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(54) **SYSTEM FOR MUITIPLE RADARS AND OPERATION METHOD THEREOF**

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(57) **ABSTRACT**

A radar system includes a first radar that generates a first transmit pulse in response to a first transmission clock signal and detects a target in response to the first transmission clock signal and a first reception clock signal with a first transmission clock and reception clock signal time difference according to a first detection distance and a second radar that generates a second transmit pulse in response to a second transmission clock signal and detects the target in response to the second transmission clock signal and a second reception clock signal with a second transmission clock and reception clock signal time difference according to a second detection distance. The first and the second transmission clock signals are not synchronous with each other. The first radar generates a minimum detection distance notification, when the first detection distance is a minimum detection distance detected by the first radar.

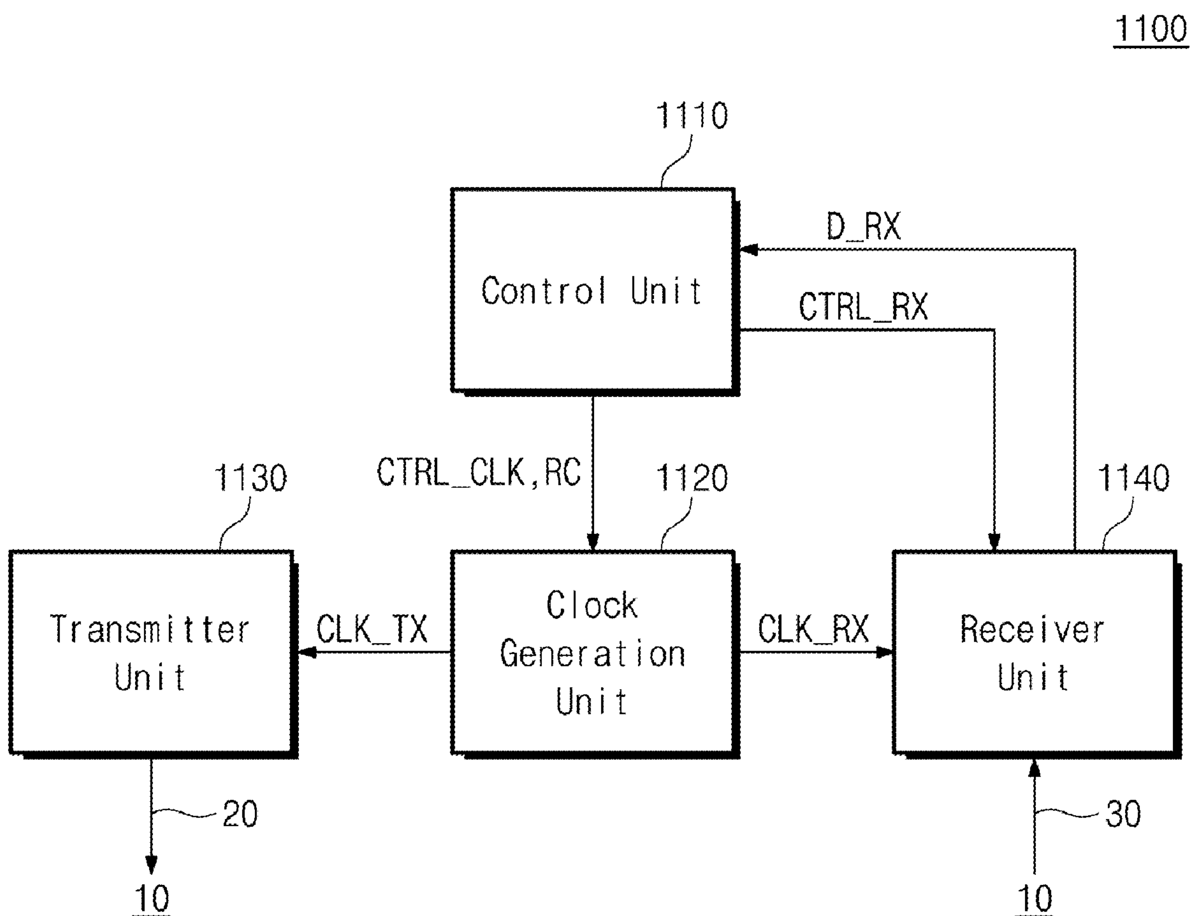


FIG. 1

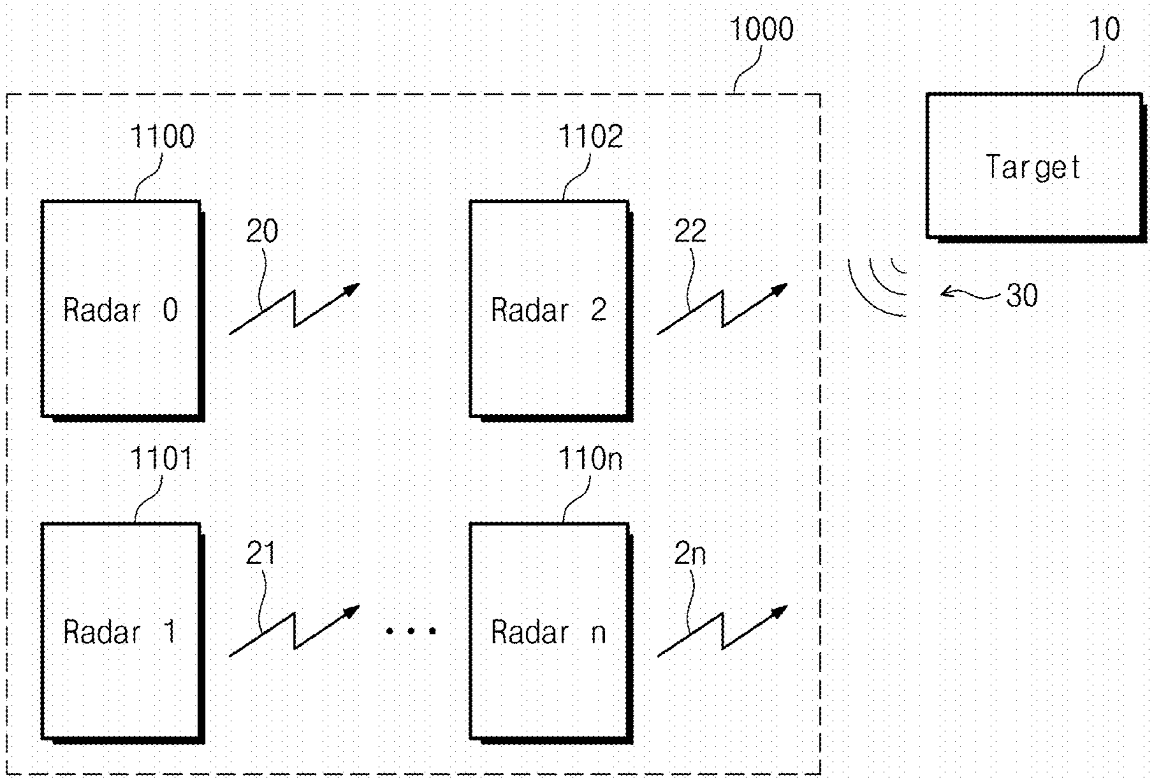

1000
10
Target
1100
Radar 0
20
1102
Radar 2
22
30
1101
Radar 1
21
110n
Radar n
2n

FIG. 2

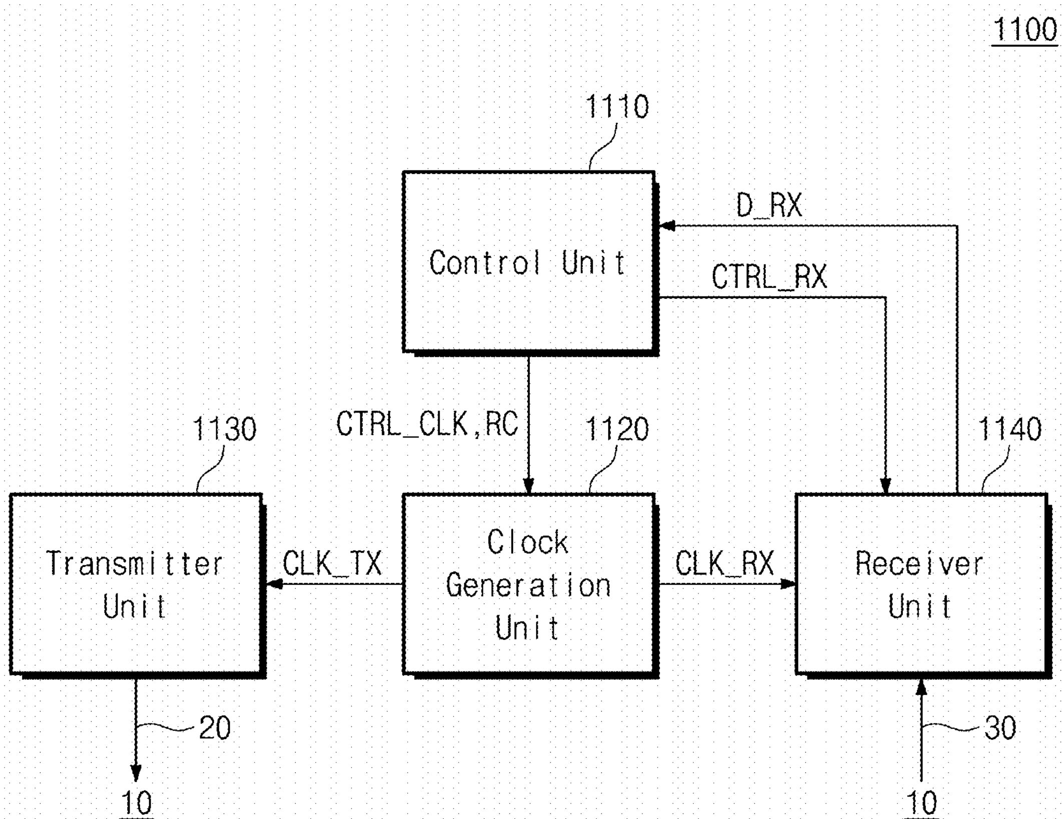

1100
1110
Control Unit
D_RX
CTRL_RX
CTRL_CLK,RC
1130
1120
1140
Transmitter Unit
CLK_TX
Clock Generation Unit
CLK_RX
Receiver Unit
20
30
10
10

FIG. 3

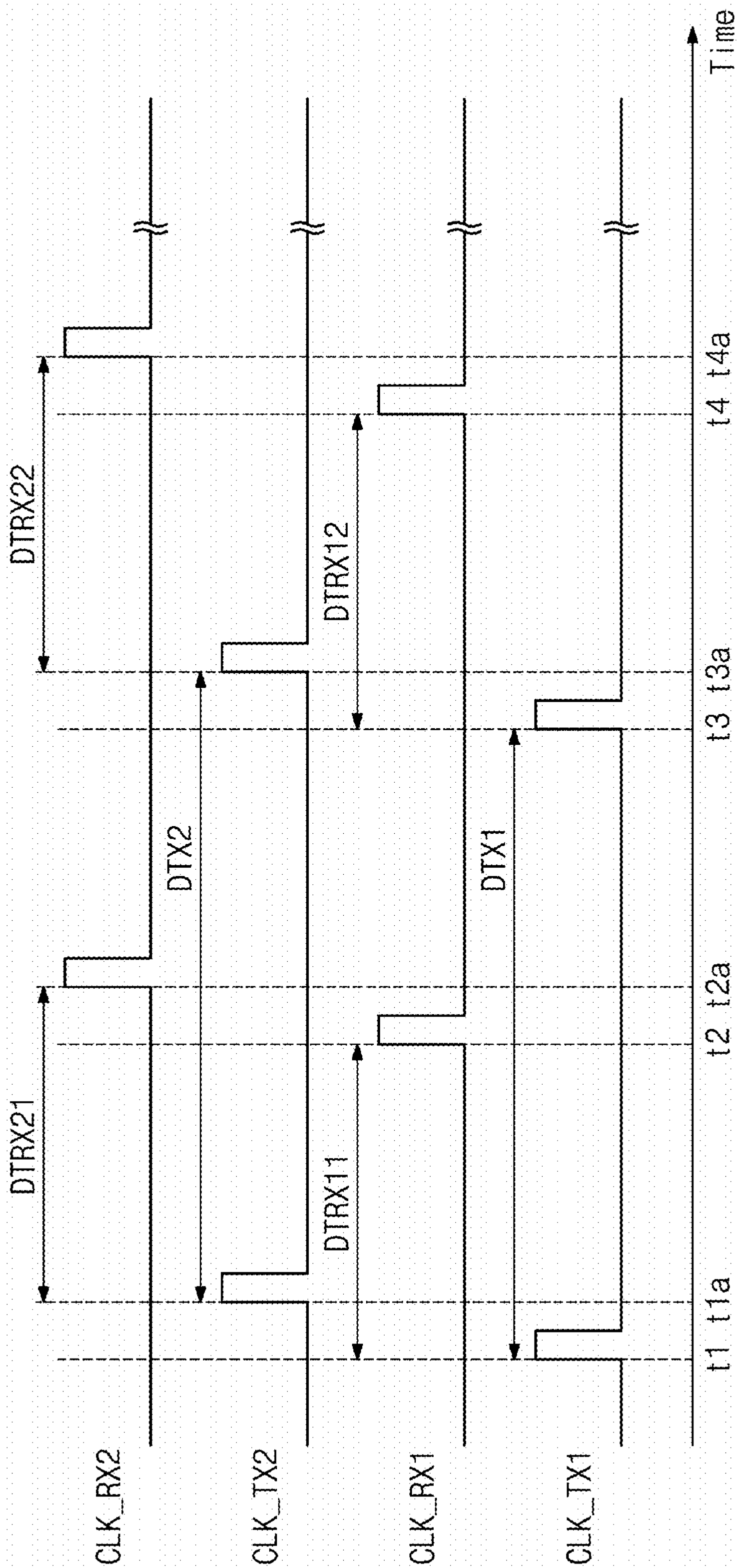
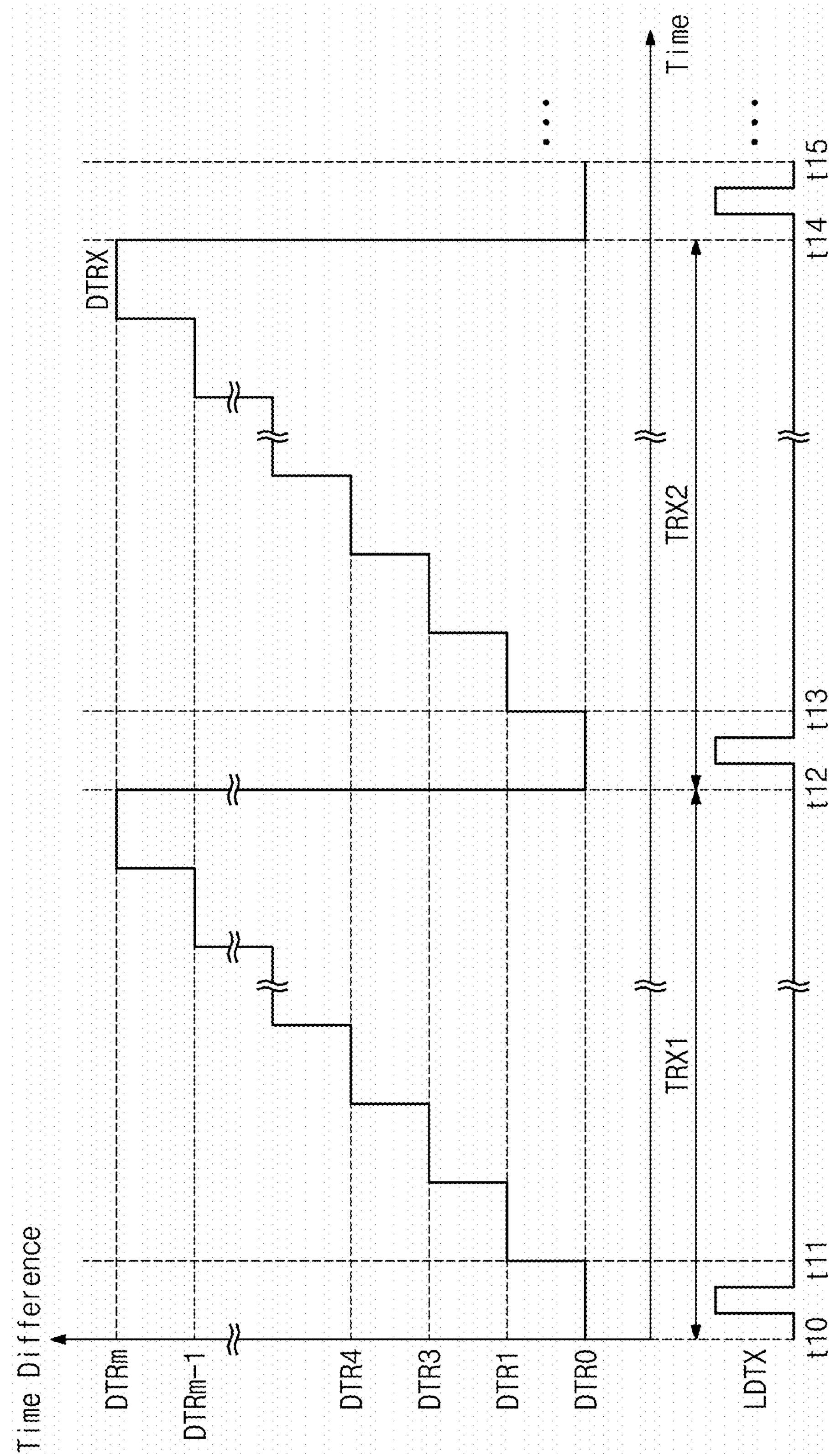

CLK_RX2
CLK_TX2
CLK_RX1
CLK_TX1
DTRX21
DTRX22
DTX2
DTRX11
DTRX12
DTX1
t1 t1a
t2 t2a
t3 t3a
t4 t4a
Time

FIG. 4



Time Difference
DTRm
DTRm-1
DTR4
DTR3
DTR1
DTR0
LDTX
DTRX
TRX1
TRX2
Time
t10
t11
t12
t13
t14
t15

FIG. 5

Radar #	Transmit Clock Period (T)	Variable Period (dT)	Transmit Interval (DTX)
Radar 0 (1100)	T0	dT0	T0-dT0 ~ T0+dT0 (DTX0)
Radar 1 (1101)	T1	dT1	T1-dT1 ~ T1+dT1 (DTX1)
Radar 2 (1102)	T2	dT2	T2-dT2 ~ T2+dT2 (DTX2)
	⋮		
Radar n (110n)	Tn	dTn	Tn-dTn ~ Tn+dTn (DTXn)

FIG. 6

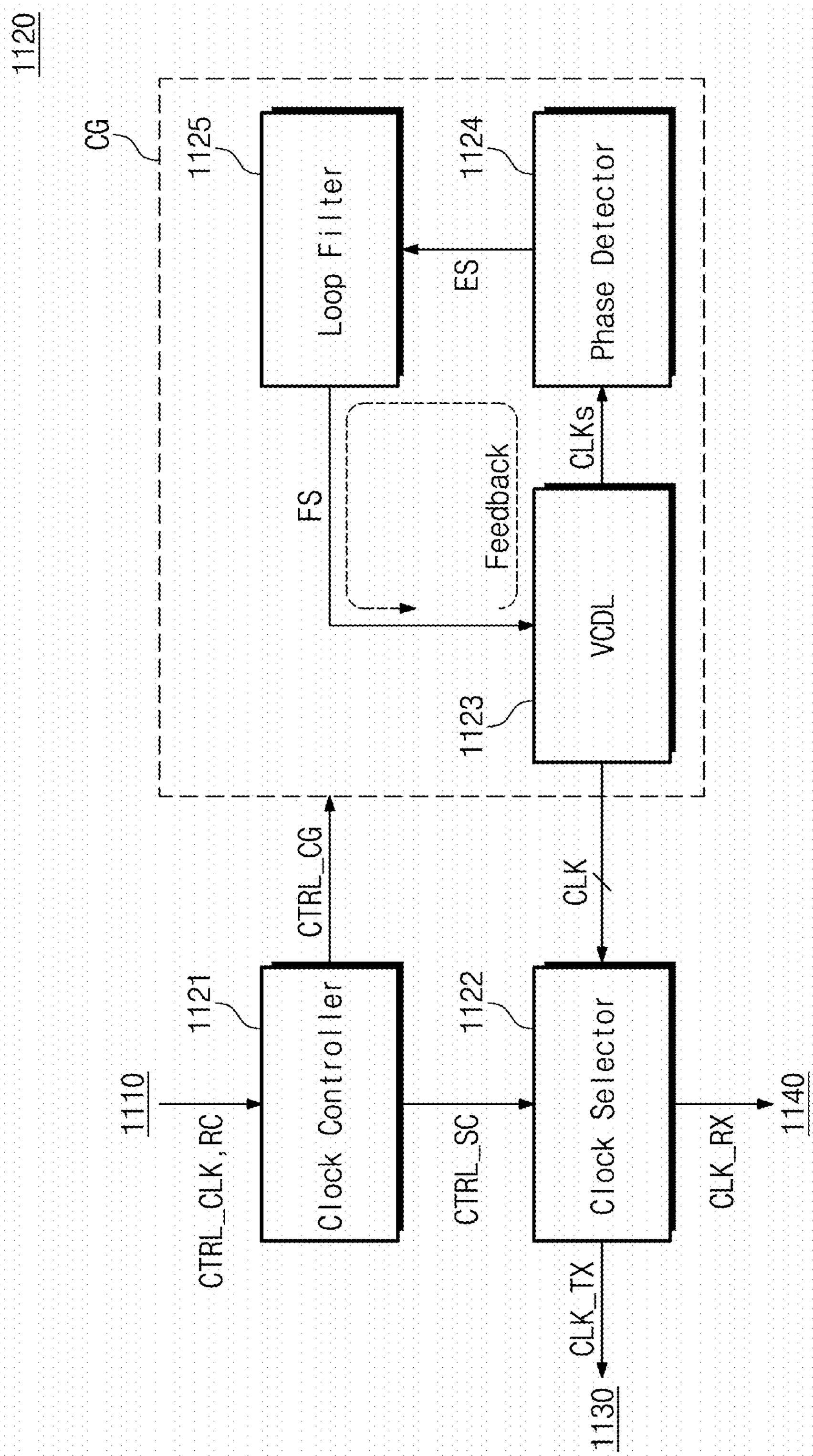

1120
CG
1125
Loop Filter
1124
Phase Detector
ES
FS
Feedback
CLKs
VCDL
1123
CTRL_CG
CLK
1110
CTRL_CLK,RC
1121
Clock Controller
CTRL_SC
1122
Clock Selector
CLK_RX
1140
CLK_TX
1130

FIG. 7

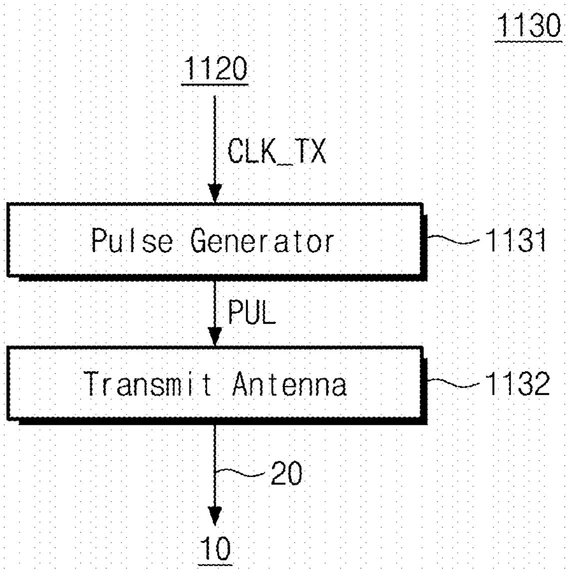


FIG. 8

Radar #	Center frequency of transmit pulse (cf)	Transmit Clock Period (T)
Radar 0 (1100)	F0	T0
Radar 1 (1101)	F1	T1
Radar 2 (1102)	F2	T2
⋮	⋮	⋮
Radar n (110n)	Fn	Tn

FIG. 9

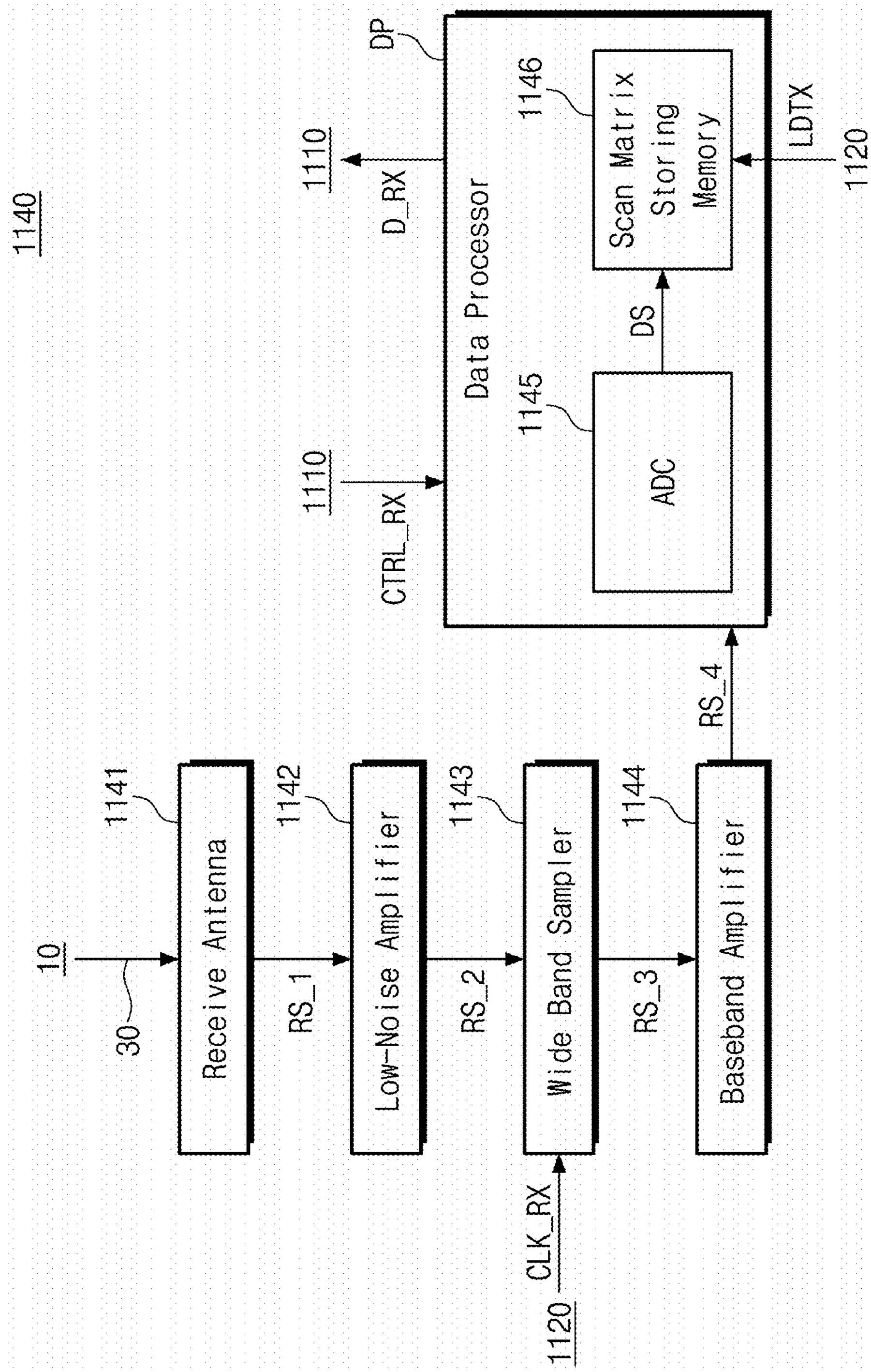
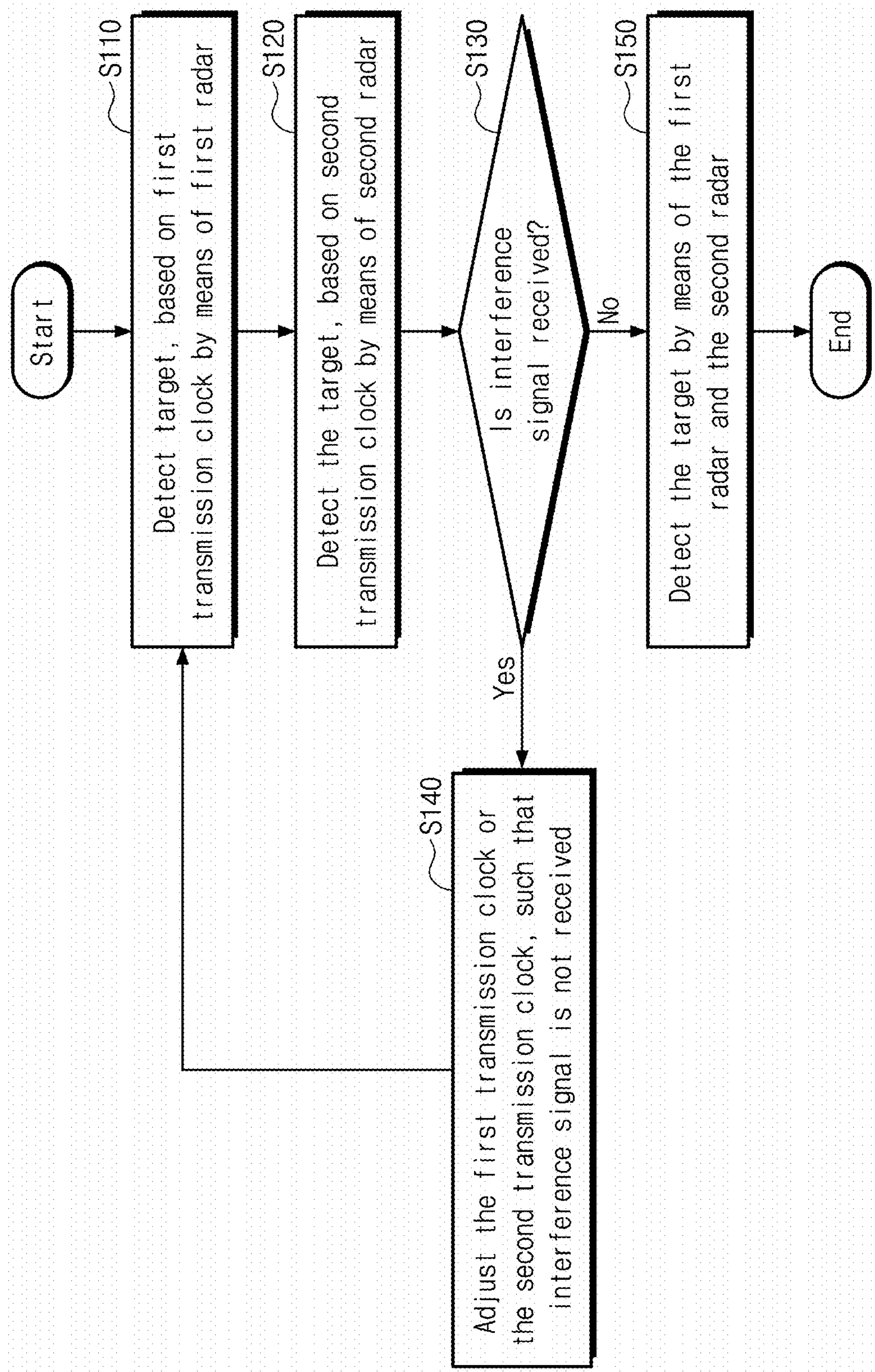

1140
10
30
Receive Antenna
1141
RS_1
Low-Noise Amplifier
1142
RS_2
Wide Band Sampler
1143
CLK_RX
1120
RS_3
Baseband Amplifier
1144
RS_4
DP
Data Processor
1110
CTRL_RX
1110
D_RX
ADC
1145
DS
Scan Matrix Storing Memory
1146
LDTX
1120

FIG. 10


Start
S110
Detect target, based on first transmission clock by means of first radar
S120
Detect the target, based on second tramission clock by means of second radar
S130
Is interference signal received?
No
S150
Detect the target by means of the first radar and the second radar
End
Yes
S140
Adjust the first transmission clock or the second trancession clock, such that interference signal is not received

SYSTEM FOR MUITIPLE RADARS AND OPERATION METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims priority under 35 U.S.C. § 119 to Korean Patent Application No. 10-2024-0019361 filed on Feb. 8, 2024, in the Korean Intellectual Property Office, the disclosures of which are incorporated by reference herein in their entireties.

BACKGROUND

1. Field of the Invention

[0002] Embodiments of the present disclosure described herein relate to a radar apparatus and a radar system, and more particularly, relate to a system for multiple radars and an operation method thereof.

2. Description of Related Art

[0003] A clock-based radar may generate and radiate a transmit signal in response to a clock signal and may receive a response signal originated by the transmit signal, in response to the clock signal. Such a clock-based radar may obtain a distance between the radar and target, with regard to a time difference between a transmission clock signal and a reception clock signal, a speed of a radiated pulse, and the like.

[0004] As it is difficult to detect all of target(s) using only a single radar, a radar system including multiple radars may be constructed for multiple targets. As another example, the radar system including the multiple radars may be constructed to improve the accuracy of detection for a target (or, targets). There is a need for an apparatus, a method, and a system capable of suppressing deterioration in detection performance of each of radars due to interference generated by mutual transmit signals between the multiple radars in such a radar system.

SUMMARY

[0005] Embodiments of the present disclosure provide a radar system for minimizing an interfering signal between multiple radars and optimizing the detection performance of an individual radar of the radar system and an operation method thereof.

[0006] According to an embodiment, a radar system may generate a first transmit pulse in response to a first transmission clock signal. A first radar may be configured to detect a target in response to the first transmission clock signal and a first reception clock signal having a clock delay between the transmission clock signal and the reception clock signal according to a first detection distance. A second radar may be configured to generate a second transmit pulse in response to a second transmission clock signal and detect the target (targets) in response to the second transmission clock signal and a second reception clock signal having a clock delay between the transmission clock signal and the reception clock signal according to a second detection distance. The first transmission clock signal and the second transmission clock signal may not operate in synchronous with each other. The first radar may generate a minimum detection range notification signal, when the first detection distance is a minimum detection distance detected by the first radar.

[0007] In an embodiment, the radar system may further include a third radar. The third radar may generate a third transmit pulse in response to a third transmission clock signal. The third radar may detect the target in response to the third transmission clock signal and a third reception clock signal having a clock delay between transmission and reception clock signal according to a third detection distance. The third transmission clock signal may not be synchronous with the first transmission clock signal and the second transmission clock signal.

[0008] In an embodiment, a first center frequency of the first transmit pulse and a second center frequency of the second transmit pulse may be different from each other

[0009] In an embodiment, the first transmission clock signal may include a first rising edge and a second rising edge. An interval between the first rising edge and the second rising edge may be an arbitrary interval between a first interval and a second interval. The second transmission clock signal may include a third rising edge and a fourth rising edge. An interval between the third rising edge and the fourth rising edge may be an arbitrary interval between a third interval and a fourth interval.

[0010] In an embodiment, the first detection distance may be a distance between a minimum detection distance and a maximum detection distance of the radar system. The second detection distance may be a distance between the minimum detection distance and the maximum detection distance of the radar system.

[0011] In an embodiment, the first radar may include a receiver unit. The configuration of the receiver unit may be as follows. A receive antenna may be configured to receive an echo signal generated after the transmit pulse is reflected from the t target. A low-noise amplifier may be configured to amplify the echo signal to generate a first receive signal. A wide band sampler may be configured to receive the first receive signal and sample the first receive signal in response to a reception clock signal to generate a second receive signal. A data processor may be configured to generate receive data, based on the second receive signal.

[0012] In an embodiment, the first interval and the second interval may be generated based on a first period and a first variable period. The third interval and the fourth interval may be generated based on a second period and a second variable period. The first interval may be a value obtained by subtracting the first variable period from the first period, and the second interval may be a value obtained by adding the first variable period to the first period. The third interval may be a value obtained by subtracting the second variable period from the second period, and the fourth interval may be a value obtained by adding the second variable period to the second period.

[0013] In an embodiment, the receiver unit may further include a baseband amplifier configured to amplify a baseband of the second receive signal to generate a third receive signal. The data processor may include an analog-digital converter (ADC) configured to convert the third receive signal into a digital signal and the digital signal is configured to form a scan vector. The scan vector generates a scan matrix. The scan matrix may be saved in a memory . . .

[0014] In an embodiment, the scan vector and the scan matrix may be generated in response to the minimum detection distance notification.

[0015] According to an embodiment, an operation method of a radar system for detecting a t target may include a first detection stage by means of a first radar based on a first transmission clock signal. The operation may include a second detection stage by means of a second radar based on a second transmission clock signal. The operation may further include detection stages in which the first radar and the second radar detect targets from a minimum detection distance of each of the first radar and the second radar to a maximum detection distance of each of the first radar and the second radar. The first transmission clock signal and the second transmission clock signal may not be synchronous with each other.

[0016] In an embodiment, the first radar may detect the target in response to the first transmission clock signal and a first reception clock signal with a first transmission clock and reception clock signal time difference according to a first detection distance. The second radar may detect the target in response to the second transmission clock signal and a second reception clock signal with a second transmit and reception clock signal time difference according to a second detection distance.

[0017] In an embodiment, the first transmission clock signal may include a first rising edge and a second rising edge. An interval between the first rising edge and the second rising edge may be an arbitrary between a first interval and a second interval. The second transmission clock signal may include a third rising edge and a fourth rising edge. An interval between the third rising edge and the fourth rising edge may be an arbitrary between a third interval and a fourth interval.

[0018] The first interval and the second interval may be generated based on a first period and a first variable period, and the third interval and the fourth interval may be generated based on a second period and a second variable period. The first interval may be a value obtained by subtracting the first variable period from the first period, and the second interval may be a value obtained by adding the first variable period to the first period. The third interval may be a value obtained by subtracting the second variable period from the second period, and the fourth interval may be a value obtained by adding the second variable period to the second period.

[0019] According to an embodiment, a radar configured to detect a target may include the following function units. A control unit may be configured to control an operation of the radar. A transmitter unit may be configured to radiate a transmit pulse to the target, in response to a transmission clock signal. A receiver unit may be configured to receive an echo signal reflected from the target in response to a reception clock signal and generate detection data. A clock generation unit may be configured to generate the transmission clock signal and the reception clock signal. The transmission clock signal may include a first rising edge and a second rising edge. An interval between the first rising edge and the second rising edge may be a first interval obtained by subtracting a first variable period from a first period to a second interval obtained by adding the first variable period to the first period.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The above and other objects and features of the present disclosure will become apparent by describing in detail embodiments thereof with reference to the accompanying drawings.

[0021] FIG. **1** is a block diagram illustrating a radar system according to an embodiment of the present disclosure;

[0022] FIG. **2** is a block diagram illustrating in detail a radar included in a radar system of FIG. **1**;

[0023] FIG. **3** is a graph illustrating a change in transmission clock signal and reception clock signal of each of a plurality of radars over time, according to an embodiment of the present disclosure;

[0024] FIG. **4** is a graph illustrating a change in transmit and reception clock signal time difference of FIG. **3** over time, according to an embodiment of the present disclosure;

[0025] FIG. **5** is a table illustrating a transmit interval between rising edges of a transmission clock signal of each of radars included in a radar system of FIG. **1**, according to an embodiment of the present disclosure;

[0026] FIG. **6** is a block diagram illustrating in detail a clock generation unit of FIG. **2**, according to an embodiment of the present disclosure;

[0027] FIG. **7** is a block diagram illustrating in detail a transmitter unit, according to an embodiment of the present disclosure;

[0028] FIG. **8** is a table illustrating a center frequency of a transmit pulse generated by a transmitter unit and a transmission clock signal frequency, according to an embodiment of the present disclosure;

[0029] FIG. **9** is a block diagram illustrating in detail a receiver unit, according to an embodiment of the present disclosure; and

[0030] FIG. **10** is a flowchart illustrating an operation method of a radar system described with reference to FIGS. **1** to **9**, according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0031] Hereinafter, embodiments of the present disclosure will be described clearly and in detail to such an extent that those skilled in the art easily carry out the present disclosure.

[0032] FIG. **1** is a block diagram illustrating a radar system, according to an embodiment of the present disclosure. Referring to FIG. **1**, a radar system **1000** may include a plurality of radars **1100** to **110*n***. Each of the plurality of radars **1100** to **110*n*** may include the 0th radar **1100** and first to nth radars **1101** to **110*n***. The radar system **1000** according to an embodiment of the present disclosure will be described in detail with reference to FIG. **1**.

[0033] The radar system **1000** may be a system for finding a target **10**. For example, the use of the radar system **1000** may vary. For example, the radar system **1000** may be included in systems of various uses, such as a system for detecting a person in indoor, a system for navigation device, a military system, or a fish detection system. In an embodiment, the radar system **1000** may be a system which operates based on a clock. The target **10** may be a target to be detected by the radar system **1000**, which may be another target depending on the purpose of the radar system **1000**. For example, when the radar system **1000** is the military system, the target **10** may be equipment, a radar, or the like of an ally or an enemy.

[0034] Each of the radars **1100** to **110***n* may detect the target **10**. In an embodiment, the radars **1100** to **110***n* may independently detect the target **10**. For example, the first radar **1101** may detect the target **10** regardless of an operation of the 0th radar **1100** or the third radar **1103**. In an embodiment, the radars **1100** to **110***n* may be clock-based radars. For example, the radars **1100** to **110***n* may operate based on a plurality of clocks generated based on reference clocks.

[0035] The radars **1100** to **110***n* may generate and radiate transmit pulses **20** to **2***n*, respectively, to detect the target **10**. For example, the 0th radar **1100** may generate the 0th transmit pulse **20** and may radiate the generated 0th transmit pulse **20** to the target **10**. Likewise, the first radar **1101** may generate the first transmit pulse **21** and may radiate the generated first transmit pulse **21** to the target **10**. The transmit pulses **20** to **2***n* radiated by the radars **1100** to **110***n* may reach the target **10** and an echo pulse **30** reflects. Each of the radars **1100** to **110***n* may generate detection data from the received echo pulse **30**, depending on an operation of a clock of the radar.

[0036] The arrangement of the radars **1100** to **110***n*, which is illustrated and described in FIG. **1**, is illustrative, and the scope of the present disclosure is not limited thereto. It should be understood that an embodiment in which the radars **1100** to **110***n* are arranged in any distance or any distribution also belongs to the scope of the present disclosure.

[0037] In the above-mentioned radar system **1000**, an interference signal from the adjacent radars may be received in each of the radars **1100** to **110***n*. The interference signal may result in deterioration in detection performance of each of the radars **1100** to **110***n* and deterioration in detection performance of the radar system **1000**. Thus, there is a need for the radar system **1000** in which the interference signal of each of the radars **1100** to **110***n* is minimized. Hereinafter, a structure and an operation of each of the radars **1100** to **110***n*, for providing the radar system **1000** in which the interference signal is minimized, and an operation of the radar system **1000** will be described in detail with reference to the drawings.

[0038] FIG. **2** is a block diagram illustrating in detail a radar **1100** of FIG. **1** according to an embodiment of the present disclosure. Hereinafter, the radar **1100** may correspond to at least one of radars **1100** to **110***n* of FIG. **1**. Referring to FIG. **2**, the radar **1100** may include a control unit **1110**, a clock generation unit **1120**, a transmitter unit **1130**, and a receiver unit **1140**. The radar according to embodiment of the present disclosure will be described in detail with reference to FIGS. **1** and **2**. In an embodiment, the radar **1100** may be a radar which operates based on a clock signal.

[0039] The control unit **1110** may control an operation of the radar **1100**, based on a control signal. In an embodiment, the control unit **1110** may control the clock generation unit **1120** and the receiver unit **1140**, based on control signals. For example, the control unit **1110** may control the clock generation unit **1120** based on a clock generation unit control signal CTRL_CLK and may control the receiver unit **1140** based on a receiver unit control signal CTRL_RX.

[0040] In an embodiment, the control unit **1110** may receive data D_RX from the receiver unit **1140**. For example, the control unit **1110** may receive the receive data D_RX from the receiver unit **1140** and may transmit detection data generated based on the receive data D_RX to an external device (not shown). In an embodiment, the control unit **1110** may generate a reference clock. For example, the control unit **1110** may generate a reference clock RC and may provide the clock generation unit **1120** with the generated reference clock RC.

[0041] The clock generation unit **1120** may generate a clock required for an operation of the radar **1100**. In an embodiment, the clock generation unit **1120** may generate clocks, under control of the control unit **1110**. For example, the clock generation unit **1120** may generate clock signals, in response to the clock generation unit control signal CTRL_CLK of the control unit **1110**. The clock signals may be generated based on the reference clock RC.

[0042] In an embodiment, the clock signals may include a transmission clock signal CLK_TX and a reception clock signal CLK_RX. For example, the clock generation unit **1120** may provide the transmitter unit **1130** with the transmission clock signal CLK_TX and may provide the receiver unit **1140** with the reception clock signal CLK_RX. A more detailed structure and example of the clock generation unit **1120** will be described with reference to FIG. **6**, and the transmission clock signal CLK_TX and the reception clock signal CLK_RX will be described in detail with reference to FIGS. **3** to **5**.

[0043] The transmitter unit **1130** may generate a transmit pulse **20**. In an embodiment, the transmitter unit **1130** may generate and radiate the transmit pulse **20**, in response to the clock signal. For example, the transmitter unit **1130** may generate the transmit pulse **20**, in response to the transmission clock signal CLK_TX received from the clock generation unit **1120**. The generated transmit pulse **20** may be radiated toward a target **10**. A more detailed structure and operation of the transmitter unit **1130** will be described in detail with reference to FIG. **7**.

[0044] The receiver unit **1140** may generate the receive data D_RX based on an echo pulse **30** received from the target **10**. In an embodiment, the receiver unit **1140** may operate, in response to the reception clock signal CLK_RX. For example, the receiver unit **1140** may generate the receive data D_RX from the echo pulse **30** generated from the target **10**, in response to the reception clock signal CLK_RX. The receiver unit **1140** may transmit the generated receive data D_RX to the control unit **1110**. A more detailed structure and operation of the receiver unit **1140** will be described in detail with reference to FIG. **9**.

[0045] Referring to FIG. **2**, the embodiment in which the radar **1100** includes only the one receiver unit **1140** is illustrated. However, the scope of the present disclosure is not limited thereto. It should be understood that an embodiment of the radar **1100** including two or more receiver units **1140** also belongs to the scope of the present disclosure. For example, the radar **1100** may receive the echo pulse **30**, via a receive antenna (e.g., a receive antenna **1141** of FIG. **9**) included in each of the plurality of receiver units.

[0046] It is illustrated in FIG. **2** that the radar **1100** includes the one transmitter unit **1130** and the one receiver unit **1140**, but the scope of the present disclosure is not limited thereto. In an embodiment, the radar **1100** may include the plurality of transmitter units **1130** or the plurality of receiver units **1140**.

[0047] Hereinafter, an operation in which a radar system **1000** of FIG. **1** may suppress an interference signal between radars **1100** to **110***n* and may use the radar system **1000** at maximum efficiency will be described, according to an embodiment of the present disclosure, with reference to FIGS. **3** to **5**.

[0048] FIG. **3** is a graph illustrating a change in clocks generated by each of two radars among radars **1100** to **110***n* over time, according to an embodiment of the present disclosure. Referring to FIG. **3**, changes in first transmission clock signal CLK_TX**1**, second transmission clock signal CLK_TX**2**, first reception clock signal CLK_RX**1**, and second reception clock signal CLK_RX**2** over time are illustrated. The horizontal axis of FIG. **3** may indicate time, and the vertical axis may indicate the signal voltage. A first clock CLK**1** may indicate or include the first transmission clock signal CLK_TX**1** or the first reception clock signal CLK_RX**1**, and a second clock CLK**2** may indicate or include the second transmission clock signal CLK_TX**2** or the second reception clock signal CLK_RX**2**.

[0049] The first transmission clock signal CLK_TX**1** or the first reception clock signal CLK_RX**1** may be a transmission clock signal CLK_TX or a reception clock signal CLK_RX generated by a clock generation unit of any one of radars **1100** to **110***n* of FIG. **1**. The second transmission clock signal CLK_TX**2** or the second reception clock signal CLK_RX**2** may be a transmission clock signal CLK_TX or the reception clock signal CLK_RX generated by a clock generation unit of any one of the radars **1100** to **110***n*, which is different from a radar which generates a first clock CLK1 of FIG. **1**. A description will be given of an operation and method for detecting a target **10** in a radar system **1000** and a method for avoiding an interference signal in each of radars **1100** to **110***n* in the radar system **1000**.

[0050] Referring to FIG. **3**, the first transmission clock signal CLK_TX**1** may has a first transmit interval DTX**1**. For example, the first transmission clock signal CLK_TX**1** may have a rising edge at a first time point t**1** and may similarly have a rising edge at a third time point t**3**. A time difference between the first time point t**1** and the third time point t**3** may be the first transmit interval DTX**1**. A transmitter unit **1130** which operates in response to the first transmission clock signal CLK_TX**1** may generate a transmit pulse (e.g., a 0th transmit pulse **20**), in response to that the first transmission clock signal CLK_TX**1** is the rising edge or the positive edge.

[0051] The first reception clock signal CLK_RX**1** may have a rising edge after a certain time after the rising edge or the positive edge of the first transmission clock signal CLK_TX**1** is generated. For example, the first reception clock signal CLK_RX**1** may have a rising edge at a second time point t**2** which is a time point after a transmission clock and reception clock signal time difference DTRX**11** from the first time point t**1**. Likewise, the first reception clock signal CLK_RX**1** may have a rising edge at a fourth time point t**4** which is a time point after a transmission clock and reception clock signal time difference DTRX**12** from the third time point t**3**. A receiver unit **1140** which operates in response to the first reception clock signal CLK_RX**1** may generate receive data D_RX from an echo pulse **30**, in response to that the first reception clock signal CLK_RX**1** is the rising edge or the positive edge.

[0052] In an embodiment, the first transmit interval DTX**1** may be maintained at the same time interval. For example, the first transmit interval DTX**1** may correspond to a first period. A transmit interval DTX may indicate or include the first transmit interval DTX**1** and a second transmit interval DTX**2**. The transmit interval DTX will be described in detail with reference to FIG. **5**. The 11th transmission clock and reception clock signal time difference DTRX**11** and the 12th transmission clock and reception clock signal time difference DTRX**12** may be an interval between the rising edge or the positive edge of the first transmission clock signal CLK_TX**1** and the rising edge or the positive edge of the first reception clock signal CLK_RX**1**. A transmission clock and reception clock signal time difference DTRX may indicate or include the 11th transmission clock and reception clock signal time difference DTRX**11** and the 12th transmission clock and reception clock signal time difference DTRX**12** and a 21st transmission clock and reception clock signal time difference DTRX**21** and a 22nd transmission clock and reception clock signal time difference DTRX**22**, which will be described below. In an embodiment, the transmission clock and reception clock signal time difference DTRX may be used to determine detection distances of radars **1100** to **110***n*. A more detailed example of the transmission clock and reception clock signal time difference DTRX will be described in detail with reference to FIG. **4**.

[0053] The second transmission clock signal CLK_TX**2** may have the second transmit interval DTX**2**. In an embodiment, the second transmission clock signal CLK_TX**2** may have a rising edge at a time point e which is different from the first transmission clock signal CLK_TX**1** edge. For example, the second transmission clock signal CLK_TX**2** may have a rising edge at a 1ath time point t**1***a* different from the first time point t**1** and may have a rising edge at a 3ath time point t**3***a* different from the third time point t**3**. An interval between the 1ath time point t**1***a* and the 3ath time point t**3***a* may be the second transmit interval DTX**2**. The transmitter unit **1130** which operates in response to the second transmission clock signal CLK_TX**2** may generate a transmit pulse (e.g., a first transmit pulse **21**), in response to that the second transmission clock signal CLK_TX**2** is the rising edge or the positive edge.

[0054] The second reception clock signal CLK_RX**2** may have a rising edge after a certain time after the rising edge or the positive edge of the second transmission clock signal CLK_TX**2** is generated. For example, the second reception clock signal CLK_RX**2** may have a rising edge at a 2ath time point t**2***a* which is a time point after the 21st transmission clock and reception clock signal time difference DTRX**21** from the 1ath time point t**1***a* and is different from the second time point t**2**. Likewise, the second reception clock signal CLK_RX**2** may have a rising edge at a 4ath time point t**4***a* which is a time point after the 22nd transmission clock and reception clock signal time difference DTRX**22** from the third time point t**3** and is different from the fourth time point t**4**. The receiver unit **1140** which operates in response to the second reception clock signal CLK_RX**2** may generate receive data D_RX from the echo pulse **30**, in response to that the second reception clock signal CLK_RX**2** is the rising edge or the positive edge.

[0055] The details described above are illustrative, and the scope of the present disclosure is not understood as being limited thereto. It should be understood that an embodiment in which the transmitter unit **1130** or the receiver unit **1140** responds to a falling edge or a negative edge also belongs to the scope of the present disclosure. In an embodiment, the transmitter unit **1130** or the receiver unit **1140** may operate, in response to that the first clock CLK**1** or the second clock CLK**2** is the rising edge or the positive edge or the falling edge or the negative edge.

[0056] A radar system **1000** may remove or reduce an interference signal of the radars **1100** to **110***n*, based on the first clock CLK**1** and the second clock CLK**2**, which are described above. The transmission clock signal of each of the radars **1100** to **110***n* may fail to be synchronous with the first transmission clock signal CLK_TX**1** and the second transmission clock signal CLK_TX**2** of FIG. **3** and may reduce an interference signal between the adjacent radars **1100** to **110***n*. This is because the radars **1100** to **110***n* are able to receive mutual interference signals, when transmission clock signals are synchronous with each other. Hereinafter, the transmission clock and reception clock signal time difference DTRX or the transmit interval DTX of the radar system **1000** will be described and an operation and a method for removing or reducing a detection range and an interference signal of the radar system **1000** will be described, with reference to FIGS. **4** and **5**.

[0057] FIG. **4** is a graph illustrating a change in transmission clock and reception clock signal time difference DTRX of FIG. **3** over time, according to an embodiment of the present disclosure. Referring to FIG. **4**, a transmission clock and reception clock signal time difference DTRX and a minimum detection distance notification signal LDTX are illustrated. The horizontal axis of FIG. **4** may indicate time, and the vertical axis may indicate the magnitude of the time difference DTR of the transmission clock and reception clock signal DTRX. A description will be given of a process of changing the transmission clock and reception clock signal time difference DTRX and a detection distance in a radar system **1000** with reference to FIGS. **1** to **4**.

[0058] The transmission clock and reception clock signal time difference DTRX may change at a certain period. The transmission clock and reception clock signal time difference DTRX may have the certain period. In an embodiment, the transmission clock and reception clock signal time difference DTRX may change at the certain period from a minimum time difference to a maximum time difference. For example, referring to FIG. **4**, the transmission clock and reception clock signal time difference DTRX may periodically change from a 0th time difference DTR**0** to an mth time difference DTRm. For a more detailed example, the transmission clock and reception clock signal time difference DTRX may increase from the 0th time difference DTR**0** to the mth time difference DTRm from a 0th time point t**10** to a second time point t**12** and may similarly increase from the 0th time difference DTR**0** to the mth time difference DTRm from the second time point t**12** to a fourth time point t**14**. A first interval TRX**1** from the 0th time point t**10** to the second time point t**12** and a second interval TRX**2** from the second time point t**12** to the fourth time point t**14** may be the same as each other. In an embodiment, the first interval TRX**1** and the second interval TRX**2** may be a detection period. In another embodiment, the first interval TRX**1** or the second interval TRX**2** may randomly change, and the first interval TRX**1** and the second interval TRX**2** may not be the same as each other.

[0059] In an embodiment, the time difference of the transmission clock and reception clock signal time difference DTRX may sequentially change in a value between the minimum time difference and the maximum time difference. For example, the time difference of the transmission clock and reception clock signal time difference DTRX may sequentially change from the 0th time difference DTR**0** to the mth time difference DTRm. For a more detailed example, the transmission clock and reception clock signal time difference DTRX may have the 0th time difference DTR**0** at the 0th time point t**10** and may sequentially increase to the first time difference DTR**1** and the second time difference DTR**2** and may increase to the mth time difference DTRm (hereinafter, where m is any natural number). The change in the transmission clock and reception clock signal time difference DTRX described above is illustrative. It should be understood that an embodiment of changing to any time difference (e.g., randomly) between the 0th time difference DTR**0** and the mth time difference DTRm and performing detection at at least one time difference during a pulse repetition period also belongs to the scope of the present disclosure.

[0060] As the transmission clock and reception clock signal time difference DTRX increases, the radar system **1000** may detect a farther distance. This is because the transmission clock and reception clock signal time difference DTRX is a time difference between a transmission clock signal CLK_TX and a reception clock signal CLK_RX. They are associated with a time when a transmit pulse **20** returns from a target **10**. A detection distance becomes longer as there is an increase in a total time when an echo pulse **30** generated after the transmit pulse **20** reaches the target **10** returns.

[0061] In an embodiment, a difference between adjacent time differences DR**0** to DRm may correspond to resolution of radars **1100** to **110***n* of FIG. **2**. For example, an interval between the 0th time difference DTR**0** and the first time difference DTR**1** may be a time difference corresponding to resolution of the radar system **1000**. Likewise, an interval between the m-1st time difference DTRm-**1** and the mth time difference DTRm may be a time difference corresponding to the resolution of the radar system **1000**.

[0062] In an embodiment, each of the radars **1100** to **110***n* may adjust the transmission clock signal CLT_TX and the reception clock signal CLK_RX, depending on the transmission clock and reception clock signal time difference DTRX of FIG. **4**. Thus, the radars **1100** to **110***n* may detect the target **10** from a minimum detection distance to a maximum detection distance. In an embodiment, the radars **1100** to **110***n* may adjust the 0th time difference DTR**0** or the mth time difference DTRm to control the minimum detection distance or the maximum detection distance. Referring to FIG. **4**, it is shown that the transmission clock and reception clock signal time difference DTRX increases at equal intervals, but the present disclosure is not limited thereto.

[0063] In an embodiment, while the magnitude of the time difference DTR is maintained, a clock generation unit **1120** may generate a plurality of rising edges of the transmission clock signal CLK_TX. In an embodiment, while the first time difference DTR**1** is maintained, the clock generation unit **1120** may generate a plurality of rising edges in the transmission clock signal CLK_TX. In an embodiment, the clock generation unit **1120** may generate each of rising edges of the transmission clock signal CLK_TX and a plurality of rising edges of the reception clock signal CLK_RX having the time difference DTR. For example, while the first time difference DTR**1** is maintained, the clock generation unit **1120** may generate a plurality of rising edges rising edges of the transmission clock signal CLK_TX and a plurality of rising edges rising edges of the reception clock signal CLK_RX having the first time difference DTR**1**. A transmitter unit **1130** or a receiver unit **1140** of FIG. **2** may generate the transmit pulse **20**, in response to that the respective clocks are rising edges, or may generate receive data D_RX from the echo pulse **30**.

[0064] When the transmission clock and reception clock signal time difference DTRX is the 0th time difference DTR**0** which is the minimum time difference, a minimum detection distance notification signal LDTX may be generated. In an embodiment, the minimum detection distance notification signal LDTX may be generated by the clock generation unit **1120**, and the generated minimum detection distance notification signal LDTX may be delivered to a control unit **1110** and the receiver unit **1140**. The minimum detection distance notification signal LDTX may be generated at any time point while the transmission clock and reception clock signal time difference DTRX is the 0th time difference DTR**0**. For example, the minimum detection distance notification signal LDTX may be generated at any time point between the 0th time point t**10** and the first time point t**11** and may be similarly generated at any time point between the second time point t**12** and the third time point t**13**.

[0065] The radar system **1000** may detect the target **10** between the minimum detection distance to the maximum detection distance, based on the above-mentioned embodiments, by means of FIG. **4**. In an embodiment, the transmission clock and reception clock signal time differences DTRX of the radars **1100** to **110***n* may change in the same manner. However, this is illustrative. An embodiment in which the transmission clock and reception clock signal time difference DTRX of each of the radars **1100** to **110***n* changes in a different manner also belongs to the scope of the present disclosure.

[0066] FIG. **5** is a table illustrating in detail a transmit interval DTX of FIG. **3**, according to an embodiment of the present disclosure. Referring to FIG. **5**, a transmission clock signal period T, a variable period dT, and a transmit interval DTX corresponding to each of radars **1100** to **110***n* are illustrated. Referring to FIGS. **1**, **2**, and **5**, according to an embodiment of the present disclosure, transmit intervals DTX of the radars **1100** to **110***n* will be described, and an operation and a method for avoiding an interference signal in each of the radars **1100** to **110***n* will be described.

[0067] Referring to FIGS. **1** and **5** together, each of the radars **1100** to **110***n* may have the transmission clock signal period T, the variable period dT, and the transmit interval DTX. In an embodiment, the transmit interval DTX of each of the radars **1100** to **110***n* may be determined based on the transmission clock signal period T and the variable period dT. For example, a 0th transmit interval DTX**0** of the 0th radar **1100** may be determined based on a 0th transmission clock signal period T**0** and a 0th variable period dT**0**.

[0068] In an embodiment, the transmit interval DTX may be any time interval which is around the transmission clock signal period T and is selected within the range of the variable period dT. For example, a first transmit interval DTX**1** of the first radar **1101** may be a time randomly selected between a first time (T**1**-dT**1**) obtained by subtracting a first variable period dT**1** from a first transmission clock signal period T**1** and a second time (T**1**+dT**1**) obtained by adding the first variable period dT**1** to the first transmission clock signal period T**1**. Like the first transmit interval DTX**1** of the first radar **1101**, each of the 0th radar **1100** and the second to nth radars **1102** to **110***n* may also have the transmit interval DTX.

[0069] In an embodiment, all the 0th to nth transmission clock signal periods T**0** to Tn may be the same as each other. For example, all the first to nth transmission clock signal periods T**1** to Tn may be the same as the 0th transmission clock signal period T**0**. In this case, all of transmission clock signals of the radars **1100** to **110***n* may not be synchronous with each other. In an embodiment, at least one of the 0th to nth transmission clock signal periods T**0** to Tn may have a value different from another transmission clock signal period. For example, the 0th transmission clock signal period T**0** may be the same as the first transmission clock signal period T**1** and may be different from the second transmission clock signal period T**2**. In this case, the 0th to nth transmission clock signal periods T**0** to Tn may be set such that all the transmission clock signals of the radars **1100** to **110***n* are not synchronous with each other. The variable period dT may be a time interval smaller than the transmission clock signal period T.

[0070] A radar system **1000** of FIG. **1** may prevent an interference signal between the radars **1100** to **110***n* in the radar system **1000** from being received, based on the embodiments described with reference to FIGS. **2** to **5**. For a more detailed example, as described with reference to FIGS. **4** and **5**, each of the radars **1100** to **110***n* may have the different transmission clock signal period T and may randomly adjust a time when a rising edge of the transmission clock signal CLK_TX is generated, by means of the variable period dT. Thus, the radars **1100** to **110***n* included in the radar system **1000** may not be synchronous in transmission clock signal CLK_TX with the adjacent radars **1100** to **110***n* and may not receive an interference signal.

[0071] FIG. **6** is a block diagram illustrating in detail a clock generation unit **1120** of FIG. **2**, according to an embodiment of the present disclosure. Referring to FIG. **6**, the clock generation unit **1120** may include a clock controller **1121**, a clock selector **1122**, and a clock generator CG. The clock generator CG may include a voltage controlled delay line (VCDL) **1123**, a phase detector **1124**, and a loop filter **1125**. In an embodiment, the clock generation unit **1120** may be implemented as an integrated circuit (IC) (e.g., an application-specific integrated circuit (ASIC), field programmable gate arrays (FPGA), or the like). The clock generation unit **1120** according to an embodiment of the present disclosure will be described in detail with reference to FIG. **6**.

[0072] The clock controller **1121** may control the overall operation of the clock generation unit **1120**. The clock controller **1121** may operate in response to control of a control unit **1110** of FIG. **2**. For example, the clock controller **1121** may receive a clock generation unit control signal CTRL_CLK from the control unit **1110** and may control the overall operation of the clock generation unit **1120**, based on the received clock generation unit control signal CTRL_CLK. The clock controller **1121** may receive a reference clock RC from the control unit **1110** and may provide the clock generator CG with the received reference clock RC.

[0073] In an embodiment, the clock controller **1121** may receive information including timing for generating rising edges rising edges of clocks from the control unit **1110**. For example, the clock controller **1121** may receive information including a transmit interval DTX described with reference to FIGS. **3** and **5** or a transmission clock and reception clock signal time difference DTRX described with reference to FIG. **4**, a change in the transmission clock and reception clock signal time difference DTRX, and the like from the control unit **1110**.

[0074] The clock controller **1121** may control the clock selector **1122** and the clock generator CG. In an embodiment, the clock controller **1121** may control the clock selector **1122** and the clock generator CG, based on control signals. For example, the clock controller **1121** may control the clock generator CG, based on a clock generator control signal CTRL_CG and may control the clock selector **1122**, based on a selection control signal CTRL_SC.

[0075] The clock selector **1122** may select a transmission clock signal CLK_TX or a reception clock signal CLK_RX among a plurality of clocks CLKs. In an embodiment, the clock selector **1122** may operate in response to the selection control signal CTRL_SC. For example, the clock selector **1122** may select the transmission clock signal CLK_TX or the reception clock signal CLK_RX among the clocks CLKs, in response to the selection control signal CTRL_SC. The clock selector **1122** may provide a transmitter unit **1130** with the generated transmission clock signal CLK_TX and may provide the receiver unit **1140** with the generated reception clock signal CLK_RX.

[0076] In an embodiment, the selection control signal CTRL_SC may include a transmit interval DTX and a transmission clock and reception clock signal time difference DTRX. For example, the clock selector **1122** may select the transmission clock signal CLK_TX based on information about the transmit interval DTX included in the selection control signal CTRL_SC. The clock selector **1122** may similarly select the reception clock signal CLK_RX based on information about the transmission clock and reception clock signal time difference DTRX included in the selection control signal CTRL_SC.

[0077] The clock generator CG may generate the clocks CLKs. For example, the clock generator CG may include a delay locked loop (DLL). The VCDL **1123** may generate a clock signal, in response to a voltage signal. In an embodiment, the VCDL **1123** may generate the clocks CLKs, in response to a clock generator control signal CTRL_CG or a feedback signal FS. In an embodiment, the VCDL **1123** may be composed of multiple stages. For example, the VCDL **1123** may be composed of the multiple stages and may generate clocks, in response to each of several voltages. The VCDL **1123** may provide the clock selector **1122** and the phase detector **1124** with the generated clocks CLKs.

[0078] The phase detector **1124** may detect phases of the clocks CLKs. In an embodiment, the phase detector **1124** may generate an error signal ES, based on comparison between the detected phase and the input signal. For example, the phase detector **1124** may detect phase of the clock CLK and may generate the error signal ES, based on comparison with the input signal included in the clock generator control signal CLK_CG. The phase detector **1124** may provide the loop filter **1125** with the generated error signal ES.

[0079] The loop filter **1125** may generate the feedback signal FS, based on the error signal ES. The loop filter **1125** may provide the VCDL **1123** with the generated feedback signal FS. The VCDL **1123** may generate the clocks CLKs again, based on the received feedback signal FS. The VCDL **1123**, the phase detector **1124**, and the loop filter **1125** may perform feedback, based on the above-mentioned operations. The clock generator CG may generate the clocks CLKs corresponding to a plurality of delays, based on the feedback.

[0080] FIG. **7** is a block diagram illustrating in detail a transmitter unit **1130** of FIG. **2**, according to an embodiment of the present disclosure. Referring to FIG. **7**, the transmitter unit **1130** may include a pulse generator **1131** and a transmit antenna **1132**. Referring to FIG. **7**, the structure of the transmitter unit **1130** according to embodiment of the present disclosure will be described in detail. In an embodiment, the transmitter unit **1130** may be implemented as an integrated circuit (IC) (e.g., an application-specific integrated circuit (ASIC), field programmable gate arrays (FPGA), or the like). For example, the pulse generator **1131** of the transmitter unit **1130** may be implemented as an IC.

[0081] The pulse generator **1131** may generate a pulse signal PUL. In an embodiment, the pulse generator **1131** may generate the pulse signal PUL, in response to a transmission clock signal CLK_TX. For example, the pulse generator **1131** may generate the pulse signal PUL, in response to that the transmission clock signal CLK_TX is a rising edge.

[0082] In an embodiment, the pulse generator **1131** may include various circuits for generating a pulse. For example, the pulse generator **1131** may include a variable oscillation interval circuit. The variable oscillation interval circuit may be a voltage-controlled oscillator circuit for oscillating during a time corresponding to a variable oscillation interval or may include the voltage-controlled oscillator circuit. The pulse generator **1131** may provide the transmit antenna **1132** with the generated pulse signal PUL.

[0083] The transmit antenna **1132** may radiate the transmit pulse **20** to a target **10**. In an embodiment, the transmit antenna **1132** may radiate the received pulse signal PUL as the transmit pulse **20**. For example, the transmit antenna **1132** may radiate the transmit pulse **20** generated based on the pulse signal PUL received from the pulse generator **1131** to the target **10**.

[0084] FIG. **7** is illustrated and described on the basis of that the transmitter unit **1130** includes the one transmit antenna **1132**, but the scope of the present disclosure is not limited thereto. In an embodiment, the transmitter unit **1130** may include the plurality of transmit antennas **1132**. Each transmit antenna **1132** may generate and radiate the transmit pulse **20** based on the pulse signal PUL received from the pulse generator **1131**.

[0085] FIG. **8** is a table illustrating a center frequency of a transmit pulse **20** of FIG. **7** of each of radars **1110** to **110***n* and a period of a transmission clock signal CLK_TX of FIGS. **3** and **5**, according to an embodiment of the present disclosure. Referring to FIG. **8**, a center frequency of a transmit pulse and a clock period of each of radars **1110** to **110***n* of FIG. **1** are illustrated. An embodiment of reducing an interference signal of a radar system **1000** of FIG. **1** will be described with reference to FIG. **8**.

[0086] Referring to FIG. **1** together, as the table shown in FIG. **8**, each of the radars **1100** to **110***n* may generate transmit pulses, each of which has a center frequency fc and has a transmission clock signal period T described with reference to FIG. **5**. In an embodiment, the center frequencies fc of the radars **1100** to **110***n* may be different from each other. For example, a 0th center frequency F**0** of the 0th radar **1100** and a first center frequency F**1** of the first radar **1101** may be different from each other. Likewise, a second center frequency F**2** of the second radar **1102** and a center frequency Fn of the nth radar **110***n* may be different from each other. A radar system **1000** may make center frequencies of transmit pulses **20** to **2***n* of the radars **1100** to **110***n* different from each other, such that interference of the adjacent radars **1100** to **110***n* is not received or reduced.

[0087] As described with reference to FIGS. **3**, **5**, and **8**, by differently setting the center frequency of each of the transmit pulses **20** to **2***n*, the radar system **1000** may suppress the reception of an interference signal between the adjacent radars **1100** to **110***n*. It should be understood that embodiments for removing or reducing the reception of the interference signal between the adjacent radars **1100** to **110***n* of the radar system **1000** of FIG. **1** may be independently executed or may be executed by combining two or more of the embodiments.

[0088] FIG. **9** is a block diagram illustrating in detail a receiver unit **1140** of FIG. **2**, according to an embodiment of the present disclosure. Referring to FIG. **9**, the receiver unit **1140** may include a receive antenna **1141**, a low-noise amplifier **1142**, a wide band sampler **1143**, a baseband amplifier **1144**, and a data processor DP. The data processor DP may include an analog-digital converter (ADC) **1145** and a scan matrix storing memory **1146**. In an embodiment, the receiver unit **1140** may be implemented as an integrated circuit (IC) (e.g., an application-specific integrated circuit (ASIC), field programmable gate arrays (FPGA), or the like). The receiver unit **1140** according to an embodiment of the present disclosure will be described in detail with reference to FIG. **9**.

[0089] The receive antenna **1141** may receive and convert an electromagnetic wave into an electrical signal. In an embodiment, the receive antenna **1141** may receive an echo pulse **30** generated from a target **10**. For example, the receive antenna **1141** may receive the echo pulse **30** from the target **10** and may provide the low-noise amplifier **1142** with the received echo pulse **30** as a first receive signal RS_**1**.

[0090] FIG. **9** is illustrated and described on the basis of that the receiver unit **1140** includes the one receive antenna **1141**, but the scope of the present disclosure is not limited thereto. In an embodiment, the receiver unit **1140** may include the plurality of receive antennas **1141**. Each receive antenna **1141** may receive the echo pulse **30** from the target **10** and may generate and provide the first receive signal RS_**1** to the low-noise amplifier **1142**, based on the received echo pulse **30**.

[0091] The low-noise amplifier **1142** may amplify only a signal, with low noise. In an embodiment, the low-noise amplifier **1142** may amplify and the receive signal RS_**1**. For example, the low-noise amplifier **1142** may amplify a signal component of the first receive signal RS_**1** and may provide the wide band sampler **1143** with the amplified and generated second receive signal RS_**2**.

[0092] The wide band sampler **1143** may sample a portion of the received signal. In an embodiment, the wide band sampler **1143** may operate in response to a reception clock signal CLK_RX described with reference to FIGS. **2** and **4**. For example, the wide band sampler **1143** may sample the second receive signal RS_**2**, in response to that the received reception clock signal CLK_RX is a rising edge.

[0093] The radar **1100** may receive the echo pulse **30** from a detection distance, based on the operation of the wide band sampler **1143**. In other words, the radar **1100** may change a detection distance of the radar **1100** based on the operation of the wide band sampler **1143**. A transmission clock and reception clock signal time difference DTRX is described with reference to FIGS. **4** and **5** The wide band sampler **1143** may provide the baseband amplifier **1144** with a third receive signal RS_**3** generated by sampling the second receive signal RS_**2**.

[0094] The baseband amplifier **1144** may amplify a baseband component of a signal. In an embodiment, the baseband amplifier **1144** may amplify a baseband of the third receive signal RS_**3**. For example, the baseband amplifier **1144** may provide the data processor DP with a fourth receive signal RS_**4** generated by amplifying the baseband of the third receive signal RS_**3**.

[0095] The data processor DP may generate receive data D_RX for the target **10**, based on the received fourth receive signal RS_**4**. In an embodiment, the data processor DP may operate in response to a receiver unit control signal CTRL_RX received from the control unit **1110**. For example, the data processor DP may process the fourth receive signal RS_**4**, in response to the receiver unit control signal CTRL_RX. The data processor DP may include the ADC **1145** and the scan matrix storing memory **1146**.

[0096] The ADC **1145** may convert an analog signal into a digital signal DS. In an embodiment, the ADC **1145** may convert the fourth receive signal RS_**4** in an analog form into the digital signal DS. For example, the ADC **1145** may convert the fourth receive signal RS_**4** into the digital signal DS (e.g., depending on the receiver unit control signal CTRL_RX) and may provide the scan matrix storing memory **1146** with the generated digital signal DS or may provide the control unit **1110** with the generated digital signal DS in the form of receive data D_RX.

[0097] The ADC **1145** may accumulate the plurality of fourth receive signals RS_**4** generated based on the plurality of echo pulses **30** received while a time difference of the transmission clock and reception clock signal time difference DTRX (any one of 0th to mth time differences DTR**0** to DTRm of FIG. **4**). For example, the ADC **1145** may include registers, a memory element, or the like capable of storing the plurality of fourth receive signals RS_**4**. In an embodiment, the ADC **1145** may generate a representative digital signal of the plurality of fourth receive signals RS_**4**. For example, the ADC **1145** may generate the representative digital signal, based on accumulation of the plurality of fourth receive signals RS_**4**. Like the digital signal DS, the representative digital signal may also be provided to the scan matrix storing memory **1146** or may also be provided to the control unit **1110** in the form of the receive data D_RX.

[0098] The scan matrix storing memory **1146** may store the receive data D_RX, based on the received digital signal DS (or the representative digital signal). In an embodiment, the scan matrix storing memory **1146** may operate in response to a minimum detection distance notification signal LDTX. For example, the scan matrix storing memory **1146** may store a scan vector from the digital signal DS (or the representative digital signal), in response to the minimum detection distance notification signal LDTX.

[0099] The scan vector may have a plurality of parameters. For example, the scan vector may be a vector, having a single column, row components of which respectively correspond to parameters. In an embodiment, the scan matrix storing memory **1146** may generate a scan matrix, based on a plurality of scan vectors. For example, the scan matrix storing memory **1146** may generate scan vectors or a scan matrix, based on the digital signal DS (or the representative digital signal) of each of the detection distances.

[0100] The column of the scan matrix may be associated with a detection distance or a magnitude of a time difference DTR, and the row of the scan matrix may be values of each of a plurality of parameters extracted from a digital signal corresponding to the detection distance or the magnitude of the time difference DTR. The scan vector or the scan matrix may be provided to the control unit **1110** in the form of the receive data D_RX and may include a detection result for the target **10**. For example, a first column of the scan matrix may correspond to a first detection distance, and respective rows of the first column may be values of respective parameters of the scan vector corresponding to the first detection distance.

[0101] Referring to FIG. **2** together, the scan matrix may be provided to the control unit **1110** in the form of the receive data D_RX. The data processor DP is included in the receiver unit **1140** in the embodiment illustrated and described with reference to FIG. **9**, but the scope of the present disclosure is not limited thereto. It should be understood that an embodiment in which the data processor DP is included in one of other components, such as the control unit **1110**, or an embodiment in which the data processor DP is included in the radar **1100** also belongs to the scope of the present disclosure.

[0102] The radar **1100** described with reference to FIGS. **2** to **9** may control not to receive an interference signal of adjacent radars (e.g., a first radar **1101** or a second radar **1102** of FIG. **1**), based on the above-mentioned embodiments. The radar **1100** may perform the above-mentioned operations, in response to control of the control unit **1110**. For example, the radar **1100** may adjust the transmission clock signal CLK_TX to prevent an interference signal from being received, such that it is not synchronous with each of clocks of adjacent radars.

[0103] FIG. **10** is a flowchart illustrating an operation method of a radar system **1000** described with reference to FIGS. **1** to **9**, according to an embodiment of the present disclosure. An operation method of the radar system **1000** will be described, according to embodiment of the present disclosure, with reference to FIGS. **1** and **10**.

[0104] In operation S**110**, the radar system **1000** may detect a target, based on a first transmission clock signal by means of (or, by using) a first radar. The first radar may be any one of radars **1100** to **110*n*** of FIG. **1**. For example, the radar system **1000** may detect a target **10**, based on the first transmission clock signal by means of a first radar **1101** of FIG. **1**. In detail, the first radar **1101** may radiate a transmit pulse **20**, in response to that the first transmission clock signal is a rising edge and may generate a rising edge of a reception clock signal to correspond to a detection distance, thus receiving an echo pulse **30** and detecting the target **10**.

[0105] In operation S**120**, the radar system **1000** may detect the target, based on a second transmission clock signal by means of (or, by using) a second radar. The second radar may be a radar different from the first radar, which may be any one of the radars **1100** to **110*n*** of FIG. **1**. The second radar may operate like the first radar. For example, the second radar may detect the target **10**, based on a second transmission clock signal and a reception clock signal corresponding to the second transmission clock signal.

[0106] The first radar and the second radar are described as an example of being used as single radars, but the present disclosure is not limited thereto. It should be understood that an embodiment in which a plurality of radars detect the target based on respective transmission clock signals in operation S**110**, an embodiment in which the plurality of radars detect the target based on respective transmission clock signals in operation S**120**, or an embodiment in which the plurality of radars detect the target based on respective transmission clock signals in the two operations also belongs to the scope of the present disclosure.

[0107] In operation S**130**, the radar system **1000** may verify whether an interference signal between the radars **1100** to **110*n*** is received. When the interference signal is received, the radar system **1000** may move to operation S**140**. Conversely, when the interference signal is not received, the radar system **1000** may move to operation S**150**.

[0108] In operation S**140**, a first radar or a second radar may adjust a first transmission clock signal or a second transmission clock signal, such that the interference signal is not received. In an embodiment, the first transmission clock signal or the second transmission clock signal may be adjusted not to be synchronous with each other, depending on the embodiment described with reference to FIGS. **3** and **5**. In another embodiment, as described with reference to FIG. **8**, the radar system **1000** may adjust center frequencies of transmit pulses of the first radar and the second radar not to overlap with each other.

[0109] When using the plurality of radars in operation S**110** or S**120**, the radar system **1000** may adjust respective transmission clock signals depending on the above-mentioned embodiments such that the interference signal is not received in all the plurality of radars. Furthermore, an embodiment in which the radar system **1000** causes transmission clock signals not to be synchronous with each other and makes center frequencies of transmit pulses different from each other to remove an interference signal may also belong to the scope of the present disclosure. After operation S**140**, the radar system **1000** may return to operation S**110** again.

[0110] In operation S**150**, the radar system **1000** may detect the target **10**, using each of the radars **1100** to **110*n***. Each of the radars **1100** to **110*n*** may detect the target **10**, without receiving interference signals, based on the method described with reference to FIGS. **3**, **5**, and **8**. In an embodiment, each of the radars **1100** to **110*n*** of the radar system **1000** may detect the target **10** from a minimum detection distance to a maximum detection distance based on the embodiment described with reference to FIGS. **4** and **5**. Each of the radars **1100** to **110*n*** in the radar system **1000** may detect the target **10**, based on the embodiment described with reference to FIGS. **6**, **7**, and **9**.

[0111] According to an embodiment of the present disclosure, the radar system and the operation method thereof may be provided to minimize interference between multiple radars and optimize the detection performance of an individual radar of the radar system.

[0112] The above-mentioned contents are detailed embodiments for executing the present disclosure. The present disclosure may also include embodiments which are simply changed in design or are easily changed, as well as the embodiments described above. Furthermore, the present disclosure may include technologies capable of being easily modified and executed using embodiments. Accordingly, the scope of the present disclosure should not be limited to the above-described embodiments, but should be determined by equivalents to the claims of the present disclosure as well as the claims described later.

What is claimed is:

1. A radar system comprising:

a first radar configured to generate a first transmit pulse in response to a first transmission clock signal and detect a target in response to a first reception clock signal with a first transmission clock and reception clock signal time difference according to a first detection distance; and

a second radar configured to generate a second transmit pulse in response to a second transmission clock signal and detect the target in response to a second reception clock signal with a second transmission clock and reception clock signal time difference according to a second detection distance,

wherein the first transmission clock signal and the second transmission clock signal are not synchronous with each other, and

wherein the first radar generates a minimum detection distance notification signal, when the first detection distance is at the minimum detection distance of the first radar.

2. The radar system of claim **1**, further comprising:

a third radar configured to generate a third transmit pulse in response to a third transmission clock signal and detect the target in response to a third reception clock signal with a third transmission clock and reception clock signal time difference according to a third detection distance,

wherein the third transmission clock signal is not synchronous with the first transmission clock signal and the second transmission clock signal.

3. The radar system of claim **1**, wherein a first center frequency of the first transmit pulse and a second center frequency of the second transmit pulse are different from each other.

4. The radar system of claim **1**, wherein the first transmission clock signal includes a first rising edge and a second rising edge and an interval between the first rising edge and the second rising edge is any interval between a first interval and a second interval, and

wherein the second transmission clock signal includes a third rising edge and a fourth rising edge and an interval between the third rising edge and the fourth rising edge is any interval between a third interval and a fourth interval.

5. The radar system of claim **1**, wherein the first detection distance is a distance between a minimum detection distance and a maximum detection distance of the radar system, and

wherein the second detection distance is a distance between the minimum detection distance and the maximum detection distance of the radar system.

6. The radar system of claim **1**, wherein the first radar includes a receiver unit, and

wherein the receiver unit includes:

a receive antenna configured to receive an echo signal generated after the transmit pulse is reflected from the target;

a low-noise amplifier configured to amplify the echo signal to generate a first receive signal;

a wide band sampler configured to receive the first receive signal and sample the first receive signal in response to a reception clock signal to generate a second receive signal; and

a data processor configured to generate receive data, based on the second receive signal.

7. The radar system of claim **4**, wherein the first interval and the second interval are generated based on a first period and a first variable period,

wherein the third interval and the fourth interval are generated based on a second period and a second variable period,

wherein the first interval is a value obtained by subtracting the first variable period from the first period,

wherein the second interval is a value obtained by adding the first variable period to the first period,

wherein the third interval is a value obtained by subtracting the second variable period from the second period, and

wherein the fourth interval is a value obtained by adding the second variable period to the second period.

8. The radar system of claim **6**, wherein the receiver unit further includes a baseband amplifier configured to amplify a baseband of the second receive signal to generate a third receive signal,

wherein the data processor includes:

an analog-digital converter (ADC) configured to convert the third receive signal into a digital signal; and

a scan matrix storing memory configured to store a scan vector based on the digital signal and generate a scan matrix based on the scan vector, and

wherein the scan matrix represents the receive data.

9. The radar system of claim **8**, wherein the scan vector and the scan matrix are generated in response to the minimum detection distance notification.

10. An operation method of a radar system for detecting a target, the operation method comprising:

detecting the target by means of a first radar based on a first transmission clock signal;

detecting the target by means of a second radar based on a second transmission clock signal; and

detecting the target from a minimum detection distance of each of the first radar and the second radar to a maximum detection distance of each of the first radar and the second radar, by means of the first radar and the second radar,

wherein the first transmission clock signal and the second transmission clock signal are not synchronous with each other.

11. The operation method of claim **10**, wherein the first radar detects the target in response to the first transmission clock signal and a first reception clock signal with a first transmission clock and reception clock signal time difference according to a first detection distance, and

wherein the second radar detects the target in response to the second transmission clock signal and a second reception clock signal with a second transmission clock and reception clock signal time difference according to a second detection distance.

12. The operation method of claim **10**, wherein the first transmission clock signal includes a first rising edge and a second rising edge and an interval between the first rising edge and the second rising edge is any interval between a first interval and a second interval, and wherein the second transmission clock signal includes a third rising edge and a fourth rising edge and an interval between the third rising edge and the fourth rising edge is any interval between a third interval and a fourth interval.

13. The operation method of claim **12**, wherein the first interval and the second interval are generated based on a first period and a first variable period,

wherein the third interval and the fourth interval are generated based on a second period and a second variable period,

wherein the first interval is a value obtained by subtracting the first variable period from the first period,

wherein the second interval is a value obtained by adding the first variable period to the first period,

wherein the third interval is a value obtained by subtracting the second variable period from the second period, and

wherein the fourth interval is a value obtained by adding the second variable period to the second period.

14. A radar configured to detect a target, the radar comprising:

a control unit configured to control an operation of the radar;

a transmitter unit configured to radiate a transmit pulse to the target, in response to a transmission clock signal;

a receiver unit configured to receive an echo signal reflected from the target in response to a reception clock signal and generate detection data; and

a clock generation unit configured to generate the transmission clock signal and the reception clock signal,

wherein the transmission clock signal includes a first rising edge and a second rising edge, and

wherein an interval between the first rising edge and the second rising edge is a first interval obtained by subtracting a first variable period from a first period to a second interval obtained by adding the first variable period to the first period.

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