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National Physical Laboratory

A digitizer for on-site power and energy measurements

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Objective / Specification

- Portable – should run on batteries, rugged.
- Isolated – No copper connections for HV safety
- 6 channels – 3 phase V & I
- Sampling trigger by external clock (optical fibre)
- Fast sampling for flicker (72 kHz)
- Environmental conditions of site – temperature range.
- Continuous real-time data collection
- 10 ppm accuracy (linearity, stability etc.)

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Why not buy one ?

- Commercial systems looked generally very good but:
  - Difficulties finding a externally triggered ADC.
  - Questions over suitability for field environment.
  - Suitability for high level language programming
  - Real time processing
  - Desire to understand the working of the instrument.
  - Customization.

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A quick solution

ANALOG DEVICES

Evaluation Board for 24-Bit,8.5mW,109dB, 128/64/32kSPs ADC

Preliminary Technical Data

EVAL-AD7767/67-1/67-2EDZ

FEATURES

Full-featured evaluation board for the:
- AD7767
- AD7767-1
- AD7767-2

CED compatible
Standalone capability
On-board analog buffering and voltage reference
Various linking options
PC software for control and data analysis when used with the EVAL-CED1Z
Linearity Evaluation

GENERAL DESCRIPTION

This data sheet describes the evaluation board for the, AD7767,

and AD7767-2 versions digitally filter more rigorously, meaning that greater noise performance is achieved, trading off on output data rate.

All the AD7767 devices (AD7767, AD7767-1, AD7767-2) offer 18-bit linearity (3ppm).

Full details on the versions of the AD7767 are available in the AD7767 data sheet, which is available from Analog Devices, Inc., and should be consulted in conjunction with this data sheet when using the evaluation board.

ON-BOARD COMPONENTS INCLUDE:

ADR445, 5 V ultrahigh precision band gap reference
Two ADA4841-1 operational amplifiers
(Run from 7.5V and -2.5V external supplies).
Various MCLK options

ANALOG DEVICES

Converter Evaluation and Development (CED) Board

Preliminary Technical Data

EVAL-CED1Z

FEATURES

Interfaces to multiple serial and parallel precision converter evaluation boards
Supports high-speed LVDS interface
32MB SDRAM
4MB SRAM
USB 2.0 connection to PC
User reprogrammable Altera Cyclone FPGA
Provides 8 separate power supplies
Connects directly to Blackfin Ez-Kit

APPLICATIONS

Evaluating Precision Converters
Creation of demonstration systems
Prototyping of end-user systems

GENERAL DESCRIPTION

The CED1 board is part of a next generation platform from Analog Devices Inc., intended for use in evaluation, demonstration and development of systems using Analog Devices precision converters. It provides the necessary communications between the converter and the PC, programming or controlling the device, transmitting or receiving data over a USB link.

PACKAGE CONTENTS

- CED Board
- USB A to Mini-B cable
- 7 Volt 15W Power Supply

FUNCTIONAL BLOCK DIAGRAM

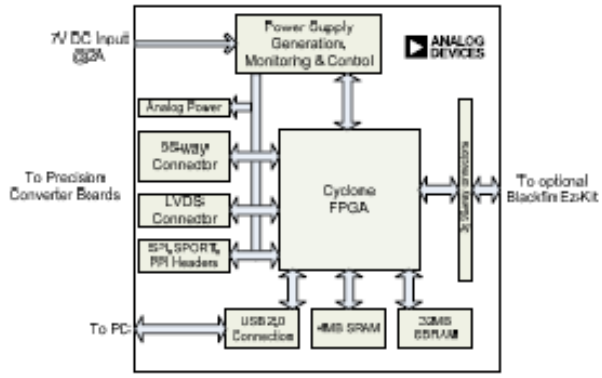

Figure 1.

Analog devices have some excellent ADC ICs

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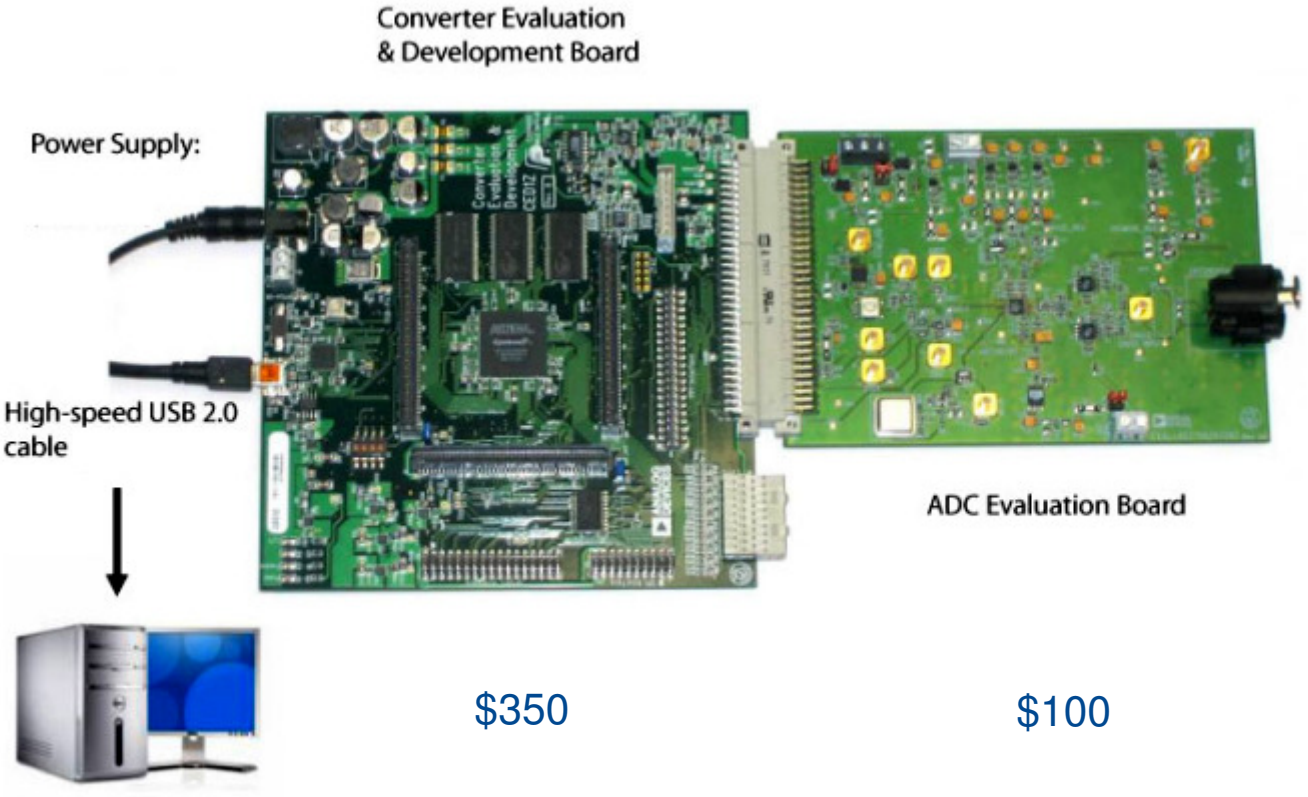
A one day 24 bit ADC



$350

$100

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Very nice – but……..

- Only one channel
- Not isolated
- Uni-polar input
- Power supplies need improvement
- Samples stored to SRAM and downloaded later using USB (limits capture length)
- No anti-aliasing filters

However…

- The ADC is Fast –100kS/s
- It should be good enough for 10ppm
- It is a sampling ADC (an external clock)

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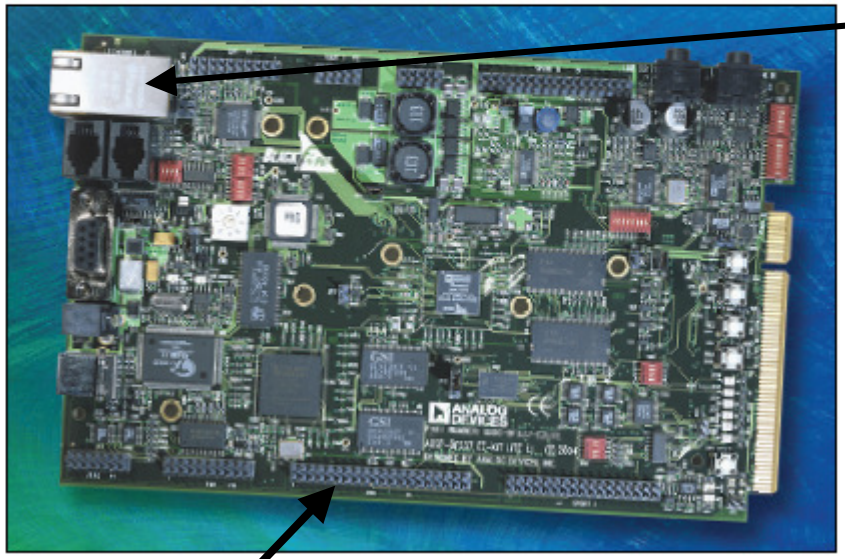
Isolated – Real time Data: Another Evaluation Card..

EZ-KIT Lite for Analog Devices ADSP-BF537 Blackfin Processor

Key Features

- ADSP-BF537 Blackfin Processor
- Max core clock rate 600 MHz
- 64 MB (32M × 16) SDRAM
- 4 MB (2M × 16) flash memory
- SMSC LAN83C185 10/100 PHY with RJ45 connector
- CAN TJA1041 transceiver with two modular connectors
- AD1871 96 kHz stereo DAC with 3.5 mm jack connector
- AD1854 96 kHz stereo ADC with 3.5 mm jack connector
- RS-232 UART line driver/receiver



Ethernet
Can be wireless!

($350)

Parallel Port to FPGA for data transfer and to boot FPGA

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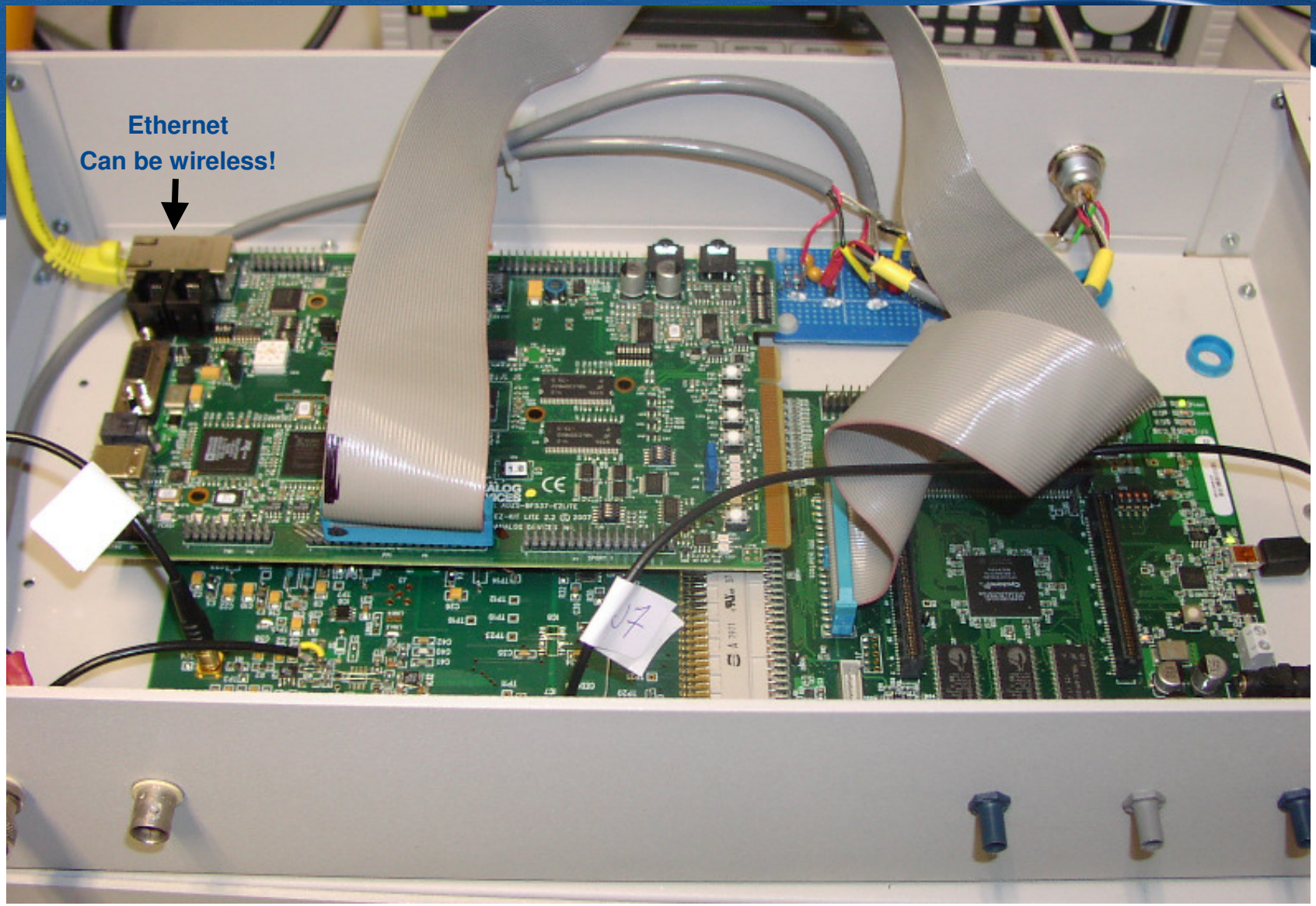

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Approx 700 euro + 1MM

Signal Conditioning & Multiple Channels

- The ADCs can be “daisy chained” to provide multiple channels with one DSP
- Bi-polar operation and anti-aliasing electronics designed
- Optical fibre sampling clock required
- Digital / analogue isolation required
- Isolated power supplies – floating channels.

Design and build a PCB for each analogue channel

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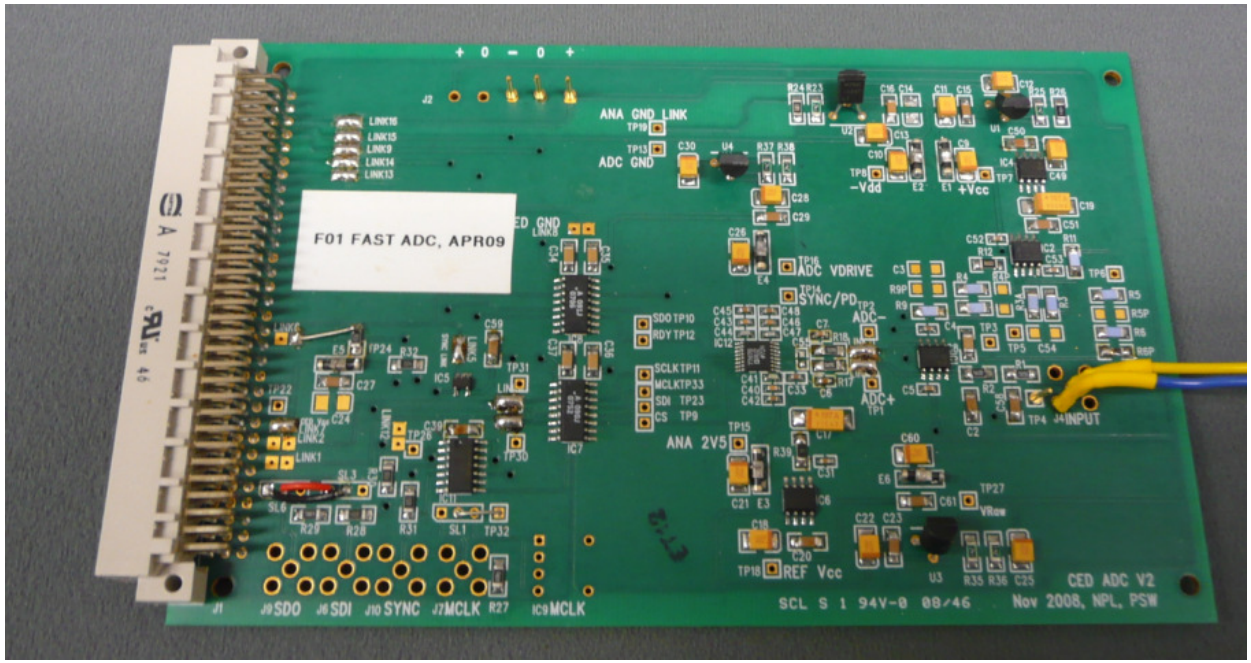
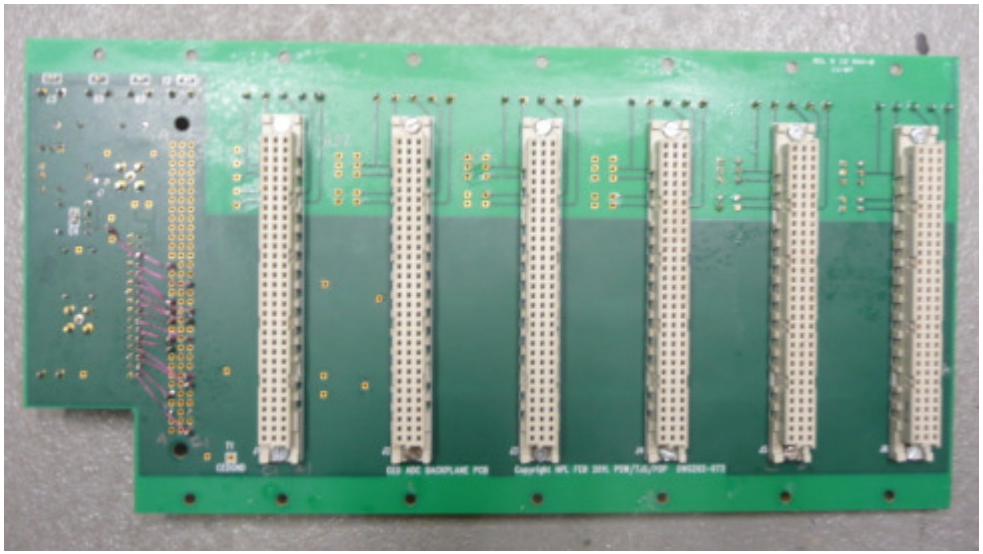
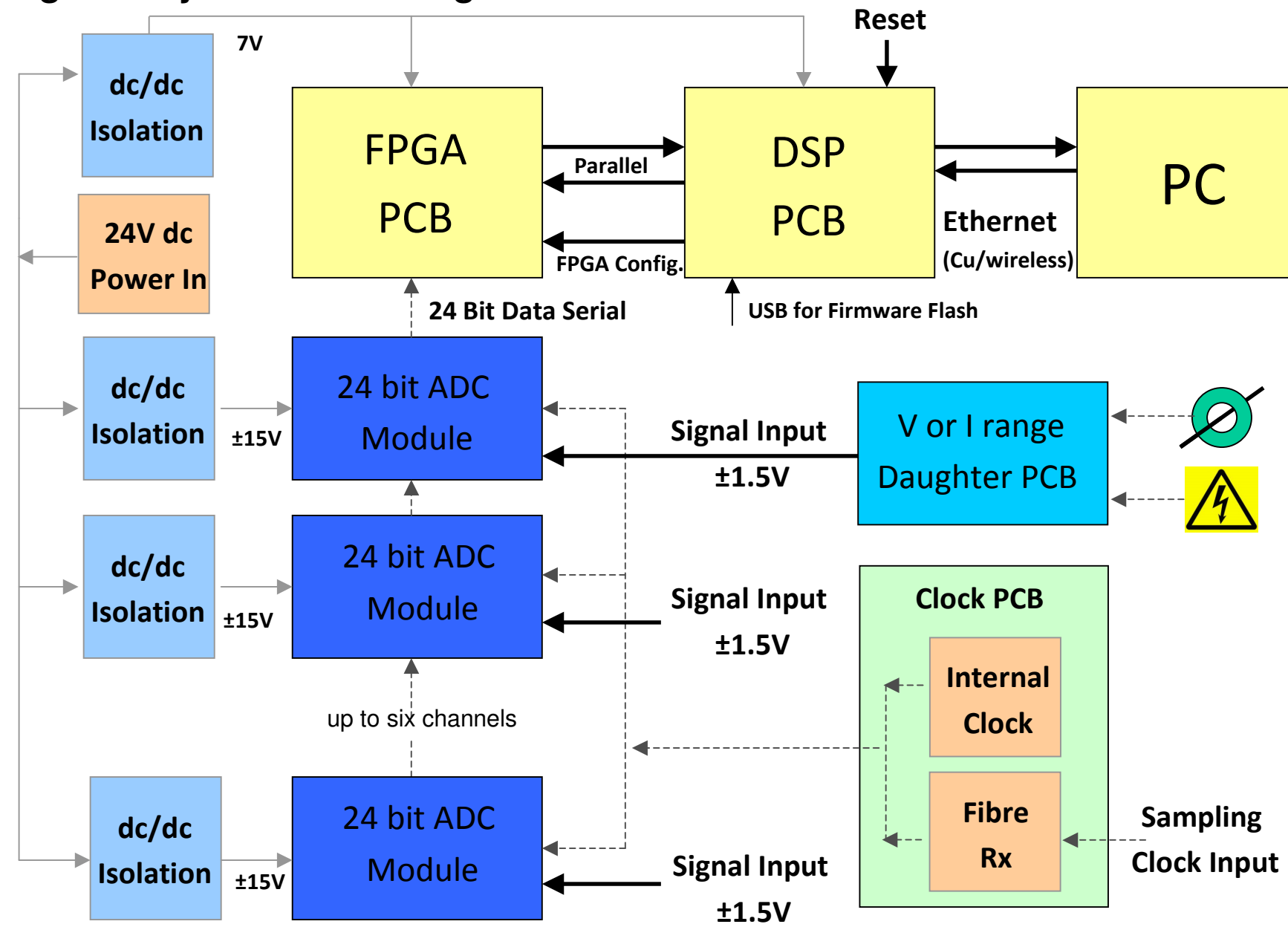
24 Bit ADC Eurocard – One channel

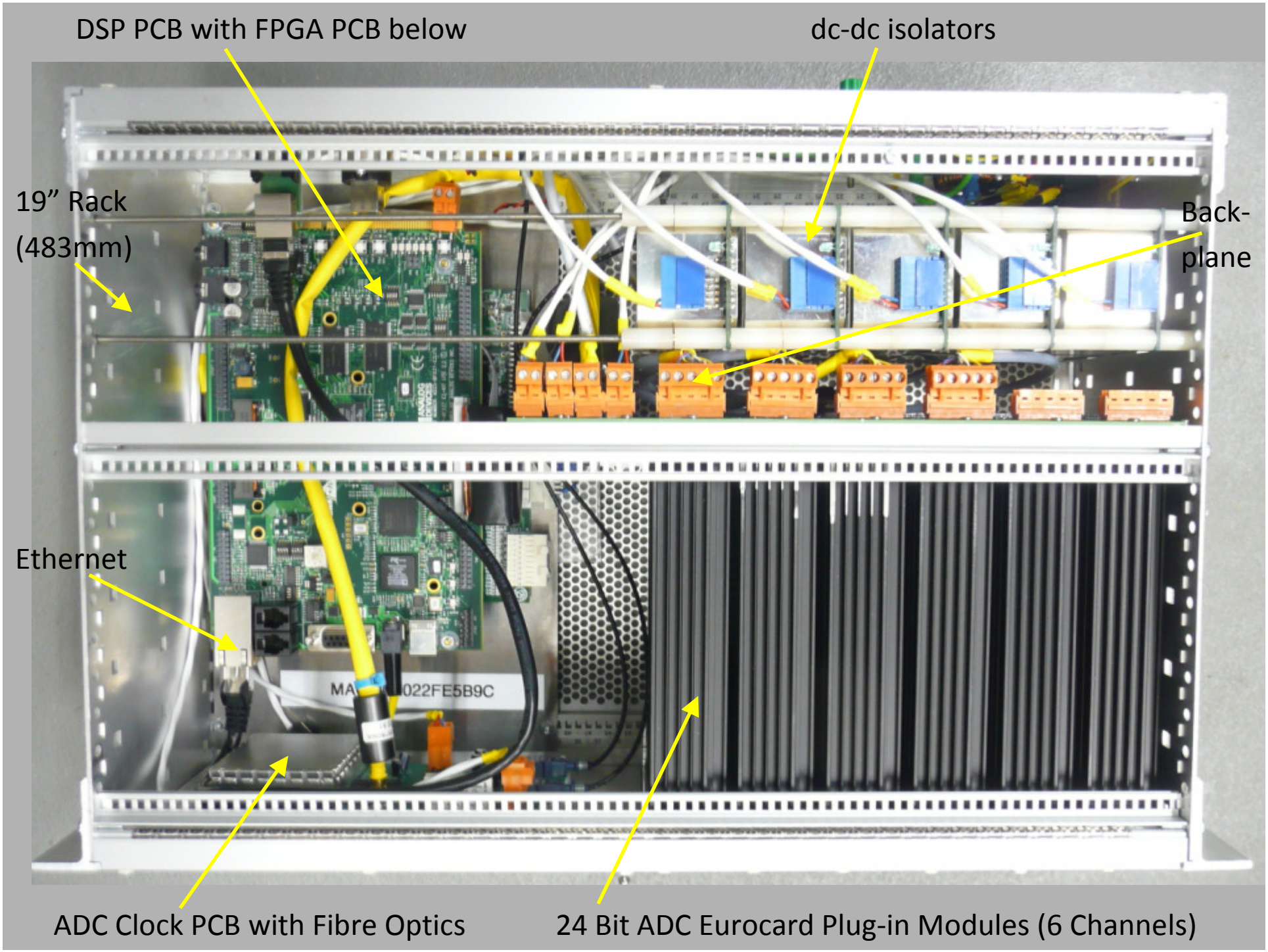


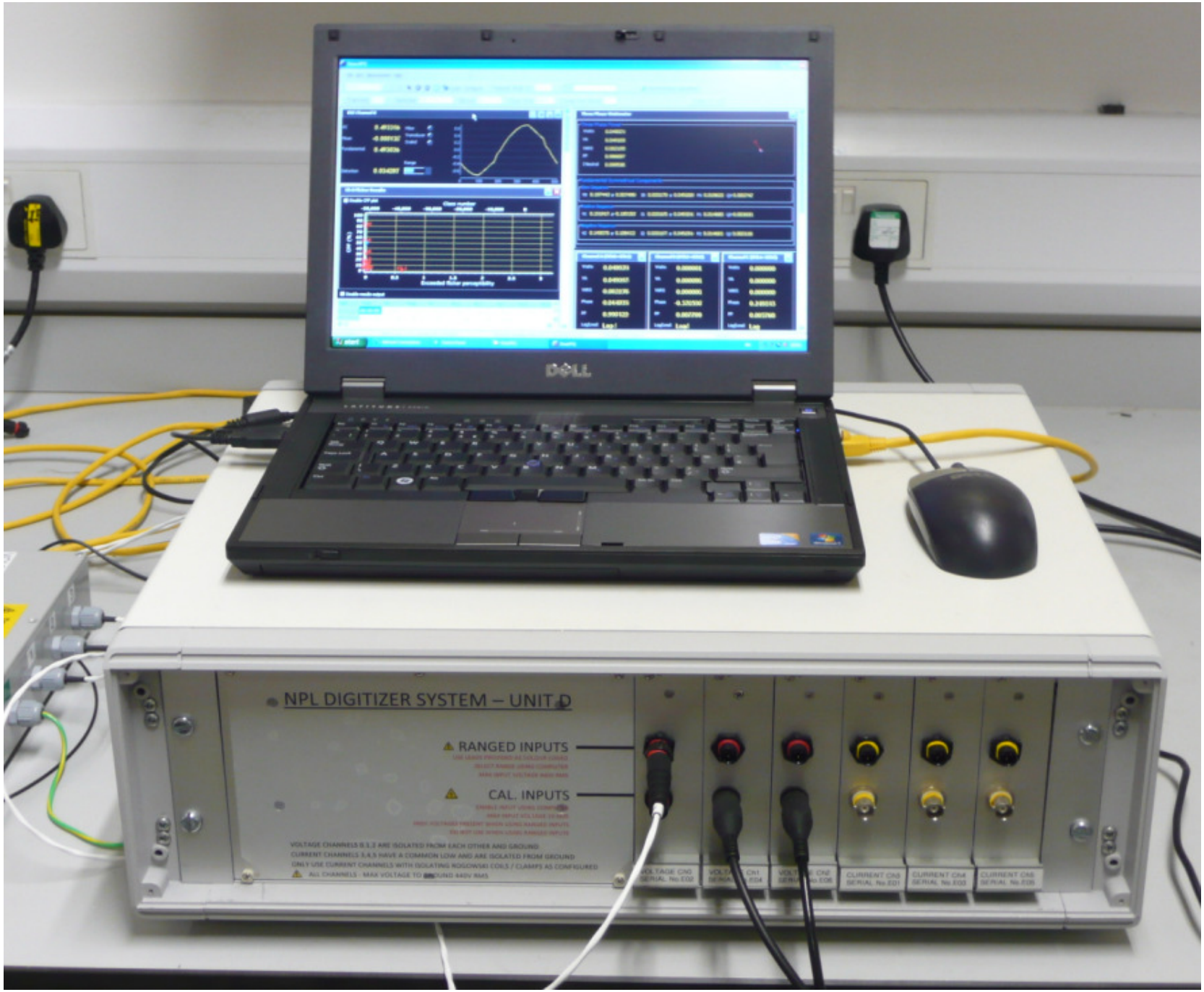
Backplane

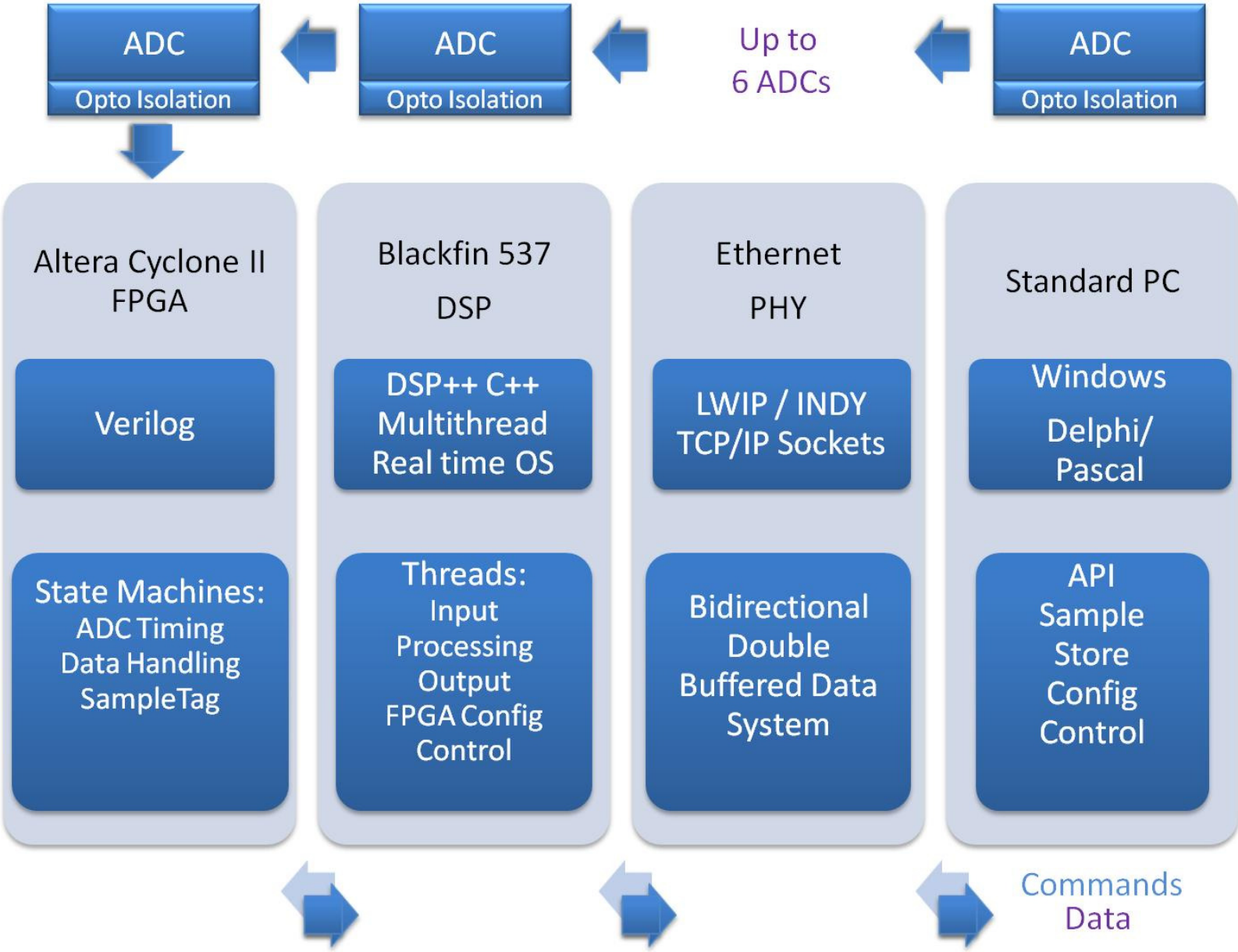


Digitizer System Block Diagram




DSP PCB with FPGA PCB below
dc-dc isolators
19” Rack
(483mm)
Back-
plane
Ethernet
ADC Clock PCB with Fibre Optics
24 Bit ADC Eurocard Plug-in Modules (6 Channels)


NPL DIGITIZER SYSTEM – UNIT D
RANGED INPUTS
CAL. INPUTS
DELL


ADC
Opto Isolation
ADC
Opto Isolation
Up to
6 ADCs
ADC
Opto Isolation
Altera Cyclone II
FPGA
Verilog
State Machines:
ADC Timing
Data Handling
SampleTag
Blackfin 537
DSP
DSP++ C++
Multithread
Real time OS
Threads:
Input
Processing
Output
FPGA Config
Control
Ethernet
PHY
LWIP / INDY
TCP/IP Sockets
Bidirectional
Double
Buffered Data
System
Standard PC
Windows
Delphi/
Pascal
API
Sample
Store
Config
Control
Commands
Data

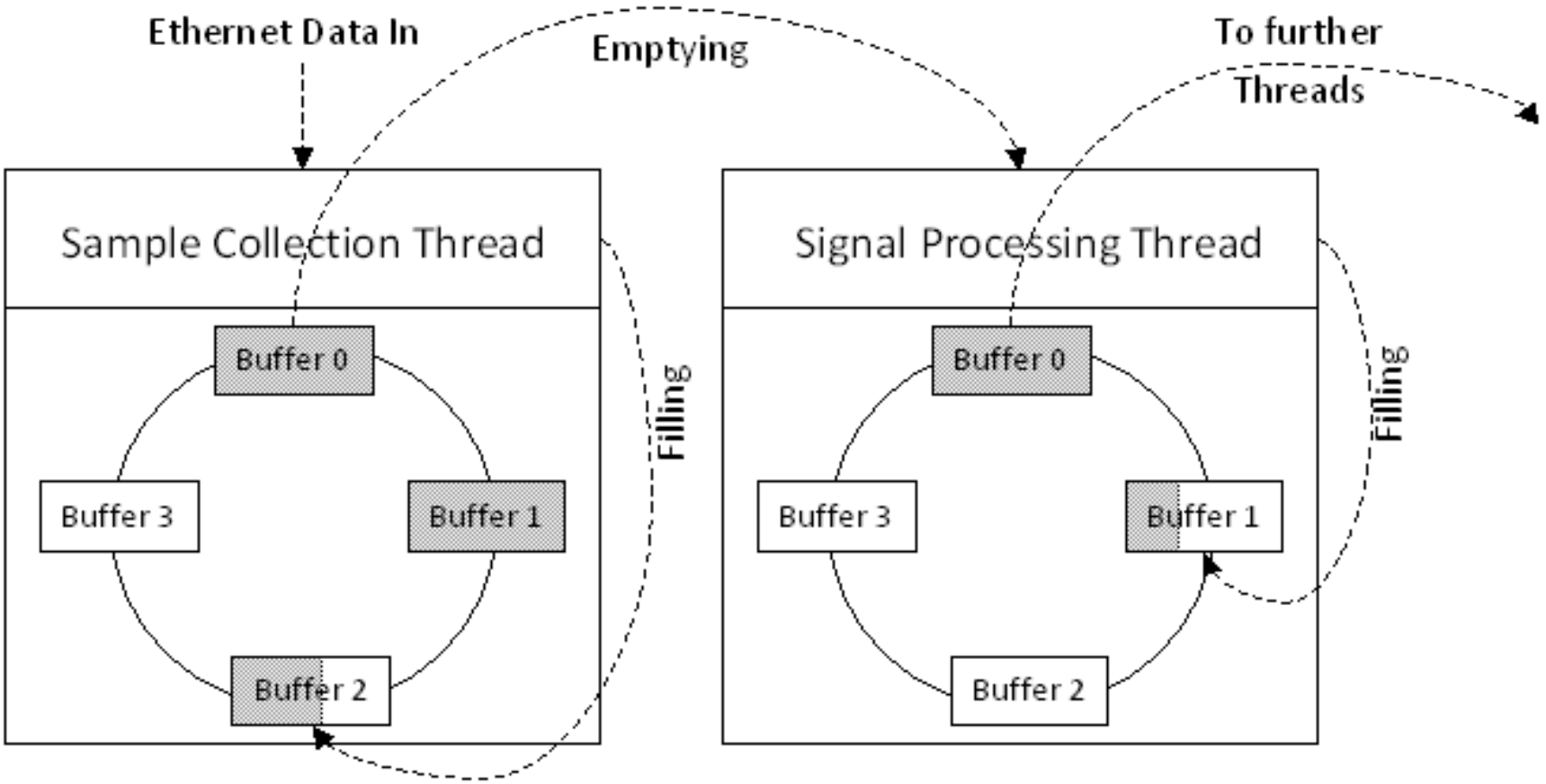
Real Time Asynchronous Sampling PQ Software

It is possible to log the following continuously to disk at rates up to once per cycle:

- 6 channels of V & I: rms, fundamental, dc, phase angle.
- Single/three phase Watts, VA, VAR, PF
- Fundamental symmetrical components.
- Harmonics with interharmonic sweep (IEC61000-4-7)
- Flicker using NPL standard flicker meter.
- Dips and Swells as IEC61000-4-30.
- Temperature (3 probes).

6 Channels - 32kHz sampling rate – 6.144MBits/second

Real Time Multi-thread scheme



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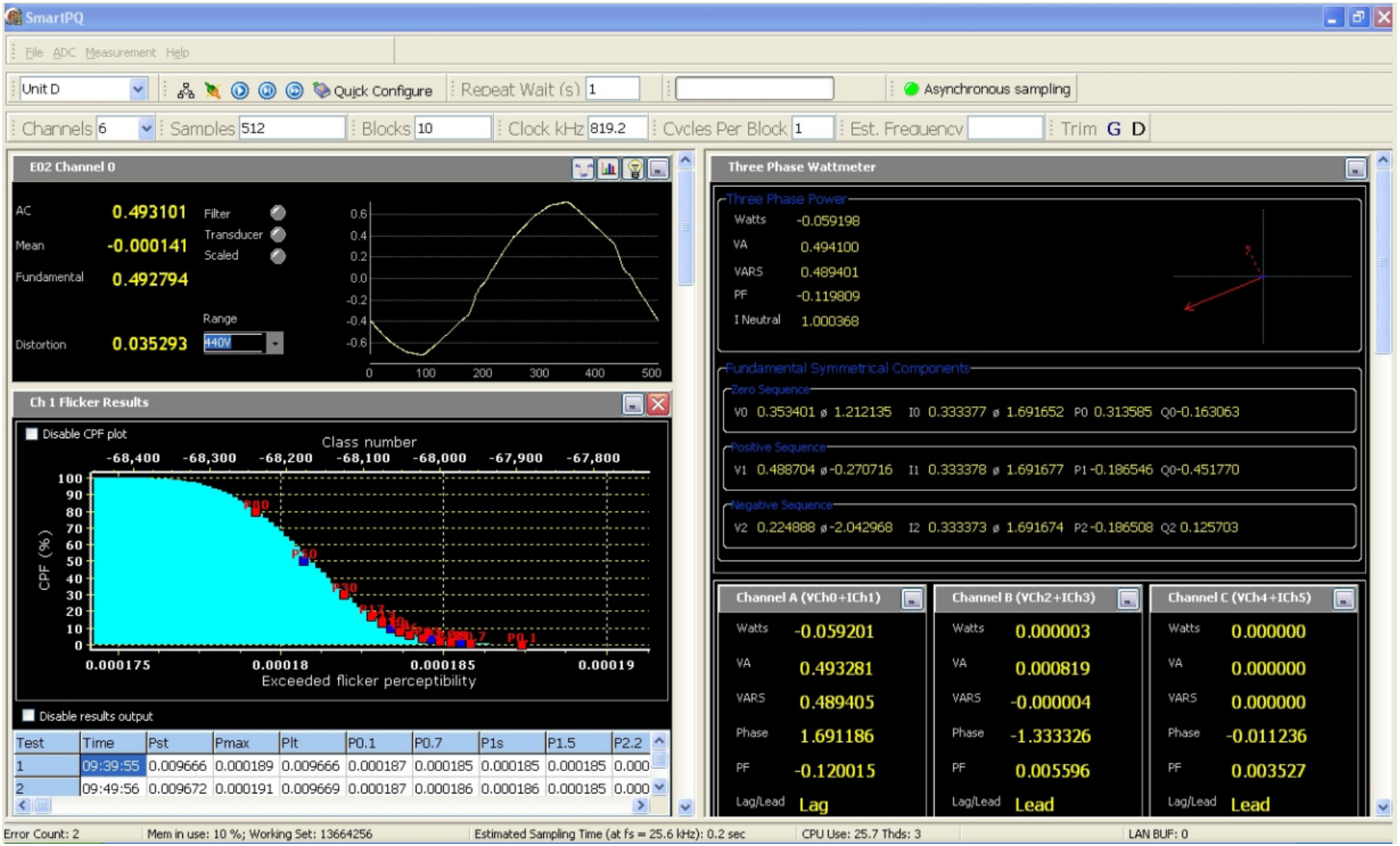
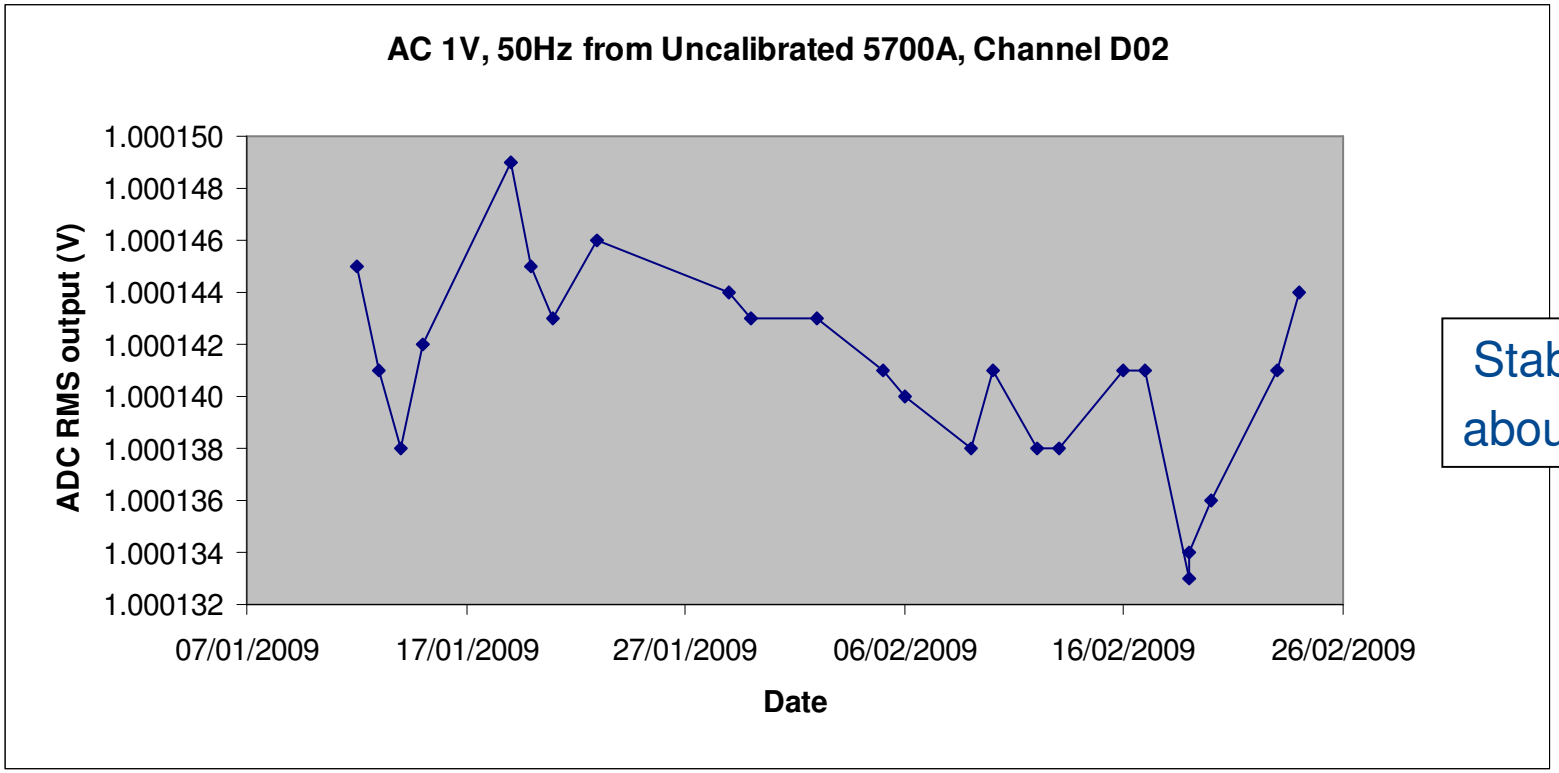
Real-time PC Software collects data over Ethernet processes, stores and displays.

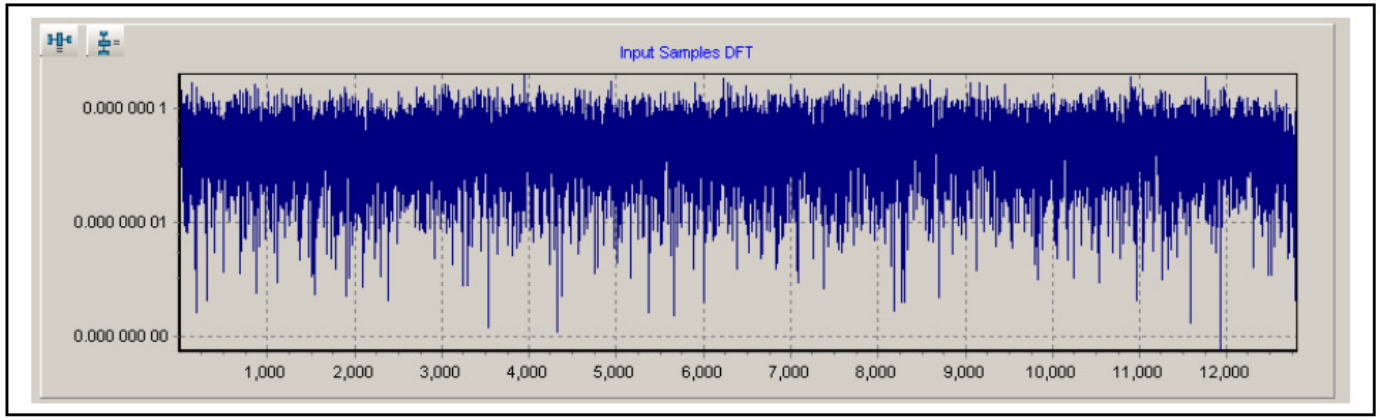


Some Results



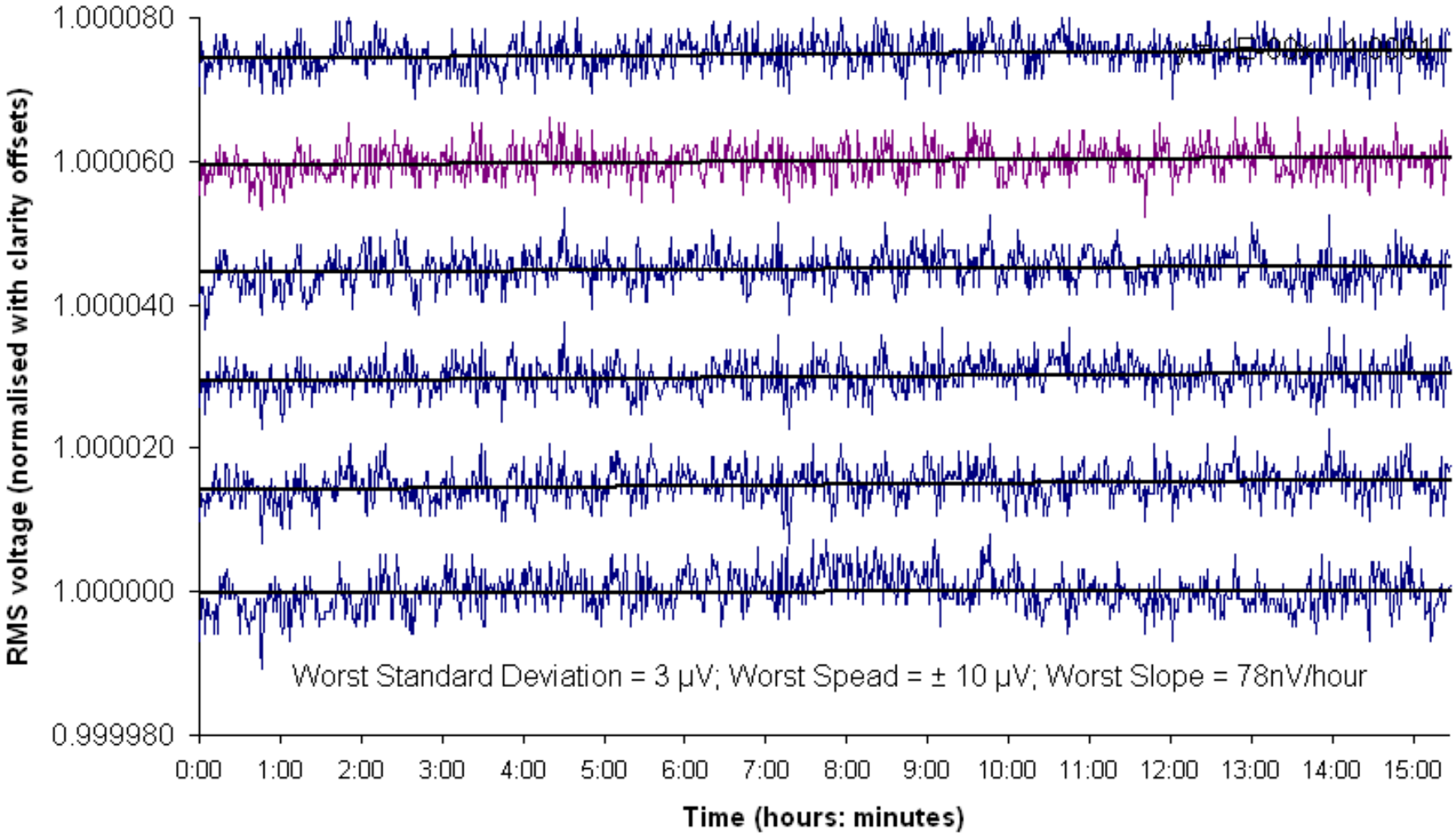
Stability over about 6 weeks

Noise Floor (shorted Input)

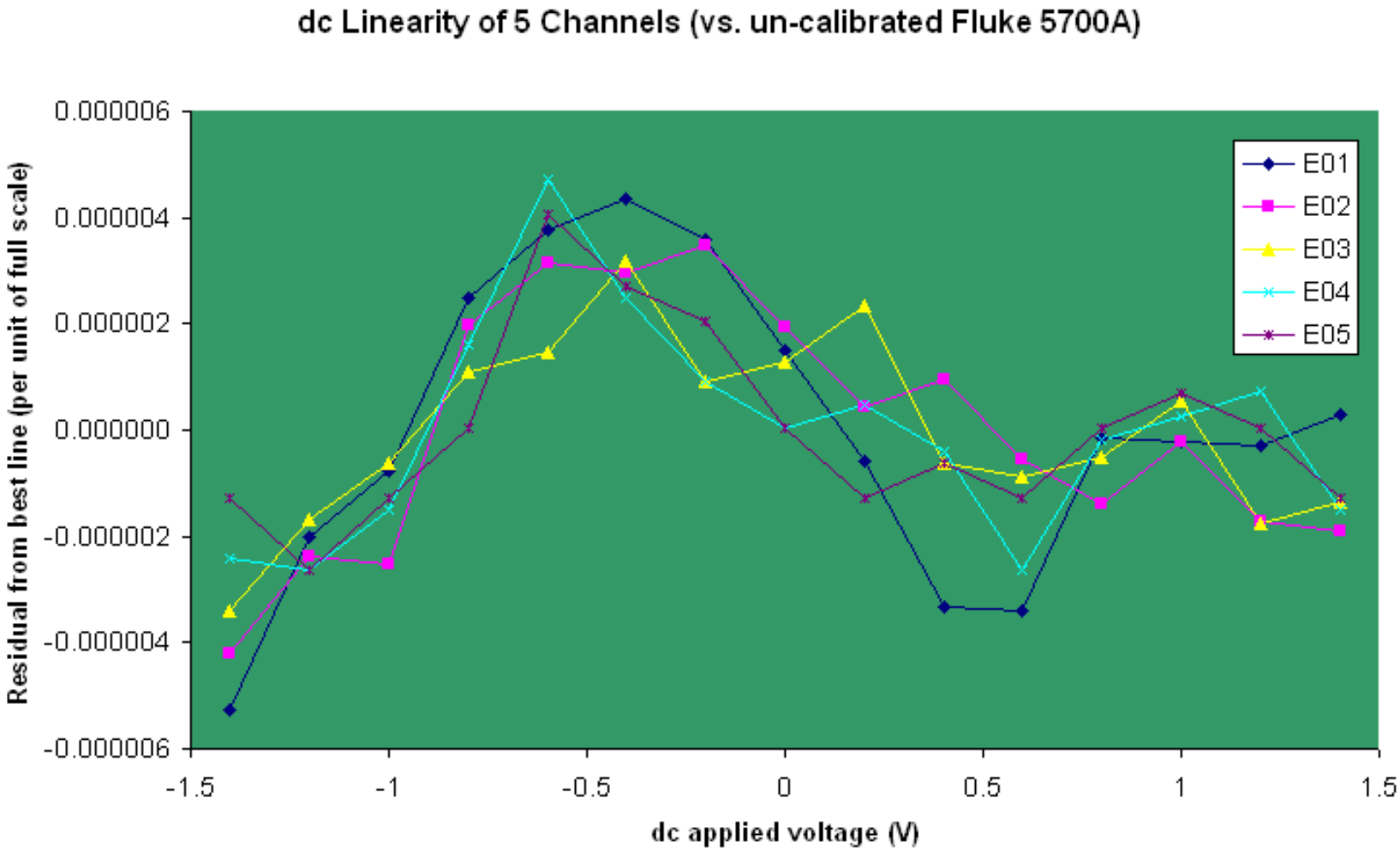


1 in 10-7 noise floor as in data sheet.

Six digitizer channels (offset for clarity) drift over 15 hours at 1V, 40Hz. Trend lines shown on each.

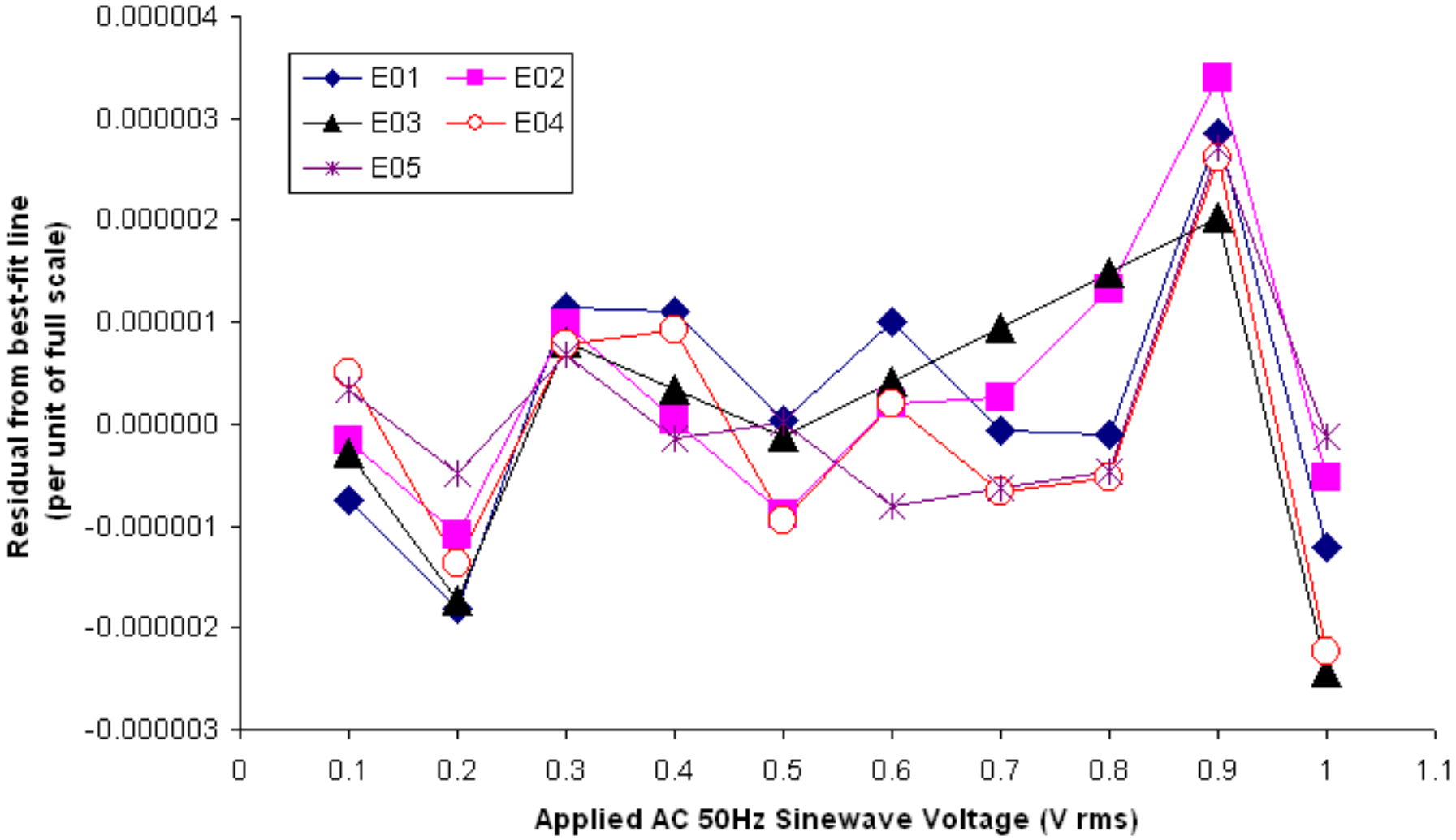


DC Linearity

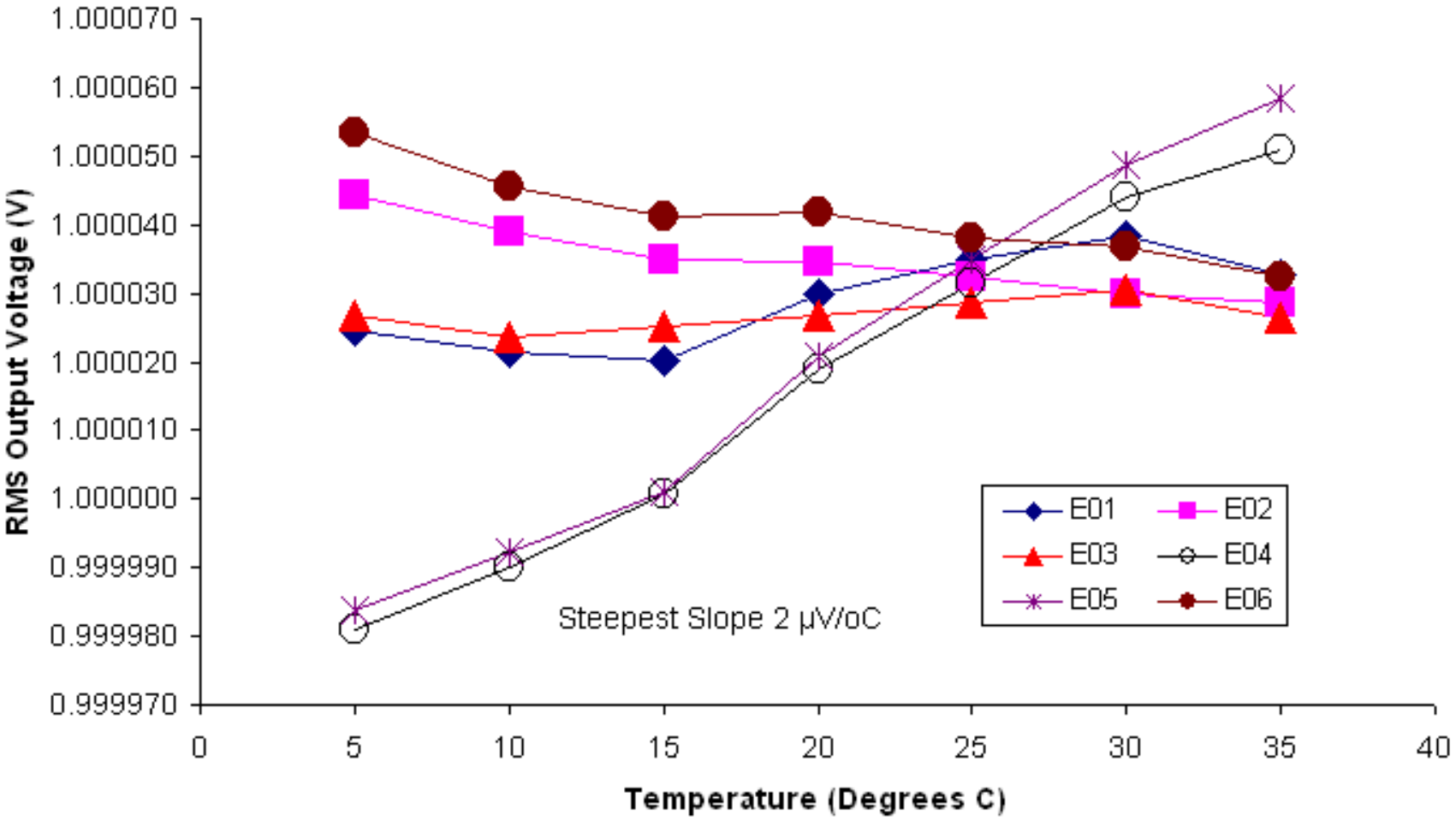


- Un-buffered Input Impedance at 50Hz = 7.5M ohm
- With buffer retrofit = 10^{13} ohm, 1pF.

AC Linearity



Temperature Coefficient



Uncertainties

RMS Voltage Lab Measurment at 50Hz

Contribution	*Notes*	*Uncertainty µV/V*
AC Calibration	Contributions of a calibration against AC/DC Transfer device (4920)	6
Gain Drift	Calibrated in past 10 hours	1
Noise	Variation in AC Values	6
Linearity	10% to 100% of 1V RMS range	1
Temperature	Controlled to ± 1 oC	2
Total k=1		9
Phase	Between two channels at 50Hz	1 µ radian

Field based Measurement at 50Hz (not including transducer)

AC Calibration	As above calibrated before leaving laboratory	6
Gain Drift	40 day	6
Noise	Variation in AC Values	6
Linearity	10% to 100% of 1V RMS range	1
Temperature	Un-Controlled ± 20 oC from cal temperature	40
Total k=1		41

Additional Work Beyond WP2 Deliverable for On-site PQ Use

- Real time PQ Software
- Voltage Input Amplifier Retrofit (440V,220V,110V,63.5V,20V,10V,1V computer selectable ranges).
- Rogowski Coil Integrator Amplifier Retrofit (10kA,1kA,100A,10A computer selectable ranges)
- GSM/3G Data Communications.
- Temperature logging and GPS channel.
- Over current and overvoltage Protection boxes.
- Winter heater & temperature controller.

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Peli-Case Design

Target Date:

Ready for Smart Grid PQ Monitoring

September 2011.