High current on the PCB

PCBs are the nerve centre of electrical devices, and it is a challenging task to transfer high power levels to them. Given the steadily increasing degree of automation, PCBs must constantly solve new problems and fulfil additional requirements. This often necessitates high rated voltages and currents to be transferred directly to the PCB, which is only possible using very reliable interfaces (Figure 1).

Photovoltaic inverters mounted on a private home, distributed drive controllers of a gantry crane, and the central control system of a packaging facility’s complex roll conveyor have one thing in common: Without electronic devices for power conversion, neither the transition to renewable energy nor the implementation of an intelligent, self-organising plant would work. In recent years, the demands placed on the performance of devices have constantly evolved: With increasingly compact dimensions, drive controllers and inverters must be configured for equal or higher performance.

This means that device manufacturers must install reliable components that offer high functionality and safety in a small space. However, international safety regulations and certification requirements, such as those of Underwriters Laboratories (UL) or the International Electrotechnical Commission (IEC), set tight limits on miniaturisation.

International standards as limiting factors

The UL defines, for example, the limit values of so-called air and creepage paths for various places of use, such as consoles, office equipment, or industrial applications. These limit values indicate the minimum distances to be observed between two conductive objects, so as to exclude the possibility of transmission via the shortest air path or the insulation material. If a manufacturer wants to certify a device for the permissible voltage of a specific group of applications, each component must also be certified.

The following example illustrates this: A string inverter of a photovoltaic system converts the direct current generated in 15 solar modules to grid-compliant alternating current. The three-phase inverter is designed on the AC side for a maximum rated voltage of 600 V. For this type of use, the UL has defined air paths of at least 9.5 mm and creepage paths of at least 12.7 mm. In order to obtain the UL certification for the inverter, all connections to the PCB must also comply with these limit values.

Manufacturers of PCB connections are thus faced with the challenge of, on the one hand, designing highly compact plug-in connectors and PCB or feed-through terminal blocks in order to make compact device design possible. On the other hand, they must further develop contact technology that has, in part, been around for decades in order to provide high connection flexibility and, at the same time, to enable high transmission security for future applications as well.
Not every connection technology is suitable

Given that the cable cross-section increases with the power to be transmitted, not all connection technologies are equally suitable for demanding applications. In the case of cable cross-sections of 2.5 mm² to 35 mm², device manufacturers and installers can select from a wide choice of PCB terminal blocks and plug-in connectors. Depending on the application, comfortable spring-cage connectors, push-in variants, or the established screw connectors with tension sleeve provide high contact reliability in addition to low installation and maintenance requirements. However, the larger the conductor cross-section, the power to be transmitted, and hence the safety requirements, the more difficult it becomes to reconcile connection comfort and security.

The Combicon power product family of Phoenix Contact covers a wide range of applications for cable cross-sections of 2.5 mm² to 150 mm². This provides device manufacturers and installers with a broad range of cross-sections from which they can choose the connection technology required for their specific application. The latest development is a push-lock spring connection. This connection technology enables users to securely clamp the contact spring on the cable and lock it into place with the help of a clearly separated lever. The technology combines security as well as comfort and provides users with direct feedback on whether the connection is secure (Figure 2).

Robust feed-through terminal blocks for the transmission of up to 309 A and 600 V UL come into play in particular for applications with large cross-sections exceeding 35 mm². The terminal blocks consist of an inner and outer part, which are interlocked through the housing panel without the need for tools. The design is not dependent on the panel thickness and provides very high safety because mechanical forces in the cable are not transmitted to the PCB, but are instead absorbed by the housing panel. Additional stability is provided by screw, rivet, or flanged connections, which link the inner and outer part to each other through the housing panel.

Flexibility is key

Despite the robust design, the panel feed-through support different connection technologies, such as push-in, screw or bolt connectors, as well as horizontal and vertical cable outlets. Therefore, device manufacturers retain a lot of design flexibility despite increased safety requirements.

The wide range of technologies on the market shows how much know-how is packed into supposedly simple connection technology. While certain solutions, such as the screw connector, are established worldwide and have barely been modified from a design point of view, it is in particular convenient plug-in connectors with quick connection technology that have continuously developed further. Typical challenges of power electronics include achieving high contact forces despite ever smaller dimensions through choice of material. From a design point of view, numerous comfort functions are desired, such as test sockets, labelling surfaces, plug-in bridges, or colour variations. The know-how required to meet these demands includes manufacturing...
methods, material properties, as well as design and application knowledge. The wider the knowledge of the supplier, the better can device manufacturers meet the increasing cost pressure. This applies to end customer markets, such as the photovoltaic sector, as well as for industrial applications in the intelligent plant (Figure 3).

Summary

Whether in the solar inverter, the robust gantry crane, or the robot control: The transmission of high power levels to the PCB poses significant challenges in terms of providing adequate comfort and safety. Despite a multitude of contact and connection technologies, there is no universal solution for all applications in the field of power electronics. Technologies that can be combined flexibly support device manufacturers and installers in achieving high power levels in a small space. Phoenix Contact offers the Combicon power product family for safe power transmission to the PCB; it includes:

- Plug-in connectors for currents up to 125 A and voltages up to 600 V UL with pitches from 5 mm to 15 mm,

- PCB terminal blocks for currents up to 125 A and voltages up to 600 V UL with pitches from 6.35 mm to 15 mm,

- Feed-through terminal blocks for currents up to 309 A and voltages up to 600 V UL with cable cross-sections of up to 150 mm²,

- Designs with spring-cage connector, push-in spring connector, screw connector with tension sleeve, as well as push-lock spring connector.

For further information visit:
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If you are interested in publishing this article, please contact Becky Smith: marketing@phoenixcontact.co.uk or telephone 0845 881 2222.