Claims

1. A receiver for receiving a combination signal comprising two separate signal portions whose pulses are shifted relative to each other and/or whose carrier waves have a phase difference,

wherein the receiver is configured to obtain a first series of samples using a first sampling, the first sampling being adjusted to a symbol phase of the first signal portion;

wherein the receiver is configured to obtain a second series of samples using a second sampling, the second sampling being adjusted to a symbol phase of the second signal portion;

wherein the receiver is configured to obtain probabilities of transmission symbols of the first signal portion and probabilities of transmission symbols of the second signal portion for a plurality of sampling times based on the first series of samples and the second series of samples;

wherein the receiver is configured to determine probabilities for symbols of the second signal portion based on samples of the first sampling and estimated or calculated probabilities for symbols of the first signal portion taking into account inter-symbol interference between transmission symbols of the second signal portion in the samples of the first sampling;

and

wherein the receiver is configured to determine probabilities for symbols of the first signal portion based on samples of the second sampling and estimated or calculated probabilities for symbols of the second signal portion taking into account inter-symbol interference between transmission symbols of the first signal portion in the samples of the second sampling.

2. The receiver according to claim 1,

wherein sampling times of the first sampling are set to sample an output signal of a signal-adjusted filter such that an output signal portion of the signal-adjusted filter which is based on the first signal portion is sampled substantially free of inter-symbol interference; and

wherein sampling times of the second sampling are set to sample an output signal of a signal-adjusted filter such that an output signal portion of the signal-adjusted filter which is based on the second signal portion is sampled substantially free of inter-symbol interference.

3. The receiver according to claim 1 or 2,

wherein the receiver is configured to adjust the first sampling to the symbol phase of the first signal portion and to the carrier phase of the second signal portion; and

wherein the receiver is configured to adjust the second sampling to the symbol phase of the second signal portion and to the carrier phase of the first signal portion.

4. The receiver according to any of claims 1 to 3,

wherein the receiver is configured to determine first branch transition probabilities between states of a first state model describing inter-symbol interference between transmission symbols of the second signal portion in the samples of the first sampling, based on the samples of the first sampling and estimated or calculated probabilities for symbols of the first signal portion, and to determine probabilities for symbols of the second signal portion based on the first branch transition probabilities; and/or

wherein the receiver is configured to determine second branch transition probabilities between states of a second state model describing inter-symbol interference between transmission symbols of the first signal portion in the samples of the second sampling, based on the samples of the second sampling and estimated or calculated probabilities for symbols of the second signal portion, and to determine probabilities for symbols of the first signal portion based on the second branch transition probabilities.

5. The receiver according to claim 4,

wherein the receiver is configured to obtain the probabilities for symbols of the second signal portion using a first probability density function of a disturbance affecting detection of transmission symbols of the second signal portion,

where the first probability density function takes into account

- a probability of at least one transmission symbol of the first signal portion,
- an expected contribution of at least one transmission symbol of the first signal portion to a sample of the first sampling, and
- an expected contribution of inter-symbol interference between transmission symbols of the second signal portion.

6. The receiver according to claim 5, wherein the receiver is configured to take into account, in an evaluation of the first probability density function, a time-varying contribution of a transmission symbol of the first signal portion resulting from a difference in carrier frequencies of the first signal portion and the second signal portion.

7. The receiver according to claim 4 or 5 or 6,

wherein the receiver is configured to obtain the probabilities for symbols of the first signal portion using a second probability density function of a disturbance affecting detection of transmission symbols of the first signal portion,

where the second probability density function takes into account

- a probability of at least one transmission symbol of the second signal portion,
- an expected contribution of at least one transmission symbol of the second signal portion to a sample of the second sampling, and
- an expected contribution of inter-symbol interference between transmission symbols of the first signal portion.

8. The receiver according to claim 7, wherein the receiver is configured to take into account, in an evaluation of the second probability density function, a time-varying

contribution of a transmission symbol of the second signal portion resulting from a difference in carrier frequencies of the first signal portion and the second signal portion.

9. The receiver according to any of claims 4 to 8,

wherein the receiver is configured to obtain first state transition probabilities based on the first branch transition probabilities, and to determine probabilities for symbols of the second signal portion using the first state transition probabilities; and/or

wherein the receiver is configured to obtain second state transition probabilities based on the second branch transition probabilities and to determine probabilities for symbols of the first signal portion using the second state transition probabilities.

10. The receiver according to any of claims 1 to 9,

wherein the receiver is configured to determine first branch transition probabilities based on a sum of probability contributions for different possible transmission symbols of the first signal portion,

wherein the probability contributions are weighted according to the estimated or calculated probabilities of the respective transmission symbols of the first signal portion and describe a probability that a predetermined transmission symbol of the second signal portion follows after a predetermined sequence of transmission symbols of the second signal portion, taking into account a current sample of the first sampling, an inter-symbol interference between transmission symbols of the second signal portion and a noise intensity; and/or

wherein the receiver is configured to determine second branch transition probabilities based on a sum of probability contributions for different possible transmission symbols of the second signal portion,

wherein the probability contributions are weighted according to the estimated or calculated probabilities of the respective transmission symbols of the second signal portion,

and describe a probability that a predetermined transmission symbol of the first signal portion follows after a predetermined sequence of transmission symbols of the first signal portion, taking into account a current sample of the second sampling, an inter-symbol interference between transmission symbols of the first signal portion and a noise intensity.

11. The receiver according to claim 10,

wherein the receiver is configured to estimate transmission symbols of the second transmission signal portion based on a selection of state transitions, wherein the receiver is configured to select the state transitions such that an overall transition probability which is based on the branch transition probabilities is maximized; and/or

wherein the receiver is configured to estimate transmission symbols of the first transmission signal portion based on a selection of state transitions, wherein the receiver is configured to select the state transitions such that an overall transition probability which is based on the branch transition probabilities is maximized.

12. The receiver according to any of claims 1 to 11,

wherein the receiver is configured to obtain first branch transition probabilities $\gamma_{1,k}[i,j]$ according to

$$\gamma_{1,k}[i,j] = \sum_{m=0}^{M_1-1} p_{1,m}[k] \mathrm{e}^{-\frac{\left|y_1[k]-(v_1\alpha_{1,m}\mathrm{e}^{j(\varphi_1-\varphi_2)}+i_{1,p})\right|^2}{v_3^2}}$$

wherein m is a control variable,

wherein M_1 is a number of constellation points of the first signal portion;
wherein $p_{1,m}[k]$ are estimated or calculated probabilities of the respective transmission symbols of the first signal portion at a time step k;

wherein $y_1[k]$ is a sample of the first sampling at a time step k;

wherein v_1 is a gain factor of the first signal portion;

wherein $a_{1,m}$ is a transmission symbol of the first signal portion with transmission symbol index m, or

wherein $a_{1,m}$ describes a contribution of a transmission symbol of the first signal portion with a transmission symbol index m to the sample $y_1[k]$, which is a time-variable contribution $a_{1,m}[k]$ in the case of a difference between a carrier frequency of the first signal portion and a carrier frequency of the second signal portion;

wherein φ_1-φ_2 describes a phase shift between transmission symbols of the first signal portion and transmission symbols of the second signal portion;

wherein $i_{1,p}$ describes inter-symbol interference between transmission symbols of the second signal portion; and

wherein v_3 describes a noise intensity;

and/or

wherein the receiver is configured to obtain second branch transition probabilities $\gamma_{2,k}[i,j]$ according to

$$\gamma_{2,k}[i,j] = \sum_{m=0}^{M_2-1} p_{2,m}[k] \mathrm{e}^{-\frac{\left|y_2[k]-(v_2\alpha_{2,m}e^{j(\varphi_2-\varphi_1)}+i_{2,p})\right|^2}{v_3^2}}$$

wherein m is a control variable,

wherein M_2 is a number of constellation points of the second signal portion;

wherein $p_{2,m}[k]$ are estimated or calculated probabilities of the respective transmission symbols of the second signal portion at a time step k;

wherein $y_2[k]$ is a sample of the second sampling at a time step k;

wherein v_2 is a gain factor of the second signal portion;

wherein $a_{2,m}$ is a transmission symbol of the second signal portion with transmission symbol index m, or

wherein $a_{2,m}$ describes a contribution of a transmission symbol of the first signal portion with a transmission symbol index m to the sample $y_2[k]$, which is a time-variable contribution $a_{2,m}[k]$ in the case of a difference between a carrier frequency of the first signal portion and a carrier frequency of the second signal portion;

wherein φ_2-φ_1 describes a phase shift between transmission symbols of the second signal portion and transmission symbols of the first signal portion;

wherein $i_{2,p}$ describes inter-symbol interference between transmission symbols of the first signal portion; and

wherein v_3 describes a noise intensity.

13. The receiver according to claim 12,

wherein the receiver is configured to determine probabilities $\alpha_{1,k}[i]$ for a state i at a k-th time step based on the first branch transition probabilities $\gamma_{1,k}[i,j]$ using forward recursion, and

to determine probabilities $\beta_{1,k+1}[j]$ for a state j at a k+1-th time step based on the first branch transition probabilities $\gamma_{1,k}[i,j]$ using backward recursion, and

to determine first state transition probabilities based on the probabilities $\alpha_{1,k}[i]$ for a state i at a k-th time step and $\beta_{1,k+1}[j]$ for a state j at a k+1-th time step and using the first branch transition probabilities $\gamma_{1,k}[i,j]$, and

to obtain probabilities of transmission symbols of the second signal portion based on the first state transition probabilities;

and/or

wherein the receiver is configured to determine probabilities $\alpha_{2,k}[i]$ for a state i at a k-th time step based on the second branch transition probabilities $\gamma_{2,k}[i,j]$ using forward recursion, and

to determine probabilities $\beta_{2,k+1}[j]$ for a state j at a k+1-th time step based on the second branch transition probabilities $\gamma_{2,k}[i,j]$ using backward recursion, and

to determine second state transition probabilities based on the probabilities $\alpha_{2,k}[i]$ for a state i at a k-th time step and $\beta_{2,k+1}[j]$ for a state j at a k+1-th time step and using the second branch transition probabilities $\gamma_{2,k}[i,j]$, and

to obtain probabilities of transmission symbols of the first signal portion based on the second state transition probabilities.

14. The receiver according to claim 13,

wherein the receiver is configured to obtain the first state transition probabilities $p_{1,k}(i,j)$ according to

$$p_{1,k}(i,j) = c_{trans,k}\alpha_{1,k}[i]\gamma_{1,k}[i,j]\beta_{1,k+1}[j]$$

wherein $c_{trans,k}$ is a normalization factor;

and/or

wherein the receiver is configured to obtain the second state transition probabilities $p_{2,k}(i,j)$ according to

$$p_{2,k}(i,j) = C_{trans,k}\alpha_{2,k}[i]\gamma_{2,k}[i,j]\beta_{2,k+1}[j]$$

wherein $c_{trans,k}$ is a normalization factor.

15. The receiver according to any of claims 1 to 14,

wherein the receiver is configured to obtain probabilities of transmission symbols of the second signal portion for a plurality of sampling times based on the first series of samples, taking into account inter-symbol interference between transmission symbols of the second signal portion in the first series of samples by using a first instance of a BCJR method, and taking into account superpositions by transmission symbols of the first signal portion as disturbance; and

wherein the receiver is configured to obtain probabilities of transmission symbols of the first signal portion for a plurality of sampling times based on the second series of samples, taking into account inter-symbol interference between transmission symbols of the first signal portion in the second series of samples by using a second instance of a BCJR method, and taking into account superpositions by transmission symbols of the second signal portion as disturbance.

16. The receiver according to any of claims 1 to 15,

wherein the receiver is configured to determine transmission symbols underlying the first signal portion, or probabilities of transmission symbols underlying the first signal portion by means of a trellis decoding method or based on the algorithm according to Bahl, Cocke, Jelinek and Raviv (BCJR algorithm); and

wherein the receiver is configured to determine transmission symbols underlying the second signal portion, or probabilities of transmission symbols underlying the second signal portion by means of a trellis decoding method or based on the algorithm according to Bahl, Cocke, Jelinek and Raviv (BCJR algorithm).

17. A method for receiving a combination signal comprising two separate signal portions whose pulses are shifted relative to each other and/or whose carrier waves have a phase difference,

wherein the method comprises obtaining a first series of samples using a first sampling, the first sampling being adjusted to a symbol phase of the first signal portion;

wherein the method comprises obtaining a second series of samples using a second sampling, the second sampling being adjusted to a symbol phase of the second signal portion;

wherein the method comprises obtaining probabilities of transmission symbols of the first signal portion and probabilities of transmission symbols of the second signal portion for a plurality of sampling times based on the first series of samples and the second series of samples;

wherein probabilities for symbols of the second signal portion are determined based on samples of the first sampling and estimated or calculated probabilities for symbols of the first signal portion taking into account inter-symbol interference between transmission symbols of the second signal portion in the samples of the first sampling;

and

wherein probabilities for symbols of the first signal portion are determined based on samples of the second sampling and estimated or calculated probabilities for symbols of the second signal portion taking into account inter-symbol interference between transmission symbols of the first signal portion in the samples of the second sampling.

18. A receiver for receiving a combination signal comprising two separate signal portions whose pulses are shifted relative to each other and/or whose carrier waves have a phase difference,

wherein the receiver is configured to obtain a first series of samples using a first sampling, the first sampling being adjusted to a symbol phase of the first signal portion;

wherein the receiver is configured to obtain a second series of samples using a second sampling, the second sampling being adjusted to a symbol phase of the second signal portion;

wherein the receiver is configured to obtain probabilities of transmission symbols of the first signal portion and probabilities of transmission symbols of the second signal portion for a plurality of sampling times based on the first series of samples and the second series of samples;

wherein the receiver is configured to determine probabilities for symbols of the second signal portion based on samples of the first sampling and estimated or calculated probabilities for symbols of the first signal portion taking into account inter-symbol interference between transmission symbols of the second signal portion in the samples of the first sampling;

and

wherein the receiver is configured to determine probabilities for symbols of the first signal portion based on samples of the second sampling and estimated or calculated probabilities for symbols of the second signal portion taking into account inter-symbol interference between transmission symbols of the first signal portion in the samples of the second sampling

wherein sampling times of the first sampling are set to sample an output signal of a signal-adjusted filter such that an output signal portion of the signal-adjusted filter which is based on the first signal portion is sampled substantially free of inter-symbol interference; and

wherein sampling times of the second sampling are set to sample an output signal of a signal-adjusted filter such that an output signal portion of the signal-adjusted filter which is based on the second signal portion is sampled substantially free of inter-symbol interference.

19. A method for receiving a combination signal comprising two separate signal portions whose pulses are shifted relative to each other and/or whose carrier waves have a phase difference,

wherein the method comprises obtaining a first series of samples using a first sampling, the first sampling being adjusted to a symbol phase of the first signal portion;

wherein the method comprises obtaining a second series of samples using a second sampling, the second sampling being adjusted to a symbol phase of the second signal portion;

wherein the method comprises obtaining probabilities of transmission symbols of the first signal portion and probabilities of transmission symbols of the second signal portion for a plurality of sampling times based on the first series of samples and the second series of samples;

wherein probabilities for symbols of the second signal portion are determined based on samples of the first sampling and estimated or calculated probabilities for symbols of the first signal portion taking into account inter-symbol interference between transmission symbols of the second signal portion in the samples of the first sampling;

wherein probabilities for symbols of the first signal portion are determined based on samples of the second sampling and estimated or calculated probabilities for symbols of the second signal portion taking into account inter-symbol interference between transmission symbols of the first signal portion in the samples of the second sampling,

wherein sampling times of the first sampling are set to sample an output signal of a signal-adjusted filter such that an output signal portion of the signal-adjusted filter which is based on the first signal portion is sampled substantially free of inter-symbol interference; and

wherein sampling times of the second sampling are set to sample an output signal of a signal-adjusted filter such that an output signal portion of the signal-adjusted filter which is based on the second signal portion is sampled substantially free of inter-symbol interference.

20. A receiver for receiving a combination signal comprising two separate signal portions whose pulses are shifted relative to each other and/or whose carrier waves have a phase difference,

wherein the receiver is configured to obtain a first series of samples using a first sampling, the first sampling being adjusted to a symbol phase of the first signal portion;

wherein the receiver is configured to obtain a second series of samples using a second sampling, the second sampling being adjusted to a symbol phase of the second signal portion;

wherein the receiver is configured to obtain probabilities of transmission symbols of the first signal portion and probabilities of transmission symbols of the second signal portion for a plurality of sampling times based on the first series of samples and the second series of samples;

wherein the receiver is configured to determine probabilities for symbols of the second signal portion based on samples of the first sampling and estimated or calculated probabilities for symbols of the first signal portion taking into account inter-symbol interference between transmission symbols of the second signal portion in the samples of the first sampling;

wherein the receiver is configured to determine probabilities for symbols of the first signal portion based on samples of the second sampling and estimated or calculated probabilities for symbols of the second signal portion taking into account inter-symbol interference between transmission symbols of the first signal portion in the samples of the second sampling

wherein the receiver is configured to obtain first branch transition probabilities $\gamma_{1,k}[i,j]$ according to

$$\gamma_{1,k}[i,j] = \sum_{m=0}^{M_1-1} p_{1,m}[k] \mathrm{e}^{-\frac{\left|y_1[k]-(v_1\alpha_{1,m}e^{j(\varphi_1-\varphi_2)}+i_{1,p})\right|^2}{v_3^2}}$$

wherein m is a control variable,

wherein M_1 is a number of constellation points of the first signal portion;

wherein $p_{1,m}[k]$ are estimated or calculated probabilities of the respective transmission symbols of the first signal portion at a time step k;

wherein $y_1[k]$ is a sample of the first sampling at a time step k;

wherein v_1 is a gain factor of the first signal portion;

wherein $a_{1,m}$ is a transmission symbol of the first signal portion with transmission symbol index m, or

wherein $a_{1,m}$ describes a contribution of a transmission symbol of the first signal portion with a transmission symbol index m to the sample $y_1[k]$, which is a time-variable contribution $a_{1,m}[k]$ in the case of a difference between a carrier frequency of the first signal portion and a carrier frequency of the second signal portion;

wherein φ_1-φ_2 describes a phase shift between transmission symbols of the first signal portion and transmission symbols of the second signal portion;

wherein $i_{1,p}$ describes inter-symbol interference between transmission symbols of the second signal portion; and

wherein v_3 describes a noise intensity;

and/or

wherein the receiver is configured to obtain second branch transition probabilities $\gamma_{2,k}[i,j]$ according to

$$\gamma_{2,k}[i,j] = \sum_{m=0}^{M_2-1} p_{2,m}[k] \mathrm{e}^{-\frac{\left|y_2[k]-(v_2\alpha_{2,m}e^{j(\varphi_2-\varphi_1)}+i_{2,p})\right|^2}{v_3^2}}$$

wherein m is a control variable,

wherein M_2 is a number of constellation points of the second signal portion;

wherein $p_{2,m}[k]$ are estimated or calculated probabilities of the respective transmission symbols of the second signal portion at a time step k;

wherein $y_2[k]$ is a sample of the second sampling at a time step k;

wherein v_2 is a gain factor of the second signal portion;

wherein $a_{2,m}$ is a transmission symbol of the second signal portion with transmission symbol index m, or

wherein $a_{2,m}$ describes a contribution of a transmission symbol of the first signal portion with a transmission symbol index m to the sample $y_2[k]$, which is a time-variable contribution $a_{2,m}[k]$ in the case of a difference between a carrier frequency of the first signal portion and a carrier frequency of the second signal portion;

wherein φ_2-φ_1 describes a phase shift between transmission symbols of the second signal portion and transmission symbols of the first signal portion;

wherein $i_{2,p}$ describes inter-symbol interference between transmission symbols of the first signal portion; and

wherein v_3 describes a noise intensity.

21. A method for receiving a combination signal comprising two separate signal portions whose pulses are shifted relative to each other and/or whose carrier waves have a phase difference,

wherein the method comprises obtaining a first series of samples using a first sampling, the first sampling being adjusted to a symbol phase of the first signal portion;

wherein the method comprises obtaining a second series of samples using a second sampling, the second sampling being adjusted to a symbol phase of the second signal portion;

wherein the method comprises obtaining probabilities of transmission symbols of the first signal portion and probabilities of transmission symbols of the second signal portion for a plurality of sampling times based on the first series of samples and the second series of samples;

wherein probabilities for symbols of the second signal portion are determined based on samples of the first sampling and estimated or calculated probabilities for symbols of the first signal portion taking into account inter-symbol interference between transmission symbols of the second signal portion in the samples of the first sampling;

wherein probabilities for symbols of the first signal portion are determined based on samples of the second sampling and estimated or calculated probabilities for symbols of the second signal portion taking into account inter-symbol interference between transmission symbols of the first signal portion in the samples of the second sampling,

first branch transition probabilities $\gamma_{1,k}[i,j]$ are obtained according to

$$\gamma_{1,k}[i,j] = \sum_{m=0}^{M_1-1} p_{1,m}[k] \mathrm{e}^{-\frac{\left|y_1[k]-(v_1\alpha_{1,m}e^{j(\varphi_1-\varphi_2)}+i_{1,p})\right|^2}{v_3^2}}$$

wherein m is a control variable,

wherein M_1 is a number of constellation points of the first signal portion;
wherein $p_{1,m}[k]$ are estimated or calculated probabilities of the respective transmission symbols of the first signal portion at a time step k;

wherein $y_1[k]$ is a sample of the first sampling at a time step k;

wherein v_1 is a gain factor of the first signal portion;

wherein $a_{1,m}$ is a transmission symbol of the first signal portion with transmission symbol index m, or

wherein $a_{1,m}$ describes a contribution of a transmission symbol of the first signal portion with a transmission symbol index m to the sample $y_1[k]$, which is a time-variable contribution $a_{1,m}[k]$ in the case of a difference between a carrier frequency of the first signal portion and a carrier frequency of the second signal portion;

wherein φ_1-φ_2 describes a phase shift between transmission symbols of the first signal portion and transmission symbols of the second signal portion;

wherein $i_{1,p}$ describes inter-symbol interference between transmission symbols of the second signal portion; and

wherein v_3 describes a noise intensity;

and/or

wherein second branch transition probabilities $\gamma_{2,k}[i,j]$ are obtained according to

$$\gamma_{2,k}[i,j] = \sum_{m=0}^{M_2-1} p_{2,m}[k] \mathrm{e}^{-\frac{\left|y_2[k]-(v_2\alpha_{2,m}e^{j(\varphi_2-\varphi_1)}+i_{2,p})\right|^2}{v_3^2}}$$

wherein m is a control variable,

wherein M_2 is a number of constellation points of the second signal portion;

wherein $p_{2,m}[k]$ are estimated or calculated probabilities of the respective transmission symbols of the second signal portion at a time step k;

wherein $y_2[k]$ is a sample of the second sampling at a time step k;

wherein v_2 is a gain factor of the second signal portion;

wherein $a_{2,m}$ is a transmission symbol of the second signal portion with transmission symbol index m, or

wherein $a_{2,m}$ describes a contribution of a transmission symbol of the first signal portion with a transmission symbol index m to the sample $y_2[k]$, which is a time-variable contribution $a_{2,m}[k]$ in the case of a difference between a carrier frequency of the first signal portion and a carrier frequency of the second signal portion;

wherein φ_2-φ_1 describes a phase shift between transmission symbols of the second signal portion and transmission symbols of the first signal portion;

wherein $i_{2,p}$ describes inter-symbol interference between transmission symbols of the first signal portion; and

wherein v_3 describes a noise intensity.

22, A computer program comprising program code for performing the method of claim 17, 19 or 21, when the program runs on a computer.