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Application of Adaptive Noise Cancelling Filters to AC Electrical Measurements

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Introduction

- Noise cancelling technology has been around for several decades.
- We are familiar with it in audio products.
- This talk presents two experiments which demonstrate the use of adaptive filters to improve electrical measurements.

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Motivation

- Need for on-site measurements at grid installations.
- Existing cabling and transformers not always well configured.
- Measurements subject to noise and “pick-up”.
- Investigate methods to reduce noise on measurements.
- Use DSP techniques such as digital and adaptive filters.
- Paper gives two examples of adaptive noise cancelling filters.

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Experiment 1:
Cancelling Magnetically Coupled Interference in Measurement Circuits

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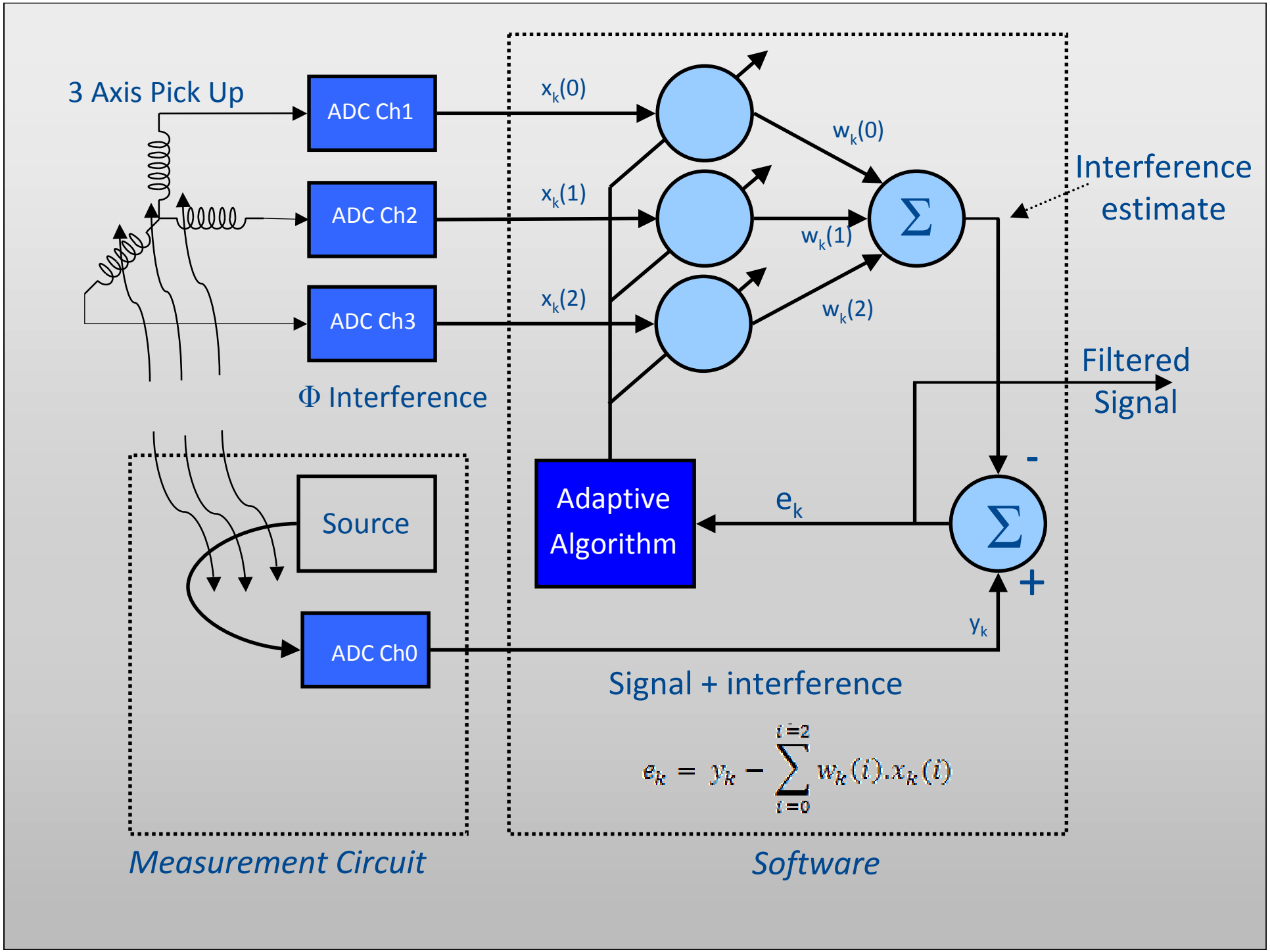
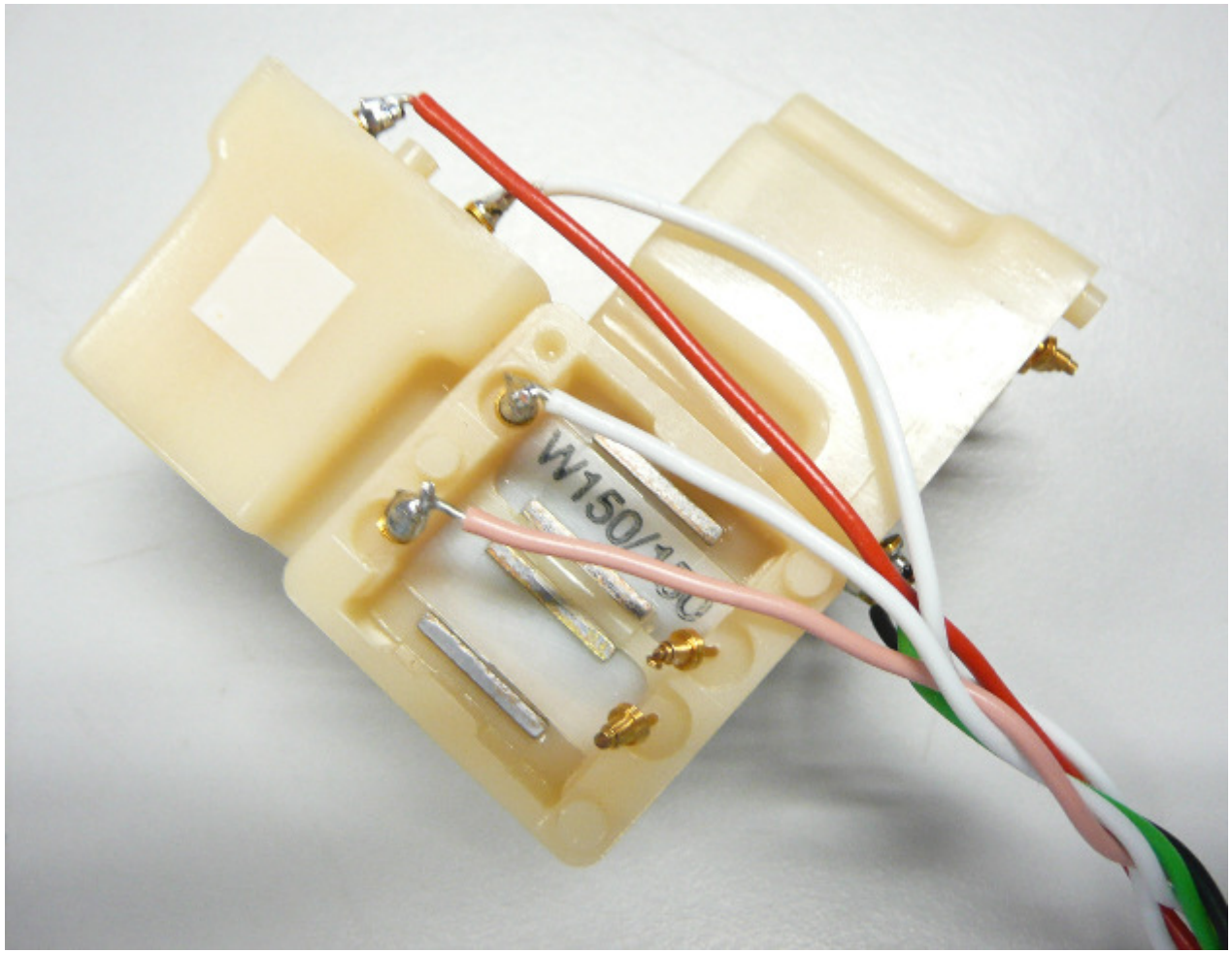
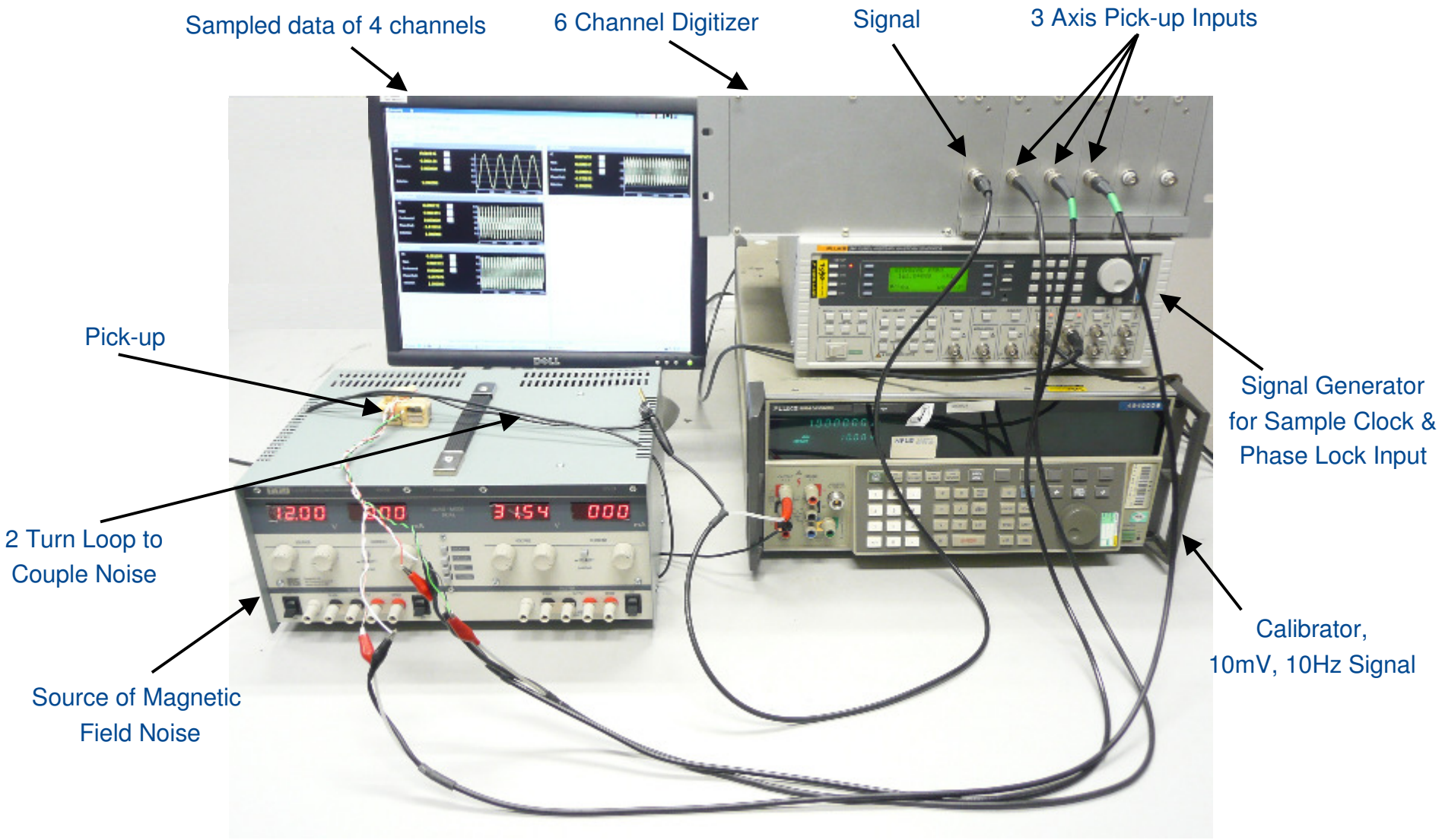

3 Axis Pick Up
ADC Ch1
ADC Ch2
ADC Ch3
Φ Interference
$x_k(0)$
$x_k(1)$
$x_k(2)$
$w_k(0)$
$w_k(1)$
$w_k(2)$
Σ
Interference estimate
Filtered Signal
Adaptive Algorithm
e_k
Σ
-
+
y_k
Source
ADC Ch0
Signal + interference
$e_k = y_k - \sum_{i=0}^{i=2} w_k(i).x_k(i)$
Measurement Circuit
Software

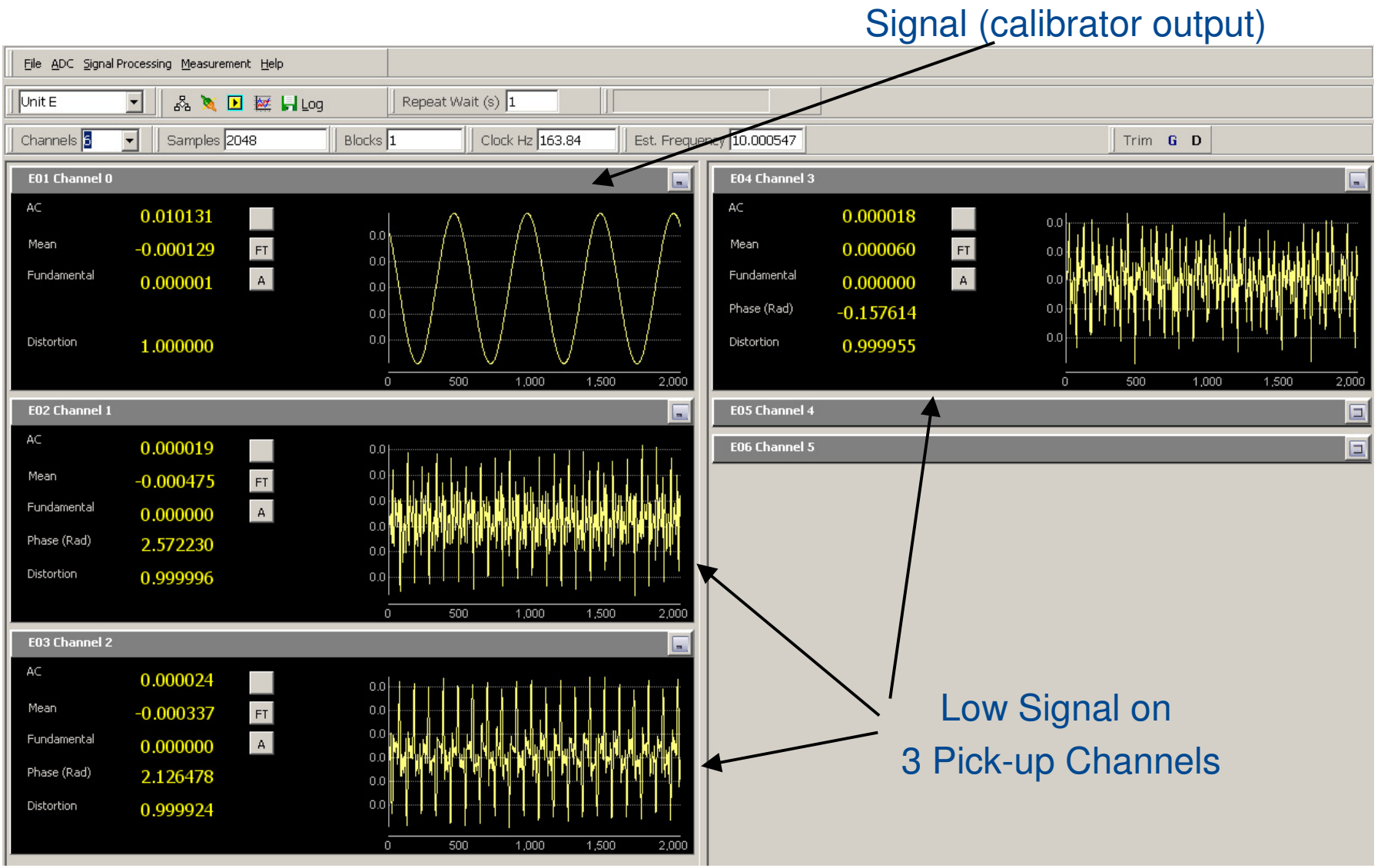


3-Axis Magnetic Field Pick-up – Made from commercial relays glued together

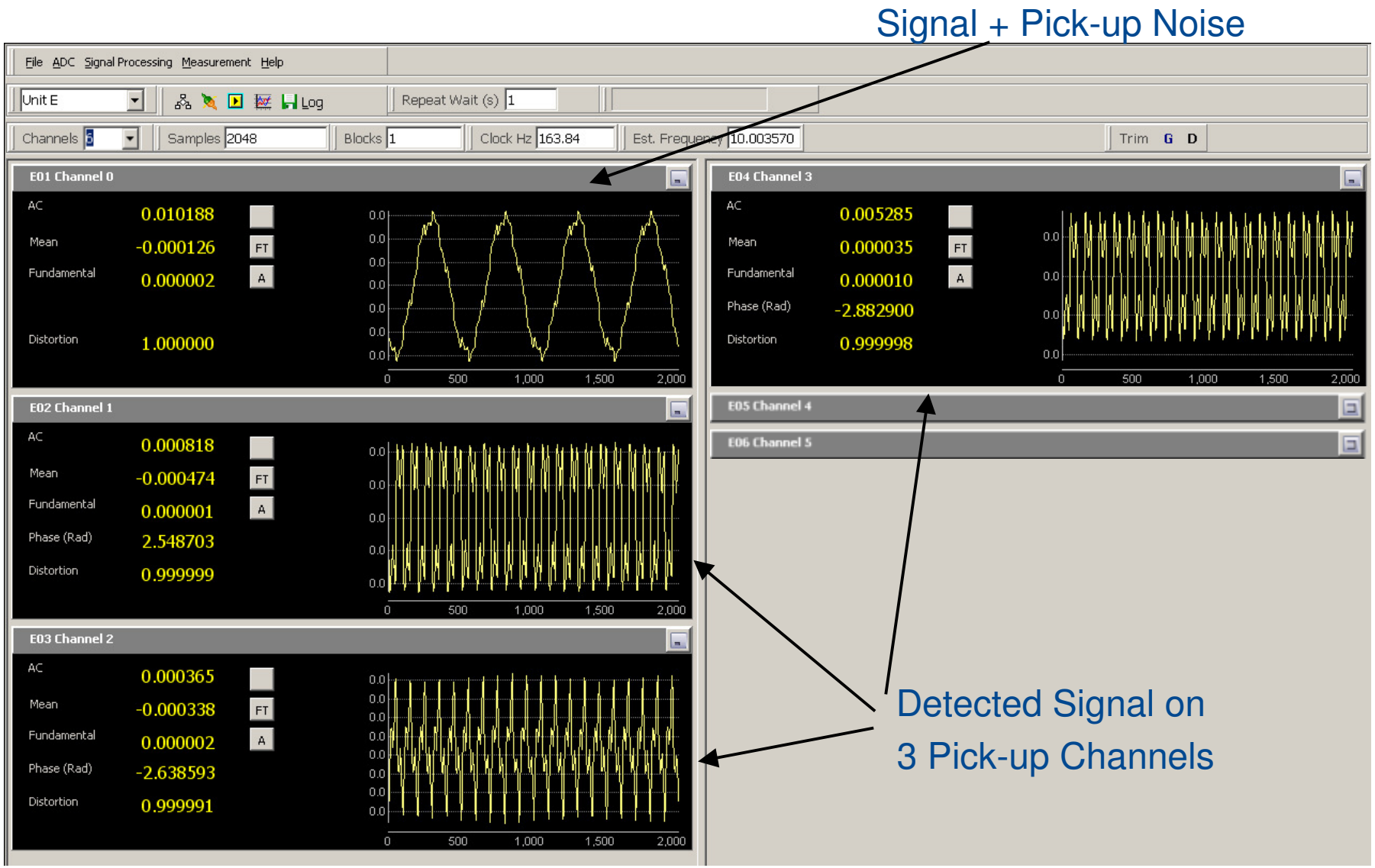


Magnetic Interference Pick-up Cancellation Experiment

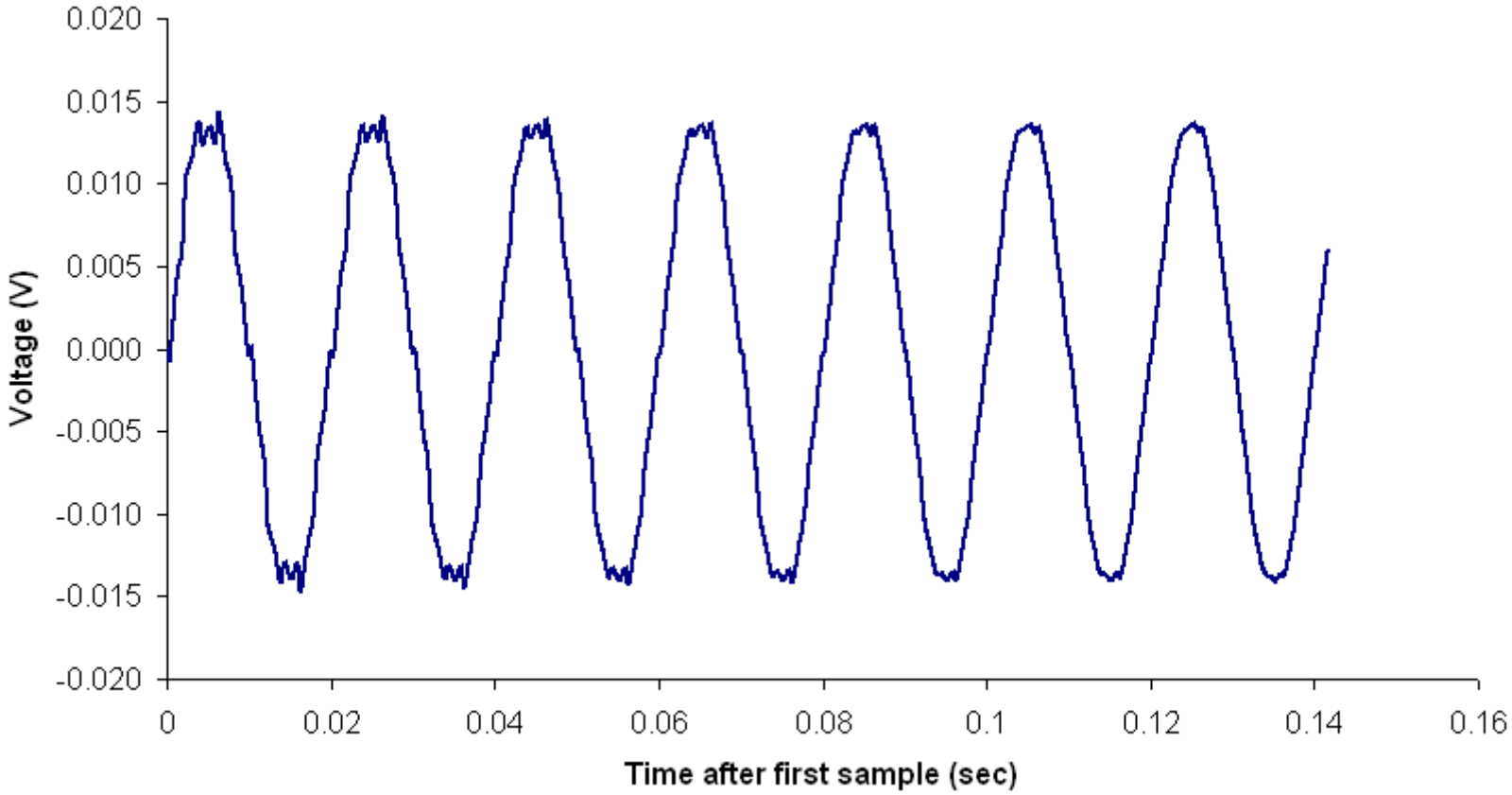
Magnetic Noise Source **Switched-Off**



Magnetic Noise Source **Switched-ON**



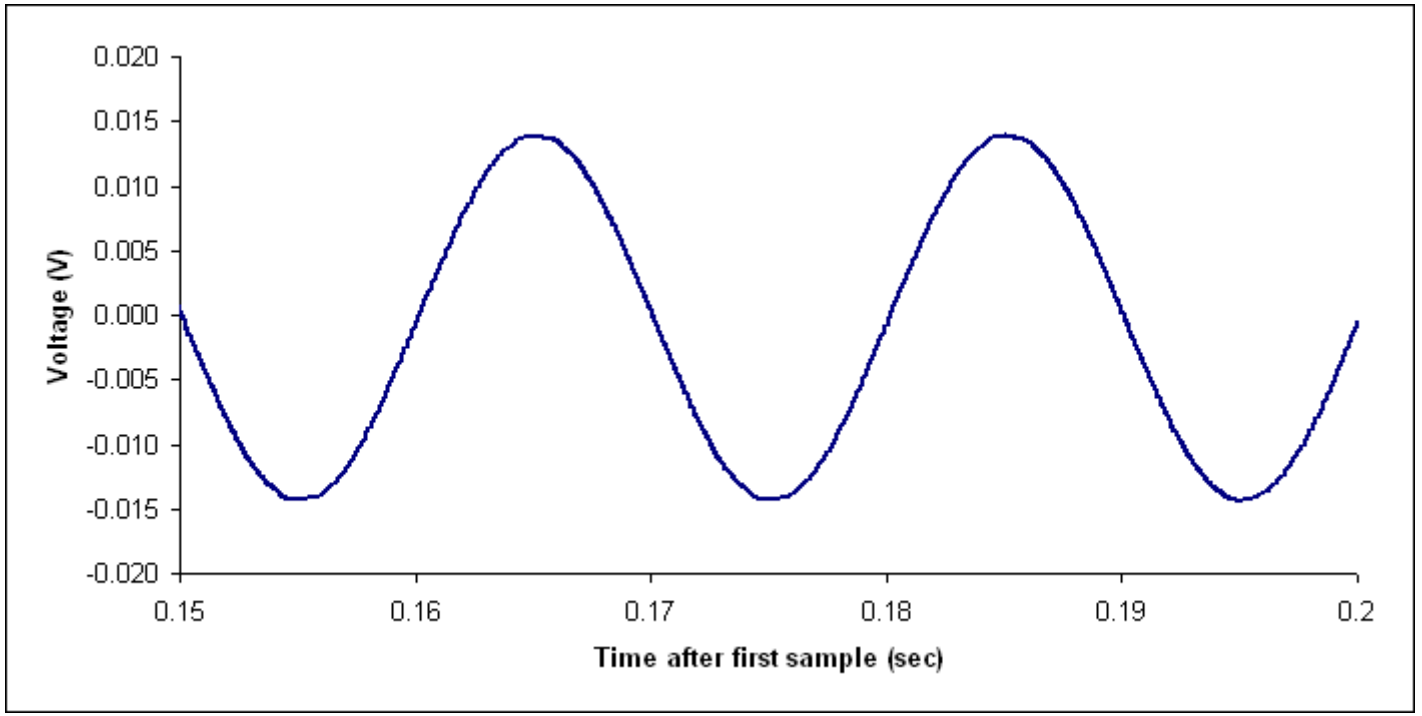
Apply the Signal and the three-axis pick-up channels to the adaptive filter…..



The amount of noise on the signal improves as the filter adapts to the signals

(NB faster response is possible – reduced here to illustrate adaptive activity)

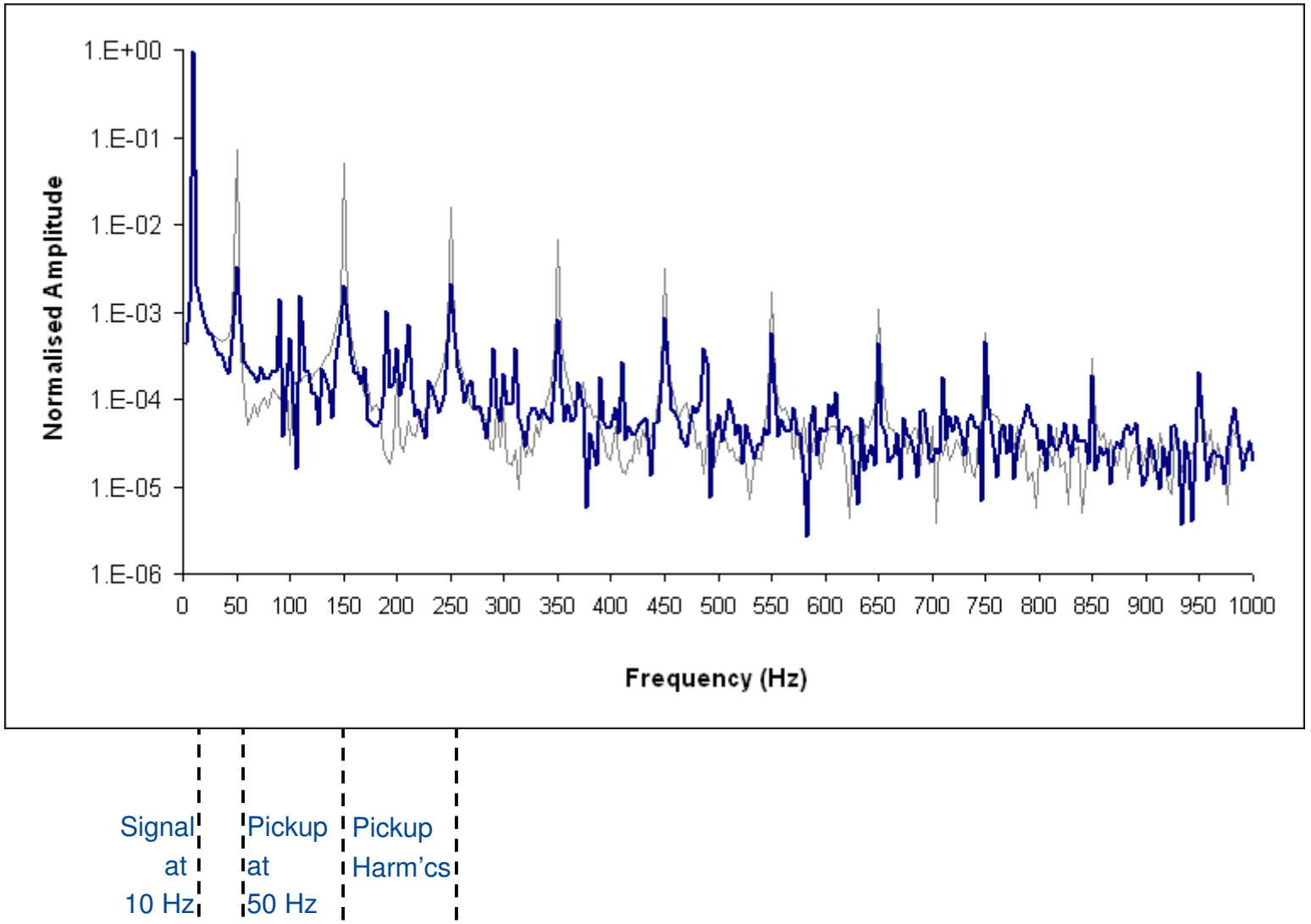
Filtered Result Using and Least Mean Square Adaptive Filter…



Noisy Signal Error in RMS value from calibrator value: + 0.47%; THD: 9.2 %

Filter Signal Error in RMS value from calibrator value: + 0.01%; THD 0.7 %

Filtered Result In the Frequency Domain



Change in 10Hz Signal after filtering: -220 ppm

Experiment 2:
Frequency Beat Noise Cancellation

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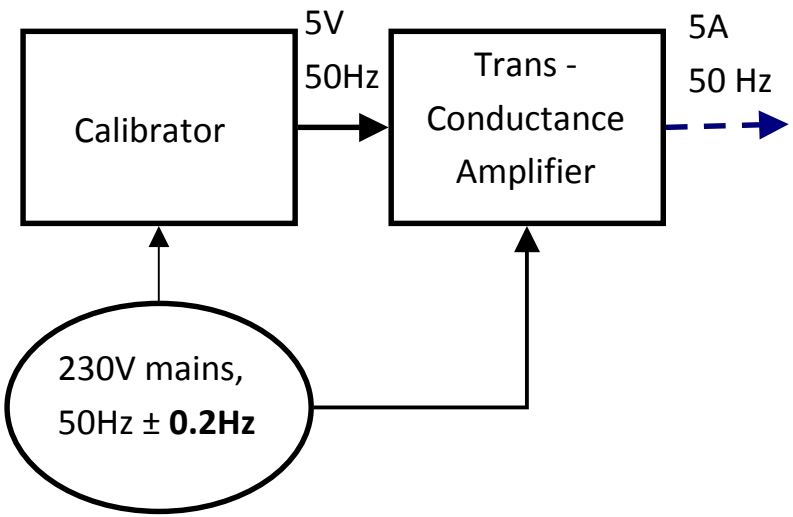
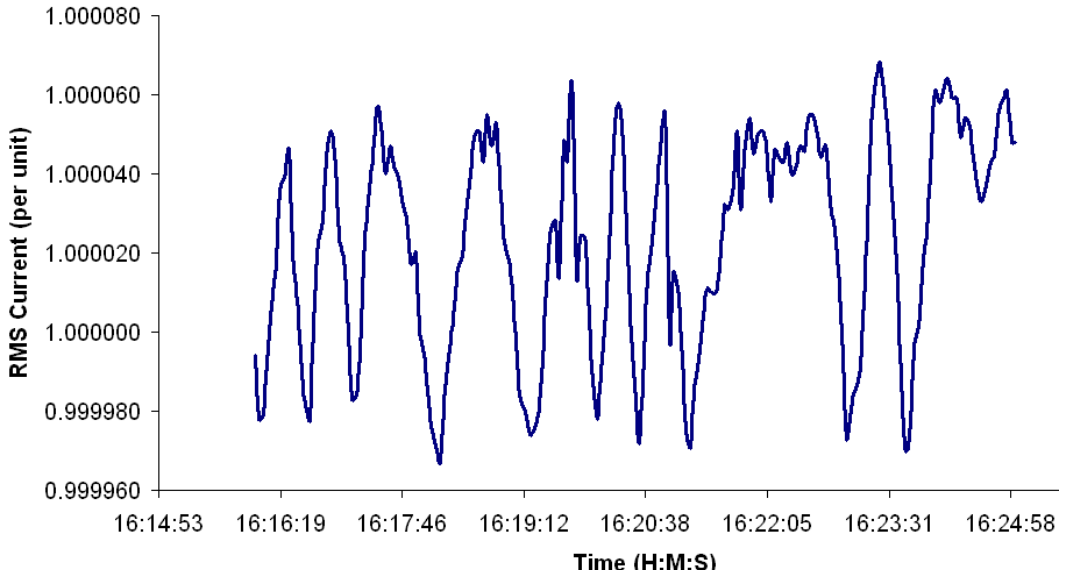
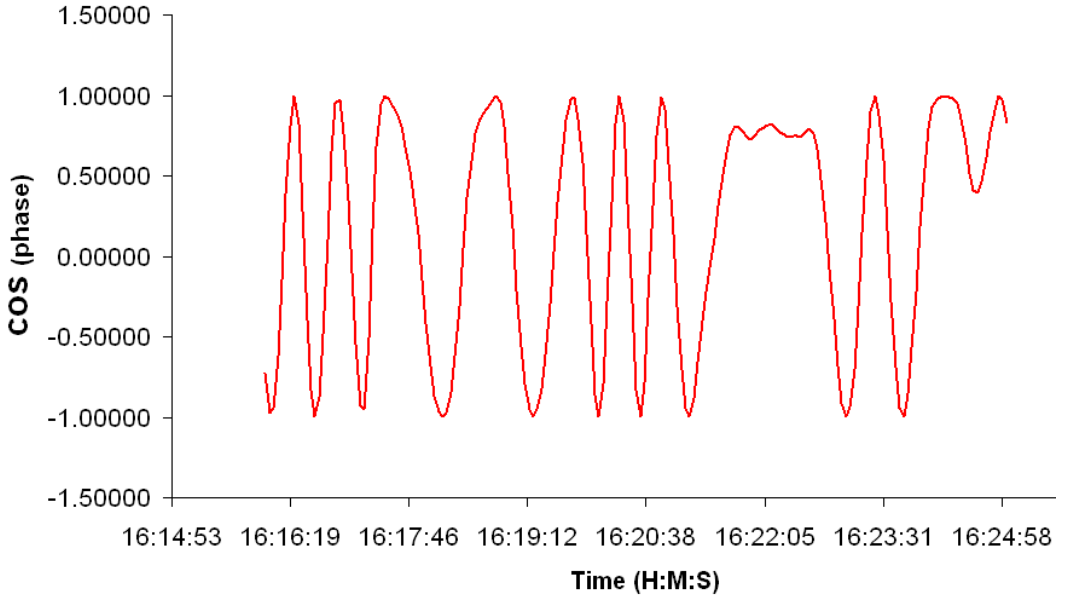
Frequency Beat Noise Cancellation

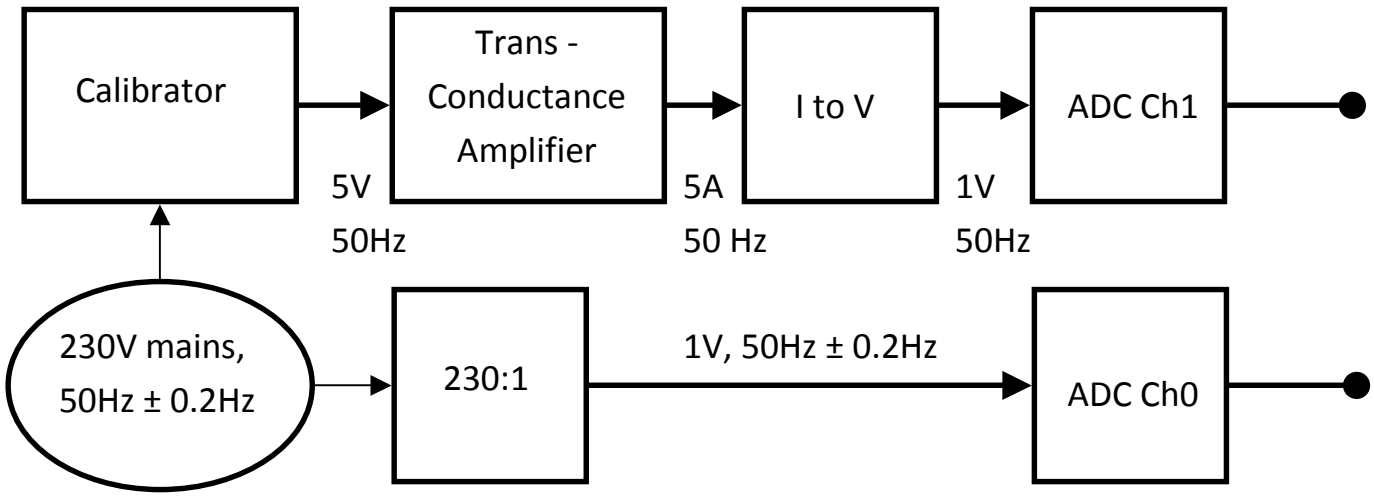


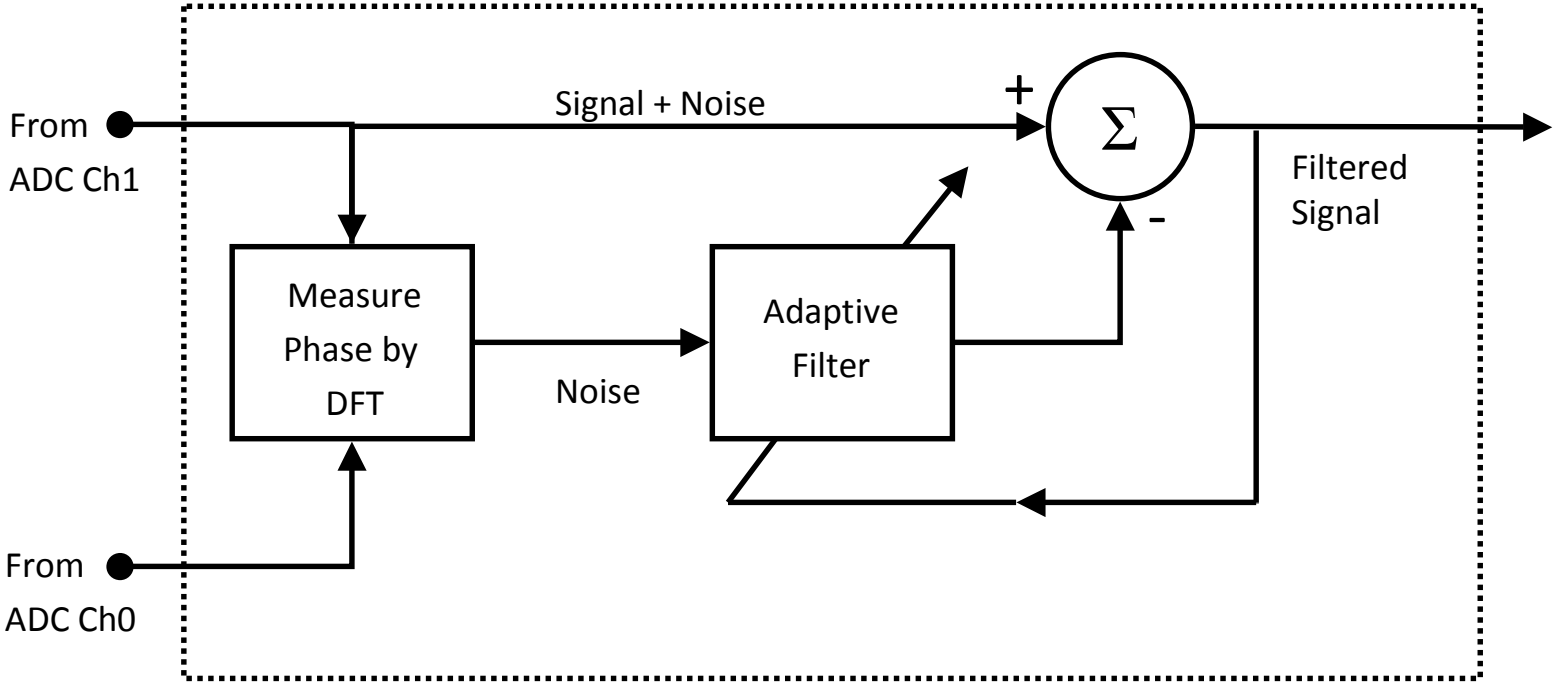




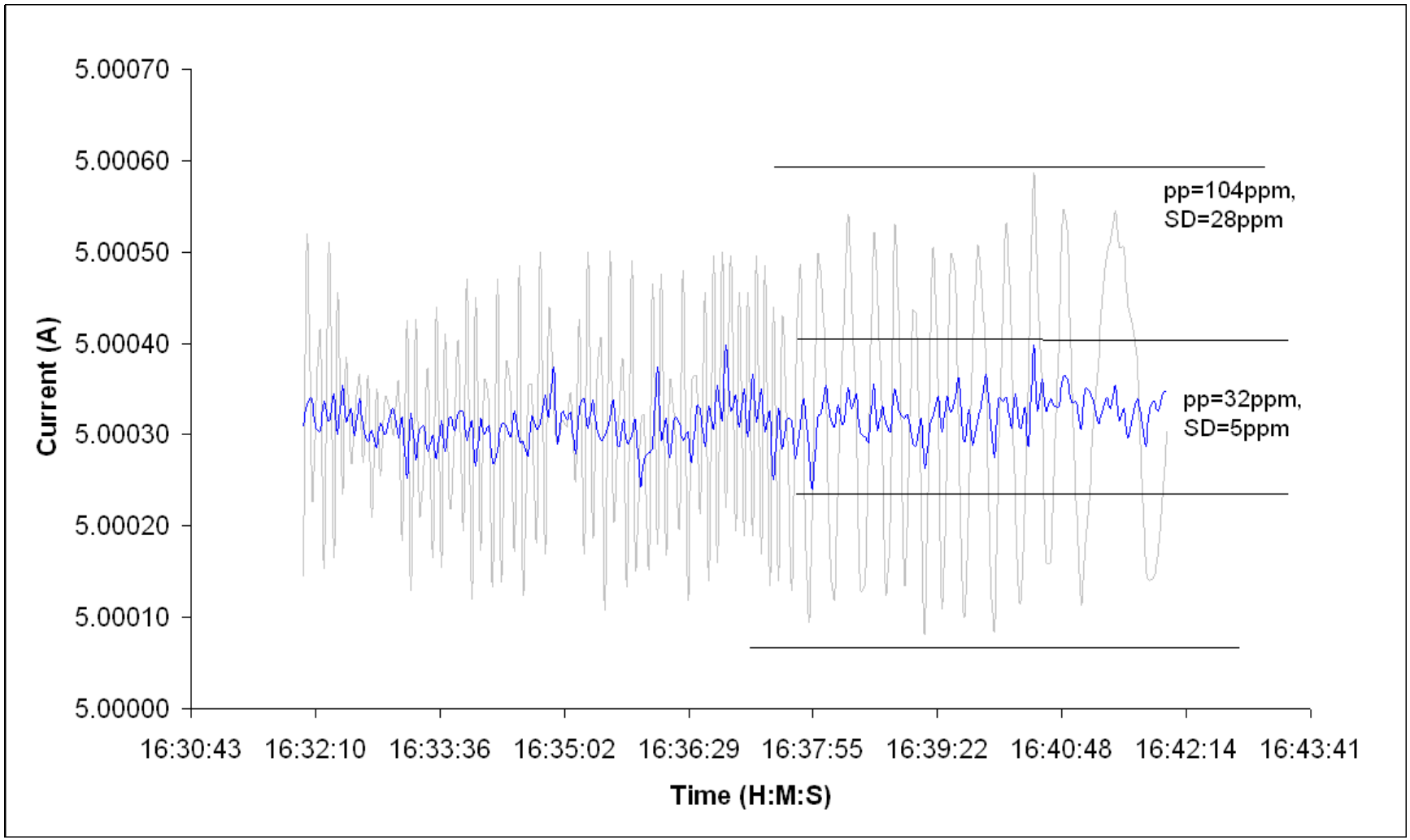
Strong Correlation between the amplifier output and the cosine of phase of the line voltage as it varies relative to the calibrator voltage.

Beat Noise Cancellation Experiment





Application of a Recursive Least Squares Adaptive Canceller



Conclusions

- Adaptive noise cancelling filters are important DSP tools.
- This talk has demonstrated their use in two poorly configured electrical measurements.
- One wouldn’t chose these solutions in the lab! But in the field there maybe no choice.
- It is intended this work be used and adapted to specific field applications as required.
- Further work on optimization metrics for setting up the filters and on uncertainty issues need developments for specific cases.

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