

# **ELECTRICAL CONNECTOR**

## **BACKGROUND OF THE INVENTION**

### **1. Field of the Invention**

The present invention relates to an electrical connector and, in particular, to a connector suitable for transmission of high frequency signals.

### **2. Description of the Related Art**

Connectors are widely utilized as means to connect two devices for communication or data transmission. To meet the requirement of the transmission of large quantities of data, the data transfer speed is continuously being increased. As the data transfer speed increases, connectors designed for lower transmission speed may have to be redesigned to ensure signal integrity.

FIG. 1 shows a conventional stacking connector 1, and FIG. 2 shows a plurality of terminals 2 and 9 arrayed in the stacking connector 1. The stacking connector 1 includes a housing 11 having upper and lower receptacles 111 and 112 configured to separately hold the contact portions 21 and 91 of the terminals 2 and 9 arranged in a side-by-side manner. Each of the plurality of upper and lower terminals 2 and 9 further includes a barbed portion 22 or 92 connected to the contact portion 21 or 91 and an extension portion 23 or 93 connected to the barbed portion 22 or 92. The extension portion 23 or 93 extends from the barbed portion 22 or 92, is bent vertically, and then extends straight to form an end that can be configured to be soldered to a through hole on a printed circuit board.

The plurality of upper terminals 2 partially received in the upper receptacle 111 may include two ground terminals (27 and 28) and two differential pairs 24 and 25, between which a ground pin 26, having a configuration similar to that of the terminal 2 of the differential pairs 24 and 25, is disposed. The two ground terminals 27 and 28 are separately

disposed on opposite sides of the two differential pairs 24 and 25. Similarly, the plurality of lower terminals 9 partially received in the lower receptacle 112 may include two ground terminals 97 and 98 and two differential pairs 94 and 95, with a ground pin 96 disposed between the two differential pairs 94 and 95. The terminals 2 of the two differential pairs 24 and 25 received in the upper receptacle 111 have extension portions 23 longer than the extension portions 93 of the lower terminals 9 partially received in the lower receptacle 112. Accordingly, when the terminals 2 of the two differential pairs 24 and 25 are adapted for high speed data transmission, for example 3Gbps, signal integrity cannot be ensured due to their longer extension portions 23. In addition, the ground pin 26 or 96 having a configuration similar to the terminal 2 or 9 cannot provide sufficient shielding effectiveness, resulting in poor signal integrity.

Further, the extension portion 23 or 93 of the terminal 2 or 9 is vertically bent, and such vertically bent terminals 2 may also affect the transmission of signals.

Moreover, because the plurality of terminals 2 and 9 are regularly arranged such that electrical fields emanating from the differential pairs 24 and 25 are not optimized, signal transmission is adversely affected.

In light of the above-mentioned problems, the conventional connector cannot satisfy high speed transmission requirements, and therefore a new connector for high signaling speed is required.

## **SUMMARY OF THE INVENTION**

An objective of the present invention is to provide a new and improved electrical connector that can be adapted for high speed data transmission.

In order to achieve the above objective, one embodiment of the present invention provides an electrical connector, which comprises a dielectric housing, at least one first differential pair, and at least one first ground terminal.

The dielectric housing is configured for connecting to a mated connector.

Each first differential pair includes a pair of first terminals. Each first terminal includes a contact portion, a retention portion, an extension portion, and a solder tail portion, wherein the contact portion of the first terminal extends within the dielectric housing, the retention portion of the first terminal extends between the contact portion of the first terminal and the extension portion of the first terminal, and the extension portion of the first terminal extends between the retention portion of the first terminal and the solder tail portion of the first terminal.

Each second differential pair includes a pair of second terminals. Each second terminal includes a contact portion, a retention portion, an extension portion, and a solder tail portion, wherein the contact portion of the second terminal extends within the dielectric housing, the retention portion of the second terminal extends between the contact portion of the second terminal and the extension portion of the second terminal, and the extension portion of the second terminal extends between the retention portion of the second terminal and the solder tail portion of the second terminal.

The at least one first ground terminal is juxtaposed to the at least one first differential pair. Each at least one first ground terminal includes a contact portion, a retention portion, an extension portion, and a solder tail portion, wherein the contact portion of the first ground terminal extends within the dielectric housing, the retention portion of the first ground terminal extends between the contact portion of the first ground terminal and the extension portion of the first ground terminal, and the extension portion of the first ground terminal extends between the retention portion of the first ground terminal and the solder tail portion of the first ground terminal. The extension portions of the first terminals and the first ground terminal are arranged in a staggered manner, and the extension portion of the middle one of the first terminals, next to the first ground terminal, includes a widened section, which extends widthwise such that the widened

section partially overlaps the extension portions of the outermost one of the first terminals and the first ground terminal.

## **BRIEF DESCRIPTION OF THE DRAWINGS**

The invention will be described according to the appended drawings in which:

FIG. 1 shows a conventional electrical connector;

FIG. 2 shows a plurality of terminals arrayed in the electrical connector of FIG. 1;

FIG. 3 is a front perspective view showing an electrical connector according to one embodiment of the present invention;

FIG. 4 is a rear perspective view of the electrical connector of FIG. 3;

FIG. 5 is a perspective, sectional view of the electrical connector of FIG. 4 according to one embodiment of the present invention;

FIG. 6 is an exploded perspective view showing an electrical connector according to one embodiment of the present invention;

FIG. 7 is a perspective view showing two first differential pairs, two second differential pairs and a middle ground terminal according to one embodiment of the present invention;

FIG. 8 is a side view of the two first differential pairs, the two second differential pairs and the middle ground terminal of FIG. 7;

FIG. 9 is a rear view of the two first differential pairs and the middle ground terminal of FIG. 7;

FIG. 10 is an exploded perspective view showing the two first differential pairs, the two second differential pairs and the middle ground terminal of FIG. 7;

FIG. 11 is a rear view showing an electrical connector according to one embodiment of the present invention;

FIG. 12 is a cross-sectional view along line Z-Z of FIG. 10; and

FIG. 13 is a cross-sectional view along line Y-Y of FIG. 10.

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## **DETAILED DESCRIPTION OF THE INVENTION**

As illustrated in FIGS. 3 to 7, one embodiment of the present invention proposes an electrical connector 3, which may comprise a dielectric housing 31 configured for connecting to a mated connector, at least one first differential pair 4 or 5, and at least one first ground terminal 35 juxtaposed to the at least one first differential pair 4 or 5.

The at least one first differential pairs 4 or 5 may comprise a pair of first terminals 33a or 33b used for differential signaling. Each of the first terminals 33a and 33b may comprise a contact portion 331 configured to extend within the dielectric housing 31, a retention portion 332 for fixing, an extension portion 333a or 333b, and a solder tail portion 334 configured to be soldered to a printed circuit board. The retention portion 332 is configured to extend between the contact portion 331 and the extension portion 333a or 333b, and the extension portion 333a or 333b is configured to extend between the retention portion 332 and the solder tail portion 334.

The at least one first ground terminal 35 may comprise a contact portion 351 configured to extend within the dielectric housing 31, a retention portion 352 for fixing, an extension portion 353, and a solder tail portion 354 configured to be soldered to a printed circuit board for grounding. The retention portion 352 is configured to extend between the contact portion 351 and the extension portion 353, and the extension portion 353 is configured to extend between the retention portion 352 and the solder tail portion 354.

In particular, in the combination of the at least one first differential pair 4 or 5 and its corresponding first ground terminal 35, the extension portions

(333a, 333b, and 353) of the first terminals 33a and 33b and the first ground terminal 35 can be arranged in a staggered manner as shown in FIG. 7. As shown in FIG. 9, in the at least one first differential pair 4 or 5, the extension portion 333b of the middle first terminal 33b, positioned next to the first ground terminal 35, may include a widened section 3331 that can extend widthwise such that the widened section 3331 partially overlaps the extension portions 333a and 353 of the outer first terminal 33a and the first ground terminal 35 when, for example, viewed from a direction along the insertion direction of the first terminals 33a and 33b or viewed from a direction that is perpendicular to one principal surface defining the extension portion 333b of the first terminal 33b. Such a staggered and partially overlapping relationship may optimize the interaction of the electrical fields induced by the at least one first differential pair 4 or 5, resulting in better coupling of signals.

In another embodiment of the present invention, the electrical connector 3 may comprise a middle ground terminal 32 configured to be electrically grounded, two first differential pairs 4 and 5 juxtaposed to each other, and two first ground terminals 35 configured to be electrically grounded. The middle ground terminal 32 can be disposed between the two first differential pairs 4 and 5. The two first ground terminals 35 can be disposed on opposite sides of the two first differential pairs 4 and 5 as shown in FIGS. 7 and 9.

In addition to the above embodiments, the electrical connector 3 can be a stacking connector according to one embodiment of the present invention. As illustrated in FIGS. 3 to 6, the electrical connector 3 comprises a dielectric housing 31 comprising a first receptacle 311 and a second receptacle 312, a middle ground terminal 32, two first differential pairs 4 and 5, and two second differential pairs 6 and 7.

As shown in FIG. 3, the first receptacle 311 and the second receptacle 312, respectively protruding forward from a main body 313, are juxtaposed in a vertical direction indicated by arrow X. The first receptacle 311 may

include a slot 3111 configured for receiving a mating plug connector. The slot 3111 can be a single slot extending within the first receptacle 311, or can be segmented by a partition 3112 as shown in FIG. 3. Similarly, the second receptacle 312 may also include an internally extending single slot 3121 for receiving a mating plug connector. The slots 3121 may also be segmented by a partition 3122 as shown in FIG. 3.

Referring to FIGS. 3 and 6, the dielectric housing 31 may comprise two side walls 314 protruding backward from the main body 313, defining an accommodation space. On the external wall surface of each side wall 314, a fixing portion 315 can be disposed. The fixing portion 315 can be near the bottom edge of the respective side wall 314 and is configured to hold a board lock 37, by which the electrical connector 3 can be fixed to a printed circuit board.

Referring to FIG. 6, a lower protrusion 3141 can be disposed on the inner surface of each side wall 314, extending along the bottom edge of the side wall 314. Moreover, a middle protrusion 3142 can be disposed on the inner surface of each side wall 314, parallel to and separated from the lower protrusion 3141 by a gap 3144. The electrical connector 3 may further comprise two plate members 38, on which a plurality of through holes 381 are formed. On the two opposite side edges of each plate member 38, recesses 382 and projected portions 383 are formed. Correspondingly, on a side surface of each lower protrusion 3141 facing the accommodation space, two juts 3143 are formed to engage the respective recesses 382 so that the plate members 38 are guided while they are being assembled, and the plate members 38 can be constrained after they are assembled. The projected portion 383 extends widthwise and is disposed adjacent to the top surface of the plate member 38. In addition, the projected portion 383 is configured to interfere with the lower protrusion 3141 and to be received by the respective gap 3144, and to be held between the middle protrusion 3142 and the lower protrusion 3141 after the plate member 38 is installed.

Referring to FIGS. 6, 7, 11, and 13, each of the first terminals 33a and

33b may comprise a contact portion 331 configured to extend above the slot 3111 and partially protrude into the slot 3111, a retention portion 332 connected to the contact portion 331, a solder tail portion 334 configured to extend through the respective through hole 381 in the plate members 38,  
5 and an extension portion 333a or 333b extending between the retention portion 332 and the solder tail portion 334. Each of the second terminals 34a and 34b may comprise a contact portion 341 configured to extend above the slot 3121 and partially protrude into the slot 3121, a retention portion 342 connected to the contact portion 341, a solder tail portion 344  
10 configured to extend through the respective through hole 381 in the plate members 38, and an extension portion 343a or 343b extending between the retention portion 342 and the solder tail portion 344.

Referring to FIG. 10, the middle ground terminal 32 may include a plate portion 321 having a first side edge 3211 and disposed within the accommodation space, a lower contact portion 322 protruding forward from  
15 the first side edge 3211, an upper contact portion 323 protruding forward from the first side edge 3211, and a solder tail portion 324 protruding downward from the plate portion 321 and configured for being soldered to a ground connection point of a printed circuit board. In particular, the lower and upper contact portions 322 and 323 and the solder tail portion 324 can  
20 be integrally formed with the plate portion 321. Referring to FIGS. 10 and 12, the lower contact portion 322 is configured to extend within the second receptacle 312, above the slot 3121, with a part of the lower contact portion 322 protruding into the slot 3121 for electrically engaging a mated  
25 connector. The upper contact portion 323 is configured to extend within the first receptacle 311, above the slot 3111, with a part of the upper contact portion 323 protruding into the slot 3111 for electrically engaging a mated connector. As shown in FIG. 10, a plurality of notches 3212 can be formed on the first side edge 3211 of the plate portion 321 so as to divide the first  
30 side edge 3211 into several segments 3213. Correspondingly, a plurality of slits 316, as shown in FIG. 6, can be formed for receiving the segments 3213. Thus, the middle ground terminal 32 can be properly held after it is

installed.

As shown in FIG. 12, two holes 317 can be separately formed to connect the slot 3111 with the respective slit 316 and to connect the slot 3121 with the respective slit 316, respectively allowing the lower and upper  
5 contact portions 322 and 323 to be inserted into the slots 3111 and 3121. Two barb portions 318 can be separately formed between the plate portion 321 and the lower contact portion 322, and between the plate portion 321 and the upper contact portion 323. The barb portions 318 are configured to engage the respective holes 317 so as to secure the middle ground terminal  
10 32 to the dielectric housing 31.

Referring to FIGS. 7, 8, 9, 11, and 13, the middle ground terminal 32 can be grounded and is configured to be disposed between the two first differential pairs 4 and 5 and between the two second differential pairs 6 and 7. Referring to FIGS. 7 and 8, the plate portion 321 of the middle  
15 ground terminal 32 is configured to separate or hide the extension portions 333a and 333b of the first terminals 33a and 33b of one first differential pair 4 from the extension portions 333a and 333b of the first terminals 33a and 33b of another first differential pair 5 such that the coupling and crosstalk between the two first differential pairs 4 and 5 can be reduced and  
20 the signal transmission speed can be increased. Furthermore, the plate portion 321 of the middle ground terminal 32 is also configured to separate or hide the extension portions 343a and 343b of the second terminals 34a and 34b of one second differential pair 6 from the extension portions 343a and 343b of the second terminals 34a and 34b of another second differential  
25 pair 7 such that the coupling and crosstalk between the two second differential pairs 6 and 7 can be reduced and the signal transmission speed can be increased.

Specifically, the plate portion 321 includes an upper edge 3214 configured to be higher than the higher end portions of the extension  
30 portions 333a and 333b connecting to the respective retention portions 332, a lower edge 3215 configured to be lower than the lower end portions of the

extension portions 343a and 343b connecting to the respective retention portions 342, and a second side edge 3216 correspondingly configured to be away from the main body 313 of the dielectric housing 31 farther than the extension portions 333a and 333b of the first terminals 33a and 33b.

5        As shown in FIGS. 6 to 9, the electrical connector 3 may further comprise two first ground terminals 35 each disposed adjacent to the respective one of the first differential pairs 4 and 5 and opposite to the middle ground terminal 32, and two second ground terminals 36 each disposed adjacent to the respective one of the second differential pairs 6 and  
10       7 and opposite to the middle ground terminal 32. In other words, the two second differential pairs 6 and 7 are disposed between the two second ground terminals 36. Each first ground terminal 35 may comprise a contact portion 351 configured to partially protrude into the slot 3111, a retention portion 352 connected to the contact portion 351, a solder tail portion 354  
15       configured to extend through the respective through hole 381 in the plate members 38 to be grounded, and an extension portion 353 extending between the retention portion 352 and the solder tail portion 354. Correspondingly, each second ground terminal 36 may comprise a contact portion 361 configured to partially protrude into the slot 3121, a retention  
20       portion 362 connected to the contact portion 361, a solder tail portion 364 configured to extend through the respective through hole 381 in the plate members 38, and an extension portion 363 extending between the retention portion 362 and the solder tail portion 364.

Referring to FIGS. 7 to 9, in the embodiment of the stacking connector,  
25       to facilitate the coupling of signals transmitted over each first differential pair 4 or 5 having a longer signal transmission path, the extension portions 333a, 333b, and 353 of the first terminals 33a and 33b and the first ground terminal 35 can be differently spaced from the main body 313 of the dielectric housing 31, and the widened section 3331 of the first terminal 33b  
30       next to the respective first ground terminal 35 may have a width greater than a spaced distance between the respective first ground terminal 35 and

another first terminal 33a. As a result, the edge portions of the widened section 3331 of the extension portion 333b can separately overlap the edge portion of the extension portion 333a and the edge portion of the extension portion 353, resulting in better coupling of signals.

5 Referring to FIGS. 7 and 8, each of the extension portions 333a, 333b and 353 of the first terminals 33a and 33b and the first ground terminals 35 may include two obtuse bends 367 and 368 such that the contact portion 331 of each first terminals (33a or 33b) and the corresponding solder tail portion 334 of the first terminal (33a or 33b) can extend in different  
10 directions, and the contact portion 351 of the first ground terminal 35 and the solder tail portion 354 of the first ground terminal 35 can extend in different directions. In addition, due to the application of the obtuse bends 367 and 368, the first terminals 33a and 33b and the ground terminals 35 do not have to be sharply bent; therefore, signal transmission can be improved.  
15 In the present embodiment, the angle of the two obtuse bends 367 and 368 can be, but is not limited to, 135 degrees.

Referring to FIGS. 6 and 7, a plurality of arrayed terminal holes 51 and 52 can be formed through the main body 313 of the dielectric housing 31 and can be communicated to the respective slots 3111 and 3121. The  
20 retention portion 332, 342, 352 or 362 of each of the first terminals 33a and 33b, the second terminals 34a and 34b, and the ground terminals 35 and 36 may include a plurality of oppositely protruding barbs 3321, 3421, 3521 or 3621 configured for secure engagement with two opposite side walls defining the respective terminal hole 51 or 52. In addition, the contact  
25 portions 331, 341, 351 and 361 of the first terminals 33a and 33b, the second terminals 34a and 34b, and the ground terminals 35 and 36 are inserted into the respective receptacles 311 and 312 through the terminal holes 51 and 52 such that each terminal hole 51 or 52 is configured to be widened vertically so as to allow the respective contact portion 331, 341,  
30 351 or 361 to pass through and to enter into the respective receptacle 311 or 312.

In addition, the barbs 3321 of the first terminals 33 can be aligned in a direction parallel to the array direction of the first terminals 33 such that the signal integrity of the signals transmitted on the first terminals 33 can be ensured. Similarly, the barbs 3421 of the second terminals 34 can be aligned in a direction parallel to the array direction of the second terminals 34 such that the signal integrity of the signals transmitted on the second terminals 34 can be ensured.

Referring to FIGS. 3 and 6, the electrical connector 3 may further comprise a plurality of first power terminals 41 each including a contact portion 411 extending below and partially protruding into the slot 3111 within the first receptacle 311, a plurality of first signal terminals 42 each including a contact portion 421 extending below and partially protruding into the slot 3111 within the first receptacle 311, a plurality of second power terminals 43 each including a contact portion 431 extending below and partially protruding into the slot 3121 within the second receptacle 312, and a plurality of second signal terminals 44 each including a contact portion 441 extending below and partially protruding into the slot 3121 within the second receptacle 312. The first and second power terminals 41 and 43 can be configured to transmit power, and the first and second signal terminals 42 and 44 can be configured to transmit signals.

In summary, an electrical connector 3 that can meet the requirements of high speed data transmission is proposed. The electrical connector 3 comprises at least one first differential pair 4 or 5 including a pair of first terminals 33a and 33b each having an extension portion 333a or 333b and at least one first ground terminal 35 juxtaposed to the at least one first differential pair 4 or 5 and having an extension portion 353. The extension portions 333a, 333b, and 353 of the first terminals 33a and 33b and the first ground terminal 35 can be arranged in a staggered and partially overlapping manner such that the interaction of the electrical fields induced by the at least one first differential pair 4 or 5 can be optimized, resulting in better coupling of signals.

The above-described embodiments of the present invention are intended to be illustrative only. Numerous alternative embodiments may be devised by persons skilled in the art without departing from the scope of the following claims.

**What is claimed is:**

1. An electrical connector, comprising:

a dielectric housing configured for connecting to a mated connector;

at least one first differential pair each including a pair of first  
5 terminals, each first terminal including a contact portion, a retention portion,  
an extension portion, and a solder tail portion, wherein the contact portion  
of the first terminal extends within the dielectric housing, the retention  
portion of the first terminal extends between the contact portion of the first  
10 terminal and the extension portion of the first terminal, and the extension  
portion of the first terminal extends between the retention portion of the  
first terminal and the solder tail portion of the first terminal; and

at least one first ground terminal juxtaposed to the at least one first  
differential pair, each at least one first ground terminal including a contact  
portion, a retention portion, an extension portion, and a solder tail portion,  
15 wherein the contact portion of the first ground terminal extends within the  
dielectric housing, the retention portion of the first ground terminal extends  
between the contact portion of the first ground terminal and the extension  
portion of the first ground terminal, and the extension portion of the first  
ground terminal extends between the retention portion of the first ground  
20 terminal and the solder tail portion of the first ground terminal;

wherein the extension portions of the first terminals and the first  
ground terminal are arranged in a staggered manner, and the extension  
portion of the middle one of the first terminals, next to the first ground  
terminal, includes a widened section, which extends widthwise such that the  
25 widened section partially overlaps the extension portions of the outermost  
of the first terminals and the first ground terminal.

2. The electrical connector of Claim 1, further comprising a  
middle ground terminal, wherein the at least one first differential pair  
comprises two first differential pairs juxtaposed to each other, and the at  
30 least one first ground terminal comprises two first ground terminals; the

middle ground terminal is disposed between the two first differential pairs, and the two first ground terminals are disposed on opposite sides of the two first differential pairs.

3. The electrical connector of Claim 2, wherein each of the  
5 extension portions of the first terminal and the first ground terminal comprises two obtuse bends.

4. The electrical connector of Claim 3, wherein the dielectric  
housing comprises a first receptacle and a second receptacle vertically  
juxtaposed, wherein the contact portions of the first terminals and the first  
10 ground terminals extend within the first receptacle.

5. The electrical connector of Claim 4, further comprising two  
second differential pairs and two second ground terminals, each second  
differential pair including two second terminals, each second terminal  
having a contact portion, a retention portion, an extension portion, and a  
15 solder tail portion, wherein the contact portion of the second terminal  
extends within the second receptacle, the retention portion of the second  
terminal extends between the contact portion of the second terminal and the  
extension portion of the second terminal, and the extension portion of the  
second terminal extends between the retention portion of the second  
20 terminal and the solder tail portion of the second terminal, wherein the two  
second differential pairs are disposed between the two second ground  
terminals.

6. The electrical connector of Claim 5, wherein the middle  
ground terminal includes a plate portion and two contact portions, the plate  
25 portion and two contact portions are integrally formed, the two contact  
portions separately extend within the first receptacle and the second  
receptacle, the plate portion is disposed between the two first differential  
pairs and between the two second differential pairs and is configured to  
separate the extension portions of the first terminals of one first differential

pair from the extension portions of the first terminals of another first differential pair, and to separate the extension portions of the second terminals of one second differential pair from the extension portions of the second terminals of another second differential pair.

5           7. The electrical connector of Claim 6, wherein the middle ground terminal further comprises at least an integrally formed solder tail portion configured for grounding.

10           8. The electrical connector of Claim 7, wherein the retention portion of each of the first terminal and the second terminal comprises a plurality of barbs, the barbs of the pair of first terminals are aligned in a direction parallel to an array direction of the first terminals, and the barbs of the pair of second terminals are aligned in a direction parallel to an array direction of the second terminals.

15           9. The electrical connector of Claim 5, further comprising a plurality of first power terminals each including a contact portion extending within the first receptacle, a plurality of first signal terminals each including a contact portion extending within the first receptacle, a plurality of second power terminals each including a contact portion extending within the second receptacle, and a plurality of second signal terminals each including  
20 a contact portion extending within the second receptacle.

10. The electrical connector of Claim 9, wherein the dielectric housing comprises two side walls, wherein the middle ground terminal is disposed between the two side walls.