VSRT MEMO #073

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To: VSRT Group

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Subject: Noise injections calibration

Introduction

Noise calibration of ozone spectrometer should allow more accurate correction for the loss and added noise from the atmosphere which changes with the weather.

The current spectrometer uses the changes in total power to make corrections. This relies on a constant gain and LNA noise temperature. The assumption of constant gain fails when there are large changes in the ambient temperature.

If we assume a constant LNA noise temperature

$$P_{off} = g\left(T_{LNA} + T_{atmos} + T_{spill}\right) = gT_{sys} \qquad (1)$$

$$P_{on} = g\left(T_{LNA} + T_{atmos} + T_{spill}\right) + gT_{cal} \qquad (2)$$

where P_{off} = total power with noise cal off

P_{on} = total power with noise cal on

g = gain

T_{LNA} = LNA noise temperature

T_{atmos} = noise contribution from atmosphere

T_{spill} = noise from spillover of LNBF

T_{cal} = calibration noise temperature

T_{sys} = system noise temperature

Attenuation in the atmosphere adds to the system noise as well as reducing the observed strength of the ozone line.

Apply the theory of radiative transfer

$$T_{atmos} = \left(1 - e^{-\tau}\right) T_{abs} \qquad (3)$$

$$T_{obs} = T_{ozone}\, e^{-\tau} \qquad (4)$$

Where τ = The opacity of the atmosphere

T_{abs} = physical temperature of the absorbing region

T_{ozone} = noise temperature from the ozone line

T_{obs} = observed ozone temperature

If T_{LNA}, T_{spill} and T_{cal} are measured with separate tests and assumed constant equations 1 through 4 can be used to measure T_{atmos}, g, and the system noise temperature. In the first stage of processing, the ozone line spectrum is extracted by subtracting the spectrum from an adjacent frequency band which acts as a comparison and then dividing by the comparison. A “first order” calibration is then obtained by multiplying this “fractional” spectrum by the system temperature to convert the units to degrees kelvin. A correction for the attenuation of the ozone line by the atmosphere can be made using the opacity from equation (3) and an assumed value for the temperature of the atmosphere.

Since this correction is small the value of T_{abs} is not critical.

Hardware

Figure 1 shows a diagram of the dish with LNBFs. The noise source antenna is located at the center of the dish at a distance of about 14” from the LNBFs. The antenna is a ½ wave dipole ¾ wavelengths above the ground plane formed by the dish surface.

The expected path loss is given by

$$\frac{G_1 G_2 \lambda^2}{2(4\pi)^2 r^2}$$

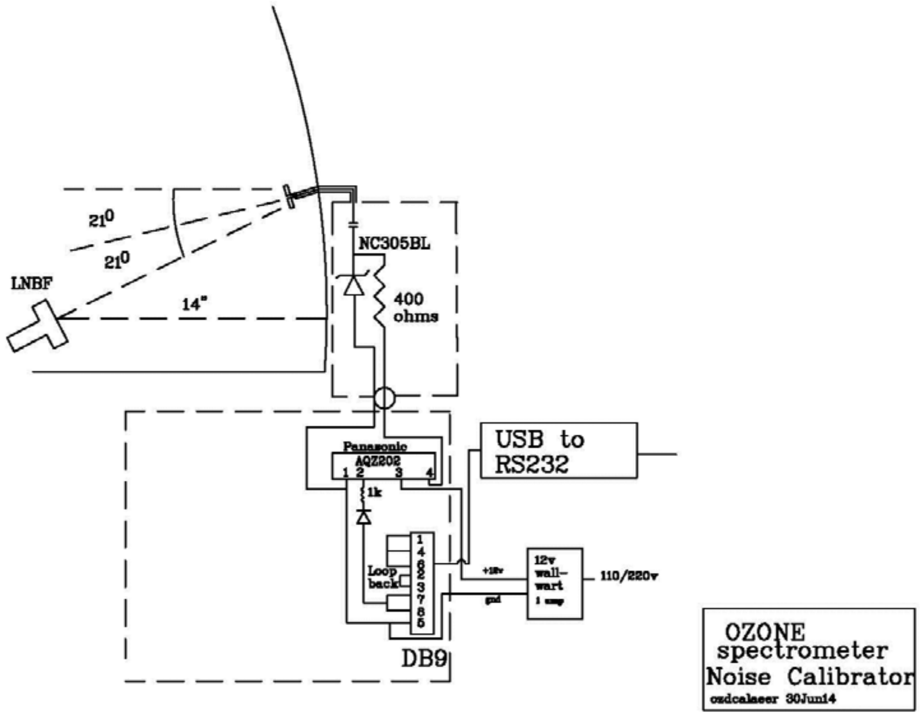
Where G_1 is the LNBF antenna gain relative to isotropic in the direction of the noise source and G_2 is the antenna noise source gain in the direction of the LNBF. r is the distance between the antennas. The added factor of 2 is based on the polarizations being oriented 4S degrees to each other.

For G_0 = 11 dBi, G_1 = 6 dBi, r = 14”, λ = 1.1” the loss is 30 dB. For a noise diode output of 30 dB ENR the expected T_{cal} is about 300 K which will result in 4.8 dB increase in power when the calibrator is turned on for $Tsys \approx 100K$.

Figure 1 also shows the circuit used for the noise diode and its control via a USB port. The noise diode is a noisecom with an output of 30-35 dB ENR. The current of 10 ma is set by the resistance of 400 ohms between the diode and a 12 v supply. The 12v is turned on and off using a Panasonic solid state switch which is controlled by the data set ready on the RS232 output of a USB to RS232 converter.

Software

The USB to RS232 converter is wired in loop-back mode to provide a method of positive identification. This is needed because a USB converter is also used for turning on and off the frequency calibrator.



21⁰
21⁰
LNBF
14"
NC305BL
400
ohms
Panasonic
AQZ202
1 2 3 4
1k
1
4
6
2
3
7
8
5
Loop
back
DB9
USB to
RS232
12v
wall-
wart
110/220v
OZONE
spectrometer
Noise Calibrator
ozdcalaeer 30Jun14

Figure 1