National Radio Astronomy Observatory
Tucson, Arizona

June 22, 1983

MEMORANDUM

TO: J. Payne

FROM: R. J. Howard

SUBJECT: Attempts to improve the sensitivity of the 3 mm Cassegrain receiver

The 3 mm Cassegrain Receiver has always had higher than theoretical noise due to 1/F noise in the receiver. To get around this, the Fast Beam Switcher was used (at 35 Hz - 40 Hz) for all continuum observers during the 82-83 season. This reduced the noise by about a factor of 2 (see NRAO Memo, "3 mm Continuum Receiver with Fast Beam Switcher, R. Howard, July 10, 1981). Since the Fast Beam Switcher can not be used on the 12-Meter due to physical limitations, two components of the receiver were changed in order to improve the RMS noise at 6.6 Hz (chopping frequency of subreflector). 1) The 4750 MHz/650 MHz BW bandpass filters were replaced by 4750 MHz/1000 MHz BW filters. 2) New Schottky Barrier diode detectors were used instead of the old point contact diode detectors.

1) From the Gain, Temperature Curves on the GASFET's used in the 3 mm receiver, it is not clear that increasing the bandwidth from 650 MHz to 1000 MHz will reduce the noise by $\sqrt{650/1000} = 0.81$. From the data sheets for the GASFET's, I estimated that the GASFET noise temperature (averaged across 1000 MHz) would be ~10% larger than for 650 MHz of bandwidth. Hot and cold load continuum measurements with both bandpass filters in the IF stage gave the same receiver temperatures (200K DSB (CH.1), 190K DSB (CH.2)). These temperatures are higher than the typical valves of several years ago when the GASFET's were first installed (190K (CH.1), 170K (CH.2)). It seems that the gain has possibly decreased on the GASFET's accounting for the higher temperatures and broader bandwidth.

2) Figure 1 shows the noise spectrum of the 3 mm receiver (CH.1) at several different points. Change 2 has the same characteristics. The curve for set-up #4,5,6 is actually the curve of set-up #6. However, set-up #4 and #5 gave identical curves to #6. Table 1 summarizes the 1/F noise measurements of Figure 1. Several conclusions can be drawn.

a) The 3 mm receiver reaches theoretical noise levels only at switching frequencies greater than 90 Hz. (The noise has been measured independently using the standard NRAO synchronous detector and is theoretical at a switching frequency of 100 Hz.)

b) The total receiver noise at 6.6 Hz is ~3.2 X theoretical.

c) The contributions to the excess noise at 6.6 Hz from different component systems are:

1) Klystron - RF Mixer = 54%
2) GASFET Amp = 37%
3) IF Amps, Detector, DC Amp = 9%

d) The Schottky detectors may have lower 1/F noise than the point contact detectors below 1 Hz. However, there is no significant difference above 1 Hz.

For observers to achieve theoretical sensitivity with the 3 mm receiver will require either lots of work on the receiver to reduce 1/F noise or a fast beam switcher for the 12-Meter. A fast beam switcher would also improve the sensitivity by ~1.25 due to the poor chopping efficiency of the subreflector.

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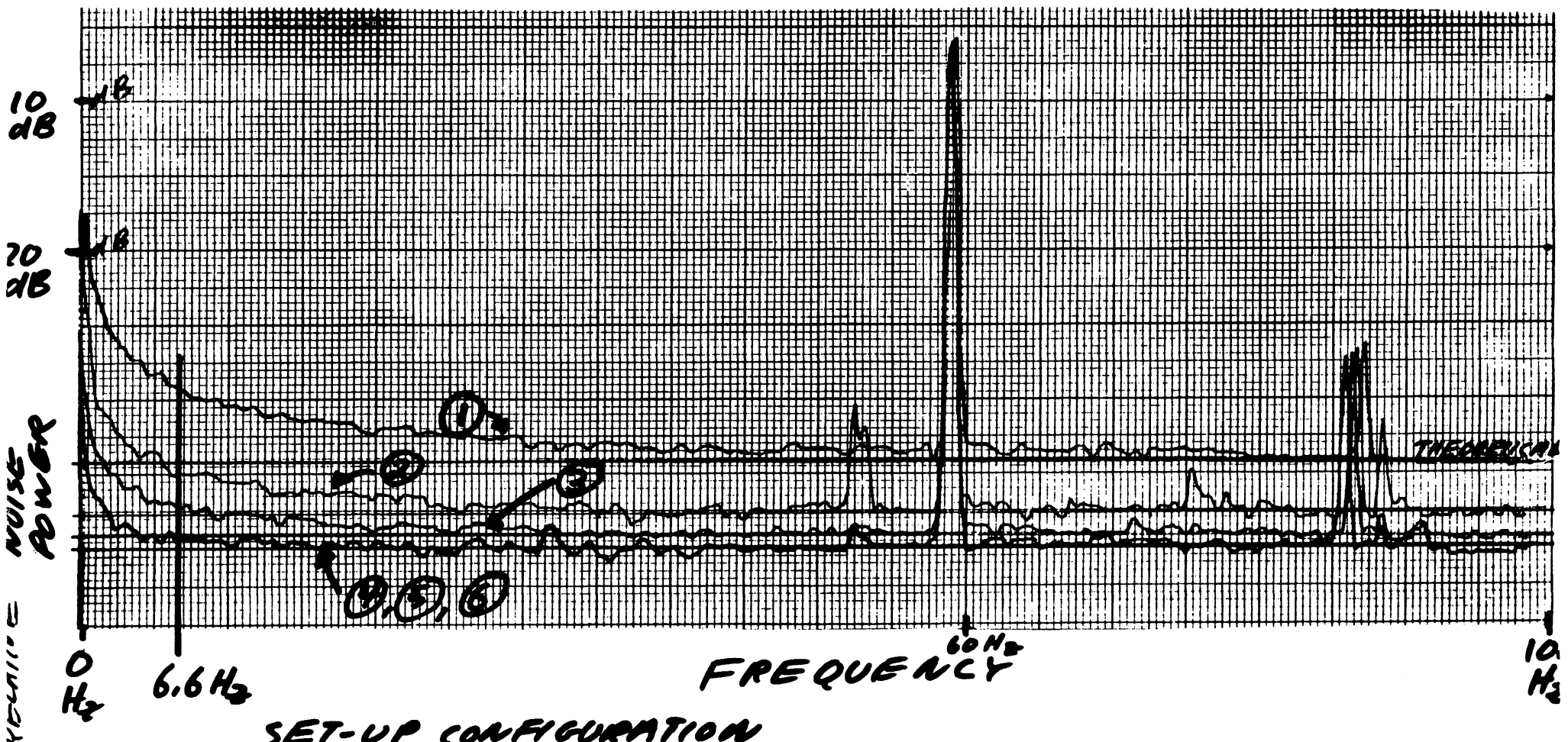
FIGURE

NOISE SPECTRUM – 3MM RECEIVER (CH. 1)



SET-UP CONFIGURATION

① FULL SYSTEM – LOOKING AT 300K LOAD
② KLYSTRON OFF – MIXER BIAS VOLTAGE = 1.0V
③ KLYSTRON OFF – MIXER BIAS VOLTAGE = 0.0V
④ 50 Ω TERMINATION ON INPUT TO IF TRAY
⑤ 50 Ω TERMINATION ON INPUT TO DETECTOR (POINT CONTACT)
⑥ 50 Ω TERMINATION ON INPUT TO DETECTOR (SCHOTTKY)

TABLE 1

Summary of 1/F Noise (CH. 1)

	SET-UP CONFIGURATION	RATIO OF NOISE AT 6.6 Hz TO NOISE AT 100 Hz	FREQUENCY WHERE NOISE SPECTRUM LEVELS OFF
1.	Full System-Looking at 300K Vane	3.16	90 Hz
2.	Klystron Turned Off - Mixer Bias Voltage = 1.0V	2.00	35 Hz
3.	Klystron Turned Off - Mixer Bias Voltage = 0.0V	2.00	35 Hz
4.	50 Ω Termination on Input to IF Amp Tray (at Room Temperature)	1.19	15-20 Hz
5.	50 Ω Termination On Input to Detector (Point Contact Type)	1.19	15-20 Hz
6.	50 Ω Termination on Input to Detector (Schottky Barrier Type)	1.19	15-20 Hz