NFM

NFM - V1.0.1

File   Edit   Utility   Options   Help

General

Title: 144MHz Low noise preamp   SCZ

Frequency (MHz): 144.000   Interval (s): 15.000   Units: dB   Tatt1 (K): 290.0   Tatt2 (K): 290.0

Source: NGen Noise generator   ENR (dB): 42.72   Thot (K): 5425268.2   Tcold (K): 290.00

Instrument calibration (2)

Att1(2) (dB): 0.00   1 Noise LO   -32.520   Y(2) (dB): 13.230   Teq(2) (K): 2417

Att2(2) (dB): 20.00   2 Noise HI   -19.290   NF(2) (dB): 9.70

Combined measurement (12)

Att1(12) (dB): 30.00   3 Noise LO   -30.130   Y(12) (dB): 8.480   Teq(12) (K): 607.1

Att2(12) (dB): 20.00   4 Noise HI   -21.650   NF(12) (dB): 4.90

Device Under Test (1)

Gain(1) (dB): 27.2   Teq(1) (K): 90.26   NF(1) (dB): 1.18   TSV   Reset

Notes

DUT is a low noise 144MHz preamp (Gain~=20dB, NF~=1dB).

Instrument is an SSB receiver operating below AGC onset by appropriate adjustment of the test attenuator. Noise measurements in dB.

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Overview

NFM

NFM (for Noise Figure Meter) is a software application to assist Noise Figure measurement. NFM implements the method of Agilent application notes AN 57-1 and AN 57-2 for noise figure measurement, but with the addition of an adjustable attenuator after the noise source and between the DUT and instrument.

This document is not a tutorial on noise figure measurement, the above two applications are an excellent text on the subject. The terminology in NFM is largely consistent with that in the applications notes.

Power measurement

NFM also incorporates a facility for true relative audio power measurement using the PC sound card, with a selectable integration time.

The technique depends on the fact that the audio output power of an SSB receiver is linearly related to the RF input power (including the equivalent internal noise power) up to the onset of AGC action, which is typically a little more than 20dB above the equivalent receiver input noise power. By using a known external attenuator to keep measured signals within this linear range, relative measurements can be made of the receiver audio output power and absolute results calculated by factoring in the noise source, attenuators, and other scenario variables.

Effectively, the SSB receiver is used as a linear down converter, to translate a narrow RF spectrum segment of interest to audio frequencies, and to analyse the audio output of the receiver using NFM. You could think of the combination as a multiple conversion super-heterodyne receiver where the last IF is at audio frequencies.
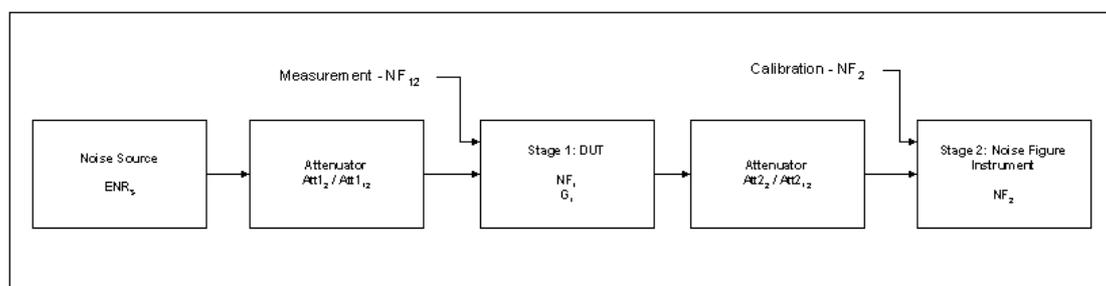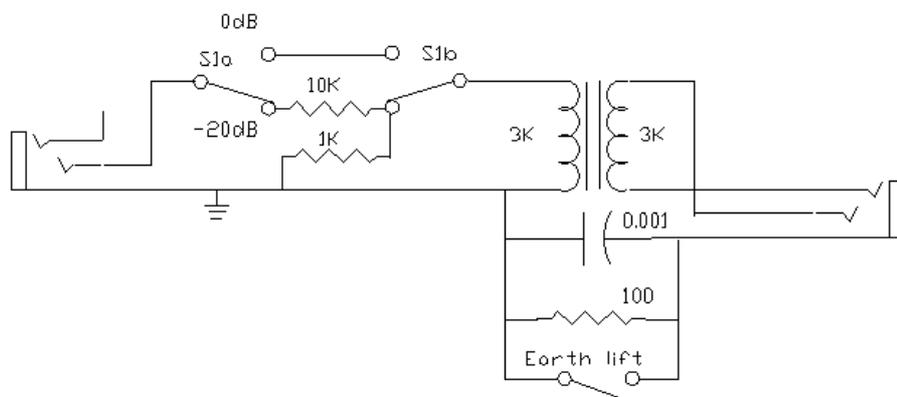
Configuration

Hardware

Figure 1: Noise Figure measurement using the two stage system.

Figure 1 is a block diagram of the hardware configuration used to make measurements with NFM.

The second attenuator is needed to reduce measured noise so that it is below the AGC threshold when using an SSB receiver.

Figure 2: Circuit of passive DI box.

The Noise Figure Instrument in Figure 1 can be an SSB receiver, PC sound card and NFM's audio power measurement facility.

A ground isolator between the receiver and sound card is advisable to minimise noise and hum because of ground loops created in the test setup. It may not be necessary, but if the SCZ results are high, a ground isolator may resolve the problem. An example design for a Passive DI Box is at www.vk1od.net/FM/DI.htm.)

Software

NFM

NFM is a software application for assisting Noise Figure measurement.

NFM should run on Win98SE, ME, 2000 and XP. It has been tested extensively Win 2000 and XP.

NFM will create files (eg the saved results) in the current working directory. You may want to edit properties for the shortcut that you use to start NFM to set a different "Start in" directory for more convenient access to the files.

NFM saves its current settings in the Windows Registry.

Visual Basic

NFM is written in Microsoft's Visual Basic 6.0 (VB6). The NFM distribution package does not include some files (known as the VB6 Runtime Files) needed for VB6 applications. Many, possibly most, people will already have VB6 Runtime Files installed on their PC and will not need to download them. If NFM cannot find the VB6 Runtime Files when it starts, it will tell you, and you will need to download and install them.

Runtime files for Visual Basic 6.0 are available at no charge from Microsoft at Visual Basic Run-time Files, choose the runtime for Visual Basic 6.0 with the latest Service Pack applied (SP6 at the time of writing this document).

MSXML3

NFM also uses Microsoft's MSXML3.DLL which will be installed on most modern computers (eg computers running IE6). The latest msxml3 (MSXML3 SP7) at the time of writing) installer is available on Microsoft's web site.

Features

NFM Receiver Noise Figure Calibration feature

Known Noise Figure Instrument

NFM has a feature for convenient calibration of **ENR**, **Thot** or **Tcold** when the Noise Figure Instrument's Noise Figure (dB) or Equivalent Noise Temperature (K) is known.

To perform this calibration:

1. Enter known or estimated values for **ENR**, **Thot** or **Tcold** as appropriate.

2. Measure / enter **Noise Lo** and **Noise Hi** for the Instrument Calibration phase.

3. Double click on one of **ENR**, **Thot** or **Tcold** to adjust that item for a known receiver.

4. Select and enter the Noise Figure Instrument's known Noise Figure (dB) or Equivalent Noise Temperature (K) as appropriate and click **OK**.

NFM will calculate the value of the identified parameter.

Known noise source

This facility can be used to transfer calibration of a known noise source to another.

To perform this transfer:

1. Connect the known noise source.

2. Enter known or estimated values for **ENR**, **Thot** or **Tcold** as appropriate.

3. Measure / enter **Noise Lo** and **Noise Hi** for the Instrument Calibration phase.

4. Double click on **NF(2)dB** to copy the value to the clipboard.

5. Connect the unknown noise source.

6. Measure / enter **Noise Lo** and **Noise Hi** for the Instrument Calibration phase.

7. Double click on one of **ENR**, **Thot** or **Tcold** to adjust that item for the unknown noise source (on the now, known receiver).

8. The Calibrate Noise Source form should pop up completed with the value copied to the clipboard at step 4, check it and click **OK**.

NFM will calculate the value of the identified parameter.

Exceptions

It is important to ensure linear operation of the entire measurement system.

NFM can detect and alert overload of the analog to digital converter in the soundcard. It will display measurement figures in red if the peak level exceeds -8dBfs (some sound cards clip at -6dBfs). NFM cannot detect overload in the linear stages of the measurement system, which is entirely the user's responsibility.

Calculated results that are inconsistent with reality will be displayed in red. Some insane results will prevent further calculation of the model until they are resolved.

Read only fields

Some fields are read only, and are displayed in blue. Although they may appear the same as other fields that can be edited, they cannot be edited, but the contents can be highlighted and copied using Ctl-C or right mouse click menu.

Check for updates

NFM has a facility to check for updates if online. Click on menu Help/Check for Updates.

ENR data file

NFM has the capability to import a file of Frequency / ENR pairs, and to automatically calculate a cubic spline interpolation for the frequency entered in the main form. The menu options to load and unload an ENR data file are on the File menu.

When an ENR data file is loaded:

- NFM's ENR field will be set and related editing will be disabled;

- ENR will be automatically calculated after completion of change to the Frequency field.

Be aware that the automated calculation will not only perform an interpolation, but ENR data will be extrapolated for frequencies outside the range of the ENR data file. This extrapolation should be used with care.

The format of the antenna data file is tab-delimited records with up to 100 Frequency and ENR pairs. Records beginning with #, and empty records are ignored. The name of the antenna data file is stored in the registry, and the file will be automatically loaded on subsequent invocation of NFM (unless unloaded).

Figure 3: Example ENR data file

```
#
#Example ENR data file
#
#Freq       ENR
3.600       50.1
5.091       49.7
7.200       49.3
10.182      49.8
14.400      50.1
20.365      50.2
28.800      50.1
```

Windows scripting

NFM is designed for convenient automation using Windows Script. Most controls are readily accessible with shortcuts.

Figure 4: Example WScript file

```
<?component error="true" debug="true"?>
<package>
<job id="vbs">
<script language="VBScript">

sub waitfortitle(id)
Do
  WScript.Sleep 500
  If Not CreateObject("Wscript.Shell").AppActivate(id) Then Exit Do
Loop
End sub

set WshShell = WScript.CreateObject("WScript.Shell")
do while WshShell.AppActivate("NFM - V")
count=count+1
WScript.Echo "NFM..." & count
WScript.Sleep 500
'Measure
WshShell.SendKeys( "%2")
waitfortitle "NFM: Working"
WScript.Sleep 500
WshShell.AppActivate("NFM - V")
WshShell.SendKeys( "^r")
'wait for next obs - time is ms
WScript.Sleep 55000
if(count=>1000) then exit do
loop
</script>
</job>
</package>
```

Figure 4 show an example WScript file that performs repeated Noise Hi measurements and records the result.

TSV

NFM can save a record of a measurement to a file. The format of the file is tab separated values, with a header record naming the column variables. The TSV file is named NFMData.tab and is saved in the current directory.

The TSV file can be opened in Excel and the results analysed, summarised, plotted, etc.

Using NFM

There are two broad ways in which NFM can be used. An external power measurement device may be used and the measurements keyed into NFM, or NFM's audio power measurement facility can be used to capture the power measurements.

External power measurement

External power measurements can be entered in voltage, power in watts, or power in dB units. Select the appropriate unit in the **Units** field before entering any measurement values.

NFM power measurement - setting up

Setting up involves connecting equipment up, and configuring the receiver, sound card settings, and NFM in preparation for the measurements.

The measurements are conducted in three stages:

- initialisation

- Stage 2: Noise Figure Instrument; and

- Stage 1: Device Under Test.

Interval

The integration interval for internal measurement can be specified in the **Interval** field of the main form. The interval is specified in seconds and can be from 0.05s to 100s. Unregistered copies of NFM will limit the interval to a maximum of 0.5s.
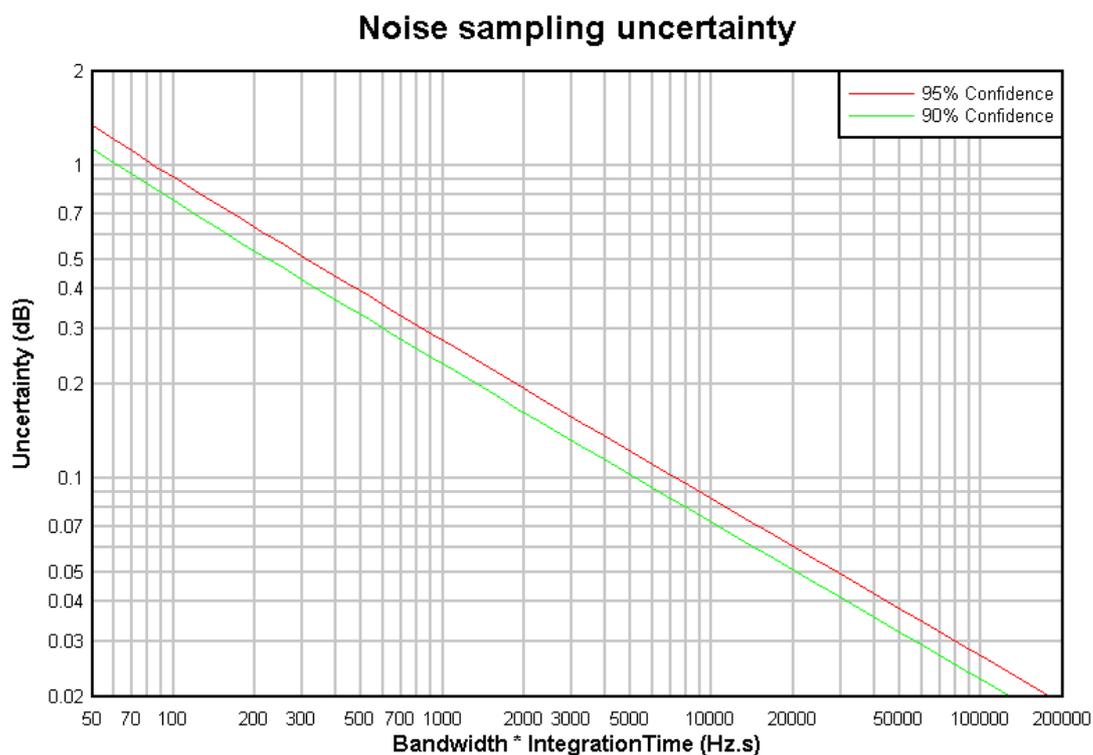
Figure 5: Noise sampling uncertainty

Figure 5 shows the relationship between noise measurement uncertainty and bandwidth * integration time. Using the chart, an integration time of 0.5s with a 2kHz wide receiver gives an uncertainty of about 0.23dB at 90% confidence.

SCZ

The initialisation step allows measurement of the noise of the PC sound card and audio connection setup so that it can be deducted from the Stage 2 and Stage 1 power measurements. The initialisation is optional, and is performed by connecting up the Noise Figure Instrument powered OFF, and clicking the SCZ button for measure the residual noise. The residual noise figure can be cleared by double clicking on the displayed value.

NFM's internal power measurement will always be in dB units.

Stage 2

Stage 2 involves measurement / entry of the Noise Lo and Noise Hi values for the Stage 2 configuration, ie with the Device Under Test bypassed.

If NFM's internal power measurement facility is used, the Stage 2 **Noise Lo** and **Noise Hi** buttons are used to make a measurement.

The measurements can be made / entered in any order, and repeated without adverse impact.

The **Instrument Calibration(2)** result fields **Y(2)**, **Teq(2)** and **NF(2)** will be calculated when both Stage 2 Noise Lo and Noise Hi are filled in with sane values.

Stage 1

Stage 1 involves measurement / entry of the Noise Lo and Noise Hi values for the Stage 2 configuration, ie with the Device Under Test in circuit.

If NFM's internal power measurement facility is used, the Stage 1 **Noise Lo** and **Noise Hi** buttons are used to make a measurement.

The measurements can be made / entered in any order, and repeated without adverse impact.

The **Combined Measurement(12)** result fields **Y(12)**, **Teq(12)** and **NF(12)** will be calculated when both Stage 1 Noise Lo and Noise Hi are filled in with sane values.

The **Device Under Test(1)** result fields **Gain(1)**, **Teq(1)** and **NF(1)** will be calculated when both Stage 1 Stage 2 Noise Lo and Noise Hi are filled in with sane values.

Results can be written to a record of a file of tab separated values by clicking the **TSV** button.

Linearity

It is important to ensure linear operation of the entire measurement system.

NFM can detect and alert overload of the analog to digital converter in the soundcard. It will display measurement figures in red if the peak level exceeds -8dBfs 9some sound cards clip at -6dBfs). NFM cannot detect overload in the linear stages of the measurement system, which is entirely the user's responsibility.

Figure 6:

Effective of a symmetric limiter on noise power
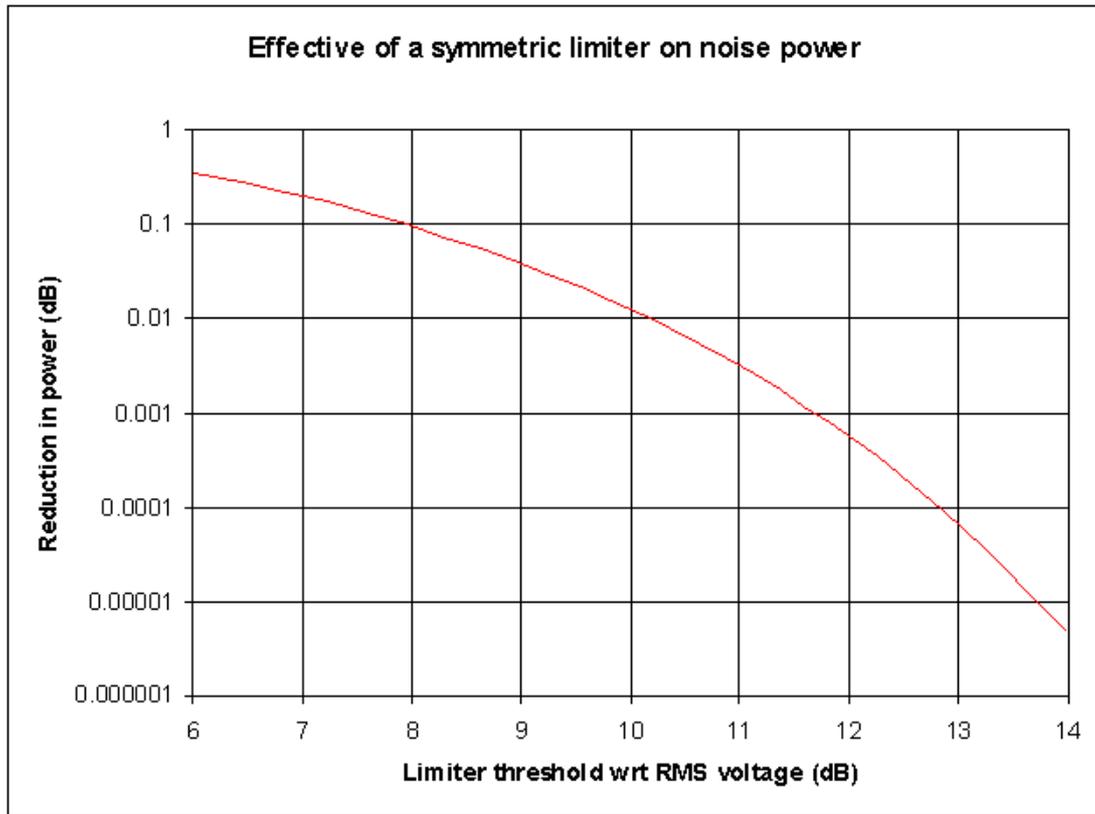
Noise is a time varying random voltage and instantaneous voltage can greatly exceed the RMS value. Linear system used to measure noise must have sufficient headroom to accommodate most peaks. Figure 6 shows the reduction in measured power where a system symmetrically limits the voltage. The measurement system should be setup for at least 12dB of headroom. For NFM's internal audio power measurement facility, ensure that the maximum reading is not higher than -20dB (being the -8dBfs alert limit reduced a further 12dB for headroom).

AGC varies receiver gain. AGC must not vary receiver gain between a Noise Lo and Noise Hi measurement. A change in S meter reading is an indication of change in AGC, but with some types of S meter, it is not a very reliable indication. The user must ensure that AGC does not change, and the safest configuration is that measurements are made well below the onset of AGC action, which is typically about 20dB above the receiver noise floor. Turning the AGC OFF does not solve this problem, receivers are highly likely to clip when the AGC is disabled, see the discussion on limiters above.

Clipboard

The normal Windows copy and paste actions using Ctl-C, Ctl-X, and Ctl-V and right most click menu are available on most fields.

In addition, the Teq, NF, and Gain, and Notes fields will copy their contents to the clipboard if double clicked.

Registration

Some features of NFM may be restricted to registered users. Registration will entitle a user to all current and future features.

Current limitations of the unregistered instance are:

- NFM's internal audio power measurement facility is limited to a maximum interval of 0.5s. An integration time of 0.5s with a 2kHz wide receiver gives an uncertainty of about 0.23dB at 90% confidence.

- ENR data file import is not available.

- Save TSV file is not available.

- Calibration features are not available.

- File/Print is not available.

- Tatt1 and Tatt2 are locked at 290K.

Registering NFM

Registration is initiated at http://www.vk1od.net/nfm/registration.htm .

Entering registration data

The registration data is stored in the file NFM.INI in the directory where the NFM program files were installed (default=C:\Program Files\NFM).

Registration data will usually be received in an email. The registration data is the line '[NFM]' and the immediately following non blank lines.

Figure 7: Entering registration data.
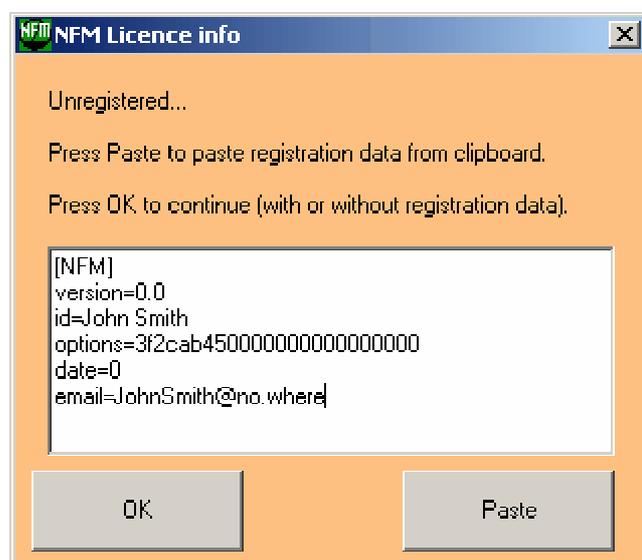
Follow these steps to save the registration data:

1. copy the registration data (described above) from your email to the clipboard by highlighting the lines and using copy in your email client;

2. start NFM. the screen in Fig 7 should pop up, press the paste button to paste the registration data;

3. click OK to continue;

4. click OK to the following message that advises to close and restart NFM so that the registration data is effective.

5. after restarting NFM, check the Help/About to see your registration details are recorded.

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Version

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