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COMPUTER ASSISTED DIAGNOSIS FOR CED-CR2 RAILWAY INSTALLATIONS (PART I)

BY

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Abstract. In this work we present a novel diagnosis method for railroad traffic safety installations of type CED-CR2. The method is based on the diagnosis charts created by the authors, charts which, in turn, are used to create a diagnosis software. The use of the diagnosis software by the railroad maintenance staff reduces the train traffic delays since defect causes are much faster detected, while, at the same time, errors caused by unprofessional staff interventions are eliminated. The use of the software does not involve additional costs for the railroad operator, as it can be installed on a PC or mobile device easily.

Key words: electrodynamic centralization; damage; diagnosis charts; diagnosis software.

1. Introduction

In Romania, to command and control the train traffic various traffic safety installations are used. Among them we find the Block Signal and Centralization installations (SCB in Romanian – in this paper, all acronyms reflect the Romanian denomination of the mentioned components and/or installations). These installations must function permanently such that a safe train traffic is ensured.

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We analyse in this work failures of SCB installations that have a relay-based electrodynamic centralisation (CED-CR2 in Romanian). The CED-CR2 SCB installations are very complex and are interconnected with other safety installations like light signals, switch electro-mechanisms, track circuits, etc.

Currently, when a failure occurs, the maintenance staff is notified by an operator about the failure, as well as about any signals associated with the damage. The maintenance staff must physically travel to the train station where the defect occurred and, according to the current regulations, determines the cause of the failure, eliminating it. During all this time, train traffic is done with restrictions (low speed), or stopped completely. During the failure analysis, the maintenance staff observe the signals, the equipment state, perform measurements until a failure cause is established. The diagnosis time depends heavily on the theoretical and practical education of the maintenance staff, as well as on the staff capability to respond to stress factors like remote failure location, night time, and unfavourable weather conditions (rain, snow).

Our diagnosis method requires that the maintenance staff give answers to a series of questions shown by the software. Depending on the answers to the questions (which may require physical measurements at certain equipment points) the damage cause is quickly established. With this method the maintenance staff can rapidly determine the failure cause. At the same time the software assistant contributes to reducing the stress factors mentioned above. This method completes the authors' work on electric power installation diagnosis (Spunei *et al.*, 2017), signal failure diagnosis (Spunei *et al.*, 2016), track circuit diagnosis (Spunei *et al.*, 2015), all installations that are part of CED-CR2 installations. The software packages for the failure diagnosis of signals, switches, track circuits, Automatic Block Signaling, and level crossings automatic signaling installations are used by the maintenance staff on the Caransebeş - Orşova railway section. The software package presented in this work will be explained in more detail in a paper to follow, and it will be made available to the railroad maintenance staff in charge of traffic installations failure diagnosis.

We mention now other methods to diagnose traffic safety installations. Jonguk *et al.*, (2016) does analysis of sounds, a method which necessitates, however, additional equipment and approvals. Other work makes use of monitoring systems (Vileiniskis *et al.*, 2016) which, again, must be first acquired and put in place. Another possibility to diagnose traffic safety installation that uses monitoring algorithms (Silmon & Roberts, 2010) makes use of simulation data about the failure, data provided by other, existing, installations. Neuro-fuzzy systems were also used in failure diagnosis in (Chen *et al.*, 2008).

To implement any of the above mentioned diagnosis methods, various additional installations and authority approvals are necessary, which bring additional, significant costs. In comparison, our method is the most efficient for the SCB installations existing in Romania.

2. CED-CR2 Centralisation Installations

The CED-CR2 type installations make use of difference schemas with sequential operation, which lead to a quick diagnosis due to the logical structure in the installation's operation.

To command a route the operator must press a corresponding signal button (for the case we present here, this is the entry signal button). During a normal and correct installation operation, on the command and control panel will display a white path which indicates the route the train will travel on. The corresponding signal will show a permissive indication (Fig. 1).

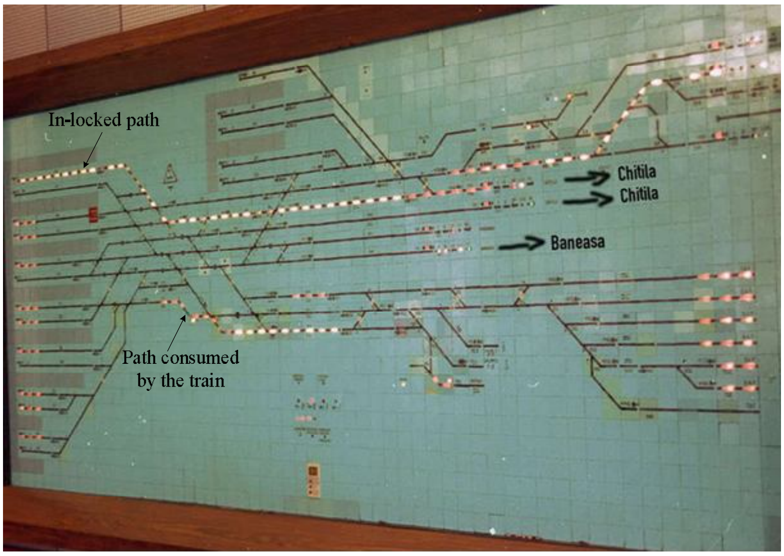

Fig. 1 – Locked route.

Should the route be cancelled, the pressed button bust be de-pressed, the cancelling confirmation being indicated by the white path turn-off and the signal state switch to the stopping indication. Once rolling material is on the first approaching signal block, a total and complete route lock is done, which makes a route cancellation by a button de-press impossible. When the occupied block is behind the signal that was commanded on the free state, the signal will change its indication to a stopping one, and, as the train advances, the following sections change their signalling to red/stop, indicating rolling stock on the section track (Fig. 1). After the train has passed, the light indication changes to white, indicating that the section is now free of rolling stock. After a short time the light indication is tuned off, which means that the section is now unlocked and can be included in another route.

For the X traffic direction, the operating sequence of the CED-CR2 installation is as follows (Stan & David, 1984):

1. *Establish the traffic direction*: pressing the signal button determines de-energizing of the following relays: the IX relay (Romanian for entry on the X traffic direction), EY relay (exit on the Y direction), the MIX relay (entry manoeuvre on the X direction), and the MEY relay (exit manoeuvre on the Y direction).

2. *Delimit the commanded route:* Through the button relay contacts and through the direction relay contacts the coils of the following relays are powered: the IP relay (IP – Romanian for start route), the TM relay (terminate manoeuvre), or the CM relay (manoeuvre common).

3. *Control the route sections:* for all the route types (traffic and manoeuvre) the KS relay (section control) is energized, and, for traffic sections only, the KSC relays (traffic section control) are energized. At this step the following checks are also done:

a) the free state of the route sections is checked by the working relay contacts of the track relays, C, and of the SI relays (isolated sections);

b) switch states on the route are checked by the working contacts of the KMP relay (positive switch control) and KMM (negative switch relay);

c) absence of incompatible routes at the station end where the route command is made, through the IP relay working contacts;

d) absence of incompatible routes at the station end opposed to the station end where the route is commanded, through the EIY relay working contacts (exclude entries on Y direction), and the ZC relay working contacts (traffic latch).

4. *Partial route lock:* the partial route lock is done through the Z relay resting contacts (latch or lock relay) and the ZC relay resting contacts (traffic latch, or traffic lock). At the same time routes subsequent to the just commanded one be *incompatible* through the resting contacts of the following relays: the EFX relay (front exclusion on X direction) and the EIX relay (entry exclusions on the X direction). The partial route lock is signalled by lighting the train path that the train will pass on the luminous schema panel.

5. *Command the signal to show the permissive state:* this step is realized by energizing one of the following relays: the SD relay (direct signal), the SM relay (manoeuvre signal), or the SE relay (exit signal). At this step the additional following checks are done:

i) the free state of the route sections, the switch states on the route, absence of incompatible routes. These checks are done through the KS relay working contacts;

ii) switch locking on the route, through the Z relay resting contacts;

iii) absence of artificial route unlock or route sections unlock, through the resting contacts of the DA relays (artificial unlock).

6. *Total route lock:* the lock is done when the proximity sections X1AD and X2AD on the Automatic Block Signalling path. At this step route

cancelations are not possible anymore without following specific procedures and regulations (button unsealing). The total route lock is realized by de-energizing the route relays, P.

7. *Stop signal indication:* the signal indication is changed to the stopping state when the train occupies the section covered by the signal. The signal indication is changed by the C relay resting contacts, which intervene in the KS relays schemas and, implicitly, in the SD/SA relay schemas.

8. *Fixing the actual train passing over the route isolated sections and successive route unlocking:* This operation is done by re-energizing the route relay of each section, on the condition that the respective section is occupied by the train (*i.e.* either the SI or the C relay is de-energized), and the prior section to be unlocked (*i.e.* the Z relay is de-energized). The section after the entry signal is excepted from this condition, in which case the P relay re-energizing is done at the section occupation time and when the signal indication is changed to the stopping indication.

3. The General Diagnosis for CED-CR2 Type Installations

The CED-CR2 installations make use of several block schemas connected sequentially. This leads to a quick diagnosis due to the logical structure of the installation's operation.

To determine the failure causes of CED-CR2 SCB installations we devised a set of diagnosis charts. In the failure analysis there are several safety conditions involved. These must be checked through several relays and their contacts, which also implement the necessary safety interlocking. All these checks are elaborate and we only present, here, the general charts in determining the damage causes. These charts have been designed based on the installations' block schemas and on the authors' knowledge in diagnosing these installations.

The main failure symptoms of a CED-CR2 installations can be:

a) pressing the signal button is not followed by illuminating the train path on the luminous schema panel (that is, the route is not partially locked);

b) by pressing the signal button, the corresponding path on the luminous schema panel lights up, but the signal light does not show the permissive state (either not at all, or it shows it for a few seconds after which the signal changes to the stopping indication).

Fig. 2 shows the general diagnosis chart for the situation where, although no damage in the installation operation is shown, after pressing the signal button, the path indicating the train route is not illuminated on the luminous schema panel.

For situations where, after the signal button is pressed, the route path is illuminated on the luminous schema panel, but the signal cannot be commanded on the free state, we have devised the chart presented in Fig. 3.

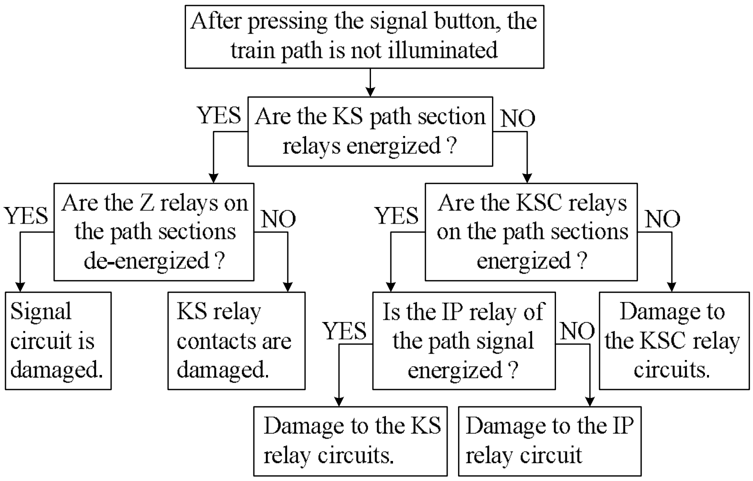

Fig. 2 – Diagnosis chart for the situation where the route path on the luminous schema panel does not light up after the signal button is pressed.

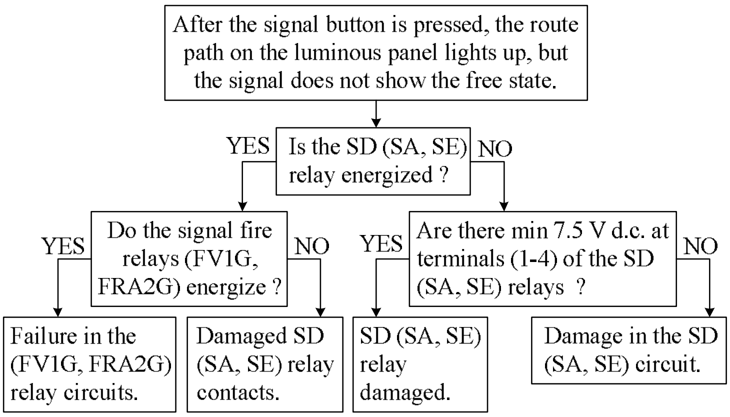

Fig. 3 – Diagnosis chart for the case when the signal light does not show the permissive state.

Based on these diagrams we created a diagnosis software, CR2Der, implemented in Visual Basic.NET. The choice of this programming environment is due to its programming ease, the quick and friendly interface design, its rapid prototyping character. Also, it can be easily interconnected with previously diagnosis software component created by the authors.

The diagnosis software shows users with key questions which, based on the answers to these questions, guide the maintenance staff towards the installation component that causes the failure. Fig. 4 shows a screenshot of the software with a key question and its two possible answers.

A series of following articles will present further diagnosis charts in all detail, identifying each possible failure cause of the installation.

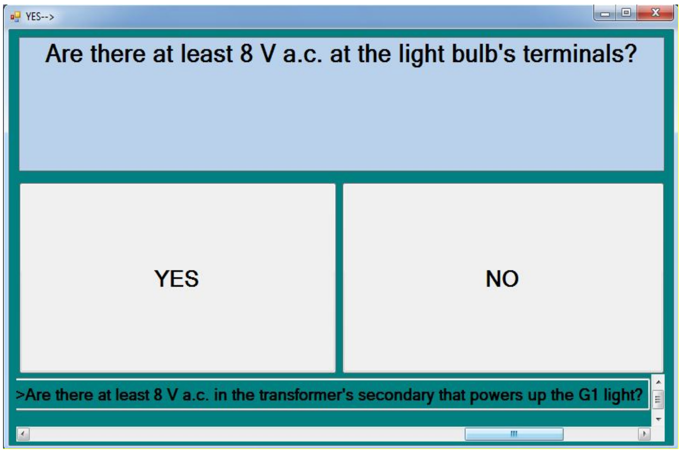

Fig. 4 – Key question in the diagnosis software.

4. Conclusions

This work presented two general diagnosis charts created for situations where a failure of SCB CED-CR2 type installations. Based on these charts we created a diagnosis software package, CR2Der, which is able to detect the block schema where the failure occurred. This work will be completed with further detailed diagnosis software and charts, which will precisely establish the damage cause. The created software substantially reduces the diagnosis time and eliminates wrong decisions which the maintenance staff might take when low know-how is available. The use of the software does not require additional equipment or costs, neither requires administrative approvals. It can be used with ease by persons without a formal IT education.

REFERENCES

Chen J., Roberts C., Weston P., *Fault Detection and Diagnosis For Railway Track Circuits Using Neuro-Fuzzy Systems*, Control Engineering Practice, **16(5)**, 585-596 (2008).

Jonguk L., Heesu C., Daihee P., Yongwha C., Hee-Young K., Sukhan Y., *Fault Detection and Diagnosis of Railway Point Machines by Sound Analysis*, Sensors, **16(4) (**2016).

Silmon J.A., Roberts C., *Improving Railway Switch System Reliability with Innovative Condition Monitoring Algorithms*, Proceedings of the Institution of Mechanical Engineers, Part F: J. of Rail and Rapid Transit, **224(F4)**, 293-302 (2010).

Spunei E., Piroi I., Chioncel C.P., Piroi F., *Rapid Diagnosis of Track Circuits in a Railroad Station*, The 9th Internat. Symp. on Advanced Topics in Electrical Engineering, May 7-9, 2015, Bucureşti, Book Group Author(s): IEEE, 710-715.

Spunei E., Piroi I., Piroi F., *Computer-Based Diagnosis for Electric Power Supply in Train Traffic Installations*, 5th International Symposium on Electrical and Electronics Engineering (ISEEE), Oct. 20-22, 2017, Galați, Book Series: Internat. Symp. on Electrical and Electronics Engineering.

Spunei E., Piroi I., Piroi F., *Computerized Diagnostic of the Red and White Entry Lighting Signal Indications*, Internat. Conf. on Applied and Theoretical Electricity ICATE, October 6-8, 2016, Craiova, Book Series: Internat. Conf. on Applied and Theoretical Electricity.

Stan A.I., David S., *Centralizări electrodinamice şi bloc de linie automat*, Ed. Didactică şi Pedagogică, Bucureşti, 1984.

Vileiniskis M., Remenyte-Prescott R., Rama D., *A Fault Detection Method for Railway Point Systems*, Proc. of the Institution of Mechanical Engineers, Part F: J. of Rail and Rapid Transit, **230(3)**, 852-865 (2016).

DIAGNOZA COMPUTERIZATĂ A INSTALAȚIILOR CED-CR2 (PARTEA I)

(Rezumat)

În lucrare este prezentată o metodă modernă de diagnoză a instalațiilor de siguranța circulației feroviare, de tip CED-CR2. Metoda are la bază diagramele de diagnoză, concepute de autori, pe baza cărora a fost creat un soft de diagnoză. Prin utilizarea softului de diagnoză de către personalul de mentenanță, se reduc timpii de întârziere a trenurilor prin determinarea mai rapidă a cauzei deranjamentului şi se elimină erorile de diagnoză cauzate de intervenția neprofesionistă a personalului de mentenanță. Utilizarea softului nu generează costuri de implementare, aplicația putând rula pe un PC, telefon sau alt device.