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Board to Board Connections: Part 1

How to Select the Right Connection Every Time

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Introduction

A very smart person once noted that all the problems in the world seem to occur at the boundary between one entity and another. While this analogy might be slightly overkill, it does place a spotlight on one of the most common problems in electronic and electro-mechanical design: board-to-board connections.

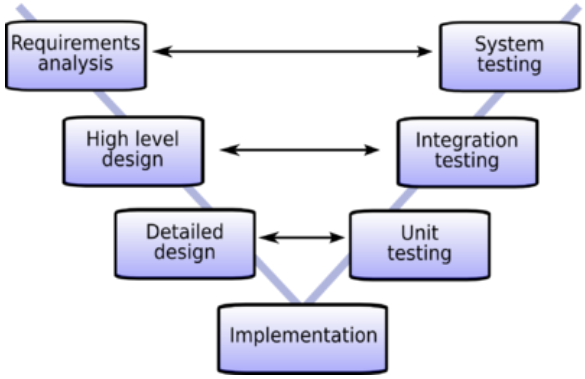
Board-to-board connections can be complex problems to solve, as they need to be responsive to a number of product requirements. Most critical of these are typically, cost, dimensional limitations, and the ability to perform rework. These problems can be solved, but designers are often not aware of the variations of board-to-board connections that are available and, due to competing requirements, can sometimes select solutions that satisfy some, but not all of the needs of the manufacturing process and the customer.

In this white paper, DfR will provide a brief overview of some of the more common board-to-board connections available and the process for selecting the optimum solution for your product design.

The Selection Process

The selection process for board-to-board connections is more of an iterative process than often realized by managers and engineers that are part of a design team. The traditional approach in scoping product development has been through the V-model (see below).

This arrangement is a very much a linear workflow, which involves scoping the requirements and then using these requirements to establish the mechanical concept vehicle and the block diagram. These two constraining factors are then used to define part selection, electrical schematic, layout, thermal solutions, and mechanical constraints. A very simple and straightforward process for managing complex product development.



Except, it doesn't really work. Especially for board-to-board connections. Far too often, companies lock themselves into constraints, especially in regards to dimensional configurations, without realizing that the solution for board-to-board connection is either problematic (too expensive, too big, not reworkable) or doesn't even exist.

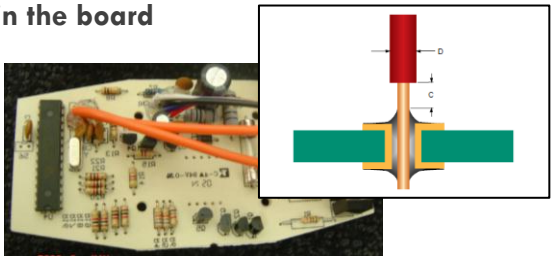
Product teams should instead try to emulate the Toyota approach. Without going into extensive detail, Toyota engineers concentrate their effort at the lowest possible design level. That is, they try to understand what technology is available before the design becomes fixed and rigid. Think of it '**test and design**' as opposed to the V-model's approach of '**design and test**'. And so, following that methodology, let's review current board-to-board connectors in regards to cost, dimensions, and permanency.

Low Cost

Board to board connections do not need to be expensive or complex. For a large number of applications, relatively simple, low cost solutions are sufficient. For the low cost solution to be effective, the designer must determine their dimensional constraints, if the connector needs to be permanent or separable, and the ability of the connector to maintain a certain degree of reliability over the desired lifetime in the expected use environment.

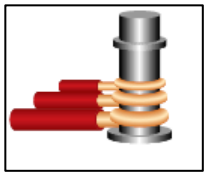
For example, wires are the simplest board-to-board connection. Simple wires. But, wires can be attached and be arranged in a number of configurations. These connections are not limited to power/ground, but also can be used for signal connections as well (have seen up to 24 I/O for these configurations). For permanent connections (soldered), options include

Twisted wire: Soldered to plated through holes in the board



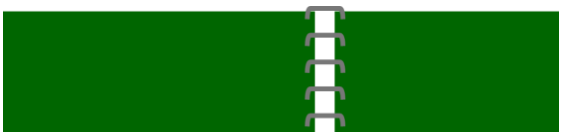
- Low material costs
- Wave soldering possible, but challenging
- Challenging for visual inspection
- Challenging for rework
- Very flexible
- Primarily for single-sided boards

Twisted wire soldered to wire wraps



- Low material costs
- Must be hand soldered
- Easily inspected
- Moderate for rework
- Very flexible
- Very popular among military applications

Solid copper wire (uninsulated) or ribbon cable soldered to plated through holes



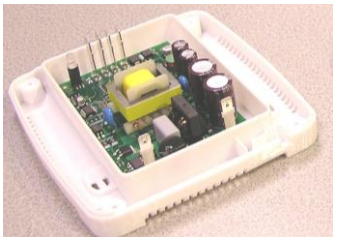
- Low material costs
- Compatible with pick and place and wave soldering
- Very effective for panel design
- Moderately challenging for inspection
- Challenging for rework
- Limited flexibility (rotation only)
- Can provide some structural support
- Can create 'virtual' double sided-board from two single-sided boards with large through-hole components
- More compatible with automated high-volume production

Wires can also establish board-to-board connections with separable connections. Separable connections are often viewed as less robust (note, not necessarily less reliable), but allow for easy debugging and rework. There are typically three[1] basic configurations for separable wire-based connections

- Spade
- Faston
- Terminal Blocks

There are a number of spade designs, but all of them have an opening to allow for the insertion of a bolt for fastening the spade connector to the surface of the printed circuit board. Typically, the bolt is connected to the housing or some other mechanical part. Critical considerations for the success of this configuration include use of a lock-nut washer, selection of an appropriate plating on the board-side, and the use of a torque wrench to ensure sufficient contact loading between the spade connection and the board plating.

Faston connections are a standardized type of spade connection. The value of Faston connection is that no tool is required, unlike other Spade connections, and it provide a very high insertion force. Because of these high insertion forces, some users consider Faston connection as reliable as soldered connections, even in extreme environments with exposure to vibration and/or corrosive gases. Faston connections can also be used for low voltage/low current applications, but power/ground connections are much more common.



Faston connections and tabs also come in a variety of shapes and sizes. This allows for 'keying', which prevents miswiring (a very common problem when an electronic OEM product is part of a larger system). It also allows the Faston connection to be more compatible with housing design, as the height of the Faston can be modified to match opening geometries and locations (though, additional specifications, such as cant, tilt, and maximum standoff, are needed in this situation).

The last, and probably most common among separable wire board-to-board connections, is the terminal block. In a terminal block, a stripped wire is inserted into a channel, where a mechanical force (applied by screw or other mechanical movement) is applied to a metal plate to make a connection. This arrangement is effective for troubleshooting in the field, but can be bulky for board-level solutions and provides multiple opportunities (incorrect insertion, insufficient torque, etc.) for poor connections.

[1] Wire solderless wrap, while included in IPC documents, is not include here as it this configuration is rarely if ever seen in modern-day electronics

Two of the limitations of all the above options are the lack of positive retention and the limited degree of keying to prevent miswiring. In addition, regardless of the configuration, separable wire connections[2] must have an appropriate level of strain relief to prevent detachment during handling, transportation, or operation. There are a number of possibilities for strain relief. A popular one is to pass the wire through an additional drilled hole within the printed circuit board (see below). To be successful, the strain relief should clearly specify the wire loop/"droop" and minimum radius.

Pin Based Connections (to be continued in Part 2)

[2] Having strain relief for soldered connections is also not a bad idea

Analysis Information

This white paper may include results obtained through analysis performed by DfR Solutions' Sherlock software. This comprehensive tool is capable of identifying design flaws and predicting product performance. For more information, please contact DfRSales@dfrsolutions.com.

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