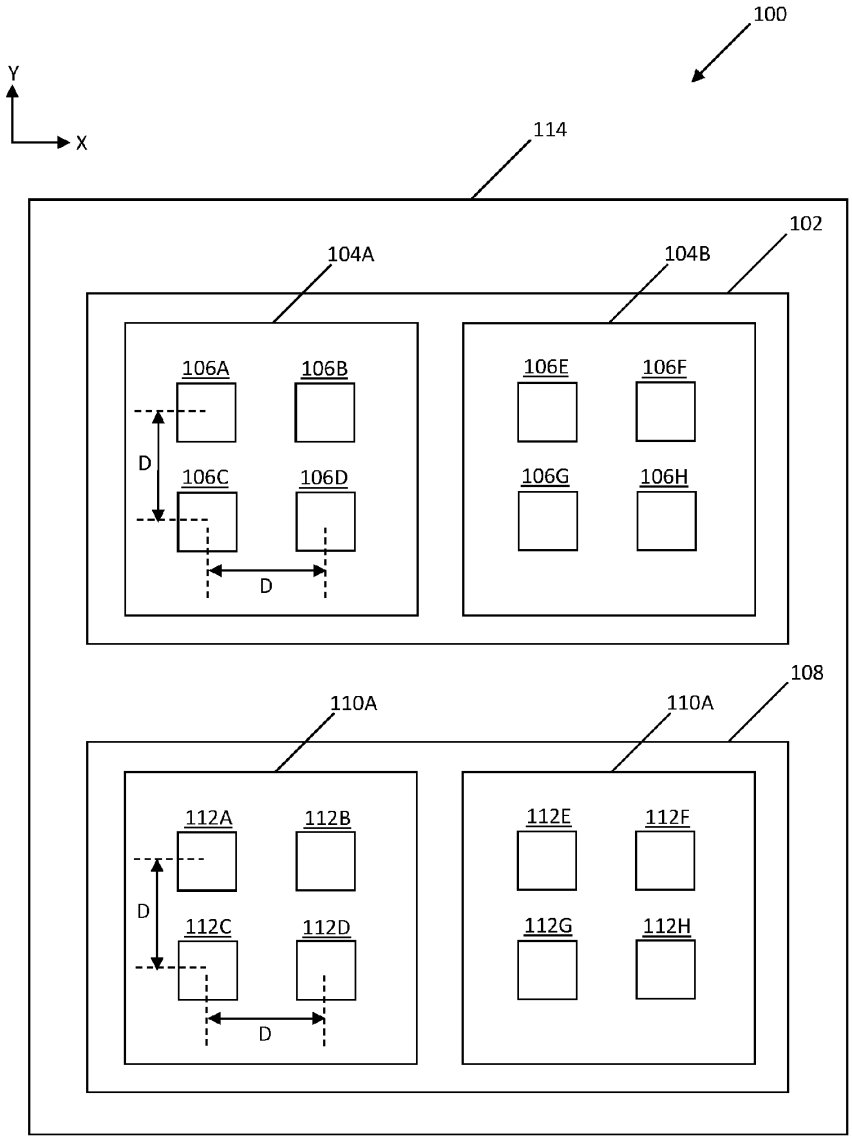
100
Y
X
114
102
104A
104B
106A
106B
106C
106D
106E
106F
106G
106H
D
D
108
110A
110A
112A
112B
112C
112D
112E
112F
112G
112H
D
D

FIG. 1

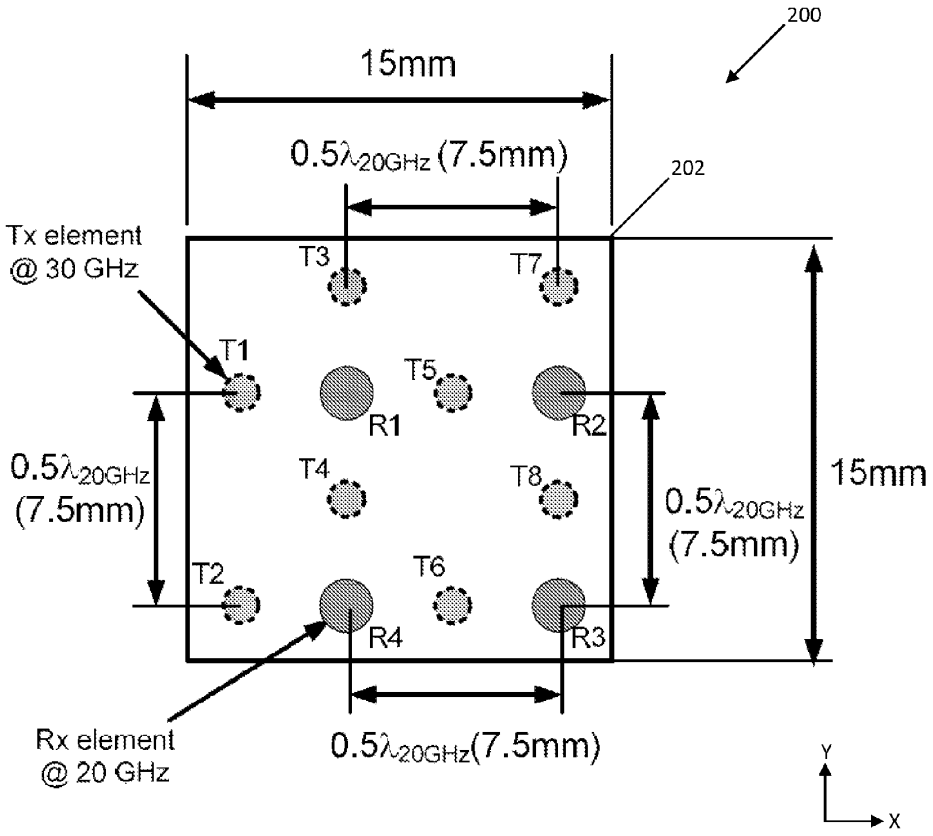
200
15mm
0.5λ20GHz (7.5mm)
202
Tx element
@ 30 GHz
T3
T7
T1
T5
R1
R2
0.5λ20GHz
(7.5mm)
T4
T8
15mm
0.5λ20GHz
(7.5mm)
T2
T6
R4
R3
Rx element
@ 20 GHz
0.5λ20GHz(7.5mm)
Y
X

FIG. 2A

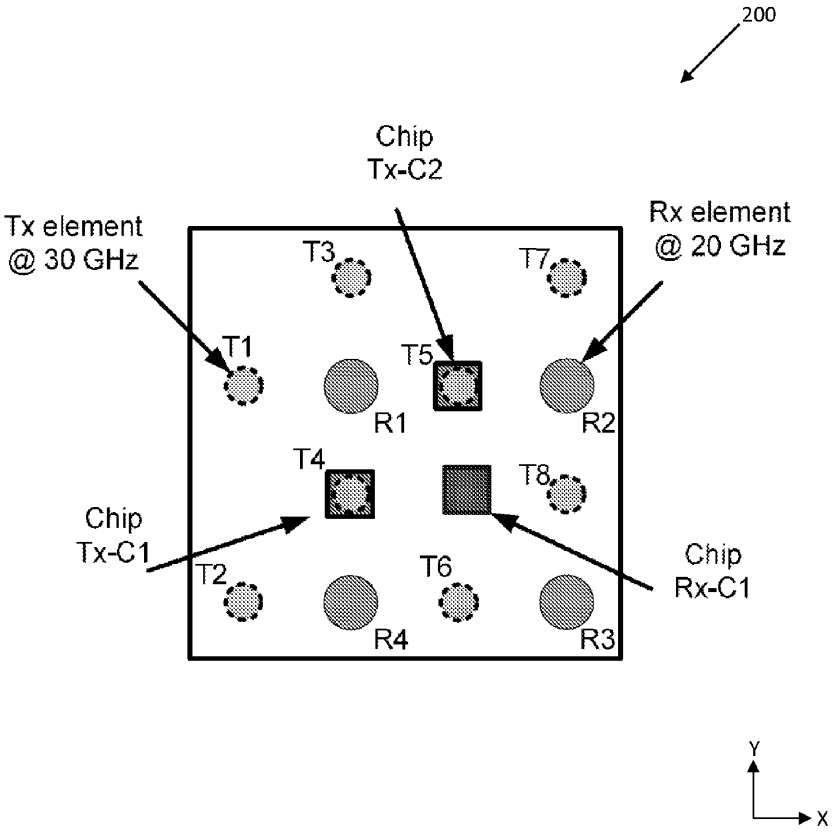
200
Chip
Tx-C2
Tx element
@ 30 GHz
Rx element
@ 20 GHz
T3
T7
T1
T5
R1
R2
T4
T8
Chip
Tx-C1
Chip
Rx-C1
T2
T6
R4
R3
Y
X

FIG. 2B

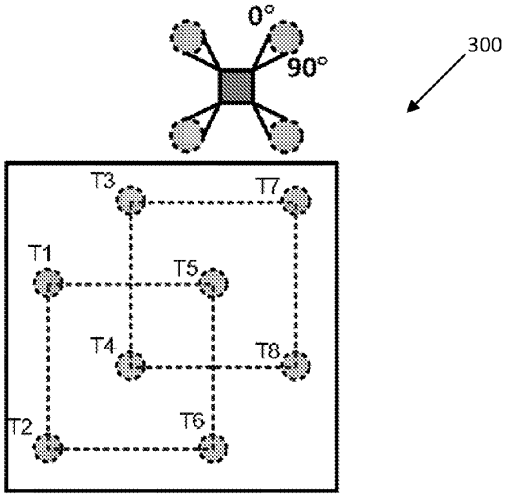


FIG. 3A

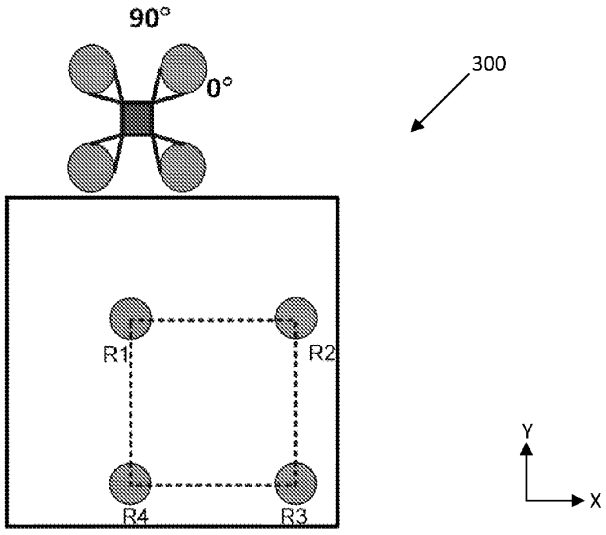


FIG. 3B

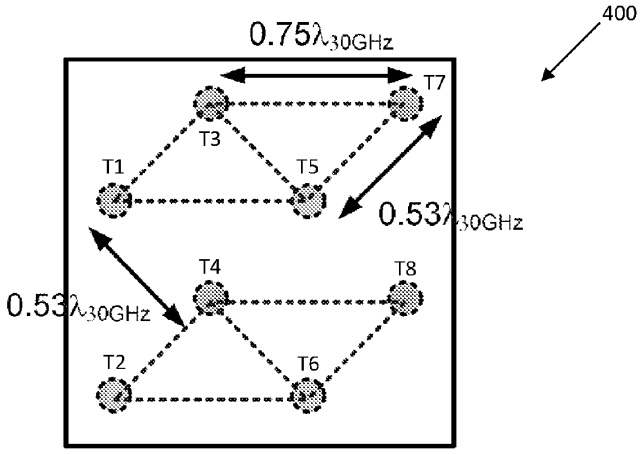
400
0.75λ30GHz
T7
T3
T1
T5
0.53λ30GHz
T4
T8
0.53λ30GHz
T2
T6

FIG. 4A

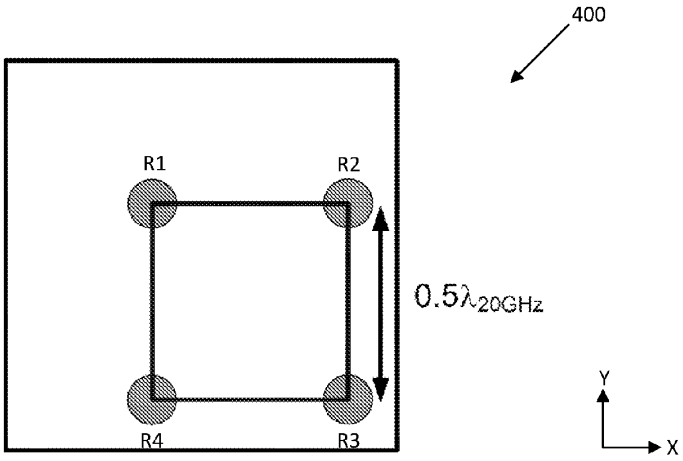
400
R1
R2
0.5λ20GHz
R4
R3
Y
X

FIG. 4B

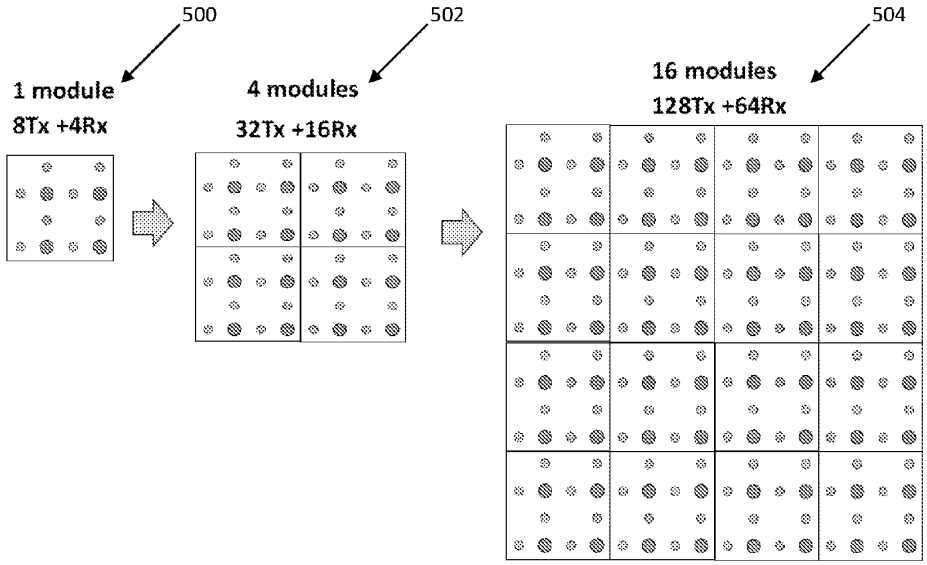
500
1 module
8Tx +4Rx
502
4 modules
32Tx +16Rx
504
16 modules
128Tx +64Rx

FIG. 5A

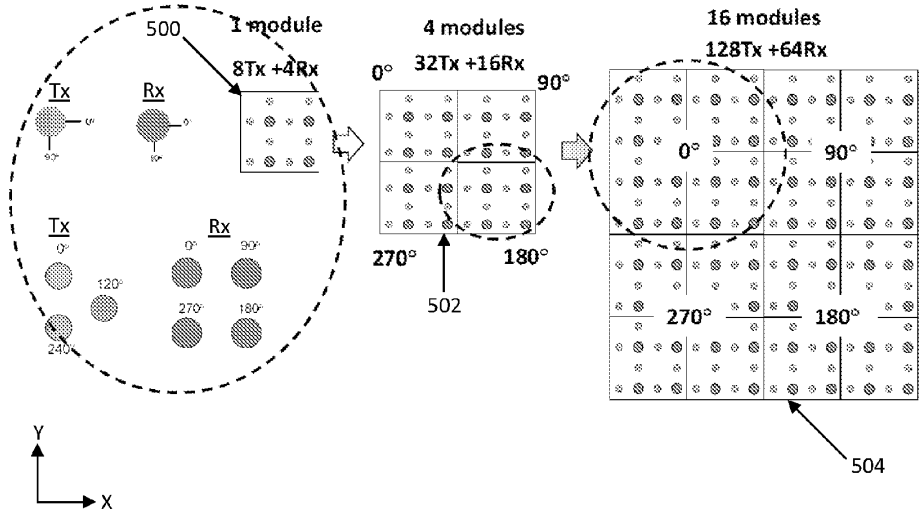
500
1 module
8Tx +4Rx
Tx
Rx
Tx
Rx
120°
240°
270°
180°
4 modules
32Tx +16Rx
0°
90°
270°
180°
502
16 modules
128Tx +64Rx
0°
90°
270°
180°
504
Y
X

FIG. 5B

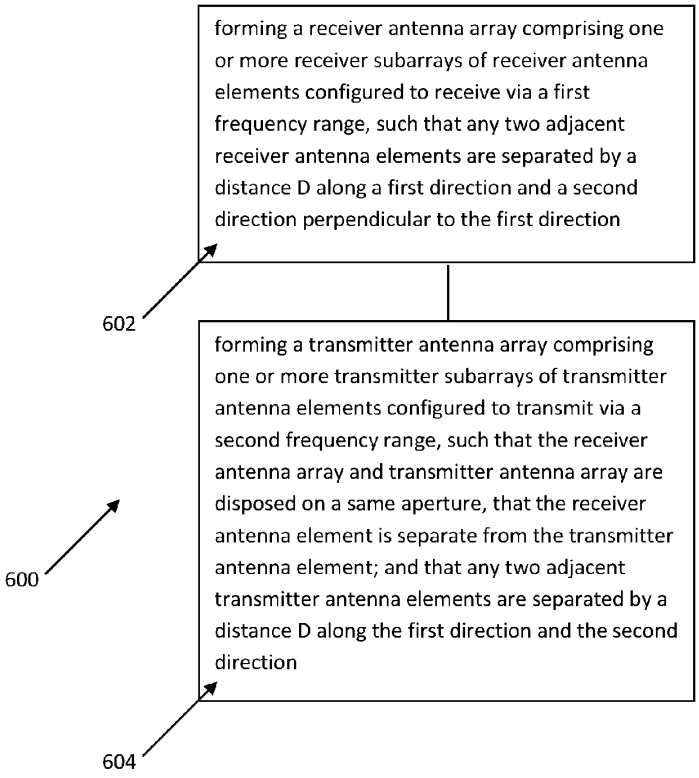
forming a receiver antenna array comprising one or more receiver subarrays of receiver antenna elements configured to receive via a first frequency range, such that any two adjacent receiver antenna elements are separated by a distance D along a first direction and a second direction perpendicular to the first direction
602
forming a transmitter antenna array comprising one or more transmitter subarrays of transmitter antenna elements configured to transmit via a second frequency range, such that the receiver antenna array and transmitter antenna array are disposed on a same aperture, that the receiver antenna element is separate from the transmitter antenna element; and that any two adjacent transmitter antenna elements are separated by a distance D along the first direction and the second direction
600
604

FIG. 6

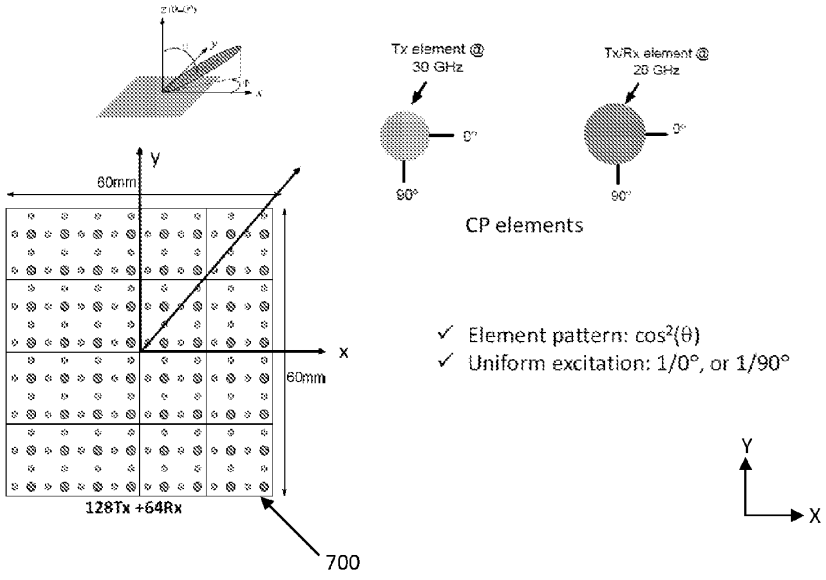
Tx element @
30 GHz
Tx/Rx element @
28 GHz
0°
90°
CP elements
y
60mm
x
60mm
128Tx +64Rx
700
✓ Element pattern: cos²(θ)
✓ Uniform excitation: 1/0°, or 1/90°
Y
X

FIG. 7

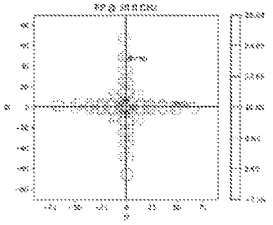

FIG. 8A

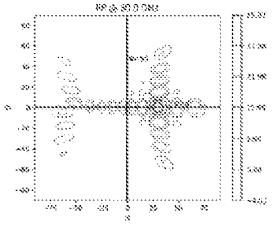

FIG. 8B

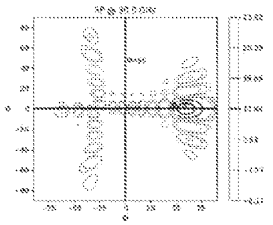

FIG. 8C

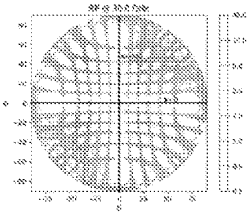

FIG. 8D

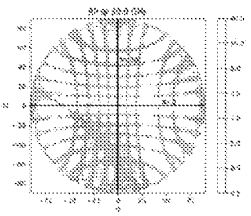

FIG. 8E

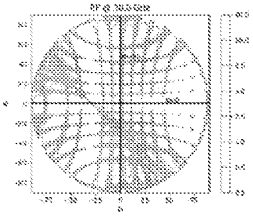

FIG. 8F

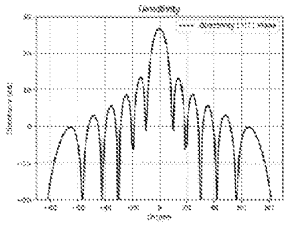

FIG. 8G

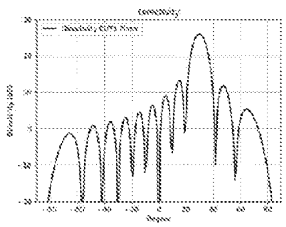

FIG. 8H

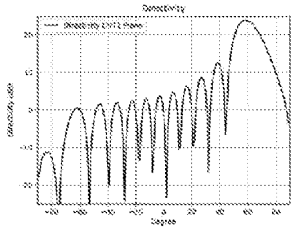

FIG. 8I

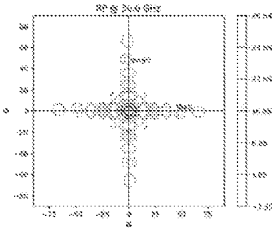

FIG. 9A

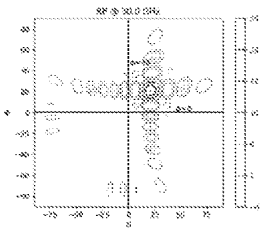

FIG. 9B

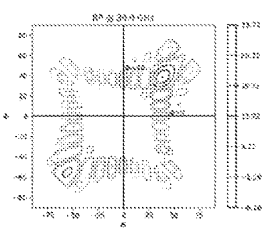

FIG. 9C

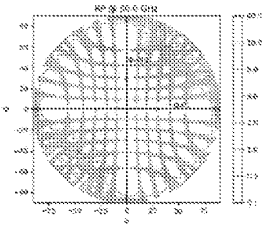

FIG. 9D

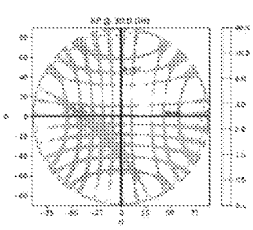

FIG. 9E

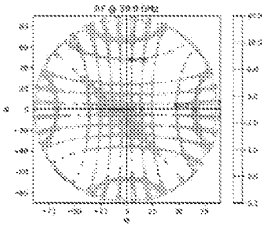

FIG. 9F

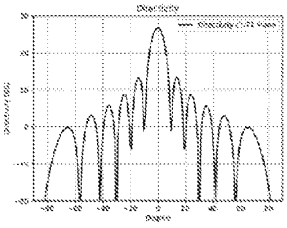

FIG. 9G

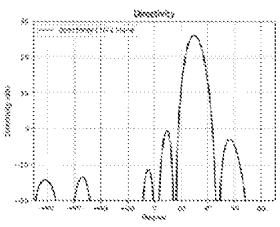

FIG. 9H

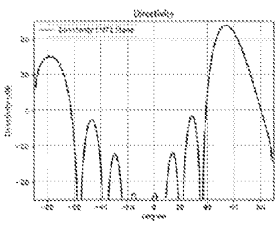

FIG. 9I

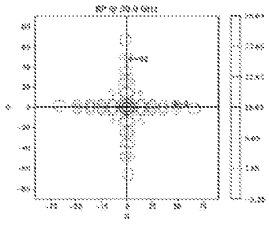

FIG. 10A

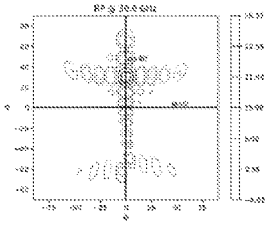

FIG. 10B

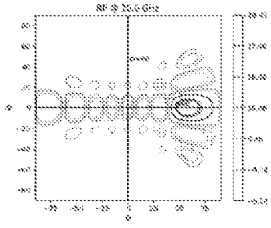

FIG. 10C

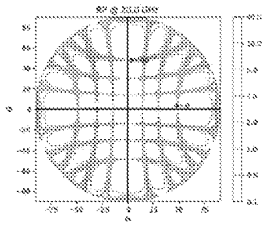

FIG. 10D

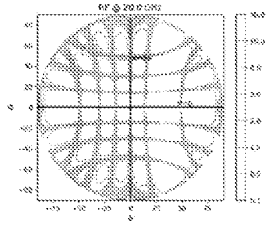

FIG. 10E

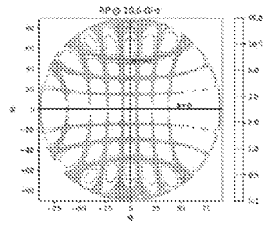

FIG. 10F

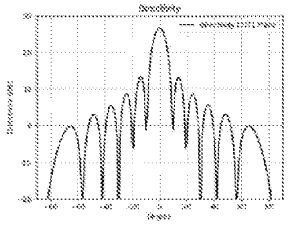

FIG. 10G

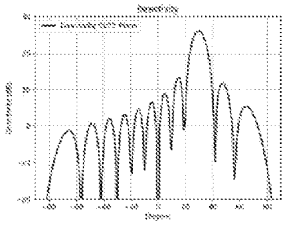

FIG. 10H

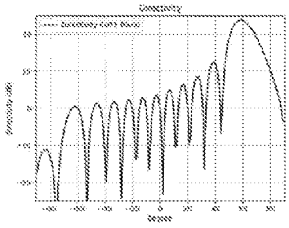

FIG. 10I

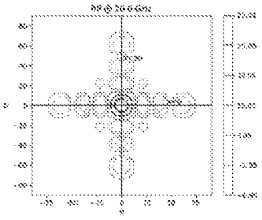

FIG. 11A

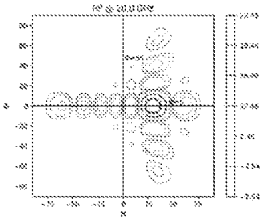

FIG. 11B

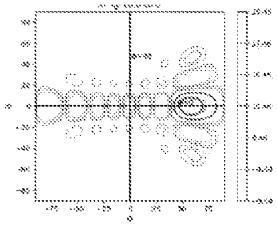

FIG. 11C

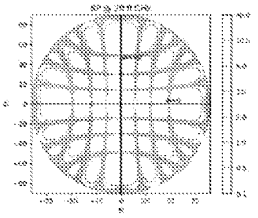

FIG. 11D

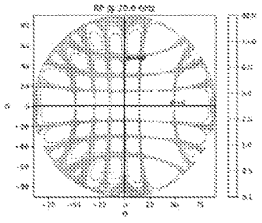

FIG. 11E

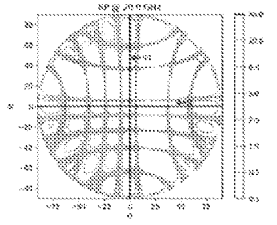

FIG. 11F

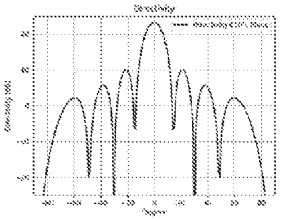

FIG. 11G

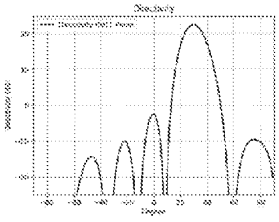

FIG. 11H

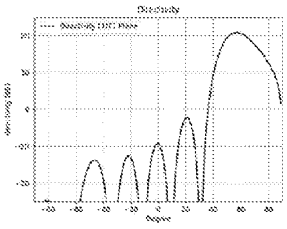

FIG. 11I

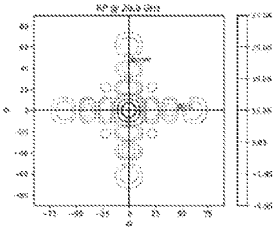

FIG. 12A

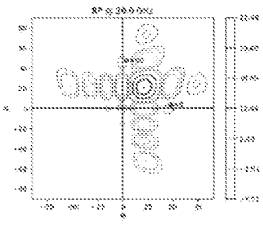

FIG. 12B

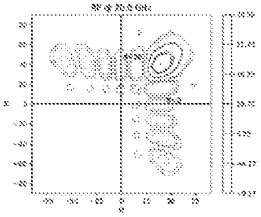

FIG. 12C

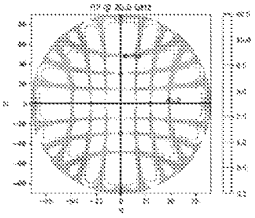

FIG. 12D

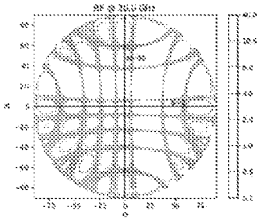

FIG. 12E

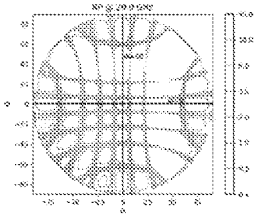

FIG. 12F

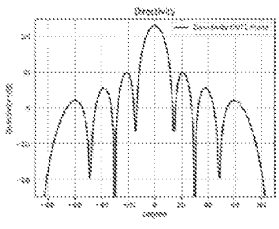

FIG. 12H

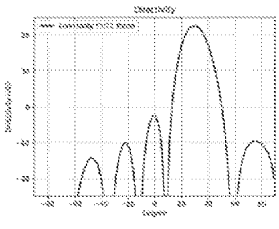

FIG. 12H

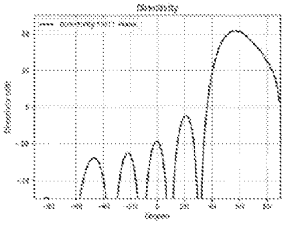

FIG. 12I

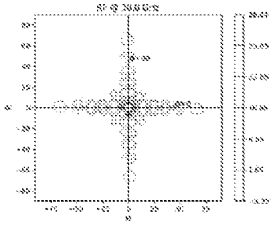

FIG. 13A

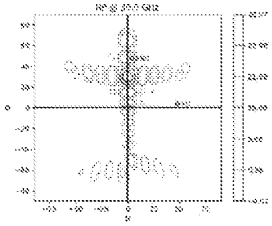

FIG. 13B

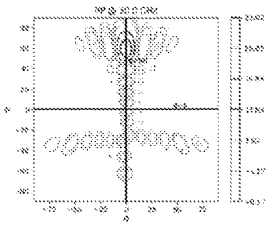

FIG. 13C

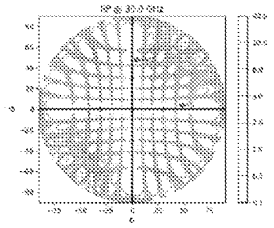

FIG. 13D

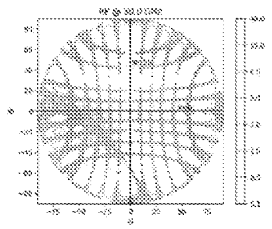

FIG. 13E

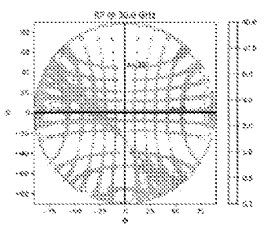

FIG. 13F

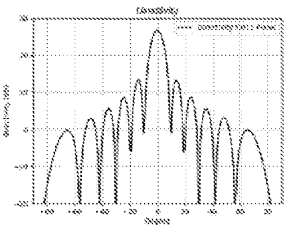

FIG. 13G

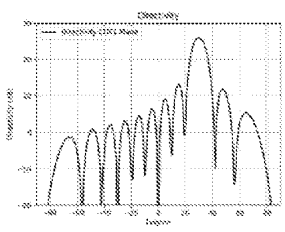

FIG. 13H

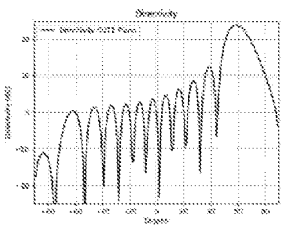

FIG. 13I

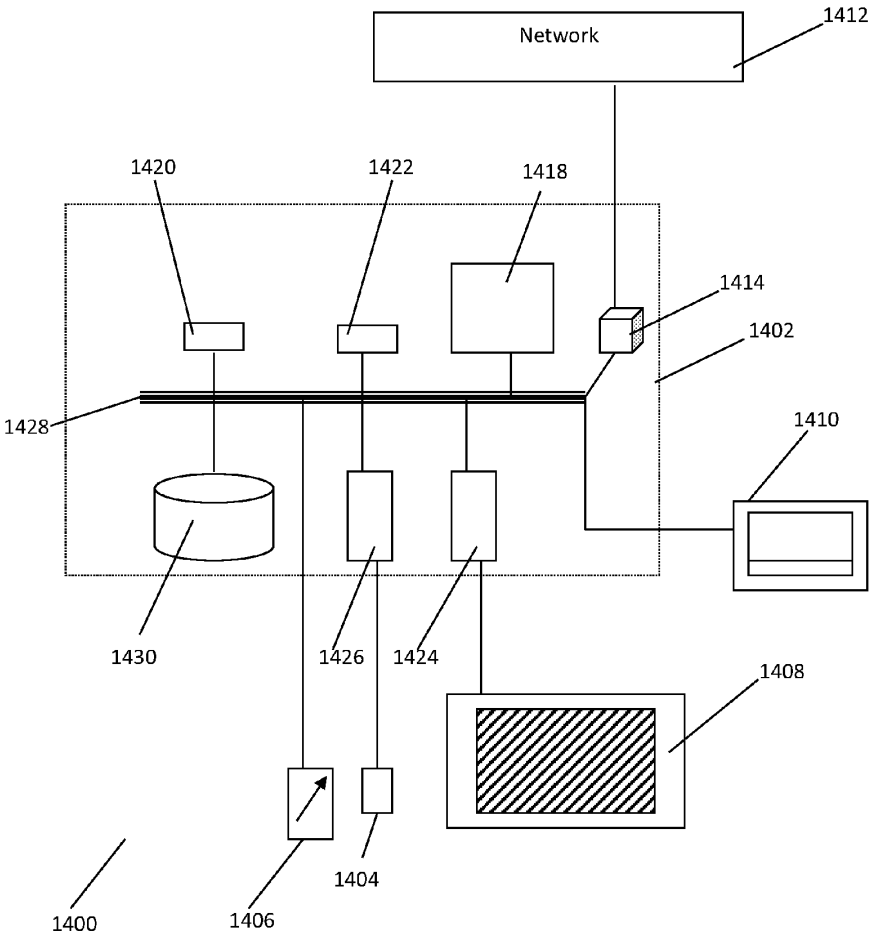
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FIG. 14