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Support Structures for Seal Switches Located Near Bus Lines

Support Structures for Seal Switches Located Near Bus Lines

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Abstract. The authors propose three designs for seal switch support structures located near power plant bus lines. The first one has a plate that is attached to bus lines located in the same plane. The second uses a support insulator as the case and can be attached to several bus lines at the same time or each of them individually to provide a wide application range. The third design stipulates seal switch installation on overhead line pylons. The authors provide detailed descriptions of the designs and explain how the trip settings are adjusted on them.

1. Introduction

Traditional power plant short circuit protection systems, including the developments of the recent decades [1-5], obtain the current data from metal-consuming and bulky current transformers. According to [6, 7], it is necessary to design such protection systems without these current transformers. The analysis of publications shows that, in most cases, to solve this problem the Rogovsky coil [7-9] or seal switches [10-13] are suggested to be used as current sensors. We selected seal switches as they have some advantages that are important for relay protection [12]. Some design principles [11-15] and protection devices [16-30] have already been developed based on them. There are also some support structures for the location of these devices near power plant bus lines [30-33]. However, since power plant designs are very diverse, these structures may not be used in some cases. In this work, we attempt to fill this gap.

2. Seal switch support structures

The first structure (Figure 1) contains a scale plate 1 located next to bus lines 2, 3, and 4 and across them, and attached to bus lines 2 and 4 using bolts and nuts 5. Plates 6-9 with seal switches 10 are attached to plates 11-14 with T-shaped protrusion. Plates 11 and 12 are inserted in the T-shaped slot 15 in plate 1, and plates 13 and 14 are inserted in the T-shaped slot 16. Plates 11-14 are held by bolts 17. Plane 18 of every plate 6-9 features nine ruts 19 (Figure 2) for the installation of seal switches 10, and one of the side planes has a scale 20. Every three ruts 19 with seal switches 10 are covered by lid 21 that is locked with screw 22. Cable channels 23-26 are installed on plates 6-9 parallel to plane 18. Plates 6-9 are covered with caps 27-30 that are fixed to plates 11-14 with bolts 31. Cable channels 32, 33 are attached to plate 1. The signal transducer unit 34 is installed in the center of plate 1 between slots 15 and 16. Seal switches 10 are connected to unit 34 with cables 35 laid in cable channels 23-26 and 32, 33.

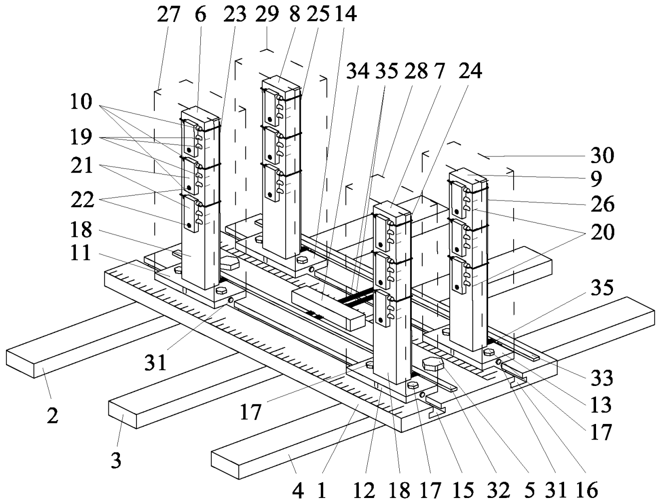


Figure 1. Seal switch support structure design for buss lines lying in the same plane.

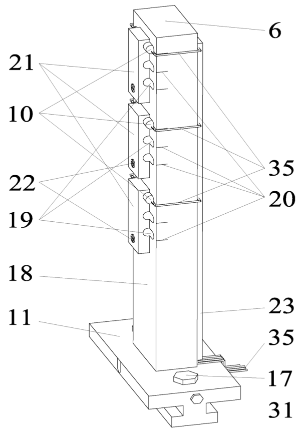


Figure 2. Seal switch plate.

The suggested metering device for seal-switch protection systems operates as follows. Scale plate 1 is attached to power plant bus lines 2 and 4 using bolts 5. Installation coordinates are calculated for each of the seal switches 10 near bus lines 2, 3, and 4 of the power plant depending on the implemented protection type and trip setting parameters. The scale on plate 1 is used to calculate the distance between phase A to the seal switch location. The plate, e.g. 11, with T-shaped protrusion and plate 6 with seal switches 10 attached is installed in slot 15 at the required distance and locked with bolts 17. The distance from the plane of bus lines 2, 3, and 4 to seal switch 10 is calculated using scale 20 on the side of plate 6. Seal switch 10 is installed in the respective rut 19 and covered with lid 21 locked with screw 22. All seal switches 10 are connected to signal transducer unit 34 with a battery. The metering device is set up and ready to work.

Under load, seal switch 10 is inactive because the induction of the magnetic field created by the currents in bus lines 2, 3, and 4 is small. If the induction of the magnetic field created in bus lines 2, 3, and 4 exceed the set value, seal switch 10 activates and send a signal to signal transducer unit 34 that sends the signal over a wireless link to the receiver (not shown in Figures 1, 2). The latter is located on the control board, and when it receives the signal, it sends it to the protection logic that sends it to the switch deactivation circuit.

The second design (KZ patent No. 35133) features (Figure 3) an electroinsulatingь case implemented as a hollow support insulator with base 1, cap 2, and case 3. Base 1 is installed on plank 4 and attached to plank 9 using bolts 5 and 6 and nuts 7 and 8. Plank 9 is attached to bus lines 12 and 15 using bolts 10 and 13 and nuts 11 and 14. Module 16 is attached to plank 4 using holding angles 17, bolts 18 and 19, and nuts 20. Seal switches 21, 22, and 23, as well as impulse meter 24 and output relay 25, are attached to module 16. One contact, e.g. of seal switch 21, one impulse meter 24 (IM), and output relay 25 (OR) input are connected to the positive terminal of the auxiliary services supply using cables 26. Other outputs of impulse meter 24 and relay 25 are connected to the negative terminal of the auxiliary services supply using cables 26. Another contact of seal switch 21 is connected to the input of the impulse meter 24 whose output is connected to relay 25. Relay 25 output is connected to the power plant switch deactivation circuit.

The suggested metering device operates as follows. Out of seal switches 21, 22, and 23, one is selected whose tripping induction is the closest to the trip setting parameter. Assume it is seal switch 21. In this case, we connect the contacts of seal switch 21 to the input of impulse meter 24 and the positive terminal of the auxiliary services supply. Then base 1 of the hollow support insulator is installed on plank 4 and attached using bolts 5, 6, and nuts 7, 8 to internal structural elements 27 of the switchgear cubicle (Figure 4). If it is impossible to attach base 1 and plank 4 to internal structural elements 27 of the switchgear cubicle, the hollow support insulator is installed, for instance, on bus line 12 using cap 2 and a bolt.

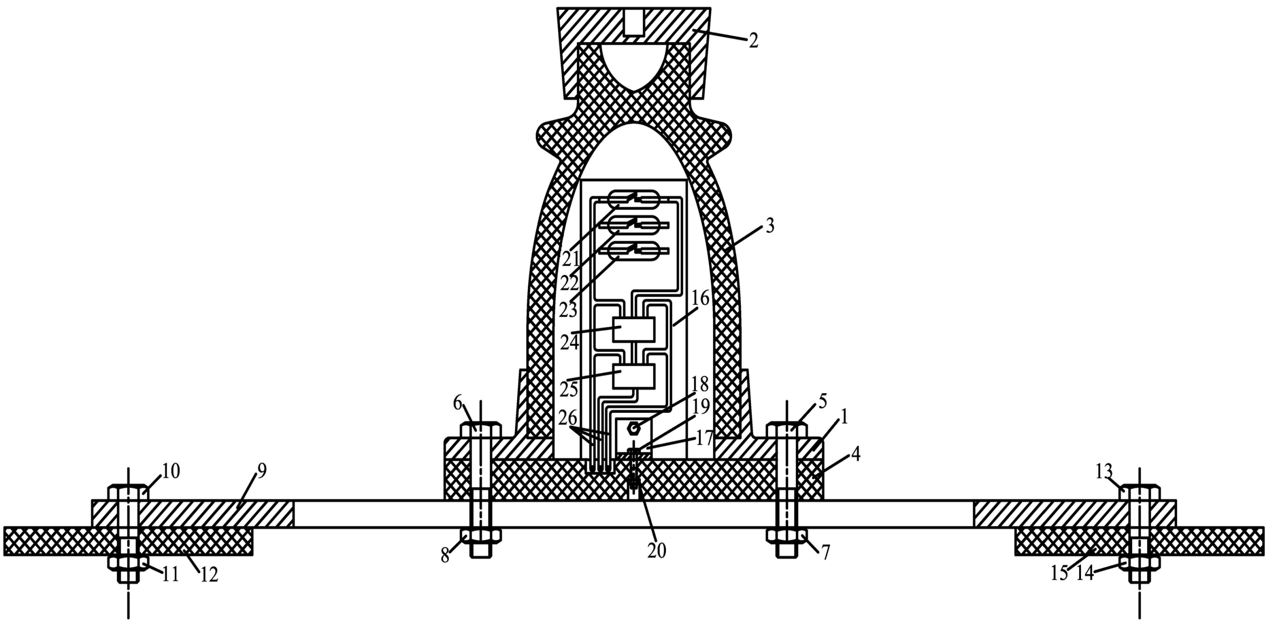


Figure 3. Supporting insulator-based seal switch design.

If the seal switch has to be moved to the left or right of the bus line and cannot be attached to the internal structural elements of the switchgear cubicle, base 1 and plank 4 are installed on plank 9 (Figure 3) using bolts 5, 6 and nuts 7, 8. In this case, bolts 5 and 6 are inserted in the through-slot in plank 9 to be able to move the hollow support insulator and plank 4 along plank 9. One end of plank 9 is attached to bus line 12 using bolt 10 and nut 11, and another end is attached to bus line 15 using bolt 13 and nut 14.

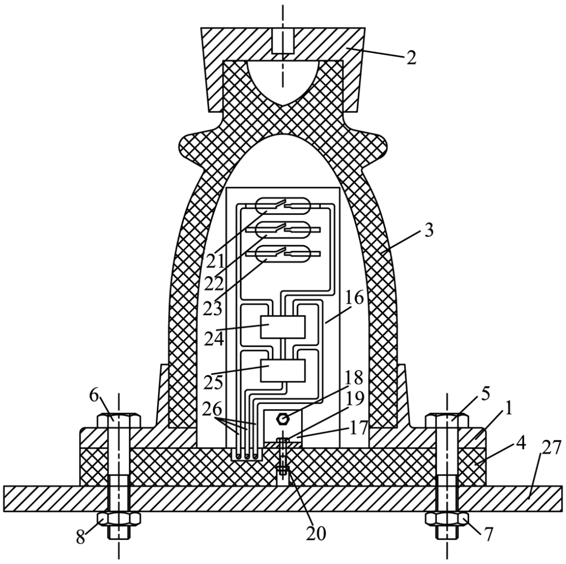
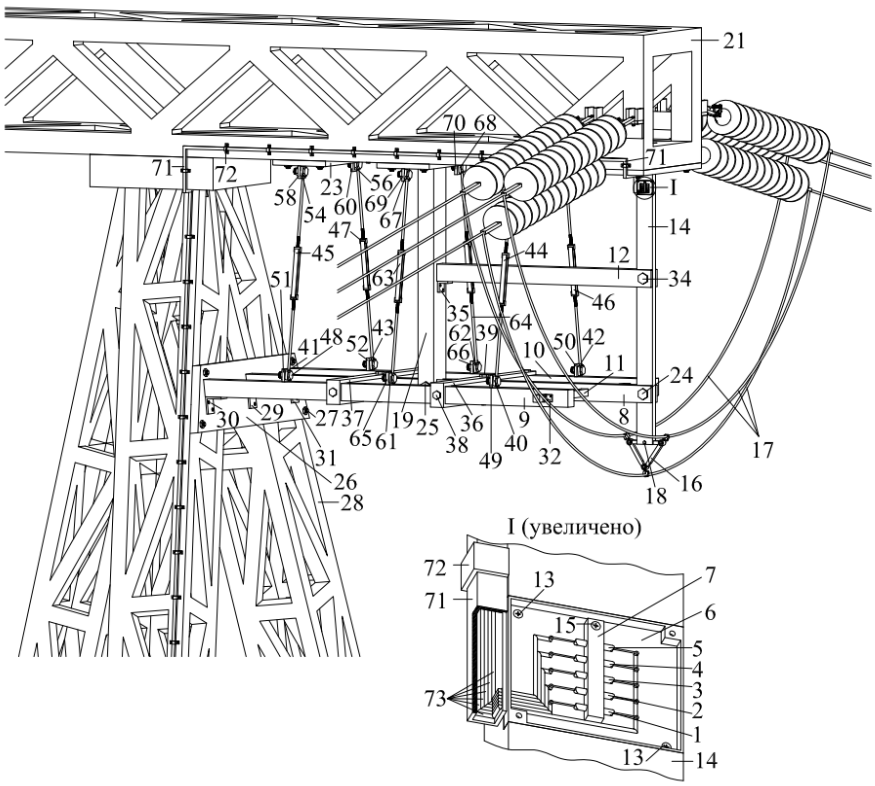


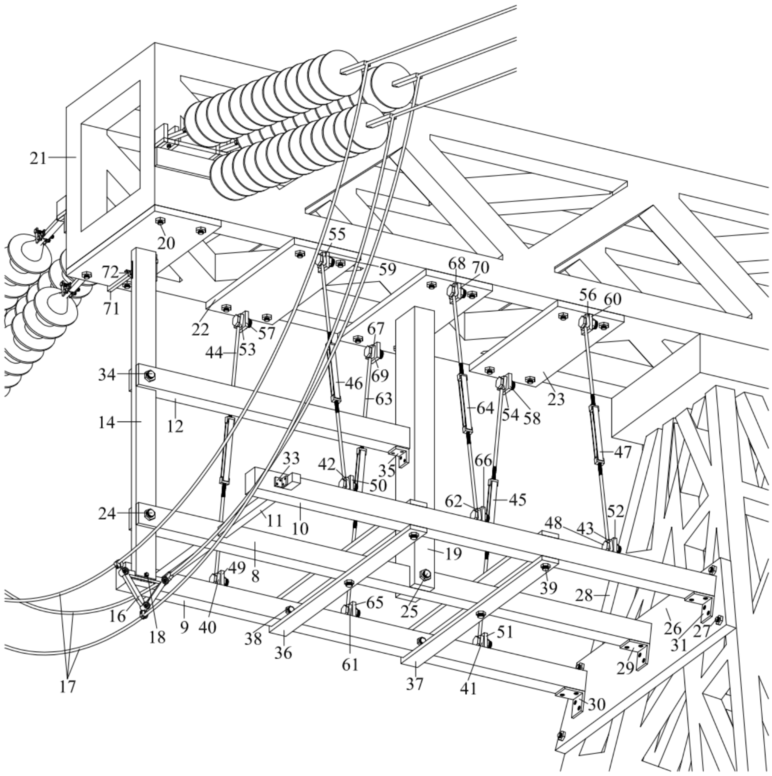
Figure 4. Installing the metering device on the internal structural element of the switchgear cubicle.

The metering device for the seal-switch-based relay protection of a 500 kV power line features (Figure 5, a, b) seal switches 1-5, case 6 with a lid, and rectangular bars 7-12. Case 6 is locked in the slot at the beginning of the long part of the first T-shaped bar 14 using two screws 13. Inside case 6, bar 7 is attached to the bottom using screw 15. Five through holes are made in the side of the bar at equal intervals. These holes are used for the parallel mounting of seal switches 1-5. The slot bottom at the end of the long part of T-shaped bar 14 meets one of the spacers 16 of three single-phase power line cables 17 connected to bar 14 using bold 18 inserted in aligned through-holes in the bar sides and the spacer and tightened with a nut. The short parts of T-shaped bars 14, 19 using four pins 20 (Figure 5b) and nuts are attached to the bottom surface of power line crossbar 21, which also has rectangular plates 22, 23 attached to it at the same distance of the T-shaped bar. The slot bottom in the end face of bar 8 meets a side of bar 14. Bolt 24 is inserted in the aligned holes in it and the sides of the bar that is tightened with a nut. The slot bottom in the long part of bar 19 meets a side of bar 8 in its center. Bolt 25 is inserted in the aligned holes in it and the sides of the bar that is tightened with a nut. Trapezoid plate 26 is attached to the sides of power line pylon 28 with four pins 27 and nuts. The plate has three sockets for the spikes located on the ends of chamfered ends of bars 8-10 that are installed in angles 29-31 respectively and locked using the screws in the plate. Bar 11 runs through the aligned holes in bars 8-10 and it is attached to the last two bars using angles 32, 33, and screws. The slot bottom in the first end face of bar 12 meets a side of bar 14. Bolt 34 is inserted in the aligned holes in it and the sides of the bar that is tightened with a nut. The spike located on the end of the second end face of bar 12 is inserted in the socket in bar 19, and the bars are interlocked using angle 35 and screws. U-shaped plates 36, 37 are positioned at the same interval from bar 19 and attached to bar 9 using bolts 38, inserted through aligned holes in it and the short part of each of the plates and locked with nuts. They are also attached to bars 8, 10 using bolts 39 inserted through aligned holes in them and both long parts of each of the plates and locked with nuts. Loops 40 and 41 (42 and 43) in threaded rods 44 and 45 (46 и 47) are attached to protrusions 49 (50) and 51 (52) using the holes in bar 9 (10) and bolts 48 with nuts. Loops 53 and 54 (55 and 56) are attached the same way to protrusions 57 and 58 (59 and 60) through the holes in plates 22 and 23. Loops 61 and 62 in threaded rods 63 and 64) are attached to protrusions 65 and 66 using the holes in bars 9 and 10 and bolts 48 with nuts. Loops 67 and 68 are attached the same way to protrusions 69 and 70 through the holes in the short part of bar 19. Cable channel 71 is attached to the side and the short part of bar 14, as well as the sides of crossbar 21 and power line pylon 28 using mounting plates 72 and screws. One end of connection cables 73 laid in cable channel 71 and through aligned holes in it and in case 6 is connected to the terminals of seal switches 1-5, and the other end is connected to the protection logic block (not shown in Figure 5 a, b).

The metering device operates as follows. It determines the protection tripping current and the tripping current for seal switches 1-5. The tripping current of each of the seal switches 1-5 is understood as the value of the current in phase cables 17 of the power line during short circuits when the seal switch closes its contacts and generates a signal that is sent into the protection logic module. Seal switches 1-5 have different tripping currents because they are located at different intervals h from cables 17 (at a fixed interval). After that, we use the obtained tripping current values for seal switches 1-5 to select the value closest to the protection tripping current, i.e. we select the seal switch whose tripping will signal that there is a short circuit in the line. Under load, the current in cables 17 is insufficient to trip the selected seal switch. During sho1 (zoomed in) e seal switch trips (closes its contacts) and sends a signal to the protection logic module over connection cables 73, which then sends the signal to the power line switch deactivation circuit.



a)



b)

Figure 5. Seal switch support design for intermediate anchor pylon (isometric views from different pylon sides).

3. Conclusions

The suggested seal switch support designs allow for the construction of short-circuit protection systems for 6-500 kV power plants without current transformers, which helps reduce the consumption of copper and steel. They are simple and make it easy to install the seal switch to the required positions near conductor lines.

4. References

[1] Kletsel M and Mashrapov B 2016 Traversal protection of two parallel lines without voltage path *Przeglad Elektrotechniczny* vol 92(2) pp 168–170

[2] Kletsel M and Mashrapov B 2017 Differential protection of three and four parallel lines of idling current control *Przeglad Elektrotechniczny* vol 93 **10** pp 109–112

[3] Kletsel M Y and Nikitin K I 1992 Analysis of the sensitivity of back-up protections for distribution networks in power systems *Elektrichestvo* **2** pp 19–23

[4] Bogdan A V, Kletsel' M Y and Nikitin K I 1991 Adaptive back-up overcurrent protection for tapped lines with single-end fud *Elektrichestvo* **2** pp 51–54

[5] Kletsel' M Y and Nikitin K I 1993 Back-up line protection that responding to the difference in magnitudes of the phase currents and their increment *Elektrichestvo* **10** pp 23–26

[6] Dyakov A F, Ishkin V Kh, Mamikonyants L G and Semenov V A 2004 Global power industry in the early XXI century (according to the materials of 39th session of CIGRE, Paris) *Energy Abroad* **4-5** p 176

[7] Kojović L A 2016 Non-conventional instrument transformers for improved substation design *CIGRE Session* **46**

[8] He P, Wang L, Liu D, Du Y and Lu H 2012 Transformer composite monitoring module with quick protection function *China Patent* no. 202372563-U

[9] Weiss R, Itzke A, Reitenspieß J, Hoffmann I and Weigel R 2019 A Novel Closed Loop Current Sensor Based on a Circular Array of Magnetic Field Sensors *in IEEE Sensors Journal* vol 19 **7** pp 2517-2524

[10] Kletsel M, Kabdualiyev N, Mashrapov B and Neftissov A 2014 Protection of busbar based on reed switches *Przegląd Elektrotechniczny* vol 90 **1** pp 88-89

[11] Kletsel M Ya 1991 Design principles and models of reed relay base energy facility differential protections *Elektrotekhnika* **10** pp 47-50

[12] Kletsel M Ya, Musin V V, Alishev Zh R and Manukovskij A V 1993 The properties of hermetically sealed reed relays used in relay protection *Elektrichestvo* **9** pp 18-21

[13] Kletsel M, Mashrapova R and Mashrapov B 2020 Methods for the Construction of Protection with Magnetosensitive Elements for the Parallel Circuits with Single end Supply Proc. of 2020 International Conference on Industrial Engineering, Applications and Manufacturing (ICIEAM)

[14] Zhantlesova A B, Kletsel M Y, Maishev P N and Neftisov A V 2014 Characterizing a sustained short-circuit current with the use of reed relays *Russian Electrical Engineering* vol 85 **4** pp 210-216

[15] Kletsel M, Borodenko V, Barukin A, Kaltayev A and Mashrapova R 2019 Constructive features of resource-saving reed relay protection and measurement devices *Rev Roumaine des Sciences Techniques-Series Electrotechnique et Energetique* vol 64 **4** pp 309-315

[16] Kletsel M Ya and Zhulamanov M A 2004 Impedance relay with hermetically sealed contacts *Elektrotekhnika* **5** pp 38-44

[17] Barukin A, Kaltayev A and Lenkov Y 2020 Majority Voting Schemes of Differential Protections without Current Transformers with Functional Diagnostics for Converting Units and Electric Motors 2020 International Conference on Industrial Engineering, Applications and Manufacturing (ICIEAM) (Sochi, Russia) pp 1-5

[18] Kletsel M, Barukin A and Amirbek D 2020 Reed Switch and Magneto Resistor-Based Differential Protection Featuring Test Diagnostics for Converters 2020 International Multi-Conference on Industrial Engineering and Modern Technologies (FarEastCon) (Vladivostok) pp 1-6

[19] Kletsel M Y, Barukin A S and Mel’nikov V Y 2021 Reed Switches Differential Protection of Conversion Facilities with the Second-harmonic Lockout 2021 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (ElConRus) pp 1446-1450

[20] Kletsel M Ya and Maishev P N 2007 Specific features of the development of differential-phase transformer protection systems on the basis of magnetic reed switches *Russian Electrical Engineering* vol 78 **12** pp 629-634

[21] Kletsel M, Barukin A and Talipov O 2017 About the Biot-Savart-Laplace law and its use for calculations in high-voltage AC installations *Przegląd Elektrotechniczny* vol 93 **11** pp 129-132

[22] Issabekov Z B, Kletsel M Y, Barukin A S and Mashrapov B E 2021 Measuring bodies for distance protection that does not use current transformers AIP Conference Proceedings AIP Publishing LLC vol 2337 **1** 030003

[23] Polyakov D A, Nikitin K I, Novozhilov A N, Kletsel M Ya 2018 Research of Electro-Thermal Aging Process of Cross-Linked Polyethylene *Journal of Physics: Conference Series* vol 1050 issue 1 012061

[24] Kletsel M, Barukin A and Gabdulov A 2020 Construction of Resource-Saving Differential Protections for Converter Units with Transformers with 2N Secondary Windings and 2N Rectifiers 2020 International Ural Conference on Electrical Power Engineering (UralCon) (Chelyabinsk, Russia) pp 264-268

[25] Mashrapov B, Talipov O and Mashrapova R 2020 Overcurrent Protection Scheme Utilising Reed Switches Instead of Current Transformers 2020 International Ural Conference on Electrical Power Engineering (UralCon) (Chelyabinsk, Russia) pp 291-295

[26] Kletsel M Ya and Zhulamanov M A 1999 Choice of the shunt resistance for cascade current transformers *Elektrotekhnika* **7** pp 13-18
[27] Mashrapov B 2020 Improving the Reliability of Diagnosing Reed Switch-Based Overcurrent Protection Circuits 2020 International Multi-Conference on Industrial Engineering and Modern Technologies (FarEastCon) (Vladivostok) pp 1-5
[28] Kletsel' M Y, Neftisov A V, Maishev P N 2020 Remote Determination of Current Amplitude and Phase Using a Reed Switc *Russian Electrical Engineering* vol 91 pp 34–40
[29] Kletsel M, Zhantlesova A, Mayshev P, Mashrapov B and Issabekov D 2018 New filters for symmetrical current components *International Journal of Electrical Power and Energy Systems* vol 101 pp 85-91
[30] Kletsel M, Kaltayev A and Mashrapov B 2017 Resource-saving protection electric motors *Przeglad Elektrotechniczny* vol 93 **5** pp 40-43
[31] Kletsel M, Barukin A and Mashrapov B 2020 Designs for Mounting Reed Switches in Vicinity of AC and DC Buses 2020 International Ural Conference on Electrical Power Engineering (UralCon) (Chelyabinsk, Russia) pp 285-290
[32] Barukin A, Berguzinov A and Talipov O 2020 Mounting Measuring Devices of Reed Switch Protection Near Conductors of Electrical Installations Proc. Of 2020 International Multi-Conference on Industrial Engineering and Modern Technologies
[33] Issabekov Z B, Mashrapov B E, Issaberov D D and Mashrapova G N 2021 Structures for mounting reed switches near the busbars of electrical installations with remote control of their position AIP Conference Proceedings *AIP Publishing LLC* vol 2337 **1** 030004

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