

Software Assisted Diagnosis for Shunting, Repeater, and Failure Light Signals in Stations with Electro-dynamic Interlocking Systems

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Abstract — The diagnosing light signals in train stations using electro-dynamic interlocking systems (EIS) is currently done by direct observations and measurements. The diagnosis times strongly depend on the technical know-how and abilities of the maintenance staff. This work presents a diagnosis method for three types of light signals in train traffic: shunting, repeating, and failure signals. The proposed method is a software assisted method that aids the maintenance staff and can be used with a personal computer (PC), smart phone or tablet. This method is based on failure diagnosis charts that are created starting from the actual stations’ wiring diagrams. The software that uses these charts has an interface that allows users to rapidly identify the failure cause. The proposed method is reliable and does not necessitate additional implementation costs in the functional facility as they do not modify these installations.

Keywords—computerised diagnosis; light signal; diagnosis charts; electro-dynamic interlocking system

I. INTRODUCTION

Train traffic security installations of the Romanian Railway Station are of the following types: mechanical, electro-mechanical, electro-dynamic, and electronic.

For all installations other than the electrical ones, failure diagnosis is done by direct observations of the state of the installation’s components and by field measurements. The time needed to remedy a failure is usually inversely proportional to the practical and technical know-how of the maintenance staff.

For electrical installation, the devices in the apparatus room continuously read and measure the state of the installation, therefore each failure situation is displayed on a monitor together with a code that indicates the possible failure reasons. The drawback of such electronically centralized traffic security installations (EIS) is that when the failure is somewhere on the field the readings in the apparatus room only show a code that the failure is outside the room and no further information about a possible cause.

The method we propose can diagnose both the failures in the apparatus room as well as those in the field.

The light signals that an electro-dynamically centralized traffic installation are the following: entry signal, exit signal, passing signal, shunting signal, breakdown/failure signal, and repeater signal [1, 2].

This work tackles with the diagnosis of light signals for shunting, breakdown/failure and repeaters in stations equipped with EIS.

The diagnosis process is using diagnosis charts that were created starting from the basic wiring schemas of the train stations. The software assisted diagnosis consist of the usage of a program, written in Visual Basic, which allows the user, after providing answers to a sequence of questions, to quickly establish the failure cause. The diagnosis charts that the software package use make the failure detection process more efficient by avoiding unnecessary repair steps or mistaken decisions which would lead to unjustified long diagnosis and repair times leading, in turn, to train traffic delays.

II. SHUNTING LIGHT SIGNALS AND THEIR DIAGNOSIS

Traffic on rails can be either [3]:

- Person and goods traffic that transits train stations, with or without stopping in stations;
- Shunt traffic which consists of all operations needed to form and disconnect trains.

Shunt traffic is done between the entry signals on any one of the station’s directions. Shunting light signals allow or interdict shunt traffic over the area they control. Shunting light signals are [4]:

- Blue: Stop at the light signal’s location;
- Lunar white: shunt operation permitted beyond the signal’s location (with at most 20 km/h speed).

Fig. 1 shows the wiring for the command and control of a maneuvering light signal.

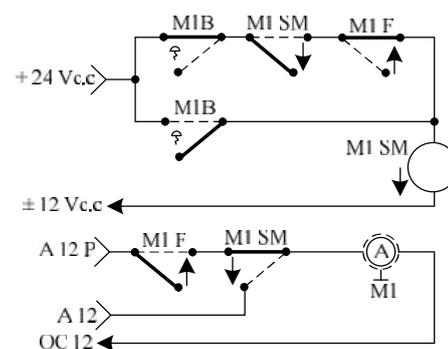


Fig. 1. Command and control wiring diagram for a shunting light signal.

To command the transition of the light signal from blue to lunar white, a user has to press the M1 B signal command button which powers the 12 V c.c. command relay coil of the SM shunting signal [1].

The state of the shunting signal on the command apparatus is given by a bulb light powered at 12 V a.c. with the following possible states:

- Off: the shunting signal shows the blue light;
- White: the shunting signal shows lunar white;
- Pulsing white: either the signal light for the blue indication is burnt or there's a failure along the corresponding electrical circuit. In this no permissive shunt command is allowed until the failure is remedied.

Fig. 2 shows the execution chart for a shunting light signal.

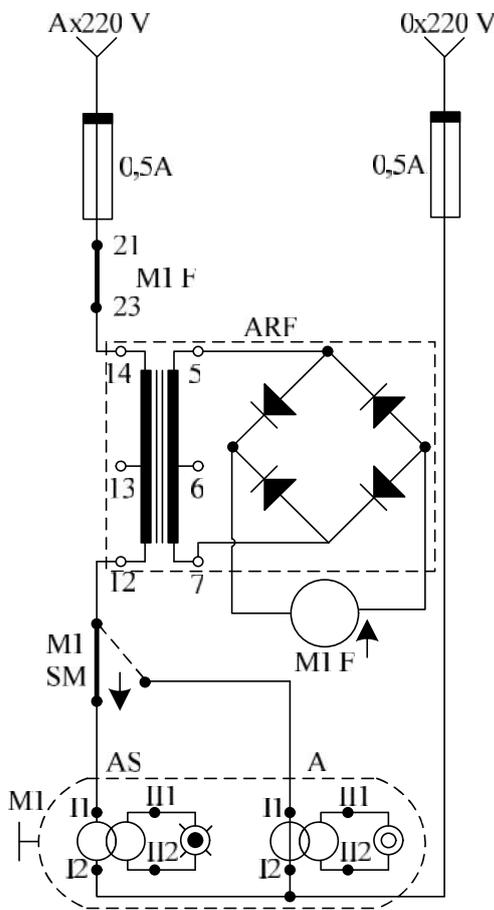


Fig. 2. Execution chart of a shunting light signal.

In its normal state, the shunting signal lights up a blue light, marked with AS in Fig. 2. Powering this light is done with 220 V a.c., 75 Hz or 50 Hz during the day, and 180 V a.c., 75 Hz or 50 Hz during the night, through a three-wire cable, one wire for each of the two signal's lights and one for the common return.

The filament integrity for the signal's lights is done through the fire relay, F, whose coil is serially connected to the primary transformer coils that power up each light bulb.

The 21-23 M1 F relay contact, serially connected to the relay's coil, disconnects the transformer and the rectifier when the fire relay is un-energized (during replacements).

The light bulbs used in light signals are usual 20 W and cause a 100 mA current in the transformer's primary.

The relays controlling the signal fire-ups are of type NF1A-200R or NF1LA-200R (N- neutral, F- connector, A- self maintaining, L- slow, delayed at fall, 200R- total coil resistance is 200Ω).

The main failures for shunting signals are:

- The white light is blinking on the command apparatus (for the shunting signal);
- The signal does not change to the permissive state when the button commanding the shunting track is pressed.

Fig. 3 shows the diagnosis chart for the shunting light signal for failures signalled by a blinking white light on the command desk.

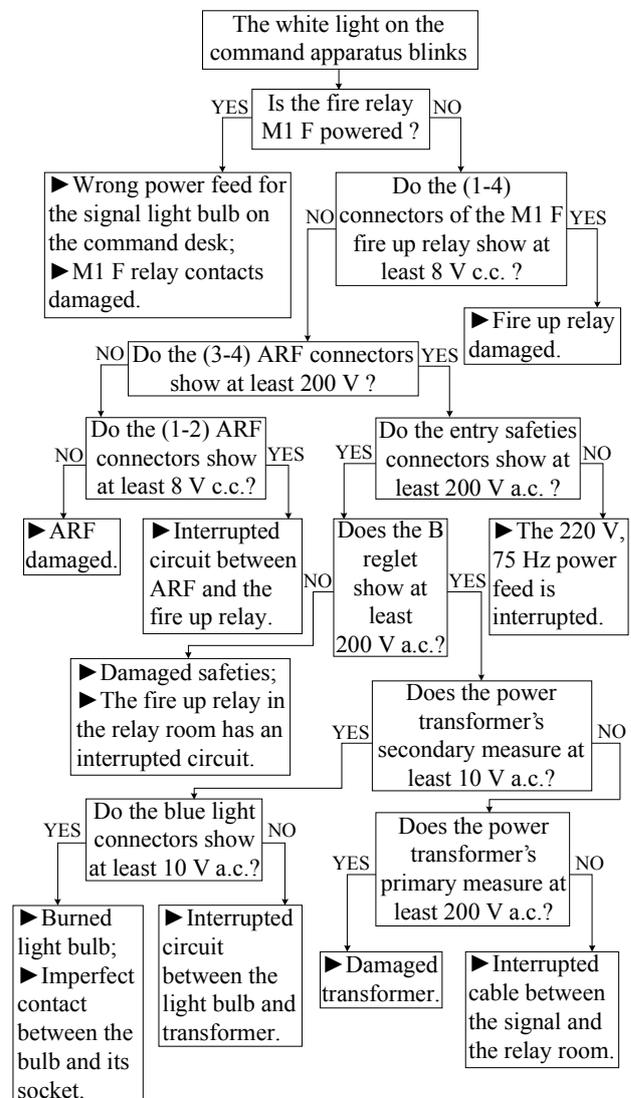


Fig. 3. Failure diagnosis chart for shunting light signals when the white light blinks on the command desk.

For the situations where on the command desk no failure is signalled and, upon commanding the shunting signal to the permissive position, the light signal does not show the commanded state (on the command desk the white light shortly lights up, then turns off), the failure is in the lunar white fire-up circuit. The diagnosis chart for this type of failures is shown in Fig. 4.

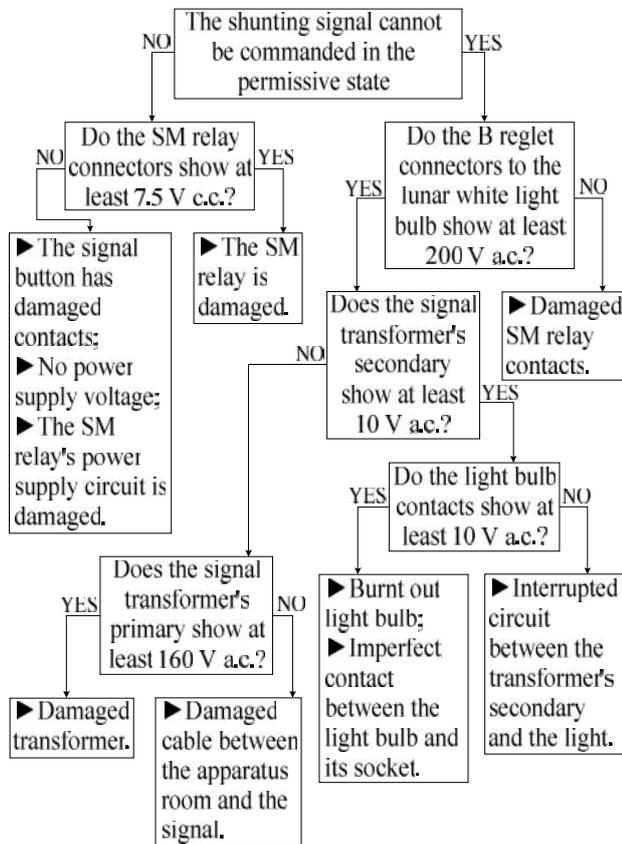


Fig. 4. Diagnosis chart for the case when the shunting signal does not change to the permissive state.

III. REPEATER LIGHT SIGNALS AND THEIR DIAGNOSIS

Repeater light signals are used in situations where the visibility distance between the entry, exit, and transit signals is shorter than the distance recommended by regulations (400 m for entry and exit signals for direct lines on tracks with maximum 120 km/h traffic speed allowed, 300 m for transit signals, and 200 m for exit signals on curved tracks, on tracks with most 120 km/h speed) [3].

The repeater signals are displayed by luminous lines formed by white light bulbs with the following configurations and meanings [4]:

-  - The following signal is a stop signal;
-  - The following signal is a free state signal with limited speed;

-  - The following signal is a free state signal with prescribed speed.

Repeater signals are powered with 220 V d.c. through a cable from the signals they are repeating or from the ABS (Automatic Blocking System) signal boxes.

Repeater signals of the entry and exit signals are permanently powered, while the ABS transit signals are powered only on the ABS orientation direction.

Fig. 5 shows the power feeding diagram of a repeater signal over a passing ABS. CJ denotes the signal's base joint box, CT denotes the transformer box, and R is the repeater signal.

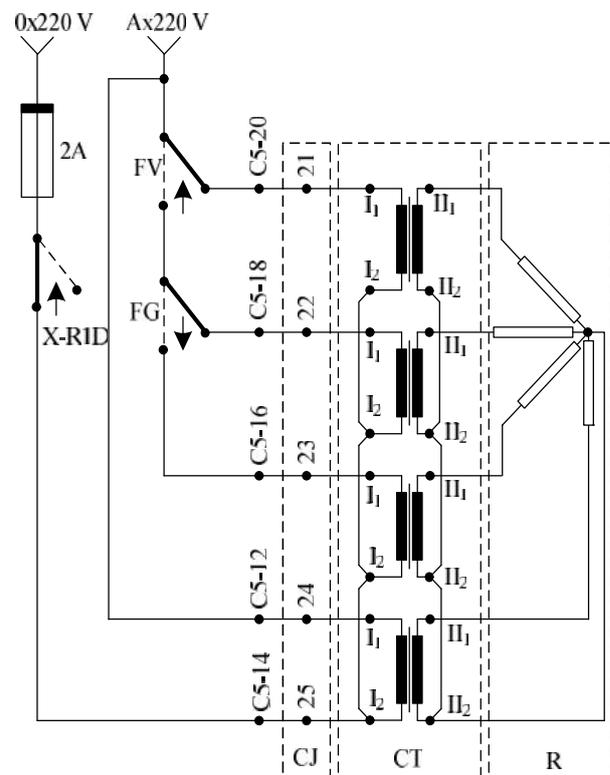


Fig. 5. Power feed wiring schema for an ABS crossing repeater signal.

The commands to display the various signal indications at the repeater signal are issued through fire-up relays of the signal whose indication they repeat. The fire-up relays are FV for green beacon, and FG for yellow light beacon.

For each light line one voltage step down transformer of 20 W is used. Each transformer powers up the electric bulbs.

- The main faults that may apply to repeating signals are:
- The signal is completely turned off;
 - The signal has one light line off.

Fig. 6 represents the diagnosis chart for the repeater signal. For every repeater signal failure it is essential to check the correct functioning of the signal whose indication the failing signal is repeating [5].

When the repeater signal indicates an entry or an exit signal, its power is fed directly from the relay room through the fire-up relays of the repeated signals.

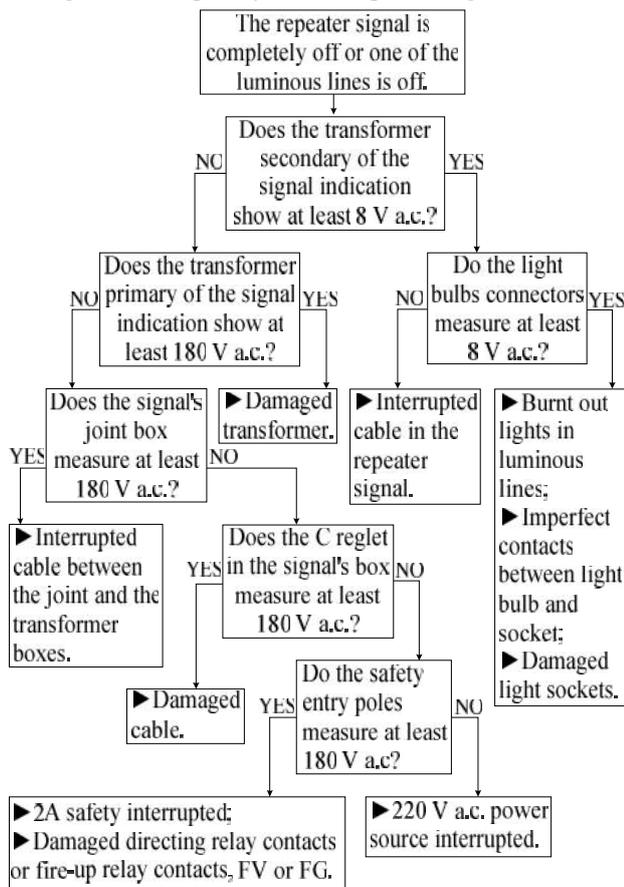


Fig. 6. Diagnosis chart for a repeater signal of an ABS crossing signal.

IV. WARNING LIGHT SIGNALS AND THEIR DIAGNOSIS

Warning light signals are placed on a running line, between two railway stations, 50 m from the level crossings between a railway and a roadway. They are designed to warn trains in traffic about the functioning or non-functioning of the roadway signal installation, SAT [3].

The normal state of the warning signals, when the roadway crossing warning signal functions correctly, is off on the commanded train traffic direction, and on for the reverse traffic direction or when the signal installation is failing.

The warning signal indicates: Red – danger at the level crossing! Take all measures to stop! [4].

Fig. 7 shows the wiring schema for the S1 and S2 warning signals, for the X and Y train traffic directions, respectively [1,2].

To power feed the warning signals we can use two power supplies: 12 V c.c. from the DR 12-10 rectifiers in the apparatus boxes along the ABS installation; and 25 V d.c. from a voltage step down transformer.

The switch from one power supply source to another is done through supervisory relay contacts, S. The installation also has a battery accumulator for situations in which the general 220 d.c. general power supply of the ABS boxes is down.

The filament integrity of the light bulbs is done through the fire-up relays S1-F for the X ABS traffic orientation and S2-F for the Y traffic orientation.

In case the SAT, roadway signal installation, is faulty, that is the light bulb's filaments are burnt, the KFR roadway fire-up control relay will de-energize.

This will cause the warning signal, AS, to de-energize as well. This relay will command the warning signal covering the level crossing to indicate red on the train traffic direction.

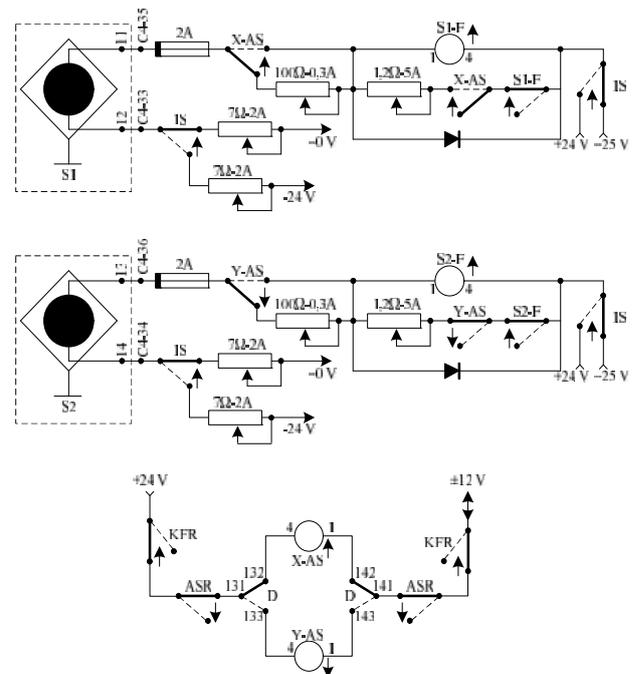


Fig. 7. Wiring schema for the S1 and S2 warning signals.

If an ABS section that contains an SAT installation signals occupied on the command apparatus, although the real state of the line is open, or when on that section rolling stock for maintenance work occupies the line, the SAT installation will permanently signal.

For these situations the traffic manager has on the command desk a button, BASR, which cancels the roadway signal.

Normally, this button is under seal, its unsealing and operation being allowed only by following specific procedures. Activating this button will energize the roadway signal cancelling relay which will command the warning signals to indicate stop.

Failures of a warning signal are:

1. The warning signal on the active train traffic direction does not change to red when pressing the BASR button or when the filaments of SAT's light bulbs are damaged;
2. The warning signal for the inverse train traffic direction is permanently off.

The warning signal diagnosis chart for first failure case is presented in Fig. 8, while the chart for the second failure cause is shown in Fig. 9.

V. THE DIAGNOSIS SOFTWARE

There are three pieces of software that deal, each, with one type of signal failure diagnosis: SEMman – for the shunt signal diagnosis, SEMrep – to diagnose of the repeater signals, SEMav – for the warning signal diagnosis.

Using the diagnosis charts, these pieces of software [6-9]. were implemented using Visual Basic. The user of the software must give yes/no answers to questions that the program shows her or him. The questions address the state of various equipment, measured values, etc. At the end of the questioning process, depending on the user's answers, the program displays the failure cause(s). With this method the diagnosis time is considerably reduced.

Fig. 10 and 11 presents a screenshot from the program's execution.

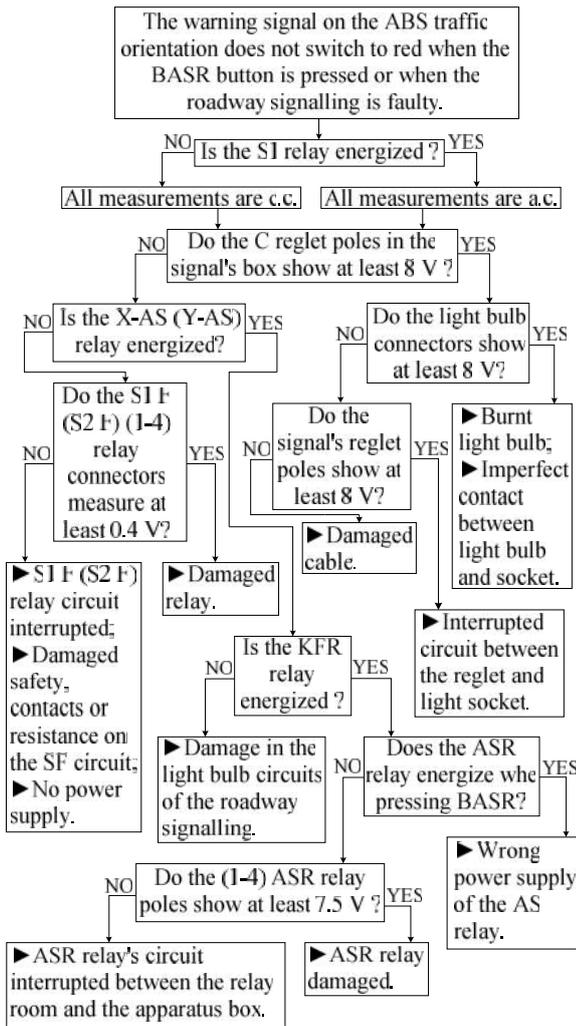


Fig. 8. Warning signal diagnosis chart for the ABS traffic orientation.

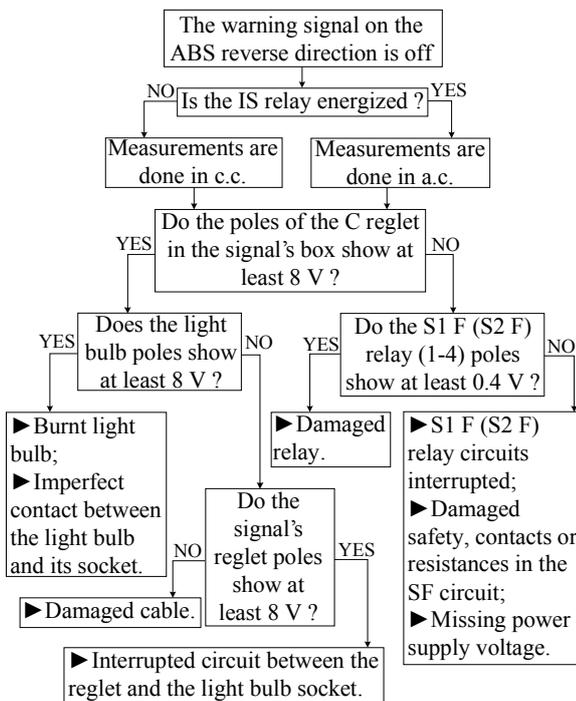


Fig. 9. Warning signal diagnosis chart for the reverse traffic direction when the signal is permanently off.

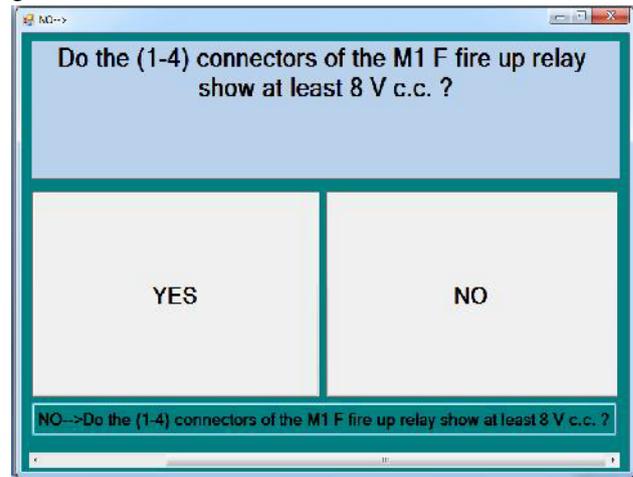


Fig. 10. Screenshot of the diagnosis software.

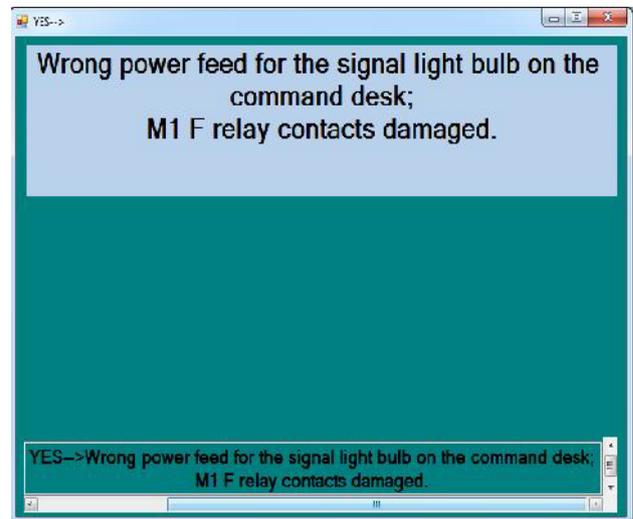


Fig. 11. Screenshot of the diagnosis software.

The user interface is extremely simplified and allows a user to trace back in the question/answer sequence.

VI. CONCLUSION

This work presented a modern method to diagnose three types of light signals – shunting signals, repeater signals, and warning signals – in electro-dynamically centralised

train stations. The advantages of the method presented are mainly:

- Substantially shorter diagnosis times;
- False fault diagnosis decisions taken by the maintenance staff are avoided;
- It does not need additional approvals from the railroad company responsible leaders as the diagnosed installations are not changed in any way;
- No additional costs are necessary, as the existing IT equipment can be readily used with this software;
- Can be used for the staff periodic instructions as well as for testing the maintenance staff;

The authors' contributions are:

- Devising the diagnosis charts;
- The creation and implementation of the three software packages for the signal diagnosis, SEMmac, SEMrep, SEMav;
- Testing, by users, the software packages.

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