NATIONAL RADIO ASTRONOMY OBSERVATORY
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# EXCESS NOISE TEMPERATURE MEASUREMENTS OF CALIBRATION SYSTEM FOR 609 MHz VLB RECEIVER, USING AN INTERNATIONAL MICROWAVE CORPORATION NOISE DIODE (NCM-0110-33386)

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Edward M. Teyssier and Jeffrey S. Waldhuter

## ABSTRACT

This is a summary of excess noise temperature measurements performed at 609 MHz on a system consisting of a noise source, 6 dB attenuator, PIN diode switch and directional coupler, provided by George Purcell. The series of tests (arbitrarily called "F" series) are considered to be the most accurate. With the average excess noise temperature calculated at 277.41 °K (for tests 1-10) and 274.74 °K (for tests 11-20),

## INTRODUCTION

Our experiments were aimed at determining the excess noise of the system provided by George Purcell. This system consisted of

a) A noise diode of unknown noise temperature.
b) A PIN diode switch.
c) A directional coupler.
d) A 6 dB coaxial attenuator.

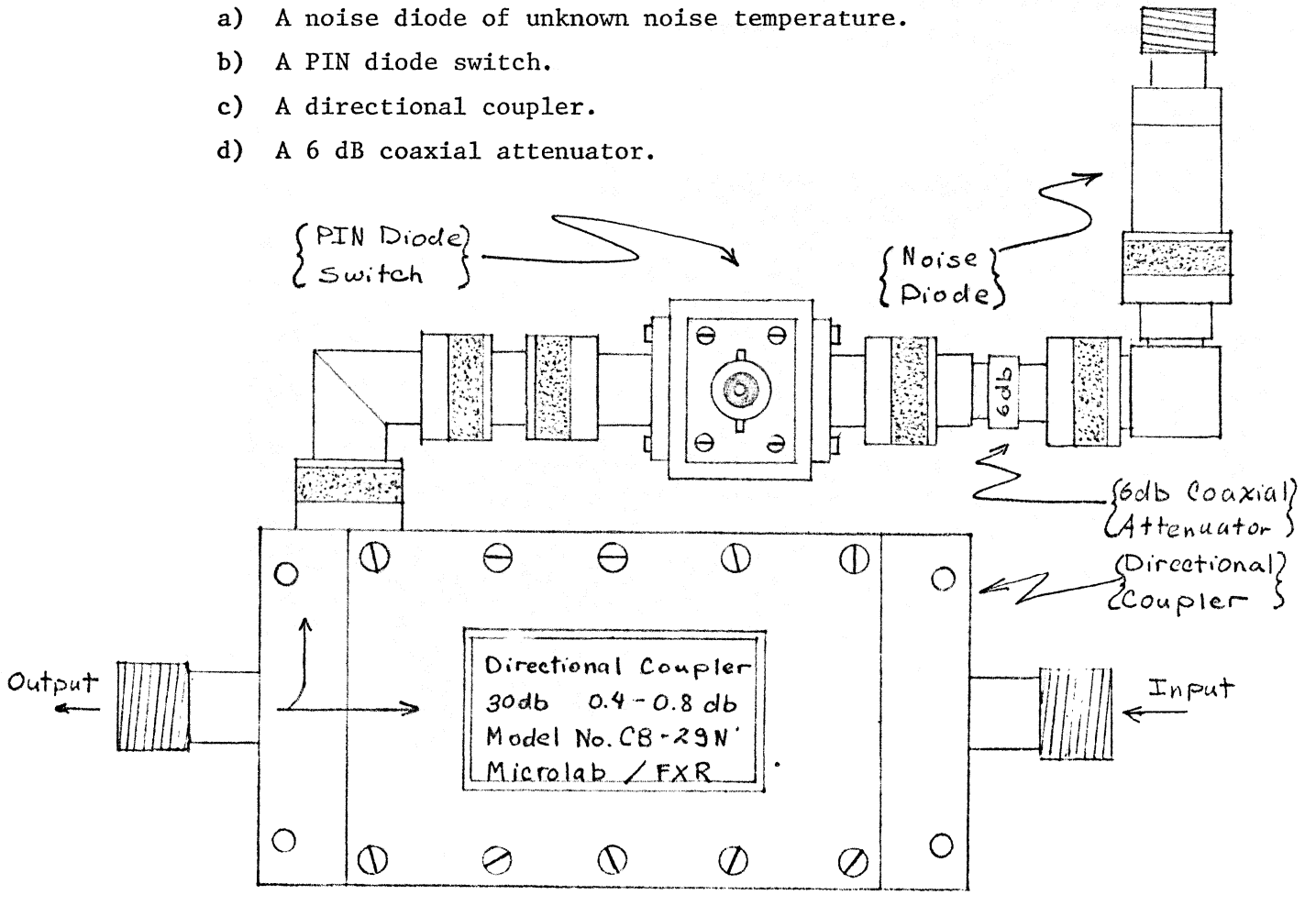


Figure 1

## SET-UP

The output of the directional coupler was connected to a 609 MHz receiver (followed by NRAO standard receiver) with well monitored output. The input of the directional coupler was switched between a cold (liquid nitrogen 77.38 °K) and hot (298 °K) load in order to calibrate the scale on the chart recorder.

Our method was aimed at simulating the condition that the system would experience in actual use. Because we were interested in the system as a whole, we did not invest any time into measuring the amount of coupling of the directional coupler nor the actual attenuation of the 6 dB pad, etc.

## PROCEDURE

Our basic procedure was to use the known temperature output from our known sources to scale the output from our receiver. Then the PIN diode switch was turned ON (+10 V at negligible current), allowing the noise energy to enter the directional coupler with the cold load (77.38 °K). The corresponding receiver output was multiplied by our scaling factor (arrived at with the cold and hot load) to obtain the excess noise temperature of the system under test.

Figure 2 shows a block diagram of our test set up. This test set up was used for all F series tests.

A typical set of measurements included recording the output from the receiver when both of our known loads were connected and then turning on the noise source when switched to the cold load. All equipment was turned on and allowed to warm up for several hours. Liquid nitrogen was then poured into the cold load and approximately another hour passed before our measurements began.

## DATA RESULTS

The data from our tests are shown in table 1. In tests 1-10 we left the PIN diode switch normally off (-1.7 V at 75 mA) except for approximately 15-30 seconds each test to record the output of the square law detector for the noise diode. Now in tests 11-20 we left the PIN diode switch ON except for a short period of time ($\sim$30 seconds) to record the output of the square law detector for the cold and hot load. For reasons that are not yet clear, our measurements indicated an average noise temperature difference of $\sim$2.7 degrees lower than for the latter tests (11-20).

## CONCLUSION

In making these measurements we have put forth a conscientious effort to be complete and accurate. Additional information and results of our other tests are available upon request.

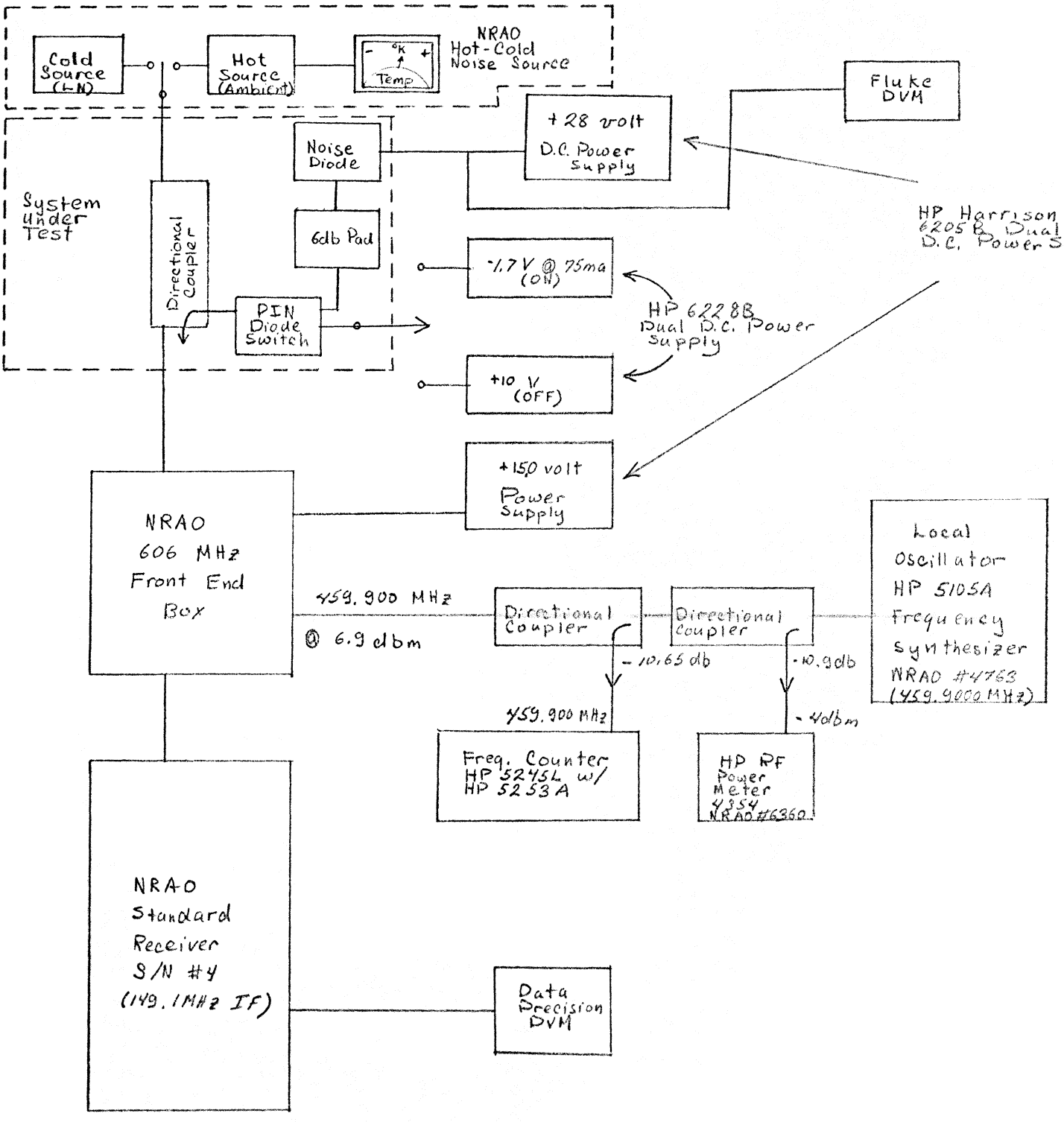


Figure 2

Test Set-up For Series "F" Diode Noise Measurements.

TABL



| Test Number | | A Test Time | B $T_{Hot}$ (°K) | D.V.M. Readings C Cold Load (V) | D Hot Load (V) | E Noise Diode (V) | Comments | F Noise Source Temperature (°K) |
|---|---|---|---|---|---|---|---|---|
| Date: 7/14/75 | | | | | | | | |
| 1 | F | 0922 | 297.94 | 2.226 | 3.945 | 4.391 | PIN diode switch on = +10 V for ∿ 30 sec each measurement. | 277.533 |
| 2 | F | 0931 | 297.94 | 2.226 | 3.946 | 4.392 | | 277.752 |
| 3 | F | 0932 | 297.94 | 2.226 | 3.946 | 4.392 | | 277.752 |
| 4 | F | 0934 | 397.94 | 2.225 | 3.945 | 4.390 | | 277.785 |
| 5 | F | 0936 | 297.94 | 2.225 | 3.943 | 4.389 | | 277.818 |
| 6 | F | 0937 | 297.94 | 2.223 | 3.945 | 4.389 | | 277.429 |
| 7 | F | 0939 | 297.94 | 2.223 | 3.945 | 4.388 | | 277.301 |
| 8 | F | 0940 | 297.94 | 2.224 | 3.944 | 4.388 | | 277.495 |
| 9 | F | 0942 | 297.96 | 2.223 | 3.949 | 4.387 | | 276.556 |
| 10 | F | 0944 | 297.96 | 2.225 | 3.952 | 4.391 | | 276.651 |
| % Error | | ± 1 min | ± .02° | ± .002 V | ± .002 V | ± .002 V | | |
| | | | | | | | Average ..... | 274.7356 °K |

1. PIN diode switch ON → 10 V.
2. PIN diode switch OFF → -1.7 V at 75 mA.
3. Noise diode voltage = +28.0 V.
4. Formula:

$$\text{Noise source excess temperature} = F = \frac{(B - 77.38\ ^\circ K)}{(D - C)} * (E - C)$$

5. Noise diode on for > 9 hours (i.e., assumed completely warmed up).

Average (rounded off) = 477.41 °K

TABLE 1 tinued)



| Test Number | A Test Time | B $T_{Hot}$ (°K) | D.V.M. Readings C Cold Load (V) | D Hot Load (V) | E Noise Diode (V) | Comments | F Noise Source Temperature (°K) |
|---|---|---|---|---|---|---|---|
| Date: 7/14/75 | | | | | | | |
| 11 F | 1430 | 298.14 | 2.221 | 3.953 | 4.383 | PIN diode switch off (= -1.7 V at 75 mA) for only ∿ 30 sec. | 257.568 |
| 12 F | 1453 | 298.12 | 2.216 | 3.945 | 4.370 | | 274.999 |
| 13 F | 1455 | 298.12 | 2.215 | 3.947 | 4.368 | | 274.396 |
| 14 F | 1457 | 298.11 | 2.216 | 3.948 | 4.369 | | 374.383 |
| 15 F | 1459 | 298.10 | 2.218 | 3.950 | 4.373 | | 274.656 |
| 16 F | 1501 | 298.10 | 2.220 | 3.954 | 4.377 | | 274.563 |
| 17 F | 1503 | 298.10 | 2.220 | 3.952 | 4.377 | | 274.880 |
| 18 F | 1505 | 298.10 | 2.219 | 3.953 | 4.375 | | 274.436 |
| 19 F | 1506 | 298.10 | 2.220 | 3.952 | 4.376 | | 374.753 |
| 20 F | 1508 | 298.10 | 2.220 | 3.953 | 4.377 | | 274.722 |
| % Error | ± 1 min | ± .02° | ± .002 V | ± .002 V | ± .002 V | | |
| | | | | | | Average ..... | 274.7356 °K |

1. PIN diode switch ON → +10 V.
2. PIN diode switch OFF → -1.7 V at 75 mA.
3. Noise diode voltage = +28.0 V.
4. Formula:

$$\text{Excess noise temperature} = F = \frac{(B - 77.38\ ^\circ K)}{(D - C)} * (E - C)$$

5. Noise diode on for > 12 hours (i.e., assumed completely warmed up).

| Average (rounded off) = 274.74 °K |
|---|