

**Automatic analysis of non-nutritive suck
in time and frequency domain among preterm
infants: NeoSuck RT**

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1 NeoSuck *RT* Setup

NeoSuck *RT* (*real time*) is used to record and analyze data associated with the non-nutritive suck (NNS), including signals related to Suck Pressure, EMG OOS-R, EMG OOS-L, EMG OOI-R, EMG OOI-L, which are recorded from 5 channels of NI DAQ 6052E PCI multifunction board installed in the acquisition PC with 3 kHz sampling rate on 16-bits vertical resolution. We currently apply this software and hardware system to test and re-analyze the suck pressure and signals from other channels for premature and term baby. The analysis tools in NeoSuck *RT* include histogram analysis, FFT analysis, bad block screening, digital signal processing, generate output ASCII files for time and frequency domain, etc.

1.1 Hardware

The Hardware for this testing equipment includes:

- A CPU with 1 GB RAM running Windows XP
- NI DAQ 6052E and BNC 2110 or BNC 2090
- Bridge Amplifier
- AC PreAmplifiers (4)
- Sensors: pressure sensor and EMG Ag/AgCl sensors

The hardware listed above is configured up according to Figure 1, and baby's suck pressure and EMG signal sampled from the Soothie™ silicon nipple receiver is input to NeoSuck *RT* for real time digitization, signal processing, and waveform display.

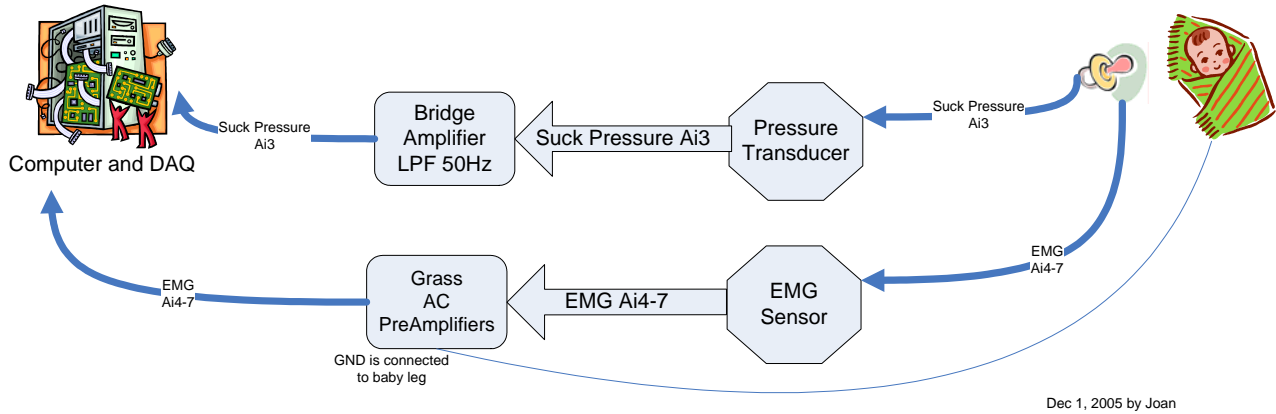
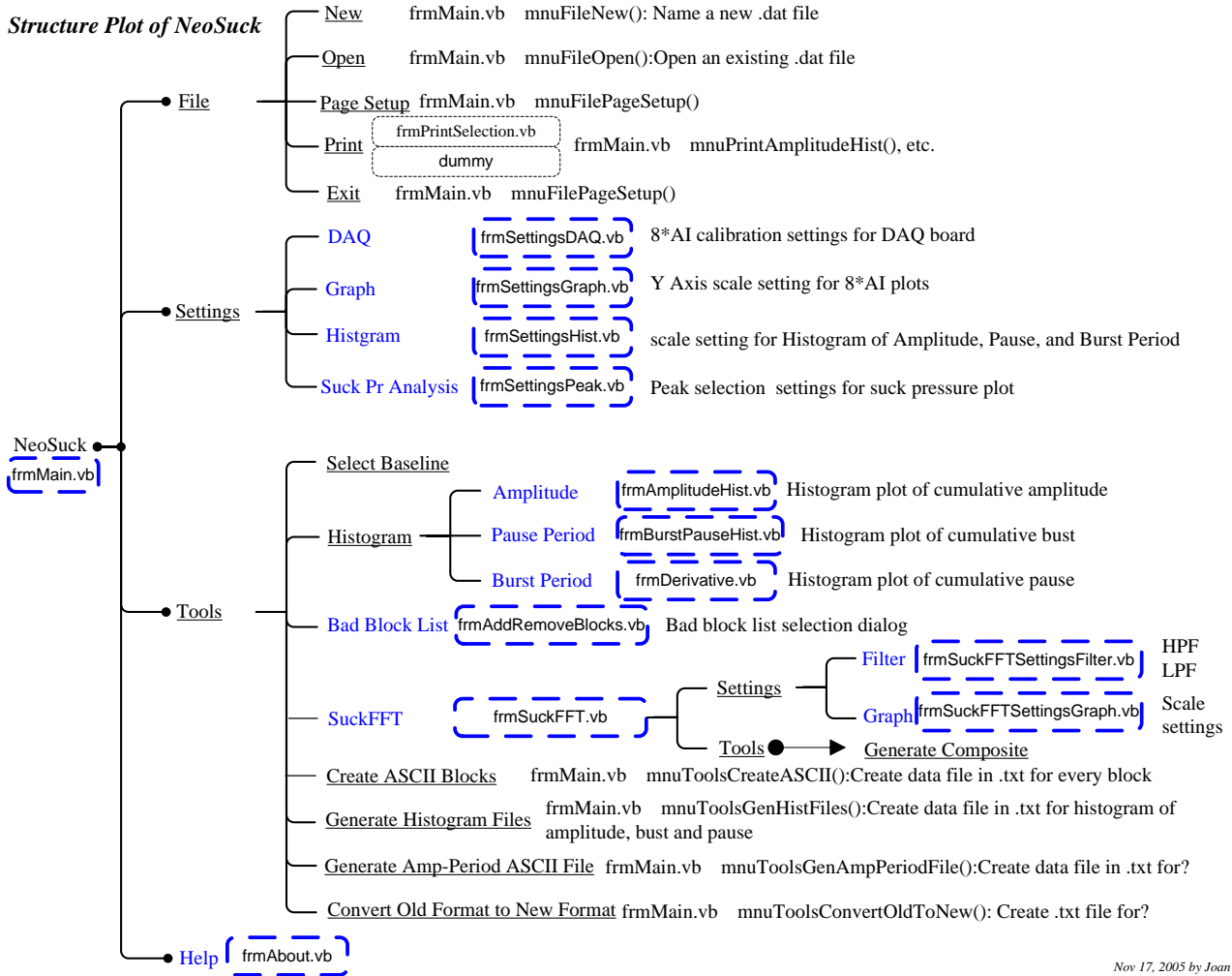


Figure 1. Hardware configuration for NeoSuck *RT*

1.2 Software

This software is coded by Visual Basic.Net (17,265 coding lines) according to the structure shown in Figure 2. The function of this software includes real-time data acquisition, histogram processing, FFT analysis, ASCII file generation, and export desired data to .txt file.

Structure Plot of NeoSuck



Nov 17, 2005 by Joan

Figure 2. Coding structure plot for NeoSuck RT

1.3 Program installation

1. Uninstall any previous installed versions of **NeoSuck RT** using Control Panel > Add/Remove Programs.
2. Install **NeoSuck RT** by running setup.exe from the installation package.



Figure 3. BNC-2090

Note: Normally, it works with BNC-2090 interface (Figure 3).
To work with the BNC-2110 (Figure 4) please make the following change:



Figure 4. BNC-2110

For BNC-2110

To work with BNC-2110, the terminal configuration has to be in **differential mode**. Terminal configuration can be set to differential mode by modifying the parameter value of “terminalConfig” to “1” under <systemConstants> section in the file NeoSuckRT.exe.config located in C:\Program Files\Neuro Logic\NeoSuck RT\. Here is the line from NeoSuckRT.exe.config that shows this parameter value:

```
<add key=" terminalConfig" value="1" />
```

“terminalConfig” can have the following values:

value="1" for **Differential**

value="2" for **Referenced single ended**

value="3" for **Nonreferenced single ended**

By default, the file NeoSuckRT.exe.config contains value="3" for "terminalConfig". This setting is used for the BNC-2090 signal interface. Here is the line from NeoSuckRT.exe.config that shows this parameter value

```
<add key="terminalConfig " value="3" />
```

2 User manual

When opening the **NeoSuck RT**, a blank window is shown as follows (Figure 5). User could apply this set of software and hardware to record new data or analysis of existing data:

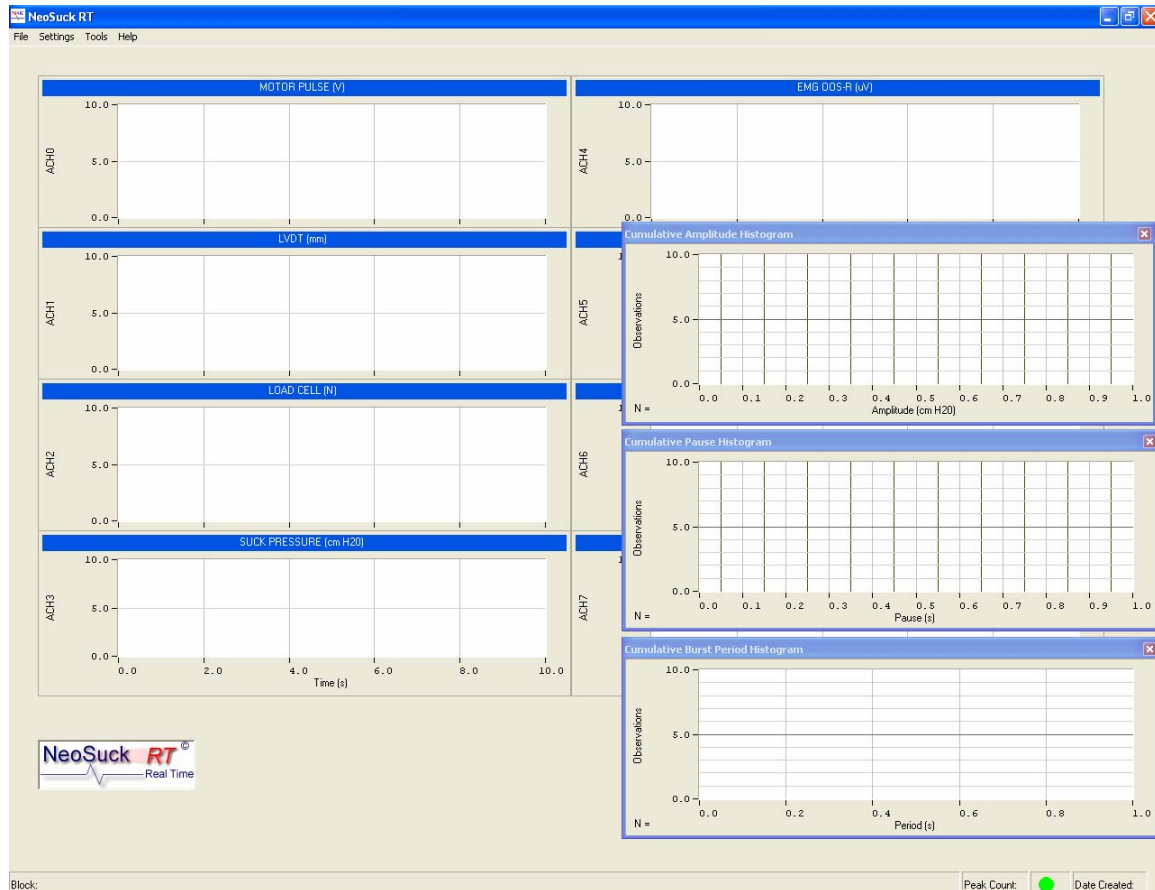


Figure 5. Blank window for recording and analysis

2.1 Record new data by NeoSuck RT

To Record data for a baby, go to **File**→**New**, then a “Save As” file dialog will pop up as shown in Figure 6. Input the file name as *.dat file which will be used for future analysis, and click “Save” button.

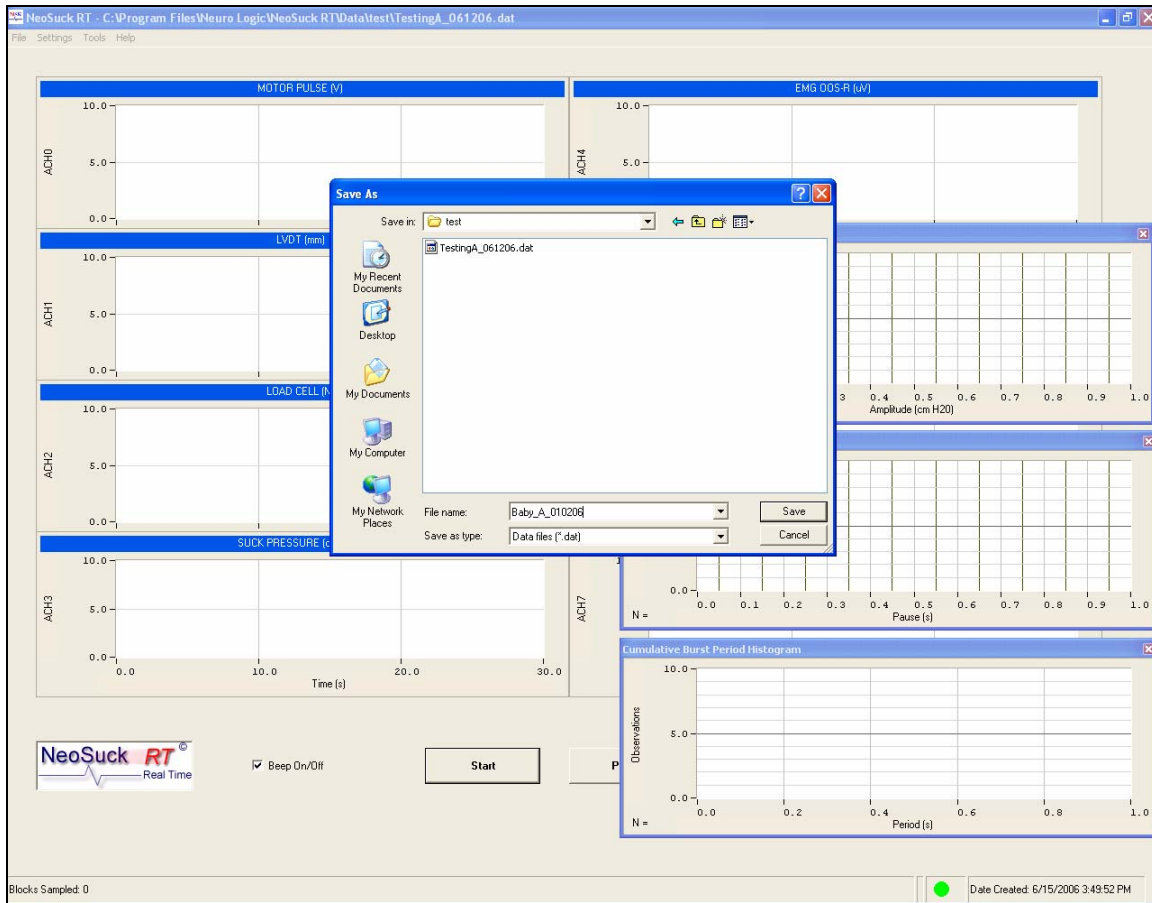


Figure 6. Recording new data

Then user can press the “Start” to begin the recording, or “Pause” button to halt it.

2.2 Analyze existing data by NeoSuck RT

Based on the data collected (described in section 2.1, **Record new data by NeoSuck**), user can systematically apply analysis tools in NeoSuck RT to investigate more detailed properties of the human infant NNS.

2.2.1 Basic analysis

Click **File**→**Open**, an open file dialogue will pop up (Figure 7) to enable the user to designate the name and path of the target data file.

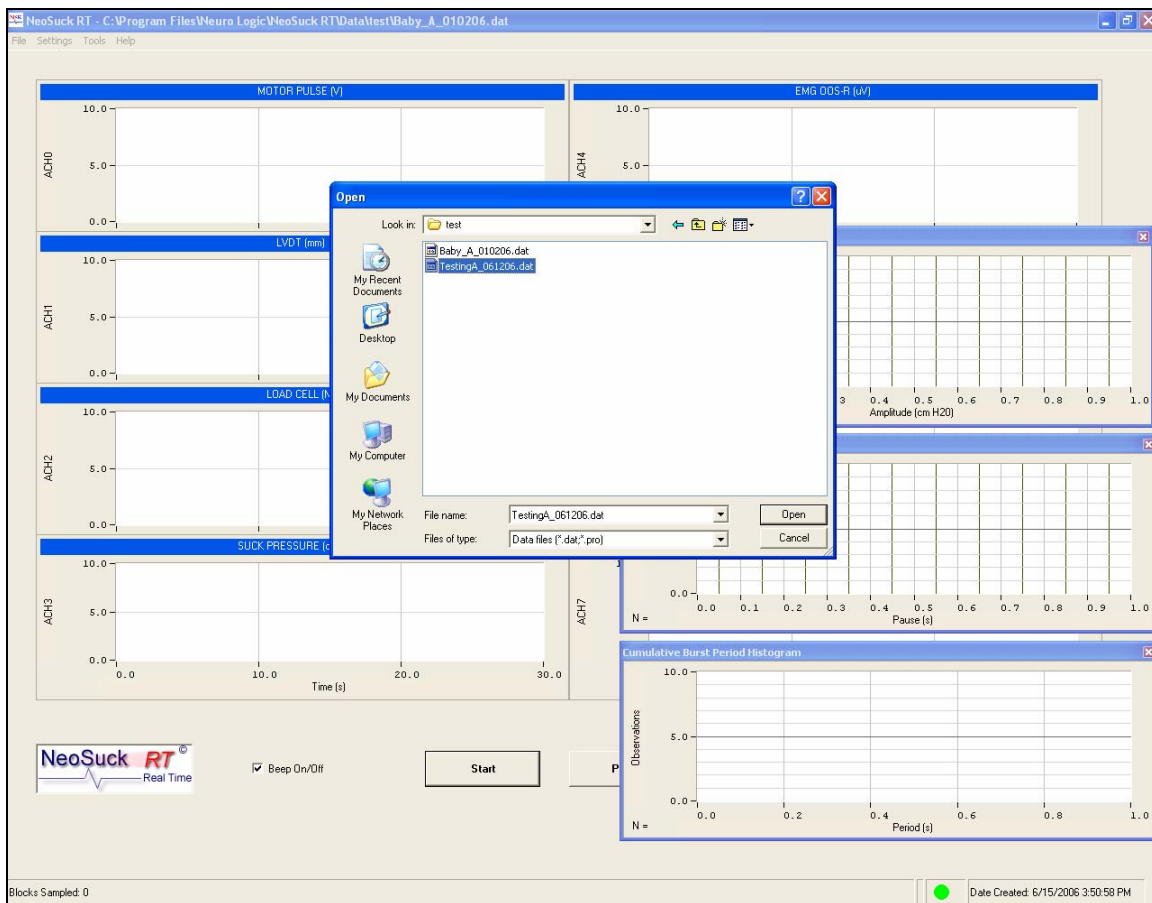


Figure 7. Opening an existing data file

Figure 8 shows the initial NeoSuck RT data analysis window. The three histogram windows on the right display the histogram plots for NNS Amplitude, Pause Periods, and NNS Burst Periods for each block that the user has selected. If the user is only interested in the analysis

of data from 8 channels displayed in the main window, then these three histogram windows can be closed by the user.

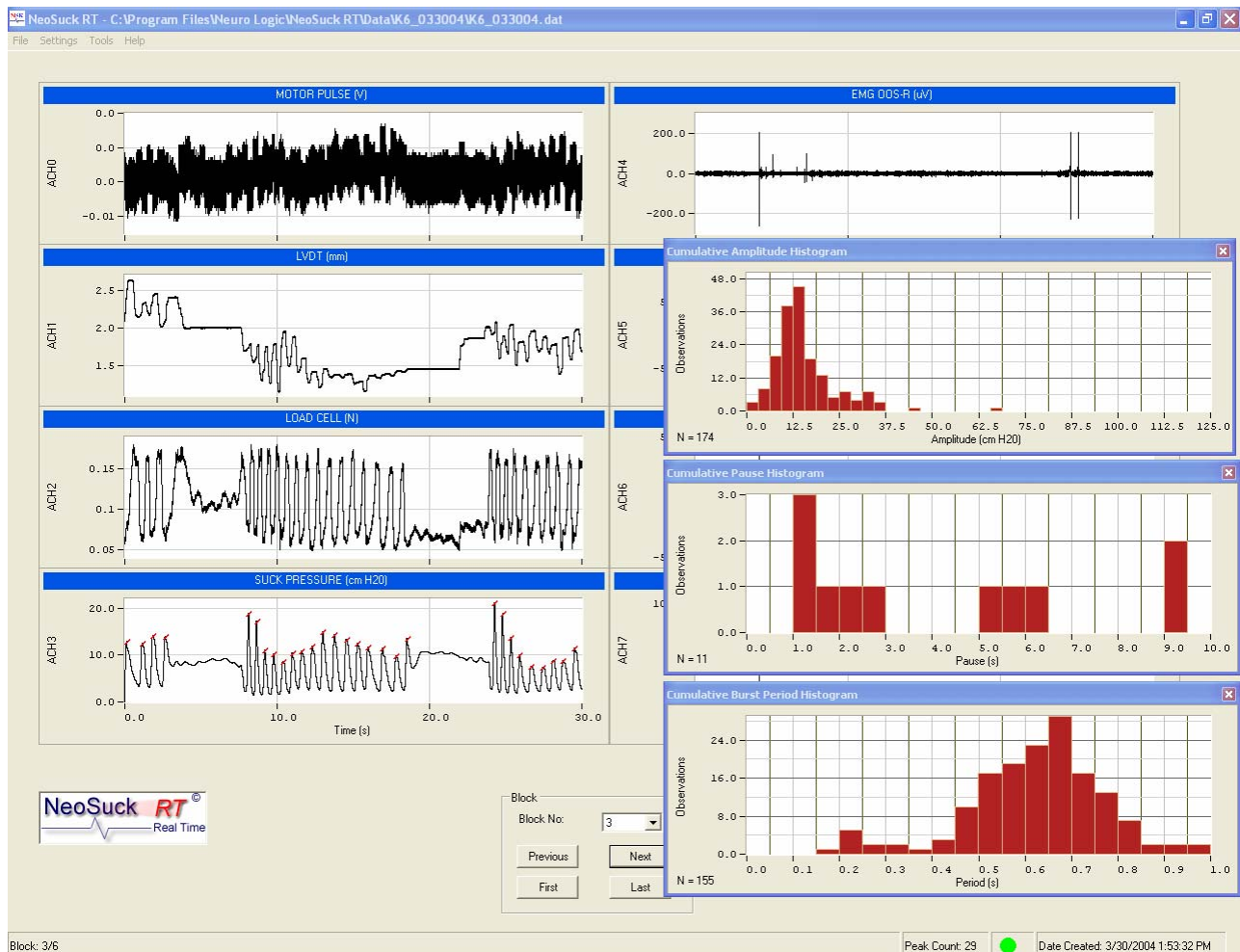


Figure 8. Open NeoSuck RT window for data analysis

The User can also call these windows by clicking desired window in **Tools**→**Histogram** as shown in Figure 9. Furthermore, the displayed histograms can also be exported to *.txt file by clicking **Tools**→**Generate Histogram Files** for future analysis. Those files will be saved under C:\Program Files\Neuro Logic\NeoSuck RT\Data.

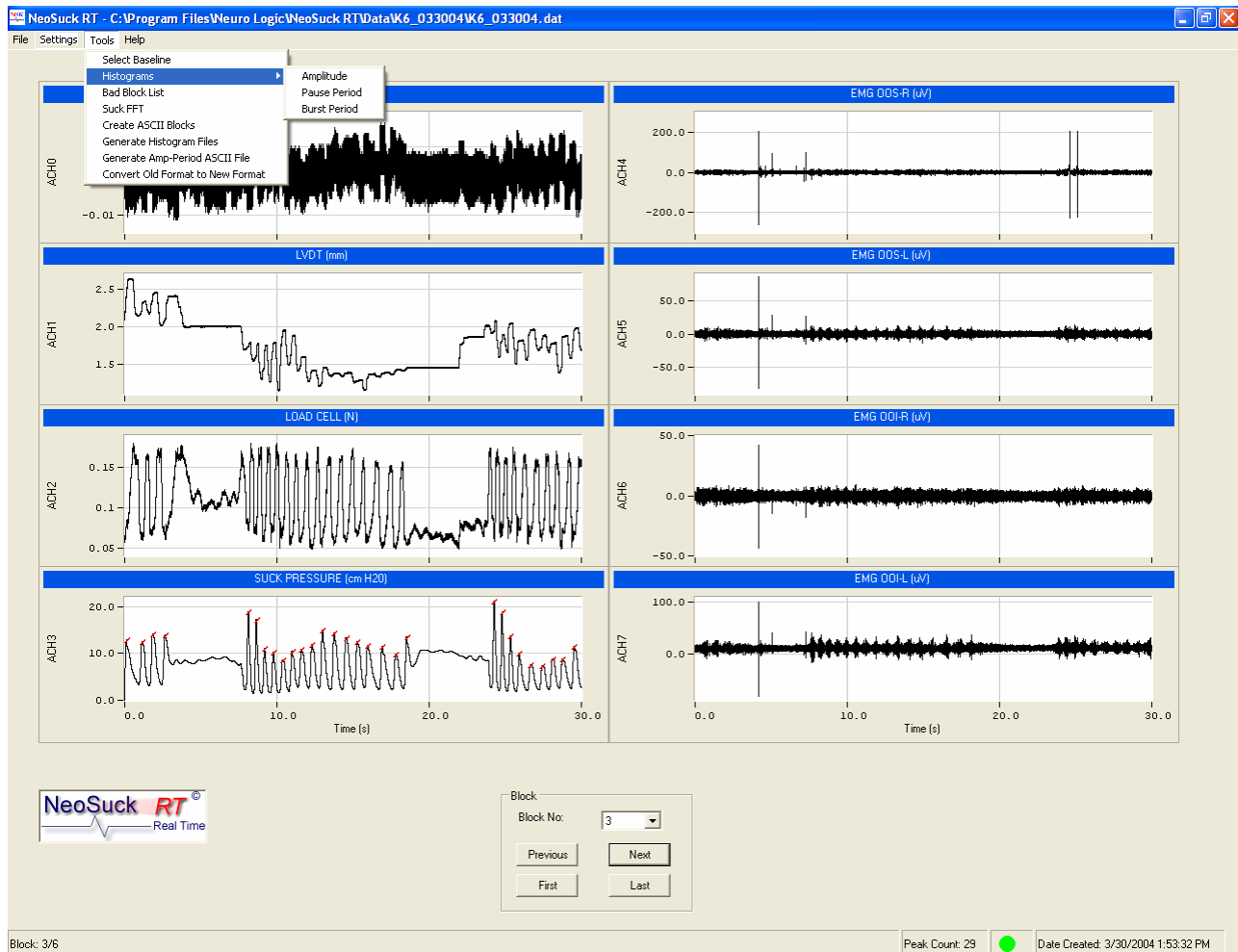


Figure 9. NeoSuck window without Histogram analysis

Similar to the recording process, NeoSuck RT analyzes data in successive blocks (30 seconds for each block). User can scroll among different blocks by clicking the “Previous” and “Next” buttons in the lower part of the window as shown in Figure 9.

NeoSuck RT is mainly for suck pressure analysis, which is shown as the last graph in the first column. NeoSuck RT can automatically recognize the peak in suck pressure, which is marked by small diagonal red lines in suck pressure plot.

2.2.2 Fourier transform of suck pressure

NeoSuck RT can be used to calculate the FFT of suck pressure. In order to get the frequency property of suck pressure, the user can click **Tools**→**Suck FFT** to call up the “FFT-Suck Pressure” window. In this analysis window, the user will find the time domain and

frequency domain plot of the currently displayed block in the main NeoSuck RT window (Figure 10). The first and second graphs are both for current block, while the third graph, named as composite FFT, shows the mean FFT for all the blocks that have been analyzed by the FFT subroutine. User could either click “Update FFT Plot/Save FFT” button, or go to **Tools**→**Generate Composite** in this window to periodically update the composite FFT.

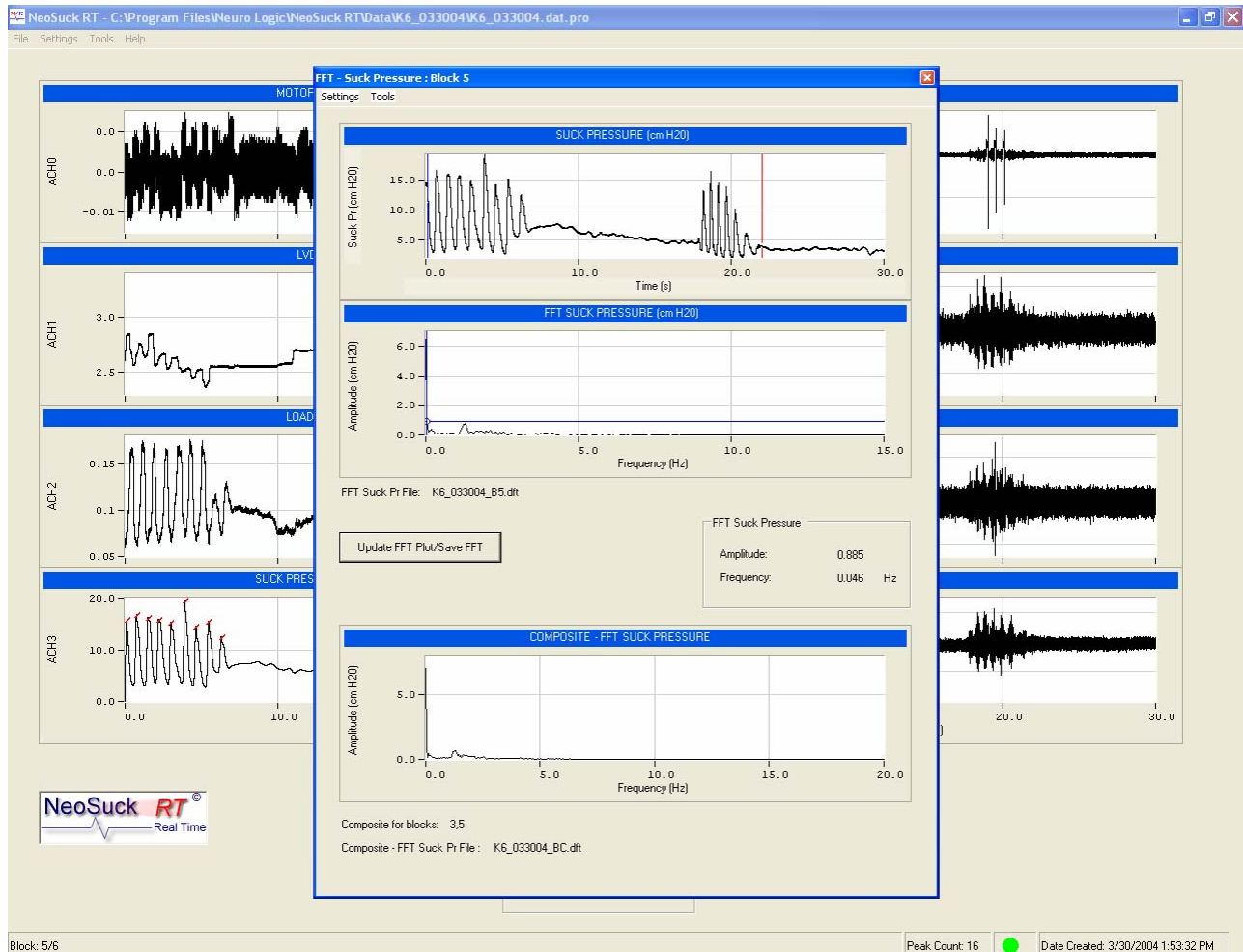


Figure 10. Suck pressure FFT analysis

In the setting menu, user could set the filter parameters (cutoff frequencies for **Low Pass** filter and **High Pass** filter) to plot the desired frequency property (Figure 11). In addition, the graph setting (Figure 12) enables the user to define the minimum and maximum values for both **x-axis** and **y-axis** for each of the three graphs shown in this window.

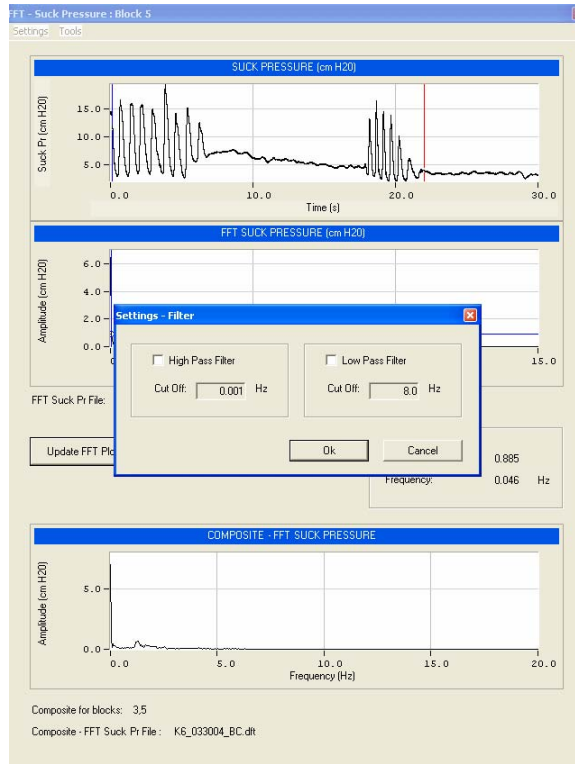


Figure 11. Filter setting in FFT analysis

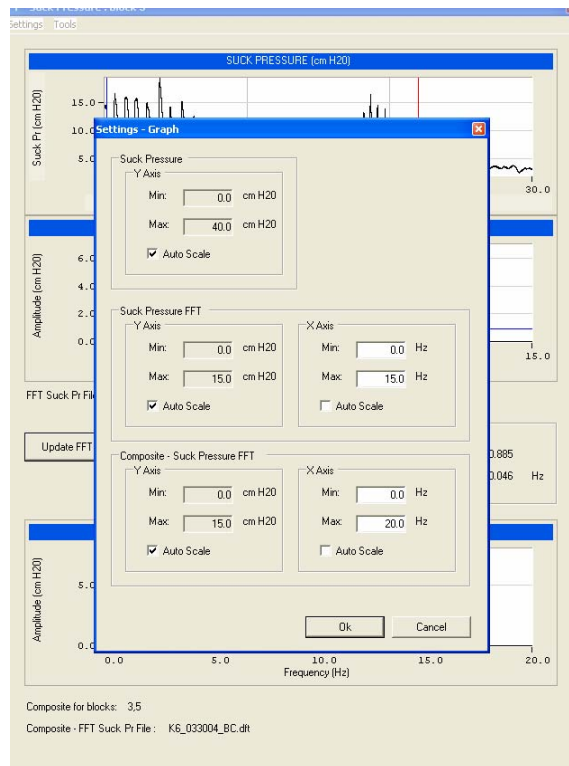


Figure 12. Graph setting in FFT analysis

2.2.3 Other analysis tools

There are some other analysis tools embedded in NeoSuck RT to either display graphs or export *.txt files which could be used for extended analyses using other commercial software like Minitab™, LabVIEW™, MATLAB™, MS Excel™, etc.

1. **Tools→Bad Block List** (Figure 13) enables the user to delete bad blocks from the entire data set, and thus generate clean analysis data for both exported data and Fourier transform analysis.

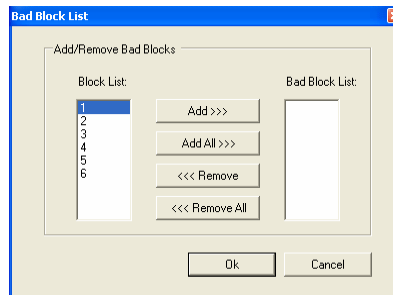


Figure 13. Bad Block List

2. **Tools→Create ASCII Blocks** (Figure 14) performs the function of exporting recorded *.dat file to .txt file block by block. The *.dat is a binary file which can be read by Visual Basic. The purpose of transforming data into *.txt file is to make the recorded data readable by 3rd party commercial graphics and statistical software.

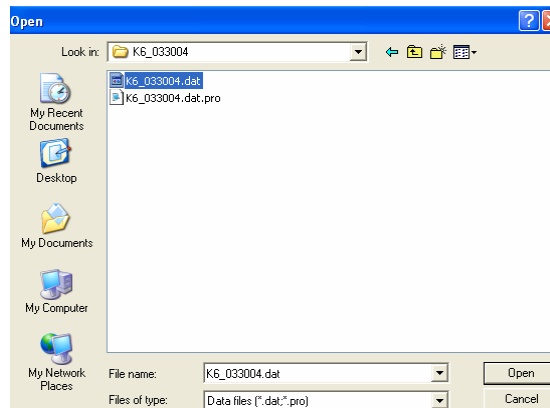


Figure 14. Create ASCII blocks for .dat file

3. The “Generate Histogram Files” and “Generate Amp-Period ASCII Files” will generate *.txt files for future analysis.

2.3 Other setups

Some other setups in **Setting** of the NeoSuck RT menu bar enable the user to set and modify analysis criteria for data acquisition, graphs, histogram plots, and FFT analysis.

Figure 15 is the DAQ setting dialog where the user can adjust the minimum and maximum acquisition limits, as well as calibration parameters. Once the DAQ parameters are set, sampled data files will assume the format established in the DAQ set-up. **Thus, these setup parameters should not be modified unless the specific intent is to change file structure and sampling rates.**

The screenshot shows the 'Settings - DAQ' dialog box. At the top, the 'DAQ Device' is set to 'PCI-6052E'. Below this, there are eight sections for different sensor types, each with its own set of parameters:

- Motor Pulse:** AI Channel: ACH0, Physical Unit: 1 V, Voltage: 1 V, A/D Min: -5 V, A/D Max: 5 V.
- LVDT:** AI Channel: ACH1, Physical Unit: 5 mm, Voltage: 0.56 V, A/D Min: -1 V, A/D Max: 1 V.
- Load Cell:** AI Channel: ACH2, Physical Unit: 0.5 N, Voltage: 0.484 V, A/D Min: -1 V, A/D Max: 1 V.
- Suck Pressure:** AI Channel: ACH3, Physical Unit: 10 cm H2O, Voltage: 0.8 V, A/D Min: -10 V, A/D Max: 10 V.
- EMG 00S-R:** AI Channel: ACH4, Physical Unit: 100 μ V, Voltage: 2 V, A/D Min: -10 V, A/D Max: 10 V.
- EMG 00S-L:** AI Channel: ACH5, Physical Unit: 100 μ V, Voltage: 2 V, A/D Min: -10 V, A/D Max: 10 V.
- EMG 00I-R:** AI Channel: ACH6, Physical Unit: 100 μ V, Voltage: 2 V, A/D Min: -10 V, A/D Max: 10 V.
- EMG 00I-L:** AI Channel: ACH7, Physical Unit: 100 μ V, Voltage: 2 V, A/D Min: -10 V, A/D Max: 10 V.

At the bottom, there is a 'Block' section with the following parameters:

- Sample Rate: 3000
- Sample Time: 30
- No. of Samples: 90000
- Down Sample: 100

A 'Cancel' button is located at the bottom right of the dialog.

Figure 15. DAQ board settings

The Graph and Histogram settings (Figure 16) include the dialog windows for lower and upper limit selection according to user's preference.

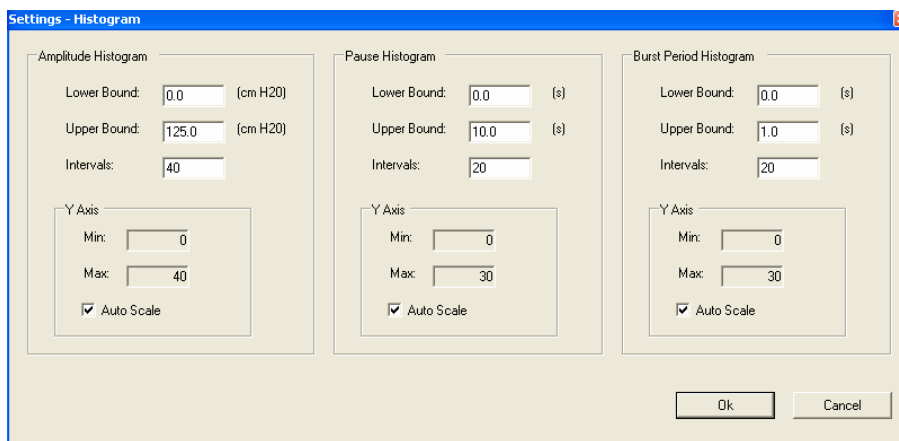
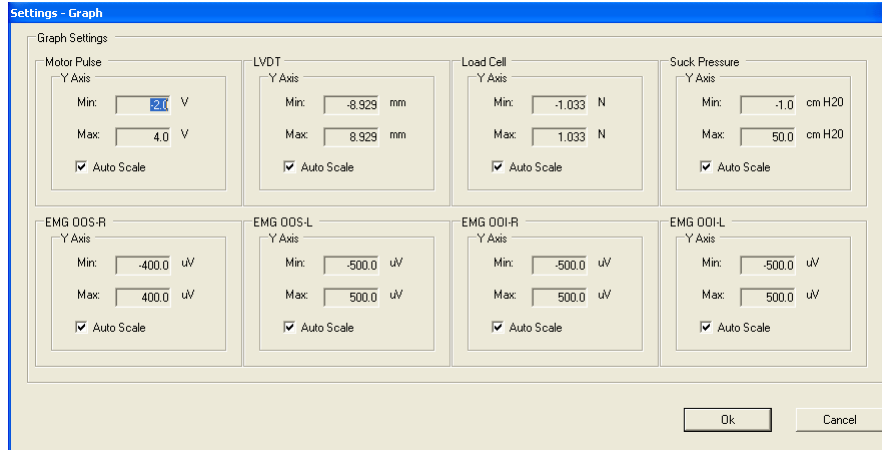


Figure 16. Graph and Histogram setting dialogue

The “Suck Pr Analysis” setting (Figure 17) defines parameters for peak selection, and suck pressure threshold value for recording, etc.

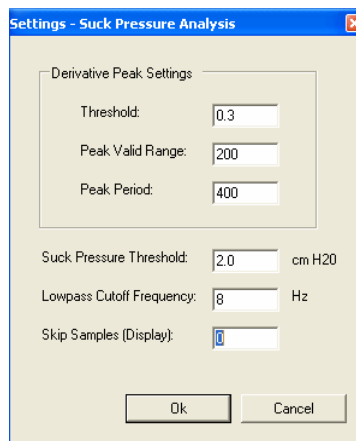


Figure 17. Suck Pr Analysis setting

3 References

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