PRECISION DIGITIZERS FOR POWER & ENERGY MEASUREMENTS

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with consent of Analog Devices Inc.
Metrology Grade Digitising Technology for Power Quality Measurements (PTB, NPL, MIKES, TRESCAL, VSL, METAS, LNE, INRIM)

1. Compact three phase voltage digitiser up to the 50th harmonic of the mains (PTB).
   a) ADC interface with USB to PC, b) self-cal., c) Self-Locking (pat. pending) & async, d) DSP is a PC, e) Ultra-Linear & unc. < 10 ppm, f) for lab. applic. (RMS, Phase, Ratio, & self-checking), e) Allow other ADCs to be used, e.g., A3458A, AD7763 (Sigma-Delta) & SAR AD7767.

2. Portable three phase digitiser for on-site measurement of the high voltage grid (NPL, MIKES).
   a) ADC 7767 interfaced to AD DSP (pre-processing data) & Wireless data transfer, b) async. Sampling, c) further DSP is a PC, d) Ultra-Linear & unc. < 50 ppm (close to above), e) for live lines.


5. Metrological characterisation of digitisers (METAS, LNE, INRIM, VSL).
Compact three phase voltage digitiser with a frequency range up to the 50th harmonic of the mains (PTB)

Design constraints:
- uncertainties < 10E-6 V/V
- compact
- self-locking¹ (digitally)
- easy calibration (chopped DC & AC)
- ac metrology: phase, ratio, ac power...
- any ADC (IADC, SAR, S-D)
- intelligent (?, algorithms)

¹ German Patent Application DE 10 2007 043 927 A1

Workshop JRP P&E, Norwijk – Holland - March 2011.
Compact three phase voltage digitiser

DDS Synchronizer allow different ADCs to be synchronized: Sigma-Delta, SAR, Dual-Slope
Synchronizer, high res. Time base, Multiplex.
Compact three phase voltage digitiser
Complete
Compact three phase voltage digitiser
Updated

Compact three phase voltage digitiser
Software (on PC)
Compact three phase voltage digitiser
Software (on PC)
Compact three phase voltage digitiser

Updated

Internal SAR ADC 24 Bit, max. 128 kHz, Nonlinearity < 10 ppm!
Compact three phase voltage digitiser
Updated

ADC Data Out

VT (60, 120, 240, 480 V)

CT (1, 2, 5, 10…100A)
Compact three phase voltage digitiser
Voltage Transformer

H-Series (Z-Foil) hermetically sealed
Time-constant < 1ns

Super Gain Amplifier: $10^{09} - 10^{12}$ V/V
Compact three phase voltage digitiser

Some figures

Nonlinearity ADC of USS from Ratio Measurements

Vin = 8.5 Vp
fo = 62.5 Hz (Sync by Software)
Sampling rate: 128 kHz
CH1: input, CH2: IVD output
Compact three phase voltage digitiser

Some figures

Nonlinearity ADC of USS from RMS Meas

Deviation (µV/V) vs. IVD Setting - k for different frequencies:
- 16 kHz
- 32 kHz
- 64 kHz
- 128 kHz
Compact three phase voltage digitiser
Some figures

Spectrum AD7767

![Graph showing spectrum AD7767]
ADC Error in respect to HP3458A in AC SYNC

- Fundamental (at 62.5 Hz): 4 V
- Spur: -40 dB added (nibbles)
- ADC sampling rate: 128 kHz
- Nyquist bandwidth: 64 kHz
- No of sampled points: 16384
- Nibble: 128 kHz/16384 = 7.8125 Hz
• 24 bit delta sigma ADC, **24 bit SAR**.
• Uses a DDS Synthesizers to generate variable sampling frequencies for digital PLL: Soft-Sync., asynchronous meas. also possible.
• Allow tight synchronous meas., quasi-sync and asynchronous too.
• Allow Agilent 3458A to be used if desired (not a must!)
The same unc. figures as the PTB primary standard.
• Internal SAR with comparable performance as the Agilent 3458A, allowing but higher sampling rates.
• Ultra-pure sinewave gen. (Spurs < -180 dB) locked to a quartz time base was developed to investigate ADCs.
• Improvements: Synchronizer with FPGA.

• Multiple ADCs to be read by FPGA & USB 2.0.

• Replacement of Agilent 3458A by USS (PTB).

• Improvements on ultra-pure sinewave generator.
Future work

THERMALLY COUPLED OSCILLATORS AS PRECISION THERMAL CONVERTERS

THANK YOU!