Data Pre-Processing Tool Manual

version 1.1
BRSystems,Inc.
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revision

date	version	changes
2019/11/14	1.0	1st edition
2020/1/9	1.1	analysis plot added in Filter Design

1．Start-up

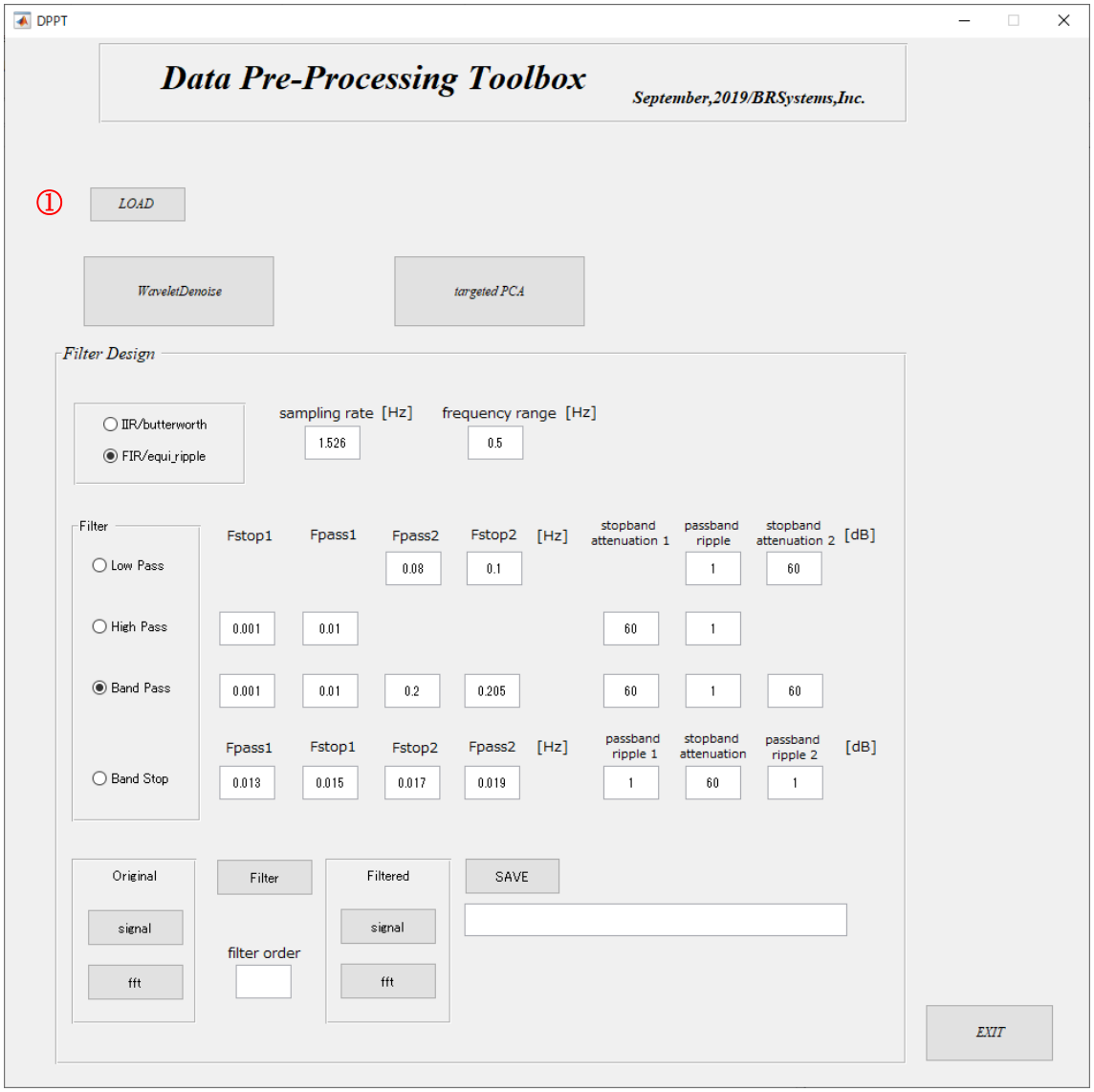
Double click “DPPT.exe”

Excel (Microsoft) is required for the PC, installed DPPT.

Wavelet Denoise, targetedPCA and CBSI(reference) are incorporated as the reducing tool of MA(Motion Artifact).

Please refer to “BRain Analyzer Guide” for technical explanation.

2．Top View

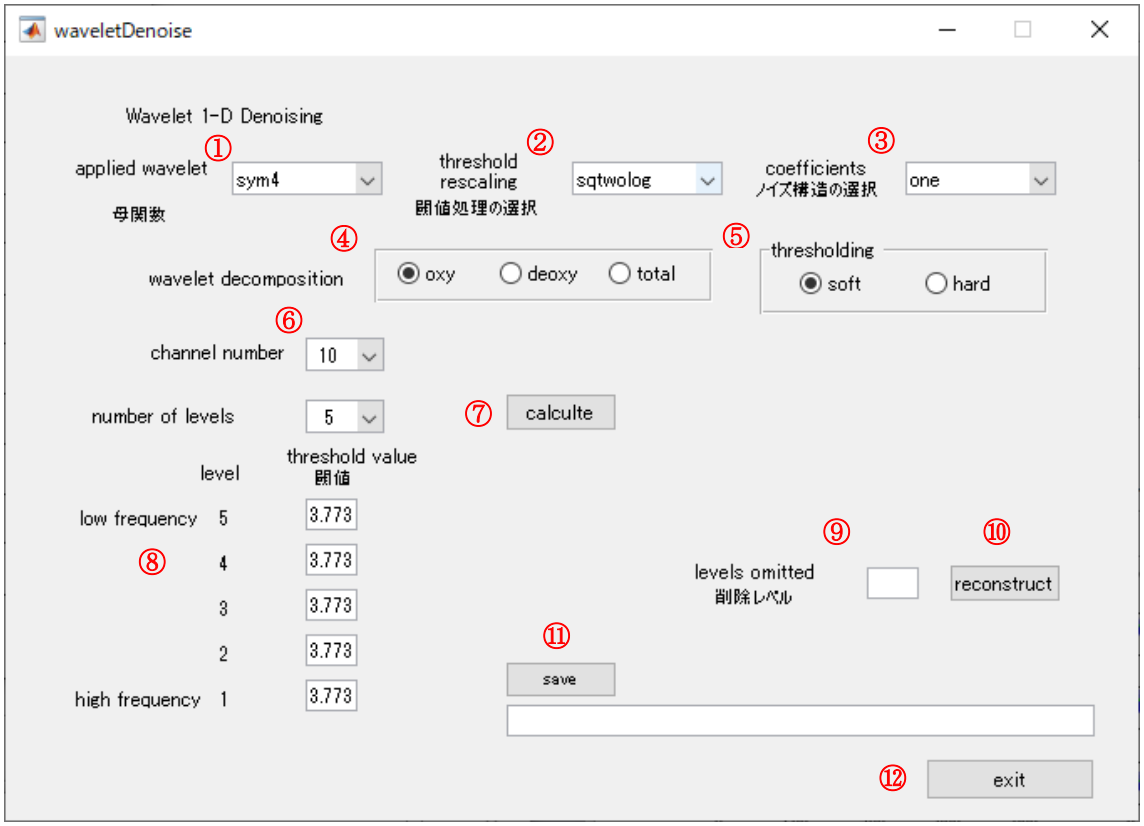


① click “LOAD”, select the data file (.csv).

② select the option to reduce the MA.

3．Wavelet Denoising（Discrete wavelet transform）

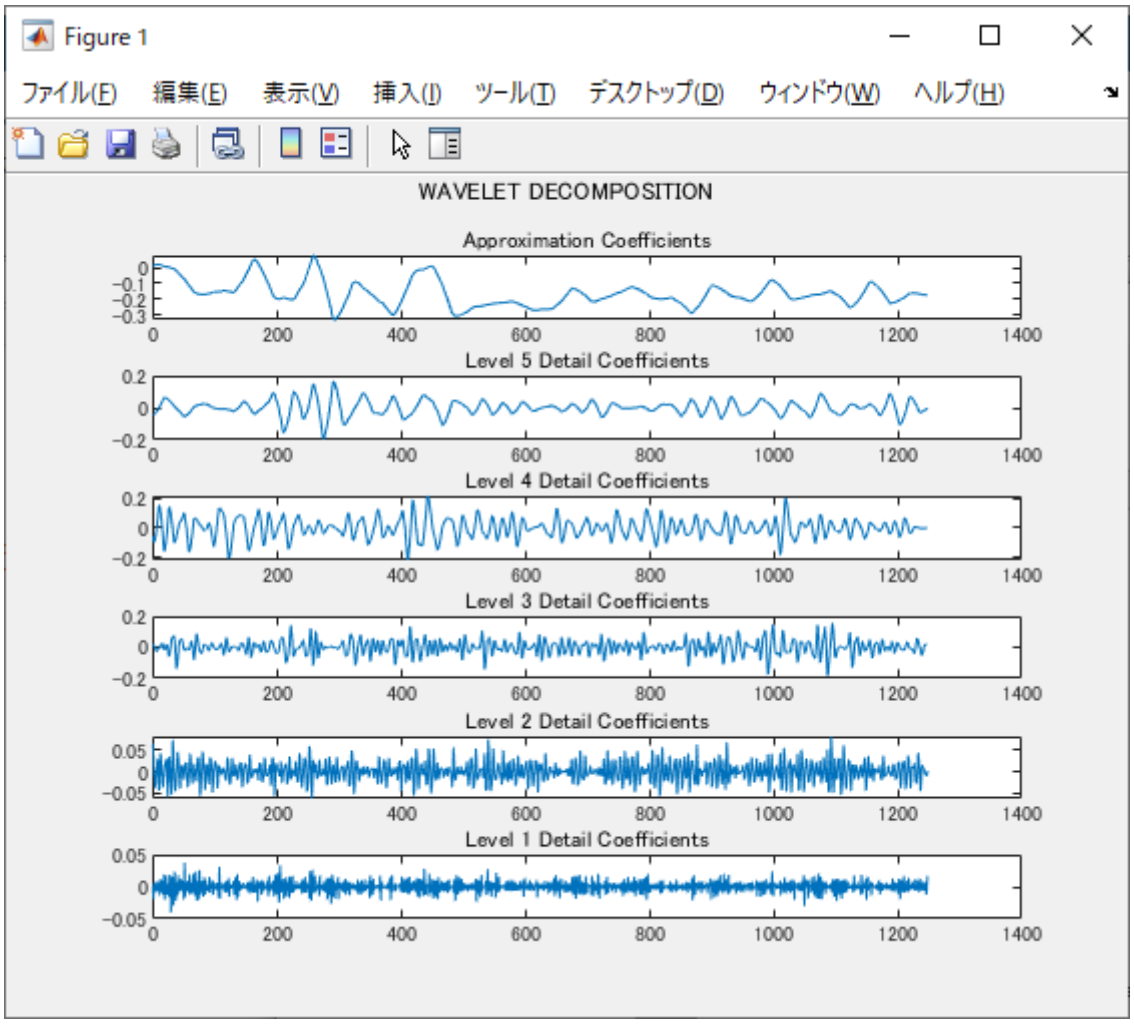
[configuration]



① select wavelet(db,symlet,haar)
② select threshold rescaling(sqtwolog,rigsure,minimaxi)
③ select coefficients(one,sln,mln)
④ select oxy-Hb, deoxy-Hb, total-Hb in the coefficients figure
⑤ select threshholding, soft or hard
⑥ select channel number in the coefficients figure
⑦ calculate
⑧ threshold values are calculated, you can set the values.
number of levels are 5 or 3.
⑨ specify the omitted levels
⑩ reconstruct the wavelet based on ⑨
⑪ save the denoised signal
⑫ exit

[result]

detail coefficients of each level (sample)

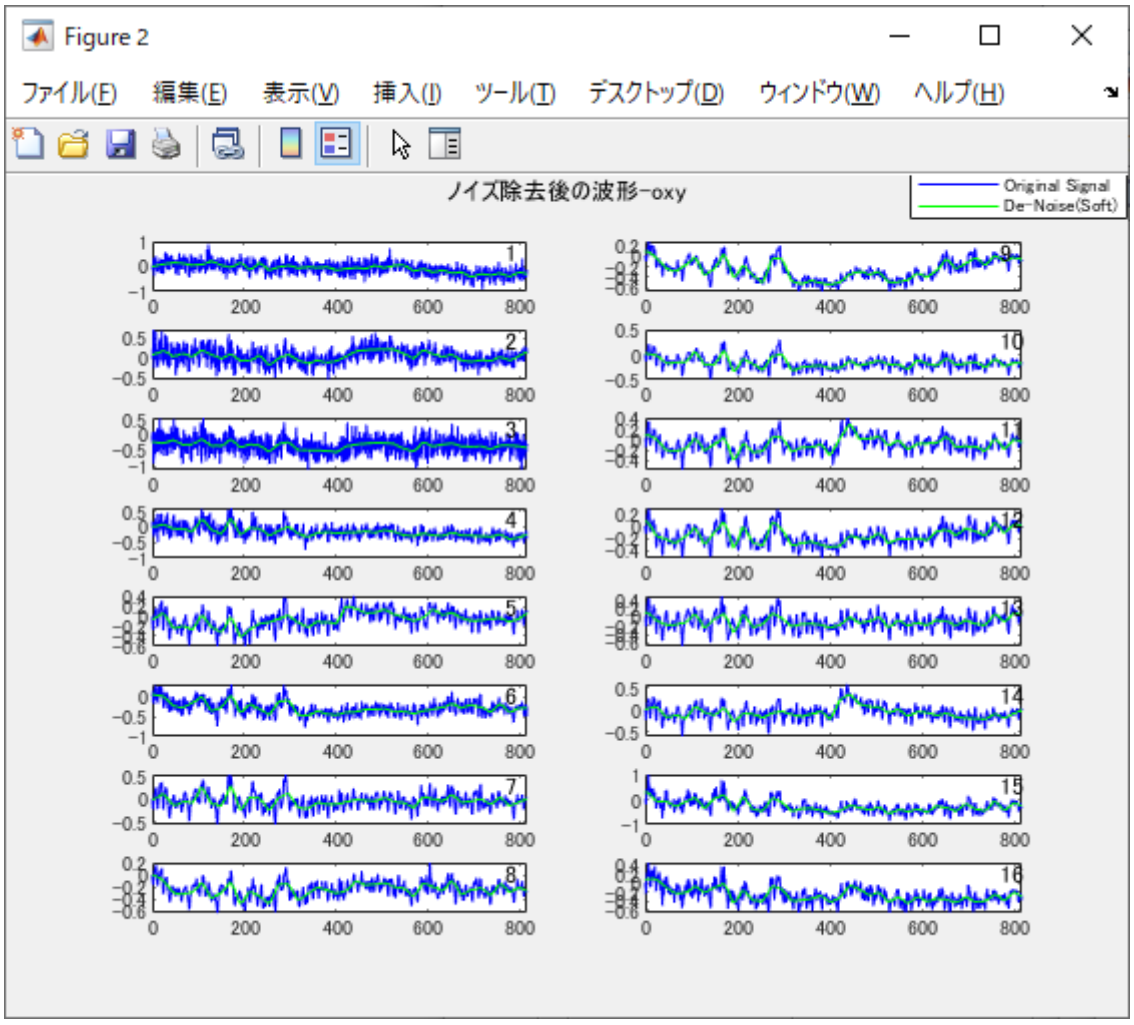


1st is high order frequency, 5th is low order frequency.

Approximation coefficients $\left(\frac{1}{\sqrt{2}}\right)c_k$ correspond to low pass filter.

Detail coefficients $\left(\frac{1}{\sqrt{2}}\right)b_k$ correspond to high pass filter.

This sample below is 16 channels.
Blue line is original wave, green line is denoised wave.



[REMARKS]
(1) When level number is set 5, wave may be too smoothed and there is a possibility to eliminate the activation of the brain. In this case, set 3.
The effect of the denoising is dependent on the value of various settings.
(2) There are many cases that the filtering effect of wavelet denoising and band pass(fft) is very similar.

This tool displays the frequency response of wavelet as below.
sample case: symlet4, nyquist frequency 6.1[Hz]

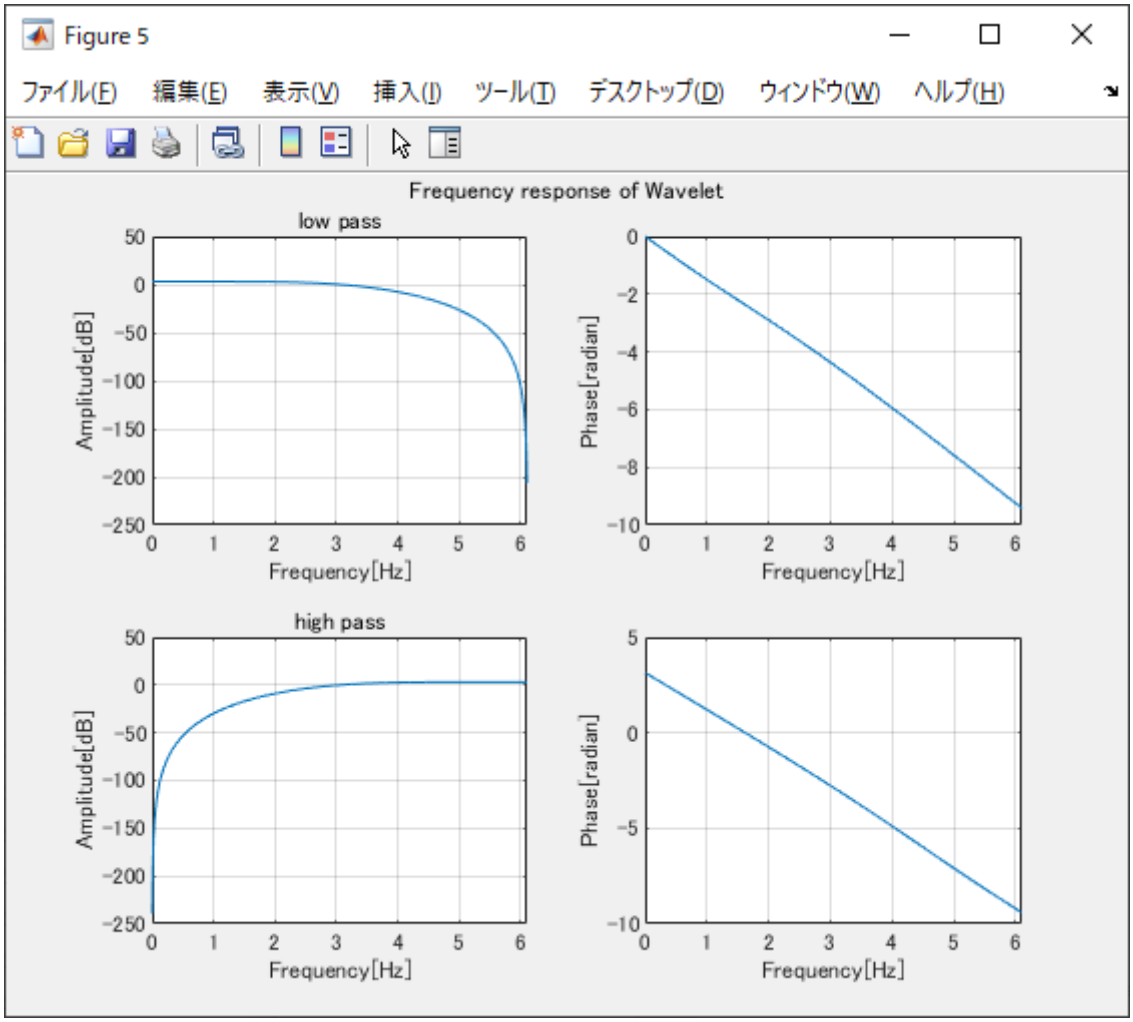
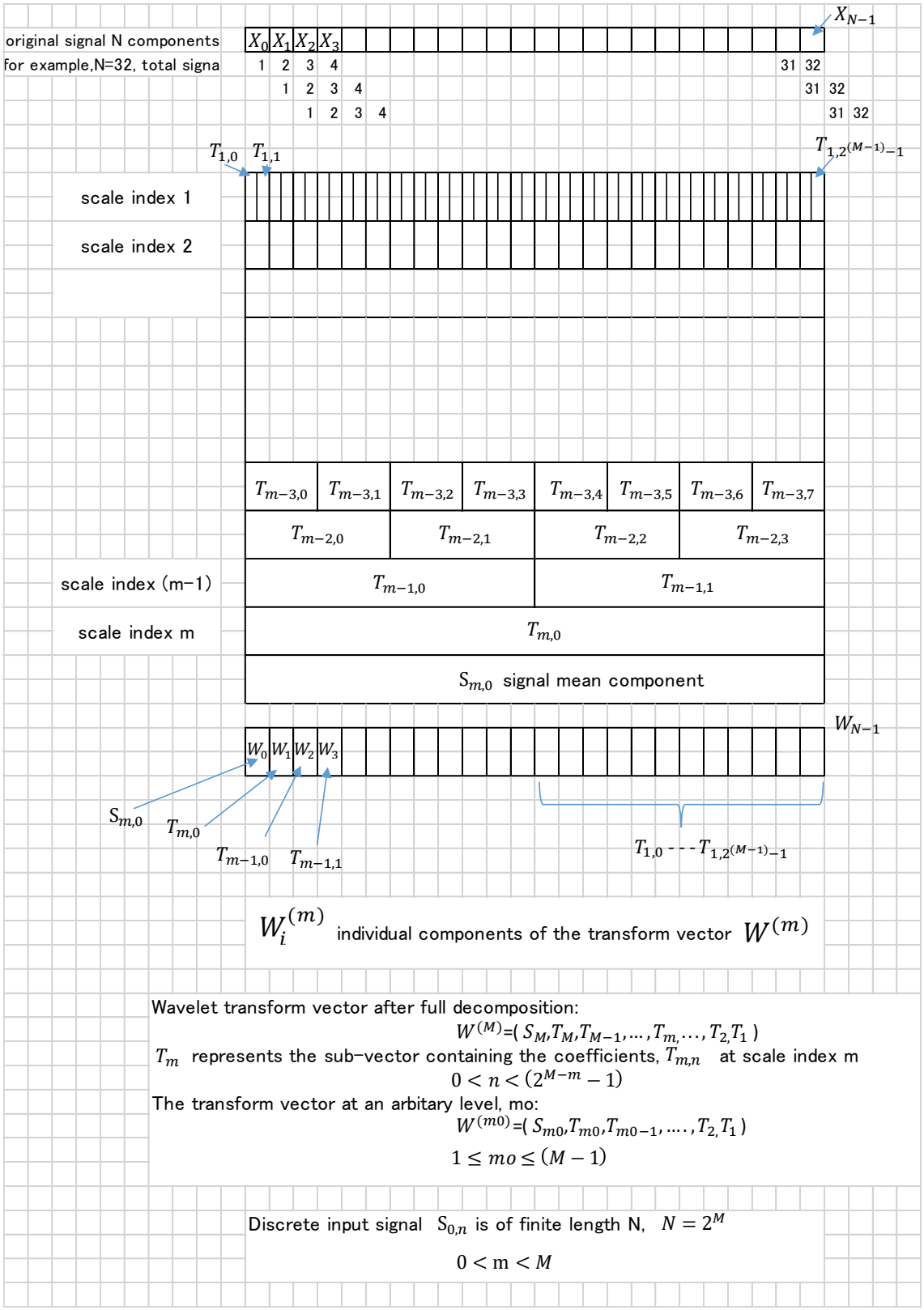


Figure 5
ファイル(F) 編集(E) 表示(V) 挿入(I) ツール(T) デスクトップ(D) ウィンドウ(W) ヘルプ(H)
Frequency response of Wavelet
low pass
Amplitude[dB]
Phase[radian]
Frequency[Hz]
high pass
Amplitude[dB]
Phase[radian]
Frequency[Hz]



Wavelet transform vector after full decomposition:

$$W^{(M)}=(S_M,T_M,T_{M-1},\dots,T_m,\dots,T_2,T_1)$$

T_m represents the sub-vector containing the coefficients, $T_{m,n}$ at scale index m

$$0 < n < (2^{M-m} - 1)$$

The transform vector at an arbitary level, mo:

$$W^{(m0)}=(S_{m0},T_{m0},T_{m0-1},\dots.,T_2,T_1)$$

$$1 \le mo \le (M-1)$$

Discrete input signal $S_{0,n}$ is of finite length N, $N = 2^M$

$$0 < \mathrm{m} < M$$

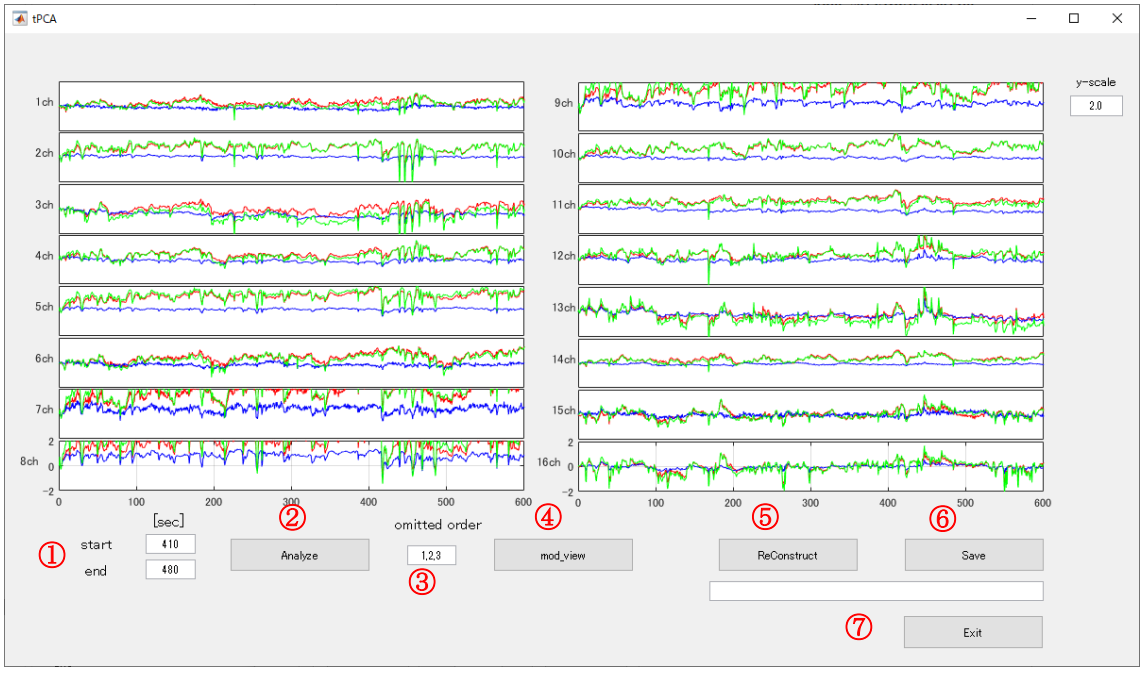
Source: "The Illustrated Wavelet Transform Handbook", Paul S Addison, Taylor & Francis

4．tPCA

“Targeted principal component analysis: A new motion artifact correction approach for near-infrared spectroscopy”, Meryem A.Yucel, et al., Journal of Innovative Optical Health Sciences, Vol.7,2014.

Measured signal consists of normal range and MA range.
When full wave is analyzer by PCA, and delete the specific order of principal components, valuable, important range of the signal to be kept, will be also deleted as a result.
In this case, only the range of MA is extruded, PCA is applied to the range and delete the MA order.
Finally modified extruded range is attached to the original signal.

click “targeted PCA”.



[configuration]

① set the excluded range （this sample is 410～480[sec])

② click “analyze”, then the raw wave of the excluded range(Fig.1) and the result of PCA(Fig.2) are displayed.

③ in this case, we delete 1,2,3 order of principal components. Set 1,2,3 in the omitted order frame.

④ click “mod_view”, the modified wave, deleted 1,2,3 orders, will be displayed (Fig.3).

⑤ click “ReConstruct”. the modified wave is embedded in the original wave after adjusting the both ends coordinates.

⑥ click “Save”. save the reconstructed wave. The reconstructed wave is displayed in detail on “BRainAnalyzer” (Fig.4-1)
Fig4-2 shows the original wave.
In the modified wave(Fig.4-1), the range 410～480[sec] is smoothed.
Fig.5-1 shows the enlarged view of the modified wave of channel 3.
Fig.5-2 shows the enlarged view of the original wave of channel 3

⑦ click “Exit”.

Fig.1

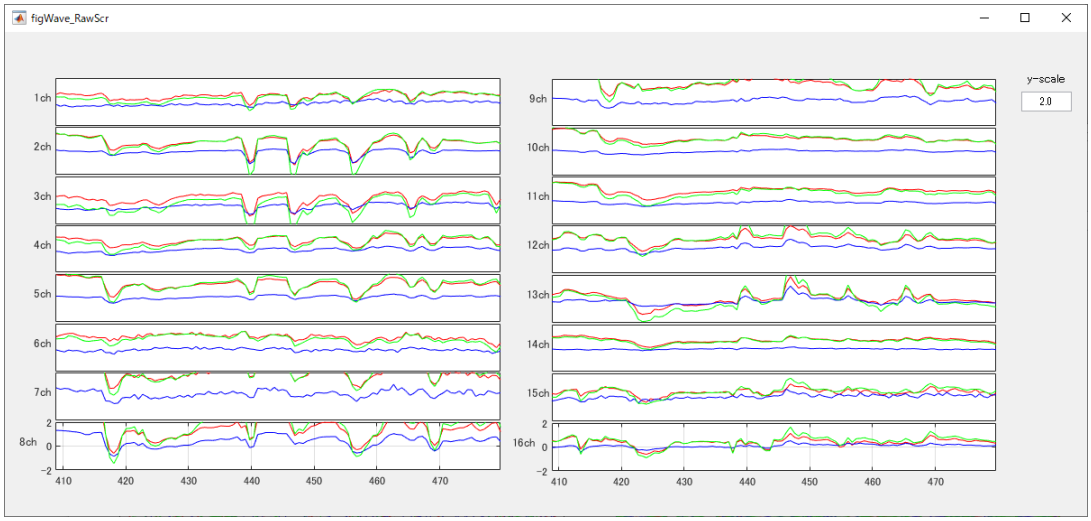


Fig.2

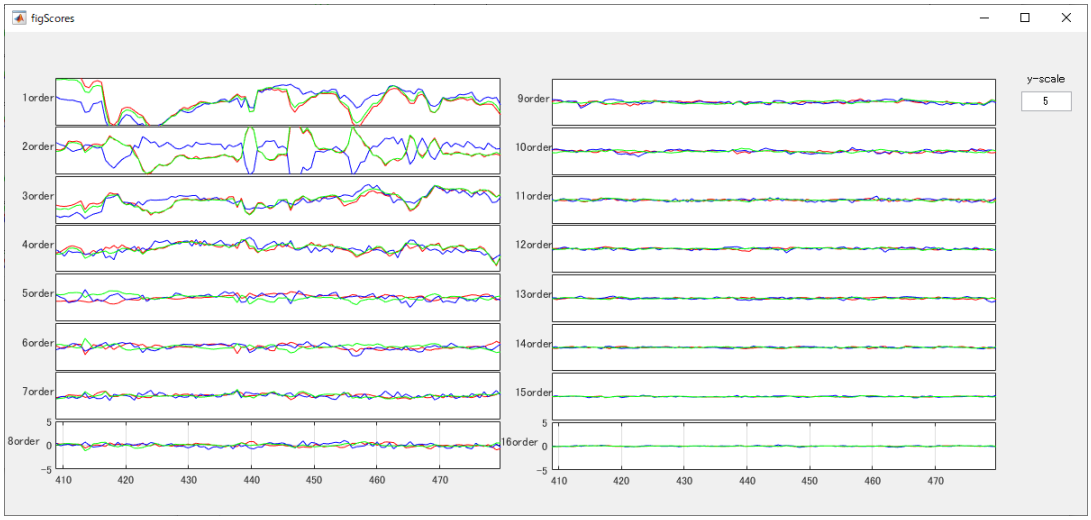


Fig.3

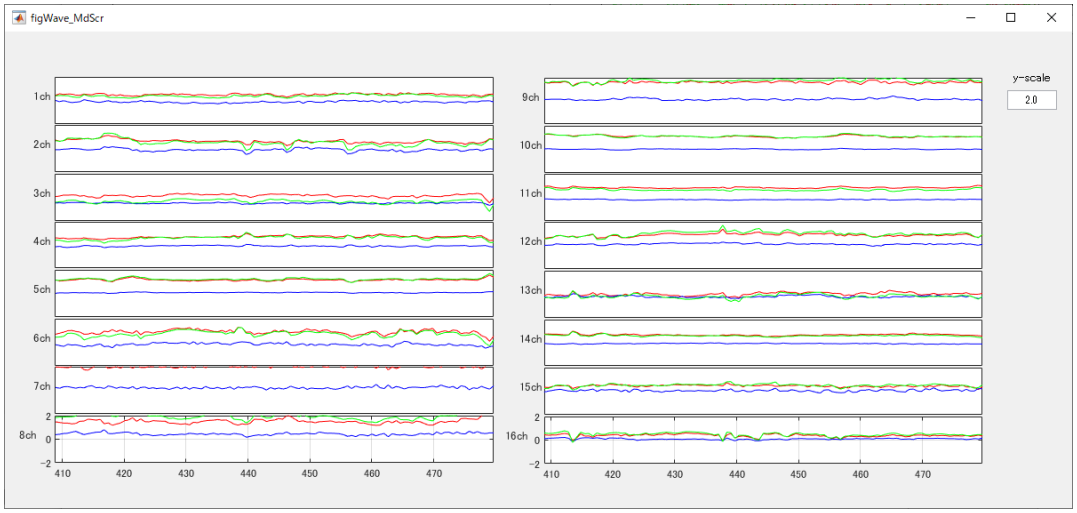


Fig.4-1 the modified wave

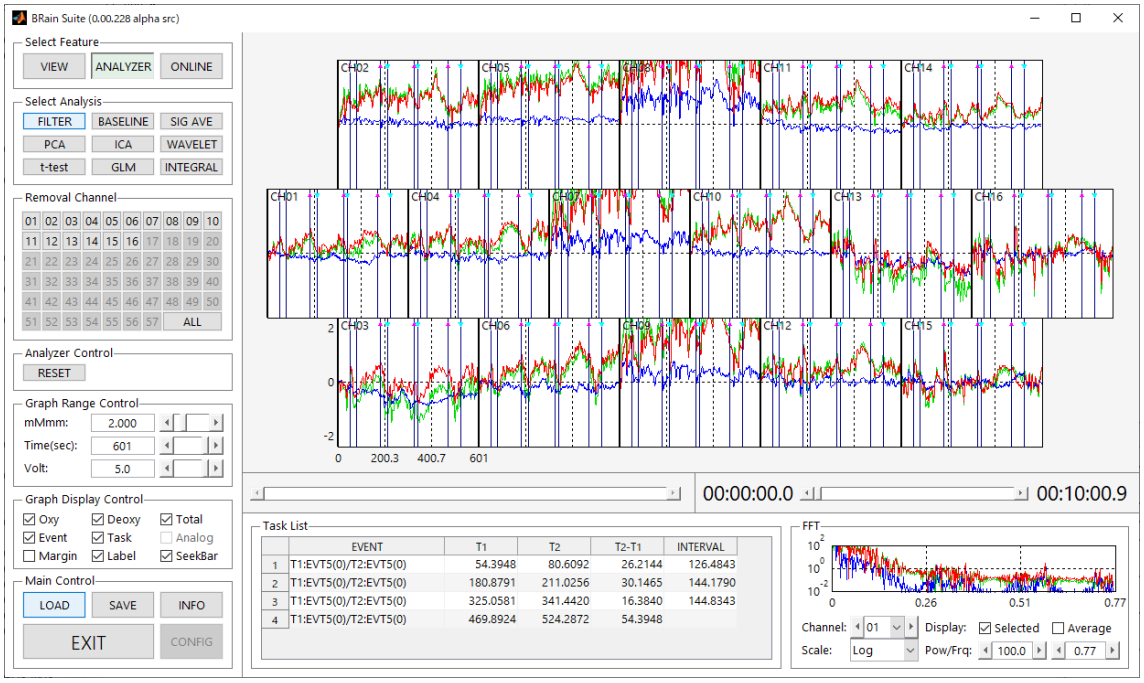


Fig.4-2 the original wave

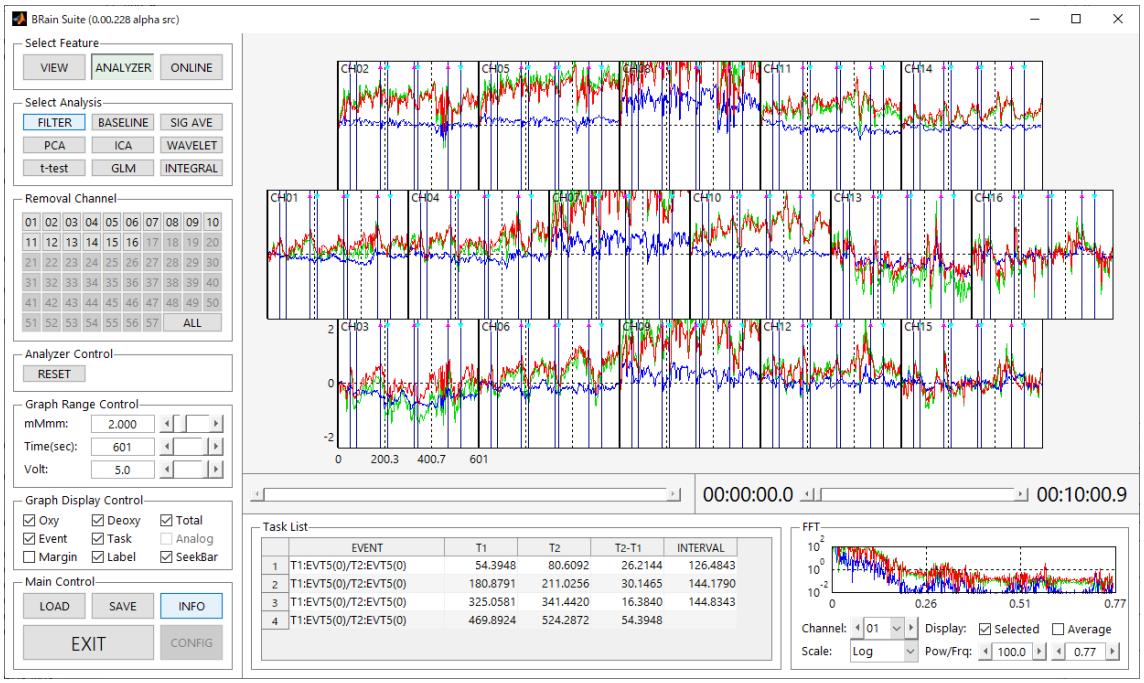


Fig.5-1　the enlarged view of the modified wave of channel 3

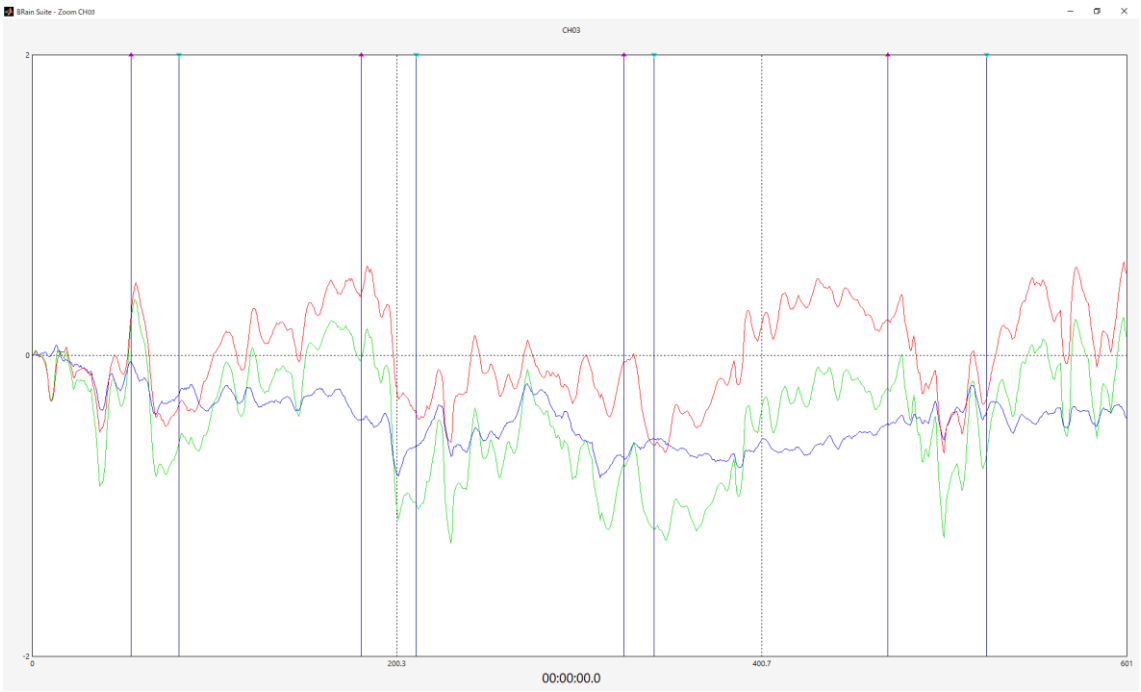
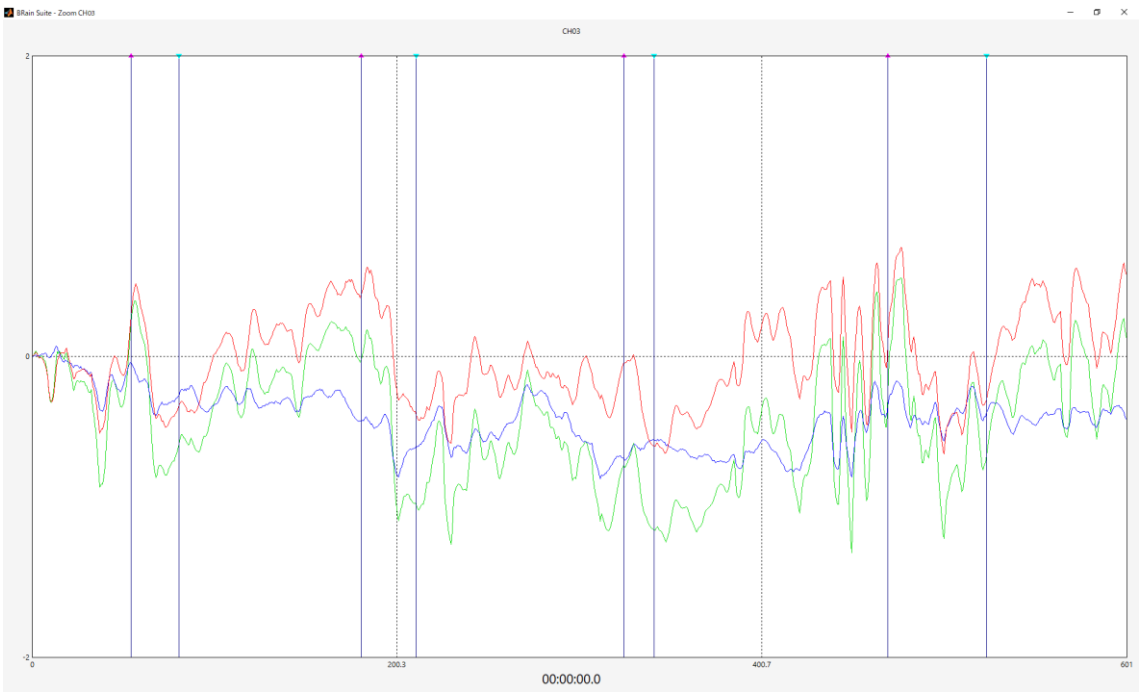
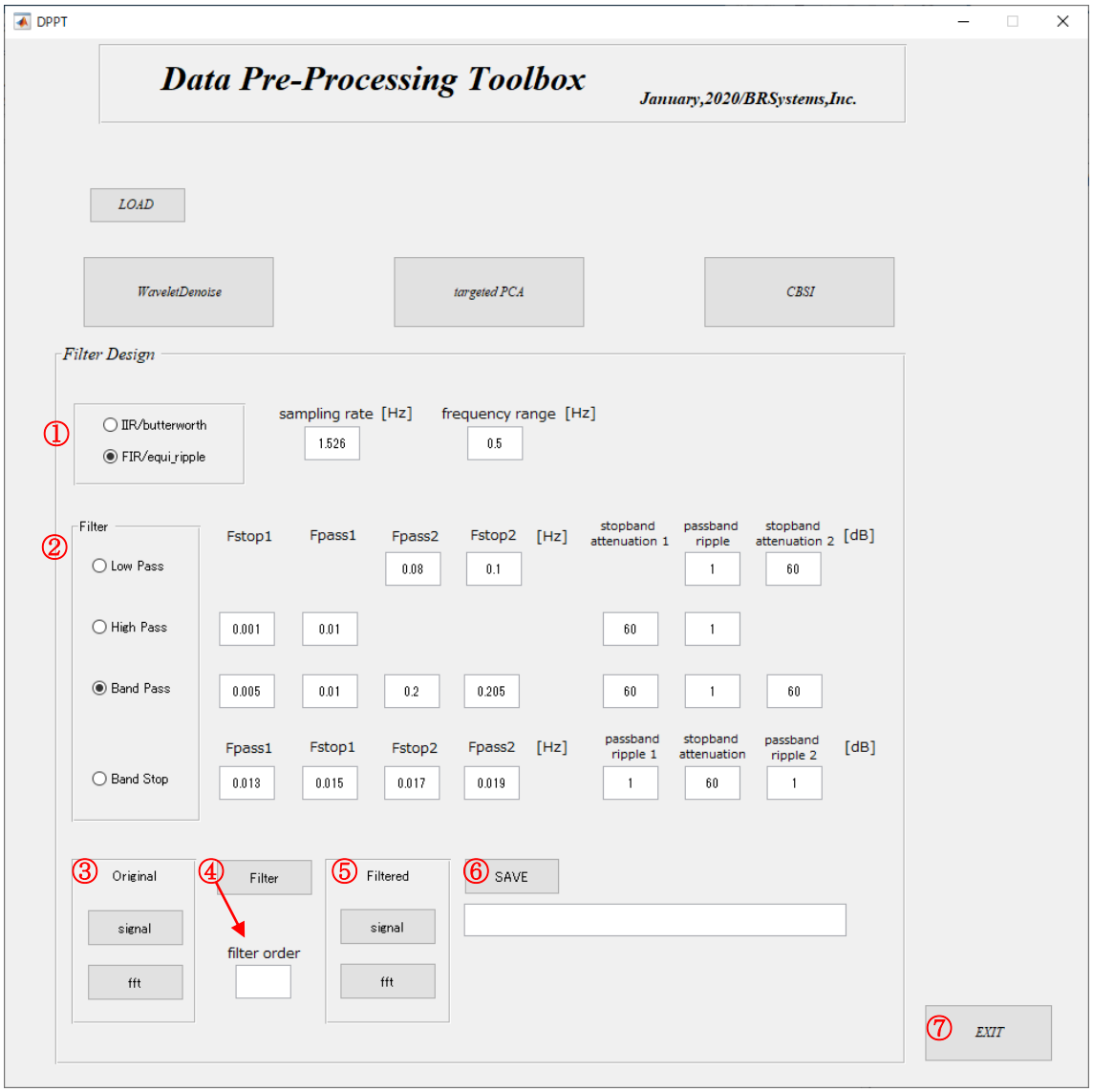


Fig.5-2　the enlarged view of the original wave of channel 3



5. Filter Design



[configuration]

① Select IIR (infinite impulse response filter) or FIR(finiite impulse response filter).

Impulse response of IIR continues indefinitely, consistent with recursive filter.

Impulse response of FIR becomes zero at finite duration, consistent with non-recursive filter.

Set sampling rate [Hz] fNIRS signal, Frequency range [Hz]. Frequency range is a limit of horizontal axis (Fig.2 &5 fft).

② Select filter pass, and input the corresponding configuration values.

③ In original panel, click “signal”. Measured raw data is displayed(Fig.1).
Click “fft”, fft of raw data is displayed(Fig.2).

④ Click “Filter”, you can see the specification of your filter, magnitude response and phase response(Fig.3). Filter order is also calculated.

⑤ In Filtered panel, click “signal”, Filtered data is displayed(Fig.4).
Click “fft”, fft of filtered data is displayed(Fig.5).

⑥ Click “SAVE”, save the filtered data. This data will be used for base-line process, or GLM

⑦ Click “EXIT”

- Our filter is considered to compensate for delay introduced by filtering.
- When excessive transient response occurred in IIR (filtfilt), we provide the option,to reduce the transient response.

Fig. 1

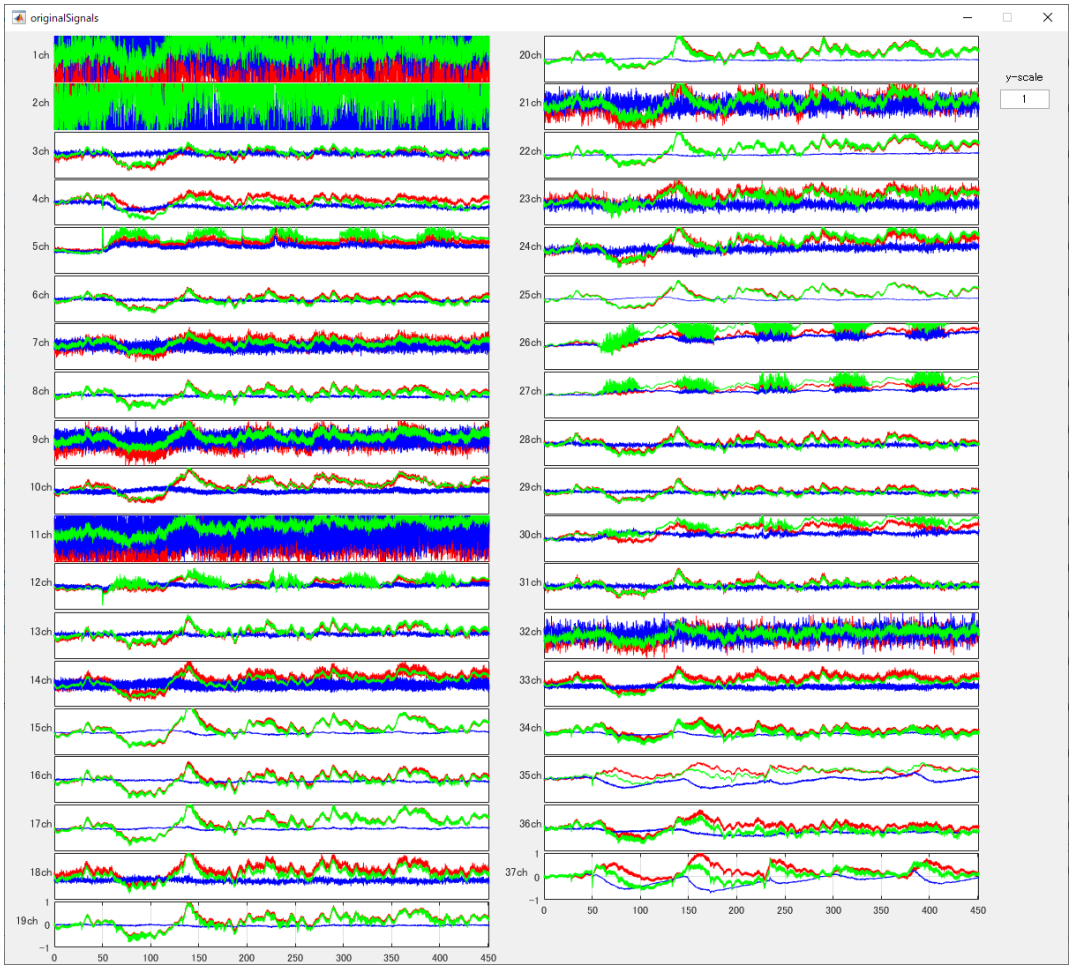


Fig. 2

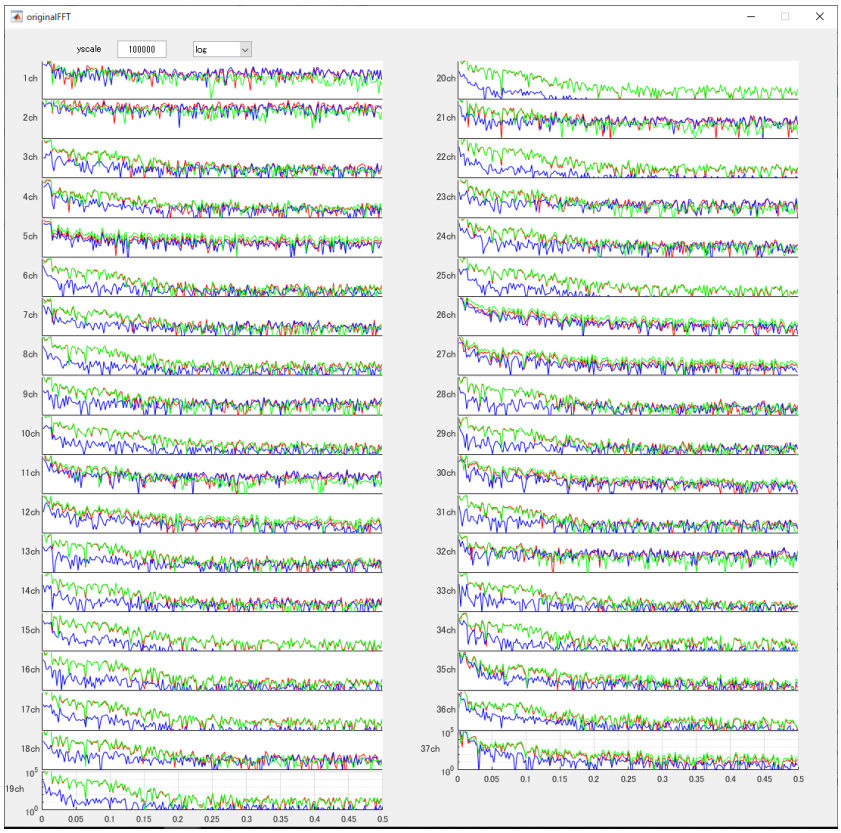
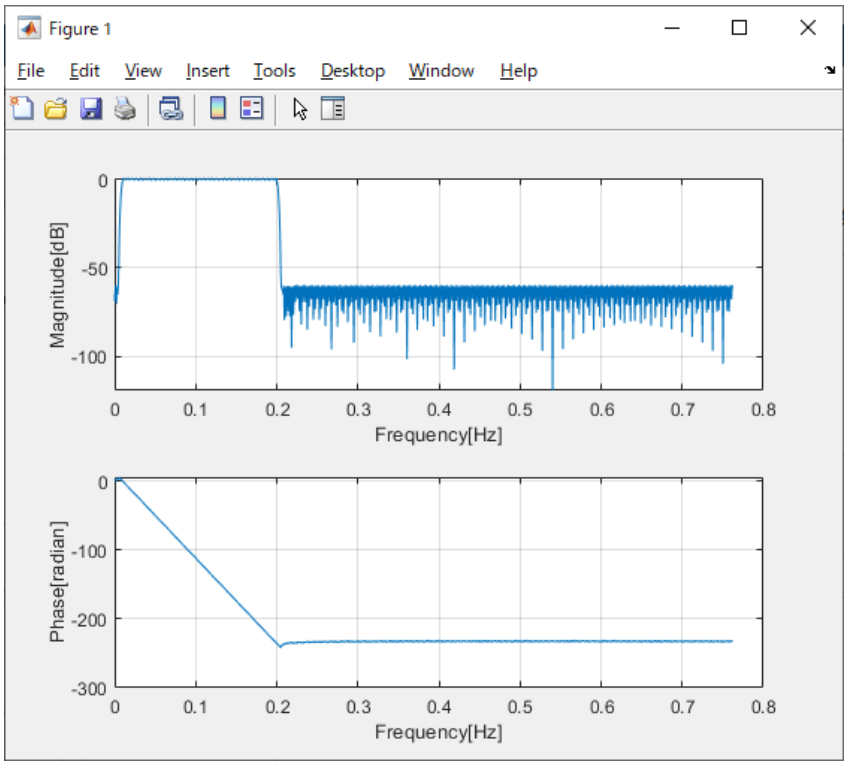
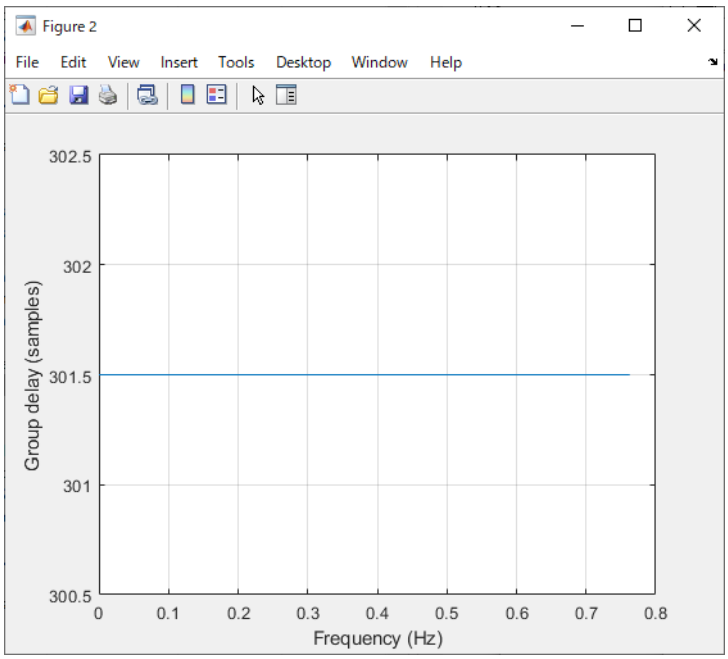


Fig. 3　magnitude response and phase response



group delay response



pole-zero plot

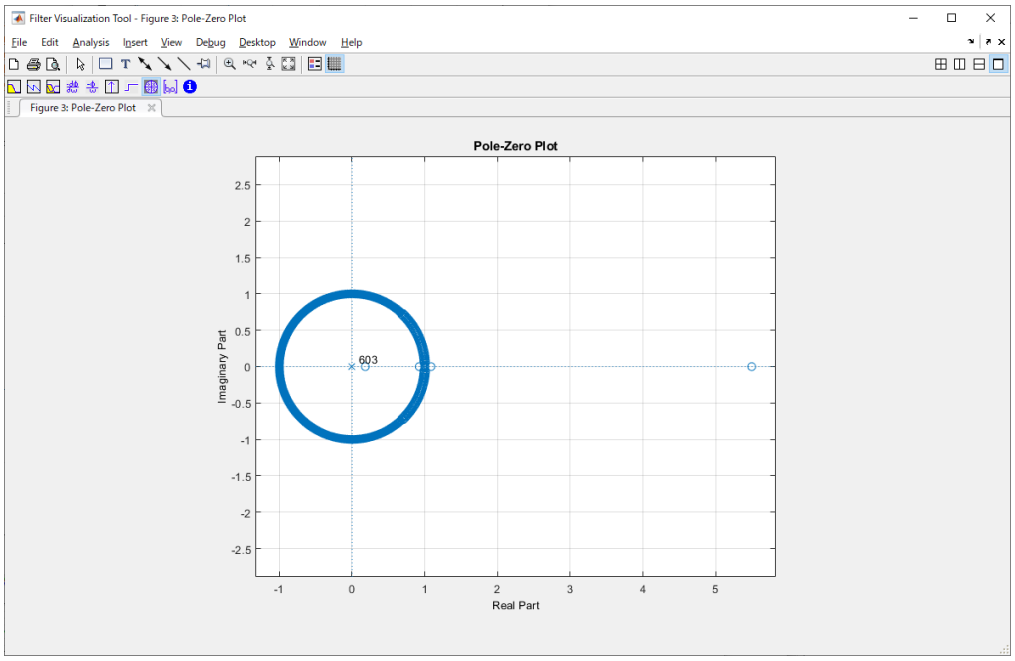


Fig. 4

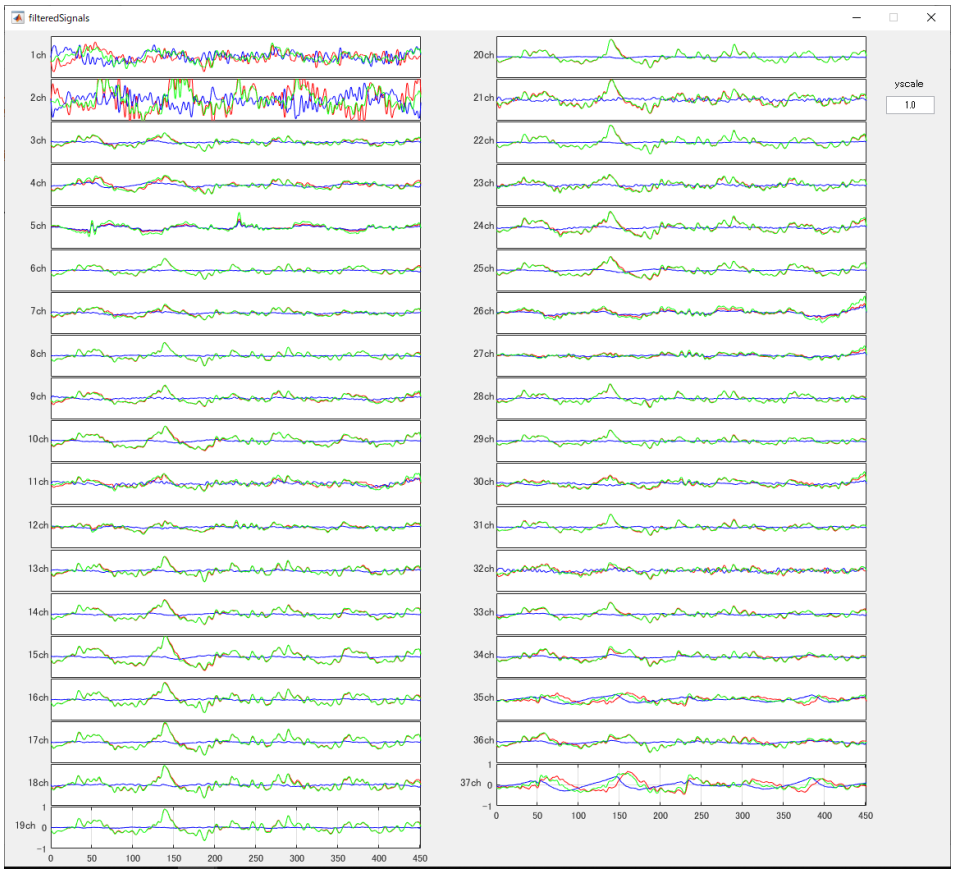


Fig. 5