United States Patent Application Publication 20250266628
Kind Code A1
Publication Date August 21, 2025
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CABLE CARD ASSEMBLY OF AN ELECTRICAL CONNECTOR

Abstract

A cable card assembly includes cables terminated to a circuit card and a cable yoke that holds the cables in fixed positions relative to each other. The cable yoke includes cable troughs at spaced apart positions receiving the corresponding cables. The cable yoke is electrically connected to the cable shields of the cables. The cable card assembly includes a ground bus coupled to the ground plane of the circuit card. The ground bus has cable pockets receiving the cable yoke and the corresponding cables. The cable yoke positions the cables in the cable pockets relative to the ground bus. The ground bus is electrically connected to the cable yoke to electrically connect the cable shields of the cables to the ground plane of the circuit card.

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Family ID: **1000007694802**

Appl. No.: **18/582109**

Filed: **February 20, 2024**

Publication Classification

Int. Cl.: **H01R12/53** (20110101); **H01R12/72** (20110101)

U.S. Cl.:

CPC **H01R12/53** (20130101); H01R12/721 (20130101)

Background/Summary

BACKGROUND OF THE INVENTION

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

[0002] Electrical connectors are typically used to electrically couple various types of electrical devices to transmit signals between the devices. At least some known electrical connectors include a cable assembly having cables connected between the electrical device and the electrical connector. The cables each have a signal conductor or a differential pair of signal conductors surrounded by a shield layer that, in turn, is surrounded by a cable jacket. The shield layer includes a conductive foil, which functions to shield the signal conductor(s) from electromagnetic interference (EMI) and generally improve performance. A drain wire may be provided within the cable, electrically connected to the conductive foil. At an end of the communication cable, the cable jacket, the shield layer, and insulation that covers the signal conductor(s) may be removed (e.g., stripped) to expose the signal conductor(s) and the drain wire. The exposed portions of the signal conductor(s) are then mechanically and electrically coupled (e.g., soldered) to corresponding conductors, such as signal pads of a circuit card.

[0003] However, signal integrity and electrical performance of the electrical connectors are negatively impacted at the interface between the cables and the circuit card. For example, as the exposed portions of the signal conductors transition to the circuit card, the exposed portions are exposed to air, which affects signal integrity and detrimentally affects performance. Some known electrical connectors include a shield to provide shielding around the exposed conductors and the termination of the signal conductors at the circuit card. Current designs require individual pair stripping, termination, drain wire routing, and soldering. Variations with regard to assembly processes and placement result in a lack of ground field consistency between differential pairs and the shield element perimeter causing unacceptable signal integrity fluctuations. Soldering the cable shield and drain wires to the shield element in the final assembly may be difficult and lead to an unreliable guaranteed ground path. Additionally, the termination between the signal conductors and the signal pads of the circuit card are areas of high stress and potential failure.

[0004] Accordingly, there is a need for an electrical connector having an improved connection interface with a circuit card.

BRIEF DESCRIPTION OF THE INVENTION

[0005] In one embodiment, a cable card assembly for an electrical connector is provided and includes a circuit card that has an upper surface and a lower surface. The circuit card has a cable end and a mating end opposite the cable end. The circuit card has mating conductors at the mating end for mating with a mating electrical connector. The circuit card has circuit conductors at the cable end. The circuit card has a ground plane. The cable card assembly includes cables terminated to the circuit card. The cables include signal conductors and cable shields surrounding the corresponding signal conductors to provide electrical shielding for the signal conductors. The cable card assembly includes a cable yoke holding the cables in fixed positions relative to each other. The cable yoke includes cable troughs at spaced apart positions receiving the corresponding cables. The cable yoke is electrically connected to the cable shields. The cable card assembly includes a ground bus coupled to the ground plane of the circuit card. The ground bus has cable pockets receiving the cable yoke and the corresponding cables. The cable yoke positions the cables in the cable pockets relative to the ground bus. The ground bus is electrically connected to the cable yoke to electrically connect the cable shields of the cables to the ground plane of the circuit card.

[0006] In another embodiment, a cable card assembly for an electrical connector is provided and includes a circuit card that has an upper surface and a lower surface. The circuit card has a cable end and a mating end opposite the cable end. The circuit card has mating conductors at the mating end for mating with a mating electrical connector. The circuit card has circuit conductors at the cable end. The circuit card has a ground plane. The cable card assembly includes cables terminated to the circuit card. The cables include signal conductors and cable shields surrounding the

corresponding signal conductors to provide electrical shielding for the signal conductors. The cable card assembly includes a cable yoke holding the cables in fixed positions relative to each other. The cable yoke includes an inner yoke member and an outer yoke member coupled to the inner yoke member. The inner yoke member includes inner cable troughs receiving the corresponding cables. The outer yoke member includes outer cable troughs receiving the corresponding cables. The inner yoke member includes inner connecting walls between the inner cable troughs. The outer yoke member includes outer connecting walls between the outer cable troughs. The inner connecting walls are laser welded to the outer connecting walls to form the cable yoke. The cable yoke is electrically connected to the cable shields. The cable card assembly includes a ground bus coupled to the ground plane of the circuit card. The ground bus has cable pockets receiving the cable yoke and the corresponding cables. The cable yoke positions the cables in the cable pockets relative to the ground bus. The ground bus is electrically connected to the cable yoke to electrically connect the cable shields of the cables to the ground plane of the circuit card.

[0007] In a further embodiment, an electrical connector is provided and includes a housing that has walls forming a cavity. The housing has a mating end at a front of the housing configured to be mated with a mating electrical connector. The electrical connector includes a cable card assembly received in the cavity of the housing. The cable card assembly includes a circuit card, cables terminated to the circuit card, a cable yoke holding the cables, and a ground bus providing shielding for the cables. The circuit card has an upper surface and a lower surface. The circuit card has a cable end and a mating end opposite the cable end. The circuit card has mating conductors at the mating end for mating with the mating electrical connector. The circuit card has circuit conductors at the cable end. The circuit card has a ground plane and the ground bus is coupled to the ground plane. The cables include signal conductors and cable shields surrounding the corresponding signal conductors to provide electrical shielding for the signal conductors. The cable yoke includes cable troughs receiving the corresponding cables and holding the cables in fixed positions relative to each other. The cable yoke is electrically connected to the cable shields. The ground bus has cable pockets receiving the cable yoke and the corresponding cables. The cable yoke positions the cables in the cable pockets relative to the ground bus. The ground bus is electrically connected to the cable yoke to electrically connect the cable shields of the cables to the ground plane of the circuit card.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a perspective view of a communication system in accordance with an exemplary embodiment.

[0009] FIG. **2** is an exploded view of the first electrical connector in accordance with an exemplary embodiment.

[0010] FIG. **3** is a perspective view of a portion of the cable card assembly in accordance with an exemplary embodiment showing a single row of cables.

[0011] FIG. **4** is a perspective view of a portion of the cable card assembly in accordance with an exemplary embodiment showing two rows of cables.

[0012] FIG. **5** is a perspective view of one of the cables in accordance with an exemplary embodiment.

[0013] FIG. **6** is a cross sectional view of one of the cables in accordance with an exemplary embodiment.

[0014] FIG. **7** is a front perspective view of a portion of the cable card assembly in accordance with an exemplary embodiment showing a cable assembly in accordance with an exemplary embodiment.

[0015] FIG. **8** is a perspective view of the inner yoke member in accordance with an exemplary embodiment.
[0016] FIG. **9** is a perspective view of a portion of the cable card assembly showing the cables arranged in the inner yoke member in accordance with an exemplary embodiment.
[0017] FIG. **10** is a front perspective view of a portion of the cable card assembly in accordance with an exemplary embodiment showing the cable assembly poised for loading into a portion of the ground bus.
[0018] FIG. **11** is a rear perspective view of a portion of the cable card assembly in accordance with an exemplary embodiment showing the cable assembly poised for loading into a portion of the ground bus.
[0019] FIG. **12** is a front perspective view of a portion of the cable card assembly in accordance with an exemplary embodiment showing the cable assembly loaded into a portion of the ground bus.
[0020] FIG. **13** is a front perspective view of a portion of the cable card assembly in accordance with an exemplary embodiment showing the cable assembly mechanically and electrically connected to the ground bus.
[0021] FIG. **14** is a cross sectional view of a portion of the cable card assembly in accordance with an exemplary embodiment showing the cable assembly mechanically and electrically connected to the ground bus.
[0022] FIG. **15** is an enlarged cross sectional view of a portion of the cable card assembly in accordance with an exemplary embodiment.
[0023] FIG. **16** is a front perspective view of a portion of the cable card assembly in accordance with an exemplary embodiment showing the cable assembly in accordance with an exemplary embodiment.
[0024] FIG. **17** is a front perspective view of a portion of the cable card assembly in accordance with an exemplary embodiment showing the cable assembly in accordance with an exemplary embodiment.
[0025] FIG. **18** is a front perspective view of a portion of the cable card assembly in accordance with an exemplary embodiment showing the cable assembly in accordance with an exemplary embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0026] FIG. **1** is a perspective view of a communication system **100** in accordance with an exemplary embodiment. The communication system **100** includes a first electrical connector **102** provided at ends of cables **104** and a second electrical connector **106** mounted to a circuit board **108**. In other various embodiments, the second electrical connector **106** may be provided at ends of cables (not shown). In an exemplary embodiment, the second electrical connector **106** is a receptacle connector, and may be referred to herein after as a receptacle connector **106**. The first electrical connector **102** is mated to the second electrical connector **106**. In an exemplary embodiment, the first electrical connector **102** is a plug connector, and may be referred to herein after as a plug connector **102**. The plug connector **102** is configured to be pluggably coupled to the receptacle connector **106**. For example, a portion of the plug connector **102** may be plugged into a receptacle of the receptacle connector **106**. In an exemplary embodiment, the plug connector **102** is coupled to the receptacle connector **106** at a separable interface. For example, the plug connector **102** is latchably coupled to the receptacle connector **106**. The connectors **102**, **106** may be input-output (I/O) connectors.
[0027] The receptacle connector **106** includes a receptacle housing **110** holding an array of contacts **112**. In an exemplary embodiment, the receptacle housing **110** includes a card slot **114** forming the receptacle receiving the plug connector **102**. The contacts **112** may have separable mating interfaces. The contacts **112** may define a compressible interface, such as including deflectable spring beams that are compressed when the plug connector **102** is received in the card slot **114**.

Optionally, the contacts **112** may be arranged in multiple rows along the top and the bottom of the card slot **114**. In various embodiments, the receptacle connector **106** is a communication device, such as a card edge socket connector. However, the receptacle connector **106** may be another type of electrical connector in an alternative embodiment. The receptacle connector **106** may be a high-speed connector.

[0028] The plug connector **102** includes a housing **120** having a cavity **122** that receives a cable card assembly **130**. The housing **120** has a cable end **124** and a mating end **126** opposite the cable end **124**. The cables **104** extend from the cable end **124**. The mating end **126** is configured to be coupled to the receptacle connector **106**. The cable card assembly **130** includes a circuit card **132**. The cables **104** are configured to be terminated to the circuit card **132**. The circuit card **132** is configured to be plugged into the card slot **114** when the plug connector **102** is mated with the receptacle connector **106**.

[0029] FIG. **2** is an exploded view of the plug connector **102** in accordance with an exemplary embodiment. The plug connector **102** includes the housing **120** and the cable card assembly **130**. The housing **120** receives the cable card assembly **130** in the cavity **122** to hold the circuit card **132** and the cables **104**. In an exemplary embodiment, the cable card assembly **130** includes a cable termination **200** where the cables **104** are terminated to the circuit card **132**. For example, the conductors of the cables **104** may be terminated directly to the circuit card **132**, such as by soldering the conductors to pads or circuits of the circuit card **132**. In other various embodiments, the cable termination **200** may include a contact array of contacts used to electrically connect the cable conductors and the circuit card **132**. For example, ends of the contacts may be soldered to circuits of the circuit card **132** and the cable conductors may be soldered to opposite ends of the contacts.

[0030] In an exemplary embodiment, the cable card assembly **130** includes a ground bus **300** providing shielding for the cable termination **200**. The ground bus **300** is coupled to the cables **104**, such as cables shields of the cables **104**. The ground bus **300** is coupled to the circuit card **132**. For example, the ground bus **300** is electrically connected to circuits or conductors of the circuit card **132**, such as to a ground plane of the circuit card **132**. The ground bus **300** provides electrical shielding for the signal conductors of the cables **104**. The ground bus **300** is electrically connected to the shield structures of the cables **104**, such as to cable shields of the cables **104** and/or drain wires of the cables **104**. In an exemplary embodiment, the ground bus **300** is soldered to the cable shields. However, the ground bus **300** may be electrically connected to the shield structures of the cables **104** by other means in alternative embodiments, such as soldering to the drain wire, welding to the drain wire, press-fitting the drain wire into a compliant feature of the ground bus **300**, using conductive adhesive, using a conductive tape or braid, using a conductive gasket, conductive foam, conductive epoxy, and the like. The ground bus **300** may be coupled to the circuit card **132** at a solderless connection, such as at an interference or press-fit connection. In various embodiments, multiple ground buses **300** may be provided, such as at top and/or at the bottom sides of the circuit card **132**. The multiple ground buses **300** may be offset, such as shifted front-to-rear and/or side-to-side.

[0031] During assembly, the cable card assembly **130**, including the circuit card **132**, the cables **104**, and the ground bus **300**, may be loaded into the housing **120**, such as into a rear of the housing **120**. The cable card assembly **130** may be secured in the housing **120** using latches, fasteners or other securing devices. In an exemplary embodiment, the ends of the cables **104** may be surrounded by a strain relief element **170**. For example, the strain relief element **170** may be molded or otherwise formed around the cables **104**. The strain relief element **170** may be secured to the circuit card **132**, such as being molded to the circuit card **132**. Optionally, multiple strain relief elements **170** may be provided, such as upper and lower strain relief elements.

[0032] FIG. **3** is a perspective view of a portion of the cable card assembly **130** in accordance with an exemplary embodiment showing a single row of cables **104**. FIG. **4** is a perspective view of a

portion of the cable card assembly **130** in accordance with an exemplary embodiment showing two rows of cables **104**. More than two rows may be provided in alternative embodiments. The cable card assembly **130** includes the circuit card **132**, the cables **104**, the cable termination(s) **200** terminated to the circuit card **132**, and the corresponding ground bus(es) **300**. The cable card assembly **130** may additionally include any number of rows of cables **104** and ground buses **300** on the opposite side of the circuit card **132**. The ground buses **300** may be similar for both rows. However, the ground buses **300** may be sized and shaped differently to accommodate the stacking (for example, flyover) situation.

[0033] The circuit card **132** extends between a cable end **134** (for example, rear portion) and a mating end **136** (for example, front portion). The circuit card **132** has a rear edge at the rear of the cable end **134** and the cables **104** are configured to be coupled to the circuit card **132** at the cable end **134** and extend rearward from the circuit card **132**. The circuit card **132** has a card edge **138** at the front of the mating end **136** configured to be plugged into the card slot **114** (shown in FIG. **1**) of the receptacle connector **106** (shown in FIG. **1**). The circuit card **132** includes an upper surface **140** and a lower surface **142**. The circuit card **132** may have any reasonable length between the cable end **134** and the mating end **136**, depending on the particular application, and may have electrical components mounted to the circuit card **132** between the cable end **134** and the mating end **136**. In alternative embodiments, the mating end **136** of the circuit card **132** may be provided at the bottom, such as including an array of mating contacts and/or solder balls, for connection to a circuit board or a socket assembly.

[0034] The circuit card **132** includes circuit conductors **144** at the cable end **134** configured to be electrically connected to the cable conductors and/or the ground bus **300**. The circuit conductors **144** may be pads or traces of the circuit card **132**. In various embodiments, the circuit conductors **144** are provided at the cable end **134** forward of the rear edge of the circuit card **132**, such as in the rear half of the circuit card **132**. The circuit conductors **144** may be provided at both the upper surface **140** and the lower surface **142**. However, the in alternative embodiments, the cable end **134** is defined at the top of the circuit card **132** and the circuit conductors **144** are provided only on the upper surface **140**, such as between the front and the rear edges of the circuit card **132**. The circuit conductors **144** include both signal conductors and ground conductors. The ground conductors may be electrically connected to a ground plane (not shown) of the circuit card **132**. Optionally, the circuit conductors **144** may be arranged in a ground-signal-signal-ground arrangement. The lengths and/or widths of the signal conductors may be different than the ground conductors. The positioning of the signal conductors on the circuit card **132** (for example, depth from the rear edge of the circuit card **132**) may be different than the ground conductors. The spacing between the signal conductors (i.e., pitch) may be different than the spacing between the signal conductors and the ground conductors.

[0035] The circuit card **132** includes mating conductors **146** at the mating end **136** configured to be electrically connected to corresponding contacts **112** (shown in FIG. **1**) of the receptacle connector **106**. The mating conductors **146** are electrically connected to corresponding circuit conductors **144** through traces, vias or other circuits of the circuit card **132**. The mating conductors **146** include both signal conductors and ground conductors. The ground conductors may be electrically connected to a ground plane (not shown) of the circuit card **132**. The mating conductors **146** may be pads or traces of the circuit card **132**. The mating conductors **146** may be provided at both the upper surface **140** and the lower surface **142**. The mating conductors **146** are provided proximate to the card edge **138**. However, in alternative embodiments, the mating end **136** is defined by the bottom of the circuit card **132** and the mating conductors **146** are provided only on the lower surface **142**, such as for mating with socket contacts of a socket connector or connection to a circuit board.

[0036] The cable termination **200** provides an electrical interface between the cables **104** and the circuit card **132**. The ground bus **300** is terminated to the cables **104** and the circuit card **132**. The

ground bus **300** provides electrical shielding for the cable termination **200**. The ground bus **300** provides electrical shielding at the interface with the cables **104**. The ground bus **300** provides electrical shielding at the interface with the circuit card **132**.

[0037] FIG. **5** is a perspective view of one of the cables **104** in accordance with an exemplary embodiment. FIG. **6** is a cross sectional view of one of the cables **104** in accordance with an exemplary embodiment. Each cable **104** includes at least one signal conductor and a shield structure providing electrical shielding for the at least one signal conductor.

[0038] In an exemplary embodiment, the cables **104** are twin-axial cables. For example, each cable **104** includes a first signal conductor **150** and a second signal conductor **152**. The signal conductors **150**, **152** carry differential signals. The signal conductors **150**, **152** are configured to be electrically connected to corresponding circuit conductors **144** of the circuit card **132** (shown in FIG. **3**). Exposed portions of the signal conductors **150**, **152** may be terminated directly to the circuit card **132** or to contacts, which are used to electrically connect the signal conductors **150**, **152** and the circuit card **132**.

[0039] The cable **104** includes insulators **154** surrounding the signal conductors **150**, **152** and a cable shield **160** surrounding the insulators **154**. The cable shield **160** provides circumferential shielding around the signal conductors **150**, **152**. The cable shield **160** may include multiple shield layers, such as an inner shield (on the insulator) and an outer shield (on the cable jacket). The cable **104** includes a cable jacket **162** surrounding the cable shield **160**. In various embodiments, the cable **104** includes one or more drain wires **164** electrically connected to the cable shield **160**. For example, drain wires **164** may be provided at both sides of the cable **104**. In alternative embodiments, the cable **104** is provided without a drain wire.

[0040] In an exemplary embodiment, the cable jacket **162**, the cable shield **160**, and the insulators **154** may be removed (e.g., stripped) to expose portions of the signal conductors **150**, **152**, respectively, which are referred to hereinafter as exposed portions **156**, **158**. The exposed portions **156**, **158** of the signal conductors **150**, **152** are configured to be mechanically and electrically coupled (e.g., soldered) to corresponding circuit conductors **144** of the circuit card **132** or to corresponding signal contacts (not shown). The exposed portions **156**, **158** may be bent, such as bent inward toward each other (distance between reduced for tighter coupling and smaller trace spacing) and/or may be bent toward the circuit card **132**. The ground bus **300** extends along the exposed portions **156**, **158** and provides shielding for the exposed portions **156**, **158**. The ground bus **300** is shaped and positioned relative to the exposed portions **156**, **158** to control impedance along the signal paths. For example, the ground bus **300** may be shaped and positioned relative to the exposed portions **156**, **158** to maintain a target impedance along the signal paths (for example, 50 Ohms, 75 Ohms, 100 Ohms, and the like).

[0041] FIG. **7** is a front perspective view of a portion of the cable card assembly **130** in accordance with an exemplary embodiment showing a cable assembly in accordance with an exemplary embodiment. FIG. **7** shows an array of the cables **104** (for example, six cables) arranged in a row. In an exemplary embodiment, the cable card assembly **130** includes a cable yoke **400** holding the cables **104** in fixed positions relative to each other. The cable yoke **400** holds the cables **104** together in a cable assembly **402**. The cable assembly **402** may be assembled into the ground bus **300** (FIG. **3**).

[0042] The cable yoke **400** includes one or more yoke members configured to be mechanically and electrically connected to the cables **104**. For example, in the illustrated embodiment, the cable yoke **400** includes an inner yoke member **420** and an outer yoke member **450**. The outer yoke member **450** is separate and discrete from the inner yoke member **420** and coupled thereto. For example, the outer yoke member **450** may be laser welded or soldered to the inner yoke member **420**. Optionally, the inner yoke member **420** and the outer yoke member **450** may be identical to each other and inverted 180°. However, the inner and outer yoke members **420**, **450** may have different features. In an exemplary embodiment, the yoke members **420**, **450** may be stamped and formed from one or

more metal sheets. However, the yoke members **420**, **450** may be die cast, additive manufactured or otherwise manufactured to form the cable yoke **400**.
[0043] In an exemplary embodiment, the cables **104** are held in cable troughs **410**. The yoke members **420**, **450** define the cable troughs **410**. In an exemplary embodiment, the yoke members **420**, **450** completely surround the cables **104**. For example, the yoke members **420**, **450** provide 360° shielding around each cable **104**. The cables **104** may be sandwiched between the inner and outer yoke members **420**, **450**, such as to mechanically hold the cables **104** in the cable troughs **410**. In an exemplary embodiment, the inner and outer yoke members **420**, **450** are electrically connected to the cables **104**, such as the cable shields **160** and/or the drain wires **164**. For example, the inner and outer yoke members **420**, **450** may be soldered to the cable shields **160** and/or the drain wires **164** in the cable troughs **410**. The inner and outer yoke members **420**, **450** may be soldered to the cable shields **160** and/or soldered or laser welded to the drain wires **164**.
[0044] FIG. **8** is a perspective view of the inner yoke member **420** in accordance with an exemplary embodiment. FIG. **9** is a perspective view of a portion of the cable card assembly **130** showing the cables **104** arranged in the inner yoke member **420**.
[0045] In an exemplary embodiment, the inner yoke member **420** is stamped and formed from a metal sheet. The inner yoke member **420** extends between a first end **422** and a second end **424**. The inner yoke member **420** extends between an inner end **426** and an outer end **428**. In various embodiments, the inner yoke member **420** is oriented such that the inner end **426** defines a top of the inner yoke member **420** and the outer end **428** defines a bottom of the inner yoke member **420**.
[0046] In an exemplary embodiment, the inner yoke member **420** includes an end wall **430**, side walls **432** extending from the end wall **430**, and connecting walls **434** extending between the side walls **432**. The end wall **430** and the side walls **432** define an inner cable trough **436**, which forms an inner portion of the cable trough **410** with the outer yoke member **450** (FIG. **7**). The end walls **430** define the outer end **428**. The end walls **430** may be co-planer with each other. The end walls **430** may define bottom walls of the inner cable troughs **436**.
[0047] The side walls **432** extend from opposite sides of the end walls **430**. Optionally, the side walls **432** are angled from the end walls **430**, such as at an angle of between 30° and 60°. In various embodiments, the side walls **432** may be angled at approximately 45° relative to the end walls **430**. In the illustrated embodiment, the side walls **432** in the end walls **430** form trapezoidal shaped inner cable troughs **436**. The side walls **432** may extend at other angles in alternative embodiments to form different shaped inner cable troughs **436**, such as extending perpendicular to the end walls **430** to form rectangular shaped inner cable troughs **436**. In other various embodiments, the side walls **432** may be curved, such as to follow a curvature of the cable **104**.
[0048] The connecting walls **434** are provided at the inner end **426**. The connecting walls **434** space the side walls **432** apart from each other to control spacing of the cables **104**. For example, lengths of the connecting walls **434** define the spacing between the inner cable troughs **436**. In an exemplary embodiment, the connecting walls **434** provide surfaces for connecting the inner yoke member **420** to the outer yoke member **450**. For example, the connecting walls **434** may be welded or soldered to the outer yoke member **450**.
[0049] In an exemplary embodiment, the inner yoke member **420** includes solder openings **440** in the end walls **430**. The solder openings **440** are used for soldering the cable shields **160** of the cables **104** to the inner yoke member **420**. In the illustrated embodiment, the solder openings **440** are circular. The solder openings **440** may have other shapes in alternative embodiments. Optionally, multiple solder openings **440** may be provided on each end wall **430**.
[0050] In an exemplary embodiment, the inner yoke member **420** includes openings **442** along the side walls **432** and/or the connecting walls **434**. The openings **442** may be used for laser welding the inner yoke member **420** to the outer yoke member **450** and/or for laser welding the drain wires **164** to the inner and/or outer yoke members **420**, **450**. In the illustrated embodiment, the openings **442** extend entirely across the connecting walls **434** into the corresponding side walls **432**. In

alternative embodiments, separate openings **442** may be provided on both side walls **432** with the connecting walls **434** extending between separate openings **442** in the side walls **432**. Optionally, multiple openings **442** may be provided in the side walls **432** and/or the connecting walls **434**.
[0051] Returning to FIG. **7**, the outer yoke member **450** is shown coupled to the inner yoke member **420**. The outer yoke member **450** may be similar to the inner yoke member **420**. Optionally, the outer yoke member **450** may be identical to the inner yoke member **420**. In an exemplary embodiment, the outer yoke member **450** is stamped and formed from a metal sheet. The outer yoke member **450** extends between a first end **452** and a second end **454**. The outer yoke member **450** extends between an inner end **456** and an outer end **458**. In various embodiments, the outer yoke member **450** is oriented such that the inner end **456** defines a bottom of the outer yoke member **450** and the outer end **458** defines a top of the outer yoke member **450**.
[0052] In an exemplary embodiment, the outer yoke member **450** includes an end wall **460**, side walls **462** extending from the end wall **460**, and connecting walls **464** extending between the side walls **462**. The end wall **460** and the side walls **462** define an outer cable trough **466**, which forms an outer portion of the cable trough **410** with the inner yoke member **420**. The end walls **460** define the outer end **458**. The end walls **460** may be co-planer with each other. The end walls **460** may define top walls of the outer cable troughs **466**.
[0053] The side walls **462** extend from opposite sides of the end walls **460**. Optionally, the side walls **462** are angled from the end walls **460**, such as at an angle of between 30° and 60°. In various embodiments, the side walls **462** may be angled at approximately 45° relative to the end walls **460**. In the illustrated embodiment, the side walls **462** in the end walls **460** form trapezoidal shaped outer cable troughs **466**. The side walls **462** may extend at other angles in alternative embodiments to form different shaped outer cable troughs **466**, such as extending perpendicular to the end walls **460** to form rectangular shaped outer cable troughs **466**. In other various embodiments, the side walls **462** may be curved, such as to follow a curvature of the cable **104**.
[0054] The connecting walls **464** are provided at the inner end **456**. The connecting walls **464** space the side walls **462** apart from each other to control spacing of the cables **104**. For example, lengths of the connecting walls **464** define the spacing between the outer cable troughs **466**. In an exemplary embodiment, the connecting walls **464** provide surfaces for connecting the outer yoke member **450** to the inner yoke member **420**. For example, the connecting walls **464** of the outer yoke member **450** may be welded or soldered to the connecting walls **434** of the inner yoke member **420**.
[0055] In an exemplary embodiment, the outer yoke member **450** includes solder openings **470** in the end walls **460**. The solder openings **470** are used for soldering the cable shields **160** of the cables **104** to the outer yoke member **450**. In the illustrated embodiment, the solder openings **470** are circular. The solder openings **470** may have other shapes in alternative embodiments. Optionally, multiple solder openings **470** may be provided on each end wall **460**.
[0056] In an exemplary embodiment, the outer yoke member **450** includes openings **472** along the side walls **462** and/or the connecting walls **464**. The openings **472** may be used for laser welding the outer yoke member **450** to the inner yoke member **420** and/or for laser welding the drain wires **164** to the outer and/or inner yoke members **450**, **420**. In the illustrated embodiment, the openings **472** extend entirely across the connecting walls **464** into the corresponding side walls **462**. In alternative embodiments, separate openings **472** may be provided on both side walls **462** with the connecting walls **464** extending between separate openings **472** in the side walls **462**. Optionally, multiple openings **472** may be provided in the side walls **462** and/or the connecting walls **464**.
[0057] When assembled, the connecting walls **464** of the outer yoke member **450** are seated on the connecting walls **434** of the inner yoke member **420**. The connecting walls **464** of the outer yoke member **450** may be laser welded to the connecting walls **434** of the inner yoke member **420** to form the cable yoke **400**. The cables **104** are captured in the cable troughs **410** between the inner yoke member **420** and the outer yoke member **450**. For example, the end walls **430**, **460** extend

along opposite ends of each cable trough **410** and may compress or hold the cables **104** in the cable troughs **410** by an interference fit. The side walls **432**, **462** extend along opposite sides of each cable trough **410**. The side walls **432**, **462** position the cables **104** in the cable troughs **410**. The cable yoke **400** provides 360° shielding around each cable **104** defined by the end walls **430**, **460** and the side walls **432**, **462**. The cable troughs **410** and the cables **104** are separated from each other by the side walls **432**, **462**.

[0058] The drain wires **164** extend into the cable troughs **410**, such as at the interface between the inner and outer yoke members **420**, **450**. In an exemplary embodiment, the drain wires **164** may extend straight forward, such as along the insulators **154**, directly into the cable troughs **410**. The drain wires **164** are located in pockets formed in the cable troughs **410**, such as along the side walls **432**, **462**. The drain wires **164** may be located adjacent the connecting walls **434**, **464**. In an exemplary embodiment, the drain wires **164** are located adjacent the openings **442**, **472**. The connecting walls **434**, **464** and/or the side walls **432**, **462** may be laser welded to the drain wires **164**, such as through the openings **442**, **472**.

[0059] FIG. **10** is a front perspective view of a portion of the cable card assembly **130** in accordance with an exemplary embodiment showing the cable assembly **402** poised for loading into a portion of the ground bus **300**. FIG. **11** is a rear perspective view of a portion of the cable card assembly **130** in accordance with an exemplary embodiment showing the cable assembly **402** poised for loading into a portion of the ground bus **300**. FIG. **12** is a front perspective view of a portion of the cable card assembly **130** in accordance with an exemplary embodiment showing the cable assembly **402** loaded into a portion of the ground bus **300**. FIG. **13** is a front perspective view of a portion of the cable card assembly **130** in accordance with an exemplary embodiment showing the cable assembly **402** mechanically and electrically connected to the ground bus **300**.

[0060] The ground bus **300** includes a shell **302** (FIG. **13**) manufactured from a conductive material, such as a metal material to provide electrical shielding. In various embodiments, the ground bus **300** may be a diecast component. In other various embodiments, the ground bus **300** may be a stamped and formed component. In the illustrated embodiment, the shell **302** of the ground bus **300** is manufactured as a single, unitary component. However, in alternative embodiments, the ground bus **300** may be manufactured from discrete components that are mechanically and electrically connected together.

[0061] The ground bus **300** extends between a front **312** and a rear **314**. The rear **314** is configured to face the cables **104**. The ground bus **300** extends between an inner end **316** and an outer end **318**. In various embodiments, the inner end **316** is at the bottom and is configured to face the circuit card **132** (FIG. **3**). The inner end **316** may be mounted to the circuit card **132** to mechanically and electrically connect the ground bus **300** to the circuit card **132**. The ground bus **300** includes a first side wall **320** and a second side wall **322** extending between the front **312** and the rear **314**. In an exemplary embodiment, the ground bus **300** includes divider walls **324** extending parallel to and spaced apart from the side walls **320**, **322**. The divider walls **324** form cavities **326** between the divider walls **324**. The cavities **326** receive the ends of the cables **104**. The divider walls **324** provide electrical shielding between the cavities **326**, such as for shielding between the cables **104**.

[0062] In an exemplary embodiment, the ground bus **300** includes a front wall **340** at the front **312** and an outer wall **342** at the outer end **318**. The front wall **340**, the outer wall **342**, the side walls **320**, **322**, and the divider walls **324** provide electrical shielding for the cavities **326**. The front wall **340**, the outer wall **342**, the side walls **320**, **322**, and the divider walls **324** form cavities **326** around the exposed portions **156**, **158** of the signal conductors **150**, **152** of the cables **104**.

[0063] In an exemplary embodiment, the ground bus **300** is a multipiece structure. The ground bus **300** includes an inner bus member **304** and an outer bus member **306**. The inner bus member **304** is located between the outer bus member **306** and the circuit card **132**. The cable assembly **402** is received between the inner bus member **304** and the outer bus member **306**. For example, the ends of the cables **104** and the cable yoke **400** are received between the inner bus member **304** and the

outer bus member **306**. In an exemplary embodiment, the inner bus member **304** and the outer bus member **306** are electrically connected to the cable yoke **400** to electrically connect the cable shields **160** of the cables **104** to the ground bus **300**, and thus the circuit card **132**.

[0064] In the illustrated embodiment, the inner bus member **304** is a diecast part forming the majority of the ground bus **300**, whereas the outer bus member **306** is a diecast part forming a cover or lid for covering the inner bus member **304**. However, in alternative embodiments, the outer bus member **306** may be a stamped and formed part forming a cover or lid for the inner bus member or a diecast part forming a significant portion of the structure of the ground bus **300**. In an exemplary embodiment, the inner bus member **304** includes the side walls **320**, **322**, the divider walls **324**, and the front wall **340**. The outer bus member **306** includes the outer wall **342**. In various embodiments, the outer bus member **306** may be soldered or welded to the inner bus member **304**. In alternative embodiments, the outer bus member **306** may be secured to the inner bus member **304** using fasteners, latches, clips, or other securing features.

[0065] In an exemplary embodiment, the inner bus member **304** includes openings **360** at the outer end **318** that receive the ends of the cables **104**. The inner bus member **304** includes base walls **362** rearward of the openings **360**. The base walls **362** span between the divider walls **324** and the side walls **320**, **322**. The base walls **362** receive and support the cables **104**. In an exemplary embodiment, the cavities **326** between the divider walls **324** include cable pockets **366**. The cable yoke **400** is received in the cable pockets **366**. The base walls **362** form the cable pockets **366**. The outer bus member **306** extends along the fourth side of the cable pockets **366** to enclose or surround the cable yoke **400** and the cables **104**.

[0066] During assembly, the cable yoke **400** holds all of the cables **104** at fixed positions relative to each other. For example, the cable troughs **410** are spaced apart at predetermined spacings to locate the cables **104** relative to each other. The cable yoke **400** is received in the cable pockets **366**. All of the cables **104** may be simultaneously loaded into the cable pockets **366** as part of the cable assembly **402**. For example, the cable yoke **400** holds the cables **104** at predetermined positions for loading into the ground bus **300**. In an exemplary embodiment, the inner bus member **304** includes mounting features, such as mounting posts **368** for mounting the cable yoke **400** to the inner bus member **304**. The mounting posts **368** are received in the openings **442**, **472**. The cable yoke **400** may be press fit on the mounting posts **368** to mechanically and electrically connect the cable yoke **400** to the inner bus member **304**. Other types of mounting features may be used in alternative embodiments. Because the drain wires **164** are previously welded, or otherwise electrically coupled to the cable yoke **400**, the drain wires **164** do not need to be individually terminated to the ground bus **300**. After the cable assembly **402** is coupled to the inner bus member **304** and the exposed portions **156**, **158** of the signal conductors **150**, **152** are terminated to the circuit card **132**, the outer bus member **306** may be coupled to the inner bus member **304**.

[0067] FIG. **14** is a cross sectional view of a portion of the cable card assembly **130** in accordance with an exemplary embodiment showing the cable assembly **402** mechanically and electrically connected to the ground bus **300**. FIG. **15** is an enlarged cross sectional view of a portion of the cable card assembly **130** in accordance with an exemplary embodiment. The cable yoke **400** holds all of the cables **104** in the ground bus **300**. The cable yoke **400** is received in the cable pockets **366**. The mounting posts **368**, connect the cable yoke **400** to the inner bus member **304**. The outer bus member **306** is coupled to the inner bus member **304** to cover the cable assembly **402**.

[0068] FIG. **16** is a front perspective view of a portion of the cable card assembly **130** in accordance with an exemplary embodiment showing the cable assembly **402** in accordance with an exemplary embodiment. In an exemplary embodiment, the cable yoke **400** includes retention features **480** used to retain the cable assembly **402** in the ground bus **300** (shown in FIG. **13**). In the illustrated embodiment, the retention features **480** include retention tabs **482**. The retention tabs **482** are configured to be received in pockets in the ground bus **300**. The retention tabs **482** may extend forward from the front of the cable yoke **400**, such as from the connecting walls **434**, **464**.

In an exemplary embodiment, the retention features **482** are shaped to prevent pull out of the cable yoke **400** from the ground bus **300**, such as in a rearward direction. The retention features **482** may be captured in the ground bus **300**, such as by an interference fit. The retention features **482** may be electrically coupled to the ground bus **300**.

[0069] FIG. **17** is a front perspective view of a portion of the cable card assembly **130** in accordance with an exemplary embodiment showing the cable assembly **402** in accordance with an exemplary embodiment. In an exemplary embodiment, the cable yoke **400** includes the retention features **480** used to retain the cable assembly **402** in the ground bus **300** (shown in FIG. **13**). In the illustrated embodiment, the retention features **480** include spring beams **484**. The spring beams **484** are configured to be received in pockets in the ground bus **300**. The spring beams **484** may extend forward from the front of the cable yoke **400**, such as from the connecting walls **434**, **464**. In an exemplary embodiment, the spring beams **484** are deflectable. The spring beams **484** may be spread outward in the pocket to prevent pull out of the cable yoke **400** from the ground bus **300**, such as in a rearward direction. The spring beams **484** may be spring biased against the ground bus **300** to electrically couple to the ground bus **300**.

[0070] FIG. **18** is a front perspective view of a portion of the cable card assembly **130** in accordance with an exemplary embodiment showing the cable assembly **402** in accordance with an exemplary embodiment. In an exemplary embodiment, the cable yoke **400** includes the retention features **480** used to retain the cable assembly **402** in the ground bus **300** (shown in FIG. **13**). In the illustrated embodiment, the retention features **480** include compliant pins **486**. The compliant pins **486** are configured to be plugged into openings in the ground bus **300**, such as into the inner bus member **304** and the outer bus member **306**. The compliant pins **486** may extend forward from the front of the cable yoke **400**, such as from the connecting walls **434**, **464**. In an exemplary embodiment, the compliant pins **486** are shaped to prevent pull out of the cable yoke **400** from the ground bus **300**, such as in a rearward direction. The compliant pins **486** may be press fit into the ground bus **300**. The compliant pins **486** may be electrically coupled to the ground bus **300**.

[0071] 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 card assembly for an electrical connector comprising: a circuit card having an upper surface and a lower surface, the circuit card having a cable end and a mating end opposite the cable end, the circuit card having mating conductors at the mating end for mating with a mating electrical connector, the circuit card having circuit conductors at the cable end, the circuit card having a

ground plane; cables terminated to the circuit card, the cables including signal conductors and cable shields surrounding the corresponding signal conductors to provide electrical shielding for the signal conductors; a cable yoke holding the cables in fixed positions relative to each other, the cable yoke including cable troughs at spaced apart positions receiving the corresponding cables, the cable yoke being electrically connected to the cable shields; and a ground bus coupled to the ground plane of the circuit card, the ground bus having cable pockets receiving the cable yoke and the corresponding cables, wherein the cable yoke positions the cables in the cable pockets relative to the ground bus, the ground bus being electrically connected to the cable yoke to electrically connect the cable shields of the cables to the ground plane of the circuit card.

2. The cable card assembly of claim 1, wherein the cable yoke is stamped and formed from one or more metal sheets.

3. The cable card assembly of claim 1, wherein the cable yoke includes an inner yoke member and an outer yoke member separate and discrete from the inner yoke member, the outer yoke member being coupled to the inner yoke member to form the cable yoke, the cables being captured in the cable troughs between the inner yoke member and the outer yoke member.

4. The cable card assembly of claim 3, wherein the inner yoke member includes inner cable troughs receiving the corresponding cables and the outer yoke member includes outer cable troughs receiving the corresponding cables, the inner yoke member including inner connecting walls between the inner cable troughs and the outer yoke member includes outer connecting walls between the outer cable troughs, the inner connecting walls being laser welded to the outer connecting walls to form the cable yoke.

5. The cable card assembly of claim 1, wherein the cable yoke includes end walls and side walls forming the cable troughs, the end walls extending along opposite ends of each cable trough, the side walls extending along opposite sides of each cable trough, the cable yoke providing 360° shielding around each cable defined by the end walls and the side walls.

6. The cable card assembly of claim 5, wherein the cable yoke includes connecting walls extending between the side walls, the connecting walls spacing the side walls apart from each other to control spacing of the cables.

7. The cable card assembly of claim 1, wherein the cable yoke includes solder openings for soldering the cable shields to the cable yoke.

8. The cable card assembly of claim 1, wherein the cables include drain wires, the drain wires extending into the cable troughs to electrically connect to the cable yoke.

9. The cable card assembly of claim 8, wherein the cable yoke includes openings aligned with the drain wires, the cable yoke being laser welded to the drain wires through the openings.

10. The cable card assembly of claim 1, wherein the cable yoke includes retention features engaging the ground bus to secure the cable yoke relative to the ground bus.

11. The cable card assembly of claim 1, wherein the ground bus includes an inner bus member and an outer bus member, the inner bus member located between the outer bus member and the circuit card, the cable yoke and the cables being received between the inner bus member and the outer bus member.

12. A cable card assembly for an electrical connector comprising: a circuit card having an upper surface and a lower surface, the circuit card having a cable end and a mating end opposite the cable end, the circuit card having mating conductors at the mating end for mating with a mating electrical connector, the circuit card having circuit conductors at the cable end, the circuit card having a ground plane; cables terminated to the circuit card, the cables including signal conductors and cable shields surrounding the corresponding signal conductors to provide electrical shielding for the signal conductors; a cable yoke holding the cables in fixed positions relative to each other, the cable yoke including an inner yoke member and an outer yoke member coupled to the inner yoke member, the inner yoke member including inner cable troughs receiving the corresponding cables, the outer yoke member including outer cable troughs receiving the corresponding cables, the inner

yoke member including inner connecting walls between the inner cable troughs, the outer yoke member including outer connecting walls between the outer cable troughs, the inner connecting walls being laser welded to the outer connecting walls to form the cable yoke, the cable yoke being electrically connected to the cable shields; and a ground bus coupled to the ground plane of the circuit card, the ground bus having cable pockets receiving the cable yoke and the corresponding cables, wherein the cable yoke positions the cables in the cable pockets relative to the ground bus, the ground bus being electrically connected to the cable yoke to electrically connect the cable shields of the cables to the ground plane of the circuit card.

13. The cable card assembly of claim 12, wherein the cables are captured in the cable troughs between the inner yoke member and the outer yoke member.

14. The cable card assembly of claim 12, wherein the inner yoke member and the outer yoke member are identical and inverted 180° relative to each other.

15. The cable card assembly of claim 12, wherein the cable yoke includes end walls and side walls forming the cable troughs, the end walls extending along opposite ends of each cable trough, the side walls extending along opposite sides of each cable trough, the cable yoke providing 360° shielding around each cable defined by the end walls and the side walls.

16. The cable card assembly of claim 12, wherein the cable yoke includes solder openings for soldering the cable shields to the cable yoke.

17. The cable card assembly of claim 12, wherein the cables include drain wires, the drain wires extending into the cable troughs to electrically connect to the cable yoke.

18. The cable card assembly of claim 12, wherein the cable yoke includes retention features engaging the ground bus to secure the cable yoke relative to the ground bus.

19. The cable card assembly of claim 12, wherein the ground bus includes an inner bus member and an outer bus member, the inner bus member located between the outer bus member and the circuit card, the cable yoke and the cables being received between the inner bus member and the outer bus member.

20. An electrical connector comprising: a housing having walls forming a cavity, the housing having a mating end at a front of the housing configured to be mated with a mating electrical connector; and a cable card assembly received in the cavity of the housing, the cable card assembly including a circuit card, cables terminated to the circuit card, a cable yoke holding the cables, and a ground bus providing shielding for the cables, the circuit card having an upper surface and a lower surface, the circuit card having a cable end and a mating end opposite the cable end, the circuit card having mating conductors at the mating end for mating with the mating electrical connector, the circuit card having circuit conductors at the cable end, the circuit card having a ground plane and the ground bus being coupled to the ground plane, the cables including signal conductors and cable shields surrounding the corresponding signal conductors to provide electrical shielding for the signal conductors, the cable yoke including cable troughs receiving the corresponding cables and holding the cables in fixed positions relative to each other, the cable yoke being electrically connected to the cable shields, the ground bus having cable pockets receiving the cable yoke and the corresponding cables, wherein the cable yoke positions the cables in the cable pockets relative to the ground bus, the ground bus being electrically connected to the cable yoke to electrically connect the cable shields of the cables to the ground plane of the circuit card.