Diagnosis diagrams for passing signals on an automatic block signaling railway section

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Abstract. This work presents a diagnosis method for railway traffic security installations. More specifically, the authors present a series of diagnosis charts for passing signals on a railway block equipped with an automatic block signaling installation. These charts are based on the exploitation electric schemes, and are subsequently used to develop a diagnosis software package. The thus developed software package contributes substantially to a reduction of failure detection and remedy for these types of installation faults. The use of the software package eliminates making wrong decisions in the fault detection process, decisions that may result in longer remedy times and, sometimes, to railway traffic events.

1. Introduction
The role of the railway traffic security installations is to command, control and ensure that the railroad traffic happens under completely safe conditions.

Any breakdown in such installations leads to traffic delays, and when wrong decisions are made, even to railway events. Therefore it desirable that:
- These installations have a low failure rate;
- In case of failures, the diagnosis and repair time are as short as possible;
- The train traffic during the installation malfunction is made in accordance to specific regulations, in order to avoid any traffic events;
- The fault diagnosis and remedy is done by specialized personnel, showing adequate theoretical and practical abilities.

For a number of Romanian railway junctions, the electro-dynamic centralized installations have been replaced with electronic centralized installations. Still, there are railway stations equipped with outdated traffic installations, installed in the 1970. Due to their physical wear and obsolescence, these installations fail often and can result in railway traffic events. Therefore, special attention must be given to the maintenance of these installations.

Currently, the diagnosis time for these installations depends strongly on the theoretical and practical know-how of the maintenance staff. In this respect, the most important problems faced are:
- Shortage of the maintenance and intervention staff;
- Remote intervention locations (sometimes distances as far as 80 km must be taken into account);
- Work in isolated conditions (lone walks between two railway stations);
- Difficult work conditions (night time, adverse weather, etc.).
All these put a certain pressure on the maintenance staff, such that in cases of failure their decisions may be negatively influenced.

The diagnosis charts proposed here together with the proposed software package, assist the maintenance personnel in their work by rapid and safe detection of the failure cause.

This work contributes to previous work on diagnosis chart design for all installation types for railway stations equipped with CR4 electro-dynamically centralized installations [1-7].

Worldwide, the control light signals can be done with specialized equipment [8-10], and diagnosis with the various logical systems [11-13].

2. Passing light signals
Along an Automatic Block Signaling block (ABS) lighting signal posts are placed at the end of each sector of the block. The minimal length of an ABS block is 1,200 m [13].

Each lighting signal on an ABS sector is a prior warning signal of the next lighting signal.

On all lighting signal posts white rectangular markers are installed. These markers indicate the possibilities available to a train driver to pass a signal post when the lighting signal on the post shows a red indication, an unclear indication, or the light is off.

Where ABS systems are installed, the normal indication of the passing signals (lighting signals), is either permissive or forbidding (stop), depending on the ABS block orientation [2], [3]. Figure 1 presents the unified ABS signal orientation for a double I track line (DI) and a double II track line (DII).

![Diagram of ABS signal orientation](image)

**Figure 1.** Signal indications on an ABL block with double line

The indications shown by the passing lighting signals of an ABS block are [14]:
- Red – “STOP, without passing the signal!” The meaning of the signal is that the first following sector of the block is occupied;
- Yellow – “Free line, travel with pre-established speed, ATTENTION! The next signal indicates stop”. The meaning of the signal in this case is that the first block sector is free, but the second one is occupied;
- Green – “FREE, proceed at line speed.” The meaning of the signal is that the next signal indicates free passing with the pre-established speed and that at least the next two block sectors are free;
- Blinking Yellow – “FREE with pre-established speed, the next signal is free with reduced speed.” This indication is used by signals that also function as prior warning of the entry signal.

The light indications of the ABS light signals must be distinguishable, both during night and day, from at least 300 m on the lines with traffic speed of at most 120 km/h, and from at least 400 m for lines with traffic speed higher than 120 km/h.

When the train driver encounters an ABS lighting signal that is unclear, red, or off, the driver must stop the train before reaching the signal, without passing it by. After this, the driver must urgently
notify the train dispatcher in the next station. If the driver is informed or sees that the next block sector is occupied he is forbidden to drive the train further. If no obstacle is identified and on the signal’s post a white rectangle marker is observed, after the time the braking is off, the train driver may continue with a speed of at most 20 km/h, paying very close attention to the railroad, up to the next signal.

To remedy a faulty lighting signal on an ABS block sector, the maintenance staff must travel to the respective signal, perform measurements for pinpointing the fault and do the necessary repairing.

3. Electrical schema for passing light signals

Figure 2 presents electric schema for the BL1 and PrYF fire signals on a double track line, unified ABS block.

![Electric schema for BL1 and PrYF passing signals](image-url)
In this context “unified” refers to the fact that, on each track, the train traffic can happen in both directions. When the traffic runs in the Y direction on track 1, we say that the train travels on the wrong track, and the following signals will be seen having a permissive indication: BL2F, BL4F, BL6F, PrYF. The signals are 12V c.c. powered by the DR-12-10 rectifiers.

The signal fires (i.e. light bulbs) are controlled by the fire relays (green fire – FV, yellow fire – FG, red fire – FR) whose coil is serially connected with the light bulbs’ filaments. Thus, whenever a light bulb is burnt, the signal changes to a restrictive or a stop indication.

When a track circuit is occupied with rolling stock or is damaged, the signal automatically changes to a stop indication by the relay G de-energization. When reversing the ABS installation’s traffic orientation, the signal indication is changed through the directing relay, D, and the orientation directing relays, X-R1D, and Y-R1D.

For improved safety, the red indication light is doubled by a spare red light, Rr, which insures the red indication operation when the primary red light is burnt. The blinking yellow warning signal is controlled by the pulsing relay P1 contacts. The signal lights and the fire relays voltages are regulated by adjustable resistors, while the shunting protection is insured by fuses.

4. Diagnosis Charts and the Sem-Bla Software Package

The main passing signal defects that may occur are:
- All signal lights are off, no matter the ABS orientation;
- The green signal indication is off, although at least two block sectors ahead are free;
- The yellow signal indication is off, although at least one block sector ahead is free;
- The signal’s red indication is off.

Figure 3 shows the diagnosis chart for situations where all light indications are off, no matter the ABS track orientation.

![Diagram](image.png)

**Figure 3.** Diagnosis diagram for cases when the signal lights are off

Figure 4 presents the diagnosis diagram for situations where the signal cannot indicate the green light, while Figure 5 shows the diagnosis charts for situations where the yellow indication is not working.

Figure 6 shows the diagnosis charts for cases where the signal cannot indicate the red or spare red lights.

These diagnosis charts, which are created to assist the maintenance staff in their decision taking, have been used as a basis for a software package, SEMBla, written in Visual Basic.Net. The software...
package has a button based interface which, by its simplicity, is one of the most efficient interaction with the software.

The SEMBla software package shows a user a series of questions to which the user (i.e. the maintenance staff) answers based on the state of matters in the field. When a question was wrongly answered, the user can navigate backwards through a series of buttons in the lower area of the screen.

**Figure 4.** Diagnosis chart for cases where the green indication is not working

**Figure 5.** Diagnosis chart for cases where the yellow indication is not working
The signal doesn't show the red indication

Are there at least 0.4 V c.c. at the (1-4) FR relay terminals?

YES ► Damaged FR relay.

NO Are there at least 10 V c.c. at the C reglet terminals of the red light?

YES ► Damaged red light.

NO Are there at least 10 V c.c. at the red light's terminals?

YES ► Red light circuit interrupted between the signal box and the signal.

NO Are there at least 10 V c.c. at the spare red light terminals?

YES ► Red spare light damaged.

NO Are there at least 10 V c.c. at the signal's reglet of the spare red light?

YES ► Interrupted wiring harness in the signal.

NO ► Sparere light circuit interrupted between the signal box and the signal.

Figure 6. Diagnosis chart for situations where the red or spare red light indications are not working

Figures 7 and 8 shows an example of a SEMBlab dialogue window, while Figure 9 shows the diagnosis reached based on the user answers and field measurements.

The signal is off
Are there 12 V c.c at the DR-12-10 rectifier's output clamp

Figure 7. SEMBlab dialogue window example
Figure 8. SEMBlA dialogue window example

Figure 9. SEMBlA dialogue window example
5. Conclusions
The realization of the SEMBla software has been made to use the diagnosis charts to detect ABS passing signal faults.

The software allows significant reduction of remedy times, and provides helpful and quick guidance to the maintenance staff using it.

The diagnosis method presented in this article does not necessitate additional infrastructure and implementation costs, being a useful assistant to the maintenance staff, both as a training method and a failure detection method.

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