

HARGAŠ Libor¹
 ŠINDLER Peter²
 ZÁBORSKÝ Lubomír³
 SIMONOVÁ Anna⁴
 KONIAR Dušan⁵

Diagnostic device for overhead contact line static parameters measurement

*Overhead contact line,
 stagger, height measurement,
 GPS*

Abstract

This paper provides information about principles of measurement with device for overhead contact line height and stagger measurement. The device is determined for overhead contact line continuous measurement. The based measured parameters are overhead contact line height and stagger. The other measured parameters are evolved from optional GPS module. The data can be copied to MMC/SD card and they can be analyzed in PC. The special software for analyzing was created.

1. INTRODUCTION

Diagnostic device for overhead contact line measurement (Fig. 1) was developed for overhead contact line continuous measurement. This device was developed in Department of mechatronics and electronics, University of Žilina in collaboration with Railways Researched and Developed Institute in Vrútky. The device is served for overhead contact line parameters measurement simplification and objectification. The device advantage is automatic data acquisition. The measured data are recorded to devices internal memory.



Fig. 1 Device for overhead contact line height and stagger measurement

This device can be operating autonomous or it can be controlled from PC by special service software. All measured data from internal memory can be evaluated in evaluation software. The parameters observation is inspected based on railways technical norms in evaluation software. The measured data are displayed as graphs or table. If parameters were overrun, the values are graphically displayed or overrun table is generated by evaluation software. The measurement results can be printed as report for other peoples.

¹ University of Žilina, Faculty of Electrical Engineering, Department of mechatronics and electronics, Univerzitná 1, Žilina, 010 26, SLOVAKIA, Phone: +421 41 513 1624, E-mail: libor.hargas@fel.uniza.sk

² University of Žilina, Faculty of Electrical Engineering, Department of mechatronics and electronics, Univerzitná 1, Žilina, 010 26, SLOVAKIA, Phone: +421 41 513 1624, E-mail: peter.sindler@fel.uniza.sk

³ Railways Researched and Developed Institute Žilina, (Výskumný a vývojový ústav železníc Žilina), Železničná 10, 038 61, Vrútky, SLOVAKIA, Phone: +421 43 229 3474, E-mail: Lubomir.Zaborsky@zsr.sk

⁴ University of Žilina, Faculty of Electrical Engineering, Department of mechatronics and electronics, Univerzitná 1, Žilina, 010 26, SLOVAKIA, Phone: +421 41 513 1624, E-mail: anna.simonova@fel.uniza.sk

⁵ University of Žilina, Faculty of Electrical Engineering, Department of mechatronics and electronics, Univerzitná 1, Žilina, 010 26, SLOVAKIA, Phone: +421 41 513 1624, E-mail: dusan.koniar@fel.uniza.sk

2. THE PRINCIPLES FOR STATIC PARAMETERS MEASUREMENT

The measurement principles are based on this condition: the wagon (locomotive) is hard and the wagon deviation, pantograph scraper height and overhead contact line position on pantograph scraper (*Fig. 2*). The overhead contact line position on pantograph scraper measured precision is about 1 cm. The other parameters have measured precision less than 1 mm. The pantograph scraper shape is corrected to overhead contact line position during calculation. The overall precision is about 1 cm.

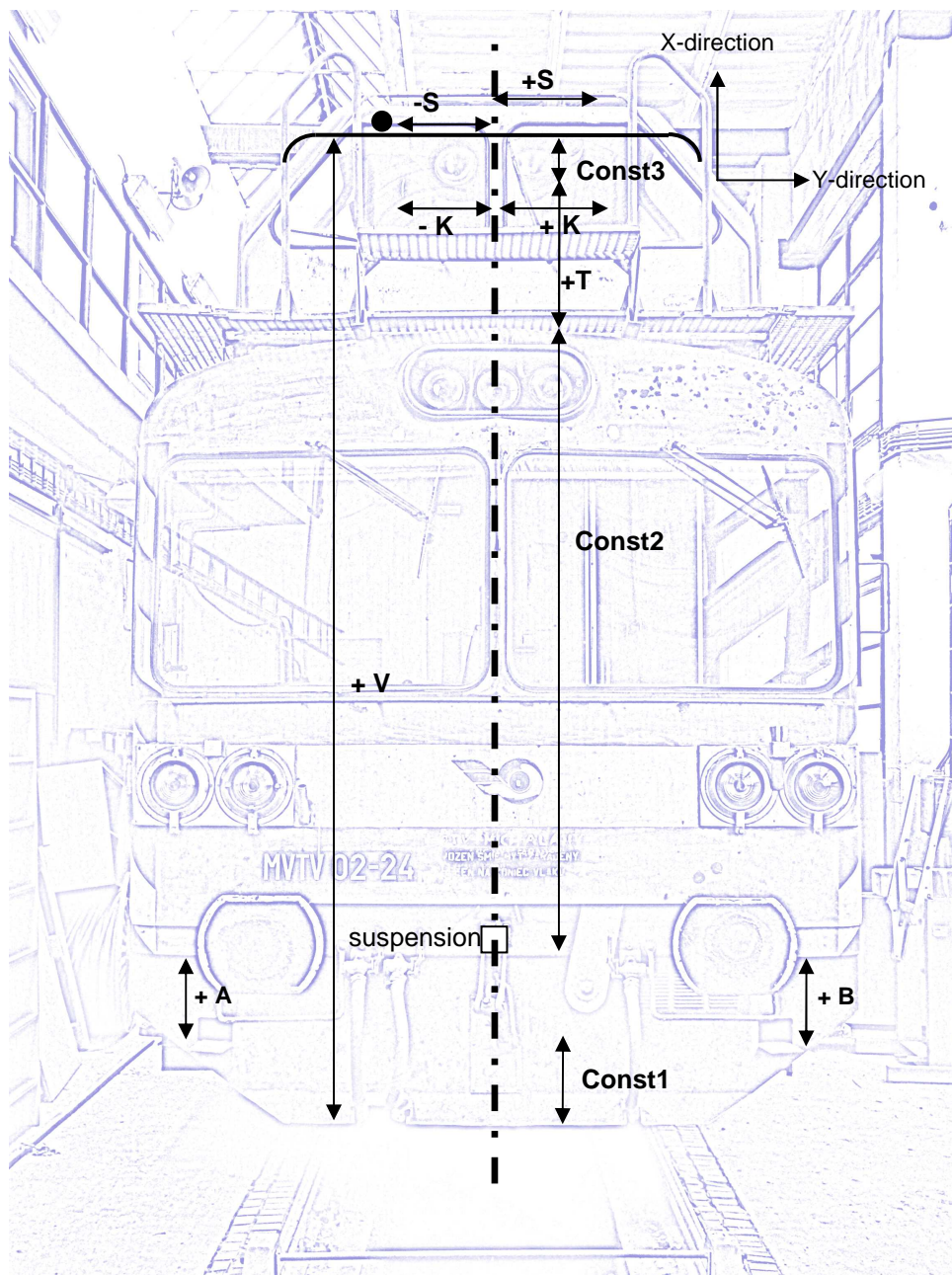


Fig. 2 The parameters measurement principles

The calculation is done for assigned increment count from trajectory incremental detector. For example if the wagon wheel diameter is about 2560 mm and increment count is 4, then overhead contact line parameters calculations will be done for every 10.24 cm. It means that the constants, calibrations information, wagon deviations values, pantograph scraper height and overhead contact line position on pantograph scraper are written to the device internal NAND memory. The other parameters which are synchronized from trajectory incremental detector are also written to the device internal NAND memory. These parameters are mast position, event position and location based on GPS coordinates.

The overhead contact line parameters measurement is done by calculation from some constants and other solved parameters of wagon. The wagon parameters are explained:

- Const1** distance from rail to zero point of the meter swing wagon [mm]
A distance from the zero point of the meter swing wagon to attachment [mm]

$$A = \frac{a - K_{a2}}{K_{a1}} \text{ [mm]} \quad (1)$$

$$a = \frac{REF * cislo}{2^{16}} \text{ [V]} \quad (2)$$

where: A deflection of left meter,
a voltage of converter,
REF reference voltage 2.5 V,
cislo measured value from converter,
K_{a1} constant [V/mm]
K_{a2} constant for zero value of the meter swing wagon [V]

B distance from the zero point of the meter swing wagon to attachment [mm]

$$B = \frac{b - K_{b2}}{K_{b1}} \text{ [mm]} \quad (3)$$

$$b = \frac{REF * cislo}{2^{16}} \text{ [V]} \quad (4)$$

where: B deflection of left meter,
b voltage of converter,
REF reference voltage 2.5 V,
cislo measured value from converter,
K_{b1} constant [V/mm]
K_{b2} constant for zero value of the meter swing wagon [V]

The angle of wagon deflection α - signed: +Y direction, -Y direction

$$\alpha = \arcsin \frac{(A - B)}{sirka} \text{ [}^\circ\text{]} \quad (5)$$

where: sirka the distance between the sensors

Const2 distance between the bottom part of wagon and the upper part of wagon [mm]
Const3 distance between the bottom part of the meter swing on wagon and the collector [mm]

3. THE DEVICE HARDWARE DESCRIPTION AND CHARACTERISTICALLY PROPERTIES

The device block scheme is at *Fig. 3*. The hardware realization is at *Fig. 4*. The devices for overhead contact line height and stagger measurement hardware part are:

- motherboard – microcontroller,
- overhead contact line position on pantograph scraper detector,
- GPS signal detector,
- wagon deviation detector,
- trajectory incremental detector,
- interconnection optical cables.

The microcontroller core is 32-bits processor from NXP. The NXP microcontroller manages all device actions. The microcontroller communicates periodically with overhead contact line position on pantograph scraper detector true optical interconnection and simultaneously with other detectors and sensors. The display and keyboard are connected true ports to microcontroller. The microcontroller manages communication with connected PC true USB port. Then the measured data can be displayed on PC. The other communication possibility is sending of measurement settings, starting or stopping measurement from PC to device.

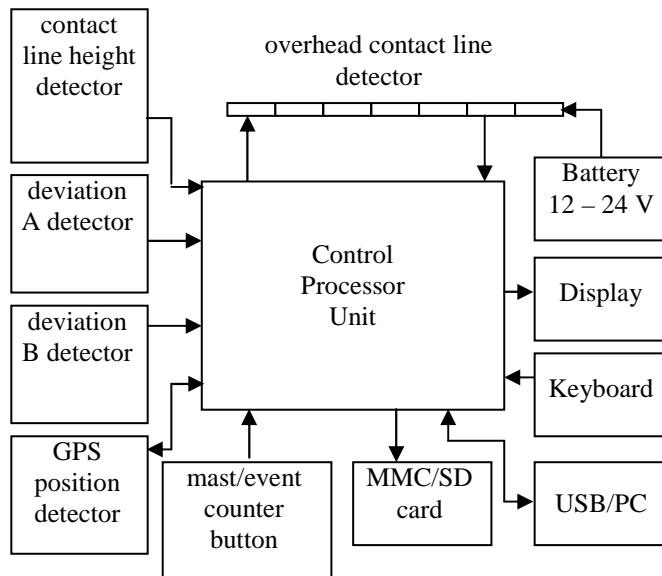


Fig. 3 The device block scheme

The motherboard is realized as dual layer board (1.5 mm). There are these blocks: processor unit, 16-bit converter with analogue multiplex, power supply part, binary signals inputs, MMC/SD card, USB controller, serial optical interface for overhead contact line position on pantograph scraper detector, GPS module and RTC controller.

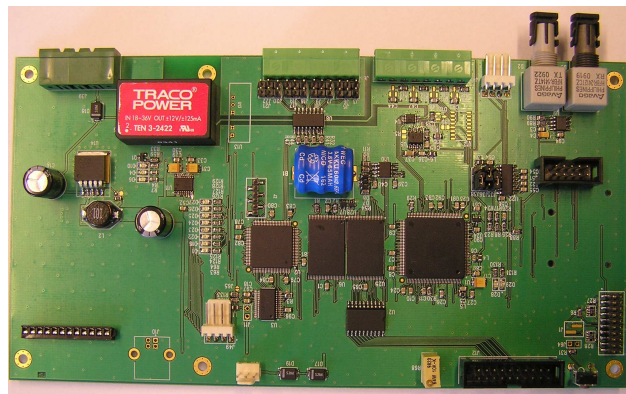


Fig. 4 The motherboard hardware realization

The 32-bit processor LPC2214 with ARM7TDMI-S core is placed on motherboard. The operating frequency is 55 MHz. This processor includes 16 kB RAM memory and 256 kB flash memory for program and other peripheral controllers. The processor is extended to external 16 Mbit integrated RAM memory CY62167DV30. This memory is used by operational system.

The external NAND memory with 1 Gbit capacity is used for measured data recording. The total capacity for recording is about 200 – 240 km. This value depends on chosen measurement precision. Measurement precision is determined by increment count from trajectory incremental detector.

All circuits are connected by standard 16-bit bus. The processor cooperates with programmable logical field XC2C64A. The following interfaces are realized with this logical field: keyboard interconnection, binary inputs interconnection, serial controller interconnection and PC interconnection [1], [2], [6], [7].

The immediate control is possible for measured parameters. The device can on-line communicate with PC. The device is characterized by:

- on-line numeric and graphic values displaying on devices display,
- on-line numeric and graphic values displaying on PC true USB cable,
- measure settings entered from device keyboard,
- measure settings entered from PC true USB cable,
- device settings entered from device keyboard,
- measure can be started from device keyboard or from PC true USB cable,
- measurement overview on device,
- measured parameters recording about 200 km,
- record can be saved to MMC/SD card,
- list of last 20 measurements,

- password oriented access to device (tree level),
- automatic actual time and date setting ,
- measured data evaluation on PC.

4. THE DEVICE SETTING SOFTWARE DESCRIPTION

The device is controlled by front panel's controls. Main control component is keyboard. The MMC/SD card connector, USB connector and connector for masts and events measurement are placed on the front panel.

The graphical display is indicator of device states. The device's menu and measured data are displayed on display too. The device's tasks are initialized by device start. The display is divided into two parts. The display left part is realized as graphical measured data representation (overhead contact line height and stagger). The display right part is realized as numerical interpretation (measured sector name, overhead contact line height and stagger, trajectory, speed, mast and event). The GPS data are displayed on the display bottom part. If the any key is pressed the Main menu is displayed.

In this menu are displayed measurement settings, device settings, measured records, actual measured data values and device information. The password is required for device setting. In this menu can be sets wagon constant, according *Fig. 5*, time and date, deviations calibration and other parameters.

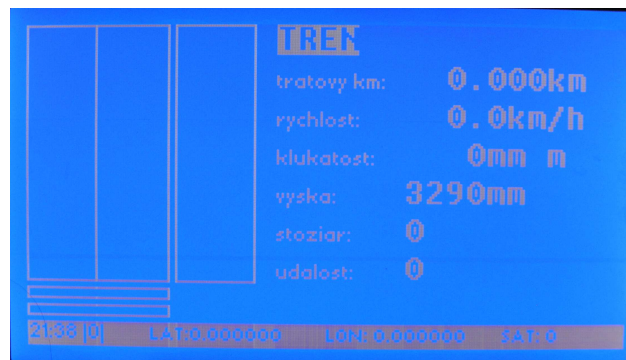


Fig. 5 The devices display

5. THE SOFTWARE FOR ANALYSIS DESCRIPTION

The software was designed as virtual instrument in LabVIEW (*Fig. 6*). The measured data evaluation, measurement settings and measurement control can be done with this virtual instrument.

The measured data evaluation is done for measured records copied to MMC/SD card. In this case the measured data are transformed to graphical and table displaying form. The connection line height and stagger is graphically displayed (*Fig. 7*). The detailed displaying can be done by control button (*Fig. 8*). The all measured data can be displayed by cross dragging by mouse. The connection line height, stagger, trajectory, mast number, event and GPS data (measurement date and time, longitude, latitude, wagon speed and absolute altitude) are presented by cross dragging.

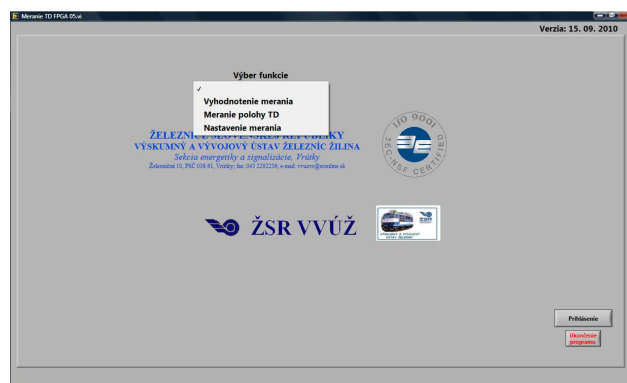


Fig. 6 Start application window

The boundary settings are determined for connection line height and stagger. These boundaries are displayed in graphs as red lines. All measured parameters must be between boundaries (*Fig. 9*).

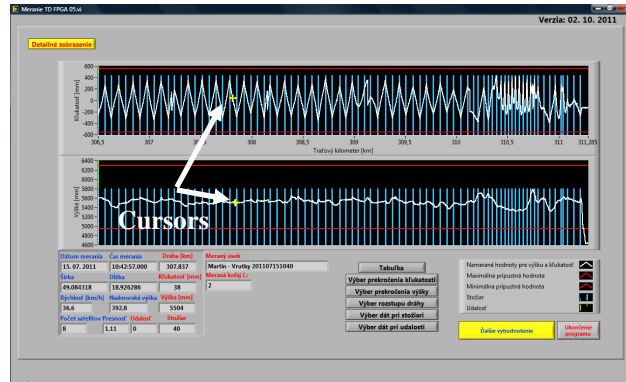


Fig. 7 Measured parameters graphs

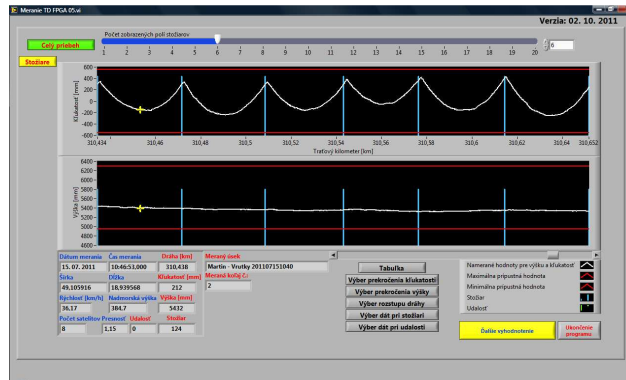


Fig. 8 Detailed display window

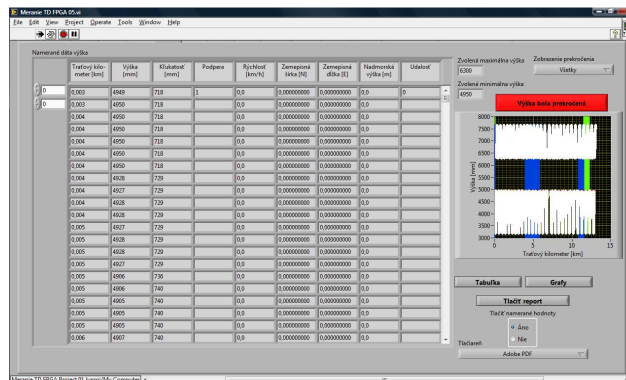


Fig. 9 Exceed limits window

If parameters were overrun, the values are graphically displayed or overrun table is generated by evaluation software [3]. These parameters are important. The overhead contact line stagger and height are determined based on railways technical norms.

The USB cable connection must be realized to connect device with PC, in the case the device is controlled by PC. Two operation modes are available in this case [4], [5].

In the first case it is “Setting mode” (Fig. 10). In this mode the measurement information’s are determined. The measurement information’s are basically a name of measured sector, starting mast number, measuring wagon motion direction and a communication options (the PC can communicate with device during measurement). The measurement can be started by PC or can be directly started in device after measurement information’s are determined.

The second mode is “On-line measurement mode” (Fig. 11). This mode is used to on-line measured parameters displaying on PC monitor. The communication between device and PC is realized thru USB cable. All measured data are on-line transmitted to PC. The PC realized all mathematical operations and corrections for data displaying. Measured data are simultaneously displayed on PC monitor and device display. The advantage of this mode is measured data comfort viewing on PC monitor. The measurement start, stop and new measurement setting can be realized in this mode too.

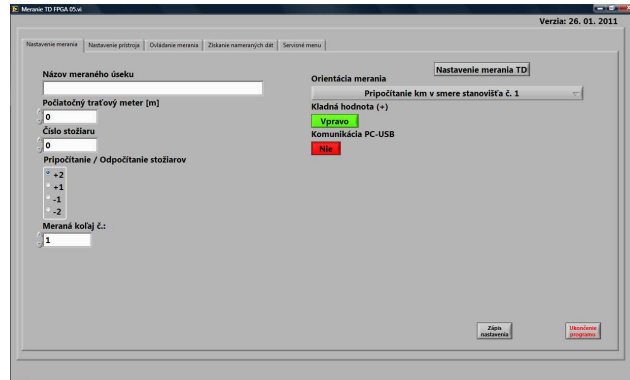


Fig. 10 Measurement settings window

The second mode is “On-line measurement mode” (Fig. 11). This mode is used to on-line measured parameters displaying on PC monitor. The communication between device and PC is realized thru USB cable. All measured data are on-line transmitted to PC. The PC realized all mathematical operations and corrections for data displaying. Measured data are simultaneously displayed on PC monitor and device display. The advantage of this mode is measured data comfort viewing on PC monitor. The measurement start, stop and new measurement setting can be realized in this mode too.

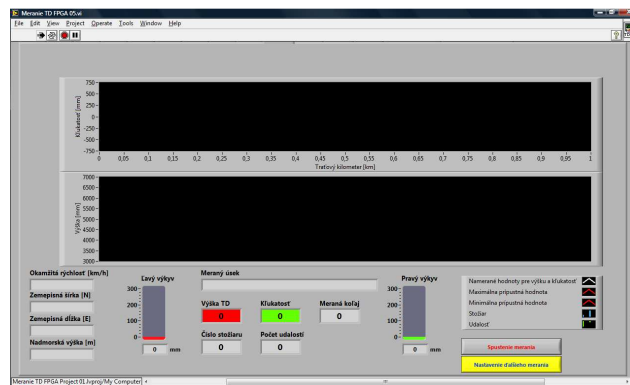


Fig. 11 On-line parameters measurement window

The measured data from GPS can be transferred to Google earth format in the special mode. The position of measured rail sector can be displayed in this software.

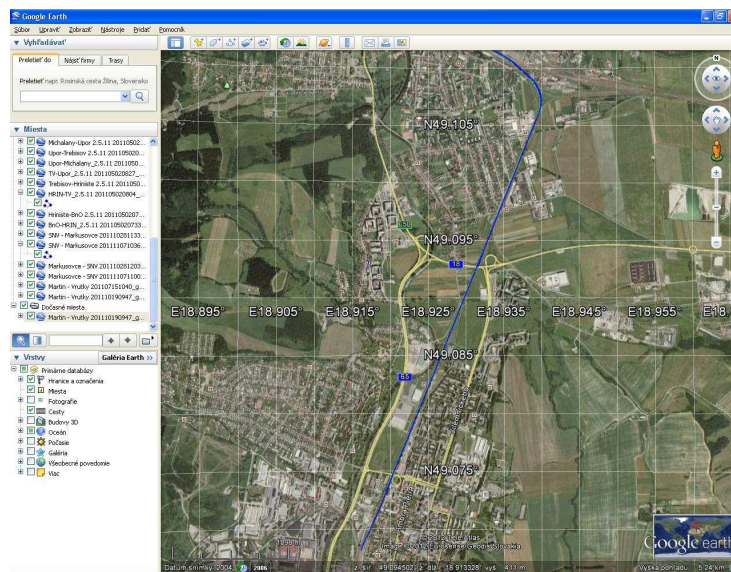


Fig. 12 On-line parameters measurement window

6. CONCLUSIONS

The device for overhead contact line height and stagger measurement is determined for overhead contact line continuous measurement. The device's advantage is automatic data acquisition. The measured data are recorded to devices internal memory. The device is served for overhead contact line parameters measurement simplification and objectification.

All measured data from internal memory can be evaluated in evaluation software. The parameters observation is inspected based on railways technical norms in evaluation software.

7. ACKNOWLEDGMENT

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8. REFERENCES

- [1] Frivaldsky M., Drgona P., Prikopova A.: *Design and modeling of 200kHz 1,5kW LLC power semiconductor resonant converter*, IEEE International conference on applied electronics, Pilsen 2009 (September)
- [2] Drgona P. - Bobek V. - Dobrucky B. - Frivaldsky M.: *Performance analysis of equation computation for real time model of PMSM for VHFIM control of PMSM position drive*, EDPE 2009 (October), International Conference on ELECTRICAL DRIVES and POWER ELECTRONICS
- [3] Jurisica, L., Vitko, A., Duchon, F., Kastan, D.: *Statistical approach to GPS positioning of mobile robot*, Journal of Control Engineering and Applied Informatics, CEAI, Vol.12, No.2, pp. 44-51, 2010
- [4] Duchon, F., Strenger, M.: *Microsoft Robotics Studio*. In: AT&P Journal Plus. - ISSN 1336-5010. - No. 1 (2008), p. 18-23
- [5] Jurisica, L., Duchon, F.: *Mapping in Mobile Robotics*. In: Acta Mechanica Slovaca. - ISSN 1335-2393. - Vol. 12, No. 2-A (2008), p. 307-320
- [6] Spanik, P., Hurtuk, P., Drgona, P., Frivaldsky, M., Radvan, R.: *Utilization of full bridge converter with synchronous rectifier for electroplating*, COMPUTER SYSTEMS AIDED SCIENCE INDUSTRY AND TRANSPORT, 14TH INTERNATIONAL CONFERENCE TRANSCOMP 2010, Zakopane, 2010, ISBN 978-83-7204-956-8.
- [7] Szychta E.: *Zero voltage switched multiresonant converters – analysis and design*, University of Žilina, Žilina 2008. ISBN 978-80-8070-889-4.