# Selecting connectors for differential applications

*Connectors specially designed for increasing speeds offer many benefits*

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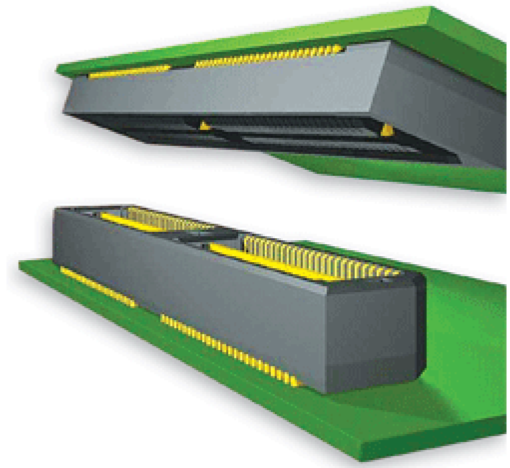
Many connector styles can be used for high-speed applications. Open pin-field connectors are often the lowest-cost solution and offer great flexibility in both differential and single-ended applications. However, as speeds increase, connectors optimized for single-ended or differential applications become more appropriate.



**Some single-ended connectors can be successfully implemented in differential applications.**

While high-speed electrical performance is critical, when choosing a connector for differential signal applications, other factors such as ease of implementation, application flexibility, density, and economics could be deciding factors in selecting the optimal part. The system designer must consider many aspects of connector performance when determining which connector is best suited for a specific application.

**Open pin-field connectors**
Generic, open pin-field connectors have pins that can be assigned at will. These connectors are constructed as an array of metallic contacts. Such connectors are programmable with respect to placement of signals and grounds, and allow the system designer to assign contacts as desired to achieve acceptable impedance, crosstalk, and density.

Single-ended circuits require both a signal path and a return, or ground path. Open pin-field connectors are used in single-ended systems by dedicating certain pins to signals and others to ground.

Various signal-to-ground ratios may be implemented depending on signal density and electrical performance requirements. More ground pins yield better electrical performance. Nonelectrical benefits—less required board space or improved trace routability—may result from higher signal-to-ground ratios and can offer attractive tradeoffs to less than optimal electrical performance.

Open pin-field connectors are often low-cost solutions, but if implemented with prudence, can perform well in high-speed systems. But extreme variations in impedance and crosstalk performance are likely with changes in signal-to-ground ratio.

Open pin-field connectors can be used for both single-ended and differential signals. For differential signals, it is usually desirable to maximize coupling between the two conductors of a pair.

This means keeping the two conductors of a pair as close as possible. But intrapair coupling could be constrained by a requirement to obtain specific target impedance.

To reduce crosstalk between pairs, coupling from each conductor of the signal pair to other nearby conductors must be minimized. It is also important to maintain electrical balance in a differential pair by ensuring equal path length and equal interaction between each half of the pair and surrounding signal conductors, shields, and grounds.

These goals can be achieved by careful use of open pin-field connectors. But more-complex connectors are available that offer even better high speed performance. Such connectors often include integral shield or ground structures that provide isolation between signals and help control impedance.

For ultimate high-speed performance, these connectors can be optimized for either differential or single-ended applications. But the flexible nature of the open pin-field connector is sacrificed as signal and ground schemes become predetermined and fixed.

**Single-ended connectors used differentially**
Some connectors designed with single-ended applications in mind can be considered semi-programmable, offering the system designer several options for implementing signal pinouts. These connectors often feature a center ground blade, but no predetermined ground pins.

In fully loaded versions, the connector ground blade provides the only ground return path. Forty single-ended signals can be implemented in one connector bank.

When used in a 1:1 signal-to-ground ratio, 20 signals can be implemented per bank. This cuts the effective density in half, but provides much better high speed performance. Similarly, a 3:1 ratio leads to 30 available signals, and so on.

Various signal-to-ground ratios can be mixed within a connector bank. For example, certain signals may require more isolation than others, so a mixed pin out such as this might be used.

When using the standard connector in differential applications, there are two logical pin outs: fully loaded and with ground pins between pairs. Fully loaded versions permit 20 differential pairs per bank, while grounded versions allows 14 pairs.

Ground pins are inserted between differential pairs primarily to lower crosstalk. At very high frequencies, grounding the extra pins can slightly lower the impedance of the differential pair.

Since additional ground pins reduce the effective density of the connector system, they can lead to an increase in connector and pc-board cost. Less obviously, such designs can also make board-trace routing much more complicated.

Accommodation must be made for vias in the board under each ground pin. The vias connect the ground pin pads to pc-board's inner ground layers. Vias affect routing on all layers of the board, not just the surface, because they are normally constructed by drilling completely through the board.

**True differential connectors**
In certain applications, true differential connectors can offer many advantages, such as reduced capacitive loading and improved crosstalk. With certain versions, pc-board trace routability is improved significantly, eliminating the need to connect between the ground pin pads and the board ground planes with vias.

By removing the connector pins from this area, a routing channel is opened between the pairs. This provides much more flexibility to the pc-board designer.

There are several tradeoffs, however. Signal density is less than with a fully populated standard connector. Crosstalk is slightly worse than in the standard version connector when the standard connector is implemented with grounds between the pairs, but the difference in crosstalk is minimal and insignificant in most applications.