Diagnosis Charts for Regular Inversion Failures of an Automatic Block Signal Installation

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*Abstract***— In train traffic, traffic security installations failure recovery is time consuming, causing time delays the the railroad traffic. Automatic Block Signal Installations (ABS) are on type of installations that ensure railroad traffic security. To decrease the failure diagnosis and remedy times for ABS Installations in cases where the installations do not regularly invert, we defined a set of diagnosis charts. Based on these charts we devised a diagnosis software tool, called INVBla, which can be used by the technical maintenance staff on both mobile devices (tablet, smart phone) and PCs. The use of the INVBla diagnosis tool is a fast and secure tool that assists the maintenance staff in determining the failures in ABS regular inversion, triggered by dispatch commands, for a unified ABS installation depending on an Electrodynamic Centralized Traffic Control Station of type 4 (CED-CR4).**

Keywords—ABS installation, failure diagnosis chart, diagnosis software tool, failure detection

I. INTRODUCTION

Train traffic on railways must conform to previously established schedules and comply with security norms. Traffic security is ensured by Signals, Centralizations, and Blocking (SCB) installations. These installations take as input point wise information from the staff handling them on the field, then issue 'proceed' or 'stop' traffic signals, allowing or forbidding train access on the railway section they control. The SCB installations in the train stations are called Centralization Installations and can be mechanical (CM), electromechanical (CEM), electrodynamic (CED) [1], or electronic installations (CE). SCB installations between two consecutive train stations are called block signals (BS) which can be automatic (ABS) or semi-automatic (SABS). BS installations are necessary for the command and control of the train traffic between two consecutive train stations.

This work does an analysis of a ABS installation de depending on an Electrodynamic Centralized Traffic Control Station of type 4 with relays (CED-CR4). This installation type can be found, for example, on the rail road between Caransebeş train station and Orşova train station, within the Timişoara Regional Train Division. The main problem of this type of installation is the long time necessary to fix the occurring failures. This is due especially to the complexity of the ABS command and control circuits.

Currently, the ABS failure diagnosis is done with no computerized aid. Thus, in case of an ABS failure, the maintenance staff on duty is told about the malfunctioning ABS block and has to travel to one of the block's adjoined train station. In the train station, the technician has to inspect the signaling on the command installation, does certain measurements and, if the failure is in that train station, fixes the damage. If the failure happens along the ABS section or in the other train station, the technician must travel on field, make measurements, find the failure cause and do the necessary repairs. Often enough, failure recovery on the distance of one ABS takes at least two hours, the recovery time closely depending also on the technician's qualification and experience.

During the whole time an ABS installation is damaged, the trains on the respective section block must not travel faster than 20km/h [2,3], must travel with extreme caution because the traffic security conditions are not fulfilled. In this case, traffic security falls back on the traffic manager following the existing regulations, on the manager's professional qualifications, and on entries logged in the Rail Lines and Traffic Security Installation Catalogue by the maintenance staff.

The solution to the long remedy times, which this work presents, is based on the devise of diagnosis charts that are, then, used in devising a software tool, INVBla, to be used on mobile devices or personal computers. The tool is dedicated to the railroad maintenance staff, and aims at substantially reducing the failure diagnosis and remedy times, which, in turn, leads to fewer traffic delays on the railroads. The software does not need a connection to the ABS installation in order to make direct measurements (voltage levels, current), thus no ABS circuit adaptations are necessary. The software takes as input the answers given by the maintenance staff based on the station signals and voltage levels at different points in the installation. The software has a simple and friendly user interface, its simplicity making it easy to use also by personnel with minimum literacy in using computers.

II. GUIDING RELAYS CIRCUITS AND REGULAR INVERSION OF THE ABS INSTALLATION

We describe in this section the way a regular inversion of the direction of an ABS installation works, giving a corresponding operating diagram. We also explain what the failures in the ABS operations are and how they may occur, setting the background for the work presented in Section 3.

Failures that may occur in the functioning of an ABS installation are:

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- Power loss in the ABS boxes along the section block;
- Power loss or other damages to the ABS return conductors;
- Current line is signaled as blocked either in both ABS adjoined stations or just in the receiving station;
- Regular ABS orientation is not possible;
- Failure of the ABS signals.

In this work, we analyze the failures caused by the impossibility to regularly change the orientation of the ABS installation. On the ABS installation schemes the station closest to Bucharest (Romania's capital city) is denoted as the dispatching station, while the second station, furthest from Bucharest is denoted as the receiving station. Relays associated with the dispatch station contain the letter Y in their denomination, and the relays associated with the receiving station contain the letter X in their denomination. If the receiving station must change its role to be a dispatch station (that is, a train leaves the receiving station towards the dispatch station), the traffic manager must press the dispatch button. This triggers the CED relays to issue a regular reversion command to the ABS installation. Any defects that hinder the regular ABS reversion limits the train traffic to at most 20 km/h, on the entire distance between the two ABS adjoin stations (at least 3 km, and up to 20km).

The main circuit that controls the regular orientation of an ABS installation is the directing relay circuit, D, sketched in "Fig. 1" [4]. This circuit uses combined relays of the type KF1-80 [5,6].

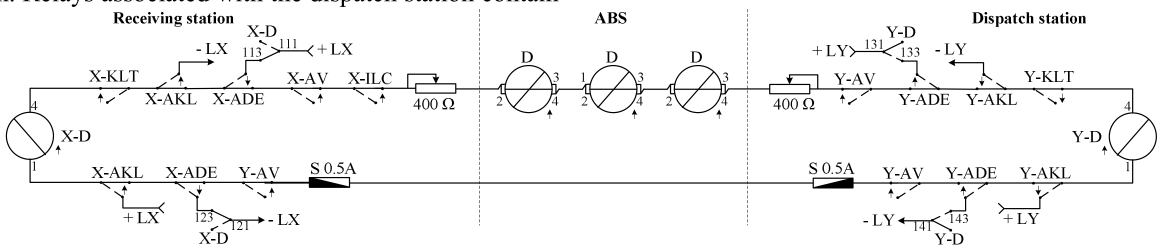


Fig. 1. Directing relays circuit.

This circuit closely interfaces with the CED installation via the ADE relay (Dispatch Aid Director[1]), which commands the inversion of the ABS orientation. Regular or normal reversion of the ABS installation can be made only when the current line is free, condition controlled by the AKL (Line Control Aid) and KLT (Thermal Line Control) relays.

The inverse orientation of the ABS installation is done in three ways [4]:

- By a dispatch command issued from the receiving station: *regular inversion*. In this case, the ASE (Dispatch Signal Aid) relay in the CED installation powers up and issues the ABS 'reverse orientation' command;
- By pressing the buttons to forcedly inverse the installation orientation when the current line is signaled as occupied, although the line is clear: *forced inversion*. The forced inversion is realized by a special circuit that powers up the OL (Occupied Line) and KL (Line Control) relays;
- Accidentally, upon a failure on the 1AD section (first Approach-Depart section) in the receiving station: *accidental inversion*.

"Fig. 2" shows the main blocks of the operating diagram for the regular inversion of an ABS installation. The diagram shows both station signals and the state of the main relays for each stage of the ABS regular inversion sequence.

The diagram in "Fig. 2" eases the understanding of the failure diagnosis charts that we will present in the following section. On the failure charts, the denotations of the dispatch and receiving stations are switched, to respectively, receiving and dispatch stations, only upon error free completion of the regular inversion of the ABS installation.

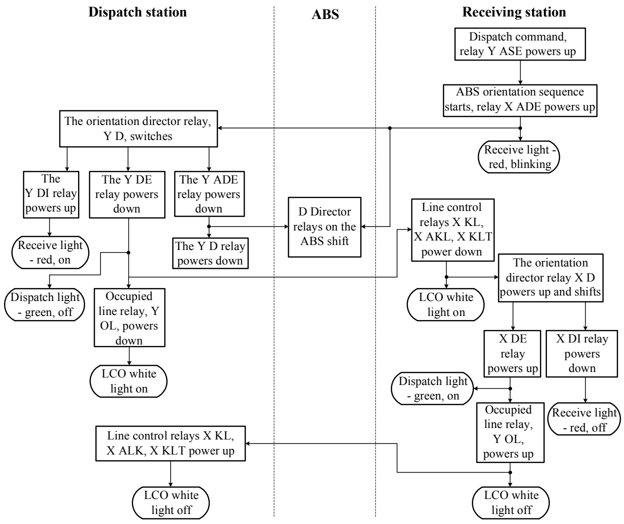


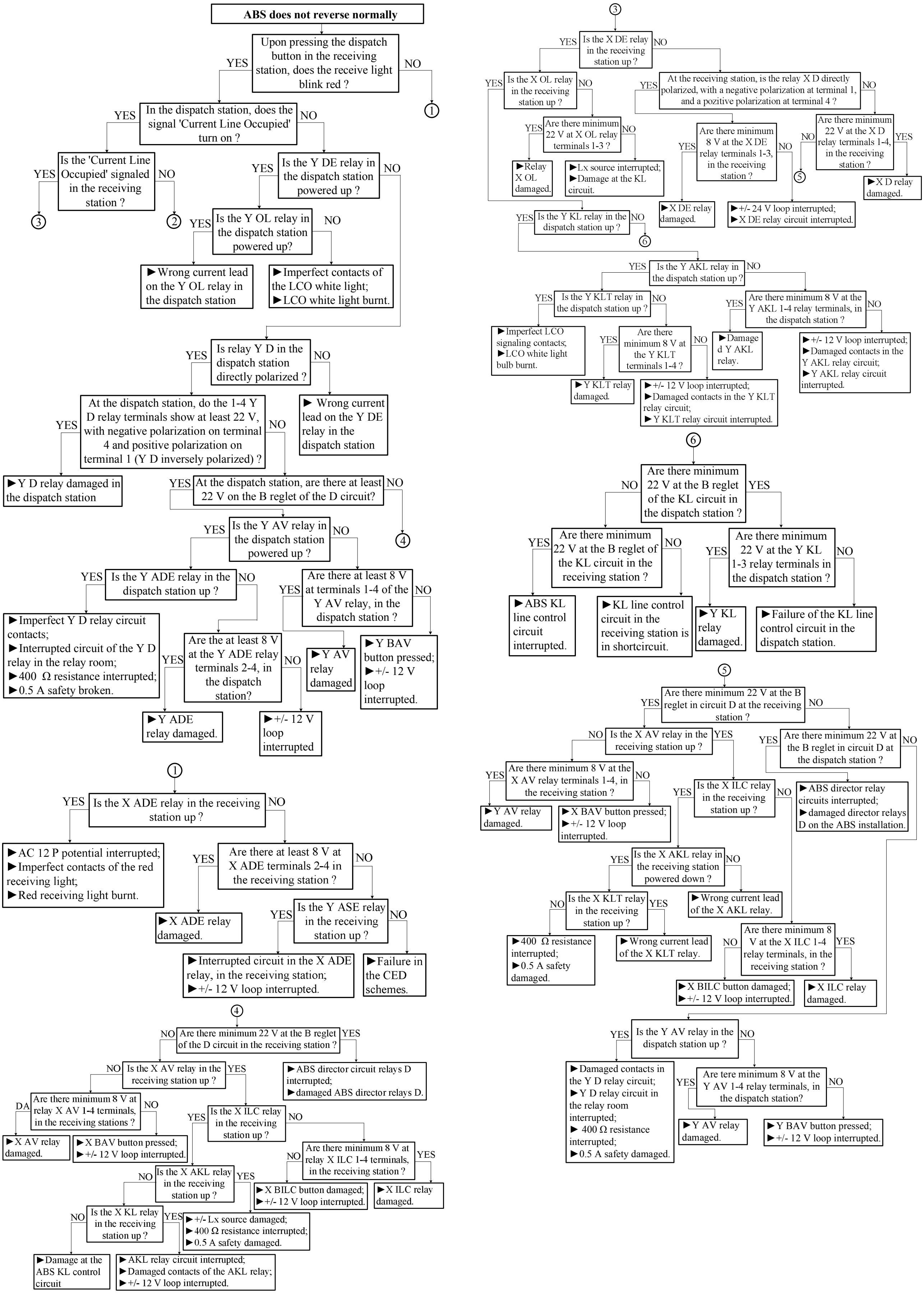
Fig. 2. Operating diagram for the regular inversion of the ABS orientation.

III. Diagnosis Charts For Inversion Failures Of The ABS Installation. The INVBLA Tool

In devising the diagrams presented in this section, "Fig. 3" we took into account the execution schemes of the CED-CR4 installations that closely work with the unified ABS installation.

Based on these diagnosis charts we created the INVBla software tool, implemented in the Visual Basic environment. This programming environment was used in implementing also other SCB failure diagnosis tools [7-9]. The user of this software tool starts the application on his phone, tablet or PC. The program requires that the user gives answers to a sequence of questions about relay states, signaling types, voltage values at different measure points of the installation.

[1] Most of the abbreviations in this work reflect the Romanian specific terminology used in the railway domain.



ABS does not reverse normally
Upon pressing the dispatch button in the receiving station, does the receive light blink red ?
YES
NO
1
In the dispatch station, does the signal 'Current Line Occupied' turn on ?
YES
NO
Is the 'Current Line Occupied' signaled in the receiving station ?
YES
NO
3
2
Is the Y DE relay in the dispatch station powered up ?
YES
NO
Is the Y OL relay in the dispatch station powered up?
YES
NO
►Wrong current lead on the Y OL relay in the dispatch station
►Imperfect contacts of the LCO white light; ►LCO white light burnt.
Is relay Y D in the dispatch station directly polarized ?
YES
NO
At the dispatch station, do the 1-4 Y D relay terminals show at least 22 V, with negative polarization on terminal 4 and positive polarization on terminal 1 (Y D inversely polarized) ?
YES
NO
► Wrong current lead on the Y DE relay in the dispatch station
►Y D relay damaged in the dispatch station
At the dispatch station, are there at least 22 V on the B reglet of the D circuit?
YES
NO
4
Is the Y AV relay in the dispatch station powered up ?
YES
NO
Is the Y ADE relay in the dispatch station up ?
YES
NO
Are there at least 8 V at terminals 1-4 of the Y AV relay, in the dispatch station ?
YES
NO
►Imperfect Y D relay circuit contacts; ►Interrupted circuit of the Y D relay in the relay room; ►400 Ω resistance interrupted; ►0.5 A safety broken.
Are the at least 8 V at the Y ADE relay terminals 2-4, in the dispatch station?
YES
NO
►Y AV relay damaged
►Y BAV button pressed; ►+/- 12 V loop interrupted.
►Y ADE relay damaged.
►+/- 12 V loop interrupted
1
Is the X ADE relay in the receiving station up ?
YES
NO
►AC 12 P potential interrupted; ►Imperfect contacts of the red receiving light; ►Red receiving light burnt.
Are there at least 8 V at X ADE terminals 2-4 in the receiving station ?
YES
NO
►X ADE relay damaged.
Is the Y ASE relay in the receiving station up ?
YES
NO
►Interrupted circuit in the X ADE relay, in the receiving station; ►+/- 12 V loop interrupted.
►Failure in the CED schemes.
4
Are there minimum 22 V at the B reglet of the D circuit in the receiving station ?
NO
YES
Is the X AV relay in the receiving station up ?
NO
YES
►ABS director circuit relays D interrupted; ►damaged ABS director relays D.
Are there minimum 8 V at relay X AV 1-4 terminals, in the receiving stations ?
DA
NO
►X AV relay damaged.
►X BAV button pressed; ►+/- 12 V loop interrupted.
Is the X ILC relay in the receiving station up ?
YES
NO
Are there minimum 8 V at relay X ILC 1-4 terminals, in the receiving station ?
NO
YES
Is the X AKL relay in the receiving station up ?
NO
YES
►X BILC button damaged; ►+/- 12 V loop interrupted.
►X ILC relay damaged.
Is the X KL relay in the receiving station up ?
NO
YES
►+/- Lx source damaged; ►400 Ω resistance interrupted; ►0.5 A safety damaged.
►Damage at the ABS KL control circuit
►AKL relay circuit interrupted; ►Damaged contacts of the AKL relay; ►+/- 12 V loop interrupted.
3
Is the X DE relay in the receiving station up ?
YES
NO
Is the X OL relay in the receiving station up ?
YES
NO
At the receiving station, is the relay X D directly polarized, with a negative polarization at terminal 1, and a pozitive polarization at terminal 4 ?
YES
NO
Are there minimum 22 V at X OL relay terminals 1-3 ?
YES
NO
►Relay X OL damaged.
►Lx source interrupted; ►Damage at the KL circuit.
Are there minimum 8 V at the X DE relay terminals 1-3, in the receiving station ?
YES
NO
Are there minimum 22 V at the X D relay terminals 1-4, in the receiving station ?
NO
YES
5
►X D relay damaged.
►X DE relay damaged.
►+/- 24 V loop interrupted; ►X DE relay circuit interrupted.
Is the Y KL relay in the dispatch station up ?
YES
NO
6
Is the Y AKL relay in the dispatch station up ?
YES
NO
Is the Y KLT relay in the dispatch station up ?
YES
NO
Are there minimum 8 V at the Y AKL 1-4 relay terminals, in the dispatch station ?
YES
NO
►Imperfect LCO signaling contacts; ►LCO white light bulb burnt.
Are there minimum 8 V at the Y KLT terminals 1-4 ?
YES
NO
►Damaged Y AKL relay.
►+/- 12 V loop interrupted; ►Damaged contacts in the Y AKL relay circuit; ►Y AKL relay circuit interrupted.
►Y KLT relay damaged.
►+/- 12 V loop interrupted; ►Damaged contacts in the Y KLT relay circuit; ►Y KLT relay circuit interrupted.
6
Are there minimum 22 V at the B reglet of the KL circuit in the dispatch station ?
NO
YES
Are there minimum 22 V at the B reglet of the KL circuit in the receiving station ?
YES
NO
Are there minimum 22 V at the Y KL 1-3 relay terminals in the dispatch station ?
YES
NO
►ABS KL line control circuit interrupted.
►KL line control circuit in the receiving station is in shortcircuit.
►Y KL relay damaged.
►Failure of the KL line control circuit in the dispatch station.
5
Are there minimum 22 V at the B reglet in circuit D at the receiving station ?
YES
NO
Is the X AV relay in the receiving station up ?
NO
YES
Are there minimum 22 V at the B reglet in circuit D at the dispatch station ?
YES
NO
Are there minimum 8 V at the X AV relay terminals 1-4, in the receiving station ?
YES
NO
Is the X ILC relay in the receiving station up ?
YES
NO
►ABS director relay circuits interrupted; ►damaged director relays D on the ABS installation.
►Y AV relay damaged.
►X BAV button pressed; ►+/- 12 V loop interrupted.
Is the X AKL relay in the receiving station powered down ?
YES
NO
Is the X KLT relay in the receiving station up ?
NO
YES
►Wrong current lead of the X AKL relay.
►400 Ω resistance interrupted; ►0.5 A safety damaged.
►Wrong current lead of the X KLT relay.
Are there minimum 8 V at the X ILC 1-4 relay terminals, in the receiving station ?
NO
YES
►X BILC button damaged; ►+/- 12 V loop interrupted.
►X ILC relay damaged.
Is the Y AV relay in the dispatch station up ?
YES
NO
►Damaged contacts in the Y D relay circuit; ►Y D relay circuit in the relay room interrupted; ► 400 Ω resistance interrupted; ►0.5 A safety damaged.
Are tere minimum 8 V at the Y AV 1-4 relay terminals, in the dispatch station?
YES
NO
►Y AV relay damaged.
►Y BAV button pressed; ►+/- 12 V loop interrupted.

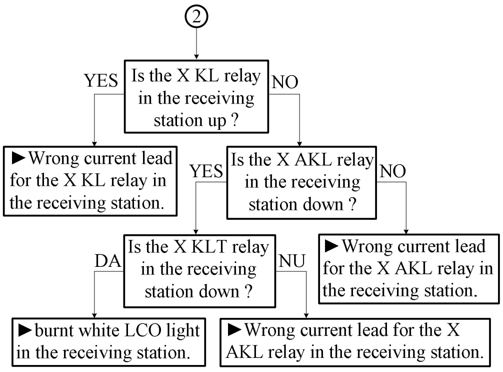


Fig. 3. Diagnosis charts for failures in the regular reversion of the ABS installations.

"Fig. 4" shows a screenshot made during the use of the INVBla software tool, which asks the user whether there are at least 8 V at the X DE 1-3 relay terminals, in the receiving station.

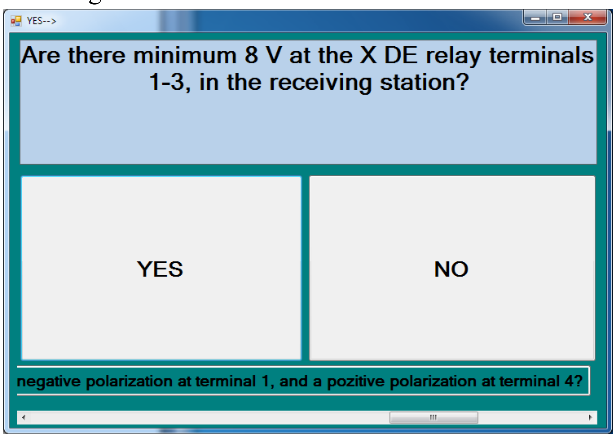


Fig. 4. Screenshot of a diagnosis step in the INVBla tool.

As answer, the user must push one of the 'YES' or 'NO' buttons, depending on the actual situation in the field. Based on his or her answer, the program, in the end, displays the causes of the failure ("Fig. 5").

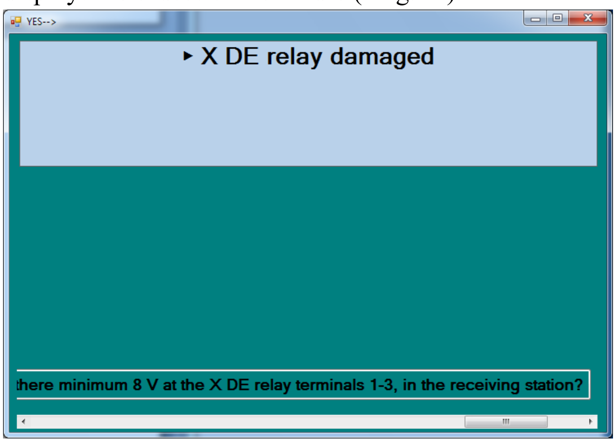


Fig. 5. Damage cause displayed by the INVBla tool: damaged X DE relay.

In the lower part of the tool's display buttons allow the user to turn back to previous questions and give different answers, according to the field measurements and signals.

IV. Conclusion

The INVBla software tool, based on the diagnosis charts devised by us and presented in this work, is of assistance in optimizing the work of the railroad traffic security maintenance staff.

Existing diagnosis software tools for the electronic centralized installations only point that the failures appear on the field, while, in the case of a damage in the relay room, they only list the possibly damaged elements, but give no information about the cause of the failure. Compared to this, the INVBla software goes into detail and gives the exact cause of the failure, both in the relay room and on the field.

The use of the program leads to shorter remedy times of the ABS installation reversion failures and contributes, thus, to increased train traffic security. An important advantage of this software tool is that its use assumes modifications to the existing infrastructure and no existing projects must be altered. Furthermore, the diagnosis charts together with the INVBla tool can be used also in the periodic training and testing the maintenance staff.

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