Noise immunity evaluation of nonlinear load frequency model estimation method

Michał Lewandowski, Janusz Walczak

Faculty of Electrical Engineering, Silesian University of Technology, ul. Akademicka 10, 44-100 Gliwice, Poland,
e-mails: michal.lewandowski@polsl.pl, janusz.walczak@polsl.pl

Abstract **The paper presents results of research on noise immunity evaluation of nonlinear load model estimation method. Immunity to additive white noise was analysed. The model evaluation method is based on Prony frequency estimator and coherent resampling and was proposed in [2]. However, the influence of the noise on the estimated model parameters has not been shown in the paper. Performed tests revealed high noise immunity of the method when SNR is bigger than 20 dB.**

Keywords **harmonic analysis, frequency domain modelling, noise analysis, Prony estimator, coherent resampling**

I. Introduction

In the contemporary power systems the number of nonlinear loads is growing each and every year. These kind of loads introduce current and voltage harmonic distortions, what raises the need for effective modelling of harmonic flow analysis in systems containing nonlinear loads [1]. One of the most effective method is the frequency domain modelling using current injection models. The model is usually estimated from time domain voltage and current measurements. Among many methods, which can be used to achieve this task, the one presented in [2] revealed its high accuracy and efficiency. In the following paragraphs, a noise immunity evaluation of the method is presented.

II. Estimation method of nonlinear load model

As has been shown in [2] to evaluate current injection frequency domain model of a nonlinear load, it is necessary to know the frequency spectrum of the current and the value of the first voltage harmonic on the load terminals. The method of current frequency spectrum estimation from [2] is shown in Fig. 2.

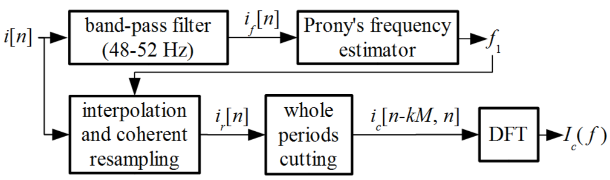

Fig. 1. Nonlinear load current spectrum estimation method

Load current $i[n]$ is filtered by a band-pass filter to extract the base frequency component. Next, from the filtered signal $i_f[n]$, the base frequency is estimated using the first order Prony estimator [3]. Afterwards, resampled signal is cut and finally the current frequency spectrum $I_c(f)$ is estimated using the DFT.

III. Noise immunity evaluation method

Noise immunity evaluation method is shown in fig.2. Test square wave signal $i[n]$ is synthesized from its Fourier series (first 20 harmonics are considered) and white Gaussian noise $s[n]$ is generated. Both signals are added and send to the current spectrum estimation algorithm shown in fig.1.

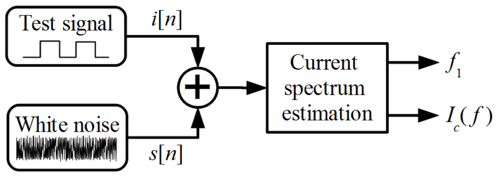

Fig. 2. Noise immunity test system

The estimated parameters are: f_1 (base frequency) and $I_c(f)$ (amplitude and phase of each harmonic). The base frequency of $i[n]$ was set to 50.5 Hz and the sampling frequency was set to 4 kHz.

IV. Noise immunity evaluation results

Exemplary results of noise immunity evaluation were shown in fig.3 (data averaged for 1000 independent tests).

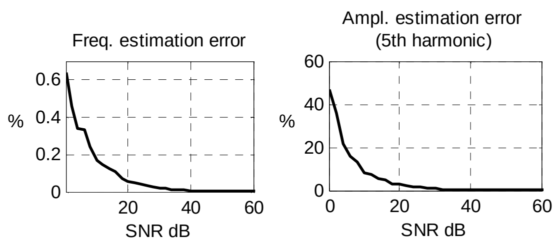

Fig. 3. Frequency and amplitude estimation errors versus SNR

Both characteristics shown in fig.3 have similar shape and they are growing fast for SNR smaller then 20 dB. For SNR bigger than 20 dB amplitude error is below 3 % and frequency error is below 0.1 % (more results in full version of the paper).

V. Conclusion

Performed tests showed that the method is relatively immune to noise when the SNR is bigger then 20 dB.

VI. References

[1] Arrillaga J., Watson N. R.: “Power system harmonics”, 2nd edition, England, Wiley, 2003.

[2] Lewandowski M., Walczak J.: “Frequency spectrum estimation of nonlinear load current using Prony’s method and coherent resampling”. Proc. of the 22nd Symposium on Electromagnetic Phenomena in Nonlinear Circuits (EPNC), Pula, Croatia, 2012, pp. 123-124.

[3] Łobos T., Rezmer J.: “Real-time determination of power system frequency”, IEEE Transactions on Instrumentation and Measurement, vol. 46, no. 4, August 1997.