SIGMA: SImple Graphical Monitoring Applet

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1 Introduction

SIGMA is an application for generating graphical and/or textual output corresponding to data it gathers from a given channel of the Laser Interferometer and Gravitational Wave Observatory (LIGO). SIGMA is capable of plotting the data, its power spectrum, and its distribution. The program can additionally fit a Gaussian curve to the distribution and compute the residual. SIGMA is ideally suited for generating images for presentation, but can just as well be used to observe the current data.

2 Syntax

All of SIGMA's user-specifiable options are given as command-line arguments. Each option has a default value, and thus no one argument is required for SIGMA to work. However, some combination of arguments must be supplied for the program to do anything useful. Those arguments that are supplied may be supplied in any order. A typical call to SIGMA would look like `sigma <options>`, where `<options>` denotes a series of command-line arguments.

Each argument begins with a two-character tag, such as `-c`. The first character is always a hyphen. Some options require additional information (ex. the channel option, which requires the channel name). If corresponding input is required, the input follows the two-character tag without any intervening whitespace. For instance, if the user wishes to monitor the H0:PEM-LVEA_SEISZ channel, he or she would specify `-cH0:PEM-LVEA_SEISZ` after the program name. The following tags can be used to manipulate options:

`-c`

Sets the channel name. The channel name immediately follows the tag (ex. `-cH0:PEM-LVEA_SEISZ`). The `-c` option is overwriting; if multiple `-c` arguments are supplied on the command-line, only the last one will be used. The default channel is H0:PEM-LVEA_SEISZ.

`-t`

Sets the time duration. The observation interval in seconds immediately follows the tag (ex. `-t12.5`). The minimum and maximum acceptable values are 0.1 and 512, respectively. The `-t` option is overwriting; only the last `-t` argument on the command-line will be used. The time should be chosen so that the total number of samples is less than 33000. The default interval is 1.

`-d`

Toggles the display. Including `-d` on the command line will disable display of the selected plots in a X window. The option has no effect without at least one of `-T`, `-F`, `-H`, `-G`, or `-R` toggled on. Including multiple `-d` tags on the command-line will toggle the display on and off. By default, the option is toggled on.

`-s`

Toggles the save feature. Including `-s` on the command line will write the time series to a text file. Including multiple `-s` tags on the command-line will toggle the save feature on and off. By default, the option is toggled off.

`-x`

Sets the image format (extension) and creates the image. The output format is specified immediately after the tag (ex. `-xgif`). The `-x` option is overwriting; only the last `-x` argument on the command-line will be used. Allowable values are `gif`, `ps`, `ai`, `png`, `svg`, `pnm`, `cgm`, `fig`, `pcl`, `hpgl`, `regis`, and `tek`. A description of these formats may be found in the documentation for the GNU Plotutils package at http://www.gnu.org/software/plotutils/plotutils.html. By default, no extension is specified, and no image is created.

`-T`

Toggles the time series plot. Including `-T` on the command-line will display a graph of the time series in the X window (if the `-d` option is toggled on) and/or image file (if the `-x` option is specified). Including multiple `-T` tags on the command-line will toggle the plot on and off. By default, the option is toggled off.

`-F`

Toggles the frequency spectrum plot. Including `-F` on the command-line will display a graph of the power spectrum in the X window (if the `-d` option is toggled on) and/or image file (if the `-x` option is specified). Including multiple `-F` tags on the command-line will toggle the plot on and off. By default, the option is toggled off. Optionally, one can specify an axes style immediately after the `-F` tag (ex. `-F1`). Allowable values are 0 (linear vs. linear), 1 (logarithmic vs. logarithmic), 2 (linear vs. logarithmic), and 3 (logarithmic vs. linear).

`-H`

Toggles the histogram plot. Including `-H` on the command line will display a plot of the distribution of time-domain data in the X window (if the `-d` option is toggled on) and/or image file (if the `-x` option is specified). Including multiple `-H` tags on the command-line will toggle the plot on and off. By default, the option is toggled off. This option shares a window with the `-G` and `-R` options.

`-G`

Toggles the gaussian fit plot. Including `-G` on the command-line will display a plot of the gaussian that best fits the time-domain distribution in the X window (if the `-d` option is toggled on) and/or image file (if the `-x` option is specified). Including multiple `-G` tags on the command-line will toggle the plot on and off. By default, the option is toggled off. This option shares a window with the `-H` and `-R` options.

`-R`

Toggles the residual plot. Including `-R` on the command-line will display a plot of the residual between the time-domain data distribution and the best-fit curve in the X window (if the `-d` option is toggled on) and/or image file (if the `-x` option is specified). Including multiple `-R` tags on the command-line will toggle the plot on and off. By default, the option is toggled off. This option shares a window with the `-H` and `-G` options.

`-b`

Sets the number of bins in the distribution plot. The number of bins is specified immediately after the tag (ex. `-b100`). The `-b` option is overwriting; only the last `-b` argument on the command-line will be used. This option has no effect without at least one of `-H`, `-G`, or `-R`. The default number of bins is 100.

`-l`

Toggles logarithmic axis in the distribution plot. Including `-l` on the command-line will display the selected distribution plots (`-H`, `-G`, and/or `-R`) with a logarithmic counting axis. Including multiple `-l` tags on the command-line will toggle the logarithmic axis on and off. By default, this option is off.

3 Running SIGMA

To run SIGMA, you will first need to open an X terminal on a DMT node. From this terminal, log in to one of the DMT computers. From here, you have full access to SIGMA's capabilities.

What follows is a walk-though of the operation of SIGMA. After logging into one of the Hanford DMT machines, enter

```
sigma -xgif -cH0:PEM-COIL_MAGX -T -F2 -H -G -b50 -s -t10
```

The output that appears is reproduced in Fig. 1.

The name of the channel and the GPS time at the beginning of the observation interval are displayed vertically on the right edge of the window. The signal is displayed in red in the top, left corner. The signal has been observed for 10 seconds, as was instructed. The distribution of the data is in the top, right corner. The red curve is the actual data; the black curve is the gaussian fit. Note that the distribution plot shares a vertical axis with the signal plot. Although it is difficult to see on the distribution plot, there are a total of 50 bins. The power spectrum, measured in arbitrary units, is plotted in red at the bottom of the window. The axes are scaled as specified on the command-line; the horizontal axis is linear, and vertical axis is logarithmic. Now, type `ls` in the terminal window. A list of all the files in the current directory will appear. Notice that two files associated with SIGMA have been generated, as indicated on the command-line. The first is `H0:PEM-COIL_MAGX-0712298138.gif` (the ten digits before the extension

will vary, depending on the GPS time at the beginning of the program call). This is the image file. The other file is `H0:PEM-COIL_MAGX-0712298138.log`. It contains the data in a two-column text file. In general, the nomenclature of files created by SIGMA is based on the channel being observed and the GPS time. Type`more H0:PEM-COIL_MAGX-0712298138.log` to see how the saved text file is formatted.

Now, type

```
sigma -cH0:PEM-COIL_MAGX -F -T -t0.1
```

Fig. 2 contains the image displayed in the X window. Here, only the signal and power spectrum are displayed. Notice that both axes of the power spectrum are linear. Type `ls` again. You will find that no new files have been created.

Now, try

```
sigma -cH0:PEM-LVEA_SEISZ -T -F1 -H -G -R -t60 -l
```

The output is reproduced in Fig. 3. The signal now spans a total of sixty seconds. Both axes of the power spectrum are logarithmic, as is the counting axis of the distribution, in accordance with the command-line specification. Notice, however, that no residual curve has been drawn, even though you instructed SIGMA to draw one. If you look at the terminal window, you will see that SIGMA has output `Logarithmic axis incompatible with residual. Toggling residual off.` The residual curve often falls below zero, and one cannot take logarithms of nonpositive numbers. To manage this incompatibility, the residual is automatically turned off. Unfortunately, this does not resolve the situation entirely. The power spectrum and the histogram can still contain zero values. As such, the `graph` application on which SIGMA is based may generate its own output indicating that certain data points are inappropriate for display on logarithmic axes. Despite these complaints, SIGMA will still function properly.

Suppose you want to see the residual. Try entering the same command as before, but remove (or include another) `-l` argument. The window generated will be the same as before, except that the counting axis of the distribution plot is no longer logarithmic, and the residual curve is displayed in green. This command is reproduced in Fig. 4 and Fig. 5, with the H0:PEM-LVEA_SEISZ and H0:PEM-COIL_MAGX channels, respectively.

Finally, suppose you want to create a single plot of the power spectrum. Say you are interested in noise at low frequencies, but want to keep the vertical axis of the spectrum linear. A linear horizontal axis will make it difficult to see low frequency data, so try

```
sigma -cH0:PEM-LVEA_SEISZ -F3 -t20
```

The resulting graph is presented in Fig. 6. Note that the horizontal axis is logarithmic, and that it is much easier to see low frequency features.

Experiment with different options until you feel comfortable with the way SIGMA handles command-line arguments.

4 System Requirements

SIGMA must run on one of the Data Monitoring Tool (DMT) computers. To run SIGMA remotely (i.e. look at the data on a non-DMT machine), the remote computer must have an X windows server. A working installation of the GNU Plotutils package is also required. All of the DMT computers should meet this requirement, but if not, the package can be obtained freely from http://www.gnu.org.

5 About SIGMA

The current version of SIGMA is 1.0. It is the first stable release.

SIGMA was co-authored by Akash Kansagra (MIT) and Ryan Williams (LSU), both with the Global Diagnostics System (GDS) at LIGO Caltech.

This guide was typeset in LyX by Akash Kansagra.

6 Contact

Please direct all questions and bug reports to Akash Kansagra (kansagra@mit.edu) or Ryan Williams (rwill37@lsu.edu). To ensure a swift reply, please include the phrase "LIGO Development: SIGMA" in the subject of your E-mail. E-mail correspondence is preferred.

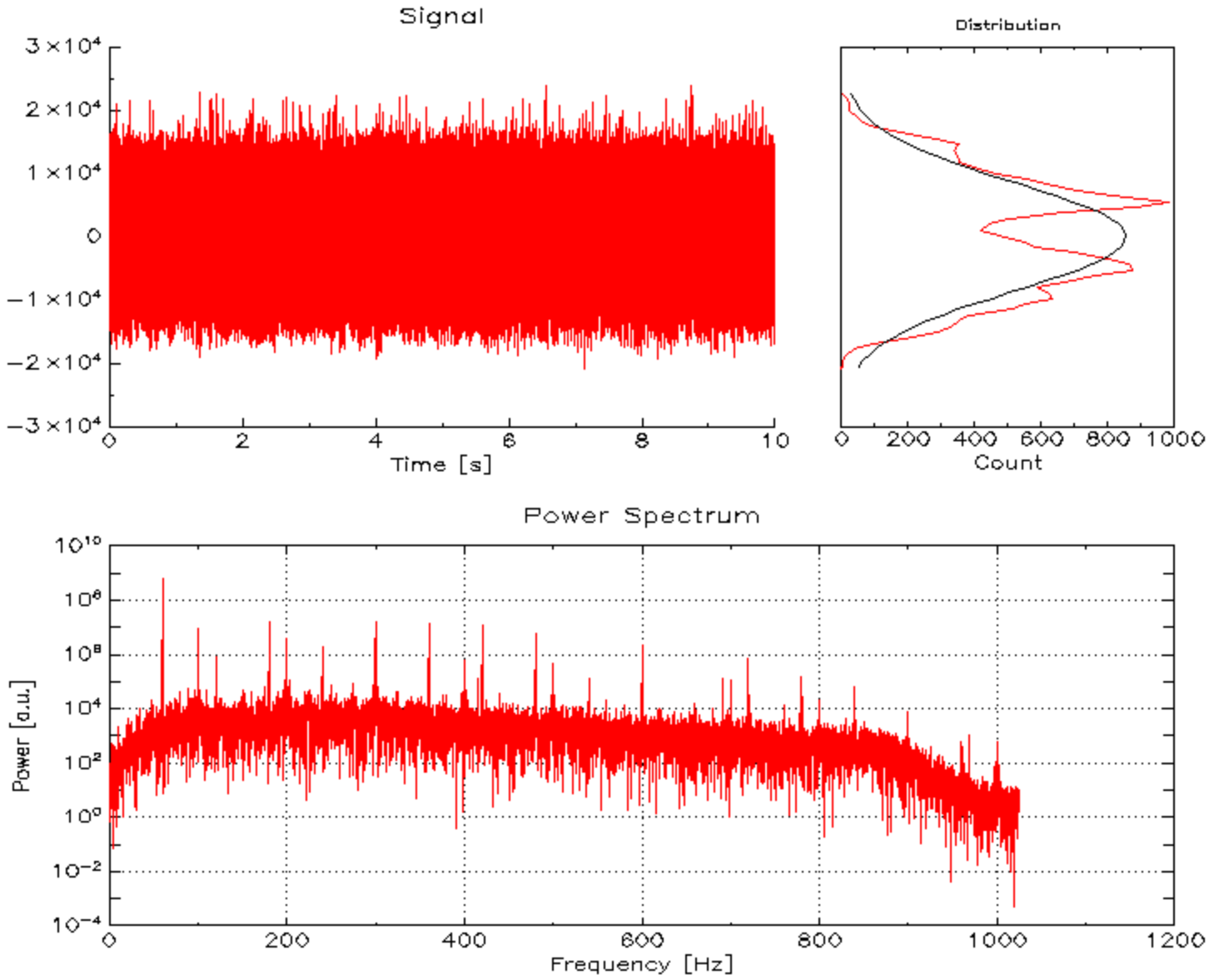

Signal
3×10⁴
2×10⁴
1×10⁴
0
−1×10⁴
−2×10⁴
−3×10⁴
0
2
4
6
8
10
Time [s]
Distribution
0
200
400
600
800
1000
Count
Power Spectrum
10¹⁰
10⁶
10⁸
10⁴
10²
10⁰
10⁻²
10⁻⁴
Power [a.u.]
0
200
400
600
800
1000
1200
Frequency [Hz]
H0:PEM-COIL_MAGX + 07123447 20

Figure 1.

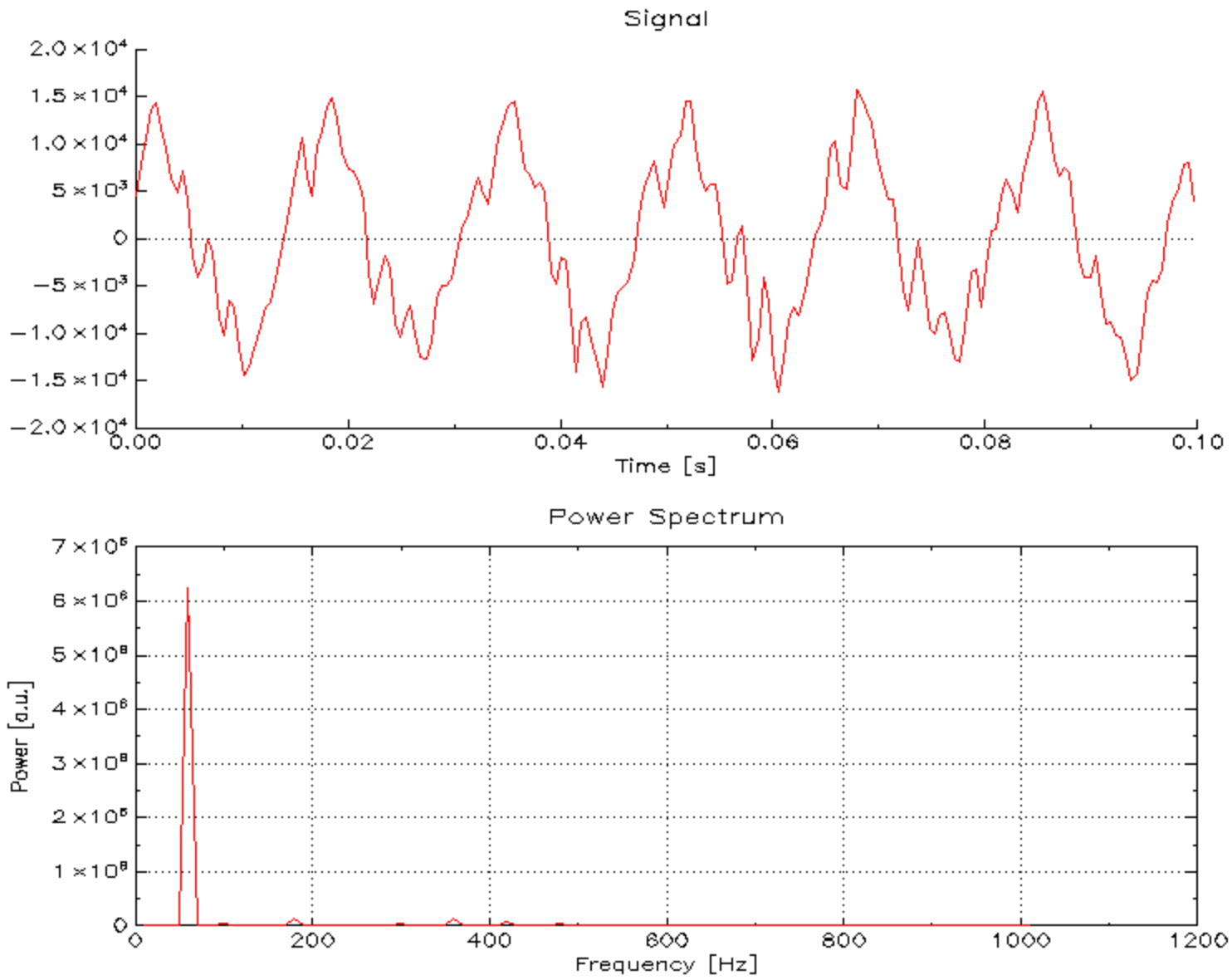
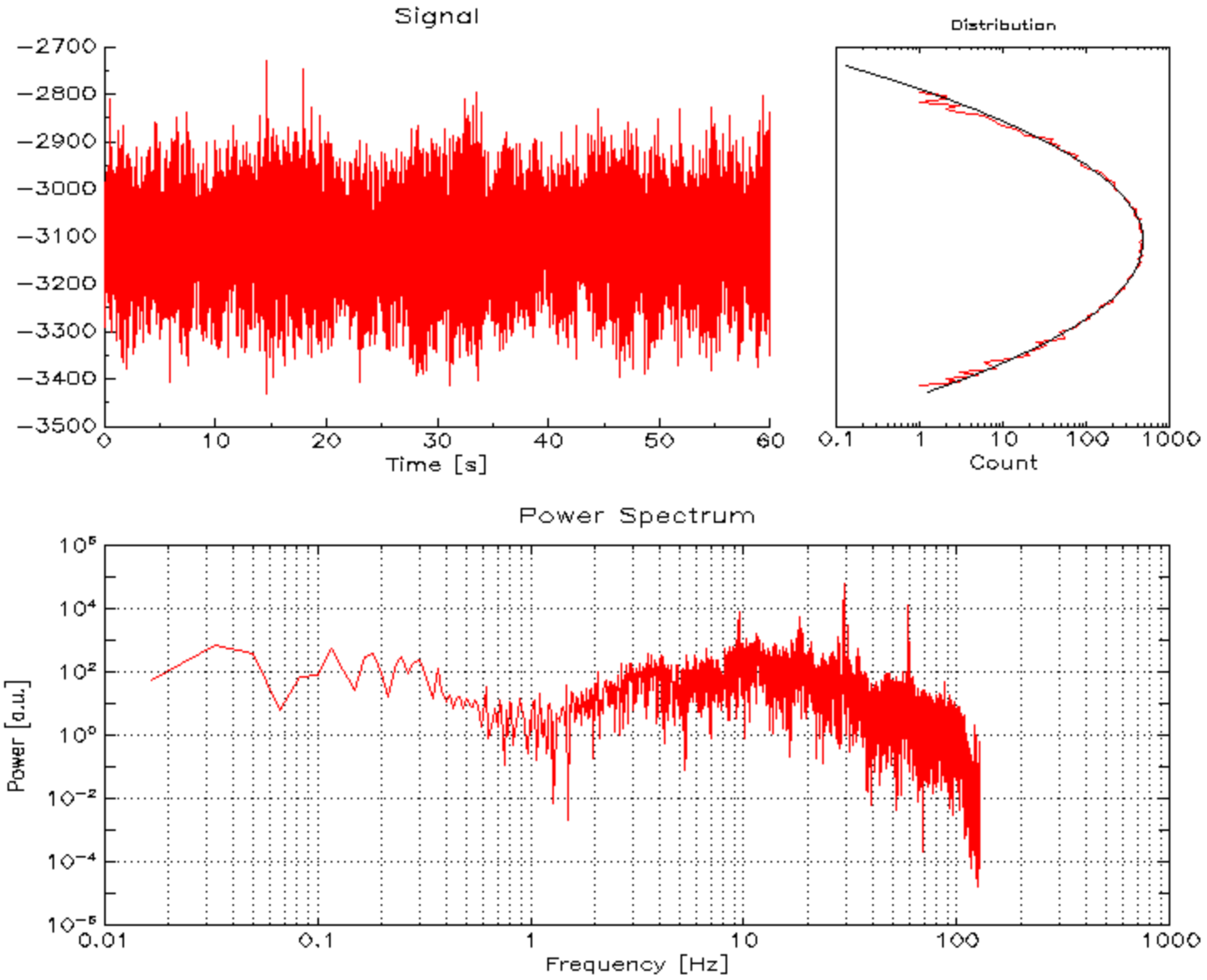

Signal
2.0×10⁴
1.5×10⁴
1.0×10⁴
5×10³
0
−5×10³
−1.0×10⁴
−1.5×10⁴
−2.0×10⁴
0.00
0.02
0.04
0.06
0.08
0.10
Time [s]
Power Spectrum
7×10⁵
6×10⁵
5×10⁵
4×10⁵
3×10⁵
2×10⁵
1×10⁵
0
Power [a.u.]
0
200
400
600
800
1000
1200
Frequency [Hz]
H0:PEM−COIL_MAGX + 071234496

Figure 2.



H0:PEM-LVEA_SEISZ + 071234523 5

Figure 3.

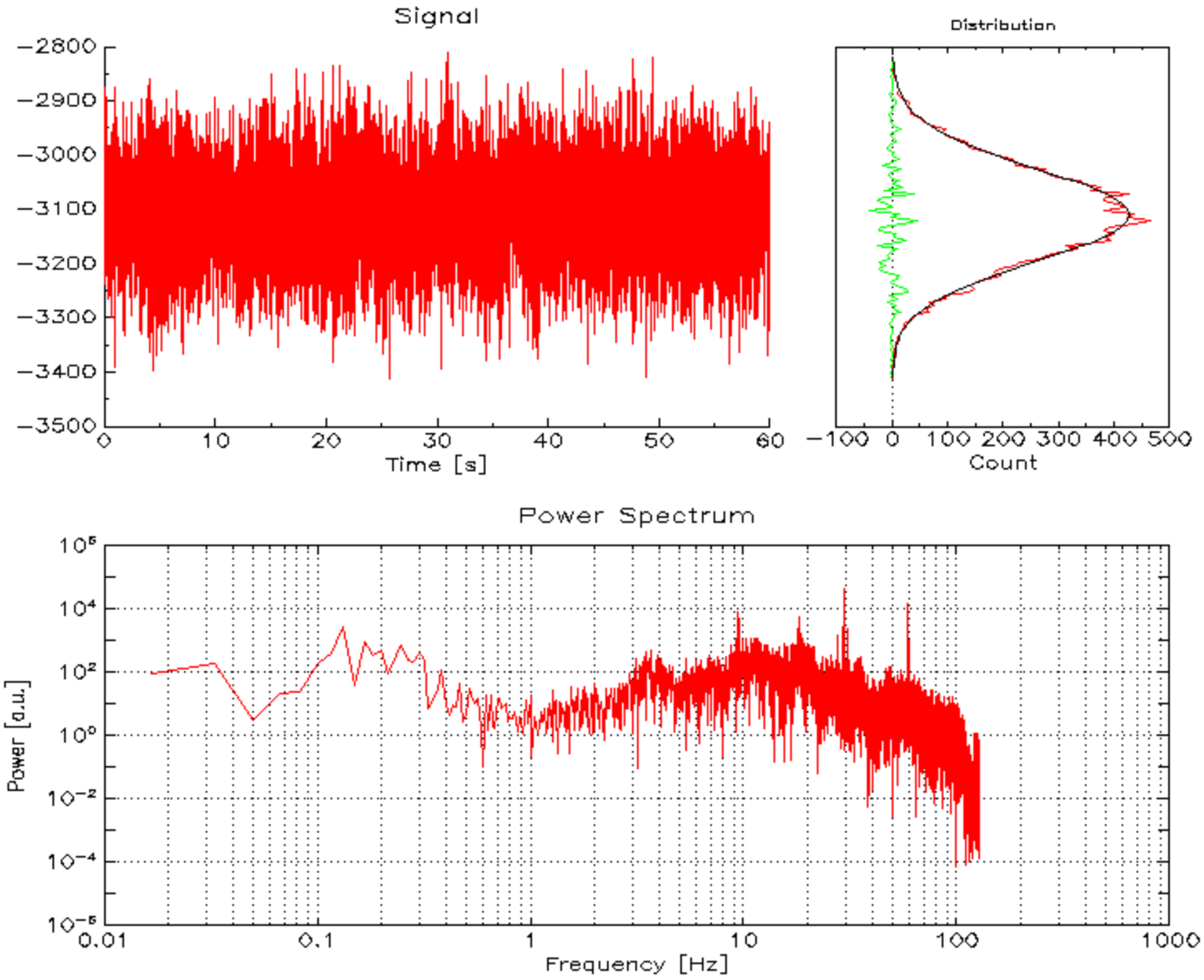

Signal
−2800
−2900
−3000
−3100
−3200
−3300
−3400
−3500
0
10
20
30
40
50
60
Time [s]
Distribution
−100
0
100
200
300
400
500
Count
Power Spectrum
Power [a.u.]
10⁵
10⁴
10²
10⁰
10⁻²
10⁻⁴
10⁻⁵
0.01
0.1
1
10
100
1000
Frequency [Hz]
H0:PEM-LVEA_SEISZ + 07123453600

Figure 4.

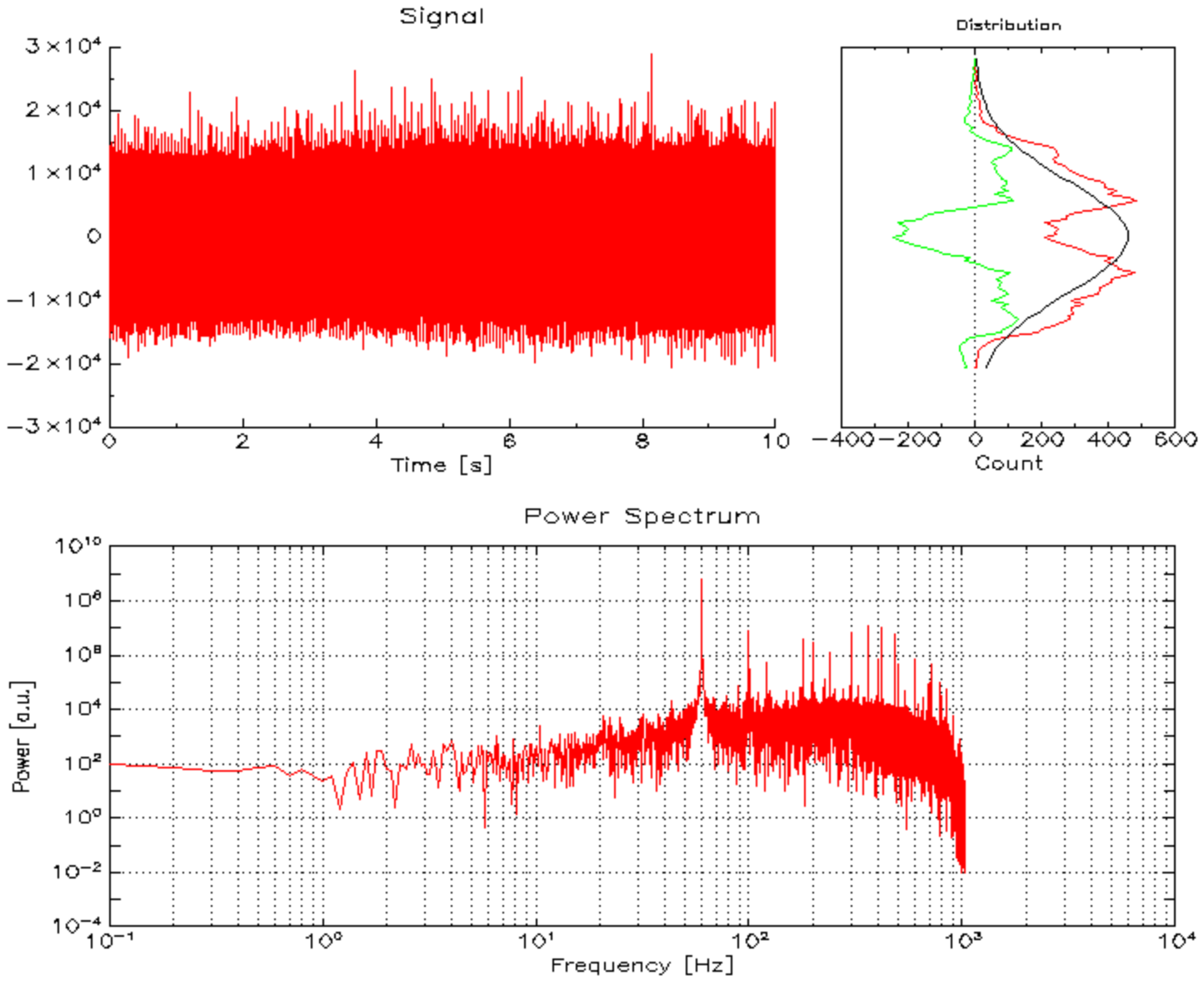
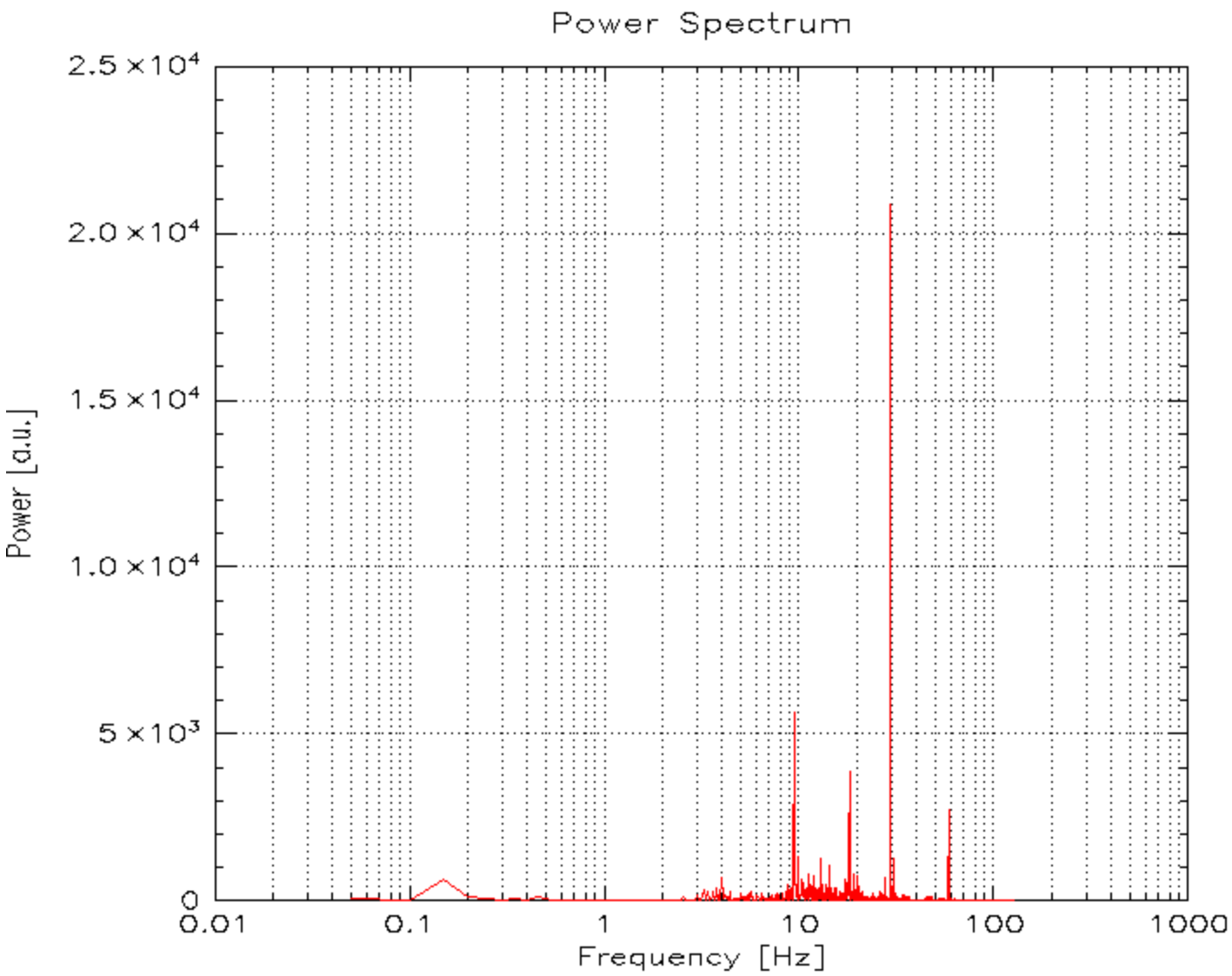

Signal
Distribution
Time [s]
Count
Power Spectrum
Power [a.u.]
Frequency [Hz]
H0:PEM-COIL_MAGX + 071234595

Figure 5.



H0:PEM-LVEA_SEISZ + 071234561 1

Figure 6.