NF Test: Callisto Test Tool

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1. Introduction

The NF Test software tool for Callisto was developed by co-author Monstein as a Callisto production test tool. Its application to Callisto noise figure measurements was previously described {Noise}. The tool's many other features and capabilities are described in this article. Some of the information in the previous article is repeated here for convenience, but a description of the noise figure measurement function is contained only in {Noise}. Callisto is the instrument used in the e-CALLISTO solar radio spectrometer network {e-CALLISTO}. The Callisto's native frequency range is 45 to 870 MHz but it often is used with an up-converter or down-converter to extend its operating frequency range and with a low noise preamplifier to increase its sensitivity.

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2. NF Test Executable

The NF Test tool is in a Zip file under the Software tab at {e-CALLISTO} or it may be downloaded directly at {NFTest}. After the files have been extracted to a convenient folder, for example, c:\Callisto\Tools\NF Test, the executable file, NF.exe, may be opened. When the files are extracted, many header files and other files used to compile NF Test are placed in the same folder. Most files are not needed for NF Test operation and may be deleted or moved; however, the following files must be retained: nf.bpr, nf.cfg, NF.exe, VersionControl.txt, and wsc.dll.

NF Test runs under Windows XP through 11 and requires one native serial port or USB port for instrument control. The installation does not change the Windows registry, and the tool may be uninstalled simply by deleting it. Generally, a shortcut to the file is placed on the Desktop. When NF Test is run, a main window opens (figure 1).

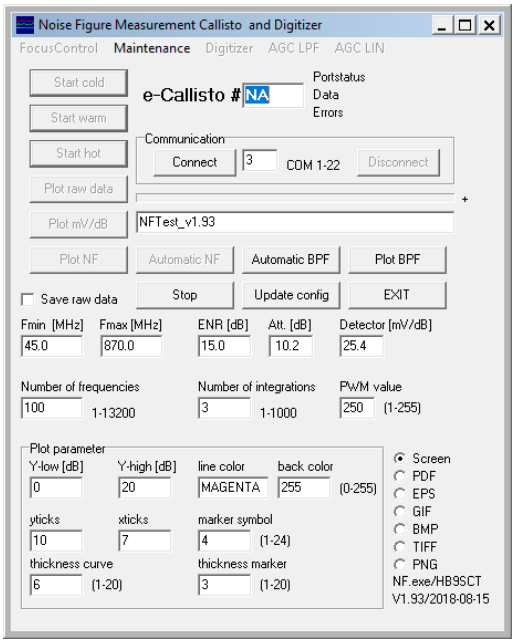

Figure 1 ~ Main window when NF Test is first opened and not yet Connected to the instrument through the serial port. At this point, the Connect button may be pressed if the *Communication* COM port is correct; otherwise, before pressing Connect, it is necessary to change the COM port to match the serial port to be used.

Default values for the various field variables are specified in a configuration file described in the next section. Detailed descriptions of the functions, buttons and menus are provided in later sections.

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3. NF Test Configuration File

NF Test uses a configuration file ***nf.cfg*** that defines its default parameters. The configuration file is an ASCII text file located in the same folder as the executable and is shown below. When first installed, nf.cfg is populated with a complete set of default values, which must be edited to comply with the user's specific setup. The configuration file may be accessed by navigating to the installation folder or by clicking on the *Maintenance* menu of the NF Test window. It may be edited with any ASCII text editor such as Notepad of Notepad++. If changes are made to nf.cfg after NF Test is opened, the Update Config button must be pressed before any measurement.

```
// Measurement Parameter
[rxcomport]=3               // 1 .... ?? RS-232

[maintitle]=NA              // any text without space, use underscore or - instead, like 00...99
[sstitle]=NFTest_v1.93      // any text without space, use underscore or - instead

[fmin]=45.0                 // lowest frequency (45.0....870.0), nominal 45.0
[fnom]=408.0                // nominal frequency (45.0....870.0) for digitizer/scope
[fmax]=870.0                // highest frequency (45.0....870.0), nominal 870.0

[enr]=15.0                  // ENR nominal 15.0 dB .... 35 dB, 5.0 dB with an LNA
[detector]=25.4             // conversion AD8307 nominal 25.4mV/dB
[channels]=200              // number of channels to measure (1...13200), nominal 200
[integrations]=3            // the more the better the resolution, (1...10'000), nominal 16
[pwm]=250                   // receiver gain control (1...255), nominal 100...250

// Plott Parameter
[xleft]=600                 // position left corner of window, default 300
[ytop]=100                  // position top edge of window, default 100
[xsize]=424                 // width of the window, default 848
[ysize]=300                 // height of the window, default 600 (golden cut)

[ylow]=0                    // yrange -100...100, nominal 0
[yhigh]=20                  // yrange -100...100, nominal 20

[yticks]=10                 // number of ticks in y-axis, nominal 10
[xticks]=7                  // number of ticks in x-axis, nominal 7 or 8

[linecolor]=MAGENTA         // BLACK, RED, GREEN, BLUE, CYAN, YELLOW, ORANGE, MAGENTA, WHITE
[backcolor]=255             // 0=black, 255=white background, inbetween some colors, I like 230

[marker]=4                  // marker symbol (1..24), nominal 4

[thickcurve]=6              // tickness of plot (1..20), nominal 8
[thickmarker]=3             // thicknes of marker (1..20), nominal 6


// Switching parameter for static relays in test fixture with focus code control
[cold]=00,S                 // cold noise source focus code
[warm]=03,S                 // focus code later used for determining detector coefficient
[hot]=01,S                  // hot noise source focus code to determine noise figure

[att]=10.2                  // attenuator value to produce 'warm' out of hot

// digitizer/scope parameter
[focus]=00                  // focuscode for digitizer/scope
[sampling]=200              // digitizer/scope sampling time [ms] 50...
[logpath]=C:\Temp\          // data path for light curve file
[ending]=csv                // data file ending (txt, prn, dat, lst, csv)
[delimiter]=;               // column-delimiter = TAB or , or ;
```

Most configuration file parameter names are identical to the field labels in the NF Test main window. The configuration file includes comments denoted by // characters. The comments are used as a guide to the allowed

range of variables and in many cases indicate a suggested default or nominal value. The comments may be edited but their length must be no more than 120 characters. The NF Test folder can contain only one nf.cfg file at any given time. Some parameters are basic to the NF Test operation and are described in more detail below.

COM port [rxcomport] parameter: The nf.cfg file above shows port 3 but it may be changed to any appropriate value to match the PC serial port or USB-Serial Converter. The maximum COM port number in the current version (v1.93) is COM24. Problems connecting to the Callisto are always traceable to a wrong [rxcomport] parameter, bad serial cable or outdated USB-Serial Converter or driver.

[Fmin] and [Fmax] frequency parameters: The maximum resolution of the Calisto tuner is 62.5 kHz. When measurements are underway, the frequency steps are rounded to the nearest multiple of 62.5 kHz. There are 13 200 possible frequencies (or [Channels]) in the Callisto's native frequency range of 45.0 to 870.0 MHz. The [Fmin] and [Fmax] frequencies can be set to any practical value in that range and divided into any practical number of [Channels], but the frequency resolution is limited to 62.5 kHz and the maximum number of [Channels] is limited to 13 200.

[PWM] gain parameter: Pulse Width Modulation (PWM) is used with a lowpass filter to control the Callisto gain. This parameter uses integer values from 0 to 255 to set the gain. Typical PWM settings are described in the following sections for different measurement types. The [PWM] parameter can be changed on-the-fly (after connection), but the Update config button must be pressed afterwards.

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4. NF Test Main Window Functions

The NF Test Main window has been sectionalized for explanation (figure 2).

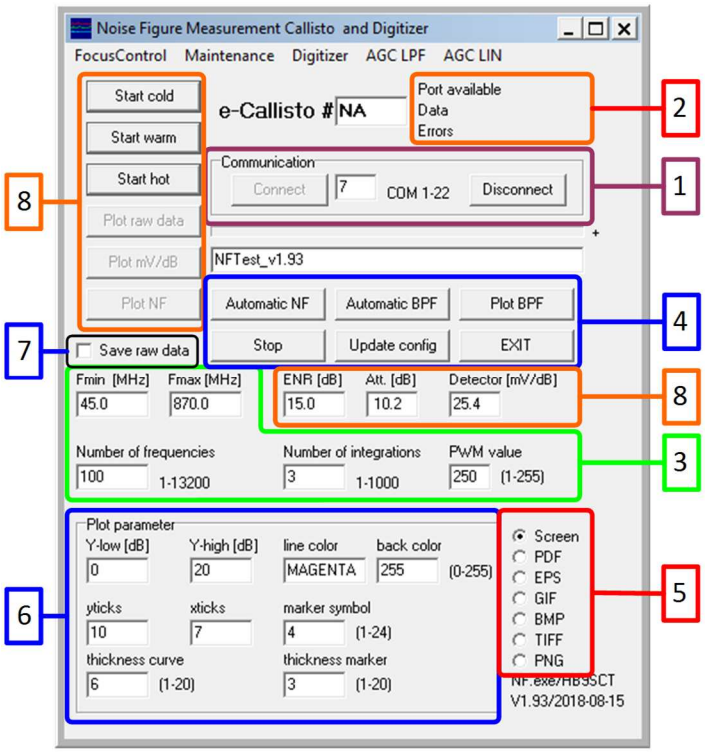

Figure 2 ~ NF Test Main window. See text.

1. *Communication* setting is critical for Callisto operation. Before pressing Connect (grayed out in this image), the correct COM Port must be entered here. If Connect is pressed with the wrong port, nothing will happen except that NF.exe may have to be closed and reopened, the correct port entered and then Connected again.
2. A correct connection is indicated by the text *Port available*. When a measurement is underway, the Data field indicates the commands sent by NF.exe to Callisto and the Error field indicates any errors in the serial connection. Errors are almost always caused by a bad serial cable or outdated USB-Serial Converter or driver.
3. Parameter fields specify the start *Fmin* and stop *Fmax* frequencies, and *Number of frequencies* (or Channels). The *Number of frequencies* determines the resolution of the measurements subject to the limitations previously described. The *Number of Integrations* averages the measurements to reduce random noise and *PWM-value* sets the Callisto gain.
4. *Automatic NF* and *Automatic BPF* buttons initiate automated noise and bandpass filter measurements using the Callisto Test Fixture. Additional buttons are *Update config*, which must be pressed if any of the parameters are changed on-the-fly, and *Plot BPF*, which can be used to replot the bandpass filter measurements if the *Plot* parameters are changed. A measurement may be stopped temporarily by pressing *Stop* and NF.exe may be closed by pressing *Exit*. The program also may be closed by pressing the X in the upper-right corner of the window.
5. Plots may be saved to the *Screen* or in different image file formats such as PDF, BMP and PNG. Images are saved at the end of a measurement in the location specified by the [logpath] parameter in the configuration file nf.cfg.
6. *Plot parameters* determine the characteristics of the plots that result from the measurements. Most of the parameters can be used as-is but some measurements require changes to the vertical scale (*Y-low* and *Y-high*). Specific measurements described later provide recommendations for the settings but users are encouraged to experiment.
7. The *Save raw data* checkbox places the ASCII text data from the noise figure and bandpass filter measurements in the file location specified in the [logpath] parameter in the configuration file nf.cfg.
8. The *Start cold*, *Start warm* and *Start hot*, *ENR*, *Alt.* and *Detector* buttons are used for noise figure measurements and are described in a previous article (see {Noise}).

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5. Measurements

The optional Callisto Test Fixture designed by co-author Reeve simplifies Callisto tests and measurements but it is not necessary. The functions in the *Focus Code* menu (figure 4-left) are used with the Callisto Test Fixture to test the operation and internal wiring of the Callisto's Focus Code connector. The Focus Code connector functions may be manually tested by measurements with a DMM or LED with a current limiting resistor.

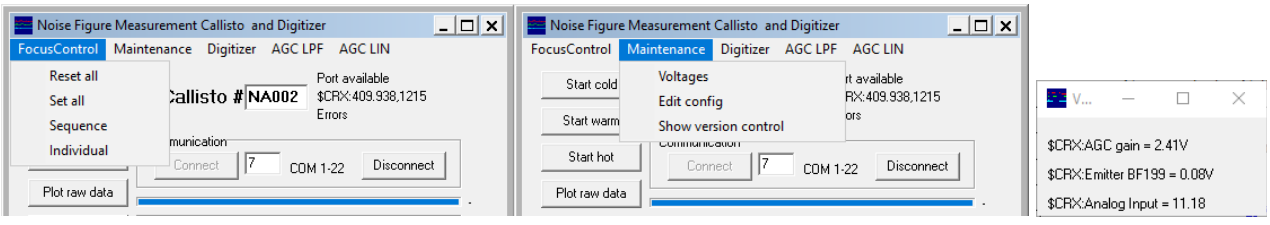

Figure 4 ~ Left: FocusControl menu. The various settings control the Focus Control connector pin states, On or Off. The settings control the Focus Code connector pin voltages so they can be measured with a DMM or indicated by LEDs on the

Callisto Test Fixture. Middle: Maintenance menu. Selecting *Voltages* shows the Callisto internal voltages. The configuration file may be edited and then saved. Selecting *Show version control* displays the NF Test change log. Right: Voltages window shows the gain control voltage applied to the tuner (this value varies with the PWM gain control setting), the emitter voltage of the 2nd IF amplifier transistor and the input voltage. The input voltage is measured after the internal polarity guard diode so it slightly lower than the voltage at the Callisto dc power connector.

The *Maintenance* menu (figure 4-middle) allows the user to see Callisto's internal operating voltages (figure 4-right) and to edit the nf.cfg configuration file on-the-fly. When the configuration file is edited and then saved, the changes will not take effect until the *Update config* button is pressed. If measurements are attempted before updating the configuration file, NF Test may freeze and will have to be restarted. The NF Test change log also may be viewed from the *Maintenance* menu by selecting Show version control.

The *Digitizer* menu opens another window (figure 5), which is used to access the test functions associated with the Callisto's internal log detector and analog-digital converter (ADC). It is useful for tuning the IF transformers and troubleshooting. For example, a defective 2nd mixer IC will display unusually low signal levels. The window has been sectionalized for explanation below.

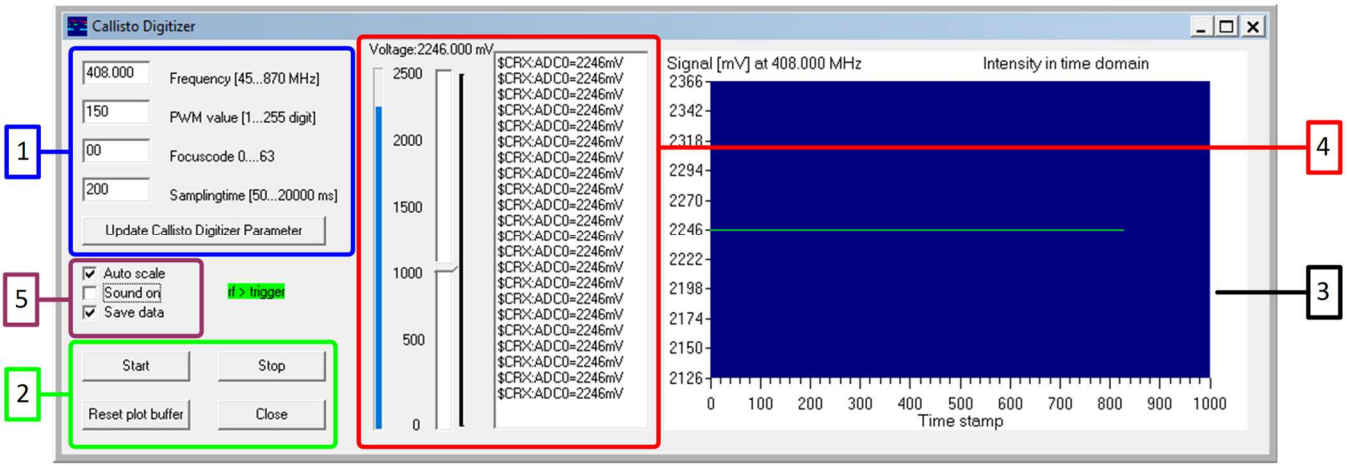

Figure 5 ~ Digitizer window. In this example, the right frame is displaying measurements at the log detector output in mV for a 408.0 MHz input signal with a level of –70 dBm from an RF signal generator. The thin green trace shows the steady signal at 2246 mV that has progressed about 800 seconds in the 1000 second wide window. The middle (red) frame shows the actual measured values at 200 ms intervals. See text.

1. The frequency, gain (PWM), Focuscode and Samplingtime fields command the Callisto to specific settings. To take effect, changes in these fields need to be followed by pressing the Update Callisto Digitizer Parameter button. The Focuscode parameter normally is used with a Test Fixture; it is included with the saved data specified in section 5. The sampling rate of Callisto data also can be set. This setting affects the scrolling rate of the ADC input voltage data shown in section 4 and in the right frame plot shown in section 3.
2. The measurements can be started and stopped by pressing the *Start* and *Stop* buttons, respectively. The *Reset plot buffer* zeros out the plot display autoscale. The Digitizer window can be closed with the *Close* button. If the Start button does nothing, the Digitizer may be frozen. To recover, it may be necessary to close both the Digitizer window and NF Test and then reopen them.
3. The right frame is a real-time plot of the digitizer measurements that shows a plot of the values displayed in section 4.

4. Log detector output voltages associated with each sample. A visual and audible tuning aid is provided by adjusting the slider to the left of the listed values. In the example shown, the trigger level is set at 1000; since the digitizer values are > 1000, the rf > trigger text has turned green. The Callisto IF transformers may be tuned for maximum noise level or, if a signal is input to the Callisto, for maximum signal level.
5. The Auto scale checkbox allows NF Test to automatically adjust the plot scale in the right frame. The Sound on checkbox provides an audible output to indicate when the trigger in section 4 is exceeded. The Save data checkbox saves the digitizer voltage values to a text file for later analysis. The file is saved in the location specified by the [logpath] parameter in nf.cfg.

Two examples are given below that show how the Digitizer can be used to view the 2nd IF bandpass filter shape. The first method uses a signal generator to sweep the RF input frequency with the Callisto set to a fixed frequency and the second method sweeps the Callisto frequency with the signal generator set to a fixed frequency. In both examples, the Callisto PWM value is set to 150 and the Callisto input signal power is set to –70 dBm.

Example 1:
To display the bandpass filter shape, the output of an RF signal generator is connected to the Callisto RF Input (figure 6). In this example, the RF signal generator output is set to –60 dBm and connected to the Callisto through a 10 dB attenuator.

- RF input level at Callisto RF input: –70 dBm
- Sweep start frequency: 407.250 MHz
- Sweep stop frequency: 408.750 MHz
- Center frequency: 408.000 MHz
- Frequency span: 1.5 MHz
- Frequency spacing: Linear
- Sweep shape: Sawtooth
- Frequency step: 1.5 kHz
- Dwell time: 40.0 ms

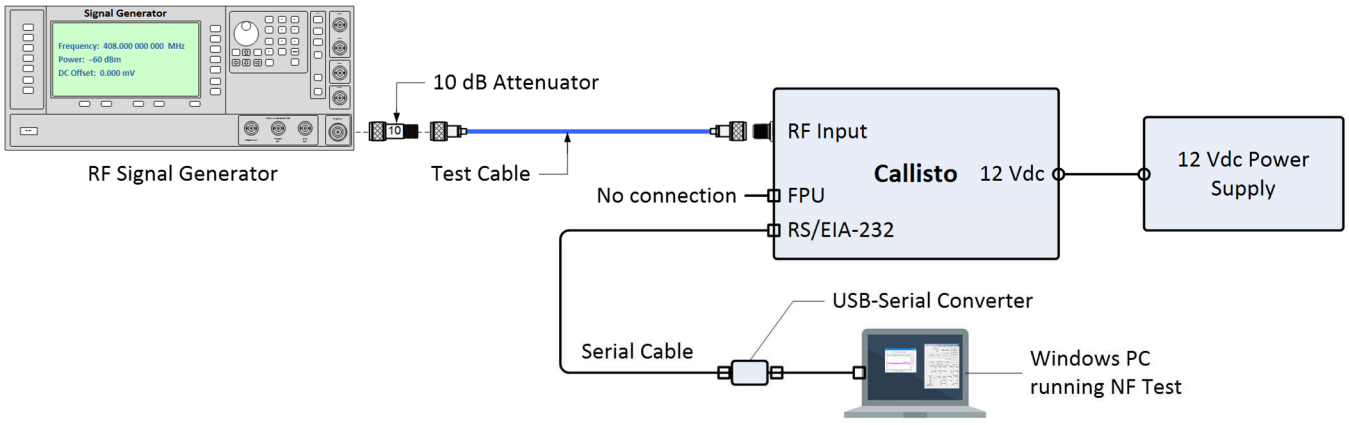

Figure 6 ~ RF signal generator setup for bandpass filter testing.

NF Test Digitizer setup as follows (figure 7):

- Frequency: 408.0 MHz
- PWM Value: 150
- Focus Code: Does not matter
- Samplingtime: 100 ms

Note: Be sure to press Update Callisto Digitizer Parameter after changing parameters

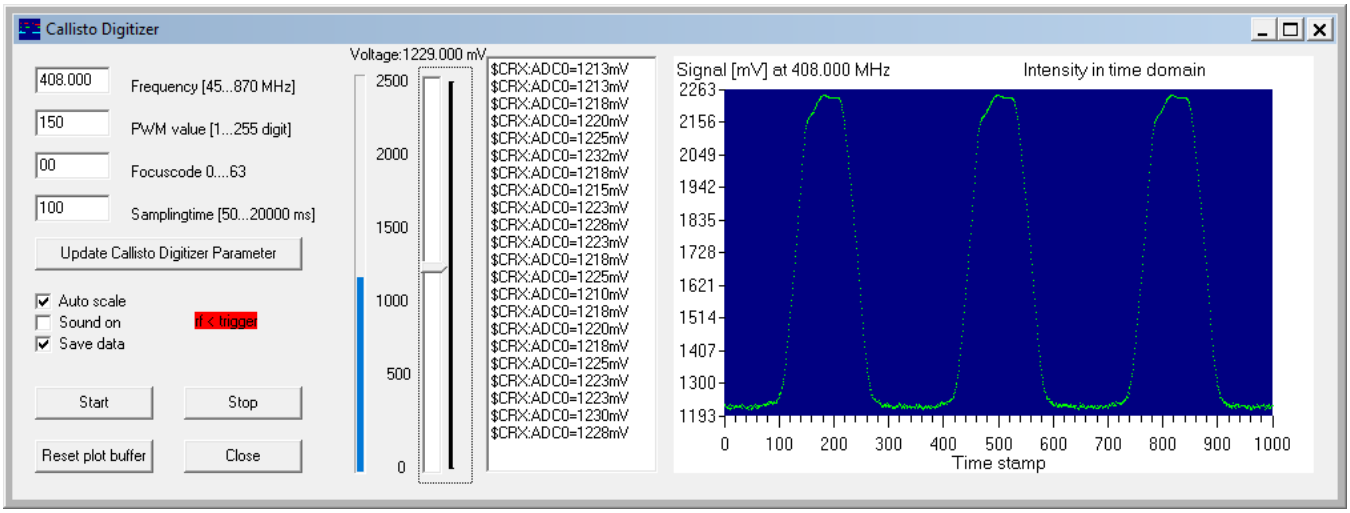

Figure 6 ~ Digitizer setup for 2nd IF bandpass filter testing with an RF signal generator. The display in the right frame shows the filter shape.

Example 2:

For Automatic bandpass filter measurements, an RF signal generator is set to a fixed frequency. The connections are the same as previously shown. Any frequency in the Callisto frequency range may be used; this example uses 408 MHz.

Signal Generator RF output connected through a 10 dB attenuator to the Callisto RF Input

- RF input level at Callisto RF input: –70 dBm
- Frequency: 408.000 MHz

NF Test setup as follows (figure 8):

- Fmin: 406.0 MHz
- Fmax: 410.0 MHz
- Number of frequencies: 64
- PWM: 150
- Plot parameters, all default except
  - Y-low (dB): –45
  - Y-high (dB): +5

Measurement procedure:

1. Turn signal generator RF output Off
2. Press Automatic Bandpass button on NF Test
3. View progress bar and wait for first sweep to finish

4. Within 2 seconds of finish and before the second sweep starts, turn RF signal generator RF output On
5. The bandpass plot window appears when finished

In the Automatic BPF test, the first part establishes the plot noise floor and the second part sweeps the Callisto frequency from 406 to 410 MHz in (410.0 – 406.0)/64 = 62.5 kHz steps, a total of 64 frequencies. The noise floor should be ≤ –38 dB and the shape should not have significant distortion. Small out-of-band spurs and slight asymmetry near the peak are acceptable.

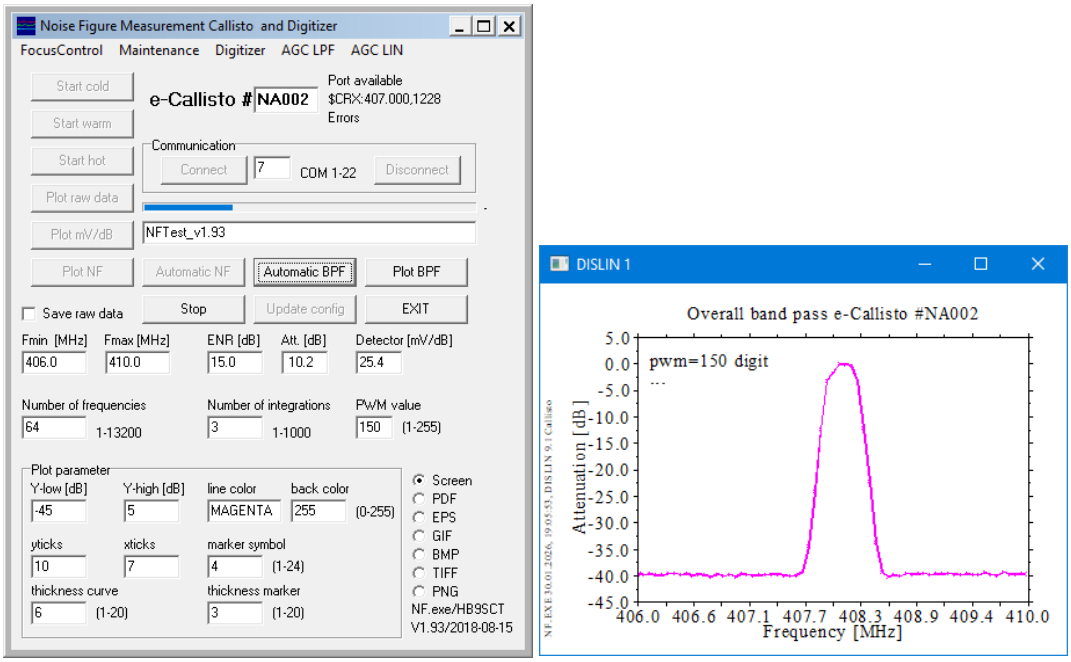

Figure 8 ~ Automatic 2nd IF bandpass filter testing with an RF signal generator set to a fixed frequency.

The *AGC LPF* menu is used to test the lowpass PWM filter that converts the PWM signal from the Callisto processor to a dc voltage that controls the Callisto tuner gain (figure 9). The Callisto only needs to be Connected to NF Test; none of the settings except Communication are used.

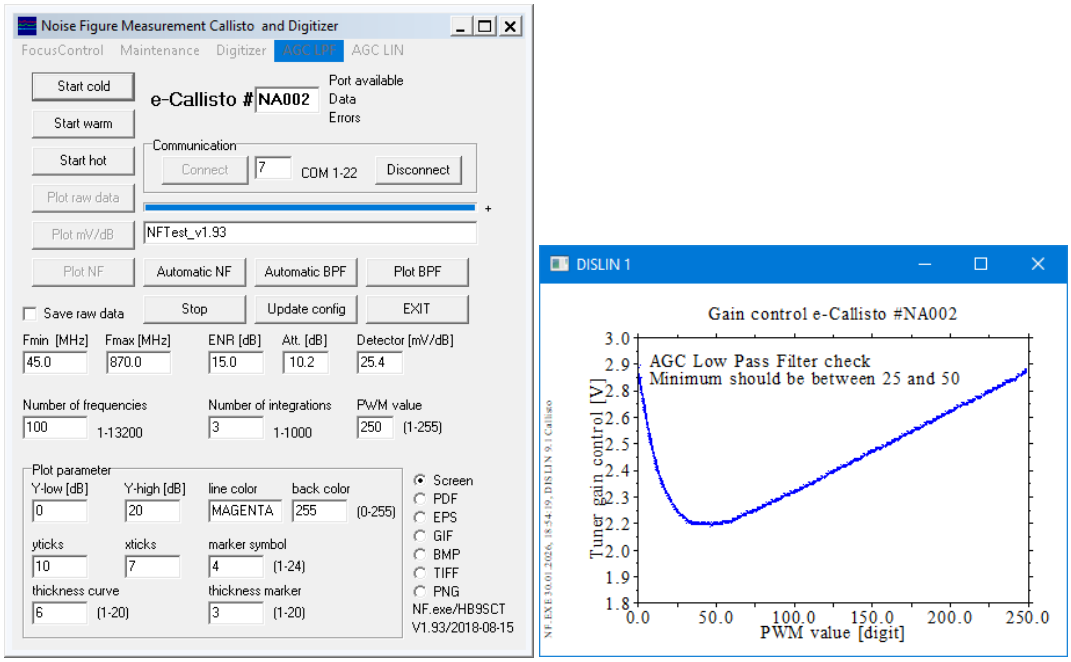

Figure 9 ~ A correctly working Callisto will show a smooth curve with a minimum PWM value between 25 and 50. The trace above the dip will be linear with no gaps or steps.

The *AGC LIN* menu is used to test the linearity of the tuner gain control circuit (figure 10). As with the AGC LPF, the Callisto only needs to be Connected and none of the settings are used except Communication.

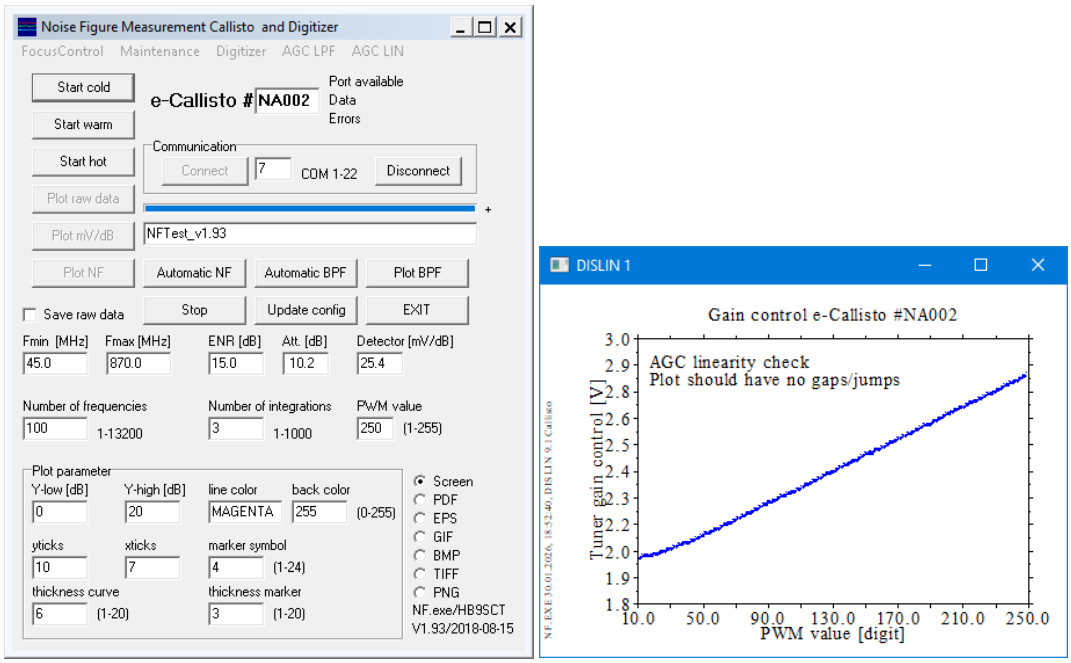

Figure 10 ~ A correctly working Callisto will show a smooth ascending trace with no gaps or step-changes.

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6. References

{e-CALLISTO} e-CALLISTO Solar Radio Astronomy Network: https://e-callisto.org/index.html

{NFTest} NF Test software tool, direct download available at: https://e-callisto.org/Software/NoiseFigurePLotterV193.zip

{Noise} Reeve, W. and Monstein, C., Noise Figure Measurements of the Callisto, 2026, available at: https://www.reeve.com/Documents/CALLISTO/Reeve-Monstein_CallistoNFMeas.pdf

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