

LOW INDUCTANCE SHIELDED CONNECTOR

Background

5 This invention relates to electrical connectors, and particularly to low inductance, high-speed electrical connectors for attachment of electrical signal transmission cables to printed circuit boards.

10 Conductors carrying high frequency signals and currents are subject to interference and cross talk when placed in close proximity to other conductors carrying high frequency signals and currents. This interference and cross talk can result in signal degradation and errors in signal reception. Shielded cables are available to carry signals from a transmission point to a reception point, and reduce the likelihood that the signal carried in one shielded or coaxial cable will interfere with the signal carried by another shielded or coaxial cable in close proximity. However, at points of connection, such as connection to a printed circuit board, the shielding for the signal is often lost, thereby allowing
15 interference and crosstalk between signals. The use of individual shielded wires and cables is often not desirable at points of connection due to the need for making a large number of connections in a very small space. In these circumstances, two-part high-speed electrical connectors containing shielded conductive paths are used.

20 In high-speed electrical connectors containing shielded conductive paths, it is desirable to provide a stable impedance profile for each of the signal conductors in the connector. Instabilities in the impedance profile will introduce undesirable distortions in the transmitted signal, and a stable impedance profile becomes of increasing importance as frequencies and currents increase. Instabilities in the impedance profile may result from, for example, failure of a ground path associated with a signal conductor, or an insufficient
25 ground path between two signal conductors. A high-speed electrical connector having improved reliability of shielding for high frequency signals and currents is needed.

Summary

30 The invention described herein provides a high-speed electrical connector for attachment of electrical signal transmission cables to printed circuit boards. In one embodiment according to the invention, the connector comprises a first terminal configured for electrical connection to a first signal conductor of a cable, and a second terminal configured for electrical connection to a second signal conductor of the cable. An

electrically insulative inner housing is configured to maintain the first and second terminals in electrical isolation from each other, and also includes a cavity for receiving a first mating ground contact therein. An electrically conductive outer housing receives the inner housing and first and second terminals, and also electrically couples with a shield of the cable. The outer housing includes a contact for electrically coupling with the first mating ground contact received in the cavity of the inner housing.

In another embodiment according to the invention, an electrical socket connector comprises an insulative carrier configured to engage a header connector. Positioned within the carrier is at least one cable connector terminating a corresponding cable. Each cable connector comprises a conductive outer housing electrically connected to a shield of the corresponding cable. The outer housing has therein an insulative inner housing holding first and second conductive terminals in electrical isolation from each other and the outer housing. The terminals are connected at one end to signal conductors of the corresponding cable. The inner housing is configured for receiving a shield blade between the first and second terminals. The outer housing includes a first contact for electrically coupling with the shield blade received between the first and second terminals, a second contact for electrically coupling with a second shield blade on an exterior surface of the outer housing, and a third contact for electrically coupling with a third shield blade on an exterior surface of the outer housing.

In another embodiment according to the invention, an electrical connector system comprises a header connector having a header body with a plurality of signal pins and a plurality of shield blades extending therefrom. A socket connector including an electrically insulative carrier is configured for engagement with the header body. The carrier contains a plurality of electrical cable connectors. Each of the plurality of cable connectors comprises an electrically conductive outer housing containing an electrically insulative inner housing. The inner housing holds at least one conductive terminal in electrical isolation from the outer housing. The inner housing includes a cavity for receiving one of the plurality of shield blades of the header connector, and the outer housing includes a contact for electrically coupling with the shield blade.

In another embodiment according to the invention, an electrical connector assembly comprises at least one electrical signal transmission cable, the at least one cable having at least one signal conductor. A socket connector comprising an insulative carrier contains at least one cable connector. The at least one cable connector comprises a

conductive outer housing having therein an insulative inner housing. The inner housing holds a first conductive terminal in electrical isolation from the outer housing. The first terminal is connected at one end to a first signal conductor of the at least one cable and has a first contact at an opposite end. The inner housing includes a cavity for receiving a shield blade therein, and the outer housing including a first contact for electrically coupling with the shield blade received in the inner housing.

Brief Description of the Drawings

Figure 1 is an exploded perspective view of a header connector in accordance with the invention having an array of male pin contacts and shield blades.

Figure 2 is a perspective view of the continuous strip of shield blades of Figure 1.

Figure 3 is a cross-sectional view of the front wall of the header connector showing signal pins surrounded by right angle portions of the shield blades forming coaxial shields around each signal pin.

Figure 4 is a perspective view showing a socket connector according to the invention mated with a header connector of Figures 1-3.

Figure 5a is a perspective view showing an individual cable connector used in the socket connector of Figure 4.

Figure 5b is a perspective view of the cable connector of Figure 5a, with the outer and inner housings removed.

Figure 6 is a perspective view showing the mating face of the socket connector of Figure 4.

Figure 7 is a top view of the socket carrier of Figure 6, with the cable connectors removed from the carrier.

Figure 8 is an illustration of the cable connectors, signal pins and shield blades of the mated socket connector and header connector of Figure 4.

Detailed Description

In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present invention. The following

detailed description, therefore, is not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims.

Figures 1, 2, and 3 show a header connector 100 for use with a low inductance shielded connector in accordance with the present invention. The header connector 100 is configured for attachment to a printed circuit board 30 and connection to a mating socket connector 200 (shown in Figure 4). The header connector 100 includes a header body 102, a plurality of signal pins 104, and a continuous strip of material having a plurality of shield blades 106 formed therein. The header body 102 is formed to include a vertical front wall 110, and top and bottom laterally-extending, horizontal walls 112 and 114 projecting perpendicularly therefrom. The front wall 110 is formed to include a plurality of first signal-pin-receiving openings 116, and a plurality of second shield-blade-receiving openings 118, all of which extend between an internal surface 122 and an external surface 124 of front wall 110. The plurality of second shield-blade-receiving openings 118 are formed to have a generally right angle cross-section. The openings 116, 118 may include chamfered entrances at one or both of internal surface 122 and external surface 124 to assist in the insertion of pins 104 and shield blades 106.

The plurality of signal pins 104 are configured for insertion into the plurality of first signal-pin-receiving openings 116 in the header connector 100 to form an array of signal pins 104 which are configured for reception in an array of signal pin-insertion windows 250 in mating socket connector 200 (shown in Figure 6), when the socket connector 200 is inserted into the header connector 100. Each signal pin 104 includes a first end 152 extending above the front wall 110 of the header connector 100, and a second end 154 spaced apart from the first end 152 and configured for insertion into an opening 32 in printed circuit board 30.

The plurality of shield blades 106 are each formed to include a generally right angle shielding portion 128 configured to be inserted into the plurality of second, generally right angle shield-blade-receiving openings 118. The generally right angle shielding portion 128 of each of the plurality of shield blades 106 includes substantially perpendicular first leg portion 130 and second leg portion 132. Each shield blade 106 includes a first end 162. The generally right angle shielding portion 128 preferably extends to internal surface 122 of the front wall. When inserted into header body 102, the first end 162 of shield blade 106 extends above the plane of internal surface 122 of the front wall 110 of the header connector 100, adjacent to a signal pin 104. Each strip of

shield blades 106 also includes at least one shield tail 148. The number of shield tails 148 may be the same as the number of shield blades 106, or may be different than the number of shield blades 106. A second end 164 of each shield tail 148 is spaced apart from the first end 162 and configured for insertion into a hole 34 in the printed circuit board 30 adjacent to the second end 154 of the signal pin 104. In one embodiment, tails 148 of shield blades 106 are electrically connected to a ground plane 40 within printed circuit board 30. In a preferred embodiment shield blades 106 are commonly grounded. In an alternate embodiment, shield blades are not commonly grounded. In another alternate embodiment, at least one signal pin 104 is electrically connected with ground plane 40 and commonly grounded with at least shield blade 106 via the ground plane.

As shown in Figure 3, the first signal-pin-receiving openings 116 and the second shield-blade-receiving openings 118 are arranged symmetrically in the front wall 110 of the header body 102 such that the generally right angle shielding portions 128 of shield blades 106 substantially surround the signal pins 104 to form a coaxial shield around each of the plurality of signal pins 104. Each of the plurality of second, generally right angle shield-blade-receiving openings 118 includes a central portion 134 coupled to first and second end portions 136 and 138 by first and second narrowed throat portions 140 and 142. The first and second narrowed throat portions 140 and 142 are dimensioned to frictionally engage the first and second leg portions 130 and 132 of the shield blades 106 to hold the shield blades 106 in place. The central portion 134 and the first and second end portions 136 and 138 of each of the plurality of second generally right angle openings 118 are formed to provide air gaps 144 surrounding the generally right angle shield portion 128 of a shield blade 106. The geometry and dimensions of the air gaps 144, the geometry, dimensions and material of the right angle shielding portions 128, and the geometry, dimensions and material of the header body 102 surrounding the air gaps 144 are configured to tune the header connector 100 to match a specified impedance (for example, 50 ohms). The configuration of the right angle shield blades 106 lends itself to mass production in a continuous strip in a manner that economizes material usage.

Each of the plurality of signal pins 104 includes a pin tail 146, and each strip of shield blades 106 includes at least one shield tail 148. The number of shield tails 148 may be the same as the number of shield blades 106, or may be different than the number of shield blades 106. In a preferred embodiment, each strip of shield blades 106 has a plurality of shield tails 148, with one shield tail 148 for every two shield blades 106,

wherein the shield tails 148 are staggered and aligned with alternate shield blades 106 along the strip of shield blades 106. In alternate embodiments, other ratios of shield tails 148 to shield blades 106 may be provided, with the shield tails 148 either uniformly or non-uniformly spaced along the length of the strip of shield blades 106. Embodiments having staggered shield tails 148 on shield blades 106 are particularly useful in back-to-back mounting of header connectors 100 on a printed circuit board, as the staggered shield tails 148 permit back-to-back mounting of header connectors 100 without interference between shield tails 148 of the opposing header connectors 100. In preferred embodiments, pin tails 146 and shield tails 148 are positioned in an evenly spaced matrix, such that back-to-back mounted header connectors may be mounted orthogonally to each other. When the signal pins 104 and shield blades 106 are inserted into the front wall 110 of the header body 102, the pin tails 146 and the shield tails 148 extend outwardly from the external surface 124 of the front wall 110. The pin tails 146 and shield tails 148 of header 100 can be either press fitted into the holes 32, 34 in the printed circuit board 30 or soldered thereto. Alternatively, the pin tails 146 and shield tails 148 could instead be surface mounted to the printed circuit board 30.

One embodiment of socket connector 200 is illustrated in Figure 4, as socket connector 200 is mated with header 100. Socket connector 200 includes an insulative carrier 210 configured to mate with header body 102. As best seen in Figures 6 and 7, insulative carrier 210 includes a front wall 212, and four laterally-extending side walls 214a, 214b, 214c, 214d projecting perpendicularly therefrom. Front wall 212 and side walls 214a, 214b, 214c, 214d define an interior 216 of carrier 210. In one embodiment according to the invention, header 100 and socket connector 200 are configured according to industry standard IEC 61076-4-101. In each embodiment, at least one, and typically a plurality of individually replaceable cable connectors 220 are positioned within the interior of carrier 210, with each cable connector 220 terminating a corresponding signal transmission cable 270. The cables 270 may be, for example, coaxial or twin-axial cables. For improved performance, the cables are preferably shielded cables. However, the cable connectors 220 are also suitable for use with unshielded cables 270.

As best seen in Figures 5a and 5b, the cable connectors 220 each include a conductive outer housing 222. When used with shielded cables, the conductive outer housing 222 is electrically connected to the shield 272 of the corresponding cable 270, such as by soldering the outer housing 222 to a shield braid of the cable using solder hole

224 in housing 222. The outer housing contains an insulative inner housing 226 that is configured to hold a first conductive terminal 228 and a second conductive terminal 230 in electrical isolation from each other and from the outer housing 222. Although the illustrated embodiment includes only first and second conductive terminals 228, 230, it will be appreciated that additional conductive terminals may be included without departing from the invention. For example, in other embodiments each cable connector may include 3, 4, 5 or more conductive terminals. Alternately, the cable connectors 220 contained in insulative carrier 210 may have differing numbers of conductive terminals. Each terminal 228, 230 is configured at a first end 232 (adjacent front or mating end of the connector 220) to make electrical connection with a signal pin 104 of header 100. The first end 232 may be configured in any suitable manner to make connection with pin 104, including beams, bumps, dimples, or other resiliently deflectable structures. Each terminal 228, 230 is configured at a second end 234 (opposite first end 232 and near a back end of the connector 220) to make electrical connection with a conductor 235 of the corresponding cable 270. The second end 234 may be configured in any suitable manner to make connection with the conductor 235 of cable 270, such as by soldering or crimping. The conductors of the corresponding cable 270 may be signal conductors or ground conductors, depending upon the particular application. In the illustrated embodiment of Figures 5a and 5b, after terminals 228, 230 have been connected to signal conductors 235 of cable 270, terminals 228, 230 are inserted in inner housing 226 and the inner housing 226 is slidably inserted into the back end of outer housing 222, until the inner and outer housings 226, 222, respectively, are secured in snap fitting engagement by the interaction of protrusion 236 on inner housing 226 and hole 237 in outer housing 222.

The inner housing 226 includes an opening 238 adjacent the front end of the cable connector 220. The opening 238 is configured for receiving a shield blade 106 of the header 100 between the first and second terminals 228, 230. The conductive outer housing 222 includes a first contact 240 for electrically coupling with the shield blade 106 received in the opening 238 between the first and second terminals 228, 230. In other embodiments, the outer housing 222 includes at least one contact 242 on an exterior surface 244 of the outer housing 222 for electrically coupling with another shield blade 106 of the header 100. In the illustrated embodiment of Figure 6, a second contact 242a and a third contact 242b are provided on the exterior surface 244 of the outer housing 222 for electrically coupling with a second and third shield blades 106 of the header 100. The

contacts 242a, 242b on the exterior surface 244 of the outer housing 222 are preferably slightly recessed from the outermost circumference of outer housing 222, to provide room for shield blade 106 between immediately adjacent cable connectors 220. The contacts of the outer housing 222 may be of any suitable design, including beams, bumps, dimples, or other resiliently deflectable structures. In alternate embodiments having more than two terminals, inner housing 226 is provided with additional openings 238, such that an opening 238 for receiving a ground blade 106 is provided between all adjacent terminals. For example, a cable connector having three terminals would have two openings, a cable connector having four terminals would have three openings, and so on.

The individual cable connectors 220 are positioned and retained within the interior 216 of insulative carrier 210, as best illustrated in Figures 6 and 7. The front wall 212 of carrier 210 is formed to include a plurality of signal-pin-receiving openings 250, and a plurality of shield-blade-receiving openings 252, all of which extend between the external surface 254 and the internal surface 256 of front wall 212. The openings 250, 252 are positioned such that they correspond to the positions of terminals 228, 230 and ground contacts 242, 242a, 242b of the cable connectors 220 when the cable connectors 220 are positioned in the carrier 210. The plurality of signal-pin-receiving openings 250 are formed to have a generally circular cross-section, while the plurality of shield-blade-receiving openings 252 are formed to have a generally rectangular cross-section. The openings 250, 252 may have other cross-sectional profiles, depending upon the cross-sectional shape of the mating signal pins 104 and shield blades 106. The openings 250, 252 may include chamfered entrances at external surface 254 to assist in the insertion of pins 104 and shield blades 106.

Positioning posts 260 extend from internal surface 256 of front wall 212, and are shaped and spaced from each other such that individual cable connectors 220 (shown in dashed lines in Figure 7) are removably retained within carrier 210. Additional positioning features 262 may be provided on the interior surface of one or more side walls 214a, 214b, 214c, 214d to aid in positioning and retaining cable connectors 220. After all of the cable connectors 220 are loaded into carrier 210, cable connectors 220 are secured in carrier 210 by a retention clip 266. Retention clip 266 is inserted through openings 268 in side walls 214a, 214b of carrier 210 in a direction transverse to the insertion direction of cable connectors 220, such that retention clip 266 is positioned behind cable connectors 220. Retention clip 266 preferably is releasably secured to carrier 210, such as by resilient

latch arms 267, so that retention clip 266 may be removed, if necessary, to repair or replace one or more cable connectors 220.

As shown in Figure 4, a cable shroud 269 is also preferably engaged with the carrier 210. The cable shroud 269 protects and guides the cables 270 as they exit the carrier 210. In one embodiment, cable shroud 268 guides cables 270 at an angle to the engagement direction of the socket connector 200, such that a low profile connection is provided. In one low profile system, cable shroud 269 guides cables 270 in a right-angle bend, where the bend radius is approximately equal to or less than ten times the cable diameter.

The interaction of individual cable connectors 220 with the signal pins 104 and shield blades 106 of header 100 that occurs when header 100 and socket 200 are engaged is best seen in Figure 8, in which only the cable connectors, signal pins 104 and shield blades 106 are illustrated. As clearly seen in Figure 8, signal pins 104 are received by terminals 228, 230 within cable connectors 220, while shield blades 106 are received in openings 238 between adjacent terminals within each connector 220, and also in recessed areas between adjacent cable connectors 220. The shield blades 106 in recessed areas between adjacent cable connectors 220 are in electrical engagement with both cable connectors 220. In the illustrated embodiments, adjacent terminal/ground pins are each separated by a ground path. However, in other embodiments according to the invention, ground paths need not be provided between every adjacent terminal/ground pin. The multiple ground paths provided in the connector system afford the connector system with a stable impedance profile. In particular, because of the multiple ground paths in the connector system, the effect on the impedance profile of the connector as a whole and of individual signal conductors caused by the failure of a single ground path is reduced or minimized.

All plastic parts of header connector 100 and socket connector 200 are molded from suitable thermoplastic material, such as liquid crystal polymer ("LCP"), having the desired mechanical and electrical properties for the intended application. The conductive metallic parts are made from, for example, plated copper alloy material, although other suitable materials will be recognized by those skilled in the art. The connector materials, geometry and dimensions are all designed to maintain a specified impedance throughout the part.

Although specific embodiments have been illustrated and described herein for purposes of description of the preferred embodiment, it will be appreciated by those of ordinary skill in the art that a wide variety of alternate and/or equivalent implementations calculated to achieve the same purposes may be substituted for the specific embodiments shown and described without departing from the scope of the present invention. Those with skill in the mechanical, electro-mechanical, and electrical arts will readily appreciate that the present invention may be implemented in a very wide variety of embodiments. This application is intended to cover any adaptations or variations of the preferred embodiments discussed herein. Therefore, it is manifestly intended that this invention be limited only by the claims and the equivalents thereof.

What is claimed is:

1. An electrical connector comprising:
an insulative carrier (210);
at least one cable connector (220) positioned in the carrier (210), each cable
5 connector (220) comprising a conductive outer housing (222) having
therein an insulative inner housing (226), the inner housing (226) holding
first and second conductive terminals (228, 230) in electrical isolation from
each other and the outer housing (222), the inner housing (226) configured
for receiving a shield blade (106) between the first and second terminals
10 (228, 230), the outer housing (222) including a first contact (240) for
electrically coupling with the shield blade (106) received between the first
and second terminals (228, 230).
2. The electrical connector of claim 1, wherein the outer housing (222) further
15 comprises a second contact (242a) for electrically coupling with a second shield
blade (106) on an exterior surface of the outer housing, and a third contact (242b)
for electrically coupling with a third shield blade (106) on an exterior surface of
the outer housing (222).
- 20 3. The electrical connector of claim 1, further comprising a retention clip (226) to
secure the at least one cable connector (220) in the carrier.
4. The electrical connector of claim 1, further comprising a cable (270) corresponding
25 to each cable connector (220), wherein each cable connector (220) terminates the
corresponding cable (270).
5. The electrical connector of claim 4, wherein the conductive outer housing (222) is
electrically connected to a shield (272) of the corresponding cable (270).
- 30 6. The electrical connector of claim 4, wherein the first terminal (228) is connected at
one end to a first signal conductor (235) of the corresponding cable (270) and the
second terminal (230) is connected at one end to a second signal conductor (235)
of the corresponding cable (270).

7. The electrical connector of claim 4, wherein the cable (270) is a coaxial cable.
8. The electrical connector of claim 4, wherein the cable (270) is a twinaxial cable.
- 5 9. The electrical connector of claim 4, further comprising a cable shroud (269) engaged with the carrier (210) to guide the cable (270) at an angle to an engagement direction of the connector.
- 10 10. The electrical socket connector of claim 9, wherein the cable (270) has a bend radius equal to or less than ten times the diameter of the cable.
11. The electrical connector of claim 1, further comprising a header connector (100) comprising a header body (102) having a plurality of signal pins (104) and a
15 plurality of shield blades (106) extending therefrom, wherein the insulative carrier (210) is configured to engage the header connector (100).
12. The electrical connector of claim 11, wherein each of the plurality of shield blades (106) has a generally right angle shielding portion (128) configured to be disposed
20 adjacent to a corresponding one of the plurality of signal pins (104).
13. The electrical connector system of claim 12, wherein the plurality of signal pins (104) and plurality of shield blades (106) are arranged in the header body (102) such that the generally right angle shielding portions (128) of the plurality of shield
25 blades (106) substantially surround the plurality of signal pins (104) to form a coaxial shield around each of the plurality of signal pins (104).
14. The electrical connector system of claim 11, wherein the plurality of shield blades (106) are formed in a continuous strip of material and includes at least one tail
30 (148) configured for engagement with a printed circuit board (30).