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GROUND BUS FOR A CABLE ASSEMBLY

Abstract

A cable assembly includes a contact assembly coupled to cables. The contact assembly includes a contact holder, contacts held by the contact holder, and a ground bus coupled to the contact holder. The contacts include signal contacts and ground contacts held in contact channels. Each contact includes an intermediate section between a forward section and a rearward section. The forward section extends forward of the front of the contact holder. The rearward section extends rearward of the rear of the contact holder. The ground bus includes ground rails connected to the ground contacts each having a front mating finger coupled to the forward portion of the corresponding ground contact and a rear mating finger coupled to the rearward portion of the corresponding ground contact.

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Background/Summary

BACKGROUND OF THE INVENTION

[0001] The subject matter herein relates generally to electrical connector assemblies.

[0002] Some communication systems utilize communication connectors, such as electrical connector assemblies to interconnect various components of the system for data communication. Some known communication systems use pluggable modules, such as I/O modules or circuit cards, which are electrically connected to the electrical connector assemblies. The pluggable modules have module circuit cards having card edges that are mated with the electrical connector assemblies during the mating operation. Each electrical connector assembly typically has an upper row of contacts and a lower row of contacts for mating with the corresponding circuit board. There is a need for connectors and circuit boards of communication systems to have greater contact density and/or data throughput. Additionally, there is a trend to increase data rates. High speed data signals have shorter frequency wavelengths, leading to increased noise and reduction in signal integrity. Shielding of the electrical connectors improves signal integrity. However, addition of shielding increases the overall cost of the electrical connector.

[0003] A need remains for an improved electrical connector assembly for a communication system.

BRIEF DESCRIPTION OF THE INVENTION

[0004] In one embodiment, a cable assembly is provided and includes cables each having at least one conductor and a cable shield providing shielding for the at least one conductor. The cable assembly includes a contact assembly coupled to the cables. The contact assembly includes a contact holder, contacts held by the contact holder, and a ground bus coupled to the contact holder. The contact holder includes a front and a rear. The contact holder includes an inner end and an outer end that extends between the front and the rear of the contact holder. The contact holder includes contact channels that extend between the front and the rear. The contacts are arranged in a row. The contacts include signal contacts and ground contacts arranged between corresponding signal contacts to provide shielding between the corresponding signal contacts. The ground contacts are electrically connected to the cable shields of the corresponding cables. Each contact includes a forward section, a rearward section, and an intermediate section between the forward section and the rearward section. The intermediate section received in the corresponding contact channel and passes through the contact holder. The forward section extends forward of the front of the contact holder. The rearward section extends rearward of the rear of the contact holder. The forward section includes a spring beam configured to be mated to a mating component. The rearward section includes a terminating end terminated to corresponding cable. The ground bus includes ground rails connected to the ground contacts. Each ground rail includes a front mating finger coupled to the forward portion of the corresponding ground contact. Each ground rail includes a rear mating finger, discrete from the front mating finger, coupled to the rearward portion of the corresponding ground contact.

[0005] In another embodiment, an electrical connector assembly is provided and includes a housing having a cavity. The housing has a slot at a housing front of the housing configured to receive a mating component. The electrical connector assembly includes a cable assembly received in the cavity. The cable assembly includes cables and a contact assembly coupled to the cables. The cables each have at least one conductor and a cable shield providing shielding for the at least one conductor. The contact assembly includes a contact holder, contacts held by the contact holder, and a ground bus coupled to the contact holder. The contact holder includes a front and a rear. The contact holder includes an inner end and an outer end that extends between the front and the rear of the contact holder. The contact holder includes contact channels that extend between the front and the rear. The contacts are arranged in a row. The contacts include signal contacts and ground

contacts arranged between corresponding signal contacts to provide shielding between the corresponding signal contacts. The ground contacts are electrically connected to the cable shields of the corresponding cables. Each contact includes a forward section, a rearward section, and an intermediate section between the forward section and the rearward section. The intermediate section received in the corresponding contact channel and passes through the contact holder. The forward section extends forward of the front of the contact holder. The rearward section extends rearward of the rear of the contact holder. The forward section includes a spring beam configured to be mated to the mating component. The rearward section includes a terminating end terminated to corresponding cable. The ground bus includes ground rails connected to the ground contacts. Each ground rail includes a front mating finger coupled to the forward portion of the corresponding ground contact. Each ground rail includes a rear mating finger, discrete from the front mating finger, coupled to the rearward portion of the corresponding ground contact.

[0006] In a further embodiment, a receptacle connector assembly is provided and includes a receptacle cage having walls forming a cavity defining a module channel configured to receive a pluggable module. The receptacle connector assembly includes an electrical connector assembly received in the cavity to mate with the pluggable module. The electrical connector assembly includes a housing and a cable assembly received in the housing. The housing having a housing cavity and a slot at a housing front of the housing configured to receive module circuit board of the pluggable module. The cable assembly includes cables and a contact assembly coupled to the cables. The cables each have at least one conductor and a cable shield providing shielding for the at least one conductor. The contact assembly includes a contact holder, contacts held by the contact holder, and a ground bus coupled to the contact holder. The contact holder includes a front and a rear. The contact holder includes an inner end and an outer end extends between the front and the rear of the contact holder. The contact holder includes contact channels that extend between the front and the rear. The contacts arranged in a row. The contacts include signal contacts and ground contacts arranged between corresponding signal contacts to provide shielding between the corresponding signal contacts. The ground contacts electrically connected to the cable shields of the corresponding cables. Each contact includes a forward section, a rearward section, and an intermediate section between the forward section and the rearward section. The intermediate section received in the corresponding contact channel and passes through the contact holder. The forward section extends forward of the front of the contact holder. The rearward section extends rearward of the rear of the contact holder. The forward section includes a spring beam configured to be mated to the mating component. The rearward section includes a terminating end terminated to corresponding cable. The ground bus includes ground rails connected to the ground contacts. Each ground rail includes a front mating finger coupled to the forward portion of the corresponding ground contact. Each ground rail includes a rear mating finger, discrete from the front mating finger, coupled to the rearward portion of the corresponding ground contact.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a front perspective view of a communication system formed in accordance with an exemplary embodiment.

[0008] FIG. **2** is a rear perspective view of the mating component in accordance with an exemplary embodiment.

[0009] FIG. **3** is a front perspective view of the electrical connector assembly in accordance with an exemplary embodiment.

[0010] FIG. **4** is a front perspective view of a portion of the electrical connector assembly in accordance with an exemplary embodiment.

[0011] FIG. **5** is an exploded view of the cable assembly in accordance with an exemplary embodiment.
[0012] FIG. **6** is an assembled view of the cable assembly in accordance with an exemplary embodiment.
[0013] FIG. **7** is a front perspective view of the contact assembly in accordance with an exemplary embodiment.
[0014] FIG. **8** is a rear perspective view of the contact assembly in accordance with an exemplary embodiment.
[0015] FIG. **9** is a side view of the cable assembly in accordance with an exemplary embodiment.
[0016] FIG. **10** is a sectional view of a portion of the electrical connector assembly in accordance with an exemplary embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0017] FIG. **1** is a front perspective view of a communication system **100** formed in accordance with an exemplary embodiment. The communication system **100** includes a device **102** and a receptacle connector assembly **104** mounted to the device **102**. The device **102** may be a circuit board in various embodiments. The device **102** may be a housing, chassis, panel, or other type of device in other various embodiments, such as arranged at the front of the connector assembly. For example, the device **102** may be a vertical wall (not shown) such as a panel or chassis with an opening or cutout that receives a portion of the receptacle connector assembly **104**. The receptacle connector assembly **104** may be coupled to the device **102** using mounting lugs or brackets. The device may be oriented horizontally, vertically, or at another orientation. A mating component is configured to be electrically connected to the receptacle connector assembly **104**. The mating component may be a pluggable module **106**, such as an I/O module or a transceiver module. The mating component may be electrically connected to the device **102**. The mating component may be connected to other components within the communication system **100**, such as an integrated circuit component, a chip, a microprocessor, a memory module, or another component of the communication system, through cable connectors. The other components may be mounted to the device **102**, such as remote from the receptacle connector assembly **104**.
[0018] In an exemplary embodiment, the receptacle connector assembly **104** includes a receptacle cage **110** and an electrical connector assembly **112** (shown in phantom) adjacent the receptacle cage **110**. For example, in the illustrated embodiment, the electrical connector assembly **112** is received in the receptacle cage **110**. In other various embodiments, the electrical connector assembly **112** may be located rearward of the receptacle cage **110**. In various embodiments, the electrical connector assembly **112** is a card edge connector and may be referred to hereinafter as a card edge connector **112**. The electrical connector assembly **112** may be electrically connected to the device **102**. The electrical connector assembly **112** may be connected to other components by cables of a cable connector.
[0019] In various embodiments, the receptacle cage **110** is enclosed and provides electrical shielding for the electrical connector assembly **112**. The pluggable module **106** is loaded into the receptacle cage **110** and is at least partially surrounded by the receptacle cage **110**. The receptacle cage **110** includes a plurality of walls **114** that define one or more module channels **116** for receipt of corresponding pluggable module(s) **106**. The walls **114** may be walls defined by solid sheets, perforated walls to allow airflow therethrough, walls with cutouts, such as for a heatsink or heat spreader to pass therethrough, or walls defined by rails or beams with relatively large openings, such as for airflow therethrough.
[0020] In the illustrated embodiment, the receptacle cage **110** is a single port cage having a single module channel **116**. In alternative embodiments, the receptacle cage **110** constitutes a multi-port cage having multiple module channels **116**. The module channels **116** may be arranged in a single row or may be stacked in multiple rows. In various embodiments, the receptacle cage **110** may include four module channels **116** arranged in a single row (for example, 1×4). However, the

receptacle cage **110** may include multiple rows in alternative embodiments (for example, 2×2, 3×2, 4×2, 4×3, etc.). Any number of module channels **116** may be provided in various embodiments. Optionally, multiple electrical connector assemblies **112** may be arranged within the receptacle cage **110** for mating with the corresponding pluggable module **106**.

[0021] In an exemplary embodiment, the walls **114** of the receptacle cage **110** include a top wall **130**, a bottom wall **132**, and side walls **134** extending between the top wall **130** and the bottom wall **132**. The bottom wall **132** may rest on the device **102**. In other various embodiments, the receptacle cage **110** may be provided without the bottom wall **132**. Optionally, the module channel **116** may be open at the front and the rear. However, the walls **114** of the receptacle cage **110** may include a rear wall and/or a front wall.

[0022] The walls **114** define a cavity **140**, which defines one or more of the module channels **116**. For example, the cavity **140** may be defined by the top wall **130**, the bottom wall **132**, and the side walls **134**. In an exemplary embodiment, other walls **114** may separate or divide the cavity **140** into the various module channels **116**. For example, the walls **114** may include divider walls between the module channels **116**.

[0023] In an exemplary embodiment, the receptacle cage **110** may include one or more gaskets **142** at the front and/or the rear for providing electrical shielding for the ports to the module channels **116**. For example, the gaskets **142** may be configured to electrically connect with the pluggable module **106** and/or the opening in the device **102** where the receptacle cage **110** is mounted. The gaskets **142** may be configured to electrically connect to a panel or bezel.

[0024] In an exemplary embodiment, the receptacle connector assembly **104** may include one or more heat sinks (not shown) for dissipating heat from the pluggable module **106**. For example, the heat sinks may be coupled to the top wall **130** for engaging the pluggable module **106** received in the module channels **116**. The heat sinks may extend through openings in the top wall **130** to directly engage the pluggable module **106**. Other types of heat sinks may be provided in alternative embodiments.

[0025] In an exemplary embodiment, each electrical connector assembly **112** is received in the cavity **140**, such as at the rear. The electrical connector assembly **112** may be removable from the receptacle cage **110**. In an exemplary embodiment, the pluggable module **106** are loaded through the front to mate with the electrical connector assembly **112**. The shielding walls **114** of the receptacle cage **110** provide electrical shielding around the electrical connector assembly **112** and the pluggable module **106**, such as around the mating interfaces between the electrical connector assembly **112** and the pluggable module **106**.

[0026] FIG. **2** is a rear perspective view of the mating component in accordance with an exemplary embodiment. In the illustrated embodiment, the mating component is a pluggable module **106**. The pluggable module **106** has a pluggable body **180**, which may be defined by one or more shells. The pluggable body **180** may be thermally conductive and/or may be electrically conductive, such as to provide EMI shielding for the pluggable module **106**. The pluggable body **180** includes a mating end **182** and an opposite front end **184**. The mating end **182** is configured to be inserted into the corresponding module channel **116** (shown in FIG. **1**). The front end **184** may be a cable end having a cable extending therefrom to another component within the system.

[0027] The pluggable module **106** includes one or more module circuit cards **190** that is/are configured to be communicatively coupled to the electrical connector assembly **112** (shown in FIG. **1**). Each module circuit card **190** may be accessible at the mating end **182**. The module circuit card **190** has a card edge **192** extending between a first or upper surface and a second or lower surface at a mating end of the module circuit card **190**. The module circuit card **190** includes mating contacts **194**, such as pads or circuits, at the card edge **192** configured to be mated with the electrical connector assembly **112**. In an exemplary embodiment, the mating contacts **194** are provided on the upper surface and the lower surface. The module circuit card **190** may include components, circuits and the like used for operating and or using the pluggable module **106**. For example, the module

circuit card **190** may have conductors, traces, pads, electronics, sensors, controllers, switches, inputs, outputs, memory, and the like associated with the module circuit card **190**, which may be mounted to the module circuit card **190**, to form various circuits.

[0028] In other various embodiments, the mating component may be a circuit card rather than an I/O module. For example, the mating component may include the module circuit card(s) **190** without the pluggable body **180** surrounding the module circuit card **190**. For example, the mating component may be a paddle card.

[0029] FIG. **3** is a front perspective view of the electrical connector assembly **112** in accordance with an exemplary embodiment. FIG. **4** is a front perspective view of a portion of the electrical connector assembly **112** in accordance with an exemplary embodiment. The electrical connector assembly **112** includes one or more cable assemblies **200** and a housing **202** holding the cable assemblies **200**. FIG. **3** shows the electrical connector assembly **112** with the housing **202**. FIG. **4** shows the electrical connector assembly **112** without the housing **202** to illustrate the cable assemblies **200**. Each cable assembly **200** includes one or more contact assemblies **300** and cables **400** terminated to the corresponding contact assembly **300**.

[0030] The housing **202** includes a cavity **204** that receives the cable assemblies **200**. The housing **202** extends between a front **206** and a rear **208**. The cavity **204** is open at the rear **208** to receive the cable assemblies **200**. The housing **202** extends between a top **210** and a bottom **212**. The housing **202** extends between opposite sides **218**. The housing **202** may be generally box shaped in various embodiments. In the illustrated embodiment, the bottom **212** may define a mounting end configured to be mounted to the device **102** (shown in FIG. **1**) and/or the receptacle cage **110**. The sides **218** may define mounting ends configured to be mounted to the receptacle cage **110** and/or the device **102**. The front **206** defines a mating end configured to be mated with the pluggable module **106** (shown in FIG. **1**). Other orientations are possible in alternative embodiments.

[0031] The housing **202** includes a top wall **220** at the top **210** and a bottom wall **222** at the bottom **212**. In the illustrated embodiment, the housing **202** includes a shroud **214** at the front **206** configured to be mated with the pluggable module **106**. The shroud **214** is a nose cone configured to be plugged into the mating ends of the pluggable module **106**. The shroud **214** includes one or more housing card slots **216** open at the front. In the illustrated embodiment, the shroud **214** includes a pair of the card slots **216**. However, in alternative embodiments, the shroud **214** may include greater or fewer card slots **216**, such as a single card slot **216**. In other various embodiments, the housing **202** may include multiple shrouds **214**, which may be plugged into different pluggable modules (for example, an upper module and a lower module). The housing card slot(s) **216** receives the card edge **192** (shown in FIG. **2**) of the corresponding module circuit card **190** (shown in FIG. **2**). In an exemplary embodiment, the contact assembly **300** is loaded in the cavity **204** and received in the shroud **214** for mating with the pluggable module **106**.

[0032] In an exemplary embodiment, each cable assembly **200** includes a pair of the contact assemblies **300**, such as an upper contact assembly **300***a* and a lower contact assembly **300***b*. The upper contact assembly **300***a* includes upper contacts and the lower contact assembly **300***b* includes lower contacts facing each other across a gap configured to receive the mating component (for example, the module circuit card **190**). The upper and lower contact assemblies **300***a*, **300***b* may be similar or identical contact assemblies (for example, similarly or identically manufactured and/or assembled). The upper and lower contact assemblies **300***a*, **300***b* may be inverted relative to each other to form an upper mating interface for mating to the upper surface of the module circuit card **190** and a lower mating interface for mating to the lower surface of the module circuit card **190**. The cables **400** are terminated to the corresponding contacts of the contact assemblies **300**. In an exemplary embodiment, each cable assembly **200** includes a carrier **250** holding the contact assemblies **300** and/or the cables **400**. The carrier **250** may hold the contact assemblies **300** in a stack. In the illustrated embodiment, multiple carriers **250** are provided corresponding to an upper cable assembly **200***a* and a lower cable assembly **200***b*. However, in other embodiments, a single

carrier **250** may be used to hold both upper and lower cable assemblies **200***a*, **200***b* or a single carrier **250** and single cable assembly **200** may be used in alternative embodiments.

[0033] In an exemplary embodiment, the carrier **250** includes walls forming a cavity **252**. The walls include a top wall **254**, a bottom wall **256**, and side walls **258** between the top and bottom walls **254**, **256**. The cavity **252** may be open at the front and/or at the rear. The contact assemblies **300** may extend from the front and/or the rear. The cables **400** may extend from the carrier **250**, such as from the rear. The carrier **250** may be generally box-shaped. However, the carrier **250** may have other shapes in alternative embodiments. The carrier **250** includes securing features **260** for securing the carrier **250** in the housing **202**. The securing features **260** may be latches, clips, or other types of securing features. The carrier **250** may include securing features (not shown) for securing the contact assemblies **300** in the carrier **250**.

[0034] The cable assembly **200** includes a plurality of the cables **400** configured to be terminated to the contact assembly **300**. The cables **400** may be arranged in multiple rows. In an exemplary embodiment, the cables **400** are twin-axial cables each having a pair of signal conductors arranged in the core of the cable **400**. The cables **400** may be shielded cables having cable shields surrounding the pairs of signal conductors. The cables **400** may include drain wires. Other types of cables may be used in alternative embodiments, such as coaxial cables, flat flexible cables, flexible circuits, twisted pair cables, and the like. In an exemplary embodiment, the cables **400** define high speed signal cables configured to transmit high speed data signals, such as 10 Gbps, 25 Gbps, 40 Gbps, 64 Gbps, 100 Gbps, or higher.

[0035] FIG. **5** is an exploded view of the cable assembly **200** in accordance with an exemplary embodiment. FIG. **6** is an assembled view of the cable assembly **200** in accordance with an exemplary embodiment. FIG. **7** is a front perspective view of the contact assembly **300** in accordance with an exemplary embodiment. FIG. **8** is a rear perspective view of the contact assembly **300** in accordance with an exemplary embodiment. FIG. **9** is a side view of the cable assembly **200** in accordance with an exemplary embodiment.

[0036] In an exemplary embodiment, the cable assembly **200** includes the contact assembly **300** and the cables **400** terminated to the contact assembly **300**. The contact assembly **300** includes an array of contacts **310**, a contact holder **330** holding the contacts **310**, and a ground bus **350** coupled to the contact holder **330** and the corresponding contacts **310**. The ground bus **350** is configured to be electrically coupled to the cable shield and/or the drain wires of the cables **400**. In an exemplary embodiment, the contacts **310** include signal contacts and ground contacts. The ground contacts are interspersed with the signal contacts, such as to provide shielding between the signal contacts. In an exemplary embodiment, the signal contacts are arranged in pairs, such as to convey differential signals. The contacts **310** may be arranged in a ground-signal-signal-ground (G-S-S-G) arrangement. Other arrangements are possible in alternative embodiments. In an exemplary embodiment, the ground bus **350** is electrically connected to each of the ground contacts, such as to common the ground contacts.

[0037] The contact holder **330** supports the array of contacts **310**, such as in a row. The contact holder **330** is used to position the contacts **310** relative to each other. The contact holder **330** includes a main body **332** extending between a front **334** and a rear **336** of the contact holder **330**. The front **334** may be planar. The rear **336** may be planar. The front **334** may be parallel to the rear **336**. The contact holder **330** includes contact channels **338** that receive corresponding contacts **310**. The contact channels **338** extend between the front **334** and the rear **336**. The main body **332** extends between opposite sides of the contact holder **330**. The main body **332** is manufactured from a dielectric material, such as a plastic material. In various embodiments, the main body **332** may be an overmold body overmolded over the contacts **310** to hold the contacts **310** relative to each other. The contacts **310** may extend forward from the front **334**, such as for mating with the module circuit card **190**. The contacts **310** may extend rearward from the rear **336**, such as for termination to the cables **400**.

[0038] In an exemplary embodiment, the contact holder **330** includes an inner end **340** and an outer end **342**. The main body **332** surrounds the contact channels **338**, such as being positioned between the contact channels **338** and the ends **340**, **342**. The inner end **340** may face the inner end of another contact holder of another contact assembly to form the cable assembly. For example, the inner ends **340** of the contact holders **330** of upper and lower contact assemblies may abut against each other in a stacked arrangement to form the cable assembly **200**. The outer end **342** includes separating walls **344** forming grooves **346**. The grooves **346** receive the ground bus **350**. The grooves **346** may be open at the outer end, such as the top of the contact holder **330**.
[0039] In an exemplary embodiment, the contacts **310** are stamped and formed contacts. The contacts **310** may be formed from a leadframe. For example, the leadframe is stamped from a metal plate to define the contacts **310**. Each contact **310** includes a forward section **320**, a rearward portion **322**, and an intermediate section **321** between the forward and rearward sections **320**, **322**. The intermediate section **321** is held by the contact holder **330**. For example, the intermediate section **321** is received in the corresponding contact channel **338** and passes through the contact holder **330**. The forward section **320** extends forward from the contact holder **330** to mate with the module circuit card **190**. The forward section **320** is forward of the front **334** of the contact holder **330**. In an exemplary embodiment, the forward section **320** includes a spring beam **324** having a mating interface configured to be mated with the module circuit card **190**. The spring beam **324** is cantilevered from the contact holder **330**. The spring beam **324** is deflectable, such as being deflected outward when mated to the module circuit card **190**. In an exemplary embodiment, the rearward portion **322** includes a terminating end **326**. The terminating end **326** is configured to be terminated to the corresponding cable **400**. For example, the terminating end **326** includes a solder pad configured to be soldered to the cable **400** such as to the conductor. The rearward portion **322** extends rearward from the contact holder **330**, such as for termination to the cable **400**. The rearward portion **322** is rearward of the rear **336** of the contact holder **330**. The rearward portion **322** is cantilevered from the contact holder **330**.
[0040] The ground bus **350** is configured to be coupled to the contact holder **330**. The ground bus **350** is configured to be electrically connected to the corresponding contacts **310**, such as the ground contacts. The ground bus **350** includes ground rails **360** connected to the corresponding ground contacts **310**. In an exemplary embodiment, the ground bus **350** includes connecting rails **370** between the ground rails **360**. In an exemplary embodiment, the ground bus **350** is a stamped and formed part. For example, the ground bus **350** may be stamped from a metal plate and formed into a predetermined shape. The ground rails **360** are connected to each other by the connecting rails **370** as a single unitary structure.
[0041] In an exemplary embodiment, each ground rail **360** includes a front mating finger **362** and a rear mating finger **364** discrete from the front mating finger **362**. Each ground rail **360** includes an intermediate portion **366** between the front mating finger **362** and the rear mating finger **364**. The intermediate portion **366** is configured to be coupled to the contact holder **330**. For example, the intermediate portion **366** is coupled to the outer end **342** of the contact holder **330**. In an exemplary embodiment, the intermediate portion **366** is received in the corresponding groove **346** between the separating walls **344**. The separating walls **344** locate the intermediate portion **366**. In alternative embodiments, the intermediate portion **366** may be overmolded by the contact holder **330**.
[0042] In an exemplary embodiment, the intermediate portion **366** includes a cap **368** coupled to the outer end **342**. In an exemplary embodiment, the ground rail **360** includes a front bumper **367** extending along the front **334** of the contact holder **330** and a rear bumper **369** extending along the rear **336** of the contact holder **330**. The ground rail **360** is positioned relative to the contact holder **330** by the front and rear bumpers **367**, **369**. For example, the contact holder **330** is captured between the front and rear bumpers **367**, **369**. The ground rail **360** is blocked from rearward movement by interference between the front bumper **367** and the front **334** of the contact holder **330**. The ground rail **360** is blocked from forward movement by interference between the rear

bumper **369** and the rear **336** of the contact holder **330**. The cap **368** extends along the outer end **342** of the contact holder **330** between the front bumper **367** and the rear bumper **369**. The cap **368** of the intermediate portion **366** may be connected to the front bumper **367** and/or the front mating finger **362** at a bend or corner. The cap **368** of the intermediate portion **366** may be connected to the rear bumper **369** and/or the rear mating finger **364** at a bend or corner. In an exemplary embodiment, the connecting rails **370** may connect the intermediate portions **366**.

[0043] The front mating finger **362** extends from the intermediate portion **366**. The front mating finger **362** is configured to be coupled to the forward section **320** of the corresponding ground contact **310**. The front mating finger **362** may be oriented perpendicular to the intermediate portion **366**. For example, the front mating finger **362** may be oriented vertically. The front mating finger **362** extends along the front **334**. The front mating finger **362** is forward of the front **334**. In an exemplary embodiment, the front mating finger **362** includes a tip **363** configured to engage the forward section **320** of the corresponding ground contact **310**. The tip **363** has a mating interface engaging the forward section **320**. The tip **363** may directly engage the forward section **320**. The tip **363** may be soldered to the ground contact **310**. In other embodiments, the tip **363** may engage the ground contact **310** by an interference or simple mechanical connection (for example, touching). The tip **363** may be preloaded to maintain connection with the ground contact **310**. In an exemplary embodiment, the front mating finger **362** is movable with the spring beam **324**. For example, the front mating finger **362** may be deflected outward with the spring beam **324** when the spring beam **324** is mated with the module circuit card **190**. In an exemplary embodiment, the front mating finger **362** engages the ground contact **310** immediately forward of the contact holder **330**, such as at the front **334**. The front mating finger **362** engages the ground contact **310** remote from the rearward portion **322**. For example, the front mating finger **362** is separated from the rear mating finger **364** by a distance. In an exemplary embodiment, the connecting rails **370** may connect the front mating fingers **362**.

[0044] The rear mating finger **364** extends from the intermediate portion **366**. The rear mating finger **364** is configured to be coupled to the rearward portion **322** of the corresponding ground contact **310**. The rear mating finger **364** may be oriented perpendicular to the intermediate portion **366**. The rear mating finger **364** may be L-shaped including a vertical portion extending from the intermediate portion **366** and a horizontal portion extending rearward from the vertical portion. The rear mating finger **364** extends along the rear **336**. The rear mating finger **364** is rearward of the rear **336**. In an exemplary embodiment, the rear mating finger **364** includes a tail **365** configured to engage the rearward portion **322** of the corresponding ground contact **310**. The tail **365** has a mating interface engaging the rearward portion **322**. The tail **365** may directly engage the rearward portion **322**, such as extending along and parallel to the terminating end **326**. The tail **365** may be soldered to the ground contact **310**, such as to the outer surface of the terminating end **326**. In other embodiments, the tail **365** may engage the ground contact **310** by an interference or simple mechanical connection (for example, touching). In an exemplary embodiment, the rear mating finger **364** engages the ground contact **310** immediately rearward of the contact holder **330**, such as at the rear **336**. The rear mating finger **364** may extend along the terminating end **326** rearward of the contact holder **330**, such as extending to the distal end of the terminating end **326**. The rear mating finger **364** engages the ground contact **310** remote from the forward section **320**. For example, the rear mating finger **364** is separated from the front mating finger **362** by a distance. In an exemplary embodiment, the connecting rails **370** may connect the front mating fingers **362**.

[0045] The ground bus **350** includes the connecting rails **370** extending between and electrically connecting the ground rails **360**. In an exemplary embodiment, the connecting rails **370** include front connecting rails **372** connecting the front mating fingers **362** and rear connecting rails **374** connecting the rear mating fingers **364**. The front connecting rails **372** extend along the front **334** of the contact holder **330**. The rear connecting rails **374** extend along the rear **336** of the contact holder **330**.

[0046] FIG. **10** is a sectional view of a portion of the electrical connector assembly **112** in accordance with an exemplary embodiment. FIG. **10** shows the upper and lower cable assemblies **200***a*, **200***b* received in the housing **202**. Each of the cable assemblies **200***a*, **200***b* include a pair of the contact assemblies **300**. The pair of contact assemblies **300** form upper contacts **310***a* and lower contacts **310***b* arranged on opposite sides of the card slot to mate with opposite sides of the module circuit card **190**. The ground bus **350** of each contact assembly **300** is electrically commoned to each ground contact **310** at multiple points of contact. In an exemplary embodiment, the front mating fingers **366** are connected to the ground contacts **310** at a location between the terminating ends **326** and the mating interfaces at the distal ends of the spring beams **324**. For example, the points of contact of the front mating fingers **366** may be approximately centered between the terminating ends **326** and the mating interfaces at the distal ends of the spring beams **324** to reduce the effective lengths of the ground paths, such as to improve signal integrity.

[0047] It is to be understood that the above description is intended to be illustrative, and not restrictive. For example, the above-described embodiments (and/or aspects thereof) may be used in combination with each other. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from its scope. Dimensions, types of materials, orientations of the various components, and the number and positions of the various components described herein are intended to define parameters of certain embodiments, and are by no means limiting and are merely exemplary embodiments. Many other embodiments and modifications within the spirit and scope of the claims will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. In the appended claims, the terms “including” and “in which” are used as the plain-English equivalents of the respective terms “comprising” and “wherein.” Moreover, in the following claims, the terms “first,” “second,” and “third,” etc. are used merely as labels, and are not intended to impose numerical requirements on their objects. Further, the limitations of the following claims are not written in means-plus-function format and are not intended to be interpreted based on 35 U.S.C. § 112(f), unless and until such claim limitations expressly use the phrase “means for” followed by a statement of function void of further structure.

Claims

1. A cable assembly comprising: cables each having at least one conductor and a cable shield providing shielding for the at least one conductor; and a contact assembly coupled to the cables, the contact assembly including a contact holder, contacts held by the contact holder, and a ground bus coupled to the contact holder; the contact holder including a front and a rear, the contact holder including an inner end and an outer end extending between the front and the rear of the contact holder, the contact holder including contact channels extending between the front and the rear; the contacts arranged in a row, the contacts including signal contacts and ground contacts arranged between corresponding signal contacts to provide shielding between the corresponding signal contacts, the ground contacts electrically connected to the cable shields of the corresponding cables, each contact including a forward section, a rearward section, and an intermediate section between the forward section and the rearward section, the intermediate section received in the corresponding contact channel and passing through the contact holder, the forward section extending forward of the front of the contact holder, the rearward section extending rearward of the rear of the contact holder, the forward section including a spring beam configured to be mated to a mating component, the rearward section including a terminating end terminated to corresponding cable; and the ground bus including ground rails connected to the ground contacts, each ground rail including a front mating finger coupled to the forward portion of the corresponding ground contact, each ground rail including a rear mating finger, discrete from the front mating finger, coupled to the

rearward portion of the corresponding ground contact.
2. The cable assembly of claim 1, wherein the front mating finger is directly connected to the forward section of the corresponding ground contact.
3. The cable assembly of claim 1, wherein the rear mating finger is soldered to the rearward section of the corresponding ground contact.
4. The cable assembly of claim 1, wherein the front mating finger includes a tip facing and engaging the spring beam of the corresponding ground contact.
5. The cable assembly of claim 1, wherein the rear mating finger includes a tail extending along and parallel to the rearward section of the corresponding ground contact.
6. The cable assembly of claim 1, wherein the ground bus includes connecting rails extending between and electrically connecting the ground rails.
7. The cable assembly of claim 6, wherein the connecting rails include front connecting rails connecting the front mating fingers and rear connecting rails connecting the rear mating fingers.
8. The cable assembly of claim 1, wherein the front mating finger extends along the front of the contact holder and the rear mating finger extends along the rear of the contact holder.
9. The cable assembly of claim 1, wherein the ground rail includes a front bumper extending along the front of the contact holder, a rear bumper extending along the rear of the contact holder, and a cap extending along the outer end of the contact holder between the front bumper and the rear bumper.
10. The cable assembly of claim 1, wherein the contact holder includes slots receiving the corresponding ground rails, the ground rails being movable in the slots.
11. The cable assembly of claim 1, wherein the spring beams are deflectable when mating with the mating component, the front mating fingers being deflectable with the corresponding spring beams.
12. The cable assembly of claim 1, wherein the contacts are arranged in a ground-signal-signal-ground arrangement.
13. An electrical connector assembly comprising: a housing having a cavity, the housing having a slot at a housing front of the housing configured to receive a mating component; a cable assembly received in the cavity, the cable assembly including cables and a contact assembly coupled to the cables, the cables each having at least one conductor and a cable shield providing shielding for the at least one conductor, the contact assembly including a contact holder, contacts held by the contact holder, and a ground bus coupled to the contact holder; the contact holder including a front and a rear, the contact holder including an inner end and an outer end extending between the front and the rear of the contact holder, the contact holder including contact channels extending between the front and the rear; the contacts arranged in a row, the contacts including signal contacts and ground contacts arranged between corresponding signal contacts to provide shielding between the corresponding signal contacts, the ground contacts electrically connected to the cable shields of the corresponding cables, each contact including a forward section, a rearward section, and an intermediate section between the forward section and the rearward section, the intermediate section received in the corresponding contact channel and passing through the contact holder, the forward section extending forward of the front of the contact holder, the rearward section extending rearward of the rear of the contact holder, the forward section including a spring beam configured to be mated to the mating component, the rearward section including a terminating end terminated to corresponding cable; and the ground bus including ground rails connected to the ground contacts, each ground rail including a front mating finger coupled to the forward portion of the corresponding ground contact, each ground rail including a rear mating finger, discrete from the front mating finger, coupled to the rearward portion of the corresponding ground contact.
14. The electrical connector assembly of claim 13, wherein the contact assembly is an upper contact assembly configured to interface with an upper portion of the mating component, the cable assembly further comprising a lower contact assembly configured to interface with a lower portion of the mating component.

15. The electrical connector assembly of claim 13, wherein the front mating finger is directly connected to the forward section of the corresponding ground contact and the rear mating finger is soldered to the rearward section of the corresponding ground contact.

16. The electrical connector assembly of claim 13, wherein the front mating finger includes a tip facing and engaging the spring beam of the corresponding ground contact and the rear mating finger includes a tail extending along and parallel to the rearward section of the corresponding ground contact.

17. The electrical connector assembly of claim 13, wherein the ground bus includes connecting rails extending between and electrically connecting the ground rails.

18. The electrical connector assembly of claim 13, wherein the front mating finger extends along the front of the contact holder and the rear mating finger extends along the rear of the contact holder, the ground rail including a cap extending along the outer end of the contact holder between the front mating finger and the rear mating finger.

19. The electrical connector assembly of claim 13, wherein the contact holder includes slots receiving the corresponding ground rails, the ground rails being movable in the slots.

20. A receptacle connector assembly comprising: a receptacle cage having walls forming a cavity defining a module channel configured to receive a pluggable module; and an electrical connector assembly received in the cavity to mate with the pluggable module, the electrical connector assembly including a housing and a cable assembly received in the housing, the housing having a housing cavity and a slot at a housing front of the housing configured to receive module circuit board of the pluggable module, the cable assembly including cables and a contact assembly coupled to the cables, the cables each having at least one conductor and a cable shield providing shielding for the at least one conductor, the contact assembly including a contact holder, contacts held by the contact holder, and a ground bus coupled to the contact holder; the contact holder including a front and a rear, the contact holder including an inner end and an outer end extending between the front and the rear of the contact holder, the contact holder including contact channels extending between the front and the rear; the contacts arranged in a row, the contacts including signal contacts and ground contacts arranged between corresponding signal contacts to provide shielding between the corresponding signal contacts, the ground contacts electrically connected to the cable shields of the corresponding cables, each contact including a forward section, a rearward section, and an intermediate section between the forward section and the rearward section, the intermediate section received in the corresponding contact channel and passing through the contact holder, the forward section extending forward of the front of the contact holder, the rearward section extending rearward of the rear of the contact holder, the forward section including a spring beam configured to be mated to the mating component, the rearward section including a terminating end terminated to corresponding cable; and the ground bus including ground rails connected to the ground contacts, each ground rail including a front mating finger coupled to the forward portion of the corresponding ground contact, each ground rail including a rear mating finger, discrete from the front mating finger, coupled to the rearward portion of the corresponding ground contact.