EDGES MEMO #068

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
HAYSTACK OBSERVATORY
WESTFORD, MASSACHUSETTS 01886

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Telephone: 781-981-5407
Fax: 781-981-0590

To: EDGES Group

From: Alan E.E. Rogers

Subject: Noise Diode Tests

EDGES uses the Noisecom NC302L noise diode. The diode is operated at a current of 6 ma. At this current the typical output is 4×10^5 K at 150 MHz with a slope of -0.2% per MHz. Below 100 MHz there is a temperature sensitivity of about 0.2%/deg C. An alternate diode is a Micronetics SM-4 operated at 4 ma. This diode puts out about 10^6 K at 150 MHz and has an almost flat response. In addition, I could not measure a temperature coefficient as changes with temperature are extremely small. When compared with the internal NC302L contained within EDGES gives the results given in table 1 below:

Noise.diode	Attenuator dB	T 40 MHz	T 190 MHz	R	Resid 3 K	Resid 5 K
NC302L 1	26	930	1167	1.376	0.70	0.1
HP346C	6	1198	1548	1.390	2.3	0.2
NC302L2	26	1035	1206	1.23	1.3	0.1
SM-4	30	900	1195	1.49	1.2	0.4
NC302L 1[1]	26	979	1145	1.24	1.3	0.07

Notes: 1] $R=(T_{190}-300)/(T_{40}-300)$

2] resid 3 is rms residual after removing 3 term polynomial

3] resid 5 is rms residual after removing 5 term polynomial

4] The internal NC302L has R ~ 0.72 (relative to the HP346C)

The HP 346C noise source has the output given in table 2 below:

Freq (MHz)	ENR	T (K)	T_{-6} (K)
10	12.7	5690	1640
100	12.82	5841	1678
1000	12.73	5727	1649

[1] After increasing the output coupling from 220 to 4700 pf

$$T = 290\left(10^{(ENR/10)} + 1\right)$$

If the internal NC302L had the same output as noise source being measured the measured output should be the same as the value assumed for the calibration provided the source is attenuated by 30 dB. Taking the HP346C values of ENR above the software needs to use

T_{cal} = 596 at 40 MHz

= 442 at 190 MHz

A linearity test was made by comparing the measured output of the NC302L-1 for with attenuation of 26 and 23 dB. The results given in table 3 below:

Attenuator dB	T 40 MHz	T 190 MHz	T′ 40 MHz	T′ 190 MHz	T′ – 209 40 MHz	T′ – 290 190 MHz
26	979	1145	1235	1150	945	860
23	1622	1985	2137	2000	1847	1710

The results which are probably limited by the accuracy of the attenuation indicate a linearity error under 2% based on the corrected values of the calibration constants, T′, derived from the HP346C noise source.

There is a difficulty in obtaining an accurately calibrated noise source in the 40 to 200 MHz range. The HP346C has only listed calibrations at 10,100 and 1000 MHz in this range and noise diode tests show that diodes have a wide range of spectral variation in this frequency range. It is noted that in this frequency range an amplifier like the minicircuits ERA-3 might be a better noise source.

Data using ERA-3 (with open input)

Noise	Attenuator dB	T_{40} MHz	T_{190} MHz	R	Resid 3 K	Resid 5 K
ERA-3	23	403	446	1.41	0.29	0.03
ERA-3	13	1361	1693	1.31	8.0	1.0
ERA-3[2]	23	688	832	1.37	0.7	0.03

The difficulty is in knowing which source is truly flat to a high level of accuracy.

[2] Module with load on input