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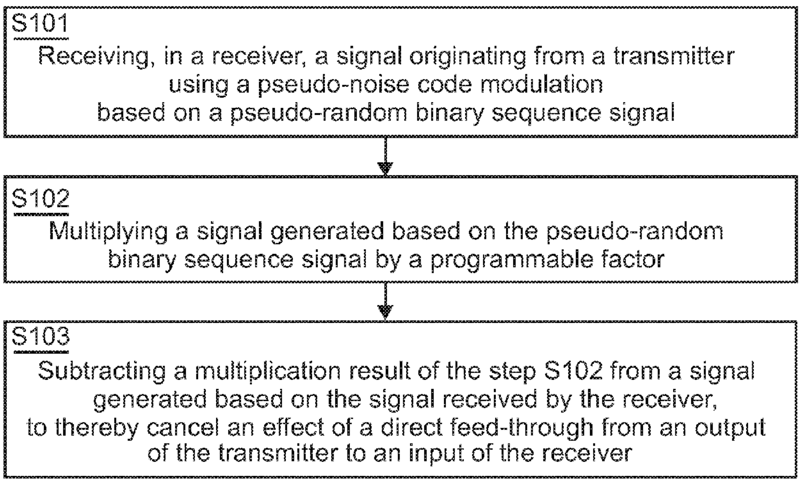

Fig.3

(57) **Abstract:** In summary, a cancellation scheme for cancelling an effect of a direct feed- through from an output of a transmitter to an input of a receiver is proposed. The cancellation scheme comprises receiving a signal originating from the transmitter using a pseudo-noise code modulation based on a pseudo-random binary sequence signal in the receiver (S101), multiplying a signal generated based on the pseudo-random binary sequence signal by a programmable factor (S102) and subtracting a multiplication result from a signal generated based on the signal received by the receiver (S103). It enables a precise cancellation of the effect of the direct feed-through. Thus, digital noise occurring in the receiver due to the direct feed-through can be reduced. As a result, the maximum range of a radar system provided with the receiver can be increased and/or isolation requirements between transmit and receive antennas can be relaxed.

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PSEUDO-NOISE TRANSMISSION SYSTEM WITH DIRECT FEED-THROUGH CANCELLATION

FIELD OF THE INVENTION

The present invention relates to a pseudo-noise (PN) transmission system which comprises a transmitter and a receiver, uses PN code modulation, and is capable of cancelling an effect of a direct feed-through from an output of its transmitter to an input of its receiver.

BACKGROUND OF THE INVENTION

Transmission systems like e.g. an ultra-wideband (UWB) transmission system can be implemented using a PN code modulation. One example of such transmission system is an UWB radar system. A transmitter thereof is disclosed in H. Veenstra, E. v.d. Heijden, D. v. Goor: "15-27 GHz Pseudo-Noise UWB transmitter for short-range automotive radar in a production SiGe technology", Proceedings ESSCIRC 2005, pp. 275-278, 12-16 September 2005, Grenoble, France. A receiver thereof is disclosed in H. Veenstra, E. v.d. Heijden, G. Dolmans, M.G.M. Notten: "A SiGe-BiCMOS receiver for 24 GHz short-range radar applications", IMS 2007, 3-8 June 2007, Honolulu, USA.

Fig. 4 shows a schematic diagram of an exemplary UWB radar system. The UWB radar system comprises a transmitter 1, a receiver 2, a transmit (Tx) antenna 3, a receive (Rx) antenna 4, a local oscillator (LO) 5 and a PN code generator 6. The transmitter 1 includes a biphase modulator 7 and an amplifier 8. The receiver 2 includes an amplifier such as e.g. a low noise amplifier (LNA) 9, a delay circuit 10, a biphase demodulator 11, a downconverter 12 and a lowpass filter 13.

The LO 5 is connected to the biphase modulator 7 and the downconverter 12. The PN code generator 6 is connected to the biphase modulator 7 and the delay circuit 10. The biphase modulator 7 is connected to the amplifier 8. The amplifier 8 is connected to the transmit antenna 3.

The receive antenna 4 is connected to the LNA 9. The LNA 9 and the delay circuit 10 are connected to the biphase demodulator 11. The biphase demodulator 11 is connected to the downconverter 12, and the downconverter 12 is connected to the lowpass filter 13.

The LO 5 generates a carrier signal at a radio frequency (RF) of e.g. 24 GHz. The PN code generator 6 generates a pseudo-random binary sequence (PRBS) signal and can also be called a PRBS generator. The biphase modulator 7 modulates the carrier signal generated by the LO 5 with the PRBS signal generated by the PN code generator 6. A signal resulting from the modulation is amplified by the amplifier 8. An output signal of the amplifier 8 is transmitted by the transmit antenna 3.

A signal received by the receive antenna 4 is amplified by the LNA 9. An output signal of the LNA 9 is demodulated by the biphase demodulator 11 by using a delayed PRBS signal from the delay circuit 10. The downconverter 12 converts an output signal of the biphase demodulator 11 to an intermediate frequency (IF) signal by using the signal generated by the LO 5. The IF signal resulting from the downconversion carried out by the downconverter 12 is filtered by the lowpass filter 13 and output at an IF output of the receiver 2.

At least a part of the signal transmitted by the transmit antenna 3 is reflected by an object 14 and then received by the receive antenna 4. If the transmitter 1 and the receiver 2 are both continuously active, the receive antenna 4 also receives a direct feed-through signal due to the finite isolation between the transmit antenna 3 and the receive antenna 4. That is, the signal received by the receive antenna 4 consists of a wanted signal resulting from the reflection from the object plus an unwanted direct feed-through signal.

A path delay difference between the reflection path and the direct feed-through path is defined as τ. An autocorrelation function R(t) of the PRBS data is unity for t=0 but not zero for $t=\tau$, resulting in digital noise. This digital noise from the direct feed-through path may limit the maximum range of the UWB radar system.

When only the digital noise is taken into consideration, the maximum range of the receiver 2 is defined as a range r for which the received power due to the reflection by the object 14 is equal to the received power from the direct feed-through path. A practical example is given below.

The receiver input power P_r received by the receiver 2 in the UWB radar system depicted in Fig. 4 can be expressed as

$$P_r = \frac{EIRP}{4\pi d^2} \cdot \sigma \cdot \frac{1}{4\pi d^2} \cdot A_E = \frac{P_T G_T G_R \sigma \lambda^2}{(4\pi)^3 d^4} \qquad (1)$$

In this equation, EIRP designates the equivalent isotropic radiation power, A_E is the effective aperture of the antenna, P_T is the transmit power (usually 2 dBm (dB(1 mW))), G_T and G_R are the transmit and receive antenna gains, σ is the object radar cross section in m^2, λ is the wavelength (1.25 cm for a RF of 24 GHz), and d is the distance to the object.

For the object radar cross section, 1 m^2 is assumed. Fig. 5 shows a diagram indicating the receiver input power P_r as a function of the object distance d for carrier frequencies of 22 GHz, 24 GHz, 29 GHz and 77 GHz, assuming a frequency-independent transmit power of 2 dBm and antenna gains of 0 dB.

As depicted in Fig. 5, there is a distance-independent difference of $20 \cdot \log(29/22) = 2.4$ dB between the receiver input power P_r at 22 GHz and 29 GHz. This follows directly from the wavelength difference and the equation (1). In practice, additional frequency dependence in the receiver input power P_r can occur due to a frequency-dependent transmit power P_T and frequency-dependent antenna gains G_T and G_R. When the distance to the object 14 doubles, the receiver input power P_r reduces by 12 dB. For the purpose of comparison, the receiver input power P_r at 77 GHz is also shown. At 77 GHz, the path loss is 10.125 dB higher than at 24 GHz.

Short-range radar systems typically target a maximum range of 30 m. As depicted in Fig. 5, for a distance d of 30 m the receiver input power P_r is approximately -130 dBm.

The digital noise in the receiver 2 is equal to the transmitted digital noise minus the direct feed-through path loss, also referred to as isolation between the Tx antenna 3 and the Rx antenna 4. The transmitted digital noise can be calculated from the autocorrelation function of the PRBS code. A PRBS code of, for example, $2^{16} - 1 = 65535$ bits has an autocorrelation function $R(x) = 1/65535$ for $x \neq 0$. Thus, the power of the digital noise is 48 dB below the wanted signal. This yields an isolation requirement of 130-48 = 82 dB, which is difficult to accomplish in practice.

There are several ways to reduce the digital noise in the receiver 2:

1) Increasing the sequence length of the PRBS. This length is $2^N - 1$ bits, wherein N is the number of flip-flops in a shift register of the PN code generator 6. When N is increased by 1, the digital noise reduces by 3 dB. A consequence of the increased PRBS code length is a doubling of the detection time (and thus the radar response time) with every bit increase in the shift register length.

2) Improving the isolation between the transmit antenna 3 and the receive antenna 4, for example by shielding. This is typically limited because of the limited maximum physical (practical) size of a radar unit. However, extreme isolation requirements have to be met to make sure that the digital noise in the receiver 2 due to the non-zero autocorrelation of the PRBS does not limit the maximum range of an UWB radar system using the receiver 2.

3) Correcting the digital noise, originating from direct feed-through, in the receiver 2.

Document GB 2 259 820 A discloses a noise radar in which a transmitted signal is coded by pseudo-random sequences. The noise radar transmits pulses of energy so as to give an opportunity to receive a returned signal during periods between pulses. That is, the transmission is interrupted during a number of periods during each pseudo-random sequence in order to allow returns from targets to be received by the same antenna as is used for transmission during those periods of interruption. In this way a problem of leakage of a transmitted signal directly into a receiver of the noise radar as occurring when a continuous transmitted signal is coded can be eliminated.

SUMMARY OF THE INVENTION

It would be advantageous to achieve a PN receiver and transmission system which are capable of reducing digital noise occurring in the receiver due to the PRBS autocorrelation. Further, it would be desirable to provide a PN radar system with an increased maximum range.

This object is achieved by a receiver according to claim 1 and a method according to claim 14.

To address one or more of these concerns, in a first aspect of the invention a receiver for receiving a signal originating from a transmitter using a pseudo-noise code modulation based on a pseudo-random binary sequence signal is presented. The receiver comprises a first multiplier configured to multiply a signal generated based on the pseudo-random binary sequence signal by a programmable factor. The receiver further comprises a subtractor configured to subtract a multiplication result of the first multiplier from a signal generated based on the signal received by the receiver, to thereby cancel an effect of a direct feed-through from an output of the transmitter to an input of the receiver. According to the first aspect, the effect of the direct feed-through can be cancelled. Thus, digital noise occurring in the receiver due to PRBS autocorrelation can be reduced. As a result, the maximum range of a PN radar system provided with the receiver can be increased.

In a second aspect of the invention the receiver further comprises a delay circuit configured to delay the pseudo-random binary sequence signal and a second multiplier configured to multiply the pseudo-random binary sequence signal by a delayed pseudo-random binary sequence signal from the delay circuit, wherein the first multiplier is configured to multiply a multiplication result of the second multiplier by the programmable factor. A multiplication result of the first multiplier can be subtracted from an IF signal in the receiver. Thus, a digital noise correction can be implemented at IF. Hence, no additional circuits that operate at RF are needed.

In a third aspect of the invention the first multiplier is configured to multiply a signal tapped at an output of the transmitter by the programmable factor. That is, (a fraction of) a signal transmitted by the transmitter is used to cancel the effect of the direct feed-through. Thus, a precise cancellation of the influence of the direct feed-through and an efficient digital noise correction can be achieved.

In a fourth aspect of the invention a transmission system comprises a transmitter generating an output signal by using a pseudo-noise code modulation based on a pseudo-random binary sequence signal and a receiver according to one of the preceding aspects or one of other aspects as set out in dependent claims. According to the fourth aspect, an effect of a direct feed-through from an output of the transmitter to an input of the receiver can be cancelled. Thus, digital noise occurring in the receiver due to PRBS autocorrelation can be reduced. If the transmission system is a radar system, then also the maximum range of this radar system can be increased.

In a fifth aspect of the invention a method of receiving, in a receiver, a signal originating from a transmitter using a pseudo-noise code modulation based on a pseudo-random binary sequence signal is presented. The method comprises the step of multiplying a signal generated based on the pseudo-random binary sequence signal by a programmable factor. The method further comprises the step of subtracting a multiplication result of the multiplying step from a signal generated based on the signal received by the receiver, to thereby cancel an effect of a direct feed-through from an output of the transmitter to an input of the receiver. According to the fifth aspect, digital noise occurring due to PRBS autocorrelation while a signal is received by the receiver can be reduced. Further, the maximum range of a PN radar system using the method can be increased.

In a sixth aspect of the invention a computer program product for a computer comprises software code portions for performing the steps of a method according to the fifth aspect when the product is run on the computer. This aspect enables a reduction of digital noise occurring in a receiver due to PRBS autocorrelation and an increase of the maximum range of a PN radar system provided with the receiver.

Further advantageous modifications are defined in the dependent claims.

These and other aspects of the invention will be apparent from and elucidated by embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described on the basis of embodiments with reference to the accompanying drawings, in which:

Fig. 1 shows a schematic diagram of an UWB radar system according to a first embodiment;

Fig. 2 shows a schematic diagram of an UWB radar system according to a second embodiment;

Fig. 3 shows a schematic flow chart of a basic cancellation scheme in accordance with the first and second embodiments;

Fig. 4 shows a schematic diagram of an exemplary UWB radar system; and

Fig. 5 shows a diagram indicating a receiver input power.

DETAILED DESCRIPTION OF EMBODIMENTS

Fig. 1 shows a schematic diagram of an UWB radar system according to a first embodiment. Elements of this UWB radar system that are identical with elements of the UWB radar system depicted in Fig. 4 are provided with the same reference signs and will not be discussed in detail again.

The receiver 2 of the UWB radar system depicted in Fig. 1 additionally comprises a second multiplier 15, a first multiplier 16, a subtractor 17 and a gain control 18 as compared with the receiver 2 of the UWB radar system depicted in Fig. 4. The second multiplier 15 is connected to the input and output of the delay circuit 10 as well as to the first multiplier 16. The first multiplier 16 is connected to the subtractor 17. The subtractor 17 is interposed between the downconverter 12 and the lowpass filter 13 and connected to both of them. The gain control 18 is connected to the first multiplier 16.

The second multiplier 15 multiplies the PRBS signal generated by the PN code generator 6 and input to the delay circuit 10 by the delayed PRBS signal output by the delay circuit 10. In this way a residue caused by the direct feed-through path can be reconstructed. The first multiplier 16 multiplies a multiplication result of the second multiplier 15 by a programmable factor α. That is, an output signal of the second multiplier 15 is scaled in amplitude by the programmable factor α. The gain control 18 controls the programmable factor α.

The subtractor 17 subtracts a multiplication result of the first multiplier 16 from the IF signal resulting from the downconversion carried out by the downconverter 12. Thus, an effect of the direct feed-through can be cancelled at IF. That is, a digital noise correction can be implemented at IF. Hence, no additional circuits that operate at RF (e.g. 24 GHz) are needed.

The second multiplier 15 multiplies two digital signals. Thus, it can be implemented by a simple Exclusive-Or (ExOr or XOR) gate. Hence, no complicated circuit is needed.

Fig. 2 shows a schematic diagram of an UWB radar system according to a second embodiment. Elements of this UWB radar system that are identical with elements of the UWB radar systems depicted in Figs. 1 and 4 are provided with the same reference signs and will not be discussed in detail again.

The receiver 2 of the UWB radar system depicted in Fig. 2 additionally comprises a first multiplier 16, a subtractor 17 and a gain control 18 as compared with the receiver 2 of the UWB radar system depicted in Fig. 4. Further, a coupler 19 is provided at an output of the transmitter 1. The coupler 19 is connected to the first multiplier 16. The first multiplier 16 is connected to the subtractor 17. The subtractor 17 is interposed between the LNA 9 and the biphase demodulator 11. The gain control 18 is connected to the first multiplier 16.

It is assumed that the delay of the direct feed-through path from the output of the transmitter 1 to the input of the receiver 2 is significantly less than one bit time of the PRBS sequence. For example, if a distance between the transmit antenna 3 and the receive antenna is 6 cm, the delay across the direct feed-through path is 200 ps. This corresponds to 0.4 bit times when operating at a PN code rate of 2 Gb/s.

The coupler 19 at the output of the transmitter 1 taps (a fraction of) the transmitted signal. This fraction is fed to the first multiplier 16, where it is multiplied by a programmable factor α. The gain control 18 controls the programmable factor α.

The subtractor 17 subtracts a multiplication result of the first multiplier 16 from an amplified receiver input signal. More specifically, an output signal of the first multiplier 16 is subtracted from the output signal of the LNA 9. The subtraction is done at the output of the LNA 9 in order to have little impact on the noise figure of the receiver 2.

In the second embodiment (a fraction of) a signal actually transmitted by the transmitter 1 is used to cancel the effect of the direct feed-through. Thus, an accurate cancellation of the influence of the direct feed-through and an effective digital noise correction can be achieved.

In both of the first and second embodiments the transmitter 1 and the receiver 2 can be continuously active. Thus, the invention may be applied in UWB transmission systems where the transmitter and receiver are continuously active, such as (automotive) short-range radar systems based on PN coding (regardless of the carrier frequency, e.g. 24 GHz or 77 GHz). When the transmitter and the receiver are continuously active, the detection time (radar response time) can be reduced as compared with a case where the transmitter and the receiver are not continuously active.

The receiver 2 can be implemented as an integrated circuit (IC) for both the first and second embodiments.

The cancellation schemes according to the first and second embodiments can be implemented in a receiving method. The steps of such method can be performed by software code portions of a computer program product for a computer when the product is run on the computer.

Fig. 3 shows a schematic flow chart of a basic cancellation scheme in accordance with the first and second embodiments. In a step S101 a signal originating from a transmitter using a pseudo-noise code modulation based on a pseudo-random binary sequence signal is received in a receiver. In a step S102 a signal generated based on the pseudo-random binary sequence signal is multiplied by a programmable factor. In a step S103 a multiplication result of the step S102 is subtracted from a signal generated based on the signal received by the receiver, to thereby cancel an effect of a direct feed-through from an output of the transmitter to an input of the receiver.

Both of the above described first and second embodiments enable a cancellation of the direct feed-through from the output of the transmitter 1 to the input of the receiver 2. Thus, digital noise occurring in the receiver 2 due to the direct feed-through can be reduced. As a result, the maximum range of the UWB radar system provided with the receiver 2 can be increased and/or isolation requirements between the transmit antenna 3 and the receive antenna 4 can be relaxed.

While the invention has been illustrated and described in detail in the drawings and the foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive. The invention is not limited to the disclosed embodiments.

Variations to the disclosed embodiments can be understood and effected by those skilled in the art, from a study of the drawings, the disclosure and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality of elements or steps. A single processor or other unit may fulfil the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. A computer program may be stored/distributed on a suitable medium, such as an optical storage medium or a solid-state medium supplied together with or as part of other hardware, but may also be distributed in other forms, such as via the Internet or other wired or wireless telecommunication systems. Any reference signs in the claims should not be construed as limiting the scope thereof.

In summary, a cancellation scheme for cancelling an effect of a direct feed-through from an output of a transmitter to an input of a receiver is proposed. The cancellation scheme comprises receiving a signal originating from the transmitter using a pseudo-noise code modulation based on a pseudo-random binary sequence signal in the receiver (S101), multiplying a signal generated based on the pseudo-random binary sequence signal by a programmable factor (S102) and subtracting a multiplication result from a signal generated based on the signal received by the receiver (S103). It enables a precise cancellation of the effect of the direct feed-through. Thus, digital noise occurring in the receiver due to the direct feed-through can be reduced. As a result, the maximum range of a radar system provided with the receiver can be increased and/or isolation requirements between transmit and receive antennas can be relaxed.

CLAIMS:

1. A receiver (2) for receiving a signal originating from a transmitter (1) using a pseudo-noise code modulation based on a pseudo-random binary sequence signal, said receiver (2) comprising:

- a first multiplier (16) configured to multiply a signal generated based on said pseudo-random binary sequence signal by a programmable factor; and

- a subtractor (17) configured to subtract a multiplication result of said first multiplier (16) from a signal generated based on said signal received by said receiver (2), to thereby cancel an effect of a direct feed-through from an output of said transmitter (1) to an input of said receiver (2).

2. A receiver (2) according to claim 1, further comprising:

- a delay circuit (10) configured to delay said pseudo-random binary sequence signal; and

- a second multiplier (15) configured to multiply said pseudo-random binary sequence signal by a delayed pseudo-random binary sequence signal from said delay circuit (10),

wherein said first multiplier (16) is configured to multiply a multiplication result of said second multiplier (15) by said programmable factor.

3. A receiver (2) according to claim 2, wherein said second multiplier (15) is implemented by an ExOr gate.

4. A receiver (2) according to claim 2, further comprising:

- an amplifier (9) configured to amplify said signal received by said receiver (2);

- a demodulator (11) configured to demodulate an output signal of said amplifier (9); and

- a downconverter (12) configured to convert an output signal of said demodulator (11) to an intermediate frequency signal, wherein said subtractor (17) is configured to subtract said multiplication result of said first multiplier (16) from said intermediate frequency signal.

5. A receiver (2) according to claim 1, wherein said first multiplier (16) is configured to multiply a signal tapped at an output of said transmitter (1) by said programmable factor.

6. A receiver (2) according to claim 5, wherein said tapped signal is tapped by a coupler (19) at said output of said transmitter (1).

7. A receiver (2) according to claim 5, further comprising:

- an amplifier (9) configured to amplify said signal received by said receiver (2),

wherein said subtractor (17) is configured to subtract said multiplication result of said first multiplier (16) from an output signal of said amplifier (9).

8 A receiver (2) according to claim 1, further comprising:

- a gain control (18) configured to control said programmable factor.

9. A receiver (2) according to claim 1, wherein said signal received by said receiver (2) is an ultra-wideband signal.

10. A receiver (2) according to claim 1, wherein said receiver (2) and said transmitter (1) are continuously active.

11. A receiver (2) according to claim 1, wherein said receiver (2) is a radar receiver and said transmitter (1) is a radar transmitter.

12. A transmission system comprising:

- a transmitter (1) generating an output signal by using a pseudo-noise code modulation based on a pseudo-random binary sequence signal; and

- a receiver (2) according to any one of the preceding claims.

13. A transmission system according to claim 12, wherein said transmission system is a short-range radar system.

14. A method of receiving, in a receiver (2), a signal originating from a transmitter (1) using a pseudo-noise code modulation based on a pseudo-random binary sequence signal, said method comprising the steps of:

- multiplying a signal generated based on said pseudo-random binary sequence signal by a programmable factor; and
- subtracting a multiplication result of said multiplying step from a signal generated based on said signal received by said receiver (2), to thereby cancel an effect of a direct feed-through from an output of said transmitter (1) to an input of said receiver (2).

15. A computer program product for a computer, comprising software code portions for performing the steps of a method according to claim 14 when said product is run on said computer.

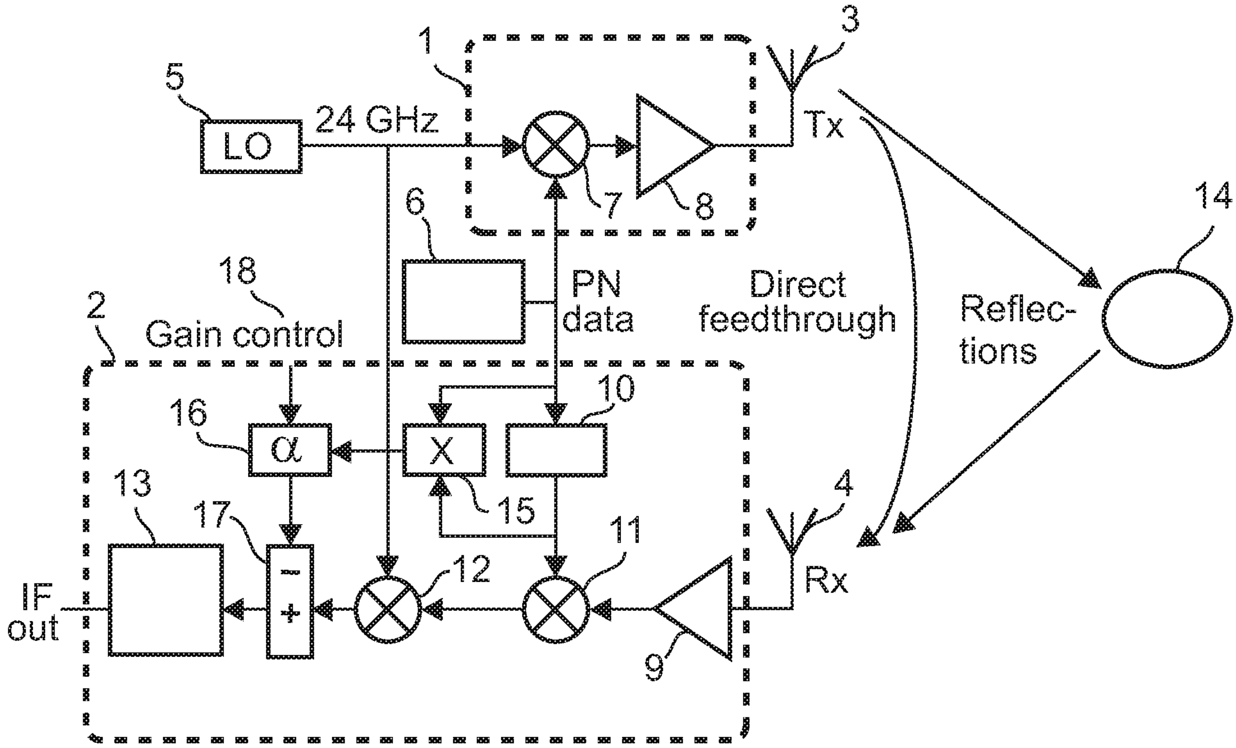
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Fig.1

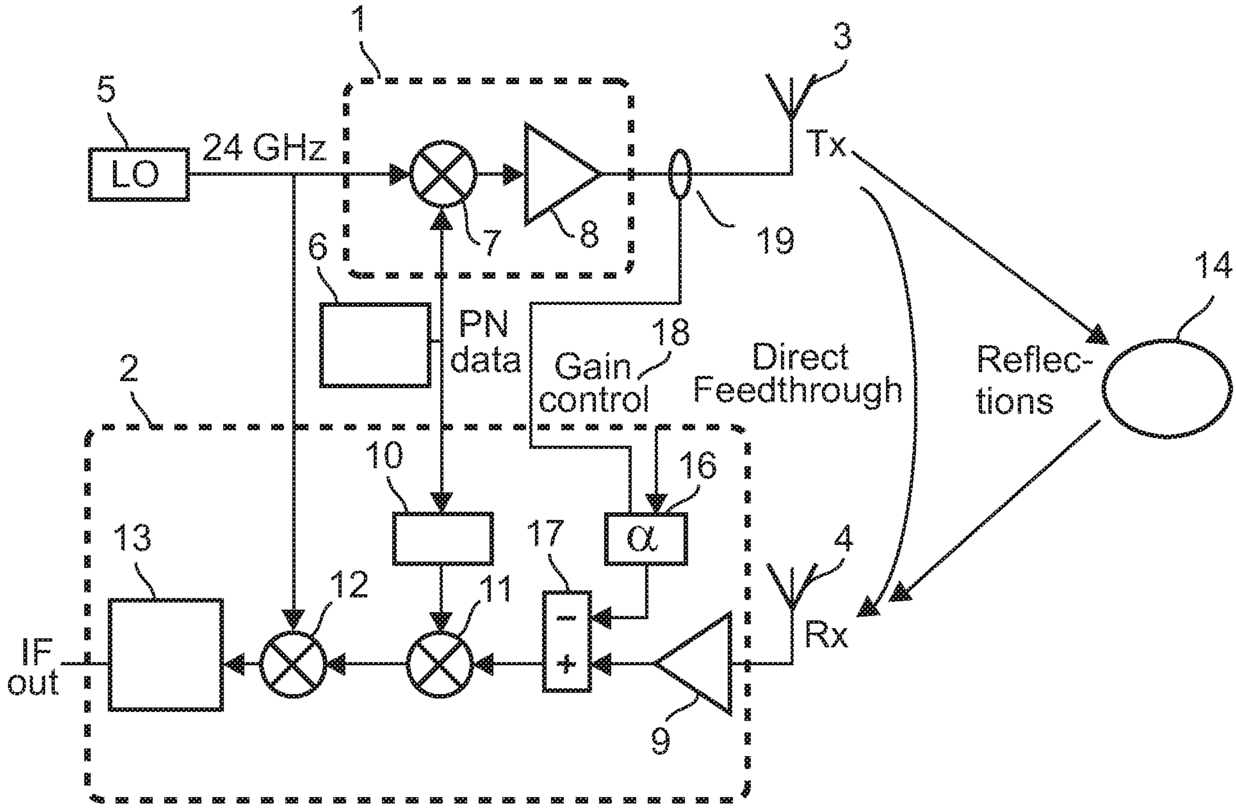
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Fig.2

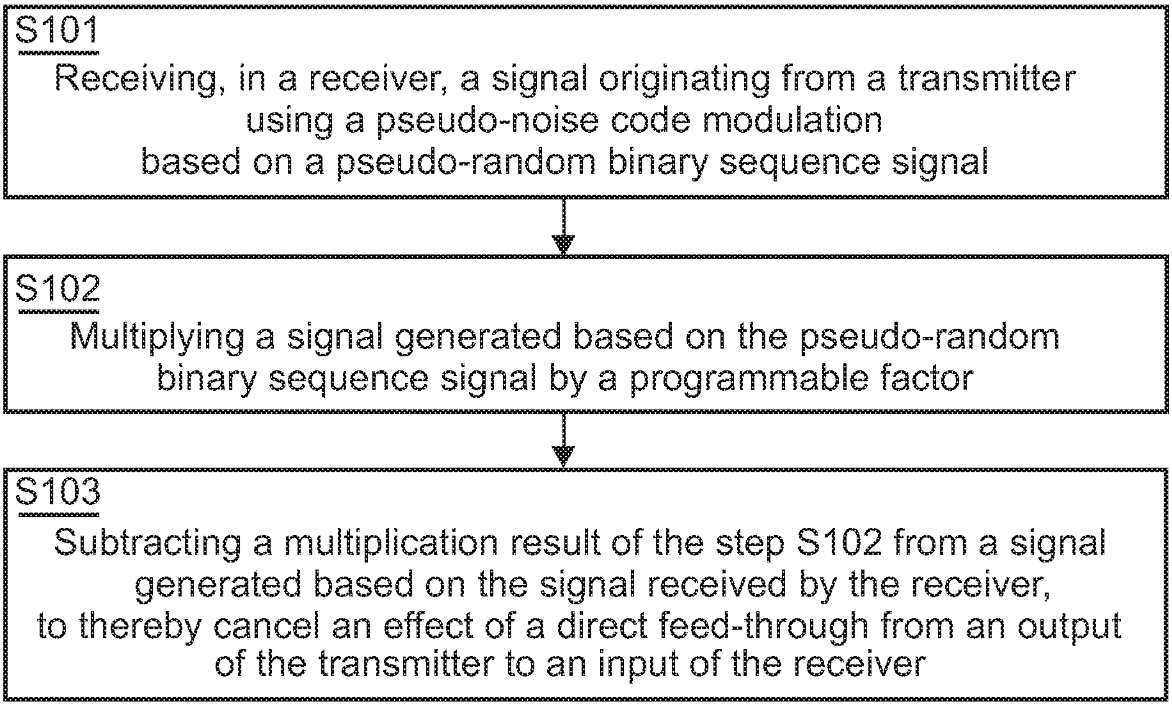
S101
Receiving, in a receiver, a signal originating from a transmitter using a pseudo-noise code modulation based on a pseudo-random binary sequence signal
S102
Multiplying a signal generated based on the pseudo-random binary sequence signal by a programmable factor
S103
Subtracting a multiplication result of the step S102 from a signal generated based on the signal received by the receiver, to thereby cancel an effect of a direct feed-through from an output of the transmitter to an input of the receiver

Fig.3

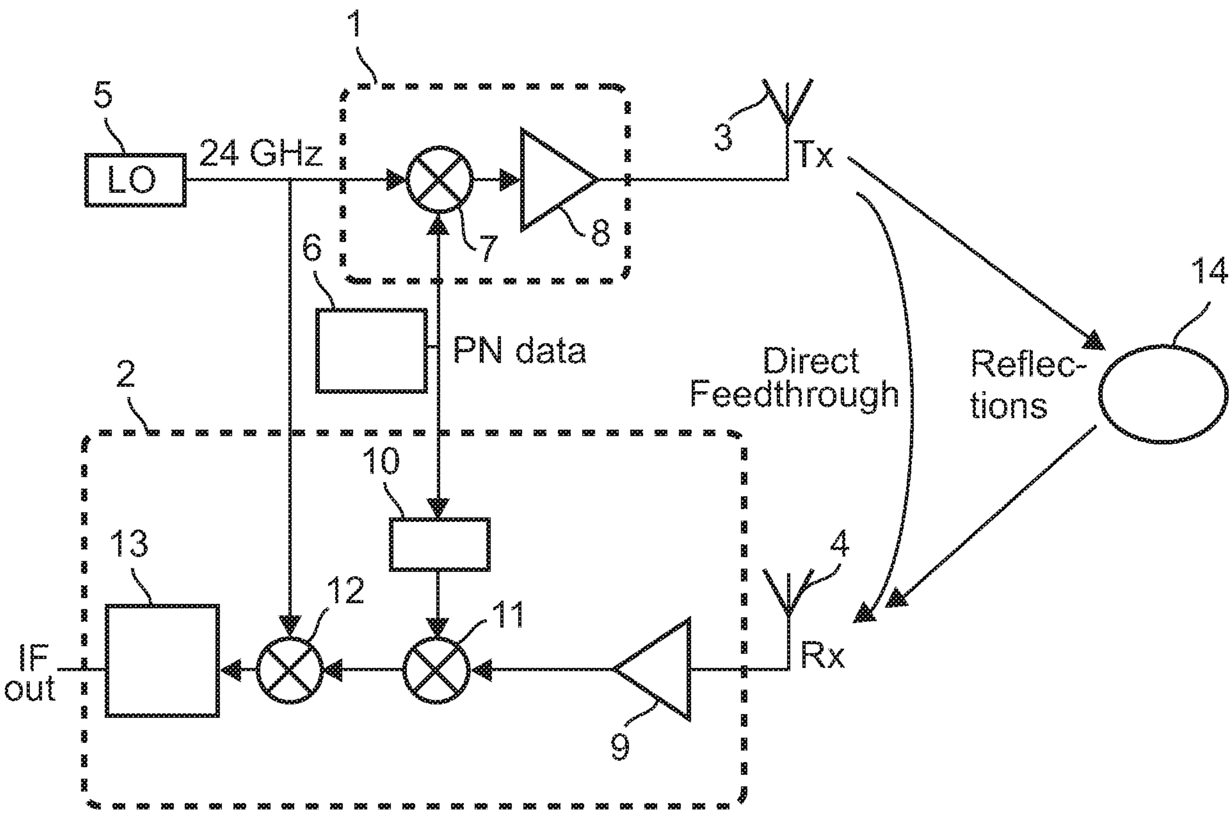
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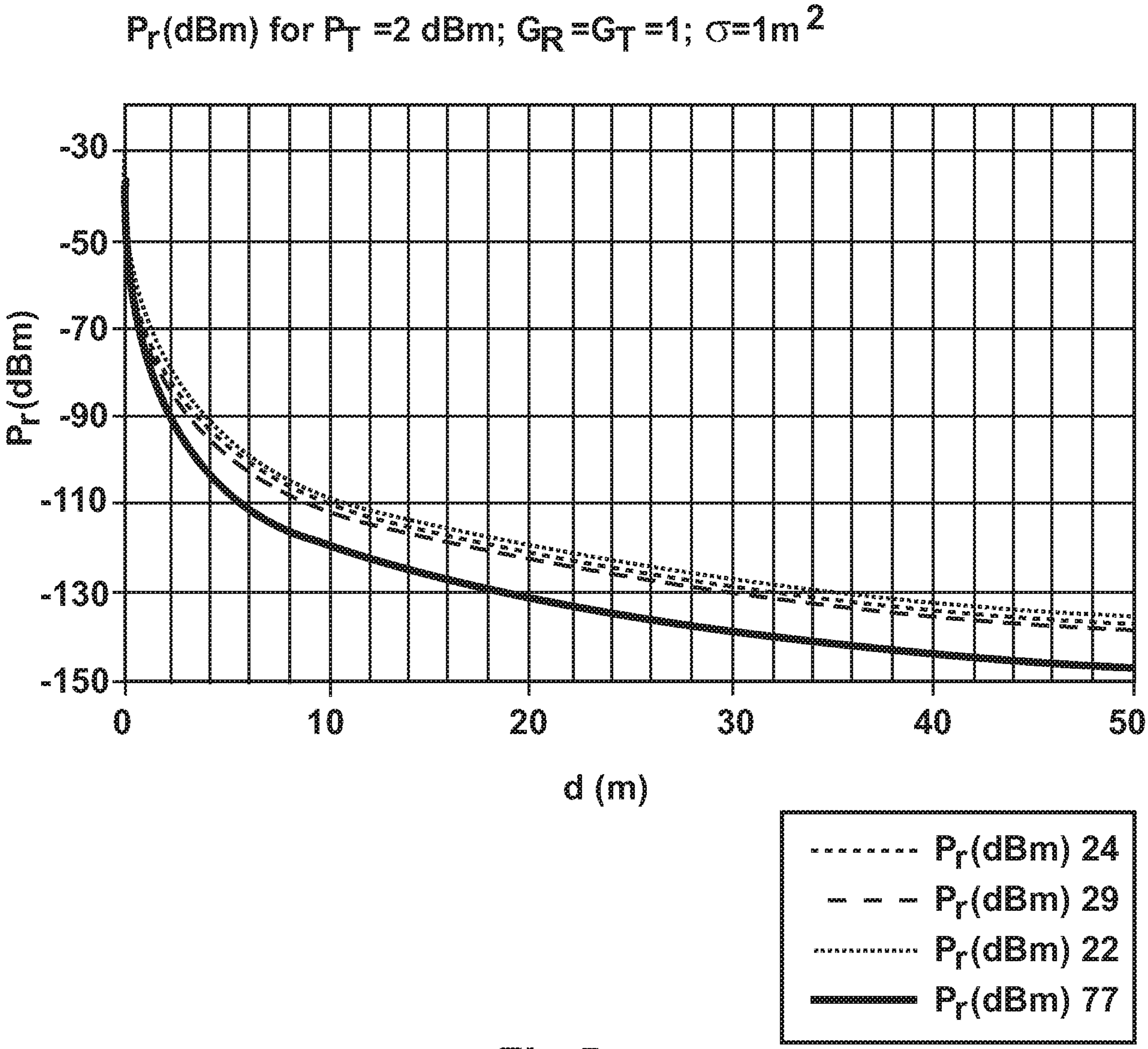
Fig.4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20
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40
50
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P_r(dBm) 24
P_r(dBm) 29
P_r(dBm) 22
P_r(dBm) 77

Fig.5

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2008/053334

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01S13/02 G01S7/03

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)
G01S

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 practical, search terms used)

EPO-Internal, WPI Data, INSPEC, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 03/038462 A (SPECTRUM TARGET DETECTION INC [CA]) 8 May 2003 (2003-05-08) abstract page 5, line 3 - line 22 page 9, line 9 - line 19 page 10, line 7 - line 8 page 12 - page 13; figure 1 -----	1-15
X	EP 1 122 555 A (EHSANI ENGINEERING ENTPR INC [CA]) 8 August 2001 (2001-08-08) abstract paragraphs [0014] - [0016] paragraphs [0025] - [0032]; figure 6 -----	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
23 January 2009	30/01/2009

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Ó Donnabháin, Emma

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2008/053334

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 03038462	A	08-05-2003	CA	2361015 A1	02-05-2003
			EP	1442313 A2	04-08-2004
			US	2003090405 A1	15-05-2003
EP 1122555	A	08-08-2001	NONE		