Weighing scale-reader

2.737 Mechatronics

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Key takeaway: Oversampling for noise reduction.

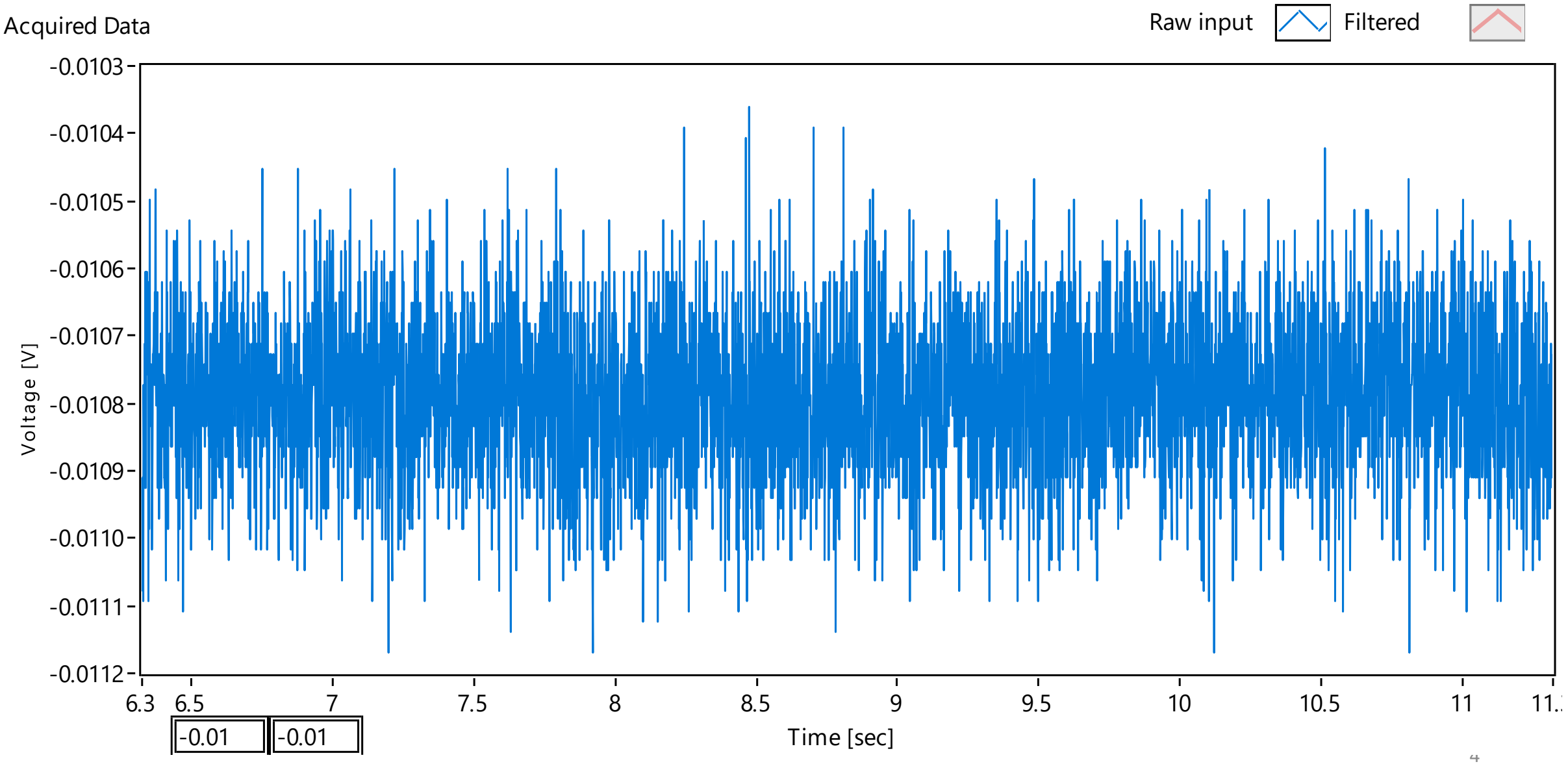
Code Overview

- Field Programmable Gate Array (FPGA)
  - Reads C/AI0 at 333 kHz as a 12-bit integer value, and
  - Oversampling Implemented: Takes a moving average with 320 previous values and converts the result into fixed point.
    - Effectively, the fidelity (tracking of AI without too much phase lag) of the output oversampled AI signal is about 0.5*333/320 = 520.83 Hz. (multiplying by 0.5 due to Shannon-Nyquist criterion)
    - We are trading of throughput (limiting how fast dynamics we can perceive from the AI signal) for lower noise and hence better resolution.
    - For more information, refer to - http://www.cypress.com/file/236481/download

- Real-Time
  - Reads the oversampled C/AI0 from the FPGA.
  - Has operations for filtering, converging voltage to load and implements the “tare” function.

Oversampling

Oversampling implemented (320:1)



Oversampling implemented (320:1)

Effective resolution increase:

$$w = \frac{\log(N_{avg})}{\log(4)}$$

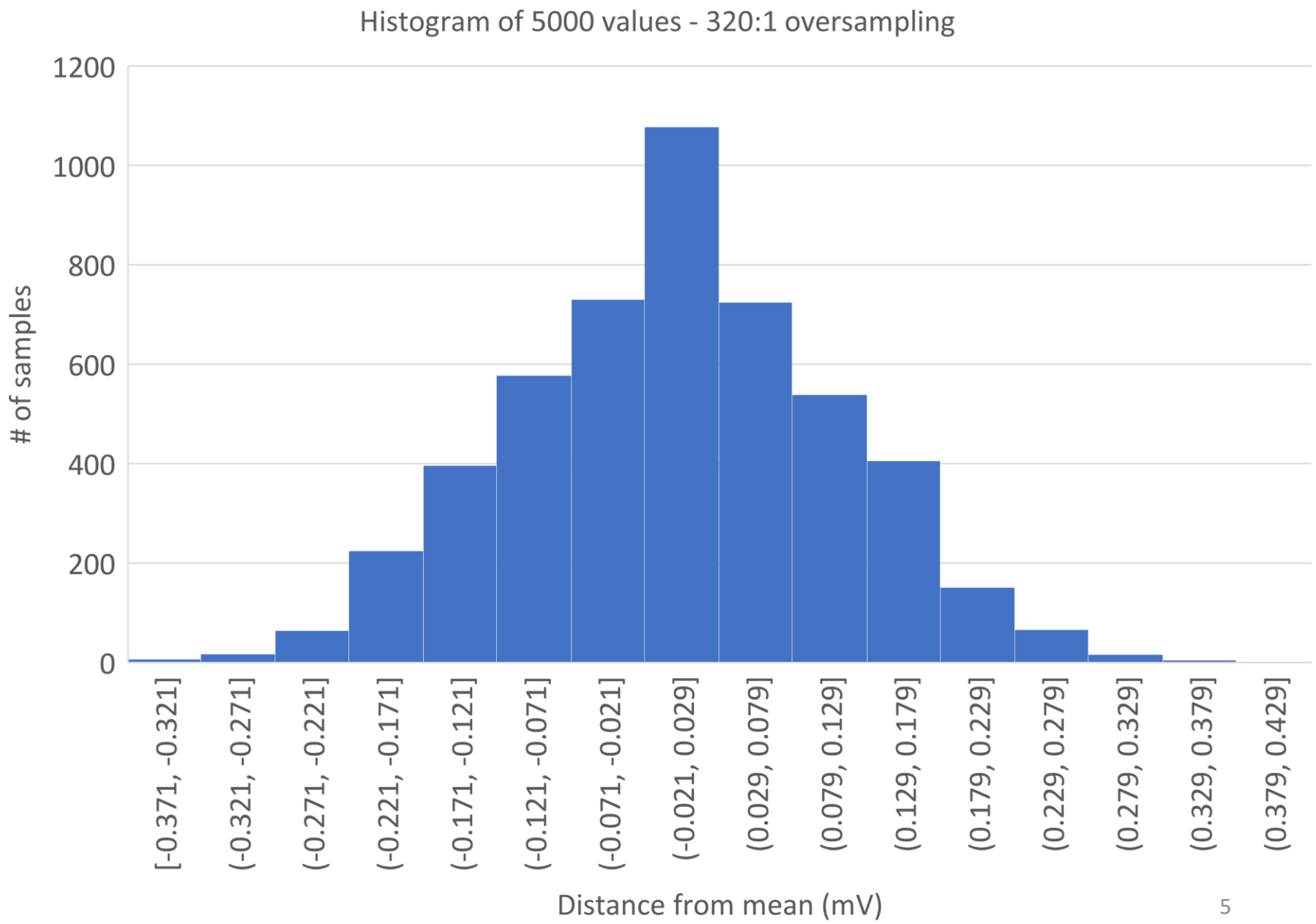
N_{avg} = 320 sample average,
w = 4.17

The system effectively should behave as a 16-bit ADC.

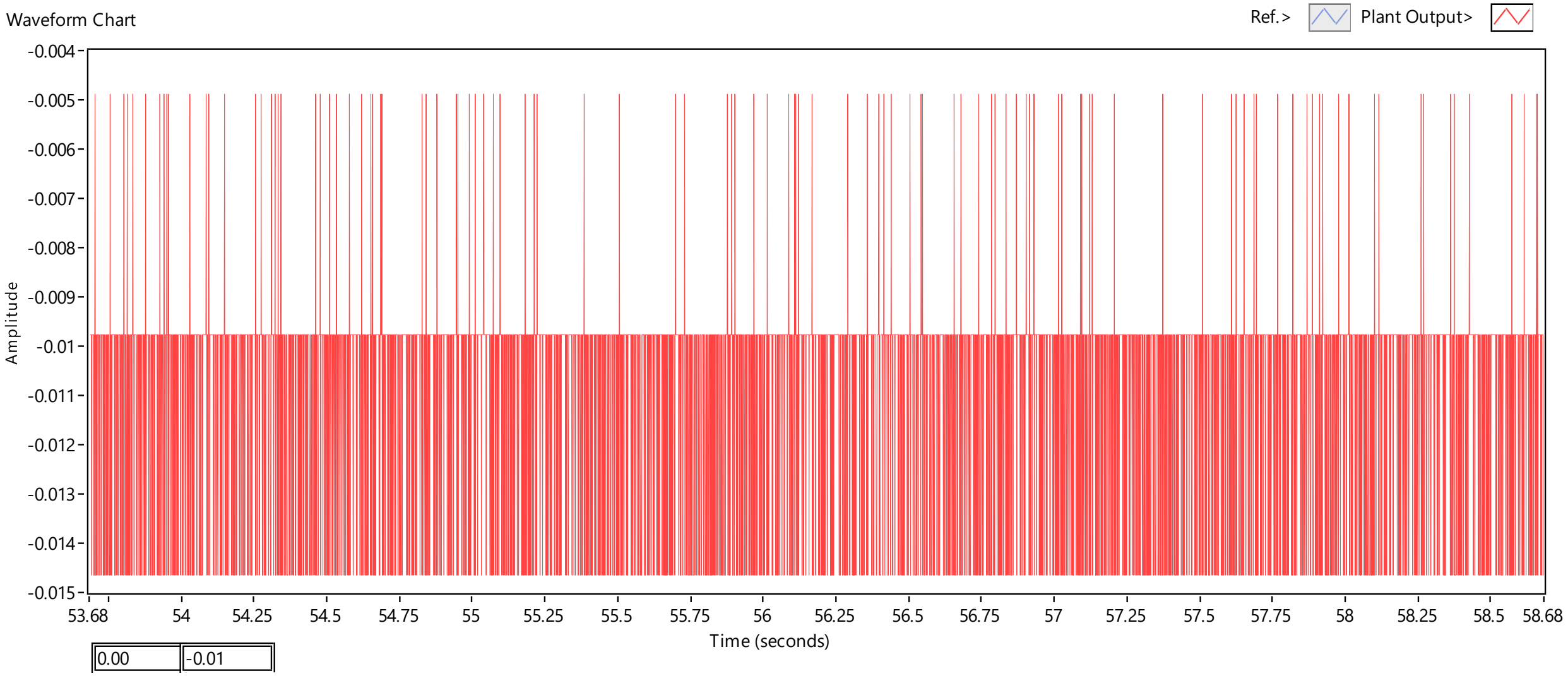
16-bit resolution:
20/2^16 = 0.305 mV

Measurement:
10 times better resolution and lower noise than original.

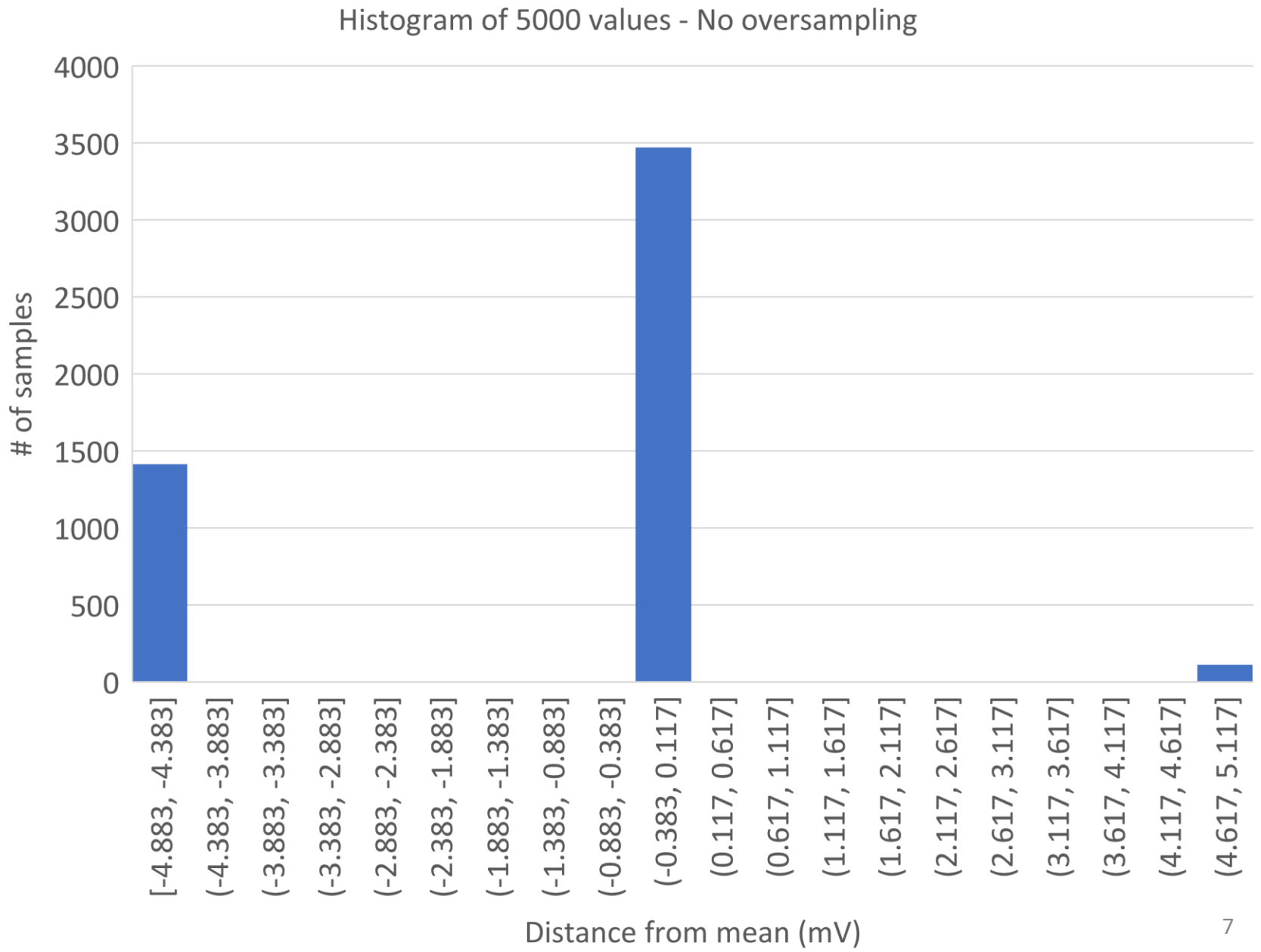
Total spread:
Max-Min = 0.778 mV



Original 12-bit Analog input



Original 12-bit Analog input

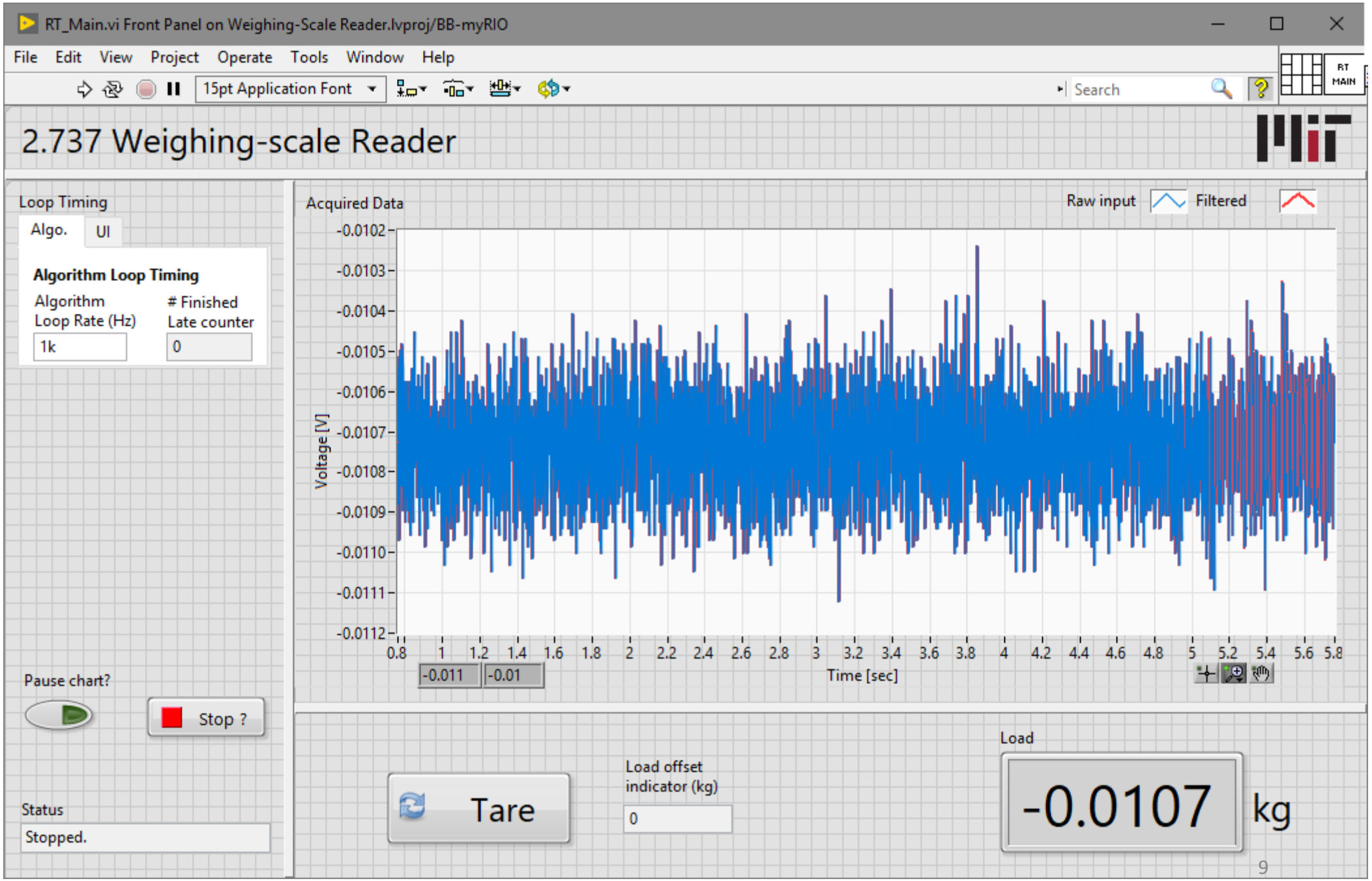


12-bit resolution:
20/2^12 = 4.883 mV

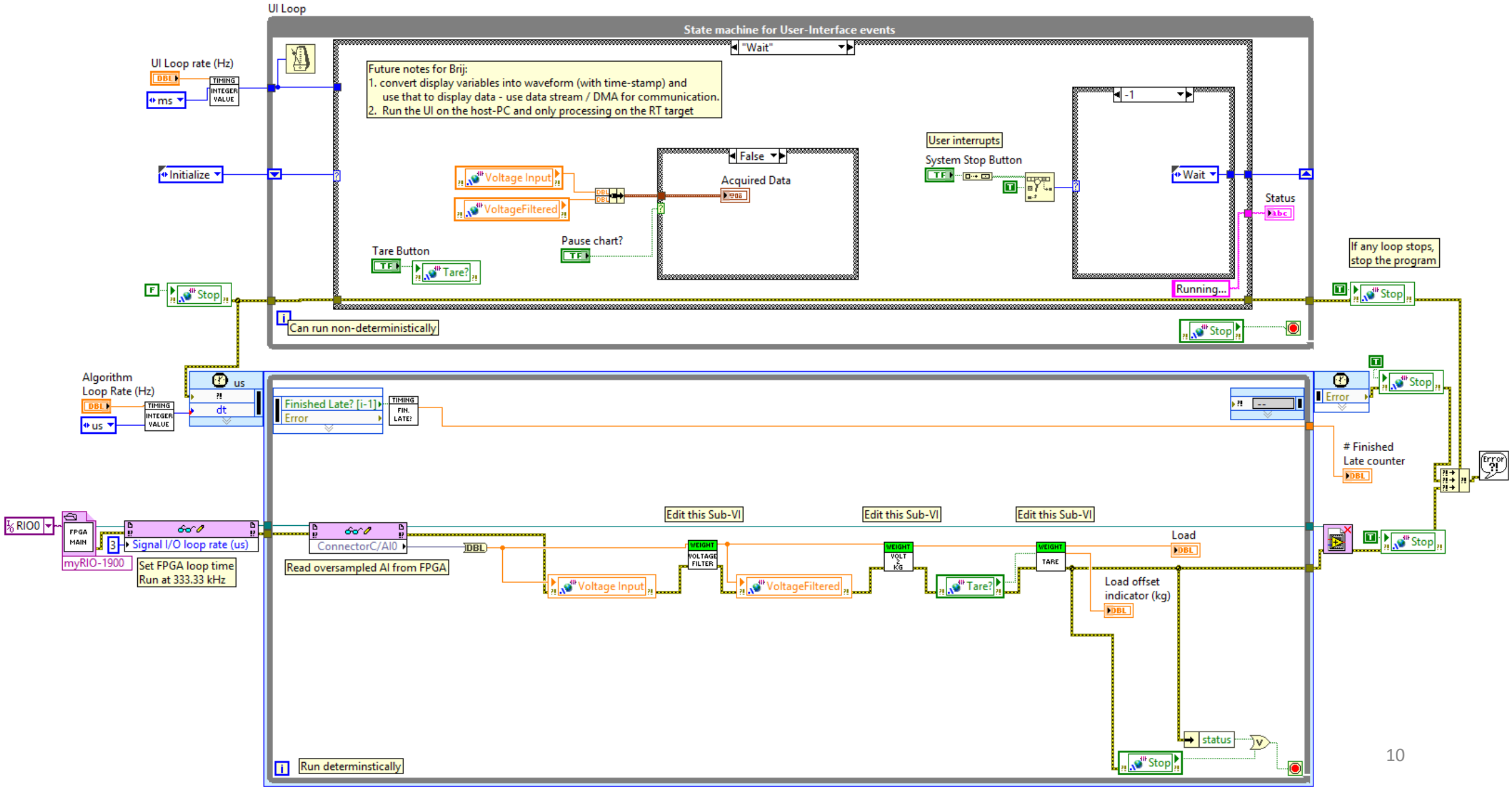
Total spread:
Max-Min = 9.776 mV

Code screenshots

Front Panel

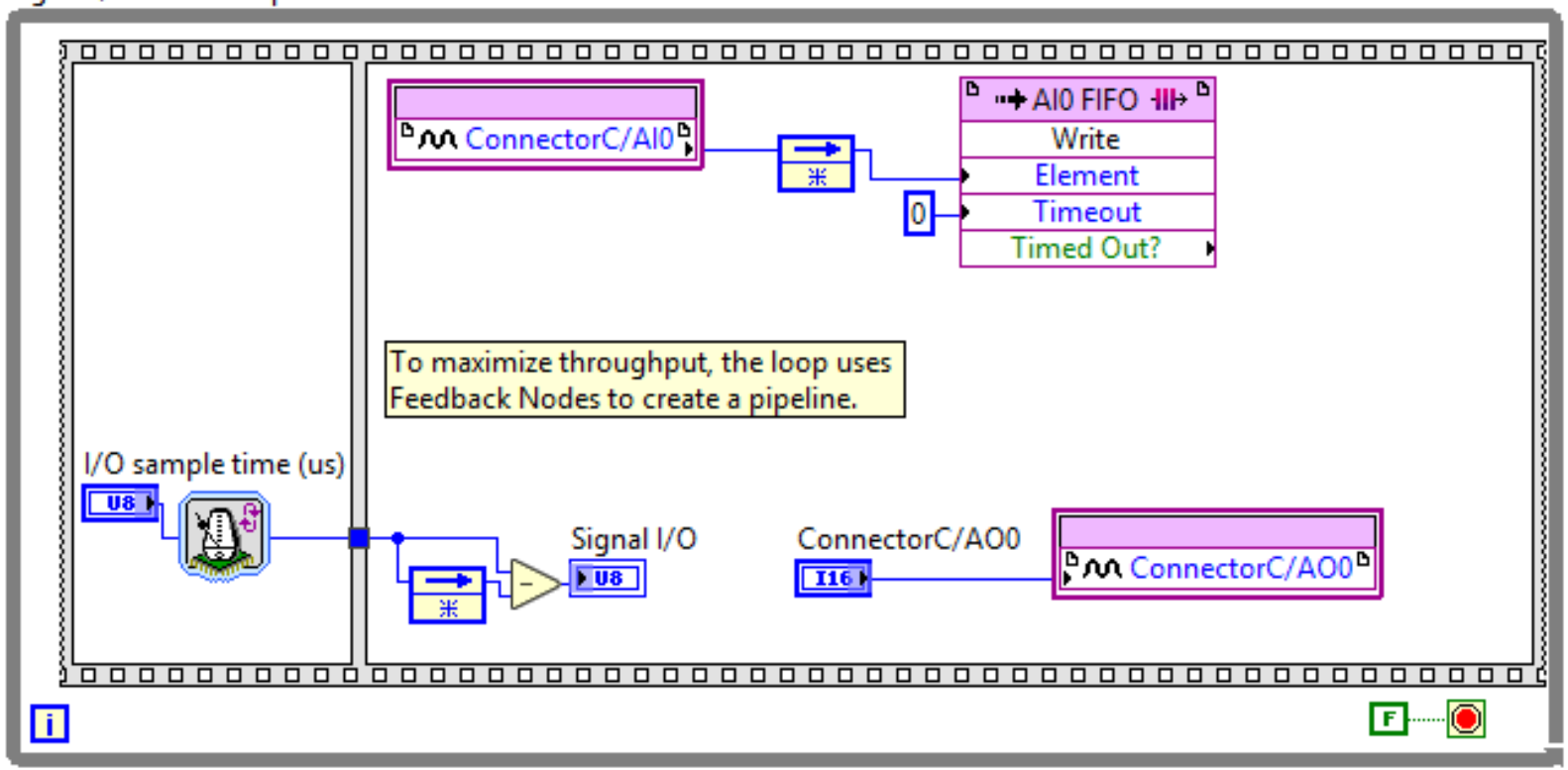

RT_Main.vi Front Panel on Weighing-Scale Reader.lvproj/BB-myRIO
File Edit View Project Operate Tools Window Help
15pt Application Font
Search
RT MAIN
2.737 Weighing-scale Reader
Loop Timing
Algo.
UI
Algorithm Loop Timing
Algorithm Loop Rate (Hz)
1k
Finished Late counter
0
Acquired Data
Raw input
Filtered
Voltage [V]
-0.0102
-0.0103
-0.0104
-0.0105
-0.0106
-0.0107
-0.0108
-0.0109
-0.0110
-0.0111
-0.0112
0.8 1 1.2 1.4 1.6 1.8 2 2.2 2.4 2.6 2.8 3 3.2 3.4 3.6 3.8 4 4.2 4.4 4.6 4.8 5 5.2 5.4 5.6 5.8
-0.011
-0.01
Time [sec]
Pause chart?
Stop ?
Status
Stopped.
Tare
Load offset indicator (kg)
0
Load
-0.0107
kg

Block diagram

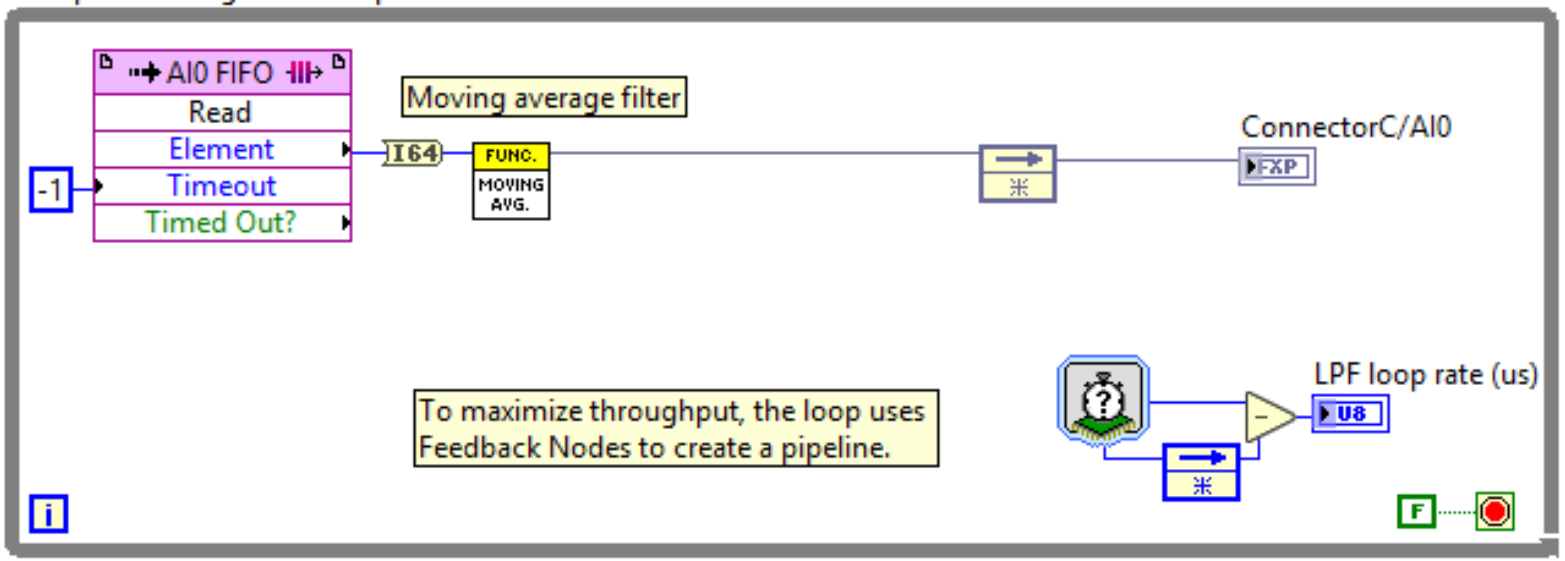


FPGA Block-diagram

Signal I/O While Loop



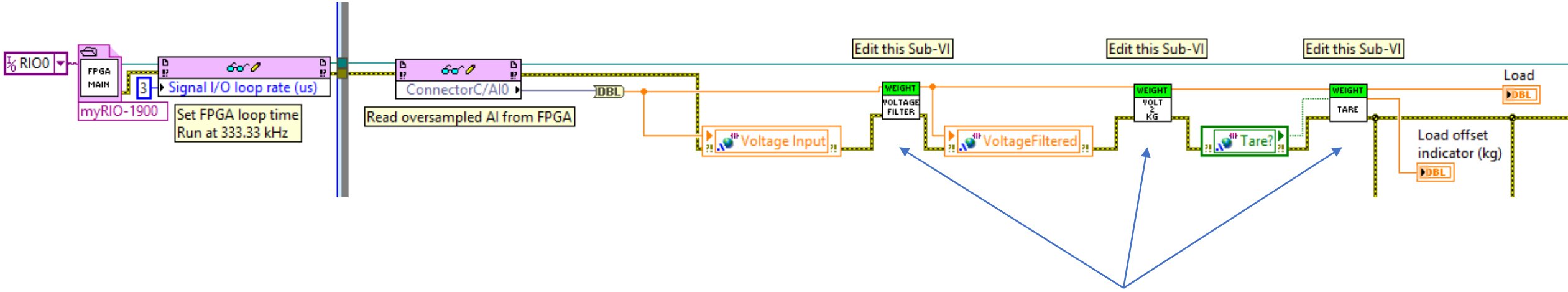
Low-pass filtering While Loop



Tasks

Modify the 3 sub-VIs

- Implement any further filtering if you would like.
- Write to code to convert from voltage to weight measurement.
- Write code to implement tare functionality on pressing the tare button.



Double-click to open sub-VI and modify to implement your own code.

References

- https://forums.ni.com/t5/Example-Programs/Convert-Sine-Wave-Generator-Raw-Output-to-Fixed-Point/ta-p/3530621
- https://forums.ni.com/t5/LabVIEW/Moving-Average-Filter/td-p/2550513
- https://terpconnect.umd.edu/~toh/spectrum/Smoothing.html
- http://www.cypress.com/file/236481/download