



Safe connection of aluminum conductors

Safely wire aluminum conductors with just a twist

Direct connection to modular terminal blocks

Using aluminum conductors is becoming ever more appealing – especially when it comes to conductor cross sections of 16 mm² or more. The advantage of using aluminum as a material for conductors is the low price in comparison to copper cables, which cost almost four times as much. Furthermore, aluminum is approximately 70 percent lighter than copper – the reduced weight makes laying the cables easier. However, some basic conditions must be met in order to contact the aluminum conductors safely (Fig. 1).

Aluminum is different

Aluminum has three physical properties which make it harder to use as an electrical conductor. First of all, there is the issue of “yielding” - under pressure, aluminum yields sharply due to a low modulus of elasticity. There is also the fact that when stripping an aluminum conductor, an oxide layer forms on the surface. If the oxidized conductor is connected in a modular terminal block without any further pre-treatment, the oxide layer increases the contact resistance between the conductor and the terminal point. This causes excessive heat at the terminal point. Another difference between aluminum and copper conductors is that the current carrying capacity of aluminum conductors is lower. The electrical conductivity of aluminum is a third lower than that of copper. As such, it is particularly important to observe the maximum current carrying capacity when using aluminum conductors. As a rule, at least a larger cross section than for a copper conductor should be selected for aluminum conductors in order to achieve the same current carrying capacity. These properties must be carefully observed when connecting aluminum conductors directly to modular terminal blocks.

Aluminum conductors can be connected to modular terminal blocks in two different ways. First, they can be directly contacted in the terminal point of a modular terminal block – here, the aluminum conductor and terminal point are directly connected to each other. The other option is to crimp cable lugs or pin sleeves to aluminum conductors and to apply the crimped connection element to the modular terminal block. In both cases, the manufacturer's instructions must be followed.

Directly connecting aluminum conductors to modular terminal blocks

Phoenix Contact offers various solutions for directly connecting aluminum conductors to modular terminal blocks. Round, single-strand aluminum conductors (Fig. 2) with a cross section range between 2.5 and 35 mm² can be connected directly to screw connection terminal blocks from the UT series (Fig. 3). Sector-shaped, single-strand aluminum conductors (Fig. 2) between 50 and 240 mm² can be connected to the screw connection terminal blocks from the UKH series (Fig. 4). The terminal sleeves of these modular terminal blocks are triangular on the underside and therefore match the shape of the connection for the sector-shaped, single-strand aluminum conductors. When the tapered side of the sector conductor is placed on the triangular shape of the terminal sleeve, the aluminum conductor nestles into the terminal sleeve of the UKH terminal. This ensures an optimum connection.

When using the UT and UKH series, the following measures for pre-treating the aluminum conductors must be followed to ensure a safe and reliable connection:

1. The oxide layer must be removed from the surface of the stripped aluminum conductor. This can be scraped off the surface of the aluminum

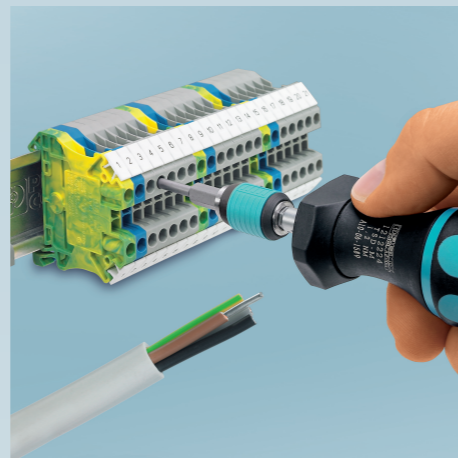


Fig. 1: Aluminum conductors are often installed in buildings – they can be directly connected to feed-through terminal blocks

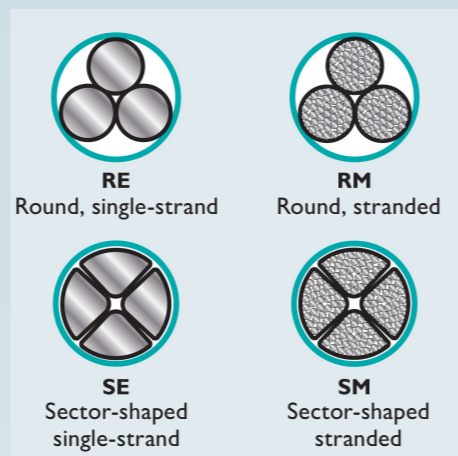


Fig. 2: In general there are four different conductor designs: round and single-strand (RE), round and stranded (RM), sector-shaped and single-strand (SE), sector-shaped and stranded (SM)

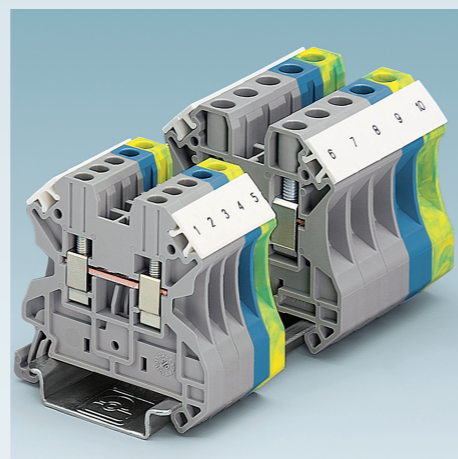


Fig. 3: The feed-through terminal blocks in the UT series are suitable for direct connection of round, single-strand aluminum conductors with a cross section range of 2.5 to 35 mm²

conductor using a knife blade, for example.

2. Immediately after the oxide layer has been removed, the stripped aluminum conductor is greased with neutral (acid- and alkali-free) Vaseline or contact grease with comparable properties. The Vaseline prevents the conductor from oxidizing again and keeps moisture away from it.

3. Then the aluminum conductor is inserted into the terminal point of the modular terminal block and tightened with the maximum tightening torque for the modular terminal block in question.

If these measures are followed, a direct, safe connection to the feed-through terminal blocks of the UT and UKH product range can be established. However, if these pre-treatment steps are not followed, there is a risk that the contact resistance will increase significantly between the aluminum conductor and power rail. This can result in extreme heating of the terminal point, which, in the worst case, can lead to a fire.

Special tests for aluminum conductors

Both series were tested and qualified for the aforementioned conductor types with the relevant cross sections. In addition to the usual standards for low-voltage products (IEC 60947-7-1/2 apply only to copper conductors), additional

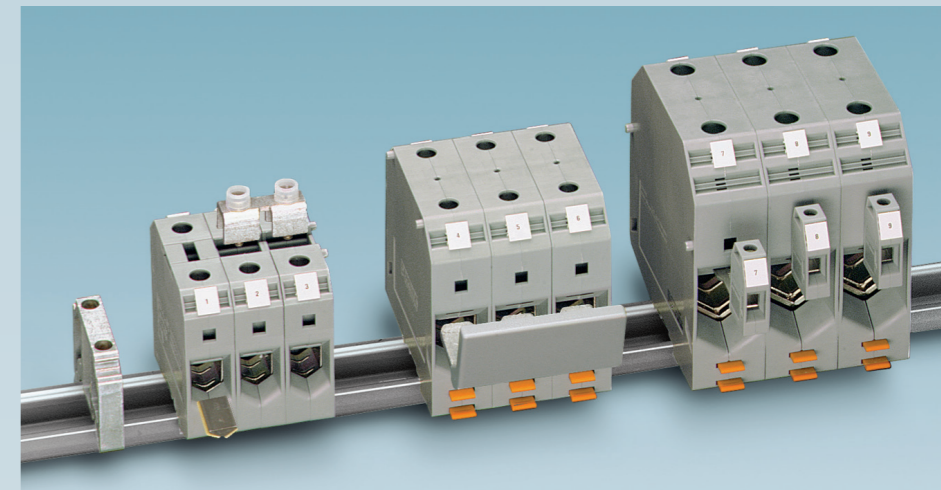


Fig. 4: Type UKH high-current terminal blocks are suitable for connecting sector-shaped, single-strand aluminum conductors with a cross section range between 50 and 240 mm² – aluminum cables offer huge savings potential for these large cross sections

tests were carried out in accordance with IEC 61545. This standard defines the connection of aluminum conductors in terminal points made of any material as well as the connection of copper conductors to terminal points made of aluminum. The UT and UKH terminal blocks were subjected to a 1000 hour current cycling test according to IEC 61545. As part of these tests, the modular terminal block and aluminum conductor combination is supplied with current for an hour and then switched off for an hour. The cycle is repeated 500 times. During the 1000 hours, temperature measurements are taken at the terminal points in accordance with a

defined schedule. The measured values must not exceed defined limit values. The 2-wire feed-through terminal blocks from the UT series and the UKH terminal blocks successfully passed the current cycling test. This means that both terminal blocks are suitable for direct connection of aluminum conductors, provided correct pre-treatment is carried out. The terminal points were not re-tightened during the current cycling test, i.e., during the 1000 hours. This clearly demonstrates that aluminum conductors can be directly connected to screw connection terminal blocks without re-tightening the screw terminal point.

Aluminum cables – savings potential for photovoltaics

With aluminum conductors, the PV sector can make considerable savings. Aluminum conductors can be used, for example, to connect inverters to the feeding point. Four-wire underground cables with sector-shaped, single-strand aluminum conductors are often used for this purpose. In some PV systems, in particular open land PV systems, there is a significant distance to be bridged between the system and the feeding point. The use of aluminum cables instead of copper cables offers huge potential savings in the stated application. The high-current terminal blocks from the UKH series are ideal

for use with sector-shaped, single-strand aluminum conductors with a cross section range between 50 and 240 mm² (Fig. 5).

Fig. 5: Underground cables with aluminum conductors are often used to connect open land PV systems, e.g., type Navy 4 x 240 SE. This sector-shaped, single-strand aluminum conductor can be connected directly to the UKH 240 screw connection terminal block.



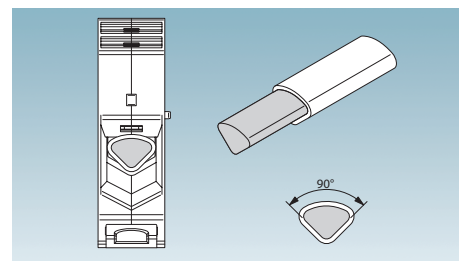
Connecting aluminum conductors

The screw terminal blocks in the UT and UKH series are suitable for the direct connection of aluminum conductors in accordance with the directives governing conductor pre-treatment. The aluminum “yields”, i.e., under pressure, aluminum yields more easily than copper due to a low modulus of elasticity. Furthermore, after stripping the aluminum conductor, an oxide layer forms on the conductor surface due to reacting with air. This oxide layer leads to increased contact resistance between the aluminum conductor and the terminal point. The oxide layer should therefore be removed before wiring. In addition, the maximum current carrying capacity of aluminum conductors is lower than that of copper conductors. In general, if the same current carrying capacity is required of the aluminum conductor, a larger cross section than for a copper conductor must be selected. UT ... and UKH ... screw connection terminal blocks from Phoenix Contact have been qualified for the use of aluminum conductors based on the properties specified through extensive tests. An important quality feature of this qualification is the 1000 hour current cycling test according to IEC 61545. As part of this test, the modular terminal block and aluminum conductor combination is supplied with

current for an hour and then switched off for an hour. The cycle is repeated 500 times. During the 1000 hours, temperature measurements are taken at the terminal points in accordance with a defined schedule. The measured values must not exceed defined limit values. All screw connection terminal blocks from Phoenix Contact that have undergone these tests are listed in the table below.

When directly connecting aluminum conductors to UT ... and UKH ... feed-through terminal blocks from Phoenix Contact, the following guidelines on conductor pre-treatment must be followed:

- The oxide layer must be removed from the stripped end of the aluminum conductor using a blade (suitable knife, e.g., WIREFOX-D 13 stripping tool).
- It must then be immediately dipped in non-acid and non-alkali, i.e., neutral Vaseline.
- The installation location must be kept free from humidity or aggressive atmospheres.
- When using an aluminum conductor, the screw in the clamping part of the screw terminal block must be tightened with the recommended tightening torque of the respective modular terminal block; there is no



Example for UKH ... – connecting sector-shaped, single-strand aluminum conductors

need to re-tighten the terminal point. (For torque screwdrivers, see Catalog 5)

- The pre-treatment must be repeated when connecting the conductors anew.

Sector-shaped aluminum conductors should be inserted in the terminal point of UKH modular terminal blocks as illustrated. The rounded section of the conductor should be at the top so that the right-angled area of the aluminum conductor is positioned on the prism-shaped base of the terminal sleeve.

Accessories, e.g., bi-metal cable lugs (Al/Cu pressure cable lugs) can be used to connect stranded aluminum conductors.

Approved combinations of screw connection terminal blocks with aluminum conductors															Recommended tightening torque
Modular terminal block	Conductor cross section in mm ²														
	2.5	4	6	10	16	25	35	50	70	95	120	150	185	250	
UT 2,5 (PE)	RE	RE													0.6 Nm
UT 4 (PE)	RE	RE	RE												0.8 Nm
UT 6 (PE)	RE	RE	RE	RE											1.8 Nm
UT 10 (PE)	RE	RE	RE	RE	RE										1.8 Nm
UT 16 (PE)	RE	RE	RE	RE	RE	RE									3.0 Nm
UT 35 (PE)	RE	RE	RE	RE	RE	RE	RE								3.7 Nm
UHK 25			RE	RE	RE	RE									4.5 Nm
UHK 50							RE	SE							8 Nm
UHK 70								SE	SE						10 Nm
UHK 95									SE	SE					20 Nm
UHK 150											SE	SE			30 Nm
UHK 240													SE	SE	30 Nm

RE Round, single-strand, class 1; approved

SE Sector-shaped, single-strand, class 1 a - 90°; approved

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