Automatic Block Signaling Installation Failure Diagnosis with LCOBla

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***Abstract*—We present in this paper a software module for the diagnosis of Automatic Bloc Signaling installation failures in situations where the train open line figures as blocked, although it is, in reality, free. The software module created by us, LCOBla, is designed for the use of maintenance staff specialized in Signals, Centralizations, Blocking (SCB) at the Romanian Railroad Company (CFR). LCOBla allows a quick and correct design of the failure causes associated with these kinds of signaling and contributes to the maintenance staff performance. Fast failure remedy improves train traffic flow and reduces train delay times. The LCOBla software module uses the diagnosis chart created for these kinds of failures, which, in turn, is based on the actual block schemes and on technical recommendations for these types of installations. The module is one of a series of modules designed to diagnose each failure type, for the various railway traffic safety installation types.**

Keywords—ABS installations, LCOBla software module, blocked open line, diagnosis;

I. INTRODUCTION

ABS installations belong to the CFR's traffic safety installations which command and control the railway traffic between two consecutive railroad stations. ABS installations make high frequency railroad traffic between two stations possible. Depending on the number of lines between the two stations the automatic the automatic block line may be [1]:

- Single direction ABS for double track rail lines, with dedicated travel direction (one track rail line for one direction);
- Bi-directional ABS for a simple track line (both directions on one track rail line);
- Bi-directional ABS for double track rail lines with train traffic taking place in both directions, on both lines.

In this work we present a software assisted diagnosis of failures for a bi-directional ABS for a simple track line, in relation to a Electrodynamic Centralized Traffic Control Station (CED) type CR4 (centralized with 4 relays).

Normally, when on the ABS sector no train is present and the track rail lines are continuous (e.g. not missing, or broken), the Occupied Current Line (OCL) light in the ABS's adjacent stations is off. Noting with A and B the two ABS adjacent stations, when a 'free exit' command is issued in station A, the OCL light in station A is white and is lighted white in station B as well, notifying station B that station A commanded a train dispatch from station A to station B. Concurrently with this signal, and corroborated with the CED installation, any dispatch command from station A towards station B is blocked, and the ABS signals are commanded to show 'free line'/'proceed' for this ABS sector.

For failures where the current line is signaled as occupied, although it is free in reality, and no train dispatch command was issues, traffic on the specific ABS sector is limited to at most 20km/h [2]. This causes traffic delays since this failure will not allow dispatching other trains from one station in the same direction before the previous train is confirmed to have arrived at the second station.

II. THE NEED FOR A SOFTWARE DIAGNOSIS MODULE AND ITS IMPLEMENTATION

Failure diagnosis for cases when the current open line is occupied (OCL) is based on the diagnosis charts created by the authors for this type of defects [3].

The software module is implemented using "Visual Basic .NET" [4,5] and can be used both on a PC and on mobile devices its use being transparent from the programming language layer.

The simple and friendly interface shows the user various questions and installation measurement recommendations or installation component's state observations. Depending on the observations and measurements, the users will choose the corresponding answer from the possibilities shown on the display. Depending on the given answer, the user is the guided through other observations and measurements until a cause of the failure is established.

In case of a defect signaled by OCL between two train stations, the maintenance staff must physically travel to each of the two ABS adjacent train stations, to take measurements and, sometimes, go along the ABS sector for further observations. Often enough, after measurements on the ABS made were made, the maintenance staff must return to one or both stations to take other measurements. Insufficiently qualified staff is usually prone to such lengthy diagnosis processes, leading to long train traffic delays. Using a diagnosis software module the maintenance staff is guided through a logical and structured succession of taking measurement steps, eliminating unnecessary measurements, reducing thus the

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failure remedy time by eliminating unnecessary travels between stations or on the ABS sector.

III. Software Assisted ABS Failure Diagnosis for Defects Signaled with OCL

For a quick diagnosis, the maintenance staff request from the train dispatchers in both train stations information about the current line's status. Depending on the signal type there are two possible situations:

- The current line is signaled as occupied in the receiving station only;
- The current line is signaled as occupied in both stations.

In the following we take the reader, step by step, through a diagnosis procedure pointing out the measurements needed to identify the failing device and failure causes. For each case we also show screenshots of the software's display seen by the software user.

In a CFR railway station the station end closer to Bucharest is marked with X, while the opposite station end is marked with Y. These two letters (X and Y) are used to differentiate the similar relays placed in the X and Y station end installations. An ABS installation also has two special buttons, BP for 'reverse entry' and BE for 'reverse dispatch', of the ABS installations are used to forcefully reverse the ABS installation when one or more ABS section blocks are signaled as occupied.

To establish which failure situation is currently happening, the first question the maintenance staff user sees on the program's screen is whether the current line is signaled as occupied in the dispatching station, Fig. 1.

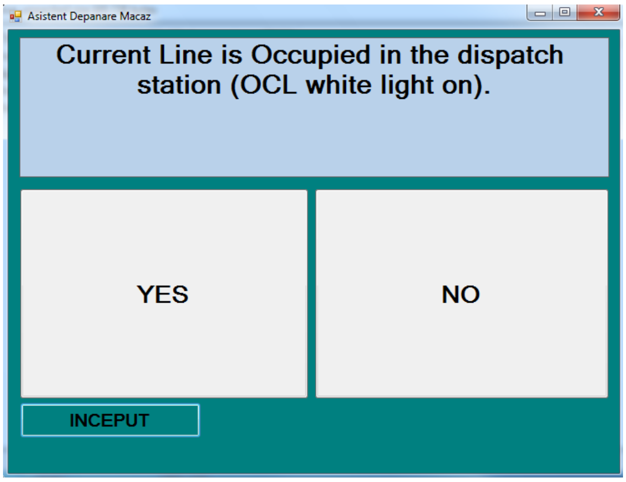

Fig. 1. Dialog window inquiring the current line signal in the dispatch station.

A. *Occupied Current Line signaled in the receiving station only.*

If the current line is not signaled as occupied in the dispatch station it is clear that it is thus signaled in the receiving station only. In this case the maintenance staff travels to the receiving station and follows the steps given indicated by the software module. In this concrete case the user is requested to check the state of the X KL relay, the 'line control' relay, Fig. 2.

If the X KL relay is not up and is not powered a voltage check on the OL-KL circuit's B reglet is requested, Fig. 3. When the measured voltage is less than 22V then the defect is caused by a short circuit between the OL-KL circuit's lead wires. In this case, the maintenance staff must travel along the ABS sector and find the short-circuited block and eliminate its cause.

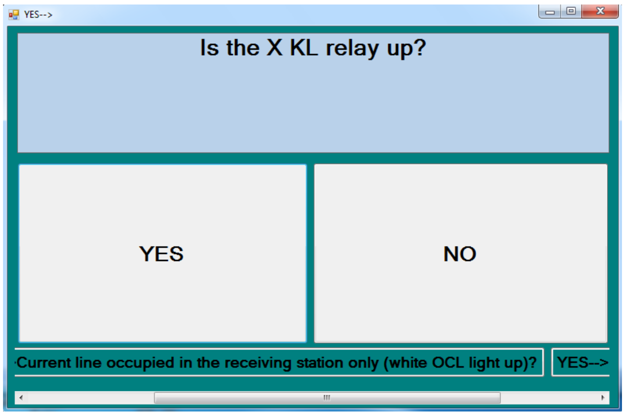

Fig. 2. Dialog window inquiring the state of the X KL relay.

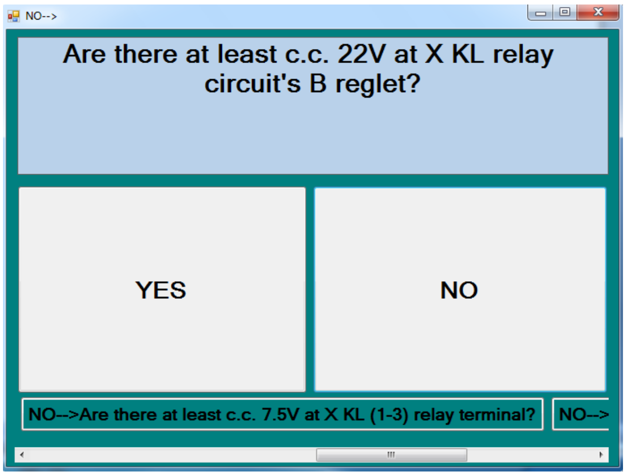

Fig. 3. Dialog window inquiring the B reglet voltage in the X KL circuit.

When the B reglet voltage is greater than 22V the defect is caused by an interrupted KL circuit in the station's relay room.

If the X KL relay is not up and the voltage measured at its terminals is a least c.c. 7.5V, the failure is caused by the X KL relay itself, which must be replaced, Fig. 4.

Fig. 4. Failure cause: a defect X KL relay.

If the X KL relay is up while the command apparatus signals an occupied current line, then the failure is a signaling one. This requires that the state of the 'line control aid' relay, X AKL, is checked and the voltage at its 1-4 terminals is measured. When the voltage is lower than c.c. 7.5V the failure causes may be damaged X AKL circuit contacts and/or an interrupted c.c. ± 24V loop, Fig. 5. If the voltage measured is at least c.c. 7.5V but the relay is not up, the failure cause is the X AKL relay which must be replaced.

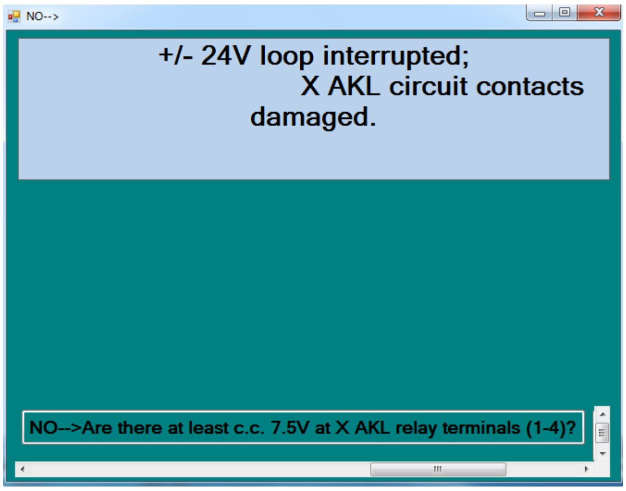

Fig. 5. Failure causes when less than c.c. 7.5V are measured at the X AKL relay terminals.

If the X AKL relay is up, the LCOBla software indicates that the state of the X KLT relay (Thermal Line Control) should be checked. When this relay is up the failure is caused by stray voltage which might occur in the OCL signaling. In this case the user must look for eventual contacts with other circuits in the command and control apparatus.

When the X KLT relay is not up the software indicates the user that he or she should measure the voltage on terminals (2-6), Fig. 6. When the measured voltage is less than c.c. 8V, the failure is caused by either broken X KLT circuit contacts and/or a broken ±24V loop. When the voltage is at least c.c. 8V the failure cause is the X KLT relay itself which is damaged and must be replaced.

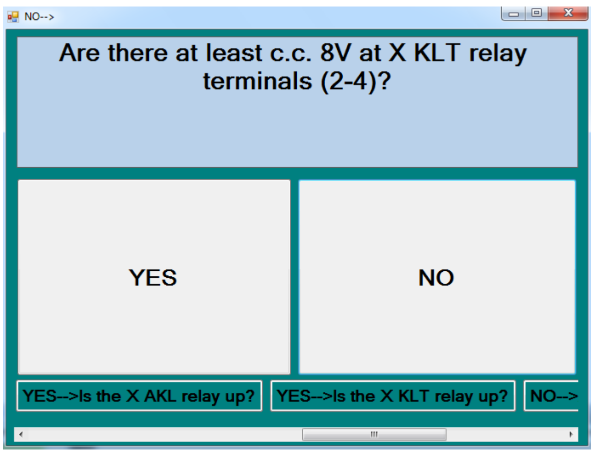

Fig. 6. Dialogue window asking about the X KLT relay terminal voltage.

B. Occupied Current Line signaled in both stations

In this case both train traffic managers in the adjacent ABS stations are asked about the state of the return conductors (open or occupied) on the ABS sector Fig.7.

If at least one of them has an occupied signal the failure may be caused by the block section that signals 'occupied' or by stationary rolling stock on the block in question.

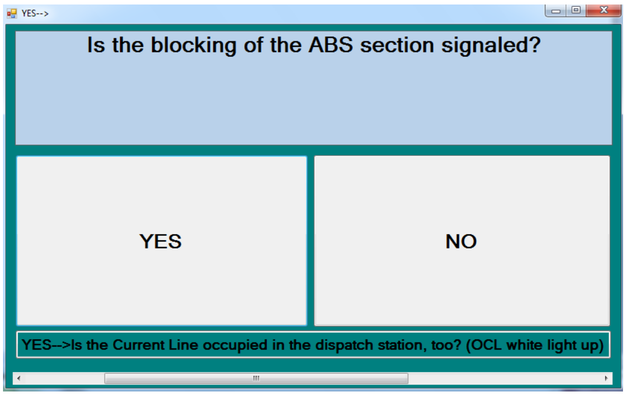

Fig. 7. Dialogue window asking about the ABS return conductors.

If the ABS return conductors don't show the 'occupied' signal, the software module recommends the user to take measurements of the supply voltage in the dispatch station of the Y OL-X KL circuits. The following situations may happen:

- Measurements show less than c.c. 22V;
- Measurements show more than c.c. 22V.

a) If the voltage is less than c.c. 22V the program guides the maintenance staff to take measurements at terminals (2-3) of the plug static converter, Fig. 8, which powers some of ABS installation's circuits [6]. In this work, the plug static converter is abbreviated both by PSC and by CSF (the Romanian translation of a PSC).

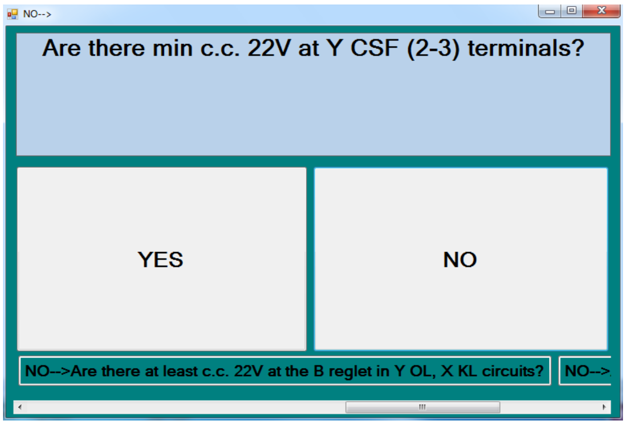

Fig. 8. Dialogue asking about the voltage delivered by the PSC.

The following situations may occur:

- The PSC delivered voltage is less than c.c. 22V;
- The PSC delivered voltage is higher than c.c. 22V;

a.1) If the plug static converter doesn't deliver a minimum c.c. 22V voltage, the software module indicates the technical staff to check the voltage on the PSC's (12-13) terminals to establish whether it is powered at 220V, 75Hz. When the measured voltage is at least d.c. 12V the failure cause is a damaged PSC. When terminals PCS's (12-13) terminals don't show a minimum of d.c. 12V, the state of the Y AR (Romanian for 'network failures') relay which insures the PSC power feed and, implicitly, the ABS installation's circuit from the secondary power source (battery of storage cells), Fig. 9.

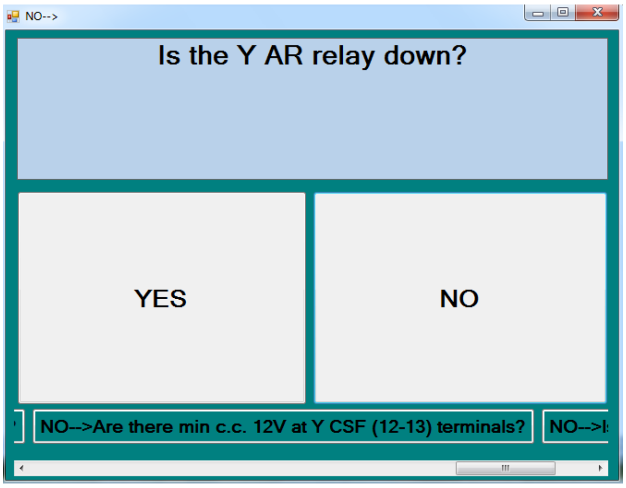

Fig. 9. Fereastra de dialog referitoare la starea releului Y AR.

If the Y AR relay is not up and the PSC does not provide the minimum c.c. 22V necessary voltage, the program asks to check the voltage levels on PCS's (1-4) terminals. Here, if the voltage is not at least c.c. 12V the failure causes are either damaged Y AR relay contacts or as interrupted ±24V loop, Fig. 10, the fault fix being, then, the replacement of the damaged relay or of the interrupted loop portion.

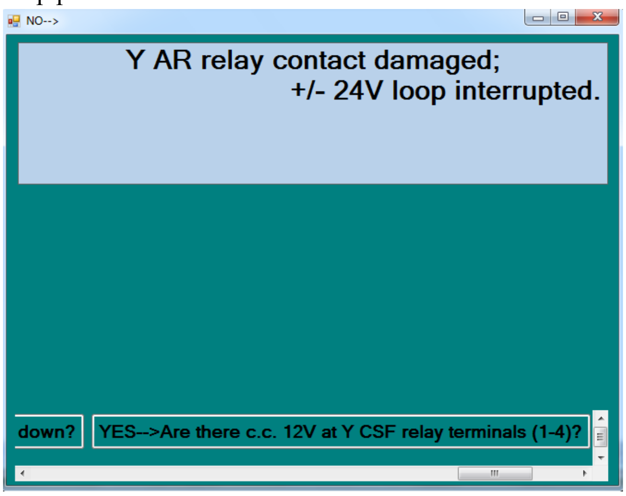

Fig. 10. Failure causes for less than c.c.12V at (1-4) Y CSF relay terminals and the Y AR relay is down.

a.2) If the PSC does deliver the necessary c.c. 22V, the program requires that the state of the Y AI relay (Romanian for 'exit aid' relay, at Y end of the station) which forceful orients the ABS installation. If this relay is up the failure cause is the accidental press of the 'forced reverse' button, Y BP, the failure being fixed by releasing this button. If the Y AI relay is not up, the Y DE relay (Romanian for 'dispatch director') must be checked, Fig. 11. The Y DE relay establishes the ABS adjacent station orientation (dispatch or receiving station).

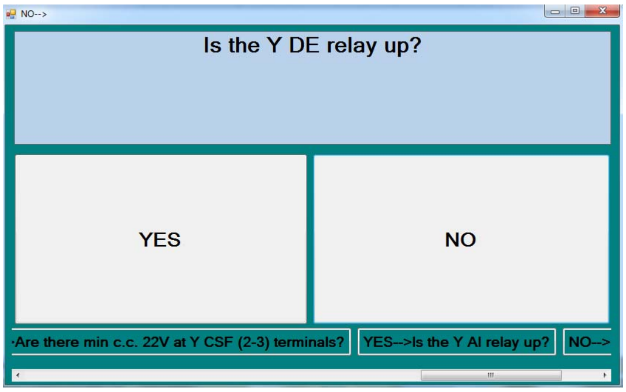

Fig. 11. Y DE relay state dialogue window.

When the railway station is not dispatch oriented, i.e. the Y DE relay is down, the polarization of the Y D relay must be checked. If it is inversely polarized, it must be polarized directly. If it is directly polarized the (1-4) Y DE relay terminal voltage must be measured, and when this voltage is higher than c.c. 7.5V the failure cause is the damaged Y DE relay. If the measured voltage is less then c.c. 7.5V, failure causes may be damages at the Y D relay's polarized terminal, an interrupted c.c. ±24V loop, or the interrupted Y DE power feed circuit, Fig. 12.

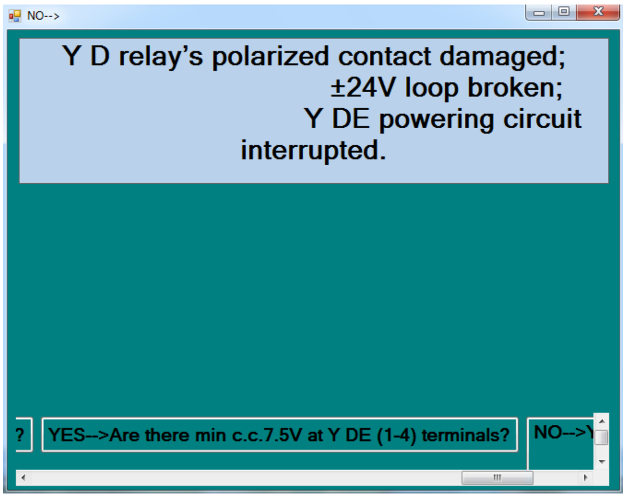

Fig. 12. Failure causes when relay Y DE terminals (1-4) show less than c.c. 7.5V.

When the train station is dispatch oriented, i.e. the Y DE relay is up, to find the faults in the ABS installation's operation, the user must check the state of the X AjZE relay and take voltage measurements at its (1-4) terminals, Fig. 13.

If the voltage is at least c.c. 7.5V, the failure is caused by a failing X AjZE, while in the opposite case the fault is caused by damaged contacts in X AjZE relay's circuit, ±24V loop broken, or a locked exit path. Remedying the latter type of damage is done under specific instructions and regulations.

If the X AjZE relay is up the program asks the technical staff to check the state of the Y ILC relay (Romanian for 'locked current line') and after that to take terminal voltage measurements, Fig. 14.

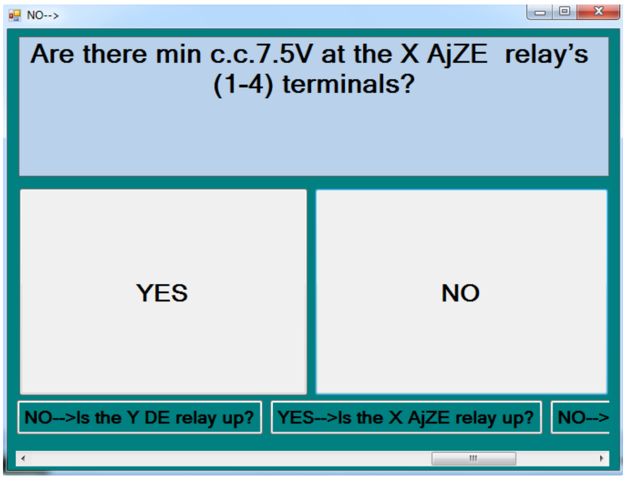

Fig. 13. Dialogue window checking on the relay's X AjZE (1-4) terminal voltage.

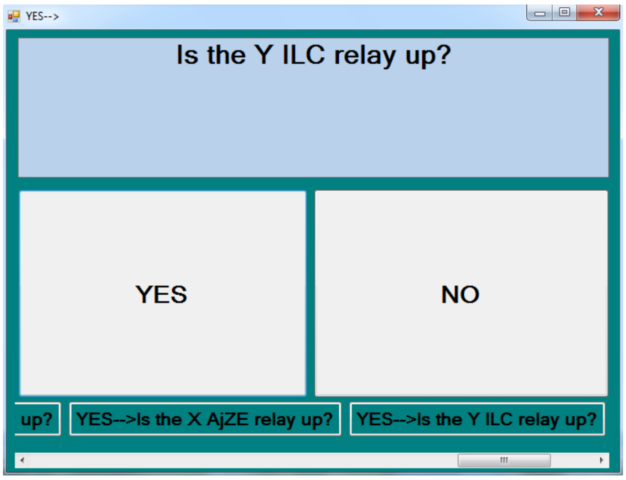

Fig. 14. Dialogue window on voltage measures of the Y ILC (1-4) terminals.

When the Y ILC relay is up, failure causes are:

- The 400 Ω resistance regulating the (60-80mA) power circuit is interrupted;
- The 0.5A safety protecting the OL-KL circuit is interrupted.

When the Y ILC relay is down and the measured terminal voltage is less than c.c. 7.5V failure causes are: damaged Y ILC terminal contacts, or an interrupted c.c. ±24V loop. When the measured voltage is at least c.c. 7.5V, the failure is caused by the Y ILC relay itself.

b) When the reglet B voltage of the Y OL-X KL circuit in the dispatch station is at least 22V the maintenance staff using the program is asked to measure the reglet B voltage of the same circuit in the receiving station, Fig. 15.

b.1) Now, if the measured voltage is below c.c. 22V the failure is caused by an interrupted Y OL-X KL circuit between the two stations, Fig. 16. In this situation the maintenance staff must travel on the ABS sector, identify the ABS block where the circuit is interrupted, and fix it.

b.2) If the measured voltage is at least c.c. 22V the program guides the user to measure the (1-3) terminal voltage of the X KL relay in the dispatch station, Fig. 17.

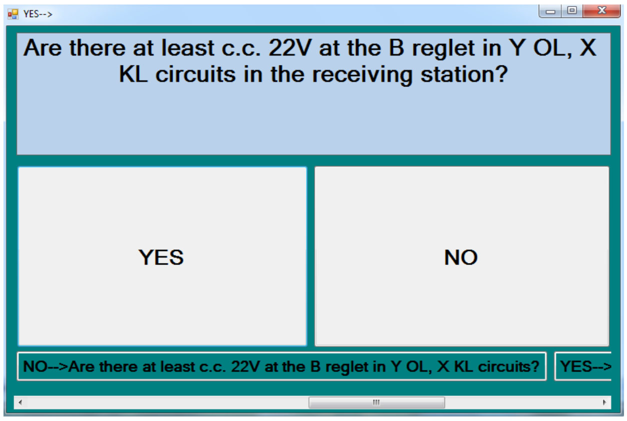

Fig. 15. Dialogue window on Y OL-X KL circuit's B reglet voltage.

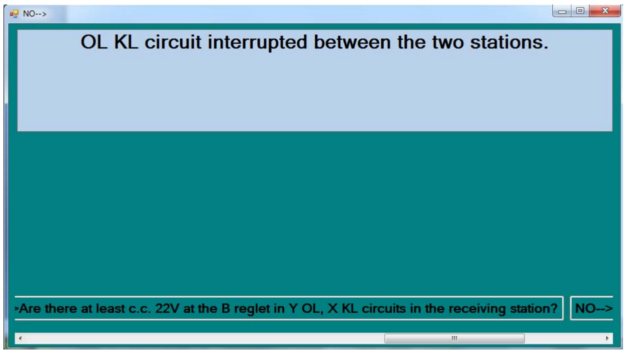

Fig. 16. Failure cause when there are less than c.c. 22V in the Y OL-X KL.

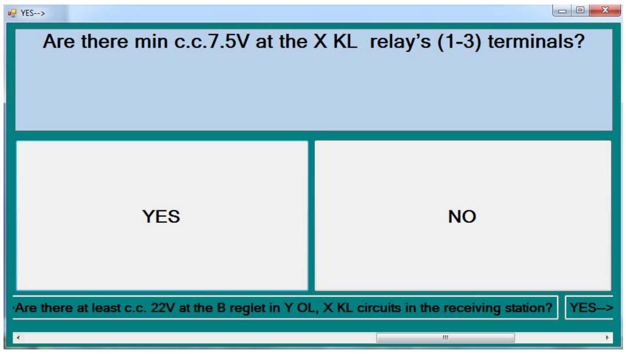

Fig. 17. Dialog asking about the terminal (1-3) voltage values for the X KL relay.

When the measured voltage is higher than c.c. 7.5V the failure is caused by the X KL relay which must be replaced. When the voltage is less than c.c. 7.5V the state of the Y AjZE relay must be checked followed by voltage measurements of its (1-4) terminals, Fig. 18.

When the measured value is higher than c.c. 7.5V, the failure is caused by the Y AjZE, which must be replaced. If the voltage is higher than this value, failure causes are either damaged contacts in the Y AjZE relay circuit, an interrupted c.c. ±24V loop, or a locked exit path.

If the Y AjZE is up the software module asks the user to check the X AI relay state, and if this is up, to check whether the X BP button for forced entry reversion is accidentally pressed, which causes the ABS's operation failure, Fig. 19.

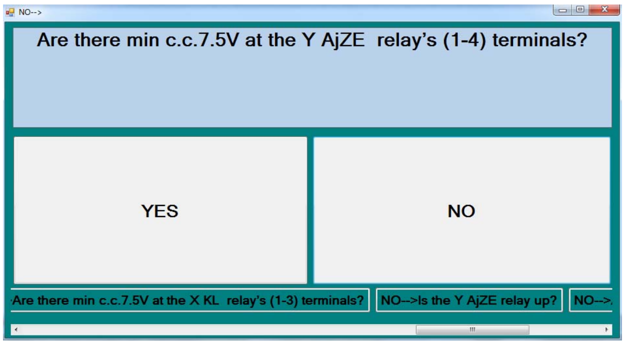

Fig. 18. Dialogue checking the (1-4) terminal voltage for the Y AjZE relay.

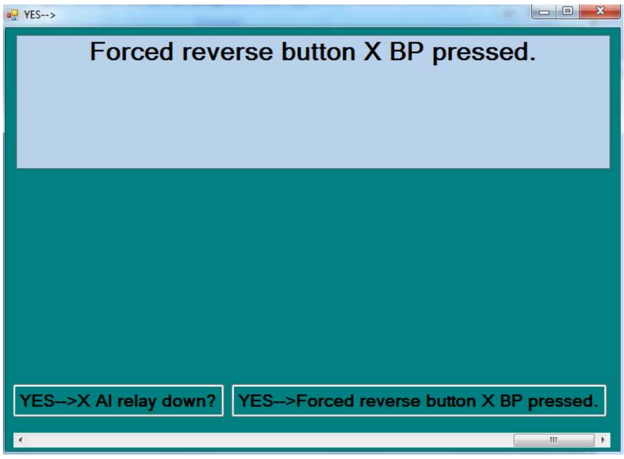

Fig. 19. Failure causes when X AI relay is up.

If the X AI relay is down, the state of the X ILC relay must be checked followed by voltage measurements at (1-4) relay terminals, Fig. 20.

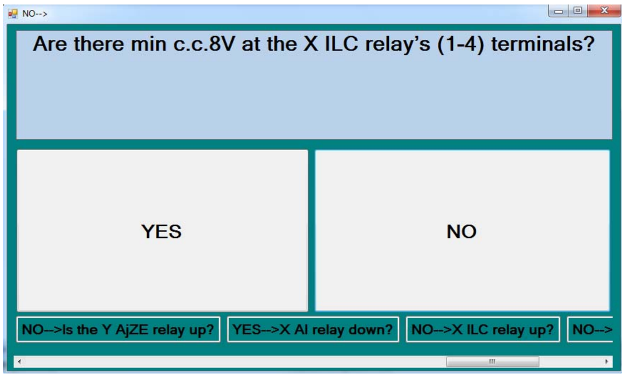

Fig. 20. Dialogue checking the (1-4) terminal voltage for the X ILC relay.

If the X ILC relay is down and its terminal voltage is higher than c.c. 8V the failure cause is the X ILC relay, while when the voltage is higher than c.c. 8V, the failure causes are damaged X ILC circuit contacts or an interrupted c.c. ±24V loop.

If the X ILC relay is up the program continues asking about the state of the X DE relay. If this relay is up failure is caused by an interrupted 400Ω resistance or an interrupted 0.5A safety, Fig. 21.

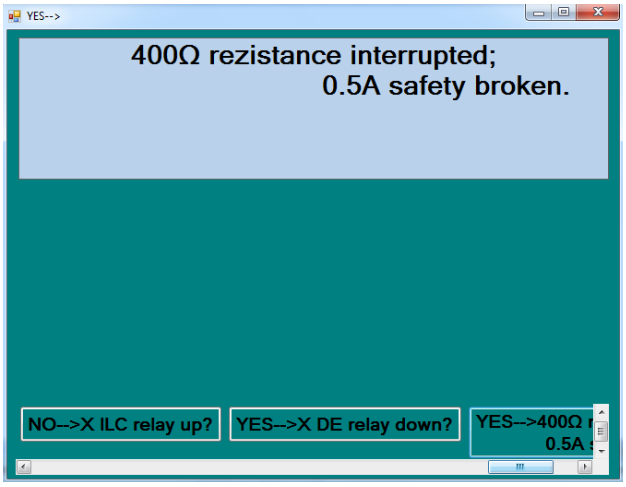

Fig. 21. Failure causes when relay X DE is down.

When relay X DE is down the failure is caused by the inverse X D relay polarization, in which case the relay must be directly polarized.

IV. Conclusion

The present work has a direct practical application in the diagnosis of ABS installations operation failures and is part of a series of works detailing ABS failure types and diagnosis. By using our LCOBla software module maintenance staff at the SCB stations can identify all failure causes when an ABS installation signals a 'Current Line Occupied' although the current line is free.

The software was tested on 5 railway stations with ABS installations of the described type between them. The failure diagnosis time was reduced by 98%.

The simple interface of our software component offers users without any computational know-how a viable solution for a quick and safe diagnosis process. The software can also be used for the periodic training and testing of the maintenance staff.

Using the LCOBla software component together with the other similar components designed by us (MANMac [4,5]) the ABS installation operation failure detection and remedies is optimized reducing drastically the diagnosis times and reducing the time delays in railroad traffic.

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