

Implementation of the test method for trackside emissions of magnetic disturbances from rolling stock according to ERA/ERTMS/033281

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The aim of the work presented in this article was to make and implement original computer software made in the LabVIEW environment. That program automate the measurement of emissions of magnetic disturbances coming from rolling stock. It is dedicated for oscilloscope card and RSAL 5340, RSAH 5324 rolling stock antennas for axle counter. The indicated algorithms of proceeding coming directly from the standards, additional own methods of fast data analysis was made. Communication between the measurement cards and computer using USB with self-power USB hub was used. The software is fully compatible with the requirements contained in the ERA/ERTMS/033281.

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1. The general background

The growing demand for the comfort and diagnostic capabilities of rail vehicles has resulted in the need for a wide use of electronics. At the same time, traffic control devices are changing along with the development of the railway infrastructure. These are both modern station systems, line blockades and train detection devices. The increasingly complex rolling stock is a source of potential interference that may affect the operation of rolling stock detection devices [1–3]. The issue of ensuring the interoperability of rolling stock and railway infrastructure is important for the implementation of a single *European Railway Traffic Management System* – ERTMS, and as part of it, for the dissemination of the use of the *European Train Control System* – ETCS safe train control system.

A number of different types of track vacancy meter systems are used on European railways, operated by only one or more infrastructure managers, while rolling stock is usually prepared and released for operation over a larger area of the European rail network, which causes a significant complexity of the compatibility problem [4]. Determining the permissible levels

of interference for individual frequencies in the operating band of rail sensors is the subject of the so-called frequency management process, covered in particular by the European standardization activity.

Before new rail vehicles are allowed to operate, verification of their *Electromagnetic Compatibility* – EMC with rail traffic control devices is carried out. One of the element of the research is the assessment of disruptive variable magnetic fields produced by the rolling stock. In terms of the subject matter of this article, the main document defining the requirements for rolling stock is ERA/ERTMS/033281 [6], which presents, i.e., the limits of magnetic field strengths for AC traction and the method of measuring these fields. Example of measurements results to previous of the document are presented in [7]. It is worth mentioning that the authors of this work are asked if the research methodology according the two documents ERA/ERTMS/033281 and CLC/TS 50238-3 is good enough for confirming compatibility of rolling stock with train detection systems. These documents do not take into account the case where two trains pass each other near the wheel counters.

As representatives of the Łukasiewicz Research Network – Poznan Institute of Technology (Ł–PIT),

Radio Technologies and Electromagnetic Compatibility Laboratory we have created a portable measuring stand for testing magnetic fields generated by railway vehicles, regardless of their power supply method.

2. Theoretical basics

2.1. Research on magnetic fields generated by rolling stock

In accordance with the requirements of the CLC/TS 50238-3 document [3], the measurements of the magnetic fields generated by rolling stock should be carried out with an antenna with standardized dimensions (length 15 cm, width 5 cm and height 5 cm) independently for three measurement planes: X, Y, Z (Fig. 1).



Fig. 1. Rail-mounted measuring antenna with the indicated directions of the plane

The limit values for the magnetic field strength from traction vehicles are defined for three frequency ranges:

- 27 – 52 kHz
- 234 – 363 kHz
- 740 – 1,250 kHz

The values of the limits for all separated axes are defined in table 10 of the ERA ERTMS document [6].

Łukasiewicz Research Network – Poznań Institute of Technology has measuring equipment that meets the applicable European requirements for this type of research. Our portable test bench consists of:

- two measuring antennas (Schwarzbeck RSAL 5340 and RSAH 5324), each with three output signals for X, Y, Z planes
- laptop (Lenovo, ThinkPad)
- three oscilloscope cards with USB communication (PicoScope series 4000)
- self-powered USB hub (D-Link)

- own measurement and data analysis software (PPM_210820_1.1.8.vi)

Test set-up for magnetic fields measurements in accordance with standard is shown in Fig. 2.

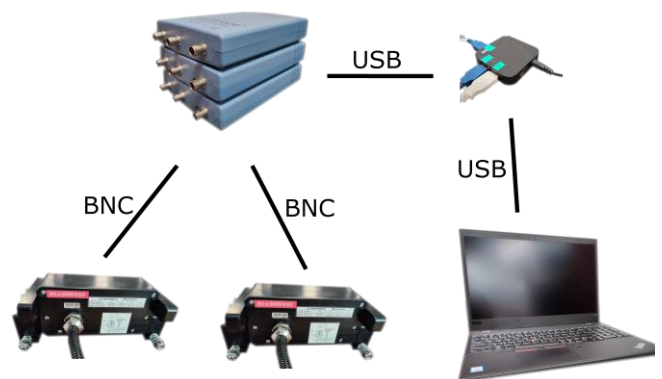


Fig. 2. Set-up for magnetic fields measurements

The voltage values induced in the antennas are registered by three oscilloscope cards with sample interval 400 ns and sensitivity of voltage measurement 500 mV. Each card has two input channels and one output channel for signal generator which was not used for measurements. The registration results are saved on the measurement computer, where the next analysis is carried out in accordance with the ERA/ERTMS/033281 guidelines, using dedicated, own software. The result of this analysis are the characteristics of the intensity values of the magnetic fields strength as a function of frequency, compared with the limit values for each of the measured planes.

2.2. LabVIEW software

A graphical development environment for data acquisition, analysis, and presentation from National Instruments is called LabVIEW (Laboratory Virtual Instrument Engineering Workbench). The main difference between LabVIEW and other applications like C or Pascal is that LabVIEW does not use text-based languages to create lines of code. LabVIEW uses a graphical programming language, G, to create programs in block diagram form. LabVIEW programs appearance and operation imitate physical instruments, such as oscilloscopes and multimeters because of that this programs are called virtual instruments. LabVIEW contains a comprehensive set of tools for acquiring, analyzing, displaying, and storing data, as well as tools for debugging.

All LabVIEW programs have a front panel and a block diagram. The front panel is the graphical user interface. This interface collects user input and displays program output. The front panel can contain knobs, push buttons, graphs, and other controls and indicators. The block diagram contains the graphical

source code of application. In the block diagram one can program an application to control and perform functions on the inputs and outputs created on the front panel. The block diagram can include functions and structures from the built-in LabVIEW libraries. It also can include terminals that are associated with controls and indicators created on the front panel [5].

The front panel of application generating sine wave is shown in Fig. 3, its block diagram is shown in Fig. 4.

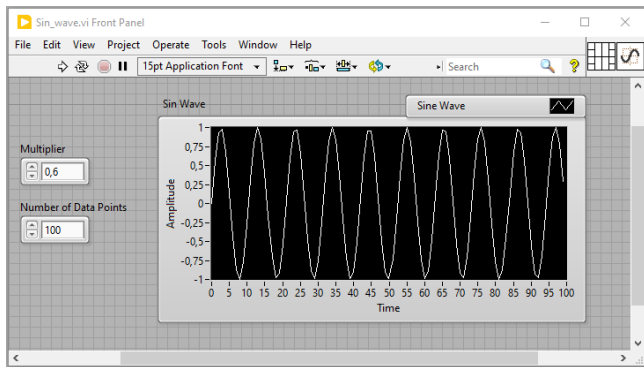


Fig. 3. Front panel of LabVIEW application

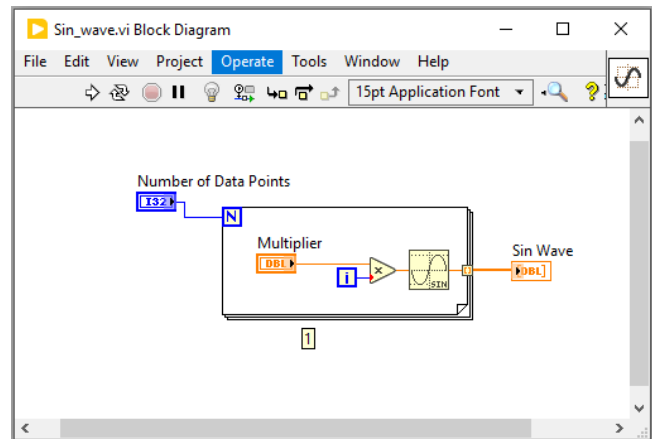


Fig. 4. Block diagram of LabVIEW application shown in Fig. 3

3. Measurement application

3.1. General information

The PPM is a software application for capturing and evaluating EMC signals fully developed in

The program is divided into three tabs:

- Description
- Acquisition
- Results

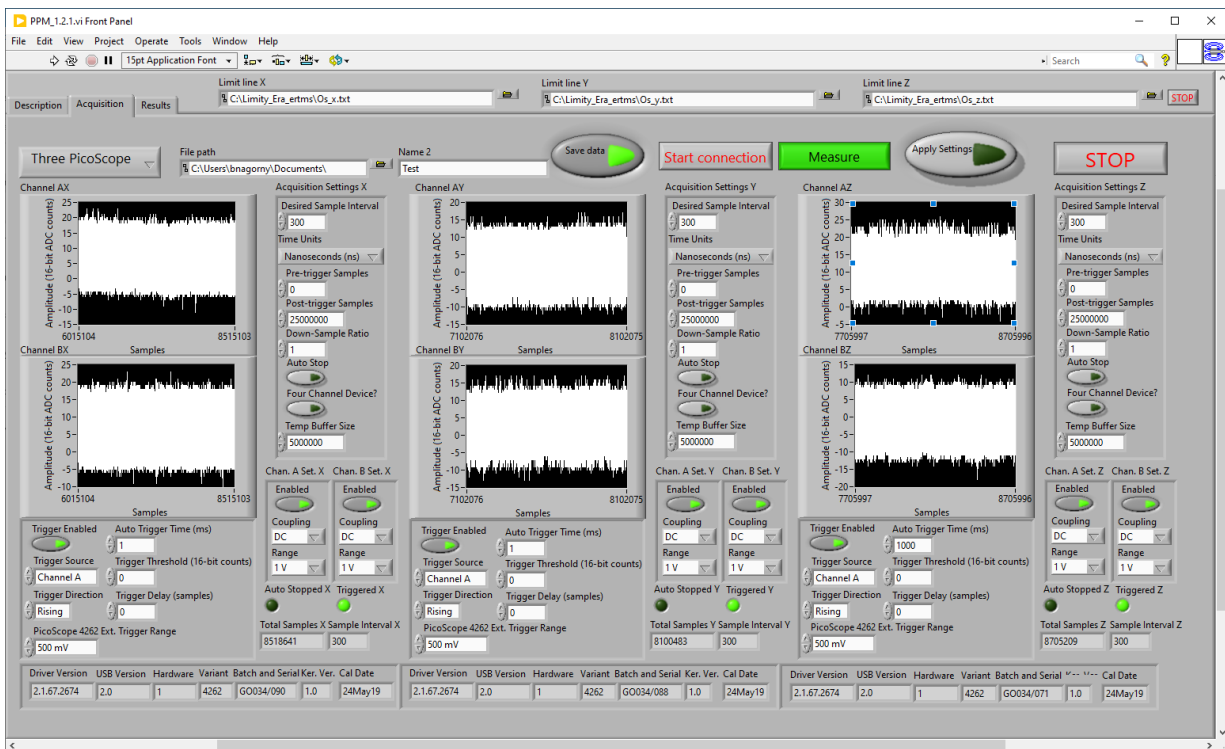


Fig. 5. Program panel – view of the acquisition mode

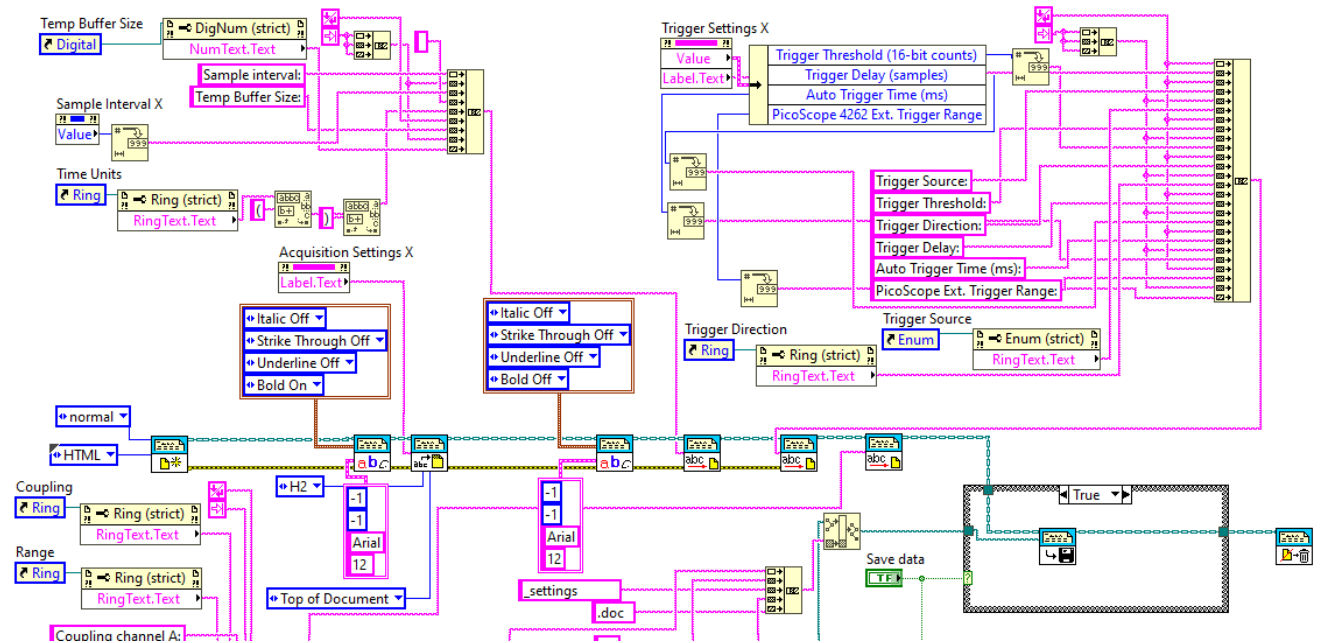
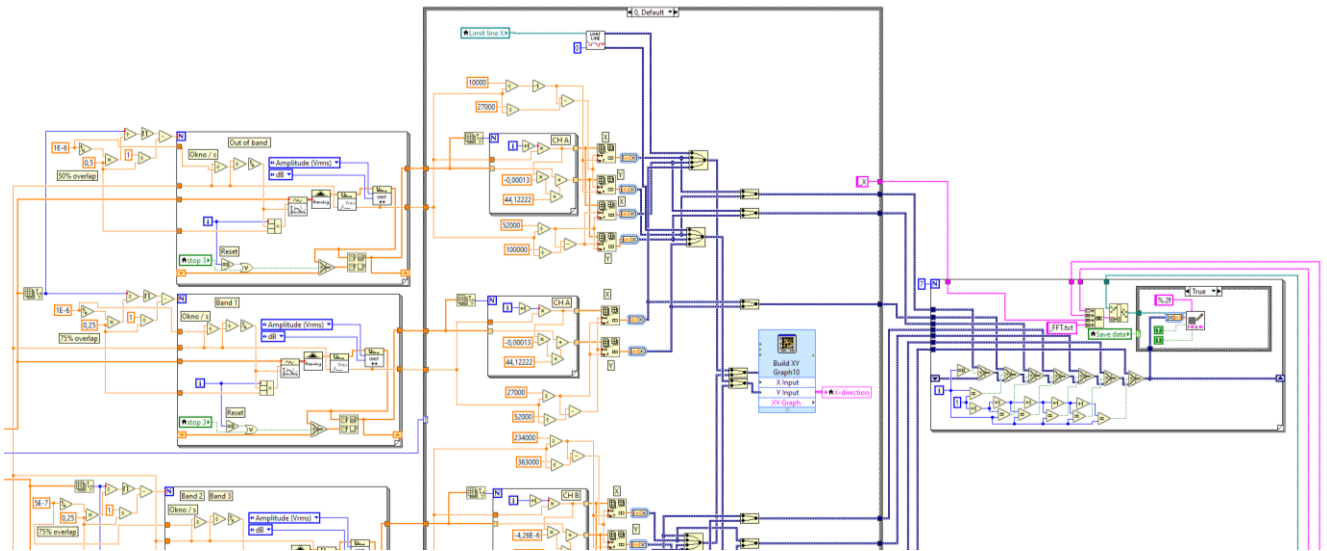


Fig. 6. Part of the block diagram of LabVIEW application shown in Fig. 5

In **description** part general information about functionality of the application are describe.

The screenshot of the **PPM** software for capturing and evaluating EMC signal panel is shown in the Fig. 5. The part of the block diagram of our software is shown in Fig. 6.

3.2. Acquisition mode

The main menu **acquisition** shows all important parameters. Each time when application is run a default parameters are set. In the main window the parameters can be changed. Approval of the new settings is done by pressing the button “Apply Settings”.

The huge memory of each sampling devices (Pico Scope) samples the whole data into the internal buffer. After the data will be transferred and store to the local or external hard disk.

The connection with Pico Scope is initialize after pushing button “Start connection”. Pushing button “Measure” will start measurement. Pushing button “STOP” will stop measurement.

The measurement results (raw data) are directly stored as a txt file. Each axis (x, y and z) is stored in a separate file with the extension *.txt. The saving path of the data can be pre-configured in the acquisition section of the application. The measurement settings are saved as a doc file separate for each axis.

3.3. Results mode

The main part of the **results** panel are the measurement visualization components, on which the data appears after the finished measurement.

On the graphs are shown the broadband evaluation using *Fast Fourier Transformation* – FFT with *Hanning window* (green lines). The result are presented for each axis in a separate graphs. The Figure 7–9 shows the result of many thousand FFT during 15 s sampled data. The analyzed data are directly stored as a txt file in three separate file for each axis. The saving path is the same like for measurement raw data.

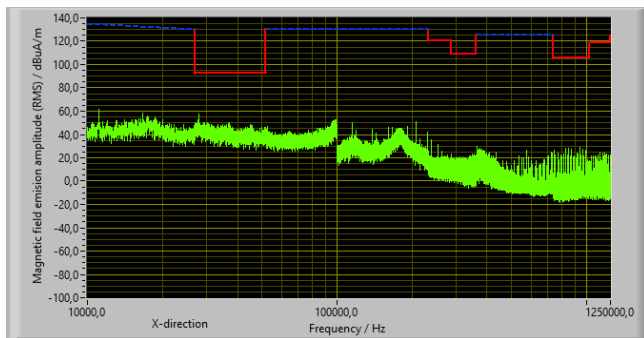


Fig. 7. Program panel – view of the results mode for X-axis

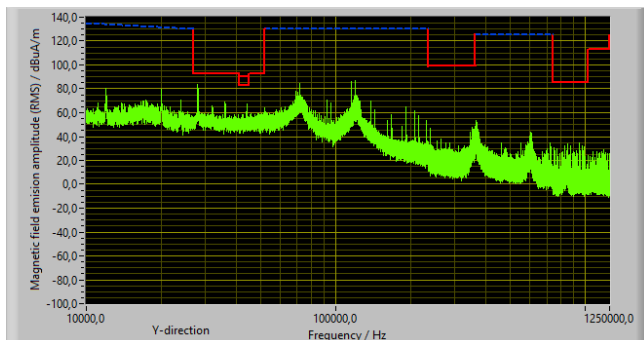


Fig. 8. Program panel – view of the results mode for Y-axis

Blue dash line indicate out of band region where FFT with Hanning window, 50% overlap is used as evaluation method. Red solid line indicate in-band limits. These regions are demonstrated by broadband evaluation using FFT with Hanning window, 75% of time overlapping and time windows of 1 ms for Band 1, 0.5 ms for Band 2 or Band 3. More details are provided in the document ERA ERTMS [6].

Nomenclature

ERTMS	European Railway Traffic Management System
ETCS	European Train Control System
EMC	Electromagnetic Compatibility

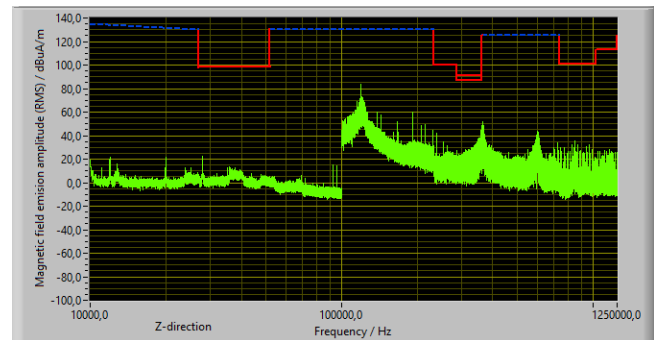


Fig. 9. Program panel – view of the results mode for Z-axis

The visible discontinuities in the spectra in Fig. 7 and Fig. 9 are the result of different mounting of the two antennas on the rail, resulting from different positioning tolerances for each of the antennas.

3. Summary

The aim of work described in present article was to create software for the measurement of magnetic field emission for railway applications. The applications were created by use of LabVIEW (version 2020 SP1) graphical development environment. This choice was dictated by the universality of the libraries available in LabVIEW, which ensure relatively easy communication with the majority of electronic measuring devices operating on the market. Additionally, creating an application in LabVIEW environment does not need advanced programming skills.

The PPM program is fully compatible with the requirements contained in the ERA/ERTMS/033281. The main advantage of our program is possibility of easy modification following the changes in [6]. This is not provided by the commercially available programs.

The program created within this work were put into practice in Radio Technologies and Electromagnetic Compatibility Laboratory at Łukasiewicz Research Network – Poznan Institute of Technology, Poland.

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LabVIEW	Laboratory Virtual Instrument Engineering Workbench
FFT	Fast Fourier Transformation
Ł –PIT	Łukasiewicz Research Network – Poznan Institute of Technology

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