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(54) **CHROMATIC DISPERSION COMPENSATION SYSTEM AND METHOD**

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(22) Filed: **May 15, 2002**

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(51) **Int. Cl.**[7] **H04B 10/12**

(52) **U.S. Cl.** **398/148**; 398/147; 398/158; 398/159

(58) **Field of Search** 398/142, 147, 398/148, 160

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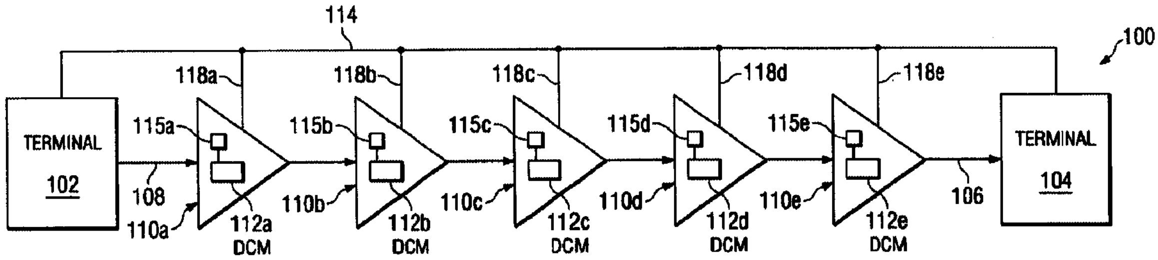
(57) **ABSTRACT**

A dispersion compensation system and method for use in an optical transmission system to compensate for signal distortion of an optical signal is provided. The dispersion compensation system includes a first and second transceivers for generating and receiving the optical signal respectively. An optical line couples the first transceiver to the second transceiver. A plurality of amplifiers are coupled to the optical line, spaced periodically throughout the optical line forming span distances, where the amplifiers amplify the optical signal and where the span differences are variable. A plurality of dispersion compensation modules are coupled to the plurality of amplifiers where the dispersion compensation models include a coarse granularity module having a resolution of at least **5** kilometers connected to a connector, the connector also connected to a fine granularity module having a resolution of one kilometer. The coarse and fine granularity modules connected through a single connector and the coarse granularity modules and the fine granularity modules correct the dispersion of the optical signal accumulated in the variable span distance. A memory is coupled to the dispersion compensators to provide information related to the value of the dispersion compensation.

6 Claims, 5 Drawing Sheets



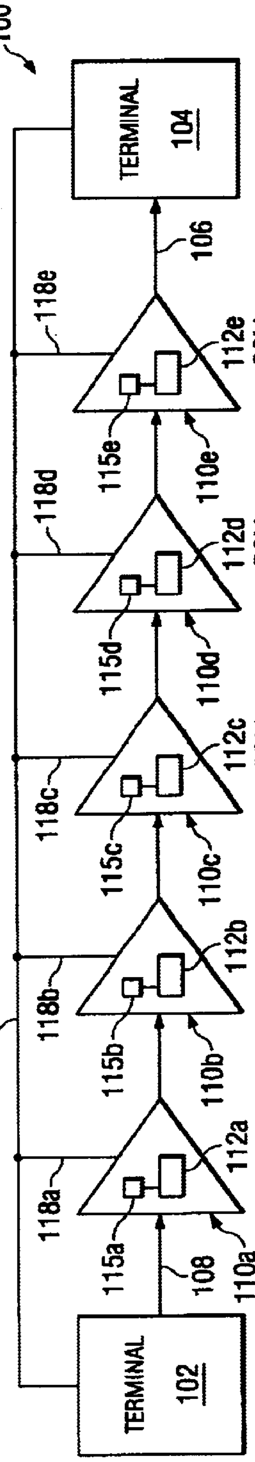


FIG. 1

FIG. 4A

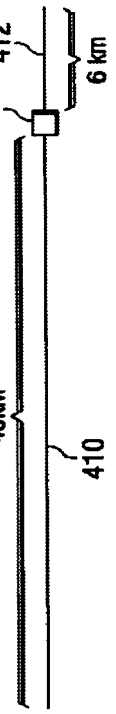


FIG. 4B

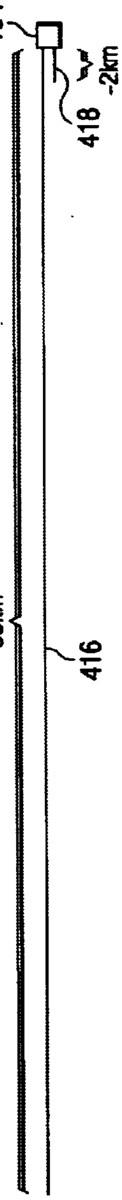


FIG. 4C

FIG. 2A

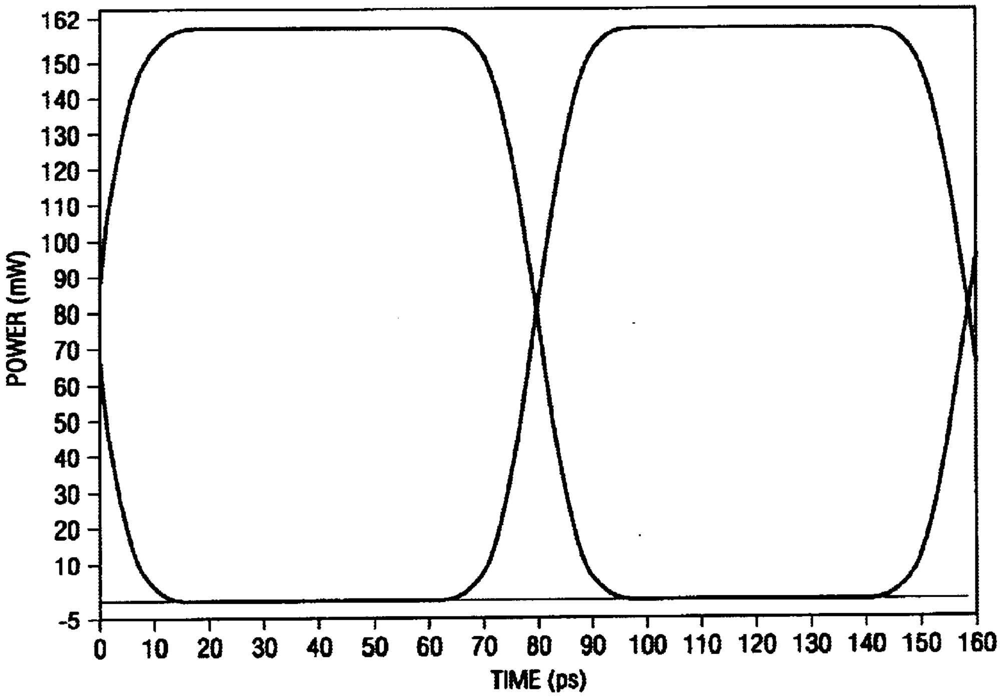
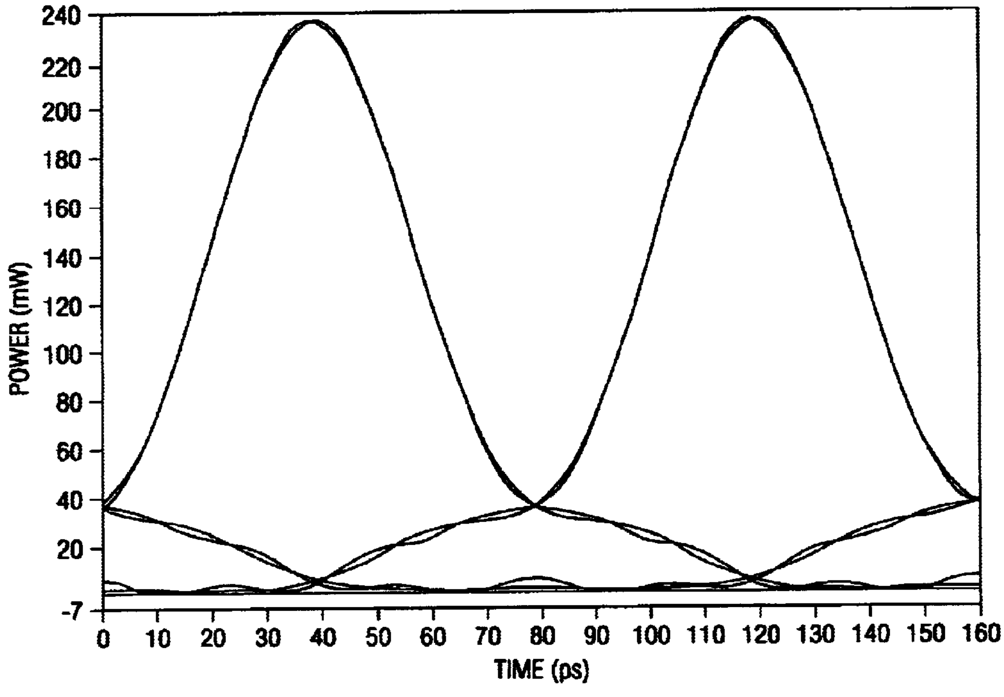

162
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
-5
POWER (mW)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
TIME (ps)

FIG. 2B


240
220
200
180
160
140
120
100
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60
40
20
-7
POWER (mW)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
TIME (ps)

FIG. 2C

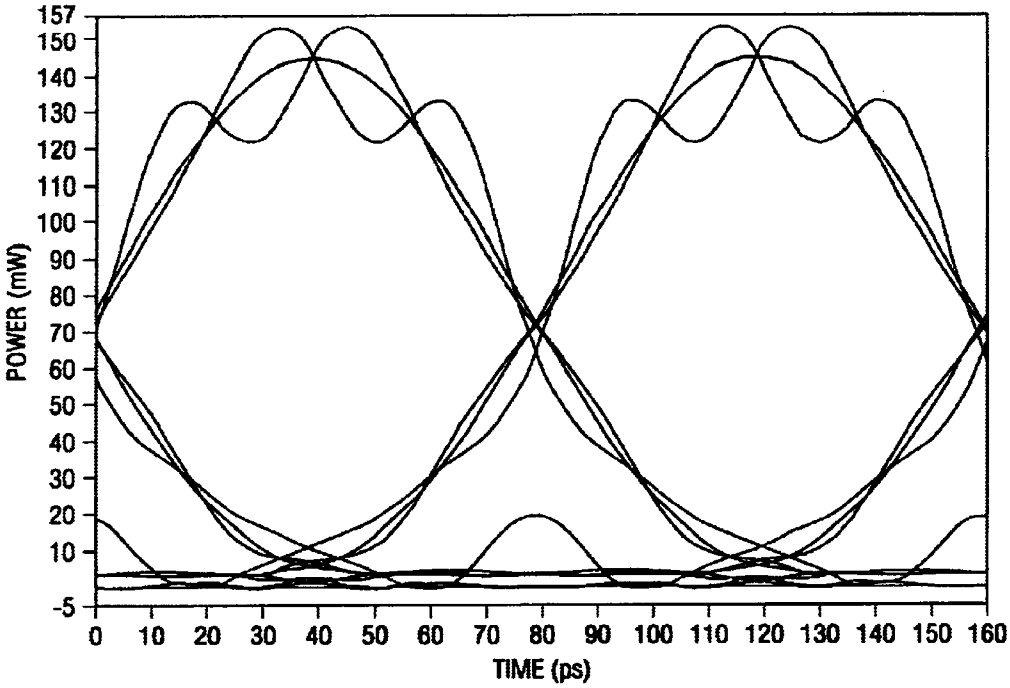

157
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
-5
POWER (mW)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
TIME (ps)

FIG. 2D

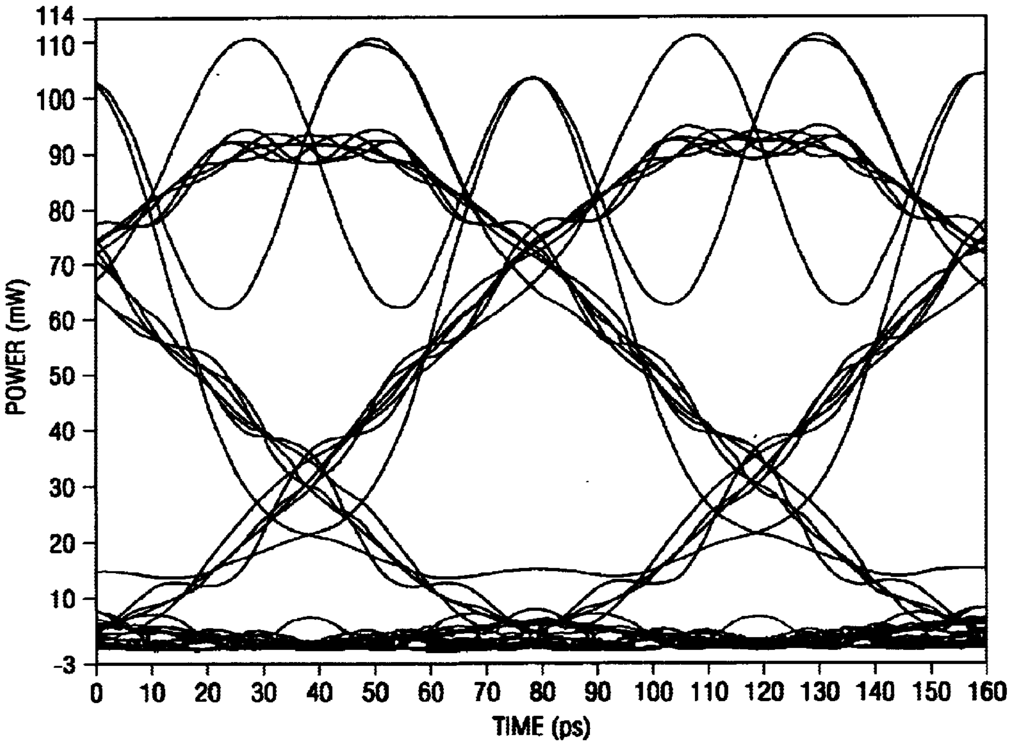

114
110
100
90
80
70
60
50
40
30
20
10
-3
POWER (mW)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
TIME (ps)

FIG. 3

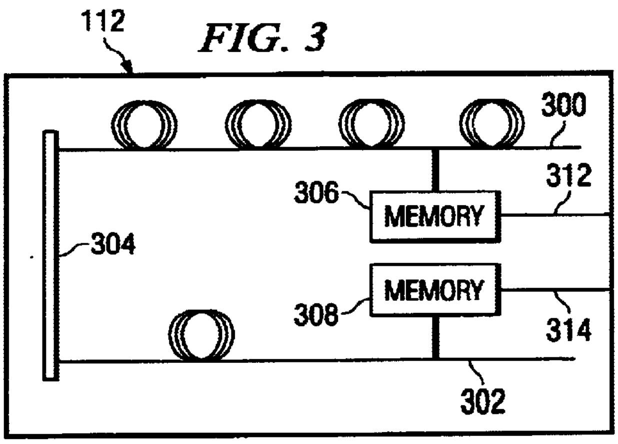

112
300
312
306
MEMORY
304
MEMORY
308
314
302

FIG. 5

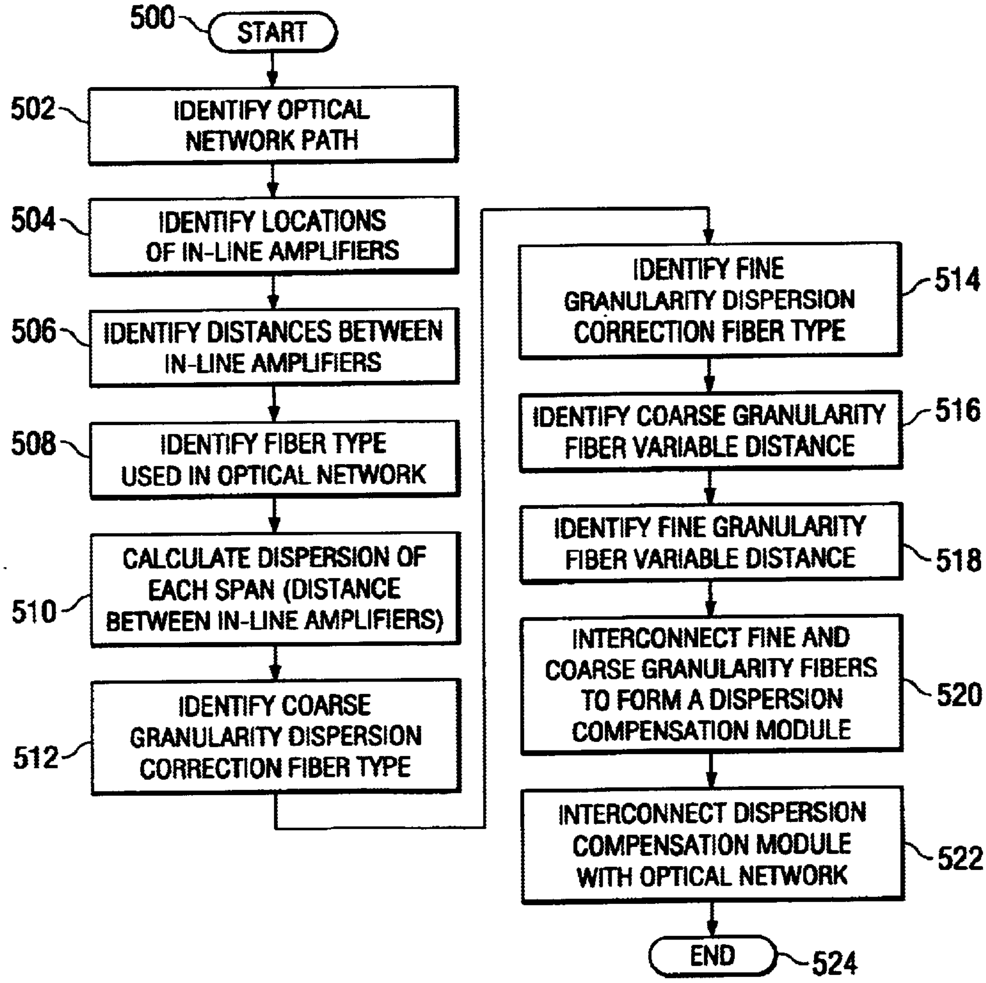
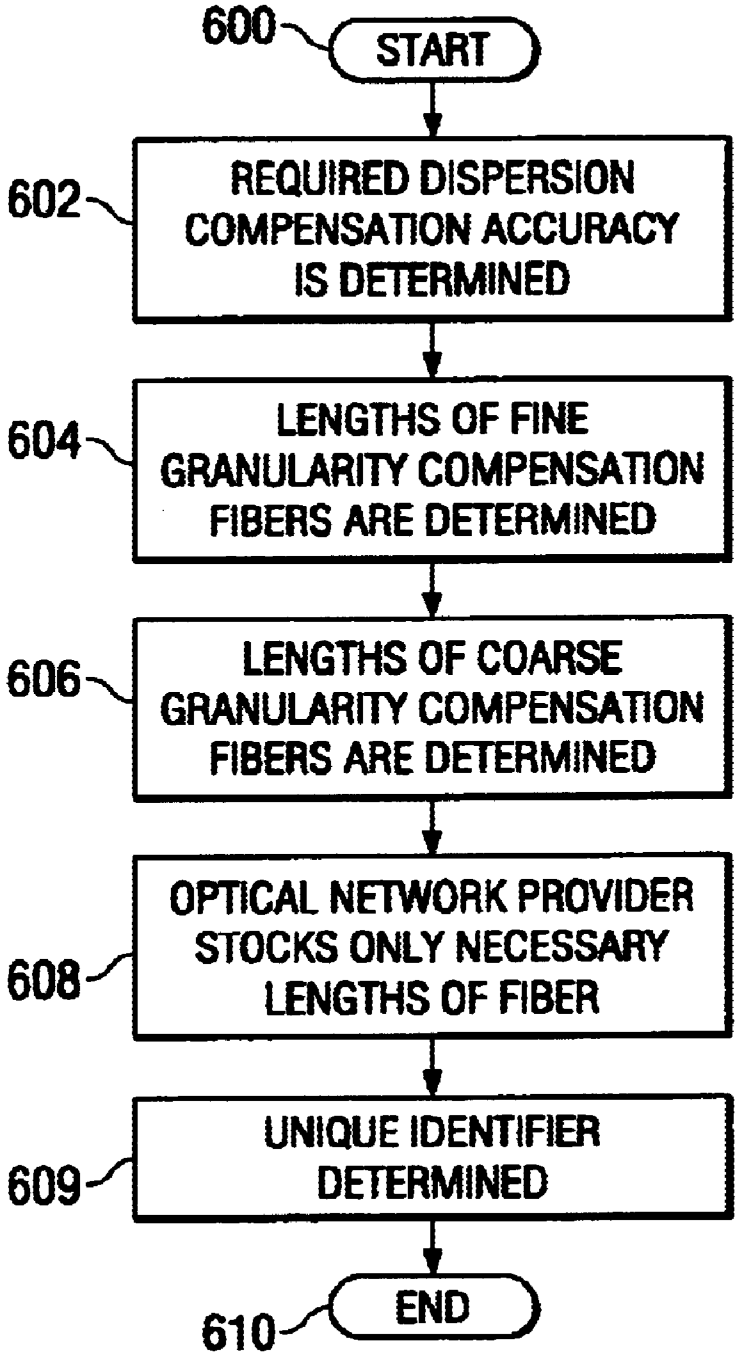

500
START
502
IDENTIFY OPTICAL NETWORK PATH
504
IDENTIFY LOCATIONS OF IN-LINE AMPLIFIERS
506
IDENTIFY DISTANCES BETWEEN IN-LINE AMPLIFIERS
508
IDENTIFY FIBER TYPE USED IN OPTICAL NETWORK
510
CALCULATE DISPERSION OF EACH SPAN (DISTANCE BETWEEN IN-LINE AMPLIFIERS)
512
IDENTIFY COARSE GRANULARITY DISPERSION CORRECTION FIBER TYPE
514
IDENTIFY FINE GRANULARITY DISPERSION CORRECTION FIBER TYPE
516
IDENTIFY COARSE GRANULARITY FIBER VARIABLE DISTANCE
518
IDENTIFY FINE GRANULARITY FIBER VARIABLE DISTANCE
520
INTERCONNECT FINE AND COARSE GRANULARITY FIBERS TO FORM A DISPERSION COMPENSATION MODULE
522
INTERCONNECT DISPERSION COMPENSATION MODULE WITH OPTICAL NETWORK
END
524

FIG. 6


600
START
602
REQUIRED DISPERSION COMPENSATION ACCURACY IS DETERMINED
604
LENGTHS OF FINE GRANULARITY COMPENSATION FIBERS ARE DETERMINED
606
LENGTHS OF COARSE GRANULARITY COMPENSATION FIBERS ARE DETERMINED
608
OPTICAL NETWORK PROVIDER STOCKS ONLY NECESSARY LENGTHS OF FIBER
609
UNIQUE IDENTIFIER DETERMINED
610
END

CHROMATIC DISPERSION COMPENSATION SYSTEM AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to Provisional Application Ser. No. 60/372,845, entitled "CHROMATIC DISPERSION COMPENSATION SYSTEM AND METHOD", by Michael H. Eiselt, et al., filed Apr. 16, 2002.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH/DEVELOPMENT

Not Applicable

FIELD OF THE INVENTION

This invention relates to a dispersion compensation system and more particularly to a chromatic dispersion compensation system for use in optical transmission systems.

BACKGROUND OF THE INVENTION

The transmission, routing and dissemination of information has occurred over computer networks for many years via standard electronic communication lines. These communication lines are effective, but place limits on the amount of information being transmitted and the speed of the transmission. With the advent of light-wave technology, a large amount of information is capable of being transmitted, routed and disseminated across great distances at a high transmission rate over fiber optic communication lines.

When information is transmitted over fiber optic communication lines, impairments to the pulse of light carrying the information can occur including pulse broadening (dispersion) and attenuation (energy loss). As an optical signal is transmitted over the fiber optic communication line, the optical signal is transmitted at various frequencies for each component of the optical signal. The high frequency components move through the fiber optic material at different speeds then compared to the low frequency components. Thus, the time between the faster components and the slower components increase as the optical signal is transmitted over the fiber optic communication line. When this occurs, the pulse broadens to the point where it interferes with the neighboring pulses; this is known as chromatic dispersion. Chromatic dispersion compensation corrects this pulse broadening.

Various chromatic dispersion compensation apparatus and methods are available.

In U.S. Pat. No. 6,259,845 entitled "Dispersion Compensating Element Having an Adjustable Dispersion" issued to Harshad P. Sardesai, a variable dispersion compensation module is disclosed. In the Sardesai patent, a dispersion compensation module including segments of optical fiber of varying lengths, some of which have a positive dispersion while others have a negative dispersion is disclosed. Selected optical fiber segments are coupled to one another to provide a desired net dispersion to offset the dispersion associated with the fiber optic communication line. The Sardesai patent allows for this variable dispersion compensation model rather than provide a unique segment of dispersion compensation fiber for each span. The Sardesai dispersion compensation module functions by interconnecting the various length of various dispersion per kilometer fibers so that the resulting total dispersion equals the dispersion of the fiber optic communication line span. The Sardesai dispersion compensation module, however, has a

high cost in that multiple dispersion compensation fibers enclosed within the Sardesai compensation module may remain unused and are therefore wasted when implemented in the field. Further, the Sardesai dispersion compensation module requires excessive interconnectivity between the various dispersion compensation fibers, allowing for a greater connection loss to be experienced.

Published U.S. Patent Application No. U.S. 2001/0009468 entitled "Method and System for Compensating for Chromatic Dispersion in an Optical Network" by John Arthur Fee discloses a method and system which automatically adjusts the dispersion of an optical signal at any location in the optical network if the optical signal does not have a desired shape. In the Fee application, a method and system using a tunable dispersion compensator in an optical network is disclosed. The tunable dispersion compensators are provided throughout the optical network at amplifier locations or they may be provided at other locations within the network. The tunable dispersion compensator functions by fine tuning the shape of the optical signal until an optimal shape is obtained. The Fee application discloses an eye diagram analyzer which analyzes the optical signal and sends this information to the tunable dispersion compensator to allow for manipulation of the optical signal until the optimal "eye" shape is obtained. The eye is the area formed by the pulses of the optical signal.

Next, in published U.S. Patent Application U.S. 2001/0007605 entitled "Apparatus and Method of Compensating for Wavelength Dispersion of Optical Transmission Line" filed by Shinya Inagaki, et al., a tunable dispersion compensator is disclosed. In the Inagaki application, the dispersion compensation method uses dispersion compensation fiber in combination with the tunable dispersion compensation module to compensate for the chromatic dispersion. The tunable dispersion compensation module disclosed in the Inagaki application is a virtually imaged phased array (VIPA) type compensator. The chromatic dispersion is simultaneously compensated through the use of the dispersion compensation fiber and the VIPA type compensator.

U.S. Pat. No. 6,275,315 entitled "Apparatus for Compensating for Dispersion of Optical Fiber in an Optical Line" issued to Park, et al. discloses a dispersion compensation method in which dispersion compensation fiber is used in conjunction with a variable dispersion module. In the Park patent, the variable dispersion compensation module is a dispersion compensation filter such as a reflective etalon filter. The etalon filter is a tunable filter and thus allows for variable dispersion compensation.

The primary focus of the fiber optic industry to correct chromatic dispersion has followed one of two paths. The first path was for the use of variable dispersion compensation modules as has been disclosed in the above referenced patent/patent applications. A second path is to manufacture dispersion compensation fibers in varying lengths to correct for dispersion compensation. Each varying length of the dispersion compensation fiber must be inventoried requiring a vast amount of assets to be tied up in inventory which is infrequently implemented. Therefore, any advancement in the ability to reduce the number of interconnectivity points between the dispersion compensating fibers and to reduce the cost incurred with the highly technical variable dispersion compensators and the high cost of inventory would be greatly appreciated.

SUMMARY OF THE INVENTION

A dispersion compensation system and method for use in an optical transmission system to compensate for signal distortion of an optical signal is provided. The dispersion compensation system includes a first and second transceivers for generating and receiving the optical signal respectively. An optical line couples the first transceiver to the second transceiver. A plurality of amplifiers are coupled to the optical line, spaced periodically throughout the optical line forming span distances, wherein the amplifiers amplify the optical signal and wherein the span distances are variable. A plurality of dispersion compensation modules are coupled to the plurality of amplifiers wherein the dispersion compensation models include a coarse granularity module having a resolution of at least 5 kilometers connected to a connector. The connector is also connected to a fine granularity module having a resolution of one kilometer. The coarse and fine granularity modules are connected through a single connector. The coarse granularity modules and the fine granularity modules correct the dispersion of the optical signal accumulated in the variable span distance. dr

DETAILED DESCRIPTION OF THE DRAWINGS

A better understanding of the invention can be obtained from the following detailed description of one exemplary embodiment as considered in conjunction with the following drawings in which:

FIG. **1** is a block diagram depicting an optical transmission system according to the present invention;

FIGS. **2***a*–**2***d* are graphical representations of an eye diagram of the optical signal;

FIG. **3** is a block diagram depicting a dispersion compensation module according to the present invention;

FIG. **4***a* is a block diagram depicting exemplary fiber combinations according to the present invention;

FIG. **4***b* is a block diagram depicting exemplary fiber combinations according to the present invention;

FIG. **4***c* is a block diagram depicting exemplary fiber combinations according to the present invention;

FIG. **5** are a flow chart of the dispersion compensation method according to the present invention; and

FIG. **6** is a flow chart depicting the inventory reduction of dispersion compensation fibers method according to the present invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

In the descriptions that follow, like parts are marked throughout the specification and drawings with the same numerals, respectively. The drawing figures are not necessarily drawn to scale and certain figures may be shown in exaggerated or generalized form in the interest of clarity and conciseness.

FIG. **1** depicts an optical transmission system according to the present invention. An optical transmission system **100** is shown including a transmitting terminal **102** and a receiving terminal **104**. For illustrative purposes only, the optical transmission system **100** is shown in a unidirectional manner. However, as is known to those skilled in the art, the optical transmission system **100** can function in a bi-directional manner without detracting from the spirit of the invention. The transmitting terminal **102** and the receiving terminal **104** are connected through optical line **106**. An optical signal **108** is transmitted over the optical line **106**. Spaced periodically throughout the optical transmission system **100** are in-line amplifiers **110**. The in-line amplifiers **110** boost the optical signal **108** as it is transmitted over the optical line **106**. As the optical signal **108** is transmitted over the optical line **106**, the optical signal **108** begins to experience chromatic dispersion. Chromatic dispersion is the broadening of the optical pulse over the various frequencies of the components of the optical signal **108**. High frequency components of the optical signal move through the optical line **106** at a different speed when compared to the low frequency components of the optical signal **108**. The longer wave-length components move at a slower rate than the shorter wave-length components of the optical signal **108**. Therefore, the optical signal **108** pulse broadens over time as the optical signal is transmitted throughout the optical line **106**. Chromatic dispersion compensation is necessary to correct for this pulse broadening impairment.

A controller **115** is resident in each in-line amplifier **110** and connects the in-line amplifiers **110**(*a–e*) to the optical supervisory channel **114** through transmission lines **118** (*a–e*). The controllers **115**(*a–e*) receive and transmit control data for the in-line amplifiers **110**(*a–e*). The controller in one embodiment includes a processor, a mass storage device, a network connection and a memory (all not shown). However, a wide range of controllers are implementable without detracting from the spirit of the invention.

A dispersion compensation module **112** is connected to the in-line amplifiers **110** such that the optical signal **108** flows through the dispersion compensation module **112** as the optical signal **108** is transmitted along the optical line **106**. The dispersion compensation modules **112**(*a–e*) are electronically connected to the controllers **115**(*a–e*) and receive control data from the optical supervisory channel **114** through transmission lines **118**(*a–e*) via the controllers **115**(*a–e*). As can be seen, dispersion compensation modules **112**(*a–e*) are located at each in-line amplifier **110**(*a–e*) location in the optical transmission system **100**. However, the quantity of dispersion compensation modules may be varied, including locating dispersion compensation modules at every other in-line amplifier or by selecting a fixed number of dispersion compensation modules and distributing those dispersion compensation modules at fixed intervals through the optical transmission system, without detracting from the spirit of the invention. Thus, in one embodiment, a dispersion compensation module **112***a* is shown co-located with in-line amplifier **110***a* within the optical transmission system **100**. The distance between the transmitting terminal **102** and the first in-line amplifier **110***a* and the distances between a first in-line amplifiers **110** and an adjacent amplifier **110** may vary according to the physical layout of the optical transmission system **100**. Thus, the frequency of the in-line amplifiers **110** within the optical transmission system **100** may vary depending upon the type of fiber used in the optical line **106** and depending upon the physical terrain that the optical transmission system **100** must span. The distances between the transmitting terminal **102** and the first in-line amplifier **110***a*, the distances between adjacent in-line amplifiers **110** and the distances between the receiving terminal **104** and the last in-line amplifier **110***e* may vary and each distance defined is a spanned distance.

Referring now to FIG. **2**, graphical representations of the eye diagram of the optical signal are shown. As the optical signal **108** is transmitted over a standard optical system, a optimal pulse shape is initially transmitted. The optimal pulse shape can be seen in FIG. **2***a*. The optimal pulse shape forms an "eye" and represents the minimum amount of chromatic dispersion of the optical signal **108** pulse. As the optical signal **108** is transmitted over the optical transmission network **100**, the pulse begins to broaden as is shown in FIGS. **2***b* and **2***c*. As the pulse broadens, the distinctions between separate optical signal **108** pulses become less discernable. As the optical signal **108** is transmitted further along the optical line **106**, the optical signal **108** continues to broaden as is shown in FIG. *2d*. Thus, as the optical signal **108** is transmitted over the optical line **106**, the optical signal **108** broadens to a point in which the information being transmitted over the optical signal **108** is no longer discernable. Thus, the optical signal **108** requires a chromatic dispersion correction to maintain an adequate "eye" or pulse shape.

Referring now to FIG. **3**, the dispersion compensation module according to the present invention is shown. Current dispersion compensation methodologies which incorporate dispersion compensation fibers can be classified in two groups. The first methodology includes the use of a dispersion compensation fiber in combination with a tunable dispersion compensation filter. The tunable compensation filter allows for the fine tuning of the dispersion compensation module to be accomplished when the exact amount of dispersion over a span is not known. Thus, when in the field, the installer can adjust through the interconnection of multiple dispersion compensation fibers within the tunable dispersion compensation module to accomplish the level of dispersion compensation necessary to offset the chromatic dispersion present in the current span. Examples of this methodology include U.S. Pat. No. 6,259,845 and U.S. patent application No. US2001/0009468 discussed herein. A second methodology requires that the exact dispersion amount of the span be calculated and then a single piece dispersion compensation fiber that exactly matches this specific dispersion amount be manufactured or obtained from a current inventory and installed to offset the chromatic dispersion of the span. A third methodology now exists and is discussed herein.

The dispersion compensation module **112** according to the present invention is comprised of a coarse granularity fiber **300** and a fine granularity fiber **302** interconnected with connector **304**. The coarse granularity fiber **300** compensates for the dispersion slope of the fiber and includes multiple dispersion compensation devices such as dispersion compensating fiber, higher order mode devices and chirped fiber bragg gratings. The fine granularity fiber **302** includes dispersion compensating fiber, higher order mode devices and chirped fiber bragg gratings but further includes the use of a standard single mode fiber (SSMF). The connector **304** is of the type commonly known to those skilled in the art for the connection of dispersion compensation fibers.

A memory **306** is physically coupled to the coarse granularity fiber **300** and is connected to the controller **115** through communication line **312**. A second memory **308** is physically coupled to the fine granularity fiber **302** and is connected to the controller **115** through communication line **314**. The memories **306** and **308**, in one embodiment, are programmable read-only memories, preferably electronically erasable programmable read-only memories. However, multiple memory systems are implementable without detracting from the spirit of the invention. Unique identifiers are stored in the memories **306** and **308** and upon a query from the controller **115**, the unique identifiers are transmitted to the controller **115** for retransmission across the optical supervisory channel **114**. Further, the unique identifiers are ascertainable through direct electrical connection to the in-line amplifier **110** as would occur by maintenance personnel in the field. The unique identifiers allow the maintenance personnel to identify the specific coarse and fine granularity fibers **300** and **302** installed in the dispersion compensation module **112**. Upon visual inspection, the resolution of the coarse and fine granularity fibers **300** and **302** is difficult to ascertain. However, if each individual fiber or each resolution or length of the coarse and fine granularity fibers **300** and **302** are assigned unique identifiers, the maintenance personnel only need cross reference the unique identifier with a master list to distinctly identify the resolution of the coarse and fine granularity fibers **300** and **302**. The coarse and fine granularity fibers **300** and **302** are manufactured at specific lengths, then inventoried such that through the use of only one coarse granularity fiber, one fine granularity fiber and one connector the dispersion accumulated in any standard span, which typically has a range of less than 100 kilometers, can be compensated. In one embodiment of the present invention, the coarse granularity fibers **300** are manufactured and inventoried at lengths which correspond to the accumulated dispersion in the optical network **100** for lengths of 10 kilometers, 20 kilometers, 30 kilometers, 40 kilometers, 50 kilometers, 60 kilometers, 70 kilometers, 80 kilometers, 90 and 100 kilometers. The fine granularity fibers **300** are manufactured and inventoried at lengths which correspond to the accumulated dispersion in the optical network **100** for lengths of 1 kilometer, 2 kilometers, 3 kilometers, 4 kilometers, 5 kilometers, 6 kilometers, 7 kilometers, 8 kilometers and 9 kilometers. Therefore for any span under 109 kilometers, the dispersion compensation module according to one embodiment of the present invention is implemented with only one coarse granularity fiber **300**, one fine granularity fiber **302** and one connector **304**. In another embodiment of the present invention, the coarse granularity fibers **300** are manufactured and inventoried at lengths which correspond to the accumulated dispersions in the optical network **100** for lengths of 5 kilometers, 10 kilometers, 15 kilometers, 20 kilometers, 25 kilometers, 30 kilometers, 35 kilometers, 40 kilometers, 45 kilometers, 50 kilometers, 55 kilometers, 60 kilometers, 65 kilometers, 70 kilometers, 75 kilometers, 80 kilometers, 85 kilometers, 90 kilometers, 95 kilometers, 100 kilometers. The fine granulated fibers **300** are manufactured and inventoried at lengths which correspond to the accumulated dispersion in the optical network for lengths of −5 kilometer, −4 kilometer, −3 kilometer, −2 kilometer, −1 kilometer, 1 kilometer, 2 kilometers, 3 kilometers, 4 kilometers, 5 kilometers. Therefore, for any span under 105 kilometers, the dispersion compensation model according to one embodiment of the present invention is implemented with only coarse granularity fiber **300**, one fine granularity fiber **302** and one connector **304**. The benefits of such systems are the reduction of manufacturing costs, the reduction of inventory costs and the reduction of time necessary to identify and install the dispersion compensation module **112**.

In one prior art system in which a single dispersion compensation fiber is used to offset the chromatic dispersion associated with any variable span under 109 kilometers, 109 different dispersion compensation fiber lengths would be necessary to offset the chromatic dispersion accumulated in various lengths varying from 1 to 109 kilometers. According to the present invention, only 19 various dispersion compensation fiber lengths would be necessary to be manufactured and inventoried. In another prior system, a tunable dispersion compensation module is attached to varying lengths of dispersion compensation fiber. However, the cost of the tunable dispersion compensation modules greatly exceed the cost of the dispersion compensation fiber itself and a tunable dispersion compensation module is necessary for each span. Further, the tunable dispersion compensation modules require multiple connections between various lengths of dispersion compensation fibers within the tunable dispersion module and therefore incur a greater amount of loss due to each of these multiple connections. As can be seen, the present invention provides a simplified and cost effective method of preparing a dispersion compensation module **112** as shown.

The dispersion compensation module **112** may be assembled in the field if the installer carries at least one each of the various lengths of the dispersion compensation fiber according to the present invention. Alternatively, the dispersion compensation module **112** may be assembled at the plant if the chromatic dispersion of the specific span is known. The dispersion compensation module **112** is then delivered and installed in the optical network by a field technician.

Referring now to FIGS. **4***a*, **4***b* and **4***c*, exemplary block diagrams are provided showing the various coarse and fine granularity fibers interconnected. FIGS. **4***a* through **4***c* demonstrate various exemplary embodiments of the dispersion compensation module. In FIG. **4***a*, a dispersion compensation module **112** is shown with a coarse granularity fiber **402** equivalent to 60 kilometers of accumulated dispersion connected through connector **404** to a fine granularity fiber **406** equivalent to the dispersion necessary for the accumulation of 2 kilometers of dispersion. Therefore, through the use of the single coarse granularity fiber **402**, the connector **404**, and the fine granularity fiber **406** the total dispersion accumulated in 62 kilometers of the optical line **106** can be compensated. In FIG. **4***b*, another exemplary embodiment is shown with the coarse granularity fiber **410** equivalent to 40 kilometers of accumulated dispersion, connected through connector **404** with the fine granularity fiber **412** equivalent to 6 kilometers of accumulated dispersion. Therefore, in this example, the dispersion associated with 46 kilometers has been offset through the use of the single coarse granularity fiber **410**, fine granularity fiber **412** and a connector **404**. In FIG. **4***c*, an alternative embodiment is shown. The coarse granularity fiber **416** is equivalent to the accumulated dispersion of 80 kilometers. The coarse granularity fiber **416** is connected through connector **404** to a fine granularity fiber **418** of an accumulated −2 kilometers. The −2 kilometer fine granularity fiber **418** is typically a standard single mode fiber (SSMF). The fine granularity fiber **418** is used to compensate for the over compensation of the coarse granularity fiber **416**. Therefore, in this example, the total distance to be compensated is 78 kilometers. To accomplish this, the 80 kilometer coarse granularity fiber **416** was connected to a −2 kilometer fine granularity fiber **418**. The benefits of this compensation for over compensation of the coarse granularity fiber include: lower connection losses due to the connection of the SSMF to the coarse granularity fiber **416** where the large connector losses are experienced between the connection of two dispersion compensation fibers; a lower power loss is experienced as a signal flows through the SSMF as compared to dispersion compensation fiber; and the SSMF is a lower cost than the standard dispersion compensation fiber. Other fiber types such as non-zero dispersion shifted fiber and silica-core fiber may be implemented as the negative fine granularity fiber without detracting from the spirit of the invention.

The dispersion compensation module **112** may include one device including the coarse granularity fiber and the fine granularity fiber, two different sub-modules, one for the coarse granularity fiber and one for the fine granularity fiber, or the fine granularity fiber may be integrated into the coarse granularity fiber through connectors or splices at manufacture. A wide range of connection possibilities exist without detracting from the spirit of the invention.

FIG. **5** is a flow diagram of the dispersion compensation method according to the present invention. The process begins with start **500**. Next, in step **502**, the physical optical network path is identified. The developers of the optical network system identify the route in which the optical network path will take over the physical terrain. Next, the locations for the in-line amplifiers **110** are identified in step **504**. The location of these in-line amplifiers **110** depend upon the physical terrain and the characteristics of the optical network. Next, in step **506**, the various distances between the in-line amplifiers **110**, the distance between the transmitting terminal **102** and the first in-line amplifier **110***a*, and the distance between the last in-line amplifier **110***e* and the receiving terminal **104** are identified. As these distances vary, the determination of the specific span distance for each span is necessary to determine the accumulated dispersion over that span. Next, in step **508**, the specific fiber type which will be used in the optical network is identified. Once this optical fiber type has been identified, the specific characteristics of this fiber are measured or obtained and will be used to determine the amount of dispersion per kilometer of the optical network. The calculation to determine the dispersion for each span in the optical network is accomplished in step **510**. This dispersion calculation depends on the specific span distances and the fiber type and characteristics of the fiber selected. In an alternative embodiment, the measurement equipment will be taken out into the field to directly measure the dispersion amount of the particular deployed span. In this embodiment, the accuracy of the dispersion is higher, as dispersion even in the same fiber type might differ among different production batches and the product of span length and average dispersion might give a less accurate result. Once the calculated accumulated dispersion for each span is determined, the coarse granularity fiber type is identified in step **512**. The fine granularity fiber type is identified next in step **514**. The fiber types are selected based upon the characteristics of the optical network fiber and are selected based upon the dispersion calculations for each span. Next, in step **516**, the coarse granularity fiber variable distances are determined. In one embodiment, the coarse granularity fiber variable distances are based upon 10 kilometer groupings. Therefore, the coarse granularity fiber variable distances are 10 kilometers, 20 kilometers, 30 kilometers, 40 kilometers, etc. The fine granularity fiber variable distances are identified in step **518**. These fiber variable distances depend upon the total dispersion amount experienced over the optical network and may depend upon the current manufacturing or inventory of specific variable distances. The variable distances are determined such that one coarse granularity fiber and one fine granularity fiber are connected to properly compensate for the accumulated dispersion of any span distance in the optical network, thus reducing inventory and cost levels. Next, in step **520**, the fine and coarse granularity fibers are interconnected to form a dispersion compensation module **112**. The dispersion compensation module may be formed in the field, interconnected at a assembly facility, or may be connected at manufacturer if the manufacturer has access to the specific variable distances. Finally, in step **522**, the dispersion compensation module is connected to the optical network to compensation for the chromatic dispersion accumulated in each span. The process ends with step **524**.

Referring now to FIG. **6**, a method of inventory reduction of dispersion compensation fibers is shown. The process begins with start **600**. Next, in step **602**, the required dispersion compensation accuracy is determined on a per span basis based upon transmission system modeling. Next, in step **604**, the lengths of the fine granularity compensation fibers are determined based upon the required compensation accuracy per span as determined in step **602**. Next, in step **606**, the lengths of the coarse granularity fibers are determined based upon the maximum length of the fine granularity fibers and the range of dispersion that needs to be compensated. For the lowest overall number of different fiber modules, the number of coarse and fine granularity fibers should be approximately equal. The necessary lengths are determined such that only one coarse and only one fine granularity fiber can be connected to compensate any standard span distance. In one embodiment, the standard span distance is less than 109 kilometers. In another embodiment, the necessary lengths of the coarse granularity fibers are based upon 10 kilometer increments and the fine granularity fibers are based upon 1 kilometer increments. In another embodiment, the fine granularity fiber compensate from a −9 kilometers to a +9 kilometers. Next, in step **608**, the optical network provider stocks only the necessary lengths of the coarse and fine granularity fibers. Thus, the intermittent lengths are not manufactured or inventoried and thus the inventory is reduced thus lowering costs of manufacture and storage. In step **609** the unique identifiers for the coarse and fine granularity fibers **300** and **302** are determined. A unique identifier is assigned to each individual fiber or a unique identifier is assigned to a specific length or resolution of the coarse and fine granularity fibers **300** and **302**. The unique identifier is stored in a memory device **306** and **308** and is physically attached to the individual fibers. The manufactured and stored coarse and fine granularity fibers **300** and **302** can be electronically polled and an automatic inventory listing determined. The process ends with step **610**.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof of various changes to the size, shape, materials, components and order may be made without departing from the spirit of the invention.

What is claimed is:

1. A dispersion compensation system for use in an optical transmission system to compensate for signal distortion of an optical signal, the system comprising:

a first transceiver, the first transceiver for generating the optical signal;

an optical line coupled to the first transceiver, the optical line transmitting the optical signal;

a second transceiver coupled to the optical line, the second transceiver for receiving the optical signal;

a plurality of amplifiers coupled to the optical line, wherein the amplifiers are spaced periodically throughout the optical line forming span distances, wherein the amplifiers amplify the optical signal and wherein the span distances are variable;

a plurality of dispersion compensation modules coupled to the plurality of amplifiers, the dispersion compensation modules comprising:

a coarse granularity module, wherein the coarse granularity module has a resolution of at least 5 km;

a connector connected to the coarse granularity module;

a fine granularity module connected to the connector, wherein the fine granularity module has a resolution of at least 1 km;

wherein the coarse granularity module and the fine granularity module are connected by a single connection and the coarse granularity module and the fine granularity module correct the dispersion of the optical signal accumulated in the variable span distance;

a supervisory channel coupled to the plurality of in-line amplifiers;

a plurality of controllers resident in at least a portion of the plurality of in-line amplifiers, each controller coupled to the supervisory channel; and,

wherein the dispersion compensation modules further comprise:

a first memory device coupled to the coarse granularity module;

a second memory coupled to the fine granularity module; and,

wherein the first and second memory devices are in communication with one of the plurality of controllers.

2. A dispersion compensation system for use in an optical transmission system to compensate for signal distortion of an optical signal, the system comprising:

a first transceiver, the first transceiver for generating the optical signal; an optical line coupled to the first transceiver, the optical line transmitting the optical signal;

a second transceiver coupled to the optical line, the second transceiver for receiving the optical signal;

a plurality of amplifiers coupled to the optical line, wherein the amplifiers are spaced periodically throughout the optical line forming span distances, wherein the amplifiers amplify the optical signal and wherein the span distances are variable;

a plurality of dispersion compensation modules coupled to the plurality of amplifiers, the dispersion compensation modules comprising:

a coarse granularity module, wherein the coarse granularity module has a resolution of at least 5 km;

a connector connected to the coarse granularity module;

a fine granularity module connected to the connector, wherein the fine granularity module has a resolution of at least 1 km;

wherein the coarse granularity module and the fine granularity module are connected by a single connection and the coarse granularity module and the fine granularity module correct the dispersion of the optical signal accumulated in the variable span distance;

a supervisory channel coupled to the plurality of in-line amplifiers;

a plurality of controllers resident in at least a portion of the plurality of in-line amplifiers, each controller coupled to the supervisory channel; and,

wherein the dispersion compensation modules further comprise:

a first memory device coupled to the coarse granularity module;

a second memory coupled to the fine granularity module; and,

wherein the first and second memory devices are in communication with one of the plurality of controllers, wherein the first and second memory devices include electronically erasable programmable read only memory.

3. A dispersion compensation system for use in an optical transmission system to compensate for signal distortion of an optical signal, the system comprising:

a first transceiver, the first transceiver for generating the optical signal;

an optical line coupled to the first transceiver, the optical line transmitting the optical signal;

a second transceiver coupled to the optical line, the second transceiver for receiving the optical signal;

a plurality of amplifiers coupled to the optical line, wherein the amplifiers are spaced periodically throughout the optical line forming span distances, wherein the amplifiers amplify the optical signal and wherein the span distances are variable;

a plurality of dispersion compensation modules coupled to the plurality of amplifiers, the dispersion compensation modules comprising:

a coarse granularity module, wherein the coarse granularity module has a resolution of at least 5 km;

a connector connected to the coarse granularity module;

a fine granularity module connected to the connector, wherein the fine granularity module has a resolution of at least 1 km;

wherein the coarse granularity module and the fine granularity module are connected by a single connection and the coarse granularity module and the fine granularity module correct the dispersion of the optical signal accumulated in the variable span distance; a supervisory channel coupled to the plurality of in-line amplifiers;

a plurality of controllers resident in at least a portion of the plurality of in-line amplifiers, each controller coupled to the supervisory channel; and,

wherein the dispersion compensation modules further comprise:

a first memory device coupled to the coarse granularity module;

a second memory coupled to the fine granularity module; and,

wherein the first and second memory devices are in communication with one of the plurality of controllers, wherein the first and second memory devices include electronically erasable programmable read only memory, wherein the first and second memory devices store identifiers.

4. A dispersion compensation system for use in an optical transmission system to compensate for signal distortion of an optical signal, the system comprising:

a first transceiver, the first transceiver for generating the optical signal;

an optical line coupled to the first transceiver, the optical line transmitting the optical signal;

a second transceiver coupled to the optical line, the second transceiver for receiving the optical signal;

a plurality of amplifiers coupled to the optical line, wherein the amplifiers are spaced periodically throughout the optical line forming span distances, wherein the amplifiers amplify the optical signal and wherein the span distances are variable;

a plurality of dispersion compensation modules coupled to the plurality of amplifiers, the dispersion compensation modules comprising:

a coarse granularity module, wherein the coarse granularity module has a resolution of at least 5 km;

a connector connected to the coarse granularity module;

a fine granularity module connected to the connector, wherein the fine granularity module has a resolution of at least 1 km;

wherein the coarse granularity module and the fine granularity module are connected by a single connection and the coarse granularity module and the fine granularity module correct the dispersion of the optical signal accumulated in the variable span distance;

a supervisory channel coupled to the plurality of in-line amplifiers;

a plurality of controllers resident in at least a portion of the plurality of in-line amplifiers, each controller coupled to the supervisory channel; and,

wherein the dispersion compensation modules further comprise:

a first memory device coupled to the coarse granularity module;

a second memory coupled to the fine granularity module; and,

wherein the first and second memory devices are in communication with one of the plurality of controllers, wherein the first and second memory devices include electronically erasable programmable read only memory, wherein the first and second memory devices store identifiers, wherein the identifiers include unique identifiers.

5. A dispersion compensation system for use in an optical transmission system to compensate for signal distortion of an optical signal, the system comprising:

a first transceiver, the first transceiver for generating the optical signal;

an optical line coupled to the first transceiver, the optical line transmitting the optical signal;

a second transceiver coupled to the optical line, the second transceiver for receiving the optical signal;

a plurality of amplifiers coupled to the optical line, wherein the amplifiers are spaced periodically throughout the optical line forming span distances, wherein the amplifiers amplify the optical signal and wherein the span distances are variable;

a plurality of dispersion compensation modules coupled to the plurality of amplifiers, the dispersion compensation modules comprising:

a coarse granularity module, wherein the coarse granularity module has a resolution of at least 5 km;

a connector connected to the coarse granularity module;

a fine granularity module connected to the connector, wherein the fine granularity module has a resolution of at least 1 km;

wherein the coarse granularity module and the fine granularity module are connected by a single connection and the coarse granularity module and the fine granularity module correct the dispersion of the optical signal accumulated in the variable span distance;

a supervisory channel coupled to the plurality of in-line amplifiers;

a plurality of controllers resident in at least a portion of the plurality of in-line amplifiers, each controller coupled to the supervisory channel; and,

wherein the dispersion compensation modules further comprise:

a first memory device coupled to the coarse granularity module;

a second memory coupled to the fine granularity module; and, wherein the first and second memory devices are in communication with one of the plurality of controllers, wherein the first and second memory devices include electronically erasable programmable read only memory, wherein the first and second memory devices store identifiers, wherein the identifiers include unique identifiers, wherein the plurality of controllers receive and transmit in-line amplifier control data, including the identifiers.

6. A dispersion compensation system for use in an optical transmission system to compensate for signal distortion of an optical signal, the system comprising:

a first transceiver, the first transceiver for generating the optical signal;

an optical line coupled to the first transceiver, the optical line transmitting the optical signal;

a second transceiver coupled to the optical line, the second transceiver for receiving the optical signal;

a plurality of amplifiers coupled to the optical line, wherein the amplifiers are spaced periodically throughout the optical line forming span distances, wherein the amplifiers amplify the optical signal and wherein the span distances are variable;

a plurality of dispersion compensation modules coupled to the plurality of amplifiers, the dispersion compensation modules comprising:

a coarse granularity module, wherein the coarse granularity module has a resolution of at least 5 km;

a connector connected to the coarse granularity module;

a fine granularity module connected to the connector, wherein the fine granularity module has a resolution of at least 1 km;

wherein the coarse granularity module and the fine granularity module are connected by a single connection and the coarse granularity module and the fine granularity module correct the dispersion of the optical signal accumulated in the variable span distance;

a supervisory channel coupled to the plurality of in-line amplifiers;

a plurality of controllers resident in at least a portion of the plurality of in-line amplifiers, each controller coupled to the supervisory channel; and,

wherein the dispersion compensation modules further comprise:

a first memory device coupled to the coarse granularity module;

a second memory coupled to the fine granularity module; and,

wherein the first and second memory devices are in communication with one of the plurality of controllers, wherein the first and second memory devices include electronically erasable programmable read only memory, wherein the first and second memory devices store identifiers, wherein the identifiers include unique identifiers, wherein the plurality of controllers receive and transmit in-line amplifier control data, including the identifiers, and wherein the first and second memory devices store data prior to installation in the optical transmission system.

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