

# SLOW WAVES MEASUREMENT WITH PIC16F84

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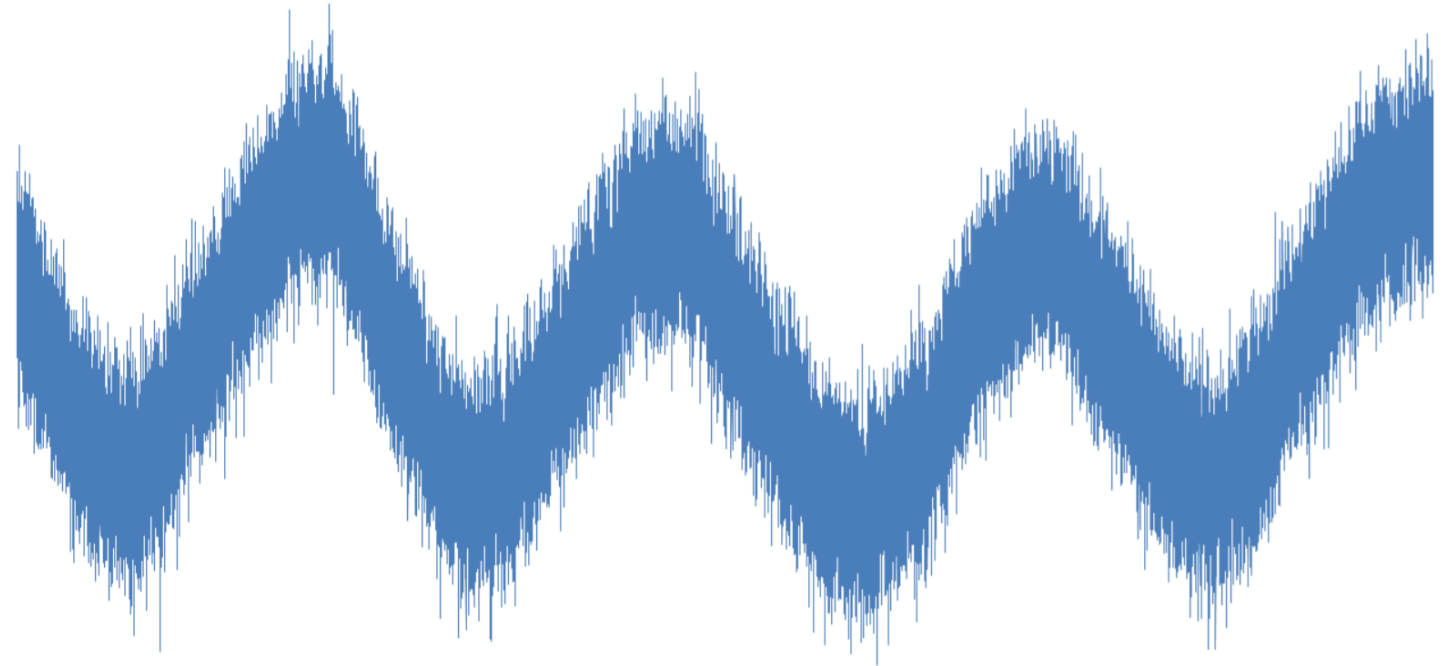
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# GLUCOSE MONITORING

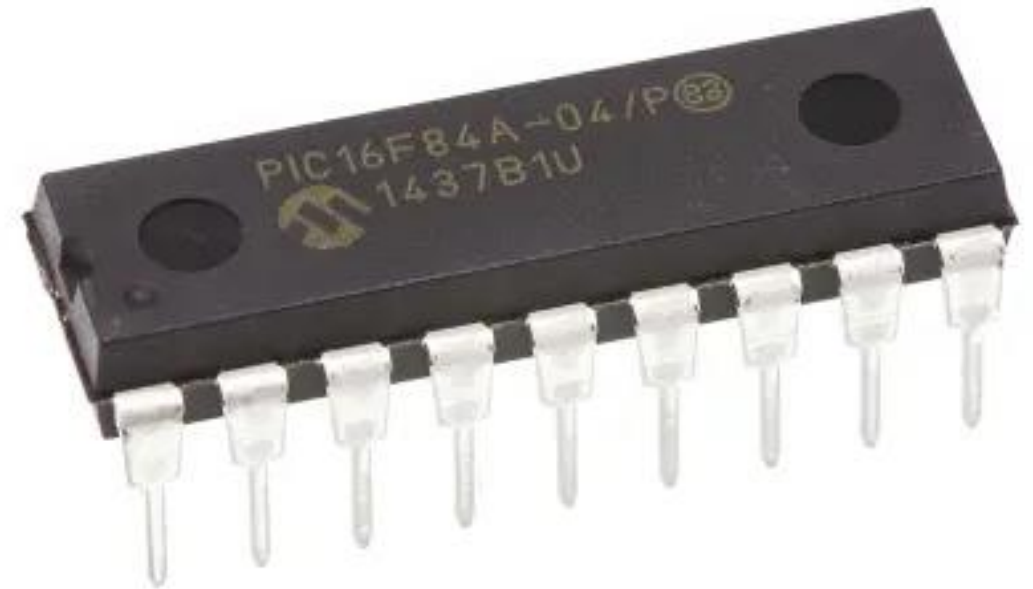
- Pancreatic Cells
- Low Frequencies Signal Characteristics



**Example of slow waves in Pancreatic cell biopotential**

# PIC16F84 MICROCONTROLLER

- 8-bit wide data bytes
  - 68 bytes of RAM data
  - 4 MHz Clock frequency
  - 1 instruction per  $\mu\text{s}$
- ECG data  $\Leftrightarrow$  16 bits  $\Leftrightarrow$  2 bytes



# SUMMARY

- I. Strategy
- II. Parameter List
- III. Latency Estimation
- IV. Hardware Cost

# STRATEGY



# FILTER

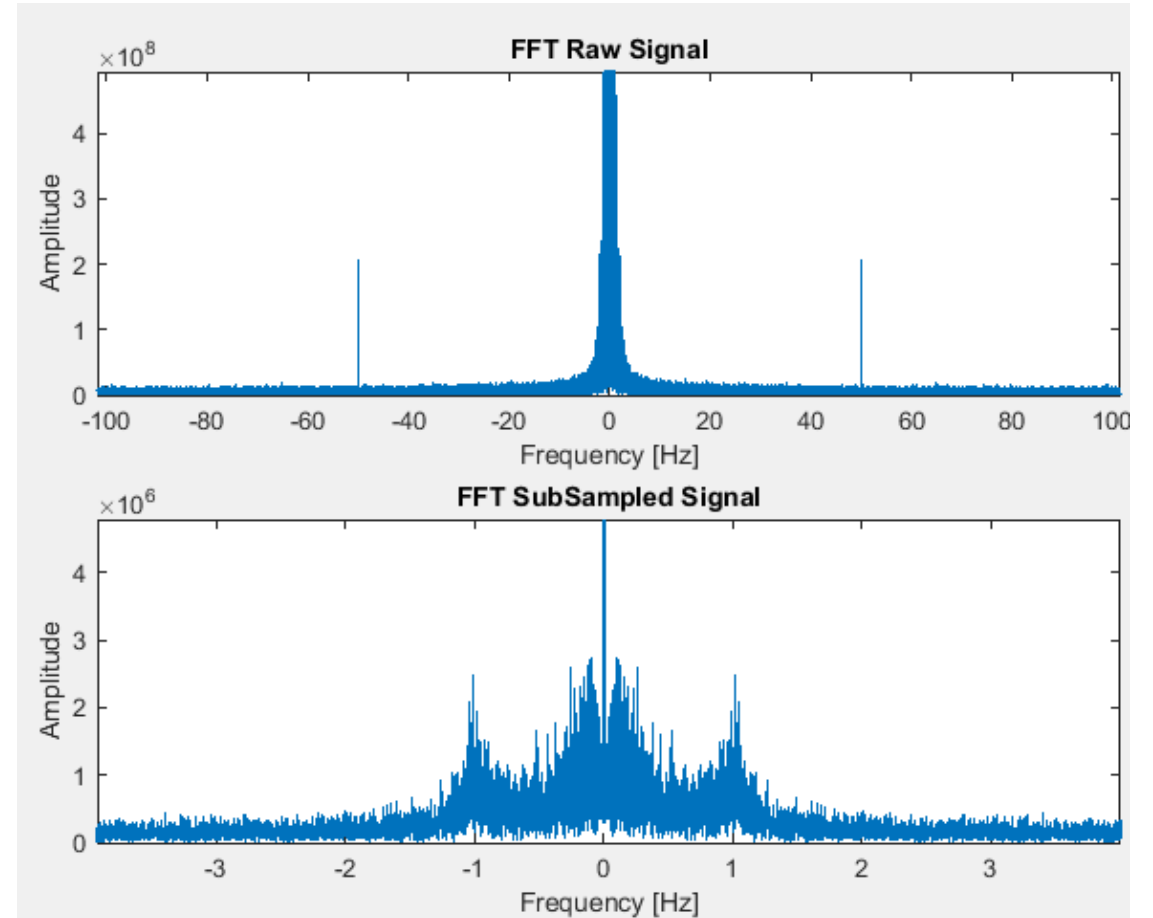
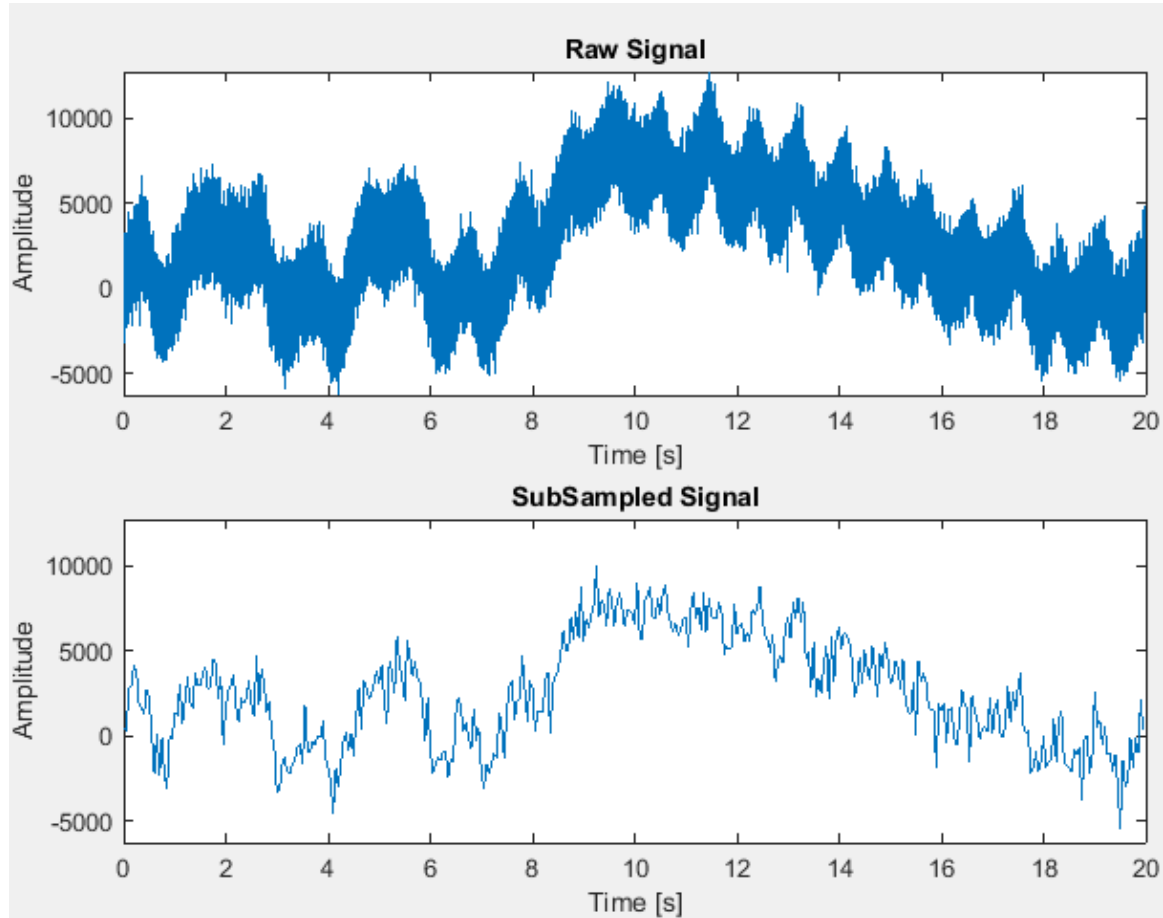
1. Low-Pass:  $y_n = \frac{\varepsilon}{2} * (x_n + x_{n-1}) + (1 - \varepsilon) * y_{n-1}$
2. High-Pass:  $z_n = x_n - y_n$

With :

- $x_n$  : the nth sub-sampled data
- $y_n$  : the nth Low-Pass Filtered data
- $z_n$  : the nth High-Pass Filtered data
- $\varepsilon$ : filter coefficient

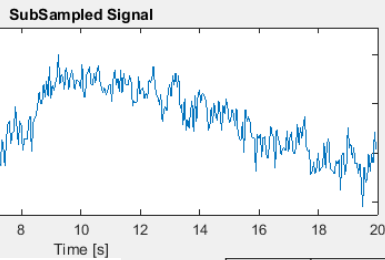
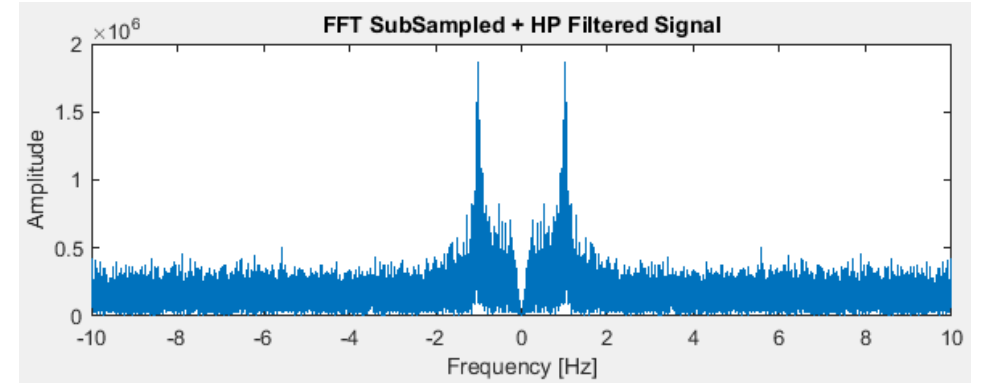
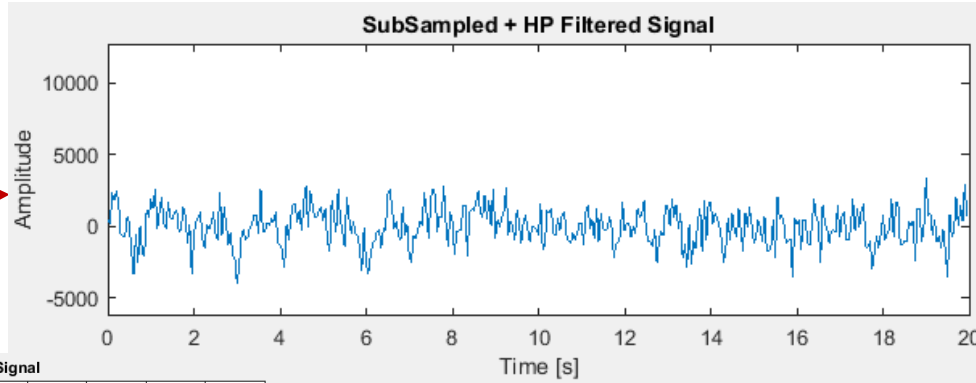
# MODEL TEST

## Sub-Sampling

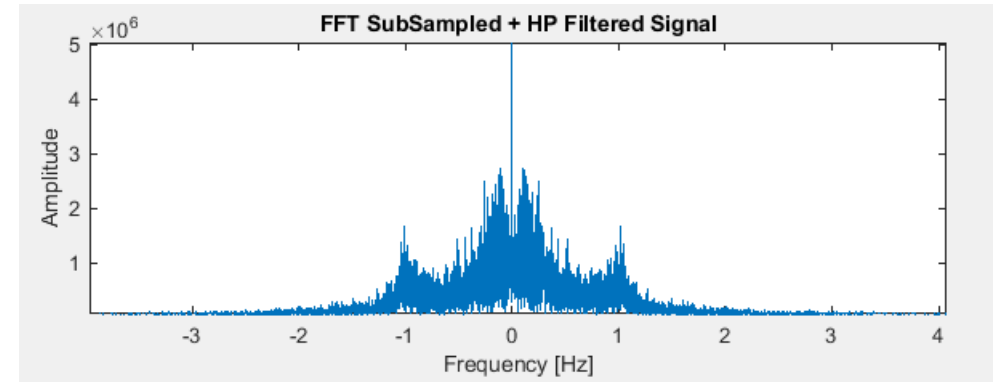
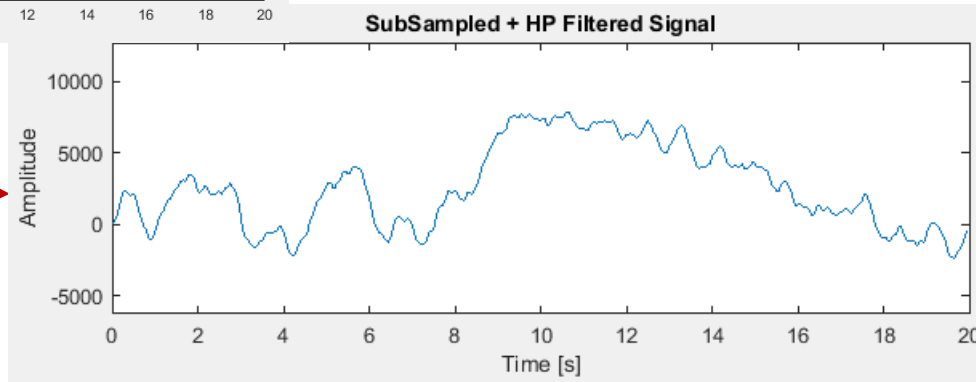


# MODEL TEST

HPF



LPF





# MODEL TEST

## LPF

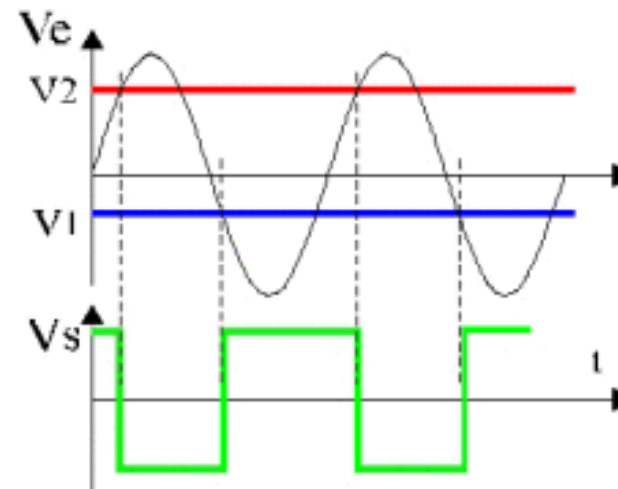
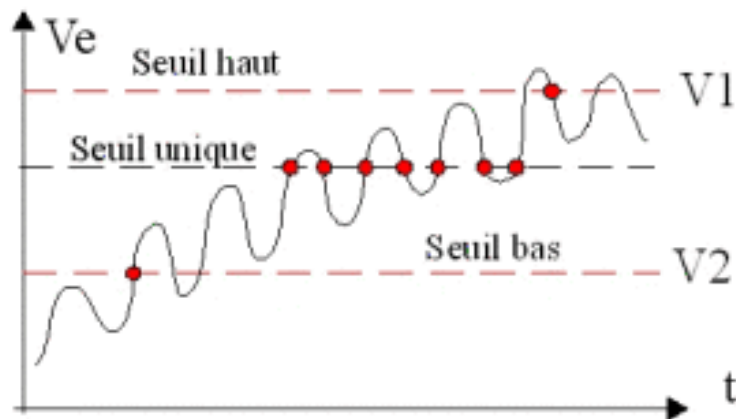
- ✓ Amplitude easily detected
- ✓ Smooth signal
- ✗ Continuous component
- ✗ No SNR improvement

## HPF

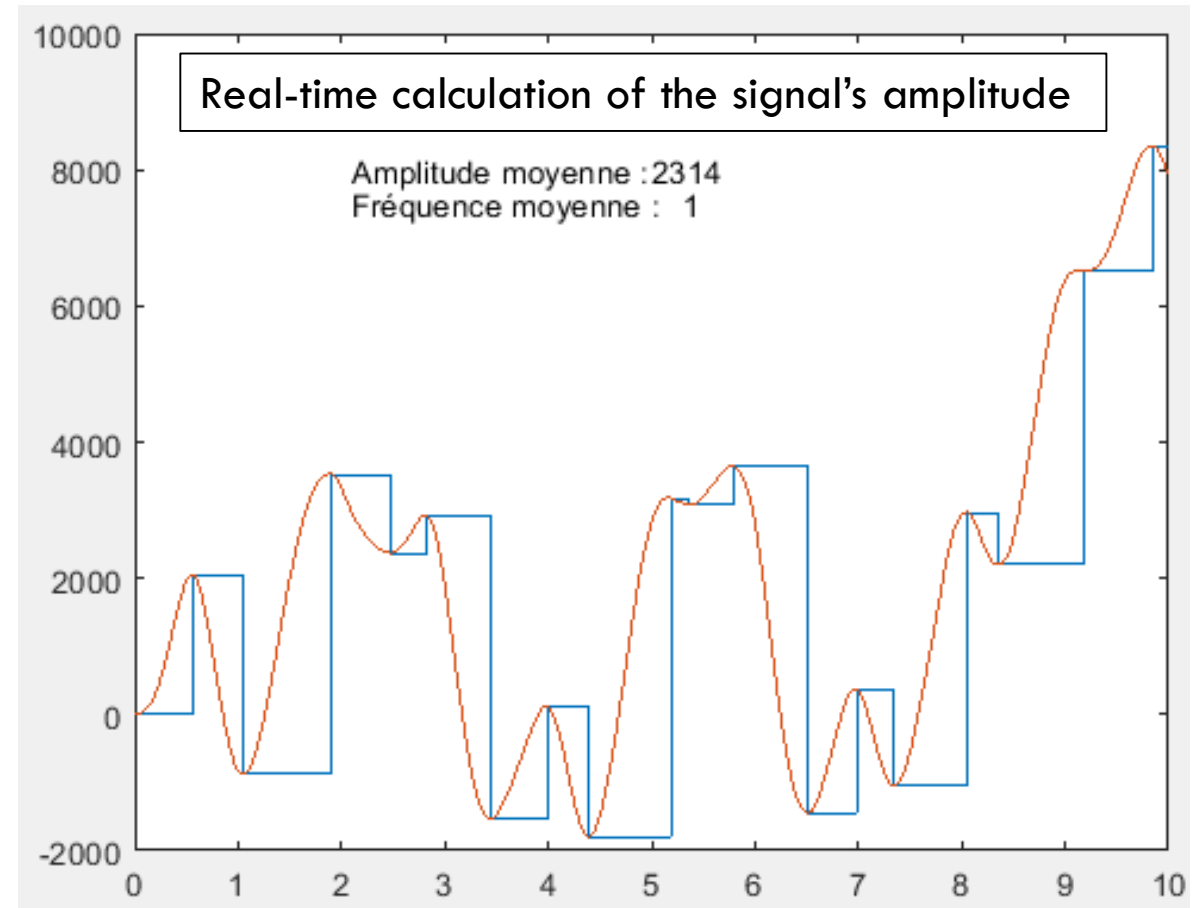
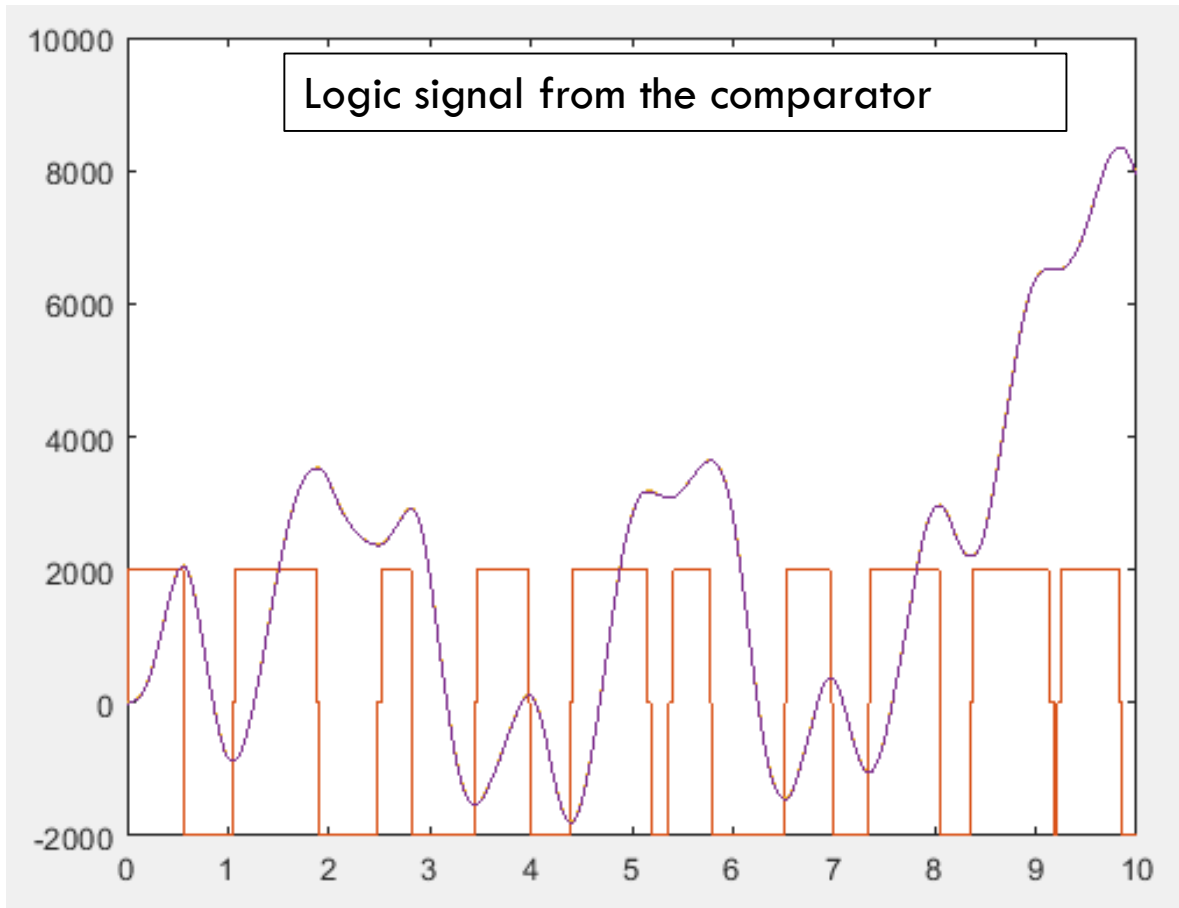
- ✓ No continuous component
- ✓ SNR improvement
- ✗ High signal variation
- ✗ Hard to detect amplitude detected

# DYNAMIC HYSTERESIS COMPARATOR

- Small physiological signals avoidance
- Necessity of smoothed signals
- Level shift problematic : dynamic follow-up of the signal



# IMPLEMENTATION OF THE DYNAMIC COMPARATOR



# PARAMETER LIST



- $F_{Slow\ Waves} < F_{Sub} < 50Hz$

- $\varepsilon = 2^i$  avec  $i \in [0,1]$

- $V_{upper}$
  - $V_{lower}$
- } Tunable

# LATENCY ISSUES AND SAMPLING FREQUENCIES

- Initial Fs:  $10^4$  Hz  $\Leftrightarrow$  100 $\mu$ s
- Chosen sub-sampling frequency : 20 Hz      for a new calculation time : 50ms !!

# LATENCY ESTIMATION

Low-Pass Filter



Dynamic Hysteresis  
Comparator

$$z_n = 2^{i-1} * (x_n + xn_{-1}) + (1 - \varepsilon) * zn_{-1}$$

- Additions/Subtractions : 5
- Divisions/Translations : 2
- RAM write access : 1
- RAM read accesses : 2
- Affectation : 1

11µs for the filter

- Affectations : 20
- RAM write accesses : 13
- RAM read accesses : 27
- Additions : 6
- Logical operations : 5
- Soustractions : 4
- Divisions/Translations : 2

77µs for the comparator

0,176 % of the measurement time

Instead of  
88% !

# HARDWARE COST

Low-Pass Filter



Dynamic Hysteresis  
Comparator

$$y_n = 2^{i-1} * (x_n + x_{n-1}) + (1 - \varepsilon) * y_{n-1}$$

- 4\*2 bytes

- 4 memorized vectors (Output, Amplitude, Vupper, Vlower) : 4\*2\*3 bytes
- 3 counters : 3\*4 bytes
- 2 stock variables (frequency and average amplitude) : 1 byte + 2 bytes

Total hardware cost: 47 bytes

69,1% of the  
RAM resources