

METHOD, DEVICE AND COMPUTER-READABLE MEDIUM FOR DEMODULATING SIGNALS

FIELD

[0001] Embodiments of the present disclosure generally relate to communication technologies, and more specifically, to a method, a device and a computer-readable medium for demodulating signals in optical fiber communications.

BACKGROUND

[0002] In recent years, a four-level pulse amplitude modulation (PAM-4) signal format has become a hot research topic in next generation passive optical network (NG-PON) and short reach optical transmission system. Compared with non-return to zero (NRZ) format, the PAM-4 technology may improve a channel spectral efficiency, which further improves the transmission capacity. In addition, due to the high spectral efficiency, the dispersion tolerance performance of the PAM-4 signal is better than NRZ and duobinary signal. Meanwhile, the transmitter and/or receiver of the PAM-4 signal have simple structures by using intensity modulation (IM) and direct detection (DD) schemes.

SUMMARY

[0003] Generally embodiments of the present disclosure provide a demodulation methods and corresponding communication devices.

[0004] In a first aspect, embodiments of the present disclosure provide a method for demodulating a signal. The method comprises: dividing a modulated signal into a first portion and a second portion, the modulated signal being generated based on a first signal and a second signal; demodulating the first portion to generate a third signal, the third signal including information of the first signal; demodulating the second portion in association with the third signal to generate a fourth signal, the fourth signal including information of the second signal.

[0005] In a second aspect, embodiments of the present disclosure provide a communication device. The communication device comprises: at least one processor; and a memory coupled to said at least one processor and having instructions stored therein, the instructions, when executed by said at least one processor, causing the communication device to perform acts, the acts comprising: dividing a modulated signal into a first portion and a second portion,

the modulated signal being generated based on a first signal and a second signal; demodulating the first portion to generate a third signal, the third signal including information of the first signal; demodulating the second portion in association with the third signal to generate a fourth signal, the fourth signal including information of the second signal.

5 [0006] In a third aspect, embodiments of the present disclosure provide a computer-readable medium. The computer-readable medium has instructions stored thereon, the instructions, when executed by a processor of the machine, causing the machine to implement: dividing a modulated signal into a first portion and a second portion, the modulated signal being generated based on a first signal and a second signal; demodulating the first portion to
10 generate a third signal, the third signal including information of the first signal; demodulating the second portion in association with the third signal to generate a fourth signal, the fourth signal including information of the second signal.

[0007] It should be appreciated contents as described in the summary are not intended to limit key or important features of embodiments of the present disclosure or used to limit
15 scopes of the present disclosure. Other features of the present disclosure will become easier to understand from the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The above and other features, advantages and aspects of various embodiments of the present disclosure will become apparent from the following detailed illustration, with
20 reference to the accompanying drawings, where:

[0009] FIG. 1 shows an example communication system in which embodiments of the present disclosure may be implemented;

[0010] FIG. 2 shows an example of demodulating a PAM-4 signal in the conventional technology;

25 [0011] FIG. 3 shows a schematic diagram of some signal processing according to embodiments of the present disclosure;

[0012] FIG. 4 shows a flow chart of a demodulating method according to some embodiments of the present disclosure;

[0013] FIG. 5 shows a block diagram of a device according to some embodiments of the
30 present disclosure;

[0014] FIG. 6 shows a block diagram of an apparatus according to some embodiments of the present disclosure;

[0015] FIG. 7 shows a simulation diagram according to some embodiments of the present disclosure; and

5 [0016] FIG. 8 shows a result diagram according to some embodiments of the present disclosure.

[0017] In the drawings, same or similar reference signs indicate the same or similar elements.

DETAILED DESCRIPTION OF EMBODIMENTS

10 [0018] Embodiments of the present disclosure will be described in details with reference to the accompanying drawings. Although some embodiments of the present disclosure have been illustrated in the accompanying drawings, it should be appreciated that the present disclosure can be implemented in various manners, and thus should not be construed to be limited to embodiments disclosed herein. On the contrary, those embodiments are provided
15 for a thorough and complete understanding of the present disclosure. It should be understood that the accompanying drawings and embodiments of the present disclosure are merely for the purpose of illustrations, rather than limiting the protection scope of the present disclosure.

[0019] The term “communication device” used herein refers to other entities or nodes
20 having specific functions in a base station or communication network. The term “base station (BS)” may represent a node B (NodeB or NB), an evolution Node B (eNodeB or eNB), a remote radio unit (RRU), a radio -frequency head (RH), a remote radio head (RRH), a relay, or a low power node such as a pico base station or a femto base station and the like. In the context of the present disclosure, the terms “network device” and “base station” may be used
25 interchangeably, and generally, the eNB is taken as an example of the network device, for the sake of discussion.

[0020] The term “terminal device” or “user equipment (UE)” used herein refers to any terminal device that can wireless communicate with the network device or each other. For example, the terminal device may comprise a mobile terminal (MT), a subscriber station (SS),
30 a portable subscriber station (PSS), a mobile station (MS) or an access terminal (AT), and the above devices mounted on vehicles. In the context of the present disclosure, the terms

“terminal device” and “user equipment” may be used interchangeably for the sake of discussion.

[0021] The terms “comprise”, “include” and their variants used herein are to be read as open terms that mean “include, but is not limited to”. The term “based on” is to be read as “based at least in part on”. The term “some embodiments” is to be read as “at least some embodiments.” The term “another embodiment” is to be read as “at least one other embodiment.” Definitions of other terms will be presented in description below.

[0022] As described above, the PAM-4 technology has become a hotspot topic in the field of optical fiber communications. In order to apply the PAM-4 signal in NG-PON and further reduce the construction cost, there are still some problems to be solved. For example, the conventional primary PAM-4 signal demodulation schemes can be divided into two approaches. One approach is to use three threshold decision circuits to demodulate the PAM-4 signal. By using this scheme, the PAM-4 signal can be directly mapped to a different level. However, if the PAM-4 signal has very high baud rate, the implementation of analog circuit of the circuit will be more difficult and expensive. The other PAM-4 signal demodulation scheme is based on analog to digital converter (ADC). By using the ADC, the received PAM-4 signal can be sampled and converted to different digital levels with online or offline digital signal processing (DSP) technologies. But the high-performance ADC is too costly. For above reasons, it is desirable to develop a cost-effective high-performance PAM-4 demodulating scheme which is appropriate for mass deployment in NG-PON and short reach optical transmission systems.

[0023] In order to overcome at least part of the above problems and other potential problems, embodiments of the present disclosure provide a demodulating method. According to embodiments of the present disclosure, it is possible to implement a simplified and cost-effective PAM-4 demodulating method. The PAM-4 demodulation may be determined based on a single threshold.

[0024] Compared with the conventional technologies, embodiments of the present disclosure at least have the following advantages: the PAM-4 signal may be demodulated using only one single decision threshold. Without using a complex multi-level threshold slicer, ordinary digital binary CDR and passive device elements may be used to demodulate the PAM-4 signal, which reduces the costs. Compared with the offline PAM-4 demodulation using the ADC, embodiments of the present disclosure support the online PAM-4 signal

demodulation to guarantee real-time services. Embodiments of the present disclosure have a bit interleaving structure which can demodulate the modulated PAM-4 signal into the most significant bit MSB and the least significant bit LSB to distinguish groups of users. In addition, embodiments of the present disclosure is compatible with the ordinary differential output photo-detector PD, which further reduces the costs.

[0025] FIG. 1 shows an example communication network 100 in which embodiments of the present disclosure may be implemented. The communication network 100 may include a transmitter 102, an optical fiber 104 and a receiver 106. It should be appreciated that although not shown in the figure, the communication system 100 may further comprise other devices, such as passive devices like a relay, an optical fiber connector and a coupler. It should be appreciated the numbers of the transmitter, receiver and optical fiber as shown in FIG. 1 are merely for the illustration purpose, without suggesting any limitation. The network 100 may include any appropriate number of transmitters, receivers and optical fibers.

[0026] Communication in the network 100 may be implemented according to any appropriate communication protocols, including but not limited to, the first generation (1G), the second generation (2G), the third generation (3G), the fourth generation (4G), the fifth generation (5G) and other cellular communication protocol, wireless local area network communication protocols such as Institute of Electrical and Electronics Engineers (IEEE) 802.11, and/or any other protocols that are currently known or to be developed later. Furthermore, the communication utilizes any appropriate wireless communication technologies and optical fiber communication, including but not limited to , code division multiple access (CDMA), frequency division multiple access (FDMA), time division multiple access (TDMA), frequency division duplexing (FDD), time division duplexing (TDD), multiple input multiple output (MIMO), orthogonal frequency division multiplexing (OFDM), and/or any other technology that is currently known or to be developed in future.

[0027] FIG. 2 shows an example 200 of demodulating a PAM-4 signal in the conventional technologies. As shown in the figure, the receiver 106 receives a PAM-4 signal 202. The signal 202 is divided 230 into two groups (the first user group and the second user group). The signal 204 of the first user group generates 250 the most significant bit (MSB) signal 208 via clock data recovery. The signal 206 of the second user group generates 270 the least significant bit (LSB) signal 210. While the signal 206 generates the signal 210, it is necessary to undergo decision of two voltage thresholds and then perform a sum operation. However, in the conventional technologies, the structure of a slicer having two voltage

thresholds is more complicated than that of the slicer having a single threshold, and is more costly. In addition, the sum operation during generation of the signal 210 needs a high-speed logic and circuit, which increases the costs of the system. Hence, it is desirable to provide a simply-structured and low-cost method for demodulating the PAM-4 signal.

5 [0028] FIG. 3 shows a schematic diagram of signal processing 300 according to some embodiments of the present disclosure. The signal processing shown in FIG. 3 may be implemented at the receiver 106. It should be appreciated that the schematic diagram of the processing 300 shown in FIG. 3 is only an example not restrictive. As shown in FIG. 3, a signal 302 is a modulated signal. For example, the signal 302 may be a modulated signal in the PAM-4 format. Although not shown, the signal 302 is formed by modulating based on
10 two signals (called “a first signal” and “a second signal”). Although not shown, in some embodiments, the signal 302 may be detected by a photo-detector (PD) (not shown). Only as an example, amplitudes of the first signal may be “2, -2, -2, 2, -2, 2, 2, -2”, amplitudes of the second signal may be “-1, 1, -1, 1, -1, -1, 1, -1”, and amplitudes of signal 302 may be “1,
15 -1, -3, 3, -3, 1, 3, -3”.

[0029] The modulated signal 302 may be divided 330 into a first portion 304 and a second portion 306. In some embodiments, the first portion 304 and second portion 306 have a predetermined power ratio. For example, the predetermined power ratio in some embodiments may be 1. That is, the first portion and second portion have the same power.

20 [0030] The first portion 304 is demodulated 340 to generate a third signal 308. The third signal 308 includes information of the first signal. For example, the third signal 308 may have the same signal sequence as the first signal, but have different amplitudes. During the demodulation 340, only one threshold (for example, zero threshold) may be used to demodulate the first portion 304.

25 [0031] In some embodiments, the first portion 304 is clock data recovered based on the predetermined threshold, to generate the third signal 308. For example, the clock data recover (CDR) may be used to clock data cover the first portion 304 to generate the third signal 308. In some embodiments, during the demodulation, the amplitude of the first portion 304 may be amplified.

30 [0032] In some embodiments, the third signal 308 is divided 350 into a third portion 310 and a fourth portion 312, and the third portion 310 and fourth portion 312 have the same power. Only as an example, when amplitudes of the first signal are “2, -2, -2, 2, -2, 2, 2, -2”,

amplitudes of the third portion 310 and fourth portion 312 may be “2, -2, -2, 2, -2, 2, 2, -2”. In some embodiments, an optical splitter may be used to divide the third signal 308 into the third portion 310 and the fourth portion 312.

[0033] The second portion 306 is demodulated in association with the third signal 308 to generate a fourth signal 316. The fourth signal 316 comprises information of the second signal. In some embodiments, the second portion 306 is amplified 360. In some embodiments, the second amplified portion 314 performs differential processing 370 with any one of the third portion 310 and fourth portion 312 to generate the fourth signal 316. In some embodiments, the second amplified portion 324 and the third portion 310 and fourth portion 312 have a predetermined power ratio. For example, the power ratio may be 1.5. It should be appreciated that the above power ratio is only an example. Those skilled in the art may set and adjust the ratio to obtain a desired power ratio. Only as an example, FIG. 3 shows that the second amplified portion 314 performs differential processing 370 with the second portion 314 and the fourth portion 312.

[0034] Only as an example, the amplitudes of the second amplified portion 314 may be “1, -1, -3, 3, -3, 1, 3, -3”, the amplitudes of the fourth portion 312 may be “2, -2, -2, 2, -2, 2, 2, -2”, and the amplitudes of the fourth signal 316 generated from the differential processing may be “-1, 1, -1, 1, -1, -1, 1, -1”.

[0035] In some embodiments, a passive Balun converter (not shown) may be used to generate the fourth signal 316. The Balun converter is used as a subtractor. Specifically, the second amplified portion 314 is sent to a positive input port of the Balun converter, and the fourth portion 312 is sent to a negative input port of the Balun converter. The output port of the Balun converter outputs the fourth signal 316. It should be appreciated that other elements may also be used for differential processing. For example, an ordinary differential output PD may be used to perform the differential operation. In this case, amplification parameter of the first portion 304 and second portion 306 may be adjusted for use in subsequent differential operation.

[0036] FIG. 4 shows a flow chart of a method 400 according to some embodiments of the present disclosure. The method 400 shown in FIG. 4 may be implemented at the receiver 106 in FIG. 1.

[0037] At 402, the modulated signal 302 is divided into the first portion 304 and the third portion 306. The modulated signal 302 is generated based on the first signal and second

signal. In some embodiments, the first portion 304 and second portion 306 have a predetermined power ratio. For example, the predetermined power ratio in some embodiments may be 1. That is, the first portion and second portion have the same power.

[0038] At 404, the first portion 304 is demodulated to generate the third signal 308. The third signal 308 includes information of the first signal. For example, the third signal 308 may have the same signal sequence as the first signal, but have different amplitudes. During the demodulation 340, only one threshold (e.g., zero threshold) may be used to demodulate the first portion 304.

[0039] In some embodiments, the first portion 304 is clock data recovered based on the predetermined threshold, to generate the third signal 308. For example, the clock data recover (CDR) may be used to clock data cover the first portion 304 to generate the third signal 308. In some embodiments, during the demodulation, the amplitude of the first portion 304 may be amplified. In some embodiments, the third signal 308 is divided into a third portion 310 and a fourth portion 312, and the third portion 310 and fourth portion 312 have the same power. In some embodiments, an optical splitter may be used to divide the third signal 308 into the third portion 310 and the fourth portion 312.

[0040] At 406, the second portion 306 is demodulated in associated with the third signal 308 to generate a fourth signal 316. The fourth signal 316 comprises information of the second signal. In some embodiments, the second portion 306 is amplified, and the second amplified portion 314 performs differential processing with any one of the third portion 310 and fourth portion 312 to generate the fourth signal 316. In some embodiments, the second amplified portion 324 and the third portion 310 and fourth portion 312 have a predetermined power ratio. For example, the power ratio may be 1.5. It should be appreciated that the above power ratio is only an example. Those skilled in the art may set and adjust the power ratio to obtain a desired power ratio.

[0041] FIG. 5 shows a block diagram of a device 500 according to some embodiments of the present disclosure. As shown in FIG. 5, the device 500 comprises one or more processors 510, one or more memories 520 coupled to the processors 510, and one or more transmitters and/or receivers 540 coupled to the processor 510.

[0042] The processors 510 may be any proper type adapted for local technical environment. As a non-restrictive example, the processors 510 may include but not be limited to one or more general-purpose computers, dedicated computers, microprocessors, digital signal

processors and processors based on multi-kernel processor architecture. The device 500 may have a plurality of processors, for example, dedicated integrated circuit chips, which are temporally synchronous with a main processor.

[0043] The memory 520 may be any proper type adapted for local technical environment, may be implemented by using any suitable data storage technology, includes but not limited to a non-transient computer-readable medium, a semiconductor-based storage device, a magnetic storage device and system, optical storage device and system.

[0044] At least a portion of instructions 430 are stored in the memory 520. The transmitter/receiver 540 may be adapted for bi-directional communications. The transmitter/receiver 540 has at least one antenna to facilitate communications. The transmitter/receiver 540 may support optical fiber communications. However, in practice, there might be several access nodes mentioned in the present disclosure. The communication interface may represent any necessary interface adapted to communicate with other network elements.

[0045] The instructions 530 are assumed as including program instructions. When an associated processor 510 executes the instructions, the instructions enable the device 500 to operate according to the embodiments described with reference to FIG. 3 and FIG. 4 in the present disclosure. That is to say, embodiments of the present disclosure may be executed by computer software and implemented by the processor 510 of the device 500, or implemented by hardware, or a combination of software and hardware.

[0046] FIG. 6 shows a block diagram of an apparatus 600 according to some embodiments of the present disclosure. It may be appreciated that the apparatus 600 may be implemented at the receiver 106 shown in FIG. 1. As shown in FIG. 6, the apparatus 600 may include: a first dividing unit 610 configured to divide a modulated signal into a first portion and a second portion, the modulated signal being generated based on a first signal and a second signal; a first demodulating unit 630 configured to demodulate the first portion to generate a third signal which includes information of the first signal; a second demodulating unit configured to demodulate the second portion in association with the third signal to generate a fourth signal which includes information of the second signal.

[0047] In some embodiments, the first dividing unit 610 is further configured to: divide the modulated signal into a first portion and a second portion so that the first portion and second portion have a predetermined power ratio.

[0048] In some embodiments, the first demodulating unit 630 is further configured to: clock data recover, based on a predetermined threshold, the first portion to generate the third signal. In some embodiments, the first demodulating unit 630 is further configured to: amplify, based on a first predetermined amplified parameter, the clock data recovered first portion to generate the third signal.

[0049] In some embodiments, the apparatus 600 further comprises a second dividing unit 670 configured to divide the third signal into a third portion and a fourth portion so that the third portion and the fourth portion have a same power. In some embodiments, a second demodulating unit 650 is configured to enlarge the second portion and perform differential processing for the second amplified portion with one of the third portion and the fourth portion, to generate the fourth signal. In some embodiments, the second demodulating unit 650 is further configured to amplify the second portion so that the amplified second portion and the third portion and fourth portion have a predetermined power ratio.

[0050] It is to be understood each unit of the apparatus 600 corresponds to each step of the processing 300 and method 400 described with reference to Figs. 3-4. Therefore, operations and features described above with reference to Figs. 3-4 are also applicable to the apparatus 600 as well as units included in them, and meanwhile have the same effect, details of which are ignored here.

[0051] The units included in the apparatus 600 may be implemented in various manners, including software, hardware, firmware, or any combination thereof. In one embodiment, one or more units may be implemented using software and/or firmware, for example, machine-executable instructions stored on the storage medium. In addition to or instead of machine-executable instructions, parts or all of the units in the apparatus 600 may be implemented, at least in part, by one or more hardware logic components. For example, and without limitation, illustrative types of hardware logic components that can be used include Field-programmable Gate Arrays (FPGAs), Application-specific Integrated Circuits (ASICs), Application-specific Standard Products (ASSPs), System-on-a-chip systems (SOCs), Complex Programmable Logic Devices (CPLDs), etc.

[0052] The units shown in FIG. 6 may be implemented, partially or entirely, as hardware modules, software modules, firmware modules or any combination thereof. In particular, in some embodiments, the flows, methods or processes described above may be implemented by hardware in the network device. For example, the network device may implement the

processing 300 shown in FIG. 3 and method 400 shown in FIG. 4 by means of its transmitter, receiver, transceiver and/or processor or controller.

[0053] FIG. 7 shows a simulation diagram of demodulating the PAM-4 signal and FIG. 8 shows a result diagram according to some embodiments of the present disclosure. As can be seen from the results shown in FIG. 7 and FIG. 8, embodiments of the present disclosure may effectively demodulate the PAM-4 signal.

[0054] Generally, various embodiments of the present disclosure may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device. While various aspects of embodiments of the present disclosure are illustrated and described as block diagrams, flowcharts, or using some other pictorial representation, it will be appreciated that the blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[0055] For example, embodiments of the present disclosure can be described in the general context of machine-executable instructions, such as those included in program modules, being executed in a device on a target real or virtual processor. Generally, program modules include routines, programs, libraries, objects, classes, components, data structures, or the like that perform particular tasks or implement particular abstract data types. The functionality of the program modules may be combined or split between program modules as desired in various embodiments. Machine-executable instructions for program modules may be executed within a local or distributed device. In a distributed device, program modules may be located in both local and remote storage media.

[0056] Program code for carrying out methods of the present disclosure may be written in any combination of one or more programming languages. These program codes may be provided to a processor or controller of a general purpose computer, special purpose computer, or other programmable data processing apparatus, such that the program codes, when executed by the processor or controller, cause the functions/operations specified in the flowcharts and/or block diagrams to be implemented. The program code may execute entirely on a machine, partly on the machine, as a stand-alone software package, partly on the

machine and partly on a remote machine or entirely on the remote machine or server.

[0057] In the context of this disclosure, a machine readable medium may be any tangible medium that may contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device. The machine readable medium may be a machine readable signal medium or a machine readable storage medium. A machine readable medium may include but is not limited to an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples of the machine readable storage medium would include an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing.

[0058] Further, while operations are depicted in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Likewise, while several specific implementation details are contained in the above discussions, these should not be construed as limitations on the scope of the present disclosure, but rather as descriptions of features that may be specific to particular embodiments. Certain features that are described in the context of divide embodiments may also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment may also be implemented in multiple embodiments dividely or in any suitable sub-combination.

[0059] Although the subject matter has been described in a language that is specific to structural features and/or method actions, it is to be understood the subject matter defined in the appended claims is not limited to the specific features or actions described above. On the contrary, the above-described specific features and actions are disclosed as an example of implementing the claims.

I/We Claim:

1. A method for signal demodulation, comprising:

dividing a modulated signal into a first portion and a second portion, the modulated signal being generated based on a first signal and a second signal;

5 demodulating the first portion to generate a third signal, the third signal including information of the first signal; and

demodulating the second portion in association with the third signal to generate a fourth signal, the fourth signal including information of the second signal.

10 2. The method of claim 1, wherein a format of the modulated signal is a four-level pulse amplitude modulation format.

3. The method of claim 1, wherein dividing a modulated signal into a first portion and a second portion comprises:

15 dividing the modulated signal into the first portion and the second portion such that the first and second portions have a predetermined power ratio.

4. The method of claim 1, wherein demodulating the first portion to generate a third signal comprises:

20 performing, based on a predetermined threshold, clock data recovering on the first portion to generate the third signal.

5. The method of claim 4, wherein demodulating the first portion to generate a third signal comprises:

25 amplifying, based on a first predetermined amplification parameter, the first clock data recovered portion to generate the third signal.

6. The method of claim 1, wherein generating a fourth signal comprises:

30 dividing the third signal into a third portion and a fourth portion such that the third and fourth portions have a same power;

amplifying the second portion; and

performing differential processing on the second amplified portion and one of the third and fourth portions to generate the fourth signal.

7. The method of claim 6, wherein amplifying the second portion comprises:
amplifying the second portion such that the second amplified portion and the third and fourth portions have a predetermined power ratio.

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8. A communication device, comprising:
at least one processor; and
a memory coupled to the at least one processor and having instructions stored thereon, the instructions, when executed by the said at least one processor, causing the communication device to perform acts, comprising:

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dividing a modulated signal into a first portion and a second portion, the modulated signal being generated based on a first signal and a second signal;

demodulating the first portion to generate a third signal, the third signal including information of the first signal; and

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demodulating the second portion in association with the third signal to generate a fourth signal, the fourth signal including information of the second signal.

9. The communication device of claim 8, wherein a format of the modulated signal is a four-level pulse amplitude modulation.

20

10. The communication device of claim 8, wherein the acts further comprise:
dividing the modulated signal into the first portion and the second portion such that the first and second portions have a predetermined power ratio.

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11. The communication device of claim 8, wherein the acts further comprise:
performing, based on a predetermined threshold, clock data recovery on the first portion to generate the third signal.

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12. The communication device of claim 11, wherein the acts further comprise:
amplifying, based on a first predetermined amplification parameter, the first clock data recovered portion to generate the third signal.

13. The communication device of claim 8, wherein the acts further comprise:
dividing the third signal into a third portion and a fourth portion such that the third and

fourth portions have a same power;

amplifying the second portion; and

performing differential processing on the second amplified portion and one of the third and fourth portions to generate the fourth signal.

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14. The communication device of claim 13, wherein the acts further comprise:

amplifying the second portion such that the second amplified portion and the third and fourth portions have a predetermined power ratio.

10

15. A computer-readable medium having instructions stored on, the instructions, when executed by at least one processing unit of a machine, causing the machine to be configured to perform a method, the method comprising:

dividing a modulated signal into a first portion and a second portion, the modulated signal being generated based on a first signal and a second signal;

15

demodulating the first portion to generate a third signal, the third signal including information of the first signal; and

demodulating the second portion in association with the third signal to generate a fourth signal, the fourth signal including information of the second signal.

20

16. The medium of claim 15, wherein a format of the modulated signal is four-level pulse amplitude modulation format.

17. The medium of claim 15, wherein the method further comprises:

dividing the modulated signal into the first portion and the second portion such that the

25

first and second portions have a predetermined power ratio.

18. The medium of claim 15, wherein the method further comprises:

performing, based on a predetermined threshold, clock data recovery on the first portion to generate the third signal.

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19. The medium of claim 18, wherein the method further comprises:

amplifying, based on a first predetermined amplification parameter, the first clock data recovered portion to generate the third signal.

20. The medium of claim 15, wherein the method further comprises:

dividing the third signal into a third portion and a fourth portion such that the third and fourth portions have a same power;

amplifying the second portion; and

5 performing differential processing on the second amplified portion and one of the third portion and fourth portion to generate the fourth signal.

21. The medium of claim 20, wherein the method further comprises:

10 amplifying the second portion such that the second amplified portion and the third and fourth portions have a predetermined power ratio.

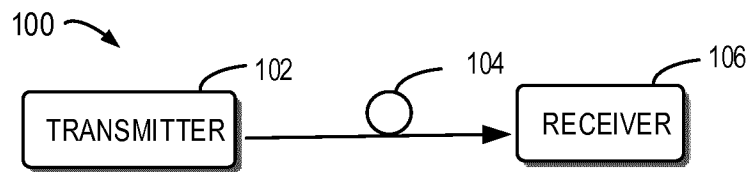


FIG. 1

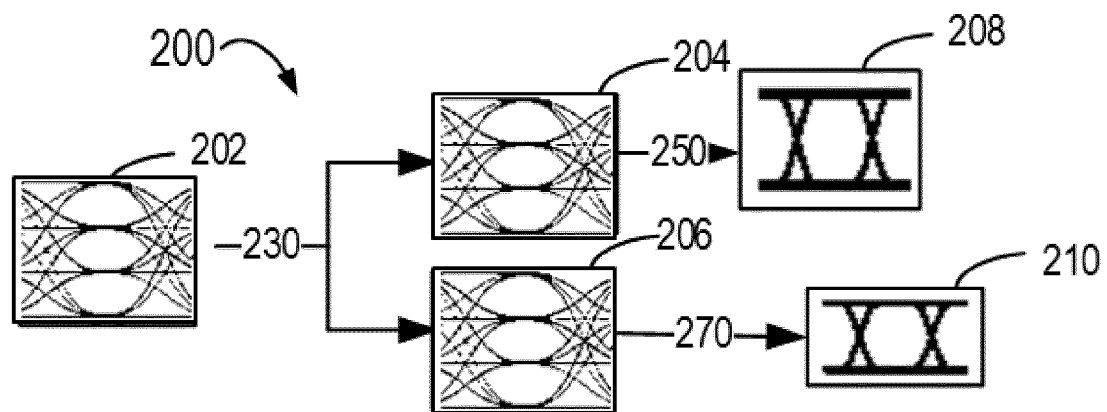


FIG. 2

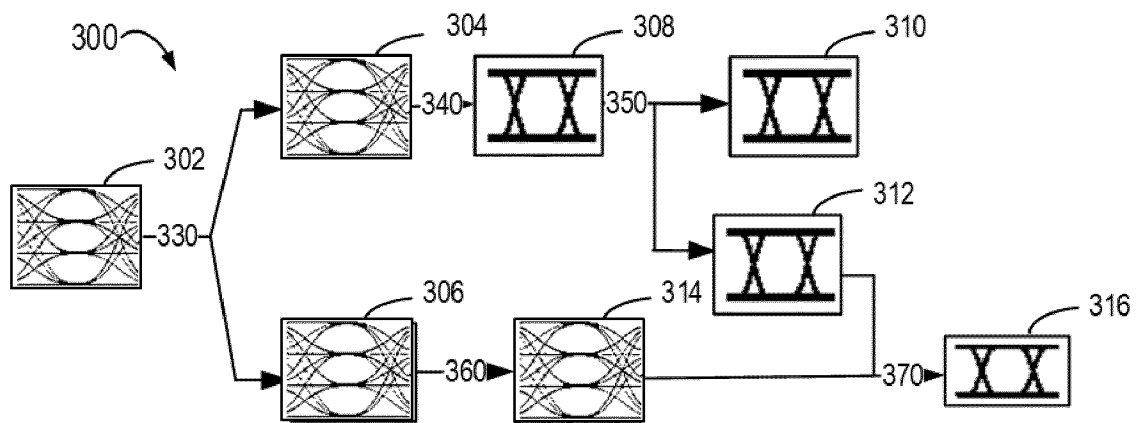


FIG. 3

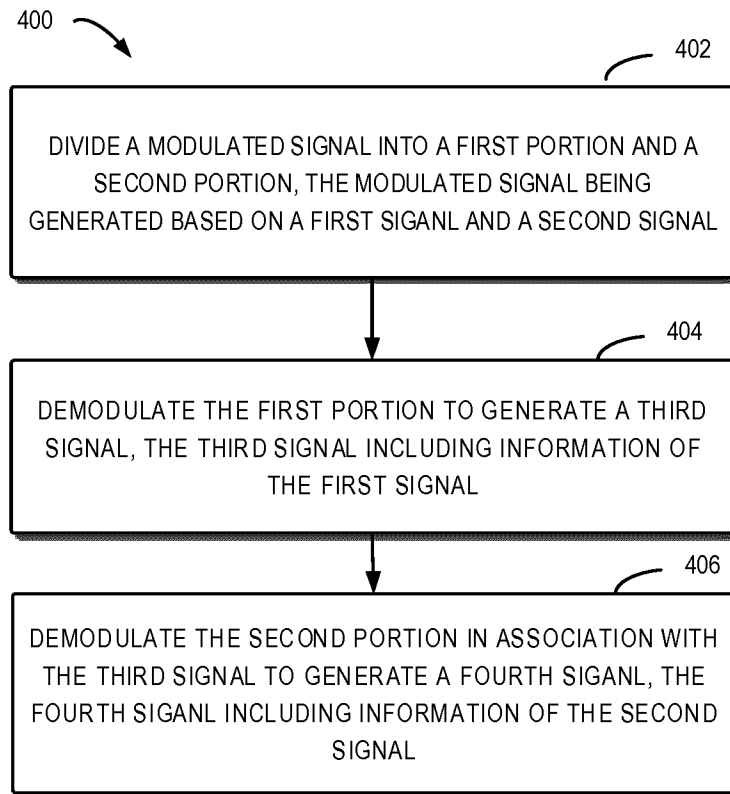


FIG. 4

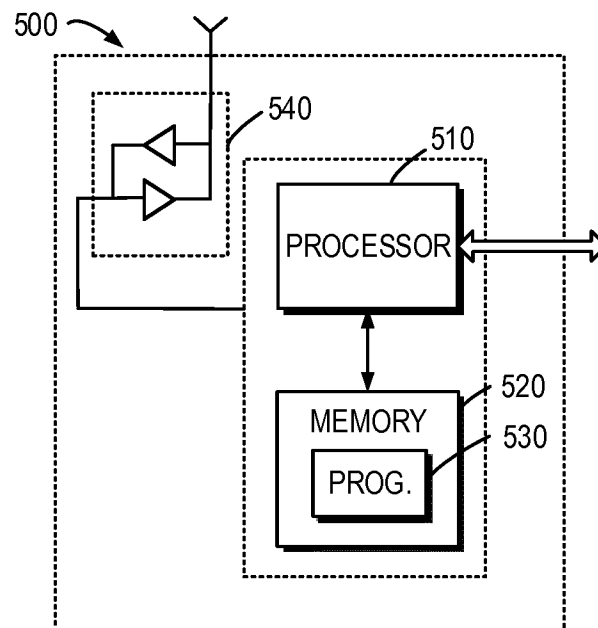


FIG. 5

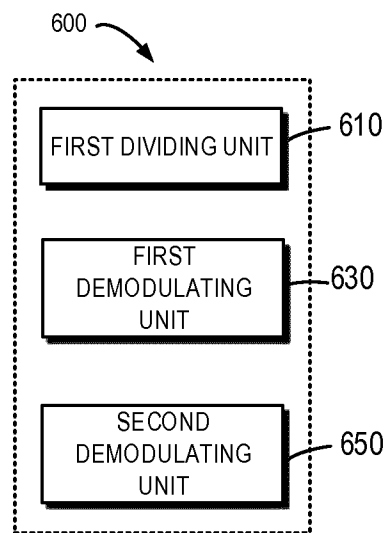


FIG. 6

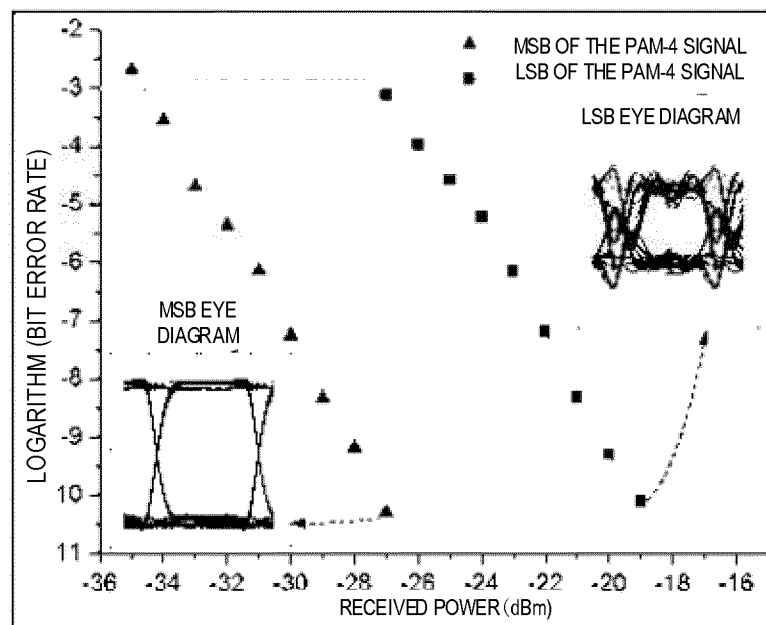


FIG. 7

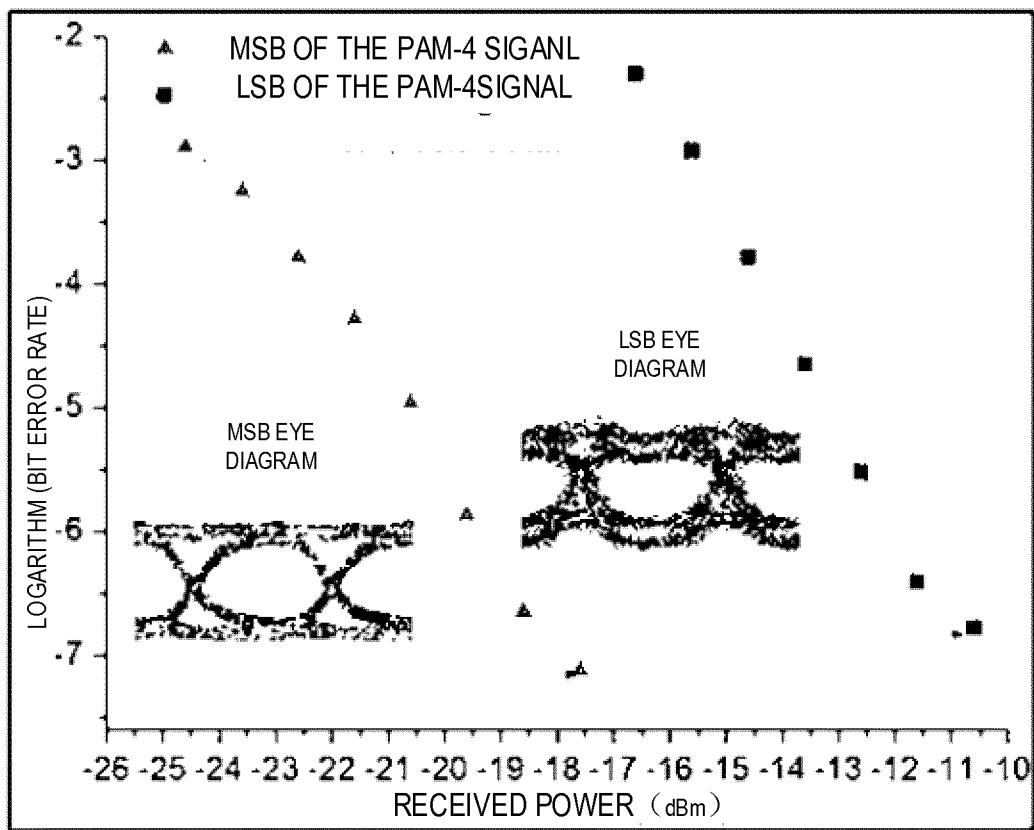


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/062276

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L27/22
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2004/112264 A2 (UBI SYSTEMS INC [US]; SOTO ALEXANDER I [US]; SOTO WALTER G [US]) 23 December 2004 (2004-12-23) abstract paragraph [0007] paragraph [0042] paragraph [0045]	1-21
A	----- EP 2 421 280 A2 (BROADCOM CORP [US]) 22 February 2012 (2012-02-22) abstract paragraph [0005] - paragraph [0008] paragraph [0044] - paragraph [0051] ----- -/-	1-21



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

3 August 2018

Date of mailing of the international search report

10/08/2018

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Authorized officer

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/062276

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 2009/231028 A1 (WANG SHUANGQUAN [US] ET AL) 17 September 2009 (2009-09-17) abstract paragraph [0008] - paragraph [0009] paragraph [0027] -----	1-21

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2018/062276

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