

CONSTANT IMPEDANCE CONNECTOR SYSTEM

Background Of The Invention

1. Field of the Invention

The present invention relates to a constant impedance connector system, utilizing the characteristics of known constant impedance connectors, some with embedded attenuation and/or filtering components. The constant impedance connector system is designed for use in computer technology, and to the connection system for a quantum computer. More specifically, the present invention may be adapted for use in a cryogenically cooled quantum computer. The constant impedance connectors may be in the form of replaceable adapters.

2. Description of Related Art

Today's computer work by manipulating bits that exist in one of two states: a 0 or a 1. Quantum computers, however, are not limited to two states; they encode information as quantum bits, or qubits, which can exist in superposition. Qubits represent atoms, ions, photons, or electrons and their respective control devices that are working together to act as computer memory and/or a processor. Because a quantum computer can contain these multiple states simultaneously, it has the potential to be millions of times more powerful than today's most powerful supercomputers.

This superposition of qubits is what gives quantum computers their inherent parallelism. This parallelism allows a quantum computer to work on a million computations at once.

As the physical attributes of the qubits continue to advance, meeting the challenge of realizing a quantum machine requires the engineering of new hardware and control architectures with complexity far beyond today's systems. One such system advancement is the implementation of computing at cryogenic temperatures using superconductor-based components. There are many benefits of cryogenic operation, such as: increased mobility and saturation velocity of the carriers, leading to higher operation speed; lower noise levels; increased electrical conductivity; increased integration densities; and the suppression of thermally activated degradation processes, to name a few. The drawbacks of cryogenic operation include: the necessity for an appropriate cooling system; the selection of materials and

components optimized for low temperature operation; and, interfacing aspects between "cold" and "warm" electronics, among others.

Summary of the Invention

Bearing in mind the problems and deficiencies of the prior art, it is therefore an object of
5 the present invention to provide a connection system capable of operating in a cryogenic environment with the ability to traverse through an external or "warm" environment to an internal or "cold" environment.

It is another object of the present invention to provide a connection system that presents a higher density of cables than the current state-of-the-art assemblies.

10 It is a further object of the present invention to accommodate system electrical attenuation in a cryogenic environment in order to reduce the thermal energy resulting from transmitted signal power.

It is another object of the present invention to establish a hermetic seal in-line with the system cabling.

15 It is another object of the present invention to provide a connection system that can be installed within a quantum computer operating system, and which can be easily assembled in the computer system without damage to the extremely small diameter center conductors of the cabling.

20 It is yet another object of the present invention to accommodate system electrical filtering in a cryogenic environment in order to reduce extraneous electrical signals (noise) coupled onto conductors.

The above and other objects, which will be apparent to those skilled in the art, are achieved in the present invention which is directed to a connection system for transmitting signal cables through tiered stages, wherein at least one stage comprises: a first signal cable having a
25 center conductor terminated by a first constant impedance receptacle connector or first constant impedance plug connector; a first connector housing for securing the first signal cable; a header housing mounted to a first plate, the header housing having a first header housing constant

impedance receptacle connector or a first header housing constant impedance plug connector mounted on a first side, and a second header housing constant impedance receptacle connector or a second header housing constant impedance plug connector mounted on a second side opposite the first side, wherein the first header housing connector on the first side is
5 complementary to the first constant impedance receptacle connector or the first constant impedance plug connector of the first signal cable, such that the first connector housing attaches to the header housing on the first side in a constant impedance cable connection; and a second connector housing a second signal cable, wherein the second signal cable has a center conductor terminated by a second constant impedance receptacle connector or second constant impedance
10 plug connector, wherein the second connector housing second signal cable connector is a complementary connector to the header housing constant impedance receptacle connector or header housing constant impedance plug connector on the second side, such that the second connector housing attaches to the header housing on the second side in a constant impedance cable connection.

15 The connection system includes a seal located between the header housing connectors on the first and second sides for sealing the center conductor passing therethrough.

 The header housing may include a removable attenuator or filter component connected at one end to the header housing constant impedance plug connector and at an opposing end to the header housing constant impedance receptacle connector, for signal attenuation and/or
20 electrical signal filtering of the first and second signal cables.

 The first plate is a heat sink or a ground potential or both for constant impedance connectors, attenuators, and/or filters.

 The first plate may be a refrigeration plate.

 The first constant impedance receptacle connector or the first constant impedance plug
25 connector of the first cable includes an attenuator or filter component embedded therein for signal attenuation and/or electrical signal filtering of the first and second signal cables.

The second constant impedance receptacle connector or the second constant impedance plug connector of the second cable includes an attenuator or filter component embedded therein for signal attenuation and/or electrical signal filtering of the first and second signal cables.

Additional connection system stages may be connected to the at least one stage.

5 In a second aspect, the present invention is directed to a connection system for transmitting signal cables through tiered stages comprising: a plurality of first signal cables, wherein at least one of the plurality of first signal cables includes a center conductor terminated by a constant impedance receptacle connector or constant impedance plug connector; a first connector housing for securing each of the first signal cables; a header housing mounted to a first
10 plate, the header housing having the constant impedance receptacle connector or the constant impedance plug connector mounted on a first side, and the constant impedance plug connector or the constant impedance receptacle connector mounted on a second side opposite the first side, wherein the header housing connectors on the first side are complementary connectors to the constant impedance receptacle connector or constant impedance plug connector of the
15 constant impedance receptacle connector or constant impedance plug connector of the at least one of the plurality of first signal cables, such that the first connector housing attaches to the header housing on the first side in a constant impedance cable connection; and a second connector housing having a plurality of second signal cables, wherein at least one of the plurality of second signal cables has a center conductor terminated by a constant impedance receptacle
20 connector or constant impedance plug connector, wherein the second connector housing second signal cable connector is complementary connector to the constant impedance receptacle connector or constant impedance plug connector of the header housing connector on the second side, such that the second connector housing attaches to the header housing on the second side in a constant impedance cable connection.

25 The connection system includes: a lower housing stage having an upper portion and a lower portion, the lower housing stage mounted to a second plate, the lower housing stage upper portion comprising a plurality of modified constant impedance connectors for mating with the plurality of second signal cables extending from the header housing on the second side.

The modified constant impedance connectors each includes an attenuator or filter component embedded therein for signal attenuation or electrical signal filtering, the lower housing stage lower portion including constant impedance connector receptacles or constant impedance plugs terminating with a plurality of third signal cables.

- 5 The second plate may be a heat sink or a ground potential or both for the modified constant impedance connectors, or may be a refrigeration plate.

The lower housing stage upper portion and lower housing stage lower portion each include extended ribs for attachment to a clamp mounted to the second plate.

- 10 The modified constant impedance connector attenuators or filters can be press-fit into the lower housing stage upper portion or the lower housing stage lower portion.

- 15 The connection system further includes: a plug housing block or a receptacle housing block for terminating the plurality of second signal cables, wherein the plug housing block includes a constant impedance plug connector for each of the plurality of second signal cables, or a constant impedance receptacle connector for each of the plurality of second signal cables, or some combination thereof; an adaptor housing having a plurality of apertures for mounting attenuator housings, filter housings, or both, each of the attenuator housings and/or filter housings associated with a signal cable of the plurality of second signal cables, and having a complementary constant impedance connector on a first side of the adaptor housing for connecting with the reciprocal constant impedance connector of plug housing block; and a
20 receptacle housing block for connecting to the adaptor housing on a second side, the receptacle housing block including a constant impedance plug connector in electrical communication with the plurality of second signal cables, or a constant impedance receptacle connector in electrical communication with the plurality of second signal cables, or some combination thereof, and having a plurality of third signal cables extending therefrom; wherein the receptacle housing
25 block connected to the adaptor housing on the adaptor housing second side, such that complementary constant impedance connectors of receptacle housing block connect to complementary constant impedance connectors of the adaptor housing second side.

The attenuator housing, the filter housing, or both, each may include a resilient component for electrical communication, thermal communication, electromagnetic interference

protection, or any combination thereof, to an inner wall of each respective aperture of the adaptor housing.

The connection system further includes at least one additional plate for mounting a second lower housing stage, the second lower housing stage comprising a second set of a plurality of modified constant impedance connectors in electrical communication with the
5 plurality of third signal cables, the second set of modified constant impedance connectors each having a second attenuator or second filter component embedded therein for signal attenuation or electrical signal filtering.

The connection system may also include: an additional plate; a second plug housing block
10 or a receptacle housing block mounted to the at least one additional plate, in electrical communication with the third signal cables, wherein the plug housing block includes a constant impedance plug connector for each of the plurality of third signal cables, or a constant impedance receptacle connector for each of the plurality of third signal cables, or some combination thereof; a second adaptor housing having a plurality of apertures for mounting
15 second attenuator housings, second filter housings, or both, each of the second attenuator housings and/or second filter housings associated with a signal cable of the plurality of third signal cables, and having a complementary constant impedance connector on a first side of the second adaptor housing for connecting with the reciprocal constant impedance connector of second plug housing block; and a second receptacle housing block for connecting to the second
20 adaptor housing on a second side, the second receptacle housing block including a constant impedance plug connector in electrical communication with the plurality of third signal cables, or a constant impedance receptacle connector in electrical communication with the plurality of third signal cables, or some combination thereof, and having a plurality of fourth signal cables extending therefrom; wherein the second receptacle housing block is connected to the second
25 adaptor housing on the second adaptor housing second side, such that complementary constant impedance connectors of the second receptacle housing block connect to complementary constant impedance connectors of the second adaptor housing second side.

The attenuator may provide up to 40dB attenuation.

The constant impedance receptacle connector may include a stabilizing bobbin around the center conductor to facilitate matched impedance.

The first and second attenuators or filters may be arranged in a casing, the casing being secured within an internal cavity of the modified constant impedance connector housing.

- 5 The plurality of second signal cables or the plurality of third signal cables, or both, comprise superconducting cabling material.

10 In a third aspect, the present invention is directed to a constant impedance connector for electrical attenuation or electrical filtering of electrical signals in a connection system comprising: a housing having an upper body portion with a first conductive or shield component disposed therein and a lower body portion with a second conductive or shield component disposed therein; the housing upper body portion having an upper constant impedance receptacle or plug mating end with a first center conductor; the housing lower body portion having a lower reciprocal constant impedance plug or receptacle mating end with a second center conductor, the second housing portion removably attachable to the first housing portion; wherein the
15 housing upper body portion, the housing lower body portion, or both, form an internal cavity for securing an attenuator or filter component embedded therein, the attenuator or filter component for attenuating or filtering an electrical signal on the first and second center conductor; wherein said housing upper body portion has an inner diameter, said first center conductor has an outer diameter, said housing lower body portion has an inner diameter, said
20 second center conductor has an outer diameter, and said attenuator or said filter component has an outer diameter, such that the first and second center conductors and the first and second conductive or shield components are shaped so that when the housing upper and lower body portions form an engaged connection along a central axis, an effective outer diameter of the first and second center conductors referenced by "d", the effective inner diameter of the first and
25 second housing upper and lower body portions or shield components referenced by "D", and a relative dielectric constant " ϵ " of a medium between the center conductors and the shield components, satisfy a constant impedance equation when in a partially engaged position and when in a fully engaged position.

30 In a fourth aspect, the present invention is directed to an adaptor for implementing an attenuator or a filter into a constant impedance signal cable, the adaptor comprising an

attenuator component or a filter component within an adaptor housing, the adaptor housing terminating on each end with a constant impedance receptacle or constant impedance plug.

5 The adaptor may include a resilient component in mechanical, electrical, and/or thermal communication with the adaptor housing on one side, and in mechanical, electrical, and/or thermal communication with an adaptor housing mounting structure on the other side, such that the resilient component in connection with the adaptor housing mounting structure provides a heat sink, a ground potential, electromagnetic interference protection, or any combination thereof, for signals traversing through the adaptor.

10 In a fifth aspect, the present invention is directed to a method of connecting electrical cables in a tiered staged connection system, comprising forming a first stage connection by:

connecting a first signal cable having a center conductor terminated by a first constant impedance receptacle connector or a first constant impedance plug connector to a first connector housing; mounting a first header housing constant impedance receptacle connector or a first header housing constant impedance plug connector mounted on a first side of a header housing; mounting a second header housing constant impedance receptacle connector or a second header housing constant impedance plug connector mounted on a second side of the header housing opposite the first side, wherein the first header housing connector on the first side is complementary to the first constant impedance receptacle connector or the first constant impedance plug connector of the first signal cable, such that the first connector housing attaches to the header housing on the first side in a constant impedance cable connection; mounting the header housing to a first plate, connecting a second signal cable to a second connector housing, wherein the second signal cable has a center conductor terminated by a second constant impedance receptacle connector or second constant impedance plug connector, wherein the second connector housing second signal cable connector is a complementary connector to the header housing constant impedance receptacle connector or the header housing constant impedance plug connector on the second side, such that the second connector housing attaches to the header housing on the second side in a constant impedance cable connection; and mounting the second connector housing to the header housing.

The method includes inserting a seal located between the header housing connectors on the first and second sides for sealing the center conductor passing therethrough.

The method further includes connecting a removable attenuator or filter component at one end to the header housing constant impedance plug connector and at an opposing end to the header housing constant impedance receptacle connector, for signal attenuation and/or electrical signal filtering of the first and second signal cables.

An attenuation or filtering component or both may be embedded within an adaptor removably insertable within an adaptor housing.

The adaptor housing may be connected at one end to the header housing constant impedance plug connector and at an opposing end to the header housing constant impedance receptacle connector.

The method further includes electrically connecting a second stage connection to the first stage connection. The second stage connection includes a second stage upper connector housing, a second stage header housing mounted to a plate, and a second stage lower connector housing, wherein complementary constant impedance plugs and receptacles are mounted to the second stage upper connector housing, the second stage header housing, and the second stage lower connector housing, to form constant impedance electrical connections for signal cables passing therethrough.

In yet another aspect, there is provided a method of assembling a constant impedance connector for electrical attenuation or electrical filtering of electrical signals in an electrical system, comprising: providing a constant impedance connector housing having an upper body portion with a first conductive or shield component disposed therein and a lower body portion with a second conductive or shield component disposed therein, said housing upper body portion having a constant impedance receptacle or plug mating end with a first center conductor, and said housing lower body portion having a constant impedance plug or receptacle mating end with a second center conductor, said housing lower body portion being removably attachable to said housing upper body portion, said housing upper and lower body portions forming an internal cavity upon engagement; providing an attenuator or filter component for attenuating or filtering an electrical signal in electrical communication with said first and second center conductors and inserting said attenuator or filter component into the internal cavity; providing a housing block having a receptacle housing block portion and a mating plug housing block portion, said receptacle housing block portion for receiving one of said housing upper body portion and said housing lower body portion, and said mating plug housing block for receiving the other of said housing upper body portion and said housing lower body portion; and attaching the housing upper body portion to the housing lower body portion such that the attenuator or filter component within said constant impedance connector is supported by said housing block; wherein said housing upper body portion has an inner diameter, said first center conductor has an outer diameter, said housing lower body portion has an inner diameter, said second center conductor has an outer diameter, and said attenuator or said filter component has an outer diameter, such that the first and second center conductors and the first and second conductive or shield components are shaped so that when the housing upper and lower body portions form an engaged connection along a central axis, an effective outer diameter of the first and second center conductors referenced by "d", the effective inner diameter of the first and second housing upper and lower body portions or shield components referenced by "D", and a relative dielectric

constant " ϵ " of a medium between the center conductors and the shield components, satisfy a constant impedance equation when in a partially engaged position and when in a fully engaged position.

In yet a further aspect, there is provided a constant impedance connector for electrical
5 attenuation or electrical filtering of electrical signals in a connection system comprising: a housing having an upper body portion with a first conductive or shield component disposed therein and a lower body portion with a second conductive or shield component disposed therein, and a hermetic seal stage disposed adjacent thereto; said housing upper body portion having a constant impedance receptacle or plug mating end with a first center conductor running
10 through said hermetic seal stage; said housing lower body portion having a constant impedance plug or receptacle mating end with a second center conductor running through said hermetic seal stage; wherein either of the first or second center conductor, or both, runs through said hermetic seal stage; and an attenuator or filter component having a first electrical connector and a second electrical connector disposed on opposite ends, the first electrical connector for reception by the
15 housing upper body portion and for forming a first electrical connection, the second electrical connector for reception by the housing lower body portion and for forming a second electrical connection, the attenuator or filter component further having a thermally conductive component disposed adjacent to the attenuator or filter component; wherein said housing upper body portion, said housing lower body portion, or both, form an internal cavity for receiving the
20 attenuator or filter component, said attenuator or filter component for attenuating or filtering an electrical signal on said first and second center conductor, and the thermally conductive component for transmitting thermal energy from the attenuator or filter component; wherein said housing upper body portion has an inner diameter, said first center conductor has an outer diameter, said housing lower body portion has an inner diameter, said second center conductor
25 has an outer diameter, and said attenuator or said filter component has an outer diameter, such that the first and second center conductors and the first and second conductive or shield components are shaped so that when the housing upper and lower body portions form an engaged connection along a central axis, an effective outer diameter of the first and second center conductors referenced by " d ", the effective inner diameter of the first and second housing
30 upper and lower body portions or shield components referenced by " D ", and a relative dielectric constant " ϵ " of a medium between the center conductors and the shield components, satisfy a constant impedance equation when in a partially engaged position and when in a fully engaged position.

Description of the Drawings

The features of the invention believed to be novel and the elements characteristic of the invention are set forth with particularity in the appended claims. The figures are for illustration purposes only and are not drawn to scale. The invention itself, however, both as to organization
5 and method of operation, may best be understood by reference to the detailed description which follows taken in conjunction with the accompanying drawings in which:

Fig. 1 is a perspective view of one embodiment of the connector system of the present invention;

Fig. 2 is a cross-sectional view of the top plate of the connector system of Fig. 1 with a
10 hermetic header housing attached thereto; Fig. 3 depicts an illustrative example of an incoming cable with a connector housing for connection to the top plate of Fig. 2;

Fig. 4 depicts the center stage of the connector system where signal attenuation is achieved;

Fig. 5 depicts an exploded, perspective view of an adaptor housing that encloses a
15 plurality of attenuator or filter components, each within respective apertures;

Fig. 6 depicts a cross-sectional view of the attenuator or filter component insertable within the adaptor housing of Fig. 5;

Fig. 7 depicts an exploded, perspective view of the adaptor housing of Fig. 5, where a section of the aperture is shown removed to expose the attenuator or filter component inserted therein;

Fig. 8 depicts a plug housing block attached to the adaptor housing of Fig. 5 on one side,
5 and receptacle housing block attached to adaptor housing on the other side;

Fig. 9 depicts a cross-section of housing blocks mated to the adaptor housing with attenuation adaptors and plug connectors;

Fig. 10 depicts the separation of the housing blocks for replacement of the attenuation adaptors, and an attenuation adaptor removed therefrom; and

10 Fig. 11 depicts the separated housing blocks and the replacement of a new attenuation adaptor or other component.

Description of the Preferred Embodiment(s)

In describing the preferred embodiment of the present invention, reference will be made herein to Figs. 1 – 11 of the drawings in which like numerals refer to like features of the
15 invention.

The present invention provides a connection system for electrical signals. The invention is preferably used to accommodate computer architecture, and preferably quantum computer architecture, although uses outside of computer architecture are not prohibited. For illustrative purposes, the application of the connection system of the present invention is demonstrated in
20 computer architecture; however, other uses for electrical signal protection using the connection system are not precluded.

In one embodiment, the present invention lends itself to operation in a cryogenically cooled environment, although the present invention is not limited to cryogenically cooled environment applications. The need for reducing input power that would otherwise provide
25 degrading thermal effects to the internal system is mitigated through the introduction of attenuators embedded within the housing of specialized constant impedance connectors, or formed as adapters that are designed to extend a constant impedance connection. In both

instances the connectors are designed with a direct thermal connection to heat sinking elements, such as refrigeration plates, or the like. In certain instances, the attenuators are cryogenically-design. Similarly, in lieu of, or in addition to, attenuators, the present invention may also accommodate filters that are either embedded within the housing of specialized constant
5 impedance connectors or attached as adapters to extend the constant impedance connections.

The design for embedding attenuators or providing an attenuating adaptor that extends a constant impedance connector readily lends itself to the implementation of filtering components within the connector or adaptor housing to reduce unwarranted coupling on the signal lines. In this manner, extraneous power on the line is further reduced by shunting at least a portion of the
10 electrically coupled noise to ground before it travels to the colder portions of the cryogenically cooled environment.

Standardized constant impedance connectors accommodate large radial and axial misalignment tolerances found in modular applications. Constant impedance technology, as that found in the PkZ® connectors of Palco Connector, Inc., of Naugatuck, Connecticut – an affiliate of
15 The Phoenix Company of Chicago – ensures constant impedance with low insertion forces and no internal engagement spring. These connectors provide consistent performance by maintaining constant impedance over the larger Z-axis mating gaps caused by system and connector tolerance challenges. This is advantageous over the SMA connectors of the prior art, which are generally threaded and unable to accommodate movement of components at low temperatures.
20 The Palco PkZ® connectors are implemented in this design as exemplary constant impedance connectors that will maintain signal integrity in a challenging environment.

The operating signals may be either RF or digital signals, typically in frequencies less than 40 GHz, but may be as high as 40 GHz to 60 GHz, with approximately 1 watt max power. This is in contrast to SMA connectors currently found in the art, which operate on the order of less than 20
25 GHz.

Fig. 1 is a perspective view of one embodiment of the connector system 1 of the present invention. The input signals travel through connector system 1 via mounting and connecting blocks with cables extending there between. Top plate 2 receives input cables 20 from an external, uncontrolled or less controlled environment, such as a less controlled temperature

environment. The center conductors of the cables pass through top plate 2 in a manner that secures and maintains a hermetic seal. After traversing through top plate 2, the signals are carried via cabling through at least one additional plate 4, which may be a plate used for heat sinking, and more preferably, a plurality of plates, to reduce and maintain a lower temperature
5 for cryogenic applications. Such plates act as heat sinks for thermal energy, which aid in prohibiting the thermal energy from transmitting further down the connector system. The signals are then connected via cabling to a lower housing stage 8 which is downstream of the top plate 2, and which utilizes a modified constant impedance connector, such as a PkZ® connector. The signal lines then traverse to a bottom housing stage 10 through which the signal lines then
10 progress to the internal computer electronics.

As will be discussed in further detail below, the modification of the constant impedance connection may be presented in different distinct designs and at different stages. For example, in a first embodiment, an attenuator or filter is embedded in either a constant impedance connector receptacle or plug. As depicted in Fig. 4, the connector receptacle is installed into a
15 receptacle housing block 9a, and the connector plug is installed into a plug housing block 9b, such that when the receptacle housing block 9a is mated to the plug housing block 9b, the receptacle and plug connectors are mated as well. This allows for proper alignment of the contacts and thermal dissipation through the housing blocks.

In a second embodiment an attenuator component or filter component adaptor is
20 employed within its own adapter body which is then mounted into an adaptor housing, which preferably accommodates a plurality of adaptor bodies. The adaptor housing is then mounted to a plate, such as a refrigeration plate. The adaptor housing will receive on one side connectors from a receptacle housing block, and on the other side connectors from a plug housing block. It is also possible for an adaptor housing to be designed to receive connectors from a receptacle
25 housing block on both sides, or connectors from a plug housing block on both sides, such that, in either embodiment, a constant impedance connection is made on each side of the adaptor housing.

The attenuator lowers the power on each center conductor without changing the signal integrity. In cooling applications, the excess thermal energy from the attenuated signals is then
30 dissipated through the housing to a heat sink, such as refrigeration plate. The system is designed

to accommodate a plurality of such heat sinks. Additional plates may have further attenuation components for further signal conditioning. External cabling then extends from bottom housing stage 10 to the computer internal electronics, and ultimately to the processor.

5 It is noted that for optimum operation of the connection system within a quantum computer application most or approximately all of the materials of the connection system are designed of non-magnetic material. For other applications, non-magnetic material may not be necessitated.

Fig. 2 is a cross-sectional view of top plate 2 of connector system 1 with a hermetic header housing 21. Top plate 2 introduces a hermetic seal in the signal lines. This is accomplished
10 by mounting hermetic header housing 21 on top plate 2. Hermetic header housing 21 passes through an aperture in top plate 2. In this manner, downstream signal cables and electronics are sealed from the outside environment. In this embodiment, on one side of top plate 2, incoming cables 20 are attached to a connector housing 22a. Connector housing 22a terminates the signal cables at a constant impedance receptacle connector 24a. Alternatively, the signal cables may be
15 terminated at a constant impedance plug connector, as receptacles and plugs may be interchanged without loss of design function. The connector housing 22a then connects to the top side of the hermetic header housing 21. The hermetic header housing 21 on its top side has reciprocal constant impedance plugs 24b for mating with the constant impedance receptacles 24a of connector housing 22a. The center conductor 25 runs through a hermetic seal material 27
20 within the hermetic header housing 21. On the bottom side of top plate 2, which correlates with the bottom side of hermetic header housing 21, a constant impedance plug 24c is installed for each signal line. A connector housing 22b then connects to the bottom side of the hermetic header housing 21. Connector housing 22b has reciprocal constant impedance receptacle connectors 24d to mate with constant impedance plugs 24c.

25 Fig. 3 depicts an illustrative embodiment of incoming cable 20 for installation into connector housing 22. A first, standard constant impedance receptacle 24a is attached thereto. The standard PkZ® receptacle is preferably a commercially available type constant impedance connector, such as that available from Palco Connector, Inc., or an equivalent thereof. It should be noted that where receptacles are utilized, plug connectors may be employed, and where plug

connectors are utilized, receptacle connectors may be employed, without degradation to the constant impedance connection.

As will be discussed in further detail below, in an alternative embodiment, a second constant impedance mating plug may be introduced, which is mated with a second constant impedance receptacle. The second receptacle is altered from the first receptacle discussed above
5 inasmuch as the second receptacle requires a different internal termination to accommodate a different cable, allowing the connection to proceed from a generally standard cabling material to cabling 32, which may be superconducting cabling material. In this manner, different cabling may be used under a similar connection scheme.

Following the signal cabling from the external environment towards the cryogenically cooled environment, through the hermetic seal stage, the cabling extends from connector housing 22b to lower housing stage 8. Fig. 4 depicts a cross-sectional view of a portion of lower housing stage 8. In this embodiment, the attenuator of the constant impedance connector is press-fitted within the receptacle housing 9a, and is thus not interchangeable or easily repairable.
10 In other embodiments, the attenuator may be secured by a clip ring or mechanical retention retaining ring. As will be shown in a second embodiment, an attenuator or filter adaptor is interchangeable, and would connect on each end to a respective constant impedance receptacle or plug.
15

In Fig. 4, receptacle housing block 9a performs an attenuation of the cable signals utilizing an embedded attenuator 38. Cabling 32 includes a constant impedance (PkZ[®]) receptacle
20 36. PkZ[®] receptacle 36 is modified to include, internally, attenuator 38. Attenuator 38 may be formed from discrete attenuator electronic components. Other attenuator components may be employed, provided their dimensions are acceptable for insertion within a modified constant impedance connector housing having an upper body portion and a lower body portion, such as
25 PkZ[®] connector upper housing body portion 42 and lower housing body portion 43. Attenuator 38 may be any level of attenuation depending upon the system requirements. In one embodiment, a 20dB attenuator is employed. Attenuator 38 is confined within an attenuator housing 40, which is secured within the modified PkZ[®] receptacle 36.

By attenuating the cable signals, energy is removed from the cables and shunted via the attenuator to the adjoining plate. In this manner, heat energy is kept further away from the internal computer electronics downstream.

Constant impedance receptacle 36 is then mated to a mating plug 44 which is inserted
5 within, and secured by, mating plug housing block 9b. Mating plug 44 extends the signal conductor to a cable 46, which under certain circumstances may be a superconducting cable. Cable 46 does not necessarily have to be the same material as cable 32, and any mating plug would be designed to accommodate the different conducting cable material, including superconducting cabling material.

10 Receptacle and plug housing blocks 9a, 9b are attached to, and in thermal communication with, lower housing stage 8 via a specialized clamp 50a,b. Clamp 50a,b are each designed to hold extended ribs 48a,b on the perimeter of each housing block 9a,b respectively. Clamps 50a,b are mechanically fastened to lower housing stage 8 on one side via a threaded or other removable attachment scheme. The bottom side of clamp 50b is in thermal communication
15 with lower housing stage 8.

Cables 46 extend from plug housing block 9b and may traverse through one or more plates that may utilize heat sinks, and which may be configured in the same manner as described above.

Fig. 5 depicts an exploded, perspective view of an adaptor housing 70 that encloses a
20 plurality of attenuator or filter components 72, each within respective apertures 74, which for illustrative purposes shall be shown as cylindrical apertures although the present invention is not restricted to any given shape. Adaptor housing 70 is attached to plate 76, which is preferably a heat sink plate or a metal structure that provides either thermal conduction for transmitting heat energy, or ground potential for removing filtered signal noise, or both. A plug housing block 78
25 attaches to adaptor housing 70 on one side, and a receptacle housing block 80 attaches to adaptor housing 70 on the other side. The plug and receptacle housing blocks 78, 80 each house a mating section of a constant impedance connector, either the receptacle or the plug portion component 82, 84, respectively, for cable connection to the adaptor housing 70 on each side, respectively.

In this manner, one end of the receptacle or plug portion component 82, 84 is a mating constant impedance connector receptacle or plug, which is designed to mate with the complementary attenuator or filter component 72, such that a constant impedance connection is formed. The mating attachment is slidably connected to the receiving attachment on the
5 attenuator or filter component 72. By this design, the attenuator or filter components 72 may be interchangeable, insomuch as attenuator components may be replaced with filter components, and vice versa. As an illustrative example, plug housing block 78 is depicted with a PkZ® plug, and receptacle housing block 80 is depicted with a PkZ® receptacle. The present invention can also accommodate the interchanging of plugs and receptacles so that the constant impedance
10 connection is still maintained.

Fig. 6 depicts a partial cross-sectional view of the attenuator or filter component 72. This component includes an attenuator or filter circuit contained in its own removable casing 90 with electrical connections 96, 98 at each end. This attenuator or filter component 72 is insertable within aperture 74 of adaptor housing 70.

15 A resilient, thermally and/or electrically conductive component 100 is attached to the outside of attenuator or filter component 72 to transmit thermal energy from the attenuator or filter component 72 to the inner wall of aperture 74 upon insertion. The resilient thermally or electrically conductive component 100 may be in the form of a spring or other resilient structure for forming a slideable, compressible connection against the inner wall of aperture 74. The
20 resilient component 100 provides movement and flexibility that a press-fit device (as depicted by the first embodiment above) cannot provide, while assuring improved thermal conductivity and/or electromagnetic interference protection.

Fig. 7 depicts an exploded, perspective view of adaptor housing 70 where a section of the aperture 74 is shown removed to expose the attenuator or filter component 72 inserted therein.
25 As shown, resilient component 100 is circumferentially attached to attenuator or filter component 72 such that the outermost side of component 72 is compressibly fit against the inner wall of aperture 74.

Figs. 8-11 depict the method steps for mating the connection system in a computer application. As depicted in Fig. 8, plug housing block 78 is attached to adaptor housing 70 on one

side, and receptacle housing block 80 is attached to adaptor housing 70 on the other side, using fixing hardware. Adaptor housing 70 is populated with attenuation adaptors.

Fig. 9 depicts a cross-section of plug housing blocks 78, 80 mated to the adaptor housing 70 with attenuation adaptors 72 and plug connectors 82, 84 shown.

5 In order to replace the attenuation adaptors 72, fixing hardware is removed on both the plug housing block and the receptacle housing block. The connector housings are then removed, and the attenuation adaptors are removed and replaced. Fig. 10 depicts the separation of the housing blocks for replacement of the attenuation adaptors, and an attenuation adaptor removed therefrom.

10 After separating the connector housing, the attenuation adaptors may be removed using appropriate tools. At this point, the entire housing may be removed for work outside of the connection system environment, or replaced with another housing containing different attenuation adaptors and/or other components.

15 Fig. 11 depicts the separated housings 78, 80 and the replacement of a new attenuation adaptor or other component 85. Fig. 12 depicts the reassembly of the connector housings 78, 80 and adaptor housing 70 with new attenuation adaptor 85.

20 While the present invention has been particularly described, in conjunction with a specific preferred embodiment, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art in light of the foregoing description. It is therefore contemplated that the appended claims will embrace any such alternatives, modifications and variations as falling within the true scope and spirit of the present invention.

Thus, having described the invention, what is claimed is:

Claims

1. A constant impedance connector for electrical attenuation or electrical filtering of electrical signals in a connection system comprising:
 - 5 a housing having an upper body portion with a first conductive or shield component disposed therein and a lower body portion with a second conductive or shield component disposed therein;
 - said housing upper body portion having an upper constant impedance receptacle or plug mating end with a first center conductor;
 - 10 said housing lower body portion having a lower reciprocal constant impedance plug or receptacle mating end with a second center conductor, said housing lower body portion removably attachable to said housing upper body portion;
 - wherein said housing upper body portion, said housing lower body portion, or both, form an internal cavity for securing an attenuator or filter component embedded therein, said attenuator or filter component for attenuating or filtering an electrical signal on said first and second center conductor;
 - 15 wherein said housing upper body portion has an inner diameter, said first center conductor has an outer diameter, said housing lower body portion has an inner diameter, said second center conductor has an outer diameter, and said attenuator or said filter component has an outer diameter, such that the first and second center conductors and the first and second conductive or shield components are shaped so that when the housing upper and lower body portions form an engaged connection along a central axis, an effective outer diameter of the first and second center conductors referenced by "d", the effective inner diameter of the first and second housing upper and lower body portions or shield components referenced by "D", and a relative dielectric constant " ϵ " of a medium between the center conductors and the shield components, satisfy a constant impedance equation when in a partially engaged position and when in a fully engaged position.
 - 20
 - 25
2. The constant impedance connector of claim 1 wherein said attenuator or said filter component is in electrical communication with said housing upper body portion first center conductor and said housing lower body portion second center conductor.
- 30
3. The constant impedance connector of claim 1 wherein said constant impedance "Z" is represented by a coaxial impedance formula as follows:
- 35

$$Z = \frac{138 \times \log_{10} \left(\frac{D}{d} \right)}{\sqrt{\epsilon_r}}$$

where "Z" is the impedance in Ohms (Ω), "D" is the effective inner diameter of the first and second housing upper and lower body portions or shield components, "d" is the effective outer diameter of the first and second center conductors, ϵ_r is the relative permeability of the dielectric, and the impedance Z is substantially constant throughout the central axis of the engaged connection.

4. The constant impedance connector of claim 1 wherein at least one of the first center conductor and second center conductor run through a hermetic seal stage disposed adjacent to the housing.

5. The constant impedance connector of claim 1 wherein said housing upper body portion, said housing lower body portion, or both, are press-fitted within a housing block.

6. The constant impedance connector of claim 5 wherein said housing block further comprises:

- a receptacle for receiving one of said housing upper body portion and said housing lower body portion; and
- a mating plug for receiving the other of said housing upper body portion and said housing lower body portion;

wherein the constant impedance connector housing upper body portion and lower body portion are press-fitted within the receptacle housing block and mating plug housing block.

7. An adaptor for implementing an attenuator or a filter into a constant impedance signal cable for use with the constant impedance connector of claim 1, said adaptor comprising an attenuator or filter component or a filter component within an adaptor housing, said adaptor housing terminating on each end with a constant impedance receptacle or constant impedance plug.

8. The adaptor of claim 7 including a resilient component in mechanical, electrical, and/or thermal communication with said adaptor housing on one side, and in mechanical, electrical, and/or thermal communication with an adaptor housing mounting structure on the other side, such that said resilient component in connection with said adaptor housing mounting structure provides a heat sink, a ground potential, electromagnetic interference protection, or any combination thereof, for signals traversing through said adaptor.

9. A constant impedance connector for electrical attenuation or electrical filtering of electrical signals in a connection system comprising:

5 a housing having an upper body portion with a first conductive or shield component disposed therein and a lower body portion with a second conductive or shield component disposed therein, and a hermetic seal stage disposed adjacent thereto;

said housing upper body portion having a constant impedance receptacle or plug mating end with a first center conductor running through said hermetic seal stage;

10 said housing lower body portion having a constant impedance plug or receptacle mating end with a second center conductor running through said hermetic seal stage;

wherein either of the first or second center conductor, or both, runs through said hermetic seal stage; and

15 an attenuator or filter component having a first electrical connector and a second electrical connector disposed on opposite ends, the first electrical connector for reception by the housing upper body portion and for forming a first electrical connection, the second electrical connector for reception by the housing lower body portion and for forming a second electrical connection, the attenuator or filter component further having a thermally conductive component disposed adjacent to the attenuator or filter component;

20 wherein said housing upper body portion, said housing lower body portion, or both, form an internal cavity for receiving the attenuator or filter component, said attenuator or filter component for attenuating or filtering an electrical signal on said first and second center conductor, and the thermally conductive component for transmitting thermal energy from the attenuator or filter component;

25 wherein said housing upper body portion has an inner diameter, said first center conductor has an outer diameter, said housing lower body portion has an inner diameter, said second center conductor has an outer diameter, and said attenuator or said filter component has an outer diameter, such that the first and second center conductors and the first and second conductive or shield components are shaped so that when the
30 housing upper and lower body portions form an engaged connection along a central axis, an effective outer diameter of the first and second center conductors referenced by "d", the effective inner diameter of the first and second housing upper and lower body portions or shield components referenced by "D", and a relative dielectric constant " ϵ " of a medium between the center conductors and the shield components, satisfy a constant
35 impedance equation when in a partially engaged position and when in a fully engaged position.

10. The constant impedance connector of claim 9 further including at least one heat sink disposed adjacent to, and in thermal communication with, the housing, wherein excess thermal
40 energy generated from the attenuated or filtered electrical signal is dissipated through the housing to said at least one heat sink.

11. The constant impedance connector of claim 10 wherein the at least one heat sink disposed adjacent to the housing is in thermal communication with the housing via a specialized thermally conductive clamp.

5

12. The constant impedance connector of claim 9 wherein the thermally conductive component is in the form of a spring or other resilient structure.

10 **13.** The constant impedance connector of claim 12 wherein the attenuator or filter component is press-fitted within an adaptor housing, and the thermally conductive component further provides movement and flexibility to the attenuator or filter component upon such press-fitted installation into the adaptor housing, the thermally conductive component assuring thermal conductivity or electromagnetic interference protection to the attenuator or filter component.

15 **14.** The constant impedance connector of claim 9 wherein the attenuator or filter component is insertable within an aperture of an adaptor housing.

15. A method of assembling a constant impedance connector for electrical attenuation or electrical filtering of electrical signals in an electrical system, comprising:

20 providing a constant impedance connector housing having an upper body portion with a first conductive or shield component disposed therein and a lower body portion with a second conductive or shield component disposed therein, said housing upper body portion having a constant impedance receptacle or plug mating end with a first center conductor, and said housing lower body portion having a constant impedance plug or
25 receptacle mating end with a second center conductor, said housing lower body portion being removably attachable to said housing upper body portion, said housing upper and lower body portions forming an internal cavity upon engagement;

30 providing an attenuator or filter component for attenuating or filtering an electrical signal in electrical communication with said first and second center conductors and inserting said attenuator or filter component into the internal cavity;

35 providing a housing block having a receptacle housing block portion and a mating plug housing block portion, said receptacle housing block portion for receiving one of said housing upper body portion and said housing lower body portion, and said mating plug housing block for receiving the other of said housing upper body portion and said housing lower body portion; and

attaching the housing upper body portion to the housing lower body portion such that the attenuator or filter component within said constant impedance connector is supported by said housing block;

wherein said housing upper body portion has an inner diameter, said first center conductor has an outer diameter, said housing lower body portion has an inner diameter, said second center conductor has an outer diameter, and said attenuator or said filter component has an outer diameter, such that the first and second center conductors and the first and second conductive or shield components are shaped so that when the housing upper and lower body portions form an engaged connection along a central axis, an effective outer diameter of the first and second center conductors referenced by “d”, the effective inner diameter of the first and second housing upper and lower body portions or shield components referenced by “D”, and a relative dielectric constant “ ϵ ” of a medium between the center conductors and the shield components, satisfy a constant impedance equation when in a partially engaged position and when in a fully engaged position.

16. The method of claim 15 further including:

press-fitting one of said housing upper body portion or lower body portion into one of said receptacle housing block portion or mating plug housing block portion; and
press-fitting the other of said housing upper body portion or lower body portion into the other of said receptacle housing block portion or mating plug housing block portion.

17. The method of claim 15 further including:

providing a hermetic seal stage disposed adjacent to the constant impedance connector housing; and
running at least one of the first center conductor and second center conductor through the hermetic seal stage.

18. The method of claim 15 further including:

providing at least one heat sink; and
connecting the at least one heat sink adjacent to the constant impedance connector housing;
wherein excess thermal energy generated from the attenuated or filtered electrical signal dissipates through the housing to said at least one heat sink.

19. The method of claim 18 further including:

providing a specialized clamp; and
clamping the at least one heat sink to the constant impedance connector housing via the specialized clamp.