INTELLIGENT ELECTRICAL NETWORK FOR SAFETY OF ELECTRICAL RAILWAY

INTELEKTUĀLIE ELEKTROTĪKLI DROŠAM ELEKTRISKAJAM TRANSPORTAM

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Keywords: mechatronic system, intelligent devises, electrical railway, substations

Introduction

The paper is based on author's scientific work researching the intelligent devises and it's using in mechatronic systems. Intelligent devises are computer modules, which work in electrical network and use methods of the artificial intelligence. Intelligent devises have possibility to cooperate with each other, to solve tasks of control, diagnostics, detect the emergency situations and have possibility to prevent railway disasters.
In this paper, the solution of problems is offered by safety power supply in traction railway substations, to create an algorithm and coordination mechanism for electric power control of railway transport.
As the electric public transport is a complex system, motion control should be coordinated with other participants. Coordination mechanism is presented with the model of generalized scheme for electric power supply by electrical traction railway substation, railway automatic devices and telemechanical control devices
Authors propose to use intelligent devises system for all safety levels. It uses all methods such as bond graph, intelligent devices for solving of the tasks of control, diagnostics and optimization. Elements of bond graphics are used to describe the intelligent control of power networks. The algorithm is workable as regular maintenance as for emergencies.
As an object, Latvian electrical network is selected. As an example of electrical energy consumers Latvian railway system is selected.

Problem definition

There are two main intelligent devise levels in electrical railroad transport systems. The first is the safety of mechatronic system of a train. That means an intelligent devises system is needed to set dangerous situations and give signal to stop trains and haven't possibility crash.
The second devise level is the safe control of mechatronic system in a train. That means an intelligent devises system is needed to stop trains.
Failure between electrical traction railway substations is 10-12 km and this gives possibility to take control in trains in each small failures. That is why the control intelligence devises is placing in electrical traction railway substations. The authors propose to use intelligent devises system for all safety levels. It uses all methods such as bond graph, intelligent devices for solving

of the tasks of control and diagnostics. Elements of bond graphics are used to describe the intelligent control of power networks. The algorithm is workable as regular maintenance as for emergencies.

Methods of solution

On the whole, case the diagram of the power supply of traction substations depends on configuration's power supply of network, reserve of the power of the feeding substations. For safety power supply of reliability attempt to have a diagram of duplicate supply of traction substations. Most typical is the diagram of power supply from the longitudinal electric line. With the two-way feed of traction substations from the twin-circuit line of transmission (Fig. 1.) two chains of line are started only on so to the supporting traction substations.

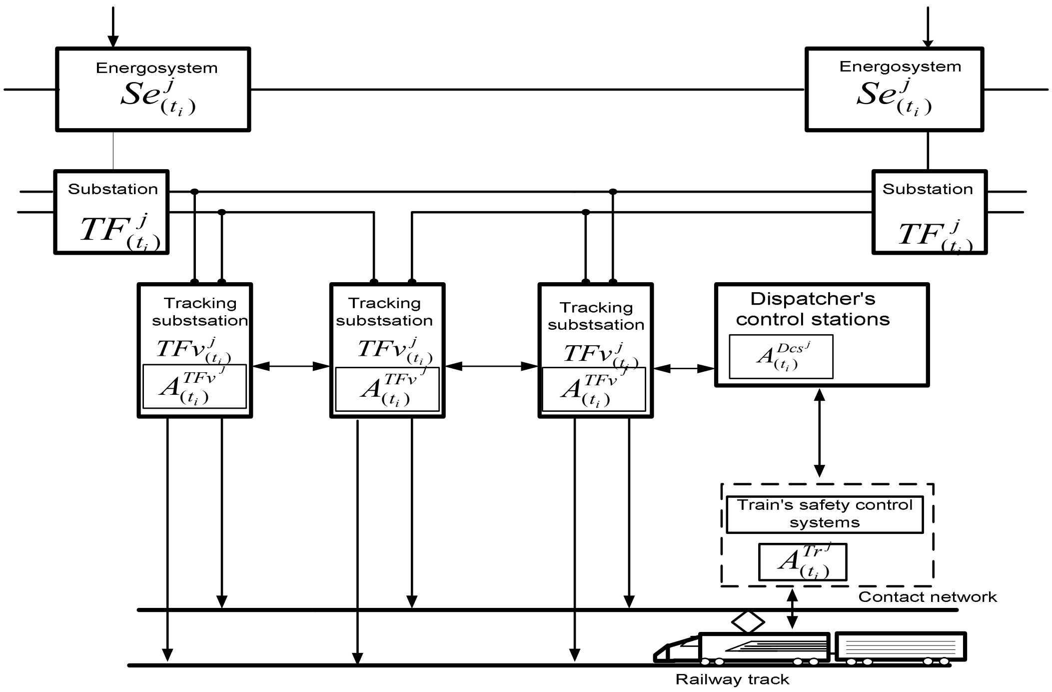

Figure 1.The model of generalized scheme for electric power supply by electrical traction railway substations.

Remaining substations - about the interstitial - obtain power supply through the unsoldering (sealing), or they put themselves in the series of the transmission line alternately to the different chains of line. Sealing and; the double-ended substations alternate between themselves so that with any emergency on the line of transmission (even damage of two chains of line) it would be disconnected not more than one substation. As can seen from Fig.1, failure of one chain of the line of electro transmission in any section between the double-ended substations leads to turning off not of one substation, since all intermediate of substations can obtain nourishment from, the intact sections. But if emergency occurs on both chains of line simultaneously, then will be opened only one sealing substation, connected by unsoldering to damaged sections of both chains of line. Authors propose to use intelligent devises system for all safety levels. It uses all methods such as bond graph, intelligent devices for solving of the tasks of control, diagnostics and optimization. Elements of bond graphics are used to describe the intelligent control of power networks. The algorithm is workable as regular maintenance as for emergencies.

Mechatronic System Parameters for Train

Railway net voltage	$U^{c}_{t(i)}$	Train motor magnetic flux	$C^{f}_{t(i)}$
Railway net current	$I^{c}_{t(i)}$	Train motor torque constant	$c,^{m}= C^{f}/6\ 28$
Railway net frequency	$f^{e}_{t(i)}$	Train motor rotation speed	n'
Train motor voltage	$U^{m}_{t(i)}$	Duty ratio of pulse regulation	g^{J}
Train motor excitation current	$I^{e}_{t(i)}$	Used net energy by train	E'_{a}
Train motor armature current	$I^{a}_{t(i)}$	Recuperation probability of train	a'
Train motor frequency	$f^{m}_{t(i)}$	Recuperation energy of train	E'_{reck}

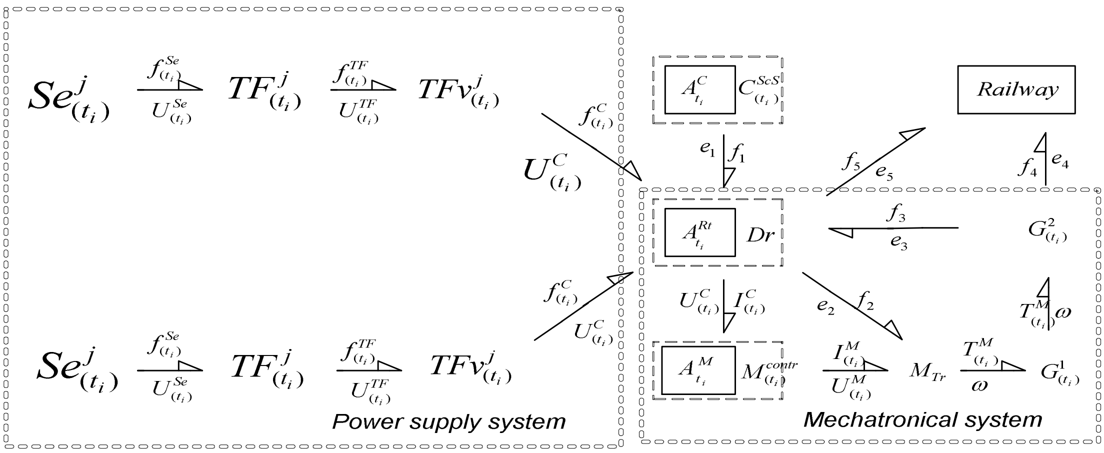

Figure 2. Model of mechatronical systems.

Power supply system:
$SE(t_i)=\{SE_i\ (t_i),\ i\in I\},\ I=\{1, 2,..., n\}.$
Train driver system:
$M(t_i)=\{M_i\ (t_i),\ i\in I\},\ I=\{1, 2,..., n\}.$
Dr – Train driver
Train mechanical system:
$Gm(t_i) =\{G_i\ (t_i),\ i\in I\},\ I=\{1, 2,..., n\}.$
Power supply substations:
$T(t_i) =\{T_i\ (t_i),\ i\in I\},\ I=\{1, 2,..., n\}$

Intelligent agents:
$A_I^{N}= \{ANi,\ i\in I\},\ I= \{1, 2... m\}.$
f_1–signals of action (accelerating, breaking);
f_2 – activation signal;
f_3, f_4, f_5, - data about parameters of vehicle;
$T^{M}_{(ti)}$ – torque;
ω - rotation speed;

The system of power supply ensures is first function of this system. The second function it is transformation of the energy for trains power line $U^{c}_{t(i)}$ and kind of current $I^{c}_{t(i)}$, and kind of current, necessary for the engine system of train.
The regime of the work of the engine system of train is determined by railway net voltage $U^{c}_{t(i)}$, train motor excitation current I^{e} train motor armature current $I^{a}_{t(i)}$ and for the engine system of train of alternating current - even and with the railway net frequency $f^{m}_{t(i)}$. The totality of the

devices, intended for changing the regime the engine system of train, is called control system. In Fig. 2 are shown the elements of electrical railroad participating in the conversion of electrical energy into mechanical energy of train, and information links between these elements, necessary for the train control.

In addition to this, control system must carry out the following supplement the body functions:
- the limitation of the velocity of motion, the thrusts and of electric braking in accordance with the parameters of the engine system of train and the requirements of safety of motion;
- the protection of electrical equipment from the damages and the dangerous regimes;
- the automation of control;

Algorithms for intelligent devices

Step 1.
Detect checkpoint - chp :
Step 2.
Calculate braking point and
Breaking time:
brp = chp dist braking way (Smin —> 0)
brt = braking time (tmin —> 0)
Step 3.
Calculating speed regime:
Step 4.
Control systems checking:
Yes – go to step 5
No – go to step 2
Step 5.
Speed regime checking:
Yes – go to step 6
No – to brake, go to step 2
Step 6.
Traffic light regime:
Yes – (green) go to step 7
No – (red) to brake, go to step 2
Step 7.
Way free checking:
Yes- check end
No – to apase brake

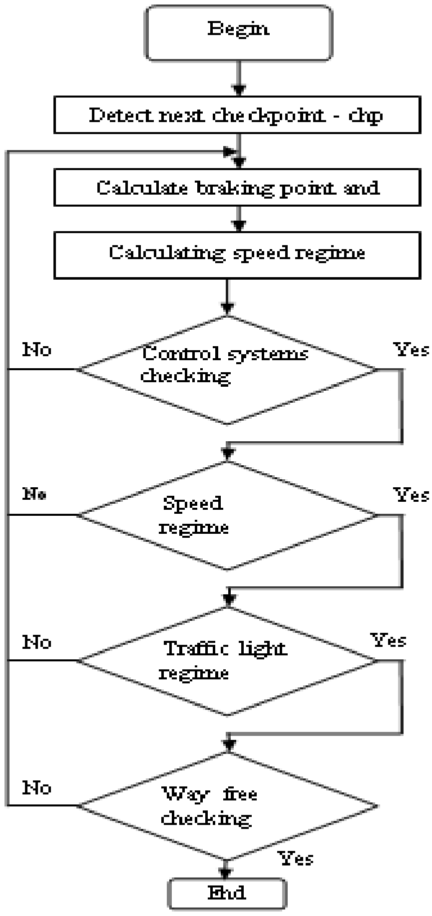

Figure 3. Scheme of algorithms for intelligent devices

Conclusions

The results prove with the condition, the proposed algorithm can be very useful for to solve the problems of energetic and electrotechnology the public electrical systems. The main advantage proposed on this stage in this stage of our work is safety of the movement of trains.

Intelligence devices using on the traction railroad substations give the possibility to divide the object of control in the small sections, which greatly increases safety level of rail transport. Proposed algorithm is possible to estimate the work of the systems, safety of the movement of trains, allow reacting very fast on power supply interruption and realizing maintenance or repair faster, not to allow catastrophe, or to stop train. The system of power supply gives the possibility steady power supply of safety level in electrical railway substations, to solve tasks of diagnostics and to detect the emergency situations.

Calculation time using intelligent agents is measured in few seconds only. Using of uninterruptible power supply gives possibility to realize intelligent agent system for mechatronic system of public electric transport control.

Authors' further plans are to continue the research of using intelligent agent systems in Computer Control of Electrotechnology.

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Uteševs I., Levčenkovs A. Intelektuālie elektrotīkli drošam elektriskajam transportam.
Šīs publikācijas pamatā ir autoru agrākie pētījumi par intelektuālajām iekārtām un to izmantošanu mehatroniskajās sistēmās.
Šajā rakstā tiek apskatīts intelektuālo elektrotīklu elektrotransporta barošanas modelis ar intelektuālo iekārtu. Rakstā parādīta vispārināta elektropadeves un dzelzceļu automātikas iekārtas intelektuālā vadības shēma.
Modelī tiek izmantoti mākslīgā intelekta elementi elektrotransporta drošības jautājumu risinājumam.
Intelektuālās iekārtas izmantošana ir viena no svarīgākajām intelektuālo elektrotīklu uzdevumu risinājuma metodēm. Rakstā analizēta moderna bondgrafu teorija kontroles un diagnostikas uzdevumu risinājumam.
Diagnostikas uzdevums ir šāds – avārijas situācijas laicīgas prognozēšanas metožu un algoritmu izstrāde, drošas elektropadeves risinājumi.
Piedāvātos modeļus un algoritmus var piemērot plaša jautājumu loka risināšanai, kas ir svarīgi Latvijas enerģētikas jomā, un tos var izmantot dažādos lēmumu pieņemšanas līmeņos.

Uteshevs I., Levchenkov A., Intelligent network for safety of electrical railway transport.
The paper is based on the research of the authors into the intelligent devices for mechatronic systems. It describes a generalized scheme for the power supply and automatic control of electrical railway transport using intelligent devices.
The model proposed by the authors is based on the bond graph methods that involve intelligent devices for solving the problems of control and diagnostics.
Since the up-to-date diagnostics of the safe power supply in the railway transport with prevention and detection of emergency situations implies the use of intelligent devices, special algorithms have been developed. In the proposed model and algorithms, bond graph theory elements were employed.

Утешев И., Левченков А., Интеллектуальные электросети для надёжного электрического транспорта.
Данная публикация основывается на предыдущие исследования авторов в области интеллектуальных устройств и их использовании в мехатронических системах
Публикация представляет модель обобщенной интеллектуальной схемы электропитания тяговых железнодорожных подстанций, управления устройствами железнодорожной автоматики. В модели используются элементы искусственного интеллекта для решения задач безопасности движения электротранспорта.
В модели использованы методы теории бондграфов, интеллектуальные устройства для решения задач управления и диагностики.
Задача диагностики для надежного электроснабжения и безопасности движения железнодорожного транспорта следующая – разработка метода и алгоритма для интеллектуальных устройств с целью предусмотреть и предотвратить аварийную ситуацию, а также для решения обеспечения надежного электроснабжения железнодорожного транспорта.