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Fig. 28 is a top plan view of a receptacle section which is engageable with the plug section of a preferred embodiment of the present invention shown in Fig. 24;

Fig. 29 is a bottom plan view of the receptacle shown in Fig. 28;

5 Fig. 30 is an end view of the receptacle shown in Fig. 28;

Fig. 31 is a side elevational view of the receptacle shown in Fig. 28;

Fig. 32 is a fragmented cross sectional view as taken through lines XXXII - XXXII in Figs. 24 and 28 showing those portions of the plug and receptacle shown in those drawings in an unengaged position; and

10 Fig. 33 is a fragmented cross sectional view as would be shown as taken through lines XXXIII - XXXIII in Figs. 24 and 28 if those elements were engaged.

Detailed Description of the Preferred Embodiments

THEORETICAL MODEL

15 The basic I-beam transmission line geometry is shown in Fig. 1. The description of this transmission line geometry as an I-beam comes from the vertical arrangement of the signal conductor shown generally at numeral 10 between the two horizontal dielectric layers 12 and 14 having a dielectric constant ϵ and ground planes 13 and 15 symmetrically placed at the top and bottom edges of the conductor. The sides
20 20 and 22 of the conductor are open to the air 24 having an air dielectric constant ϵ_0 . In a connector application the conductor would be comprised of two sections 26 and 28 which abut end to end or face to face. The thickness, t_1 and t_2 of the dielectric layers 12 and 14, to first order, controls the characteristic impedance of the transmission line and the aspect ratio of the overall height h to dielectric width w_d
25 controls the electric and magnetic field penetration to an adjacent contact. The aspect ratio to minimize coupling beyond A and B is approximately unity as illustrated in Fig. 1. The lines 30, 32, 34, 36 and 38 in Fig. 1 are equipotentials of voltage in the air-dielectric space. Taking an equipotential line close to one of the ground planes and following it out towards the boundaries A and B, it will be seen that both boundary A



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are very close to the ground potential. This means that at both boundary A and boundary B we have virtual ground surfaces and if two or more I-beam modules are placed side by side, a virtual ground surface exists between the modules and there will be no coupling between the modules. In general, the conductor width w_c and dielectric thickness should be small compared to the dielectric width or module pitch.

Given the mechanical constraints on a practical connector design, the proportioning of the signal conductor (blade/beam contact) width and dielectric thicknesses will, of necessity, deviate somewhat from the preferred ratios and some minimal coupling will exist between adjacent signal conductors. However, designs using the basic I-beam guidelines will have lower cross talk than more conventional approaches. Referring to Fig. 1a, an alternate embodiment is shown in which the dielectric is shown at 12' and 14' with their respective ground planes at 13' and 15'. In this embodiment the conductor 26' and 28' extend respectively from dielectric layers 12' and 14', but the conductors 26' and 28' abut side to side rather than edge to edge.

An example of a practical electrical and mechanical I-beam design for a .025 inch pitch connector uses 8 x 8 mil beams 26" and 8 x 8 mil blades 28", which when mated, form an 8 x 16 mil signal contact and the contact cross-section is shown in Fig. 2. The dielectric thickness, t , is 12 mils. The voltage equipotentials for this geometry are shown in Fig. 3 where virtual grounds are at the adjacent contact locations and some coupling will now exist between adjacent contacts.

Referring to Fig. 2, the I-beam transmission geometry is shown as being adapted to a less than ideally proportioned multi-conductor system. Signal conductors 40, 42, 44, 46 and 48 extend perpendicularly between two dielectric and horizontal ground plane 50 and mounted on base 51 and plane 52 mounted on base 53 which have a dielectric ϵ . To the sides of the conductors are air spaces 54, 56, 58, 60, 62 and 64.

Referring to Fig. 3, another multi-conductor connector is shown wherein there are parallel conductors 66, 68 and 70 which extend perpendicularly between two dielectric and horizontal ground planes 72 mounted on base 73 and 74 mounted on base 73. To the sides of the conductors are air spaces 76, 78, 80 and 82 and equipotential lines are shown as at 84 and 86.

ELECTRICAL CONNECTOR

Referring particularly to Figs. 4 to 12 it will be seen that the connector of the present invention is generally comprised of a plug shown generally at numeral 90 and a receptacle shown generally at numeral 92. The plug consists of a preferably metallic plug housing 94 which has a narrow front section 96 and a wide rear section 98. The front section has a top side 100 and a bottom side 102. The wide rear section has a top side 104 and a bottom side 106. The plug also has end surfaces 108 and 110. On the top side of both the front and rear sections there are longitudinal grooves 112, 114, 116 and 118 and 119. In these grooves there are also apertures 120, 122, 124, 126 and 128. Similarly on the bottom sides of both the front and rear section there are longitudinal grooves as at 129 which each have apertures as at 130. On the top sides there is also a top transverse groove 132, while on the bottom side there is a similarly positioned bottom transverse groove 134. The plug also has rear standoffs 136 and 138. Referring particularly to Fig. 9 it will be seen that the plug includes a dielectric element 140 which has a rear upward extension 142 and a rear downward extension 144 as well as a major forward extension 146 and a minor forward extension 148. The housing also includes opposed downwardly extending projection 150 and upwardly extending projection 152 which assist in retaining the dielectric in its position. In the longitudinal grooves on the top side of the plug there are top axial ground springs 154, 156, 158, 160 and 162. In the transverse groove there is also a top transverse ground spring 164. This transverse ground spring is fixed to the housing by means of ground spring fasteners 166, 168, 170 and 172. At the rearward terminal ends of the longitudinal ground springs there are top grounding contacts 176, 178, 180, 182 and 184. Similarly the grooves on the bottom side of the plug there are bottom longitudinal ground springs 186, 188, 190, 192 and 194. In the bottom transverse groove there is a bottom transverse ground spring 196 as with the top transverse ground spring, this spring is fixed in the housing by means of ground spring fasteners 198, 200, 202, 204 and 206. At the rear terminal ends of the ground springs there are bottom ground contacts 208, 210, 212, 214 and 216. The plug also includes a metallic contact

receptacle consists of receptacle housing 610, receptacle ground contact 612, receptacle ground springs 614 and receptacle contact 616. An alignment frame 618 and receptacle signal pins 620 and 622 are also provided. It will be appreciated that this arrangement affords the same I-beam geometry as was described above.

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COMPARATIVE TEST

The measured near end (NEXT) and far end (FEXT) cross talk at the rise time of 35p sec, for a .05" pitch scaled up model of a connector made according to the foregoing first described embodiment are shown in Fig. 17. The valley in the NEXT wave form of approximately 7% is the near end cross talk arising in the I-beam section of the connector. The leading and trailing peaks come from cross talk at the input and output sections of the connector where the I-beam geometry cannot be maintained because of mechanical constraints.

The cross talk performance for a range of risetimes greater than twice the delay through the connector of the connector relative to other connector systems is best illustrated by a plot of the measured rise time-cross talk product (nanoseconds percent) versus signal density (signals/inch). The different signal densities correspond to different signal to ground ratio connections in the connector. The measured rise time-cross talk product of the scaled up .05" pitch model I-beam connector is shown in Fig. 18 for three signal to ground ratios; 1:1, 2:1, and all signals. Since the cross talk of the scaled up model is twice that of the .025 inch design, the performance of the .025 inch pitch, single row design is easily extrapolated to twice the density and one half the model cross talk. For the two row design, the density is four times that of the model and the cross talk is again one half. The extrapolated performance of the one row and two row .025 inch pitch connectors are also shown in Fig. 18 relative to that of a number of conventional connectors as are identified in that figure. The rise time cross talk product of the .025 inch pitch I-beam connector for all signals is .75 and is much less than that of the other interconnects at correspondingly high signal to ground ratios.

- Referring particularly to the .05 inch pitch model curve
- 5 in Fig. 18, it will be observed that the rise time cross-talk product is independent of signal density for signal to ground ratios greater than 1:1.

ELECTRICAL CABLE ASSEMBLY

- Referring to Figs. 19 and 20, it will be seen that the beneficial results achieved with the connector of the present invention may also be achieved in a cable assembly.
- 10 That is, a dielectric may be extruded in an I-beam shape and a conductor may be positioned on that I-beam on the web and the horizontal flanges so as to achieve low cross talk as was described above. I-beam dielectric extrusions are shown at numerals 369 and 370. Each of these extensions has a web 371 which is perpendicularly interposed at its upper and lower edges between flanges as at 372
- 15 and 373. The flanges have inwardly facing interior surfaces and outwardly facing exterior surfaces which have metallized top ground plane sections 374 and 376 and metallized bottom ground plane sections respectively at 378 and 380. The webs also have conductive layers on their lateral sides. I-beam extrusion 370 has vertical signal lines 382 and 384 and I-beam extrusion 374 has vertical signal lines 386 and 388.
- 20 These vertical signal lines and ground plane sections will preferably be metallized as for example, metal tape. It will be understood that the pair of vertical metallized sections on each extrusion will form one signal line. The property of the I-beam geometry as it relates to impedance and cross talk control will be generally the same as is discussed above in connection with the connector of the present invention.
- 25 Referring particularly to Fig. 20, it will be seen that the I-beam extrusions have interlocking steps as at 390 and 392 to maintain alignment of each I-beam element in the assembly. Referring to Fig. 21, I-beam elements shown generally at 394, 396 and 398 are metallized (not shown) as described above and may be wrapped in a foil and elastic insulative jacket shown generally at numeral 400. Because of the regular

51. An electrical cable assembly comprising:

- (a) a pair of spaced parallel elongated dielectric flange elements each having an inwardly facing interior surface and an opposed exterior surface;
- (b) a conductive layer superimposed over at least part of the exterior surfaces of said flange elements;
- (c) an elongated central dielectric web element having opposed edges and opposed lateral sides and being perpendicularly interposed between said dielectric flange elements such that each of said opposed edges is fixed to one of the inner surfaces of the dielectric flange elements; and
- (d) a conductive layer superimposed over at least part of one of the lateral surfaces of the web element.

52. An electrical cable assembly in which rise time cross-talk product is independent of signal density for signal to ground ratios greater than 1:1.

53. An electrical connector comprising a first member comprising a first plurality of a metallic contact and a dielectric base having a grounding means wherein the metallic contacts project generally perpendicularly from the dielectric base and a second member comprising a second plurality of metallic contacts and a second dielectric base wherein the second plurality of metallic contacts projects generally perpendicularly from the second dielectric base so that each of said plurality of metallic contacts projecting from the first member is in electrical

contact which one of said second plurality of metallic contacts projecting from the second member.

54. An electrical connector comprising: (a) a first member comprising a first plurality of a metallic contacts and a dielectric base having a grounding means and opposed sides and wherein the metallic contacts project generally perpendicularly from one of said opposed sides of the dielectric base and at least one of said first plurality of metallic contacts is connected to a solder means positioned adjacent the other of said opposed sides of the dielectric base and (b) a second member comprising a second plurality of metallic contacts and a second dielectric base wherein the second plurality of metallic contacts projects generally perpendicularly from the second dielectric base so that each of said plurality of metallic contacts projecting from the first member is in electrical contact which one of said second plurality of metallic contacts projecting from the second member.

55. The electrical connector of claim 54 wherein the second dielectric base has opposed sides and at least one of said plurality of second metallic contacts projects from one of said opposed sides of the second dielectric base and is connected to a solder means positioned adjacent the other of said opposed sides of the second dielectric base.

56. An electrical connector comprising a first member comprising a first metallic contact having opposed ends and opposed sides and at least one of said sides being exposed to material having a first dielectric constant and a first dielectric base having a second dielectric constant greater than said first dielectric constant and being positioned at one of said ends of said first metallic contact and having a first ground plane wherein the metallic contact projects from the dielectric base and a second member comprising a second metallic contact having opposed sides and at least one of said sides being exposed to said material having a first dielectric constant and a second dielectric base having a dielectric constant about equal to said first dielectric base and being positioned at the other of said ends of the second metallic contact and having a second ground plane positioned in parallel relation to said first ground plane and wherein the second metallic contact projects from the second dielectric base to be in electrical contact with the first metallic contact of the first member, whereby said first and second metallic contacts form a means for conducting a signal in parallel medial relation to said first and second ground planes.

57. The electrical connector of claim 56 wherein in the first member the metallic contact projects generally perpendicularly from the dielectric base.

58. The electrical connector of claim 56 wherein in the second member the second metallic contact projects generally perpendicularly from the second dielectric base.

59. A method of reducing cross talk and controlling impedance in an electrical connector comprising the steps of providing a first dielectric base and a second dielectric base spaced from said first dielectric base connecting said first dielectric base and said second dielectric base with at least one metallic contact causing a signal to be conducted through said contact in medial relation between said first dielectric base and said second dielectric base.

60. The method of claim 59 wherein the signal is conducted in parallel relation to said first dielectric base and said second dielectric base.

61. The method of claim 59 wherein the metallic contact is oriented in perpendicular relation to the first dielectric base and the second dielectric base.

62. An electric cable assembly comprising a metallic element generally perpendicularly interposed between opposed dielectric elements wherein the opposed dielectric elements are flanges and include grounding means and there are a pair of voids positioned in opposed lateral relation to said metallic element and interposed between said flanges.