

SIMULATION AND MEASUREMENT OF AXLE COUNTER WITH FPGA

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Abstract

The paper describes development of axle counter PN300 for the railway industry in high speeds railway corridors up to speed of 300 km/h. Project deals with counting of axles of vehicles in rails for determining of occupied or free sections of the rail corridor. Axle counter PN300 is based on digital processing of signals by FPGA devices as data evaluation system and microcontroller for data communication between the axle counter and superior system. As a sensor, it is used approved electromagnetic sensor. This solution must fulfill whole range of aspects focused especially on safety and security on railway. For recording the passage of railway vehicles are currently being developed inductive sensors with subsequent digital signal processing. This document describes the simulation function of such sensors in transit vehicles and also measurement and signal processing in real testing sensors.

1 Introduction

The axle counter is used for determining, whether the tracked sections of the rails are free or are still occupied by a train. Solution is provided by counting the number of axles that has entered the monitored sector of the track and then counting the axles that has left this sector of rails. If the number of axles that has entered the tracked sector is the same as the number of axles that has left the sector, then the sector is free and next train is allowed to enter this sector of the track. If the sector is occupied, next awaiting trains must be stopped otherwise there is impending danger of crash. Besides signaling of free or occupied sector of the track, the axle counter can be used for alert devices on rail crossings or junctions.

Quite similar function to the axle counter has older devices measuring electrical contact between left and right rails. If the train drives through some sector of the track, rails are conductively connected, and this state is evaluated with relay circuit. The axle counter is developed as a modern solution. In this case, every tracked sector must be equipped with an axle counter on the beginning and on the ending of the sector. Rail sectors must be equipped at least with 2 axle counters, in some special cases, there are more axle counter – free or four, according to Fig. 1.

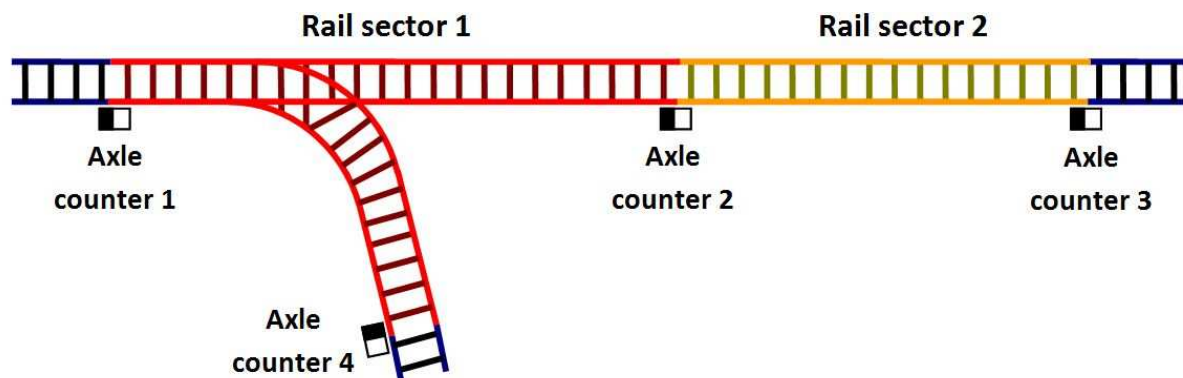


Figure 1: Example of monitored sectors of the rail track

2 Evaluation of measured signal

Instead of previous axles counters, this one is being developed for speed up to 300km/h, what leads to difficulties with the signal evaluation. In this case, it is very important signal to noise ratio and other noise voltage related to atmospheric phenomenon like lightning during the thunderstorm. The amplitude of noise due to lightning can be same or even a higher than amplitude of a useful signal and holds for a hundreds of microseconds. When the sensor was developed only for speed up to 80 km/h, the atmospheric noise could be filtrated. But in higher speeds of trains like in 300km/h, the axle passing around sensor takes about 1-2 milliseconds. This time is already very close to atmospheric noise. This is way it was necessary to find new way of evaluation of signal of accessing coils. The created solution is based on Fast Fourier Transform. Because signal has to be analyzed in a real time, it was chosen solution with Field Programmable Gate Array (FPGA). Signals from coils are at first digitalized in analog-digital converters outside FPGA and then digitally analyzed. Output states of FPGA are then sent into control system with microcontrollers AVR that allow remote change of parameters in FPGA and long-distance communication to the control center.

Because the axle counter must fulfill whole range of security aspects, the part of measurement and evaluation is doubled. This means that we collaterally analyze the output signal of electromagnetic sensor at the same time with two different ways. Electromagnetic sensor and hardware of the FPGA with auxiliary circuits are the same for both of the evaluation systems, but the ways of analyzing implemented in both FPGA are different. In first FPGA we use our own developed algorithm working in real-time with digitalized data, second FPGA use the Fast Fourier Transform to determine the amplitude of measured signal. For the right evaluation of number of axles, both results must match.

Both algorithms use leveling of input measured data into several levels, which are then analyzed in real-time and with the state-computer, the axles are numbered.

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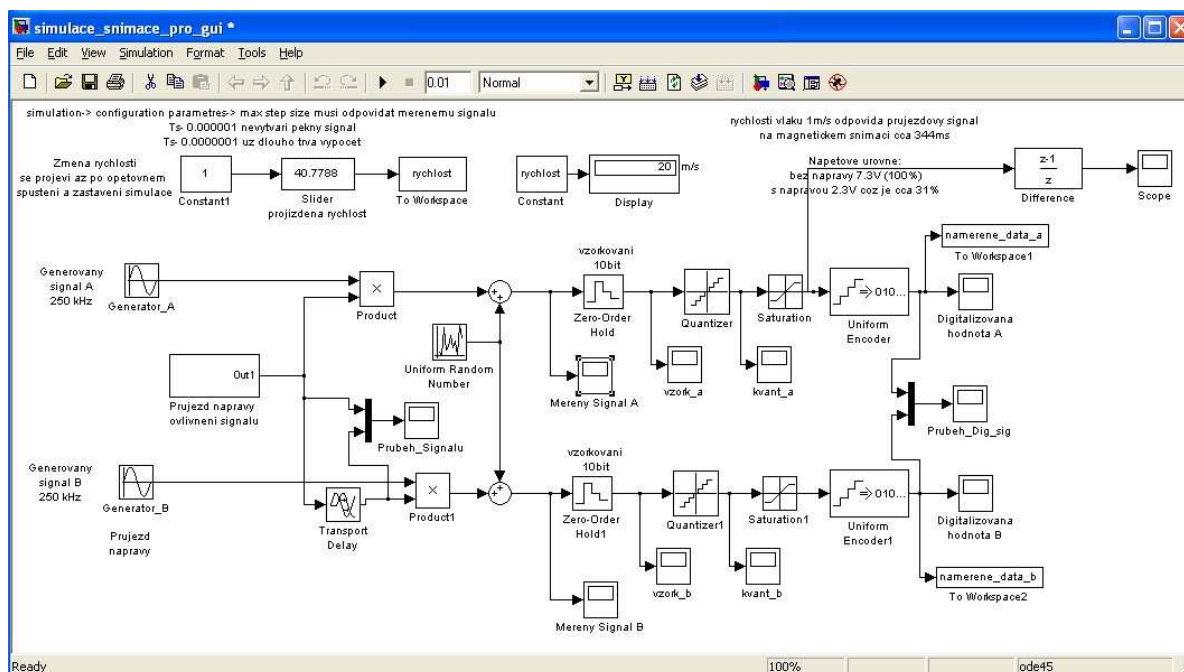


Figure 2: Simulation diagram of the passage of axles in Matlab/Simulink

For this purpose a simulation program was developed in Matlab / Simulink to generate data simulating the behavior of sensors with A / D converters for railway axles passing around sets of sensors (see Figure 1). It is possible to simulate different rates of passing railway trains, different frequency generators of periodic signals in the sensors, as well as different distances between the two magnetic sensors. The simulation parameters can be entered both in the generated graphical user interface, as well as in the simulation scheme

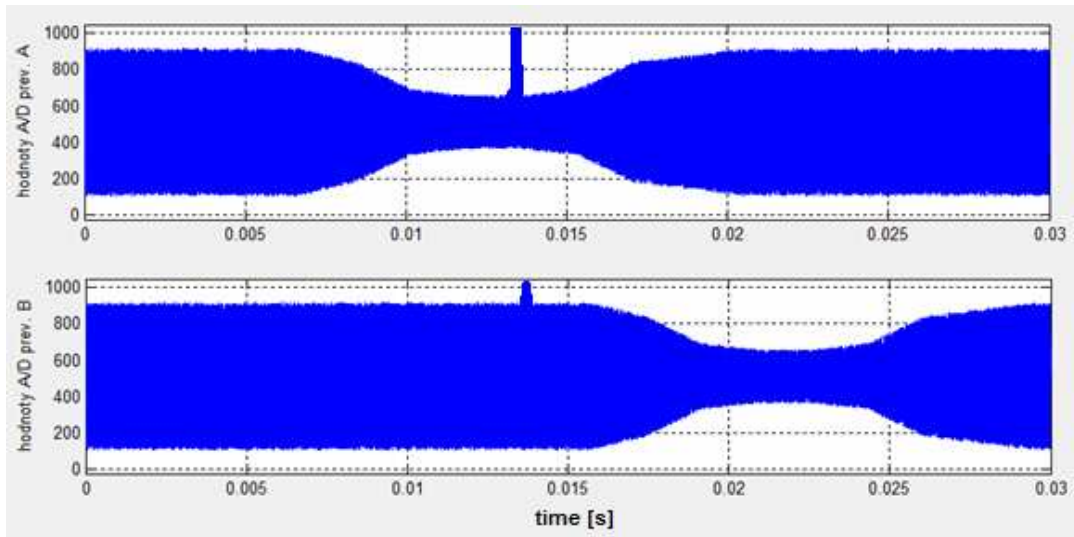


Figure 3: Simulated harmonic signal from sensor A and B.

The proposed algorithm in Simulink can simulate some common types of interference and set their parameters. Figure 3 shows the simulated fault signal from the sensors at the time of 0.013 seconds from the beginning of the simulation. At the stage of development the simulated signal can be loaded into internal block memory of FPGA device, which should be able to detect these types of faults.

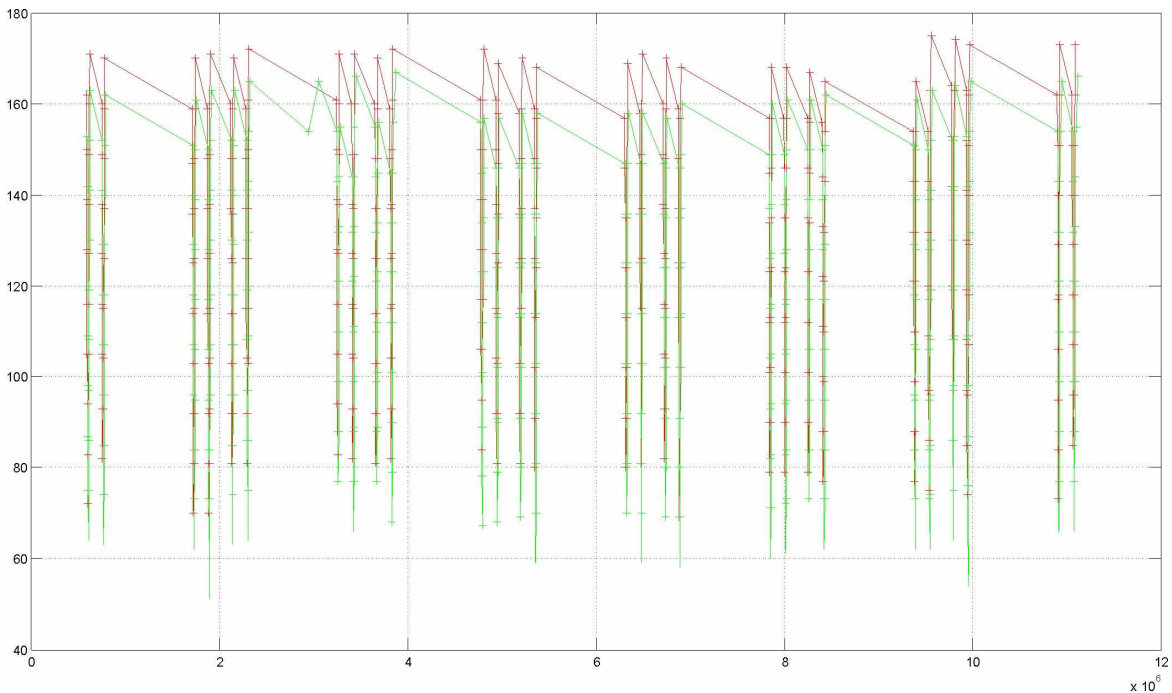


Figure 4: Digital evaluation of the amplitude of the signal transducers: Passing trains Pendolino.

For digital processing of signals from the sensors was used programmable logic FPGA Xilinx Spartan3S200A. These include the management of A/D converters, AC signal amplitude evaluation of sensors and other logic to evaluate conditions. To accelerate the calculation it uses pipelined data processing and specific algorithms designed for parallel processing in hardware. A / D converters operate with a sampling frequency of 3 MHz, while the system frequency of FPGA is 42 MHz.

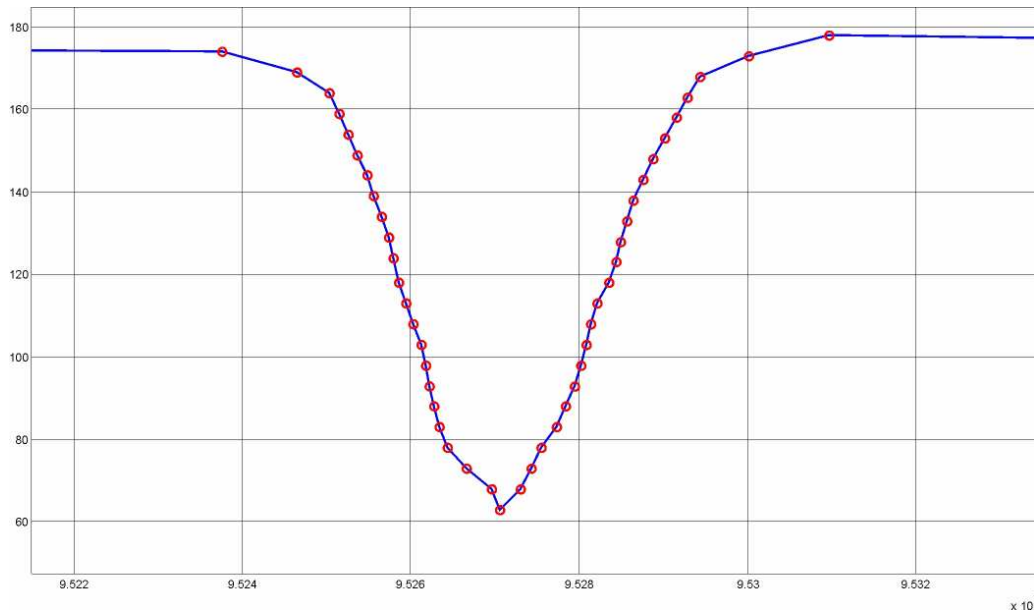


Figure 5: Digital evaluation of the amplitude of the signal transducers: Single wheel detail.

Simulation software Matlab / Simulink in this development is an important tool to verify the functionality and features developed hardware. The software is used here as in the initial design stage and in the validation phase of a real system to visualize the measured data.

3 Results

The solution was verified in operation and the results are great promise for further work on the development of security technology. It reached a solution by minimizing the analog elements, stands high resistance to interference, operational stability and low temperature drift. Simulation results have led to faster development of the whole system and revealed some potential problems of the proposed solutions.

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References

- [1] R. Hrbac, V. Kolar, V. Kasik, R. Blaha. *Development of the new Axle Counter Sensor for Rail Vehicle Detection at Speeds up to 300 km/h*. New RAILWAY TRENDS NEW RAILWAY TECHNIQUE News in rail transport, No. 1, February 2011, Volume 19. KPM CONSULT, Brno , Czech Republic.
- [2] M. Augustynek, M. Penhaker, D. Korpas. *Controlling Peacemakers by Accelerometers*. In 2010 The 2nd International Conference on Telecom Technology and Applications, ICTTA 2010. March 19-21, 2010, Bali Island, Indonesia, Volume2 NJ. IEEE Conference Publishing Services, 2010, p. 161–163. ISBN 978-0-7695-3982-9, DOI: 10.1109/ICCEA.2010.288
- [3] O. Krejcar. *Large Multimedia Artifacts Prebuffering in Mobile Information Systems as Location Context Awareness*. In 4th International Symposium on Wireless Pervasive Computing, ISWPC 2009, February 11-13, 2009, Melbourne, Australia. pp 216-220. ISBN 978-1-4244-4299-7, DOI 10.1109/ISWPC.2009.4800591

- [4] M. Penhaker, M. Cerny, M. Rosulek. *Sensitivity Analysis and Application of Transducers*. In conference proceedings 5th International Summer School and Symposium on Medical Devices and Biosensors, JUN 01-03, 2008 Hong Kong, PEOPLES R CHINA, Pages: 85-88 Published: 2008, ISBN: 978-1-4244-2252-4
- [5] P. Dondio, L. Longo, S. Barrett. *A translation mechanism for recommendations*. In IFIP, Volume 268, IFIPTM 2008/Joint iTrust and PST Conference on Privacy, Trust Management and Security Trondheim, Norway, Jun 18-20, 2008, pp. 87-102. (2008)
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