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# Longitudinal Sectioning of Overhead Contact Lines in Stations on Single-Track Lines

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**Summary**

The length of standard gauge rail lines under the management of PKP Polskie Linie Kolejowe S.A. is 18,522.503 km, including 11,940.509 km of electrified lines. In order to ensure reliable power supply to the electric traction, as well as to ensure that work can be carried out when the voltage on the overhead contact lines is switched off or as a result of a breakdown, sectioning is used. By electrically sectioning the overhead contact line, specific sections of it can be switched off. The impact on station capacity as a result of a power outage in the overhead contact line depends on how the sectioning is performed. This performance is not strictly defined in the case of stations on single-track lines, where the sectioning of the overhead contact line is done in different ways. The article analyses the impact of longitudinal sectioning on the possibility of running trains by electric traction, using the example of two sections of single-track railroad lines No. 15 and No. 16.

**Keywords:** overhead contact line, longitudinal sectioning, station capacity, track closures, maintenance of overhead contact line

## 1. Introduction

Out of 18,522.503 km of railway lines managed by PKP Polskie Linie Kolejowe S.A., 11,940.509 km of them are equipped with devices enabling trains to be operated by electric traction, which constitutes 65% of the national standard gauge rail lines network in Poland [1]. Important communication routes and railway junctions serving both passenger transport, facilitating passenger travel between place of residence and work, school, university, and other purposes, as well as freight routes, including international transport corridors, have been electrified. The reconstruction of Warsaw's railroad junction in interwar Poland, carried out in the mid-1930s, represented a leap forward in rail transport, with technological advances including the use of high-quality electric traction power equipment [2]. Direct current with a voltage of 3 kV was adopted for electrification [3], which was an innovative system at the time. While in the 1950s, an alternative system (25 kV alternating current) was considered, this plan eventually abandoned in 1965 [4]. It was not until the construction of the rail network planned in the 21st century as part of the Central Communication Port project that the possibility of electrifying the lines with a 2 × 25 kV AC system (and leaving the 3 kV DC system in the area of junctions with conventional rail) opened up [5].

The overhead contact line, like any other equipment, to operate reliably and run trains safely, requires cyclic maintenance work, as well as checking and making adjustments to numerous components [6]. Carrying out these activities safely requires turning off the voltage to eliminate electrocution of personnel.

In order to ensure uninterrupted railway traffic and minimise the impact of failures, as well as to enable power shutdowns in a small area limited to the needs of ongoing operations (rather than across the entire electrified rail network), sectioning is employed, involving the division of the overhead contact line into electrically independent segments. Two types of sectioning are distinguished: cross-sectioning and longitudinal sectioning [7]. Cross-sectioning involves electrically insulation the overhead contact lines of adjacent tracks. Longitudinal sectioning is an electrical division – separating sections of the overhead contact line of the same track. Sectioning should be designed to enable the disconnection of power supply to individual segments of the overhead contact line and adapted to the ability to manage train traffic in case of disruptions resulting from the disconnection of individual segments from power [8]. The basic principle

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of longitudinal sectioning is to separate the station tracks from the route tracks, the main tracks from the additional main tracks, and the other tracks with different purposes [9]. In stations located on double-track lines, the electrical division of the overhead contact line in the event of switching off the power supply to the network of individual tracks should ensure that it is possible to exit on one of the tracks of the route, as well as to pass between odd and even tracks in the turnout points. For single-track railroads, the principles of longitudinal sectioning are not strictly systematised. Various methods of implementing electrical division of station track overhead contact lines in such cases are the subject of this article, illustrated by comparing two single-track line sections: railway line No. 15 between Łowicz Przedmieście and Zgierz with railway line No. 16 between Zgierz and Kutno.

## 2. Methods of Longitudinal Sectioning of the Overhead Contact Line

The overhead contact line is electrically insulated by using:

- insulated tension spans,
- section insulators,
- insulated air gaps.

A tension span is a structure in which two independent mechanically networks of tension segments run parallel and next to each other – one segment of the overhead contact line ends, and the other begins, and their parallel arrangement allows the free movement of the current collector slipper of the traction vehicle (locomotive or traction unit). The difference between a typical tension span and an insulated span is that an insulated span has no electrical connections for the free flow of current between tension sections, and these sections (may or may not be) are connected by a section isolating switch or disconnector (Fig. 1) or, rarely, do not have electrical connection (Fig. 2). In an isolated tension span, the horizontal distance between the closest contact wires of different tension segments is increased from 150 mm to 200 mm.

Another method of electrical separation is to insert a section insulator in the overhead contact line. Y stitch wires are not isolated in overhead contact lines with one catenary wire. In this case, flexibility of the overhead contact line is not applied at the point of suspension at which the section insulator is located.

The section insulator is subjected to the tension force of the contact wire(s) [10]. It must allow free movement of the current collector slipper and cannot be a mechanical obstacle. For this purpose, special guides are used to guide the pantograph in an unobstructed manner, preventing contact between the slipper and other parts of the insulator, including the insulating parts. In case of improper interaction between the collector and the insulator, damage can occur to both the overhead contact line and the rolling stock, and until the overhead contact line is repaired, and the vehicle is removed, voltage shutdown can also be inconvenient.

Fig. 1. Insulated six-post tension span with an isolating switch; YC120-2CS150 type overhead contact line, Łódź Żabieniec, 2021 [photo taken by D. Dratwa]

Fig. 2. Insulated six-post tension span without an isolating switch or sectional disconnector; YC120-2CS150 type overhead contact line, Łódź Żabieniec, 2021 [photo taken by D. Dratwa]

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Section insulators are cheaper and less complicated in construction than isolated tension spans. The length of the most commonly used plastic insulators (Fig. 3), catalogue number 7500, is 3060 mm, and the increasingly common newer types are even shortened to 2330 mm. The weight of these insulators varies from 17 kg (solid wire) to 21 kg, lighter types appear with weights of 13 kg and 15 kg, respectively [11]. Previously, roller ceramic insulators (Fig. 4) were used, whose weight in the line and in the contact wire exceeded 50 kg [12]. Despite the significant reduction in weight, insulators are a rigid point in the overhead contact line, and this generally avoids the use of sectioning of track networks on which trains can run at speeds above 120 km/h, although there are types of insulators suitable for train speeds up to 160 km/h (Fig. 5a and 5b). However, in these cases, only isolated tension spans should be used. section insulators should not be installed in the overhead contact line at speeds exceeding 160 km/h [13].

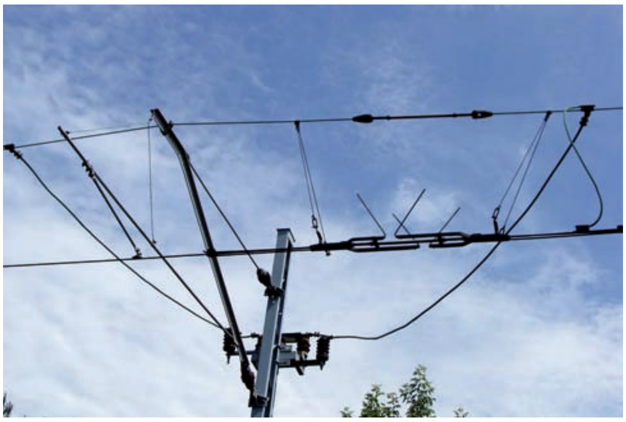

Fig. 3. Suspension with a section insulator made of plastic and an isolating switch; sKB70-C type overhead contact line, Głowno, 2011 [photo taken by D. Dratwa]

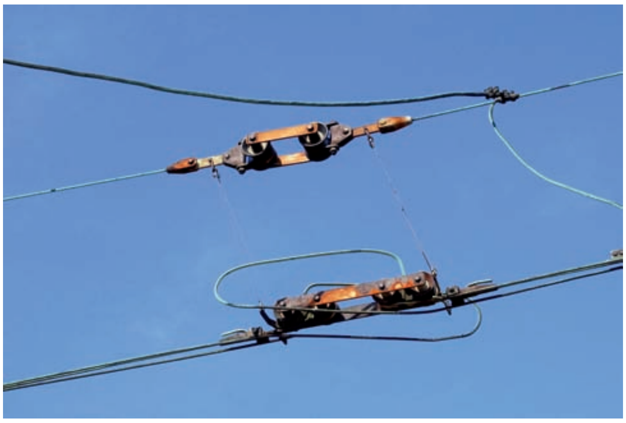

Figure 4. Ceramic section insulator; sKB70-C type overhead contact line, Domaniewice, 2017 [photo taken by D. Dratwa]

a)

b)

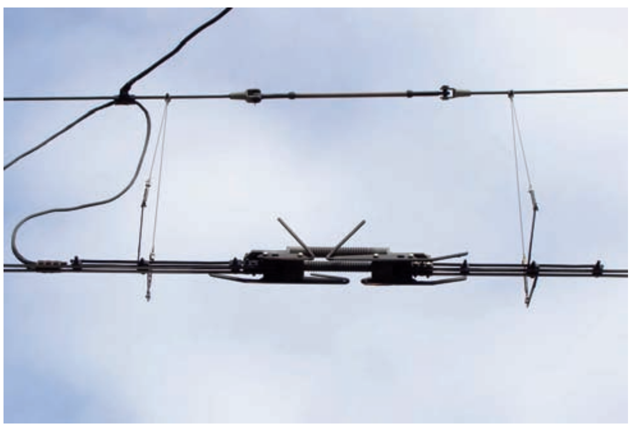

Fig. 5. (a) Sectioning of the YwsC120-2C type overhead contact line with a section insulator at a location where trains run with V max 160 km/h, no Y stitch wire at the insulator suspension point, Jackowice, 2012; (b) section insulator [photo taken by D. Dratwa]

Due to their weight, ceramic section insulators required limiting train speeds to 40 km/h. In order to eliminate (costly construction of isolated tension spans, requiring the setting of additional support structures, and thus minimising the use of steel for the construction of traction poles), air gaps were used until the 1980s. Their construction involved running an additional pair of contact wires in the span, creating a common raceway in the centre of the passage, as in the tension span. The contact wires are directly attached to the auxiliary arm, similar to a cross suspension. Subsequently, after forming the track with the second pair of wires, they are guided to the correct height and fastened by steady arms, where the second pair is lifted to the auxiliary arm of the supporting structure. When suspended, divider insulators are inserted into the raised contact wires (Fig. 6). One insulator is inserted into the catenary wire, depending on the sectional construction of the gap in the centre of the passage (Fig. 7) or at one of the suspensions. In the latter case, it was necessary to additionally use insulated droppers (Fig. 8).

Fig. 6. Suspension at the air gap, with insulators in the catenary wire and contact wire; original ceramic section insulator and a dropper insulated by a ceramic single-shed strain insulator are preserved; sKB70-C type overhead contact line, Czachówek Południowy, 2018 [photo taken by D. Dratwa]

Fig. 7. Air gap with insulated catenary wire in the middle of the passage; C120-2C type overhead contact line, Głowno, 2010 [photo taken by D. Dratwa]

Fig. 8. Air gap with insulated catenary wire at one of the suspensions (on the right) and insulated droppers. Ceramic divider insulators from the time of electrification are preserved in the contact wires; droppers insulated with ceramic double-shed strain insulators. YC120-2C type overhead contact line, no Y auxiliary wires at gap suspensions, Żerków, 2018 [photo taken by D. Dratwa]

Due to their design, air gaps did not limit train speeds to 40 km/h like the ceramic insulators used at that time and were quite commonly used instead of additional tension spans for both economic (cheaper) and structural reasons – it was sufficient to shorten one passage instead of using additional cross and anchor poles and lead the contact lines to anchorage, which is often complicated at turnout points. However, due to the complicated construction and difficult regulation of the overhead contact line, this solution was discontinued. The disadvantage of insulated air gaps and insulated tension spans is their length. In the case of voltage outages, they shorten the useful length of the track, since the wires cannot be short-circuited by the slipper of the traction vehicle's current collector, thereby transferring voltage to the outage section.

## 3. Principles of Longitudinal Sectioning of the Overhead Contact Line

Sectioning makes it possible to separate independent sections of the overhead contact line of the same track and between tracks. As a result, breakdowns, inspections and contact line maintenance or other activities that require power shutdowns in the overhead contact line do not paralyse traffic over a large area but are limited to the necessary scope.

In accordance with the adopted rules at PKP Polskie Linie Kolejowe S.A. (Iet-107), the following should be electrically separated from each other:
1) route tracks from station tracks,
2) additional main tracks from main tracks,
3) secondary tracks from main tracks,
4) groups of secondary tracks with different purposes (e.g. stabling, arrival, departure) from each other,

5) in addition, electrified tracks introduced into maintenance and repair halls, in the wash area and points of dangerous materials transfer, especially flammable ones, are separated.

The isolation of the contact lines of the station tracks from the contact lines of double-track route tracks should be done in such a way that, in the event of a power outage, there is a possibility of train passage between the odd-numbered track on the route track and the even-numbered track in the station, and vice versa – between the odd-numbered station track and the even-numbered route track. The isolation of the route overhead contact line from the station overhead contact line is called the electrical boundary of the station and should be implemented as an isolated tension span. In the past, isolated air gaps were used interchangeably. Exceptionally, the use of a section insulator (made of plastic) is permissible, but subject to the following conditions:

- the insulator should be located near the anchorage staying of the overhead contact line or the middle anchorage;
- the insulator must be positioned before the fixed or central anchorage in the direction of the route.

For structural reasons and due to their significant weight, ceramic section insulators were avoided in this role and in general in the overhead contact lines of main tracks and route tracks. Such insulators were only installed when the maximum speed of trains travelling on that track did not exceed 40 km/h, and the insulation point did not serve as an electrical boundary.

Isolated tension spans, both full-size and shortened (Fig. 9), are also used to divide the station contact lines of main and additional main tracks, while the route track contact lines in the area of traction substations and sectional cabins is divided only by full-size tension spans.

Fig. 9. Shortened isolated six-post tension span, YC150-2C150 type overhead contact line, Zielonczyn, 2016 [photo taken by D. Dratwa]

Section insulators are commonly used in isolating contact lines sections of track segments between turnout joints, station contact lines of main and additional main tracks, as well as sidings and yard areas. They are less frequently used in the area of traction substations and section cabins. New air gaps are not built in, and existing ones are successively converted to insulated tension spans or section insulators.

## 4. Functionality of Overhead Contact Line Sectioning and Impact on Station Operation Using the Example of Single-track Lines

The theoretical idea is to divide the overhead contact line into electrically independent sections run over tracks with different purposes. As a rule, the main tracks are fed on both sides to maintain electrical continuity between substations. The additional main track network is powered from one side, which in practice reveals some dysfunctions that adversely affect the capacity of the station and the ability to perform work with power shutdowns. As a result of a significant reduction in capacity or the need to implement an interruption in train traffic, track closures are granted to a limited extent, often less than required, or are not assigned at all due to a failure to match the operating timetable, if not notified in advance. The deadlines for notification of the need to carry out work requiring closures are regulated by the instruction “Principles of organisation and granting of track closures Ir-19” of PKP PLK S.A. [14].

As a general rule, the sectioning of the overhead contact line of small stations and those of medium size is uncomplicated and fulfils the design requirements, i.e. separates the contact lines of route tracks from station tracks and station tracks with different purposes between each other. However, it is worth noting two fundamental approaches to locating electrical boundaries in the case of through stations limited by single-track lines:

1) locating electrical boundaries within the station involves powering the additional tracks and turnout connections from the contact line of the route tracks (Fig. 10),
2) locating electrical boundaries of the station in the tracks adjacent to the signal box, then additional tracks and turnout points are powered from the station contact line (Fig. 11).

There are also hybrid variants, in which the contact lines of the main track and at least one additional main track are fed from the route track contact line, while the contact lines of the subsequent additional tracks and sidings are fed from the station track contact line (Fig. 12).

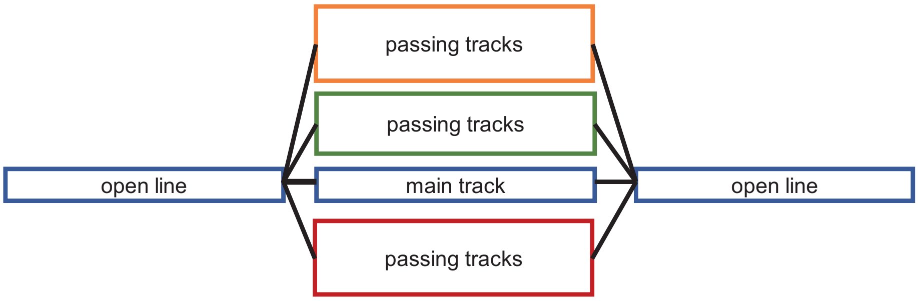


Fig. 10. Supply of main tracks (groups of tracks) in the station independently of each other from the route track network [own work]

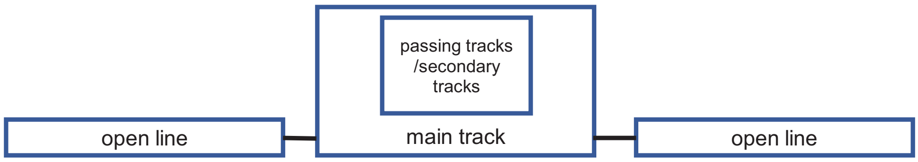


Fig. 11. Supply of station tracks (groups of tracks) from the main track contact line [own work]

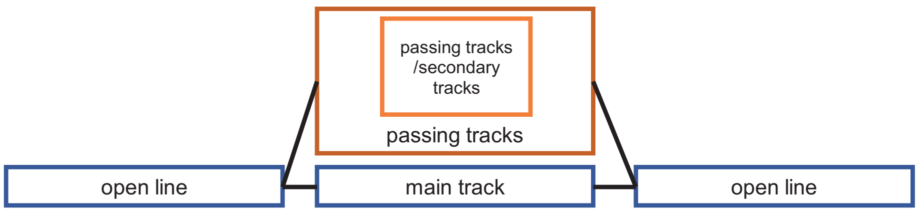


Fig. 12. Example of a hybrid variant – the contact line of the nearest additional main track (group of tracks) is powered from the route track contact line, while the contact lines of further tracks are powered from the additional track [own work]

With the location of the electrical boundaries in the station, the tracks are actually electrically independent of each other, and their supply depends on the location of the connectors. Designing boundaries in the route tracks, when the power is switched off on the main track, results in the lack of power supply to the remaining station tracks, making it impossible to operate railway traffic with electric traction. This is particularly significant during maintenance work and routine repairs on the overhead contact line or other activities requiring power shutdowns, sometimes mundane ones such as semaphore replacement. Although this limits the flexibility of running traffic, albeit on a neighbouring track next to the site of the work requiring a voltage cut, such a solution can be successfully used on lines with little train traffic. On the other hand, the benefits of this type of sectioning become apparent when power is switched off from the route direction, which has no impact on the station's operation itself. Hence, the design and installation of electrical boundaries and sectioning depend on the purpose of the station, the functions of individual main tracks and sidings, and train traffic – existing and predicted in the future, and should be supported by appropriate traffic analysis. Solutions involving a combination of the mentioned approaches are also designed, i.e. locating electrical boundaries on adjacent route tracks and additional sectioning within the station. Such solutions are most advantageous in terms of organisation and traffic flow, but are more expensive to implement. The functions and dysfunctions of sectioning have been described using specific station examples.

This article focuses on two sections of single-track lines of similar length: line No. 15 from Łowicz Przedmieście to Zgierz and line No. 16 from Zgierz to Kutno. The sectioning of these stations corresponds to the conceptual diagrams in Figures 10 and 12. These sections were electrified at different times: line No. 15 from Arkadia to Łódź Kaliska was made available for electric traction in the fourth quarter of 1965, while the section from Zgierz to Kutno was electrified in 1981 [15]. It is worth noting the differences in the applied methods. During the electrification of railway line No. 15, full-length, maximum, or close to maximum length tension sections were used at stations, and the main track contact line at the station was sectioned on one side with an insulated tension span, while on the other side with an air gap, a solution commonly used at that time. Until 2023, there was still an air gap in Domaniewice, while in other stations air gaps were gradually replaced with section insulators. During the electrification of railway line No. 16, longitudinal sectioning of the main track contact line was done only through insulated tension spans both on straight tracks (Fig. 13) and in curves (Fig. 14), shortening the tension sections, and equipping at least two additional tracks on both sides with section isolating switches. Only in Chociszew, after a major repair of the overhead contact line as part of the revitalisation carried out on the Zgierz – Łęczyca section, an insulated section insulator was installed at the middle anchorage instead of one of the tension spans (Fig. 15).

Fig. 13. Isolated tension span of an isolating switch No. 1 on a straight track in Chociszew before station reconstruction, 2019 [photo taken by D. Dratwa]

Fig. 14. Isolated tension span of an isolating switch No. 3 in a curve in Chociszew before station reconstruction, 2019 [photo taken by D. Dratwa]

Fig. 15. Section insulator at disconnector No. 17 in the location of isolated tension span of an isolating switch No. 3, middle anchorage at the insulation, Chociszew 2021 [photo taken by D. Dratwa]

Analysing the longitudinal sectioning of these lines, differences in the functionality of electrical division between them can be observed. Although the layout of sectioning of the electrified railway line No. 15, which was electrified 16 years earlier, is identical and in line with generally accepted principles, the sectioning of the network of line No. 15 is characterised by dysfunctionality. The difference lies in the use of section switches. On line No. 15, the necessary number of switches was used, constituting the required minimum to power the contact lines of individual tracks. The functionality of sectioning the contact line on line No. 16 was increased by using additional switches in the additional tracks, thereby providing the possibility of alternative power supply to the overhead contact line of these tracks in case of the need to disconnect the power from the adjacent track direction.Figure 16 depicts the diagram of sections of lines No. 15 and No, 16, while Figures 17–21 show the sectioning schemes of stations located on railway line No. 15. Figures 22-27 show the sectioning of individual stations on line No. 16.

**Line No. 15**

Using the example of stations located on the section between Łowicz Przedmieście and Zgierz, the scheme of locating the electrical boundaries of stations according to the idea presented in Figure 10 is shown. The station Głowno is exceptional because within its boundary in the contact line of the route track from the direction of Stryków, a connection to the substation is located, which results in an additional one-sided isolation of the station from the route, consistent with the principle of locating electrical boundaries of stations on adjacent tracks. The separation of additional tracks from the main tracks is clearly visible, and all tracks can be independently disconnected. The sectioning of the contact line in Glinnik (Fig. 17) is universal because passing point's both tracks (a specific case of a station allowing only train crossing and overtaking) have isolating switches on both sides of

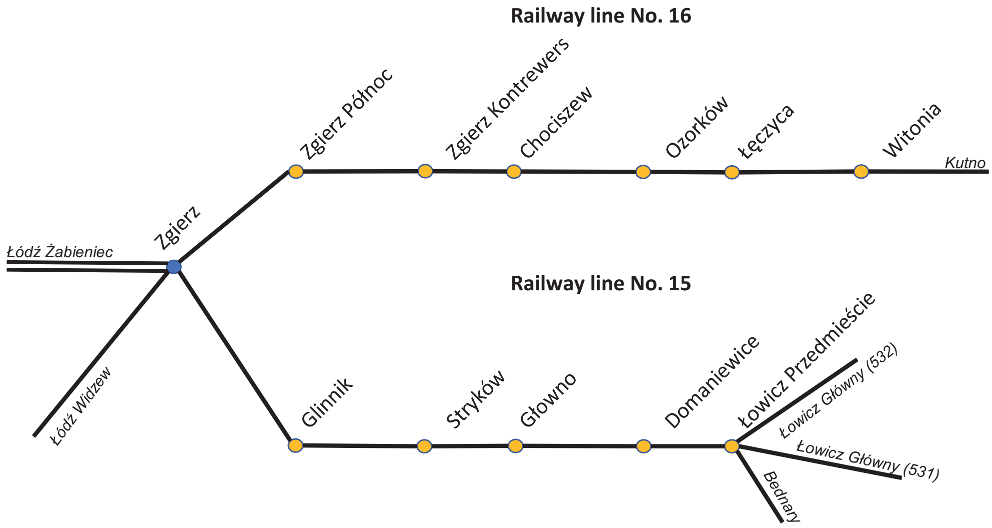


Fig. 16. Layout of railway lines covered by the study; orange dots indicate stations whose sectioning diagrams are included in figures 17–27 [own work]

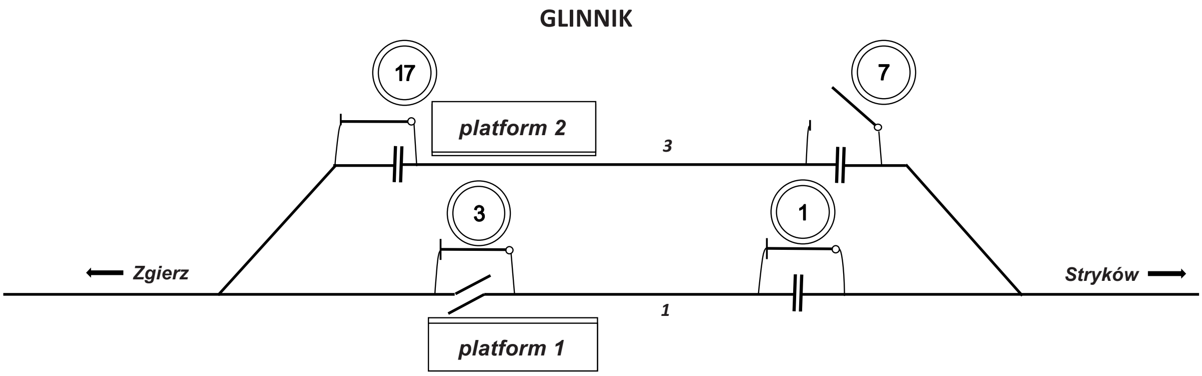


Fig. 17. Diagram of sectioning of the Glinnik station; both track contact lines are equipped with switches from both sides [own work]

the operating control point, so disconnecting the power in the contact line of one track does not completely prevent train traffic. Complications arise at other stations where isolating switches (disconnectors) are not located at all isolation points. During the electrification of the line, reducing the number of switches, similar to the installation of isolated air gaps, had economic reasons.

According to the "Guidelines for designing and accepting overhead contact lines, taking into account the standards and requirements for interoperable lines Iet-107" in force at PKP PLK S.A., one-sided power supply should be used for tracks other than those constituting the extension of the route tracks. Thus, in cases of line closures with power disconnection in the contact line, it is not possible to carry out railway traffic by electric traction:

- during closure on the Głowno – Stryków route on track No. 2 in Stryków station (this is a track with a platform edge, so in this case passenger trains must operate in shuttle mode) (Fig. 18);
- during closure on the Domaniewice – Głowno route on tracks No. 3 and 5 in Głowno station, which makes the acceptance of freight trains operated by electric traction hindered (Fig. 19);
- during closure on the Łowicz Przedmieście – Domaniewice route on track No. 2 in Domaniewice station – the only additional track, which, as in Stryków, forces the passenger trains to operate in shuttle mode (Fig. 20);
- during closure on the Łowicz Przedmieście – Domaniewice route on track No. 4 in Łowicz Przedmieście (Fig. 21).

The shuttle operation of passenger trains determines the timetable and, consequently, the commercial offer of the rail carrier, which may deviate from demand, for example, by reducing the frequency of trains, especially during peak travel times. In this case, shorting section insulators is often used as an ad hoc solution, with the approval of the relevant Railway Lines District Unit, so

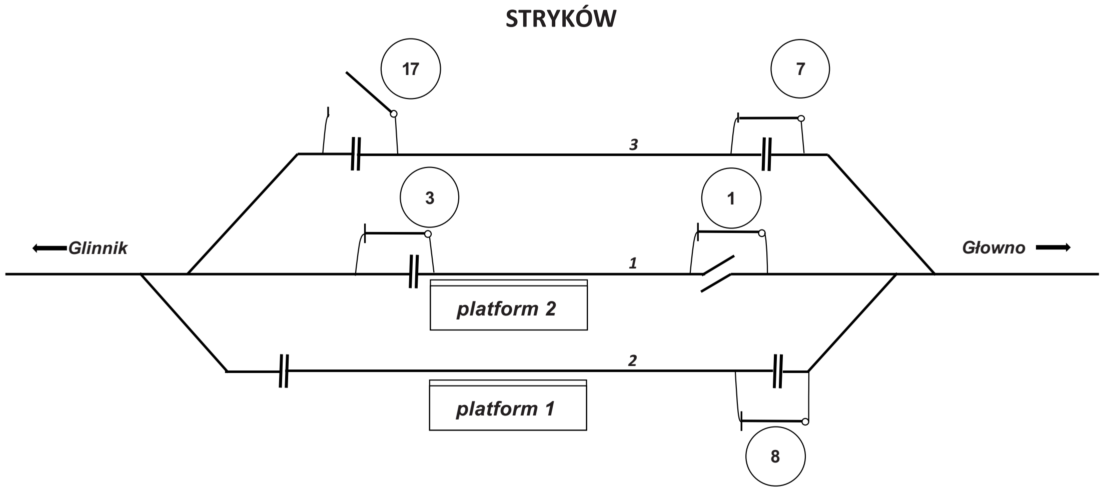


Fig. 18. Diagram of sectioning of the Stryków station; the contact line of track No. 2 does not have a section switch from the direction of Glinnik; in the event of a power outage on the route from the direction of Głowno, platform No. 1 becomes inaccessible to electric traction [own work]

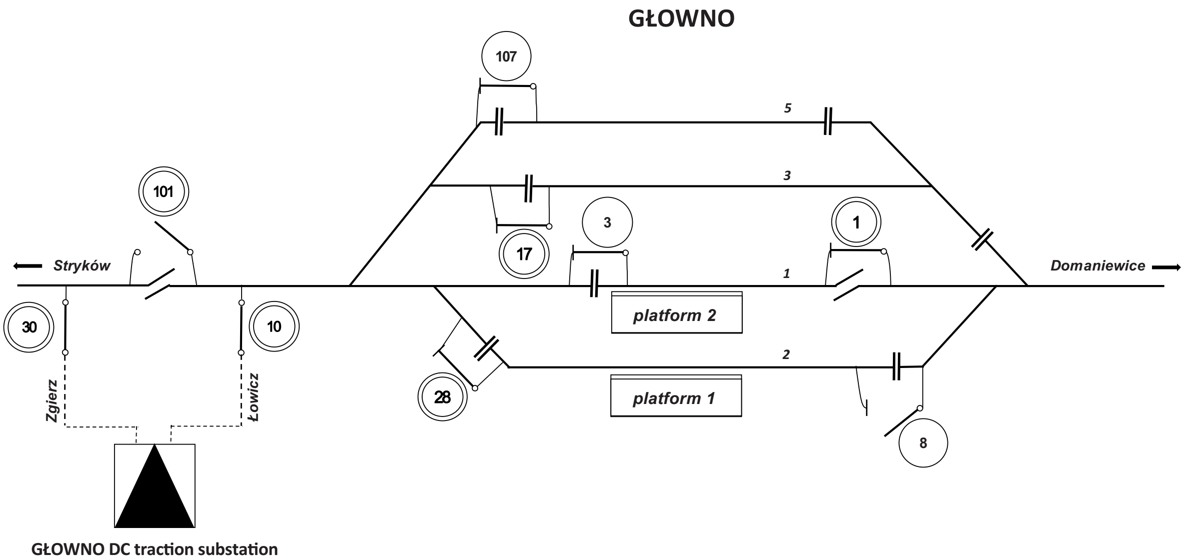


Fig. 19. Diagram of sectioning of the Głowno station; the contact lines of tracks 3 and 5 have switches on one side; the possibility of leaving track No. 5 by electric traction in the direction of Domaniewice depends on the power supply of the contact line of track No. 3; the incorporation of power supplies from substations within the station limits gives additional possibilities for shunting by electric traction in the direction of Stryków during a power outage on the route [own work]

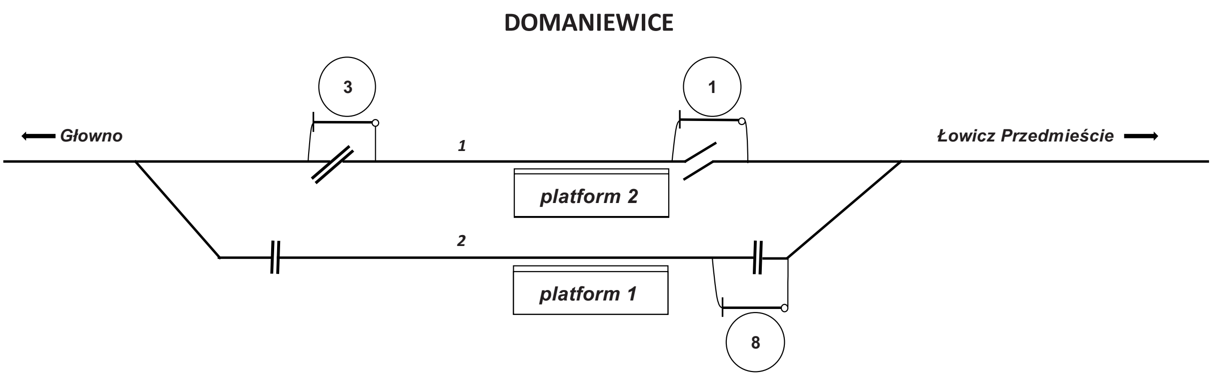


Fig. 20. Diagram of sectioning of the Domaniewice station. Contact line of the track no. 2 does not have a section switch from the direction of Głowno; in the event of power outage on the track from the direction of Łowicz Przedmieście, platform no. 1 becomes inaccessible for electric traction [own work]

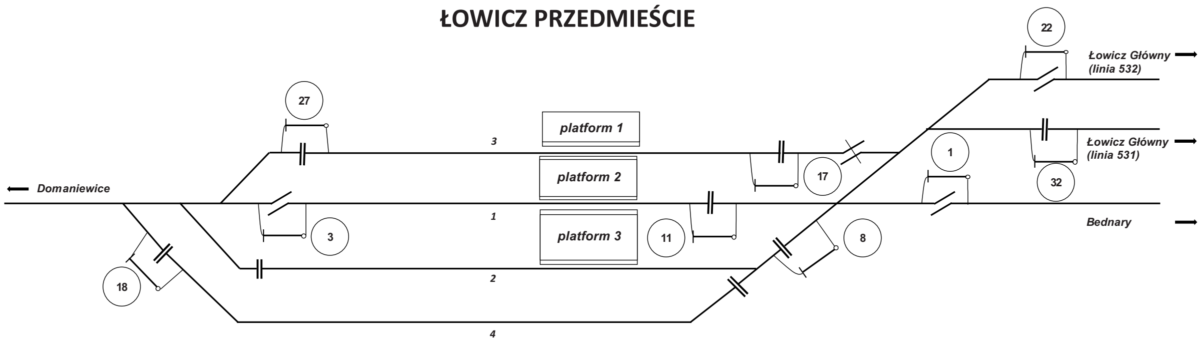


Fig. 21. Diagram of sectioning of the Łowicz Przedmieście station; despite locating the electrical boundaries from the direction of Łowicz Główny and Bednary in the contact lines of route tracks, the use of switches No. 11 and 17 allows independent disconnection of the power supply to tracks No. 1 and 3; tracks 2 and 4 have switches only on one side, and the departure of electric traction from track No. 4 towards Łowicz Główny and Bednary depends on the power supply to track No. 2 [own work]

as not to eliminate the possibility of operating electric vehicles. However, this is an additional organisational complication that is not always feasible and is associated with other complications, such as completely disconnecting power on the route and at stations by short-circuiting, and then reopening the insulator after work completion. The necessity of using this solution should be included as one of the phases of the work in the Temporary Train Operation Regulations during the execution of the works.

**Line No. 16**

In contrast to railway line No. 15 on the section between Łowicz Przedmieście and Zgierz, railway line No. 16 between Zgierz and Kutno was equipped with section isolating switches in most isolation points during electrification in 1981, thereby creating more possibilities for connection operations and thus power supply to individual station tracks. Railway line No. 16 between Zgierz and Łęczyca (including the stations) underwent revitalisation in all sectors, including the overhead contact line, in the years 2020–2021. As part of this, the reconstruction of the Zgierz Północ station was planned to meet the needs of terminating and starting runs of agglomeration trains serving the Łódź agglomeration. From the point of view of sectioning, this station is a special case because it does not have electrical boundaries in the main track or in the adjacent route tracks. Only the additional main track No. 3 and the side stabling track No. 3b are separately sectioned (Fig. 22). This leads to a situation where disconnecting power from the direction of Zgierz also deprives the Zgierz Północ – Zgierz Kontrewers route of power. Therefore, overnight stabling of electric vehicles is avoided, as this is usually the only time window for carrying out maintenance and inspection work on railway infrastructure and overhead contact line.

The revitalisation did not worsen the existing sectioning in the area of existing signal boxes, allowing the Zgierz Kontrewers station (formerly Jedlicze Łódzkie) (Fig. 23), Chociszew (Fig. 24), and Ozorków (Fig. 25) stations to have the possibility of independently supplying power to different station tracks without being affected by route closures. In Łęczyca (Fig. 26), similar to Głowno, the additional tracks designated for freight trains remain interdependent. For example, in the event of energising the power supply to the extreme tracks (track 5 in Głowno and track 4 in Łęczyca), it can be done independently of the others. However, when disconnecting the power supply

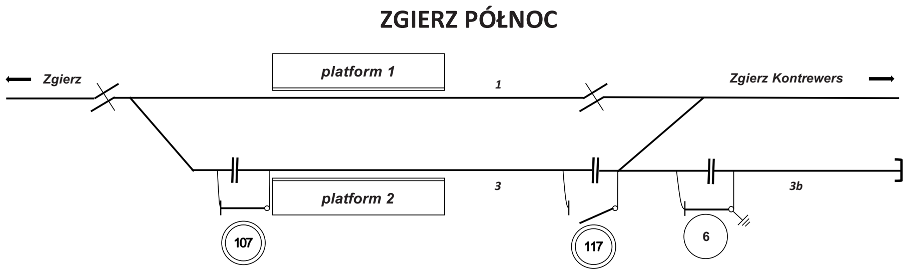


Fig. 22. Diagram of sectioning of the Zgierz Północ station; sectioning of the contact line of track No. 1 is not provided for, therefore power disconnections must occur from Zgierz to Zgierz Kontrewers; this is important in the context of terminating and starting trains, as well as vehicle stopping at the station [own work]

to track 3 in Głowno, it forces the shutdown of the odd side, and for track 2 in Łęczyca, it affects the even side of the station. In Witonia (Fig. 27), which was not subjected to reconstruction, despite separate isolation of the contact lines by section isolators, tracks 3 and 5 have a common power supply through isolating switches in the contact line of track No. 5 and electrical connections (bridges) between both contact lines.

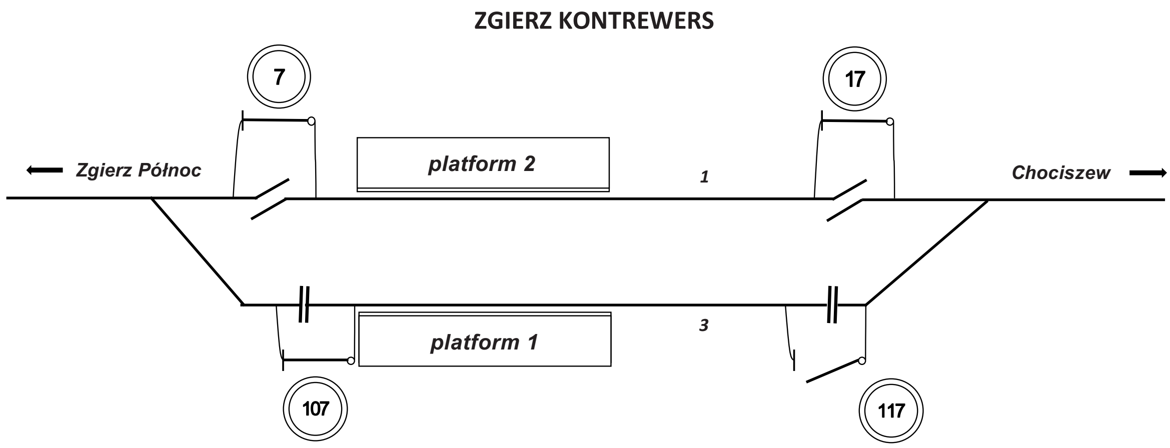


Fig. 23. Diagram of sectioning of the Zgierz Kontrewers station; both track contact lines are equipped with switches from both sides [own work]

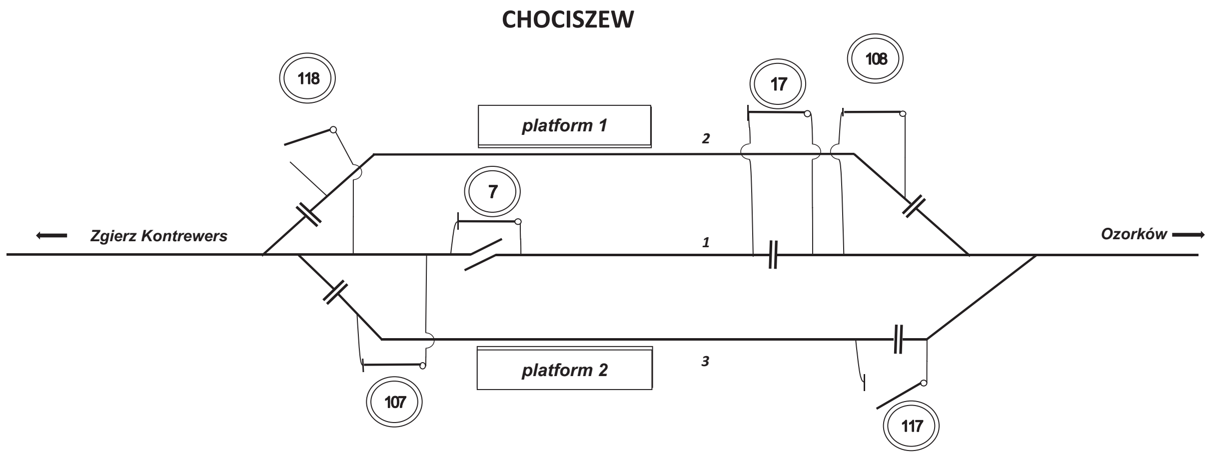


Fig. 24. Diagram of sectioning of the Chociszew station; additional track contact lines are equipped with switches from both sides [own work]

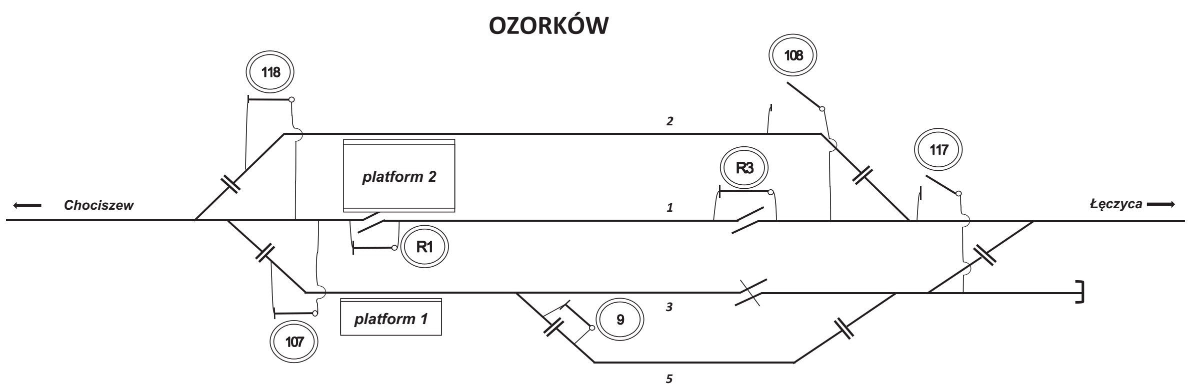


Fig. 25. Diagram of sectioning of the Ozorków station; additional track contact lines are equipped with switches from both sides; the contact line of the siding No. 5 is powered from the additional track No. 3 through one switch; Ozorków's sectioning corresponds to the conceptual diagram from Figure 12 [own work]

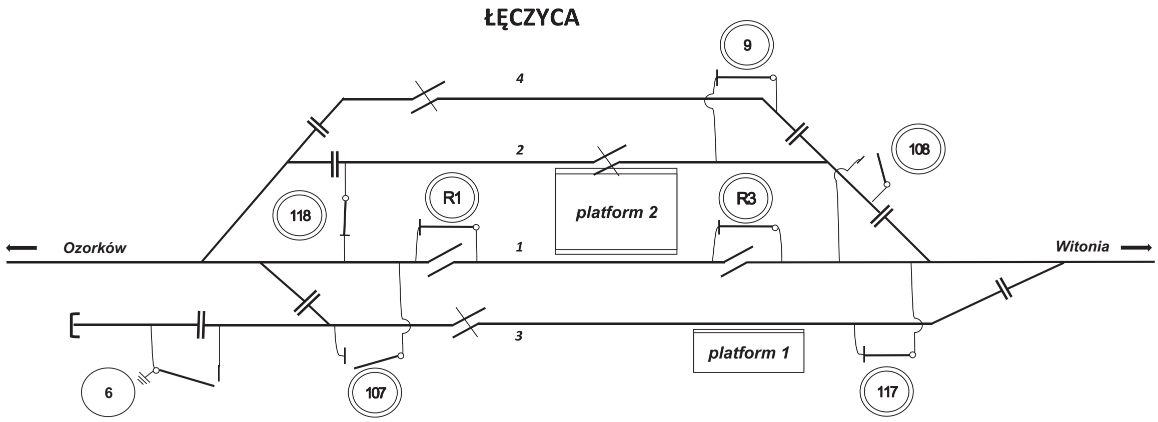


Fig. 26. Diagram of sectioning of the Łęczyca station; power disconnection in the contact line of the additional track No. 2 deprives the contact line of the track No. 4 of power, which is a less favourable solution than in Głowno (tracks No. 3 and 5); the overhead contact line of the track No. 4 can be disconnected independently of the other tracks, similar to the contact lines of tracks No. 1 and 3; similar to Ozorków, it corresponds to the conceptual diagram from Figure 12 [own work]

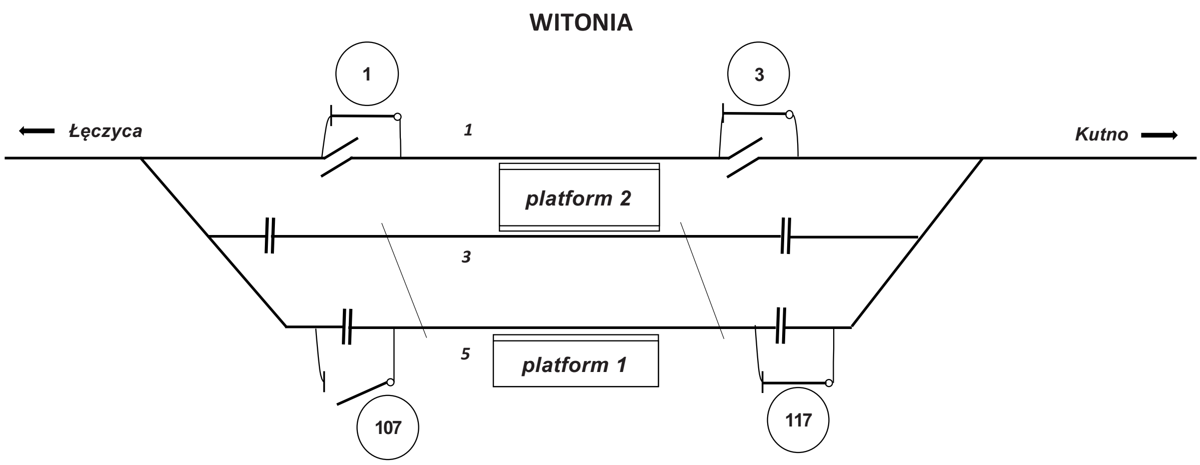


Fig. 27. Diagram of sectioning of the Witonia station; additional tracks No. 3 and 5 form a group powered together, having switches from both sides in the contact line of the track No. 5 and electrical connections of both overhead contact lines (so-called bridges) near the switches [own work]

## 5. Conclusions

The electrical division of the overhead contact line into independent sections effectively serves its purpose. Based on the examples provided, the drawbacks of sectioning that negatively impact station capacity have been highlighted. Two contrasting cases have been compared. The sectioning applied on the section of line No. 16 is more favourable in terms of conducting railway traffic (passenger and shunting) with electric traction than the solutions on line No. 15, although the drawback in Łęczyca was not avoided by making the power supply to track No. 4 dependent on track No. 2. In a similar scenario observed in Głowno, track No. 5 has the capability of being powered from one side despite the power disconnection in the contact line of the track No. 3.

The use of a greater number of switches increases the flexibility of train traffic and shunting operations in the station. Although it is a more expensive solution considering the cost of each switch and the increasingly common remote control systems, this financial burden constitutes a small percentage of all investment costs and is incurred only once during purchase and subsequent installation of the switch. In the case of closures, especially for long-term works on the routes, which are successively carried out on line No. 15, the exclusion of platform edges in stations such as Stryków or Domaniewice from electric traction negatively affects train schedules, especially due to the necessity of shuttle traffic to these stations (one EMU on the adjacent track and in the station at the same time).

For the most efficient conduct of railway traffic and the ability to carry out maintenance, repairs, and other works accompanied by power outages of the overhead contact line, it is advisable to use additional sectional switches for an alternative power supply option for the additional track, following the example of stations on line No. 16. Considering the intensity of regional and long-distance train traffic, for reasons described in this article, it is reasonable to maintain the possibility of powering the track with a platform edge from both sides, which in the case of prolonged closures with power outages on the track will minimise negative deviations in train traffic and enable shunting work with electric traction.

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