# Choice of the Parameters of an EMI Monitoring System for an AC Traction Network

Volodymyr Havryliuk
dept. of automatic and telecommunication
Ukrainian State University of Science and Technologies
Dnipro, Ukraine
vl.havryliuk@gmail.com

Regis Nibaruta
Faculty of Electrical Engineering, Mathematics & Computer Science (EEMCS)
University of Twente, Enschede, Netherlands
nibaregis@gmail.com



***Abstract*— The problem considered in the paper is related to the formulation of criteria for choice of the parameters of the electromagnetic interference monitoring system for AC traction network in accordance with the requirements of the standards.**

***Keywords*— *electromagnetic interference, electromagnetic compatibility, traction current harmonics***

Monitoring of electromagnetic interference (EMI) in the traction network makes it possible to timely detect their excessive increase and prevent the occurrence of possible failures in the railway signaling systems [1], [2]. A plug-in data acquisition device (DAQ) allows you to create a spectrum analyzer in accordance with the necessary specific requirements [2]. The choice of basic DAQ blocks, such as analog-to-digital converter (ADC), antialiasing filter, short-time Fourier transform (STFT) processor is described in detail [3]-[5]. The problem is that the AC traction current has a very large dynamic range, which limits the accuracy of detecting weak harmonics against the background of strong ones, as well as the proximity of harmonics in the frequency range from 19 to 125 Hz to each other and to the main harmonic, which leads to masking of weak harmonics due to spectrum leakage. Also, the choice of the window function for STFT is associated with a trade-off between the width of the main lobe and the level of the side lobes [5].

The purpose of the work is to develop, on the basis of literature data, an approach to choosing the parameters of an EMI monitoring system in an AC traction network that meets the stringent requirements of regulatory documentation for the accuracy of determining the magnitude, frequency, and duration of harmonics with frequencies corresponding to the signal current of automation systems. The dynamic range of the ADC can be selected using the expression

$$D_{\mathrm{ADC}} \geq D_{\mathrm{TC}} + D_{\mathrm{A}} + D_{\mathrm{R}} + D_{\mathrm{AD}} \quad (\mathrm{dB}), \qquad (1)$$

where $D_{\mathrm{TC}} = 20\log_{10}\left(I_{\mathrm{f0}}/I_{\mathrm{fi}}\right)$ is the dynamic range of a traction current; $I_{\mathrm{f0}}/I_{\mathrm{fi}}$ is the ratio of the current of the fundamental frequency harmonic to the current of the weakest normative harmonic; $D_{\mathrm{A}}$ is included to ensure the required measurement accuracy of the weakest normative harmonic; $D_{\mathrm{R}}$ is included to account for a sudden increase in traction current; $D_{\mathrm{AD}}$ (~ 0.5-1 dB) is included to account additional unpredictable factors [2]. The resolution in magnitude of a DAQ device is limited by its SNR. The theoretical SNR for an ADC with the following m-point windowed Fourier transform is given by [4], [5]

$$SNR = 6.02n + 1.76 + 10\log_{10}\left(\frac{m}{2}\right) \quad (\mathrm{dB}), \qquad (2)$$

where $n$ is the ADC resolution (or number of bits). The resolutions of the windowed STFT in the frequency and time domains are given by [4], [5]

$$\Delta f = B_{\mathrm{W}} F_{\mathrm{S}} / N_{\mathrm{W}}; \qquad (3)$$

$$\Delta t = N_{\mathrm{W}} / F_{\mathrm{S}}; \qquad (4)$$

where $B_{\mathrm{W}}$ is the width of the main lobe of the window in the frequency domain, $F_{\mathrm{S}}$ is the sampling frequency, the value of which is chosen in accordance with the Nyquist criterion, $N_{\mathrm{W}}$ is the size of the window (in the number of samples). For a STFT with overlapping windows, the number of frequency bins is given by

$$N_{\mathrm{bins}} = 1 + \left(N_{\mathrm{T}} - N_{\mathrm{W}}\right)/H, \qquad (5)$$

where $N_{\mathrm{T}}$ is the total number of samples measured by the DAQ device, $H$ is the window hop-size. The obtained expressions (1)-(5) and the criteria for the choosing of window function [5] were used to choose the parameters of the DAQ device for the spectral analysis of the traction current. For measurements, a 14-bit ADC was used, the sampling frequency was 22 kHz. The FFT was carried out using four types of window functions. For a Blackman window of size 1 s, the relative error in determining the parameters of a 25 Hz harmonic with a level of 1 A is 0.7 % in frequency and 2.1 % in RMS.

## REFERENCES

[1] V. Havryliuk, “Wavelet based detection of signal disturbances in cab signalling system,” 2019 International Symposium on Electromagnetic Compatibility - EMC EUROPE, 2019, pp. 94-99.

[2] V. Havryliuk, “Audio frequency track circuits monitoring based on wavelet transform and artificial neural network classifier,” 2019 IEEE 2nd Ukraine Conference on Electrical and Computer Engineering (UKRCON), IEEE, 2019, pp. 491-496.

[3] Walt Kester. Data Conversion Handbook. Newnes, 2005.

[4] F. J. Harris, “On the use of windows for harmonic analysis with the discrete Fourier transform,” Proceedings of the IEEE, vol. 66, pp. 51-83, 1978.

[5] M. Cerna, and A. F. Harvey, “The fundamentals of FFT-based signal analysis and measurement,” Application Note 041, National Instruments, 2000..