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iMERA PLUS

Session 3

Algorithms for Power and Energy Measurements

Paul Clarkson, NPL

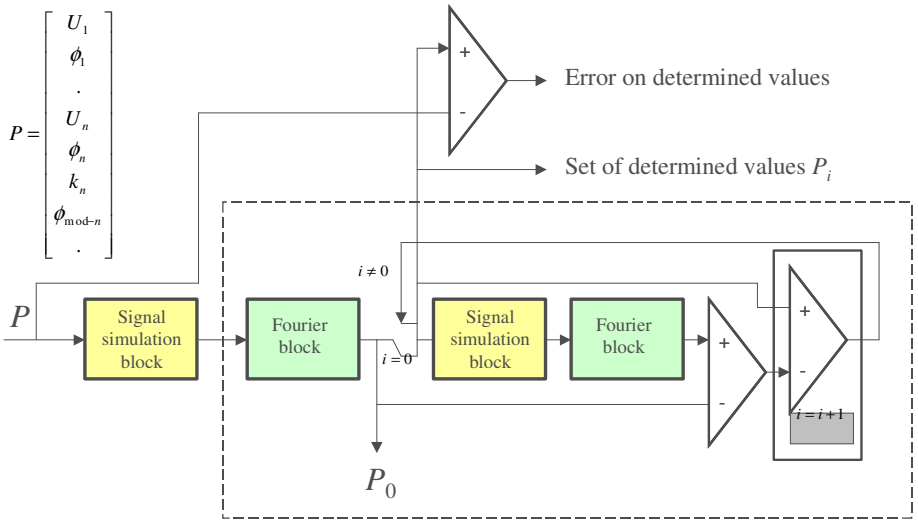
Task 1 Develop/adapt analysis algorithms for the accurate determination of power quality parameters – PTB, LNE, CEM, NPL

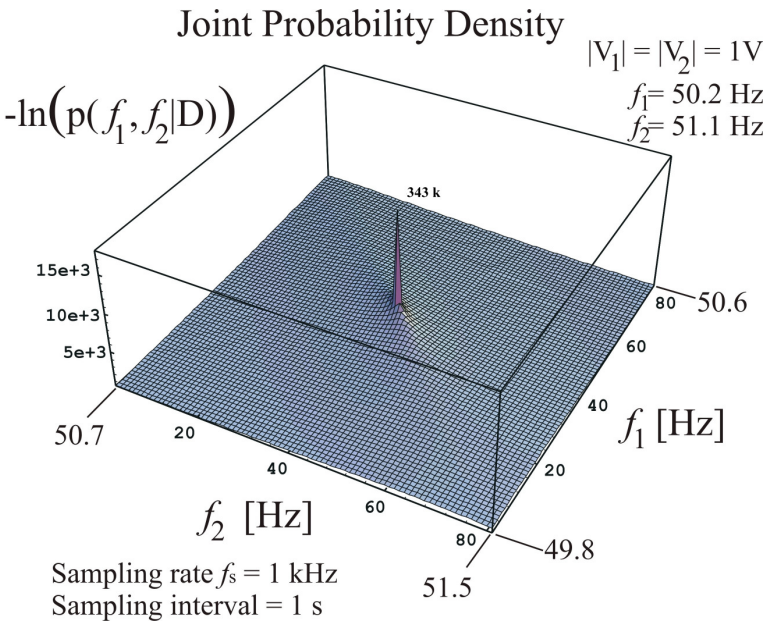
Task 2 Develop asynchronous sampling techniques suitable for application to power quality measurements – NPL, SIQ, INRIM

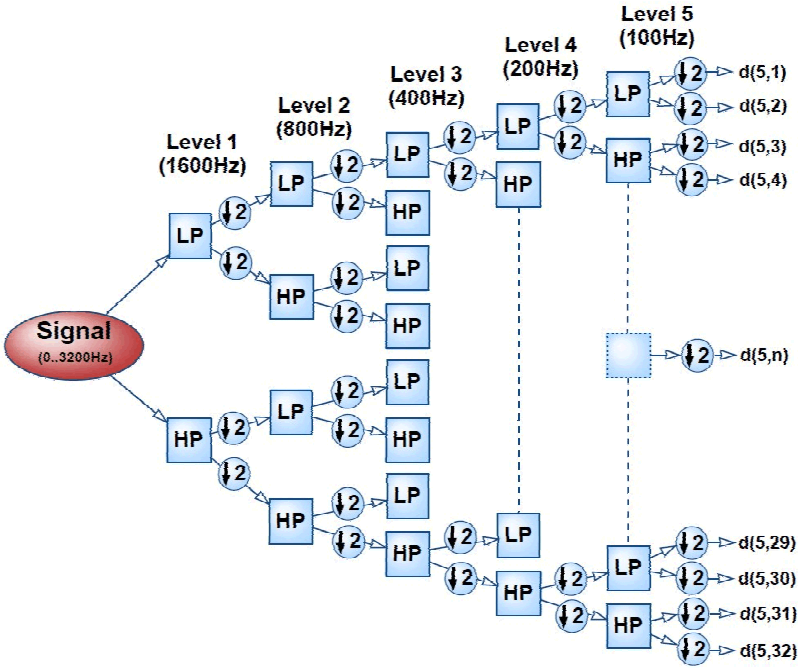
Task 3 Develop noise mitigation techniques/algorithms to improve Power Quality measurements – NPL, PTB

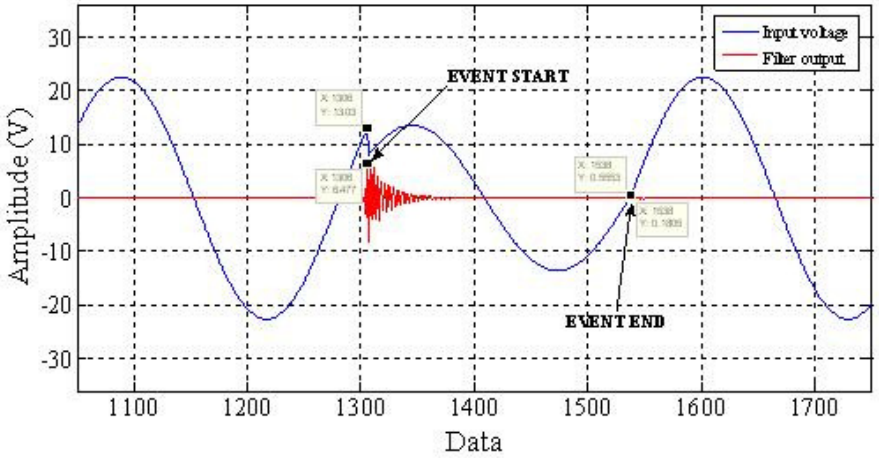
Fluctuating harmonics

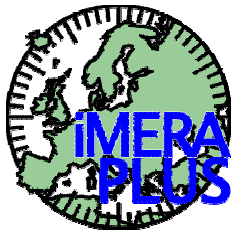
- LNE Windowing techniques – Applied to signals containing harmonics modulated by square and sinewaves – Applicable to harmonic analyser calibration, recovers modulation depths and harmonic amplitudes
- CEM – Wavelet techniques isolate energy into frequency bands and give T-F distribution
- PTB – Bayesian inference, very promising and more generally applicable


P =
U_1
ϕ_1
U_n
ϕ_n
k_n
$\phi_{\text{mod}-n}$
P
Signal simulation block
Fourier block
Signal simulation block
Fourier block
Error on determined values
Set of determined values P_i
$i \neq 0$
$i = 0$
$i = i+1$
P_0


Joint Probability Density
$|V_1| = |V_2| = 1V$
f_1= 50.2 Hz
f_2= 51.1 Hz
$-\ln(p(f_1, f_2|D))$
343 k
15e+3
10e+3
5e+3
50.7
20
40
60
80
f_2 [Hz]
50.6
49.8
51.5
f_1 [Hz]
Sampling rate f_s = 1 kHz
Sampling interval = 1 s


Signal
(0..3200Hz)
Level 1
(1600Hz)
Level 2
(800Hz)
Level 3
(400Hz)
Level 4
(200Hz)
Level 5
(100Hz)
LP
HP
d(5,1)
d(5,2)
d(5,3)
d(5,4)
d(5,n)
d(5,29)
d(5,30)
d(5,31)
d(5,32)


Input voltage
Filter output
EVENT START
EVENT END
Amplitude (V)
30
20
10
0
-10
-20
-30
1100
1200
1300
1400
1500
1600
1700
Data



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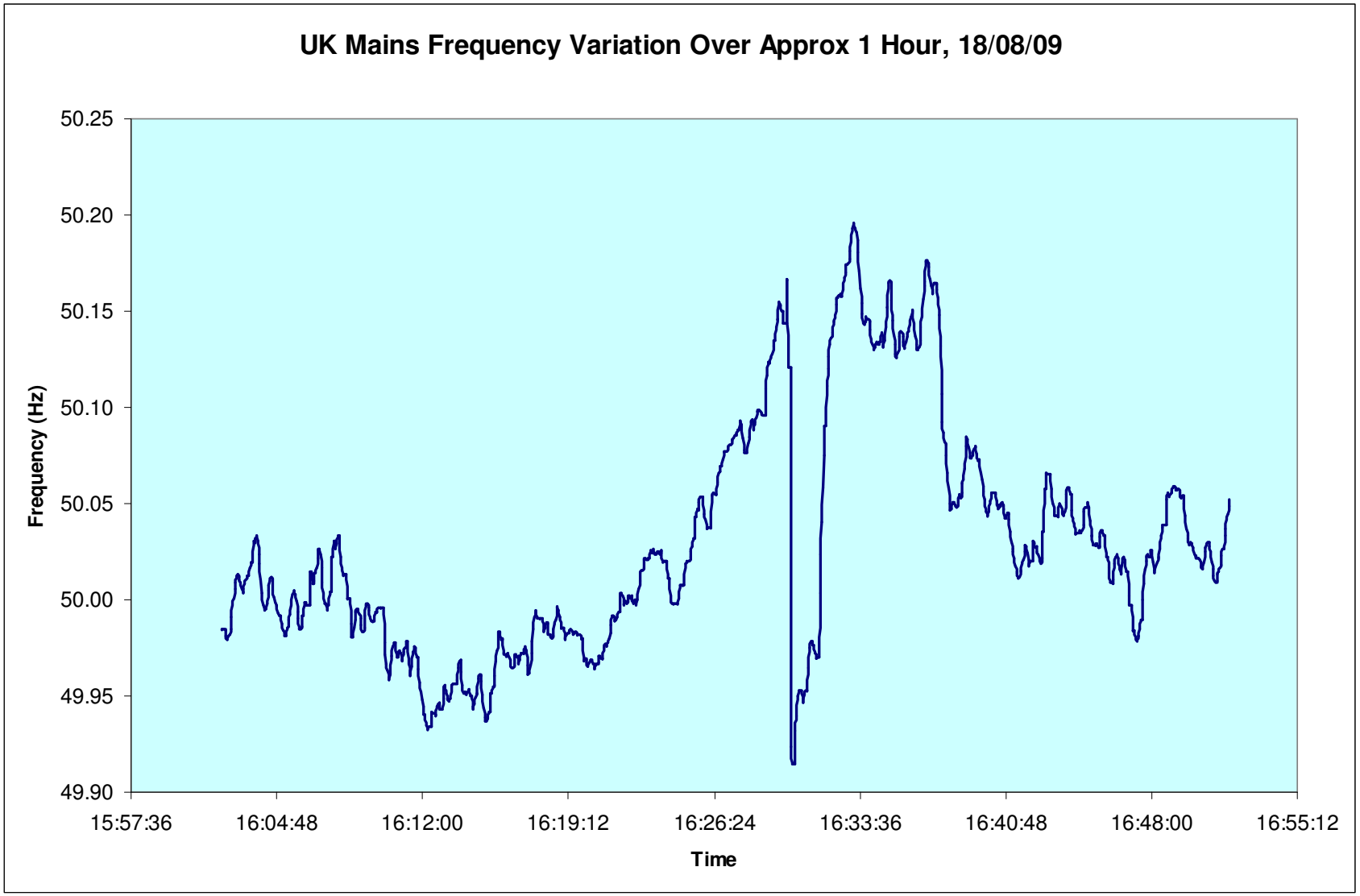
Task 2 Develop asynchronous sampling techniques suitable for application to power quality measurements – NPL, SIQ, INRIM

Presentation by Rado Lapuh, MIRS/SIQ –
"Methods and comparisons of asynchronous Sampling applied to ac measurements"

Mains frequency variation



Correction algorithms

- MIRS/SIQ – Phase Sensitive Frequency Estimation with interpolated phase (PSFEi)
- NPL – Time Domain Interpolation and Scanning (TDIS)
- INRIM – Dynamic Segmented Phase Shift/Harmonic Best Fit (D-SPS/HBF)
- 4 Parameter Sine Fit (4PSF)
- Quinn Estimator

Testing performance

- Algorithms compared with real sampled waveforms
- Frequency estimates of voltage and current waveforms were compared
- Laboratory equipment and railway power line data used

Task 3 Develop noise mitigation techniques/algorithms to improve Power Quality measurements – NPL, PTB

Presentation by Paul Wright, NPL – "Application of adaptive noise cancelling filters in ac electrical measurements"

Achievements

- Comprehensive PQ standards review
- Task 1 algorithms – LNE method can be applied to analyser calibration
- Task 1 algorithms – Integration into on-site measurement software
- Task 2 algorithms successfully implemented in on-site measurement software
- Task 2 SIQ methods also used for oscilloscope calibration
- Task 3 Adaptive filtering techniques successfully implemented in on-site measurement software

Papers

- Task 1 – Fluctuating harmonics – A. Poletaeff and P. Espel, “New method for determination of amplitude and modulation depth of fluctuating harmonics”, Proc. 17th Symp. IMEKO TC4, Kosice (Slovakia), 8-10 Sept. 2010.
- Task 1 – Fluctuating harmonics – A. Poletaeff and P. Espel, “New approach for the determination of the characteristics of signals containing fluctuating harmonics”, submitted to Metrologia, 2010.
- Task 2 – Asynchronous sampling – R. Lapuh, P. Clarkson, U. Pogliano, P. S. Wright and J. Hällström, “Comparison of Asynchronous Sampling Correction Algorithms for Frequency Estimation of Signals of Poor Power Quality”, Accepted for publication, IEEE Trans. Instrum. Meas.
- Task 3 – Noise reduction – P. S. Wright and P. Clarkson, “Application of Adaptive Noise Cancelling Filters to AC Electrical Measurements”, CPEM 2010, June 2010.