Noise figure measurements on the amateur radio bands of 122-134 GHz

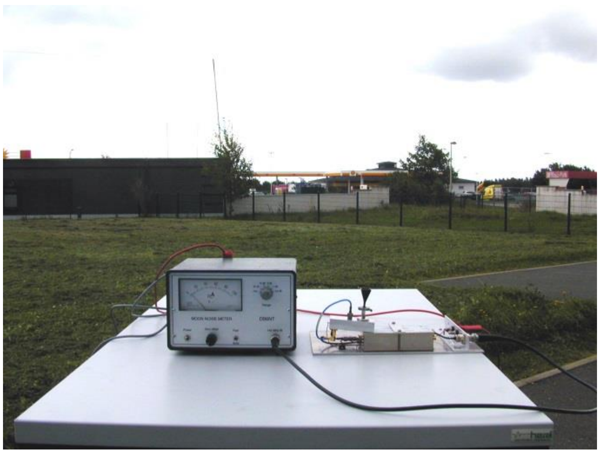
DB6NT 12.2016

The noise figure measurements on the millimeter wave bands usually fail at the noise sources required for this purpose. It is very difficult and usually also expensive to get a suitable source for it. I was lucky enough to buy a noise tube with power supply on Ebay covering the range of 90 ... 140 GHz. It is a device type Clare TN-167.

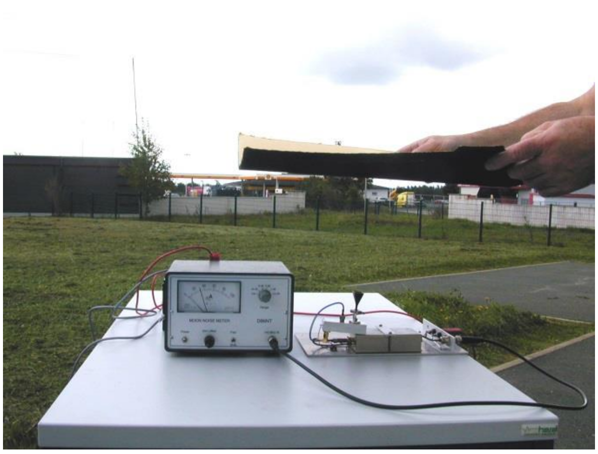
Another method is the Y measurement between two sources such as nitrogen or the "cold sky" opposite the ground. The method is, however, usually only to be applied cleanly with a slightly better noise figure of the receiver of less than 20 dB NF. In this case, the receiver is directed steeply upwards into the clear sky with a horn antenna and measured in the IF with a level meter which is calibrated in dB. The antenna can only see the "cold sky" without the sun, trees, buildings or anything else.

The resolution of the level meter must be quite high and stable. The measuring bandwidth should be approximately 2 MHz. I use my "Moon Noise Meter" from the EME station with a log. Detector AD8307.

Various PC solutions with an SDR receiver at the USB input can also be used for this purpose. If you now measure the noise level with antenna to the sky, you get a value displayed. If you now hold an absorber mat in front of the antenna or swivel the antenna to the ground, the level display increases slightly. This level difference in dB is read off and simply converted into NF using the following table. This table is also valid for the other microwave bands, provided that the noise temperatures of T-hot 295 Kelvin and T-cold 35 Kelvin are assumed [1].



Level measurement with horn antenna



Absorber mat in front of the antenna

NF(dB) Tabelle in Abhängigkeit vom Y Faktor OE2JOM/2017

T(heiß): 295 Kelvin T(kalt): 35 Kelvin u. Himmel – Erde

Y(dB)	NF(dB)
0,05	18,94
0,10	15,95
0,15	14,21
0,20	12,99
0,25	12,04
0,30	11,28
0,35	10,63
0,40	10,07
0,45	9,59
0,50	9,15
0,55	8,76
0,60	8,41
0,65	8,08
0,70	7,79
0,75	7,51
0,80	7,25
0,85	7,01
0,90	6,79
0,95	6,58
1,00	6,38
1,05	6,19
1,10	6,01
1,15	5,84
1,20	5,68
1,25	5,52
1,30	5,38
1,35	5,24
1,40	5,10
1,45	4,97
1,50	4,85
1,55	4,73
1,60	4,61
1,65	4,50
1,70	4,39
1,75	4,29
1,80	4,19
1,85	4,10
1,90	4,00
1,95	3,91
2,00	3,82
2,05	3,74
2,10	3,66
2,15	3,58
2,20	3,50
2,25	3,42
2,30	3,35
2,35	3,28
2,40	3,21
2,45	3,14

Y(dB)	NF(dB)
2,50	3,08
2,55	3,01
2,60	2,95
2,65	2,89
2,70	2,83
2,75	2,77
2,80	2,72
2,85	2,66
2,90	2,61
2,95	2,56
3,00	2,50
3,10	2,41
3,20	2,31
3,30	2,22
3,40	2,13
3,50	2,05
3,60	1,97
3,70	1,89
3,80	1,82
3,90	1,75
4,00	1,68
4,10	1,61
4,20	1,55
4,30	1,49
4,40	1,43
4,50	1,37
4,60	1,32
4,70	1,27
4,80	1,22
4,90	1,17
5,00	1,12
5,10	1,07
5,20	1,03
5,30	0,99
5,40	0,94
5,50	0,90
5,60	0,86
5,70	0,83
5,80	0,79
5,90	0,75
6,00	0,72
6,10	0,69
6,20	0,65
6,30	0,62
6,40	0,59
6,50	0,56
6,60	0,53
6,70	0,50
6,80	0,48

Y(dB)	NF(dB)
6,90	0,45
7,00	0,42
7,10	0,40
7,20	0,38
7,30	0,35
7,40	0,33
7,50	0,31
7,60	0,29
7,70	0,26
7,80	0,24
7,90	0,22
8,00	0,20

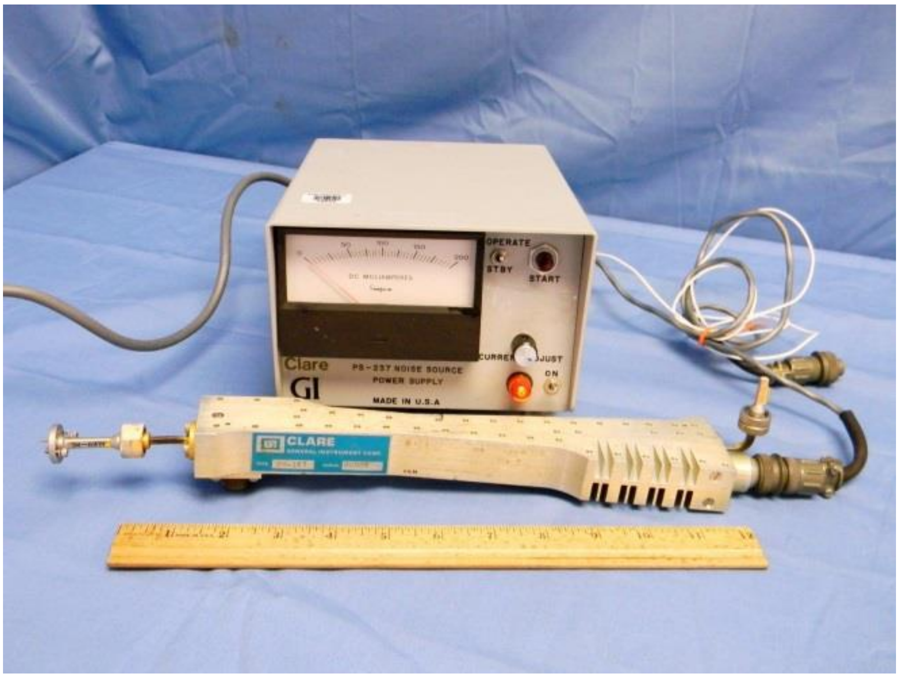
It is of course possible to calculate with the corresponding formula, but I prefer a table for a quick orientation first. This measurement can be falsified by weather influences such as high humidity, clouds or adaptation losses of the antenna. This means that the measured value is usually slightly worse than the actual value.

The sunshine can also be displayed. This is, however, also decisively dependent on the antenna gain and the state of the sun, and thus it is not meaningful for the noise figure measurement of the receiver alone. Below are the measurements of my two portable stations complete with their antennas listed. The waveguide switch with 0.5 ... 1 dB attenuation of the left station as well as the waveguide transitions and the antenna efficiency must be taken into account.

30cm antenna diameter	20cm antenna diameter
Difference in dB sky / ground at	Difference in dB sky / ground at
122 GHz 0,1 dB	122 GHz 0,05 dB
134 GHz 0,05 dB	134 GHz 0,05 dB
Difference in dB sun / sky bei	Difference in dB sun / sky bei
122 GHz 0,38 dB	122 GHz 0,22 dB
134 GHz 0,13 dB	134 GHz 0,22 dB

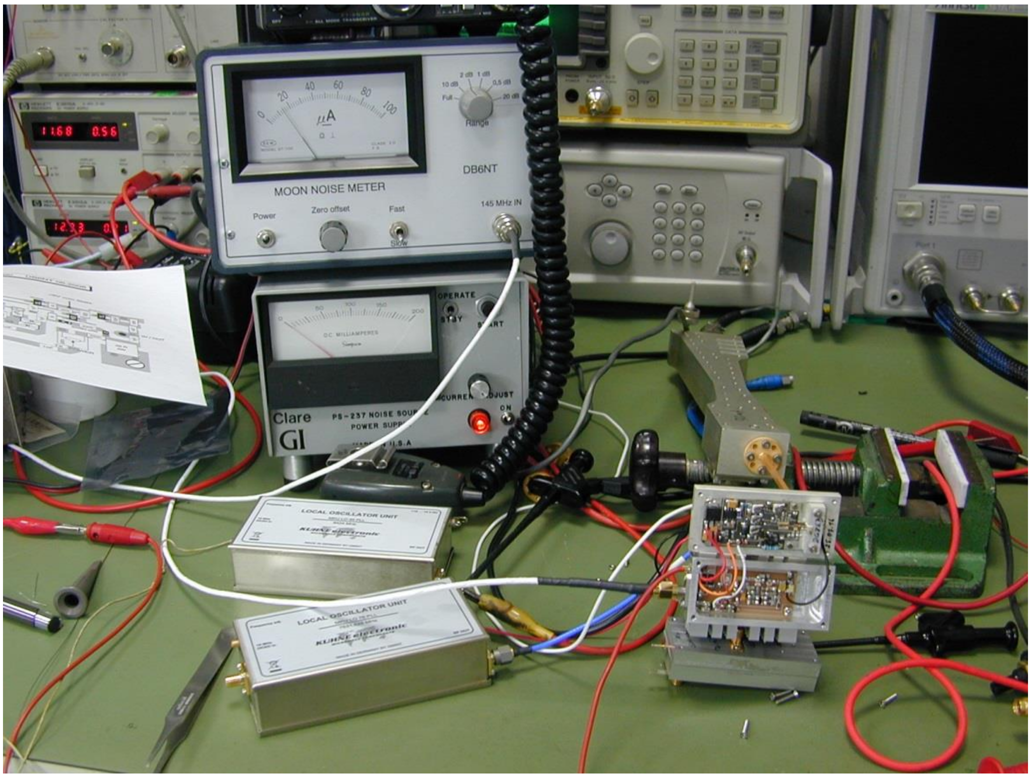
In the case of the measured values, it must be taken into account that the right station with the smaller parabolic mirror uses a 134 GHz optimized mixer (the short-circuit slide is optimized at 134 GHz).
These measured values represent the result of the complete system (receiving part with antenna "overall").

Now to the measurements with the noise tube.

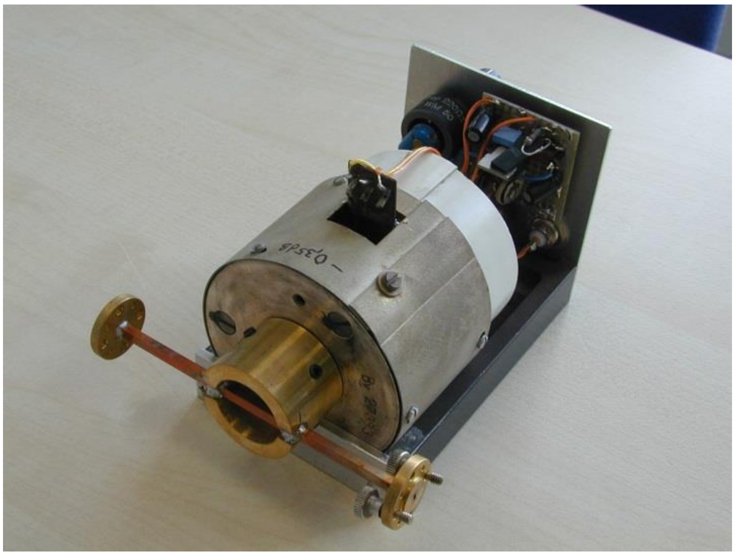


Since the noise tube has a much higher noise temperature than that of the earth, it is also possible to measure significantly less sensitive receivers. Also the display accuracy is more stable.

Here is the measurement setup with the open transverter head.



Here, another table with the higher noise temperature is used for the conversion. The display of the noise figure NF can also be carried out by means of an automatic measuring device (EATON 2075). However, the noise source must be switched on and off quickly. The noise tube with the power supply does not provide this possibility. For this purpose, a fast change-over switch or switchable damping element must be inserted between the noise tube and the measuring object. Here is the photo of the switchable damping element built by **Gert DG8EB**.



In this case, an absorber material is immersed into the waveguide by means of an electromagnet, which is controlled by an amplifier. At the same time this offers a good adjustment. The arrangement is controlled by the 28 volt output of the noise meter.

Thanks:

My special thanks go to Hermann DK8CI for the introduction into the world of hot-cold noise measurements and the practical demonstrations at the meetings in Hohenbachern. My thanks go to Hans OE2JOM for creating the tables and to Gert DG8EB for the construction of the switchable damping element.

[1] Millitech Y-FACTOR TO NOISE FIGURE CONVERSION TABLE
http://www.millitech.com/pdfs/y-factor.pdf

Literature notes:

Hermann Hagn DK8CI: Die Heiß-kalt Rauschtemperaturmessung im Labor und in der Natur. UKW-Berichte, Ausgabe 4/1996

Jan Kappert PA0PLY: Moon noise detector system: http://www.pa0ply.nl/articles.htm

Charlie Kahwagi VK3NX: Moon Noise Meter: http://www.vk3nx.com/files/Noise_Meter.pdf

Michael Kuhne DB6NT: Download Archiv: http://www.db6nt.de/download-archiv.html