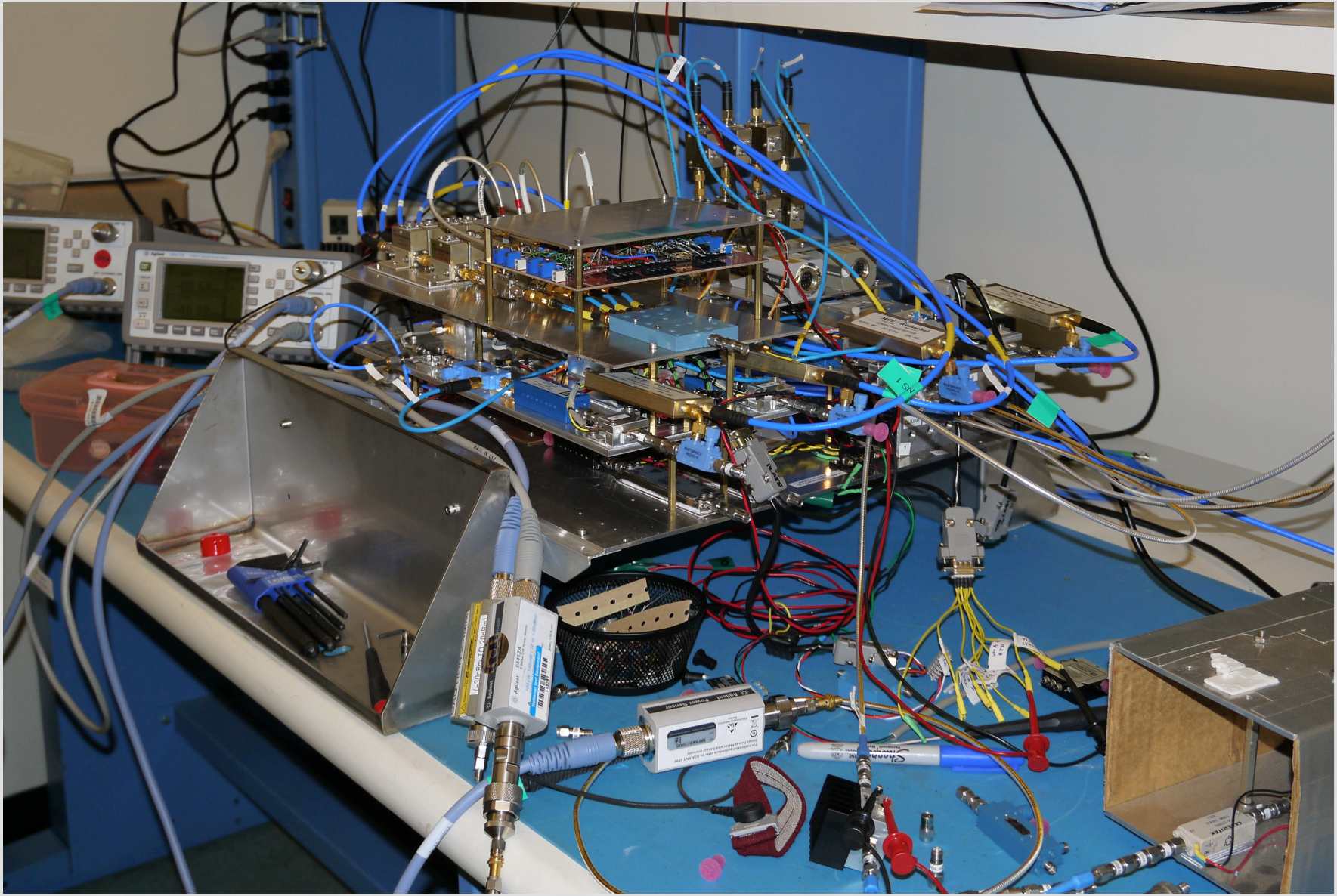
YTLA Project
Prototype Down Converter Plate Characterization

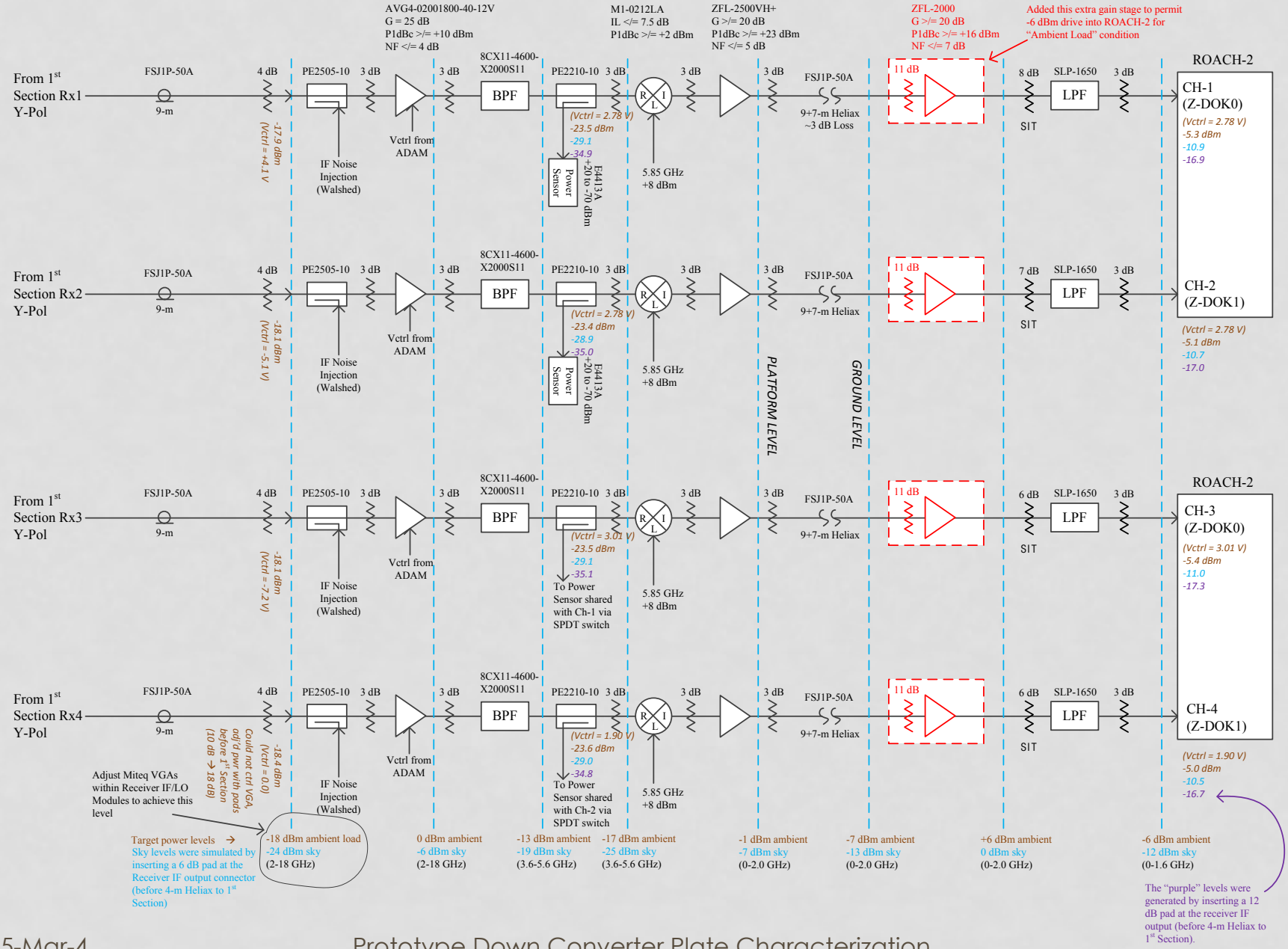
Timeline:
2015-Feb-12 Down Converter removed from telescope platform and brought down to Hilo
2015-Feb-25 Down Converter reinstalled on telescope platform

Filename = DC_Plate_Tests

Derek Kubo
John Kuroda



"As Built Configuration" Down Converter Plate Schematic (cal noise source not shown)



Baseband Output SNR Measurements

2-18 GHz noise source @ -24 dBm connected to down converter input

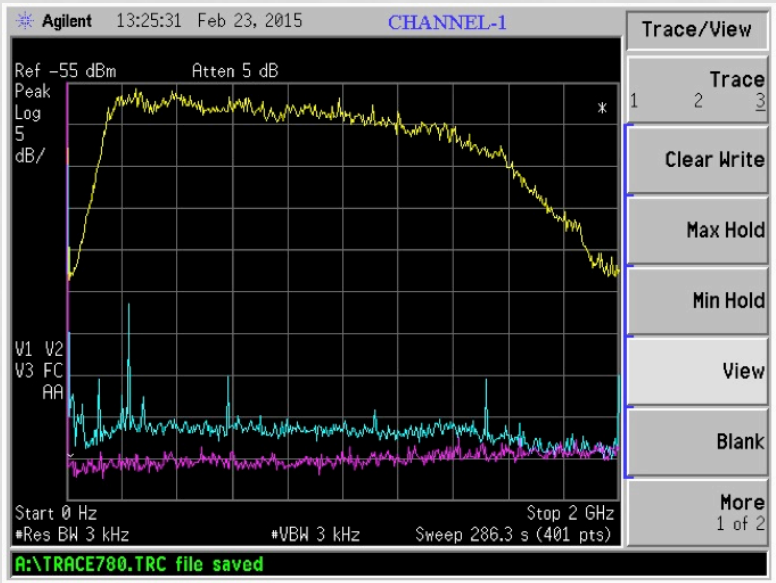
Yellow – VGAs set to produce -12 dBm at baseband output

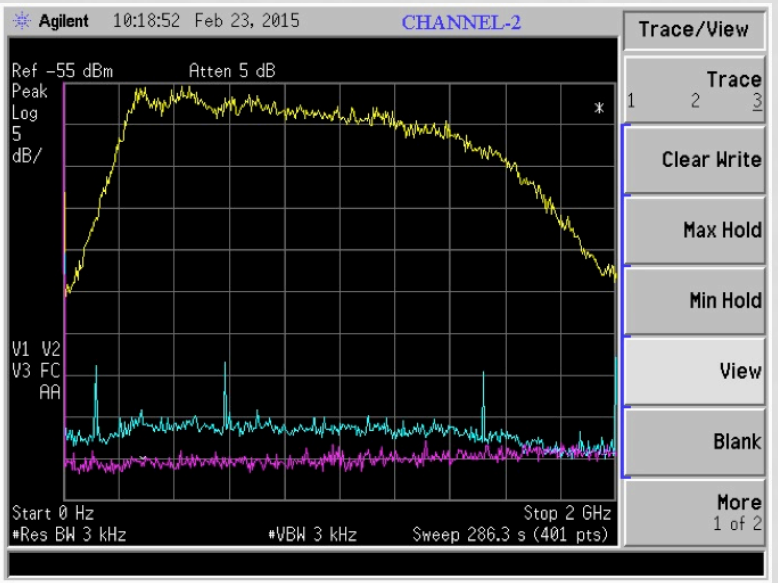
Blue – Noise source removed from down converter input and terminated to 50 Ohms

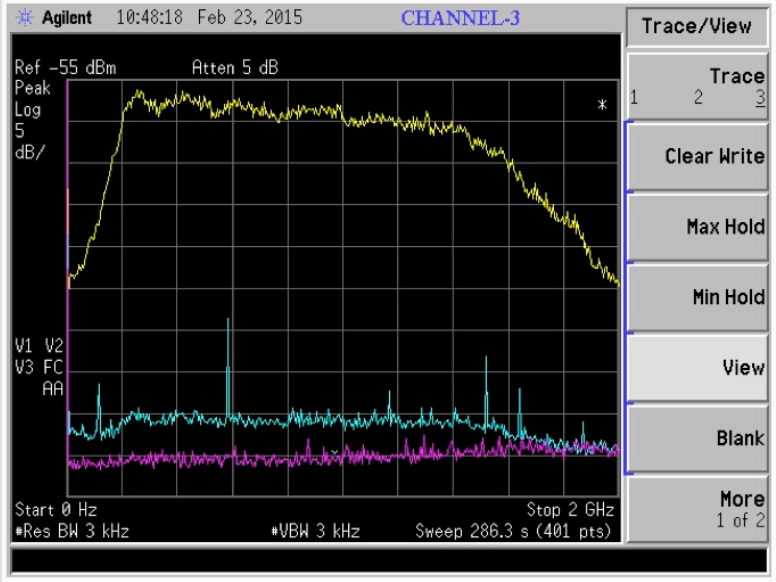
Purple – Spectrum analyzer noise floor

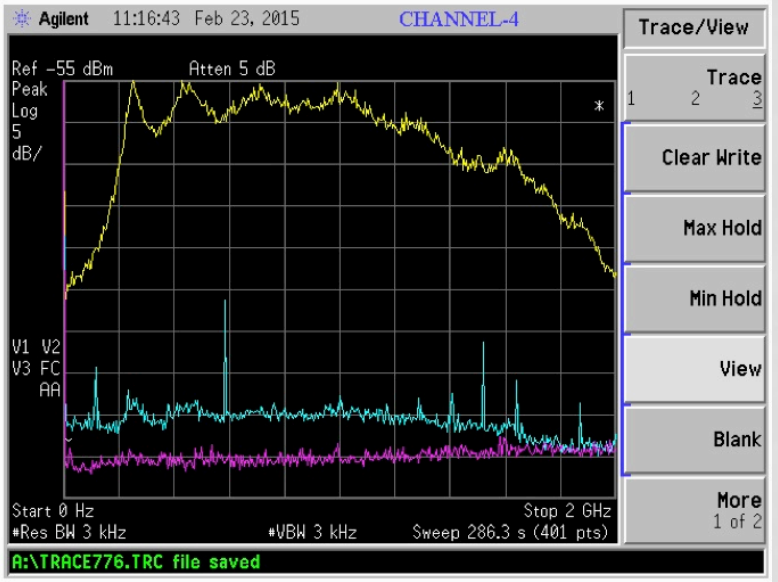
Approximate spot SNRs at 1 GHz:

CH1 >/= 40 dB
CH2 >/= 38 dB
CH3 >/= 36 dB
CH4 >/= 38 dB









Noise Figure Measurement and Analysis

With -24 dBm broadband noise (2-18 GHz) presented at the inputs, fine adjusted the VGA gains to produce -12 dBm at the outputs of the 4 channels.

Terminated the inputs with 50 Ohms and measured the baseband noise power level outputs for the 4 channels*:

CH1 = -46 dBm → SNR = 34 dB
CH2 = -52 dBm → SNR = 40 dB
CH3 = -51 dBm → SNR = 39 dB
CH4 = -49 dBm → SNR = 37 dB

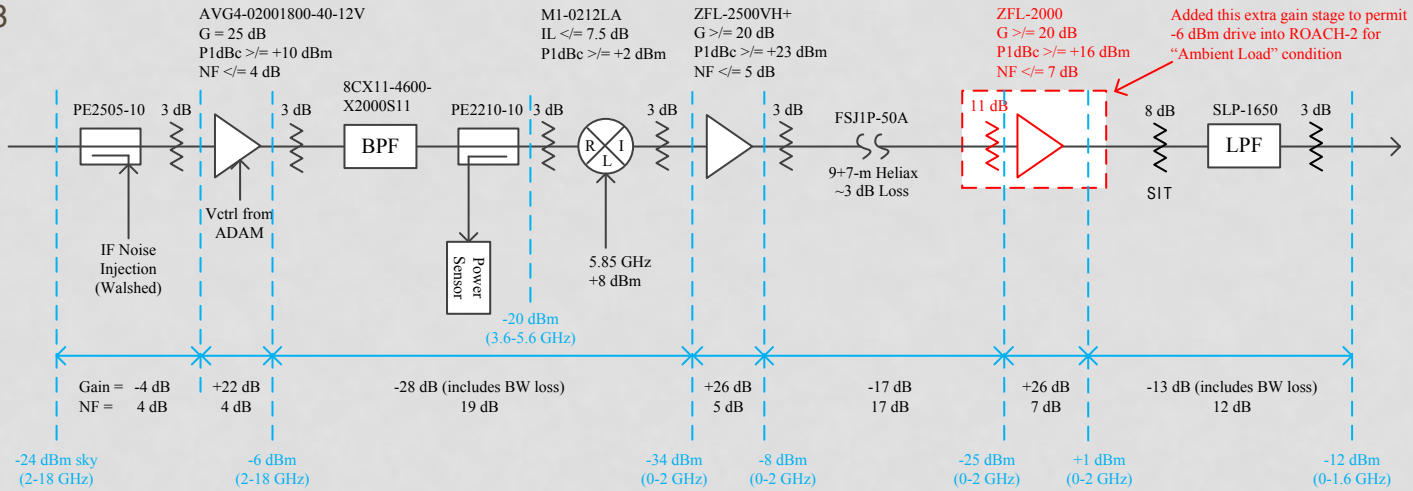
Noise Figure analysis to right shows equivalent noise power output of -49.5 dBm, fairly close to the measured values.

Reduction in Y-factor due to down converter noise:

300K → -8.0 dBm → 1.585e-1 mW
LN2 → -12.0 dBm → 6.310e-2 mW
300K/LN2 = 2.5119 → **4.0000 dB**

-49 dBm → 1.259e-5 mW
(1.585e-1 + 1.259e-5)/(6.310e-2 + 1.259e-5)
= 2.5116 → **3.9995 dB**

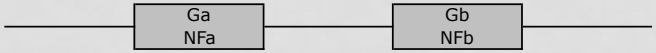
*Measurements may have been affected by spurs



NOISE FIGURE CALCULATOR 2015mar3

Enter values in yellow columns, if you have less than 10 items then enter in a gain of 0 dB and NF of 0 dB.
Read final values shaded in green in lower right.

This spreadsheet is based on the following relationship for 2 cascaded devices:
NFab = NFa + [(NFb - 1)/Ga]



Item #	Gain (dB)	NF (dB)	gain	nf	cascaded gain	cascaded nf	Final Gain (dB)	Final NF (dB)
1	-4	4	0.40	2.51	0.40	2.51	-4.00	4.00
2	22	4	158.49	2.51	63.10	6.31	18.00	8.00
3	-19	19	0.01	79.43	0.79	7.55	-1.00	8.78
4	26	5	398.11	3.16	316.23	10.27	25.00	10.12
5	-17	17	0.02	50.12	6.31	10.43	8.00	10.18
6	26	7	398.11	5.01	2511.89	11.07	34.00	10.44
7	-12	12	0.06	15.85	158.49	11.07	22.00	10.44
8	0	0	1.00	1.00	158.49	11.07	22.00	10.44
9	0	0	1.00	1.00	158.49	11.07	22.00	10.44
10	0	0	1.00	1.00	158.49	11.07	22.00	10.44

The formula below calcuates the equivalent noise output of the circuit with the input port terminated to 50 Ohms.
It uses the values of G and NF determined above. Enter the bw in Hz in the yellow box below:

Pout = (k*T*bw)*g*nf in Watts
Pout = -174 dBm/Hz + 10*Log(bw) + G + NF in dBm

bandwidth		Pout (dBm)
1.60E+09	Hz	-49.52

Baseband Magnitude Response vs. VGA Gain Measurements

Broadband noise source (2-18 GHz) used as stimulus, -24 dBm

VGAs adjusted to produce +/-5 dB variations from nominal -12 dBm baseband outputs.

Blue – High output power of -7 dBm:

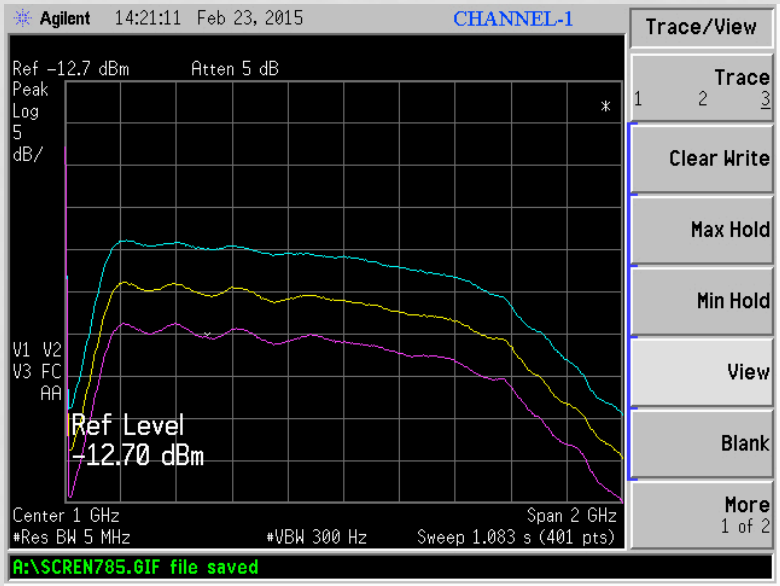
CH1 (2.69V) = -6.6 dBm
CH2 (2.69V) = -6.4 dBm
CH3 (2.78V) = -7.4 dBm
CH4 (2.68V) = -6.7 dBm

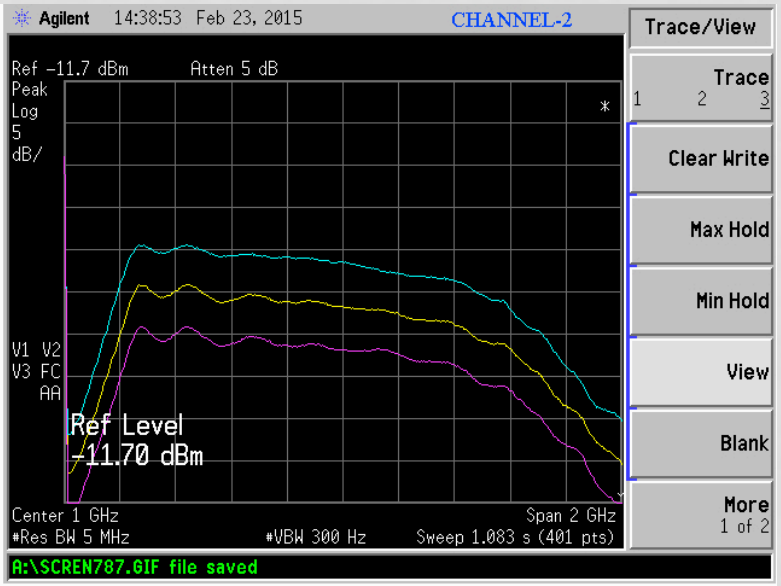
Yellow – Nominal output power of -12 dBm:

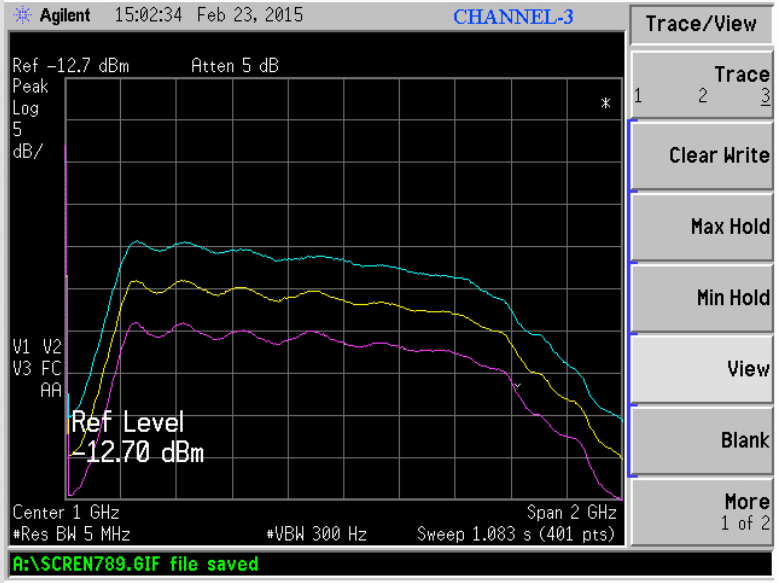
CH1 (3.75V) = -11.8 dBm
CH2 (3.75V) = -11.5 dBm
CH3 (3.75V) = -12.0 dBm
CH4 (3.75V) = -11.7 dBm

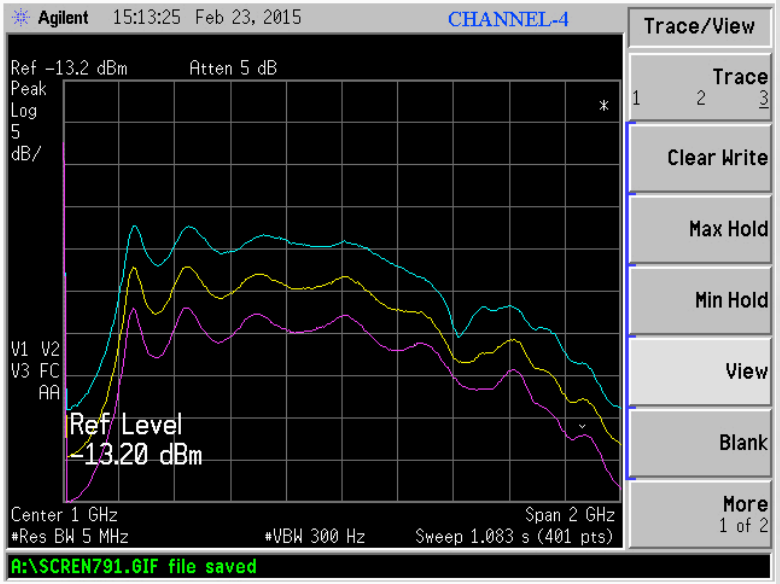
Purple – Nominal output power of -17 dBm:

CH1 (5.61V) = -17.0 dBm
CH2 (5.61V) = -16.7 dBm
CH3 (5.60V) = -17.3 dBm
CH4 (5.70V) = -16.7 dBm

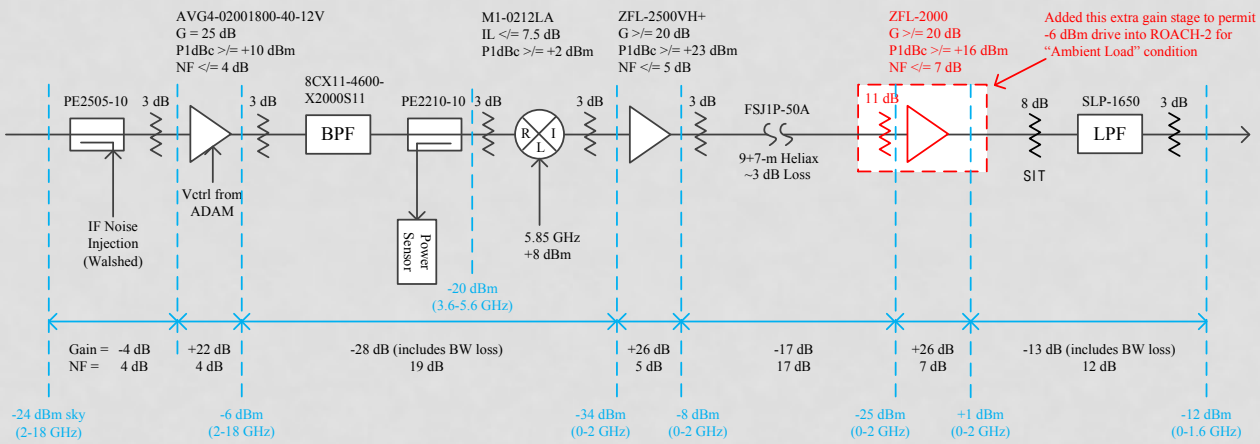


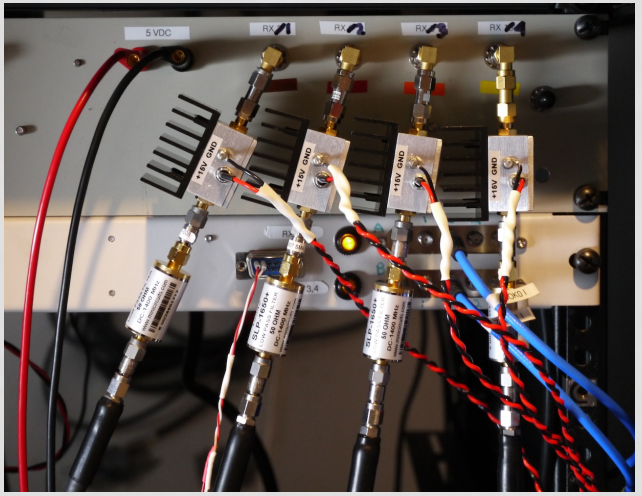






Signal Linearity Measurements (performed at Mauna Loa)





Characterized linearity shortly after plate was brought down to Hilo but results have been invalidated since the addition of the 2nd baseband amplifier (ZFL-2000)

Ran out of time so conducted a simulated Y-factor test using pads (0, 6 and 12 dB) at the receiver IF output after we installed the plate back onto the telescope platform

Changing 12 dB pad to 6 dB results in 6 dB* change at baseband outputs and implies linear operation in this regime

Changing 6 dB pad to 0 dB results in results in 5.6 dB change at baseband outputs and implies signal compression

*Some channels showed larger than 6 dB deltas and may be attributed to VSWR mismatch errors

Rx #	Simulated Condition	Pad at Rx Out (dB)	Coupler Pwr (dBm)	Delta Pwr (dB)	Pwr before cable (dBm)	Pwr at R2 (dBm)	Delta Pwr (dB)
1	Low	12	-34.9	0.0	-16.9	-17.6	0.0
1	Nom	6	-29.1	5.8	-10.9	-11.6	6.0
1	High	0	-23.5	11.4	-5.3	-6.0	5.6
2	Low	12	-35.0	0.0	-17.0	-17.7	0.0
2	Nom	6	-28.9	6.0	-10.7	-11.4	6.3
2	High	0	-23.5	11.4	-5.1	-5.8	5.6
3	Low	12	-35.1	0.0	-17.3	-18.0	0.0
3	Nom	6	-29.1	6.0	-11.0	-11.7	6.3
3	High	0	-23.5	11.6	-5.4	-6.1	5.6
4	Low	12	-34.8	0.0	-16.7	-17.4	0.0
4	Nom	6	-29.0	5.8	-10.5	-11.2	6.2
4	High	0	-23.6	11.2	-5.0	-5.7	5.5