



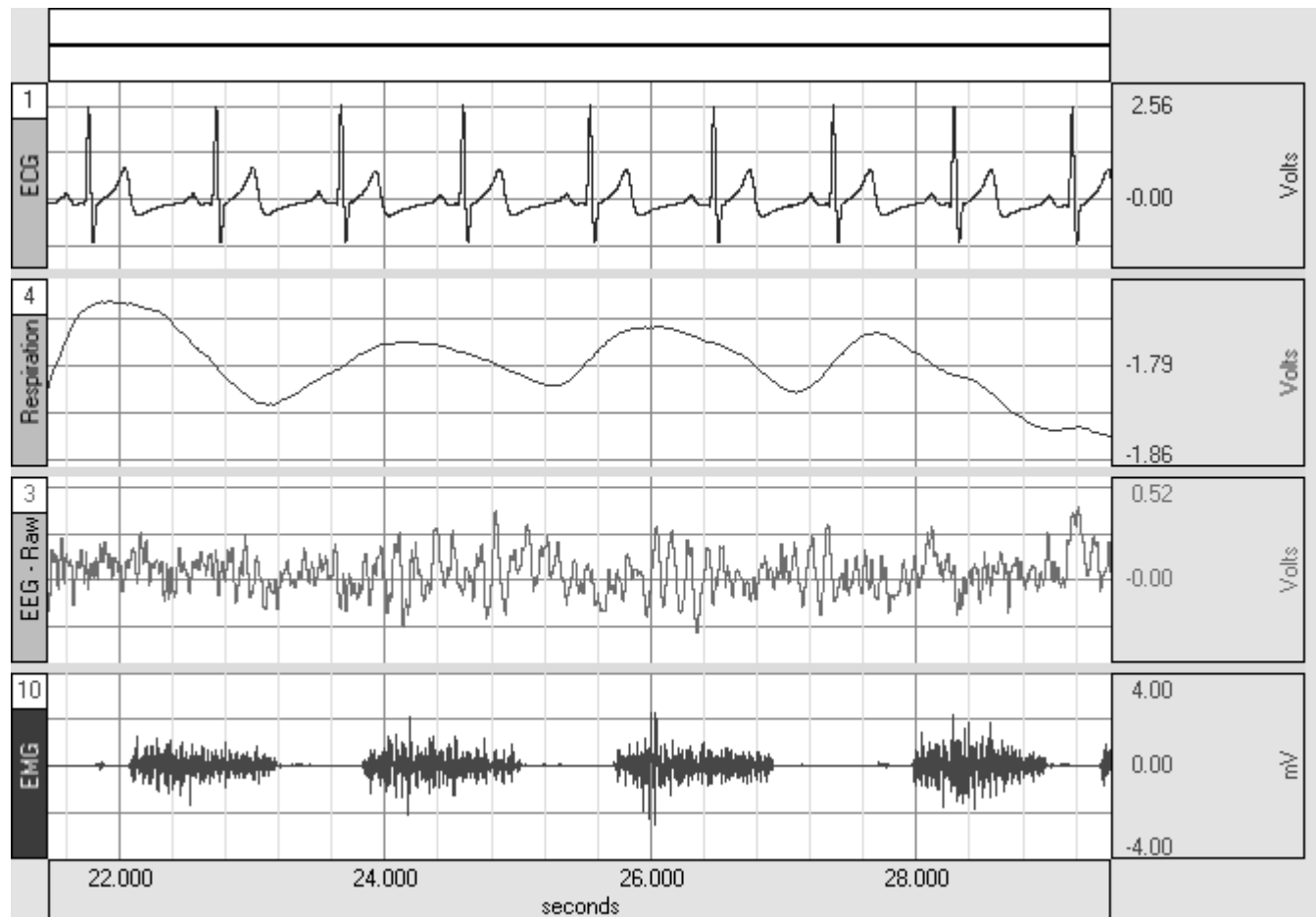
Cours SIGNAL

Caractéristiques d'un signal physiologique et post-traitement

Olivier Stücker
CEROM, 155 rue du Fg St Denis
7501 Paris
info@cerom.fr

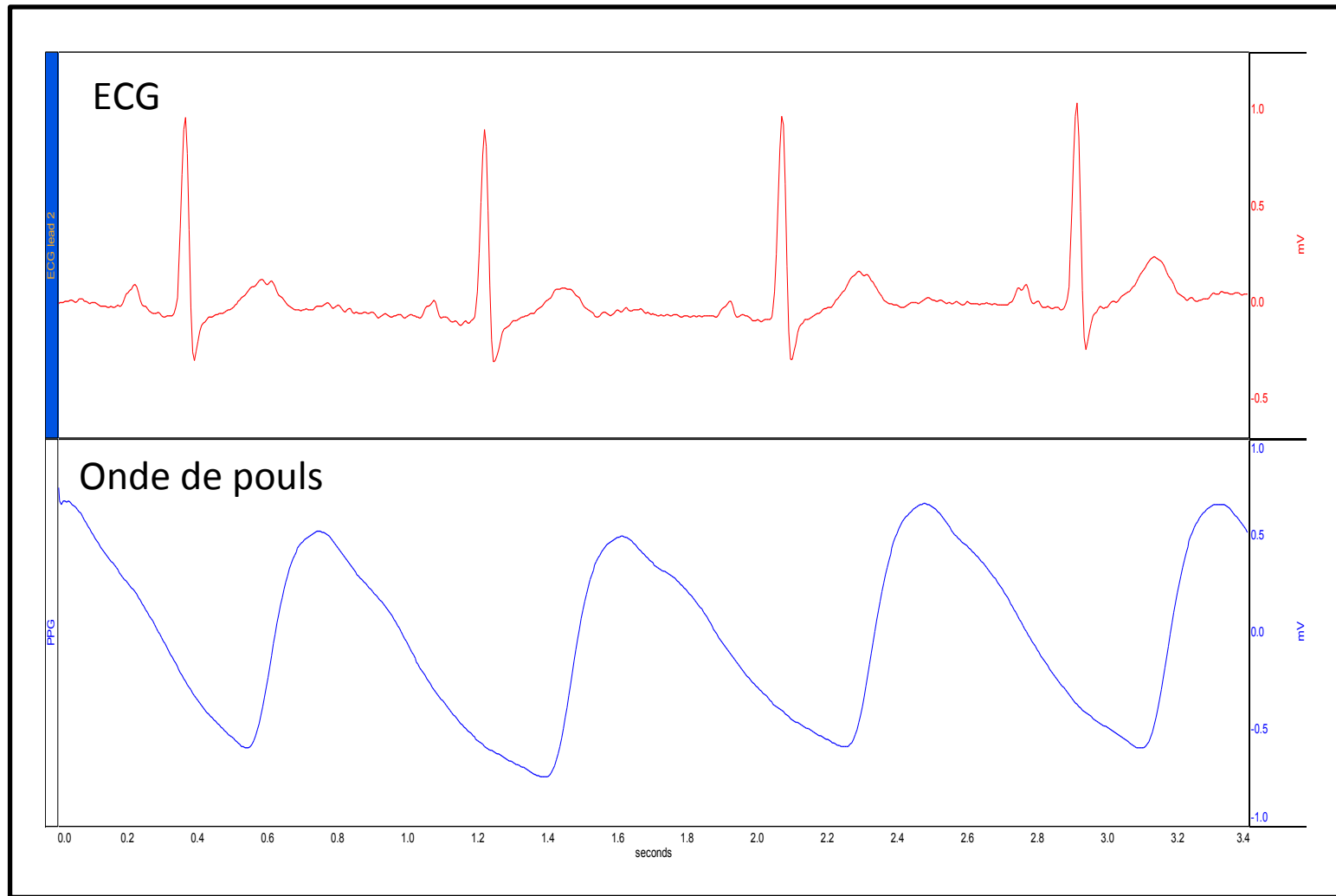


Signaux physiologiques



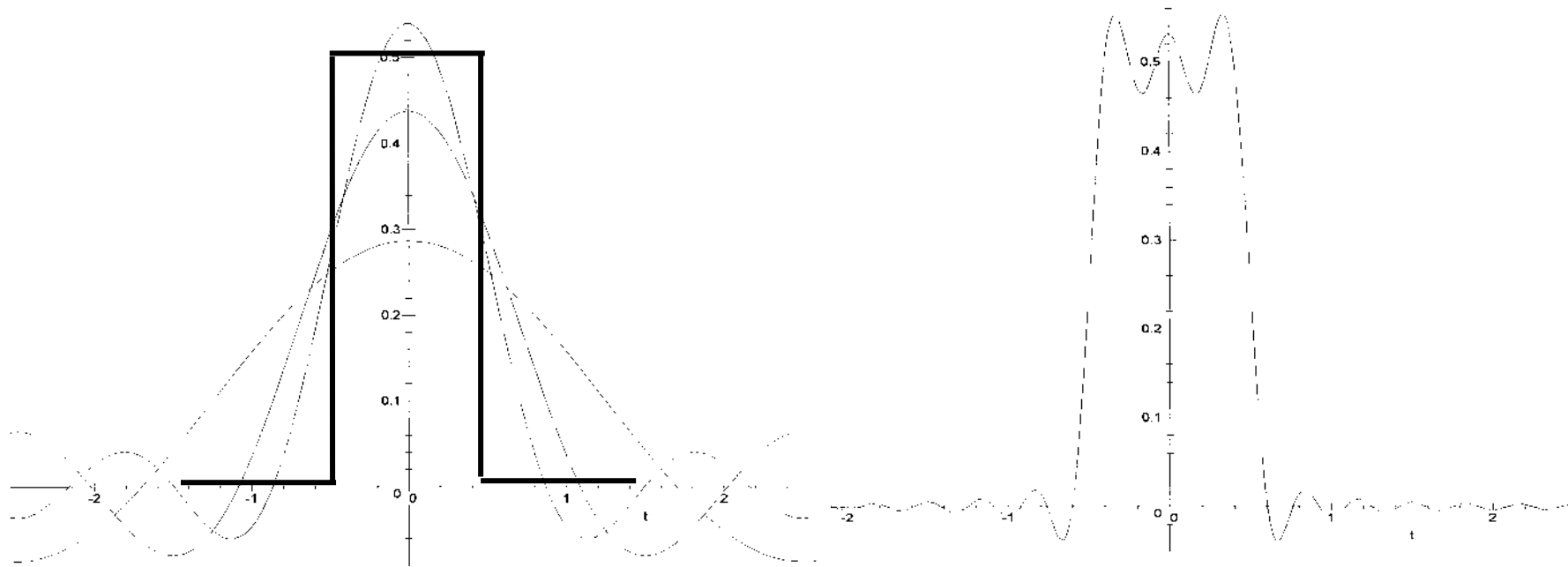


Même période



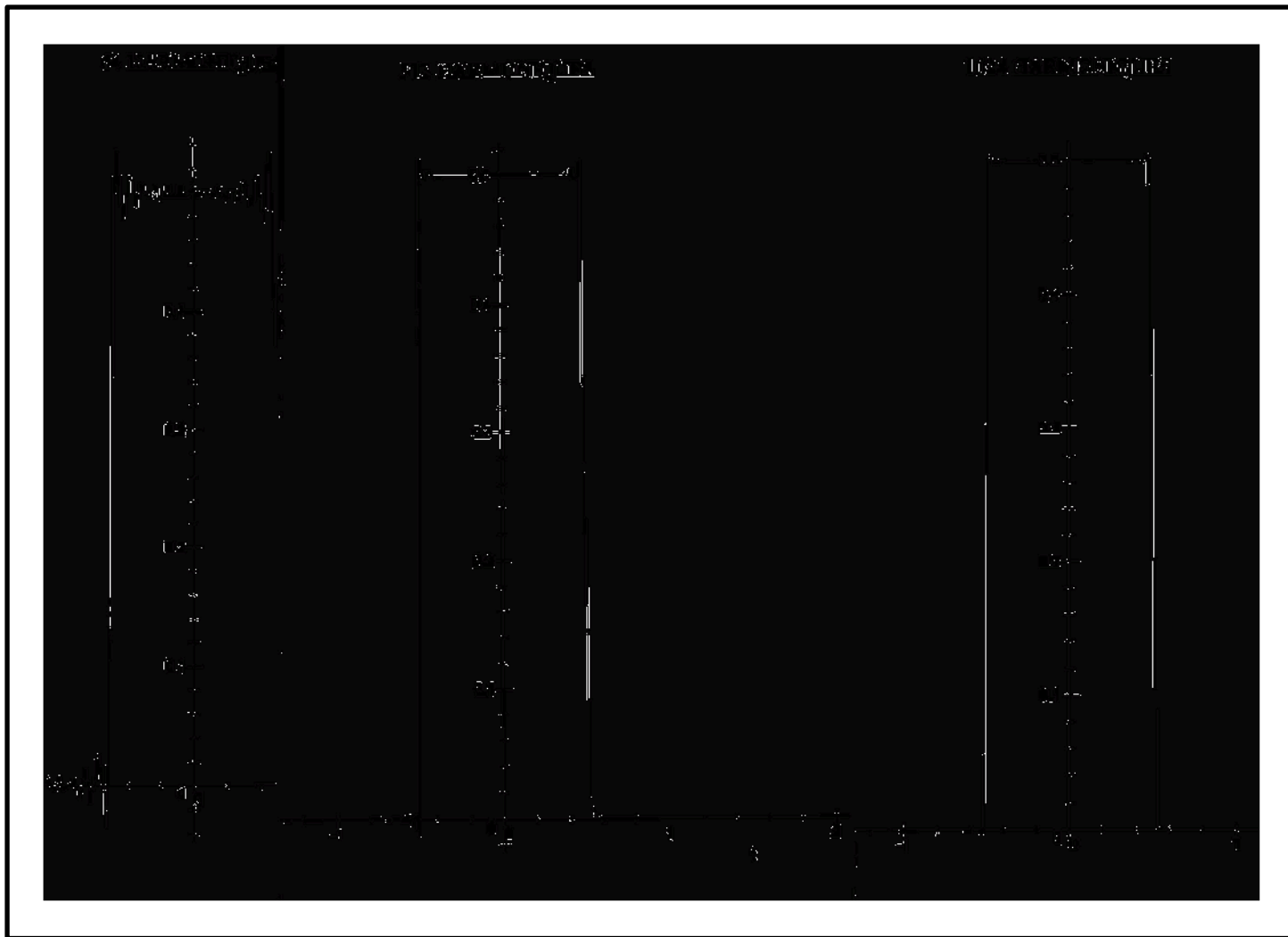
Composition du signal

Il est possible de reconstruire n'importe quel signal avec des sinusoïdes



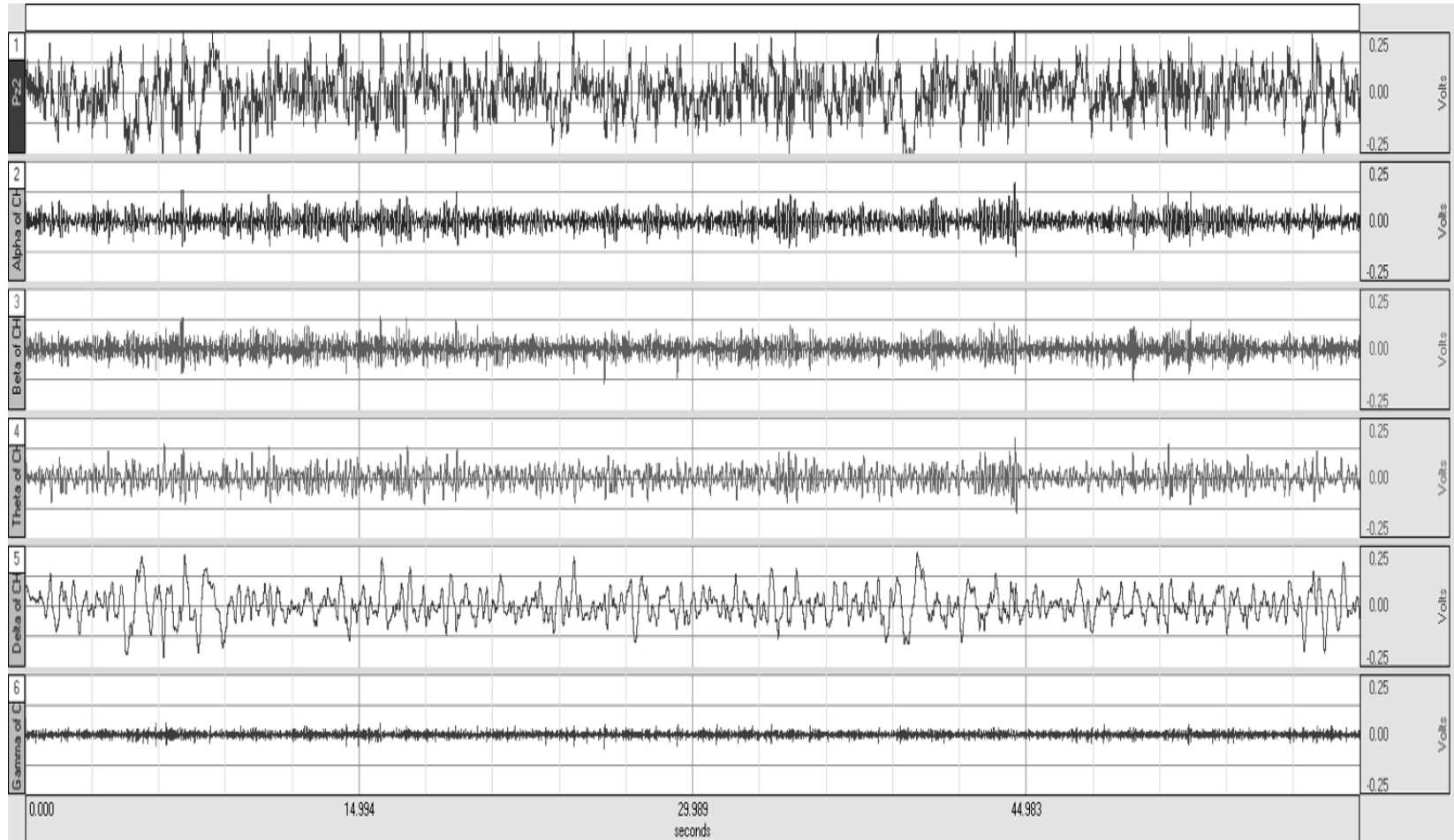


Composition du signal 2





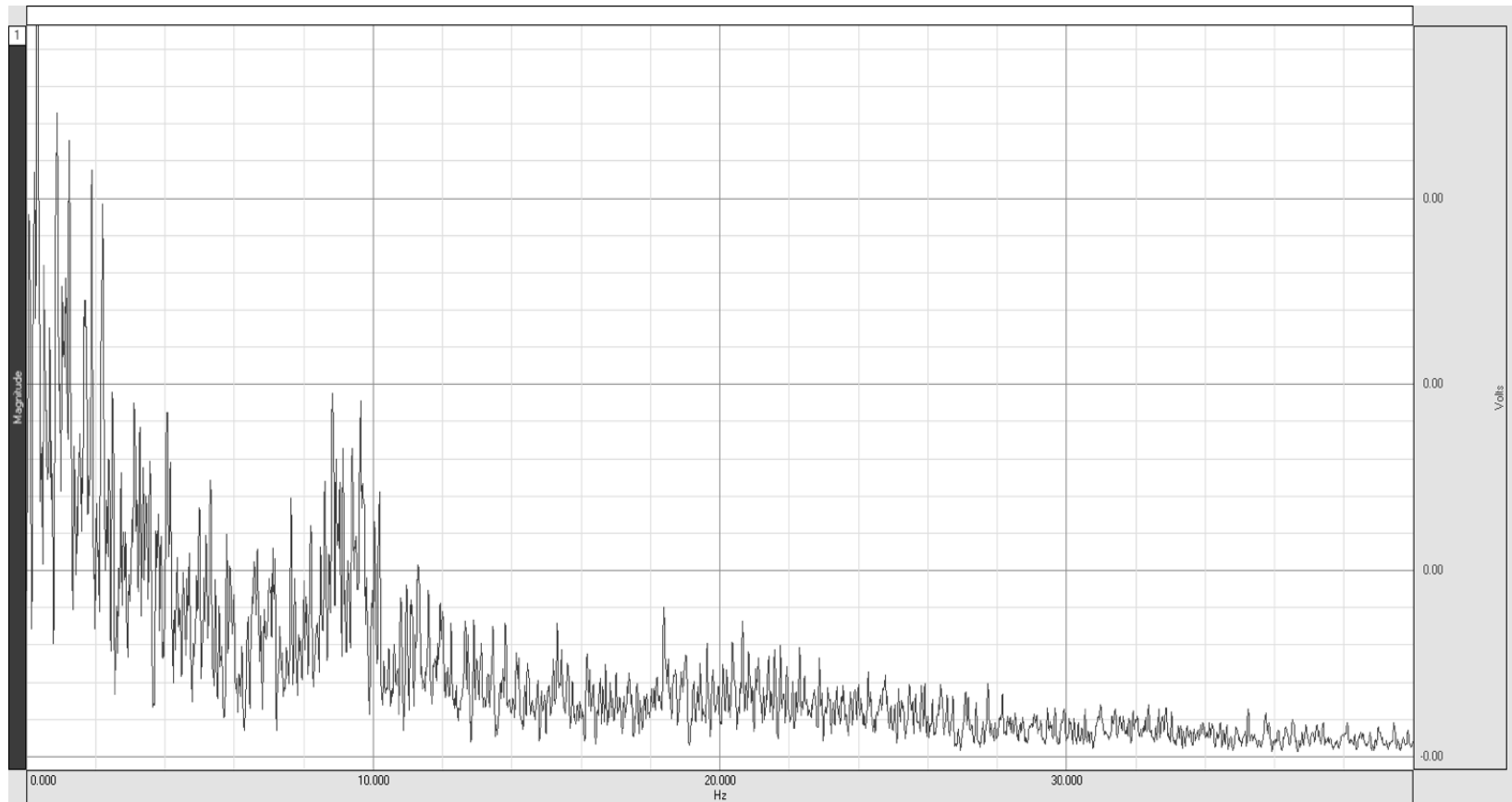
EEG



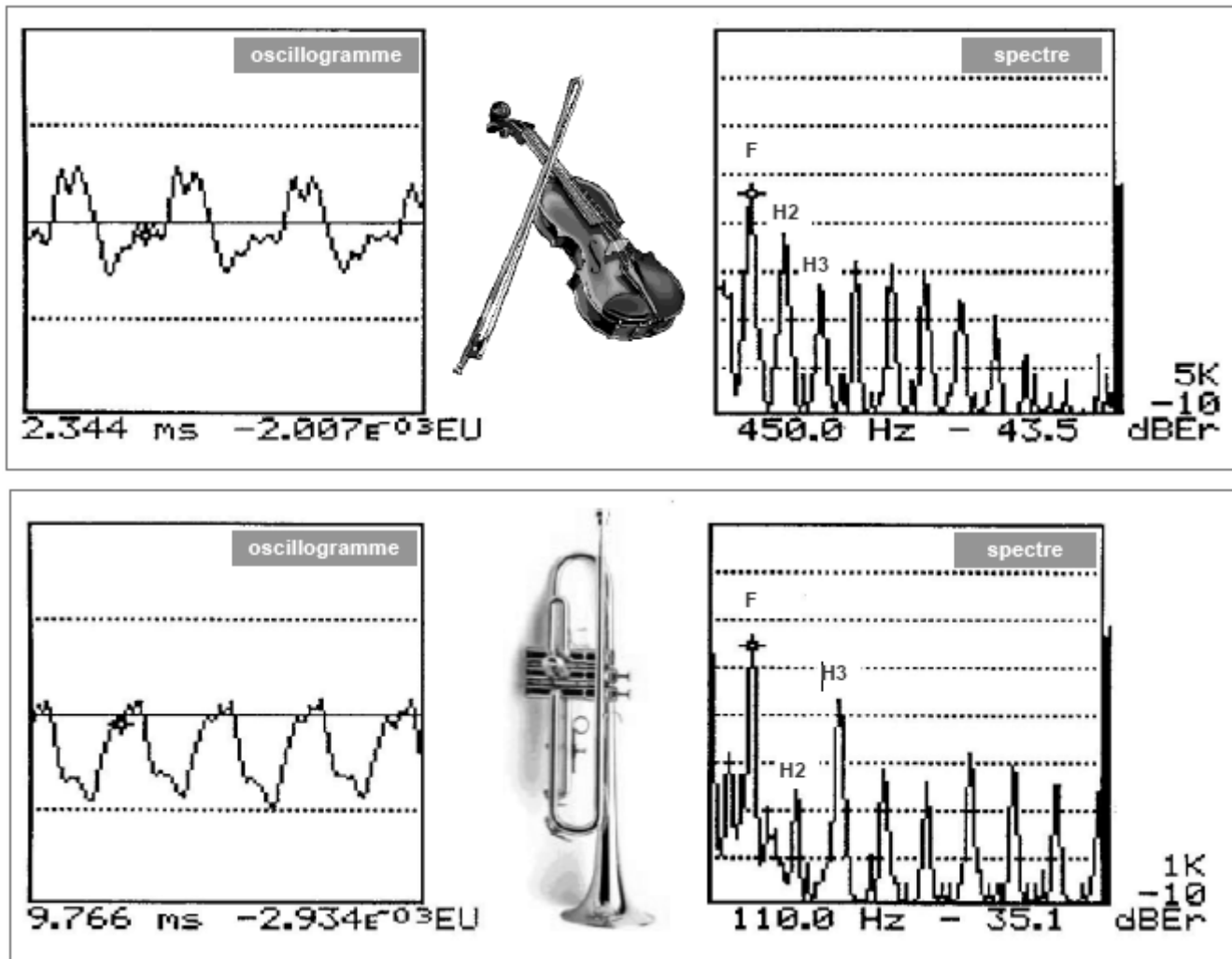


FFT composition spectrale

EEG

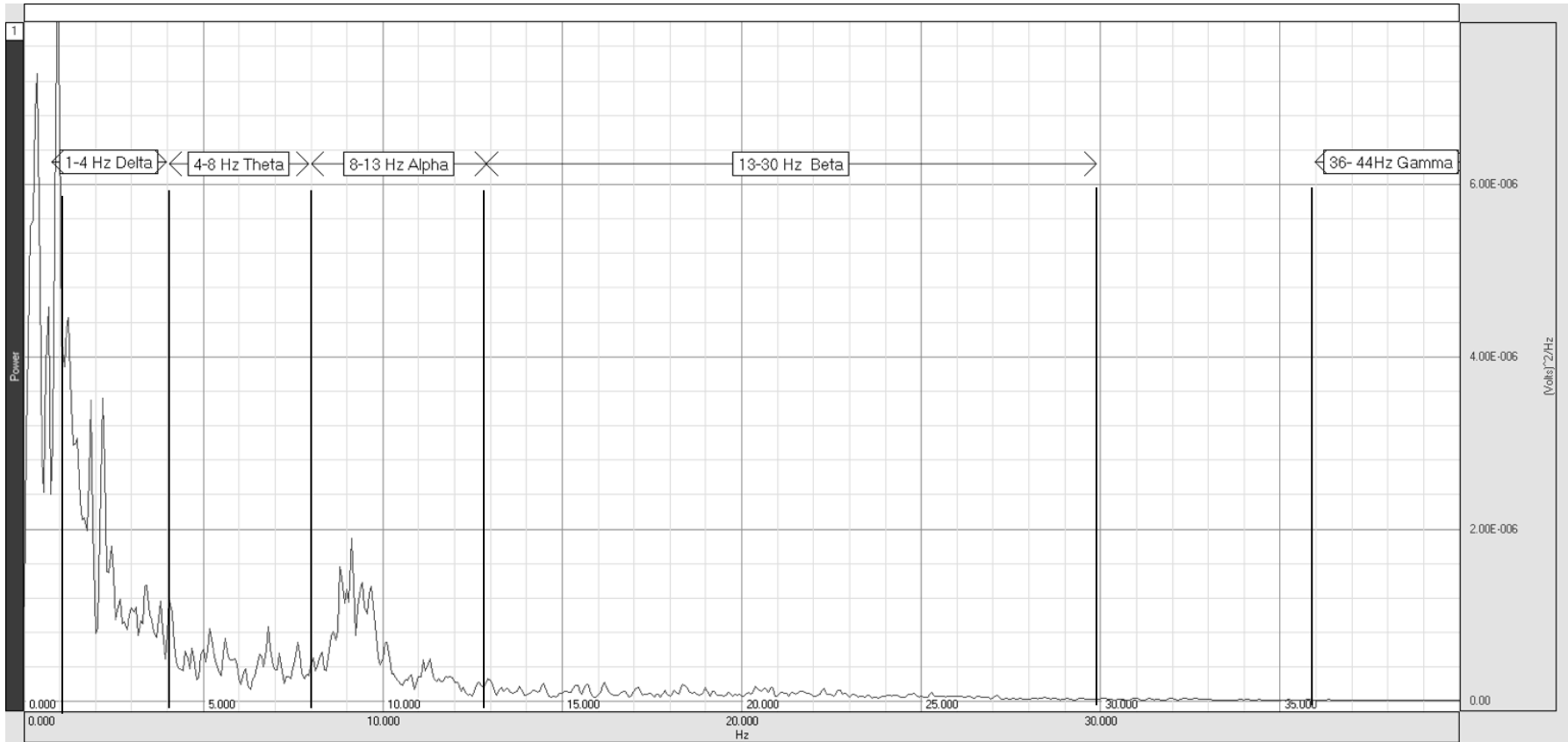


Composition spectrale d'un signal



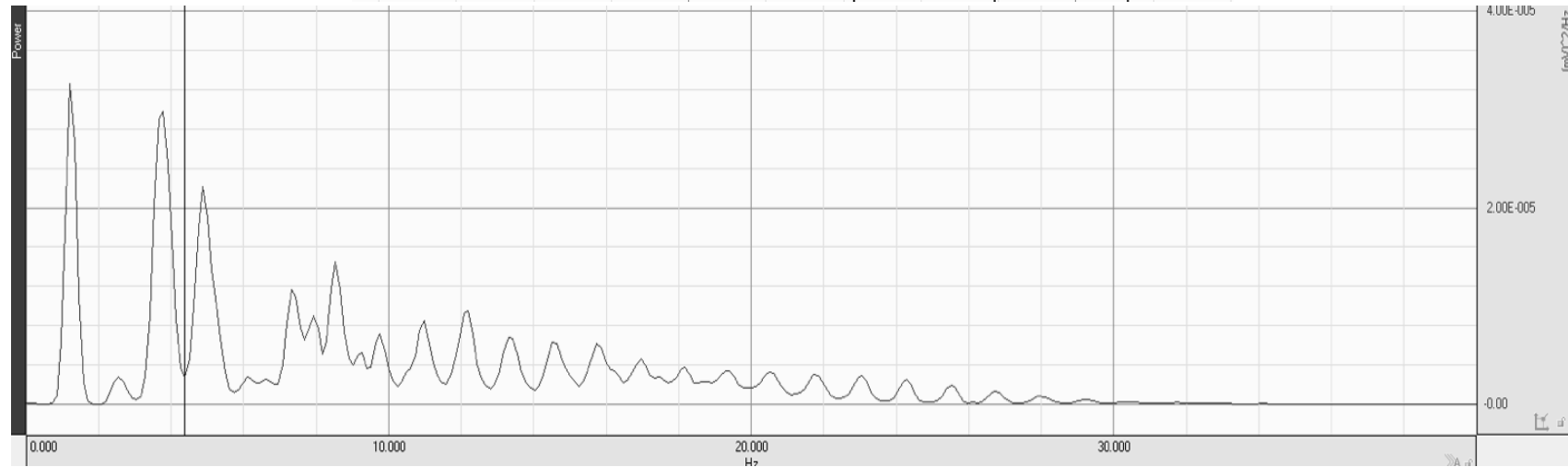
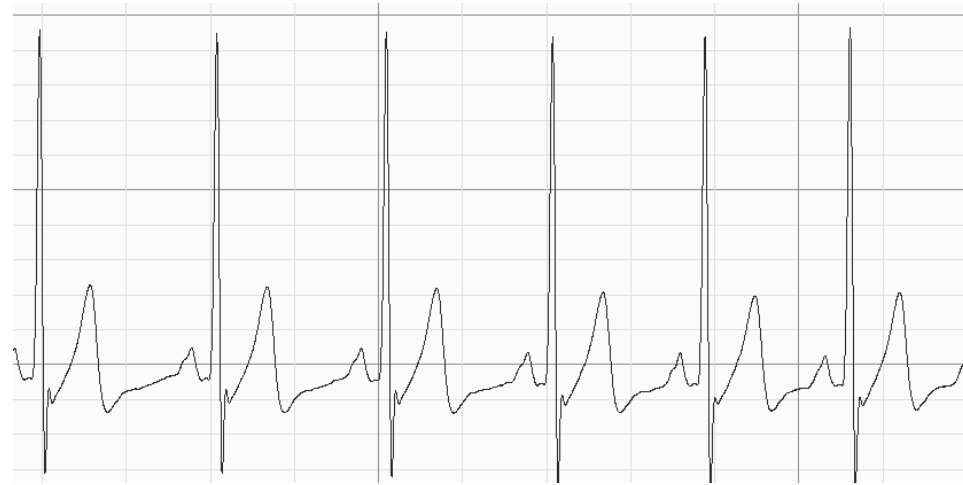


PSD





Composition spectrale ECG





Filtres

-
-
-

Low pass, high pass, band pass, band stop

Filtres IIR

calculs plus rapides (on line) mais déphasage
(Infinite Impulse Response)



Préset d'acquisition

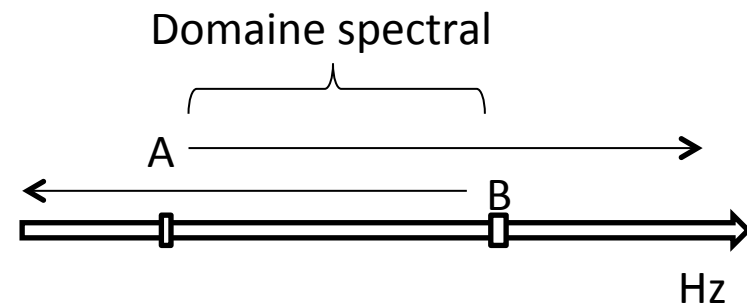
Electrocardiogram (ECG), .5 - 35 Hz
Electrocardiogram (ECG), .05 - 35 Hz
Electrocardiogram (ECG), .05 - 100 Hz, AHA
Electrocardiogram (ECG), .05 - 150 Hz
Electrodermal Activity (EDA), 0 - 35 Hz
Electrodermal Activity (EDA) Change
Electroencephalogram (EEG), .5 - 35 Hz
Electroencephalogram (EEG), .5 - 100 Hz w/notch
Electrogastrogram (EGG)
Electromyogram (EMG), 5 - 250 Hz w/notch
Electromyogram (EMG), 5 - 500 Hz
Electromyogram (EMG), 5 - 1000 Hz
Electromyogram (EMG), 30 - 250 Hz w/notch
Electromyogram (EMG), 30 - 500 Hz
Electromyogram (EMG), 30 - 1000 Hz
Electrooculogram (EOG), .05 - 35 Hz

Temperature (deg. C)
Temperature (deg. F)
Temperature Change (deg. C)
Temperature Change (deg. F)

ElectroX, A - B Hz

A : filtre Passe haut

B : filtre passe bas





Réglage d'un amplificateur

AcqKnowledge - Input Channel Parameters

Channel Number: CH1

Channel Label: ECG (.5 - 35 Hz)

Preset: Electrocardiogram (ECG), .5 - 35 Hz

Digital Filters

	Type	Frequency	Q
1	Low Pass	66.5	0.5
2	Low Pass	38.5	1
3	Band Stop - Line Freq	50	1

Gain: x1000 Offset: 0 mV

High Pass Filter (Hz): Off (DC) 0.05 0.5 5

New Channel Preset Advanced... Scaling ... OK Cancel



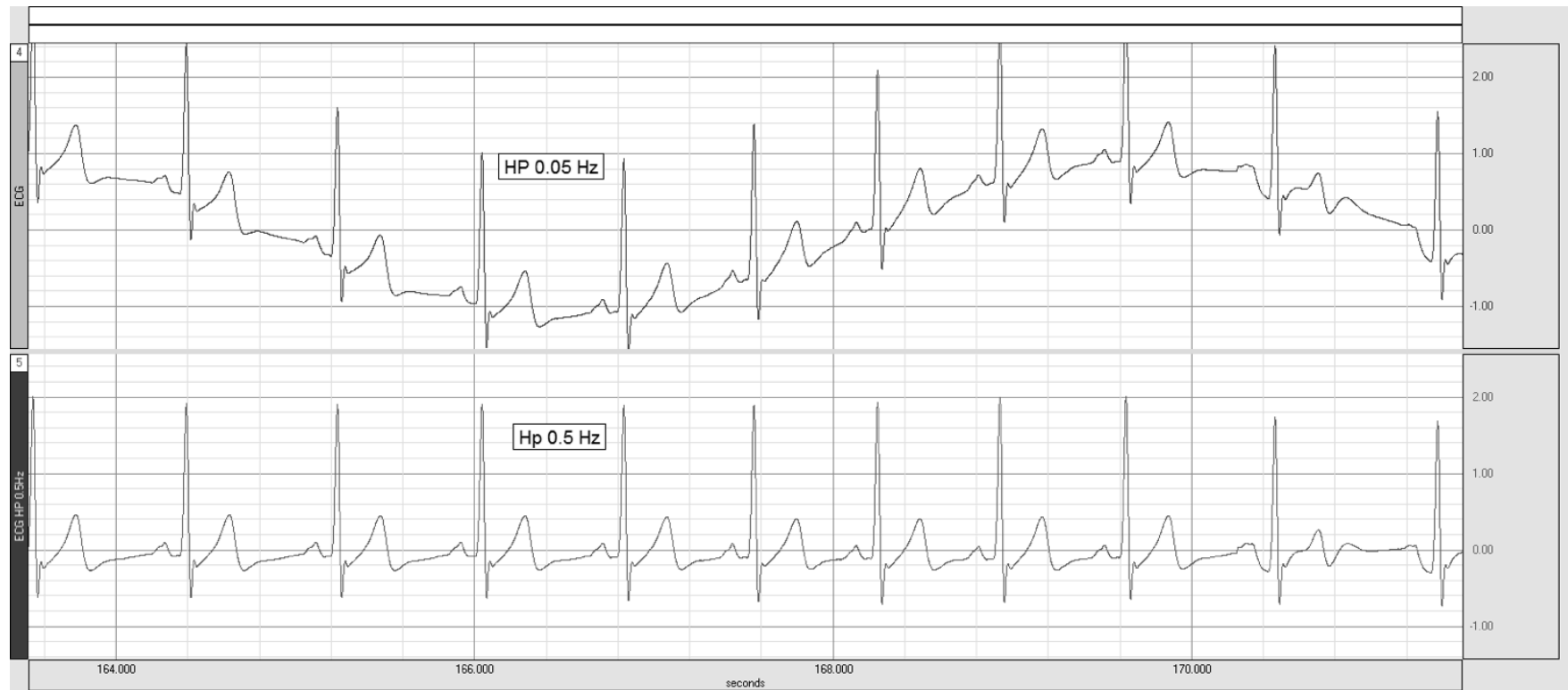
Intérêt du domaine spectral

-
-
-
-



Stabilisation de la ligne de base

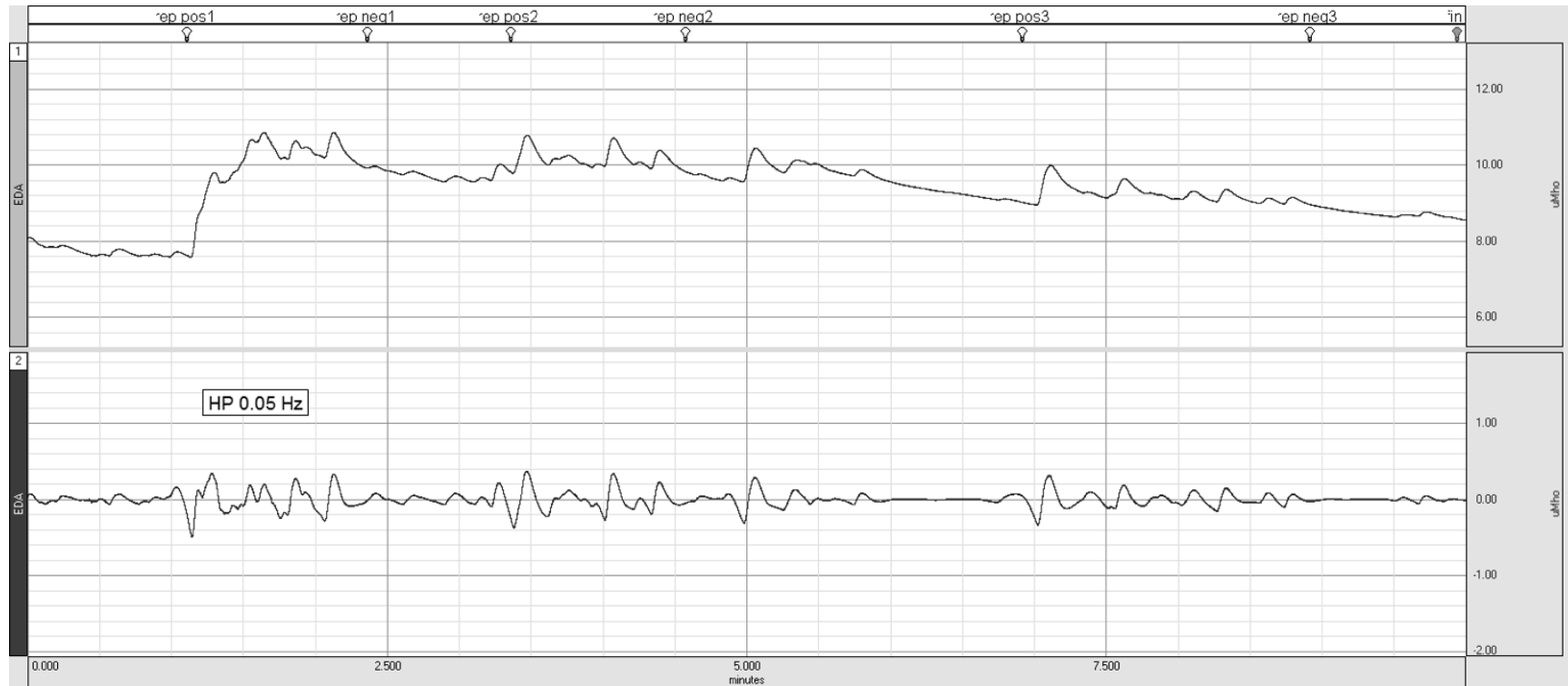
ECG





Suppression de la composante continue

AED





Préset d'acquisition

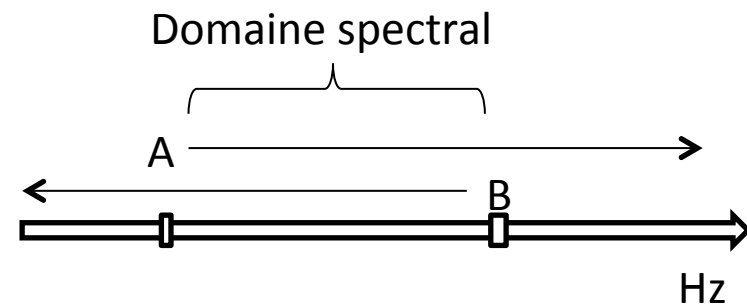
Electrocardiogram (ECG), .5 - 35 Hz
Electrocardiogram (ECG), .05 - 35 Hz
Electrocardiogram (ECG), .05 - 100 Hz, AHA
Electrocardiogram (ECG), .05 - 150 Hz
Electrodermal Activity (EDA), 0 - 35 Hz
Electrodermal Activity (EDA) Change
Electroencephalogram (EEG), .5 - 35 Hz
Electroencephalogram (EEG), .5 - 100 Hz w/notch
Electrogastrogram (EGG)
Electromyogram (EMG), 5 - 250 Hz w/notch
Electromyogram (EMG), 5 - 500 Hz
Electromyogram (EMG), 5 - 1000 Hz
Electromyogram (EMG), 30 - 250 Hz w/notch
Electromyogram (EMG), 30 - 500 Hz
Electromyogram (EMG), 30 - 1000 Hz
Electrooculogram (EOG), .05 - 35 Hz

Temperature (deg. C)
Temperature (deg. F)
Temperature Change (deg. C)
Temperature Change (deg. F)

ElectroX, A - B Hz

A : filtre Passe haut

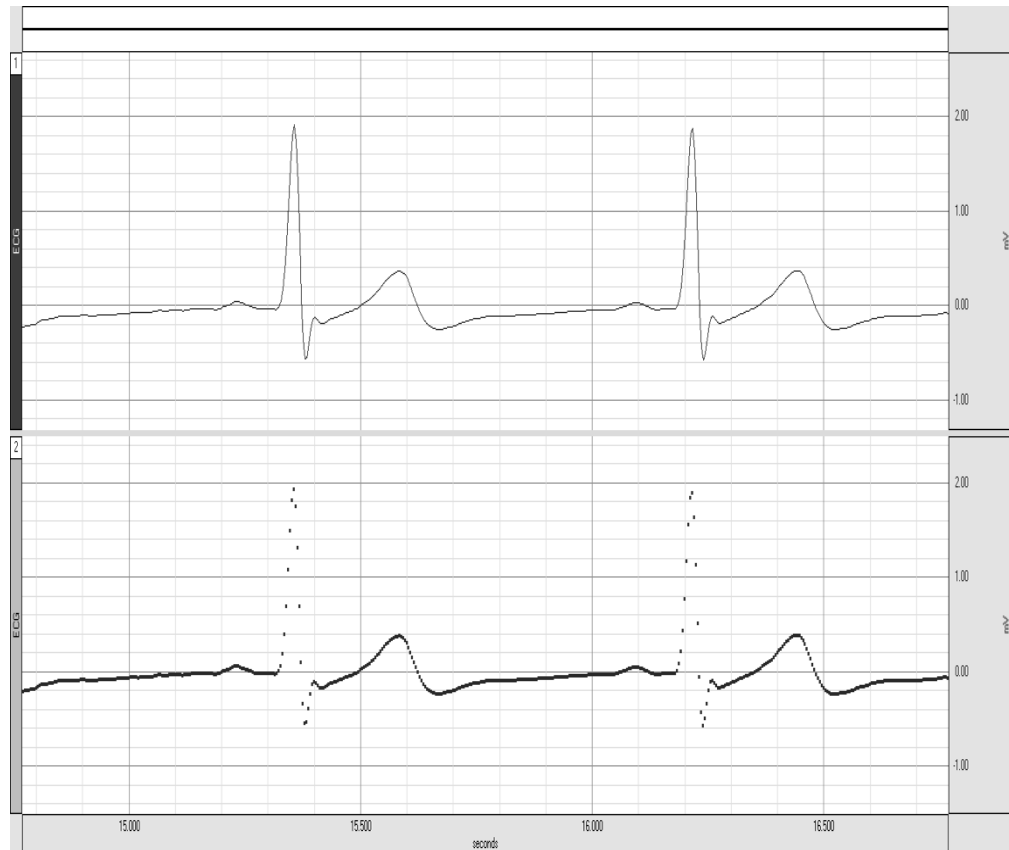
B : filtre passe bas



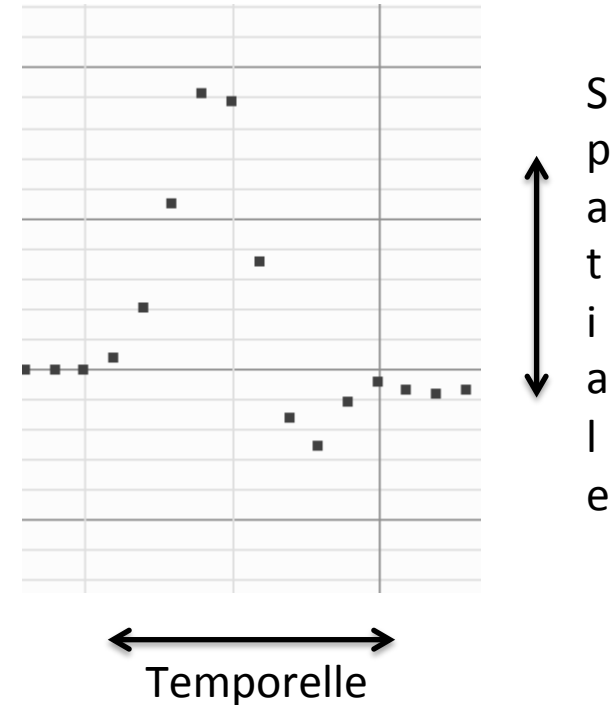


Quelle fréquence d'échantillonnage?

Numérisation == discrétisation



Résolution



200 Hz = 5 ms

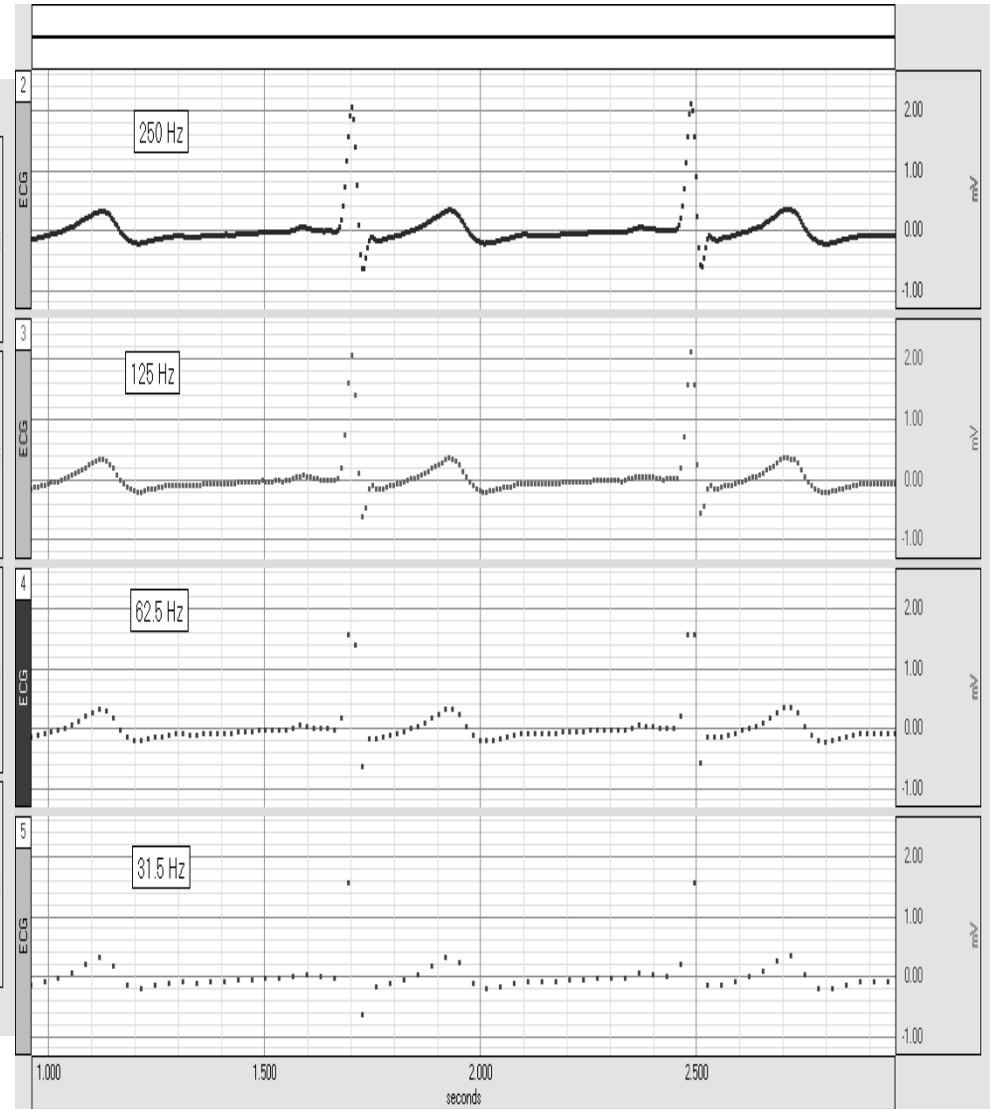
16 bits = 65 536 pts

Si 10 mV pleine échelle >> 0.15 μ V

24 bits = 16 777 216 pts



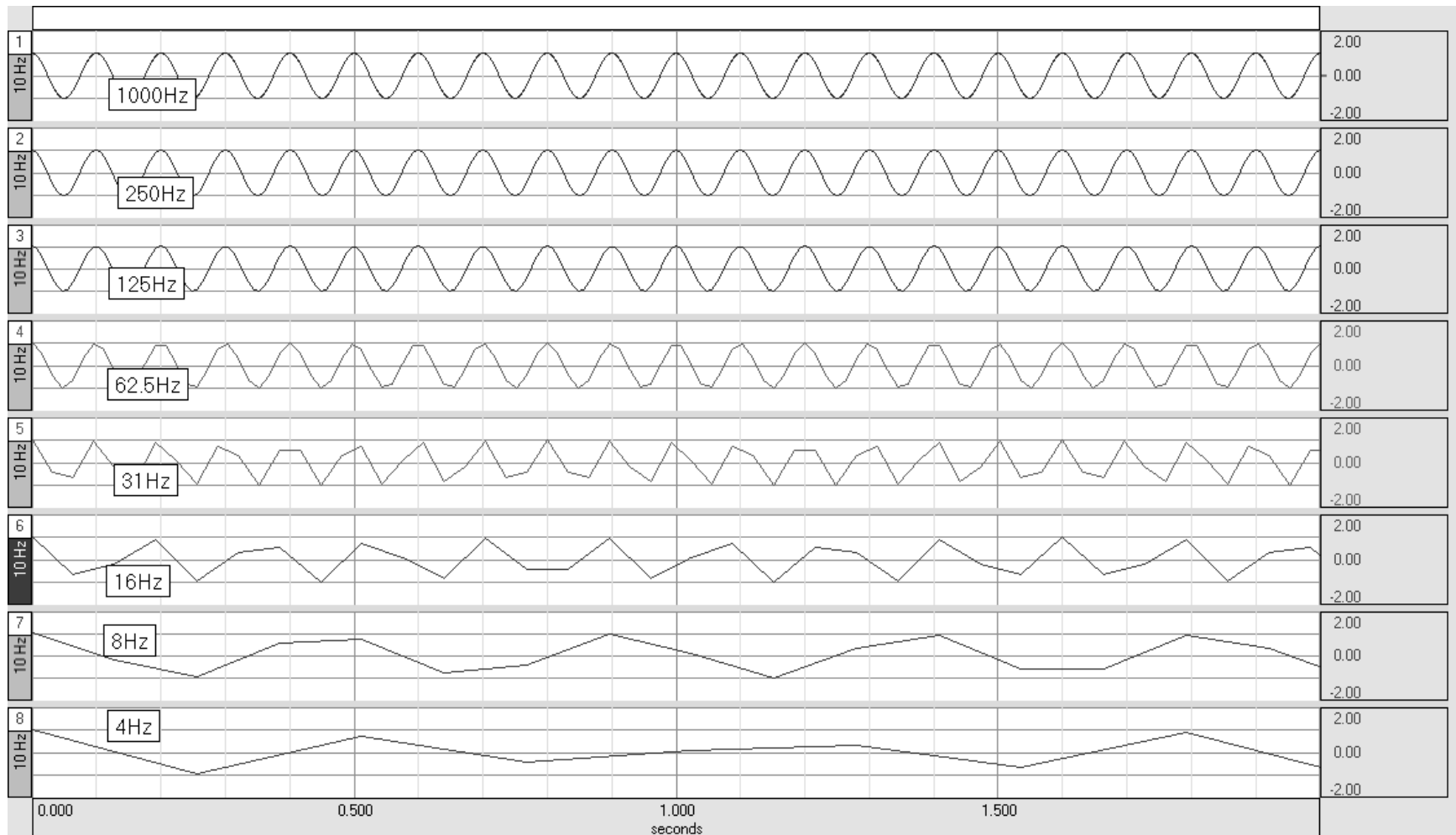
Fréquence d'acquisition optimale





Aliasing

Sinusoïde à 10 Hz



Erreur sur l'amplitude et la fréquence



Traitement du signal

- - Suppressions des artéfacts
 - Supression des parasites
- Effectuer des transformations
 - Extraire l'information
 - Faires des mesures et des analyses



Préparation du signal

suppression du bruit et des parasites



Fonctions pour la suppression des artéfacts et des parasites

- Connect end points »
- Fonction Smoothing (lissage)
 - Moyenne
 - Médiane
- Fonction Slew
- Filtrage numérique du signal



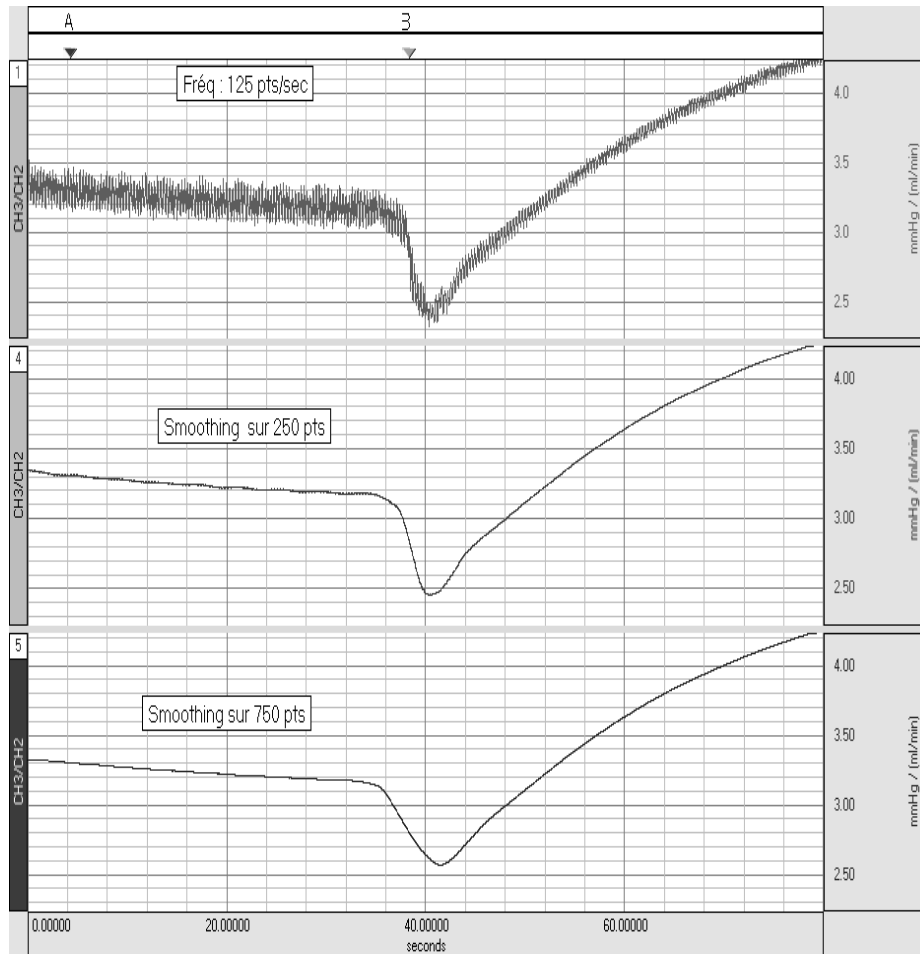
Suppression du bruit

- Un bruit blanc n'a pas de fréquences spécifiques et est symétrique autour du signal principal donc
La moyenne du bruit blanc = zéro
- Pour supprimer un bruit :
 - par soustraction : filtres adaptatifs
il faut un canal d'enregistrement du bruit
 - par moyennage : lissage (smoothing)
 - par filtrage (band stop, filtre en peigne, HP, LP)



Smoothing (lissage par moyennage)

Suppression de bruit



Chaque point est le résultat d'un moyennage sur un intervalle de temps :

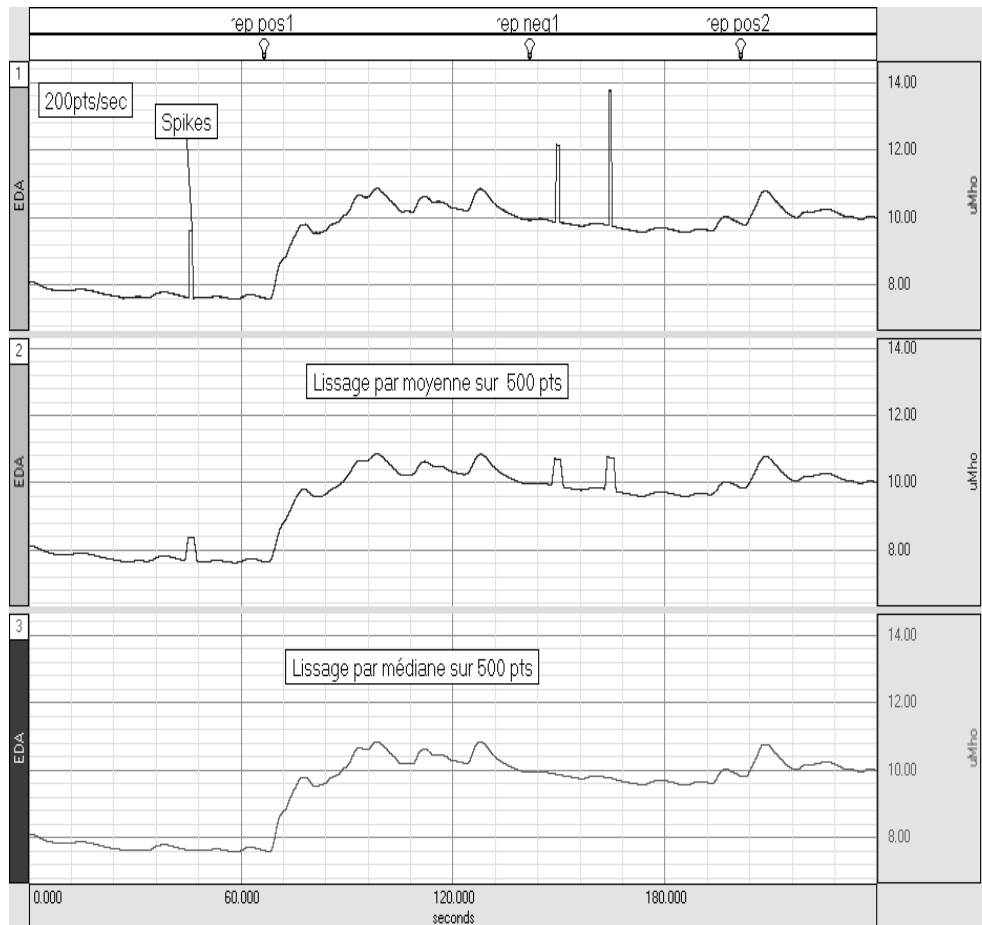
Si fréquence d'acquisition = 125pts/sec et $n = 250$ pts
>> interval = 2 sec.

$$f_{\text{output}}(n) = \frac{\sum_{k=n-(m/2)}^{k=n+(m-1)/2} f_{\text{input}}(k)}{m}$$



Lissage par la médiane

Suppression d'artéfacts



Chaque point est le résultat de la médiane d'un intervalle de temps :

Si fréquence d'acquisition = 200pts/sec et $n = 500$ pts
>> interval = 2.5 sec.

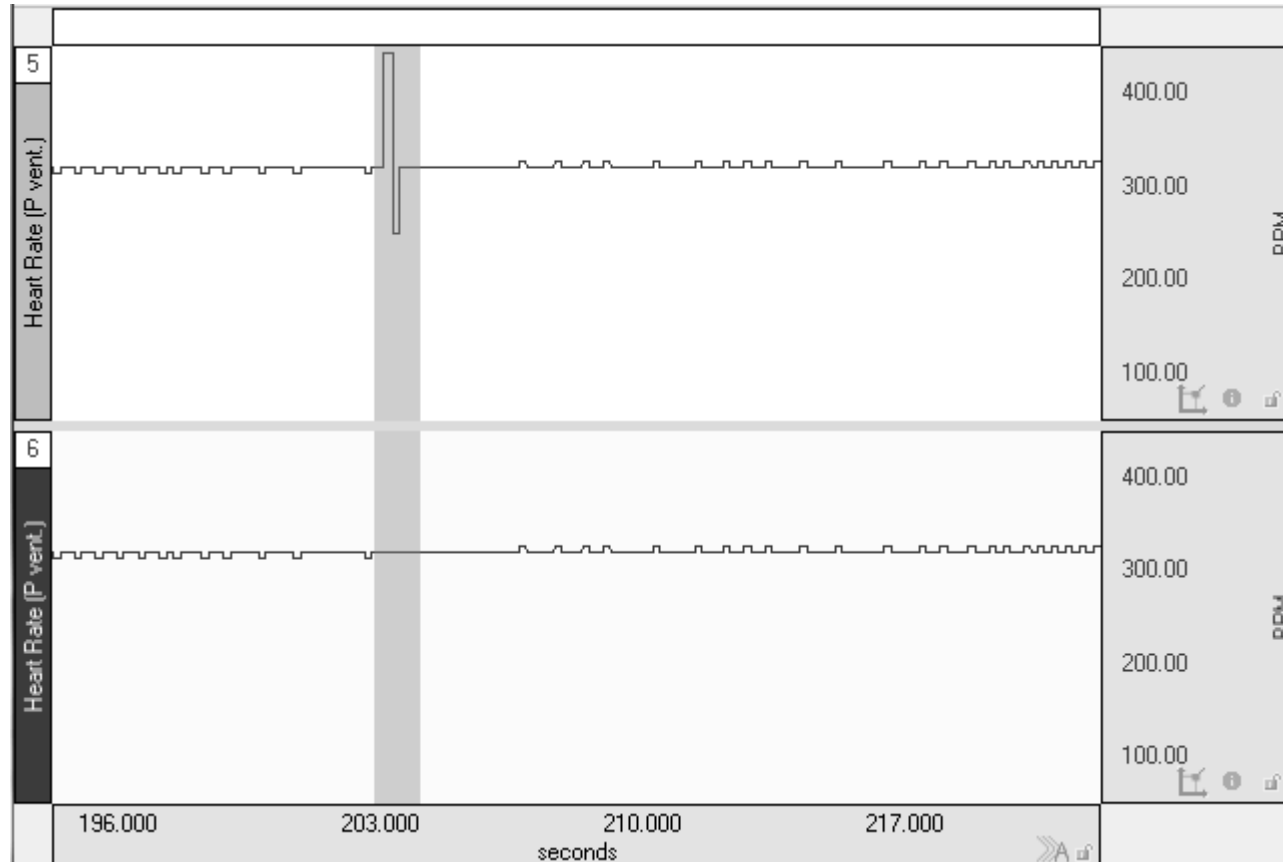
$$f_{\text{output}}(n) = \text{median}(n - [m/2]; n + [m/2])$$

Resource pour la calcul importante



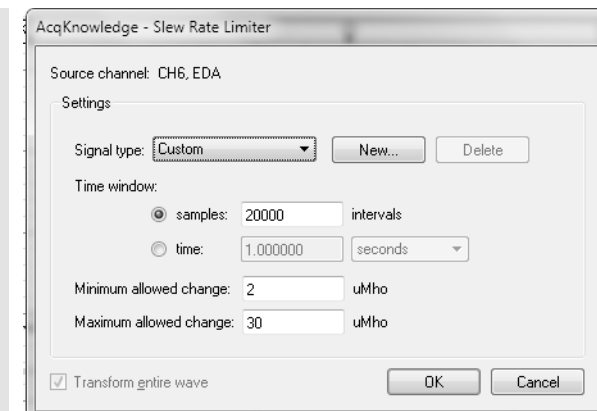
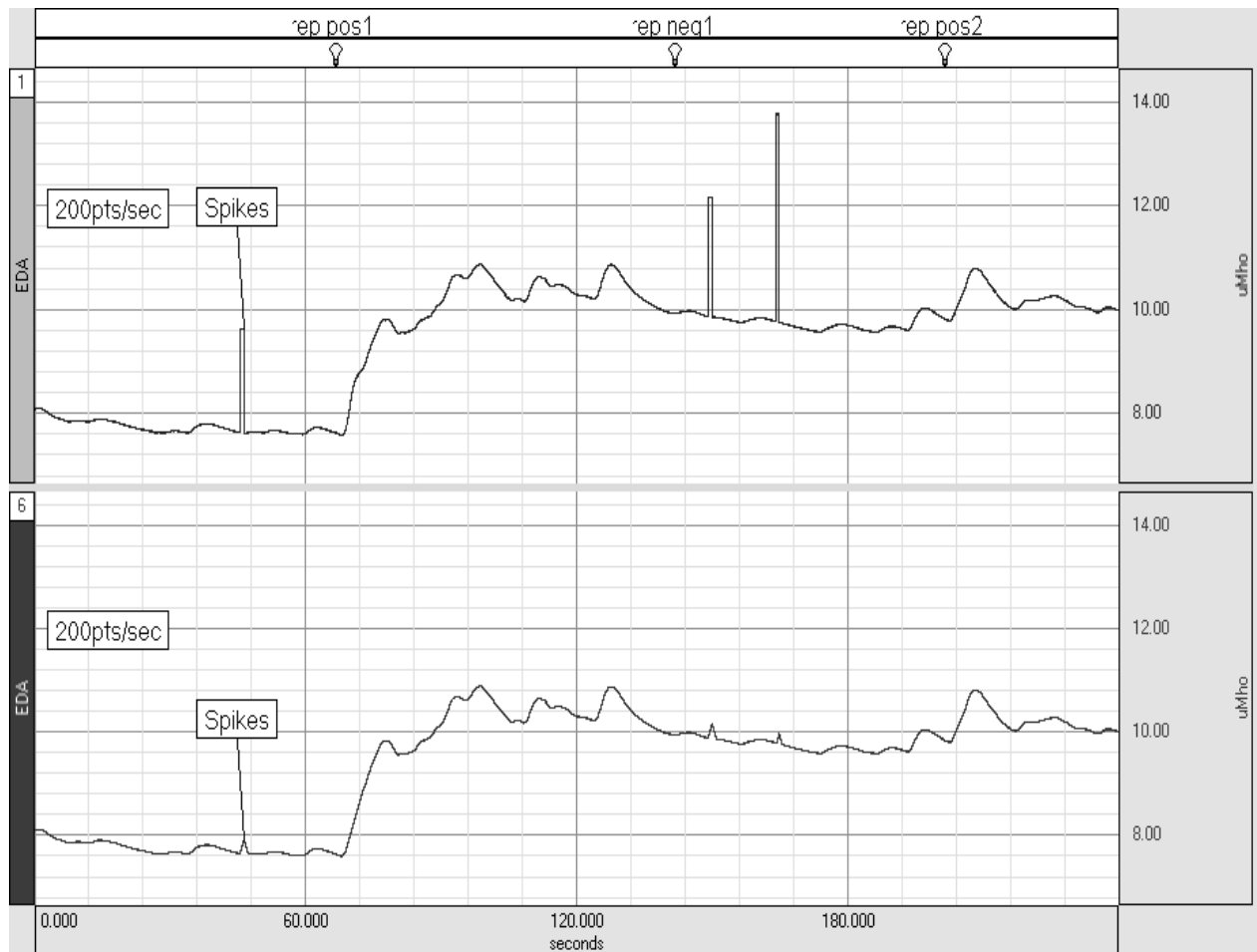
Suppression d'artéfact

« Connect end points »





Fonction « Slew rate limiter »





Filtrage

Low pass, high pass, band pass, band stop

Deux types de filtres numériques : IIR ou FIR

IIR calculs plus rapides (on line) mais déphasage

FIR plus performants, pas de déphasage mais calcul plus lourd

(Finite infinite Impulse Response)

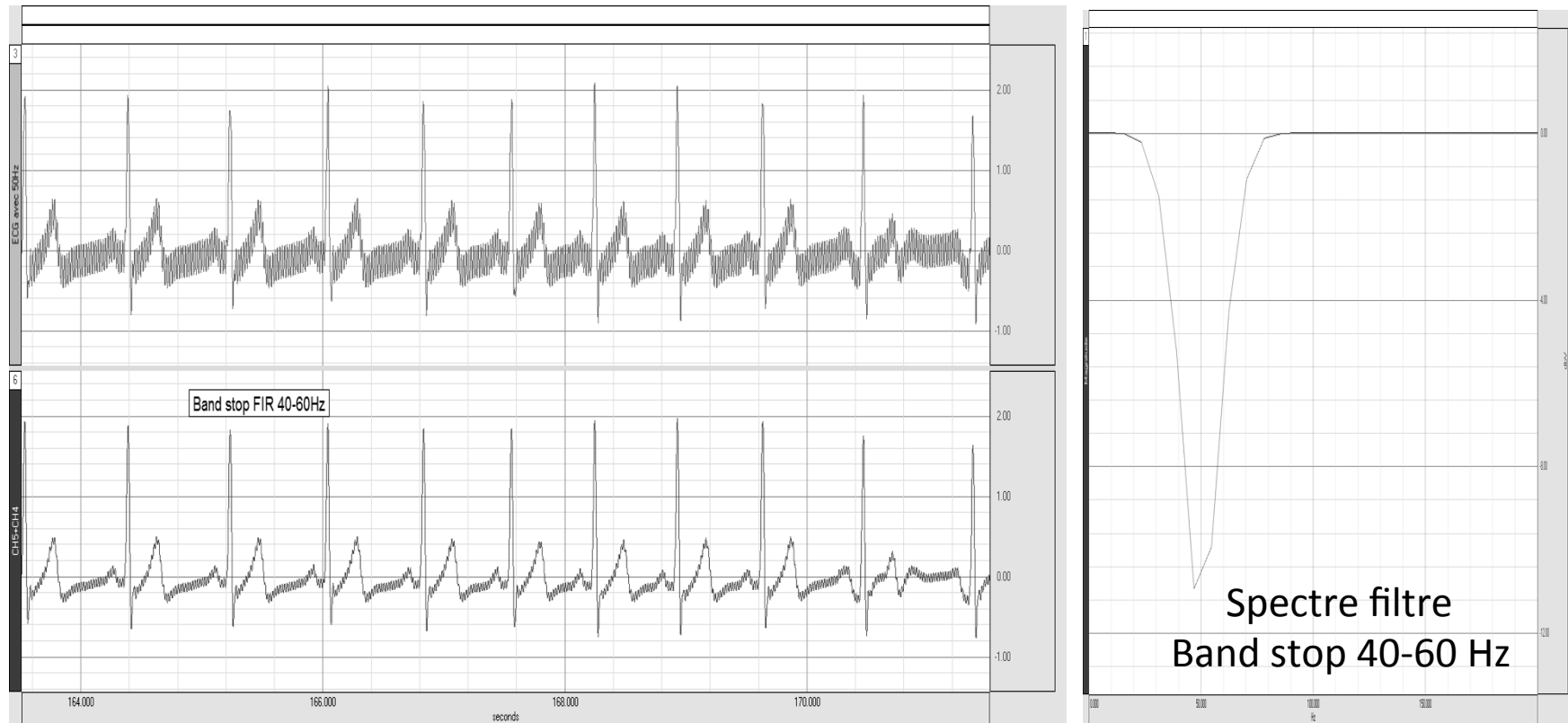
Filtres spéciaux:

Filtres adaptatifs, filtres en peigne



Suppression des parasitages

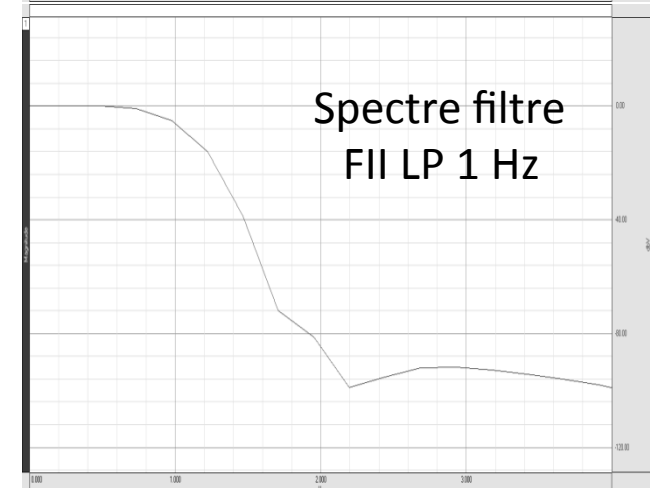
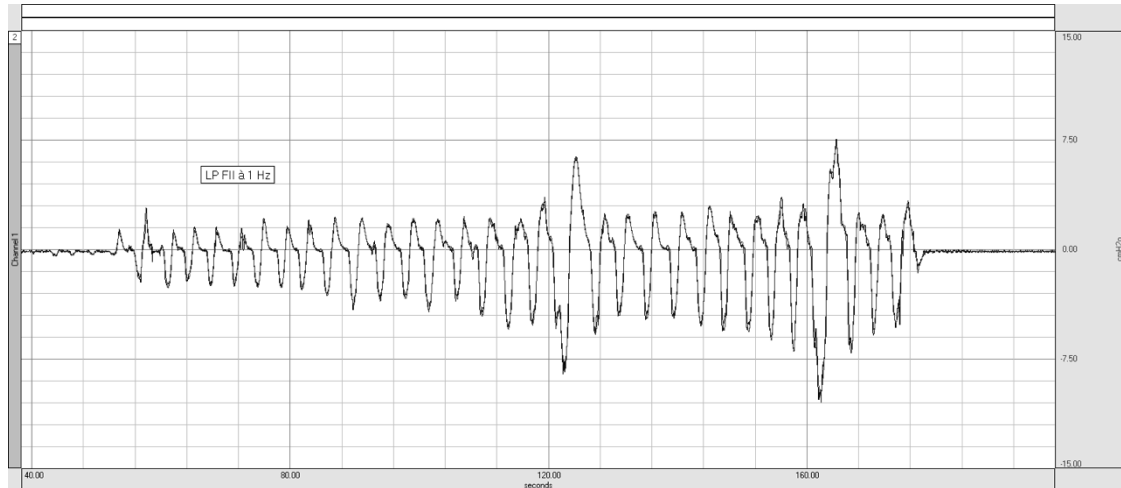
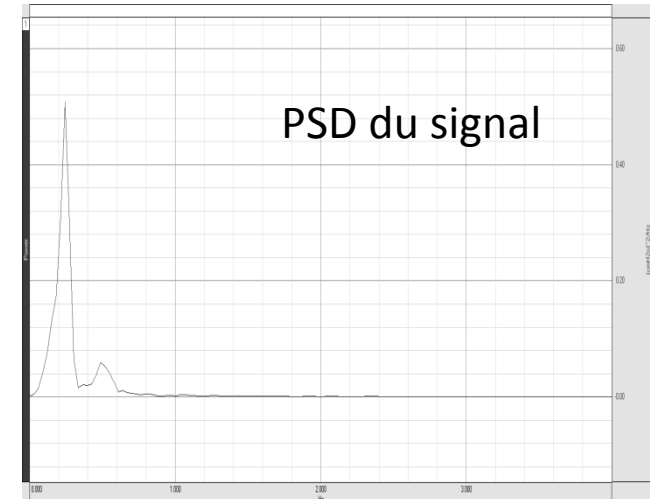
Présence de 50Hz





Suppression des parasitages

Présence de bruit



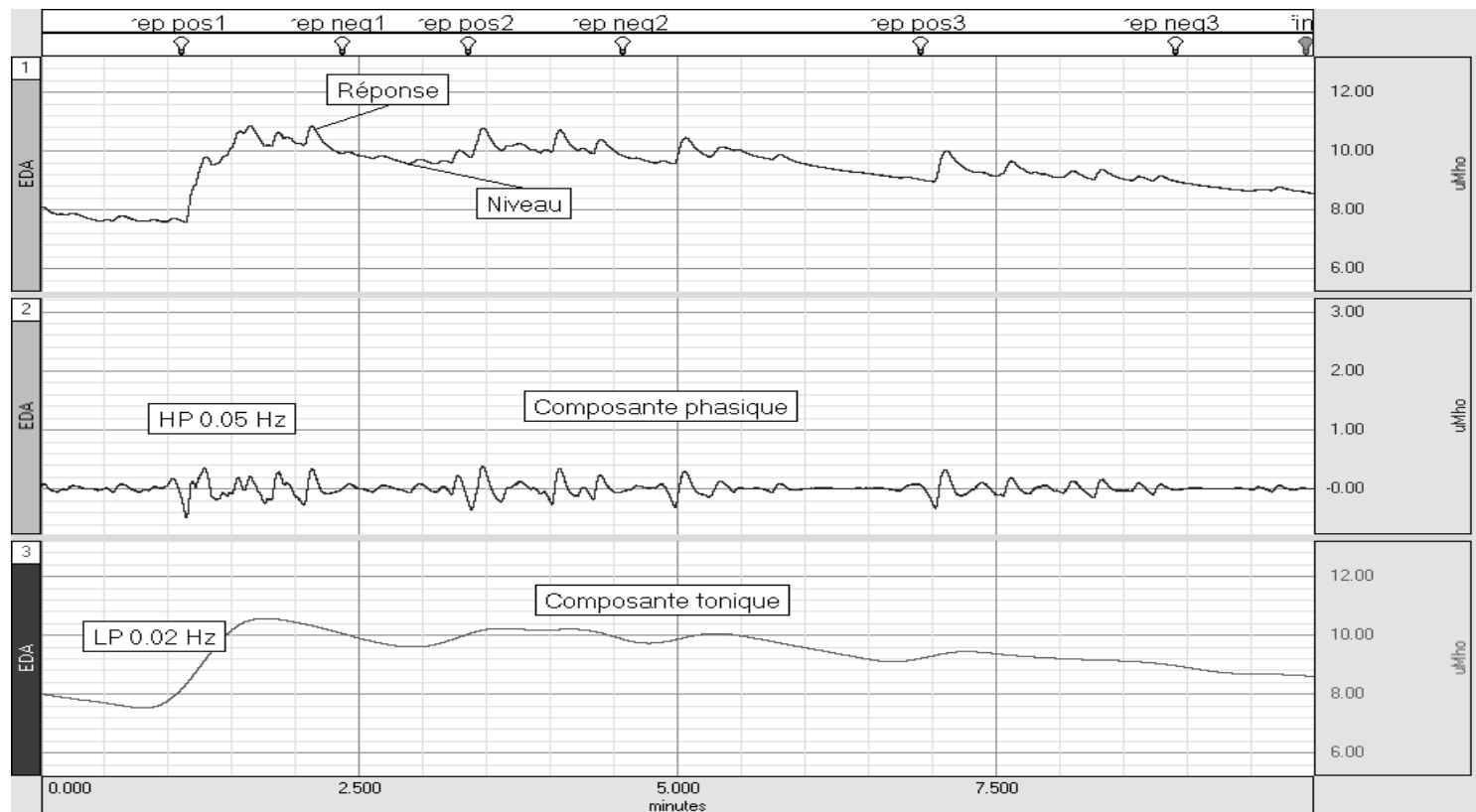


Traitement des courbes pour extraction de l'information



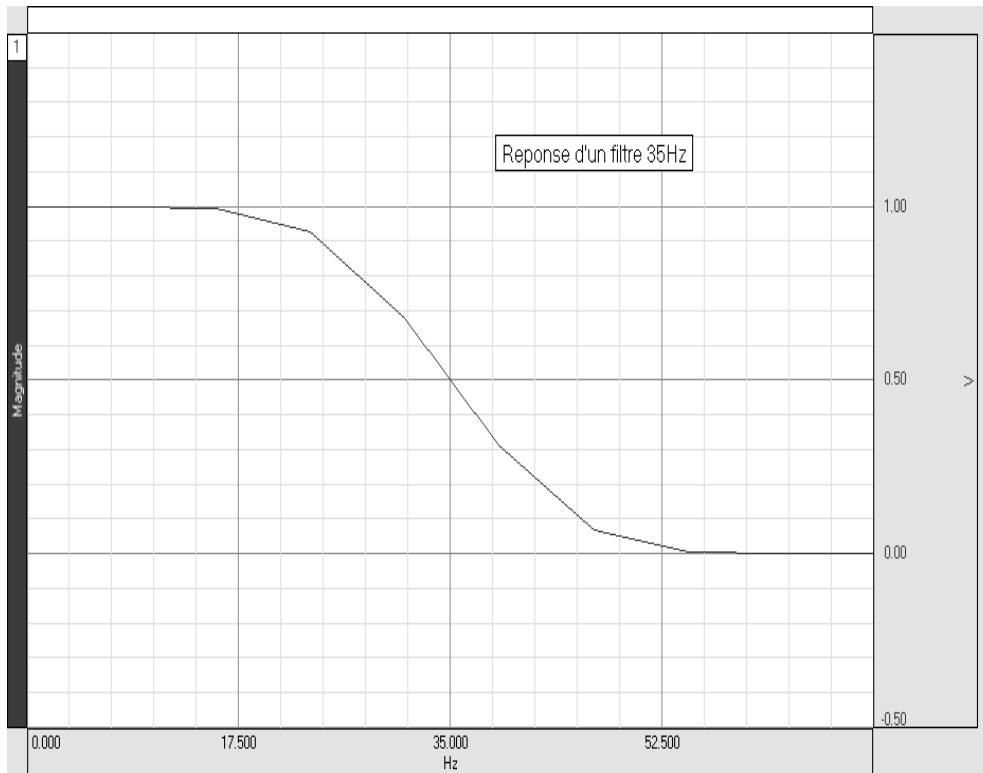
Exemple d'utilisation des filtres numériques

Conductance cutanée





Réponse d'un filtre



AcqKnowledge - Input Channel Parameters

Channel Number: CH1
Channel Label: ECG (.5 - 35 Hz)
Preset: Electrocardiogram (ECG), .5 - 35 Hz

Digital Filters

	Type	Frequency	Q
1	Low Pass	66.5	0.5
2	Low Pass	38.5	1
3	Band Stop - Line Freq	50	1

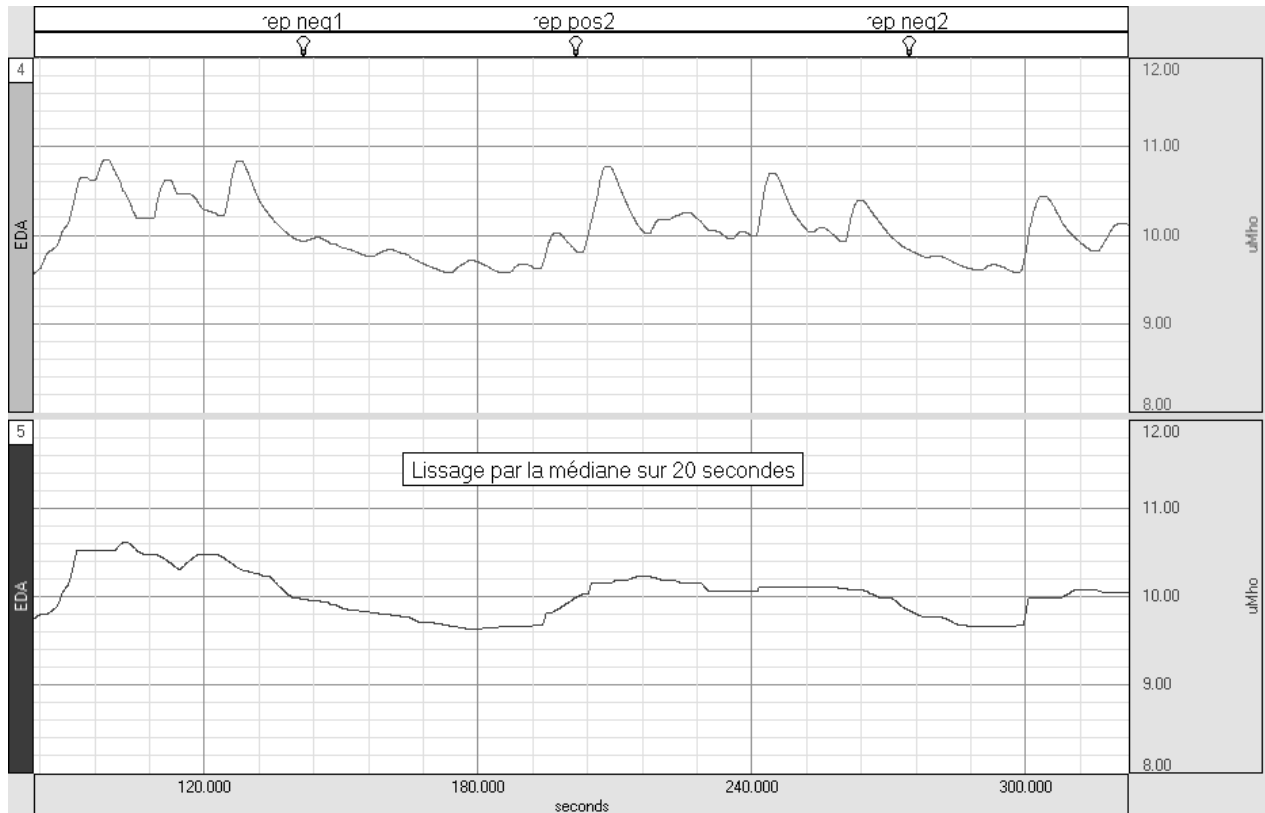
Gain: x1000 Offset: 0 mV
High Pass Filter (Hz): Off (DC) 0.05 0.5 5

New Channel Preset Advanced... Scaling... OK Cancel



Lissage par la médiane

Signal de conductance cutanée



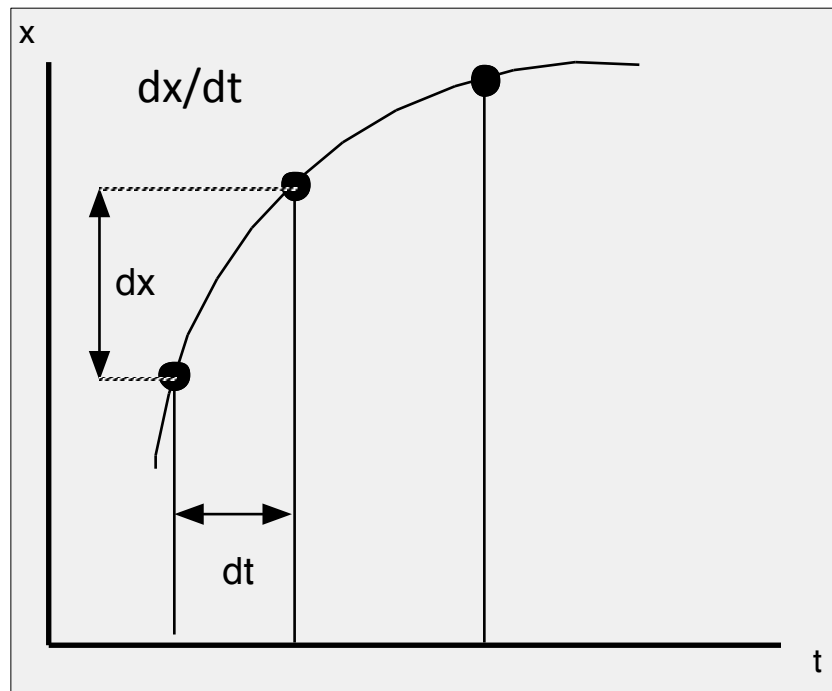
Suppression des réponses

Dérivée

Définition

- Différence entre deux points séparés par m points
En direct

$$f_{\text{output}}(n) = f_{\text{input}}(n - m) - f_{\text{input}}(n) / (\Delta T_s * m)$$

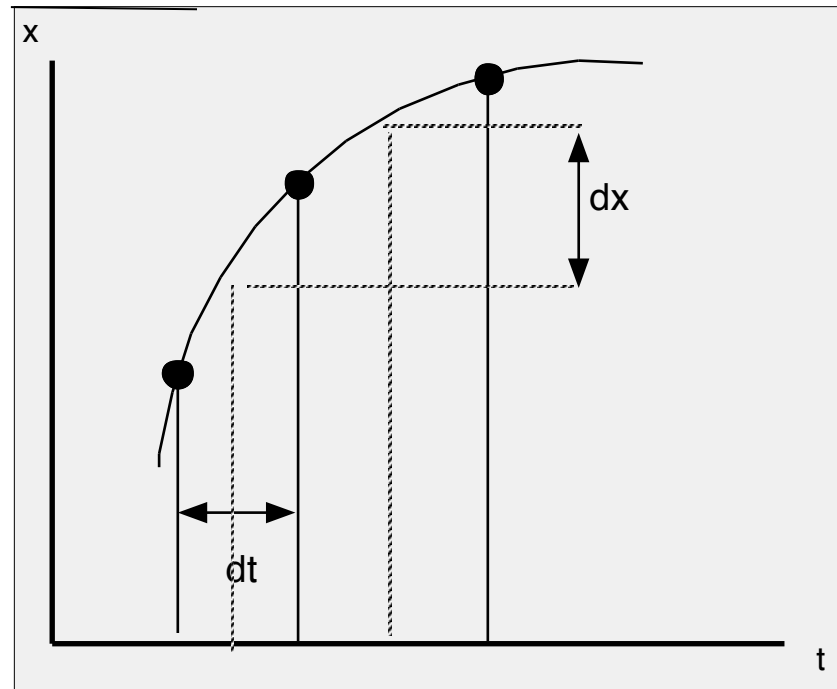


Dérivée

Définition

- Différence entre deux points séparés par m points
En différé

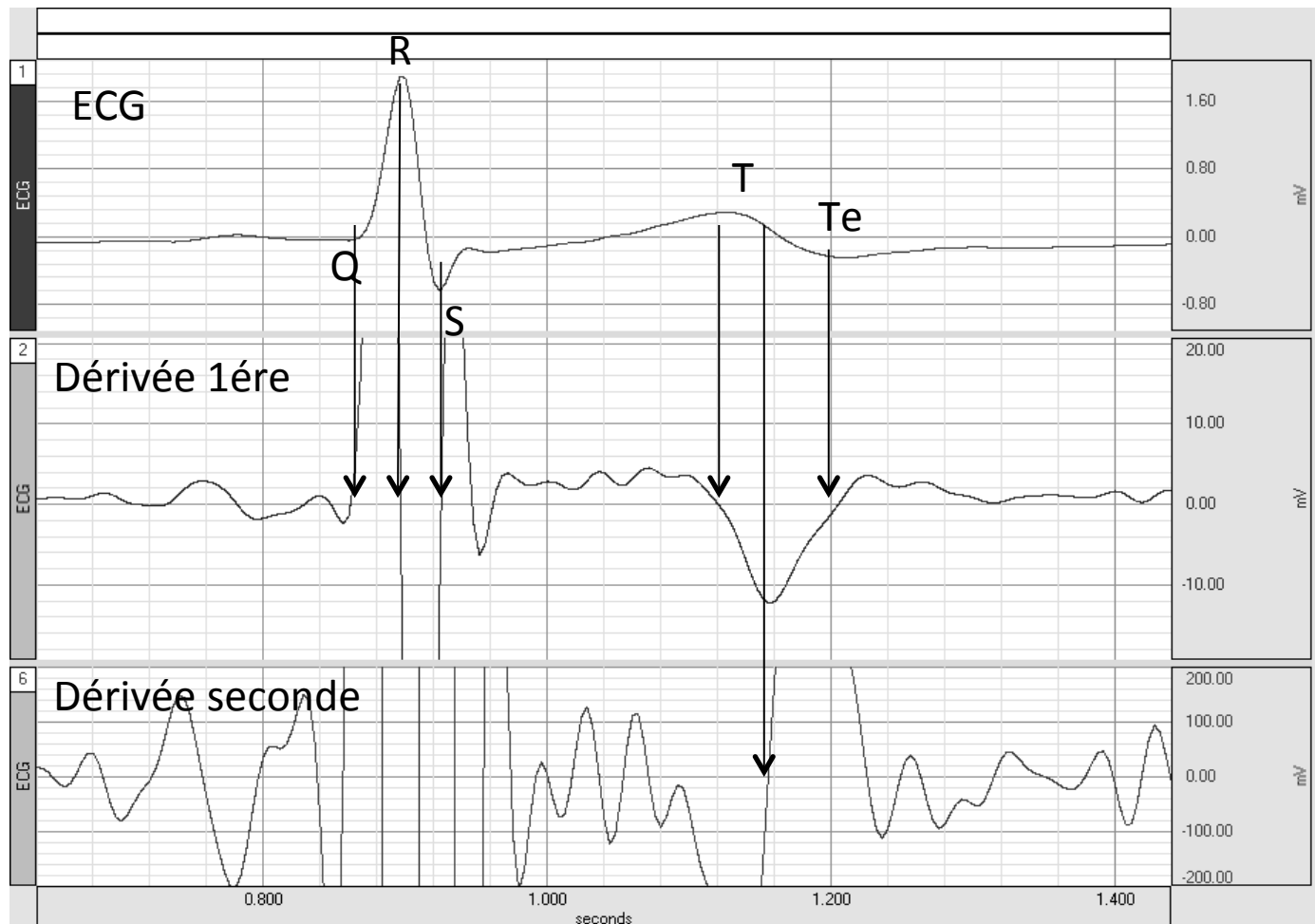
$$f_{\text{output}}(n) = \frac{f_{\text{input}}(n + \lceil m/2 \rceil) - f_{\text{input}}(n - \lceil (m+1)/2 \rceil)}{(\Delta T_s * m)}$$





Dérivée Utilité

- Etude de la variation d'un signal
- Détermination de points remarquables
Dérivée max, dérivée nulle





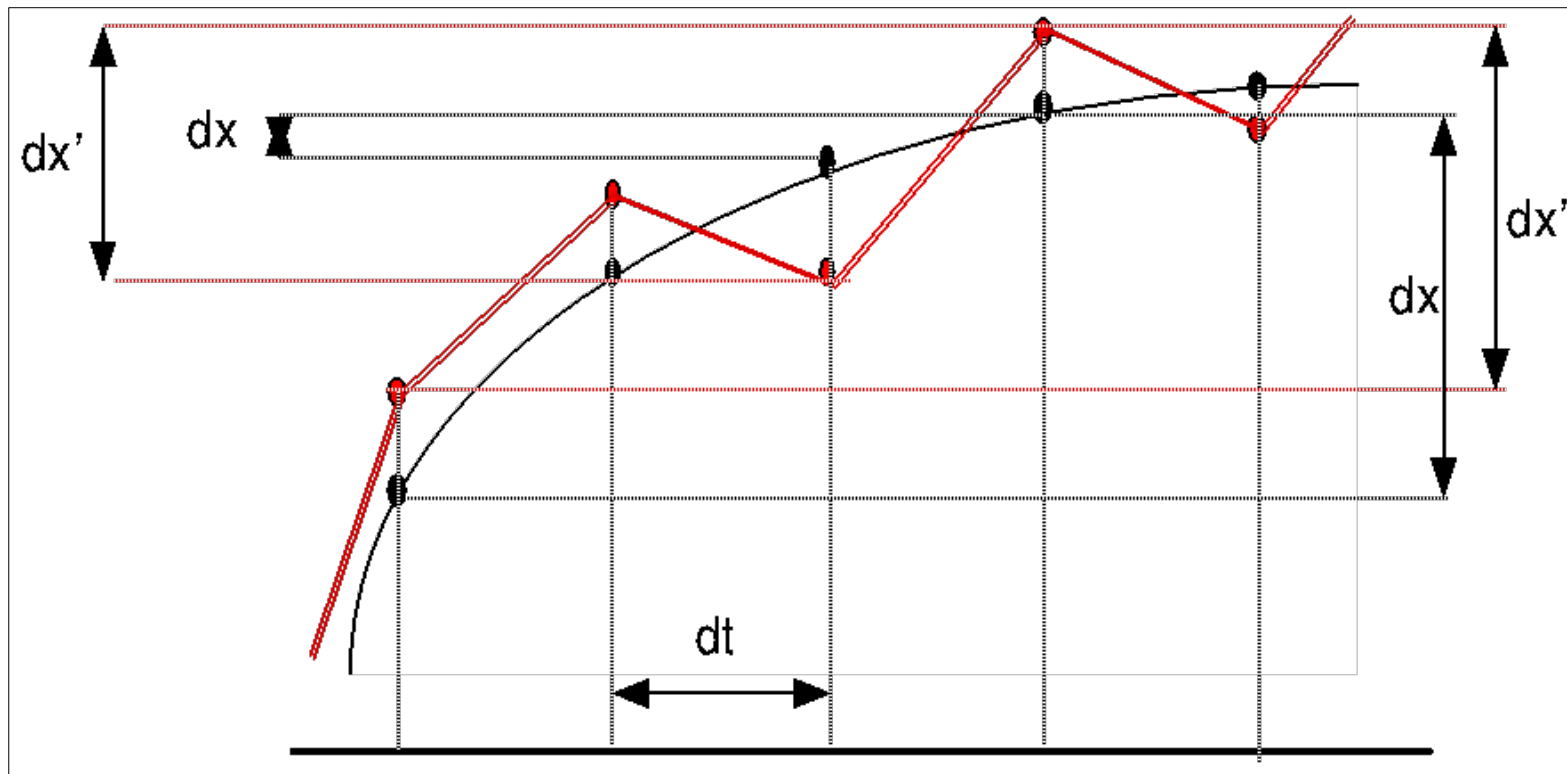
Dérivée Utilité

- Etude de la variation d'un signal
- Détermination de points remarquables dans signal asymptotique



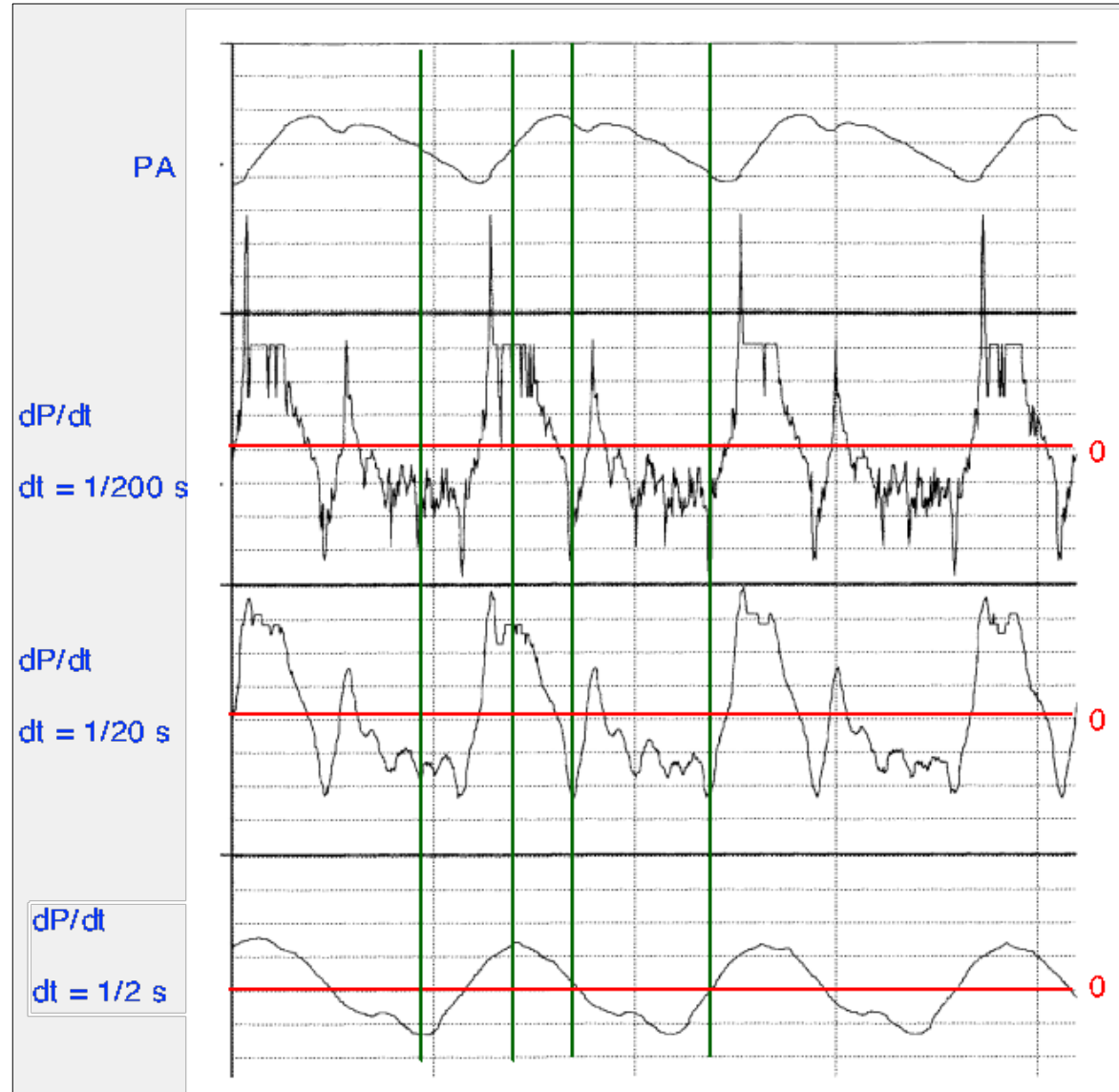
Dérivée

Choix du pas de dérivée



Dérivée

Choix du pas de dérivée



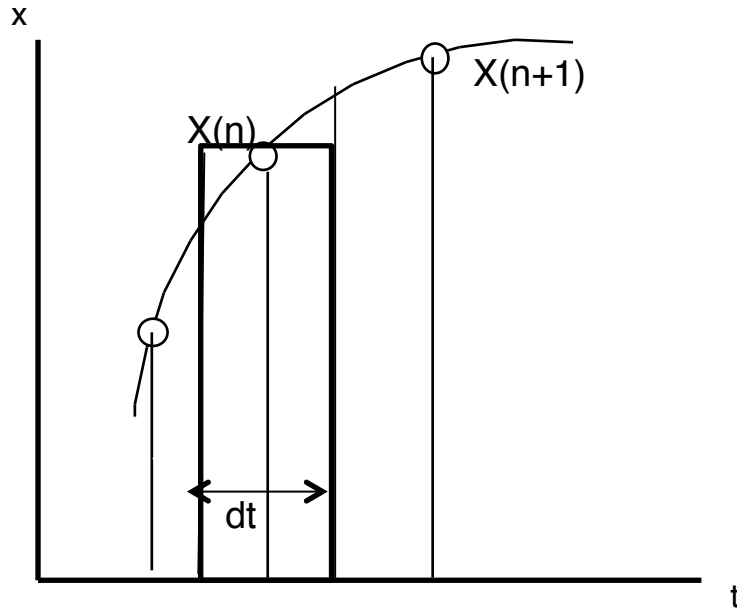
Difficulté à déterminer
la dP/dt_{\max}

Deux possibilités

Adapter le pas de
dérivation

Appliquer un filtre LP
avant de dériver le
signal

Intégration

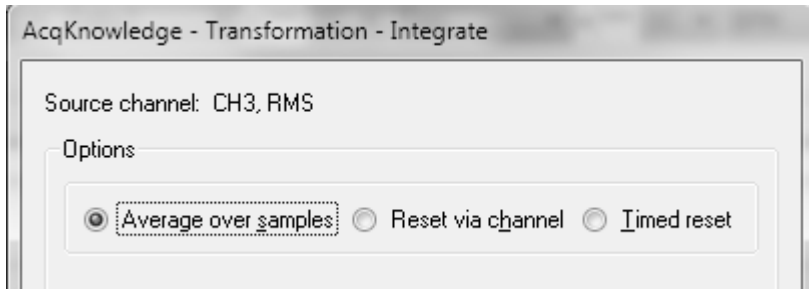


Via samples, no extra parameters selected:
$$V_K = \sum_{i=K-samples+1}^K V_{(i)} * \Delta T_s$$

Via samples, rectify:
$$V_K = \sum_{i=K-samples+1}^K \text{abs}(V_{(i)}) * \Delta T_s$$

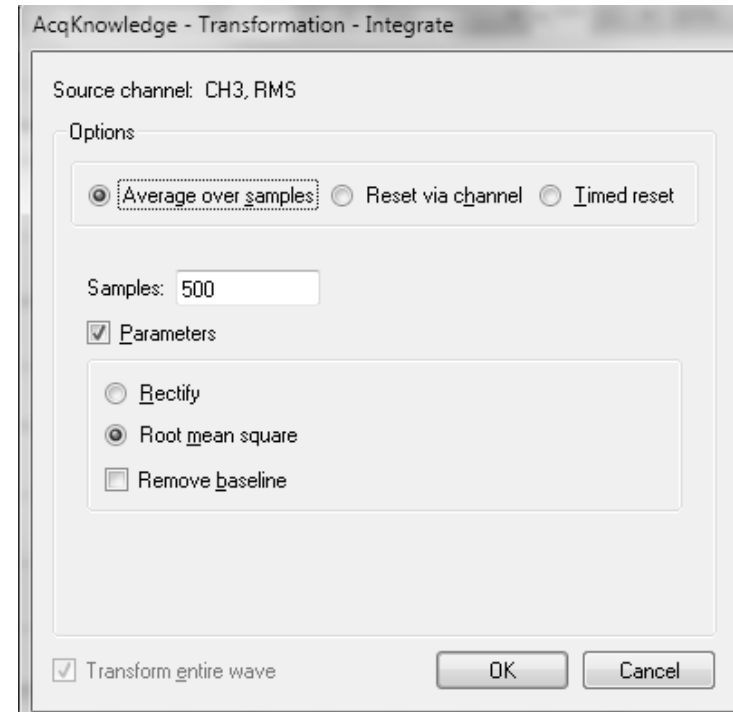
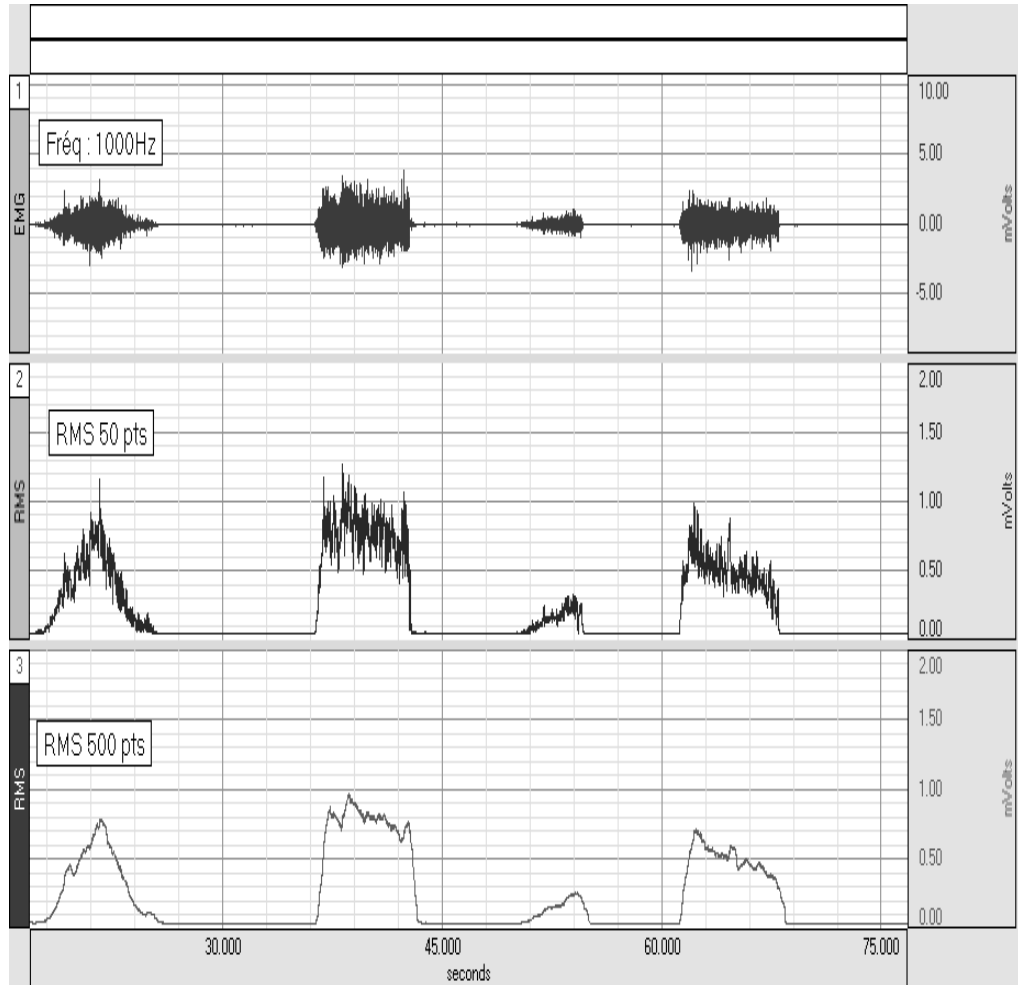
Via samples, root mean square:
$$V_K = \sqrt{\frac{\sum_{i=K-samples+1}^K V_{(i)} * V_{(i)}}{(samples-1)}}$$

Via samples, root mean square, remove baseline:
$$V_K = \sqrt{\frac{\sum_{i=K-samples+1}^K (V_{(i)} - \frac{\sum_{j=K-samples+1}^K V_{(j)}}{samples})^2}{samples-1}}$$



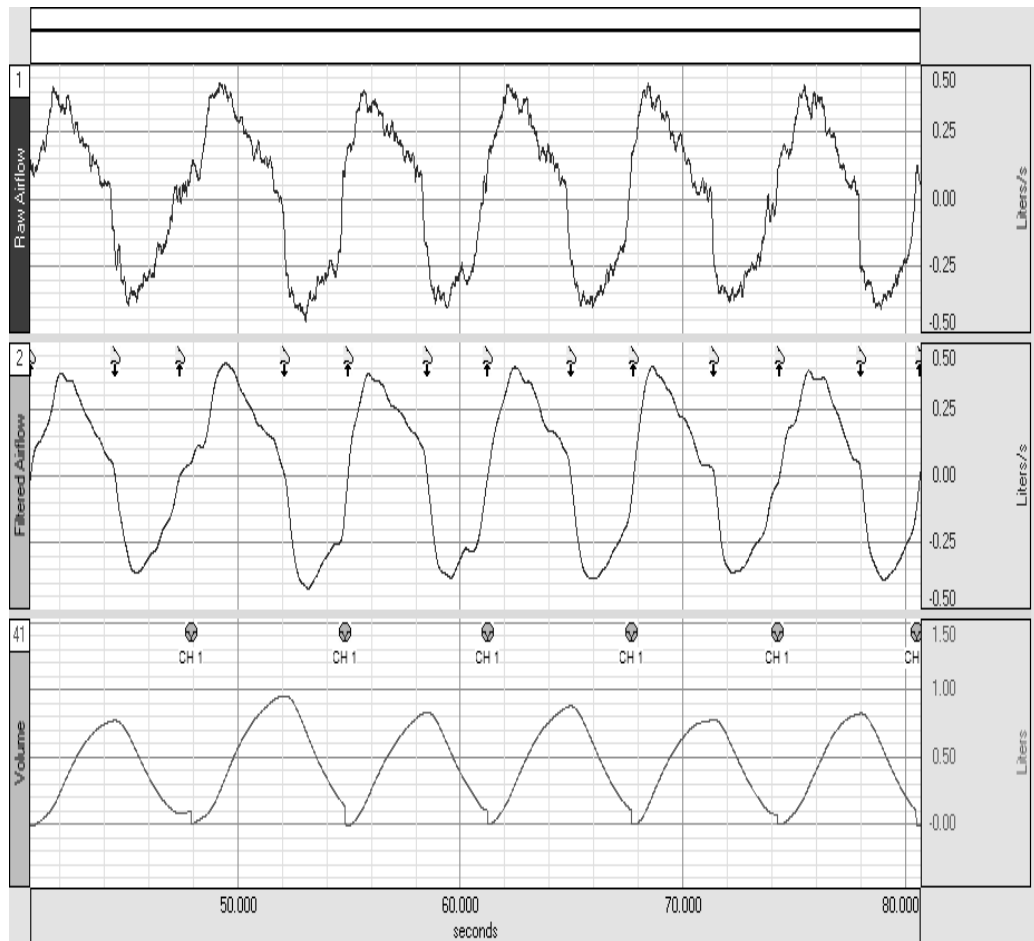


Intégration simple cycle à cycle





Intégration cycle à cycle



AcqKnowledge - Transformation - Integrate

Source channel: CH1, Raw Airflow

Options

Average over samples Reset via channel Timed reset

Control Channel: CH2, Filtered Airflow

Reset thresholds

LOW 0.000000 Volts

HIGH 5.000000 Volts

Reset trigger

Positive Negative

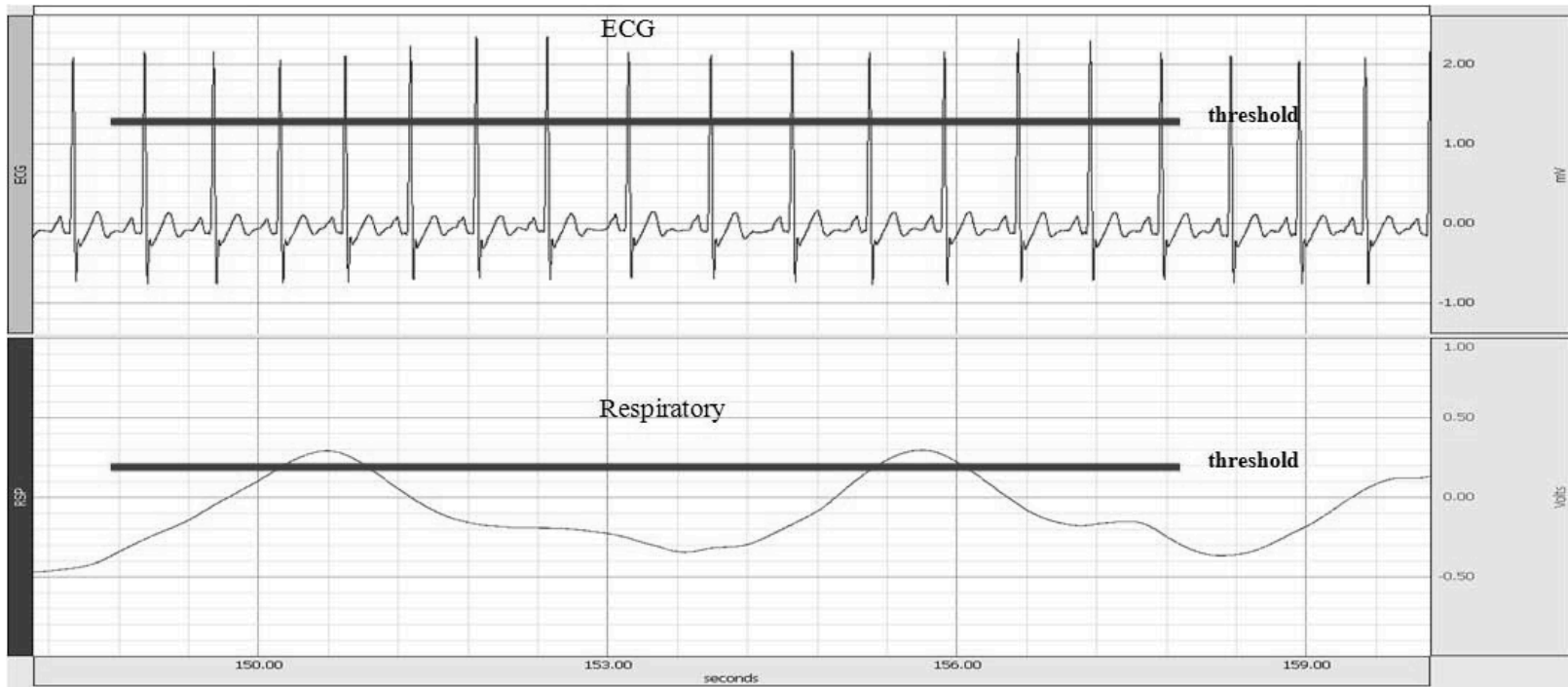
Mean subtraction Output reset events

Transform entire wave

OK Cancel



Rate





Fonction Rate

AcqKnowledge - Rate

CO, Rate setup

Source channel: A1, Analog input

Label: CO -Rate

Preset: none

Signal Parameters | Output

Signal type: Custom [New... Delete]

Peak detect

Positive Negative

Remove baseline

Baseline window width: 25.000000 ms

Auto threshold detect

Noise rejection: 5.0000 % of peak

Cycle Interval Window

Windowing Units: BPM

Min: 40.000000 BPM

Max: 180.000000 BPM

New Channel Preset [OK Cancel]

AcqKnowledge - Rate

CO, Rate setup

Source channel: A1, Analog input

Label: CO -Rate

Preset: none

Signal Parameters | Output

Function: Rate (BPM)

- Rate (Hz)
- Rate (BPM)
- Interval (sec)
- Peak Time (sec)
- Count Peaks
- Peak Minimum
- Peak Maximum
- Peak to Peak
- Mean Value
- Area

Use a

Fixed [000000] sec

Fixed

Re

Output

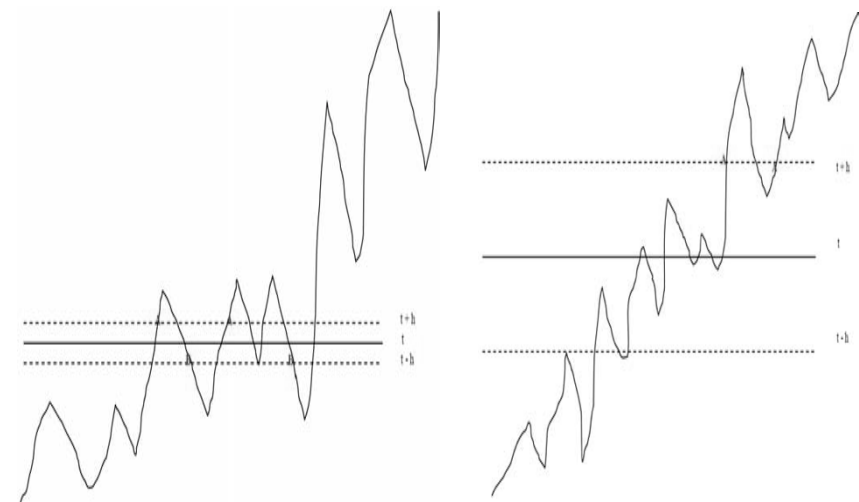
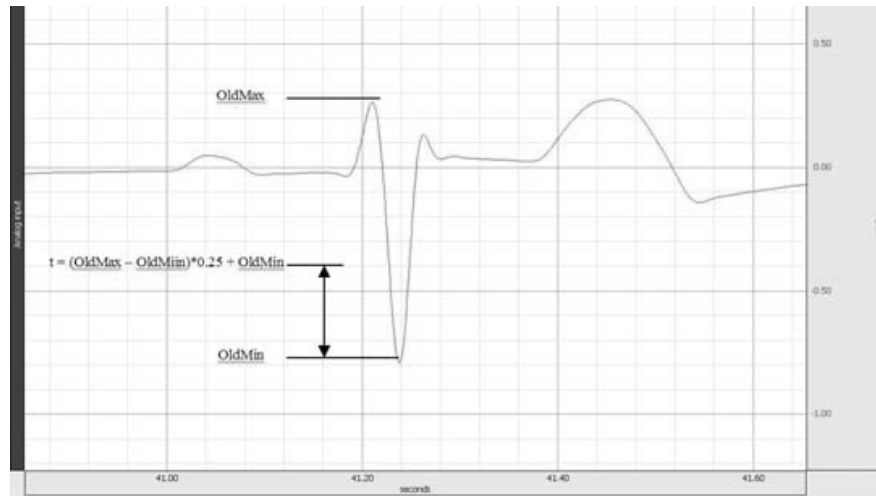
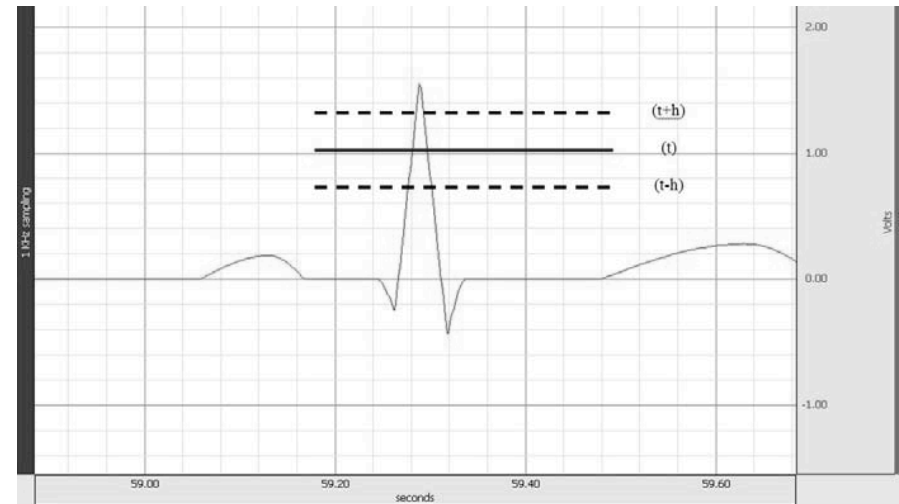
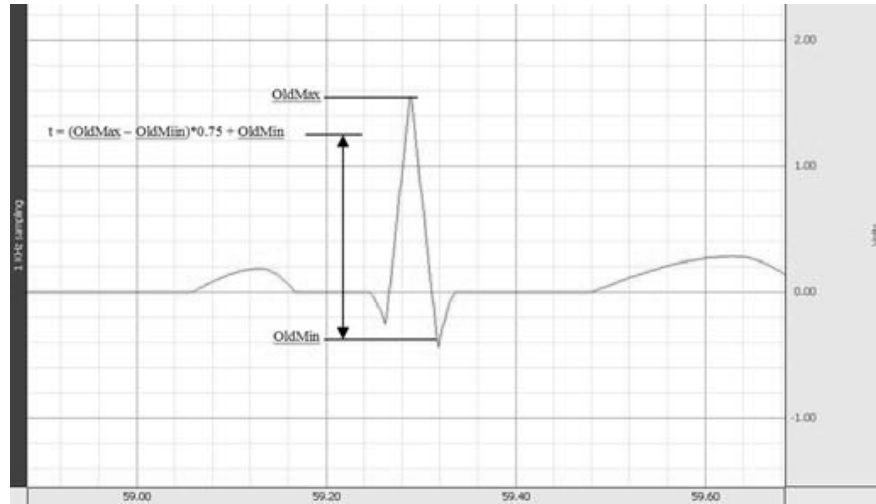
Show

Threshold Modified

New Channel Preset [OK Cancel]



Function Rate





Fonction Rate

AcqKnowledge - Rate

CO, Rate setup

Source channel: A1, Analog input

Label: CO -Rate

Preset: none

Signal Parameters | Output

Signal type: Custom [New... Delete]

Peak detect

Positive Negative

Remove baseline

Baseline window width: 25.000000 ms

Auto threshold detect

Noise rejection: 5.0000 % of peak

Cycle Interval Window

Windowing Units: BPM

Min: 40.000000 BPM

Max: 180.000000 BPM

New Channel Preset [OK Cancel]

AcqKnowledge - Rate

CO, Rate setup

Source channel: A1, Analog input

Label: CO -Rate

Preset: none

Signal Parameters | Output

Function: Rate (BPM)

- Rate (Hz)
- Rate (BPM)
- Interval (sec)
- Peak Time (sec)
- Count Peaks
- Peak Minimum
- Peak Maximum
- Peak to Peak
- Mean Value
- Area

Use a

Fixed [000000] sec

Fixed

Re

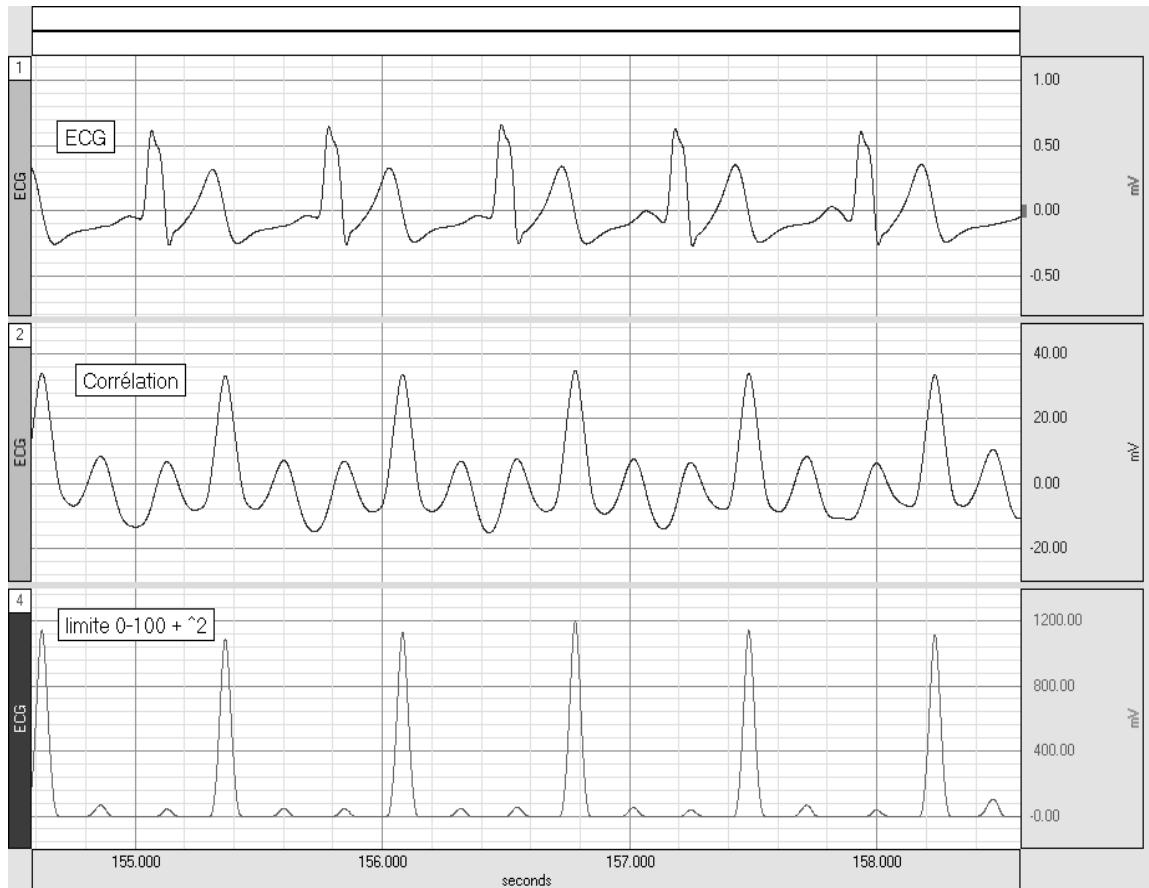
Output

Show

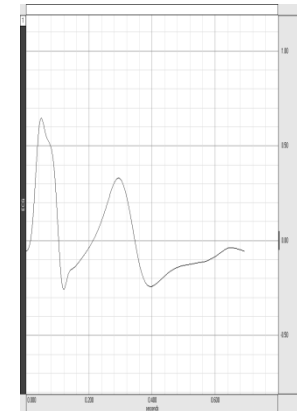
Threshold Modified

New Channel Preset [OK Cancel]

Corrélation



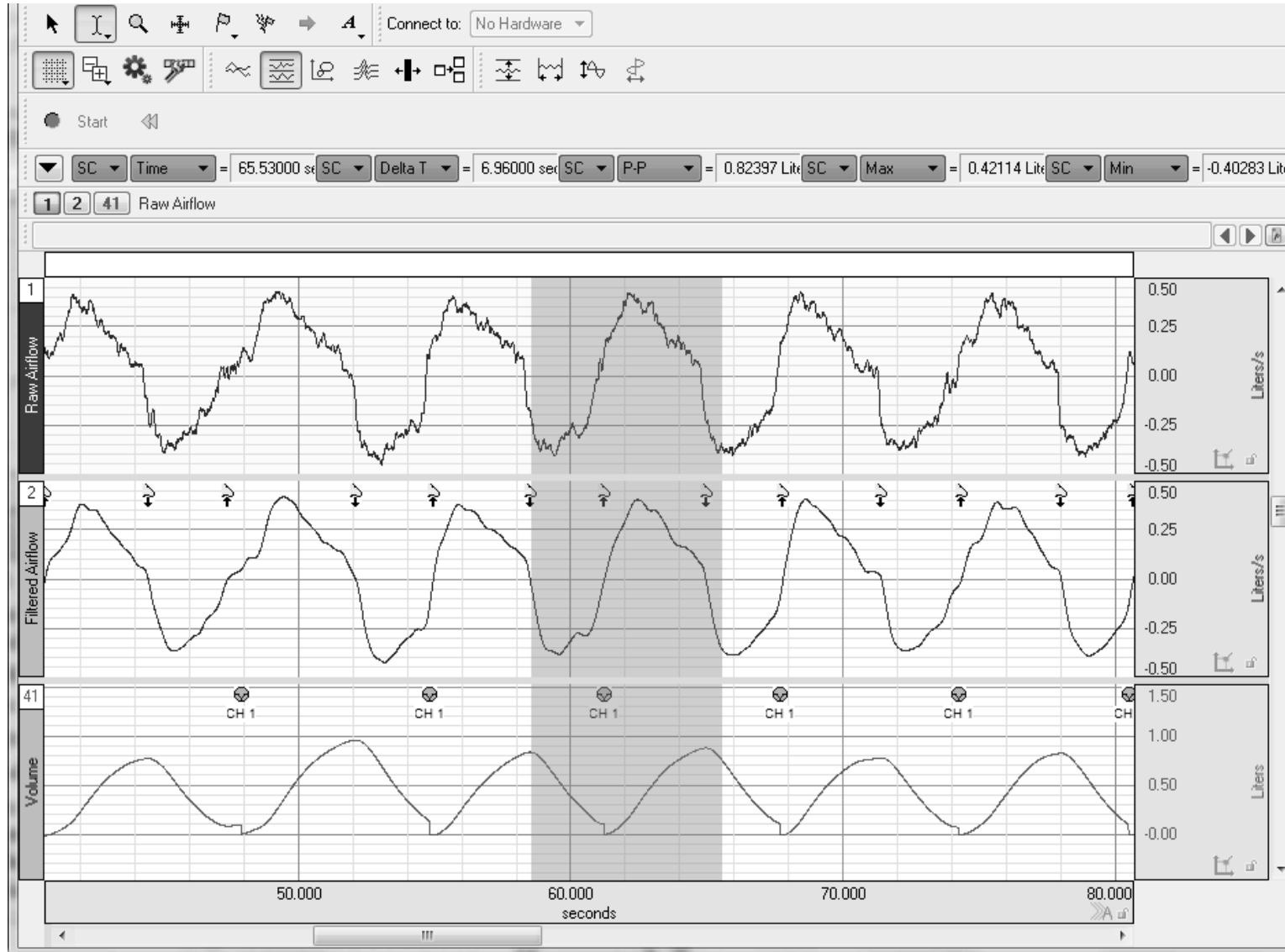
Template



$$f_{\text{output}}(n) = \sum_{k=1}^K f_{\text{template}}(k) * f_{\text{waveform}}(n)$$



Find cycle





Find cycle

Cycles/Peaks | Selection | Output

Locate cycles from:

peaks events fixed time intervals

Find peaks in: CH1, Analog input

Peak direction

Positive/Upward
 Negative/Downward

Threshold

Level: 0.00000 mV

Use selected maximum

Fixed
 Tracking using mean value and 90.00000 % of peak value
 Tracking using 90.00000 % of peak value

Cycles/Peaks | Selection | Output

Locate cycles from:

peaks events fixed time intervals

Start event: Flag

located on: Anywhere

with labels containing text: R-wave

End event: Flag

located on: Anywhere

with labels containing text:

Match pairs of events only

Cycles/Peaks | Selection | Output

Locate cycles from:

peaks events fixed time intervals

Starting Time

Current cursor position
 Start first interval at 0.000000 seconds

Interval width: 1.000000 seconds

seconds
milliseconds
seconds
minutes
hours



Find cycle

