Terminal block systems
What distinguishes the quality of the contacts?

When using terminal block systems, users have a choice of various connection technologies, all of which having their advantages and disadvantages. In order to assess the contact quality, it is necessary to take into account both the general testing standards and the requirements of specific application areas, such as the processing industry or railroad industry. The Clipline complete terminal block series has thus developed over decades into a comprehensive system (Figure 1).

Focus on system philosophy

Terminal blocks have always played an important role in control cabinet wiring. At first glance, terminal blocks are simple and unassuming components. However, they have been continuing to develop for some time into complex systems. In light of differing regional and industry requirements, completely different connection technologies have evolved. Each connection technology has its very specific advantages:

- The screw connection technology (UT) is the most commonly used connection technology worldwide for electrical connections. The terminal blocks with screw connection technology from Phoenix Contact provide a high level of safety, and thanks to its patented Reakdyn terminal principle, they do not have to be retightened.
In addition, it is the only connection technology that permits the clamping of two conductors in a standards-compliant manner.

- The bolt connection technology (RT) is frequently used for connections having large cross sections. For cables with up to 240 mm², it provides the highest withdrawal force for the terminal position and the advantage of protection against loss.

- The spring connection technologies (ST), in particular the push-in direct-plug technology (PT), allow quick and easy processing. PT terminal blocks allow direct assembly of rigid cables and cables having ferrules, without the need for tools. The spring force of the leg spring, which always remains the same, ensures high contact quality.

- The quick-connection technology (QT) connects rigid and flexible cables without having to remove the cable insulation, i.e., without stripping. Processing is carried out extremely rapidly, and the vibration resistance is comparable to that of other connection technologies.

Growing demands due to ever more complex machines and systems also require more and more contact points in the control cabinet, which takes up space. Terminal blocks having a width of just 3.5 mm can potentially save lots of space.

**Modularisation and standardisation**

Machine and system parts are increasingly being designed modularly. Machine parts are often not assembled until the manufacturing stage, and modules can be added right up to the last moment. The maintenance of the machine and system parts must also be simplified. The Combi terminal blocks from Phoenix Contact are designed to be systematically pluggable. The labelling system ensures the correct assignment of the plug-in points, and the coding system makes sure that assembly is error-free.
One of the basic principles of Clipline complete is the standardised accessories. This means an easily pluggable bridge system as well as terminal blocks in which function modules such as fuses, diodes, or resistors can be integrated. Furthermore, the marking systems are always identical and are compatible across all product lines.

**Lots of contact points**

The wide variety of terminal block connection options in control cabinets provides various contact points:

- Contacting the cables using the conventional UT, PT, ST, QT, and RT connection technologies.
- The plug-in connections of the Combi series, which make the terminal blocks pluggable.
- The plug-in zones in function terminal blocks, which accommodate the feed-through connectors, disconnection plugs, component plugs, and fuse plugs. The plug-in zones simultaneously form the basis for terminal blocks having integrated knife disconnections and fuses.
- The multifunction shaft having the contact points for the flexible plug-in bridge system and the test connector system.

High-value materials and patented connection technologies ensure a consistently high contact quality. All metal parts are manufactured from corrosion-free materials. The current-conducting components, in which a contact resistance which is as low as possible is paramount, consist of high-value copper alloys that are protected by a lead-free nickel or tin layer. The spring elements of the push-in and spring-cage connector terminals are manufactured from high-strength chrome-nickel spring steel and thus ensure a constant contact force and high vibration resistance.
Approval tests pose a challenge for the contacts

The approval tests cover the mechanical and electrical properties of the terminals as well their materials. Generally, a voltage-drop test, which ascertains the contact resistance of the terminal point, is carried out for demonstrating that the terminal point is intact before, during, and after the mechanical, electrical, and climatic tests. Under an applied current of with 0.1 times the rated current and at a room temperature of 20°C, the voltage drop at the terminal block must not exceed 3.2 mV and 1.5 times the initial value (Figure 2).

The mechanical tests for qualifying the contact points include tests according to IEC 60947-7-1/-2. Here, the connection capability of the contact points is tested, the mechanical strength is demonstrated by repeatedly connecting and via a bending test, and the cable withdrawal forces are ascertained.

The permissible ambient temperature of the terminal block is ascertained via a heating test according to IEC and UL testing standards. The short-circuit resistance is demonstrated by a current density of 120 A/mm² of the rated cross section being applied to the terminal points three times for one second (Figure 3).

An aging test is performed to ensure a long service life. Here, the terminal blocks are subjected to defined temperature cycles between +20°C and +85°C in a climatic test enclosure, while the rated current is applied to them simultaneously. Thus, the service life is simulated at the maximum permitted operating temperature. During the total of 192 cycles, the voltage drop is measured after each 24 cycles in order to demonstrate that the contact resistance is constant, thus ensuring that the contact quality is consistently high.
Industry-specific testing

In addition to these standard approval tests, industry-specific tests are also carried out, many of which, however, have been incorporated into the standard testing program. Since terminals are used in rapidly changing temperature ranges, for example, in railroad traffic, a temperature shock test derived from traffic technology is carried out. The terminal points initially remain at -55°C for 45 minutes, and are then raised to a temperature in the range of +100°C within seconds. After 100 cycles, as soon as room temperature has been reached, the test objects are then again subjected to the voltage-drop test (Figure 4).

Aggressive environmental media are often found in industrial environments. In order to simulate this, test objects are exposed to an environment containing sulphur dioxide. After remaining for eight hours in the testing chamber, the test objects are first allowed to dry, and then have to pass the voltage drop test.

Vibration and shock effects occur not only in railroad traffic, but also in wind-turbine facilities. Vibration and shock tests are therefore carried out according to the requirements of the DIN EN 50155 railroad standard. Shock and vibration, which occur near engines, rotating drives, and axles, are simulated. The criteria for passing the test are clear: no mechanical damage to the test objects and no interruption of contact at the contact points for more than 1 μs (Figure 5).

Summary

Terminal blocks have become indispensable in modern industrial applications. In addition to growing demands on quality, they handle an increasing number of functional tasks. A high level of contact quality is therefore an important prerequisite for the economical long-term operation of machines or systems. Installing the Clipline complete terminal block system from
Phoenix Contact in control cabinets allows the use of all common connection technologies with standard accessories, and provides the assurance that all contacts function reliably.

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