NATIONAL RADIO ASTRONOMY OBSERVATORY

ELECTRONICS DIVISION TECHNICAL NOTE NO. 111

TITLE: Calibration of HP-346B Noise Sources at 1.3-1.7 GHz

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Two HP-346B avalanche diode noise sources were compared against NRAO liquid-nitrogen noise standard LN1 using the test setup shown in Figure 1. The noise standard LN1 has previously been compared with two Maury Microwave MT7118A liquid-nitrogen standards with agreement within $\pm$ 0.5K as described in NRAO Technical Note #101. An 0.5K temperature error corresponds to an error in excess noise ratio (ENR) of 10 log(220.5/220) = .01 dB.

The HP-346B sources had APC 3.5 male output connectors and were attenuated by an HP-8493B coaxial pad with attenuation measured with an HP-436 digital power meter; the attenuation at 100 MHz frequency steps from 1300 to 1700 MHz was 19.90, 19.89, 19.91, 19.93, and 19.92 dB. The return loss of the attenuator at its female and male connectors was 36 $\pm$ 1 dB and 27.5 $\pm$ 0.5 dB from 1 to 2 GHz. NRAO LN1 has return losses of 39 $\pm$ 1 dB at its cold port and 33 $\pm$ 1 dB at its hot port in the 1.3 to 1.7 GHz range. The receiver utilized a NRAO cooled GASFET amplifier with $\sim$ 9K noise temperature as described in NRAO EDIR #220. The receiver input return loss was 20 $\pm$ 2 dB from 1.3 to 1.7 GHz. Neither the phase of reflection coefficients nor the receiver noise parameters were measured; thus no corrections have been made for mismatch errors. However, since the reflection coefficients are so small, a maximum ENR error of .05 dB is expected from mismatch.

The NRAO Apple program, NOISECAL 2, was used for the measurements. The hot load is first connected and the receiver output, corrected for detector zero offset, is measured at 50 frequencies between 1 and 2 GHz. This is repeated with the cold load applied and the receiver noise temperature is then

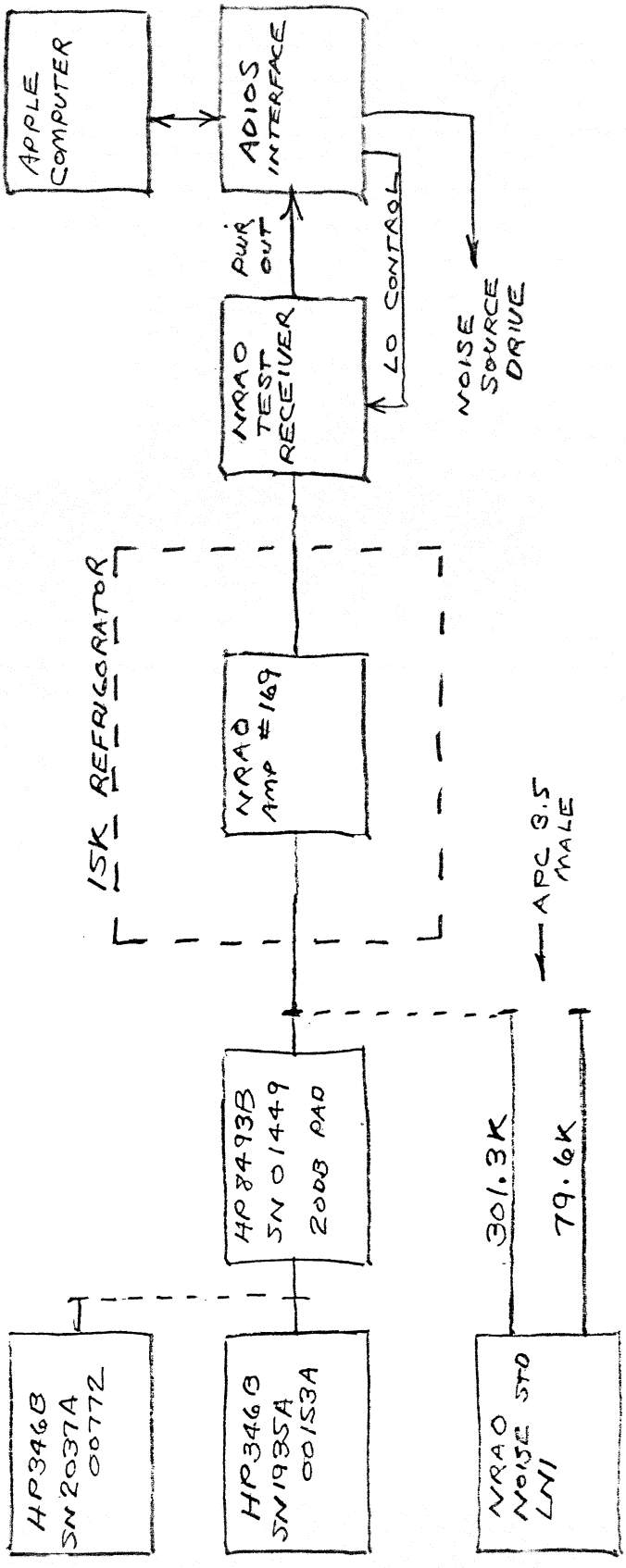

Fig. 1. Test setup for calibration measurements.

computed. The HP noise source plus attenuator is then connected and receiver output is measured with the noise source off and then on. This on/off switching was performed in two ways - statically or unmodulated and modulated at a 0.8 second on, 0.08 second blank time, 0.8 second off, 0.08 second blank time cycle.

A typical printout is shown in Figure 2 and a summary of results is shown in Table I. In conclusion:

1. HP-346B, S/N 1935A00153A, has ENR 0.22 dB lower than calibrated by HP on October 3, 1979.
2. HP-346B, S/N 2037A00772, has ENR 0.28 dB higher than calibrated by HP on July 1, 1981.
3. Both sources show less than .07 dB variation with frequency from 1300 to 1700 MHz and little variation between static and 0.57 Hz modulated operation.

HP346B 1955A00153A UNMODULATED

TCOLD=79.6 THOT=301.3 TIME= 7/2/82

F,MHZ	TX(K)		TF(K)	T2(K)	G2(K)		
1000	110.7		312.9	64.5	1.24		
1020	109.2		311.1	57.8	1.38		
1040	108.4		307.8	52	1.53		
1060	106.9		303.7	45.7	1.72		
1080	104.9		299.3	39.8	1.98		
1100	103		294.5	34.3	2.34		
1120	100.3		290.9	29.5	2.85		
1140	98.1		288.1	25.9	3.45		
1160	97.5		286.3	23.2	4.09		
1180	97.7		286.3	21.3	4.68		
1200	97.3		287.2	20.4	5.29		
1220	98.7		288.9	19.5	5.86		
1240	99.8		291.4	17.8	6.51		
1260	100.8		293	16.4	7.43	ATT (dB)	ENR (dB)
1280	101.3		294.4	15.4	8.55		
1300	101.5	-4,56	295.1	14.3	9.5	19.80	15.34
1320	101.3		295	13.2	10.01		
1340	101.8		294.4	12.2	10.06		
1360	102.7		294.3	11.5	9.82		
1380	102.6		294.2	10.9	9.52		
1400	102.2	-4,53	294.8	10.8	9.31	19.89	15.36
1420	102.3		295.5	10.8	9.22		
1440	102.6		296	10.8	9.13		
1460	103.1		296.9	11	9.08		
1480	103.2		297.6	10.9	9.11		
1500	103.3	-4,48	297.5	10.8	9.14	19.91	15.43
1520	103		297.6	10.6	9.29		
1540	102.6		297	10.5	9.61		
1560	102.2		296.3	10.3	9.97		
1580	102.2		295.7	10.3	10.24		
1600	102.1	-4,53	295.1	10.2	10.59	19.93	15.40
1620	102.3		295	10.5	11.06		
1640	102.1		294.9	10.7	11.67		
1660	102.7		295.4	11	12.17		
1680	102.8		296.1	11.3	12.02		
1700	102.6	-4,51	296.6	11.2	11.6	19.92	15.41
1720	102.6		297.1	11.1	11.23		
1740	102.3		297.4	10.8	10.93		
1760	102		296.5	10.3	10.66		
1780	101.4		295.2	9.9	10.37		
1800	101		293.7	9.9	9.96		
1820	101.2		291.7	10.4	9.35		
1840	101.5		289.7	11.4	8.79		
1860	101.6		288.3	13.1	8.28		
1880	102.5		287.8	15.7	7.8		
1900	103.7		289.1	18.9	7.29		
1920	105		291	22.9	6.69		
1940	105.8		293.4	27.1	6.01		
1960	107.2		296.3	32	5.37		
1980	107.3		299.6	37.3	4.72		
2000	107.5		302.7	43.5	4.03		

NOISE SOURCE + PAD NOISE TEMP

OFF NOISE TEMP

RECEIVER NOISE

RECEIVER GAIN

Fig. 2. Apple computer printout for tests of one noise source.

TABLE I - Results of Noise Source Calibration

	HP-346B S/N 1935A00153A		HP-346B S/N 2037A00772	
	UNMOD	MOD	UNMOD	UNMOD REPEAT
Measured ENR				
1300 MHz	15.34	15.41	15.63	15.62
1400 MHz	15.36	15.39	15.60	15.60
1500 MHz	15.43	15.43	15.67	15.65
1600 MHz	15.40	15.39	15.64	15.62
1700 MHz	15.41	15.41	15.64	15.60
AV, 1300 - 1700 MHz	15.39	15.41	15.64	15.62
HP CAL ENR				
1000 MHz	15.67		15.40	
2000 MHz	15.56		15.28	
AV, 1000 - 2000 MHz	15.61		15.36	