TRANSMISSION METHOD AND RECEPTION METHOD FOR OPTICAL COMMUNICATION, AND CORRESPONDING DEVICE

[0001]

[0002]

[0003]

TECHNICAL FIELD

[0004] This application relates to the field of optical communication, and in particular, to a transmission method and a reception method for optical communication, and a corresponding device.

BACKGROUND

[0005] Driven by the continuous development of 5G, cloud computing, big data, artificial intelligence, and other technologies, high-speed optical transport networks are developing toward high capacity, packet-based, and intelligence. A coherent optical communication system uses the amplitude, phase, polarization, and frequency of light waves to carry information. To combat optical signal distortion caused by dispersion, polarization-dependent impairment, noise, non-linear effect, and other factors in a transmission process and maintain long-distance transmission, a coherent optical communication system usually adds some designed fixed symbol sequences to

sequence in the two polarization directions is not greater than 0.176. A frame overhead of the super-frame structure provided in this embodiment of this application is also as low as 1.79%, and the sequence of pilot symbols has relatively good autocorrelation and cross-correlation characteristics. The training symbols and the pilot symbols can also be combined together to meet direct current balance, which helps the receiver end restore a signal, and improves quality of the restored signal.

[00313] Persons skilled in the art should understand that embodiments of this application may be provided as a method or a computer program product. Therefore, this application may be in the form of a hardware-only embodiment, a software-only embodiment, or an embodiment with a combination of software and hardware. In addition, this application may be in the form of a computer program product implemented on one or more computer-usable storage media (including but not limited to a disk memory, a CD-ROM, an optical memory, and the like) that include computer-usable program code.

[00314] The foregoing descriptions are merely embodiments of the technical solutions of this application, but are not intended to limit the protection scope of this application. Any modifications, equivalent replacements, improvements, or the like within the and principle of this application shall fall within the protection scope of this application.

CLAIMS

1. A transmission method for optical communication, comprising:

generating a super-frame comprising a plurality of sub-frames, wherein the sub-frame comprises training symbols and pilot symbols; in one polarization direction, a sum of quantities of training symbols and pilot symbols comprised in the sub-frame is not less than 5, and there is one symbol that is both a training symbol and a pilot symbol; and each of the training symbols and the pilot symbols is one of -A-Aj, -A+Aj, A-Aj, or A+Aj, A being a real number;

in the training symbols and the pilot symbols comprised in each sub-frame, quantities of -A-Aj, -A+Aj, A-Aj, and A+Aj in one polarization direction are respectively $\lfloor(N_{TS}+N_{PS}-1)/4\rfloor$, $(N_{TS}+N_{PS}-1)/2-\lfloor(N_{TS}+N_{PS}-1)/4\rfloor$, $(N_{TS}+N_{PS}-1)/2-\lfloor(N_{TS}+N_{PS}-1)/4\rfloor$, and $\lfloor(N_{TS}+N_{PS}-1)/4\rfloor$, and quantities thereof in the other polarization direction are respectively $(N_{TS}+N_{PS}-1)/2-\lfloor(N_{TS}+N_{PS}-1)/4\rfloor$, $\lfloor(N_{TS}+N_{PS}-1)/4\rfloor$, $\lfloor(N_{TS}+N_{PS}-1)/4\rfloor$, and $(N_{TS}+N_{PS}-1)/2-\lfloor(N_{TS}+N_{PS}-1)/4\rfloor$, wherein N_{TS} is a quantity of the training symbols in each sub-frame in one polarization direction, N_{PS} is a quantity of the pilot symbols in each sub-frame in one polarization direction, $N_{TS}+N_{PS}$ is an odd number, and the two polarization directions are orthogonal to each other; and

transmitting the super-frame.

2. The transmission method according to claim 1, wherein in one sub-frame, a sequence consisting of training symbols in one polarization direction is different from a sequence consisting of training symbols in the other polarization direction, and a sequence consisting of pilot symbols in one polarization direction is different from a sequence consisting of pilot symbols in the other polarization direction.

3. The transmission method according to claim 1 or 2, wherein the training symbols are consecutively arranged in the sub-frame, and in one polarization direction, in the training symbols comprised in the sub-frame, a quantity of consecutive same real part elements is not greater than 5, and a quantity of consecutive same imaginary part elements is not greater than 5.

4. The transmission method according to claim 3, wherein in one polarization direction, a quantity of consecutive same training symbols in one sub-frame does not exceed 4.

5. The transmission method according to any one of claims 1 to 4, wherein a modulation format of the symbols in the super-frame is 16QAM, and a value of A is ±1, ±3, or $\pm\sqrt{5}$.

6. The transmission method according to any one of claims 1 to 5, wherein in each sub-frame, a symbol at a fixed position in every 64 symbols is the pilot symbol.

7. The transmission method according to any one of claims 1 to 6, wherein in each sub-frame, a symbol at a fixed position in every 48 symbols is the pilot symbol.8. A reception method for optical communication, comprising:

receiving a super-frame comprising a plurality of sub-frames, wherein the sub-frame comprises training symbols and pilot symbols; in one polarization direction, a sum of quantities of training symbols and pilot symbols comprised in the sub-frame is not less than 5, and there is one symbol that is both a training symbol and a pilot symbol; and each of the training symbols and the pilot symbols is one of -A-Aj, -A+Aj, A-Aj, or A+Aj, A being a real number;

in the training symbols and the pilot symbols comprised in each sub-frame, quantities of -A-Aj, -A+Aj, A-Aj, and A+Aj in one polarization direction are respectively $\lfloor(N_{TS}+N_{PS}-1)/4\rfloor$, $(N_{TS}+N_{PS}-1)/2-\lfloor(N_{TS}+N_{PS}-1)/4\rfloor$, $(N_{TS}+N_{PS}-1)/2-\lfloor(N_{TS}+N_{PS}-1)/4\rfloor$, and $\lfloor(N_{TS}+N_{PS}-1)/4\rfloor$, and quantities thereof in the other polarization direction are respectively $(N_{TS}+N_{PS}-1)/2-\lfloor(N_{TS}+N_{PS}-1)/4\rfloor$, $\lfloor(N_{TS}+N_{PS}-1)/4\rfloor$, $\lfloor(N_{TS}+N_{PS}-1)/4\rfloor$, and $(N_{TS}+N_{PS}-1)/2-\lfloor(N_{TS}+N_{PS}-1)/4\rfloor$, wherein N_{TS} is a quantity of the training symbols in each sub-frame in one polarization direction, N_{PS} is a quantity of the pilot symbols in each sub-frame in one polarization direction, $N_{TS}+N_{PS}$ is an odd number, and the two polarization directions are orthogonal to each other; and

decoding the received super-frame.

9. The reception method according to claim 8, wherein in one sub-frame, a sequence consisting of training symbols in one polarization direction is different from a sequence consisting of training symbols in the other polarization direction, and a sequence consisting of pilot symbols in one polarization direction is different from a sequence consisting of pilot symbols in the other polarization direction.

10. The reception method according to claim 8 or 9, wherein the training symbols are consecutively arranged in the sub-frame, and in one polarization direction, in the training symbols comprised in the sub-frame, a quantity of consecutive same real part elements is not greater than 5, and a quantity of consecutive same imaginary part elements is not greater than 5.

11. The reception method according to claim 10, wherein in one polarization direction, a quantity of consecutive same training symbols in one sub-frame does not exceed 4.

12. The reception method according to any one of claims 8 to 11, wherein a modulation format of the symbols in the super-frame is 16QAM, and a value of A is ±1, ±3, or $\pm\sqrt{5}$.

13. The reception method according to any one of claims 8 to 12, wherein in each sub-frame, a symbol at a fixed position in every 64 symbols is the pilot symbol; or in each sub-frame, a symbol at a fixed position in every 48 symbols is the pilot symbol.

14. A transmission method for optical communication, comprising:

generating a super-frame comprising a plurality of sub-frames, wherein the sub-frame comprises training symbols and pilot symbols; in one polarization direction, there is one symbol that is both a training symbol and a pilot symbol; in each sub-frame, in the one polarization direction, the pilot symbols are generated based on a target polynomial and a seed, there are N_{PS}

pilot symbols and N_{TS} training symbols, and $N_{TS}+N_{PS}$ is an odd number; and the target polynomial is $x^{10}+x^7+x^3+x+1$; transmitting the super-frame.

15. The transmission method according to claim 14, wherein in one polarization direction, a total quantity N_F of symbols in the super-frame is 175104, a quantity N_{SF} of sub-frames is 24, a quantity N_S of symbols in each sub-frame is 7296, N_{TS} = 11, and N_{PS} = 114, and a quantity of symbols before framing of the super-frame is 172032.

16. The transmission method according to claim 15, wherein a sum $N_{FAW}+N_{RES}$ of a quantity N_{FAW} of frame alignment word symbols and a quantity N_{RES} of reserved symbols is 96.

17. The transmission method according to any one of claims 14 to 16, wherein the target polynomial and hexadecimal seeds in two polarization directions are in the following Table:

Index	Target polynomial	Seed in the direction of polarization 1	Seed in the direction of polarization 2
1	$x^{10}+x^7+x^3+x+1$	0x34E	0x084

18. The transmission method according to any one of claims 14 to 17, wherein each of the training symbols and the pilot symbols is one of -A-Aj, -A+Aj, A-Aj, and A+Aj, A being a real number, in one polarization direction, in a combination of 114 pilot symbols and 11 training symbols, quantities of -A-Aj, -A+Aj, A-Aj, and A+Aj in the one polarization direction are all 31.

19. The transmission method according to any one of claims 14 to 18, wherein each of the training symbols and the pilot symbols is one of -A-Aj, -A+Aj, A-Aj, and A+Aj, A being a real number, in one polarization direction, in a combination of 114 pilot symbols and 11 training symbols, the respective 114 pilot symbols in the two polarization directions are shown in the following table:

Polarization direction	Pilot symbol
Polarization 1	-A+Aj, A+Aj, -A-Aj, A-Aj, A+Aj, -A+Aj, A-Aj, A+Aj, -A-Aj, -A-Aj, A+Aj, -A-Aj, A+Aj, -A-Aj, -A+Aj, -A-Aj, -A+Aj, -A+Aj, -A-Aj, -A+Aj, A-Aj, A-Aj, A-Aj, A-Aj, A-Aj, A+Aj, A+Aj, -A+Aj, -A-Aj, A-Aj, A+Aj, A-Aj, -A+Aj, -A-Aj, A-Aj, -A+Aj, -A-Aj, -A-Aj, -A+Aj, -A-Aj, -A+Aj, -A-Aj, -A-Aj, A+Aj, A+Aj, -A-Aj, A+Aj, A+Aj, -A+Aj, A-Aj, -A+Aj, A-Aj, -A+Aj, A-Aj, A-Aj, A+Aj, -A-Aj, -A+Aj, A-Aj, A-Aj, -A-Aj, A+Aj, -A+Aj, A-Aj, -A-Aj, A+Aj, A+Aj, A+Aj, -A-Aj, -A-Aj, A+Aj, A+Aj, A-Aj, A-Aj, A+Aj, A-Aj, A-Aj, A+Aj, -A+Aj, A+Aj, -A+Aj, A+Aj, -A+Aj, A-Aj, -A+Aj, -A-Aj, -A-Aj, A-Aj, -A+Aj, A+Aj, A-Aj, A-Aj, -A-Aj, -A+Aj, -A+Aj, -A+Aj, -A-Aj, -A-Aj, -A+Aj, -A+Aj, -A+Aj, A-Aj, -A+Aj, -A+Aj, A-Aj, -A+Aj, -

Polarization direction	Pilot symbol
	A-Aj, A-Aj, A+Aj, -A+Aj, -A-Aj, A-Aj, -A-Aj, A+Aj, A+Aj
Polarization 2	-A-Aj, A-Aj, -A-Aj, -A+Aj, -A-Aj, A+Aj, A+Aj, -A+Aj, -A-Aj, -A-Aj, A-Aj, A-Aj, A-Aj, -A-Aj, -A-Aj, A-Aj, A-Aj, A+Aj, -A-Aj, A-Aj, A+Aj, -A-Aj, A-Aj, -A+Aj, -A+Aj, A-Aj, A-Aj, -A+Aj, -A-Aj, -A+Aj, A+Aj, A+Aj, -A-Aj, -A+Aj, -A+Aj, -A-Aj, A+Aj, A+Aj, A-Aj, -A+Aj, A-Aj, -A-Aj, -A-Aj, -A+Aj, A-Aj, -A+Aj, -A-Aj, -A+Aj, A-Aj, A+Aj, A-Aj, -A-Aj, A+Aj, -A+Aj, A-Aj, -A-Aj, A+Aj, A+Aj, -A+Aj, -A+Aj, -A-Aj, -A-Aj, A+Aj, -A-Aj, -A+Aj, -A+Aj, -A+Aj, A+Aj, -A+Aj, A+Aj, A+Aj, A+Aj, -A+Aj, A+Aj, -A-Aj, -A-Aj, A-Aj, -A+Aj, -A+Aj, A+Aj, A-Aj, A+Aj, -A+Aj, A+Aj, A-Aj, A-Aj, A+Aj, -A-Aj, A+Aj, A+Aj, A-Aj, A+Aj, A+Aj, -A-Aj, A+Aj, -A+Aj, -A-Aj, A-Aj, A-Aj, A-Aj, A+Aj, -A+Aj, -A-Aj, -A-Aj, -A+Aj, A+Aj, -A-Aj, A-Aj, A-Aj, -A+Aj, -A-Aj, A-Aj, A-Aj, -A+Aj

20. The transmission method according to any one of claims 14 to 19, wherein the N_{PS} pilot symbols are combined with the N_{TS} training symbols to achieve direct current balance.

21. A reception method for optical communication, comprising:

receiving a super-frame comprising a plurality of sub-frames, wherein the sub-frame comprises training symbols and pilot symbols; in one polarization direction, there is one symbol that is both a training symbol and a pilot symbol; in each sub-frame, in the one polarization direction, the pilot symbols are generated based on a target polynomial and a seed, there are N_{PS} pilot symbols and N_{TS} training symbols, and $N_{TS}+N_{PS}$ is an odd number; and the target polynomial is $x^{10}+x^{7}+x^{3}+x+1$; anddecoding the received super-frame.

22. The reception method according to claim 21, wherein in one polarization direction, a total quantity N_{F} of symbols in the super-frame is 175104, a quantity N_{SF} of sub-frames is 24, a quantity N_{S} of symbols in each sub-frame is 7296, N_{TS} = 11, and N_{PS} = 114, and a quantity of symbols before framing of the super-frame is 172032.

23. The reception method according to claim 22, wherein a sum $N_{\mathrm{FAW}}+N_{\mathrm{RES}}$ of a quantity N_{FAW} of frame alignment word symbols and a quantity N_{RES} of reserved symbols is 96.

24. The reception method according to claim any one of claims 21 to 23, wherein the target polynomial and hexadecimal seeds in two polarization directions are in the following Table:

Index	Target polynomial	Seed in the direction of polarization 1	Seed in the direction of polarization 2
1	$x^{10}+x^{7}+x^{3}+x+1$	0x34E	0x084

25. The reception method according to any one of claims 21 to 24, wherein each of the training symbols and the pilot symbols is one of -A-Aj, -A+Aj, A-Aj, and A+Aj, A being a real number, in one polarization direction, in a combination of 114 pilot symbols and 11 training symbols, quantities of -A-Aj, -A+Aj, A-Aj, and A+Aj in the one polarization direction are all 31.

26. The transmission method according to any one of claims 21 to 25, wherein each of the training symbols and the pilot symbols is one of -A-Aj, -A+Aj, A-Aj, and A+Aj, A being a real number, in one polarization direction, in a combination of 114 pilot symbols and 11 training symbols, the respective 114 pilot symbols in the two polarization directions are shown in the following table:

Polarization direction	Pilot symbol
Polarization 1	-A+Aj, A+Aj, -A-Aj, A-Aj, A+Aj, -A+Aj, A-Aj, A+Aj, -A-Aj, -A-Aj, A+Aj, -A-Aj, A+Aj, -A-Aj, -A+Aj, -A-Aj, -A+Aj, -A+Aj, -A-Aj, -A+Aj, A-Aj, A-Aj, A-Aj, A-Aj, A-Aj, A+Aj, A+Aj, -A+Aj, -A-Aj, A-Aj, A+Aj, A-Aj, -A+Aj, -A-Aj, A-Aj, -A+Aj, -A-Aj, -A-Aj, -A+Aj, -A-Aj, -A+Aj, -A-Aj, -A-Aj, A+Aj, A+Aj, -A-Aj, A+Aj, A+Aj, -A+Aj, A-Aj, -A+Aj, A-Aj, -A+Aj, A-Aj, A-Aj, A+Aj, -A-Aj, -A+Aj, A-Aj, A-Aj, -A-Aj, A+Aj, A+Aj, A+Aj, -A-Aj, -A-Aj, A+Aj, A+Aj, A-Aj, A-Aj, A+Aj, A-Aj, A-Aj, A+Aj, -A+Aj, A+Aj, -A+Aj, A+Aj, -A+Aj, A-Aj, -A+Aj, -A-Aj, -A-Aj, A-Aj, -A+Aj, A+Aj, A-Aj, A-Aj, -A-Aj, -A-Aj, -A+Aj, -A+Aj, -A+Aj, A-Aj, -A+Aj, -A+Aj, A-Aj, -A+Aj, -A-Aj, A-Aj, A+Aj, -A+Aj, -A-Aj, -A-Aj, A-Aj, -A+Aj
Polarization 2	-A-Aj, A-Aj, -A-Aj, -A+Aj, -A-Aj, A+Aj, A+Aj, -A+Aj, -A-Aj, -A-Aj, A-Aj, A-Aj, A-Aj, -A-Aj, -A-Aj, A-Aj, A-Aj, A+Aj, -A-Aj, A-Aj, A+Aj, -A-Aj, A-Aj, -A+Aj, -A+Aj, A-Aj, A-Aj, -A+Aj, -A-Aj, -A+Aj, A+Aj, A+Aj, -A-Aj, -A+Aj, -A+Aj, -A-Aj, A+Aj, A+Aj, A-Aj, -A+Aj, A-Aj, -A-Aj, -A-Aj, -A+Aj, A-Aj, -A+Aj, -A-Aj, -A+Aj, A-Aj, A+Aj, A-Aj, -A-Aj, A+Aj, -A+Aj, A-Aj, -A-Aj, A+Aj, A+Aj, -A+Aj, -A+Aj, -A-Aj, -A-Aj, A+Aj, -A-Aj, -A+Aj, -A+Aj, -A+Aj, A+Aj, -A+Aj, A+Aj, A+Aj, A+Aj, -A+Aj, A+Aj, -A-Aj, -A-Aj, A-Aj, -A+Aj, -A+Aj, A+Aj, A-Aj, A+Aj, -A+Aj, A+Aj, A-Aj, A-Aj, A+Aj, -A-Aj, A+Aj, A+Aj, A-Aj, A+Aj, A+Aj, -A-Aj, A+Aj, -A+Aj, -A-Aj, A-Aj, A-Aj, A-Aj, A+Aj, -A+Aj, -A-Aj, -A-Aj, -A+Aj, A+Aj, -A-Aj, A-Aj, A-Aj, -A+Aj, -A-Aj, A-Aj, A-Aj, -A+Aj

27. The transmission method according to any one of claims 21 to 26, wherein the NPS pilot

symbols are combined with the NTS training symbols to achieve direct current balance.

28. A communication device for optical communication, wherein the communication device is configured to implement the method according to any one of claims 1 to 27.

29. A system for optical communication, wherein the system comprises a transmitting device and a receiving device, wherein the transmitting device is configured to implement the method according to any one of claims 1 to 7 and 14 to 20, the receiving device is configured to implement the method according to any one of claims 8 to 13 and 21 to 27.