HIGH-ACCURACY MEASUREMENT OF POWER QUALITY PARAMETERS USING ASYNCHRONOUS SAMPLING TECHNIQUE

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Goal

Development of measurement procedure for calibration of power quality parameters using asynchronous sampling technique with multi harmonic sine fit algorithm to separately determine:

- harmonics,
- interharmonics,
- fluctuating harmonics,
- flickers.

Uncertainties must be small enough to cover calibrations of all commercially available power quality sources and meters.

Power Quality (PQ) measurement challenges

- Power Quality (PQ) measurements became increasingly important
- calibration laboratories were faced with new measurement requirements
- thermal voltage converter technique is not sufficient for complex waveforms

Synchronous sampling

- synchronous sampling technique requires highly elaborated measuring system setup when using commercially available instrumentation
- synchronous sampling technique requires that all spectral components, resulting from generated signal containing harmonics, flickers, interharmonics or fluctuating harmonics, fall exactly into the FFT bins when the sampled record is transformed into the frequency domain
- coherent sampling is strictly required for all signals components
- leakage does not interfere the measurement results
- only a limited set of signal frequencies and their combinations are available to fulfill these criteria
- highest possible uncertainties are attainable in that case

Sample: Interharmonics

Each inteharmonics frequency is selected as:

$$f_i = f_1 \cdot (h + q/M)$$

- f_1 fundamental signal frequency
- h integer indicating harmonic frequency number
- M small integer number (e.g. M = 5)
- q $q \leq M$ - 1 is also an integer number

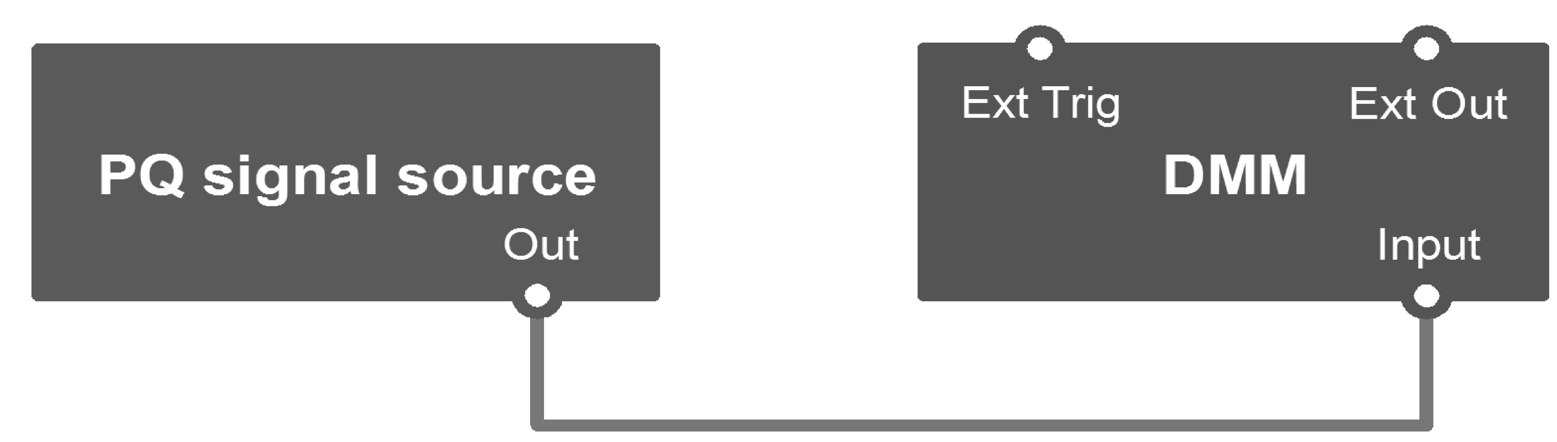
Initial fundamental frequency is not determined automatically but is given a-priori as f_{s1}/M.
MHFE algorithm than locks its frequency estimation only to harmonic components present in the signal.

Asynchronous approach

- Multi Harmonic Sine Fit algorithm (MHFE) is used
- FFT and MHFE are unbiased estimators, no additional error is added
- MHFE requires all signal components are harmonically related
- for non-harmonically related signals components, this was achieved by calculating a corresponding low frequency to which all components are harmonically related and forcing MHFE to use this frequency as the initial estimate

Asynchronous sampling measurement system

- high accuracy sampling digital multimeter Agilent 3458A is used for calibration of PQ signal source (e.g. Fluke 6100A)



- the sampling system requires no synchronization with the source
- to cover all signals adequately, the DMM was programmed to sample at 20 kHz with aperture time of 25 µs, using 8000 samples
- capturing approximately 20 fundamental signal cycles
- the used DMM needs to be dc calibrated before measurement and corrected for aperture time and bandwidth roll-off

Measurement results

- measurement uncertainty defined by DMM performance
- stability of PQ source was calibrated
- uncertainties are summarized in table below

PQ parameter	estimated	uncertainty (k = 2)	A	h	q	M
harmonic distortion	HD = 1%	0.0004%	0.1 V	3		
interharmonic distortion	IHD = 1%	0.0004%	0.1 V	3	2	5
fluctuating harmonic	m = 0.1	0.0006	1 V	3	1	5
flicker	m = 0.1	0.00006			1	5

Conclusions

- ✓ Power Quality parameters generated by highest accuracy PQ generators could be sufficiently well determined by using asynchronous sampling technique
- ✓ achieved uncertainties in ppm range
- ✓ MHFE algorithm need's an a-priori information on the calculated fundamental frequency
- ✓ this technique shall be used with limited set of signal frequencies and their combinations to attain lowest uncertainty levels