REPUBLIC OF SLOVENIA
MINISTRY OF HIGHER EDUCATION, SCIENCE AND TECHNOLOGY
METROLOGY INSTITUTE OF THE REPUBLIC OF SLOVENIA

EURAMET European Association of National Metrology Institutes

EMRP European Metrology Research Programme
Programme of EURAMET

SIQ Slovenski institut za kakovost in merosłovje
Slovenian Institute of Quality and Metrology

EMRP 2007

Next generation of power and energy measuring techniques

'Power & Energy'

WP4

by Rado Lapuh, MIRS/SIQ
P. Clarkson, P. Wright, J. Hällström, U. Pogliano

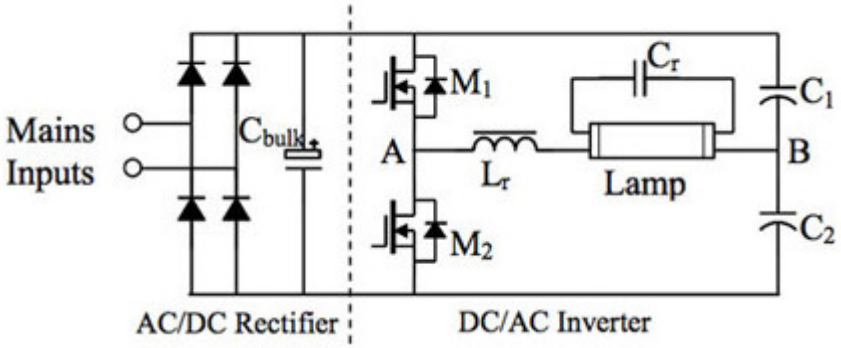
22-23 March 2011, Delft

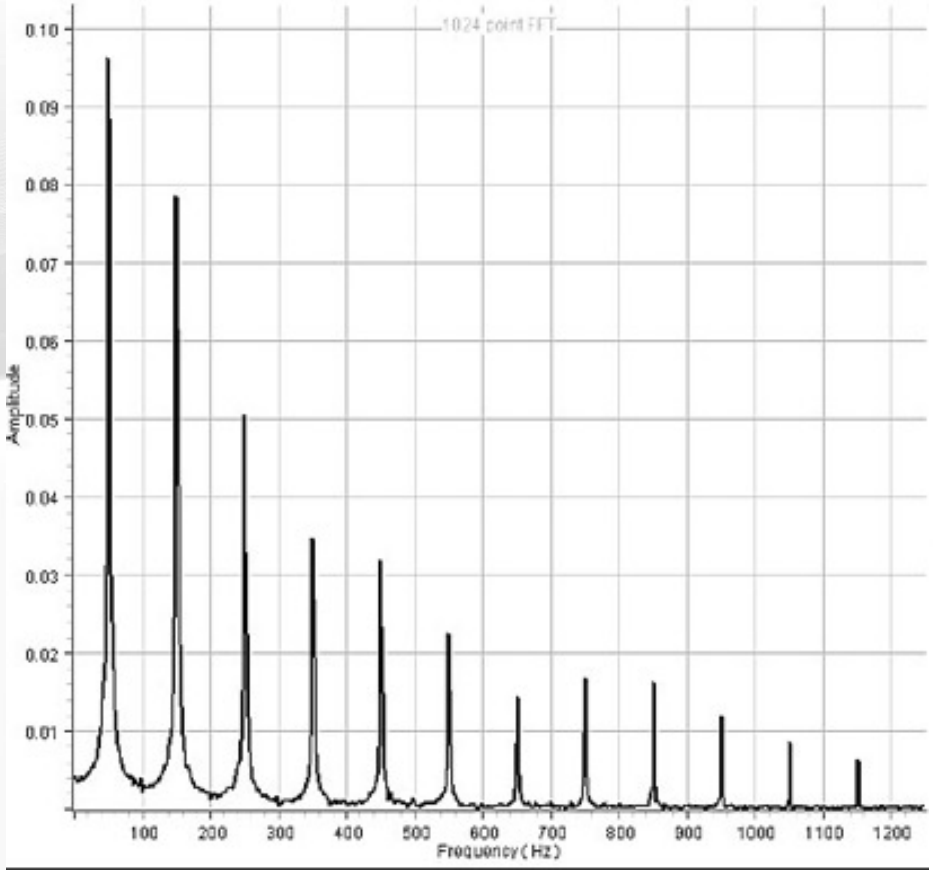
Accurate Analysis Algorithms in Support of Power Quality

Content

- Social and scientific challenge
- Existing solutions
- Project team achievements
- Improving state-of-the-art
- Applications, impact & benefit

Social and scientific challenge





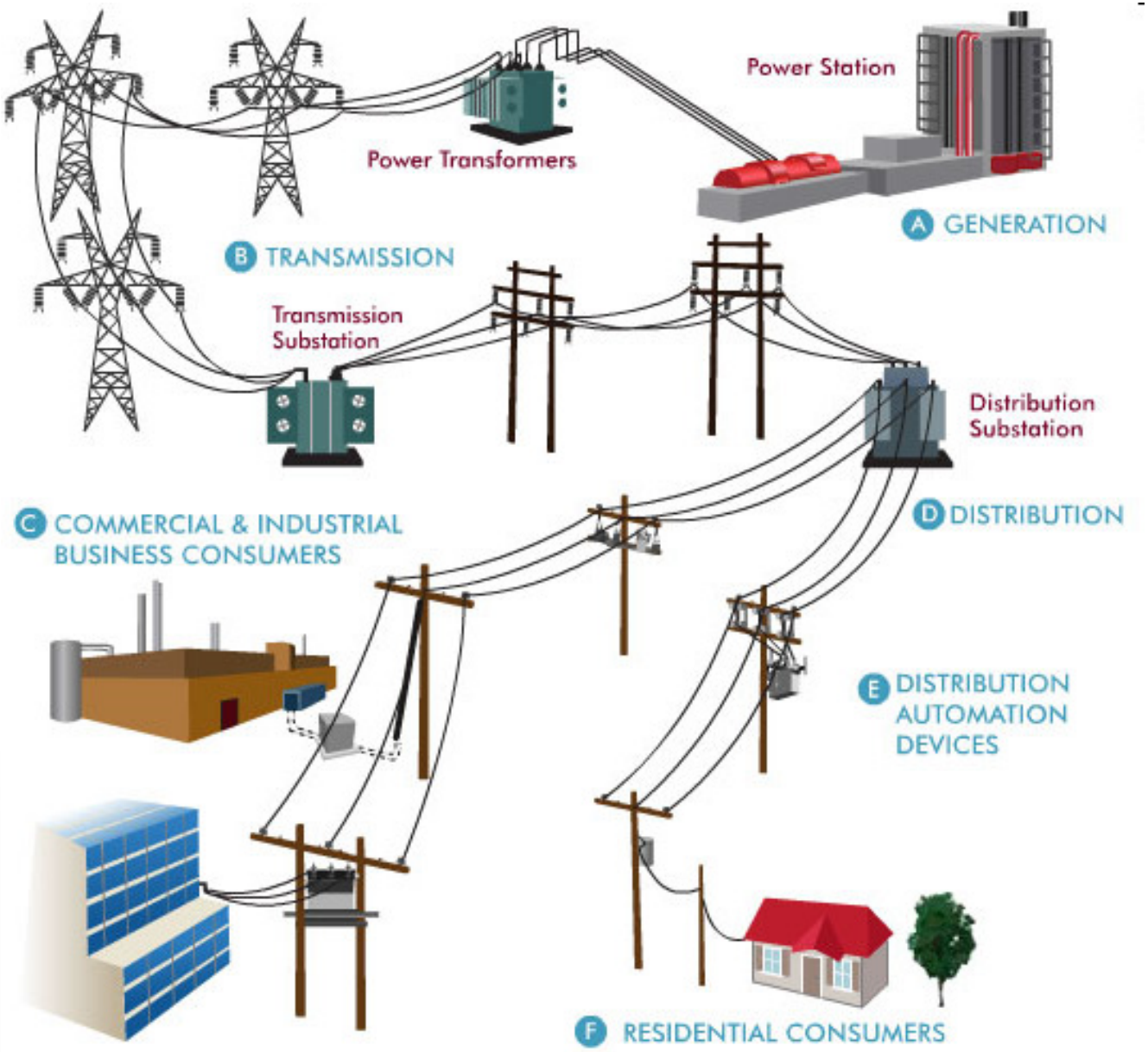
Social and scientific challenge

Issues

- Power losses
- EMI, RFI
- Billing
- Stability

Requirements

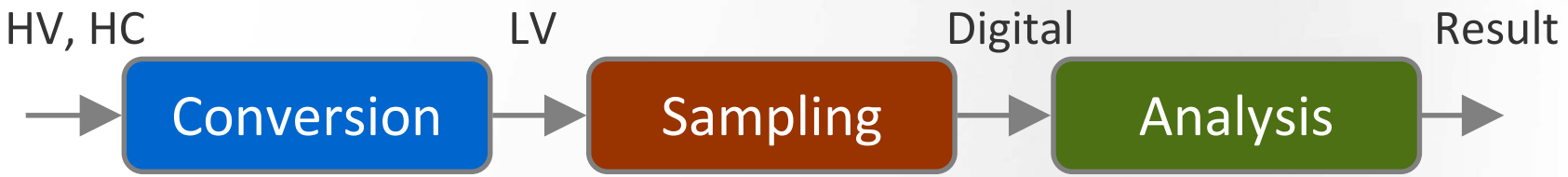
- Real time
- Accuracy



Scientific challenge

Accurate measurement of ac waveforms

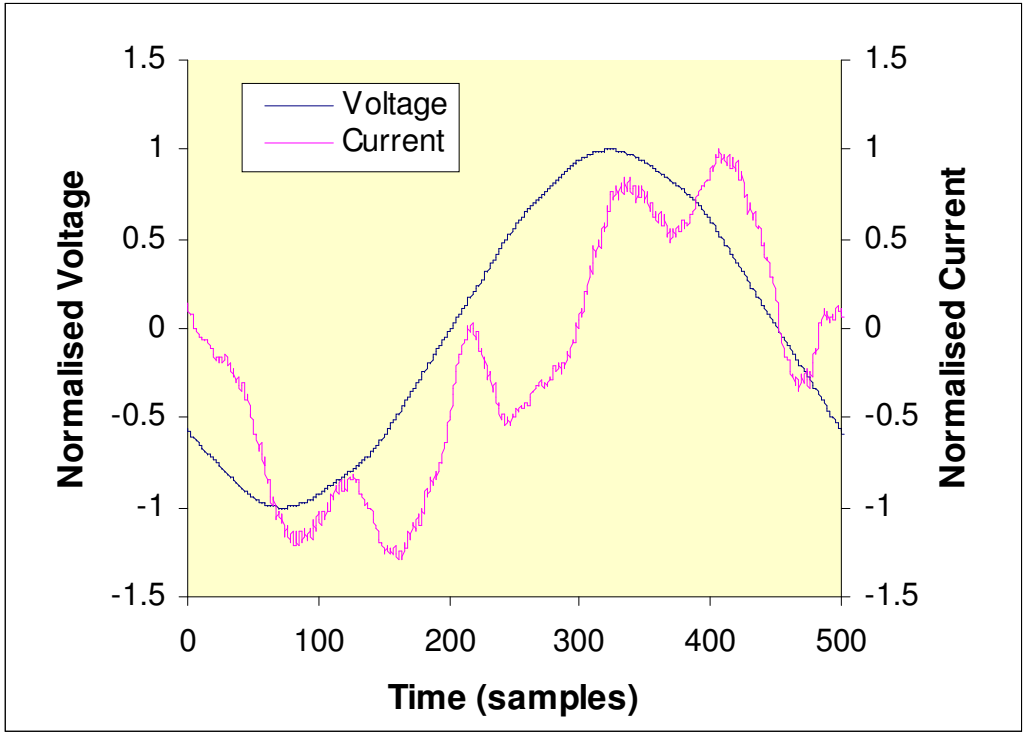
- By developing highly accurate voltage and current transducers
- By developing precision sampling devices
- By developing algorithms to accurately analyze these waveforms and determine power quality parameters



Scientific challenge

Algorithm's requirements

- THD > 80%
- SNR < 60 dB
- > 2 periods
- > 100 samples



UK railway power line

Scientific challenge

Algorithm's requirements

- asynchronous operation
- noise performance at the theoretical minimum
- practically insensitive to harmonic distortions
- insensitive to power quality related disturbances

Existing solutions

Algorithm	Pro	Cons
FFT	▪ fastest	▪ not asynchronous
interpolated DFT	▪ fast	▪ sensitive to noise, ▪ requires longer records
4PSF	▪ accurate ▪ standardised	▪ very sensitive for harmonic distortions
multi-harmonic	▪ accurate, ▪ insensitive to harmonic distortions	▪ very slow

Project team achievements

Two (three) algorithms developed

- PSFE – Phase Sensitive Frequency Estimator (developed in SIQ)
- PSFEi – interpolated PSFE (developed in SIQ)
- TDIS – Time Domain Interpolation and Scanning (developed in NPL)

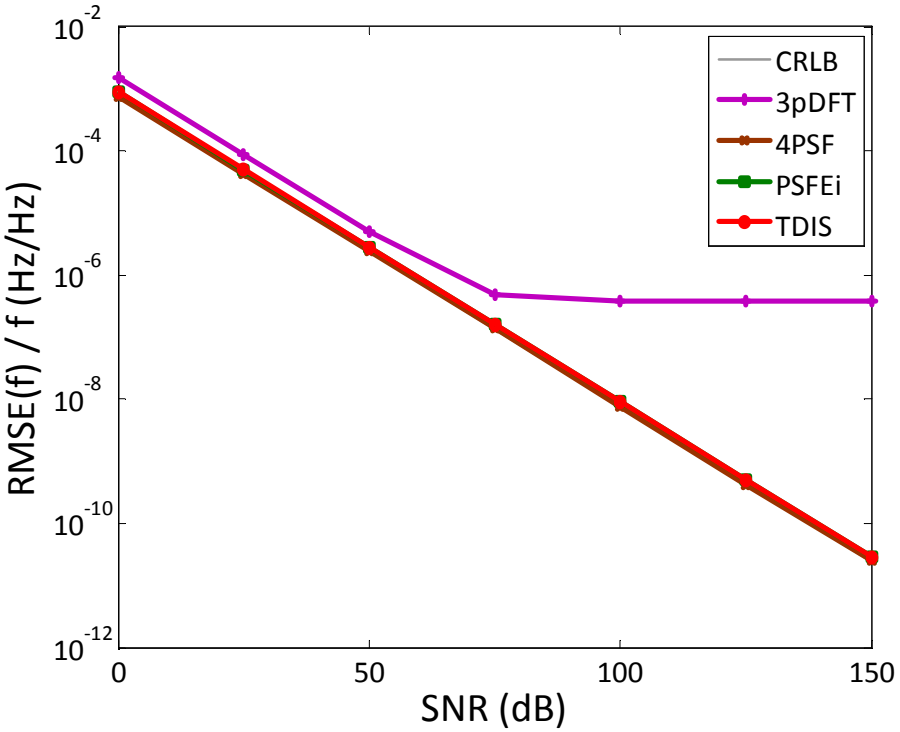
Improving state-of-the-art

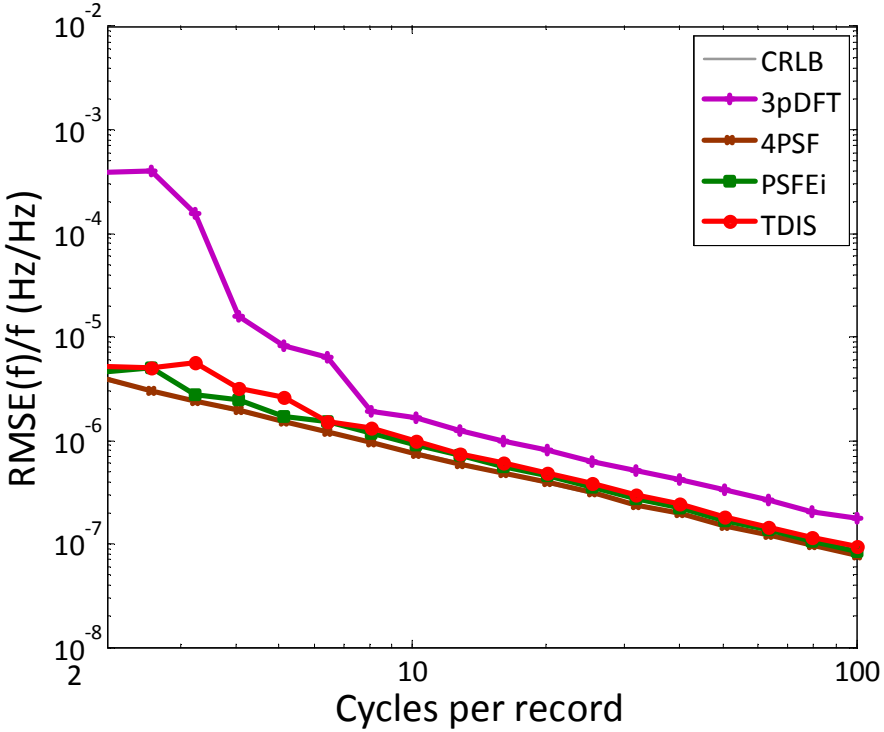
Frequency estimation

- Algorithms typically estimate
  - frequency,
  - amplitude,
  - phase
- Most important (and demanding) is
  - frequency

Improving state-of-the-art

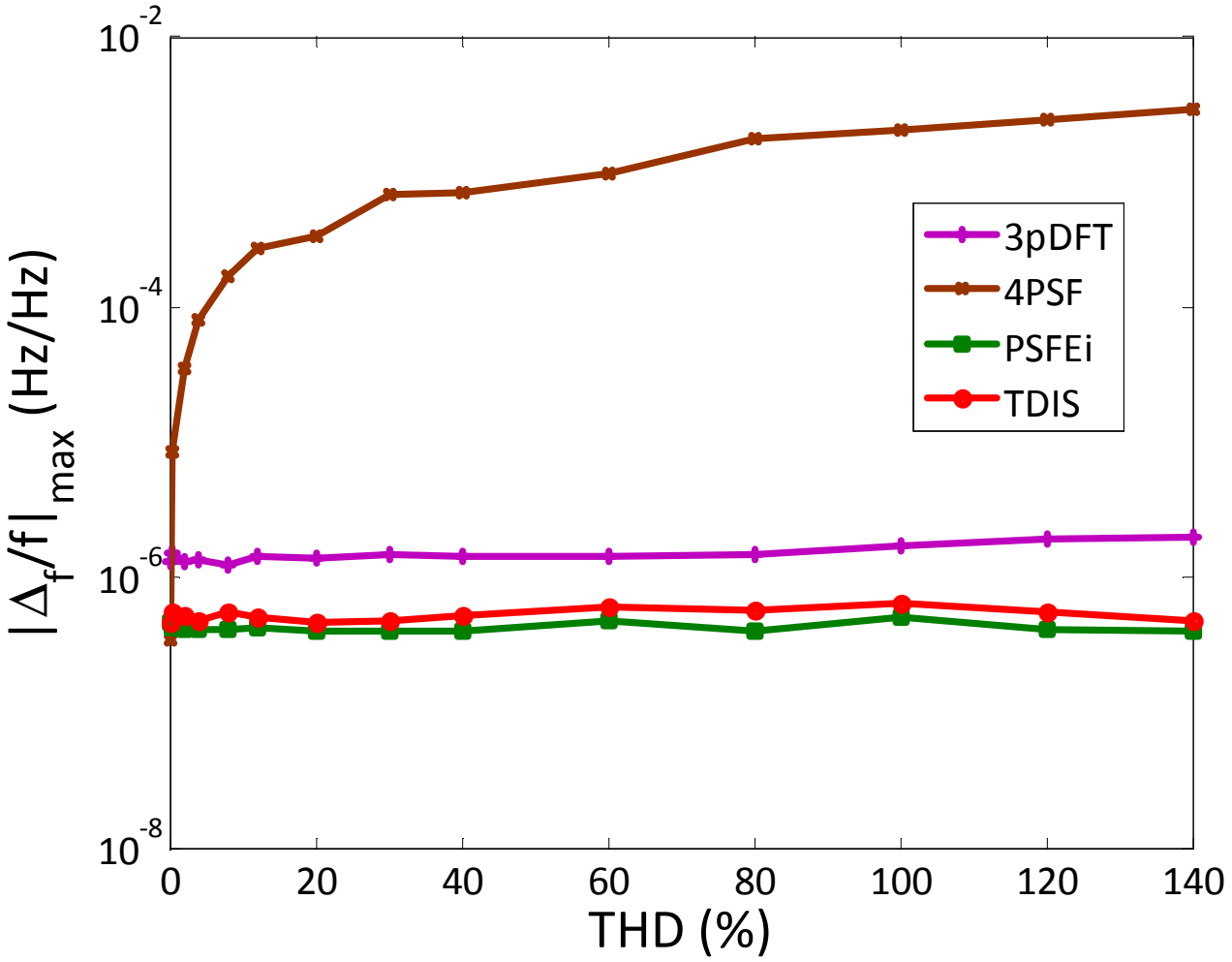
Noise performance





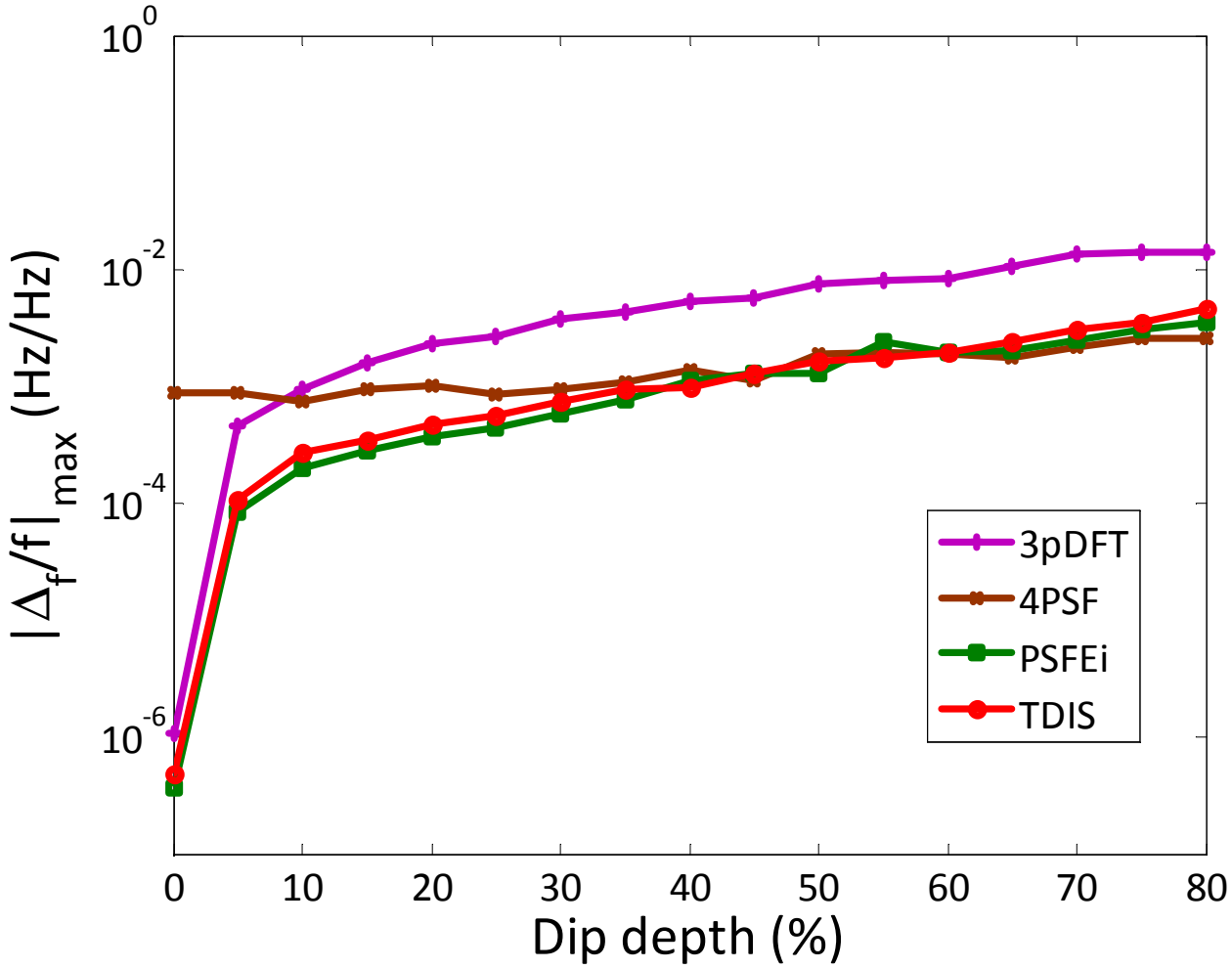
Improving state-of-the-art

Harmonic distortions



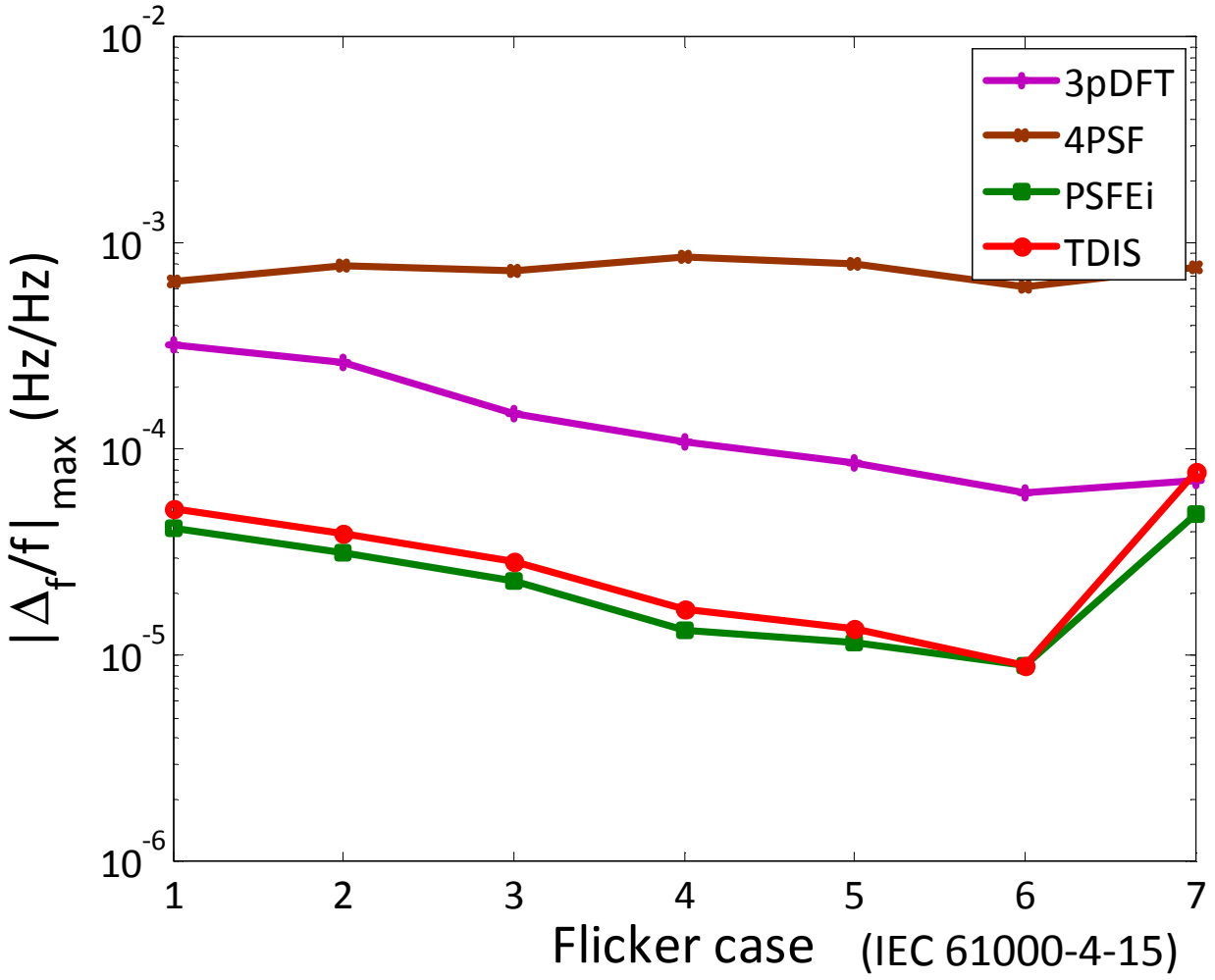
Improving state-of-the-art

Dips + Harmonics



Improving state-of-the-art

Flicker + Harmonics



Improving state-of-the-art

Time consumption

- Record length: 10 000 samples
- Processor used: 2 GHz Core2Duo
- Environment: MATLAB

3pDFT	4PSF	PSFE	PSFEi	TDIS
3,3 ms	14 ms	17 ms	21 ms	114 ms

Improving state-of-the-art

Other comparisons

- PSFE compared to 7 independent algorithms in 2009 (I^2MTC). The statement for PSFE was:

Good and stable overall performance close to theoretical limits

Czech Technical University in Prague

University of Ljubljana

Slovenian Institute for Quality and Metrology

University of Perugia

University of Trento

Instituto de Telecomuni-cações

Vrije Universiteit Brussel

Applications, impact & benefit

Applications

- power-quality instrumentation
- grid instrumentation
- calibration platform for emerging instrumentation

Impact

- better power related measurements
- better control over grid pullution
- key tools for Metrology for Smart Grids initiative

Benefit

- industry
- power grid operators
- general public