Introduction

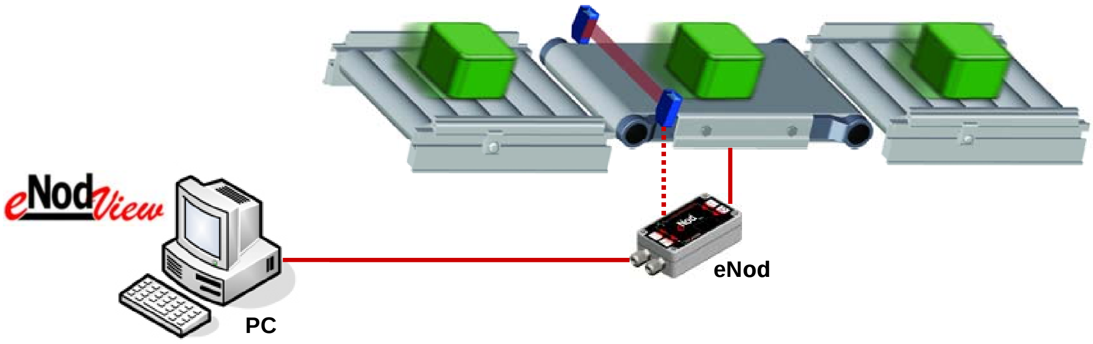
In dynamic weighing, the accuracy of results mainly depends on the system's ability to overcome disturbances and vibrations generated by the mechanical (engine, conveyor). eNod3 provides 3 successive levels of digital filtering:

- Analog-Digital converter filter
- Digital filter (Butterworth or Bessel) in order 2, 3 or 4
- Self-adaptive SCAIME filter

For a perfect filtering adjustment in the application, eNod3 comes with eNodView software, an analytical tool able to simulate filtering effects on the signal.

The purpose of this document is to provide a settings optimization methodology with eNodView software.

Installation overview



Principle of operation

The diagram below shows an object passing on a weighing belt. During this time, eNod3 performs the following operations:

A. Waiting for cycle start (measurement level or external trigger)
B. Waiting for a “stabilization time”.
C. Measurement average calculation during a “measurement time”.

Minimum conversion frequency

In a first step, we will estimate the frequency conversion to be set for the analog-digital converter.

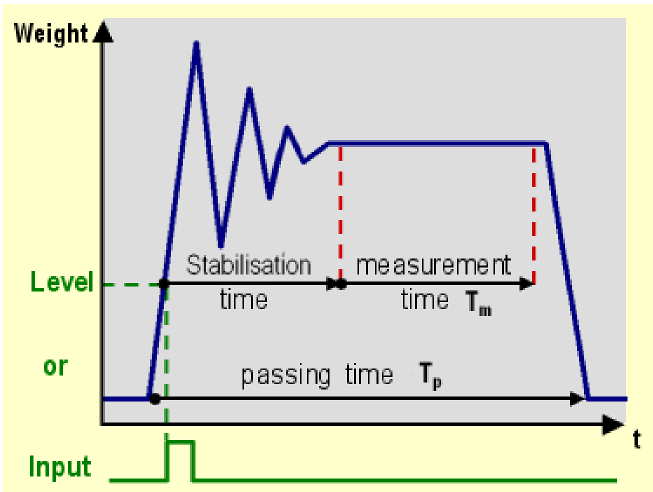
For a first approach, considering the passing time on the weighing belt $\mathbf{T_p}$, we can consider that:

- The measurement time $\mathbf{T_m}$ will be near $\mathbf{T_p/2}$.
- We can get a good result by calculating an average from a nb. of measurement $\mathbf{N_m \sim 20}$ during time $\mathbf{T_m}$.

With these data's, the minimum conversion frequency $\mathbf{F_{c\,min}}$ is:

$$F_{cmin}(Hz) = \frac{2xN_m}{T_p(s)} = \frac{40}{T_p(s)}$$

example : For a passing time of 200 ms, the A/D converter frequency should be more than 40/0.2=200 Hz



Non filtered signal acquisition

To simulate the digital filters integrated into eNod3, eNodView software use a measurement file built from a non filtered signal acquisition.
To be usable, an acquisition file created from eNodView must :

- Include some real weight passing on the weighing belt in works.
- Be realized by following the rules explained hereafter.

eNod3 setting

Before running measurements acquisition with eNodView, eNod3 should be set as follows :

- **Communication settings**

A.Protocol: **Fast SCMBus**
B.Baud rate : **115200bds**

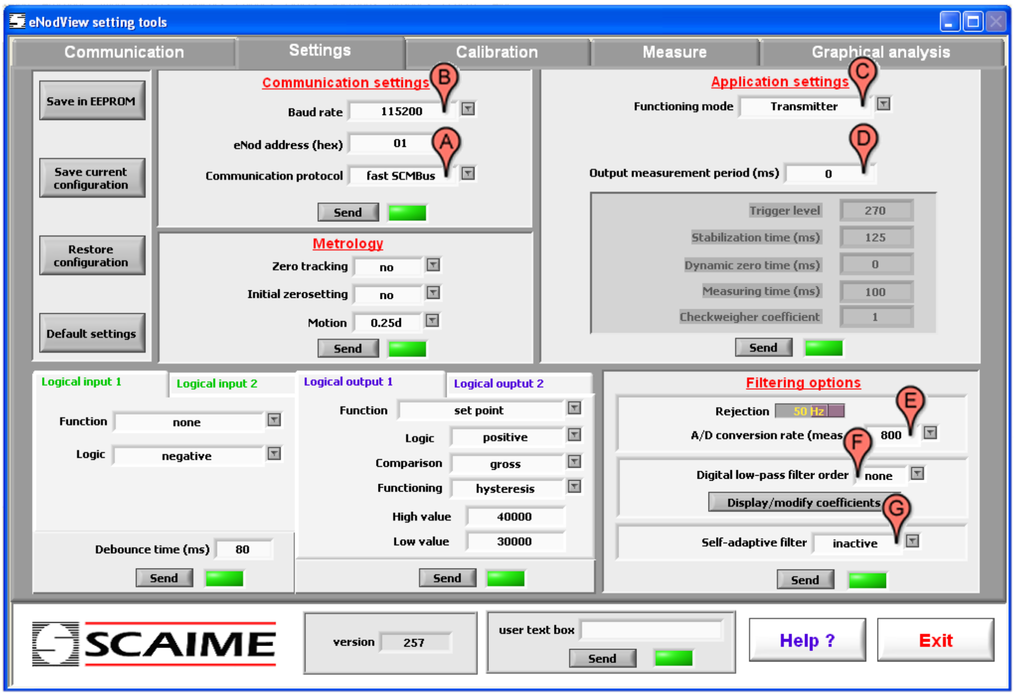
- **Application settings**

C.mode **Transmitter**
D.Output meas. period : **0**

- **Filtering options**

E. Conv. rate.: **between $F_{c\ min}$ and 800 meas/s**
F. Low-pass filter order : **none**
G. Adaptive filter : **inactive**

This setting allows the maximum transmission rate between eNod3 and the PC. It also allows to synchronize measurement transmission with A/D converter frequency.



To be accurate, the digital filters simulation must be realized from a measurement acquisition synchronized with the A/D converter frequency. The max. transmission rate between eNod3 and the PC is 900 meas/s, so, the maximum usable A/D converter frequency (for a simulation) is 800 meas/s.

Proceed with signal acquisition

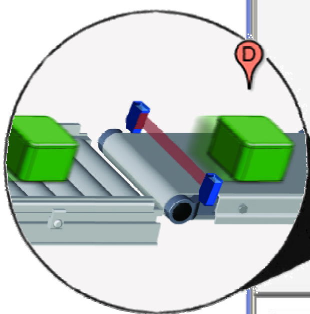
After saving the settings in EEPROM, use the tab "Graphical analysis" to make the measurements acquisition as follows:

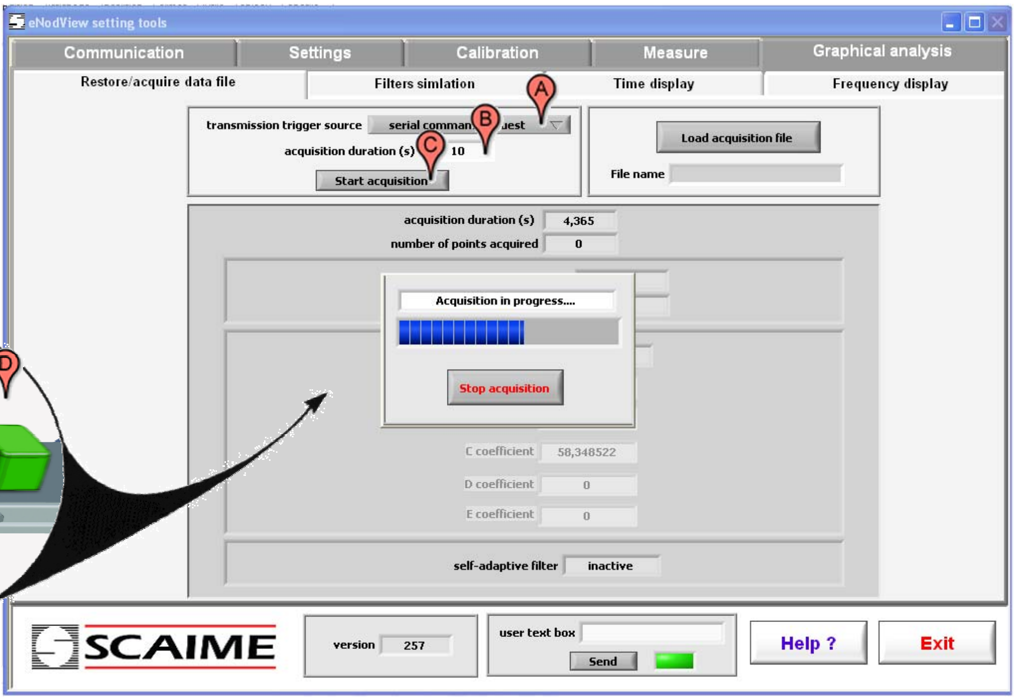
- **Settings :**

A.Trigger source: **serial command request**
B.Acquisition duration

- **Run acquisition**

A.Press on « start acquisition »
B. Putting an object several times on the weighing belt.





Now, you are ready to analyse the acquisition signal and optimize the digital filter settings.

Non filtered signal analysis

To illustrate this presentation, we have used a fruit sorting machine with following features :

- **Weighing principle** : Cups chain passing on a weighing part of 15cm long
- **Objects to weigh** : fruits from 50 to 500g, rate of 6 cups per second

We made the signal acquisition at 800 meas/s by putting a fruit (170g) on one of the cups.

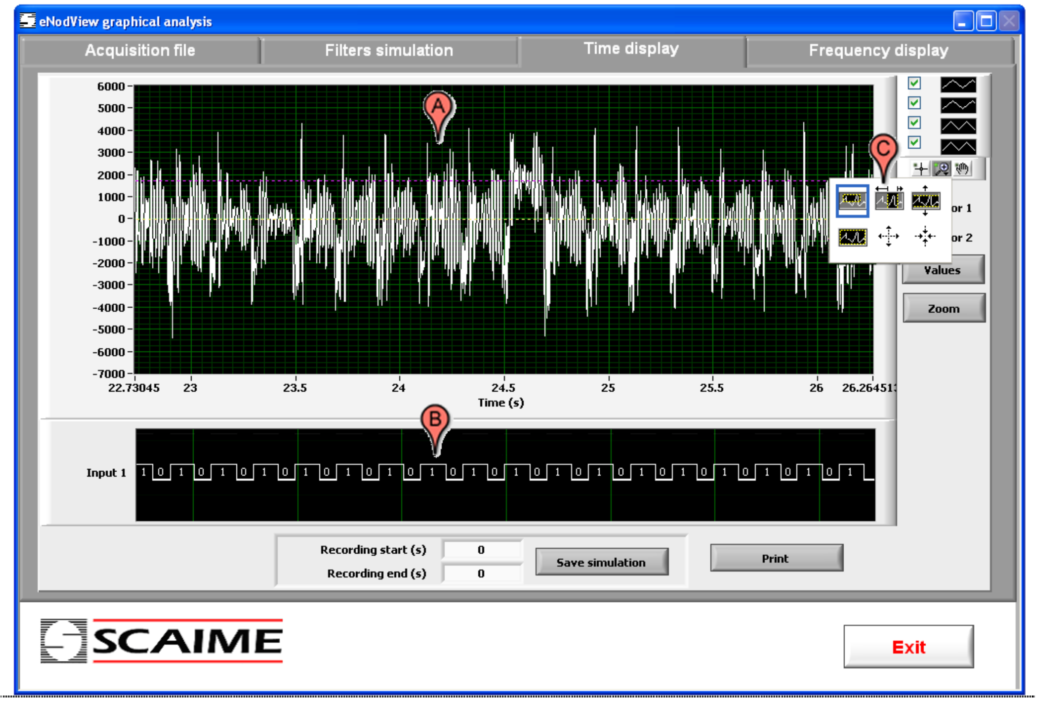
Time display window

A. Viewing unfiltered time signal

B. Viewing trigger input : The logical input is activated each time the fruit passes on the weighing part.

C. Zoom selection.

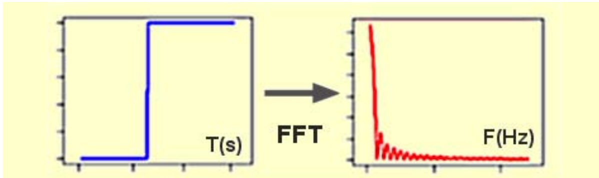
The signal is very disturbed by mechanical vibrations. We will attenuate these vibrations through digital filters offered by eNod3.



Frequency analysis

To determine the filter parameters, we will use the frequency analysis of signal (FFT)

In theory, an object passing on a weighing belt is represented by a time signal square. The figure below shows the Fourier transform (FFT) of such a signal.

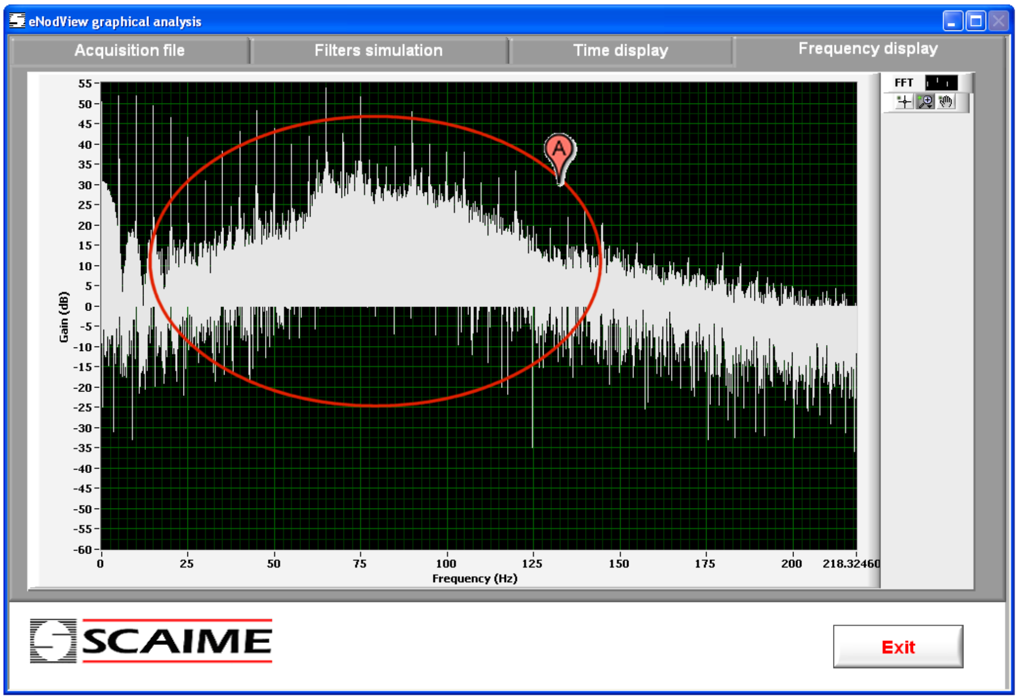


The purpose of the frequency analysis is to determine the interference frequencies that differ from this theoretical view.

We see on theoretical view that the useful frequency components for weighing are the low frequencies.

We observe on the real signal analysis, important frequency components between 20Hz and 100Hz **(A).**

These frequency components are due to mechanical vibrations, we will filter it with eNod3.



Simulation of digital filter effects

Available filters

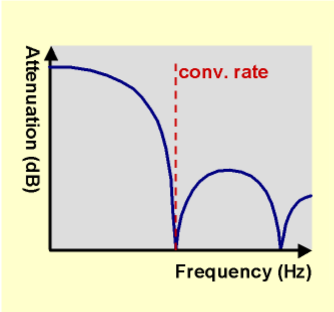
1^{st} level : A/D converter filter

The 1st level of filtering is done by the A / D converter of eNod3. This filter is set by the frequency conversion: More this frequency is higher, less the signal will be filtered and accurate.

For a first test, we will use the formula : $\mathbf{F_{c\ min}=40/T_p}$ (see § conversion rate). This calculation gives a starting value to be adjusted to get the best compromise Accuracy/Number of samples

In our example:

The sorting rate is 6 fruits/s, $\mathbf{T_p=0.18s}$ and $\mathbf{F_c min.= 222Hz}$
*So, for the simulation, we will choose a conversion rate of **400meas/s.***



2^{nd} level : Digital Low-pass filter

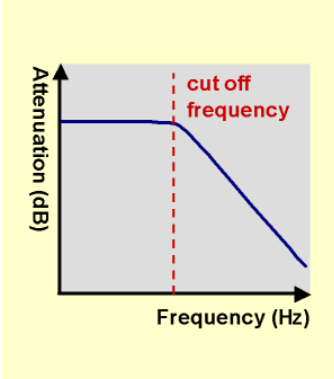
eNod3 also integrates two low-pass digital filter types : **Butterworth** or **Bessel**. Their parameters are:

- Filter order (2, 3 or 4)
- Cut-off frequency (Hz)

By experience, Bessel filter gives better results if it's necessary to use a high order filtering.

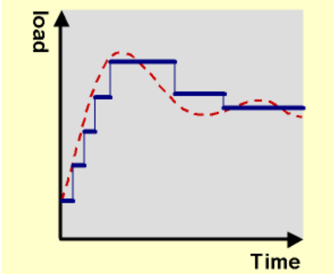
In our example *:*

The frequency analysis has shown significant disturbances between 20 and 100Hz. For the simulation, we will choose the Bessel filter in order 3 with a cut-off frequency of 15Hz (value allows to have a strong signal attenuation at 20Hz).



3^{rd} level : Self-adaptive filter

This level of digital filtering is dedicated to stabilize the measure for use in static weighing. It should therefore generally be disabled for use in dynamic weighing.



The tab« filter simulation » allows you to select and set the 3 successive filtering levels of eNod3 before viewing their effect on the signal.

Simulated filters

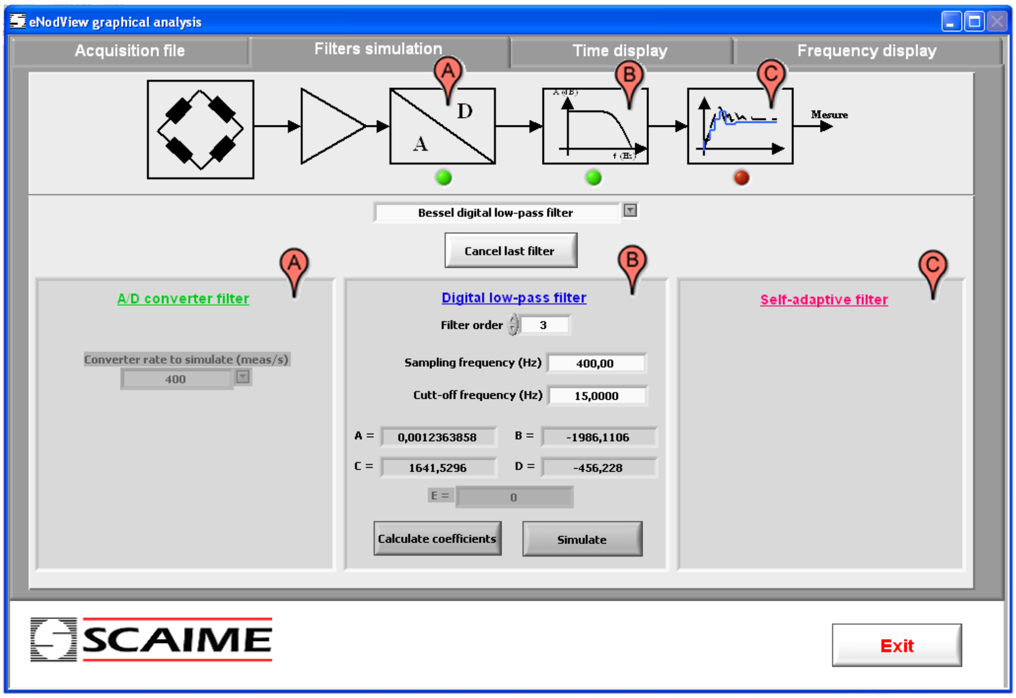
A. A/D converter filter.

- Conv. rate. : **400 meas/s.**

B. Digital low-pass filter.

- Type : **Bessel**
- Order : **3**
- Cut-off frequency : **15Hz**

C. Self-adaptive filter not used.



Analysis of filtered signal

Viewing time signal

After validating the simulation parameters, eNodView allows you to superimpose the unfiltered signal and simulated signal to check the filters effectiveness.

Viewing tab

A. Passage of an empty cup

B. Passage of the cup loaded with fruit.

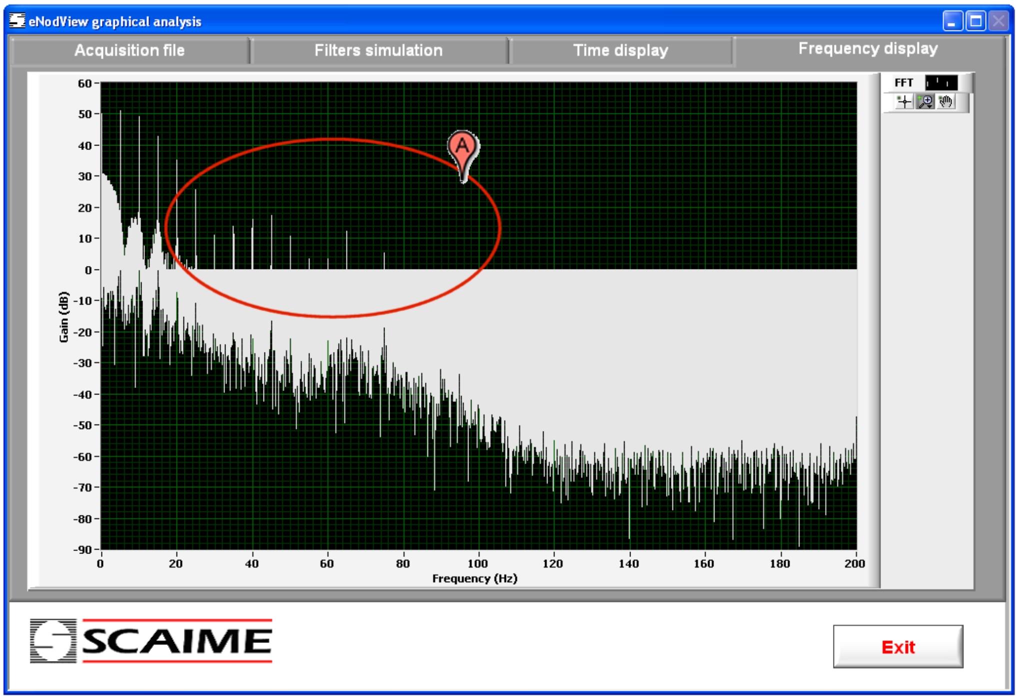
C. State of the logic input synchronized on each cup

After viewing the effect of the simulation (that seems effective), we can also see the frequency analysis of simulated signal.

Viewing frequency analysis

On this frequency analysis, we note the effectiveness of selected filters.

The disturbances between 20Hz and 100Hz **(A)** were significantly reduced.



We'll now go back on time display of filtered signal to determine the timing dynamic weighing cycle.

Timing of dynamic weighing cycle

Measurement time

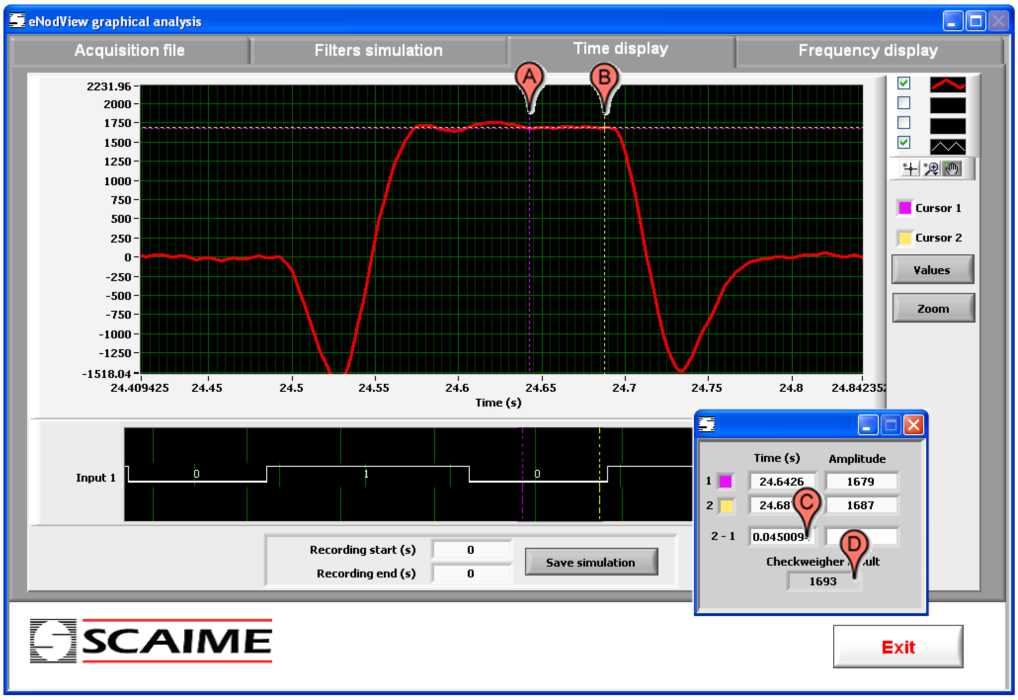
Now, the shape of the signal is satisfactory, so we will determine through cursors, the time period when eNod3 calculate a measurements average.

Viewing tab

It is possible to freely move 2 cursors **(A)** and **(B)** on the signal.

A window, attached to the cursors, can display:

- The time between the 2 cursors **(C)**.
- The measurements average between the 2 cursors **(D) –** checkweigher result.



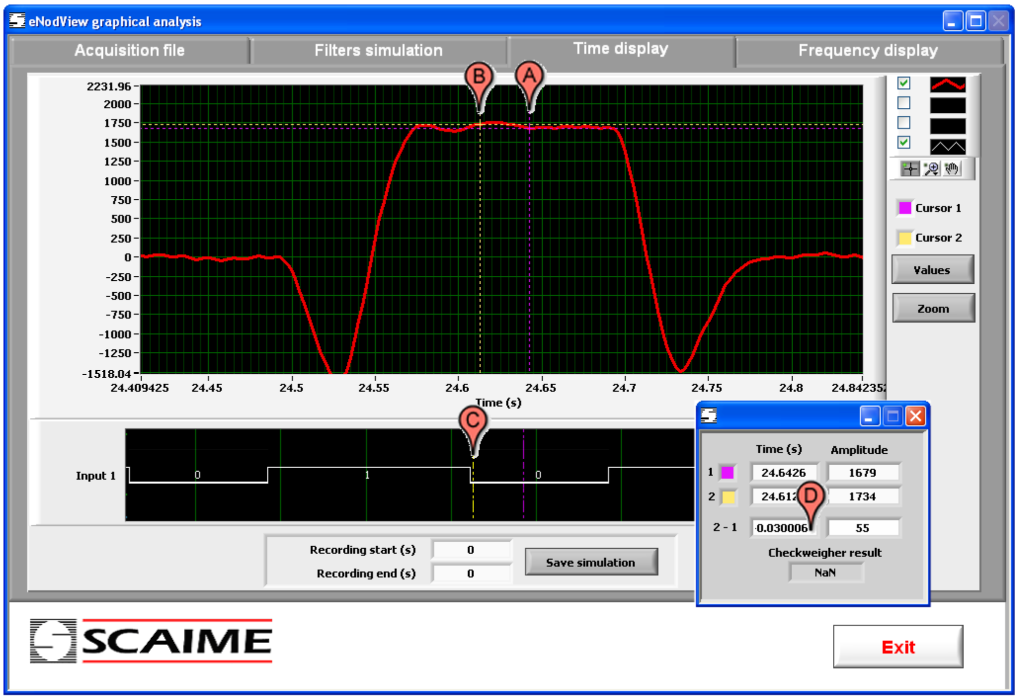
By positioning correctly the cursors, we calculated a weight (checkweigher result) of 169.3 grams for a real weight of 170.0 g. **The measurement time to obtain this result was 45 ms.**

Stabilisation time

To finalize the cycle setting, It remains to determine the stabilization time. For this, we will move the cursor **(B)** on the trigger position (logic input or measurement level) and read the stabilization time value.

In our example, the weighing cycle is triggered by a logic input. We thus positioning the cursor **(B)** at the state change of the input **(C).**

The stabilization time is then read in the cursors attached window **(D).**

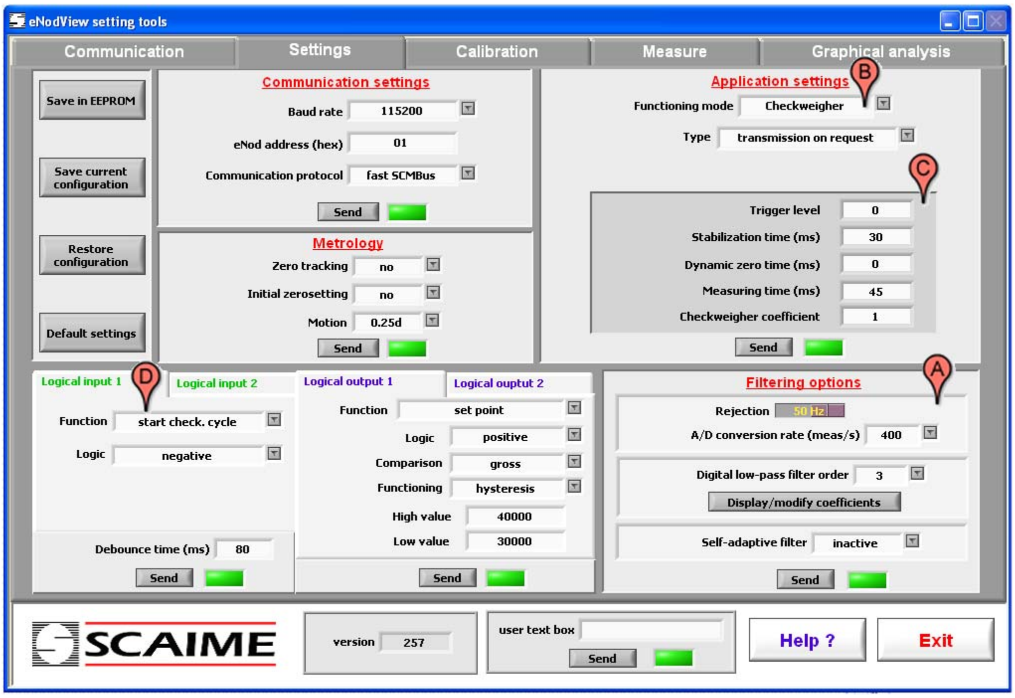


By placing the cursors according to the cycle triggering and measurement time, **we obtained a stabilization time of 30 ms.**

Checkweigher mode setting

Measurement time

When the results of filtering and timing simulation are satisfactory, we save these new parameters in eNod3 as follows:



► "Filter simulation" tab

Sending and activating filter parameters in eNod3 is operated by clicking on the button:

Send/Activate these filltering settings

► "Settings" tab

The filter settings have been updated **(A)**.

In our example, the parameters of the application will be:

- **B.** Mode: **Checkweigher, trans. On request**
- **C.** Stab. time : **30 ms**
  Meas. time : **45 ms**

The weighing cycle is triggered by a logical input activation **(D).**

We can now check the proper functioning of the dynamic weighing cycle by using the "Measure" tab.

Real test of the dynamic weighing cycle

eNodView allows to view the dynamic weighing cycle in real-time. It's thus possible to see the measurements, the logical input / outputs state and the checkweigher results.

► « Measure » tab

- **A.** Measurements curve and logical input/outputs state
- **B.** Checkweigher results windows
- **C.** Statistical data : Nb. of cycles, results average, accumulation and deviation