBm)
283	-31,8	-30,44	-30,37	-29,27
287	-31,37	-30,14	-30,49	-29,52
291	-31,61	-30,21	-30,89	-29,62
295	-31,8	-30,68	-30,79	-30,38
299	-31,91	-30,54	-31,15	-30,16
303	-31,75	-30,59	-32,22	-30,78
307	-32,25	-30,86	-31,92	-30,09
311	-32,26	-31,09	-31,79	-30,18
315	-32,4	-31,3	-31,74	-30,38
319	-32,66	-31,29	-32	-30,52
323	-32,7	-31,65	-31,88	-30,63
327	-33,04	-31,78	-31,97	-30,79
331	-32,86	-32,05	-32,06	-30,78
335	-33,47	-32,19	-32,16	-30,91
339	-33,54	-32,67	-32,34	-31,2
343	-33,66	-32,49	-32,23	-30,99
347	-33,7	-32,7	-32,35	-31,2
351	-34,15	-32,89	-32,94	-31,58
355	-34,2	-33,42	-32,7	-31,82
359	-34,31	-33,23	-32,86	-31,59
363	-34,99	-33,98	-32,91	-32,01
365	-35,54	-34,49	-33,34	-32,43

Table 6: Cartridge#1 and WCA#1 Total Power

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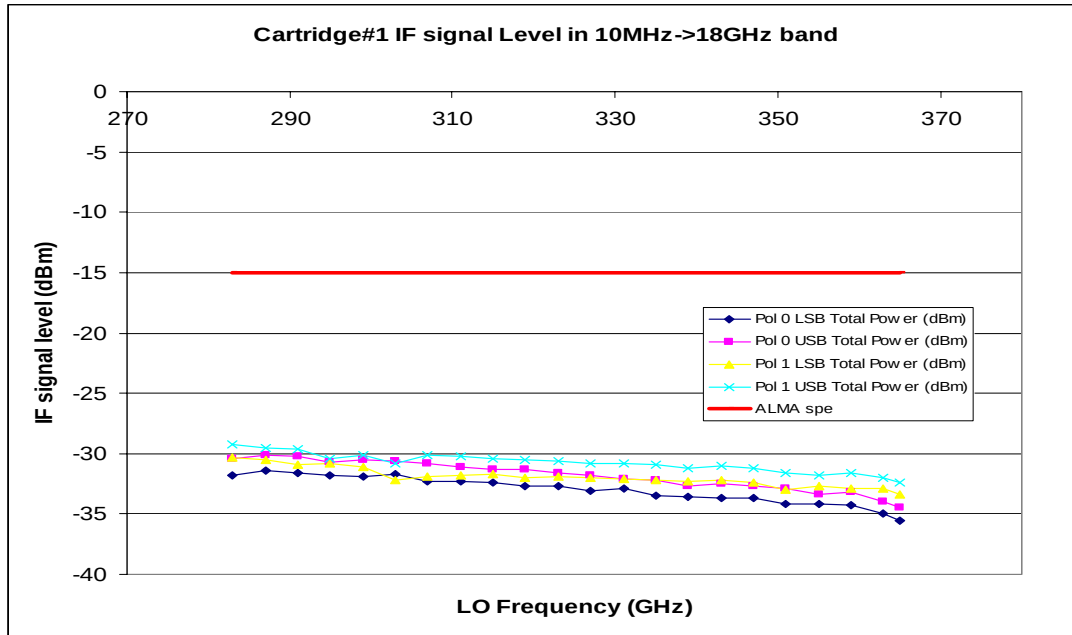


Figure 10: cartridge#1 total power in the frequency range 10MHz to 18 GHz

2.2.2.3 IF Power Variations

The IF power variation has to be ± 2 dB peak to peak in any 2GHz portion of the IF band and ± 3 dB peak to peak across the whole IF band.

The cartridge is compliant with the second part of the specification (± 3 dB full band). Regarding the first part (± 2 dB any 2GHz sub-band), the cartridge fails to meet the spec in just one case: Polarization channel 0, 303GHz LO, LSB. See Figure 13 and Figure 14.

Table 7 below shows the results obtained for the whole IF band.

LO Freq (GHz)	Pol 0 LSB (dB)	Pol 0 USB (dB)	Pol 1 LSB (dB)	Pol 1 USB (dB)
283	4,69	3,87	3,04	2,37
303	5,85	3,72	2,10	3,03
319	3,88	3,80	2,62	3,15
343	4,72	3,94	2,55	2,66
363	4,25	3,94	3,03	2,85

Table 7: Cartridge #1 IF Power Variation with WCA#1 warm IF Amplifiers and attenuators



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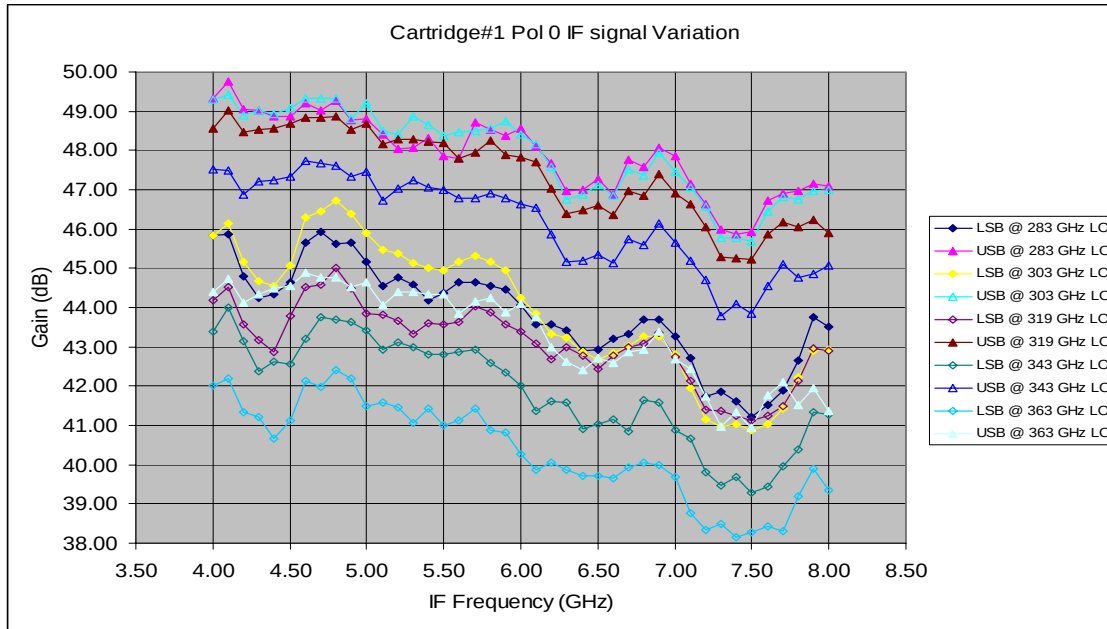


Figure 11: Cartridge#1, Pol0, IF Power Variation

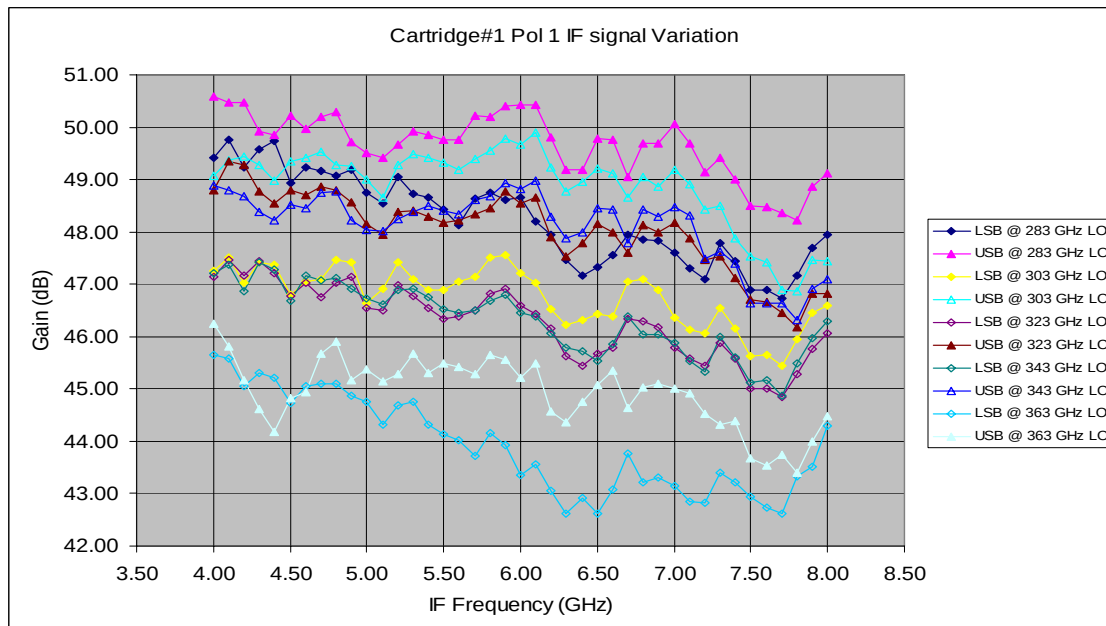


Figure 12: : Cartridge#1, Pol1, IF Power Variation



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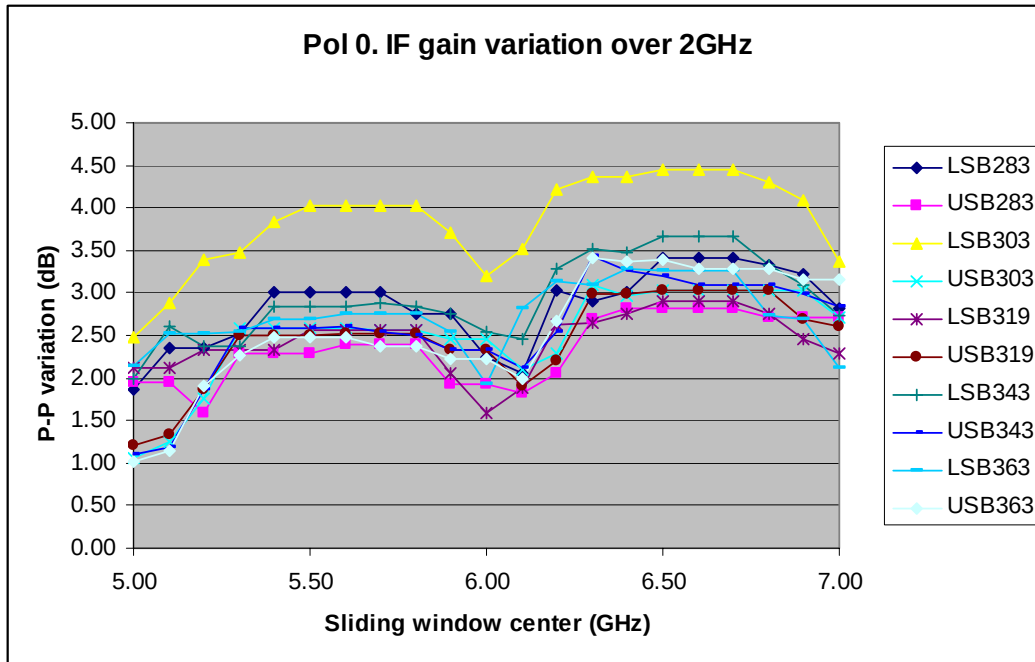


Figure 13. Pol 0 gain variation over 2GHz sliding window.

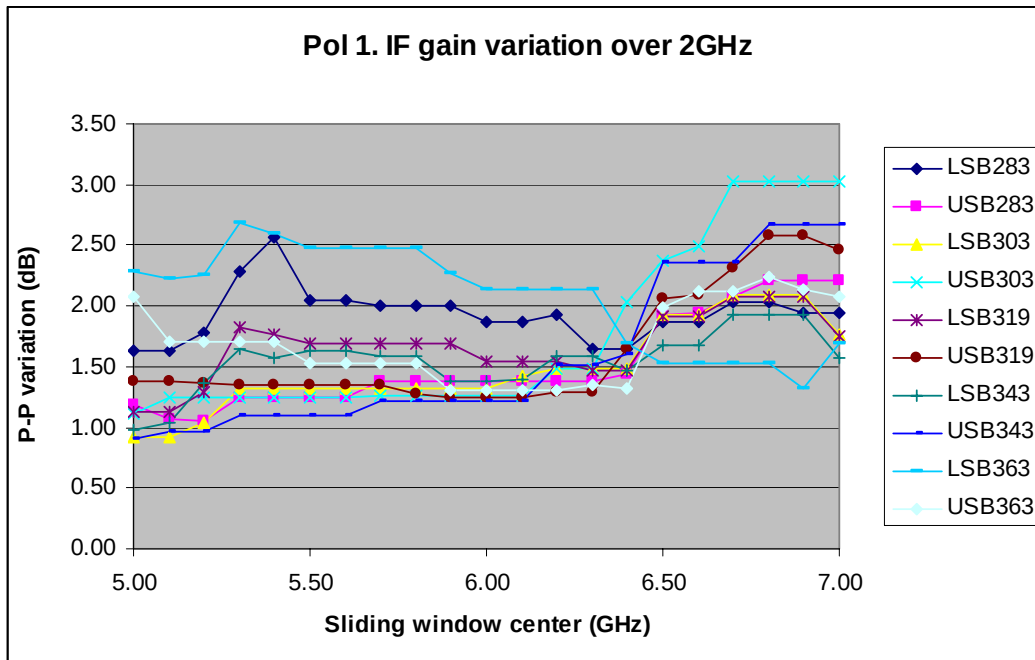


Figure 14. Pol 1 gain variation over 2GHz sliding window.

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3 Image Band Rejection

3.1 Compliance Matrix

The table below lists the performance compliance for each requirement. Additionally, the electronic database confirming the compliance to the requirements of [AD1] and [AD4] will be completed and supplied along with the cartridge.

The image band suppression shall be at least 10dB across the 4-8GHz IF band.

Serial No	Item	Specification No	Compliance
3	Performance Requirements		
3.2	Image Band Suppression or sideband mismatch	FEND-40.02.07.00-00180-00/T	Mostly C

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3.2 Test Results

The standard test plan was not fully followed for cartridge #1, as concerns rejection measurements across the IF bandpass. This is partly due to the fact that the test plan was discussed after all measurements were done. Polarization channel 0 was 100% tested at 22 LO frequencies, as per test plan. Polarization channel 1 was 100% tested at component level (sideband separating mixer), with partial testing at cartridge level at five LO frequencies only. Nevertheless, the level of agreement between mixer and cartridge measurements is generally good and is shown on specific graphs.

The cartridge#1 is compliant in terms of image band rejection over most of the frequency band. The image rejection is worse than the spec of -10dB in a few narrow RF frequency ranges, especially for polarization channel 0; this generally occurs at the edge of the IF bandpass. It remains to be seen in a broader context (SSB *system* temperature) whether such a cartridge meets the *scientific* requirements.

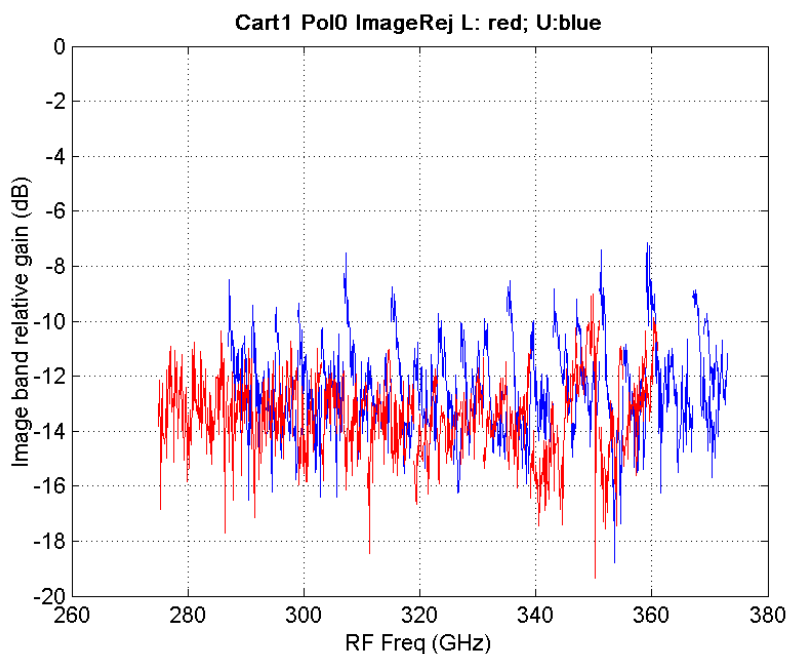


Figure 15: Cartridge#1 Pol 0 Image Rejection

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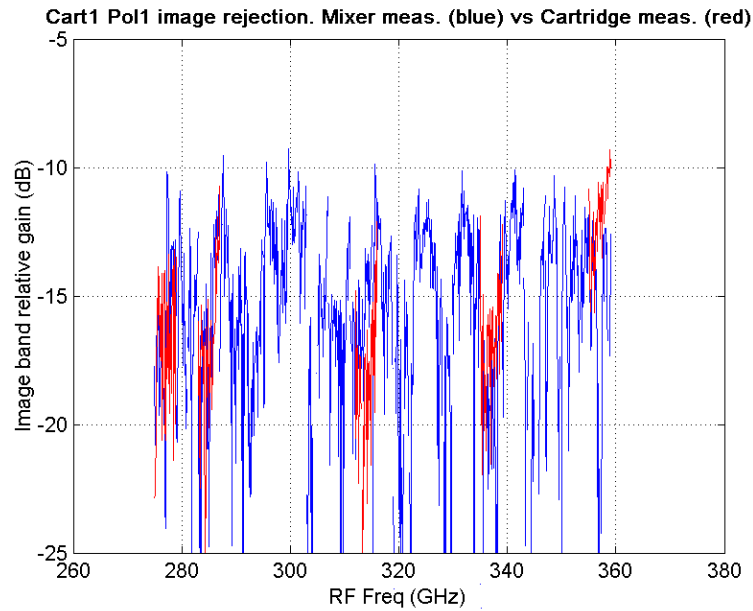


Figure 16: Cartridge#1 (5 LO Freq), and 2SB mixer (22 LO Freq) LSB image rejection

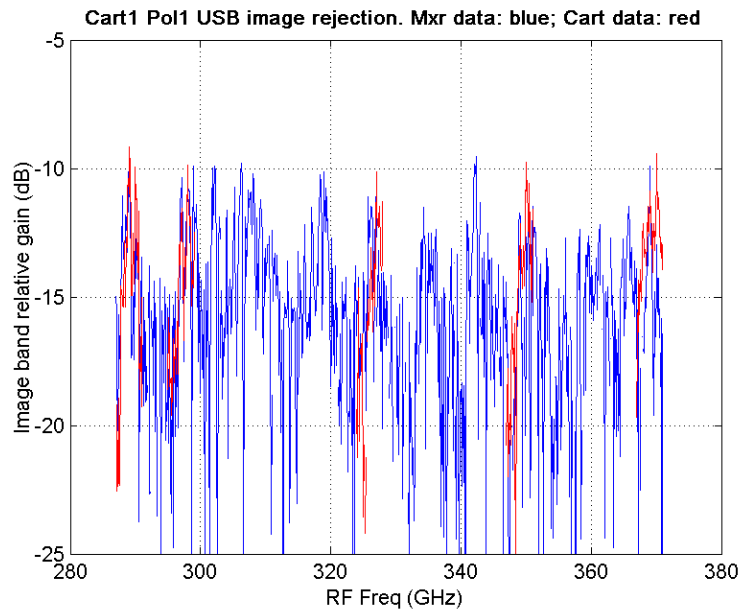


Figure 17: Cartridge#1 (5 LO Freq), and 2SB mixer (22 LO Freq) USB image rejection

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4 Gain Saturation

4.1 Compliance Matrix

The table below lists the performance compliance for the specific test. Additionally, the electronic database confirming the compliance to the requirements of [AD1] and [AD4] will be completed and supplied along with the cartridge.

Serial No	Item	Specification No	Compliance
3	Performance Requirements		
3.4	Gain saturation/compression	FEND-40.02.07.00-00230-00/T	C

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4.2 Test Results

The cartridge#1 gain saturation is between 0.36% and 1.56% that gives a large headroom with respect to the 5% specification.

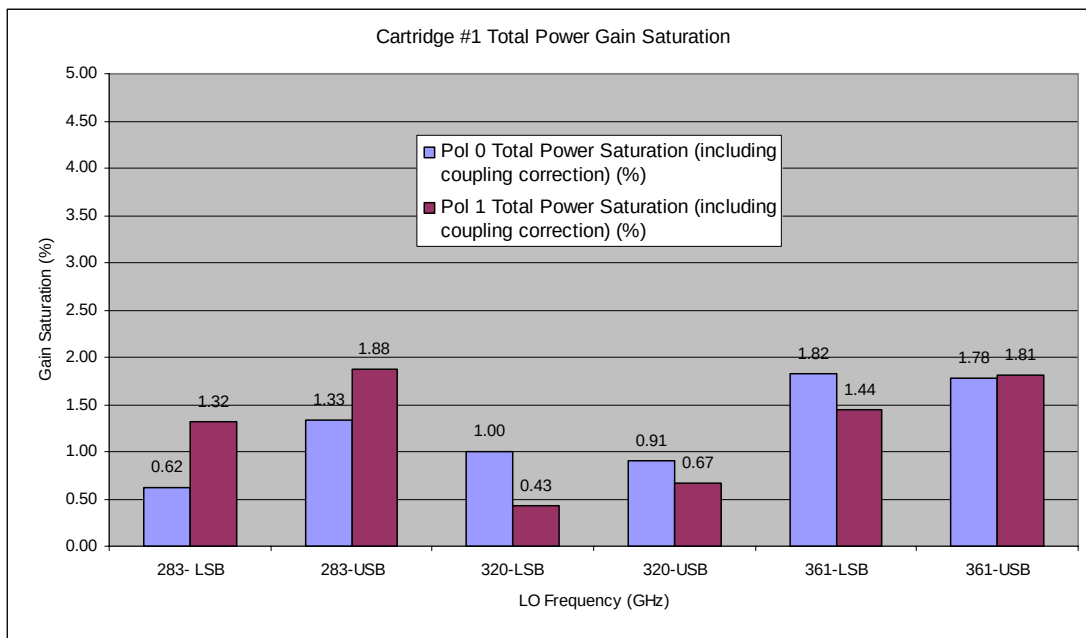


Figure 18: Cartridge#1 gain saturation

5 Amplitude Stability

5.1 Compliance Matrix

The table below lists the performance compliance for the specific test. Additionally, the electronic database confirming the compliance to the requirements of [AD1] and [AD4] will be completed and supplied along with the cartridge.

Serial No	Item	Specification No	Compliance
3	Performance Requirements		
3.5	Amplitude stability	FEND-40.02.07.00-00240-00/T	C
3.5.1	<i>Allan variance of IF output</i>		C

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	<i>power in any channel</i>		
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5.2 Test Results

The Allan deviation ($\sqrt{\text{var}}$) of the IF output power shall be less than $6.3 \cdot 10^{-4}$ over 0.1 to 1 sec timescale. Worst case is about $3 \cdot 10^{-4}$, the spec is met.; see Figure 19.

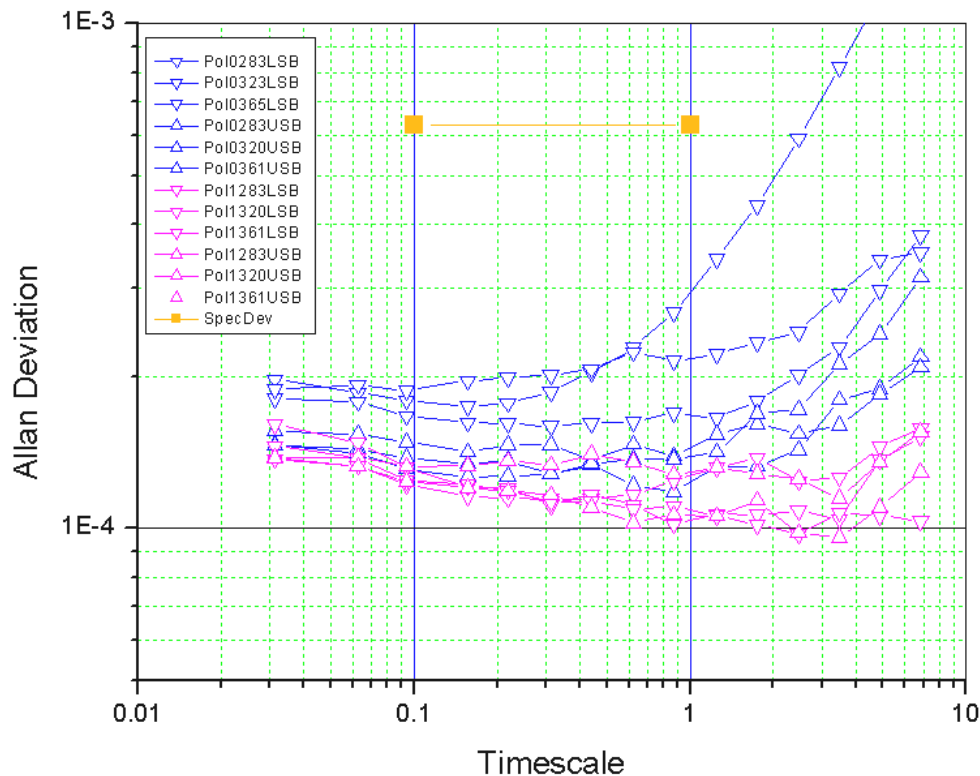


Figure 19: Cartridge#1 amplitude stability

6 Phase Stability

6.1 Compliance Matrix

The table below lists the performance compliance for the specific test. Additionally, the electronic database confirming the compliance to the requirements of [AD1] and [AD4] will be completed and supplied along with the cartridge.

For all frequencies within the IF passband, the signal path transfer function shall maintain a phase stability of better than 0.9° on timescales up to 300 seconds.

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Serial No	Item	Specification No	Compliance
3	Performance Requirements		
3.6	Signal path phase stability	FEND-40.02.07.00-00250-00/T	C

6.2 Test Results

As one can see on Figure 20, the phase drift over 5 minutes is less than one degree. In order to get such results, we have thermally insulated the coaxial cables that carry critical signals (essentially from the YIG to the harmonic mixer) as well as stabilized the in-line amplifier drift versus temperature variations using a big brick of copper to cool it down.

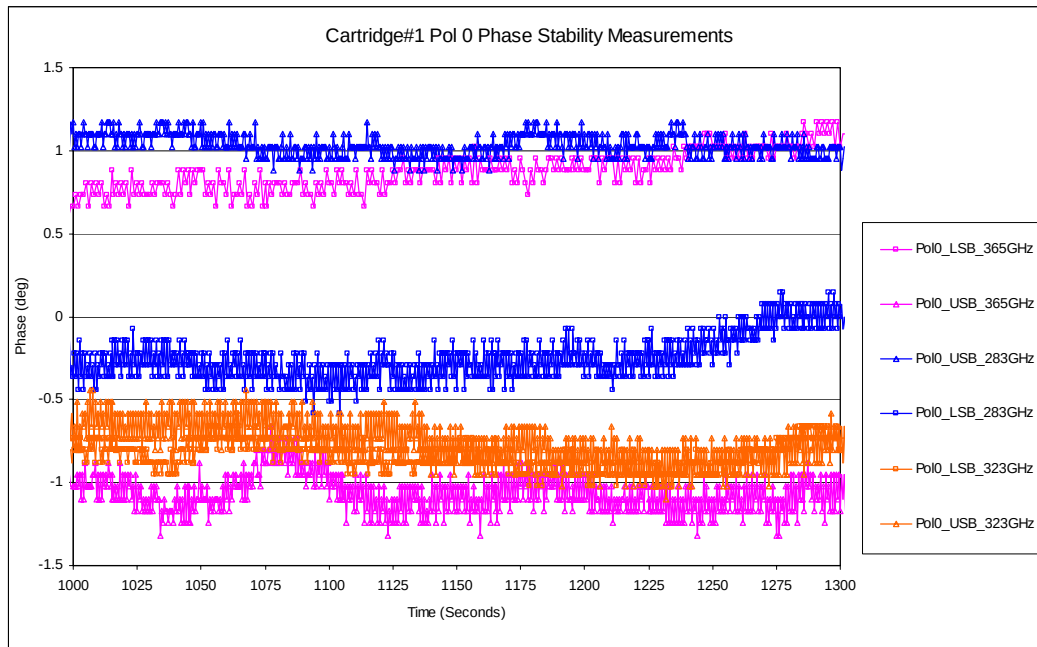


Figure 20: Cartridge#1 Pol 0 phase stability

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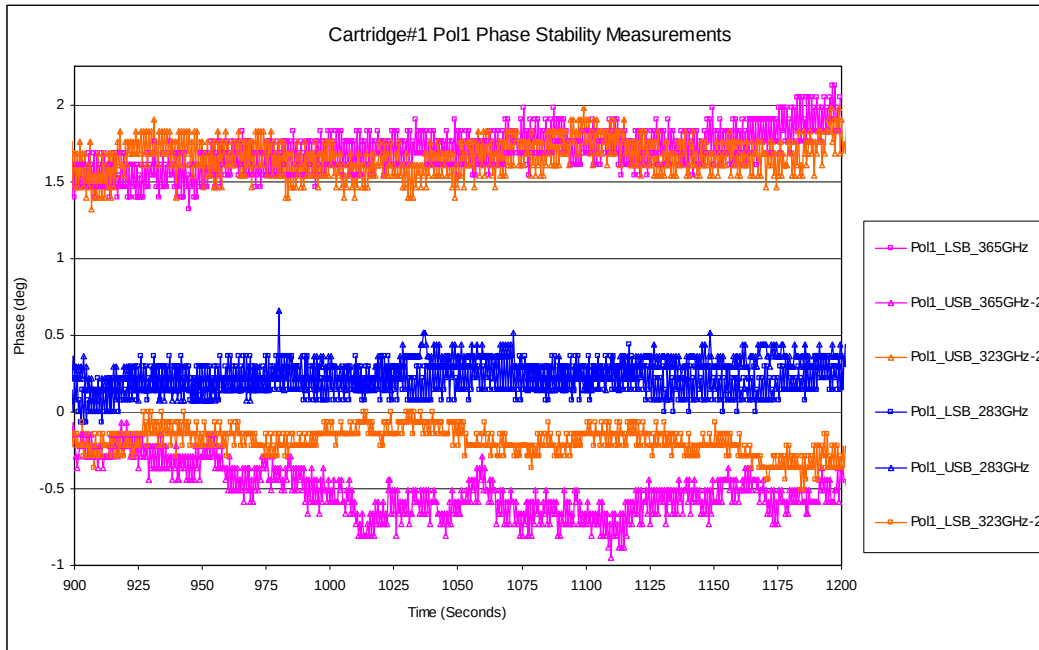


Figure 21: Cartridge#1 Pol1 Phase Stability

7 Beam Efficiency

7.1 Compliance Matrix

The table below lists the performance compliance for the specific test. Additionally, the electronic database confirming the compliance to the requirements of [AD1] and [AD4] will be completed and supplied along with the cartridge.

Serial No	Item	Specification No	Compliance
3	Performance Requirements		
3.7	Optics		
3.7.1	RF beam efficiency	FEND-40.02.07.00-00260-00/T	C

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7.2 Test Results

The fraction of the cartridge radiation diagram coupled to the subreflector shall exceed 90%.

For the cartridge#1, the coupling is better than 93%.

The results obtained by measurement agree with computed values derived from 2D scan measurements.

Table 9: table showing the beam efficiency test results.

Freq (LO)	At Cryostat Window		At 900 mm (f/8) from window		Efficiency	Polarisation
	Phot (uW)	Pcold	Phot	Cold		
283	2,62	1,14	2,72	1,3	0,96	Pol0 (LSB)
320	1,9	0,784	2	0,92	0,97	Pol0 (LSB)
361	1,44	0,789	1,5	0,88	0,95	Pol0(LSB)
361	1,4	0,77	1,44	0,85	0,94	Pol0 (USB)
283	1,88	0,7	1,97	0,819	0,98	Pol1 (LSB)
320	1,16	0,525	1,21	0,6	0,96	Pol1 (LSB)
361	0,875	0,429	0,898	0,483	0,93	Pol1 (USB)

8 Polarization Alignment Accuracy

8.1 Compliance Matrix

The table below lists the performance compliance for the specific test. Additionally, the electronic database confirming the compliance to the requirements of [AD1] and [AD4] will be completed and supplied along with the cartridge.

Serial No	Item	Specification No	Compliance
3	Performance Requirements		
3.7	Optics		
3.7.3	Polarization alignment accuracy	FEND-40.02.07.00-00280-00/T	C

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8.2 Test Results

The actual angle between the orientation of the E-vector of the polarisation channel designated “polarisation 0” at the cartridge RF input and the ideal polarisation alignment shall be less than 2 degree. It is actually better than 0.8 degrees for both polarisations.

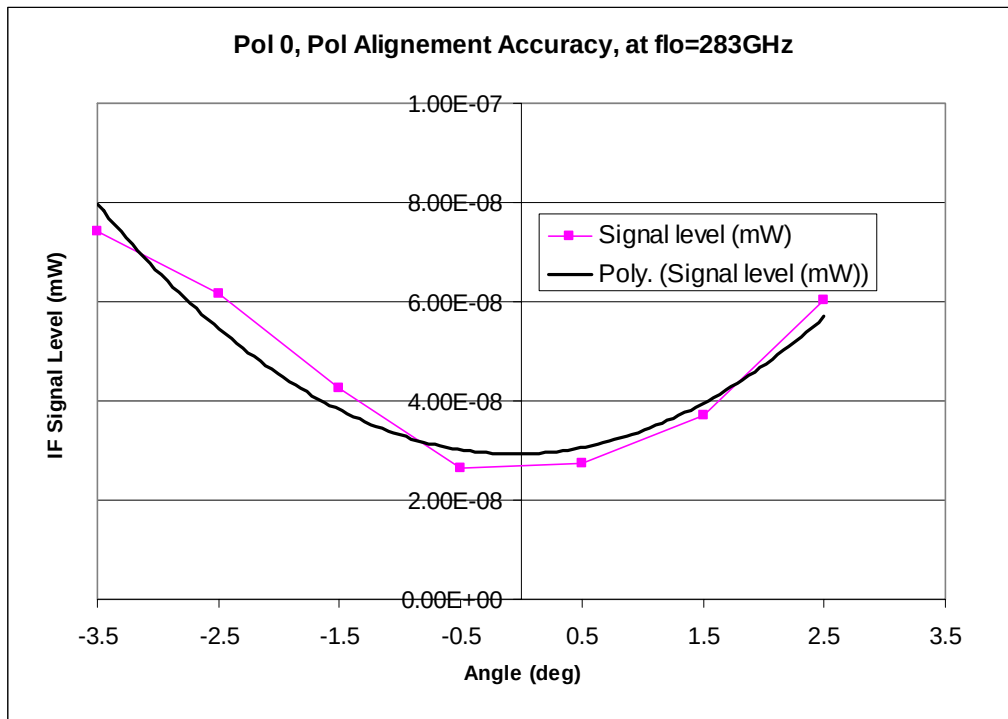


Figure 22: Pol 0 alignment accuracy, flo=283GHz, alignment offset close to 0 degree

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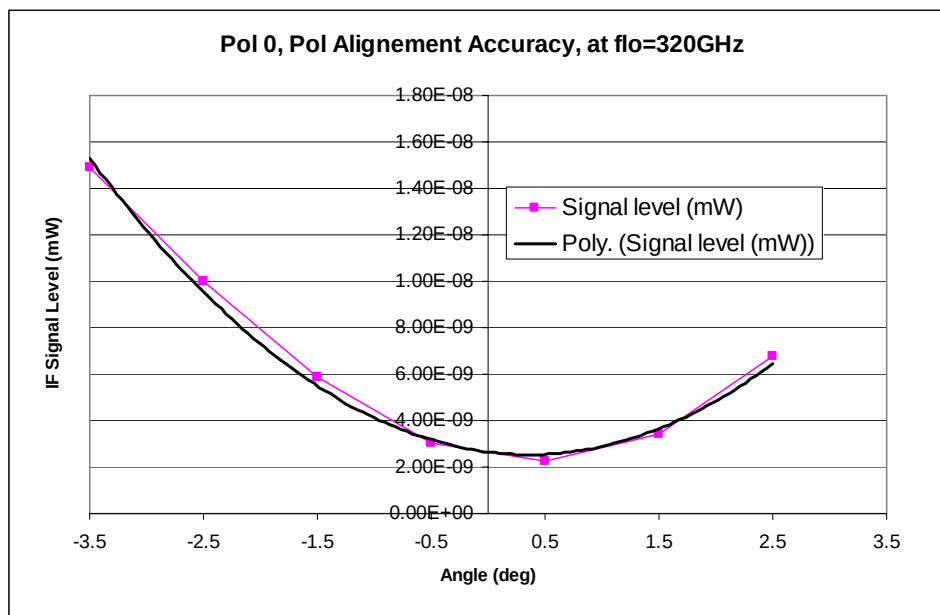


Figure 23: Pol 0 alignment accuracy, flo=320GHz, alignment offset close to 0.5 degree

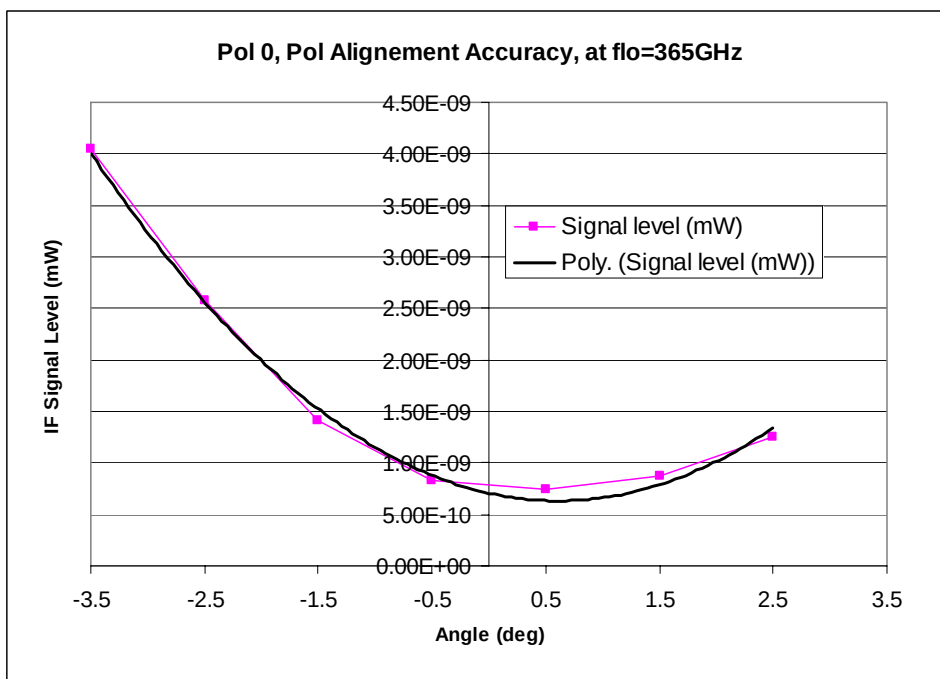


Figure 24: Pol 0 alignment accuracy, flo=365GHz, alignment offset close to 0.6 degree

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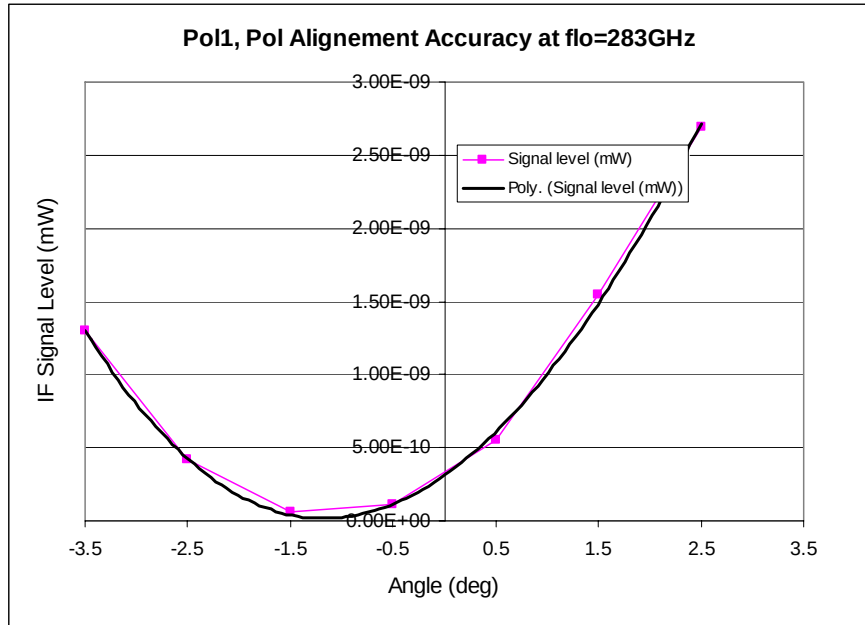


Figure 25: Pol 1 alignment accuracy, flo=283GHz, alignment offset close to -1.25 degree

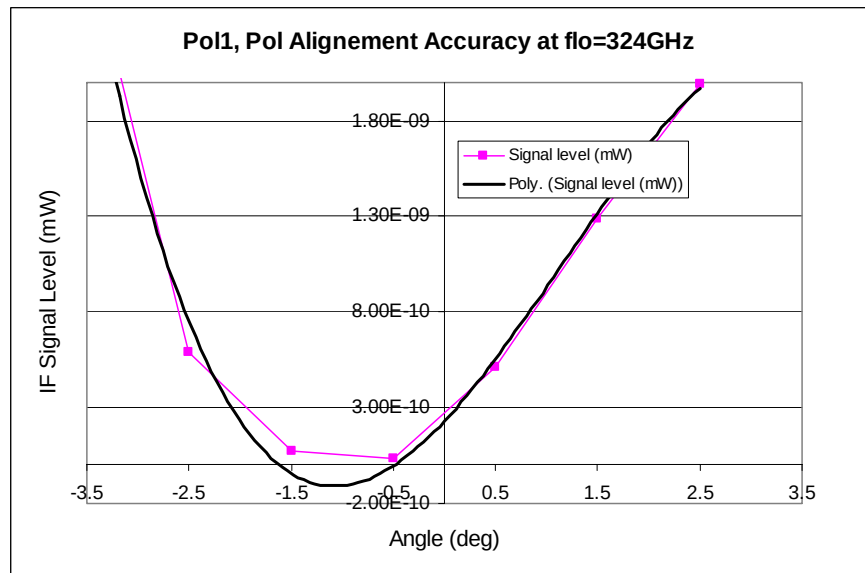


Figure 26: : Pol 1 alignment accuracy, f=324GHz, alignment offset close to -1.0 degree

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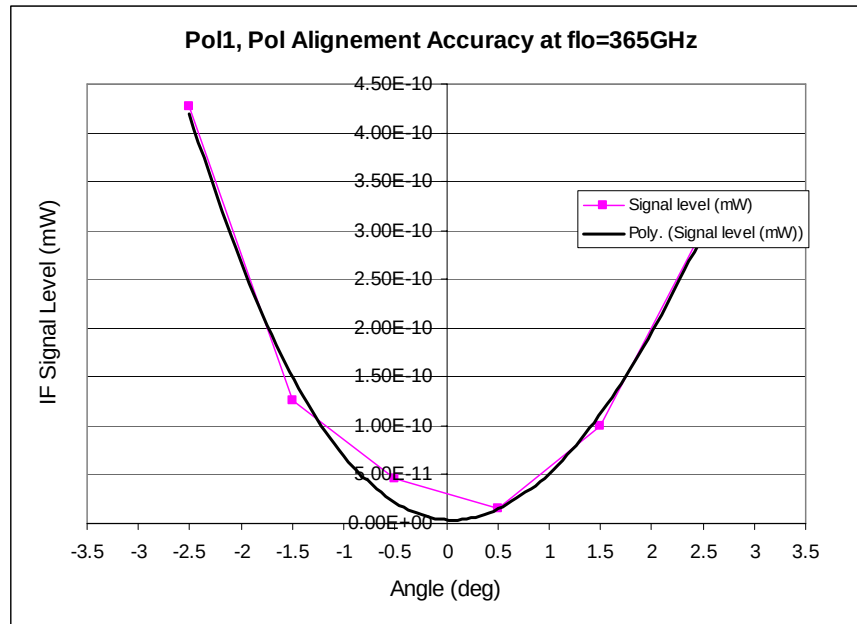


Figure 27: : Pol 1 alignment accuracy, f=367GHz, alignment offset close to 0.2 degree

9 Cross Polarization

9.1 Compliance Matrix

The table below lists the performance compliance for the specific test. Additionally, the electronic database confirming the compliance to the requirements of [AD1] and [AD4] will be completed and supplied along with the cartridge.

Serial No	Item	Specification No	Compliance
3	Performance Requirements		
3.7	Optics		
3.7.4	Cross-polarization	FEND-40.02.07.00-00290-00/T	Mostly C

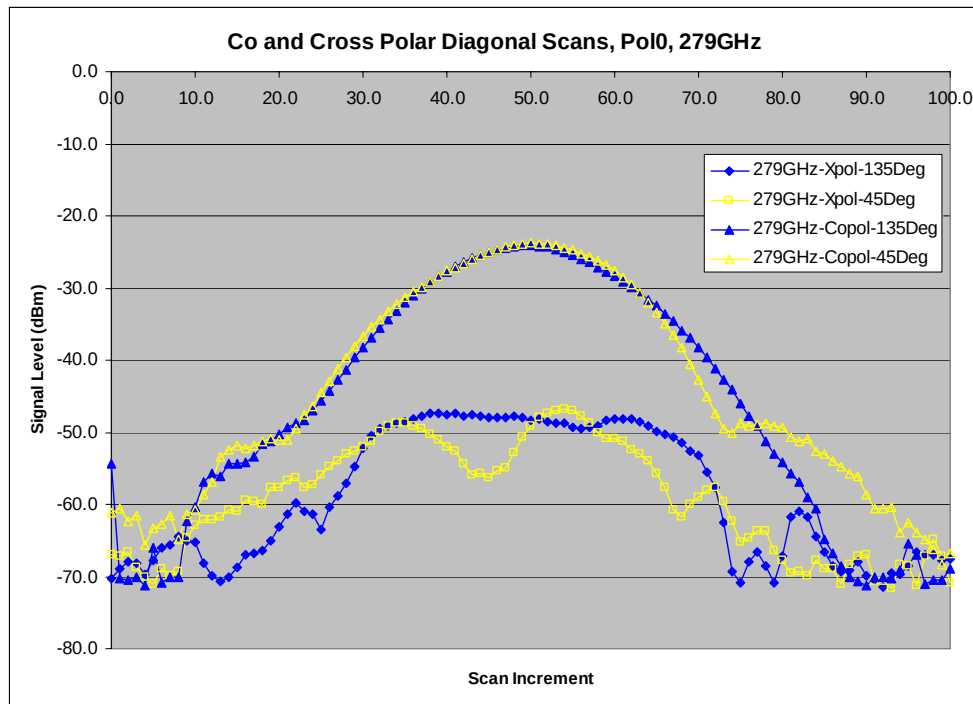
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9.2 Test Results

At any frequency within the Front End's tuning range, the cross polarised component for each of the polarisation channels shall be at least 20dB below the desired co-polar signal component.

	P0_279	P0_324	P0_365	P1_279	P1_324	P1_365
-135Deg	-23.29	-20.85	-23.01	-21.26	-21.13	-20.20
-45Deg	-22.97	-19.60	-22.62	-23.83	-22.09	-21.78

Table 10: Cross-polarisation Test results





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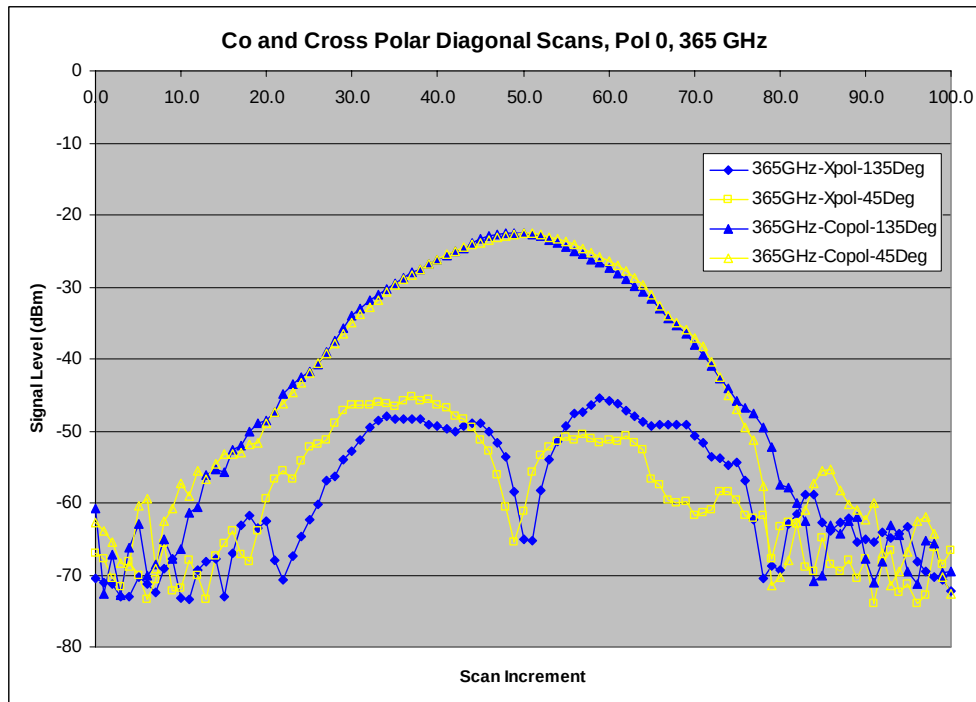
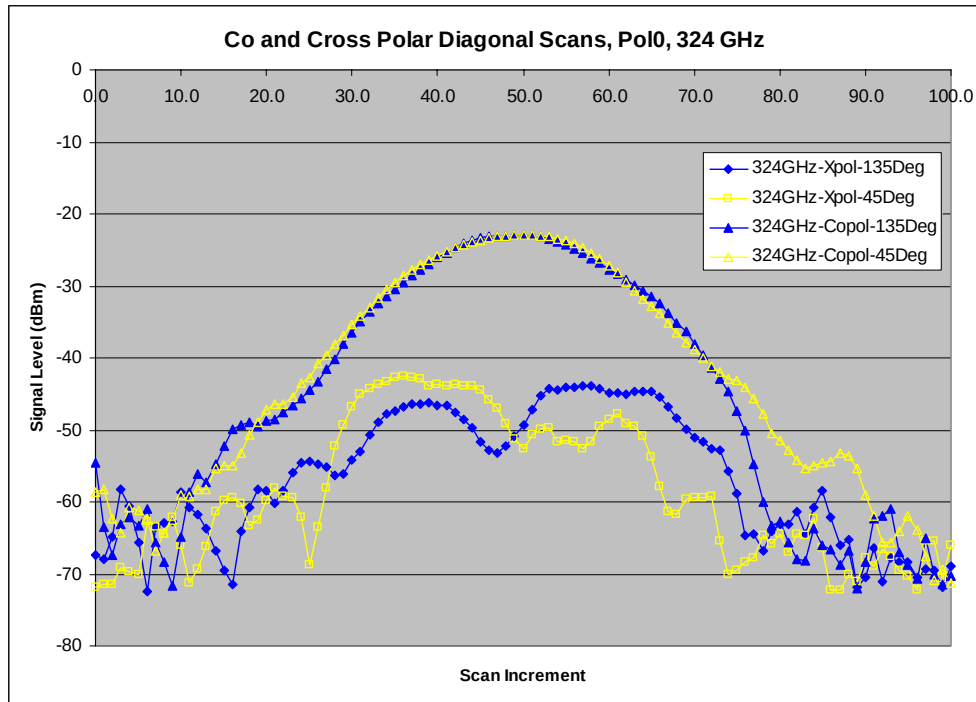
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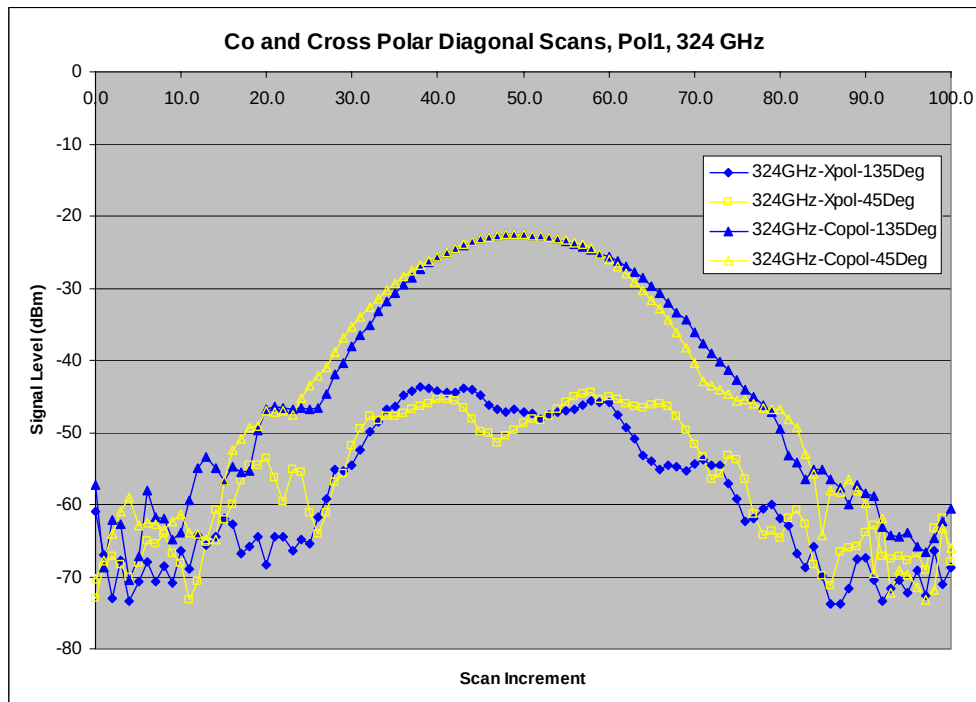
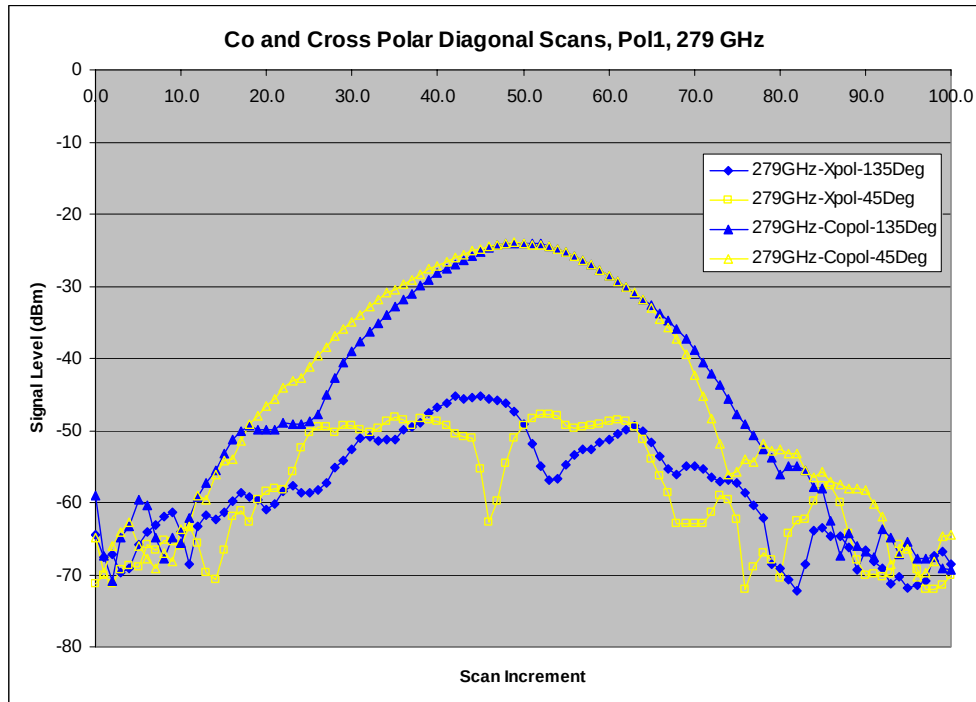
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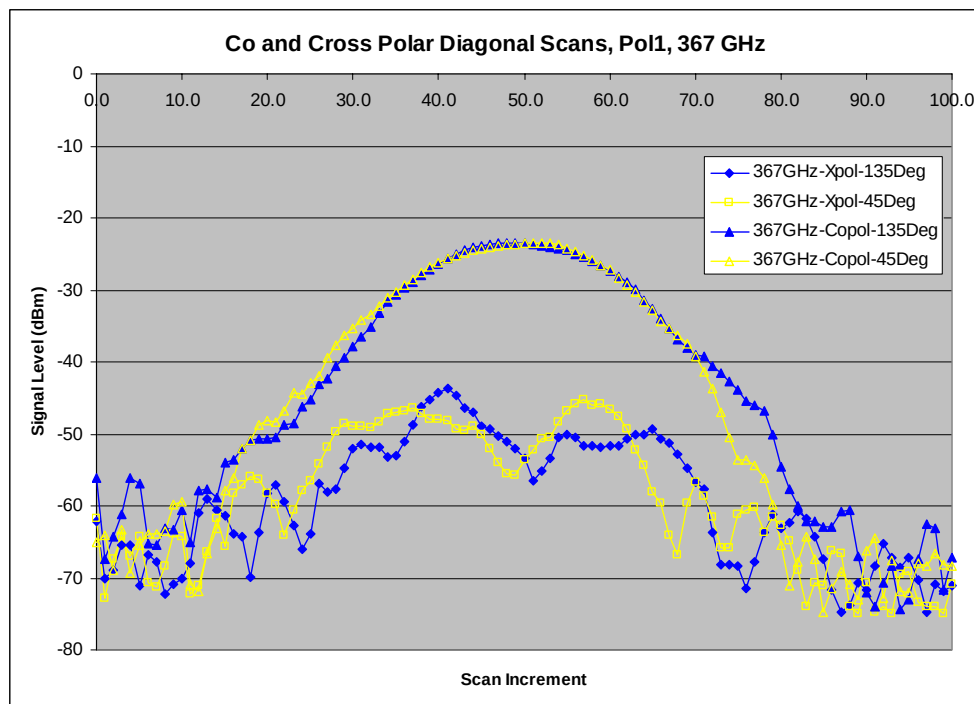
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10 Stabilization Time

10.1 Compliance matrix

The table below lists the performance compliance for the specific test

Serial No	Item	Specification No	Compliance
3	Performance Requirements		
3.8	Stabilization Time		
3.8.1	From non-operational mode	FEND-40.02.07.00-00300-00/T	C
3.8.2	From stand-by mode	FEND-40.02.07.00-00305-00/T	Not Checked

10.2 Test results

From the non-operational mode, the front end shall reach the operational mode within 15 minutes.

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That specification has been checked measuring the cartridge phase stability. Two cases were looked at.

- WCA already powered and stabilized, cold cartridge and warm IF power supplies turned ON
- Cold Cartridge & WCA power supplies turned ON (full cold start)

In both cases, the variation of the receiver phase stability has been recorded. (see Figure 28).

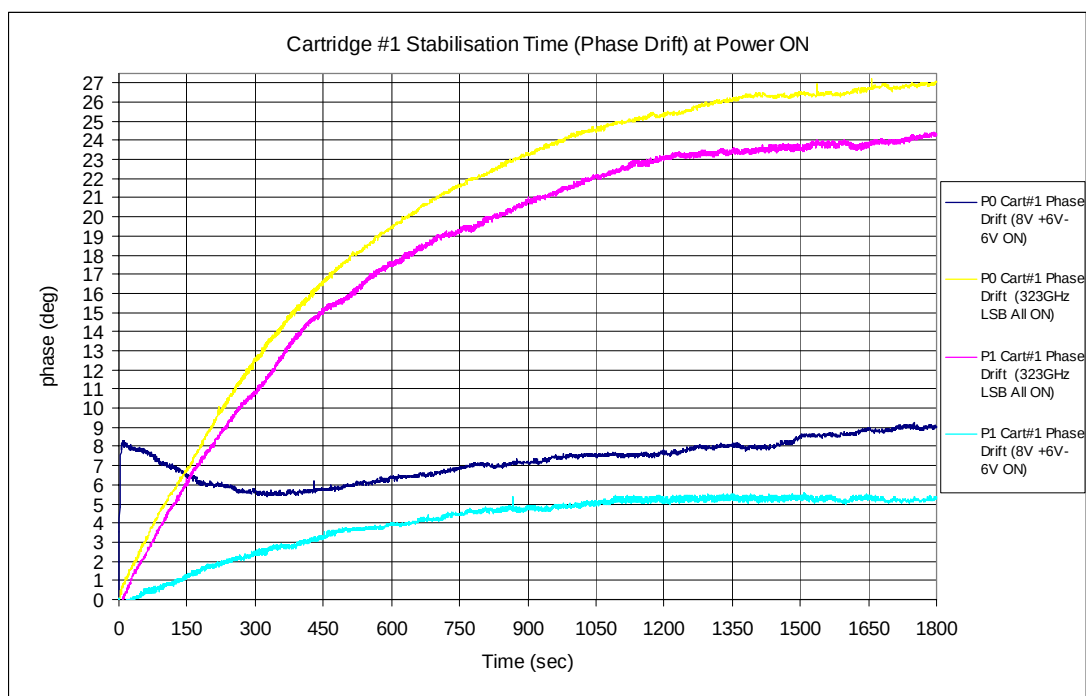


Figure 28: Cart#1 Phase Stability measurements. A) all power supplies turned on at t=0. B) WCA already on and stabilized; at t=0 power on cold cartridge and warm IF.

From the stand-by mode, the operational mode shall be reached within 1.5 seconds. That has not been checked since it takes more than 1.5 seconds to set up the test system.

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11 Spurious

11.1 Compliance matrix

The table below lists the performance compliance for the specific test

Serial No	Item	Specification No	Compliance
3	Performance Requirements		
3.x	Spurious	No spurious specification is written-up in the Band 7 Cartridge Technical Specifications document	C

11.2 Test results

The test is carried out performing a sweep across the IF band with 50MHz steps. Any spurs present in the band would show up.

The Figure 29 below does not show any abnormal signal excess across the band.

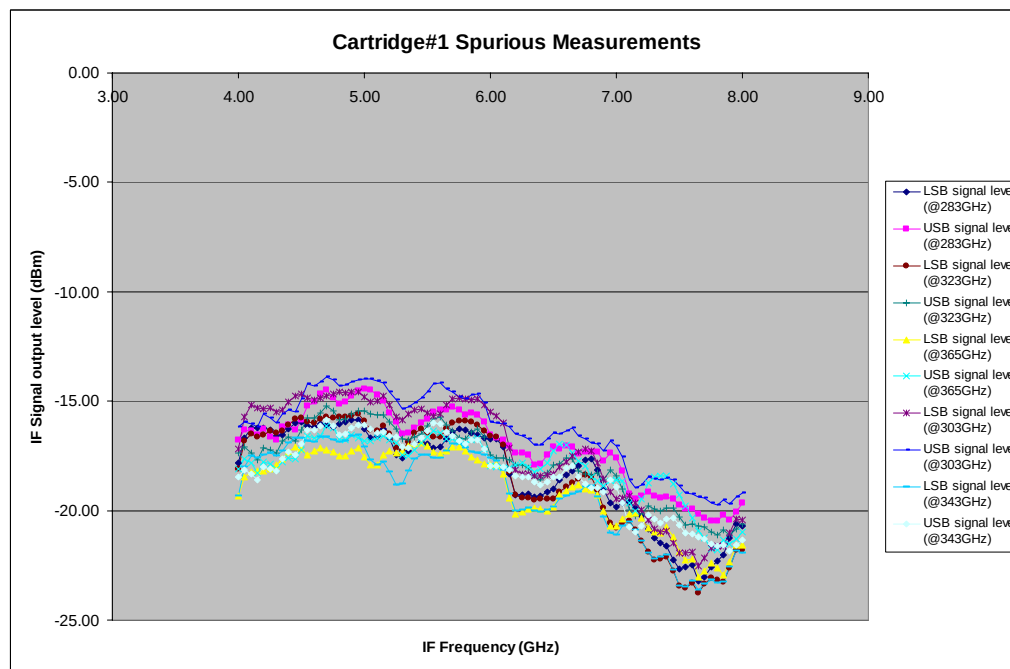


Figure 29: Cart#1 Spurious Test Results at three LO frequencies.

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12 Leak Rate

12.1 Compliance matrix

The table below lists the performance compliance for the specific test

Serial No	Item	Specification No	Compliance
5	Operating conditions		
5.3	Vacuum conditions	FEND-40.02.07.00-00470-00/R In addition to the requirements of [AD7], leak rate should be measured on at least one baseplate to ensure compliance to [AD6]	NC

Notes:

[AD6]: ICD between Band 7 Cartridge and Dewar

[AD7]: Vacuum requirements for receiver components inside the ALMA Front End Cryostat

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12.2 Test results

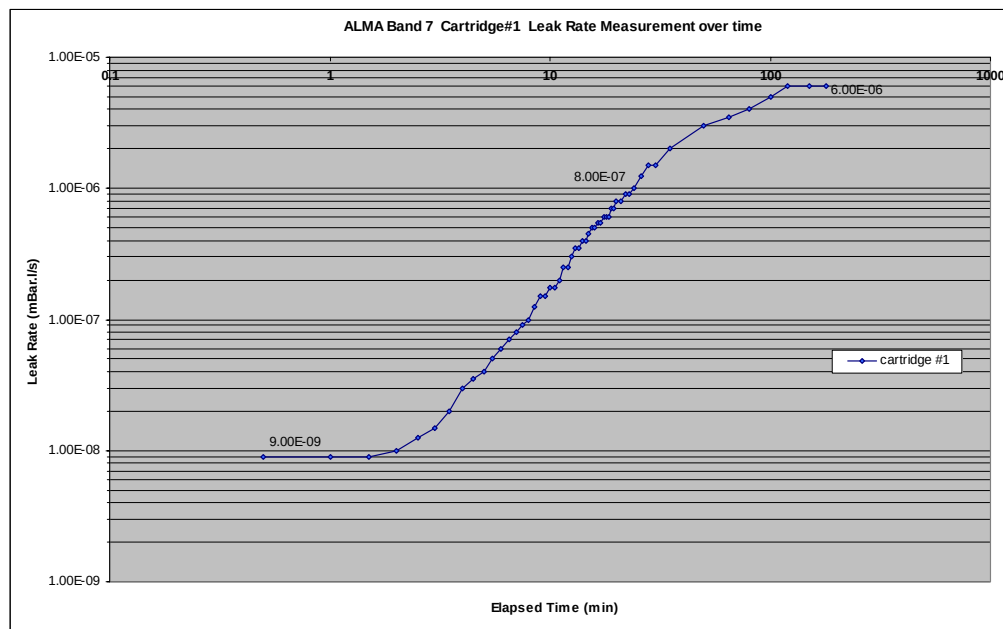


Figure 30: Cartridge#1 leak rate measurement over time

The proposed specification was to achieve a leak rate after 20 minutes of 2×10^{-7} mBar.l/sec; specification that is not met, since we get 8×10^{-7} mBar.l/sec after 20 minutes of constant exposure to Helium gas.

13 Conclusion

The cartridge #1 meets most of the specification described in the [AD1]. In some cases , the frequency at which the tests have been carried out differ from the frequency that are specified in the test plan. This is due to the fact that the test plan has only been agreed recently, after the cartridge#1 had been tested.

In the future, there will be a strict agreement between the test plan and the frequencies at which the cartridges will be tested.