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Optical devices having internally field-configurable splitting ratios and methods of using the same

Abstract

Field-configurable optical devices and methods are disclosed. In one example, a field-configurable optical device includes a housing defining an enclosure, an input port located at the housing, a pass-through port located at the housing, a plurality of output ports located at the housing, a splitter disposed within the enclosure, a plurality of couplers within the enclosure, each coupler including an input, a first output, and a second output. Each coupler has a power splitting ratio between the first output and the second output that is different from the other couplers. An input port fiber optic jumper assembly within the enclosure. A pass-through port fiber optic jumper assembly is within the enclosure. Moving the input port fiber optic jumper assembly and the pass-through port fiber optic jumper assembly from a first coupler to a second coupler of the plurality of couplers changes the power splitting ratio of the field-configurable optical device.

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References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
9571218	12/2016	Ji	N/A	H04B 10/5561
2015/0125152	12/2014	Ji et al.	N/A	N/A
2017/0212321	12/2016	Gronvall	N/A	G02B 6/3874
2018/0084320	12/2017	Martinho	N/A	H04J 14/02126
2020/0196035	12/2019	Rousseaux et al.	N/A	N/A
2024/0402453	12/2023	Gildehaus	N/A	G02B 6/4471

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
2019/143510	12/2018	WO	N/A

OTHER PUBLICATIONS

Invitation to Pay Additional Fee; PCT/US2021/041983; dated Oct. 8, 2021; 13 pages; European Patent Office. cited by applicant

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation of International Patent Application Serial No. PCT/US2021/041983 filed on Jul. 16, 2021 designating the United States of America, and U.S. Provisional Application Ser. No. 63/059,289 filed Jul. 31, 2020, the contents of which are relied upon and incorporated herein by reference in their entirety.

BACKGROUND

- (1) The present disclosure is directed to optical devices of an optical communication network and, more particularly, optical devices having a field-configurable splitting ratio and methods of using the same.
- (2) Optical fiber is increasingly being used for a variety of applications, including, but not limited

to, broadband voice, video, and data transmission. As bandwidth demands increase, optical fiber is migrating toward subscribers in outdoor communication networks such as in fiber to the premises applications such as FTTx and the like.

(3) Optical communication networks commonly employ a daisy-chain architecture, where an optical signal is sequentially tapped-off at access points along a distribution cable. At each access point, the optical signal is split such that a percentage of the optical signal is split amongst subscribers and another percentage is provided further downstream to the next access point. Couplers having different splitting ratios are used to split the optical signal. For example, couplers in a daisy-chain may have 90%/10% (i.e., 10% of the signal provided to a plurality of subscribers and 90% provided to the next coupler) 80%/20%, 70%/30%, and 60%/40% splitting ratios. Each one of these couplers requires different components to provide the desired splitting ratio. Thus, in this example, six individual parts need to be manufactured, inventoried, stored, and transported by the installation team. Many different stock keeping units (SKU) add cost and complexity to building optical communication networks.

SUMMARY

(4) The present disclosure is directed to optical devices, such as multiport devices or cabinets, having a splitting ratio that is configurable in the field. Therefore, rather than having multiple individual parts to manufacture, inventory and store, only one part number is needed. The craft may take one optical device and add it to any point in the optical network, which adds significant flexibility. The reduced number of SKUs further reduces the cost to build optical communication networks.

(5) One aspect of the disclosure is directed to a field-configurable optical device including a housing defining an enclosure, an input port located at the housing, a pass-through port located at the housing, a plurality of output ports located at the housing, a splitter disposed within the enclosure and including one or more splitter inputs and a plurality of splitter outputs coupled to the plurality of output ports, a plurality of couplers within the enclosure, each coupler including an input, a first output, and a second output. Each coupler has a power splitting ratio between the first output and the second output that is different from other couplers of the plurality of couplers. The second output of at least one coupler of the plurality of couplers is in optical communication with at least one splitter input of the one or more splitter inputs. An input port fiber optic jumper assembly within the enclosure, wherein the input port fiber optic jumper assembly is configured to selectively connect the input port to the input of an individual coupler of the plurality of couplers. A pass-through port fiber optic jumper assembly is disposed within the enclosure that is configured to selectively connect the pass-through port to the first output of the individual coupler of the plurality of couplers. Moving the input port fiber optic jumper assembly and the pass-through port fiber optic jumper assembly from a first coupler to a second coupler of the plurality of couplers changes the power splitting ratio of the field-configurable optical device.

(6) Another aspect of the disclosure is directed to a field-configurable optical device including a housing defining an enclosure, an input port located at the housing, a pass-through port located at the housing, and a plurality of output ports located at the housing. The field-configurable optical device further includes a splitter disposed within the enclosure and including one or more splitter inputs and a plurality of splitter outputs coupled to the plurality of output ports, and a plurality of couplers within the enclosure. Each coupler includes an input, a first output, and a second output. Each coupler has a power splitting ratio between the first output and the second output that is different from other couplers of the plurality of couplers. The second output of at least one coupler of the plurality of couplers is in optical communication with at least one splitter input of the one or more splitter inputs. The field-configurable optical device further includes a plurality of sets of splitting ratio selection ports, wherein each set of splitting ratio selection ports includes a coupler input port and a coupler pass-through port. The coupler input port is in optical communication with the input of an individual coupler, and the coupler pass-through port is in optical communication

with the first output of the individual coupler. The field-configurable optical device also includes an input port fiber optic jumper assembly disposed within the enclosure. The input port fiber optic jumper assembly includes an input optical fiber that is connected to the input port at a first end and an input port fiber optic jumper assembly connector at a second end. The input port fiber optic jumper assembly connector is configured to selectively mate with an individual coupler input port of an individual set of splitting ratio selection ports. The field-configurable optical device further includes a pass-through port fiber optic jumper assembly within the enclosure that includes a pass-through optical fiber and a pass-through fiber optic jumper assembly connector. The pass-through fiber optic jumper assembly connector is configured to selectively mate with an individual coupler pass-through port of the individual set of splitting ratio selection ports. Moving the input port fiber optic jumper assembly and the pass-through port fiber optic jumper assembly from a first coupler to a second coupler of the plurality of couplers changes the power splitting ratio of the field-configurable optical device.

(7) Still another aspect of the disclosure is directed to a method of configuring a field-configurable optical device. The method includes opening a housing of the field-configurable optical device to access an enclosure defined by the housing, and connecting an input port fiber optic jumper assembly connector to a coupler input port of an individual set of splitting ratio selection ports among a plurality of sets of splitting ratio selection ports within the enclosure. The plurality of sets of splitting ratio selection ports correspond to a plurality of couplers within the enclosure, wherein each coupler has a power splitting ratio that is different from other couplers of the plurality of couplers. The method further includes connecting a pass-through port fiber optic jumper assembly connector to a coupler pass-through port of the individual set of splitting ratio selection ports. A connection of the input port fiber optic jumper assembly connector and the pass-through port fiber optic jumper assembly connector establishes a power splitting ratio among a plurality of power splitting ratios of the field-configurable optical device.

(8) Additional features and advantages will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the same as described herein, including the detailed description that follows, the claims, as well as the appended drawings.

(9) It is to be understood that both the foregoing general description and the following detailed description present embodiments that are intended to provide an overview or framework for understanding the nature and character of the claims. The accompanying drawings are included to provide a further understanding of the disclosure, and are incorporated into and constitute a part of this specification. The drawings illustrate various embodiments and together with the description serve to explain the principles and operation.

Description

BRIEF DESCRIPTION OF THE FIGURES

- (1) FIG. 1 illustrates an example optical communication network;
- (2) FIG. 2 illustrates a partial view of an example optical communication network according to one or more embodiments disclosed and illustrated herein;
- (3) FIG. 3A illustrates an example optical device having a selected splitting ratio that is selected within an enclosure of the optical device and uses an $N \times M$ splitter according to one or more embodiments disclosed and illustrated herein;
- (4) FIG. 3B illustrates an example optical module cassette comprising a plurality of couplers according to one or more embodiments disclosed and illustrated herein;
- (5) FIG. 3C illustrates an example housing of an optical device according to one or more embodiments disclosed and illustrated herein;

- (6) FIG. 4 illustrates an example optical device having a selected splitting ratio that is selected within an enclosure of the optical device and uses a $1 \times M$ splitter according to one or more embodiments disclosed and illustrated herein;
- (7) FIG. 5 illustrates an example optical device in an “end-of-line” configuration having a selected splitting ratio that is selected within an enclosure of the optical device and uses a $1 \times M$ splitter according to one or more embodiments disclosed and illustrated herein;
- (8) FIG. 6 illustrates another example optical device in an “end-of-line” configuration having a selected splitting ratio that is selected within an enclosure of the optical device and uses a $1 \times M$ splitter according to one or more embodiments disclosed and illustrated herein;
- (9) FIG. 7 illustrates another example optical device in an “end-of-line” configuration having a selected splitting ratio that is selected within an enclosure of the optical device and uses a $1 \times M$ splitter and a short circuit coupler according to one or more embodiments disclosed and illustrated herein;
- (10) FIG. 8 illustrates an example optical device having a selected splitting ratio that is selected at an exterior of the optical device and uses an $N \times M$ splitter according to one or more embodiments disclosed and illustrated herein;
- (11) FIG. 9 illustrates a close-up view of an example optical communication network using an optical device of FIG. 8 according to one or more embodiments disclosed and illustrated herein;
- (12) FIG. 10 illustrates an example optical device having a selected splitting ratio that is selected at an exterior of the optical device and uses a $N \times M$ splitter according to one or more embodiments disclosed and illustrated herein;
- (13) FIG. 11 illustrates another example optical device having a selected splitting ratio that is selected at an exterior of the optical device and uses an $1 \times M$ splitter according to one or more embodiments disclosed and illustrated herein;
- (14) FIG. 12 illustrates another example optical device having a selected splitting ratio that is selected at an exterior of the optical device and within a covered recess, and uses a $1 \times M$ splitter according to one or more embodiments disclosed and illustrated herein;
- (15) FIG. 13 illustrates a perspective view of an example optical device as illustrated by FIG. 12 according to one or more embodiments disclosed and illustrated herein; and
- (16) FIG. 14 illustrates another example optical device having a selected splitting ratio that is selected at an exterior of the optical device using an actuator, and uses a $1 \times M$ splitter according to one or more embodiments disclosed and illustrated herein.

DETAILED DESCRIPTION

- (17) Reference will now be made in detail to the embodiments of the disclosure, examples of which are illustrated in the accompanying drawings. Whenever possible, like reference numbers will be used to refer to like components or parts.
- (18) Embodiments of the present disclosure are directed to optical devices, such as multiport devices, that are field-configurable such that a power splitting ratio may be established in the field, rather than at the factory. As described in detail below, embodiments reduce the number of unique part numbers that the manufacture of the optical device needs to manufacture, which reduces manufacturing and inventory costs, among other benefits. It should be understood that, although the optical devices are described herein in the context of multiport devices, embodiments may be configured as other optical devices that employ optical splitters. Thus, embodiments are not limited to multiport devices.
- (19) Optical communication networks rely on optical fiber cables to communicate data by way of optical signals. Fiber cable installation in sparsely populated rural areas is an especially expensive undertaking. Long lengths of fiber optic cable serve a small population. The cable material and installation costs are divided by a low population of end-users.
- (20) Therefore, an architecture which maximizes the number of users served by each fiber strand in the distribution cable may be attractive. Obviously, the more users that can be served by each fiber

strand, allows the material and installation costs to be divided among that many more users.

(21) A daisy-chained tap fiber to the x (FTTx) in the optical communication network **5** as shown in FIG. **1** is a common solution for optical communication network installation, such as those in rural areas. An optical line termination launches a high-power optical signal into a single fiber strand of a multifiber distribution cable **7**. In the illustrated example, a first 1×2 coupler **10** splits the high-power optical signal into a first optical signal that is 98% of the power of the high-power optical signal that is passed to a next coupler **10A**, and a second optical signal that is 2% of the power of the high-power optical signal to be used for monitoring purposes by a monitoring system **14E**.

(22) A plurality of asymmetric 1×2 optical tap couplers **10A-10D** (also known as tap splitters) are inserted along the length of a given fiber strand of the distribution cable to tap-off a portion of the optical power to feed sets of users **14A-14D** along the length of the distribution cable. It is noted that FIG. **1** only illustrates how the daisy chain distributes power to the various sets of users **14A-14D** over a single fiber strand. However, the distribution cable (which is not shown in the figure) generally contains multiple fiber strands.

(23) Generally, the power tapped off at each tap point is less than 50% and the power that continues downstream on the distribution cable is greater than 50%. Due to the uneven distribution of power between the two coupler output ports, the couplers are referred to as “asymmetric couplers” or “unbalanced couplers.” However, it should be understood that a 50%/50% 1×2 coupler may be used.

(24) Note that the distribution of the optical power between the two output ports of the couplers **10A-10D** is most unbalanced at the first drop point and gradually approaches a more balanced distribution at the last tap coupler in the chain. This is because the minimum power required by each of the sets of users **14A-14D** along the chain is identical, however the total optical power available in the chain is gradually being siphoned off at each subsequent coupler/tap point as the daisy-chain progresses downstream. As a result, each subsequent coupler/tap point in the daisy-chain needs to tap-off a larger percentage of the total power in order to keep the power to the end nodes constant.

(25) The tapped optical signal exiting the coupler is then split again to be evenly provided to individual users. For example, the 10% optical signal is split again and provided to individual users. The couplers **10A-10D** may be provided in a multiport device that includes not only a 1×2 coupler, but also an $N\times M$ splitter. For example, an eight output multiport device may utilize a 1×8 splitter to split the 10% optical signal eight ways. Fiber optic cable assemblies are connected to the output ports of the multiport device and delivered to individual users.

(26) Each coupler has a tolerance on maximum loss due to changes in loss over the range of optical wavelengths used in the system, aging, manufacturing tolerances and environmental factors such as temperature. The splitting ratio and/or optical loss may vary as a result of any of these factors. An optical budget is calculated for each end node considering the worst-case loss for each coupler. Being that the total optical budget available is a given, any additional dB that needs to be subtracted from the total budget due to large tolerances of the components will result in compromises on the allowable number of drop points along the daisy chain.

(27) For example, using very tightly tolerance components which maintain an almost constant loss (even over wavelength and environmental conditions) may afford up to six drop points. At the other extreme, components with losses that vary greatly over temperature and wavelength may only allow three drop points along the chain. Thus, couplers which can maintain a constant and predictable low loss over temperature, wavelength and environmental stresses are best positioned to deliver the most drop points along the daisy chain.

(28) Therefore, there is value in using optical coupler components which have tighter tolerances to maximize the number of attainable drop points for a given optical budget. This tradeoff between number of attainable drop points and tolerances of components should ideally be optimized to attain the best combination.

(29) Still referring to FIG. 1, couplers **10**, **10A-10D** each have a different power splitting ratio. Thus, internal components of the couplers **10**, **10A-10D** are different and therefore require the manufacture to produce and inventory many unique part numbers, which adds cost. For example, if six different asymmetric coupler splitter ratio values are employed over the length of a distribution cable in a daisy-chain, then six unique stock keeping units (SKU) must be created, inventoried, and carried by the craft during installation or maintenance.

(30) Embodiments of the present disclosure provide a field-configurable optical device that contains all of the 1×2 couplers corresponding to a plurality of selectable splitting ratios. Thus, only one SKU is provided for a device covering a plurality of selectable splitting ratios. In some embodiments, the optical device is environmentally sealed at the factory and field-configuration is performed at the exterior of the optical device. In other embodiments, the housing of the optical device is configured to be opened such that field-configuration is performed within an enclosure of the optical device. The housing may then be closed and sealed again after field-configuration.

(31) Embodiments reduce inventory and warehouse space because one part may reduce a plurality of parts (e.g., one multiport device may replace six in the daisy-chain). This is logistically much simpler than manufacturing and storing many different parts.

(32) Embodiments also increase labor efficiency, reduce installation complexity, and enable faster subscriber turn-on using the same crew of craftsmen. An installation team only needs to carry one single SKU with them to the field for installation. This one SKU may be installed at any point along the distribution cable. The team is not required to work with discrete coupler components, and the optical devices disclosed herein do not require fiber splicing. All optical components are preassembled in a pigtailed module.

(33) The flexibility of the optical devices disclosed herein enable them to be included in a “snap in” family of interchangeable optical modules that provide a platform that can be easily extended. For example, the optical device, such as a multiport device, may be added at any point within the optical network. One optical device may act as a host to a wide range of optical modules that can perform a multitude of functions to the optical signals running through the optical device for future systems.

(34) Various embodiments of optical devices and methods are described in detail below.

(35) Referring to FIG. 2, and example daisy-chain implementation of an optical communication network **50** is illustrated. The optical communication network **50** includes a distribution cable **70** and a plurality of pre-terminated access points **106A**, **106B** that are engineered into the distribution cable **70**. Any number of access points may be provided (e.g., six access points). The access points **106A**, **106B** provide a break in an optical fiber within the distribution cable **70**. An optical fiber within a connectorized tether assembly **107** is optically coupled to the broken optical fiber at the access point **106A**, **106B**. As used herein, the phrases “optically coupled” and “in optical communication with” mean that optical signals pass between two components.

(36) An intermediate cable assembly **108** has a first connector **109** that connects to the tether assembly **107** and a second connector **111** that connects to an optical device **100**, which in the illustrated embodiment is configured as a multiport device or cabinet. The intermediate cable assembly **108** comprises an input optical fiber and a pass-through optical fiber (not shown). An input optical signal is provided to the input optical fiber of the intermediate cable assembly **108** through the tether assembly **107**. The pass-through optical fiber receives a pass-through optical signal (i.e., a tapped optical signal) from a selected coupler within the optical device, and provides the pass-through optical signal to the distribution cable **70** by way of the tether assembly **107**. The pass-through optical signal is then propagated downstream to the next access point over the distribution cable **70**. For example, a pass-through signal generated by the optical device **100** after a first access point **106A** is provided as an input to an optical device of a second access point **106B** (see FIG. 1).

(37) Referring now to FIG. 3A, an example optical device configured as a field-configurable

multiport device **100** is schematically illustrated as a block diagram. “Field-configurable” as used herein means that a craft or other user can select an intended splitting ratio of the multiport device in the field rather than just at the factory. As described in more detail below, the multiport device **100** is capable of being configured as having an intended splitting ratio among a plurality of splitting ratios. Non-limiting splitting ratios include 95/5%, 90/10%, 85/15%, 80/20%, 70/30%, and 60%/40%.

(38) The example multiport device **100** generally comprises a housing **130** defining an enclosure **131** and an optical module **140** disposed within the enclosure. The exterior of the housing **130** has several ports for mating with connectors to optically couple the multiport device **100** to various other components within the optical network. As used herein, the term “port” means a receptacle that receives a connector. It is noted that the term “adapter” may be used synonymously with the term “port” herein as is known in the art.

(39) In the example of FIG. 3A, the multiport device **100** comprises an input port **134**, a pass-through port **132**, and a plurality of output ports **149A-149H**. The input port **134** is configured to receive an input connector of a tether assembly **107** having an input fiber that is tapped from a distribution cable **70** as described above with respect to FIG. 2. The pass-through port **132** is configured to receive a pass-through connector of the tether assembly **107** having a pass-through fiber that receives a pass-through signal as an output from the multiport device **100** that is used to daisy-chain multiple multiport devices **100** together.

(40) In some embodiments, the input port **134** and the pass-through port **132** are configured as a single multifiber port configured to receive a second connector **111**, which may be a multifiber connector, such as an MPT connector, as shown in FIG. 2. In other embodiments, the input port **134** and the pass-through port **132** are separate ports configured to receive separate connectors.

(41) The output ports **149A-149H** ports are located at an exterior wall of the housing **130** and are configured to receive connectors of cable assemblies (not shown) that route optical signals to users of the optical communication network. Embodiments are not limited by the style and configuration of the output ports **149A-149H**. As a non-limiting example, the output ports **149A-149H** may be configured as OptiTap® bulkhead adapters manufactured by Corning Optical Communications of Charlotte, North Carolina FIG. 3C illustrates an example housing **130** of a multiport device **100** having four output ports **149** configured as OptiTap® bulkhead adapters. However, it should be understood that more or fewer than four output ports **149** may be provided, and that embodiments are not limited to the shape, size and configuration of the housing depicted by FIG. 3C. The housing **130** and style of the output ports **149** may take on any configuration.

(42) Disposed within the enclosure **131** defined by the housing **130** is an optical module **140** configured to split the optical signal provided at the input port **134** into a first optical signal that is split into a plurality of output signals and a second optical signal that is passed to the next multiport (i.e., a pass-through optical signal). The optical module **140** is configured to selectively split the input optical signal into the first optical signal and the second optical signal in accordance with a select splitting ratio that is selected by the craft among a plurality of possible splitting ratios offered by the multiport device **100**.

(43) The optical module **140** includes a plurality of couplers **142A-142F**, wherein each coupler has a different splitting ratio. In the embodiment of FIG. 3A, each coupler of the plurality of couplers **142A-142F** is an asymmetric (also known as “unbalanced”) because of the first optical signal and the second optical signal have different power levels. However, it should be understood that embodiments may also employ couplers having a 50-50 splitting ratio. In the illustrated embodiment a first coupler **142A** has a 5%-95% splitting ratio, a second coupler **142B** has a 10%-90% splitting ratio, a third coupler **142C** has a 15%-85% splitting ratio, a fourth coupler **142D** has a 20%-80% splitting ratio, a fifth coupler **142E** has a 30%-70% splitting ratio, and a sixth coupler **142F** has a 40%-60% splitting ratio. It should be understood that embodiments are not limited to any particular splitting ratio.

- (44) Each coupler of the plurality of couplers **142A-142F** includes an input **152**, a first output **151** that outputs the first output signal, and a second output **153** that outputs the second output signal.
- (45) A plurality of sets of splitting ratio selection ports **141A-141F** that enable the craft to select the desired splitting ratio of the multiport device **100** is disposed within the enclosure **131**. The plurality of sets of splitting ratio selection ports **141A-141F** comprise a plurality of coupler input ports **146A-146F** for receiving an input port fiber optic jumper assembly **135** and a plurality of coupler pass-through ports **144A-144F** for receiving a pass-through port fiber optic jumper assembly **133**.
- (46) The sets of splitting ratio selection ports **141A-141F** may be configured as duplex adapters, such as, without limitation, duplex LC adapters for receiving duplex LC connectors. FIG. 3B illustrates an example optical module **140** configured as a cassette with a housing, and pairs of LC adapters as the sets of splitting ratio selection ports **141**. In some embodiments, the two-fiber duplex adapters are keyed to allow the connection of duplex connectors in only one polarity/orientation.
- (47) It should be understood that other configurations are also possible. For example, simplex ports may be utilized.
- (48) As shown by FIG. 3A, the input **152** of each coupler **142** is in optical communication with a coupler input port **146**, the first output **151** of each coupler **142** is in optical communication with the coupler pass-through port **144**, and the second output **153** is in optical communication with an input of a splitter **148**. As used herein, the term “splitter” refers to a symmetric $N \times M$ splitter wherein $N < M$ (e.g., a NM splitter) and the term “coupler” refers to an asymmetric 1×2 coupler or in some cases a symmetric 1×2 coupler.
- (49) As described in more detail below, the plurality of couplers **142A-142F** and the splitter **148** may be provided by a single planar lightwave circuit (PLC) in a non-limiting embodiment. Thus, a single PLC chip may provide the splitting ratios of the plurality of couplers and the splitter. Further, the PLC chip may also include waveguides to optically couple the plurality of couplers **142A-142F** to the splitter **148** and the plurality of sets of splitting ratio selection ports **141A-141F**. For example one or more of the input **152**, the first output **151** and the second output **153** may be provided by a waveguide on or within the PLC chip. One or more of the input **152**, the first output **151** and the second output **153** may be provided by an optical fiber and connectors, for example. In a non-limiting example the second output **153** is provided by a waveguide of a PLC and the input **152** and the first output **151** are provided by optical fibers.
- (50) As a non-limiting example, the optical fibers providing the internal connections between the plurality of couplers **142A-142F** and the connected components may be provided by pigtailed input and output ports. For example, the pigtailed input ports and pigtailed output ports may include LC input/output ports for receiving LC connectors. However, other connector and port styles may be utilized.
- (51) The splitter **148** has one or more splitter inputs **155A-155F** and one or more splitter outputs **157A-157H**. The splitter **148** is an $N \times M$ splitter having N inputs and N outputs where N is equal to or less than M . In the example of FIG. 3A, the splitter **148** has 6 inputs and 8 outputs. In other embodiments, the splitter may have, without limitation, 4 inputs and 8 outputs, 2 inputs and 8 outputs, or 1 input and 8 outputs. Any number of inputs or outputs may be provided. As stated above, the splitter may be provided by a PLC chip.
- (52) The splitter **148** and the plurality of couplers **142A-142F** may split the optical signals by any known or yet-to-be-developed methods. Although the plurality of couplers **142A-142F** are described above as being implemented by a PLC chip (i.e., PLC couplers), embodiments are not limited thereto. For example, the plurality of couplers **142A-142F** and/or the splitter **148** may be thin-film couplers, fused biconic taper couplers, variable ratio couplers, and/or any known or yet-to-be-developed couplers. Further, it should also be understood that the splitter and/or the plurality of couplers **142A-142F** may employ wavelength division multiplexing (WDM) or any other known

or yet-to-be-developed method of splitting an optical signal.

(53) The splitter outputs **157A-157H** may be configured as connectorized pigtails having connectors (e.g., SC connectors) that are mated to the output ports **149A-149H** (e.g, OptiTap® bulkhead adapters).

(54) The multiport device **100** further includes an input port fiber optic jumper assembly **135** within the enclosure **131**. The input port fiber optic jumper assembly **135** is in optical communication with the input port **134** of the housing **130**. In a non-limiting example, the input port fiber optic jumper assembly **135** is configured as an optical fiber having a connector (not shown) at a first end that mates with the input port **134** (e.g., an OptiTap® bulkhead adapter) and a connector (not shown) on a second end that mates with a coupler input port of the plurality of coupler input ports **146A-146F**. For example, the connector on the first end may be an SC connector and the connector on the second end may be an LC connector configured to be received by an LC coupler input port.

(55) The multiport device **100** further includes a pass-through port fiber optic jumper assembly **133** within the enclosure **131**. The pass-through port fiber optic jumper assembly **133** is in optical communication with the pass-through port **132** of the housing **130**. In a non-limiting example, the a pass-through port fiber optic jumper assembly **133** is configured as an optical fiber having a connector (not shown) at a first end that mates with the pass-through port **132** (e.g., an OptiTap® bulkhead adapter) and a connector (not shown) on a second end that mates with a coupler input port of the plurality of coupler pass-through ports **144A-144F**. For example, the connector on the first end may be an SC connector and the connector on the second end may be an LC connector configured to be received by an LC coupler pass-through port.

(56) One or both ends of the pass-through port fiber optic jumper assembly **133** and the input port fiber optic jumper assembly **135** may have two simplex connectors or one duplex connector. In embodiments where duplex connectors are used, the pass-through port fiber optic jumper assembly **133** and the input port fiber optic jumper assembly **135** are provided in a single assembly. As a non-limiting example, the single assembly may be a duplex SC connector (at the first end for mating with the input port **134** and the pass-through port **132**) to LC connector (at the second end for mating with the plurality of sets of splitting ratio selection ports **141A-141F**) cable assembly.

(57) To configure the multiport device **100** in the field, the craft opens the housing **130** to gain access to the enclosure **131**. Each set of splitting ratio selection ports **141** has a particular power splitting ratio associated therewith. The optical module **140**, such as the example optical module illustrated in FIG. 3B, may be labeled with indicia of the power splitting ratio for the plurality of sets of splitting ratio selection ports **141A-141F**. The craft inserts the connector of the input port fiber optic jumper assembly **135** into the desired coupler input port **146** and the connector of the pass-through port fiber optic jumper assembly **133** into the desired coupler pass-through port **144**.

(58) In some embodiments, where duplex connectors and ports are utilized, the duplex sets of splitting ratio selection ports **141** are spaced to have a pitch that allows only one polarity of a duplex connector (e.g, an LC duplex connector). Thus, the pitch of the splitting ratio selection ports **141** and a keying feature provides that the craft can only connect the input port fiber optic jumper assembly **135** to the coupler input port **146** and the pass-through port fiber optic jumper assembly **133** to the coupler pass-through port **144**. The pitch will not allow mating of one connector to one duplex splitting ratio port and the second connector to a neighboring duplex splitting ratio port.

(59) In the illustrated embodiment, the craft desires the multiport device **100** to have a 40%-60% power splitting ratio and therefore has connected the input port fiber optic jumper assembly **135** to coupler input port **146A** and the pass-through port fiber optic jumper assembly **133** to coupler pass-through port **144A**. Thus, the optical signal at the input port **134** will propagate through the fiber of the input port fiber optic jumper assembly **135**, enter first coupler **142A** where 40% of its power is provided to input **155F** of the splitter **148** and 60% of its power is provided to the pass-through port fiber optic jumper assembly **133** for transmission downstream. The 40% power optical signal that

is provided to the splitter **148** is then split N ways (8 ways in the example of FIG. 3A) and provided to output ports **149A-149H**. Only one coupler of the plurality of couplers **142A-142F** is active and has light passing therethrough at a time. To change the power splitting ratio of the multiport device, the craft changes the set of splitting ratio ports that the input port fiber optic jumper assembly **135** and the pass-through port fiber optic jumper assembly **133** are connected to.

(60) After connecting the input port fiber optic jumper assembly **135** and the pass-through port fiber optic jumper assembly **133**, the craft then closes the housing **130** to seal the enclosure **131** from the environment.

(61) Thus, the multiport device **100** of FIG. 3A enables selection from a plurality of power splitting ratios in one optical device, and therefore reduces the number of unique parts the manufacturer needs to produce and the number of parts the craft needs to carry during installation and maintenance. There is no splicing of optical fibers in the field, and there is a minimum number of connections and very little leeway for error. The connectors of the input port fiber optic jumper assembly **135** and the pass-through port fiber optic jumper assembly **133** may be color-coded with the plurality of sets of splitting ratio selection ports **141A-141F** in the enclosure **131** so that all that is needed is to mate the connectors to the appropriate color-coded port.

(62) Referring now to FIG. 4, an optical device configured as a multiport device **200** having a single-input splitter **248** is illustrated. In the illustrated example, the splitter is a 1×8 splitter. However, it should be understood that more or fewer splitter outputs **257A-257H** may be provided.

(63) The advantage of using a 1×M splitter is greater flexibility and improved resourcing as 1×M splitters are widely available and at low cost. Additionally, the 1×2 couplers with different splitting ratios may all be realized in separate (sub)cassettes/housing to allow greater flexibility during manufacturing and/or modifications after the optical device has been deployed in the field. For example each 1×2 coupler may be provided in its own housing so that the optical module (e.g., a multiport device **200**) may be customizable at the factory and/or in the field by inserting 1×2 couplers having the desired splitting ratios.

(64) The example multiport device **200** comprises a plurality of couplers **242A-242F** having different splitting ratios. Each coupler **242** has an input **252**, a first output **251** that outputs a first output signal, and a second output **253** that outputs a second output signal.

(65) The example multiport device **200** also includes a plurality of sets of splitting ratio selection ports **241A-241F** that enable the craft to select the desired splitting ratio of the multiport device **200**. The plurality of sets of splitting ratio selection ports **141A-141F** comprise a plurality of coupler input ports **246A-246F** for receiving an input port fiber optic jumper assembly **135**, a plurality of coupler pass-through ports **244A-244F** for receiving a pass-through port fiber optic jumper assembly **133**, and a plurality of coupler splitter input ports **247A-247F** for receiving a splitter input optical fiber jumper assembly **258** described in more detail below.

(66) The sets of splitting ratio selection ports **141A-141F** may be configured as duplex adapters, such as, without limitation, duplex LC adapters for receiving duplex LC connectors **236**.

Alternatively, the sets of splitting ratio selection ports **141A-141F** may be configured as simplex adapters, or as triplex adapters.

(67) The input **252** of each coupler **242** is in optical communication with a coupler input port **246**, the first output **251** of each coupler **242** is in optical communication with the coupler pass-through port **244**, and the second output **253** is in optical communication with the input **255** of the splitter **148**.

(68) Unlike the multiport device **100** of FIG. 3A, the example multiport device **200** further includes a splitter input optical fiber jumper assembly **258** that is used to connect the second output **253** of a selected coupler **242** to the single input **255** of the splitter **248**. A first end of the splitter input optical fiber jumper assembly **258** is optically coupled to the splitter input **255** of the splitter **248** (e.g., by a connector). The second end of the splitter input optical fiber jumper assembly **258** is connectorized to be mated with a selected coupler splitter input port **247**. In some embodiments,

the second end of the splitter input optical fiber jumper assembly **258** has a simplex connector (e.g., a simplex LC connector). However, the connector at the second end of the splitter input optical fiber jumper assembly **258** may be provided in a triplex connector configured to mate with a set of splitting ratio ports configured as a triplex port (see FIG. 6, described below).

(69) To configure the multiport device **200** for a desired power splitting ratio, the craft opens the housing **230** to access the enclosure **231**. The craft then connects the input port fiber optic jumper assembly **135** to the coupler input port **246** and the pass-through port fiber optic jumper assembly **133** to the coupler pass-through port **244** of the desired set of splitting ratio selection ports **241**. In the illustrated example, the input port fiber optic jumper assembly **135** and the pass-through port fiber optic jumper assembly **133** are terminated at a common duplex connector **236** (e.g., an LC duplex connector). However, it should be understood that simplex or triplex connectors may be utilized. The craft in the example of FIG. 4 has selected coupler **242C** for a power splitting ratio of 20%/80%. To complete the configuration, the craft also connects the connector of the second end of the splitter input optical fiber jumper assembly **258** to coupler splitter input port **247C**. In the example of FIG. 4, each set of splitting ratio selection ports is configured as a triplex port configured to mate with duplex connector **236** of the input port fiber optic jumper assembly **135** and the pass-through port fiber optic jumper assembly **133** and a simplex connector of the splitter input optical fiber jumper assembly **258**.

(70) The optical signal from the input port **134** will propagate through the input port fiber optic jumper assembly **135** and into coupler **242C** where it will be split into a first optical signal having 80% power through the first output **251** and a second optical signal having 20% optical power through the second output **253**. The second optical signal propagates through the splitter input optical fiber jumper assembly **258** and into the splitter **248** where it is split into eight optical signals provided at output ports **149A-149H**.

(71) An advantage of using a NM splitter is that it enables an “end-of-line” configuration wherein the plurality of couplers are bypassed altogether and the input port is directly coupled to the input of the splitter. When a multiport device acts as an end-of-line device, the pass-through port is not utilized as the end-of-line multiport device is the last device in the daisy-chained sub-network.

(72) FIG. 5 illustrates an example multiport device **300** similar to the multiport device **200** however the multiport device **300** of FIG. 5 is configured as an end-of-line multiport device. A splitter input **255** is in direct optical communication with the input port **134** in this example configuration. In the illustrated embodiment, an input port fiber optic jumper assembly **335** is connected to a splitter input optical fiber jumper assembly **358**. The connection between these two jumper assemblies may be made by any means. In one non-limiting example, the splitter input optical fiber jumper assembly **358** is terminated with a port (i.e., an adapter, such as an LC adapter) and the input port fiber optic jumper assembly **335** is terminated with a connector (e.g., an LC connector). In other embodiments, an adapter is used to connect the connector of the splitter input optical fiber jumper assembly **358** to the input port fiber optic jumper assembly **335**. As shown by FIG. 5, the pass-through optical fiber jumper assembly and the pass-through port **132** are not used.

(73) The optical signal enters the end-of-line multiport device **300** at the input port **134**, propagates through the input port fiber optic jumper assembly **335** and the splitter input optical fiber jumper assembly **358**, and enters the splitter **248** at the splitter input **255**. This end-of-line optical signal is then split eight ways by the splitter and provided at the output ports **149A-149H**.

(74) Other end-of-line configurations are also possible. Referring now to FIG. 6, another example multiport device **400** is illustrated. The multiport device **400** is operable to be configured as an end-of-line device in the field by the craft. The example multiport device **400** includes a plurality of couplers **442A-442F** corresponding to a plurality of sets of splitting ratio selection ports **441A-441F**. However, coupler **442F** is configured as a short-circuit coupler that does not split the optical signal. Rather, it includes a loop-back optical fiber **465**. In the illustrated embodiment, each set of splitting ratio selection ports is configured as a triplex port such that the plurality of sets of splitting

ratio selection ports have a plurality of coupler pass-through ports **444A-444F**, a plurality of coupler input ports **446A-446F**, and a plurality of coupler splitter input ports **447A-447F**.

(75) Set of splitting ratio selection ports **441F** (i.e., short circuit ports) may not have a coupler pass-through port **444F**, or it may have a coupler pass-through port **444F** configured as a blank or dummy port. The loop-back optical fiber **465** is terminated at the coupler input port **446F** and the coupler splitter input port **447F** such that an optical signal entering the coupler input port **446F** is provided directly to the coupler splitter input port **447F** and thus directly to the splitter input **255** of the splitter **248**.

(76) The input port fiber optic jumper assembly **135**, the pass-through port fiber optic jumper assembly **133**, and a splitter input optical fiber jumper assembly **458** are terminated by a triplex connector **460** (e.g., a triplex LC connector) for mating with an individual set of splitting ratio selection ports **441**. The example of FIG. **6** is shown in the end-of-line configuration wherein the triplex connector **460** is connected to the triplex short circuit ports **441F** such that the optical signal is passed directly to the splitter **248** and bypasses the 1×2 couplers **442A-442E**.

(77) FIG. **7** illustrates another single-input splitter embodiment of a multiport device **500**. In this embodiment, a short circuit coupler **570** configured as an adapter (e.g., a triplex short circuit port) having an integrated loop-back fiber or waveguide **573**. The input port fiber optic jumper assembly **135**, the pass-through port fiber optic jumper assembly **133**, and a splitter input optical fiber jumper assembly **558** are terminated by a triplex connector **755** (e.g., a triplex LC connector) for mating with the short circuit coupler **570**. When the triplex connector **755** is mated to the short circuit coupler **570**, the input port fiber optic jumper assembly **135** is in optical communication with a first end of the integrated loop-back fiber or waveguide **573** and the splitter input optical fiber jumper assembly **558** is in optical communication with a second end of the integrated loop-back fiber or waveguide **573**. Thus, the input port fiber optic jumper assembly **135** is in optical communication with the splitter input **255** of the splitter **248**.

(78) The embodiments described above enable a craft to configure an optical device by opening a housing to gain access to an enclosure where optical connections and field configurations are made. However, embodiments of the present disclosure also include field-configurable optical devices wherein the configuration is made such that access to an internal enclosure is not needed.

(79) Referring to FIGS. **8** and **9**, an example system **600** for an optical communication network is illustrated. FIG. **8** illustrates internal components of the system **600** and FIG. **9** illustrates example physical hardware components of the system **600**. The system **600** generally includes a terminated access point **106A** engineered into a distribution cable **70** similar to as described above with respect to FIG. **2**. A tether assembly **107** provides mid-span access to optical fibers of the distribution cable **70**. As a non-limiting example, the tether assembly **107** comprises a two-fiber pigtail connectorized with a duplex hardened connector hanging from the access point.

(80) The example system further includes an optical device configured as a multiport device **601** and an intermediate cable assembly **680** comprising a cable **110**, a pass-through optical fiber **687** and an input optical fiber **689** within the cable **110**, and a connector **682** for mating with the multiport device **601** (FIG. **8**). The example intermediate cable assembly **680** also includes a first connector **109** for mating with the connector of the tether assembly **107**. The connector **682** may be a duplex connector that provides both an input connector **684** and a pass-through connector **683**.

(81) Referring to FIG. **8**, the multiport device **601** includes a housing **630** that defines an enclosure **631**. Disposed within the enclosure are a splitter **148** and a plurality of couplers **642A-642F**. More or fewer couplers may be provided. Further, any $N\times M$ splitter may be provided, and embodiments are not limited to the 6×8 splitter shown in FIG. **8**. As described above with respect to FIG. **3A**, the plurality of couplers **642A-642F** have different power splitting ratios, and may be asymmetric couplers as shown in FIG. **8**. Each coupler **642** includes an input **652**, a first output **651**, and a second output **652**.

(82) A plurality of sets of splitting ratio selection ports **641A-641F** are provided at an exterior

surface of the housing **630** of the multiport device **601**. Because these splitting ratio selection ports are external, they should be hardened ports to withstand the environment in which the multiport device **601** will be deployed.

(83) The plurality of sets of splitting ratio selection ports **641A-641F** comprise a plurality of coupler input ports **646A-646F** and a plurality of coupler pass-through ports **644A-644F**. The plurality of coupler input ports **646A-646F** and the plurality of coupler pass-through ports **644A-644F** (i.e., the plurality of sets of splitting ratio selection ports **641A-641F**) may be configured as hardened simplex ports or hardened duplex ports, for example. As a non-limiting example, the plurality of sets of splitting ratio selection ports **641A-641F** may be configured as LC adapters.

(84) Rather than accessing an interior enclosure **631** of the multiport device **601**, the craft connects the connector **682** of the intermediate cable assembly **680** to the set of splitting ratio selection ports **641** corresponding to the coupler **642** having the desired power splitting ratio. In the example illustrated by FIG. **8**, the connector **682** of the intermediate cable assembly **680** will be connected to set of splitting ratio selection ports **641C**. This connects the pass-through connector **683** to the coupler pass-through port **644C** and the input connector **684** to the coupler input port **646C**. Thus, the pass-through optical fiber **687** and the input optical fiber **689** will be in optical communication with the first output **651** of coupler **642C** and the input **652** of coupler **642C**, respectively.

(85) To change the power splitting ratio of the multiport device **601**, the craft simply may connect the connector **682** to a different set of splitting ratio selection ports **641**.

(86) FIG. **10** illustrates another example of a multiport device **701** wherein the plurality of coupler input ports **746A-746F** and the plurality of coupler pass-through ports **744A-744F** are provided by a multi-fiber port **741** at an exterior surface of the housing **730**. In the illustrated embodiment, the multi-fiber port **741** is a twelve-fiber, hardened port. The selection of the desired power splitting ratio is achieved through addressing the correct fibers in a corresponding hardened multi-fiber connector **782** of the intermediate cable assembly **780**. No other further configuration of the multiport device **701** is needed. As shown in FIG. **10**, the optical fibers of the intermediate cable assembly **680** are in positions such that coupler **742A** is selected, providing a power splitting ratio of 40%/60% for the multiport device **701**.

(87) Each coupler of the plurality of couplers **742A-742F** has an input **752**, a first output **751**, and a second output **753**. The second outputs **753** of the plurality of couplers **742A-742F** are in optical communication with the splitter inputs **758** of the splitter **148**. In some embodiments, the second outputs **753** and the splitter inputs **758** are connectorized fiber pigtails and make with one another. In other embodiments, the plurality of couplers **742A-742F** and the splitter **148** are provided on the same PLC chip and thus the second outputs **753** of the plurality of couplers **742A-742F** may be provided directly to the splitter **148** by waveguides integrated on or within the PLC chip.

(88) Externally configurable optical devices employing a $1\times M$ splitter are also disclosed. Referring now to FIG. **11**, another multiport device **801** device having a multi-fiber port **741** at an exterior surface of a housing **830** is illustrated. The multi-fiber port **741** is configured to receive a multi-fiber connector **782** for selecting a power splitting ratio as described above with respect to FIG. **10**. However, rather than a 6×8 splitter, the example multiport device **801** employs a 1×8 splitter **248**. However, it should be understood that the splitter may have more or fewer outputs (i.e., a $1\times M$ splitter).

(89) The multiport device **801** has a plurality of couplers **742A-742F** similar to as shown in FIG. **10**. However, the second outputs **853** of the plurality of couplers **742A-742F** are routed to coupler output ports **847A-847F** at the exterior surface of the housing **830**. The coupler output ports **847A-847F** may take on any configuration. However, they should be hardened because they are exposed to the environment being located at the exterior surface of the housing **830**. A splitter input port **856** is also provided at the exterior surface of the housing **830**. The splitter input port **856**, which should also be hardened, is in optical communication with a splitter input optical fiber jumper assembly **858** that is optically coupled to the input **255** of the splitter **248**. To connect the second output **853**

of a desired optical coupler **742**, the craft will connect an end of a splitter input jumper **859** to a desired coupler output port **847**. As a non-limiting example, the splitter input jumper **859** is configured as a loop-back fiber that optically couples the splitter input port **856** to the selected coupler output port **847**. The splitter input jumper **859** may include connector on each end that plug into the splitter input port **856** and the selected coupler output port **847**. In the example of FIG. **11**, the craft has connected an end of the splitter input jumper **859** to coupler output port **847A**, and addressed the optical fibers of the intermediate cable assembly **680** in the multi-fiber connector **782** so that they are in optical communication with the input **752** and the first output **751** of coupler **742A**. Thus, the multiport device **801** of FIG. **11** is configured to have a power splitting ratio of 40%/60%.

(90) In some embodiments, there is no splitter input port **856**. Rather, the splitter input optical fiber jumper assembly **858** is configured as a pigtail that extends out of the housing **830** for connection to a coupler output port **847**. A gasket or other sealing member may be disposed between the splitter input optical jumper assembly **585** and the housing to provide environmental sealing.

(91) The hardened coupler output ports **847A-847F** and the hardened splitter input port **856** are large and may take up a lot of space on the housing **830**. In some embodiments, the splitter input ports and the common splitter input port may be non-hardened and sealed within a recess.

Referring now to FIG. **12**, another multiport device **901** is illustrated. The coupler output ports **947A-947F** and the splitter input port **956** are non-hardened and disposed on a recessed face **997** within a recess **990** of the housing **930**. A cover **992** seals the recess **990** and the ports therein from the environment. Thus, the coupler output ports **947A-947F** and the splitter input port **956** may be non-hardened and smaller than the coupler output ports **847A-847F** and the splitter input port **856** shown in FIG. **11**.

(92) A splitter input jumper **959** having a non-hardened connector optically couples the splitter input **956** to a selected coupler output port **847**. The splitter input jumper **959** is also sealed within the recess **990**.

(93) FIG. **13** shows an example close-up perspective view of the recess **990**, cover **992** and the splitter input jumper **959** of the multiport device **901** depicted by FIG. **12**. In the example of FIG. **13**, the splitter input jumper **959** is configured as a plug having two ferrules **958** that are coupled to an internal splitter optical fiber (not shown).

(94) The recess **990** is within a face of the housing **930**, and defines a recessed face **997**. In the illustrated example, the coupler output ports **947A-947F** are split-sleeve receptacles that surround a central splitter input port **956** that is also configured as a split-sleeve receptacle. The split-sleeve receptacles are configured to receive the ferrules **958** of the splitter input jumper **959** to optically couple the splitter input port **956** to a selected coupler output port **947**. It should be understood that ports other than split-sleeve receptacles may be used for the splitter input port **956** and the coupler output ports **947A-947F**.

(95) In the illustrated embodiment, a gasket surrounds the recess **990** opening to provide environmental sealing. The cover **992** is configured as a plate that is disposed over the recess. Fastener members **995** of the cover **992** may cooperate with fastener members **994** of the housing to secure the cover **992** to the housing **930**. As a non-limiting example, fastener members **994** may be threaded bores, fastener members **995** may be holes. Screws may be disposed through fastener members **995** and screwed into fastener members **994** to secure the cover **992** to the housing **930**. The cover **992** may also include a jumper recess **998** to provide space for the splitter input jumper **959**. It should be understood that in other embodiments the jumper recess is not provided.

(96) Referring now to FIG. **14**, another non-enterable, field-configurable multiport device **1001** is illustrated. Rather than providing a recess as illustrated by FIGS. **12** and **13**, the embodiment of FIG. **14** provides coupler output ports **1047A-1047F** and a splitter input port **1056** that are sealed within the enclosure **1031**. The splitter input jumper is configured as an actuator **1059** (e.g. a knob, a lever, a dial, and the like) configured such that actuation of the actuator changes which coupler

output port **1047** is optically coupled to the common splitter input port. The actuator **1059** includes an optical fiber for optically coupling the desired coupler output port **1047** to the common splitter input port. As a non-limiting example, the actuator **1059** may be configured as a knob that is partially external to the housing **1030**, and rotation of the knob indexes which coupler output port **1047** is selected.

(97) In some embodiments, the optical device may include wavelength selection components within the enclosure in addition to or in lieu of the 1×2 couplers disclosed herein. The wavelength selection components may enable the selection of different channels or subsets of channels in a wavelength division multiplexing (WDM) application. For example, any of the internally accessible or externally accessible means for selecting a 1×2 coupled described herein may also be used in the same manner to select a wavelength selection component to select different channels or subsets of channels in a WDM application. As a non-limiting example, any one of the optical couplers **142A-142F** of FIG. **3A** may be replaced with a wavelength selection component operable to pass only the desired wavelength(s).

(98) As one non-limiting example, the optical device may be employed in a coarse wavelength division multiplexing scheme. Referring to FIG. **3A**, each of the optical couplers **142A-142F** may be replaced with wavelength selection devices comprising a filter that passes one wavelength to the splitter **148**. The craft may use the input port fiber optic jumper assembly **135** and the pass-through port fiber optic jumper assembly **133** to make the wavelength selection in the manner described above with respect to optical power selection. It should be understood that any of the optical devices described herein may be used to select wavelengths using wavelength selection devices.

(99) As another non-limiting example, the optical device may be employed in a dense wavelength division multiplexing scheme. Referring to FIG. **3A**, each of the optical couplers **142A-142F** may be replaced with wavelength selection devices comprising a filter that passes a plurality of wavelengths to the splitter **148**. The plurality of wavelengths is a subset of the wavelengths entering the optical device. Thus, each wavelength selection device passes one band of wavelengths. The craft may use the input port fiber optic jumper assembly **135** and the pass-through port fiber optic jumper assembly **133** to make the wavelength selection in the manner described above with respect to optical power selection. In such embodiments, a subscriber may have another wavelength selection device at the premises to select the single wavelength for the premises.

(100) It should now be understood that embodiments of the present disclosure are directed to optical devices, such as multiport devices, and methods for configuring a power splitting ratio of the optical device in the field. By including multiple 1×2 couplers within the optical device, the desired power splitting ratio may be established in the field rather than at the factory. This enables the manufacturer to produce and inventory fewer unique part numbers, which reduces costs for the manufacturer. Further, fewer unique part numbers are needed to be carried by the craft to a work site, which can help avoid confusion and add flexibility to implementation of the optical communication network.

(101) Although the disclosure has been illustrated and described herein with reference to explanatory embodiments and specific examples thereof, it will be readily apparent to those of ordinary skill in the art that other embodiments and examples can perform similar functions and/or achieve like results. All such equivalent embodiments and examples are within the spirit and scope of the disclosure and are intended to be covered by the appended claims. It will also be apparent to those skilled in the art that various modifications and variations can be made to the concepts disclosed without departing from the spirit and scope of the same. Thus, it is intended that the present application cover the modifications and variations provided they come within the scope of the appended claims and their equivalents.

Claims

1. A field-configurable optical device comprising: a housing defining an enclosure; an input port located at the housing; a pass-through port located at the housing; a plurality of output ports located at the housing; a splitter disposed within the enclosure and comprising one or more splitter inputs and a plurality of splitter outputs coupled to the plurality of output ports; a plurality of couplers within the enclosure, each coupler comprising an input, a first output, and a second output, wherein: each coupler has a power splitting ratio between the first output and the second output that is different from other couplers of the plurality of couplers; and the second output of at least one coupler of the plurality of couplers is in optical communication with at least one splitter input of the one or more splitter inputs; an input port fiber optic jumper assembly within the enclosure, wherein the input port fiber optic jumper assembly is configured to selectively connect the input port to the input of an individual coupler of the plurality of couplers; and a pass-through port fiber optic jumper assembly within the enclosure, wherein the pass-through port fiber optic jumper assembly is configured to selectively connect the pass-through port to the first output of the individual coupler of the plurality of couplers, wherein moving the input port fiber optic jumper assembly and the pass-through port fiber optic jumper assembly from a first coupler to a second coupler of the plurality of couplers changes the power splitting ratio of the field-configurable optical device.
2. The field-configurable optical device of claim 1, wherein the field-configurable optical device is a multiport device.
3. The field-configurable optical device of claim 1, wherein the plurality of couplers is a plurality of asymmetric couplers.
4. The field-configurable optical device of claim 1, wherein the input port fiber optic jumper assembly and the pass-through port fiber optic jumper assembly are such that an optical signal is present within only one coupler of the plurality of couplers at a time.
5. The field-configurable optical device of claim 1, wherein at least a portion of the housing is openable to enable access to the enclosure to move the input port fiber optic jumper assembly and the pass-through port fiber optic jumper assembly.
6. The field-configurable optical device of claim 1, wherein the one or more splitter inputs of the splitter comprises a plurality of splitter inputs.
7. The field-configurable optical device of claim 1, wherein the one or more splitter inputs of the splitter comprises a single splitter input.
8. The field-configurable optical device of claim 7, further comprising a splitter input optical fiber jumper assembly having a first end that is connected to the single splitter input of the splitter and a second end that is selectively connected to the second output of the individual coupler.
9. The field-configurable optical device of claim 7, wherein the input port fiber optic jumper assembly is capable of being connected directly to the single splitter input for an end-of-line configuration.
10. The field-configurable optical device of claim 1, wherein the splitter and the plurality of couplers are provided by one or more of a planar lightwave circuit, a fused biconic taper coupler, and a thin film coupler.
11. The field-configurable optical device of claim 1, wherein the splitter and the plurality of couplers are disposed within a cassette within the enclosure.
12. The field-configurable optical device of claim 1, wherein each coupler of the plurality of couplers is disposed within its own housing within the enclosure.
13. A field-configurable optical device comprising: a housing defining an enclosure; an input port located at the housing; a pass-through port located at the housing; a plurality of output ports located at the housing; a splitter disposed within the enclosure and comprising one or more splitter inputs

and a plurality of splitter outputs coupled to the plurality of output ports; a plurality of couplers within the enclosure, each coupler comprising an input, a first output, and a second output, wherein: each coupler has a power splitting ratio between the first output and the second output that is different from other couplers of the plurality of couplers; and the second output of at least one coupler of the plurality of couplers is in optical communication with at least one splitter input of the one or more splitter inputs; a plurality of sets of splitting ratio selection ports, wherein: each set of splitting ratio selection ports comprises a coupler input port and a coupler pass-through port; the coupler input port is in optical communication with the input of an individual coupler, and the coupler pass-through port is in optical communication with the first output of the individual coupler; and an input port fiber optic jumper assembly within the enclosure, the input port fiber optic jumper assembly comprising an input optical fiber that is connected to the input port at a first end and an input port fiber optic jumper assembly connector at a second end, wherein the input port fiber optic jumper assembly connector is configured to selectively mate with an individual coupler input port of an individual set of splitting ratio selection ports; and a pass-through port fiber optic jumper assembly within the enclosure, the pass-through port fiber optic jumper assembly comprising a pass-through optical fiber and a pass-through fiber optic jumper assembly connector, wherein the pass-through fiber optic jumper assembly connector is configured to selectively mate with an individual coupler pass-through port of the individual set of splitting ratio selection ports, wherein moving the input port fiber optic jumper assembly and the pass-through port fiber optic jumper assembly from a first coupler to a second coupler of the plurality of couplers changes the power splitting ratio of the field-configurable optical device.

14. The field-configurable optical device of claim 13, wherein the field-configurable optical device is a multiport device.

15. The field-configurable optical device of claim 13, where the plurality of couplers is a plurality of asymmetric couplers.

16. The field-configurable optical device of claim 13, wherein the input port fiber optic jumper assembly and the pass-through port fiber optic jumper assembly are such that an optical signal is present within only one coupler of the plurality of couplers at a time.

17. The field-configurable optical device of claim 13, wherein at least a portion of the housing is openable to enable access to the enclosure to move the input port fiber optic jumper assembly and the pass-through port fiber optic jumper assembly.

18. The field-configurable optical device of claim 13, wherein the one or more splitter inputs of the splitter comprises a plurality of splitter inputs.

19. The field-configurable optical device of claim 13, wherein the one or more splitter inputs of the splitter comprises a single splitter input.

20. The field-configurable optical device of claim 19, wherein the input port fiber optic jumper assembly is capable of being connected directly to the single splitter input for an end-of-line configuration.

21. The field-configurable optical device of claim 19, further comprising a splitter input optical fiber jumper assembly having a first end that is connected to the single splitter input of the splitter and a second end that is selectively connected to the second output of the individual coupler.

22. The field-configurable optical device of claim 21, further comprising a splitter input optical fiber jumper assembly connector that is connected to the first end of the splitter input optical fiber jumper assembly.

23. The field-configurable optical device of claim 22, wherein: the plurality of sets of splitting ratio selection ports is a plurality of sets of triplex adapters; each set of triplex adapters of the plurality of sets of triplex adapters comprises an individual coupler input port, an individual pass-through port, and a coupler output port; and a second end of the splitter input optical fiber jumper assembly connector is in optical communication with the single splitter input.

24. The field-configurable optical device of claim 23, wherein the input port fiber optic jumper

assembly connector and the pass-through fiber optic jumper assembly connector are provided by a duplex connector and the splitter input optical fiber jumper assembly connector is provided by a single connector.

25. The field-configurable optical device of claim 23, the input port fiber optic jumper assembly connector, the pass-through fiber optic jumper assembly connector, and the splitter input optical fiber jumper assembly connector are provided by a triplex connector.

26. The field-configurable optical device of claim 25, further comprising a short circuit coupler comprising a triplex short circuit port, wherein the short circuit coupler optically couples the input port fiber optic jumper assembly connector to the splitter input optical fiber jumper assembly connector.

27. The field-configurable optical device of claim 26, wherein the short circuit coupler is configured as a plug.

28. The field-configurable optical device of claim 13, wherein the plurality of sets of splitting ratio selection ports is a plurality of sets of duplex adapters.

29. The field-configurable optical device of claim 28, wherein the plurality of sets of duplex adapters is a plurality of sets of LC adapters.

30. The field-configurable optical device of claim 29, wherein the input port fiber optic jumper assembly connector and the pass-through fiber optic jumper assembly connector are LC connectors.

31. The field-configurable optical device of claim 13, wherein the splitter and the plurality of couplers are provided by one or more of a planar lightwave circuit, a fused biconic taper coupler, and a thin film coupler.

32. The field-configurable optical device of claim 13, wherein the splitter and the plurality of couplers are disposed within a cassette within the enclosure.

33. The field-configurable optical device of claim 13, wherein each coupler of the plurality of couplers is disposed within its own housing within the enclosure.

34. A method of configuring a field-configurable optical device, the method comprising: opening a housing of the field-configurable optical device to access an enclosure defined by the housing; connecting an input port fiber optic jumper assembly connector to a coupler input port of an individual set of splitting ratio selection ports among a plurality of sets of splitting ratio selection ports within the enclosure, wherein the plurality of sets of splitting ratio selection ports correspond to a plurality of couplers within the enclosure, wherein each coupler has a power splitting ratio that is different from other couplers of the plurality of couplers; and connecting a pass-through port fiber optic jumper assembly connector to a coupler pass-through port of the individual set of splitting ratio selection ports, wherein a connection of the input port fiber optic jumper assembly connector and the pass-through port fiber optic jumper assembly connector establishes a power splitting ratio among a plurality of power splitting ratios of the field-configurable optical device.

35. The method of claim 34, further comprising closing the enclosure such that the enclosure is sealed from the environment.

36. The method of claim 34, wherein: each set of splitting ratio selection ports of the plurality of sets of splitting ratio selection ports further comprises a coupler output port; and the method further comprises connecting a splitter input optical fiber jumper assembly to the coupler output port of the individual set of splitting ratio selection ports.

37. A field-configurable optical device comprising: a housing defining an enclosure; an input port located at the housing; a pass-through port located at the housing; a plurality of output ports located at the housing; a plurality of wavelength selection devices within the enclosure, each wavelength selection device comprising an input, a first output, and a second output, wherein: each wavelength selection device passes an optical signal with at least one wavelength that is different from other wavelength selection devices of the plurality of wavelength selection devices; and the second output of at least one wavelength selection device of the plurality of wavelength selection devices

is in optical communication with at least one splitter input of the one or more splitter inputs; an input port fiber optic jumper assembly within the enclosure, wherein the input port fiber optic jumper assembly is configured to selectively connect the input port to the input of an individual wavelength selection device of the plurality of wavelength selection devices; and a pass-through port fiber optic jumper assembly within the enclosure, wherein the pass-through port fiber optic jumper assembly is configured to selectively connect the pass-through port to the first output of the individual wavelength selection device of the plurality of wavelength selection devices, wherein moving the input port fiber optic jumper assembly and the pass-through port fiber optic jumper assembly from a first wavelength selection device to a second wavelength selection device of the plurality of wavelength selection devices changes the at least one wavelength of the field-configurable optical device.

38. The field-configurable optical device of claim 37, wherein the at least one wavelength is a single wavelength.

39. The field-configurable optical device of claim 37, wherein the at least one wavelength is a plurality of wavelengths.
