MINDMEDIA
NEURO AND BIOFEEDBACK SYSTEMS

User Guide

Resonance Frequency Protocol

This user guide has been created to educate and inform the reader about the Resonance Frequency Protocol.

For more information about NeXus, our BioTrace+ software, please visit our website or contact us.

www.mindmedia.com

V2.0

Contents

Introduction

The Resonance Frequency (RF) Protocol User Guide provides a step-by-step review of how to install the RF protocol, how to use the RF protocol and how to exporting the data as IBI table for further analysis in Kubios. This RF protocol has been developed in cooperation with Richard Gevirtz.

Required equipment

Depending on the chosen setup, the following is required to perform the RF Protocol using a BVP (Blood Volume Pulse) sensor setup:

- Nexus-4, NeXus-10 or NeXus-32
- Blood Volume Pulse Sensor

The following is required to perform the RF Protocol using an ECG setup:

- Nexus-4, NeXus-10 or NeXus-32
- EXG Sensor
- EXG Ground
- Pre-gelled ECG electrodes (Ag/AgCl)*
- Alcohol pads

*High quality electrodes like the Meditrace or ARBO electrodes are recommended to ensure good signal quality.

Blood Volume Pulse measurement setup

Before the actual measurement can start, the equipment has to be connected. Detailed information on setting up the NeXus can be found in the NeXus User Manual or Quick Start.

Connect the Blood Volume Pulse sensor to input C of the NeXus-4, input G of the NeXus-10 or input 30 of the NeXus-32. Make sure the red dot of the connector is facing downward with the NeXus-4 or NeXus-10 or upward with the NeXus-32.

Place the Blood Volume Pulse clip on one of the fingers. Place the clip with the cable along the upper side of the finger.

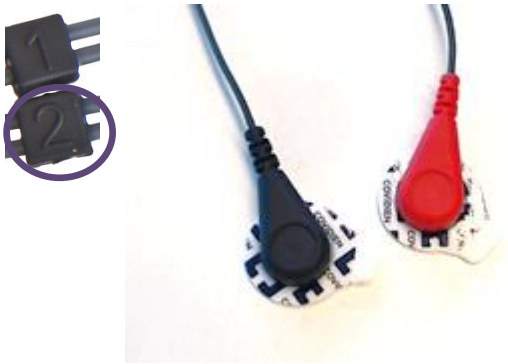
ECG measurement setup

Before the actual measurement can start, the equipment has to be connected. Detailed information on setting up the NeXus can be found in the NeXus User Manual or Quick Start.

Connect the EXG Sensor to input A&B of the NeXus-4 or NeXus-10 and input 25&26 of the NeXus-32. Make sure the red dot of the connector is facing downward with the NeXus-4 or NeXus-10 or upward with the NeXus-32.

Connect the EXG Ground to the Ground (Gnd) of the NeXus.

Snap the electrodes on to the black and red snap on of **pair two** of the EXG Sensor. The use of high quality electrodes like ECG Meditrace or ARBO electrodes is recommended.

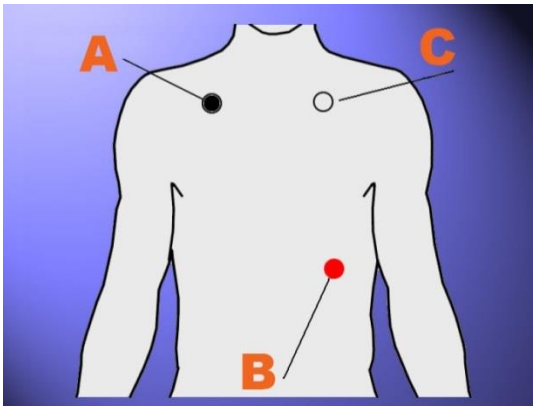


Snap an electrode on to the EXG ground snap-on.

Optionally clean the skin with an alcohol pad at all electrode positions before applying the electrodes.

To acquire an ECG signal that is suitable for heart rate detection, the negative and positive electrode should be placed in such a way that the electrical activity of the heart (especially the R-peak) can be measured between the electrodes. Optimally, the electrodes are placed along the electrical heart axis, like the vertical lead II of Einthoven's triangle. Electrodes can also be placed according to the horizontal lead I of Einthoven's triangle.
Optimally, the red (positive) electrode of **pair two** of the EXG Sensor would be placed below the left rib cage (B) and the black (negative) electrode of **pair two** of the EXG Sensor just below the right collarbone (A). The positive and negative electrodes should not be switched to avoid an inverted ECG signal and therefore incorrect R-peak detection and incorrect heart rate detection.

Place the ground electrode just below the left collarbone (C).



Additional Biofeedback sensors

Additional biofeedback sensors (EMG (1 position), Skin Conductance, Temperature, Respiration) can be applied, using the following NeXus inputs.

NeXus-10		NeXus-32	
A&B	ECG (EXG sensor, pair 2)	**25&26**	ECG (EXG sensor, pair 2)
C&D	EMG (EXG sensor, pair 1)	**27&28**	EMG (EXG sensor, pair 2)
E	Skin Conductance	**29**	Skin Conductance
F	Temperature	**30**	Blood Volume Pulse
G	Blood Volume Pulse	**31**	Respiration
H	Respiration	**32**	Temperature

Using the RF protocol

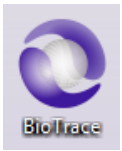
Make sure to install the RF protocol first (Appendix: Installation).

The protocol will go through the following sequence.

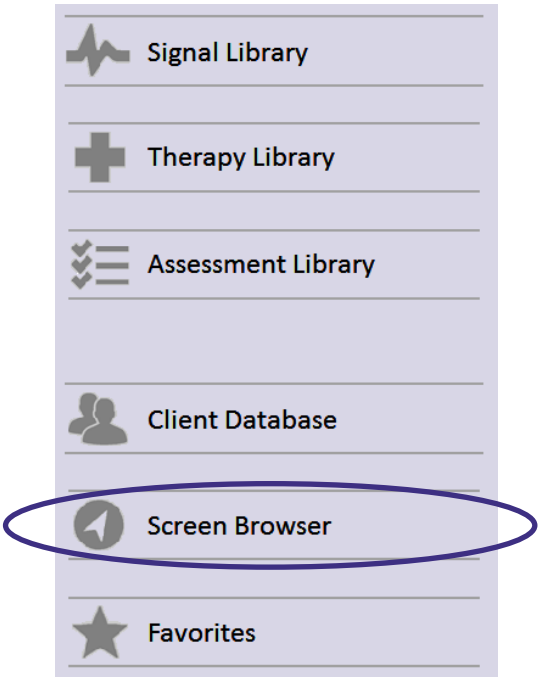
Screen	Duration	Segment	Marker
Pacer 7.0 bpm	240 seconds	Breathing Pacer	Pacer 7.0 bpm
Pacer 6.5 bpm	240 seconds	Breathing Pacer	Pacer 6.5 bpm
Pacer 6.0 bpm	240 seconds	Breathing Pacer	Pacer 6.0 bpm
Pacer 5.5 bpm	240 seconds	Breathing Pacer	Pacer 5.5 bpm
Pacer 5.0 bpm	240 seconds	Breathing Pacer	Pacer 5.0 bpm
Pacer 4.5 bpm	240 seconds	Breathing Pacer	Pacer 4.5 bpm
Finished			Finished

During the protocol, the respiration pacer inhalation/exhalation time ratio is 40%/60%. Each breathing segment will automatically be color coded in the background, including markers describing the actual pacer rate for that particular segment.

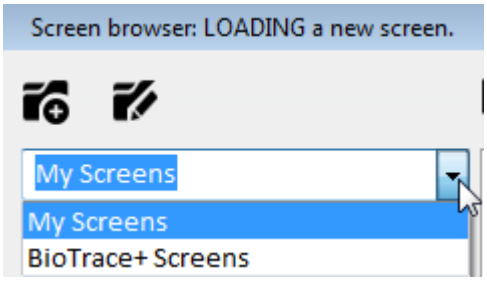
Open BioTrace+.



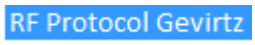
Select ‘Screen Browser’.



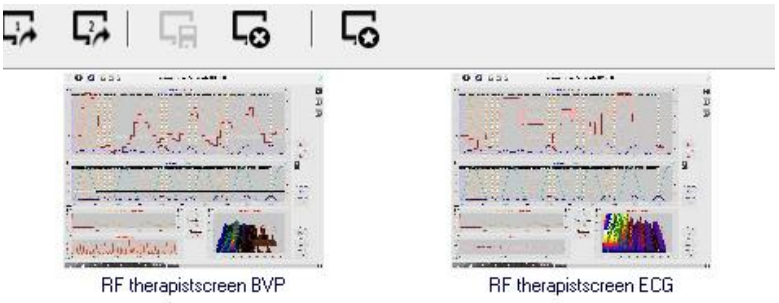
Select ‘My Screens’.



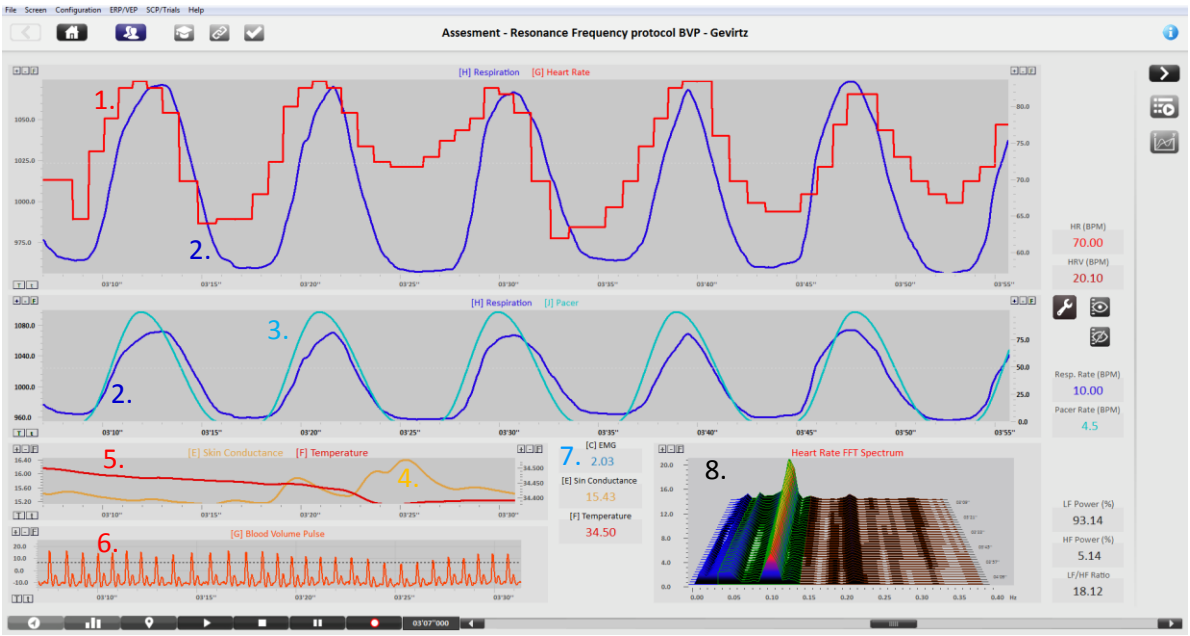
Select ‘RF Protocol Gevirtz’.



Double Click ‘RF therapist screen BVP’ or ‘RF therapist screen ECG’ to open the therapist screen.



The therapist screen will be opened.



The following is displayed in the therapist screen: Heart Rate (1); Respiration wave (2); Pacer (3); Skin Conductance (4); Temperature (5); Raw ECG or BVP signal (6); EMG amplitude (7); Spectral Display (8).

Turn on the NeXus device.

Start a recording.

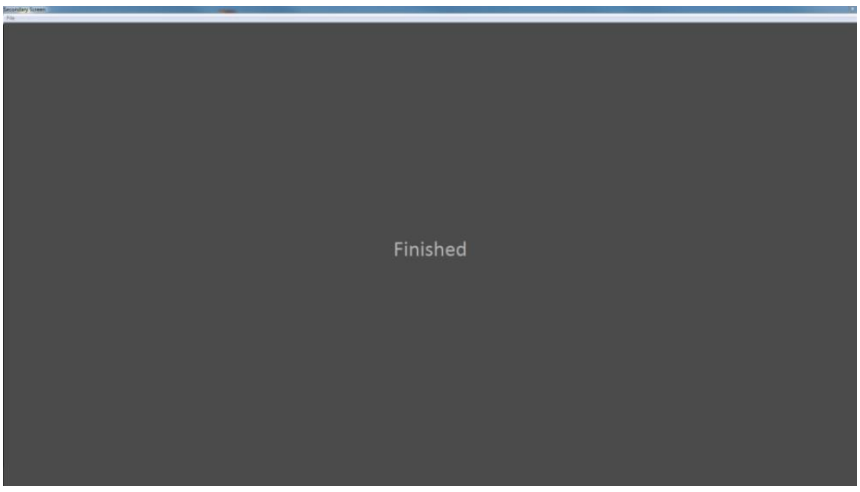
Visually inspect the recorded signal to pinpoint and possibly reduce artifacts.

The actual RF protocol is started by clicking the protocol button in the right top corner.

A dual monitor setup is recommended. Press the Windows logo key +P for extending display to dual monitor setup. The protocol will be opened automatically on the second monitor. When using a single monitor setup the protocol will be opened on the first screen.

Optionally use the 'next button' to proceed to the next breathing rate.

Once the protocol is finished, the recording will stop.



Click 'Yes' to save the session and to enter a description of the session. Confirm by clicking 'OK', the session is now saved.

HRV Training

After finishing the RF protocol, HRV training can be done using the HRV training screen.

Start a new recording.

Visually inspect the recorded signal to pinpoint and possibly reduce artifacts.

The actual HRV training screen is opened by clicking the training screen button in the right top corner.

Click the following icon to set the respiration pacer (or go to the top menu and select Configuration > RSP/HRV Pacer Settings).

The following parameters can be set (time entered in milliseconds):
- *T1 Inhale Time*: the time it takes to go from baseline (0) to the maximum (inhale).
- *T2 Sustain Time*: the time the signal will be sustained (hold) at maximum.
- *T3 Exhale Time*: the time the signal will drop from maximum to baseline (exhale).
- *T4 Pause Time*: the 'pause time' in between this and the next cycle.

Based on these parameters, a pacer rate in breaths per minutes (BPM) will be calculated.

Click the **+** and **-** button to change the pacer rate while maintaining the same ratios.

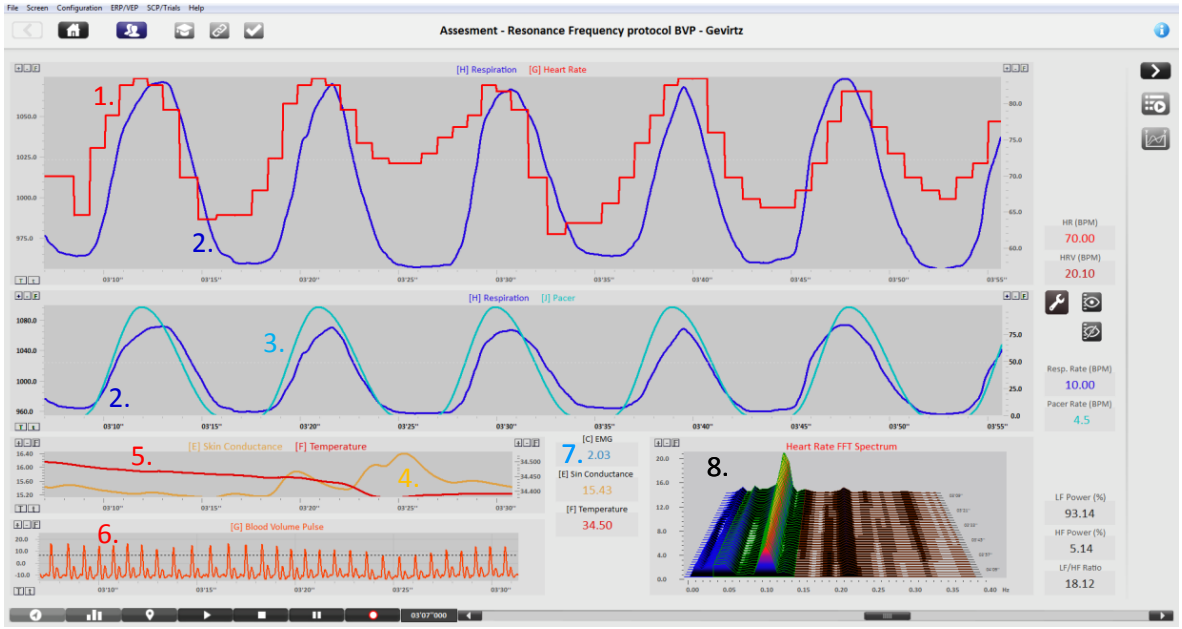
It is possible to show and hide the pacer signal on the training screen screen

Show graph on client screen

Hide graph on client screen

Data interpretation

The following is displayed in the therapist screen: Heart Rate (1), beat by beat; Respiration wave (2) in arbitrary units; Pacer (3), set by clinician to RF; Skin Conductance (4) and Temperature (5), during RF breathing you want Temperature to be increasing and Skin Conductance decreasing; Raw ECG or Heart Rate signal (6); EMG amplitude (7); Spectral Display (8), looking for a single peak at about 0.1 Hz.

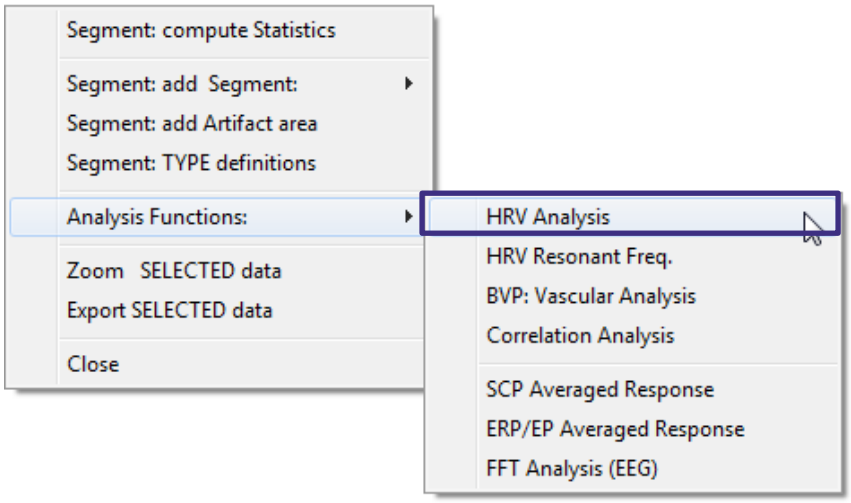


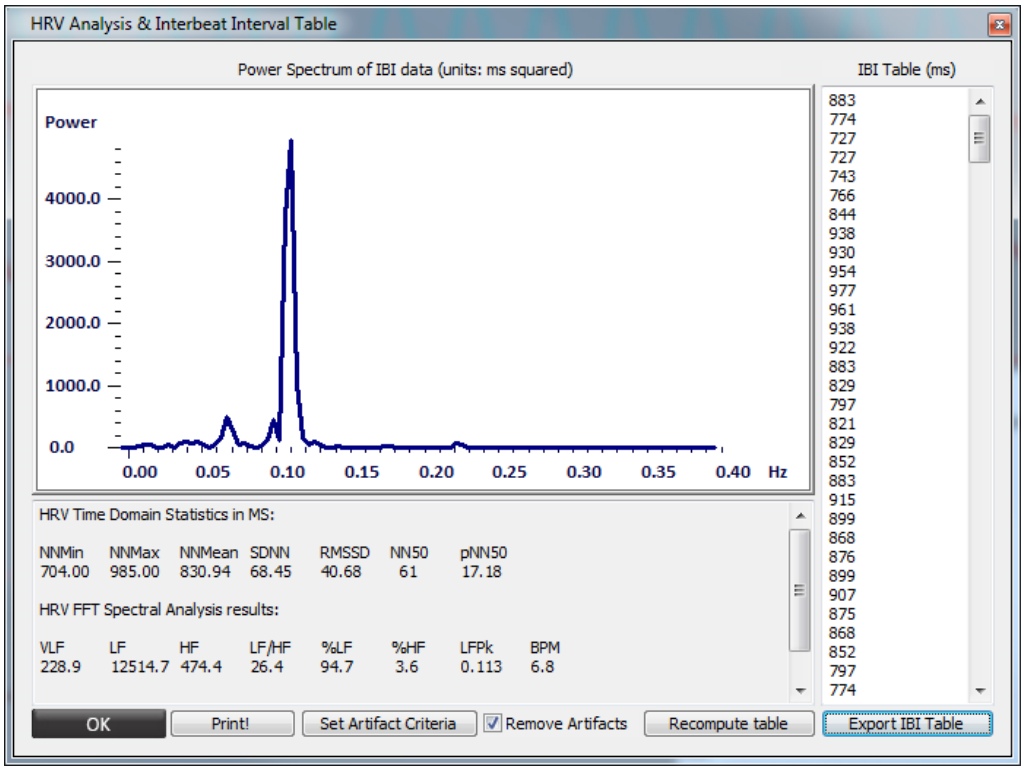
Criteria for RF:
-Max valley/peak difference in BPM (example: above 62 to 82 is 20 BPM)
-Phase angle, Respiration and Heart Rate wave lined up (in phase)
-Smoothness of HR wave
-Temperature rising (may take a while)
-Skin Conductance decreasing (less reliable sign)

Exporting HRV data

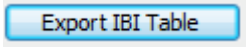
IBI intervals or IBI data can be exported for further analysis to e.g. Kubios. In order to export the data, select the data to be exported by clicking the left mouse button on the time axis and dragging the mouse to the right.

After releasing the left mouse button select ‘Analysis Functions’ > ‘HRV Analysis’.





Click ‘Export IBI Table’ in the right bottom.



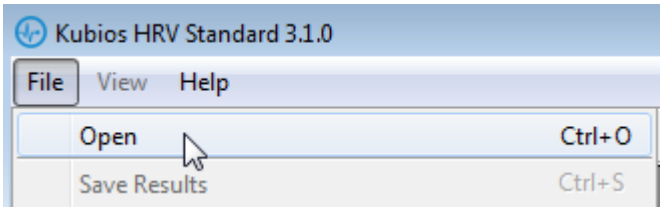
Name the file and save the file in a preferred folder to be imported later on in Kubios (Appendix: Kubios).

Appendix: Kubios

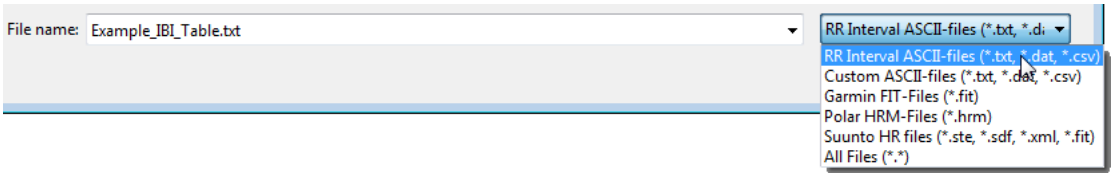
Open Kubios HRV Standard 3.1.0

Import data

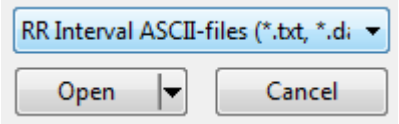
Select File > Open



Select the exported *.txt file with IBI Table and choose 'RR Interval ASCII-files' in the dropdown menu.

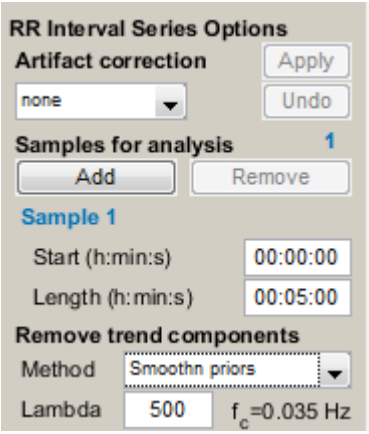


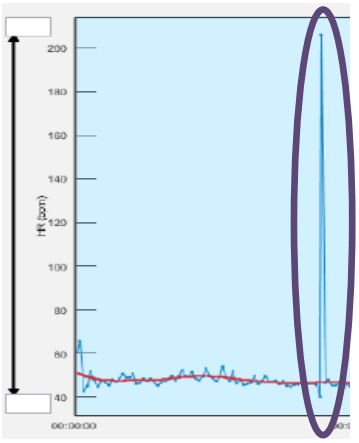
Select 'Open'.



Data interpretation

Choose Method 'Smoothn Priors' to correct for drift. If there are ectopic or atypical beats (e.g. clearly invalid beat as the Heart Rate can't go from 55 BPM to 220 BPM and back in one beat) choose strongest Artifact Correction needed.





Select ‘Nonlinear’.

The Nonlinear tab gives you a Poincare plot. A good way to spot outliers.

Time domain interpretation

Select ‘Time-Domain’.

The Time Domain measures are an indication of all the sources of variability. They represent a rough indicator of autonomic flexibility.

SDNN is the standard deviation of the normal R-R interval in milliseconds. 50 Milliseconds is a rough average. RMSSD is the root mean square (RMS) of successive differences. It is similar to SDNN, but a bit more dependent on vagal tone. Values are usually a bit lower than SDNN.

Time-Domain Results

Variable	Value	Units
Mean RR*	830.06	ms
STD RR (SDNN)	64.484	ms
Mean HR*	72.284	beats/min
STD HR	5.7217	beats/min
Min HR	62.604	beats/min
Max HR	82.012	beats/min
RMSSD	40.248	ms
NNxx	63	
pNNxx	17.500	%
HRV triangular index	19	
TINN	355	ms

Frequency domain interpretation

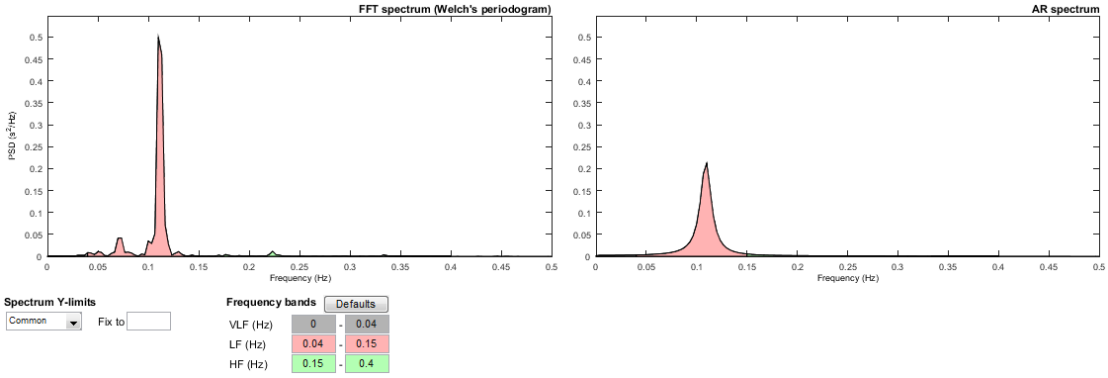
Select ‘Frequency-Domain’.

The Frequency Domain measures are an indication of more specific sources of variability.

The most important measure is the Power (log) of HF (LnHF), the natural log of the high frequency. It is an approximation of vagal tone. It represents the area under the green curve of the FFT spectrum (0.15-0.4 Hz). Norms are available: see Nunan et al. The LF (LnLF, the Power (log) of LF) represents activity from the Baroreceptors with frequencies in the range of 4.5 to 7 per minute (area under the red curve of the FFT spectrum, 0.04-0.15 Hz). It is supposedly a representation of both sympathetic and parasympathetic activity, but is not an agreed upon parameter. Some researchers look at LF/HF ratio values.

Frequency-Domain Results

Variable	VLF	LF	HF	LF/HF
FFT Results				
Peak (Hz)	0.040000	0.11000	0.22333	
Power (ms2)	38.895	4599.6	186.86	24.615
Power (log)	3.6609	8.4337	5.2304	
Power (%)	0.80604	95.321	3.8724	
Power (n.u.)		96.095	3.9039	
AR Results				
Peak (Hz)	0.040000	0.11000	0.15000	
Power (ms2)	98.666	4113.0	258.48	15.912
Power (log)	4.5917	8.3219	5.5548	
Power (%)	2.2071	92.003	5.7820	
Power (n.u.)		94.079	5.9125	



Create report

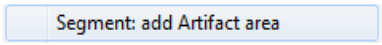
Select the 'Report button' to open the HRV Analysis results.

This report can be saved or printed.

Appendix: RF Analysis BioTrace+

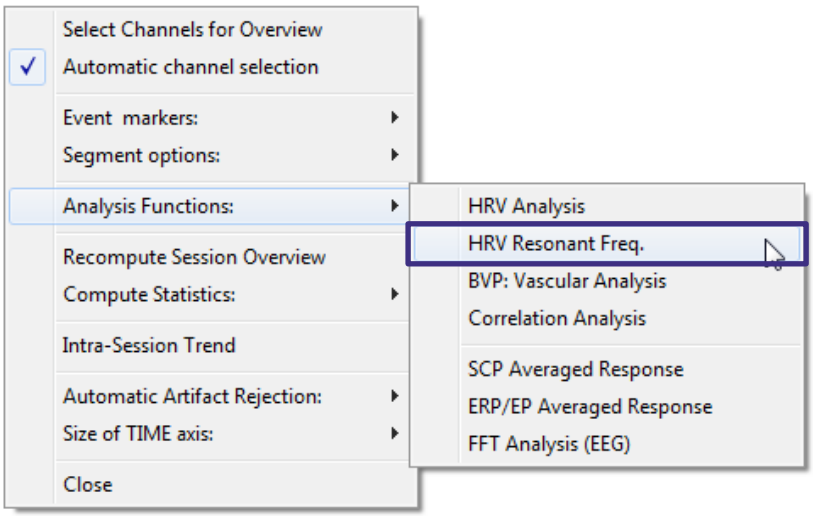
Open the signal overview screen.

Make sure to have a clean record before analyzing. In order to remove artifacts, create artifact areas by selecting data, and choosing **Segment: add Artifact area**. The artifact segment will appear as a red cross hatched area.

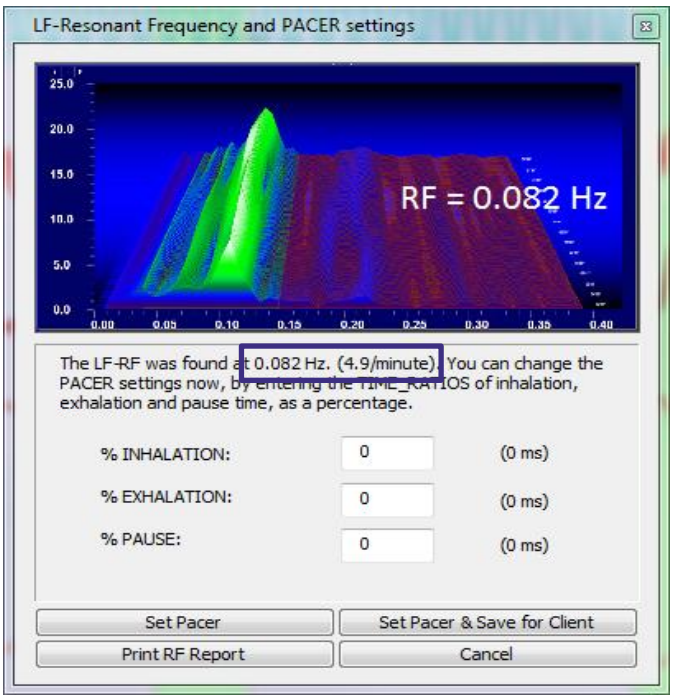


Each breathing segment is color coded in the background, including markers describing the actual pacer rate for that particular segment.

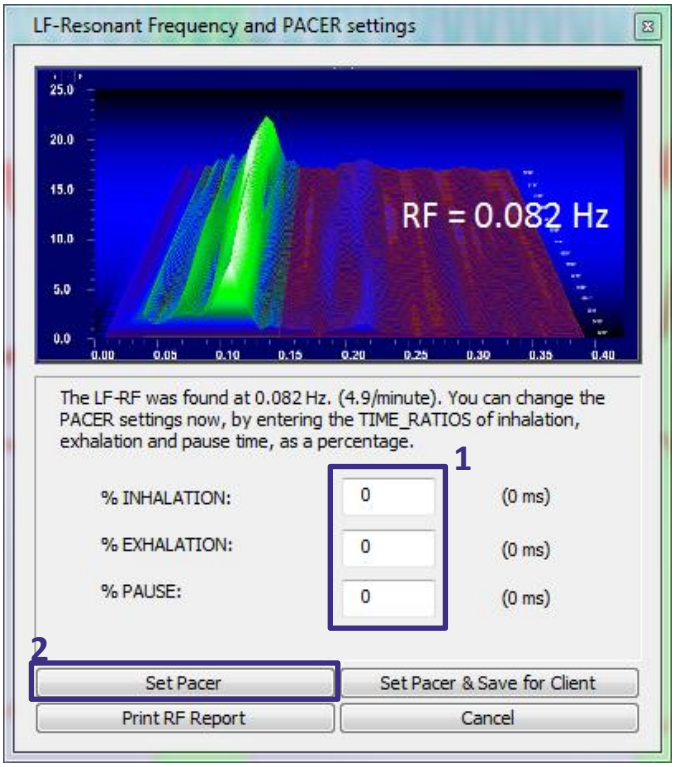
The resonance frequency can be determined by opening the resonance frequency analysis by right clicking in the overview screen and selecting 'Analysis Functions' > 'HRV Resonance Freq.'



The found resonance frequency is now displayed in the 'LF-Resonance Frequency and PACER settings' screen.



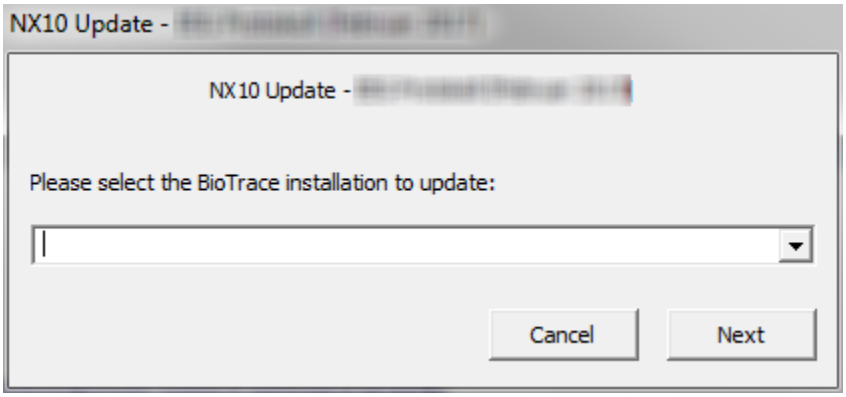
Set the PACER setting by entering the time ratios (1), based on the found RF, and press 'Set Pacer' (2).



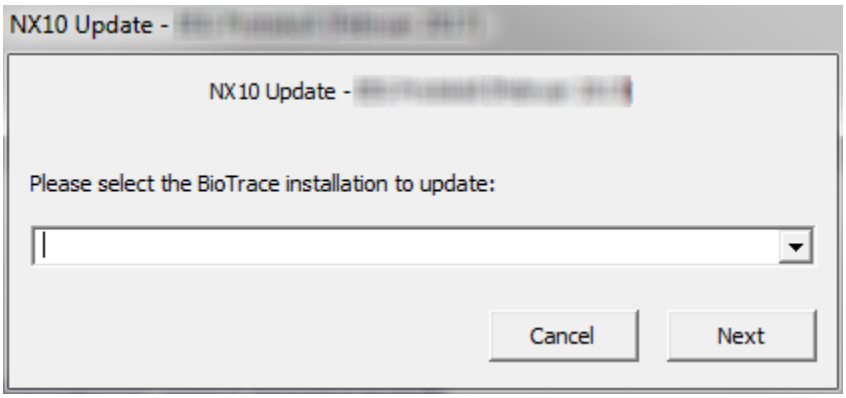
Select 'Print RF Report' to show the RF report.

Appendix: Installation

Open the '***.exe**'-file. The software will now search for BioTrace+ installations on the computer.



Select the BioTrace+ directory where the protocol needs to be installed (this step is only necessary when there are multiple versions of BioTrace+ installed) and click 'Next'.



Click 'Exit' once installation has finished.