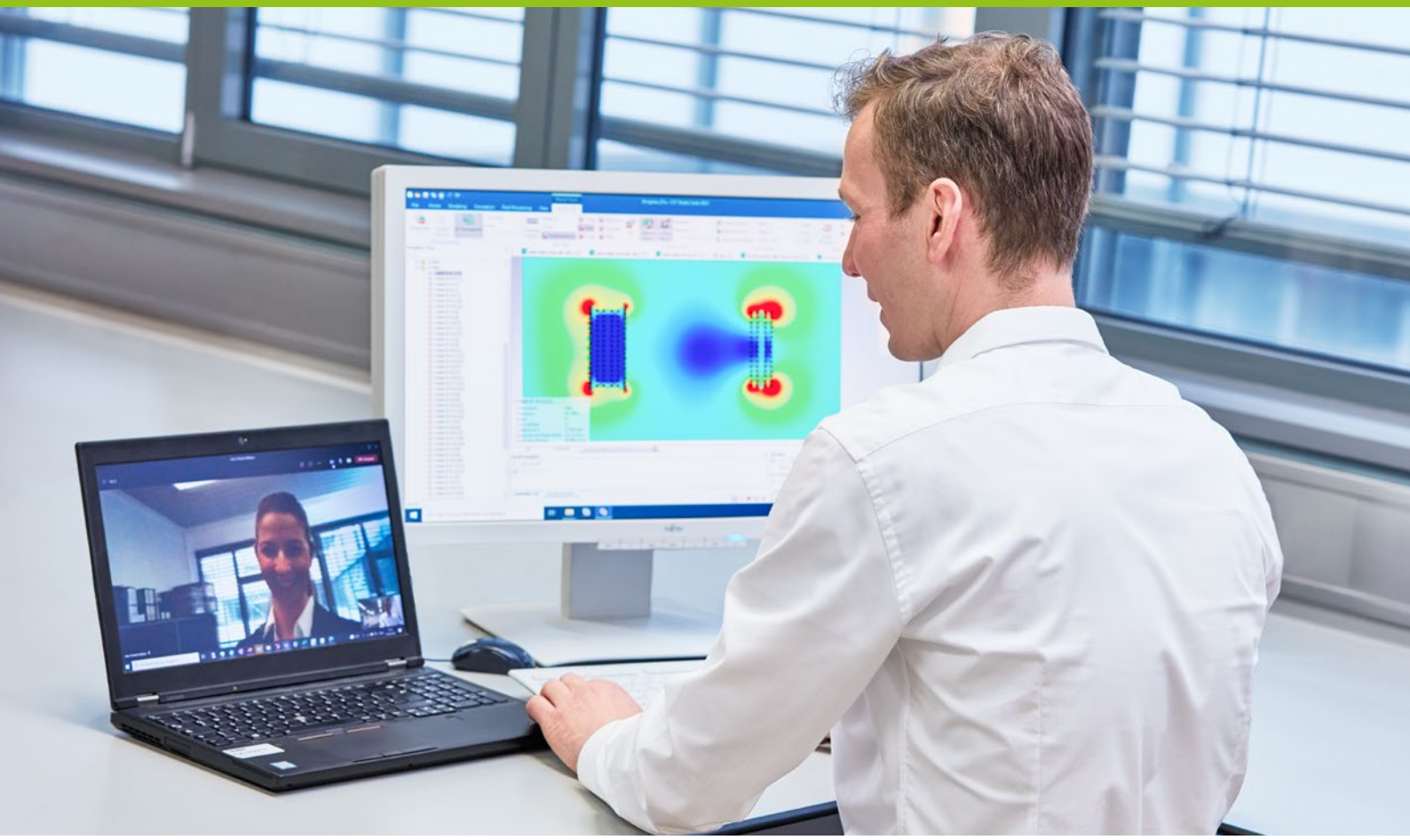
White paper



Optimizing Signal Integrity Through Simulations and Measurements

Industry 4.0 requires networked devices, which also means more seamless interfaces

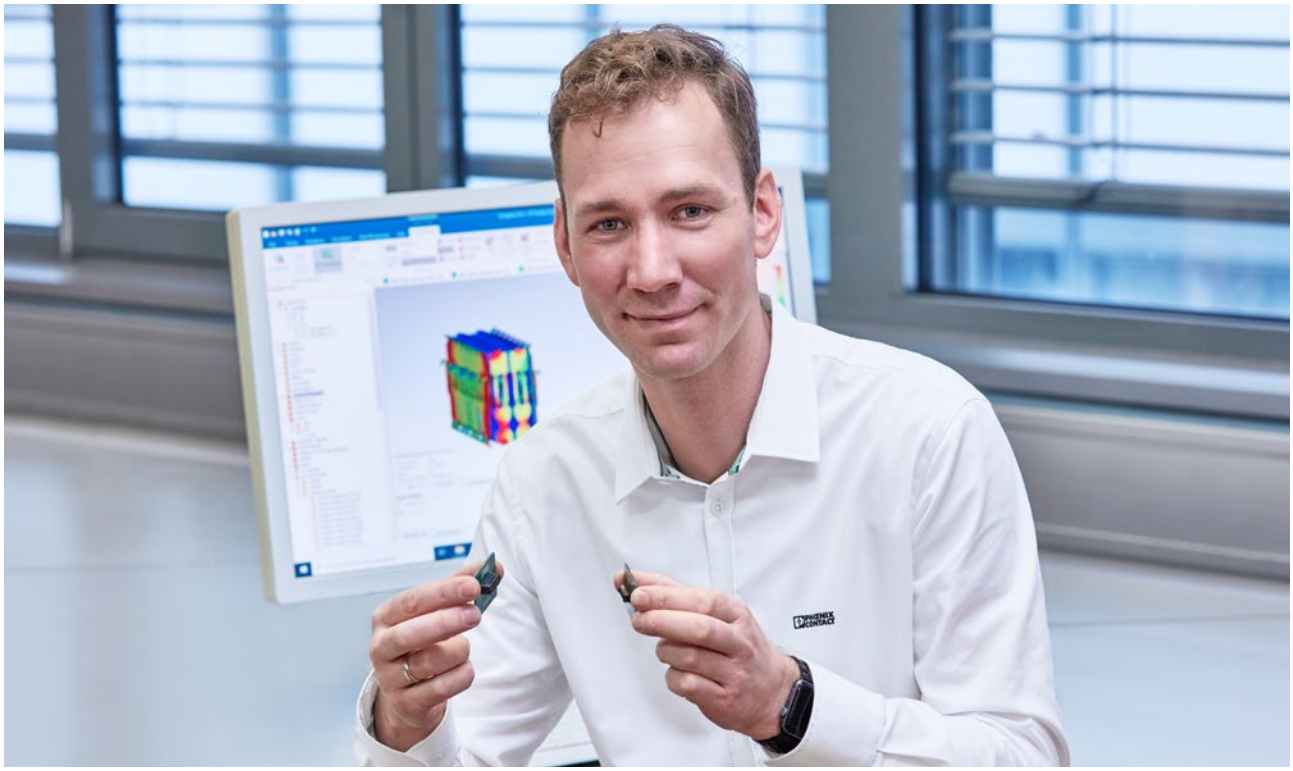
Find out more about

- → Signal integrity as a performance factor
- → Factors that affect connector impedance
- → Individual support to leverage potential

The demands on connection technology performance are constantly increasing. With the steady increase in the networking of modern devices, the number of interfaces is also growing. The goal is to achieve data transmission that is impaired as little as possible. This depends to a large extent on the interaction of all cables and connector components.
One property of connectors that is directly related to signal integrity is impedance. The target impedance of a connector depends on the transmission technology of the connector application. Deviations from the target impedance reflect the data signal back to the transmitter. If the reflections become too high, the reflected and transmitted signals overlap. This results in impaired data transmission.

Connector impedance depends on a several factors

Factors such as material selection, geometry, and the arrangement of the signal-routing components influence the impedance of a connector. An additional factor is the frequency, i.e., the level transition time of the transmission technology used. This depends on the application, and the manufacturer of the connector cannot influence it. The trend is moving towards increasingly larger data volumes and therefore higher transmission frequencies with shorter level transition times. Phoenix Contact is working to address these challenges.



Simulation expertise for deriving customer-specific recommendations

With regard to connector impedance, it is almost impossible to make generally valid statements about the best geometry, materials, or component arrangements, since in principle the nominal impedances of the transmission technologies and the level transition times must also be taken into account. What is advantageous for the design of an SPE connector can be a knock-out criterion when it comes to board-to-board connectors.

Different optimization approaches for various connection components

No matter how consistent the effort is for providing all components with high signal integrity, the requirements of the components vary greatly. Data connectors of device interfaces such as compact SPE connectors in accordance with IEC 63171-2, robust IP67 SPE connectors in accordance with IEC 63171-5, or RJ45 connectors are usually standardized. The pin connector pattern and contact assignments are subject to cross-manufacturer standards. Furthermore, these standards define specific requirements for signal integrity in the form of frequency-dependent limits for the transmission properties of the connectors, such as return loss or crosstalk. Phoenix Contact achieves a high level of signal integrity in these components through a clever selection of contact and insulation materials, as well as through a sophisticated design of the contact geometries inside the connectors that are not specified by the standards.

No standardized requirements for device-internal connections

Device-internal connections are usually not standardized. These connectors are interesting for customers with various transmission technologies.
For example, if you consider an Ethernet application, a board-to-board connector could be used in a device with an SPE interface. In this case, an impedance of 100 ohms would be ideal for the board-to-board connector. However, the same board-to-board connector could also encounter a USB protocol in another application where an impedance of 90 ohms would be advantageous. Actually, the same board-to-board connector could be used for both applications. Since there are no generally valid wiring diagrams for this non-standard interface, signal integrity can be optimized explicitly by selecting a suitable contact assignment within the connector. Particularly for board-to-board connectors, simulations help to ensure the highest signal integrity for special applications. They often show the customer unexpected areas of potential for their application.

Optimization even with standardized connectors

Experience with individual optimization routines

The optimum is always the result of several iterations and the associated optimization routines – both in the development of standardized and non-standardized connectors as well as in application-specific configuration. The simulations often use parameters that are common in many applications.
When simulating board-to-board connectors, an impedance environment of 100 ohms for differential signals and 50 ohms for single-ended signals is usually applied. High signal integrity is present if the impedance behavior of the components deviates as little as possible from this target impedance. Simulations are prepared for such common parameter settings and common contact assignments. Phoenix Contact can provide the results within a very short time. In addition, simulation results for selected types are available on the website as examples.
As part of design-in support, experts from Phoenix Contact run simulations based on individual parameters to provide product managers and engineers with the best possible advice on selecting optimum connector combinations and suitable contact assignments. The appropriate impedances and level transition times can be considered, as can interference in the form of crosstalk from other signals in the same connector or interference from other components on the PCB. When interference comes from other components, observation or simulation of the electric and magnetic fields is a suitable approach. Shielded connectors help to reduce or even eliminate this interference entirely.

Individual support for optimally appropriate solutions and products

Based on the values that customers provide, Phoenix Contact starts a customer-specific simulation and uses it to derive suggestions for suitable combinations of items and contact assignments. The team informs customers about findings, answers questions, and then provides the appropriate documentation. These individual simulations can usually be completed within a few days. To do so, the engineers need information on the respective application, such as the arrangement of the printed circuit boards in the device, the type of data transmission, or the target impedance of the system. Phoenix Contact's board-to-board connectors offer a high degree of flexibility, particularly in terms of PCB arrangements. Mezzanine, coplanar, and backplane arrangements with different PCB spacing are all possible, as are connections with preassembled flat-ribbon cables. Direct exchange between the experts on both sides is especially important. This has repeatedly led to unexpected optimization potential for signal integrity in past projects, for example through an alternative contact assignment or the use of shielded connectors. Phoenix Contact provides support for the development of devices, as local contact persons establish contact with the relevant specialists within the company.

Beyond the standard: SPE technology places specific requirements on the transmission properties of the connectors

Summary

On the market, there are many different connectors for many different applications in all sorts of versions and price levels. In the vast majority of these applications, the quality and security of data transmission are aspects that should not be neglected. Phoenix Contact offers a broad portfolio of data connectors with the highest possible signal integrity and comprehensive design-in support. Engineers can look back on a wealth of experience in simulations and tests. The simulation software used is optimally adapted to the products we produce. The experts have already been able to support countless customers with suitable connectors for individual applications with optimum data transmission.

Leveraging the advantages of top signal integrity:

- **Tap potential through individual simulations**
- **Benefit from many years of consultation expertise during concept development**
- **Expertise in the field of signal integrity allows for the highest possible data transmission quality**
- **Portfolios and trend technologies such as SPE ensure the future-proof networking of all communication interfaces**
- **Reliable products enable stable data connections**

Contact

Create your individual simulation with us

Request your own individual simulation if a suitable standard does not exist. We have already been able to support countless customers and place the appropriate connectors in their applications. Feel free to contact us.

Visit us at:
phoenixcontact.com/en-us/data-connectors-for-smart-networks/high-signal-integrity

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