RESEARCH PAPER | Engineering | Volume : 4 | Issue : 12 | Dec 2014 | ISSN - 2249-555X

Train Control And Monitoring System Simulator

KEYWORDS: Train Control and Monitoring System (TCMS), TCMS simulator, rail vehicle, software development

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ABSTRACT *In this paper we present the Train Control and Monitoring System (TCMS) simulator. The simulator was designed and constructed within the framework of cooperation between the Kazimierz Pulaski University of Technology and Humanities in Radom and MEDCOM Ltd Company, Warsaw. Poland. The simulator will be installed in the (TCMS) Laboratory of the Ukrainian Academy of Railway Transport in Kharkov under the project, which is the part of Development Cooperation Programme provided by the Ministry of Foreign Affairs of the Republic of Poland. The main goal of the project is to equip the (Ukrainian) Laboratory of the Rail Vehicle Diagnostic and Control Systems with the TCMS training simulator. It allows the Ukrainian Academy Staff to organize a series of training courses and seminars, and to carry out the scientific research of control systems including the energy efficiency effects connected with the vehicle start-up and braking phases.*

The project is partially granted (co-financed) by the Ministry of Foreign Affairs of the Republic of Poland under the Development Cooperation Programme.

INTRODUCTION

The Kazimierz Pulaski University of Technology and Humanities in Radom cooperates with the MEDCOM Ltd Company from Warsaw, Poland, within a large project "Organizing and equipping the Train Control and Monitoring System (TCMS) of Railway Vehicles Laboratory" of the Ukrainian Academy of Railway Transport in Kharkov. The project is partially granted (co-financed) by the Ministry of Foreign Affairs of the Republic of Poland under the Development Cooperation Programme.

The objectives of this project are following:

Increasing general education level of full-time engineering students, graduate, postgraduate, and PhD ones by enforcing the educational process by implementing the latest modern hardware and software tools for programming the control and diagnostic systems of traction vehicles with asynchronous energy-efficient drives.

Transferring knowledge of the designing energy-efficient drive systems and energy conversions in rail-vehicles.

Providing trainings and technical assistance in design of the rail-vehicles control and diagnostic systems, and in train board systems integration.

The achievement of these objectives will be possible thanks to modern TCMS simulator constructed by the project partners. The principle of operation of the simulator is based on the TCMS device manufactured by MEDCOM, which is originally dedicated to electric traction units EN57 operating in Poland (EN57 EMUs - EN57 Electric Multiple Units).

TRAIN CONTROL AND MONITORING SYSTEM

The TCMS system ensures comprehensive and reliable operation of a rail vehicle and enables for example [1, 4]:

- to control the drive systems,
- to eliminate vehicle skid during start-up and electrodynamic braking,
- to stabilize the vehicle speed,
- to cooperate both, the electrodynamic and electropneumatic brakes,
- to register the kinetic parameters of the motion,
- to control the compressed air system,
- control of the high-speed circuit breaker.

Additionally, the TCMS system allows the driver to know and monitor all necessary control and diagnostic information, e.g. [1, 4]:

- state of the train drive system,
- state of the train braking system,
- state of the main inverter,
- state of the high-speed circuit breaker, pantographs, doors, and lifts,
- multiple parameters visualization and recording (voltage, current, power, temperature, etc.),
- state of the manual switches and MCB's (Master Circuit Breakers),
- HSCB (High Speed Current Breakers), Current Leakage Detectors and Emergency Power-off monitoring.

The TCMS is produced by using the microprocessor technology. The application of the modern, specialized computers and tested communication standards guarantee safe and reliable operation of rail vehicle drive system [5, 6]. The implemented control algorithm is realized by a master controller and ensures optimal control of the motors torque and speed during the starting and electrodynamics braking. During normal driving torque is adjusted by train driver by using speed controller. The exemplary block diagram of TCMS traction unit is shown in Figure 1.

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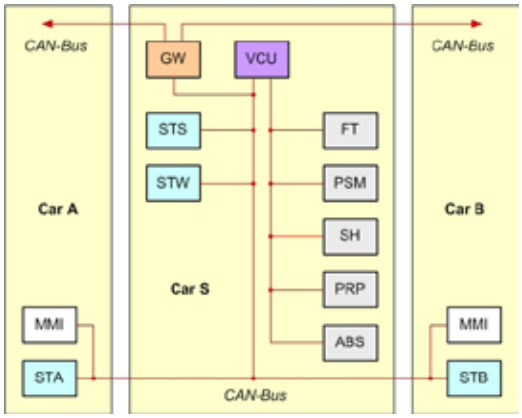

Figure 1. Block diagram of TCMS [1].
VCU – Vehicle main unit controller;
GW –bus gateway controller;

FT – traction inverters;
PSM – static converter;

SH – brake controller;
PRP – redundant protection controller ;

ABS – anti-slip anti-skid controller;
MMI – operator interfaces;

STS, STW, STA, STB – local controllers.

TCMS SIMULATOR

The TCMS simulator applies the MAS technology of the Selectron, Switzerland. It is very powerful platform for the rail industry application [2]. The Selectron Company specializes in the industrial automation systems production (including PLCs - Programmable Logic Controllers). The Selectron widely implements open communication protocols, such as e.g.: Ethernet, CAN, MVB, WTB, and RS485. The MAS platform modules meet the high requirements of standards EN 50155 and EN 50121.

To build train driver operating console simulator the following MAS platform elements were used [2]:

Vehicle Control Unit CPU831-TG,
Expansion modules AAT732-TG/16B,
Expansion modules DDT 732-TG/05A,
Expansion modules DIT732-TG.

The connected components are presented in Figure 2.

Figure 2. Vehicle Control Unit and expansion modules inside the TCMS simulator

On the control desktop a diagnostic Deuta-Werke screen was placed. It is controlled by the built-in independent computer, which is independent from the main VCU Selectron contoller. The VCU and the diagnostic screen communicate directly via the CAN network (Controller Area Network) by the CANOpen protocol. Additionally, there are the velocity and brake adjusters, and the set of analog switches and gauges installed on the train driver operating console simulator (see Figure 3).

Figure 3. TCMS simulator- train driver operating console view

The simulator of the train driver operating console is a simplified version of TCMS system, and therefore, some elements, such as the pneumatic system and the high-voltage installation have been replaced by a simple electrical circuits or simulated by an appropriate software implemented in the main controller. For example, such activities as switching on the auxiliary compressor, raising the pantographs or turning high speed current breaker are simulated by appropriately connected relays. It enables to validate a correctness of dependencies in a designed software. The brake adjuster, which in the real train is a part of pneumatic control system, was replaced by an appropriate one, which transforms given adjuster displacement on appropriate current signal. The manometers were replaced by the analog gauges, which are voltage controlled by the main controller. The simulation of the correct operation of the braking system is fully realized by the software executed on the main controller.

SIMULATOR SOFTWARE DEVELOPMENT ENVIRONMENT

The simulator uses Selectron® CAP1131 environment, which is most suitable for the MES software development [3]. The CAP1131 environment offers all PLC programming languages according to the IEC 61131-3 standard:

Graphical: Ladder diagram (LD), Function Block Diagram (FBD), Sequential Function Chart (SFC).

Textual: Structured Text (ST), Instruction List (IL).

The software development environment for train driver operating console simulator allows to introduce students to the basics of TCMS systems programming, testing, and verifying control algorithms for traction vehicles.

CONCLUSIONS

In the last years in Poland, the intense development of the power supply technology and the control systems of traction vehicles drives has been observed. The TCMS system

Volume : 4 | Issue : 12 | Dec 2014 | ISSN - 2249-555X

developed by the MEDCOM is a good example of a system controlling train drive operation, which ensures maximum efficiency and minimum energy losses during train exploitation. In turn, Ukraine have no such technology, which makes the country dependent from the import of such technology from external suppliers. Due to this reason, there was created the project of Polish - Ukrainian cooperation in this field (partially granted) co-financed by the Ministry of Foreign Affairs of the Republic of Poland. The aim of this project is to equip the Laboratory of Diagnostic and Control Systems of Rail Vehicles Ukrainian Academy of Railway Transport in Kharkov with modern TCMS system simulator. The best way to share knowledge and experience is to provide Ukrainian Academy of Railway Transport in Kharkov with energy-efficient technologies and specialized technical solutions. The modern laboratory equipped with TCMS simulator allows Ukrainian scientists and students to learn the design of the controls and diagnostics traction vehicles drives, as well as learning PLC programming.

Polish aid

The Project co-financed by the Polish Development Cooperation Programme of the Ministry of Foreign Affairs of the Republic of Poland.

The publication expresses exclusively the views of the author and cannot be identified with the official stance of the Ministry of Foreign Affairs of the Republic of Poland.

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