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(54) SEE-THROUGH OBJECT-SCANNING DEVICE

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(57) **ABSTRACT**

A see-through object-scanning device includes a transmission unit that transmits, to a target object, a transmission radio wave obtained by iteratively performing frequency sweeps from a first frequency to a second frequency over a frequency sweep time, a reception unit that receives, using array antenna elements, a reception radio wave resulting from reflection of the transmission radio wave on the target object, a three-dimensional image generation unit that generates a three-dimensional image every single one of the frequency sweeps, from a reception signal of a corresponding one of the array antenna elements, and an object detection unit that detects an object based on multiple three-dimensional images. The see-through object-scanning device changes at least one of the first frequency, the second frequency, the frequency sweep time, or the number of ones of the array antenna elements to be used in detection of an object, in a time division manner.

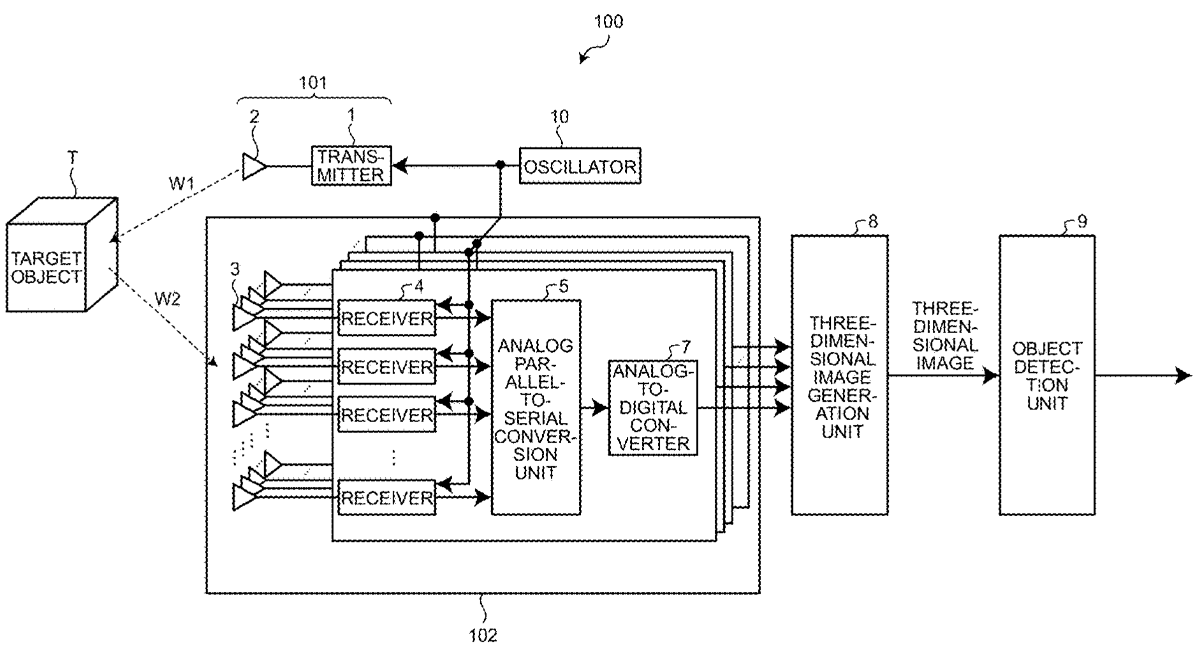


FIG.1

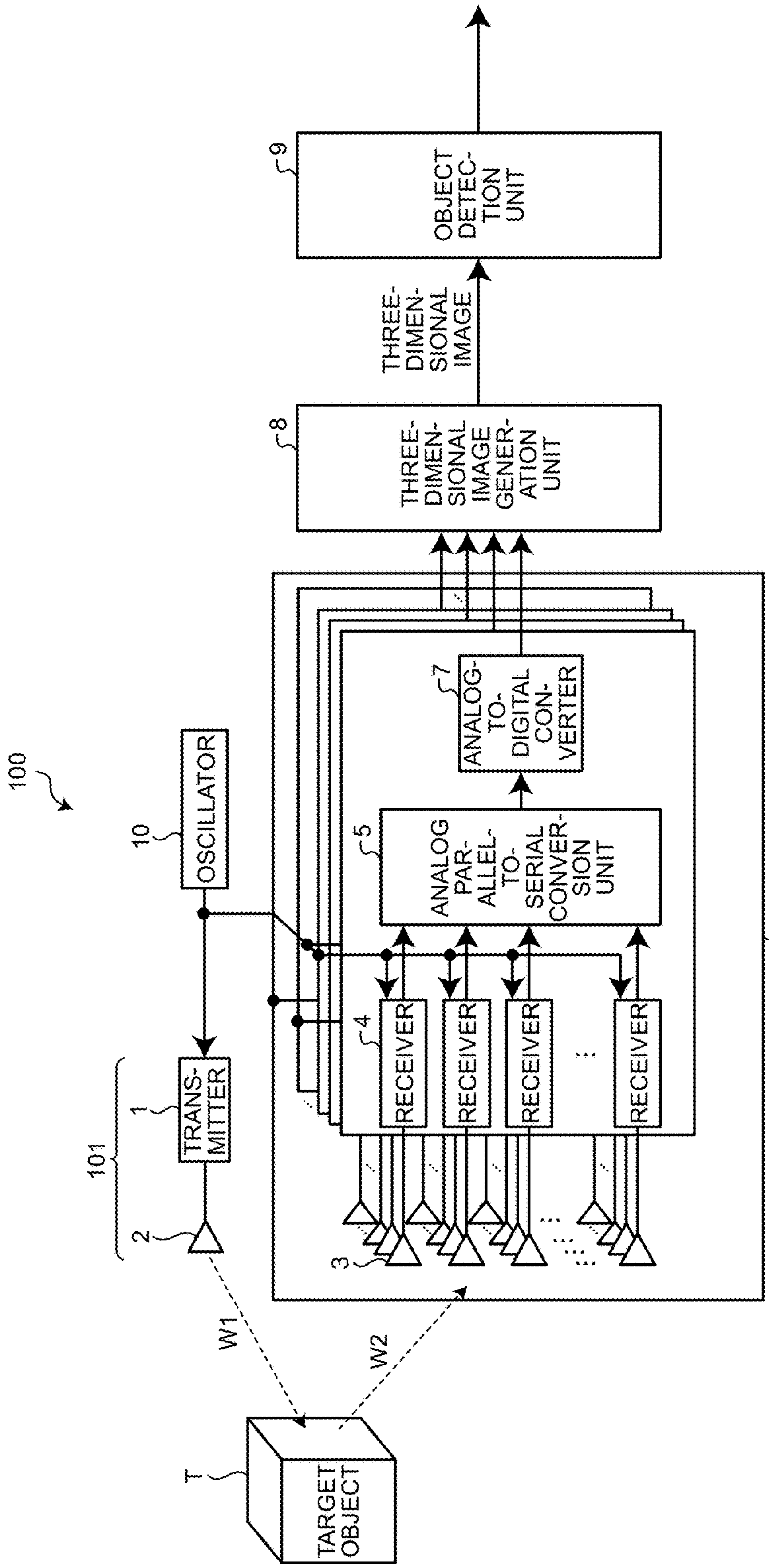

100
10
OSCILLATOR
101
1
TRANS-MITTER
2
3
4
RECEIVER
RECEIVER
RECEIVER
RECEIVER
5
ANALOG PAR-ALLEL-TO-SERIAL CONVER-SION UNIT
7
ANALOG-TO-DIGITAL CON-VERTER
102
8
THREE-DIMEN-SIONAL IMAGE GENER-ATION UNIT
THREE-DIMEN-SIONAL IMAGE
9
OBJECT DETEC-TION UNIT
W1
W2
T
TARGET OBJECT

FIG.2

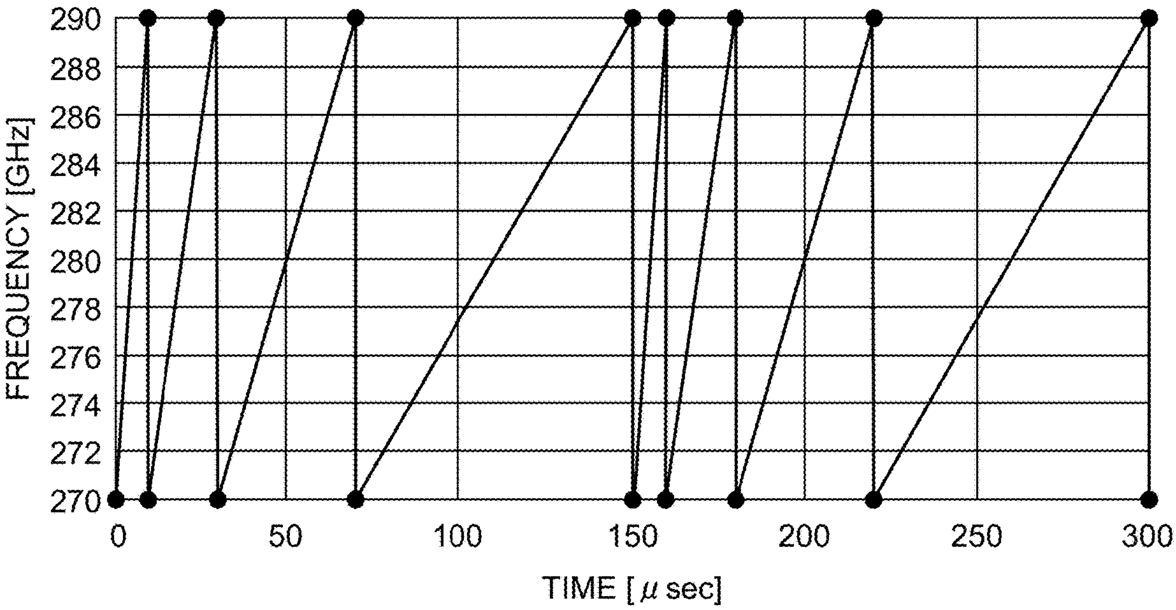

290
288
286
284
282
280
278
276
274
272
270
FREQUENCY [GHz]
0
50
100
150
200
250
300
TIME [μ sec]

FIG.3

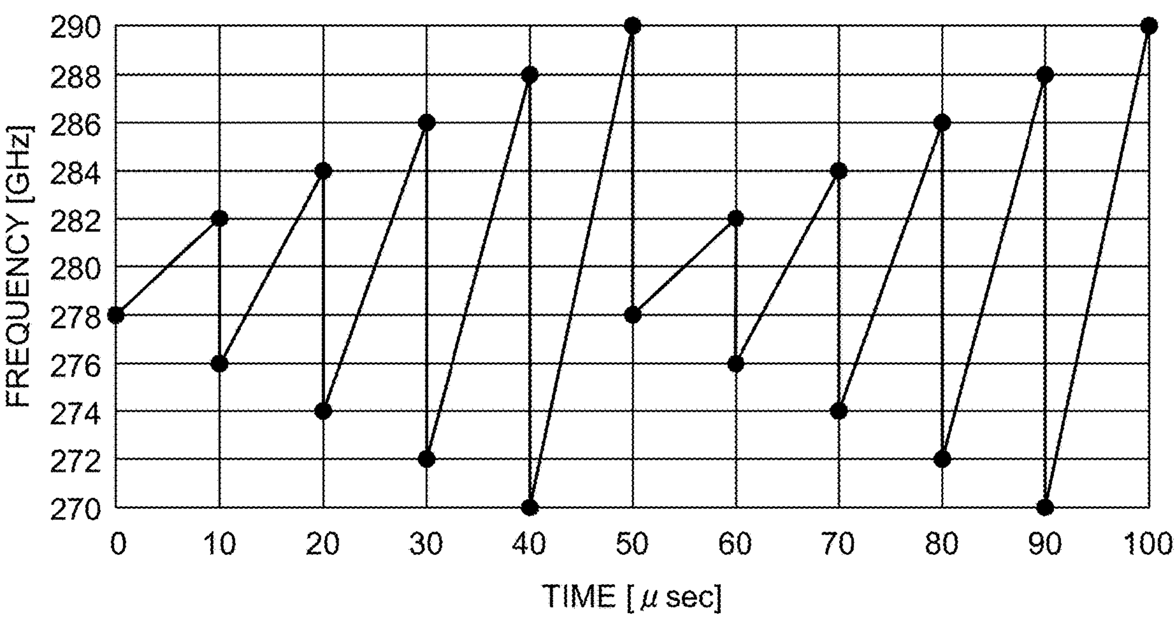

290
288
286
284
282
280
278
276
274
272
270
FREQUENCY [GHz]
0
10
20
30
40
50
60
70
80
90
100
TIME [μ sec]

FIG.4

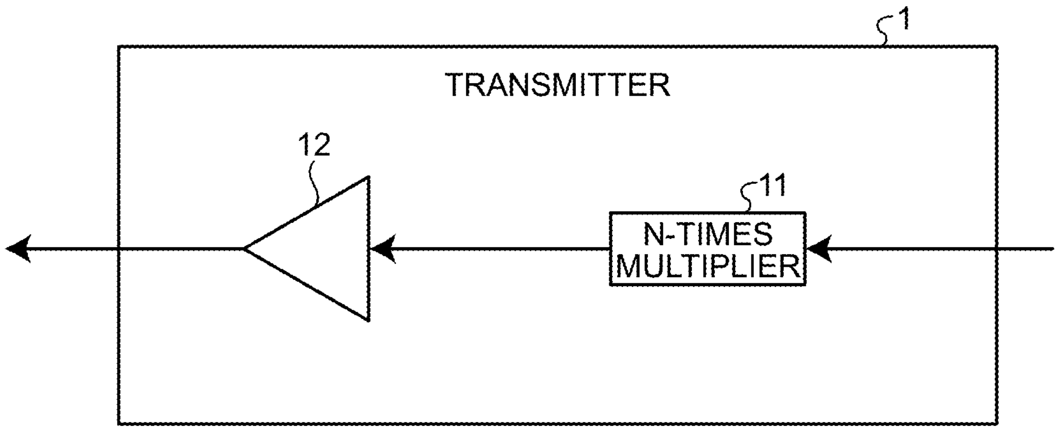

1
TRANSMITTER
12
11
N-TIMES
MULTIPLIER

FIG.5

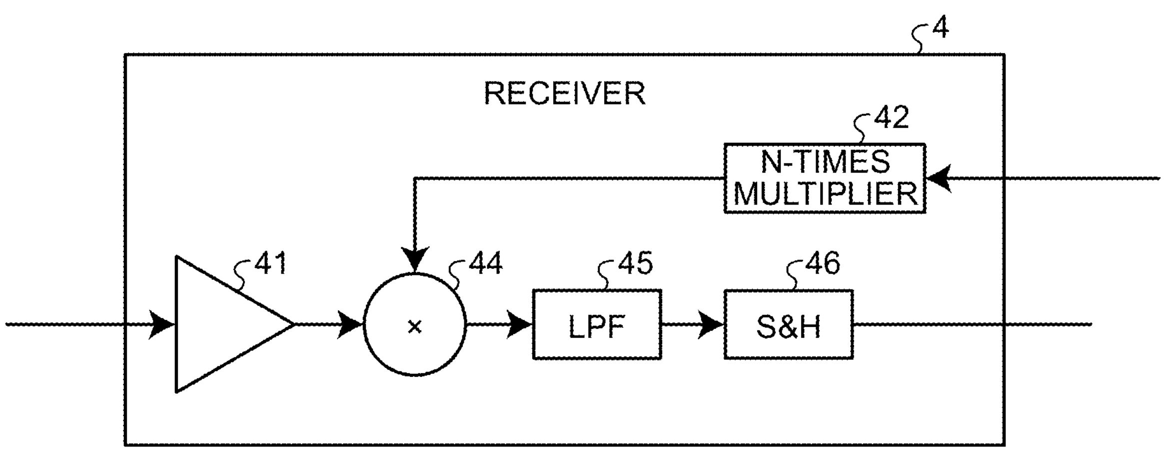
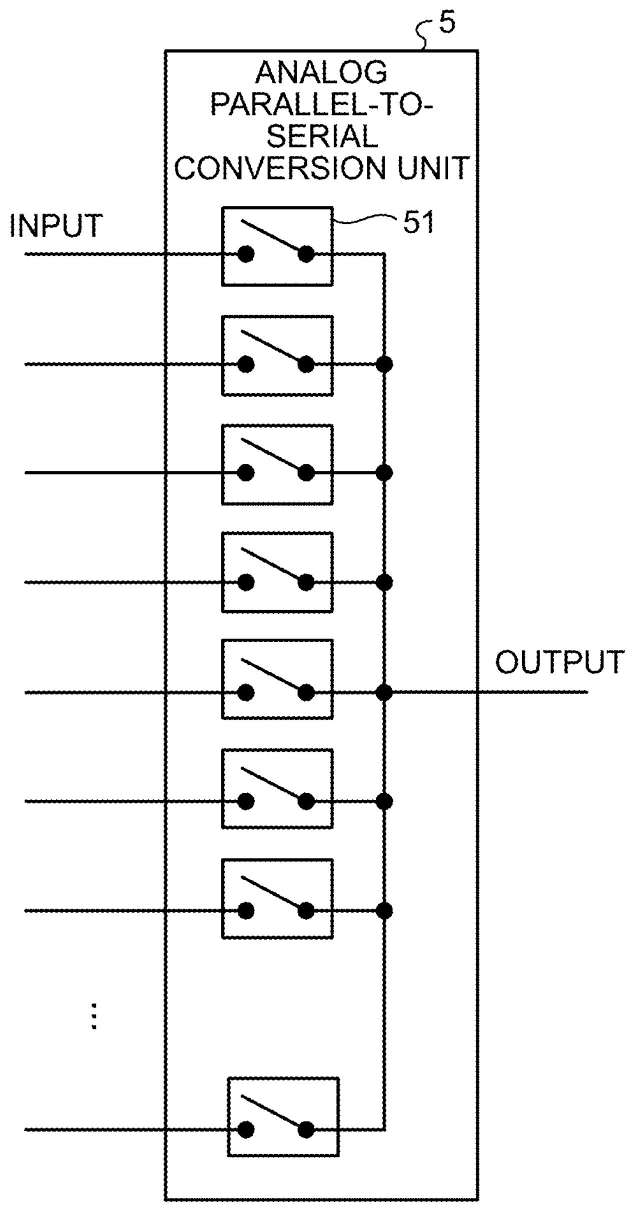

4
RECEIVER
42
N-TIMES
MULTIPLIER
41
44
×
45
LPF
46
S&H

FIG.6


5
ANALOG
PARALLEL-TO-
SERIAL
CONVERSION UNIT
INPUT
51
OUTPUT

SEE-THROUGH OBJECT-SCANNING DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation application of International Application PCT/JP2022/042085, filed on Nov. 11, 2022, and designating the U.S., the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present disclosure relates to a see-through object-scanning device for seeing through an object using a radio wave.

2. Description of the Related Art

[0003] A device that sees through an object to detect a foreign matter or a dangerous article is used in applications such as foreign matter detection in food inspection and a security gate at an airport. A conventional see-through object-scanning device typically uses an X-ray. A see-through object-scanning device using an X-ray has a problem of X-ray exposure, and has therefore a limited use. As a method that presents no exposure problem, a see-through object-scanning device that uses nuclear magnetic resonance is in practical use for medical use. However, a see-through object-scanning device that uses nuclear magnetic resonance requires a strong magnetic field, thereby resulting in a large device size, and causing a great force under existence of a magnetic material such as iron. Thus, a see-through object-scanning device that uses nuclear magnetic resonance requires a large space for device installation, and has a significant limitation on the place for installing the device such as necessity for control of entering and leaving by persons and things of the place where the device is installed. The use thereof is therefore limited.

[0004] In contrast, a see-through object-scanning device that uses a radio wave presents no problem of radiation exposure, and has less limitation on the place for installing the device. When a radio wave is used, a resolution limit is limited by the wavelength of the radio wave used. This has conventionally resulted in a low resolution of a see-through object-scanning image obtained using a radio wave, thereby making identification of an object difficult. With the recent progress of device technology, it is becoming practicable to use a radio wave having a frequency of 100 GHz or higher, and an increase in the resolution is thus expected. For example, Japanese Patent Application Laid-open No. 2018-77192 discloses a device for checking for a defect inside a tire using a microwave.

[0005] However, according to the foregoing conventional technology, there is a problem in which a movement of the detection target will reduce detection accuracy.

SUMMARY OF THE INVENTION

[0006] In order to solve the above-described problems and achieve the object, a see-through object-scanning device according to the present disclosure includes: a transmission unit to transmit a transmission radio wave to a target object, the transmission radio wave obtained by iteratively performing frequency sweeps each to change a frequency from a first frequency to a second frequency over a frequency sweep time; a reception unit to receive a reception radio wave using array antenna elements, the reception radio wave resulting from reflection of the transmission radio wave on the target object; a three-dimensional image generation unit to generate a three-dimensional image every single one of the frequency sweeps, from a reception signal of a corresponding one of the array antenna elements; and an object detection unit to detect an object on a basis of multiple ones of the three-dimensional image. The see-through object-scanning device changes at least one of the first frequency, the second frequency, the frequency sweep time, or a number of ones of the array antenna elements to be used in detection of an object, in a time division manner.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a diagram illustrating a configuration of a see-through object-scanning device according to a first embodiment;

[0008] FIG. **2** is a diagram illustrating a first example of waveform of a transmission radio wave;

[0009] FIG. **3** is a diagram illustrating a second example of waveform of the transmission radio wave;

[0010] FIG. **4** is a diagram illustrating a configuration of the transmitter illustrated in FIG. **1**;

[0011] FIG. **5** is a diagram illustrating a configuration of the receivers illustrated in FIG. **1**;

[0012] FIG. **6** is a diagram illustrating a configuration of the analog parallel-to-serial conversion unit illustrated in FIG. **1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] A see-through object-scanning device according to an embodiment of the present disclosure will be described in detail below with reference to the drawings.

First Embodiment

[0014] FIG. **1** is a diagram illustrating a configuration of a see-through object-scanning device **100** according to a first embodiment. The see-through object-scanning device **100** has a function to see through an object using a radio wave. The see-through object-scanning device **100** is used for purposes such as, for example, detection of a dangerous article such as a weapon at an airport, and detection of a foreign matter mixed in a product at a production site.

[0015] The see-through object-scanning device **100** includes a transmitter **1**, a transmission antenna **2**, reception antennas **3**, receivers **4**, an analog parallel-to-serial conversion unit **5**, an analog-to-digital converter **7**, a three-dimensional image generation unit **8**, an object detection unit **9**, and an oscillator **10**. The transmitter **1** and the transmission antenna **2** are collectively referred to herein as transmission unit **101**. The reception antennas **3**, the receivers **4**, the analog parallel-to-serial conversion unit **5**, and the analog-to-digital converter **7** are collectively referred to herein as reception unit **102**.

[0016] The transmitter **1** generates a transmission radio wave W**1** to be transmitted toward a target object T, and transmits the transmission radio wave W**1** generated, using the transmission antenna **2**. The waveform of the transmission radio wave W**1** will next be described. The transmitter **1** generates the transmission radio wave W**1** having a waveform obtained by iteratively performing frequency sweeps each to change the frequency thereof from a first frequency to a second frequency. The time length required to change a frequency from the first frequency to the second frequency is referred to herein as frequency sweep time. The transmitter **1** is capable of changing, in a time division manner, at least one of the first frequency, the second frequency, and the frequency sweep time, which are frequency sweep parameters.

[0017] FIG. **2** is a diagram illustrating a first example of waveform of the transmission radio wave W**1**. In the first example illustrated in FIG. **2**, the first frequency is 270 GHz, and the second frequency is 290 GHz. The first frequency and the second frequency have fixed values, whereas the frequency sweep time is changed every single frequency sweep. The frequency sweep time is 10 microseconds (μsec) in the first frequency sweep. The frequency sweep time is 20 μsec in the second frequency sweep. The frequency sweep time is 40 μsec in the third frequency sweep. The frequency sweep time is 80 μsec in the fourth frequency sweep. In addition, the frequency sweep time is 10 μsec in the fifth frequency sweep. The frequency sweep time is 20 μsec in the sixth frequency sweep. The frequency sweep time is 40 μsec in the seventh frequency sweep. The frequency sweep time is 80 μsec in the eighth frequency sweep.

[0018] FIG. **3** is a diagram illustrating a second example of waveform of the transmission radio wave W**1**. In the second example illustrated in FIG. **3**, the frequency sweep time has a constant value of 10 μsec, whereas the first frequency and the second frequency are changed every single frequency sweep. The first frequency is 278 GHz and the second frequency is 282 GHz in the first frequency sweep. The first frequency is 276 GHz and the second frequency is 284 GHz in the second frequency sweep. The first frequency is 274 GHz and the second frequency is 286 GHz in the third frequency sweep. The first frequency is 272 GHz and the second frequency is 288 GHz in the fourth frequency sweep. The first frequency is 270 GHz and the second frequency is 290 GHz in the fifth frequency sweep. In addition, the first frequency is 278 GHz and the second frequency is 282 GHz in the sixth frequency sweep. The first frequency is 276 GHz and the second frequency is 284 GHz in the seventh frequency sweep. The first frequency is 274 GHz and the second frequency is 286 GHz in the eighth frequency sweep. The first frequency is 272 GHz and the second frequency is 288 GHz in the ninth frequency sweep. The first frequency is 270 GHz and the second frequency is 290 GHz in the tenth frequency sweep.

[0019] FIG. **4** is a diagram illustrating a configuration of the transmitter **1** illustrated in FIG. **1**. The transmitter **1** receives a signal having a constant envelope from the oscillator **10**. The transmitter **1** includes an N-times multiplier **11** and a transmission amplifier **12**. The transmitter **1** multiplies the frequency of the signal having a constant envelope input from the oscillator **10** by N using the N-times multiplier **11**. The oscillator **10** accordingly generates a signal having a frequency that is one Nth of the frequency of the transmission radio wave W**1**. An output of the N-times multiplier **11** is amplified by the transmission amplifier **12**, and the transmission radio wave W**1** is emitted by the transmission antenna **2**.

[0020] Returning to the description with reference to FIG. **1**, the reception antennas **3** receive a reception radio wave W**2**, which is a radio wave resulting from reflection of the transmission radio wave W**1** transmitted by the transmission unit **101** on the target object T. The reception antennas **3** are array antenna elements arranged to form a two-dimensional array.

[0021] The receivers **4** are provided correspondingly to the respective reception antennas **3**, and each have a function to process the analog signal of the radio wave received by the corresponding one of the reception antennas **3**. The receivers **4** each output an analog signal obtained by processing, to the analog parallel-to-serial conversion unit **5**.

[0022] FIG. **5** is a diagram illustrating a configuration of each of the receivers **4** illustrated in FIG. **1**. Each of the receivers **4** receives a signal having a constant envelope from the oscillator **10**, and receives an analog signal of a radio wave received from a corresponding one of the reception antennas **3**. Each of the receivers **4** includes a reception amplifier **41**, an N-times multiplier **42**, a frequency mixer **44**, a low-pass filter (LPF) **45**, and a sample-and-hold element **46**, which is indicated as "S&H" in the figure.

[0023] The analog signal input from a corresponding one of the reception antennas **3** is amplified by the reception amplifier **41**, and a resulting signal is then input to the frequency mixer **44**. In addition, the frequency of the signal having a constant envelope input from the oscillator **10** is multiplied by N by the N-times multiplier **42**, and the signal having the frequency multiplied by N is also input to the frequency mixer **44**. The frequency mixer **44** mixes together, and down-converts, the signals respectively input from the reception amplifier **41** and the N-times multiplier **42**, and outputs a resulting signal to the LPF **45**.

[0024] The LPF **45** is a filter with a variable cut-off bandwidth. The LPF **45** cuts off signal components having frequencies higher than or equal to a frequency that has been set to remove unnecessary high frequency components, and outputs a resulting signal to the sample-and-hold element **46**. The sample-and-hold element **46** samples and holds the analog signal. The sample-and-hold operation is simultaneously performed by all the receivers **4**. The output of the sample-and-hold element **46** is connected to the analog parallel-to-serial conversion unit **5**.

[0025] Returning to the description with reference to FIG. **1**, the analog signals sampled and held by the multiple respective receivers **4** are converted into a serial analog signal in the analog parallel-to-serial conversion unit **5**. The serial analog signal is output to the analog-to-digital converter **7**.

[0026] FIG. **6** is a diagram illustrating a configuration of the analog parallel-to-serial conversion unit **5** illustrated in FIG. **1**. The analog parallel-to-serial conversion unit **5** includes multiple analog switches **51**. The analog parallel-to-serial conversion unit **5** is capable of selecting a signal to be output by the reception unit **102** to the three-dimensional image generation unit **8**, i.e., a signal for use in generation of a three-dimensional image and in detection of an object, by turning on one of the analog switches **51**. Thus, the array antenna element of the reception antenna **3** connected to the analog switch **51** that is in an ON state can be designated as the array antenna element to be used in detection of an object. Note that only one of the multiple analog switches **51** is turned on at one time. The analog parallel-to-serial conversion unit **5** can perform parallel-to-serial conversion by sequentially changing the analog switch **51** to be turned on. In addition, the analog parallel-to-serial conversion unit **5** can change the array antenna element to be used, by changing the switching pattern of the analog switches **51**, that is, by changing the conversion pattern for use in the parallel-to-serial conversion. The analog parallel-to-serial conversion unit **5** can change the number of array antenna elements to be used in detection of an object on a per-frequency sweep basis, by changing the conversion pattern for use in the parallel-to-serial conversion in a time division manner at timing synchronized with the frequency sweeps of the transmission radio wave W**1**. Note that the analog parallel-to-serial conversion unit **5** does not necessarily need to turn on all the analog switches **51**. The analog parallel-to-serial conversion unit **5** can limit the number of array antenna elements to be used, by changing the conversion pattern for use in the parallel-to-serial conversion to limit the number of the analog switches **51** to be turned on. For example, the analog parallel-to-serial conversion unit **5** can reduce the number of array antenna elements to be used to a greater degree for a wider frequency sweep range.

[0027] The analog-to-digital converter **7** converts the serial analog signal output by the analog parallel-to-serial conversion unit **5** into a digital signal, and outputs the digital signal obtained by conversion to the three-dimensional image generation unit **8**. As described above, use of the analog parallel-to-serial conversion unit **5** causes the multiple analog signals received by the multiple array antenna elements to be converted into a serial analog signal by parallel-to-serial conversion. This enables the reception unit **102** to include merely one analog-to-digital converter **7**. In addition, the analog parallel-to-serial conversion unit **5** can reduce the bandwidth used by the analog-to-digital converter **7** by limiting the number of array antenna elements to be used. When the see-through object-scanning device **100** sees through a moving target object T such as in a case of, for example, a walk-through security gate, the reception unit **102** needs to process a large amount of data at high speed, thereby requiring a very high-speed analog-to-digital converter **7**. This will lead to a high cost. The use of the analog parallel-to-serial conversion unit **5** in the reception unit **102** enables the number of analog-to-digital converters **7** to be reduced, and the bandwidth used by the analog-to-digital converter **7** to be reduced. This can reduce overall cost of the see-through object-scanning device **100**.

[0028] The three-dimensional image generation unit **8** generates a three-dimensional image every single frequency sweep, from the digital signal output by the reception unit **102**. The three-dimensional image generation unit **8** outputs the three-dimensional image generated, to the object detection unit **9**.

[0029] The object detection unit **9** detects an object on the basis of multiple three-dimensional images output from the three-dimensional image generation unit **8**. The object to be detected by the object detection unit **9** is a preset type of object such as, for example, a foreign matter or a weapon. The object detection unit **9** includes a neural network or the like to allow a preset object to be detected using a learned model that has previously learned about objects to be detected. When an object is to be detected using neural network, the object detection unit **9** inputs multiple three-dimensional images to the learned model. The learned model then outputs a detection result representing whether the target object T includes a preset type of object to be detected such as, for example, a foreign matter or a weapon. When a preset object is detected, the detection result may include, for example, the type of the detected object.

[0030] As described above, the see-through object-scanning device **100** according to the first embodiment includes the transmission unit **101**, which transmits, to the target object T, the transmission radio wave W**1**, which has been obtained by iteratively performing frequency sweeps each to change the frequency from the first frequency to the second frequency over the frequency sweep time; the reception unit **102**, which receives, using array antenna elements, the reception radio wave W**2**, which has resulted from reflection of the transmission radio wave W**1** on the target object T; the three-dimensional image generation unit **8**, which generates a three-dimensional image every single frequency sweep, from reception signals of the array antenna elements; and the object detection unit **9**, which detects an object on the basis of multiple three-dimensional images. The see-through object-scanning device **100** changes at least one of the first frequency, the second frequency, the frequency sweep time, and the number of array antenna elements to be used in detection of an object, in a time division manner.

[0031] Changing at least one of the first frequency, the second frequency, and the frequency sweep time enables the frequency sweep speed to be changed. Changing the first frequency or the second frequency enables the frequency sweep range to be changed. When the first frequency and the second frequency are each fixed, a shorter frequency sweep time leads to a higher frequency sweep speed. Alternatively, when the frequency sweep time is fixed, a wider frequency sweep range leads to a higher frequency sweep speed. Use of a high frequency sweep speed allows a decrease in image quality of an obtainable three-dimensional image to be reduced or prevented even when the target object T moves. A wide frequency sweep range causing a high frequency sweep speed will however cause the outputs of the receivers **4** to have a broad bandwidth. In this case, reduction of the number of array antenna elements to be used in detection of an object can reduce the bandwidth used by the analog-to-digital converter **7**, but reduction of the number of array antenna elements to be used in detection of an object causes a decrease in angular resolution. In addition, when the frequency sweep speed is increased by reduction of the frequency sweep time, distance resolution will decrease. Thus, changing at least one of the first frequency, the second frequency, the frequency sweep time, and the number of array antenna elements to be used in detection of an object, in a time division manner, enables multiple three-dimensional images having different levels of distance resolution and angular resolution to be obtained, and detection of an object using such three-dimensional images in combination enables reduction or prevention of decrease in detection accuracy even when the target object T moves.

[0032] In the first embodiment, the waveform illustrated in FIG. **2** and the waveform illustrated in FIG. **3** are presented as examples of the waveform of the transmission radio wave W**1**. Thus, when the transmission radio wave W**1** having the waveform illustrated in FIG. **2** is used, the transmission unit **101** changes the frequency sweep time in a time division manner, and the reception unit **102** changes the number of array antenna elements to be used in detection of an object, in a time division manner. Alternatively, when the transmission radio wave W**1** having the waveform illustrated in FIG. **3** is used, the transmission unit **101** changes the first frequency and the second frequency in a time division manner, and the reception unit **102** changes the number of array antenna elements to be used in detection of an object, in a time division manner. However, these operations are merely by way of example. It is satisfactory that the see-through object-scanning device **100** changes at least one parameter in a time division manner among the first frequency, the second frequency, the frequency sweep time, and the array antenna elements to be used in detection of an object. In addition, although the first embodiment has been described in which the at least one parameter described above is changed every single frequency sweep, the at least one parameter may be changed every unit of frequency sweeps instead of every frequency sweep, that is, the at least one parameter described above may be changed every multiple frequency sweeps.

[0033] In addition, in the see-through object-scanning device **100**, the reception unit **102** includes multiple array antenna elements, performs parallel-to-serial conversion on multiple analog signals from the respective array antenna elements, and converts a resulting analog signal into a digital signal using the single analog-to-digital converter **7**. This enables the number of analog-to-digital converters **7** to be reduced, and cost of the see-through object-scanning device **100** to be reduced.

[0034] Moreover, the see-through object-scanning device **100** can limit the number of array antenna elements to be used in detection of an object by changing the conversion pattern for use in parallel-to-serial conversion. This enables the angular resolution used in object detection to be changed.

[0035] Furthermore, the see-through object-scanning device **100** can change the number of array antenna elements to be used, by changing the conversion pattern for use in parallel-to-serial conversion in a time division manner at timing synchronized with the frequency sweeps. This enables the angular resolution used in object detection to be changed for each three-dimensional image.

[0036] In addition, the object detection unit **9** is capable of detecting an object using neural network.

[0037] Moreover, the see-through object-scanning device **100** can reduce the number of array antenna elements to be used in detection of an object to a greater degree for a larger difference between the first frequency and the second frequency. This enables the bandwidth used by the analog-to-digital converter **7** to be reduced by reducing the number of array antenna elements to be used in detection of an object even when the frequency sweep range is wide causing the outputs of the receivers **4** to have a broad bandwidth.

[0038] Note that components of the see-through object-scanning device **100** can be implemented using processing circuitry. The processing circuitry may be implemented by a dedicated hardware element or by a control circuit using a central processing unit (CPU).

[0039] When the foregoing processing circuitry is implemented by a dedicated hardware element, the processing circuitry is a single circuit, a set of multiple circuits, a programmed processor, a parallel programmed processor, an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), or a combination thereof.

[0040] When the foregoing processing circuitry is implemented by a control circuit using a CPU, this control circuit includes, for example, a processor and a memory. The processor is a CPU, which is also known as a computing unit, a microprocessor, a microcomputer, a digital signal processor (DSP), and the like. The memory is, for example, a non-volatile or volatile semiconductor memory such as a random access memory (RAM), a read-only memory (ROM), a flash memory, an erasable programmable ROM (EPROM), or an electrically erasable programmable ROM (EEPROM) (registered trademark); a magnetic disk, a flexible disk, an optical disk, a compact disc, a MiniDisc, a digital versatile disk (DVD), or the like.

[0041] When the foregoing processing circuitry is implemented by a control circuit, components of the see-through object-scanning device **100** are implemented in such a manner that the processor reads and executes a program stored in the memory, corresponding to processing of each of the components. The memory is also used as a temporary memory for each processing performed by the processor.

[0042] A see-through object-scanning device according to the present disclosure provides an advantage in capability of reducing or preventing a decrease in detection accuracy even when the detection target moves.

[0043] The configurations described in the foregoing embodiment are merely examples. These configurations can be combined with another known technology, and part of such configurations can be omitted and/or modified without departing from the spirit.

What is claimed is:

1. A see-through object-scanner comprising:

a transmitter to transmit a transmission radio wave to a target object, the transmission radio wave obtained by iteratively performing frequency sweeps each to change a frequency from a first frequency to a second frequency over a frequency sweep time;

a receiver to receive a reception radio wave using array antenna elements, the reception radio wave resulting from reflection of the transmission radio wave on the target object;

a three-dimensional image generator to generate a three-dimensional image every single one of the frequency sweeps, from a reception signal of a corresponding one of the array antenna elements; and

an object detector to detect the target object on a basis of multiple ones of the three-dimensional image, wherein

the see-through object-scanner changes at least one of the first frequency, the second frequency, the frequency sweep time, or a number of ones of the array antenna elements to be used in detection of the target object, in a time division manner,

the receiver

comprises the plurality of array antenna elements, performs parallel-to-serial conversion on a plurality of analog signals from the respective array antenna elements, and converts a resulting signal into a digital signal using a single analog-to-digital converter, and

the see-through object-scanner limits the number of the ones of the array antenna elements to be used in detection of the target object, by changing a conversion pattern for use in the parallel-to-serial conversion.

2. A see-through object-scanner comprising:

a transmitter to transmit a transmission radio wave to a target object, the transmission radio wave obtained by iteratively performing frequency sweeps each to change a frequency from a first frequency to a second frequency over a frequency sweep time;

a receiver to receive a reception radio wave using array antenna elements, the reception radio wave resulting from reflection of the transmission radio wave on the target object;

a three-dimensional image generator to generate a three-dimensional image every single one of the frequency sweeps, from a reception signal of a corresponding one of the array antenna elements; and

an object detector to detect the target object on a basis of multiple ones of the three-dimensional image, wherein

the see-through object-scanner changes at least one of the first frequency, the second frequency, the frequency sweep time, or a number of ones of the array antenna elements to be used in detection of the target object, in a time division manner,

the receiver

comprises the plurality of array antenna elements, performs parallel-to-serial conversion on a plurality of analog signals from the respective array antenna elements, and converts a resulting signal into a digital signal using a single analog-to-digital converter, and

the see-through object-scanner changes, for each of the frequency sweeps, the number of the ones of the array antenna elements to be used in detection of the target object, by changing a conversion pattern for use in the parallel-to-serial conversion in a time division manner at timing synchronized with a corresponding one of the frequency sweeps.

3. The see-through object-scanner according to claim **1**, wherein

the object detector detects the target object using neural network.

4. The see-through object-scanner according to claim **2**, wherein

the object detector detects the target object using neural network.

5. The see-through object-scanner according to claim **1**, wherein

the see-through object-scanner reduces the number of the ones of the array antenna elements to be used in detection of the target object to a greater degree for a larger difference between the first frequency and the second frequency.

6. The see-through object-scanner according to claim **2**, wherein

the see-through object-scanner reduces the number of the ones of the array antenna elements to be used in detection of the target object to a greater degree for a larger difference between the first frequency and the second frequency.

* * * * *