

Terminal Blocks: Safety And Performance in Electrical Connections

Oğuzhan DÖNER

ONKA Electric Materials

Orhan KARA

ONKA Electric Materials

Şerafettin DEMİRBAŞ

ONKA Electric Materials

Hasan ÖKTEM

Kocaeli University

To Cite This Chapter

Döner, O., Kara, O., Demirbaş, Ş., & Öktem H. (2024). Terminal Blocks: Safety And Performance in Electrical Connections. In F. Zerrin Saltan, H. Arıkan & Y. Uzun (Eds.), *Current Studies in Basic Sciences, Engineering and Technology 2024* (pp. 130-136). ISRES Publishing.

Introduction

Terminal blocks are critical components used in electrical circuits to ensure the safe and organized connection of conductors. These elements are commonly used in industrial automation systems, energy distribution panels, and electrical installations. The historical development of terminal blocks began with the Industrial Revolution and the increasing complexity of electrical systems. In the early days, electrical connections were typically made by soldering, but this method soon became impractical and inadequate. In the early 20th century, with the development of screw-type connectors, terminal blocks became widely used. These products were initially employed for simple connections, but as technology advanced, terminal blocks evolved into integral components of more complex and modular electrical systems (Turton, 1988).

The post-World War II era saw rapid advancements in industrial production and automation, accelerating the evolution of terminal blocks. In the 1950s, the introduction of more durable and robust materials led to the use of plastic and metal combinations in the production of terminal blocks. During this period, spring pressure connection systems were also developed alongside screw-type connections, allowing users to make faster and more reliable connections. Today, terminal blocks are produced in various designs and materials, offering a wide range of application possibilities. In electrical panels, energy distribution systems, machinery control, and industrial automation systems, terminal blocks play a crucial role in both safety and functionality (Smyth, 1996; Hudson, 2012).

Advantages and Disadvantages

Terminal blocks (e.g. Figure 1) offer several advantages, making them a reliable solution for electrical connections. One of the most significant advantages is their modular structure. This modularity increases flexibility in electrical circuits and allows for the quick addition of new connections. Modular terminal blocks are especially preferred in energy distribution panels and control systems, as these systems may expand or change over time, and terminal blocks make it easy to implement such modifications (Brown, 2011).

Figure 1

Simple Screw Connection Terminal Block



Another advantage is the strength and security of the connection. In screw-type terminal a block, the connection point tightens as the screw is fastened, firmly securing the conductor. This improves the quality of the electrical connection and reduces electrical resistance. In spring pressure terminal blocks, the spring mechanism continuously presses the conductor, ensuring a firm connection even under vibration or harsh operating conditions. This feature makes spring pressure terminal blocks particularly suitable for industrial environments where vibrations are prevalent. Additionally, spring pressure terminal blocks expedite the installation and maintenance processes, saving time (Mason, 2015).

However, there are some disadvantages to terminal blocks. First, screw-type connections require regular inspection, as the screws may loosen over time, weakening the connection. While spring pressure terminal blocks mitigate this issue, problems can arise when working with fine or delicate conductors, where the spring mechanism may not hold the conductor as securely as needed. Furthermore, the physical size of terminal blocks can present space management challenges in large and complex electrical panels. In confined spaces, organizing and arranging terminal blocks can become more difficult and complicated (Roberts, 2020).

Lastly, the cost of terminal blocks can be higher than more traditional connection methods in some cases. This cost difference becomes more apparent in large projects and extensive systems. However, considering the long-term benefits in terms of safety and functionality, this cost is often viewed as a justified investment (Allen, 2013).

Applications

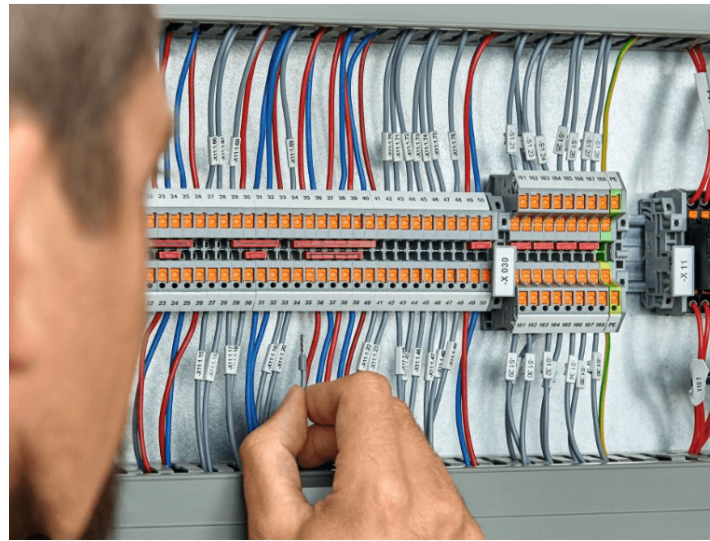
Terminal blocks are widely used across many industries. One of their most common applications is in industrial automation systems. In factories, terminal blocks ensure safe and organized electrical connections in the control and management of production lines (e.g. Figure 2). The acceleration of production processes and the increasing complexity

of modern factories have made terminal blocks a critical component. In addition to industrial automation, terminal blocks are widely used in energy distribution systems. These systems range from high-voltage energy transmission to low-voltage building energy distribution (Grant, 2014).

Today, terminal blocks also play a crucial role in renewable energy systems. In particular, they are used in solar and wind energy projects, where they ensure reliable connections in energy storage and distribution systems. Terminal blocks in these systems help increase energy efficiency and minimize the risk of failures. In solar energy systems, terminal blocks are essential for the proper transmission and distribution of electricity from the panels. In wind energy systems, spring pressure terminal blocks are often preferred due to their resistance to vibrations (Thompson, 2018).

Figure 2

Terminal Block Application In A Control Panel



Terminal blocks are also commonly used in building automation, railway signaling, automotive electronics, and the maritime industry. In building automation systems, terminal blocks are frequently used for the electrical connections of heating, cooling, lighting, and security systems. In the railway and automotive industries, spring pressure terminal blocks are preferred for their durability and resistance to vibrations in harsh operating conditions (Taylor, 2005).

Operating Principle

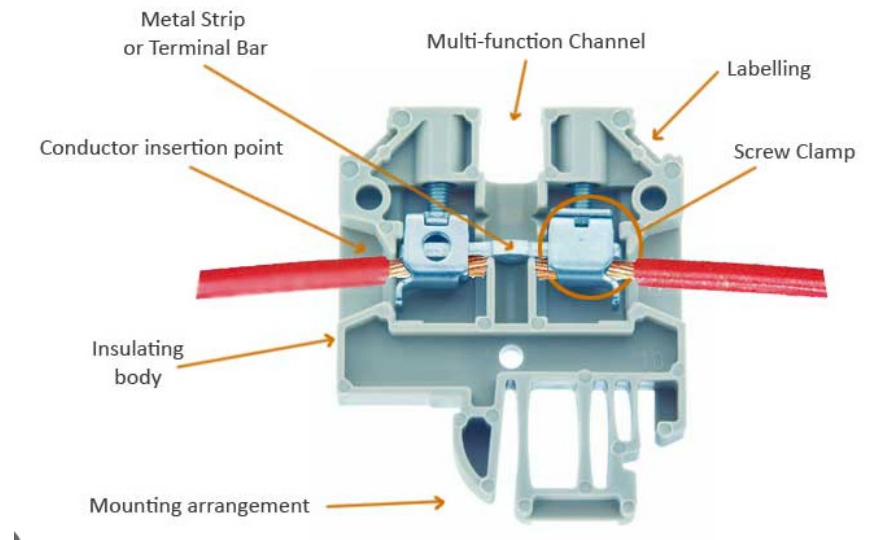
Terminal blocks operate using simple yet effective mechanisms (e.g. Figure 3) to connect conductors electrically. There are two main connection mechanisms: screw connections and spring pressure connections. In screw-type terminal blocks, the conductor is tightened by a screw, creating an electrical connection. The screw presses the conductor onto the base of the terminal block, forming a tight electrical contact. This mechanism is commonly used in circuits with thicker cables and higher currents, as the pressure provided by the screw ensures high electrical conductivity. The main advantage of screw-type terminal blocks is that the clamping force can be manually adjusted, allowing users to adapt to different types and sizes of conductors (Smith, 2017).

Spring pressure terminal blocks, on the other hand, offer a faster and maintenance-free solution. In these blocks, the conductor is pressed tightly onto the terminal base by a spring mechanism. The spring holds the conductor with constant pressure, ensuring durability even under vibrations and environmental factors. Spring pressure terminal blocks are preferred in environments where continuous connections are important, and they reduce the need for maintenance. The connection process in spring-loaded terminals

is generally quick, making the installation time shorter compared to screw-type terminals (Johnson, 2019).

Figure 3

Working Principle Of A Simple Rail Terminal Block



Another crucial aspect of the operation of terminal blocks is the rail structure itself. Rails, often referred to as DIN rails (Figure 4), are metal strips used to secure and organize the terminal blocks. These rails allow for easy mounting and adjustment of terminal blocks on electrical panels. This mounting system facilitates the installation maintenance and expansion processes (Wilson, 2016).

Figure 4

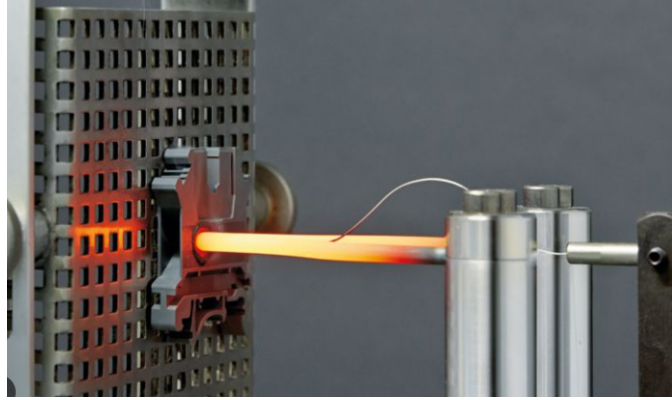
Terminal Blocks Arrayed On The Mounting Rail



Design Features

The materials and structural features used in the design of terminal blocks are critical to the product's durability and performance. The outer body of the terminal blocks is typically made of plastics such as Polyamide 6.6, which are resistant to high temperatures and mechanical stress. Polyamide 6.6 stands out for its excellent insulating properties and chemical resistance. This material offers long-lasting and reliable use even in harsh industrial environments. Additionally, flame-retardant versions of Polyamide 6.6 (e.g. Figure 5) are preferred in applications where fire safety is critical (Green, 2020).

Figure 5
Glow Wire Test On Terminal Block

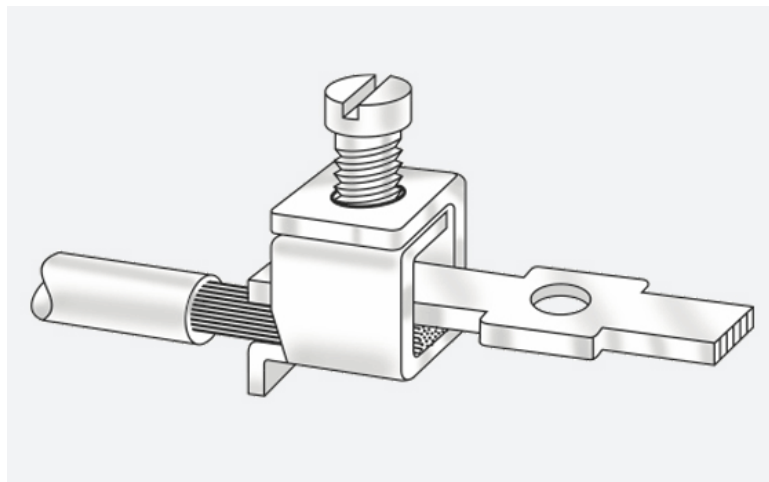


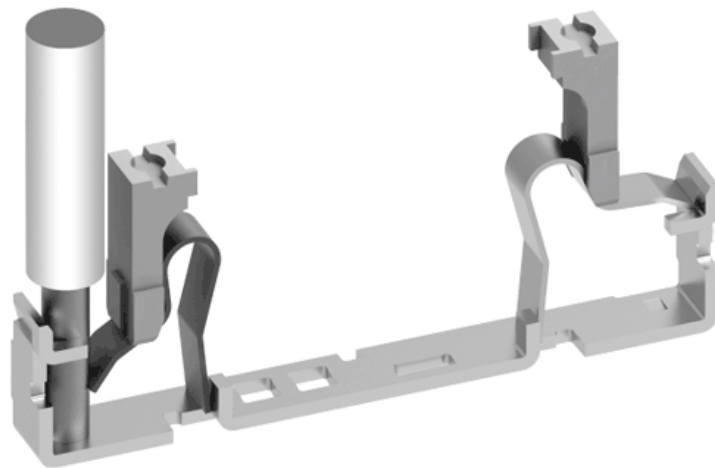
Inside the terminal blocks, copper and steel materials are used to ensure reliable connections for conductors. Copper is known for its high electrical conductivity and is commonly used at the contact points of terminal blocks. Steel is used to enhance mechanical durability. Copper is typically coated with tin or nickel to protect against oxidation. These coatings ensure that terminal blocks can operate reliably over long periods (Davis, 2017).

Terminal blocks come in two main types: screw-type and spring-pressure (e.g. Figure 6) connections. Screw-type blocks are suitable for applications requiring manual adjustment, while spring pressure blocks offer faster and maintenance-free solutions. Another important consideration in design is ease of installation. Most terminal blocks are designed to be compatible with DIN rails. These rails allow terminal blocks to be mounted quickly and easily. Moreover, the modular design of terminal blocks simplifies expansion or rearrangement processes (IEC, 2002a).

The design of terminal blocks must comply with international standards. These standards define the safety, performance, and durability requirements for the products. For example, IEC 60947-7-1 and IEC 60947-7-2 standards specify the electrical properties and safety criteria for terminal blocks. Additionally, international certifications such as UL and CE enhance the global reliability of terminal blocks. These certifications are essential for ensuring that the products can be used in international markets (IEC, 2002b; UL, 2015).

Figure 6
Screw Type And Spring Type Pressure Systems





Conclusion

Terminal blocks are critical components that provide safety, functionality, and durability in electrical connections. Their historical development has paralleled the evolution of industrial automation and energy distribution systems. With their wide range of applications, various connection types, and durable materials, terminal blocks play a vital role in modern electrical systems. They offer secure connections, easy installation, and maintenance, making them essential in organizing electrical circuits. Moreover, their compliance with international standards enhances their reliability in global markets. With these features, terminal blocks will continue to be a key component of the electrical industry.

References

- Allen, R. (2013). Spring pressure and electrical connection systems. *Journal of Electrical Engineering*, 55(4), 567–575.
- Brown, A. (2011). *Electrical connections in high current systems*. Wiley.
- Davis, C. A. (2017). Electrical conductivity in contact materials: A comparative study. *Journal of Materials Science*, 58(5), 1064–1075.
- Grant, D. R. (2014). Screw and spring connection systems. *Elektrik Tesisat Dergisi*, 22, 43–49.
- Green, M. (2020). Polyamide 6.6 and its electrical applications: Advances and challenges. *Journal of Polymer Science*, 65(7), 921–932.
- Hudson, M. A. (2012). *Industrial control equipment and practices*. Elsevier.
- International Electrotechnical Commission. (2002). IEC 60947-7-1: Low-voltage switchgear and controlgear – Part 7-1: Ancillary equipment – Terminal blocks for copper conductors. IEC.
- International Electrotechnical Commission. (2002). IEC 60947-7-2: Low-voltage switchgear and controlgear – Part 7-2: Ancillary equipment – Protective conductor terminal blocks for copper conductors. IEC.
- Johnson, T. K. (2019). Industrial wiring systems and automation. *IEEE Transactions on Electrical Systems*, 62(4), 1020–1028.

- Mason, T. R. (2015). Renewable energy systems: Design and applications. Cambridge University Press.
- Roberts, J. W. (2020). Electrical systems in modern manufacturing. IEEE Transactions on Automation Science and Engineering, 46(2), 325–333.
- Smith, J. (2017). Electrical wiring and connections: Theory and practice. Wiley.
- Smyth, P. (1996). Automation systems and electrical installations. IEEE Transactions on Industry Applications, 32(6), 1245–1251.
- Taylor, G. B. (2005). Electrical contact mechanisms: Fundamentals and applications. CRC Press.
- Thompson, S. L. (2018). Polyamide applications in electrical engineering. Materials Science Journal, 89(3), 1345–1353.
- Turton, C. J. (1988). Electricity in industry. Springer.
- Underwriters Laboratories. (2015). UL 486A-486B: Standard for wire connectors and soldering lugs for use with copper conductors. UL.
- Wilson, D. (2016). Modular electrical connections: Design principles and applications. Elsevier.

About the Authors

Hasan ÖKTEM is a Professor at Kocaeli University, Hereke Asım Kocabıyık Vocational School, Department of Machine and Metal Technologies. He has scientific areas: mechanical engineering, Brake pad systems, composites, machining, and polymers.

E-mail: hoktem@kocaeli.edu.tr, **ORCID:** [0000-0003-2526-8364](https://orcid.org/0000-0003-2526-8364)

Oğuzhan DÖNER graduated from Kocaeli University, Department of Mechanical Engineering. He works as an engineer in the R&D department at ONKA Electric Materials. Her main areas of interest are mechanical design, connection technologies, and research.

E-mail: oguzhan.doner@onka.com.tr, **ORCID:** [0009-0001-6776-3550](https://orcid.org/0009-0001-6776-3550)

Orhan KARA graduated from Kocaeli University, Department of Mechanical Engineering. He works as a director in the R&D department at ONKA Electric Materials. Her main areas of interest are mechanical design, connection technologies and research.

E-mail: orhan.kara@onka.com.tr, **ORCID:** [0000-0002-0544-5821](https://orcid.org/0000-0002-0544-5821)

Şerafettin DEMİRBAŞ graduated from Gebze Technical University, Department of Materials Engineering And Science. He works as a project manager in the R&D department at ONKA Electric Materials. Her main areas of interest are design, connection technologies and research.

E-mail: serafettin.demirbas@onka.com.tr, **ORCID:** [0009-0004-3634-6115](https://orcid.org/0009-0004-3634-6115)

Similarity Index

The similarity index obtained from the plagiarism software for this book chapter is 2%.