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Power coupling coefficient measuring method and power coupling coefficient measuring device

Abstract

An object of the present disclosure is to provide a power coupling coefficient measurement method and a power coupling coefficient measurement device capable of inexpensively and easily measuring a power coupling coefficient. The power coupling coefficient measurement method according to the present disclosure is a power coupling coefficient measurement method for measuring a power coupling coefficient of a multi-core fiber in order to achieve the aforementioned object, and includes: inputting a test light pulse from one end of the multi-core fiber to any one of cores; receiving backscattered light of the core to which the test light pulse is input or any one of the other cores; measuring an intensity distribution of the backscattered light with respect to a distance from the one end of the multi-core fiber; and calculating the power coupling coefficient from the intensity distribution of the backscattered light.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

(1) This application is a 371 U.S. National Phase of International Application No. PCT/JP2020/031608, filed on Aug. 21, 2020. The entire disclosure of the above application is incorporated herein by reference.

TECHNICAL FIELD

(2) The present invention relates to a method and device for measuring a power coupling coefficient of a multi-core fiber.

BACKGROUND ART

(3) Due to the spread of various Internet services, the amount of traffic flowing through one optical fiber has rapidly increased year by year. On the other hand, the transmission capacity that can be propagated through an optical fiber is limited, and it is predicted that a single-mode fiber (SMF), which is widely used at present, will not be able to cope with future traffic increase. In order to overcome this situation, a spatial multiplex transmission system using an optical fiber having a plurality of cores in one optical fiber (hereinafter referred to as a multi-core fiber) has been studied.

(4) In recent years, in order to achieve both high-density spatial multiplexing and reduction in a group delay time difference between propagation modes, attention has been paid to a multi-core fiber in which modes between cores are randomly coupled by random bending or twisting in the longitudinal direction of an optical fiber (hereinafter referred to as a coupled multi-core fiber). In the coupled multi-core fiber, digital signal processing is applied on a receiving side in order to restore a transmission signal deteriorated by coupling between cores. The load of this digital signal processing is closely related to the impulse response characteristics of the coupled multi-core fiber, and the smaller the impulse response width, the smaller signal processing load. The impulse response width is determined by an inter-mode group delay time difference specific to an optical fiber and a coupling amount between modes. Therefore, a power coupling coefficient representing a degree of coupling between modes is an important characteristic, and it is important to ascertain the value thereof.

CITATION LIST

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SUMMARY OF INVENTION

Technical Problem

(6) For example, NPL 1 and NPL 2 disclose methods of measuring a power coupling coefficient in a multi-core fiber. These methods are methods for calculating a power coupling coefficient from a ratio of backscattered light intensities in a specific core and an adjacent core when a test light pulse is input to the specific core. In these methods, two light receivers are used to simultaneously acquire backscattered light from two cores, or two measurements are required to sequentially acquire backscattered light from two cores. As a result, there is a problem that a measurement device becomes expensive or a measurement procedure becomes complicated.

(7) In order to solve the above problem, an object of the present invention is to provide a power coupling coefficient measurement method and a power coupling coefficient measurement device capable of inexpensively and easily measuring a power coupling coefficient.

Solution to Problem

(8) In order to achieve the above object, according to a power coupling coefficient measurement method and a power coupling coefficient measurement device according to the present invention, a power coupling coefficient is calculated from the intensity of backscattered light from a single core.

(9) Specifically, a power coupling coefficient measurement method according to the present disclosure is a power coupling coefficient measurement method for measuring a power coupling coefficient of a multi-core fiber, and includes inputting a test light pulse from one end of the multi-core fiber to any one of cores, receiving backscattered light of the core to which the test light pulse has been input or any one of the other cores, measuring an intensity distribution of the backscattered light with respect to a distance from the one end of the multi-core fiber, and calculating a power coupling coefficient from the intensity distribution of the backscattered light.

(10) For example, in the power coupling coefficient measurement method according to the present disclosure, calculation of the power coupling coefficient may include representing the intensity distribution in a logarithm, calculating an approximate intensity distribution of a linear expression with respect to the distance on the basis of the intensity of the backscattered light in a region where the logarithm of the intensity distribution can be approximated by the linear expression of the distance, calculating a normalized intensity distribution by normalizing the intensity distribution with the approximate intensity distribution, and calculating the power coupling coefficient from the normalized intensity distribution.

(11) Specifically, a power coupling coefficient measurement device according to the present disclosure is a power coupling coefficient measurement device connected to one end of a multi-core fiber and measuring a power coupling coefficient of the multi-core fiber, and includes a test light pulse generator configured to generate a test light pulse, an input/output device configured to input the test light pulse generated by the test light pulse generator to any one of cores of the multi-core fiber and to output backscattered light of the core to which the test light pulse is input or any one of the other cores, a measurement device configured to measure an intensity distribution of the backscattered light output by the input/output device with respect to a distance from the one end of the multi-core fiber, and an arithmetic device configured to calculate a power coupling coefficient from the intensity distribution of the backscattered light measured by the measurement device.

(12) For example, in the power coupling coefficient measurement device according to the present disclosure, at the time of calculating the power coupling coefficient, the arithmetic device may further perform representing the intensity distribution in a logarithm, calculating an approximate intensity distribution of a linear expression with respect to the distance on the basis of the intensity of the backscattered light in a region where the logarithm of the intensity distribution can be approximated by the linear expression of the distance, calculating a normalized intensity distribution by normalizing the intensity distribution with the approximate intensity distribution, and calculating the power coupling coefficient from the normalized intensity distribution.

(13) Since the power coupling coefficient is calculate from the intensity of backscattered light from one core, according to the power coupling coefficient measurement method and the power coupling coefficient measurement device according to the present disclosure, a light receiver can measure the power coupling coefficient of the multi-core fiber with one measurement device and one measurement.

(14) Accordingly, the present invention can provide a power coupling coefficient measurement method and a power coupling coefficient measurement device capable of inexpensively and easily measuring a power coupling coefficient.

(15) The inventions described above can be combined where possible.

Advantageous Effects of Invention

(16) According to the present disclosure, it is possible to provide a power coupling coefficient measurement method and a power coupling coefficient measurement device capable of inexpensively and easily measuring a power coupling coefficient.

Description

BRIEF DESCRIPTION OF DRAWINGS

(1) FIG. **1** shows an example of a schematic configuration and usage of a power coupling coefficient measurement device according to the present invention.

(2) FIG. **2** shows an example of a schematic configuration and usage of the power coupling coefficient measurement device according to the present invention.

(3) FIG. **3** shows an example of a schematic configuration and usage of the power coupling coefficient measurement device according to the present invention.

(4) FIG. **4** shows an example of a schematic configuration and usage of the power coupling coefficient measurement device according to the present invention.

(5) FIG. **5** shows an example of a flowchart of a power coupling coefficient measurement method according to the present invention.

(6) FIG. **6** is a diagram illustrating the power coupling coefficient measurement method according to the present invention.

(7) FIG. **7** is a diagram illustrating the power coupling coefficient measurement method according to the present invention.

DESCRIPTION OF EMBODIMENTS

(8) Hereinafter, an embodiment of the present disclosure will be described in detail with reference to the drawings. Note that the present disclosure is not limited to the embodiment described below. These implementation examples are only illustrative, and the present disclosure can be implemented in various modified and improved modes based on the knowledge of those skilled in the art. Note that constituent elements with the same reference signs in the present description and the drawings are identical to each other.

Embodiment

(9) FIG. **1** shows an example of a schematic configuration of a power coupling coefficient measurement device according to the present embodiment. The power coupling coefficient measurement device **101** is a power coupling coefficient measurement device **101** that is connected to one end of a multi-core fiber **10** and measures a power coupling coefficient of the multi-core fiber **10**, and includes: a test light pulse generator **11** that generates a test light pulse; an input/output device **12** that inputs the test light pulse generated by the test light pulse generator **11** to any one core of the multi-core fiber **10** and outputs backscattered light of the core to which the test light pulse is input or any other core, a measurement device **13** that measures an intensity distribution of the backscattered light output by the input/output device **12** with respect to a distance from one end of the multi-core fiber **10**, and an arithmetic device **14** that calculates a

power coupling coefficient from the intensity distribution of the backscattered light measured by the measurement device **13**.

(10) An example of the configuration of the power coupling coefficient measurement device according to the present embodiment will be specifically described with reference to FIG. **2** to FIG. **4**. FIG. **2** is a diagram illustrating an example of the test light pulse generator **11**. The test light pulse generator **11** includes a light source **11-1**, a light intensity modulator **11-2**, and a pulse generator **11-3**.

(11) The light source **11-1** outputs continuous light of a wavelength to be used as test light.

(12) The pulse generator **11-3** sends a pulse signal to the light intensity modulator **11-2**. Further, the pulse generator **11-3** may output a trigger signal for determining a timing at which measurement of an intensity distribution of backscattered light is started to the measurement device **13**.

(13) The light intensity modulator **11-2** pulses the continuous light output from the light source **11-1** according to the signal of the pulse generator **11-3** to form a test light pulse. The light intensity modulator **11-2** may be, for example, an acousto-optic modulator including an acousto-optic switch for pulse-driving an acousto-optic element.

(14) FIG. **3** is a diagram illustrating the input/output device **12**. The input/output device **12** includes optical switches **12-1** and **12-2**, a fan-in fan-out **12-3**, and optical circulators **12-4** and **12-5**.

(15) The optical switch **12-1** is connected to the light intensity modulator **11-2** through a single core fiber and switches an optical path according to a core of the multi-core fiber **10** to which the test light pulse is input. The optical switch **12-2** switches an optical path according to a core of the multi-core fiber **10** that measures backscattered light.

(16) As shown in FIG. **3**, the optical circulators **12-4** and **12-5** are inserted between the optical switches **12-1** and **12-2** and the fan-in fan-out **12-3** and control a propagation direction of light.

(17) The fan-in fan-out **12-3** is used to couple each core of the multi-core fiber **10** and a single core fiber from the optical circulators **12-4** and **12-5**.

(18) FIG. **4** is a diagram illustrating the measurement device **13**. The measurement device **13** includes a light receiver **13-1**, an analog/digital (A/D) converter **13-2**, and a signal processing unit **13-3**.

(19) The light receiver **13-1** is connected to the optical switch **12-2** through a single core fiber and receives backscattered light generated in the multi-core fiber **10** via the fan-in fan-out **12-3**, the optical circulator **12-4** or **12-5**, and the optical switch **12-2**.

(20) The A/D converter **13-2** converts an electrical signal from the light receiver **13-1** into digital data. The A/D converter **13-2** inputs the digital data to the signal processing unit **13-3**.

(21) The signal processing unit **13-3** acquires the intensity distribution of the backscattered light from the input digital data.

(22) The arithmetic device **14** performs arithmetic processing for calculating a power coupling coefficient from the intensity distribution of the backscattered light acquired by the signal processing unit **13-3**. The arithmetic device **14** may further perform representing the intensity distribution by a logarithm, calculating an approximate intensity distribution of a linear expression with respect to a distance on the basis of the intensity of backscattered light in a region where the logarithm of the intensity distribution can be approximated by the linear expression of the distance, calculating a normalized intensity distribution by normalizing the intensity distribution with the approximate intensity distribution, and calculating a power coupling coefficient from the normalized intensity distribution at the time of calculating the power coupling coefficient. The content of processing performed by the arithmetic device **14** corresponds to step S**04** of a power coupling coefficient measurement method which will be described later. The details of the content of processing performed by the arithmetic device **14** will be described through the power coupling coefficient measurement method as step S**04** of the power coupling coefficient measurement method.

(23) Note that the signal processing unit **13-3** and the arithmetic device **14** can also be realized by a

computer and a program, and the program can be recorded in a recording medium and can also be provided through a network.

(24) FIG. **5** shows a flowchart of the power coupling coefficient measurement method according to the present embodiment. The power coupling coefficient measurement method is a power coupling coefficient measurement method for measuring the power coupling coefficient of the multi-core fiber **10** and includes: an input step S**01** of inputting a test light pulse from one end of the multi-core fiber **10** to any one core; a light receiving step S**02** of receiving backscattered light of the core to which the test light pulse is input or any other core; a measurement step S**03** of measuring an intensity distribution of the backscattered light with respect to the distance from one end of the multi-core fiber **10**, and a calculation step S**04** of calculating a power coupling coefficient from the intensity distribution of the backscattered light. Hereinafter, steps S**01** to S**04** will be described in detail.

(25) (Step S**01**)

(26) As described above, the test light pulse generator **11** converts continuous light output from the light source **11-1** into a test light pulse and inputs the test light pulse to the multi-core fiber **10** via the input/output device **12**.

(27) (Step S**02**)

(28) As described above, the measurement device **13** receives backscattered light generated in the multi-core fiber **10** through the input/output device **12**.

(29) (Step S**03**)

(30) The measurement device **13** acquires the intensity distribution of the received backscattered light through the signal processing unit **13-3**.

(31) (Step S**04**)

(32) The arithmetic device **14** calculates a power coupling coefficient from the intensity distribution of the backscattered light acquired by the signal processing unit **13-3**. Calculation of the power coupling coefficient may further include: a sub-step S**04-1** of representing the intensity distribution by a logarithm; a sub-step S**04-2** of calculating an approximate intensity distribution of a linear expression with respect to a distance on the basis of the intensity of the backscattered light in a region where the logarithm of the intensity distribution can be approximated by the linear expression of the distance; a sub-step S**04-3** of calculating a normalized intensity distribution by normalizing the intensity distribution by the approximate intensity distribution; and a sub-step S**04-4** of calculating the power coupling coefficient from the normalized intensity distribution.

(33) Sub-steps S**04-1** to S**04-4** in this step will be described in detail with reference to FIG. **6** and FIG. **7**. Hereinafter, calculation of a power coupling coefficient will be described with reference to a multi-core fiber having two cores as an example. The two cores are referred to as core **1** and core **2**. It is assumed that the cores have the same loss coefficient α, Rayleigh scattering coefficient as, and backscattered light capture rate B, and the power coupling coefficient h can be regarded as being uniform in the longitudinal direction. The distance from the end face of an optical fiber to be tested to which test light pulse is input is represented by z. Further, the intensity of the test light pulse input from one end of the multi-core fiber **10** is set to P.sub.0.

(34) Sub-step S**04-1** and S**04-2** will be described. In input step S**01**, a case of inputting a test light pulse to core **1** is conceived. At this time, the intensity distribution of backscattered light of each core can be expressed by formula 1 for core **1** and formula 2 for core **2**.

[Math. 1]

(35)
$$P_{bs1}(z) = \frac{P_0}{2}\alpha_s B\exp(-2\alpha z)[1 + \exp(-4hz)] \quad (1)$$

[Math. 2]

$$P_{bs2}(z) = \frac{P_0}{2}\alpha_s B\exp(-2\alpha z)[1 - \exp(-4hz)] \quad (2)$$

Note that P.sub.bs1(z) and P.sub.bs2(z) represent intensity distributions of backscattered light in core **1** and core **2**.

(36) Here, when the product of the power coupling coefficient h and the distance z sufficiently increases, both P.sub.bs1(z) and P.sub.bs2(z) converge to P.sub.conv(z) represented by formula 3.

[Math . 3]

(37)
$$P_{conv}(z) = \frac{P_G}{2}\alpha_s B\exp(-2\alpha z) \quad (3)$$

P.sub.conv(z) is called an approximate intensity distribution.

(38) The intensity distributions P.sub.bs1(z) and P.sub.bs2(z) and the approximate intensity distribution P.sub.conv(z) are shown in FIG. **6** with the ordinate axis as a logarithmic scale. In the logarithmic scale, P.sub.bs1(z) or P.sub.bs2(z) are curved lines and P.sub.conv(z) is a straight line. Further, when the distance z increases, P.sub.bs1(z) and P.sub.bs2(z) approach the straight line of P.sub.conv(z) and converge thereon. Furthermore, P.sub.conv(z) does not depend on a core whose intensity distribution has been measured.

(39) Therefore, in this step, when the relationship between the intensity distribution P.sub.bs1(z) or P.sub.bs2(z) and the approximate intensity distribution P.sub.conv(z) that is, the distance z increases, P.sub.bs1(z) and P.sub.bs2(z) of the logarithmic scale converge on the same straight line, and the fact that the straight line is P.sub.conv(z) is used. In sub-step S**04**-**1**, the intensity distribution P.sub.bs1(z) or P.sub.bs2(z) is represented on a logarithmic scale in order to facilitate extraction of a straight line part which becomes the approximate intensity distribution P.sub.conv(z) from the measured intensity distribution P.sub.bs1(z) or P.sub.bs2(z).

(40) In sub-step S**04**-**2**, first, the arithmetic device **14** obtains a ratio of change for two distances z in the vicinity of an end (hereinafter abbreviated as "other end") on the opposite side to the end on which an input pulse is incident with respect to the intensity distribution P.sub.bs1(z) or P.sub.bs2(z) which is represented on the logarithmic scale. Here, the ratio of change is expressed as ΔP.sub.bsi÷Δz where Δz is a difference between the two distances z.sub.α and z.sub.β, and ΔP.sub.bsi is a difference between the intensities of a core i on the logarithmic scale corresponding to Δz. Further, the difference ΔP.sub.bsi between the intensities of the core i on the logarithmic scale corresponding to Δz is ΔP.sub.bsi=(log.sub.10 [P.sub.bsi(z.sub.α)]−log.sub.10 [P.sub.bsi(z.sub.β)]) using the intensities P.sub.bsi(z.sub.α) and P.sub.bsi(z.sub.β) corresponding to the distances z.sub.α and z.sub.β. Further, the vicinity of the other end may be a point separated by 1 km or more from the end on which the input pulse is incident, for example, if it is a coupling type multi-core fiber.

(41) Then, the arithmetic device **14** extracts a region in which the ratio of change for two distances is regarded as almost the same as a ratio of change in the vicinity of the other end which has already been obtained even if the two distances z in the intensity distribution P.sub.bs1(z) or P.sub.bs2(z) represented on the logarithmic scale are taken. The arithmetic device **14** linearly approximates measured data of the intensities constituting the intensity distribution of the extracted region using the least square method and represents the measured data by a linear expression of the distance z. Since the linear expression of the distance z is the approximate intensity distribution P.sub.conv(z) on the logarithmic scale, P.sub.conv(z) is obtained by returning the linear expression of the distance z from the logarithmic scale to the original one.

(42) Sub-step S**04**-**3** will be described. In sub-step S**04**-**3**, the measured intensity distribution P.sub.bs1(z) or P.sub.bs2(z) is divided by the approximate intensity distribution P.sub.conv(z) obtained in sub-step S**04**-**2** to obtain a normalized intensity distribution P.sub.bsi(Z)+P.sub.conv(z) of core **1** or core **2**.

(43) The advantage of using the normalized intensity distribution will be described. As described above, in a case where Math. 1 and Math. 2 are established for the intensity distributions P.sub.bs1(z) and P.sub.bs2(z), when the distance z increases, the intensity distributions converge on the same approximate intensity distribution P.sub.conv(z) regardless of the core. Then, the intensity distributions P.sub.bs1(z) and P.sub.bs2(z) are normalized by the approximate intensity distribution P.sub.conv(z). The normalized intensity distributions P.sub.bs1(z) and P.sub.bs2(z) are represented

by Math. 4 and Math. 5. The left side of Math. 4 is a normalized intensity distribution of core **1**, and the left side of Math. 5 is a normalized intensity distribution of core **2**.

[Math. 4]   [Math. 5]

(44) $\frac{P_{bs1}(z)}{P_{conv}(z)} = 1 + \exp(-4hz)$ (4) $\frac{P_{bs2}(z)}{P_{conv}(z)} = 1 - \exp(-4hz)$ (5)

As represented by Math. 4 and Math. 5, the loss coefficient α, the Rayleigh scattering coefficient $\alpha.\text{sub.s}$, the backscattered light capture rate B, and the intensity $P.\text{sub.0}$ of the test light pulse of each core which are parameters of intensity do not appear in the normalized intensity distribution. Accordingly, when the normalized intensity distribution is used, the power coupling coefficient h can be easily obtained without determining these parameters.

(45) FIG. **7** shows the normalized intensity distributions of Math. 4 and Math. 5. As shown in FIG. **7**, the normalized intensity distributions of core **1** and core **2** converge on 1 as the product of the power coupling coefficient h and the distance z increases.

(46) Sub-step S**04**-4 will be described. Math. 6 and Math. 7 are obtained by solving Math. 4 and Math. 5 with respect to the power coupling coefficient h.

[Math. 6]   [Math. 7]

(47) $h = -\frac{1}{4z}\ln(\frac{P_{bs1}(z)}{P_{conv}(z)} - 1)$ (6) $h = -\frac{1}{4z}\ln(1 - \frac{P_{bs2}(z)}{P_{conv}(z)})$ (7)

According to Math. 6 and Math. 7, if the normalized intensity distribution of core **1** or core **2** is obtained, the power coupling coefficient h in the region until the normalized intensity distribution converges on 1 can be obtained.

(48) Therefore, in sub-step S**04**-4, Math. 6 or Math. 7 is used. Specifically, the power coupling coefficient h is obtained by inserting the obtained normalized intensity distribution into Math. 6 or Math. 7.

(49) Further, the power coupling coefficient h may be obtained using the following method. Hereinafter, the intensity measured at a distance z.sub.α farther than a predetermined distance z.sub.1 among the measured intensities is set to P.sub.bs1(z.sub.a|z.sub.a>z.sub.1) or P.sub.bs2(z.sub.a|z.sub.a>z.sub.1). For example, z.sub.α may be a distance of 1 km or more from the end on which the input pulse is incident in the case of a coupling type multi-core fiber. A plurality of distances z.sub.α are prepared, and the intensity P.sub.bs1(z.sub.a|z.sub.a>z.sub.1) or P.sub.bs2(z.sub.a|z.sub.a>z.sub.1) measured at each distance z.sub.α is linearly approximated using the least square method. The distribution obtained by linear approximation is assumed to be an approximate intensity distribution P.sub.conv(z). An intensity is measured at an arbitrary distance z.sub.m to obtain an intensity P.sub.bsi(z.sub.m) or P.sub.bs2(z.sub.m). Further, the measured distance z.sub.m is inserted into the approximate intensity distribution P.sub.conv(z) to obtain an approximate intensity P.sub.conv(z.sub.m). The measured intensity P.sub.bsi(z.sub.m) or P.sub.bs2(z.sub.m) for the approximate intensity P.sub.conv(z.sub.m) is obtained as a normalized intensity. The obtained normalized intensity is inserted into Math. 6 or Math. 7 to obtain a power coupling coefficient h.

(50) Although the multi-core fiber having two cores has been described as an example, the same concept can be applied to a multi-core fiber having three or more cores.

(51) As described above, since the power coupling coefficient measurement method and the power coupling coefficient measurement device according to the present disclosure calculate a power coupling coefficient from a backscattered light intensity from one core, the receiver can measure the power coupling coefficient of the multi-core fiber with one measurement device and one measurement.

(52) Therefore, according to the present invention, it is possible to provide a power coupling coefficient measurement method and a power coupling coefficient measurement device capable of inexpensively and easily measuring a power coupling coefficient.

(53) In addition, when backscattered light of the same core as an input core is measured, it is

desirable to access only a measurement target core, and thus measurement can be performed only by fusion splicing a general-purpose single-core single-mode fiber without using fan-in fan-out.

(54) However, in the case of measuring the same core as the above-described input core, there is a case where a region (dead zone) in which change in backscattered light due to Fresnel reflection occurring in components such as fan-in fan-out cannot be measured at the time of inputting an optical pulse is generated. On the other hand, when a core different from the input core is measured, measurement can be performed while avoiding Fresnel reflection, and thus measurement can be performed without generating a dead zone. Since the coupled multi-core fiber has a large power coupling coefficient and a normalized backscattered light intensity may converge on 1 at a distance of several tens of meters or less, it can be an important effect that measurement can be performed without a dead zone.

(55) The inventions described above can be combined as much as possible.

INDUSTRIAL APPLICABILITY

(56) The power coupling coefficient measurement method and the power coupling coefficient measurement device according to the present disclosure can be applied to information communication industry.

REFERENCE SIGNS LIST

(57) **10** Multi-core fiber **11** Test light pulse generator **11-1** Light source **11-2** Light Intensity modulator **11-3** Pulse generator **12** Input/output device **12-1** Optical switch **12-2** Optical switch **12-3** Fan-in fan-out **12-4** Optical circulator **12-5** Optical circulator **13** Measurement device **13-1** Light receiver **13-2** A/D converter **13-3** Signal processing unit **14** Arithmetic device **101** Power coupling coefficient measurement device

Claims

1. A power coupling coefficient measurement method for measuring a power coupling coefficient of a multi-core fiber, comprising: inputting a test light pulse from one end of the multi-core fiber to any one of cores; receiving backscattered light of the core to which the test light pulse has been input or any one of the other cores; measuring an intensity distribution of the backscattered light with respect to a distance from the one end of the multi-core fiber; and calculating a power coupling coefficient from the intensity distribution of the backscattered light, wherein the calculating of the power coupling coefficient further includes: representing the intensity distribution in a logarithm; calculating an approximate intensity distribution of a linear expression with respect to the distance on the basis of the intensity of the backscattered light in a region where the logarithm of the intensity distribution can be approximated by the linear expression of the distance; calculating a normalized intensity distribution by normalizing the intensity distribution with the approximate intensity distribution; and calculating the power coupling coefficient from the normalized intensity distribution.

2. The power coupling coefficient measurement method of claim 1, wherein the calculating the power coupling coefficient includes calculating the power coupling coefficient using the equation: $h=-\frac{1}{4}z*In((P.sub.bs1(z)/P.sub.conv(z))-1)$, where h is the power coupling coefficient, In represents natural log, and P.sub.bs1 (z) is the normalized intensity distribution for the core to which the test light pulse is input and P.sub.conv (z) is the approximate intensity distribution.

3. The power coupling coefficient measurement method of claim 1, wherein the calculating the power coupling coefficient includes calculating the power coupling coefficient using the equation: $h=-\frac{1}{4}z*In(1-(P.sub.bs2(z)/P.sub.conv(z)))$, where h is the power coupling coefficient, In represents natural log, and P.sub.bs2 (z) is the normalized intensity distribution for any one of the other cores to which the test light pulse is not input and P.sub.conv (z) is the approximate intensity distribution.

4. The power coupling coefficient measurement method of claim 1, wherein the arithmetic device

calculates the power coupling coefficient by using the equation:

$h=-\frac{1}{4}z*In(1-(P.sub.bs2(z)/P.sub.conv(z)))$, where h is the power coupling coefficient, In represents natural log, and P.sub.bs2 (z) is the normalized intensity distribution for any one of the other cores to which the test light pulse is not input and P.sub.conv (z) is the approximate intensity distribution.

5. A power coupling coefficient measurement device connected to one end of a multi-core fiber and measuring a power coupling coefficient of the multi-core fiber, comprising: a test light pulse generator configured to generate a test light pulse; an input/output device configured to input the test light pulse generated by the test light pulse generator to any one of cores of the multi-core fiber and to output backscattered light of the core to which the test light pulse is input or any one of the other cores; a measurement device configured to measure an intensity distribution of the backscattered light output by the input/output device with respect to a distance from the one end of the multi-core fiber; and an arithmetic device configured to calculate a power coupling coefficient from the intensity distribution of the backscattered light measured by the measurement device, wherein, the arithmetic device calculates the power coupling coefficient by: representing the intensity distribution in a logarithm, calculating an approximate intensity distribution of a linear expression with respect to the distance on the basis of the intensity of the backscattered light in a region where the logarithm of the intensity distribution can be approximated by the linear expression of the distance, calculating a normalized intensity distribution by normalizing the intensity distribution with the approximate intensity distribution, and calculating the power coupling coefficient from the normalized intensity distribution.

6. The power coupling coefficient measurement device of claim 5, wherein the arithmetic device calculates the power coupling coefficient by using the equation:

$h=-\frac{1}{4}z*In((P.sub.bs1(z)/P.sub.conv(z))-1)$, where h is the power coupling coefficient, In represents natural log, and P.sub.bs1 (z) is the normalized intensity distribution for the core to which the test light pulse is input and P.sub.conv (z) is the approximate intensity distribution.